CONSULTATION REGULATION IMPACT STATEMENT (RIS 2010-01)

Proposal to Revise Building Code of Australia requirements for Construction in Cyclone Affected Regions

March 2010

The Australian Building Codes Board (ABCB) has prepared this Consultation Regulation Impact Statement (Consultation RIS) in accordance with the requirements of *Best Practice Regulation: A Guide for Ministerial Councils and National Standard Setting Bodies,* endorsed by the Council of Australian Governments in 2007. Its purpose is to inform interested parties regarding a proposal to revise existing regulatory requirements for construction in cyclone affected regions. Comments are invited by **10 September 2010**. Please title *"Cyclone RIS Public Comment"* and forward by email to: Consultationris@abcb.gov.au.

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Contents

1 Executive Summary

1.1 The Regulatory Impact Assessment process

Under Council of Australian Governments' (COAG) requirements, national standard-setting bodies such as the Australian Building Codes Board (ABCB) are required to develop a Regulatory Impact Statement (RIS) for public consultation for proposals that substantially alter existing regulatory arrangements. The requirements are detailed in COAG *Best Practice Regulation*[1].

This RIS has been prepared by the ABCB for the incorporation of proposed amendments to the delineation of regions in Australia in which buildings must be designed to resist tropical cyclones and to the level of stringency in cyclone and adjacent non-cyclone regions. The designation of cyclone regions and wind actions are currently contained in the Australian New Zealand Standard AS/NZS 1170.2 – 2002, *Wind Actions* and the Australian Standard AS 4055 – 2006, *Wind loads for housing* (hereafter called the Wind Standards)[2], which is referenced by the Building Code of Australia (BCA)[3] for the determination of wind loads on buildings and other structures. The BCA is a national code and accommodates changes in requirements, such as wind loads, based on geographic and/or climatic grounds. The RIS examines a number of regulatory proposals and demonstrates they are likely to result in slightly higher net benefits to the community compared to the status quo.

It should be noted that this RIS considers the impacts of the proposed measures on new buildings only, and in particular on a sample of Class 1 buildings (i.e. houses). Although the provisions can also be applied to existing building alterations and additions, the BCA has been developed predominantly to apply to new construction and its application to existing buildings is at the discretion of the local approval authority and respective jurisdictional legislation. As such, an analysis of the impacts on existing buildings is not included in this RIS.

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[1] COAG Best Practice Regulation, A Guide for Ministerial Councils and National Standard Setting Bodies, October 2007.

[2] Standards Australia/Standards New Zealand, (2002), *Australia/New Zealand Standard AS/NZS 1170.2-2002, Structural design actions, Part 2: Wind actions*. Sydney (Australia), Wellington (New Zealand); Standards Australia, (2006) *Australian Standard AS 4055-2006, Wind loads for housing*, Sydney (Australia).

[3] The BCA is produced and maintained by the Australian Building Codes Board on behalf of the Australian Government and State and Territory Governments. The BCA has been given the status of building regulations by all States and Territories. These regulations are effected through jurisdictional legislation.

The RIS considers the impacts of the proposed measures in areas affected by tropical cyclones i.e. the coastal zones of the Northern Territory, Queensland, northern Western Australia and northern New South Wales.

1.2 The review process

The Australian Government recently endorsed the view that "at least every five years, all regulation (not subject to sunset provisions) should, following a screening process, be reviewed with the scope of the review tailored to the nature of the regulation and its perceived performance".[4]

The Council of Australian Governments (COAG) endorsed the National Adaptation Framework[5] in April 2007 as part of its Plan of Collaborative Action on Climate Change. A key focus of the Framework is to support decision-makers in understanding and incorporating climate change into policy and operational decisions at all scales and across all vulnerable sectors. The Framework identifies that adaptation measures include using codes and standards to increase resilience to climate change and that:

- the Australian Building Codes Board should consider climate change as part of their periodic reviews;
- information used to determine vulnerability of settlements to climate-related hazards (floods, bushfires, cyclones and coastal inundation) should be reviewed.

This RIS in part responds to the National Adaptation Framework.

The RIS also in part responds to the 2009 Review of the Inter-Governmental Agreement which establishes the ABCB. The Review recommends Governments and industry be open to the potential to reflect climate change adaptation risks within the BCA, where such inclusion can be justified in RIS analysis.

1.3 Cyclone risk in Australia

The problem targeted by the Wind Standards is the risk that property owners will not voluntarily include appropriate levels of cyclone protection in new buildings in areas subject to cyclones. In addition, the Wind Standards do not currently cover possible increases in wind actions due to climate change. In the preface to the standard it states "The wind speeds provided are based on existing data. At the time of drafting, it was considered that there was

[4] Department of Prime Minister and Cabinet (2006), *Rethinking regulation: Report of the Taskforce on Reducing Regulatory Burdens on Businesses: Australian Government's Response*, p. 88.
[5] National Adaptation Framework *http://www.coag.gov.au/coag_meeting_outcomes/2007-04-13/docs/national_climate_change_adaption_framework.pdf*

insufficient evidence to indicate any trend in wind speeds due to climatic change."

Where building purchasers do not perceive value from cyclone protection or do not understand their level of exposure to the risk of cyclones, there is little or no incentive for builders to include cyclone resistant features in construction. This is because purchasers are unlikely to choose to meet the additional costs that builders may incur to provide these protections. Where homes are not adequately protected from cyclone damage, costs are borne by many parties, including home owners, insurance companies and the Australian government.

The cyclone risk associated with a given building is related to its design and construction, its exposure in terms of shielding, topography, proximity to the coast, its location in relation to a cyclone region and the intensity and duration of the cyclone. There are also other factors outside the scope of the BCA, including site and building maintenance, and flying debris.

From around 1981 and as a result of damage to housing caused by Cyclone Althea in 1971 and Cyclone Tracy in 1974, there have been considerable developments in building standards in cyclone and high wind affected areas. These improvements mean that houses constructed post 1981 are much more resilient to cyclone events. As the proportion of houses built post 1981 increases, the resilience of the entire community to cyclone damage improves.

In addition to evident existing cyclone risk, a report to the Australian Greenhouse Office, Department of the Environment and Water Resources by BRANZ Limited (August 2007)[6] has found that cyclone peak winds are likely to increase by 2 to 5% by 2030 and by 5 to 10% by 2070, in turn increasing the risk to buildings and their occupants. This is exacerbated by the threat of a southward shift of Category 3 to 5 storms by 2-3^0 latitude.

Similarly, the Bureau of Meteorology (BOM)[7] has identified that although trends in tropical cyclone activity in the Australian region (south of equator; 105 - 160°E) show that the total number of cyclones has decreased in recent decades, the number of stronger cyclones (minimum central pressure less than 970 hPa) has not declined.

BOM also identified that projected changes in tropical cyclone characteristics are inherently tied to changes in large-scale patterns such as El Niño-Southern Oscillation (ENSO), changes in sea surface temperature and changes in deep convection. As global climate models improve, their simulation of tropical

[6] BRANZ Limited (August 2007) "An Assessment of the Need to Adapt Buildings for the Unavoidable Consequences of Climate Change", http://www.climatechange.gov.au/impacts/publications/pubs/buildings-report.pdf accessed April 2009.
[7] http://www.bom.gov.au/weather/cyclone/tc-trends.shtml accessed April 2009.

cyclones is expected to improve, thus providing greater certainty in projections of tropical cyclone changes in a warmer world.[22]

In summary, while the likelihood of a significant cyclone event impacting a given site or homeowner is relatively low, the potential consequences from such an event are considerable. Further, continued construction activity in cyclone affected areas and the potential impacts of climate change suggest that it is likely that a greater number of households will be exposed to more intense cyclone risk in the future.

1.4 Objectives

The proposals which are the subject of this study would result in amendments to the BCA and/or the Wind Standards. The proposals seek to provide an efficient response to the risk that property owners will not voluntarily include higher levels of structural resistance in new buildings in areas subject to cyclones.

Specifically, the proposed changes and the alternative options considered are seeking to achieve the following Government objectives:

- Improve the resilience of buildings to climate change and review climate-related hazards to reduce vulnerability of settlements by considering appropriate measures such as the inclusion of adaptation measures into codes and standards;
- Reduce the danger to life and the risk of property damage by ensuring that buildings have appropriate resistance to cyclones taking into account the impact of climate change;
- Provide outcome based regulation which allows industry to develop the most technically efficient and appropriate solutions;
- Address the identified market failures in relation to the provision of cyclone resistant buildings; and
- Ensure that the regulatory requirements are cost effective and transparent.

1.5 Identification of feasible policy options

In accordance with COAG requirements, this RIS identifies and considers the merits of alternative means of achieving the objectives of effective cyclone protection including:

- Intermediate forms of regulation (self regulation, co-regulation or quasi-regulation);
- Non-regulatory options (information campaigns, voluntary Standards, or taxes and subsidies); and
- Alternative levels of regulatory stringency of the regulatory proposal (i.e. look at different options which increase the stringency of the current Standard and how they differ from the status quo of continuing with the current Standard).

The lack of alignment between those with responsibility for incorporating cyclone protection in the design and construction of houses and those who realise their benefits, mean it is unlikely that an intermediate form of regulation would achieve the Government’s objectives. The risks associated with non-compliance are exacerbated by the potentially serious consequences of cyclonic events, including both substantial risks to public health and safety, and economic impacts.

Non-regulatory interventions on their own appear to be inappropriate responses to cyclone protection measures for buildings built in cyclone prone areas, because they would not provide the level of protection and minimisation of damages required by the public and the government.

The proposed changes to the Standard represent a regulatory option and involve revised cyclone regions and increased stringency within those regions, which would result in increased construction requirements.

Therefore, this RIS provides a comparative assessment between the current arrangements (i.e. current BCA and the Wind Standards) and a number of alternative regulatory proposals, namely:

1. A shift in the boundary to cyclone Region D to extend it NE along the Western Australian (WA) coast to 15^{o}S which would include Broome and Derby (resulting in an approximate 50% increase in design wind force to affected areas).
2. A shift in the boundary to cyclone Region D to extend it north of 12^{o}S along the Northern Territory (NT) coastline to include the islands of NT but not Darwin (resulting in an approximate 50% increase in design wind force to affected areas).
3. A shift in the boundary to cyclone Region C to extend it south on the Queensland coast to 27^{o}S to include areas just north of Caboolture i.e.

include the Sunshine coast but not Brisbane (resulting in an approximate 50% increase in design wind force to affected areas).

4. An increase in the uncertainty factor for Region C from 1.05 to 1.10 (resulting in a 10% increase in design wind force to affected areas).

5. An increase in the uncertainty factor for Region B from 1.0 to 1.10 (resulting in a 20% increase in design wind force to affected areas).

Note the above proposals are not alternative but separate options that are being assessed through this RIS process to determine the extent of their respective costs and benefits to the community.

Cost benefit analysis

Within the methodology of the RIS, it is assumed that the regulations have a life span of 10 years. That is, the cost impacts on newly built houses will continue for 10 years and then cease. It is assumed that the regulation will then be superseded. However, the benefits derived from the regulatory changes are assumed to continue for the life time of each affected building; that is for 40 years.

Under these assumptions, the RIS provides an assessment of the costs and benefits associated with each proposal compared to the current arrangements. The analysis separately considers the following:

- Estimated cost impact on individual building owners;
- Estimated aggregate cost impacts at a State / Territory level;
- Estimated financial benefit impacts at a State / Territory level; and
- An assessment of the expected qualitative costs and benefits.

The outcome of each component of the analysis is presented below.

Costs and benefits for each proposal would apply to all buildings. However, this study relates primarily to housing. The reason being that damage to housing is the greatest component of building insurance losses (90% of Cyclone Tracy insurance losses for buildings related to housing), and due to ongoing concerns about housing affordability, housing is most sensitive to any cost increases. In addition, it is considered that the percentage cost impact on commercial, public and industrial buildings to cater for increased wind loads would be less sensitive compared to housing, because these other buildings are usually specifically engineer designed, the structures are often constructed of reinforced concrete or structural steel (i.e. they are likely to have greater structural capacity), and the cost of structural adequacy is likely to be a smaller percentage of total building cost. However, subject to public consultation response, further analysis could be considered for other classes of buildings.

1.5.1 Cost impact on individual building owners

The quantitative analysis indicates that the introduction of each of the proposals would be expected to impose a financial cost to the majority of building owners with higher cost increases expected in some circumstances due to specific site characteristics and/or the type of construction.

Table 1-1 below provides a summary of the expected cost impacts of the proposals for a representative sample of houses. These costs represent the change in construction costs for each option compared to current arrangements (i.e. the Wind Standards).

Table 1-1: Expected construction cost increase by house type

Proposal	*Base house one storey $*			*Average one storey $*			*Average two storey $*		
	Current	**Proposal**	**% incr**	**Current**	**Proposal**	**% incr**	**Current**	**Proposal**	**% incr**
1. Extend Region D for WA	195,000	206,700	6	254,000	269,200	6	303,000	321,200	6
2. Extend Region D for NT	195,000	206,700	6	254,000	269,200	6	303,000	321,200	6
3. Extend Region C for QLD	163,000	172,800	6	202,000	214,100	6	252,000	267,100	6
4. Increase uncertainty factor for Region C	163,000	165,000	1.2	202,000	204,400	1.2	252,000	255,000	1.2
5. Increase uncertainty factor for Region B	140,000	143,400	2.4	172,000	176,100	2.4	212,000	217,100	2.4

The above Table can be summarised as follows (for full details refer Appendix B):

- An increase in construction costs of around 6 per cent for all house types under proposals 1, 2 and 3;
- An increase in construction costs of around 1.2 per cent for all house types under proposal 4;

- An increase in construction costs of around 2.4 per cent for all house types under proposal 5;
- Across all house types, construction costs are expected to increase. The increase in costs ranges from $2000 to $18,200, depending on the type and location of house constructed.

The estimated cost impacts described above are likely to be a reflection of an improved alignment between the assessed level of risk and the associated construction requirements under climate change scenarios. As such, the expected increase in construction costs at the aggregate level represents an acceptance of the likelihood of increased cyclone risk, and a higher level of protection in response.

1.5.2 Aggregate cost impacts

The estimated annual cost impacts associated with each option are based on estimated construction activity in areas subject to cyclones and the cost estimates for each house type. In the absence of any available data it is assumed construction in areas subject to cyclones is spread evenly across the different house types.

Table 1-2 provides the estimated annual impact in construction costs at the regional and the national level for all proposals.

Table 1-2: Estimated annual cost increase

Proposal	*Number of new houses constructed in each region per annum*	*Cost Impact for each new house $*	*Cost Impact for each proposal per annum $m*
1. Extend Region D for WA	125	15,100	1.89
2. Extend Region D for NT	50	15,100	0.76
3. Extend Region C for QLD	3,854	12,400	47.8
4. Increase uncertainty factor for Region C	6,112	2,500	15.3
5. Increase uncertainty factor for Region B	19,363	4,200	81.3
TOTAL OF ALL PROPOSALS PER ANNUM			**$147 million**

The expected aggregate annual construction cost increase ranges from $0.76m for Proposal 2 to $81.3m for Proposal 5, while the cost increase per house is least for Proposal 4.

This indicates that while all proposals are likely to deliver cost increases to building owners, Proposals 4 and 5 are expected to impose the smallest annual increase in per house construction costs. This is driven by the relative differences in the stringency changes of the alternate proposals. Due to the higher number of house constructions affected in these regions however, Proposal 5 represents the greatest total annual additional construction costs and Proposal 4 the third highest.

1.5.3 Aggregate financial benefits

The proposals will benefit new houses by making them more resilient to cyclone events. Table 1-3 below shows the financial benefit for each of the proposals. The benefits are based on annual average cyclone related insured losses of $261 million per year, estimated over the period from mid 1960s to 2006. The figure of $261 million per year was derived by normalising observed nominal values of annual losses over changes in house values and the number of houses, as well as accounting for the likely reduction in these losses because of improved building standards. The benefits also take into account the predicted increase in cyclone peak winds of 5-10% by 2070 and southward movement of category 3 intensity cyclones by up to 3^{o}S latitude as a consequence of climate change[8].

Under a ‘do nothing’ or status quo option, Australia might expect to incur an average annual cost of $261 million a year from cyclone damage.

Table 1-3: Estimated annual financial benefit

Proposal	*Number of new houses constructed in each region per annum*	*Existing houses in each region*	*Reduction in loss ratio as a result of the proposal**	*Benefit for each proposal per annum $m*	*Total Benefit for each proposal per annum $m including indirect benefits***
1. Extend Region D for WA	125	7,771	0.85	0.07	0.3
2. Extend Region D for NT	50	10,156	0.85	0.03	0.1
3. Extend Region C for QLD	3,854	164,804	0.85	2.11	10.5
4. Increase uncertainty factor for Region C (WA, NT, Qld)	6,112	377,545	0.30	1.18	5.9

[8] JDH Consulting 2008

Proposal	*Number of new houses constructed in each region per annum*	*Existing houses in each region*	*Reduction in loss ratio as a result of the proposal**	*Benefit for each proposal per annum $m*	*Total Benefit for each proposal per annum $m including indirect benefits***
5. Increase uncertainty factor for Region B (WA, NT, Qld, NSW)	19,363	1,170,744	0.30	3.74	18.7
TOTAL OF ALL PROPOSALS PER ANNUM				7.13	35.6

Notes: Obtained from damage functions for Wind Regions B, C and D residential buildings from Walker (1995) taking into account 10% increase in peak winds and southward movement of cyclones to 3^{o}S latitude. ** The total benefit figures were obtained by applying a multiplier of five to the total value of insurance liability for cyclones to obtain an estimate total benefit (direct plus indirect benefits).*[9]

1.5.4 Net present value of costs and benefits

Table 1-4 below provides the estimated net present value (NPV) of the expected cost increases and benefits (direct and indirect) under each proposal, as well as the estimated benefit to cost ratio (BCR). The central case of the RIS analysis is based on an assumed discount rate of 7 per cent. The NPV is also estimated based on alternative discount rates of 3% and 11% for the purposes of sensitivity testing.

All proposals are estimated to generate a positive NPV under all discount rates. In the central case, Proposal 5 is estimated to return the highest NPV (due to the high level of house construction affected, and relatively low additional construction costs), but Proposal 4 is estimated to return the highest BCR. This relativity is unchanged under alternate discount rates.

Table 1-4 Breakeven based on NPV of the expected costs and benefits $m and BCR

[9] The multipliers were based on a study by Joy, C.S. 1991, 'The cost of natural disasters in Australia', paper presented at the Climate Change Impacts and Adaptation Workshop, Climatic Impacts Centre, Macquarie University, New South Wales, Australia, 13–15 May.

Discount rate	*3 per cent*		*7 per cent*		*11 per cent*	
Proposal	*NPV*	*BCR*	*NPV*	*BCR*	*NPV*	*BCR*
1. Extend Region D for WA	53.38	4.32	21.02	2.59	8.90	1.80
2. Extend Region D for NT	21.35	4.32	8.41	2.59	3.56	1.80
3. Extend Region C for QLD	1734.61	5.26	721.20	3.15	335.78	2.19
4. Increase uncertainty factor for Region C (WA, NT, Qld)	1068.73	9.20	484.23	5.51	255.49	3.84
5. Increase uncertainty factor for Region B (WA, NT, Qld, NSW)	3104.99	5.48	1302.85	3.28	615.53	2.29
TOTAL OF ALL PROPOSALS	5983.07	5.77	2537.70	3.46	1219.26	2.41

The effects of climate change are likely to have a negligible effect on the cost-benefit for the first 10 years and therefore there would be a limited impact on the NPV calculations due to the 10 year regulation lifetime assumptions, and the discounting of future benefits. However, when considering climate change, the benefits of the proposals are potentially much greater in the long term on the cost-benefit analyses. The outcomes for the five proposals are presented in Appendix C: Effects of Long Term Climate Change on Cost Benefit Analyses of Proposed Changes of NPV Calculations.

1.5.5 Qualitative assessment

In addition to quantitative cost and benefits impacts, qualitative costs and benefits should also be considered when assessing the overall impact of the proposals. Qualitative costs and benefits include:

- *Costs*

- Individuals – the proposals are expected to impact adversely on individuals depending on the site characteristics and preferred house design. The construction of all house types will become more expensive, unless the individual chooses a less expensive alternative design hence potentially reducing the amenity value of the house.

- Businesses – the proposals may impact on the demand for certain house types, but is not expected to impact on the overall demand for construction in areas subject to cyclones. That is, while some houses will become more expensive, the increase is across the board so there is a level playing field across the building industry. However, there could be a shift in consumer preferences for smaller, less expensive houses.

• *Benefits*

- Individuals – The proposals are expected to lead to a reduction in the costs associated with cyclonic events, such as damage costs, disruptions to normal life and impacts on health and well-being (for more detail see Section 7.6). Annual building related damage costs attributed to cyclonic events is estimated at $261 million (insured losses normalised to 2006 values), but this figure is likely to be significantly conservative as it does not include the broader costs associated with cyclonic events (i.e. consequential losses).

- Businesses – the proposals may stimulate demand for the construction of some house types, which become relatively less expensive and more attractive under the proposed arrangements; and

- Government – the proposals could lead to a reduction in social disruption costs, emergency response and the adverse economic impacts associated with cyclone events.

1.6 Findings

The RIS analysis concludes the following:

Construction cost impacts

• All proposals are likely to lead to cost increases when building in areas subject to cyclones:

- On an individual level, all proposals are likely to lead to cost increases for all three house designs i.e. the base house, the average one storey house and the average two storey house. The changes to the cyclone

Region boundaries (i.e. Proposals 1, 2 and 3) are likely to be responsible for the largest comparative cost increases while the increases in uncertainty factors for Regions B and C (Proposals 4 and 5) are likely to lead to comparatively lower construction cost increases;

- Proposals 1 and 2 are expected to increase construction costs by 6 per cent per house, or $15 100. Proposal 3 is also expected to increase construction costs by 6 per cent, or $12 400 per house. Proposals 4 and 5 are expected to increase construction costs by 1.2 and 2.4 per cent, or $2 500 and $4 200 respectively.

- On an aggregate level, all five proposals would lead to an increase in construction costs for new houses located in cyclone affected areas by approximately $147m per annum nationally. Proposal 3 relating to extending Region C in Queensland provides the greatest additional cost increase of around $48m per annum; and

- It must be noted that the cost estimates are dependent on the assumptions used (e.g. level of adoption of the BCA), and do not consider there would be any increased acceptance of cyclone risk in construction by the market. Further, they do not provide for changes in consumer demand patterns in favour of less expensive house designs.

- The proposals will impose minimal incremental business compliance costs and have no adverse impact on competition.

Benefits

- There are incremental benefits associated with the proposals above those provided by the current arrangements. Estimated benefits are based on potential Australia wide cyclone related insured losses of approximately $261 million per year being incurred under the status quo. Over the expected life of the proposals this equates to just over $3.5 billion of net benefits of avoided insured and uninsured losses.

  - Proposals 1, 2 and 3 provide the greatest reduction in cyclone loss ratios, estimated to reduce damages by up to 85 per cent compared to the status quo. Proposals 4 and 5 are estimated to reduce damages by up to 30 per cent.

  - Total benefits for each proposal are based on both the reduction in loss ratio as well as the number of houses affected. Proposals 5 and 3 are estimated to provide the greatest NPV of total benefits, at $18.7m and $10.5m respectively.

- While these estimated benefits based on insured loss estimates provide an indication of the total benefits of the Proposals, additional benefits are difficult to quantify because:

  - It is difficult to measure the improvement in housing survivability as a result of the proposals as housing survivability (and conversely, the level of building damage) can be influenced by a range of factors other than cyclone protection measures that are provided by designs under the Wind Standards;

  - It is difficult to estimate building related costs, as not all damage incurred in a cyclone event can be attributed to the loss of a building; and

  - It is difficult to compare the quantitative costs and benefits against the qualitative benefits.

Results

It can be concluded that compared to the status quo all five potential regulatory proposals are likely to deliver an overall net benefit, bearing in mind that there are some uncertainties surrounding two major benefit calculation inputs. That is, the benefits of increased protection, as assessed in the preliminary analysis, are likely to outweigh the additional construction costs. Details of the findings are as follows.

The estimated net present values of the net benefits for each of the five Proposals are:

- Proposal 1 - $21 million;

- Proposal 2 - $8 million;

- Proposal 3 – $721 million;

- Proposal 4 – $484 million; and

- Proposal 5 – $1 302 million.

The BCRs of Proposals 1, 2 and 3 relating to changes to cyclone region boundaries are generally less than the benefits of Proposals 4 and 5 relating to increases in uncertainty factors for Regions B and C. These differences reflect the varying cost elements underlying the net benefit calculations.

Proposals 1, 2 and 3 have BCRs of 2.59, 2.59 and 3.15 respectively. Proposals 4 and 5 have BCRs of 5.51 and 3.28 respectively. All proposals were assessed as likely to support the achievement of the Government objectives, with Proposals 4 and 5 assessed relatively more favourably as they provide an improved level of protection at a lesser cost per house compared to the remaining proposals.

Proposal 1, the extension of Region D in WA to include Broome and Derby, while not providing significant benefit, could be considered to be justified because of the close proximity to the existing Region D, which represents the area of highest risk of severe cyclones, a high level of cyclone activity and a high number of near misses.

Proposal 2, the creation of a new Region D in the NT, would introduce a higher construction standard for houses just north of Darwin. This proposal, whilst creating greater protection for those buildings constructed in the affected area, has the potential to create confusion around the Region boundary and would potentially be difficult to administer. Additional stakeholder input to assist in the justification of its adoption would assist decision makers, considering likely local government and industry concerns, and the relatively small preliminary estimated net benefit of $8 million.

Proposal 3, the extension of Region C for Queensland, whilst also providing a net benefit will have a significant cost impact on this large growth area. Again, stakeholder feedback would be beneficial in assisting decision makers in determining the suitability of adopting such a proposal, bearing in mind that an increased level of protection would be provided for this area under Proposal 5 (although not quite to the same extent as Proposal 3).

Consultation comments sought

The results presented in this Consultation RIS are published for review by stakeholders. A number of uncertainties have been discussed with respect to the estimates of costs and benefits as well as the methodology used. A sensitivity analysis has demonstrated that there is the potential for these areas of uncertainty to result in negative NPV estimates for Proposals 1 and 2. Through the consultation period, submissions from stakeholders are sought on all areas of the RIS. Some guiding questions to be addressed include the following.

- Are the normalised and annualised damage figures a reasonable representation of damages caused by cyclones in Australia? If not, then where does the concern arise from, and what evidence is there to suggest a change in the estimate?

- Are the estimates of insured damages to total damage arising from cyclones reasonable? If not, what evidence is there that they should be altered? Such evidence could include the estimation of lost productivity associated with housing dislocation.
- Would a bottoms up methodology provide a more reasonable representation of the costs and benefits of the proposals? If so, what sources of information are available on house level damages and probability of cyclone activity?
- Are the estimates of the costs of altered construction requirements reasonable? If not, which ones are of concern, and what evidence is there that they may be over or under estimated?
- How does the insurance industry rely on the BCA in determining premiums in cyclone affected areas? Will there be additional benefits resulting from greater information flows across house builders, owners and insurance companies on the resistance of houses to cyclone damage?
- What would be the impact on associated building industry issues, for example, housing affordability, due to these Proposals?

2 Introduction

Under Council of Australian Governments' (COAG) requirements, national standard-setting bodies such as the Australian Building Codes Board (ABCB) are required to develop a Regulatory Impact Statement (RIS) for proposals that substantially alter existing regulatory arrangements. This requirement is reaffirmed in the ABCB's Inter-Government Agreement[10] (IGA) which requires that there must be a rigorously tested rationale for regulation.

A draft RIS is initially undertaken for the purposes of public consultation ('Consultation RIS'). The Consultation RIS may be developed further following its public release, taking into account the outcomes from the community consultation. A Final RIS is then developed for decision-makers. This entire process is undertaken in cooperation with the Office of Best Practice Regulation and in accordance with the process established in the COAG *Best Practice Regulation Guide*[1] and presents the rationale, costs and benefits, and impacts of the proposal.

The primary purpose of a RIS is to examine the policy choices through a rational, comparative framework and to demonstrate that the resulting regulatory proposal is likely to result in higher net benefits to the community than the identified alternatives.

This Consultation RIS analyses the likely impact of adopting changes to the Building Code of Australia (BCA) or the Wind Standards, for buildings in cyclone areas. These changes are identified in a number of reports (refer Chapter 3.3)

Whilst the current regulatory framework in this area has worked well, increasing knowledge of the risks of cyclones together with how these risks are affected by climate change and how these can best be managed has prompted a review of the existing Standard. Ensuring that the Standard is up to date and reflects current research and contemporary building practices is important given the ongoing level of building activity in areas subject to cyclones and the expectation that cyclone events occurring in the future will have a greater risk of being more intense and occur in areas currently not considered cyclone prone.

The need for a review is supported by the National Adaptation Framework[5] endorsed by the Council of Australian Governments (COAG) in April 2007 as part of its Plan of Collaborative Action on Climate Change. The Framework identifies that adaptation measures include using codes and standards to increase resilience to climate change and that:

- the Australian Building Codes Board should consider climate change as part of their periodic reviews;

[10] The ABCB IGA can be located at www.abcb.gov.au

- o information used to determine vulnerability of settlements to climate-related hazards (floods, bushfires, cyclones and coastal inundation) should be reviewed.

This RIS is prepared as a part of that initiative.

2.1 Policy context

There are large areas across Australia where the incidence of cyclones is considered a serious risk. These areas are currently predominantly north of latitude 25° in Queensland (i.e. from Bundaberg north) and within 50kms of the coast; across the Northern Territory within 50kms of the coast; and north of latitude 27° in Western Australia between 50-100kms from the coast. However, under climate change scenarios, cyclones are expected to occur beyond current latitude boundaries and to be more intense, while fewer in number.

The BCA and the Australian Standards

This RIS impacts on the BCA and the Wind Standards referenced by the BCA for the design wind loads on buildings, including cyclonic wind loads.

Requirements of the BCA

The BCA in B1.2 specifies that for most building types, including most residential buildings, the design annual probability of exceedance for wind, including cyclonic wind, is 1:500 or a 10% chance of exceedance in 50 years, the typical design life of most buildings. For buildings containing a large number of people (e.g. a theatre with a capacity of more than 300, or a secondary school with a capacity greater than 250) the design annual probability of exceedance for wind, including cyclonic wind, is 1:1000 or a 5% chance of exceedance in 50 years. For buildings that are essential to post-disaster recovery such as essential hospitals or emergency service facilities (eg police and fire stations) the design annual probability of exceedance for wind, including cyclonic wind, is 1:2000 or a 2.5% chance of exceedance in 50 years.

The BCA establishes Performance Requirements that require buildings to remain stable and not collapse by resisting the actions, including wind actions, to which they may reasonably be subjected. The BCA is performance based and allows compliance with the Performance Requirements by adopting two broad types of building solutions:

- Implementing the Deemed-to-Satisfy (DTS) provisions which are specific design or construction requirements that are either contained in the BCA or in BCA referenced documents such as Australian Standards. DTS compliance is achieved for all buildings by conformity with AS/NZS 1170.2-2002, or for housing AS 4055-2006.

- Formulating an alternative solution that can be shown to be at least equivalent to the DTS provisions or which can be demonstrated as complying with the Performance Requirements.

Periodic review of the Standard

The Wind Standards are the primary design standard for wind action. They identify the areas in Australia where buildings must be designed to resist cyclonic wind forces, and the magnitude of those forces. The importance of the Standards is reinforced by the frequent occurrence of cyclone events within Australia and the significant level of ongoing construction activity in areas subject to cyclones.

The Standard was last revised in 2002 and the most recent amendment published in 2005. There are several reasons why individual Standards within the BCA are reviewed on a regular basis. These include changes to the understanding of risks which exist in the broader built environment and how these can best be managed, and changes in building materials and practices as a result of technological developments. Given the BCA is the technical basis for building standards in all of Australia's jurisdictions, it is important that standards are reviewed on a regular basis to take account of these changes; so relevancy can be maintained and compliance burdens minimised.

The current consideration of changes to the Wind Standards primarily relate to the possible impact of climate change on cyclone events. Under climate change scenarios, cyclones are predicted to be fewer in number but more intense, and affect parts of the Australian coastline currently not considered subject to cyclones or considered subject to less intense cyclones.

The current consideration of changes primarily originates from a number of recent reports and cyclone events in Australia in recent years and insights from research around these. They also reflect a heightened level of awareness in the building industry and community about the potential impacts of climate change in Australia in coming years on climate related hazards such as cyclones. Should these revisions proceed, they will be given effect through jurisdictional legislative frameworks.

Recent Reports

There have been a number of recent reports discussing possible changes to Standards as a result of climate change and the increased risk of more intense cyclones impacting over a wider area (refer Chapter 3.3).

2.2 Current legislative framework

The BCA forms part of the building law of each State and Territory by reason of its adoption by the building legislation of each jurisdiction. The BCA references the Wind Standards which identify the cyclone regions in Australia and the wind actions which buildings must be designed to resist. New buildings located in regions determined to be cyclone prone must be designed and constructed to resist the wind actions determined in accordance with the Standard. A summary of the existence and extent of cyclonic regions in each State and Territory is provided in Table 2-1 below.

Table 2-1: Cyclonic regions in each State and Territory (refer Figure 3-1)

State / Territory	*Cyclonic Regions*
Australian Capital Territory	No areas are cyclone prone.
New South Wales	No areas are cyclone prone, however, non-cyclonic Region B (a transition zone between cyclone and non-cyclone) extends from the Queensland border to 30^o latitude (just below Corindi) and within 100kms from the smoothed coastline.
Northern Territory	Cyclone Region C extends from the smoothed coastline to 50kms inland. Non-cyclone Region B extends 50kms inland of Region C (i.e. from 50-100kms of the coast).
Queensland	Cyclone Region C extends from the smoothed coastline to 50kms inland from the NT border to 25^o latitude (just south of Bundaberg). Non-cyclone Region B extends 50kms inland of Region C and 100kms inland south of 25^o latitude.
South Australia	No areas are cyclone prone.
Tasmania	No areas are cyclone prone.
Victoria	No areas are cyclone prone.
Western Australia	Cyclone Region C extends from the smoothed coastline to 50kms inland from the NT border to 20^o latitude (just north of Port Headland), and from 25^o latitude to 27^o latitude. Region C also extends 50kms inland of Region D. Severe Cyclone Region D extends from the smoothed coastline to 50kms inland from 20^o latitude to 25^o latitude (just south of Carnarvon). Non-cyclone Region B extends 50kms inland of Region C and 100kms inland south of 27^o latitude to 30^o latitude.

Current BCA position:

BCA Volume One provides requirements for buildings of Class 2 - 9 (all buildings except houses and small non-habitable buildings). The requirements are based on specified design wind speeds affecting structural and glazing design. The design wind speeds vary with the regions. Australia is divided into four regions A, B, C and D with increasing design wind speeds. Regions A and B are known as non-cyclonic, while Regions C and D are cyclonic. The design wind speed also varies with the Importance Level of the building. The BCA has adopted a four Importance Level classification. The design wind speed is specified in terms of the annual probability of exceedance as shown in Table 2-2.

Table 2-2: Annual probability of exceedance

Importance Level	*Annual probability of exceedance*	
	Non- cyclonic	Cyclonic
1	1:100	1:200
2	1:500	1:500
3	1:1000	1:1000
4	1:2000	1:2000

Source: BCA 2009, Table B1.2b, Design Events for Safety

BCA Volume Two provides requirements for buildings of Class 1 & 10 (houses and non-habitable buildings). In terms of Table 2-2, buildings of Class 1 & 10 are in Importance Level 2. However, for practical direct application, wind classification is based on actual wind speeds on specific sites. Wind classes for non-cyclonic regions vary from N1-N6 (34m/s to 86 m/s) and cyclonic regions C1-C4 (50 m/s to 86 m/s).

For both volumes of the BCA, in cyclonic regions, there is an additional requirement of cyclic testing for metal roof cladding, its connections and immediate supporting members.

3 Nature and extent of the problem

3.1 Overview

The problem targeted by the Wind Standards is the risk that property owners will not voluntarily include appropriate levels of cyclone protection in new buildings in areas subject to cyclones.

Further, given there are a number of reports (refer Chapter 3.3) about whether the current cyclone region boundaries and the design wind speeds within the regions are appropriate, it may be timely to review the Standard. The objective being to ensure that the Standard provides an accurate assessment of the risks associated with high winds, and particularly cyclonic winds acting on a particular site. The need for a review is supported by COAG (2007) as part of its Plan of Collaborative Action on Climate Change which identifies that the Australian Building Codes Board should consider climate change as part of their periodic reviews; and information used to determine vulnerability of settlements to climate- related hazards (including cyclones) should be reviewed.

Where building purchasers do not perceive value from cyclone protection or do not understand their level of exposure to the risk of cyclones, there is little or no incentive for builders to include cyclone resistant features in construction. This is because purchasers are unlikely to choose to meet the additional costs that builders may incur to provide these protections. Interactions with insurance markets as well as government assistance payments in the event of a cyclone are important factors also affecting actions of builders and home owners. In general, home insurance companies appear to rely on building standards to determine insurability of houses, as indicated through product disclosure statements that do not mention further protection beyond building standards. The Australian Government has also provided payments to uninsured families and sole occupants in the aftermath of a cyclone when houses have been damaged. After Cyclone Larry, these payments were:

- $4500 for families and $1500 for sole occupants for home contents; and
- $12,500 for families and $9,300 for sole occupants for rebuilding[11].

The proposed changes aim to reduce these private and public costs of cyclones, as well as reducing inefficient relief payments through improving building standards.

In this section the nature and extent of the problem is explored. The nature of the threat posed by cyclones to buildings and the profile of cyclone risk in Australia are discussed. The level of ongoing building activity in cyclone

[11] Goodall, W (2007) The insurers plan, action and response to natural disasters, EIG-Ansvar Ltd, Coastal cities natural disasters conference, Sydney, February

affected areas is also considered in addition to whether the current regulatory arrangements, individual responses and the insurance industry provide a robust solution to the problem of houses in cyclone affected areas being adequately protected against the risk of cyclone events.

This discussion highlights the unique nature of the problem and outlines evidence which suggests that the magnitude of the problem may increase in years to come taking climate change into account. Combined, these considerations underpin the case for government intervention in this area.

3.2 Nature of cyclone risk

3.2.1 Cyclones and buildings

The cyclone risk associated with a given building is related to its design and construction, its exposure in terms of shielding, topography, proximity to the coast, its location in relation to a cyclonic region and the intensity and duration of the cyclone. There are also other factors outside the scope of the BCA, including site and building maintenance, and flying debris.

Shielding, topographical risks and location

In addition to the design and construction of the building, there are other variables which have an important bearing on a building's susceptibility to cyclones — namely the proximity and size of any permanent structures which could shield the building, the topography of the site or the slope of the surrounding terrain (houses with a view or near crests of hills etc are generally subjected to higher wind speeds than those on flat ground), and the regional location of the building (eg buildings near Onslow in WA and within 50 kms of the coast are in cyclone Region D, the most severe cyclone region in Australia).

The intensity and duration of the cyclone

Tropical cyclone intensity is defined by the maximum mean wind speed over open flat land or water. This is sometimes referred to as the maximum sustained wind and will be experienced around the eye-wall of the cyclone. The mean wind speed is defined as the wind speed averaged over a period of 10 minutes measured at 10 m above the surface while the wind gust speed is defined as the wind speed averaged over 3 seconds.

Typically gusts over open land will be about 40% greater than the mean wind and gusts over the ocean will be 25 - 30% greater than the mean wind. The stronger gusts usually cause the most significant damage to buildings.

While a cyclone advice or warning may refer to a certain maximum sustained wind or gust, there will be localised points where the winds will exceed this value, particularly in gullies, about ridges and between buildings where winds can be funnelled by the landscape.

The Bureau of Meteorology (http://www.bom.gov.au/weather/cyclone/about/tropical-cyclone-intensity.shtml) categorises Tropical Cyclones into five groups, depending on their intensity as follows-

CATEGORY 1 (tropical cyclone)
Characterised by negligible house damage; damage to some crops, trees and caravans; craft may drag moorings.
A Category 1 cyclone's strongest winds are GALES with typical gusts over open flat land of 90 - 124 km/h. These winds correspond to Beaufort 8 and 9 (Gales and strong gales). The central pressure is typically greater than 985hPa.

CATEGORY 2 (tropical cyclone)
Characterised by minor house damage; significant damage to signs, trees and caravans; heavy damage to some crops; risk of power failure; small craft may break moorings.
A Category 2 cyclone's strongest winds are DESTRUCTIVE winds with typical gusts over open flat land of 125 - 164 km/h. These winds correspond to Beaufort 10 and 11 (Storm and violent storm). The central pressure is typically 985 - 970hPa.

CATEGORY 3 (severe tropical cyclone)
Characterised by some roof and structural damage; some caravans destroyed; power failures likely.
A Category 3 cyclone's strongest winds are VERY DESTRUCTIVE winds with typical gusts over open flat land of 165 - 224 km/h.
These winds correspond to the highest category on the Beaufort scale, Beaufort 12 (Hurricane). The central pressure is typically 970 - 945hPa.

CATEGORY 4 (severe tropical cyclone)
Characterised by significant roofing loss and structural damage; many caravans destroyed and blown away; dangerous airborne debris; widespread power failures.
A Category 4 cyclone's strongest winds are VERY DESTRUCTIVE winds with typical gusts over open flat land of 225 - 279 km/h.
These winds correspond to the highest category on the Beaufort scale, Beaufort 12 (Hurricane). The central pressure is typically 945 - 920hPa.

CATEGORY 5 (severe tropical cyclone)
Extremely dangerous, characterised by widespread destruction.

A Category 5 cyclone's strongest winds are VERY DESTRUCTIVE winds with typical gusts over open flat land of more than 280 km/h.
These winds correspond to the highest category on the Beaufort scale, Beaufort 12 (Hurricane). The central pressure is typically below 920hPa.

Cyclone severity categories are summarised in Table 3-1 below.

Table 3-1: Cyclone severity categories

CATEGORY	*WIND STRENGTH (Max gust in km/hr)**	*WIND STRENGTH (Max gust in m/s)**	*DAMAGE POTENTIAL*
1	Gale 90 - 124	25 - 34	Minimal
2	Storm 125 - 164	35 - 45	Moderate
3	Hurricane 165 - 224	46 - 62	Major
4	Hurricane 225 - 279	63 - 78	Devastating
5	Hurricane >280	> 78	Extreme

** Gust speeds refer to 3 second gusts at a height of 10m above open flat terrain.*

Note that the force exerted by the wind increases approximately as the square of the velocity. Thus a 60km/h wind exerts 100 times the force of a 6km/h wind.

Another important consideration is the duration of the cyclone. A slow moving cyclone will subject buildings to excessive wind actions and cyclic loading for a longer period of time compared to a fast moving cyclone. This means there would be a greater risk of building failure in the case of a slow moving cyclone compared to a fast moving cyclone even if the intensities were similar.

In accordance with AS 1170.2: 2002, the 3 second design gust wind speed for terrain category 2 (open flat terrain) at a height of 10m equates to 57m/s for Region B (equating to a mid range category 3 cyclone), 69m/s for Region C (equating to a mid range category 4 cyclone), and 88m/s for Region D (a category 5 cyclone). Typically for houses with a height of 6m, a terrain/height multiplier of 0.93 for Region B and 0.96 for Regions C and D can be applied. This results in a 3 second design gust wind speed (at height 6m for terrain category 2 situations) of 53m/s for Region B, 66m/s for Region C, and 84m/s for Region D.

Other risks

There are additional factors that influence a building's susceptibility to cyclone damage. These include the standard of construction applicable when the building was erected, the level of construction of any subsequent alterations and additions to the building, the deterioration of the building over time determined by the level of maintenance and factors such as termite degradation and corrosion of metal fasteners, and the risk of damage from falling trees and flying debris.

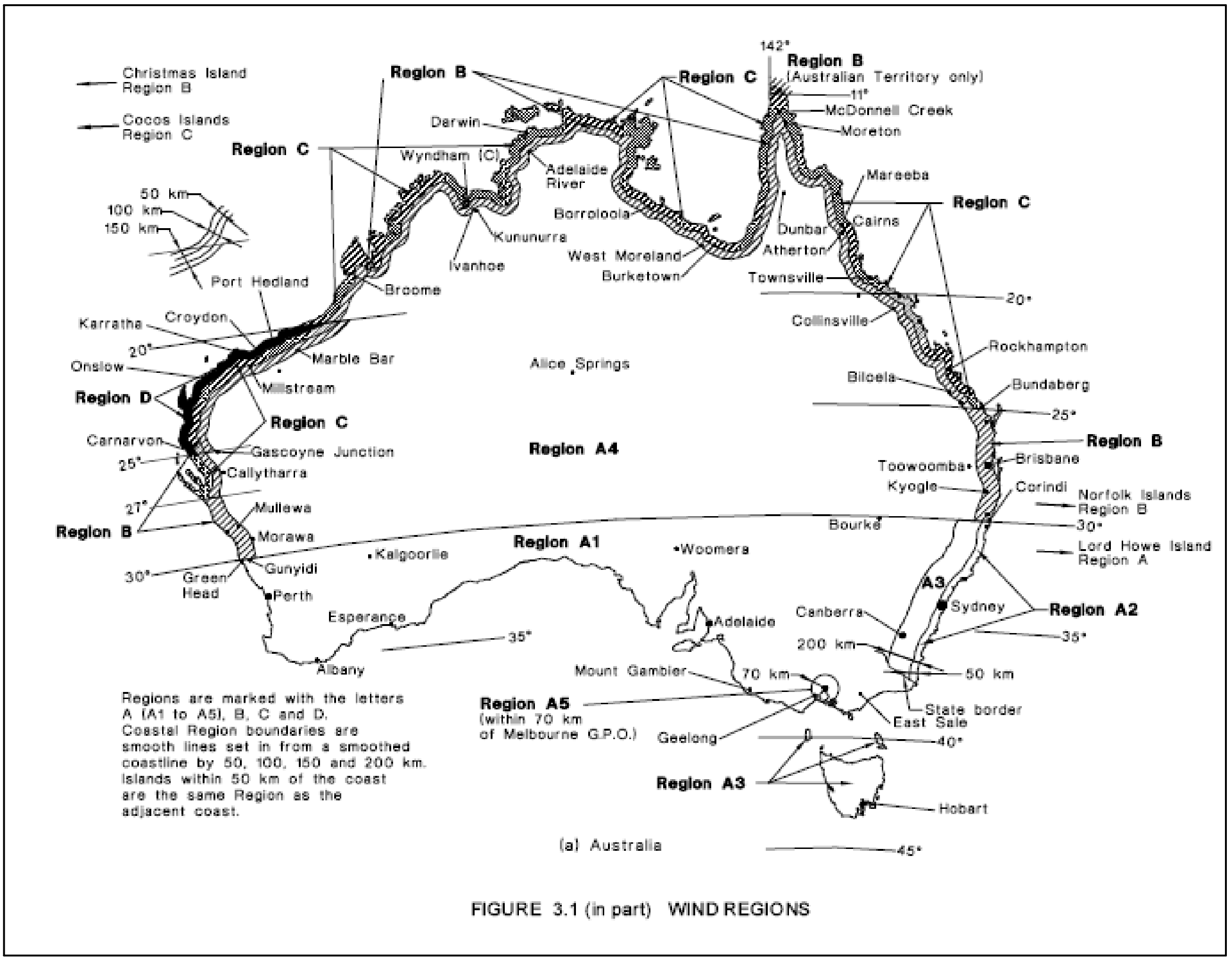
These factors, although potentially major contributors, are beyond the scope of the BCA and therefore not included in this analysis.

3.2.2 Geographic profile of cyclone risk in Australia

In addition to building and site-specific factors, the level of cyclone risk also varies according to geographic location. The Wind Standards identify the cyclone regional boundaries in Australia. Buildings constructed in these regions must be designed to resist cyclone events. The region boundaries have been determined from historical data. The most severe category is Region D which occurs from 20^o to 25^o latitude in WA within 50kms of the coast, using a smoothed coastline. Region C extends north from 27^o in WA, through NT and to 25^o in Qld, again either within 50kms of the coast or 50kms inland of Region D (refer Figure 3-1).

For an annual probability of exceedance of 1:500, which the BCA specifies is applicable for the majority of buildings such as housing (i.e. not designed to accommodate large numbers of people, not essential to post-disaster recoveries or associated with hazardous facilities, and not presenting a low degree of hazard to life or property) the ultimate regional design wind speed (based on 3 second gust wind data) is 69m/s for Region C and 88m/s for Region D. These values equate to mid range category 4 and 5 cyclones respectively.

Figure 3-1: Regional cyclonic boundaries in Australia



Source: Reproduced from AS/NZS 1170.2-2002 [2]

3.2.3 Conclusion – nature of cyclone risk

In summary, the level of risk for a particular building is related to a combination of the following factors:

- Building materials used and the structural capacity incorporated in the design and construction of the building;
- The topography in the immediate vicinity of the site and the level of shielding available to protect the building; and

- The geographical location of the site.

AS/NZS1170.2-2002 and the BCA take account of these factors in determining the design wind speed and appropriate structural capacity of the building. As noted, additional risks such as how well existing buildings have been maintained are outside both the scope of the BCA and this analysis.

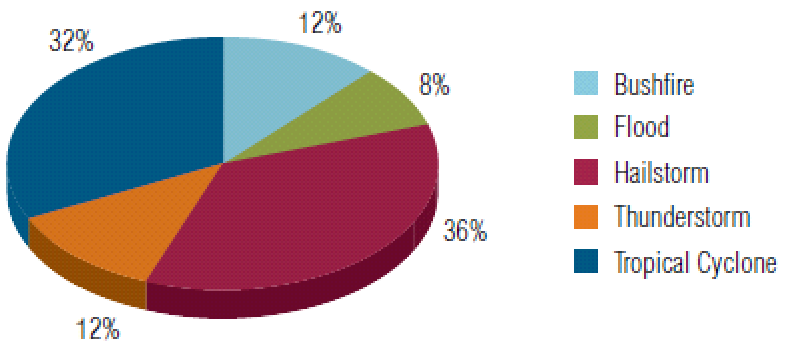
3.3 Extent of cyclone risk

3.3.1 Current level of cyclone risk and rate of damages / losses

Researchers from Macquarie University's Risk Frontiers undertook a study for the ABCB on financial benefits arising from improved wind loading construction standards in tropical cyclone prone areas of Australia which provides insights on the cyclone risk and cost of past cyclones[12].

The study identifies that tropical cyclones account for around 20% of the number of weather related events in the ICA Natural Disaster Event List, and around 32% of the total normalised loss as presented in Figure 3-2. Normalised to 2006 values, tropical cyclone-related losses average AUD$261 million per year. The study also estimates an annual economic benefit to the nation of AUD$1.4 billion in 2006 dollars as a result of improved building standards as specified in the BCA and Australian Standards referenced in the BCA.

Figure 3-2: Percentage of the total accumulated current losses as at 2006 of weather-related events in the Disaster List classified by hazard type



Source: A Century of Damage – Property Losses due to Natural Perils – McAneney J et al 2007[13]

[12] McAneney J, Crompton R, Coates L, 2007, _Financial benefits arising from improved wind loading construction standards in Tropical-Cyclone prone areas of Australia,_ Risk Frontiers, Macquarie University
[13] McAneney J et al, 2007, _A Century of Damage – Property Losses due to Natural Perils,_ Australian and New Zealand Institute of Finance Journal, Volume 30 No 3 June/July 2007

Only one life has been reportedly lost as a result of a cyclone since Cyclone Tracy in 1974. As buildings have become more resilient to cyclones, people sheltering in these buildings are also much safer.

The Risk Frontiers study also provided for the five highest tropical cyclone original losses, a breakdown of pre and post 1981 residential buildings both in the year the event occurred and 2006 as presented in Table 3-2 below. The year 1981 was chosen because significantly improved structural standards were introduced around this time as a consequence of Cyclone Althea in 1971 and Cyclone Tracy in 1974.

Table 3-2: Five highest tropical cyclone original losses

Tropical Cyclone	*Year*	*Australian (Saffir-Simpson) Category Scale*	*Original Loss (AUD$ million)*	*Proportion of Wind Damage (%)*	*Proportion of pre-1981 residential construction (%)*	
					Original	**2006**
Larry	2006	4 (3)	350	100	51	51
Tracy	1974	4 (4)	200	100	100	44
Sid	1998	Tropical Low (Tropical Depression)	71	0	51	41
Les	1998	Tropical Low (Tropical Depression)	70	0	41	32
Wanda	1974	Tropical Low (Tropical Depression)	68	0	100	53

Source: *McAneney J et al 2007*

Whilst this data is useful, it does not readily provide quantitative support for the proposals and possible revisions to the Wind Standards discussed here. This is because approximately half of the buildings in cyclone prone areas pre-date the higher structural standards introduced around 1981, and any changes to the BCA or wind standard will only impact on new buildings and to a limited extent, those existing buildings undergoing extensive renovation or extension.

3.3.2 Building activity in Cyclone affected areas

ABS data indicates that in 2006, there were 8.45 million private dwellings in Australia, of which 6.26 million (74%) were separate houses. In 2005-06, the value of building construction activity was $61.6 billion, of which new houses were responsible for $20.9 billion, other residential building $10.3 billion, alterations and additions $5.7 billion and non-residential building $22.1 billion.

A study of population and ABS data indicates building activity in cyclone affected areas of each of the four affected States and Territories as presented in the following Table 3-3 (for greater detail refer Appendix A). Note that the data only relates to the parts of the States and Territories located in cyclone regions C and D and in non-cyclone region B. The number of new houses constructed per year in the region is based on the population and the average construction activity for the State/Territory.

Table 3-3: Building Activity in Cyclone affected areas

State/Territory	*Cyclone Region*	*Population (000)*	*No of new houses constructed per year in the region*
WA	D	39 900	182
WA	C	20 200	125
WA	B (note this is a non-cyclone region)	41 100	340
NT	C	1 500 000	600
Qld	C	8 114 000	5 387
Qld	B (note this is a non-cyclone region)	27 533 000	17 833
NSW	B (note this is a non-cyclone region)	2 495 000	1 190

Table 3-3 shows that there are almost 25 000 new houses built each year in areas potentially affected by cyclones, compared to a total of approximately 130,000 constructed across Australia. This, in addition to the discussion on climate change as a risk factor below, further reiterates the importance of reviewing the standards for the construction of buildings in cyclone affected areas on a regular basis. Reviewing the AS/NZS 1170.2 wind standard is particularly relevant considering that in the preface it states "The wind speeds provided are based on existing data. At the time of drafting, it was considered that there was insufficient evidence to indicate any trend in wind speeds due to climatic change."

Of the new construction activity in cyclone Regions C and D, the majority is concentrated in Queensland (about 85.5 per cent), with the Northern Territory (about 9.5 per cent) and WA (about 5 per cent). If Region B is included, the majority is again concentrated in Queensland (about 92 per cent), with NSW (about 4 per cent) the Northern Territory (about 2 per cent) and WA (about 2 per cent).

3.3.3 Studies by Cook and Nicholls

Recent studies by G.D. Cook (2007) and Nicholls et al (2007)[14]suggest design wind speeds in the Northern Territory should be significantly higher than currently prescribed in the relevant Australian Standard for wind actions, AS/NZS1170.2 (the wind code). The studies, inter alia, cast doubt on the current Region C zoning for Darwin and suggest the cyclone risk to the NT relate better to Region D, the most intense cyclone region in Australia. The only area currently zoned Region D is located in WA between 20^0 and 25^0S within 50km of the coastline. In addition, various climate change reports[15] suggest cyclonic activity may become more severe under climate change scenarios.

For more detailed information on studies on cyclone activity in Australia refer to Appendix E.

3.3.4 Studies by McAneney et al.

McAneney et al (2007)[16], found tropical cyclone activity in the South-Western Pacific region is strongly related to the El Niño – Southern Oscillation (ENSO resulting in fewer than average numbers of landfalling tropical cyclones during the El Niño phase than the La Niña phase.

McAneney et al conclude that while the small number of tropical cyclones per five–year time interval makes it difficult to draw robust conclusions, there is no indication that tropical cyclones are becoming more frequent or more dangerous.

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[14] GD Cook (2007), Has the hazard from tropical cyclone gusts been underestimated for northern Australia? CSIRO Sustainable Ecosystems
M Nicholls et al (2007), Review of NT cyclone risks, Report by the Community Group for the review of NT cyclone risks, April 2007
[15] IPCC (2001)
PJ Webster et al, (2005), Changes in tropical cyclone number, duration and intensity in a warming environment, *Science*, Vol 309
CSIRO (2007) *Climate change in Australia*, Technical Report
PJ Klotzbach (2006), Trends in global tropical cyclone activity in the last twenty years, *Geophysical Research Letters*, Vol 33
K Emmanuel (2005), Increasing destructiveness of tropical cyclones over the past thirty years, *Nature*, Vol 436

[16] J McAneney et al (2007) Risk Frontiers, Macquarie University,NSW, Australia, *Personal Lines Insurance, A Century of Damage, Property Losses Due to Natural Perils*, Australian and New Zealand Institute of Insurance Finance Journal Volume 30 Number 3 June/July 2007

3.3.5 Studies by JDH Consulting

The ABCB commissioned Dr John Holmes (JDH Consulting) to determine whether there is sufficient information and justification to change design wind speeds in cyclonic regions of Australia in the wind code, firstly with reference to currently available wind data, and secondly with reference to climate change. The JDH Consulting Report "Impact of Climate Change on Design Wind Speeds in Cyclonic Regions" was completed in June 2008.

The key findings of the JDH Report[17] are-

1. The current wind code does not include the effects of climate change.
2. Australia suffers from a lack of basic data leading to an inaccurate cyclone database.
3. Simulations, predictions and cyclone profiling could be improved.
4. Current assumptions about inland weakening and penetration of tropical cyclones appear adequate.
5. Speculation that frequency of severe tropical cyclones world-wide has been increased as a result of global warming appears to be caused by observational error.
6. Latest IPCC assessment (2007) is that 'there is no clear trend in the annual numbers of tropical cyclones'.
7. In Australia, there are fewer cyclones in El Nino events, but the more intense cyclones are less influenced by El Nino.
8. As a result of climate change, over the next 50 years there is likely to be an increase in the number and frequency of strong storms Cat. 3 to 5, a southward shift of 2-3^{o} of these strong storms, and a storm of Cat. 3 is likely in the Brisbane region. No comparable climate change studies have apparently yet been made for the Indian Ocean (WA Coast) or the Arafura Sea (NT).
9. For the NT, studies by Nicholls and Cook significantly over-estimate the gust speed near ground level. However they do identify significant effects on the northern coast line and islands of NT.
10. Uncertainty resulting from climate change can be handled by the ‘uncertainty’ factors for Darwin and other locations rather than a change in basic design wind speeds (i.e. rather than a change from cyclone Region C to D).
11. The quality of the climate model predictions is low given the current resolution of the prediction models. It is expected that the resolution and hence the quality of the predictions will improve over the next few years.

[17] JDH Consulting (2008), *Impact of Climate Change on Design Wind Speeds in Cyclonic Regions*, an unpublished study on behalf of the Australian Building Codes Board.

The JDH Report recommendations which impact on the BCA and the wind code could, if adopted, result in-

1. A shift in the boundary to cyclone Region D to extend it NE along the WA coast to 15°S which would include Broome and Derby (resulting in a 50% increase in design strength)

2. A shift in the boundary to cyclone Region D to extend it north of 12°S along the NT coastline to include the islands of NT but not Darwin (resulting in a 50% increase in design strength)

3. A shift in the boundary to cyclone Region C to extend it south on the Queensland coast to 27°S to include areas just north of Caboolture i.e. include the Sunshine coast but not Brisbane (resulting in a 50% increase in design strength)

4. An increase in the uncertainty factor for Region C from 1.05 to 1.10 (resulting in a 10% increase in design strength)

5. An increase in the uncertainty factor for Region B, an increase from 1.0 to 1.10 (resulting in a 20% increase in design strength).

These recommendations form the basis of this study.

3.3.6 Improving Community Resilience

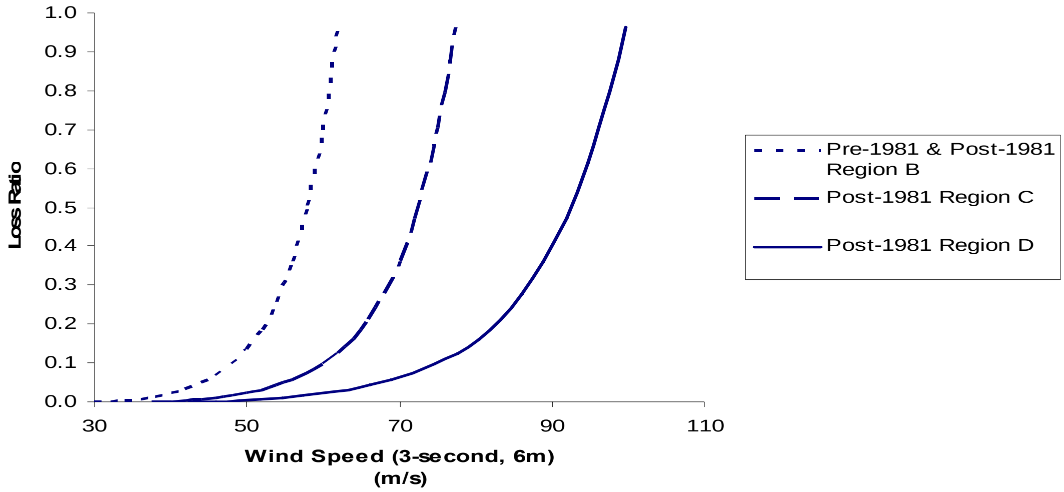
As a result of damage to housing caused by Cyclone Althea in 1971 and Cyclone Tracy in 1974, there have been considerable developments in building standards in cyclone and high wind affected areas from around 1981 to improve the structural adequacy of housing. These improvements mean that houses constructed post 1981 are much more resilient to cyclone events. As the proportion of houses built post 1981 increases, the resilience of the entire community to cyclone damage improves.

For example, using damage functions for pre and post 1981 houses in Region C published by Walker (1995) and cited in McAneney et al (2007) (reproduced in Figure 3-5) if a cyclone with a wind speed of 65m/s (3 second gust at 6m, equating to a mid range Category 4 cyclone) impacted on a community in Region C in 1981, total destruction of all houses would likely have resulted. However, if the same cyclone occurred in 2001, half of the houses in the community would have been constructed to the post 1981 improved standard of which only 20% would likely have been destroyed. Therefore, compared to the 100% housing loss in 1981, the loss would be reduced to 70% in 2001. The positive impact of the improved standard will also increase as more older and weaker houses are demolished or upgraded.

Similarly, the improved standards discussed in this paper would only apply to newly constructed houses and to certain alterations and renovations. ABS data[18] indicates that between 2001 and 2026 Queensland households are projected to increase by between 63% and 76%, from 1.4 million in 2001 to between 2.3 million and 2.4 million in 2026, representing an annual average increase of around 2.8%, compared to the Western Australia average of around 2.2% and the Northern Territory average of around 1.7%.

It is likely the construction of new housing to improved standards is improving community resilience faster than wind forces are increasing, which means the community in total will be in a better position as the years progress.

Figure 3-5: Damage functions for pre-1981 and post-1981 Wind Regions B, C and D residential buildings



Source: McAneney et al[12]

Note: Gust speeds are at a height of 6m allowing for terrain and topographic effects. The pre- and post-1981 Wind Region C functions are from Walker (1995).

3.3.7 Climate Change Reports

A number of reports have been produced making reference to changes to the cyclone risk as a result of climate change. The IPCC (2001) concluded that, by

[18] ABS Household and Family Projections Australia, 2001-2026, Catalogue No 3236.0 http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/DF2989BFFA7392E1CA256EB6007D63F4/$File/32360_2001%20to%202026.pdf accessed May 2009

the late 21st century, tropical cyclone frequency may change in some regions and peak winds may increase by 5-10%. Projections of climate change in Australia developed by CSIRO and the Australian Bureau of Meteorology for the Australian Climate Change Science Programme[19] indicate a likely increase in the proportion of the tropical cyclones on the more intense categories, but a possible decrease in the total number of cyclones. Further reports are discussed in the following chapters.

3.3.8 BRANZ Report

A Report to the Australian Greenhouse Office, Department of the Environment and Water Resources by BRANZ Limited (August 2007)20 titled "An Assessment of the Need to Adapt Buildings for the Unavoidable Consequences of Climate Change" finds that cyclone peak winds are likely to increase by 2 to 5% by 2030 and by 5 to 10% by 2070.

The report also indicates the increased cost of house construction from adapting to increased wind/cyclones resulting from climate change as presented in the following Table 3-4. The increased costs include increased roof and wall framing sizes, increased bracing and increased tie down. There appears to be no allowance however for increased window/glazing strength, increased fastening of wall cladding, metal roof sheeting or tiles, increased stormwater drainage requirements and increased strength of items such as garage doors. The actual figures are therefore likely to be significantly higher as discussed in Chapters 6 and 7.

Table 3-4: House Construction Costs by BRANZ

Floor construction	*Estimated Cost per House ($)*		
	N2 →C1	**C1 →C2**	**C2 →C3**
Timber Floor	3270	3940	5260
Concrete Floor	2170	3040	3740

Note: N2 equates to a sheltered urban flat Region B location; C1 equates to a sheltered urban flat Region C location; C2 equates to a sheltered urban flat Region D location.

[19] CSIRO, Australian Bureau of Meteorology, *Climate Change in Australia – Technical Report 2007*
[20] BRANZ Limited (August 2007)20 An Assessment of the Need to Adapt Buildings for the Unavoidable Consequences of Climate Change http://www.climatechange.gov.au/impacts/publications/pubs/buildings-report.pdf accessed April 2009

3.3.9 ICA Report

A report by the Insurance Council of Australia[21]stated that cyclone activity has been predicted by the CSIRO to decrease overall by up to 44% in some areas of Australia but the number of extreme cyclone events (Category 3-5) is expected to increase. That is, there will be a higher percentage of more destructive and longer living cyclone events. Furthermore, the average decay location of cyclones is predicted to move southwards by up to 3^{o} of latitude. The ICA therefore considers that the BCA and Standards should extend mandatory cyclone resistant standards to north of 33^{o} S latitude (i.e. from Newcastle NSW). Note that in Eastern Australia, cyclone region C currently commences north of 25^{o}S latitude.

The ABCB undertook an investigation of possible BCA adaptation measures as a result of climate change for the Commonwealth Department of Climate Change in 2008 with information largely sourced from the CSIRO Climate Change in Australia Report[19]. The investigation covered the current BCA position in regard to cyclones and extreme winds, the risk rating in cyclone and non-cyclone areas, possible adaptation measures and areas of potential future research.

Climate change projections

Average wind speed projections suggest increases in most coastal areas in 2030 (best estimate 2 to 5%) except for a band around 30^{0} S in winter and 40^{0} S in summer where there are decreases (best estimate -2 to -5%). For 2070, best estimates increases of 15% in some regions under one scenario but less than 10% everywhere under another scenario.

The projected increase in extreme wind speed projections in non-cyclonic regions is generally within the error band of current methods for determining design wind speeds. However, cyclones are also predicted to impact outside the current designated cyclone regions by moving 3^{o} latitude southward on the Queensland coast. New buildings are likely to sustain less damage compared with older buildings due to the general deterioration of buildings with time which might accelerate because of the effects of climate change.

Increases in extreme wind speeds of between 5-10% by 2070 in cyclonic regions have been predicted as a consequence of climate change, while the actual number of cyclones is predicted to reduce.

IPCC (2001) concluded that 'there is some evidence that regional frequencies of tropical cyclones may change but none that their locations will change. There is also evidence that the peak intensity may increase by 5% to 10%.

[21] Insurance Council of Australia, *Improving Community Resilience to Extreme Weather Events, April 2008*

3.3.10 Bureau of Meteorology

The Bureau of Meteorology (BOM)[22] identified that trends in tropical cyclone activity in the Australian region (south of equator; 105 - 160°E) show that the total number of cyclones has decreased in recent decades. However, the number of stronger cyclones (minimum central pressure less than 970 hPa) has not declined.

BOM also identified that projected changes in tropical cyclone characteristics are inherently tied to changes in large-scale patterns such as ENSO, changes in sea surface temperature and changes in deep convection. As global climate models improve, their simulation of tropical cyclones is expected to improve, thus providing greater certainty in projections of tropical cyclone changes in a warmer world.[22]

Nevertheless, there has been a growing number of studies that indicate a consistent signal of fewer tropical cyclones globally in a warmer climate. However, there are significant regional variations in the direction of the changes and these vary between models. Substantial disagreement remains between climate models concerning future changes in tropical cyclone intensity, although the highest resolution models show evidence of an increase in tropical cyclone intensity in a warmer world.

There have been three recent studies producing projections for tropical cyclone changes in the Australian region. Two suggest that there will be no significant change in tropical cyclone numbers off the east coast of Australia to the middle of the 21st century. The third study, based on the CSIRO simulations, shows a significant decrease in tropical cyclone numbers for the Australian region especially off the coastline of Western Australia. The simulations also show more long-lived eastern Australian tropical cyclones although one study showed a decrease in long-lived cyclones off the Western Australian coast.

Each of the above studies finds a marked increase in the severe Category 3 - 5 storms. Some also reported a poleward extension of tropical cyclone tracks.

3.3.11 Conclusion – extent of cyclone risk

In summary, while the likelihood of a significant cyclone event impacting a given site or homeowner is relatively low, the potential consequences from such an event are considerable.

While research on the potential impacts of climate change on Australia is ongoing, most studies to date suggest there will be no significant change in tropical cyclone numbers off the east coast of Australia to the middle of the 21st

[22] http://www.bom.gov.au/weather/cyclone/tc-trends.shtml accessed April 2009

century, and a decrease for the west coast. However, most studies also find a marked increase in the severe Category 3 - 5 storms. Some also reported a poleward extension of tropical cyclone tracks. As global climate models improve, their simulation of tropical cyclones is expected to improve, thus providing greater certainty in projections of tropical cyclone changes in a warmer world.

Nevertheless, continued construction activity in cyclone affected areas and the potential impacts of climate change suggest that it is likely that a greater number of households will be exposed to more intense cyclone risk in the future.

These results reiterate the importance of reviewing the Standard for the design of buildings in cyclone areas on a regular basis to ensure they reflect current research and contemporary building practices for managing emerging risks in this area.

3.4 The rationale for intervention – market failures

3.4.1 Introduction

Given the nature and extent of the risks faced by householders in cyclone affected areas, it is important that appropriate levels of construction are included for new buildings in these areas. However, due to a range of issues, it is unlikely that in the absence of intervention, the market will deliver the best outcomes for society (i.e. appropriate levels of protection). Non-intervention increases the risk of widespread damage and loss of life in areas subjected to cyclones.

In the event that a market does not deliver the best outcomes for society – for example, because of the existence of market distortions or imperfections, the market is said to be ‘failing’ and government intervention could be justified on the grounds that it could improve economic outcomes and the economic welfare of society.

This section suggests that the threat of cyclone damage is unlikely to be addressed appropriately by the market due to:

- imperfect individual responses;
- imperfect industry responses;
- insurance market limitations; and

- unpriced negative externalities.

These imperfect responses would arise due to an array of market failures including insufficient information, bounded rationality and information asymmetry, and provide a rationale for continued Government intervention. These market failures are further explored in the sections below.

3.4.2 Imperfect individual responses

Building owners clearly have a strong self interest in protecting themselves and their properties from the risks and consequences of a cyclone event. In principle, owners can undertake direct measures, such as using building designs and materials that resist cyclonic wind forces and flying debris, provided that information on these risks is easily available. Owners can then analyse the information to balance the risk of loss against the cost of risk reduction measures, and thus choose the level of exposure they are willing to accept. However in practice, this may not occur because of market failures summarised below.

Insufficient information and 'bounded rationality'

To determine the risks associated with building on a particular site and the appropriate mitigation measures to adopt building owners would need information about how risks are influenced by factors such as:

- Building characteristics – such as the structural adequacy of the building including the bracing capacity and tie-down capacity from the roof to the footings, materials for the building envelope, quality of maintenance, size and nature of openings, and the ability to withstand flying debris;

- Property characteristics – including proximity to other buildings and obstructions that could provide shielding to the subject building, and height of the building;

- Environmental characteristics – including topography, distance to more exposed locations such as the coast, open terrain etc, location in cyclone region C or D; and

- Occupant characteristics – such as quality of preparedness before a cyclone event such as taping or protecting windows, and removing loose outdoor furniture and other objects which have the potential to become airborne debris.

The information may be highly technical, extensive and difficult to comprehend. In practical terms it may not be realistic to assume that individuals would, as a matter of course, have the capacity to assemble, analyse and assess the range of information necessary to form a fully informed view of the building risks. For example, studies, such as that by Kunreuther et al[23], have documented the limitations of individuals' rationality in the context of natural hazard perception and insurance decisions.

Given the above, 'bounded rationality' could potentially result in failure to adopt appropriate cyclone protection measures during the construction phase of a house and the under-insurance of houses in cyclone affected areas due to the inability of individuals to fully comprehend and interpret the cyclone and damage risks they are exposed to.

3.4.3 Imperfect industry response – split incentives

The benefits of cyclone protection of buildings do not accrue to the party that designs or builds the house. Designers and builders have incentives to minimise building costs in order to attract home owners and remain competitive in the building industry, yet decisions made during the building design and construction phases can significantly impact on the probability of house survival and on the damage incurred in the event of a cyclone. Without intervention, builders do not have incentives to voluntarily incorporate cyclone protection measures in the design and building materials of houses, where house owners are price driven and unable to verify the benefits arising from an increase in building costs.

3.4.4 Insurance market limitations

The insurance industry seeks to help individuals (a) strike an optimal balance between risk and the cost of risk reduction and (b) diversify risks and losses associated with a given event equitably. Whilst the services provided by the insurance industry are valuable to many people, there is a limit to their usefulness in terms of managing the risk of damage from cyclone events.

While Risk Frontiers' (2008) analysis suggests that levels of insurance penetration in Australia are generally high at around 90 per cent, there is still a likely disconnect between insurance coverage and total economic damages. Specifically, the insurance market is unlikely to provide an adequate response for the following reasons:

[23] Kunreuther H., R. Binsber, L. Miller, P. Sagi, P. Slovic and N. Katz (1978), *Disaster Insurance Protection: Public Policy Lessons*, John Wiley and Sons, Interscience Publications, New York.

- Insurance does not reduce the risk of a cyclone occurring or provide homeowners with protection, it only provides ex-post compensation for damages arising from cyclone events with the cost of insurance reflecting the risk of loss and damage; and

- Insurance may not provide adequate compensation for the full impacts of cyclone events (e.g. social disruption).

Evidence in Australia of limitations of the insurance market with respect to cyclone related damage is not complete. However, in the aftermath of Cyclone Larry in Innisfail in 2006, there have been some investigations into the level of under insurance and non-insurance of buildings and contents which were both noted as being significant[24]. A survey of Australian insurers by the Australian Securities and Investment Commission (ASIC) in 2005 also highlighted risks of underinsurance in the event of mass disasters. In these situations, escalating rebuild costs, due to increased demand, can often lead to houses becoming underinsured in changing market conditions[25].

Insurance companies also appear to rely heavily on building standards to ensure that the houses being covered by policies are as protected as possible.

A possible contributing factor to the limitations of the insurance market is the fact that the Australian Government, in the aftermath of cyclones, made payments to uninsured families and sole occupants to cover both contents and rebuilding. While these payments are relatively small compared to total costs of rebuilding and replacement, there is an inefficient transfer from taxpayers to uninsured houses.

Furthermore, to the extent that regulatory arrangements can reduce the risk of damages to buildings caused by cyclone events, the cost of insurance should decrease.

3.4.5 Unpriced negative externality

Imposing costs on neighbours

To some extent the level of protection associated with a given property depends not only on the actions of that property's owner, but also those of neighbouring property owners. That is, the individual response of one householder can have

[24] Goodall, W (2007) The insurers plan, action and response to natural disasters, EIG-Ansvar Ltd, Coastal cities natural disasters conference, Sydney, February
[25] ASIC (2005) Getting home insurance right

'external effects' which can increase the risk to other buildings in the immediate vicinity.

These 'external effects' include failure to maintain the building which could make it more susceptible to cyclone damage which could then damage nearby buildings, non-approved and/or inadequate alterations or additions, building with inappropriate construction materials, trees which could blow down onto buildings, and loose outdoor objects which could become airborne and damage nearby buildings. The non-action of house owners can affect the probability of damage to surrounding houses in the event of a cyclone. As the costs associated with these negative external effects are not borne by the house owner that generates them, there is little incentive for owners to minimise such effects.

Non-action by house owners not only increases the risk of destruction of their own houses but can have adverse effects on neighbouring houses. Incentives to take mitigating measures is reduced when a house owner has purchased insurance and when they cannot be made liable for the destruction of neighbouring houses even if their non-action was a contributing factor.

Imposing costs on society

The actions or non-actions of property owners in minimising the risk and cost of damage to their own or surrounding properties can also have a wider impact on society. In the event of a cyclone where houses are destroyed and individuals are left homeless and possibly destitute, the Government or society would be expected to provide assistance to such individuals. Assistance could come in the form of disaster relief or welfare assistance.

Society would also incur costs associated with emergency services, volunteer time, and production losses. While the Wind Standard will not prevent the occurrence or frequency of cyclones, the Standard and associated material Standards (i.e. those relating to timber, steel, masonry etc) are likely to ensure houses are better equipped to withstand cyclone events, and so reduce the broader impacts on society of cyclone events. Government intervention is justified in order to minimise the cost impact to society.

3.4.6 Conclusion – market failures

In summary, due to the imperfect responses and a range of market failures explained above, it is unlikely that in the absence of regulation, householders would voluntarily or have the knowledge to include appropriate levels of cyclone protection in new buildings in cyclone affected areas. This is likely to result in increased risks associated with death, injuries and damage costs to property.

Therefore, Government intervention is justified on the grounds that it could deliver a more efficient outcome for society.

3.5 Periodic review of the Standard – regulatory review

Having established the rationale for Government intervention in Section 3.4, a periodic review and update of the current arrangements is necessary to:

- Enhance consistency with the Australian Government policy objectives;
- Reflect stakeholder feedback;
- Minimise losses that may result from increased building activity and climate change; and
- Address imperfections in the current Standard.

That is, it is important that the chosen form of Government intervention supports the efficient delivery of improved economic and welfare outcomes.

3.5.1 Consistency with the Australian Government policy objectives

The Australian Government recently endorsed the need for a periodic review of regulation. In its response to the recommendations of a review by the Regulation Taskforce on reducing regulatory burden on businesses, the Australian Government agreed that “at least every five years, all regulation (not subject to sunset provisions) should, following a screening process, be reviewed, with the scope of the review tailored to the nature of the regulation and its perceived performance”.[26]

There are several reasons why individual standards within the BCA are reviewed on a regular basis. These include changes to the understanding of risks which exist in the broader built environment and how these can best be managed, and changes in the stock of building materials as a result of technological developments. Given the BCA is the basis for the regulatory building standards in all of Australia’s jurisdictions, it is important that they are reviewed on a regular basis to take account of these changes so their relevancy can be maintained and compliance burdens minimised.

[26] Department of Prime Minister and Cabinet (2006), *Rethinking regulation: Report of the Taskforce on Reducing Regulatory Burdens on Businesses: Australian Government’s Response*, p. 88.

3.5.2 Increased building activity and climate change

As discussed in Section 3.3, an increase in building activity in cyclone affected areas and possible increased risk of cyclones as a result of climate change, increases both cyclone risks and potential damage costs for house owners. A revision of the BCA and/or current Standard would incorporate the latest wind data available and could potentially lower the risks and damage costs that house owners would otherwise be exposed to.

3.5.3 Insufficiencies in the current Standard

The Wind Standards do not cover possible increases in wind actions due to climate change. In the preface to the standard it states "The wind speeds provided are based on existing data. At the time of drafting, it was considered that there was insufficient evidence to indicate any trend in wind speeds due to climatic change."

3.5.4 Conclusion – a need to review the Standard

In summary, it is important that the BCA and/or Standard be reviewed to ensure they reflect current wind data and address the risks of cyclones and how those risks can best be managed.

In particular, there may be opportunity to consider whether the impact of climate change warrants a change to the Standard to improve the protection of houses to future cyclone events. Any improvements to house design and construction to cater for cyclone risk would improve the resilience of communities faced with a cyclone event. Also, the requirement for periodic review is a stated Australian Government policy objective.

3.6 Summary of rationale for Government intervention and proposed amendments

The problem targeted by the Wind Standards is the risk that property owners will not voluntarily include sufficient cyclone protection measures in new buildings in cyclone affected areas.

The discussion on the nature and extent of this problem highlighted the range of factors that influence the level of risk faced by householders in cyclone affected areas, and how cyclone risk is likely to be an ongoing public concern given ongoing building activity in cyclone affected areas and the anticipated impacts of climate change.

Imperfections in current regulatory arrangements and the capacity of individuals and the market to respond effectively, provides the rationale for continuing Government intervention, and a review of the current Standard.

The rationale for continued Government intervention is based on the following market failures:

- Individuals are unlikely to make appropriate decisions due to insufficient information and bounded rationality (i.e. sufficient information is difficult to obtain and analyse);

- The building industry is unlikely to incorporate appropriate cyclone protection measures in the design and construction of a new house as they involve an increase in building costs, and because homeowners are unable to verify the long term benefits associated with those measures;

- While insurance provides ex-post compensation for cyclone damages, it does not mitigate the risk of a cyclone occurring, and it does not provide adequate compensation for the full impacts associated with cyclone events; and

- The existence of unpriced negative externalities in that the action of a particular property owner influences the risk exposure of neighbouring property owners, and could also result in broader societal impacts.

The rationale for a review of the current regulatory arrangements (i.e. the type of Government intervention) is based on the following:

- Australian Government support for the periodic review of regulation to reflect current knowledge and technology;

- A report commissioned by the ABCB on the impact of climate change on design wind speeds in cyclonic regions by JDH Consulting;

- Concerns expressed in the media by insurance representatives that houses are vulnerable to extreme weather events such as cyclones, particularly taking climate change into account; and

- The anticipated increase in both the number of houses constructed in cyclone affected areas and the frequency and intensity of cyclone events.

In light of these considerations, there is a strong case for a review of the current regulatory arrangements, so the risk of cyclone events to buildings, and humans, can be minimised.

4 Objectives of Government intervention

The ABCB's mission is to address issues relating to health, safety, amenity and sustainability in buildings through the creation of nationally consistent building codes, standards, regulatory requirements and regulatory systems.

The objectives of the ABCB are to:

- develop building codes and standards that accord with strategic priorities established by Ministers from time to time, having regard to societal needs and expectations;
- establish building codes and standards that are the minimum necessary to achieve relevant health, safety, amenity and sustainability objectives efficiently; and
- ensure that, in determining the area of regulation and the level of the requirements:
  - there is a rigorously tested rationale for the regulation;
  - the regulation would generate benefits to society greater than the costs (that is, net benefits);
  - there is no regulatory or non-regulatory alternative (whether under the responsibility of the Board or not) that would generate higher net benefits; and
  - the competitive effects of the regulation have been considered and the regulation is no more restrictive than necessary in the public interest.

The investigation of amendments to the BCA and the Wind Standards are designed to support the objectives of both the ABCB and COAG, and seek to provide an efficient response to the risk that property owners will not voluntarily include cyclone protection in new buildings in cyclone affected areas.

In particular, the proposed Standard and the alternative options being considered are seeking to achieve the following:

- A reduction in the danger to life and the risk of property damage by ensuring that buildings have appropriate resistance to cyclones;
- The provision of outcome based regulation which allows industry to develop the most technically efficient and appropriate solutions;

- Address the identified market failures in relation to cyclone resistant design and construction; and

- Ensure that the regulatory requirements are cost effective and transparent.

Furthermore, the proposed Standard reflects an Australian Government initiative to complete five yearly periodic reviews of regulation, to ensure that it remains suitable for its purpose.

5 Identification of feasible policy options

5.1 Introduction

This chapter identifies and considers the merits of alternative means of achieving the Government objectives of effective cyclone protection.

This discussion of feasible alternatives is divided into four sections:

- A description of the regulatory Proposals and how they differ from the status quo (i.e. continuing with the current Standard);
- A discussion of other forms of regulation and non-regulatory options;
- Consideration of alternative levels of regulatory stringency; and
- A detailed assessment of the Proposals.

The Proposals are then assessed in further detail in the subsequent analysis.

5.2 Description of the regulatory proposal

The regulatory proposals as contained in the JDH Report which impact on the BCA and the wind code and which are the subject of this study involve-

1. A shift in the boundary to cyclone Region D to extend it NE along the WA coast to 15^{o}S which would include Broome and Derby (resulting in a 50% increase in design strength)
2. A shift in the boundary to cyclone Region D to extend it north of 12^{o}S along the NT coastline to include the islands of NT but not Darwin (resulting in a 50% increase in design strength)
3. A shift in the boundary to cyclone Region C to extend it south on the Queensland coast to 27^{o}S to include areas just north of Caboolture i.e. include the Sunshine coast but not Brisbane (resulting in a 50% increase in design strength)
4. An increase in the uncertainty factor for Region C from 1.05 to 1.10 (resulting in a 10% increase in design strength)
5. An increase in the uncertainty factor for Region B, an increase from 1.0 to 1.10 (resulting in a 20% increase in design strength).

The above proposals represent a substantial increase in wind design requirements for new buildings constructed in affected areas. These increases are in response to the higher level of risk associated with a given site based on an analysis of wind data future projections of wind actions as a result of climate change.

The following is a brief description of the regulatory proposals, and the nature and effect of the main changes from existing arrangements.

5.2.1 Shift in cyclone Region D boundary for Western Australia

The proposal involves a shift in the boundary to cyclone Region D to extend it NE along the WA coast to 15^{o}S which would include Broome and Derby.

Broome and Derby, both currently in cyclone Region C are located close to the most active cyclone region in Australia i.e. cyclone Region D which extends from 20^{o}S latitude to 25^{o}S latitude in WA i.e. from around Port Headland to Carnarvon.

Figure 3-6 representing the average occurrence of tropical cyclones in Australian waters from 1969 – 2007 shows significant cyclone occurrence in the area around the north west coast of WA including the area around Broome and Derby. Cyclone records for Broome from 1957 – 2007 show 3 events with wind gust speeds of over 40m/s.

The BOM website[27] advises that since 1910 there have been 22 cyclones that have caused gale-force winds at Broome. On average this equates to about one every four years although the frequency has been less in recent times, there being only two cyclones from 1990 to 2004. The strongest wind gust recorded at Broome during a cyclone since 1939 is 161 km/h in February 1957. Other significant impacts occurred in 1910, 1926, 1935, 1957 and Rosita in 2000.

Broome's most destructive cyclonic event probably occurred in 1910 when winds estimated to reach 175 km/h resulted in 40 deaths and 20 houses destroyed. However, there have been a number of near misses including Cyclone Rosita in April 2000 which passed just 15km south of the town. While Broome airport recorded a gust of 153 km/h, wind gusts closer to the centre were estimated in excess of 250 km/h.

[27] http://www.bom.gov.au/weather/wa/cyclone/about/broome/index.shtml accessed 23 April 2009

Table 5-1: Design Gust Wind Speed (V_h) for Classification

Wind class		Design gust wind speed (V_h) at height (h) m/s	
Regions A and B (non-cyclonic)	Regions C and D (cyclonic)	Serviceability limit state ($V_{h,s}$)	Ultimate limit state ($V_{h,u}$)
N1	—	26	34
N2	—	26	40
N3	C1	32	50
N4	C2	39	61
N5	C3	47	74
N6	C4	55	86

Source: Table 2.1 from AS 4055 - 2006

For a house in Broome in a sheltered suburban location the ultimate limit state design gust wind speed from AS 4055 -2006, Wind Loads for Housing (ie Region C, terrain category 2.5, full shielding, no topographic effect) is determined to be 50m/s (180km/hr). If Broome is located in Region D, the equivalent ultimate limit state design gust wind speed would be 61m/s (220km/hr), i.e. a 22% increase in wind speed or a 49% increase in wind force.

From AS/NZS 1170.2:2002, the ultimate regional wind speed for an average recurrence interval of 500 years (specified in the BCA for houses and expressed as an annual probability of exceedance of 1:500) for Region C is 69m/s (248km/hr), while for Region D the value is 88m/s (316km/hr). Note that for Region B the value is 57m/s (205km/hr).

Note also that maximum gust wind speeds recorded during a cyclonic event are usually obtained from anemometers situated 10m above the ground in open level terrain, free of all obstructions to the air flow such as at an airport. The wind gusts experienced by a house on flat land in a town and surrounded by similarly sized houses in the same event would be expected to be less than the maximum wind gust recorded by an anemometer. Conversely, a house in an exposed location near the top of a hill in open terrain is likely to experience higher wind gusts.

JDH Consulting[17] reported on the study described by Leslie et al (2007) which modelled cyclone activity in the 2000-2050 period with both current and enhanced greenhouse gas concentrations. The study found no significant change in the total tropical cyclone numbers in the south-west Pacific during 2000-2050. However, there was a marked increase (about 22%) in the number of Category 3-5 storms in response to increasing greenhouse gases. JDH

Consulting considered a number of additional studies including those by Walsh et al (2000-4) Abbs et al (2006), and Geoscience Australia and concluded that-

- The overall number of tropical cyclones in the SW Pacific is not expected to change significantly in a warmer world over the next fifty years or so.

- There is expected to be an increase in the number and frequency of the strongest storms in the next fifty years – i.e. in the Category 3 to 5 storms that are of interest in the structural design of buildings and other structures.

Based on this information, it would be reasonable to consider the next step of determining the costs and benefits of extending cyclone Region D to include Broome and Derby.

5.2.2 Shift in cyclone Region D boundary for Northern Territory

The proposal involves a shift in the boundary to cyclone Region D to extend it north of 12^{o}S along the NT coastline to include the islands of NT but not Darwin.

The JDH Consulting report[17] reviewed studies by Nicholls and Cook in regard to cyclonic wind speeds in Darwin and the NT. The Nicholls study found that three of the most intense cyclones that have been observed in Australian waters since satellite observations began in 1960, namely Cyclones Thelma 1998, Ingrid 2005 and Monica 2006 (the TIM cyclones) all came within 350 km of Darwin when they were at maximum intensity and within a nine-year period. Nicholls concluded that NT buildings should probably be designed for wind loads that are at least 60% higher than the minimum loads permitted under the current AS/NZS1170.2, i.e. similar to those prescribed for cyclone Region D rather than the current Region C.

G.D. Cook (2007) also makes predictions about tropical cyclone wind speeds impacting on Darwin and the NT and like Nicholls, concluded that the NT cyclone risk is better described by Region D than by Region C.

JDH Consulting contended that the arguments provided by Nicholls and Cook were based on overestimated wind gust values at ground level based on inaccurate upper level speed estimates and did not consider a number of relevant factors such as the preferred tracks of cyclones and the weakening of cyclones over land. Also, the Nicholls and Cook conclusions on design wind speeds for the NT were not supported by studies undertaken before or since. JDH Consulting reported that a recent study by Geoscience Australia (Arthur et al 2008) found a similar risk for Darwin as for the North Queensland coast (i.e.

Region C), but significantly lower than for the Port Hedland – Onslow area in WA (Region D).

JDH Consulting considered that while the TIM cyclones may have been the result of global warming, they may also signal the return of a more active period similar to one that appears to have existed in the first 90 years of (European) NT settlement. JDH Consulting also recognised that while the TIM cyclones had little effect on Darwin, they had a significant effect on the northern coastline and the islands of the NT and a stronger case can be made for upgrading the latter locations to Region D. However, JDH Consulting also recognised there is scope for new probability based simulations to determine wind speeds for the NT based on the latest available data.

In conclusion, JDH Consulting considered the uncertainty in the future number and strength of tropical cyclones resulting from climate change for Darwin, and other locations, can be handled by increases in the 'Uncertainty' Factor F_C i.e. increasing the current F_C from 1.05 to 1.10.

5.2.3 Shift in cyclone Region C boundary for Queensland

The proposal involves a shift in the boundary to cyclone Region C to extend it south on the Queensland coast from the current 25^oS to 27^oS. This would restore the boundary to that previously defined in 1975-89 and make it consistent with the boundary of Region C on the WA coast. This would include areas north of Caboolture i.e. include the Sunshine coast but not Brisbane.

A study by Leslie et al (2007) modelled climate and cyclone activity for the period 2000 – 2050 with both current and enhanced greenhouse gas concentrations. The study found no significant change in the total tropical cyclone numbers in the south-west Pacific during 2000-2050. However, the study found a marked increase (about 22%) in the number of Category 3-5 storms in response to increasing greenhouse gases. A southerly shift of over 2 degrees of latitude in the tropical-cyclone genesis region was also found.

An interesting finding of the study was a prediction of a Category 3 Cyclone directly hitting the Brisbane area in the next 50 years. The study also concluded that there is a potential for tropical cyclones to develop during the next fifty years that are more intense than any so far recorded in the south-west Pacific, including 'super cyclones' with central pressures below 900hPa. The latter would produce extreme winds considerably in excess of those specified for building design for any return period up to 2000 years along the Queensland coast.

JDH Consulting analysed studies by Walsh et al (2000-4) Abbs et al (2006), Leslie et al (2007) and Geoscience Australia and concluded there appears to be consensus that-

- The overall number of tropical cyclones in the SW Pacific is not expected to change significantly in a warmer world over the next fifty years or so.
- There is expected to be an increase in the number and frequency of the strongest storms in the next fifty years – i.e. in the Category 3 to 5 storms that are interest in structural design of buildings and other structures.
- It is expected that a southward shift of 2-3^0 in the genesis region and track locations will occur in the next 50 years.
- A storm of Category 3 strength in the Brisbane area is quite likely in the next 50 years.

However, JDH Consulting considers the quality of these predictions is low given the current resolution of the prediction models. It is expected that the resolution and hence the quality of the predictions will improve over the next few years.

A southward shift of 2-3^0 in the Region C boundary from the current 25^oS (just below Bundaberg) to 27^oS (just north of Caboolture) would result in a change from Region B to Region C for areas including the Sunshine Coast (Noosa to Caloundra), Hervey Bay, Maryborough and areas in between within 50kms of the coast. A change from Region B to Region C involves an increase of regional wind speed for an annual probability of exceedance of 1:500 from 57m/s to 66m/s. The ultimate limit state design gust wind speed for housing increases from 40m/s (N2) to 50m/s (C1) i.e. a 25% increase in wind speed or a 56% increase in wind force. Therefore, the design strength of a house in Region C (in terms of bracing, tie down and strength of various cladding elements such as glazing) is about 50% higher compared to a house in Region B. This has obvious cost impacts.

5.2.4 Increase in uncertainty factor for Regions B and C

The proposal involves an increase in the uncertainty factor F_C for Region C from 1.05 to 1.10 (i.e. a 10% increase in design wind force), and for Region B, an increase in F_B from 1.0 to 1.10 (i.e. a 20% increase in design wind force).

AS/NZS 1170.2 – 2002 notes in relation to uncertainty factors "the frequency of Category 5 cyclone crossings in Region D in the years 1998 to 2002 is much greater than predicted from the historic data on which the wind speeds in this Standard are based. The factors in this Clause have been introduced to allow for uncertainties in the prediction of ultimate design wind speeds in Regions C and D (tropical cyclones regions) when they are based on recorded wind speeds. The values of these factors may be revised in the future following simulations based on recorded cyclone tracks. Such an analysis would naturally include cyclone activity throughout the northern coast of Australia (i.e., in Regions C and D). The effects of long-term climate change may also be included."

These proposed increases in the uncertainty factors are primarily in response to predictions of increased Category 3-5 cyclones in Queensland waters by climate model simulations. It is noted that a F_B of 1.25 would be required to convert the current V50 for Region B of 44 m/s to the peak gust associated with a Category 3 cyclone (about 55 m/s), so that a factor of 1.10 is only a partial adjustment. These factors are likely to be reviewed in the future as predictions of global warming effects improve with higher resolution models.

The uncertainty factor for the non-cyclonic Region B, and cyclonic Regions C and D might be more conveniently handled as a single factor (e.g. Mc) of 1.10. For Region D, a 1.10 uncertainty factor already applies.

5.2.5 Construction requirements

Increases in design wind forces need to be resisted by higher levels of structural resistance to ensure houses achieve appropriate levels of structural adequacy. Typically, this is achieved by constructing houses with higher levels of bracing and tie-down and increased strength of components forming the building envelope.

Higher levels of bracing can be achieved using a greater number of bracing panels or panels of higher racking strength. Difficulties can arise however in house designs with large open spaces (i.e. minimal internal walls) and/or houses with large windows/doors in the external façade. Improved tie down can generally be achieved reasonably simply through the use of more robust connections from the roof to the footings. Windows, garage doors, other elements in the building envelope and external attachments (eg antennae and air vents) also need to be stronger to resist the higher wind forces.

Generally these increased construction requirements are incremental and reasonably proportional to the higher wind forces. The exception being where the higher forces result in or promote a construction step change or a change in the form of construction. For example, single skin reinforced masonry is the predominant form of construction north of Mackay in Qld and in the NT, and double skin unreinforced masonry predominant in Perth, whereas timber or steel framed construction is predominant in the remainder of Qld and in the high wind areas of WA. There appears to be a significant cost jump in houses constructed of single skin reinforced masonry compared to a similar masonry veneer house (refer Appendix B).

5.3 Alternative policy approaches

5.3.1 Other forms of regulation

The regulatory proposal involves the level of cyclone design requirements for buildings being subject to explicit government regulation, which is one form of regulation. The COAG *Best Practice Regulation* guide identified a spectrum of regulatory approaches with explicit government regulation at one end of the spectrum and self-regulation at the other. Intermediate forms of regulation (quasi-regulation and co-regulation) are also identified.

Self-regulation

Self-regulation involves industry formulating rules and codes of conduct, and being solely responsible for their enforcement. It generally requires a viable industry association with broad coverage and members that will voluntarily adhere to a code of conduct devised by other members. Minimal sanctions such as loss of membership or peer disapproval are required to ensure broad compliance, and the government role is reduced to facilitation and advice.

Self-regulation should be considered where:

- There is no strong public concern, in particular, no major health and safety concern;
- The problem is a low risk event and of low impact or significance; and
- The problem can be fixed by the market itself, for example, there may be an incentive for individuals or groups to develop and comply with self-regulatory arrangements (industry survival or market advantage).[28]

Based on the above criteria, self-regulation is unlikely to provide an appropriate response for construction in cyclone affected areas. This is because although cyclones are a low risk of occurrence event, their potential impacts are substantial, and there are major public health and safety concerns. Further, because the benefits of enhanced cyclone protection in buildings do not accrue to the building industry (i.e. split incentives) it is unlikely that self-regulation

[28] Office of Best Practice Regulation *Best Practice Regulation Handbook 2006, p. 4-7.*

would result in an appropriate level of protection being incorporated in the design and construction of new houses.

Quasi-regulation

Quasi-regulation is similar to self-regulation, but is distinguished by a stronger role for government in endorsing industry codes, providing technical guidance, or entering into government-industry agreements.

One option could be for the government to encourage and assist the building industry to formulate appropriate standards but leave the compliance as a voluntary matter or subject to professional sanction. Possible sanctions range from information sanctions to exclusions from professional bodies.

Similar to self-regulation, it is unlikely that quasi-regulation would deliver an efficient outcome for construction in cyclone affected areas. This is due to an unacceptable risk of non-compliance and the potentially serious and widespread consequences of cyclone events.

Co-regulation

Co-regulation involves government providing some form of legislative underpinning for industry codes and standards. This may involve delegating regulatory powers to industry, enforcement of undertakings to comply with codes, or providing a fall-back position of explicit regulation in the event that industry fails to self-regulate.

Co-regulation is also unlikely to achieve the Government policy objectives for construction in cyclone affected areas. While the current arrangements possess some elements of co-regulation (i.e. Standards backed by legislation), the Standards are enforced by Government organisations rather than industry itself. This is because without Government and legislative backing, there is considerable risk that a co-regulatory approach would result in higher levels of non-compliance, and the potential consequences of that non-compliance are unacceptable to Government.

Conclusions

The lack of alignment between those with responsibility for incorporating cyclone protection in the design and construction of buildings, and those who realise their benefits, mean it is unlikely that an intermediate form of regulation would achieve the Government's objectives. The risks associated with non-compliance are exacerbated by the potentially serious consequences of cyclone events, including both substantial risks to public health and safety, and economic impacts.

5.3.2 Non-regulatory intervention

A range of alternative instruments that might be used as alternatives to regulatory intervention, include:

- Information and education campaigns;
- Standards including voluntary, non-regulatory, performance-based or prescriptive; and
- Market-based instruments such as taxes and subsidies.

Information and education campaigns

Information and education campaigns dealing with the removal of loose objects that potentially can become flying debris in a cyclone event and maintenance of the building are important and can improve building survivability, but are outside the scope of the BCA. Section 3.4.2 suggests that even with complete information, individuals are unlikely to be able to adopt appropriate cyclone protection measures due to the technical aspects of risk assessment and product knowledge combined with the assumed limited technical and analytical ability of lay-people. This limits the effectiveness of any information or education campaigns.

Standards

While voluntary Standards could provide flexibility, it is unlikely that without legislative backing, e.g. through State and Territory based legislation that the building industry would voluntarily comply with the Standards. This relates to the issue of split incentives, where the building industry does not realise the benefits associated with the increased levels of protection.

The current arrangement incorporates some characteristics of a non-regulatory approach such as using a performance-based framework and providing builders with flexibility to satisfy the performance requirements through the DTS provisions or allowing builders to formulate an alternative solution that demonstrates compliance. That is, the Standards facilitate the process of compliance but the BCA does not mandate compulsory compliance with the Standards if a builder is able to demonstrate compliance via an alternative manner.

Taxes and subsidies

Taxes and subsidies are unlikely to provide sufficient incentive to encourage the adoption of appropriate cyclone protection measures as they would still require individuals to bear substantial up-front costs. Although these additional costs are likely to be outweighed by longer term benefits, the lack of readily available information around cyclone risk and the likely difficulties individuals would face in comprehending and acting rationally on that information, mean that there could be a significant risk that individuals would have insufficient incentive to incur the costs of implementing effective cyclone protection.

Conclusions

Non-regulatory interventions, on their own, appear to be inappropriate responses to cyclone protection measures for buildings in cyclone affected areas, because they would not provide the level of assurance of protection and minimisation of damages required by the public and the government.

5.4 Alternative degrees of regulatory stringency

In addition to alternative forms of regulation or non-regulatory measures, there are alternatives available that are similar to the regulatory proposal, but that are more or less stringent. The alternative degrees of regulatory stringency would require comparably higher or lower levels of cyclone protection in areas affected by cyclones.

In considering the appropriate level of regulatory stringency, it is important to recognise the inability of policy makers to access the information required to optimise the level of stringency in the proposed regulations. This includes information about the range of factors that influence the frequency and severity of cyclone events, information relating to building materials and their properties, construction costs, and information relating to the benefits associated with increased cyclone protection.

Given the inherent complexity in achieving an optimal balance between the increased construction costs associated with prevention measures and the additional cyclone protection they provide, the regulatory proposals considered in this study reflect the recommendations identified in the JDH Consulting study.

5.5 Conclusion

Overall, government policy for the construction of buildings in cyclone affected areas is for mandated Performance Requirements to be implemented through the BCA. This reflects a view, partly based on experience, that voluntary and information based approaches are likely to have limited effectiveness. Given the anticipated increase in the frequency and severity of cyclone events, recent increases in the construction activity in cyclone affected areas, and imperfections in the individual and market responses to this problem, government has settled on a regulatory approach.

The costs and benefits associated with the proposals identified in this section are assessed in detail in the subsequent analysis.

6 Cost impact of proposals on building owners

6.1 Introduction

This Section provides an assessment of the impact of the proposed changes to the Standard on individual building owners. It involves quantification of the change in construction costs for a sample of house designs constructed in different cyclonic regions. For example, the cost of a specific project house in Region B is compared to the cost of the same design in Region C. However, the cost increase is not necessarily totally a result of the increased construction requirements due to increased design wind speed. Other factors such as possible increased labour costs, increased transport costs, and increased material costs could also play a role. The incremental change in construction costs will also vary according to the size, design and type of building being constructed.

The analysis is structured as follows:

- Identification of a sample of representative building designs for assessment;
- An estimate of the incremental changes in the building and construction costs for the identified sample.

The remainder of this Section details the analysis in each of these areas.

Costs and benefits for each Proposal would apply to all buildings. However, this study relates primarily to housing. The reason being that damage to housing is the greatest component of building insurance losses (90% of Cyclone Tracy insurance losses for buildings related to housing), and due to ongoing concerns about housing affordability, housing is most sensitive to any cost increases. In addition, it is considered that the percentage cost impact on commercial, public and industrial buildings to cater for increased wind loads would be less sensitive compared to housing, because these other buildings are usually specifically engineer designed, the structures are often constructed of reinforced concrete or structural steel (i.e. they are likely to have greater structural capacity compared to housing), and the cost of structural adequacy is likely to be a smaller percentage of total building cost.

6.2 Identifying a sample of buildings

Three typical house designs were identified as representative and selected for further analysis:

- A small single storey house of around 160m2;

- An average single storey house of around 240m2; and
- An average 2 storey house of around 240m2.

The chosen designs were selected from the websites of two major Queensland builders who construct project homes state wide i.e. across non-cyclonic and cyclonic regions.

6.3 Construction cost impacts

The estimated construction cost impacts for the sample of house designs was identified as the cost difference between a house constructed in a non-cyclonic region compared to a house with the same floor plan constructed in a cyclonic region. Table 6-1 below provides a summary of the additional construction costs incurred for each house type comparing Region B to Region C.

Housing costs were obtained from the websites of two large Queensland builders who constructed project houses throughout the State. This allowed comparison of the cost of constructing the same project house in Townsville (wind classification C1), Bundaberg (C1), and Sunshine Coast/Brisbane (N2), representing the base case. Note that wind classification C1 relates to a typical sheltered suburban situation on flat ground in Region C, while N2 relates to a similar site in Region B. The following table provides a selection of house designs/sizes. For more detail, refer Appendix B.

Table 6-1 – Additional Costs for Houses comparing Regions B and C

Builder	*House Description*	*Sunshine Coast Region B*		*Bundaberg Region C*		*Townsville Region C**	
		Cost $	*% incr*	*Cost $*	*% incr*	*Cost $*	*% incr*
Builder A	*Small Base House* 160m2, 1 storey, 3 bed, 1 bath, 1 garage	120 800	0	149 800	24	166 200	38
	Average Single Storey House 232m2, 1 storey, 4 bed, study, 2 bath, 2 garage	148 100	0	184 200	24	228 600	54
	Average 2 Storey House 244m2, 2 storey, 4 bed, study, 3 bath, 2 garage	196 200	0	248 700	27	395 200	101
Builder B	*Small Base House* 141m2, 1 storey, 3 bed, 2 bath, 1 garage	142 400	0	158 500	11	204 000	43

Builder	*House Description*	*Sunshine Coast Region B*		*Bundaberg Region C*		*Townsville Region C**	
		Cost $	*% incr*	*Cost $*	*% incr*	*Cost $*	*% incr*
	Average Single Storey House 247m2, 1 storey, 4 bed, 3 bath, 2 garage	201 000	0	226 500	13	286 300	42
	Average 2 Storey House 248m2, 2 storey, 4 bed, 3 bath, 2 garage	241 100	0	269 000	12	NA	
Typical Base House		140 000	0	163 000	16	195 000	39
Typical Single Storey House		172 000	0	202 000	17	254 000	47
Typical Two Storey House		212 000	0	252 000	18	303 000	43

*Notes: * Figures reflect masonry block construction.*

The above housing costs show a significant cost increase for the same house floor plan in Townsville compared to Brisbane. The reason is likely to be the result of the different form of construction typical for areas above Mackay i.e. single skin reinforced masonry, whereas in SE Qld timber frame/masonry veneer is the typical construction method. Therefore, for the purpose of comparing N2 (sheltered Region B) with C1 (sheltered Region C) a similar construction method (i.e. timber frame/masonry veneer) as applicable for Bundaberg will be used, rather than the Townsville case. Also, some of the cost increase evident in Bundaberg may result from increased transport/material/labour costs compared to SE Qld. Therefore, the actual cost increase due to increased construction requirements is conservatively taken to be around half of the least percentage increase. Therefore, an increase of 6% is assumed from N2 to C1.

The above data is reasonably consistent with data from Rawlinsons Edition 27, 2009, which suggests house construction costs in Mackay and Townsville are around 5-6% higher than in Brisbane.

Single skin reinforced masonry is also the predominant house construction form in the Northern Territory. Therefore, it is assumed the NT housing costs would be similar to Townsville costs. For Broome and Derby in WA, lightweight cladding on a structural frame is the predominant form of house construction. However, for the purpose of this study, it is assumed housing costs in these areas would be similar to those in the NT and north Qld.

The increase in wind force from N2 to C1, and C1 to C2 results in a corresponding increase in the design and construction robustness of a house. Note that wind force is proportional to the square of the wind speed.

AS/NZS 1170.2 identifies ultimate regional wind speeds (for V_{500}) of 57m/s for Region B, 69m/s for Region C and 88m/s for Region D. This equates to a 46% increase in wind force from Region B to Region C, and a 62% increase in wind force from Region C to Region D.

Using AS 4055, the ultimate design gust wind speeds applicable for typical sheltered urban housing on flat ground are 40m/s for Region B, 50m/s for Region C and 61m/s for Region D. This equates to a 56% increase in wind force from Region B to Region C, and a 49% increase in wind force from Region C to Region D.

Therefore, for the purpose of this exercise, it is taken there is a 50% increase in design strength required from Region B to Region C, and a further 50% increase from Region C to Region D. To calculate the cost increase from Region C to Region D, it is assumed it is proportional to the cost increase applicable from Region B to Region C. As the percentage increase in design strength is similar, it is likely the cost increase of 6% is also similar. In other words, there is a 1.2% cost increase for every 10% increase in design strength.

To calculate the cost of introducing each of the proposals, the applicable cost increases are applied together with the Building Activity data as shown in Table 6-2.

Table 6-2 – Cost of compliance per house with current and proposed changes to the Standard

Proposal	_Base house one storey $_			_Average one storey $_			_Average two storey $_		
	Current	**Proposal**	**% incr**	**Current**	**Proposal**	**% incr**	**Current**	**Proposal**	**% incr**
**1. Extend Region D for WA**	195 000	206 700	6.0	254 000	269 200	6.0	303 000	321 200	6.0
**2. Extend Region D for NT**	195 000	206 700	6.0	254 000	269 200	6.0	303 000	321 200	6.0
**3. Extend Region C for QLD**	163 000	172 800	6.0	202 000	214 100	6.0	252 000	267 100	6.0
**4. Increase uncertainty factor for Region C**	163 000	165 000	1.2	202 000	204 400	1.2	252 000	255 000	1.2
**5. Increase uncertainty factor for Region B**	140 000	143 400	2.4	172 000	176 100	2.4	212 000	217 100	2.4

The cost of the changes for each proposal is based on a one third split for each of the categories of base house, average one storey house and average 2 storey house, taking into account the housing construction activity for the particular region affected by the proposal (refer Appendix A). For example, extending Region D in WA affects only Broome, Derby and environs, while applying the 10% increase in the uncertainty factor for Region B affects all areas within 100kms of the coast from just below Bundaberg in Qld to just above Coffs Harbour in NSW. The cost impacts for each Proposal are shown in Table 6-3 below.

Table 6-3: Cost changes for each Proposal

Proposal	*Cost of average house in affected region $*				*Number of houses affected in each region per annum*	*Cost Impact for each proposal per annum $m*
	Current	**Proposal**	**Difference**	**% incr**		
1. Extend Region D for WA	251 000	266 100	15 100	6	125	1.89
2. Extend Region D for NT	251 000	266 100	15 100	6	50	0.76
3. Extend Region C for QLD	206 000	218 400	12 400	6	3 854	47.8
4. Increase uncertainty factor for Region C (WA, NT, Qld)	206 000	208 500	2 500	1.2	6 112	15.3
5. Increase uncertainty factor for Region B (WA, NT, Qld, NSW)	175 000	179 200	4 200	2.4	19 363	81.3
TOTAL OF ALL PROPOSALS PER ANNUM						**$147 million**

The cost estimates above suggest the following broad conclusions:

- An increase in construction costs of around 6 per cent for all house types under Proposals 1, 2 and 3;
- An increase in construction costs of around 1.2 per cent for all house types under Proposal 4;
- An increase in construction costs of around 2.4 per cent for all house types under Proposal 5;
- Across all house types, construction costs are expected to increase. The increase in costs ranges from $2000 to $18,200, depending on the type of house constructed.

The estimated cost impacts described above are likely to be a reflection of an improved alignment between the assessed level of risk and the associated construction requirements under climate change scenarios. As such, the expected increase in construction costs at the aggregate level represents a greater acceptance of the likelihood of increased cyclone risk, and a more appropriate level of protection in response.

7 Estimate the impact of the proposed changes at the state and national level

7.1 Introduction

This Section provides an assessment of the impact of the Proposals (i.e. the five proposed changes to the Standard) at the state and national level, and is structured as follows:

- Identification of the different groups impacted by the Proposals;
- A quantitative assessment of the costs associated with each Proposal;
- A qualitative assessment of the costs associated with each Proposal (information may be unavailable for the quantification of some costs);
- A quantitative assessment of the benefits associated with each Proposal;
- A qualitative assessment of the benefits associated with each Proposal; and
- A comparative assessment of the costs and benefits associated with each Proposal.

With the exception of the estimated changes to construction costs, and benefits resulting from reduced insurance costs, the analysis is qualitative rather than quantitative. This reflects the data limitations and uncertainty associated with many of the anticipated impacts. For example, it is not possible to identify the extent to which a change in the construction requirements will reduce the risk of damage due to cyclones. However, where possible, the assessment has sought to utilise data to understand the general magnitude of the unquantifiable impacts.

7.2 Groups impacted by the Proposals

The groups affected by the Proposals are individuals, businesses and the Government. This section discusses the costs and benefits of the Proposals on each group.

7.2.1 Individuals

Householders who choose to build houses in cyclone affected areas are directly impacted by the Proposals. Better alignment of construction requirements to the assessed level of risk should enhance the cyclone protection of houses and hence improve house survivability and reduce potential costs of damage for house owners. However, increasing the strength of houses to cater for the increased risk would impose additional building costs on house owners.

Emergency service and disaster relief workers may also be indirectly affected by the Proposals in that if house survivability improves, the manpower required to repair properties and protect the community and house persons whose houses have been destroyed or made unliveable as a result of cyclones would be impacted, with consequent production impacts to the economy and future community disruption due to cyclones.

7.2.2 Businesses

The Proposals directly impact businesses in the design and construction industry as well as certification practitioners. The changes will increase construction costs and will require the design and construction industry and certification practitioners to adapt, to become familiar with and implement the Proposals. This could involve additional training or education costs for such businesses.

The insurance industry would be indirectly impacted by the Proposals in that its implementation may support a more accurate and efficient pricing of cyclone risk, which will also provide benefits to individuals taking out insurance.

7.2.3 Government

An improvement in house survivability and potential reduction in damage costs implies that Government could incur less cost associated with providing disaster funding and assistance to individuals and communities in the event of a cyclone. The Proposals may also reduce the costs associated with community disruption and the adverse economic impacts associated with cyclone events.

7.3 Quantitative assessment – construction cost impacts

The quantitative assessment is limited to an estimate of the change in construction costs at the state and national level associated with the Proposals. The cost estimates provided are based on the estimated impacts on a sample of building owners (refer to Section 6) and estimated construction activity in cyclone affected areas across Australia.

Due to data limitations and uncertainty around the nature and extent of future construction activity, the aggregate cost estimates are based on a number of simplifying assumptions and should be considered indicative.

7.3.1 Construction activity in cyclone affected areas across Australia

The estimated construction activity in cyclone affected areas was based on the population in cyclone affected areas and the typical number of houses constructed per head of population for the State or Territory. It concluded that construction in cyclone affected areas amounted to around 6.4 houses per year per 1000 head of population in WA, 4.0 in NT and 6.6 in Qld.

Table 7-1 below provides a summary of estimated construction in cyclone affected areas for each State and Territory. For more detail refer Appendix A.

Table 7-1: Estimated construction activity in cyclone affected areas

State/Territory	*Cyclone Region*	*City/Town*	*Population (2006 census)*	*Total Houses*	*New Houses pa*
WA	WA Region D Total		39,874	15,336	182
	WA Region C Total (north of 20^{o} S)		20,206	7,771	125
	WA Region B Total		41,100	15,807	340
WA TOTAL STATEWIDE			**2,059,000**	**806,300**	**21,285**
NT	NT Coastal (not Darwin)		32,500	10,156	50
	NT Region C Total		150,000	46,875	600
NT TOTAL TERRITORY WIDE			**215,000**	**67,200**	**760**
QLD	Qld Region C Total		811,411	312,081	5,387
QLD	Qld Region B Hervey Bay to Caloundra Sub-Total		428,491	164,804	3854
	Qld Region B Caboolture to Gold Coast Sub-Total		2,324,816	894,160	13,979
	Qld Region B Total		2,753,307	1,058,964	17,833
QLD TOTAL STATEWIDE (June 2008)			**4,279,400**	**1,583,100**	**28,000**
NSW	NSW Region B Total		249,530	95,973	1,190
NSW TOTAL STATEWIDE (2006)			**6,817,200**	**2,643,000**	**16,181**
Australia Region B Total			**3,043,937**	**1,170,744**	**19,363**
Australia Region C Total			**981,617**	**366,727**	**6,112**
Australia Region D Total			**39,874**	**15,336**	**182**

Source: ABS, State and local government data

The data on the number of houses and construction activity is based on a combination of ABS, State and local government data. Cost effects described in this section are limited by the data available and uncertainty in future construction activity. Total houses are based on the average people per household of 2.6 (ABS[18]) and ABS data[18].

Average construction cost impacts (per annum)

In the absence of any available data, it was also necessary to make an assumption around the proportion of each house type constructed in cyclone affected areas. It is considered that construction is spread evenly across the three different house types.

Table 7-2 below provides the estimated annual impact in construction costs at the regional and the national level as well as the total estimated NPV of construction costs over the lifetime of the regulation.

Table 7-2: Estimated cost increases

Proposal	New houses per region per annum	Cost impact for each new house $	Cost impact for each proposal per annum $m	NPV of total costs for each proposal $m
1. Extend Region D for WA	125	15100	1.89	13.26
2. Extend Region D for NT	50	15100	0.76	5.30
3. Extend Region C for QLD	3854	12400	47.79	335.65
4. Increase uncertainty factor for Region C	6112	2500	15.28	107.32
5. Increase uncertainty factor for Region B	19363	4200	81.32	571.19
TOTAL OF ALL PROPOSALS PER ANNUM			147.04	1032.72

Based on the above, the total expected increase in annual construction costs for all of the five proposals is in the order of $147 million. Total additional construction costs over the lifetime of the regulation (10 years) are estimated at $1.03 billion, with Proposal 5 accounting for more than half of these construction costs and Proposal 3 approximately one third.

7.4 Qualitative assessment – costs associated with the Proposals

7.4.1 Individuals

The Proposals could impact on the preferences of potential house builders to build in particular regions due to costs. Individuals may choose to purchase land outside cyclone regions because it is cheaper to build there compared to building in cyclone regions. In some cases, the construction of certain house types (eg large two-storey) may be more expensive in cyclone regions and individuals may choose a less expensive alternative. Therefore, the impacts are largely limited to a restriction in consumer choice, rather than a cost impost.

7.4.2 Businesses

The Proposals would impose more stringent construction requirements for cyclone regions and therefore it could possibly lead to a reduction in market demand for new housing in these regions. However, due to housing demand in these regions and the lack of a reasonable alternative, it is unlikely that there would be a material decrease in construction due to the Proposals. Instead, it is more likely that all house construction will increase by similar percentages in cyclone regions to maintain a level playing field and buyers will either accept the increased prices or modify the house size or features, or buy outside the cyclone region to reduce costs.

7.5 Quantitative assessment – benefits associated with the Proposals

The Proposals will benefit new and altered houses designed and constructed to the new standards by making them more resilient to cyclone events. Evidence has shown that newer houses, built to more stringent wind resistance requirements experience, on average, less damage than older houses with lower wind load factors. This was observed in the damage figures estimated after Cyclone Larry 2006, where the characteristics of the cyclone were considered to be similar to those of Cyclone Tracy which was one of the most expensive natural disasters in Australia's history. The significant difference in damage costs across the two cyclones has been attributed to improved building design and building standards[29].

If we assume all houses in cyclone affected areas are correctly designed and constructed to the appropriate standard, we can also assume the risk of damage/collapse is also reasonably equivalent. That is, houses in WA

[29] Goodall, W. (2007) The insurers plan, action and response to natural disasters, EIG-Ansvar Ltd, Coastal cities natural disasters conference, Sydney, February

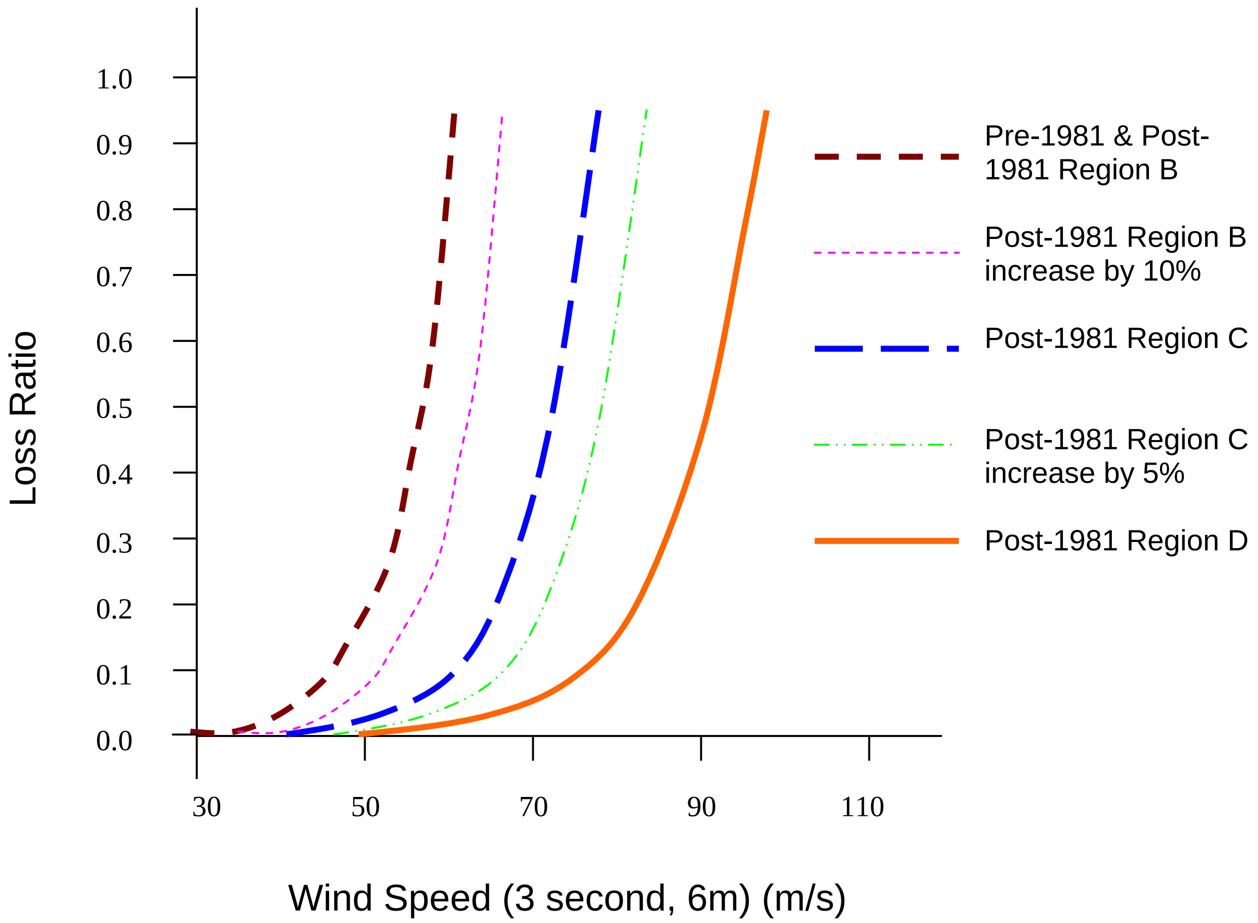
subjected to Category 5 cyclones are also built stronger to resist these cyclones and the risk of damage/collapse to a house in Qld subjected to Category 4 cyclones is about the same. This assumption appears to be supported by reference to the damage functions for wind regions B, C and D which shows a loss ratio of around 0.15 for a Category 5 cyclone (84m/s) in Region D and a similar loss ratio for a mid range Category 4 cyclone (66m/s) in Region C (see Figure 3-5).

Climate change is predicted to increase cyclone peak winds by 5-10% by 2070 and move Category 3 intensity cyclones southward by up to 3^{o}S latitude (refer Chapter 3.3). From Table 3-1, a Category 3 cyclone at 6m height equates to a 3 second gust wind speed over open terrain, of between 43 and 58 m/s. 58m/s equates to a 10% increase in wind speed over the current 53m/s applicable for Region B. From Figure 7-1, there is a reduction in the loss ratio of approximately 0.3 comparing the current Region B damage function with the Region B damage function with the 10% increase.

A 10% increase in wind speed for Region C over the current 66m/s would result in a design wind speed of 73m/s. From Figure 7-1, a similar reduction of 0.3 in the loss ratio results comparing the current Region C damage function with the Region C damage function with the 5% increase.

Also from Figure 7-1, there is a 0.85 reduction in loss ratio between the Region B and Region C damage functions when considering a Region C design event. A similar reduction in loss ratio occurs between the Region C and Region D damage functions when considering a Region D design event.

Figure 7-1: Damage functions for pre-1981 and post-1981 Wind Regions B, C and D residential buildings, and for increased uncertainty factors of 5% and 10% for Regions C and B respectively.



Note: Gust speeds are at a height of 6m allowing for terrain and topographic effects. The pre- and post-1981 Wind Region C functions are from Walker (1995). The Region B and D functions are from McAneney (2007).

Table 7-3 shows the estimated financial benefit for each of the proposals. There are a number of key assumptions behind these figures:

- Stated reductions in loss ratios due to improved building standards;
- Predicted increase in cyclone peak winds of 5-10% by 2070 and southward movement of category 3 intensity cyclones by up to 3^{o}S latitude (refer Chapter 3.3).

- Cyclone related insurance losses estimated at approximately $261 million per year, normalised to 2006 (where normalisation accounts for changes in dwelling numbers and dwelling values);

- The total number of Australian houses exposed to cyclones is those in cyclone Regions C and D which amounts to approximately 392,900 houses. Therefore, the proportion of potential cyclone related insured losses for each house is around $644 per year; and

- Total damage to insured damage ratio of 5 to 1.

Table 7-3: Financial Benefit of Proposals

Proposal	*Reduction in loss ratio as a result of the proposal*	*Direct benefit for each proposal per annum $m*	*Total benefit for each proposal per annum $m (inc uninsured benefits)*	*NPV of total benefits for each proposal $m*
1. Extend Region D for WA	0.85	0.07	0.34	34.28
2. Extend Region D for NT	0.85	0.03	0.14	13.71
3. Extend Region C for QLD	0.85	2.11	10.55	1 056.85
4. Increase uncertainty factor for Region C (WA, NT, Qld)	0.30	1.18	5.90	591.55
5. Increase uncertainty factor for Region B (WA, NT, Qld, NSW)	0.30	3.74	18.70	1 874.04
TOTAL OF ALL PROPOSALS PER ANNUM		7.13	35.64	3 570.42

Notes: Obtained from damage functions for Wind Regions B, C and D residential buildings from Walker (1995) and McAneney (2007) taking into account 10% increase in peak winds and southward movement of cyclones to 3°S latitude. ** The total benefit figures were obtained by applying a multiplier of five to the total value of insurance liability for cyclones to obtain an estimate total benefit (direct plus indirect benefits).[30] Direct and total benefits based on new house constructions in each region annually.*

[30] The multipliers were based on a study by Joy, C.S. 1991, 'The cost of natural disasters in Australia', paper presented at the Climate Change Impacts and Adaptation Workshop, Climatic Impacts Centre, Macquarie University, New South Wales, Australia, 13–15 May.

Overall, the annual estimated benefits accrued through the proposed changes are approximately $36 million, including both insured and uninsured damage avoidance. Over the lifetime of the regulation the total estimated benefits, including both avoided insured and uninsured losses, are approximately $3.5 billion.

A number of notes should be made about these assumptions, particularly the estimation of total annual damage figures, as well as the ratio of insured losses to total damages.

Firstly, Risk Frontiers (2007 and 2008) evaluate the annual, normalised cyclone related insurance losses in Australia based on observed losses over the period from the mid 1960's to 2006. This time period covers a change in regulatory policy implemented in the aftermath of Cyclones Tracey and Althea in the 1970's. As such, the normalisations process takes into account factors such as changing house valuations, changes in the number of houses over time, as well as changes in the vulnerability of houses to tropical cyclones. It is estimated that these improved wind loading regulations, referred to as the wind code and initially implemented in the early 1980's have the effect of approximately halving annual insured damages due to tropical cyclones.

Overall, without the underlying changes in the wind code, annual insured losses due to tropical cyclones are estimated at approximately $425 million. This is in contrast to the estimated $146 million per year if the wind code had have been in place since 1967. Using a weighted average of wind code implementation over the time period, Risk Frontiers analysis estimates an annual loss of $261 million.

Discussions around the justification of this methodology are presented in the sensitivity analysis section, as well as estimates of the effect of changing this figure on the NPV of the proposals.

The second note to be made surrounds the use of a 5:1 ratio of insured losses to total damage due to tropical cyclones. This figure is dependent on a number of factors specific to the nature of the geographic region in which a cyclone strikes as well as other factors such as population size, infrastructure levels, as well as proportion of a township that is damaged. Again, discussions around these assumptions are presented in the sensitivity analysis section, as well as estimates of the changes in NPV resulting from changes in the ratio.

7.6 Qualitative assessment – benefits associated with the proposed Standard

The Proposals (i.e. proposed changes to the Wind Standard) do not reduce the probability of a cyclone event occurring or ensure the survival of a house. The Proposals are beneficial to the Australian community to the extent that they have the potential to reduce the costs that individuals, businesses and the Government incur as a result of damages due to cyclone events.

7.6.1 Benefits to individuals

Potential reduction in direct tangible costs – damage costs

Direct tangible costs are physical losses such as the costs associated with the destruction of a house as a result of a cyclone event. To the extent that the Proposals aim to improve the survivability of a house in the event of a cyclone, as a result of higher design loads and corresponding increased construction strength, it should translate to a decrease in the costs incurred by householders, both individually and at the aggregate level.

Normalised to 2006 values, tropical cyclone-related losses average $261 million per year, including those from Cyclone Larry.[31] This figure is consistent with an analysis of the cost of cyclone damages in Australia estimated by the Bureau of Transport Economics (BTE)[32] in 2001. The analysis found the cost of cyclones averages $266 million per year. This is considerably more than the average annual cost over the past 20 years ($80 million). Possible reasons for the lower costs during the last two decades include:

- the number of cyclones actually occurring may have fallen;
- better building codes and standards, so that cyclones are less damaging when they do hit populated areas; and
- vulnerable communities have been lucky in that severe cyclones have missed them.

[31] Risk Frontiers (June 2008) 'Assessing the benefits of improved wind loading construction standards in Tropical Cyclone prone areas of Australia', Newsletter, Volume 7, Issue 4
[32] Now the Bureau of Transport and Regional Economics (BTRE). BTE (2001), *Economic costs of natural disasters in Australia*, BTE Report 103.

The BTE figures were estimated by applying a multiplier of five to the total value of insurance claims for cyclones to obtain an estimate total cost (direct plus indirect costs) of the disaster.[33]

From 1967 to 1999, 46 cyclones causing more than $10 million damage have been recorded in Australia. The greatest number of these cyclones in any individual year was four (in 1976, 1980 and 1984).

Research has shown that cyclone activity on the eastern coast of Australia is strongly related to the value of the Southern Oscillation Index (SOI). During La Niña periods (SOI greater than 5) cyclones are more frequent than during El Niño periods (SOI less than -5). Of the 51 severe cyclones occurring since 1876, 36 coincided with a positive SOI (pers.comm, Jeff Callaghan, Bureau of Meteorology, Queensland, 17 November 2000).

For the 20 years prior to 1977, the SOI was mostly positive, and mostly negative for the following 20 years. For the first ten years of the analysis period, the SOI was mostly positive and associated with the likelihood of more frequent and severe cyclones on the eastern seaboard. During the latter part of the analysis period, eastern coast cyclones were less likely to be severe. Therefore, the downward trend in cyclone damage costs may be a reflection of the trend in the SOI (pers.comm, Jeff Callaghan, Bureau of Meteorology, Queensland, 17 November 2000). If so, a return to mostly positive SOI conditions over several years could see a reversal of the downward trend in cyclone damage costs.

Key findings are presented in Table 7-4 below, with values expressed in 1998 dollars.

Table 7-4: Key findings of the BTE study

Cyclone events	*BTE estimates (Costs in 1998 dollars)*
Frequency	There were 46 cyclone events that caused significant property loss[34] in the 33 years from 1967 to 1999, with a maximum of four occurring in three of those years.
Total cost	$8.8 billion over the period of 1967-99
Average annual cost	$266 million per year
Significance of large	Cyclone Tracy was the most damaging cyclone in modern Australian history. Darwin was almost totally destroyed and

[33] The multipliers were based on a study by Joy, C.S. 1991, 'The cost of natural disasters in Australia', paper presented at the Climate Change Impacts and Adaptation Workshop, Climatic Impacts Centre, Macquarie University, New South Wales, Australia, 13–15 May.
[34] The BTE study only considers natural disasters that result in damage above $10 million. Cyclones with damage costs below $10 million have not been included.

Cyclone events	_BTE estimates (Costs in 1998 dollars)_
cyclones	most of the town's population was evacuated. The BTE estimate of the total cost of Cyclone Tracy is $1.97 billion. However, this is far short of the $4.2 billion estimate contained in the EMA database based on ratio of five between insurance cost and total cost developed by Joy (1991).
Relationship with SOI	A positive SOI is associated with the likelihood of more frequent and severe cyclones on the eastern seaboard.

Source: BTE (2001)

The BTE provided a more detailed breakdown of costs for Cyclone Tracy in 1974. These are reported in Table 7-5 below together with the percentage assigned as building related costs, which are the costs incurred as a consequence of the destruction of a building.

Table 7-5: Estimated costs of Cyclone Tracy, 1974

Cost category	_Estimated costs ($'000)* in 1999 dollars_
Direct Costs	
Residential structures and contents	1,144,909
Commercial & Industrial structures & contents	65,382
Public buildings – structures & contents	65,382
Vehicles	NA
Infrastructure	131,818
Agriculture (crops, pasture, fences, livestock)	NA
Subtotal	**1,407,491**
Indirect Costs	
Business disruption	NA
Loss of public services	NA
Business clean-up	NA
Household clean-up	NA
Public buildings clean-up	NA
Household alternative accommodation	320,318
Agriculture	NA
Transport networks	NA
Disaster response & relief (inc. volunteers)	23,918
Volunteer contributions to disaster relief	70,970
Subtotal	**415,206**
Intangible Costs	
Fatalities	84,500

Cost category	*Estimated costs ($'000)* in 1999 dollars*
Injuries	58,731
Emotional and psychological effects	NA
Environmental damage, memorabilia & cultural heritage	NA
Subtotal	**143,231**
Total	**1,965,928**

Notes:
NA No estimates found in the available literature
** BTE (2001 table 5.3) collated these costs estimates from a number of reports dealing with various impacts of Cyclone Tracy. Costs are in 1999 prices.*
Indirect costs are 29% of direct costs.

Source: BTE (2001)

Significant improvements to building standards were introduced in the early 1980's in cyclone prone areas as a result of the devastation caused by Cyclone Tracy in 1974 and Cyclone Althea which struck Townsville in 1971. These improvements are likely to result in significant reductions in building damage and much fewer lives lost if an event such as Cyclone Tracy occurred today.

Research conducted for the ABCB by John McAneney et al[35] from Risk Frontiers, identified the financial benefits arising from improved wind loading construction standards in tropical-cyclone prone areas of Australia. The research found improved building standards have been responsible for reducing annual average cyclone-related losses by nearly two thirds, and provides an annual economic benefit to the nation of $1.4 billion in 2006 dollars.

Potential reduction in indirect tangible costs – disruptions to normal life

Indirect tangible costs include broader economic impacts such as loss of production as a result of disruption to businesses and productive work requiring volunteers when housing is lost. Other costs include clean up costs and disaster relief packages. Improvement in house resistance to cyclones is likely to lead to a reduction in the other cost categories.

Potential reduction in intangible costs – health and wellbeing

Intangible costs are those for which no market exists, such as injuries and fatalities, emotional and physiological effects, household disruption and loss of memorabilia.

[35] John McAneney et al (December 2007), 'Financial benefits arising from improved wind loading construction standards in Tropical-Cyclone prone areas of Australia', Risk Frontiers, Macquarie University, NSW.

Risk Frontiers PerilAUS database lists 66 tropical cyclone events that have caused a total of 1,560 deaths from 1899 to 1999. The majority of these deaths resulted from drownings at sea, and as a consequence of storm surge, riverine flooding and flash flooding. Relatively few deaths have been caused by building collapse or flying debris. The PerilAUS lists only 6 fatalities caused by building collapse or flying debris, but does not include a number of other "unknown" deaths, including the 49 land related deaths from Cyclone Tracy.

The data shows that improved construction requirements increase the chance of a building surviving a cyclone event. Greater building survivability would also help to mitigate trauma and other intangible costs.

7.6.2 Businesses

Potential reduction in tangible costs – insurance pay outs

The insurance industry bears significant risk of cyclone events. In terms of the weather related events in the Disaster List, three cyclone events are included in the ten highest ranked normalised losses. Cyclone Tracy is number two on the list with a normalised loss in 2006 dollars of $3.65 billion. The total normalised losses resulting from the three cyclones are $6.89 billion. Normalised to 2006 values, tropical cyclone-related losses average $261 million per year, including those from Cyclone Larry.[36]

To the extent that the revised Standard may reduce potential losses, the price of risk reflected in insurance prices borne by households should also reduce.

Note that as discussed by Joy (1991)[33], the total tropical cyclone-related losses are around five times the insurance cost. This means that the total tropical cyclone-related community cost normalised to 2006 values averages around $1.3 billion per year.

7.6.3 Government

Disaster relief and assistance funding

The Governments of all States and Territories, as well as the Commonwealth, provide disaster relief and assistance in the event of cyclones. Such assistance is available to individuals as well as communities. Natural disaster management is constitutionally a State and Territory responsibility, and each jurisdiction

[36] Risk Frontiers (June 2008) 'Assessing the benefits of improved wind loading construction standards in Tropical Cyclone prone areas of Australia', Newsletter, Volume 7, Issue 4

determines the criteria and level of assistance provided to individuals and communities affected by a natural disaster.

The Australian Government reimburses 50 per cent of State and Territory expenditure on personal hardship and distress (PHD) for individuals. PHD expenditure is used for emergency food, clothes, accommodation, repairs to housing and replacement of essential household items and personal effects. Assistance to communities for restoration or replacement of essential public infrastructure (such as roads and bridges) and concessional interest rate loans to small businesses, voluntary non-profit bodies and needy individuals are also provided by State and Territory governments. The Australian Government reimburses 50 to 75 per cent of such expenditure.[37]

If housing survivability improves as a result of the revised Standard, PHD expenditure which relates to costs mostly associated with the destruction of houses and property could decrease. Overall, disaster relief and assistance funding to individuals and the community in the event of a cyclone could potentially decrease if more houses survive.

Other Australian Government payments are also made available after cyclones and other natural disasters. In the aftermath of Cyclone Larry in Queensland in 2006 comprised of a range of initiatives, including payments to uninsured individuals and families[38]. These payments were means tested and were up to:

- $4 500 for families and $1 500 for sole occupants for home contents; and
- $12 500 for families and $9 300 for sole occupants for rebuilding.

While these should not necessarily be considered as additional costs of the cyclone, they can be taken into account as further reductions in government transfers that would potentially result.

7.7 Evaluation of Options – comparative assessment of costs and benefits

In assessing the overall impact of the proposed Standard this RIS uses the following approach:

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[37] http://www.ema.gov.au/agd/EMA/emaInternet.nsf/Page/Communities_Natural_Disasters_NDRRA_NDRRA_Funding_Assistance

[38] Goodall, W (2007) The insurers plan, action and response to natural disasters, EIG-Ansvar Ltd, Coastal cities natural disasters conference, Sydney, February

- A qualitative summary of the overall costs and benefits associated with each Proposal, relative to the status quo.

7.7.1 Summary of costs and benefits

Table 7-6 provides a summary of the NPV of the net benefits discussed in the sections above, and Table 7-7 provides a qualitative assessment of the likely overall impact of each Proposal relative to the status quo.

Net present value of costs and benefits

Table 7-6 below outlines the estimated net benefits of each Proposal at both the regional level as well as the national level. The NPV calculated is based on an assumed discount rate of 7 per cent (NPV calculations on alternative discount rates of 3% and 11% are presented in the sensitivity testing section).

Table 7-6: Estimated NPV of the expected net benefits and BCR for each proposal

Proposal	*NPV of total costs for each proposal $m*	*NPV of total benefits for each proposal $m*	*NPV net benefits for each proposal $m*	*BCR for each proposal*
1. Extend Region D for WA	13.26	34.28	21.02	2.59
2. Extend Region D for NT	5.30	13.71	8.41	2.59
3. Extend Region C for QLD	335.65	1 056.85	721.20	3.15
4. Increase uncertainty factor for Region C (WA, NT, Qld)	107.32	591.55	484.23	5.51
5. Increase uncertainty factor for Region B (WA, NT, Qld, NSW)	571.19	1 874.04	1 302.85	3.28
TOTAL OF ALL PROPOSALS	1 033.00	3 570.00	2 538.00	3.46

All proposals are estimated to return net benefits compared to a continuation of the current regulations. Proposal 5 is estimated to return the greatest net benefits of all the proposals individually, $1.3 billion. However, proposal 4 returns the greatest BCR of 5.51.

Impact of Climate Change on NPV

The effects of climate change are likely to have a negligible effect on the cost-benefit for the first 10 years and therefore would have no significant impact on the years to breakeven for any of the proposals. However, when considering climate change, the benefits of the proposals are potentially much greater in the long term on the cost-benefit analyses. The outcomes are presented in Figures A1 to A5 for the five proposals in Appendix D: Effects of Long Term Climate Change on Cost Benefit Analyses of Proposed Changes of NPV Calculations.

Conclusions

The proposals will benefit Government, business and individuals by improving community resilience through improved house survivability in the event of a cyclone. Better housing resilience would reduce demand for disaster funding and support, reduce insurance liability and damage costs for home owners. However, the proposals will also increase construction costs for individuals by around $147 million per year.

Table 7.7: Summary table of impacts by Proposal

Option	*Costs / Benefits*	*Groups impacted*			*Overall impact*
		Government	*Business*	*Individuals*	
Proposal 1	**Costs**	Administration and review of Standards	Minimal compliance costs Reduced market demand for certain house types or sites	An increase in construction costs of around $1.89m pa	It appears that the benefits associated with reduced cyclone damages would not outweigh the aggregate construction cost savings and anticipated costs. However, while some individual building owners and businesses may be adversely impacted, it is likely that the aggregate impacts (both direct and indirect) would be positive (i.e. a net benefit) The potential variation in assessed impacts is discussed in more detail below.
	Benefits	Potential reduction in disaster relief funding	Increased market demand for certain house types Reduced insurance liability	Potential reduction in the annual building related damage cost of around $0.35m pa Improved health and wellbeing	
Proposal 2	**Costs**	Administration and review of Standards	Minimal compliance costs Reduced market demand for certain house types or sites	An increase in construction costs of around $0.76m pa	
	Benefits	Potential reduction in disaster relief funding	Increased market demand for certain house types Reduced insurance liability	Potential reduction in the annual building related damage cost of around $0.15m pa Improved health and wellbeing	
Proposal 3	**Costs**	Administration and review of Standards	Minimal compliance costs Reduced market demand for certain	An increase in construction costs of around $47.8m pa	

Option	_Costs / Benefits_	_Groups impacted_			_Overall impact_
		Government	_Business_	_Individuals_	
			house types or sites		
	Benefits	Potential reduction in disaster relief funding	Increased market demand for certain house types Reduced insurance liability	Potential reduction in the annual building related damage cost of around $10.9m pa Improved health and wellbeing	
**Proposal 4**	**Costs**	Administration and review of Standards	Minimal compliance costs Reduced market demand for certain house types or sites	An increase in construction costs of around $15.3m pa	
	Benefits	Potential reduction in disaster relief funding	Increased market demand for certain house types Reduced insurance liability	Potential reduction in the annual building related damage cost of around $5.9m pa Improved health and wellbeing	
**Proposal 5**	**Costs**	Administration and review of Standards	Minimal compliance costs Reduced market demand for certain house types or sites	An increase in construction costs of around $81.3m pa	
	Benefits	Potential reduction in disaster relief funding	Increased market demand for certain house types Reduced insurance liability	Potential reduction in the annual building related damage cost of around $19.3m pa Improved health and wellbeing	

Based on the above summary table, it can be concluded that all Proposals appear unlikely to deliver an overall net benefit compared to the current arrangements based solely on direct financial costs (i.e. direct financial benefits of increased protection and reduced damage are unlikely to outweigh increased construction costs and any additional costs).

7.8 Summary

The cost benefit analysis in this Section provides a quantitative assessment of the expected construction cost impacts and benefits at a state and national level, and a qualitative assessment of the other costs and benefits associated with the Proposals being considered.

The analysis indicates that the introduction of the proposals could result in a net benefit to the Australian economy. The BCRs range from 2.5 to 5.5 across the proposals. However, as mentioned through the analysis, there still remains some uncertainty around some of the variables. The following section presents a sensitivity analysis on these variables.

8 Sensitivity analysis

Given the uncertainty surrounding a number of factors in the consultation RIS, a sensitivity analysis allows the effects of these uncertainties to be explicitly identified and their impact on the final estimates to be determined. Three sensitivity analyses are presented in this section, covering the value of insured losses due to cyclones, the ratio of insured losses to total damage costs and finally the choice of discount rate.

8.1 Insured damages

The source studies utilised in this RIS note the difficulties in estimating cyclone damages on a continuous timescale due to the inherently sporadic nature of the cyclonic events, their location and the resulting damages. The normalised and annualised figure used in the base case of this Consultation RIS is $261 million. This figure is derived from studies completed by Risk Frontiers, in which historically observed damage costs from cyclones are adjusted for changing house values over time, as well as changes in the number of houses. However, there remains some level of uncertainty around the effect that changing policies over this time period had on the annual damage figure. In the early 1980's increased wind loading regulations were implemented in cyclone prone areas. These regulations had the effect of reducing the value of observed damages due to cyclones.

Within the analysis by Risk Frontiers it is noted that had the wind code not been implemented, annualised and normalised insurance losses due to cyclones would have been approximately $410 million. Further analysis showed that had the wind code been implemented at the beginning of the analysis period (1967), annualised, normalised losses would have been approximately $146 million. That is, the $146 million estimate is as if the entire building stock were new homes built to the wind code since 1967.

The discussion relevant for this Consultation RIS is the use of either the $261 million per annum, or the $146 million per annum insurance losses. Losses of $261 million are estimated based on a change in policy half way through the analysis period. But this RIS relates only to new houses, those built from 2010 onwards. For the $261 million to be relevant, the cyclone resilience of new houses being built in the areas to be covered by the proposed change would need to reflect the average cyclone resistance of underlying the stock of houses behind the $261 million estimate. However, these include old houses as well as some new ones. It could be argued that the new housing stock would more accurately reflect the cyclone resilience of new houses represented by the $146 million estimate.

Table 8-1 Insured damage sensitivity results, NPV $m

Proposal	*Insured damage $146million*		*Insured damage $261 million*	
	NPV	**BCR**	*NPV*	**BCR**
1. Extend Region D for WA	6.49	1.49	21.02	2.59
2. Extend Region D for NT	2.60	1.49	8.41	2.59
3. Extend Region C for QLD	273.19	1.81	721.20	3.15
4. Increase uncertainty factor for Region C (WA, NT, Qld)	233.46	3.18	484.23	5.51
5. Increase uncertainty factor for Region B (WA, NT, Qld, NSW)	508.42	1.89	1 302.85	3.28
Total for all proposals	1 024.15	1.99	2 537.70	3.46

While the NPVs remain positive for all proposals when the lower damage value is applied, there is a significant drop in the value of the NPVs, between 50 and 70 per cent reduction.

Within the dataset used by Risk Frontiers to calculate these normalised annual damages from cyclones, there is a high degree of variability. Cyclone Tracy alone accounts for approximately 35 per cent of the damages in the dataset, and both Cyclone Tracy and Cyclone Wanda occurred in the same year (with combined, normalised losses of $5740 million). The damage caused by subsequent cyclones, in contrast, has been comparatively small.

Adding to discussions around the methodology for annualising these damage figures is the implied probability of a large loss event occurring. The dataset covers only 40 years, in which Cyclone Tracy was observed. Therefore Cyclone Tracy is implicitly being treated as a 1 in 40 year event. However, this is likely to be an over representation of the likelihood of another event of the same magnitude occurring. In contrast, if Cyclone Tracy was treated as a 1 in 100 year event, the normalised annual damages would drop by 21 per cent. In this case, the $261 million figure would be reduced to $206 million and the $146 million figure would be reduced to $115 million.

Critical review of the dataset would also raise questions around the inclusion of Cyclone Wanda, as it is reported that wind related damages from the cyclone were nil, with all damages resulting from flooding (Risk Frontiers, 2007).

8.2 Damage to loss ratio

The second sensitivity analysis that was conducted was based around the total damage to insured damage loss ratio. The central case of the Consultation RIS analysis was based around a 5:1 ratio, that is, total damages were fives times the value of insured damages. This multiplying factor was required as the most pertinent data on cyclone damage costs was expressed in terms of insured losses.

The use of the multiplier is due to the fact that total economic and social damages from a natural disaster are not completely accounted for in the estimation of insured damage costs. For example, there are social issues of dislocation and isolation from goods and services, there are potential issues of productivity from workers as well when affected by changes in access to housing. In the case of this Consultation RIS, it is important that the multiple accounts only for those additional social and economic costs linked directly to whether buildings remain standing or not in the cyclone. That is, social costs associated with regional flooding or rebuilding of roads and bridges should not be included.

The factor of 5 used in the Consultation RIS was derived from a 1991 study of cyclone related losses, and has the potential to greatly affect the estimated net benefits of each proposal. It is also likely that this figure is at the higher end of the scale of probability. Risk Frontiers studies in contrast utilise a 3:1 ratio, to account for the difference between the insured and total damages from tropical cyclones. Of interest to note is that the basis for this figure draws on reports by international insurers Munich Re evaluating losses from a wide variety of natural disasters around the world, not just cyclones. Given the large variability in losses across natural disasters by type, as well as by region, there could be justification to consider an even lower multiple of 2.

As an illustration, a 1:1 ratio is also included, which assumes that all damages are covered by insurance. Under a 1:1 ratio, only proposal 4 maintains a positive NPV.

Table 8-2 Damage to insured ratio sensitivity results, NPV $m

Proposal	*Damage to insured ratio*		
	1 time	*3 times*	*5 times (base case)*
1. Extend Region D for WA	-6.40	7.31	21.02
2. Extend Region D for NT	-2.56	2.92	8.41

Proposal	*Damage to insured ratio*		
	1 time	*3 times*	*5 times (base case)*
3. Extend Region C for QLD	-124.28	298.46	721.20
4. Increase uncertainty factor for Region C (WA, NT, Qld)	10.99	247.61	484.23
5. Increase uncertainty factor for Region B (WA, NT, Qld, NSW)	-196.38	553.23	1 302.85

8.3 Downside scenario

A downside assessment of the first two sensitivity analyses (damages at $146 million and 1:3 insured to total losses), indicates that there is the potential for unresolved uncertainty to result in negative NPV estimates for proposals 1 and 2 as shown in Table 8-4.

Table 8-4 Downside assessment estimates, NPV $m

Proposal	*NPV*
1. Extend Region D for WA	-1.41
2. Extend Region D for NT	-0.56
3. Extend Region C for QLD	29.65
4. Increase uncertainty factor for Region C (WA, NT, Qld)	97.15
5. Increase uncertainty factor for Region B (WA, NT, Qld, NSW)	76.57

Information, evidence and data around these areas of uncertainty are provided to assist the consultation period. This is discussed further in section 11.

8.4 Discount rate

Finally, the selected discount rate provides information on the relative value placed on cost and benefits in the future, relative to those payed and received in the future. The central case discount rate through the Consultation RIS was 7 per cent, reflecting Australian Government requirements. However, in table 7-11 a sensitivity analysis around this chosen discount rate is presented. At a lower discount rate of 3 per cent, benefits and costs in the future are not penalised as much as under a 7 per cent discount rate. As the benefits of the regulation extend further into the future than do the costs, lowering the discount rate to 3 per cent increases the estimated NPV of the benefits for all proposals.

For the same reasons as above, increasing the discount rate to 11 per cent has the effect of lowering the estimated NPV of benefits for all proposals. However, this reduction in value of future costs and benefits is not great enough to remove the net benefits of the proposed regulation changes. Under a stricter discount rate of 11 per cent all proposals still have a positive NPV.

Table 8-3 Discount rate sensitivity results, NPV $m

Proposal	*Discount rates*		
	3 per cent	*7 per cent (base case)*	*11 per cent*
1. Extend Region D for WA	53.38	21.02	8.90
2. Extend Region D for NT	21.35	8.41	3.56
3. Extend Region C for QLD	1 734.61	721.20	335.78
4. Increase uncertainty factor for Region C (WA, NT, Qld)	1 068.73	484.23	255.49
5. Increase uncertainty factor for Region B (WA, NT, Qld, NSW)	3104.99	1 302.85	615.53

9 Business Compliance Costs

9.1 Introduction

The COAG *Best Practice Regulation* guide requires consideration of the compliance burden imposed on businesses. This is the additional (incremental) cost incurred by businesses when complying with regulations. Quantification of compliance costs using the Business Costs Calculator (BCC) is required for proposals that are likely to impose medium or significant compliance costs on business.

Compliance costs include:

- Notification costs – requirement to report certain events;
- Education costs – keeping abreast with regulatory requirements;
- Cost of gaining permission – to conduct certain activities;
- Purchase costs – requirement to purchase materials or equipment;
- Record keeping costs – keeping up-to-date records;
- Enforcement costs – cooperating with audits or inspections;
- Publication and documentation costs – producing documents for third parties; and
- Procedural costs – costs incurred that are of a non-administrative nature (e.g. requirement to conduct emergency evacuation drills).[39]

Business, particularly the building industry, already incurs compliance costs under existing arrangements. We consider below the potential extent of any additional compliance costs under the proposed Standard.

9.2 Assessment of additional compliance costs

The Proposals may impose additional compliance costs in two ways:

- Identification of revised wind categories;
- Familiarisation and education costs; and

[39] COAG Best Practice Regulation, A Guide for Ministerial Councils and National Standard Setting Bodies, October 2007, p. 27.

- Revised publications from builders, manufacturers etc.

The likelihood of additional compliance costs in each of these areas is discussed below.

Identification of revised wind categories

The Proposals clearly identify the regions to which they apply and modify current regions that practitioners are already familiar with. Therefore, identification of the revised wind categories will have a minimal impact on business compliance costs.

Assessment methods

Each Proposal involves an increase in design wind forces which would necessitate a review of manufacturer and product literature and standard building specifications. However, once these are established, the assessment process will be similar to the status quo.

Therefore, it is unlikely that there will be an incremental change in compliance costs for the implementation of the Proposals.

Familiarisation and Educational costs

As stated previously there is really no change in the assessment process. Some time or effort could be required from practitioners and regulators (including building certifiers and building surveyors) to familiarise or educate themselves with the revised Proposals and subsequent changes to manufacturer and product literature and standard building specifications but this is unlikely to impose significant compliance costs.

Revised Publications

Manufacturers and suppliers of building products may need to review their product and design literature to ensure compliance with the Proposals. Builders may also need to review their standard building specifications but this is unlikely to impose significant costs.

9.3 Conclusion

The Proposals are likely to impose minimal business compliance costs through familiarisation with the changes and the need to revise manufacturer and product literature and standard building specifications.

While the familiarisation with the Proposals will result in practitioners and regulators incurring some educational and familiarisation costs, it is unlikely that the time and effort would impose significant business costs.

Based on the assessment above, the Proposals are unlikely to impose medium or significant compliance costs on businesses. Therefore, it is not necessary to calculate the compliance costs on businesses using the BCC as required by the COAG *Best Practice Regulation.*

10 Assessment of competition impacts

As part of the RIS process, the COAG *Best Practice Regulation* guide requires that the competition impacts of proposed regulation be considered. A preliminary analysis can be conducted by working through the questions in the Competition Assessment Checklist set out in the guide. Where this preliminary analysis indicates there could be an impact on competition, a competition assessment should be undertaken as part of the RIS.

The checklist questions are:

- Would the regulatory proposal restrict or reduce the number and range of suppliers?
- Would the regulatory proposal restrict or reduce the ability of suppliers to compete?
- Would the regulatory proposal alter suppliers' incentives to compete vigorously?[40]

Do the Proposals restrict or reduce the number and range of suppliers?

It is unlikely that the Proposals will affect or restrict competition. The Proposals impose minimal incremental compliance costs on businesses. This would not act as a barrier to entry nor restrict or reduce the number or range of businesses operating in the design or construction industry.

Do the Proposals restrict or reduce the ability of suppliers to compete?

The Proposals may impose a different set of construction requirements based on the assessed cyclone risk level, which could restrict builders to the use of a particular type of product or material in order to meet the regulatory requirements. However, because the BCA is performance based, it is unlikely that the proposed arrangements would restrict or reduce the ability of any suppliers to compete or impact on the ability of a builder to build houses that comply with the requirements.

Do the Proposals impact on incentives to compete vigorously?

The Proposals do not impact or alter material suppliers' nor builders' incentives to compete vigorously. Building in cyclone affected areas is likely to cost slightly more under the Proposals, however it is unlikely to lead to any decrease in

[40] COAG Best Practice Regulation, A Guide for Ministerial Councils and National Standard Setting Bodies, October 2007, p. 29.

building activity. Broader external factors would have greater influence of whether builders decide to participate in the building industry and increase competition amongst builders.

Conclusion

Overall, it is likely that competition will not be impacted by the Proposals. The Proposals would either be included in the BCA itself or included in the Wind Standards which are part of the BCA. The BCA is a performance-based code which provides flexibility to builders by permitting alternatives to the DTS solutions.

11 Consultation

Principle 7 in the COAG *Best Practice Regulations* guide requires effective consultation with affected stakeholders at all stages of the regulatory cycle. Public consultation is an important part of any regulatory development process. Consultation should occur when the options for regulatory action are being considered. The COAG process recommends a best practice consultation process that adheres to seven principles:

- *Continuity* – Consultation should be a continuous process that starts early in the policy development process.
- *Targeting* – Consultation should be widely based to ensure it captures the diversity of stakeholders affected by the proposed changes. This includes Commonwealth, State, Territory and local governments, as appropriate.
- *Appropriate timeliness* – Consultation should start when policy objectives and options are being identified. Throughout the consultation process stakeholders should be given sufficient time to provide considered responses.
- *Accessibility* – Stakeholder groups should be informed of proposed consultations, and be provided with information about proposals, via a range of means appropriate to those groups.
- *Transparency* – Ministerial Councils need to explain clearly the objectives of the consultation process, the regulation policy framework within which consultations will take place and provide feedback on how they have considered consultation responses.
- *Consistency and flexibility* – Consistent consultation procedures can make it easier for stakeholders to participate. However, this must be balanced with the need for consultation arrangements to be designed to suit the circumstances of the particular proposal under consideration.
- *Evaluation and review* – Policy agencies should evaluate consultation processes and continue to examine ways of making them more effective.

The ABCB and Standards Australia consultation processes discussed below are consistent with best practice consultation processes and adhere to the seven principles set out above.

11.1 Information sought in the consultation period

This Consultation RIS has been prepared as part of the best practice consultation process and will be made publicly available to interested parties for comments and feedback.

This section provides some background discussion around the uncertainties that have been raised through the construction of this Consultation RIS that the ABCB is seeking stakeholder comment on. In addition, the summary section outlines selected questions that will be of interest in completing the Final RIS.

11.1.1 Value of insured losses

Two figures have been presented in this RIS as possible estimates of annualised insured damages. These figures are $261 million, around which the base case of the RIS has estimated the NPV and BCR of the respective proposals, as well as a lower figure of $146 million which possibly more accurately reflects future damages, based on changes in wind regulations.

Further discussion has also been presented over the methodology of calculating these figures. Firstly, the treatment of large scale loss events as 1 in 40 year events, where they may more accurately be considered to be 1 in 100 year events. And secondly, the inclusion of non wind related damages in the total damage costs of cyclones, for example, Cyclone Wanda in 1974 had nil wind damage losses recorded.

11.1.2 Multiple of insured to total losses

There is a recognised difference between insured losses and total economic losses resulting from wind damage to houses. This difference accounts for inconvenience costs of dislocation, reduced productivity and other associated costs. However, it is important within this Consultation RIS to ensure that only additional economic costs related to wind damage to houses is included. The base case of the RIS utilised a 5:1 ratio, sourced from an Australian study published in 1991.

However, discussions were also presented on the use of a 3:1 ratio, which was included in a number of international studies, considering damages from a wide range of natural disasters.

11.1.3 Top down versus bottoms up

The methodology used within this Consultation RIS is a tops down approach, reviewing the total annualised damages from cyclones across Australia.

However, an alternative methodology would be a bottoms up approach in which the probability of any one house being affected by cyclone force winds, and the likely value of that damage. Difficulties arise with either methodology, predominantly associated with data availability.

What is known, however, is that where a single house, with a life expectancy of 40 years, costs approximately $200,000 to build, additional build costs to strengthen wind resistance, in Region D, would be approximately $15,000, or 7.5 per cent of the build costs. On the face of the issue, this may suggest that the probability of a cyclone with adequate strength to fully damage the building, to require it to be entirely rebuilt, would need to be 1 in 104 years to justify the additional build costs. Incorporating a 1:5 or 1:3 total damage ratio would increase this to either 1 in 610 or 1 in 366 year events.

11.1.4 Summary of questions

While submissions on any aspect of the Consultation RIS are welcomed, the following provides a summary of key issues.

- Are the normalised and annualised damage figures a reasonable representation of damages caused by cyclone wind strength in Australia? If not, then where does the concern arise from, and what evidence is there to suggest a change in the estimate?
- Are the estimates of insured damages to total damage arising from cyclone winds reasonable? If not, what evidence is there that they should be altered? Such evidence could include the estimation of lost productivity associated with housing dislocation.
- Would a bottoms up methodology provide a more reasonable representation of the costs and benefits of the proposals? If so, what sources of information are available on house level damages and probability of cyclone activity?
- Are the estimates of the costs of altered construction requirements reasonable? If not, which ones are of concern, and what evidence is there that they may be over or under estimated?
- How does the insurance industry rely on the BCA in determining premiums in cyclone affected areas. Will there be additional benefits resulting from greater information flows across house builders, owners and insurance companies on the resistance of houses to cyclone wind damage?
- What would be the impact on associated building industry issues, for example, housing affordability, due to these Proposals?

11.2 ABCB Consultation Process

The Consultation Protocol

The ABCB is committed to regular review of the BCA and to amend and update the BCA to ensure that it meets changing community standards. To facilitate this, the ABCB maintains regular and extensive consultative relationships with a wide range of stakeholders. In particular, a continuous feedback mechanism exists and is maintained through State and Territory building control administrations and industry via the ABCB's Building Codes Committee. These mechanisms ensure that opportunities for regulatory reform are identified and assessed for implementation in a timely manner.

All ABCB regulatory proposals are developed in a consultative framework in accordance with the Inter-Government Agreement. Key stakeholders are identified and approached for inclusion in relevant project specific committees and working groups. Thus, all proposals have widespread industry and government involvement.

The ABCB has also developed a Consultation Protocol[41], which includes provisions for a consultation process and consultation forums. The Protocol explains the ABCB's philosophy of engaging constructively with the community and industry in key issues affecting buildings and describes the various consultation mechanisms available to ABCB stakeholders.

The ABCB's consultation processes are a range of programs that allows the ABCB to consult widely with stakeholders via:

- the proposal for change process ;
- the release of BCA amendments for comments;
- regulatory impact assessments;
- impact assessment protocol;
- research consultations;
- ABCB approval that reports directly to ministers responsible for building; and
- international collaboration.

[41] Available on http://www.abcb.gov.au/index.cfm?objectid=49960DC7-BD3E-5920-745CE09F1334889C

The Protocol also ensures that the ABCB engages with their stakeholders via a range of events and information series through:

- the Building Codes Committee with representatives from a broad cross section of building professions and all levels of government;
- its Consultation Committees;
- public information seminars;
- its biennial National Conference;
- its technical magazine, the ABRB;
- its free 1300 service advisory line which provides information for industry and the general public to clarify BCA technical matters and access technical advice about provisions; and
- the ABCB website.

The Impact Assessment Protocol 2007

The ABCB Impact Assessment Protocol 2007 ensures that the impact assessment processes are accountable and transparent, and allow for significant stakeholder consultation and participation. The impact assessment processes include:

- Proposals for Change (PFC) which require a change-proposer to justify any projected amendment to the BCA, in accordance with COAG regulatory principles. All PCFs are consulted on and considered by industry representatives, government officials and members of the research community;
- Preliminary Impact Assessments (PIA) which allow for early-stage impact analysis of proposed changes to the BCA. Although complementary to the PFC process, a PIA allows for a more thorough impact assessment to be carried out by the ABCB; and
- Regulatory Impact Statements (RIS) which provide a comprehensive assessment of the impacts of proposed regulation.

Additional stakeholder consultation

Before any changes could be made to the Wind Standards, they will need to be agreed to by the relevant Standards Australia Committee and subjected to the normal Standards amendment processes, including public comment.

11.3 Standards Australia Development and Consultation Process[42]

Standards development

A formal request for a new Standard must come from the community, often from an industry body or a government department. Standards Australia does not initiate a new Standard project - it responds to the requests of the public.

On receipt of a formal request research is undertaken to address the issues:

- Is there genuine community support for the Standard?
- Will it improve economic efficiency?
- Can it show a cost benefit?
- Is it in our national interest?

Once research has established positive support for these issues a new Standards project is approved by the appropriate Technical Committee and Standards Sector Board.

Standards published around the world are prepared by Technical Committees. The essential characteristic is that membership is balanced and that it represents the broadest possible spectrum of interests. Each Committee has an unpaid external chairperson. Standards Australia nominates one of its staff Projects Managers to be Committee Secretary, responsible for co-ordinating committee work and ensuring the draft Standard, which emerges from the committee work, follows the basic principles of standardisation. These principles are published in a series of Standardisation Guides.

The Committee is obliged to ensure that the proposed Standard will in no way act as a barrier to trade, competition or innovative development, before any drafting work is undertaken. It is also strict policy to adopt International Standards to the maximum possible extent. In the absence of an appropriate

[42] Sourced from Standards Australia website at: http://www.standards.org.au/cat.asp?catid=7 on 16 February 2010.

International Standard existing, and after verification that the proposed Standard will in no way be anti-competitive, the Committee proceeds to prepare a draft for a new Australian Standard.

Most of the necessary drafting work is done offline in subcommittees and expert working groups, using advanced web-based authoring, administration and balloting systems. The Committee meets to discuss progress, co-ordinate work programs and seek to maintain consensus in the technical content of the emerging draft.

Public consultation and publishing

The public comment draft stage is very important and requires the draft to be published and made available to the public for two or three months. All comments from the public are considered in detail by the Committee and, if necessary, further drafting is undertaken. The Committee then votes on the final draft. For the Standard to be published, the ballot must demonstrate substantial agreement with no major dissenting interests.

A final process approval is then given by the relevant Standards Sector Board on behalf of the Council of Standards Australia, and the Standard is now ready for publication. Transparency is critical in the preparation of Standards. Transparency means that every act must follow a well-established procedure; that the procedure is equitable to all parties; and that every step in the standardising process is open and available for scrutiny.

Consensus

Consensus in standardisation is the process through which a Technical Committee, consisting of many different and sometimes opposed interests, arrives at a general agreement on the content and requirements of a Standard.

The Technical Committees are under an obligation to work towards consensus. This distils opinions from many different points of view and allows a broad-based agreement to emerge. In turn, this produces a Standard which best matches the needs and values of our society as a whole, and due to representation of a range of parties, broad community acceptance is assured.

Revision of existing Standards

All Standards need to be reviewed from time to time, as technology, knowledge and community needs change. For this reason an automatic review process exists. Major Standards and those dealing with topics continually undergoing rapid change are revised and republished within a maximum period of seven years. Most others are revised within ten years of their publication date.

Draft Revised Standards Development Process

Any changes to the Wind Standards would be subject to the established Standards Australia review process.

11.4 Conclusion

The ABCB and Standards Australia consultation processes are consistent with the seven principles associated with best practice consultation process. Examples of how the processes meet the seven principles include:

- Continuity – the requirement for a PIA under the Impact Assessment Protocol 2007 addresses this principle;
- Targeting – both the ABCB and Standards Australia have technical committees made up of a range of stakeholders from both industry and different levels of government;
- Appropriate timeliness – A draft Standard is usually available for public comment over a period of two to three months to ensure that anybody who feels that they have something to contribute is given ample time to do so;
- Accessibility – the ABCB engages with stakeholders using various communication channels including websites, public information seminars, conferences and the production of a technical magazine;
- Transparency – the requirement that a consultation RIS be prepared for public comment ensures that the process of revising Australian Standards is transparent;
- Consistency and flexibility – the Impact Assessment Protocol 2007 ensures that there is a consistent consultation framework to ensure that relevant stakeholders are consulted at the appropriate time in the review process; and
- Evaluation and review – the Impact Assessment Protocol 2007 was prepared as a response to the 2006 COAG *National Reform Agenda* and the Regulation Taskforce report *Rethinking Regulation*, where the ABCB undertook a review of its processes to ensure the rigour of its impact assessment and consultation processes and to further its role as a 'gatekeeper' of robust regulatory procedures.

12 Implementation and review

If approved, the measures are proposed for reference in the BCA to replace those in the current the Wind Standards.

As a matter of policy, proposed changes to the BCA are released in advance of implementation to allow time for familiarisation and education and for industry to modify its practices to accommodate the changes.

It is expected that building control administrations and industry organisations, in association with the ABCB, will conduct information training seminars on the new measures prior to their introduction in to the BCA.

There is no fixed schedule for reviewing provisions of the BCA. However, the ABCB maintains regular and extensive consultative relationships with a wide range of stakeholders. It relies on this process to identify emerging concerns.

13 Conclusions and further analysis

Five proposed cyclone related changes to the BCA are considered in this RIS. In light of the probability of changing cyclone patterns across Australia, the objective of the changes is to address the risk that property owners in cyclone affected regions will not voluntarily include higher levels of structural resistance in new buildings. Specifically, the proposed changes and the alternative options considered are seeking to achieve the following Government objectives:

- Improve the resilience of buildings to climate change and review climate-related hazards to reduce vulnerability of settlements by considering appropriate measures such as the inclusion of adaptation measures into codes and standards;

- Reduce the danger to life and the risk of property damage by ensuring that buildings have appropriate resistance to cyclones taking into account the impact of climate change;

- Provide outcome based regulation which allows industry to develop the most technically efficient and appropriate solutions;

- Address the identified market failures in relation to the provision of cyclone resistant buildings; and

- Ensure that the regulatory requirements are cost effective and transparent.

The lack of alignment between those with responsibility for incorporating cyclone protection in the design and construction of houses and those who realise their benefits means it is unlikely that an intermediate form of regulation would achieve Government objectives. The risks associated with non-compliance are exacerbated by the potentially serious consequences of cyclonic events, including both substantial risks to public health and safety, and economic impacts.

Non-regulatory interventions on their own appear to be inappropriate responses to cyclone protection measures for buildings built in cyclone prone areas, because they would not provide the level of protection and minimisation of damages required by the public and Governments. The proposed changes therefore represent a regulatory option that includes revised cyclone regions and increased stringency within those regions, both of which would result in increased construction requirements.

The five proposed changes cover five separate risk management options that may be included either as a suite of measures or selectively.

1. A shift in the boundary to cyclone Region D to extend it NE along the Western Australian (WA) coast to 15^{o}S which would include Broome and Derby (resulting in an approximate 50% increase in design wind force to affected areas).

2. A shift in the boundary to cyclone Region D to extend it north of 12^{o}S along the Northern Territory (NT) coastline to include the islands of NT but not Darwin (resulting in an approximate 50% increase in design wind force to affected areas).

3. A shift in the boundary to cyclone Region C to extend it south on the Queensland coast to 27^{o}S to include areas just north of Caboolture i.e. include the Sunshine coast but not Brisbane (resulting in an approximate 50% increase in design wind force to affected areas).

4. An increase in the uncertainty factor for Region C from 1.05 to 1.10 (resulting in a 10% increase in design wind force to affected areas).

5. An increase in the uncertainty factor for Region B from 1.0 to 1.10 (resulting in a 20% increase in design wind force to affected areas).

The results presented in this Consultation RIS are published for review by stakeholders and to seek comment and discussion. While specific questions have been posed, submissions on any element of the Consultation RIS are welcomed.

13.1 Findings

13.1.1 Cost assessment

Construction cost impacts

The estimated annual cost impacts associated with each proposal are based on estimated construction activity in areas subject to cyclones and the cost estimates for each house type. In the absence of any available data, it was also necessary to make assumptions on the proportion of each house type constructed in areas subject to cyclones. It is assumed construction in areas subject to cyclones is spread evenly across the three different house types.

All proposals are likely to lead to cost increases when building in areas subject to cyclones. These increases are estimated at approximately $1.0billion over the expected life of the proposals. They are disaggregated as follows:

- an increase in construction costs of around 6 per cent for all house types under Proposals 1, 2 and 3 (this equates to around $15 100 per house for Proposals 1 and 2, and $12 400 per house for Proposal 3);
- an increase in construction costs of around 1.2 per cent for all house types under Proposal 4 ($2 500 per house); and
- an increase in construction costs of around 2.4 per cent for all house types under Proposal 5 ($4 200 per house) are estimated.

This equates to estimated cost increase, per house, of between $2,000 and $18,200, depending on the type of house constructed. The estimated cost impacts are likely to reflect a higher level of housing robustness resulting in a reduced level of risk of damage or collapse in a cyclone event. The issue is whether the assessed level of risk aligns appropriately with the associated construction requirements.

On an individual level, all proposals are likely to lead to cost increases for all three house designs, i.e. the base house, the average one storey house and the average two storey house. The changes to the cyclone Region boundaries are likely to be responsible for the largest comparative per house cost increases (i.e. Proposals 1, 2 and 3) while the increases in uncertainty factors for Regions B and C (proposals 4 and 5) are likely to lead to comparatively lower per house construction cost increases.

In contrast, at an aggregate level, Proposal 5, increasing the uncertainty factor for Region B, would result in the greatest aggregate cost increases for newly constructed houses each year of $81 million, followed by Proposal 3, extending the boundary of Region C, resulting in aggregate cost increases of $48 million. These differences are driven by the relative numbers of house constructions affected.

It must be noted that the cost estimates are dependent on the assumptions used (e.g. level of adoption of the BCA and level of construction activity for each house type), and do not consider that there would be any increased acceptance of cyclone risk in construction by the market. Further, they do not provide for changes in consumer demand patterns in favour of less expensive house designs.

Additional cost impacts

In addition to those measurable costs noted above, additional cost impacts should also be considered when assessing the overall impact of the proposed Wind Standards and the alternative options. These include:

- Individuals – the proposals are likely to impact adversely on individuals depending on the site characteristics and preferred house design. The construction of all house types will become more expensive, unless the individual chooses a less expensive alternative design; and

- Businesses – the proposals may impact on the demand for certain house types, but is unlikely to impact the overall demand for construction in areas subject to cyclones. That is, while some houses will become more expensive, the increase is across the board so there is a level playing field across the building industry. There could be a shift in consumer preference for smaller less expensive houses.

  It is anticipated that the proposals will impose minimal incremental business compliance costs and have no adverse impact on competition.

13.1.2 Benefit assessment

Measurable benefits

The proposals will benefit new and altered houses by making them more resilient to cyclone events. The benefits are estimated based on total cyclone related insured losses of $261 million per year normalised to 2006 values and the likely reduction in these losses because of improved building standards. The benefits also take into account the predicted increase in cyclone peak winds of 5-10% by 2070 and southward movement of Category 3 intensity cyclones by up to 3^{o}S latitude.

There are incremental benefits associated with the proposals above those provided by the current arrangements. The estimated insurance cost savings and other direct cost savings resulting from the Proposals are estimated to be around $36m per annum, equating to approximately $3.5billion over the lifetime of the regulation and constructed houses.

- Proposals 1, 2 and 3 provide the greatest reduction in cyclone loss ratios, estimated to reduce damages by up to 85 per cent compared to the status quo. Proposals 4 and 5 are estimated to reduce damages by up to 30 per cent.

- Total benefits for each proposal are based on both the reduction in loss ratio as well as the number of houses affected. Proposals 5 and 3 are estimated to provide the greatest benefits, at $18.7m and $10.5m per annum respectively.

Other benefits

Other, additional benefits are difficult to quantify but they should also be considered when assessing the overall impacts.

- It is difficult to measure the improvement in housing survivability as a result of the proposals as housing survivability (and conversely, the level of building damage) can be influenced by a range of factors other than cyclone protection measures that are provided by designs under the Wind Standards.
- It is difficult to estimate building related costs, as not all damage incurred in a cyclone event can be attributed to the loss of a building.
- It is difficult to compare the quantitative costs and benefits against the qualitative benefits.

In addition, potential benefits for specific sectors:

- Individuals – The proposals are likely to lead to a reduction in the costs associated with cyclonic events, such as damage costs, disruptions to normal life and impacts on health and well-being. Annual building related damage costs attributed to cyclonic events is estimated at $261 million (insured losses normalised to 2006 values), but this figure is likely to be significantly conservative (by a factor of five times) as it does not include the broader costs associated with cyclonic events (i.e. consequential losses).
- Businesses – the proposals may stimulate demand for the construction of some house types, which become relatively less expensive and more attractive under the proposed arrangements.
- Government – the proposals could lead to a reduction in social disruption costs, emergency response and the adverse economic impacts associated with cyclone events.

13.2 Conclusion

It can be concluded that all five regulatory proposals are likely to deliver an overall net benefit compared to the current arrangements, individually and collectively. That is, the benefits of increased protection are likely to outweigh the additional construction costs.

The estimated net present values of the net benefits for each of the five Proposals are:

- Proposal 1 - $21 million;
- Proposal 2 - $8 million;
- Proposal 3 – $721 million;
- Proposal 4 – $484 million; and
- Proposal 5 – $1 302 million.

However, the BCRs of Proposals 1, 2 and 3 relating to changes to cyclone region boundaries are generally less than the net benefits of Proposals 4 and 5 relating to increases in uncertainty factors for Regions B and C. These differences reflect the varying cost elements underlying the net benefit calculations.

Proposals 1, 2 and 3 have BCRs of 2.59, 2.59 and 3.15 respectively. In contrast, Proposals 4 and 5 have BCRs of 5.51 and 3.28 respectively. All proposals were assessed as likely to support the achievement of the Government objectives, with Proposals 4 and 5 assessed relatively more favourably as they provide an improved level of protection with the least cost impacts per house compared to the remaining proposals.

Proposal 1, the extension of Region D in WA to include Broome and Derby, while not providing significant benefit, could be considered to be justified because of the close proximity to the existing Region D which represents the area of highest risk of severe cyclones, the high level of cyclone activity and a high number of near misses.

Proposal 2, the creation of a new Region D in the NT, would introduce a higher construction standard for houses just north of Darwin. This proposal, whilst creating greater protection for those buildings constructed in the affected area, also has the potential to create confusion around the Region boundary and would potentially be difficult to administer. Additional stakeholder input to assist in the justification of its adoption would assist decision makers, considering likely local government and industry concerns, and the relatively small preliminary estimated net benefit of $8 million.

Proposal 3, the extension of Region C for Queensland, whilst also providing a net benefit will have a significant cost impact on this large growth area. Again, stakeholder feedback would be beneficial in assisting decision makers in determining the suitability of adopting such a proposal, bearing in mind also that an increased level of protection would be provided for this area under Proposal 5 (although not quite to the same extent).

In summary, when compared with the non-mandatory and business as usual options assessed, all five parts of the proposal to revise the BCA result in a greater net benefit, based on the assumptions and data used. As highlighted however, some of the proposals are more beneficial than others and there are uncertainties associated with the benefit estimates used, which if adjusted, have the potential to markedly affect the outcome.

13.3 Further analysis

Due to the uncertainties surrounding some estimates used to calculate the net benefits, a sensitivity analysis was undertaken to estimate the impact that they would have on the overall results of the RIS, in particular insured damages and the damage to loss ratio. It was noted that, while most of the estimates were robust to the uncertainty, and remained positive, some combinations of uncertainties could result in a negative NPV for Proposals 1 and 2.

Stakeholder submissions are sought on all areas of the RIS, including the estimation of costs and benefits, nature of the Australian insurance market as well as data sourcing and methodology.

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A Detailed cost estimates

POPULATION AND HOUSE BUILDING ACTIVITY DATA

State/Territory	*Cyclone Region*	*City/Town*	*Population (2006 census)*	*New Houses pa*
WA	D	Carnarvon, Exmouth, and environs	8,331	27
	D	Onslow	880	5
	D	Karratha, Dampier, Roeburne and environs	17,670	100
	D	Port Headland	12,993	50
	WA Region D Total		**39,874**	**182**
	C	Broome	14,436	110
	C	Derby	5,000	10
	C	Wyndham	770	5
	WA Region C (north of 20^{o} S)		**20,206**	**125**
	B	Geraldton	33,500	250
	B	Northampton	3,360	35
	B	Chapman Valley	957	15
	B	Irwin	3,240	40
	WA Region B Total		**41,100**	**340**
WA TOTAL STATEWIDE			**2,059,000**	**21,285**
NT	C	Darwin, including Palmerston, Litchfield	117,500	550
	C	Borroloola, Arnhem, Groote Eylandt and cyclone affected coastal communities	32,500	50
	NT Region C Total		**150,000**	**600**
NT TOTAL TERRITORY WIDE			**215,000**	**760**
QLD	C	Burke Shire	535	0
	C	Carpentaria Shire	2084	5
	C	Cook Shire	3688	26
	C	Hope Vale Shire	856	1
	C	Lockhart River	605	1
	C	Aurukun	1,138	0
	C	Weipa	3029	4
	C	Cairns and environs	147,505	958
	C	Tablelands	40,906	222
	C	Cassowary Coast Innisfail, Johnstone Cardwell, Tully	27,787	195
	C	Hinchinbrook and	12,244	19

State/Territory	_Cyclone Region_	_City/Town_	_Population (2006 census)_	_New Houses pa_
		environs		
	C	Townville, Thuringowa and environs	164,955	1311
	C	Ayr, Home Hill and environs	18,044	30
	C	Bowen, Proserpine	31,329	140
	C	Mackay and environs	107,372	1150
	C	Rockhampton and environs	107,630	420
	C	Gladstone and environs	53,974	372
	C	Bundaberg	87,730	533
	Qld Region C Total		**811,411**	**5,387**
Australia Region C Total			**981,617**	**6,112**
	B	Hervey Bay, Maryborough	89,380	1024
	B	Gympie and environs	43,986	550
	B	Noosa, Caloundra, Maroochydore, Nambour	295,125	2280
	Qld Region B Hervey Bay to Caloundra Sub-Total		**428,491**	**3854**
	B	Caboolture	332,737	3035
	B	Brisbane	992,176	3030
	B	Redland	131,332	1128
	B	Logan	259,608	1223
	B	Gold Coast	466,651	3848
	B	Ipswich	142,312	1715
	Qld Region B Caboolture to Gold Coast Sub-Total		**2,324,816**	**13,979**
	Qld Region B Total		**2,753,307**	**17,833**
QLD TOTAL STATEWIDE (June 2008)			**4,279,400**	**28,000**
NSW	B	Tweed Heads	62,059	410
	B	Byron	30,635	130
	B	Lismore	44,255	150
	B	Ballina	40,266	150
	B	Richmond Valley	22,172	100
	B	Clarence Valley	50,143	250

State/Territory	*Cyclone Region*	*City/Town*	*Population (2006 census)*	*New Houses pa*
	NSW Region B Total		**249,530**	**1,190**
NSW TOTAL STATEWIDE (2006)			**6,817,200**	**16,181**

Source: Various, including ABS July 2008 and March 2009 data, Queensland Dept of Infrastructure and Planning data accessed April 2009 and web searches of towns/cities

B Detailed housing cost comparison

Housing costs were obtained from the website of Tamawood/Dixon Homes (http://www.dixonhomes.com.au/ accessed April 2009). According to a HIA Housing 100, in 2007/08 Tamawood (including franchises) constructed nearly 1500 houses ranking them as the 6th largest home builder in Australia.
The following table compares the cost of constructing the same Tamawood/Dixon range of houses in Townsville (wind classification C1), Bundaberg (C1), and Sunshine Coast/Brisbane (N2).

Model No	*House Description*	*Sunshine Coast Region B*		*Bundaberg Region C*		*Townsville Region C**	
		Cost $	**% incr**	**Cost $**	**% incr**	**Cost $**	**% incr**
SR4024	160m2, 1 storey, 3 bed, 1 bath, 1 garage	120,800	0	149,800	24	166,200	38
SR9402	167m2, 1 storey, 4 bed, 1 bath, 1 garage	122,100	0	151,300	24	167,900	38
SR9401	156m2, 1 storey, 4 bed, 1 bath, 1 garage	117,400	0	145,400	24	161,300	37
BR4018	164m2, 1 storey, 3 bed, 1 bath, 1 garage, verandah	119,900	0	148,000	23	206,400	72
BR4016	164m2, 1 storey, 4 bed, 1 bath, 1 garage, verandah	119,200	0	147,700	24	205,100	72
Shepparton	232m2, 1 storey, 4 bed, study, 2 bath, 2 garage	148,100		184,200	24	228,600	54
FT0701	249m2, 2 storey, 4 bed, 3 bath, 2 garage,	204,800	0	259,700	27	412,700	102
FL0901	231m2, 2 storey, 5 bed, 3 bath, 2 garage	197,800	0	250,800	27	398,500	101
FC0901	240m2, 2 storey, 4 bed, 3 bath, 2 garage	197,600	0	250,600	27	398,100	101
FR8502	244m2, 2 storey, 5 bed, 3 bath, 2 garage	196,200	0	248,700	27	395,200	101

Notes: * Figures reflect masonry block construction.

Housing costs were also obtained from the website of Gold Award Homes (http://www.goldaward.com.au/ accessed April 2009).
The following table compares the cost of constructing the same Gold Award house in Townsville (C1), Bundaberg (C1), and Sunshine Coast/Brisbane (N2).

Model No	*House Description*	*Sunshine Coast / Brisbane Region B*		*Bundaberg Region C*		*Townsville Region C*	
		Cost $	**% incr**	**Cost $**	**% incr**	**Cost $**	**% incr**
Bonnie 141	141m2, 1 storey, 3 bed, 2 bath, 1 garage	142,400	0	158,500	11	204,000	43
Darwin 165	165m2, 1 storey, 3 bed, 2 bath, 2 garage	157,800	0	176,200	12	225,000	43
Picasso 247	247m2, 1 storey, 4 bed, 3 bath, 2 garage	201,000	0	226,500	13	286,300	42
Belinda 246	246m2, 1 storey, 4 bed, 3 bath, 2 garage,	195,600	0	220,700	13	280,300	43
Carla 236	236m2, 2 storey, 3 bed, 3 bath, 2 garage	226,200	0	252,600	12	NA	
Van Gogh 248	248m2, 2 storey, 4 bed, 3 bath, 2 garage	241,100		269,000	12	NA	

C Effects of Long Term Climate Change on Cost Benefit Analyses of Proposed Changes of NPV Calculations

1. INTRODUCTION

This Appendix describes the effects of long term climate change on the cost-benefit analyses of the proposed changes

2. DEFINITIONS

The following definitions are used in this study-

COST: increase in construction cost as a consequence of increase in design wind speeds from current values as given in AS/NZS1170.2-2002. This is a 'real' quantity since all future construction will have to comply with the new requirements. The assumptions on costs are the same as those used in the Consultation RIS.

BENEFIT: decrease in anticipated damage in a high wind event. For the purpose of this report, the anticipated damages are provided by 'fragility' curves already established in technical literature. This is a 'probable' estimate that will be weighted by the probability of the occurrence of the event. The sum of this quantity over the range of wind speeds represents the total impact that flows from a particular proposal.

BENEFIT TO COST RATIO: ratio of benefit to cost as described above. This is the metric for comparison of the merits of various options. The number of years it will take to achieve a benefit/cost ratio of 1.0 is also used as a measure for comparing effectiveness of the options.

3. ASSUMPTIONS

Reference time period of 50 years.

Annual discount rate of 7% applied to both cost and benefit calculations.

Annual costs and benefits for all proposals are the same as those used in the Consultation RIS.

The climate change assumption: the annual recurrence interval of extreme wind will be halved in 50 years and the rate of change is linear.

4. OUTCOMES

The outcomes are presented in Figures A1 to A5 for the five propositions discussed in the report. It is noted that under the assumed scenario climate change will have negligible effects on the cost-benefit for the first 10 years but the benefits of the propositions are potentially much greater in the long term.

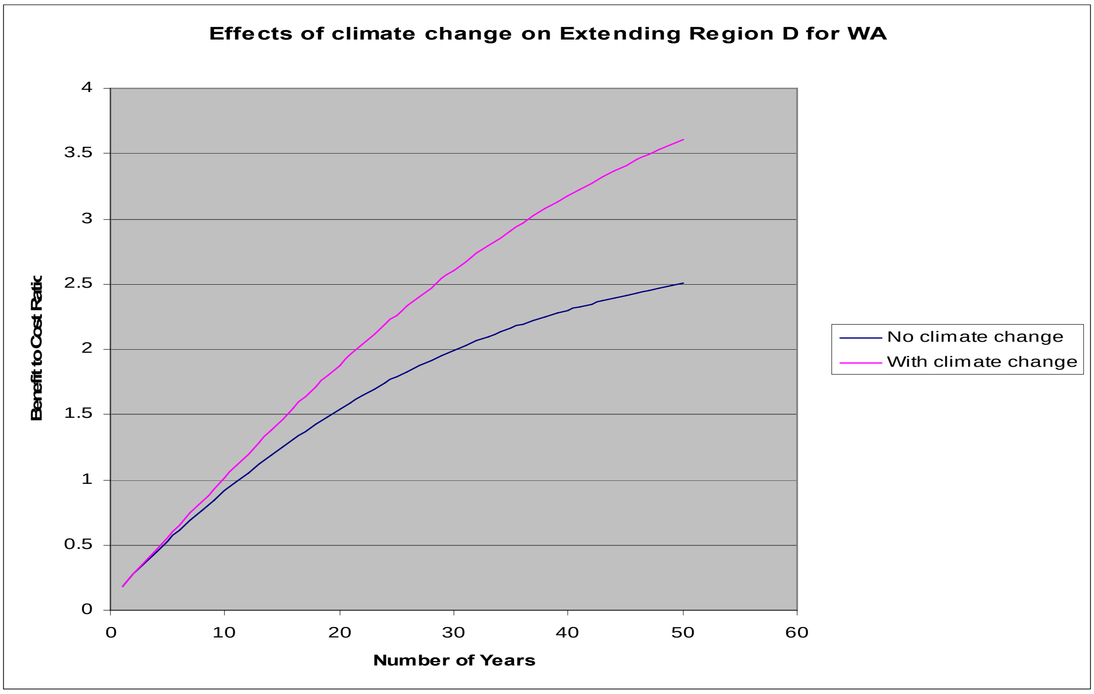


Figure A1 – Effects of climate change on extending region D for WA

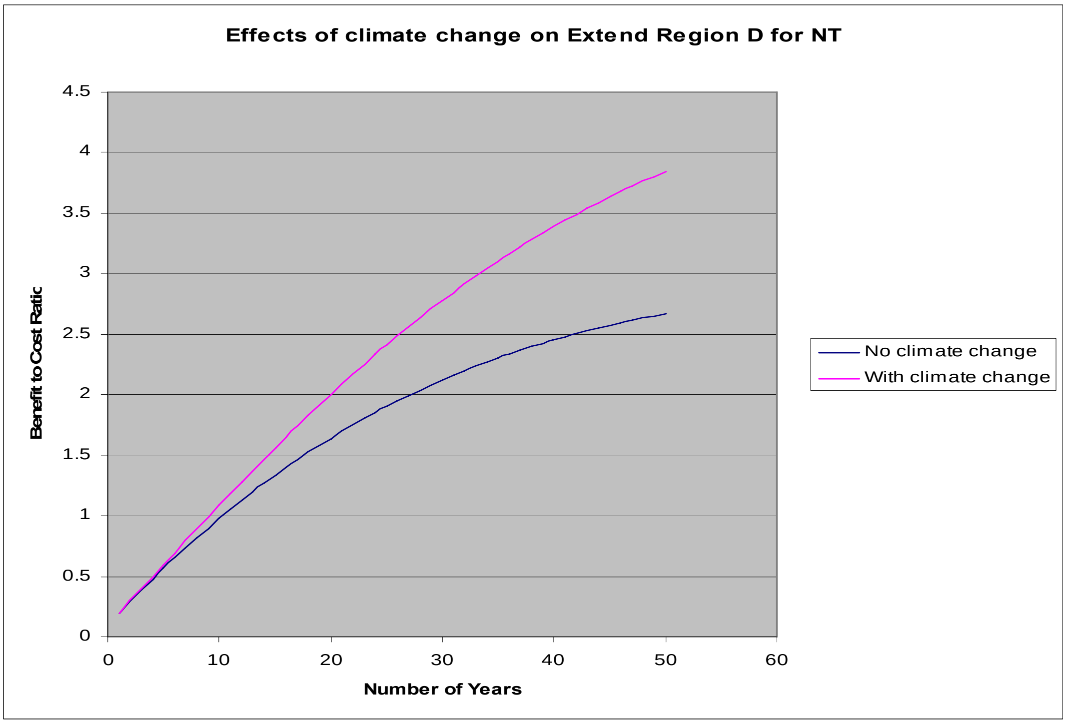


Figure A2 – Effects of climate change on extending region D for NT

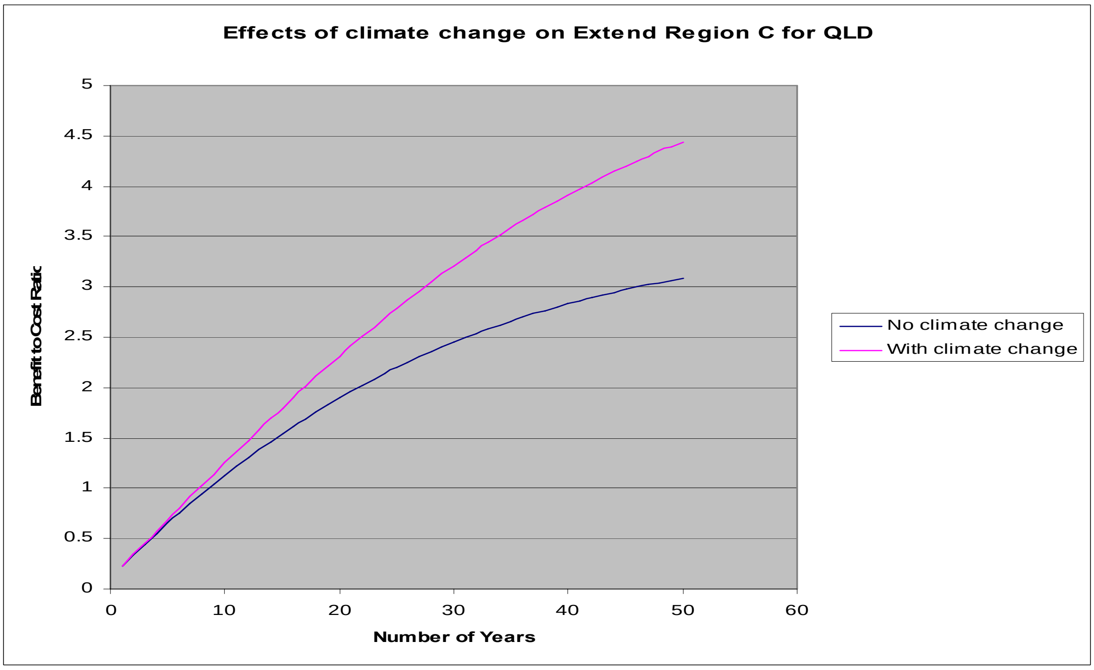


Figure A3 – Effects of climate change on extending region C for QLD

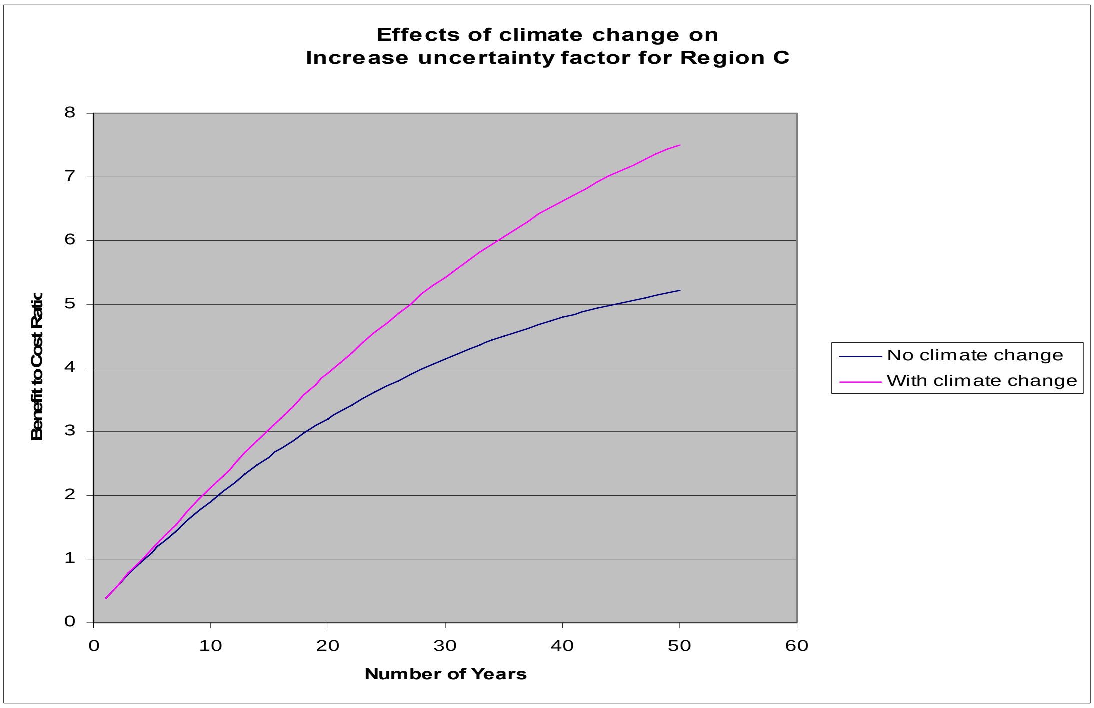


Figure A4 – Effects of climate change on increasing uncertainty factor for Region C

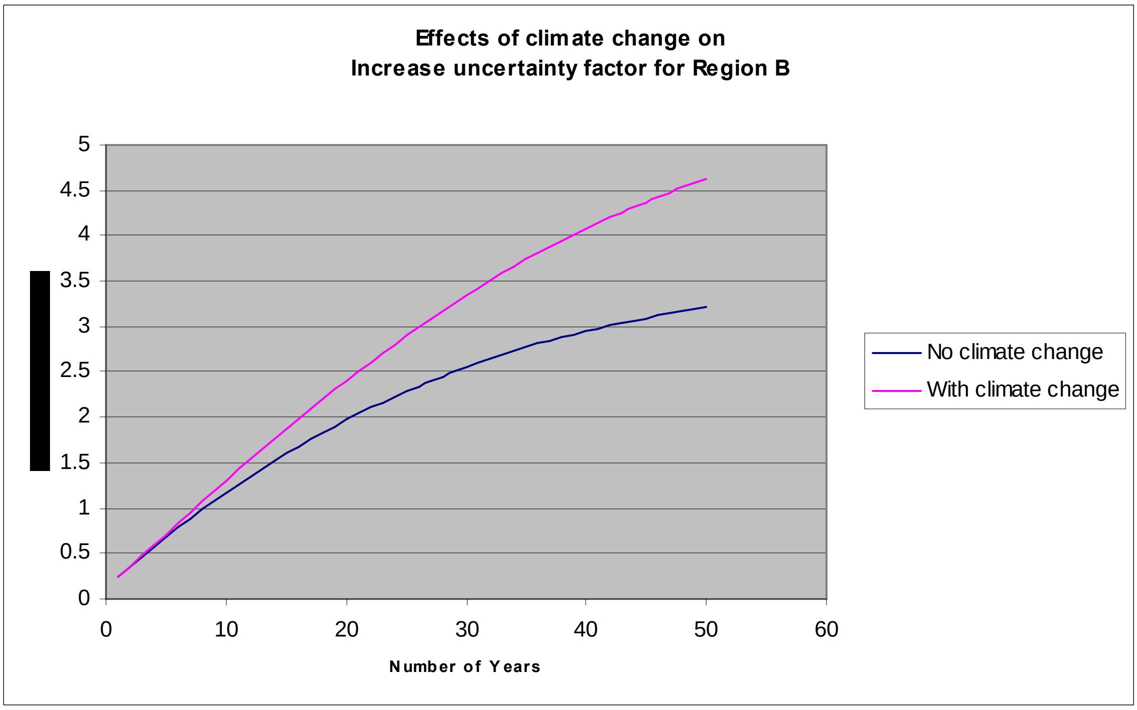


Figure A5 – Effects of climate change on increasing uncertainty factor for Region B

D Studies into Cyclone Activity in Australia

E.1 Studies by Cook and Nicholls

Recent studies by G.D. Cook (2007) and Nicholls et al (2007) [43]suggest design wind speeds in the Northern Territory should be significantly higher than currently prescribed in the relevant Australian Standard for wind actions, AS/NZS1170.2 (the wind code). The studies, inter alia, cast doubt on the current Region C zoning for Darwin and suggest the cyclone risk to the NT relate better to Region D, the most intense cyclone region in Australia. The only area currently zoned Region D is located in WA between 20^0 and 25^0S within 50km of the coastline. In addition, various climate change reports[44] suggest cyclonic activity may become more severe under climate change scenarios.

E.2 Studies by McAneney et al

McAneney et al (2007)[45], in an article in the Australian and New Zealand Institute of Insurance Finance Journal, analysed data from the Bureau of Meteorology (www.bom.gov.au) involving tropical cyclones crossing the east coast of Australia during the last 45 years and having a central pressure less than or equal to 995hPa.

They found tropical cyclone activity in the South-Western Pacific region is strongly related to the El Niño – Southern Oscillation (ENSO). Cooler ocean temperatures exist in the Western Pacific and Coral Sea during El Niño episodes and ocean temperatures near the Queensland coast are typically

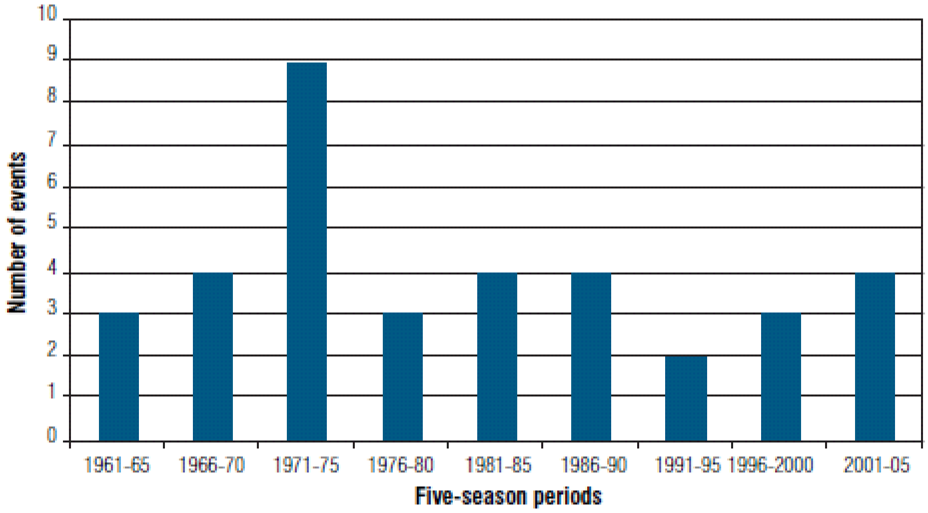
[43] GD Cook (2007), Has the hazard from tropical cyclone gusts been underestimated for northern Australia? CSIRO Sustainable Ecosystems
M Nicholls et al (2007), Review of NT cyclone risks, Report by the Community Group for the review of NT cyclone risks, April 2007
[44] IPCC (2001)
PJ Webster et al, (2005), Changes in tropical cyclone number, duration and intensity in a warming environment, *Science*, Vol 309
CSIRO (2007) *Climate change in Australia*, Technical Report
PJ Klotzbach (2006), Trends in global tropical cyclone activity in the last twenty years, *Geophysical Research Letters*, Vol 33
K Emmanuel (2005), Increasing destructiveness of tropical cyclones over the past thirty years, *Nature*, Vol 436

[45] J McAneney et al (2007) Risk Frontiers, Macquarie University,NSW, Australia, *Personal Lines Insurance, A Century of Damage, Property Losses Due to Natural Perils*, Australian and New Zealand Institute of Insurance Finance Journal Volume 30 Number 3 June/July 2007

above average during La Niña phases. Consequently, tropical cyclone activity tends to shift further away from the east coast of Queensland and further north resulting in fewer than average numbers of landfalling tropical cyclones during the El Niño phase than the La Niña phase.

Figure E-1 shows successive five-season period frequencies of tropical cyclones that have crossed the east coast since the 1961 season (1961/62). Within each of the five-season periods there are different numbers of El Niño, La Niña, and neutral events. With the exception of 1971-75, there have been between two and four tropical cyclones for each period. It comes as no surprise that La Niña episodes dominated the 1971-75 period.

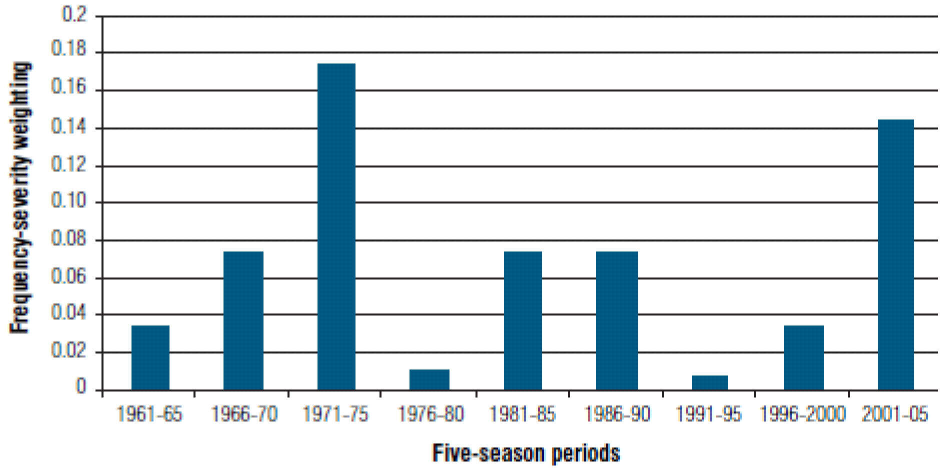
Figure E-1: Number of tropical cyclones to cross the east coast during five-year periods.



Source: McAneney et al[16]

McAneney et al then normalised the data taking into account the cyclone intensity to obtain a potential destructiveness index as represented in the following Figure E-2.

Figure E-2: Potential destructiveness index of tropical cyclones that have crossed the east coast of Australia during five-year periods.



Source: McAneney et al[16]

While the Figure focuses on the east coast, McAneney et al contend very similar results hold for the western and north coasts of Australia and conclude that while the small number of tropical cyclones per five–year time interval makes it difficult to draw robust conclusions, there is no indication that tropical cyclones are becoming more frequent or more dangerous.

E.3 Studies by JDH Consulting

The ABCB commissioned Dr John Holmes (JDH Consulting) to determine whether there is sufficient information and justification to change design wind speeds in cyclonic regions of Australia in the wind code, firstly with reference to currently available wind data, and secondly with reference to climate change. The JDH Consulting Report "Impact of Climate Change on Design Wind Speeds in Cyclonic Regions" was completed in June 2008.

The key findings of the JDH Report[46] are-

1. The current wind code does not include the effects of climate change.
2. Australia suffers from a lack of basic data leading to an inaccurate cyclone database.

[46] JDH Consulting (2008), _Impact of Climate Change on Design Wind Speeds in Cyclonic Regions_, an unpublished study on behalf of the Australian Building Codes Board.

3. Simulations, predictions and cyclone profiling could be improved.
4. Current assumptions about inland weakening and penetration of tropical cyclones appear adequate.
5. Speculation that frequency of severe tropical cyclones world-wide has been increased as a result of global warming appears to be caused by observational error.
6. Latest IPCC assessment (2007) is that 'there is no clear trend in the annual numbers of tropical cyclones'.
7. In Australia, there are fewer cyclones in El Nino events, but the more intense cyclones are less influenced by El Nino.
8. As a result of climate change, over the next 50 years there is likely to be an increase in the number and frequency of strong storms Cat. 3 to 5, a southward shift of 2-3^{o} of these strong storms, and a storm of Cat. 3 is likely in the Brisbane region. No comparable climate change studies have apparently yet been made for the Indian Ocean (WA Coast) or the Arafura Sea (NT).
9. For the NT, studies by Nicholls and Cook significantly over-estimate the gust speed near ground level. However they do identify significant effects on the northern coast line and islands of NT.
10. Uncertainty resulting from climate change can be handled by the ‘uncertainty’ factors for Darwin and other locations rather than a change in basic design wind speeds (i.e. rather than a change from cyclone Region C to D).
11. The quality of the climate model predictions is low given the current resolution of the prediction models. It is expected that the resolution and hence the quality of the predictions will improve over the next few years.

The JDH Report recommendations which impact on the BCA and the wind code could, if adopted, result in-

1. A shift in the boundary to cyclone Region D to extend it NE along the WA coast to 15^{o}S which would include Broome and Derby (resulting in a 50% increase in design strength)
2. A shift in the boundary to cyclone Region D to extend it north of 12^{o}S along the NT coastline to include the islands of NT but not Darwin (resulting in a 50% increase in design strength)
3. A shift in the boundary to cyclone Region C to extend it south on the Queensland coast to 27^{o}S to include areas just north of Caboolture i.e. include the Sunshine coast but not Brisbane (resulting in a 50% increase in design strength)
4. An increase in the uncertainty factor for Region C from 1.05 to 1.10 (resulting in a 10% increase in design strength)
5. An increase in the uncertainty factor for Region B, an increase from 1.0 to 1.10 (resulting in a 20% increase in design strength).

These recommendations form the basis of this study.

E.4 Improving Community Resilience

As a result of damage to housing caused by Cyclone Althea in 1971 and Cyclone Tracy in 1974, there have been considerable developments in building standards in cyclone and high wind affected areas from around 1981 to improve the structural adequacy of housing. These improvements mean that houses constructed post 1981 are much more resilient to cyclone events. As the proportion of houses built post 1981 increases, the resilience of the entire community to cyclone damage improves.

For example, using damage functions for pre and post 1981 houses in Region C published by Walker (1995) and cited in McAneney et al (2007) (reproduced in Figure 3-5) if a cyclone with a wind speed of 65m/s (3 second gust at 6m, equating to a mid range Category 4 cyclone) impacted on a community in Region C in 1981, total destruction of all houses would likely have resulted. However, if the same cyclone occurred in 2001, half of the houses in the community would have been constructed to the post 1981 improved standard of which only 20% would likely have been destroyed. Therefore, compared to the 100% housing loss in 1981, the loss would be reduced to 70% in 2001. The positive impact of the improved standard will also increase as more older and weaker houses are demolished or upgraded.

Similarly, the improved standards discussed in this paper would only apply to newly constructed houses and to certain alterations and renovations. ABS data[47] indicates that between 2001 and 2026 Queensland households are projected to increase by between 63% and 76%, from 1.4 million in 2001 to between 2.3 million and 2.4 million in 2026, representing an annual average increase of around 2.8%, compared to the Western Australia average of around 2.2% and the Northern Territory average of around 1.7%.

It is likely the construction of new housing to improved standards is improving community resilience faster than wind forces are increasing, which means the community in total will be in a better position as the years progress.

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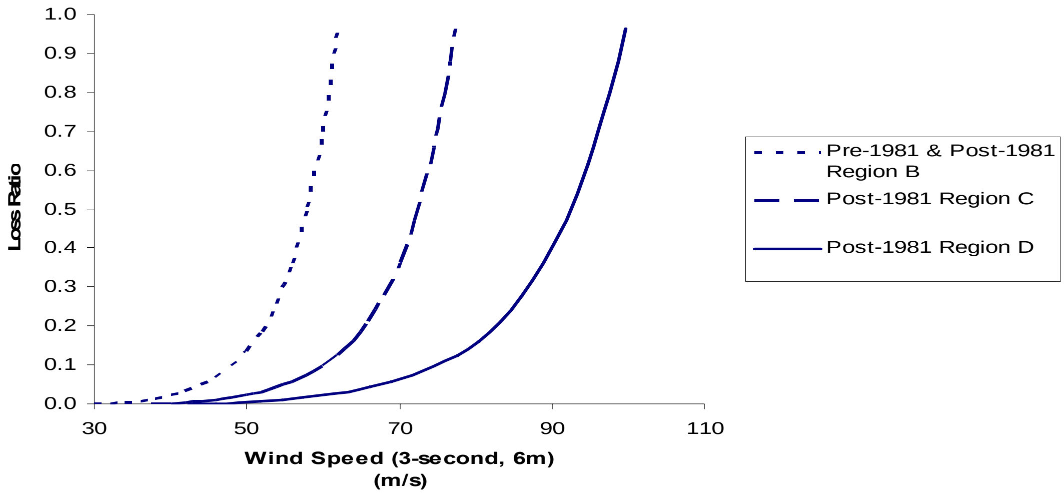
[47] ABS Household and Family Projections Australia, 2001-2026, Catalogue No 3236.0 http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/DF2989BFFA7392E1CA256EB6007D63F4/$File/32360_2001%20to%202026.pdf accessed May 2009

Figure E-3: Damage functions for pre-1981 and post-1981 Wind Regions B, C and D residential buildings.



Source: McAneney et al[12]

Note: Gust speeds are at a height of 6m allowing for terrain and topographic effects. The pre- and post-1981 Wind Region C functions are from Walker (1995).

E.5 Climate Change Reports

A number of reports have been produced making reference to changes to the cyclone risk as a result of climate change. The IPCC (2001) concluded that, by the late 21st century, tropical cyclone frequency may change in some regions and peak winds may increase by 5-10%. Projections of climate change in Australia developed by CSIRO and the Australian Bureau of Meteorology for the Australian Climate Change Science Programme[48] indicate a likely increase in the proportion of the tropical cyclones on the more intense categories, but a possible decrease in the total number of cyclones. Further reports are discussed in the following chapters.

E.6 BRANZ Report

[48] CSIRO, Australian Bureau of Meteorology, *Climate Change in Australia – Technical Report 2007*

A Report to the Australian Greenhouse Office, Department of the Environment and Water Resources by BRANZ Limited (August 2007)[49] titled "An Assessment of the Need to Adapt Buildings for the Unavoidable Consequences of Climate Change" finds that cyclone peak winds are likely to increase by 2 to 5% by 2030 and by 5 to 10% by 2070.

The report also indicates the increased cost of house construction from adapting to increased wind/cyclones resulting from climate change as presented in the following Table E-3. The increased costs include increased roof and wall framing sizes, increased bracing and increased tie down. There appears to be no allowance however for increased window/glazing strength, increased fastening of wall cladding, metal roof sheeting or tiles, increased stormwater drainage requirements and increased strength of items such as garage doors. The actual figures are therefore likely to be significantly higher as discussed in Chapters 6 and 7.

Table E-3: House Construction Costs by BRANZ

Floor construction	*Estimated Cost per House ($)*		
	N2 →C1	**C1 →C2**	**C2 →C3**
Timber Floor	3270	3940	5260
Concrete Floor	2170	3040	3740

Note: N2 equates to a sheltered urban flat Region B location; C1 equates to a sheltered urban flat Region C location; C2 equates to a sheltered urban flat Region D location.

E.7 ICA Report

A report by the Insurance Council of Australia [50]stated that cyclone activity has been predicted by the CSIRO to decrease overall by up to 44% in some areas of Australia but the number of extreme cyclone events (Category 3-5) is expected to increase. That is, there will be a higher percentage of more destructive and longer living cyclone events. Furthermore, the average decay location of cyclones is predicted to move southwards by up to 3^{o} of latitude. The ICA therefore considers that the BCA and Standards should extend mandatory cyclone resistant standards north of 33^{o} S latitude (i.e. from

[49] BRANZ Limited (August 2007)49 An Assessment of the Need to Adapt Buildings for the Unavoidable Consequences of Climate Change http://www.climatechange.gov.au/impacts/publications/pubs/buildings-report.pdf accessed April 2009
[50] Insurance Council of Australia, *Improving Community Resilience to Extreme Weather Events, April 2008*

Newcastle NSW). Note that in Eastern Australia, cyclone region C currently commences north of 25^{o} S latitude.

E.8 Investigation of possible BCA adaptation measures for climate change

The ABCB undertook an investigation of possible BCA adaptation measures as a result of climate change for the Commonwealth Department of Climate Change in 2008. The investigation covered the current BCA position in regard to cyclones and extreme winds, the risk rating in cyclone and non-cyclone areas, possible adaptation measures and areas of potential future research. The following information is sourced from the ABCB investigation and the CSIRO Climate Change in Australia Report[19].

Past climate change
For the non-cyclonic regions, 'mid-latitude westerly winds appear to have decreased…with a corresponding increase in wind speed in the polar latitudes...There has been a 20% reduction in the strength of the subtropical jet over Australia and an associated reduction in the likelihood of synoptic disturbances developing over south-west Western Australia since the early 1970'.

For the cyclonic regions, 'analysis of the existing Australian cyclone data base indicates substantial increases in detected tropical cyclone numbers with the advent of weather radar in the late 1950s, although there have been apparent decreases in the east Australian numbers since 1970s. A review of the WA tropical cyclone data base…proportion of tropical cyclones that was severe (i.e. category 3 or 4 cyclones) being larger (41%) during 1989-1998 than during the earlier period 1974-1988 (29%)'.

Climate change projections
<u>Average wind speed projections</u>
Increases in most coastal areas in 2030 (best estimate 2 to 5%) except for a band around 30^{o} S in winter and 40^{o} S in summer where there are decreases (best estimate -2 to -5%). Later in the century changes can be larger depending on the emission scenario. For 2070, best estimates increases of 15% in some regions under one scenario but less than 10% everywhere under another scenario.

<u>Extreme wind speed projections</u>
Extreme winds in summer are likely to be governed by small scale systems (including tropical cyclones) that are not adequately captured by the resolution of the climate models. Extreme winds in winter are more likely governed by larger scale systems that are better captured at the resolution of the models.

Tropical cyclones: Likely increase in the proportion of the tropical cyclones in the more intense categories, but a possible decrease in the total number of cyclones.
Severe thunderstorms: Conditions will become less suitable for the occurrence of tornadoes in southern Australia in the cool season (May to October).

Risk rating Non-cyclonic regions

Likelihood
The likelihood of increases in extreme wind speeds in non-cyclonic regions appears to be low. The projected increase (if any) is within the error band of current methods for determining design wind speeds.

Consequence
Current situation: The consequences of damages to buildings due to extreme wind could be widespread particularly for existing buildings due to the general decay of the infrastructure. For the period 1967 to 1999, annual cost of severe storms is $284 millions[51]. A major part of the damage is property damage caused by water penetration problems when the integrity of the building envelop is breached. Although it has been reported over 770 people have died as a result of severe thunderstorms since 1824 (Blong 2005) [52], most of the deaths have been attributed to being struck by lightning, falling trees or boat capsizing. There is no separate report on building related fatalities.

Effects of climate change: The effects of climate change may place some areas currently classified as 'non- cyclonic' to 'cyclonic'. This might cause radical changes to design requirements and construction practice in these areas. For areas that still remain 'non-cyclonic', the consequences of damage to buildings is likely to stay the same as for current situation. New buildings are likely to sustain less damage compared with older buildings due to the general deterioration of buildings with time which might accelerate because of the effects of climate change.

Risk Rating Cyclonic regions

Likelihood
Increases in extreme wind speeds of between 5-10% by 2070 in cyclonic regions have been predicted as a consequence of climate change, while the actual number of cyclones is predicted to reduce. However, cyclones are also predicted to impact outside the current designated cyclone regions by moving 3^{o} latitude southward on the Queensland coast.

[51] BTE, _Economic Costs of Natural Disasters in Australia_. Report 103, Bureau of Transport Economics, Canberra, 2001.
[52] M Middelmann, _Natural Hazards in Australia: Identifying Risk Analysis Requirements_, Geosciences Australia, Canberra, 2007, pp. 82—97.

Consequence

Current situation: Tropical cyclone-related losses average $261 million per year, including those from Cyclone Larry.[53] The reduction of damage in recent times could be attributed largely to improved building regulatory measures, which have been responsible for reducing annual average cyclone-related losses by nearly two thirds. This results in an estimated annual economic benefit to the nation of $1.4 billion in 2006 dollars[54]. Although it has been reported over 2100 people have died as a result of cyclones since 1839 (Blong 2005), most of the deaths have been related to shipwreck. Only one incidence of building related fatalities was reported (Cyclone George) since Cyclone Tracy in 1974.

From investigations following recent cyclones, there are known issues that need to be resolved, such as the boundaries of the cyclonic regions, the appropriateness of the current classification system, and the extent of inland penetration of cyclones. There are also known areas of vulnerability such as 'shed like' buildings and garage doors. High wind speed can also cause storm surge, which in combination with high tide could cause wide spread inundation.

Effects of climate change: The concern for the cyclonic regions is similar to that of the non cyclonic regions in that the general deterioration of buildings with time will result in more damage to old buildings and the deterioration will be accelerated as result of climate change. If there is any change to the boundaries of the cyclonic regions, the main concern will be for these new 'cyclonic' areas since the building regulation, design and construction practice for these areas will have to undergo radical changes as well as the community awareness and acceptance.

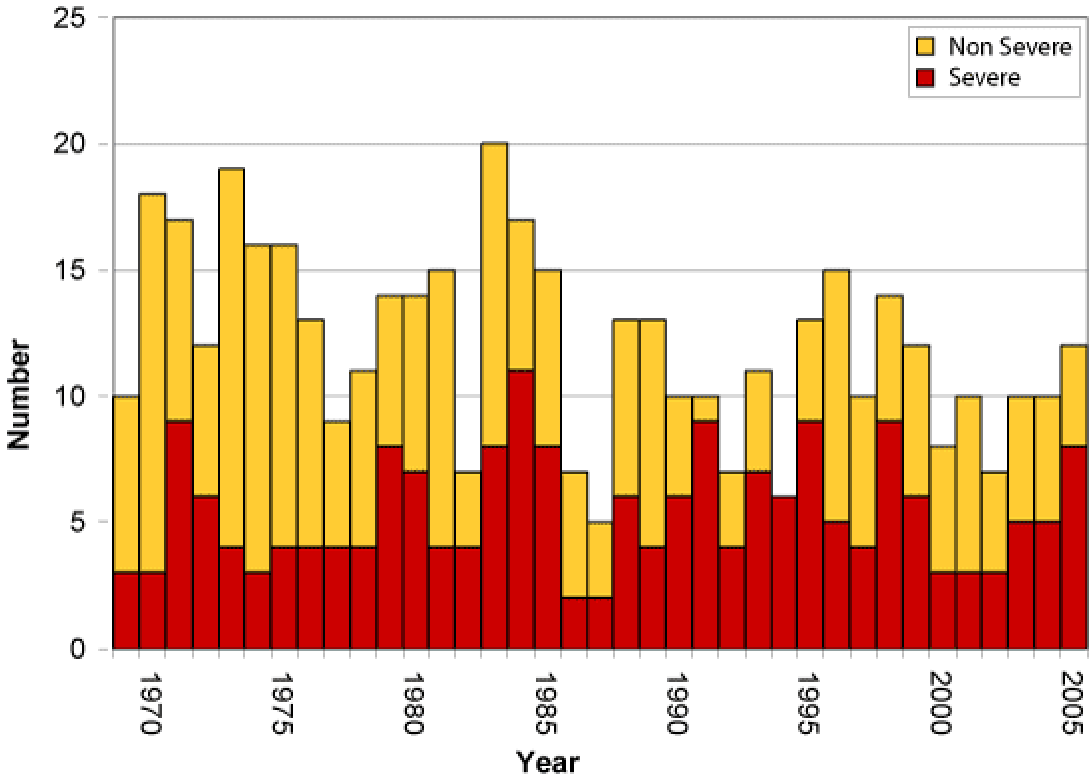
E.9 Bureau of Meteorology

The Bureau of Meteorology (BOM) in their website[55] identifies that trends in tropical cyclone activity in the Australian region (south of equator; 105 - 160°E) show that the total number of cyclones has decreased in recent decades. However, the number of stronger cyclones (minimum central pressure less than 970 hPa) has not declined.

The following Figure E-4 shows the number of severe and non-severe tropical cyclones from 1970 - 2005.

[53] Risk Frontiers (June 2008) 'Assessing the benefits of improved wind loading construction standards in Tropical Cyclone prone areas of Australia', Newsletter, Volume 7, Issue 4
[54] McAneney, Crompton and Coates, *Financial benefits arising from improved wind loading construction standards in Tropical-Cyclone prone areas of Australia*, Risk Frontiers, Macquarie University, 2007
[55] http://www.bom.gov.au/weather/cyclone/tc-trends.shtml accessed April 2009

Figure E-4: Number of severe and non-severe tropical cyclones from 1970 – 2005



Source: http://www.bom.gov.au/weather/cyclone/tc-trends.shtml accessed April 2009

BOM considers the overall decrease may partly be due to an improved discrimination between tropical cyclones and sub-cyclone intensity tropical lows. Tropical cyclone numbers in the Australian region are influenced by the El Niño-Southern Oscillation phenomenon and the decrease in total cyclone numbers may be associated with an increased frequency of El Niño events. A number of long-term trends and oscillations have been observed in other parts of the world, extending over many decades. It is difficult to sort these natural trends from those that may result from global warming.

Potential changes in tropical cyclone occurrence and intensity are discussed in detail in the 2007 report, Climate Change in Australia, Technical Report - Chapter 5: Regional climate change projections – Chapter 5.9.1 Severe weather: Tropical cyclones. There is substantial evidence from theory and model experiments that the large-scale environment in which tropical cyclones form and evolve is changing as a result of greenhouse warming. Projected changes in tropical cyclones are subject to the sources of uncertainty inherent in climate change projections. These include errors in the modelled tropical cyclone climatology and regional patterns and magnitude of change for various fields and climate patterns such as ENSO. Consequently there is large uncertainty in the future change in tropical cyclone frequency projected by climate models.

IPCC (2001) concluded that 'there is some evidence that regional frequencies of tropical cyclones may change but none that their locations will change. There is also evidence that the peak intensity may increase by 5% to 10% and precipitation rates may increase by 20% to 30%. There is a need for much more work in this area to provide more robust results.'

Since that time there has been a growing number of studies that indicate a consistent signal of fewer tropical cyclones globally in a warmer climate. However, there are significant regional variations in the direction of the changes and these vary between models. Substantial disagreement remains between climate models concerning future changes in tropical cyclone intensity, although the highest resolution models show evidence of an increase in tropical cyclone intensity in a warmer world.

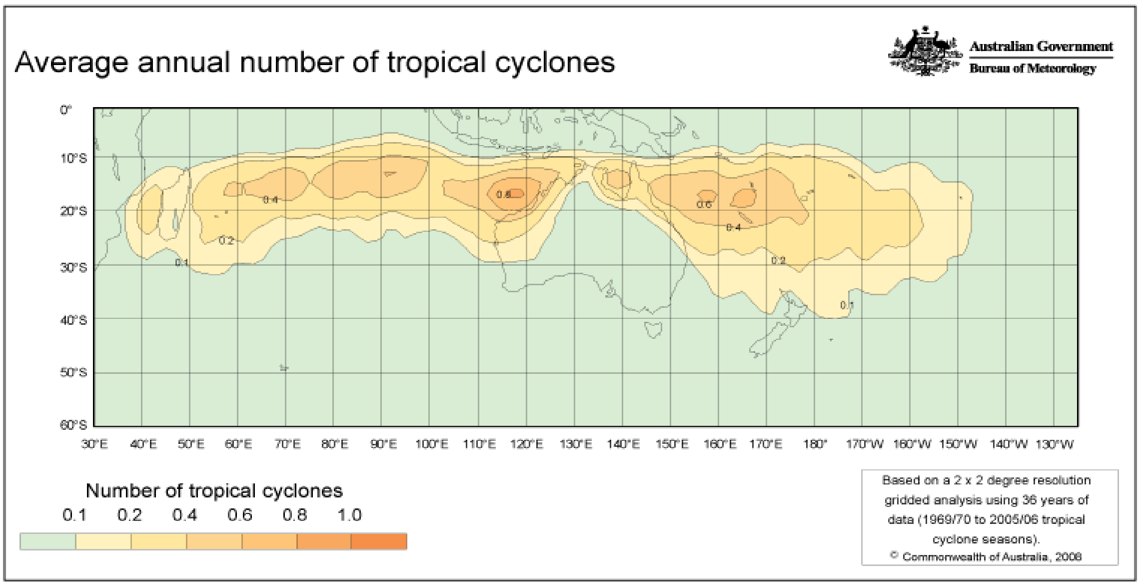
There have been three recent studies producing projections for tropical cyclone changes in the Australian region. Two suggest that there will be no significant change in tropical cyclone numbers off the east coast of Australia to the middle of the 21st century. The third study, based on the CSIRO simulations, shows a significant decrease in tropical cyclone numbers for the Australian region especially off the coastline of Western Australia. The simulations also show more long-lived eastern Australian tropical cyclones although one study showed a decrease in long-lived cyclones off the Western Australian coast.

Each of the above studies finds a marked increase in the severe Category 3 - 5 storms. Some also reported a poleward extension of tropical cyclone tracks.

BOM also identifies that projected changes in tropical cyclone characteristics are inherently tied to changes in large-scale teleconnection patterns such as ENSO, changes in sea surface temperature and changes in deep convection. As global climate models improve, their simulation of tropical cyclones is expected to improve, thus providing greater certainty in projections of tropical cyclone changes in a warmer world.[22]

The following Figure E-5 shows the average annual number of tropical cyclones using 36 years of data from 1969/70 to 2005/06.

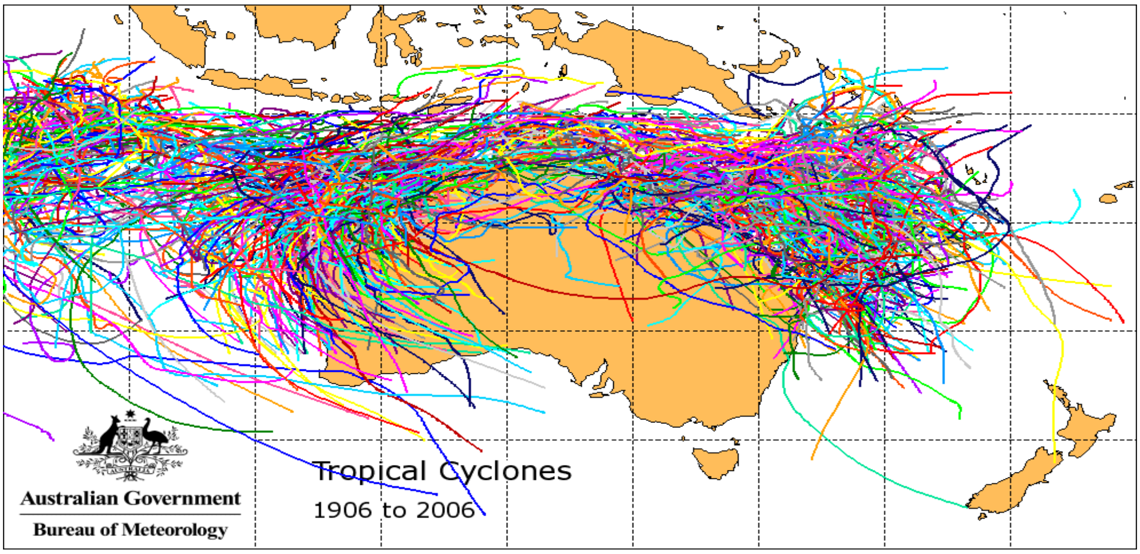
Figure E-5: Average annual number of tropical cyclones using 36 years of data from 1969/70 to 2005/06



Source: http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/tropical_cyclone.cgi accessed April 2009.

The following Figure E-6 shows paths of tropical cyclones from 1906 to 2006.

Figure E-6: Paths of tropical cyclones from 1906 to 2006



Source: http://www.bom.gov.au/cgi-bin/silo/cyclones.cgi?region=aus&syear=1906&eyear=2006&cyclone=all&loc=0 accessed April 2009.