



AMSTECI

## Association for Mitigation Studies for Top End Cyclones Inc.

### **Submission to the Senate Committee Inquiry: Recent trends in and preparedness for extreme weather events.**

The Association for Mitigation Studies for Top End Cyclones Inc. (AMSTECI) was formed in July 2007. It is a Darwin based, community group of people who have a professional scientific or engineering interest in the risks from tropical cyclones and/or are survivors of Cyclone Tracy.

This submission was prepared by Michael Nicholls who is AMSTECI's secretary. He is a retired structural engineer and has been studying and reporting on Darwin's cyclone risk since June 1974 – six months before Cyclone Tracy destroyed most of the housing in Darwin including the house that he and his family were sheltering in at the time.

AMSTECI's research has led us to conclude that Darwin (including Palmerston) is at greater risk from impact from Category 5<sup>1</sup> cyclones than any other city in Australia and probably in the world. The reason relates to the physics of cyclone intensification and the temperatures in the region, in particular to the high temperatures of the shallow seas and the low temperatures of the tropopause at low latitudes. (This opinion is supported by Prof. Kerry Emanuel of MIT who is one of the world's foremost experts in the physics of the intensification of tropical cyclones.)

#### **Comments on the Terms of Reference (ToR)**

##### **ToR (a) Recent trends on the frequency of extreme weather events.....**

Our research of historic and modern Bureau of Meteorology (BoM) records for the NT indicates that there has been no discernible trend in the frequency of 'intense tropical cyclones' (defined here as having maximum gust speeds > 250 kph). But there have been some interesting anomalies. For instance all five of the intense tropical cyclones that have come within 50 km of Darwin since its settlement in 1869 (1897, 1915, 1919, 1937, 1974<sup>2</sup>) have tracked toward Darwin with an easterly component in track direction. This is the direction that will lead to the largest storm surges and is quite contrary to the normal situation where NT cyclones tend to track westward.

A further anomaly is that Category 5 Cyclones Thelma (1998), Ingrid (2005) and Monica (2006) all came within 350 km of Darwin within only 9 years. To make matters worse, Monica made landfall with maximum gusts of 360 kph – the highest ever recorded in Australia<sup>3</sup>. But it is not considered that this clustering of Category 5 cyclones is related to global warming – more likely it is a combination of chance plus the fact that since the 1980s, satellites enable the certain detection of cyclones and estimation of their intensities.

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<sup>1</sup> Categories here are to the Australian Cyclone Severity Scale. The following lists Category numbers and range of maximum gust speeds in kph. Cat 1, 90-124; Cat 2, 125-169; Cat 3, 170-224; Cat 4, 225-279; Cat 5 > 280.

<sup>2</sup> The intensity of Cyclone Tracy (1974) has been recently re-examined by various authorities. The consensus is that it was a Cat 5 cyclone during its approach on Darwin and produced maximum gusts near the coast in the Northern Suburbs that were at or near Cat 5 intensity – much more than the estimate of 217 – 240 kph made by BoM in 1977.

<sup>3</sup> By way of comparison, Cyclone Yasi is probably the most intense cyclone to have made landfall in Queensland in recorded history and its maximum gusts at landfall are estimated by BoM to have been only 285 kph.

## **ToR (b) Based on global warming scenarios of the IPCC and CSIRO of 1°-5° C by 2070**

AMSTECI base their research findings only on past climate and tropical cyclone records and do not wish to relate their findings to the global warming issue. (Our membership is divided between people with a range of views varying, at one extreme, to an alarmist view of anthropogenic global warming, and at the other extreme, to the view that any warming that may occur is easily managed and not at all likely to be dangerous.) Our position is that even if global warming did lead to increased intensities of cyclones in this region, those increases are projected to be minor and the increased risk would be insignificant compared to the under-estimation of the risk from tropical cyclones to Darwin from the climatology that exists today.

We have concluded that the Australian wind code (AS/NZS 1170.2:2011) should include most of the NT coast (including Darwin) in its so-called Region D<sup>4</sup> where houses are designed to withstand a Category 5 cyclone having gusts of 317 kph. The current situation is that the NT coast is included in the code's Region C<sup>5</sup> where houses and apartments are designed to withstand only a mid-level Category 4 cyclone with gusts of 250 kph<sup>6</sup>. One speed is only 27% more than the other, but loads increase as the square of the speed so the loads increase by about 60%, and destructive potential (which takes into account debris effects) increases by at least the cube of the speed so the **destructive potential of the sort of cyclones that Darwin should be allowing for is more than double that being allowed for at present**. (It should be noted that the loads in the wind code make no allowance for debris other than the requirement that if it is assumed that the building interior will not become pressurized, then the building's openings and outer envelope must be capable of resisting penetration by specified debris missiles. Almost invariably designers ignore this requirement, assume that the building will be penetrated by debris and allow for internal pressures. Meanwhile, no allowance is made for any loads caused directly by debris impact or accumulation. This is the reason why many more buildings designed for a mid-level Category 4 cyclone will be demolished by a Category 5 cyclone – not only will they not be designed for the increased (clean) wind loads, but nor will they be designed to withstand the concurrent loads from the barrage of debris that will be unleashed.)

### **ToR (b) (ii) the costs of extreme weather events and impacts on ....social and economic infrastructure and human health.**

If a cyclone of Monica's intensity made a direct hit on today's Darwin, it would damage nearly every building to some extent or other. It would produce damage that would probably exceed \$10 billion and could easily cause in excess of 1,000 fatalities.

Tornadoes having the top Fujita rating of EF5 have surface wind speeds comparable to mid-level Category 5 cyclones such as Monica. The pictures of damage from the tornado that hit Moore, Oklahoma on 20<sup>th</sup> May 2013 remind us of the destructive power of such winds. The Moore tornado was at EF5 intensity for only a short period and presumably that is one reason why there were only 24 fatalities. A tornado that caused more damage and fatalities was the EF5 tornado that hit the city of Joplin, Missouri on 22<sup>nd</sup> May 2011. Joplin has a population of 50,000, the tornado tracked through the centre of the city with a maximum damage swathe width of 1.6 km causing a damage bill of US\$2.8 billion and 158 fatalities.

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<sup>4</sup> Region D is a 50 km wide coastal strip that currently extends from near Carnarvon to Port Hedland in WA.

<sup>5</sup> The Region C coastal strip extends all the way around the coast from just north of Port Hedland to Bundaberg, Qld.

<sup>6</sup> The Building Code of Australia requires that houses and apartments for all Regions be designed to resist wind gust speeds that have no more than a 1 in 500 annual chance of being equalled or exceeded. Most of Australia is in Region A for which that gust speed is 162 kph. For Region B it is 205 kph, for Region C it is 250 kph and for Region D it is 317 kph. Other types of buildings have different criteria. For instance, major hospitals must be designed to withstand wind gusts that have no more than a 1 in 2000 chance of being exceeded in any one year.

The higher estimates of damage costs and fatalities given above for similar strength winds over Darwin take account of the fact that the damage swathes for tornadoes are typically much less than 1/10<sup>th</sup> the width of those for cyclones and a tornado's maximum winds last only a few seconds at a given point instead of many minutes for a cyclone.

**ToR (b) (iii) the availability and affordability of private insurance, .....**

Most Darwin residents are insured with TIO which is owned by the NT Government. Some time ago, the writer asked the TIO manager what percentage of their cover against cyclone loss was reinsured. He replied that it was 20%. He then admitted that neither TIO's reinsurance nor the NT Government had the money to cover anywhere near the insured losses for a Category 5 impact and said words to the effect that the Federal Government could be counted on to step in to fill the breach. It would be interesting to know if this remains the current situation.

**ToR (c) an assessment of the preparedness of key sectors for extreme weather events, including major infrastructure ...construction and property.....**

**AND**

**ToR (d) an assessment of the preparedness and adequacy of resources in the emergency services sector to prevent and respond to extreme weather events.**

1. **Transport sector.** The Stuart Highway is the only highway out of Darwin that leads south and away from potential high wind areas. This highway converts down to two lanes at about 50 km travel distance from the Darwin CBD but at this point it is still only 15 km away from the East Arm of Darwin Harbour. It is clear that there is no possibility of the city being safely evacuated by the number of people who might want to do so in the event of a Category 5 cyclone bearing down. (It is understood that ADF personnel and their families do intend to evacuate to Tindal if a Category 5 cyclone is threatening Darwin – hopefully they decide to go early before the highway becomes hopelessly clogged with vehicles.)

The NT Emergency Service's webpage "Cyclone Action Guide" does not mention evacuation as an option and the only webpage that does is "Shelters in the NT" which has a small section titled "Evacuation Inland" which states "*If you choose to evacuate, you should leave early.....well before strong winds affect your area*". This is good advice but "early" needs to be quantified. If evacuation is ever to become a serious option for the majority, then much work much needs to be done on the Stuart Highway to enable it to cope with the traffic.

2. **Telecommunications sector.** It is obviously important that mobile phone communications remain effective during impact from a cyclone - or are at least restored quickly. We have examined the Telstra submission to this inquiry but could see no mention of the maximum wind speeds which the system is designed to cope with, nor any mention of design winds for mobile towers, etc. It is recommended that this Senate Committee question Telstra on what would happen to their system if say a cyclone with wind gusts of 317 kph were to hit Darwin. (AMSTECI's research shows that there is more than a 1 in 500 annual chance that Darwin will experience wind gusts greater than this value.)
3. **Construction sector \_ Buildings:** Nearly all modern infrastructure in Darwin is under-designed in terms of withstanding a hit from a Category 5 cyclone. As already stated, this can be easily corrected for new infrastructure by requiring it to be designed for the wind code's Region D (as done now in Port Hedland for instance). But it is virtually impossible to

upgrade existing structures and so it will take 50 years or more before the whole of Darwin would be adequately resilient to a hit from a Category 5 cyclone.

The word “modern” is underlined above because houses being built now are only about half as strong as those built in Darwin between 1975 and 1983 (ref pages D11-16, Attachment 1). The reason is partly because the design wind speed used in those years was 279 kph (compared to 250 kph now) but mainly because since that time, the various factors used by structural engineers to convert wind speeds into design loads have been progressively revised to lead to lower loads for a given speed. This also means that houses built in those first 8 years after Tracy, if properly maintained, should withstand a hit from a mid-level Category 5 cyclone of Monica’s intensity ( 360 kph).

AMSTECI’s concern is that Darwin be quickly declared to be in Region D, but concurrently, there needs to much more attention paid to providing adequate cyclone shelters.

**3 (a) Residential cyclone shelters:** Most houses and apartments will not provide safe shelter during a hit by a Category 5 cyclone unless they are equipped with a small shelter that is specifically designed for the purpose – both in terms of structural strength and protection against penetration by debris. Very few Darwin residences are so equipped.

The NT Emergency Services webpage on preparing for cyclones states “*Check to see if your own home is safe in a cyclone is a great place to start*” and it then links to a Department of Lands and Planning webpage titled ‘Is your house safe in a cyclone?’ Four pages are devoted to the topic but none of them actually answer the question and there is no mention made that cyclones might have winds greater than 250 kph. To make matters worse, the first of those four pages contains a very misleading statement, namely: “*Experience with cyclones Ingrid (2005) and Monica (2006) has shown that buildings built to code can withstand severe conditions very well.*” It is misleading because neither of these Category 5 cyclones made direct hits on settled areas – those settlements that were affected experienced winds that were much less than the 250 kph design winds so of course the buildings performed “very well”.

Another NT Emergency Services webpage titled ‘Shelters in the NT’ contains the oft repeated statement “*If your home has been built to code and is well maintained, you should shelter at home.*” It then goes on to advise on sheltering in the smallest room and other advice which is appropriate for most cyclones – but not for Category 5 cyclones when that smallest room will most likely be demolished along with the rest of the house.

AMSTECI consider that once the real risk of a Category 5 hit on Darwin is accepted, the NT Government should provide a series of plans and specifications for a variety of cyclone shelters for houses and also provide house owners with a subsidy to assist with their construction. There are also small, transportable, proprietary shelters that could be upgraded to be suitable for the Darwin market if such possibilities were properly investigated and encouraged – also by means of subsidies. The amount of these subsidies could be calculated on the basis of the savings made in reduced requirements for public shelters and an expanded Stuart Highway.

**3 (b) Public Cyclone Shelters:** The NT Emergency Services webpage titled “Shelters in the NT” states that shelters are “*provided for residents who are at risk from storm surge, live in caravan parks or other non-coded homes.*” But contrary to popular opinion, these are not cyclone shelters. The shelters have a total capacity for about 15,000 people and comprise

four old buildings that survived Cyclone Tracy and have received upgrades for window protection etc., and six new buildings that are mainly within schools. The latter are designed for loads specified by the Building Code of Australia as the minimum required for buildings that are essential for post-disaster recovery (not mid-disaster shelter) which means that they are designed to resist cyclones having a 1 in 2,000 annual chance of being exceeded. Because the NT Government accepts the Australian wind code's specification that Darwin belongs in Region C, the combined result is that these emergency shelters are designed for wind speeds of only 276 kph. That speed is still Category 4 and is even less than the maxima now considered to have occurred during Cyclone Tracy.

The NT Government is presumably aware that their shelters do not conform to the requirements of the Building Code of Australia (BCA) because the NT Emergency Services webpage 'Shelters in the NT' is careful to describe these buildings only as 'Emergency Shelters' and goes on to state that they "*do not guarantee safety in all circumstances*" and "*they are used at your own risk – the NT Government accepts no liability for any loss, injury or death arising from the use by the public during a cyclone.*" This is a deplorable admission of failure. Darwin's 'Emergency Shelters' are presumably adequate for cyclones up to Category 4 and are obviously better than nothing - but they could easily become death traps during a mid-level Category 5 cyclone.

Meanwhile, the Queensland Government has bitten the bullet on this issue and has recently announced the construction of ten new cyclone shelters at locations extending from Weipa in the north to Mackay in the south which were all constructed under a \$60 million cyclone shelter program that is jointly funded by the Queensland government and the government of the Emirate of Abu Dhabi. Importantly, they can be rightfully called 'Cyclone Shelters' because, they are designed for winds having a 1 in 10,000 annual chance of being exceeded and Queensland does appropriately belong in the wind code's Region C. This means that their design wind speed is 305 kph and that means they are designed to resist low-level Category 5 cyclones. (The 1 in 10,000 annual chance is the standard adopted in the US for construction of hurricane and tornado shelters. 1 in 10,000 may seem excessive but it is the risk level commonly adopted by engineers for sizing things like dam spillways, where cost-benefit analysis shows spending a few extra dollars will potentially save hundreds of lives.)

The above means that Darwin's shelters are inadequate at two levels – firstly they should be designed for Region D instead of Region C winds and secondly for a 1 in 10,000 annual risk instead of 1 in 2,000 annual risk.

The following shows the consequences on design wind speeds:

Region C and 1:2,000 (Current Darwin 'Emergency Shelters')	276 kph
Region C and 1:10,000 (new Queensland cyclone shelters)	305 kph
Region D and 1:2000 (appropriate for <u>post-disaster</u> shelters in Darwin)	356 kph
Region D and 1:10,000 (appropriate for public cyclone shelters in Darwin)	392 kph

- 4. Property Sector – Surge Maps.** In 2011, the NT Government issued "Storm Surge Inundation for 2100" maps for planning purposes based on modelling work done under Dr. Bruce Harper. AMSTECI has checked the results for the Darwin area using the cyclone track/intensity model data supplied by Wind Risk Tech for the Cook and Nicholls 2009 paper (WRT is a company established by Prof. Kerry Emanuel), and the surge response to cyclone

conditions as determined under an earlier Darwin storm surge study by VIPAC Pty Ltd. If we adopted the same figure as the government to allow for the sea-level rise from global warming (GW) by the year 2100 (0.8 m), we found that our 1 in 1,000 year storm tide exceedence levels (the lowest ground levels allowed for new residential building) were about 1.9 m higher than those given in the government's 2011 maps.

This is an alarming difference and demands further study but AMSTECI believe that our figures are more likely to be accurate. One historical instance that indicates that the government's 2011 maps are too optimistic is detailed on page E10 in Attachment 1. It relates to a hearsay report that during a cyclone in 1919, "*Darwin became an island*". (There is no reason to suspect the source of this statement.) The 1919 cyclone is considered to have been a low-level Category 5 when its centre passed 45 km north of Darwin. It caused hardly any wind damage to trees or buildings in Darwin but did cause some damage to shipping, jetties, etc,. The area inundated to form the island is the crest of a low 'saddle' which separates the headwaters of two tidal creeks at 'The Narrows'. If that crest level is applied to an extrapolation of both the storm tide levels (minus the GW sea level rise) and the frequency data on the 2011 maps, then that distant 1919 cyclone produced a storm tide that should only be exceeded on average once every 200,000 years. Something is obviously wrong somewhere!

AMSTECI are intending to ask the NT Government to commission a further storm tide study using alternative modelling. This is particularly important from a public safety and emergency planning perspective.

**ToR (e) the current roles and effectiveness of the division of responsibilities between different levels of government (federal, state and local) to manage extreme weather events AND**

**ToR (f) progress in developing effective national coordination of .....risk management, including legislative and regulatory reform, standards and codes ..... AND**

**ToR (g) any gaps in ....the steps required for effective national coordination of .....risk management.**

Much could be written under these three ToRs but the two most important matters are:

1. Figure 3.1(A) of Standard Australia's wind code (numbered AS/NZS 1170.2:2011) should be amended to show the Top End coast of the NT being in Region D instead of Region C.
2. There is urgent need for national regulations covering the requirements for cyclone shelters – both public and residential. The BCA (issued and updated annually by the Australian Building Codes Board which is a COAG standards writing body) has next to nothing to say on this important facet of building safety. In particular, Tables B1.2a and B1.2b in Volume One of the BCA and Tables 3.11.3a and 3.11.3b in Volume 2 of the BCA should be amended to include an 'Importance Level 5' which would be specifically for cyclone shelters and would attract an 'Annual probability of exceedence' of 1:10,000

**ToR (h) any related matter**

We use this section to introduce the documents that we consider demonstrate our case that Darwin is indeed at much greater risk from impact of very intense tropical cyclones than allowed for in current building regulation and emergency management arrangements. These documents are listed, in chronological order of their publication, in the References below. They are accessible either via the attachments to this submission or by the web links provided.



**1. Nicholls 2007** was prepared by the writer on behalf of an incorporated community group formed in July 2005 in order to obtain a \$50,000 grant from Emergency Management Australia (EMA) – a division of the Attorney General’s Department which was then under Hon. Phillip Ruddock MP. (The grant was part of the \$33 million Local Grants Scheme which aimed to fund projects which would enhance community safety from emergency risks.)

The report was released on the 10th April 2007 with the launch of a website for that purpose and with a mail-out of one hundred CDs to representatives at all levels of government, to professional bodies and to the media. There was some media interest and our website received many hits – but reaction from governments was disappointing. The Federal Government’s attitude is best demonstrated under the heading “Disclaimers” on the first page of the report (See Attachment 1) where the text (supplied by EMA) contains no less than eight sentences indicating that the Australian Government disclaims all responsibility and gives no endorsement for the report or its findings. However Minister Macfarlane immediately asked Geoscience Australia for their opinion on our report – their comments in the 6 page document to him were mainly negative but they also demonstrated their ignorance on many of the issues.

The Northern Territory Government was more pro-active – they organised a two day workshop to examine the effect that tropical cyclones have on building regulations and public cyclone shelters and invited experts such as Dr. John Holmes and Dr. Bruce Harper to address the invited gathering. (The writer also made a presentation but the chair terminated it half way through and allowed no questions.) The object of the workshop was to defend the status quo.

**2. Cook and Nicholls 2009** It was realised that a self-published report by a retired engineer was not going to counter the advice given to government by acknowledged experts such as Geoscience Australia, Dr. John Holmes and Dr. Bruce Harper and so we decided to seek publication in one of the world’s most prestigious, peer-reviewed journals. After 18 months work and extensive peer review, our paper was published in the American Meteorological Society’s November 2009 issue of the Journal of Applied Meteorology and Climatology (JAMC).

On Saturday, 10<sup>th</sup> December 2009, the front page of the Northern Territory News had a picture of the writer with Darwin’s two tallest apartment buildings in the background (one is 33 storeys high) and the words “*We’re not ready for cyclone*”. The ‘exclusive’ story was followed up on page 2 and on the first three pages of the paper’s Saturday Extra magazine. At my suggestion, the journalist (Paul Toohey) contacted Dr. John Holmes who reportedly said “*I don’t think much of their work. I don’t understand why the American Meteorological Society published such a paper. They wouldn’t get it published here and went to America.*” That was rather churlish of him but more surprisingly, he then went on to question whether the Bureau of Meteorology had gone overboard in describing Cyclones Thelma, Ingrid and Monica as being Category 5. A few days later a letter from Dr. Andrew Tupper, Regional Director of the BoM office in Darwin was published in the NT News where he stated “*We stand by our category assessments which are based on world’s best practice and which are post-analysed after each event. The assessments are never “perfect” since it is impossible to measure the exact worst wind in a cyclone, but we have a high degree of confidence in the category assessments.*” So if nothing else, our paper caused the engineer mainly responsible for setting the wind speeds used for design of buildings in Australia having a public squabble about whether or not the Bureau of Meteorology could measure wind speeds in cyclones.

**3. Harper et al 2012** In November 2010 we received the news that Harper et al had submitted a paper to JAMC which made adverse comment on our 2009 paper – this was good news because it was first time that expert protagonists such as Drs. Harper and Holmes had directly engaged with us in rebuttal. It was also good news because it is the journal’s policy to allow the original authors the right of reply. The Abstract to *Harper et al 2012* concludes with the statement “the authors conclude that Darwin’s tropical cyclone wind risk is adequately described by its location in region C.” It must be stated that the authors are an impressive list of experts: Dr. Bruce Harper is acknowledged as one of Australia’s foremost experts on storm surge modelling; Dr. John Holmes is acknowledged as one of Australia’s foremost experts on wind engineering for structures and was a long-time chairman (and still current committee member) of the Australian Standards Committee responsible for the writing of the wind code; Dr. Jeffrey Keperter is probably the Bureau of Meteorology’s foremost expert on tropical cyclones, Luciano Mason works for the Australian Maritime College (an institute of the University of Tasmania) and has done extensive work on storm surge studies; finally, Dr. Peter Vickery is acknowledged as one of the foremost wind engineers in the US and his company has written most of the wind load provisions currently used for the design of structures along the hurricane affected regions of the US and the Caribbean. Given that impressive list, it is astonishing that the *Harper et al 2012* rebuttal is so weak in its arguments and we conclude that most of the authors were mainly coopted to boost the credentials of the paper and were unable to devote the time to adequately examine its details.

**4. Cook and Nicholls 2012** *Harper et al 2012* did uncover some minor errors in our 2009 paper, but their corrections made hardly any difference to our bottom line figures and no difference to our conclusions. The Abstract to our 2012 reply to Harper et al concluded that the main points of their criticisms were invalid and that our earlier conclusion that Darwin’s wind hazard is substantially underestimated in the current Australian wind code is correct.

**5. Conclusion** It is now 16 months since the last two papers were published in a respected journal with an international readership but little has been done to resolve the important issues at stake. Governments have a duty of care to prepare and protect the community from natural disasters using the best available estimates of the risks from those disasters. AMSTECI urge the Australian Government to commission a well-funded, independent report to resolve the issues presented, particularly the conflict epitomized by the last two papers discussed above.

## References

Nicholls, M. J. 2007. Review of NT Cyclone Risks. *A report published by The Community Group for the Review of NT Cyclone Risks Inc.* (see **Attachment 1 to this submission**)

Cook, G. D. and M. J. Nicholls. 2009. Estimation of tropical cyclone wind hazard for Darwin: comparison to two other locations and the Australian wind loading code. *J. Appl. Meteor. Climatol.* **48**: 2331 –2340. <http://journals.ametsoc.org/doi/pdf/10.1175/2009JAMC2013.1>

Harper, B. A., J. D. Holmes, J. D. Keperter, L. M. Mason and P. J. Vickery. 2012. Comments on "Estimation of tropical cyclone wind hazard for Darwin: comparison with two other locations and the Australian Wind-Loading Code". *J. Appl. Meteor. Climatol.* **51**: 161 – 171. (May be found on-line by a link in Keperter’s publication list at <http://www.cawcr.gov.au/staff/jdk/mypapers.pdf> )

Cook, G. D. and M. Nicholls. 2012. Reply (to Harper et al.) *J. Appl. Meteor. Climatol.* **51**: 172 - 181. (see **Attachment 2 to this submission**)