Water Spout Damage At Lennox Head

M.J. Glanville[1] and J.P. Quinn[2]

1. Cermak Peterka Petersen Pty Ltd.
2. ECS Pty Ltd.

1. INTRODUCTION

A water spout swept through the coastal town of Lennox Head 3rd June 2010 causing extensive property damage. This paper documents observed damage and attempts to trace the path of the spout and quantify intensity of winds.

2. BACKGROUND

At 7:30 am on 3rd June 2010 a water spout swept through the coastal town of Lennox Head on the far north coast of New South Wales causing extensive damage to houses, overturning caravans and bringing power lines down. Wind driven debris from the destroyed homes was spread over a wider area and caused cosmetic damage to homes not directly impacted. There were no reported serious injuries.

Fair-weather waterspouts are intense low pressure vortex columns that most frequently develop on the sea surface typically lasting from 2 to 20 minutes. The funnels occur most frequently off the lee shores of continents in the tropics and sub-tropics. Because of their small size water spouts have rarely passed over a weather station although their intensity at maturity is known anecdotally to be of cyclonic strength.

The water spout at Lennox Head formed under a supercell at sea and moved over land. Similar water spouts were observed off the NSW coast in the weeks preceding the event including Byron Bay 20 km to the north of Lennox Head, Cronulla in Sydney and Broulee on the State's South Coast. On 2nd May 2010 a water spout caused damage to a caravan park at The Entrance in central NSW with recorded injuries. On 4th August 2006 a water spout was filmed ripping the roof off a house in La Perouse Sydney landing some 100 m downstream.

3. DAMAGE OVERVIEW

Fig. 1 traces the approximate path of the spout between landfall near the corner of Pacific Parade and Lennox Street then moving inland in a north-westerly direction over Stewart Street before losing intensity at Lake Ainsworth Caravan Park.

A photographic recording of the damage was obtained during a site inspection within hours of the storm by Quinn and also on 12th June 2010 by Quinn and Glanville. A summary of the damage sustained to each of the dwellings within the effected zone are shown in Fig. 1, ranked by the authors against the Enhanced Fujita scale (2006), Fig. 2.

Of the 12 homes estimated to have sustained damage at Enhanced Fujita scales of EF1 and EF2, 7 were estimated to be of pre 1980 construction, and 5 of more recent construction. Of the 3 homes estimated to have sustained EF2 level damage, 2 appeared to be of post 1980 construction. Some photographic examples of property damage are provided in Fig. 2. Comparing the observed damage against the Enhanced Fujita Scale it could be estimated winds reached velocities of up to 60 m/s.

The path of recorded damage is traced in red lines of Figure 1. Shattered windows and damaged cladding due to projectile impact was observed beyond this boundary.

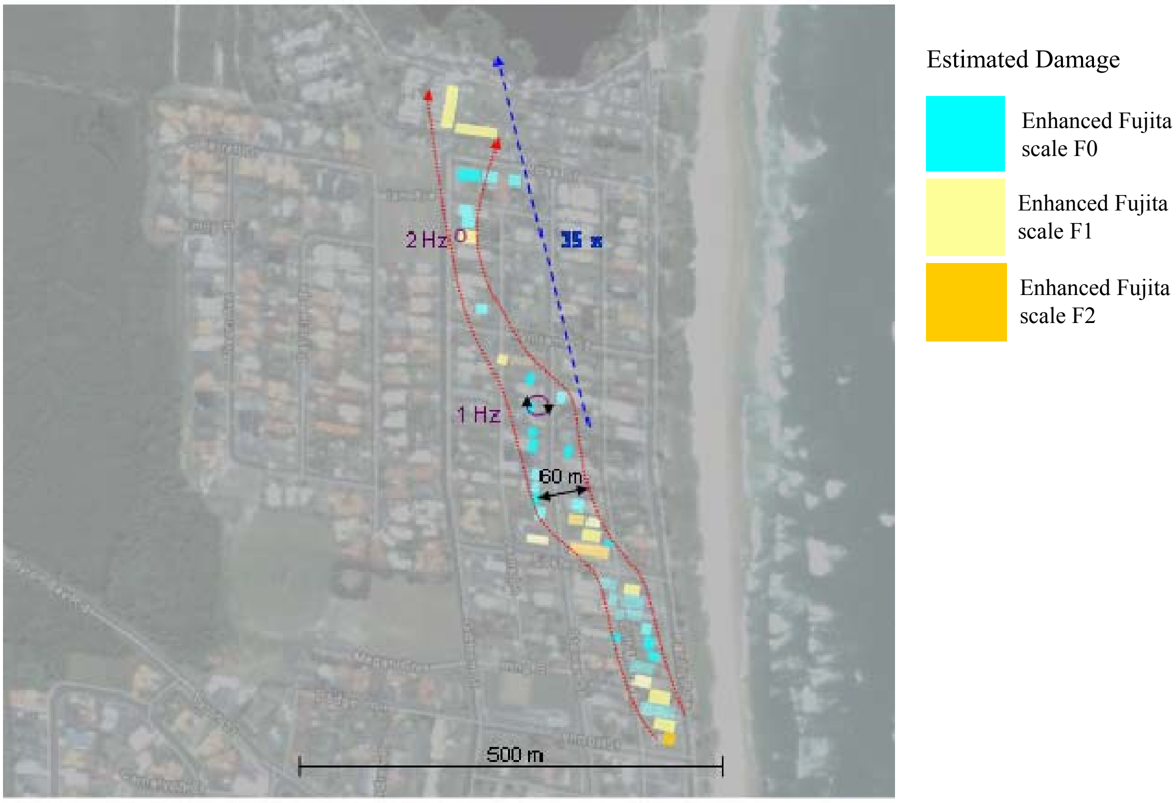

Fig. 1 Water spout path through Lennox Head 3rd June 2010 with recorded damage.

Enhanced Fujita scale EF0, 29-38 m/s Enhanced Fujita scale EF1, 39-49 m/s Enhanced Fujita scale EF2, 49-60 m/s

Fig. 2 Example Water spout damage at Lennox Head.

4. OBSERVED STRUCTURAL FAILURES

The least affected roofs of the damaged structures in the direct path of the spout were those with hip construction, regardless of the roof slope. Secondly were the skillion roofs, which tended to be on construction built most recently, and most affected were gable roofs, regardless of their orientation.

The collapse of windward gable ends typically followed a breach of the gable cladding. Collapsed gables were typically observed with strutting beams absent. In considering the design windward pressure, (with reference AS4055 & AS1170), the presence of the strutting beam constructed to AS1684 was considered similar in effect to the bracing ridge on the hip constructed roofs, which resisted direct windward pressure the most effectively. On failure of the gable end, the windward and leeward roof could expect up to about 80% more design uplift due to increased roof cavity pressure, depending on the roof constructed in either metal sheet or tile construction. Typically, the rest of the roof would fail by uplift, progressively. The most graphic example of this is the loss of the leeward roof on a building on the rear of Pacific Pde, with the roof section landing on the windward side on the southern end of Stewart St. Dutch gable ends, similarly on a hip roof construction on the east of Stewart St, were deposited on the roof of buildings on the opposite side of the street, also at the southern end of Stewart St.

Leeward roof sections were more affected on steel sheet roofs than tiled roofs. On the worst affected, there was a conspicuous absence of tie down. Typically for the area, tie down would consist of 30x0.8mm galvanised (G330 Typ) strap + 3 x 3.5mm x 35 Flat head, connecting truss to stud, which is not to be confused with tie down or 'Cyclone' rods, typically M10 or M12mm thread mild steel at 1.2 to 1.8m centres through to the top plates. Older construction, typically in hard wood framing did not have this provision, and would be expected to have ~75 x 2.4mm skew nail from truss to top plate.

Skillion roofs constructed most recently will have tie down straps at a ratio of 1:1 truss:frame, with few observed failing. A notable exception was the skillion roof, down sloped at mid Pacific Pde. This roof did not fail from absence of tie down, instead several rafters appear to have broken in bending in the zippering effect during uplift. The building was constructed in unreinforced, and unengaged brick masonry. The heights of the masonry construction appeared in general compliance with AS3700 and BCA S3.3, however there were little side ties, in a direction parallel to the rafters. This is not unusual. The increased pressure from the partial failure of the leeward or windward roof, leads to a 'significant opening' as defined in AS1170, creating an outward pressure greater than would be expected in the design. The masonry then appears to behave as unengaged, non laterally supported, and at up to two storey, collapsed with the loss of the roof. Another example of this is the two storey brick construction, collapsed east through west between Gibbon and Stewart St.

Tiled roofs fared better than steel sheet generally. A tiled roof collapsed under the (debris) of a steel sheet roof dropped from Pacific Pde. Tiled roofs tended to not 'zipper' as a result of the event, with most damage through debris.

Roofs and walls having sarking of any type fared better than those without. Sarking was observed to enclose framing from a lost roof or wall sheet. It is apparent the presence of sarking, even damaged, resisted negative and inward pressures, sealing significant outer breaches. The presence of the sarking appeared to protect the roof cavities from charging pressure.

Tie down (rod), strap and ply bracing were effective at resisting windward pressure. Two storey construction at one location was found to resisted 30mm lateral movement and racking. Buckling in the bracing, provided on the internal wall side resulted in damage to the internal linings, unlike that provided in the external side, and in most cfc clad buildings with significant 'nominal sheet bracing'.

Two featured heavily damaged buildings - one constructed of poly, showed little lateral resistance, with racking poorly resisted in the mode above, and a brick construction on the beach- losing its upper floor, constructed with little or no rod, with racking/sliding poorly resisted in the mode above.

5. ESTIMATED WIND INTENSITY

Some video footage of the water spout is available in the public domain (e.g. www.youtube.com/J1MZO#p/search/0/s0GB1i0Zs5A). Inspection of the video footage and triangulation against some Lennox Head landmarks provides approximate dimensions of the spout. Rotational speed could also be estimated from footage of dust and smaller debris being carried by the funnel. It was estimated the funnel diameter varied between about 15m and rotational frequency 1 Hz shrinking to approximately half that diameter at times but with twice the rotational speed. With reference to Fig. 1 these diameters are reasonably consistent with the path of recorded damage. Hence the maximum tangential velocity of the funnel was in the order of 50 m/s being consistent with the observed damage as rated against the Enhanced Fujita scale.

During the period of video footage it is estimated the spout travelled a path of approximately 500 m in 35 seconds (Fig. 1), i.e. an average velocity of 14 m/s. Thus velocities experienced in the path of the spout could therefore have been in the vicinity of 65 m/s.

6. DISCUSSION

Three separate water spout events causing property damage (approximately 20 residential dwellings damaged) have been recorded over the past five years to the author's knowledge in populated areas of NSW. Statistically this represents about 4 homes across the state per year suffering EF2 level damage. The number of residential homes within a 1 km distance from the NSW coastline potentially prone to direct water spout impact would number in the tens of thousands hence the risk to any one home from water spout impact based on historic evidence is negligible.

Notwithstanding, roof sheeting and other building projectiles strewn widely and at high velocity across a residential area is a community risk. Other hazards such as asbestos cladding spread across vast areas represent a costly clean up. In this sense a tornado risk model for transmission lines, e.g. Twisdale and Dunn (1983), may be better suited for modelling the impact of water spouts on the narrow coastal 'line like' strip where a failure of any one structure has more widespread implication.

7. CONCLUSIONS

It is estimated the Lennox Head spout travelled a path of approximately 1 km inland reaching velocities in the order of 65 m/s. Property damage resulting from the spout was estimated to be as high as EF2 on the Enhanced Fujita scale and some structural failure mechanisms of the homes have been identified. Roof sheeting and other building projectiles strewn widely and at high velocity represent a community risk.

8. REFERENCES

[1] Building Code of Australia, Class 1 and Class 10 Buildings Housing Provisions Vol 2 (2008)

[2] McDonald, James; Kishor C. Mehta, "A Recommendation for an Enhanced Fujita Scale (EF-Scale)", Lubbock, Texas Wind Science and Engineering Research Center, (2006)

[3] Twisdale, L. A. and Dunn, W.L. "Probabilistic analysis of tornado wind risks", Journal of Structural Engineering (A.S.C.E.) (1983)

[4] Standards Association of Australia, Structural Design Actions, Part 2: Wind Loads, Australian Standard 1170.2, (1989).

[5] Standards Association of Australia, Wind Loads for Housing, Australian Standard 4055, (1992).

[6] Standards Association of Australia, Residential Timber Framed Construction – non cyclonic areas, Australian Standard 1684.2, (2010).

[7] Standards Association of Australia, Masonry structures, Australian Standard 3700, (2001).