

Cyclone Testing Station Preliminary Damage Report

Tropical Cyclone Olwyn, WA, Australia

March 11-14th, 2015



(Reference: Perth Weather Live)

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About the International Wind Hazard Damage Assessment Group

This report was prepared predominantly from media-sourced content by the Cyclone Testing Station at James Cook University and engineering faculty and students at the University of Florida. The study compliments experimental research at both institutions seeking to characterize extreme wind events and their impact on civil infrastructure. The purpose of the report is to provide a preliminary engineering assessment of severe weather events, within the first 24 to 48 hours when recovery decisions are critical. As a result, much of the information is necessarily collated from immediately available sources (i.e. social media, local news outlets, weather agencies, etc.).

The International Wind Hazard Damage Assessment Group was originally created by Dr. David Prevatt at the University of Florida and expanded to Australia in 2014 through Dr. Daniel Smith and the Cyclone Testing Station at James Cook University. Central to its objectives, is training university students and personnel in novel forensic engineering and techniques for post-hazard damage surveys and data collection. The team has surveyed damage after severe wind events throughout the Australia and the U.S. and continuously monitors severe wind events worldwide.

Please visit <https://www.jcu.edu.au/cts/> and <http://windhazard.davidoprevatt.com> for additional information, and for access to previous rapid assessment damage reports. Questions and comments on any aspects of our work are most welcome. Please direct your enquiries to Dr. Daniel Smith (daniel.smith8@jcu.edu.au) or Dr. Geoff Boughton (boughton@timbered.com.au) at the Cyclone Testing Station or NSF Graduate Research Fellow and PhD Student, Mr. David B. Roueche (david.roueche@ufl.edu) at the University of Florida.

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BACKGROUND

At 12:57 PM (Australian Western Standard Time) on Tuesday, 10 March 2015, the Australian Government Bureau of Meteorology (BoM) issued a four day outlook for the West Pilbara coast, noting “the most likely scenario is for the low to track towards the West Pilbara coast and develop into a tropical cyclone late Wednesday or on Thursday” (Figure 1). Port Hedland to Ningaloo, including Karratha, Onslow and Exmouth were listed as watch zones. The threat materialized when the BoM announced Tropical Cyclone Olwyn had formed at 2:57 PM on Wednesday, 11 March, approximately 500 km (311 mi) North of Karratha and 660 km (410 mi) N-NE of Exmouth in Western Australia, and continued to strengthen as it moved South. The BoM issued a tropical cyclone warning for the coastal region of Port Hedland to Ningaloo. The convective outlook included destructive winds and potential for flooding.

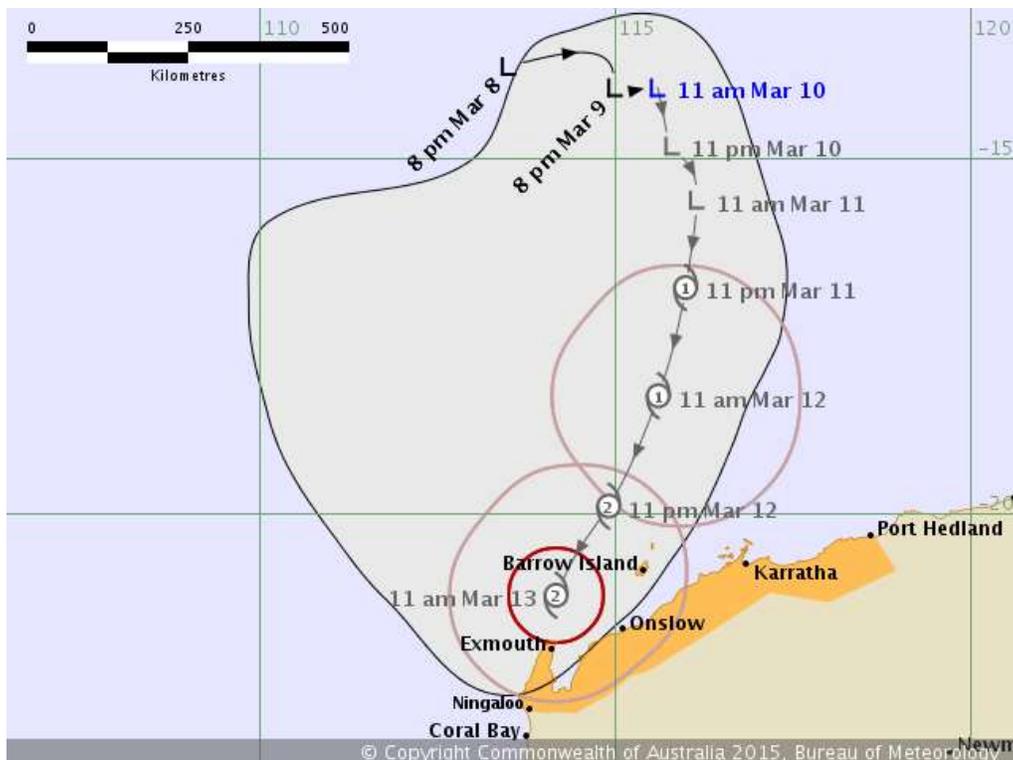


Figure 1. The Australia Bureau of Meteorology severe weather outlook issued at 12:57 PM on 10 March, 2015).

The BoM’s outlook for 12 March as of 6:00 PM is provided in Figure 2. The southerly moving system was expected to affect the towns of Exmouth, Coral Bay, Carnarvon, Denham, Geraldton and weaken to a tropical low south of Jurien Bay. Preliminary warnings for Perth and the South West of WA were issued in news broadcasts.

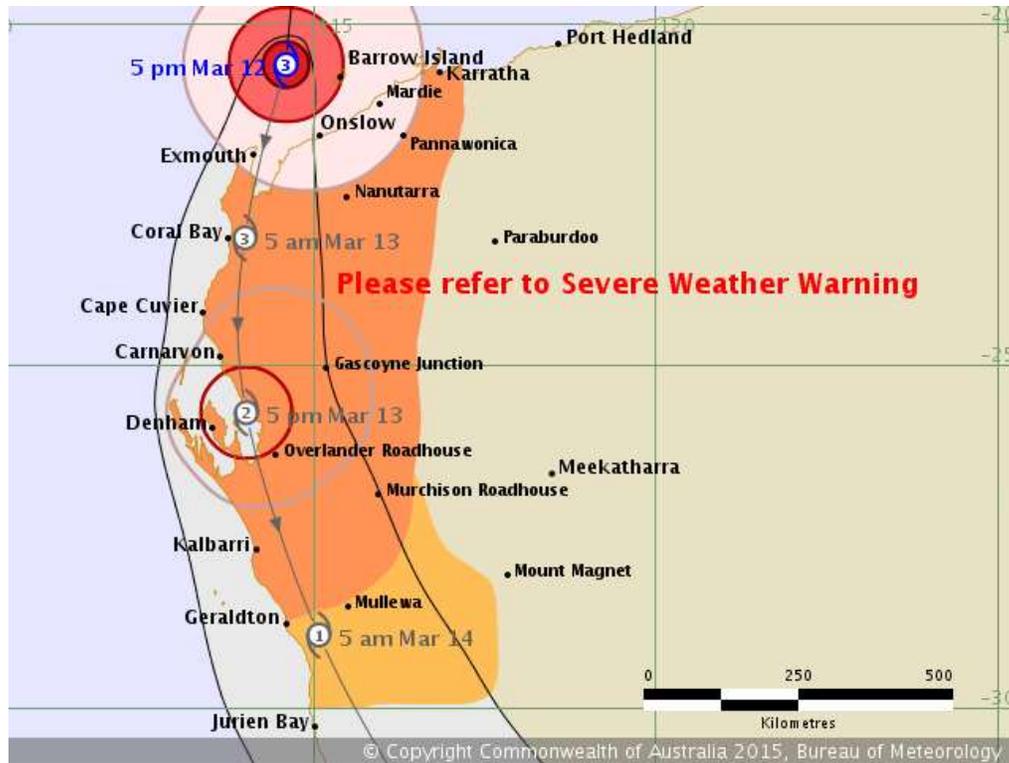


Figure 2. The Australia Bureau of Meteorology severe weather outlook as TC Olywn is upgraded to Category 3 (issued at 6:00 PM on 12 March, 2015).

On Friday, March 13, 2015 at approximately 1:00 AM Tropical Cyclone Olywn crossed the West Pilbara coast near Exmouth as a Category 3 cyclone (sustained wind speeds greater than 118 km/h). The BoM anemometers recorded maximum 10 minute mean wind speeds of 137 km/h (85 mph) with gusts (3-second average) up to 180 km/h (112 mph) at Learmonth Airport near Exmouth around 1:30 am on March 13, 2013.

Exmouth is in wind Region D as defined in AS 1170.2 as shown in Figure 3 with regional design gust wind speed in standard conditions for Importance Level 2 buildings of 316 km/h (88 m/s, 196 mph). Residential structures designed in WA since the mid-1980s should meet a design wind speed defined in different ways in the varying standards but with an ultimate wind speed equivalent always near 310 km/h (86 m/s, 193 mph). Hence the recorded peak gust in the cyclone near landfall was ~64% of the design ultimate wind speed for residential buildings in that location (allowing for the conversion of 3 second gusts to design wind speeds).

After first crossing the coast near Exmouth with wind speeds within the Category 3 range, the tropical cyclone continued mainly over land near Coral Bay to Carnarvon. These three towns are within Region D. From the BoM data, wind speeds were well below design level in all of the affected areas. By the time it reached Carnarvon (very close to the southern edge of Region D, the measured gust wind speed of 146 km/h (41 m/s, 91 mph) was ~53% of the current Region D

ultimate wind design velocity (allowing for the conversion of 3 second gusts to design wind speeds).

Table 1. Ultimate design regional wind speeds by region for 1/500 annual probability (appropriate for housing and other Importance Level 2 structures)

Regions	V_u (m/s)(mph) AS 1170.2:1989	V_{500} (m/s)(mph) AS/NZS 1170.2:2002	V_{500} (m/s)(mph) AS/NZS 1170.2:2012
A	50 (112)	45 (101)	45 (101)
B	60 (134)	57 (128)	57 (128)
C	70 (157)	69 (154)	69 (154)
D	85 (190)	88 (197)	88 (197)

(Source: Australian Standard AS 1170.2:1989 to AS/NZS 1170.2:2012)

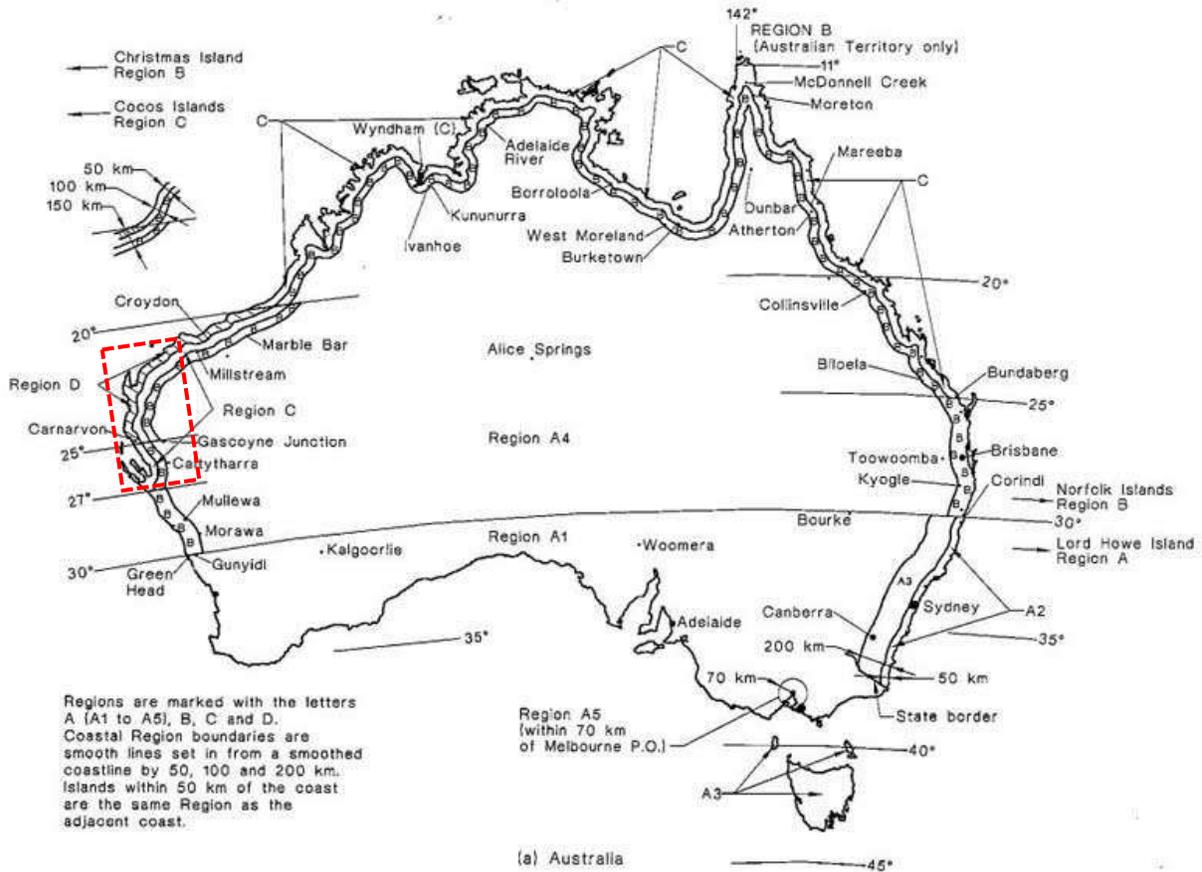


Figure 3. Design wind speeds for Australia based upon AS 1170.2 (2002). The region impacted by Tropical Cyclone Olwyn (highlighted by the rectangle) has a design wind speed varying from 88 m/s (316 km/h, 197 mph, $V_{0.2}$) for Exmouth to Carnarvon in Region D, to 57 m/s (205 km/h, 128 mph, $V_{0.2}$) at Geraldton in Region B.

PREVIOUS CYCLONES

Cyclone Vance passed over Exmouth in March 1999. The BoM listed Vance as a Category 5 cyclone. The AWS at Learmonth, (35 km S of Exmouth), measured gusts of 267 km/h (166 mph), setting a new high record for recorded wind speed in mainland Australia at the time. Wind speeds on buildings ranged from 200-250 km/h (124-155 mph). Comprehensive damage reports on TC Vance were completed by the Western Australian Department of Local Government and the Cyclone Testing Station (report available at the CTS website: <https://www.jcu.edu.au/cts/publications/content/technical-reports/jcuprd1-071967.pdf/view>).

TC Vance continued on a much more inland path than that shown for TC Olwyn and Carnarvon was not significantly affected by it. Field damage assessments will be conducted in Exmouth and the surrounding areas by the CTS and performance comparisons from TC Vance to TC Olwyn will be included in a comprehensive report to be completed in the coming months.

TIMING OF STORM

The timeline (per BoM alerts) of Tropical Cyclone Olwyn as it impacted the Western Australia coast is as follows (note all times are Australian Western Standard Time - AWST):

March 11, 2015

8:51 AM – First Cyclone Warning issued for Roebourne to Ningaloo. TC Olwyn moving S-SW at 10 km/h (6 mph).

2:57 PM – Tropical Cyclone Olwyn has formed at a Category 1 North of WA, and will track towards the West Pilbara coast. Warning zone expanded from Port Hedland to Ningaloo. Sustained winds estimated at 65 km/h (40 mph) and gusts 95 km/h (59 mph).

March 12, 2015

1:54 AM – TC Olwyn intensifies to Category 2, expected impacts from Thursday. Sustained winds estimated at 95 km/h (59 mph) and gusts of 130 km/h (81 mph).

6:00 PM – TC Olwyn upgraded to Category 3 as it rapidly approaches the West Pilbara coast. Sustained wind estimated at 120 km/h (75 mph) with gusts of 165 km/h (103 mph).

March 13, 2015

1:20 AM – TC Olwyn is located 25 km (15.5 mi) West of Exmouth and making landfall as a Category 3. Storm tide warnings are made.

1:30 AM – Maximum 3 second gust of 180 km/h (112 mph) measured at Learmonth weather station

9:01 AM – Category 3, sustained winds estimated at 150 km/h (93 mph) with gusts to 205 km/h (127 mph). Estimated to be 75 km (47 mi) S-SW of Coral Bay and 120 km (75 mi) North of Carnarvon moving South at 24 km/h (15 mph).

1:30 PM – Maximum 3 second gust of 146 km/h (91 mph) measured at Carnarvon AWS. This is within the Category 2 range.

6:55 PM – Category 2, sustained winds estimated at 110 km/h (68 mph) with 3 second gusts to 155 km/h (96 mph). Estimated to be 25 km (15.5 mi) E-NE of Denham and 210 km (130 mph) N-NW of Kalbarri moving S-SW at 24 km/h (15 mph).

March 14, 2015

12:00 AM – Category 1, sustained winds estimated at 85 km/h (53 mph) with 3 second gusts to 120 km/h (75 mph). Estimated to be 45 km (28 mi) N-NE of Kalbarri and 165 km (103 mi) North of Geraldton.

4:03 AM – Maximum 3 second gust of 76 km/h (47 mph) measured at Geraldton AWS. This is below the Category 1 range. The centre of TC Olwyn was plotted to the East of Geraldton.

8:00 AM – Ex-Tropical Cyclone Olwyn weakened below cyclone intensity. Sustained winds estimated at 55 km/h (34 mph) with 3 second gusts to 85 km/h (53 mph).

STORM TRACK AND INTENSITY

Figure 4 shows the track of TC Olwyn based upon bulletins from the Australian Bureau of Meteorology (BoM). Times are given in Australian Western Standard Time (AWST), which is 8 hours ahead of UTC. It should be noted that the Category designations are from the BoM. The scales are summarized in Table 2. Note that the Australian classification uses 10-minute sustained (mean) as opposed to the 1-minute sustained (mean) used by the Saffir-Simpson Scale in the U.S.. Therefore, the 3-second peak gust speeds (used by both scales) should be used for comparison purposes.

Table 2. Wind speed categories (in km/h) for Australian BoM and Saffir-Simpson Scale

Cyclone Category	Australia Bureau of Meteorology		Saffir-Simpson Scale	
	10-min Sustained	3-sec Gust	1-min Sustained	3-sec Gust
Category 1	63-88	91-125	119-153	154-200
Category 2	89-117	125-164	154-177	201-230
Category 3	118-159	165-224	178-209	232-272
Category 4	160-200	225-279	210-249	273-325
Category 5	>200	>279	≥250	>325

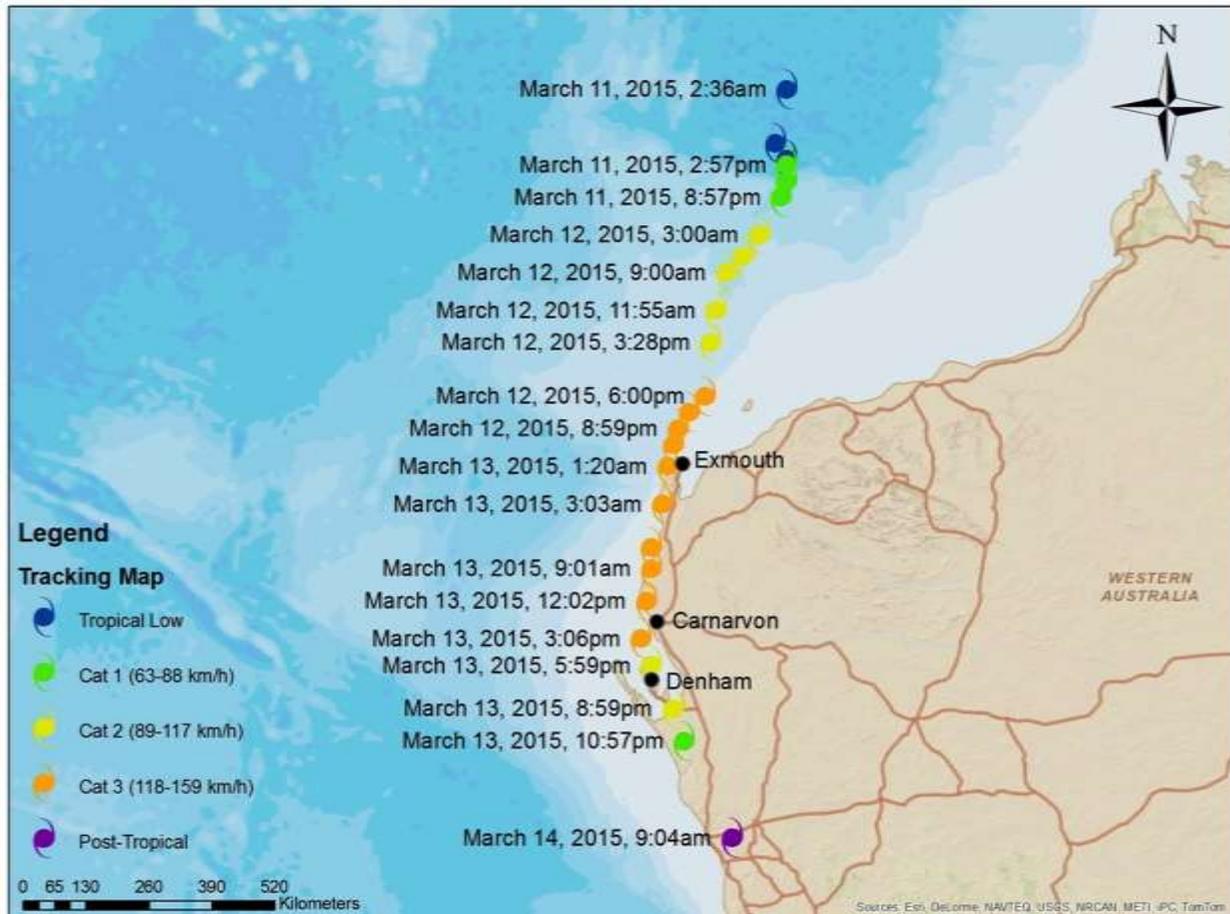


Figure 4. Tracking map for Tropical Cyclone Olwyn based upon bulletins from the Australian Bureau of Meteorology. Times are in Australian Western Standard Time (+8 UTC). The legend shows cyclone categories with 10-minute sustained wind speeds (See Table 1 for 3 second gust speeds).

Figures 5-7 provide summarized time-history data for the BoM automatic weather stations (AWS) located at Learmonth, Carnarvon, Geraldton, and Pearce that are available on the public BoM website. The Denham information comes from personal correspondence with the BoM as this AWS presents only daily summaries on the public BoM website.

In each of Figures 5-7, the data from the four AWS have been summarized to show the reduction in intensity of the system with time over land. This is raw data and has yet to be confirmed by the Bureau of Meteorology. Their more detailed analysis of the AWS data may involve correction for calibration factors of each instrument and establishing whether the reported data may have been truncated or corrupted for any reason. However, for a preliminary assessment, the data shows that measured wind speeds correlate well with measured pressures and show a consistent reduction with time over land.

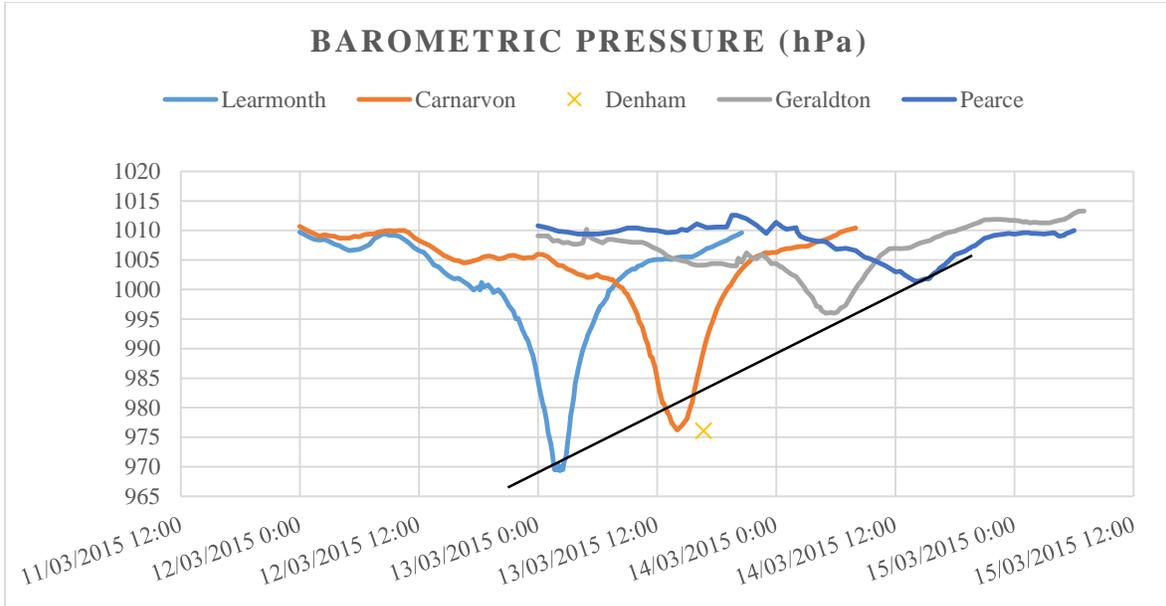


Figure 5. Barometric pressure (hPa) time-histories for BoM automatic weather stations during Tropical Cyclone Olwyn.

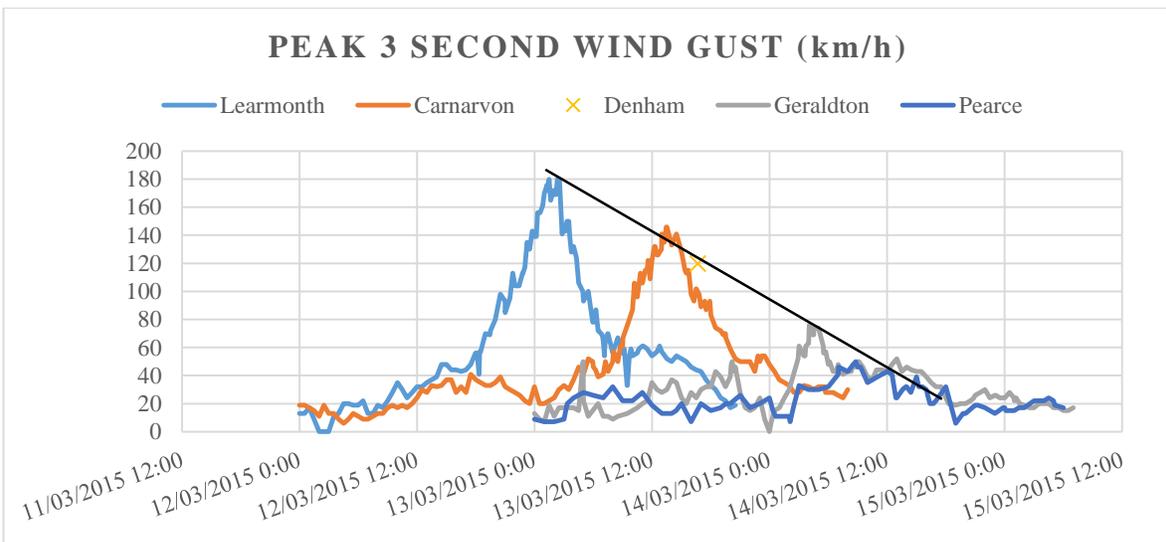


Figure 6. Peak 3 second wind gust (km/h) time-histories for BoM automatic weather stations during Tropical Cyclone Olwyn.

The change in wind speed and central pressure has been highlighted in Figures 5 and 6 by trend lines. In Figure 7 the change in direction with the passage of the eye has been highlighted using ellipses for Learmonth, Carnarvon, Geraldton and Pearce from left to right on the plot. For both Exmouth and Carnarvon, the wind shifted from SE to N via E with the peak wind coming from NE. For both Geraldton and Pearce, the wind shifted from SE to NW via W with the peak wind coming from SE.

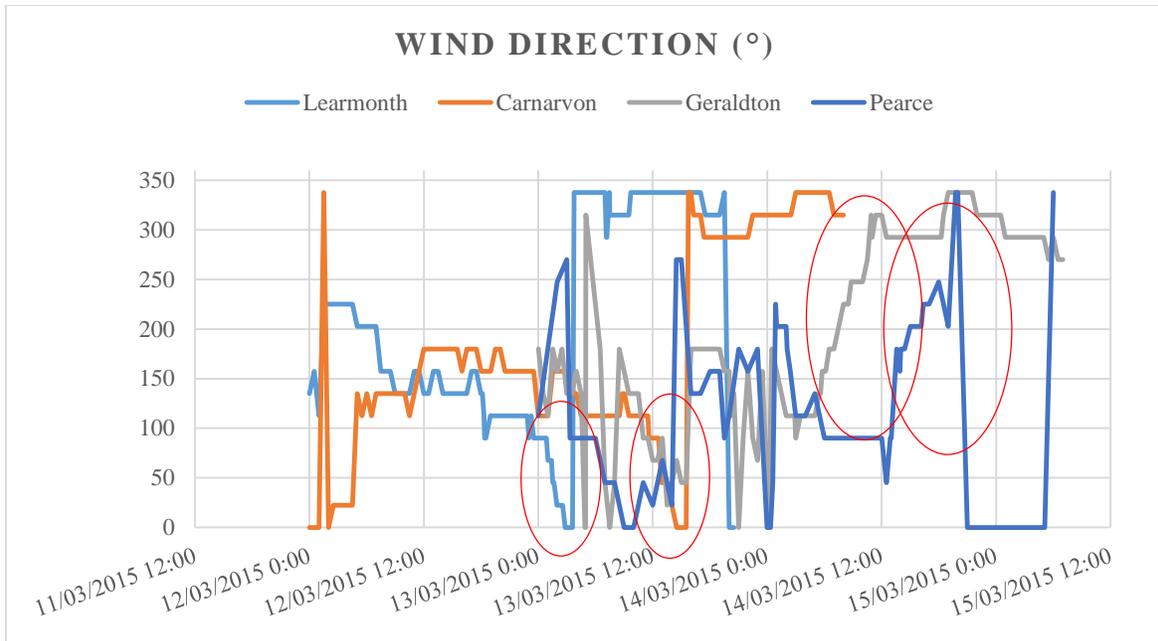


Figure 7. Wind direction (°) time-histories for BoM automatic weather stations during Tropical Cyclone Olwyn.

OBSERVED DAMAGE

Photos in this section have been sourced from publicly available media and social media sites. Analysis is based on photo observations, discussions with WA Department of Fire and Emergency Services (DFES) and other people from the towns affected.

Exmouth

The population of Exmouth is approximately 2200 as of the 2011 census. Media reports from Exmouth indicated that 20 buildings needed SES attention. Indications are that roof damage was relatively minor. Damage to a power poles and older light industrial building shown in Figures 8 and 9 respectively is reminiscent of that seen after TC Vance in 1999, but this type of damage was more widespread in TC Vance.



Figure 8. Damage to power poles in Exmouth (Courtesy: ABC news).



Figure 9. Damage to shed in Exmouth (Courtesy: Daniel Mumby)

Figure 10 shows fence and tree damage in Exmouth. As the media chose to show this type of damage, it is likely that there is little structural damage to report.



Figure 10. Fence damage in Exmouth (Courtesy: Perth Now).

Water penetration into buildings appears to have caused some non-structural damage with anecdotal reports of ceiling loss and significant water ingress in a number of newer houses. Figure 11 shows one that has lost flashing. Water was reported to have gained entry to the ceiling space through flashings, and to the floors via window weep-holes. In some cases, new houses with no apparent physical damage sustained significant water damage to linings.



Figure 11. Flashing damage to more recent buildings in Exmouth

Carnarvon

The population of Carnarvon is approximately 4500 per the 2011 census. The majority of buildings in Carnarvon were constructed prior to 2000. Media focus has been on the total loss of the banana plantations and damage to other crops with a few photos showing roof damage to older commercial and residential buildings.



Figure 12. Damage to banana crops at Carnarvon (Courtesy: Katie Pilgram).

Much of the reported building damage was due to trees as shown in Figure 13 and wind loads on roof sheeting in older buildings as shown in Figure 14.



Figure 13. Fallen tree damage to a building in Carnarvon (Courtesy: Perth Weather Live).



Figure 14. Roof loss at batten-to-truss connection in Carnarvon (Courtesy: Mary Bettini)

News reports indicate that the wind in Carnarvon was the strongest in 50 years, so it is likely that many older houses with nailed batten to truss or rafter connections have never experienced a strong enough wind to test the connections before. Figure 15 shows a similar type of failure to metal clad roofing in agricultural buildings just North of Carnarvon. Reports have also suggested several newer tiled roofs have also sustained damage.



Figure 15. Roof loss at truss/batten connection Boolathana Carnarvon (Courtesy: Mary Bettini)

Denham/Geraldton

The population of Denham per the 2006 census is approximately 600. Some roof damage to buildings was reported in Denham, however media-sourced information was unavailable for this region. The population of Geraldton is approximately 36,000 per the 2011 census and damage reports in Geraldton were mainly confined to flooding and tree damage.

SUMMARY

The path of TC Olwyn was very close to the path predicted by the BoM four days prior to landfall. The intensity predicted at landfall one day in advance of its arrival was also accurate. Warnings showed appropriate categories through the duration of TC Olwyn. The preliminary data from AWS anemometers (which remained functioning throughout the event) were used to relate wind speeds to preliminary reports of damage:

- **Exmouth:** Peak 3-second gust wind speed was measured at 180 km/h (50 m/s, 112 mph), approximately 64% of the Region D design wind speed for housing (allowing for the conversion of 3 second gusts to design wind speeds). A few older buildings appear to have been damaged in spite of the fact that the town experienced much higher wind speeds in TC Vance (1999). However, even at the recorded wind speeds, water entry appears to have been a problem.
- **Carnarvon:** Peak 3-second gust wind speed was measured at 146 km/h (41 m/s, 91 mph), approximately 53% of the Region D design wind speed for housing (allowing for the conversion of 3 second gusts to design wind speeds). A number of older buildings appear to have been damaged. These have been the focus of news reports together with the impact on banana plantations.
- **Denham:** Peak 3-second gust wind speed was measured at 120 km/h (33 m/s, 75 mph), approximately 55% of the Region C design wind speed for housing (allowing for the conversion of 3 second gusts to design wind speeds). Minimal structural damage appears to have been sustained.
- **Geraldton:** Peak 3-second gust wind speed was measured at 76 km/h (21 m/s, 47 mph), approximately 36% of the Region B design wind speed for housing (allowing for the conversion of 3 second gusts to design wind speeds). Minimal structural damage appears to have been sustained.