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Super Typhoon HAIYAN in Tacloban City & Leyte, Philippines

Data & documentation from the landfall zone of a Category-5 cyclone.

storm	Super Typhoon HAIYAN (YOLANDA)		
location & date	Tacloban City & Leyte, Philippines – 08 November 2013		
report date	03 April 2014		
author	Josh Morgerman	version	1.0



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1. Introduction

On the morning of 08 November 2013, **Super Typhoon HAIYAN** (known by Filipinos as **YOLANDA**) struck the Eastern Visayas region of the Philippines.

After first brushing S portions of the island of **Samar** in the early-morning darkness, the cyclone came ashore on the island of **Leyte** just after dawn. The region's capital, Tacloban City (pop. 221K), was in the firing line, experiencing a direct hit from the cyclone's inner core as the center crossed the coast ~14 n mi S of Downtown.

HAIYAN was extremely severe at landfall in Leyte—a Category 5 on the Saffir-Simpson Hurricane Wind Scale. Tacloban City is therefore the largest population center to receive a direct hit from such a strong cyclone since Santo Domingo, Dominican Republic, was stricken by Hurricane David in 1979.

It's difficult to overstate the storm's impact on this region. The destruction was massive, and death-toll estimates range from 6,000 to >10,000, making HAIYAN by-far the deadliest Philippines typhoon since the 19th century.

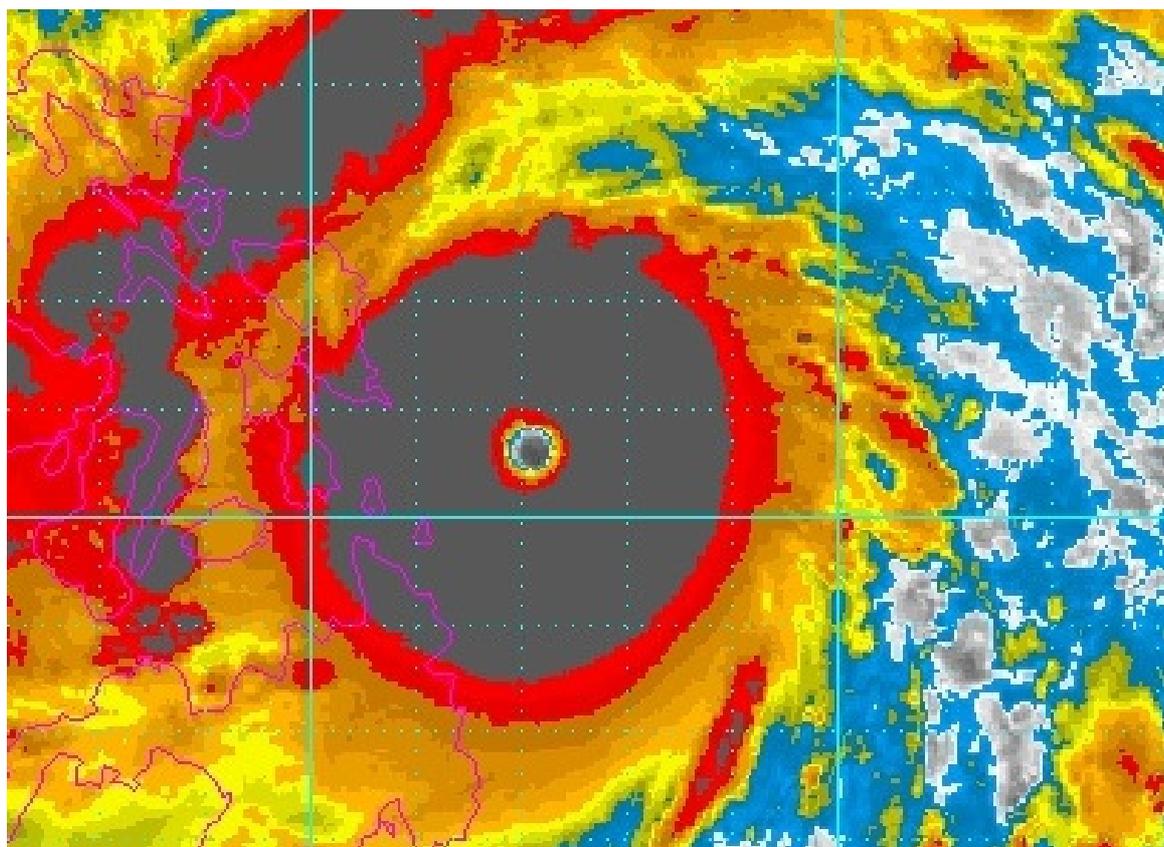


Figure 1. Infrared satellite image of HAIYAN as it approached the Philippines, the night before landfall (1657Z 07 Nov 2013).



1.1 Purpose

HAIYAN struck a region of the world that isn't covered by reconnaissance aircraft. The few weather stations in the typhoon's landfall zone—for example, Tacloban City's airport—delivered sparse, incomplete data from the event. The nearest radar site, Cebu City, is ~80 n mi from the landfall point and >85 n mi from Tacloban City. Much of the stricken region is sparsely populated, with many residents living in small villages, in poverty.

Given all this, we're still learning about what happened in the typhoon's direct-impact zone—that is, the stretch of Leyte coast stricken by the typhoon's inner core.

This report attempts to add to the growing body of knowledge about this typhoon's meteorological impact in Leyte.

1.2 Background & Scope

The author was in Tacloban City during the typhoon, collecting data, recording the event on time-stamped video, and making detailed observations. The author returned to the region in late February and early March 2014 to research the cyclone's impact in Leyte and Samar. These two expeditions—during and after the typhoon—form the basis of this report.

Despite the above, **this report is not comprehensive**. It simply documents the data and information the author was able to collect on the ground, in Leyte and neighboring Samar, during the two expeditions.

The author hopes that parties studying the impact of Super Typhoon HAIYAN will find this report helpful, and that it will be a useful addition to the body of knowledge about this historic storm.



2. Leyte (Ground Survey)

Super Typhoon HAIYAN moved WNW across the Leyte Gulf, impacting portions of Samar before the center crossed the Leyte coast just after 7:00 am PHT. At landfall, the storm was moving rapidly, at >20 kt. Agency estimates of the maximum sustained (1-min/10-m) winds at landfall range from **140 kt** (JMA—converted from a 10-min wind of 125 kt) to **170 kt** (JTWC). JMA estimates a central pressure of **895 mb**.

Below is a map of HAIYAN's Leyte landfall, followed by an explanation of how each map feature was derived:

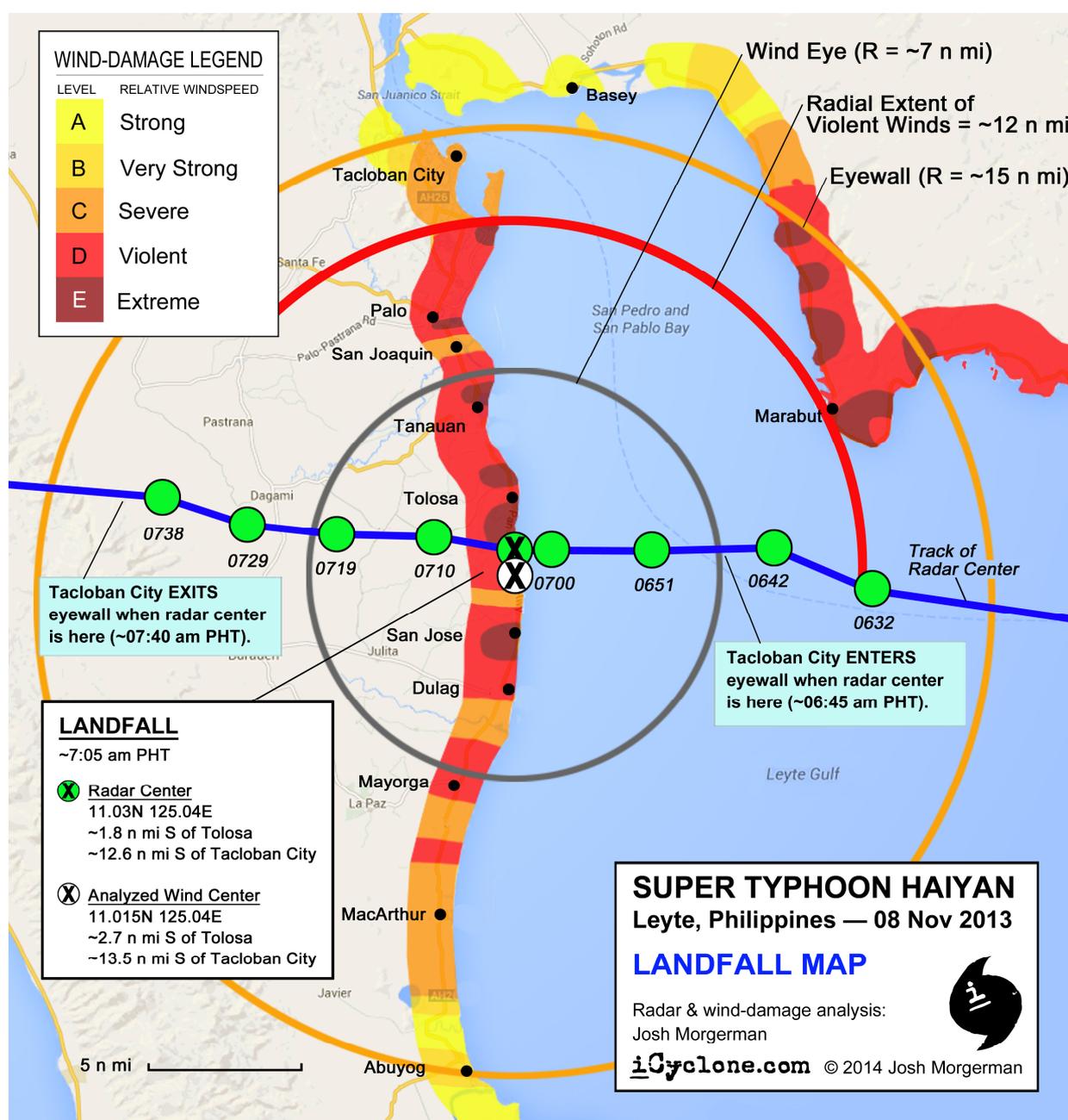


Figure 2. Map of HAIYAN's Leyte landfall (referred to throughout this document as the **Landfall Map**).



2.1 Radar Track

Center positions (small green circles) represent the geometric centers of the eye, as derived from PAGASA's Cebu City radar imagery. These center positions can be used to reconstruct a storm track.

While HAIYAN was generally moving WNW, note that the center was wobbling almost due W at the time it crossed the coast.

The radar center made **landfall** at ~7:05 am PHT near **11.03N 125.04E**. This location (marked with an X in a green circle) is:

- ~1.8 n mi S of Tolosa (Downtown)
- ~12.6 n mi S of Tacloban City (Downtown)

2.2 Wind Eye (& Center)

The **large grey circle** represents the approximate size and location of the wind eye at landfall. This was derived via eyewitness interviews.

2.2.1 Methodology

Residents who rode out the cyclone in towns along the Leyte coast were interviewed. The objective: **determine the location/dimensions of the typhoon's wind eye.**

There were over 40 interview subjects, spread across the following towns (going from N to S):

- Tacloban City
- Palo
- San Joaquin
- Tanauan
- Tolosa
- San Jose
- Dulag
- Mayorga
- MacArthur
- Abuyog

Subjects were approached in busy market areas and civic centers in each town. (Most residents of this region—across all socioeconomic levels—have some English proficiency, but a translator was on-hand.)

Willing subjects were asked to verify their location during the storm, then to describe what happened. While all details were interesting, **the primary goal in each interview was to understand if the subject had experienced a calm or lull during the storm.**

The author did his best to avoid asking “leading questions”—that is, ones that lead the interviewee to favor a specific answer. So, for example, “Did you experience the eye?” was not an interview question. However, subjects were sometimes asked questions like, “Was the wind strong the whole time, or did it change at some point?” or, “Did the wind ever stop, or did it just keep going?”

Almost all subjects had been through the core of a violent, deadly typhoon, and interviews needed to be conducted with appropriate sensitivity. Almost all subjects reported being very frightened during the storm. Most experienced heavy damage to their dwellings, and many had been left homeless. Many had harrowing stories of escape—for example, swimming across storm surge and riding out the cyclone clinging to a coconut tree in powerful winds.



Given the above, subjects' memories—and the sequences of events—weren't always clear, and the described timing and duration of events are not assumed to be completely accurate. Multiple subjects were interviewed in each town, and in cases of conflicting accounts, judgment calls needed to be made.

Note: While this survey focuses solely on whether each subject experienced calm, see **Appendix A** for the full account from each subject. There are many fascinating details.

2.2.2 Analysis & Findings

Following is a tally of reports from each town.

Y = definitely experienced distinct calm

N = definitely experienced no calm

M = experienced fluctuations, lessening, or can't remember

- **Tacloban City:** numerous **N** (includes author's firsthand recollection)
- **Palo:** **6N**, **1Y**
- **San Joaquin:** **1N**, **3M** (includes group interview—with father & daughter)
- **Tanauan:** **2N**, **3M** (includes group interview—with husband & wife), **2Y**, **1?**
- **Tolosa (Downtown):** **4Y**
- **Tolosa (S):** **2Y** (group interview—with husband & wife)
- **San Jose:** **3Y** (group interview—with extended family)
- **Dulag:** **3Y**, **1N**
- **Mayorga:** **2M** (group interview—with relatives), **1N**, **1?**
- **MacArthur:** **2N**
- **Abuyog:** **2N**

As can be seen, multiple residents in **Tolosa**, **San Jose**, and **Dulag** reported distinct calm, so **these towns are deemed to have been squarely in the typhoon's eye**. (The one report of no calm in Dulag is discounted because of a serious language barrier, and it doesn't jibe well with all other accounts there.)

But how far N and S did the eye reach?

2.2.2.1 Eye's N Boundary

The one report of calm in **Palo** is discounted because 1) it conflicts with many other reports in Palo; 2) it's several miles N of any other reports of a calm; and 3) her recollection of the timing doesn't jibe well with other data. Both **San Joaquin** and **Tanauan** seem to have been in a sort of "border zone," as several residents in these towns seemed unsure of whether they'd had a calm—describing fluctuations or lessening in the wind. However, two particularly articulate subjects in Tanauan—including a town worker who rode out the cyclone in Town Hall—independently reported distinct calms, and they corroborate on a duration of 5-10 minutes.

Given the above: **the N boundary of the eye is estimated to have passed between San Joaquin and Tanauan**, with Downtown **Tanauan** clipping the N edge of the eye and experiencing a very brief calm.

- **Latitude of eye's N boundary at landfall: 11.13N**

2.2.2.2 Eye's S Boundary

Dulag is believed to have been in the S portion of the eye. Subjects in **MacArthur** and **Abuyog** did not report calm. This leaves **Mayorga**—the town in between—where two subjects reported fluctuations in the windspeeds, one reported no calm, and one yielded no conclusion. It seems Mayorga was the border zone.



Given the above: **the S boundary of the eye is estimated to have passed near Mayorga**, with **Dulag** (to the N) squarely in the eye and **MacArthur** (to the S) definitely **outside** of the eye.

- **Latitude of eye's S boundary at landfall: 10.90N**

2.2.2.3 Eye's Dimensions

The estimated N and S boundaries of the eye suggest the following dimensions at landfall:

- **Eye Diameter = ~14 n mi**
- **Eye Radius = ~7 n mi**

2.2.2.4 Landfall Point

The **midpoint** between the wind eye's estimated N and S boundaries at landfall is **11.015N**, and this is deemed to be the center's latitude at landfall.

Given this, the wind center is estimated to have made **landfall shortly after 7 am PHT near 11.015N 125.04E**. This location (marked with an **X** in a **white circle**) is:

- **~2.7 n mi S of Tolosa (Downtown)**
- **~13.5 n mi S of Tacloban City (Downtown)**

2.2.2.5 Radar Center vs. Wind Center: Comparison

There's surprisingly good corroboration between the **radar center** and **analyzed wind center**.

The two centers are less than 1 n mi apart at landfall (with the radar center N of the wind center). Also, the radar-eye boundaries correspond very well with the wind-eye boundaries (derived via eyewitness interviews). Compare the **Landfall Map (Figure 2, above)** with the **Radar Image (Figure 3, below)**:

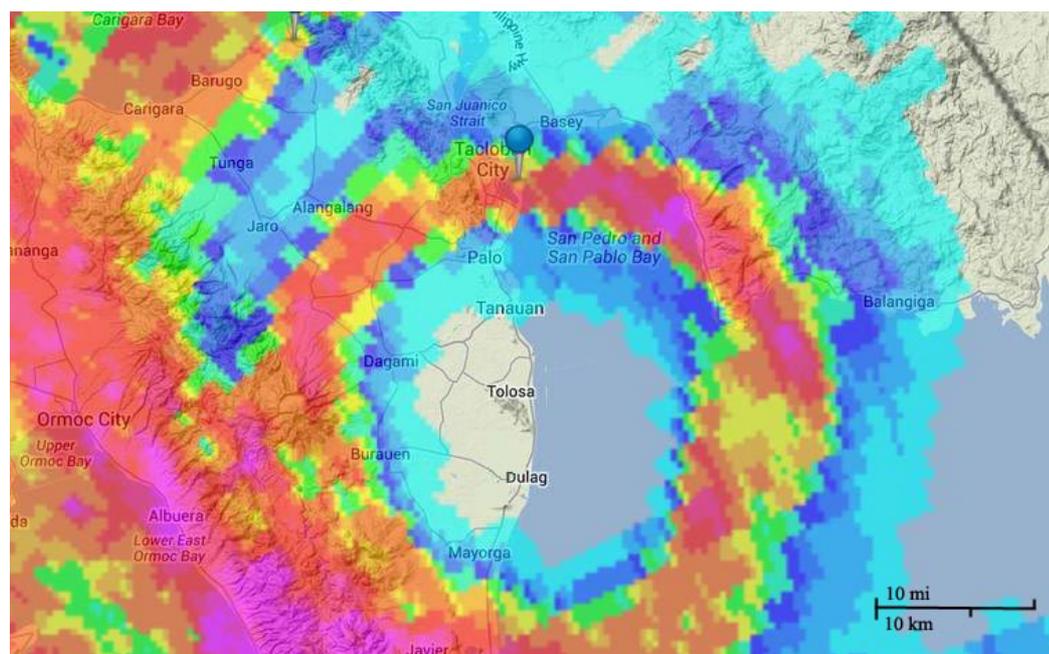


Figure 3. Radar image of HAIYAN's inner core at 07:00 PHT, near the time of landfall in Leyte.



2.3 Wind Damage & Radii

The **color coding** shows the relative severity of the wind damage that occurred at (or near) the immediate coast. The thickness of the colored area is exaggerated to enhance map readability.

While this report focuses primarily on HAIYAN's Leyte impact, the effects in W Samar are included to give wider context.

2.3.1 Methodology

Wind damage along the Leyte and Samar coasts was surveyed and documented. The objective: **determine the location/dimensions of the typhoon's core, including relative wind radii and location(s) where the highest winds occurred.**

Please note: This survey assesses the location/dimensions of the typhoon's core solely by **comparing** damage severity between different locations. ***Estimating actual windspeeds is beyond the scope of this survey, and therefore no conclusions regarding the storm's intensity are offered.***

2.3.1.1 Survey Area

Two ground surveys were performed on different days:

- **Heading N** from Tacloban City into extreme-N Leyte, across San Juanico Strait, then E across the **S coast of Samar** to Guiuan.
- **Heading S** from Tacloban City, down the **E coast of Leyte** to Abuyog.

2.3.1.2 Process

With a couple of special exceptions, the survey focused solely on **wind damage to coconut palms**—for two reasons: 1) these are a plentiful feature all along the coast of the stricken region, thus offering a reliable way to compare damage between locations; 2) assessing the relative quality of building construction in the stricken area is outside the scope of this survey.

The process was as follows:

1. **Photos were taken** of clusters of coconut palms at multiple points along the coast (34 points in Samar and 36 in Leyte). The distance between points was usually 2 n mi or less. **Locations were recorded** via GPS.
2. **Damage to palms at each point was rated** on a relative scale from A to E (see next section).
3. **Points were plotted** on a map and **color-coded** to reflect the damage rating.
4. Where necessary, **damage zones between points were interpolated** to form a continuous band of color along the coast.

The result is shown in the **Landfall Map (Figure 2, above)**. **Appendix C** shows the hand-plotted, numbered points, with damage ratings.

Photo data from Abuyog are admittedly sparse. For this reason, a YouTube video showing numerous still photos from the town right after the typhoon was used to supplement the estimates:
<http://youtu.be/wAmhUG3UtFk>



2.3.1.3 Damage Scale

The scale levels are as follows—with all damage descriptions pertaining to coconut palms. Examples are shown in **Appendix B**:

- **Level A: Strong.** Light damage to palms, including minor tearing off or bending of fronds.
- **Level B: Very Strong.** Moderate damage to palms, including some (but not many) fronds torn off or badly bent.
- **Level C: Severe.** A wide category indicating extensive damage to palms. Examples include many fronds torn off or badly bent, and some trees blown town.
- **Level D: Violent.** Many palms snapped off at the trunk (but <50%) and/or heavy defroning.
- **Level E: Extreme.** >50% of palms snapped off at the trunk and/or complete or near-complete defroning.

This damage scale does not indicate specific windspeeds, nor does it map to Saffir-Simpson Hurricane Wind Scale categories. It is a **purely relative scale**, aimed only at comparing the severity of damage between different locations. The objective was to understand the cyclone's **dimensions** and the **location** of the highest winds, not estimate the actual windspeeds.

Because the survey focused solely on **wind damage to coconut palms**, this meant:

- **Building damage was generally not considered**, as assessing the relative quality of building construction in the stricken area is outside the scope of this survey.
 - **Exceptions.** Two points that saw major wind-induced failures of concrete buildings (**Point 6b** in S Tacloban City and **Point 8a** in Palo) were assigned Level D in the absence of sufficient palm images. (See **Figure 4 & 5**, below.)
- **All of the assessed damage is wind damage—not water damage.** The palms analyzed were above the surge line (except for the bases in many cases). San Joaquin is an example of an area with extreme storm surge damage (much of the town was destroyed and there were many fatalities) that had a relatively low rating, because no examples of wind damage above Level C were seen. The same applies to Downtown Tacloban City: large sections of the City were leveled, but as it seemed to be mostly water damage, the highest rating in Downtown was Level C.



Figure 4. Major wind-induced failure of a concrete commercial building in the S part of Tacloban City (**Point 6b** on the plotted map in **Appendix C**). Given the absence of coconut-palm images at this point that apparently experienced very high wind, this was considered in the survey and assigned Level D.

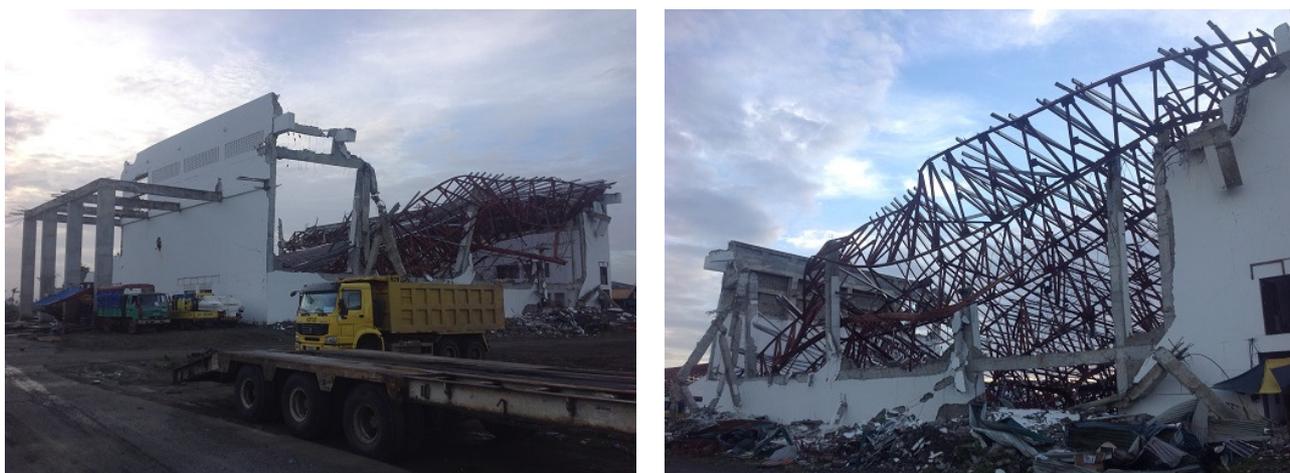


Figure 5. Major wind-induced failure of a concrete building in N Palo (**Point 8a** on the plotted map in **Appendix C**). Given the absence of coconut-palm images at this point that apparently experienced very high wind, this was considered in the survey and assigned Level D.

Additional notes regarding the inherent limitations of this survey:

- **Damage ratings are inevitably subjective.** Assigning a rating was not always a cut-and-dried verdict because 1) damage was streaky and 2) many locations showed **combinations** of damage levels—for example, numerous snapped-off palms next to others that still had many fronds. In such instances, judgment calls had to be made.
- **Damage zones on the Landfall Map are approximate.** The scope of the survey did not allow for documenting every mile of the coast, and some town centers didn't have coconut palms. Given this, damage zones had to be interpolated between the 70 documented points, and the map should not be viewed as precise down to the mile. Refer to **Appendix C** to view the 70 points that were plotted and rated.

Despite these limitations, the author believes the **Landfall Map** gives the user a valuable overview of Super Typhoon HAIYAN's core dimensions, including the radial extent of destructive winds and the location of the highest winds.

2.3.2 **Analysis & Findings**

The wind-damage survey yields valuable insights regarding HAIYAN's core structure at landfall:

2.3.2.1 **Eyewall**

In some cyclones, the eyewall—that is, the inner ring of deep convection and destructive winds surrounding the eye—is not easy to precisely define. In HAIYAN, however, the eyewall was a **distinct, sharply-defined structural feature**—both on radar and on the ground—with clear boundaries and at least a partial moat surrounding it.

On the **Landfall Map**, the **Eyewall** is defined by the **radial extent of severe (Level C) winds**. N of the center, this zone extends only a little beyond Downtown Tacloban City. As can be seen, wind damage drops off dramatically outside of this ring. Based on this:

- **Eyewall Radius = ~15 n mi**



Two other sources support this estimate of ~15 n mi:

- **Radar.** Radar imagery, as shown in **Figure 3** and **Appendix E**, also suggests the N eyewall reached—but did not extend much beyond—Tacloban City. Notice the distinct moat NW and N of the eyewall. (**Note:** *Radar images, especially at this distance, are not expected to precisely reflect conditions on the ground.*)
- **Video from Tacloban City.** The author shot continuous, time-stamped video in Downtown Tacloban City during the typhoon. The video clearly shows the arrival and exit of the eyewall, as well as the preceding moat:
 - **Moat.** The sky brightens around 6:32 am PHT, as the moat passes over.
 - **Eyewall Arrives.** A sudden and dramatic increase in rain and winds (to very destructive speeds) occurs ~**6:45 am**. Extremely turbulent conditions increase and peak between 7:10 and 7:30 am, when winds are most intense and visibility is near zero.
 - **Eyewall Exits.** Video shows extremely turbulent conditions (and destructive winds) continuing until at least 7:31 am. By 7:45 am, video shows conditions have markedly improved—the rain is much lighter, the winds have lessened (though they're still dangerous), and the sky has brightened. Given this, the eyewall cleared Downtown sometime between 7:30 and 7:45 am, and it's estimated to have occurred at ~7:40 am.

Measuring the distance from the approximate radar center to Downtown at the time of eyewall **entry** (~6:45 am) **and** exit (~7:40 am) yields distances of ~**14-16 n mi**.

(**Note:** *The author's video footage referenced above can be viewed at these links: <http://youtu.be/4wrgrJwYdy8> and <http://youtu.be/133F6-5qi2w>.)*

2.3.2.2 Radial Extent of Violent Winds

On the **Landfall Map**, the **Radial Extent of Violent Winds** encompasses **locations experiencing at least violent (Level D) winds**. N of the center, this zone extends to the S neighborhoods of Tacloban City. Based on this:

- **Radial Extent of Violent Winds = ~12 n mi**

Embedded within this larger zone of violent (Level D) winds were **small streaks or pockets of extreme (Level E) damage**. These locations—from N to S—were:

- **Point 7:** S Tacloban City (San Jose neighborhood)
- **Point 8c:** Palo
- **Point 12:** Tanauan
- **Point 14:** Tolosa
- **Point 16-17:** Tolosa
- **Points 21-22:** San Jose

Figure 6 shows the palms at these locations of extreme (Level E) damage. As can be seen, >50% of the palms are snapped off at the trunk in all of these images.



S Tacloban City (San Jose neighborhood) (Point 7)



Palo (Point 8c)



Tanauan (Point 12)



Tolosa (Point 14)



Tolosa (Points 16-17)



San Jose (Points 21-22)

Figure 6. Instances of extreme (Level E) wind damage along the Leyte coast, going from N to S. All images were taken months later.



2.3.2.3 Radius of Maximum Winds (RMW)

A precise **Radius of Maximum Winds (RMW)** has not been determined. However:

- The eye radius was **~7 n mi**.
- The instance of extreme (Level E) damage furthest from the center is Point 7—which is **~11 n mi from the center**.

Wind damage at **Points 12, 14, 16, and 17** is perhaps more severe than **Points 7 and 8c** (further N)—and, it's possible Points 7 and 8c were isolated incidents caused by localized disturbances (i.e., eyewall mesovortices or microbursts). If this is accepted—that the damage at Points 12, 14, 16, and 17 was both heavier **and** more representative of the storm's circulation—then the wind max was likely WNW or ENE of the center, **not due N**, since these four points were **N of the center but in the eye**. Unfortunately, this doesn't help us narrow the RMW range—and, in fact, it could be even greater than 11 n mi, as it's unknown how far WNW or ENE of the center these extreme winds might have occurred. It's possible these winds were as much as ~15 n mi from the center (the outer edge of the eyewall, as determined from radar and analysis). However, the strongest winds were most likely in the **inner** portion of the eyewall.

Given this, the author believes **the RMW was very likely between 7 and 11 n mi**.

Wherever the RMW falls in this range, this makes HAIYAN a small typhoon.



3. Tacloban City (Data)

The author rode out Super Typhoon HAIYAN in Downtown Tacloban City.

The cyclone's center crossed the Leyte coast ~14 n mi S of Downtown, and came to within ~13 n mi at its point of closest approach. Downtown was raked by the cyclone's N eyewall, with the RMW and the ring of most-violent winds passing a little S of the City center. A tremendous storm surge inundated most of Downtown, leveling large areas of the City and causing thousands of deaths.

Despite the great danger, this was a unique opportunity to observe, document, and analyze a violent cyclone **from the inside**. It's exceedingly rare for an experienced observer to shoot video and collect data from the inner core of a Category-5 cyclone.

This section documents the author's rare data from this event, along with follow-up postanalysis.

3.1 Location

The author observed the typhoon's passage from Hotel Alejandro, in the heart of Downtown, about three blocks from the waterfront (11.2414N 125.0036E).



Figure 7. The location from which the author observed the passage of HAIYAN.



3.2 Chronology

The cyclone was small and fast-moving—so it didn't last long.

HAIYAN dealt a **fast but devastating** blow to Downtown. Following is a chronology of the event. Times (PHT) are rounded to the nearest 5-minute increments:

- **6:30 am.** Sky brightens, rain tapers in Downtown as “moat” passes over.
- **6:45 am.** Eyewall arrives; wind & rain increase dramatically.
- **7:10 – 7:30 am.** Peak winds, with particularly extreme gusts around 7:25 am.
- **7:12 & 7:20 am.** Lowest air pressure (two devices).
- **7:30 am – 7:45 am.** Storm surge inundates Downtown as eyewall pulls away. Lighting & thunder observed.
- **8:00 – 8:15 am.** Peak storm surge.
- **8:45 am.** Winds & storm surge rapidly receding.

Note that:

- **Peak winds** (and heaviest rain) occurred **near and after** the center's closest approach, **in the NE eyewall**, as the center pulled away from the City.
- **Peak storm-surge** inundation occurred **after** the peak winds—after the eyewall had passed.
- Very destructive winds and storm-surge inundation lasted only a couple of hours—basically from ~6:45 am to ~8:45 am. **This was a short-duration event compared with a typical tropical-cyclone impact.**

The above chronology and observations were reconstructed afterward from the author's time-stamped video footage of the event. Highlights can be viewed in these two online videos:

- **Entire event (12:34):** <http://youtu.be/4wrgrJwYdy8>
- **Eyewall only (6:19):** <http://youtu.be/133F6-5qi2w>

All footage is time-stamped in local time (PHT).

3.3 Air Pressure

Data from two devices suggest an extremely steep core gradient.

The author deployed two devices for measuring air pressure and collected continuous, quality-controlled data during the entire passage of the typhoon's core over this location. Lowest pressures and times (PHT) are as follows:

- **Device 1: 960.4 mb at 7:12 am** (corrected from original 960.8 mb)
- **Device 2: 959.9 mb at 7:20 am** (corrected from original 960.3 mb)

Please note that these values are corrected 0.4 mb from the initial readings, as the devices had been calibrated with a slightly incorrect elevation (see **Methodology—Calibration**, below).

The complete data traces for both devices appear below, in **Figures 8-11**. The healthy corroboration between the two instruments, spaced four stories apart, gives some confidence to these readings—but not 100%. **As far as the author knows, these are the only complete, quality-controlled pressure data from HAIYAN's inner core at landfall.**



3.3.1 Methodology

3.3.1.1 Devices

Two devices were deployed in the hotel (Kestrel 4500s). The sampling rate was one reading per 30 seconds.

3.3.1.2 Calibration

USGS data indicate the ground elevation at the hotel is ~26 ft. Before the storm, the author attempted to verify this with a three-block walk to the waterfront—to “eyeball it”—but it was difficult to assess with confidence. Given this, 26 ft was used.

Device 1 was deployed in a small drawer in the hotel lobby, on the ground floor. Since it was several feet off the ground, the device was calibrated (for sea-level readings) using an altitude of 30 ft.

Device 2 was deployed in our fourth-floor room. To calibrate this device, we used the air-pressure value from Device 1 as a reference, setting the altitude in Device 2 to make the air-pressure value match that shown by Device 1 (60 ft).

Upon returning to Tacloban City afterward, the author used a pressure altimeter to check the elevation and found it was much lower than the 26 ft indicated by USGS data. The correct elevation is ~15 ft—which is 11 ft lower than the value used to calibrate the barometers. This required the air pressure readings to be adjusted down 0.4 mb.

3.3.1.3 Disruption of Device 1

Sometime after 7:30 am (and probably after 7:45 am), storm surge flooded the hotel lobby, knocking over the piece of furniture holding Device 1. The drawer holding Device 1 was submerged for a time—until the storm died down and the author was able to retrieve it from the wreckage.

It’s unclear what effect this may have had on the air-pressure data—and there are no obvious irregularities in the trace that can help identify when the disruption occurred. Either way, this disruption happened **after** the lowest pressure was reached and the center was moving away from the city.

3.3.2 Analysis & Findings

3.3.2.1 Lowest Pressure & Intensity

As shown above, both instruments had low pressures of ~**960 mb** in the cyclone’s N eyewall. At this time, the center was passing only ~13 n mi to the S.

Given that the typhoon was estimated to have a central pressure under 900 mb at the time, **this suggests an extremely steep core gradient of >4.5 mb/n mi**.

3.3.2.2 Eyewall Irregularity

Data from both devices show a slight—yet distinct—irregularity from ~6:53 to ~6:56 am. This was just minutes after we’d entered the typhoon’s eyewall, as the center was approaching and the pressure was still dropping. This irregularity might be evidence of an eyewall mesovortex or other localized disturbance passing near the building.



3.3.2.3 Barograms—Clean

Following are clean barograms for both devices—plotted for the same time period (for easy comparison), and excluding some non-representative pressure spikes:

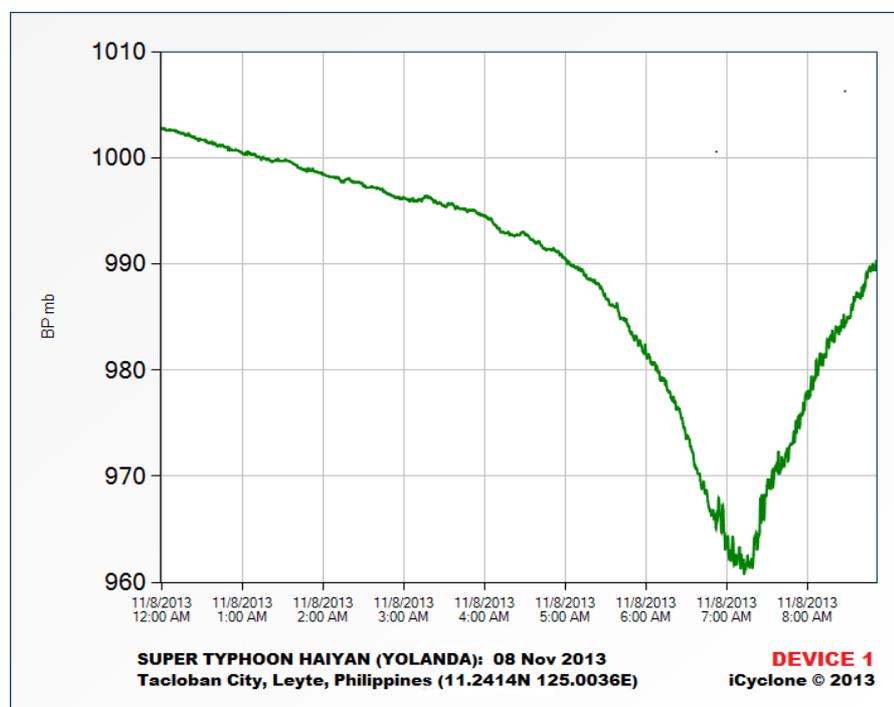


Figure 8. Barogram—Device 1 (CLEAN)

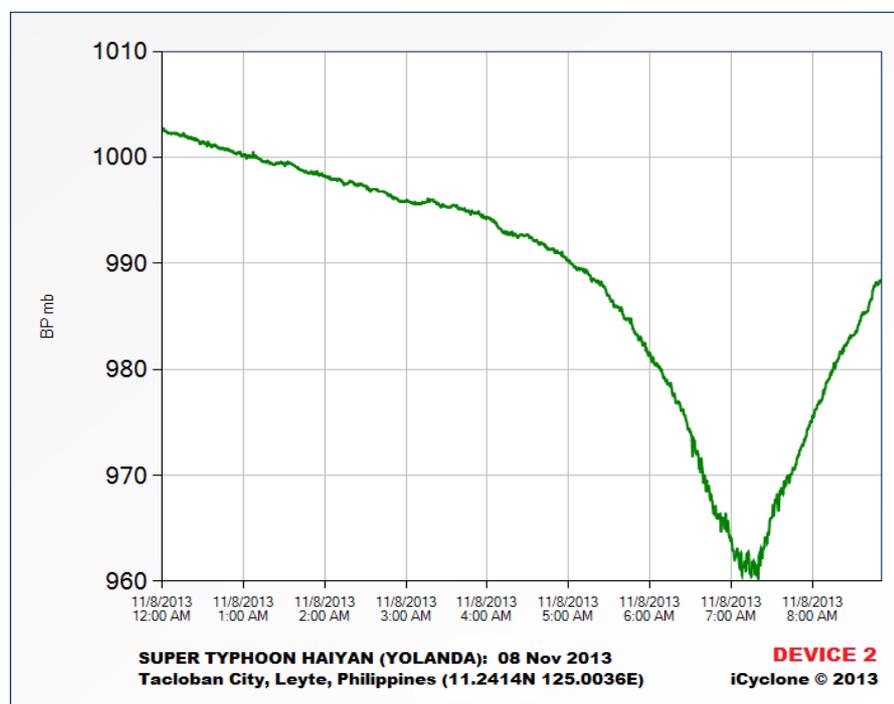


Figure 9. Barogram—Device 2 (CLEAN)



3.3.2.4 Barograms—Raw

Following are barograms of the raw data. Notice that the two devices ran for different periods—and also Device 2 had some odd pressure spikes which are not considered representative:

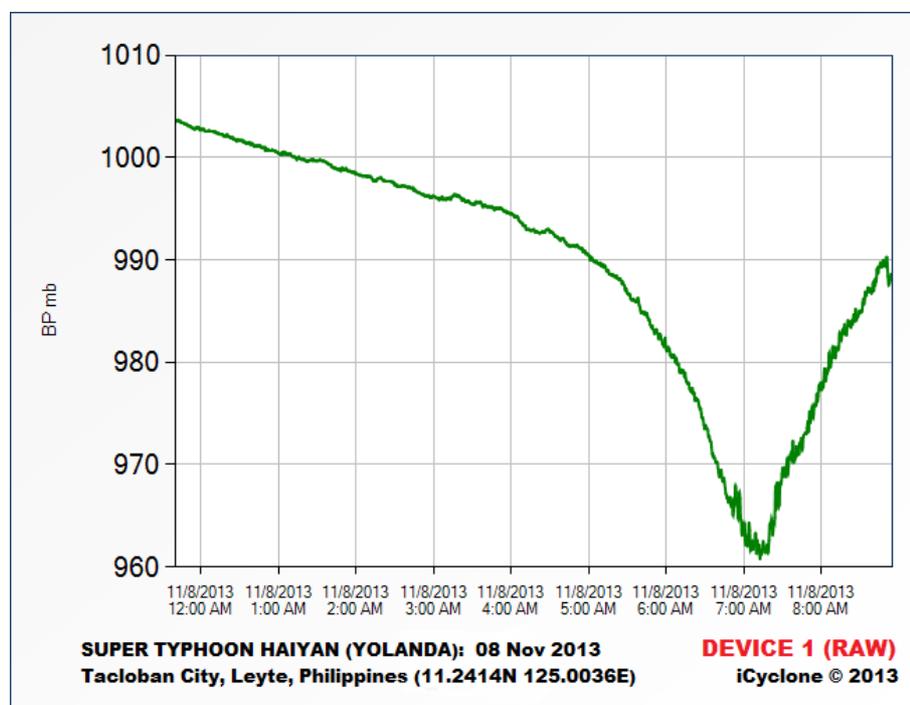


Figure 10. Barogram—Device 1 (RAW)

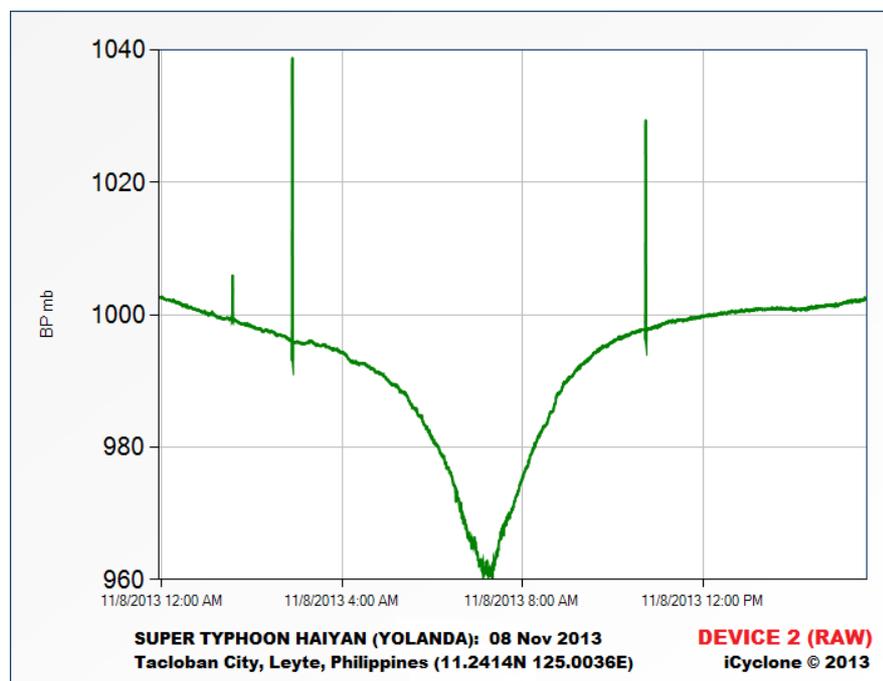


Figure 11. Barogram—Device 2 (RAW)



3.4 Winds

The max winds missed Downtown—but the City’s S neighborhoods weren’t as lucky.

The author did not collect wind data in this storm, and unfortunately, there are no known wind records from anywhere in the City or along the Leyte coast.

On the **Wind Damage Plots (Appendix C)**, Points 4 – 7 (in Leyte) cover Tacloban City. Damage across most of the city was Level C, with Level D occurring in the S neighborhoods and a small pocket of Level E in the San Jose neighborhood, near the waterfront.

3.4.1 Downtown

Although the RMW passed just to the S, Downtown Tacloban City was in HAIYAN’s N eyewall and experienced very destructive winds. Significant wind damage occurred across Downtown—including widespread unroofings and broken windows. Lethal flying debris filled the air during the height of the storm, smashing into buildings to inflict serious secondary damage. Deciduous trees were completely defoliated and in some instances debarked.

Despite the heavy damage, the author estimates that sustained hurricane-force winds lasted less than one hour in Downtown—from ~6:45 am to ~7:40 am.



Unroofed government building.



Extensive window breakage at modern church.

Figure 12. Wind damage in Downtown Tacloban City.



**Unroofed church with damaged steeple.
(Damage in foreground is from storm surge.)**



Unroofed church—from inside.



Unroofed business (months later).



Destroyed rooftop lounge.



Completely defoliated (& partially debarked) tree.



Heavy tree damage.

Figure 12 (cont'd). Wind damage in Downtown Tacloban City.



3.4.2 S Tacloban (& San Jose Neighborhood)

A pocket of **extreme damage** occurred in the City's S outskirts, in the San Jose neighborhood—where many palms were snapped-off at the trunk. Furthermore, at least one large concrete building failed in a nearby commercial area, also in the S part of the City.

It's unclear whether this damage pocket reflects the cyclone's RMW, or perhaps a localized eyewall disturbance—for example, a mesovortex or microburst.



Figure 13. Very heavy wind damage in S Tacloban—in the San Jose neighborhood and a nearby commercial area—months later. (These images also appear in **Figures 6** and **4**, above.)

3.4.3 Airport

The Airport—on an exposed peninsula, 1.5 n mi ESE of Downtown—was devastated. While it was difficult to distinguish between wind and storm-surge damage, the area was obviously swept by extremely high winds.



Figure 14. A fierce combination of wind and water destroyed Tacloban City's airport.



Figure 14 (cont'd). A fierce combination of wind and water destroyed Tacloban City's airport.

3.5 Storm Surge

The surge inundated Downtown after the peak winds—as the center moved rapidly away.

The most tragic force of Super Typhoon HAIYAN was its tremendous storm surge in Tacloban City.

As the center passed S of the City and pulled away to the SW, strong SE winds funneled water into San Pedro Bay, causing a **sudden and massive overflow into Downtown**. Thousands of people in the City were killed—many of whom were caught off guard by how fast the water rose. It didn't last long—sweeping into the City and then back out again with devastating speed.

At the author's location (Hotel Alejandro in Downtown), the **storm surge rose very suddenly and rapidly between 7:30 and 7:45 am**, and probably **peaked between 8:00 and 8:15 am—well after** the center's closest approach. By 8:45 am, it was already noticeably **receding**—so its impact was significant but short-lived. During the peak surge, the hotel flooded to a depth of ~4 ft.

As per the author's measurements during postanalysis, the surge reached **16-20 ft (above normal)** in Downtown.



3.5.1 Methodology

Estimating storm surge requires knowing elevation—and elevation is unfortunately one of the more difficult geographical features to accurately assess.

Before the typhoon struck, the author used USGS data to derive an elevation of 26 ft at his location. Since the hotel flooded to a depth of ~4 ft, this resulted in an estimated storm surge of an incredible 30 ft.

Upon returning for postanalysis, the author used pressure altimeters (Kestrel 4500s) to get a more precise measurement. The process was as follows:

1. The two devices were brought to the **exact level of the Bay**.
2. In the **barometer function**, the reference altitude was set to 0 ft, and the **air pressure was noted**.
3. Switching to the **altimeter function**, the **reference air pressure was set** to the noted value.
4. From here, the author brought the altimeters to known high-water marks to measure **height above current sea level**.
5. The height-above-current-sea-level values were corrected for tide phases to get **storm-surge-above-normal** values. (Normal = predicted astronomical tide.)
 - **Example:** HAIYAN's peak surge occurred at **~8:00 am, 08 Nov 2013**, when the tide was ~0.05 m. If a high-water mark was measured in postanalysis with the altimeter when the tide was 0.20 m, this required a correction of +0.15 m (~0.5 ft) to the measured value to get the storm-surge-above-normal value.

Pressure altimeters are sensitive gadgets, easily affected by subtle environmental factors like wind and heat. Therefore, the author performed these measurements at the same locations several times throughout the week and noticed some variation in the readings. The accepted values were measured on a day when 1) the two devices corroborated nicely, 2) the devices didn't fluctuate as much, 3) the readings made sense in relation to each other (i.e., higher elevations gave higher readings), and 4) the readings seemed in line with other readings taken throughout the week.

Storm surge was measured at four locations. These locations were selected because eyewitnesses distinctly remembered how high the water rose.

The most reliable location is considered to be **Hotel Alejandro** because:

- The author was **there to witness** the peak surge.
- The peak surge was **captured on video**, so there's a clear record of how high it got.
- The surge occurred **within an enclosed courtyard**, so it's a true height, without wave contamination.

3.5.2 Analysis & Findings

3.5.2.1 Maximum Heights

Following are the four locations, and the measured storm surge (above normal) at each:

- **Point A. Hotel Alejandro** (11.2414N 125.0036E) – **19 ft**
 - Time/date of measurements: **8:15-8:30 am, 01 Mar 2014**
 - Measured height above current sea level: **18 ft**
 - Correction for tide cycle: **+0.5 ft**
 - Storm surge above normal: **18.5 ft**
 - **Rounded value: 19 ft**
 - **Notes:** This surge occurred within an enclosed courtyard and was witnessed by the author. No fatalities at this site, although guests were trapped in rising water and needed rescue.



The following video stills give a clear record of **how fast the water rose, how high it got, and when it peaked at Hotel Alejandro:**



Figure 15a. The surge was still rapidly rising at 7:57 am, when the author shot this video still. Notice the water's height against the door.



Figure 15b. This next video still is not time-stamped but is estimated to have occurred no more than 10 or 15 minutes after the previous one—probably around 8:10 or 8:15 am. The water is much higher and near its peak. Again, notice the height of the water against the door. The author is seen rescuing an elderly woman from the surge. (Video still courtesy of Earth Uncut TV.)



- **Point B. Villa Deriada Pensione** (11.2410N 125.0064E) – **19 ft**
 - Time/date of measurements: **8:15-8:30 am, 01 Mar 2014**
 - Measured height above current sea level: **18 ft**
 - Correction for tide cycle: **+0.5 ft**
 - Storm surge above normal: **18.5 ft**
 - **Rounded value: 19 ft**
 - **Notes:** Much of this hotel was demolished, with multiple fatalities at this site.
- **Point C. Home of Leo & Malyn Larraga** (11.2396N 125.0050E) – **16 ft**
 - Time/date of measurements: **8:15-8:30 am, 01 Mar 2014**
 - Measured height above current sea level: **15 ft**
 - Correction for tide cycle: **+0.5 ft**
 - Storm surge above normal: **15.5 ft**
 - **Rounded value: 16 ft**
 - **Notes:** This building is right on the edge of a poor waterfront neighborhood that was completely leveled, with many fatalities.
- **Point D. Home of Mate Family** (11.2405N 125.0060E) – **20 ft**
 - Time/date of measurements: **4:45 pm, 25 Feb 2014**
 - Measured height above current sea level: **18 ft**
 - Correction for tide cycle: **+1.8 ft**
 - Storm surge above normal: **19.8 ft**
 - **Rounded value: 20 ft**
 - **Notes:** Home of the City's former Mayor, Uldarico E. Mate. There was heavy damage, with much of the structure destroyed—however, there were no fatalities at this site.

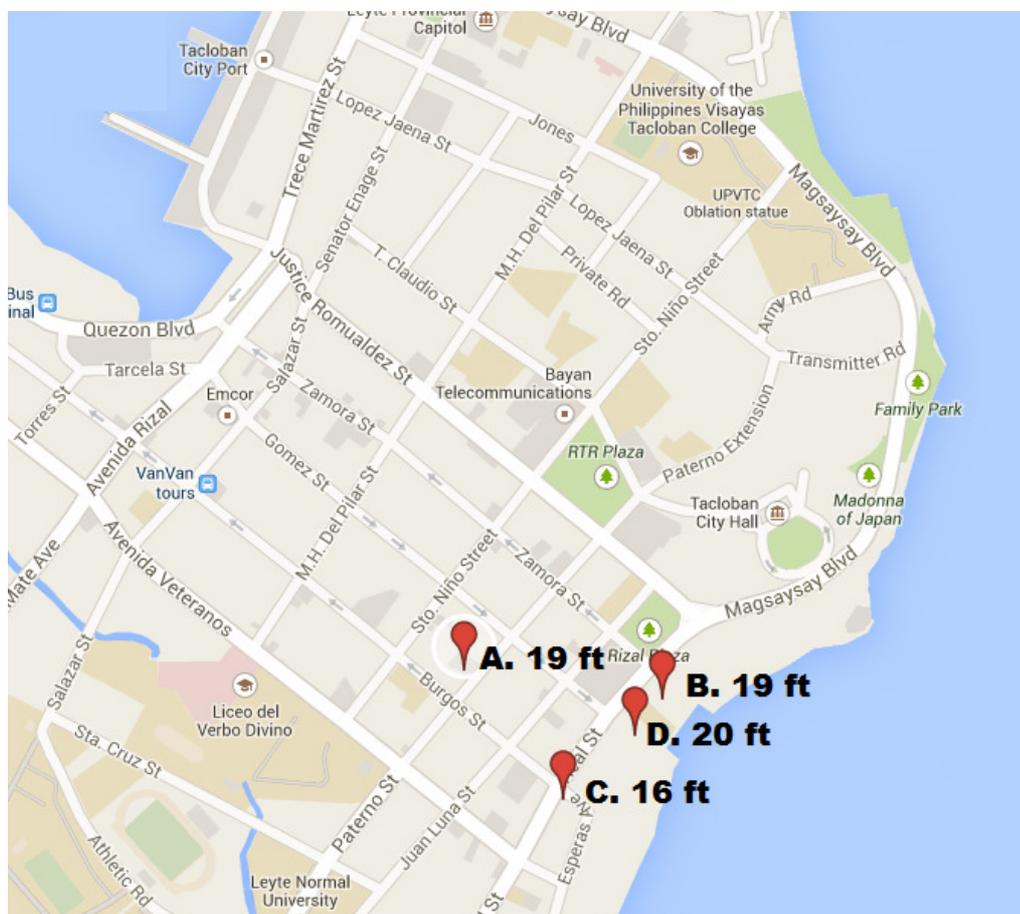


Figure 16. Map of measured storm surge values in Downtown, showing a range of 16-20 ft above normal.



Figure 17. Villa Deriada Pensione (**Point B** in **Figure 16**) was mostly demolished by the storm surge, which is estimated to have reached ~19 ft at this location. Multiple fatalities occurred at this site.



Figure 18. Remains of the Mate residence (**Point D** in **Figure 16**). Uldarico E. Mate was Mayor of Tacloban City from 1988 to 1998. The surge is estimated to have reached ~20 ft at this location.

3.5.2.2 Characteristics

A few characteristics made HAIYAN's storm surge in Tacloban City unique:

- **Suddenness & speed.** Survivors and eyewitnesses reported being surprised by the rapid onset of the surge—so sudden they hardly had time to react. This no doubt added to the high death toll. In the author's hotel, first-floor guests were trapped in their rooms by rising water because they didn't flee to the upper floors at the first hint of inundation. At that location, the inundation was extensive but short-lived. The author and his colleagues didn't even realize the surge was flooding the neighborhood until ~7:45 am; it peaked by ~8:00 or 8:15 am; and it was already rapidly receding by around ~8:45 am or 9 am. The rapid onset (and equally rapid recession) was no doubt the product of the cyclone's small size, rapid motion, and great intensity.
- **"Tsunami-like."** Related to the previous point... The terrific rush of water into the Downtown area reminded residents of a tsunami—and many thought that's what it was. In fact, the day after the typhoon, rumors of "more tsunamis" on the way caused panic among survivors.
- **Three waves.** Multiple survivors at the shoreline described **three large waves**. One witness said the first wasn't too damaging, the second was dark from all the mud it carried, and the third was very damaging because it carried a lot of debris.
- **Pre-surge recession.** Some eyewitnesses reported that the water actually receded early in the morning, before the storm surge—with the water pulling out into the Bay and reducing to unusually low levels.



Figure 19. HAIYAN's powerful storm surge brought almost total destruction to the City's poorer waterfront neighborhoods.



4. Conclusion

The author expects that analysis of this historic and devastating cyclone landfall will continue, and that the body of knowledge about Super Typhoon HAIYAN will only grow.

Feedback to this report is welcomed and encouraged:

Josh Morgerman
info@icyclone.com

Website
<http://www.icyclone.com/>

Facebook
<http://www.facebook.com/iCyclone>

YouTube
<http://www.youtube.com/cyclonejosh>

Thank you.



5. Appendices

5.1 A. Eyewitness Interview Notes

Following are detailed notes from many—but not all—of the interviews conducted by the author. Color-coding indicates **whether the subject experienced calm or not**. Notes Re: wind damage are included, where relevant.

- **YES:** definitely experienced distinct calm.
- **NO:** definitely experienced no calm.
- **MAYBE:** experienced lessening, fluctuations, or can't remember.
- **NO RECORD:** didn't say, & can't be inferred from the notes.

Tacloban City

*Note: The author was in Downtown Tacloban City during the storm. There was **no lull anywhere in the City**—not even a slight lessening of the winds as the center passed nearby. The highest winds happened during and just after the lowest pressure. (See the **Tacloban City—Chronology** section, above, for more details.)*

Leo & Malyn Larraga (husband & wife)

- **Downtown Tacloban City.** They rode out the storm in second-story apartment in a modern building near the waterfront. The windows exploded and they took refuge in a small room, so they didn't see the surge, which came up almost to their second-floor apartment. A boy was swimming by their balcony and they pulled him out of the water and into to their apartment. He'd been swept from his parents, who survived in another house nearby.

Venus

- **San Jose Neighborhood.** When the surge came up, she had to swim for her life.

Peachy

- **San Jose Neighborhood.** Black, muddy water came up really fast. She stayed up in her attic for three days after the typhoon, living on crackers. Dead bodies were everywhere. A friend of hers described the house as "exploding" from the force of the wind.

Palo

Nimfa

- Power went out, very strong wind, lots of damage.
- Wind made whistling sound. (*She pointed to her ears as she said this.*)
- Strongest winds lasted one hour.
- Wind changed directions, but she did not recall a lull.

Alex

- Big wind, changing direction a lot—like a tornado, with fog.
- Strongest winds between 8 and 10 am.
- Whistling sounds.
- Subject did not recall a lull.



April

- Wind was so strong she stayed in the house.
- After 7 am, the water inside the house was up to 5 ft.
- Once the roof blew off, she climbed on a wall to reach a neighbor's house.
- Winds blew hardest for an hour or hour and a half.
- For 15 minutes it calmed and rain was light for a while—around 8 am.
- Then it started up again for an hour.

Genciano

- Strong wind—roofs were flying.
- Visibility was almost zero, couldn't see.
- The wind was “like pressing the pedal of a motor engine”—like revving an engine.
- Worst was past 7 am.
- Lightning and thunder happened during the strongest winds.
- The most-intense part lasted 20 minutes.
- Past 8 am it was slower.
- It started SW and then shifted, with strongest winds from E.
- Subject did not recall a lull.

Lorna

- She couldn't see neighbor's house during height of the storm—“zero visibility”.
- Wind made a whistling sound—like airplanes.
- Some of the roof blew off.
- Strongest winds happened around 7 am and lasted an hour.
- Winds changed direction.
- Subject did not recall a lull.

Primitivo

- Winds started to pick up around 6 am.
- Ceiling started lifting off, so he ran to the bathroom.
- Only thing they could hear was “strong wind and rain”—like an airplane, or like trucks passing.
- It was strongest for 3 hours—steady for 3 hours.
- Subject did not recall a lull.

Charee

- Subject was emotional.
- She was at home during storm.
- At 4 am the wind got strong, and she was alarmed by it, said she “felt something was wrong” and “this was the first time I experienced this.”
- Bu 6 or 6:30 am she gathered her children into one room.
- Strongest winds occurred around 7 am—and it was “very terrible” and everyone was crying.
- “Zero visibility”—like “fog and clouds”... swirling.
- She rescued the children.
- The wind changed direction, but she did not recall a lull.

San Joaquin

Jasmine

Note: This subject was interviewed in Palo—however, she rode out the storm in San Joaquin.

- The wind broke the windows.
- The wind shifted and the water came up.
- She went up to the attic and the roof blew off.
- After an hour, the water went down.
- It blew hard for two hours, and it was steady—no calm.
- She felt pressure on her ears.



Ginalin

- She woke up at 4:30 am, wind got strong around 5.
- At around 5:30 am, windows smashed and it was getting stronger.
- At around 6 am, stuff was breaking and a door blew off.
- The water came up in a giant wave—3 waves:
 - First came up to shins and then “calmed”...
 - Second came in 3-5 minutes later.
 - Third one swept her away, out the back door, with lots of wind.
- She held onto a tree for an hour, in “zero visibility”—saw only sky and water.
- Worst of it lasted an hour.
- She seemed to remember a calming or inconsistency in the windspeed—it seemed to fluctuate.

Joseph & Kirztin (father & daughter)

- Wind started destroying the house, so she (Kirztin) got under a cupboard in the kitchen.
- Water swept in and they were trapped.
- They climbed to the attic and spent an hour and a half there.
- The wind “hurt their ears.”
- The father (Joseph) seemed to describe intense downdrafts—said the wind was coming **downward**—swirling.
- But rain was never very heavy.
- No lull, but wind seemed to fluctuate for an hour.
- Water came in 6 waves, spaced ~5 minutes apart.

Tanauan

Don

- At 5 am, the wind was strong.
- House shook, “like an earthquake.”
- At 6 am, it was getting stronger, and coconut trees were snapping off.
- At 7 am, the second floor of the house blew away.
- 12 people crammed into one small room and hid there.
- They heard whistling sounds, and airplane sounds.
- At 8 am, there was an “explosion” or “thunder.”
- The water came up between 8 and 9 am.
- There was a lull for 5-10 minutes.
- When the wind started up again, it was stronger than before—and he couldn't see 2 meters away.
- He hugged a coconut palm until the storm ended.
- It died down around 10 or 11 am.

Fernando & Florinda (husband & wife)

Note: *This interview was challenging, and the author had difficulty understanding some of what the subjects were describing.*

- By 7:30 am, the wind was “swirling” and had destroyed the house. The door blew open and they hid under the sink.
- Water got up to their knees and within seconds up to their heads.
- Most of the house was gone, but they climbed into the remaining part.
- The waves were “dark... and black” and she felt like it was nighttime—couldn't tell if the water was rain or ocean—and they felt very cold.
- They held onto a coconut tree for the rest of the storm, until around 11 am.
- Strongest winds around 8:30 am, “darkness” around 9 am.
- Water came in 3 waves between 7:30 and 8 am—waves covered everything, like darkness.
- Lulls and fluctuations occurred between 7:30 and 9 am.



Hazel Ann

- Very strong winds happened between 6 and 7 am.
- There was a weird “echo” or whistling.
- Heavy damage to the house—to the doors and windows, with $\frac{3}{4}$ of the roof gone.
- House is near river, and she saw the water come up fast.
- The children were traumatized.
- Strongest winds lasted 15 minutes, between 6 and 7 am—with swirling.
- Direction changed but it stayed strong, with no lull.

Channette

- Wind was very strong.
- By 5 am, it was already strong and the house was already damaged.
- Winds were strongest around 7:30 or 8 am.
- Surge came flooding in between 7:45 and 8 am.
- Winder was weaker then stronger, weaker then stronger—with these fluctuations happening after 7 am.

Lauro

- Wind was very strong at 5 am or earlier.
- It was very dark.
- Rain was very heavy and winds were very strong—strongest at 7 am.
- The surge came in fast around 8 am.
- There was no lull.
- It died down at 11 am.

Rosario

- Rode out the storm in Town Hall.
- At 5 am it was blowing much harder than they’d expected.
- It was “like a washing machine”—but the rain was not that heavy.
- Water flooded the ground floor.
- Wind was same strength for four hours.
- There was a distinct lull for 5 minutes—and she though the storm was over—but then it started up again.

Harold

- Wind got strong at 5 am.
- Wind was strongest at 6 or 7 am.
- Wind died down around 10 am.
- No record of whether he remembered a lull.

Tolosa (Downtown)

Stephanie Advincula

- She rode out storm in one-story house.
- It was not that bad at 5 am—seemed like a “normal storm.”
- At 6 or 7 am, the trees were swaying.
- At some point it totally and suddenly stopped; it got brighter and she saw blue sky—for maybe 5 minutes—and she went outside.
- It went from zero back up to full strength in maybe 5 minutes.
- Second half was worse.
- She couldn’t see because of the “clouds and fog.” Walls were shaking and she thought it was an earthquake.
- Heard whistling sounds.
- Windows broke and some of roof blew off.
- No surge.



Michael

- Woke up at 12 midnight because of the howling wind.
- At 6 am it was very strong.
- They “felt air being sucked out of our ears” and tried to close the door.
- The roof blew off just after they went downstairs, around 7 am.
- 15 people stayed in the kitchen, praying.
- Their ears hurt from the “sucking air;” they were crying, covering their ears from the pain.
- Howling, whistling sounds.
- They prayed it would end.
- Suddenly rain and wind both stopped.
- The sky was brighter, but he couldn’t recall seeing blue sky or sun.
- They went upstairs to gather what they could use.
- The calm lasted less than 15 minutes.
- Wind ramped back up within 15 minutes.
- The water came up after the calm.
- A total whiteout occurred after the calm.
- By 9 or 10 am it was slowing down.
- Winds were stronger **before** eye.

Desiree Ibanez

Note: She is a Tolosa City Councilmember.

- Remembered distinct calm.

Regin Olimberio

- He recalls a 15-minute dead calm; sky was cloudy and “milky” at the time.
- Winds gradually ramped back up.
- He was only 1 km from the shoreline, but “we did not experience storm surge as high as Tacloban.”

Tolosa (S area—near San Jose)

Odell & Cheryl (husband & wife)

- Wind was strong by 4 am.
- Raining very hard.
- Their property has 2 houses; several families were in the front house.
- At 7 am, the roof ripped off the front house, and 30 people moved to the back house.
- At 7:45 am, a wave came from the S.
- Eye was at 7, or between 7 and 8 am. (They described it as “the eye”—actually used that word.)
- There was no wind in the eye—it was calm. They saw the sun, and saw the clouds make a circle. The calm lasted 20-30 mins.
- Water “sucked out” during first half, then flooded in during the eye in 3 waves, with debris and pigs floating in it. The house flooded and they had to go upstairs. (*Note: At one point they described the water “coming down” and flooding them, so this may have been at least partially freshwater from nearby hills—or perhaps it “came down the coast”. It’s not clear.*)
- Winds started up again.
- It sounded worse after the eye; Odell said winds were stronger after eye.
- At 9 am, the house was shaking, and they were covering themselves.
- By around 10 or 10:30 am, the wind was slowly decreasing, water was subsiding.

Note: *Of the felled trees in the Tolosa area, 75-80% of them fell to the S, suggesting they fell before the eye. The rest fell to the N. This doesn’t mean winds before the eye were **necessarily** stronger—but just something to note.*



San Jose

Tanawan, Adbinacula, Lidinila (extended family)

- Wind was strong at 5 am.
- Wind stopped at 7:30 am for 5-10 minutes.
- Strongest winds around 8 am.
- Whistling sounds.

Dulaq

Jayde

- He rode out storm in two-story house.
- He woke up at 2 am.
- At 5 am, storm was getting stronger.
- He didn't want to go outside.
- There were 2 hours of strong wind and rain.
- There was a 5-minute calm, with no wind or rain—but it remained cloudy.
- Wind and rain and darkness returned suddenly.
- People were running and screaming, "It's coming again!"
- It picked up again in about 1 minute, and lasted 5 hours.
- Storm's second part was worse; most of the damage to houses happened in the second half.
- His ears hurt—like being in an airplane.
- Not a lot of storm surge—mostly wind and rain.

Brenda

- She rode out storm in one-story house.
- At 5:19 am, the wind was strong—typhoon started then. (*Note: She was very specific about this time.*)
- The strongest winds happened at 7 am, when the roof blew off and windows broke.
- 12 people in the house went to the bedroom and put the bed up against the door.
- Stuff scattered around house.
- Water from the nearby river came up.
- At 10 am, the wind was still strong.
- At 11 am, the wind started to die.
- The wind didn't stop. (She did not remember a lull.)

Anastasia

- Woke up around 1 am because of the wind.
- It got stronger.
- At 6:30 am, the wind and rain relaxed.
- Lull lasted until around 7 am.
- She "had fear about the sea".
- Winds after the calm were more destructive.
- The roof blew off—although rest of house was made of concrete.
- At 11 am, winds started to relax.

Edward

- Woke up 3 am because of the wind.
- It got stronger, blowing hard from 4 to 8 am.
- The first wind, at 4-5 am, came from the N.
- At around 6 am, the wind stopped 30 minutes, with just drizzle and some sunshine.
- The "second wind," from the S, was stronger. It started about 6:30 am.
- Subject reports that people died because they were caught outside after the calm.
- Many trees went down.



Note: Just S of Dulag, the trees fell mostly to the E and N, suggesting the backside winds actually may have been stronger.

Mayorga

Maria

- At 6:30 am, the wind got strong.
- At 8:30 am, the roof blew off.
- At 9:30 am, a coconut tree fell on the house.
- She was afraid—and had a baby to care for.
- The water was not a concern—just the wind.
- Wind died at 1 pm.
- Wind was strongest 6:30 to 10:30 am.
- Subject did not recall a lull.

Audrey Kaye & Rowell (relatives)

- Storm started around 4 or 5 am, ended 11 am.
- Strongest from 6 to 10 am.
- The house shook.
- Did not recall a lull, but the wind seemed to go up and down, fluctuate.

Winnie

- He rode out storm in two-story house.
- He couldn't sleep because of the strong winds that started around 4 am.
- It felt like a motor vehicle in motion.
- It got stronger and a concrete wall got destroyed.
- The roof blew off at 4 or 5 am.
- He was not scared, but he was upset because of the house.
- There was “zero visibility” and he was “hiding from the wind.”
- At 6 or 7 am you could make out objects again—i.e., the visibility was improving.
- By 9 am it was over.
- No record of whether he remembered a lull.

Note: Between Mayorga and MacArthur, the trees fell mostly to the E and N, suggesting the backside winds actually may have been stronger.

MacArthur

Leoncio

- At 6 am, wind was strong.
- At 7 or 8 am, it was strongest, and went full force until about 9 am.
- By 9:30 am, it was lessening.
- The house was destroyed—he felt frightened.
- Subject did not recall a lull.

Sherill

- At 3 am, there was a blackout.
- At 5 am, the wind was stronger.
- At 5:30 am, the kitchen wall collapsed.
- At 6 am, it was very strong.
- A neighbor who lost his roof sought refuge in subject's house, but then the subject's house lost its entire roof at 6:15 am.
- House shook “like an earthquake,” with “zero visibility.”
- Winds were strongest between 6 and 7 am.
- At around 9 am, it started to decrease.



- At around 12 noon, it was calming.
- Subject did not recall a lull.

Note: S of MacArthur, the trees fell mostly to the NE. Damage generally looked less severe.

Abuyog

Roland Brylle R. Ong

- Wind woke him up at 4 am.
- It sounded like heavy whistle.
- From 4 to 6 am, it was a “normal bad typhoon, like Signal 2 or 3.”
- At 7 am, “things went from bad to worse.”
- It was strongest from 7 to 10 am.
- After 10 am, it went “back to normal.”
- There was some damage to the house: part of rear roof was damaged by falling tree.
- Subject did not recall a lull.

Reyneldo

- Wind started around 5 am and got stronger and stronger.
- Wind was strongest around 5:30 am.
- From 6 to 7 am, there were “clouds and fog” and “zero visibility.”
- The storm got weaker around 8 or 9 am.
- His roof blew off, and the nearby school lost its roof.
- He was scared during storm.
- There was no storm surge in town.
- Subject did not recall a lull.



Primitivo (Palo)



Charee (Palo)



Ginalin (San Joaquin)



Joseph & Kirztin (San Joaquin)



Don (Tanauan)



Hazel Ann (Tanauan)



Channette (Tanauan)



Lauro (Tanauan)



Rosario (Tanauan)



Harold (Tanauan)



Stephanie (Tolosa)



Michael (Tolosa)



Cheryl (S Tolosa)



Tanawan, Adbincula, & Lidinila—with friends & family (San Jose)



Jayde (Dulag)



Brenda (Dulag)



Anastasia (Dulag)



Edward (Dulag)



Maria (Mayorga)



Audrey Kaye & Rowell (Mayorga)



Winnie (Mayorga)



Leoncio (MacArthur)



Sherill (MacArthur)



Roland Brylle R. Ong (Abuyog)



Reyneldo (Abuyog)



Leo & Malyn Larraga, Peach, Venus, & other friends (Tacloban City)



5.2 B. Damage Scale Examples

The scale levels are as follows—with all damage descriptions pertaining to coconut palms.

- **Level A: Strong.** Light damage to palms, including minor tearing off or bending of fronds.
- **Level B: Very Strong.** Moderate damage to palms, including some (but not many) fronds torn off or badly bent.
- **Level C: Severe.** A wide category indicating extensive damage to palms. Examples include many fronds torn off or badly bent, and some trees blown town.
- **Level D: Violent.** Many palms snapped off at the trunk (but <50%) and/or heavy defroning.
- **Level E: Extreme.** >50% of palms snapped off at the trunk and/or complete or near-complete defroning.

Following are examples of each level of damage:



Level A (Strong)



Level B (Very Strong)



Level C (Severe)



Level C (Severe)



Level D (Violent)



Level D (Violent)



Level E (Extreme)



Level E (Extreme)

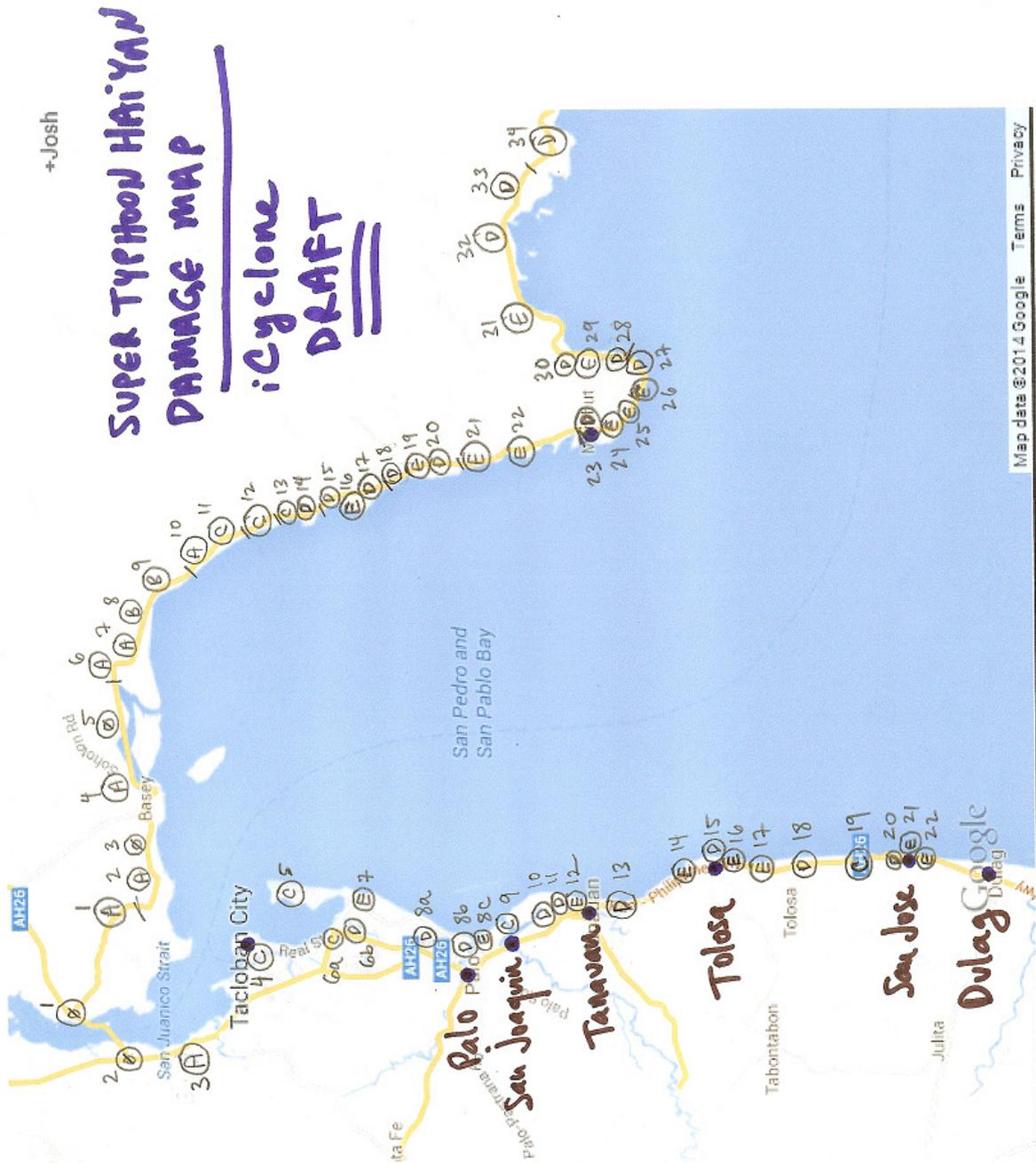


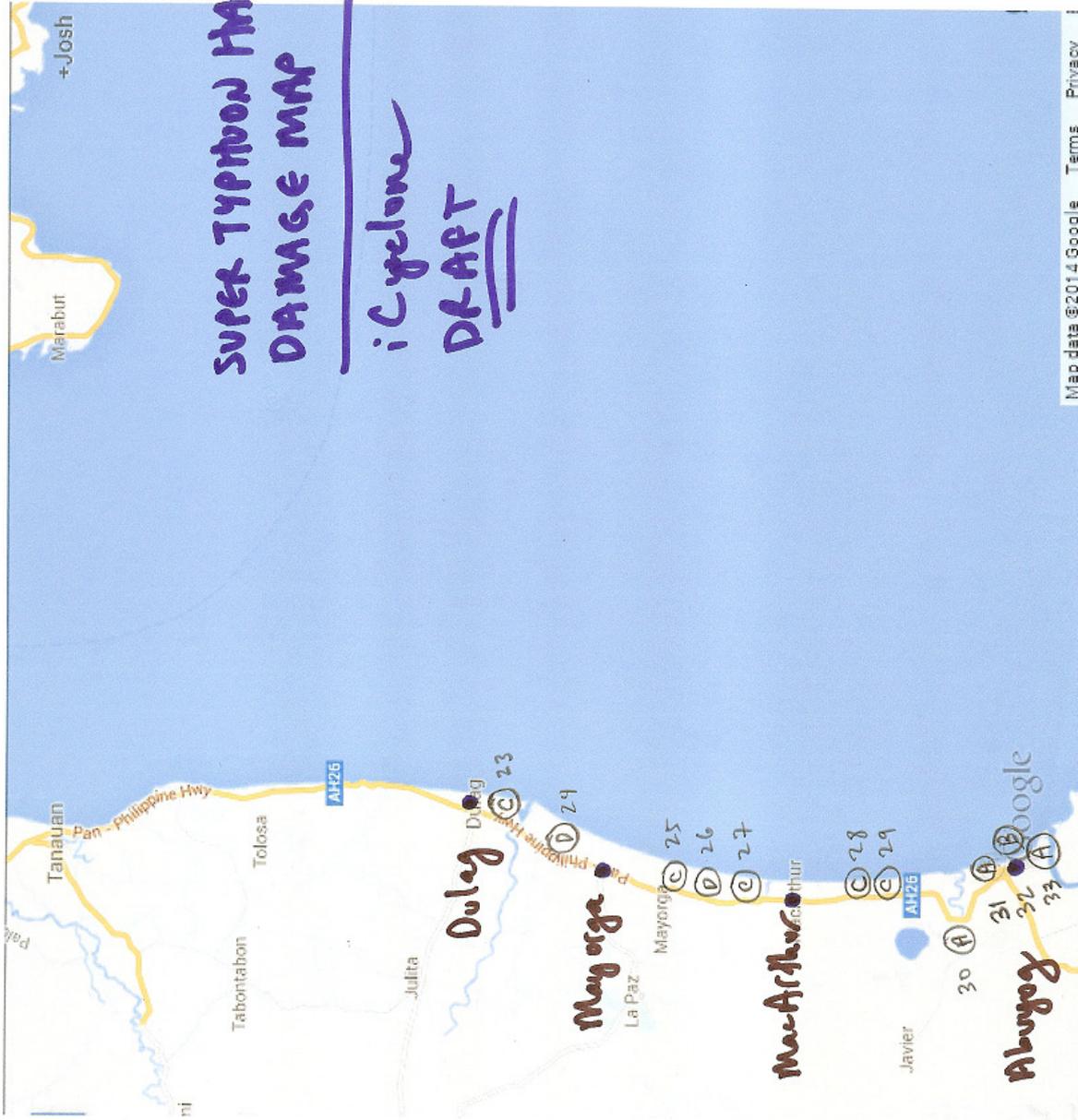
Level E (Extreme)



Level E (Extreme)

5.3 C. Wind Damage Plots







5.4 D. Wind Damage Images

All damage images used in this survey are available for review.

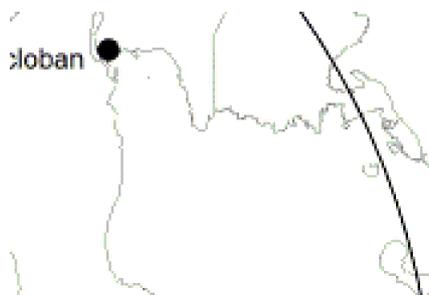
They can be downloaded at this link:

https://www.dropbox.com/s/qw00w2s1pfzyzeb/iCyclone_HAIYAN_Wind_Damage_Images.zip

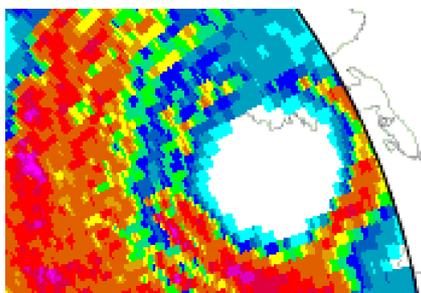
The files are organized into folders based on **island** (LEYTE or SAMA) and **point number**.

5.5 E. Landfall Radar Images—Close

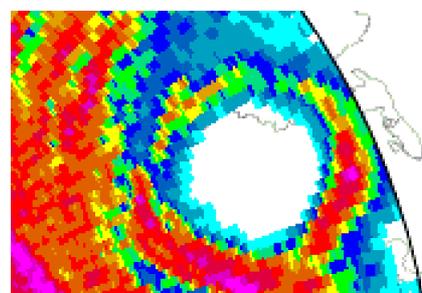
Following are up-close radar stills from the Leyte landfall, with times (PHT). *(Images courtesy of PAGASA, Philippines.)*



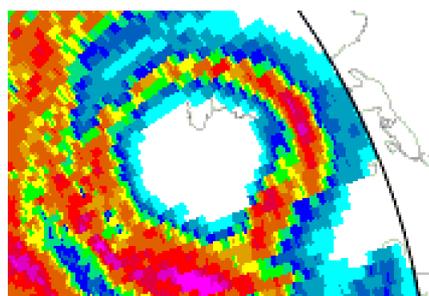
MAP (Note: Tacloban City point is slightly N of Downtown.)



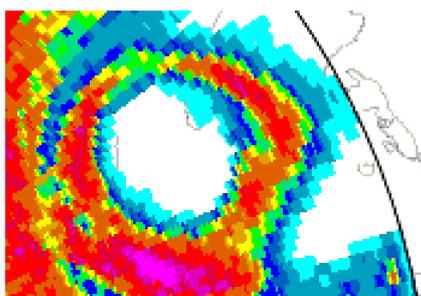
0604



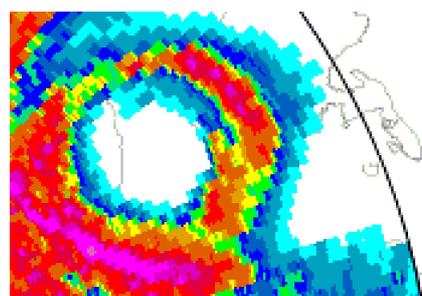
0614



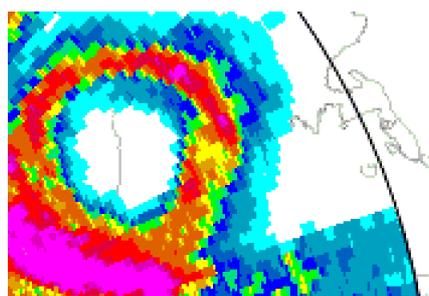
0632



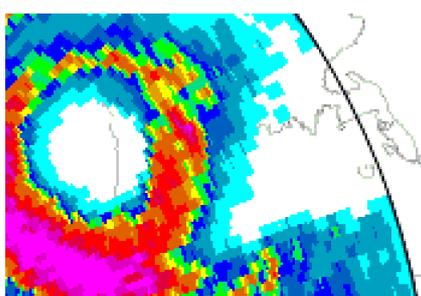
0642



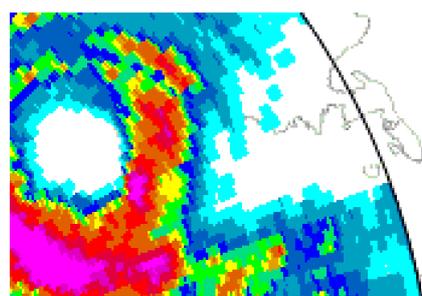
0651



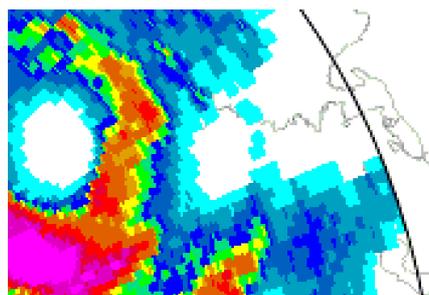
0700



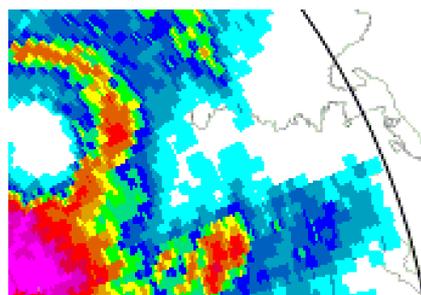
0710



0719



0729

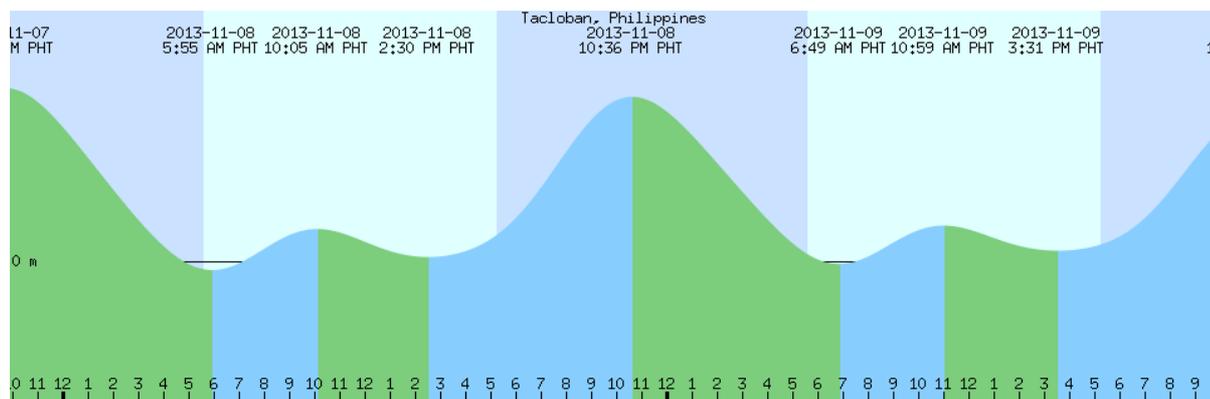


0738

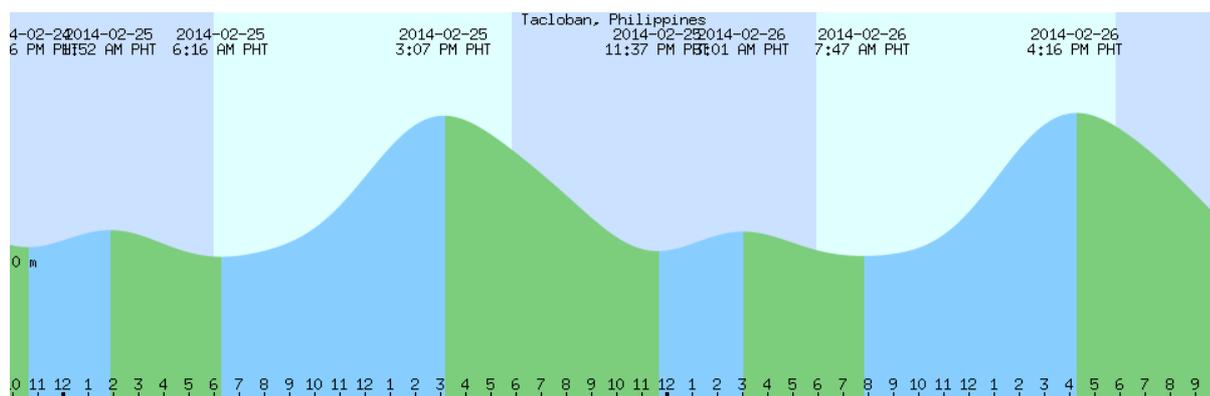


5.6 F. Tacloban City Tide Tables

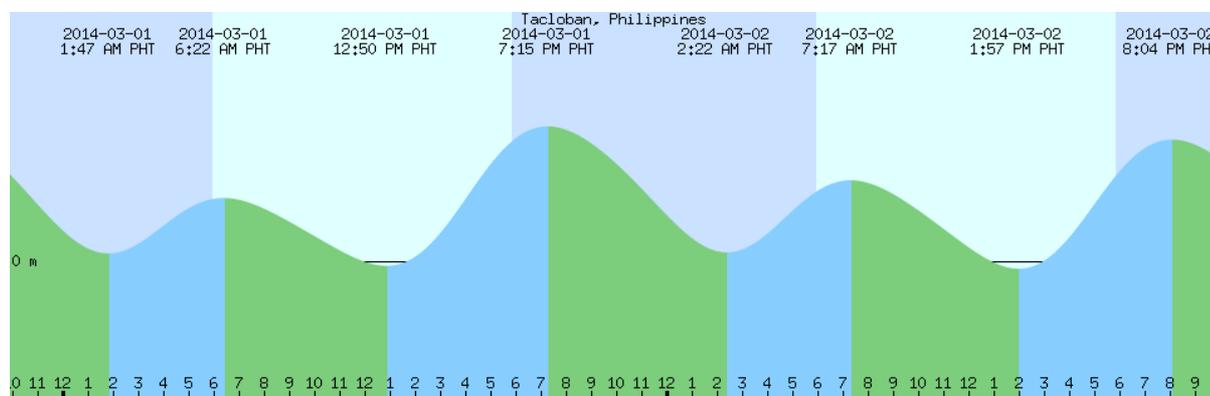
Following are the tide tables for the date of HAIYAN's landfall (08 Nov 2013) and the dates that follow-up storm-surge measurements were made (25 Feb 2014 and 01 Mar 2014). (Source: <http://tides.mobilegeographics.com/locations/6302.html>.)



08 Nov 2013



25 Feb 2014



01 Mar 2014