High Wind Event
Long Beach Container Terminal
Long Beach, CA
February 17, 2017

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Table of Contents

Executive Summary

During the afternoon of Feb 17, 2017, a severe wind event brought measured wind gusts in excess of 74 MPH to the Long Beach Container Terminal (LBCT). Estimated wind gusts were more than 100 MPH and as much as 118 MPH with official wind damage indicators to support these estimates. While the overall storm system itself was forecast by the National Weather Service (NWS), the intensity of the associated wind event was not foreseen and the LBCT received no forewarning. Historically speaking, an event of this magnitude has not been observed at the LBCT in at least the last 5 years and has never been observed at the nearby Long Beach Airport who's records date back more than 60 years.

Overview

On Feb 17, 2017, a very intense mid-winter weather system swept through southern CA bringing heavy rain and strong gusty winds to nearly all locations. While winter storms are not uncommon in southern CA during the winter months, the magnitude of the measured winds at sea level at the Long Beach Container Terminal (LBCT) were highly unusual. This report looks at this particular winter storm in some detail, providing a thorough analysis of the meteorological parameters and documents what actually occurred. The report goes on to discuss the foreseeability of the event by government meteorologists at the National Weather Service (NWS). The report continues with a look at how common an event of this magnitude is in the LBCT area. Finally, the report concludes with a few take-aways for future use.

Analysis

Climatologically, February is a winter month in the northern hemisphere including California. Winter months bring winter storms, typically driven by an abundance of moisture, a cold airmass following the storm, and a strong jet stream. When any of these 3 elements are enhanced, the resulting winter storm also can be enhanced. A colder airmass means more widespread mountain snow, more moisture means more rainfall, and a stronger jet stream can mean stronger surface winds. The winter storm to impact the LBCT on Feb 17, 2017 at first glance was not unlike other storms in the past.

At upper levels of the atmosphere, an active jetstream stretched across the Pacific Ocean to a position just off the California coast. The red arrow in Figure 1 depicts the axis of this jet stream.

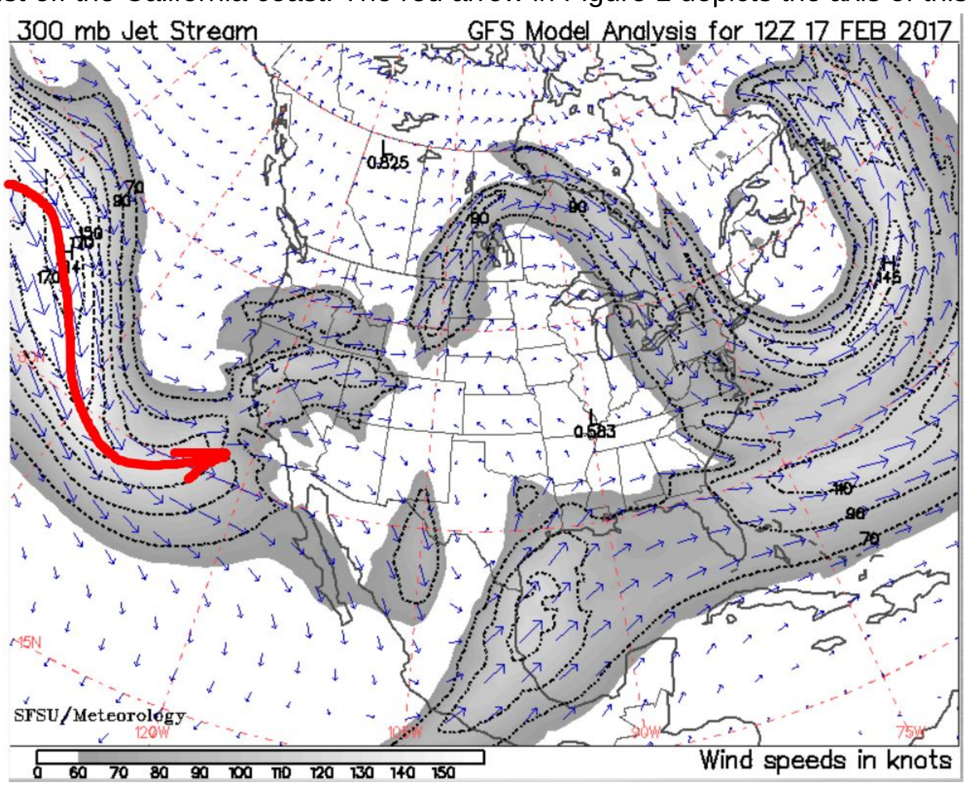

Figure 1 - 300 mb Jet Stream for 4:00 AM PST on Feb 17, 2017

Wind speeds in this jet stream were analyzed at over 150 knots (173 mph) out over the open waters of the Pacific Ocean. These are unusually strong and at the higher end of the jetstream wind speed scale given the latitude and time of year.

At the surface, an area of low pressure and an associated frontal system was just off the central California coast at 4:00 AM PST (See figure 2). Rain and mountain snows associated with this system were beginning to work their way down the coast toward Los Angeles and Long Beach. A corresponding visible satellite image from late morning on Feb 17, 2017 (Also figure 2) shows extensive cloud cover over most of the west coast from the Oregon border south to the Mexican border, except for the southern California deserts.

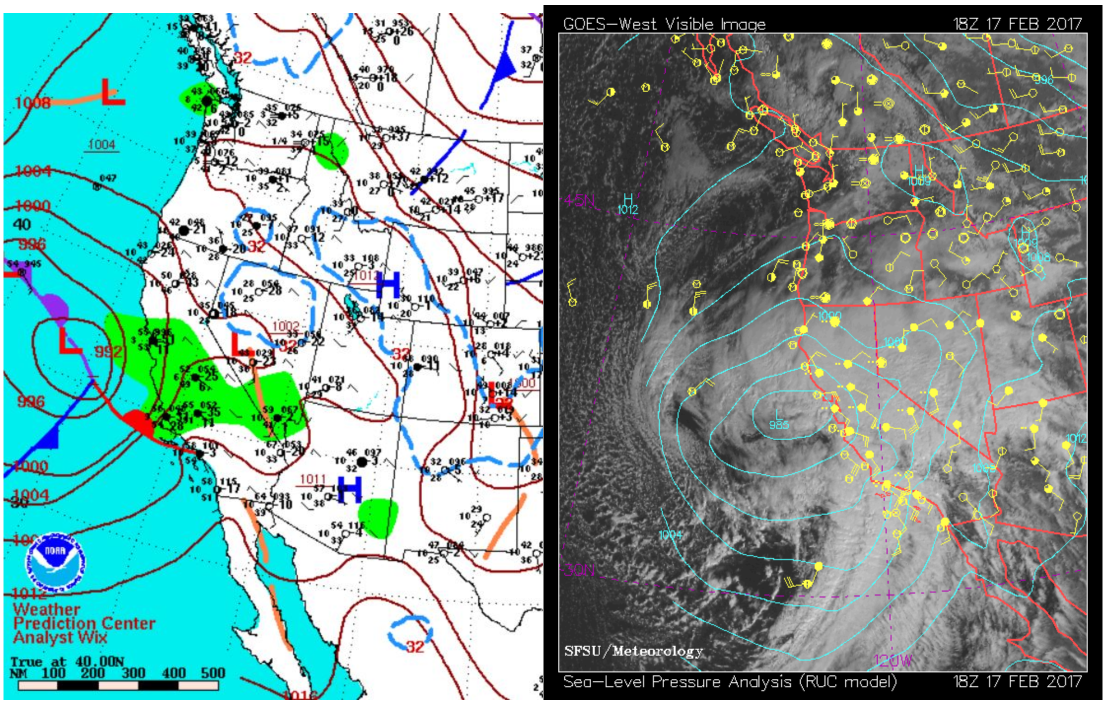

Figure 2 – Surface Weather Map (L) and Visible Satellite Imagery (R) for Feb 17, 2017

By late morning (10:00 AM PST) on Feb 17, 2017, atmospheric conditions began to show unusual and unexpected intensification. At the jet stream level, the strong winds out over the open ocean continued and began to approach the California coast. This jet stream also began to show signs of sharpening up and increasing in speed at or over the immediate coast (See figure 3). From an energy standpoint, this action would tend to increase the strength of the entire frontal system and the intensity of the low pressure area itself. This intensification begins to affect all aspects of the storm…surface winds become stronger and cover a larger area, rainfall becomes heavier and more widespread, mountain snows increase in intensity.

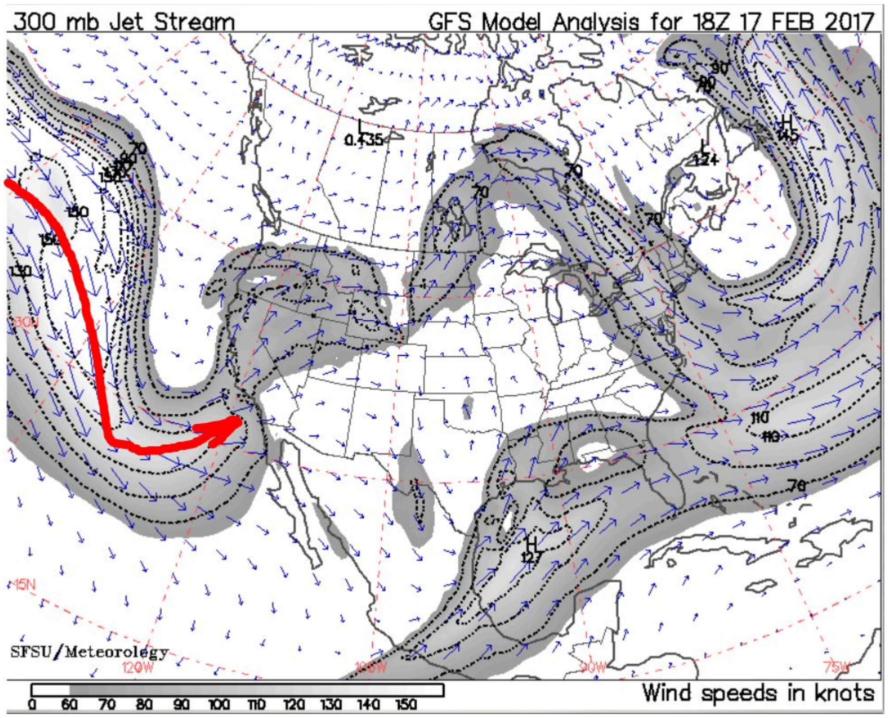

Figure 3 - 300 mb Jet Stream for 10:00 AM PST on Feb 17, 2017

By early afternoon (12:25 PM PST), NWS NEXRAD radars began showing widespread light to moderate showers moving into the greater Los Angeles area and just beginning to reach the LBCT (See figure 4). The strongest cells were still well offshore beyond the Channel Islands.

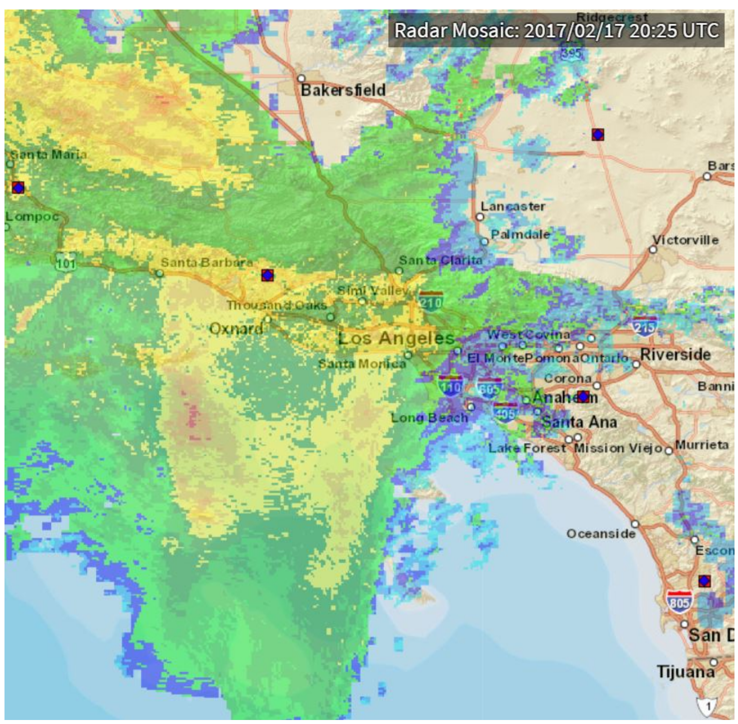

Figure 4 – NWS NEXRAD Mosaic at 1225 PM PST on Feb 17, 2017

By late afternoon (4:20 PM PST), with the low pressure area and associated frontal system bearing down on southern California, NWS NEXRAD radars showed a discontinuous and bowing line of intense cells imbedded within a larger area of rain that encompassed the entire metro area (See figure 5).

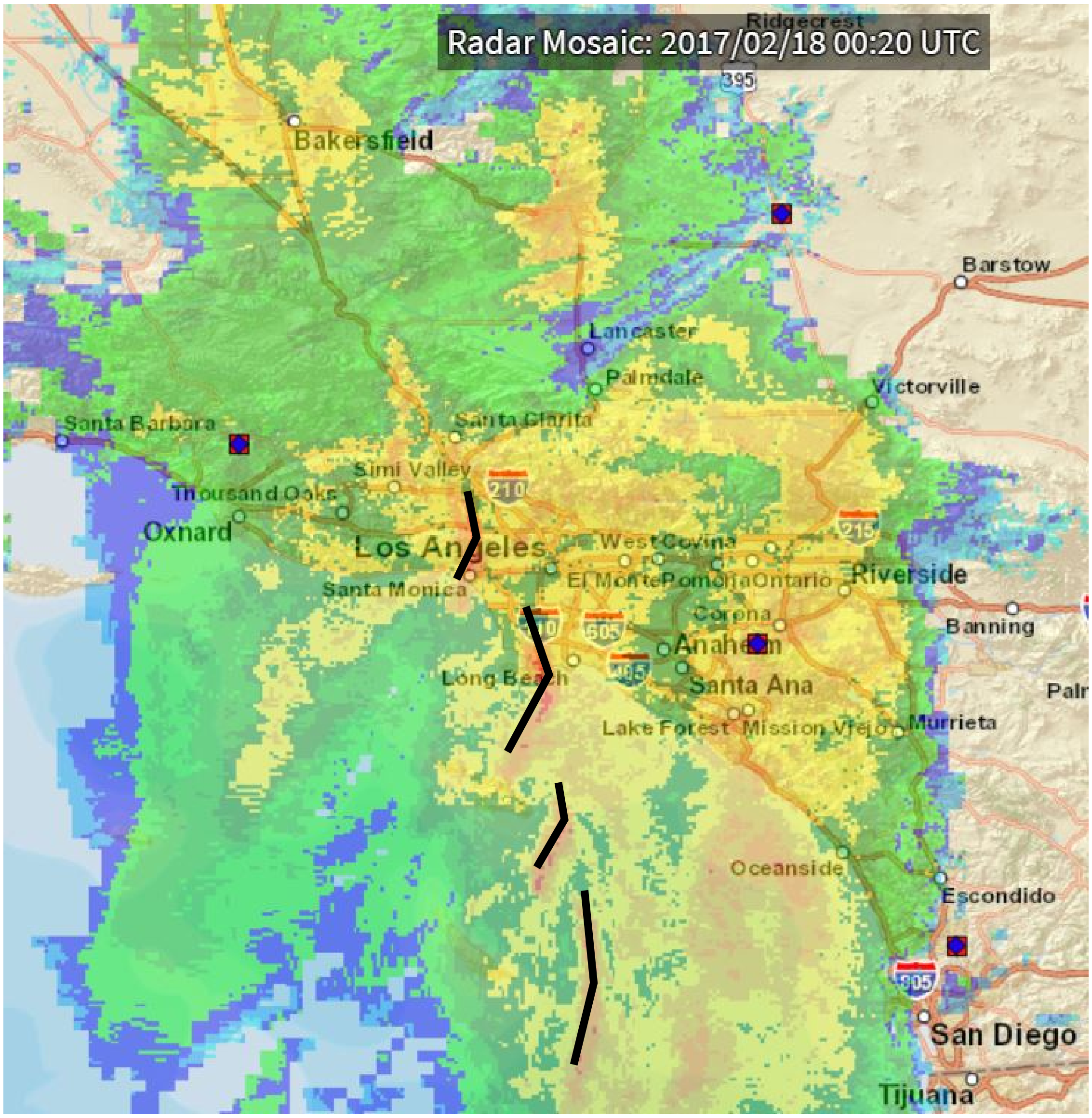

Figure 5 – NWS NEXRAD Mosaic at 420 PM PST on Feb 17, 2017

This discontinuous bowing line signature of storm cells is more commonly referred to as a Line Echo Wave Pattern or LEWP and the individual bowing features are commonly referred to as “Bow Echoes”. The significance of a LEWP or Bow Echo is that historically these features are very often associated with very severe weather such as strong and damaging winds in excess of 55 MPH, large hail, or even small tornadoes[1].

[1] http://glossary.ametsoc.org/wiki/Line_echo_wave_patterns

Concentrating on the bow echo just west of the LBCT in figure 5, we can see the most intense part of the northern half of the bow echo slams into the LBCT shortly before 425 PM PST (See figure 6),

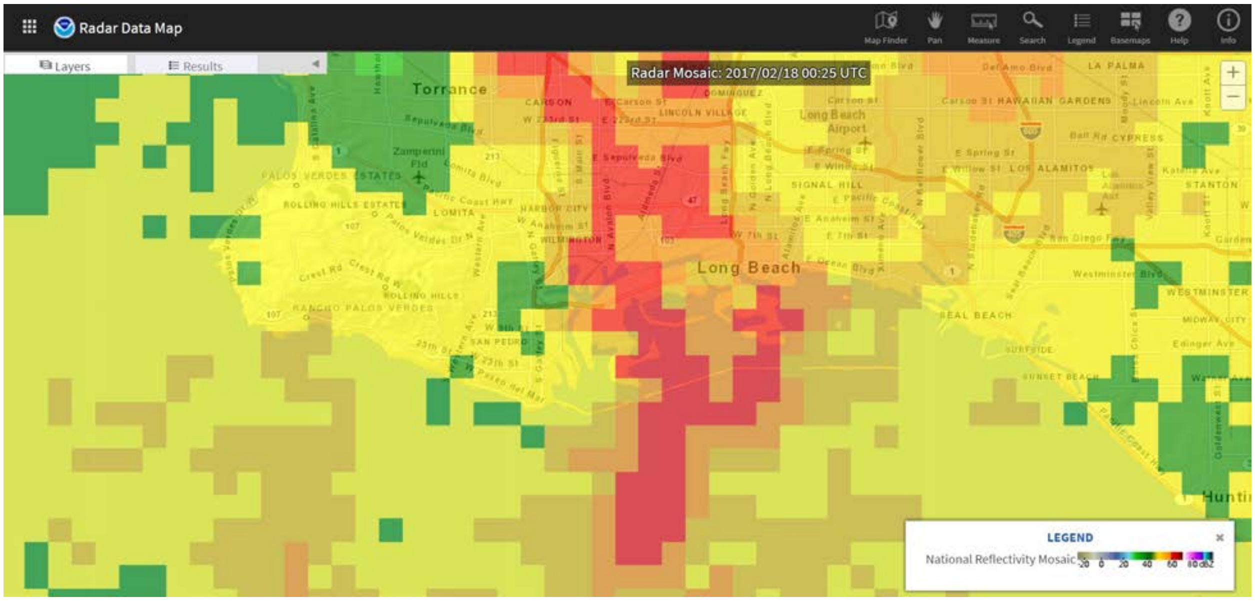

Figure 6 – NWS NEXRAD Mosaic at 425 PM PST on Feb 17, 2017

Examination of NOAA's Severe Weather Data Inventory[2] (See figure 7) revealed that indeed NWS NEXRAD radars identified a potentially severe thunderstorm directly over the Ports of Los Angeles/Long Beach shortly before the image time found in figure 6 above.

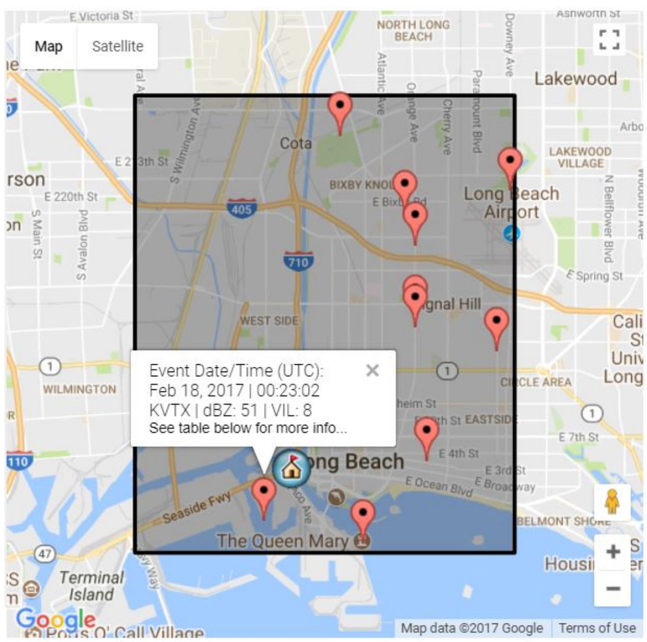

Figure 7 – NOAA's SWDI Display for Feb 17, 2017 (Note: UTC is used here)

[2] https://www.ncdc.noaa.gov/swdi/#TileSearch

Observations

Wind observations taken at the combined Los Angeles/Long Beach Ports reflected the overall intensity of this line of storms (See table 1). Observations ranged from 40 MPH at Pier S to 75 MPH at Pier F. Pier F is highlighted in red in table 1 to note the strongest recorded winds of all stations at the Los Angeles/Long Beach Ports during this event.

Maximum Wind Gusts			
17-Feb-17			
Station Name	**Max (MPH)**	**Time (PST)**	**Dist (SM)**
Pier S	40	1436	0.9
Pier F	**75**	**1624**	**1.1**
Badger Ave B	51	1524	1.7
Pier J	51	1554	2.5
Pier 400	49	1524	2.6
Berth 161	42	1600	3.2

Table 1 – Maximum Recorded Wind Gusts on 17 Feb 2017

The significance of this recorded 75 MPH wind gust at Pier F goes beyond this one event. This 75 MPH wind gust was the strongest gust recorded at Pier F in the past 5 years[3]. It is possible that this is the strongest gust ever officially recorded at the Ports of Los Angeles/Long Beach. Full access to all station datasets is the only limitation to validating this last claim.

A review of onsite security video camera footage as the storm passed over the LBCT revealed much more information about the character and strength of the storm system. It also provided a visual method for estimating the wind gusts based upon visual cues and a few measurements.

While viewing the footage of the storm's passage from Camera #29 (See figure 8), and armed with a few measurements, one can estimate the speed of the wind based upon the wind's movement of the rain across the pavement. The video footage is recorded every tenth of a second. This makes it very easy to step through small increments of time and follow bands of rain water being driven across the pavement. By knowing the amount of time passed and the distance travelled by the bands of rain water, we can calculate the speed at which the rain bands are moving and infer that this speed is roughly equal to the speed of the wind at that time.

From figure 8, the length of the white dashed lines is 6' 10.5" and the length of the space between two white dashed lines is 17' 2". Therefore, a combined line and space segment is equal to slightly more than 24'. Armed with this measurement and while incrementally stepping through the footage from Camera #29, especially around the time of the Pier F peak wind gust and the observed container damage, I made several calculations to determine that the estimated "observed" peak wind speed/gust ranged between 81-118 MPH.

[3] https://tidesandcurrents.noaa.gov/met.html?id=9410670

Figure 8 - Snapshot of the View from Camera #29.

Table 2 provides a list of those time increments used to calculate the estimated “observed” peak wind speed/gust.

Estimated "Observed" Wind Calculations			
17-Feb-17			
Clock Time (PDT)	**Time (SECS)**	**Distance (FT)**	**Max (MPH)**
17:23:51.238 => 17:23:51.439	0.201	24	81
17:23:52.829 => 17:23:52.928	0.1	16	109
17:24:14.963 => 17:24:16.068	1.105	192	118

Table 2 – Estimated “Observed” Wind Speed/Gust Calculations

Most certainly there is some subjectivity in the samples used but support for these numbers can be found by evaluating the Enhanced F-Scale Wind Damage Indicators provided by the NWS (and used by federal government officials during storm surveys to estimate wind gusts based on damage[4]) and comparing them to damage found at the LBCT.

LBCT video camera footage at the time of the strongest wind gusts showed fully loaded cargo containers toppling over. This damage can arguably be compared to that of a single-wide manufactured home being rolled off its support pilings – an Enhanced F-Scale Wind Damage Indicator (See figure 9), with a lower wind boundary (LB) of 84 MPH and an upper wind boundary (UB) of 114 MPH.

[4] http://www.spc.noaa.gov/faq/tornado/ef-scale.html

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	61	51	76
2	Loss of shingles or partial uplift of one-piece metal roof covering	74	61	92
3	Unit slides off block piers but remains upright	87	72	103
4	Complete uplift of roof; most walls remain standing	89	73	112
5	Unit rolls on its side or upside down; remains essentially intact	98	84	114
6	Destruction of roof and walls leaving floor and undercarriage in place	105	87	123
7	Unit rolls or vaults; roof and walls separate from floor and undercarriage	109	96	128
8	Undercarriage separates from unit; rolls, tumbles and is badly bent	118	101	136
9	Complete destruction of unit; debris blown away	127	110	148

* Degree of Damage

Figure 9 – EF Scale Wind Damage Indicator for a Single-Wide Manufactured Home

Foreseeability

The NWS is the gold standard when it comes to publicly available forecasts and is the sole source for official severe weather watches, warnings, and advisories. Their alert system is the only public alert system in existence in the United States. All federal, state, county, and local officials and emergency responders rely on the NWS for weather and warning information.

The NWS in Oxnard, CA, which provides forecast and warning services for the area of southern CA where the LBCT is located, began advertising the potential for "another" weather system as early as Feb 12, 2017. It wasn't until late on Feb 13, 2017 that they began emphasizing a strong storm with a prolonged period (72 hrs) of rain for southern California. Early on Feb 14, 2017 forecasters mentioned the potential for strong winds with gusts over 60 mph in coastal regions but emphasized it was most likely north of Pt. Conception. By early on Feb 15, 2017, NWS forecasters recognized the dynamics and strength of the developing system and added thunderstorms to all areas but maintained that the stronger winds would be north of the LA basin.

By the afternoon of Feb 15, 2017, the NWS was in storm mode and advertising a very strong dynamic weather system to affect all southern California with copious amounts of rain, strong gusty winds, thunderstorms likely, and flash flooding. Clearly more emphasis was being placed on the rain and flooding potential for the LA Basin (including coastal areas) than the damaging wind potential at this point. Table 3 below provides a service timeline as the storm began to unfold.

It is fairly clear from the chronology that the services provided by the NWS were a mixed message, especially within 24 hours of the event. The public forecast was ramping up the potential hazards and wind gusts while both the aviation and coastal waters forecasts were giving the indication that conditions were not going to be as hazardous as earlier forecast or advertised. At best, this was confusing, especially to users of multiple kinds of products (public/aviation/marine). The forecasters also were "late to the game" regarding the strengthening of the system and the ultimate wind potential. It also was clear that forecasters were more concerned with and focusing on the flash flood potential vs. the severe wind potential associated convective storm cells.

NWS Service Chronology			
2/16-17/2017			
Date	**Time (PST)**	**Products**	**Details**
16-Feb	839PM	Discussion	Strongest storm of the season
16-Feb	1036PM	Aviation Forecast	Winds gusting to 37 MPH at LGB airport added for the following afternoon
17-Feb	254AM	Marine Forecast	Potential for winds to gust to 58 MPH in the coastal waters Fri/Fri night
17-Feb	446AM	Aviation Forecast	Continued forecast of winds gusting to 37 MPH at LGB airport
17-Feb	503AM	Public Forecast	Potential for winds to gust to 50 MPH in coastal areas (incl LBCT)
17-Feb	603AM	Aviation Forecast	Updated wind potential at LGB airport to 40 MPH
17-Feb	647AM	Public Alert	"Very strong/damaging winds across much of SW CA today" Gusts to 58 MPH
17-Feb	733AM	Public Forecast	Chance of thunderstorms added with wind gusts to 63 MPH
17-Feb	737AM	Aviation Forecast	Forecast wind gusts at LGB airport lowered to 35 MPH
17-Feb	921AM	Marine Forecast	Wind gust potential for coastal waters lowered to 52 MPH
17-Feb	213PM	Discussion	"Widespread gusts to at or above 50 MPH through tonight"
17-Feb	223PM	Marine Forecast	Wind gust potential for coastal waters lowered to 46 MPH
17-Feb	234PM	Public Alert	Wind advisory issued for coastal LA county with wind gusts to 50 MPH
17-Feb	337PM	Aviation Forecast	Forecast wind gusts at LGB airport lowered to 32 MPH
17-Feb	416PM	Public Alert	Strong line of storms approaching with potential gusts to 55 MPH

Table 3 – NWS Service Timeline as Storm Unfolds

Of most significance to the LBCT is the fact that forecasters underestimated the ultimate strength of the approaching storm cells. The only alert issued prior to the event was issued at 416 PM, only 7 mins before the event and it only mentioned gusts to 55 MPH. No wind warnings or severe thunderstorm warnings were issued for the event despite NWS NEXRAD radars identified a potentially severe thunderstorm. Regardless, I can say with a reasonable degree of meteorological and scientific probability that based on the available meteorological data, winds at the earth's surface would never have been expected to exceed 75-80 MPH let alone 100 MPH.

Historical Perspective

One might wonder "How common are these observed winds?" or "Are these observed winds unique or rare?" We already mentioned that these winds had not been observed at the Los Angeles/Long Beach Ports in at least the last 5 years and maybe longer, if ever. That certainly makes them rare.

To more fully answer this question though, one needs to take an historical look back at the observed winds at nearby weather stations with a solid wind record. Long Beach Airport (LGB), less than 5 miles away, is one of those stations with a solid record dating back to 1956. The records show that in those 61 years, the wind has gusted over 50 MPH on only 2 occasions (11/1985 and 2/2016). The strongest all-time wind gust at LGB was only 54 MPH. That, in and of itself, says volumes. So, wind gusts to 75 MPH in the LGB/LBCT vicinity are not at all common.

Another approach to wind gust frequencies is to examine the situation from an engineering perspective. The American Society of Civil Engineers (ASCE), an internationally recognized authoritative source for building codes and standards, provides minimum design loads for buildings and other structures (ASCE 7-10)[5]. ASCE 7-10 directs users to a website whose purpose is to provide users with a site-specific windspeed that is used in the determination of

[5] http://ascelibrary.org/doi/book/10.1061/9780784412916

design wind loads. Part of the output (for serviceability purposes) is 10-, 25-, 50-, and 100-year return periods. These return periods are site specific for the location provided and are found by interpolation of map contours (to the nearest 1-MPH) found on the wind maps located in the ASCE 7-10. Using the Lat/Lon of the incident location reveals the output found in figure 10.

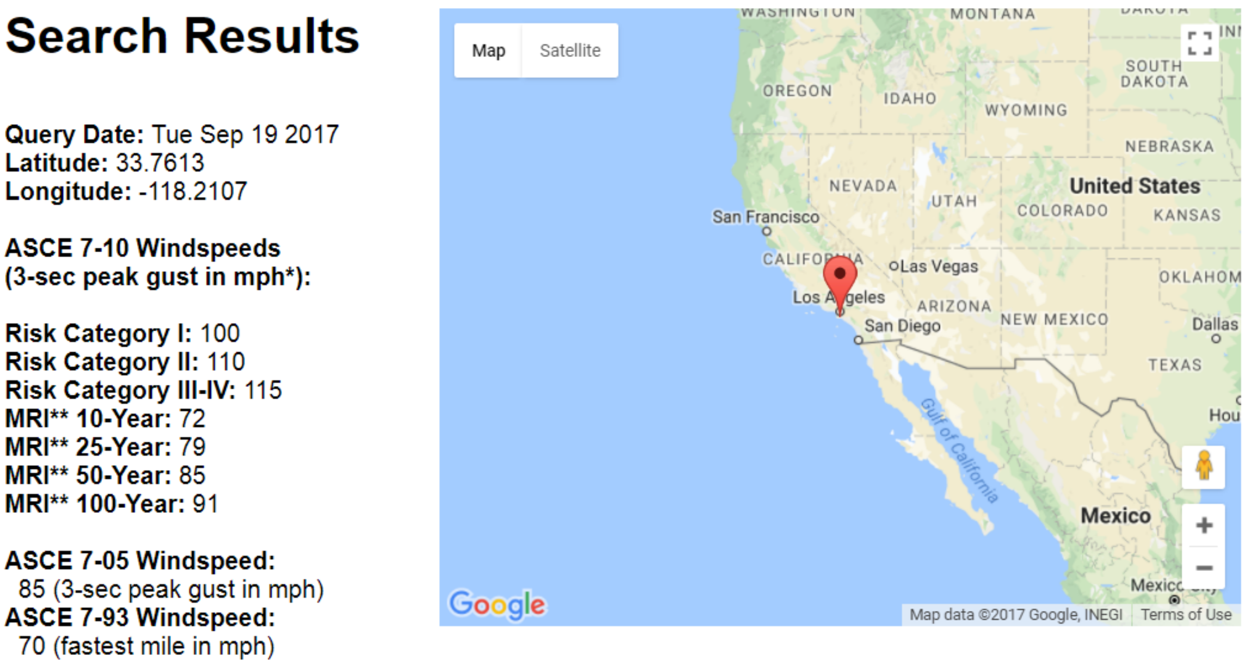

Figure 10 – Search Results from ASCE 7-10 directed website for the incident location

The search results provide an engineering-perspective statistical Mean Recurrence Interval (MRI) of 10 years for a 72 MPH 3-sec peak wind gust. This further drives the point home that the observed winds on Feb 17, 2017 at the LBCT were exceptional and very rare and statistically are not expected for a period of 50-100 years minimum.

Summary/Takeaways

- On Feb 17, 2017, a very intense mid-winter weather system swept through southern CA bringing heavy rain and strong gusty winds to nearly all locations.
- During the late afternoon of Feb 17, 2017, a Line Echo Wave Pattern (LEWP) of thunderstorms and associated Bow Echo (commonly associated with very severe weather) slammed into the LBCT.
- This resulted in measured wind observations at the LBCT reaching as high as 75 MPH and estimated "observed" peak wind speeds between 81-118 MPH.
- The 75 MPH wind gust was the highest gust recorded at the LBCT in the past 5 years and possibly the strongest ever officially recorded.
- The estimated "observed" peak wind speeds of 81-118 MPH are consistent with the resulting storm damage observed when compared to NWS Enhanced F-Scale Wind Damage Indicators.
- Forecast services provided by the NWS were a mixed message, especially within 24 hours of the event.

- Forecast services provided by the NWS underestimated the potential and ultimate strength of not only the system but the individual cells that ultimately impacted the LBCT on Feb 17, 2017.
- No severe thunderstorm warning was ever issued by the NWS although NWS NEXRAD radars indicated that such a storm potentially and most likely existed.
- Both the recorded maximum wind gust of 75 MPH and the estimated “observed” wind speeds of 81-118 MPH at the LBCT exceed the highest wind gust ever recorded at the Long Beach Airport with a 61-year record…by at least 21 MPH.
- The recorded maximum wind gust of 75 MPH has statistically a 10-25 year Mean Recurrence Interval.
- The estimated “observed” wind speeds of 81-118 MPH have statistically at least a 50-100 year Mean Recurrence Interval.