



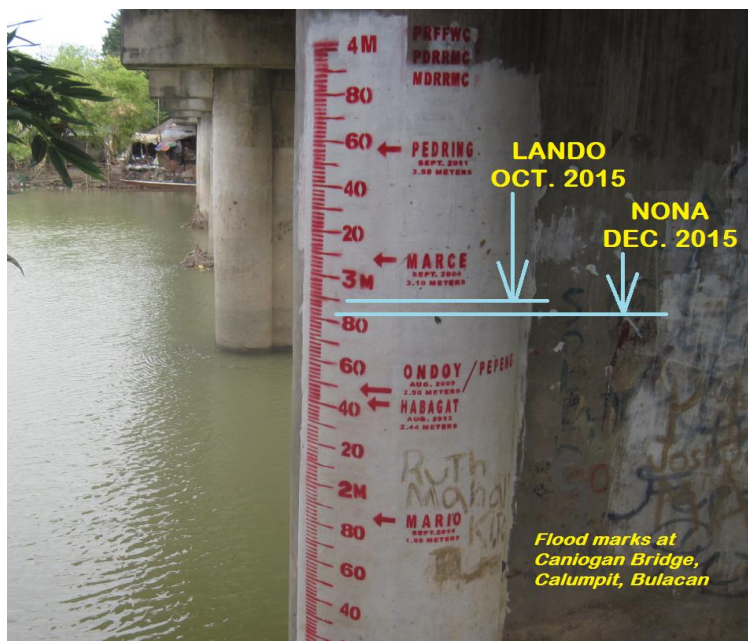
Pampanga River Basin Flood Forecasting & Warning Center (PRFFWC)
 Philippine Atmospheric, Geophysical & Astronomical Services
 Administration (PAGASA)
 DOST Region 3 Compound, San Fernando, Pampanga 2000
 Website: prffwc.webs.com / prffwc.synthasite.com



PRFFWC Post-Flood Report 2015-1 ¹

PAMPANGA RIVER BASIN Flood Events 2015:

1. Typhoon “LANDO” (KOPPU), October 16 to 24
2. Typhoon “NONA” (MELOR), December 16 to 22



¹ Area surveys carried-out (intermittently) between November to December, 2015.

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1.0 Hydrological Area Background – Pampanga River Basin (PRB)²

The Pampanga River basin is the 4th largest basin in the Philippines with an aggregate area of 10,434 km² and is generally divided into three sub-basins, namely: (a) Pampanga main river basin with its catchment area of 7,978 km², (b) Pasac river basin (also known as the Pasac-Guagua allied river basin system) with 1,371 km² and (c) Angat River basin with 1,085 km². These three basins originate from different mountain areas having separate river mouths towards the Manila Bay but are interconnected by channels and their water resources / management works are mutually and closely related. The basin area (about 95%) transcends the bounds of four provinces, namely, Nueva Ecija, Tarlac, Pampanga and Bulacan while the remaining fringe area (about 5%) is a part of other seven provinces, Aurora, Zambales, Rizal, Quezon, Pangasinan, Bataan and Nueva Vizcaya.



Figure 1.0. Pampanga River at Arayat station (photo taken at 1253H of October 20, 2015) during typhoon Lando; telemetry reading was 9.93 meters and already receding after peaking at 10.03 meters 10 hours ago)

Pampanga River has a river length of about 265 kms with headwaters originating in the Caraballo Mountains at north of the basin, and flows into Pantabangan storage dam. After the dam, it flows southward meeting with several tributaries until emptying into Manila Bay. The major tributaries are Coronel, Peñaranda, and Rio Chico Rivers. Rio Chico has the largest catchment area at 2,895 km² and it joins the main stream of Pampanga just before Mt. Arayat (elevation 1,026 m).

The Angat River system on the other hand originates in the Sierra Madre Mountains and flows into Angat storage dam. From the dam, the river flows westward and finally empties into the Manila Bay through the Labangan Floodway. There is a connecting channel with Pampanga River, the Bagbag River, situated between the towns of Pulilan and Calumpit in Bulacan.

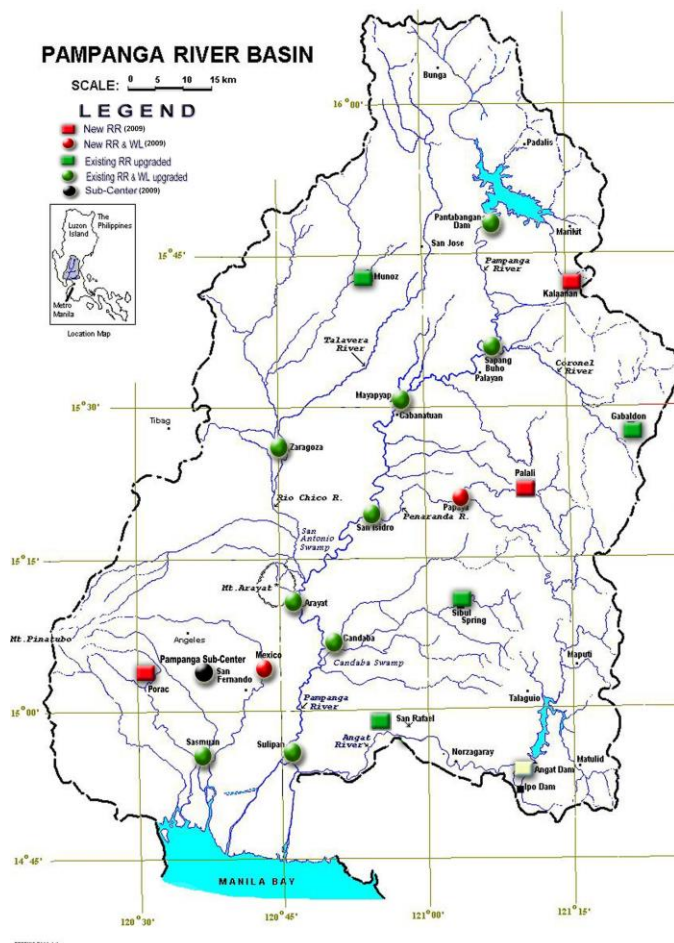
The Pasac-Guagua River system includes various channels running on the eastern slope of Mt. Pinatubo. These are the Abacan-San Fernando, Pasig-Potrero and Porac-Gumain Rivers. All these rivers originate in Mt. Pinatubo and flow into Manila Bay. At the lower reaches, the river system is connected with Main Pampanga River by the Bebe-San Esteban Cut-off Channel. The Pasac River had been much affected by the eruption of Mt. Pinatubo in 1991 such that river alignments had significantly changed due to mudflow (lahar), and serious sediment deposition in the river channel is still active.



Figure 1.1 Pampanga River taken at around 1412H of December 17, 2015 during event “Nona” at a telemetry reading of 9.57 meters and river was still rising.

² Some portions taken from the Draft Final Report “The Study on Integrated Water Resources Management for Poverty Alleviation and Economic Development in the Pampanga River Basin”. NWRB-JICA Project, December 2010. (PRFFWC is a project TWG member)

The basin has two swamp areas, the Candaba and the San Antonio Swamps with an area of about 250 and 100 km², respectively. Candaba Swamp has the maximum inundation area of around 330 km² during rainy season.



There are two major hydraulic structures within the basin: Pantabangan and Angat Dams. Pantabangan is at the northeast of the basin, the upper main Pampanga River and operates both as hydropower and as an irrigation dam. Angat is located on the eastern portion of the basin and drains through the Angat River via Ipo and Bustos Dams. Angat operates as a hydropower plant while Ipo and Bustos as water supply reservoir and irrigation dams, respectively.

The long-term average annual precipitation in the study area is estimated at about 2,155 mm/year, and about 83% of this is concentrated during the rainy season from May to October.

Figure 1.2 (Left) - The Pampanga River Basin with the present network of telemetered rainfall and water level stations (2009).

2.0 The Pampanga River Basin Flood Forecasting & Warning Center (PRFFWC)

The system is composed of 18 rainfall (RR), including a digitally-read tipping bucket type in the PRFFWC, and 10 water level (WL) stations. It is complemented with several RR observations from the provinces of Bulacan and Pampanga; 2 synoptic and 1 agrometeorological stations within the basin. These latter stations, however, are not transmitting data on a real-time basis to the center. The PRFFWC operations center is located in the DOST Region 3 compound in the City of San Fernando, Province of Pampanga. Further information is available at the following link: <http://prffwc.synthasite.com/station-info.php>

Table 1.0 RR and WL Stations within the Pampanga River Basin System

Station	Station Type	Coordinates
Muñoz	Telemeterized RR	15°44'17"N, 120°57'38"E
Sapang Buho	Telemeterized RR & WL	15°35'39"N, 121°07'09"E
Calaanan	Telemeterized RR	15°38'53"N, 121°11'09"E
Mayapyap	Telemeterized RR & WL	15°30'52"N, 120°57'20"E
Gabaldon	Telemeterized RR	15°29'55"N, 121°21'20"E
Palali	Telemeterized RR	15°22'50"N, 121°9'41"E
Zaragoza	Telemeterized RR & WL	15°26'36"N, 120°45'03"E
Peñaranda	Telemeterized RR & WL	15°21'14"N, 121°00'20"E

San Isidro	Telemeterized RR & WL	15°18'49"N, 120°54'09"E
Sibul Spring	Telemeterized RR	15°10'05"N, 121°03'33"E
Arayat	Telemeterized RR & WL	15°10'06"N, 120°46'56"E
Candaba	Telemeterized RR & WL	15°06'56"N, 120°51'01"E
San Rafael	Telemeterized RR	14°58'05"N, 120°54'52"E
Sulipan	Telemeterized RR & WL	14°56'21"N, 120°45'39"E
Porac	Telemeterized RR	15°04'48"N, 120°32'43"E
Mexico	Telemeterized RR & WL	15°04'05"N, 120°43'51"E
Sasmuan	Telemeterized RR & WL	14°56'11"N, 120°37'23"E
San Fernando	Digital tipping-bucket RR	15°04'04"N, 120°39'22"E
Clark	Synoptic	15°10'N, 120°34'E
Cabanatuan	Synoptic	15°44'N, 120°56'E
CLSU, Muñoz	Agrometeorological	15°43'N, 120°54'E

I. Typhoon Lando Flood Event Report

1. Summary

Tropical Cyclone “Lando” entered the Philippine Area of Responsibility (PAR) in the afternoon of October 14 as a tropical storm. It made landfall on the Province of Aurora in the early morning of October 18 as a typhoon category having maximum winds of 175 kph (kilometer per hour) and gusts of up to more than 210 kph. It tracked through central and northern Luzon, making a pass at the northeastern portion of Pampanga River Basin (PRB), until it weakened into a low pressure area (LPA) in the Babuyan Channel or northern sea of Luzon in the afternoon of October 21.

Continuous heavy rains spawned by “Lando” over the east northeast portions of the PRB was observed at the telemetry rainfall station of Gabaldon in Nueva Ecija starting in the afternoon of October 17 and for almost 24 hours which caused flash floods that washed-out several riverside structures and roads at the said town. The eastern and northeastern parts of the basin likewise received heavy downpour for almost 10 hours beginning in the early morning of October 18 causing the upper main Pampanga River including its tributaries Digmala, Coronel, Penaranda, and relatively smaller streams such as Tabuating, Minatula and Cabu rivers to overflow its banks inundating several towns of Nueva Ecija including the cities of Palayan, Gapan and Cabanatuan from morning till afternoon of that same day. By late October 18 until early October 19 main Pampanga River overflowed its banks at the Cabiao floodway and similarly at some riverside areas of Arayat in Pampanga. On the morning of October 20, riverside areas from San Luis down to Apalit in Pampanga and Calumpit in Bulacan started to get flooded as well. Floodwaters reached other parts of Calumpit and Hagonoy inundating riverside barangays along the Pampanga River by October 21. Flood levels attained at some of the forecasting points in the PRB have surpassed flood records particularly those at the upstream sections of the main Pampanga River. On the other hand, except for isolated ponding of rainwater, the allied river system of Pasac-Guagua did not experience any river flooding during event Lando.

The local government units (LGUs) of the provinces of Nueva Ecija and Tarlac, the towns of San Miguel and Calumpit in Bulacan, and the towns of Arayat and San Luis in Pampanga declared a state of calamity in their respective area of jurisdiction as a result of the flooding within the basin. A total of 8 fatalities were reported for the whole of Region 3 as per NDRRMC situation report no. 26 dated November 03, 2015. The Pampanga River Basin Flood Forecasting and Warning Center (PRFFWC) of

PAGASA issued a total of 2 Flood Advisories (FAs) and 15 Flood Bulletins (FBs) for the event covering the period from October 16 to 24 for PRB.

Typhoon Lando is considered as one of the most devastating tropical cyclone to hit the country for the year 2015. Furthermore, the year 2015 has been marked with a significantly strong El Niño episode.

2. Meteorological Aspect: Typhoon “LANDO” (International name: “Koppu”)³

“LANDO” as a storm entered the PAR in the afternoon of October 14, 2015. It gained strength and reached typhoon intensity while moving west towards Luzon. It made landfall over Aurora province in the early morning (around 0100H-0200H LST) of October 18 and partly weakened. It then tracked across several provinces in Central and Northern Luzon and out into the West Philippine Sea a day later. “Lando” weakened further and moved slowly on a north to northeast directions passing across Babuyan Islands. The disturbance became a low pressure area over the Babuyan Channel in the afternoon of October 21.

Public Storm Warning Signals raised: #4 in Aurora and Southern Isabela; #3 in Quirino, Northern Isabela, Pollilio Island, Nueva Vizcaya, Nueva Ecija, Ifugao, Northern Quezon, Benguet, Mt. Province, Kalinga, La Union, Pangasinan, Ilocos Sur, Ilocos Norte, Zambales, and Abra; #2 in Southern Quezon, Apayao, Cagayan, Babuyan & Calayan group of Islands, Bulacan, Pampanga, Tarlac, Rizal, Camarines Norte, Catanduanes, Metro Manila, and Bataan; #1 in Batanes, Batangas, Laguna, Cavite, Albay, Camarines Sur, Lubang Island, Oriental Mindoro, and Marinduque.

Impacts: Regions affected – Regions I, II, III, IV-A, V, NCR and CAR; Estimated damage to Agriculture and Infrastructure at around (Philippine) ₱ 11.0 B; Casualties: Dead – 48; Injured – 83; Missing – 4 (NDRRMC Sitrep No. 26 dated November 03, 2015)

Maximum gust observed was 252 kph at Casiguran station, minimum pressure of 942.5 hPa recorded at Baler station and maximum 24-hr rainfall of 775.4 mm recorded at Baguio station. “Lando” was considered to be the most devastating tropical cyclone that affected the country for the year 2015.

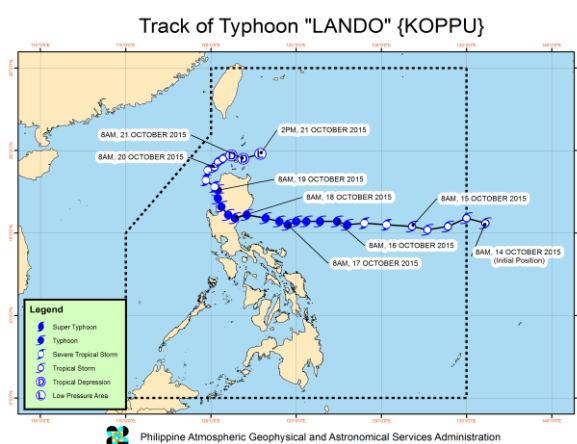


Figure 2.0 Track of Typhoon “Lando” during its course within the PAR (Oct. 14 to 21).⁴

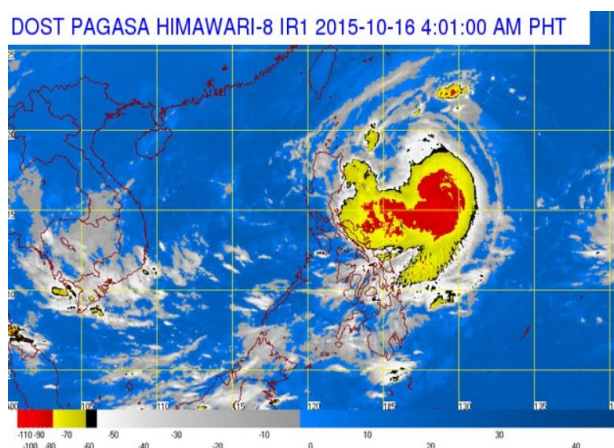


Figure 2.1 IR satellite image of “Lando” at 0401H (LST), October 16, 2015.

³ Portions were taken from TC summary report for 2015 by TAU, Weather Division, PAGASA

3. Rainfall associated with Typhoon Lando

Table 2.0 Rainfall Intensity Classification Table (mm/hr)

Category	1 hour	3 hours	6 hours	12 hours	24 hours
Light	< 2.5	< 7.5	< 15	< 30	< 60
Moderate	2.5 – 7.5	7.5 – 22.5	15 – 45	30 – 90	60 – 180
Heavy	> 7.5	> 22.5	> 45	> 90	> 180

Table 2.1 Pampanga River Basin observed 24-hr (meteorological day) rainfall in millimeters for the period October 17 to 19, 2015.

Stations	October 2015			Maximum one – hour observed RR	Time (LST) / Day of maximum 1-hr RR for the period October 17 to 19, 2015
	17	18	19		
Muñoz	40	168	26	20	2200H / Oct 18
Sapang Buho	109	203	12	24	1200H & 1300H / Oct 18
Gabalton	323	205	16	37	0900H / Oct 18
Zaragoza	51	130	2	22	1700H / Oct 18
Mayapyap	*	*	*	*	
Peñaranda	81	194	6	26	1100H / Oct 18
Calaanan	83	255	23	39	1400H / Oct 18
Palali	179	232	5	38	1000H / Oct 18
San Isidro	58	168	2	26	1700H / Oct 18
Arayat	53	117	2	21	1500H / Oct 18
Candaba	**	**	**	**	
Sibul Springs	118	154	0	21	1200H / Oct 18
Sulipan	33	87	2	16	1100H / Oct 18
San Rafael	26	98	2	15	1400H / Oct 18

Note: * station remained totally down; ** station's rain gauge was not functioning at that time

Table 2.2 Pasac-Guagua River Basin (Allied basin) 24-hr (meteorological day) RR in millimeters for the period October 17 to 19, 2015.

Stations	October 2015			Maximum one – hour observed RR	Time (LST) / Day of maximum 1-hr RR for the period October 17 to 19, 2015
	17	18	19		
Sasmuan	29	39	1	12	1200H / Oct 18
Mexico	46	104	10	17	1300H / Oct 18
Porac	22	50	2	9	1100H / Oct 18
San Fernando	30	80	7	27	1300H / Oct 18

24-hour rainfall totals using the (Philippine) meteorological day format (8:00am till 8:00am of the next day) from various telemetry stations within the PRB were used to produce the 24-hr isohyets for the period October 17 and 18. The maximum observed 1-hr RR were also determined based on a fixed 1-hour regular time period.

⁴ Track of Tropical Cyclone "Lando" courtesy of "dyuwi@yahoo.com"

Table 2.3 Rainfall total in millimeters at other stations (in Central Luzon) for the following period:

Stations	October 2015		
	17	18	19
Clark, Pampanga	30.0	103.4	10.2
Cabanatuan, Nueva Ecija	67.4		
Baler, Aurora	60.6		
Subic, Zambales	9.5	22.0	31.0
Iba, Zambales	16.8	154.8	13.8
Carmen, Pangasinan (ARB)	40	123	41
Sta. Maria, Pangasinan (ARB)	25	90	80
Mapandan, Pangasinan (ARB)	21	84	
San Vicente, Pangasinan (ARB)	58	250	28
Sta. Barbara, Pangasinan (ARB)	23	98	
Bugallon, Pangasinan (ARB)	27	254	
Maasin, Tarlac (ARB)	7	292	16
Tibag, Tarlac (ARB)	40	209	3
Camp O'Donnell, Tarlac (ARB)	38	206	3

Shaded cells are as per available info from Flood Forecasting & Warning Section of the HydroMeteorological Division.
ARB - Agno River Basin telemetry stations, RR data extracted from ARB Flood Forecasting & Warning Center dataset; Blanks – no data available

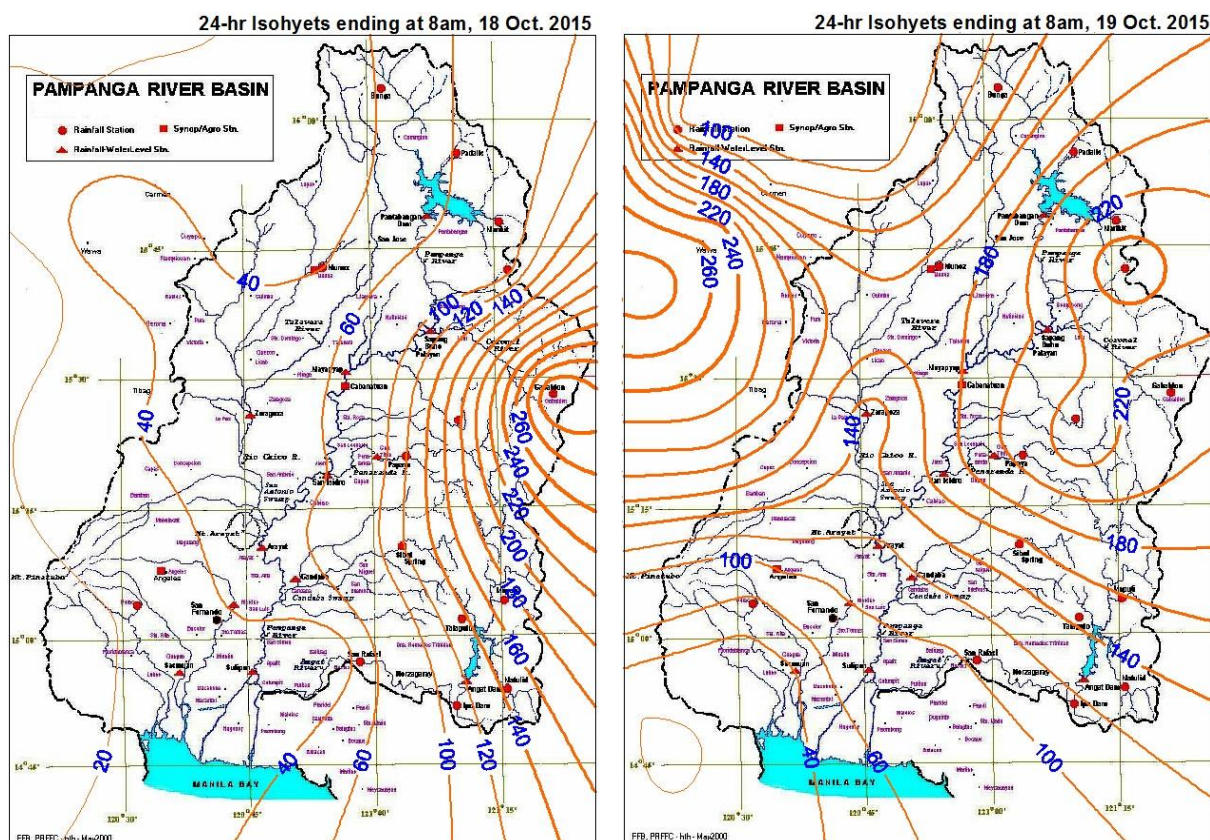


Figure 3.0 The 24-hour meteorological day isohyets for October 17 (top left) and October 18 (top right) for PRB during the passage of Typhoon "Lando".

4. River levels during event Lando

4.1 River stages during “Lando” at PRFFWC forecasting points

Table 3.0 Time / Day of Station’s Flood Assessment Gauge Heights were reached

Station Point	Alert Level	Alarm Level	Critical Level	Remarks
Sapang Buho	(3.70 m) Before 0930H of Oct. 18	(4.50 m) Before 1000H of Oct. 18	(6.50 m) Before 1100H of Oct. 18	Peak WL was 8.08 m (58.274 m AMSL) attained at around 1430H of Oct. 18.
Mayapyap	(3.00 m) Station remained down during the event	(3.50 m) Station remained down during the event	(4.50 m) Station remained down during the event	Approximate peak WL based on available flood marks was 7.3 m (33.1 m AMSL) estimated to have been attained between 1800H-1900H of Oct. 18.
Zaragoza	(11.00 m) Around 1130H of Oct. 18	(12.50 m) Before 0230H of Oct. 19	(14.50 m) Not reached	WL crested, as per telemetry records, at 4.19 m (14.403 m AMSL) attained at 2000H, Oct. 20.
Peñaranda	No assigned assessment levels at the moment			Maximum telemetry reading was 7.72 m (26.016 m based on a TBM) reached around 1400H of Oct. 18.
San Isidro	(3.20 m) Before 1140H of Oct. 18	(4.50 m) Before 1250H of Oct. 18	(6.00 m) Before 1350H of Oct. 18	Peak WL was at 8.23 m (17.815 m AMSL) attained at around 2250H of Oct. 18.
Arayat (station out of order)	(5.00 m) Before 1220H of Oct. 18	(6.00 m) Before 1400H of Oct. 18	(8.50 m) Before 2140H of Oct. 18	WL crested, as per telemetry records, at 10.03 m (10.107 m AMSL) attained before 0320H of Oct. 20.
Candaba	(3.00 m) Around 1000H of Oct. 18	(4.50 m) Before 0150H of Oct. 19	(5.00 m) Before 0510H of Oct. 19	Swamp water level crested, as per telemetry records, at 7.13 m (6.973 m AMSL) on 2140H, Oct. 20 and remained above the 7.00 m level until 1820H of Oct. 21
Mexico	No assigned assessment levels at the moment (no river overflowing)			Maximum WL based on telemetry readings was 1.57 m (7.503 m TBM based) and was attained on 1800H of Oct. 18.
Sasmuan	No assigned assessment levels at the moment (no river overflowing)			Guagua River at Sasmuan station crested, as per telemetry records, at 2.0 m (0.583 m AMSL) attained on 0130H of Oct. 19.
Sulipan	(3.60 m) Around 1850H of Oct. 20	(4.20 m) Around 1110H of Oct. 21	(5.00 m) Not reached	Maximum WL based on telemetry observation was 4.29 m (4.228 m AMSL) attained on 2210H of Oct. 21.
<i>Note: Elevation of “0” of staff gages were based on surveys undertaken on August 2009. TBM – Temporary Bench Mark; Water levels were based from a 10-minute observation duration period</i>				

4.2. Tides

Table 4.0 High Tide (highest for the day) from October 16 to October 24, 2015

Day	Time	Height (in meters)
Oct. 16	12:42 pm	0.56

17	1:49 pm	0.48
18	8:34 am	0.23
19	12:02 am	1.09
20	12:48 am	1.08
21	1:44 am	1.06
22	2:56 am	1.02
23	4:28 am	0.99
24	8:51 pm	0.75

Note: Based on Navotas port, Latitude 14° 41' N, Longitude 120° 56' E

Tides were at moderately high during the event particularly during the period October 19 to 23 which were close to a meter. This coincided with the arrival of the floodwaters coming from the upstream part of the basin towards its outlet in Manila Bay. High tide effects in the basin can sometimes reached further upstream of Sulipan station up to Arayat during low flow conditions of the Pampanga River. There were no storm surges reported during Lando at the coastal areas of PRB.

4.3 Hydraulic Structures / Dam Releases

Pantabangan and Angat Dams are the two major hydraulic structures within PRB. The former is located upstream of upper main Pampanga River and operates both as hydropower and as an irrigation reservoir. Conversely, Angat Dam is located on the eastern lower main portion of Pampanga River and drains through the Angat River via the Ipo and Bustos Dams. It operates mainly as a hydropower plant. Ipo Dam, which supports and minimally regulates releases coming from the Angat Dam, is situated about 7 kms downstream of the latter. Ipo serves as an active reservoir for water supply requirements of Metro Manila. It is not an impounding reservoir but more of a diversion dam and quite smaller than Angat Dam. Bustos Dam is located around 38 kms downstream of Ipo and serves chiefly as an irrigation reservoir.

During the flood event period, Bustos and Ipo Dams were reported to have releases on October 18. Ipo Dam was reported to have a maximum attained discharge of around 150 cumecs (cubic meters per second). Bustos had some of its sluice gates opened and at some point including its side gate were opened with a reported maximum discharge reaching 370 cumecs.

5. Basin Hydrological Situation during Event Lando

Typhoon Lando's effect on the PRB generally started before noontime of October 17 with light rains occurring at the eastern sections of the basin. However, by afternoon of that day Gabaldon rainfall telemetry station registered continuous intense (heavy) rainfall for almost 24 hours. Early on the following day, other stations mostly on the eastern upstream portions of the basin registered heavy rainfall as well until afternoon of that day. Subsequent deteriorating hydrological situations ensued with immediate flooding that started as early as 0400H on October 18 occurring at the Bongabon-Laur-Gabaldon areas and some other areas on the eastern parts of the basin. Before midday, more areas were now being inundated as floods made its way down towards the mid-stream portions of the basin. Later that day, floods have already started engulfing the central plains of the basin, the

Cabiao-Candaba area. The next two days, Oct. 19-20, floodwaters have reached the downstream parts of the basin particularly the Apalit-Calumpit-Hagonoy-Paombong areas and the riverside areas of Macabebe-Masantol.

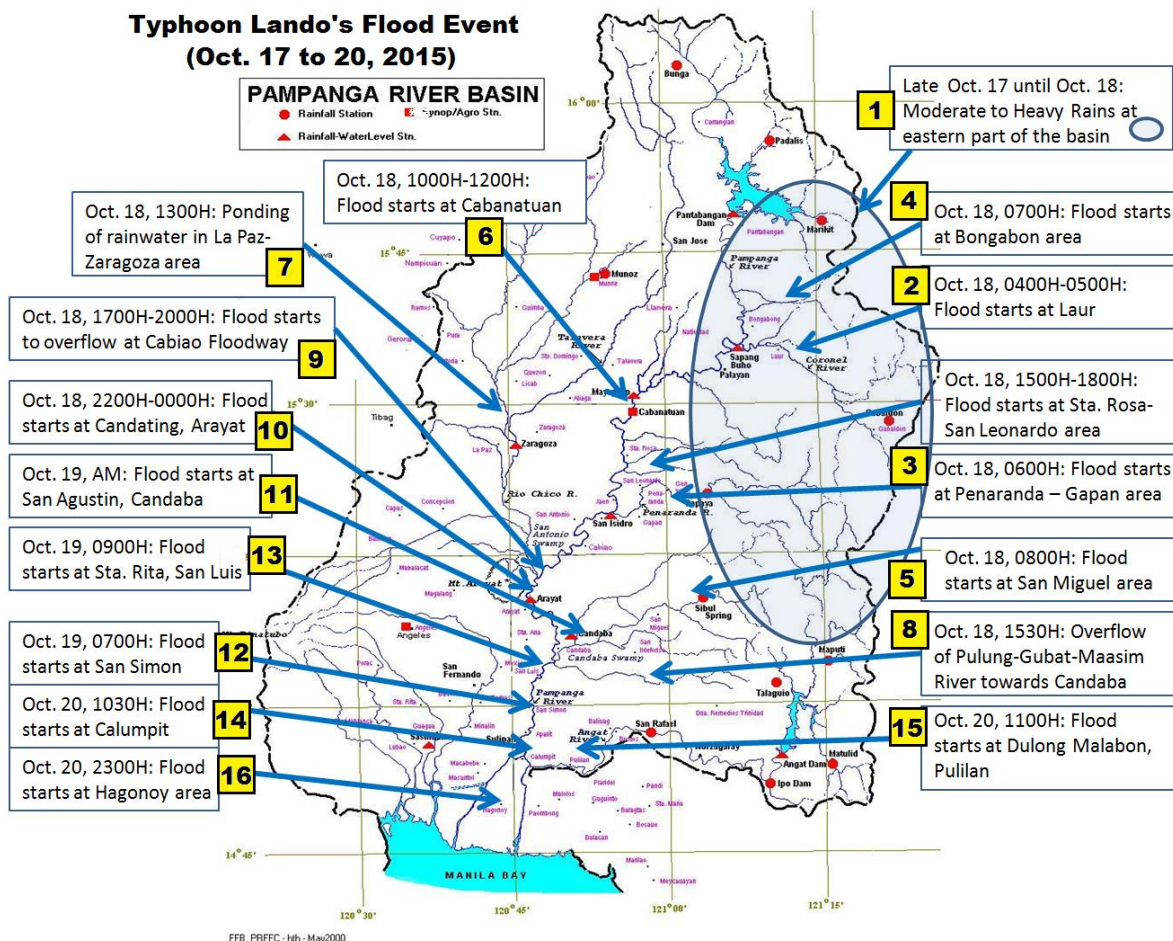


Figure 4.0 Lando's flood event sequence map showing the start of flooding at particular areas within the PRB (October 17 to 20, 2015).

Flood peaks were immediately established at the upstream areas of the basin as early as before noontime of December 18 and this can be seen in Figure 4.1. This signifies a flashy effect of floodwaters.

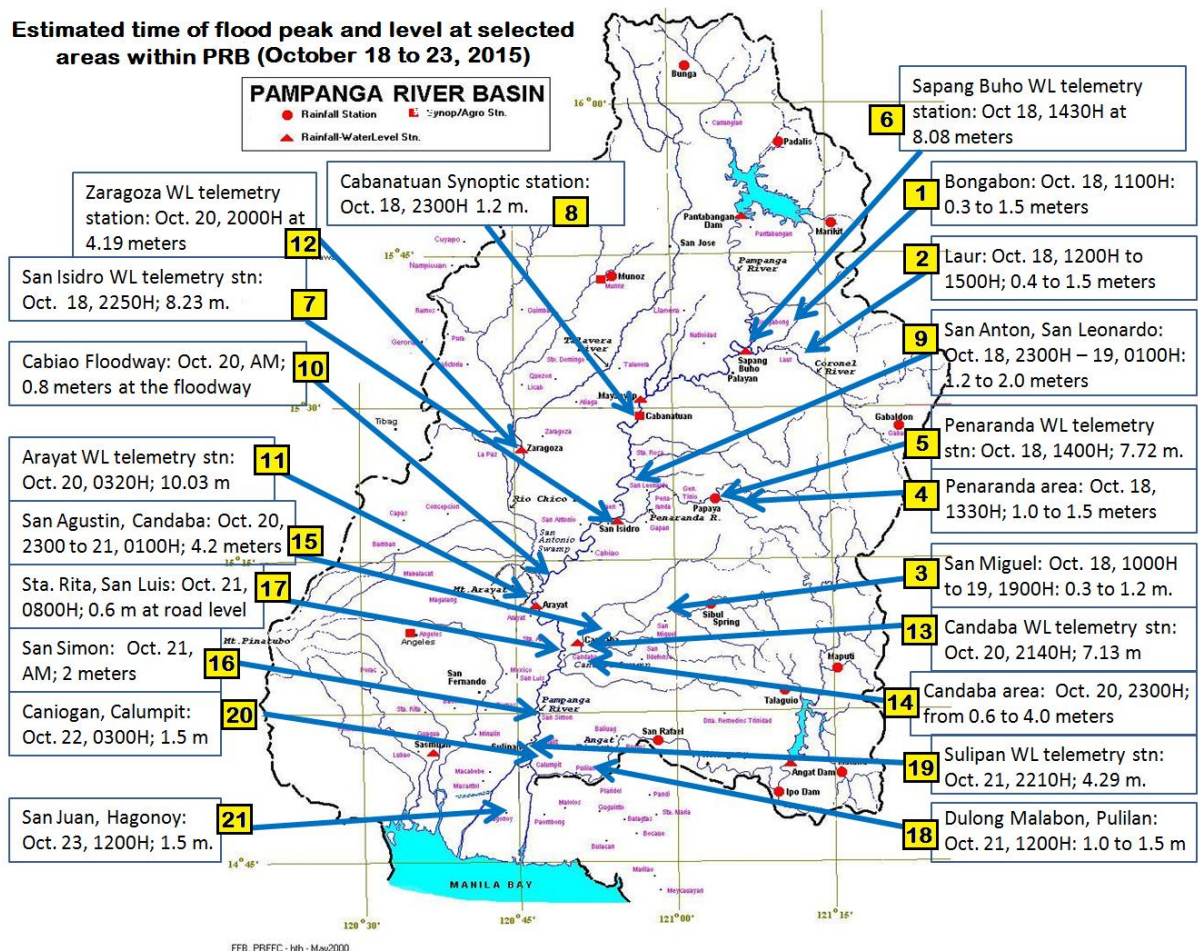


Figure 4.1 Estimated time of flood peaks and levels at selected areas within PRB (October 18 to 23, 2015)


Lando's flood regime in the PRB was a classic case of rains occurring at the upstream eastern side of the catchment with floodwaters all coming down towards the middle and lower plains of the basin with an average of one to two days lag time. It is also worth noting that the allied river system of Pasac-Guagua, which is on the southwest side of the basin, was not affected by river overflowing during Lando's passage.

6. Flood Forecasting & Warning Activities (Event Lando)


Flood Advisory (FA) is hydrological information in its simplest form suggesting awareness and / or preparedness of communities and local DRRM areas that are within or adjacent to the watercourses indicated in the message. It is initialized anytime to signify the start of the flood watch period.⁵

During event Lando the initial Flood Advisory (FA) information was issued at 0800H of October 16 (Figure 5.0). The message focused on tributaries that are mostly situated at the eastern and upstream parts of the basin. Further, in the awareness information / warning section, communities are alerted for possible flash floods at upstream sections and possible landslides for mountainside communities.

It is quite significant to note that FA #1 was issued almost 2 days prior to the initial flooding, which was October 18. Subsequently the next FA (#2) was issued in the morning of October 17 for continued preparedness of communities and DRRMOs.



REPUBLIC OF THE PHILIPPINES
Department of Science and Technology
Philippine Atmospheric, Geophysical and
Astronomical Services Administration (PAGASA)
PAGASA Science Garden, Agham Road, Diliman, Quezon City 1100
Websites: www.pagasa.dost.gov.ph
www.prffwc.webs.com / www.prffwc.synthasite.com



PAMPANGA RIVER BASIN FLOOD FORECASTING & WARNING CENTER
DOST-3 compound, Bgy. Maimpis, San Fernando, Pampanga 2000

GENERAL FLOOD ADVISORY No. 1 (ONE)

PAMPANGA RIVER BASIN & ALLIED RIVERS
ISSUED AT 8:00 AM, 16 OCTOBER 2015
(VALID FOR THE NEXT 24 HOURS UNLESS AN INTERVENING ADVISORY OR AN INITIAL FLOOD BULLETIN WILL BE ISSUED)

AVERAGE BASIN RAINFALL AS OF 8:00 A.M. TODAY

PAST 24-HR RAINFALL: LESS THAN 5 millimeters

FORECAST 24-HR RAINFALL: BETWEEN 20 TO 30 millimeters

WATERCOURSES LIKELY TO BE AFFECTED:

- **TRIBUTARIES CORONEL, DIGMALA, PENARANDA, TALAVERA, RIO CHICO RIVERS AND OTHER STREAMS WITHIN NUEVA ECJA; UPPER MAIN PAMPANGA RIVER**
- **MAASIM, SAN MIGUEL, BULU, AND ANGAT RIVERS (BULACAN)**

AWARENESS INFORMATION / WARNING:

GENERALLY RIVERS WITHIN THE BASIN ARE STILL RELATIVELY LOW; HOWEVER LIGHT TO OCCASSIONAL MODERATE RAINS ARE EXPECTED OVER THE EASTERN SECTIONS OF THE BASIN BEGINNING LATE TODAY; RESIDENTS AND LOCAL DISASTER RISK REDUCTION AND MANAGEMENT COUNCILS (DRRMC's) ADJACENT TO AND / OR ALONG THE ABOVEMENTIONED WATERWAYS ARE ADVISED TO BE ON ALERT FOR POSSIBLE FLASH FLOODS AT THE RIVER UPSTREAM PORTIONS AND RIVER OVERFLOWING AT MID-STREAM SECTIONS; COMMUNITIES NEAR MOUNTAIN SLOPES ARE ADVISED TO BE ON ALERT FOR POSSIBLE LANDSLIDES.

Prepared by:

PRFFWC – HTH / NBN / RPY / PTH

Figure 5.0 Initial Flood Information during the event.

Flood Bulletins (FB) are more specific flood information issued whether or not it is being preceded by a basin general flood advisory (depends on the situation) during flood watch period. It can be initialized anytime and issued regularly at 5 AM and 5 PM by FFWCs thereafter until being finalized when floodwaters are generally receding below critical levels or there are no longer significant increases expected. FB is more near specific as to river level changes, in terms of its rising and falling trends including possible areas (towns/cities) to be affected. An intermediate FB is issued when situations warrants its needs any time between the 5 AM and 5 PM regular issuance stages to cover any unfavorable situations that are likely to happen before the next issuance stage.

During Lando, FB #1 was issued on October 17 still a whole day before flood actually occurred within the basin. FB #3, was an intermediate flood bulletin, and was issued 1200H of October 18 following a gradual to rapid rise of river stages observed at Sapang Buho and Penaranda telemetry stations.

⁵ Provision of Hydro (Flood) Information Protocol (as of July 2011) by H.M. Borja, AWSC, HMD

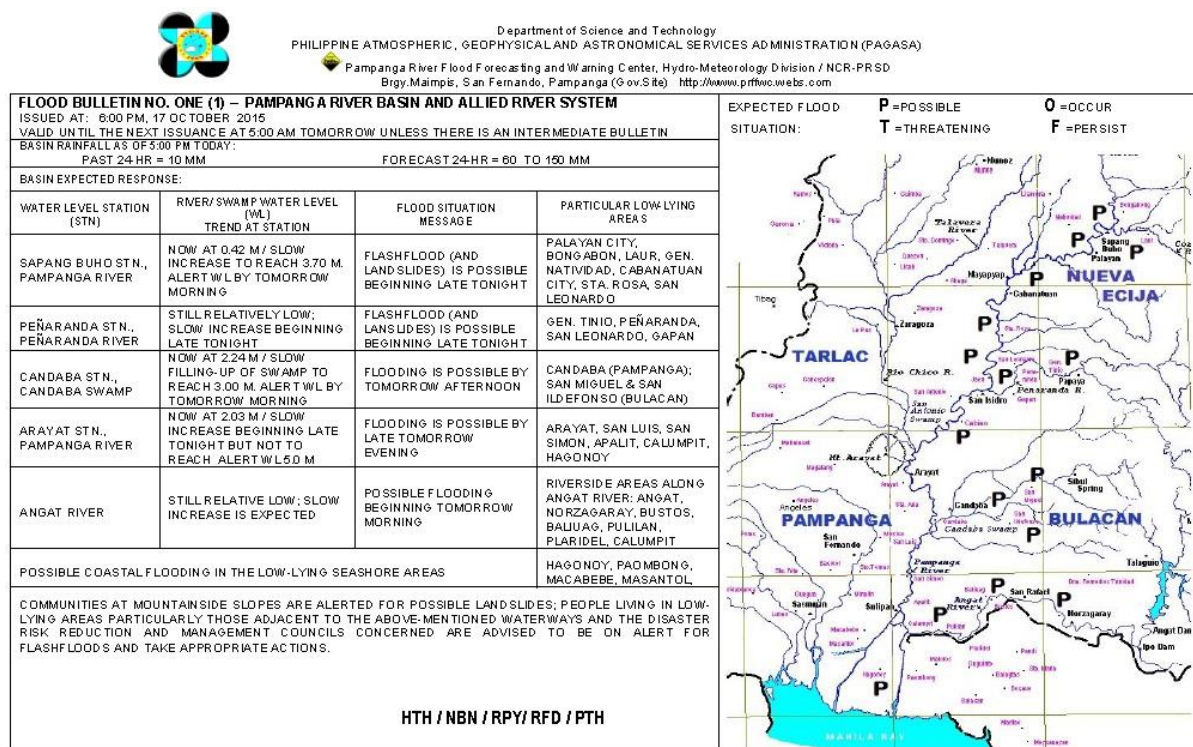


Figure 5.1 Flood Bulletin No. 1 issued at 0600H, 17 October 2015.

All subsequent FBs afterwards were issued at 5 AM and 5 PM covering the period from October 18 to 24, inclusively for event Lando. Flood information issued for the event totalled 17 (2 FAs and 15 FBs). Further, other than being forwarded directly to DRRM offices at national and local levels within the basin, all issued flood information were uploaded at the center's website (prffwc.webs.com / prffwc.synthasite.com) and are also sent by e-mails directly to various local DRRM entities, individuals, etc; it is also shared in various social networks such as "facebook" and "twitter".

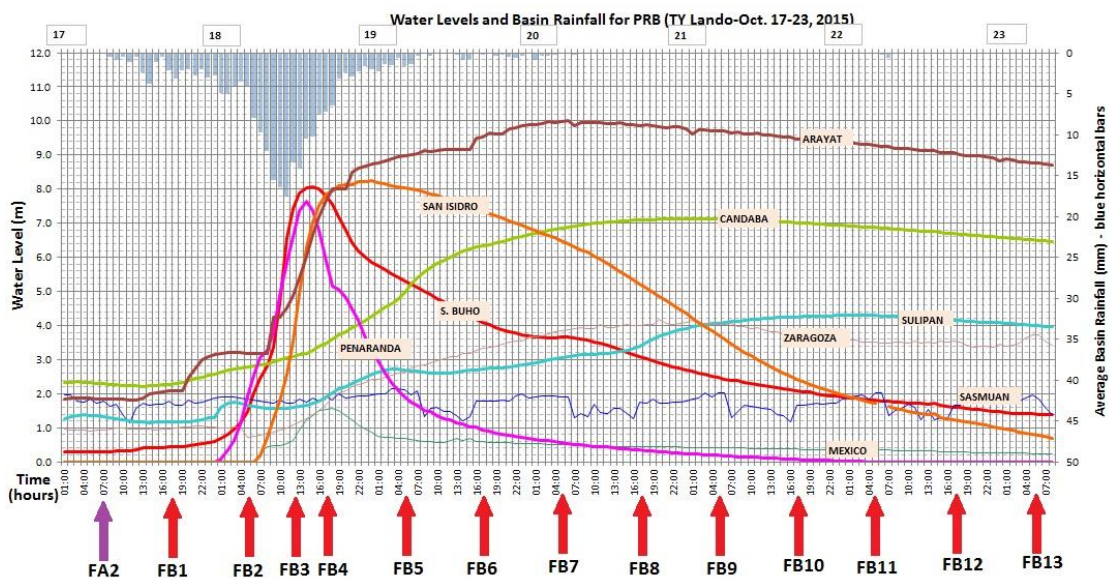


Figure 5.2 The figure above shows an event-based basin hyetograph (average basin rainfall vs. time) and hydrographs (river height vs. time) at various forecasting points during Typhoon Lando and the issuance of FAs and FBs, from October 17 to 23. The figure clearly shows that the PRFFWC was able to issue a warning with a lead time of at least 2 days prior to the initial rise of river stages at various forecasting points within the basin.



Department of Science and Technology
PHILIPPINE ATMOSPHERIC, GEOPHYSICAL AND ASTRONOMICAL SERVICES ADMINISTRATION (PAGASA)
Pampanga River Flood Forecasting and Warning Center, Hydro-Meteorology Division / NCR-PRSD
Brgy. Maimpis, City of San Fernando, Pampanga (Gov. Site) <http://www.prffwc.webs.com>

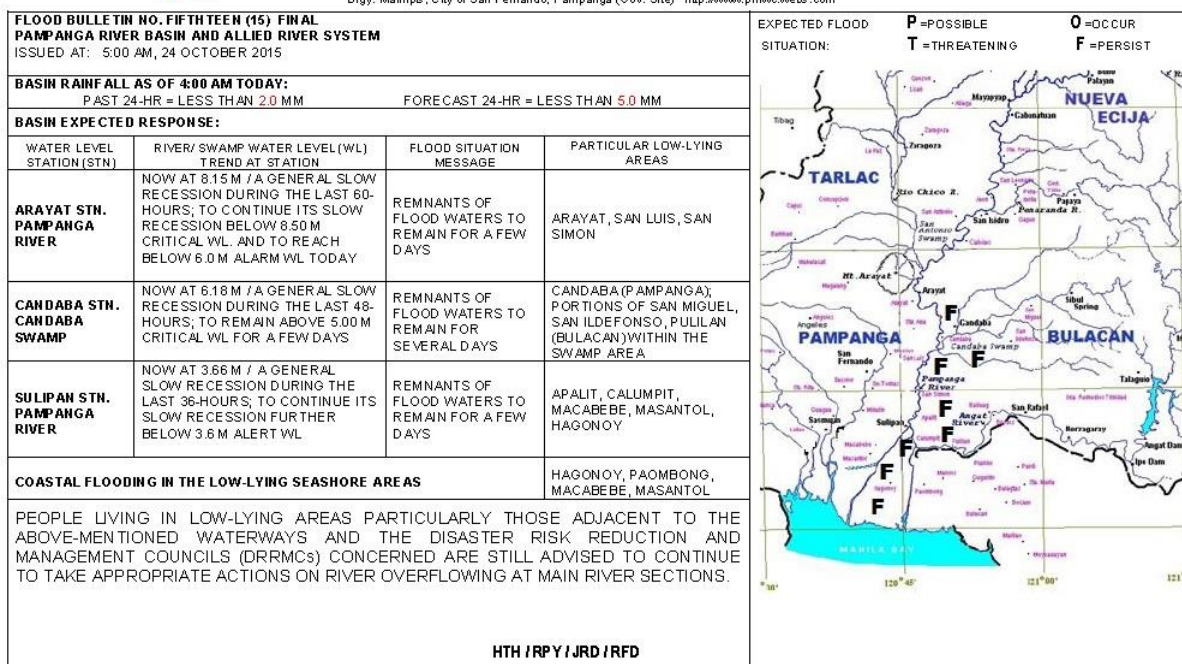


Figure 5.3 Final flood information, FB #15

Final FB was issued at 0500H of October 24, with water level at one station, though continuously receding, was still above critical level and another two still above alert and alarm levels. This situation is normally undertaken because of the relatively long period for flood to totally diminish at some areas within the basin particularly at Candaba swamp; and as well as the slow recession of Pampanga River at the downstream sections due to relatively flat terrain and effects of high tide.

7. Event Lando Highlights (in pictures)





Above, a resident of barangay San Vicente, Laur points to the maximum flood level attained during passage of Lando (picture taken Dec. 09, 2015).



Bangkerohan Bridge between Palayan City and Bongabon was overtopped by floodwaters on October 18; (above) the bridge after the flood had partly subsided at the area (picture provided by Palayan City-CDRRMO).



Flood mark of about 90 cms. left by “Lando” on a steel cabinet inside the PAGASA Cabanatuan synoptic station as pointed out by the station’s CMO, Mr. Demi Campo.



A flooded Central District of Gapan City taken at around 1451H, Oct. 18, 2015 (photo courtesy of LS of Bulacan Rescue).



(Top) The flood plain area on the right bank of Penaranda River during Lando flood event taken at the Doña Josefa Bridge in Gapan, N.E. (picture taken Oct. 18, 2015 & provided by Gapan City-CDRRMO) Below, the same area more than a month after Lando (picture taken Dec. 10, 2015).



Bgy. San Anton, San Leonardo, N.E. (Dec. 09, 2015)
prffwc - 2015
A long-time resident of Bgy. San Anton, San Leonardo, N.E., Ms. Perlita Tinio points to the maximum flood level attained during Lando's flood event (photo taken 1137H, Dec. 09, 2015).



One of the areas affected by the overflowing of Pampanga River in Barangay Sto. Cristo, San Isidro, N.E. (1256H, Oct. 19, 2015).



Pampanga River at San Isidro-Jaen Bridge at a gauge reading of about 7.60 meters (1307H, Oct. 19, 2015); Pampanga River was already in recession phase at this time; at the background are riverside houses that are still partly flooded by the river.



(Top left) The Pampanga River at the San Isidro-Jaen Bridge at a relatively low river stage below the "0" gauge reading of the San Isidro telemetry station (Dec. 09, 2015); (Top right) The same spot during event Lando at a telemetry gauge reading of around 7.60 meters (1309H, Oct. 19, 2015).



Cabiao floodway at Bgy. San Vicente, Cabiao (N.E.) during Pampanga River's spill-over at the area taken atop the viaduct bridge in the area (1235H, Oct. 19, 2015).

The raging floodwaters of Peñaranda River at almost peak flow over the Peñaranda River Irrigation System at San Josef, Peñaranda, N.E taken at around 0111H, Oct. 19, 2015 (photo provided by Peñaranda-MDRMO).



The municipal road at Barangay Sapang, Jaen in Nueva Ecija with floodwaters coming from the right bank of the overflowing Pampanga River (1320H, Oct. 19, 2015).

Cong Dadong Dam at Arayat with a spill over (background) of the Pampanga River on the flood plain on its left bank taken on 1347H, Oct. 20, 2015.



A flooded alley in Bgy. Paralaya in Candaba with floodwaters coming from the overflowed left bank of Pampanga River (1121H, Oct. 19, 2015).



A breached on the sandbagging efforts at Bgy. San Sebastian, San Luis at around 0938H, Oct. 20, 2015 (photo provided by San Luis-MDRRMO).



At the entry point to Barangay Candating with a flooded barangay road at the background (1308H, Oct. 20, 2015).



San Simon area at around 0908H, Oct. 21, 2015 (picture provided by San Simon-MDRRMO).



A view of the flooded lower Candaba area taken along the NLEX-Viaduct road (1058H, Oct. 21, 2015).



A barangay personnel points to the estimated maximum flood level reached at the Bgy. San Agustin Hall in Candaba (Dec. 07, 2015)



Barangay San Miguel, Hagonoy on Oct. 22, 2015 (picture from the internet)



Central district (Poblacion) of the town of Hagonoy which went underwater starting around morning of Oct. 21, 2015. (picture from the internet)



(Top left) The road stretch along the Calizon-Bulusan area at the start of overflowing of Pampanga River and (Top right) the road which is already underwater (Picture provided by Calumpit-DRRM)



Maximum flood height reached at the Calumpit District Hospital reached to more than 1.5 meters from ground level. Note that hospital is already elevated by several centimeters from the ground. (Nov. 12, 2015)

II. Typhoon Nona Flood Event Report

1. Summary

Barely two months just after Typhoon Lando devastated and inundated the Pampanga River Basin in October (2015), Typhoon Nona's enhanced frontal system dumped intense heavy rains over the eastern sections of Luzon particularly over the upstream eastern parts of PRB causing its second major inundation for the year 2015. This occurred quite surprisingly considering that a notably strong El Niño episode has been persisting for more than a year already and its general effect to the country is supposed lower than the average rainfall condition, drier and hotter days.

Tropical Cyclone Nona entered the PAR in the morning of December 12 as a storm. It made landfall on the northeast coast of northern Samar as a typhoon category with winds of 150 kph and gusts of 185 kph. It then trekked west northwest passing through Sorsogon, Masbate, Romblon, and Oriental Mindoro provinces. On the morning of December 17 Nona eventually diminished after becoming a low pressure area over at the West Philippine Sea.

Nona's path did not cross over the central Luzon Island however it brought in intense heavy rains on its eastern coast which resulted in the inundation of a reported total of 332 areas in Regions I, III, IV-B, and NCR (NDRRMC Sitrep No. 19 dated December 24, 2015). The basin rainfall observed during Nona was higher than that of event Lando (Oct. 2015) however, river stages and flooding were relatively lower at the upstream points and had almost equalled the Lando at the about the middle and lower sections of the basin. In general, Nona's flooding lasted for over a week but there were still some areas that remained flooded until Christmas time 2015 and even New Year's Day.

The filling-up of Angat Dam above its normal high water level of elevation 212 meters, even reaching above elevation 215 meters, led to the opening of its spillway gates from December 17 to 23. Discharges from the dam reached more than 600 cubic meters per second at some length during the said period. The subsequent increase of flow in the Angat River during that time mainly caused a slowdown of the movement of floodwaters of the Pampanga River towards its outlet at the Manila Bay during that time.

The Pampanga River Basin Flood Forecasting and Warning Center (PRFFWC) issued a total of 15 flood information (1 Flood Advisory (FA) and 14 Flood Bulletins (FB)) for the event covering the period December 16 to 24.

Seemingly, Nona's effect on the PRB is considered as another major flood event for 2015 even as the year has been marked with a significantly strong El Niño episode.

2. Meteorological Aspect: Typhoon "Nona" (*International name: "Melor"*)⁶

"NONA" was the 14th tropical cyclone to enter the Philippine Area of Responsibility (PAR) for the year 2015. It entered the PAR as a storm around morning of December 12 headed towards the eastern coast of Samar. It made landfall as a typhoon somewhere in the vicinity of Batag Island in Laoang, Northern Samar at around 11 AM of December 14. It trekked along the northern coast of Samar and by 4 PM of that day was already in the vicinity of Bulusan in Sorsogon. It continued its westward track

⁶ Were mainly based on the day-to-day Severe Weather Bulletins(SWB) issued during the event.

throughout the rest of that day. By early morning of the following day, December 15, it passed north of the Romblon Island. Before noontime of December 15, Nona was already in the vicinity of Pinamalayan, Oriental Mindoro and proceeded on a west northwest track through the Mindoro Island. Early morning of the next day, December 16, Nona was already somewhere between Mindoro and Batangas Provinces. Slightly weakened in strength Nona continued its WNW direction towards the West Philippine Sea. It downgraded into a severe tropical storm by afternoon of December 16th and eventually into a storm category later on that same day. Nona further weakened into a tropical depression the following day, December 17, and became a low pressure area by midday that day just 60 kilometers west of Iba, Zambales.

Nona actually made 3 landfalls on December 14: around 11 AM at Batag Island, Northern Samar; 4 PM at Bulusan, Sorsogon; and 9:45 PM at Burias Island, Masbate. On December 15, it made 2 more landfalls: 5:30 AM at Banton Island, Romblon; and finally at 10:30 AM at Pinamalayan, Oriental Mindoro.

Nona's typhoon strength over land reached 150 kph with gusts reaching up to 185 kph. Nona not only caused wind-generated destruction over land but likewise enhanced a frontal system over at the eastern coast of northern, central down to southern Luzon dumping intense rains for almost two days causing widespread flooding in several areas particularly in the Pampanga River Basin area and other parts of southern Luzon as well.

Impacts: A total of 332 flooded areas were reported in Regions I, III, IV-B, and NCR; Estimated damage to Agriculture and Infrastructure at around (Philippine) ₱ 6.5 B combined II, III, IV-A, IV-B, V, and VIII; Casualties: Dead – 42; Injured – 24; Missing – 4 (NDRRMC Sitrep No. 19 dated December 24, 2015)

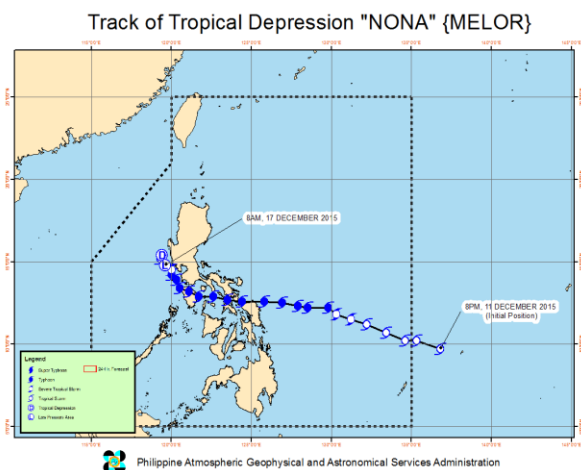


Figure 6.0 Track of Typhoon Nona during its course within the PAR (Dec. 11 to 17, 2015).⁷

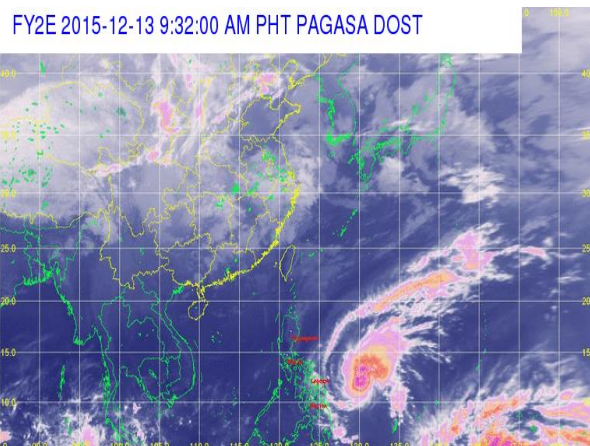


Figure 6.1 Satellite image of Nona at 0932H (LST), Dec. 13, 2015 showing an enhanced frontal band swirl just north of the disturbance.

⁷ Track of Tropical Cyclone "Nona" from SWB # 21 (Final)

FY2E 2015-12-14 3:32:00 AM PHT PAGASA DOST

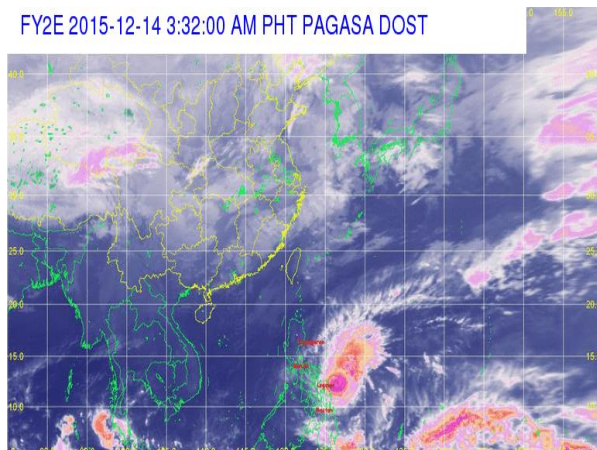


Figure 6.2 Satellite image of Nona at 0332H (LST), Dec. 14, 2015 few hours before making landfall at northern Samar Island.

FY2E 2015-12-15 3:32:00 AM PHT PAGASA DOST

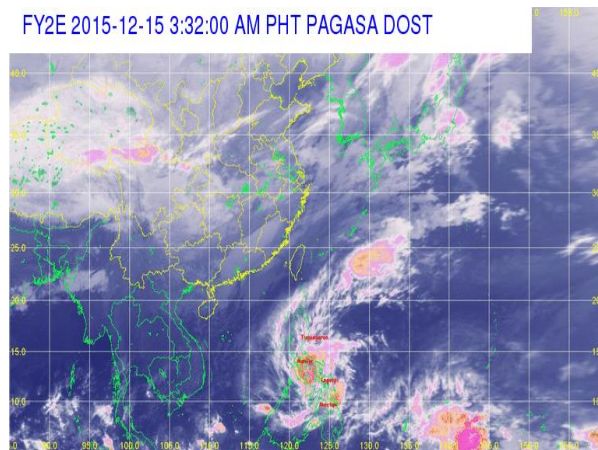


Figure 6.3 Satellite image of a rather diffused Nona at around 0332H (LST), Dec. 15, 2015.

3. Rainfall associated with Typhoon Nona

Table 5.0 Pampanga River Basin recorded 24-hr (meteorological day) rainfall in millimeters for the period December 15-16, 2015.

Stations	December 2015		Maximum one - hour observed RR	Time (LST) / Day of maximum 1-hr RR for the period December 15-16, 2015
	15	16		
Muñoz	227	135	50	0300H / Dec 16
Sapang Buho	170	198	35	1800H / Dec 16
Gabaldon	392	336	56	1500H / Dec 16
Zaragoza	130	67	29	0600H / Dec 16
Mayapyap	*	*	*	
Peñaranda	255	114	67	0200H / Dec 16
Calaanan	189	253	37	0800H / Dec 16
Palali	362	287	91	0800H / Dec 16
San Isidro	166	68	33	0300H / Dec 16
Arayat	88	60	16	1500H / Dec 16
Candaba	101	83	22	1500H / Dec 16
Sibul Springs	276	98	76	0200H / Dec 16
Sulipan	111	38	20	1500H / Dec 15
San Rafael	81	64	19	2200H / Dec 16

Note: * station still out of order

Table 5.1 Pasac-Guagua River Basin (Allied basin) 24-hr (meteorological day) RR in millimeters for the period December 15-16, 2015.

Stations	December 2015		Maximum one - hour observed RR	Time (LST) / Day of maximum 1-hr RR for the December 15—16, 2015
	17	18		
Sasmuan	105	60	23	0000H / Dec 16
Mexico	37	30	7	1800H / Dec 19
Porac	65	40	10	0200H / Dec 16
San Fernando	92	52	17	1400H / Dec 16

24-hour meteorological day format (8:00am till 8:00am of the next day) rainfall totals from various telemetry stations within the PRB were used to produce the 24-hr isohyets for the period December

15 and 16. The maximum observed 1-hr RR were also determined based on a fixed 1-hour regular time period.

Table 5.2 Rainfall total in millimeters of other stations (in Central Luzon) for the following period:

Stations	December 2015	
	15	16
Clark, Pampanga		112.2
Cabanatuan, Nueva Ecija	232.5	261.4
Baler, Aurora	112.2	273.8
Subic, Zambales	114.0	88.5
Iba, Zambales	56.7	71.0
Carmen, Pangasinan (ARB)	103	80
Sta. Maria, Pangasinan (ARB)	63	97
Mapandan, Pangasinan (ARB)	43	65
San Vicente, Pangasinan (ARB)	101	101
Sta. Barbara, Pangasinan (ARB)	48	67
Bugallon, Pangasinan (ARB)	48	56
Maasin, Tarlac (ARB)		
Tibag, Tarlac (ARB)	115	59
Camp O'Donnell, Tarlac (ARB)	96	102
ARB – Agno River Basin telemetry stations Shaded cells are as per available FFWS-HMD info Blanks – no data provided		

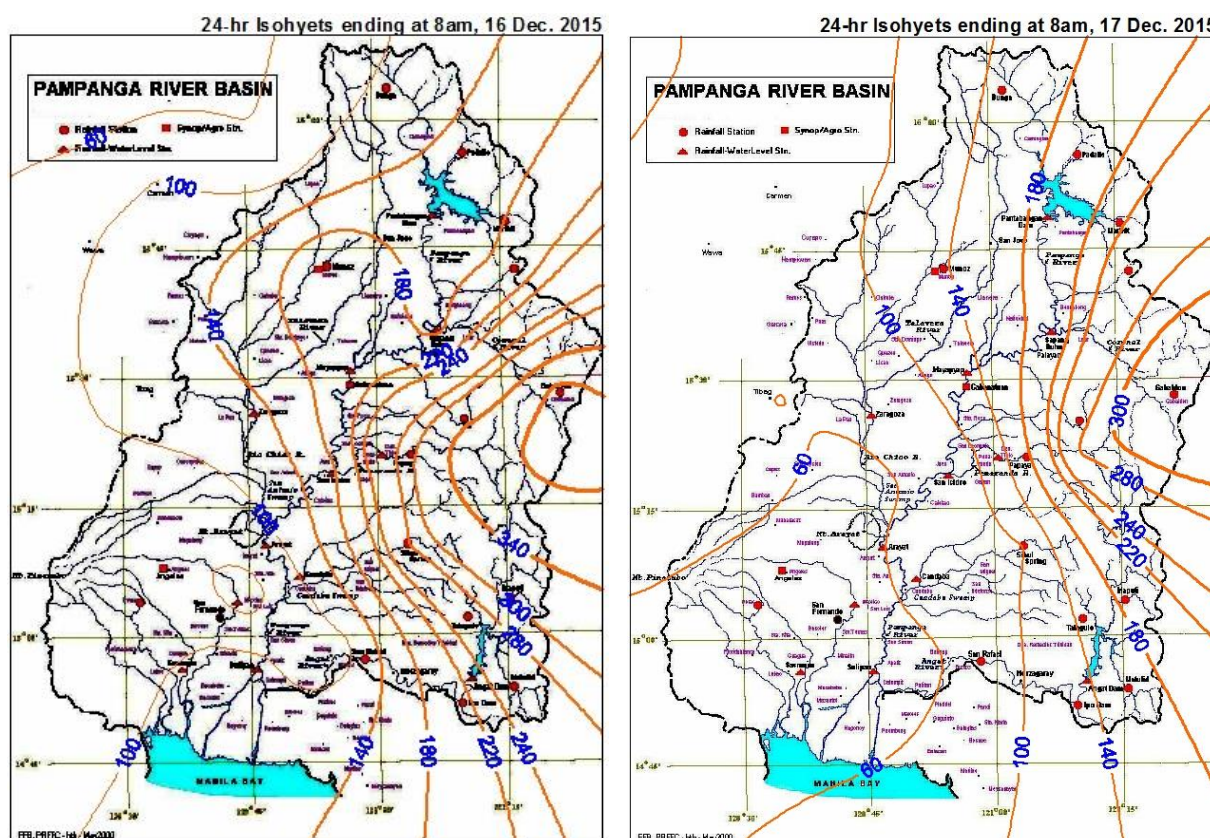


Figure 7.0 The 24-hour meteorological day isohyets for December 15 (top left) and December 16 (top right) during the passage of Typhoon Nona.

4. River levels during event Nona

4.1 Station gauge heights during “Nona”

Table 6.0 Time / Day of Station’s Flood Assessment Gage Heights were reached

Station Point	Alert Level	Alarm Level	Critical Level	Remarks
Sapang Buho	(3.70 m) Before 0900H of Dec. 16	(4.50 m) Before 1100H of Dec. 16	(6.50 m) Before 1800H of Dec. 16	Peak WL was 6.84 m (57.034 m AMSL) attained at around 1900H of Dec. 16
Mayapyap	(3.00 m) Station remained down during the event	(3.50 m) Station remained down during the event	(4.50 m) Station remained down during the event	(station still remains out of order for several months due to theft and vandalism)
Zaragoza	(11.00 m) Before 0200H of Dec. 16	(12.50 m) Before 1100H of Dec. 16	(14.50 m) Before 0700H of Dec. 17	WL crested, as per telemetry records, at 5.22 (15.433 m AMSL) attained at 1500H, Dec. 17.
Peñaranda	No assigned assessment levels at the moment			Maximum telemetry reading was 5.72 m (24.016 m based on TBM) reached around 1300H of Dec. 16.
San Isidro	(3.20 m) Before 0800H of Dec. 16	(4.50 m) Before 1000H of Dec. 16	(6.00 m) Before 1200H of Dec. 16	Peak WL was 7.80 m (17.385 m AMSL) attained at around 0700H of Dec. 17.
Arayat (station out of order)	(5.00 m) Before 0800H of Dec. 16	(6.00 m) At around 0900H of Dec. 16	(8.50 m) Around 1800H of Dec. 16	WL crested, as per telemetry records, at 9.98 m (10.057 m AMSL) attained around 0300H of Dec. 18
Candaba	(3.00 m) Around 0900H of Dec. 16	(4.50 m) Around 0000H of Dec. 17	(5.00 m) Around 0300H of Dec. 17	Swamp water level crested, as per telemetry records, at 6.94 m (6.783 m AMSL) on 1900H, Dec. 18 and remained above the 6.00 m level until 1900H of Dec. 22
Mexico	No assigned assessment levels at the moment (no river overflowing)			Maximum WL, based on telemetry readings, was 1.62 m (7.553 m TBM based) and was attained on 1800H of Dec. 16.
Sasmuan	No assigned assessment levels at the moment (no river overflowing)			Guagua River at Sasmuan station crested, as per telemetry records, at 2.13 m (0.713 m AMSL) attained on 0200H of Dec. 17
Sulipan	(3.60 m) Around 1800H of Dec. 18	(4.20 m) Not reached	(5.00 m) Not reached	Maximum WL, based on telemetry observation, was 4.13 m (4.068 m AMSL) attained on 1100H of Dec. 19
<i>Note: Elevation of “0” of staff gages were based on surveys undertaken on August 2009. TBM – Temporary Bench Mark</i>				

4.2 Tides

Tides during the period may have contributed partly in the slow recession of floodwaters towards Manila Bay for event Nona. Tides were not that relatively high during that time except on December 23 and 25 which were above 1.0 meter height.

Table 7.0 High Tide (highest for the day) from December 17 to December 25, 2015

Day	Time	Height (in meters)
Dec. 17	12:21 am	1.05
18	1:12 am	0.95
19	2:06 am	0.81
20	6:52 pm	0.64
21	7:18 pm	0.77
22	7:49 pm	0.90
23	8:24 pm	1.03
24	11:06 am	0.35
25	9:38 pm	1.18

Note: Based on Navotas port, Latitude 14° 41' N, Longitude 120° 56' E

4.3 Hydraulic Structures / Dam Releases

Angat Dam started releasing reservoir water through its spillway at about 0800H of Dec. 17 with an estimated discharge of 60 cumecs (cubic meters per second). Reservoir elevation at that time was already above the normal high water level (NHWL) of elevation 212.0 m. AMSL (as per Notice of Dam Discharge Warning Operation Ref. No. ANG-15-04 issued 2100H, 16 Dec. 2015).

Around 1700H of December 19 Angat Dam was already at elevation 215 meters. Later that day, at around 2300H, dam discharge reached almost 600 cumecs. On the following day, at about 0900H, total discharge reached more than 860 cumecs with Angat Dam at elevation 215.91 m. By evening of December 21 total discharge was reduced from outflows of 520 to 370 cumecs. The following day, December 22, total discharge was around 460 cumecs. Eventually on Dec. 23 total discharge was further reduced to almost 71 cumecs. By 1400H of that same day Angat Dam closed its gates at an elevation of 214.94 m. Similarly Ipo Dam, which has quite a smaller reservoir capacity, opened its gates in the afternoon of December 19. It continued spilling through its gates until 1400H of December 23. The same operations were also carried-out at Bustos Dam; an irrigation dam situated some 38 kilometers downstream of Ipo Dam. (Info on Dam discharges were taken from the Bulacan-PDRMO Sitrep No. 19 on Typhoon Nona, 8 PM, 23 Dec. 2015)

5. Basin Hydrological Situation during Event Nona

Rains which resulted from the enhanced frontal system pulled by Nona started affecting the PRB at around 9 AM of December 15; in particular, continuous heavy rainfall intensity were recorded at the Gabaldon telemetry station for almost 36 hours. Heavy rains at other stations started before midnight after several hours of generally light to moderate rains. The upstream block areas at both north and eastern sections of the basin (Muñoz, Sapang Buho, Gabaldon, Zaragoza, Peñaranda, Calaan, Palali and Sibul Springs) registered moderate to heavy rainfall intensities for less than 20 hours which started on the early morning of December 16. Flooding at the Bongabon-Laur-Gabaldon areas in general started around 6 AM of that same day. Before noontime flood had started in the

Palayan-Cabanatuan area. Flood started at the middle plains of the basin by late afternoon. Early the following day, December 17, areas (La Paz-Zaragoza areas) along the tributary Rio Chico River started to get inundated as well and as the day progressed the middle-lower sections of the basin were now starting to absorb the flood flows coming from the upstream. December 18 to 20, floods have now covered the rest of the lower sections of the basin particularly the Apalit-Calumpit-Hagonoy areas.

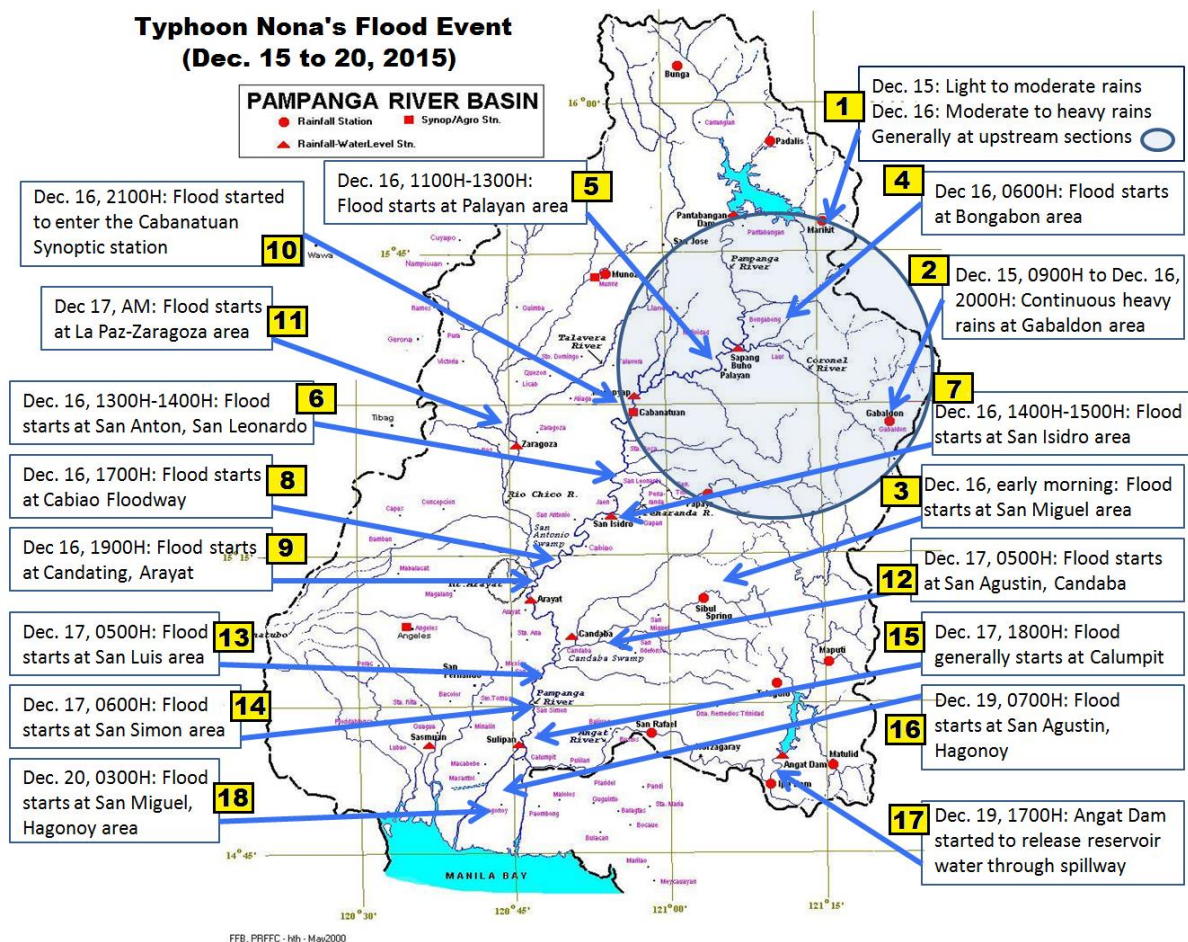
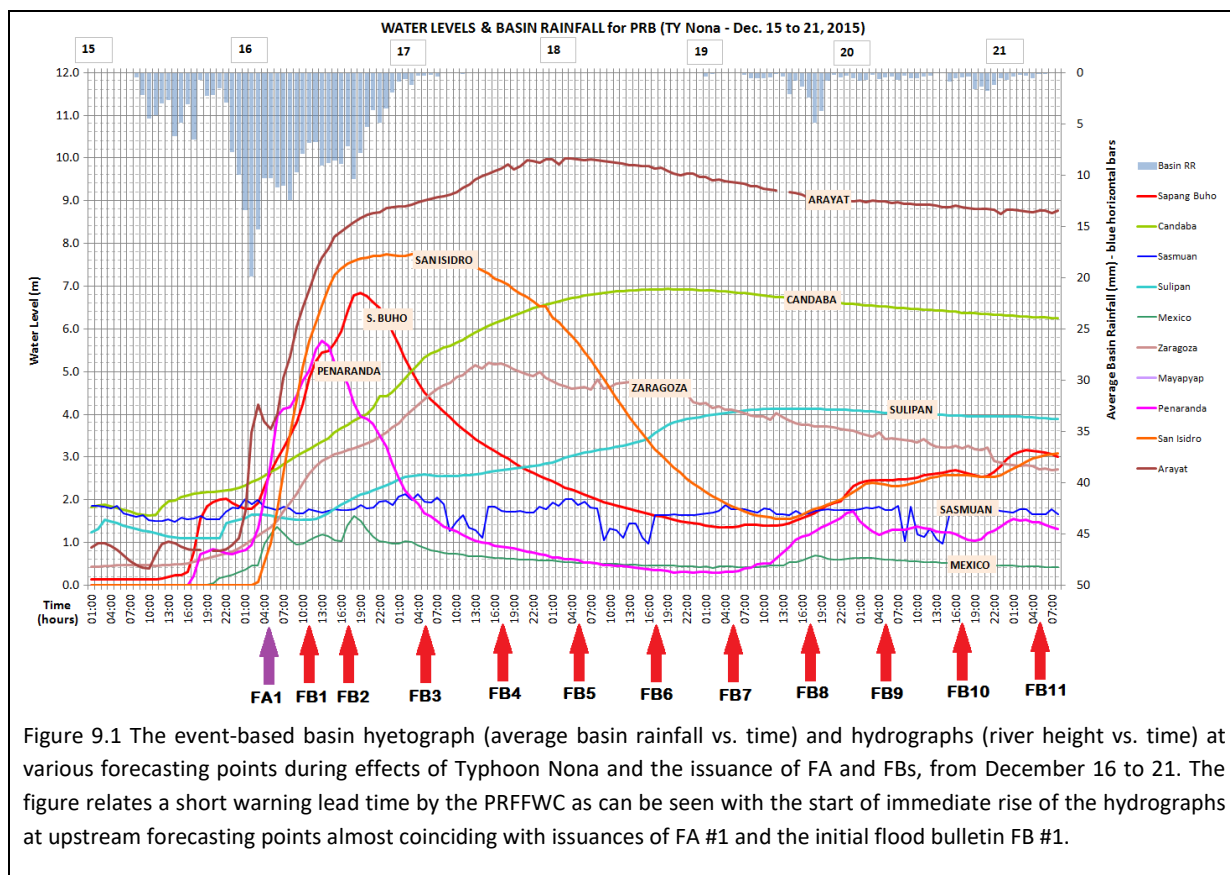


Figure 8.0 Above figure shows the sequence of flooding from the period December 15 to 20, 2015.

The corresponding river stage peaks recorded at telemetry station's observations and from selected areas within the basin based on post-flood surveys and reports from various participating LGUs is presented in figure 14.0. Flooding within the PRB due to the enhanced tail-end of a front by Nona, in general, lasted for more than 2 weeks with a lot still inundated during Christmas 2015 and even some until New Year's Day.

Floods at the lower sections of the basin, particularly at San Luis-San Simon-Apalit areas started around December 17 and were mainly due to rainwater that have already accumulated over the relatively low-lying areas within these municipalities.



7. Event Nona highlights (in pictures)



Top left shows a flooded road (along the Nueva Ecija to Aurora route) in Bongabon at around late noon of December 16 (Picture provided by Bongabon-MDRRRMO); Top right is the Manacnac Bridge, Palayan which is almost just about a meter above the Cabu River taken at around 1400H, Dec. 16, 2015 (photo provided by Palayan-MDRRRMO).



A flooded portion of Cabanatuan City taken around December 17, 2015 with the Cabanatuan City Hall at the foreground below (internet pics).



The Pampanga River at Valdefuente Bridge in Cabanatuan City taken at about December 17, 2015 (internet pics by philipmartin esteban)



Cabanatuan Synoptic station CMO, Mr. Demi Campo, points to the level attained inside the station during the Nona's flood event and a comparison with that attained by event Lando (Dec. 21, 2015)



Pampanga River overflowed the Cabiao floodway as seen here taken in the afternoon (1433H) of December 17, 2015.



A long-time resident of the area, Ms. Perlita Tinio, points to the level reached by the flood due to event Nona in Bgy. San Anton, San Leonardo (Dec. 28, 2015).



A view at the background of the barangay road after the welcome post going to main area of Bgy. Candating which is already flooded (1458H, Dec. 17, 2015).



The Pampanga River overflowed the riverside road in Bgy. Pasig in Candaba (1339H, Dec. 17, 2015).



A barangay official of Bgy. San Agustin, Candaba points to the level reached by floodwater during event Nona at the San Agustin Elementary School (Dec. 28, 2015).



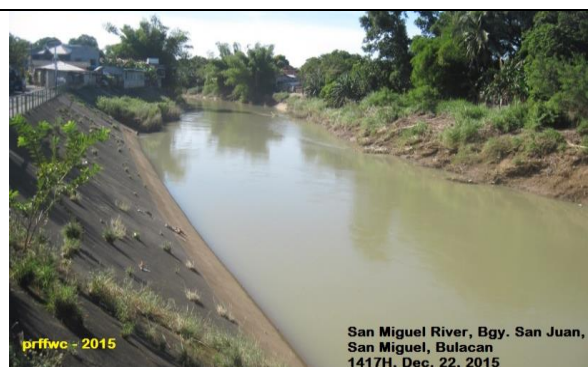
A still flooded barangay road in Bgy. San Agustin, Candaba three days before New Year's celebration. (1651H, Dec. 28, 2015)



A flooded lower Candaba swamp area as seen from the NLEX-Viaduct. (0848H, Dec. 20, 2015)



San Miguel River at Bgy. San Juan in San Miguel, Bulacan at around Dec. 17, 2015. (Photo provided by San Miguel-MDRMO)



San Miguel River at the same spot as in the picture on the left about five days after at a relatively lower stage (Dec. 22, 2015).



A flooded area in Bgy. San Jose, San Simon on December 18, 2015 (Photo provided by San Simon-MDRRMO).



A still very high Pampanga River at NLEX in Apalit two days before Christmas Day (0937H, Dec. 23, 2015).



A flooded area in Bgy. Calizon, Calumpit as a result of the overflowing of Pampanga River (1346H, Dec. 18, 2015).



Pampanga River already overflowing a stretch of the Calumpit-Hagonoy Road at Bgy. Calizon in Calumpit (1352H, Dec. 18, 2015).



The flooded Calumpit-Hagonoy Road at Bgy. Calizon, Calumpit at around 0900H, Dec. 19, 2015 (photo provided by Calumpit-MDRRMO).



McArthur Highway Junction (Infront of former Caltex Station) at Bgy. Corazon, Calumpit, at around 0600H of December 19, 2015 (Photo provided by Calumpit-MDRRMO).



A flooded area of the Calumpit-Pulilan Road at Bgy. Caniogan, in Calumpit taken at around 1000H of December 19, 2015 (Photo courtesy of Calumpit-MDRRMO).



A waist to chest deep flooded barangay road in Bgy. San Jose, Calumpit taken at around 0613H, December 20, 2015 (Photo courtesy of Calumpit-MDRRMO).



A semi-aerial view of the central district of the town of Hagonoy showing about a foot to knee-deep of floodwaters taken on December 20, 2015 (Photo courtesy of Hagonoy-MDRRMO).



A flooded barangay road of Bgy. San Agustin, Hagonoy on December 20, 2015 (Photo provided by Hagonoy-MDRRMO).



Thigh-deep floodwaters at Bgy. San Juan, Hagonoy on December 20, 2015 (Photo provided by Hagonoy-MDRRMO).

8. Event comparison and analyses

The flood events brought about by Typhoon Lando and the enhanced frontal system by Typhoon Nona in the PRB are the two major ones for the PRB for the year 2015. The former had historical high record river stages at upstream stations of the basin while the latter had a comparatively higher basin rainfall distribution than the other. Flood effects at the downstream part of the basin for both events were almost the same with the former, Lando, a bit higher by several centimeters in almost all of the areas covered during the post-flood surveys undertaken by PRFFWC. Below is a comparison of river stages at forecasting points of several flood events that affected the PRB since 1993.

Table 8.0

Peak Water Level attained at each streamgauging station as per various flood events in the PRB

Event	Sapang Buho	Mayayap	Zaragoza	Peñaranda	San Isidro	Arayat	Candaba	Sulipan	Mexico	Sasmuan	Remarks
T. Kadiang (Sept-Oct. 1993)	6.30 (SG)	6.18 (SG)	15.9 (SG)		7.65 (SG)	9.81 (SG)	7.6 (SG)	4.91 (SG)			
T. Loleng (Oct. 1998)	7.15 (est)	6.50 (est)	15.76		7.38	9.47	6.62	4.87			
T.D. Winnie-T. Yoyong (Nov.-Dec. 2004)	7.60 (est)	7.18	13.63		7.16 (est)	9.42 (est)	6.96	3.97			
T. Marce-SW (Aug. 2004)	5.45	5.06	15.39		6.70	10.03	7.38	4.39		2.06 (est)	Flooding w/in PRB & Allied river system
T.S. Ondoy (Sept. 2009)	3.38	1.72	14.14	3.93	3.89	8.35	6.40	3.29	2.81	3.03	Flooding only at PRB lower sections & allied river system
T. Pepeng (Oct. 2009)	6.29	5.46	15.68	2.79	6.46	9.66	7.02	4.03	4.03	2.73	Flooding w/in PRB & Allied river system
T.S. Falcon-SW (June 2011)	3.47	2.57	14.88	2.56	4.08	8.37	6.24	2.80	2.72	3.22	Flooding at PRB middle-lower sections & Allied river system
T. Pedring (Sept.-Oct. 2011)	7.17	6.86	15.40	6.01	7.75	10.6 (est)	7.62	4.85	3.30	3.09	Flooding w/in PRB & Allied river system
SW of August 2012	1.67	0.6	4.64	1.68	3.29	9.24	6.93	3.17	3.46	3.17	Flooding at PRB middle-lower sections & Allied river system
T.S. Maring-SW (Aug. 2013)	1.36		4.31	1.08	1.46	8.39	6.30	3.26	2.61	3.06	Flooding at PRB middle-lower sections & Allied river system
T. Lando** (Oct. 2015)	8.08	7.30 (est)	4.19	7.72	8.23	10.03	7.13	4.29	1.57	2.00	Flooding w/in PRB only
T.Nona enhanced Frontal System (Dec. 2015)	6.84		5.22	5.72	7.80	9.98	6.94	4.13	1.62	2.13	Flooding w/in PRB only

Note: ** - based on a 10-minute telemetry observation; blue shaded events are enhanced SW monsoon related events; blanks indicate station either did not yet exist or station's telemetry system was down / out of order during that time; light orange shaded values +10.213; (est) – levels were based on available flood marks only

Comparative analyses between the effects of Typhoons Lando and Nona in the PRB:

- Typhoon Lando crossed Luzon and passed-by north of the basin whereas Typhoon Nona crossed the Philippines way down of the PRB but enhanced a frontal system over the eastern sections of the basin (see figure 2.0 and 6.0). Both events started its effects at the eastern sections of the PRB;
 - Both events did not generate any river flooding at the Pasac-Guagua sub-basin;
 - Basin rainfall during event Nona was comparatively higher than that of event Lando even for a 2-day total for each event. It is likely that the rains occurring between stations were not totally represented by the present existing stations and of which could have spelled the difference in the resulting flood effects for each event;
 - River stages recorded during event Lando were a lot higher than that of Nona at the upstream forecasting points (Sapang Buho, Peñaranda and San Isidro) except for Zaragoza station, located at the Rio Chico sub-basin, which registered a much higher stage for event Nona; river stages for both events were almost similar at the downstream sections of the basin with event Lando leading event Nona several centimeters higher;
 - River stages generated at Sapang Buho, Peñaranda and San Isidro during event Lando are historically high records in the last 30 years for the PRB;
 - Ocular observations showed that before Nona, Lando brought down a lot of sediments in the river channels causing siltation and sedimentation which eventually reduced the river channel capacity and hence, contributed bigger flood effects for Nona;
 - A total of 90 barangays for Pampanga and 69 barangays for Bulacan were affected by floods during event Lando; and 72 barangays for Pampanga and 65 barangays for Bulacan were affected by floods during event Nona (from the terminal reports of PDRRMOs of Pampanga and Bulacan);
 - For the last 30 years, Typhoon Pedring's flood event still remain as the biggest flood yet for both PRB and the allied river system of Pasac-Guagua.
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References:

Reports:

PRFFWC Post-Flood Report 2011-2: Typhoons Pedring (Nesat) and Quiel (Nalgae), (September 26 to October 04, 2011); PRFFWC, PAGASA, DOST. 2012

NDRRMC Updates: Sitrep No. 26 re Preparedness Measures and Effects of Typhoon “Lando”, November 03, 2015

NDRRMC Updates: Sitrep No. 19 re Preparedness Measures and Effects of Typhoon “Nona”, December 24, 2015

Resource Entities:

1. Office of Civil Defense Reg. 3 / Regional Disaster Risk Reduction & Management Council 3
2. Pampanga PDRRMO
3. Bulacan PDRRMO
4. Nueva Ecija PDRRMO
5. Bongabon MDRRMO & MPDO
6. Laur MDRRMO
7. Palayan MDRRMO
8. Peñaranda MDRRMO
9. Gapan MDRRMO
10. Cabiao MDRRMO
11. San Isidro MDRRMO
12. Sta. Rosa MDRRMO
13. La paz MDRRMO
14. Apalit MPDC
15. Candaba MDRRMO
16. Masantol MDRRMO
17. San Luis MDRRMO
18. San Simon MDRRMO
19. Calumpit MDRRMO
20. Pulilan MDRRMO
21. Hagonoy MDRRMO
22. San Miguel MDRRMO
23. Flood Forecasting & Warning Section (FFWS), HMD, PAGASA

Resource Persons:

1. Henry Cajucom, MPDO, Bongabon, N.E.
2. John Ryan Ong, MDRRMO, Bongabon, N.E.
3. Engr. Edwin P. De Fiesta, Municipal Engineer-MDRRMO, Laur, N.E.
4. Lody Aguilar, MDRRM office, Cabiao, N.E.
5. Jaki Dayao, MDRRM office, Sta. Rosa, N.E.
6. Perlita Tinio, resident of Bgy. San Anton, San Leonardo, N.E.
7. Andy Macapagal, resident of Bgy. San Vicente, Cabiao, N.E.

8. Janneth yambao, MDRRMO, San Isidro, N.E.
9. Bong Hilado, CDRRMO office, Palayan City, N.E.
10. Bencel Parumog, PDRRMO Officer, PDRRMO-N.E.
11. Dr. Abraham A. Pascua, Consultant, Nueva Ecija
12. James Andre M. Paras, MPDC, Vice Chair MDRRMC, Peñaranda, N.E.
13. Arleen Alacon, CDRRMO, Gapan City, N.E.
14. Phillip Sabangan, resident near Valdefuente Bridge, Cabanatuan City
15. Jojo Y. Manalo, MDRRMO, La Paz, Tarlac
16. Ula O. Supan, MO-MPDC, San Simon, Pampanga
17. Engr. Allan Odchigue, MPDO, Apalit, Pampanga
18. Cesar Jornadal, resident of Bgy. San Mateo, Arayat, Pampanga
19. Willie Manalastas, Bgy. Tanod, San Agustin, Candaba, Pampanga
20. Mel Manimbo, MDRRMO, Candaba, Pampanga
21. Engr. Ernesto Bondoc, MDRRMO, San Luis, Pampanga
22. Jess Manansala, MDRRMO, Masantol, Pampanga
23. Janeth Jiao, PDRRMO office, Pampanga
24. Janica Yambao, PDRRMO office, Pampanga
25. Angie Blanco, Executive Officer, PDRRMO, Pampanga
26. Aldwin Mallari, MDRRMO, Guagua, Pampanga
27. Adjeck Eclane, MDRRMO, San Miguel, Bulacan
28. Gerry Belen, MDRRMO office, Calumpit, Bulacan
29. "Boie" Salonga, MDRRMO office, Calumpit, Bulacan
30. Renato S. Crisostomo, DRRM Officer, Hagonoy, Bulacan
31. Boy Montances, DRRM office, Hagonoy, Bulacan
32. Bryan Cyro Velasco, PDRRMO-Bulacan
33. Raul Agustin, PDRRMO-Bulacan
34. Lambert Sylvestre, PDRRMO-Bulacan
35. Liz L. Mungcal, Executive Officer, PDRRMO-Bulacan
36. Rodolfo Santos, resident of San Agustin, Hagonoy, Bulacan
37. Cymbeline C. Mano, Designated MDRRMO, Pulilan, Bulacan
38. Senator Richard Gordon, Chairman, Philippine Red Cross



prffwc_ffb@yahoo.com / prffwc@pagasa.dost.gov.ph