



04 March 2023

Angat River Assessment Values (results by river cross-sections) by the PRBFFWC, NCR-PRSD, PAGASA

Backgrounder:

Light to moderate with at times heavy rains brought about by the effects of the shear line and northeast (NE) monsoon in the morning of January 05, 2023 affected the eastern sections of Luzon including the eastern part of the Pampanga River Basin. The Angat watershed was similarly affected with rains even before January 05. At around 1700H of that 5th day of the year, the Angat Dam, and through the Ipo Dam, started releasing their reservoir waters at the rate of 72 cumecs and 88 cumecs, respectively. The releases continued for about 4 days with peak discharges eventually reaching up to 1,249 cumecs for Angat and 1,292.62 cumecs after the Ipo Dam. Several riverside areas along the Angat River were affected as a result of these flows. By early morning of January 08, the gates of both dams were closed (info / data on the dam discharges were provided by Bulacan-PDRRMO).

About a month later, on February 08-09, 2023, the Pampanga River Basin Flood Forecasting & Warning Center (PRBFFWC) & Bulacan-PDRRMO personnel conducted a joint river cross-sectioning of some specific points along the Angat River as per request by the Provincial Government of Bulacan. The various LDRRMOs of the towns of Norzagaray, Angat, Bustos, Plaridel, and Calumpit were on hand to provide support and assistance during the conduct of the said activities. There were 5 river cross-sections surveyed as follows:

1. Angat River at Matictic Bridge, Norzagaray
2. Angat River at Sta. Lucia Bridge in Angat
3. Angat River at Alejo Santos Bridge, Bustos-Baliuag boundary
4. Angat River at Plaridel-Pulilan Bridge
5. Bagbag River at Bagbag Bridge, Calumpit

The main purpose of the undertaking was to determine the likely maximum water level and / or discharge that the Angat River can hold prior to flooding or before residents along the river will be affected by an overflow of the river. The activity conducted was limited only to taking the river cross-sections and no other river measurements such as river velocity measurements, river channel profiling, etc. were carried-out.



(Fig. 1) Above shows the locations of bridges (encircled red numbers) where river cross-sections were taken along the Angat River and Bagbag River.

"tracking the sky...helping the country"



The River Cross-sections:

1. Angat River at Matictic Bridge in Norzagaray, Bulacan



(Pic 1, above) A Google Earth view of the Angat River at Matictic bridge in Norzagaray, Bulacan with a distinct view of the concrete lined dike on the right bank of the river.

(Pic 2, left) A view of the stretched concrete dike as seen from the upstream right bank (RB) side of the Matictic bridge. The area on the left side of the dike is the protected part.

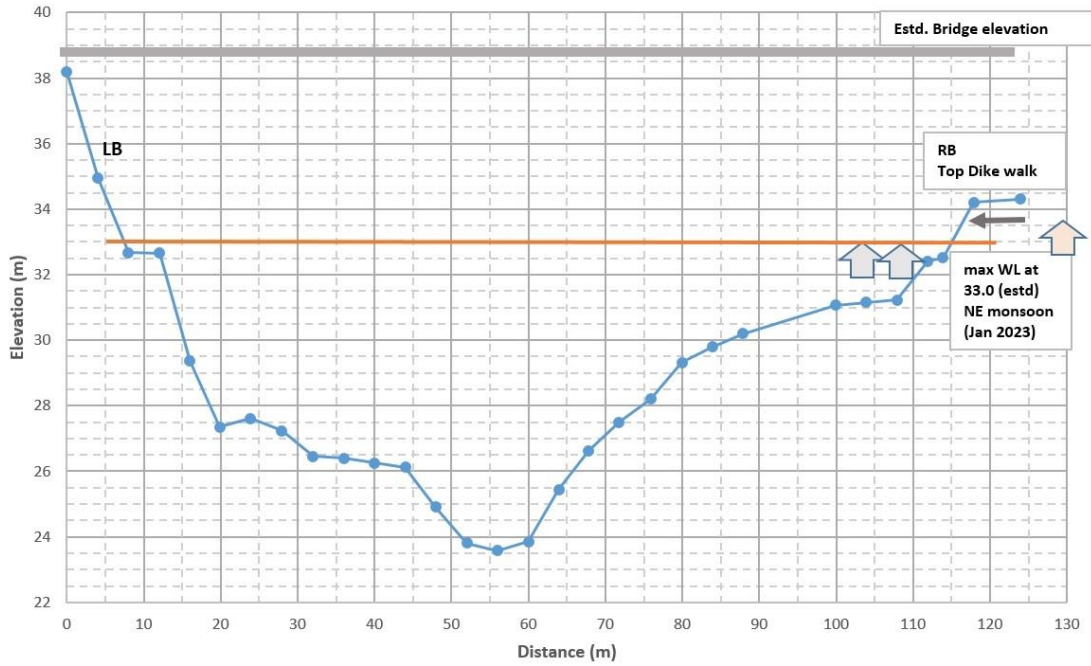


The upstream (Pic 3, top left) and downstream (Pic 4, top right) views of Angat River as seen from the Matictic bridge at the time of the cross-sectioning activity at the site.



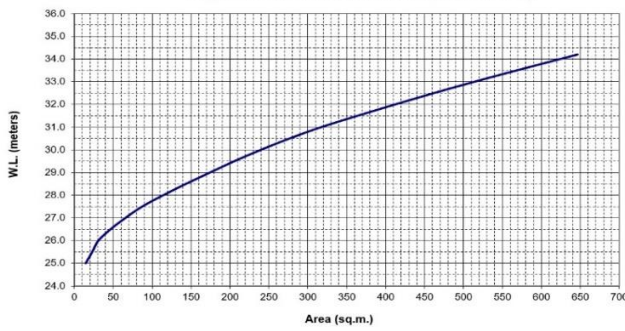
(Pic 5, left) A personnel of Norzagaray MDRRMO points to the estimated maximum water level reached in the area during the NE monsoon event of January 2023. This picture was taken inside the dike protected area which means that the river affected the area even without overtopping the said dike at the bridge section. As per information by the MDRRMO personnel, floodwaters streamed to the protected area from the upstream portion from where the concrete dike starts.

Angat River X-section at Matictic Bridge (Feb. 08, 2023)



(Fig. 2, Above) The river cross-section of Angat River at the upstream side of Matictic bridge with maximum WL attained during the NE monsoon event (orange line) and the indicated concrete dike on the right with house symbols that shows their likely positions at both sides of the dike.

Angat River at Matictic H-A curve (Feb 08, 2023)



(Fig. 3, left) The river stage vs. Area (H-A curve) of Angat River at Matictic bridge.

2. Angat River at Sta. Lucia Bridge in Angat, Bulacan

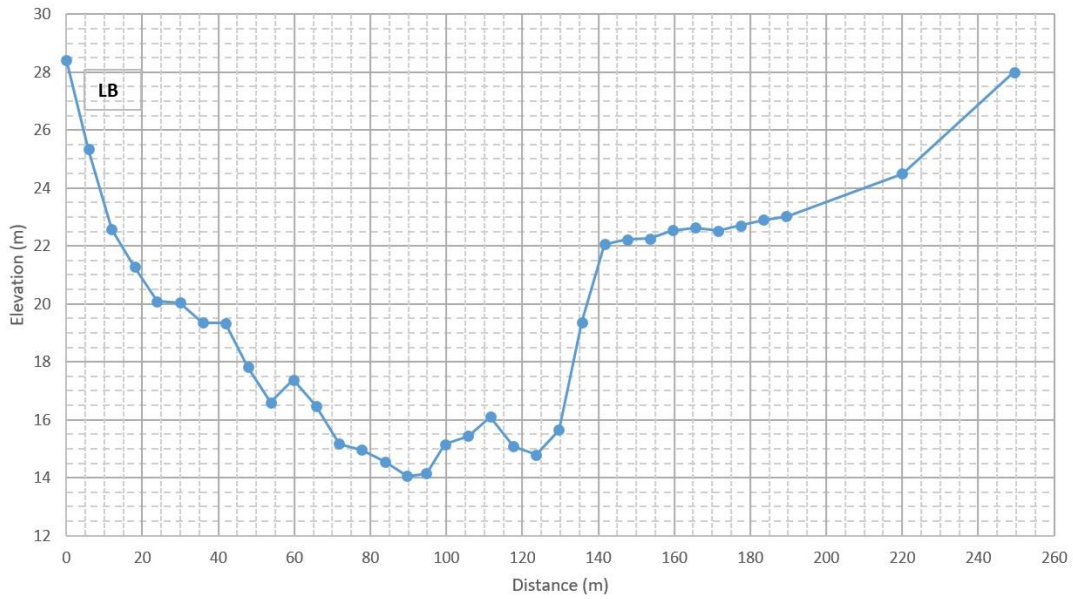


(Pic 6, Top) Picture shows a google earth view of the Sta. Lucia Bridge in Angat, Bulacan.

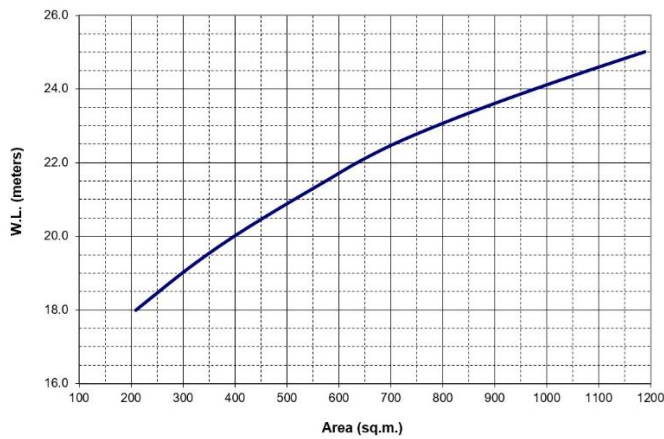


An upstream (Pic 7, top left) and downstream views (Pic 8, top right) of the Angat River at seen from the Sta. Lucia Bridge in Angat, Bulacan.

Angat River at Sta. Lucia Bridge (Feb 08, 2023)



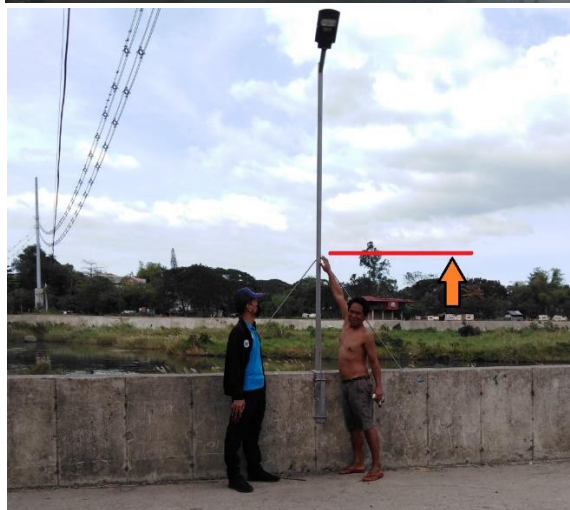
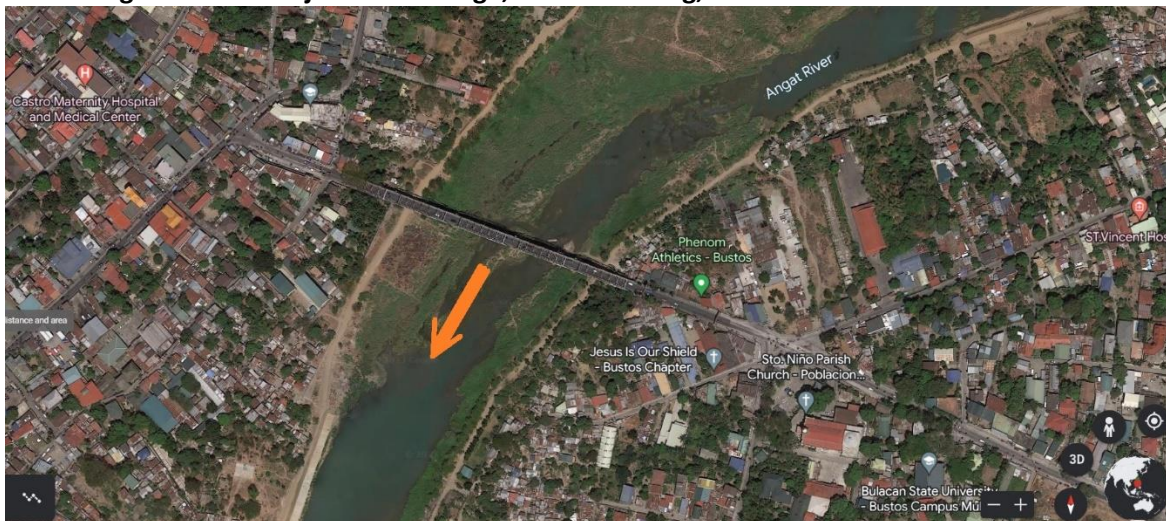
Angat River at Sta. Lucia, Angat H-A Curve (Feb 08, 2023)



(Fig. 4, Above) The surveyed cross-section of Angat River at Sta. Lucia Bridge in Angat, Bulacan. The cross-section was taken at the upstream side of the bridge. Note, the rather gentle sloping ground on the right bank which represents an area for depositing & hauling of gravel and sand (see Pic 6).

(Fig. 5, left) The graph represents the estimated WL vs. Area (H-A curve) of Angat River at the said cross-section.

3. Angat River at Alejo Santos Bridge, Bustos-Baliuag, Bulacan

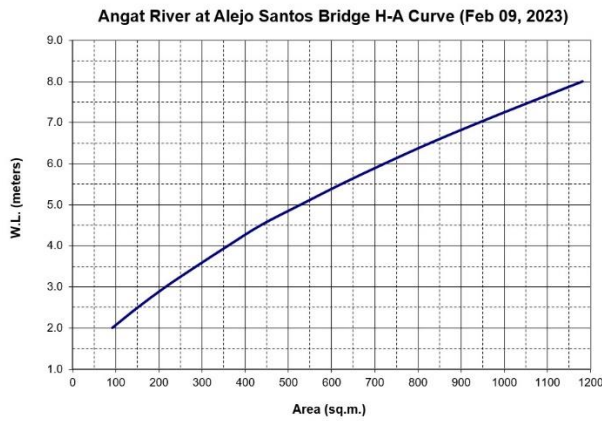
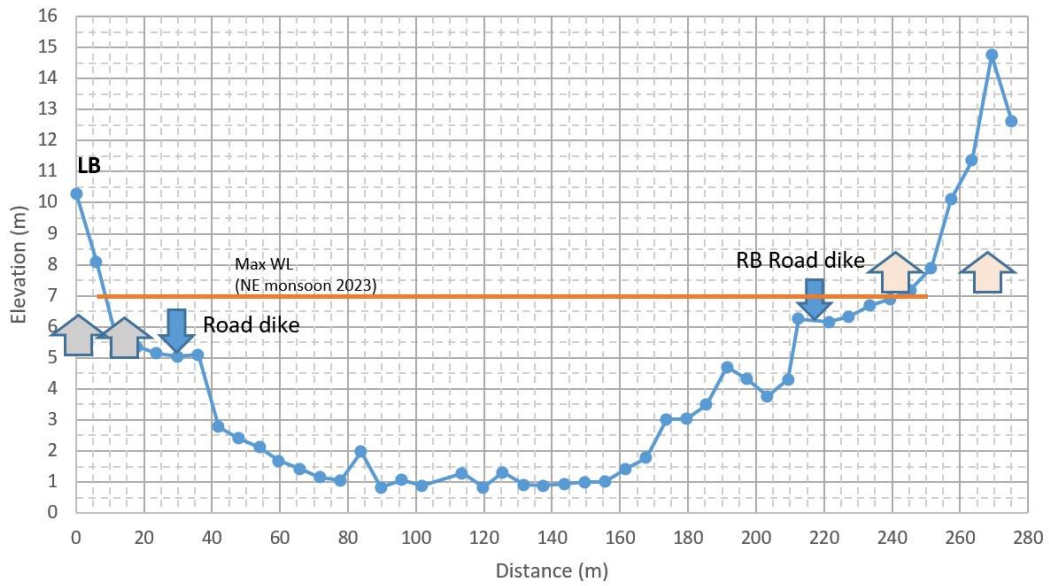


(Pic 9, Topmost picture) The google earth view of the cross-section site. Next row pictures show the upstream (Pic 10, top left) and the downstream views (Pic 11, top right) of the Angat River as seen from the Alejo Santos Bridge.

(Pic 12, left) A resident in the area points to the estimated maximum WL attained during the January 2023 event. This was along the road dike on the left bank side of the river.



Angat River X-sect at Alejo Santos Bridge (Feb. 09, 2023)



(Fig 6, above) The surveyed river cross-section of Angat River taken at the downstream side of the Alejo Santos Bridge in Bustos-Baliuag area. The estimated maximum WL attained (orange line) overtopped the road dikes at both sides of the river.

(Fig. 7, left) graph representing the estimated WL vs. Area (H-A curve) for the surveyed cross-section.

4. Angat River at Plaridel-Pulilan Bridge



(Pic 15, above) The google earth view of the Pulilan-Plaridel Bridge crossing over Angat River.

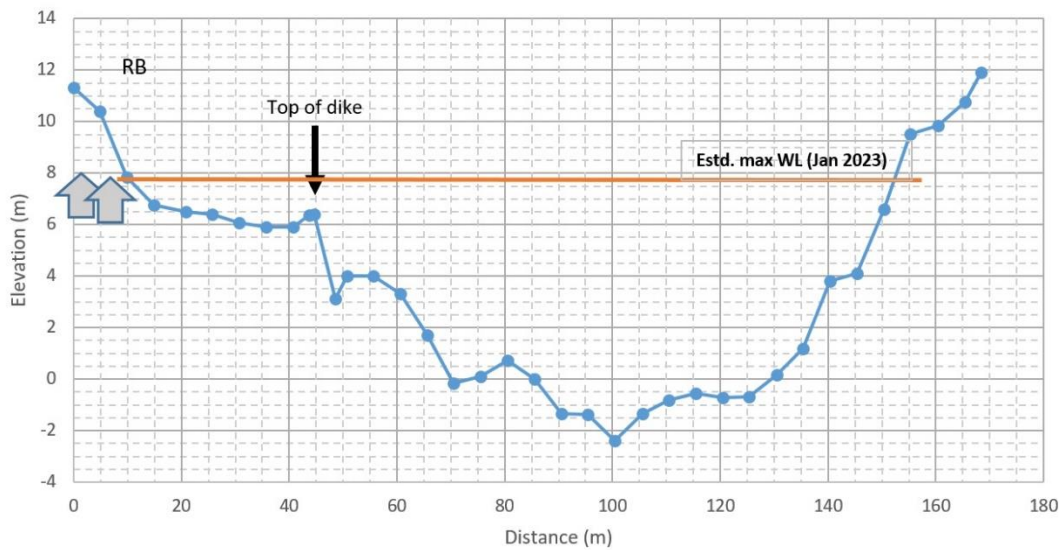


(Pic 16, left) A view of the concrete lined dike on the right bank (RB) of Angat River as seen downstream from the Plaridel-Pulilan Bridge.

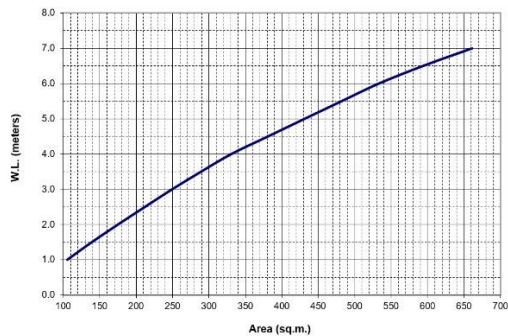


Pictures below shows a comparison of the left bank side of the Angat River just downstream of the Plaridel-Pulilan bridge during normal flow (Pic 17, left) and during the January 2023 NE monsoon event (Pic 18, right). For WL referencing, take note of the 2 white information board in the middle of the picture.

Angat River X-sect at Plaridel-Pulilan Bridge (Feb 09, 2023)



Angat River at Pulilan-Plaridel Bridge H-A (Feb 09, 2023)



(Fig. 8, above) The representative cross-section of the Angat River taken at the downstream side of the Plaridel-Pulilan Bridge with an estimated maximum WL attained during the January 2023 NE monsoon event (orange line); (Fig. 9, left) the estimated WL vs. Area (H-A curve) for the said cross-section.

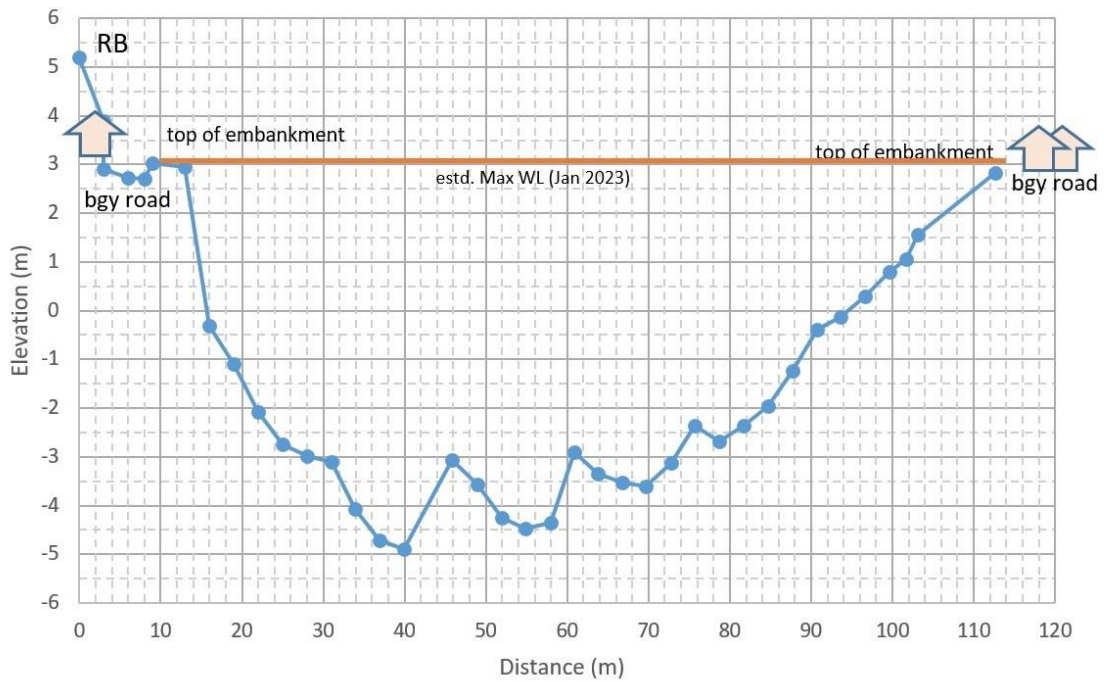
5. Bagbag River at Bagbag Bridge, Bgy. Caniogan, Calumpit, Bulacan



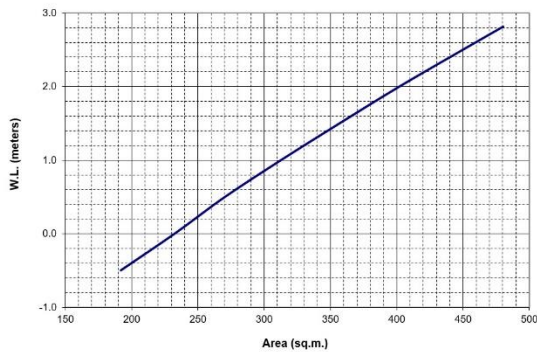
(Pic 20, above) Bagbag River is a merging waterway to the Angat River situated in Calumpit and is clearly shown in the google earth map view above. (Pic 21, left) The orange arrow points to the estimated maximum WL attained on the RB during the January 2023 NE monsoon event. (Pic 22, bottom left) upstream view of Bagbag River as seen from atop the Bagbag Bridge. (Pic 23, bottom right) upstream view, LB side of the Bagbag River from the same vantage point. (Pic 24, lowermost left) Downstream, LB and (Pic 25, lowermost right) downstream, RB views of Bagbag River as it joins with the Angat River.



Bagbag R. at Bgy. Caniogan, Calumpit (Feb 09, 2023)



Bagbag River at Bagbag-Caniogan Bridge H-A Curve (Feb 09, 2023)



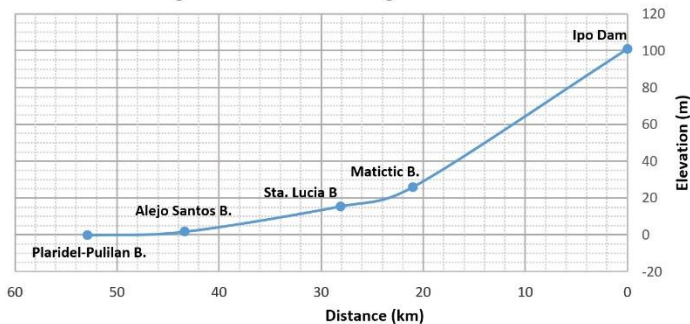
(Fig. 9, above) The representative river cross-section of Bagbag River at Bagbag Bridge in Calumpit, Bulacan with the estimated maximum WL (orange line) attained during the January 2023 NE monsoon event.

(Fig. 10, left) The estimated WL vs. Area or H-A Curve for the river cross-section of Bagbag River.

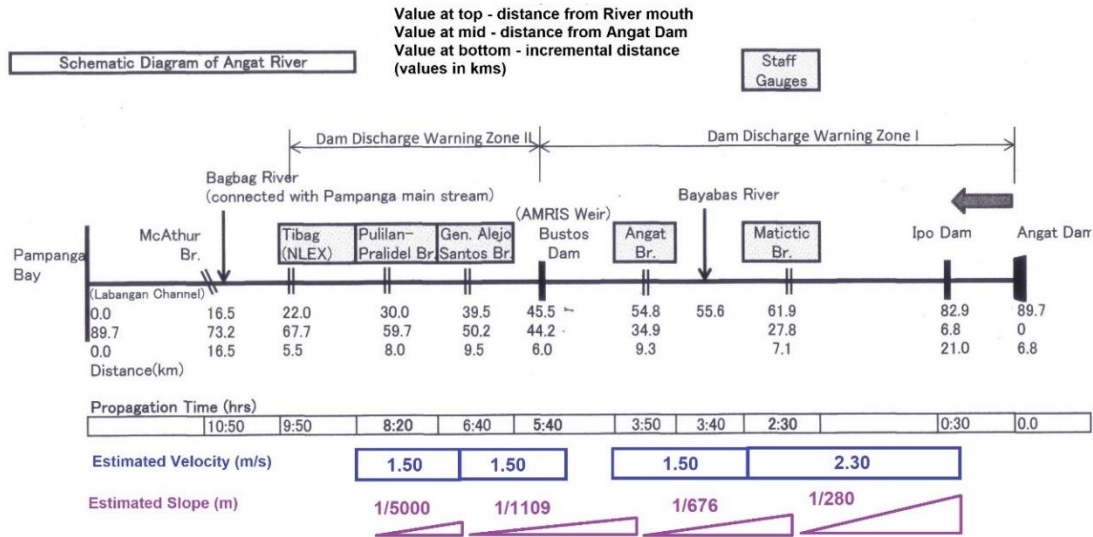
Assessment Levels:

Below are some of the available information that were gathered from various reports and were taken as an additional source of data / information for the worked-out suggested assessment levels for this undertaking.

Angat R. Estimated Longitudinal Profile



(Fig. 11) An estimated longitudinal profile of Angat River from Ipo Dam down to the Pulilan-Plaridel Bridge as per estimated average riverbed elevation of surveyed x-sectional points (Matictic to Plaridel-Puilan bridge)



(Fig. 12, above) The schematic diagram of the Angat River with various information showing distances (in kilometers) from Angat Dam down to Pampanga Bay and vice-versa; incremental distances from Pampanga Bay to Angat Dam; the propagation time (in hours); estimated river velocity (m/s) and slope (m) between the river cross-section points that were surveyed. (This diagram was taken from a JICA report except for the estimated velocity (blue colored) & slope (violet colored) values which were inserted below the diagram)

(Table 1) Results based on River Cross-section per station:

Bridge station	Elevation at dike level limit based on x-sect (m)	Remarks (lowest dike level location)	Estimated x-sect area at elevation (dike level limit) (m ²)	Estimated River velocity (m/s)	Estimated discharge (m ³ /s)
Matictic	34.0	Top of RB dike	622	2.3	1431
Sta. Lucia	22.0	At RB	635	1.5	953
Alejo Santos	5.0	Top of LB dike	528	1.5	792
Pulilan-Plaridel	6.4	Top of RB dike	575	1.5	863
Bagbag	1.6	Top of LB dike	370		

(Table 2)

Initial Assessment Levels (based on river x-sects)			
Station Bridge	Alert	Alarm	Critical
Matictic WL (m)	31.5	32.8	34.0
estd Q* (cumecs)	858	1145	1431
Sta. Lucia WL	19.8	21.0	22.0
estd Q* (cumecs)	572	762	953
Alejo Santos WL	3.75	4.4	5.0
estd Q* (cumecs)	475	633	792
Plaridel-Pulilan WL	4.2	5.4	6.4
estd Q* (cumecs)	518	690	963
Bagbag WL	-0.1	0.8	1.6

Basis:

Alert level assumes 60% of the X-sectional Area at dike level limit

Alarm level assumes 80% of the X-sectional Area at dike level limit

Critical level assumes the estd X-sectional area at dike level limit

* Estimated Q values assumes that velocity is the same at all river stages at the given x-section

Analysis:

- There are a number of caveats which concerns the results in this report; first, the resulting values were primarily based on the measured river cross-sections only at the specific points along the Angat River, specifically at the 4 bridge crossings along Angat River and at one bridge crossing at Bagbag River near its confluence with Angat River;
- There were no river velocity measurements carried-out during the cross-sectioning activities;
- Assumptions were made in several instances due to lack of directly measured data, except for the cross-sections; other information / data were gathered from available loose pages of various reports which cannot be cited specifically in this report;
- Elevations were based on the available WL observations at each of the bridge section as provided by the Bulacan-PDRRMO during the time of the survey proceedings;
- The estimated river velocities (in Fig 12) per river channel section were computed based on the given distances between points and the propagation time along the Angat river;
- The discharges presented in the assessment levels were computed with the assumption that river velocity is the same at all river stages (WL) at respective river x-section; this is to say that a steady and uniform flow was considered; the controlling or variable factor is only the x-sectional area (from H-A curves). It should be noted that river velocity is subsequently reduced as river stage recedes;
- The maximum reported discharge during the NE monsoon event reached 1,292.62 cumecs after Ipo Dam and a recorded peaked WL of 32.96 meters at Matictic. The dike protected areas on the RB at the Matictic bridge crossing were flooded during this event (see Pic 5);
- As per surveyed river x-sect at Matictic, the critical assessment level is at 34.0 meters based on the elevation of the top of the concrete dike on the LB corresponding to an estimated discharge of 1,431 cumecs (from Table 2);
- It can be assumed that the critical assessment WL computed based on x-sect for Matictic is quite high for pre-flood warning level considering that at less than 33.0 meters WL, the dike protected area was submerged by more than a meter of floodwater during the NE monsoon.
- The Norzagaray MDRRMO presupposes that the floodwaters have entered at the upstream part of the area from where the concrete dike starts (this requires further investigation);
- The suggested critical discharges (Table 2) did not consider informal settlers who are, from most of the time, situating themselves along the riverside areas of Angat River, outside the dike protected area. These inhabitants may already be affected by floodwaters along Angat River even before the suggested critical discharges had been attained at respective x-sect points.
- Of the 4 bridge crossings along Angat River (Bagbag River is not included) the smallest critical estimated discharge is at Alejo Santos Bridge which is at WL equal to 5.0 meters corresponding to an estimated discharge of 792 cumecs;
- **Hence, from the foregoing statements, it can be proposed as an inference that a critical discharge of 792 cumecs is the maximum pre-flood level of discharge.**

Recommendations:

- Based on the foregoing analysis section, the maximum pre-flood discharge along the Angat River is about 792 cumecs, as per Alejo Santos x-sect point. This, however, is a suggestion only and can be treated as an initial starting point subject for adjustments and further modification through actual measurements and observations before, during, and after flood events;
- Conduct regular stream gauging activities (river x-sects and velocity measurements) at the bridge's sections at various river stages with more focus on medium to higher flow regimes;
- Install staff gages at all bridge sectional points for a more permanent stage referencing and to be placed at locations that can be easily viewed from the bridge; it is also suggested that water level / river gages be ubiquitously installed at riverside areas for critical level reference and / or purposes of possible early warning means to these areas;

- Conduct additional or tighter x-sect measurements along the Angat River channel; also conduct river assessment surveys along the stretched of the Angat River channel before, during, and after flood events for a more visual validation of flood levels at the riverside areas;
- Lastly, to conduct information and education campaigns at all (critical) riverside barangays along the Angat River for flood hazard preparedness and risk reduction planning activities.

River Cross-sectioning activity pictures (February 08-09, 2023)



(Pic 26 & 27, above) PRBFFWC and Norzagaray MDRRMO personnel take river sounding atop the Matictic Bridge during the cross-sectioning activities on Feb. 08 & 09, 2023.; (Pic 28, left) River x-sect activities at Sta. Lucia Bridge in Angat, Bulacan; (Pic 29, 30 & 31, below) The same activities at the Plaridel-Pulilan Bridge (left below), and at Bagbag Bridge (middle & right below) in Calumpit, Bulacan.

