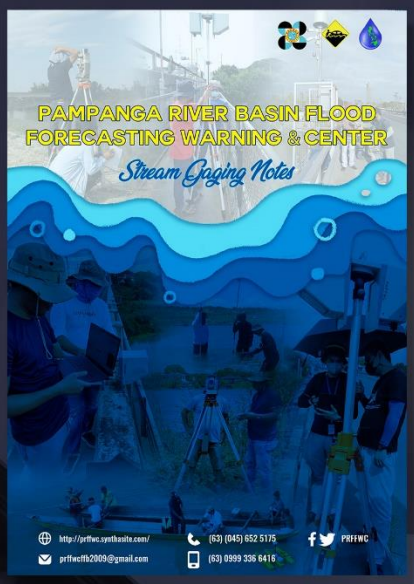
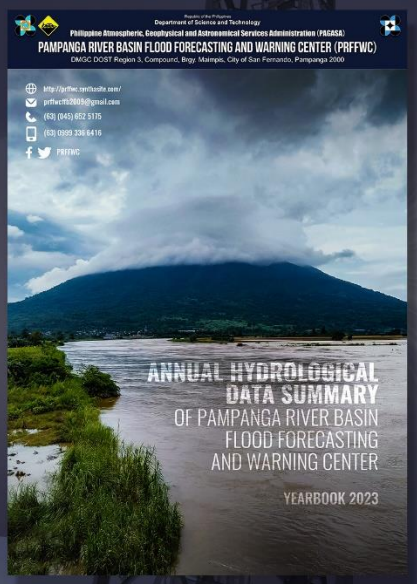
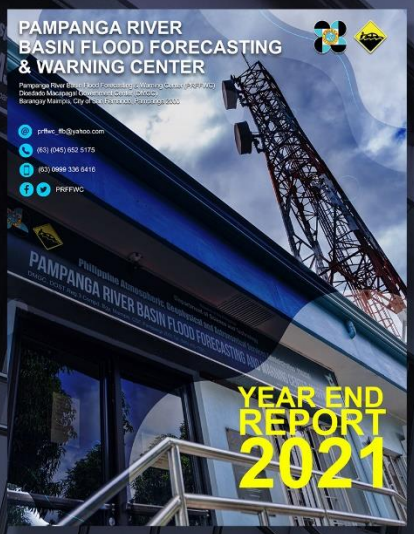
Reference Manual No. 1 for

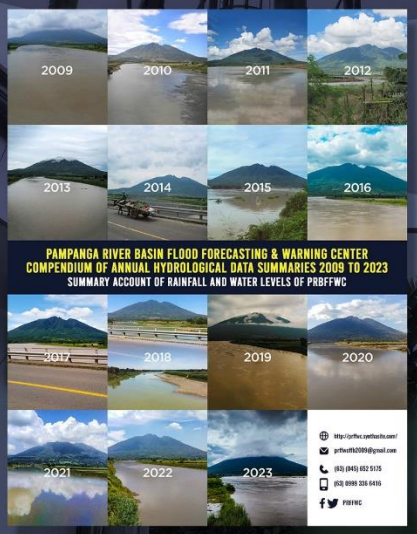
Pampanga River Basin Flood Forecasting & Warning Center





General Information on Floods, Telemetry System, Pampanga River Basin, & the operational activities for Flood Forecasting & Warning of the PRBFFWC





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Reference Manual No. 1 of the PAMPANGA RIVER BASIN FLOOD FORECASTING and WARNING CENTER (PRBFFWC)

General Information on Floods, Telemetry System, Pampanga River Basin, and the Operational Activities for Flood Forecasting & Warning of the PRBFFWC

(Updated / revised: September 2024)

Acronyms & Abbreviations:

- CL – Central Luzon
- CSFP – City of San Fernando, Pampanga
- DRRM – Disaster Risk Reduction and Management
- DRRMO – Disaster Risk Reduction & Management Office; L / C / M / P / R DRRMO – Local / City / Municipal / Provincial / Regional Disaster Risk Reduction & Management Office
- D/S - downstream
- D/T - downtime
- FA – Flood Advisory
- FB – Flood Bulletin
- FFWS – Flood Forecasting & Warning System / FFW – Flood Forecasting & Warning
- FM – Flood Marker
- FW – Flood Watch (status)
- FWWL - flood warning water level
- HMD – Hydro-Meteorology Division
- HMTS – Hydromet Telecommunications Section
- HMDAS – Hydromet Data Application Section
- LB – Left Bank
- LGU – Local Government Unit
- MGB – Mines & Geosciences Bureau
- NCR-PRSD – National Capital Region – PAGASA Regional Services Division
- NGO – Non-Governmental Organization
- NE Monsoon – Northeast Monsoon (or Amihan)
- NFW – non-Flood Watch (status)
- OCD – Office of Civil Defense
- PAR – Philippine Area of Responsibility
- PRB – Pampanga River Basin
- PRBFFWC / PRFFWC – Pampanga River Basin Flood Forecasting & Warning Center / Pampanga River Flood Forecasting & Warning Center
- PAGASA – Philippine Atmospheric, Geophysical and Astronomical Services Administration
- RB – Right Bank
- RR – Rainfall
- SG or S.G. – Staff Gauge
- STS – Severe Tropical Storm
- STy – Super Typhoon
- SW Monsoon – Southwest Monsoon (or Habagat)
- TC – Tropical Cyclone
- TCWS – Tropical Cyclone Warning Signal
- TD – Tropical Depression
- TS – Tropical Storm
- Ty - Typhoon
- U/S - upstream
- WL – Water Level
- WMO – World Meteorological Organization
- Wx or wx – weather

Table of Contents:

Overview

The Operational Activities of the Pampanga River Basin Flood Forecasting & Warning Center are presented in 2 document reports, Reference Manuals No. 1 and No. 2. Reference Manual No. 1, which is actually this document, is mainly a general backgrounder on several basic topics and issues which includes a passing discussion about floods and telemetry system, the physical features of the Pampanga River Basin, a brief on the history of the Flood Forecasting & Warning System in the Philippines which basically started with the PRBFFWC and partly on its regular operational activities and information relating to the telemetry stations / system that comprises the river basin center's monitoring. Reference Manual No. 2 covers the operational activities of the PRBFFWC during non-flood watch (NFW) and flood watch (FW) status; additionally, some specific information relating to the issues of flooding in the PRB such as flood-prone target areas, lead (or lag) time(s) of flood propagation, and many other aspects.

These document reports have been updated a few times already and may continue to be revised and updated as often as necessary as new technologies and systems are constantly being introduced and implemented to enhance the flood forecasting & warning activities in the PRB, and practically to adjust to the changing and dynamic hydrological features in the basin as it becomes more complicated in some particular aspect. *Furthermore, in a rather realistic but quite sad situation, these reports (Reference Manuals No. 1 & 2) may not have any chance of being read nor browsed by most of the PRBFFWC personnel, which is actually the main focused of these manuals, as almost all of them remain passive and not at all responsive in their attitude towards the river basin center's thrust and agenda in its area of concern.* For now, these manuals will remain just as references, and hopefully as a guide anytime or in the future for whoever may have an interest or may have the seriousness of providing and improving the FFW services to the target communities within the PRB. The various issues covering the topics in these documents have been prepared in bulleted format for simplification of presentation.

PRBFFWC, September 2024

PART 1. Introduction

1.0 About Reference Manual No. 1

- A general backgrounder relating to the Flood Forecasting & Warning activities specific to the PRBFFWC of the NCR-PRSD of PAGASA;
- Contains generic and general information for operational flood forecasting & warning activities in which the data, information and materials were taken from various sources available from the date of its inception and were intentionally not cited herein;
- Includes notes on floods, brief description of the PRB, the PRBFFWC, including a brief of its history, the telemetry system, and several relevant materials on operational FFWS;
- Some definite activities on the daily operational FFW of the PRBFFWC for the Pampanga River Basin which was generally based on the river basin center's defined regular operational practices;
- As much as possible presented in bulleted lists, with figures and/or pictures, some tables to serve as guides for the operational hydrologist / flood forecaster, hydro technicians in their daily activities and in particular during FW status;
- This will serve as a "look-up" guide whenever confronted with issues relating to center's activities, flooding in the PRB, and for other materials that may be used for presentation, for orientation to visiting entities, as reference during media interviews, and for other related situations such for new personnel of the center;
- Standard operating procedures (SOP) was explicitly not used as a title for this manual since there are quite a number of situations where no definite nor specific pattern of activity / procedure are being followed such as during basin situational instances that may require personnel discussions / brainstorming; in the center's usual daily operational activities particularly when commencing FW status;
- The various data and information contained herein were determined from the best possible means and / or methods at the time of its preparation and is solely for PRBFFWC specific use only. Any other person (non-PRBFFWC) or entity may use the data / information contained herein at their own risk.

1.1 Floods

(A) Definition

The World Meteorological Organization (WMO)/UNESCO *International Glossary of Hydrology* (WMO-No. 385, 1992) provides the following definitions for flood:

(1) Rise, usually brief, in the water level in a stream to a peak from which the water level recedes at a slower rate.
(2) Relatively high flow as measured by a stage height or discharge.
(3) Rising tide.

"Flooding" is defined as: Overflowing by water of the normal confines of a stream or other bodies of water, or accumulation of water by drainage over areas that are not normally submerged. Generally, there is not one single definite meaning to describe flood. It can have a relative meaning to an individual and will vary from area to area as per one's perception / experience of the hazard.

(B) Types of floods (*WMO Manual of Flood Forecasting & Warning*; WMO-No. 1072)

(1) Flash floods – These floods are frequently associated with violent convection storms of short duration falling over a small area. Flash flooding can occur in almost any area where there are steep slopes, but is most common in mountain districts subject to frequent severe thunderstorms or often result of heavy rains of short duration.
(2) Fluvial (riverine) floods – Floods in river valleys occur mostly on flood plains or wash lands as a result of flow exceeding the capacity of stream channels and spilling over the natural banks or artificial embankments.
(3) Single event floods – The most common type of flooding in which widespread heavy rains lasting several hours to a few days over a drainage basin area results in severe floods. Typically, these heavy rains are associated with cyclonic disturbances, depressions and storms, with well-marked synoptic frontal systems.
(4) Multiple event floods – Results from heavy rainfall associated with successive weather disturbances following closely after each other; often caused by the passage of a series of low pressure areas or depressions, more or less along the same path.
(5) Seasonal floods – These are floods that occur with general regularity as a result of major seasonal rainfall activity such as monsoons; frequently a basin-wide situation that can last for periods of several weeks.
(6) Coastal floods - Storm surges and high winds coinciding with high tides are the most frequent cause. Tsunamis resulting from sub-seabed earthquakes are a very specific cause of occasionally severe coastal flooding.
(7) Estuarine floods – Estuaries are inlet areas of the coastline where the coastal tide meets a concentrated seaward flow of freshwater in a river. The interaction between the seaward flow of river water and landward flow of saline water during high tides may cause a build-up of water or inland-moving tidal bore.
(8) Urban floods – It occurs when intense rainfall within towns and cities creates rapid runoff from paved and built-up areas, exceeding the capacity of storm drainage systems.
(9) Snowmelt floods and (10) Ice- and debris-jam floods, defined as other types of flood by WMO but will not be considered in this manual due to obvious reasons that snow or ice events are not experienced within the Pampanga River Basin.

Flood relating to numbers 2, 3, 4 & 5 are generally the main focus of this manual as these are the more regular, frequent and prevalent flood types experienced within the Pampanga River Basin.

1.2 Flood Forecasting & Warning System

(A) Concept

Floods can occur at anytime and anywhere after occurrence of heavy or continuous rain. This hazard when not properly manage oftentimes result in disasters especially when it occurs in areas that are densely populated. Traditionally, society responds by protecting the people from floodwaters by means of constructing structural measures. But the reality of economic limits the provision of structural flood defenses, together with the possibility that the capacity of such defense systems may be exceeded or that they may fail, necessitate that other measures are needed. A paradigm shifts to effectively reduce the impacts of flood hazards is by keeping the people away from floodwaters and that is employing non-structural flood mitigating measures. A holistic and the best approach is to judiciously combine both structural and non-structural measures. Lately, more emphasis is now being given to the latter under the DRRM concept.

Flood Forecasting and Warning System (FFWS) is one of the non-structural flood mitigating measures. It is the dissemination of adequate and reliable flood information and warning to people (community) that are likely to be affected by floodwaters with sufficient lead time in order for them to take necessary actions against the incoming flood. The main purpose of the system is to provide, as much as possible, an advance notice of an impending flood to the authorities and the general public. Over time, the demands for flood forecasts evolve from a general indication of a likelihood of flooding, for example on major rivers, ***to a more definitive prediction of magnitude and timing at key locations.*** To date, there are now quite a number of flood forecasting and warning system set-ups all over the world.

Flood forecasting requires an understanding of both meteorological and hydrological behavior for the particular conditions of an area in question. Ultimate responsibility lies with appropriate government agencies at a national level, but information and operational activities need to be made available at more localized levels such as an area of population within a river basin.

Provision of flood forecasts will also form part of flood management planning and development strategies, which recognize that there are occupied flood plain areas where non-structural measures can be effective. This can include the use of temporary mitigating defenses (flood gates or demountable barriers, etc.), domestic protection (sandbagging), local evacuation (to flood shelters) and adaptation (situational-based).

Additionally, the concept of FFWS can be taken as follows:

- *main purpose is to **avert** and **minimize** loss of life (Plessis, 2002)*
- *establishing public safety, to **reduce** damage to property and to **relieve** public anxiety; reduce material, human and cultural losses (Parker and Fordham, 1996)*
- *one component of various flood control options that could be installed to **reduce** tangible flood losses (Smith & Handmer, 1986; Krzysztofowic & Davis, 1983)*

(B) Purpose of Flood Forecasting & Warning System

Flood warnings are different from hydrological forecasts, as they are issued whenever there is an event, or that is when floods are imminent. The flood warnings are issued to a wide-range of users for various purposes which may include:

- Preparedness: to give individuals and organizations (Local DRRMOs) time to take preparatory action;
- to have operational teams and emergency groups in a state of awareness and eventual readiness; to warn the public of the timing and location of the event;
- to be on alert for any possible associated hazards such as flash floods and / or landslides;
- and in extreme cases, to state directly in the warnings, based on the river levels, for possible appropriate actions (such as preparation for evacuation) and emergency procedures; if possible and now the focus of many warning entities is to state the impacts of the hazards associated with the event.

(C) Features of an effective Flood Forecasting and Warning System

- The FFWS must provide sufficient lead time for communities to respond, act properly to a certain level of preparedness depending on the warning provided;
- It must be reliable and designed to operate during the most severe weather and flood conditions (extreme hydrometeorological events); hence, the operations center and the network of stations comprising the system should be appropriately situated such that all aspects of possibilities in terms of both natural-related and anthropogenic-related hazards are considered to some extent;
- It must provide forecasts and warnings that are sufficiently (adequately) accurate to promote confidence so that communities will respond properly when warned; forecasts & warnings must be straightforward; simple but well-understood;
- Must have an integrated combinational requirements of continuous real-time data, forecasting tools, and specifically basin trained and knowledgeable forecasters;
- The system must fit well within the holistic Integrated Water Resources Management (IWRM) framework, programs and activities of the river basin;
- Must always maintain good rapport with the various entities, agencies (Regional and National), local government units (LGUs), Non-Government Organizations (NGOs), the tri-media, and most especially the target communities within the basin of concern;
- The flood forecasting & warning center, being independent from the central office, must have sufficient logistics and mobility **(a service vehicle that is capable to operate during relatively manageable flood events)** in order to be able to validate its forecasts, be able to update basin thresholds and conditions through surveys, stream gaging and related hydrological measurements, and precisely to be able to establish good rapport with the entities within its basin of concern.

PART 2. Flood Forecasting and Warning in the Pampanga River Basin

2.1 Background

(A) Start of program

The floods of August 1960, July 1962, and May 1966 are several of the destructive floods that affected the then flourishing agricultural areas in the Pampanga River Basin. However, a flood in

July 1972, which was considered as one of the most disastrous in Philippine flood records, affected Central Luzon. It inflicted a total damage of about $300 million (US) in Central Luzon area mostly in the Pampanga River Basin. Flood control structures were a no match to the level of flooding at that time, being structurally limited only to regular recurring floods and the fact that such structures normally require enormous annual amount of maintenance. That flood opened the eyes of the Philippine government authorities and saw the importance and the need for a non-structural measure of mitigating flood loss and damages – a Flood Forecasting and Warning System (FFWS) in the Pampanga River Basin.

(B) The start of FFWS: Circa 70's

Exchange of communication notes between the Governments of Japan (GOJ) and the Philippines subsequently led to an agreement for the establishment of a flood forecasting system. But prior to this, a proposal for a flood forecasting project was submitted by the GOJ in March 1970 and by April 1971, the Diet of Japan approved the appropriations of a sum of US$ 260,000 for the provision of equipment and training of personnel for the Pampanga River Basin Flood Forecasting system while the then Bureau of Public Works (BPW and now DPWH) allocated ₱ 500,000 for the construction of housing and other facilities that were needed for the equipment.

In May-June 1973, the equipment from Japan was received and at which time a good part of the station housings and other facilities were already completed by the Bureau of Public Works (now DPWH). The Japan Radio Co., Ltd. (JRC) was the accredited entity tasked to supply and install the equipment for the system.

(C) Start of Operations

Flood Forecasting & Warning operations in the Philippines practically started in the PRB around August of 1973 with the first rainfall data monitored at the FFWS Center in Quezon City being received at 10am of August 09, 1973. There were only three stations (San Isidro, Sulipan, and San Rafael) at the start of operations; however, by end of the month of September, 10 rainfall and 7 water level stations were already reporting. Though most of the stations were still being reviewed and under observation by both Japanese and Filipino experts, nonetheless, operational monitoring activities functioned reasonably well in the succeeding years. The normal data transmission was 12-hr interval during dry season and 3-hourly intervals during wet season. However, the system can be made to transmit data for shorter intervals whenever necessary such as when the basin is threatened by tropical cyclones and other tropical disturbances.

As a pilot flood forecasting system in the country, the network consisted of 7 combined rainfall and water level stations, 2 standalone rainfall stations, 1 combined repeater and rainfall station, and 1 repeater station strategically located within the basin. The terminal telemetry station serving as the nerve center of data collection was originally located at the Flood Forecasting Center in the PAGASA Central Office, which was situated in the then Asiatrust Bldg. along Quezon Ave., Quezon City with a monitoring station at the former BPW (Bureau of Public Works) Main office. The effectiveness of the system was proven during the major floods of October 1973 (start of operations), August and November 1974, May 1976, August and October of 1978 and a lot more onwards.

An old map of Central Luzon (1899) showing the main Pampanga River and several of its tributaries, including Candaba swamp (bluish spot) and Mt. Arayat (a small orange smudge just adjacent to the Main Pampanga River)

(D) FFWS in the Philippines

As a major service of PAGASA, flood forecasting is mandated by Presidential Decree (PD) 78 dated December 8, 1972 as amended by PD 1149, dated June 8, 1977. To implement its mandated function, the National Flood Forecasting Office now known as the Hydro-Meteorology Division (HMD), was created.

The effectiveness of the Pampanga FFWS in mitigating the impacts of floods has eventually paved the way for the establishment of the Agno, Bicol and Cagayan (ABC) FFWS in 1982 through the Official Development Assistance (ODA) from the Government of Japan.

In October 1978, a disastrous flood due to the release of excess reservoir water from Angat Dam in Bulacan Province made the government saw the need for a flood forecasting and warning system for dam operations. The FFWS was extended to cover the operations of Angat and Pantabangan dams in the Pampanga River Basin under the project / activity "Flood Forecasting and Warning System for Dam Operation (FFWSDO)" in 1983. Again in 1992 it was extended to include the Magat,

Binga and Ambuklao dams under the project /activity of "FFWSDO-II". Further in 2002, San Roque dam was integrated in FFWSDO–II after its construction.

The PRBFFWC has relocated to the heart of the City of San Fernando, Province of Pampanga after a grant-aid rehabilitation and strengthening program implemented by the Japan International Cooperation Agency (JICA) in March 2009. As of the year 2023, PRBFFWC has already been in FFW operations for 5 decades.

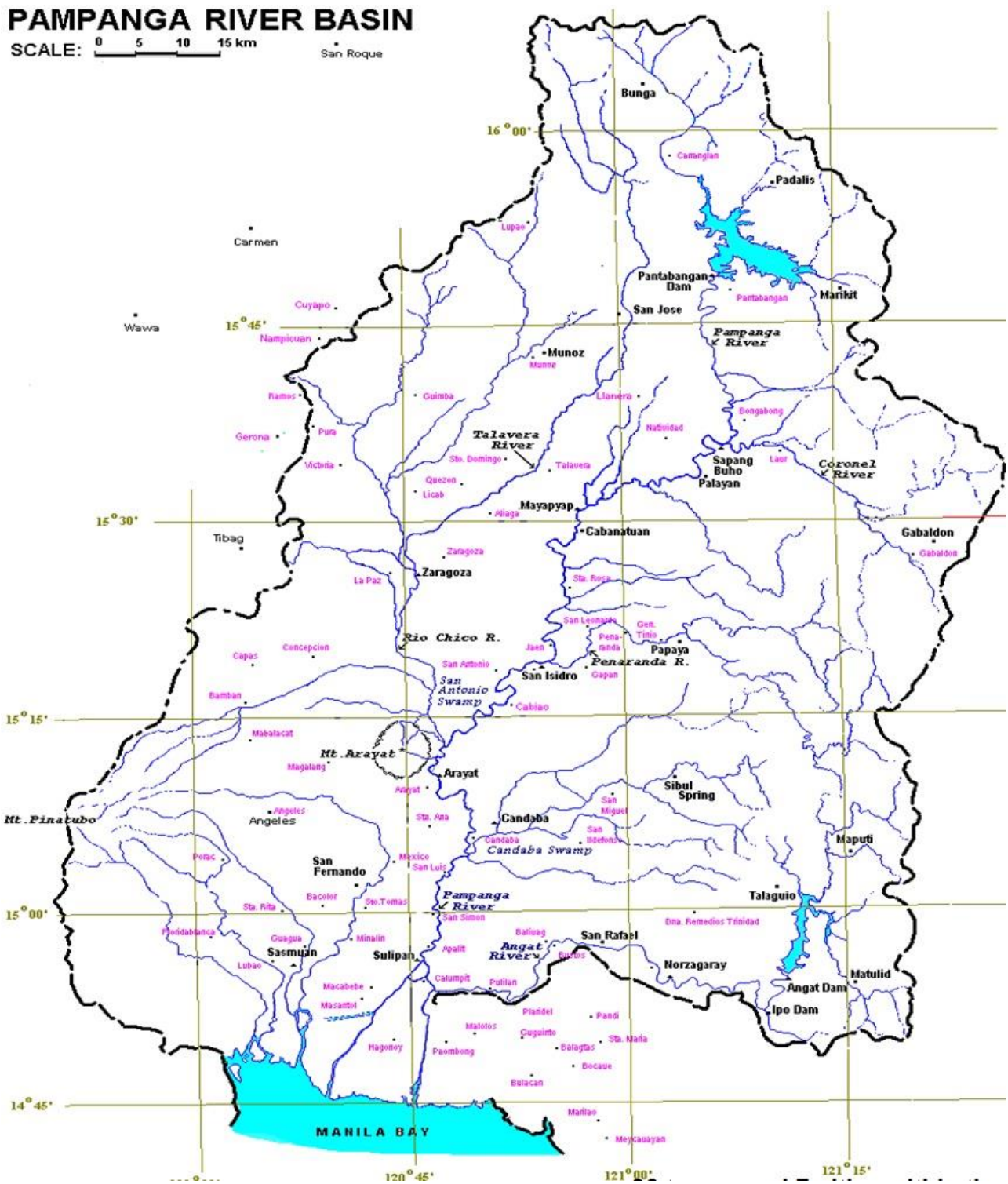
2.2 The Pampanga River Basin and its Flood Forecasting and Warning System

(A) The Pampanga River Basin (PRB)

(many points taken from the Final Draft Report on Study of IWRM for Poverty Alleviation & Economic Development in Pampanga River Basin, Dec. 2010, NWRB-JICA)

- The 4th largest basin in the Philippines (after Cagayan, Mindanao, and Agusan River Basins in that order)
- Basin area of 10,434 km^2
- Broadly divided into three sub-basins, namely: (a) Pampanga main river basin with its catchment area of 7,978 km^2, (b) Pasac river basin (or alternatively known as the Pasac-Guagua allied river basin) with 1,371 km^2 and the (c) Angat River basin with 1,085 km^2.
- Transcends over the administrative areas of eleven (11) provinces covering partly or wholly some 90 municipalities/cities. The substantial part of the basin area of about 95% is, however, within the bounds of four provinces. These are the provinces of Nueva Ecija, Tarlac, Pampanga and Bulacan while the remaining fringe area of about 5% covers the other seven provinces which are Aurora, Zambales, Rizal, Quezon, Pangasinan, Bataan and Nueva Vizcaya.
- Channel length of 265 km. (JICA report); 284 km. (BPW report 1969)
- Headwaters originating from the Caraballo Mountains which is north of the basin flows into the Pantabangan storage dam. After the dam it flows southward meeting with several tributaries until emptying into Manila Bay.
- Major tributaries are Coronel, Peñaranda, and Rio Chico Rivers. Rio Chico has the largest catchment area at 2,895 km^2 (3009 km^2 BPW report 1969) and it joins the main stream of Pampanga nearby **Mt. Arayat (*with an estimated elevation of 1,026 meters*).**
- The Angat River system originates in the Sierra Madre Mountains and flows into Angat storage dam meandering through a narrow valley. From the dam, the river flows westward and finally empties into the Manila Bay through Labangan Floodway. There is a connecting channel with Pampanga River, the Bagbag River, situated in the town of Calumpit in Bulacan.
- The Pasac-Guagua River system includes various channels running on the eastern slope of Mt. Pinatubo, such as the Abacan-San Fernando, Pasig-Potrero and Porac-Gumain Rivers. All these rivers originate in Mt. Pinatubo and flow into Manila Bay. In the lower reaches, the river system is connected with Main Pampanga River by the Bebe-San Esteban Cut-off Channel in Masantol, Pampanga. The morphologies of Pasac River have been much affected by the eruption of **Mt. Pinatubo (*estimated elevation of 1,486 meters*)** in June 15, 1991; river alignments have changed due to mudflow (lahar) movement, and serious sediment deposition in the river channel is still progressively active during flood events.
- The basin has two swamp areas, the Candaba and the San Antonio Swamps with an estimated area of about 250 and 100 km^2, respectively. Candaba Swamp has a maximum inundation area that extends to about 330 km^2 during rainy season.

- Estimated flood prone area in PRB is around 2,200 km^2; 221 km^2 for Pasac-Guagua River sub-basin.
- Two major hydraulic structures within the basin are Pantabangan and Angat Dams. Pantabangan is located upstream of the upper main Pampanga River and operates both as hydropower and as an irrigation dam. Angat is located on the eastern portion of the lower main Pampanga River 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. There are other irrigation dams within the basin such as the Cong Dadong Dam in Arayat, Pampanga; the Peñaranda Irrigation Dam in Peñaranda, Nueva Ecija; Atate Irrigation Dam in Palayan City; etc. but these dams are relatively smaller reservoir that are designed for irrigation purposes only.
- 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.
- The basin experiences, on an average, at least one to two floods in a year. The dry season generally occurs from December to May, and wet the rest of the year. The relatively wettest months are from July to September. The frequency of TC passage over the basin is about 5 TC in every 3 years.



Map of the Pampanga River Basin with towns and some important river names.

Table A: List of provinces and respective municipalities / cities including estimated area (percentage) within the PRB

Province		City/Municipality	Total Area (km^2)	Area Inside Study Area (km^2)	Area out of Study Area (km^2)	Overlapping Ration with Study Area
Bulacan		Angat	59	53	6	89.8%
		Baliuag	44	44	0	100.0%
		Bulacan	69	11	58	16.1%
		Bustos	40	18	23	43.8%
		Calumpit	47	47	0	100.0%
		Dona Remedios Trinidad	879	854	25	97.2%
		Guiguinto	25	2	23	6.6%
		Hagonoy	95	95	0	100.0%
		Malolos City	73	73	0	100.0%
		Norzagaray	247	207	40	83.9%
		Pandi	50	1	49	2.8%
		Paombong	46	46	0	100.0%
		Plaridel	35	20	15	56.5%
		Pulilan	44	44	0	100.0%
		San Ildefonso	167	167	0	100.0%
		San Miguel	236	236	0	100.0%
		San Rafael	105	105	0	100.0%
		Santa Maria	79	1	78	1.0%
		Total	**2,337**	**2,021**	**317**	**86.4%**
Nueva Ecija		Aliaga	92	92	0	100.0%
		Bongabon	229	225	5	97.9%
		Cabanatuan City	198	198	0	100.0%
		Cabiao	113	113	0	100.0%
		Carranglan	739	693	46	93.7%
		Gabaldon	253	252	0	99.9%
		Gapan	165	165	0	100.0%
		Gen Mamerto Natividad	98	98	0	100.0%
		General Tinio	581	580	1	99.9%
		Guimba	219	137	82	62.6%
		Jaen	90	90	0	100.0%
		Laur	221	221	0	100.0%
		Licab	60	60	0	100.0%
		Llanera	114	114	0	100.0%
		Lupao	143	130	13	90.9%
		Palayan City	136	136	0	100.0%
		Pantabangan	421	421	0	100.0%
		Penaranda	79	79	0	100.0%
		Quezon	68	68	0	100.0%
		Rizal	124	124	0	100.0%
		San Antonio	157	157	0	100.0%
		San Isidro	58	58	0	100.0%
		San Jose City	162	162	0	100.0%
		San Leonardo	52	52	0	100.0%
		Santa Rosa	117	117	0	100.0%
		Santo Domingo	83	83	0	100.0%
		Science City Of Munoz	142	142	0	100.0%
		Talavera	135	135	0	100.0%
		Talugtug	73	39	35	52.8%
		Zaragosa	72	72	0	100.0%
		Total	**5,195**	**5,013**	**182**	**96.5%**
Pampanga		Angeles City	63	63	0	100.0%
		Apalit	60	60	0	100.0%
		Arayat	177	177	0	100.0%
		Bacolor	74	74	0	100.0%
		Candaba	208	208	0	100.0%
		City Of San Fernando	69	69	0	100.0%
		Floridablanca	121	83	38	69.0%
		Guagua	49	49	0	100.0%
		Lubao	155	149	6	96.0%
		Mabalacat	146	140	6	96.2%
		Macabebe	102	102	0	100.0%
		Magalang	105	105	0	100.0%
		Masantol	46	46	0	100.0%
		Mexico	122	122	0	100.0%
		Minalin	45	45	0	100.0%
		Porac	293	292	1	99.5%
		San Luis	55	55	0	100.0%
		San Simon	60	60	0	100.0%
		Santa Ana	40	40	0	100.0%
		Santa Rita	23	23	0	100.0%
		Santo Tomas	14	14	0	100.0%
		Sasmuan	45	45	0	99.9%
		Total	**2,073**	**2,022**	**51**	**97.6%**
Tarlac		Bamban	251	147	104	58.5%
		Capas	422	134	288	31.7%
		Concepcion	221	221	0	100.0%
		La Paz	117	117	0	100.0%
		Tarlac City	261	132	129	50.6%
		Victoria	112	83	29	74.4%
		Total	**1,384**	**834**	**550**	**60.3%**
Other Province	Aurora	Dingalan	330	62	268	18.9%
		Maria Aurora	415	9	406	2.1%
		San Luis	568	123	445	21.7%
	Bataan	Hermosa	126	5	121	4.0%
		Orani	47	9	38	19.0%
	Nueva Vizcaya	Alfonso Castaneda	570	144	426	25.2%
		Aritao	275	7	268	2.6%
		Dupax del Sur	380	5	375	1.3%
		Santa Fe	347	7	339	2.1%
	Pangasinan	Umingan	230	26	204	11.3%
	Quezon	General Nakar	1,438	30	1,408	2.1%
	Rizal	Rodriguez	309	42	267	13.6%
	Zambales	Botolan	654	3	652	0.5%
		San Marcelino	393	71	322	18.0%
	Total		**6,083**	**544**	**5,539**	**8.9%**
Grand Total			**17,073**	**10,434**	**6,639**	**61.1%**

Source: JICA Study Team

(B) The PRBFFWC

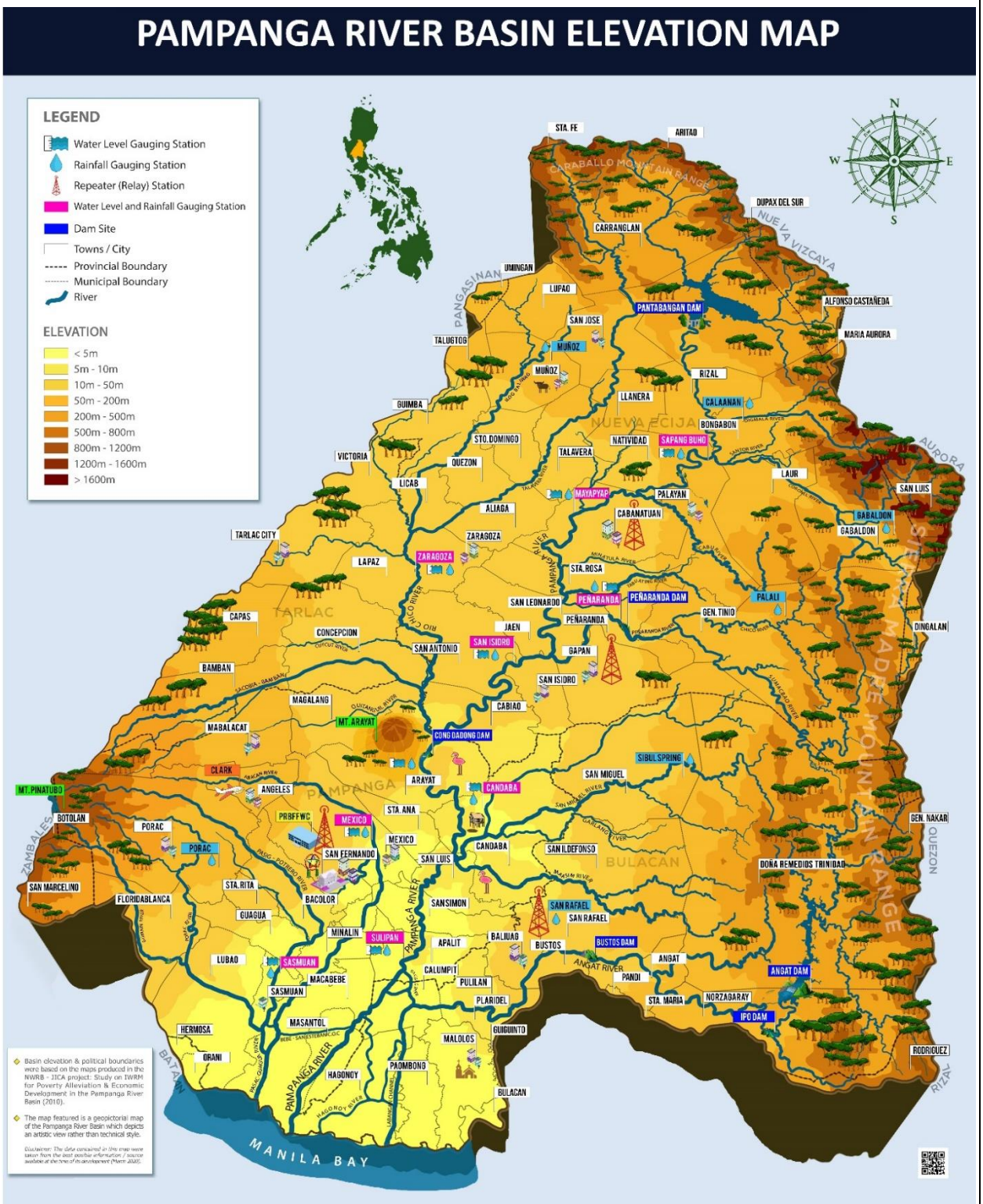
The PRBFFWC (or PRFFWC) is one of the FFWS center of PAGASA under the Department of Science & Technology (DOST). Its main tasked is to continuously monitor the hydrological situation, forecast and provide flood warnings to the flood-prone areas within the PRB including its allied river system, the Pasac-Guagua sub-basin, of flooding events that are related to the overflowing of the monitored rivers / trobutaries in the said basin. The center is presently located within the in the DMGC (Diosdado Macapagal Government Center) adjacent to the DOST-3 compound in Bgy. Maimpis, City of San Fernando, Pampanga (CSFP). The center maintain and operates several rainfall and river gauging stations that are strategically located within the said basin area.

Personnel list & inclusive years of service with the PRBFFWC

Name	Service dates (estimated)
Zacarias Macaraeg	1973 – 1980s (?)
Nestor L. Canuel (+)	1973 – mid 1980s
Lydia B. Lim (+)	mid 1970's - late 1980
Heraclio M. Borja	mid 1970's - early 1990's (retired on 2014 (?))
Alan L. Pineda	early 1980's to late 1980's
Judith Bugauisan	late 1970's – early 1980's
Leticia P. Padilla	1980 - early 1990's
Elviza R. Gonzales	1980 to late 1980's
Solomon L. Santillan (+)	Late 1970's to mid-1980's
Rufino R. Pamis (+)	1982 to mid-1990's
Anacleta C. Agustin	1980 to 2005 (retired on 2022)
Adelina C. Parcia	1980's – 1990s (?)
Hilton T. Hernando	1982 to 2024 (retired on 2024)
Teodora P. Santos (+)	1992 to 2005
Antonio A. Lobo (+)	Late 1980's to late 1990's (?)
Danilo D. Flores	Early 1990's to 2000 (retired on 2021)
Arnel Garcia (+)	2000 - 2003
Robert B. Zervoulakos (+)	Early 2000 (?)
Armando P. Taruc	2005 - 2010 (retired on 2010)
Jaime Enriquez	2005 - 2006
Edgardo dela Cruz	2005 - 2006
Larry Esperanza	2005 - 2006
Lani Mercado	2007 – Mar 2009 (retired on 2022)
Lane Fabregas	2006 – Mar 2009 (retired on 2021)
Feliciano Madrazo	2007 – Mar 2009 (retired on 2021)
Romeo F. Dayao	Mar 2009 - present
John R. Dabu	Mar 2009 - present
Rommel P. Yutuc	May 2011 - present
Nestor B. Nimes	Oct. 2011 - present
Pedro T. Hagad	Feb 2014 – 2023 (retired on Apr. 2023)
Larry Andrew Urriza	Sept 2019 – 2023 (transferred to Subic, 2023)
Jermie Lugtu	Sept 2019 – present
Gerald Hernandez	Oct. 2017 – present (JO) / 2022 (permanent)
Manuel Joson	Jul 2018 – 2020 (JO) / 2023 Abucay (transferred as permanent)

(C) The PRFFW System

The PRBFFW system (as of 2009) has 17 rainfall (RR) and 10 water level (WL) stations within its monitoring network and is complemented with several RR observations in Bulacan and Pampanga. There are 2 synoptic and 1 agrometeorological stations within the basin. These stations are not, however, transmitting data on a real-time basis to the center. The PRBFFW operations center which is located in the DOST Region 3 compound in the city of San Fernando, Province of Pampanga has a digital rain gage that is manually recorded.



A generalized "Geopictorial" elevation map of the Pampanga River Basin showing the locations of telemetry stations, dams, towns, rivers and tributaries and many other features.

Station Profile

Table of Rainfall and Water Level Stations (PAGASA) within the Pampanga River Basin

Station	Telemetry Station Number		Station Type	Location	Coordinates (estimated)
	(DEC) 6301 XX	(HEX)			
Muñoz	61	3D	Telemetered RR	Within the compound of the Philippine Carabao Center in the Science City of Muñoz, N.E.	15°44'17"N, 120°57'38"E
Sapang Buho	62	3E	Telemetered RR & WL	@ LB of Pampanga River in Bgy. Sapang Buho, Palayan City, Nueva Ecija	15°35'39"N, 121°07'09"E
Gabaldon	63	3F	Telemetered RR	Around 450 meters above the natural ground elevation of Bgy. Malinao, Gabaldon, N.E.	15°29'55"N, 121°21'20"E
Zaragoza	64	40	Telemetered RR & WL	Along the Zaragoza – La Paz road (RB-D/S of the Rio Chico Bridge)	15°26'36"N, 120°45'03"E
Mayapyap	65	41	Telemetered RR & WL (defunct as of 2015)	@ RB-D/S of Gen. Luna Bridge, (Bgys. Mayapyap & Valdefuente) Cabanatuan City, Nueva Ecija	15°30'52"N, 120°57'20"E
Mayapyap (NIA-UPRIIS)			Telemetered RR (transferred Oct. 2019)	On top of the NIA-UPRIIS Operations Center Bldg., NIA-UPRIIS Compd., Cabanatuan City	15°28'33"N, 120°57'30"E
Peñaranda	66	42	Telemetered RR & WL	@ LB-D/S side of the bridge, around 550 meters D/S of Peñaranda River Irrigation Dam at Bgy. Uno, Poblacion, Peñaranda, N.E.	15°21'14"N, 121°00'20"E
Calaanan	67	43	Telemetered RR	Inside the Pesa Elementary School compound, Purok 2, Bgy. Pesa, Bongabon, N.E.	15°38'53"N, 121°11'09"E
Palali	68	44	Telemetered RR	Within Nueva Ecija Provincial Stock Farm in Bgy. Nazareth, Gen. Tinio, N.E.	15°22'50"N, 121°9'41"E
San Isidro	71	47	Telemetered RR & WL	@ the RB-D/S side of the San Isidro-Jaen Bridge, San Isidro, N.E.	15°18'49"N, 120°54'09"E
Arayat	72	48	Telemetered RR & WL	@ RB-D/S side of San Agustin Bridge, Arayat, Pampanga	15°10'06"N, 120°46'56"E
Candaba	73	49	Telemetered RR & WL	Along Candaba-San Miguel road (Dukma) at Bgy. Paralaya, Candaba, Pampanga	15°06'56"N, 120°51'01"E
Sibul Spring	74	4A	Telemetered RR	Bgy. Sibul, San Miguel, Bulacan	15°10'05"N, 121°03'33"E
Sasmuan	75	4B	Telemetered RR & WL	Bgy. Sta. Lucia (Poblacion), Sasmuan, Pampanga	14°56'11"N, 120°37'23"E
Sulipan	76	4C	Telemetered RR & WL	@ RB of Pampanga River at Bgy. Sulipan, Apalit, Pampanga	14°56'21"N, 120°45'39"E
Mexico	77	4D	Telemetered RR & WL	LB-D/S of Mexico Bridge No. 2, Bgy. Sto. Rosario, Mexico, Pampanga	15°04'05"N, 120°43'51"E
Porac	78	4E	Telemetered RR	Within the municipal compound property, Bgy. Cangatba, Porac, Pampanga	15°04'48"N, 120°32'43"E

San Rafael	90	59	Telemetered RR (Repeater)	NIA compound, Bgy. Sabang, Baliwag, Bulacan	14°58'05"N, 120°54'52"E
Cabanatuan	89	59	Repeater	Within the NIA-UPRIIS Compound, Cabanatuan City	15°28'33"N, 120°57'30"E
San Fernando (PRFFWC)			Digital tipping-bucket / manually recorded	PRBFFWC area compound adjacent to DOST-3 bldg., DMGC, Bgy. Maimpis, CSFP	15°04'04"N, 120°39'22"E
Clark *			Synoptic station	DMIA, Clark, Angeles, Pampanga	15°10'N, 120°34'E
Cabanatuan *			Synoptic station (defunct as of Dec. 2018)	Cabanatuan City Hall Compound, Cabanatuan, N.E. (transferred to CLSU, Muñoz)	15°44'N, 120°56'E
CLSU, Muñoz *			Synop (as of Jan 2019) / Agrometeorological station	CLSU, Muñoz, Nueva Ecija	15°43'N, 120°54'E

*Note: * these stations are within the basin but not directly linked to the PRBFFWC system.*

PART 3. PRFFWC Telemetry and Telecommunication System

3.1 Scope

This section is limited to some important details pertaining to the telemetry and telecommunications aspects of the center, mainly some of those that are only relevant to the flood hydrologist / forecaster and the hydrological technicians or "hydro techs". Further information relating to more technical aspects of telemetry and telecommunications of the center can be directly referred to the several volumes of "Manuals for Technical Transfer" prepared by JICA specifically for the project "Improvement of Flood Forecasting and Warning System in the Pampanga and Agno River Basins (January 2009).

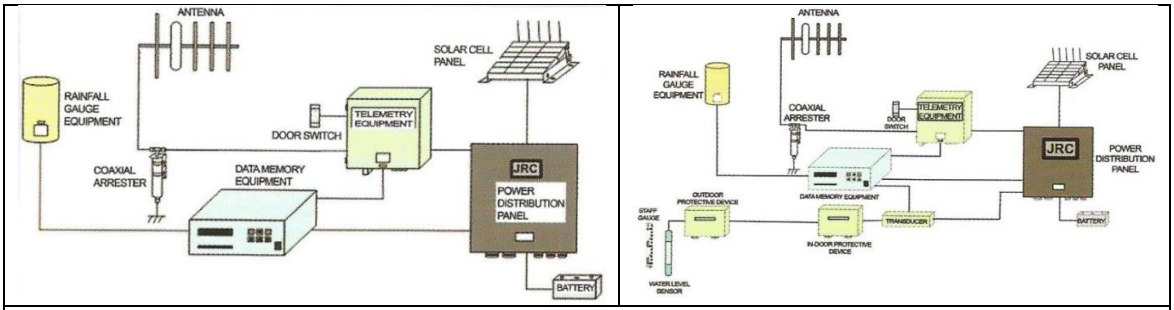
3.2 Brief on the PRBFFWC telemetry and telecommunication system

(A) Telemetry is the "highly automated communications process by which measurements are made and other data collected at remote or inaccessible points and transmitted to receiving equipment for monitoring" *(Wikipedia)*. It commonly refers to wireless data mechanism such as using radio, ultrasonic, or infrared systems, and encompasses data transferred over other media such as a telephone or computer network, etc. Lately many modern telemetry systems take advantage of the low cost and ubiquity of GSM networks by using SMS to receive and transmit telemetry data; although limitations such as delay of transmission and reception, and most of the time downed system during inclement weather conditions have prompted systems to shift back to radio frequency especially for crucial applications such as weather and flood monitoring systems.

The principal advantage of a telemetry system to other communication systems is the rapidity of data collection. The stations can operate unmanned and it is possible to collect data from any or all of the stations at any time desired by the control station. Further, the system operates on a microwave (line of sight) link which is more flexible and durable than the SMS (Short Messaging System) in terms of a continuous data transmission.

The telemetry observation system consists of a network of unmanned gauging stations, supervisory and monitoring offices. Gauging stations are either equipped with a tipping bucket rain gauge to measure rainfall and a pressure-type water level gauge to measure river water level. The telemetry system transmits observed rainfall and water level data to the monitoring station via a 150 MHz

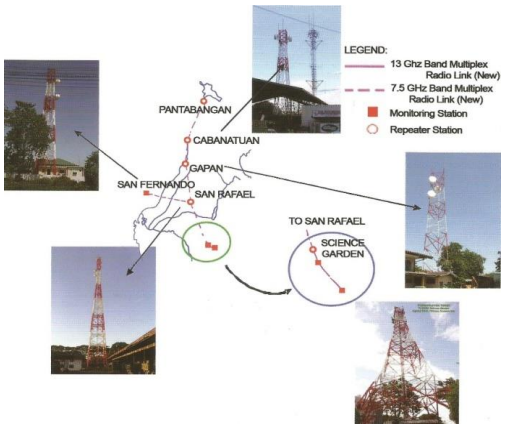
band radio and ensure that data are stored in the data memory equipment (data logger) in case of network failure. Each gauging station is equipped with solar cells to power the gauging station and ensure continuous operation of the system.



Schematic diagram of a telemetered RR gauging station (top left) and telemetered RR-WL gauging station (top right).

(B) Telecommunications - Multiplex Radio System: Multiplexing *(or muxing)* is a way of sending multiple signals or streams of information over a communications link at the same time in the form of a single, complex signal; the receiver recovers the separate signals, a process called demultiplexing *(or demuxing)*. Networks use multiplexing for two reasons: to make it possible for any network device to talk to other network device without having to dedicate a connection. This requires shared media; to make a scarce or expensive resource stretch further – e.g., to send many signals down each cable or fiber strand running between major metropolitan areas, or across one satellite uplink.

The previous backbone multiplex radio network of the FFWS at 800 MHz and 2 GHz frequencies have been upgraded to 7.5 GHz in order to avoid interference from mobile phones and other telecommunication networks. The scope of the project included the construction of additional repeater stations to ensure enough capacity for the transmission of large amount of data.

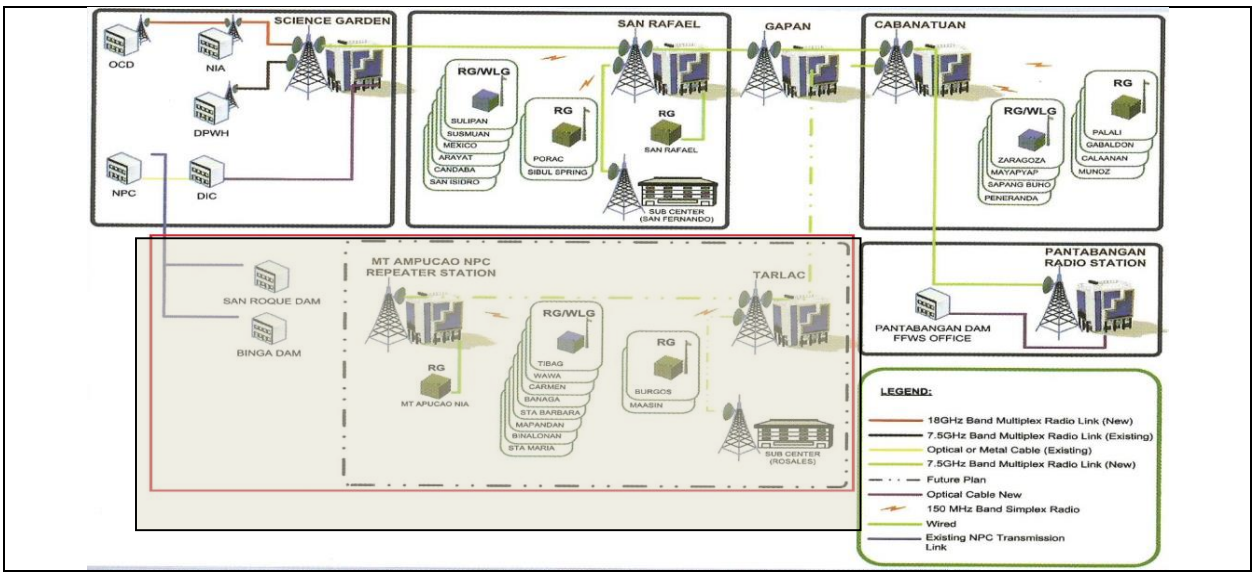


The multiplex radio network uses an IP network protocol. The repeater stations are equipped with telephone set as a communication channel for maintenance work, radio transmission of IP digital data, an engine generator, lightning-proof transformer, and DC 48V power supply. The 3 repeaters constructed are located in NIA-UPRIIS, Cabanatuan City, San Rafael in Bulacan, and in the PRBFFWC in CSFP; retrofitted the repeater / relay stations in Pantabangan Dam, Gapan and PAGASA Science Garden.

(C) Network Configuration: Overall network of the system

Observations from 8 basin upstream stations, namely Sapang Buho, Mayapyap, Zaragoza, Peñaranda, Palali, Gabaldon, Calaanan and Muñoz are pooled and relayed to San Rafael Repeater via the Cabanatuan and Gapan Relay stations. Mid-basin and Downstream stations, namely San Isidro, Arayat, Candaba, Sibul Spring, San Rafael, Porac, Sasmuan and Mexico are transmitted directly to San Rafael Repeater station.

All data are pooled at San Rafael Repeater serving as a hub for both Pampanga and Agno River FFWSs and transmitted to Science Garden, Quezon City including the Sub-Centers in San Fernando (PRBFFWC), Carmen, Rosales (Agno RFFWC), and Pantabangan FFWS Dam Office, simultaneously. From Science Garden the data proceeds to the Weather and Flood Forecasting Center (WFFC formerly known as Data Information Center or DIC) and to the OCD, NIA and DPWH. From WFFC, all data are transmitted to NPC FFWS Center and eventually transmitted to San Roque and Binga FFWS Dam Offices as shown schematically below.



PART 4. PRB Flood Forecasting and Warning Operations

4.1 PRBFFWC's main functions and activities

In general, the activities of a PRBFFWC include the following:

1. Monitor the meteorological and real-time hydrological conditions of the PRB (regular operations) for the issuance of the daily 5:00 am basin hydrological forecast which is uploaded in the center's website, other social platforms such Facebook, Twitter (x), Viber, and shared via email to specific stakeholders;
2. Updating of the center website which includes uploading of past 24-hour rainfall totals and the instantaneous water level readings at all stations within the basin for the time ending at 4:00 am and 4:00 pm which are updated and uploaded every 5:00 am & 5:00 pm daily;
3. Shifts into a FW status operation for flood forecasting and warning activities during imminent flood event periods; issues flood information / warnings (FAs or FBs) as need arises (refer to reference manual PRFFWC- 02);
4. Actual near real-time flood level validation / verification (on site field survey) during flooding situation whenever able and possible;
5. Undertake primary data (RR and WL) processing of PRB system (rainfall / water level quality-control, checking and updating);
6. Relay, as a redundant information channel, the dam info (Angat and Pantabangan Dams only) such as dam reservoir releases, advisories and warnings, weather forecasts (as requested), weather bulletins (as requested), and other flood-related information within basin of concern including the FAs and FBs;
7. Apply flood forecasting tools (simple hydrological modelling, statistical analyses, etc.);

8. River related surveys and measurements (stream gaging, river cross-sectioning, flood assessment levels, survey of flood marks, post-flood investigations and surveys including mapping of flood extent, determination of time of start of flooding, etc.);
9. Installation of hydrological-related measuring instrument such as rain gauges, staff gauges and flood markers, etc.;
10. Conducts regular quarterly maintenance which includes checking of telecommunication facilities, physical station repairs, downloading of data loggers, and the like; emergency maintenance whenever necessary; supports the HMTS group in critical maintenance of PRB telemetry system;
11. Public information and education campaigns (IEC) including participation in local, provincial, regional and national undertakings pertaining to hydrological-related activities mainly in river basin flood related matters and DRRM issues;
12. Maintain its own river basin hydrological database which includes various analyses of its datasets;
13. Coordinates with the HMD (Hydro-Met Division), and other divisions of PAGASA in programs, activities, etc.; constant coordination before, during and after flood events affecting the basin;
14. Collaborate / cooperate with local (municipal, provincial, regional, and national) and even international institutions (including schools) involved in flood disaster mitigation and other related activities

Center activities are divided into non-flood watch status (mainly activities 1, 2, 5, 7, 8, 9, 10, 11, 12, 13 & 14 as listed above) and flood watch status (activities 3 & 4 as listed above) status; activities such as 1, 2, 5, & 10 are carried-out for both NFW and FW status particularly emergency maintenance. Simply stated, non-flood watch activities are those that are undertaken when the basin of concern is not in any imminent danger of flooding.

4.2 Related FFWSDO (Dam Operations) Activities

The PRBFFWC serves as a redundant information disseminator for the FFWSDO operations. The center relays the information received from the FFWS of HMD and / or from dam offices (Angat and Pantabangan) particularly information relating to dam releases and forward the said info down to other government agencies / LGUs / entities / etc. Below is the flow of information for both FFWSDO for Angat and Pantabangan dams, respectively. At the moment, the schematic diagrams for both FFWSDO info dissemination may have significantly changed such that present scheme should be checked with the dams or from the FFWS of HMD.

View of Angat Dam spillway

View of the Pantabangan Dam spillway

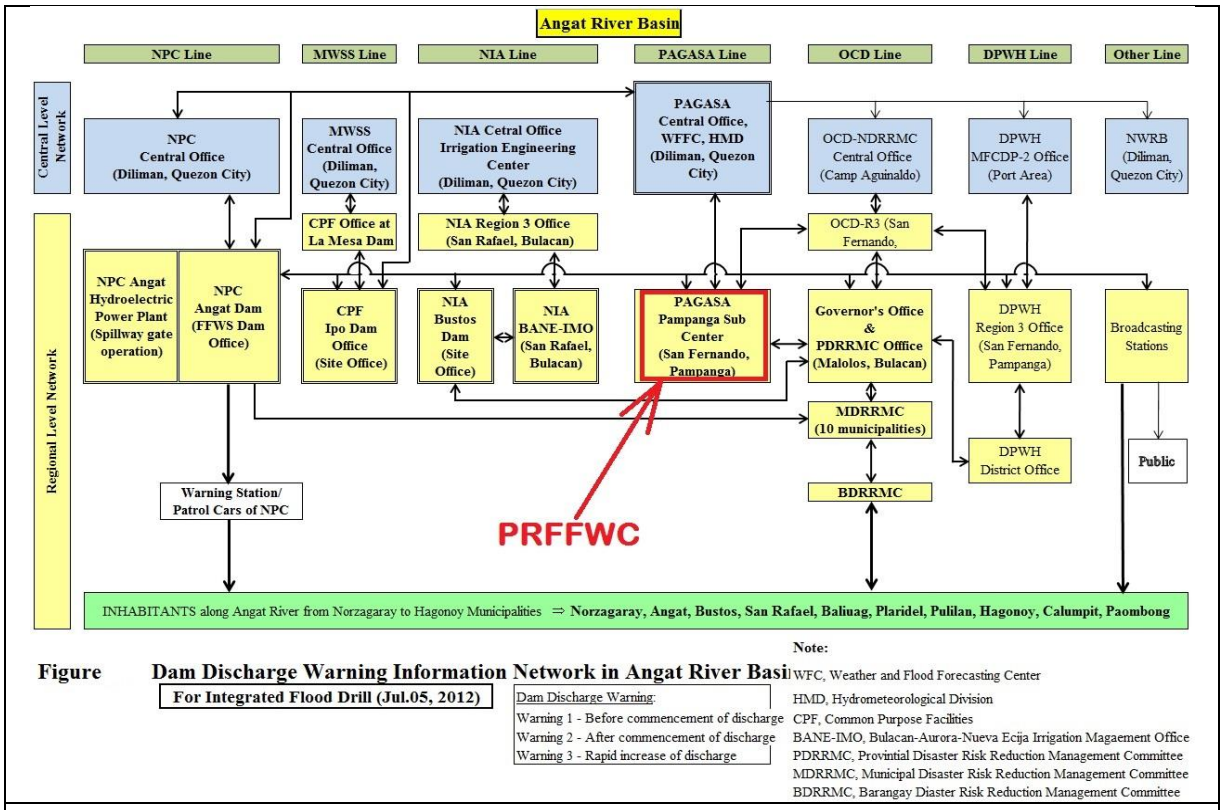


Figure xx Dam releases and other related info dissemination scheme for Angat Dam FFWSDO (original scheme)

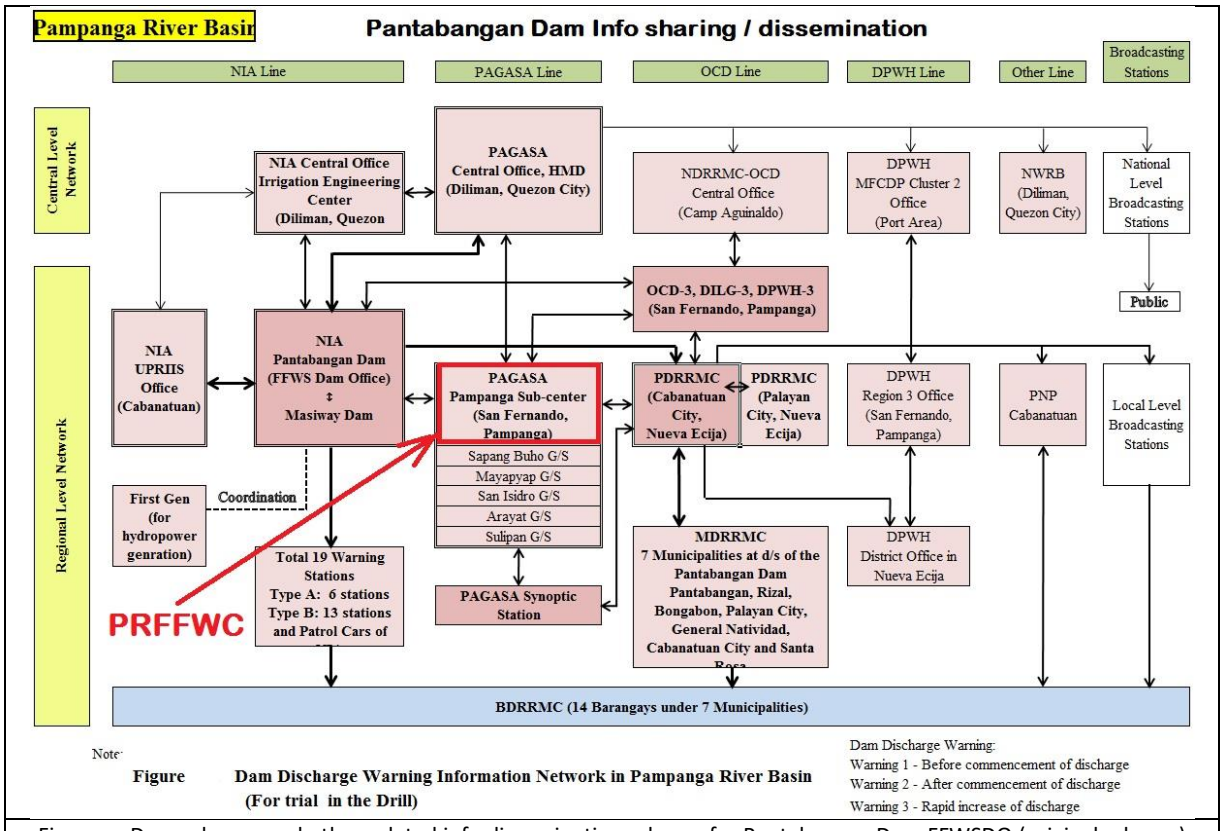


Figure xx Dam releases and other related info dissemination scheme for Pantabangan Dam FFWSDO (original scheme)

4.3 Non-Flood Watch (NFW) status

Non-flood watch status refers to the center's operational condition relating to the PRB situation such that:

1. River stages in most of the forecasting points are below their respective flood assessment levels (alert, alarm and critical levels);
2. There is no significant rainfall amount observed at any of the rainfall stations within the PRB; significant such that widespread rains the past 12 to 24 consecutive hours or more and with rains still expected thereafter (sub-basin wide or basin-wide condition);
3. There are no tropical disturbances (TC, monsoons) adjacent or close to the PRB or affecting / may affect and / or headed towards the basin such as the case of an approaching TC forecasted towards PRB (or Region 3) or will pass close to the PRB; No TCWS raised in any of the major provinces covered within the PRB - Nueva Ecija, Tarlac, Pampanga and Bulacan;
4. Any or both of the major dams within the basin, Angat and Pantabangan, are not in the immediate status of releasing reservoir water;
5. Present or ongoing PRB hydrological conditions will not produce any river (riverine) floods or overflowing of the river channel of the main Pampanga River and / or its major tributaries.

Non-flood watch status is oftentimes referred to as "peace time" status for an FFW center. Hence, during such condition, only the updating of hydrological forecast and uploading of past 24-hour rainfall ending at 4:00 am (and pm) and instantaneous water level reading observed at the same hour (4:00 am) of all the stations in the basin are updated & uploaded in the center's website on or before 5:00 am / pm daily. Encoding of hourly telemetry data, rainfall and water level at all stations, whenever necessary, into the center's customized database; conduct other regular operational activities other than the issuance of FA / FB or field validation of river stages and flood levels which are carried-out during FW status.

4.4 Flood Watch (FW) status

Flood Watch status refers basically to the PRB's operational condition that is a direct opposite of the conditions stated during the non-flood watch status as stated above. FW is a state condition of the PRBFFWC when imminent or impending flood episode will occur within the PRB. The flood information issued during such status is for community awareness, preparedness, response and positive actions to possibly mitigate the effects of the flood in the basin.

(Please see reference manual PRFFWC-02, for more specific information with regards to FW activities)

4.5 Flood Warning Information: Flood Advisory (FA) and Flood Bulletin (FB) during Flood Watch status

Flood Advisory (FA) is the hydrological information in general or in its simplest form. It is initialized anytime during flood watch period for "**awareness or preparedness purposes"** of the local disaster risk reduction and management offices / authorities of flood prone areas within telemetered basins, when rivers and streams are likely to be affected by a relatively large streamflow, flood or flash flood. FA is normally issued whenever there is an approaching tropical disturbance which is likely to affect the basin but still relative far (about 24 to 48-hours lead time) and there may still be a chance that it may not affect the basin as well; or whenever rivers within the basin are likely to rise significantly or mountainside and mountain slope areas are in danger of possible landslides because of the said disturbance. Issuance of such information is subject to model forecasts or basin forecaster's intuitions, and discussions / "brainstorming" with other forecasters of the basin.

Flood Bulletins (FB) are more specific flood information issued whether or not it is being preceded by a basin flood advisory (depending on the situation) during flood watch monitoring. It can be initialized anytime and issued on a regular specified time by FFWCs thereafter until being finalized when floodwaters have generally subsided or no significant increases in the present situation is expected further. FB is more near specific as to river level, its changes in terms of its rising and falling trends including the possible areas (towns/cities) to be affected and is time bounded; specifics as to when (forecasts) assessment levels and the peak will be attained in general or in detail.

(Please see reference manual PRFFWC-02, for more specific information with regards to this section.)

PART 5. Other Activities (NFW)

5.1 Other regular operational activities during Non-Flood watch status:

- Updating of Dam status (for Angat, Pantabangan, and Ipo dams) in the whiteboard
- Updating on the center's information board the General Weather Forecast (synopsis) for the country and specific weather forecast for Central Luzon (Check for Clark / Subic stations' forecast) which includes time of sunrise / sunset (normally based on Manila), Temperature range (based on Subic / Clark), high tide occurrence based on Navotas port; also posting of astronomical diary for the month of concern;
- Daily encoding of RR-WL data in the center's excel suite whenever possible;
- Continuous quality-control of RR-WL telemetry data (in relation to the previous item);
- Posting of important and pertinent information (Central Office's press releases, climate outlook updates, etc.) in the center's information (white) board whenever necessary.
- The whiteboard will serve as all-around information board of the center and should be checked regularly by all center personnel.

PART 6.

PAMPANGA RIVER BASIN FLOOD FORECASTING & WARNING CENTER SYSTEM

A. STATION INFORMATION (Rainfall and Water level Telemetry stations)

1. Muñoz RR telemetry station

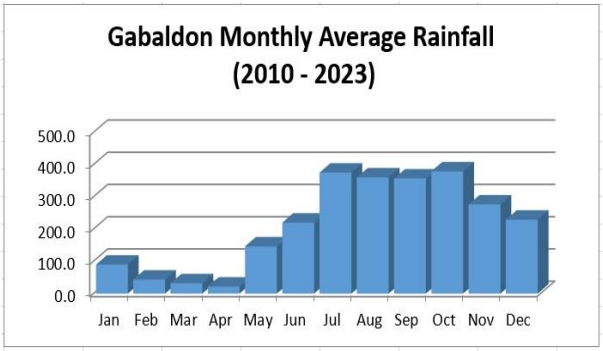
Latitude: 15°44'17" N
Longitude: 120°57'38" E
(Start of operation: around June 1986)
Description: Station is located inside the compound of the Philippine Carabao Center along the Pan-Philippine Highway within the CLSU (Central Luzon State University) area, Science City of Muñoz, Nueva Ecija.
Present Condition: Station is operational with numerous data gaps / breaks.

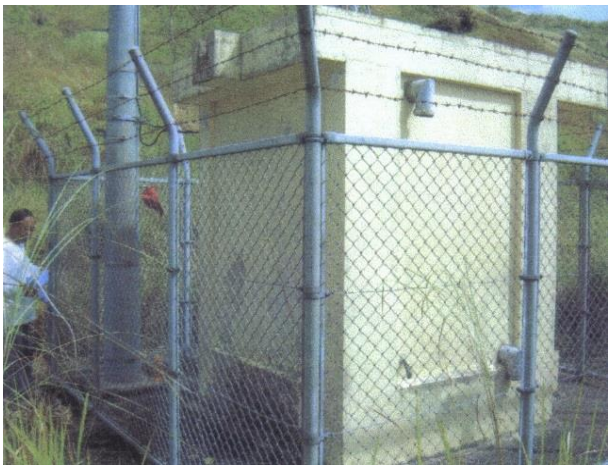
Topmost figure above shows the monthly average rainfall (2010 to 2023) for Muñoz RR Telemetry station.

All pictures show the telemetry station at various angles and its surrounding area which is within the Philippine Carabao Center.

2. Gabaldon RR telemetry station

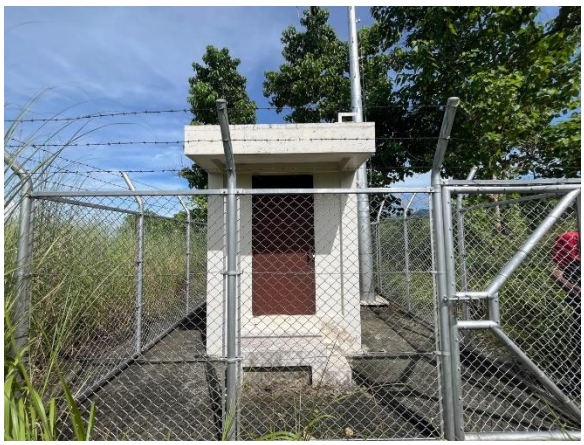
Latitude: 15°29'55"N,
Longitude: 121°21'20"E
(Start of operation: July 04, 1986)
Description: Station is located between 450 to about 500 meters (estimated) from natural ground elevation of Bgy. Malinao, in the Municipality of Gabaldon, Nueva Ecija. The station can be accessed by foot, generally around 2 to 2.5 hours going up during sunny days and less than an hour going down.
Present Condition: Operational with numerous data breaks / gaps.





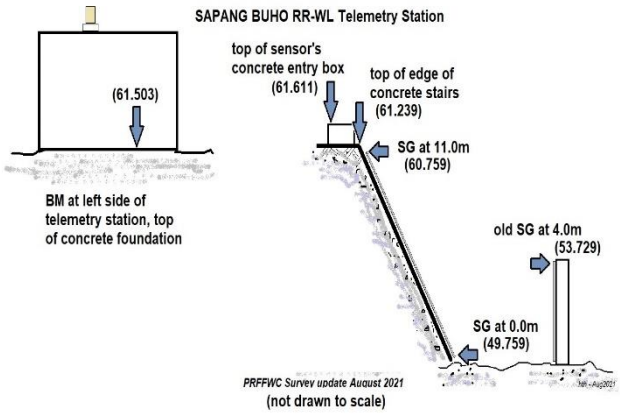
Topmost figure above is the monthly average rainfall (2010 to 2023) for Gabaldon Telemetry station,

All pictures: View of the Gabaldon station at different angles.

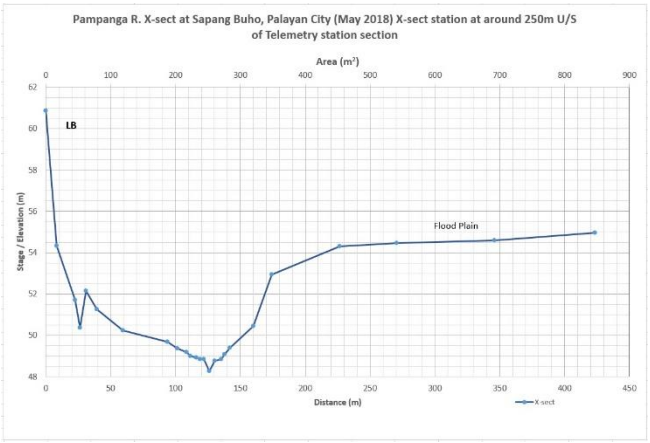


3. Sapang Buho RR-WL telemetry station

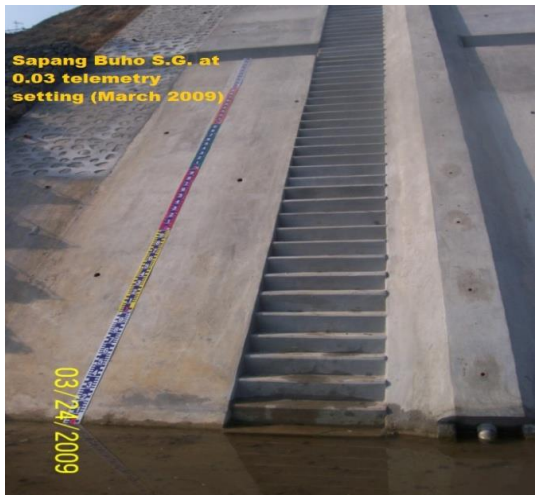
Latitude: 15°35'39" N
Longitude: 121°07'09" E
(start of operation: RR – August 23, 1973 @ 1200H; WL – August 24, 1973)
Description: Station is located at the RB of Pampanga River in Bgy. Sapang Buho, Palayan City, Nueva Ecija; around 1.2 kms. D/S of the confluence of Pampanga R. and Coronel R.
Present Condition: Operational with many data breaks / gaps.
Remarks: S.G. is up to 11.0 m

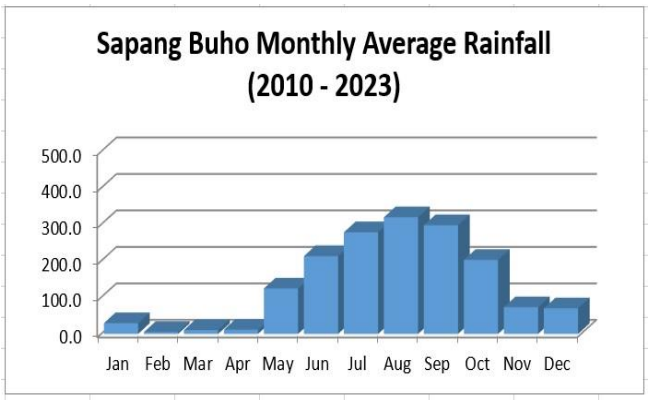


Schematic view of the profile of the Sapang Buho station with corresponding equivalent MSL elevations.



The estimated Pampanga River x-section at about 250m u/s of the Sapang Buho telemetry station (2018 survey)

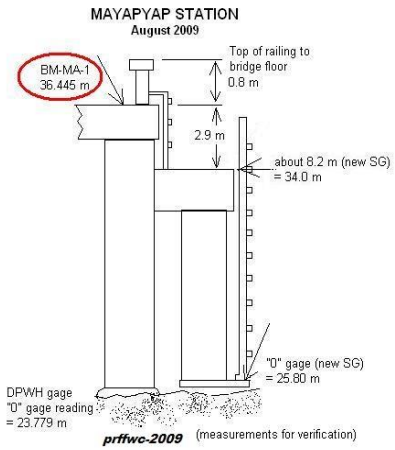




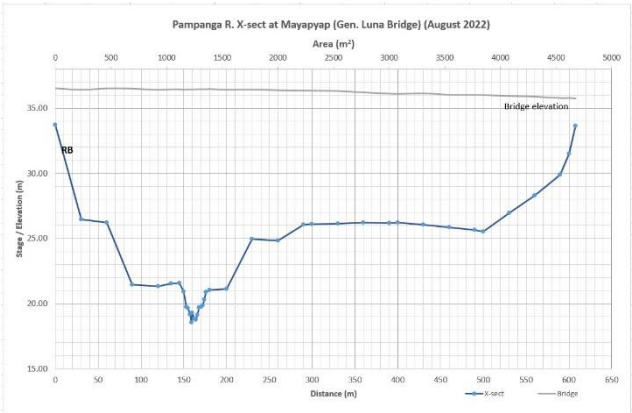
Uppermost picture: A view of the Sapang Buho station; top 2nd row R picture: A view of the river section (Pampanga River) as seen from the telemetry station which is actually the LB of the river; Top picture: The S.G. installed after rehabilitation in 2009; Bar graph on the left shows the monthly average rainfall based on an available data from 2010 to 2023 for the station.

4. Mayapyap RR-WL telemetry station

Latitude: 15°30'52" N,
Longitude: 120°57'20" E
(start of operation: October 1991)
Description: Station is situated at the D/S, RB side of Gen. Luna Bridge, which is between the Barangays of Mayapyap & Valdefuente, Cabanatuan City, Nueva Ecija
Present Condition: WL monitoring has been out-of-order since year 2015. No WL data since that time.
Remarks: Original S.G. is up to 10.0m; Station was vandalized / ransacked on October 27, 2006;
Rainfall station was relocated to the NIA-UPRIIS Compound in Cabanatuan City on October 2019 (see next station description no. 4.1, next page)



Schematic view of station profile with corresponding equivalent MSL elevations. (surveyed 2009)

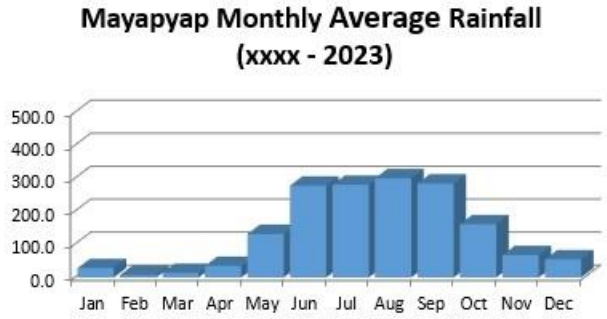


The estimated Pampanga River x-section at the stream gaging station of Mayapyap.

Uppermost picture: A view of the Mayapyap station as seen from the Gen. Luna Bridge; Top 2nd row R picture: A view of the S.G. location and the old sensing poles at one of the Bridge's piers; Above picture: D/S view of the Pampanga River as seen from Gen. Luna Bridge; Picture on the left shows a view of the Gen. Luna Bridge as seen several meters from its D/S side.

4.1 Mayapyap RR Telemetry station (relocated)

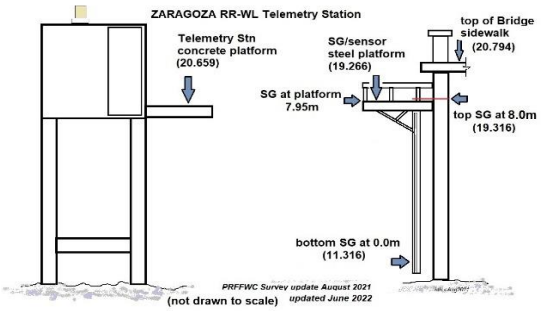
Latitude: 15°28'33" N
Longitude: 120°57'30" E
(start of operation: October 2019)
Description: Presently at the top of the Operations Building of NIA-UPRIIS situated at the back of the Agency's compound in Cabanatuan City, NE.
Present Condition: Operational since October 2019 with lots of data breaks and gaps.
Remarks: Rainfall station was relocated to the NIA-UPRIIS Compound in Cabanatuan City on October 2019. retransferred to its present location in 2022 but still within the NIA-UPRIIS compound



Bar graph figure above 2nd row depicts the estimated average monthly rainfall for the said station; Pictures on the right (topmost and above) shows the present lcoation of the telemetry RR gauge station for Mayapyap; Picture on the left shows the previous location of the RR telemetry station (2019 to 2022)

5. Zaragoza RR-WL telemetry station

Latitude: 15°26'36" N
Longitude: 120°45'03" E
(start of operation: RR – Sept. 04, 1973 @ 1300H; WL – Sept. 04, 1973 @ 2000H)
Description: Telemetry station is located at the D/S, RB side of the Rio Chico Bridge in Bgy. San Roque, La Paz, Tarlac.
Present Condition: Station is operational with numerous data breaks and gaps
Remarks: S.G. is up to 8.0 meters



Note: S.G. equivalent MSL updated as per survey based on NAMRIA BM (BM TA262 2008) indicates that the road surface adjacent to the S.G. & sensor platform is at 20.785 m; sensor platform is at 19.258 m; S.G. of 8.0m is estimated at 19.30m (more than a meter difference from the August 2009 survey)
** The elevation of the *BM TA262 2008* is 19.7554 m.

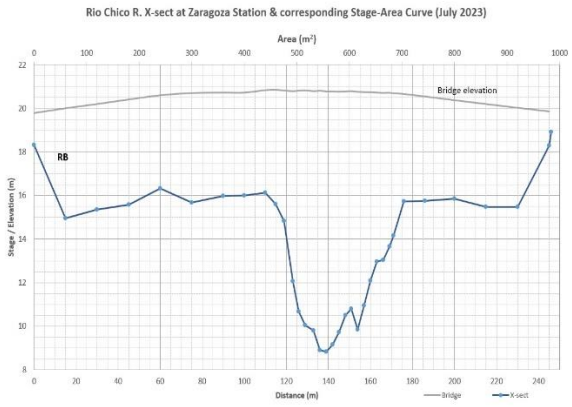
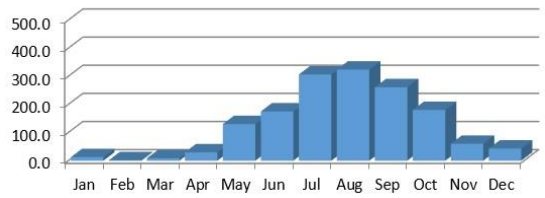


Figure above is the estimated river x-sect of the Rio Chico R. at D/S of Rio Chico Bridge.

Zaragoza Monthly Average Rainfall (2010 - 2023)

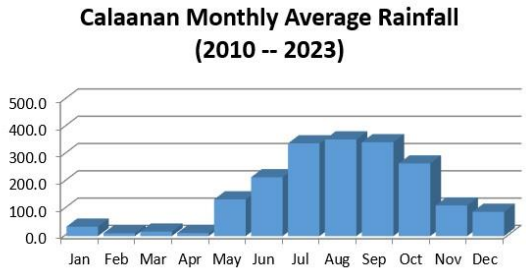


Uppermost picture: The Zaragoza Station on the D/S of the Rio Chico Bridge; Top 2nd row right picture: A view of the S.G. and sensor location for the said station; Above picture: D/S view of Rio Chico River taken from the Rio Chico Bridge; Left bar graph shows the average monthly rainfall based on available data from 2010 to 2023 for the station.

6. Calaanan RR telemetry station

Latitude: 15°38'53" N
Longitude: 121°11'09" E
(start of operation: April 2009)
Description: Telemetry station is located inside the compound of Pesa Elementary School, Purok 2, Bgy. Pesa, Bongabon, N.E.
Present Condition: Station is operational with numerous data breaks/ gaps
Remarks: Station is actually situated in Bgy. Pesa and not in Bgy. Calaanan as the station name suggests.

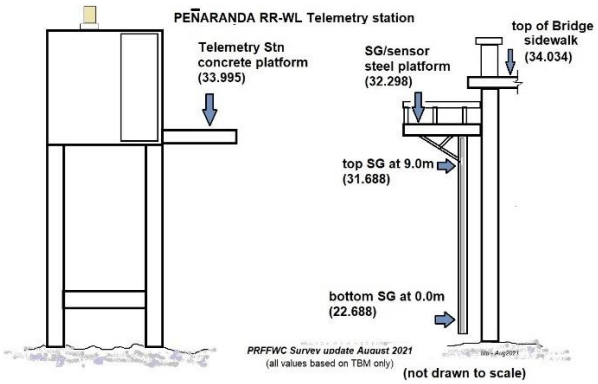
The view of the inside of the station; this was during in one of the quarterly maintenances carried-out by PRBFFWC

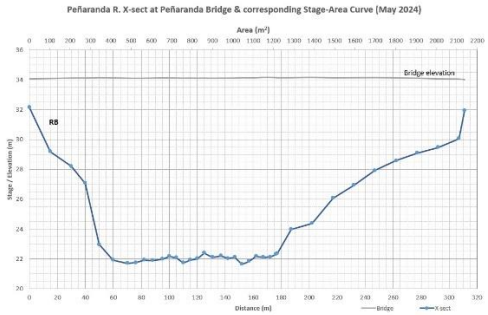


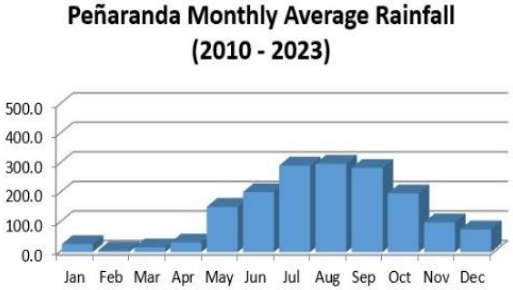
All pictures: Pictures on topmost and above shows various views of the Calaanan telemetry station; Bar graph on the left shows the average monthly rainfall at the station based on the years 2010 to 2023. Below picture is a wider view of the telemetry station's location within the Pesa Elementary School.

7. Peñaranda RR-WL telemetry station

Latitude: 15°21'14" N
Longitude: 121°00'20" E
(start of operation: April 2009)
Description: Telemetry station housing is located @ LB-D/S side of the Peñaranda bridge which is at about 500 meters D/S of the Peñaranda River Irrigation Dam (PENRIS) at Bgy. Uno, Poblacion, Peñaranda, Nueva Ecija.
Present Condition: Station is operational with many data breaks / gaps
Remarks: S.G. is up to 9.0m
Below: Schematic view of station profile with corresponding equivalent MSL elevations.







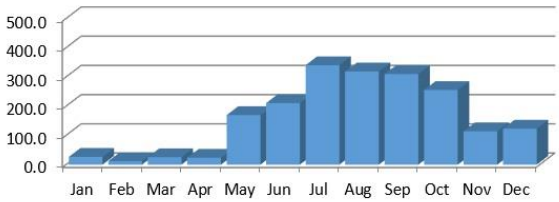
Uppermost picture: The Peñaranda station along the Peñaranda Bridge. Top 2nd row right picture shows the S.G. location of the station; 3rd Row L picture is the D/S section view of the Peñaranda River at the Peñaranda Bridge while the right picture above shows the U/S section view of the river, which is actually the D/S section of the Peñaranda Irrigation Dam;

The left figure shows the estimated Peñaranda River x-section as per survey made on April 2009; Below left figure is the bar graph representing the monthly average RR for the station as per 2010-2023 data.

8. Palali RR telemetry station

Latitude: 15°22'50"N
Longitude: 121°9'41"E
(start of operation: April 2009)
Description: Station is located within the compound of the NESF (Nueva Ecija Provincial Stock Farm) in Bgy. Nazareth, Gen. Tinio, Nueva Ecija.
Present Condition: Station is operational; dataset is relatively okay

Palali Monthly Average Rainfall (2010 - 2023)



All pictures show various views of the Palali RR telemetry station; The graph on the left is the average monthly rainfall for the station based on the years 2010 to 2023.

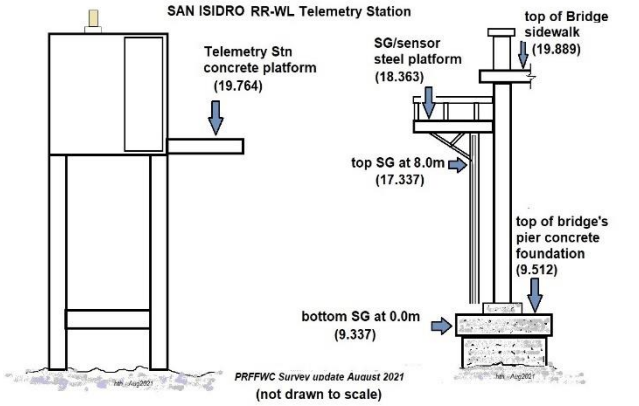
Below left picture shows the rain gage and solar cell panels as installed on top of the telemetry station.

9. San Isidro RR-WL telemetry station

Latitude: 15°18'49" N
Longitude: 120°54'09" E
(start of operation: RR – August 06, 1973 @ 0800H; WL – August 13, 1973@ 0900H)
Description: Telemetry station housing is situated at the D/S, RB side of the San Leonardo-Jaen San Isidro by-pass Bridge (at Jaen side) at Bgy. Sapang, Jaen, Nueva Ecija
Present Condition: Station is operational with many data breaks / gaps
Remarks: S.G. is up to 8.0m

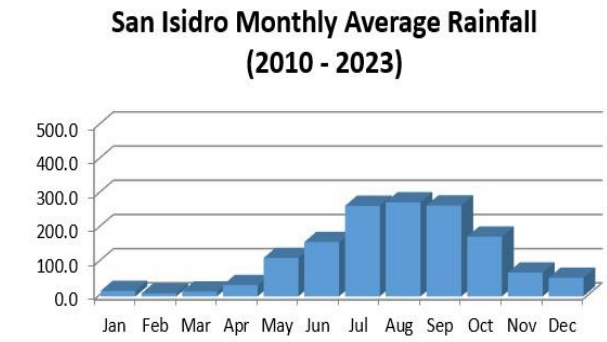
Top: San Isidro station at a relative low water level situation; picture below shows the station at a relatively high flow situation of the Pampanga River.

Figure just below is the schematic profile of the telemetry station with corresponding elevations



The Pampanga R. x-sect at the said stream gaging station.

Above is a D/S view of the Pampanga River from the San Leonardo-Jaen San Isidro by-pass Bridge. Below is a view of the station just after its rehabilitation in 2009.

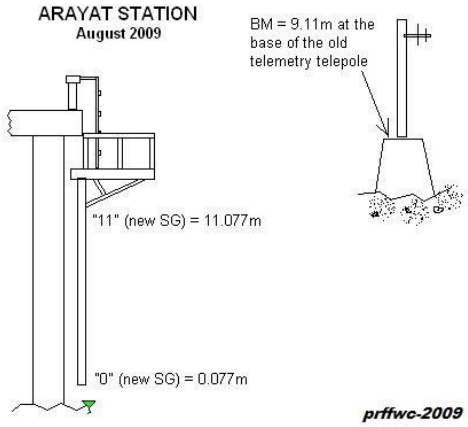


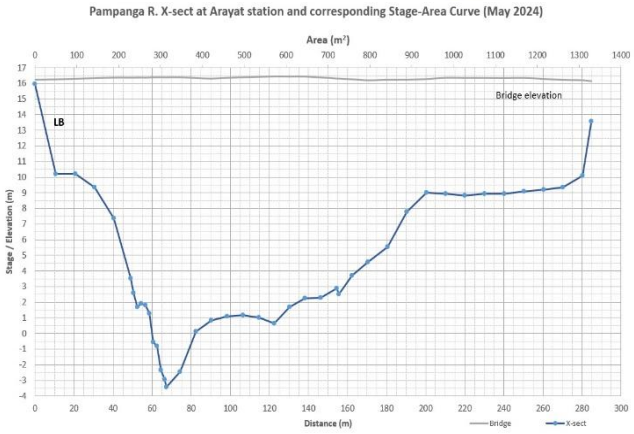
The average monthly RR distribution for the station based on available dataset from 2010 to 2023

10. Arayat RR-WL telemetry station

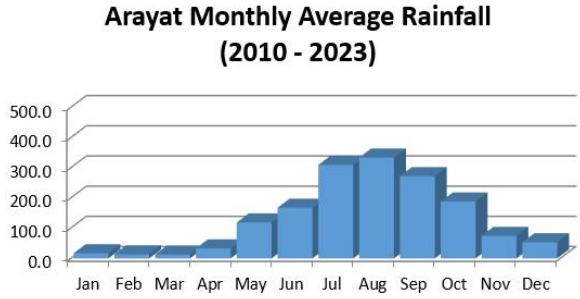
Latitude: 15°10'06" N
Longitude: 120°46'56" E
(start of operation: RR & WL – September 01, 1973 @ 1300H)
Description: Telemetry station housing situated at the D/S, RB side of the San Agustin Bridge in Arayat, Pampanga
Present Condition: Station is operational and dataset with many breaks / gaps (affected usually by interferences)
Remarks: S.G. is up to 11.0m

Figure below is the schematic profile of the station with corresponding elevations





Pampanga R. x-sect at Arayat stream gaging station.



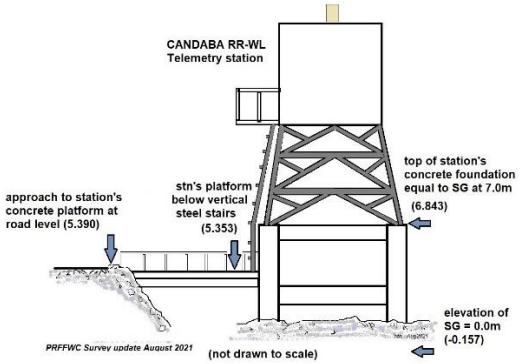
The average monthly RR distribution for the station based on available dataset from 1973 to 2007

Top: A frontal view of the Arayat RR-WL telemetry station housing; picture below shows the S.G. and sensor platform for the said station.

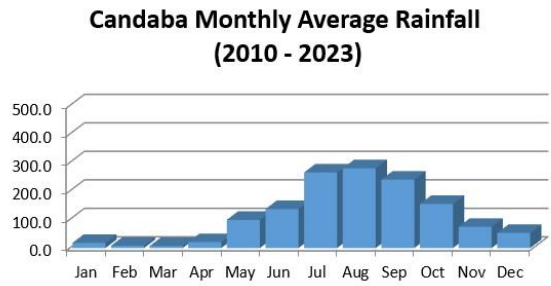
Above shows the downstream view of the Pampanga River at the San Agustin Bridge, Arayat. Below is another view of the Arayat telemetry station.

11. Candaba RR-WL telemetry station

Latitude: 15°06'56" N
Longitude: 120°51'01" E
(start of operation: RR- September 07, 1973 @ 0900H; WL – September 08, 1973 @ 1500H)
Description: Telemetry station is located in the middle of Candaba Swamp along the Candaba-San Miguel Road (Dukma) right side if headed towards San Miguel, Bulacan at Bgy. Paralaya, Candaba, Pampanga.
Present Condition: Station is operational with many data breaks / gaps
Remarks: S.G. is up to 7.0m at the station's post; station was vandalized / ransacked in April 2006



Above figure is the schematic profile of the telemetry station with corresponding elevations.



The average monthly RR distribution for the station based on available dataset from 2010 to 2023.

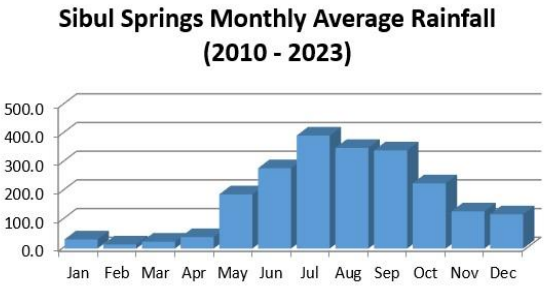
Top: A view of the station at a relatively dry period. Below is the sensor and S.G. platform at the bridge beside the station (old location).

A view of the station with various flood level peaks attained during 3 different events from highest to lowest level – Pedring (Oct. 2013), Lando (Oct. 2015) and Nona (Dec. 2015)

12. Sibul Spring RR telemetry station

Latitude: 15°10'05" N
Longitude: 121°03'33" E
(start of operation: August 28, 1973 @ 1200H)
Description: Telemetry station is located in a corner lot adjacent to the Barangay Hall of Bgy. Sibul, San Miguel, Bulacan.
Present Condition: Station is operational and station dataset with numerous breaks / gaps
Remarks:

Top and below pictures shows the side and front views of the station housing, respectively.



The average monthly RR distribution for the station based on available dataset from 2010 to 2023

Above shows various views of the telemetry station taken during a quarterly maintenance by PRBFFC personnel.

13. Sasmuan RR-WL telemetry station

Latitude: 14°56'11" N
Longitude: 120°37'23" E
(start of operation: around August 1986)
Description: Telemetry station is located before the one-way bridge leading to Bgy. San Pedro on its U/S, RB side of Pasac-Guagua River in Bgy. Sta. Lucia (Poblacion), Sasmuan, Pampanga
Present Condition: Station is operational with many breaks / gaps
Remarks: S.G. is up to 4.0m although the rehabilitation set-up (March 2009) of S.G. was only 2 meters high up to bottom of sensor platform. No report as to when S.G. was changed; S.G. pictured below right is as of Aug 2009.

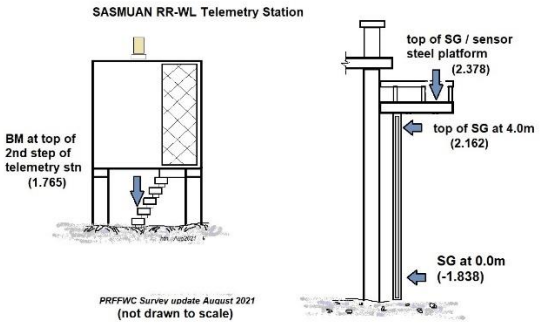
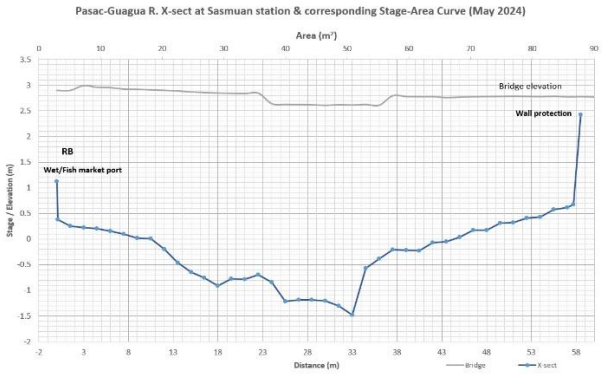
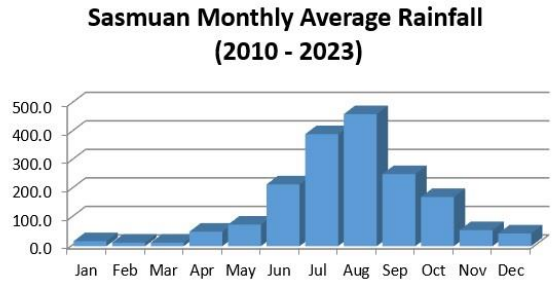


Figure above is a schematic view of the station profile with corresponding elevations.
Figure below is the river x-sect at the said stream gaging site of the station.





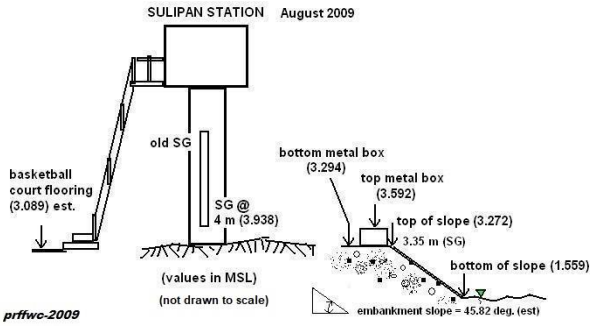
The average monthly RR distribution for the station based on available dataset from 2010 to 2023

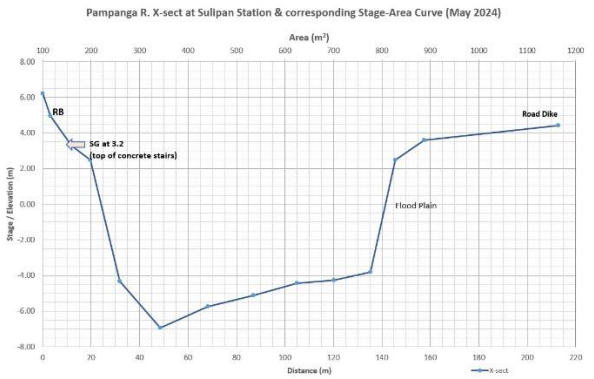
Top: The station after its rehabilitation in 2009; Below is the S.G. and sensor platform for the said station.

Top picture shows the downstream view of the Guagua River at the S.G. location; Below is another view of the station.

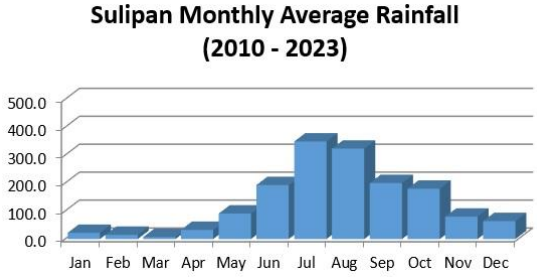
14. Sulipan RR-WL telemetry station

Latitude: 14°56'21" N
Longitude: 120°45'39" E
(start of operation: RR – August 01, 1973; WL – August 13, 1973 @ 0900H)
Description: At the RB of Pampanga River outside of the dike at Bgy. Sulipan (Apalit, Pampanga) some 250 meters upstream of (before) the junction of Pampanga River with Bagbag River.
Present Condition: Station is operational; station dataset with numerous gaps / breaks
Remarks: Maximum S.G. is up to 6.0m; station is just adjacent to a basketball court in the area. Station's part-time observer / caretaker is Mr. Daniel Flores (as of Apr 2017)





The estimated Pampanga River x-sect at the said stream gaging station



The average monthly RR distribution for the station based on available dataset from 1973 to 2007.

Top picture shows the latest view the station condition (Sept. 2016); middle picture shows the station just after rehabilitation in 2009; lower picture is a view of the river section as seen from the station.

15. Mexico RR-WL telemetry station

Latitude: 15°04'05" N
Longitude: 120°43'51" E
(start of operation: around April 2009)
Description: Station housing is situated at the LB-D/S side of Mexico Bridge No. 2, Bgy. Sto. Rosario, Mexico, Pampanga; station is very visible on the said bridge heading towards Sta. Ana, Pampanga.
Present Condition: Station is operational with numerous data breaks / gaps
Remarks: S.G. is up to 6.0m; station S.G. & pressure sensor is heavily affected by siltation and sedimentation

The station as seen from the Mexico Bridge No. 2

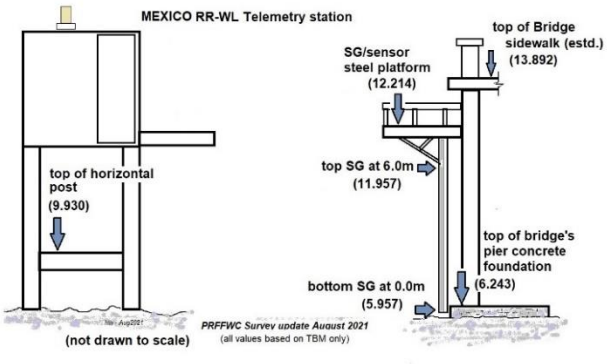
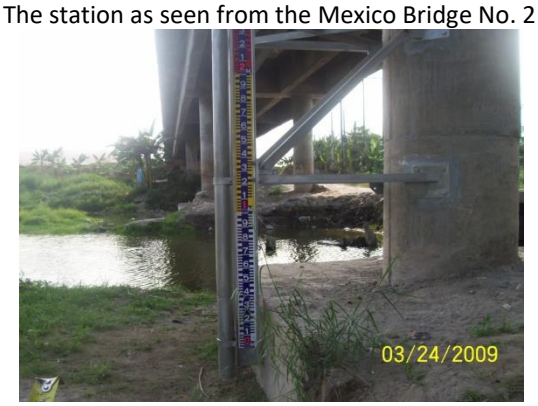
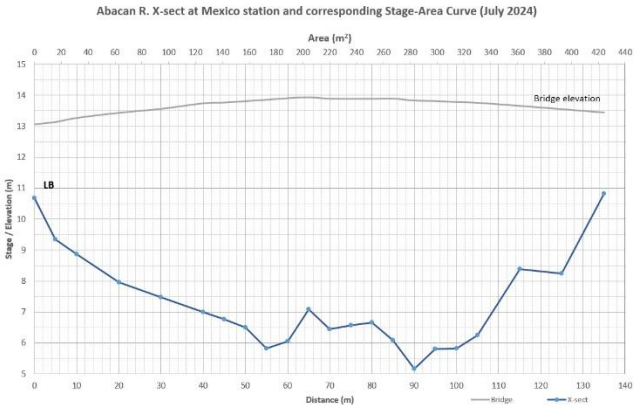


Figure above is the schematic profile of the Mexico Telemetry station

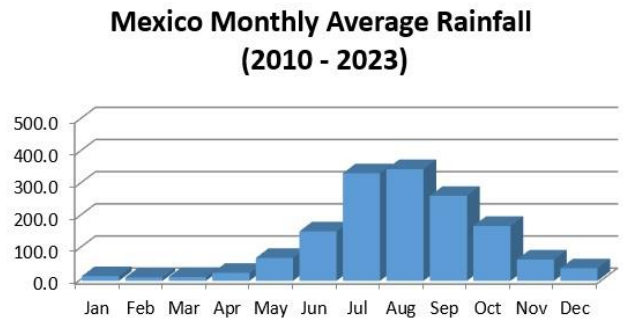


The S.G. and station sensor is located at the middle bridge pier



The Abacan river x-sect at Mexico station

The old overflow bridge at upstream of the Mexico Bridge No.2 is shown above.



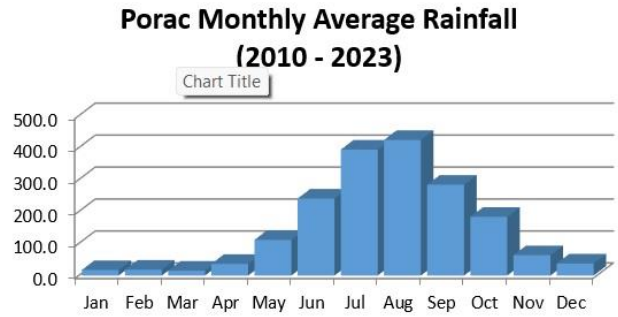
The monthly average rainfall distribution based on available data from 2010 to 2023.

The latest situation of the station housing, the S.G. and sensor which is about a meter below the ground

16. Porac RR telemetry station

Latitude: 15°04'48" N
Longitude: 120°32'43" E
(start of operation: around April 2009)
Description: Station is located inside the motor pool and other extension offices of the local government of the municipality of Porac in Bgy. Cangatba, Porac, Pampanga.
Present Condition: Station is operational; dataset has numerous breaks / gaps
Remarks:

The Porac RR telemetry station



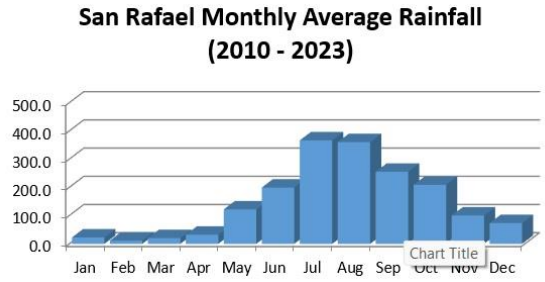
The average monthly rainfall distribution based on available data from 2010 to 2023

Another view of the Porac RR telemetry station

17. San Rafael Repeater and RR telemetry station

Latitude: 14°58'05" N
Longitude: 120°54'52" E
(start of operation: August 01, 1973)
Description: Both repeater and RR station are located inside the NIA motor pool compound in Bgy. Sabang, Baliuag, Bulacan.
Present Condition: Station is operational with numerous gaps / breaks
Remarks: Original station (in 1973) was originally located in another place (Bgy. Talacsan (?)) within the same town; it was again relocated during the rehabilitation works in around 1986; station's present location came about in 2009. The repeater tower stands at around 75m.

The RR and repeater station housing

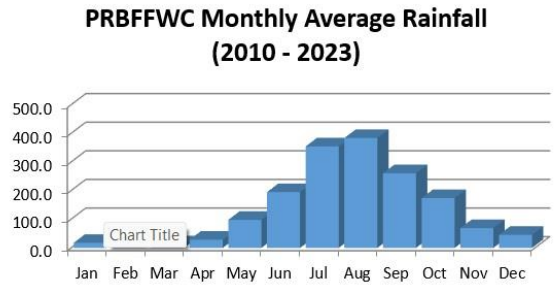


The average monthly RR distribution at the station based on available dataset from 2010 to 2023.

The 75 meter repeater tower of the station

18. PRBFFWC (San Fernando) RR station (Operations Center for PRB)

Latitude: 15°04'04" N
Longitude: 120°39'22" E
(start of operation: around April 2009)
Description: RR gauge is located on top of the generator's room; within the PRFFWC area, DOST-3 compound, DMGC compound (Government Center), Bgy. Maimpis, City of San Fernando, Pampanga.
Present Condition: Station is operational; RR dataset is very good especially for daily totals with no breaks / gaps
Remarks: RR gauge is a digital LCD, manually observed unit

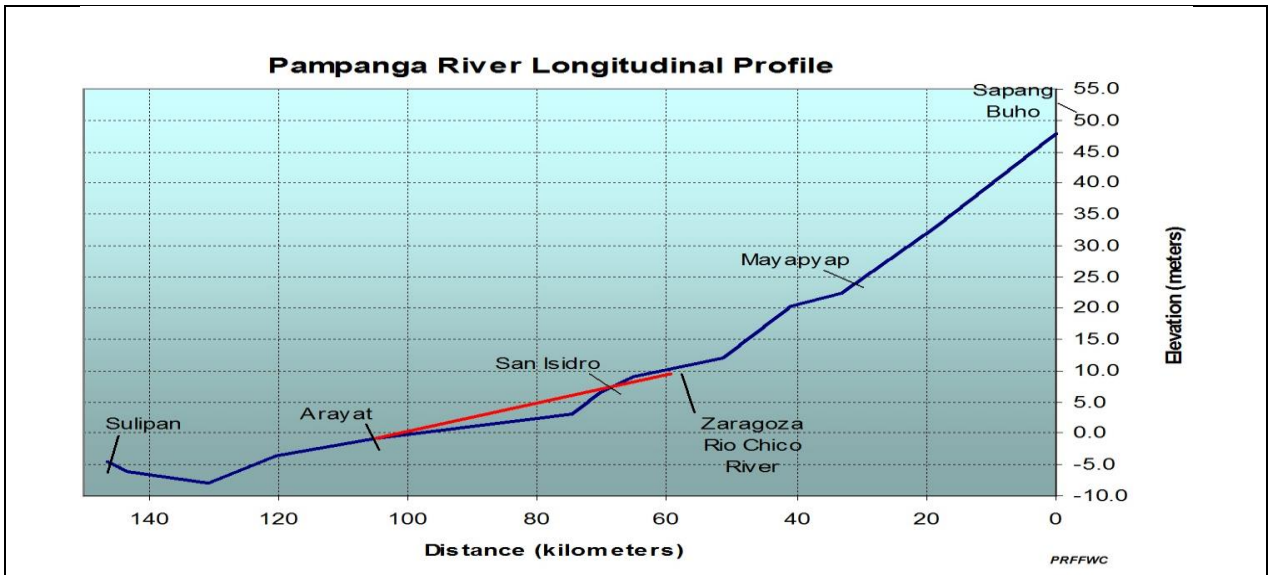


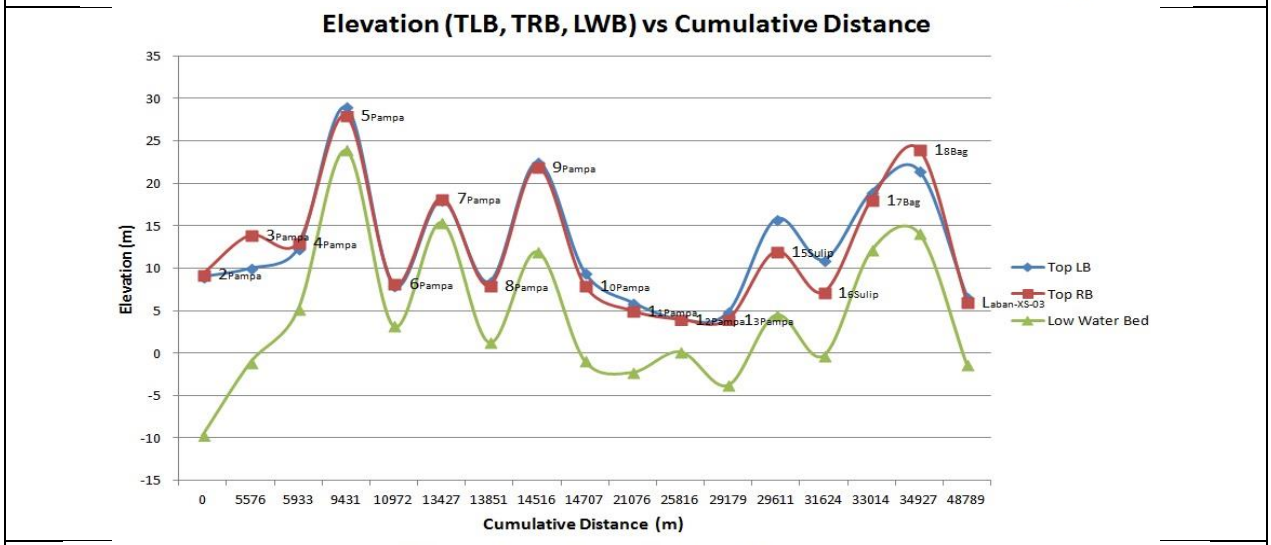
The average monthly RR distribution at the center as per available observations from 2010 to 2023

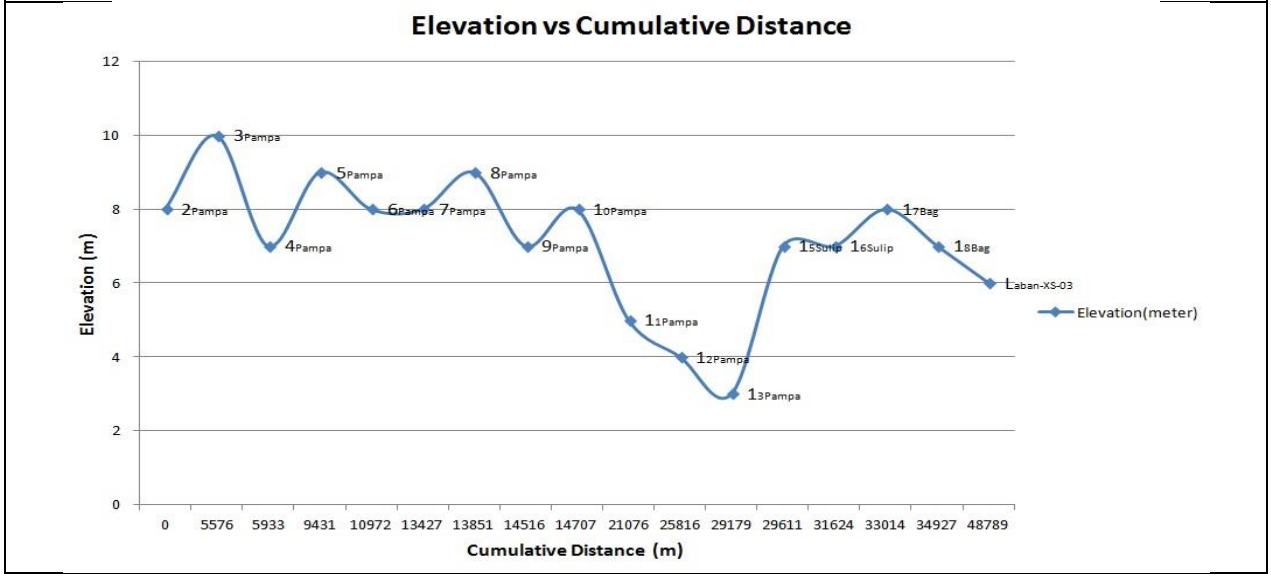
A semi-aerial view of the PRBFFWC station adjacent to the telemetry tower

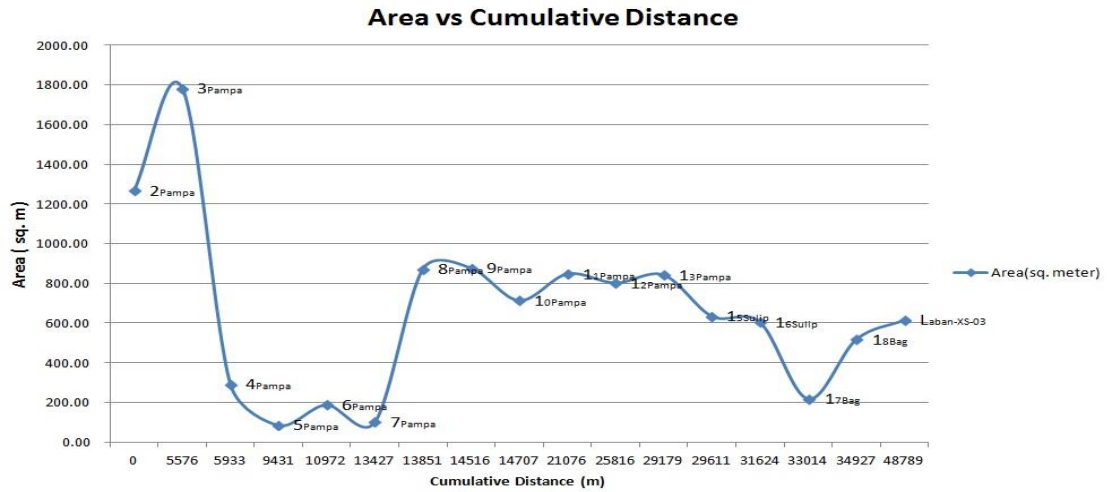
B. BASIN Features & other General Information

1. Pampanga River estimated Longitudinal Profile and other related river profile characteristics:









Station Name	Latittude	Longitude	Location	Elevation(meter)	Top LB	Top RB	Low Water Bed	Distance (meter)	Cumulative Distance (meter)	Area(sq. meter)	Bank Full(meter)	Wetted Perimeter(meter)	Hydraulic Radius(meter)
2Pampa-XS-26	14°59'40.33"N	120°46'52.88"E	San Miguel Bridge, San Simon, Pampanga	8	9	9.3	-9.72	0	0	1267.07	148.68	156.72	8.52
3Pampa-XS-26C	14°57'18.98"N	120°46'32.93"E	NLEX-Apalit	10	10	13.91	-1.12	5576	5576	1782.91	327.63	332.20	5.44
4Pampa-XS-26A	14°56'26.5"N	120°45'32"E	Sulipan Station	7	12.34	13	5.11	357	5933	291.07	68.90	76.52	4.22
5Pampa-XS-26B	14°56'15.8"N	120°45'36.2"E	Capalangan, Calumpit	9	29	28	23.9	3498	9431	84.61	31.09	32.57	2.72
6Pampa-XS-27	14°55'44.11"N	120°46'14.12"E	Calumpit-Capalangan Area:	8	8	8.25	3.18	1541	10972	188.55	69.60	70.83	2.71
7Pampa-XS-27A	14°55'04.4"N	120°44'50.5"E	at the Right bank at Frances	8	18	18.25	15.4	2455	13427	101.25	47.50	48.47	2.13
8Pampa-XS-27B	14°54'56.71"N	120°44'37.53"E	Brgy. San Miguel Calumpit	9	8.42	8	1.26	424	13851	872.60	156.93	159.62	5.56
9Pampa-XS-28	14°54'38.2"N	120°44'19.7"E	Prk 2, Meysulao, Calumpit	7	22.49	22	11.95	665	14516	876.78	137.00	139.72	6.40
10Pampa-XS-29	14°54'31.27"N	120°44'28.36"E	Prk 1, Bulusan Calumpit	8	9.5	8	-0.91	191	14707	713.61	104.50	107.54	6.83
11Pampa-XS-30	14°52'09.30"N	120°42'23.83"E	Brgy. Bebe Matua, Masantol	5	5.96	5	-2.27	6369	21076	847.73	196.09	197.45	4.32
12Pampa-XS-31	14°50'9.95"N	120°40'58.05"E	Brgy. Bulacus, Masantol	4	4	4	0.15	4740	25816	802.16	215.57	216.41	3.72
13Pampa-XS-32	14°48'48.31"N	120°39'43.49"E	Brgy. Consuelo, Macabebe	3	4.82	4	-3.79	3363	29179	841.85	242.75	243.87	3.47
15Sulip-XS-01	14°56'13.8"N	120°45'20.8"E	Sulipan Bridge	7	15.8	12	4.5	432	29611	634.25	110.00	114.44	5.77
16Sulip-XS-02	14°55'24.8"N	120°44'53.3"E	Near the Fishpond(Sulipan)	7	11	7.2	-0.3	2013	31624	603.72	72.96	81.14	8.27
17Bag-XS-01	14°55'11.2"N	120°46'00.2"E	Capalangan Hanging Bridge	8	19	18.1	12.1	1390	33014	218.00	50.00	53.06	4.36
18Bag-XS-02	14°54'22.8"N	120°46'28.2"E	Caniogan Bridge	7	21.5	24	14.1	1913	34927	517.56	105.26	109.29	4.92
Laban-XS-03	14°47'15.04"N	120°45'36.49"E	Buga-Bakahan Area	6	6.62	6	-1.42	13862	48789	615.38	131.15	132.52	4.69

Note: Specific updated information for the respective forecasting sites of the PRBFFWC, including updated x-sects, hydraulic profile parameters, Q ratings, etc., are presented in the PRBFFWC report "PRBFFWC Stream Gauging Notes" as of September 2024.

Table A. The assessment WL for the various stream gaging stations in the Pampanga River Basin (as of Oct 2022)

PAMPANGA RIVER BASIN ASSESSMENT LEVELS (meters) as Oct 2022

color code	YELLOW	ORANGE	RED
STATION	ALERT	ALARM	CRITICAL
Sapang Buho	3.70	4.50	6.50
Mayapyap			
Zaragoza	3.00	4.00	5.00
Penaranda	2.50 **	3.50 **	4.50 **
San Isidro	5.00	6.00	8.00
Arayat	5.00	6.00	8.50
Candaba	3.50	4.50	5.00
Mexico	2.00 **	2.50 **	3.50 **
Sasmuan			3.00
Sulipan	2.60	3.20	3.80

** Initial value (for validation)

2. Stream gauging Rating Equations:

Table A1. Water Level Station notes (for updating)

Water Level Station	Elevation of "0" of Staff Gauge (m) (as of Aug. 2009)	Rating Curve (RC) Equation as of April 2009	RC range of applicability
Sapang Buho	50.212	Q = 4.015 (H–(-2.94))^2.961*	0 < H <= 3.4
Zaragoza	10.213	Q = 12.111 (H - 0.0)^2	(for validation)
Peñaranda	22.498**	Q = 2.30 (H - (-1.20))^2	0 < H <= 4.0
San Isidro	9.585	Q = 15.2 (H - (-1.70))^2	0 < H <= 8.0
Arayat	0.077	Q = 9.106 (H - (-0.39))^2	0 < H <= 9.0
Candaba	-0.157	Q = 1.80 (H - (-1.30))^2	0 < H <= 2.0
Sasmuan	-1.147	Q = 1.50 (H- (-2.0))^2	0 < H <= 2.0
Sulipan	-0.062	Q = 9.50 (H - (-0.4))^2	0 < H <= 3.0
Mexico	5.933**	Q = 11.0 (H - (-0.50))^2	0 < H <= 3.0

Notes: RC equations by JICA Consultants

** - based on x-section of March 2000 (by PRFFWC)*

*** - based on temporary markers (TBM)*

3. River Channel Flow Capacity and Probable Peak Runoff Discharge:

River	Stretch	Channel Flow Capacity (m^3/s)	Probable Peak Flood Runoff Discharge	
			5-year return period	10-year return period
Pampanga	River Mouth – Masantol	4,300 (500)*	2,654	3,517
	Masantol – Sulipan	2,200	2,654	3,517
	Sulipan – Arayat	1,800	2,349	2,731
	Arayat – Cabiao	2,000	2,424	3,071
	Cabiao - San Isidro	2,500	2,408	3,051
Angat	Calumpit - Expressway Bridge	900	737	854
San Fernando	Sasmuan - San Fernando	200	272	363

Note: *: The channel flow capacity was increased from 500 to 4,300 m^3/s through the PPDP-Phase I in 1993.
Source: Feasibility Study Report on the Pampanga Delta Development Project, JICA, 1982

4. Distances and Drainage Areas (Pampanga River System)

Location	Distance from mouth (km)	Drainage Area (km^2)	Location	Distance from mouth (km)	Drainage Area (km^2)
Pampanga River					
At source	284	0	Above mouth of Tambo River	129	2746
Above mouth of Barak River	269	72	Below mouth of Tambo River	129	2767
Below mouth of Barak River	269	207	At gauging stn, San Anton, San Leonardo, N.E.	123	2851
At Carranglan, N.E.	258	344	Above mouth of Peñaranda River	115	2860
Above mouth of Diamman River	244	439	Below mouth of Peñaranda River	115	3438
Below mouth of Diamman River	244	523	At Poblacion, San Isidro, N.E.	114	3441
Above mouth of Pantabangan River	237	573	At San Antonio, Cabiao, N.E.	95	3457
Below mouth of Pantabangan River	237	835	At Flood Channel, San Vicente, Cabiao, N.E.	89	3466
At Dam Pampanga River Irrig. System	214	899	Above mouth of Rio Chico River	84	3469
At gauging stn, Gandos, Rizal, N.E.	214	899	Below mouth of Rio Chico River	84	6478
Above mouth of Digmala River	205	984	At gauging stn, San Agustin, Arayat, Pampanga	77	6487
Below mouth of Digmala River	205	1202	At gauging stn, Arayat, Pampanga	71	6492
Above mouth of Santor River	196	1240	Above mouth of Maasim River	56	7483
Below mouth of Santor River	196	1946	Below mouth of Maasim River	56	7714
At gauging stn, Manacnac, Bongabon	180	2015	At Poblacion, San Luis, Pampanga	51	7756
Above mouth of Cabu River	173	2021	At gauging stn, San Juan, San Simon, Pampanga	41	7776
Below mouth of Cabu River	173	2168	At gauging stn, Sulipan, Apalit, Pampanga	31	7872
Above mouth of Casili River	153	2349	At gauging stn, Sulipan Cut-Off, Sulipan, Apalit, Pampanga	29	7874
Below mouth of Casili River	153	2467	At gauging stn, Calumpit, Bulacan	29	8882 *
At gauging stn, Poblacion, Cabanatuan, N.E.	148	2494	At gauging, San Miguel, Calumpit, Bulacan	26	8886 *

Above mouth of Tabuating River	131	2633	At mouth of Pampanga River (Manila Bay)	0	8912
Below mouth of Tabuating River	131	2735	* Drainage of Angat River 972 km^2, included		

Location	Distance from mouth (km)	Drainage Area (km^2)	Location	Distance from mouth (km)	Drainage Area (km^2)
Talavera River					
At source	135	0	At San Nicolas, Gapan, N.E.	3	576
At gauging stn, Lomboy, San Jose, N.E.	91	261	At mouth of Penaranda River (at junction with Pampanga R.)	0	578
At gauging stn, Kitakita, San Jose, N.E.	87	284	**Rio Chico River**		
At Dam, Talavera River Irrig. System	86	288	At gauging stn, Catalanacan, Munoz, N.E. (Baliwag River)	101	284
At road crossing bet. San Jose & Rizal	75	362	At gauging stn, Sto. Rosario, Sto. Domingo, N.E.	92	334
At gauging stn, Kobobolonan, Talavera, N.E.	60	431	At gauging stn, Licab, N.E.	70	460
At gauging stn, Calipahan, Talavera	48	460	Above mouth of Benituan River	63	496
Above mouth of Dibabuyan Creek	37	487	Below mouth of Benituan River	63	1003
Below mouth of Dibabuyan Creek	37	570	Above mouth of Boudog River	62	1005
At Tabing Ilog, Aliaga, N.E.	32	582	Below mouth of Boudog River	62	1112
At mouth of Talavera River (at junction with Rio Chico River)	0	726	Above mouth of Boino River	59	1122
Santor River			Below mouth of Boino River	59	1140
At gauging stn, Cuyapa, Gabaldon	38	89	At bridge bet. La Paz and Zaragoza (Baliwag R. in upper reaches)	50	1177
At gauging stn, San Vicente, Laur	15	544	Above mouth of Darabulbul River	33	1311
At mouth of Santor R. (at junction with Pampanga River)	0	706	Below mouth of Darabulbul River	33	1438
Peñaranda River			Above mouth of Talavera River	28	1462
At gauging stn, Santuyo, Papaya, N.E. (Chico River)	34	150	Below mouth of Talavera River	28	2188
At gauging stn, Pias, Papaya, N.E. (Minalungao River)	29	294	Above mouth of Bamban River	13	2335
At gauging stn, Poblacion, Papaya, NE	26	473	Below mouth of Bamban River	13	2801
At Dam, Peñaranda R. Irrig. System	19	511	Above mouth of Quitanguil River	8	2825
At gauging stn, (Railroad B.) San Josef, Peñaranda, N.E.	18	512	Below mouth of Quitanguil River	8	2968
At gauging stn, Gapan, N.E.	5	573	At mouth of Rio Chico River (at junction with Pampanga R.)	0	3009

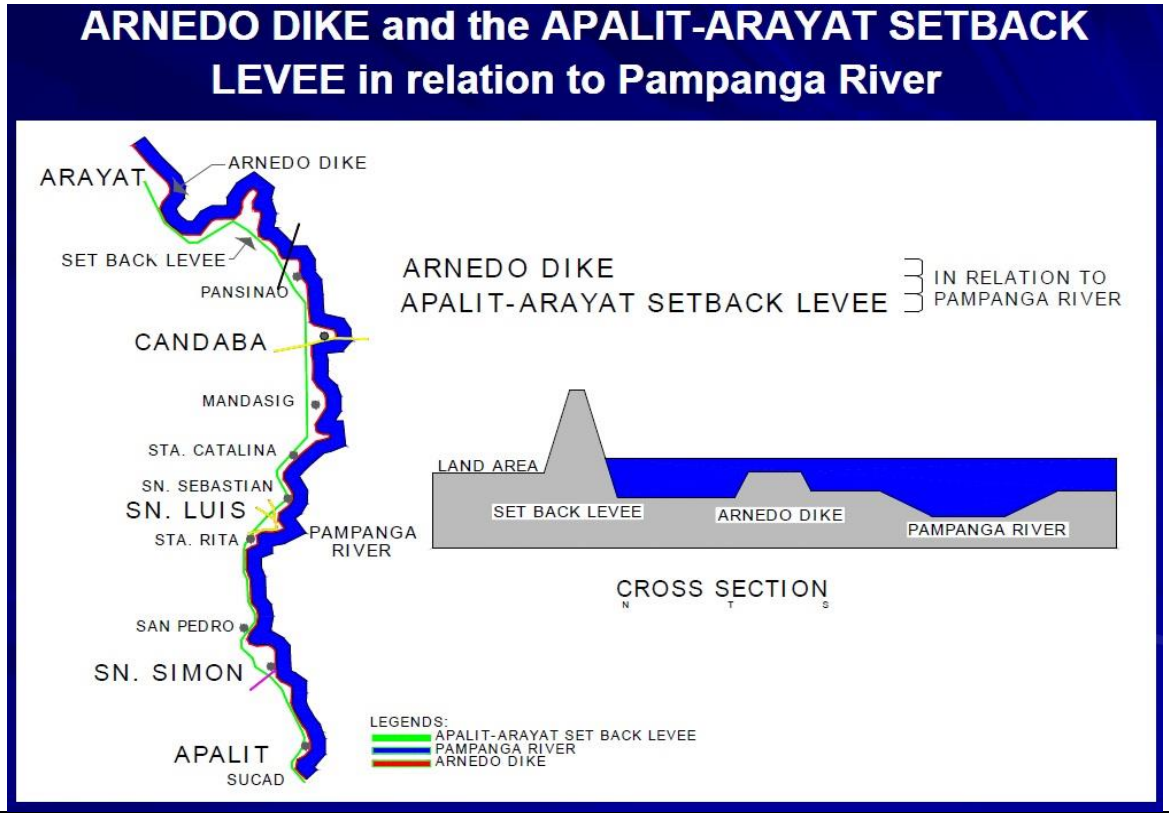
Location	Distance from mouth (km)	Drainage Area (km^2)
Angat River		
At gauging stn, Ipo, Norzagaray, Bulacan (above Dam)	82	551
At Ipo, Norzagaray, Bulacan	72	628
At gauging stn, Ipo, Norzagaray, Bulacan (below Dam)	71	629
At gauging stn, Matictic, Norzagaray, Bulacan	55	655
At Dam, Angat River Irrig. System (Bustos Dam)	32	830
At gauging stn, Plaridel, Bulacan	14	959
At mouth of Angat River (at junction with Labangan River)	0	972
Information taken from the Report by the then Department of Public Works and Communications , Manila, Philippines, 1969		

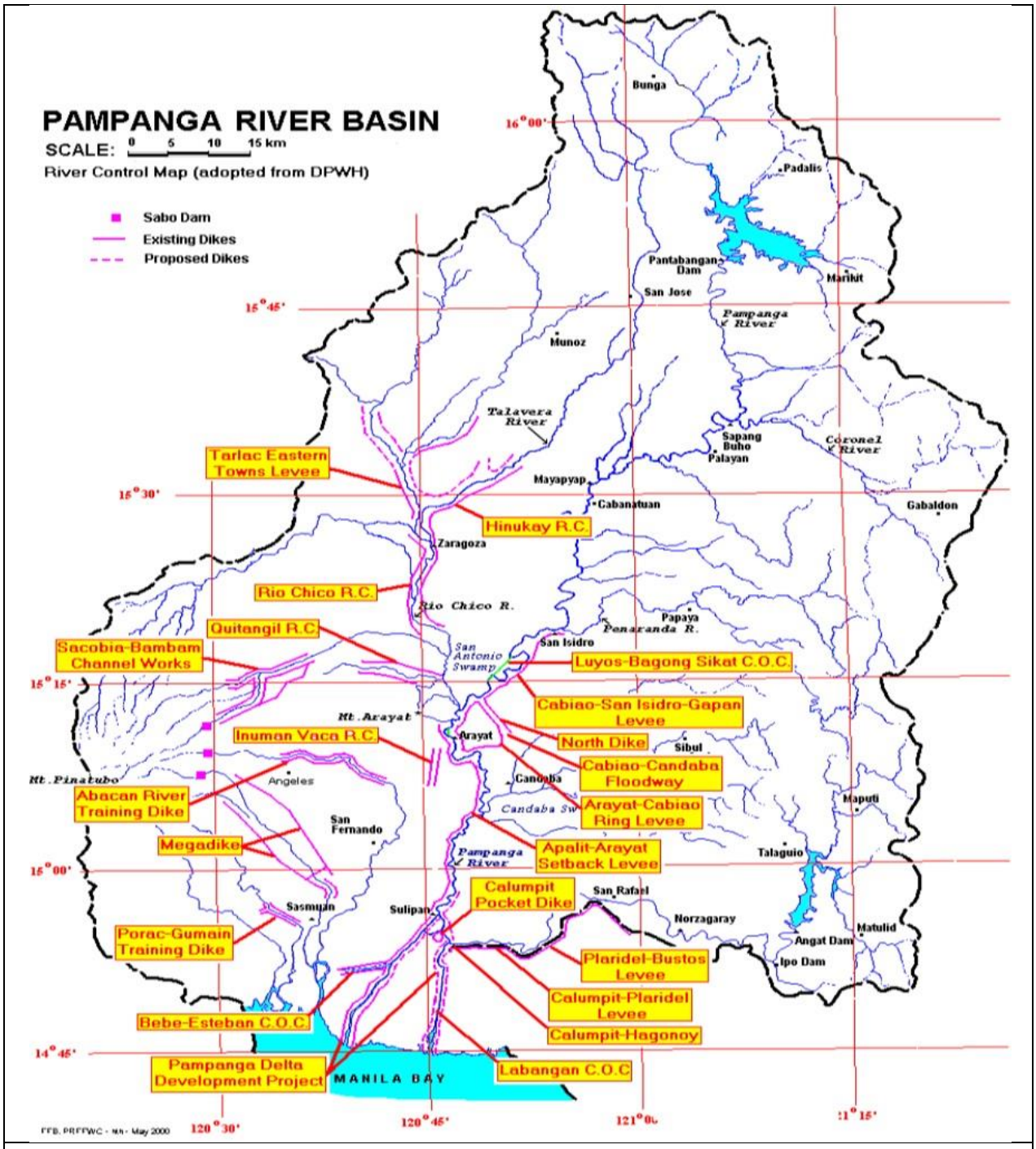
5. (some) Flood mitigating structures:

There are quite a number of flood mitigating structures within the basin initiated by the DPWH and even by other local government entities. However, only some of the major ones are provided herein. Further information on these structures can be taken at respective agencies that were responsible for its construction. Info on this section partly taken from the Flood Management presentation of DPWH-3.

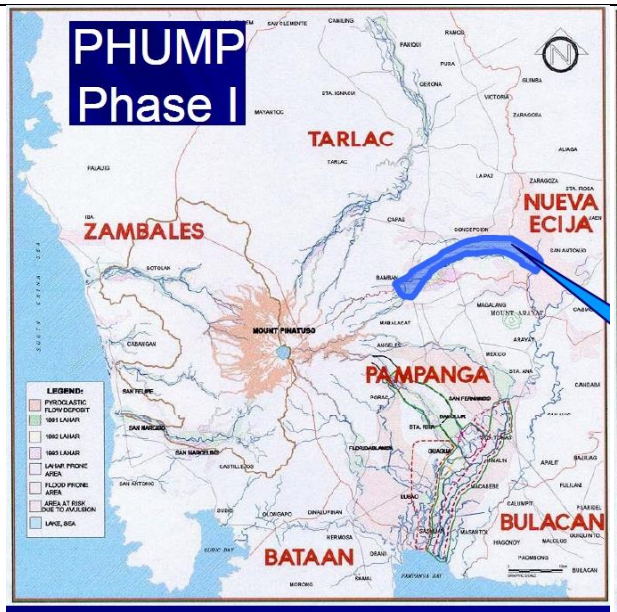
- Arnedo Dike – was built 1940 with a net length of 36 km. extending from Sulipan, Apalit to Cupang, Arayat in Pampanga. It is considered the first line of defense against the overflowing of the right bank of the Pampanga River. Very recently, the DENR-3 through the MGB-3 conducted assessment on the stability of the Dike to verify and determine the structural condition that might result to breaching in the event of heavy rainfall. Geologic hazard such as riverbank erosion was delineated and actual sounding was conducted. The primary hazard in the area is mainly related to flooding in the form of overbank flooding and riverbank erosion.
  The identified critical areas / sections along Arnedo Dike are as follows: Candaba – Pansinao, Buas, Gulap, Lanang, Pasig and Mandasig; San Luis – Sta. Rita, Sta. Catalina, Sta. Cruz, San Sebastian and Sto. Tomas; San Simon – San Jose and San Pablo; Apalit – Sucad and San Vicente; those who are in these areas are normally affected by overflowing of the Pampanga River.
- The Arayat-Apalit-Masantol Setback Levee – was constructed in 1973 and has a total length of 40 km. divided into 2 segments:
  - Apalit-Arayat setback levee – 31 km. from Sulipan, Apalit to Cupang, Arayat;
  - Aplit-Masantol levee – 9 km. from Sulipan, Apalit to Bebe-San Esteban in Masantol

  This levee was designed to contain the bank overflow of the Pampanga River after it overtops the depressed Arnedo dike. It serves as the second and last line of defense against overflow of the Pampanga River, as protection against flood damaged to adjoining barangays of Candaba, San Luis, San Simon, Apalit, Macabebe, and Masantol
- Pampanga Delta Development Project (PDDP) Flood Control Component
  - PDDP I – completed portion length 13.90 km (deleted portion of 1.5 km due to strong opposition of Bgy. Candelaria, Macabebe, Pampanga up to Bgy. Meyto, Calumpit, Bulacan)
  - PDDP II - cancelled

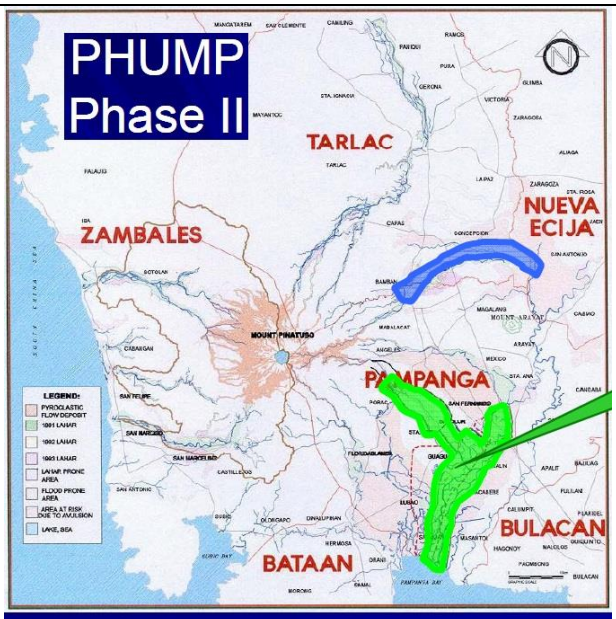




- Pinatubo Hazard Urgent Mitigation Projects (PHUMP)
  - Phase I – Bamban-Sacobia-Parua River Basin
  - Phase II – Pasig-Potrero River Basin and Pasac Delta
  - Phase III – Pasac Delta including Porac-Gumain River (info available from DPWH)
- Bebe-Esteban Cut-off Channel – the estimated terrain elevation is about 2 meters. The channel relieves some of the water from the Pampanga River and some of the tributaries; and it generally benefits the Macabebe and Masantol areas.
- Labangan Cut-off Channel – acts to relieve the Angat River during high flows; it also acts as a diversion channel for the Pampanga River when said river is higher than that of Angat River.
- Cabiao-Candaba Floodway – whenever Pampanga River overflows over its left bank prior to Arayat in Pampanga (normally at Arayat S.G. reading of 8.8 to 9.0 meters or over – for further validation) the floodway will divert the overflowing runoff of Pampanga River towards the Candaba swamp via the Cabiao-Candaba floodway.

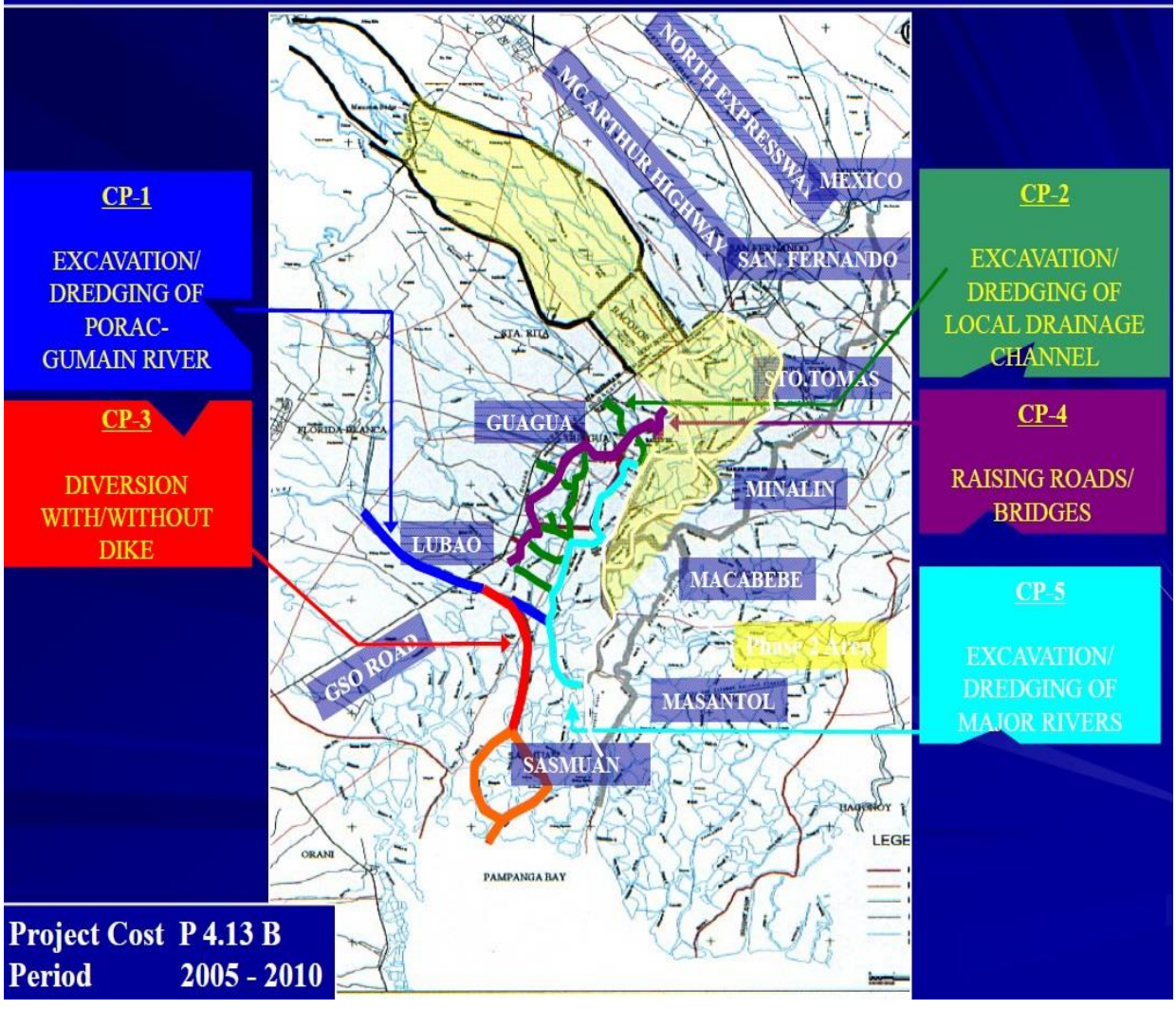


LOCATION MAP

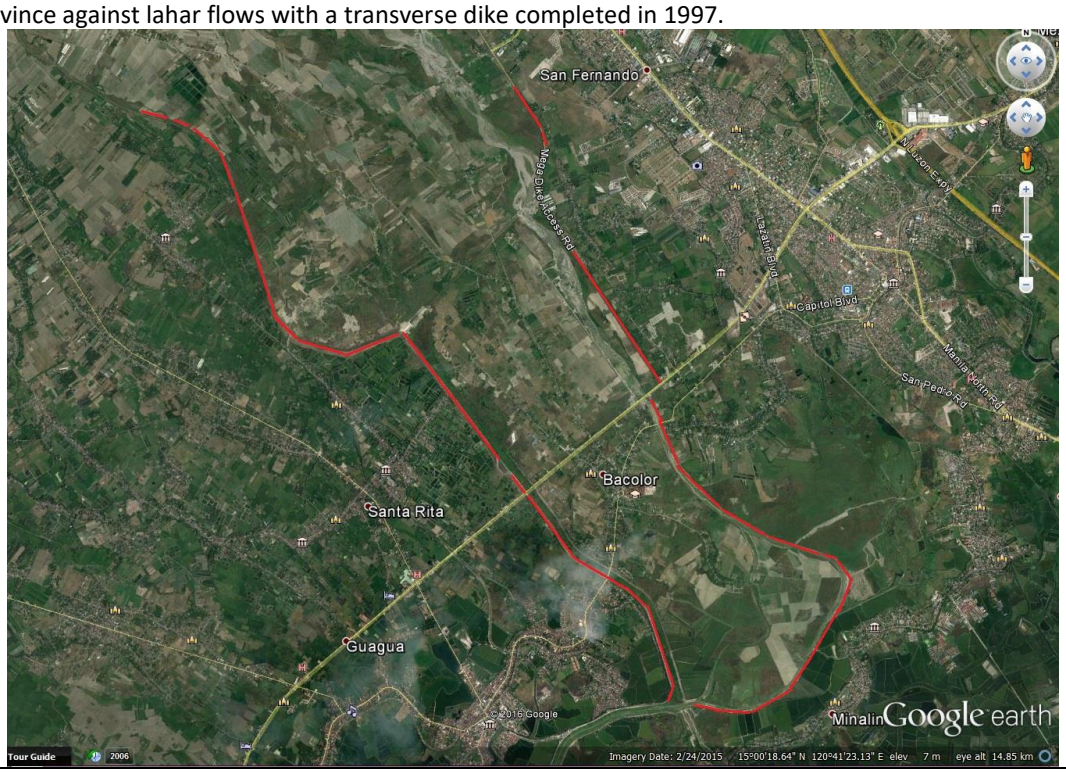


LOCATION MAP

Pinatubo Hazard Urgent Mitigation Project Phase 3



- The Megadike – was built after lahar, or volcanic sediments remobilized by rain, overflowed the Pasig-Potrero River in Oct. 1, 1995 burrying the town of Bacolor. The U-shaped 56-kilometer long structure turned 17 Bacolor villages into a catch basin of lahar. It is considered as the last defense of Pampanga province against lahar flows with a transverse dike completed in 1997.



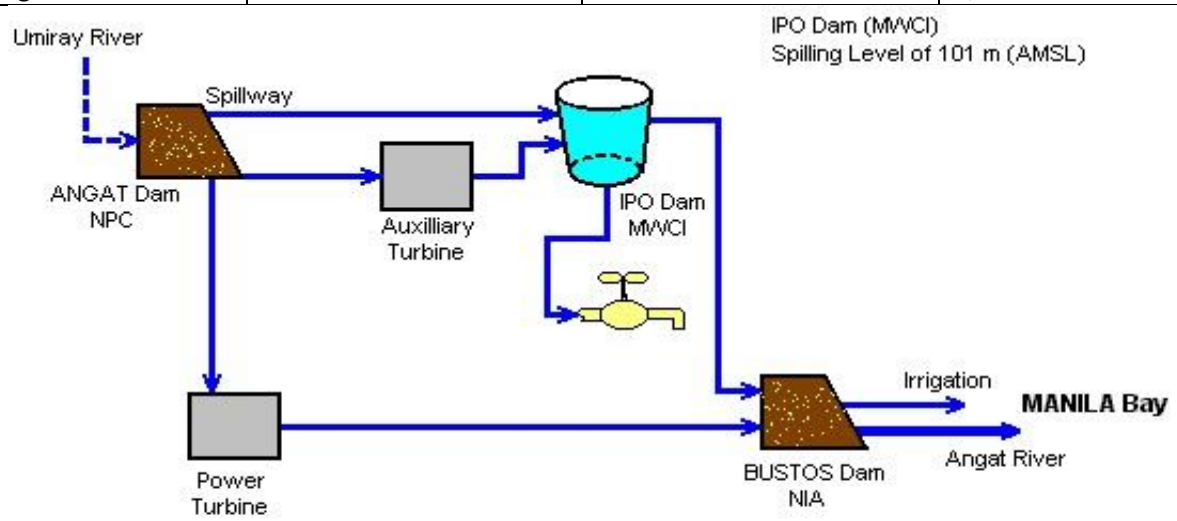
6. **Major Dam Structure Profiles (within the basin) – Angat & Pantabangan**

	ANGAT	**PANTA**		**ANGAT**	**PANTA**
Catchment Area (km^2)	568*	853	Dam Type	Gated	Gated; free overflow – 1 lane
Surface Area (Design HWL) (km^2)	23.6	84.2	Gate Dimensions (m)	Radial-3 units 15 (H) x 12.5(W)	Radial-3 units 10 (H) x 8 (W)
Max. HWL (El. m)	219.0	230.0	Flood control storage	Relatively small	330 x 10^6 m^3
Normal HWL (El. m)	212.0	221.0	Hydropower Generation (installed capacity)	218 MW	100 MW
LWL (El. m) – see critical below	180.0	171.5	Irrigation	30,000 ha	106,400 ha
Total Reservoir storage volume (10^6 m^3)	1,077	3,004	Water Supply	695.4 x 10^6/yr	Relatively small
Effective Res. storage volume (10^6 m^3)	850	2,087	Construction / Commissioning	Sept 1969	May 1977
Dam type	Rockfill	Rockfill	FFWSDO Commencement	Jul 1986	Jul 1986
Dam Height (m)	131.0	107.0	Responsible agency of dam / reservoir operation	NPC	NIA
Crest length (m)	368.0	1,615.0	Power generation	NPC	!st Gen Power Corp
Crest elevation (El. m)	221.5	232.0	Transmission of power	NGCP	NGCP
Spillway outflow capacity (m^3/s)	7,500	13,000	Design slope		43.5%
Design flood peak Q (m^3/s)	5,600	4,200	Lowest recorded WL	157.56 (Jul 2010)	169.93 (May 1983)
Critical (Low) Level	180	177 (power); 171.5 (irrigation)	Note: * Excluding incremental inflow from Umiray watershed		

Brief on IPO Dam:

It is a component of the Manila Water Supply Project II (MWSP II) functions as a diversion dam. It is located on the Angat River near its confluence with the Ipo River in the Province of Bulacan, about 35 km. NE of Manila and 7 km. downstream of Angat Hydroelectric Plant. It was designed by Camp Dresse and McKEE and Constructed in 1978 to 1984 by Nam Kweng Construction Co. Ltd. It is a mass concrete dam and is basically smaller compared to Angat. It is not an impounding reservoir but functions as a diversion dam. The useful or active storage capacity is only 5.9 million cubic meters, equivalent to just 2-days water requirement of Metro Manila. Below is an schematic diagram of Angat Dam and Ipo Dam system.

Dam Type:	Mass Concrete, gravity Gated spillway & Diversion control	Capacity of Dam	5.9 million cubic meters
Concrete Quantity	85,000 m^3	Maximum Elevation	102.0 m
Crest Length	202.0 m	Optimum Oprtg. Level	100.0 m
Height	32.0 m	Watershed Area	6,600 m^2



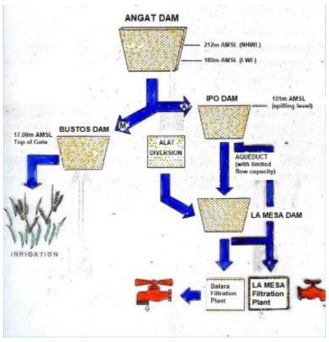
Angat Dam (NPC)
Started Operations in 1986
Storage Capacity of 848.6 MCM
Dam Crest Elevation of 221.5 m (AMSL)
Spillway Gate Crest Elev. = 217.0 m (AMSL)
Power Generation of 228 MW

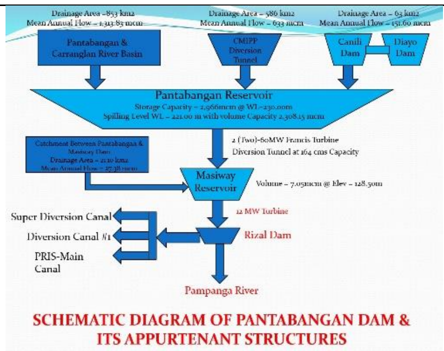
Angat Spillway

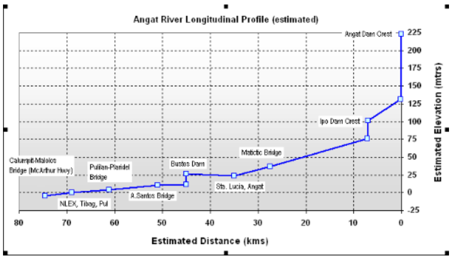
Pantabangan Spillway & reservoir

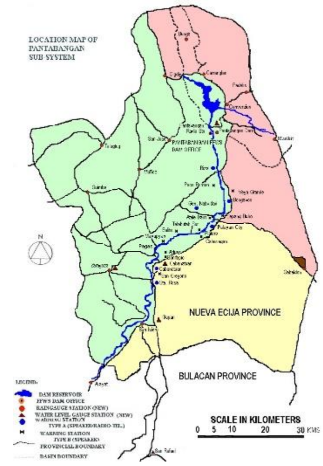
Ipo Dam reservoir

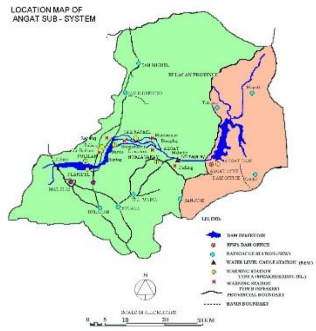

Main Dam
Power Plant
Aya Dam
Spill-Way


ANGAT DAM
212m AMSL (NHWL)
180m AMSL (LWL)
IPO DAM
101m AMSL (spilling level)
BUSTOS DAM
17.00m AMSL Top of Gate
ALAT DIVERSION
AQUEDUCT (with limited flow capacity)
LA MESA DAM
IRRIGATION
Balara Filtration Plant
LA MESA Filtration Plant


Pantabangan & Carranglan River Basin
CMIPP Diversion Tunnel
Canili Dam
Diayo Dam
Pantabangan Reservoir
Masiway Reservoir
12 MW Turbine
Super Diversion Canal
Diversion Canal #1
PRIS-Main Canal
Rizal Dam
Pampanga River
SCHEMATIC DIAGRAM OF PANTABANGAN DAM & ITS APPURTENANT STRUCTURES


Angat River Longitudinal Profile (estimated)
Angat Dam Crest
Ipo Dam Crest
Matictic Bridge
Bustos Dam
Sta. Lucia, Angat
Pulilan-Plaridel Bridge
A.Santos Bridge
Calumpit-Malolos Bridge (McArthur Hwy)
NLEX, Tibag, Pul
Estimated Distance (kms)
Estimated Elevation (mtrs)


LOCATION MAP OF PANTABANGAN SUB SYSTEM
NUEVA ECIJA PROVINCE
BULACAN PROVINCE
SCALE IN KILOMETERS


LOCATION MAP OF ANGAT SUB - SYSTEM

NOTES:

PRBFFWC 2024

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