REGION 3

Pampanga River:

DREAM Ground Surveys Report

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY

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List of Abbreviations

ADCP	Acoustic Doppler Current Profiler
AWLS	Automated Water Level Sensor
BM	Benchmark
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DG	Depth Gauge
DOST	Department of Science and Technology
DPC	Data Processing Component
DREAM	Disaster Risk Exposure and Assessment for Mitigation
DVC	Data Validation Component
EGM 2008	Earth Gravitation Model 2008
FMC	Flood Modeling Component
GCP	Ground Control Point
GE	Geodetic Engineer
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
LGUs	Local Government Units
NAMRIA	National Mapping and Resource Information Authority
PCG	Philippine Coast Guard
PDRRMC	Provincial Disaster Risk Reduction Management Council
PPA	Philippine Ports Authority
PPK	Post Processed Kinematic
RG	Rain Gauge
TCAGP	Training Center for Applied Geodesy and Photogrammetry
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984

Introduction

Introduction

1.1 DREAM Program Overview

The UP training Center for Applied Geodesy and Photogrammetry (UP TCAGP) conducts a research program entitled "Nationwide Disaster Risk and Exposure Assessment for Mitigation" supported by the Department of Science and Technology (DOST) Grant-in-Aide Program. The DREAM Program aims to produce detailed, up-to-date, national elevation dataset for 3D flood and hazard mapping to address disaster risk reduction and mitigation in the country.

The DREAM Program consists of four components that operationalize the various stages of implementation. The Data Acquisition Component (DAC) conducts aerial surveys to collect LiDAR data and aerial images in major river basins and priority areas. The Data Validation Component (DVC) implements ground surveys to validate acquired LiDAR data, along with bathymetric measurements to gather river discharge data. The Data Processing Component (DPC) processes and compiles all data generated by the DAC and DVC. Finally, the Flood Modeling Component (FMC) utilizes compiled data for flood modeling and simulation.

Overall, the target output is a national elevation dataset suitable for 1:5000 scale mapping, with 50 centimeter horizontal and vertical accuracies, respectively. These accuracies are achieved through the use of state-of-the-art airborne Light Detection and Ranging (LiDAR) Systems collects point cloud data at a rate of 100,000 to 500,000 points per second, and is capable of collecting elevation data at a rate of 300 to 400 square kilometer per day, per sensor.

1.2 Objectives and target outputs

The program aims to achieve the following objectives:

a. To acquire a national elevation and resource dataset at sufficient resolution to produce information necessary to support the different phases of disaster management,
b. To operationalize the development of flood hazard models that would produce updated and detailed flood hazard maps for the major river systems in the country,
c. To develop the capacity to process, produce and analyze various proven and potential thematic map layers from the 3D data useful for government agencies,
d. To transfer product development technologies to government agencies with geospatial information requirements, and,
e. To generate the following outputs
    1. flood hazard map
    2. digital surface model
    3. digital terrain model and
    4. orthophotograph

1.3 General methodological framework

The methodology employed to accomplish the project's expected outputs are subdivided into four (4) major components, as shown in Figure 1. Each component is described in detail in the following sections.

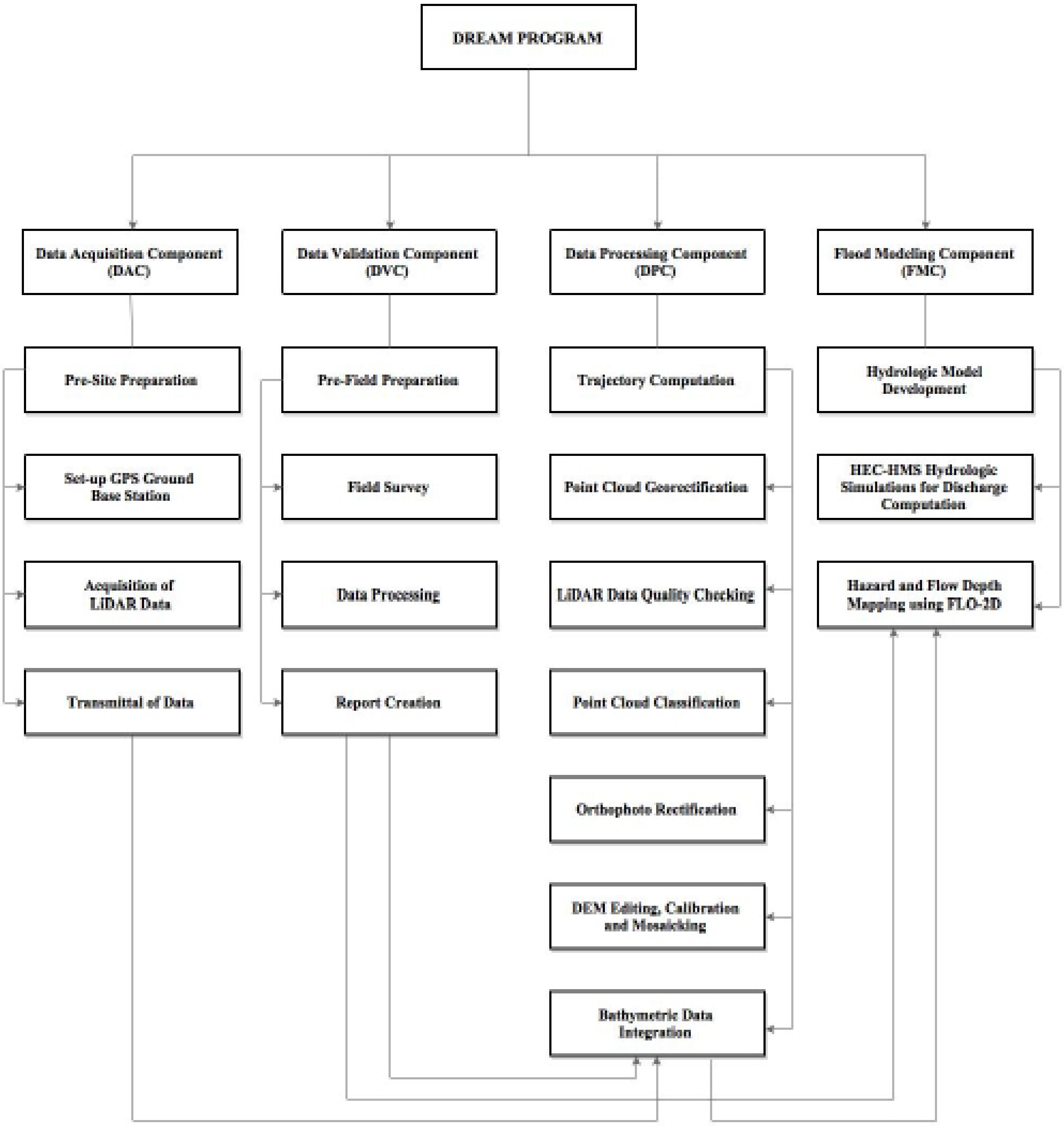


Figure 1. The General Methodological Framework of the Program

The Pampanga River Basin

The Pampanga River Basin

The Pampanga River Basin is located in the Central Luzon Region. The Pampanga River Basin is considered as the fourth largest river basin in the Philippines. It is also considered as the second largest of Luzon's catchments, next to Cagayan River. It has an estimated basin area of 9,759 square kilometers. The location of Pampanga River Basin is as shown in Figure 2.

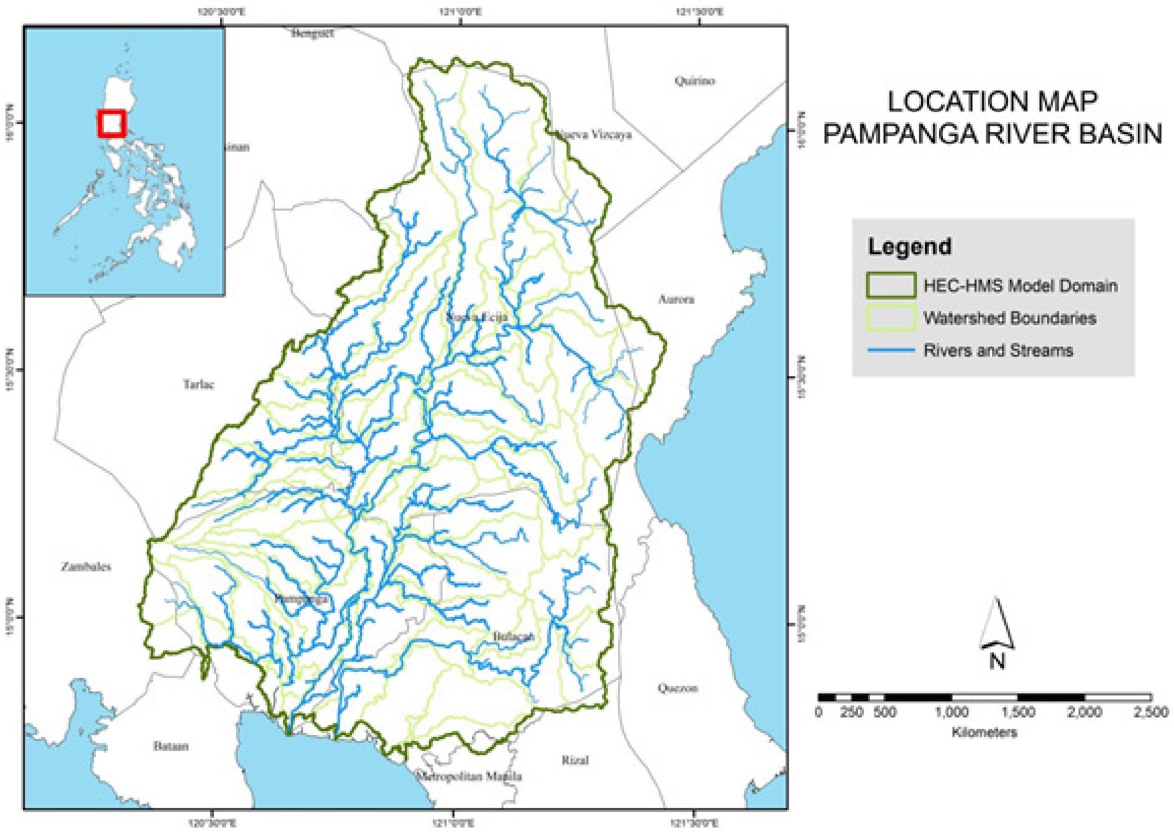


Figure 2. The Pampanga River Basin Location Map

It traverses from the southern slopes of Caraballo Mountains, range of Sierra Madre, Central Plain of the Luzon Island to its mouth in Manila Bay via the Lanbangan Channel. It is supported by four tributaries namely: Penaranda River, Coronel-Santor River, Rio Chico River and Bagbag River. The river basin encompasses parts of the following provinces: Aurora, Bataan, Bulacan, Nueva Ecija, Nueva Vizcaya, Pampanga, Pangasinan, Rizal and some parts of the national capital region including Valenzuela, Caloocan, and Quezon City. The Pampanga River Basin serves as a source of water supply for the irrigation of Nueva Ecijia.

The land and soil characteristics are important parameters used in assigning the roughness coefficient for different areas within the river basin. The roughness coefficient, also called Manning's coefficient, represents the variable flow of water in different land covers (i.e. rougher, restricted flow within vegetated areas, smoother flow within channels and fluvial environments).

The shape files of the soil and land cover were taken from the Bureau of Soils, which is under the Department of Environment and Natural Resources Management, and National Mapping and Resource Information Authority (NAMRIA). The soil and land cover of the Pampanga River Basin are shown in Figures 2 and 3, respectively.

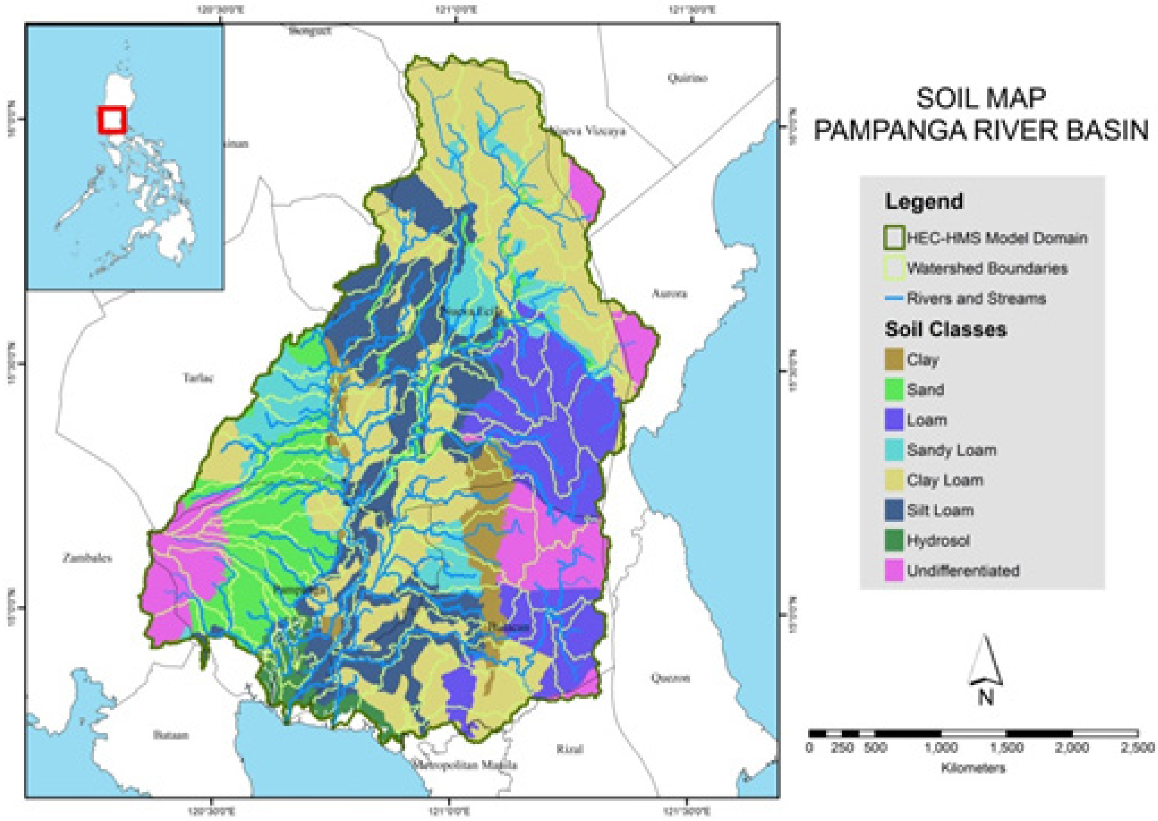


Figure 3. Pampanga River Basin Soil Map

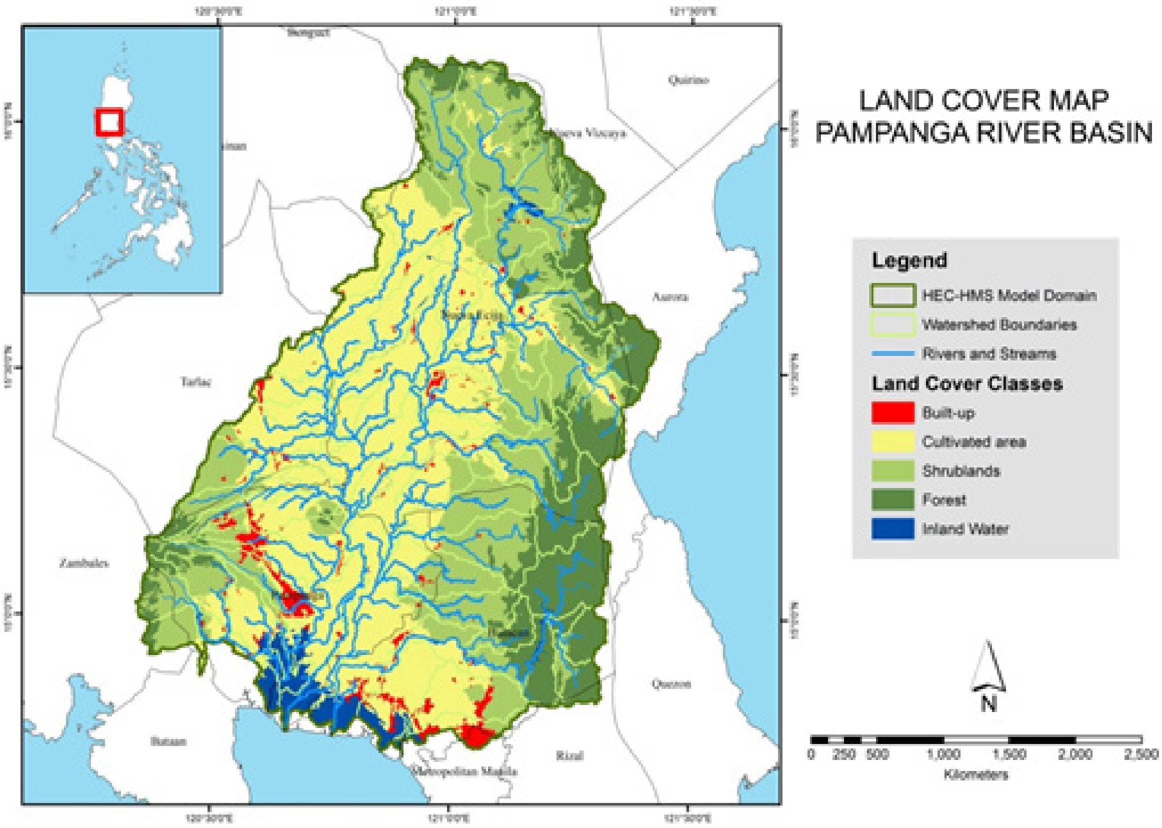


Figure 4. Pampanga River Basin Land Cover Map

DVC Methodology

DVC Methodology

A set of activities were designed and implemented by DVC with four (4) main activities as shown in Figure 5.

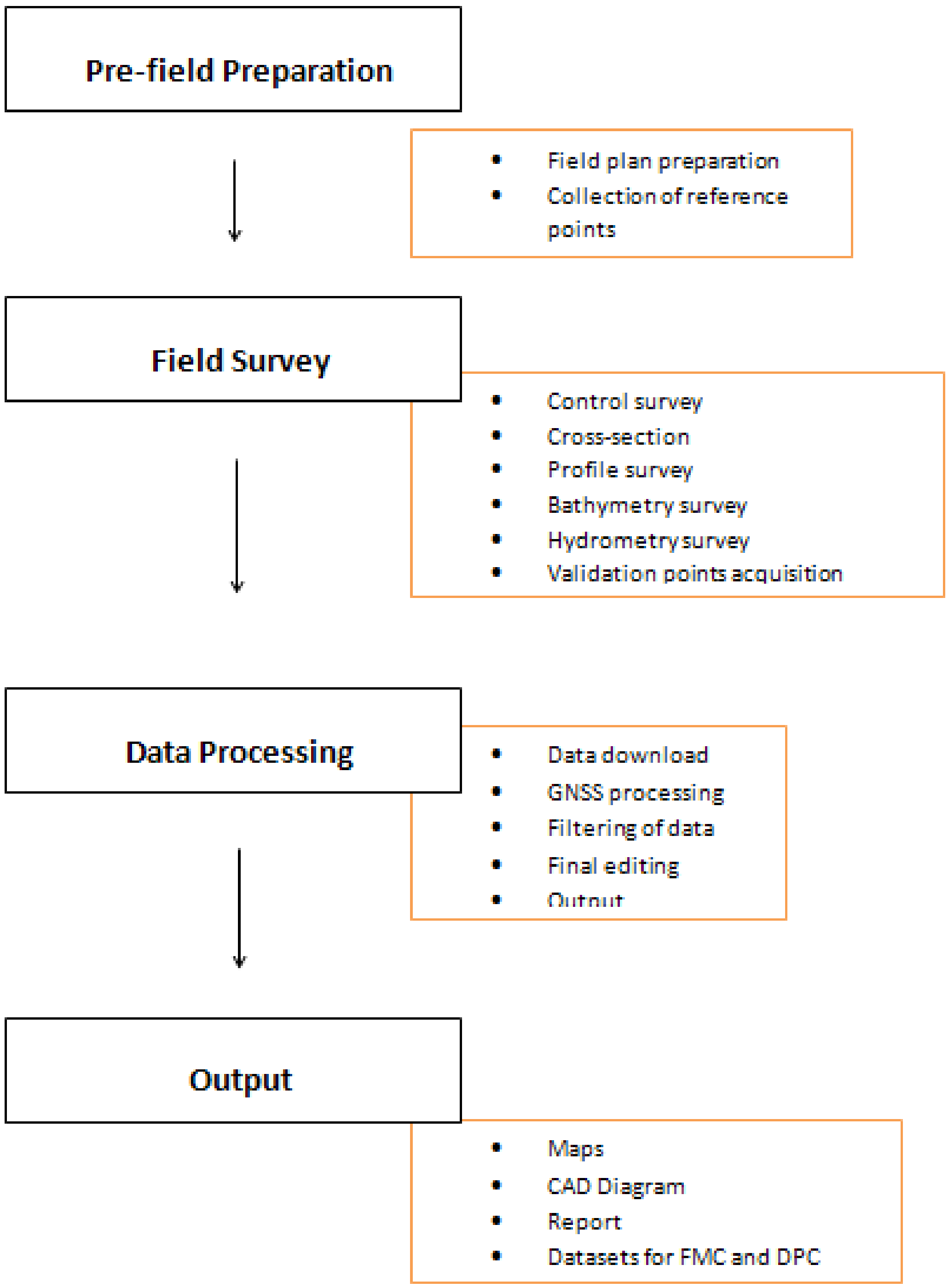


Figure 5. DVC Main Activities

DVC Methodology

3.1 Pre-field Preparation

3.1.1 Preparation of Field Plan

The planning for research fieldwork considers all the necessary technical and logistical concerns conceptualized in a field plan.

This serves as a basis and guide of the survey team in the implementation of the fieldwork activities and included the following activities:

- Delineation of bathymetry lines and determination of the river basin extent using Google Earth® images and available topographic maps;
- Listing and preparation of the survey equipment and other materials needed;
- Designation of tasks to DVC members for the field survey;
- Approximation of field duration and cost based on the delineated survey extent; and
- Assessment of the initial field plan by the program management for approval and implementation.

3.1.2 Collection of Reference Points

Technical data and other relevant information are collected from the National Mapping and Resource Information Authority (NAMRIA) such as locations and descriptions of established horizontal and vertical control points with a minimum of 2nd order accuracy. These ground control points and benchmarks are selected and occupied as primary reference points for the establishment of a GNSS network for the survey.

3.2 Field Surveys

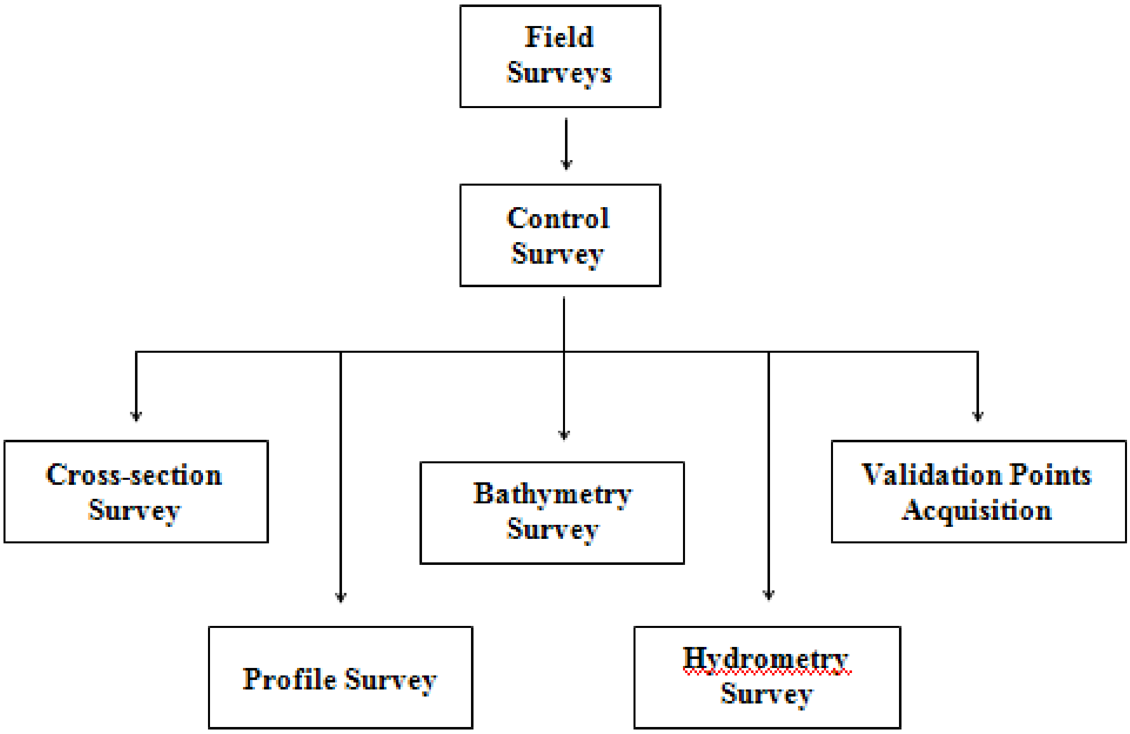


Figure 6. DVC Field Activities

3.2.1 Control Survey

A GNSS network is established through occupation of reference points with dual frequency GNSS receivers for four (4) hours. Reference points from NAMRIA only bear vertical coordinates (z or elevation value) and horizontal coordinates (x and y values) for benchmarks and ground control points, respectively.

Control survey aims to provide both the horizontal and vertical position for every control point established through network adjustment. Horizontal position is acquired through static survey while establishment of vertical position can be done either using a Total Station (TS) or digital level or through static survey.

For the vertical position control survey using a TS or Level, a double run is carried out connecting the nearest existing NAMRIA benchmarks (BMs) to the control point. A double run consists of a forward run (from BM to GCP) and backward run (from GCP to BM). The accuracy shall be assessed and accepted if it is within the third order differential leveling standard.

A benchmark may be used to refer elevation data to Mean Sea Level (MSL) within 20-km radius. Additional benchmarks are located for survey areas exceeding this 20-km radius.

Establishment of a GNSS network through control survey is pre-requisite for the conduct of other ground survey activities. Reference and control points occupied for the control survey may serve as base stations throughout the survey area.

3.2.2 Cross-section Survey

The objective of this activity is to derive a sectional view of the main river and the flood plain (right and left banks). Cross-sections are surveyed perpendicular to the riverbanks with an average length of 100 meters for each bank. The cross-section line shall follow the path of the nearby road or goat trails with a 10-meter interval for each point measurement. Additional points are obtained to describe apparent change in elevation along the cross-section line. Each cross-section is identified sequentially from upstream to downstream direction.

Cross-section surveys are done using dual frequency GNSS receivers and differential kinematic GNSS survey technique. The accuracy of the horizontal position and elevation of each individual cross-section surveys is within ±20 cm for horizontal and ±10 cm for vertical position residuals.

Areas where kinematic GNSS survey is not applicable due to the presence of obstructions such as tall structures and canopy of trees, conventional surveying techniques such as total stations and level are used to collect cross-sectional data.

3.2.3 Profile Surveys

Profile surveys are conducted to obtain the upper and lower banks of the river. This data is overlaid with LIDAR data to delineate the longitudinal extent of the river.

A profile survey consists of the Left Upper Bank (LUB) and Left Lower Bank (LLB), Right Upper Bank (RUB) and Right Lower Bank (RLB). An interval between successive profile points is approximately 10 meters. Additional points are gathered to describe apparent change in elevation along the profile line

Profile surveys are conducted using dual frequency GNSS receivers and kinematic survey technique with a prescribed vertical accuracies of ±20 cm for horizontal and ±10 cm for vertical position, respectively. Conventional surveying techniques such as total stations and level are used to collect profile data for areas where kinematic GNSS survey is not applicable due to obstructions such as tall structures and canopy of trees.

3.2.4 Bathymetric Survey

Bathymetric survey is performed using a survey-grade single beam echo sounder capable of logging time-stamped depth value in centimeter and dual frequency GNSS using kinematic survey technique, with prescribed vertical accuracies of ±20 cm for horizontal and ±10 cm for vertical position for rivers navigable by boat. Data acquisition is logged at one second intervals both for GPS positions and elevation and echo sounder depth reading

For portions of the river that is not navigable by boat due to shallow waterless than a meter, riverbed may be acquired using manual bathymetric survey. Manual bathymetric survey means manually acquiring riverbed points without the use of an echo sounder. It can be done using a GPS receiver, Total Station or Level.

3.2.5 Hydrometric Survey

Hydrometric survey consists of deployment of flow gathering sensors in order to produce a Stage-Discharge (HQ) computation for specific locations in the river such as in its upstream, tributaries, and downstream. This is done to determine the behavior of the river given specific precipitation levels.

The elements of discharge computation are the ff.:

- **River flow data –** river flow data can be acquired using an Acoustic Doppler Current Profiler (ADCP) or by mechanical or digital flow meters. River flow data sensors measure velocity of the river for a specific time period and interval.
- **Cross-section data –** cross section data is acquired using dual frequency GPS receivers to obtain the cross-section area of the river. Cross-section area of a river changes in time as influenced by water level change.
- **Water level change –** water level change is measured using either a depth gauge or an Automated Water Level Sensor (AWLS) installed by DOST. Depth gauges relates pressure to water level change while AWLS uses laser pulsed at specific time intervals for measurement.
- **Water surface elevation –** water surface elevation in MSL is measured near the banks of the river with dual frequency GPS receivers. This will refer the measured water level change to a corresponding elevation value in MSL in order to derive Stage or water level height a particular time.

Precipitation is the biggest factor influencing stage and river velocity. These two (2) sets of data must be synchronized by time in order to compute for its cross-section area, and subsequently, for discharge.

The element of time is crucial in determining the delay between the onset of precipitation and the time of significant water level change along key points of the river for early flood warning system of communities. The correlation of stage-discharge computation is used for calibrating flood-simulation programs utilized by the Flood Modeling Component (FMC).

The summary of elements for discharge computation is illustrated in Figure 7.

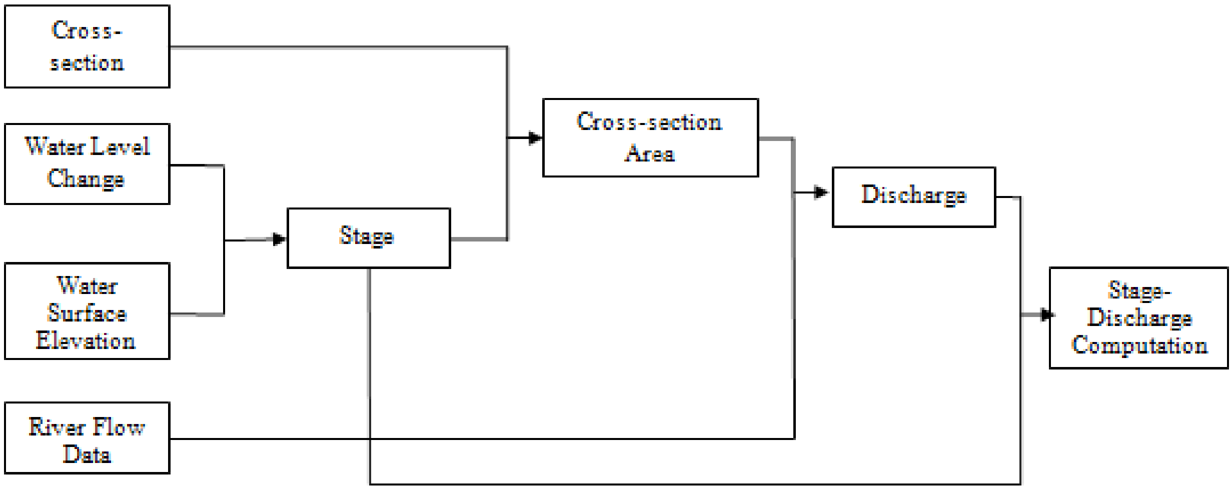


Figure 7. Flow Chart for Stage-Discharge Correlation Computation

3.2.6 Validation Points Acquisition Survey

Ground validation survey is conducted for quality checking purpose of the Aerial LiDAR data acquired by the Data Acquisition Component (DAC). A roving GNSS receiver is mounted on a range pole attached to a vehicle to gather points thru continuous topo method in a PPK Survey Technique. Points are measured along major roads and highway across the flight strips provided by DAC.

GNSS surveys setup used to accomplish DVC's field survey activities are illustrated in Figure 8.

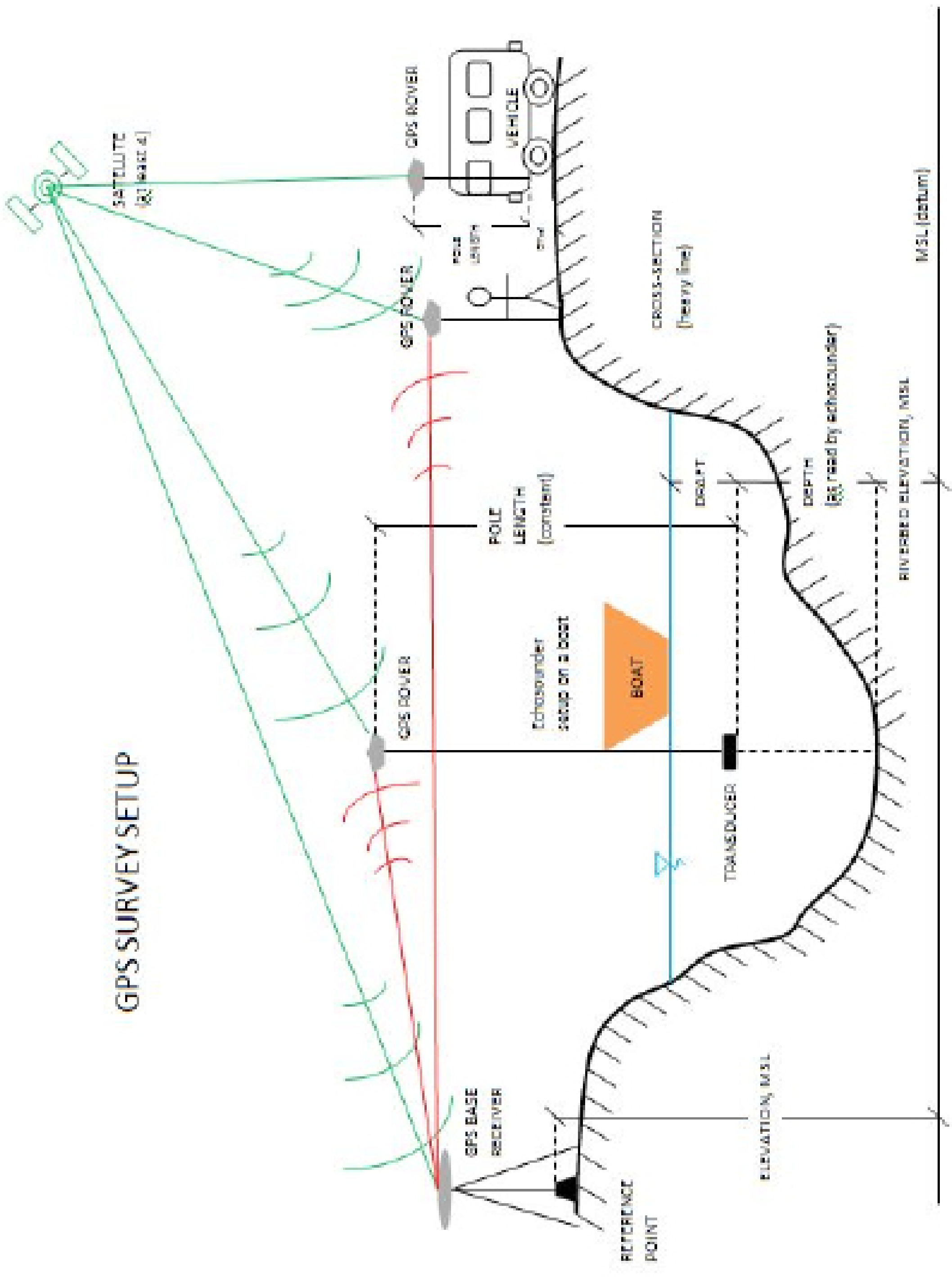


Figure 8. Set-up for GNSS Survey

3.3 Data Processing

Data processing procedures used by DVC are summarized in Figure 9.

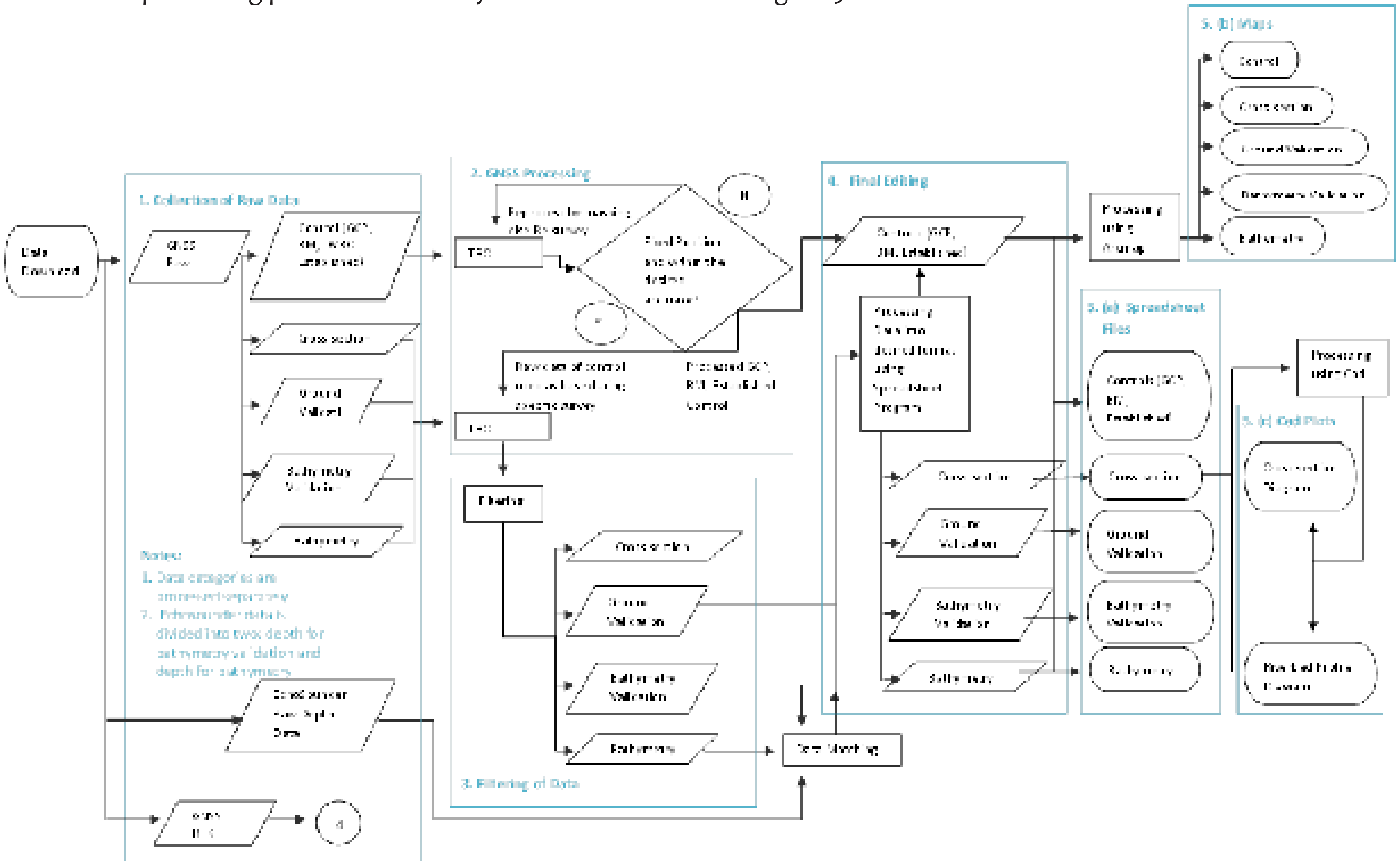


Figure 9. DVC Data Processing Methodology

3.3.1 Collection of Raw Data

GPS Raw data in (*.t02) format are downloaded from Trimble™ GPS receivers used in static, cross-section, LiDAR ground validation, and bathymetric surveys. Depth values in (*.som) files from bathymetric surveys are also downloaded from OHMEX® echo sounder.

3.3.2 Data Processing

Processing for GNSS Data

The horizontal and vertical coordinates of the reference point used as base station are held fixed, based on its NAMRIA certification, for the establishment of a GNSS network for the survey area. Coordinates of this fixed point is used to give horizontal and vertical coordinates for the other reference points occupied and control points established.

Data from GNSS control surveys are processed in Trimble™ Business Center (TBC) software and settings were set to the required accuracy of +/-10cm for vertical and +/-20cm for horizontal controls. The TBC coordinate system parameters were set to Universal Transverse Mercator (UTM) Zone 51 North, World Geodetic System of 1984 (WGS1984), and the geoid model EGM2008 for horizontal and vertical datum, respectively.

An offset is derived by comparing the MSL elevation of the benchmark stated in the NAMRIA certification and its elevation value that resulted from the processed and adjusted control survey. This offset is used to refer all elevation from other surveys into MSL (BM_Ortho).

The formulas used for offset and BM_Ortho computation are shown in Equations 1-2:

Computation for offset:

Equation 1:

$$OFFSET = BM - EGM$$

Computation for BM_ortho:

Equation 2:

$$BM_{\_ortho} = EGM_{\_ortho} \pm OFFSET$$

where:

OFFSET	= difference/offset between Geoid model, EGM 2008 and MSL datum. Can be a positive or negative value
BM	= MSL elevation of vertical control point certified by NAMRIA
EGM	= EGM2008 elevation of the same NAMRIA vertical control point derived from TBC software processing
***EGM** $_{\_Ortho}$*	= elevation of points referred to geoid model, EGM 2008
***BM** $_{\_Ortho}$*	= elevation of points referred to MSL

GNSS processing is also done for the other surveys with the coordinates from the occupied points for the control survey held fixed, depending on which base station is used for the survey.

Processed and adjusted data are exported to comma delimited (*.csv) file format with the ff. columns: Point Name, Latitude, Longitude, Ellipsoidal Height, Northing, Easting, and Elevation (EGM_Ortho). This file format can be accessed through Microsoft Excel/Spreadsheet program.

Depth Data Processing

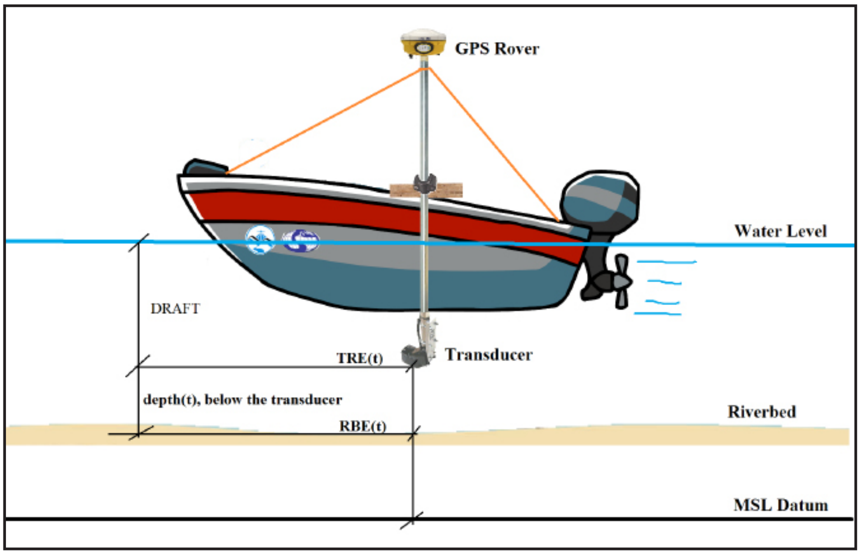


Figure 10. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

There are two types of echo sounders used for bathymetric surveys – Hi-Target™ single beam echo sounder which is capable of recording depth data of one decimal place and the OHMEX™ single beam echo sounder capable of recording two-decimal places of depth data.

Raw depth data from Hi-Target™ single beam echo sounder is exported in (*.txt) file format with the ff. columns: Point No., Time, Depths H, Depths L, Draft, and Sound Velocity. This (*.txt) file is copied to a spreadsheet, retaining only the columns for Time and Depths H.

Raw depth data from OHMEX™ single beam echo sounder are exported in (*.som) file format. It is imported into SonarVista then exported into *.csv format with the ff. columns: Type, Date/Time, Sec, X/E, Y/N, Z/H, Tide, Depth and QA. SonarVista is used as file conversion tool only. The (*.csv) file opened using spreadsheet, making use of only the columns for Date/Time and Depth.

Data Matching for Bathymetric Data

Data matching is done by pairing an individual attribute of a bathymetric point to a depth data acquired using either OHMEX or HI-Target echo sounder. Matching is possible by ensuring that both bathymetric points and depth values acquisition has time stamp capability. These two sets of data are matched using VLOOKUP tool of a spreadsheet program, such that each point will have an accompanying (x,y,z) and depth data.

Below is the formula used for computing the elevation of the riverbed:

Equation 3:

$$RBE(t) = TRE(t) - Depth(t)$$

where:

RBE(t) = elevation of the riverbed during time t,

TRE(t) = transducer elevation (reckoned from EGM 2008)

Depth(t) = depth recorded by the echo sounder at time t, with the assumption that depth is measured from the bottom of the transducer down to the riverbed

The resulting RBE(t) data are referred to MSL (BM_ortho) by applying the offset for the established network.

Final processed data are imported to Google Earth™ and Geographic Information Systems (GIS) software for viewing and checking horizontal position.

Hydrometry Data Processing

The processes done for Hydrometry data for HQ computation are described in the ff. steps:

1. River Flow Data

a.) ADCP

Data from the ADCP is logged internally and can be downloaded using either SonUtils™ or View Argonaut™ software. River velocity is recorded for a specified time duration and interval can be exported in a (*.csv) format.

b.) Flow Meter

Acquisition of river velocity using flow meters is done manually. Measurements for a specified time duration and interval is recorded in a field notebook and saved in a spreadsheet program.

2. Cross Section and Water Surface Elevation Data

Cross Section data and water surface elevation data is acquired using GNSS receivers described in section 3.3.4 for GNSS data processing with a resulting file in (*.xls) format.

3. Water Level Change-Stage

a.) Depth Gauge

Data from depth gauge can be downloaded using HobowarePro™. Water level in meters are logged for a specific time interval and it can be exported in a (*.csv) format.

b.) AWLS

Data from installed AWLS can be accessed via the internet (http://repo.pscigrid.gov.ph/predict/). Water levels are logged in ten-minute time intervals and can be copied into a spreadsheet program.

4. Discharge Computation

River flow data and water level change is synchronized by time. Parameters were preset in its respective programs so the deployment of each instrument will begin and end in the same time. All data in (*.csv) and (*.csv) format are combined in a single worksheet wherein the computation for the coefficient of determination or R2 are done.

The illustration in Figure 7 shows how each set of data from each instrument can be synchronized.

3.3.3 Filtering of Data

A processed point which resulted to float or did not meet the desired accuracy is filtered out. Resurveys are conducted immediately if data gaps are present for the ground surveys.

3.3.4 Final Editing

Final editing is performed to be able to come up with the desired data format: Point Value, Latitude, Longitude, Ellipsoidal Height, Northing, Easting, EGM_Ortho and BM_Ortho.

Processes discussed are valid for static, cross section, ground validation, and manual bathymetric surveys not employing echo sounders. For bathymetric surveys using a single beam echo sounder, the GPS rover is mounted on top of a 2m pole and a transducer at the bottom (see Figure 10). Figure is valid in both using OHMEX and HI-Target echo sounders. The GPS rover provides horizontal and vertical coordinates whereas the echo sounder transducer measures depth of the river from its bottom down to the riverbed.

3.3.5 Output

Filtered data are furthered processed into desired template using a spreadsheet program. Final data are generated into maps and CAD plots for cross-section, profile, and riverbed profiles. Cross-section, Profile, Validation Points, and Bathymetric data shall be turned-over to DPC while hydrometric data shall be turned-over to FMC.

Pampanga River Basin Survey

Pampanga River Basin Survey

The survey for Pampanga River Basin was conducted on June 21-29, 2012 with the following activities: profile, cross-section, bathymetric and flow measurement surveys.

Pampanga River consists of 34 delineated cross section lines with a total length of 68.70 km for both left and right banks starting from Brgy. San Juan Bano, Arayat, Pampanga in the upstream down to Brgy. San Roque, Hagonoy Bulacan near the mouth of the river. The total length of profile lines is about 23 km for its both left and right banks.

Other sets of fieldwork were conducted on July 9-24, 2012, October 22-30, 2012, August 22-23, 2013 and February 27-March 5, 2014 to acquire the cross-section and sensor elevation of the installed Automated Water Level Sensor (AWLS) and to perform flow data gathering.

4.1 Control Survey

Two (2) NAMRIA and four (4) established reference points were considered for the static GNSS observations Pampanga River System survey on June 21 – 29, 2012. These include a first order benchmark, PA-177, which is located in Brgy. San Agustin, Arayat Pampanga; a third-order reference point, BLN-3062, situated at Brgy. Sapang-Bayan, Calumpit, Bulacan; and an established control points located on Candaba, San Luis, Sulipan and San Miguel in Pampanga. The locations of these controls are shown in Figure 11.

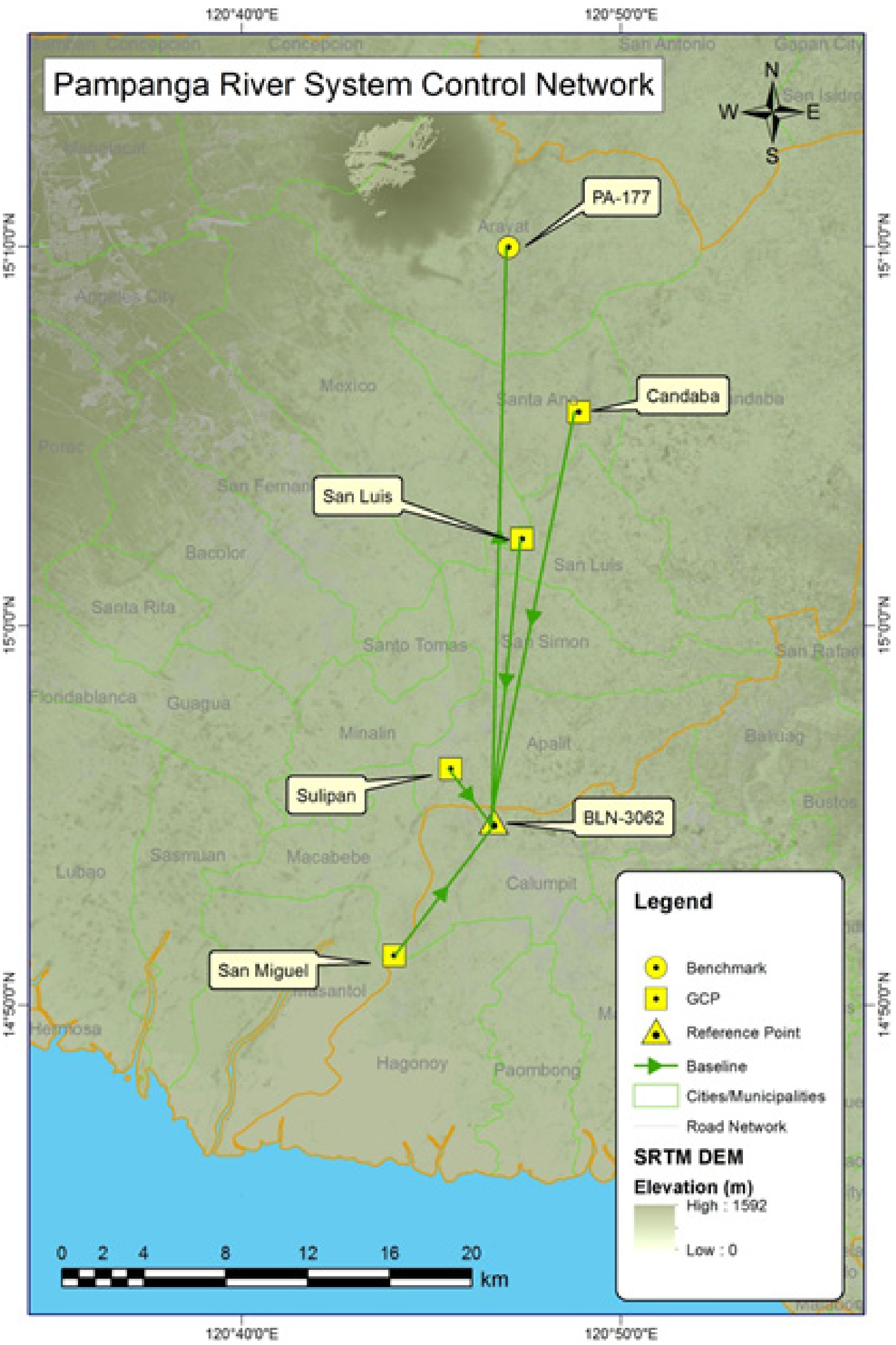


Figure 11. Location of control points for Pampanga River Survey

Continuous differential static observations were done simultaneously at these five stations for two hours to provide reference control points for the ground and bathymetric surveys. The horizontal coordinates and elevations of the five (5) control points were computed using Trimble® Business Center GNSS processing software. The result of control survey for the control points are indicated in Table 1.

Table 1. Control points occupied during Pampanga River Survey (Source: NAMRIA, UP-TCAGP)

Point Name	WGS84 UTM Zone 51N					Elevation in MSL (m)
	Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	
San Miguel	14.511865	120.440146	51.666	1643545.303	256141.177	8.6240
Sulipan	14.561419	120.453031	59.302	1652604.406	258889.384	16.1670
BLN-3062	14.545025	120.463795	46.259	1650003.740	260885.565	1.8909
Candaba	15.053922	120.485327	51.944	1669914.796	265128.133	8.6180
PA-177	15.095962	120.470200	59.994	1677953.608	261885.383	15.5589
San Luis	15.021844	120.472364	57.379	1663768.972	262388.892	14.0410

The GNSS setup for the two (2) of six (6) control points are illustrated in Figures 12 and 13:

Figure 12. Static GNSS observation at BLN-3062

Figure 13. RTK Base set-up in Brgy. Cupang Arayat, Pampanga

4.2 Cross-section Survey

The topography of a river can be described using series of cross-sections that cut perpendicularly across its channel of the river. Bathymetric survey data of the river co which combined with ground survey data of the floodplain can produce a series of cross-sections along the stretch of the river.

Horizontal position (easting and northing) and vertical (elevation) measurements were done at a specific interval as one traverses starting from riverbank across the floodplain. Cross-section survey was done by the team through differential kinematic GNSS surveying of either post-processed kinematic or in real-time kinematic.

Cross section survey was conducted on June 21-29, 2012, July 9-24, 2012 and October 22-30, 2012. Five (5) survey grade, dual frequency GPS receivers were used for data acquisition of cross-section lines on the left and right bank. A total of 33 cross section were gathered starting from Brgy. Camba, Arayat Pampanga down to Sto. Rosario, Hagonoy, Bulacan. A total of 3662 points were gathered for the left and right banks of the river.

Gathering of cross-section point is shown in Figure 14 while data gathered is illustrated in Figure 15.

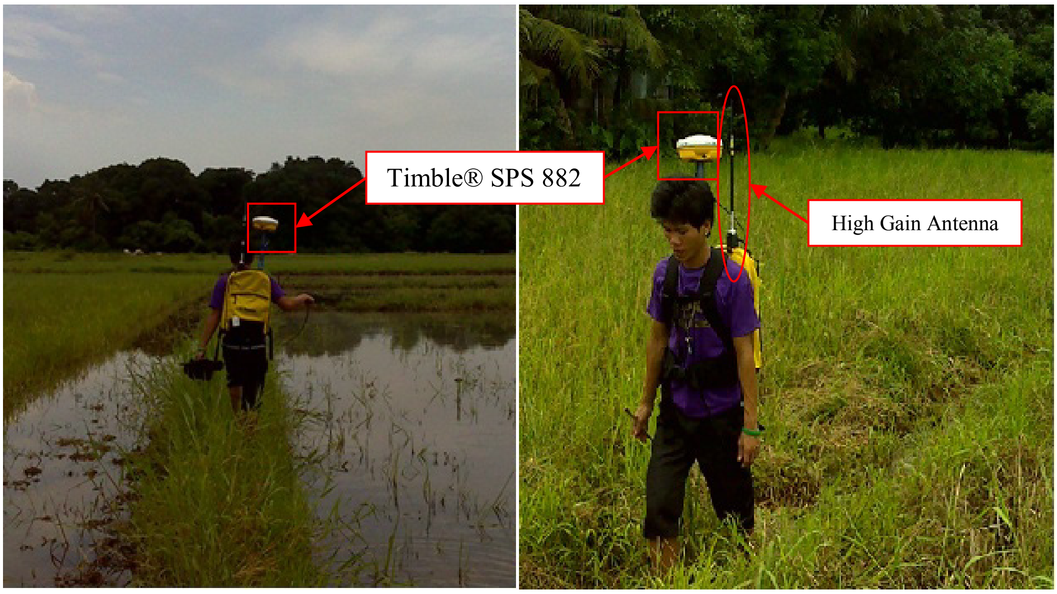


Figure 14. Cross-section teams conducting RTK GNSS survey in Pampanga River

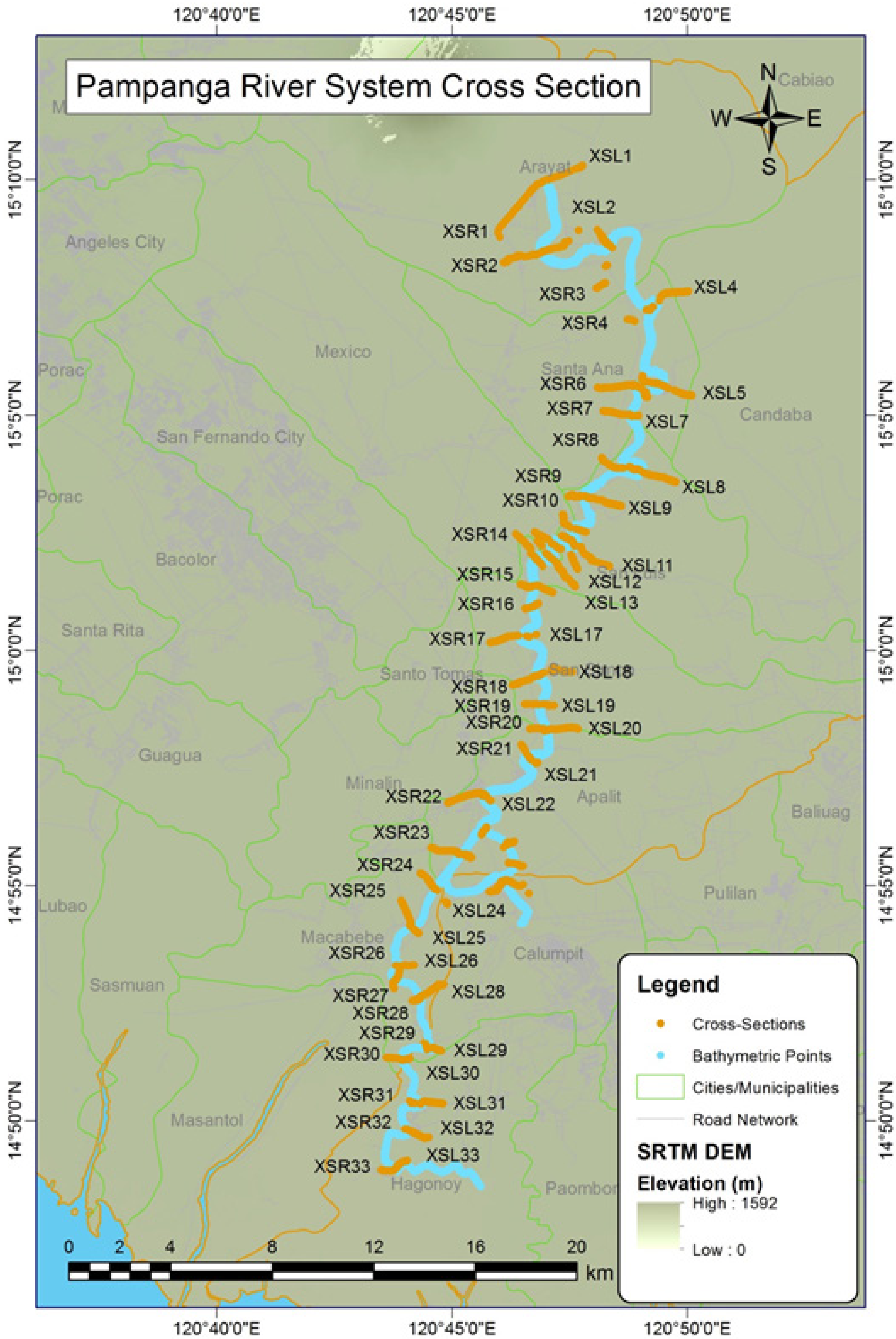


Figure 15. Cross-section data of Pampanga River

4.3 Profile Survey

Another set of ground surveys were conducted along the banks of the river on June 21-29, 2012. The upper and lower banks were measured using MDL Dynascan™ (see Figure 16) covering the entire centerline bathymetry length, approximately 62 kilometers. Profile survey started at Brgy. San Juan Bano, Arayat, Pampanga in the upstream down to Brgy. San Roque, Hagonoy Bulacan near the mouth of the river. This instrument utilizes laser and GNSS technology to take accurate 3D survey measurements. Dubbed as mobile mapping scanner (MMS), the MDL Dynascan™ was attached to the boat of the Special Forces, scans as the boat traverse along the length of the river. The dual-antenna design of the MDL Dynascan™ provides both accurate positioning and heading of the instrument. A high-gain antenna was attached to the MDL Dynascan™ to improve the reception of the RTK.

Figure 16. MDL Dynascan™ installed on one end of the boat for the river bank profile surveys of Pampanga River

4. 4 Bathymetric Survey

The bathymetry of the river channel was surveyed using an echo sounding surveying technique. Differential GNSS surveying technique and an Ohmex™ single beam echo sounder were utilized in measuring the depth, eventually obtaining elevation with corresponding horizontal position. Bathymetry setup during the Pampanga bathymetry survey is illustrated in Figure 17.

The entire bathymetry survey took twelve (12) days to accomplish from June 25 to 28, 2012 and July 12 to 19. 2012 for the centerline and zigzag bathymetry. The Bathymetry Team executed the survey using a rubber boat borrowed from the Special Forces (SF) accompanied by two (2) SF personnel. Centerline and zigzag sweep of the survey were performed in order to fully capture the topography of the river with Special Forces personnel as shown in Figure 18.

An approximate centerline length of 62 km and a zigzag sweep length of 96.19 km were covered starting from Brgy. San Juan, Arayat down to Brgy. Sta. Elena, Hagonoy Bulacan as illustrated in Figure 19.

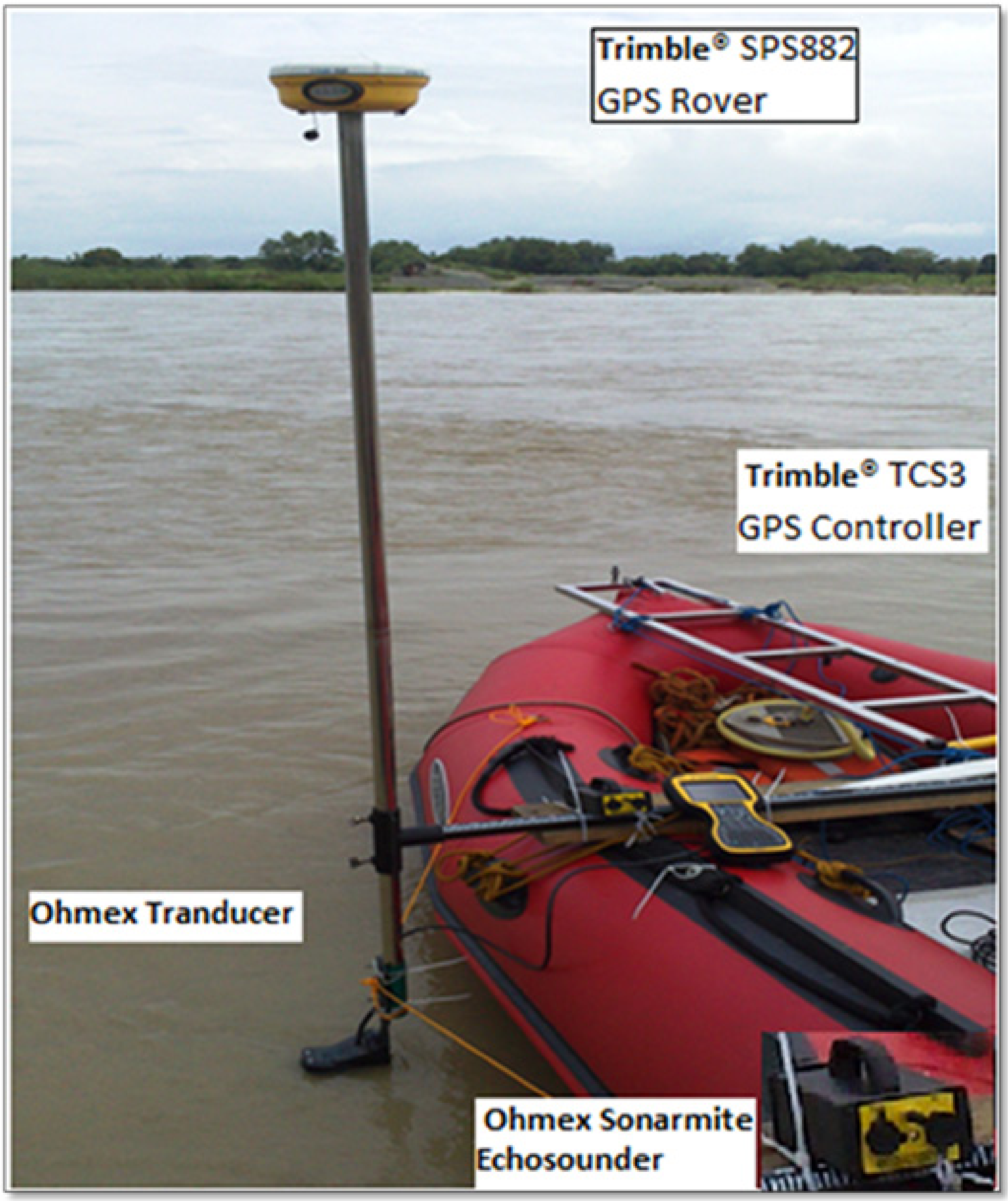


Figure 17. Bathymetric survey setup

Figure 18. Bathymetry team with the Special Forces personnel

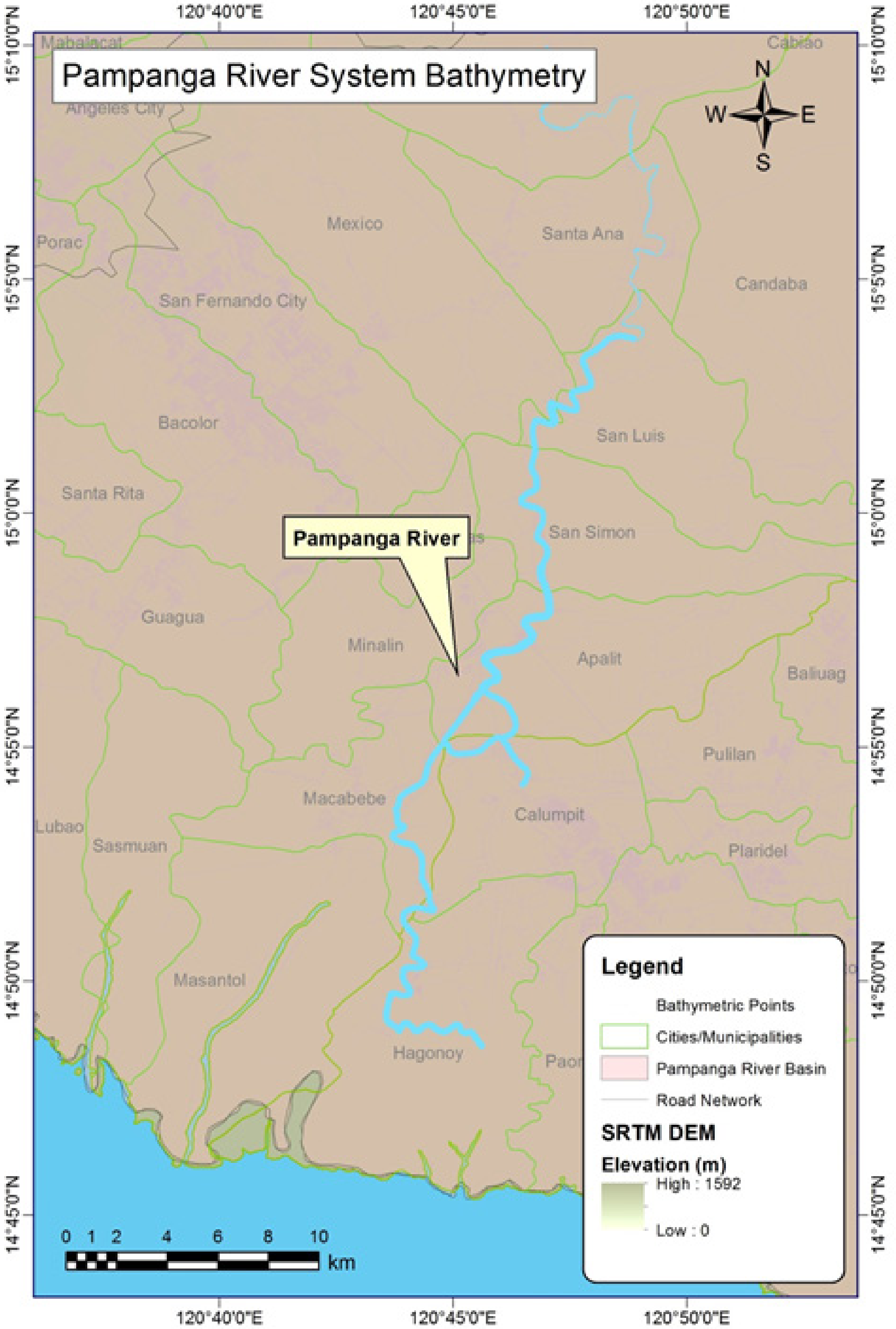


Figure 19. Bathymetric data in Pampanga River

4.5 Hydrometric Survey

Different sensors were deployed on the banks of Pampanga River to obtain its physical characteristics such as cross-section elevation in MSL, velocity, and elevation of water level in MSL at a particular time.

Data collection in Brgy Camba, Arayat using side-looking ADCP for deployment on October 22-29, 2012; Brgy Pulong Vicitas, Apalit using a side-looking ADCP, depth gauge and rain gauge for deployment on August 22-24, 2013; Brgy. San Francisco, Macabebe Pampanga on August 23-25, 2013. The ADCP, depth gauge and rain gauge were monitored and its data downloaded on the day of retrieval.

The data gathered from rain gauge shows the distribution of rainfall within the observation period from October 22 to 29, 2012. The sensor has five (5)-minute interval. The rain gauge is installed in Brgy Camba, Arayat, Pampanga.

The relationship of rainfall data gathered using rain gauge peaking at 5.6 mm/5 min on October 26 at around 4:00 in the afternoon and stage from the deployed depth gauge in Brgy. Camba, Arayat is shown in Figure 20.

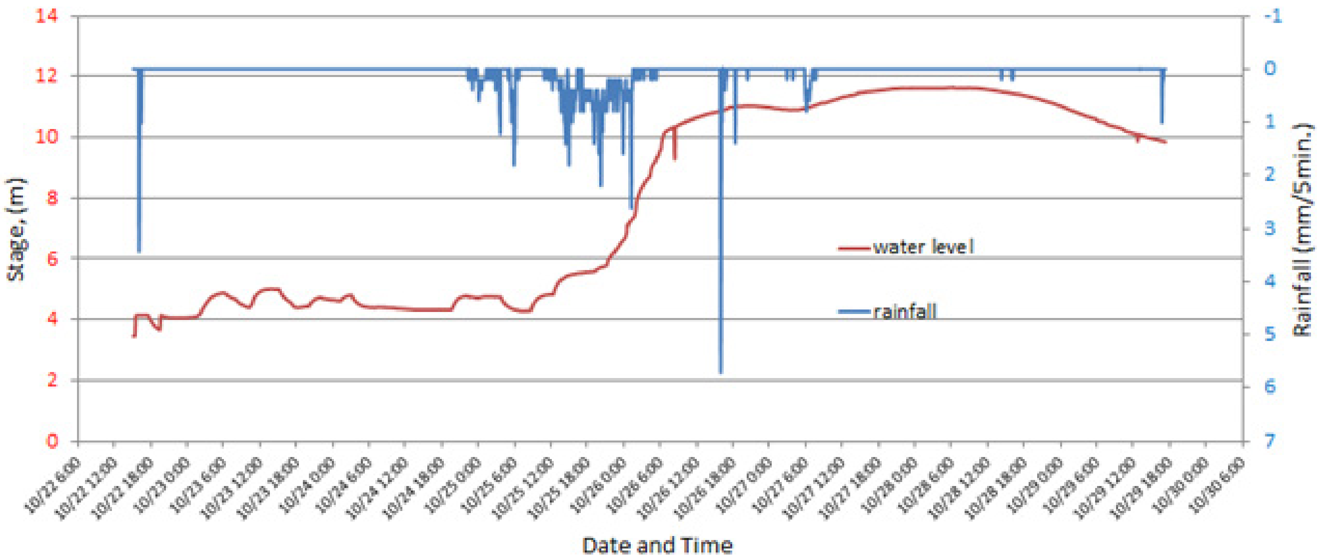


Figure 20. Relationship between velocity and stage in Brgy. Camba, Arayat Pampanga

The relationship of velocity gathered using a side looking ADCP and stage from the deployed depth gauge in Brgy. Camba, Arayat is shown in Figure 21.

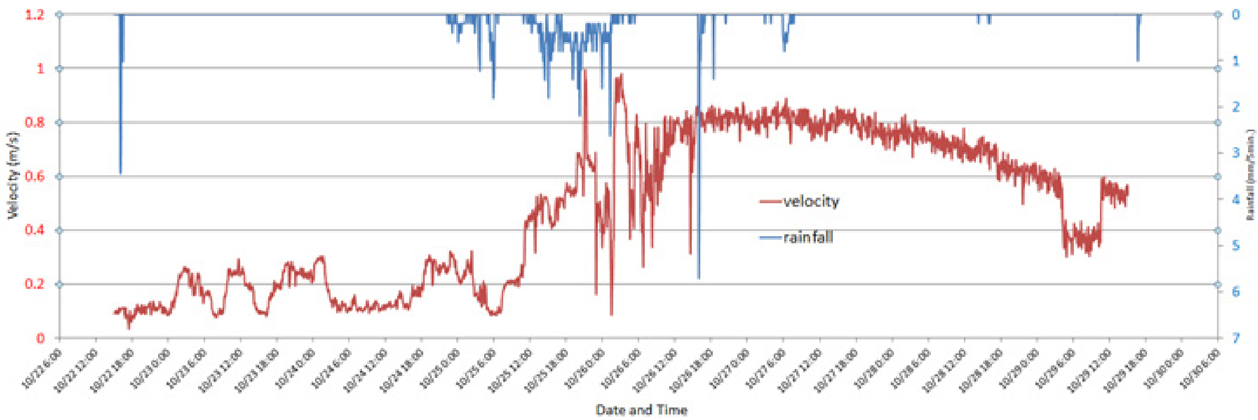


Figure 21. Relationship between velocity and rainfall in Brgy. Camba, Arayat Pampanga

The relationship of velocity gathered using a side looking ADCP and stage from the deployed depth gauge in Brgy. Camba, Arayat is shown in Figure 22.

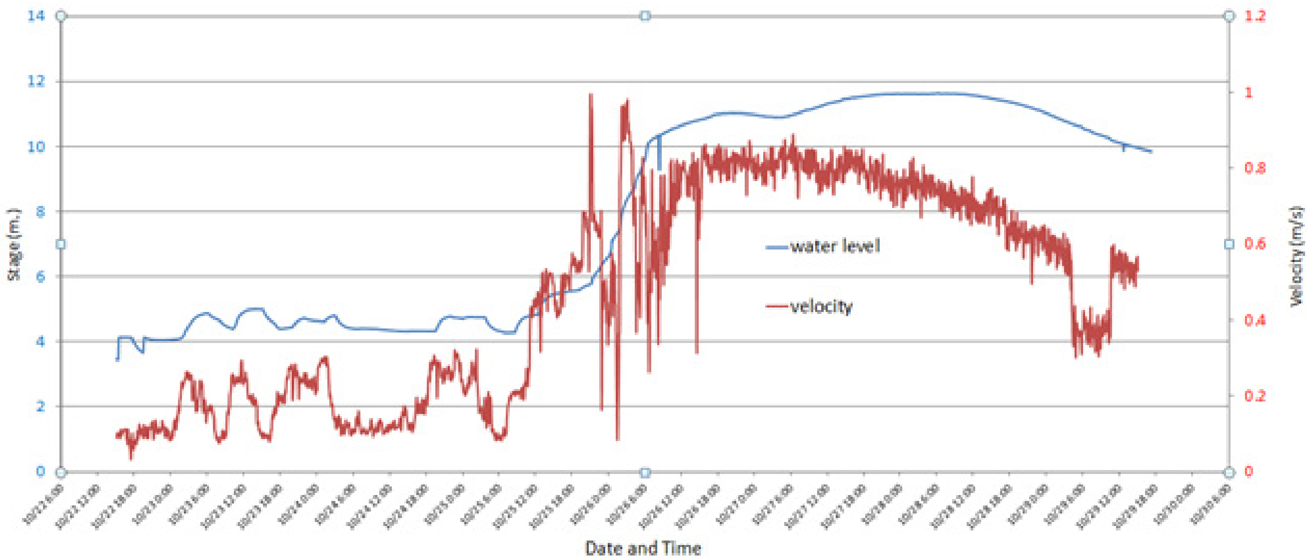


Figure 22. Relationship between velocity and stage in Brgy. Camba, Arayat, Pampanga

The relationship between stage and discharge for October 22- 29, 2013 resulted to an R2 of 8.83E-01in Brgy. Camba Arayat is shown in Figure 23.

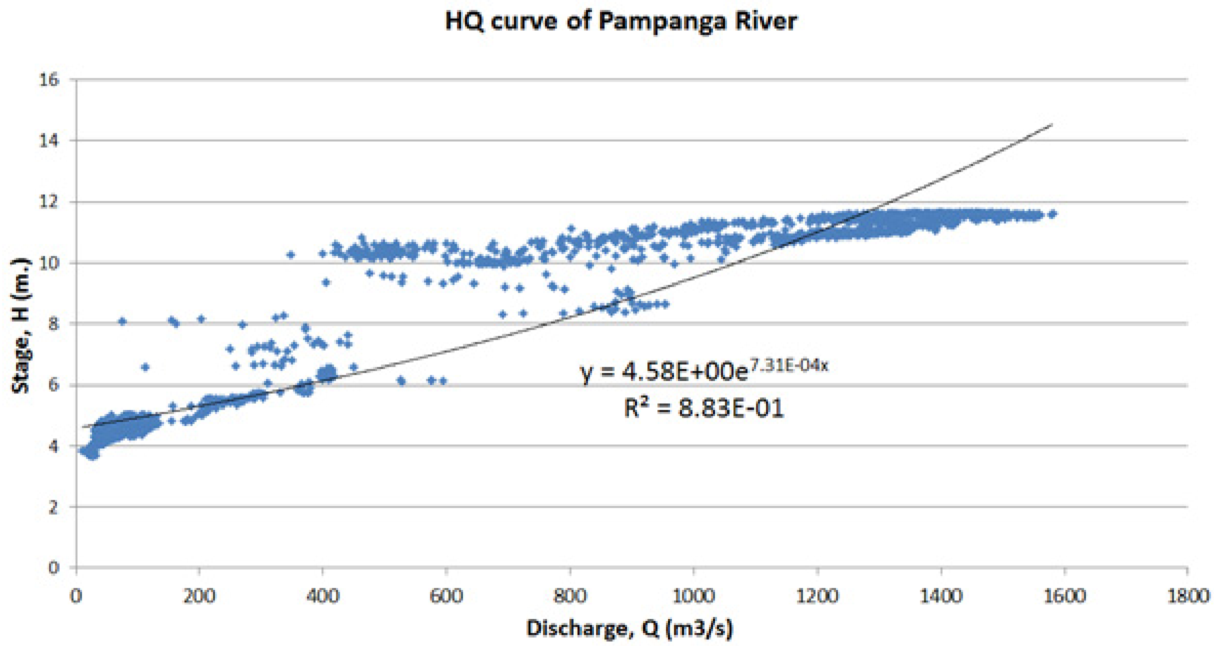


Figure 23. Stage-discharge computation for Brgy. Camba, Arayat, Pampanga

The relationship of rainfall data gathered using the installed rain gauge peaking at 1 mm/5 min. on August 25, 2013 and stage from the deployed depth gauge in Brgy. Pulong Vicitas, Apalit on August 22 to 26, 20 is shown in Figure 24.

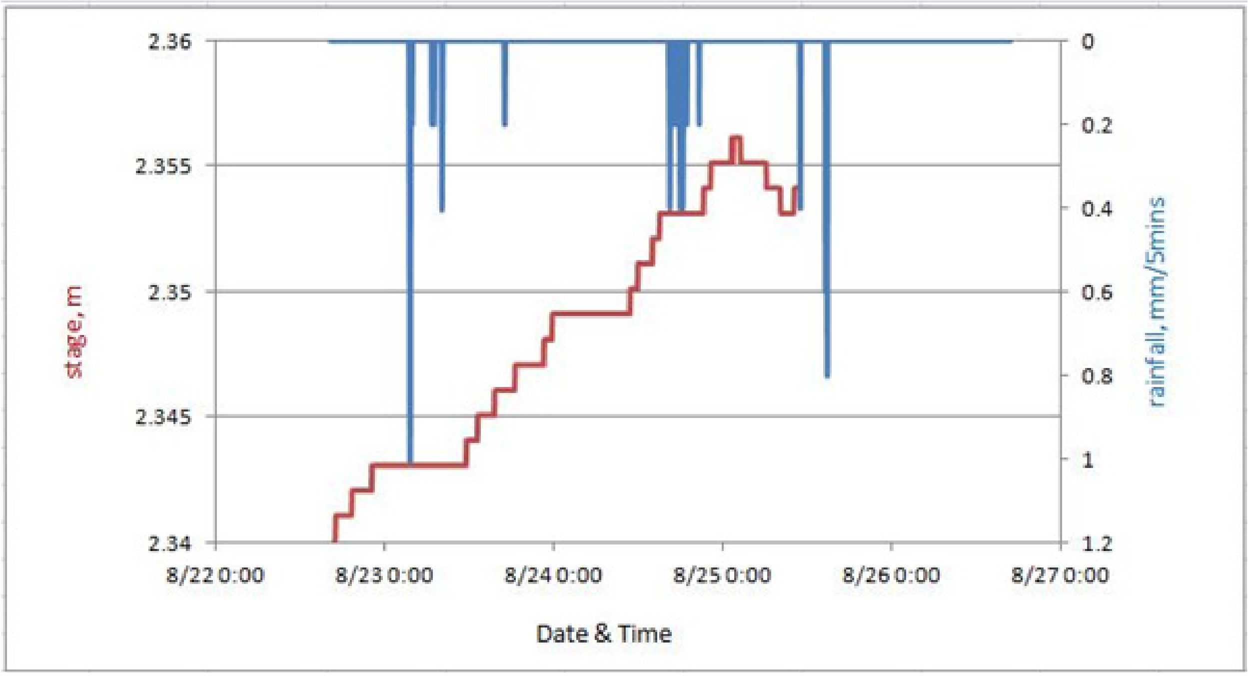


Figure 24. Relationship between rainfall and stage in Brgy. Pulong Visitas, Apalit, Pampanga

The relationship of velocity gathered using a side looking ADCP and rainfall date from the deployed rain gauge gauge in Brgy. Pulong Vicitas, Apalit is shown in Figure 25.

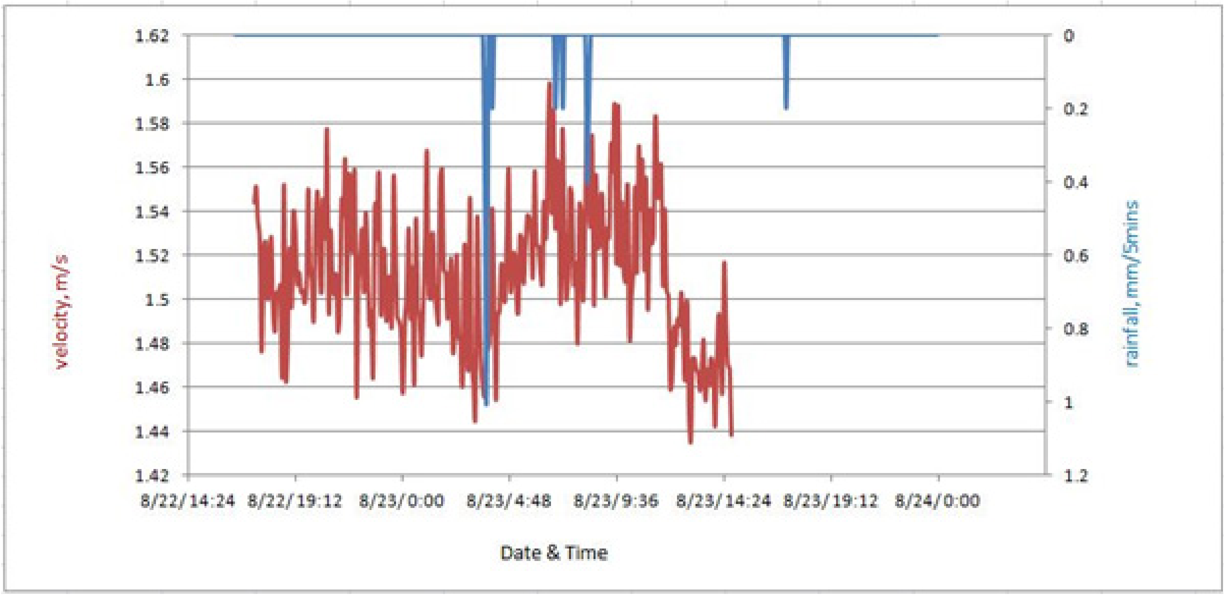


Figure 25. Relationship between velocity and rainfall in Brgy. Pulong Visitas, Apalit, Pampanga

The plot of velocity gathered using a side looking ADCP and stage from the deployed depth gauge in Brgy. Pulong Vicitas, Apalit is shown in Figure 26.

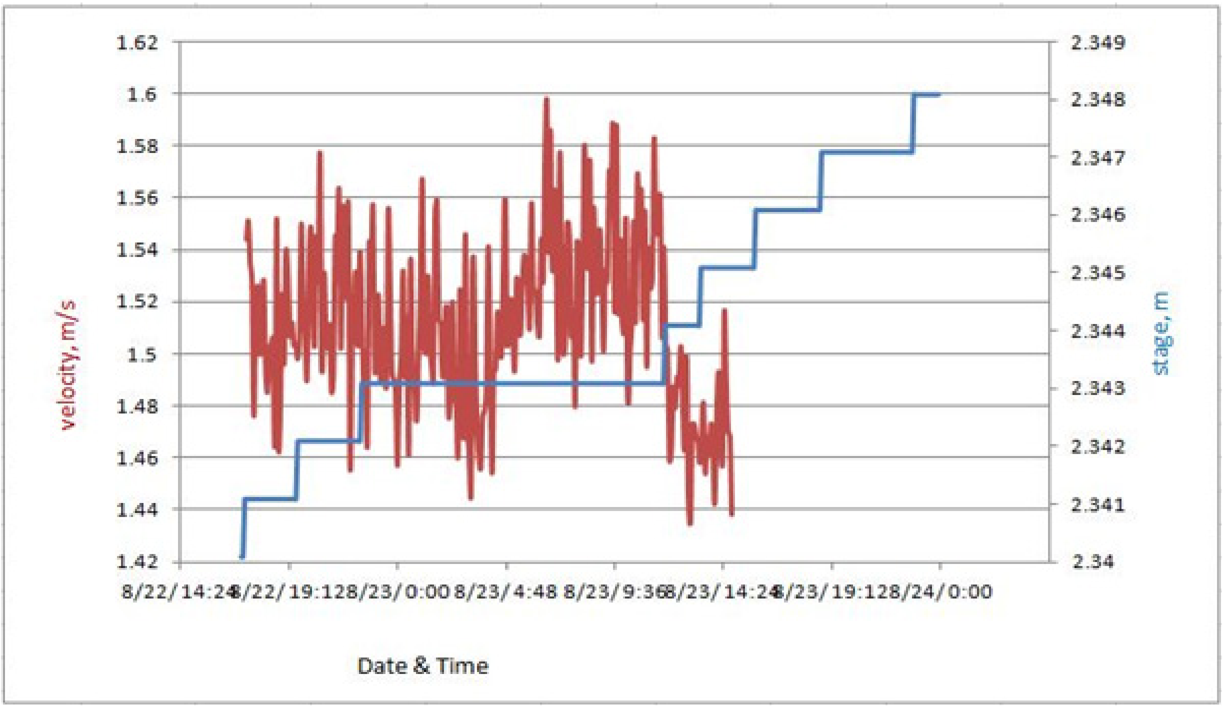


Figure 26. Relationship between Velocity and Stage in Brgy. Pulong Visitas, Apalit, Pampanga

The relationship between stage and discharge for August 22, 2013 resulted to an R2 of 0.3932 in Brgy. Pulong Vicitas, Apalit, Pampanga is shown in Figure 27.

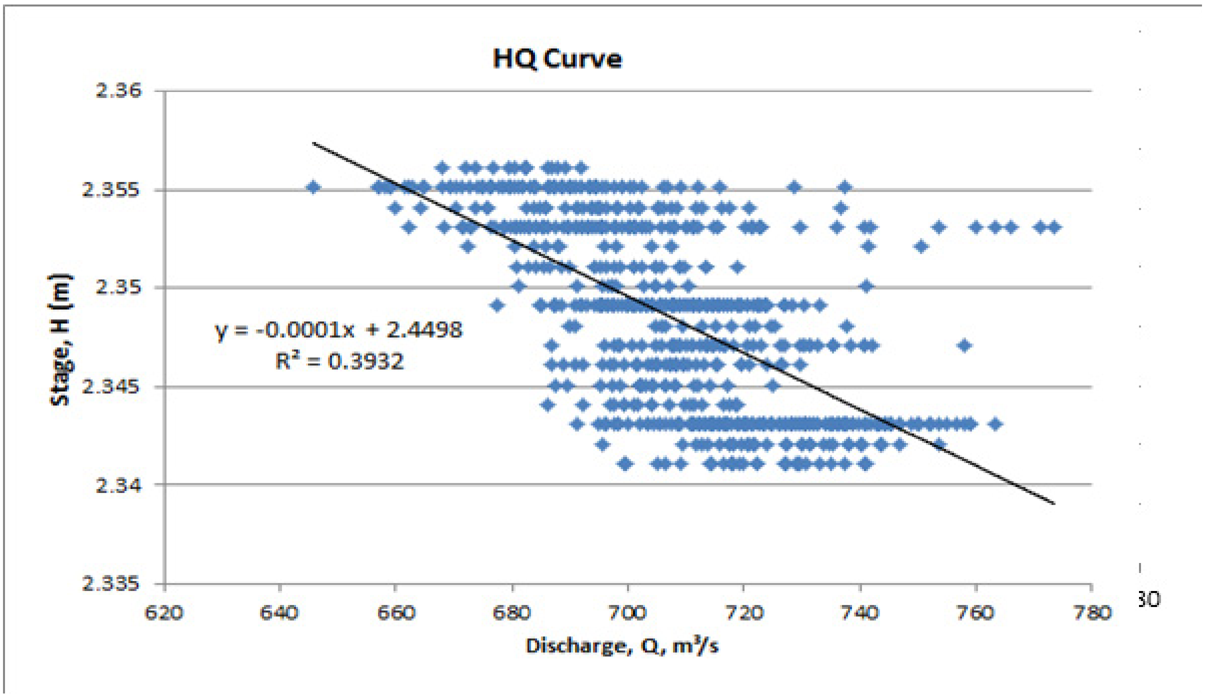


Figure 27. Stage-discharge computation along Pampanga River in Brgy. Pulong Vicitas, Apalit, Pampanga

The relationship of rainfall data gathered using the installed rain gauge in Brgy. Pulong Vicitas, Apalit peaking at 1 mm/5min. on August 23, 2014 and stage from the deployed depth gauge in Brgy. San Francisco, Macabebe, Pampanga is shown in Figure 28.

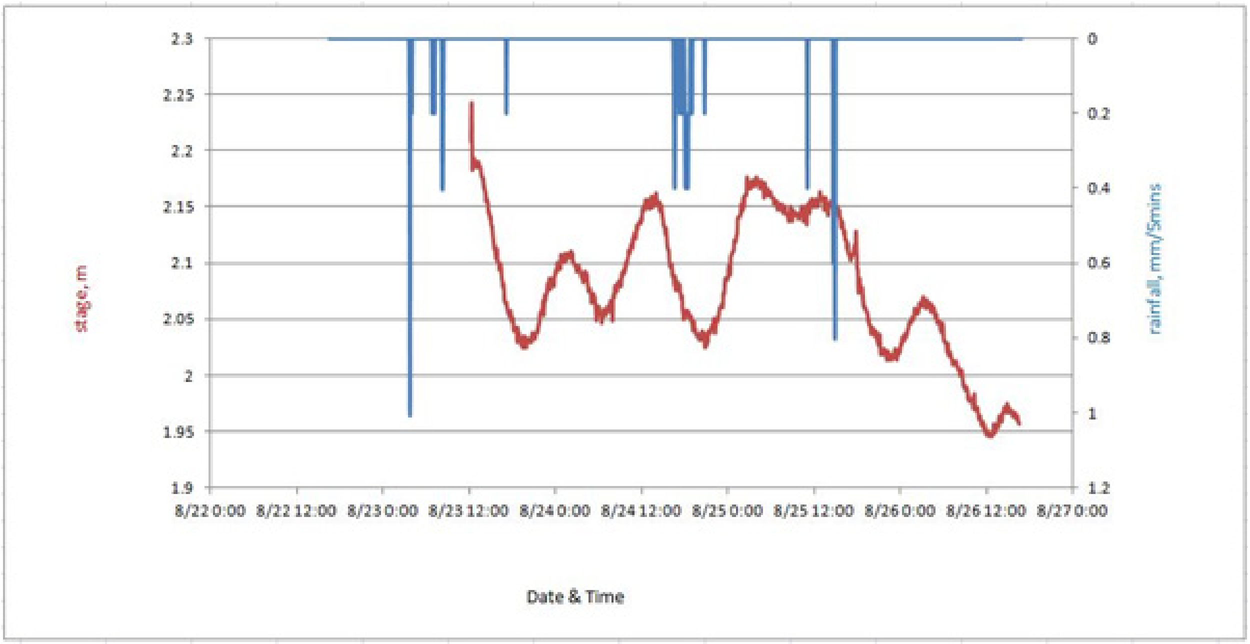


Figure 28. Relationship between Rainfall and Stage in Brgy. San Francisco, Macabebe, Pampanga

The relationship of rainfall data gathered using the installed rain gauge in Brgy. Pulong Vicitas, Apalit and velocity from the deployed ADCP in Brgy. San Francisco, Macabebe, Pampanga is shown in Figure 29.

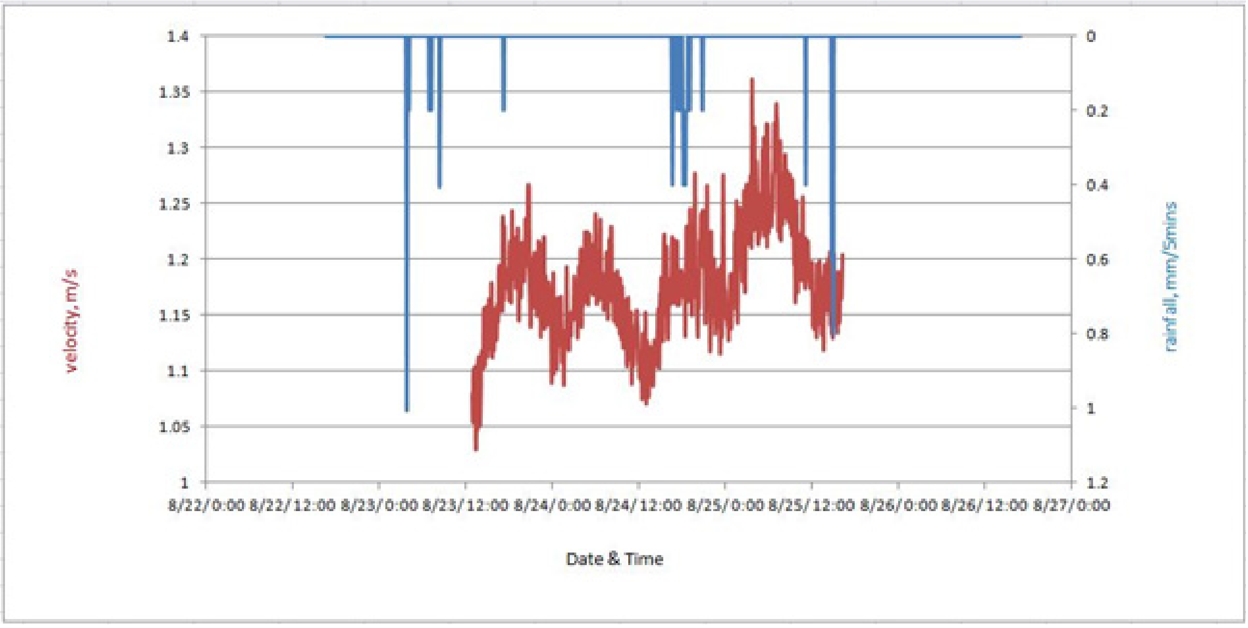


Figure 29. Relationship between Velocity and Rainfall in Brgy. San Francisco, Macabebe, Pampanga

The relationship of stage and velocity from the deployed depth gauge and ADCP in Brgy. San Francisco, Macabebe, Pampanga is shown in Figure 30.

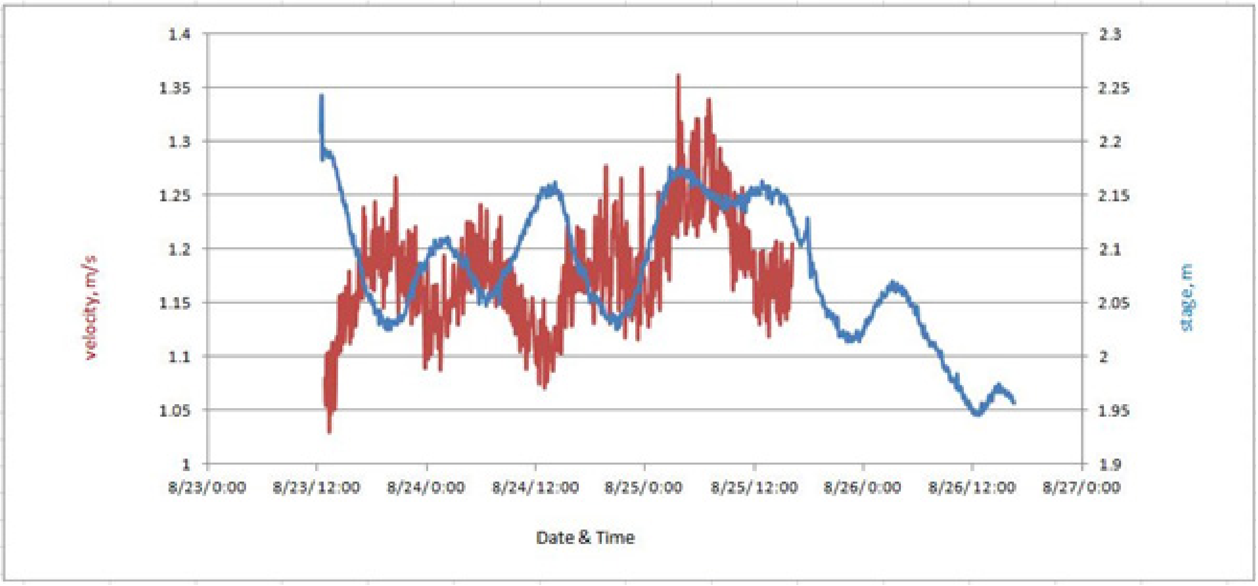


Figure 30. Relationship between Velocity and Stage in Brgy. San Francisco, Macabebe, Pampanga

The relationship between stage and discharge for August 23, 2013 resulted to an R2 of 0.0003 in Brgy. San Francisco, Macabebeis shown in Figure 31.

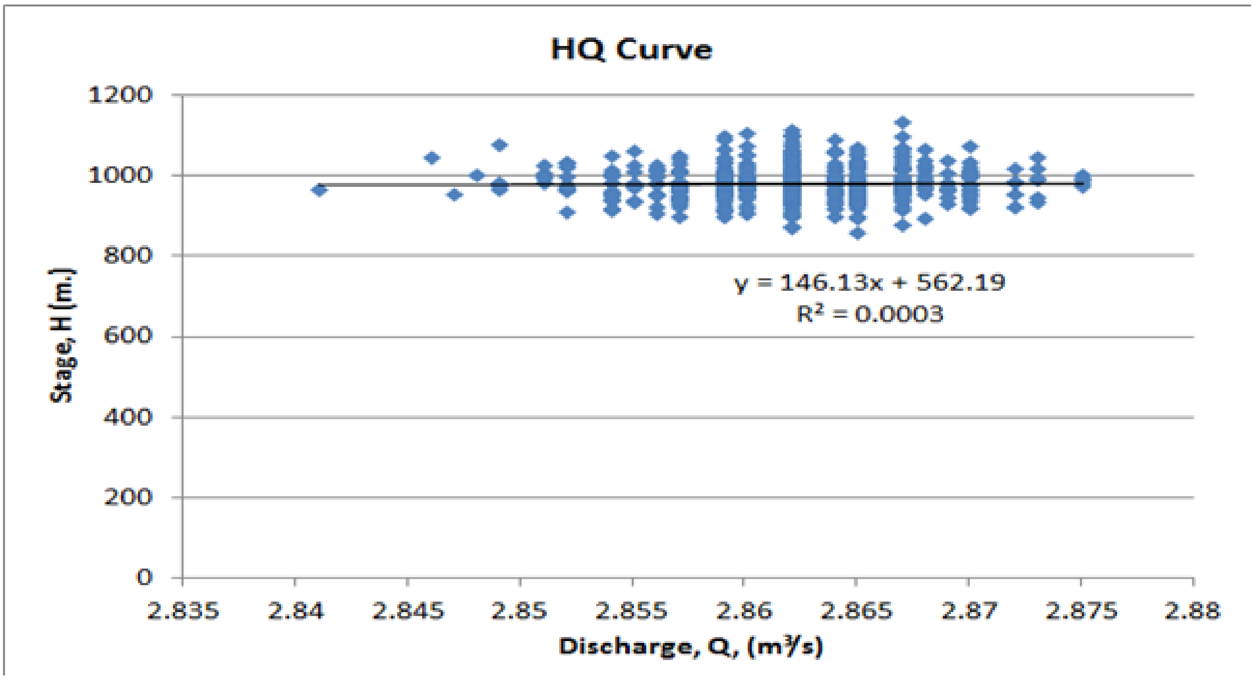


Figure 31. Relationship between stage and discharge along Pampanga River in Brgy. San Francisco, Macabebe, Pampanga

The setup for sensors deployment is illustrated in Figures 32, 33 and 34.

Figure 32. ADCP set up and deployment Site in Brgy. Camba, Arayat, Pampanga

Figure 33. Deployment site in Macabebe Pampanga

Figure 34. Rain Gauge deployed in Brgy. Camba, Arayat, Pampanga

The summary of location of sensor deployment are shown in Table 2 and Figure 35.

Table 2. Deployment of sensors along Pampanga River Sytem

Sensor	Location	Deployment	Retrieval	Latitude	Longitude
ADCP Side Looking, Depth Gauge and Raining Gauge	Brgy. Camba, Arayat Pampanga	October 22, 2012	October 29, 2012	15°9'50.75"N	120°46'57.13"E
ADCP Side Looking, Rain Gauge and Depth Gauge	Brgy. Pulong Vicitas, Apalit, Pampanga	August 22, 2013	August 24, 2013	14°57'12.6"N	120°46'35.76"E
ADCP Side Looking and Depth gauge	San Francisco, Macabebe Pampanga	August 23, 2013	August 25, 2013	14°54'5.60"N	120°44'11.39"E

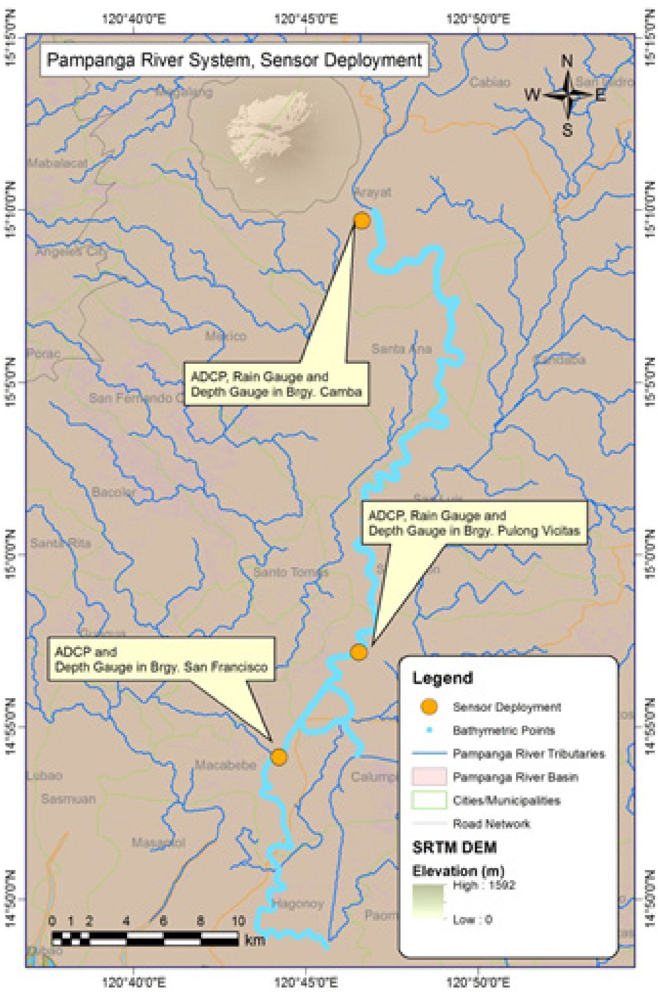


Figure 35. Location of Sensors in Pampanga River

4.5.1 AWLS Survey

Another survey was conducted for the installed AWLS on Pampanga River in order to get its cross-sectional area and water surface elevation in MSL. River velocity was also acquired using side-looking ADCP and digital flow meter. ADCP and flow meter were entrusted to a local living near the bridge to gather river velocity measurements during the course of the survey (see Table 3 for Velocity Capturing Duration).

Cross-section and as-built survey of 7 bridges with installed AWLS was conducted on February 27-March 5, 2014. Flow meter was deployed on 6 of the bridges. ADCP and Depth gauge was deployed at Sta. Rosa Bridge in the Municipality of Sta. Rosa from March 1, 2014 until its retrieval on March 5, 2014. However, the team was only able to gather the flow of the river because no precipitation occurred throughout the duration of the survey. AWLS survey site is shown in Figure 36.

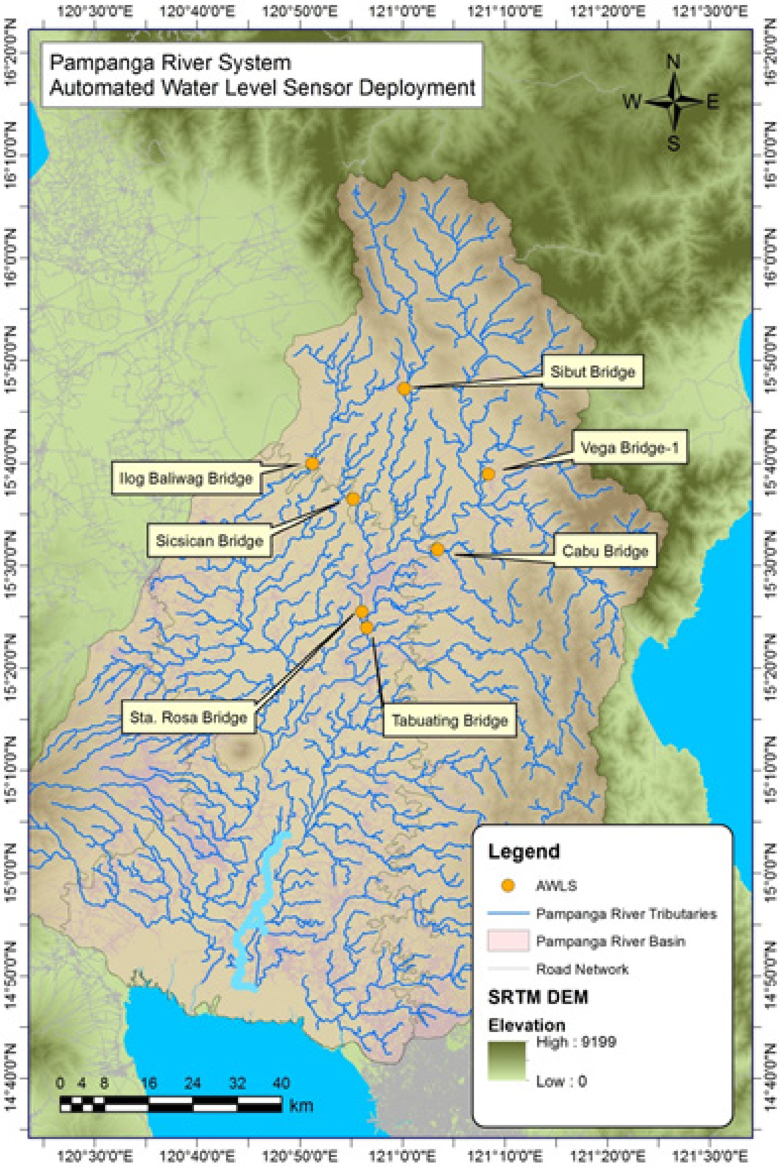
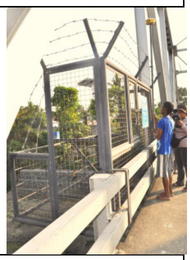


Figure 36. Location of AWLS in Pampanga River

4.5.1.1 Cross-section Survey

Summary of seven (7) bridges with AWLS in Pampanga River with corresponding coordinates, date and time of elevation determination and duration of flow data gathering, and images are shown below:

Table 3. Location and summary of data for Pampanga River System AWLS field survey

LOCATION	COORDINATES	WATER SURFACE ELEVATION, (MSL)	VELOCITY CAPTURING DURATION	ELEVATION OF AWLS, (MSL)	IMAGES
Sibut Bridge	Lat 15°47'16.82613"N Long 121°00'14.56957"E	97.746 m (March 3, 2014 at 5:35:51 PM)	March 3, 2014 At 4:00 PM- 7:00 PM 4 hours using flow meter	103.938 m	
Ilog-Baliwag Bridge	Lat 15°40'00.15686"N Long 120°51'13.33663"E	35.265 m (March 3, 2014 at 5:35:51 PM)	March 3, 2014- At 12:00 NN- 3:00 PM 3 hours using flow meter March 4, 2014 At 9:00 AM-12:00 PM and 1:00 PM-4:00 PM 6 hours using flow meter	46.280 m	
Vega Bridge-1	Lat 15°38'57.82899"N Long 121°08'23.69157"E	65.533 m (March 3, 2014 at 6:23:44 PM)	March 3, 2014- At 5:00 PM- 6:00 PM 1 hour using flow meter March 4, 2014 At 8:00 AM-10:00 AM and 1:00 PM-5:40 PM r 6 hours using flow meter	72.580 m	
Cabu Bridge	Lat 15°31'32.90064"N Long 121°03'25.13091"E	39.625 m (March 2, 2014 at 5:08:13PM)	March 3, 2014- At 6:30 AM- 9:20 AM At 3:10 PM-6:00 PM 6 hours using flow meter March 4, 2014 At 6:20 AM-9:10 AM and 2:20 PM-5:10 PM 6 hours using flow meter	47.564 m	
Sicsican Bridge	Lat 15°36'30.93903"N Long 120°55'13.00922"E	34.590 m (March 3, 2014 at 2:11:16 PM)	March 3, 2014 At 1:40 PM- 3:40 PM 2 hours using flow meter	61.682 m	

LOCATION	COORDINATES	WATER SURFACE ELEVATION, (MSL)	VELOCITY CAPTURING DURATION	ELEVATION OF AWLS, (MSL)	IMAGES
Tabuating Bridge	Latitude 15°23'58.02605"N Longitude 120°56'32.24863"E	14.279 m (March 2, 2014 at 2:58:03 PM)	March 3, 2014 At 6:30 AM- 9:30 AM, 3:10 PM-6:10 PM 6 hours using flow meter March 4, 2014 At 6:20 AM- 9:20 AM, 2:20 PM-5:20 PM 6 hours using flow meter	26.245 m	
Sta. Rosa Bridge	Latitude 15°25'29.89829"N Longitude 120°56'03.22047"E	15.431 m (March 1, 2014 at 4:51:57 PM)	March 1-5, 2014 At 5:00 PM- 10:25 AM Using ADCP	30.640 m	

The images in Figure 37-42 shows the cross-sectional diagram with water level elevation and installed AWLS referred to MSL.

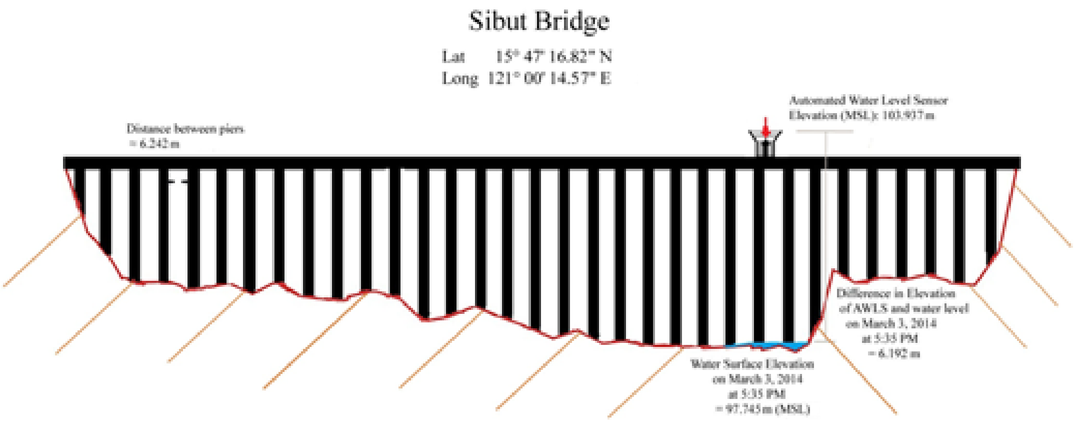


Figure 37. Cross-section diagram of Sibut Bridge

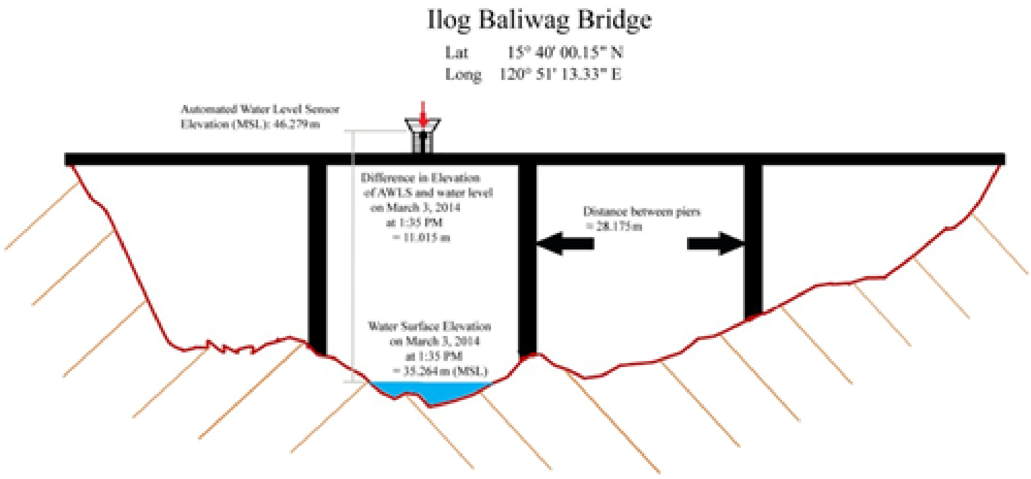


Figure 38. Cross-section diagram of Ilog Baliwag Bridge

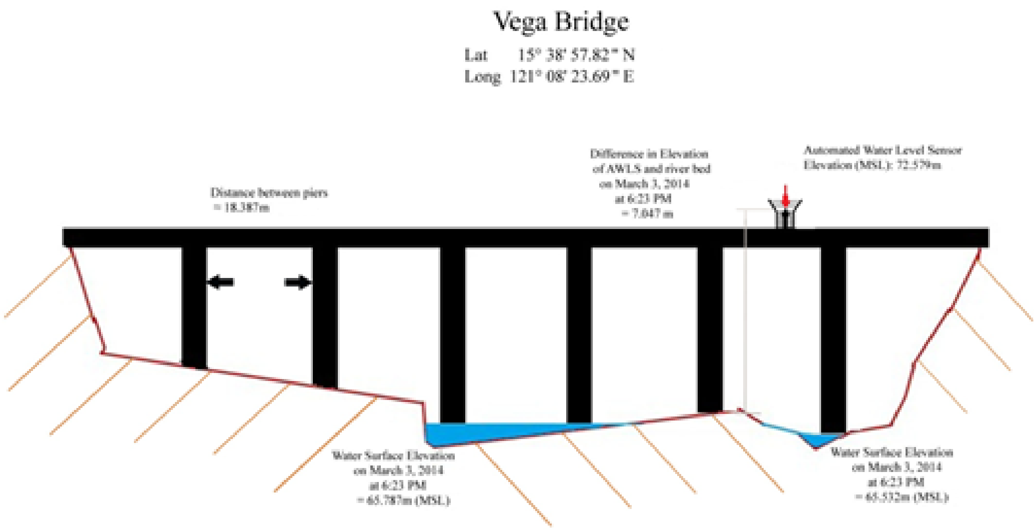


Figure 39. Cross-section diagram of Vega Bridge

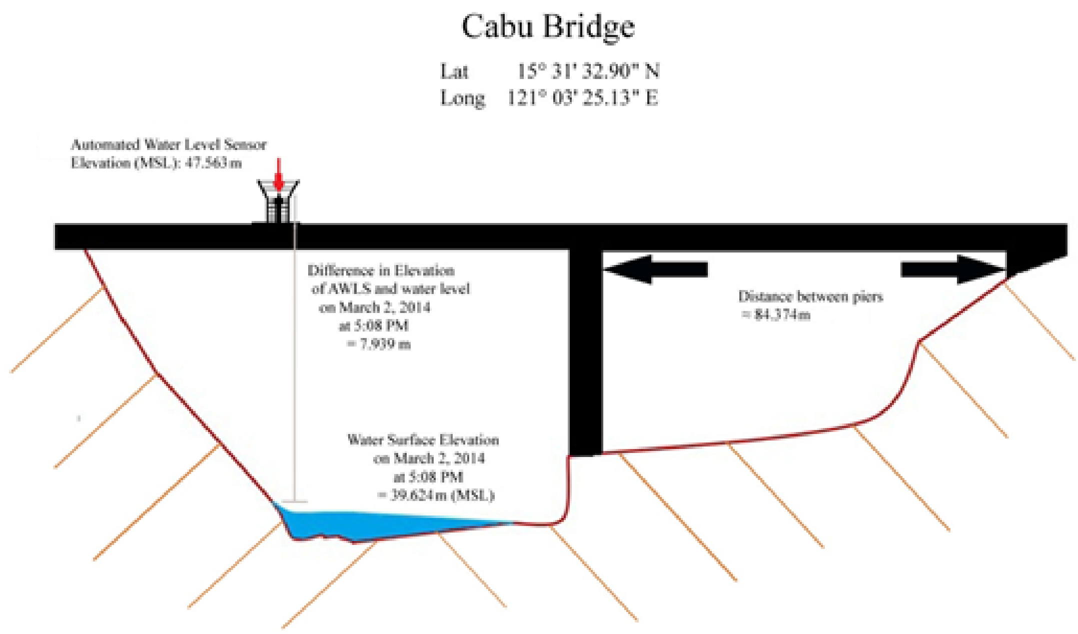


Figure 40. Cross-section diagram of Cabu Bridge

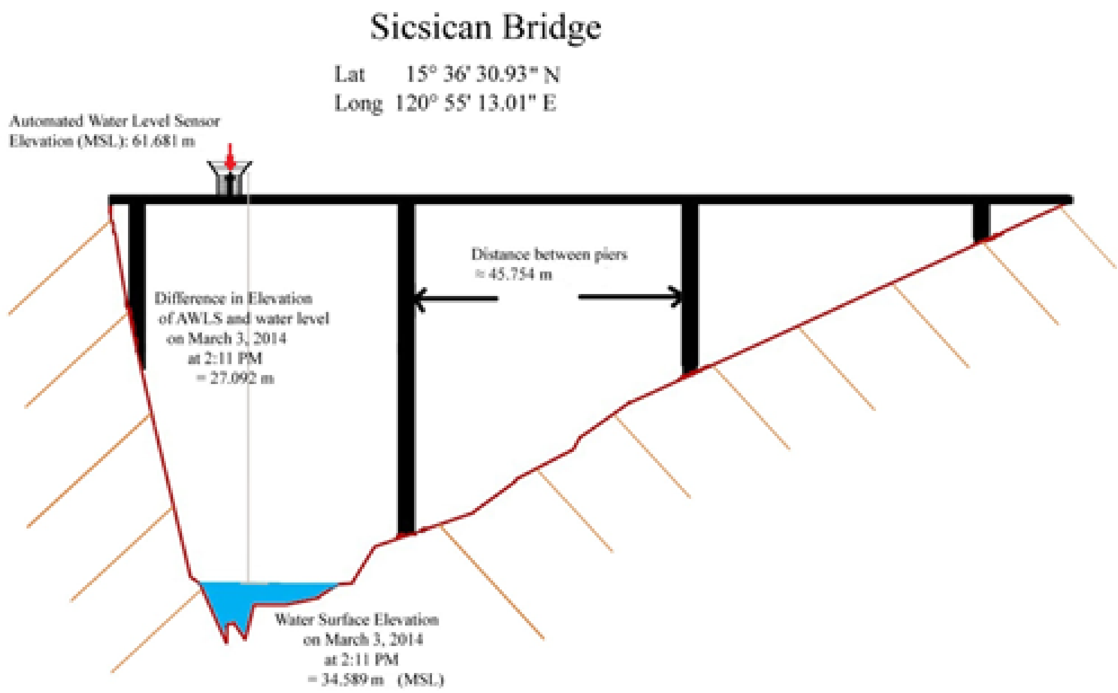


Figure 41. Cross-section diagram of Sicsican Bridge

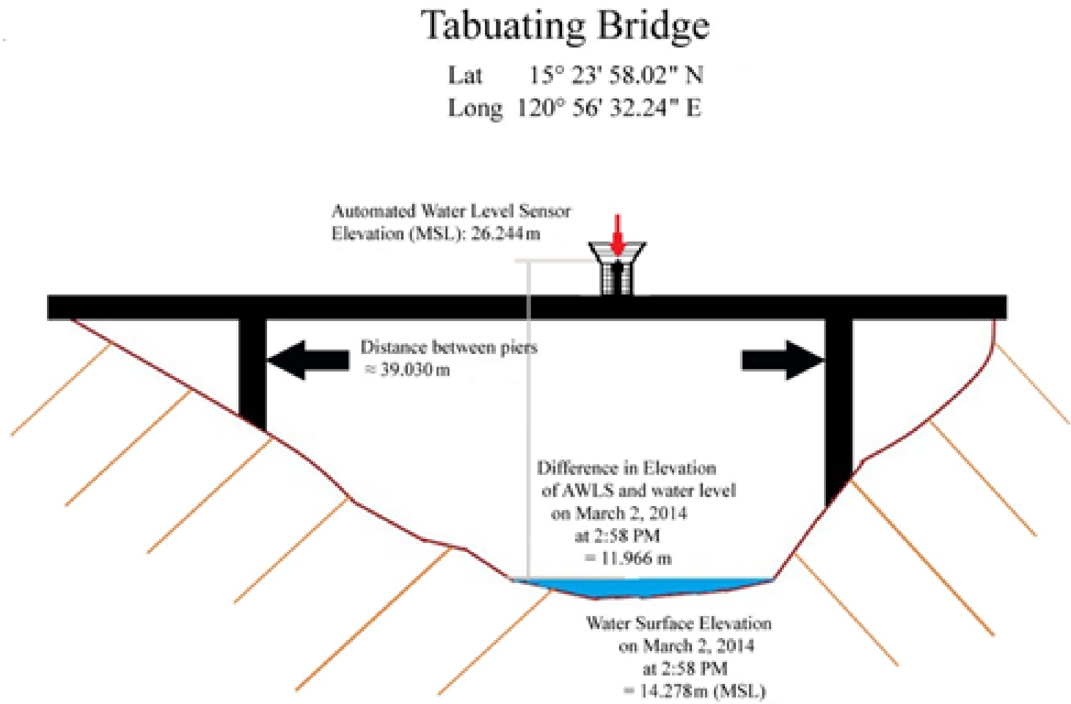


Figure 42. Cross-section diagram of Tabuating Bridge

4.5.1.2 Flow Measurement

Two local hires living within the vicinity of the bridge were employed to gather flow measurements. Two types of events are needed by the team – (1) base flow or the normal stream flow, without the influence of a precipitation. In this scenario, local hires were tasked to record the velocity of the river for three hours each in the morning and afternoon for a single day; and (2) the flow of the river during the occurrence of a rain event. The survey team needed at least two rainfall events prior retrieval of the flow meters. In this type of event, the water velocity was recorded for six-hours straight while precipitation was on-going, day and night. Continuous recording of flow measurements were done until two rain events were observed. However, the team was only able to gather flow for the river with no precipitation occurred throughout the duration of the survey. The images in Figure 43-44 shows the team instructing the local hires on using flow meter.

The setup for the flow meter deployment is illustrated in Figures 43-45. The ADCP Deployment set up in Sta. Rosa Bridge is shown in Figure 46.

Figure 43. Flow Measurement set up in Vega Bridge-1

Figure 44. Flow measurement in Cabu Bridge

Figure 45. Instructing local hires to gather flow data in Tabuating Bridge

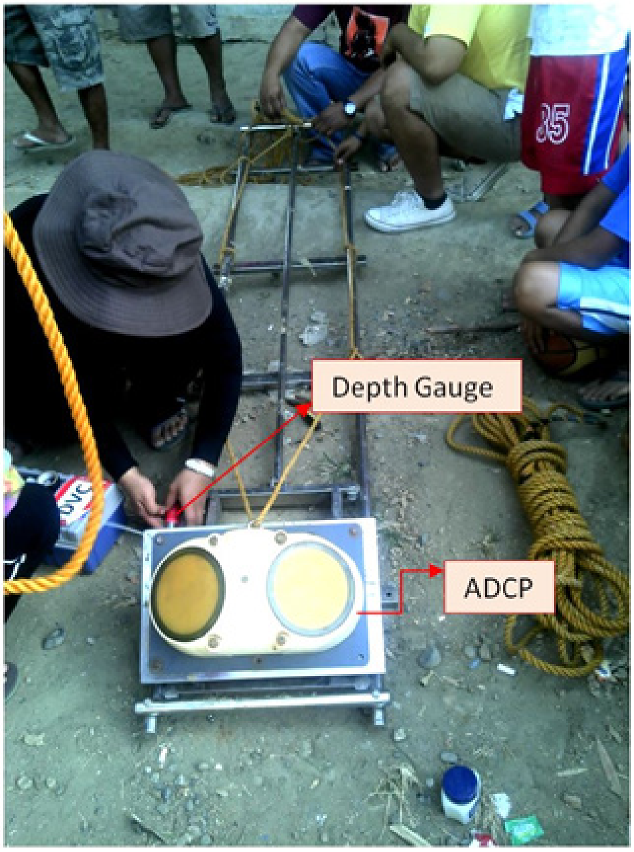


Figure 46. ADCP set up in Sta. Rosa Bridge

Summary of cross-section with flow measurement, stream gauges and rain gauges data are shown in Table 4.

Table 4. Summary of Pampanga River System AWLS Field Survey

Bridges	Cross Section	Water Level	Flow Measurement	Rainfall	Remarks
A. Sibut Bridge	√	√	√	√	Rainfall data was extracted from repo.pscigrid.gov.ph located at Llanera Town Hall. There was no rainfall data collected in the duration of the fieldwork
B. Ilog-Baliwag Bridge	√	√	√	√	Rainfall data was extracted from repo.pscigrid.gov.ph located at Llanera Town Hall. There was no rainfall data collected in the duration of the fieldwork
C. Vega Bridge-1	√	√	√	√	Rainfall data was extracted from repo.pscigrid.gov.ph located at Llanera Town Hall. There was no rainfall data collected in the duration of the fieldwork
D. Cabu Bridge	√	√	√	√	Rainfall data was extracted from repo.pscigrid.gov.ph located at Llanera Town Hall. There was no rainfall data collected in the duration of the fieldwork
E. Sicsican Bridge	√	√	√	√	Rainfall data was extracted from repo.pscigrid.gov.ph located at Llanera Town Hall. There was no rainfall data collected in the duration of the fieldwork
F. Tabuating Bridge	√	√	√	√	Rainfall data was extracted from repo.pscigrid.gov.ph located at Llanera Town Hall. There was no rainfall data collected in the duration of the fieldwork
G. Sta.. Rosa Bridge	√	√	√	√	Rainfall data was extracted from repo.pscigrid.gov.ph located at Llanera Town Hall. There was no rainfall data collected in the duration of the fieldwork

The following series of graphs shows the sensor data of the deployed flow meter and depth gauge during the Pampanga AWLS Cross-section Field Survey.

A. Sensor graph of Sibut Bridge

The relationship of rainfall data and stage during the March 3, 2014 flow meter deployment is shown in Figure 47.

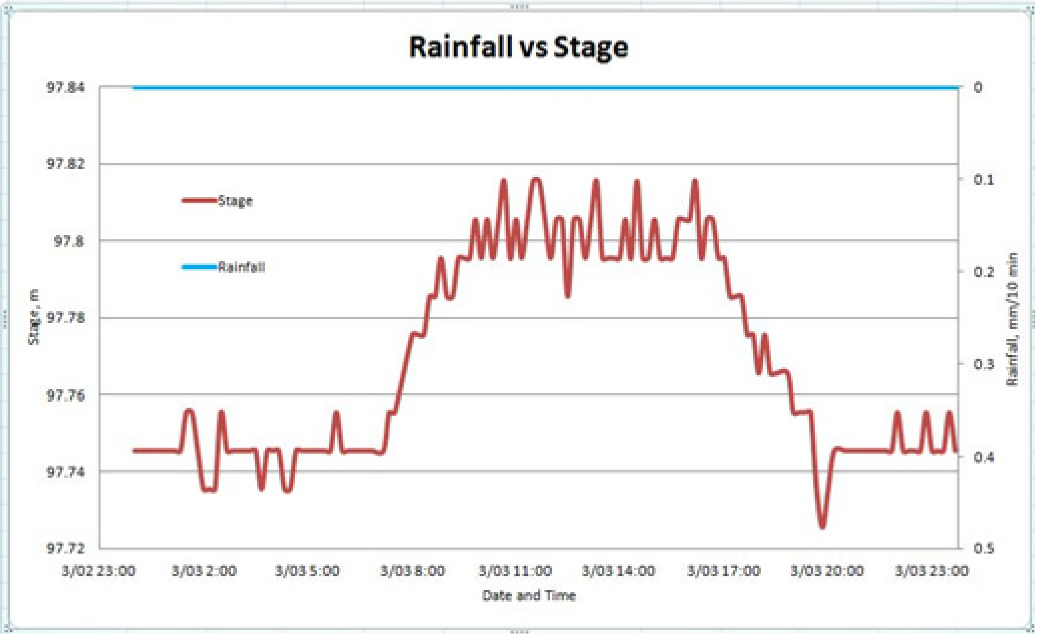


Figure 47. Relationship between Stage and Rainfall in Sibut Bridge

The plot of water velocity data using flow meter deployed on March 3, 2014 and the stage during the sensor deployment is shown in Figure 48.

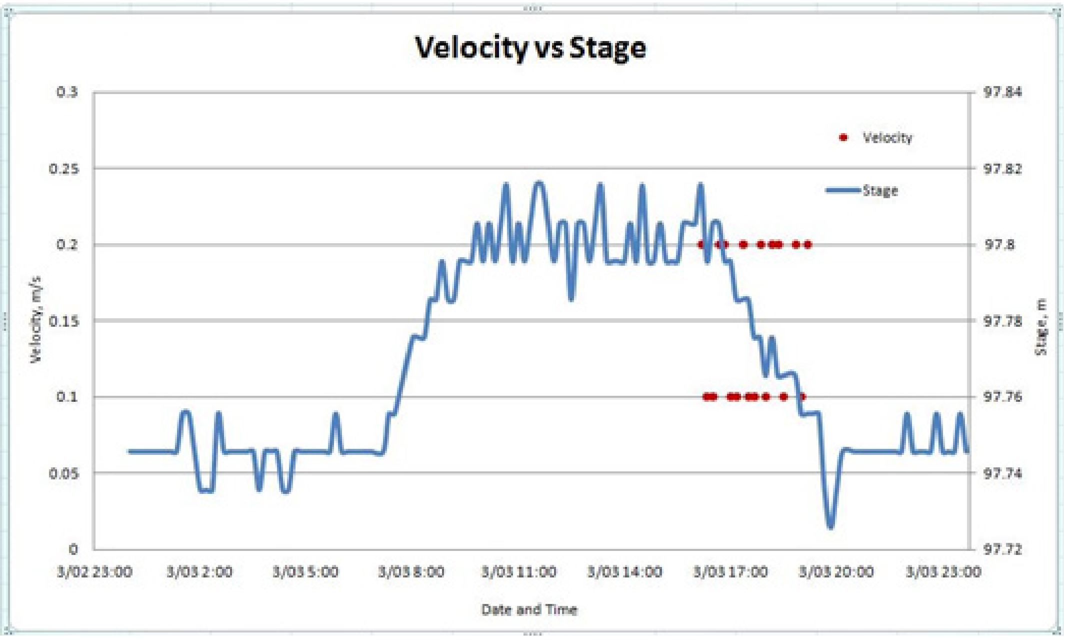


Figure 48. Relationship between Stage and Velocity in Sibut Bridge

The relationship of water velocity data using flow meter deployed on March 3, 2014 and the rainfall during the sensor deployment is shown in Figure 49.

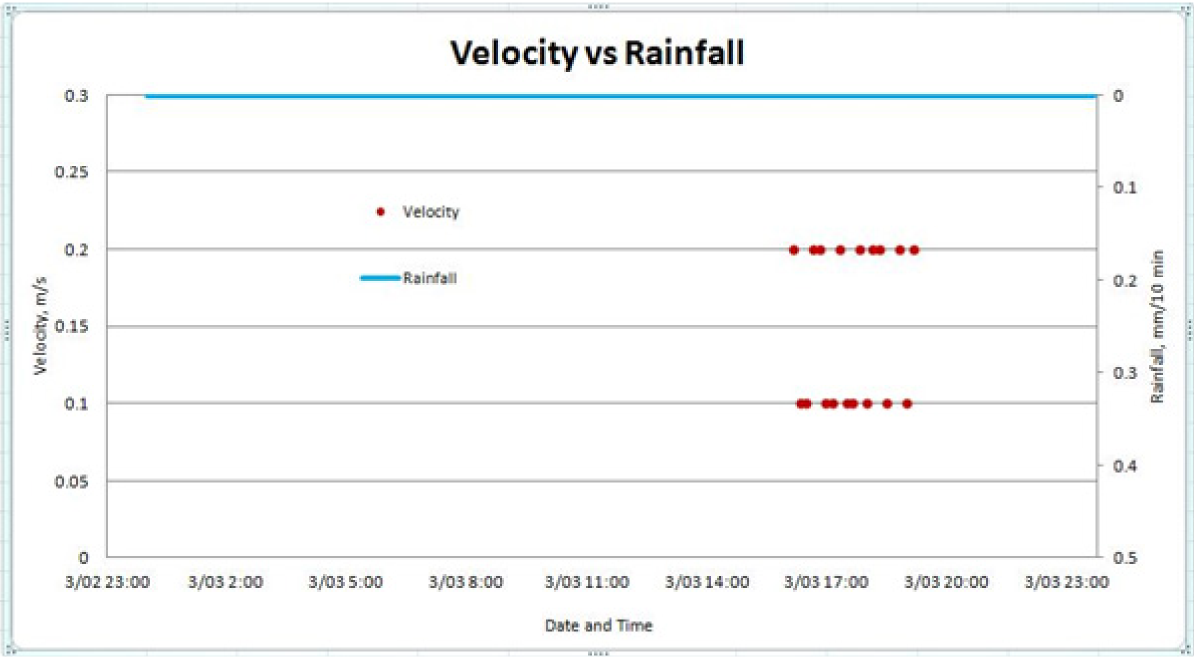


Figure 49. Relationship between Velocity and Rainfall in Sibut Bridge

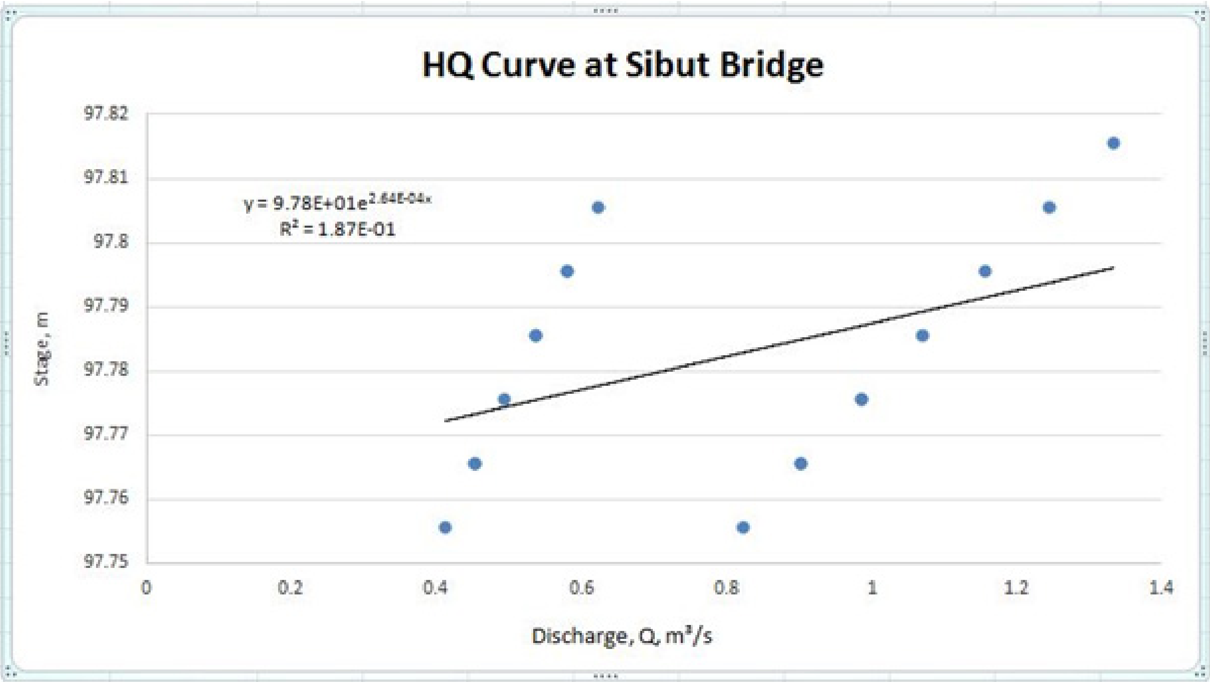


Figure 50. HQ Curve in Sibut Bridge

B. Sensor graph of Ilog-Baliwag Bridge

The relationship of rainfall data and stage during the flow meter deployment on March 3-4, 2014 is shown in Figure 51. No rainfall was recorded during the deployment.

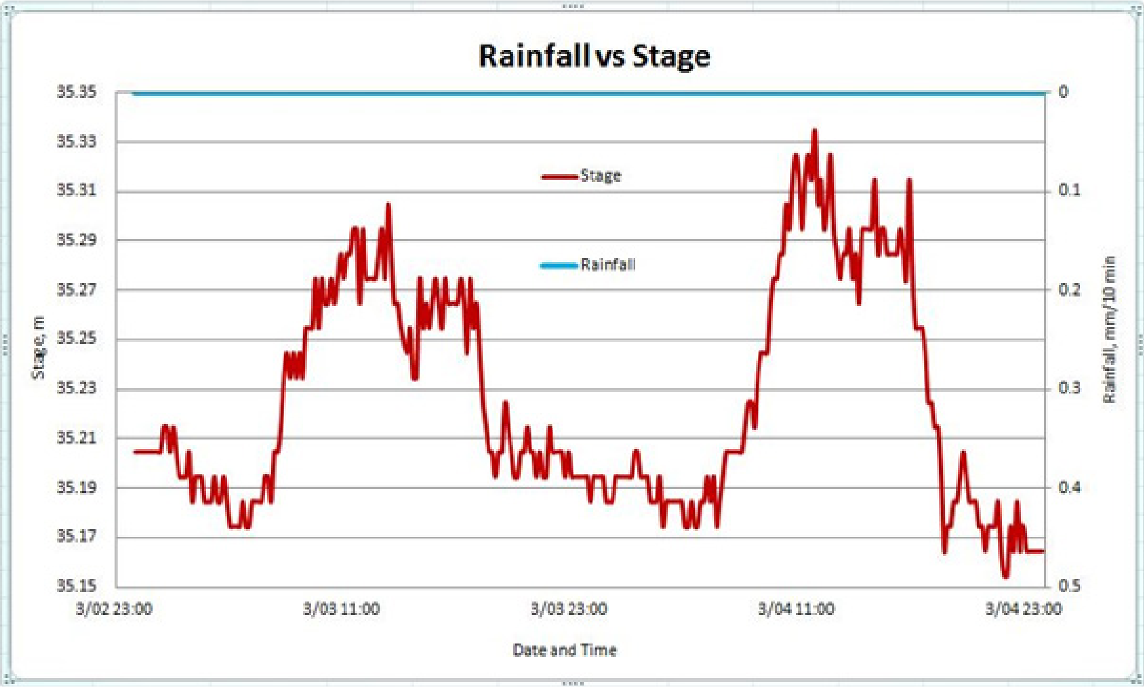


Figure 51. Relationship between Rainfall and Stage in Ilog-Baliwag Bridge

The plot of water velocity data using flow meter deployed on March 3-4, 2014 and the stage during the sensor deployment is shown in Figure 52.

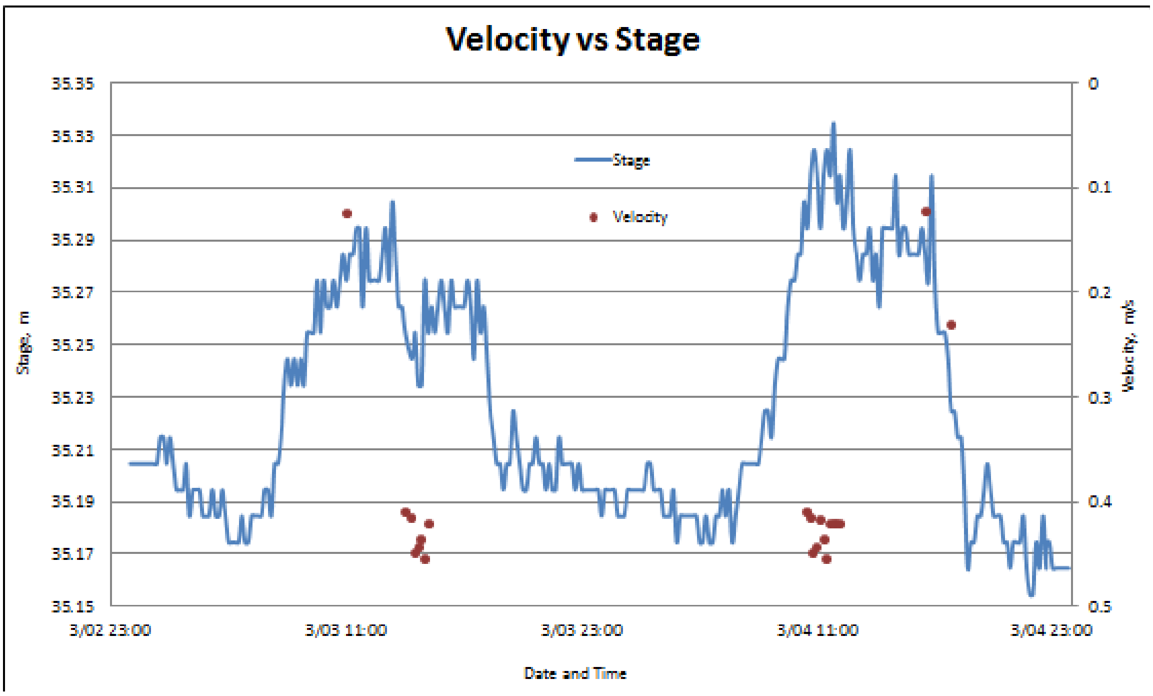


Figure 52. Relationship between Velocity and Stage in Ilog-Baliwag Bridge

The relationship of water velocity with 0.89 m/s as the highest reading using flow meter deployed on March 3-4, 2014 and the rainfall during the sensor deployment is shown in Figure 53.

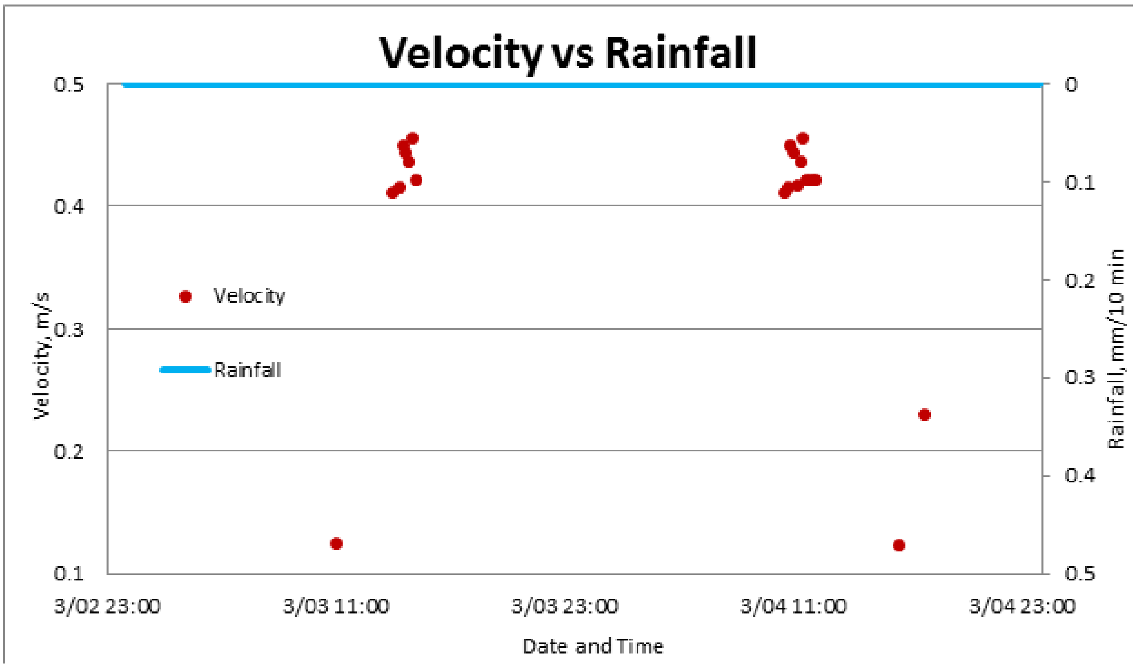


Figure 53. Relationship between Velocity and Rainfall in Ilog-Baliwag Bridge

An R^2 of 0.033 resulted in getting the goodness of fit between the stage and dischare. The plot is shown in Figure 54.

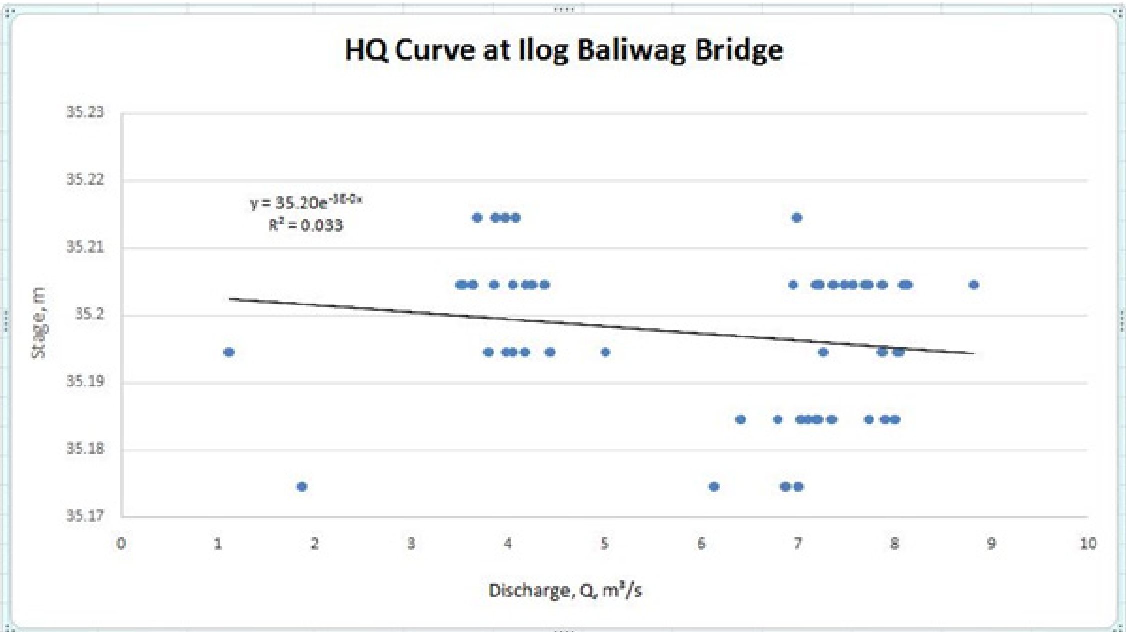


Figure 54. HQ Curve in Ilog-Baliwag Bridge

C. Sensor graph of Vega Bridge-1

The relationship of rainfall data and stage during the flow meter deployment on March 3-4, 2014 is shown in Figure 55. No rainfall data was recorded during the deployment.

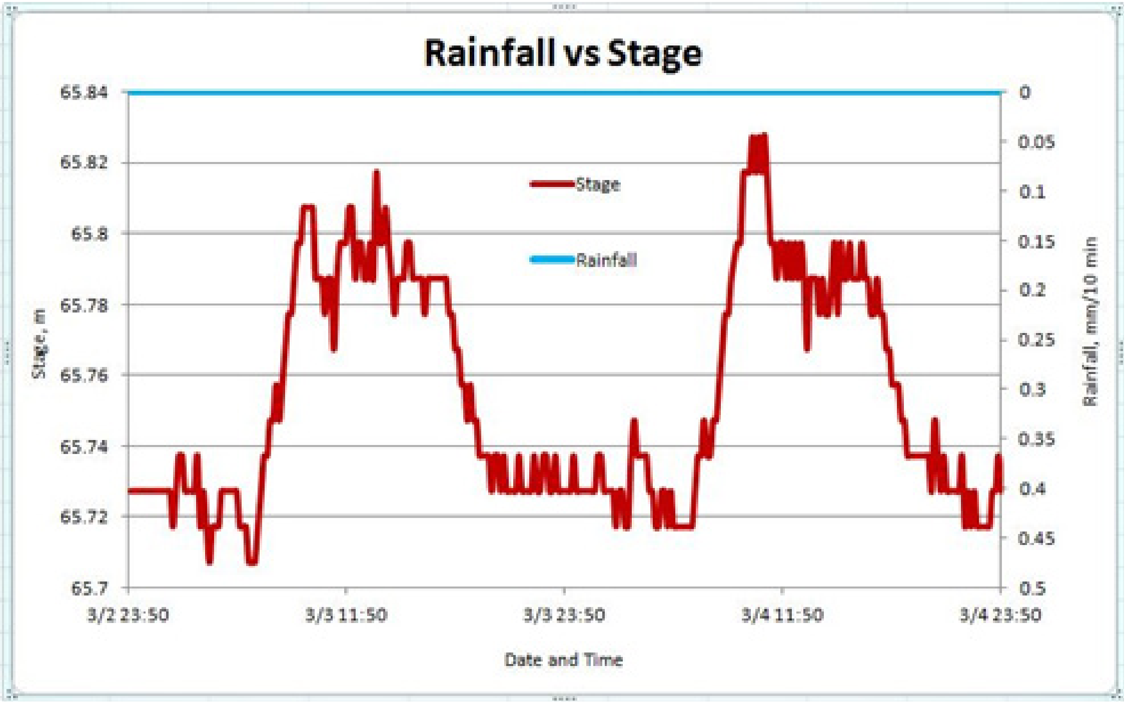


Figure 55. Relationship between Rainfall and Stage in Vega Bridge-1

The relationship of water velocity data using flow meter deployed on March 3-4, 2014 and the stage during the sensor deployment is shown in Figure 56. The maximum reading for the stage is 65.827 meters and it was recorded on March 4, 2014 at around 1:10 in the morning.

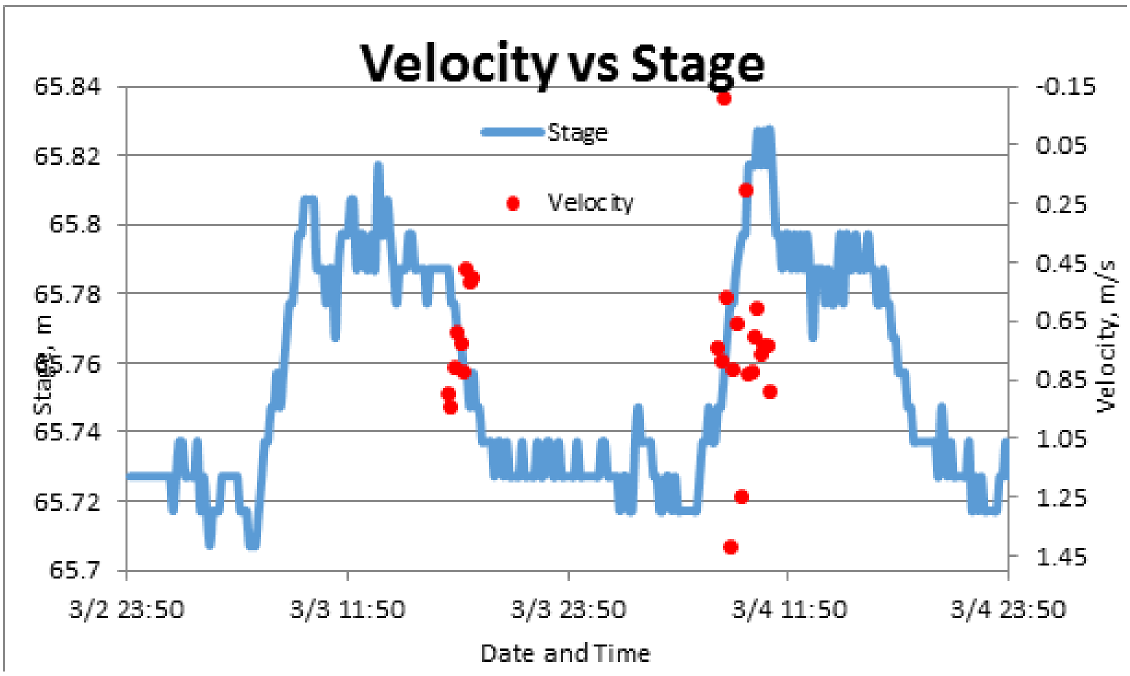


Figure 56. Relationship between Velocity and Stage in Vega Bridge-1

The plot of water velocity data using flow meter deployed on March 3-4, 2014 and the rainfall during the sensor deployment is shown in Figure 57. The maximum reading for the velocity is 1. 41 m/s and it was recorded on March 4, 2014 at around 8:40 in the morning.

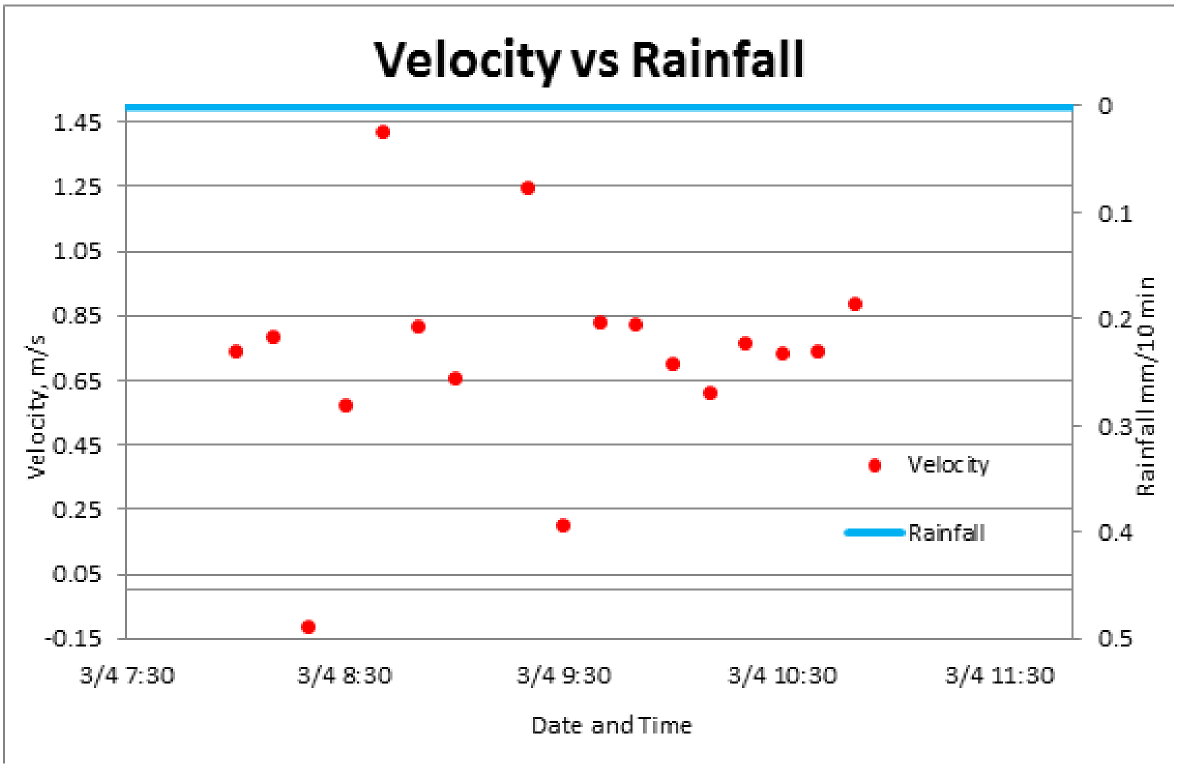


Figure 57. Relationship between Velocity and Rainfall in Vega Bridge-1

The relationship between stage and discharge for March 3-4, 2014 resulted to an R^2 of 3.96e-01 is shown in Figure 58.

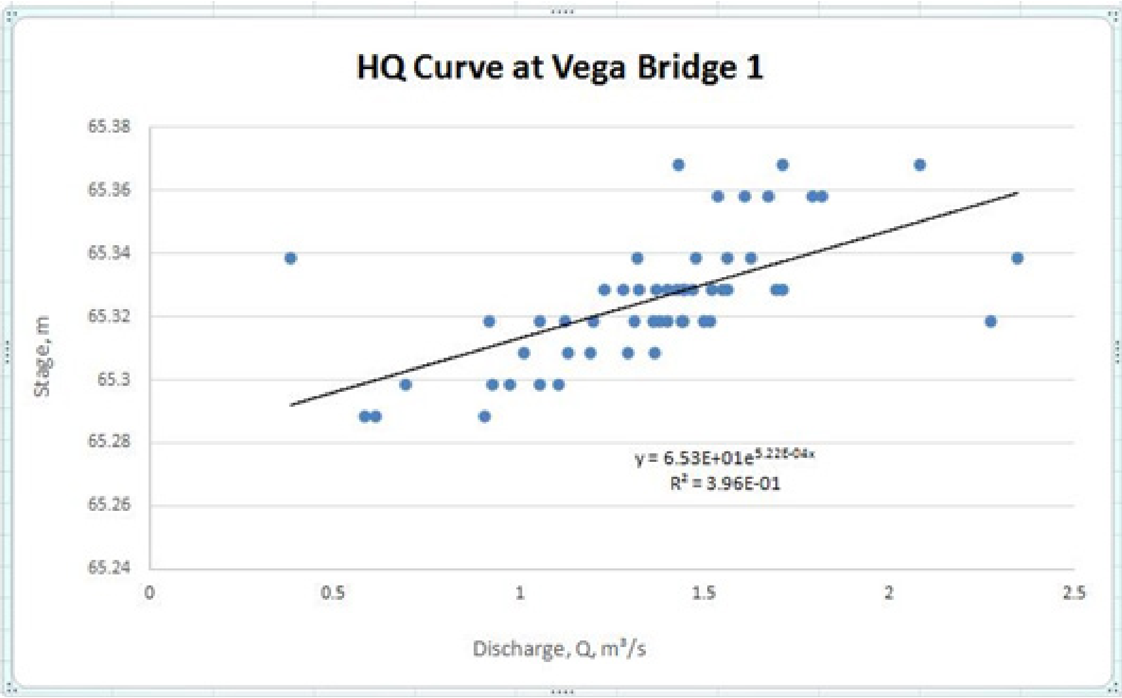


Figure 58. HQ Curve in Vega Bridge-1

D. Sensor graph of Cabu Bridge

The plot of rainfall data and stage during the flow meter deployment on March 3-4, 2014 is shown in Figure 59. No rainfall event was captured during the deployment.

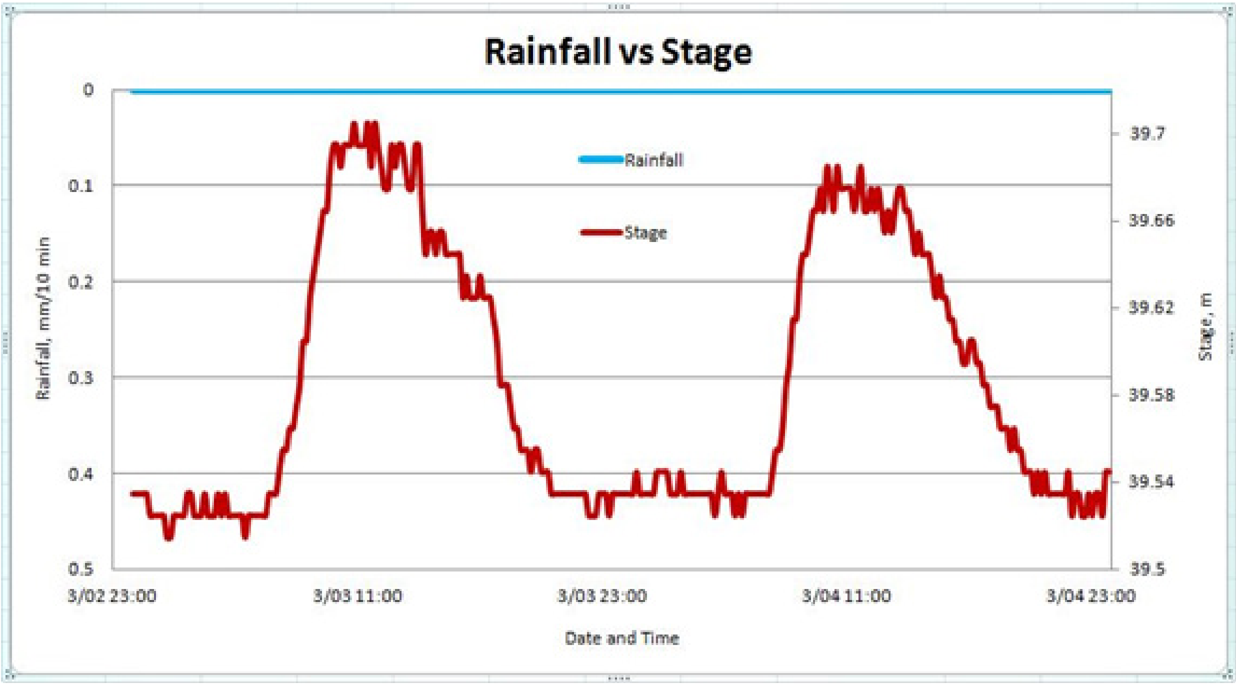


Figure 59. Relationship between Rainfall and Stage in Cabu Bridge

The relationship of water velocity data using flow meter deployed on March 3-4, 2014 and the stage during the sensor deployment is shown in Figure 60. The maximum stage observed in Cabu Bridge is 39.70 m. on March 3, 2014 at 11:00 in the morning.

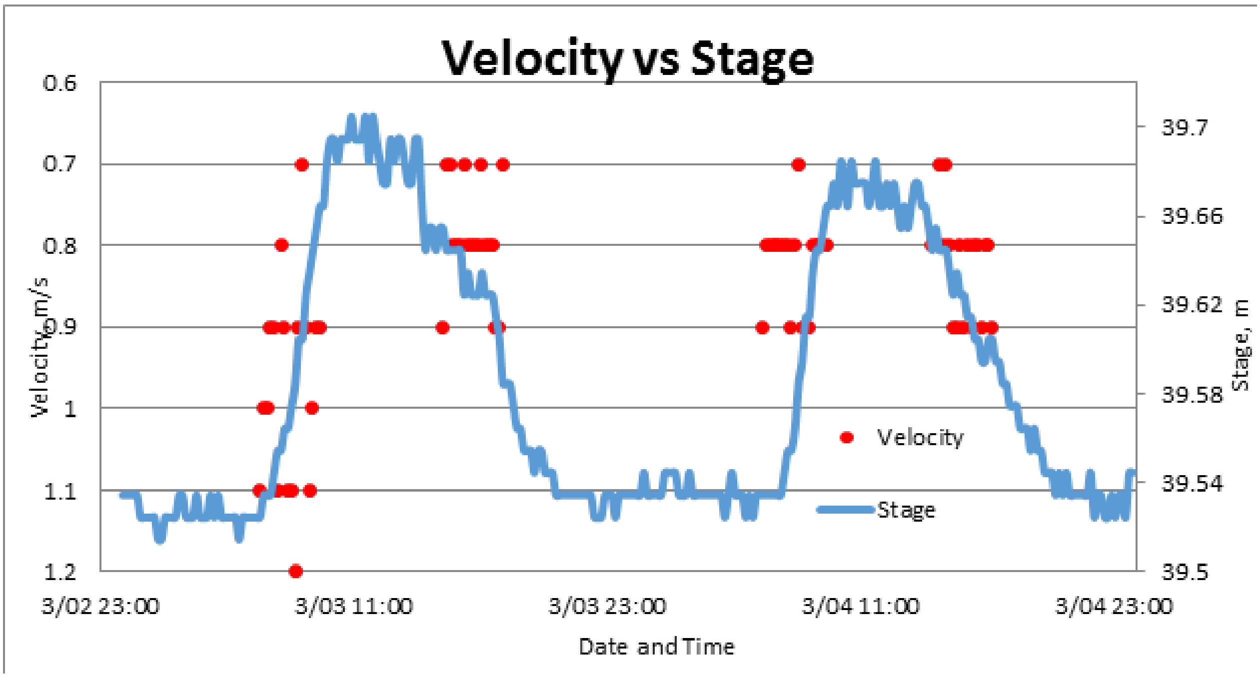


Figure 60. Relationship between Velocity and Stage in Cabu Bridge

The maximum velocity recorded in Cabu Bridge is 1.2 m/s on March 3, 2014 at 8:10 in the morning. The relationship of water velocity data using flow meter deployed on March 3-4, 2014 and the rainfall during the sensor deployment is shown in Figure 61.

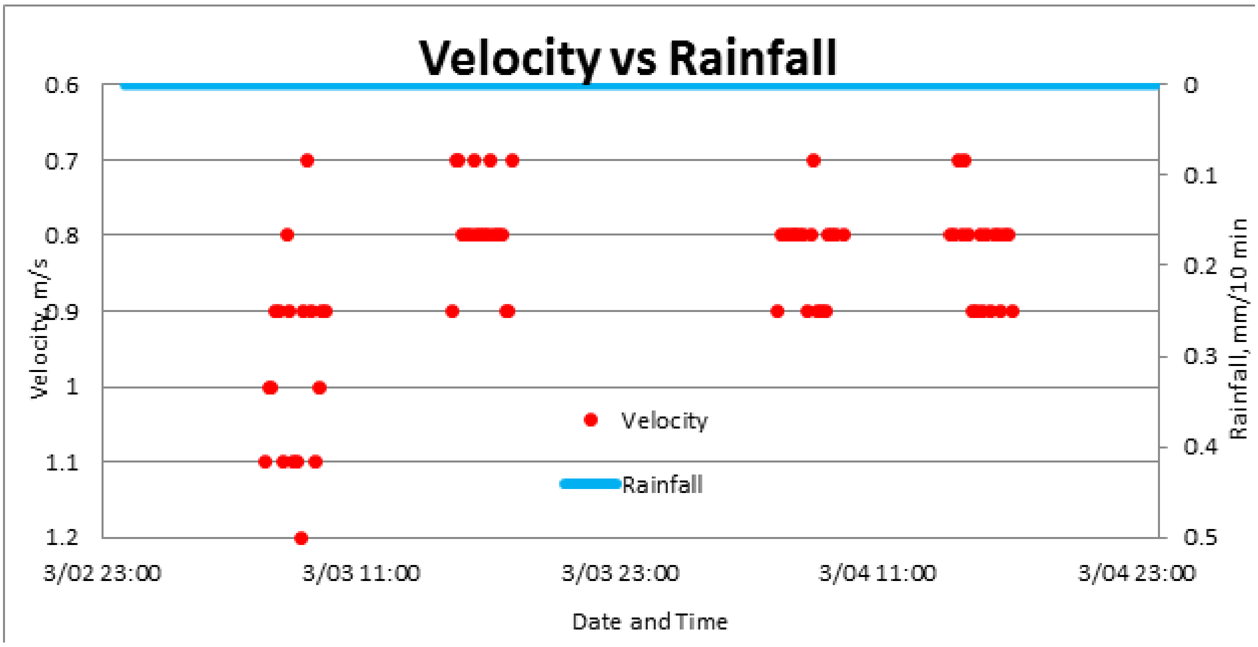


Figure 61. Relationship between Velocity and Rainfall in Cabu Bridge

The relationship between stage and discharge for March 3-4, 2014 resulted to an R^2 of 0.0196 is shown in Figure 62.

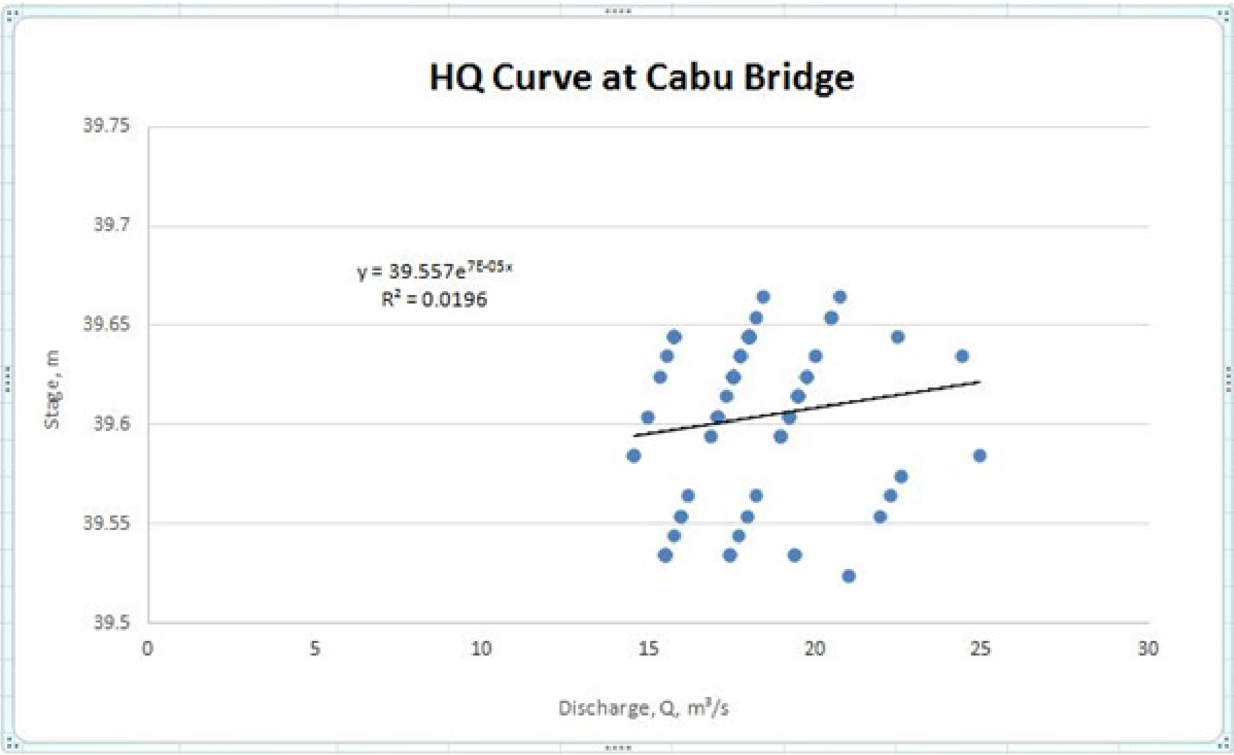


Figure 62. HQ Curve in Cabu Bridge

E. Sensor graph of Sicsican Bridge

No rainfall was recorded during the March 3, 2014 deployment. The relationship of rainfall data and stage during the flow meter deployment is shown in Figure 63.

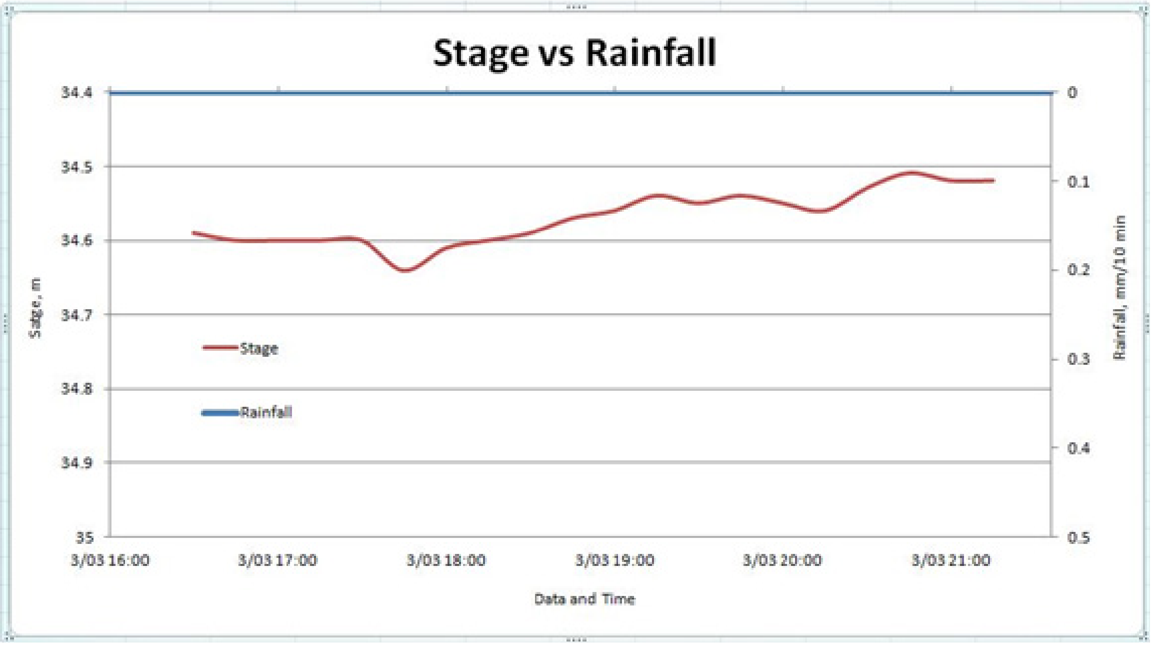


Figure 63. Relationship between Stage and Rainfall in Sicsican Bridge

The relationship of water velocity data using flow meter deployed on March 3, 2014 and the stage during the sensor deployment is shown in Figure 64. The highest stage recorded was 34.5096 m. on March 3, 2014 at 8:45 in the afternoon.

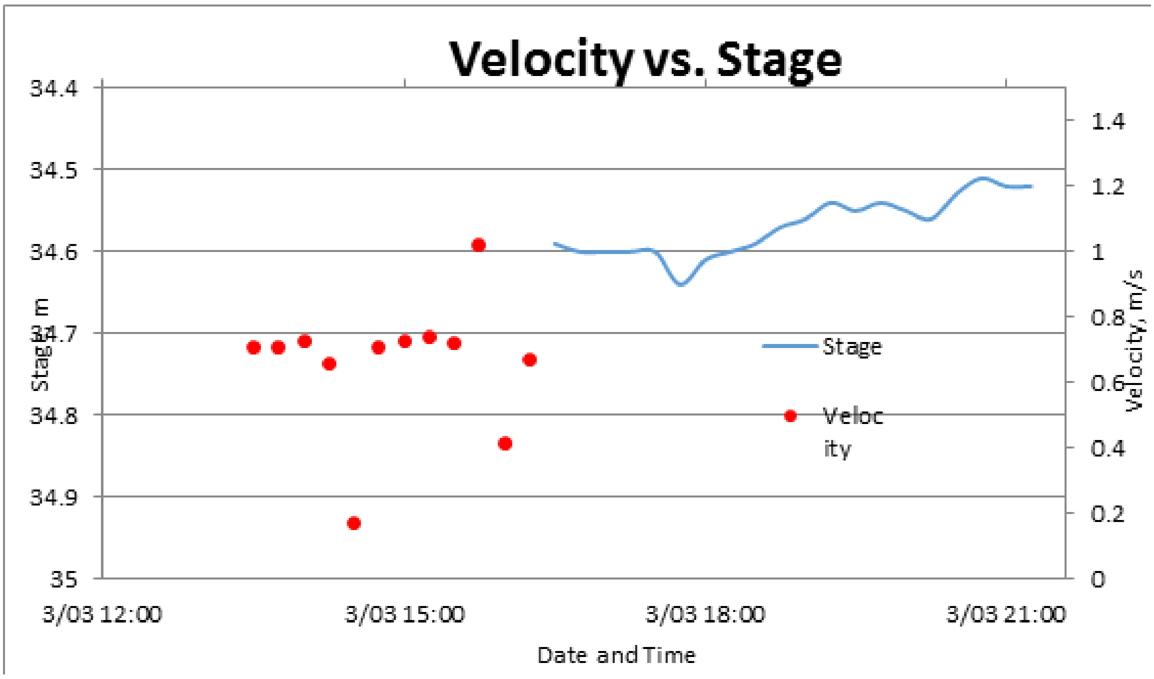


Figure 64. Relationship between Velocity and Stage in Sicsican Bridge

The fastest recorded velocity for Sicsican Bridge is 1.01 m/s and was recorded on March 3, 2014 at 3:45 PM. The relationship of water velocity data using flow meter deployed on March 3, 2014 and the rainfall during the sensor deployment is shown in Figure 65.

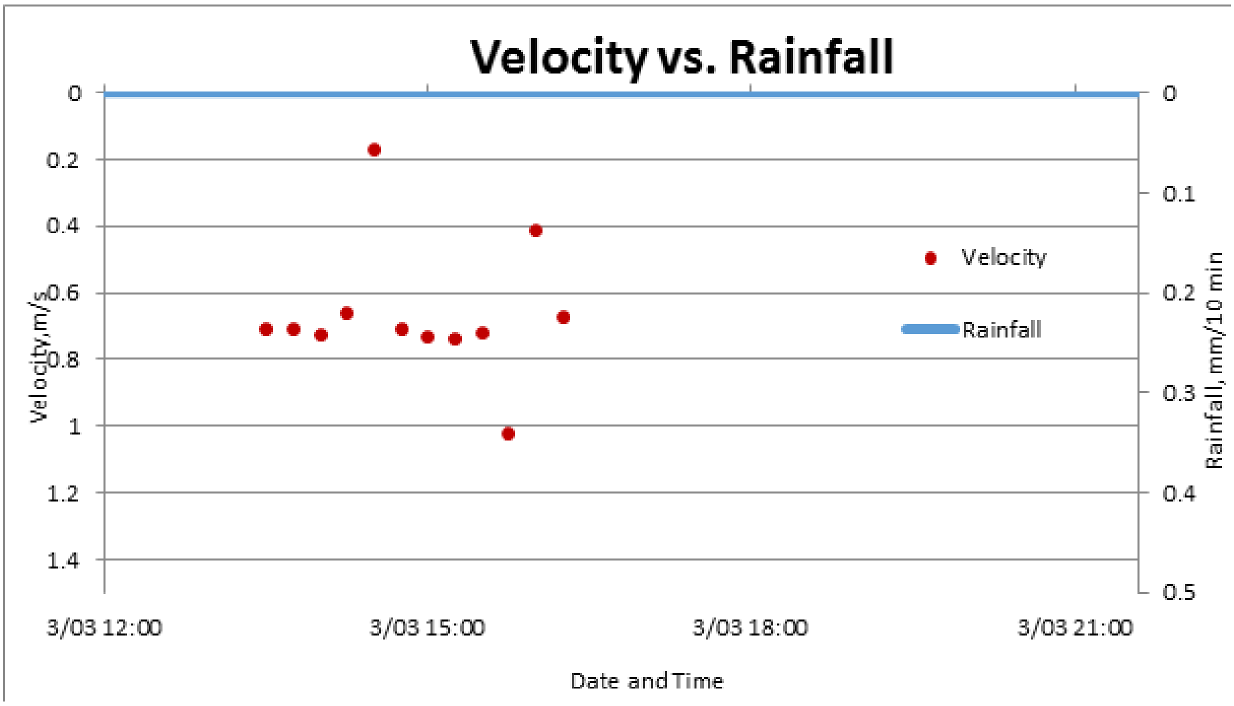


Figure 65. Relationship between Velocity and Rainfall in Sicsican Bridge

The relationship between stage and discharge for March 3, 2014 resulted to an R2 of 0.016 is shown in Figure 66.

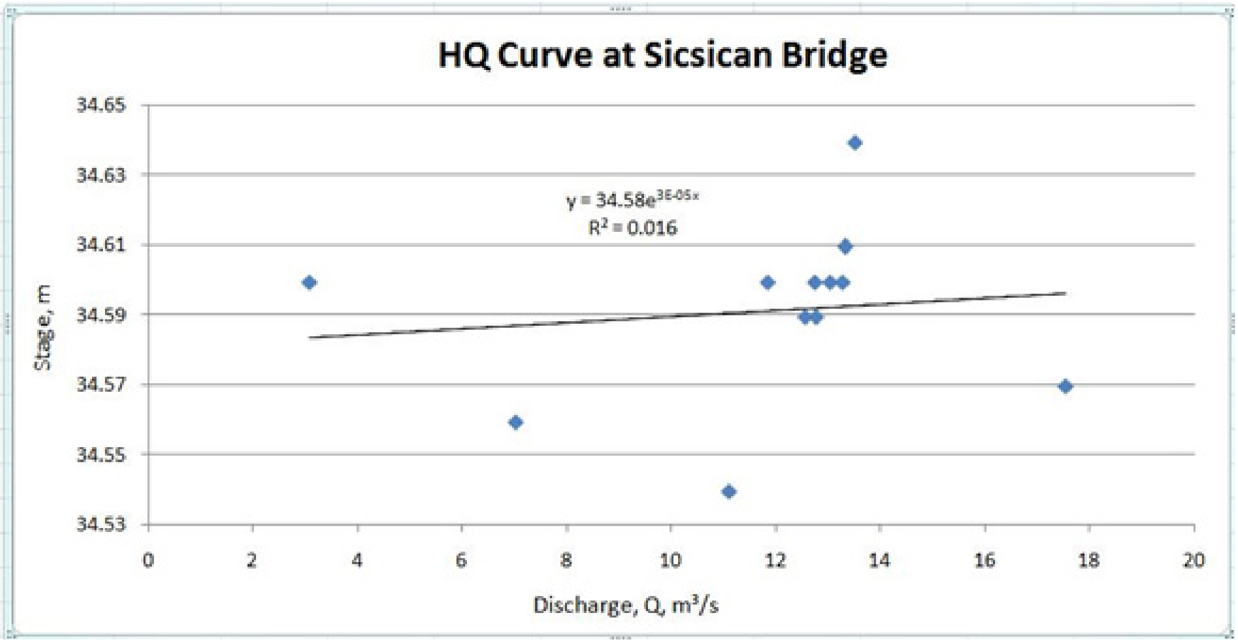


Figure 66. HQ Curve in Sicsican Bridge

F. Sensor graph of Tabuating Bridge

The relationship of rainfall data and stage during the flow meter deployment on March 3-4, 2014 is shown in Figure 67. No rainfall was recorded during the deployment.

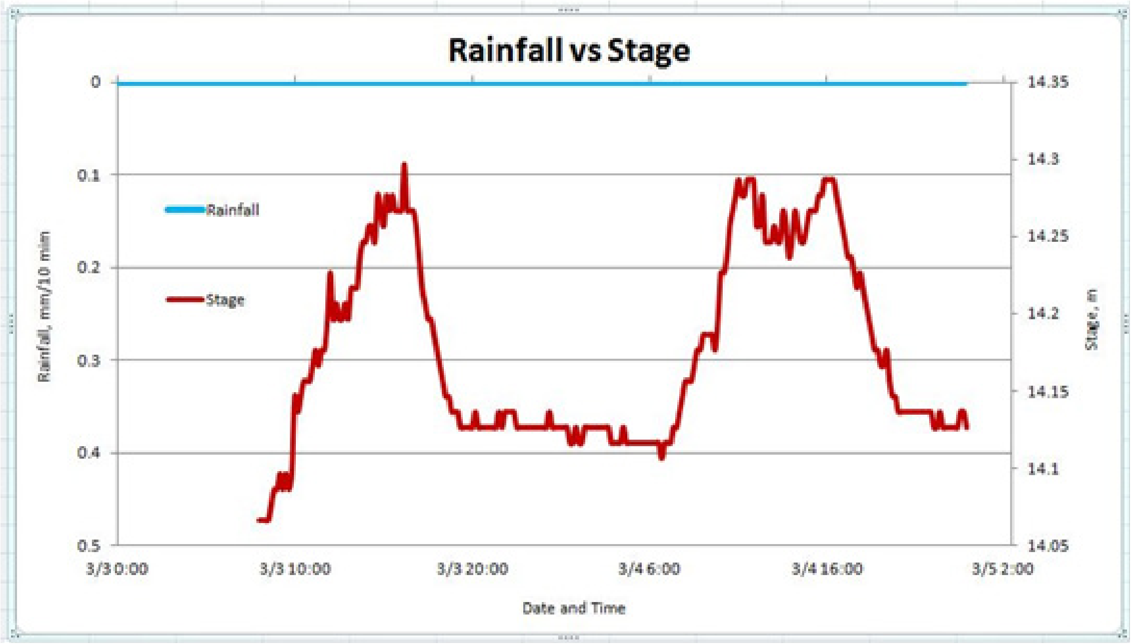


Figure 67. Relationship between Rainfall and Stage in Tabuating Bridge

The highest stage recorded was 14.296 m. on March 3. 2014 at 4:10 PM. The plot of water velocity data using flow meter deployed on March 3-4, 2014 and the stage during the sensor deployment is shown in Figure 68.

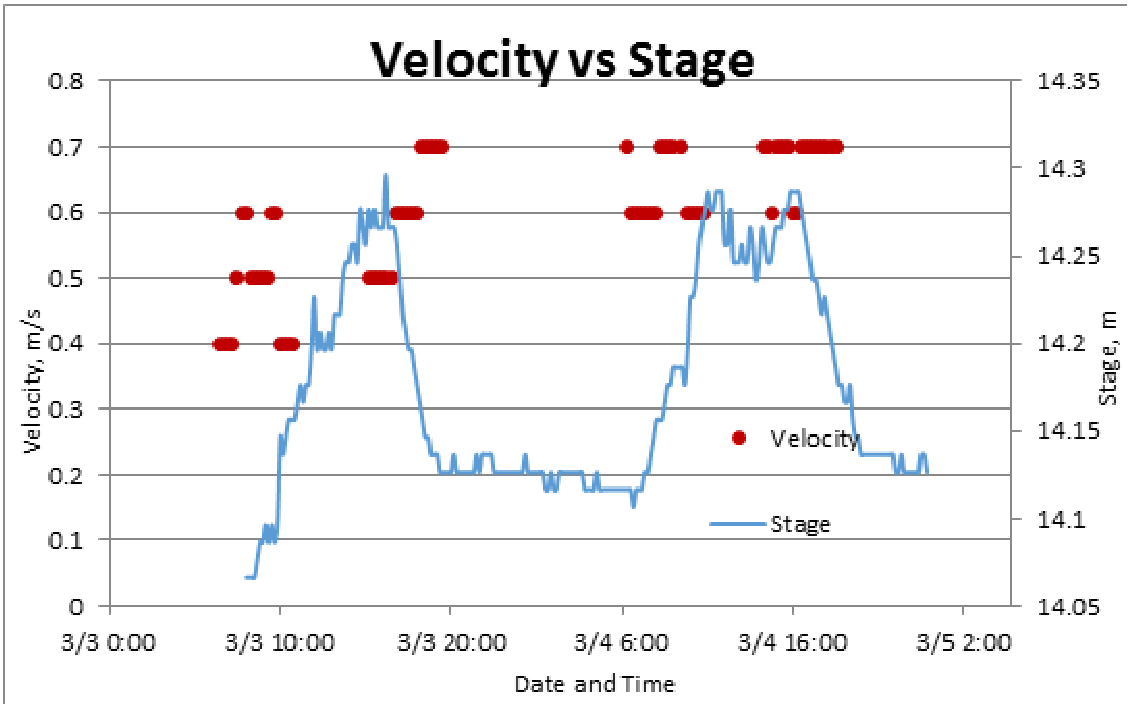


Figure 68. Relationship between Velocity and Stage in Tabuating Bridge

The plot of water velocity data using flow meter deployed on March 3-4, 2014 and the rainfall during the sensor deployment is shown in Figure 69. Fastest velocity recorded for Tabuating Bridge is 0.7 m/s.

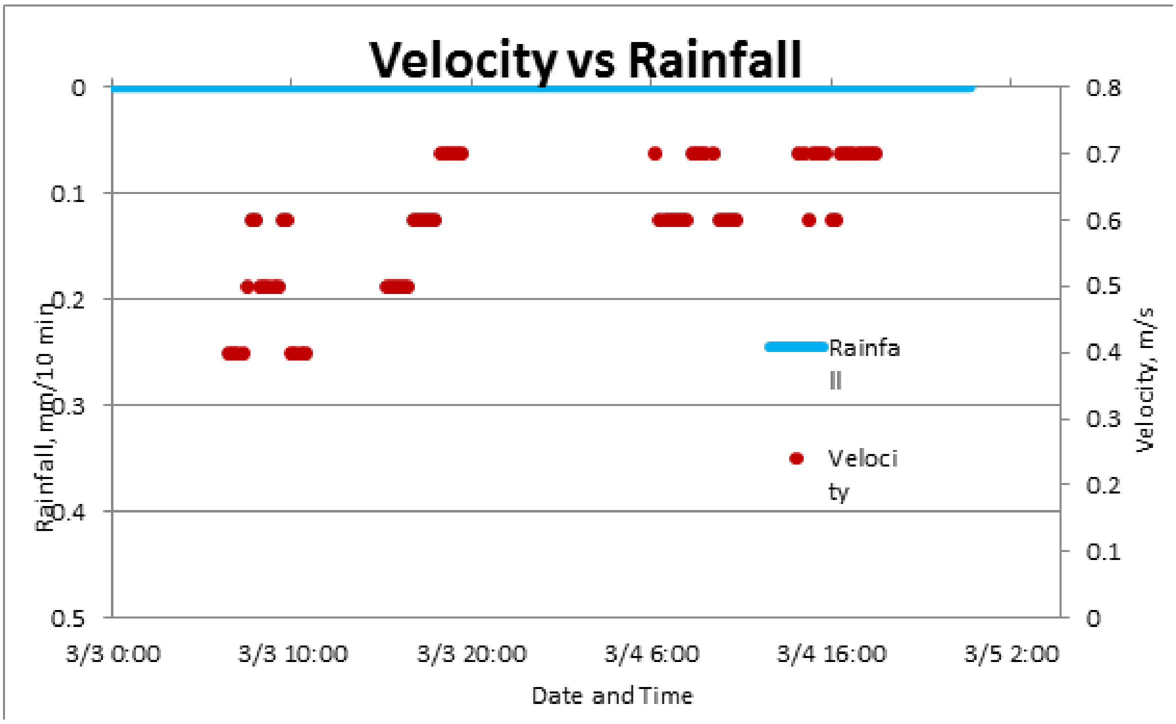


Figure 69. Relationship between Velocity and Rainfall in Tabuting Bridge

The relationship between stage and discharge for March 3, 2014 resulted to an R2 of 3.45e-01 is shown in Figure 70.

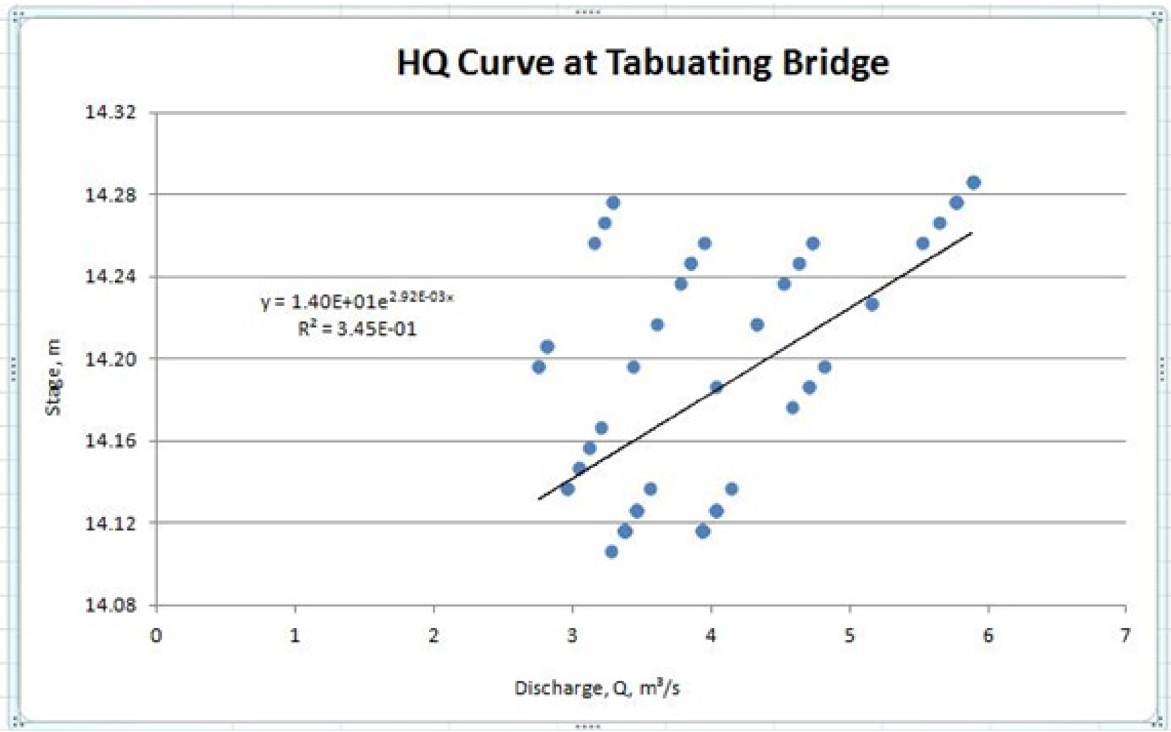


Figure 70. HQ Curve in Tabuating Bridge

G. Sensor graph of Sta. Rosa Bridge

The plot of rainfall data and stage during the flow meter deployment on March 1-5, 2014 is shown in Figure 71. No rainfall data was observed during the deployment.

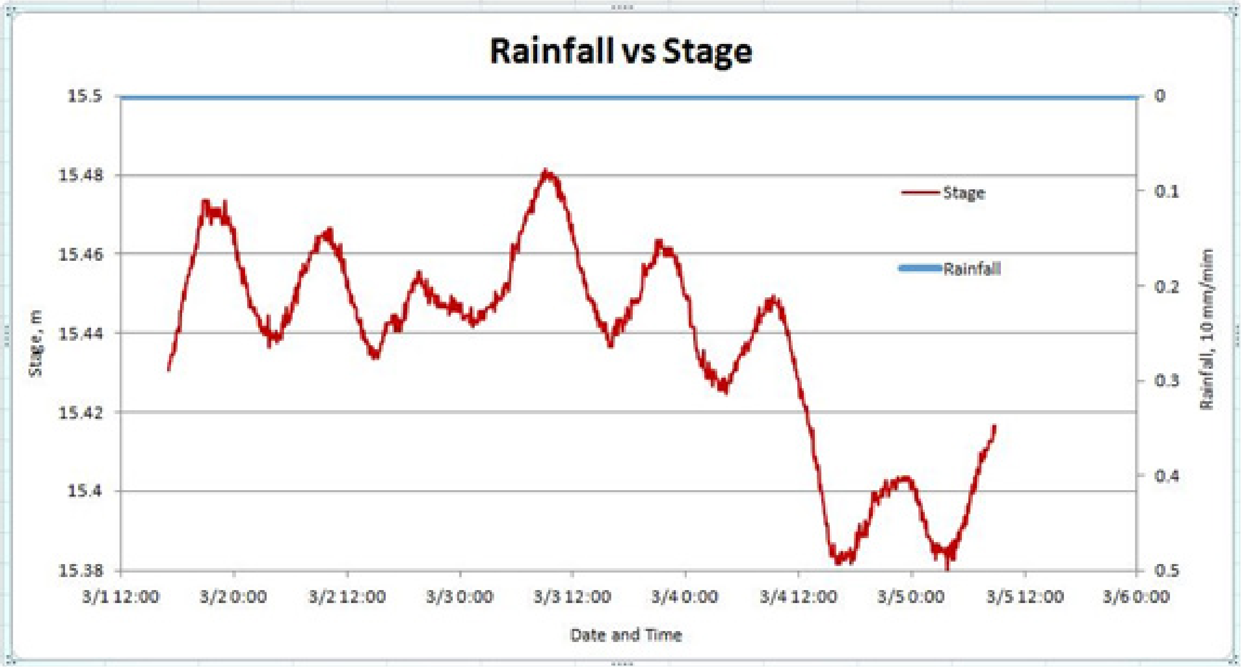


Figure 71. Relationship between Stage and Rainfall in Sta. Rosa Bridge

The relationship of water velocity data using flow meter deployed on March 1-5, 2014 and the stage during the sensor deployment is shown in Figure 72. The highest recorded stage was 15.482 on March 3, 2014 at 9:05 AM.

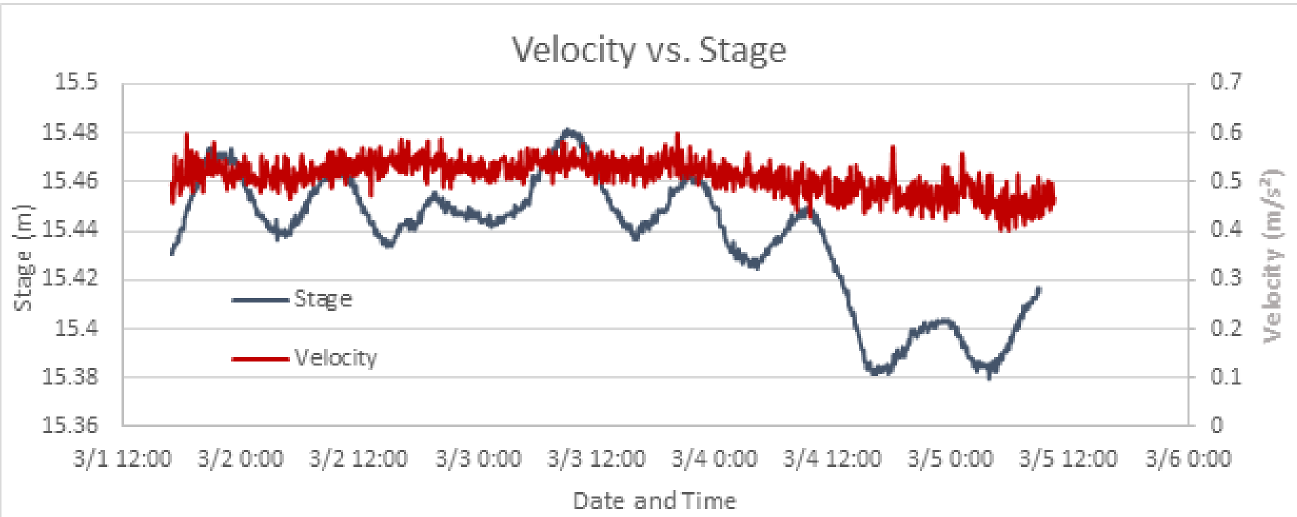


Figure 72. Relationship between Stage and Velocity in Sta. Rosa Bridge

The fastest velocity recorded was 0.599 m/son March 3, 2014 at 6:15 PM. The relationship of water velocity data using flow meter deployed on March 1-5, 2014 and the rainfall during the sensor deployment is shown in Figure 73.

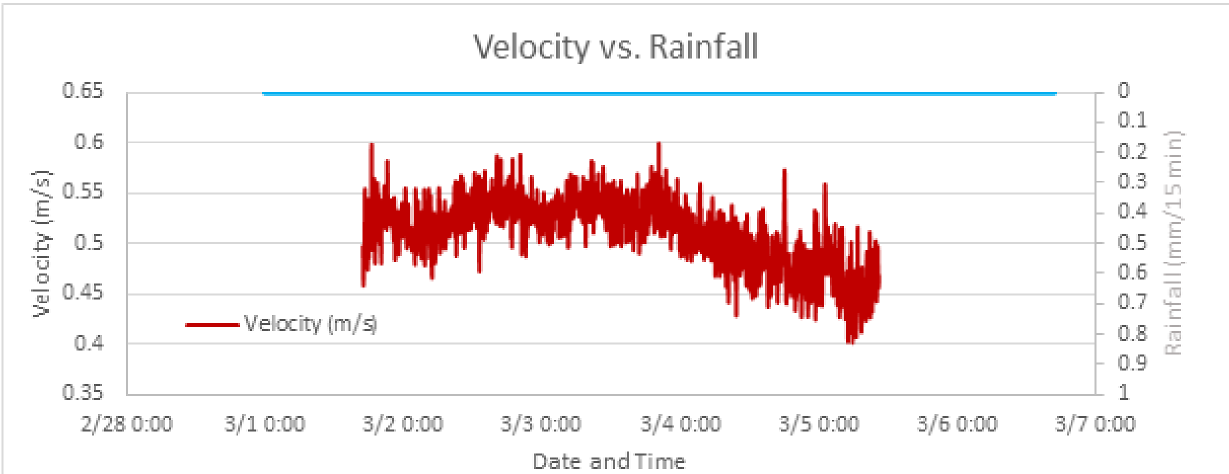
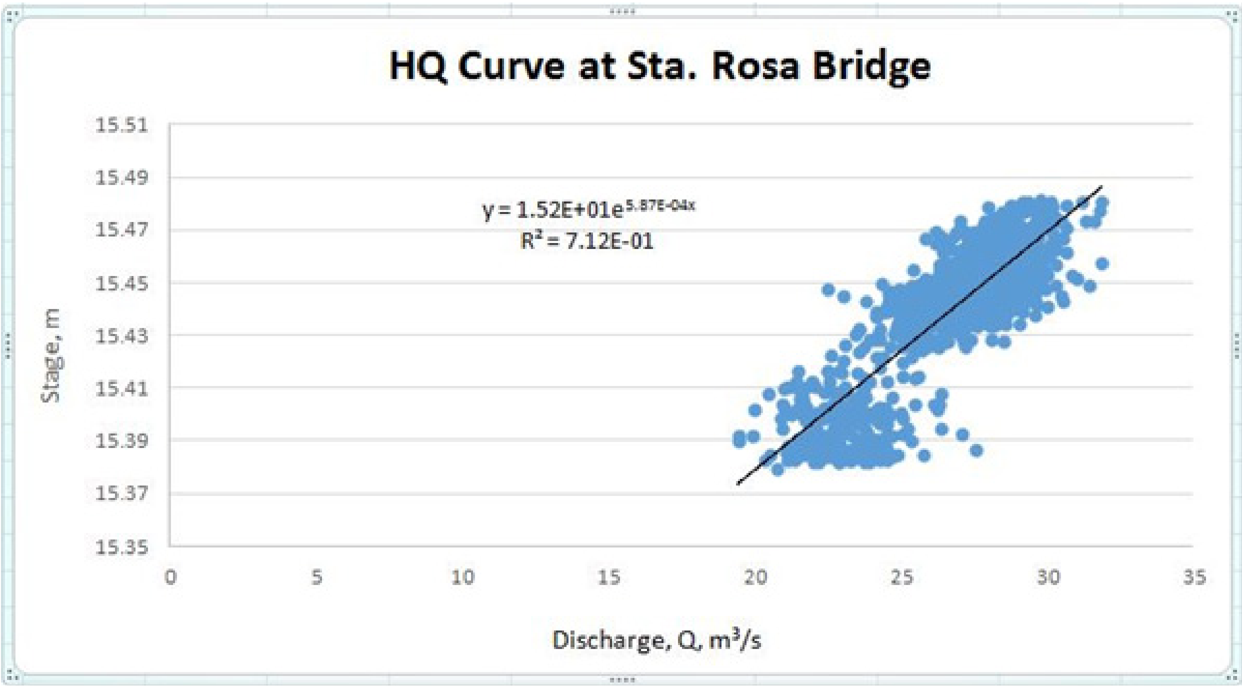


Figure 73. Relationship betweenVelocity and Rainfall in Sta. Rosa Bridge

The relationship between stage and discharge for March 1-5, 2014 resulted to an R^2 of 7.12e-01 is shown in Figure 74.



Annexes

ANNEX A. PROBLEMS ENCOUNTERED AND RESOLUTIONS APPLIED

The following shows the problems and limitations encountered during the fieldwork and the actions or solutions taken by the team during Pampanga Field Survey.

Limitation/Problems	Solutions
1) Stranded at first day of reconnaissance in Hagonoy , Bulacan because of inundation.	Took alternate path and walked up to the Municipal Office of Hagonoy.
2) June 25, 2012 Malfunctioned echosounder (Hi-Target)	Checked wirings and connecting cables. Restarted the program.
3) June 25-27, 2012 RTK base radio signal did not received by the RTK GPS receiver	Looked for a higher area to set-up the base.
4) July 12, 2012 Zigzag sweep bathymetric data was corrupted	Re-survey the portion of corrupted bathymetric data.
4) July 20, 2012 the Bathymetric Team could not conduct a survey because of unavailability of the boat from GEOTECH.	Find available boat to use. Coordinated again to Special Forces to lend a boat and also for the assistance.
6) June 21-22, 2012 bad weather condition because of a typhoon.	Checked the deployed sensors.

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

Type	Brand	Serial Number	Owner	Quantity
GPS Receiver (Base)	Trimble™ SPS852		UP-TCAGP	Two (2) units
GPS Receiver (Rover)	Trimble™ SPS882		UP-TCAGP	Eight (8) units
GPS Controller	Trimble™ TSC3		UP-TCAGP	Eight (8) units
High-Gain Antenna			UP- TCAGP	One (1) units
RTK radio and antenna			UP-TCAGP	One (1) unit with battery
Single beam Echo sounder	Hi-Target		UP- TCAGP	One (1) unit with accessories
Acoustic Doppler Current Profiler (ADCP)	Sontek™		UP- TCAGP	One (1) unit with accessories
Coupler-2a and 2b			UP- TCAGP	One (1) unit each
Handheld GPS	Garmin Oregon™ 550	1MW086831	UP-TCAGP	Four (4) units
		1MW086842		
		1MW086920		
		1MW079764		
AA-Battery Charger	Akari		UP-TCAGP	Two (2) unit
Multi-tester			UP-TCAGP	One (1) unit
Laptops	Lenovo ThinkPad		UP-TCAGP	One (1) unit
	Dell Laptop			One (1) unit
Digital Level	Topcon DL502		UP-TCAGP	One (1) unit with two (2) level rods
Depth Gauge	Onset Hobo wares	9997437,9951530 9983753,9759371	UP- TCAGP	Three (3) units
Rain Gauge		1293784	UP-TCAGP	One (1) unit
Digital Flow Meter	For repair	F494	UP-TCAGP	Zero (0) unit
Echo sounder	Ohmex™	2969	UP-TCAGP	One (1) unit
Range Pole	Trimble®		UP-TCAGP	Six (6) units
12-volt deep cycle batteries			UP-TCAGP	Two (2) units
Tripod	Trimble®		UP-TCAGP	Four (4) units
Bipod	Trimble®		UP-TCAGP	Six (6) units

Tribrack			UP-TCAGP	Three (3) units
Laser Range Finder	Bushnell		UP-TCAGP	Two (2) units
Installers	SonTek™		UP-TCAGP	One (1) unit
	Topcon™			One (1) unit
	Trimble™ Business Center			One (1) unit
	Trimble Realworks			One (1) unit
Toolbox			UP-TCAGP	One (1) unit
Printer	Canon™	Ip2700	UP-TCAGP	One (1) unit
QINSy dongle			UP-TCAGP	One (1) unit
MMS mount			UP-TCAGP	One (1) unit
Interconnect cables			UP-TCAGP	One (1) unit
External GPS			UP-TCAGP	One (1) unit
MDL Dynascan™			UP-TCAGP	One (1) unit
MDL Box			UP-TCAGP	One (1) unit
MMS			UP-TCAGP	One (1) unit
Transducer	Ohmex™		UP-TCAGP	One (1) unit
D90 Camera	Nikon™		UP-TCAGP	Two (2) units

ANNEX C. THE SURVEY TEAM

Data Validation Component Sub-team	Designation	Name	Agency/Affiliation
Data Component Leader	Data Component Project Leader -II	ENGR. LOUIE P. BALICANTA	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. JOEMARIE S. CABALLERO	UP TCAGP
Bathymetric Survey Team	Senior Science Research Specialist	ENGR. DEXTER T. LOZANO	UP TCAGP
	Research Associate	ENGR. JMSON J. CALALANG	UP TCAGP
Profile Survey Team	Senior Science Research Specialist	ENGR. BERNARD PAUL D. MARAMOT	UP TCAGP
	Senior Science Research Specialist	ENGR. MELCHOR REY M. NERY	UP TCAGP
Cross Section Survey Team and Deployment Team	Research Associate	JELINE AMANTE	UP TCAGP
	Research Associate	PATRIZCIA MAE P. DELACRUZ	UP TCAGP
	Research Associate	JOJO E. MORILLO	UP TCAGP
	Research Associate	MARY GRACE JASON	UP TCAGP
	Research Associate	MARK LESTER D. ROJAS	UP TCAGP
AWLS Cross Section Survey Team	Research Associate	MICHAEL ANTHONY C. LABRADOR	UP TCAGP
	Research Associate	KRISTINE AILENE BORROMEO	UP TCAGP
	Research Associate	NANCY DIMAYACYAC	UP TCAGP
	Consultant	MATT HORITT	VISITOR

ANNEX D. NAMRIA CERTIFICATION

Republic of the Philippines
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY
Department of Environment and Natural Resources
Lawton Avenue, Fort Andres Bonifacio, 1634 Taguig City

June 20, 2012

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows -

Province: **PAMPANGA**
Station Name: **PA-177**

Island: **LUZON**	Municipality: **ARAYAT**	Barangay: **SAN AGUSTIN**
Elevation: **15.5589 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

PA-177 is located on the N side of the Olongapo - Gapan Road. It is on the E end of the sidewalk of the San Agustin Bridge, and is 0.24m S of the easternmost post of the steel railing. The concrete bridge is marked with Km. 90 and its E approach is the boundary between barangay San Agustin Norte and Camba of Arayat.

Mark is the head of a 4" copper nail set in a drilled hole and cemented flushed on the pavement with an inscription "PA 177; NAMRIA; 2006."

Requesting Party: **Joemarie Caballero**
Pupose: **Reference**
OR Number: **4480776 U**
T.N.: **626-2012**

For JOSE GALO P. ISADA, JR.
Director, MGD

9906202012160213

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

June 11, 2013

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows -

Province: **BULACAN**
Station Name: **BLN-3062**
Order: **4th**

Island: **LUZON**		Barangay: **SAPANG BAYAN**
Municipality: **CALUMPIT**		
	PRS92 Coordinates	
Latitude: **14° 54' 55.63872"**	Longitude: **120° 46' 33.09915"**	Ellipsoidal Hgt: **4.71100 m.**
	WGS84 Coordinates	
Latitude: **14° 54' 50.12985"**	Longitude: **120° 46' 37.96741"**	Ellipsoidal Hgt: **46.80100 m.**
	PTM Coordinates	
Northing: **1649463.205 m.**	Easting: **475885.112 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,650,069.47**	Easting: **260,739.06**	Zone: **51**

Location Description

BLN-3062

Station is located in the Province of Bulacan, Mun. of Calumpit, Brgy. Sapang Bayan. From Pungo Boundary travel 30 m W past the Smart Tower. Then, travel 450 m N towards Sapang Bayan. Station is situated at the left side of the road about 480 m from Pugong Boundary, about 280 m from BLN-3061 and about 250 m from the concrete road going to BLN-3061. Mark is the head of a 4 in. copper nail centered on a 0.20 m x 0.20 m x 1.00 m concrete monument embedded in the ground with inscriptions, "BLN-3062, 2008, NAMRIA".

Requesting Party: **UP-TCAGP DREAM**
Pupose: **Reference**
OR Number: **3943775B**
T.N.: **2013-0556**

RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy Department

NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3494 to 98
www.namria.gov.ph

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DREAM

Disaster Risk and Exposure Assessment for Mitigation