REGION 2

Cagayan River:

DREAM Ground Surveys Report

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY

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List of Abbreviations

ADCP	Acoustic Doppler Current Profiler
ARG	Automated Rain Gauge
AWLS	Automated Water Level Sensor
BM	Benchmark
BST	Bathymetric Survey Team
CST	Cross-Section Team
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DG	Depth Gauge
DOST	Department of Science and Technology
DPC	Data Processing Component
DREAM	Disaster Risk and Exposure 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
HQ Curve	Stage (H) and Discharge (Q)of River relationship curve
LGUs	Local Government Units
LIDAR	Light Detection and Ranging
MSL	Mean Sea Level
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
PST	Profile Survey Team
RG	Rain Gauge
RINEX	Receiver Independent Exchange
TBC	Trimble Business Center
TCAGP	Training Center for Applied Geodesy and Photogrammetry
TGBM	Tidal Gauge Benchmark
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.

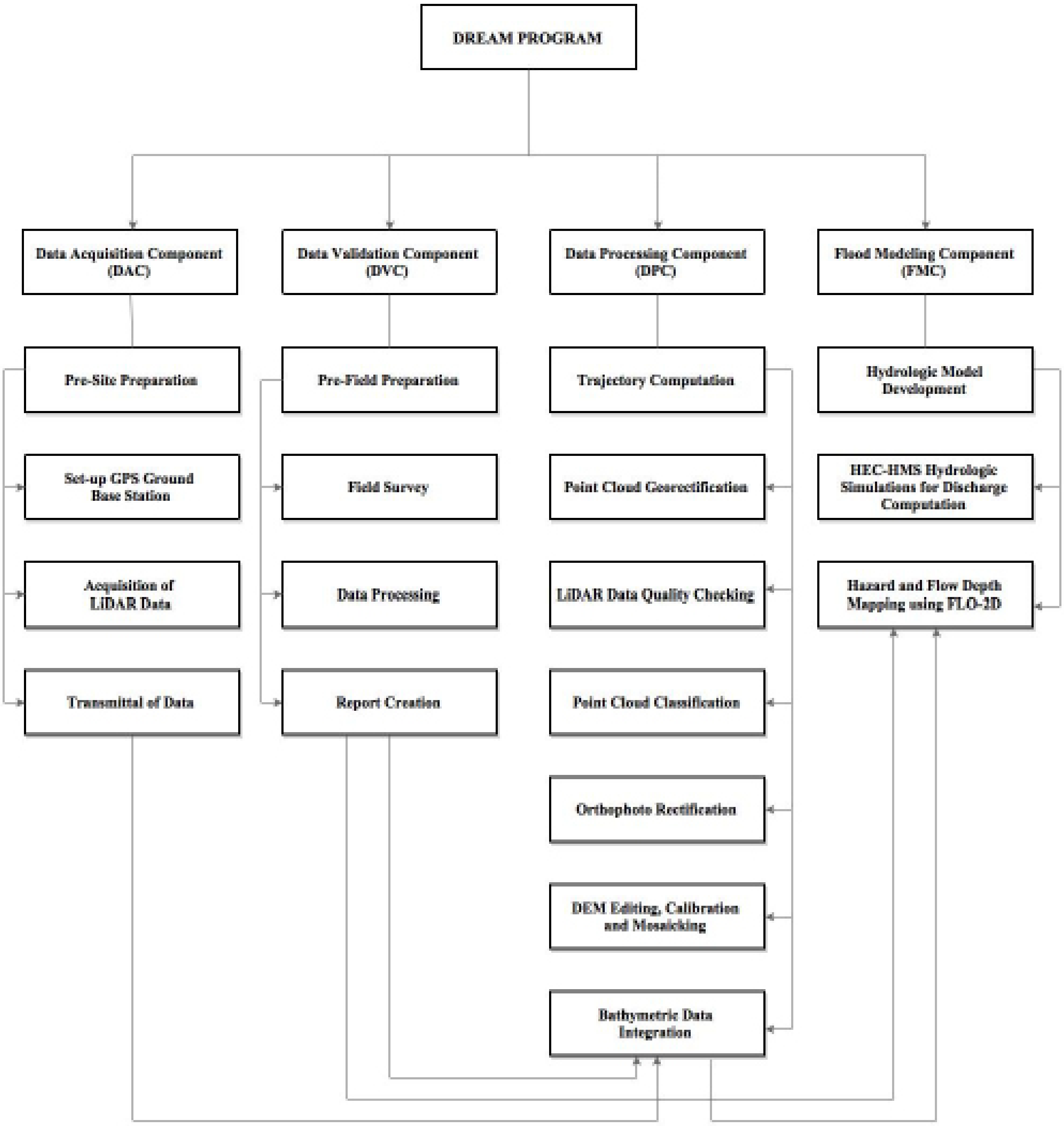


Figure 1. The General Methodological Framework of the Program

The Cagayan River Basin

The Cagayan River Basin

The Cagayan River Basin is located in the north eastern part of Luzon. The Cagayan River Basin is considered as the largest river catchment in the Philippines with an area of 27,280 square kilometers. The location of Cagayan River Basin is as shown in Figure 2.

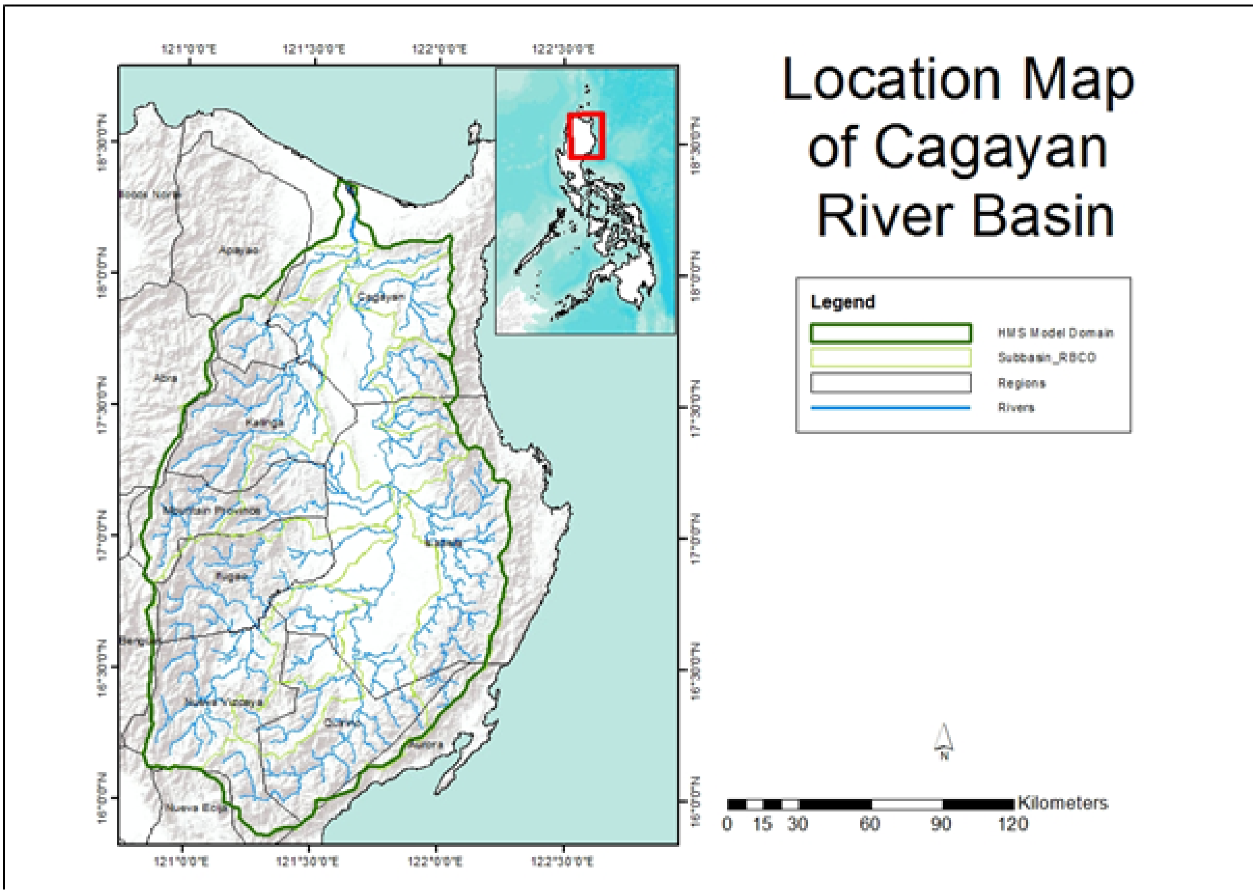


Figure 2. Location Map of Cagayan River Basin

It is characterized by a valley oriented north to south. The valley is bounded on the east by the Sierra Madre Mountains, on the west by the Cordillera Mountains, on the south by the Caraballo Mountains, and on the north by the coastline of the Babuyan Channel. The basin covers the provinces Quirino, Nueva Vizcaya, Ifugao, Mountain Province, Kalinga, Apayao, Isabela, and Cagayan.

It drains the northern portion of the island and traverses through Tuguegarao City and Cauayan City and the towns of Natipunan and Maddela in Quirino; San Mateo in Ifugao; San Agustin, Jones, Echague, Angadanan, Naguilian, San Mariano, Gamu, Benito Soliven and Ilagan, Tumauini, Santo, Tomas, Cabagan, Santa Maria and San Pablo in Isabela; and, Enrile, Solana, Iguig, Samulung, Alcala, Santo Niño, Gattaran, Lasam, Lal-lo, Camalaniugan and Aparri in Cagayan.

The average annual rainfall ranges from 1,000 millimeters in the northern part up to 3,000 millimeters in the southern mountains. Floods caused by the Cagayan River flow slowly because of surface retention over the floodplain. Cagayan Valley is relatively flat and basin coverage has a gentle slope. Also, there are retardations of flooding due to several river meanders and gorges.

The Cagayan River Basin

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 Cagayan River Basin are shown in Figure 3 & Figure 4, respectively.

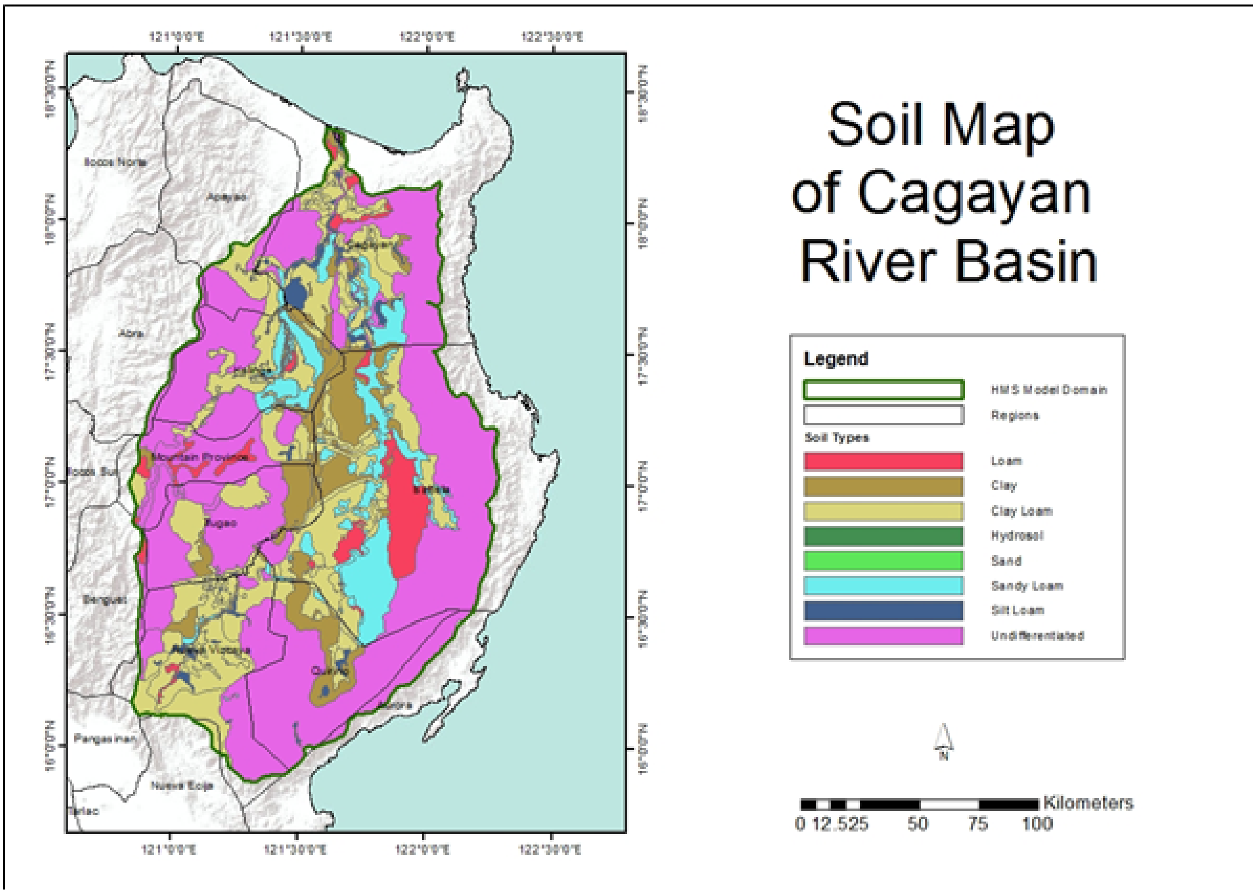


Figure 3. Soil Map of Cagayan River Basin

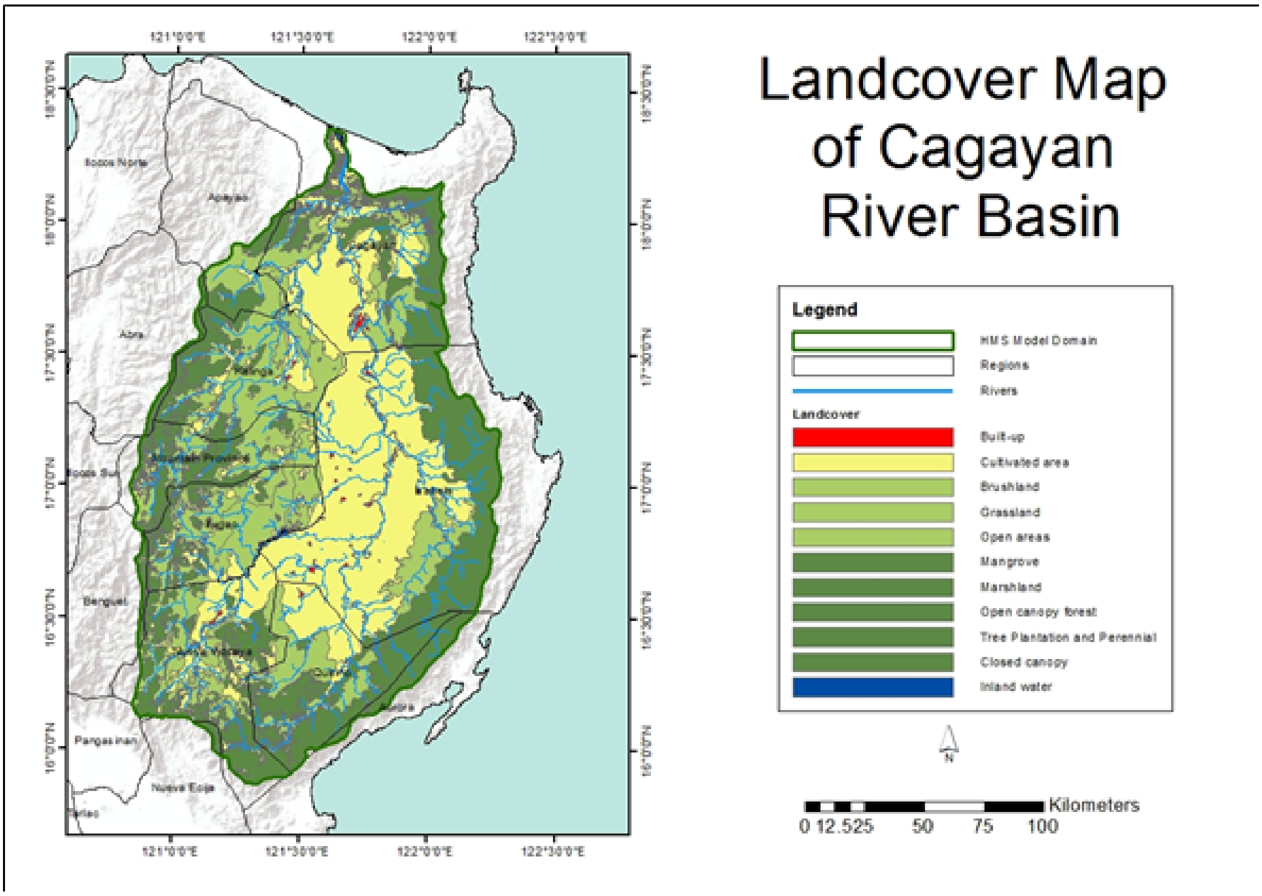


Figure 4. Land Cover Map of Cagayan River Basin

DVC Methodology

DVC Methodology

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

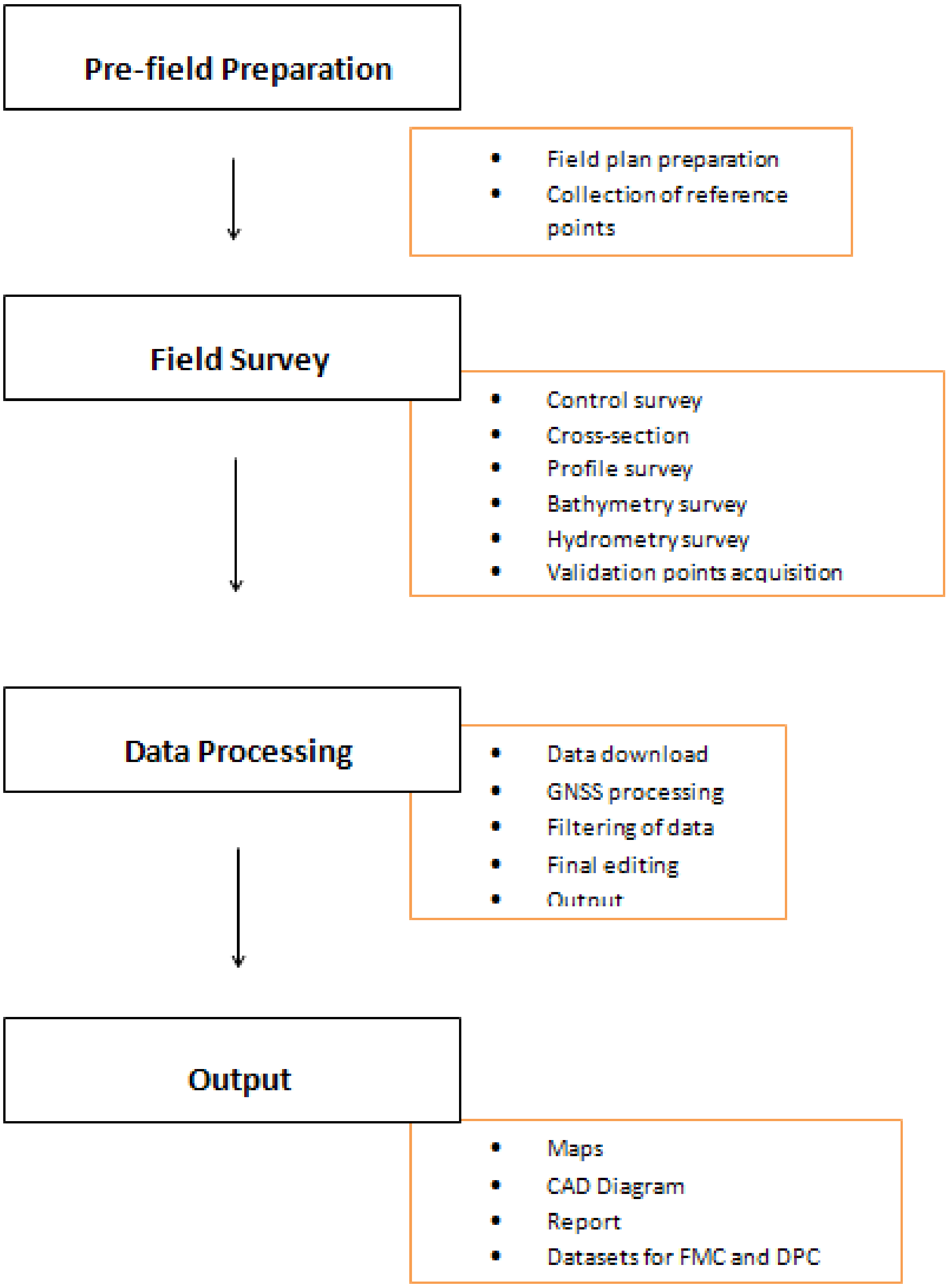


Figure 5. DVC Main Activities

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

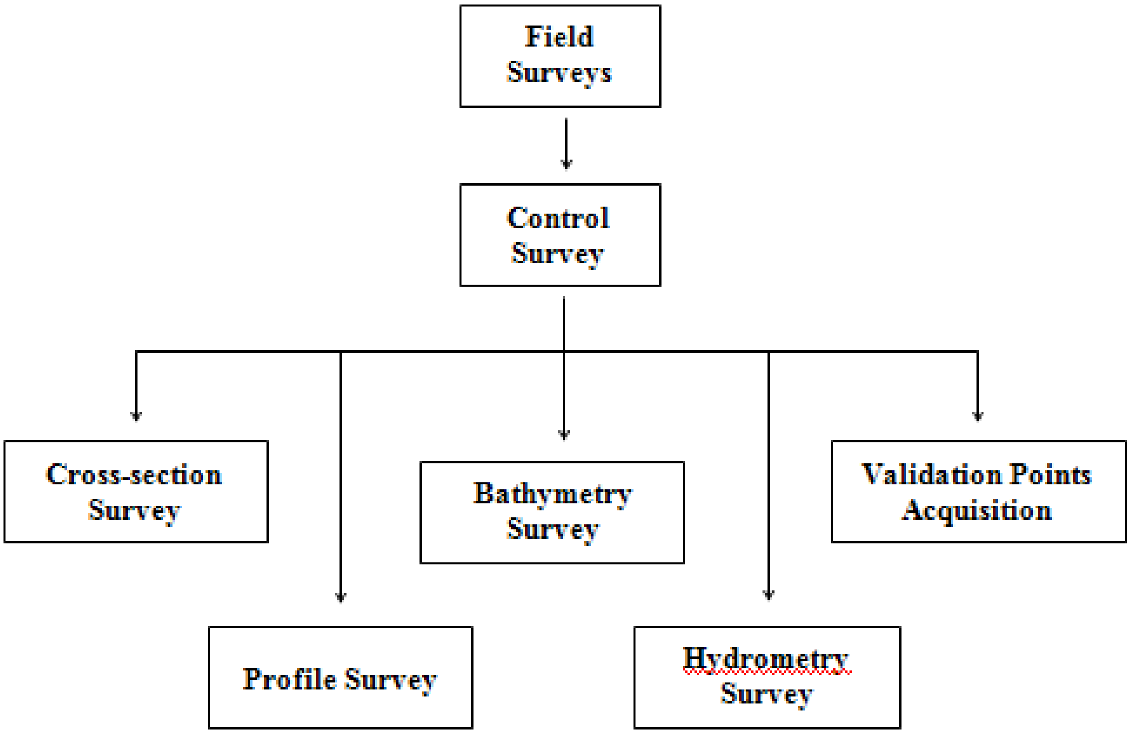


Figure 6. DVC Field Activities

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.

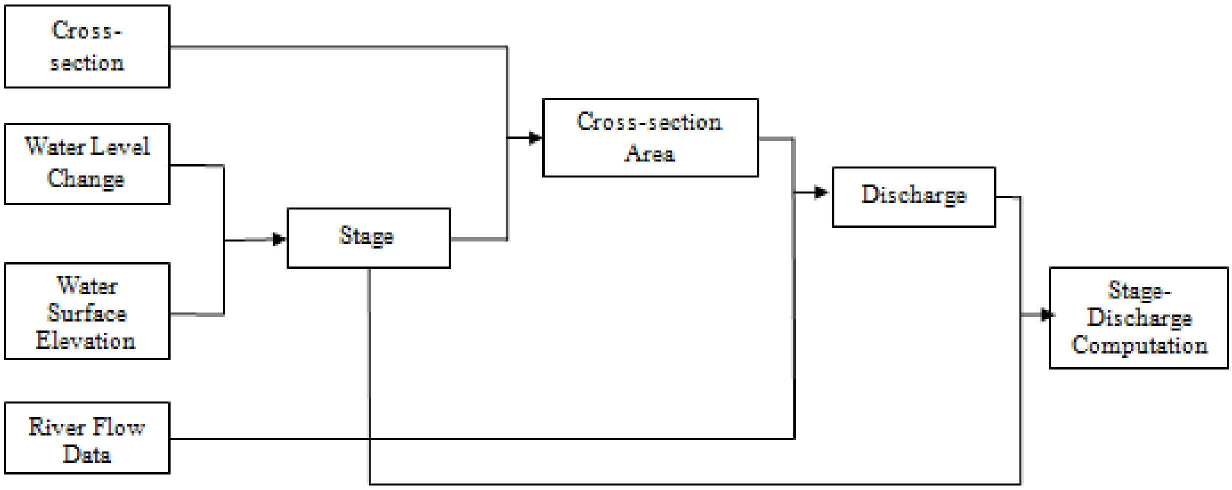


Figure 7. Flow Chart for Stage-Discharge Correlation Computation

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.

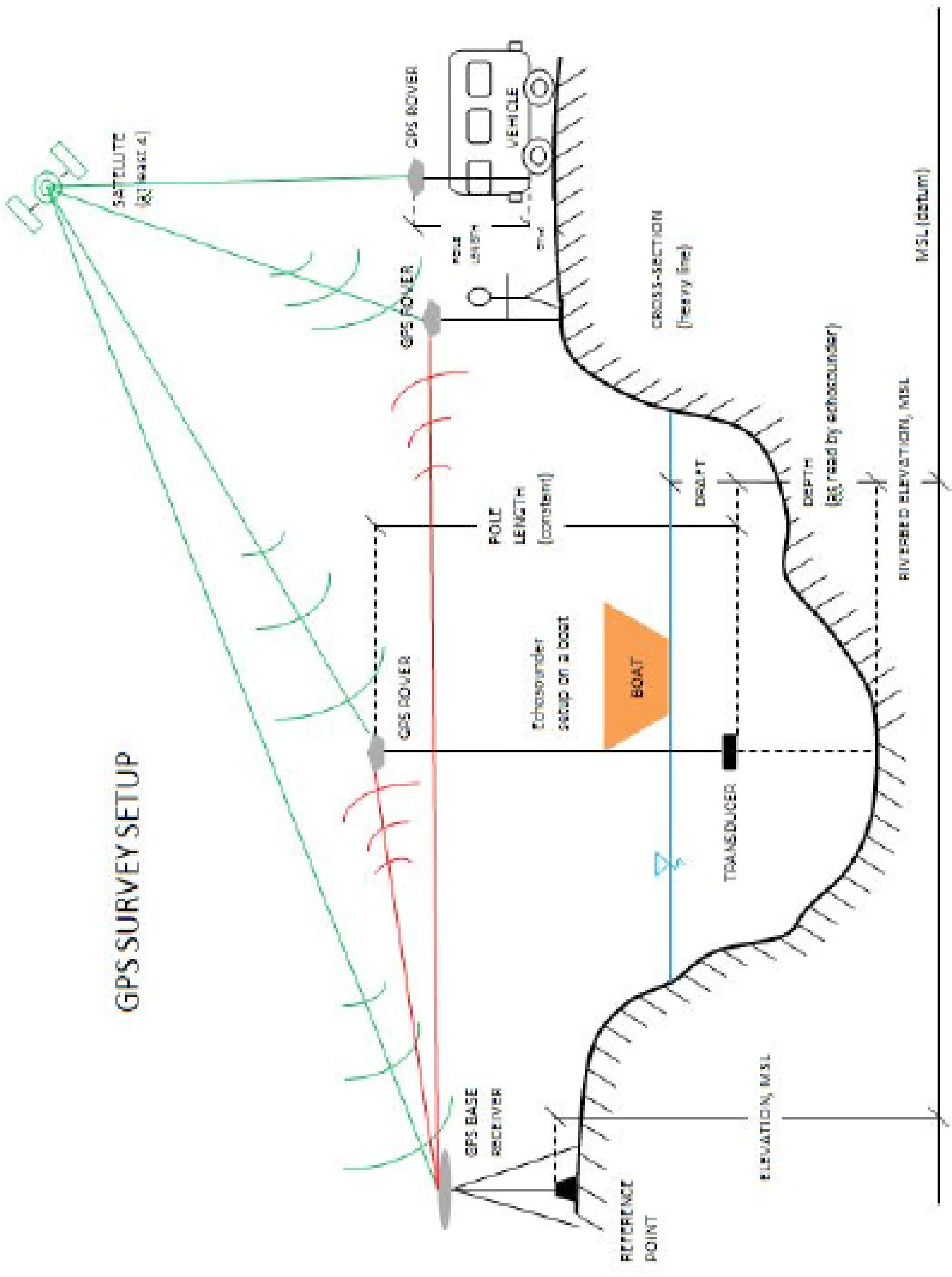


Figure 8. Set-up for GNSS Survey

3.3 Data Processing

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

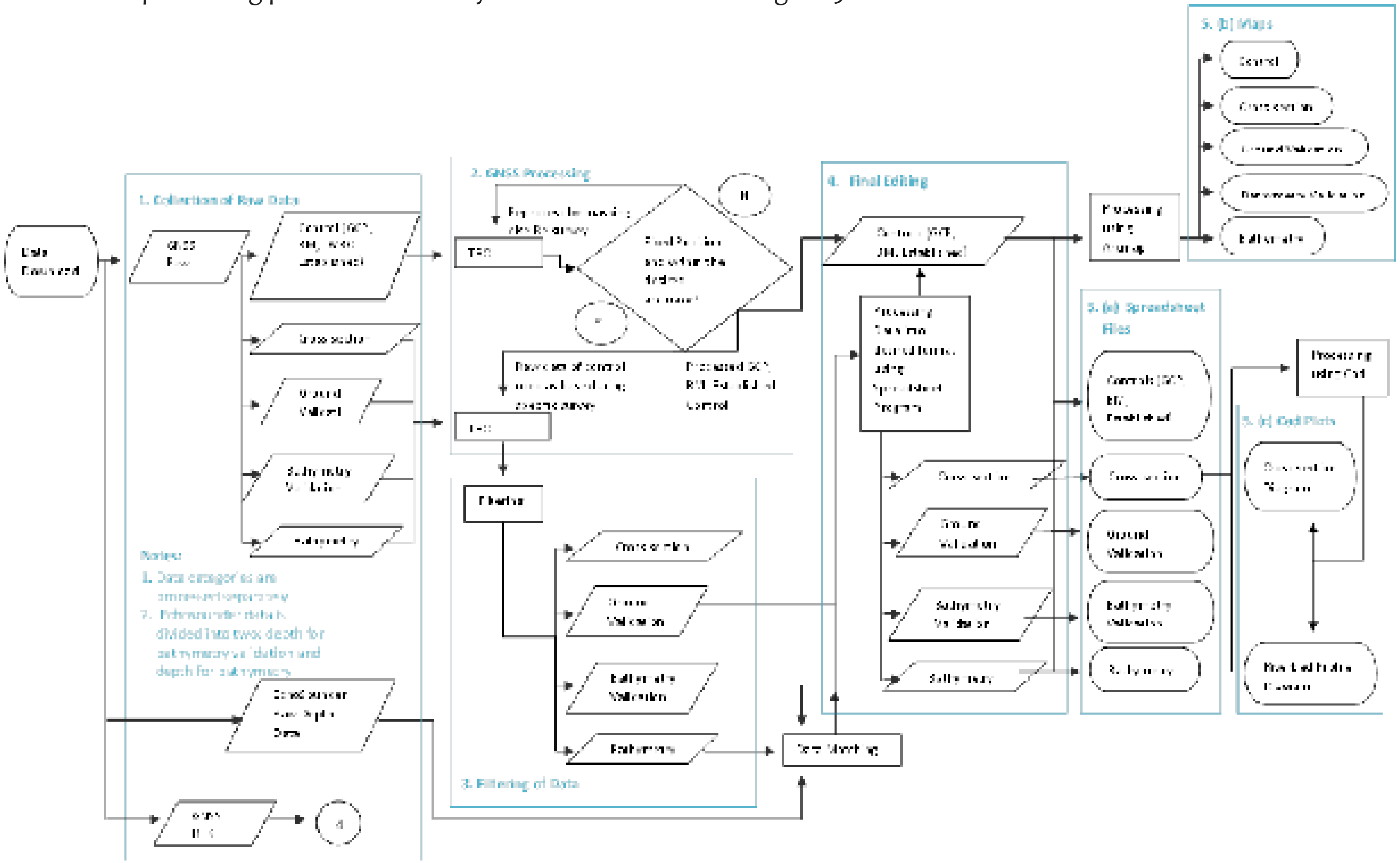


Figure 9. DVC Data Processing Methodology

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

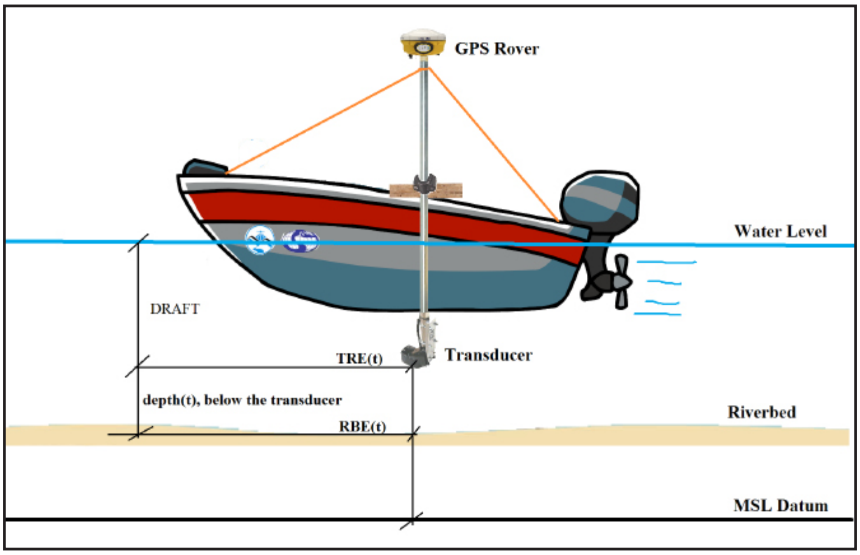


Figure 10. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

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.

DVC Methodology

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.

Cagayan River Basin Survey

Cagayan River Basin Survey

The survey performed in Cagayan River Basin was comprised of four fieldworks due to logistical concerns such as availability of DVC personnel and equipment. These surveys were conducted on September 16 – 30, 2013 (Initial Survey), March 17-April 6, 2014 (Phase 1), January 29 to February 12, 2014 (Phase 2), and April 28 - May 8, 2014 (Phase 3).

The initial survey included cross-sections, installation of ADCP and data gathering from deployed sensors of all bridges in the river basin with AWLS as shown in Figure 11. Data collection from sensors which were not able to give sufficient data and completion of unaccomplished cross-section survey were designated to the remaining three (3) surveys.

Due to the huge length of Cagayan River, the bathymetry survey was divided into three (3) fieldworks. Any phase mentioned until the end of the report corresponds to the 3 phase survey for the bathymetry of Cagayan River.

Cagayan River Survey Phase 1 covered bathymetric survey starting from the Municipality of Ramon, Isabela down to the Municipality of Aparri, Cagayan; cross section and flow measurements surveys were also conducted in the AWLS of four (4) bridges in Cagayan and Isabela; and ground validation survey traversing the provinces of Cagayan down to Isabela.

The scope of the Cagayan River Survey Phase 2 included bathymetric survey of two principal tributaries of Cagayan River – Magat and Ilagan Rivers; cross section flow measurements surveys were also conducted in AWLS of three bridge; ground validation survey from Roxas to Gamu and from Delfin Albano to San Mariano; and deployment of ADCP in two (2) bridges, all in the province of Isabela.

Last phase of the survey in Cagayan River covered a bathymetric survey from Quirino down to the the southern part of Isabela; cross section and flow measurements surveys in four (4) bridges; ground validation survey traversing Cordon to Maddela and Jones to Nagtipunan; and deployment of ADCP in two (2) bridges, all in Quirino and Isabela. The extent of the bathymetry survey for Cagayan River is summarized in Figure 12.

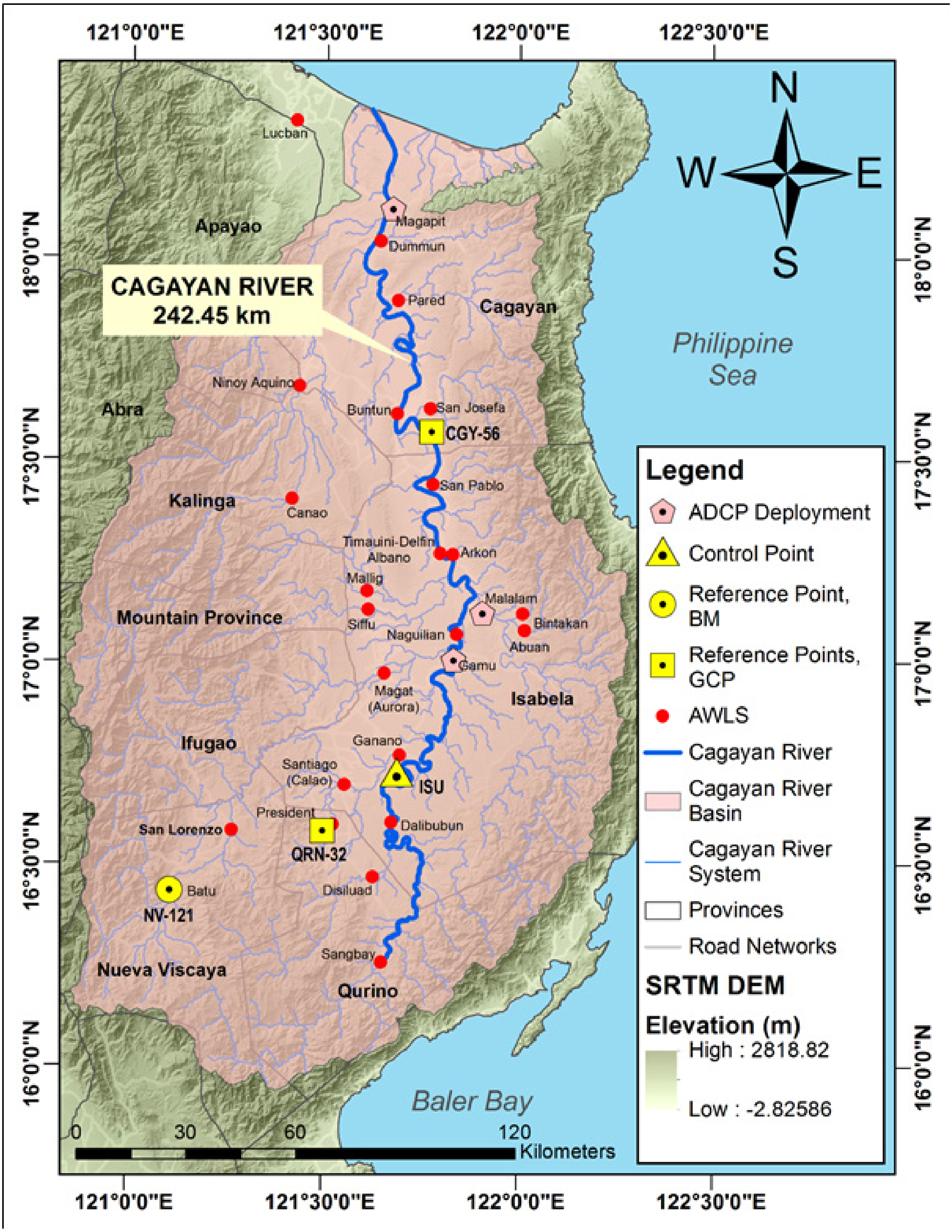


Figure 11. Extent of the initial Cagayan River Survey (September 16 – 30, 2013)

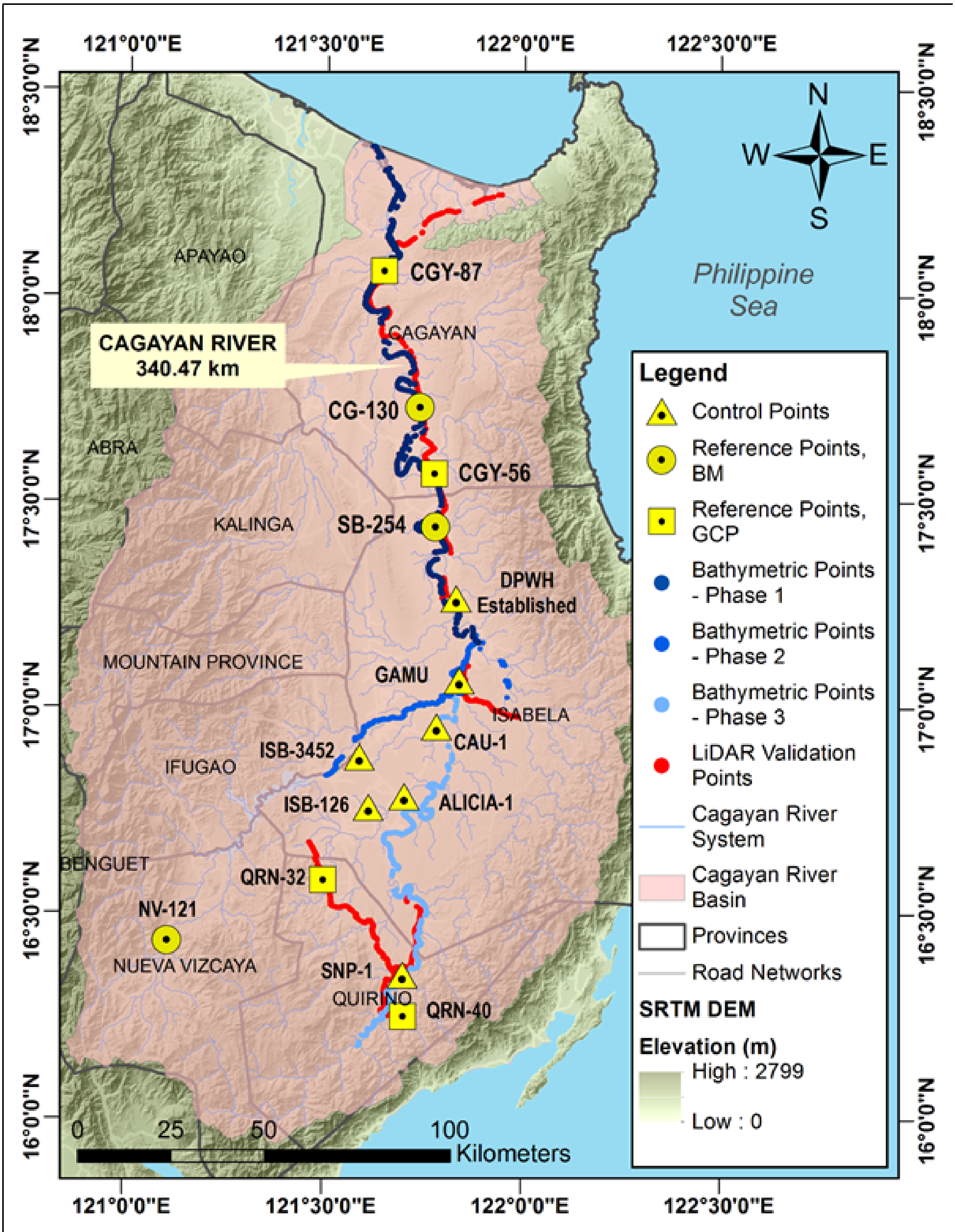


Figure 12. Extent of Cagayan River Bathymetry and Ground Validation Survey

Cagayan River Basin Survey

4.1 Control Survey

Technical data and available information from NAMRIA relevant to the ground validation surveys were reviewed and retrieved. Coordination with NAMRIA was done to collect information on location and descriptions of established horizontal and vertical ground control points within or near the survey area. These control points were obtained because of their importance in the establishment of the network for the GNSS survey.

Continuous differential static observations using a Trimble® SPS 852 GNSS Modular Receiver were done for at least three (3) hours in these stations. NAMRIA established control points such as reference points bear horizontal coordinates (Northing and Easting) whereas benchmarks bear vertical coordinate (Elevation in MSL). A static GNSS observation occupying these control points will tie their coordinates, so each control point will have its individual Northing, Easting, and Elevation in mean sea level (MSL). This provided coordinates for the newly established control point for ground and bathymetric surveys. The horizontal coordinates and elevations of these control points were derived using Trimble® Business Center GNSS processing software.

The initial control survey conducted in Cagayan River Basin on September 16 – 30, 2013 as exhibited in Figure 13 occupied Ground Control Point (GCP) QRN-32 at Brgy. Liwayway, Diffun, Quirino; a Benchmark (BM) NV-121 in Nueva Vizcaya; another GCP, CGY-56 in Cagayan and ISU, a UP-established control point inside Isabela State University as bases for GPS surveying.

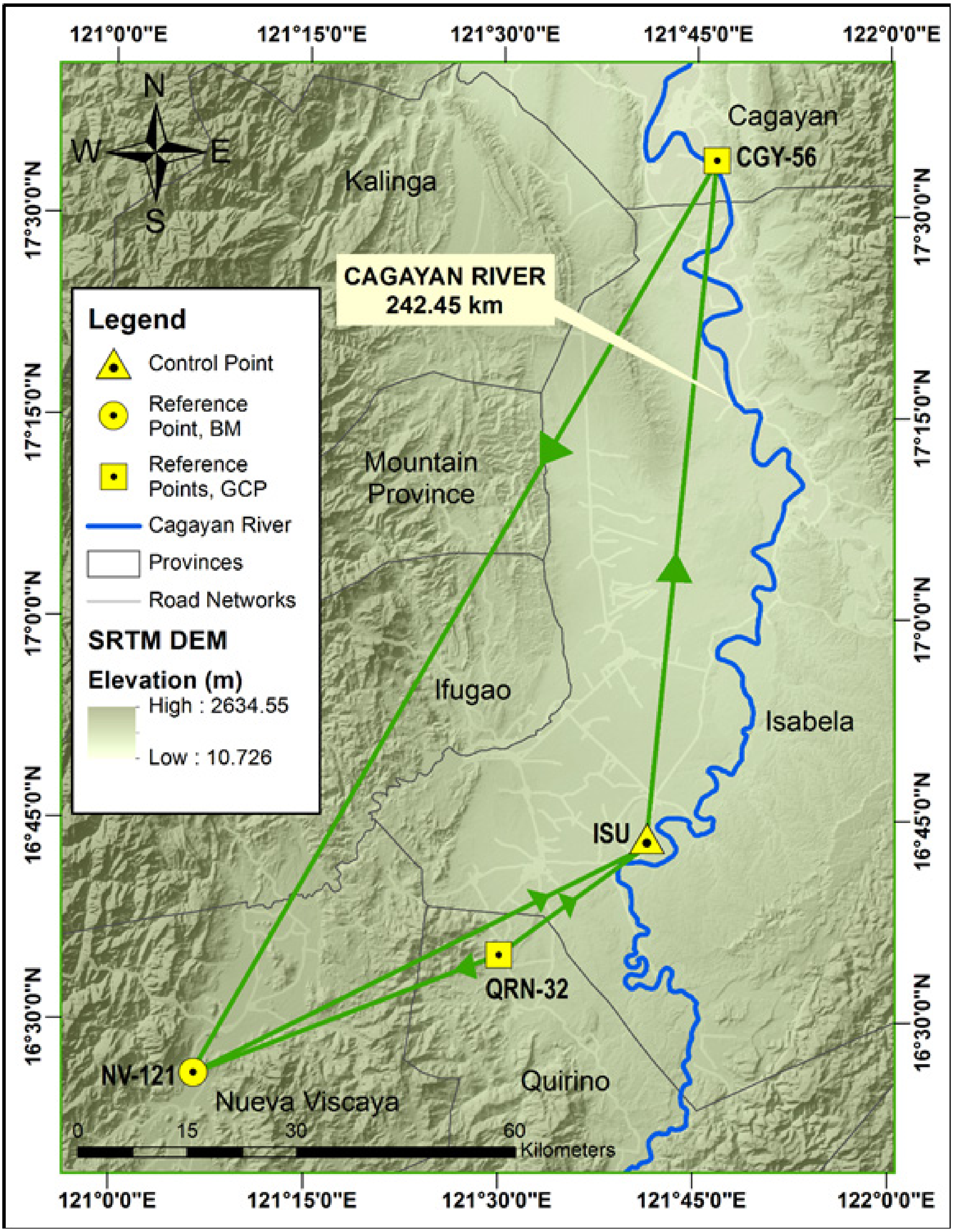


Figure 13. GNSS Network of the initial survey in Cagayan River Basin

Cagayan River Basin Survey

Cagayan River Survey – Phase 1 established two (2) GNSS networks on March 17-April 6, 2014 The control points considered for the survey area are the ff.: SB-254 in the Municipality of San Pablo (Figure 15); CGY-56 in Tuguegarao City (Figure 17); CG-130 in the Municipality of Iguig (Figure 16), and CGY-87 (Figure 18) in the Municipality of Gattaran. Additionally, baseline surveys were performed at the approach of the bridges with installed AWLS in Isabela and Cagayan, namely: Delfin Albano (Figure 19), Ninoy Aquino (Figure 21), Pared (Figure 22), Buntun (Figure 20), Dummun (Figure 23), and Magapit Bridges (Figure 24) in mainstream Cagayan River.

A summary of the control points used during the survey is shown in Table 1. The map on Figure 14 exhibits the location of the control points used for Cagayan River Phase 1 fieldwork.

Table 1. List of Control Points used in Cagayan River Survey Phase 1 (March 17-April 6, 2014)

Base Station	Order of Accuracy	Latitude	Longitude	Ellipsoidal Height (m)
CGY - 56	2nd order	17034'07.37984" N	121046'30.66402" E	75.522
SB-254	1st order	17 026'20.72161" N	121046'43.82331" E	74.364
CGY-87	2nd order	18003'40.17189" N	121038'43.36204" E	71.061
CG-130	1st order	17043'47.82677" N	121044'20.02512" E	65.224
DPWH (UP Occupied)	-	17015'55.43093" N	121049'57.14379" E	79.58

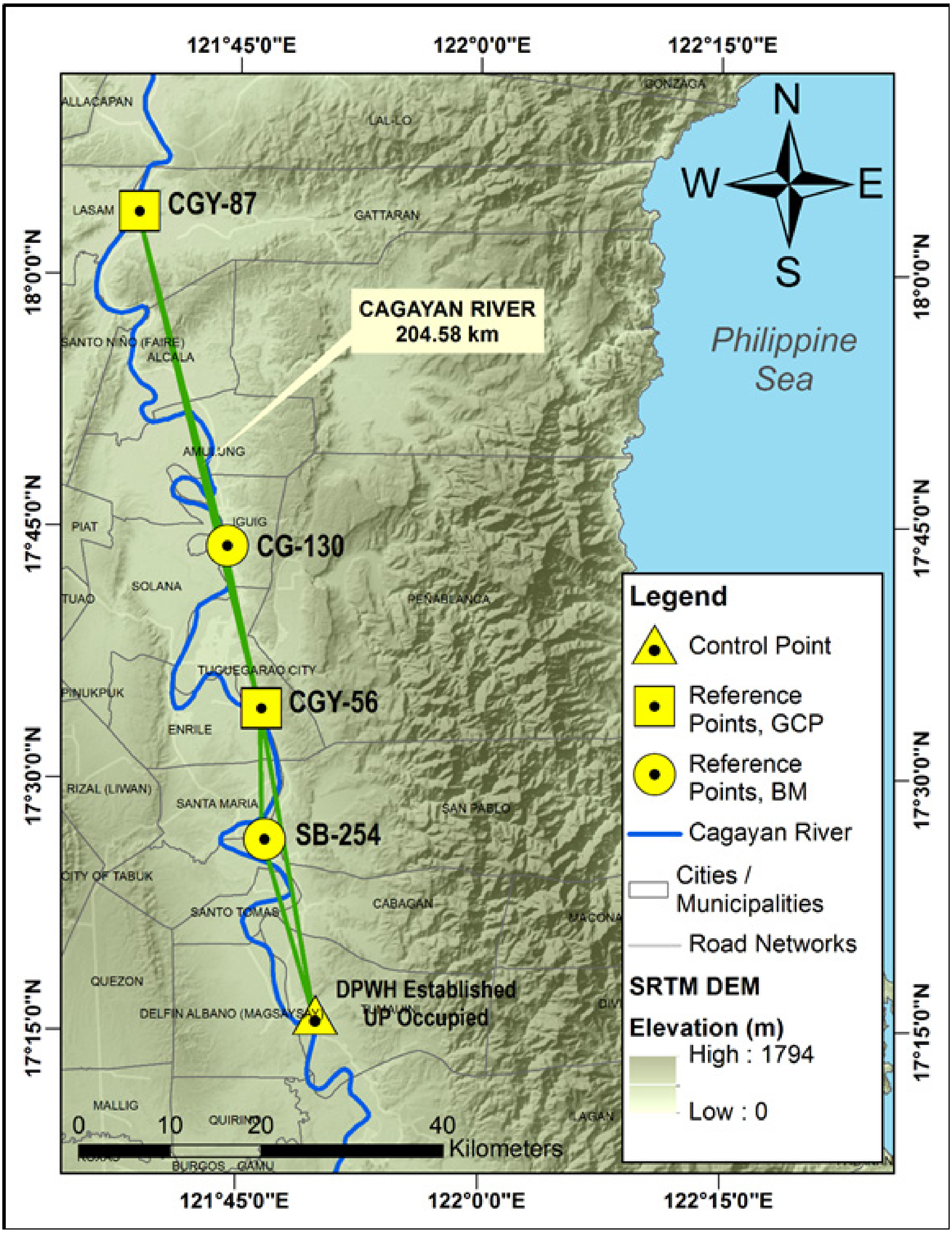


Figure 14. GNSS Network of Cagayan River Survey Phase 1 (March 17-April 6, 2014)

The GPS setups made in the location of the reference and control points are shown in Figures 15-18:

Figure 15. GNSS receiver set up, Trimble® SPS 882 at SB-254 at San Pablo Bridge in San Pablo, Isabela

Figure 16. Trimble® SPS 852 setup at CG-130 in Iguig, Cagayan

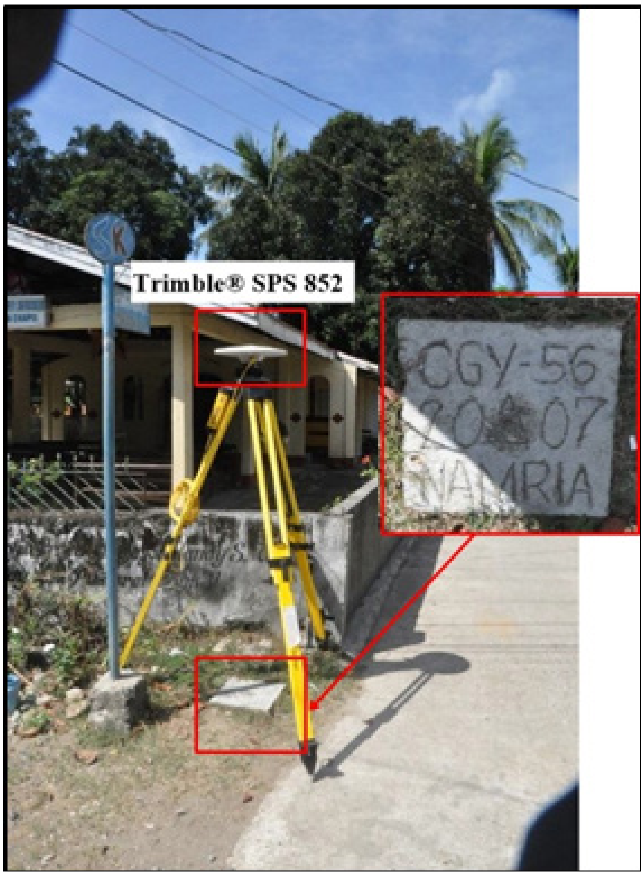


Figure 17. GNSS base set up, Trimble® SPS 852 at CGY-56 in Tuguegarao City, Cagayan

Figure 18. Trimble® SPS 985 setup at CGY-87 in Gattaran, Cagayan

The following images from Figures 19-24 show the UP established control points at the approach of Delfin Albano, Buntun, Ninoy Aquino, Pared, Dummun, and Magapit Bridges.

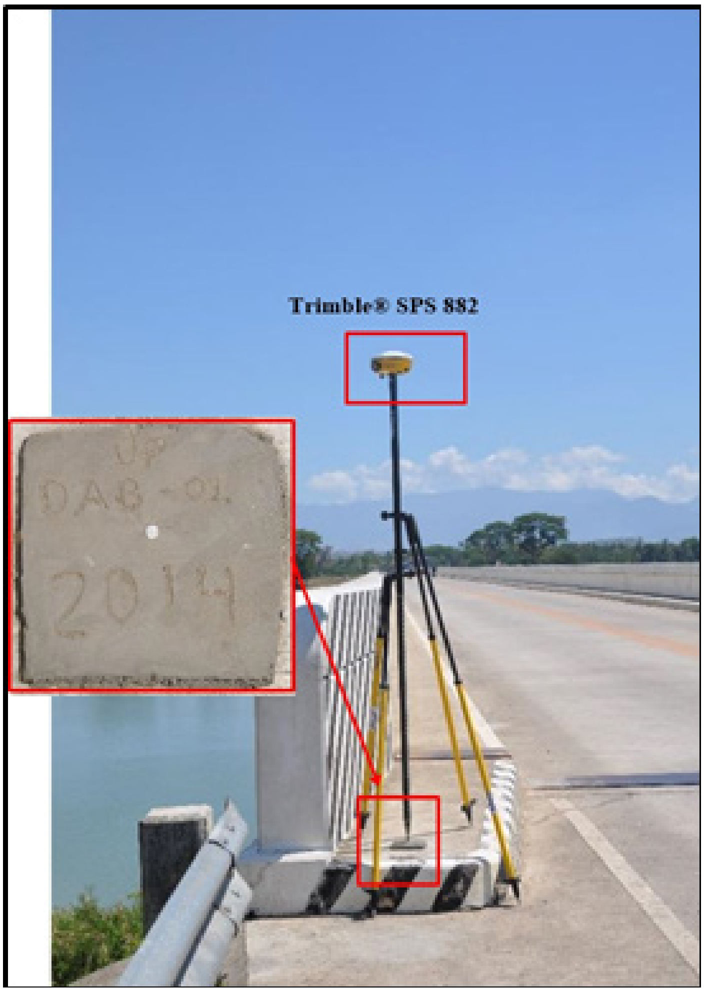


Figure 19. GNSS receiver set up, Trimble® SPS 882 at UP DAB-1 2014 at Delfin Albano Bridge, Delfin Albino, Isabela

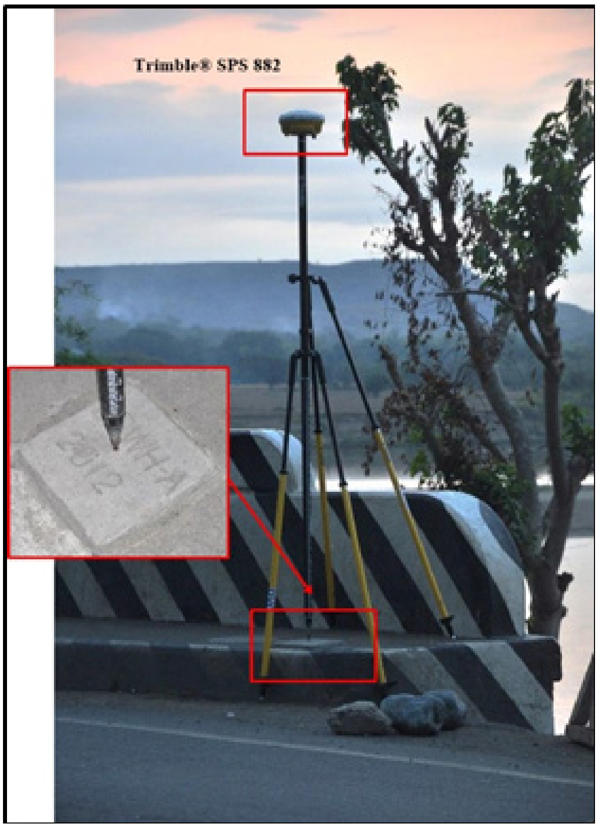


Figure 20. Trimble® SPS 882 setup at DPWH-A 2012, at Buntun Bridge, Tuguegarao City, Cagayan

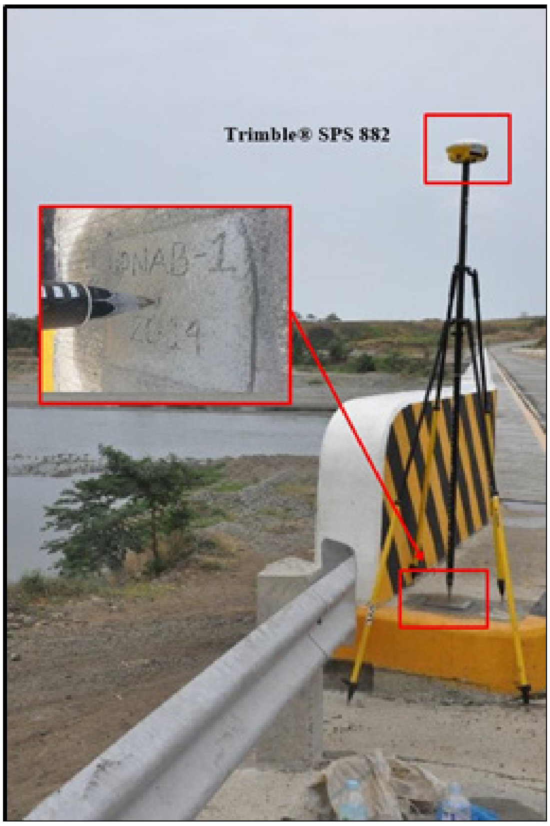


Figure 21. GNSS base set up, Trimble® SPS 882, at UP NAB-1 in Ninoy Aquino Bridge, Brgy. San Luis, Tuao, Cagayan

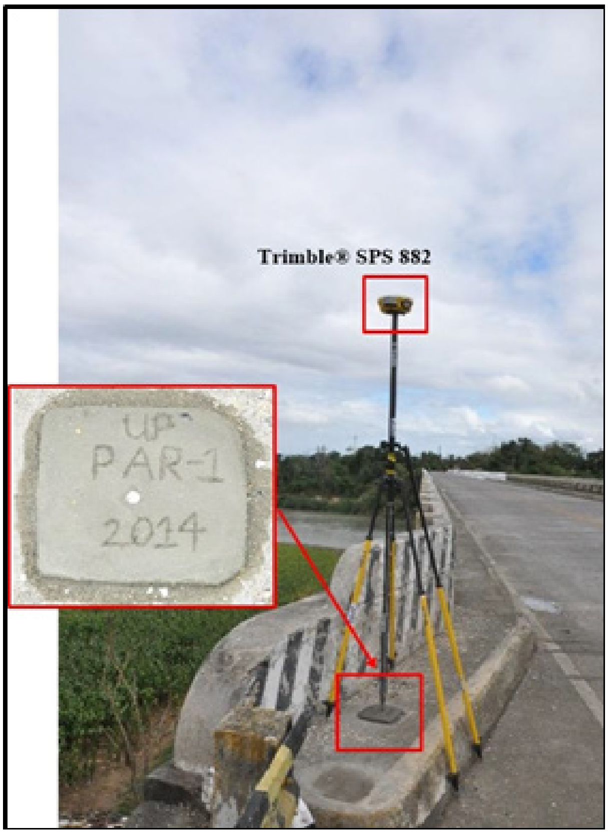


Figure 22. Trimble® SPS 882 setup at UP PAR-1, at Pared Bridge, Brgy. Pared, Alcala, Cagayan

Figure 23. GNSS base set up, Trimble® SPS 882, at UP DUM-1, at Dummum Bridge in Gattaran, Cagayan

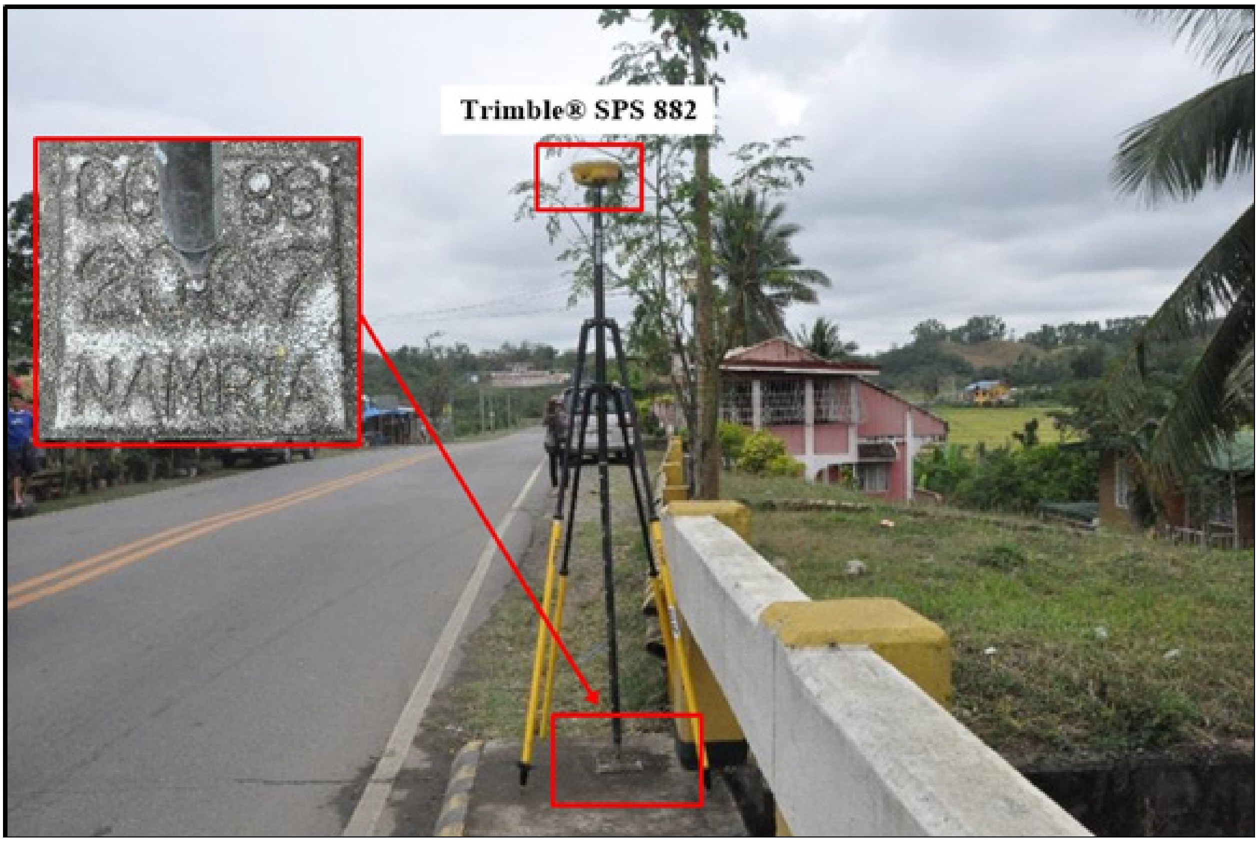


Figure 24. Trimble® SPS 882 setup at CG - 186, at Magapit Bridge, Brgy. Magapit, Lal-lo, Cagayan

The second phase for Cagayan River Survey was conducted on January 29 – February 12, 2014. The control points recovered and occupied for this fieldwork were QRN-32, a 2nd-order GCP in Brgy. Liwayway, Diffun, Quirino Province; ISB-3452, a 3rd-order GCP in Brgy. Poblacion, San Mateo, Isabela; NV-121, a 1st-order BM in Brgy. Sto. Domingo, Bayombong, Nueva Viscaya and GAMU, an established point located in Brgy. Buenavista in Gamu, Isabela.

A summary of the control points used during the survey is shown in Table 2. A difference in elevation of 3.3741 meters between geoid (EGM2008) and MSL values of the reference point NV-121 was applied for referring the elevation of the control points to MSL. The map on Figure 25 shows the location of the control points used for Cagayan River Phase 2 fieldwork.

Table 2. List of Control Points used in Cagayan River Survey Phase (January 29 to February 12, 2014)

Control Point	Order of Accuracy	Latitude	Longitude	Ellipsoid Height, (m)	Northing, (m)	Easting, (m)	EGM Ortho 2008	BM Ortho
QRN-32	2nd Order	16d34'53.28043"	121d30'02.16602"	162.778	1833853	340033.8	118.993	115.6189
ISB-3452	3rd order	16d52'45.49631"	121d35'23.48074"	123.601	1866740	349791.2	81.642	78.2679
NV-121	1st order	16d25'58.01266''	121d06'33.3337''	354.481	1817751	298117	309.095	305.7209
GAMU	Established	17d03'59.46646''	121d50'28.09859''	90.137	1887280	3766844	48.877	45.5029

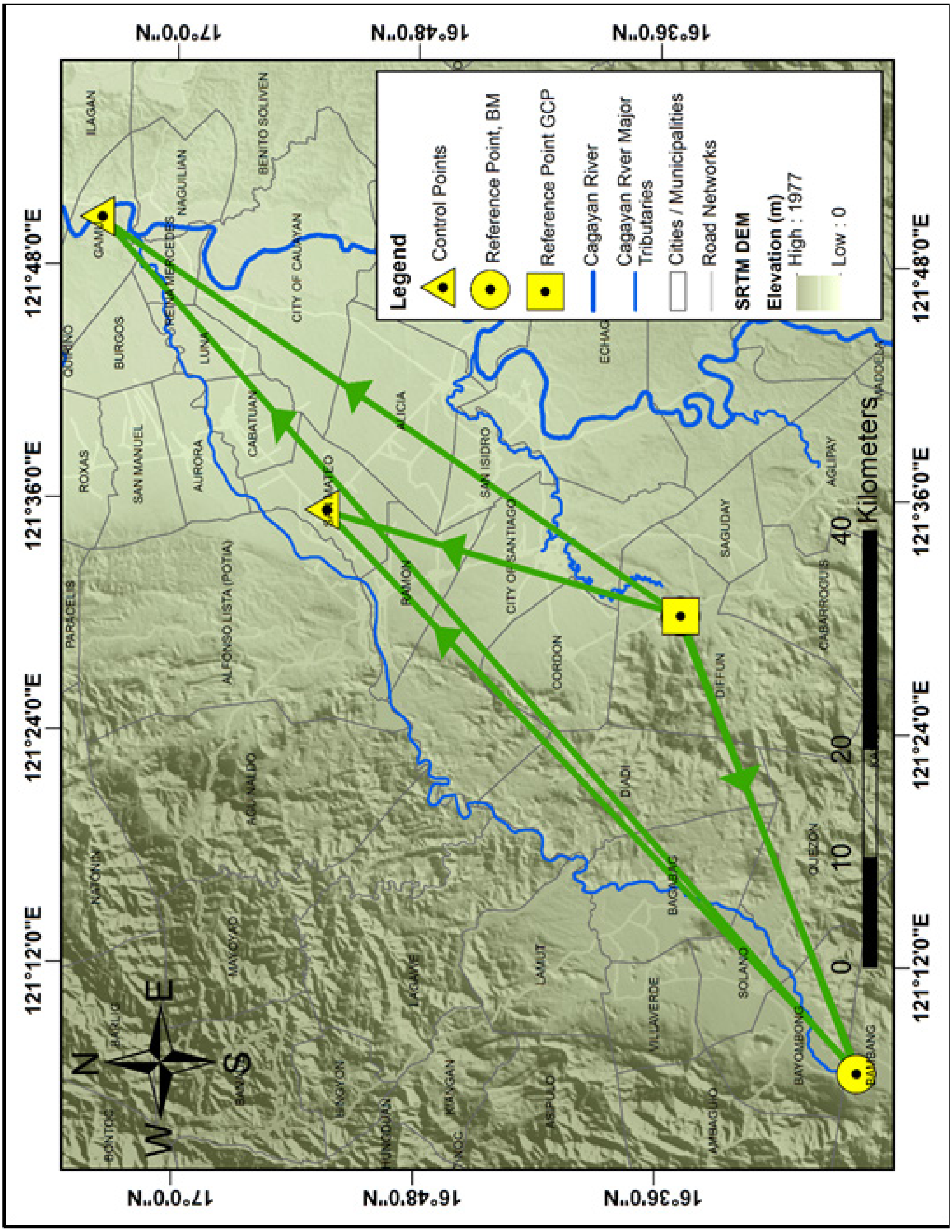


Figure 25. GNSS Network of Cagayan River Survey Phase 2 (January 29 to February 12, 2014

The last fieldwork, Phase 3, conducted in Cagayan River Basin was held on April 28 - May 8, 2014. Static survey was conducted among the following control points: QRN-32 (Figure 30) located at Brgy. Liwayway Diffun, Quirino; QRN-40 situated at Villa Agullana, the UP established control points, CAU-1 (Figure 31), SNP-1; and ALICIA-1 (Figure 32) While benchmark NV-121, which was occupied as base in the previous fieldwork last September 16-30, 2013, was used to tie with QRN-32 to refer the AWLS elevation to MSL.

A summary of the control points used during the survey is shown in Table 3. A difference in elevation of 3.3741 meters between geoid (EGM2008) and MSL values of the reference point NV-121 was applied for referring the elevation of the control points to MSL. The map on Figure 26 shows the location of the control points used for Cagayan River Phase 2 fieldwork.

Table 3. List of Control Points used in Cagayan River Survey Phase 3 (April 28 - May 8, 2014)

Control Point	Order of Accuracy	Latitude	Longitude	Ellipsoid Height, (m)	Northing, (m)	Easting, (m)	EGM Ortho 2008	BM Ortho
CAU-1	3rd Order	16d57'14.22297"	121d47'04.65121"	86.949	1874861	370591.9	45.565	42.1909
ISB-126	2nd Order	16d45'25.25196"	121d36'50.37015"	118.036	1853190	352267.9	75.555	72.1809
QRN-32	2nd Order	16d34'53.28044"	121d30'02.16601"	162.778	1833853	340033.8	118.993	115.6189
QRN-40	2nd Order	16d15'02.32851"	121d42'11.92719"	502.369	1797100	361429.7	457.354	453.9799
SNP-1	3rd Order	16d21'01.17958"	121d42'07.61455"	195.573	1808129	361371.8	150.976	147.6019
ALICIA-1	3rd Order	16d47'01.57111"	121d42'11.38556"	109.747	1856087	361793.2	67.566	64.1919
NV-121	1st order	16d25'58.01266"	121d06'33.3337"	354.481	1817751	298117	309.095	305.7209

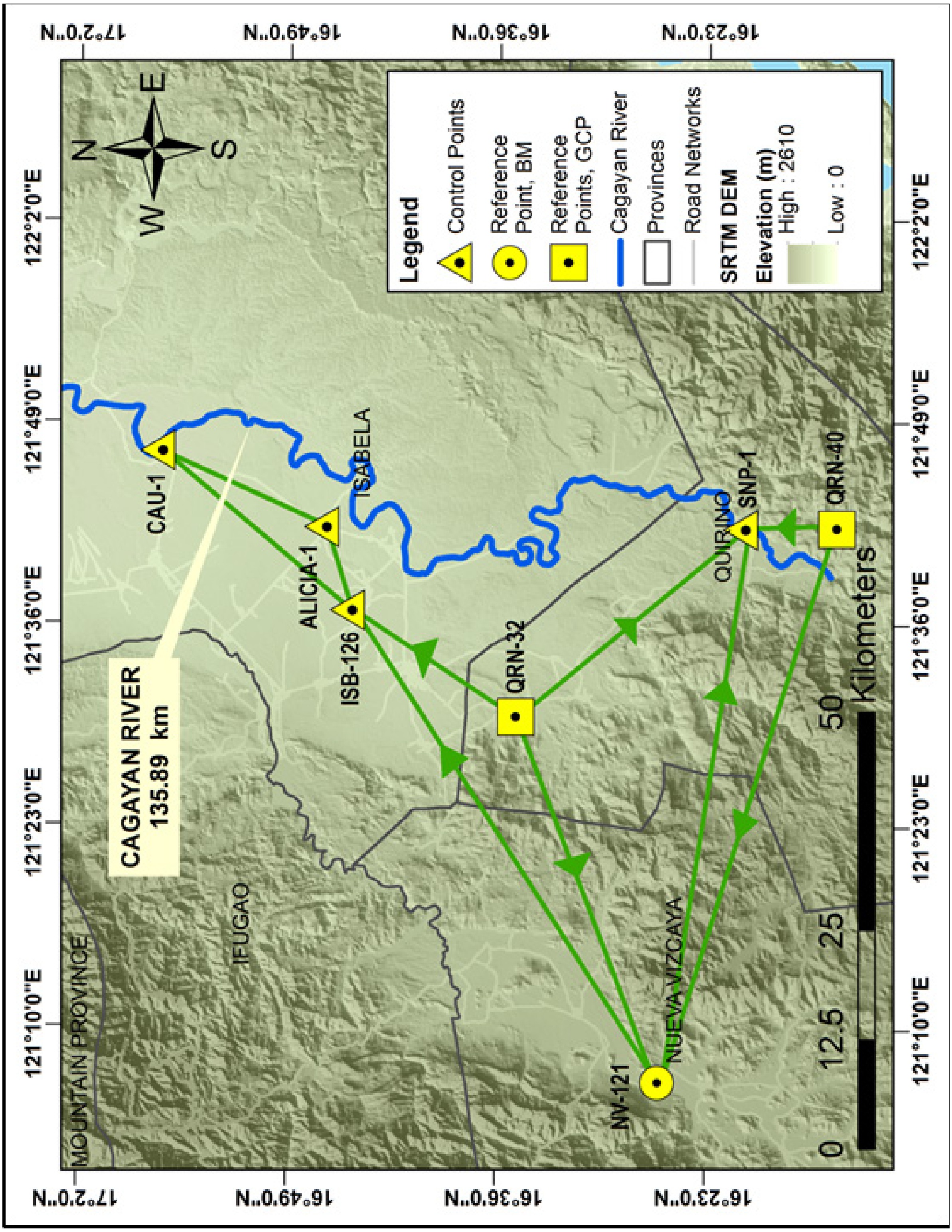


Figure 26. GNSS Network of Cagayan River Survey Phase 3 (April 28 - May 8, 2014)

The GPS setups made in the location of the reference and control points are exhibited in Figures 27-29:

Figure 27. GNSS receiver set up, Trimble® SPS 852 at QRN-32, Brgy. Liwayway Diffun, Quirino

Figure 28. Trimble® SPS 985 setup at CAU-1, Cauyan City Isabela

Figure 29. GNSS receiver set up, Trimble® SPS 985 at ALICIA-1, Alicia, Isabela

4.2 Reconnaissance of Cross-section

Cross-section survey is necessary to compute the discharge of the river. In order for the data of AWLS be usable, cross-section elevation were obtained and referred to MSL. Acquired cross-section and water surface elevation from AWLS, will eventually produce cross-sectional area. This cross-sectional area varies the water level changes thru time. Combining cross-sectional area with river velocity will obtain discharge. These discharge data will be plugged in to the flood simulation program to create flood scenarios.

Ocular inspection and cross-section measurements of most of the bridges with AWLS in Cagayan River System was conducted in the initial fieldwork on September 16 – 30, 2013. For those bridges that were not able to be measured was resurveyed on the next fieldworks.

Each cross-section lines were located using handheld GPS (Garmin Montana™ 650). Summary of reconnaissance for the 24 cross-sections are shown in the next figures. Reconnaissance for profile lines were conducted simultaneously with the bathymetric surveys.

Examples of cross-section survey conducted are exhibited in Figures 30-36.

Figure 30. Cross-section survey along Disiluad Bridge, Aglipay, Quirino during the initial Cagayan River Survey on September 16 – 30, 2013

Figure 31. Cross-section survey along Disiluad Bridge, Bagabag, Nueva Viscaya during the initial Cagayan River Survey on September 16 – 30, 2013

Figure 32. Cross Section survey along Delfin Albano Bridge in Delfin Albano, Isabela during Cagayan River Survey Phase 1 on March 17-April 6, 2014

Figure 33. Cross Section survey along San Pablo Bridge in San Pablo, Isabela during Cagayan River Survey Phase 1 on March 17-April 6, 2014

Figure 34. Cross Section survey along Pared Bridge in Alcala, Cagayan during Cagayan River Survey Phase 1 on March 17-April 6, 2014

Figure 35. Actual cross section survey in Mallig bridge during Cagayan River Survey Phase 2 on January 29-February 12, 2014 (a) Gathering of data from the right bank of river (b) Gathering data for sensor elevation

Figure 36. Cross section Survey during Cagayan River Survey Phase 3 on April 28 - May 8, 2014 at (a) Dalibubon Bridge and (b) President Bridge

All the data gathered from cross-section surveys were processed and visualized using AutoCAD. Cross-section diagrams of measured bridges are shown in Figures 37-61.

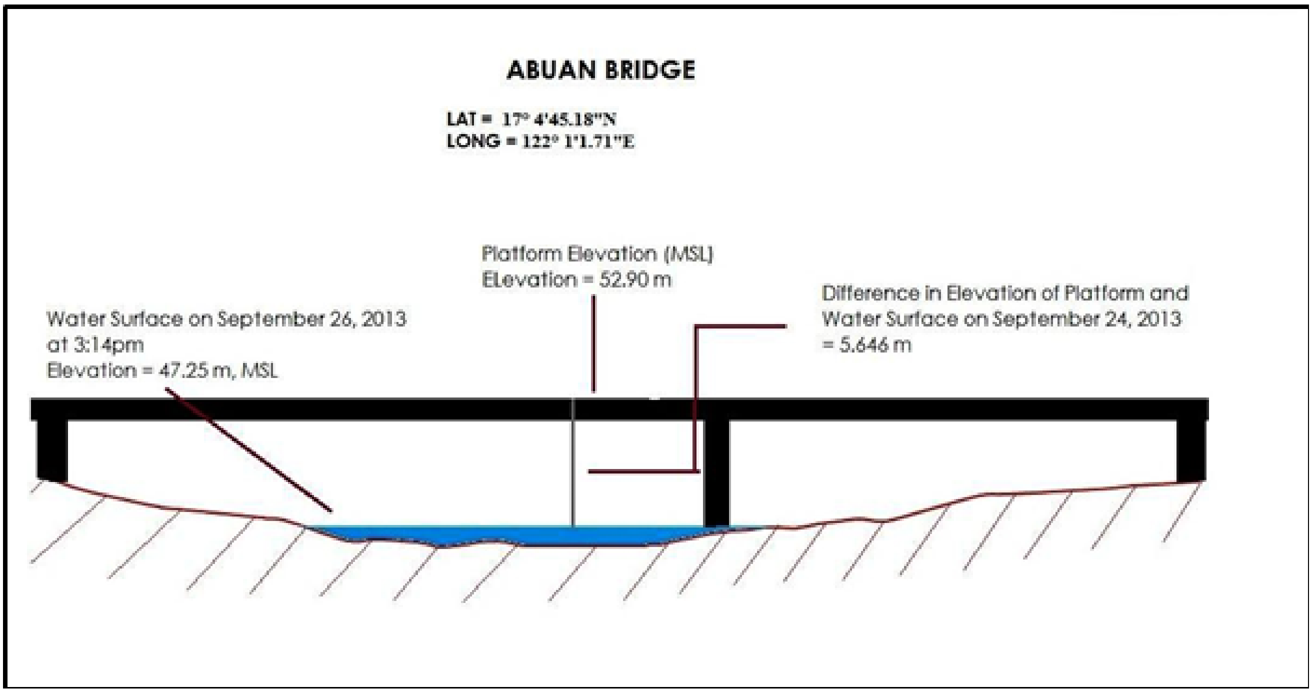


Figure 37. Abuan Bridge Cross-Section Diagram

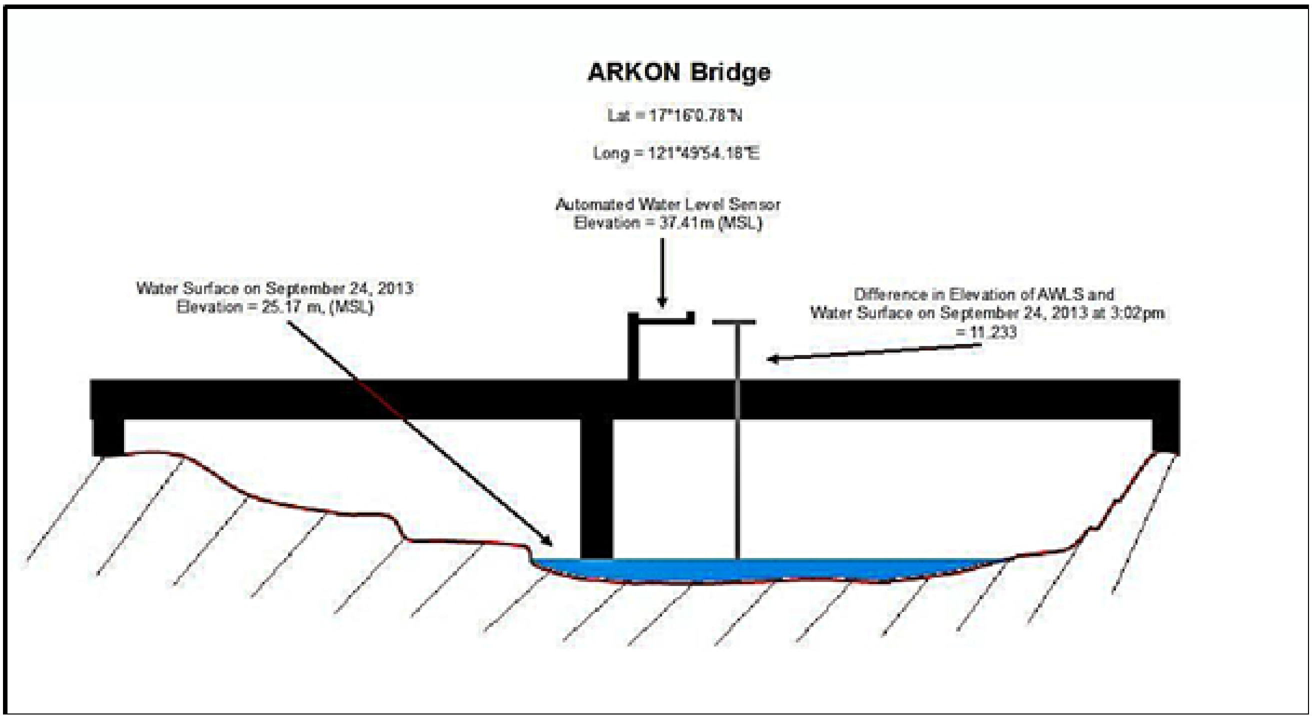


Figure 38. Arkon Bridge Cross-Section Diagram

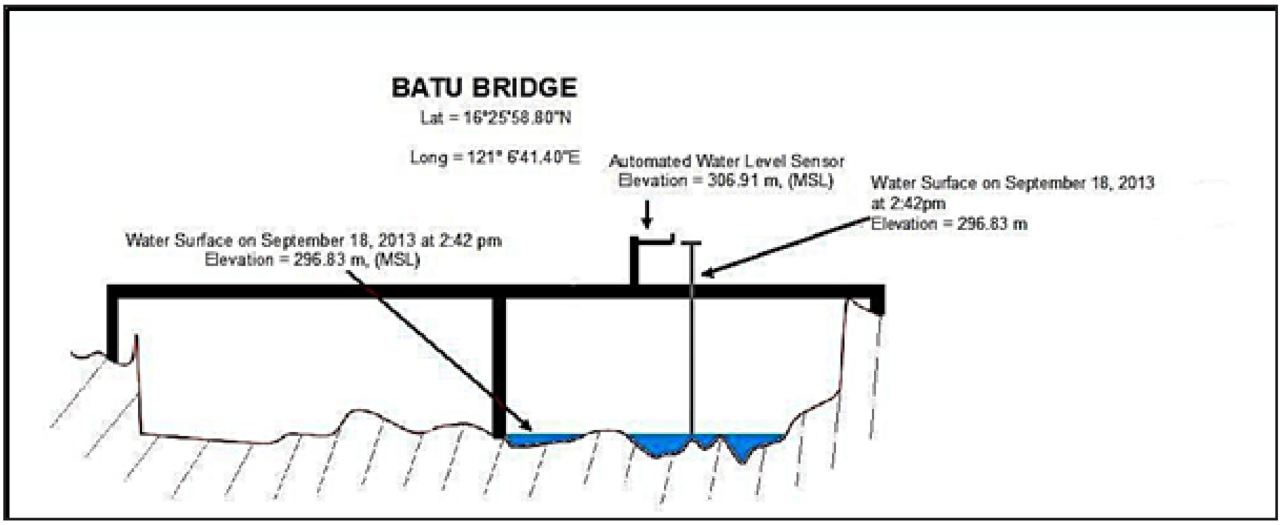


Figure 39. Batu Bridge Cross-Section Diagram

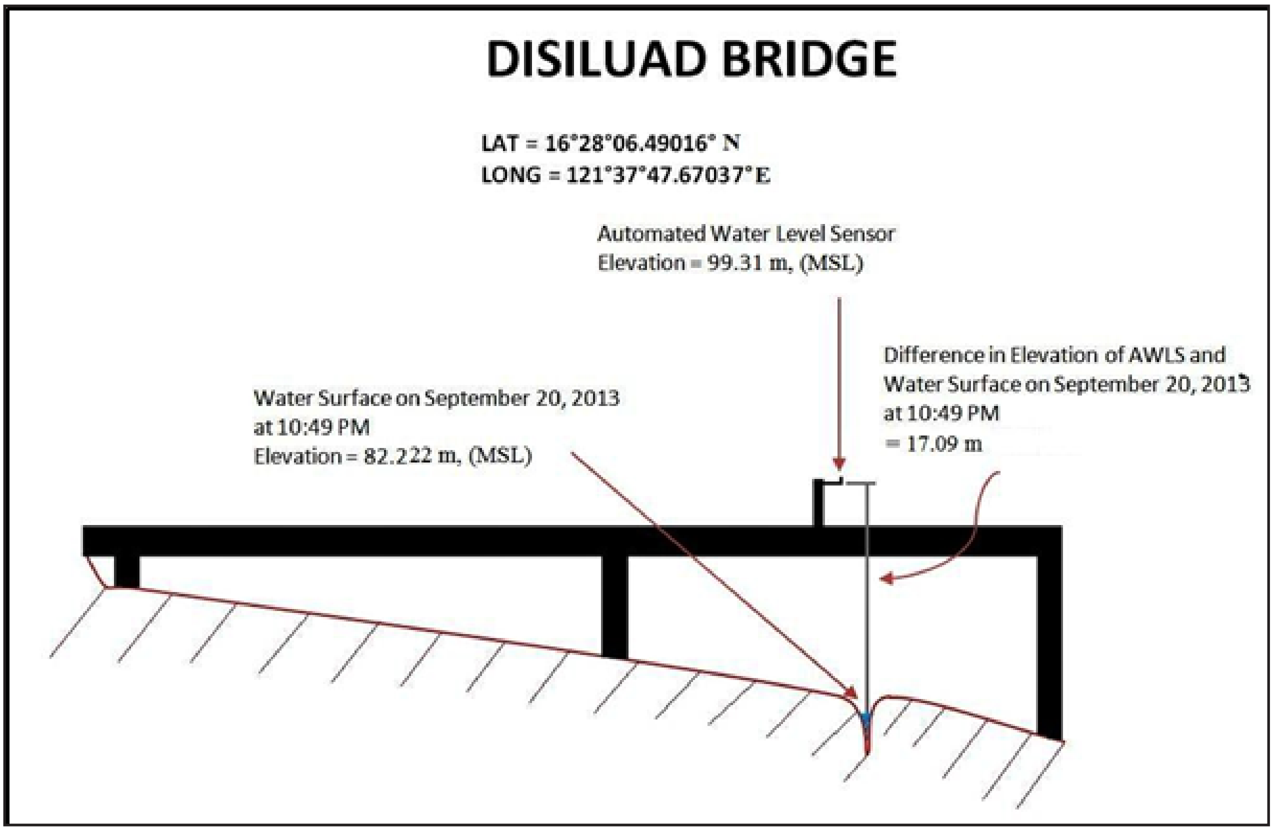


Figure 40. Disiluad Bridge Cross-Section Diagram

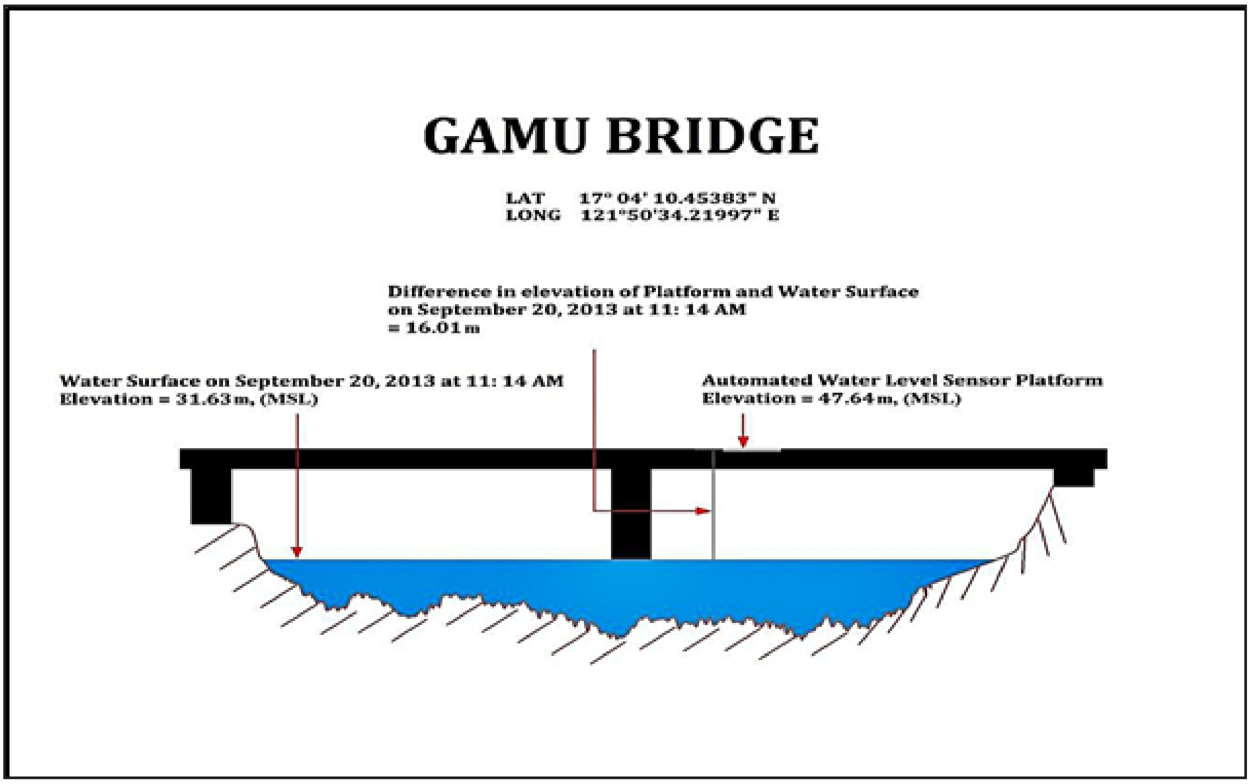


Figure 41. Gamu Bridge Cross-Section Diagram

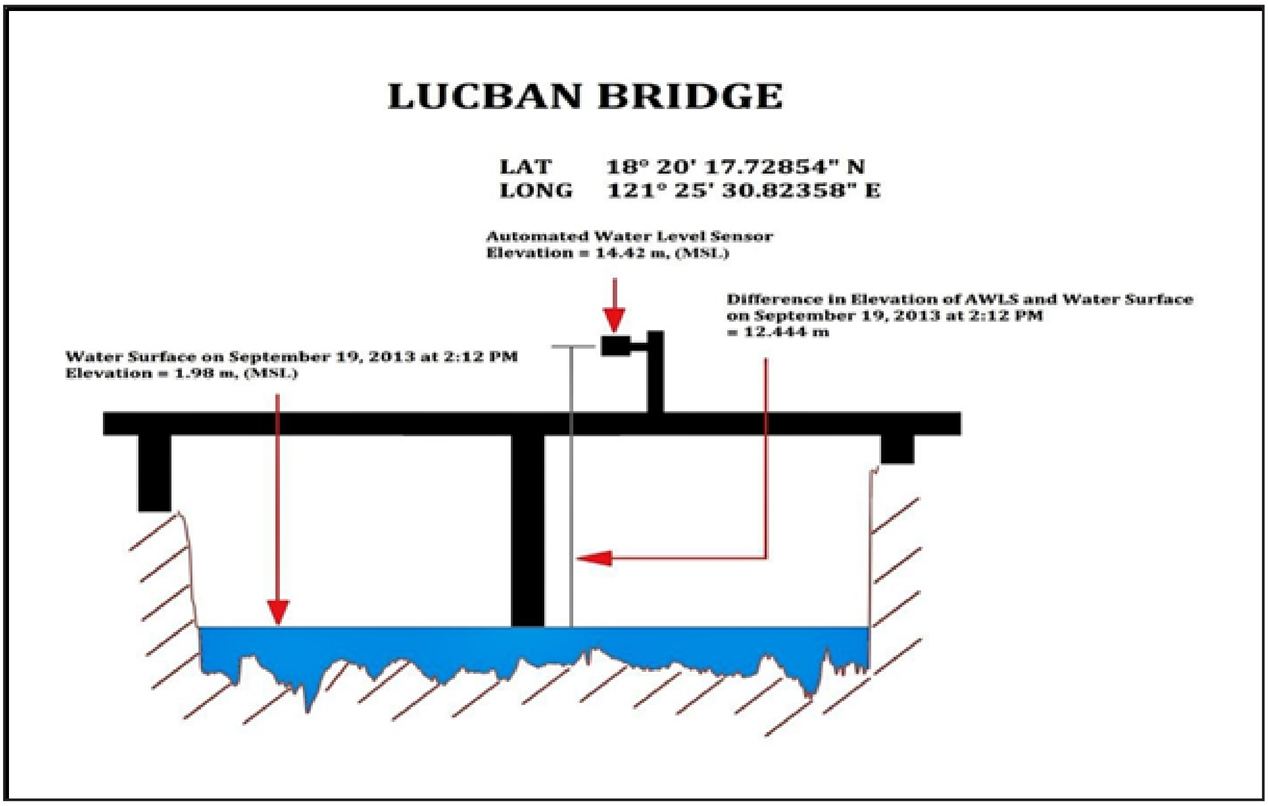


Figure 42. Lucban Bridge Cross-Section Diagram

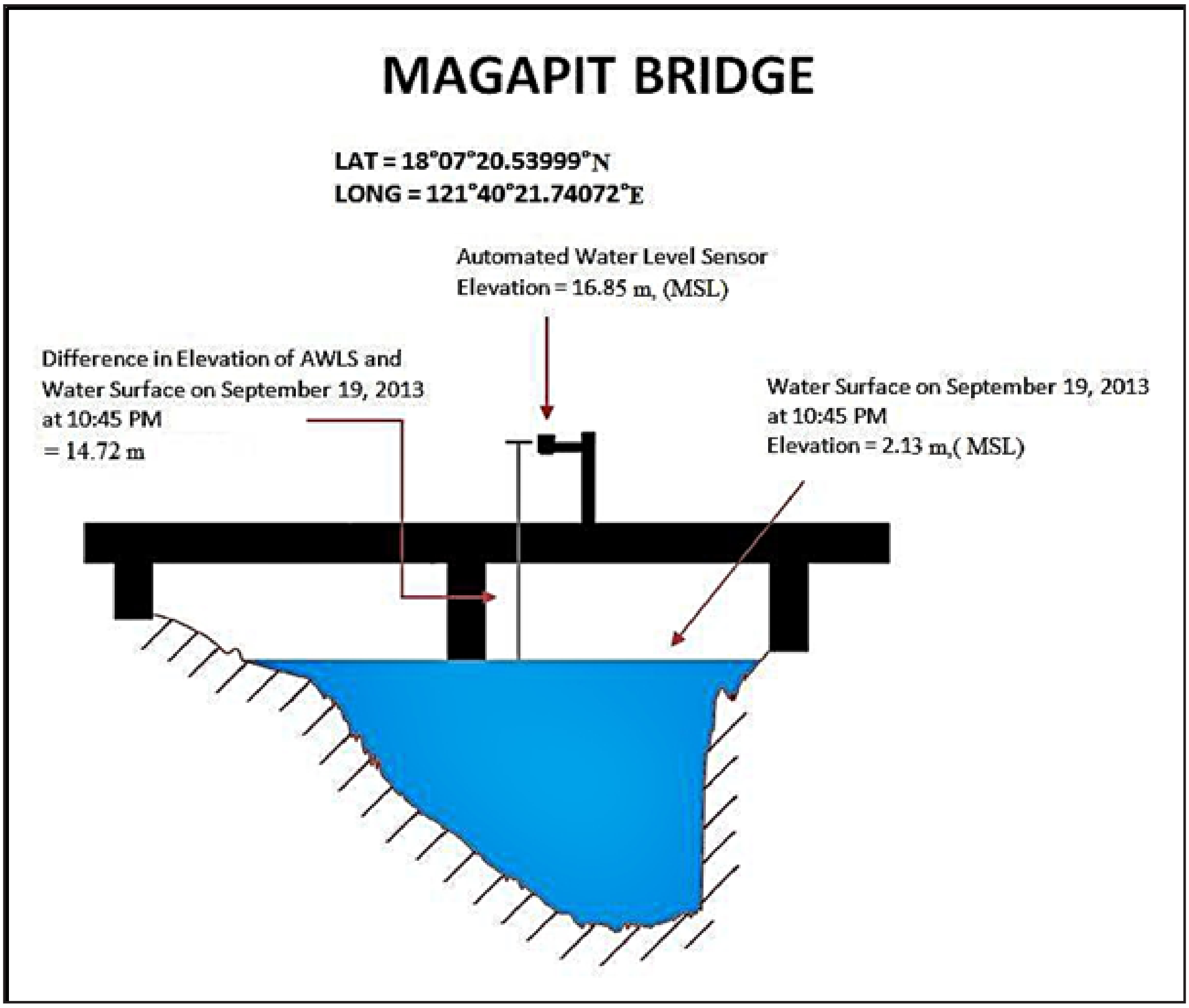


Figure 43. Magapit Bridge Cross-Section Diagram

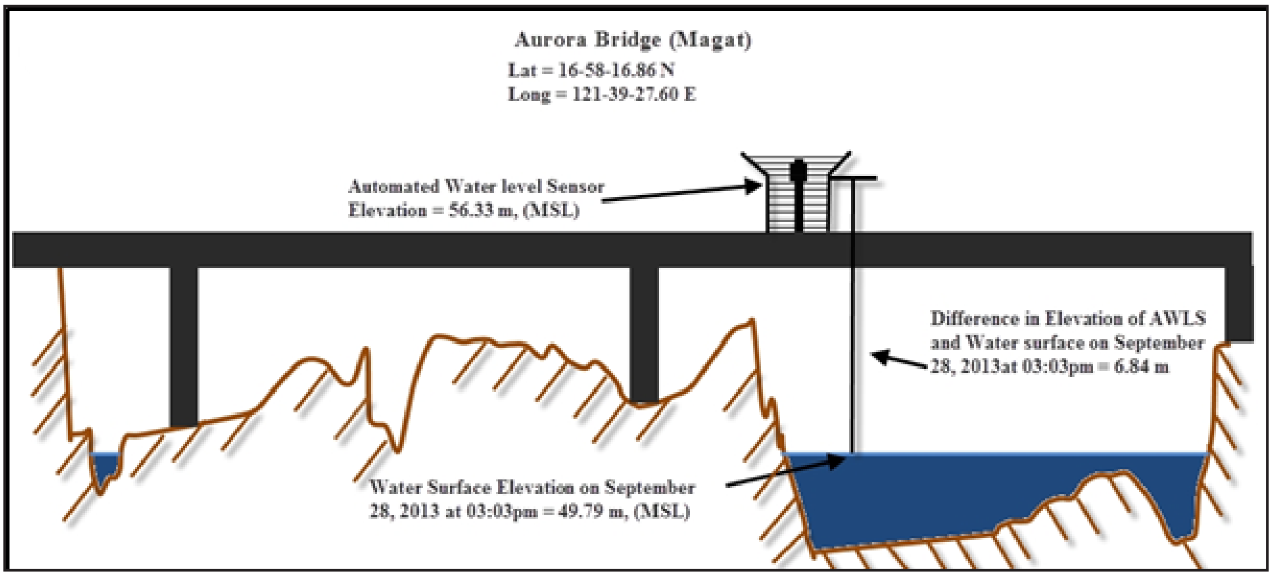


Figure 44. Aurora (Magat) Bridge Cross-Section Diagram

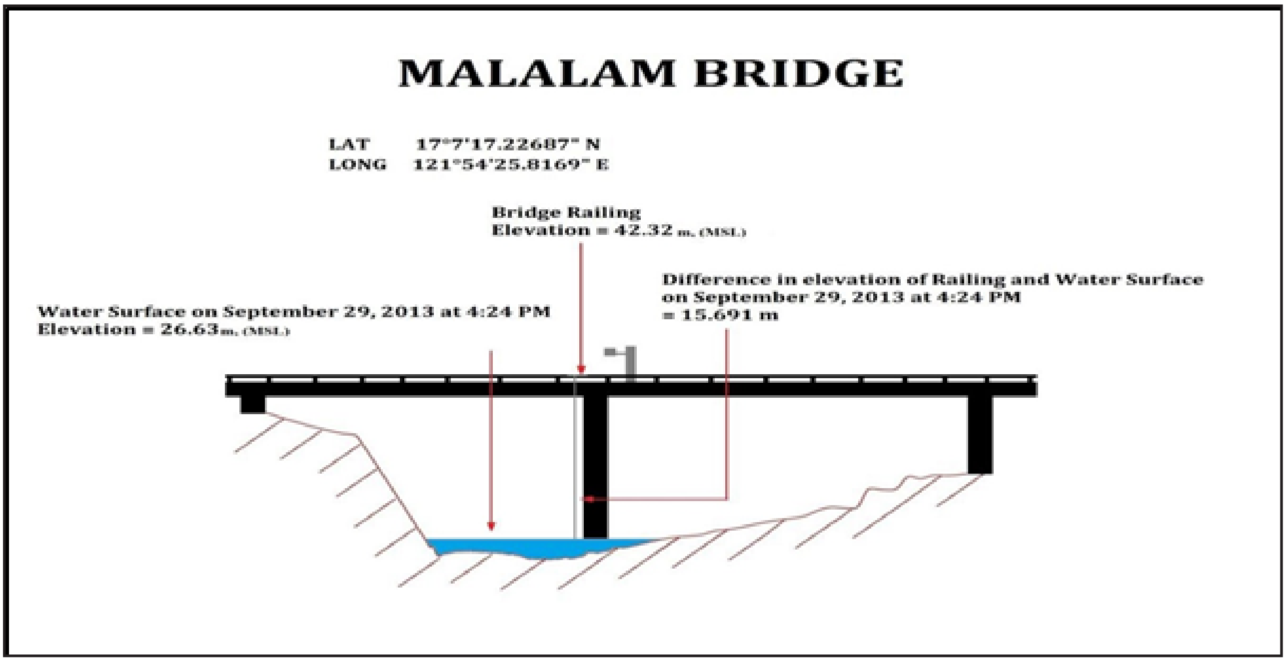


Figure 45. Malalam Bridge Cross-Section Diagram

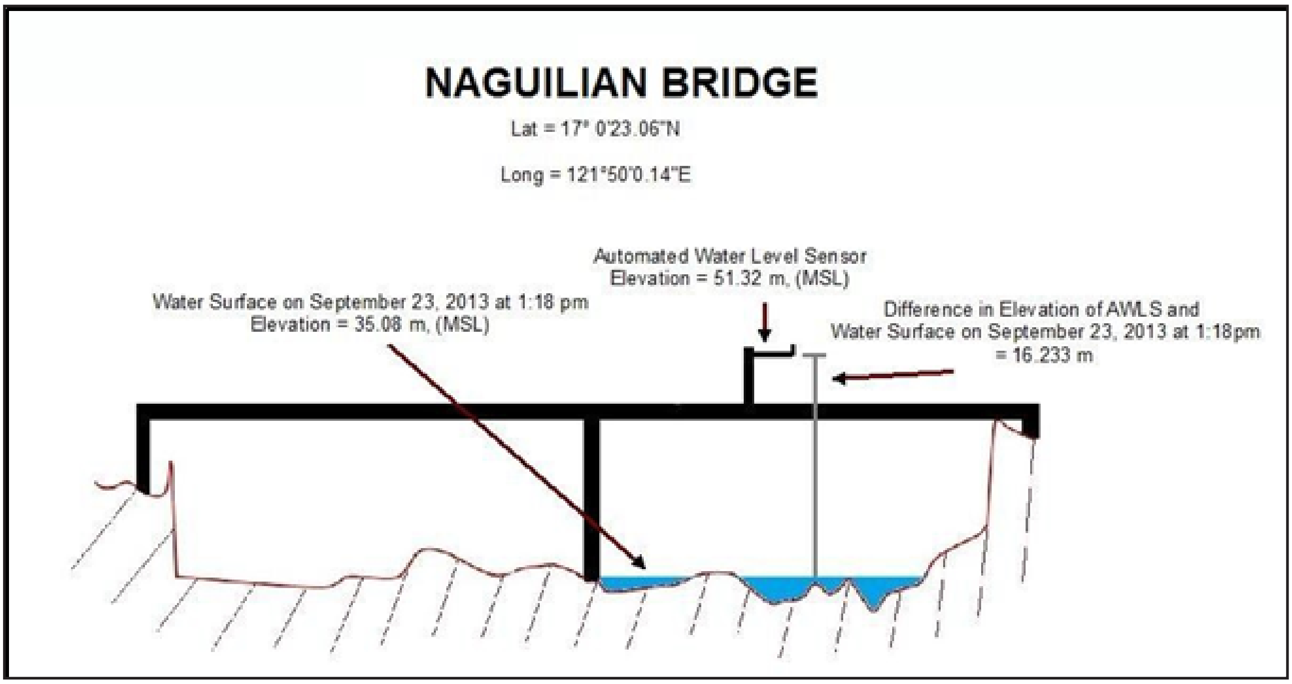


Figure 46. Naguilian Bridge Cross-Section Diagram

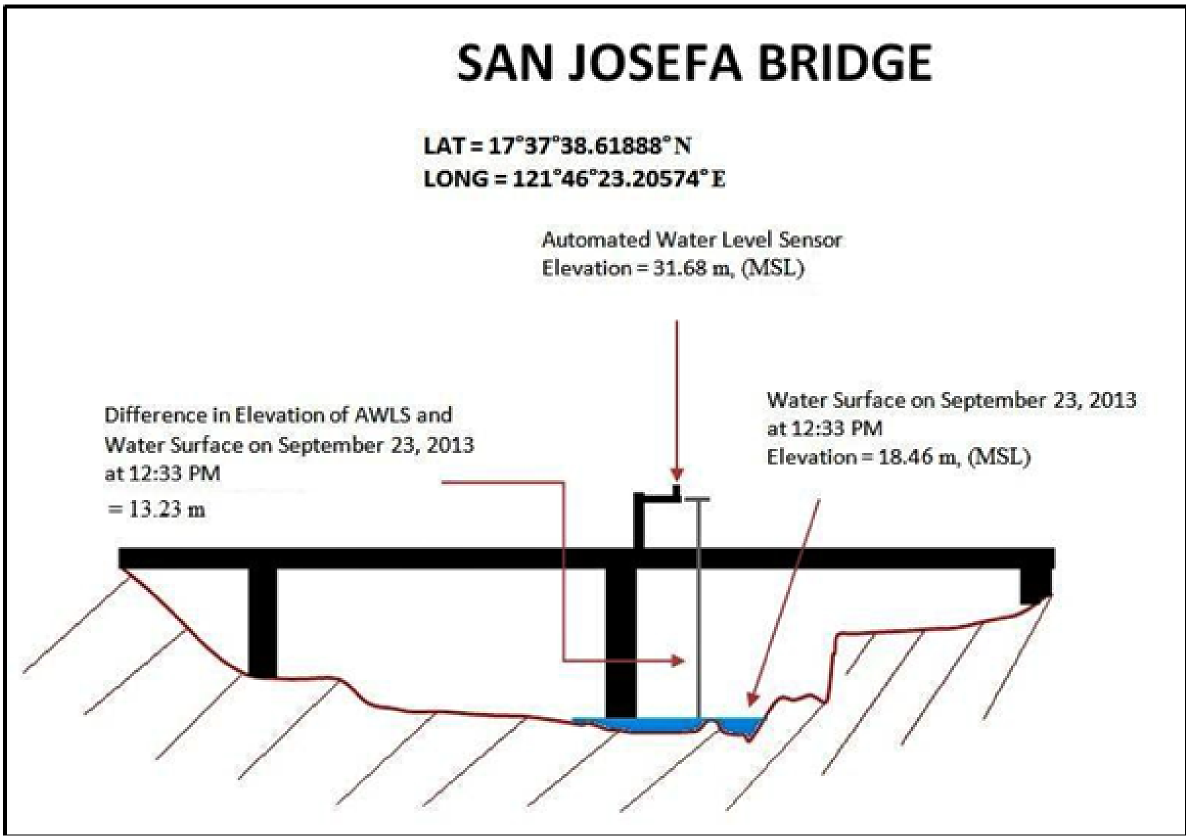


Figure 47. San Josefa Bridge Cross-Section Diagram

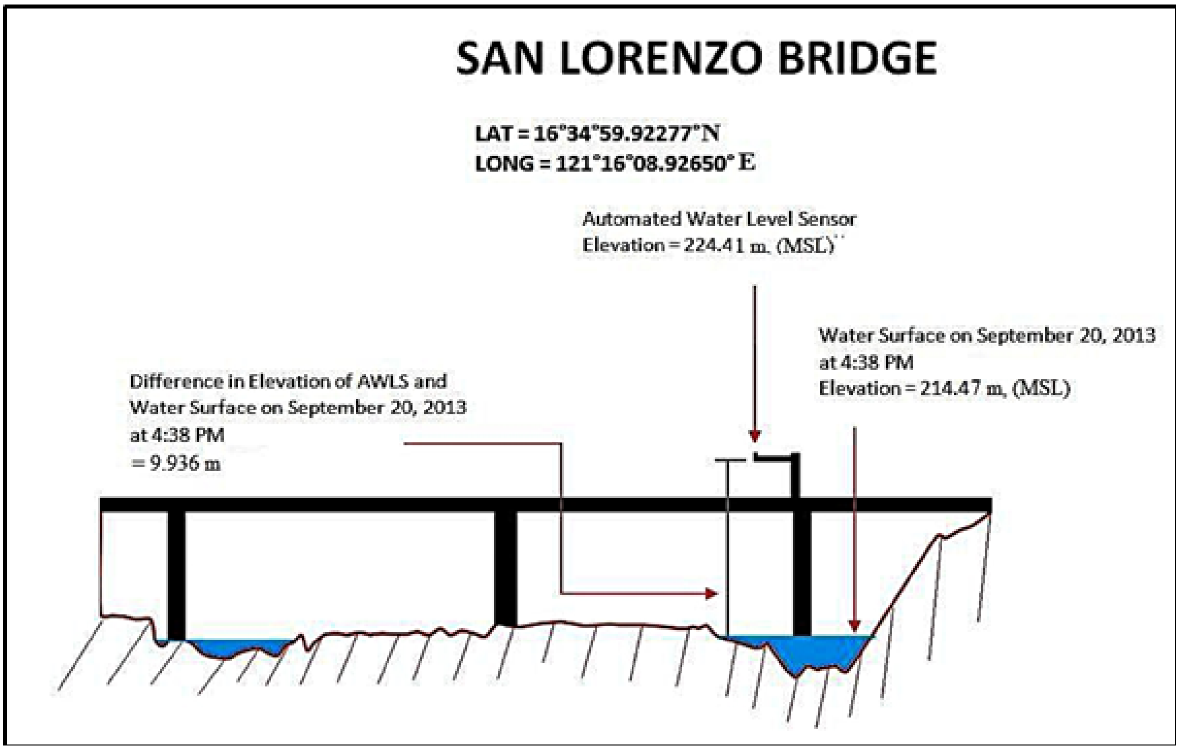


Figure 48. San Lorenzo Bridge Cross-Section Diagram

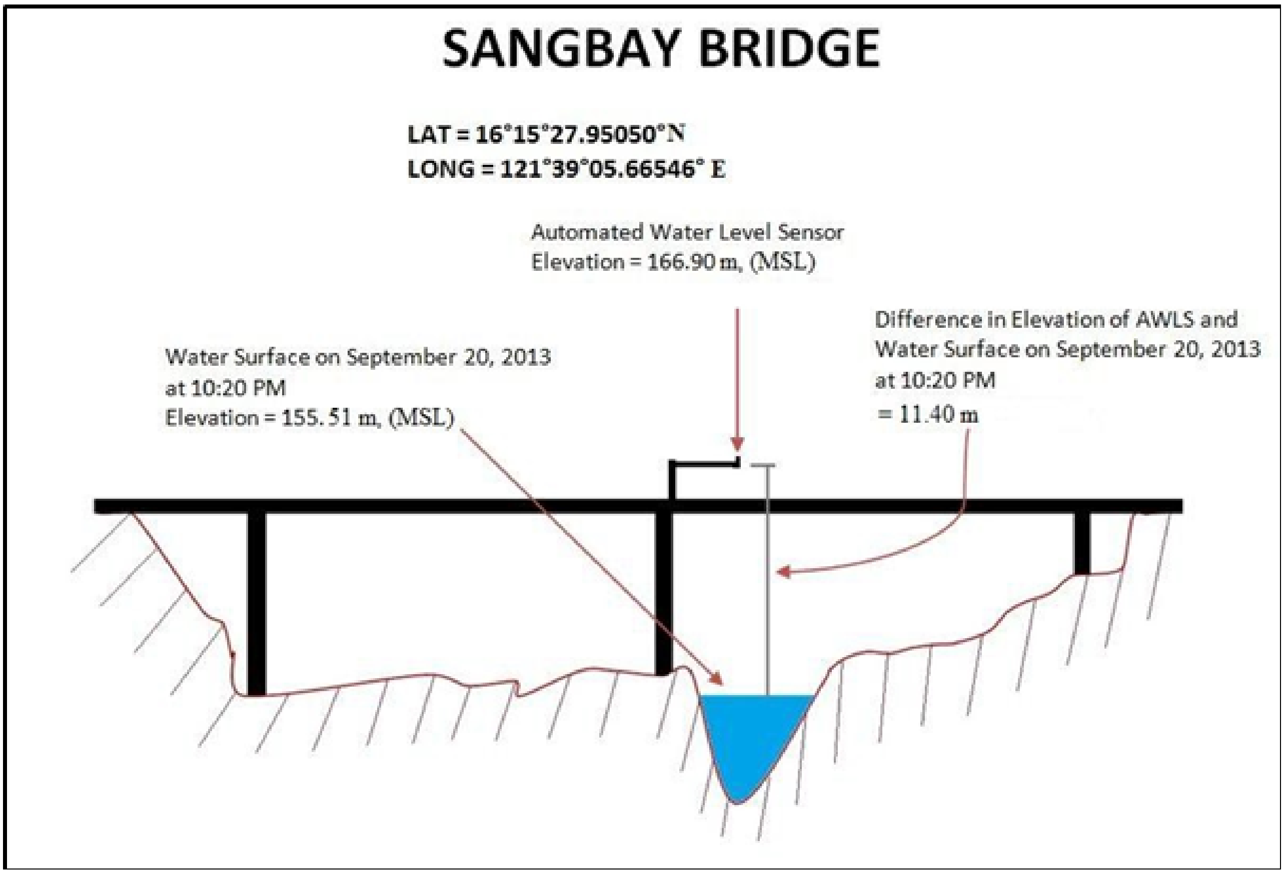


Figure 49. Sangbay Bridge Cross-Section Diagram

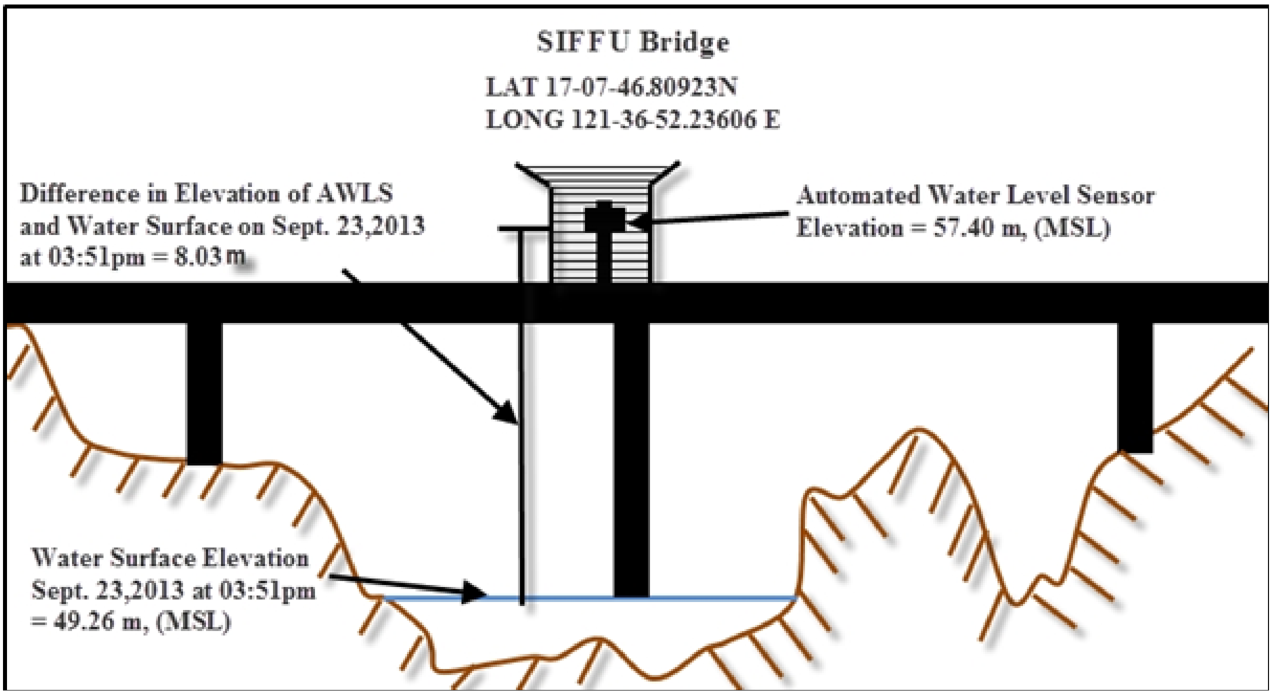


Figure 50. Siffu Bridge Cross-Section Diagram

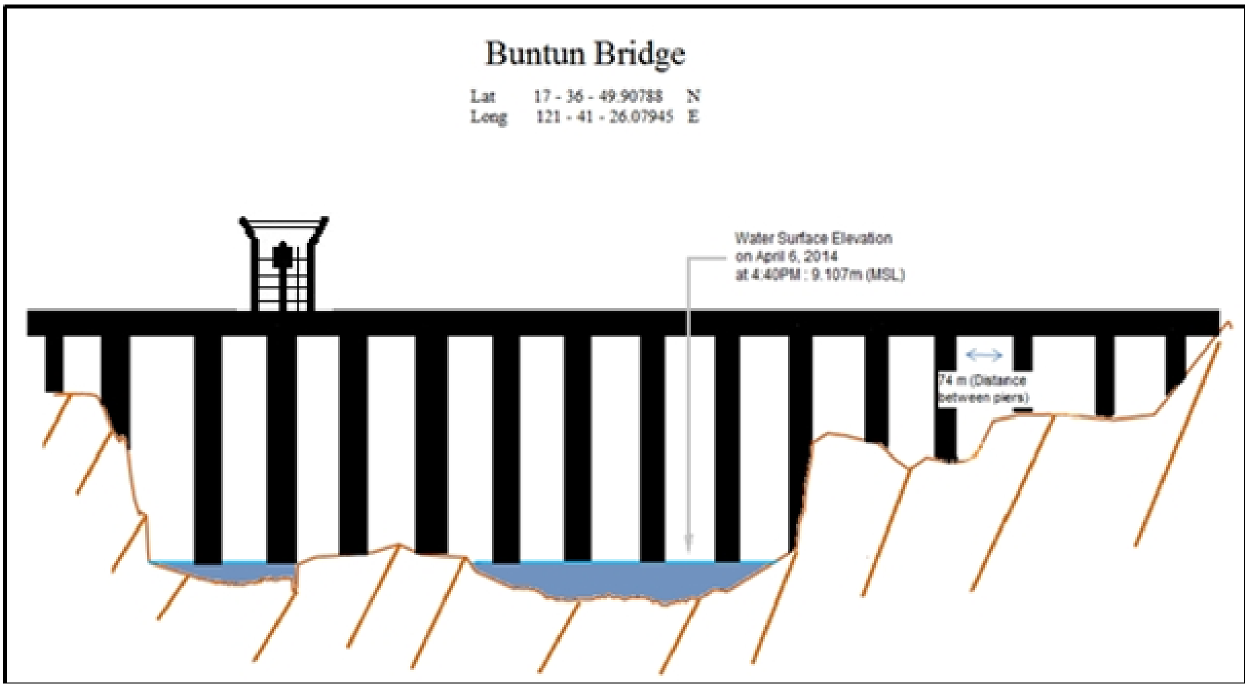


Figure 51. Buntun Bridge Cross-Section Diagram

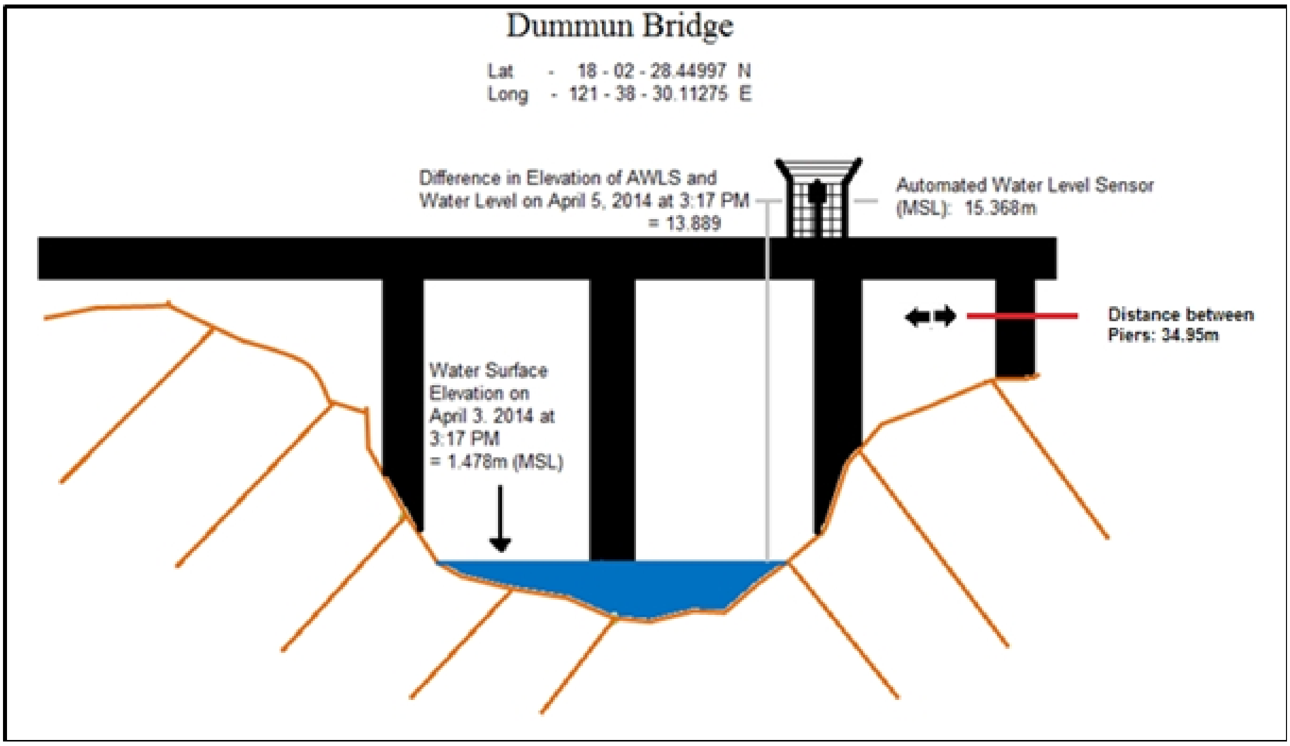


Figure 52. Dummun Bridge Cross-Section Diagram

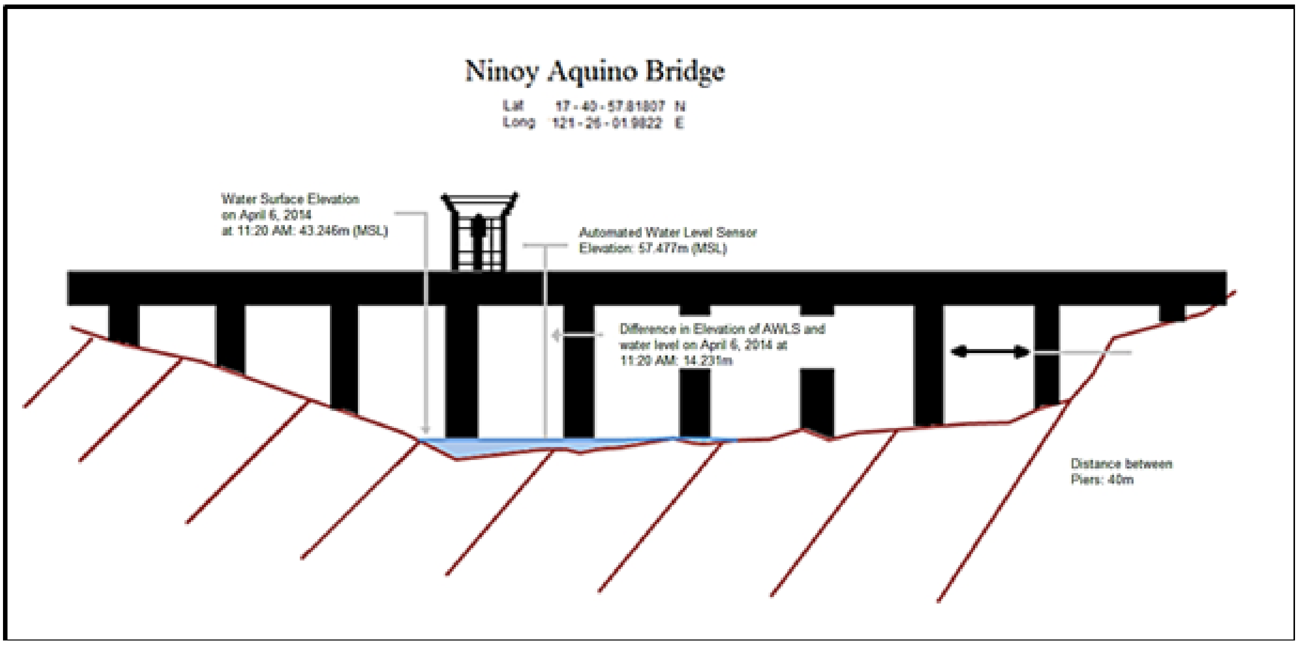


Figure 53. Ninoy Aquino Bridge Cross-Section Diagram

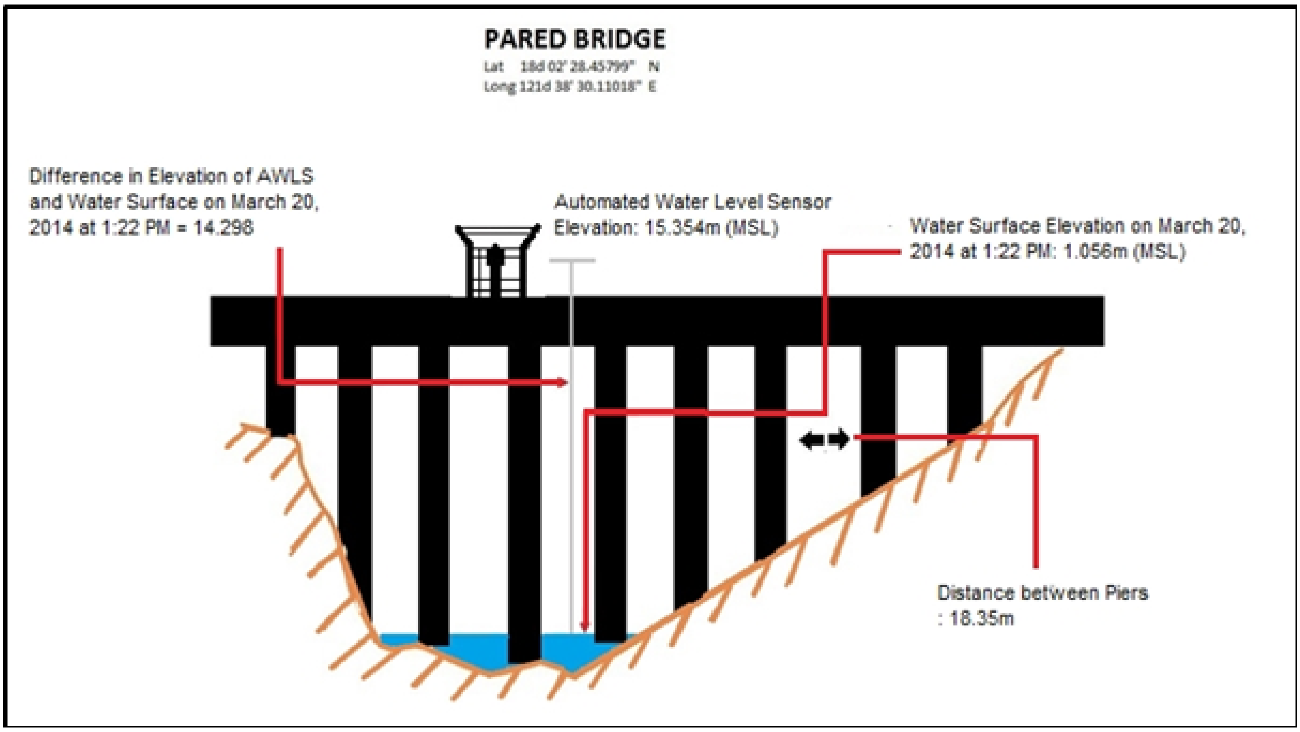


Figure 54. Pared Bridge Cross-Section Diagram

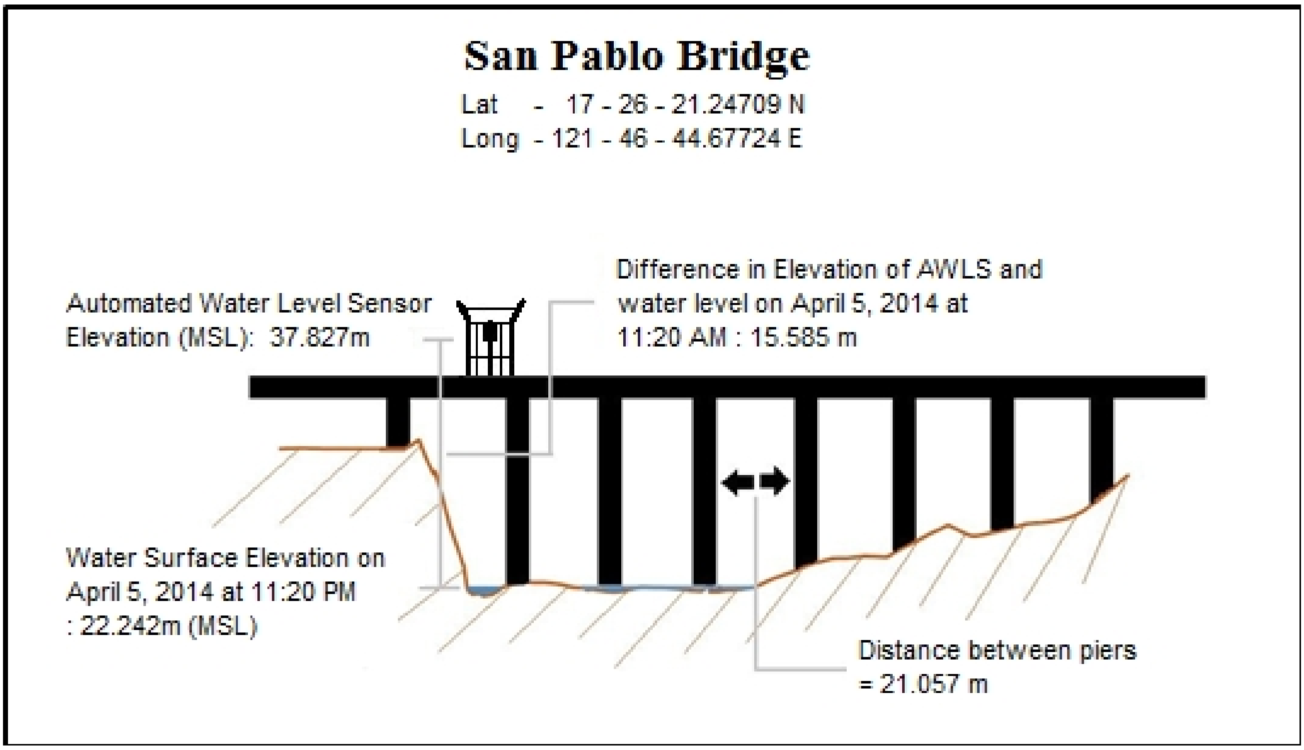


Figure 55. San Pablo Bridge Cross-Section Diagram

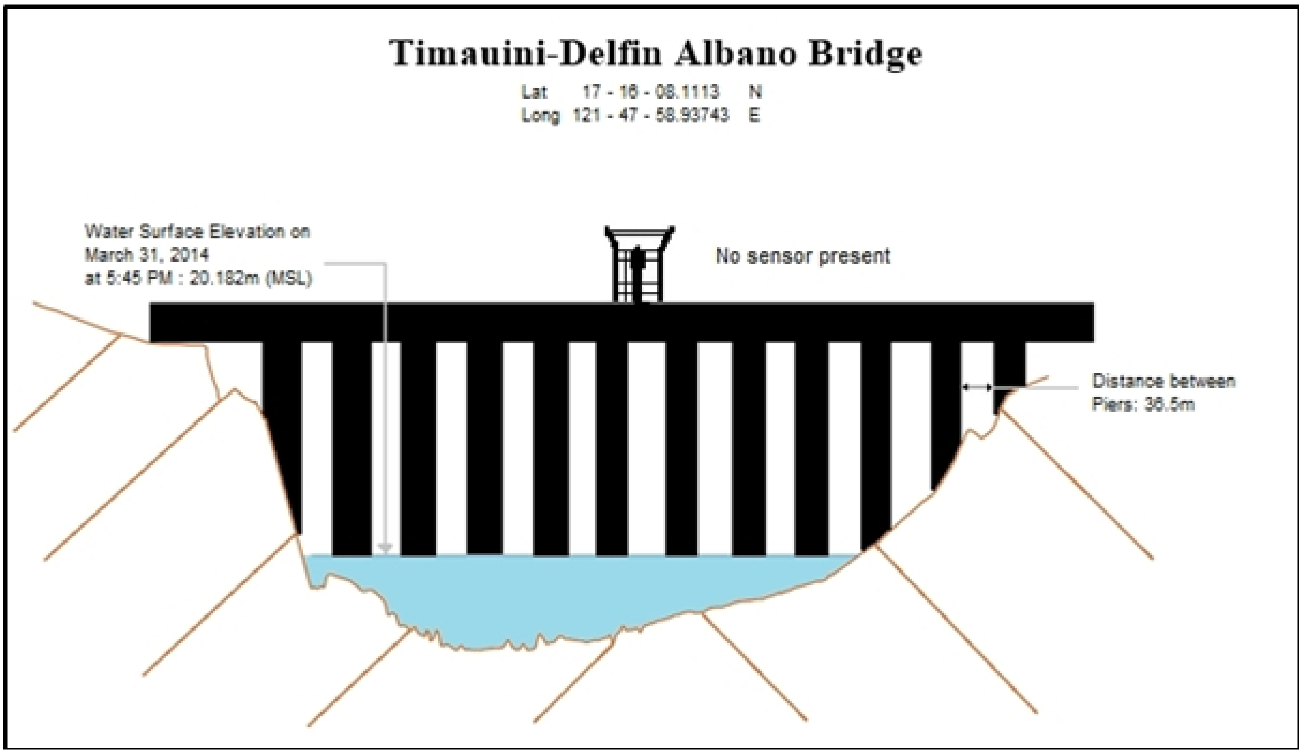


Figure 56. Timauini-Delfin Albano Bridge Cross-Section Diagram

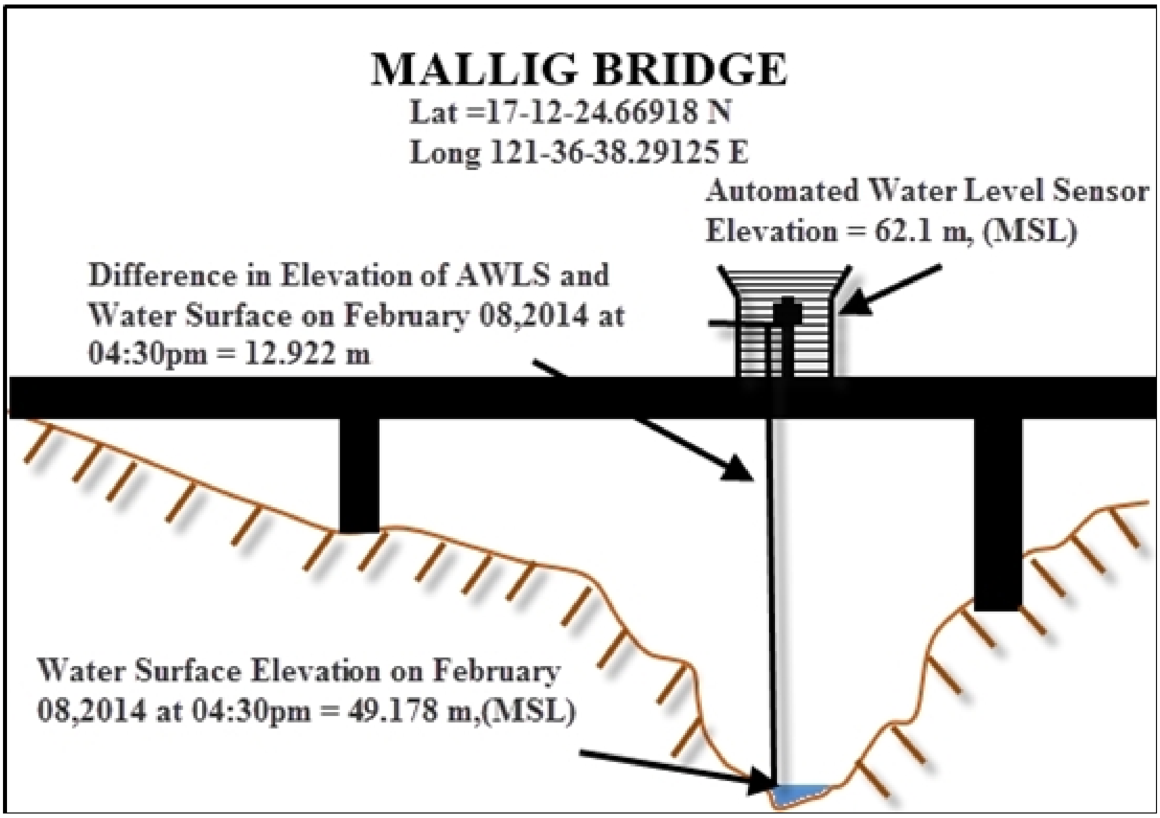


Figure 57. Mallig Bridge Cross-Section Diagram

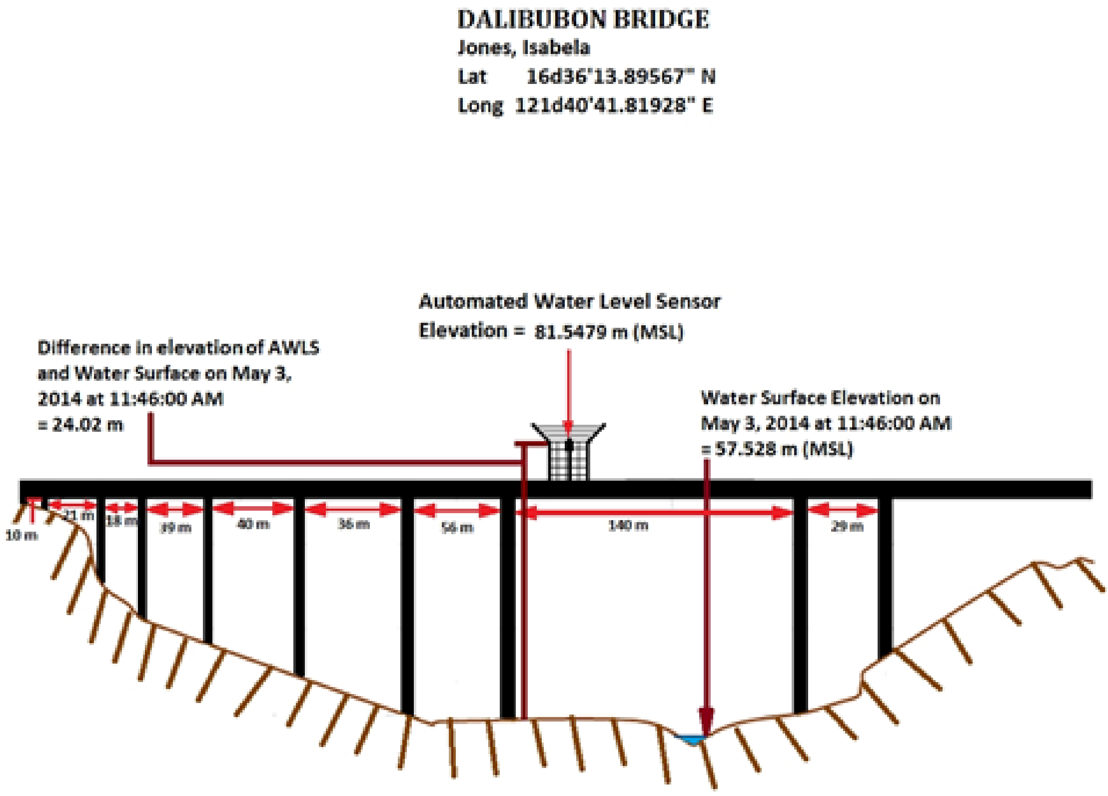


Figure 58. Dalibubon Bridge Cross-Section Diagram

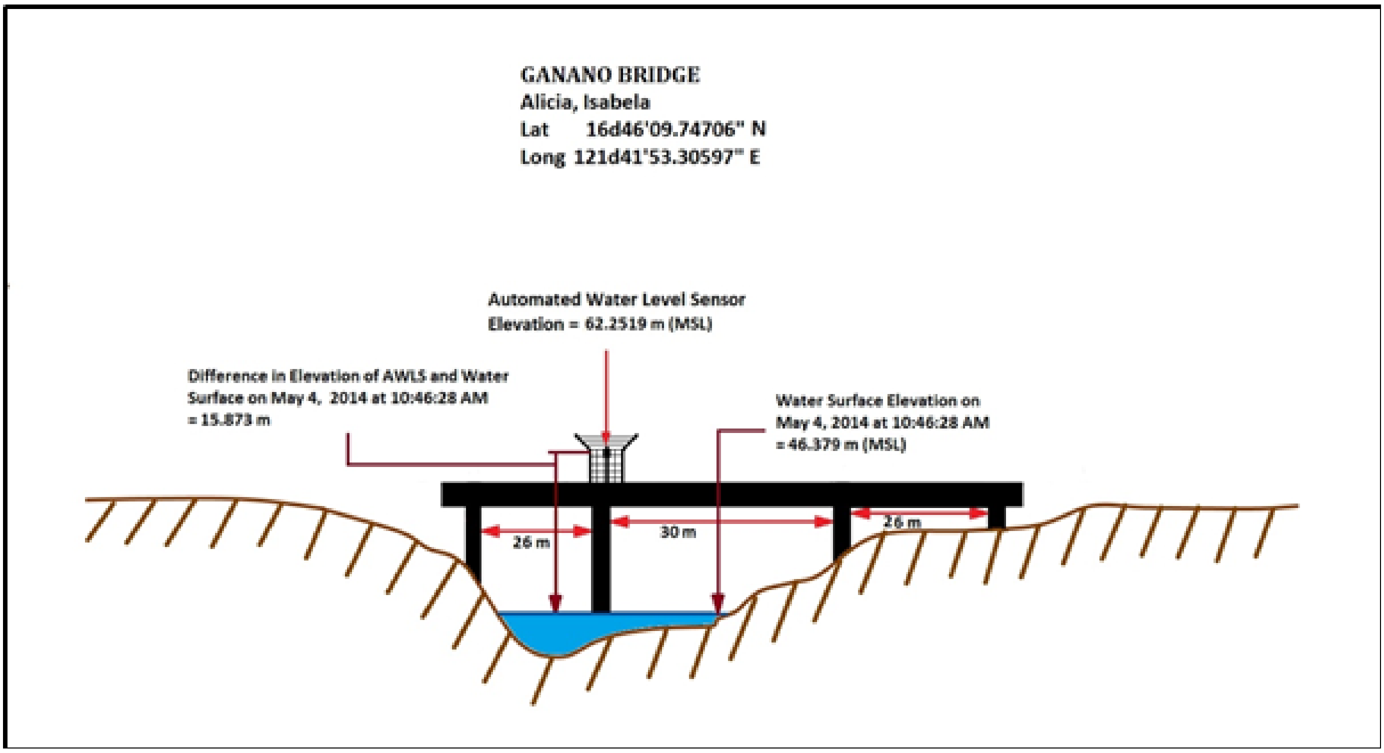


Figure 59. Ganano Bridge Cross-Section Diagram

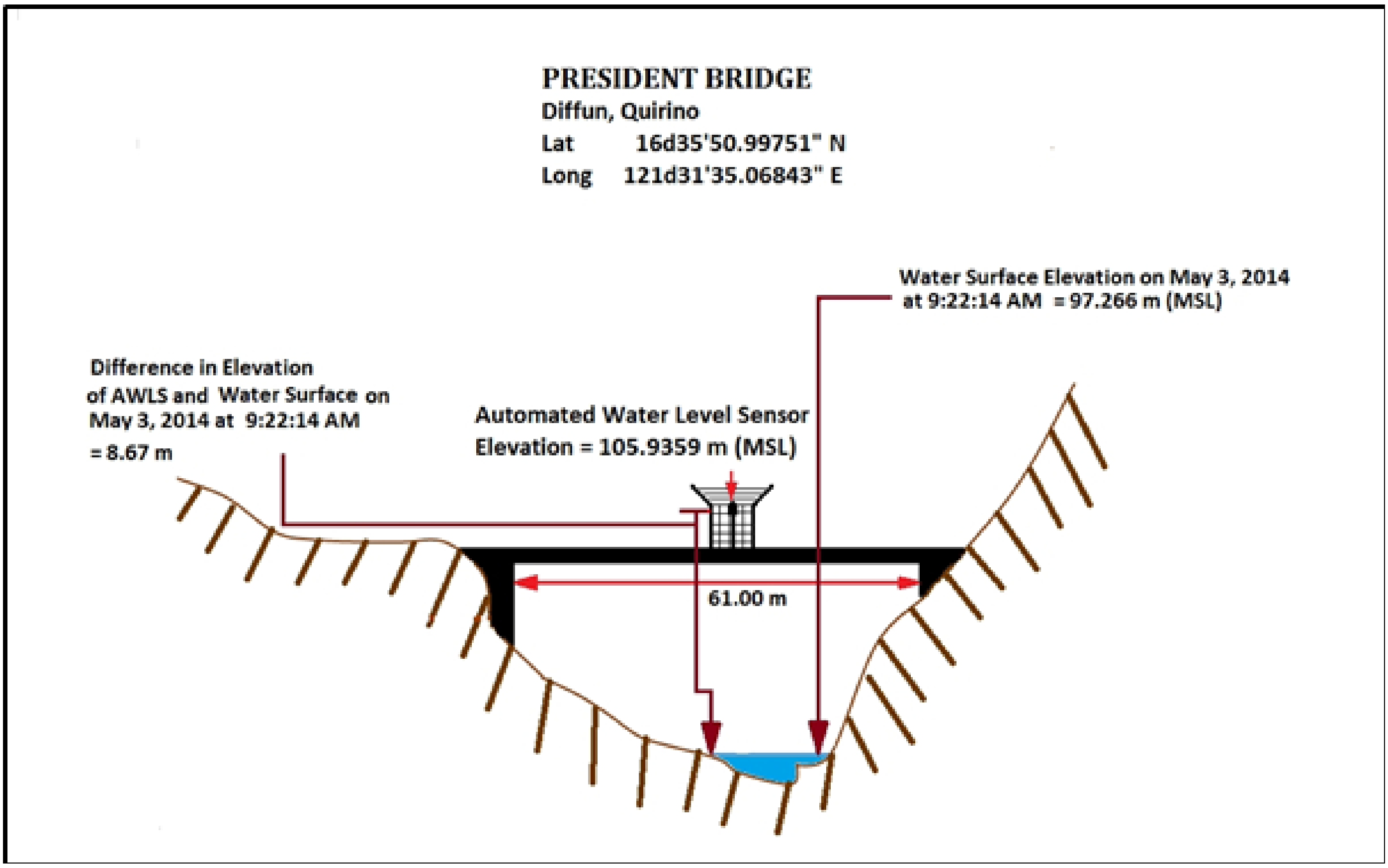


Figure 60. President Bridge Cross-Section Diagram

SANTIAGO (CALAO) BRIDGE

Santiago City

Lat 16d41'45.14492" N

Long 121d33'18.46358" E

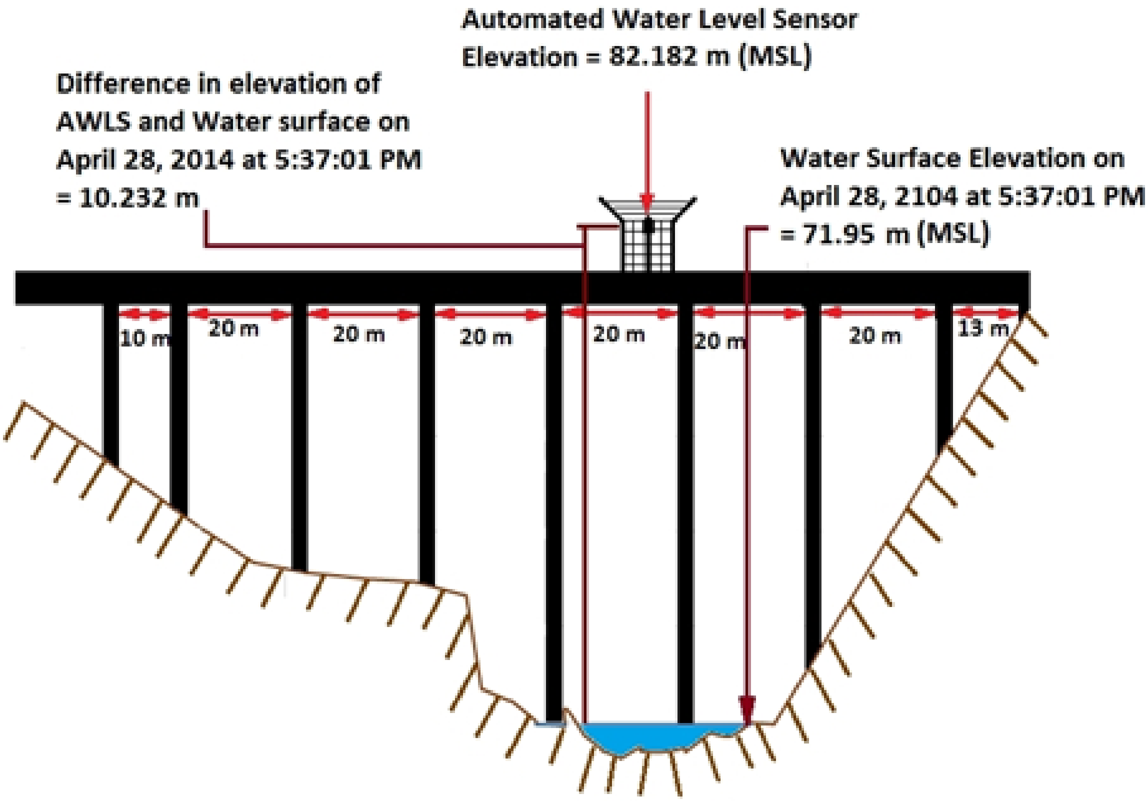


Figure 61. Santiago Bridge Cross-Section Diagram

4.3 Bathymetric Survey

The bathymetry of the river channel was surveyed using an echosounder. Differential GNSS surveying technique using survey grade GNSS Receivers and an Ohmex™ single beam echosounder were utilized in measuring the depth, eventually obtaining elevation with corresponding horizontal position.

Bathymetric survey of the entire Cagayan River System was divided into three different fieldworks. The first phase covered the province of Cagayan and central Isabela. The second phase involved only the major tributary rivers of Cagayan River, which are Magat and Ilagan Rivers. The last phase included the remaining part of Cagayan River from central Isabela to Quirino. Extent of bathymetric survey conducted is exhibited in Figure 62.

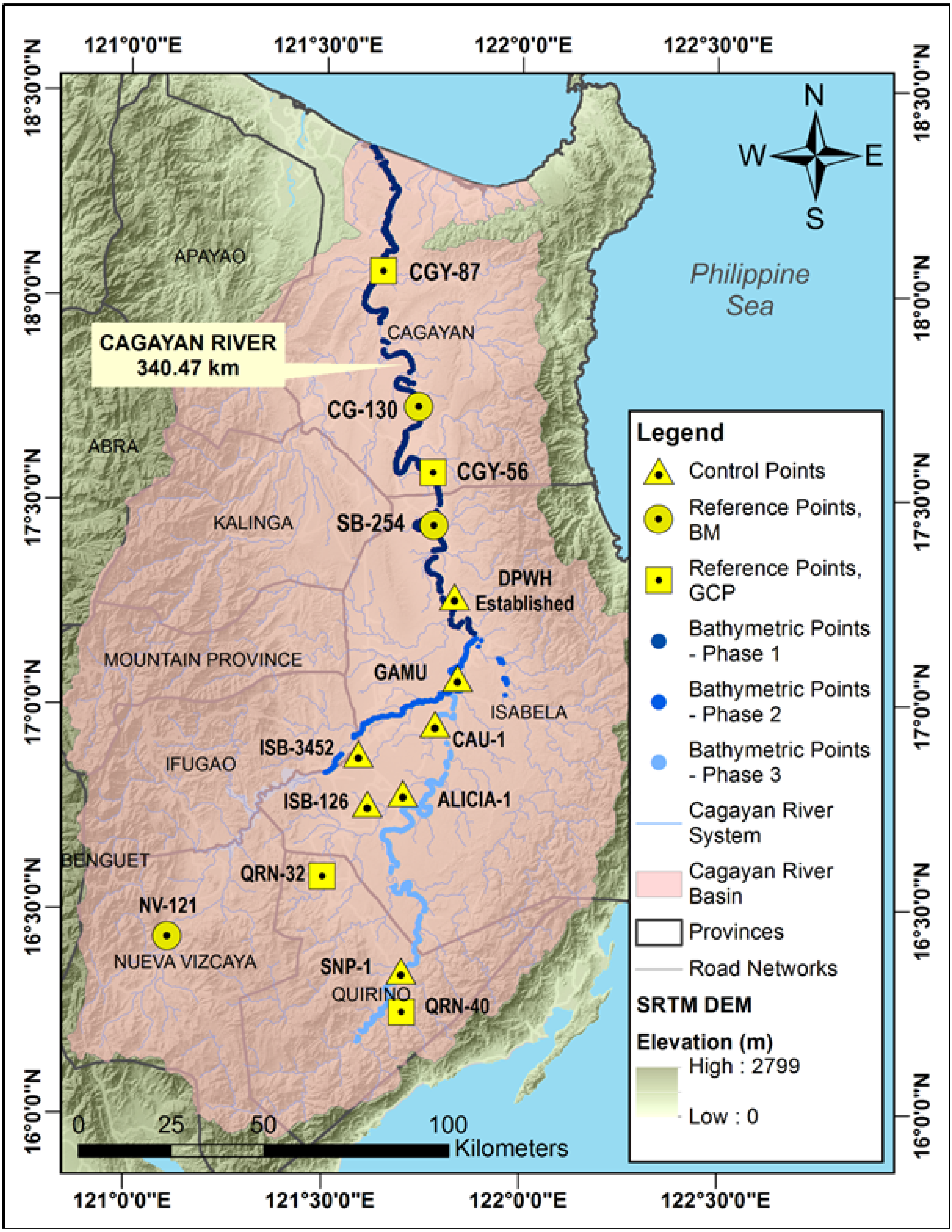


Figure 62. Extent of Bathymetric Survey in Cagayan River

4.3.1 Cagayan River Survey – Phase 1

During March 17-April 6, 2014, this phase of bathymetric survey started from the Municipality of Ilagan in Isabela down to its mouth in Aparri in Cagayan. The team sought assistance from PDRRMC Cagayan and Isabela for boat and manpower prior the execution of the survey. It took ten (10) days to finish the 204.58 km centerline bathymetric survey. Sample boat setup is exhibited in Figure 63 and riverbed centerline profiles are shown in Figures 64-70.

Figure 63. Bathymetric survey (Phase 1) setup with installed Ohmex™ Single Beam Echosounder and mounted Trimble® SPS 882

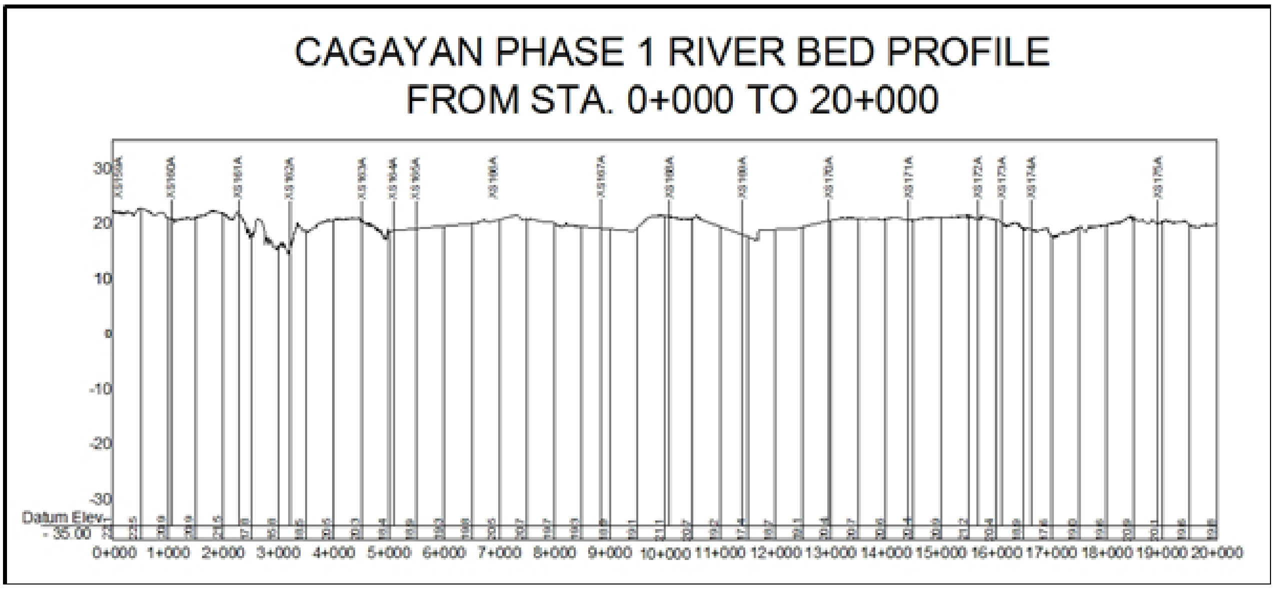


Figure 64. Bathymetry center line from the Municipality of Ilagan to Tumauni in Isabela

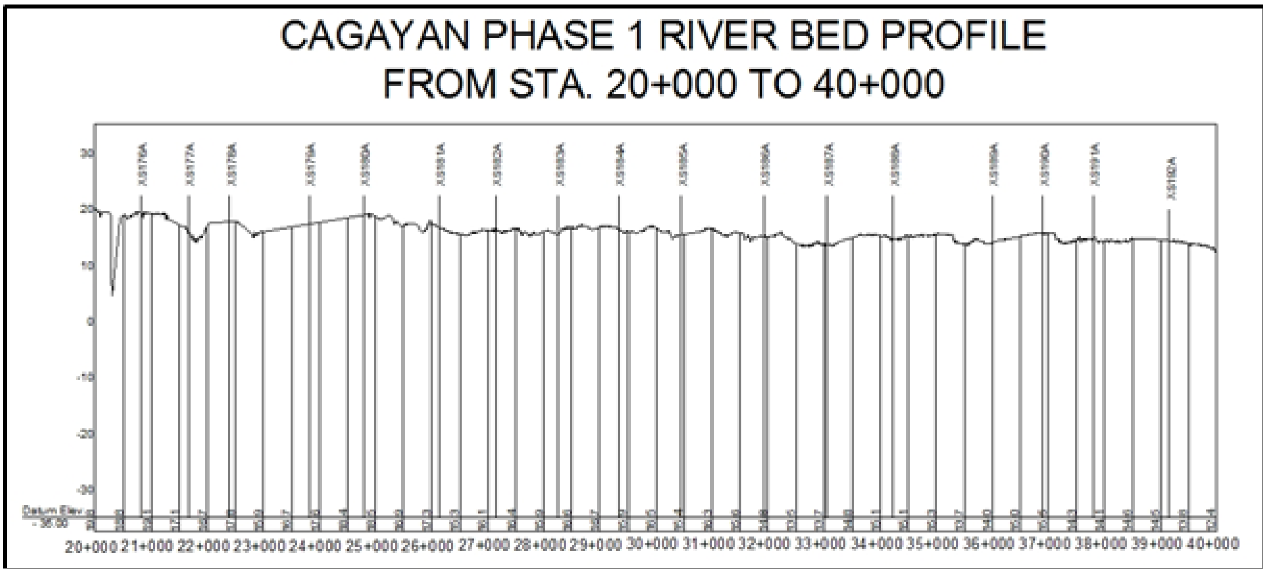


Figure 65. Bathymetry center line from the Municipality of Tumauni to Santo Tomas in Isabela

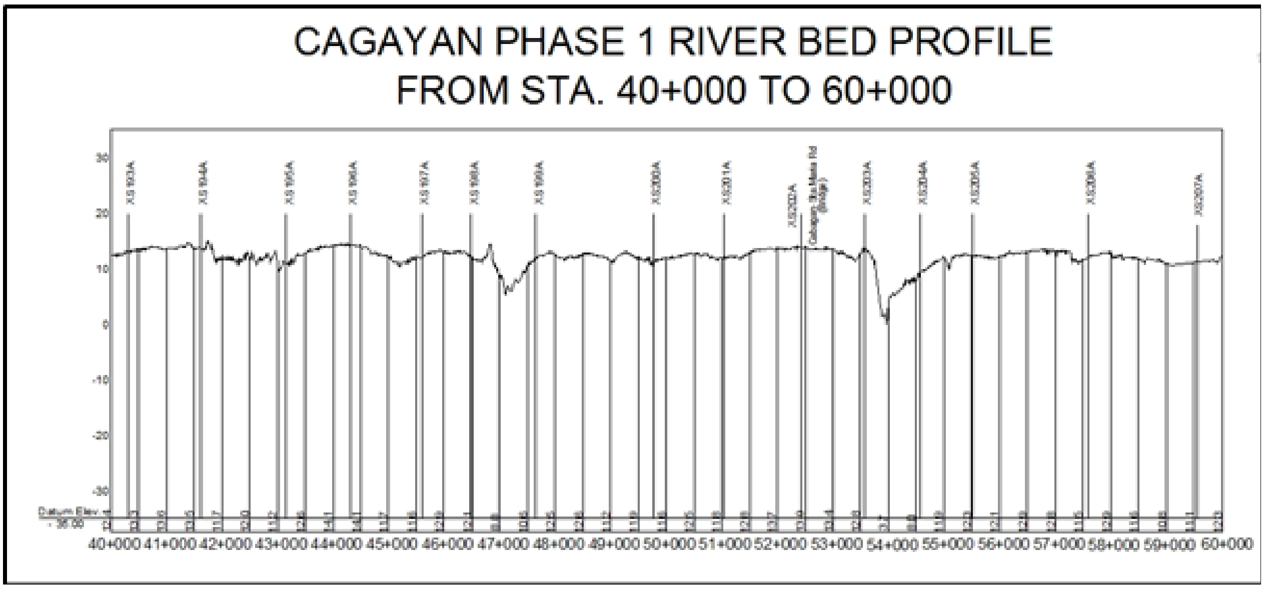


Figure 66. Bathymetry center line from the Municipality of Santo Tomas to San Pablo and Santa Maria in Isabela

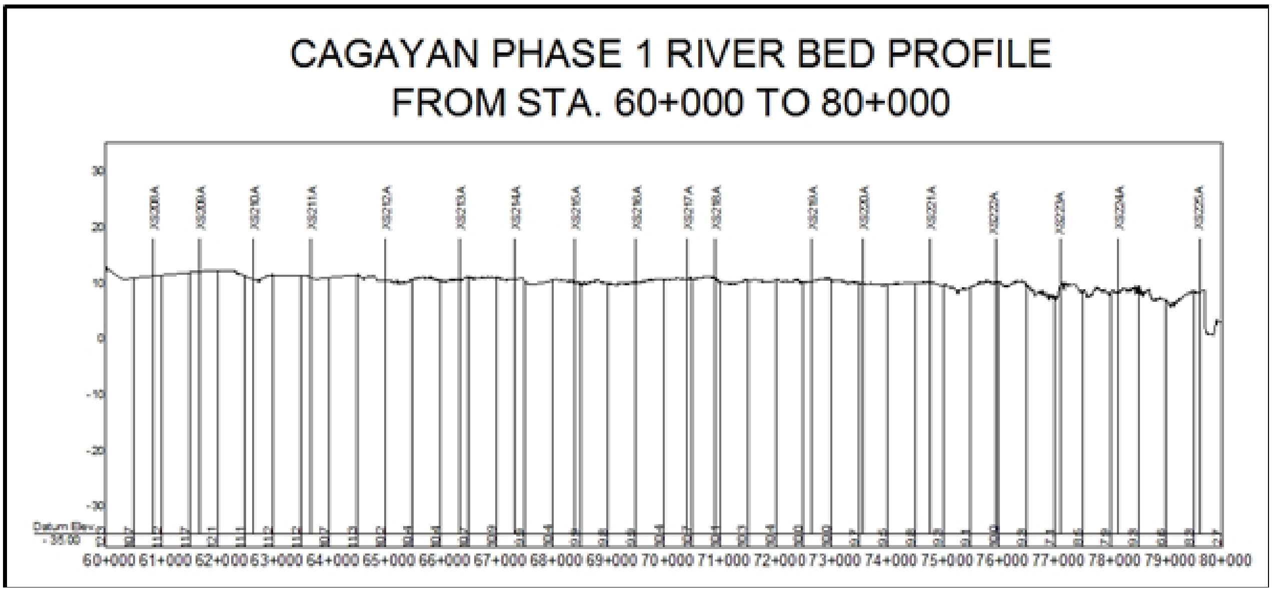


Figure 67. Bathymetry center line from the Municipalities of Santa Maria and San Pablo in Isabela to the Municipality of Alcala in Cagayan

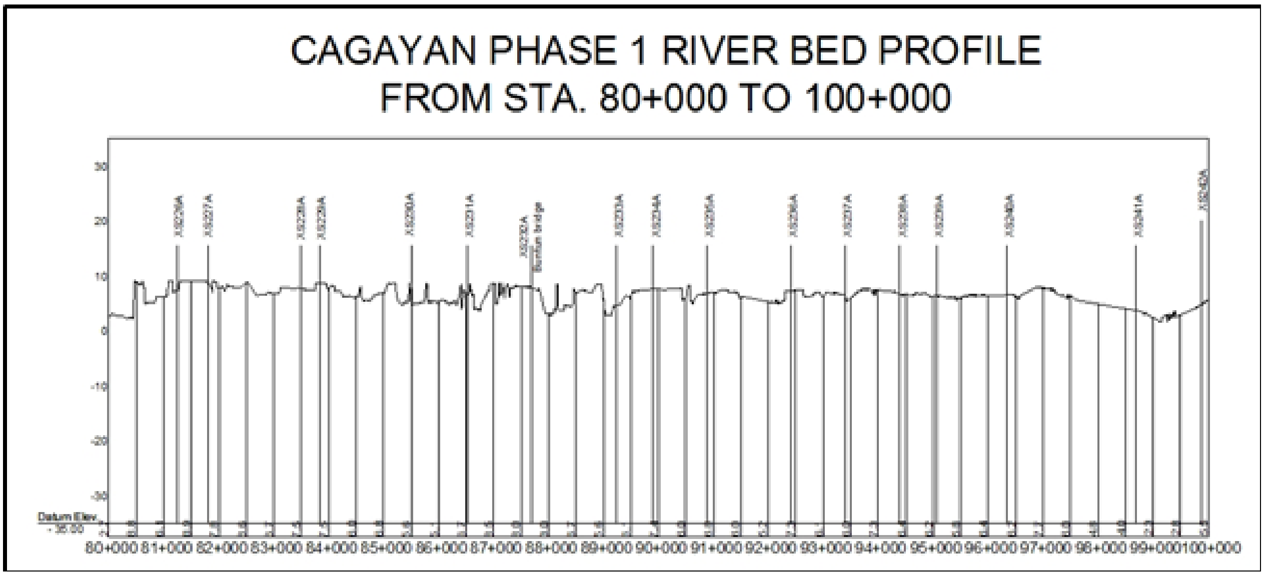


Figure 68. Bathymetry center line from the Municipality of Alcala to Solana and Iguig in Cagayan

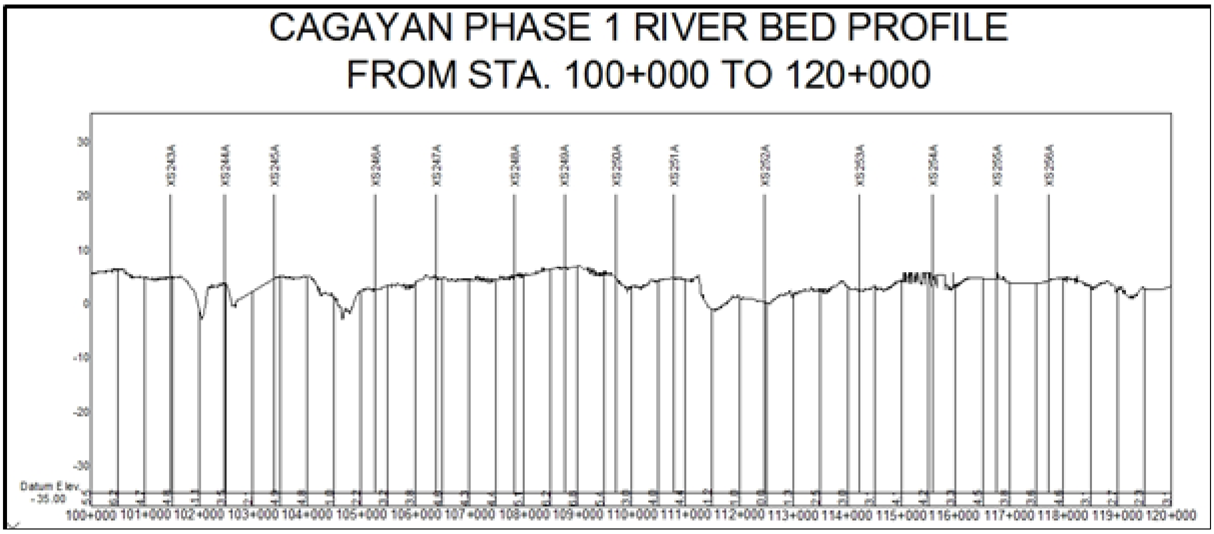


Figure 69. Bathymetry center line from the Municipalities of Iguig and Solana to Amulung in Cagayan

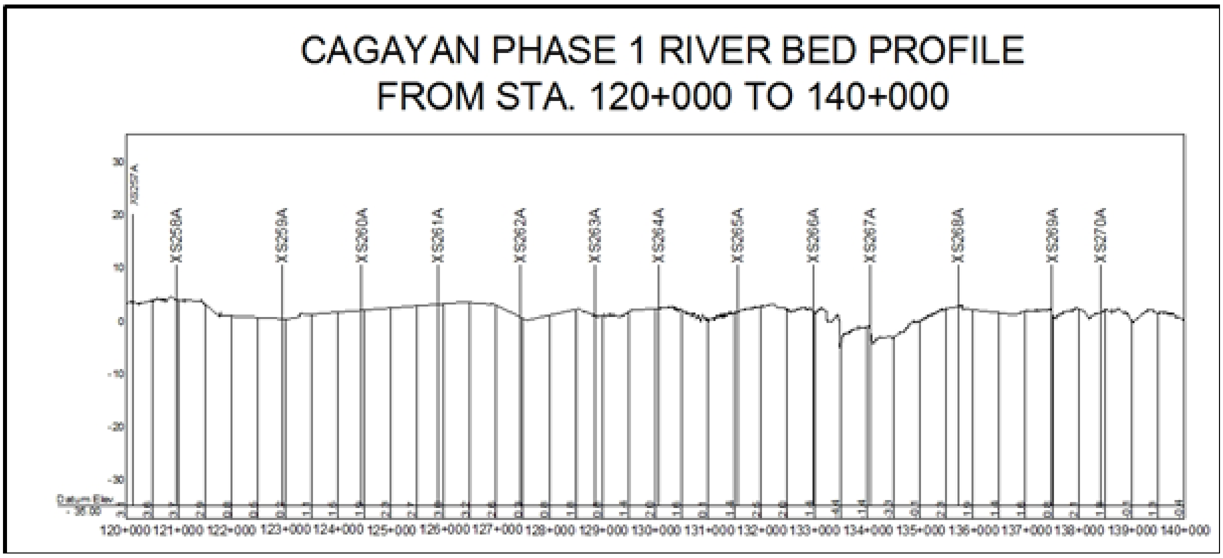


Figure 70. Bathymetry center line from the Municipality of Amulung to Aparri in Cagayan

4.3.2 Cagayan River Survey – Phase 2

This phase of bathymetric survey was conducted on January 29 - February 12, 2014 and covered the major tributaries of Cagayan River, Magat and Ilagan Rivers. Magat River was surveyed from Magat Dam which is about 71.10 km before merging with Cagayan River. It is on the western portion of the mainstream. On the other hand, Ilagan River survey started from the Municipality of San Mariano, Isabela, about 39.11 km upon merging with the Cagayan River. It lies on the eastern part of the mainstream

The survey teams sought for an assistance from the Provincial Disaster Risk Reduction and Management Council (PDRRMC) of Isabela headed by Mr. Edmund A. Guzman. The Council lent four (4) portable boat with outboard motor. The teams were accompanied with four (4) personnel of PDRRMC. Sample boat setup is exhibited in Figures 71-73 and a much closer-look at the extent of this bathymetric survey is shown in Figure 74.

Figure 71. Bathymetric survey at Magat River using portable boat borrowed from PDRRMC. (a) Assembling the boat in preparation for the survey (b) Gathering bathymetric data using OHMEX™ single beam echosounder with mounted Trimble® SPS 882

Figure 72. Bathymetric survey at Ilagan River using portable boat borrowed from PDRRMC. (a) Assembling the boat in preparation for the survey (b) Gathering bathymetric data using OHMEX™ single beam echosounder with mounted Trimble® SPS 882

Upstream of Magat River is shallow and mostly dry. Quarry activities are dominant along the river. Manual gathering of bathymetry data was initiated. The downstream of the Magat River is navigable. Using single beam echosounder is applicable in this area.

Figure 73. Upstream of Magat River. (a) Carrying the portable boat because of shallow water. (b) Carrying the portable boat back to the site and initiated manual gathering.

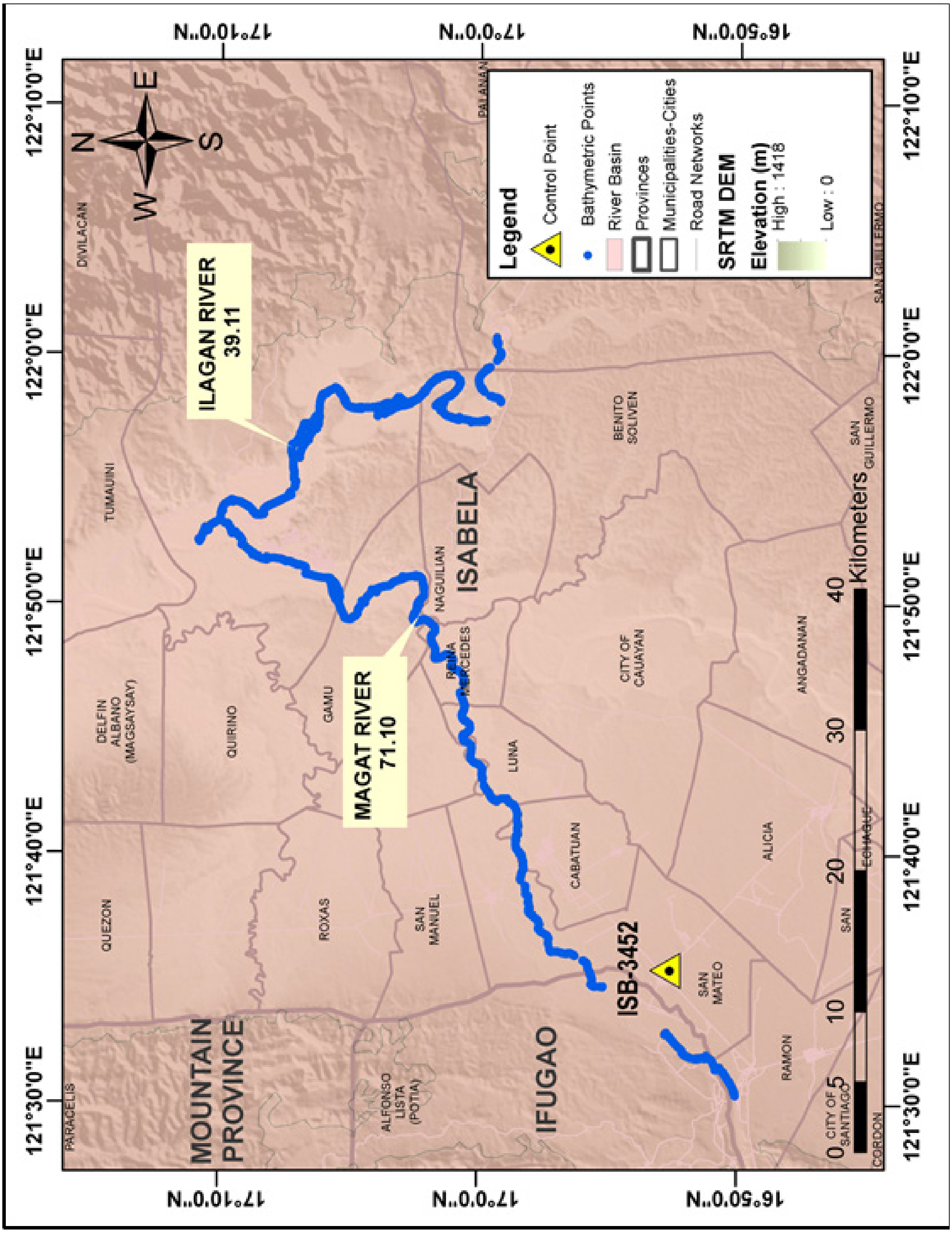


Figure 74. Bathymetric Survey of Cagayan River's Major Tributaries – Magat and Ilagan Rivers

4.3.3 Cagayan River Survey – Phase 3

This phase of bathymetric survey was conducted on April 28 - May 8, 2014 and covered the remaining survey portions of Cagayan River from Nagtipunan, Quirino down to Naguilian, Isabela with a length of 135.89 km. Sample boat setup is exhibited in Figure 75 and riverbed centerline profiles are shown in Figure 76-82.

Figure 75. Bathymetric survey (Phase 3) setup on a boat (a) Qurino and (b) Isabela

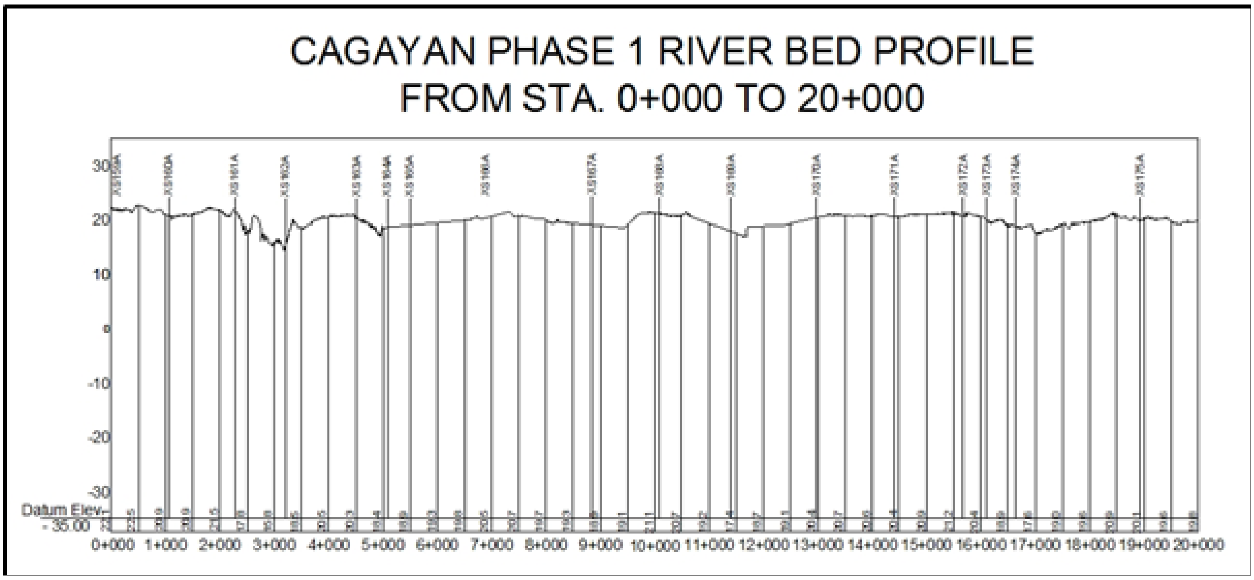


Figure 76. Bathymetry center line from Nagtipunan to Maddela in Quirino

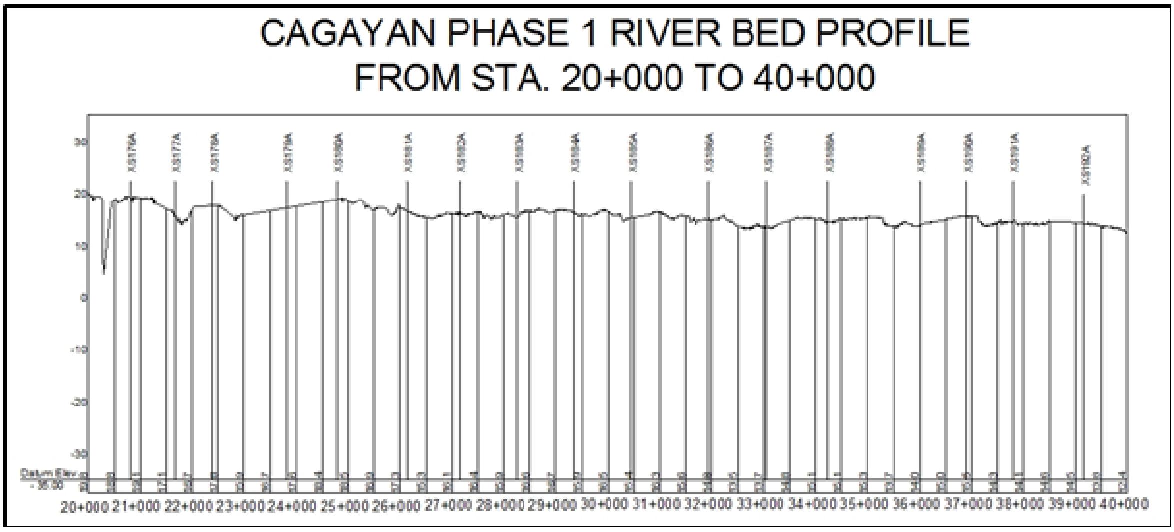


Figure 77. Bathymetry center line from Maddela, Quirino to San Agustin, Isabela

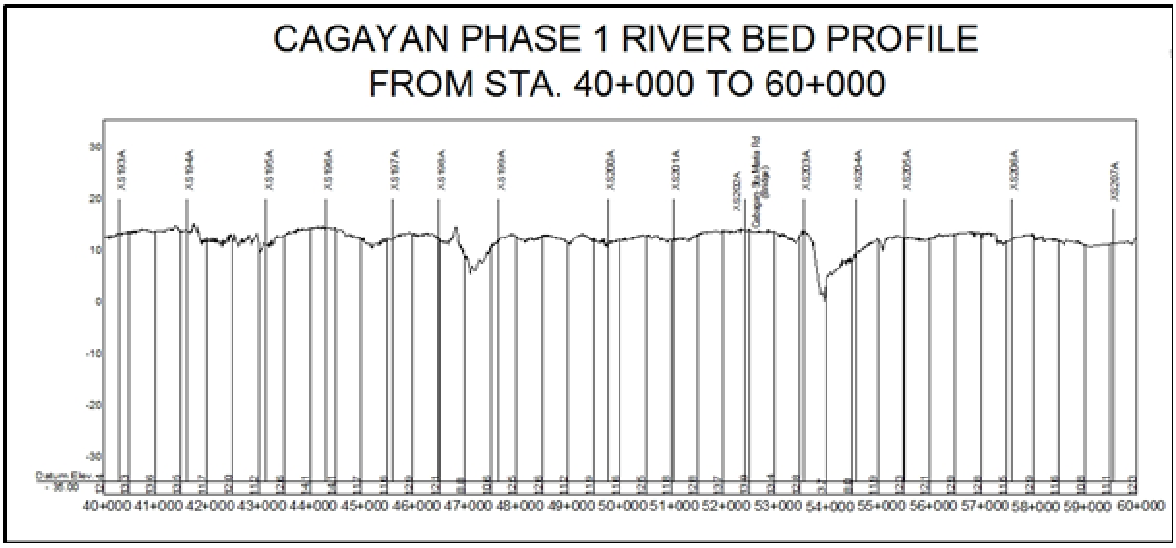


Figure 78. Bathymetry center line from San Agustin to Jones in Isabela

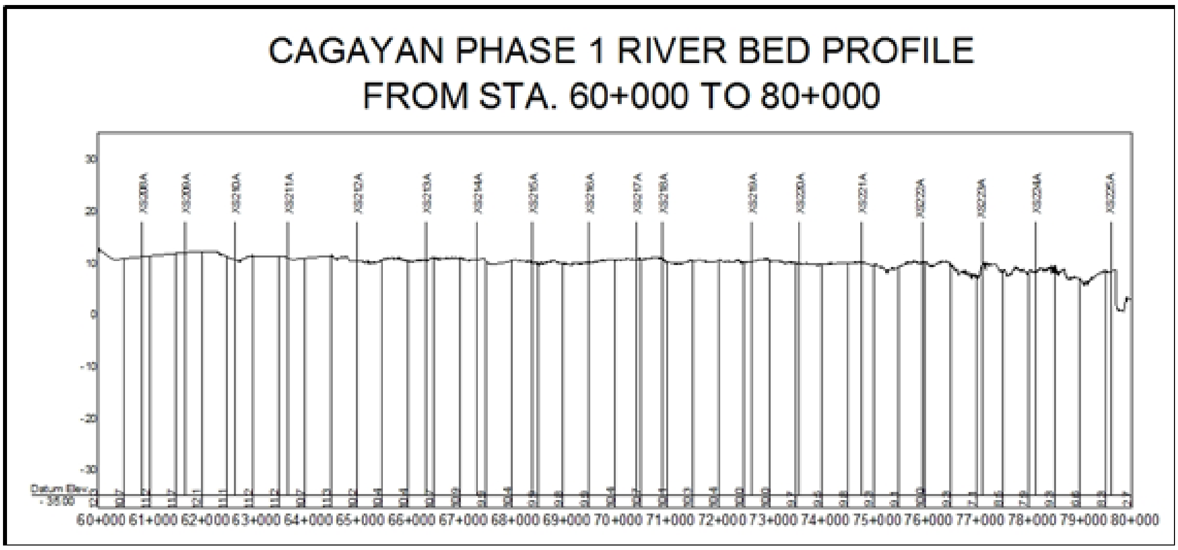


Figure 79. Bathymetry center line from Jones to Dalibubon in Isabela

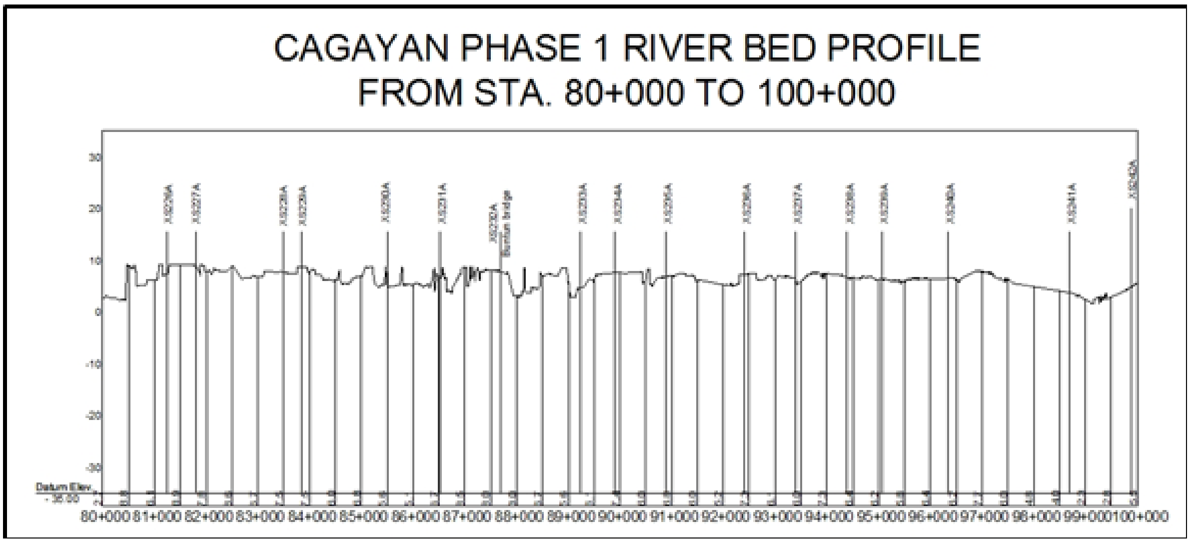


Figure 80. Bathymetry center line from Dalibubon to Alicia in Isabela

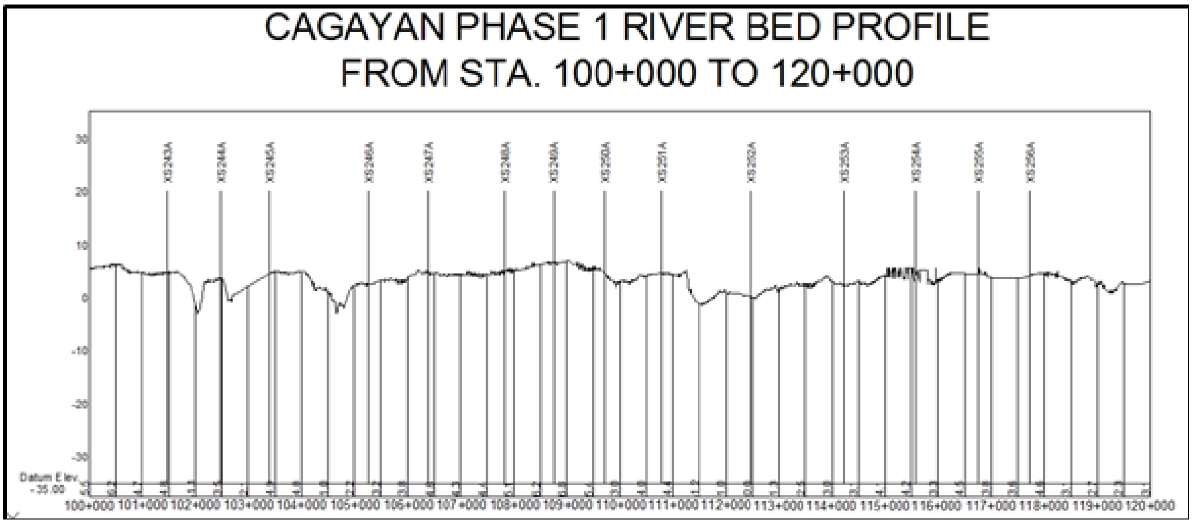


Figure 81. Bathymetry center line from Alicia to Angadanan in Isabela

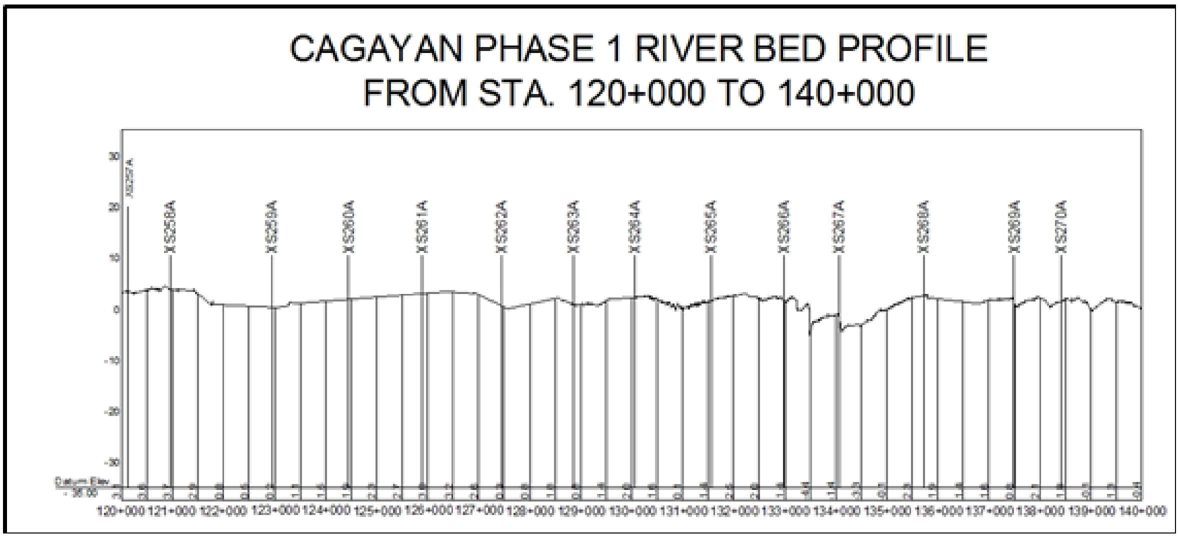


Figure 82. Bathymetry center line from Cauayan to Naguilian Bridge in Isabela

4.4 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. For Cagayan River, deployment of ADCP sensors was done in six (6) bridges. All gathered data were processed to produce a statistical output that determines the behavior of Cagayan River in different locations in specific amount of rainfall. The locations of these sensors are exhibited in Figure 83.

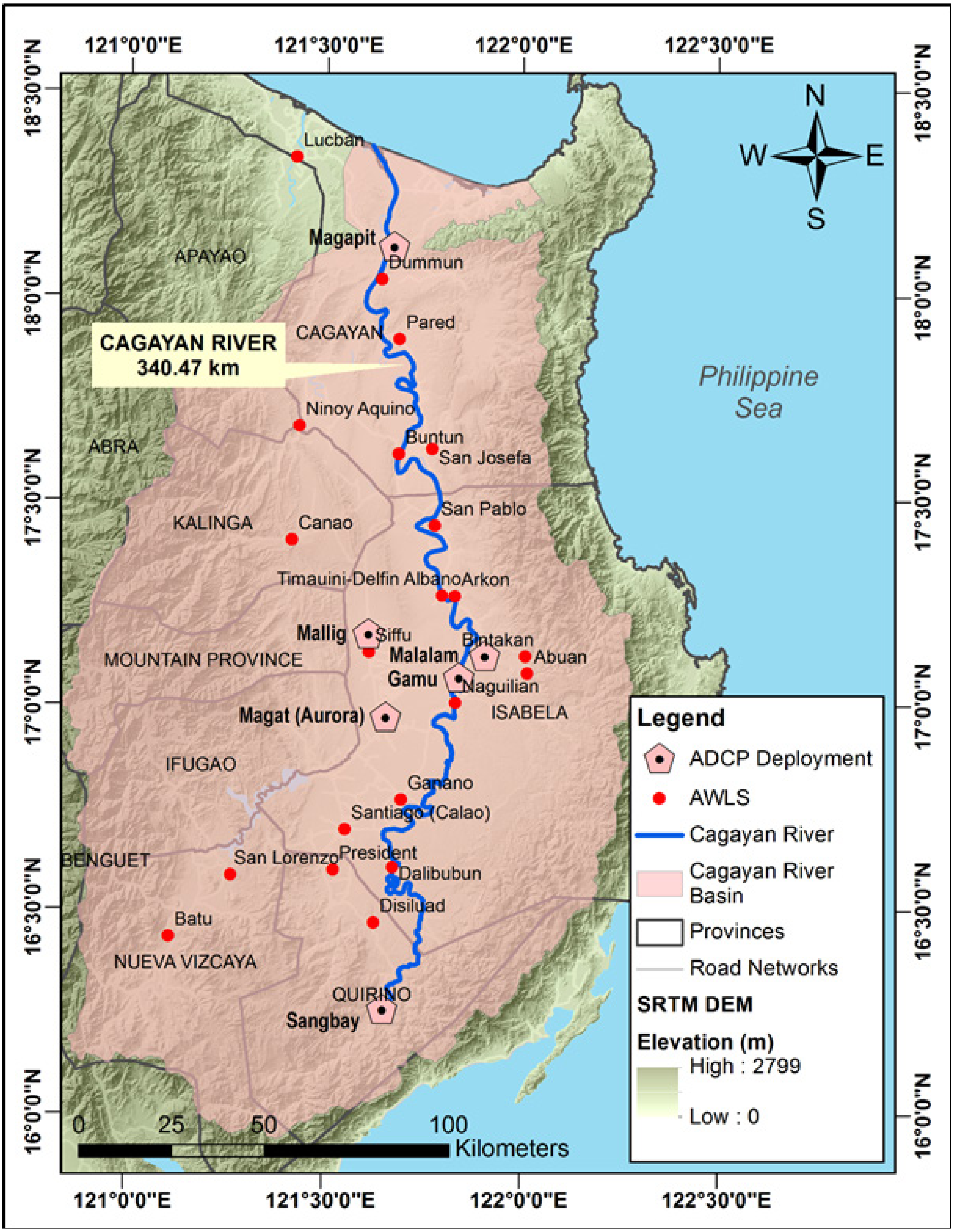


Figure 83. Location of the deployed ADCP during the Cagayan River Survey

4.4.1 Sensor Deployment

The deployed sensors were left on the site to continuously collect data while being monitored by a group of temporarily employed local hires. The sensors were checked every day especially during and after rainfall events to ensure the safety of the equipment as well as downloading of data for safekeeping in case of unforeseen events.

During the initial fieldwork on September 16–30, 2013, three (3) ADCPs were deployed. Side Looking ADCP with Depth Gauges were deployed in Gamu and Magapit Bridges while a Vertical ADCP with Depth Gauge was deployed in Malalam Bridge.

Vertical ADCP with Depth Gauge was deployed along Malalam Bridge on September 20, 2013 with the aid of the Philippine Coast Guard. The ADCP and depth gauge was then retrieved on September 29, 2013, after nine (9) days. Setting up of vertical ADCP at Malalam bridge are shown in Figures 84-85.

Figure 84. ADCP (vertical) and Depth Gauge Deployment at Malalam Bridge with Philippine Coast Guard

Figure 85. Retrieval of ADCP (vertical) at Malalam Bridge on September 29, 2013

Side Looking ADCPs with Depth Gauges were deployed along Magapit and Gamu Bridges on September 22, 2013 and September 24, 2013, respectively. The ADCPs and depth gauges were then retrieved on September 29, 2013, after 5 days in Gamu Bridge and 7 days in Magapit Bridge. Setups for side-looking ADCP at Gamu and Magapit bridges are shown in Figures 86-87.

Figure 86. ADCP and Depth Gauge Deployment along Gamu Bridge

Figure 87. ADCP and Depth Gauge Deployment along Magapit Bridge

Cagayan River Basin Survey

On January 29 - February 12, 2014, Cagayan River Survey Phase 2 included two (2) deployment of side-looking ADCP in Mallig and Aurora Bridges. The setup of these deployed sensors are exhibited in Figure 88-89.

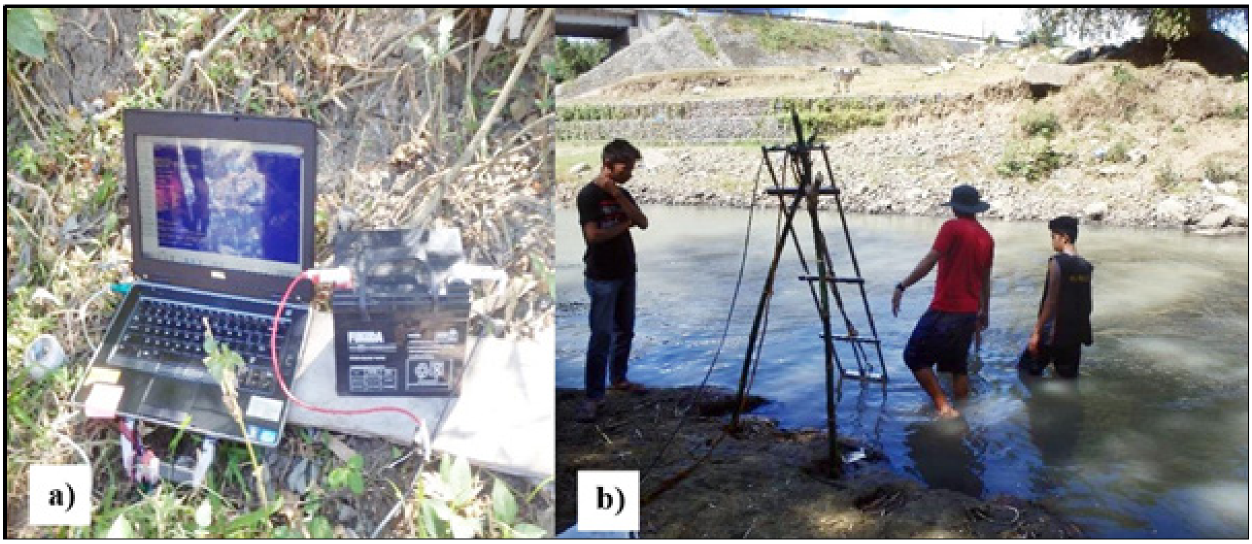


Figure 88. At Mallig River (a) setting up the ADCP (b) deployment of ADCP in Mallig River

Figure 89. At Magat River (Aurora Bridge) (a) Setting up both Depth gauge and ADCP (b) Deployment of ADCP

On April 28 - May 8, 2014, Cagayan River Survey Phase 3 included two (2) deployment of side-looking ADCP in Malalam and Sangbay Bridges. The setup of these deployed sensors are exhibited in Figure 90-91.

Figure 90. Deployed ADCP at Malalam Bridge, Isabela

Figure 91. Deployed ADCP at Sangbay Bridge in Nagtipunan, Quirino

4.4.2 Sensor Data

All the data involving river flow, cross-section, water level change and water level elevation were process to come up with Stage-Discharge (HQ) computation. Diagrams showing the behavior of the river for specific locations are shown in Figure 92-150.

Hydrometry data for following bridges, Figure 92-119, were acquired during the initial survey for Cagayan River.

Arkon Bridge – Timauini, Isabela

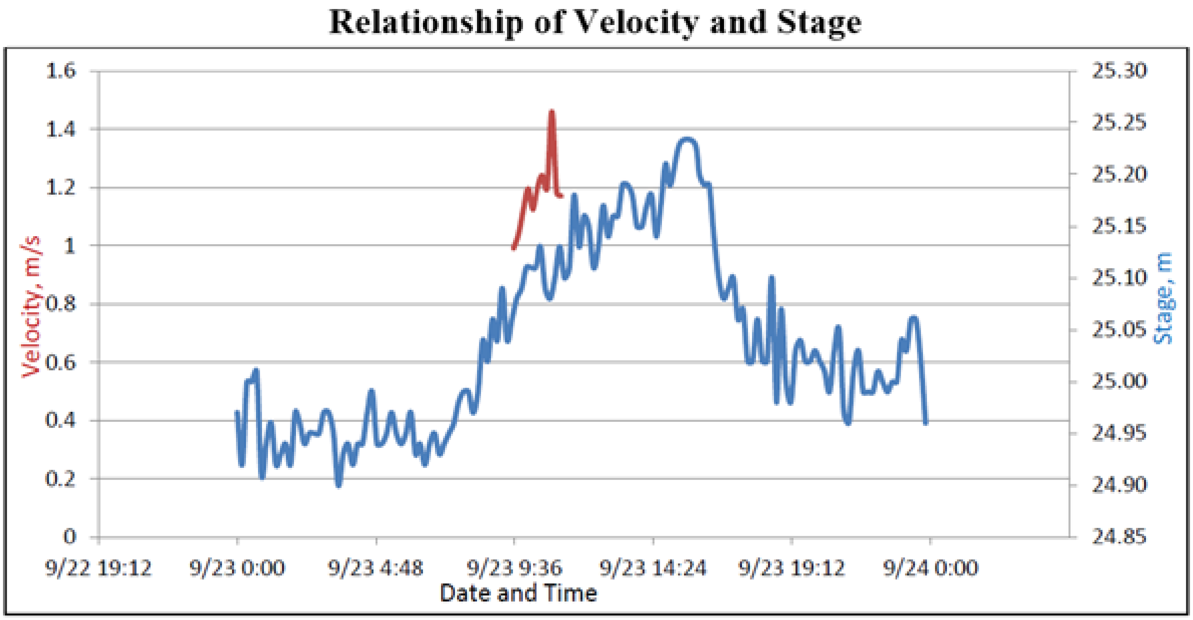


Figure 92. Relationship between velocity and stage in Arkon Bridge within the observation period

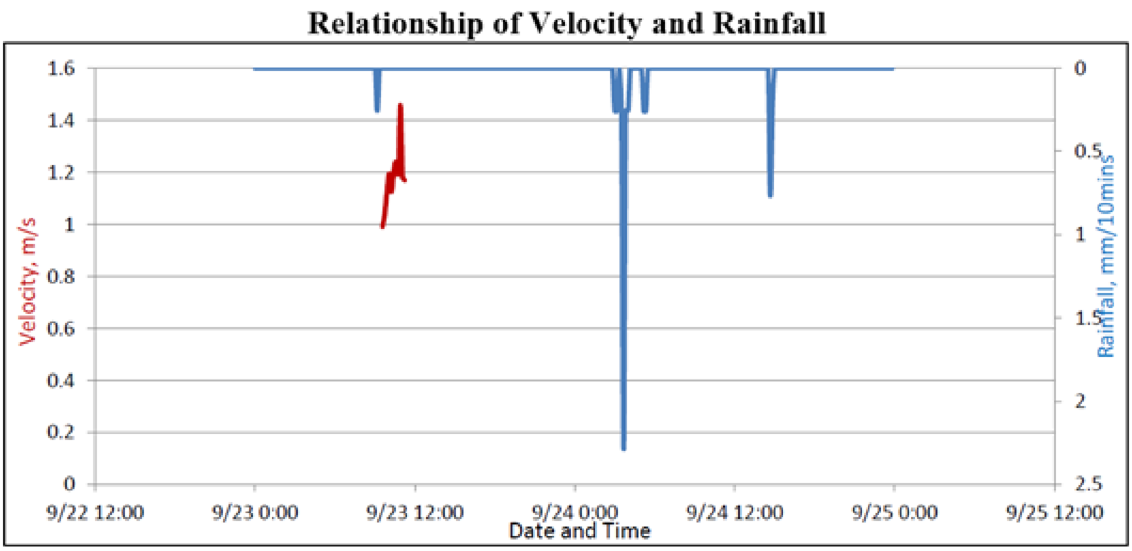


Figure 93. Relationship between velocity and rainfall in Arkon Bridge within the observation period

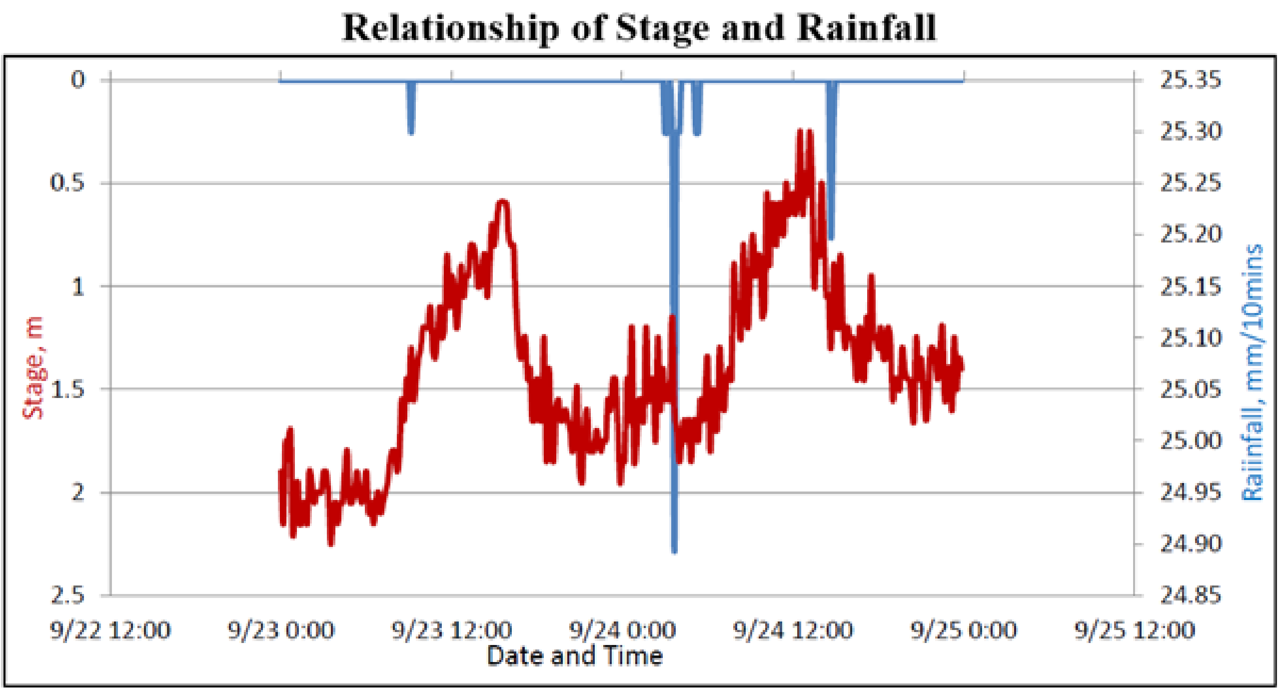


Figure 94. Relationship between stage and rainfall in Arkon Bridge within the observation period

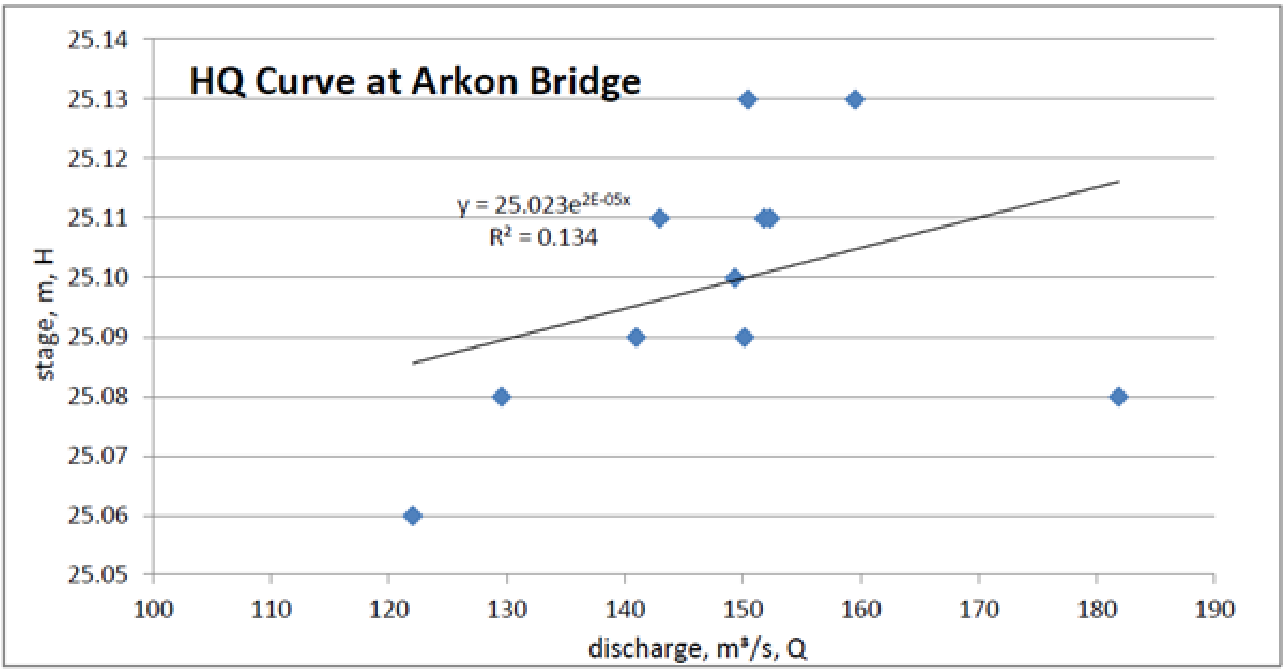


Figure 95. Relationship between stage and discharge in Arkon Bridge within the observation period

Batu Bridge – Bayombong, Nueva Vizcaya

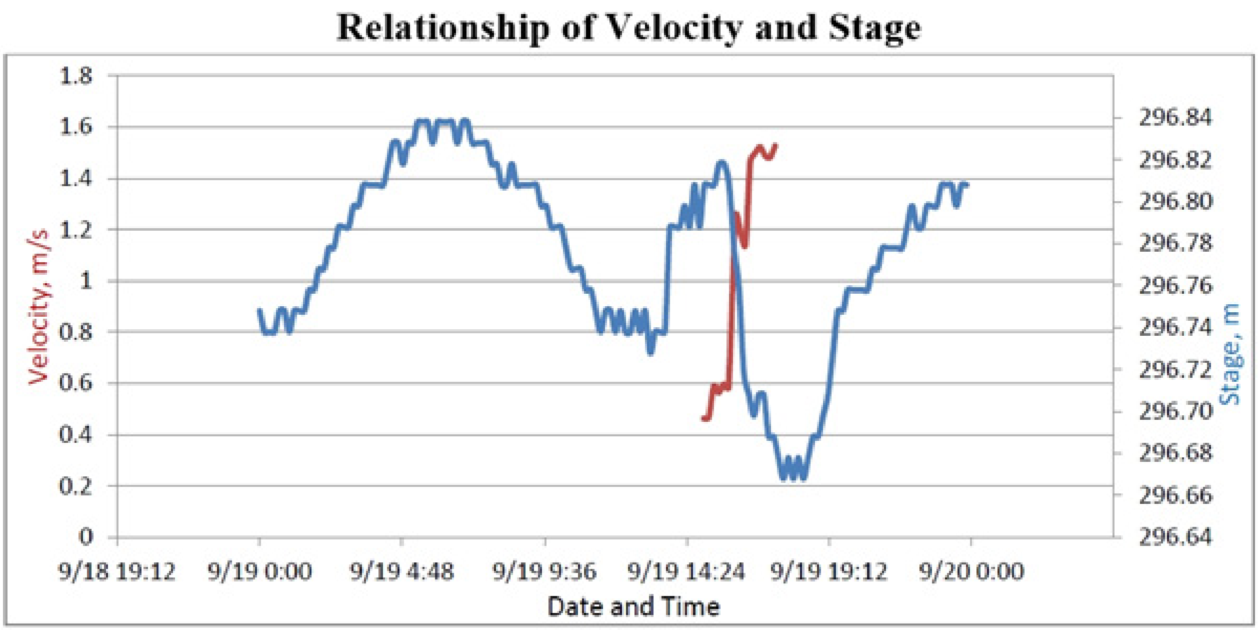


Figure 96. Relationship between velocity and stage in Batu Bridge within the observation period

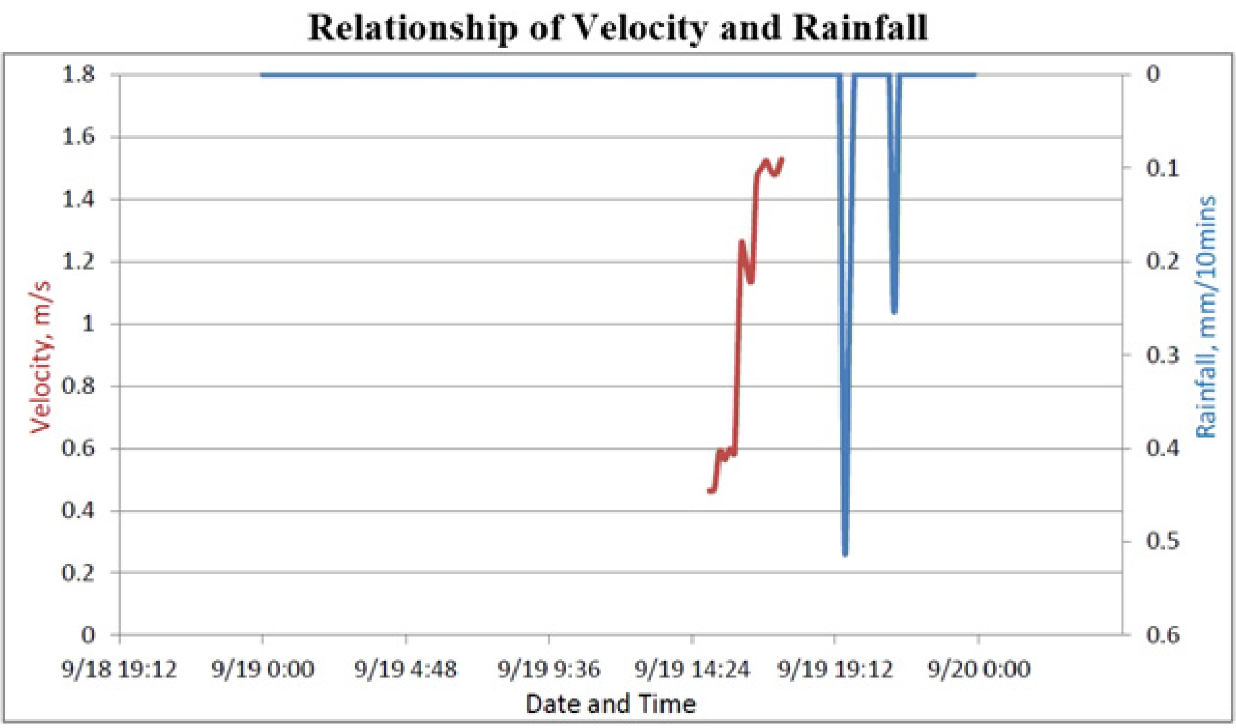


Figure 97. Relationship between velocity and rainfall in Batu Bridge within the observation period

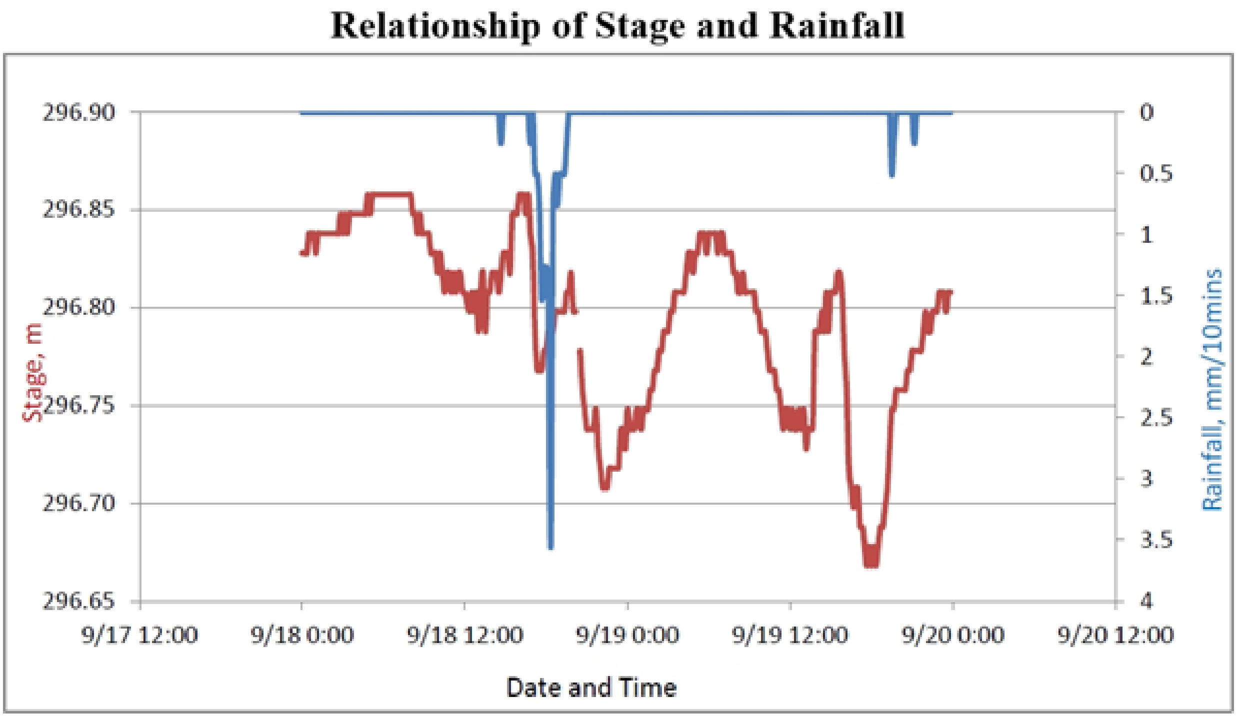


Figure 98. Relationship between stage and rainfall in Batu Bridge within the observation period

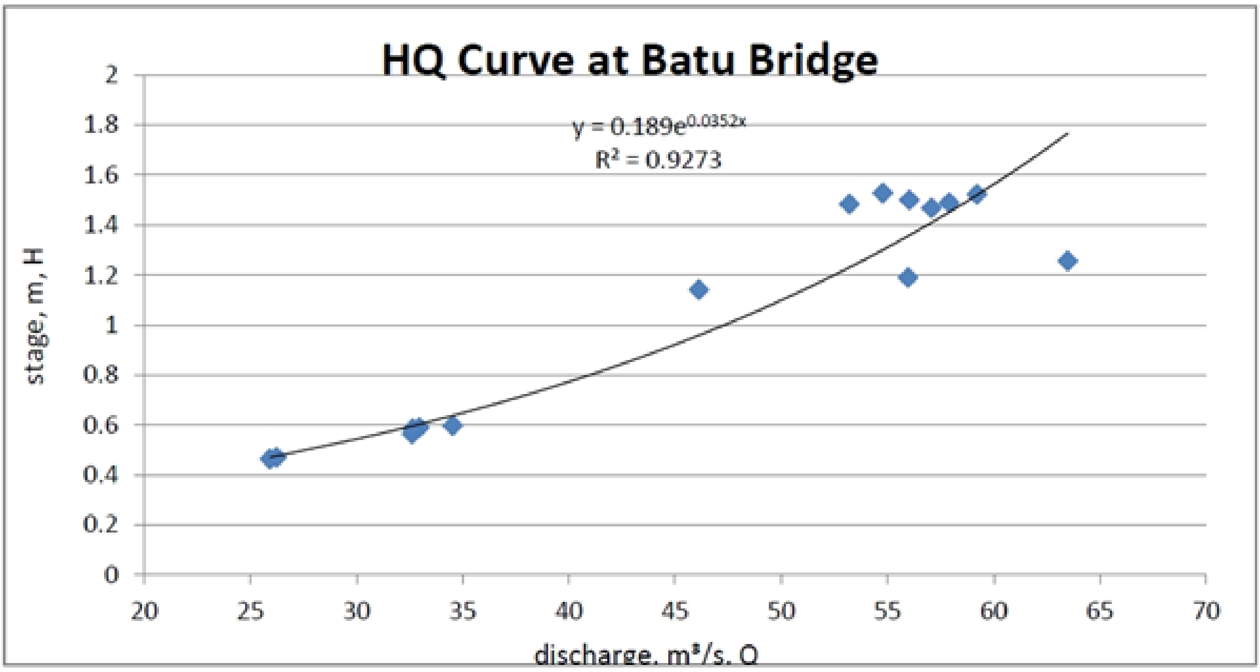


Figure 99. Relationship between stage and discharge in Batu Bridge within the observation period

Lucban Bridge – Abulug, Cagayan

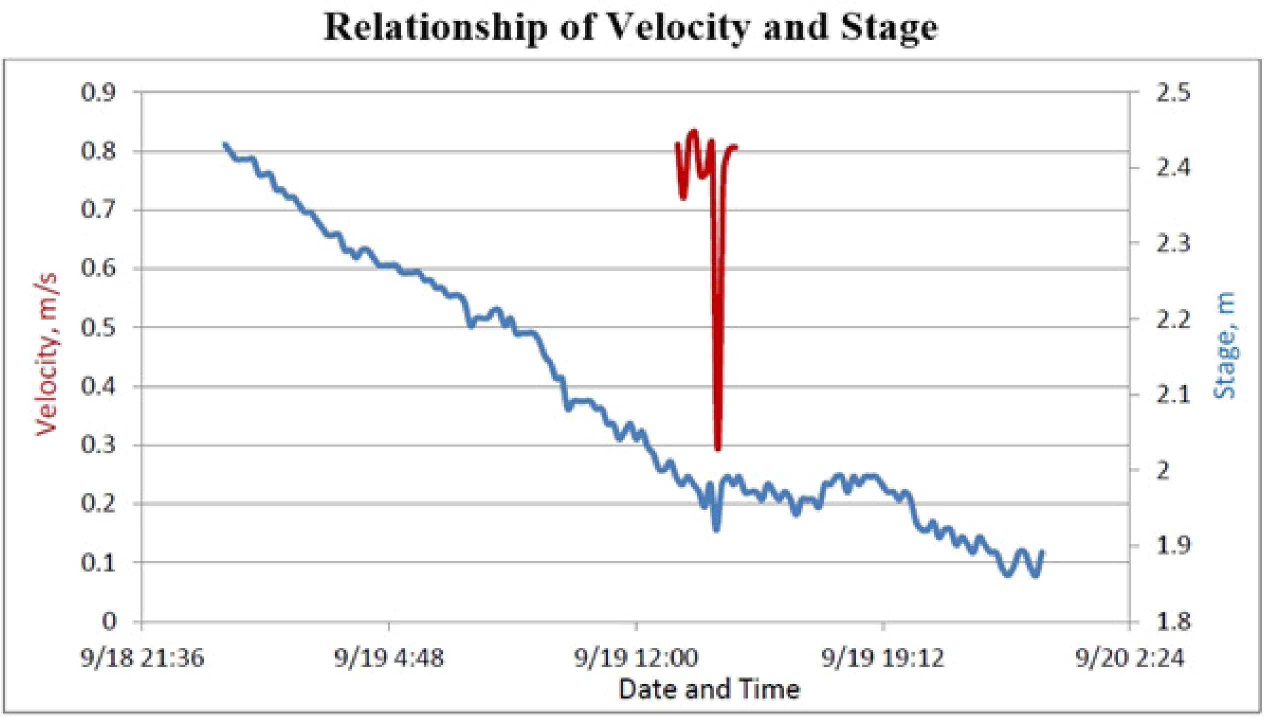


Figure 100. Relationship between velocity and stage in Lucban Bridge within the observation period

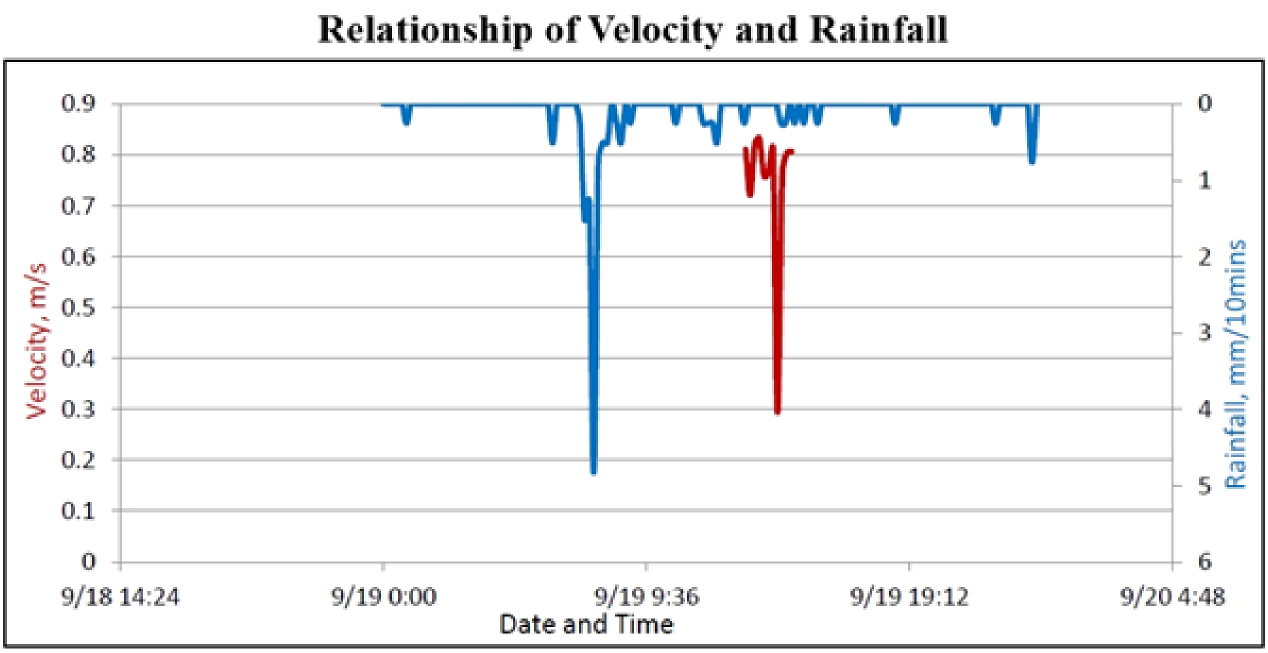


Figure 101. Relationship between velocity and rainfall in Lucban Bridge within the observation period

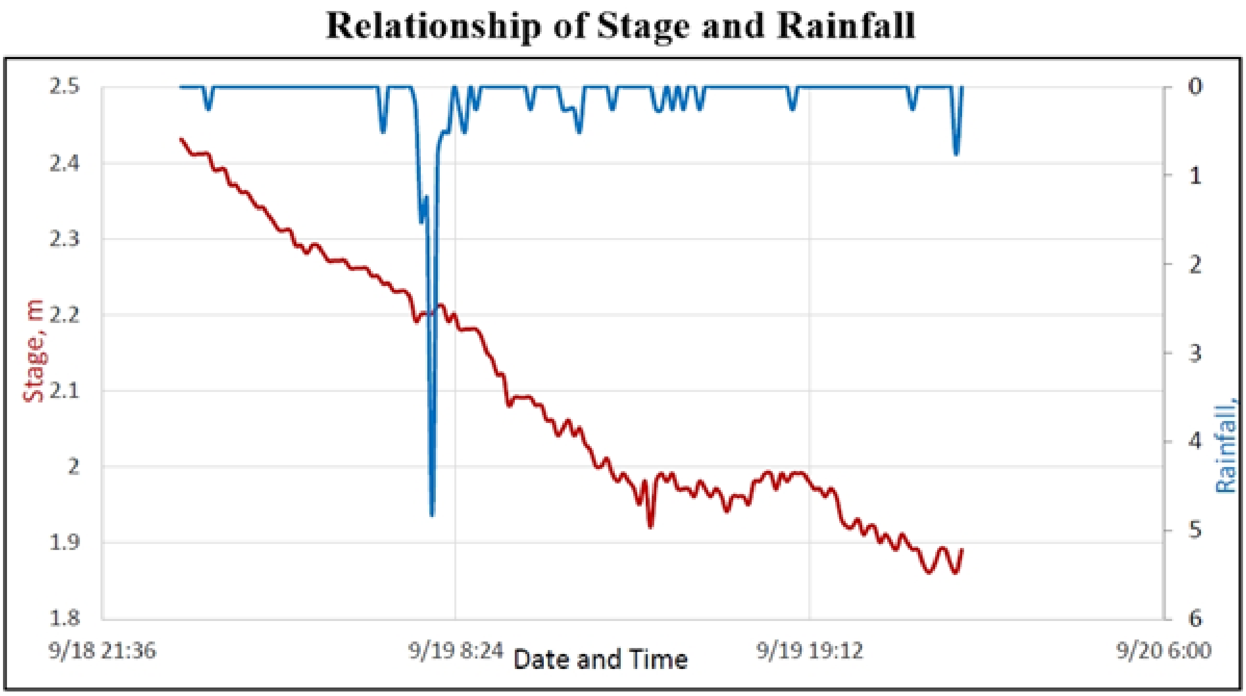


Figure 102. Relationship between stage and rainfall in Lucban Bridge within the observation period

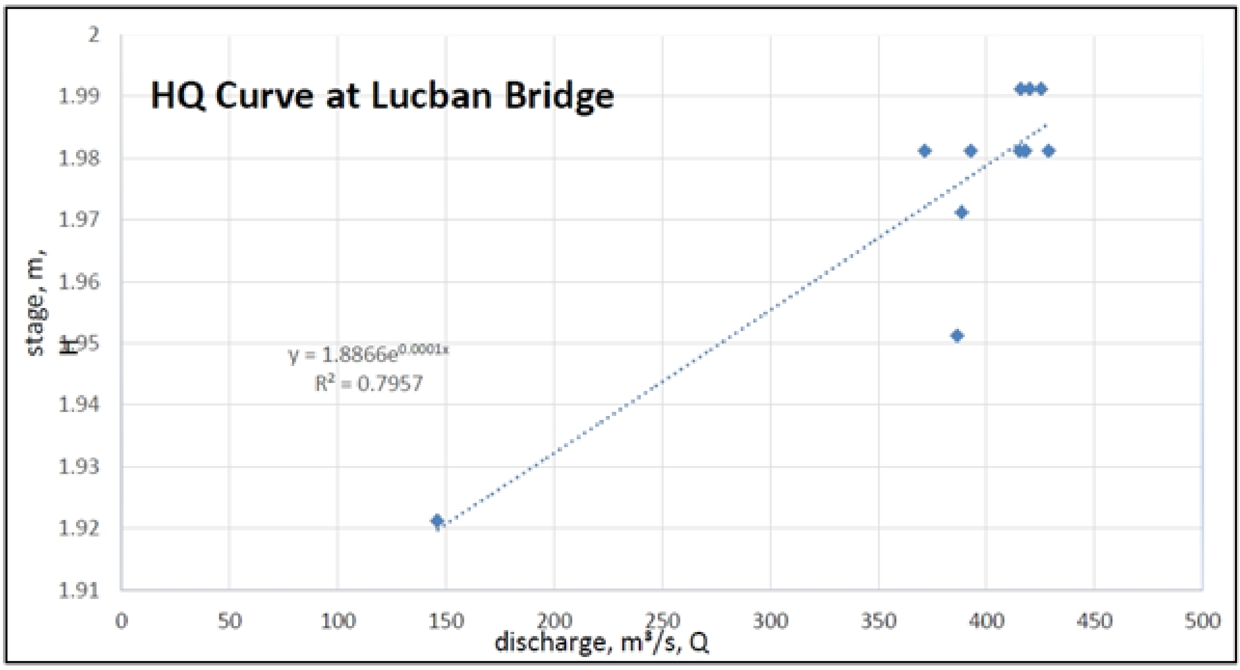


Figure 103. Relationship between stage and discharge in Lucban Bridge within the observation period

Magat (Aurora) Bridge – Aurora, Isabela

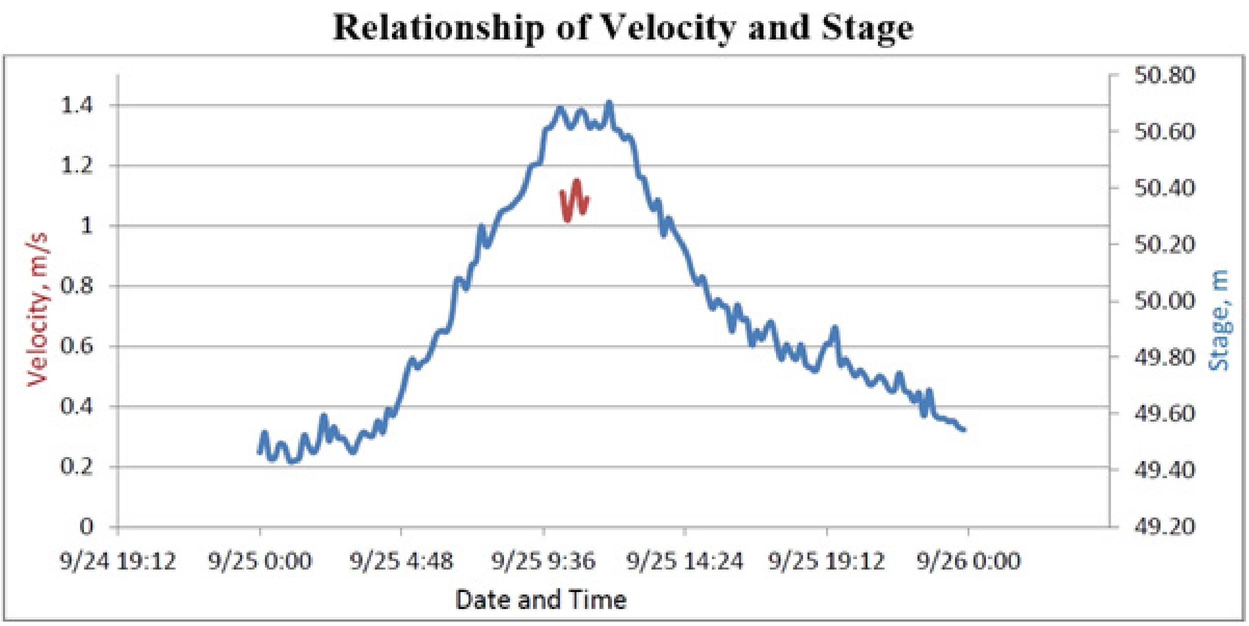


Figure 104. Relationship between velocity and stage in Magat (Aurora) Bridge within the observation period

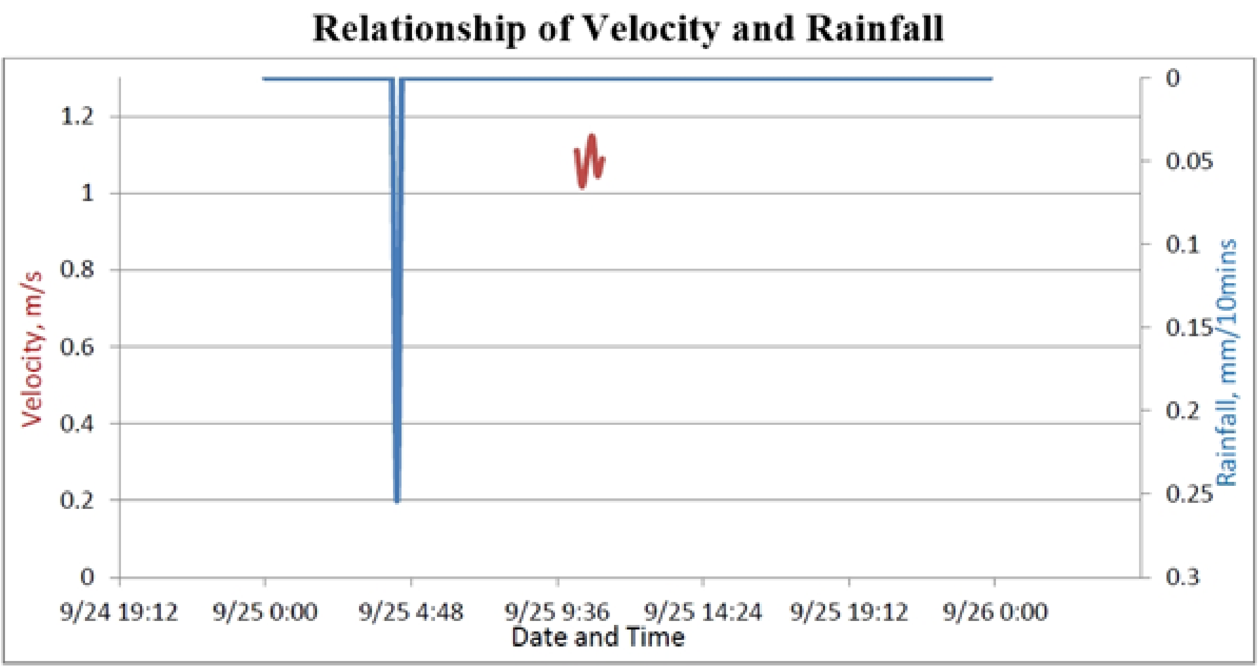


Figure 105. Relationship between velocity and rainfall in Magat (Aurora) Bridge within the observation period

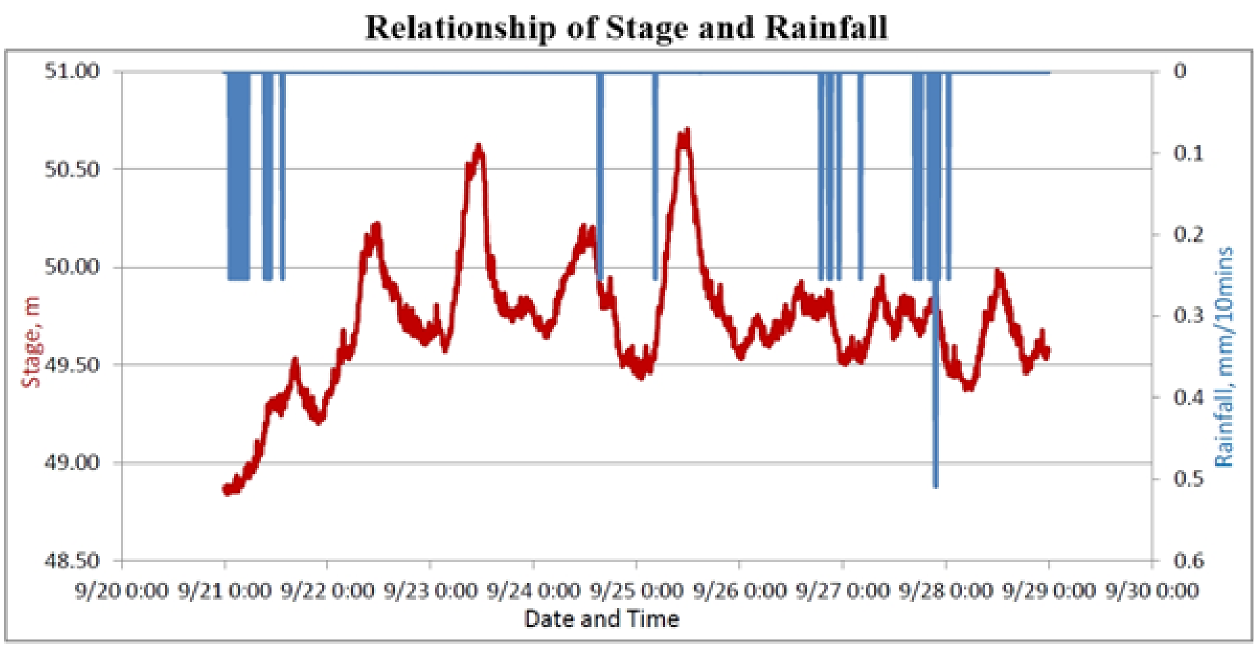


Figure 106. Relationship between stage and rainfall in Magat (Aurora) Bridge within the observation period

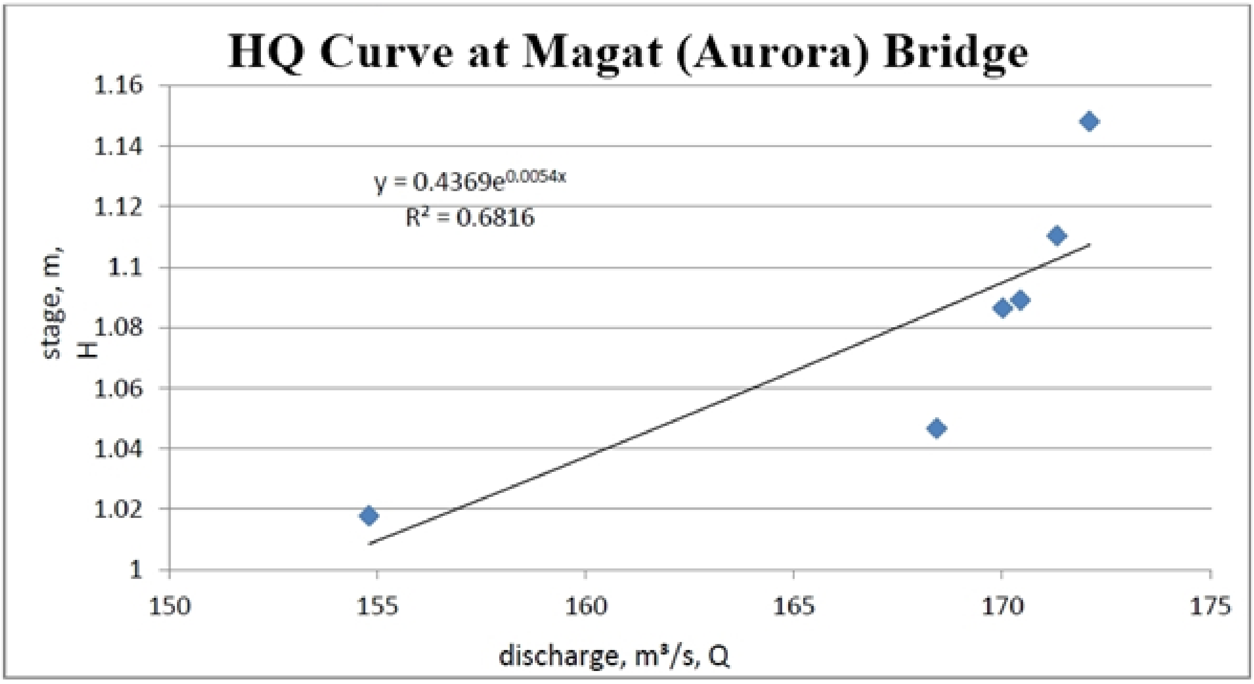


Figure 107. Relationship between stage and discharge in Magat (Aurora) Bridge within the observation period

Malalam Bridge – Ilagan, Isabela

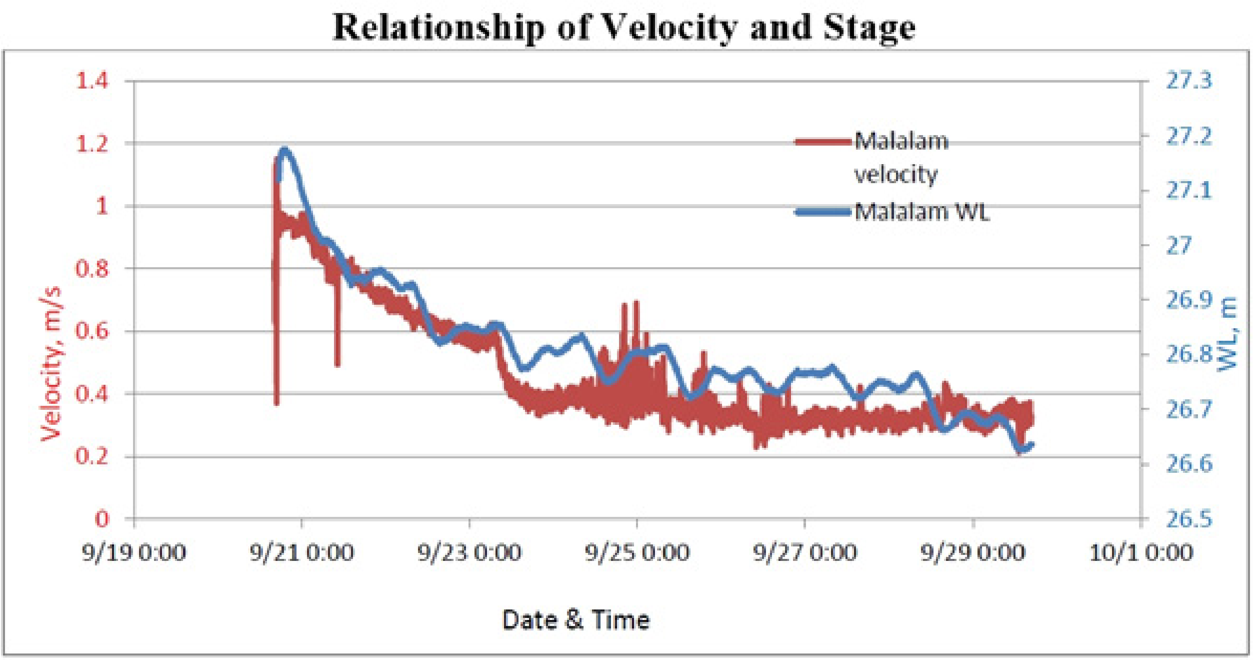


Figure 108. Relationship between velocity and stage in Malalam Bridge within the observation period

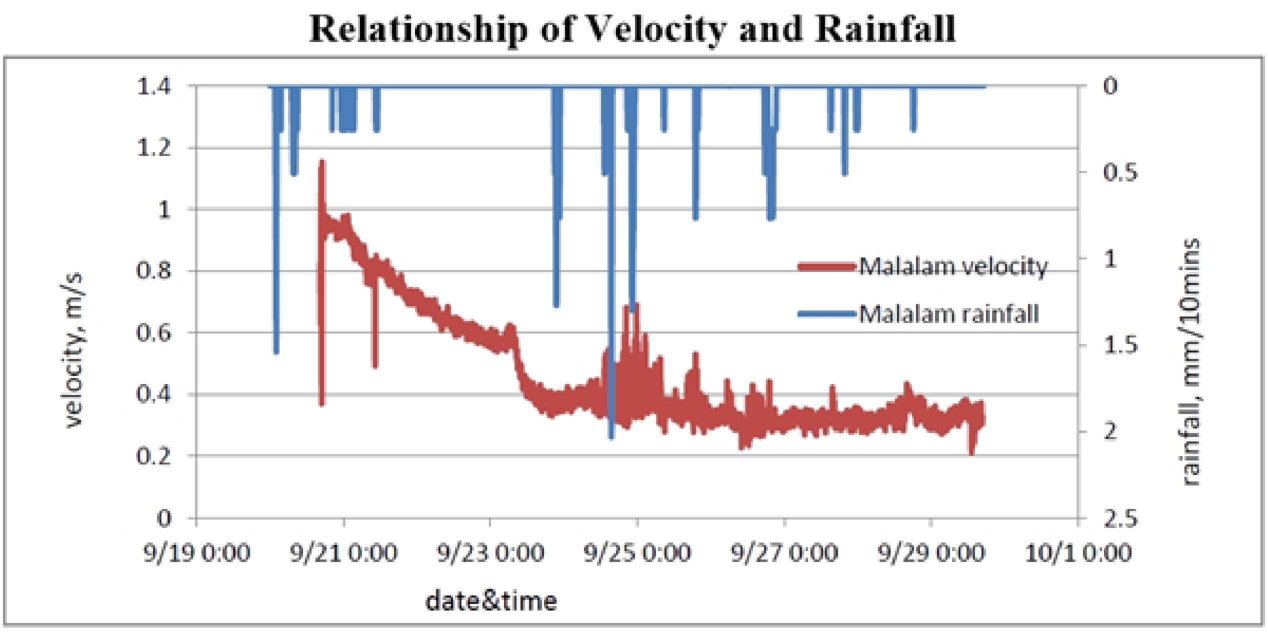


Figure 109. Relationship between velocity and rainfall in Malalam Bridge within the observation period

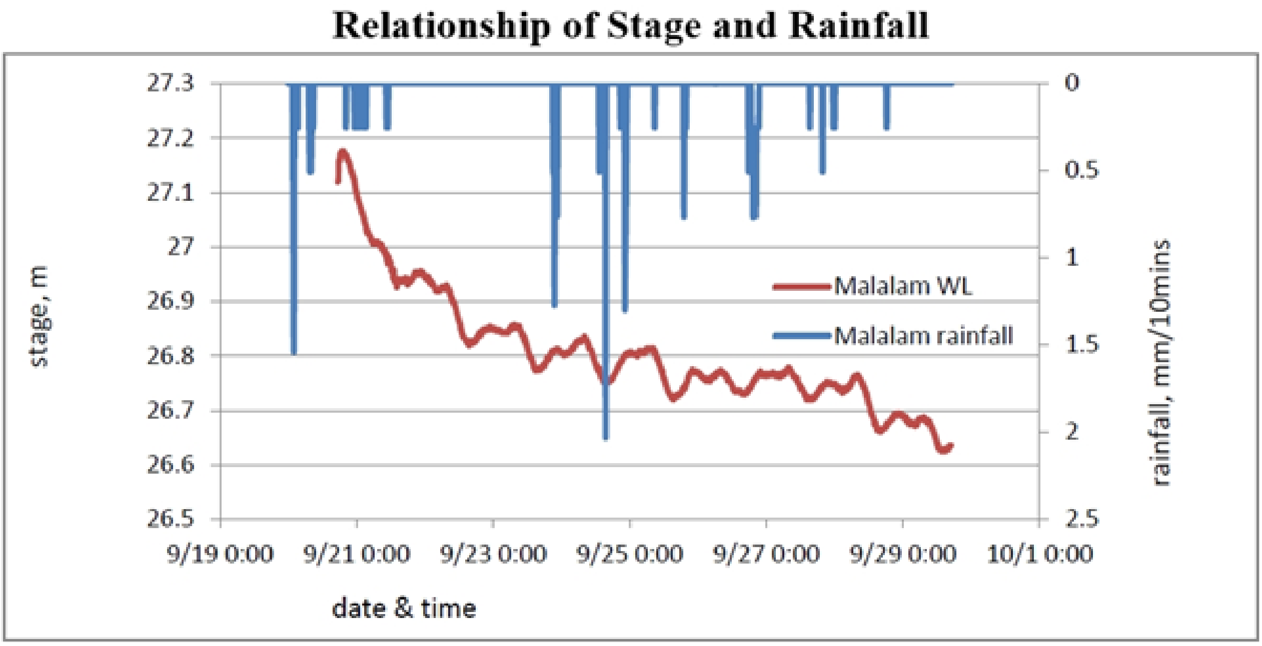


Figure 110. Relationship between stage and rainfall in Malalam Bridge within the observation period

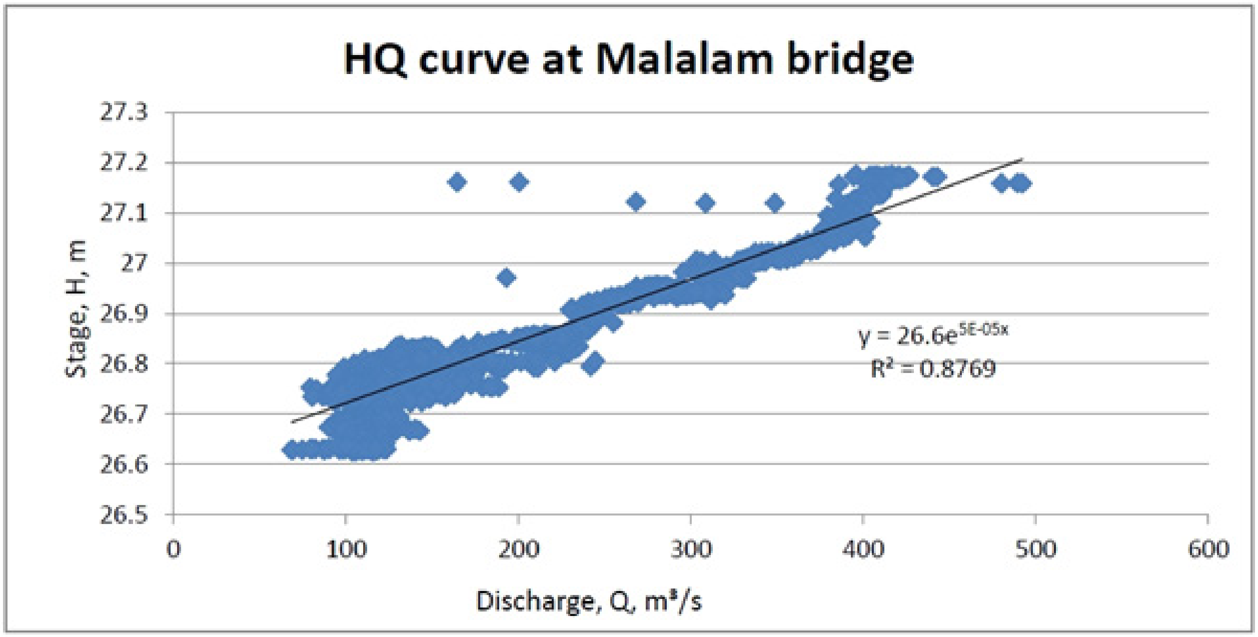


Figure 111. Relationship between stage and discharge in Malalam Bridge within the observation period

Sangbay Bridge – Maddela, Quirino

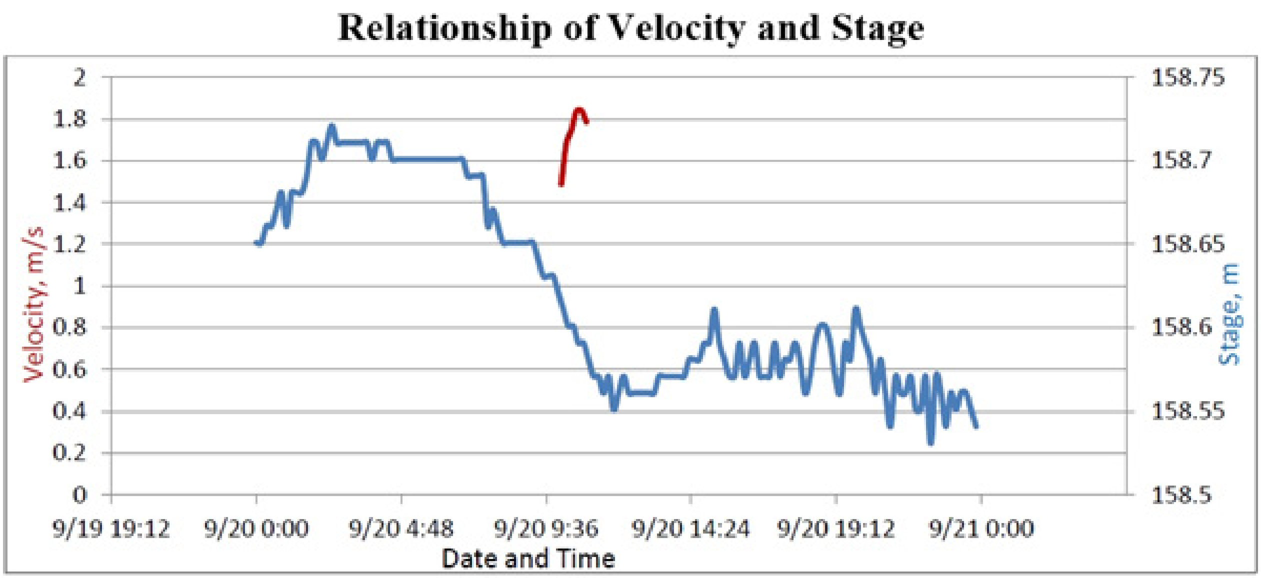


Figure 112. Relationship between velocity and stage in Sangbay Bridge within the observation period

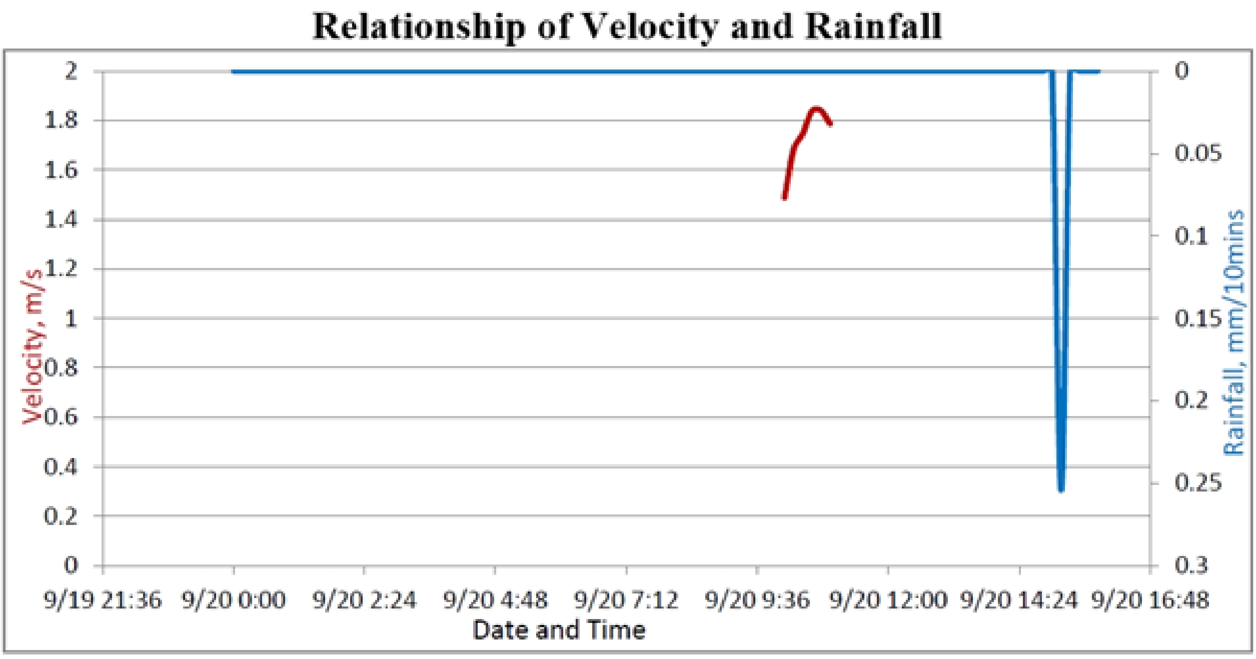


Figure 113. Relationship between velocity and rainfall in Sangbay Bridge within the observation period

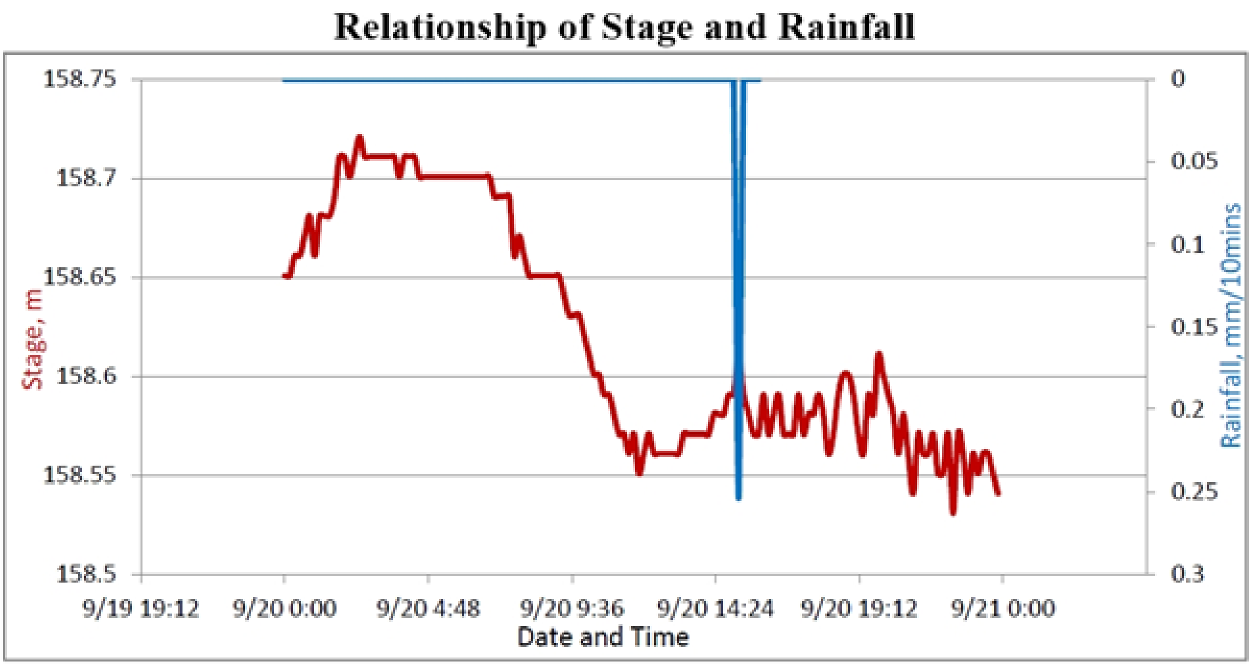


Figure 114. Relationship between stage and rainfall in Sangbay Bridge within the observation period

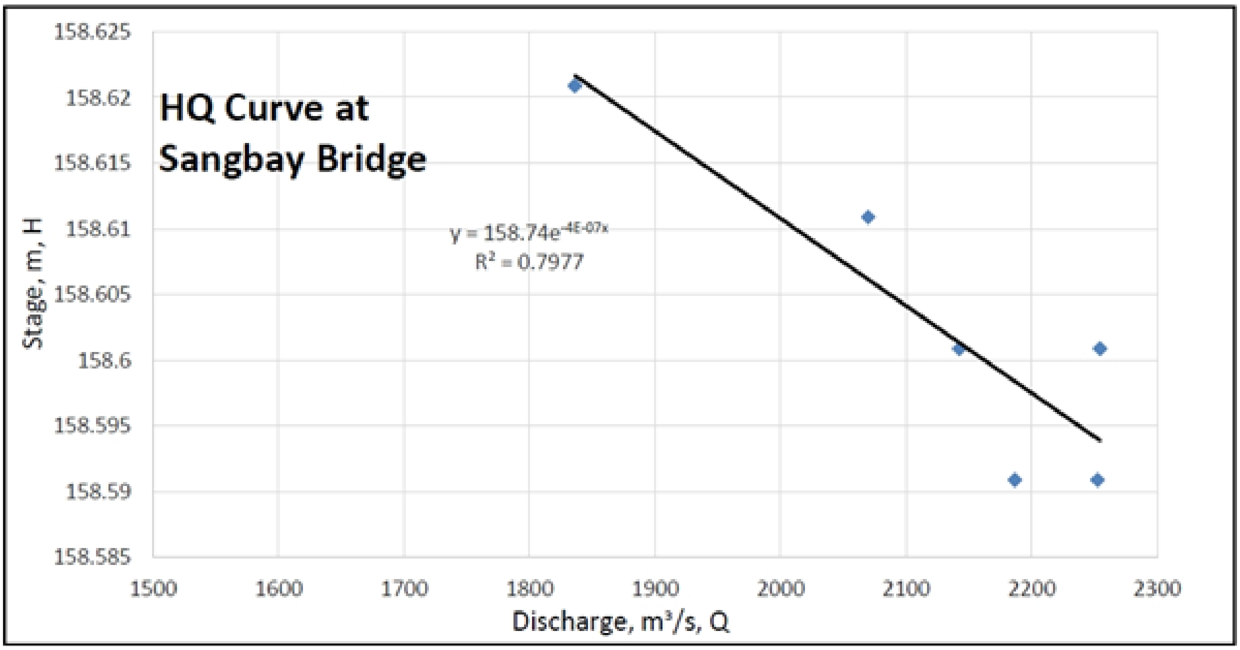


Figure 115. Relationship between stage and discharge in Sangbay Bridge within the observation period

Siffu Bridge – Roxas, Isabela

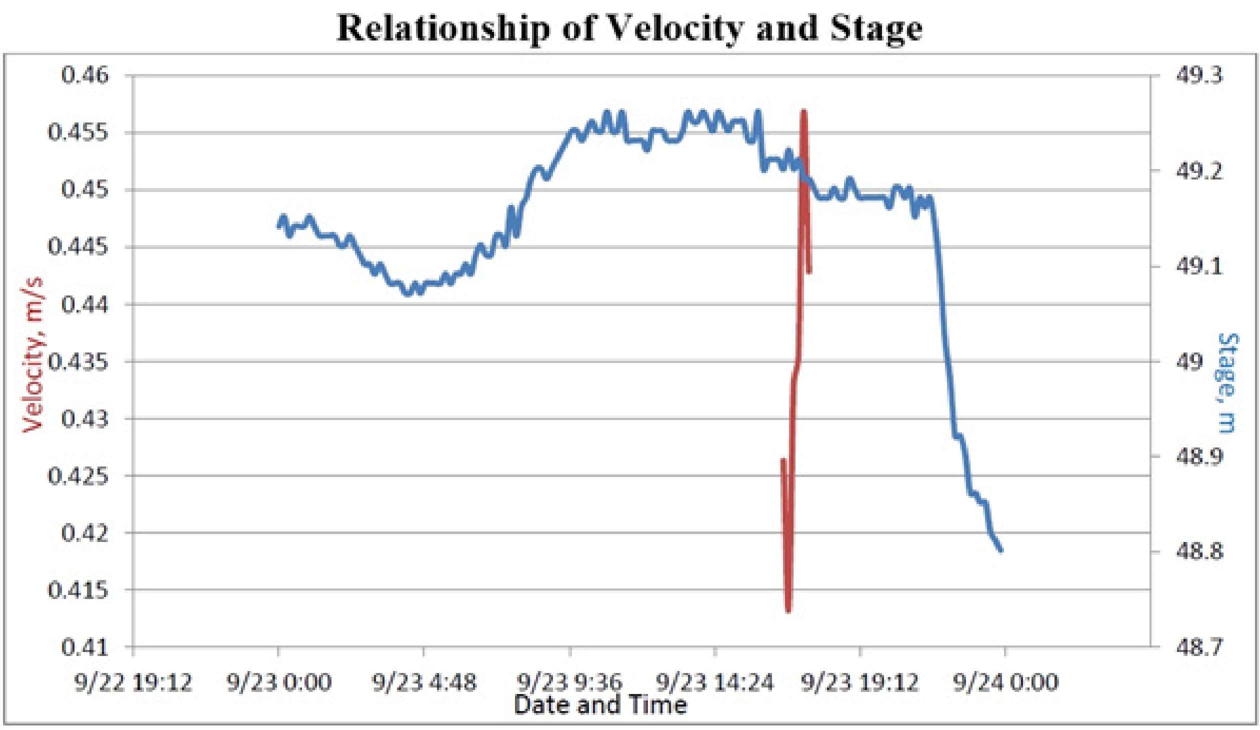


Figure 116. Relationship between velocity and stage in Siffu Bridge within the observation period

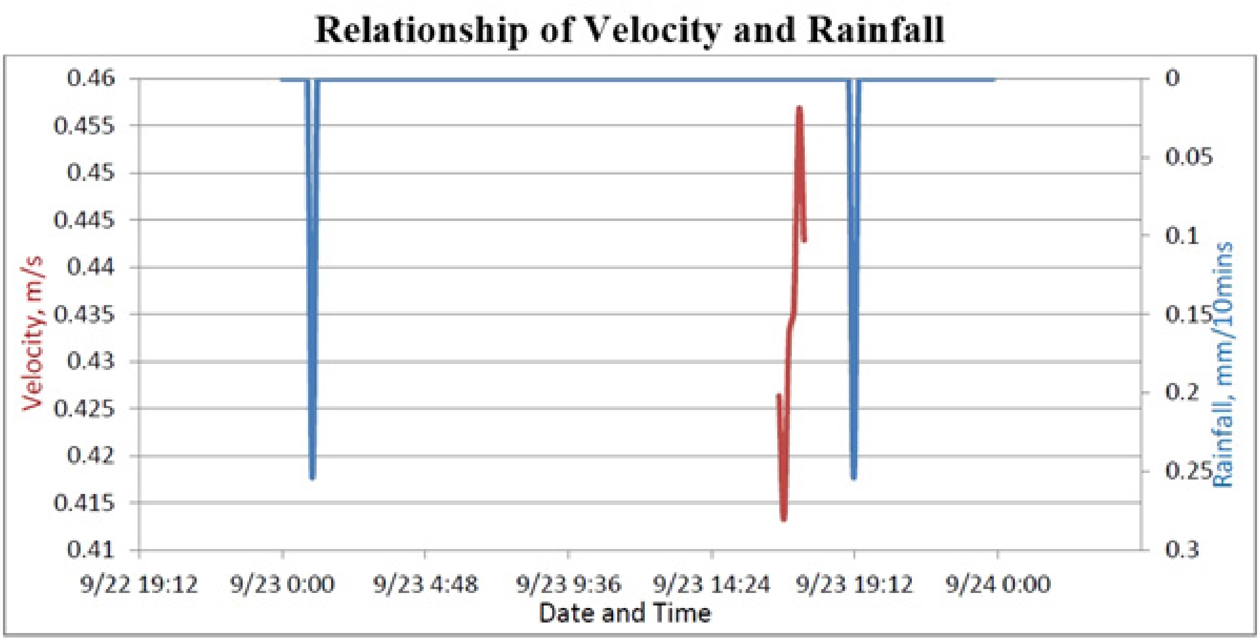


Figure 117. Relationship between velocity and rainfall in Siffu Bridge within the observation period

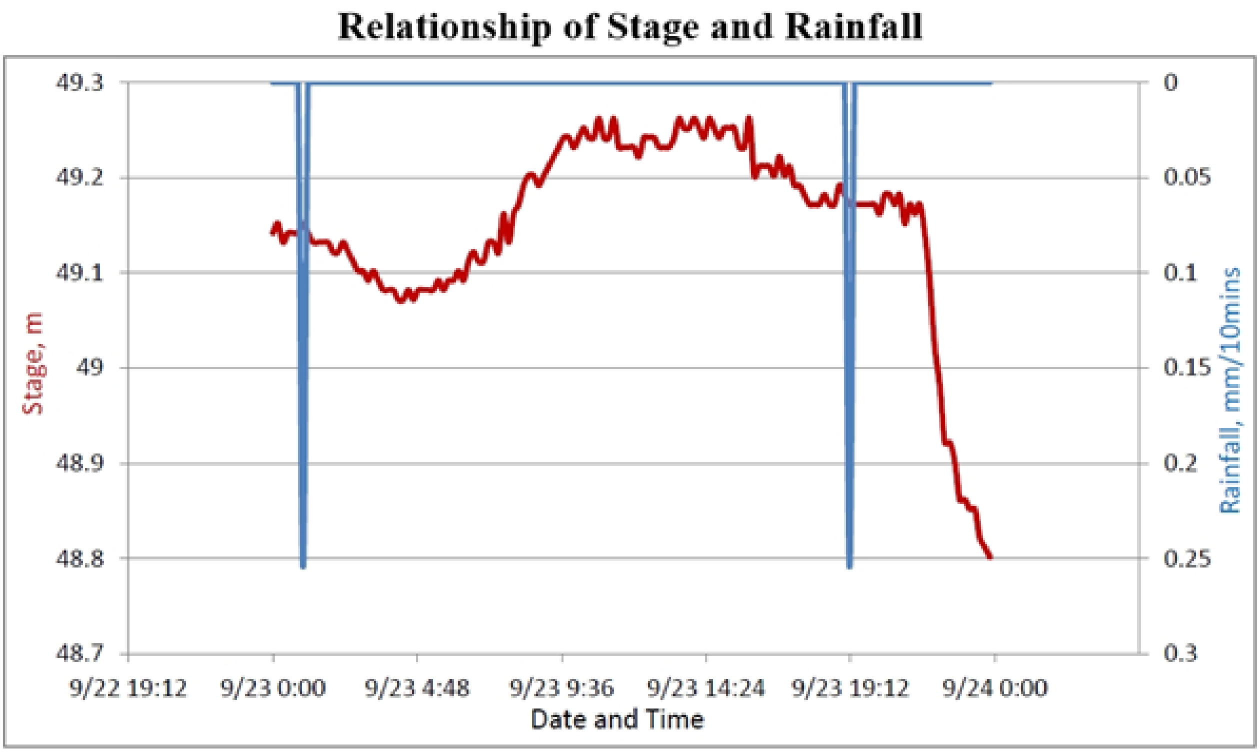


Figure 118. Relationship between stage and rainfall in Siffu Bridge within the observation period

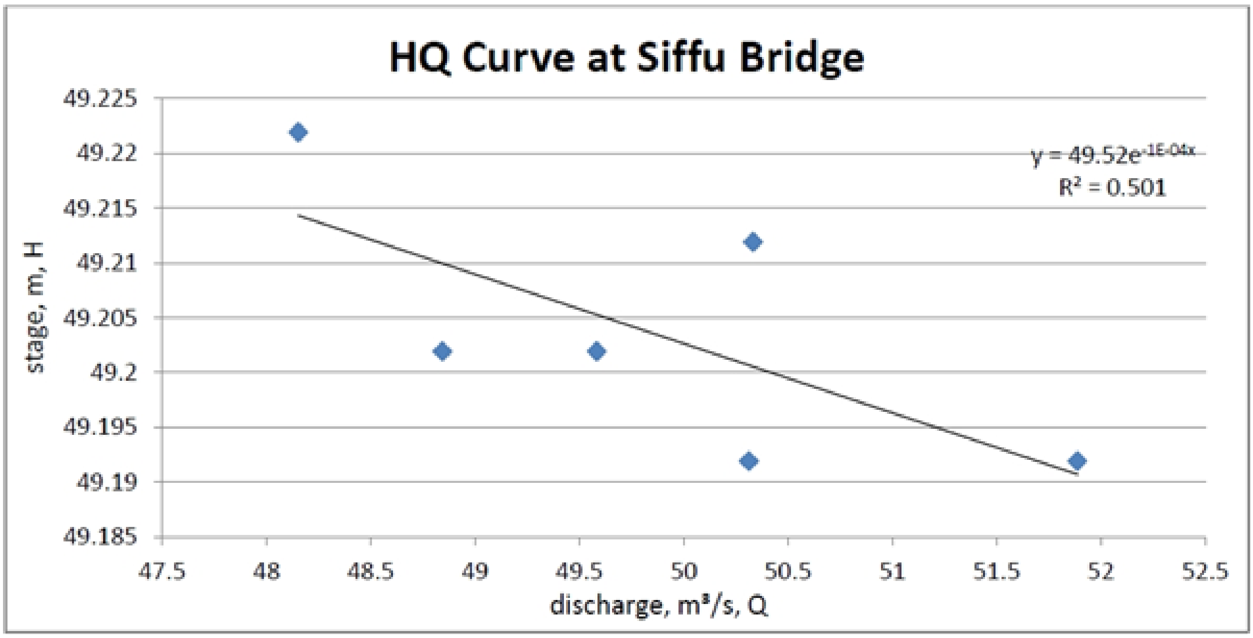


Figure 119. Relationship between stage and discharge in Siffu Bridge within the observation period

Hydrometry data for following bridges, Figure 120-128, were acquired during Cagayan River Survey Phase 1

Buntun Bridge – Tuguegarao City, Cagayan

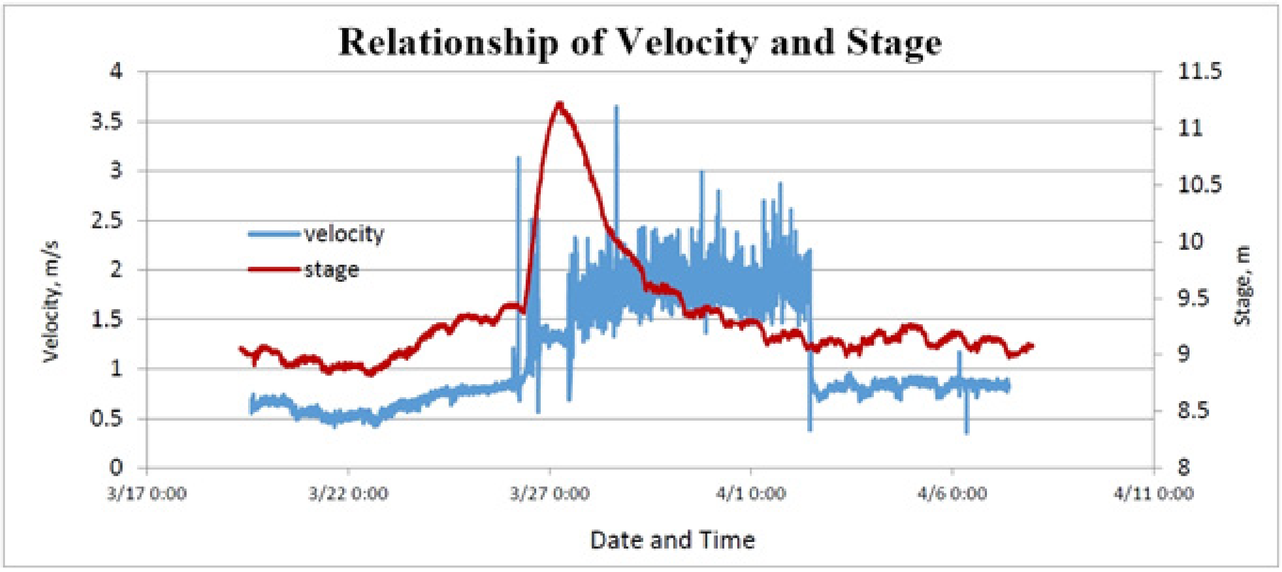


Figure 120. Relationship between velocity and stage in Buntun Bridge within the observation period

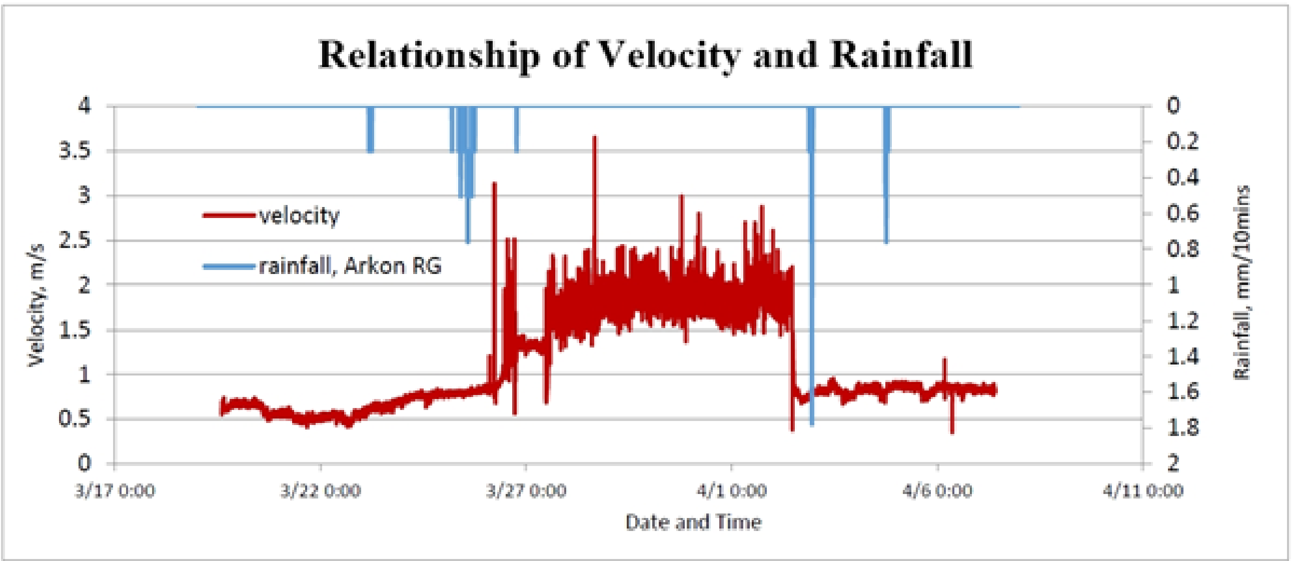


Figure 121. Relationship between velocity and rainfall in Buntun Bridge within the observation period

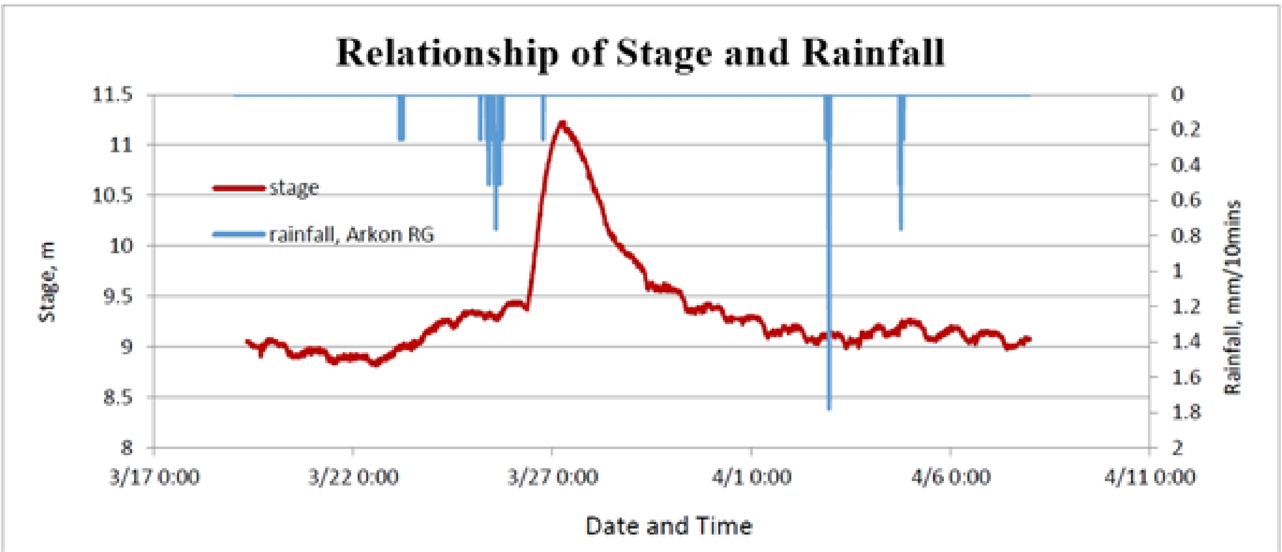


Figure 122. Relationship between stage and rainfall in Buntun Bridge within the observation period

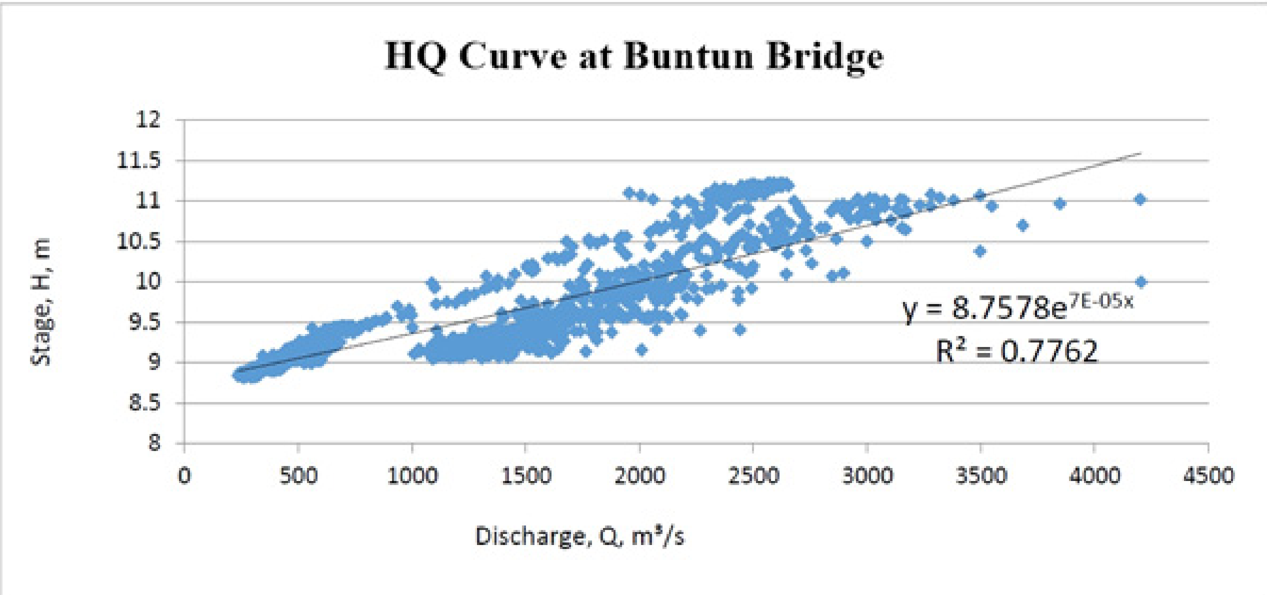


Figure 123. Relationship between stage and discharge in Buntun Bridge within the observation period

Ninoy Aquino Bridge - Tuao, Cagayan

HQ Curve for Ninoy Aquino Bridge was not able to generate because no water level data was read by the sensor by the time of acquisition of river velocity data.

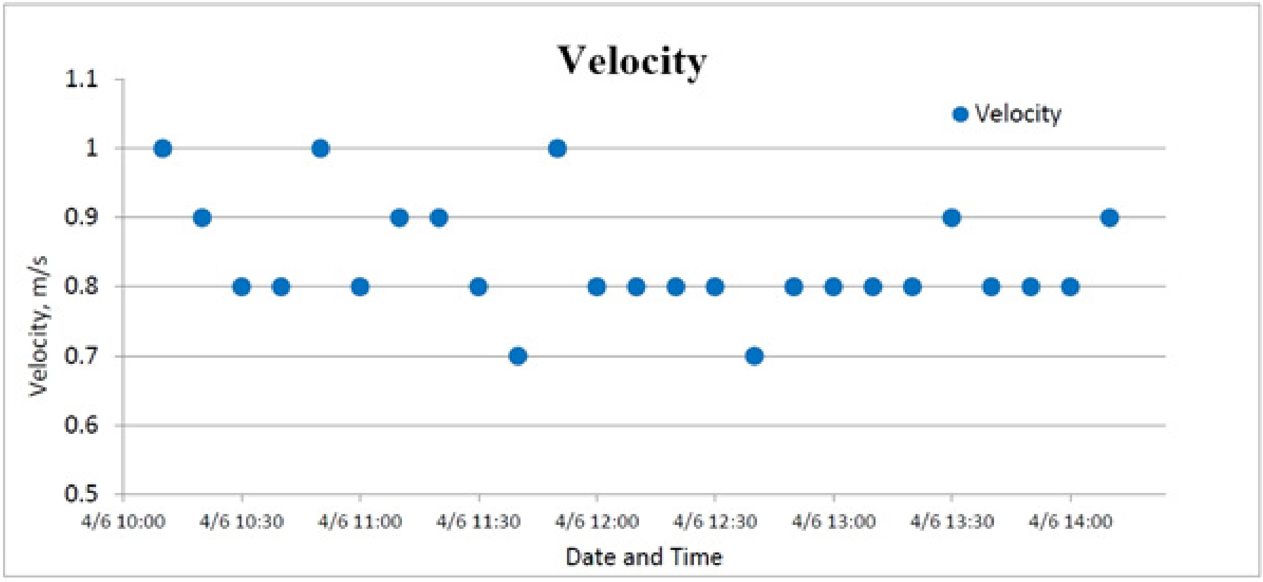


Figure 124. Velocity time series data for Ninoy Aquino Bridge

San Pablo Bridge - San Pablo, Isabela

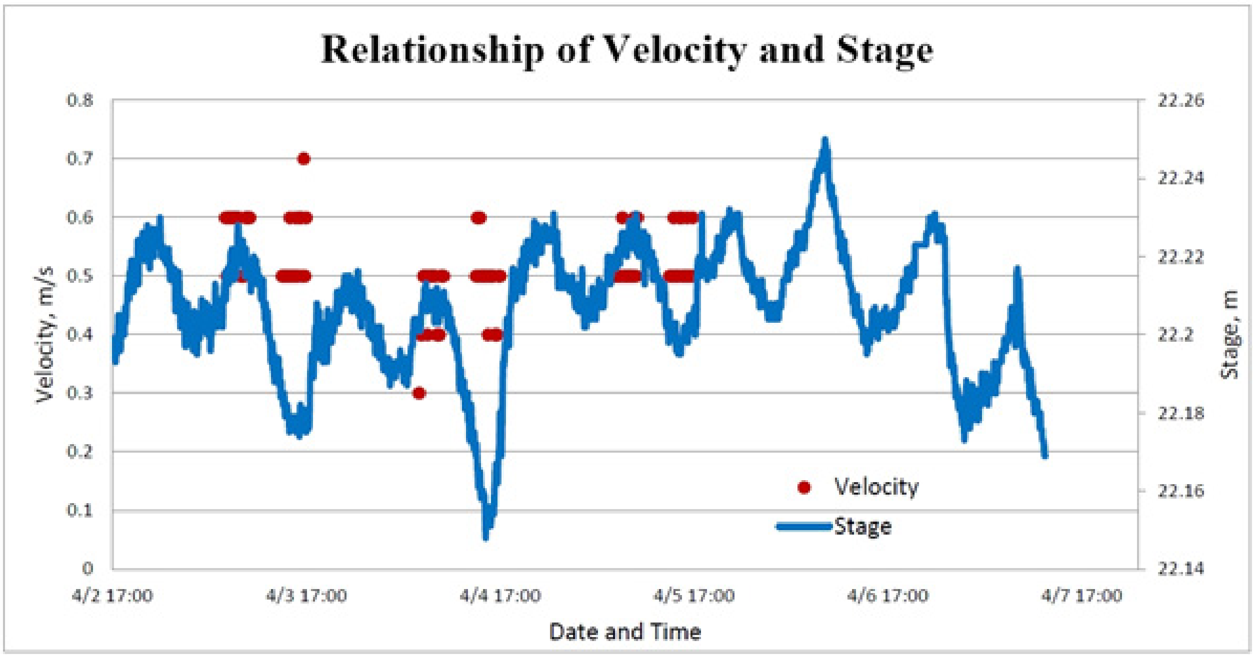


Figure 125. Relationship between velocity and stage in San Pablo Bridge within the observation period

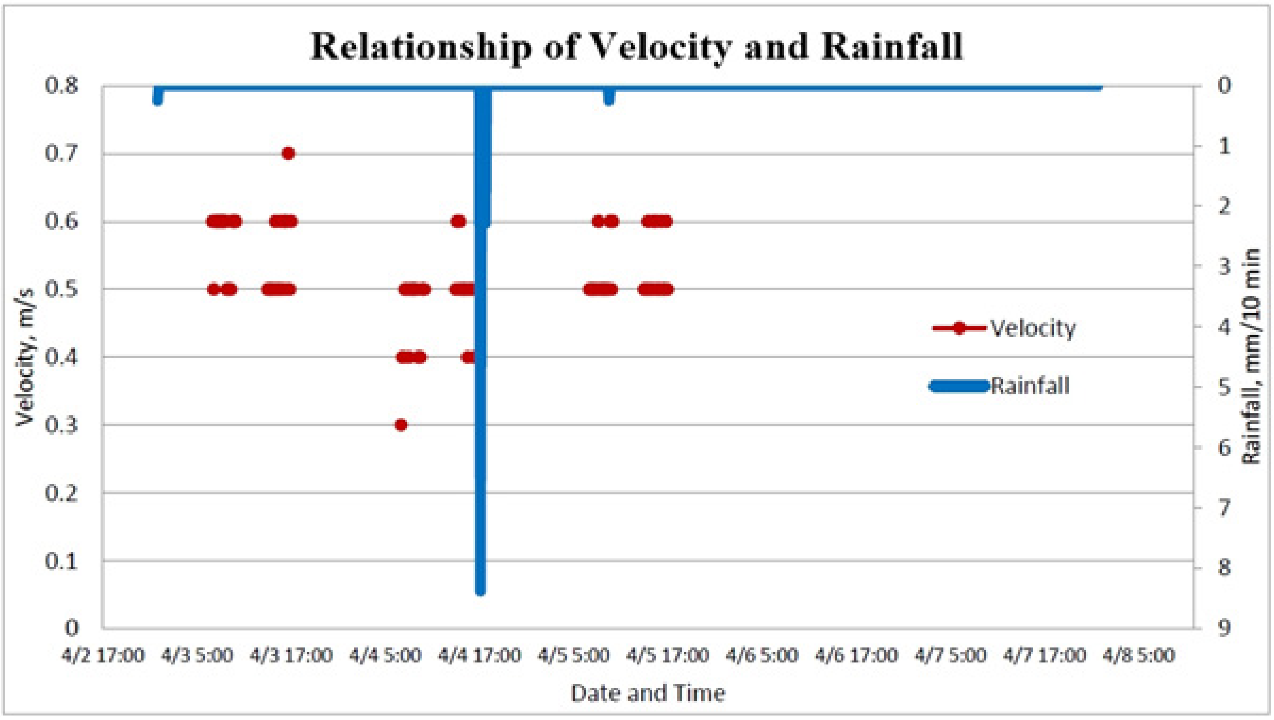


Figure 126. Relationship between velocity and rainfall in San Pablo Bridge within the observation period

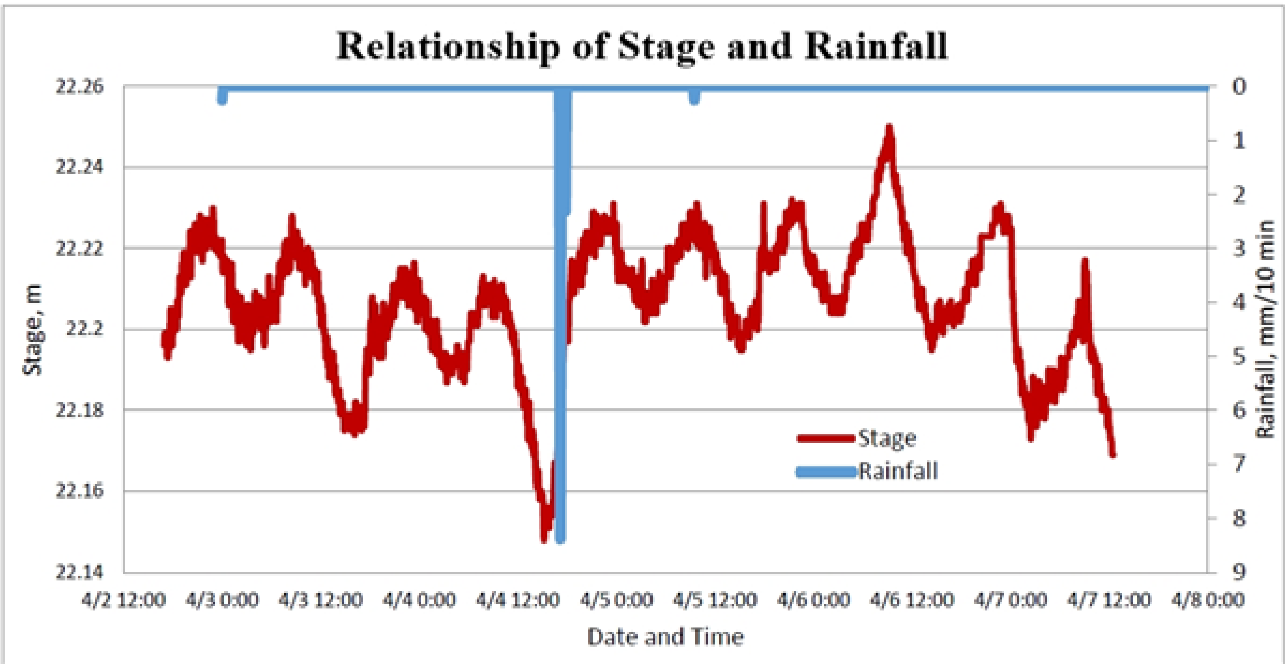


Figure 127. Relationship between stage and rainfall in San Pablo Bridge within the observation period

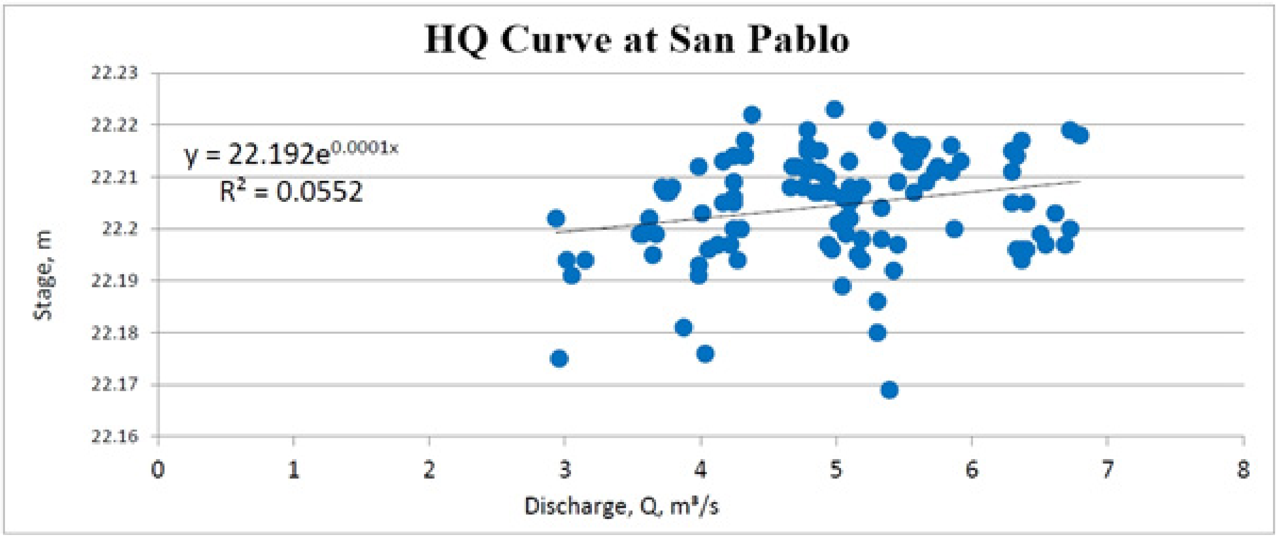


Figure 128. Relationship between stage and discharge in San Pablo Bridge within the observation period

Hydrometry data for following bridges, Figure 129-134, were acquired during Cagayan River Survey Phase 2.

Magat (Aurora) Bridge – Aurora, Isabela

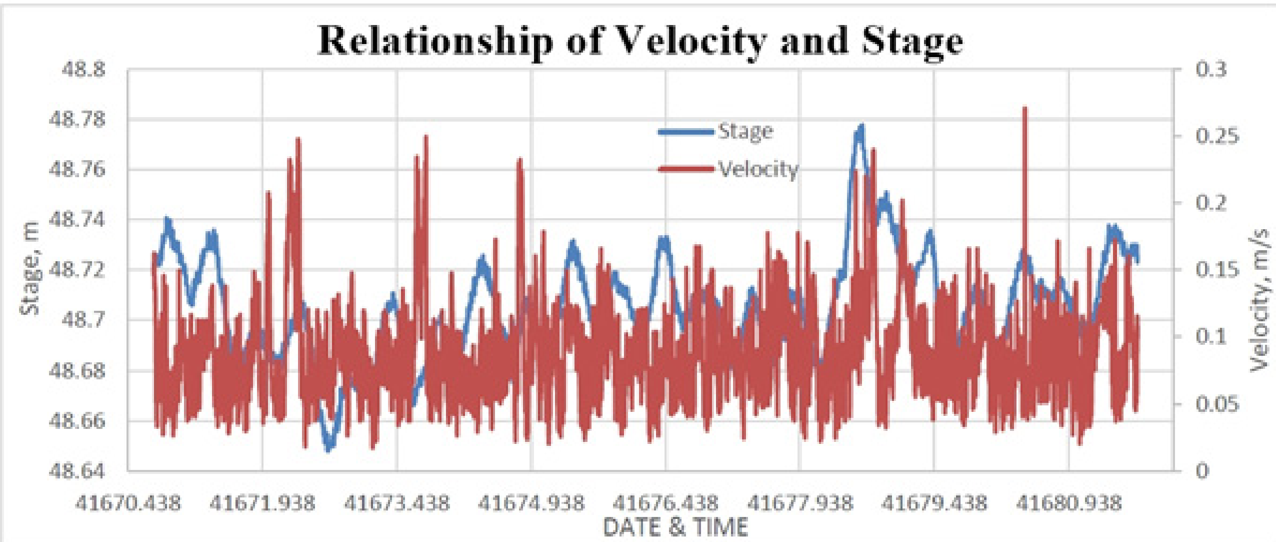


Figure 129. Relationship between velocity and stage in Magat (Aurora) Bridge within the observation period

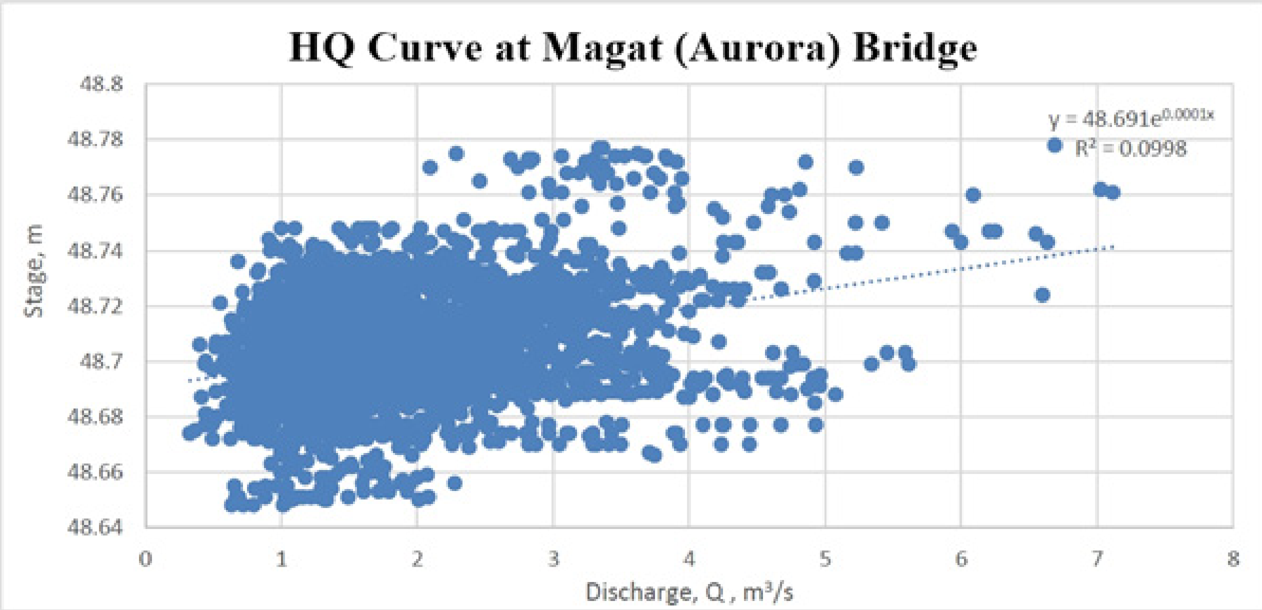


Figure 130. Scatter plot showing the relationship between stage and discharge in Magat (Aurora) Bridge within the observation period

Mallig Bridge – Mallig, Isabela

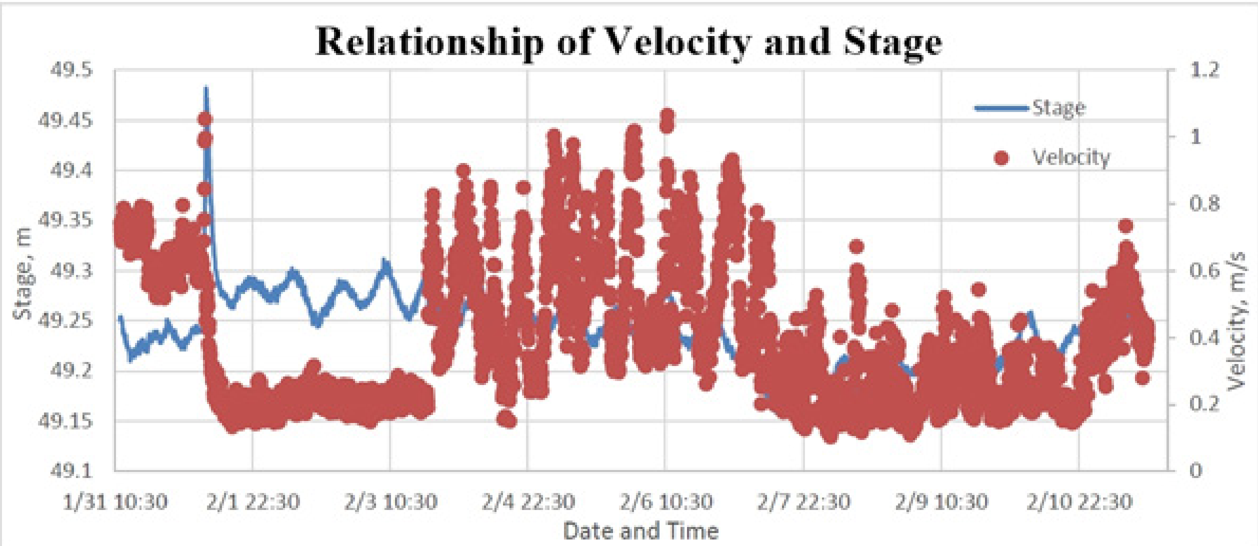


Figure 131. Relationship between velocity and stage in Mallig Bridge within the observation period

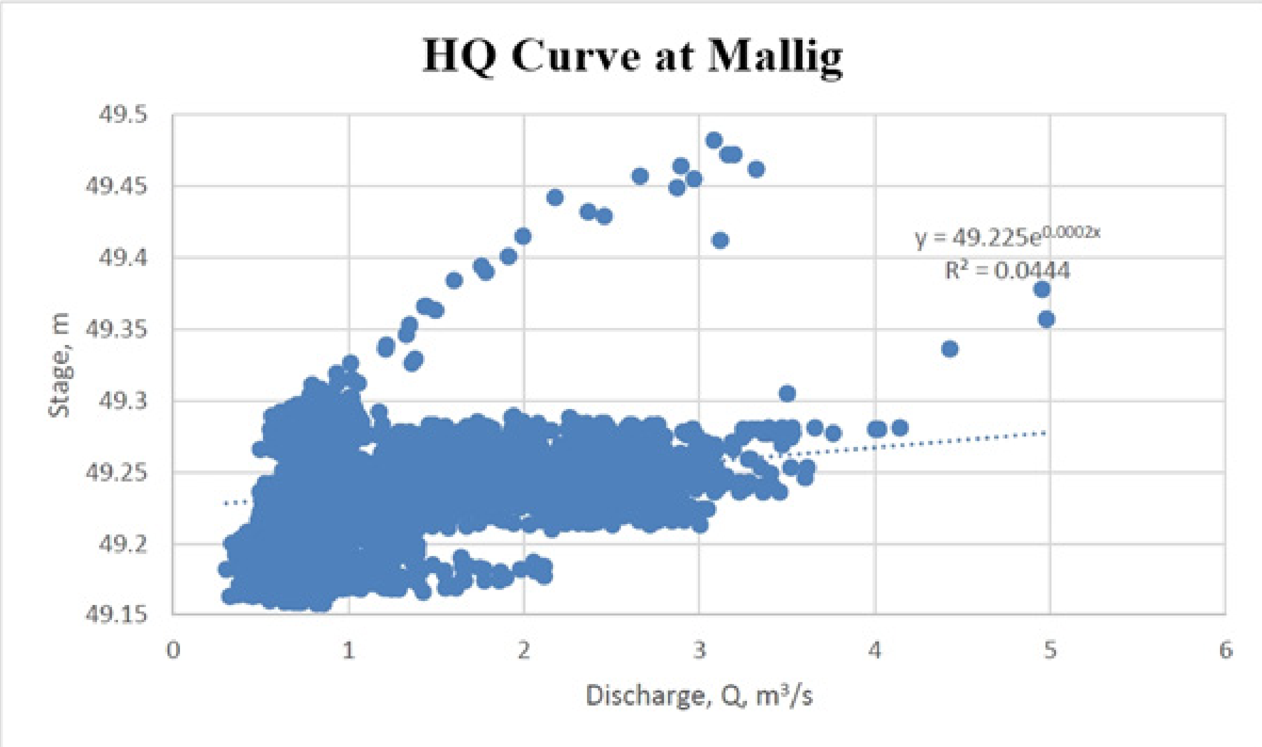


Figure 132. Relationship between stage and discharge in Mallig Bridge within the observation period

Siffu Bridge – Roxas, Isabela

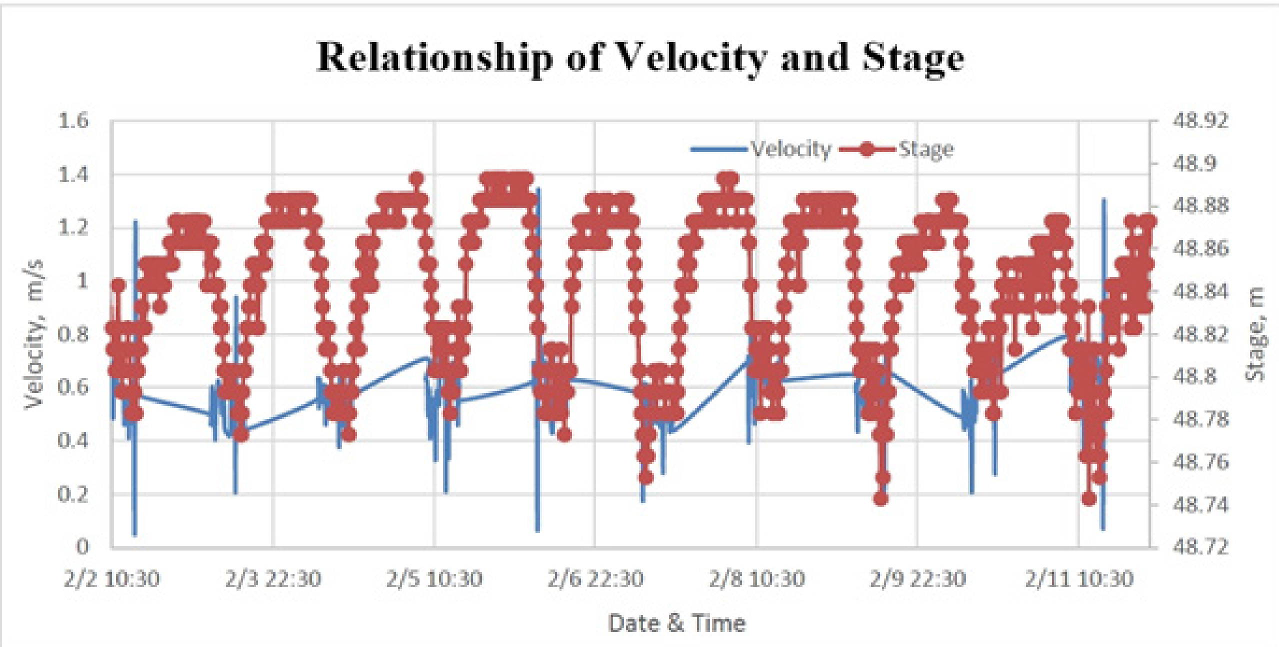


Figure 133. Relationship between velocity and stage in Siffu Bridge within the observation period

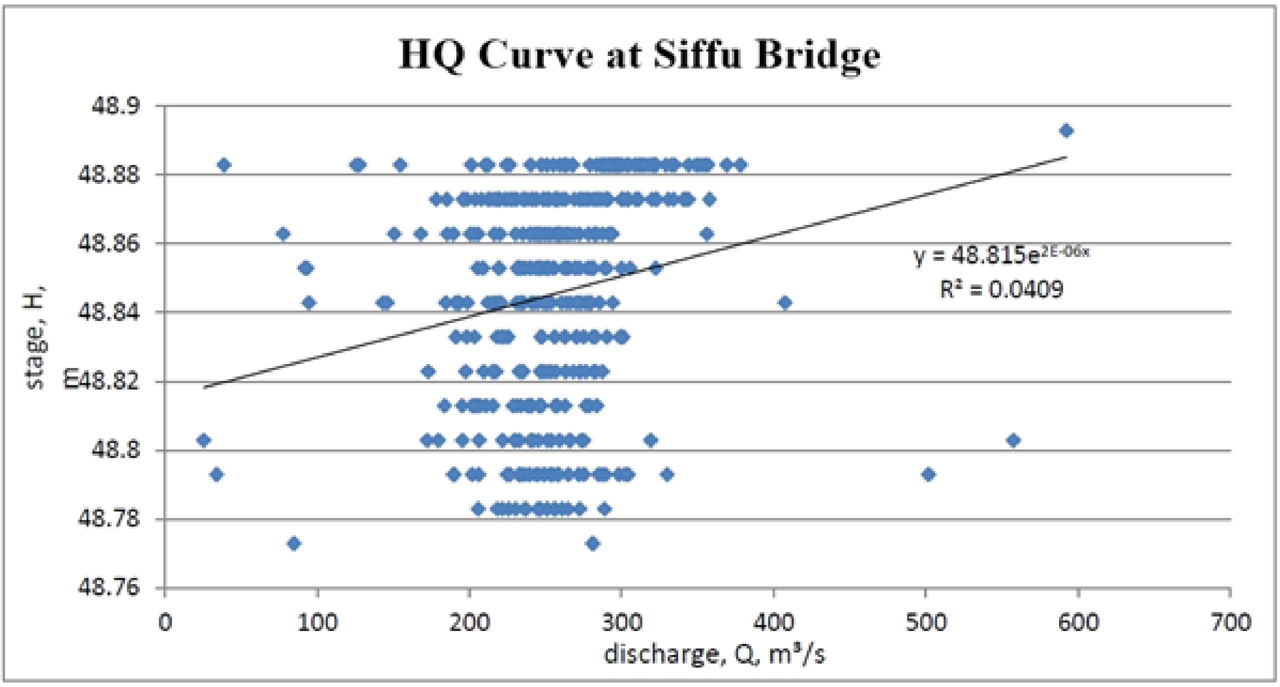


Figure 134. Relationship between stage and discharge in Siffu Bridge within the observation period

Hydrometry data for following bridges, Figure 135-150, were acquired during Cagayan River Survey Phase 3.

Malalam Bridge – Ilagan, Isabela

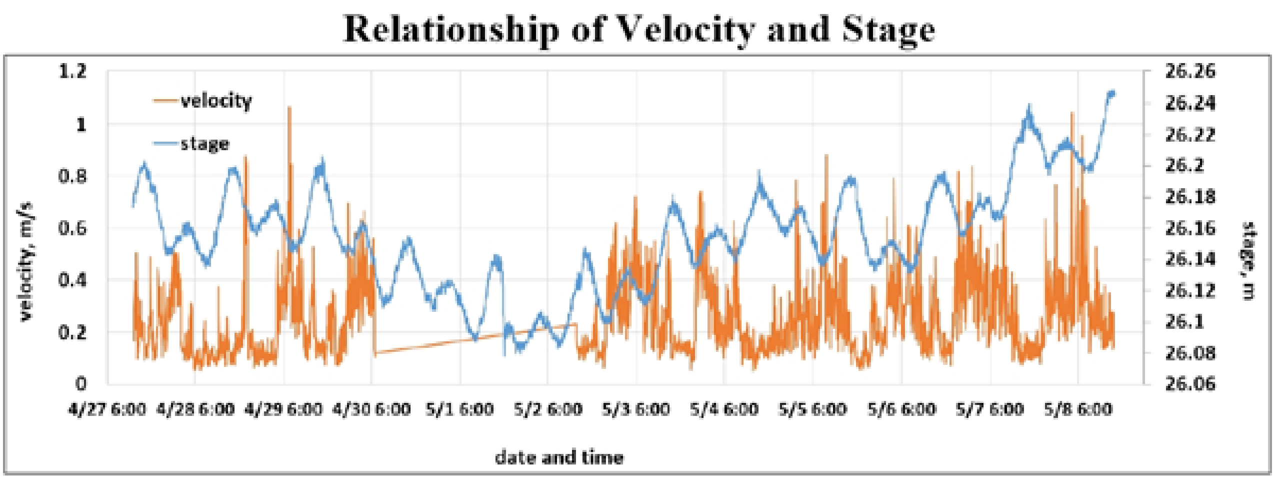


Figure 135. Relationship between velocity and stage in Malalam Bridge within the observation period

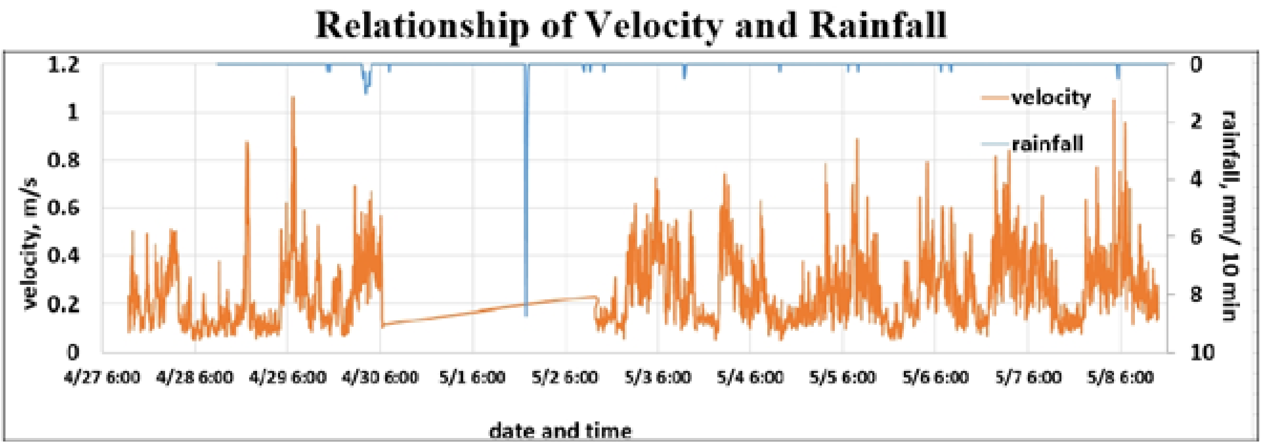


Figure 136. Relationship between velocity and rainfall in Malalam Bridge within the observation period

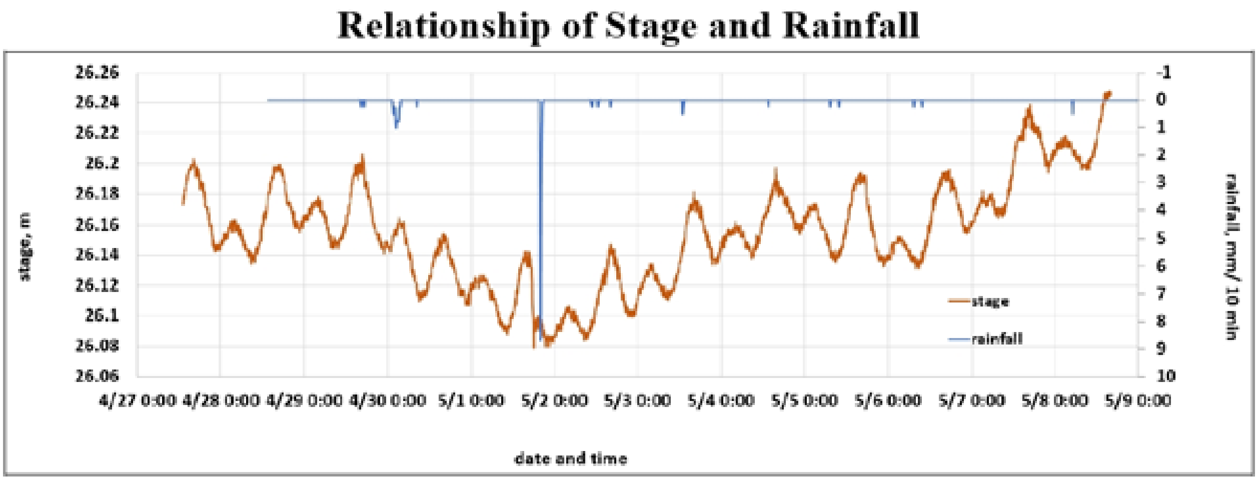


Figure 137. Relationship between stage and rainfall in Malalam Bridge within the observation period

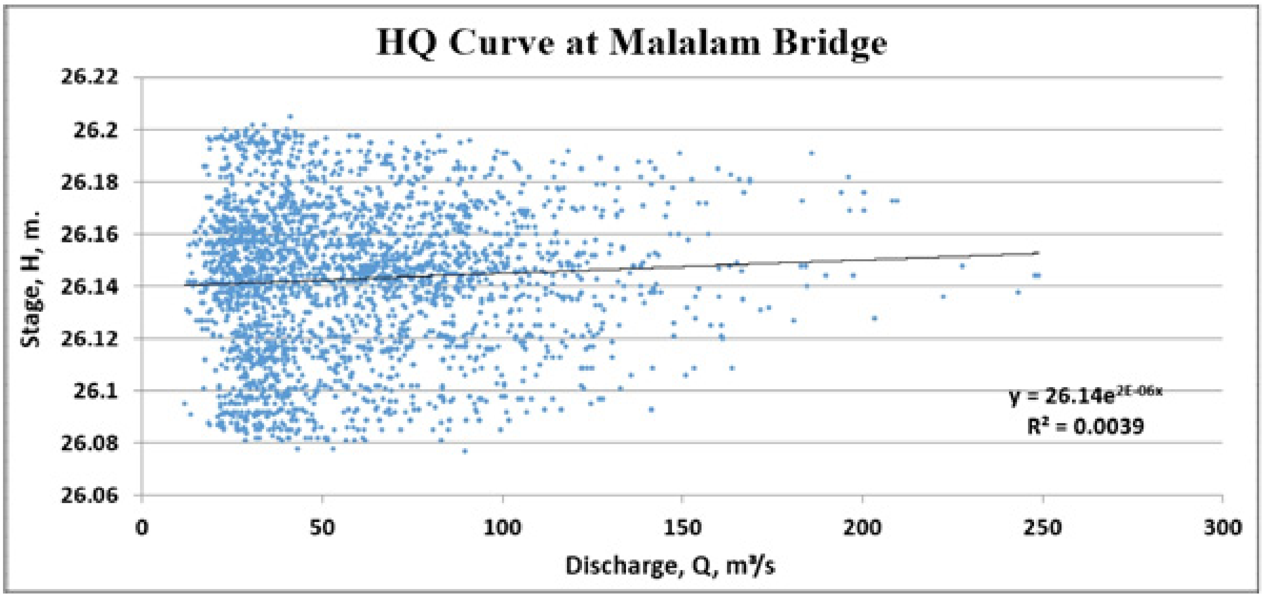


Figure 138. Relationship between stage and discharge in Malalam Bridge within the observation period

Naguilian Bridge – Naguilian, Isabela

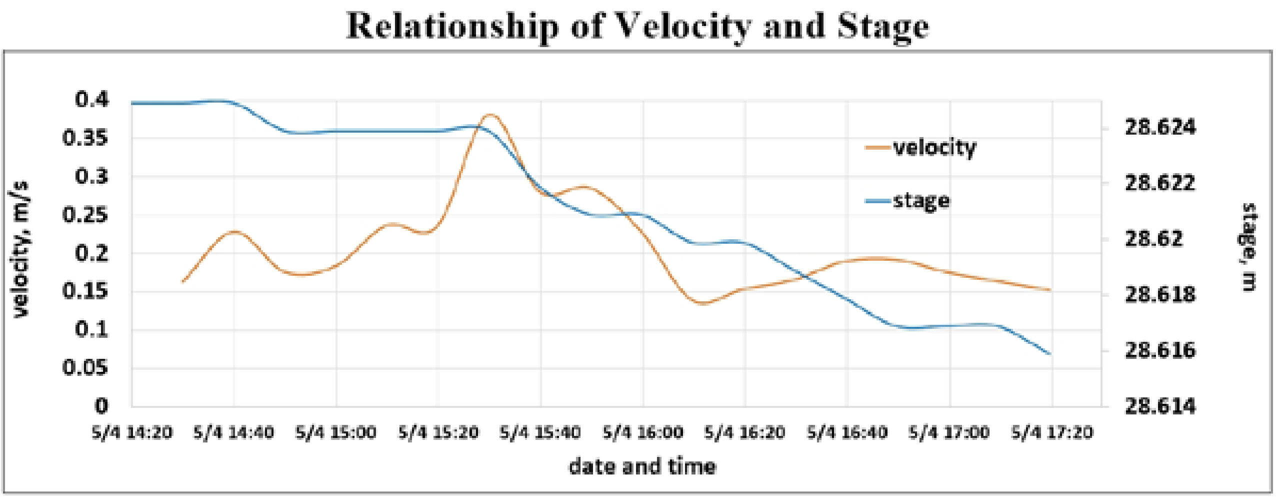


Figure 139. Relationship between velocity and stage in Naguilian Bridge within the observation period

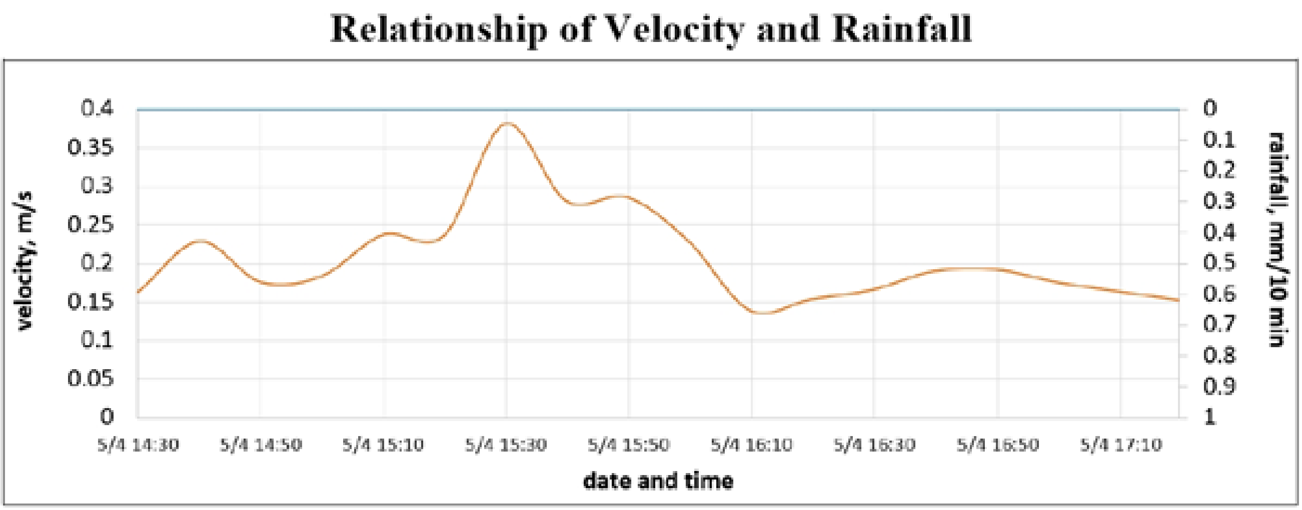


Figure 140. Relationship between velocity and rainfall in Naguilian Bridge within the observation period

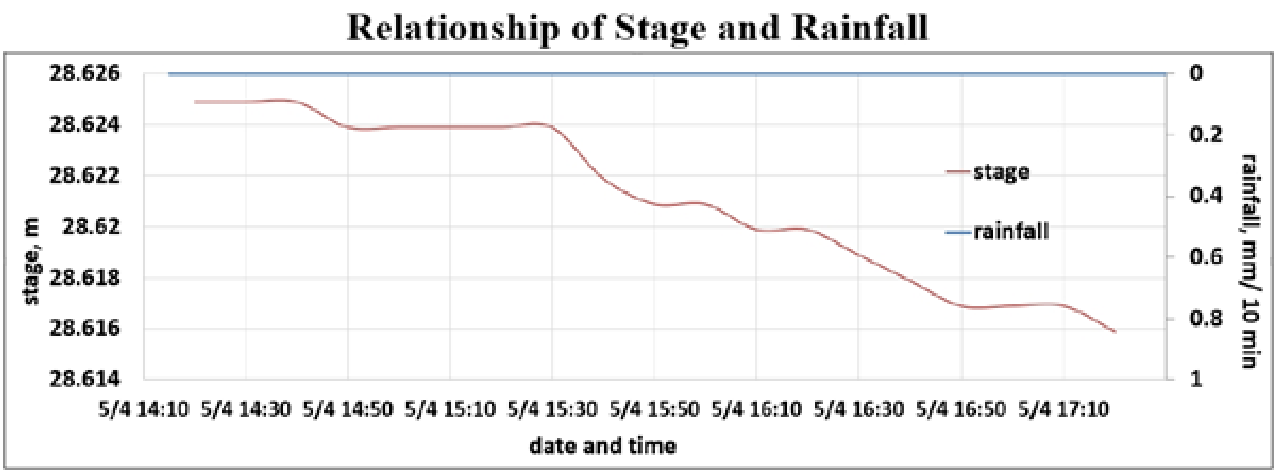


Figure 141. Relationship between stage and rainfall in Naguilian Bridge within the observation period

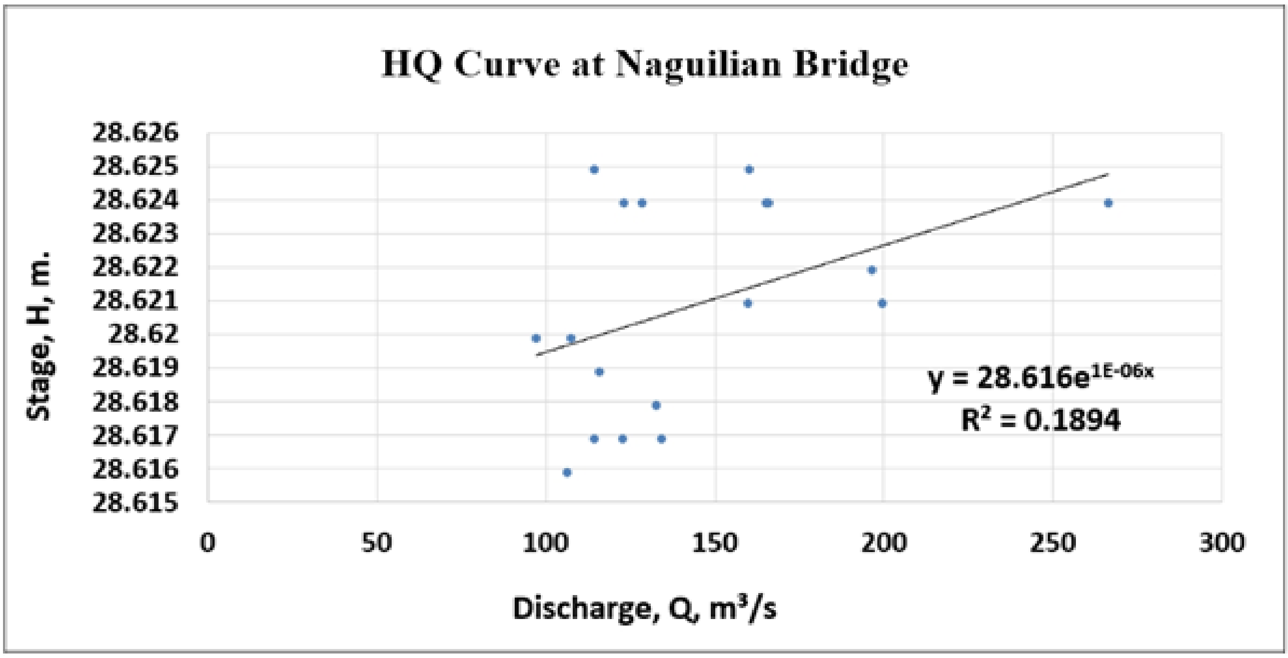


Figure 142. Relationship between stage and discharge in Naguilian Bridge within the observation period

Sangbay Bridge – Maddela, Quirino

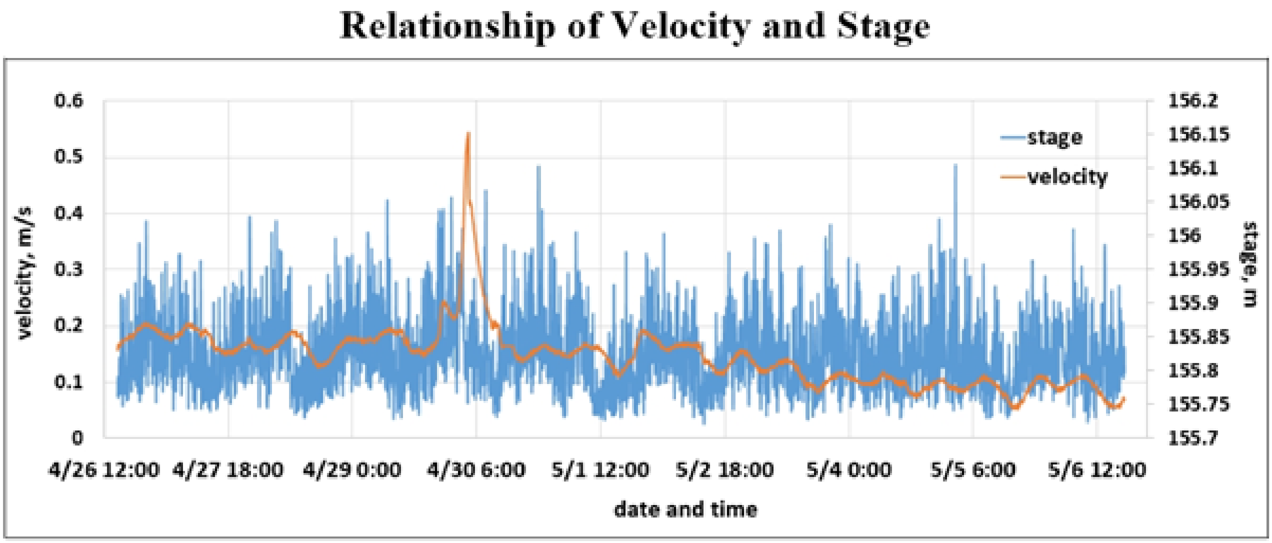


Figure 143. Relationship between velocity and stage in Sangbay Bridge within the observation period

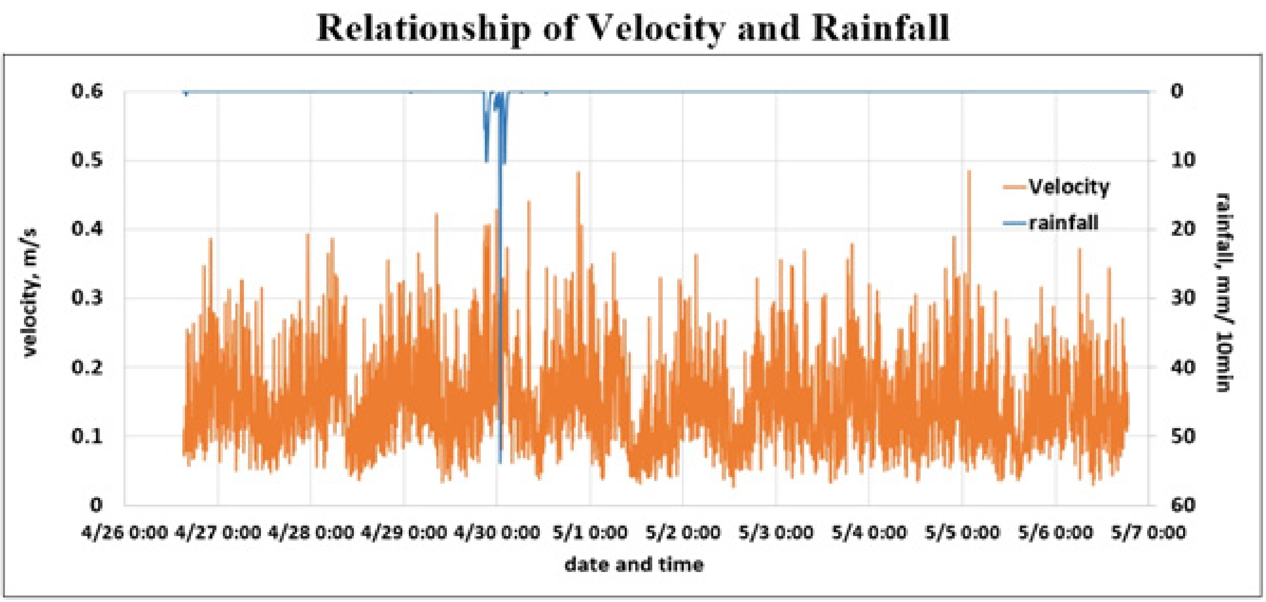


Figure 144. Relationship between velocity and rainfall in Sangbay Bridge within the observation period

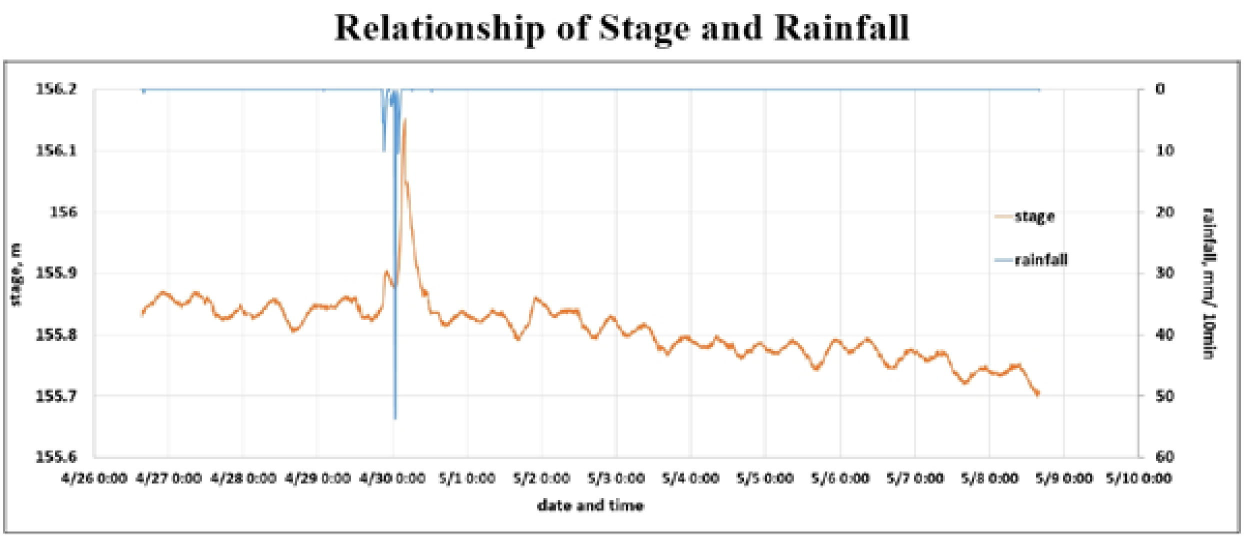


Figure 145. Relationship between stage and rainfall in Sangbay Bridge within the observation period

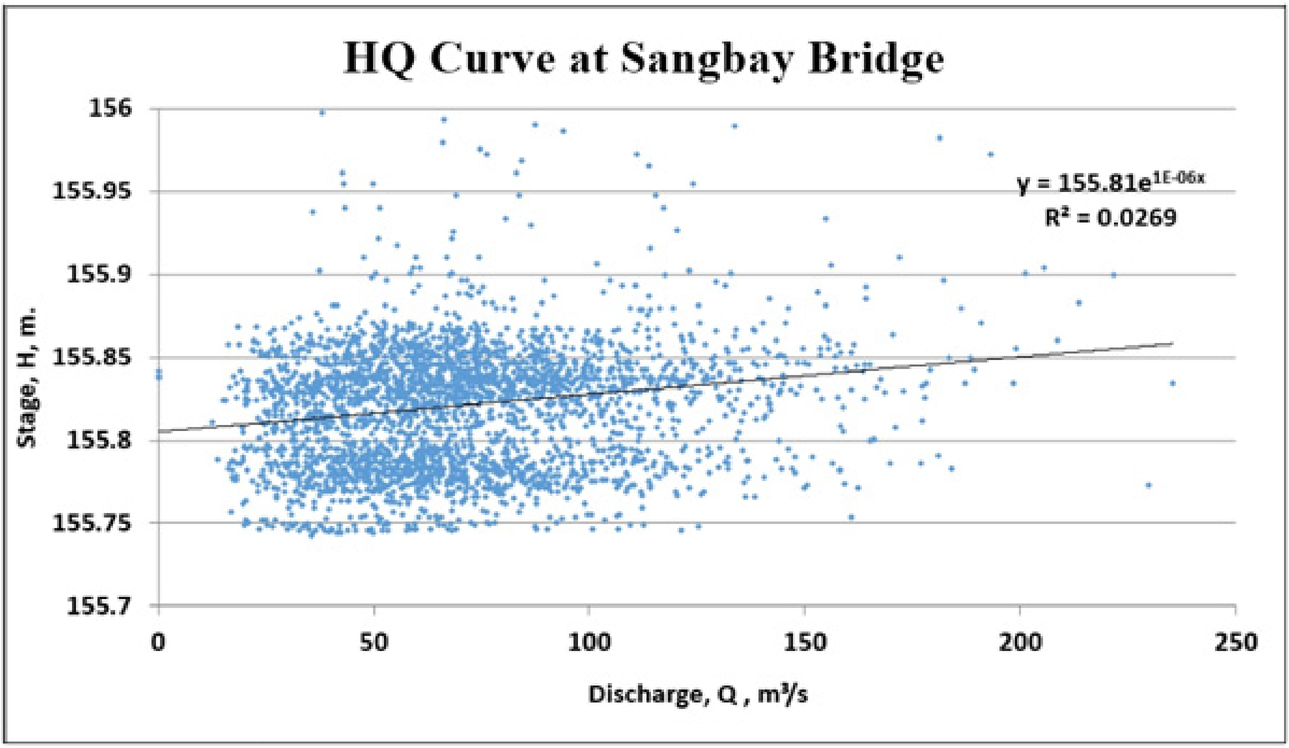


Figure 146. Relationship between stage and discharge in Sangbay Bridge within the observation period

Santiago (Calao) Bridge – Santiago City, Isabela

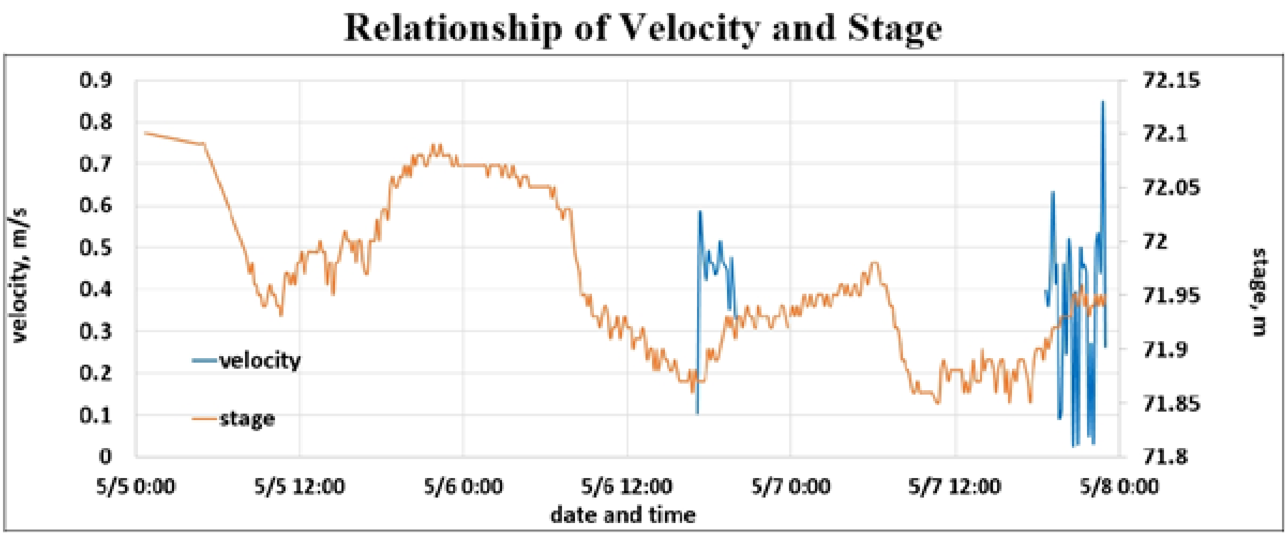


Figure 147. Relationship between velocity and stage in Santiago (Calao) Bridge within the observation period

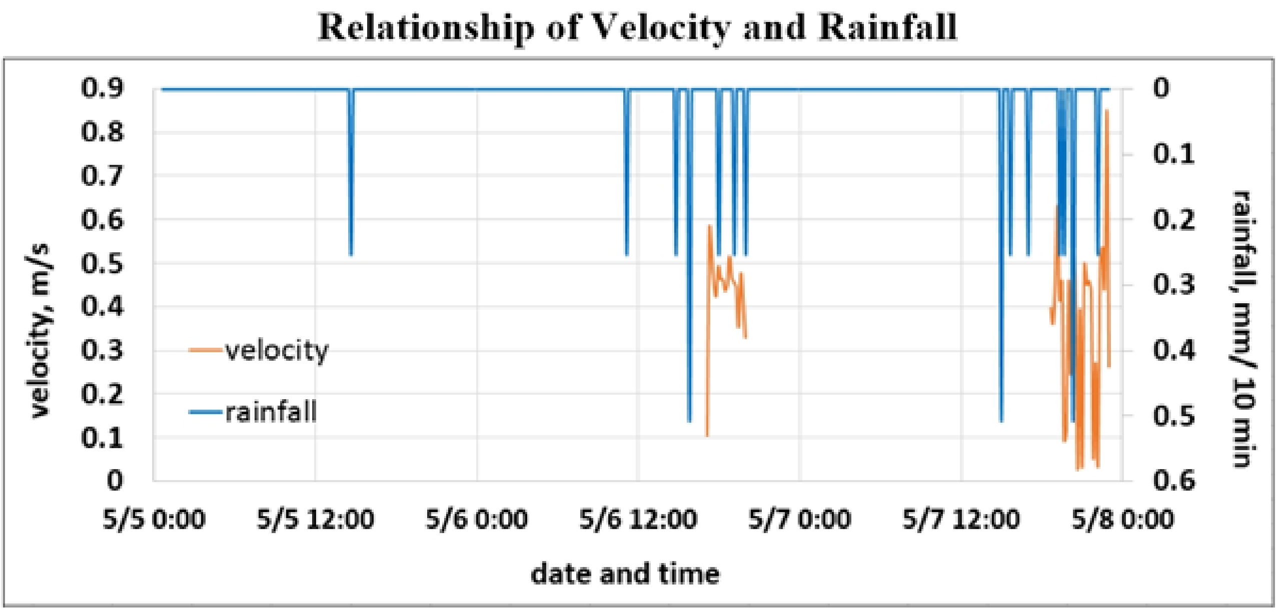


Figure 148. Relationship between velocity and rainfall in Santiago (Calao) Bridge within the observation period

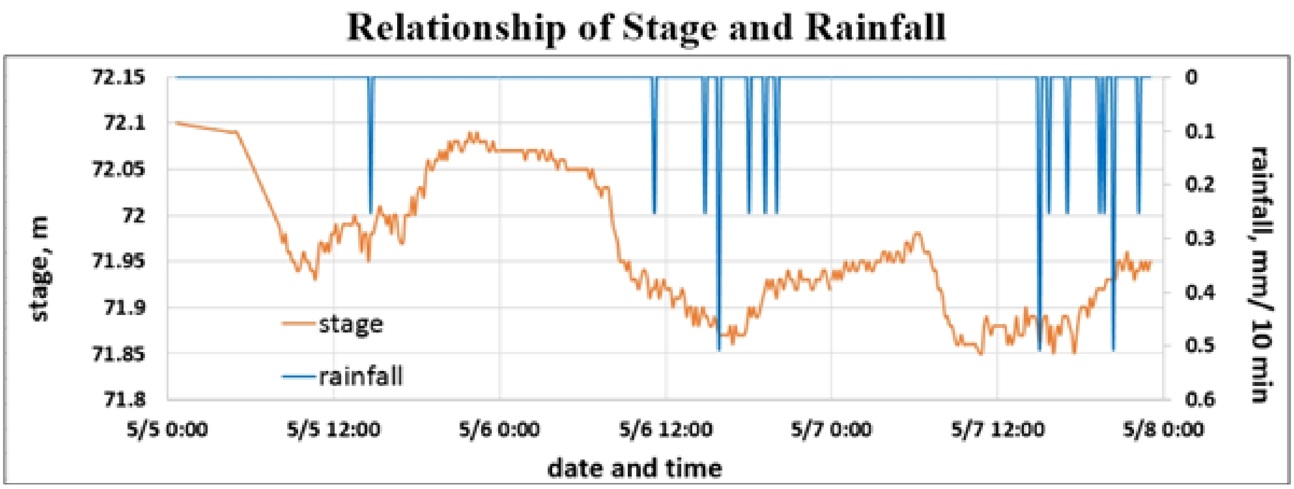


Figure 149. Relationship between stage and rainfall in Santiago (Calao) Bridge within the observation period

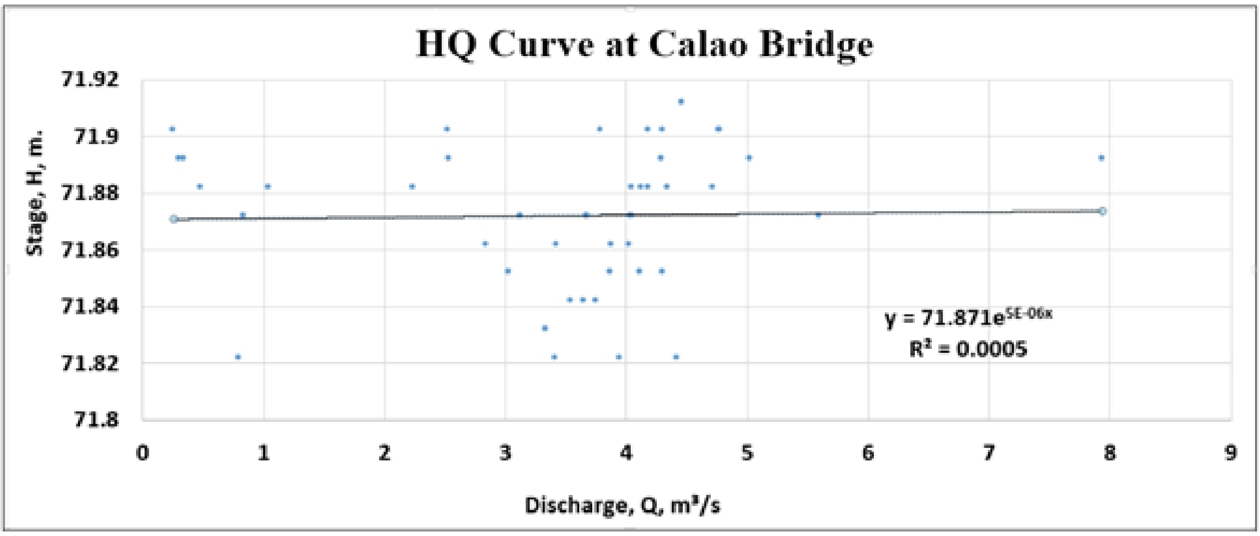


Figure 150. Relationship between stage and discharge in Santiago (Calao) Bridge within the observation period

4.5 Validation Points Acquisition Survey

Ground Validation Survey was done for quality checking purpose of the Aerial LiDAR Survey done by DAC of the DREAM Program. In this survey, a roving GNSS receiver, Trimble™ SPS882, was mounted on a range pole attached to a vehicle to measure points utilizing Continuous Topo Method in a PPK Survey Technique. The GPS was set in continuous topo mode with a 1-second interval and observing a vehicle speed of 10 – 15 kph. Points were measured along major roads and highways across the flight plans provided by DAC. The road or ground should be concrete so that it has occurred relatively minimal amount of change especially in vertical positions. The offset for the instrument height was recorded in the Trimble® TSC3 GNSS controller. Data were processed using Trimble® Business Center Software. The figures below show the ground validation done for each Cagayan River Survey.

The first phase of ground validation was conducted on March 17-April 6, 2014 with a length of 153 km traversing the provinces of Cagayan down to Isabela. The second phase was on January 29 - February 12, 2014 covering 67 km from Roxas to Gamu and from Delfin Albano to San Mariano in Isabela. The last phase was on April 28 - May 8, 2014 completing 103 km of ground validation from Cordon, Isabela to Maddela, Quirno and Jones, Isabela to Nagtipunan, Quirino. Extent of the entire ground validation survey is exhibited in Figure 151.

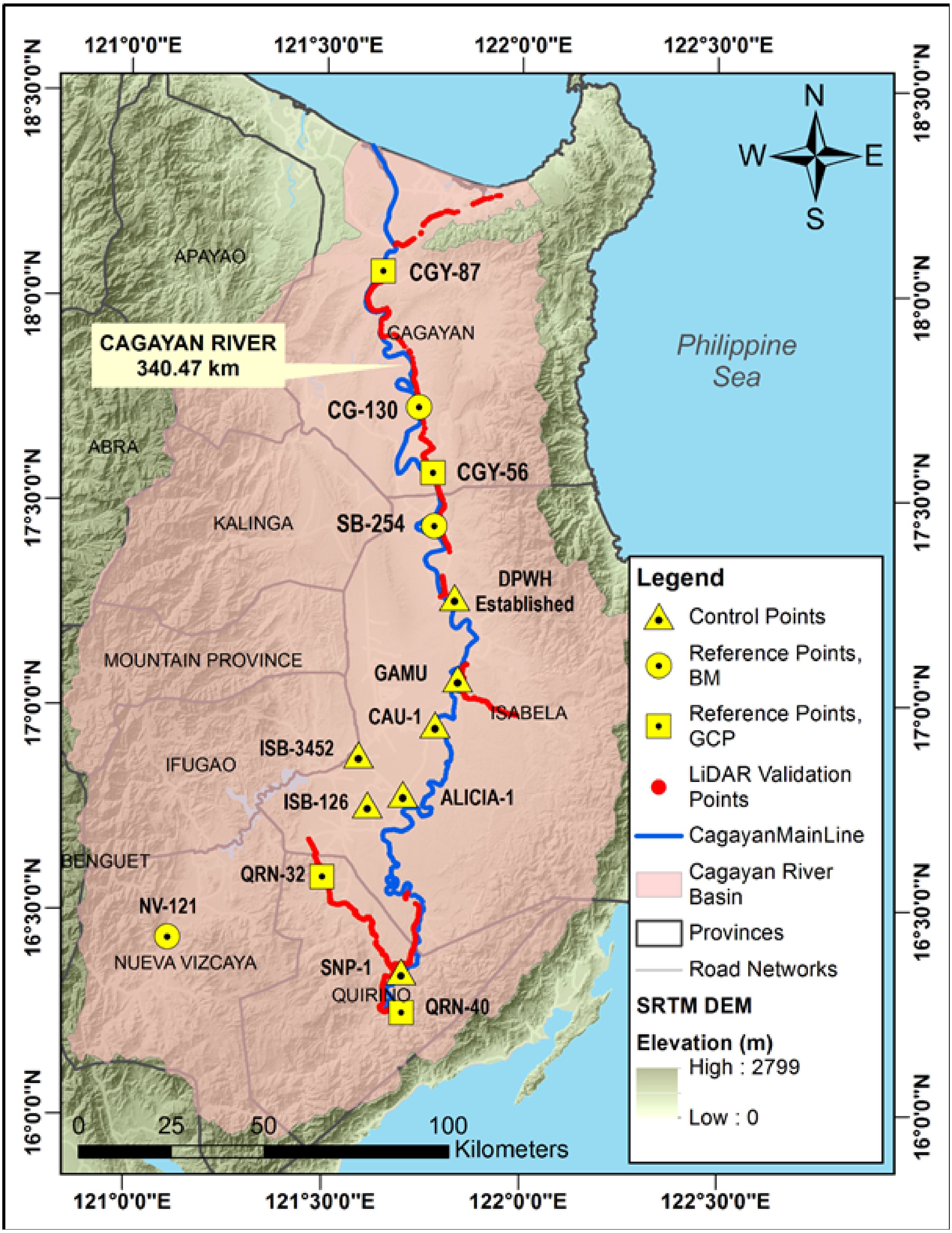


Figure 151. Validation points acquisition survey extent in Cagayan River Basin

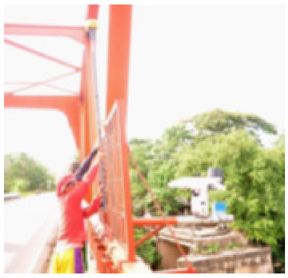
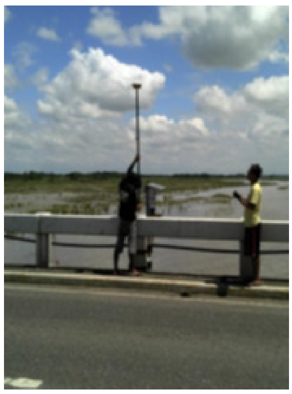
Annexes

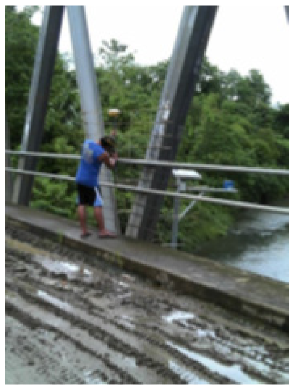
Annexes

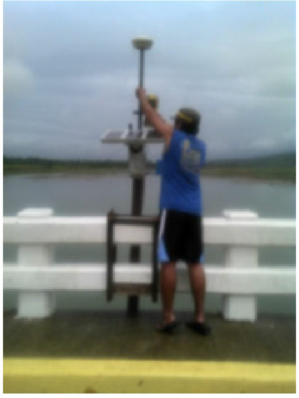
ANNEX A. SUMMARY OF AWLS SURVEY

Name of Bridge		Location	Coordinates	AWLS	Cross-section	Sensor Data	Documentation
1	Abuan	Ilagan City, Isabela	17°4'45.18"N 122°1'1.71"E	None yet	AWLS Survey (Sept. 26, 2013)	-	
2	Arkon	Timauini, Isabela	17°16'0.78"N 121°49'54.18"E	Installed	AWLS Survey (Sept. 24, 2013)	AWLS Survey	
3	Batu	Bayombong, Nueva Vizcaya	16°25'58.80"N 121°6'41.40"E	Installed	AWLS Survey (Sept. 18, 2013)	AWLS Survey	
4	Bintakan	Ilagan City, Isabela	17° 7'11.50"N 122° 0'42.27"E	None yet	-	-	

Name of Bridge		Location	Coordinates	AWLS	Cross-section	Sensor Data	Documentation
5	Buntun	Tuguegarao City, Cagayan	17°36’42.47”N 121°41’38.02”E	Installed	Phase 1 (Apr. 6, 2014)	Phase 1	
6	Canao	Tabuk, Kalinga	17°24’9.45”N 121°25’4.12”E	Installed	-	-	
7	Dalibubun	Echague, Isabela	16°36’13.85”N 121°40’36.81”E	Installed	Phase 3 (May 3, 2014)	-	
8	Disiluad	Aglipay, Quirino	16°28’6.99”N 121°37’47.91”E	Installed	AWLS Survey (Sept. 20, 2013)	-	
9	Dummun	Gattaran, Cagayan	18°2’29.96”N 121°38’29.29”E	Installed	Phase 1 (Apr. 5, 2014)	-	

Name of Bridge		Location	Coordinates	AWLS	Cross-section	Sensor Data	Documentation
10	Gamu	Gamu, Isabela	17°4'8.22"N 121°50'33.59"E	Installed but stolen	AWLS Survey (Sept. 20, 2013)	-	
11	Ganano	Alicia, Isabela	16°46'10.83"N 121°41'52.16"E	Installed	Phase 3 (May 4, 2014)	-	
12	Lucban	Abulag, Cagayan	18°20'17.74"N 121°25'30.81"E	Installed	AWLS Survey (Sept. 19, 2013)	AWLS Survey	
13	Magapit	Lal-Lo, Cagayan	18°7'19.70"N 121°40'21.02"E	Installed	AWLS Survey (Sept. 19, 2013)	-	
14	Magat (Aurora)	Aurora, Isabela	16°58'16.86"N 121°39'27.60"E	Installed	AWLS Survey (Sept. 28, 2013)	AWLS Survey; Phase 2	

Name of Bridge		Location	Coordinates	AWLS	Cross-section	Sensor Data	Documentation
15	Malalam	GIlagan, Isabela	17°7’18.10”N 121°54’26.46”E	Installed	AWLS Survey (Sept. 29, 2013)	AWLS Survey; Phase 3	<no image>
16	Mallig	Mallig, Isabela	17°10’29.89”N 121°36’42.39”E	Installed	Phase 2 (Feb. 8, 2014)	Phase 2	
17	Naguilian	Naguilian, Isabela	17°0’23.06”N 121°50’0.14”E	Installed	AWLS Survey (Sept. 23, 2013)	Phase 3	
18	Ninoy Aquino	Tuao, Cagayan	17°41’0.74”N 121°25’58.72”E	Installed	Phase 1 (Apr. 6, 2014)	Phase 1	
19	Pared	Alcala, Cagayan	17°53’39.93”N 121°41’16.26”E	Installed	Phase 1 (Mar. 20, 2014)	-	
20	President	Diffun, Isabela	16°35’51.00”N 121°31’35.07”E	Installed	Phase 3 (May 3, 2014)	-	

Name of Bridge		Location	Coordinates	AWLS	Cross-section	Sensor Data	Documentation
21	San Josefa	Peñablanca, Cagayan	17°37'45.30"N 121°46'17.80"E	Installed	AWLS Survey (Sept. 23, 2013)	-	
22	San Lorenzo	Bagabag, Nueva Vizcaya	16°34'59.92"N 121°16'8.93"E	Installed	AWLS Survey (Sept. 20, 2013)	-	
23	San Pablo	San Pablo, Isabela	17°26'21.26"N 121°46'44.67"E	Installed	Phase 1 (Apr. 5, 2014)	Phase 1	
24	Sangbay	Maddela Quirino	16°15'26.44"N 121°39'8.13"E	Installed	AWLS Survey (Sept. 20, 2013)	AWLS Survey; Phase 3	
25	Santiago (Calao)	Santiago City, Isabela	16°41'46.91"N 121°33'21.84"E	Installed	Phase 3 (Apr. 28, 2014)	Phase 3	

Name of Bridge		Location	Coordinates	AWLS	Cross-section	Sensor Data	Documentation
26	Siffu	Roxas, Isabela	17°7'54.30"N 121°36'46.80"E	Installed	AWLS Survey (Sept. 23, 2013)	AWLS Survey; Phase 2	
27	Timauini-Delfin Albano	Timauini-Delfin Albano, Isabela	17°16'21.60"N 121°47'50.90"E	Installed	Phase 1 (March 31, 2014	-	

ANNEX B. SURVEY TEAM

AWLS SURVEY SURVEY TEAM	
Name	**In-Charge Of:**
Engr. Dexter T. Lozano	Supervising
Engr. Bernard Paul D. Maramot	Cross-section
Jeline M. Amante	
Engr. JMson J. Calalang	
Michael Anthony C. Labrador	
Kenneth Niño Punay	Sensor Deployment
Neil Eneri Tingin	
Maximo A. Nieves	Driver

PHASE 1 SURVEY TEAM	
Name	**In-Charge Of:**
Engr. Melchor Rey M. Nery	Supervising / Bathymetry
Jeline M. Amante	Supervising / GPS Base Setup
Engr. JMson J. Calalang	Cross Section / Flow Measurement
Engr. Edjie M. Abalos	Cross Section/GPS Base Setup
Michael Anthony C. Labrador	Cross Section/Bathymetry
Patrizcia Mae P. dela Cruz	Bathymetry/Flow Measurement
For. Nancy A. Dimayacyac	

PHASE 2 SURVEY TEAM	
Name	**In-Charge Of:**
Engr. Melchor Rey M. Nery	Supervising (Team 1)
Engr. JMson J. Calalang	Bathymetry (Team 1)
Engr. Edjie M. Abalos	
Michael Anthony C. Labrador	
Engr. Bernard Paul D. Maramot	Supervising (Team 2)
Engr. Mark Lester Rojas	Bathymetry (Team 2)
For. Maridel P. Miras	
Erlan Patrick Mendoza	

PHASE 3 SURVEY TEAM	
Name	**In-Charge Of:**
Engr. Melchor Rey M. Nery	Supervising
Engr. Bernard Paul D. Maramot	Supervising / GPS Base Setup
Engr. Mark Lester Rojas	Cross Section / Flow Measurement
For. Rodel C. Alberto	Cross Section/GPS Base Setup
Erlan Patrick Mendoza	Cross Section/Bathymetry
Engr. Bernice H. Furagganan	
For. Maridel P. Miras	Bathymetry/Flow Measurement
For. Dona Rina Patricia C. Tajora	

ANNEX C. LIST OF EQUIPMENT AND INSTRUMENTS USED

CAGAYAN RIVER SURVEY PHASE 1		
Equipment	**Quantity**	**Serial Number**
Dual Frequency GPS (Base)	1 unit	2
Dual Frequency GPS (Rover)	4 units	2297, 9327, 2302, 2179
Tripod	2 units	TP9, DL TP1
Digital Level	1 unit	Box 5
Bipods	4 units	BP7, BP10, BP9, BP11
Notebook Computer	1 unit	D6420 Dell Latitude
Handheld GPS	2 units	5, 10
OHMEX Sonarmite Echo Sounder	1 unit	(Rented from Sitech Philippines with 3 parts transducer)
Portable Depth Sounder	1 unit	236946
Flow Meter	4 unit (1 propeller type and 2 digital flow meters)	4977, 4975, 26297
Trimble Business Center Don-gle	1 unit	
Toolbox	1 unit	

CAGAYAN RIVER SURVEY PHASE 2		
Type	**Brand**	**Quantity**
GPS Receivers	Trimble SPS882	5 rovers
	Trimble SPS852	1 base
	Trimble SPS985	1 rover
Single Beam Echosounder	OHMEX	1 unit
	HI-TARGET	1 unit
Handheld	Garmin Oregon 550	5 units
Laptop	Dell ATG	2 units
Tripod	Trimble	2 units
Range pole with Bipod	Trimble	5 units
Acoustic Current Profiler (Side Looking)	Sontek	2 units
Flowmeter (Propeller type)		1 units
Depth Gauge	Hobo	2 units

CAGAYAN RIVER SURVEY PHASE 3		
Equipment	**Quantity**	**Serial Number**
Dual Frequency GPS (852)	1 unit	5208k82363
Dual Frequency GPS (ROVER)	4 units	1142, 2056, 9972, 2179
Digital Level	1 unit	510770
Controller	5 units	3446, 13419, 8662, 6213, 13432
Trimble bags	4 pieces	1, 2, 3, 4
Level Rods	2	
Tripods	2 units	8,4
Tripods (aluminum)	1 unit	5
Range Poles and Bipods	6 units	1, 2, 3. 4, 5, 6
data connector (Hobo)	2 units	HB1, HB 2
Depth gauge	3 units	5080, 5078, 3753
Rain gauge	2 units	10431539, 10431538
ADCP (SL or XR) with accesso-ries	2 units	
Notebook Computer	2 units	
Handheld GPS	4 units	1,2,6,3
Trimble battery	12 units	25, 27, 28, 7, 8, 9, 10, 12, 15, 16, 19, 20
Battery charger (dock)	4 units	1, 2, 3, 4
Battery charger	3 units	3, 4, 6
Car Battery charger	2 units	2 & 6
Controller charger	4 units	4, 5, 6, 7
Toolbox	2 units	
Single Beam Echo sounder (OHMEX and HI-Target) and accessories	2 units	
Outboard motors (OBM 25 HP & 30 HP)	2 units	

ANNEX D. SUMMARY OF ACTIVITIES

CAGAYAN RIVER SURVEY AWLS SURVEY				
Bridges	**Cross-section**	**AWLS**	**Flow measurement**	**Remarks**
Abuan	√	√	√	
Arkon	√	√	√	
Batu	√	√	√	
Bintakan	√	√	√	
Canao	No data	No data	No data	Lost data
Dalibunbun	No data	No data	√	
Disiluad	√	√	√	
Dummun	No data	No data	√	Float cross-section data
Gamu	√	√	ADCP	ADCP - Side looking deployed
Ganano	√	√	√	
Ganano	√	√	√	
Lucban	√	√	√	
Magapit	√	√	ADCP	ADCP - Side looking deployed
Magat (Aurora)	√	√	√	
Malalam	√	√	ADCP	ADCP - Vertical de-ployed
Mallig	No data	No data	√	
Naguillian	√	√	No flow	Lost data
Pared	No data	No data	√	Float cross-section data
San Josefa	√	√	√	
San Lorenzo	√	√	√	
San Pablo	√	√	√	
Sangbay	√	√	√	
Santiago (Calao)	No data	No data	No data	Lost data
Siffu	√		√	
Timauini-Delfin Albano	No data	No data	√	Lost data

CAGAYAN RIVER SURVEY PHASE 2	
Date	**Activities**
January 29 - 30, 2014	Preparation of equipment and instruments to be used in the survey. Land travel from UP Diliman, Quezon City to Ilagan City, Province of Isabela.
January 31, 2014	Arrived at Provincial Capitol of Isabela, Courtesy call and co-ordination with the Local Government such as PDRRMC and Governor's Office.
February 01, 2014	Deployment of ADCP at Mallig and Aurora bridges. Reconnaissance and recovery of control point monuments within the survey area.
February 2, 2013	Established a GPS network thru conducting a GPS Static observation along control points.
February 3 – 10, 2013	Bathymetric survey in Magat (Team 1) and Ilagan (Team 2) Rivers
February 11-12	LIDAR Validation Survey and Preparation for departure.

CAGAYAN RIVER SURVEY PHASE 3		
Date	**Activities**	**Location**
April 24, 2014	• Arrival at Santiago Isabela • Courtesy call with the LGUs Courtesy call in Isabela PDRRMC	• Santiago Isabela • Governor's Office in Quirino and Ilagan Isabela
April 25, 2014	• Reconnaissance of NAMRIA established control points • Static Survey	• Quirino and Isabela
April 26, 2014	• Ground Validation • Sensor Deployment • Deployment of ADCP, depth gauge, and rain gauge • Flow measurement	• Sangbay to Cordon, Isabela • Sangbay and Malalam Bridge • Calao Bridge
April 27, 2014	• Flow measurement • Cross-section Survey • Ground Validation • Static Survey	• Calao Bridge • Malalam Bridge • Naguilian and Jones to • Maddela • Isabela and Quirino
April 28, 2014	• Bathymetry Survey Center line • Courtesy call in Maddela Mayor's office • Cross-section Survey	• San Augustine to Jones • Maddela Municipal Hall • Calao Bridge
April 29, 2014	• Bathymetry Survey Center line • Courtesy call in Maddela Mayor's office • Cross-section Survey	• San Augustine to Jones • Maddela Municipal Hall • Calao Bridge

CAGAYAN RIVER SURVEY PHASE 3		
Date	Activities	Location
April 30, 2014	• Bathymetry Survey Center line • Flow measurement	• Echague to Angadanan • Calao Bridge
May 1, 2014	• Bathymetry Survey Center line • Flow measurement	• Angadanan to Naguilian • Calao Bridge
May 2, 2015	• Courtesy call with LGUs in the Barangays of Nagtipunan and Maddela • Checked sensors; downloaded data	• Nagtipunan and Maddela Isabela • Sangbay and Malalam Bridge
May 3, 2015	• Bathymetry Survey Center line • Cross-section Survey	• Maddela Quirino • Dalibubon and President's Bridge
May 4, 2015	• Bathymetry Survey Center line • Flow measurement	• Nagtipunan Quirino • Naguilian Bridge
May 5, 2015	• Returned the boats to PDRRMC of Isabela • Bathy Data Processing	• Ilagan Isabela
May 6, 2015	• Flow measurement	• Calao Bridge
May 7, 2015	• Flow measurement • Instrument inventory	
May 8, 2015	• Sensor Retrieval of ADCP, depth gauge, and rain gauge • Checked sensors; downloaded data • Preparation for Travel	• Malalam and Sangbay Bridge

ANNEX E. PROBLEMS ENCOUNTERED AND SOLUTIONS APPLIED

CAGAYAN RIVER SURVEY PHASE 1	
Problems	**Remarks/Solutions**
Float data for bathymetric survey at certain portions of Cagayan River along the municipalities of Cabagan, Alcala, and Aparri	The survey team immediately processed the data to identify data gaps needed to be re-surveyed. Re-survey was done for the identified portions of Cagayan River with float data
Float data for Buntun Bridge Cross Section	The bridge was re-surveyed thrice to obtain cross section data
No rainfall data gathered for flow measurements site in San Pablo and Ninoy Aquino Bridges during the survey period	Base flow data were gathered for the AWLS sites
No water level data was read by the AWLS in Ninoy Aquino Bridge by the time of cross section and flow measurement survey done by the team	No HQ Curve was generated for Ninoy Aquino Bridge

CAGAYAN RIVER SURVEY PHASE 2	
Problems	**Remarks/Solutions**
Bathymetric survey using echosounder is not suitable.	The team conducted a manual gathering of bathymetry data.
Dense tree canopies along the road which made the acquisition of ground validation point more challenging. This consumed more time.	The team allot extra time for this activity. Data gathered before and after the canopies were filtered out.

CAGAYAN RIVER SURVEY PHASE 3	
Problems	**Remarks/Solutions**
The battery of the ADCP deployed at Malalam bridge got empty	Replaced the empty battery with fully charge one
The BST had difficulties in surveying the river along Maddela because of the unsecured part of the area	The BST coordinated and requested assistance from the LGU in Maddela to reassure the safety of the team
Some parts of the river are rapid that the instruments cannot function properly	The BST as much as possible avoid the very rapid part of the river

ANNEX F. NAMRIA CERTIFICATES

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

September 20, 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: **QUIRINO**
Station Name: **QRN-32**
Order: **2nd**

Island: **LUZON**
Municipality: **DIFFUN**
Barangay: **LIWAYWAY**

PRS92 Coordinates

Latitude:	**16° 34' 59.10993"**	Longitude:	**121° 29' 57.44278"**	Ellipsoidal Hgt:	**123.92700 m.**

WGS84 Coordinates

Latitude:	**16° 34' 53.28043"**	Longitude:	**121° 30' 2.16602"**	Ellipsoidal Hgt:	**162.77800 m.**

PTM Coordinates

Northing:	**1834031.513 m.**	Easting:	**553282.072 m.**	Zone:	**3**

UTM Coordinates

Northing:	**1,833,921.87**	Easting:	**339,892.90**	Zone:	**51**

Location Description

QRN-32

Station is located beside the drying pavement of Purok 1 Brgy. Liwayway. About 20 m SW corner of the pavement and the waiting shed. The drying pavement is approx. 240 m away from the marker of Brgy. Liwayway, the said marker is approx. 150 m away from the Nat'l Road. To access to this station, from the Mun. Hall of Diffun Quirino, travel S along Nat'l Road. Turn right or beside the waiting shed. Station is marked by a 4 in. copper nail set at the center of a concrete monument, 30 cm x 30 cm x 1.20 m set 0.20 m above the ground surface, with inscriptions, "QRN-32, 2007, NAMRIA".

Requesting Party:	**UP-TCAGP**
Pupose:	**Reference**
OR Number:	**3946909 B**
T.N.:	**2013-0932**

for **RUEL DM. BELEN, MNSA**
Director, Mapping And Geodesy Branch

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CERTIFICATION INTERNATIONAL ISO 9001:2008
CIP/4701/12/09/814

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

September 20, 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: **NUEVA VIZCAYA**
Station Name: **NV-121**

Island: **LUZON**	Municipality: **BAYOMBONG (CAPITAL)**	Barangay: **STO. DOMINGO**
Elevation: **305.8799 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

BM NV-121 is in the province of Nueva Vizcaya, municipality of Bayombong, barangay of Sto. Domingo, along the national road (Maharlika Highway), and about 911 m NW of kilometer post no 255. It is embedded in a hole drilled on top of and near the NE end of the east abutment of a concrete bridge, about 0.20 m above the level of the surface of the road, and it is located at the right side of the national road of the national road going to Santiago City, about 4.35 m north of the centerline of the bridge, and it is almost 9 m north of Batu bridge, and 39.9 m east of a waiting shed. Mark is a 1/2" x 2" brass rod embedded in a drilled hole with an inscription on the cement putty placed around the mark as shown: NV-121; 2007; NAMRIA".

Requesting Party:	**UP-TCAGP**
Pupose:	**Reference**
OR Number:	**3946909 B**
T.N.:	**2013-0931**

for RUEL DM. BELEN, MNSA
Director, Mapping And Geodesy Branch

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NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

September 20, 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: **CAGAYAN**
Station Name: **CGY-56**
Order: **2nd**

Island:	**LUZON**			Barangay:	**DADDA**
Municipality:	**TUGUEGARAO**				
		PRS92 Coordinates			
Latitude:	**17° 34' 13.40536"**	Longitude:	**121° 46' 26.02506"**	Ellipsoidal Hgt:	**39.12800 m.**
		WGS84 Coordinates			
Latitude:	**17° 34' 7.37984"**	Longitude:	**121° 46' 30.66402"**	Ellipsoidal Hgt:	**75.52200 m.**
		PTM Coordinates			
Northing:	**1943386.436 m.**	Easting:	**582154.718 m.**	Zone:	**3**
		UTM Coordinates			
Northing:	**1,942,959.11**	Easting:	**369,880.69**	Zone:	**51**

Location Description

CGY-56
Is located near the NE concrete corner fence of Brgy. Dadda Catholic Church and at the intersection of the nat'l. highway and Cagurangan St. Mark is the head of a 3 in. copper nail set flushed on top of a standard concrete monument, with inscriptions "CGY-56 2007 NAMRIA".

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3946909 B**
T.N.: **2013-0933**

for **RUEL DM. BELEN, MNSA**
Director, Mapping And Geodesy Branch

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CIP/4701/12/09/814

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

October 29, 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: **CAGAYAN**
Station Name: **CG-130**

Island: **Luzon**	Municipality: **IGUIG**	Barangay: **REDONDO**
Elevation: **23.5374 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

CG-130 is in the Province of Cagayan, Municipality of Iguig, Barangay of Redondo, along the national road (maharlika highway), and about 200m. North kilometer post no. 493, it is embedded in a hole drilled on top of near the south end of the west sidewalk of a concrete bridge, it is 0.15 m above the bridge floor, almost 4.25 m east of the centerline of the bridge. It is located at the right side of the national road going to Aparri, Cagayan. Mark is a 1/2"x 2"brass rod embedded in a drilled hole, with a inscription on the cement putty placed around the mark, as shown: CG-130; 2007; NAMRIA.

Requesting Party:	**UP-DREAM**
Pupose:	**Reference**
OR Number:	**3947103 B**
T.N.:	**2013-1168**

RUEL DM. BELEN, MNSA
Director, Mapping And Geodesy Branch

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CIP/4701/12/04/884

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

November 05, 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: **CAGAYAN**
Station Name: **CGY-87**
Order: **2nd**

Island: **LUZON**
Municipality: **LAL-LO**
Barangay: **CABAYABASAN**

PRS92 Coordinates

Latitude: **18° 3' 46.30032"**	Longitude: **121° 38' 38.76326"**	Ellipsoidal Hgt: **37.21200 m.**

WGS84 Coordinates

Latitude: **18° 3' 40.16861"**	Longitude: **121° 38' 43.36193"**	Ellipsoidal Hgt: **71.69600 m.**

PTM Coordinates

Northing: **1997837.978 m.**	Easting: **568188.029 m.**	Zone: **3**

UTM Coordinates

Northing: **1,997,546.44**	Easting: **356,498.94**	Zone: **51**

Location Description

CGY-87
Is located on a solar dryer at Brgy. Cabayabasan, fronting the brgy. hall. Mark is the head of a copper nail centered and flushed on a 30 cm. x 30 cm. concrete monument, with inscriptions "CGY-87 2007 NAMRIA".

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3947129 B**
T.N.: **2013-1201**

for **RUEL DM. BELEN, MNSA**
Director, Mapping And Geodesy Branch

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

April 29, 2014

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: **QUIRINO**	
	Station Name: **QRN-40**	
	Order: **2nd**	
Island: **LUZON**		Barangay: **VILLA AGULLANA**
Municipality: **MADDELA**		
	PRS92 Coordinates	
Latitude: **16° 15' 8.06863"**	Longitude: **121° 42' 7.18107"**	Ellipsoidal Hgt: **461.92500 m.**
	WGS84 Coordinates	
Latitude: **16° 15' 2.32934"**	Longitude: **121° 42' 11.93071"**	Ellipsoidal Hgt: **502.28500 m.**
	PTM Coordinates	
Northing: **1797485.468 m.**	Easting: **575041.463 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,797,167.49**	Easting: **361,287.95**	Zone: **51**

Location Description

QRN-40

Station is located E part of Day Care Center of Disimungal, located at Brgy. Disimungal, Nagtipunan, Quirino along brgy. road going to Disimungal Proper. Station is marked by a 4 in. copper nail, set at the center of a 0.30 m x 0.30 m x 1 cm thick cement putty with inscriptions, "QRN-40, 2007, NAMRIA".

Requesting Party: **TCAGP DREAM**
Pupose: **Reference**
OR Number: **8796058 A**
T.N.: **2014-972**

For **RUEL DM. BELEN, MNSA**
Director, Mapping And Geodesy Branch

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NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

April 29, 2014

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: **ISABELA**
Station Name: **SB-254**

Island: **LUZON**	Municipality: **CABAGAN**	Barangay: **UGAD**
Elevation: **31.4430 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

BM SB-254
It is in the province of Isabela, municipality of Cabagan, Brgy. of Ugad along the national road (Maharlika Highway) and about 124 m N of KM post 449. It is embedded in a hole drilled on top of and near the east end of the north sidewalk of a concrete bridge. It is 38 cm above the bridge floor, almost 4.05 m N of the centerline of the bridge. It is located at the right side of the national road going to Aparri, Cagayan. Mark is a 1/2" x 2" brass rod embedded in a drilled hole with an inscription on the cement putty placed around the mark as shown SB-254 2007 NAMRIA.

Requesting Party:	**TCAGP DREAM**
Pupose:	**Reference**
OR Number:	**8796058 A**
T.N.:	**2014-974**

For **RUEL DM. BELEN, MNSA**
Director, Mapping And Geodesy Branch

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ANNEX F. ACKNOWLEDGMENTS

We are very thankful to the following individuals and agencies for their generous support during the conduct of our field surveys:

- The Provincial Government of Cagayan Valley and Isabela and their respective PDRRMCs for lending us portable boat and manpower to assist and guide us in the survey
- DOST Region 2 for the assistance extended to the UP Survey Team;
- Local hires from Region 2, without which, the field survey would not be made possible.
- Joy C. Samson Transport van rentals for the survey team's mobilization;
- Piazza Zicarelli for the team's accommodations during the survey; and
- The local residents of Cagayan, Isabela, Quirino and Nueva Viscaya for the invaluable assistance extended to the UP Survey team.

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DREAM

Disaster Risk and Exposure Assessment for Mitigation