REGION 5

Bicol River:

DREAM Ground Surveys Report

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY

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List of Abbreviations

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

Introduction

Introduction

1.1 DREAM Program Overview

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

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

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

1.2 Objectives and target outputs

The program aims to achieve the following objectives:

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

1.3 General methodological framework

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

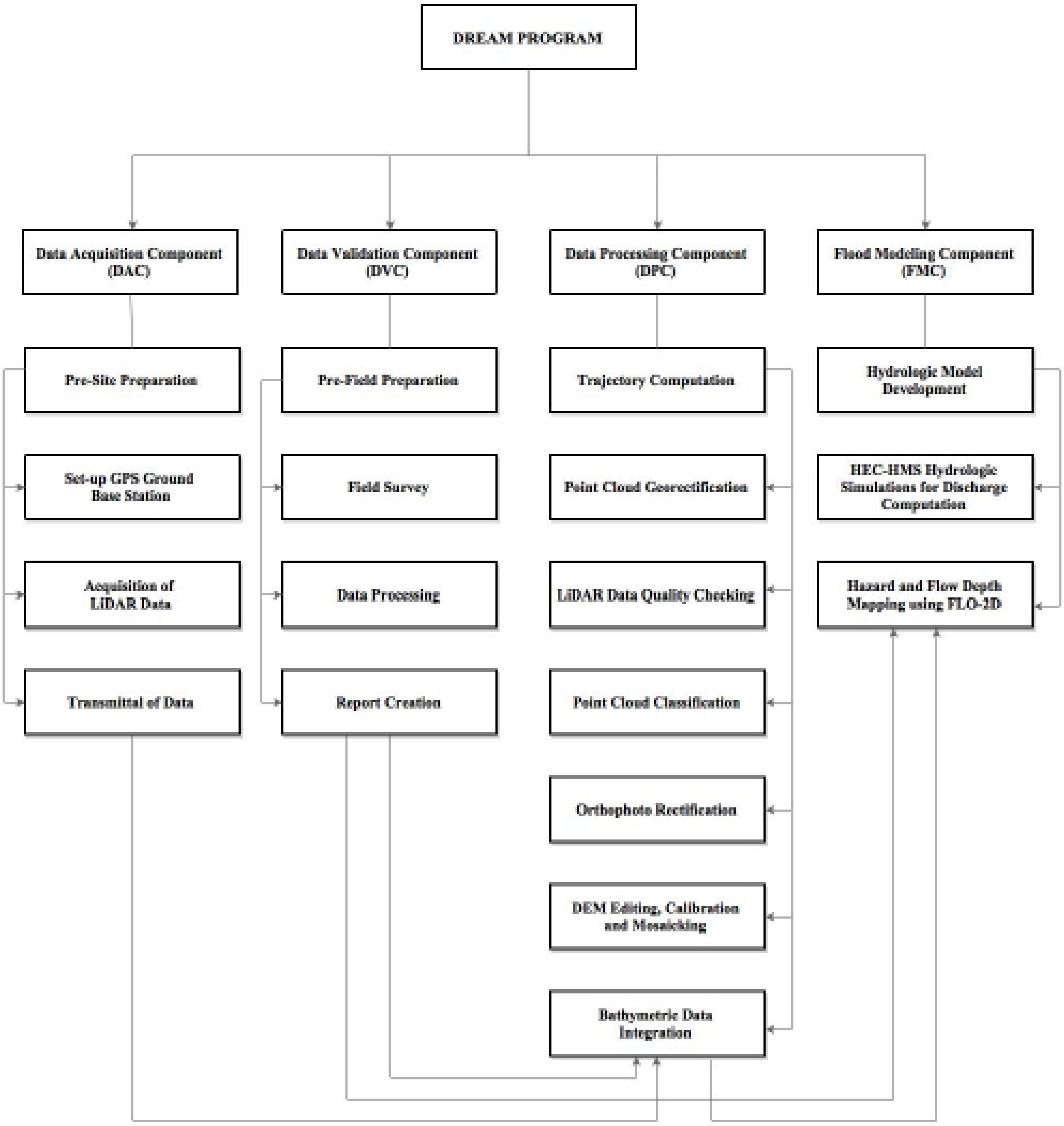


Figure 1. The General Methodological Framework of the Program

The Bicol River Basin

The Bicol River Basin

The Bicol River Basin is located in the central portion of the Bicol region, with an estimated basin area of 3,770 square kilometers, becoming the eighth largest river in the Philippines in terms of drainage basin size. From its headwaters in Bato, Camarines Sur, it traverses though northern Albay and Camarines Norte until it drains into the southwestern portion of Luzon. It is also bounded by a chain of volcanoes, highlands and lowhills. The location of Bicol River Basin is as shown in Figure 1.

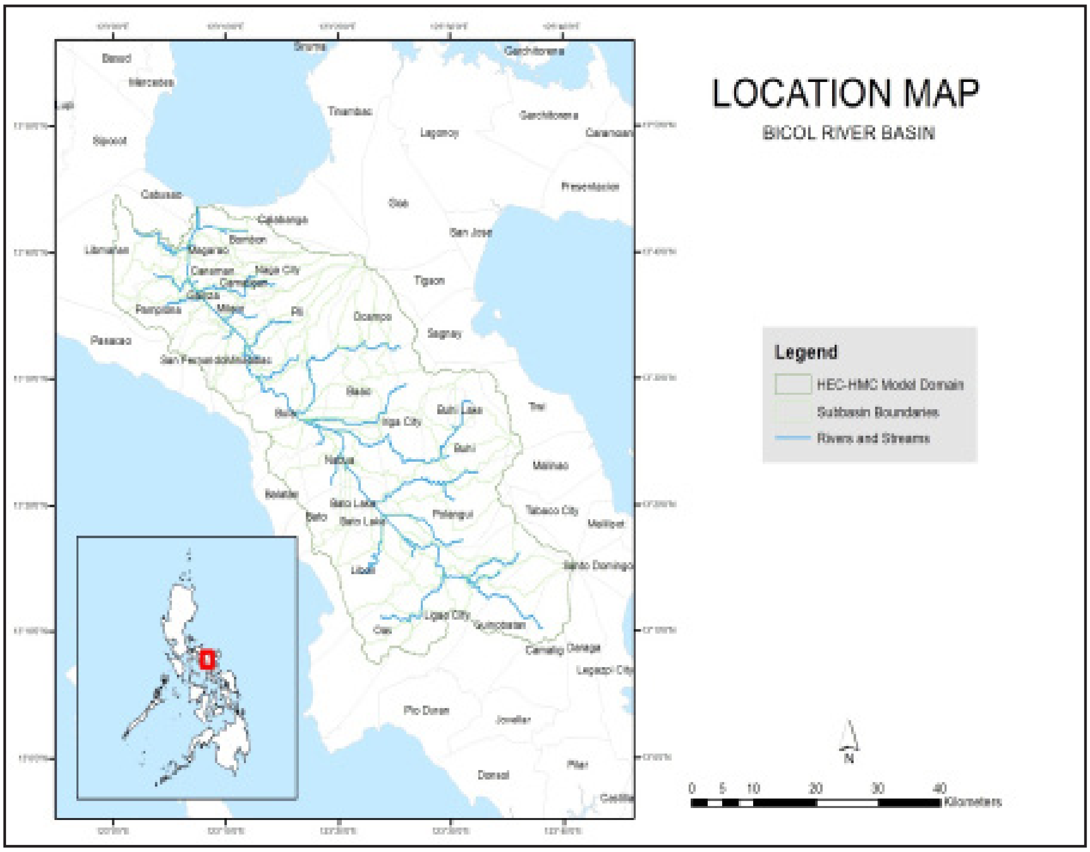


Figure 2. Bicol River Basin Location Map

Average annual rainfall ranges between 1,850 – 2,300 millimeters in the lower basin and 2,000 – 3,600 millimeters in the southwestern section of the basin. Storm surges associated with slow-moving typhoons cause flooding in the alluvial plain near or over the San Miguel Bay. Flood target areas are the central part of the basin, extending from Baao Lake to Bato Lake and the alluvial plain, which extends from Naga City to the river mouth.

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 Bicol River Basin are shown in Figures 3 and 4, respectively.

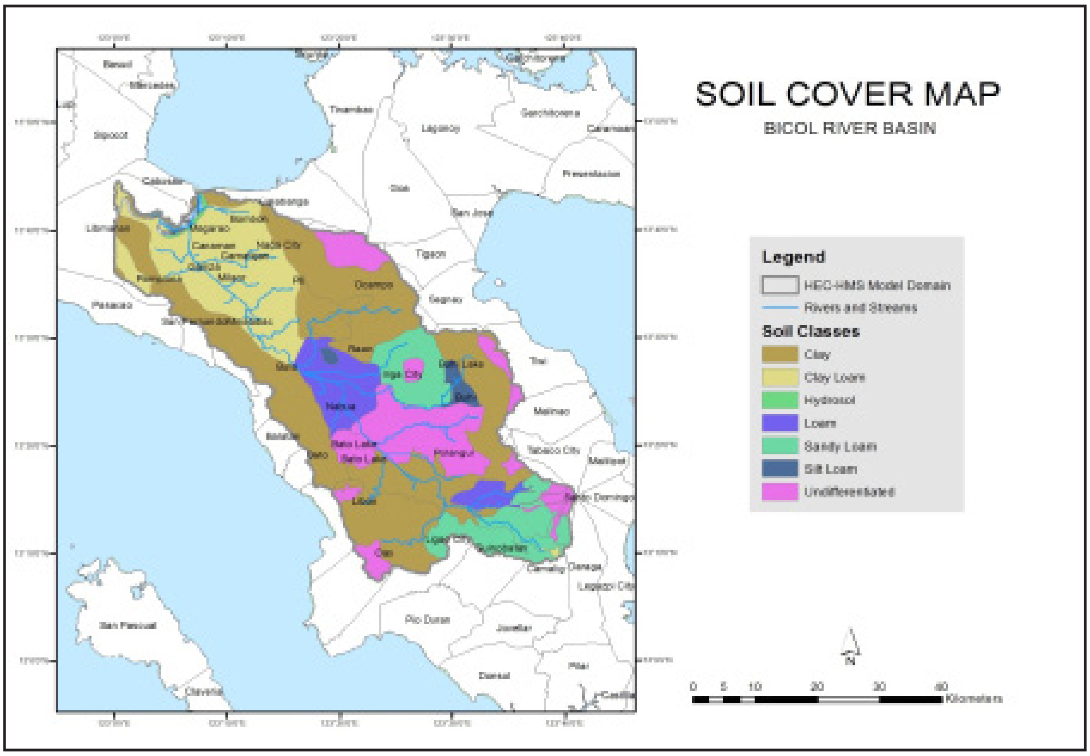


Figure 3. Bicol River Basin Soil Cover Map

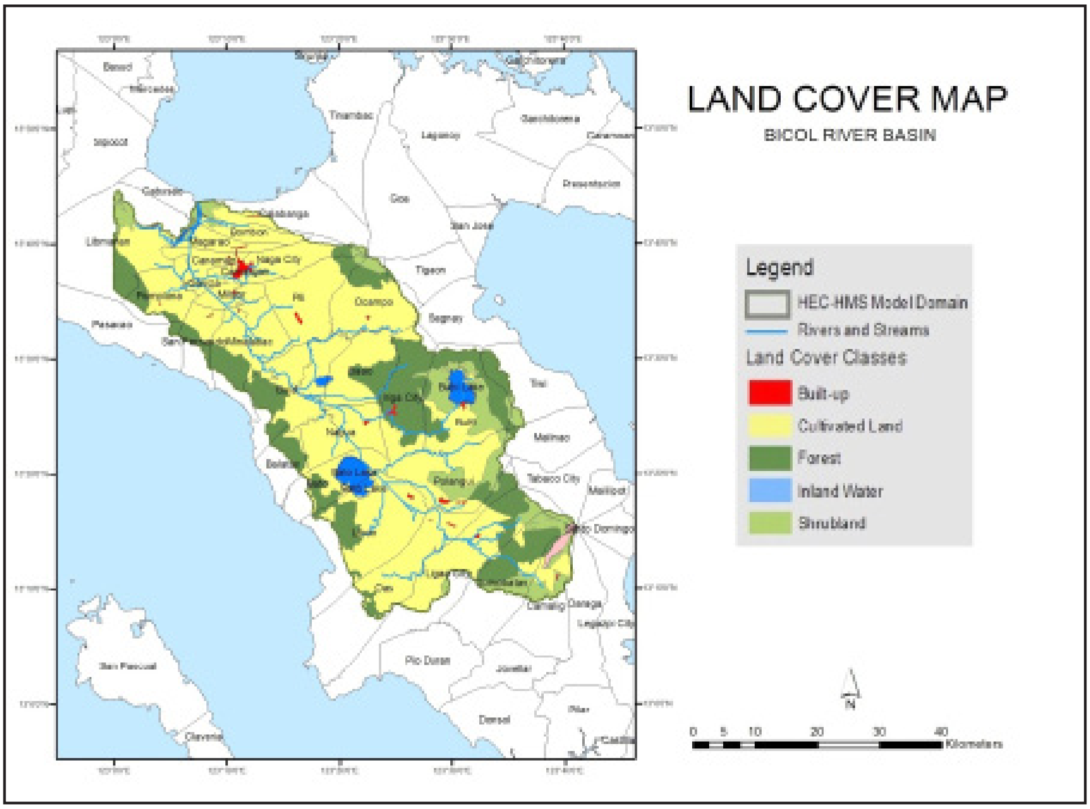


Figure 4. Bicol River Basin Land Cover Map

DVC Methodology

DVC Methodology

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

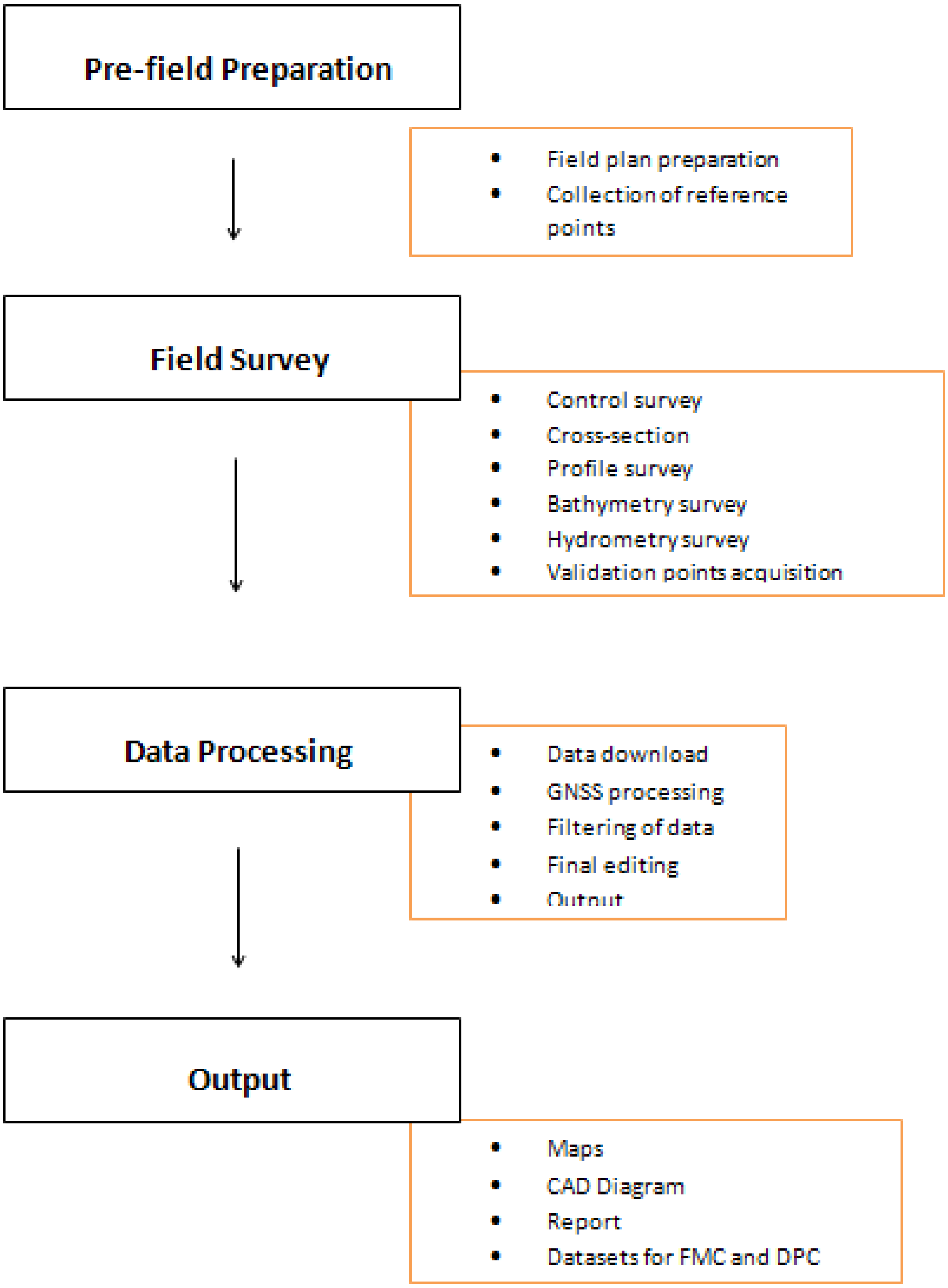


Figure 5. DVC Main Activities

DVC Methodology

3.1 Pre-field Preparation

3.1.1 Preparation of Field Plan

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

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

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

3.1.2 Collection of Reference Points

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

3.2 Field Surveys

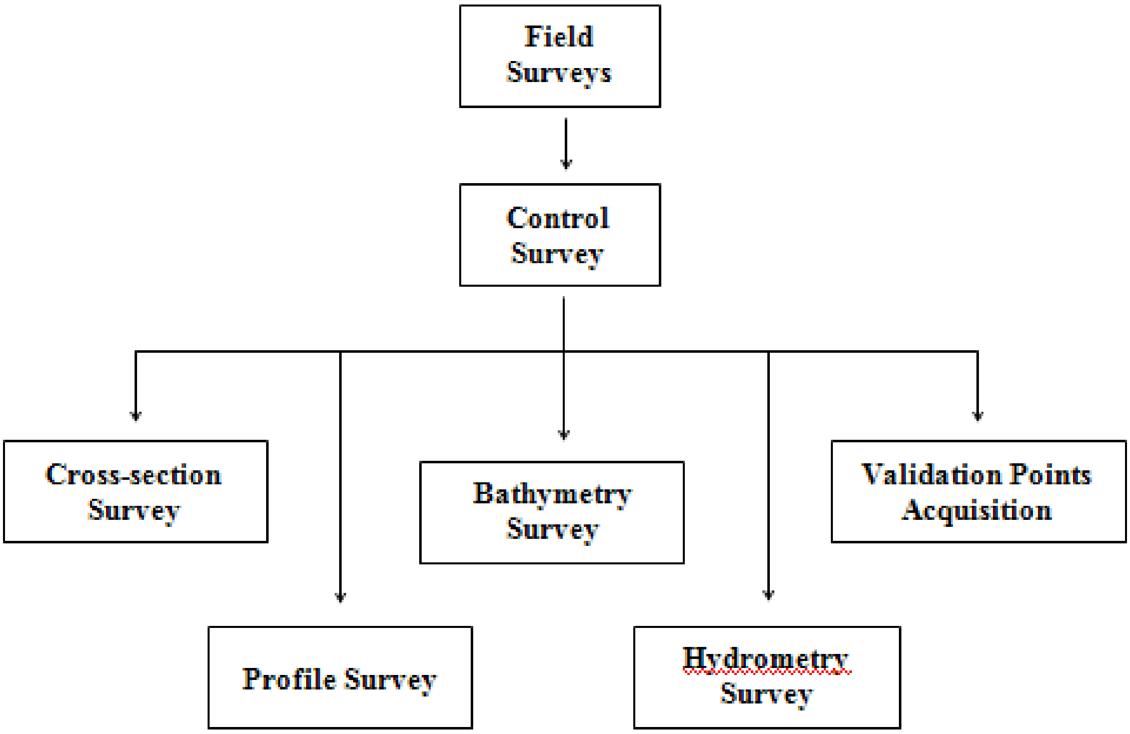


Figure 6. DVC Field Activities

3.2.1 Control Survey

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

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

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

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

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

3.2.2 Cross-section Survey

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

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

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

3.2.3 Profile Surveys

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

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

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

3.2.4 Bathymetric Survey

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

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

3.2.5 Hydrometric Survey

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

The elements of discharge computation are the ff.:

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

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

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

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

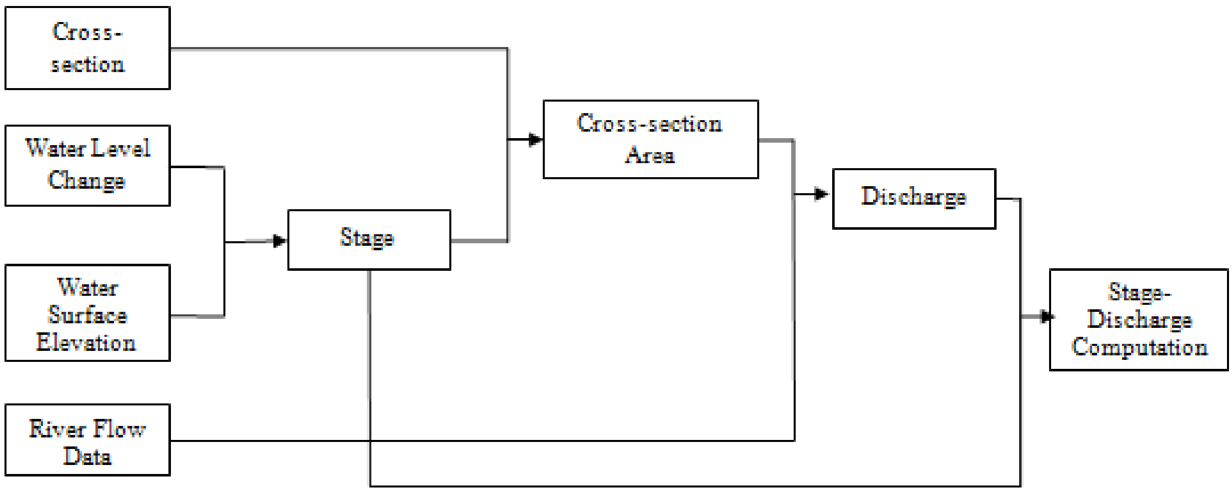


Figure 7. Flow Chart for Stage-Discharge Correlation Computation

3.2.5 Validation Points Acquisition Survey

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

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

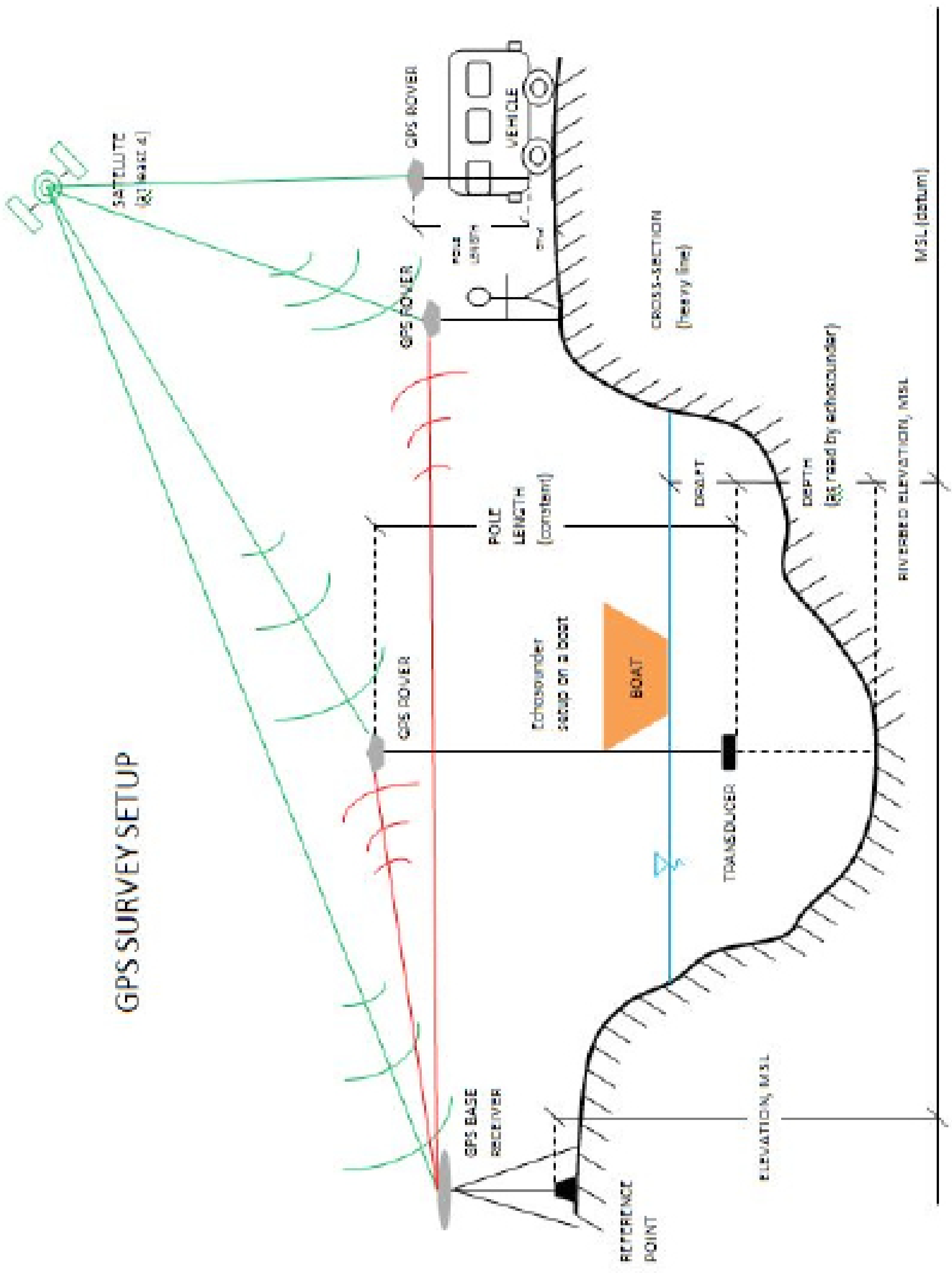


Figure 8. Set-up for GNSS Survey

3.3 Data Processing

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

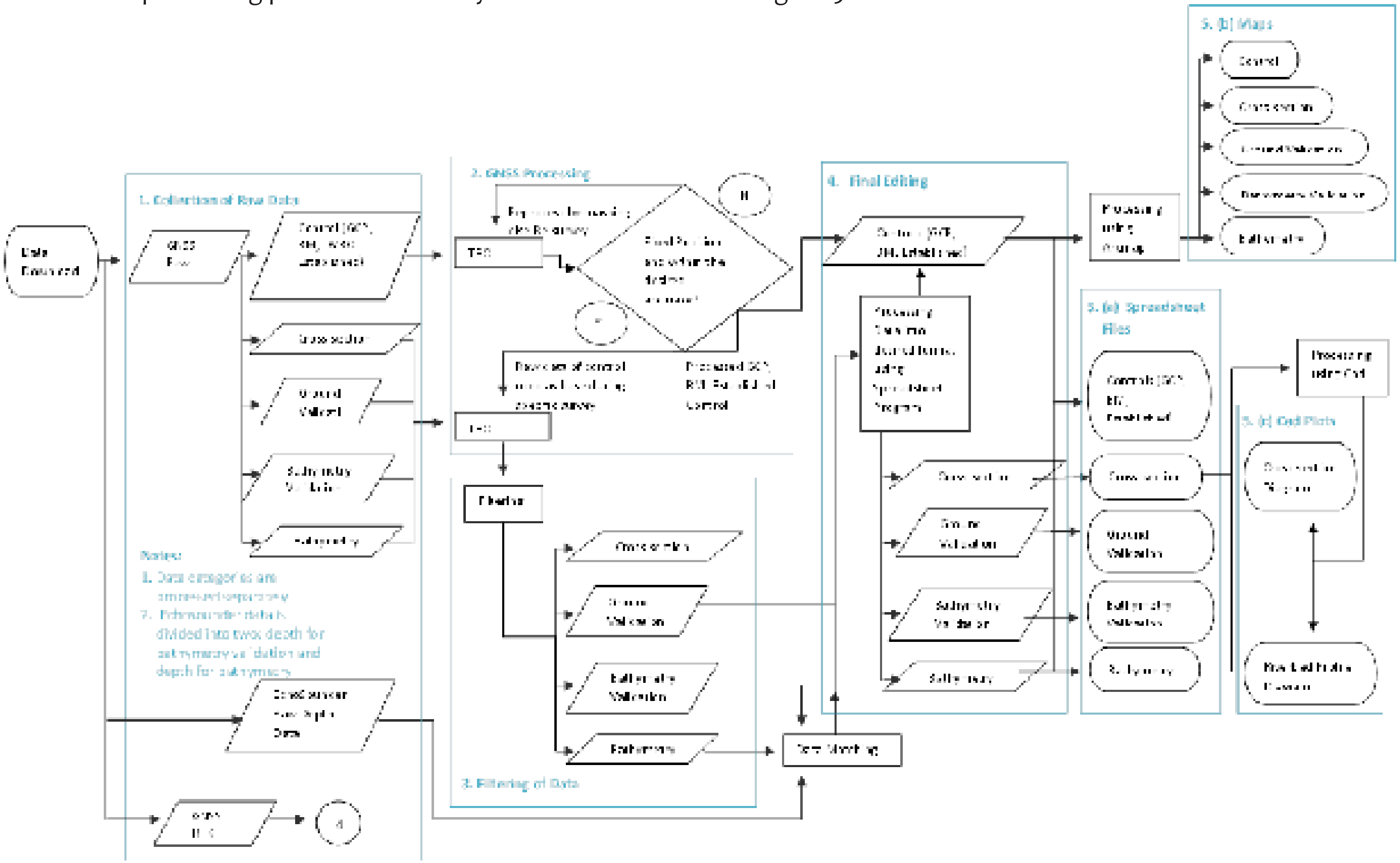


Figure 9. DVC Data Processing Methodology

3.3.1 Collection of Raw Data

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

3.3.2 Data Processing

Processing for GNSS Data

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

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

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

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

Computation for offset:

Equation 1:

$$OFFSET = BM - EGM$$

Computation for BM_ortho:

Equation 2:

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

where:

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

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

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

Depth Data Processing

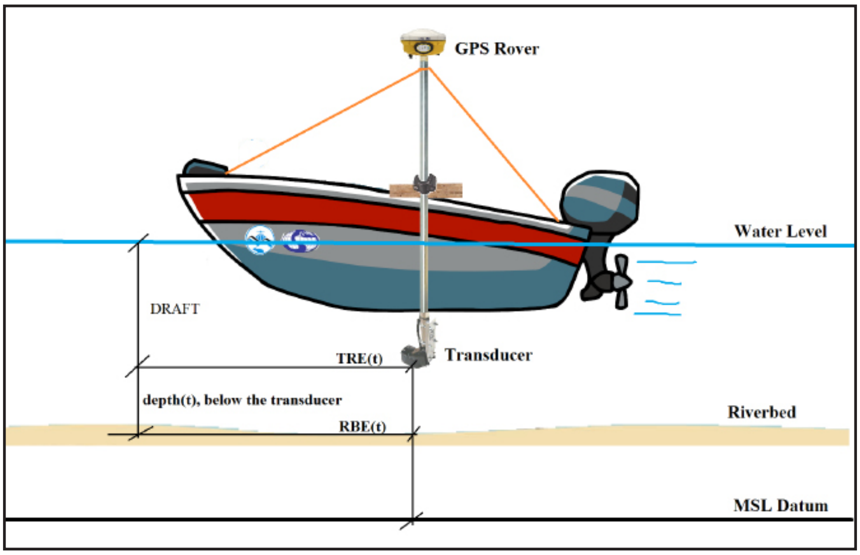


Figure 10. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

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

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

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

Data Matching for Bathymetric Data

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

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

Equation 3:

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

where:

RBE(t)	= elevation of the riverbed during time t,
TRE(t)	= transducer elevation (reckoned from EGM 2008)
Depth(t)	= depth recorded by the echo sounder at time t, with the assumption that depth is measured from the bottom of the transducer down to the riverbed

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

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

Hydrometry Data Processing

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

1. **River Flow Data**

a.) ADCP

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

b.) Flow Meter

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

2. **Cross Section and Water Surface Elevation Data**

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

3. **Water Level Change-Stage**

a.) Depth Gauge

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

b.) AWLS

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

4. **Discharge Computation**

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

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

3.3.3 Filtering of Data

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

3.3.4 Final Editing

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

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

3.3.5 Output

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

Bicol River Basin Survey

Bicol River Basin Survey

The survey for Bicol River Basin was conducted on September 9 – 29, 2012 with the following activities: profile, cross-section, bathymetric and flow measurement surveys.

Bicol River consists of 47 delineated cross section lines with a total length of 98.45 km for both left and right banks starting from Brgy. San Miguel, Minalabac in the upstream down to Brgy. Castillo, Cabusao near the mouth of the river. The total length of profile lines is about 23 km for its both left and right banks.

Other sets of fieldwork were conducted on November 27 – December 5, 2013 and April 25 – May 6, 2014 to acquire the cross-section and sensor elevation of the installed Automated Water Level Sensor (AWLS) and to perform flow data gathering.

4.1 Control Survey

Two (2) NAMRIA and three (3) established control points were considered for the static GNSS observations Bicol River System survey on September 9 – 29, 2012. These include a benchmark, CS-360, which is located in Brgy. Camagong, Cabusao; a third-order reference point, CMS-3179, situated at Brgy. Isidro, Uguis, Libmanan; and an established control points located on top of Mabolo Barangay Hall, in Mangayawan National High School, Canaman, and Barangay San Nicholas, Canaman. The locations of these controls are shown in Figure 8 while the GNSS set-up for the five (5) base stations are shown in Figure 11 - 16.

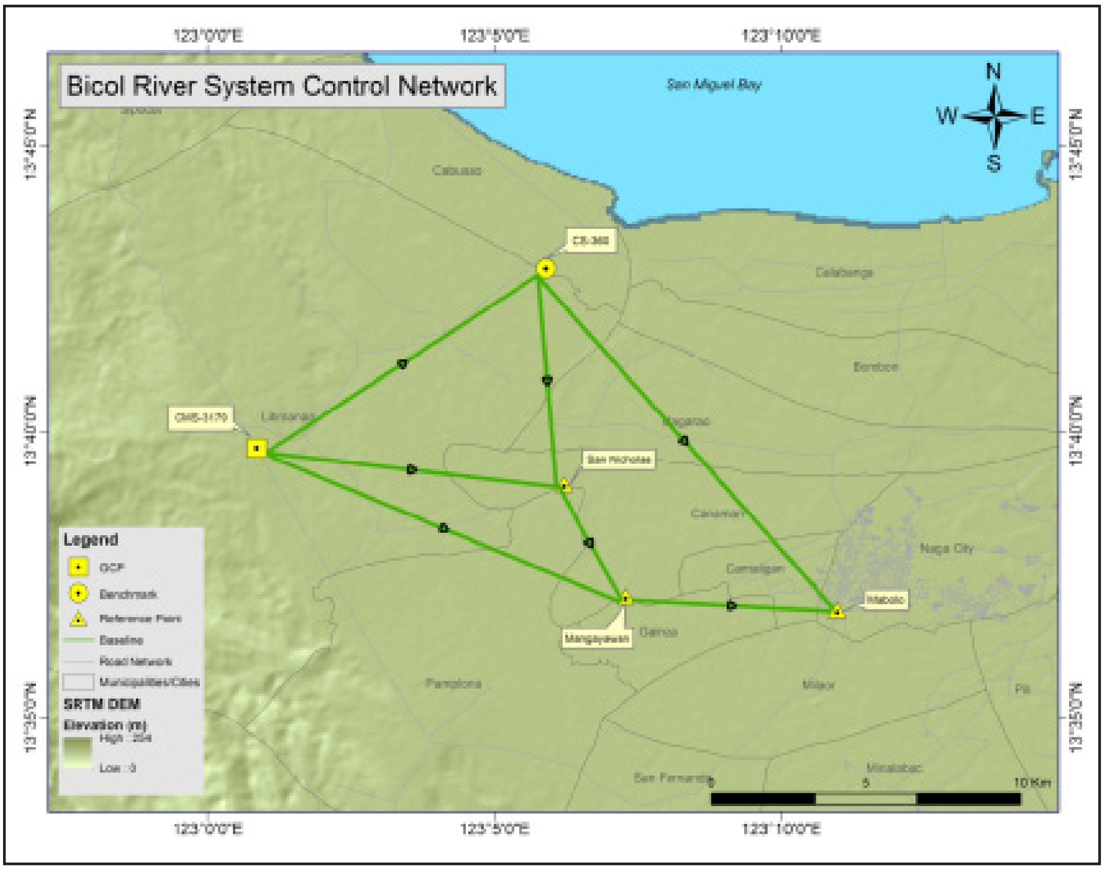


Figure 11. Location of control points for Bicol River Survey

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

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

Point Name	WGS84 UTM Zone 51N					Elevation in MSL (m)
	Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	
CMS-3179	13°39’42.75”N	123° 0’51.10”E	15.272	1510332.322	501535.303	66.523
CS-360	13°42’50.44”N	123° 5’53.66”E	3.678	1516100.932	510622.332	55.215
Mabolo	13°36’53.21”N	123°10’58.11”E	11.182	1505131.532	519774.381	63.038
Mangayawan	13°37’7.50”N	123° 7’17.23”E	9.798	1505566.113	513137.749	9.718
San Nicholas	13°39’4.88”N	123° 6’12.48”xE	11.080	1509171.603	511190.951	11.084

The GNSS setup for the five (5) control points are illustrated in Figures 12 to 16:

Figure 12. Static GNSS observation at CMS-3179

Figure 13. Static GNSS observation at CS-360

Figure 14. Static GNSS observation on top of Mabolo Barangay Hall

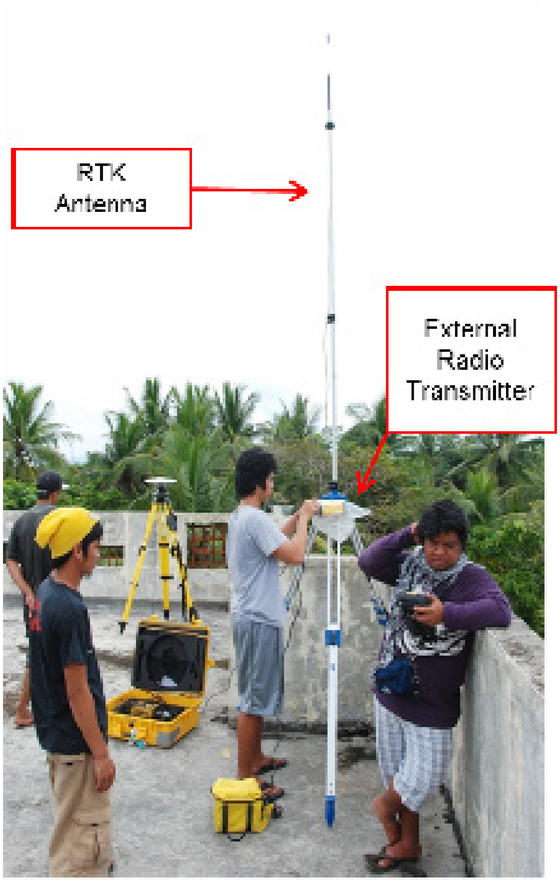


Figure 15. Static GNSS observation at San Nicholas

Figure 16. Static GNSS observation at Mangayawan

4.2 Cross-section Survey

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

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

Each cross-section lines were located using handheld GPS (Garmin Montana™ 650). Summary of reconnaissance for the 47 cross-sections are shown in detail in Annex E. Reconnaissance for profile lines were conducted simultaneously with the bathymetric surveys.

Actual gathering of cross-section point is shown in Figure 17 while data gathered is illustrated in Figure 18.

Figure 17. Cross-section teams conducting PPK GNSS survey

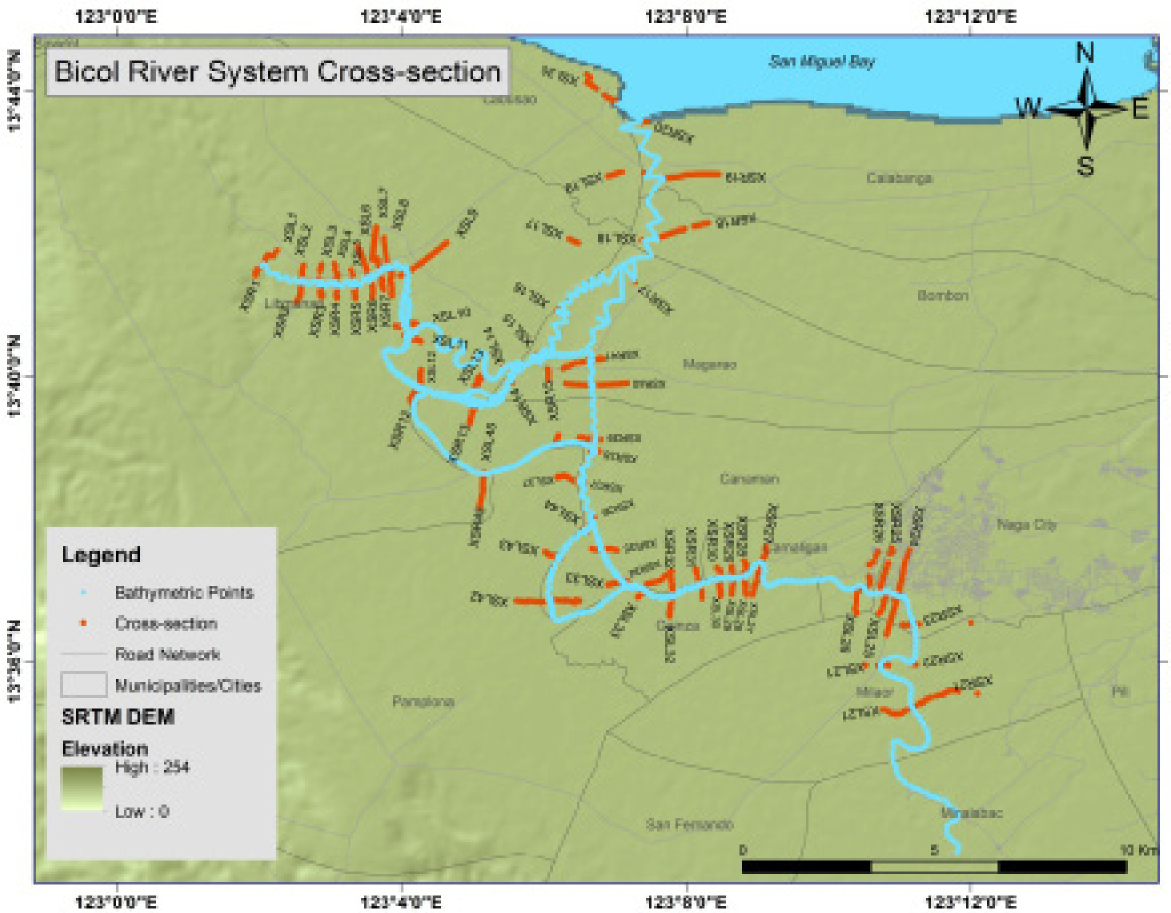


Figure 18. Cross-section data of Bicol River

4.3 Profile Survey

Another set of ground surveys were conducted along the banks of the river. The upper and lower banks were measured using MDL Dynascan™ (see Figure 19). This instrument utilizes laser and GNSS technology to take accurate 3D survey measurements. Dubbed as mobile mapping scanner (MMS), the MDL Dynascan™ was attached to the fishing boat with roof and scans as the boat traverse along the length of the river. The dual-antenna design of the MDL Dynascan™ provides both accurate positioning and heading of the instrument. A high-gain antenna was attached to the MDL Dynascan™ to improve the reception of the RTK corrections from the Mabolo (1), Mangayawan (2) and San Nicholas (3) base stations, respectively.

Figure 19. MDL Dynascan™ installed on one end of the boat for the river bank profile surveys of Bicol River

4. 4 Bathymetric Survey

The bathymetry of the river channel was surveyed using an echo sounding surveying technique. Differential GNSS surveying technique and an Ohmex™ single beam echo sounder were utilized in measuring the depth, eventually obtaining elevation with corresponding horizontal position. Bathymetry setup during the Bicol bathymetry survey is illustrated in Figure 20.

The entire bathymetry survey took eight (8) days to accomplish from September 11 to 13, 2013 for the centertline and September 16-20, 2013 for zigzag bathymetry. The Bathymetry Team executed the survey using a rubber boat borrowed from the Philippine Coast Guard (PCG) accompanied by three (3) coast guard personnel. Centerline and zigzag sweep of the survey were performed in order to fully capture the topography of the river as shown in Figure 21.

An approximate centerline length of 45.23 km and a zigzag sweep length of 98.45 km were covered starting from Brgy. San Miguel, Minlabac down to Brgy. Castillo, Cabusao illustrated in Figure 22.

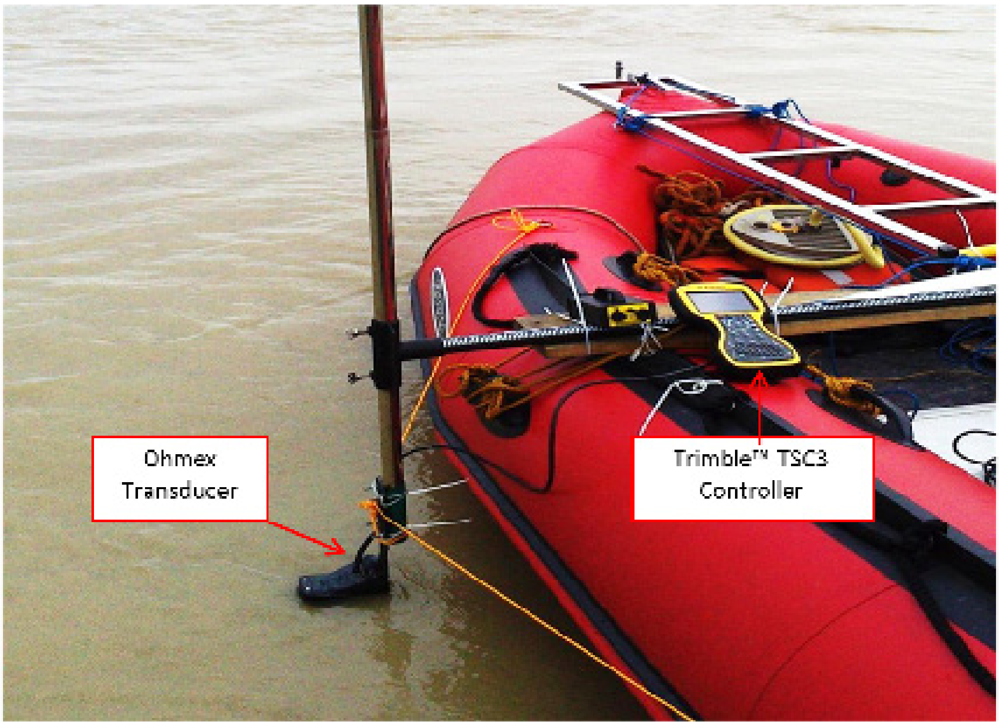


Figure 20. Bathymetric survey setup

Figure 21. Bathymetry team with the Philippine Coast Guard personnel

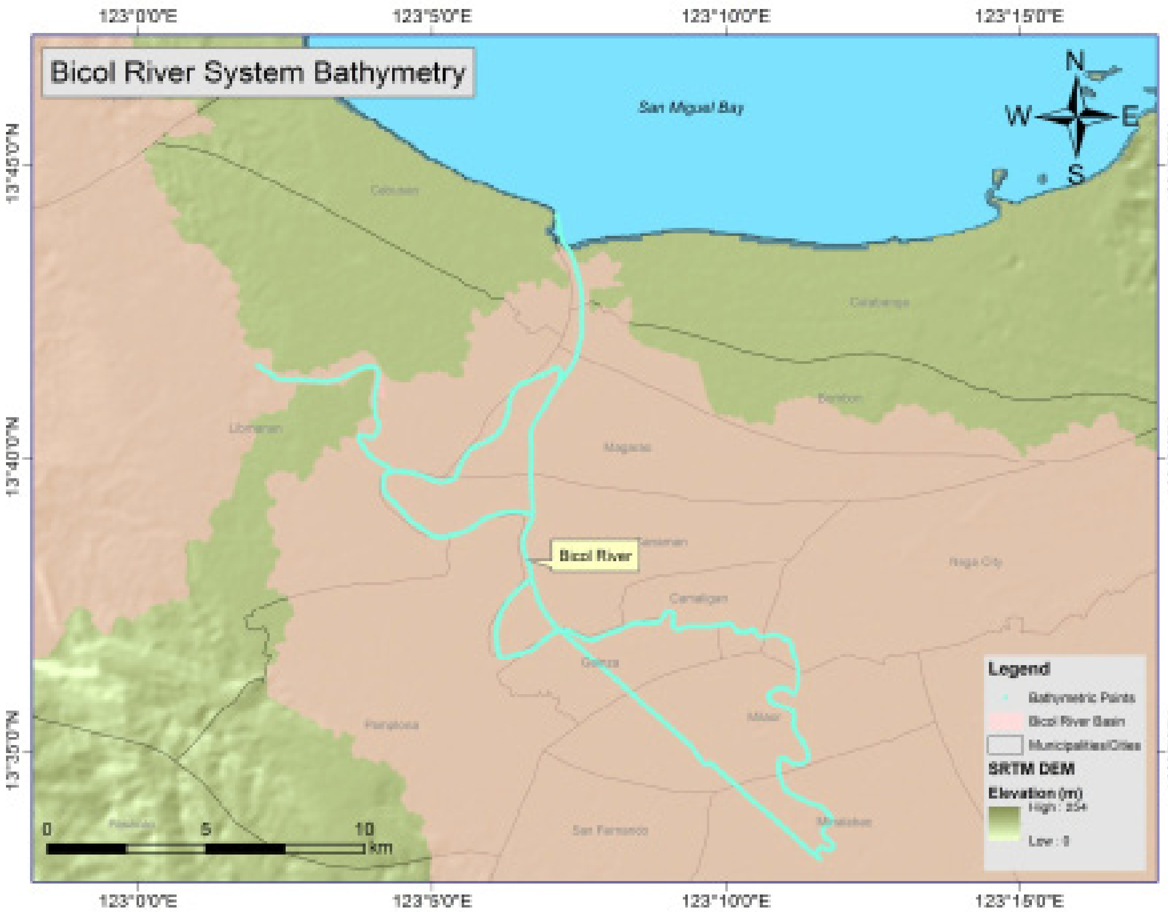


Figure 22. Bathymetric data in Bicol River

4.5 Hydrometric Survey

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

Data collection in Brgy Puro Batia, Libmanan using side looking ADCP for the 1st deployment on September 14-17, 2012 and 3rd deployment on September 18-22, 2012; Brgy. Barobaybay, Canaman on the 2nd deployment of side looking ADCP on September 23-28, 2012. For the deployment of vertical ADCP, Sitio Bagumbayan Minlabac on September 13-22, 2012 and Barangay Carigsa, Magarao on September 23-28, 2012. 1st Depth Gauge was deployed at Brgy. Puro Batia, Libmanan on September 14-28, 2012 and the 2nd Depth Gauge was deployed at Brgy. Castillo Cabusao on September 18-28, 2012. Rain Gauge deployment started on the 13th of September, 2012 and retrieved on the 23th of September, 2013 on Sitio Bagumbayan, Minalabac. The ADCP, depth gauge and rain gauge were monitored and its data downloaded on the day of retrieval.

The data gathered from rain gauge shows the distribution of rainfall within the observation period from April 24 to 30, 2013. Each sensor has five (5)-minute interval. The first surge of rain, which reached 1mm , was observed on April 24, 2013 at 1:35 pm. Highest amount of rain collected occurred on the 24th, 27th and 28th of April, 2013 at 2.2 mm. Relationships of data gathered within the observation period are illustrated Figure 23, 24, and 25.

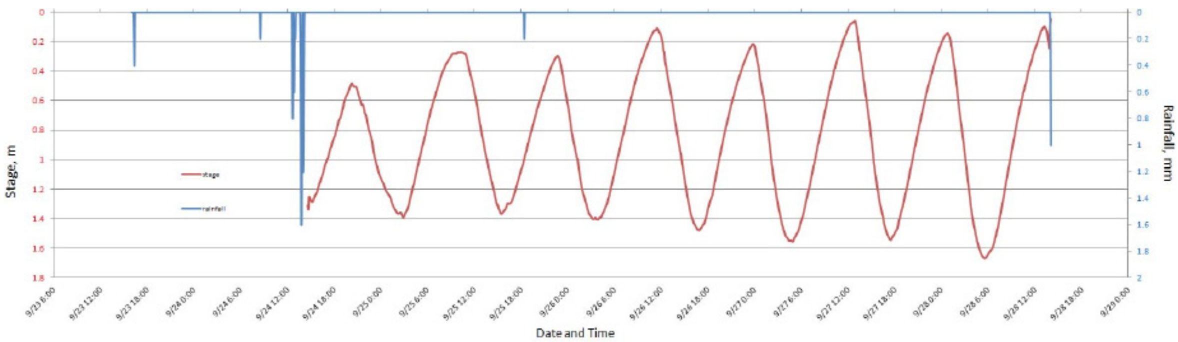


Figure 23. Relationship between stage and rainfall in Minalabac

The relationship of rainfall data gathered using rain gauge and stage from the deployed depth gauge in Brgy. Baras, Minlabac is shown in Figure 23.

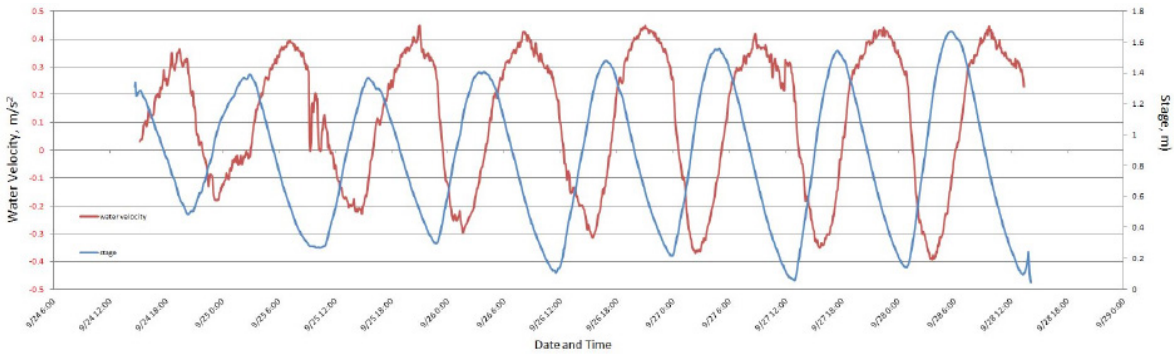


Figure 24. Relationship between velocity and stage in Minalabac

The relationship of velocity gathered using a vertical adcp and stage from the deployed depth gauge in Brgy. Baras, Minlabac is shown in Figure 24.

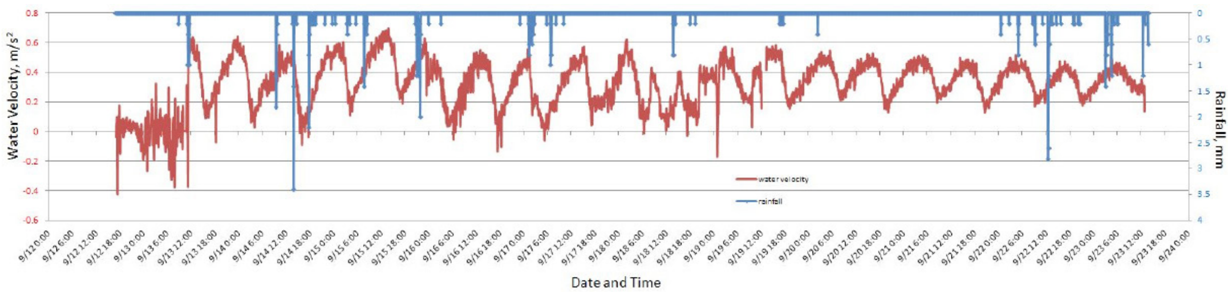


Figure 25. Relationship between velocity and rainfall in Minalabac

The relationship of rainfall data gathered using rain gauge and stage from the deployed depth gauge in Brgy. Baras, Minlabac is shown in Figure 25.

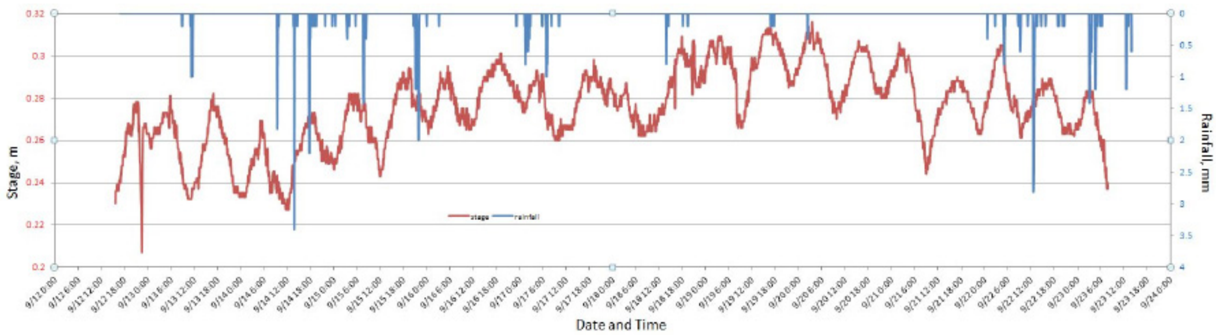


Figure 26. Relationship between stage and rainfall in Libmanan

The relationship of rainfall data gathered using rain gauge and stage from the deployed depth gauge in Brgy. Puro Batia, Libmanan is shown in Figure 26.

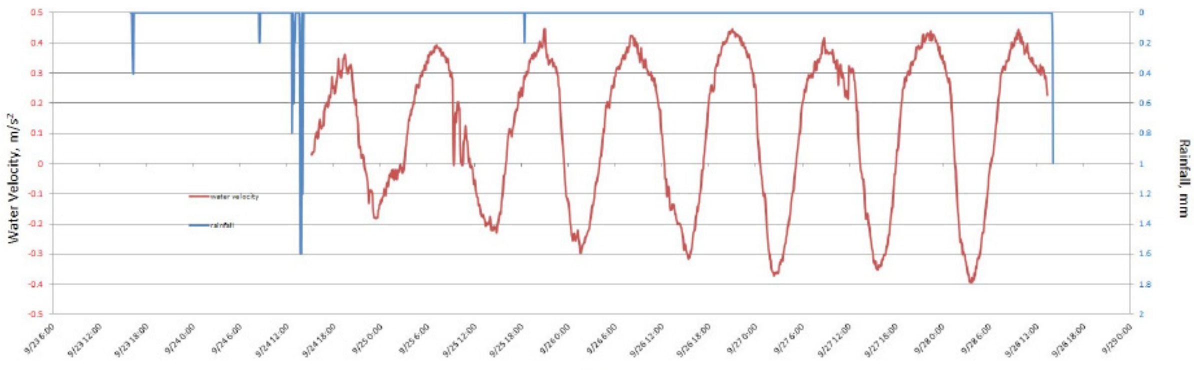


Figure 27. Relationship between velocity and rainfall in Libmanan

The relationship of rainfall data gathered using rain gauge and stage from the deployed depth gauge in Brgy. Puro Batia, Libmanan in Figure 27.

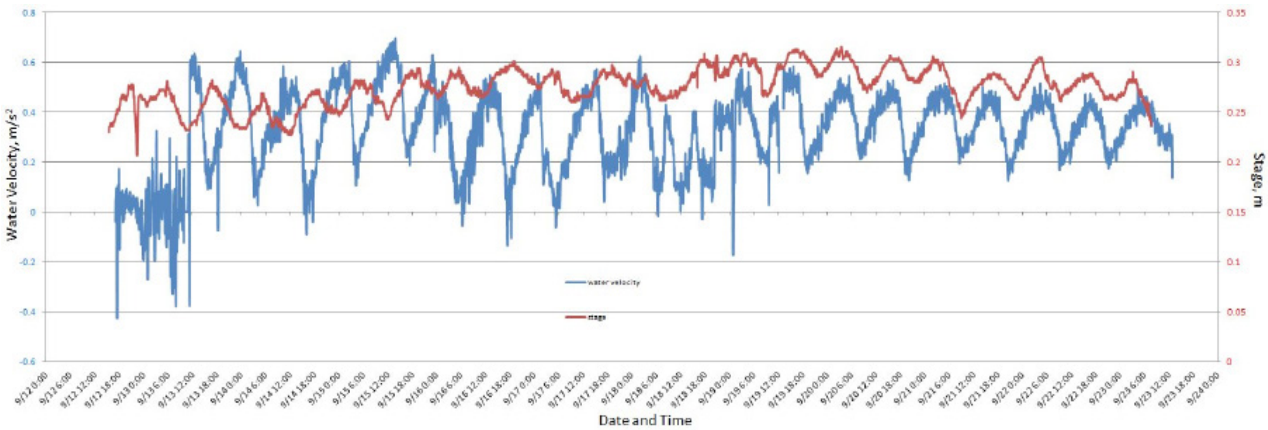


Figure 28. Relationship between stage and velocity in Libmanan

The relationship of velocity gathered using a vertical adcp and stage from the deployed depth gauge in Brgy. Puro Batia, Libmanan is shown in Figure 28.

The setup for sensors deployment is illustrated in Figures 29, 30 and 31.

Figure 29. Deployment of ADCP with Depth Gauge in Barangay Puro Batia, Libamanan

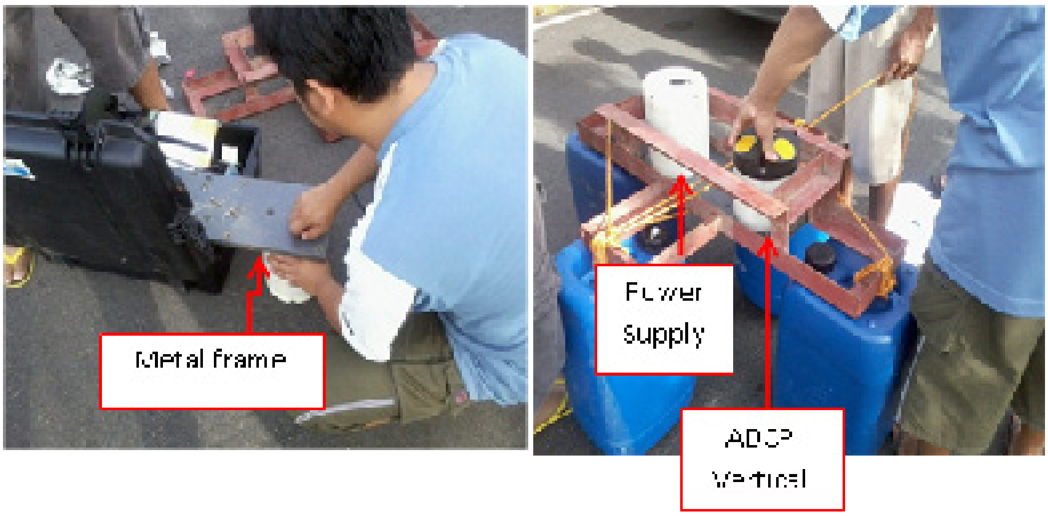


Figure 30. The Vertical ADCP deployed in Brgy. Baras. Minalabac

Figure 31. Rain gauge deployment in Zone 3 Sitio Bagumbayan, Minlabac

The summary of location of sensor deployment are shown in Table 2 and Figure 32.

Table 2. Deployment of sensors along Bicol River in Bicol Region

Sensor	Location	Deployment	Retrieval	Latitude	Longitude
ADCP Side Looking and Depth Gauge (1)	Brgy. Puro Batia, Libmanan	September 14, 2012	September 17, 2012	13°41'23.93"N	123° 2'24.54"E
ADCP Side Looking 2nd Deployment	Barangay Barobaybay, Canaman	September 18, 2012	September 22, 2012	13°39'30.81"N	123° 6'37.88"E
ADCP Side Looking 3rd Deployment	Barangay Puro Batia, Libmanan	September 23, 2012	September 28, 2012	13°41'23.93"N	123° 2'24.54"E
ADCP Vertical 1st Deployment	Sitio Bagumbayan, Minlabac	September 13, 2012	September 22, 2012	13°33'9.18"N	123°11'33.61"E
ADCP Vertical 2nd Deployment	Barangay Carigsa, Magarao	September 23, 2012	September 28, 2012	13°41'15.50"N	123° 7'11.63"E
Rain Gauge	Sitio Bagumbayan, Zone 3Minlabac	September 13, 2012	September 23, 2012	13°33'9.18"N	123°11'33.61"E
Depth Gauge 1	Brgy. Puro Batia, Libmanan	September 14, 2012	September 28, 2012	13°41'23.93"N	123° 2'24.54"E
Depth Gauge 2	Barangay Castillo, Cabusao	September 18, 2012	September 28, 2012	13°41'23.93"N	123° 2'24.54"E

Figure 32. Location of Sensors in Bicol River

4.5.1 AWLS Survey

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

Cross-section survey of 11 bridges with installed AWLS was conducted on November 27 – December 7, 2013 and for bridge as-built determination was conducted from April 30, 2014 – May 5, 2014 with deployed flow meter. Depth gauges were also deployed at Don Mariano Bridge in the Municipality of Bula from April 29, 2014 until its retrieval on May 5, 2014 and Padre Garcia Bridge in Naga City from April 30, 2014 until its retrieval on May 5, 2014. However, the team was only able to gather flow for the river with no precipitation occurred throughout the duration of the survey.

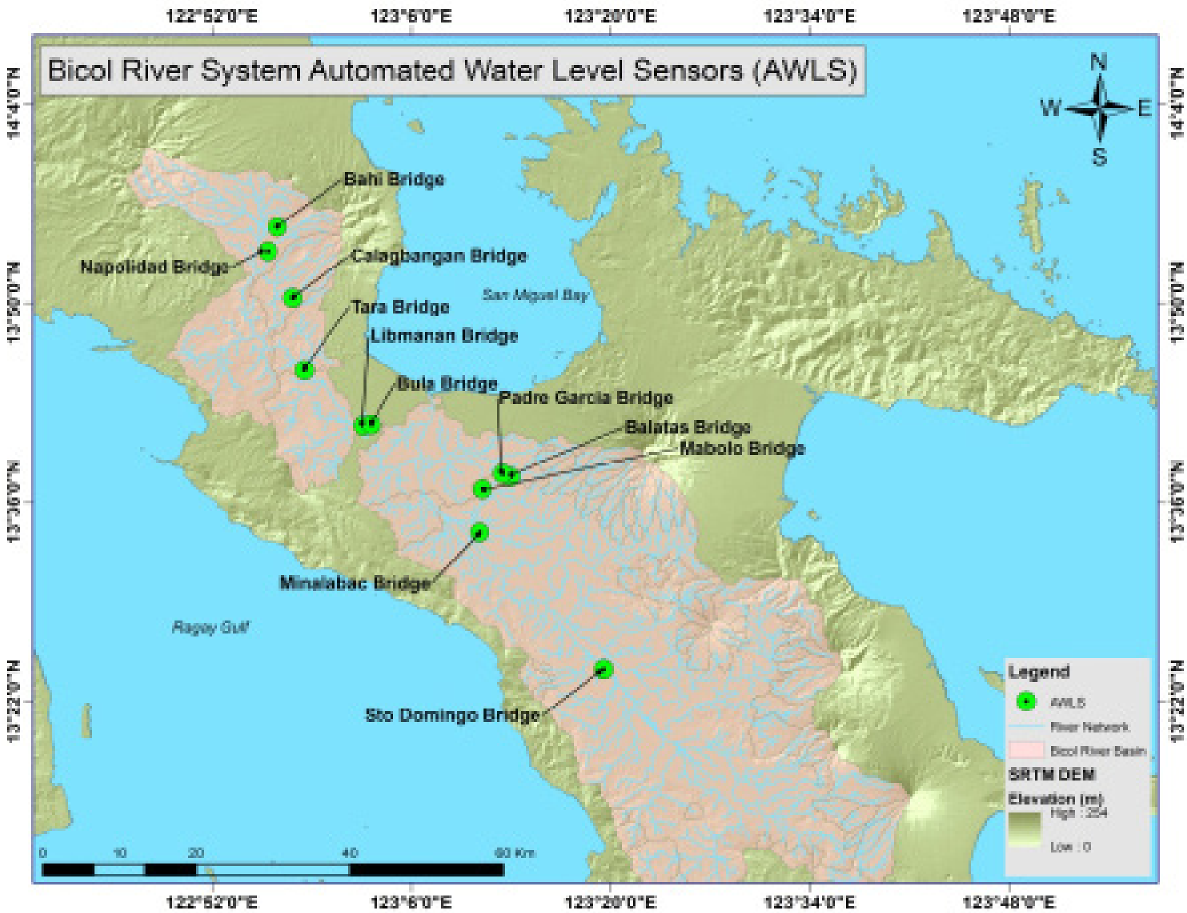
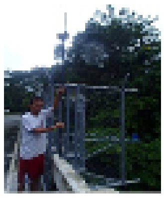
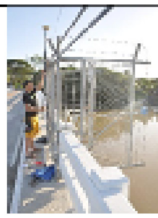
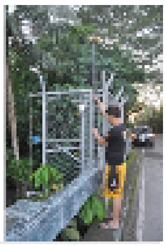


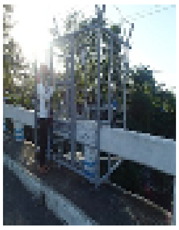
Figure 33. Location of AWLS in Bicol River

4.5.1.1 Cross-section Survey

Summary of eleven (11) bridges with AWLS in Bicol River with corresponding coordinates, date and time of elevation determination and duration of flow data gathering, and images are shown in Table 3:

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

LOCATION	COORDINATES	WATER SURFACE ELEVATION, (MSL)	VELOCITY CAPTURING DURATION	ELEVATION OF AWLS, (MSL)	IMAGES
Bahi Bridge	Lat 14 55 16.41344 N Long 122-56-34.18537 E	87.[illegible] m (Nov. 30, 2013 at 12:37 PM)	Nov. 29, 2013 At 12:00 NN 4:00 PM 4 hours using flow meter	101.656 m	
Balatas Bridge	Lat 12-48-05.06270 N Long 12[illegible] 28 20.[illegible] E	17.866 m (Dec. 1 2013 at 12:06 PM)	Dec. 1 2013 At 10:00 AM-1:00 PM 3 hours using flow meter	18.126 m	
Bulaong Bridge	Lat 13 41 19.9[illegible] N Long 12[illegible]-02-16.[illegible] E	4.791 m (Dec. 1, 2013 at 1:54 PM)	Dec. 1 2013 At 2:30 PM – 4:30 PM 2 hours using flow meter	11.864 m	
Calagbangan Bridge/Pan Philippine Highway 2	Lat 13 56 26.62403 N Long 123-57-40 [illegible]1949 E	9.403 m (Nov. 29, 2013 at 12:40 PM)	Nov. 29 2013 At 1:10 PM 3:50 PM 2.67 hours using flow meter	15.[illegible] m	
Libmanan Bridge	Lat13-41-25.67316 N Long 123 03 11.35330 E	5.178 m (Dec. 1, 2013 at 5:00 PM	Nov. 30 2013 At 2:00 PM – 5:00 PM 3 hours using flow meter	9.879 m	
Malualo Bridge/Pan Philippine Highway	Lat 14 46 51.85[illegible] N Long 123-10-54.74273 E	1.894 m (Dec. 6 2014 at 1:14 PM)	Dec. 1 2013 At 9:00 AM 12 NN & 1:00 PM – 4:00 pm 6 hours using flow meter	8.873 m	
Minalabac	Lat 13 33 52.54538 N Long 123 10 47.1462 E	2.909 m (Dec. 2, 2013 at 9:55 AM)	Dec. 2 2013 At 9:00 AM 12:00 PM 3 hours using flow meter	8.528 m	

LOCATION	COORDINATES	WATER SURFACE ELEVATION, (MSL)	VELOCITY CAPTURING DURATION	ELEVATION OF AWLS, (MSL)	IMAGES
Napolidan Bridge/Pan Philippine Highway 1	Lat 13 53 36.24089 N Long 122 55 51.61070 E	5.572 m (Nov. 30, 2013 at 4:41 PM)	Dec 1, 2013 At 11:05 AM – 1:05 PM 2 hours using flow meter	70.458 m	
Padre Garcia	Lat 13-38-00.27411 N Long 12[illegible]-25.[illegible] E	3.662 m (Dec. 1 2013 at 4:43 PM)	Dec 1 2013 3:00-5:00 PM 2 hours Dec 4 2013 At 1:00 PM – 5:00 PM 4 hours Dec 5 & 6 2013 At 9:00 AM-12:NN & 1:00 PM – 5:00 PM 14 hours Total = 20 hrs using flow meter	14.938 m	
Sto. Domingo Bridge	Lat 13-24-15.00427 N Long 123 19 31.61608 E	8.162 m (Dec. 3 2013 at 10:31 AM	Dec. 3 2013 At 10:00 AM-1:00 PM 3 hours using flow meter	14.168 m	
Iara Bridge	Lat 13-45-15.58071 N Long 122-56-29.2400 E	19.3 m (Dec. 2 2013 at 4:06 PM)	Nov. 28 to December 10, 2013 using ADCP (Side Looking)	75.05 m	

The images in Figure 34-45 shows the cross-sectional diagram with water level elevation and installed AWLS referred to MSL.

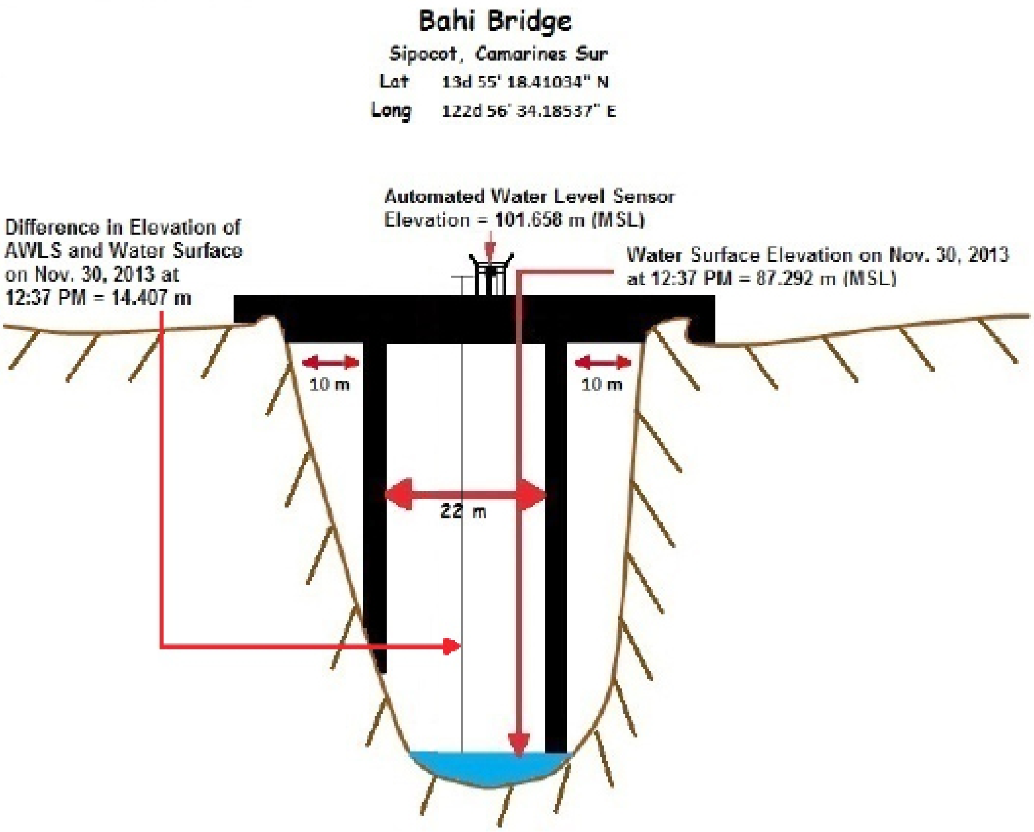


Figure 34. Cross-section diagram of Bahi Bridge

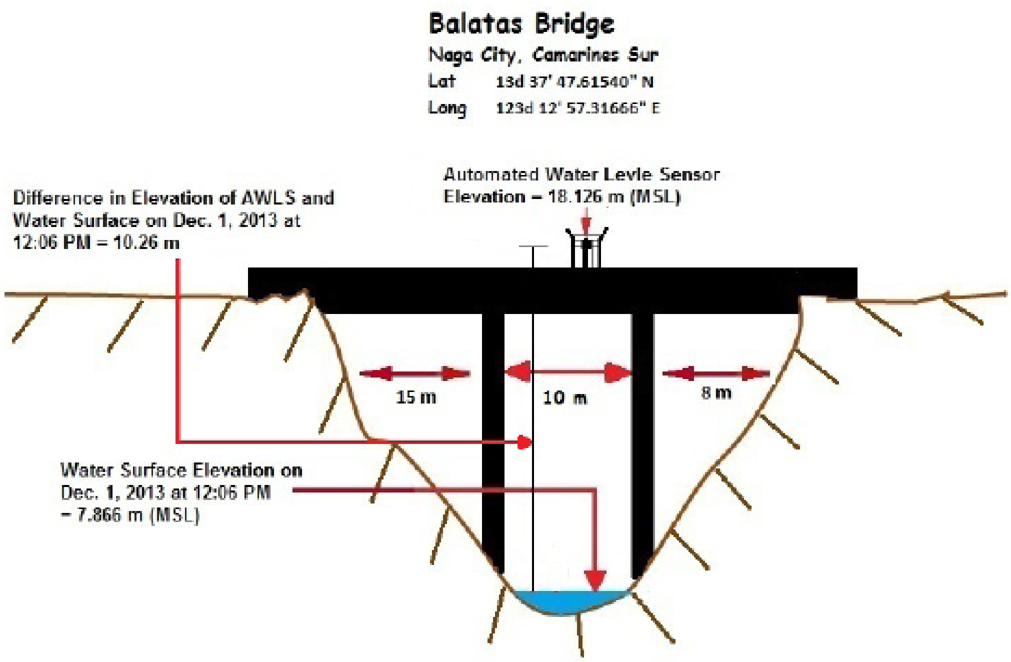


Figure 35. Cross-section diagram of Balatas Bridge

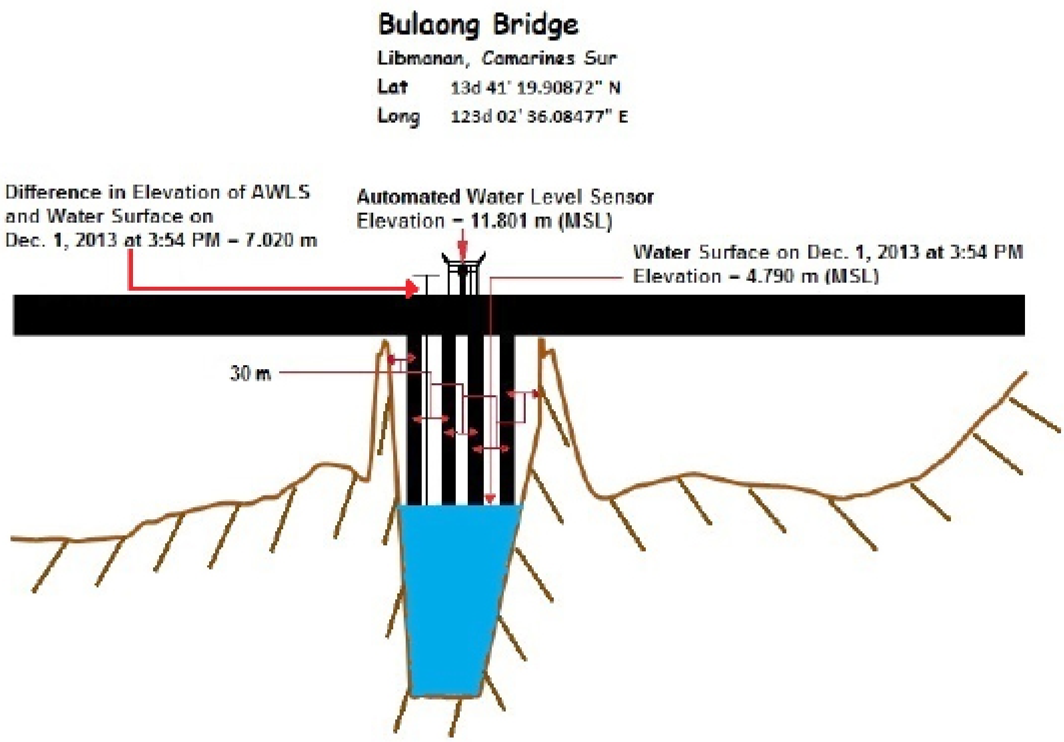


Figure 36. Cross-section diagram of Bulaong Bridge

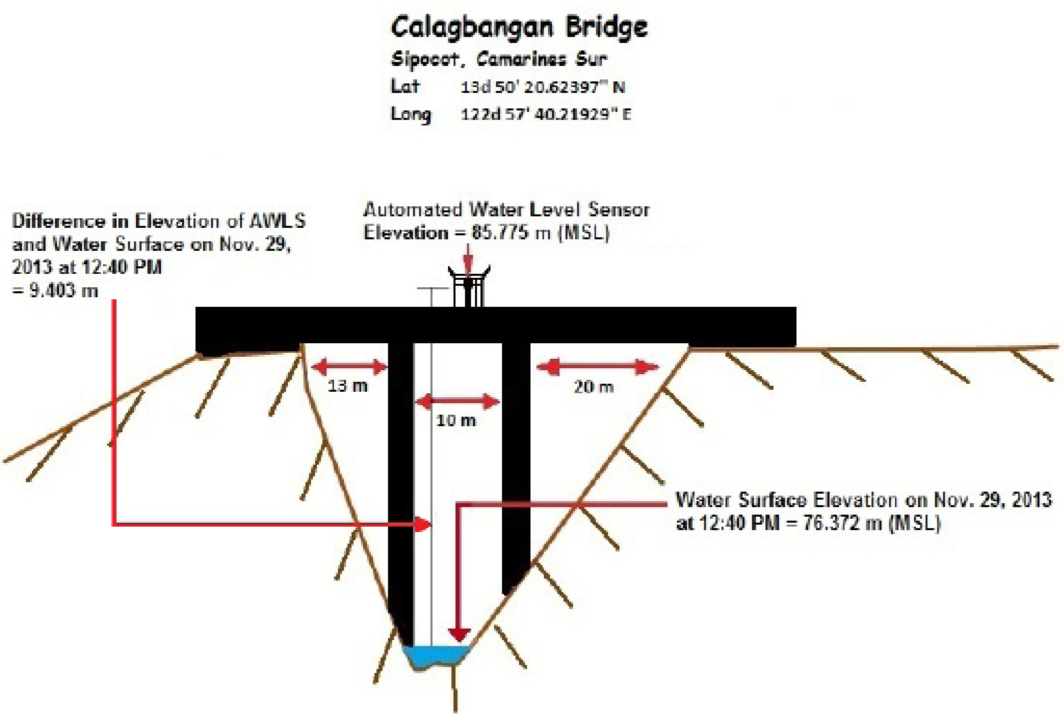


Figure 37. Cross-section diagram of Calagbangan Bridge

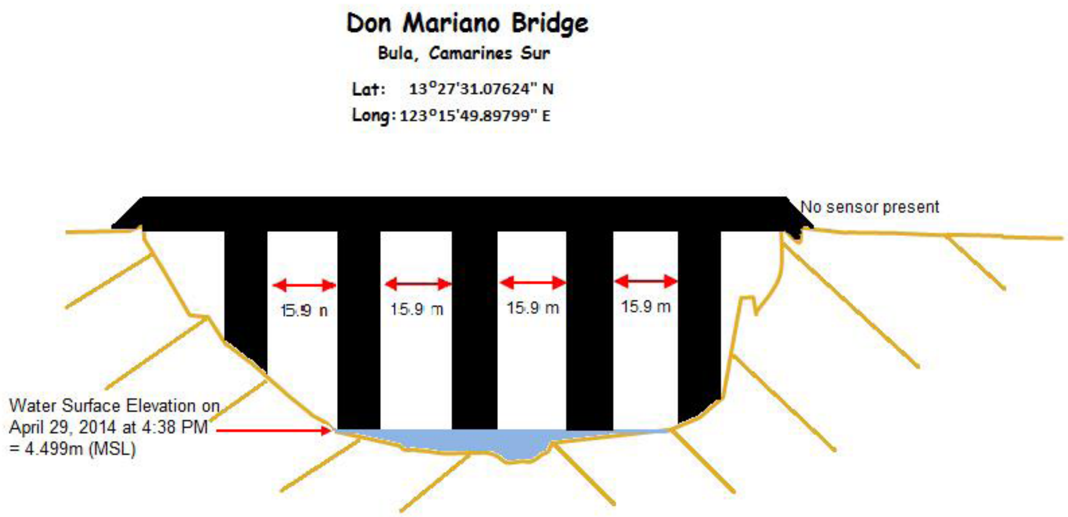


Figure 38. Cross-section diagram of Don Mariano Bridge

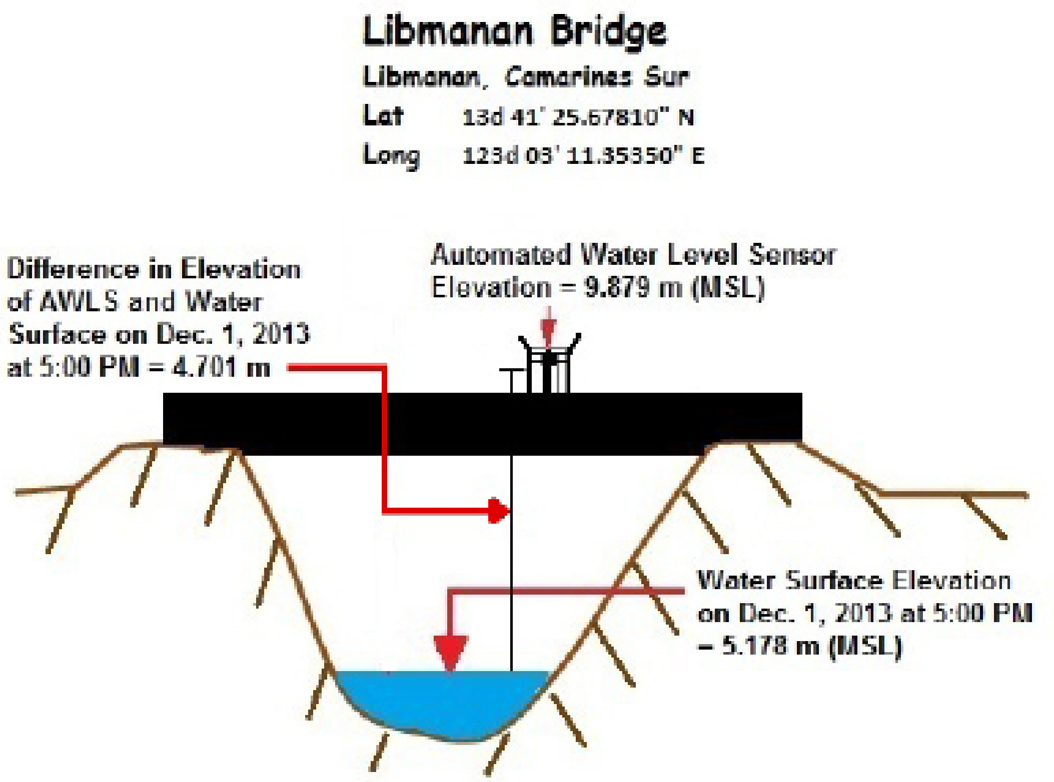


Figure 39. Cross-section diagram of Libmanan Bridge

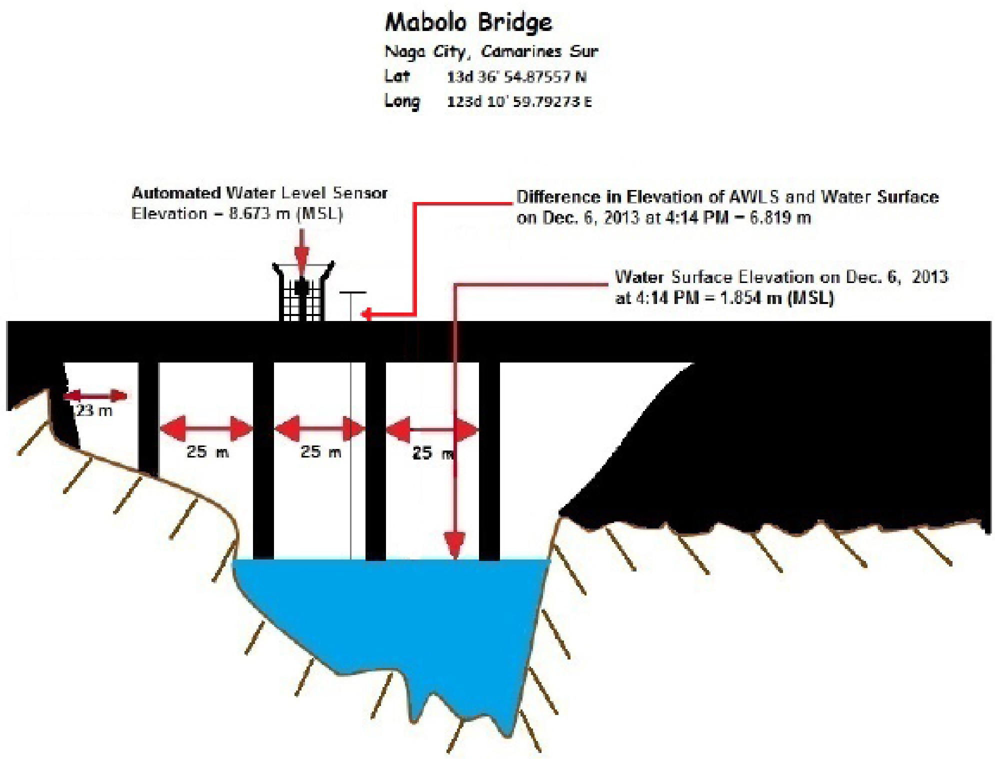


Figure 40. Cross-section diagram of Mabolo Bridge

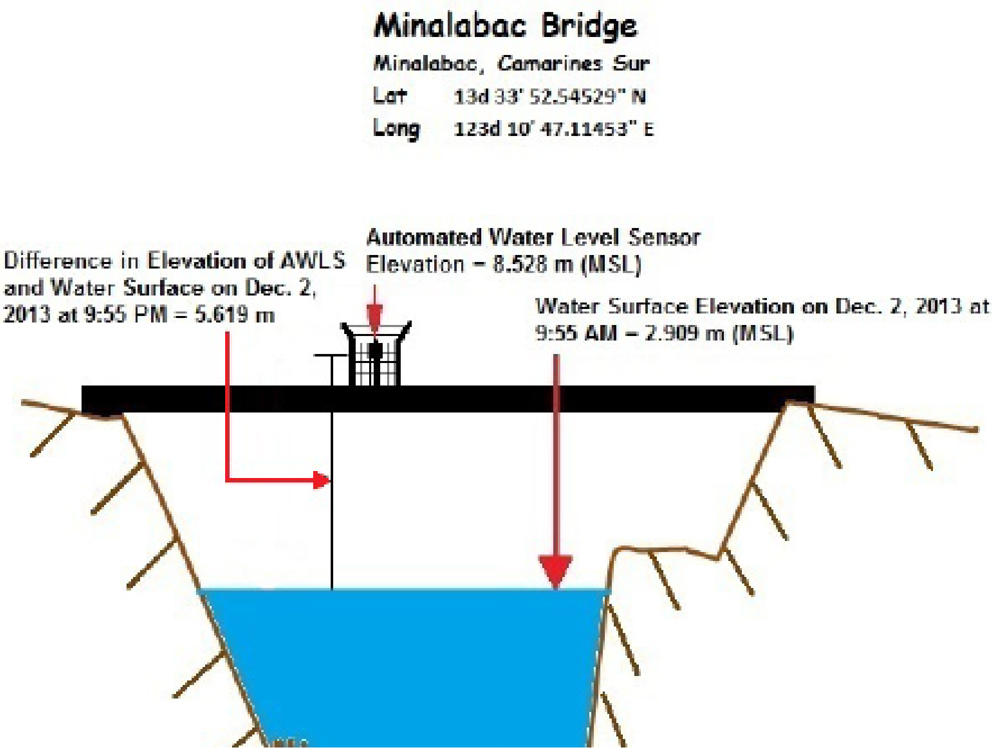


Figure 41. Cross-section diagram of Minlabac Bridge

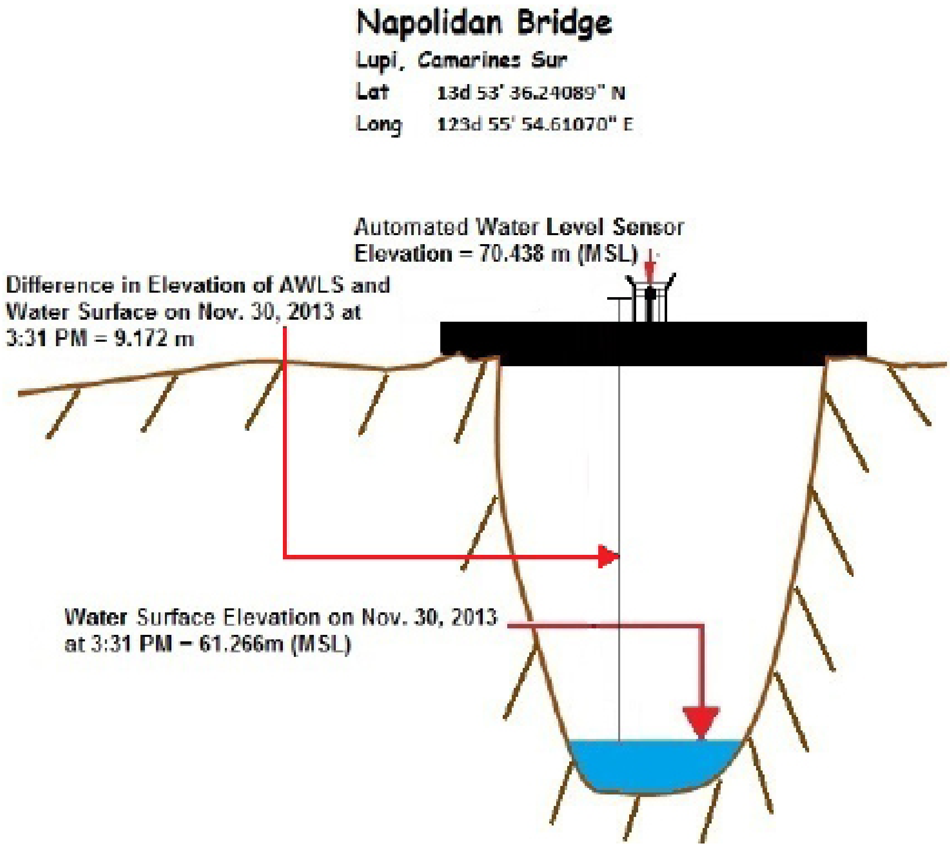


Figure 42. Cross-section diagram of Napolidan Bridge

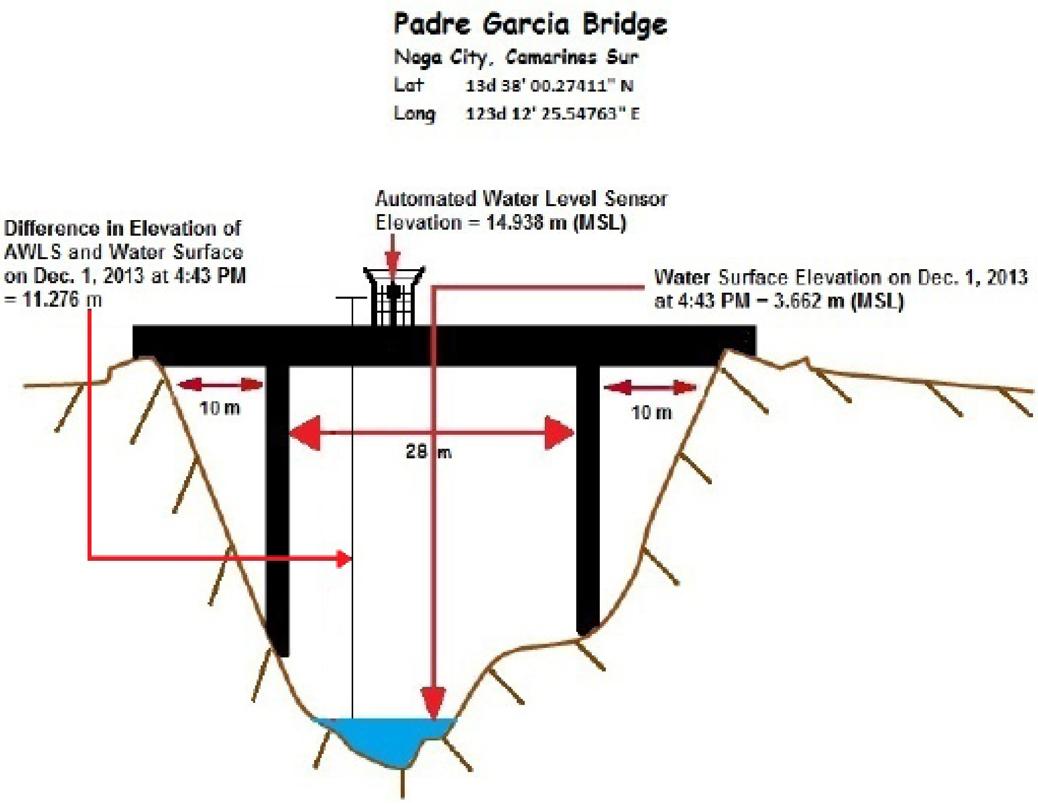


Figure 43. Cross-section diagram of Padre Garcia Bridge

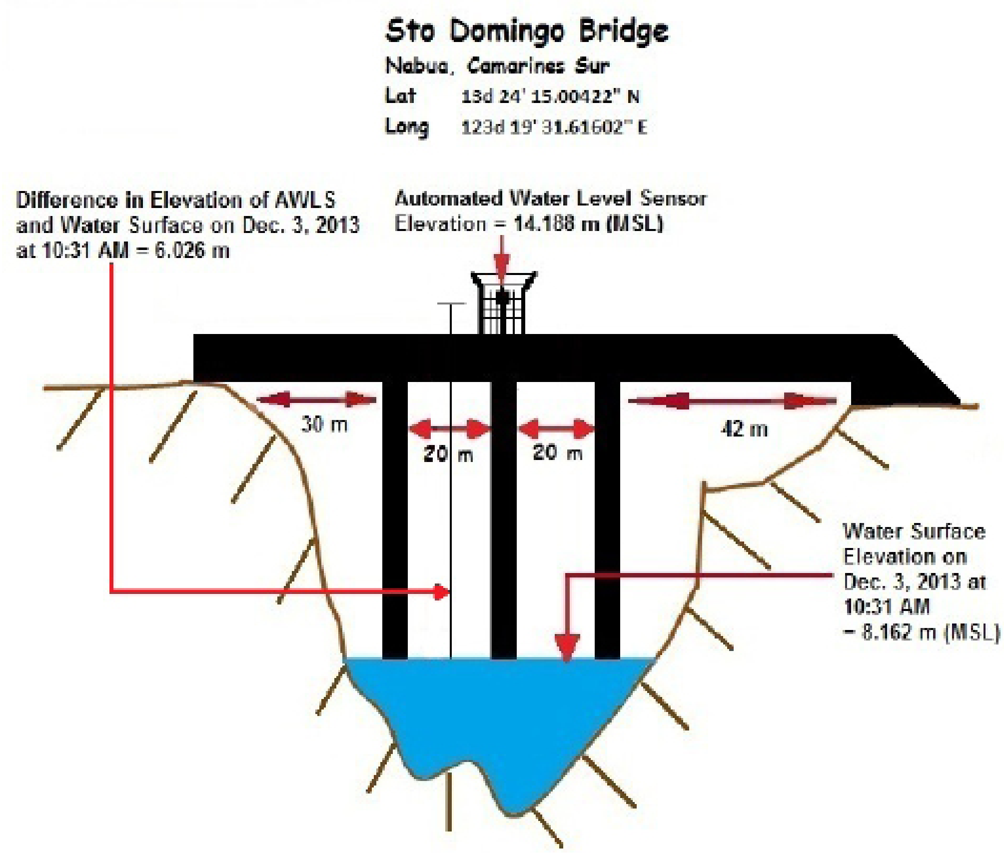


Figure 44. Cross-section diagram of Sto. Domingo Bridge

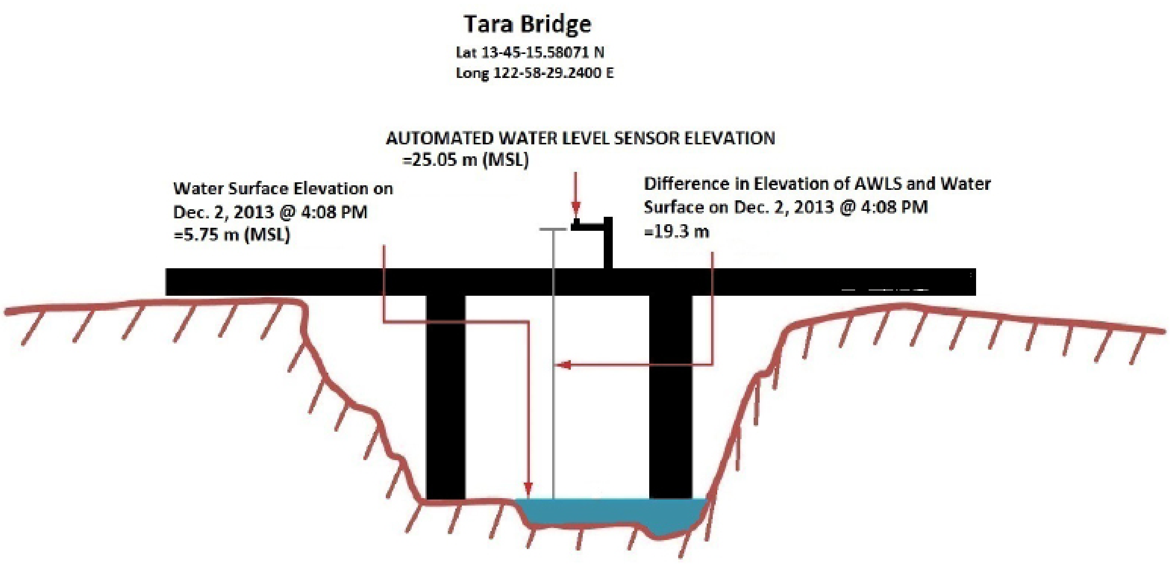


Figure 45. Cross-section diagram of Tara Bridge

4.5.1.2 Flow Measurement

Two local hires living within the vicinity of the bridge were employed to gather flow measurements. Two types of events are needed by the team – (1) base flow or the normal stream flow, without the influence of a precipitation. In this scenario, local hires were tasked to record the velocity of the river for three hours each in the morning and afternoon for a single day; and (2) the flow of the river during the occurrence of a rain event. The survey team needed at least two rainfall events prior retrieval of the flow meters. In this type of event, the water velocity was recorded for six-hours straight while precipitation was on-going, day and night. Continuous recording of flow measurements were done until two rain events were observed. However, the team was only able to gather flow for the river with no precipitation occurred throughout the duration of the survey. The images in Figure 46-47 shows the team instructing the local hires on using flow meter.

Figure 46. Instructing local hires how to gather flow data in Bula Bridge

Figure 47. Flow measurements in Padre Garcia Bridge using Flow Probe FP111

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

Table 4. Summary of Bicol River System AWLS Field Survey

Bridges	Cross Section	Water Level	Flow Measurement	Rainfall	Remarks
A. Bahi	✓	✓	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
B. Balatas	✓	No data from repo.pscigrid.gov.ph	✓	No data from repo.pscigrid.gov.ph	No water level and rainfall data from repo.pscigrid.gov.ph; Flow measurement is not applicable within the observation period.
C. Bulaong	✓	No data from repo.pscigrid.gov.ph	✓	No data from repo.pscigrid.gov.ph	No rainfall and water level data from repo.pscigrid.gov.ph within the observation period.
D. Calaban-gan	✓	✓	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
E. Libmanan	✓	✓	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
F. Mabolo	✓	No data from repo.pscigrid.gov.ph	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
G. Minalabac	✓	No data from repo.pscigrid.gov.ph	✓	✓	No rainfall data from repo.pscigrid.gov.ph within the observation period.
H. Napoli-dan	✓	✓	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
I. Padre Garcia	✓	✓	✓	✓	
J. Sto. Domi-go	✓	No data from repo.pscigrid.gov.ph	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
K. Tara	✓	Depth gauge from DVC	ADCP	✓	Used ADCP side looking

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

A. Sensor graph of Bahi Bridge

The relationship of water velocity data using flow meter deployed on November 29, 2014 and the water level during the sensor deployment is shown in Figure 48. Note: No rainfall data from repo.pscigrid.gov.ph at Bahi Bridge.

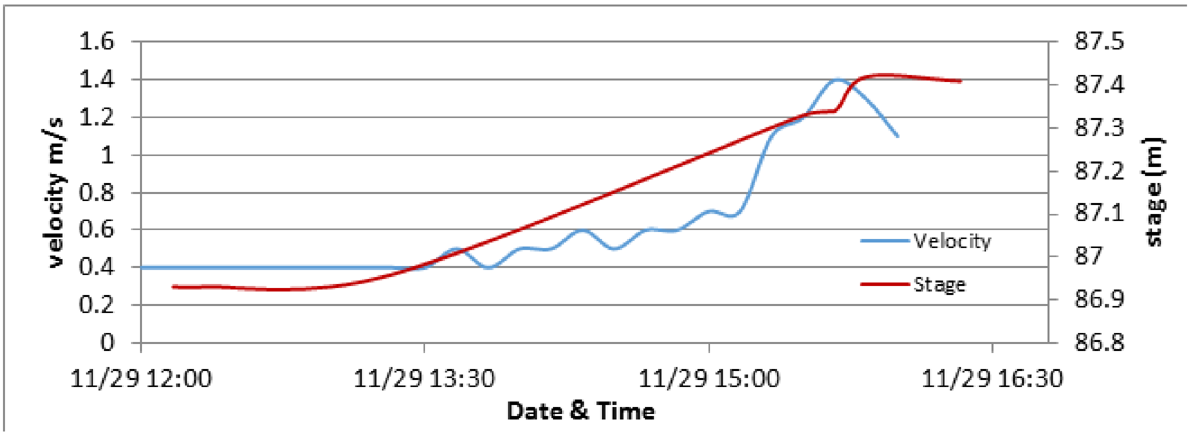


Figure 48. Water velocity and Stage at Bahi Bridge within the observation period.

The relationship between stage and discharge for November 29, 2013 resulted to an R2 of .9997 is shown in Figure 49.

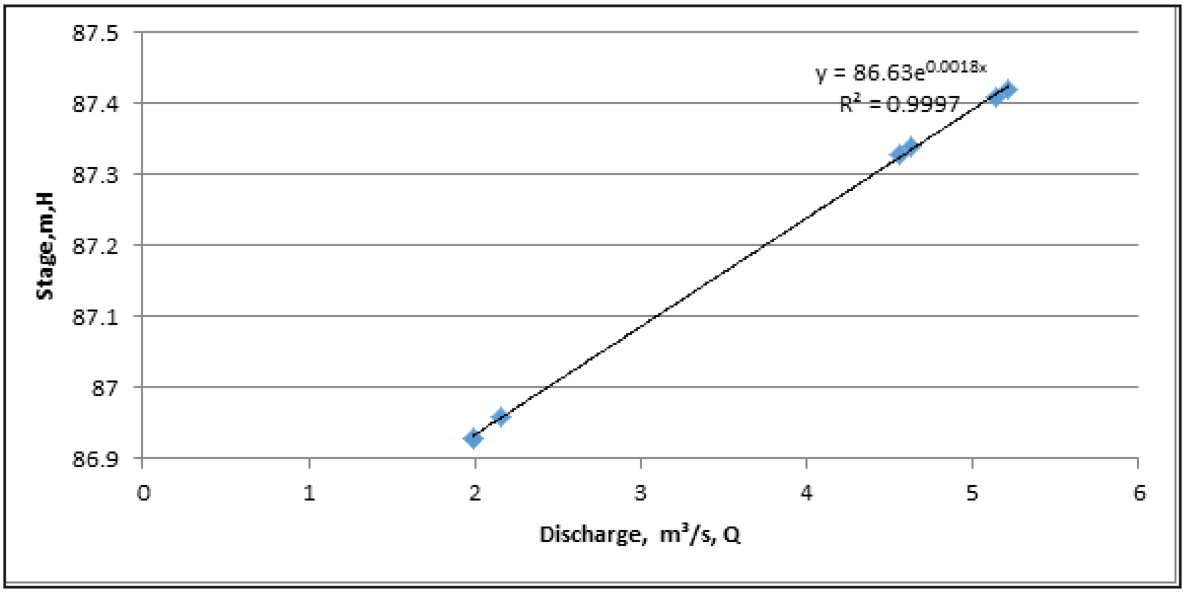


Figure 49. Scatter plot of discharge vs. stage at Bahi Bridge, Brgy. Tuaca, Basud, Camarines Norte

B. Balatas Bridge sensor graph

Water velocity data using flow meter deployed on December 1, 2014 is shown in Figure 50. Note: No water level and rainfall data from repo.pscigrid.gov.ph at Balatas Bridge.

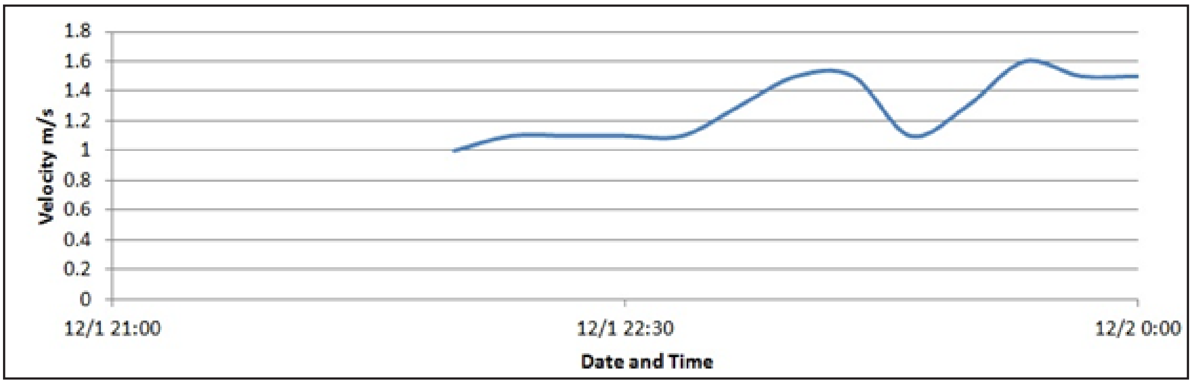


Figure 50. Velocity at Balatas Bridge River with respect to date and time

C. Bulaong Bridge sensor graph

Water velocity data using flow meter deployed on December 1, 2014 is shown in Figure 51. Note: No water level and rainfall data from repo.pscigrid.gov.ph at Bulaong Bridge.

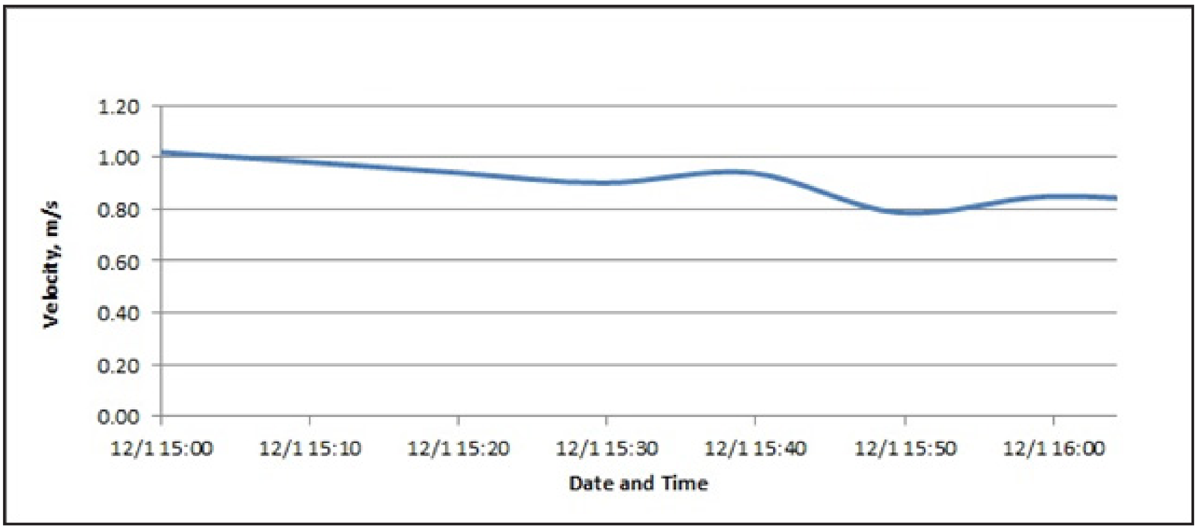


Figure 51. Velocity at Bulaong Bridge River with respect to date and time

D. Calagbangan Bridge sensor graph

The relationship of water velocity data using flow meter deployed on November 29, 2014 and the water level during the sensor deployment is shown in Figure 52. Note: No rainfall data from repo.pscigrid.gov.ph at Calagbangan Bridge.

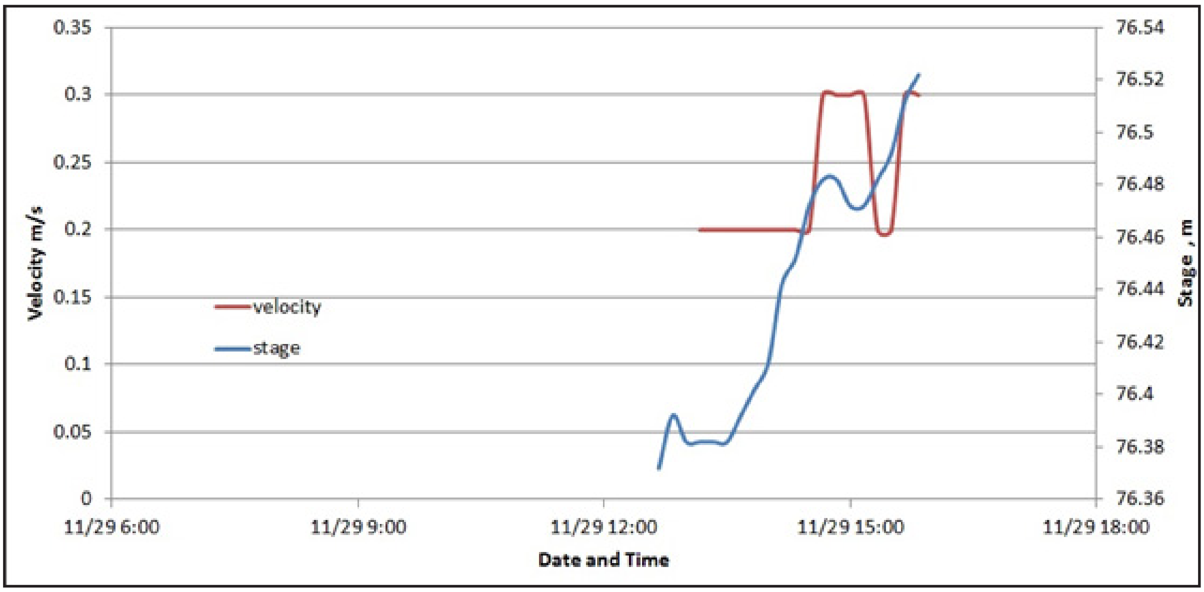


Figure 52. Water velocity and stage at Calagbangan Bridge within the observation period.

The relationship between stage and discharge for November 29, 2013 resulted to an R2 of 0.9999 is shown in Figure 53.

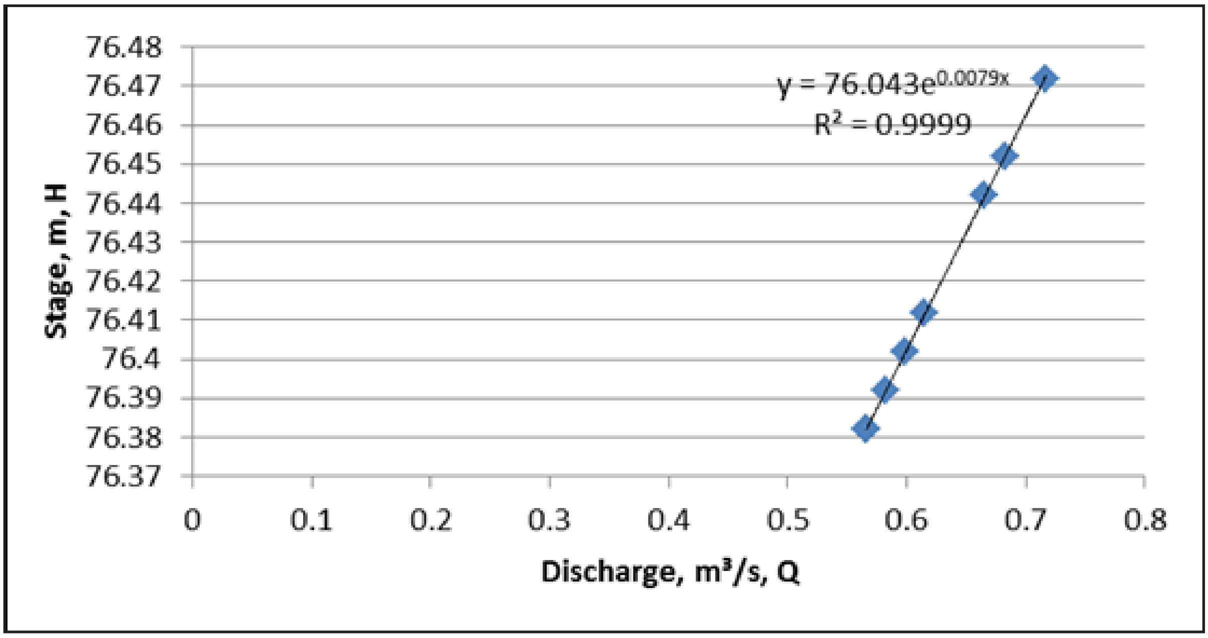


Figure 53. Scatter plot of discharge vs. stage at Calagbangan Bridge, Brgy. Vigaan, Sipocot, Camarines Sur within the observation period.

E. Libmanan Bridge sensor graph

The relationship of water velocity data using flow meter deployed on November30, 2014 and the water level during the sensor deployment is shown in Figure 54. Note: No data of rainfall from repo.pscigrid.gov.ph at Libmanan Bridge.

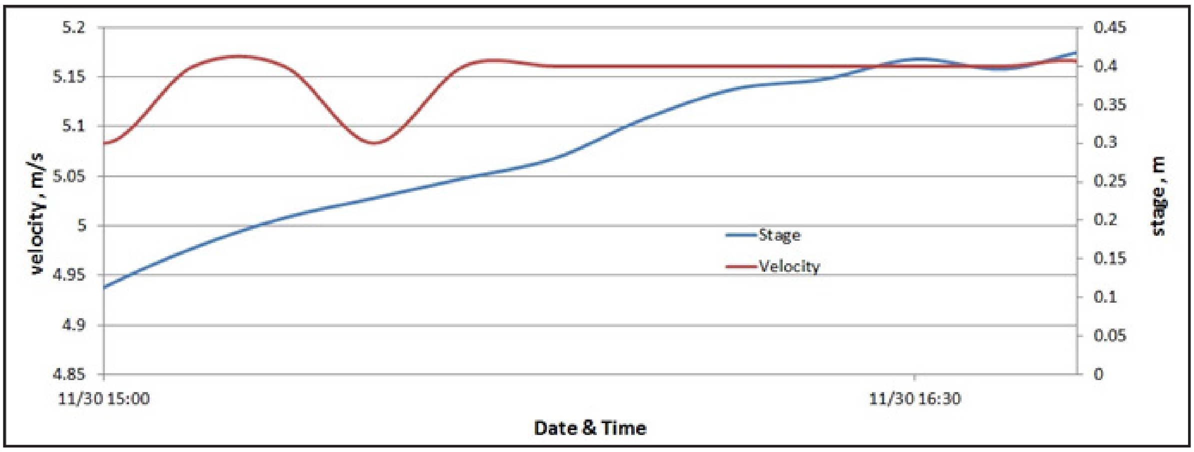


Figure 54. Water velocity and stage within the observation period.

The relationship between stage and discharge for November 30, 2013 resulted to an R2 of 0.9744 is shown in Figure 55.

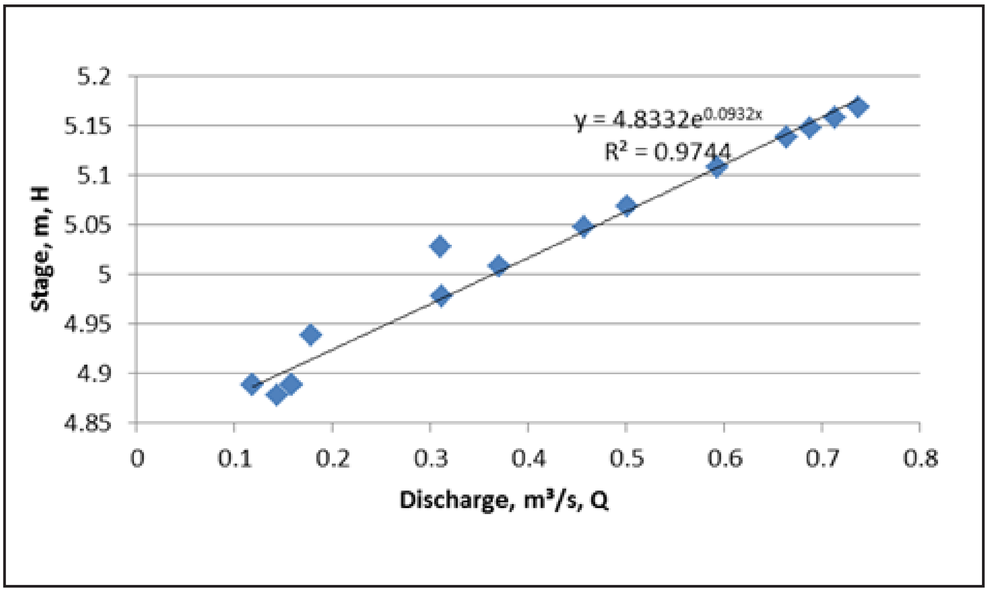


Figure 55. Scatter plot of discharge vs. stage at Libmanan Bridge, Brgy. Taban Fundanao Libmanan, Camarines Sur

F. Mabolo Bridge sensor graph

Water velocity data using flow meter deployed on December 1, 2014 is shown in Figure 56. Note: No water level and rainfall data from repo.pscigrid.gov.ph at Mabolo Bridge.

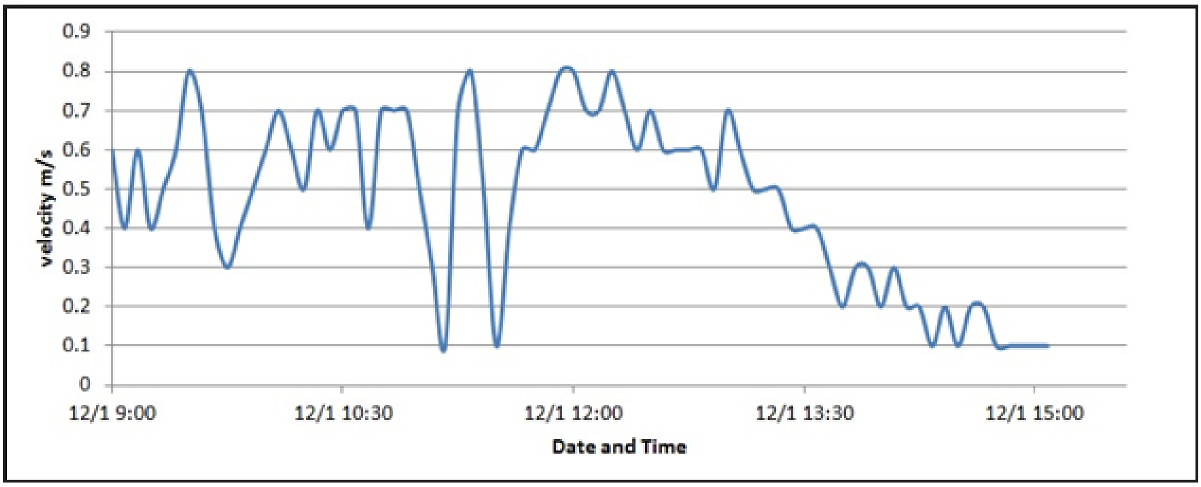


Figure 56. Velocity at Mabolo Bridge River with respect to date and time

G. Minlabac Bridge sensor graph

Water velocity data using flow meter deployed on December 1, 2014 is shown in Figure 57. Note: No water level and rainfall data from repo.pscigrid.gov.ph at Minalabac Bridge.

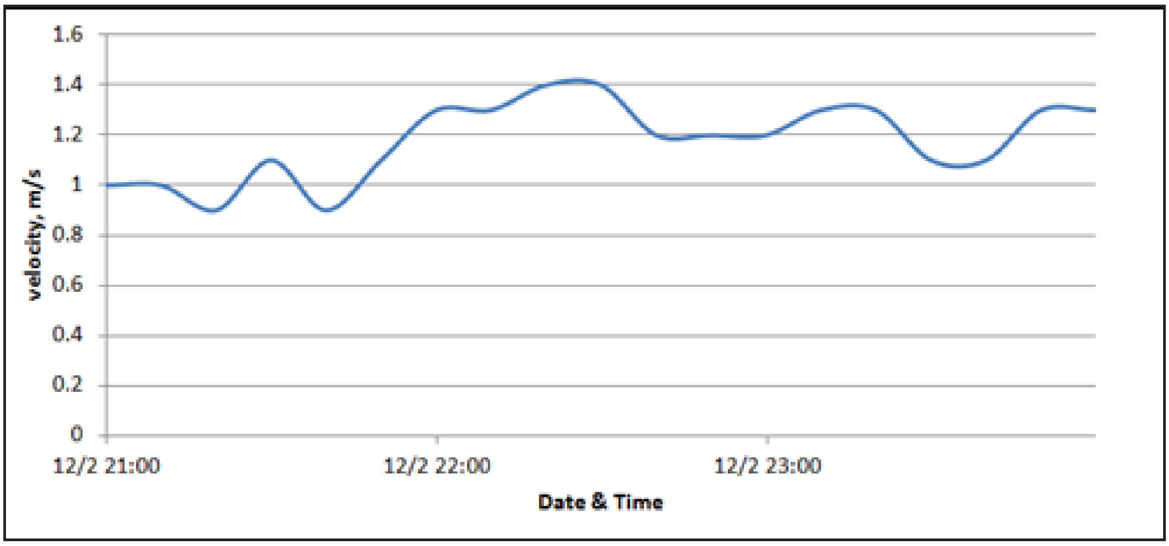


Figure 57. Minalabac Bridge velocity with respect to date and time

H. Napolidan Bridge sensor graph

The relationship of water velocity data using flow meter deployed on November 30 to December 6, 2014 and the water level during the sensor deployment is shown in Figure 58. Note: No rainfall data from repo.pscigrid.gov.ph at Napolidan Bridge.

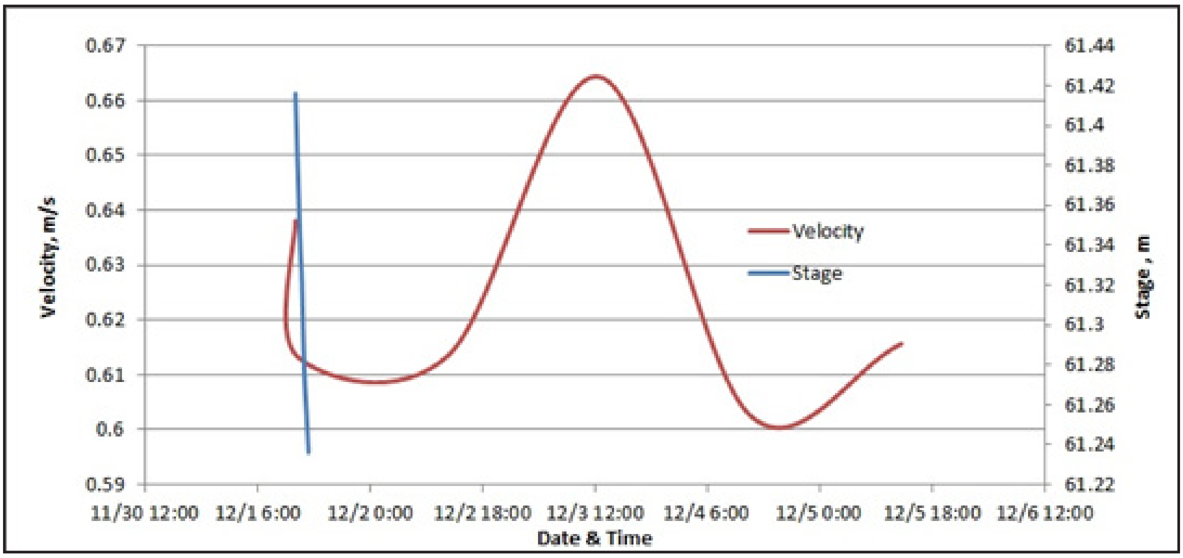


Figure 58. Relationship between water velocity and stage within the observation period.

The relationship between stage and discharge for November 29, 2013 resulted to an R2 of 0.9002 is shown in Figure 59.

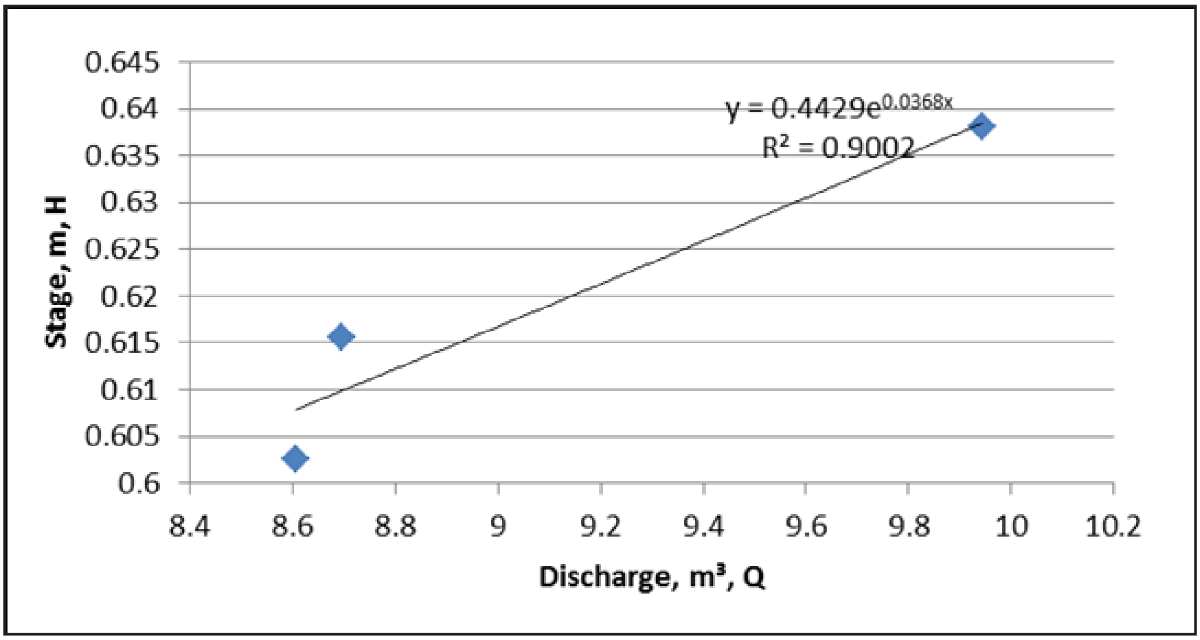


Figure 59. Scatter plot of discharge vs. stage at Napolidan Bridge, Brgy. Napolidan, Lupi, Camarines Sur

I. Padre Garcia Bridge sensor graph

The relationship of water velocity data using flow meter deployed from December 1 to 7, 2014 and the water level during the sensor deployment is shown in Figure 60.
Note: No rainfall data from repo.pscigrid.gov.ph at Padre Garcia Bridge.

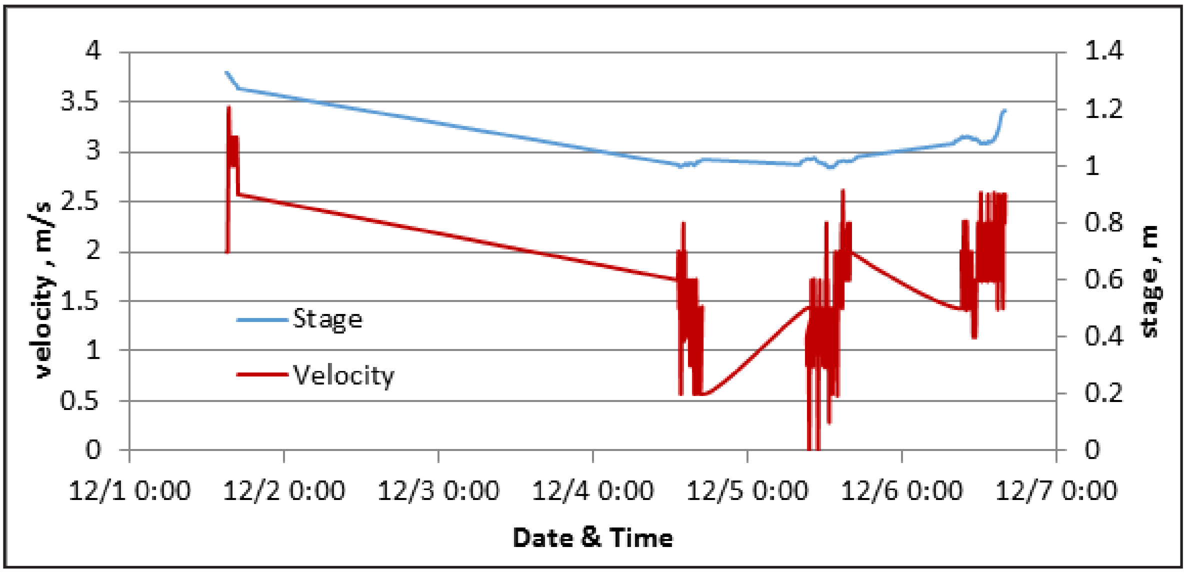


Figure 60. Graph showing the relationship between the water velocity and stage of Padre Garcia Bridge

The relationship between stage and discharge for November 29, 2013 resulted to an R2 of 0.8619 is shown in Figure 61.

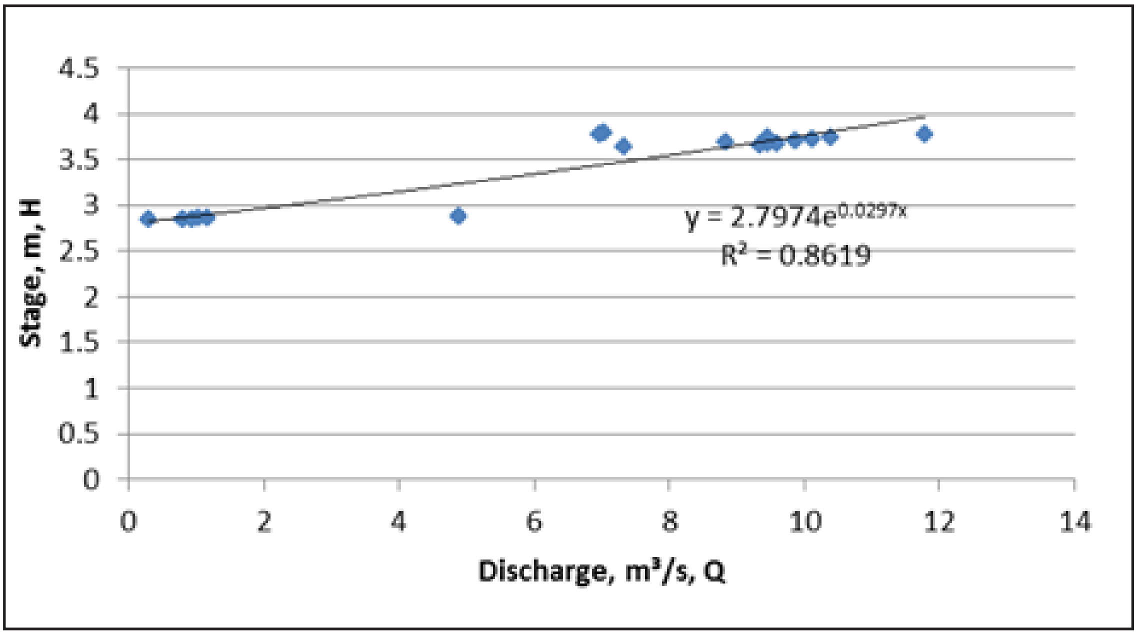


Figure 61. Scatter plot of discharge vs. stage at Padre Garcia Bridge, Zone 5, Balatas, Naga City

J. Sto. Domingo Bridge sensor graph

Water velocity data using flow meter deployed on December 3, 2014 is shown in Figure 62. Note: No water level and rainfall data from repo.pscigrid.gov.ph at Sto. Domingo Bridge.

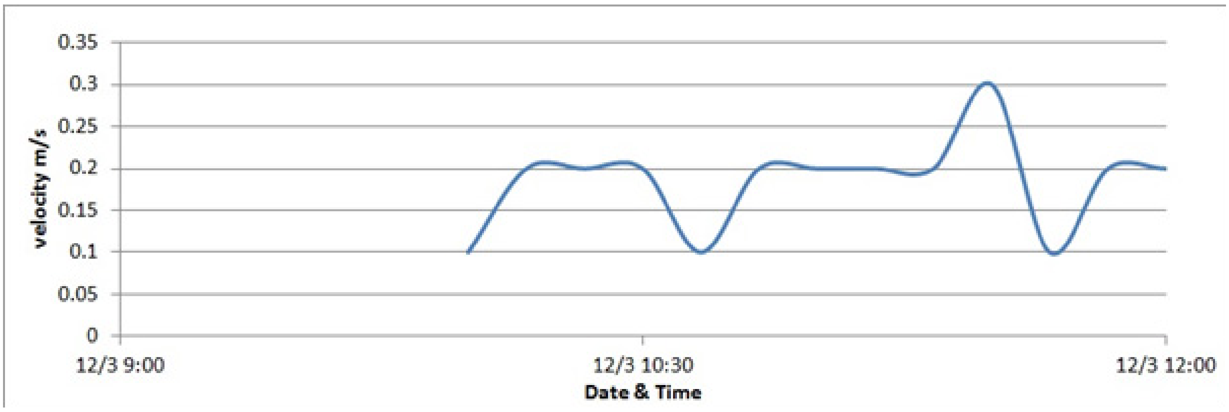


Figure 62. Velocity at Sto. Domingo Bridge River with respect to date and time

K. Tara Bridge sensor graph

The relationship of water velocity data using ADCP from November 28, 2014 to December 8, 2014 and the water level during the sensor deployment is shown in Figure 63.

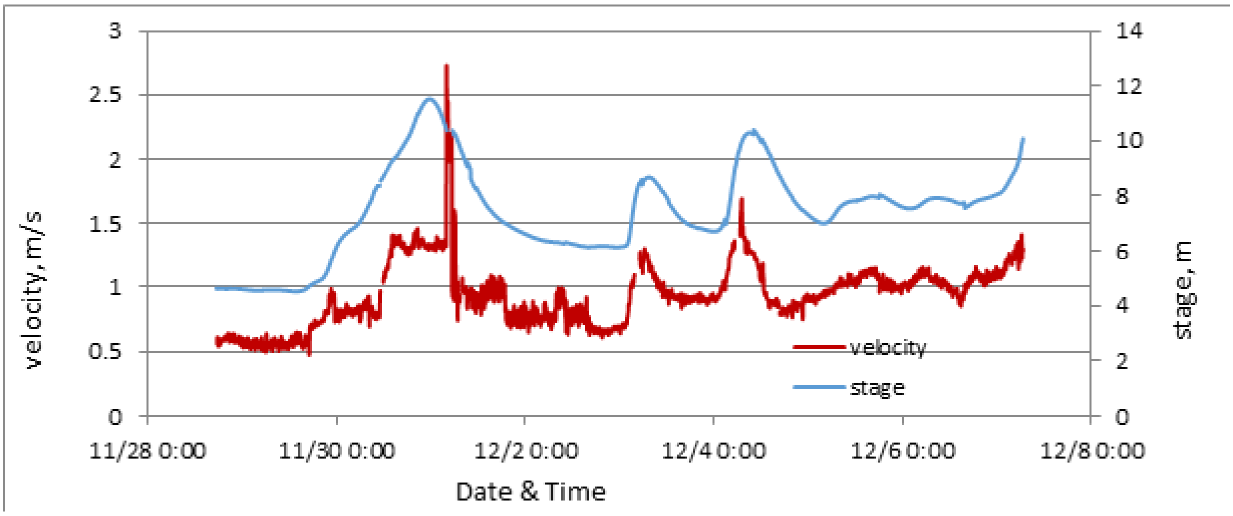


Figure 63. Velocity and stage of Tara Bridge, Brgy. Tara, Sipocot, Camarine Sur

The relationship of rainfall data using the deployed rain gauge data and the water level during the sensor deployment is shown in Figure 64.

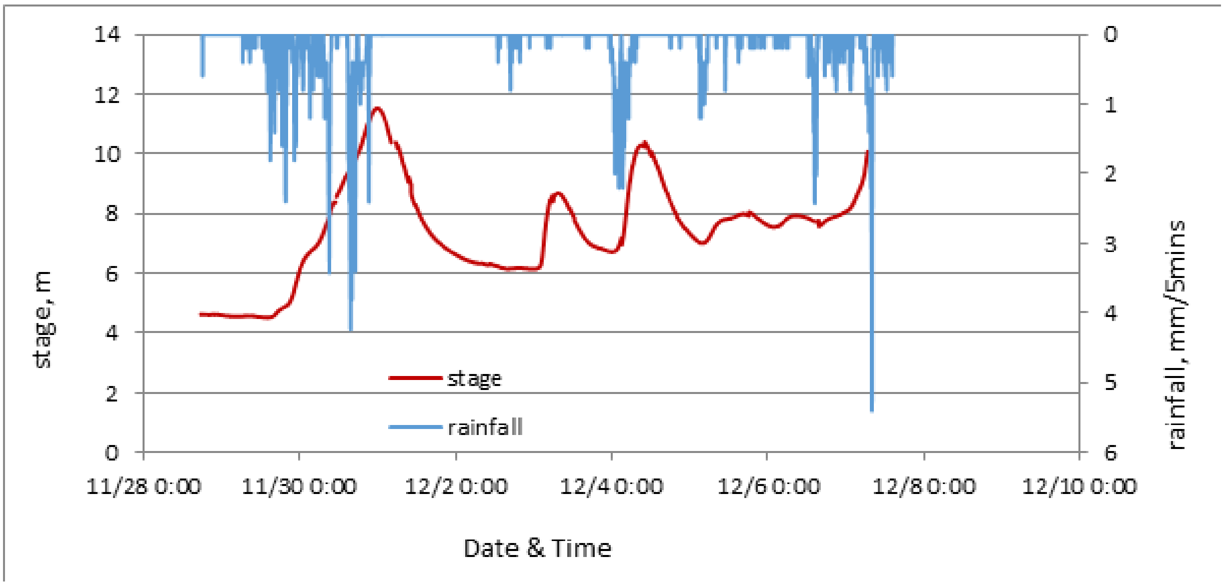


Figure 64. Rainfall and stage of Tara Bridge, Brgy. Tara, Sipocot, Camarines Sur

The relationship of rainfall data using the deployed rain gauge data and the water velocity data using ADCP during the sensor deployment is shown in Figure 65.

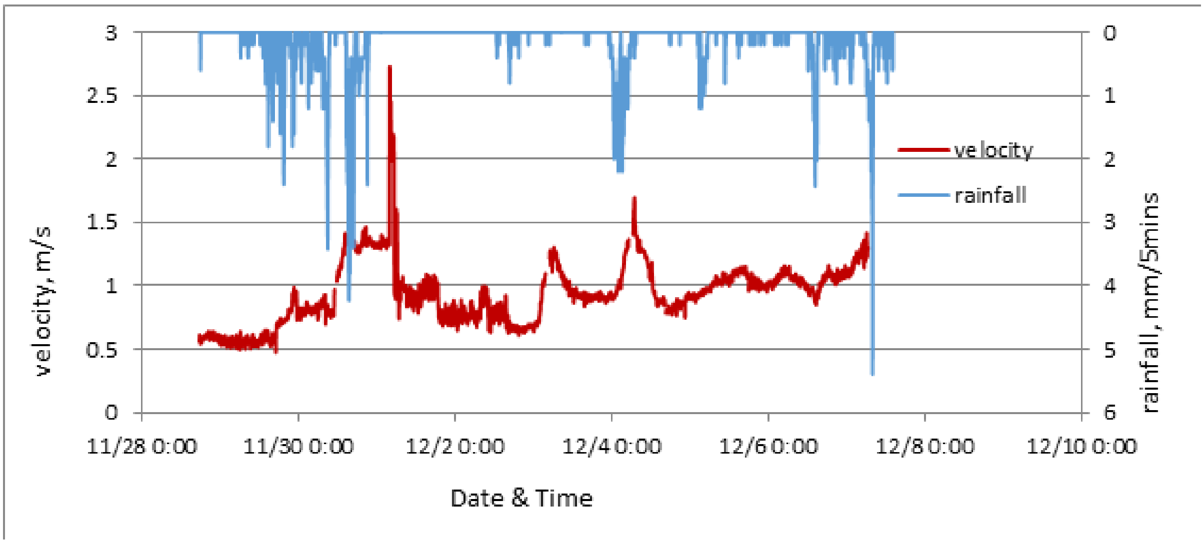


Figure 65. Water velocity and rainfall at Tara Bridge, Brgy. Tara, Sipocot, Camarines Sur

The relationship between stage and discharge for November 29, 2013 resulted to an R2 of 8.35E-01 is shown in Figure 66.

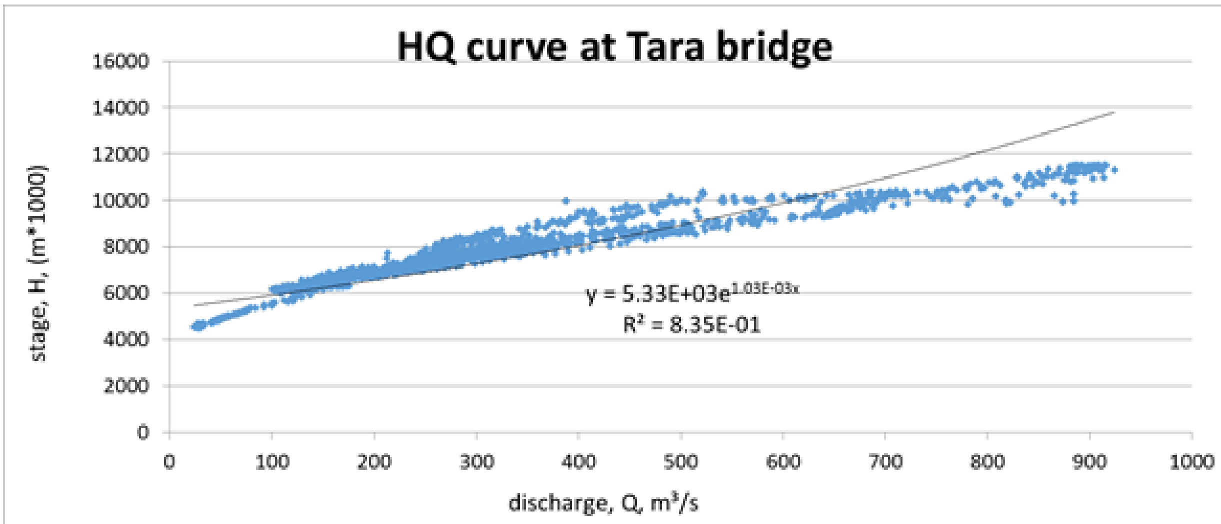


Figure 66. Scatter plot of discharge vs. stage at Tara Bridge, Brgy. Tara, Sipocot, Camarines Sur

Annexes

Annexes

ANNEX A. PROBLEMS ENCOUNTERED AND RESOLUTIONS APPLIED

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

Limitation/Problems	Solutions
1. Sept.12: Unable to follow the straight path of the cross-section XSR01B due to think cogon grasses and Bad weather conditions. 2. Sept.12: The rubber boat have a leak.	-Found Alternative path which ran parallel from XSR01B. -put some patches to continue the deployment.
3. Sept. 13: The cross-section R02B cannot follow the straight path due to have a man made river.	-Find the some boat for transportation to go the XSR02B, and then this boat use going in start point XSR03B.
4. Sept. 14: XSR08B not visible to go the start point, Full of cogon grasses.	-Found alternative path way which ran parallel to the XSR08B
5. Sept 16: Cross-section L01A and L02A have a small hills, and full of trees.	The team continue to do the challenge.
6. Sept. 17: XSR01A and XSR02A not visible to do the end point	Found an alternate path which ran parallel from cross-section R01A and R02A
7. Sept. 18: Unable to initially follow a straight path as corn fields obstructed the proposed XSR21B.	Follow an alternate path which deviated a few meters away from XSR21B
8. Sept. 20: Unable to follow the straight path along XSL18B due to thick cogon grasses and Nipa trees	Found an alternate path which ran parallel from XSL18B
9. Sept. 22: Unable to follow the straight path along XSL11B due to thick cogon grasses and Nipa trees. 10. 10) Sept 22: Unable to initialize; red OXTX IMU heading.	-Continue to the next cross-section -Continue the initialization must be done along the current, not against it. -need 12 kph speed of the boat for IMU heading.
11. Sept 23: Rover cannot connect to the RTK base station. 12. Sept. 23: Red mark on the Network PPS. 13. Sept.23: Libmanan bridge under Construction that's why the DVC team, stranded.	-Replace the rover unit with a functioning one. -double check the cable if properly connected. -Found the next cross section.
14. Sept. 25: Loss of RTK Signal for MMS.	-Found the structure facility like Mangayawan High School 200 meters along the river bank to set-up the RTK and PPK base signal.
15. Sept. 26: The Cross-section L13B have a 2 way of Bicol river along the XSL13B.	-Rent the boat for this XSL13B.
16. Sept.27: River too wide, hardware restrictions for MMS surveys.	-The profile team had to conduct two scans for portions of Bicol River.
17. Sept. 28: Hard to retrieve the all deploy instruments such as ADCP and depth gauges, bad weather and the river current.	Continue to retrieval operations ao all instruments.

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

Type	Brand	Serial number	Owner	Quantity
GPS Receiver (Base)	Trimble™ SPS852		UP-TCAGP	Two (2) units
GPS Receiver (Rover)	Trimble™ SPS882		UP-TCAGP	Eight (8) units
GPS Controller	Trimble™ TSC3		UP-TCAGP	Eight (8) units
High-Gain Antenna			UP-TCAGP	One (1) units
RTK radio and antenna			UP-TCAGP	One (1) unit with battery
Single beam Echo sounder	Hi-Target		UP-TCAGP	One (1) unit with accessories
Acoustic Doppler Current Profiler (ADCP)	Sontek™		UP-TCAGP	One (1) unit with accessories
Coupler-2a and 2b			UP- TCAGP	One (1) unit each
Handheld GPS	Garmin Oregon™ 550	1MW086831	UP- TCAGP	Four (4) units
		1MW086842		
		1MW086920		
		1MW079764		
AA-Battery Charger	Akari		UP- TCAGP	Two (2) units
Multi-tester			UP-TCAGP	One (1) unit
Laptops	Lenovo Think-Pad		UP-TCAGP	One (1) unit
	Dell Laptop			One (1) unit
	Panasonic Tough book (MDL)			One (1) unit
Digital Level	Topcon DL502		UP-TCAGP	One (1) unit with two (2) level rods
Depth Gauge	Onset Hobo wares		UP-TCAGP	Four (4) units
Rain Gauge		1293784	UP-TCAGP	One (1) unit

Type	Brand	Serial number	Owner	Quantity
Digital Flow Meter	For repair	F494	UP-TCAGP	Zero (0) unit
Echosounder	Ohmex™	2969	UP-TCAGP	One (1) unit
Range Pole	Trimble™		UP-TCAGP	Six (6) units
12-volt deep cycle batteries			UP-TCAGP	Two (2) units
Tripod	Trimble™		UP-TCAGP	Four (4) units
Bipod	Trimble™		UP-TCAGP	Six (6) units
Tribrack			UP-TCAGP	Three (3) units
Laser Range Finder	Bushnell		UP-TCAGP	Two (2) units
Installers	SonTek™		UP-TCAGP	One (1) unit
	Topcon™			One (1) unit
	Trimble™ Business Center			One (1) unit
	Trimble Realworks			One (1) unit
Mobile Mapping Scanner (MMS)	MDL Dynascan		UP-TCAGP	One (1) unit with dual-GPS antenna, one (1) interface adapter and accessories
Toolbox			UP-TCAGP	One (1) unit
Printer	Canon™	Ip2700	UP-TCAGP	One (1) unit
QINSy donlge			UP-TCAGP	One (1) unit
MMS mount			UP-TCAGP	One (1) unit
Interconnect cables			UP-TCAGP	One (1) unit
External GPS			UP-TCAGP	One (1) unit
MDL Dynascan™			UP-TCAGP	One (1) unit
MDL Box			UP-TCAGP	One (1) unit
MMS			UP-TCAGP	One (1) unit
Transducer	Ohmex™		UP-TCAGP	One (1) unit
D90 Camera	Ohmex™		UP-TCAGP	Two (2) units

ANNEX C. THE SURVEY TEAM

Data Validation Component Sub-team	Designation	Name	Agency/Affiliation
Data Component Leader	Data Component Project Leader -II	ENGR. LOUIE P. BALICANTA	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. JOEMARIE S. CABALLERO	UP-TCAGP
Bathymetric Survey Team	Senior Science Research Specialist	ENGR. DEXTER T. LOZANO	UP-TCAGP
	Research Associate	RAQUEL NAJJA M. HAO	UP-TCAGP
Profile Survey Team	Senior Science Research Specialist	ENGR. BERNARD PAUL D. MARAMOT	UP-TCAGP
	Senior Science Research Specialist	ENGR. MELCHOR REY M. NERY	UP-TCAGP
Cross Section Survey Team and Deployment Team	Research Associate	ENGR. JMSON J. CALALANG	UP-TCAGP
	Research Associate	PATRIZCIA MAE P. DELACRUZ	UP-TCAGP
	Research Associate	JOJO E. MORILLO	UP-TCAGP
	Research Associate	JELINE AMANTE	UP-TCAGP
	Research Associate	KRISTINE AILENE P. BORROMEO	UP-TCAGP

ANNEX D. NAMRIA CERTIFICATION

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

April 18, 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: **CAMARINES SUR**	
	Station Name: **CMS-3179**	
Island: **LUZON**	Order: **3rd**	Barangay: **SAN ISIDRO**
Municipality: **LIBMANAN**		
	PRS92 Coordinates	
Latitude: **13° 39' 47.79510"**	Longitude: **123° 0' 46.14554"**	Ellipsoidal Hgt: **16.33500 m.**
	WGS84 Coordinates	
Latitude: **13° 39' 42.76304"**	Longitude: **123° 0' 51.10730"**	Ellipsoidal Hgt: **67.41000 m.**
	PTM Coordinates	
Northing: **1510922.385 m.**	Easting: **501386.743 m.**	Zone: **4**
	UTM Coordinates	
Northing: **1,510,393.54**	Easting: **501,386.26**	Zone: **51**

Location Description

CMS-3179

From Naga City, travel W passing through Mun. of Milaor and San Fernando approx. 1 Km. before Libmanan Junction. Station is located at Uguis Bridge along Maharlika Highway. It was established at NE wing of bridge. Mark is the head of a 4 in. copper nail centered on a drilled hole with cement putty, embedded at concrete bridge with inscriptions, "CMS-3179, 2007, NAMRIA".

Requesting Party:	**UP DREAM/ Melchor Nery**
Pupose:	**Reference**
OR Number:	**3943540 B**
T.N.:	**2013-0310**

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

9 9 0 4 1 8 2 0 1 3 1 0 1 5 4 6

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

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

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

April 18, 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: **CAMARINES SUR**		
Station Name: **CS-360**		
Island: **LUZON**	Municipality: **CABUSAO**	Barangay: **CAMAGONG**
Elevation: **4.0972 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

CS-360 is in the Province of Camarines Sur, Municipality of Cabusao, Brgy. Camagong along Libmanan to Cabusao Road. The station is located at the bridge near the Paraiso ni Genova.

Mark is a copper nail embedded and cemented in the middle of a 6 in x 6 in cement putty with the inscription "CS-360; 2008; NAMRIA."

Requesting Party: **UP DREAM/ Melchor Nery**
Pupose: **Reference**
OR Number: **3943541 B**
T.N.: **2013-0312**

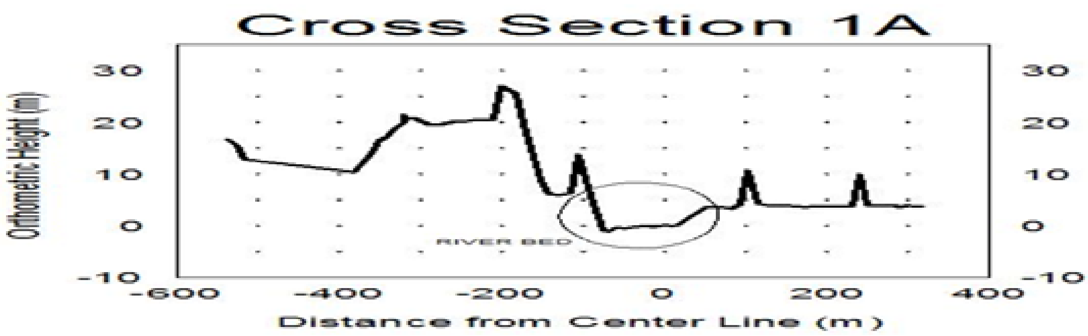
RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy Department

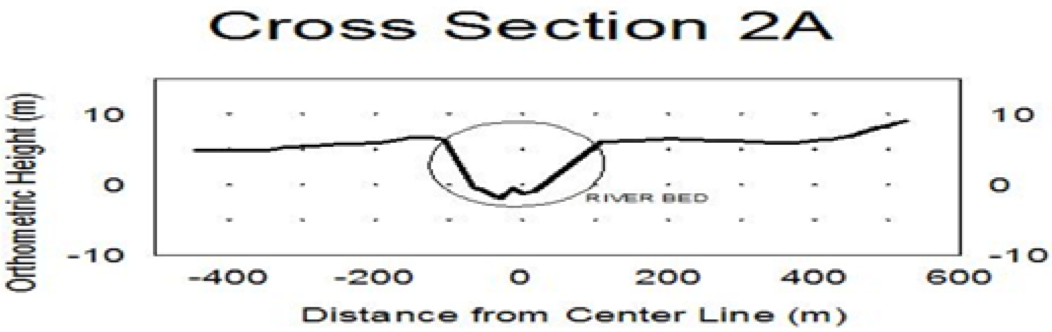
9 9 0 4 1 8 2 0 1 3 1 0 1 6 3 7

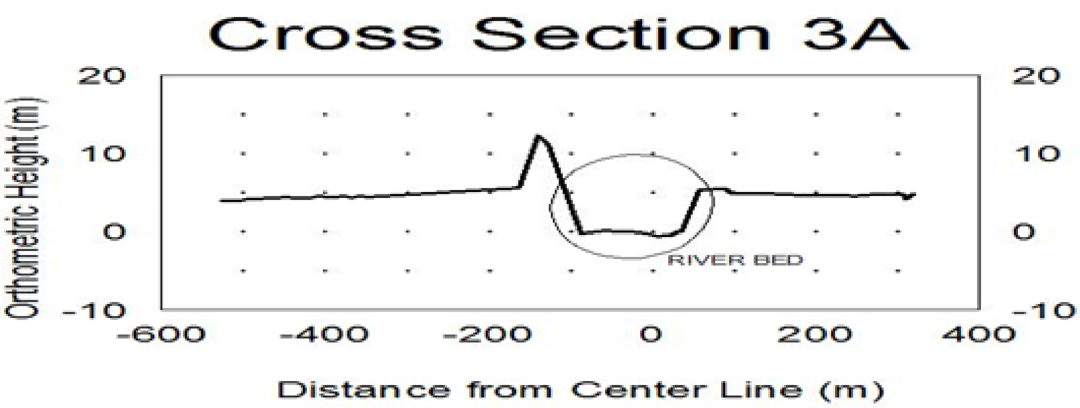
CIP/4701/12/09/814

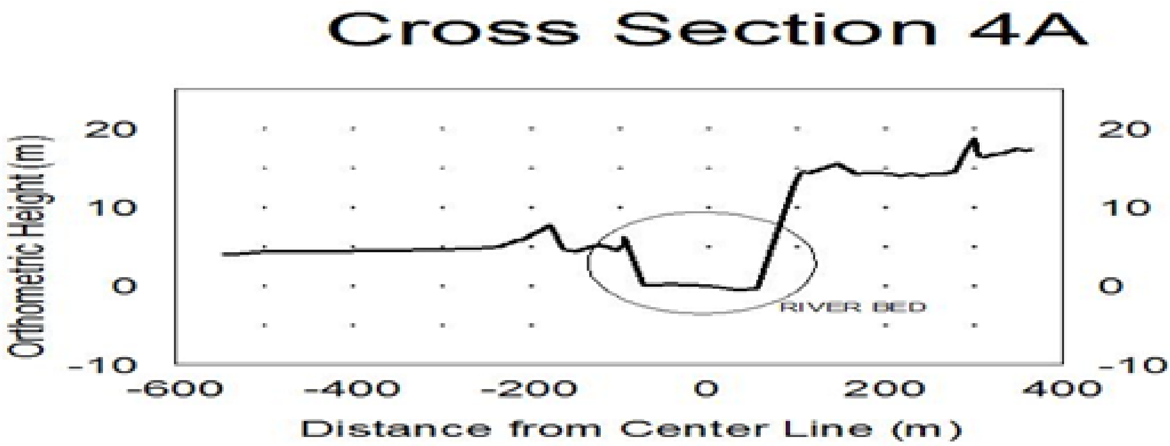
NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3494 to 98
www.namria.gov.ph

ANNEX E. CROSS-SECTION








Cross Section 4A
Orthometric Height (m)
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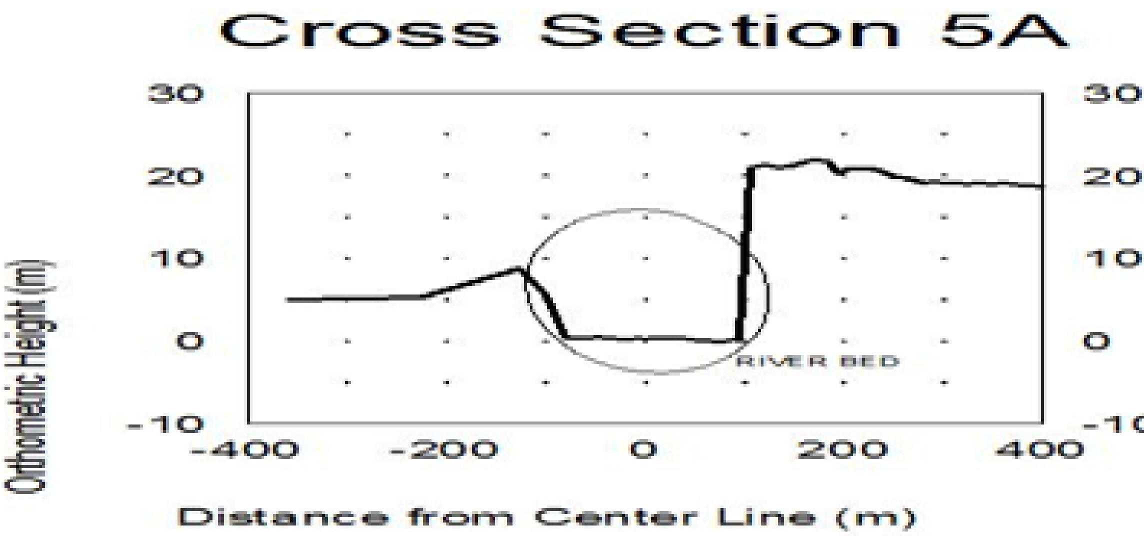
0
200
400
RIVER BED
Distance from Center Line (m)


Cross Section 5A
Orthometric Height (m)
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0
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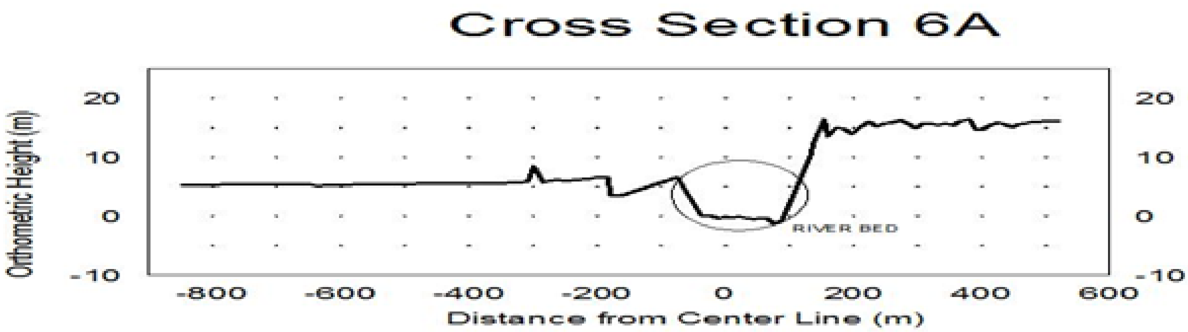
0
200
400
RIVER BED
Distance from Center Line (m)


Cross Section 6A
Orthometric Height (m)
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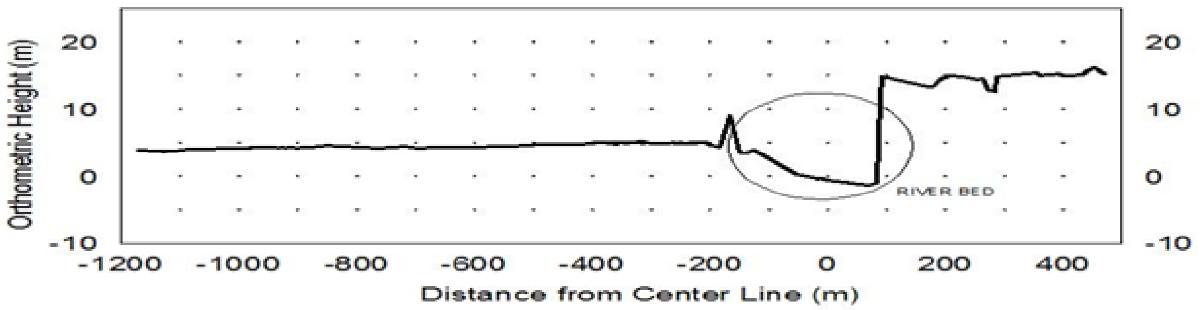
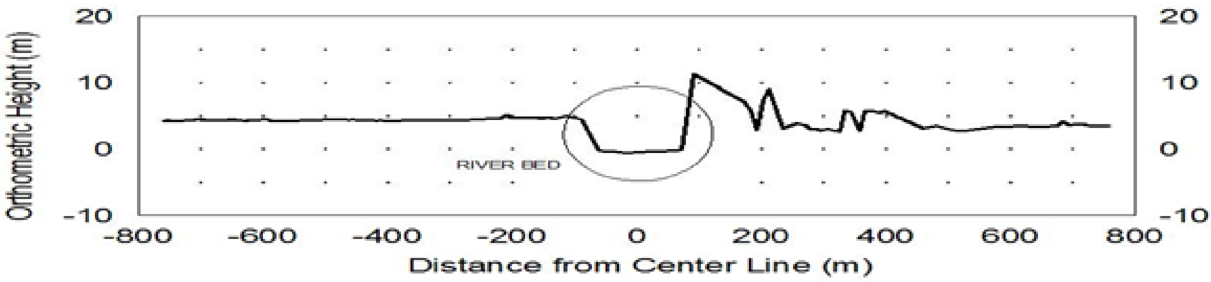
10
0
-10
-800
-600
-400
-200
0
200
400
600
RIVER BED
Distance from Center Line (m)

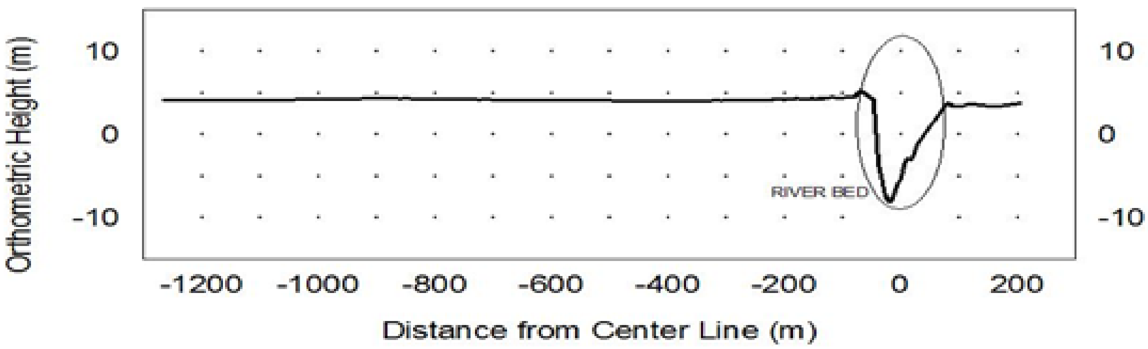
Cross Section 7A

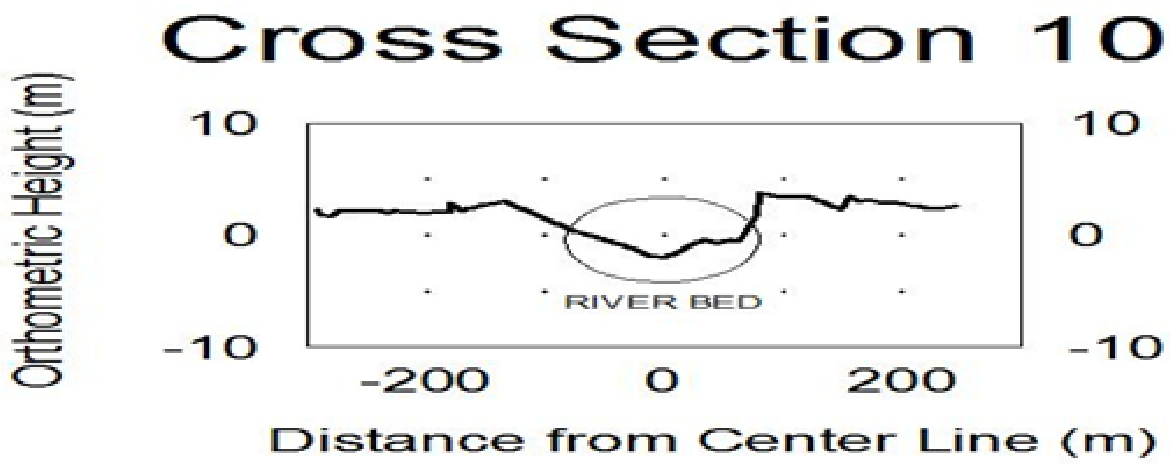


Cross Section 8A



Cross Section 9A




Cross Section 10
Orthometric Height (m)
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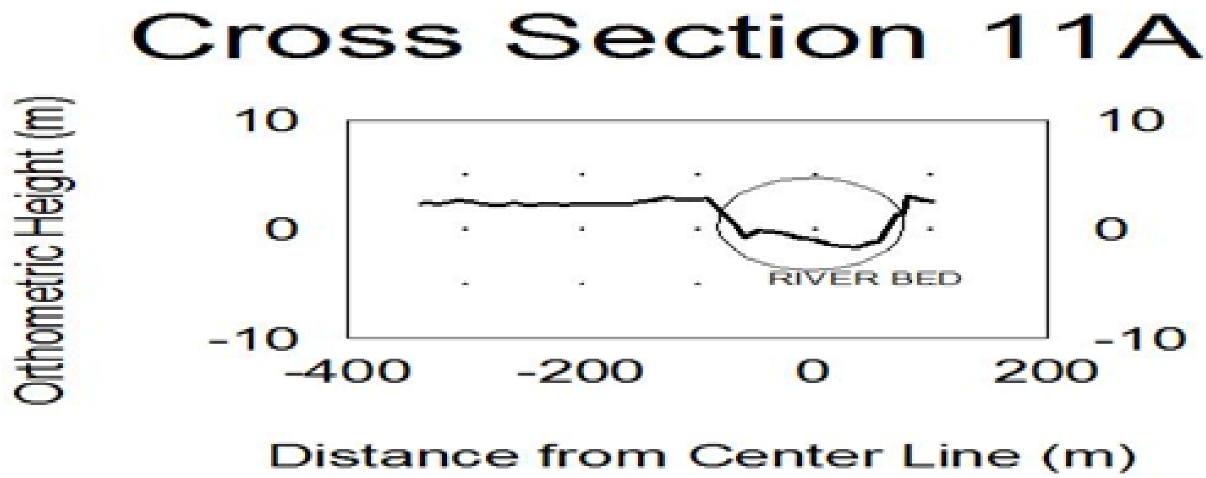
0
-10
10
0
-10
RIVER BED
-200
0
200
Distance from Center Line (m)


Cross Section 11A
Orthometric Height (m)
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0
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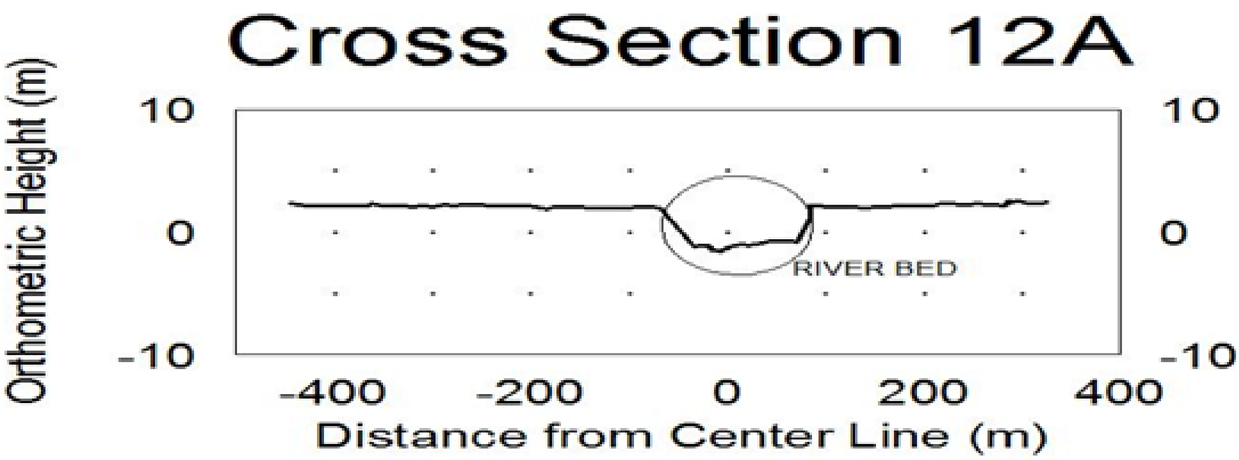
10
0
-10
RIVER BED
-400
-200
0
200
Distance from Center Line (m)


Cross Section 12A
Orthometric Height (m)
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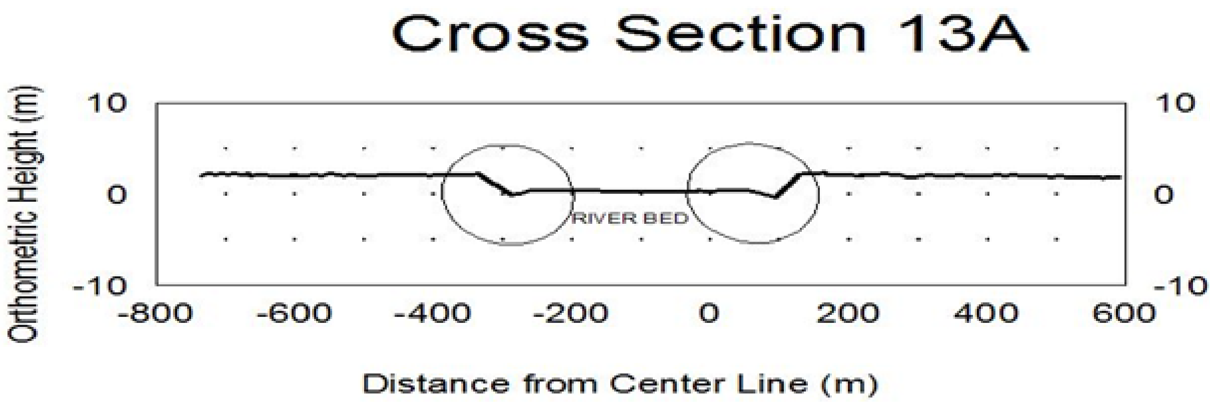
0
-10
10
0
-10
RIVER BED
-400
-200
0
200
400
Distance from Center Line (m)



Cross Section 13A
Orthometric Height (m)
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0
-10
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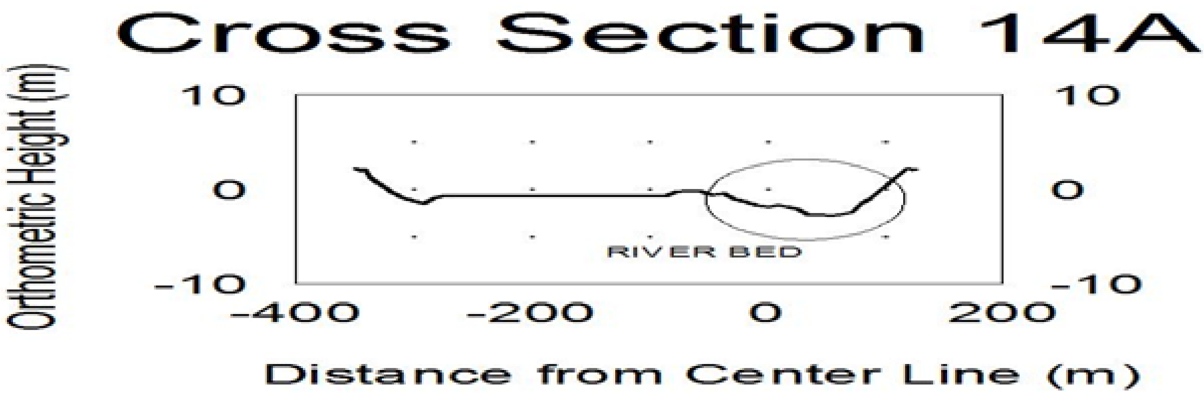
-400
-200
0
200
400
600
RIVER BED
Distance from Center Line (m)



Cross Section 14A
Orthometric Height (m)
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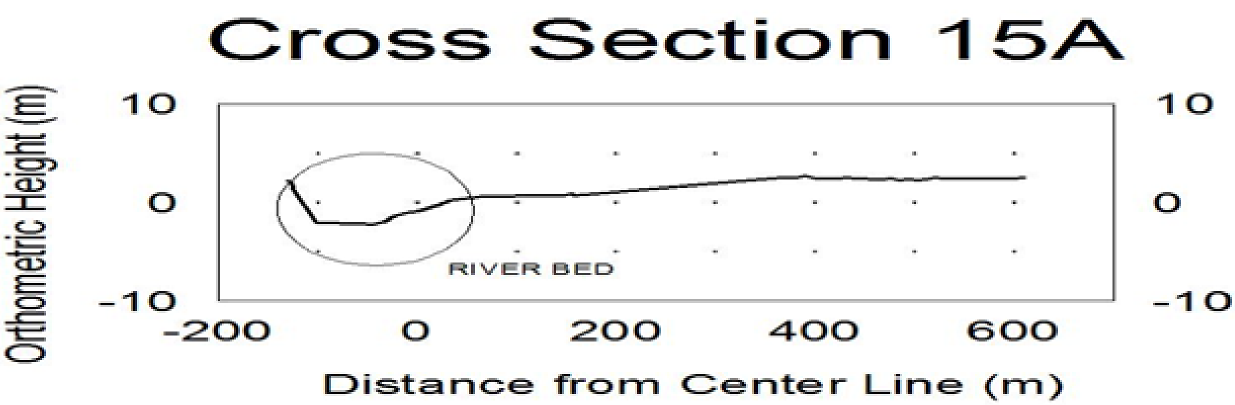
0
-10
-400
-200
0
200
RIVER BED
Distance from Center Line (m)



Cross Section 15A
Orthometric Height (m)
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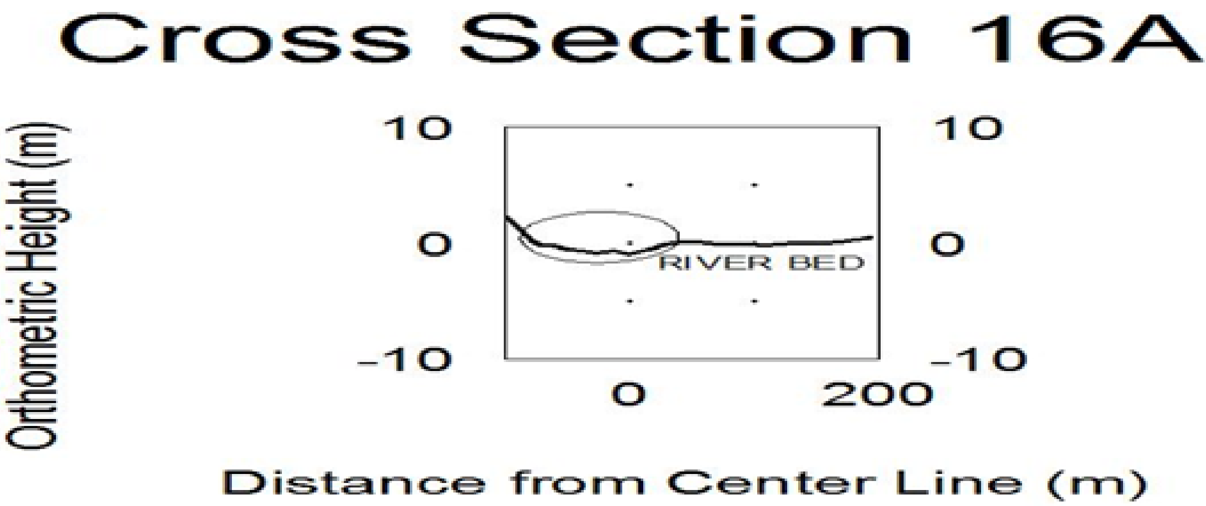
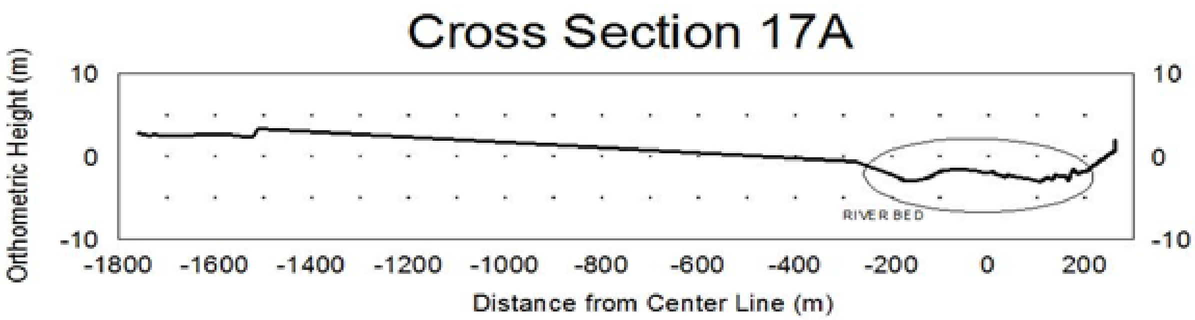
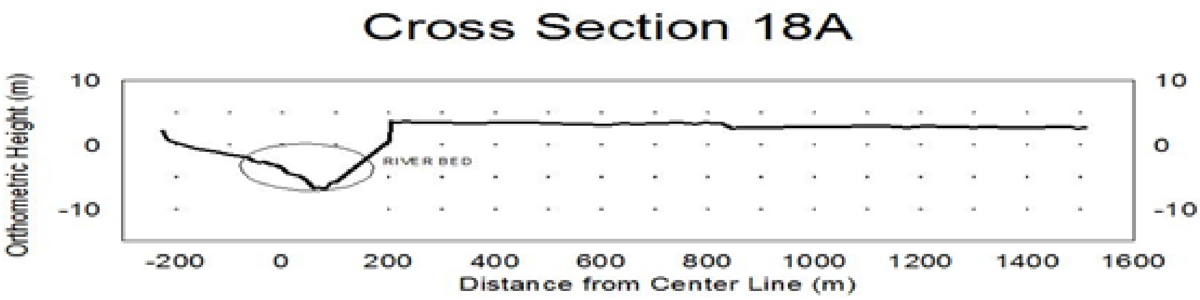
0
-10
-200
0
200
400
600
RIVER BED
Distance from Center Line (m)


Cross Section 16A
Orthometric Height (m)
10
0
-10
RIVER BED
0
200
Distance from Center Line (m)


Cross Section 17A
Orthometric Height (m)
10
0
-10
RIVER BED
-1800 -1600 -1400 -1200 -1000 -800 -600 -400 -200 0 200
Distance from Center Line (m)


Cross Section 18A
Orthometric Height (m)
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0
-10
RIVER BED
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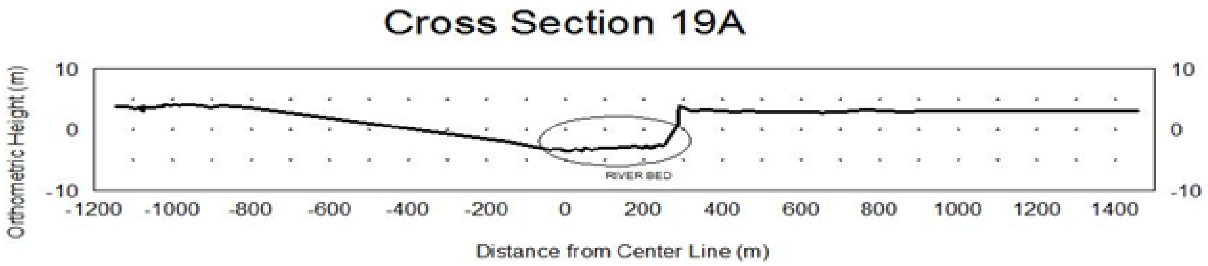
Distance from Center Line (m)


Cross Section 19A
Orthometric Height (m)
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0
-10
-1200
-1000
-800
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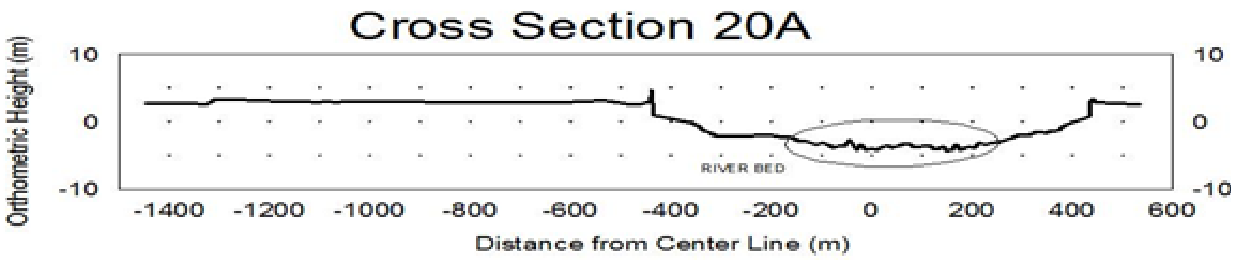
-200
0
200
400
600
800
1000
1200
1400
RIVER BED
Distance from Center Line (m)


Cross Section 20A
Orthometric Height (m)
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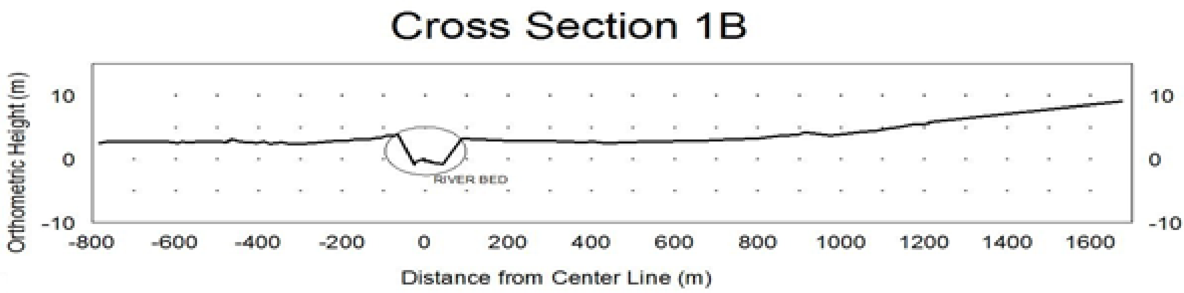
-1200
-1000
-800
-600
-400
-200
0
200
400
600
RIVER BED
Distance from Center Line (m)


Cross Section 1B
Orthometric Height (m)
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-10
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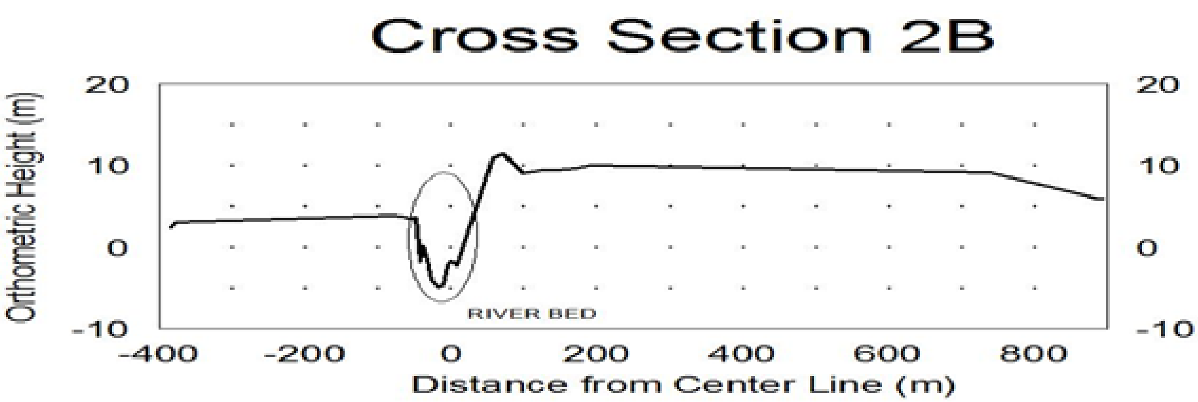
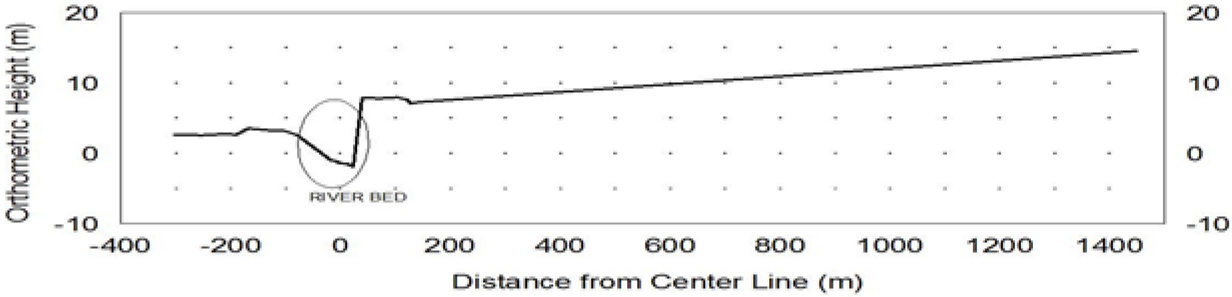
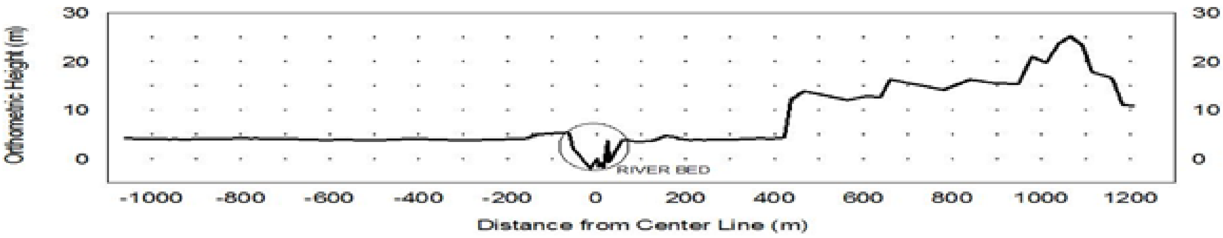
-600
-400
-200
0
200
400
600
800
1000
1200
1400
1600
RIVER BED
Distance from Center Line (m)


Cross Section 2B
Orthometric Height (m)
20
10
0
-10
-400
-200
0
200
400
600
800
RIVER BED
Distance from Center Line (m)

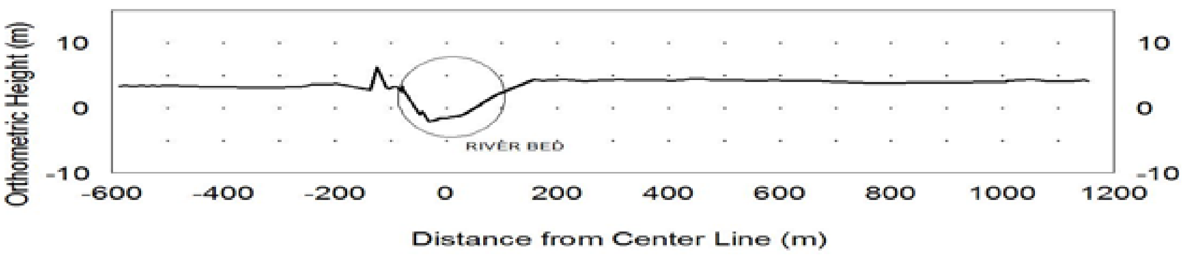
Cross Section 3B



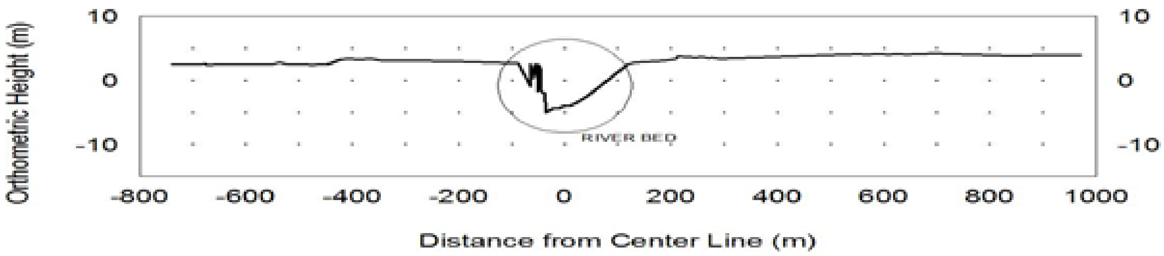
Cross Section 4B

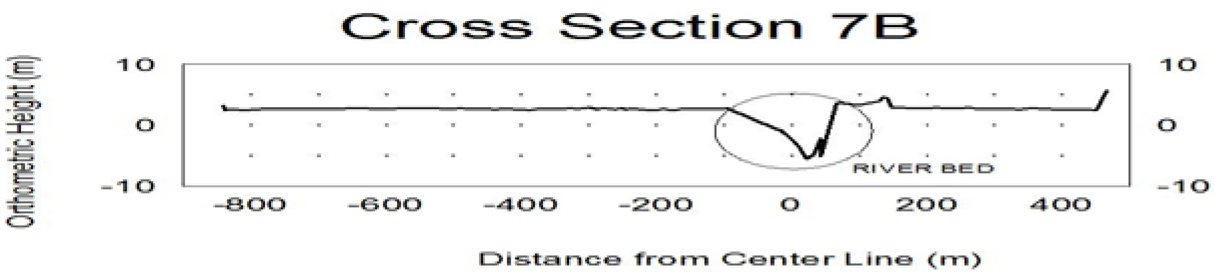


Cross Section 5B

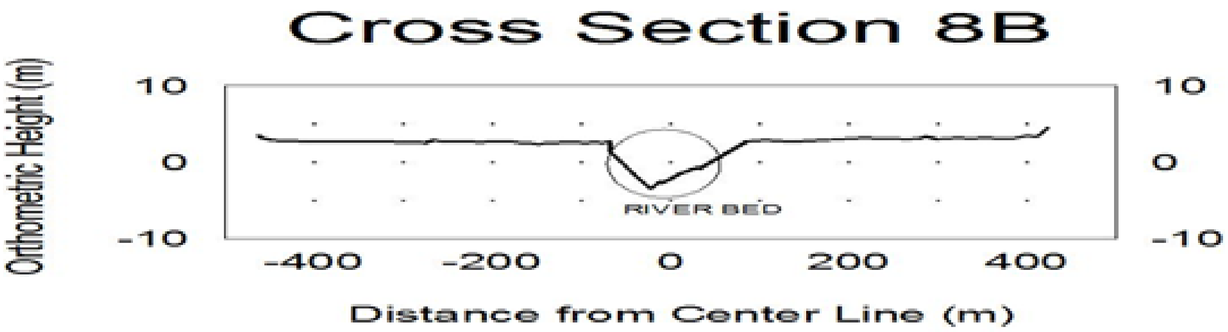


Cross Section 6B

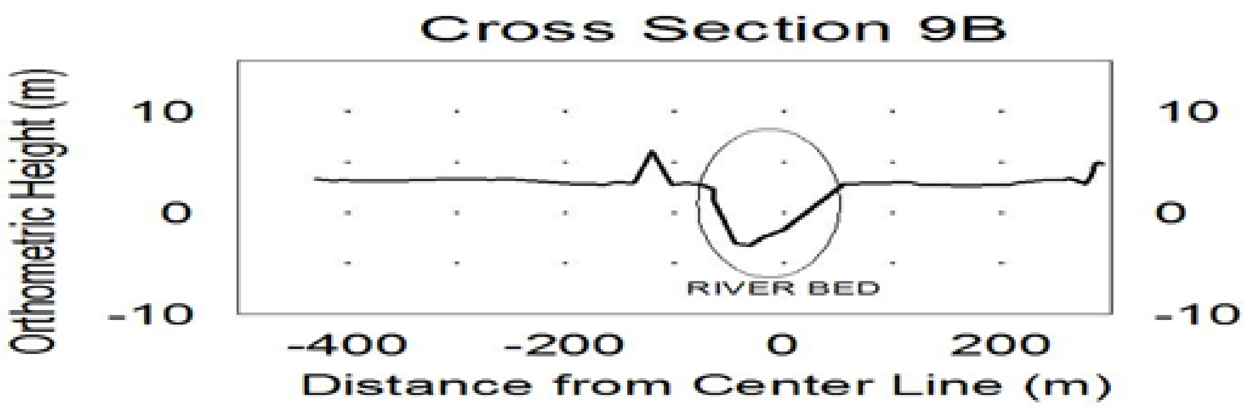




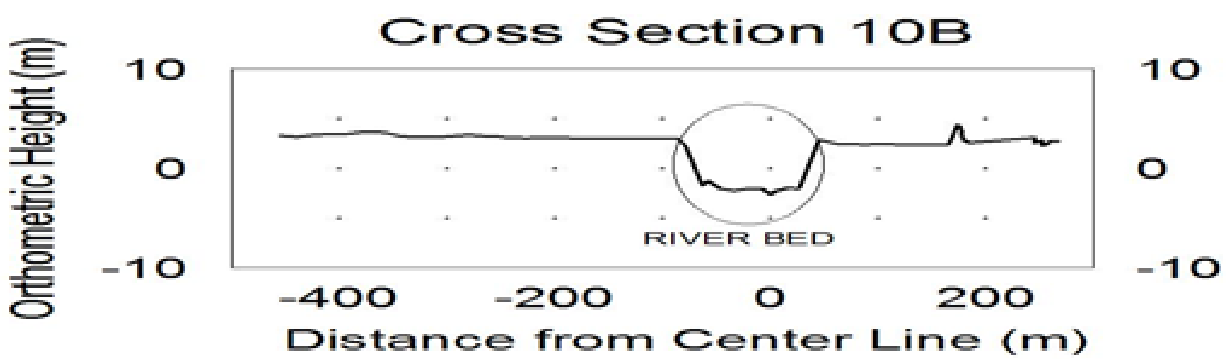
Cross Section 7B
Orthometric Height (m)
10
0
-10
RIVER BED
-800
-600
-400
-200
0
200
400
Distance from Center Line (m)



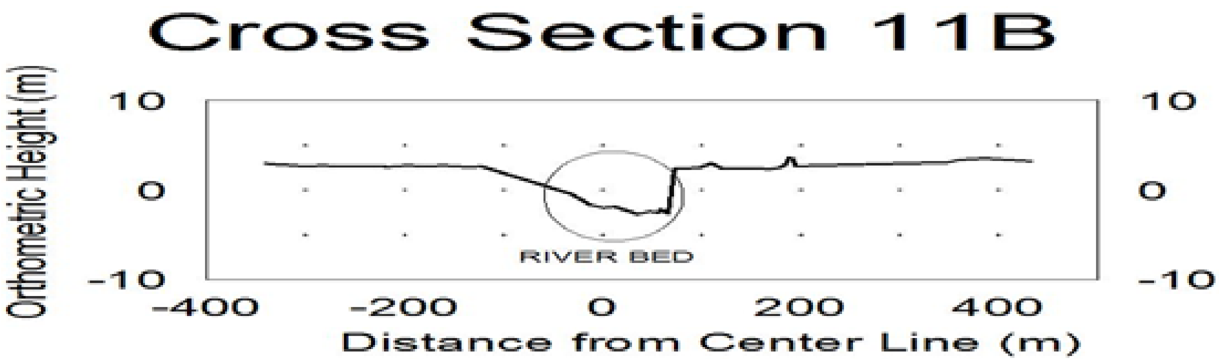
Cross Section 8B
Orthometric Height (m)
10
0
-10
RIVER BED
-400
-200
0
200
400
Distance from Center Line (m)

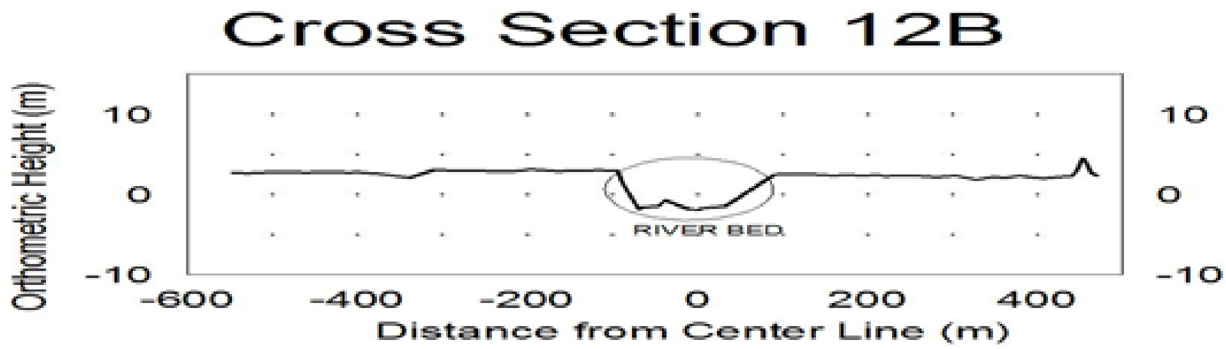


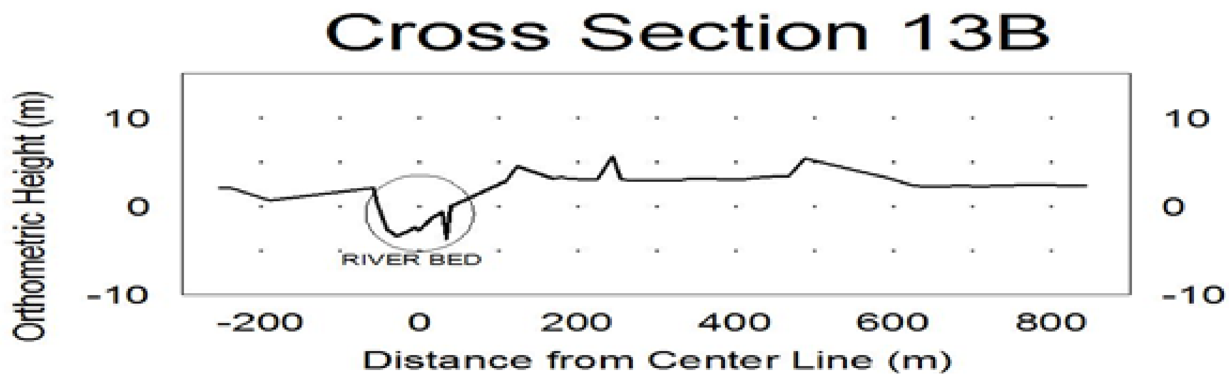
Cross Section 9B
Orthometric Height (m)
10
0
-10
RIVER BED
-400
-200
0
200
Distance from Center Line (m)

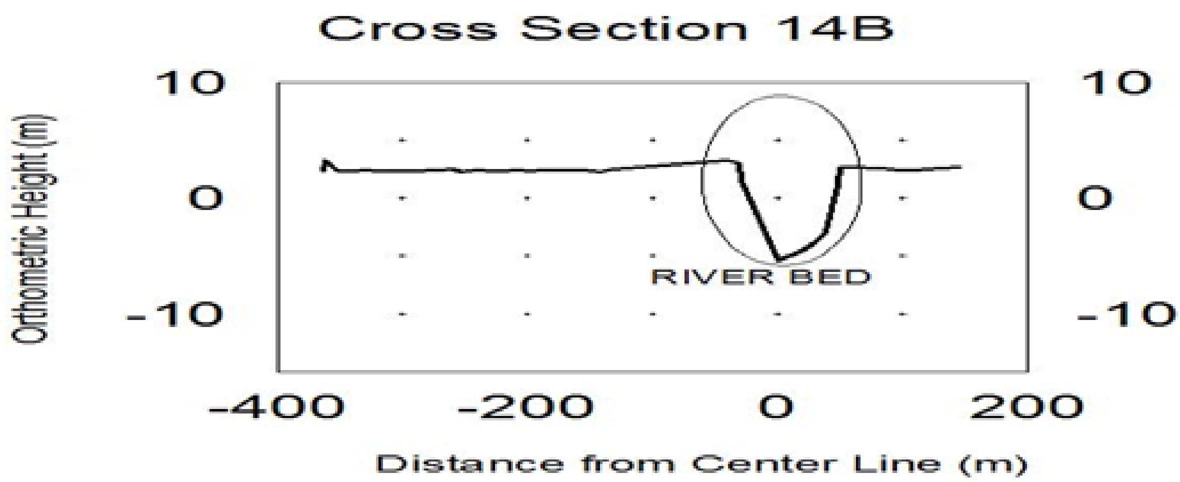


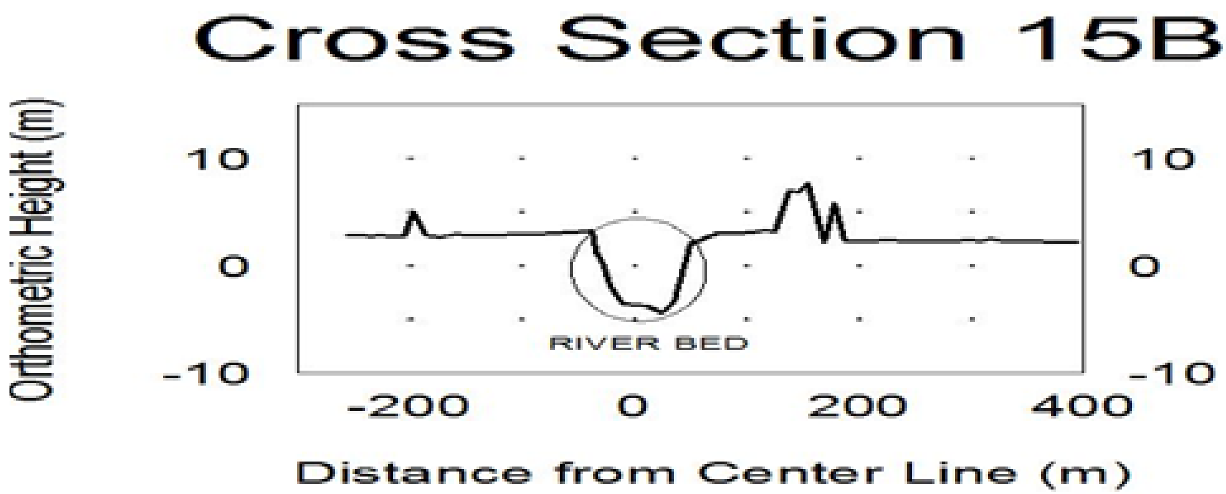
Cross Section 10B
Orthometric Height (m)
10
0
-10
RIVER BED
-400
-200
0
200
Distance from Center Line (m)

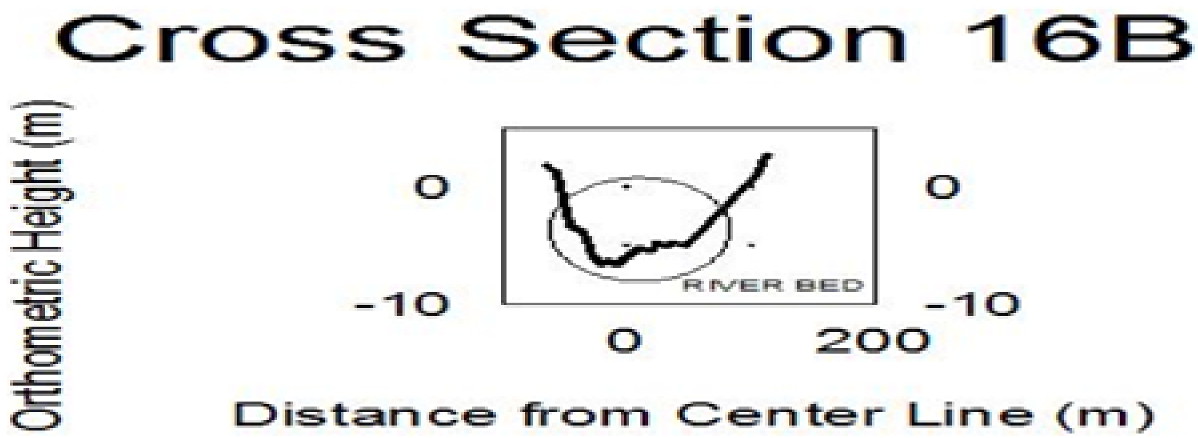

Cross Section 11B
Orthometric Height (m)
10
0
-10
-400
-200
0
200
400
RIVER BED
Distance from Center Line (m)

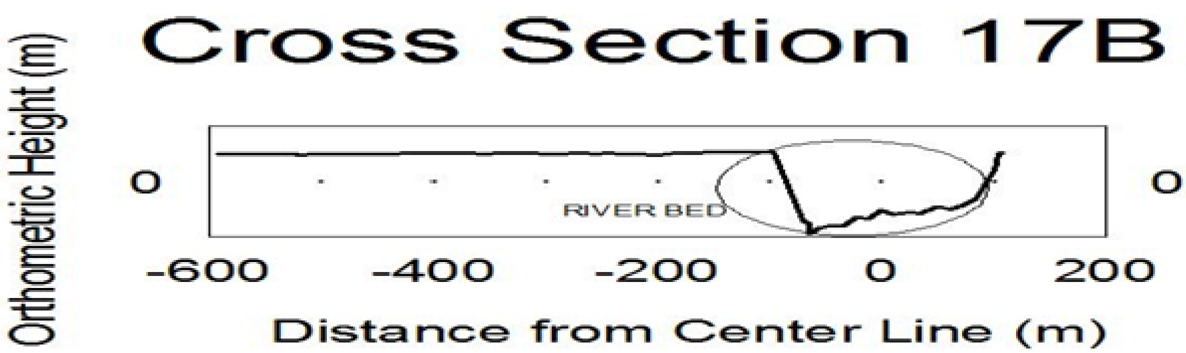

Cross Section 12B
Orthometric Height (m)
10
0
-10
-600
-400
-200
0
200
400
RIVER BED
Distance from Center Line (m)

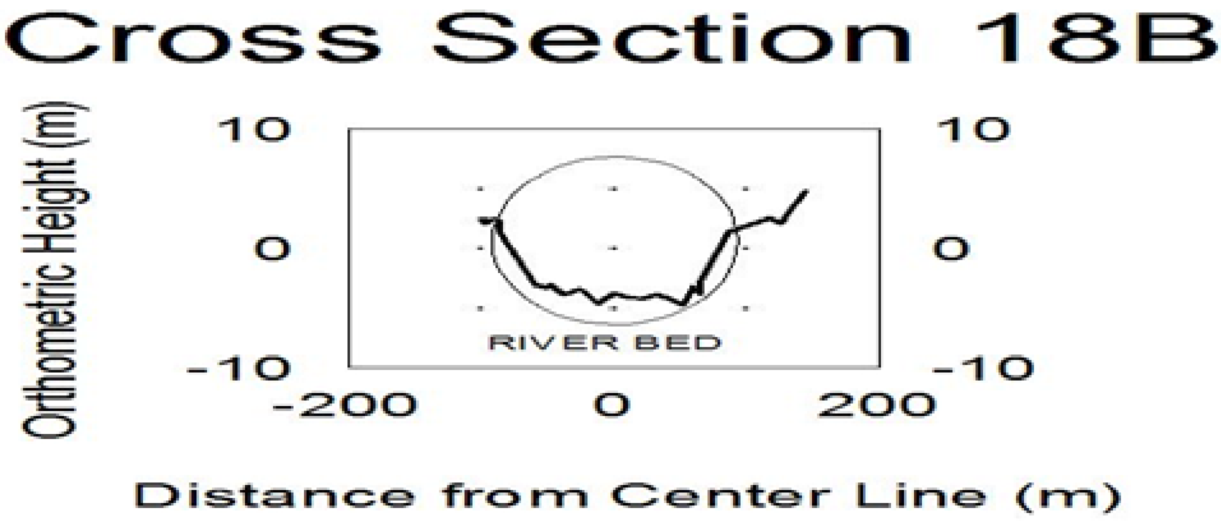

Cross Section 13B
Orthometric Height (m)
10
0
-10
-200
0
200
400
600
800
RIVER BED
Distance from Center Line (m)

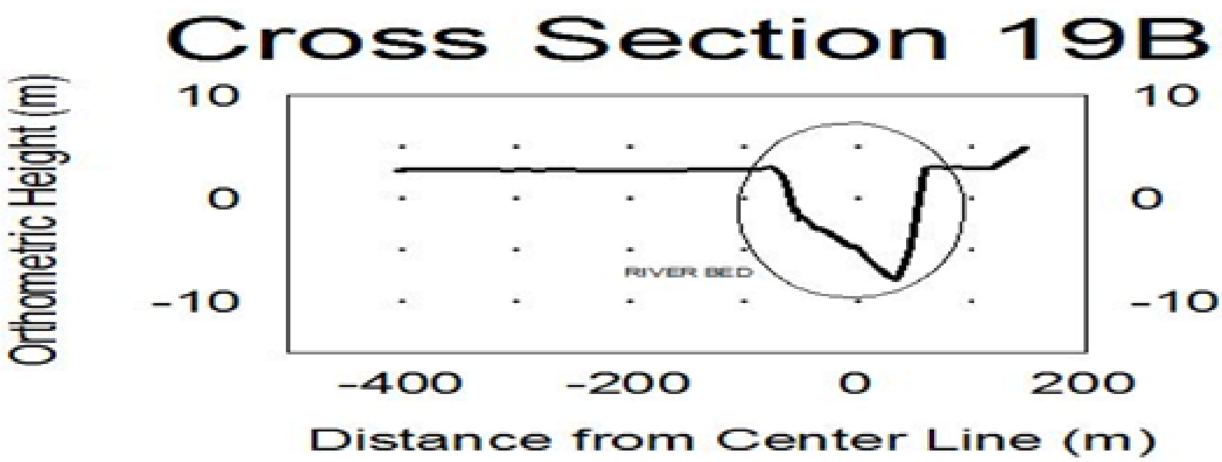

Cross Section 14B
Orthometric Height (m)
10
0
-10
-400
-200
0
200
RIVER BED
Distance from Center Line (m)

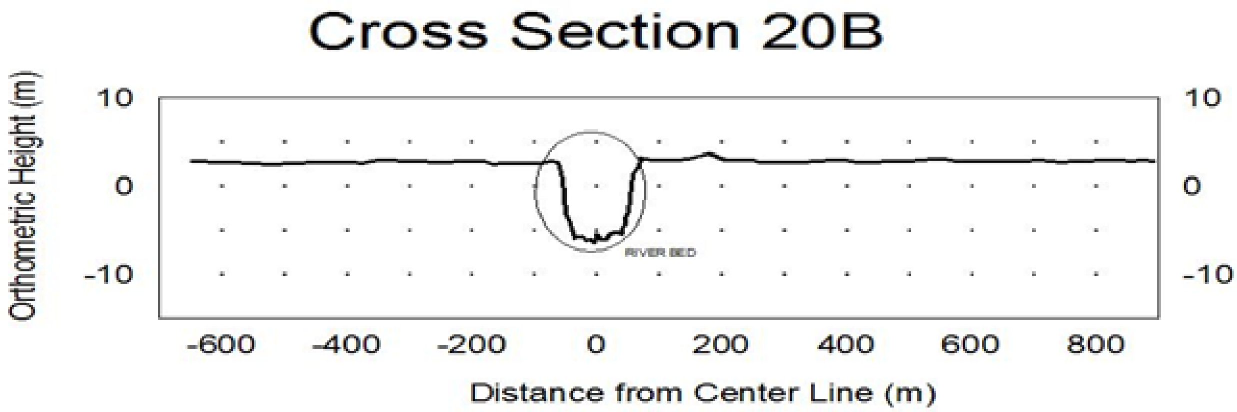

Cross Section 15B
Orthometric Height (m)
10
0
-10
RIVER BED
-200
0
200
400
Distance from Center Line (m)

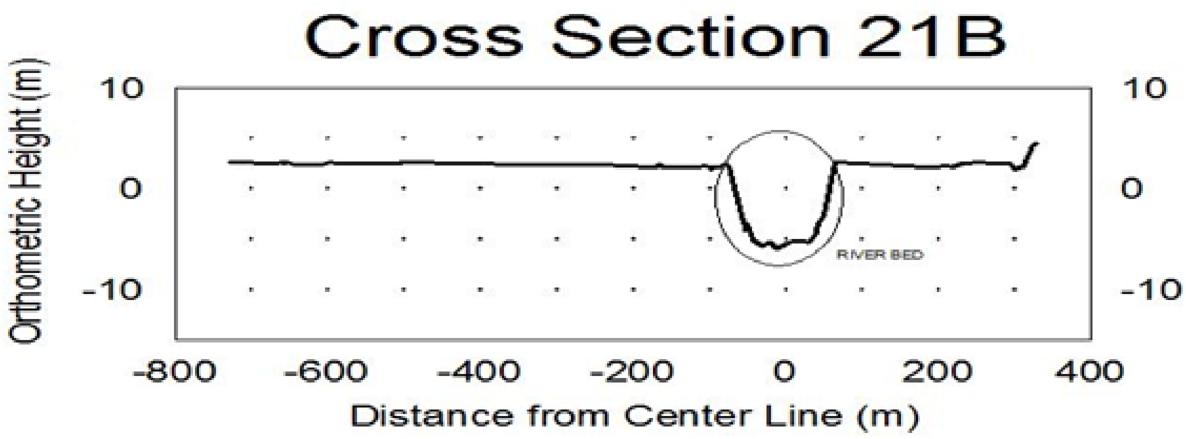

Cross Section 16B
Orthometric Height (m)
0
-10
RIVER BED
0
200
Distance from Center Line (m)


Cross Section 17B
Orthometric Height (m)
0
RIVER BED
-600
-400
-200
0
200
Distance from Center Line (m)

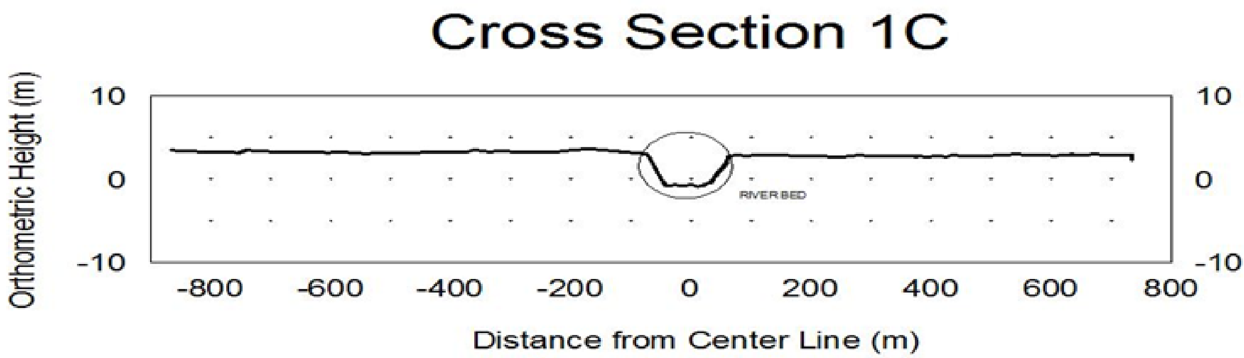

Cross Section 18B
Orthometric Height (m)
10
0
-10
10
0
-10
RIVER BED
-200
0
200
Distance from Center Line (m)


Cross Section 19B
Orthometric Height (m)
10
0
-10
10
0
-10
RIVER BED
-400
-200
0
200
Distance from Center Line (m)

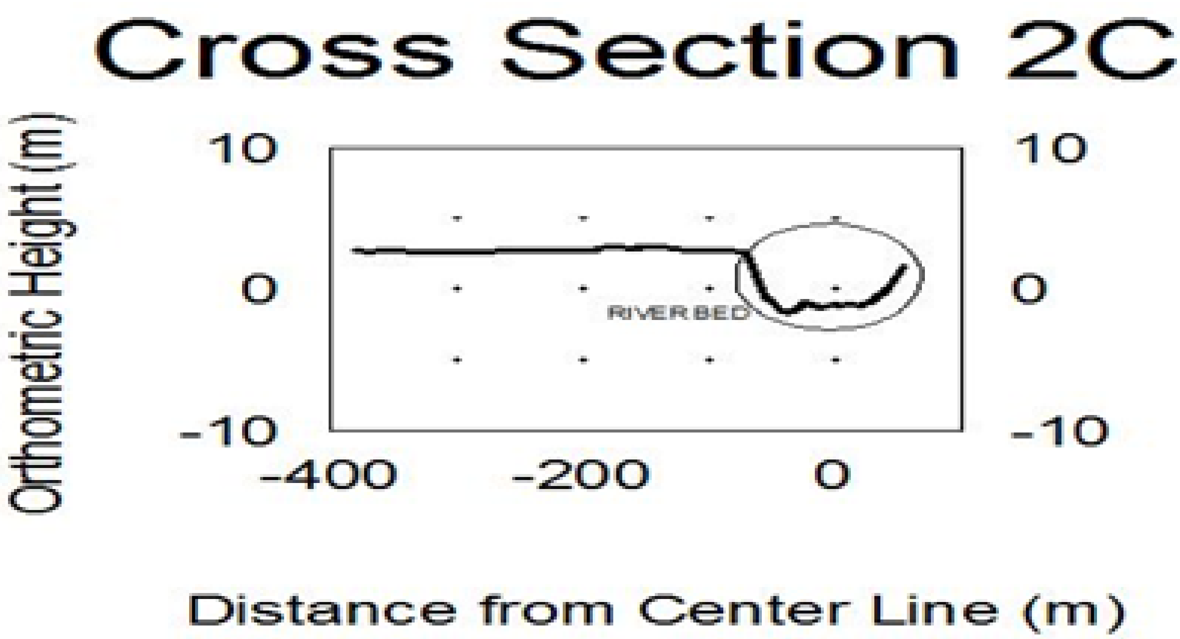

Cross Section 20B
Orthometric Height (m)
10
0
-10
10
0
-10
RIVER BED
-600
-400
-200
0
200
400
600
800
Distance from Center Line (m)



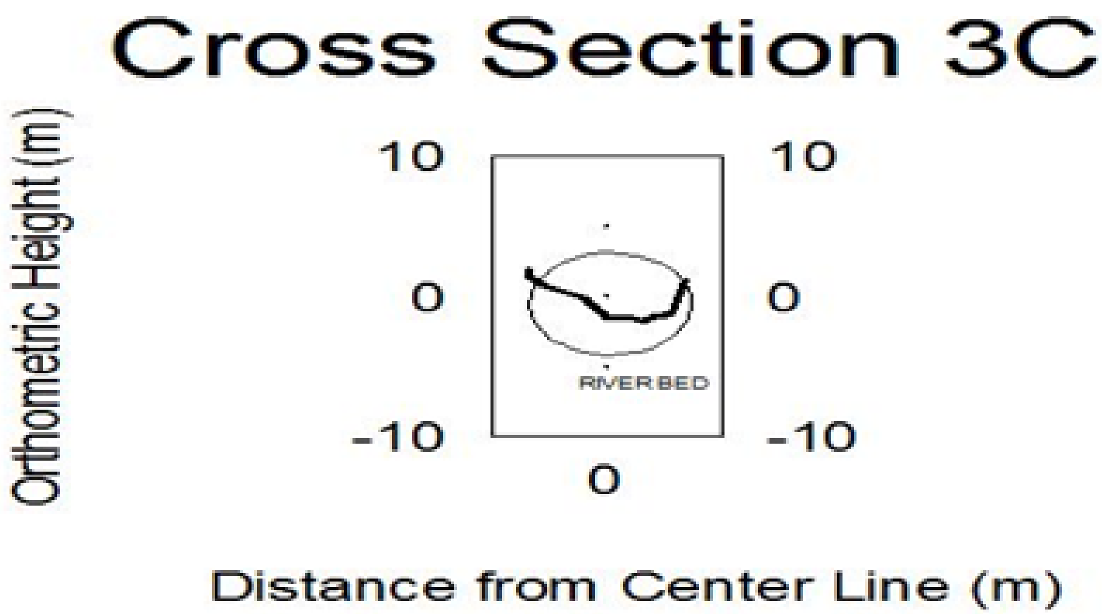
Cross Section 21B
Orthometric Height (m)
10
0
-10
RIVER BED
-800
-600
-400
-200
0
200
400
Distance from Center Line (m)

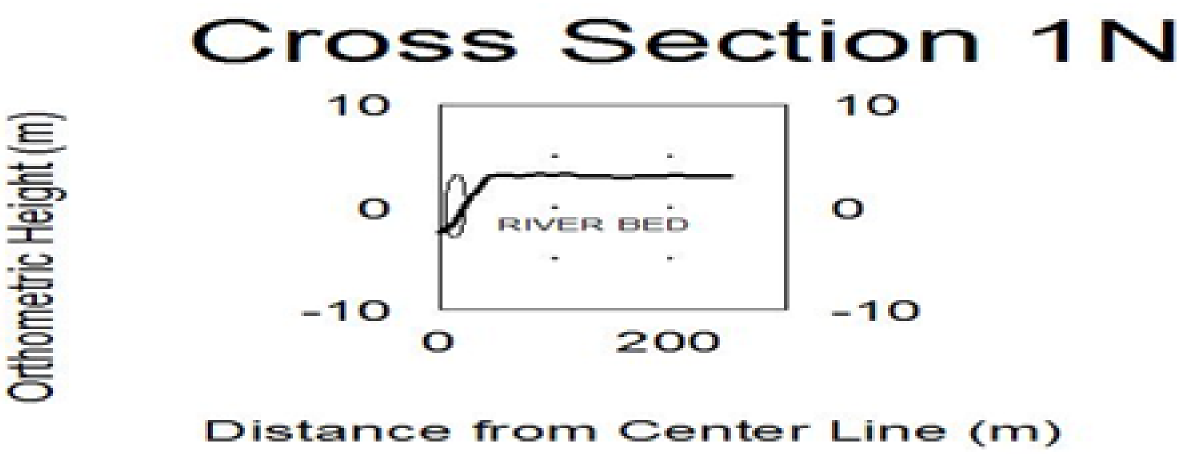


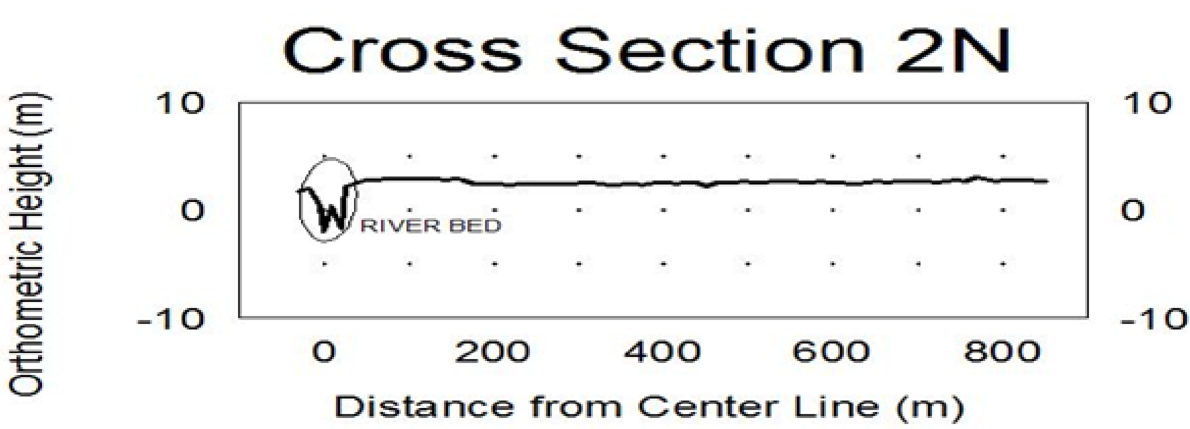
Cross Section 1C
Orthometric Height (m)
10
0
-10
RIVER BED
-800
-600
-400
-200
0
200
400
600
800
Distance from Center Line (m)



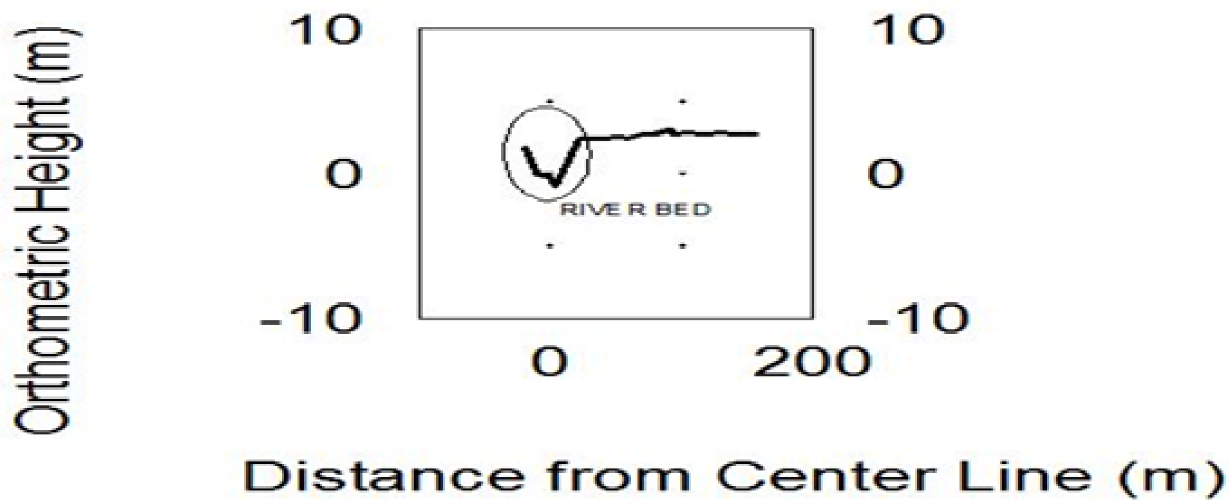
Cross Section 2C
Orthometric Height (m)
10
0
-10
RIVER BED
-400
-200
0
Distance from Center Line (m)


Cross Section 3C
Orthometric Height (m)
10
0
-10
10
0
-10
RIVER BED
0
Distance from Center Line (m)


Cross Section 1N
Orthometric Height (m)
10
0
-10
10
0
-10
RIVER BED
0
200
Distance from Center Line (m)


Cross Section 2N
Orthometric Height (m)
10
0
-10
10
0
-10
RIVER BED
0
200
400
600
800
Distance from Center Line (m)

Cross Section 3N



Bibliography

- Otieno, J. (2004, March 1). Scenario Study for Flood Hazard Assessment in the Lower Bicol Floodplain: The Philippines Using a 2D Flood Model. Retrieved August 12, 2015, from http://www.itc.nl/library/Papers_2004/msc/ereg/otieno.pdf

- Bicol River Basin and Water Management Project. Regional Development Council - Bicol Region. Archived from the original on 16 September 2008. Retrieved 2008-09-12

DREAM

Disaster Risk and Exposure Assessment for Mitigation