REGION 7

Ilog-Hilabangan River:

DREAM Ground Surveys Report

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY

2015

Published by the UP Training Center for Applied Geodesy and Photogrammetry (TCAGP)
College of Engineering
University of the Philippines Diliman
Quezon City
1101 PHILIPPINES

This research work is supported by the Department of Science and Technology (DOST) Grants-in-Aid Program and is to be cited as:

UP TCAGP (2015), DREAM Ground Survey for Davao River, Disaster Risk and Exposure Assessment for Mitigation (DREAM) Program, DOST Grants-In-Aid Program, 109 pp.

For questions/queries regarding this report, contact:

Engr. Louie P. Balicanta, MAURP
Project Leader, Data Validation Component, DREAM Program
University of the Philippines Diliman
Quezon City, Philippines 1101
Email: louie_balicanta@yahoo.com

Enrico C. Paringit, Dr. Eng.
Program Leader, DREAM Program
University of the Philippines Diliman
Quezon City, Philippines 1101
E-mail: paringit@gmail.com

National Library of the Philippines
ISBN: 978-971-9695-36-3

Table of Contents

List of Figures

List of Figures

List of Tables

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.

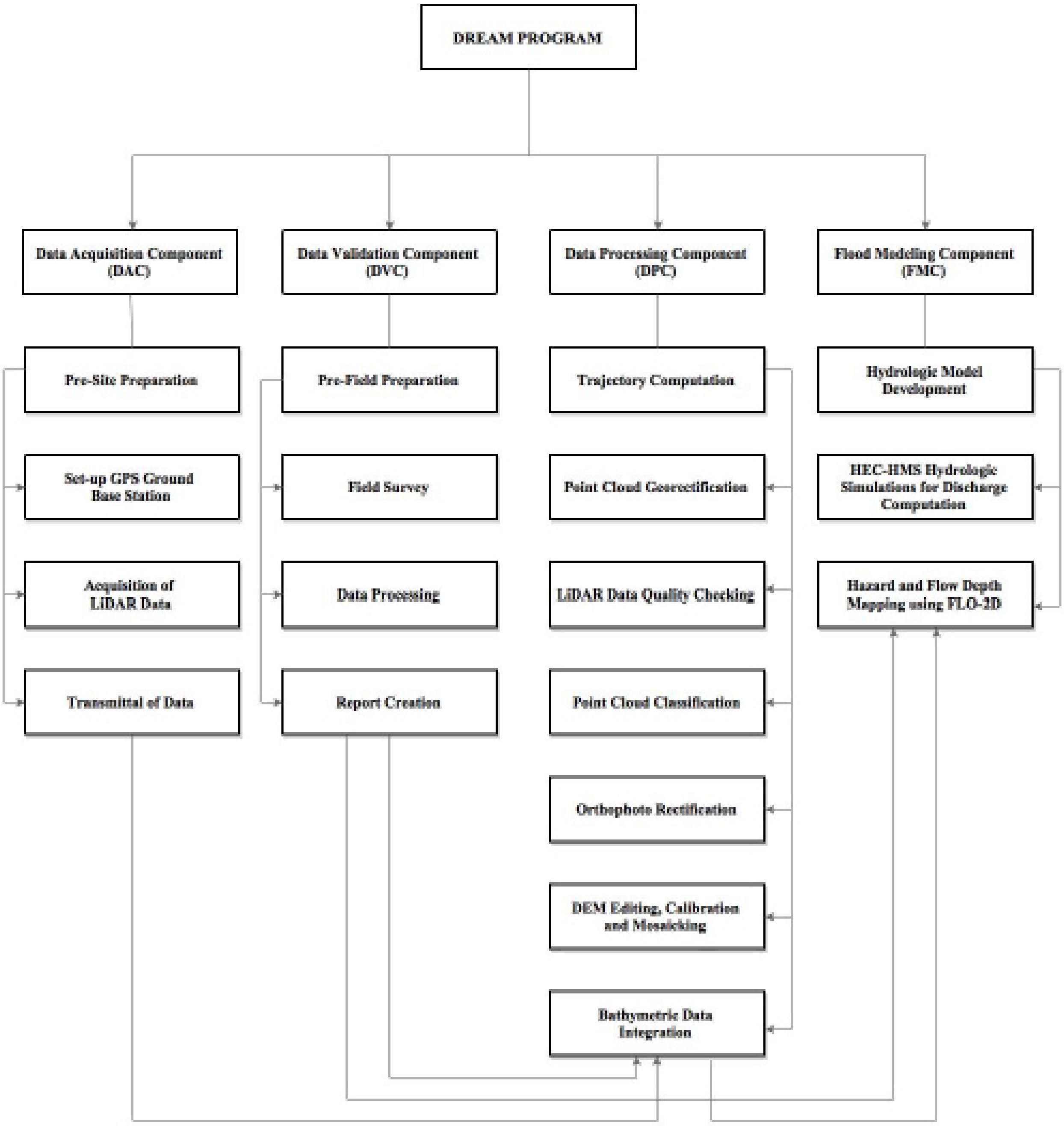


Figure 1. The General Methodological Framework of the Program

Ilog-Hilabangan River Basin

Ilog-Hilabangan River Basin

The Hilabangan River Basin is located in the island of Negros. With an estimated basin area of 1,945 square kilometres, the Hilabangan River Basin is the 11th largest river basin in the Philippines. It covers the cities of Kabankalan, Sipalay and Himamaylan and the municipalities of Cauayan, Ilog and Candoni in Negros Occidental, and the cities of Tanjay, Bais and Bayawan and the municipalities of Jimalalud, Tayasan, Ayungon, Bindoy, Manjuyod and Mabinay in Negros Oriental.

The location of the Hilabangan River Basin is as shown in Figure 1.

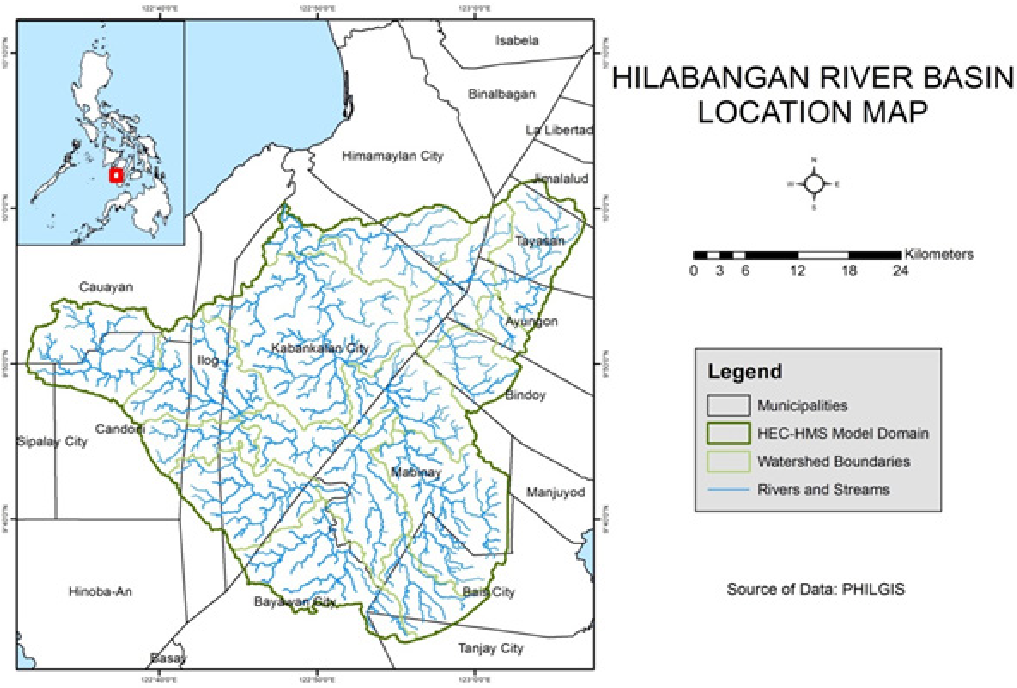


Figure 2. The Ilog-Hilabangan River Basin Location Map

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 Ilog-Hilabangan River Basin are shown in Figure 3 and 4, respectively.

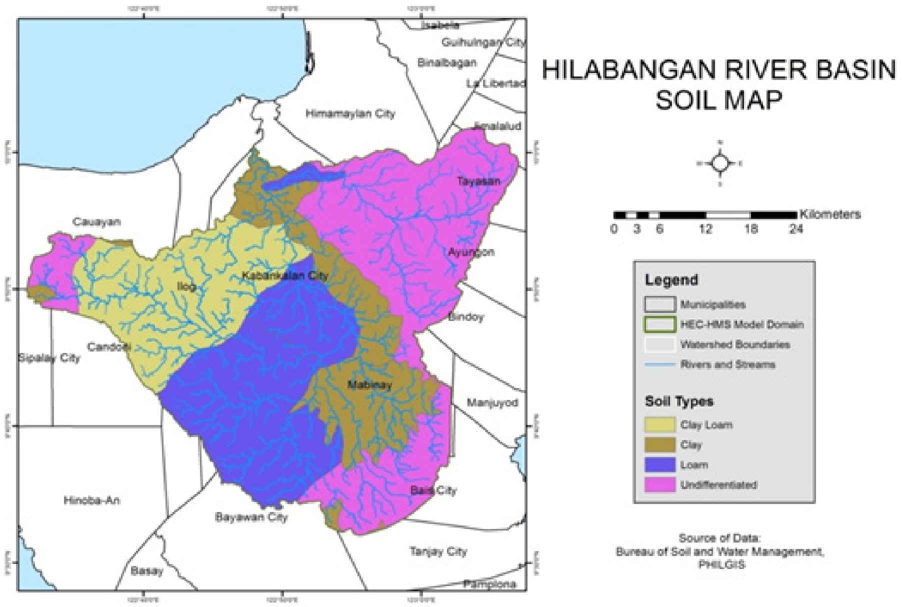


Figure 3. Ilog-Hilabangan River Basin Soil Map

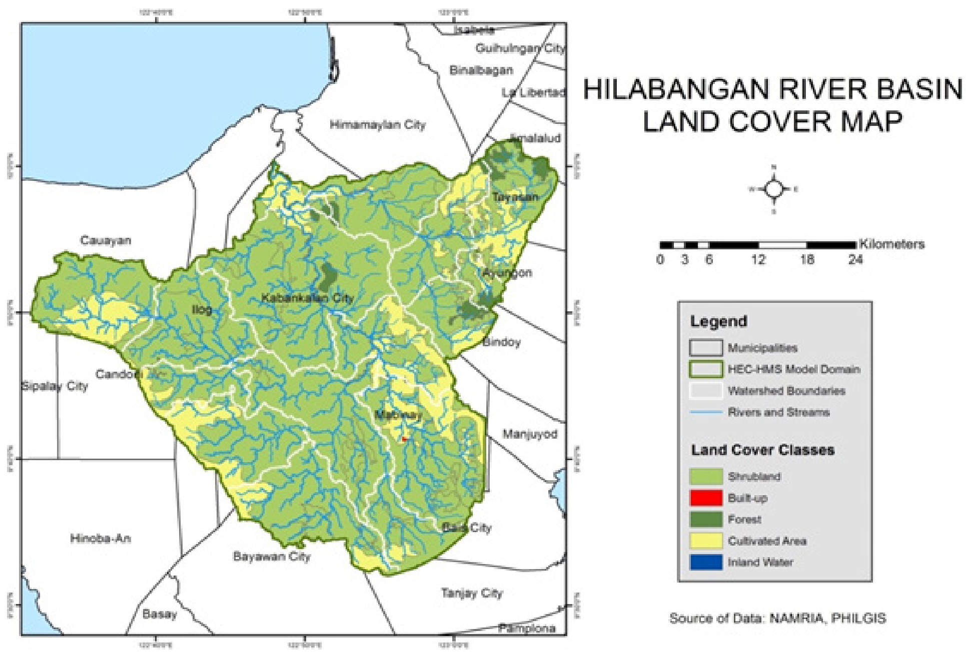


Figure 4. Ilog-Hilabangan River Basin Land Cover Map

DVC Methodology

DVC Methodology

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

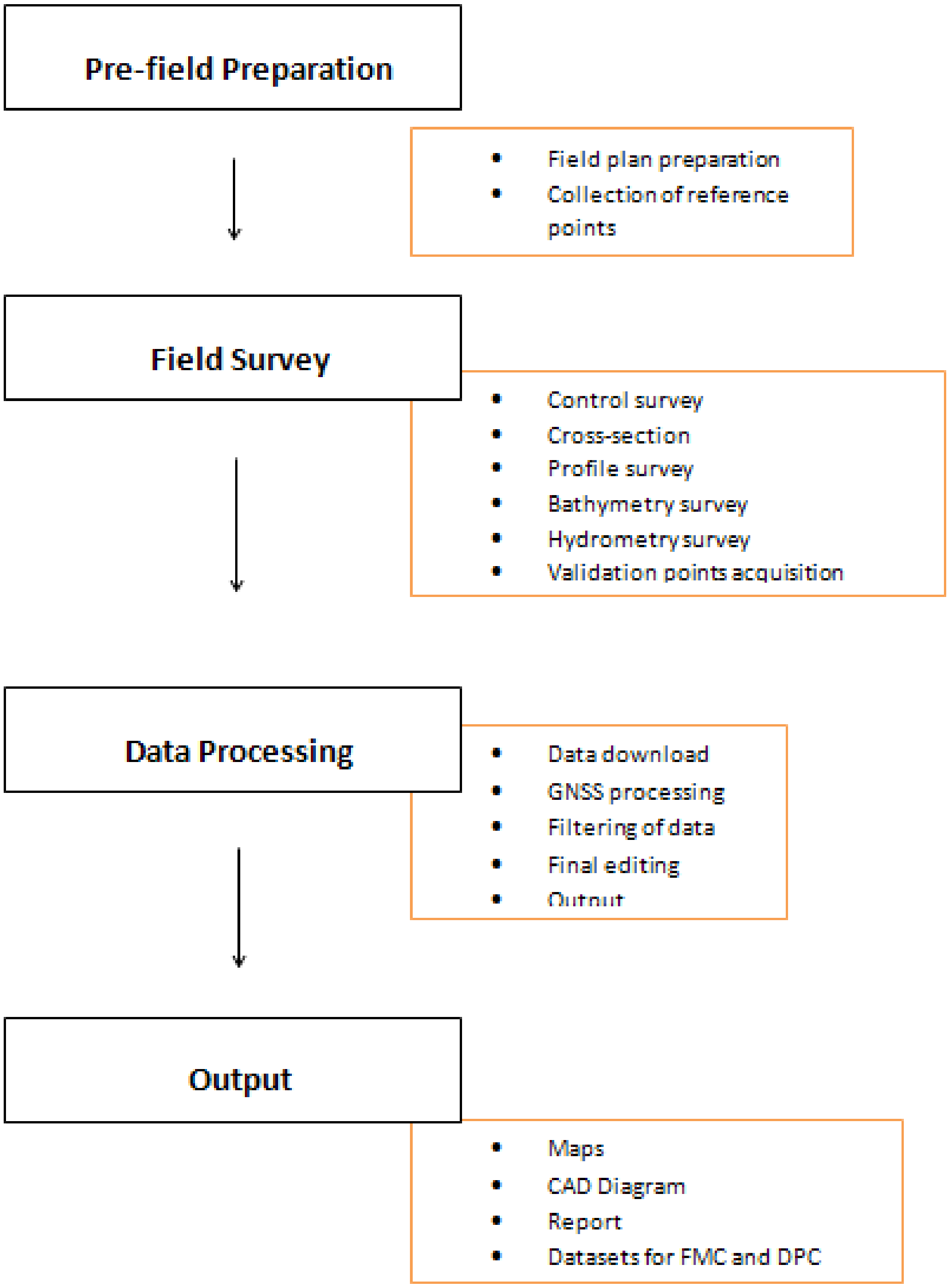


Figure 5. DVC Main Activities

DVC Methodology

3.1 Pre-field Preparation

3.1.1 Preparation of Field Plan

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

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

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

3.1.2 Collection of Reference Points

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

3.2 Field Surveys

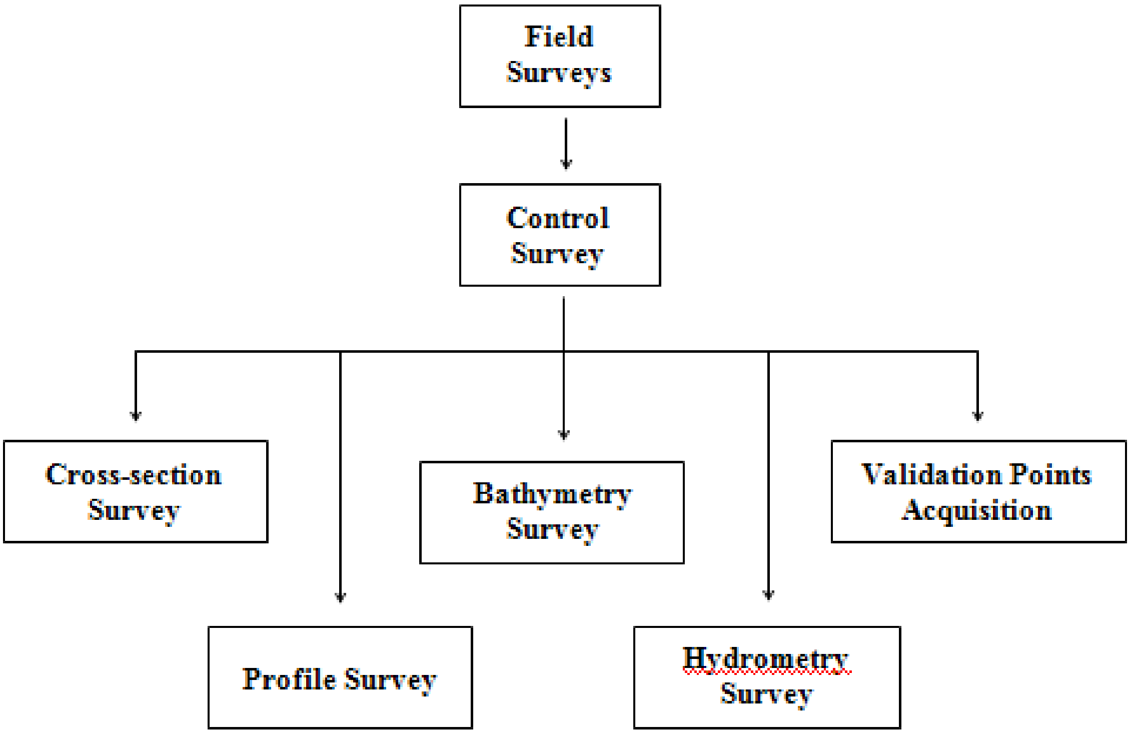


Figure 6. DVC Field Activities

3.2.1 Control Survey

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

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

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

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

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

3.2.2 Cross-section Survey

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

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

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

3.2.3 Profile Surveys

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

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

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

3.2.4 Bathymetric Survey

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

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

3.2.5 Hydrometric Survey

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

The elements of discharge computation are the ff.:

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

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

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

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

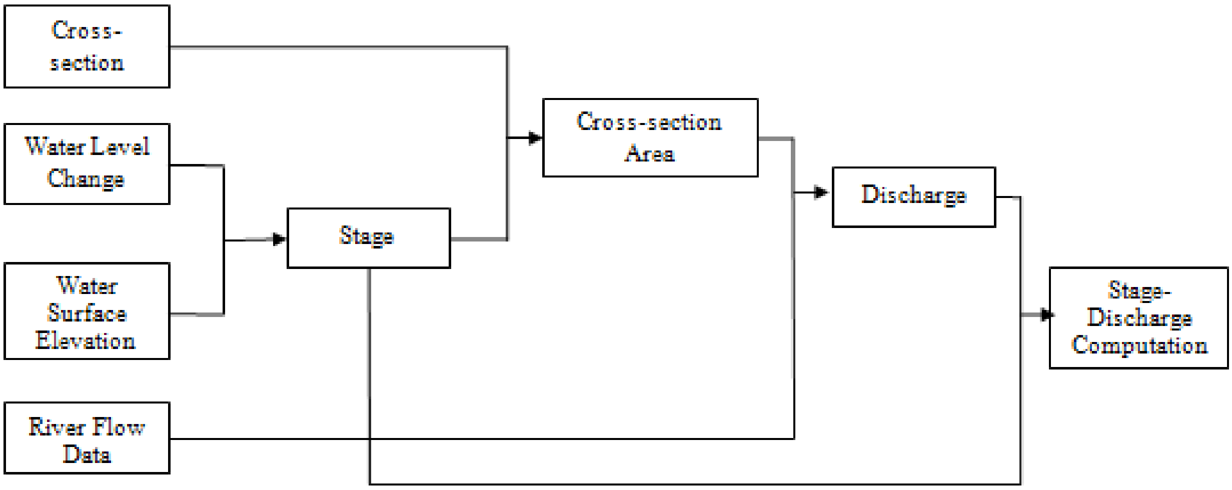


Figure 7. Flow Chart for Stage-Discharge Correlation Computation

3.2.6 Validation Points Acquisition Survey

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

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

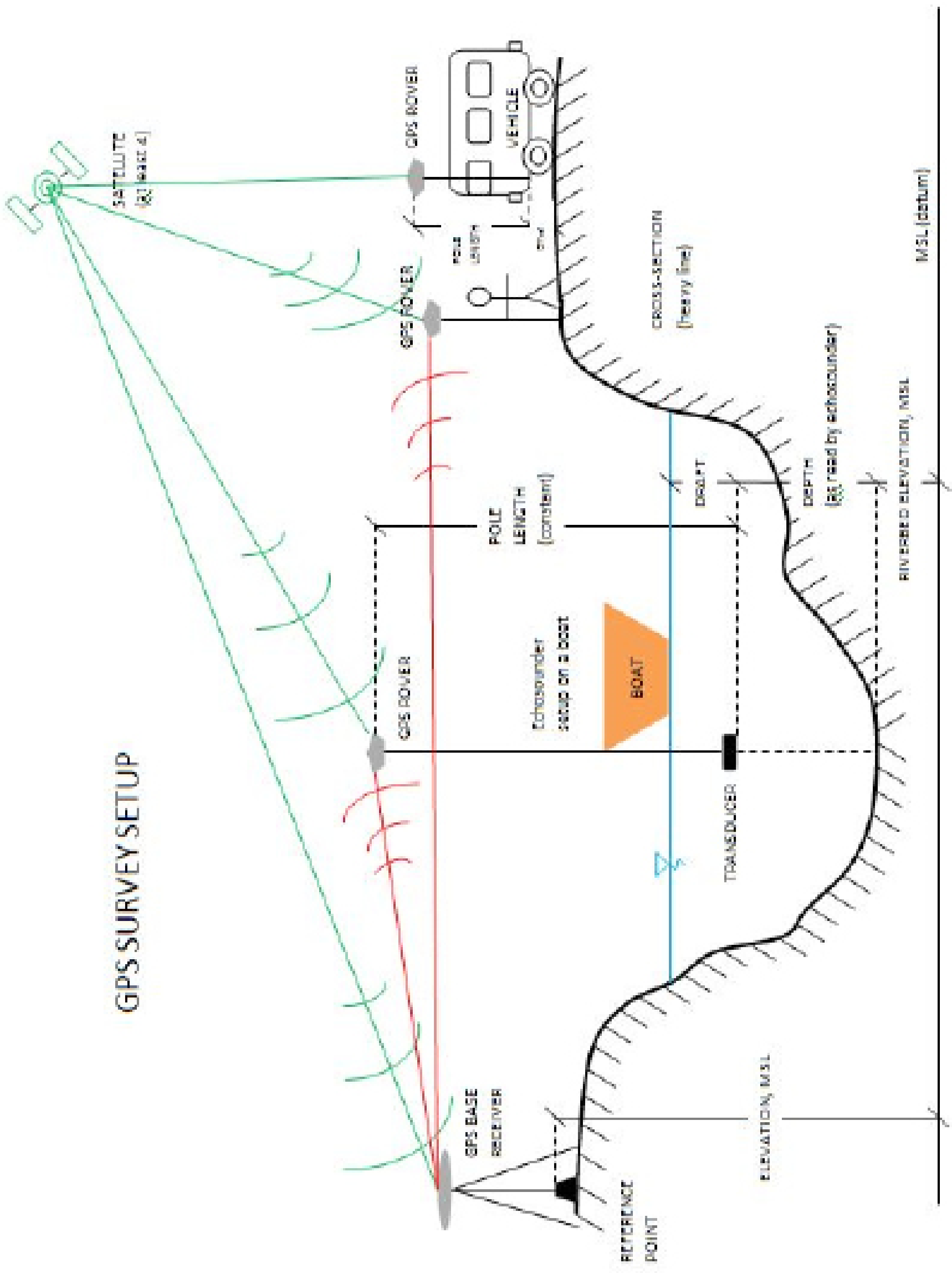


Figure 8. Set-up for GNSS Survey

3.3 Data Processing

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

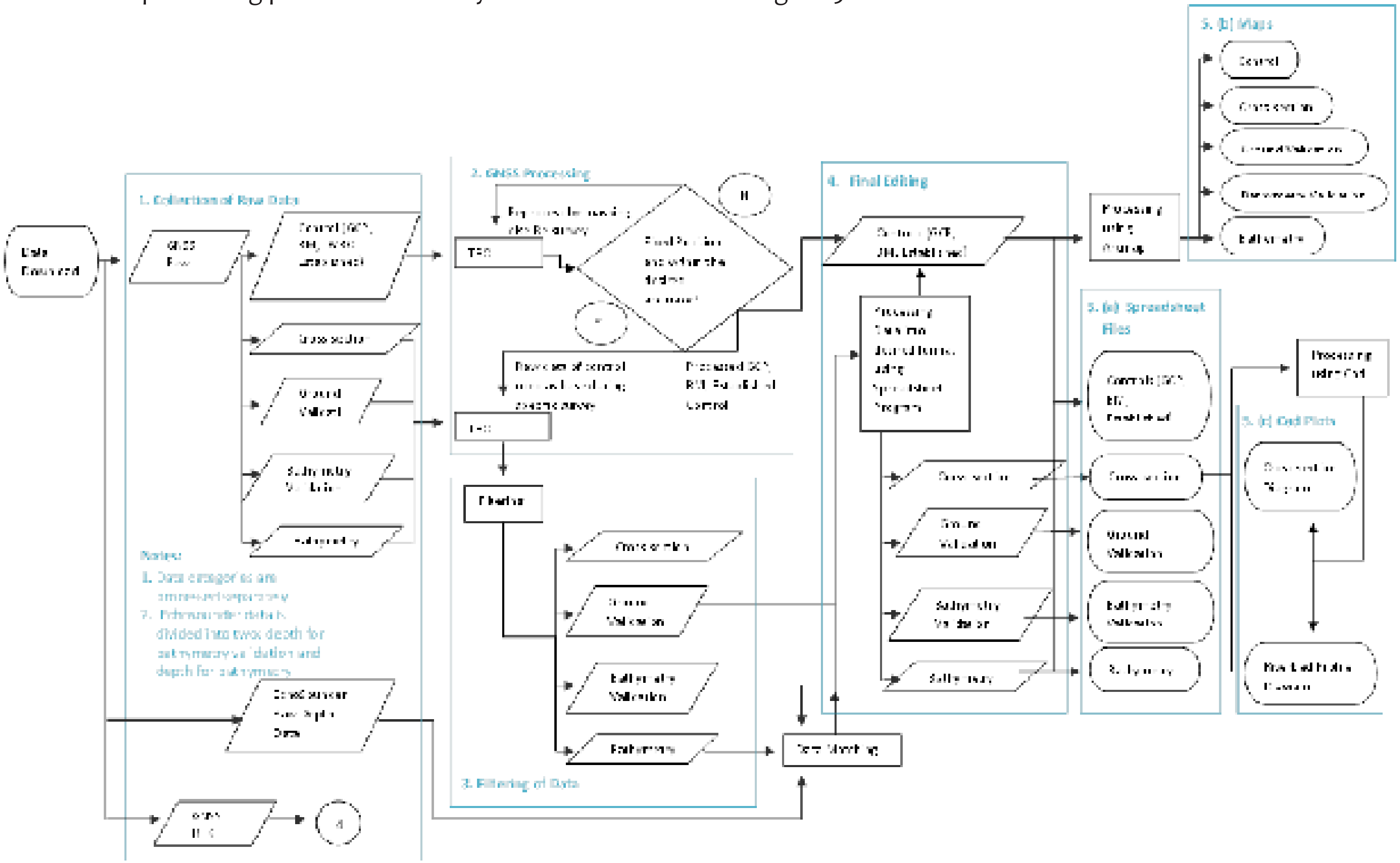


Figure 9. DVC Data Processing Methodology

3.3.1 Collection of Raw Data

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

3.3.2 Data Processing

Processing for GNSS Data

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

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

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

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

Computation for offset:

Equation 1:

$$OFFSET = BM - EGM$$

Computation for BM_ortho:

Equation 2:

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

where:

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

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

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

Depth Data Processing

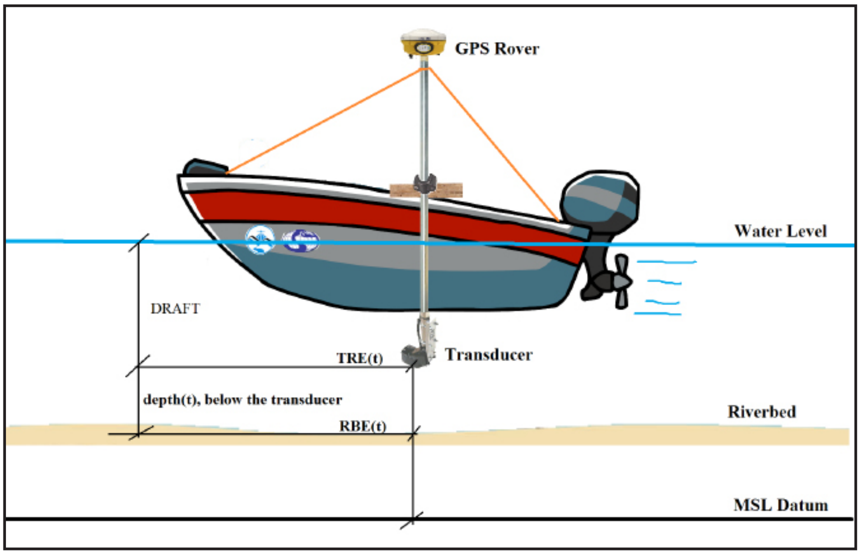


Figure 10. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

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

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

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

Data Matching for Bathymetric Data

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

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

Equation 3:

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

where:

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

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

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

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

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

Hydrometry Data Processing

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

1. **River Flow Data**

a.) ADCP

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

b.) Flow Meter

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

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

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

3. **Water Level Change-Stage**

a.) Depth Gauge

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

b.) AWLS

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

4. **Discharge Computation**

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

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

3.3.3 Filtering of Data

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

3.3.4 Final Editing

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

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

3.3.5 Output

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

Ilog-Hilabangan River Basin Survey

Ilog-Hilabangan River Basin Survey

The survey for Ilog-Hilabangan River Basin was conducted on February 28 – March 14, 2013 with the following activities: reconnaissance; control, cross-section, LiDAR ground validation and bathymetric surveys; deployment of ADCP, rain gauge and depth gauges; and searching for possible AWLS installation sites.

Ilog-Hilabangan River consists of thirty-three (33) cross-sectional lines with an approximate length of 60.28 km. The total length of profile lines is about 102.6 km longitudinal profile along the banks of Ilog-Hilabangan River starting from Brgy. Camansi and Orong, Kabankalan City downstream to Brgy. II and Bocana, Ilog. Bathymetric survey of Ilog-Hilabangan River starting with the same start and end points as that of the profile survey with an approximate centerline length of 25.4 km and a zigzag sweep length of 47.6 km.

Ground surveys for both cross-section and profile lines were conducted by Thetan Computerized Mapping & Engineering Services on May 24, 2013 to June 8, 2013 as described in Annex F.

Another set of fieldwork was conducted on October 10-14, 2013 to acquire the cross-section and sensor elevation of the installed AWLS and to perform flow data gathering in Matina Pangi Bridge II in Brgy. Matina Pangi, Ilog-Hilabangan City.

4.1 Control Survey

Three (3) NAMRIA established control points were considered for the static GNSS observations. These include BM NW 353, located in front of the old municipal hall of Kabankalan City; NW249 at Malabog Bridge, Ilog; NGW 104 at Moog Bridge, Vista Alegre, Ilog; and NGW 105 at Ilog-Hilabangan Bridge, respectively. The reference point NW-353 was occupied as a GNSS base station for the bathymetric survey. Locations of these controls are shown in Figure 11 while the GNSS set-up for the three (3) base stations are shown in Figures 12-15.

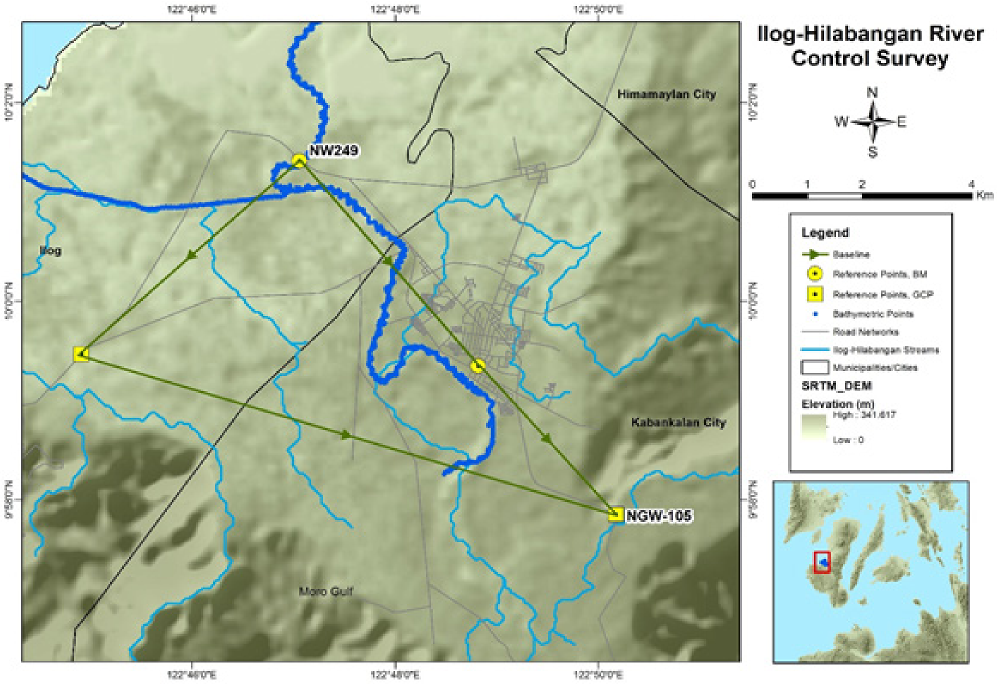


Figure 11. Location of control points

Continuous differential static observations were done simultaneously at these three stations for two hours to provide reference control points for the ground and bathymetric surveys. The horizontal coordinates and elevations of the three (3) 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 Ilog-Hilabangan 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)	
NW249	10d01'24.89176"	122d47'03.55061"	69.618	1108027.440	476364.052	7.2123
BM NW 353	9d59'20.85149"	122d48'49.18188"	70.901	1104215.920	479577.439	8.0794
NGW-104	9d59'27.96861"	122d44'54.77368"	66.905	1104439.23	472441.184	4.3297
NGW-105	9d57'51.17609"	122d50'10.59734"	83.245	1101460.481	482054.716	20.1406

The GNSS setup for the three (3) control points are illustrated in Figures 12-15:

Figure 12. PPK base station at BM-NW 353 located in front of the old Municipal Hall of Kabankalan City

Figure 13. NW-249 located at Sitio Malabong, Malabong Bridge considered as a ground control point for the creation of GNSS Network

Figure 14. NGW-104 located at Moog Bridge in Vista Alegre, Municipality of Ilog

Figure 15. NGW-105 is located in Ilog-Hilabangan Bridge that was also used to establish a GNSS Network

Ilog-Hilabangan River Basin Survey-

The objective of the Reconnaissance Team (RT) is to inspect the pre-defined cross section and profile lines along Panay River. The RT noted the characteristics of the location of the cross section and took pictures of the area. Garmin Montana™ 650 was used to locate the planned cross section and profile lines.

The majority of the cross sections were deemed passable. Most obstructions are caused canopy of trees which makes GNSS surveying not ideal. Using a total station is advised in such cases.

4.2 Reconnaissance of Cross-section and Profile Lines

Reconnaissance was conducted for four (4) days and reported that both the proposed routes for cross-section and profile lines were deemed generally confirmed traversable and feasible since the contractor has the option to conduct the survey using either differential PPK/ RTK or Total Station, depending on the actual situation and features (vegetative cover, thick tree canopies, etc) where the pre-determined lines lie at (see ANNEX E). Possible NAMRIA established control points were also identified for static GNSS observations.

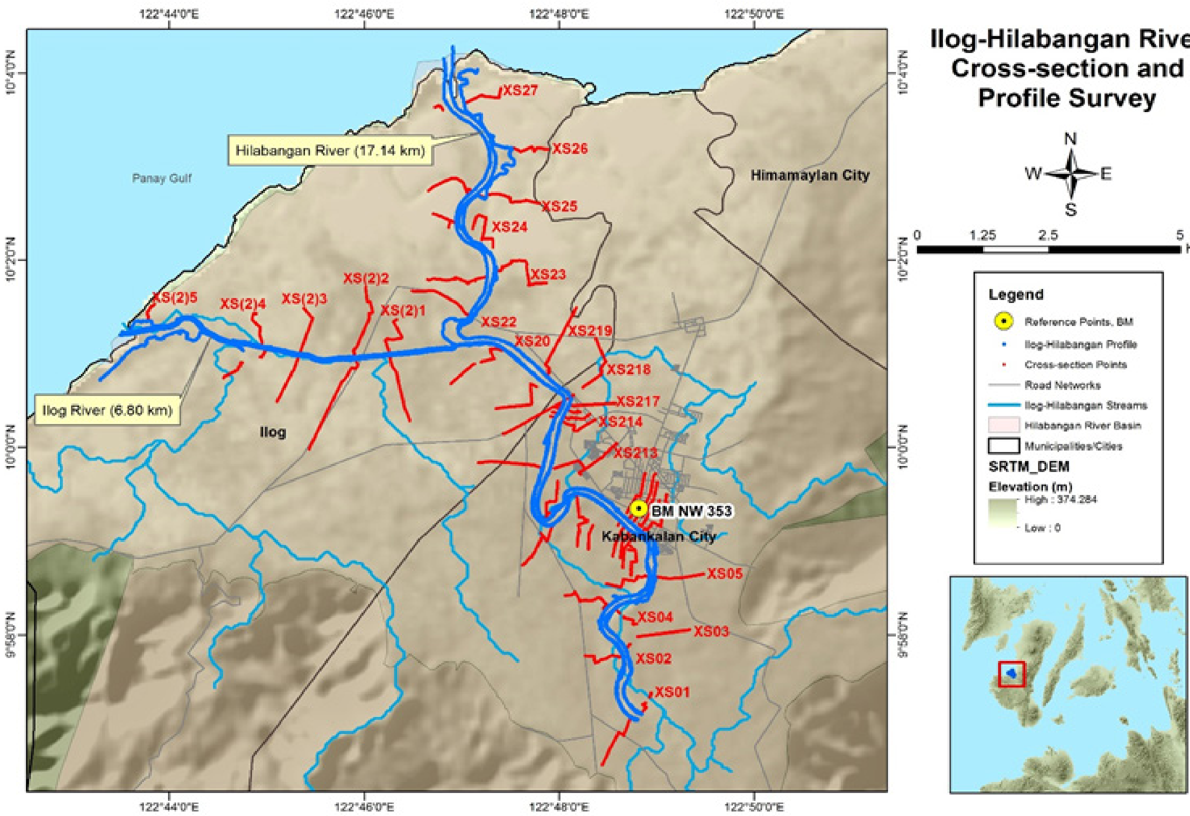


Figure 16. Profile and Cross-section of Ilog-Hilabangan River

4.3 Bathymetric Survey

The underwater terrain of the river channel was surveyed using an echo sounding surveying technique. Hi-Target™ HD-370 Digital VF single beam echo sounder was used for the bathymetric/hydrographic survey that measured the depth of the river.

The coordinates of these points were measured using differential GNSS PPK mode in which a PPK base station was occupying on a known location at BM NW-353 in Kabankalan City and a roving GNSS receiver, Trimble® SPS882, mounted above the transducer which determines the position of the points gathered by the echo sounder.

In order to fully capture the topography of the riverbed, the bathymetry survey was done in two directions, one is along the centerline which approximates the thalweg of the river while the other courses through the river in a zigzag fashion, from one bank to the other. The setup for the bathymetric survey is shown in Figures 17-19.

The entire bathymetric survey took two (2) days to accomplish, from March 3 to 4, 2013 starting from Brgy. Camansi and Brgy. Orong in Kabankalan City down to Brgy 2 and Bocana in Ilog covering approximately of 47.61 km. The acquired bathymetric data is illustrated in a map in Figure 20.

Figure 17. Securing the Hi-Target™ HD-370 Digital VF single beam echo sounder on top of the rubber boat with a metal frame and wooden plank

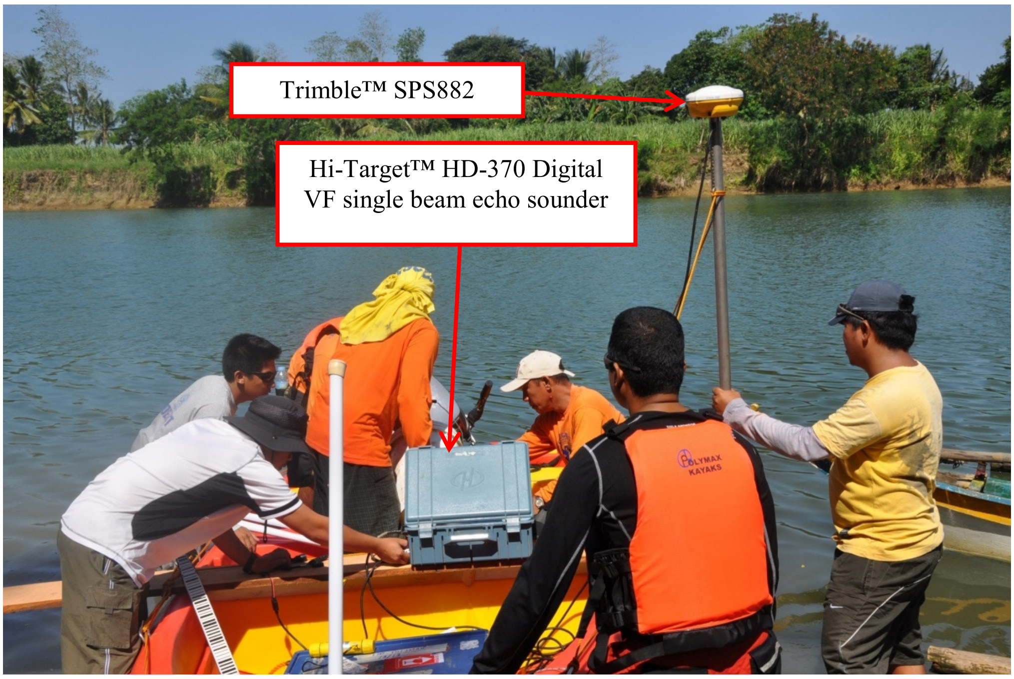


Figure 18. The set-up of instruments for the bathymetry survey with the Trimble® SPS882 mounted on top of the Hi-Target™ Transducer

Figure 19. Deployment of the bathymetry team together with members of Ilog Rescue Unit

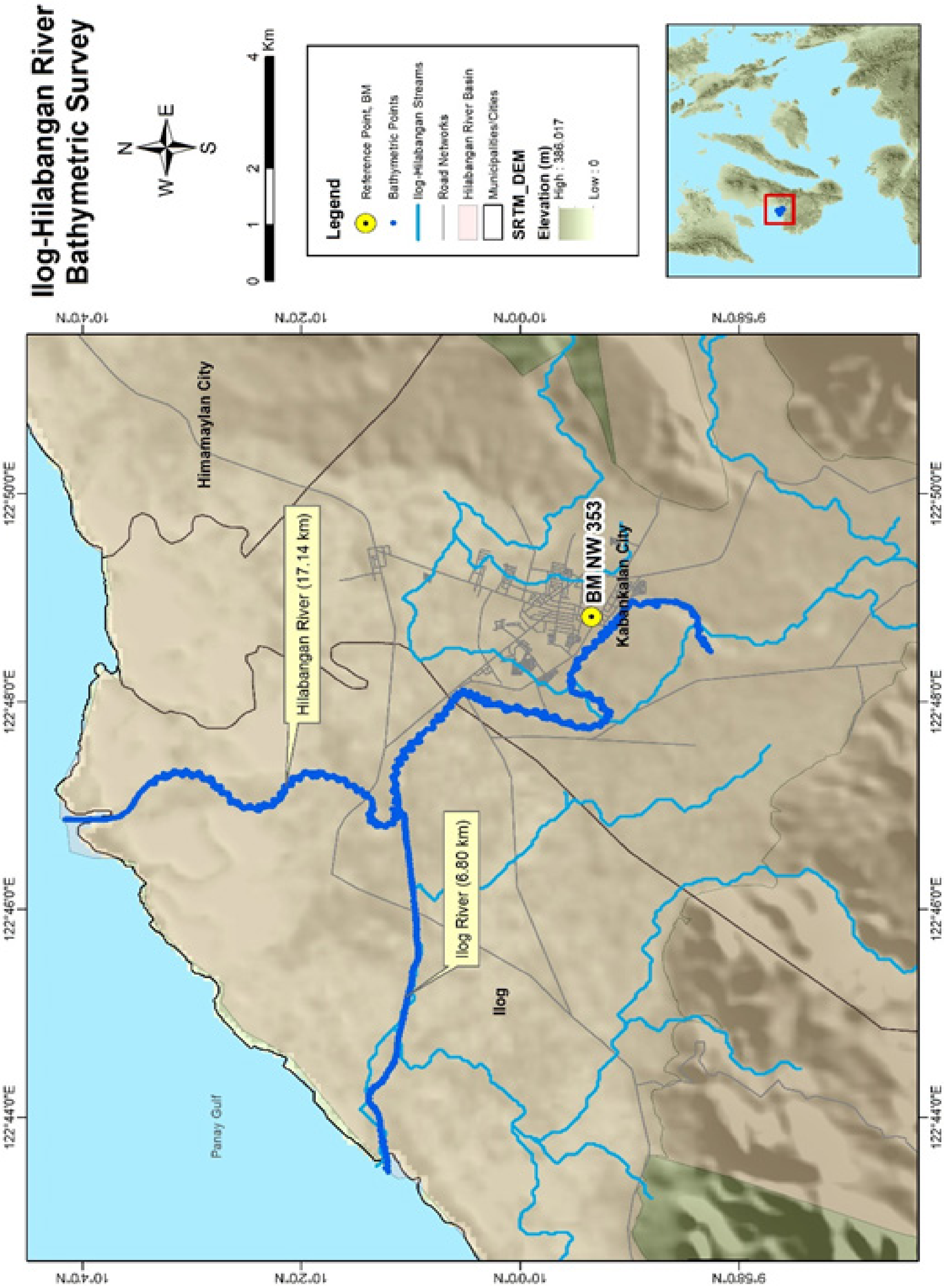


Figure 20. Bathymetric data in Ilog-Hilabangan River

4.4 Hydrometric Survey

Different sensors were deployed on the banks of Ilog-Hilabangan 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 Camansi, Kabankalan City using ADCP, Depth Gauge and Rain Gauge deployment started on the 2nd of March, 2013 and retrieved on the 12th of March, 2013. The ADCP was monitored and its data downloaded every two (2) days while the depth gauge which was installed on the metal frame together with the ADCP and the Rain Gauge, installed in Ilog, Hilabangan and Tabla Bridge continued gathering data until its retrieval.

The data gathered from the rain gauge shows the distribution of rainfall within the observation period on March 2-12, 2013. Measurements were recorded every five (5) minutes. The first surge of rainfall, reaching 0.2 mm, was observed on March 8, 2013 at 3:15 PM. Rainfall peaked on March 8, 2013 at 0.4 mm. The highest amount of rainfall, at 0.8 mm, was observed on March 12, 2013 at 3:35 PM. The amount of rainfall corresponded with peaks in water velocity are shown in Figures 21-22. Water level measurements show pronounced variations in the first five days that have slightly lessened in the last five days. Abrupt changes in rainfall also seem to correspond with a more unstable water level. Plotting the relationship of hydrometric data gathered by the sensors for water velocity vs rainfall and water level vs velocity are shown in Figure 23 and 24, respectively. Discharge is measured by multiplying the velocity of the river (measured by the ADCP) and the cross-sectional area within the polygon bounded by the stage and cross-section (see Figure 25).

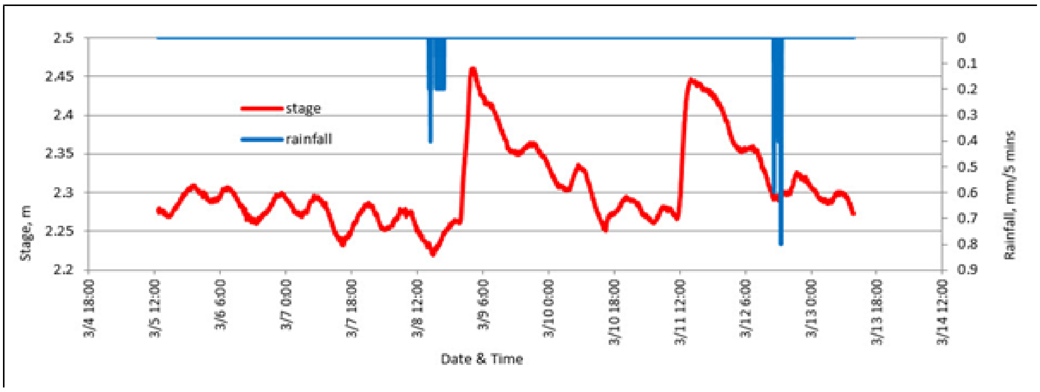


Figure 21. Graph showing the relationship between rainfall and stage of Ilog-Hilabangan River within the observation period

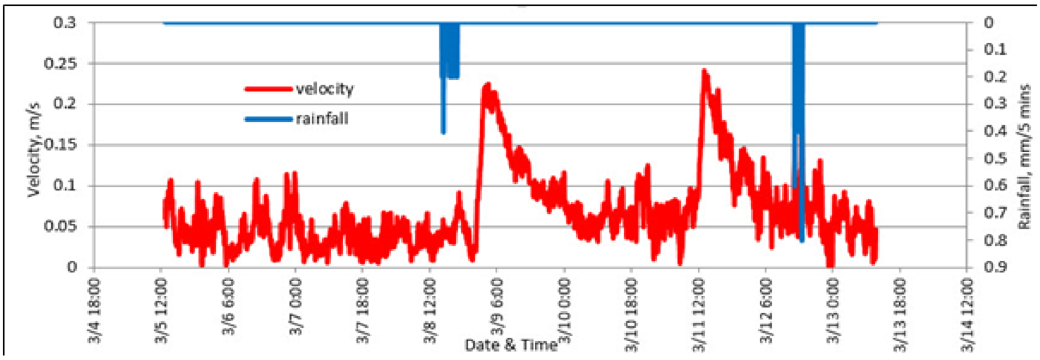


Figure 22. Graph showing the relationship between rainfall and water velocity of Ilog-Hilabangan River within the observation period

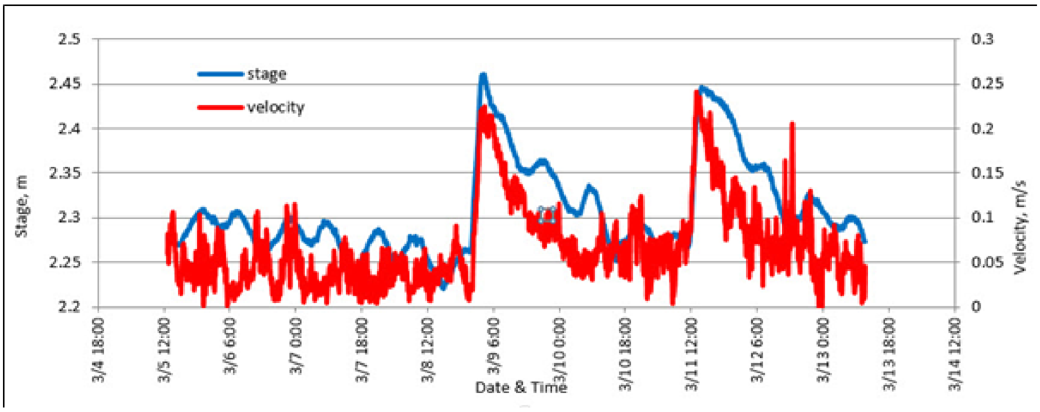


Figure 23. Graph showing the relationship between water velocity and water level of Ilog-Hilabangan River within the observation period

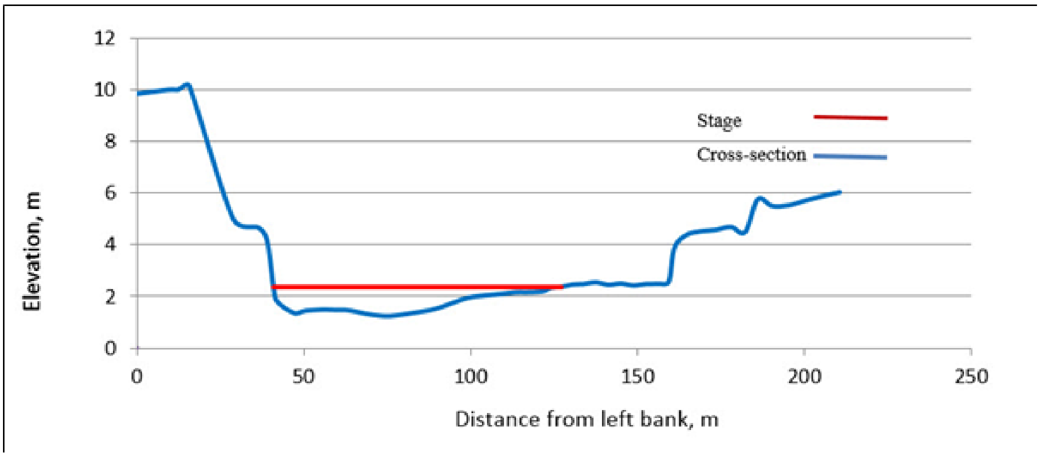


Figure 24. A graph showing the stage and the cross-section along the ADCP deployment site in Brgy. Camansi, Kabankalan City

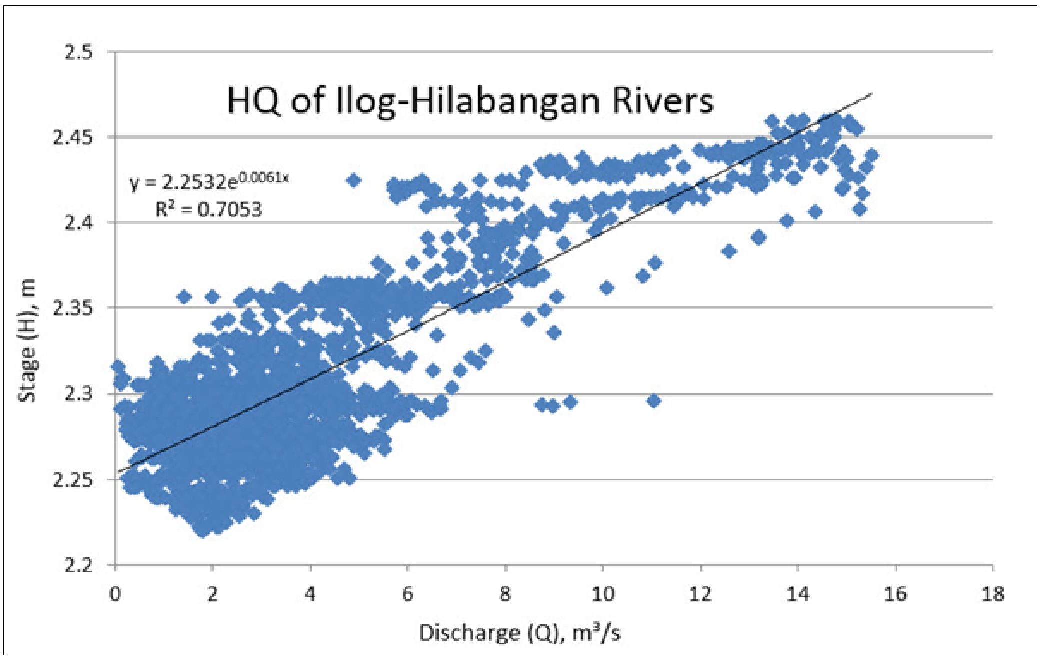


Figure 25. Graph showing the derived rating curve along the Ilog-Hilabangan River

An ADCP was first deployed on March 2, 2013 along the riverbank of Ilog-Hilabangan River in Purok 9, Brgy. Poblacion Kabankalan City. The first deployment showed poor data quality due to the effect of tide. This event led the team to retrieve the instrument and redeploy it in Brgy. Camansi, Kabankalan City on March 5, 2013. After deployment, the ADCP was left on the site to continuously collect data while being monitored by a group of local hires. The ADCP was also monitored every so often by the team, inspecting the progress of the data collection especially after a rainfall event brought about by monsoon winds. The ADCP was then retrieved on March 13, 2013, after eight (8) days of continuous data gathering.

Figure 26. A series of images of ADCP deployment on the bank of Ilog-Hilabangan River in Brgy. Camansi, Kabankalan City

Figure 27. A local hire fixing the position of the Acoustic Doppler Current Profiler along the bank of Ilog-Hilabangan River in Brgy. Camansi, Kabankalan City

Figure 28. The deployment site of the depth gauge

The depth gauge was attached to the frame together with the ADCP which acquires data on March 5-12, 2013.

The rain gauge was installed on an irrigation canal's pumping station in Brgy. Camansi, Kabankalan City about 288 meters upstream from the ADCP deployment site (see Figure 29). Rainfall data observations started upon installation on March 2-13, 2013.

Figure 29. The rain gauge installation on an irrigation canal in Brgy. Camansi, Kabankalan City

The list of sensors deployed and its location is illustrated in Table 2.

Table 2. A summary of the location, start and end of deployment of all the sensors used for stream flow measurements for Ilog-Hilabangan River

Sensor	Location	Municipality	Deployment - Start	Deployment - End	LATITUDE	LONGITUDE
ADCP	Brgy. Camansi	Kabankalan City	05-Mar 2013	12-Mar 2013	9057'07.03068"N	122048'47.83993"E
Rain Gauge	Brgy. Camansi	Kabankalan City	02-Mar 2013	12-Mar 2013	9°57'0.8700"N	122°48'54.89"E
Depth Gauge	Brgy. Camansi	Kabankalan City	05-Mar 2013	12-Mar 2013	9057'07.03068"N	122048'47.83993"E

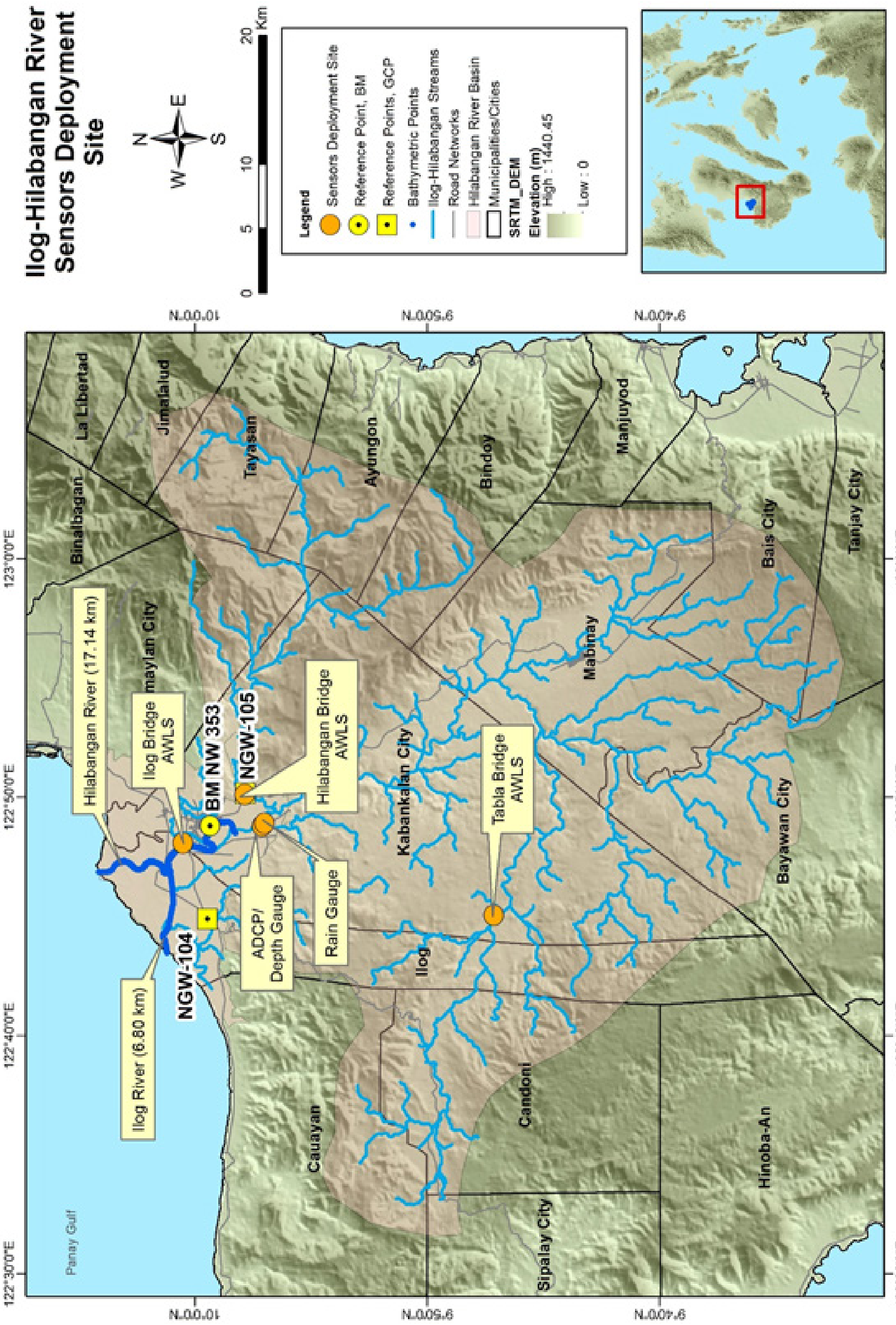


Figure 30. Sensors deployment site in Kabankalan City, Negros Occidental

Ilog-Hilabangan River Basin Survey

4.4.1 Ilog-Hilabangan AWLS Survey

Another survey was conducted for the installed AWLS along Hilabangan Bridge and Tabla Bridge in order to get its cross-sectional area and water surface elevation in MSL on October 10-14, 2013.

There are three installed AWLS identified on the online web page of NOAH. The base was set-up on a recovered benchmark BM NW -353, located in front of the old Municipal Hall of Kabankalan City (see Figure 31). This was occupied on a previous field survey on February 28 to March 14, 2013.

The summary of AWLS locations is shown in Table 3.

Figure 31. PPK base station at BM-NW 353 located in front of the old Municipal Hall of Kabankalan City

Sensors deployed were depth gauges, ADCP, and a velocity meter for the Ilog and Hilabangan Bridges as shown in Figures 32-33.

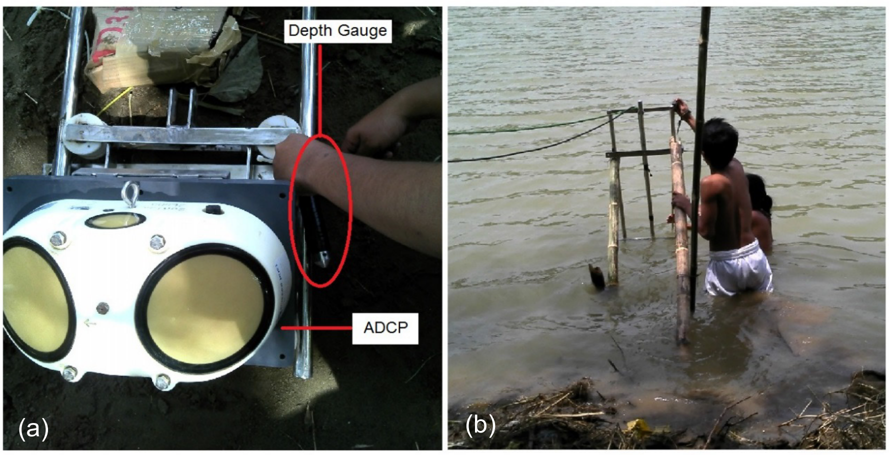


Figure 32. (a) ADCP and depth gauge set-up (b) Deployment site of the ADCP at Ilog Bridge, Kabankalan City, Negros Occidental

Figure 33. (a) Velocity Meter and Depth Gauge set-up (b) Deployment site of the Velocity Meter at Hilabangan Bridge, Kabankalan City, Negros Occidental

Table 3. The MSL elevation of the AWLS installed on Ilog, Hilabangan and Tabla Bridge

AWLS	BRGY.	LOCATION	ELEVATION (MSL), m	WATER SURFACE ELEVATION m	DATE & TIME	IMAGE	REMARKS
Hilabangan Bridge	Brgy. Hilamonan, Kabankalan City	9°57'52.35507" N 122°50'7.49721" E	21.104	7.656	10/11/2013 2:24 PM		Installed and Working
Ilog Bridge	Brgy. Talubangi, Kabankalan City	10°0'31.51026" N 122°48'5.50946" E	12.605	0.858	10/12/2013 5:51 PM		AWLS was pulled out because of the on going bridge renovation, elevation shown is the MSL elevation of the railing of the bridge.
Tabla Bridge	Bgy. Magballo, Kabankalan City	9°47'9.01241" N 122°45'3.54112" E	132.190	118.957	10/11/2013 4:53 PM		Tabla bridge is the actual deployment site of the sensor, not Magballo Bridge

The MSL elevation of the AWLS, water surface elevation and its respective differences are illustrated in Figures 34-36.

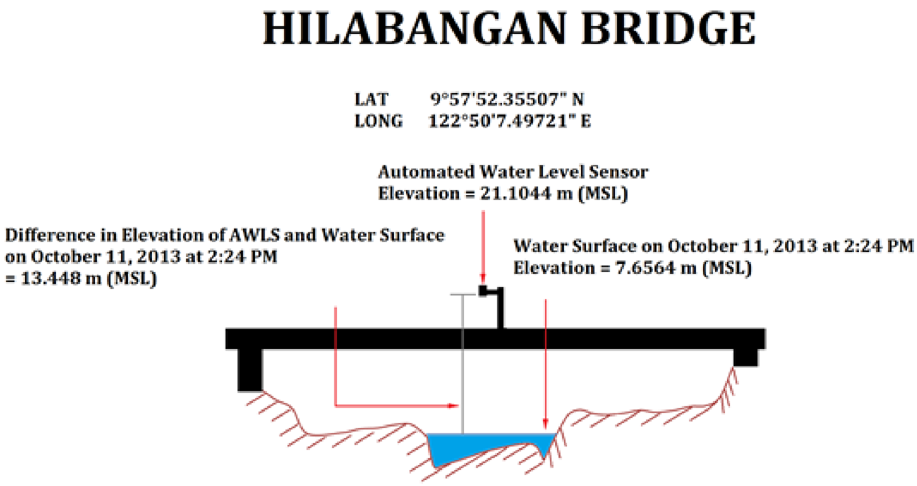


Figure 34. AWLS diagram for Hilabangan Bridge in Brgy. Hilamonan, Kabankalan City

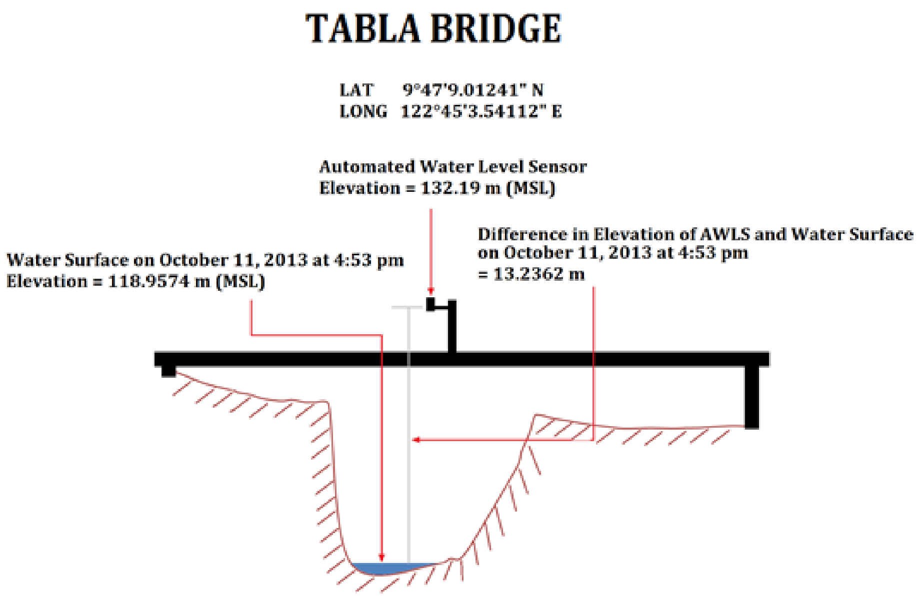


Figure 35. AWLS diagram for Tabla Bridge Bgy. Magballo, Kabankalan

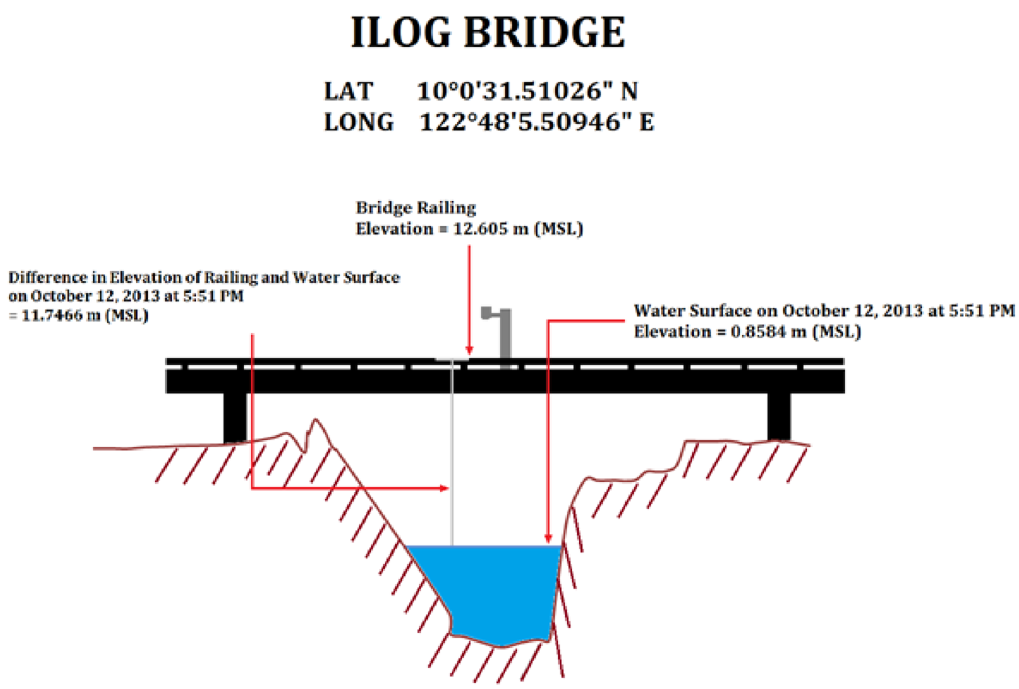


Figure 36. AWLS diagram for Ilog Bridge Brgy. Talubangi, Kabankalan City

The rain gauge data was extracted from repo.pscigrid.gov.ph while a velocity meter was deployed from October 9-13, 2013 at Ilog Bridge, Kabankalan City, Negros Occidental to obtain other hydrometric properties of the river. The data shows that the highest rainfall recorded was during October 13, 2013 with a rain value of 3.556 mm. The data are summarized in Figures 37-40.

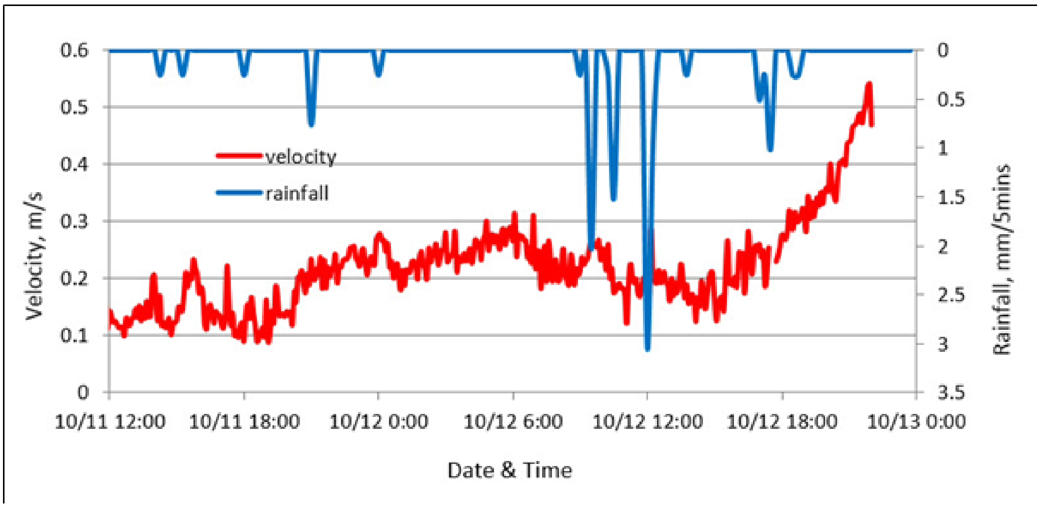


Figure 37. Graph of velocity vs. rainfall at Ilog Bridge, Kabankalan City, Negros Occidental

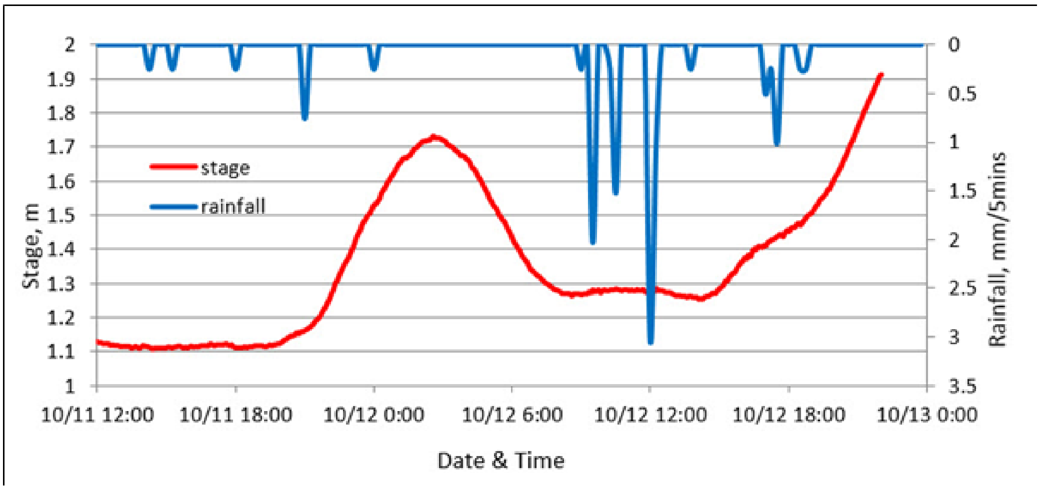


Figure 38. Graph of Rainfall vs. stage at Ilog Bridge, Kabankalan City, Negros Occidental

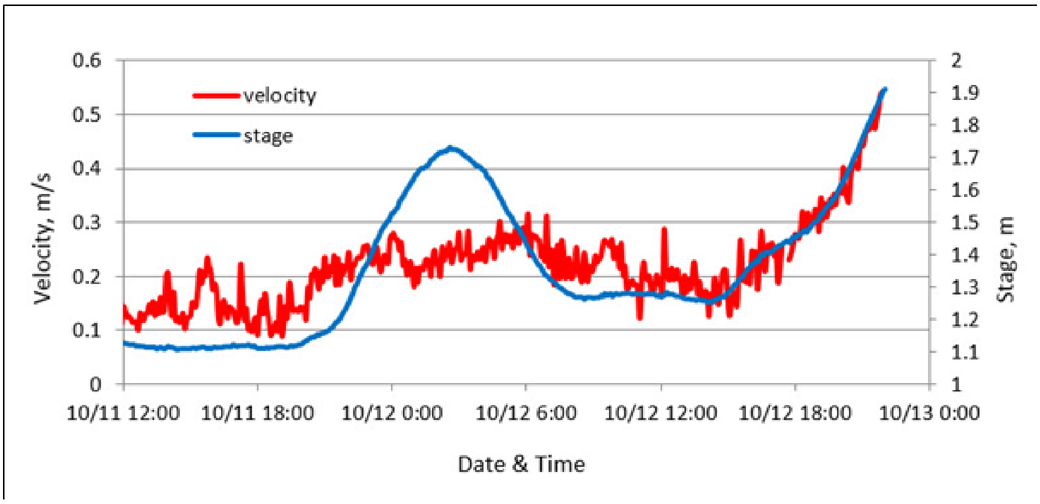


Figure 39. Graph of Stage vs. velocity at Ilog Bridge, Kabankalan City, Negros Occidental

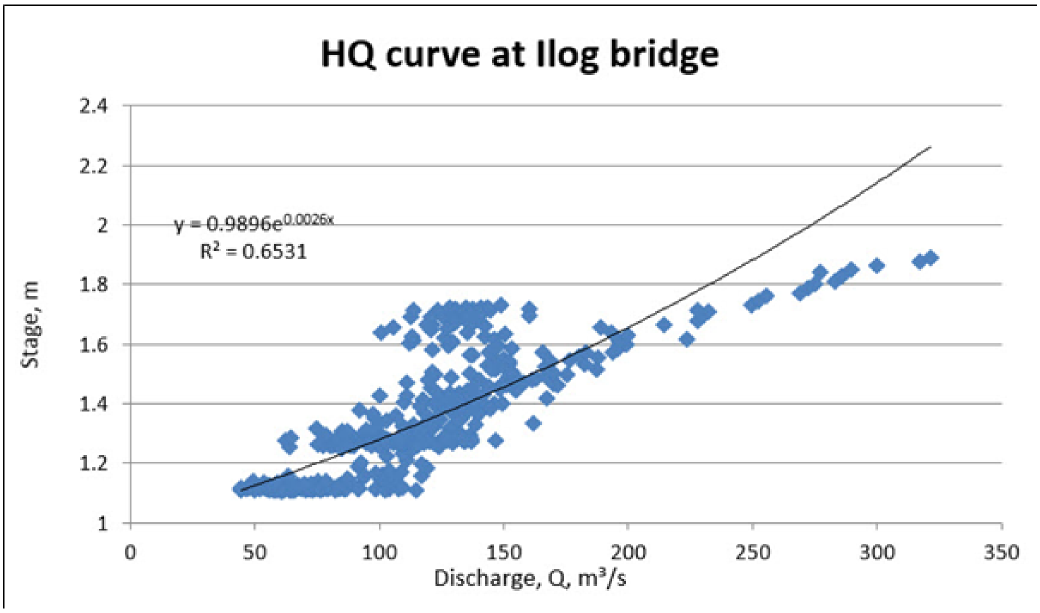


Figure 40. Stage-discharge computation at Ilog Bridge, Kabankalan City, Negros Occidental

The rain gauge data was extracted from repo.pscigrid.gov.ph while a velocity meter was deployed from October 9-13, 2013 at Hilabangan Bridge, Kabankalan City, Negros Occidental to obtain other hydrometric properties of the river. The data shows that the highest rainfall recorded was during October 10, 2013 with a rain value of 6.604 mm. The data are summarized in Figures 41-44.

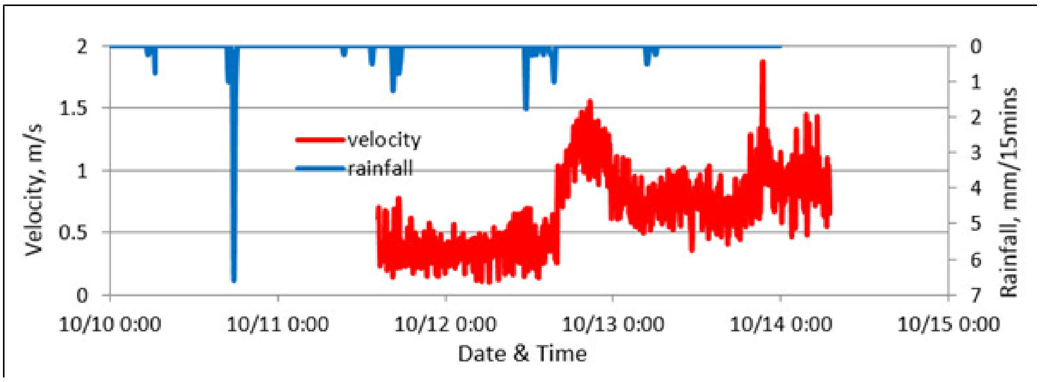


Figure 41. Velocity vs. rainfall at Hilabangan Bridge, Kabankalan City, Negros Occidental

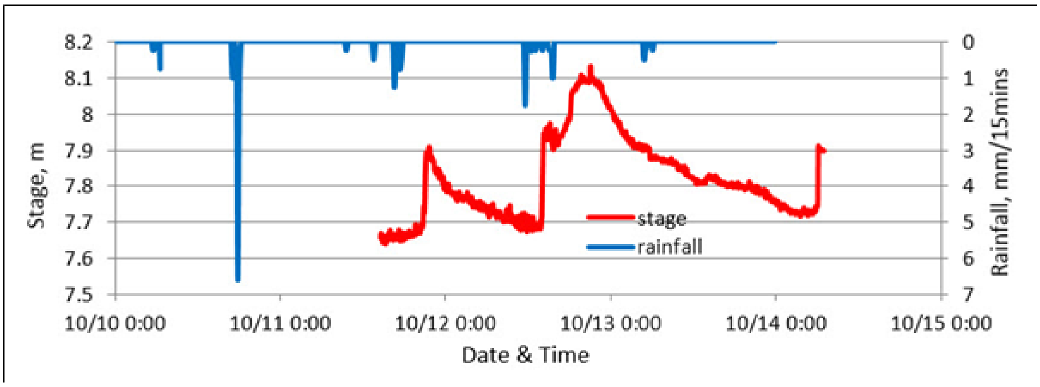


Figure 42. Rainfall vs. at Hilabangan Bridge, Kabankalan City, Negros Occidental

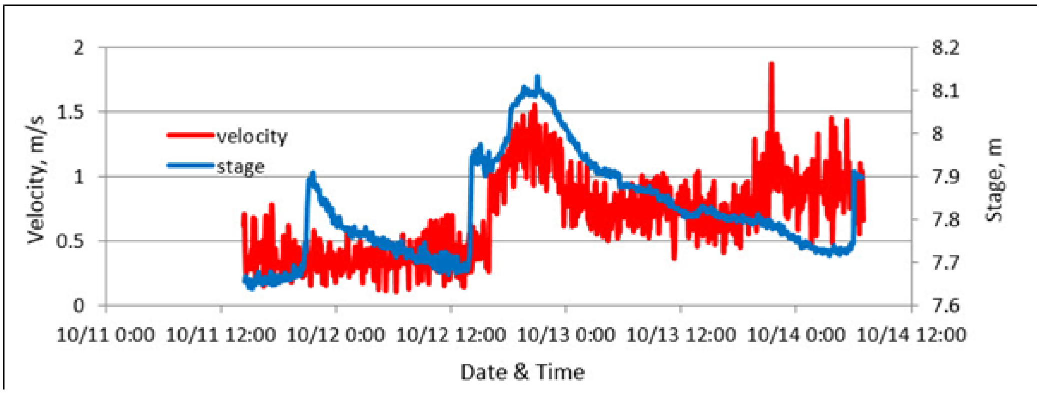


Figure 43. Velocity vs. stage in a definite Time at Hilabangan Bridge, Kabankalan City, Negros Occidental

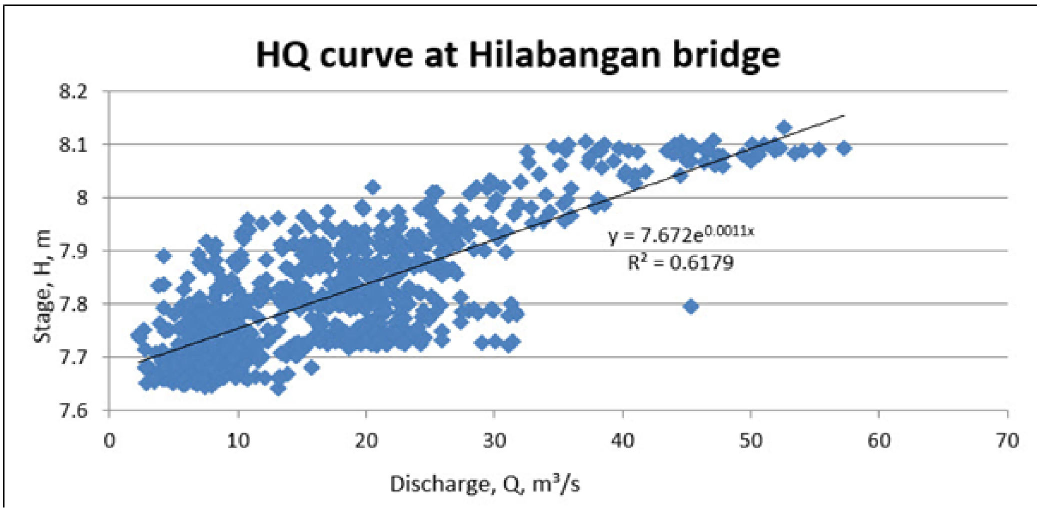


Figure 44. Stage-discharge computation at Hilabangan Bridge, Kabankalan City, Negros Occidental

The relationship between the stage or water surface elevation referred to MSL and river discharge on a specific area of the river is illustrated in Figure 44. A value approaching R2 = 1 indicates a good correlation.

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.

Problems Encountered	Resolution Applied
No available rubber boat from PCG in Bacolod City which caused the delay in bathymetry survey	Coordinated with the Local Government of Kabankalan City, Himamaylan City and Ilog for available boat to be utilized in bathymetry survey
ADCP data is affected by tide in Cross Section 6	Redeployed the ADCP in the upstream along Cross Section 1
Cross Section 6-10 left can only be accessed through a farm road	Borrowed a 4x4 truck from the Local Government of Kabankalan City
Echo sounder does not record data due to shallow water in Cross sections 1-5	Started manual bathymetric survey and traversed the length of the river by foot
Cross section 22-27 is inaccessible through land travel because the area is near the mouth of the river.	Rented a motor banca to reach the start of Cross sections 22-27

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

Type	Brand	Serial Number	Owner	Quantity
GNSS Receiver (Base)	Trimble® SPS852		UP-TCAGP	One (1) unit
GNSS Receiver (Rover)	Trimble® SPS882		UP-TCAGP	Three (3) units
GNSS Controller	Trimble® TSC3		UP-TCAGP	Three (3) units
High-Gain Antenna			UP- TCAGP	Three (3) units
Singlebeam Echosounder	Hi-Target		UP-TCAGP	One (1) unit with accessories
Acoustic Doppler Current Profiler (ADCP)	SonTek		UP- TCAGP	One (1) unit with accessories
Coupler-2B			UP- TCAGP	One (1) unit
Handheld GNSS	Garmin Oregon 550		UP-TCAGP	Four (4) units
	Montana 650		UP-TCAGP	
AA-Battery Charger	Akari		UP-TCAGP	Two (2) units
Laptops	Lenovo		UP-TCAGP	One (1) unit
	Dell Latitude E6420		UP-TCAGP	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			UP-TCAGP	One (1) unit
Range Pole			UP-TCAGP	Two (2) units
Tripod	Trimble®		UP-TCAGP	One (1) unit
Bipod	Trimble®		UP-TCAGP	Three (3) units
Tribrach			UP-TCAGP	One (1) unit
Installers	SonTek			One (1) unit
	Trimble® Business Center			One (1) unit
Toolbox				One (1) unit

ANNEX C. THE SURVEY TEAM

Data Validation Component	Designation	Name	Agency/Affiliation
Sub-Team	Chief Science Research Specialist (CSRS)	ENGR. JOEMARIE S. CABALLERO	UP TCAGP
Survey Coordinator	Senior Science Research Specialist	ENGR. MELCHOR REY M. NERY	UP TCAGP
	Bathymetric Survey Team	JOJO E. MORILLO	UP TCAGP
Profile and Cross Section Reconnaissance Team	Research Associate	JELINE M. AMANTE	UP TCAGP
	Research Associate	CARL VINCENT C. CARO	UP TCAGP
Sensors Deployment Team	Research Associate	PATRIZCIA MAE P. DELA CRUZ	UP TCAGP

ANNEX D. NAMRIA CERTIFICATION

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

March 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: **NEGROS OCCIDENTAL** Station Name: **NGW-104**		
Island: **VISAYAS**	Municipality: **ILOG**	Barangay: **VISTA ALEGRE**
Elevation: **4.3297 m.**	Order: **1st Order**	Datum: **Mean Tide Level**

Location Description

BM-NGW-104

BM-NGW-104 is in the Province of Negros Occidental, Municiapality of Ilog, Barangay Vista Alegre, Sitio Moog along the Cauayan-Kabankalan National highway. The station is located at the southeast end of the sidewalk of Moog Bridge at KM. 98+759.

Mark is the had of a 4" copper nail set flush on a 15cm. x 15cm. cement putty with inscriptions "BM-NGW-104; 2008; NAMRIA."

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3910456 B**
T.N.: **2013-0164**

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

9 9 0 3 0 5 2 0 1 3 1 5 3 7 1 5

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

March 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: **NEGROS OCCIDENTAL** Station Name: **NGW-105**	
Island: **VISAYAS**	Municipality: **KABANKALAN**	Barangay: **ORONG**
Elevation: **20.1406 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

BM-NGW-105

Is in the Province of Negros Occidental, City of Kabankalan, Brgy. Orong. The station is at the north-west of the sidewalk of Hilabangan Bridge at Km. Post 95+1047m. along the Bacolod-Bais National Highway. Mark is the head of a 4" copper nail set flush on 15cm x15cm cement putty with inscription "NGW-105, 2007, NAMRIA."

Requesting Party:	**UP-TCAGP**
Pupose:	**Reference**
OR Number:	**3910456 B**
T.N.:	**2013-0163**

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

9903052013153635

CERTIFICATION INTERNATIONAL ISO 9001:2008
CIP/4703/12/09/834

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

March 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: **NEGROS OCCIDENTAL**
Station Name: **NW-249**

Island: **VISAYAS**	Municipality: **ILOG**	Barangay: **BARANGAY II (POB.)**
Elevation: **7.2123 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

NW-249 is in the province of Negros Occidental, Municipality of Ilog, Barangay 2 Poblacion, Sitio Malabong, along municipal road.

Station is located on concrete sidewalk, Southwest end of Malabong concrete bridge, about 1.4 kilometer East of Ilog Public Cemetery.

Mark is the head of a 4" copper nail set on a drilled hole and flushed to a 6" x 6" cement putty with inscription "NW – 249, 2007, NAMRIA".

Requesting Party:	**UP-TCAGP**
Pupose:	**Reference**
OR Number:	**3910456 B**
T.N.:	**2013-0165**

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

9903052013153733

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

Annexes

ANNEX E. RECONNAISSANCE SUMMARY

Left					
Xsec Left	Brgy.	Municipality	Remarks	Comments	Photo
1	Camansi	Kabangkalan City	Traversable	Farm road; Generally traversable	
2	Camansi	Kabangkalan City	Traversable	Farm road; Generally traversable	
3	Hilamonan	Kabangkalan City	Traversable	Dirt Road; Generally traversable	
4	Hilamonan	Kabangkalan City	Traversable	Sugar Cane plantation; Generally traversable	

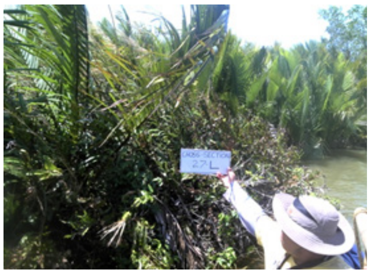
5	Hilamonan	Kabangkalan City	Traversable	Sugar Cane plantation; Generally traversable	
6	Camugao	Kabangkalan City	Traversable	Generally traversable	
7	Camugao	Kabangkalan City	Traversable	Generally traversable	
8	Camugao	Kabangkalan City	Traversable	Generally traversable	

9	Camugao	Kabangkalan City	Traversable	Generally traversable	
10	Camugao	Kabangkalan City	Traversable	Generally traversable	
11	Camugao	Kabangkalan City	Traversable	Sugar Cane plantation; Generally traversable	
12	Linao	Kabangkalan City	Traversable	Sugar Cane plantation; Generally traversable	

13	Talubangi	Kabangkalan City	Traversable	Farm road; Generally traversable	
14	Talubangi	Kabangkalan City	Traversable	Sugar Cane plantation; Generally traversable	
15	Talubangi	Kabangkalan City	Traversable	Sugar Cane plantation; Generally traversable	
16	Talubangi	Kabangkalan City	Traversable	Sugar Cane plantation; Generally traversable	

17	**Talubangi**	**Kabangkalan City**	**Traversable**	**Generally traversable**	
18	**Talubangi**	**Kabangkalan City**	**Traversable**	**Generally traversable**	
19	**Manalad**	**Kabangkalan City**	**Traversable**	**Farm road; Generally traversable**	
20	**Manalad**	**Kabangkalan City**	**Traversable**	**Farm road; Generally traversable**	
21	Andaluan	Ilog	Traversable	Generally traversable	
22	Andaluan	Ilog	Traversable	Generally traversable	
23	Andaluan	Ilog	Traversable	Rented a motorbanca to reach the Cross Section starting point	

24	Brgy. 2	Ilog	Traversable	Rented a motorbanca to reach the Cross Section starting point	
25	Brgy. 2	Ilog	Traversable	Rented a motorbanca to reach the Cross Section starting point	
26	Brgy. 2	Ilog	Traversable	Rented a motorbanca to reach the Cross Section starting point	

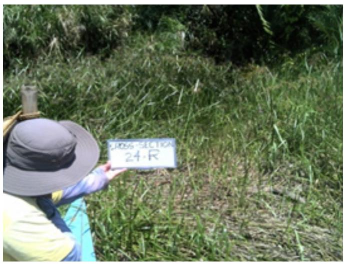
27	**Brgy. 2**	**Ilog**	**Traversable**	**Rented a motorbanca to reach the Cross Section starting point**	
(2)1	**Consuelo**	**Ilog**	**Traversable**	**Farm road; Generally traversable**	
(2)2	**Consuelo**	**Ilog**	**Traversable**	**Generally traversable**	
(2)3	Bocana	Ilog	Traversable	Generally traversable	
(2)4	Bocana	Ilog	Traversable	Rented a motorbanca to reach the Cross Section starting point	
(2)5	Bocana	Ilog	Traversable	Rented a motorbanca to reach the Cross Section starting point	

Right					
Xsec	Brgy.	Municipality	Remarks	Comments	Photo
1	Orong	Kabangkalan City	Traversable	Sugar Cane plantation; Generally traversable	
2	Hilamonan	Kabangkalan City	Traversable	Farm road; Generally traversable	
3	Hilamonan	Kabangkalan City	Traversable	Generally traversable	

4	**Hilamonan**	**Kabangkalan City**	**Traversable**	**Sugar Cane plantation; Generally traversable**	
5	**Hilamonan**	**Kabangkalan City**	**Traversable**	**Sugar Cane plantation; Generally traversable**	
6	**Hilamonan**	**Kabangkalan City**	**Traversable**	**Dirt Road; Generally traversable**	
7	Brgy. 9 (Pob)	Kabangkalan City	Traversable	Generally traversable	

12	Talubangi	Kabangkalan City	Traversable	Sugar Cane plantation; Generally traversable	
13	Talubangi	Kabangkalan City	Traversable	Farm road; Generally traversable	
14	Talubangi	Kabangkalan City	Traversable	Generally traversable	
15	Talubangi	Kabangkalan City	Traversable	Dirt Road; Generally traversable	

16	**Talubangi**	**Kabangkalan City**	**Traversable**	**Generally traversable**	
17	**Talubangi**	**Kabangkalan City**	**Traversable**	**Generally traversable**	
18	**Talubangi**	**Kabangkalan City**	**Traversable**	**Sugar Cane plantation; Generally traversable**	
19	Anduluan	Ilog	Traversable	Farm Road; Generally traversable	

20	**Anduluan**	**Ilog**	**Traversable**	**Generally traversable**	
21	**Anduluan**	**Ilog**	**Traversable**	**Rented a motorbanca to reach the Cross Section starting point**	
22	**Anduluan**	**Ilog**	**Traversable**	**Generally traversable**	
23	Anduluan	Ilog	Traversable	Rented a motorbanca to reach the Cross Section starting point	
24	Anduluan	Ilog	Traversable	Rented a motorbanca to reach the Cross Section starting point	

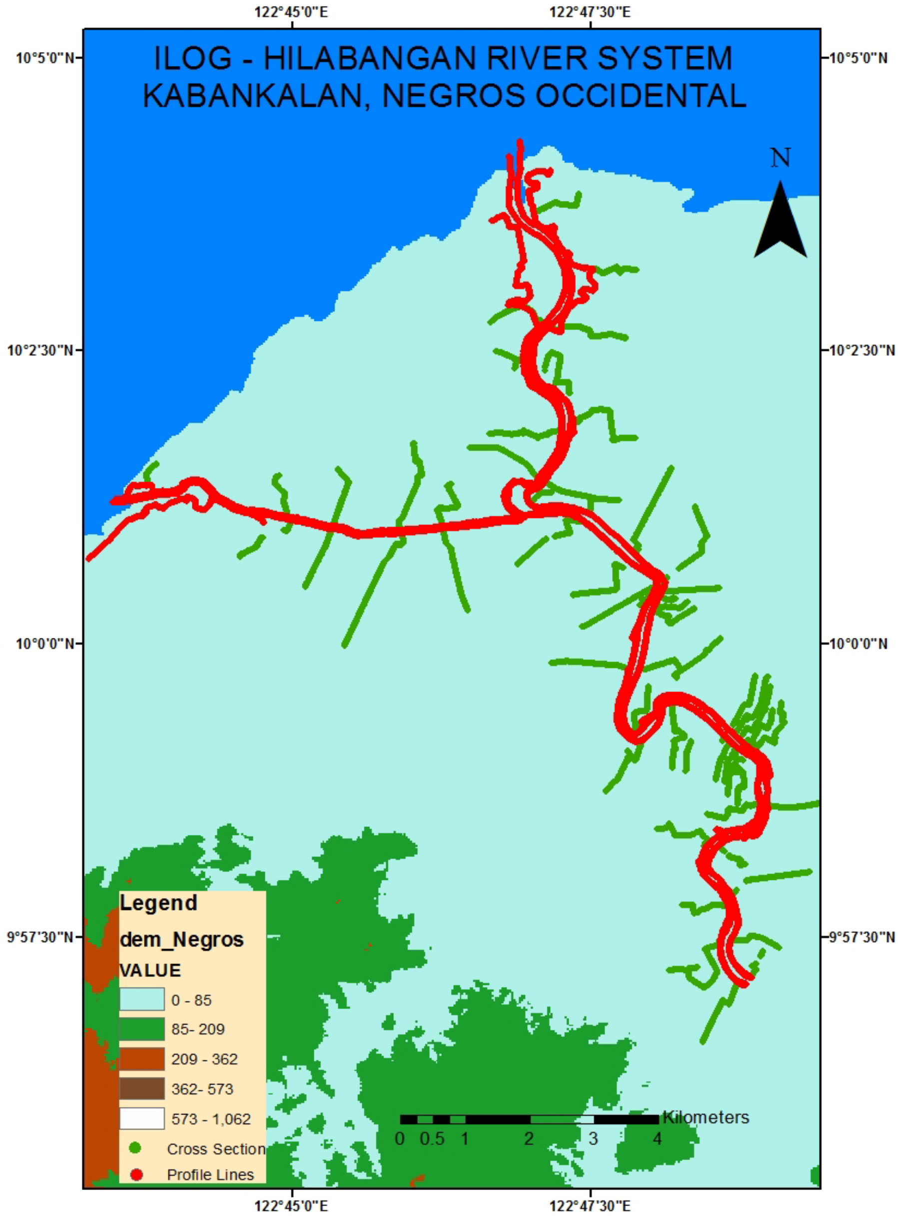
25	**Anduluan**	**Ilog**	**Traversable**	**Rented a motorbanca to reach the Cross Section starting point**	
26	**Brgy. 2**	**Ilog**	**Traversable**	**Rented a motorbanca to reach the Cross Section starting point**	
27	**Brgy. 2**	**Ilog**	**Traversable**	**Rented a motorbanca to reach the Cross Section starting point**	
(2)1	Consuelo	Ilog	Traversable	Dirt Road; Generally traversable	

(2)2	**Brgy. 1**	**Ilog**	**Traversable**	**Generally traversable**	
(2)3	**Bocana**	**Ilog**	**Traversable**	**Generally traversable**	
(2)4	**Bocana**	**Ilog**	**Traversable**	**Generally traversable**	
(2)5	Bocana	Ilog	Traversable	Rented a motorbanca to reach the Cross Section starting point	

ANNEX E. RECONNAISSANCE SUMMARY

PROFILE AND CROSS SECTION, SURVEYS IN ILOG-HILABANGAN RIVER, KABANKALAN CITY, NEGROS OCCIDENTAL

DREAM
Disaster Risk and Exposure Assessment for Mitigation



Prepared by:
Engr. Cesar Valdez
Thetan Computerized Mapping & Engineering Services
Rm 203 JIAO Building
#2 Timog Avenue
Quezon City,
Philippines

Survey Period:
May 24, 2013 to
June 8, 2013

Annexes

Annexes

Annexes

List of Abbreviations

BM	Benchmark
DOST	Department of Science and Technology
DREAMDisaster Risk Exposure and Assessment for Mitigation	Benchmark
DVC	Data Validation Component
EGM2008	Earth Gravitation Model 2008
GE	Geodetic Engineer
GIS	Geographic Information System
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
IBSS	Internet Base Satellite Service
LIDAR	Light Detection and Ranging
MSL	Mean Sea Level
NAMRIA	National Mapping and Resource Information Authority
PST	Profile Survey Team
RINEX	Receiver Independent Exchange
TBC	Trimble® Business Center
TCAGP	Training Center for Applied Geodesy and Photogrammetry
TS	Total Station
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984
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

Annexes

Introduction

Annexes

1.1 Background

Thetan Computerized Mapping and Engineering Services is conducting a ground validation survey for the Nationwide Disaster Risk and Exposure Assessment for Mitigation (DREAM) Program funded by the Department of Science and Technology (DOST) and implemented by the University of the Philippines – Training Center for Applied Geodesy and Photogrammetry (TCAGP).

One of the 18 major river systems targeted for the Program is the Ilog- Hilabangan River System in Kabankalan City, Negros Occidental which experienced the raged of Typhoon Pablo which makes 75 families homeless last December 2012.

1.2 Scope of Work

The scope of work of the field survey will include the performance of the following activities:

Scope 1: Establishment of control points with the NAMRIA reference points and benchmarks. This include establishment of the base station with an Internet Base Satellite Service (IBSS) installed in strategic location to cover the extent of the project area.

Scope 2: Cross section survey along Ilog-Hilabangan River which composed of 32 cross section lines with a total distance of 60.28km.

Scope 3: Profile survey shall consist of Upper and lower banks of the Ilog – Hilabangan River with a total length of 25 km which traverses the City of Kabankalan and Municipality of Ilog.

Scope 4: Data processing which includes the processing and adjustments of GNSS data and computations, corrections and plotting of surveyed cross sections and profiles.

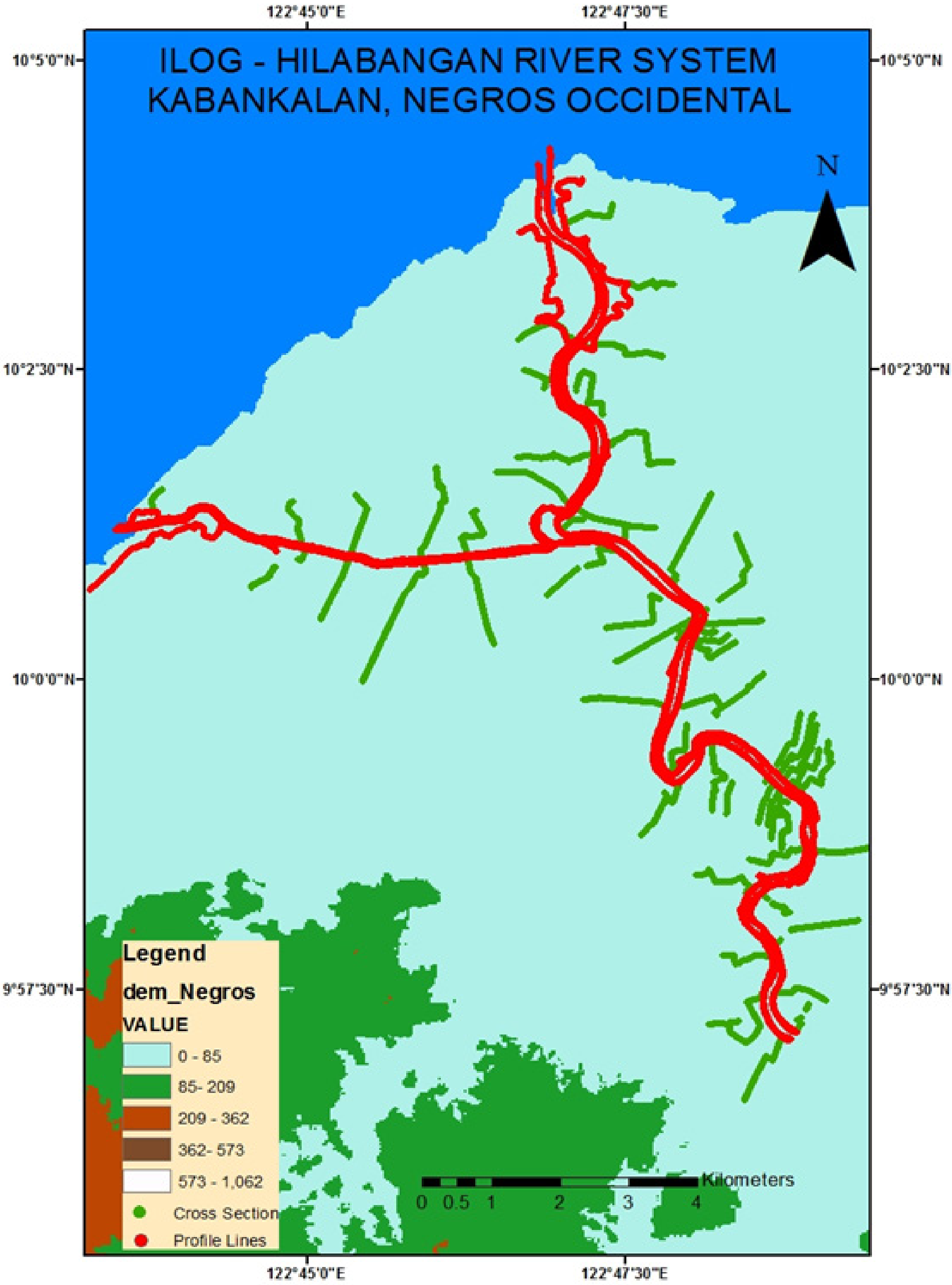


Figure 45. Actual Cross Section and Profile points in Ilog- Hilabangan River System.

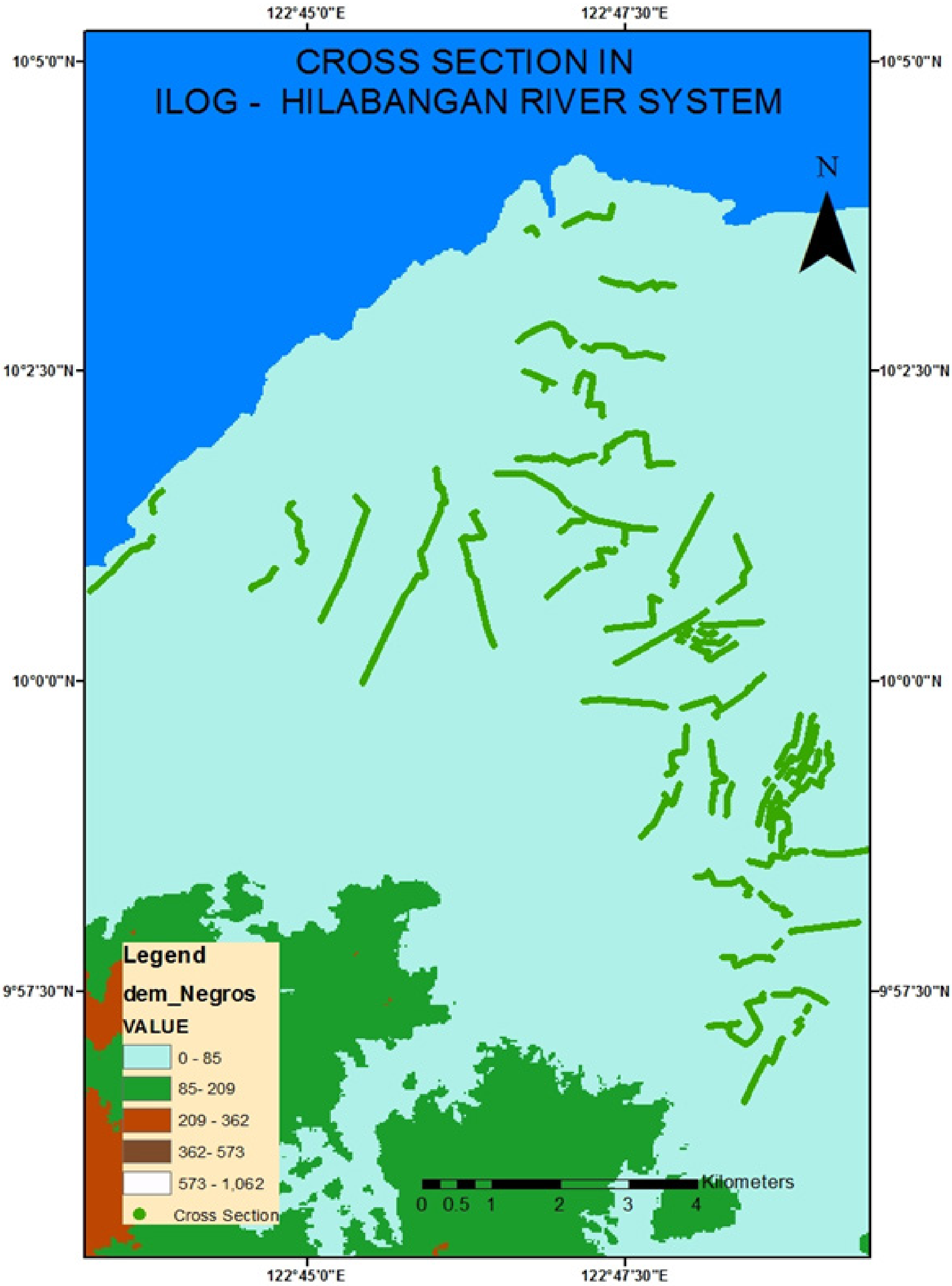


Figure 46. Cross Section Points in Ilog - Hilabangan River System.

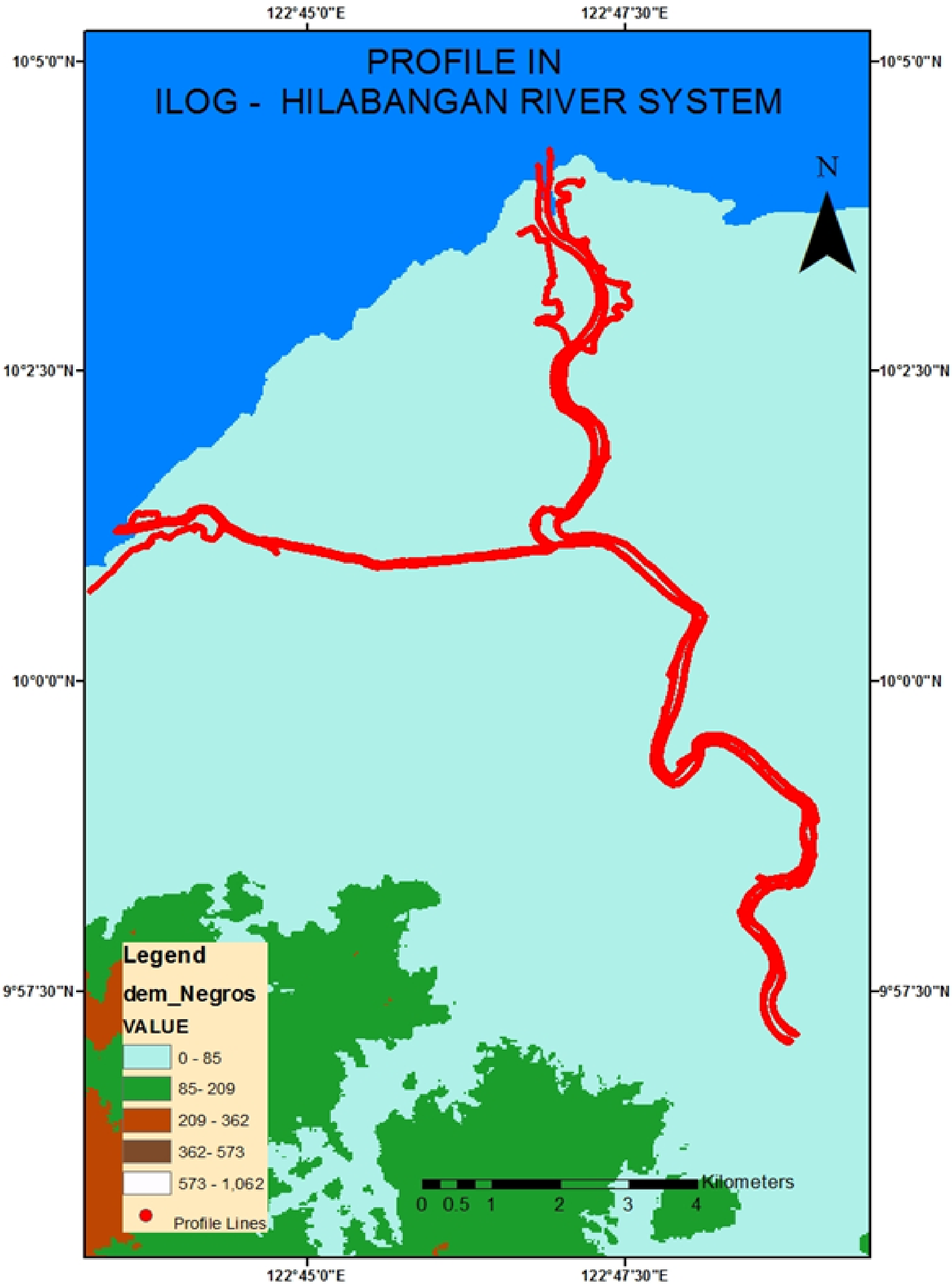


Figure 47. Profile points in Ilog - Hilabangan River System.

1.3 Professional Staffing and Implementation

The project implementation team shall be composed of qualified staff. A duly license Geodetic Engineer shall oversee the whole project. Another Geodetic Engineer acted as Chief of Party who will supervise the entire survey. Additional personnel will be needed for the survey proper for the following position.

Instrument Man – responsible for the GNSS receiver and the responsible for the gathering of data.

Autocad Operator – responsible for plotting the data and analyzing the data.

Encoder – responsible for encoding the data and securing the data to be downloaded.

Survey Aid – to assist the Instrument Man during the survey proper.

Annexes

Annexes

Field Survey Methodology

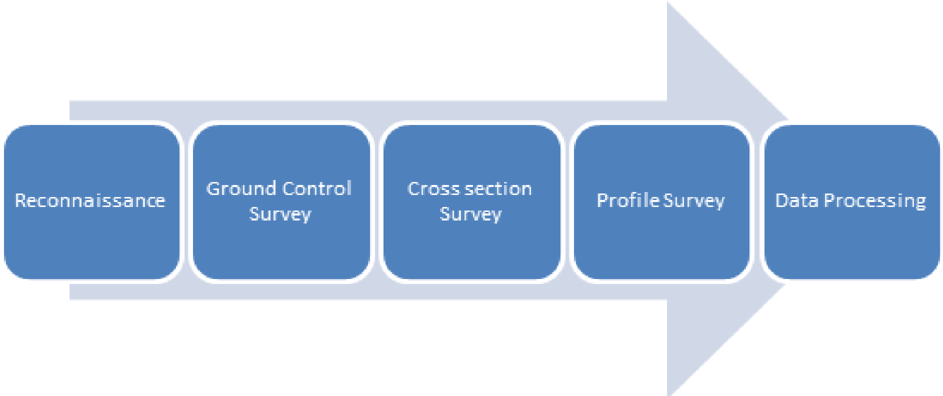


Figure 48. Methodology used during the survey.

2.1 Field Plan

Field plan is important in the survey. It will served as guide to the survey team during the survey period. The field plan shall include the schedule of the activities, list of personnel with its respective task, list of equipment to be used during the survey, processing of the data gathered and preparation of the reports.

2.2 Research for Reference points and Benchmarks

Research of all pertinent information on the area that includes the reference points and benchmarks established by NAMRIA were gathered and reviewed prior to the execution of the survey. This information will be used as primary references for the cross sections and profile surveys.

2.3 Reconnaissance

The list of NAMRIA reference points and benchmarks near the Ilog-Hilabangan area were checked and validated. The NGW-104 as reference point located at Brgy. Vista Alegre, Municipality of Ilog and NGW-353 as benchmark located at Poblacion, Kabankalan City. The existing Reference points and benchmark were used in the project. Every cross section lines were checked for entry points and terrain inspections.

2.4 Establishment of control points and GNSS network

Throughout the survey a control point will be establish at a strategic site. This control point will be tied up with the Reference point (NGW-104) for the horizontal coordinates and with the benchmark (NGw-353) for the vertical coordinates. It is a simultaneous observations in the three control points. Then an accuracy and precision shall be assessed based on the following criteria:

Horizontal Position <= + 0.5 pmm x D
Vertical Position <= + 0.5 pmm x D

Where "D" is the baseline distance between the reference point, benchmark and an established control point in meters.

Table 4. List of Reference points and benchmark used during the survey.

STATION NAME	GEOGRAPHIC COORDINATES, WGS-84			GRID COORDINATES, UTM51N		ELEVATION, EGM08	ELEVATION, MEAN SEA LEVEL
	LATITUDE	LONGITUDE	ELLIPSIODAL HEIGHT	NORTHING	EASTING		
NGW 104	9d59'27.96861"	122d44'54.77368"	66.905	1104439.232	472441.184	4.668	4.3954
NGW 353	9d59'20.85149"	122d48'49.18188"	70.901	1104215.92	479577.439	8.352	8.0794
Office	9d59'35.93001"	122d48'39.85723"	76.232	1104679.176	479293.821	13.729	13.4564

Figure 49. Reference point, Benchmark and established point: a.) NGW 104 for Reference point, b.) NGW 353 for Benchmark and c.) Internet Base Satellite System.

2.5 Field Survey

2.5.1.Cross section survey

Cross section survey aims to derive a cross sectional view of the Ilog-Hilabangan River and its flood plain. The survey team was composed of an Instrument Man and survey aides. The task of the survey team is to measure horizontal position (Northing, Easting) and elevation (in MSL) of series of points with an interval of 10 meters along a specified cross section lines.

The survey team carried out the survey using a Internet Base Station Service (IBSS) of Trimble®. These techniques use a mobile network for transmitting the signal from the Base station to the rover in the survey area. This technique can encompass wide areas as compared to using a radio emitting signals which must in a high ground and less obstructions. The Internet Base Station will reply on the mobile network availability in the area.

2.5.2.Profile Survey

The profile survey aims to gather points along the banks of the Ilog-Hilabangan River. Points on upper and lower banks respectively of the left and right banks were gathered by the survey team. The survey team used the IBSS of Trimble® to gathered data.

2.6 Data Processing

2.6.1.Control Survey data

The data gathered from the static observation were downloaded and processed in Trimble® Business Center (software used in processing data of the GPS) with an accuracy of +20cm for horizontal and +10cm for vertical. The coordinates used was Universal Transverse Mercator Zone 51N (UTM51N) with a datum of World Geodetic System of 1984 (WGS84) also the Earth Gravitation Model 2008 (EGM08).

The data were double checked to ensure that the results were within the set standards by the Data Validation Component of Nationwide DREAM Program. The corrected data from the post processing were used during the survey. Because the survey technique was Real Time Kinematic (RTK) with the use of IBSS.

2.6.2.Cross section survey data

At the end of the every survey, data were downloaded from the GPS receivers. Because the technique was Real time Kinematic the data were expected to be correct and post processing were not needed anymore. The downloaded data were exported as .csv file format with the following columns: PT_Name, Latitude, Longitude, Ellipsiodal_Height, Northing, Easting and Elevation. The autocad operator will get the distance between points together with the corresponding elevation then saved the data to PRN format.

The data were imported to Civil 3D software. Afterwards, polylining of the cross section and deletion of all the unnecessary points were done. The cross sections were generated at a horizontal scale of 1:2000 and vertical scale of 1:100.

2.6.3.Profile survey data

At the end of every survey, data were downloaded from the instrument. The downloaded data were exported as .csv file format with the following columns: PT_Name, Latitude, Longitude, Ellipsoidal_Height, Northing, Easting and Elevation. Then the file were imported to civil 3D software, Left and Right banks with their respective upper and lower banks were polylined. Then generating of the surfaces and contour took place.

The generated profile of each upper and lower bank, left and right bank with horizontal 1:2000 and vertical scale of 1:100, title block and scale text to make it readable.

Annexes

Annexes

Results and Discussions

The areas covered by the project were mostly sugarcane plantations and fishponds. The terrain was relatively flat. The TELCO Signal was good whether Smart or Globe networks. The banks of Ilog-Hilabangan River were surrounded by mangroves and nipas approaching the mouth of the river.

During the actual field survey, the cross section and profile survey were conducted using RTK-GPS using internet communication. Almost ninety percent (90%) of the data were acquired using the RTK-GPS using IBSS. A total station was used on the rest of the points with satellite communication difficulties.

Weather conditions were also not favourable to the survey project. Heavy rains made the terrain difficult to traverse because of the thick muds. In order to continue the survey with a tight schedule to follow the project waterproof survey grade equipment was used to address this issue.

The survey team encountered problems in cross section lines which were such as private properties and built up areas. Also most of the cross section lines traversed sugarcane plantations and fishponds. In order to address the issue the survey team look for an alternative routes near the cross section line which were passable and were surveyed to connect the cross section lines. Not only in cross section survey we encountered problems also in profile especially near the delta were mangroves and nipas were present in these areas.

A total of 32 cross sections were surveyed in Ilog-Hilabangan River. These cross section were divided in two groups the Hilabangan River (Main River) and Ilog River. For the Hilabangan River there were 27 cross sections and 5 cross sections for Ilog River.

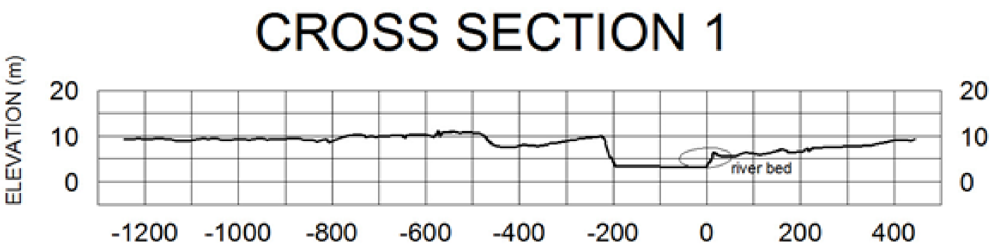


Figure 50. Cross Section 1.

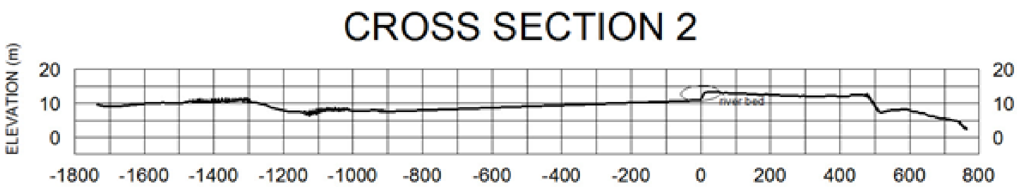


Figure 51. Cross Section 2.

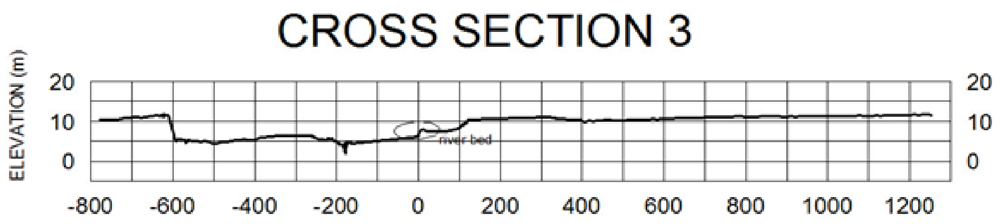


Figure 52. Cross Section 3.

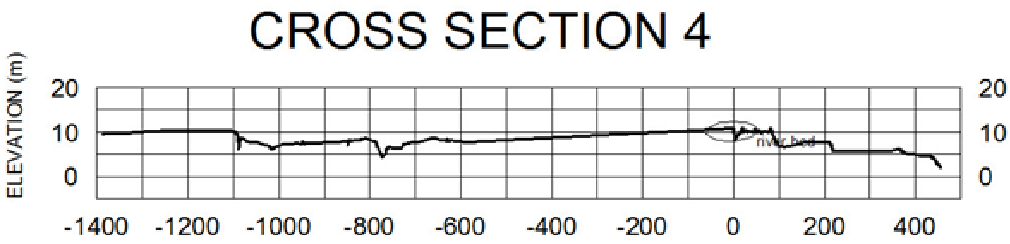


Figure 53. Cross Section 4.

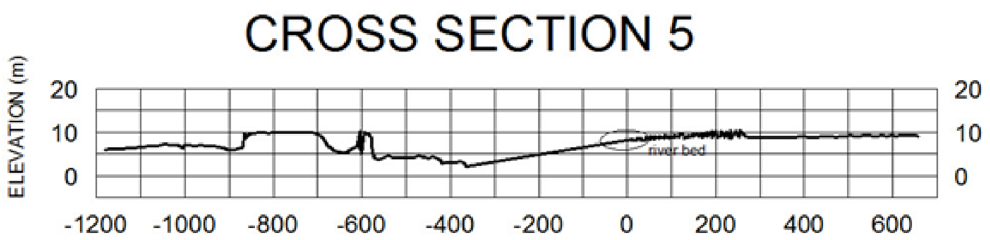


Figure 54. Cross Section 5.

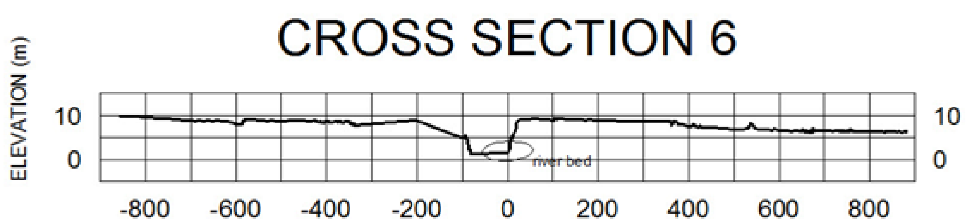


Figure 55. Cross Section 6.

Figure 56. Cross Section 7.

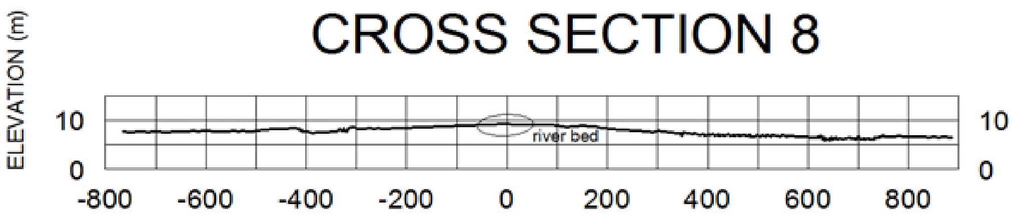


Figure 57. Cross Section 8.

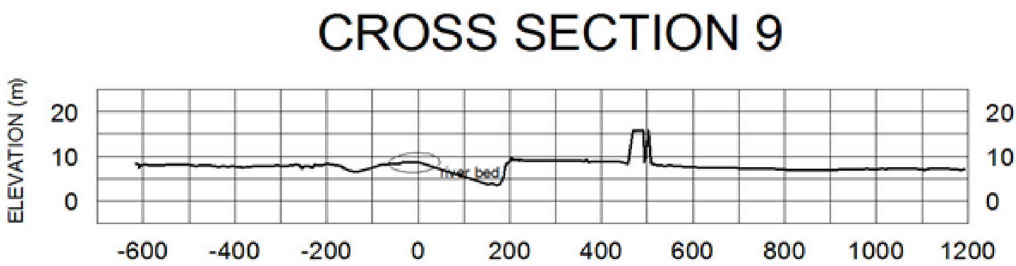


Figure 58. Cross Section 9.

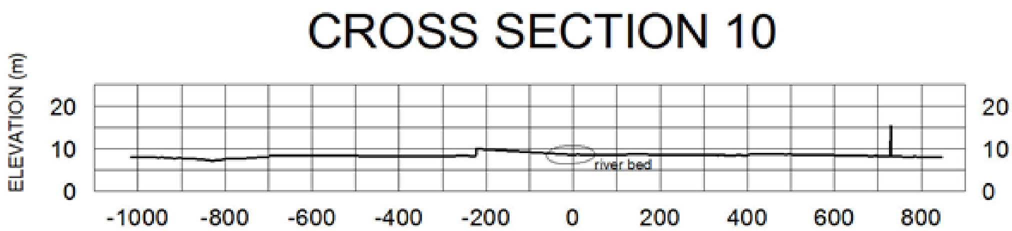


Figure 59. Cross Section 10.

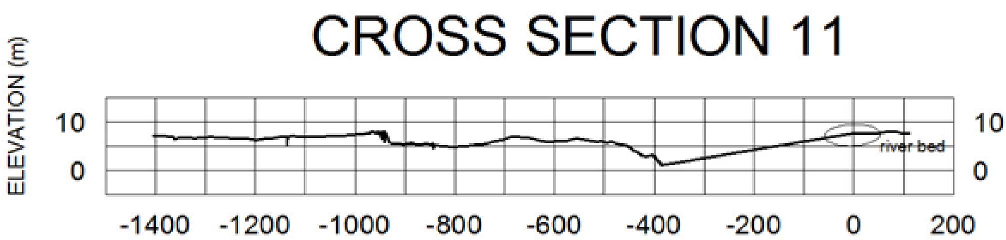


Figure 60. Cross Section 11.

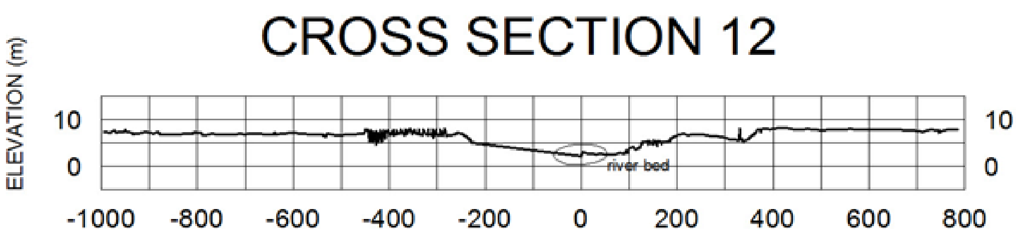


Figure 61. Cross Section 12.

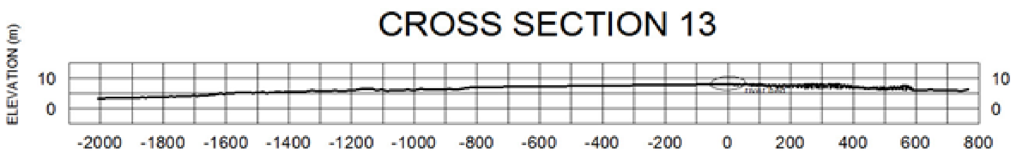


Figure 62. Cross Section 13.

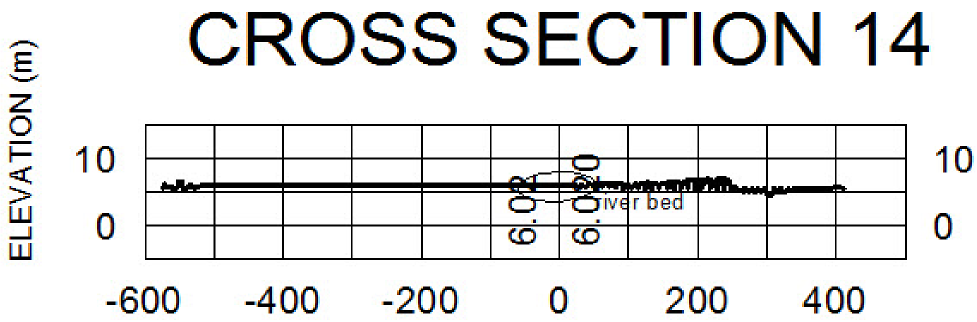


Figure 63. Cross Section 14.

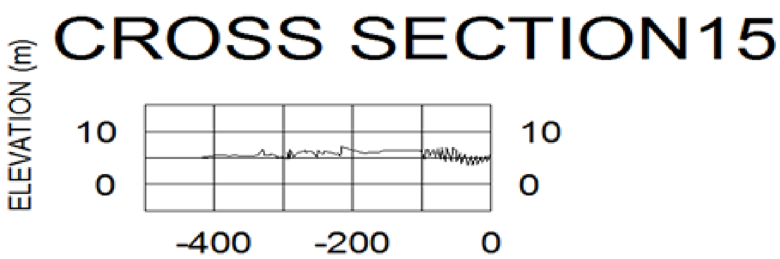


Figure 64. Cross Section 15.

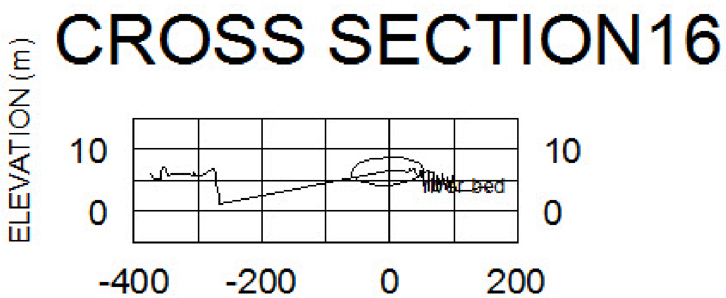


Figure 65. Cross Section 16.

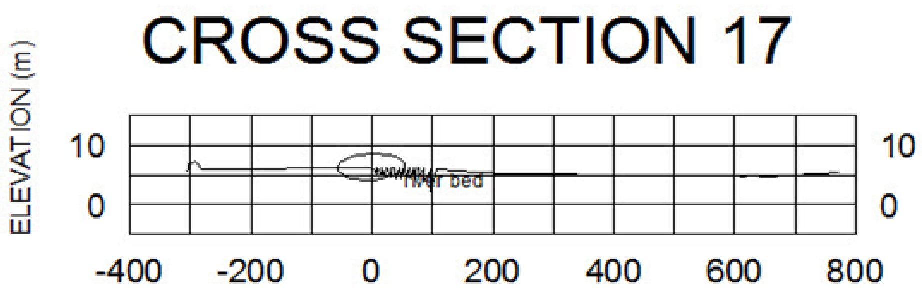


Figure 66. Cross Section 17.

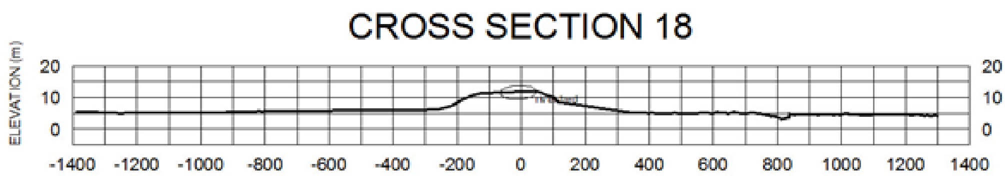


Figure 67. Cross Section 18.

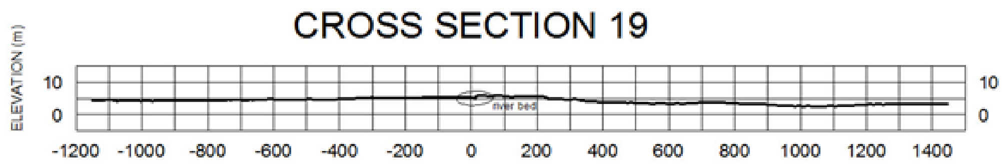


Figure 68. Cross Section 19.

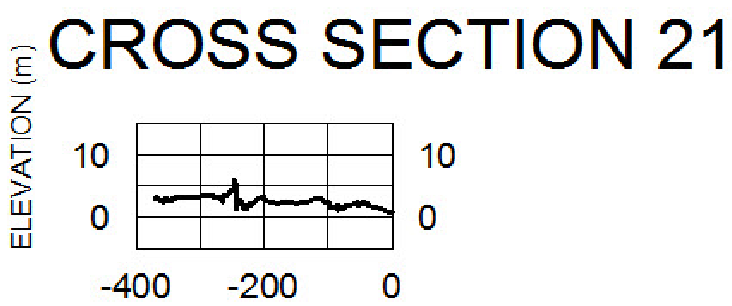


Figure 69. Cross Section 21.

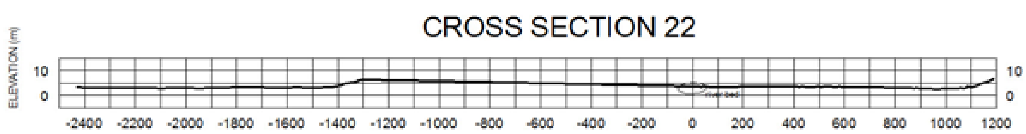


Figure 70. Cross Section 22.

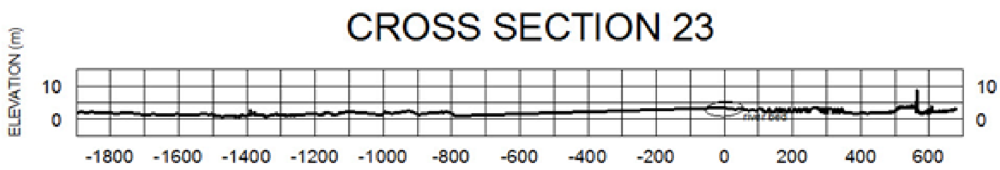


Figure 71. Cross Section 23.

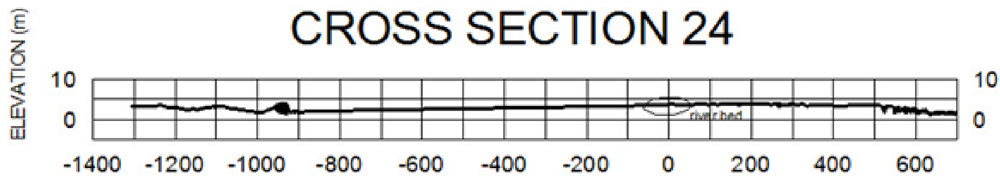


Figure 72. Cross Section 24.

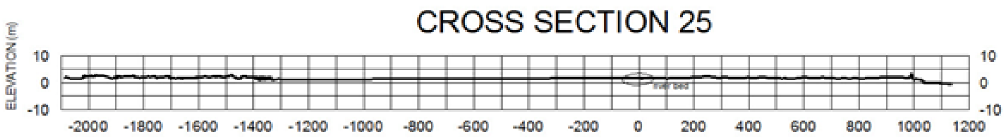


Figure 73. Cross Section 25.

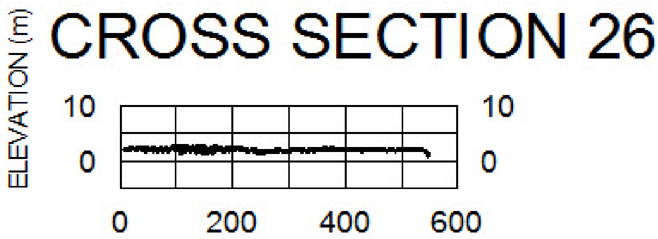


Figure 74. Cross Section 26.

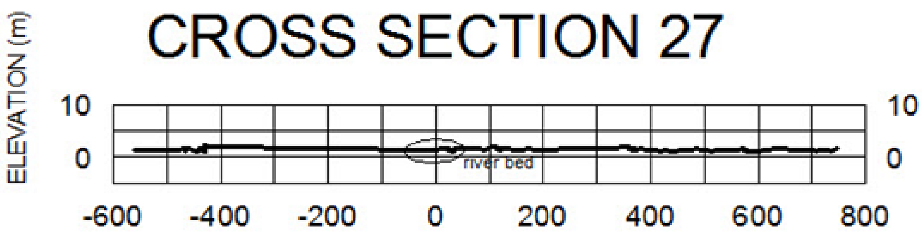


Figure 75. Cross Section 27.

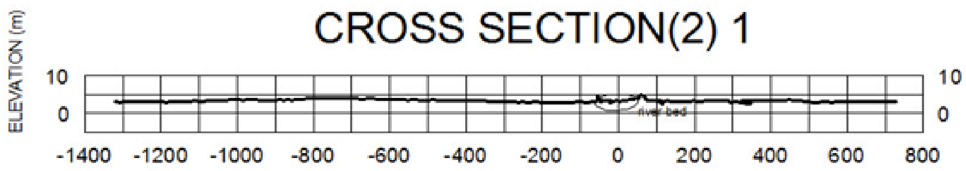


Figure 76. Cross Section (2)1.

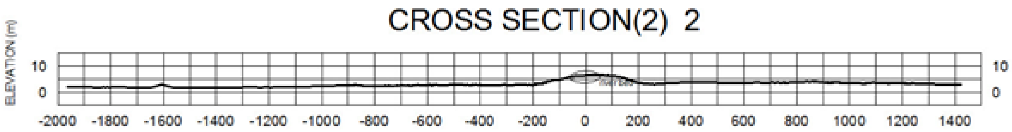


Figure 77. Cross Section (2)2.

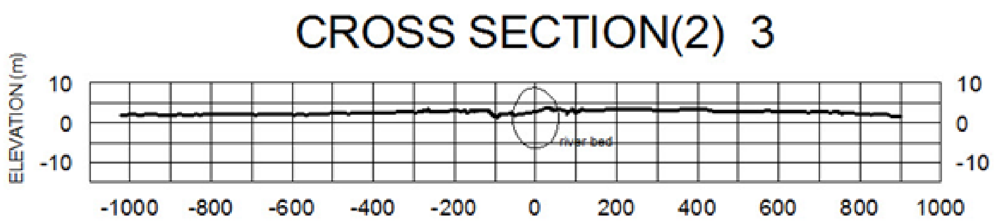


Figure 78. Cross Section (2)3.

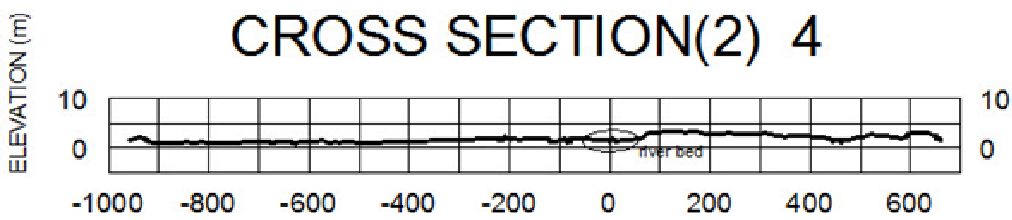


Figure 79. Cross Section (2)4.

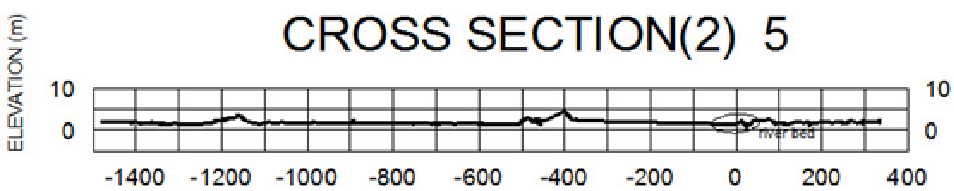


Figure 80. Cross Section (2)5.

Profile of Hilabangan River was compose of Upper and Lower Left and Upper and Lower Right. Each profile lines were approximately 19km from the upstream at Brgy. Hilamonan of Kabankalan City upto the mouth of the river at Brgy. Daan Buana.

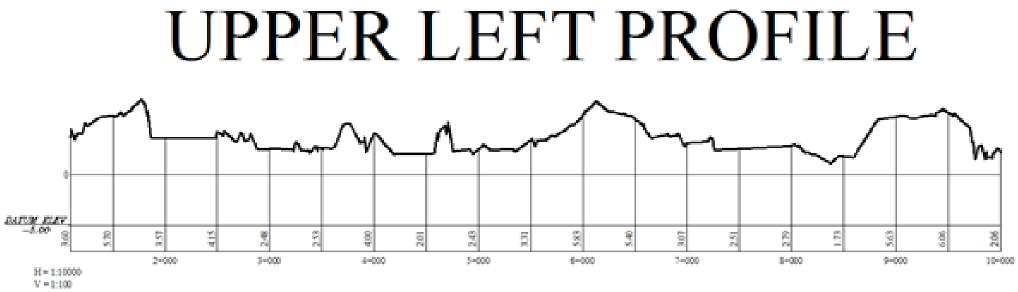


Figure 81. Upper Left Profile (Distance from 0+000 to 10+000).

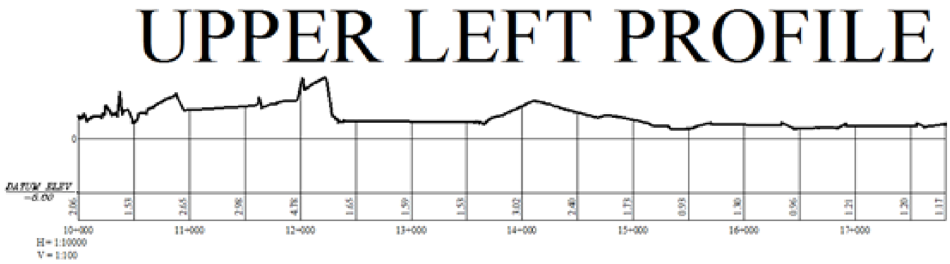


Figure 82. Upper Left Profile (Distance from 10+000 to 17+000).

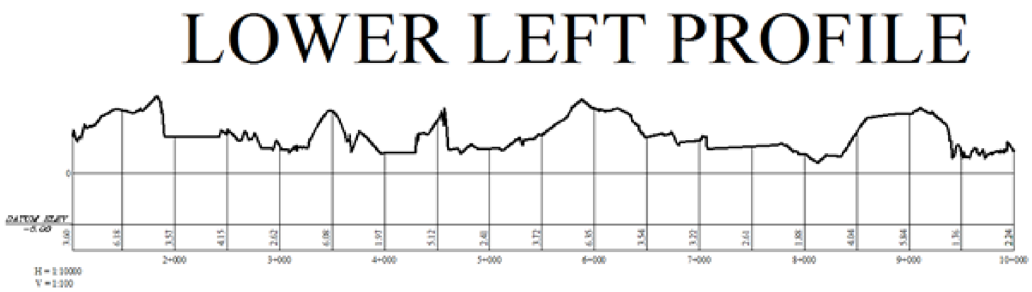


Figure 83. Lower Left Profile (Distance from 0+000 to 10+0000.

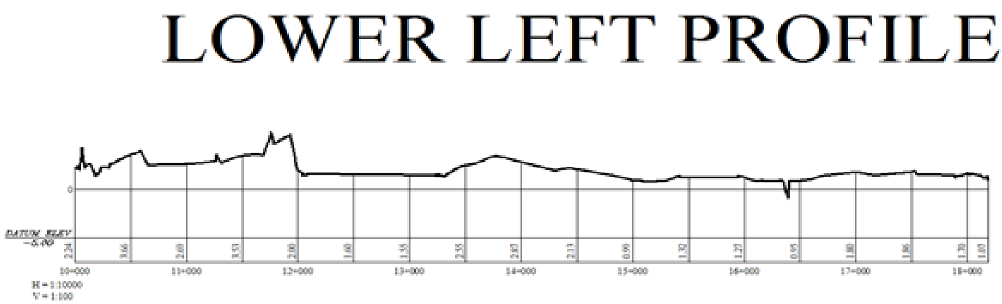


Figure 84. Lower Left Profile (Distance from 10+000 to 18+000).

Figure 85. Upper Right Profile (Distance from 0+000 to 10+000).

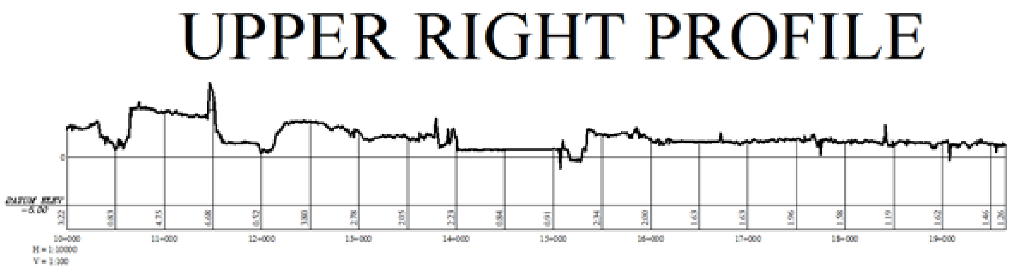


Figure 86. Upper Right Profile (Distance from 10+000 to 19+000).

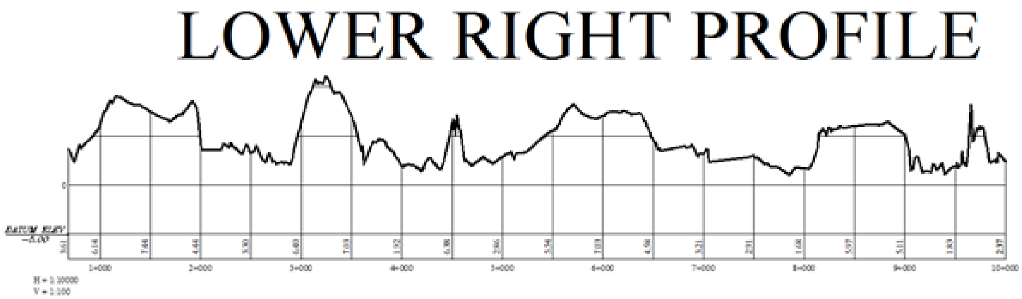


Figure 87. Lower Right Profile (Distance from 0+000 to 10+000).

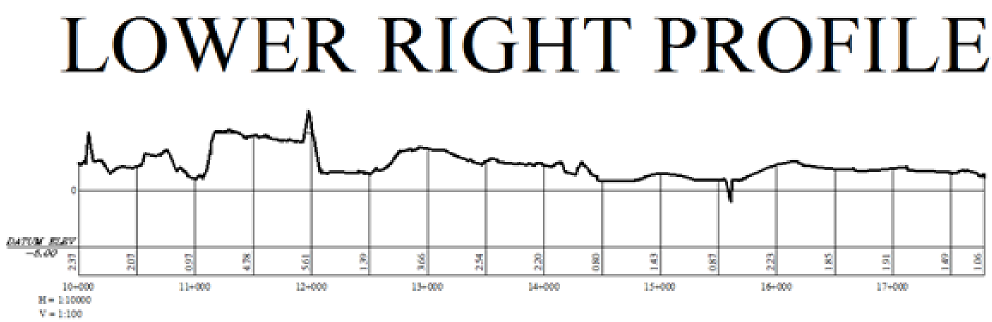


Figure 88. Lower Right Profile (Distance from 10+000 to 17+000).

Profile of Ilog River was compose of Upper and Lower Left and Upper and Lower Right. Each profile lines were approximately 8km from the upstream at Brgy. Manalad of Municipality of Ilog upto the mouth of the river at Brgy. Bucana.

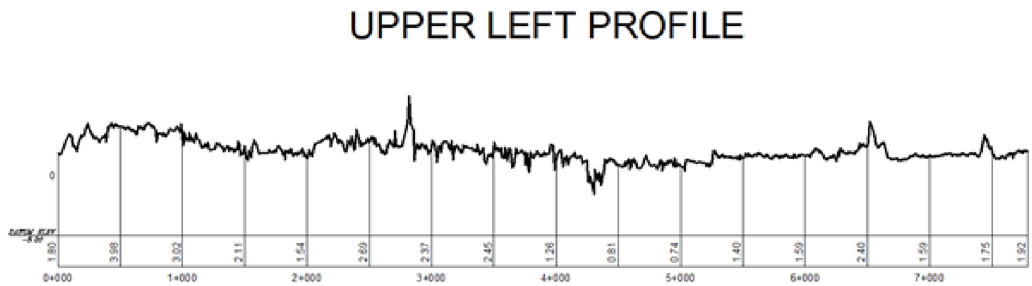


Figure 89. Upper Left Profile (Distance from 0+000 to 7+000).

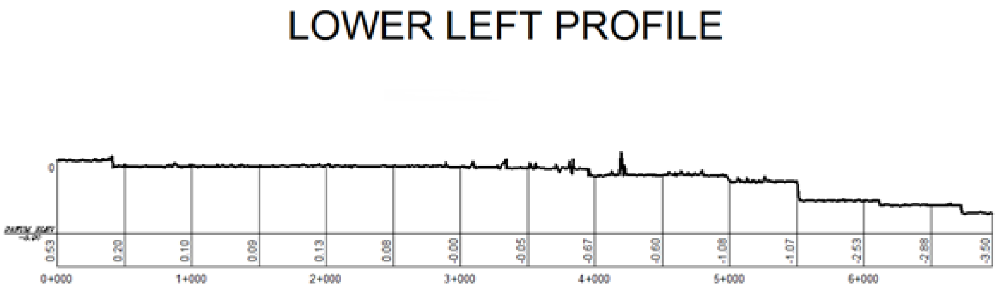


Figure 90. Lower Left Profile (Distance from 0+000 to 7+000).

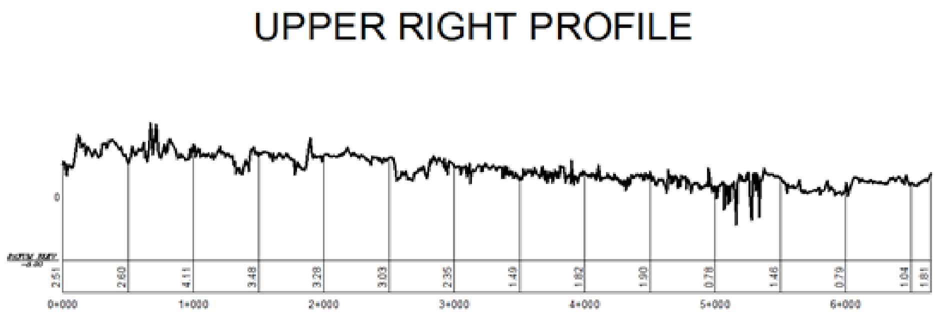


Figure 91. Upper Right Profile (Distance from 0+000 to 6+000).

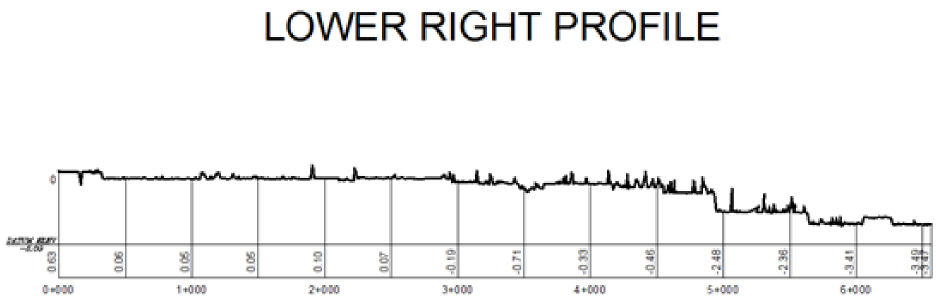


Figure 92. Lower Right Profile (Distance from 0+000 to 6+000).

Annexes

The Survey Team

Table 5. The Survey Team

TEAM	Name
Senior Geodetic Engineer	Engr. Cesar Valdez
Party Chief	Renato Capistrano
Driver	Luisito Dacara
Cross-Section	Jaycel Roy Dimaden
	Darwin Santos
	Lito Salvacion
	Arman Reyes
	Ronald Ventura
	Ariel Tagle
Profile	Arnel Cordano
	Babilito Pancho
	Houdini Abonal
	Eduard Cabrera
	Nikos Pidelo
	Bryan Koh
Autocadd Operator	Vanessa Sanchez

FIELD ACTIVITIES

Table 6. Daily Activities

Date	Activities	Location
May 24, 2013	Mobilization at Kabankalan City	
May 25 – 26, 2013	Reconnaissance and Recovery of Reference Points and Bench Marks and Establishment of IBSS	
May 27, 2013	Start of Cross section and Profile survey	Brgy Camasi and Hilamonan, Kabankalan City
May 28, 2013	Continuation of Cross section and Profile Survey	Brgy. Camugao – Brgy 6 to 9 , Kabankalan City
May 39, 2013	Continuation of Cross section and Profile Survey	Brgy. Camugao – Brgy 6 to 9 , Kabankalan City
May 30, 2013	Continuation of Cross section and Profile Survey	Brgy Linao and Talubangi of Kabankalan City
May 31, 2013	Continuation of Cross section and Profile Survey	Brgy Linao and Talubangi of Kabankalan City
June 01, 2013	Continuation of Cross section and Profile Survey	Brgy Manalad and Andulauan, Kabankalan City
June 02, 2013	Continuation of Cross section and Profile Survey	Brgy 1 of Mun. Ilog and Brgy Anduluan Kabankalan City
June 03, 2013	Continuation of Cross section and Profile Survey	Brgy 1 of Mun. Ilog and Brgy Anduluan Kabankalan City
June 04, 2013	Continuation of Cross section and Profile Survey	Brgy. 2 , Consuelo Municipality of Ilog
June 05, 2013	Continuation of Cross section and Profile Survey	Brgy. Consuelo , Bocana, Municipality of Ilog
June 06, 2013	Continuation of Cross section and Profile Survey	Brgy. Bocana, Municipality of Ilog
June 07, 2013	Extra day for additional activities	
June 08, 2013	Extra day for additional activities	

Baseline Processing

Project Information	Coordinate System	
Name:	Name:	UTM
Size:	Datum:	WGS 1984
Modified:	Zone:	51 North (123E)
Time zone:	Geoid:	EGM08-1
Reference number:	Vertical datum:	
Description:		

Network Adjustment Report

Adjustment Settings
Set-Up Errors
GNSS

Error in Height of Antenna:	0.000 m
Centering Error:	0.000 m

Covariance Display
Horizontal:

Propagated Linear Error [E]:	U.S.
Constant Term [C]:	0.000 m
Scale on Linear Error [S]:	1.960

Three-Dimensional

Propagated Linear Error [E]:	U.S.
Constant Term [C]:	0.000 m
Scale on Linear Error [S]:	1.960

Adjustment Statistics

Number of Iterations for Successful Adjustment:	2
Network Reference Factor:	1.00
Chi Square Test (95%):	Passed
Precision Confidence Level:	95%
Degrees of Freedom:	4

Post Processed Vector Statistics

Reference Factor:	1.00
Redundancy Number:	4.00
A Priori Scalar:	5.15

Control Point Constraints

Point ID	Type	East σ (Metre)	North σ (Metre)	Height σ (Metre)	Elevation σ (Metre)
NGW 104	Global	Fixed	(Metre)	Height σ	
NGW 353	Global	Fixed	(Metre)	Fixed	
Fixed = 0.000001(Metre)					

Adjusted Grid Coordinates

Point ID	Easting (Metre)	Easting Error (Metre)	Northing (Metre)	Northing Error (metre)	Elevation (Metre)	Elevation Error (Metre)	Constraint
NGW 104	472441.184	?	1104439.232	?	4.668	?	LLh
NGW 353	479577.439	?	1104215.920	?	8.352	?	LLh
Office	479293.821	0.005	1104679.176	0.004	13.729	0.010	

Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Height (Metre)	Height Error (Metre)	Constraint
NGW 104	N9°59'27.96861"	E122°44'54.77368"	66.905	?	LLh
NGW 353	N9°59'20.85149"	E122°48'49.18188"	70.901	?	LLh
Office	N9°59'35.93001"	E122°48'39.85723"	76.232	0.010	

Adjusted ECEF Coordinates

Point ID	X (Metre)	X Error (Metre)	Y (Metre)	Y Error (metre)	Z (Metre)	Z Error (Metre)	3D Error (Metre)	Constraint
NGW 104	-3398327.013	?	5283585.315	?	1099290.949	?	?	LLh
NGW 353	-3404352.001	?	5279755.088	?	1099076.287	?	?	LLh
Office	-3404072.605	0.007	5279845.841	0.009	1099533.469	0.004	0.012	

Error Ellipse Components

Point ID	Semi-major axis (Metre)	Semi-minor axis (Metre)	Azimuth
Office	0.007	0.005	104°

Adjusted GPS Observations

Transformation Parameters
Azimuth Rotation: 0.528 sec (95%) 0.344 sec
Scale Factor: 0.99999743 (95%) 0.00000214

Observation ID		Observation	A-posteriori Error	Residual	Standardized
NGW 104 --> Office (PV3)	Az.	87°57'04"	0.360 sec	0.037 sec	0.214
	ΔHt.	9.327 m	0.010 m	-0.108 m	-1.565
	Ellip Dist.	6859.548 m	0.015 m	0.001 m	0.159
NGW 353 --> Office (PV5)	Az.	328°29'30"	1.805 sec	0.041 sec	0.246
	ΔHt.	5.331 m	0.010 m	0.001 m	1.558
	Ellip Dist.	543.397 m	0.005 m	0.000 m	-0.499
NGW 353 --> NGW 104 (PV1)	Az.	271°45'37"	0.344 sec	0.143 sec	0.697
	ΔHt.	-3.996 m	0.000 m	0.094 m	1.107
	Ellip Dist.	7142.573 m	0.015 m	0.005 m	0.658

Covariance Terms

From Point	To Point		Components	A-posteriori Error	Horiz. Precision (Ratio)	3D Precision (Ratio)
NGW 104	Office	Az.	87°57'04"	0.122 sec	1 : 1264322	1 : 1264642
		ΔHt.	9.327 m	0.010 m		
		ΔElev.	9.060 m	0.010 m		
		Ellip Dist.	6859.531 m	0.005 m		
NGW 353	NGW 104	Az.	271°45'36"	0.000 sec	1 : 0	1 : 0
		ΔHt.	-3.996 m	0.000 m		
		ΔElev.	-3.684 m	0.000 m		
		Ellip Dist.	7142.554 m	0.000 m		
NGW 353	Office	Az.	328°29'30"	1.816 sec	1 : 112966	1 : 112685
		ΔHt.	5.331 m	0.010 m		
		ΔElev.	5.377 m	0.010 m		
		Ellip Dist.	543.396 m	0.005 m		

NAMRIA CERTIFIFCATIONS

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

June 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: **NEGROS OCCIDENTAL**
Station Name: **NW-353(w)**

Island: **Visayas**	Municipality: **CITY OF KABANKALAN**	Barangay: **BARANGAY 7 (POB.)**
Elevation: **8.0794 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

BM NW-353(w)

The station is located at the City Plaza fronting the Old Kabankalan City Hall. It is at the base of the falgpole 14.0m from Rizal Monument.

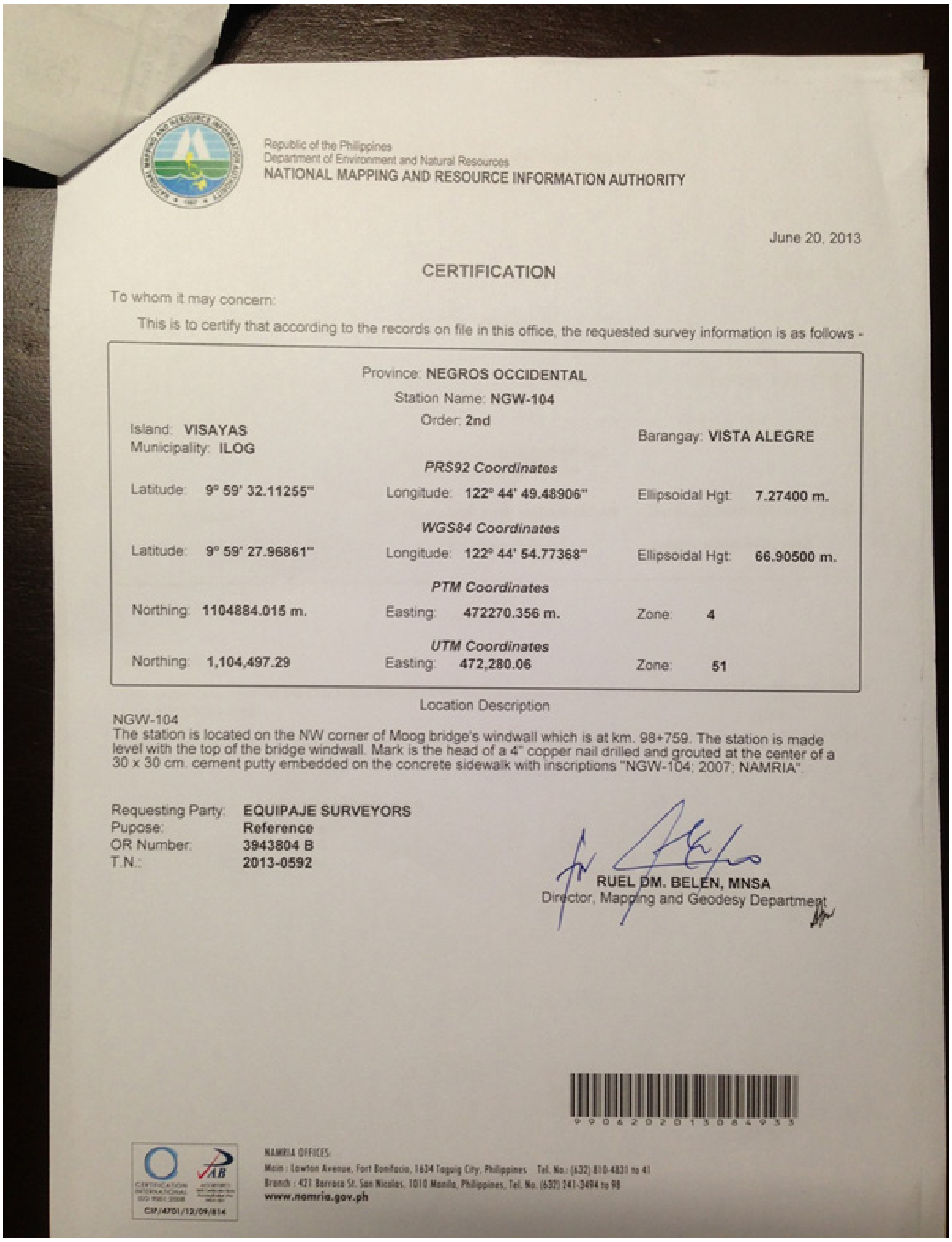
Mark is the head of a 4" copper nail set flushed on a 15cm x 15cm cement putty with inscriptions "BM NW-353, 2008, NAMRIA".

Requesting Party: **EQUIPAJE SURVEYORS**
Pupose: **Reference**
OR Number: **3943804 B**
T.N.: **2013-0591**

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

CIP/4P01/12/09/814

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

June 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: **NEGROS OCCIDENTAL**	
	Station Name: **NGW-104**	
Island: **VISAYAS**	Order: **2nd**	Barangay: **VISTA ALEGRE**
Municipality: **ILOG**		
	PRS92 Coordinates	
Latitude: **9° 59' 32.11255"**	Longitude: **122° 44' 49.48906"**	Ellipsoidal Hgt: **7.27400 m.**
	WGS84 Coordinates	
Latitude: **9° 59' 27.96861"**	Longitude: **122° 44' 54.77368"**	Ellipsoidal Hgt: **66.90500 m.**
	PTM Coordinates	
Northing: **1104884.015 m.**	Easting: **472270.356 m.**	Zone: **4**
	UTM Coordinates	
Northing: **1,104,497.29**	Easting: **472,280.06**	Zone: **51**

Location Description

NGW-104
The station is located on the NW corner of Moog bridge's windwall which is at km. 98+759. The station is made level with the top of the bridge windwall. Mark is the head of a 4" copper nail drilled and grouted at the center of a 30 x 30 cm. cement putty embedded on the concrete sidewalk with inscriptions "NGW-104; 2007; NAMRIA".

Requesting Party: **EQUIPAJE SURVEYORS**
Pupose: **Reference**
OR Number: **3943804 B**
T.N.: **2013-0592**

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

9906202013084933

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

ACKNOWLEDGEMENTS

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

- SITECH PHL Inc. for the support that they have given our team especially with the establishment of Internet Base Station Service.

- The Local Government of Kabankalan City and the Municipality of Ilog.

109

Bibliography

- FLORAL AND FAUNAL ASSESSMENT OF ILOG-HILABANGAN WATERSHED FOREST RESERVE IN NEGROS OCCIDENTAL. (2011, August 10). Retrieved August 12, 2015, from http://www.pcaarrd.dost.gov.ph/home/momentum/environment/index.php?option=com_content&view=article&id=996:floral-and-faunal-assessment-of-ilog-hilabangan-watershed-forest-reserve-in-negros-occidental&catid=98&Itemid=228

- Hinojas, Sr., E. (2014, December 1). An Overview: The Negros Island Region Initiative (Third part of the Tenth Series). Retrieved August 12, 2015, from http://www.watchmendaily.com/opinion/overview-negros-island-region-initiative-third-part-tenth-series/

- Ilog-Hilabangan River Basin. (n.d.). Retrieved August 12, 2015, from http://rbco.denr.gov.ph/wp-content/themes/vantage/RB/ilog-hilabangan.htm

- Tababa, R. Dagunan, M. A; Depra, R.; Moraca, A.; Cabalo, N.; Paalan, R.; muleta, E. Floral and faunal assessment of Ilog-Hilabangan Watershed Forest Reserve in Negros Occidental, Philippines. Paper presented during the WESVARRDEC Regional Symposium on R&D Highlights; La Paz, Iloilo City; August 26, 2009. - (Haribon Foundation for Conservation Natural Resources Inc., -funded; completed project)

DREAM

Disaster Risk and Exposure Assessment for Mitigation