REGION 10

Iponan 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.

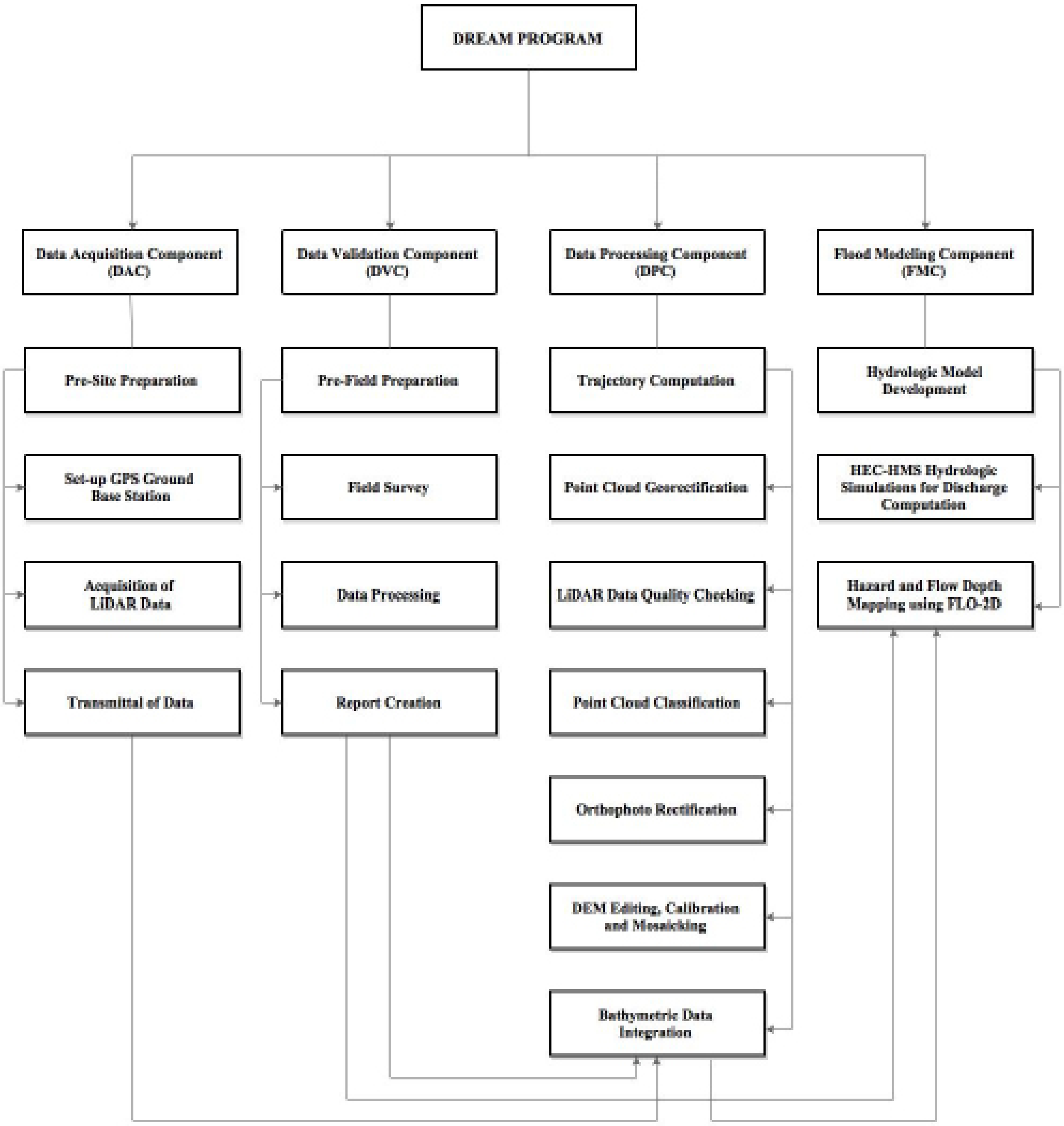


Figure 1. The General Methodological Framework of the Program

The Iponan River Basin

The Iponan River Basin

The Iponan River Basin is located in the northern part of Mindanao. Covering an estimated basin area of 407 square kilometers, it traverses through Iponan City in Misamis Oriental and the municipalities of Talakag, Baungon and Libona in Bukidnon. Iponan River, the main tributary of this river basin, has a length of 60 kilometers running from Iligan City and draining towards Macajalar Bay.
The location of Iponan River Basin is as shown in Figure 1.

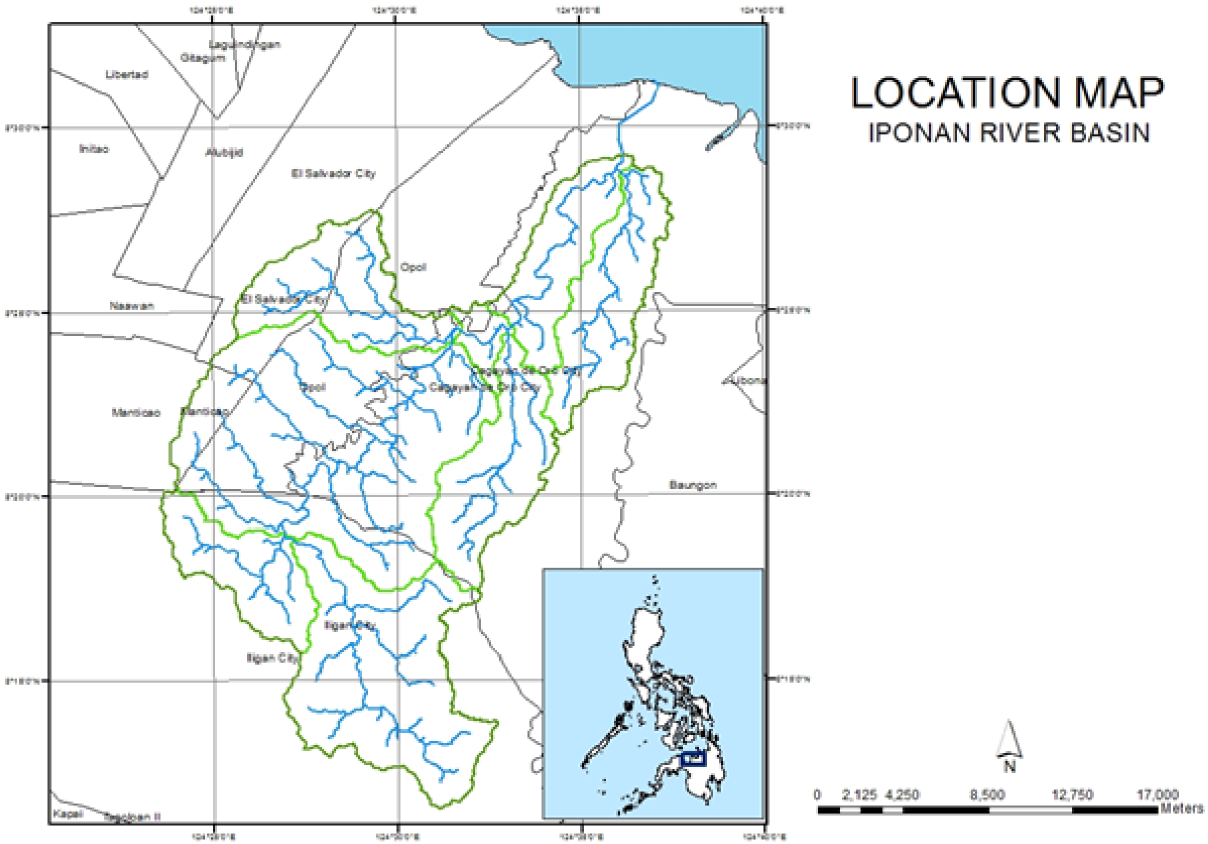


Figure 2. The Iponan River Basin Location Map

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

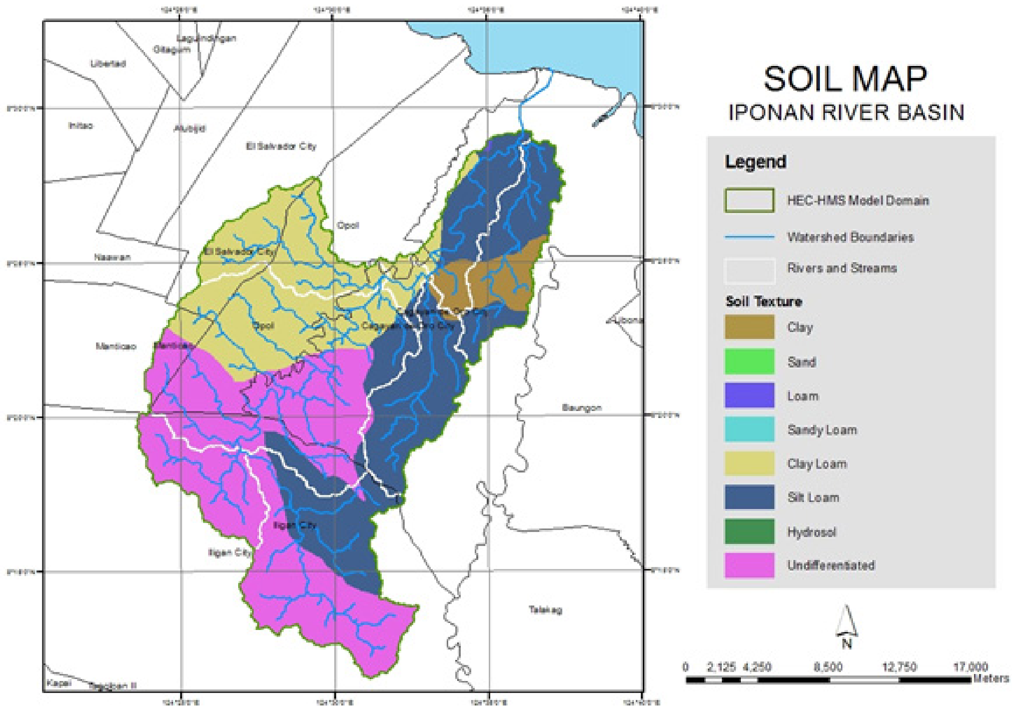


Figure 3. Iponan River Basin Soil Map

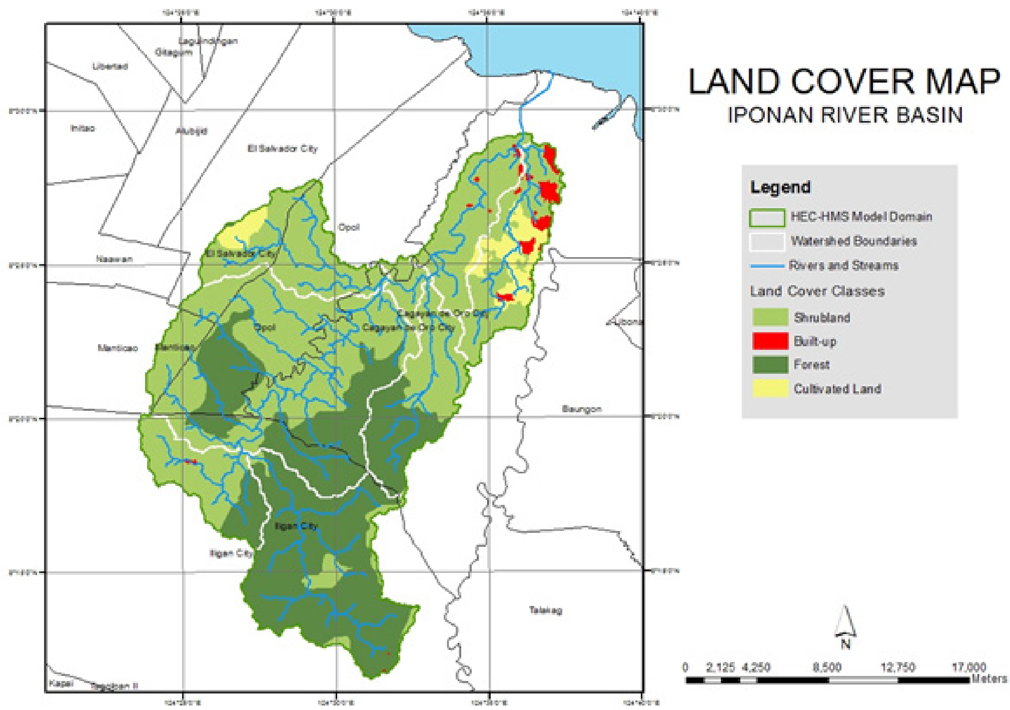


Figure 4. Iponan River Basin Land Cover Map

DVC Methodology

DVC Methodology

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

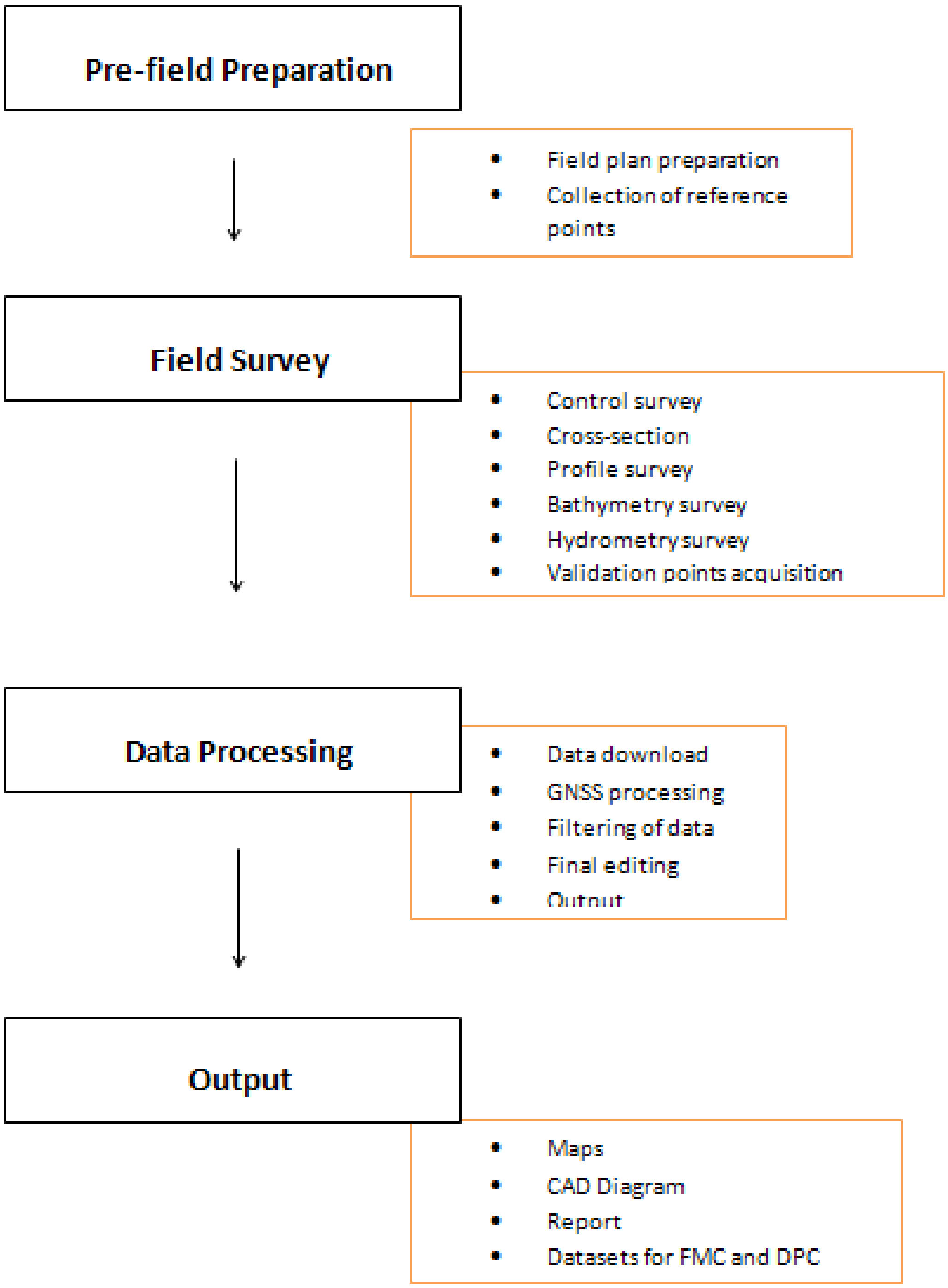


Figure 5. DVC Main Activities

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

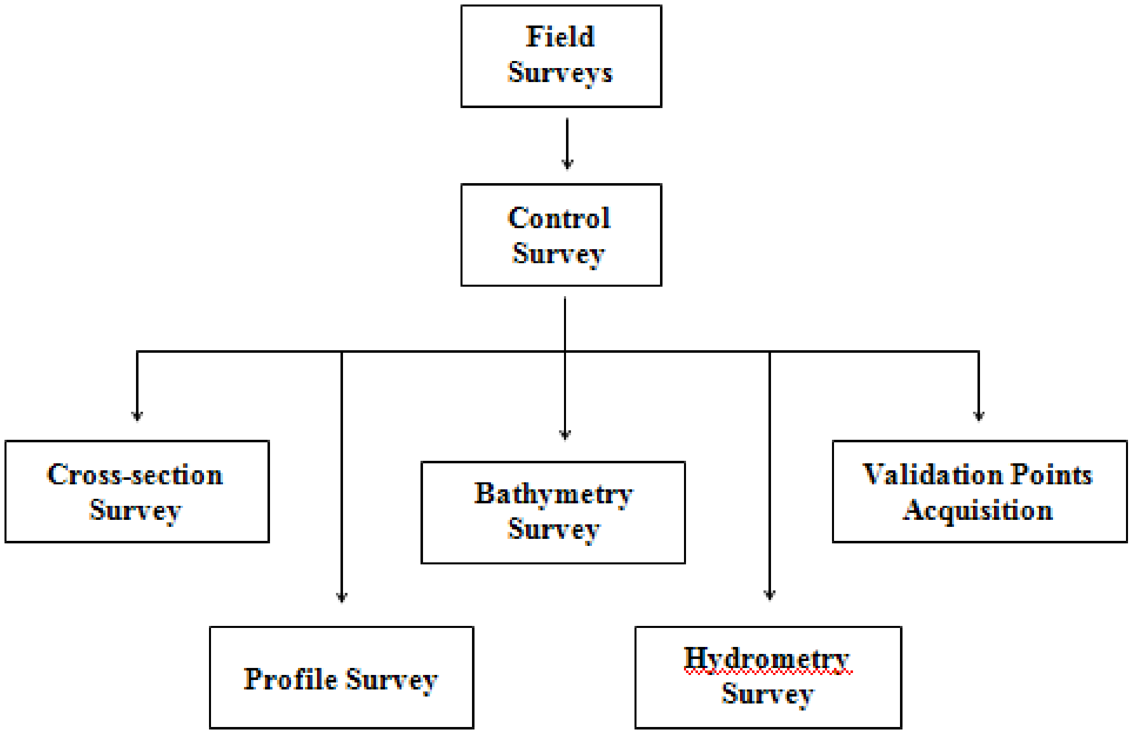


Figure 6. DVC Field Activities

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.

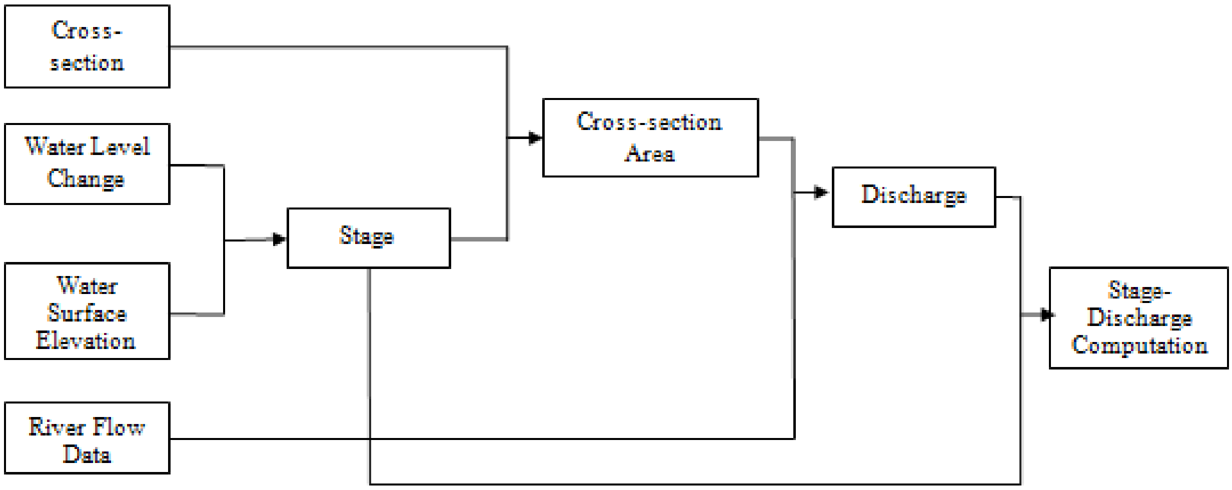


Figure 7. Flow Chart for Stage-Discharge Correlation Computation

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.

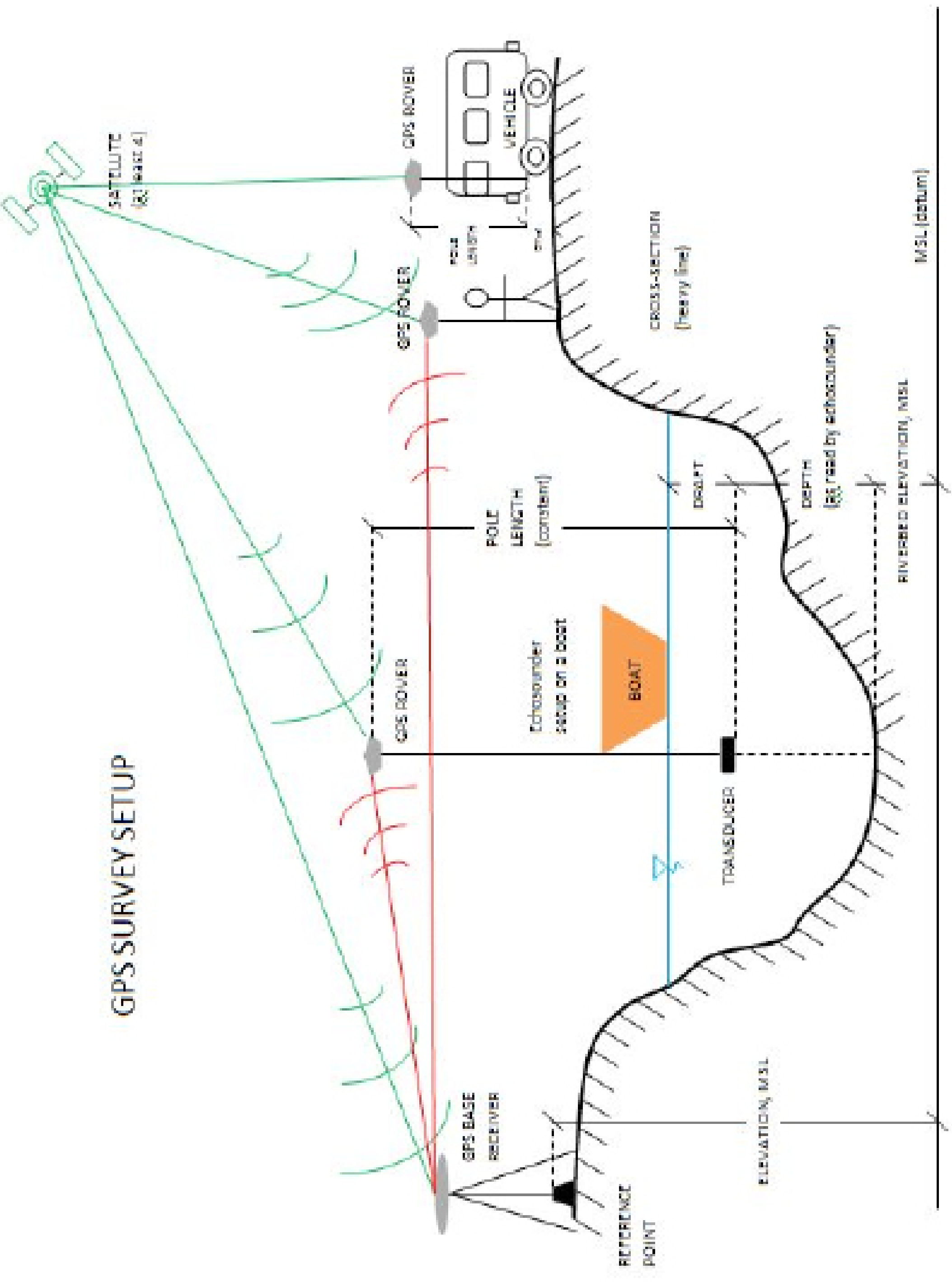


Figure 8. Set-up for GNSS Survey

3.3 Data Processing

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

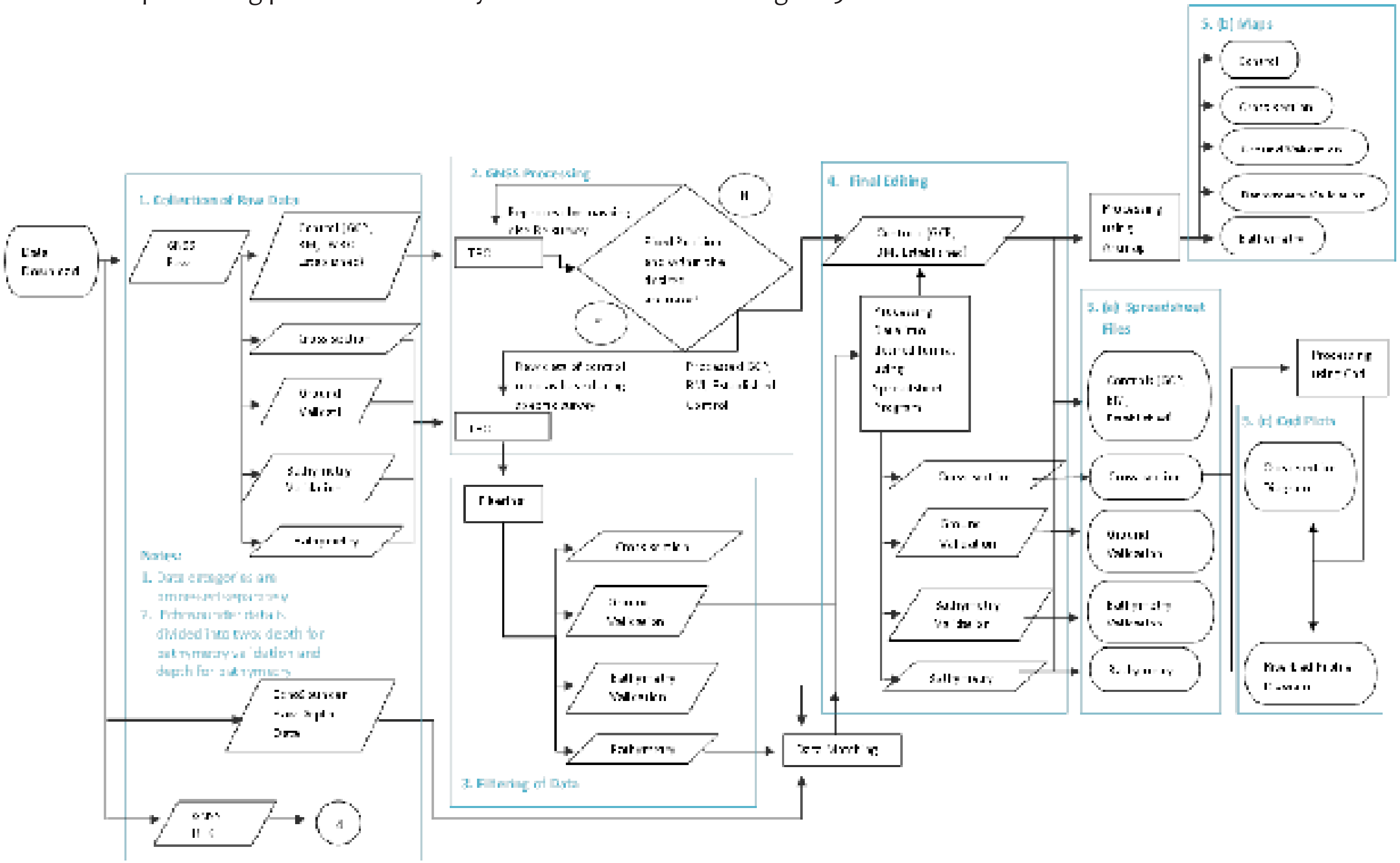


Figure 9. DVC Data Processing Methodology

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

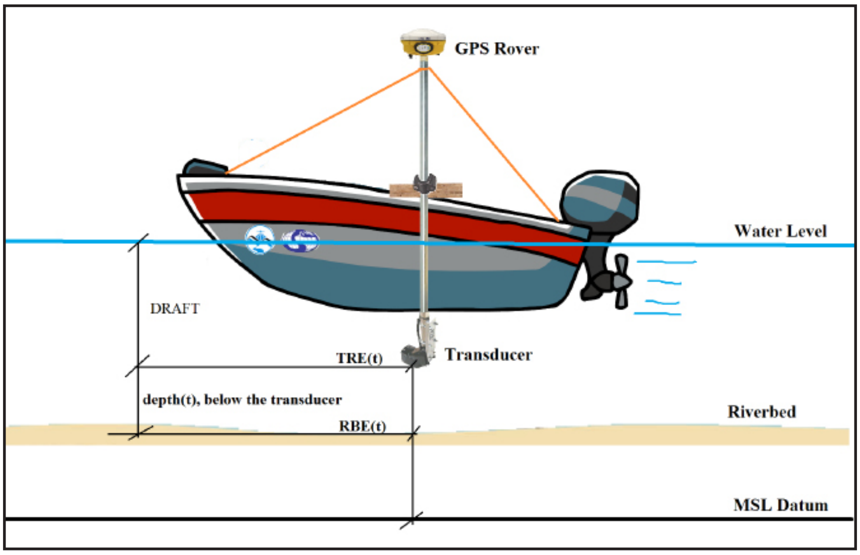


Figure 10. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

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.

DVC Methodology

Hydrometry Data Processing

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

1. **River Flow Data**

    a.) ADCP

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

    b.) Flow Meter

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

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

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

3. **Water Level Change-Stage**

    a.) Depth Gauge

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

    b.) AWLS

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

4. **Discharge Computation**

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

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

3.3.3 Filtering of Data

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

3.3.4 Final Editing

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

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

3.3.5 Output

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

Iponan River Basin Survey

Iponan River Basin Survey

The survey for Iponan River Basin was conducted on May 24- June 7, 2012 with the following activities: profile, cross section, bathymetric surveys and flow measurements.

Iponan River consists of 16 delineated cross section lines with a total length of 45.87 km for both left and right banks starting from Brgy. Pagatpat in the upstream down to Brgy. Bulua near the mouth of the river. The total length of profile lines is about 34.73 km for its both left and right banks.

4.1 Control Survey

One (1) NAMRIA established control point, MSE3241, which is located near SM Shoe Mart- Cagayan De Oro Branch, was considered for post- processed kinematic (PPK) observations which is used for the left cross section, left profile and bathymetric survey of Iponan River Basin. A control point was established at Golden Haven Cemetery and served as GNSS base station for real-time kinematic (RTK) observation of the right cross section and right profile survey.

The location of control points occupied is shown in the map in Figure 11 while its corresponding base setup is shown in Figure 12 and 13.

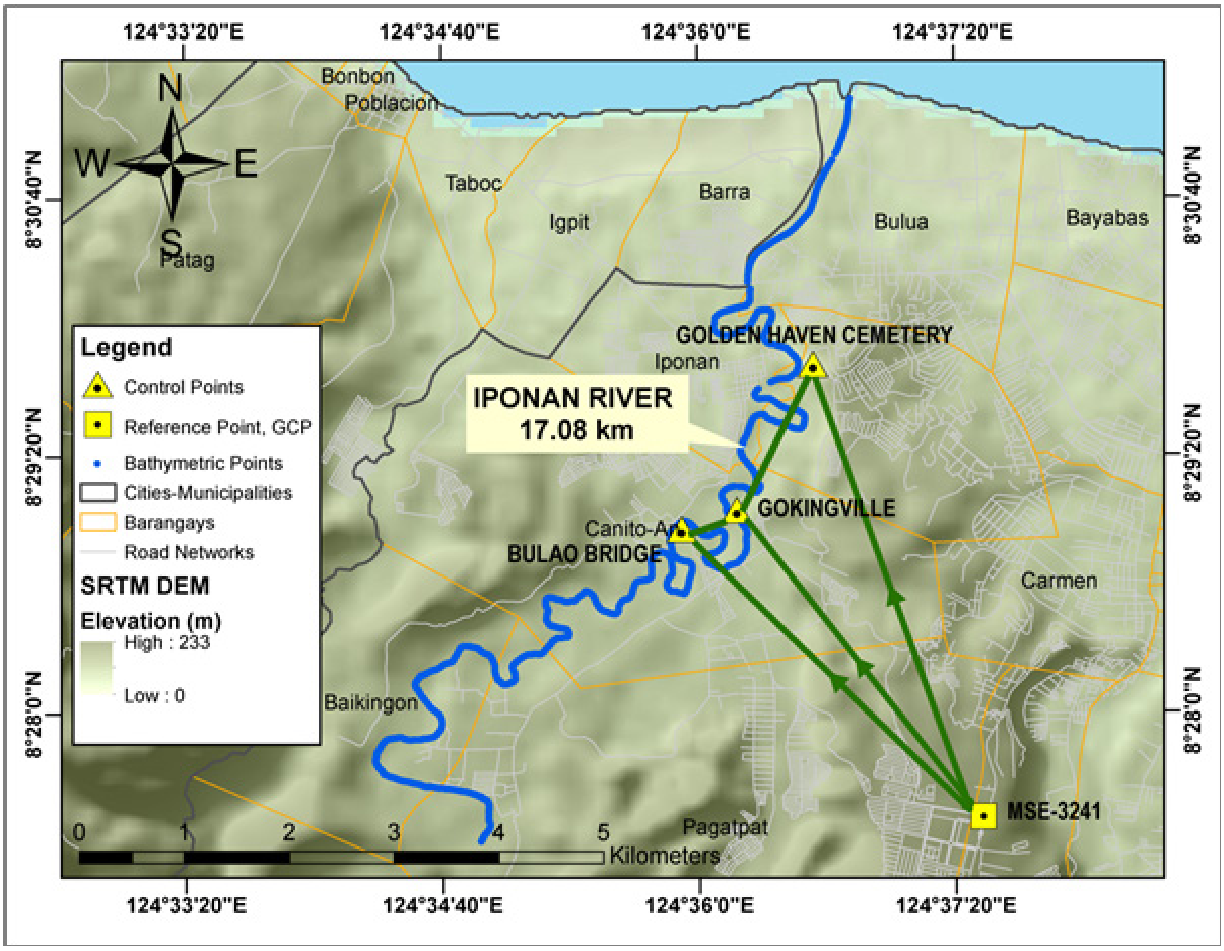


Figure 11. Location of control points

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 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 Iligan 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)	
MSE3241	8027'27.49638" N	124037'28.59587" E	177.055	935264.004	678848.459	106.954
Golden Haven Cemetery	8030'5.754" N	124039'46.044" E	97.423	939575.529	677217.522	27.743
Bulao Bridge	8029'48.058" N	124036'35.860" E	76.245	937997.281	675970.391	9.551
Gokingville Subdivision	8028'56.854" N	124035'54.871" E	79.330	938182.795	676497.984	6.466
ME-TGBM From Cagayan de Oro Survey used for MSL Elevation						
ME-TGBM	8030'02.171" N	124039'51.452" E	70.828	940034.365	683197.778	2.285

The Baseline setup for the two (2) control points are illustrated in Figures 12 and 13:

Figure 12. Base set-up at MSE-3241 located near SM Shoe Mart-Cagayan De Oro Branch

Figure 13. Static GNSS observation at a control point at Golden Heaven Cemetery, Cagayan De Oro City

Ground Surveys

The main objective of this activity is to perform reconnaissance to ensure the accessibility of the proposed cross-section and profile routes for the conduct of ground surveys.

Reconnaissance was conducted simultaneously with bathymetric and hydrometric measurements from May 24 to 26, 2012. The remaining days were allotted for the conduct of ground surveys for Iponan River.

4.2 Reconnaissance of Cross-section and Profile Lines

Ocular inspection of the proposed cross-section and profile lines of Iponan River was conducted. Each cross-section lines were located using Base GPS station and three (3) rover GPS receivers. Reconnaissance for profile lines, bathymetric survey extents and suitable sensor deployment sites were conducted simultaneously with the cross section surveys.

Features such as thick bushes, large tree canopy covers, tall grasses, etc. were noted and indicated on the field notebook and were relayed to the contractor prior the scheduled ground surveys.

4.2.1. Cross-section Survey

Cross-section survey started on May 27, 2012 and ended in June 6, 2012. Iponan River consists sixteen (16) cross-section lines with a total distance of 45.87 km. Cross-section lines run perpendicular to riverbanks with a typical width of at least one hundred (100) m on each bank after which, the cross-sections usually extended to 1 kilometer or more. First four cross-sections are located from Barangay Pagatpat to Barangay San Simon; both of which are situated in Cagayan de Oro City. A boat was used to transport the team to each cross-section site. A GNSS Base Receiver Trimble® SPS852 and TopconTM HiperGa receiver were the main instruments used.

(a) (b)

Figure 14. Left cross section team from (a) Brgy Pagatpat to (b) Brgy San Simon

(a)

(b)

Figure 15. Right cross section team doing (a) XSR12 at Zone-8 Brgy. Bayabas and (b) XSR6 at Brgy. Bulao Sitio Anhawan

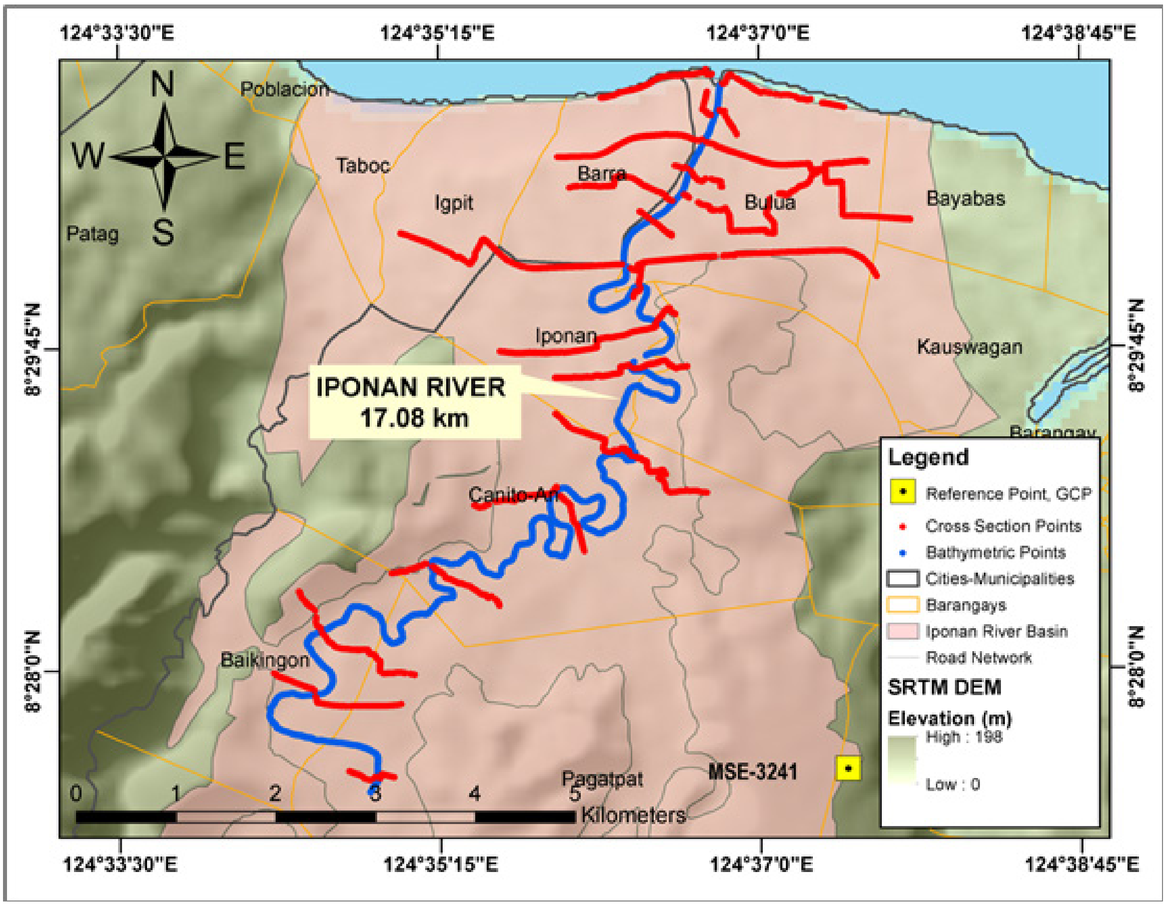
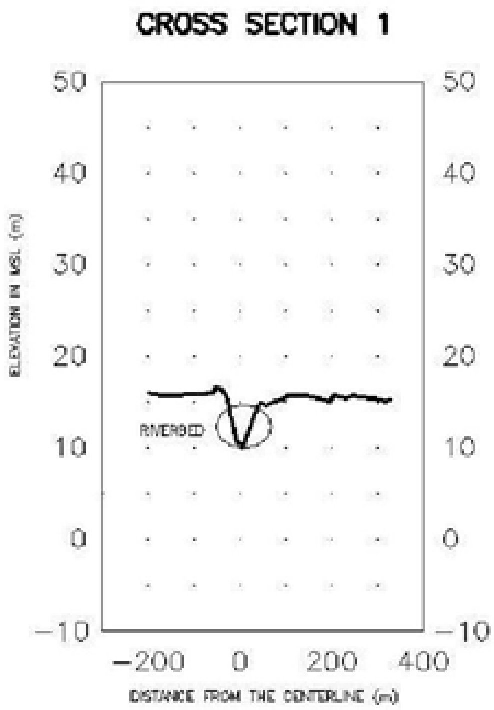


Figure 16. Cross Section data in Iponan River

Sixteen (16) cross sections were surveyed which started from Brgy. Pagatpat and ended to Brgy. Bulua. Each cross section, with an average length of 1.84 km, and are illustrated as a CAD diagram in Figures 17 to 24. The summary of surveyed cross sections is shown in Table 2.



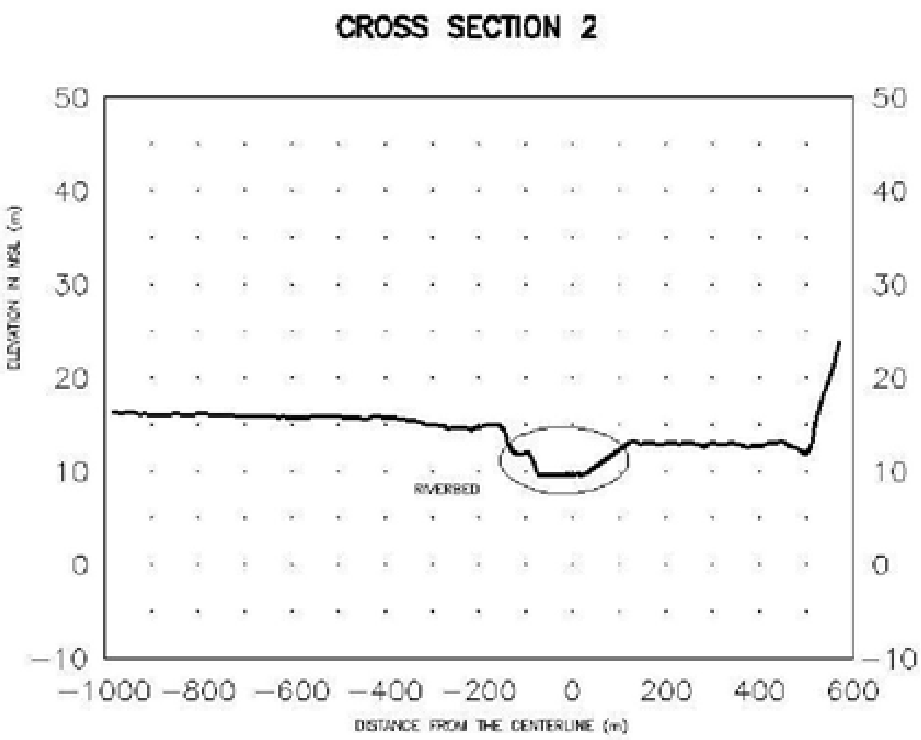
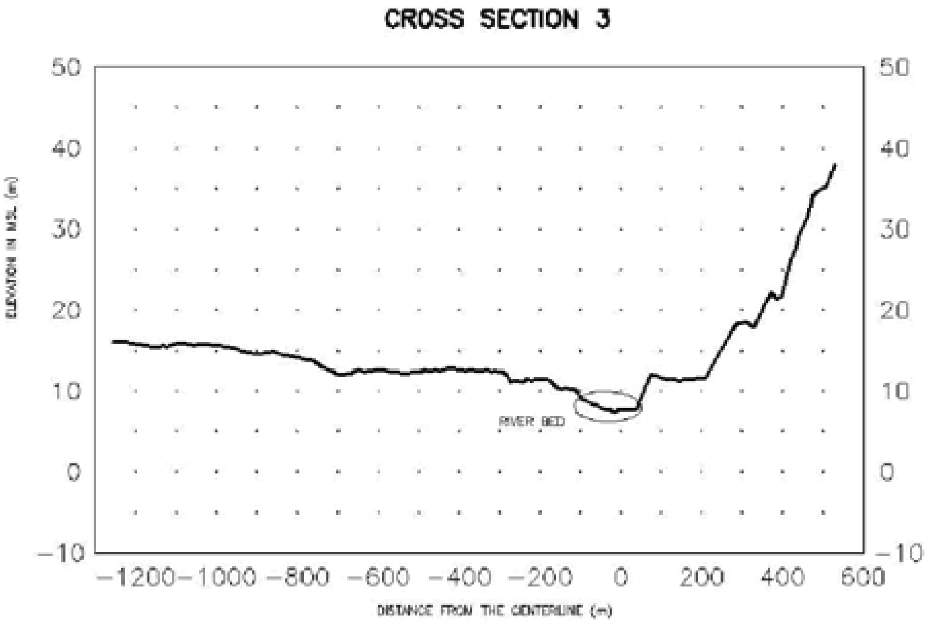


Figure 17. Cross-sections (1 and 2) along Iponan River



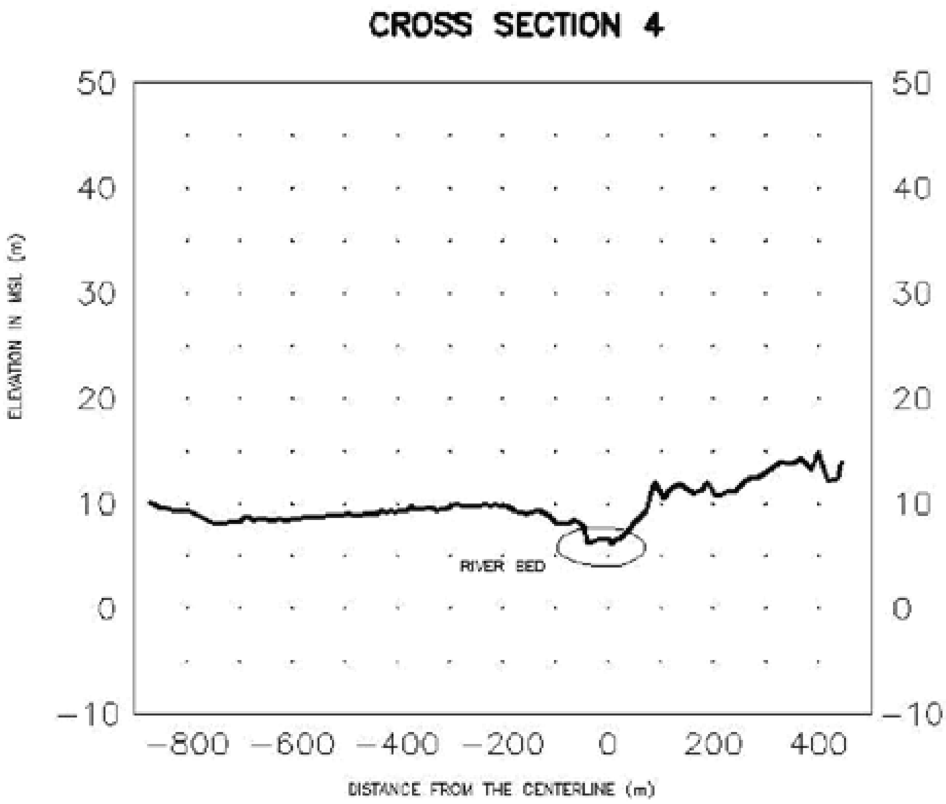
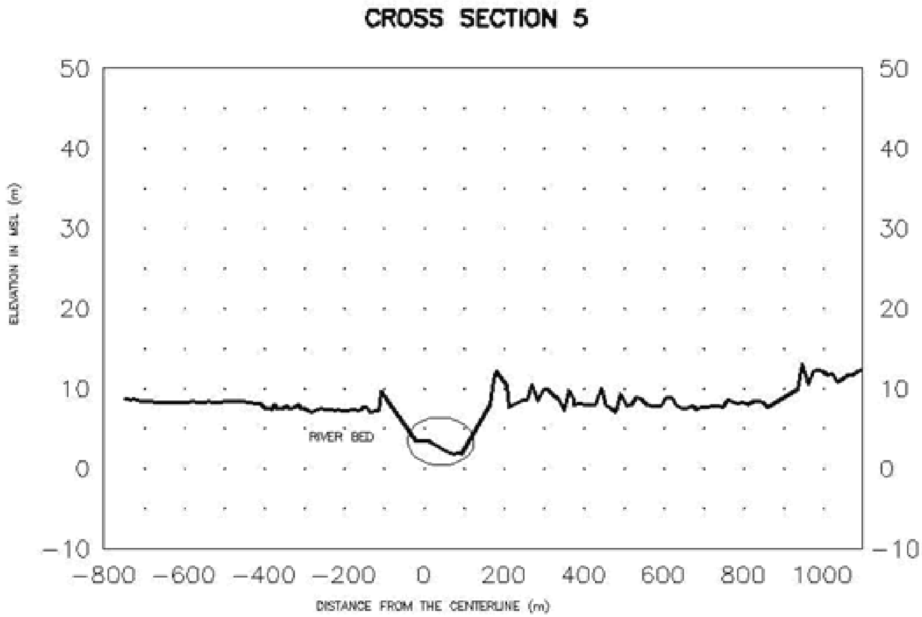


Figure 18. Cross-sections (3 and 4) along Iponan River



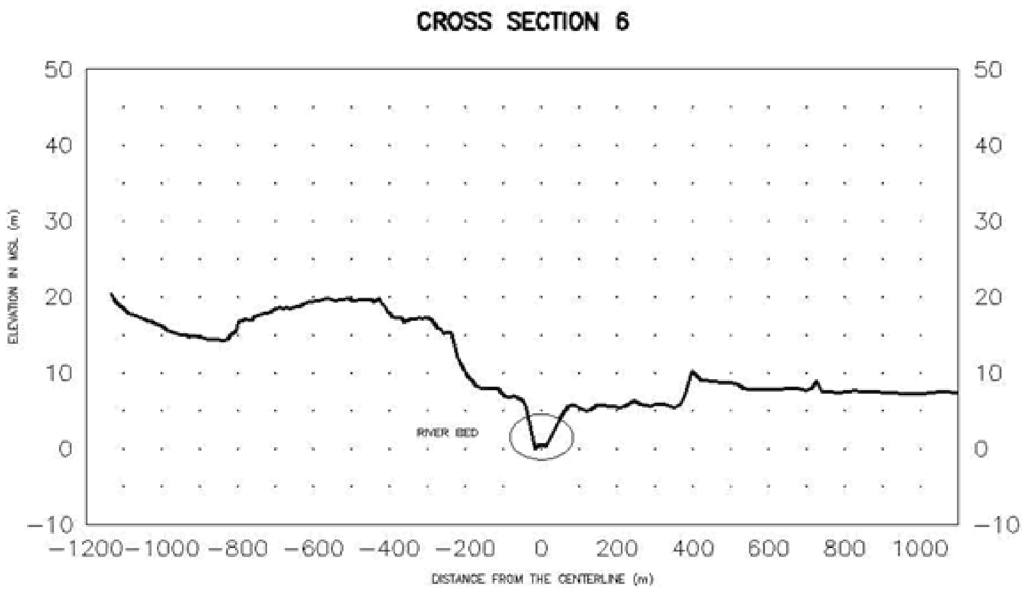
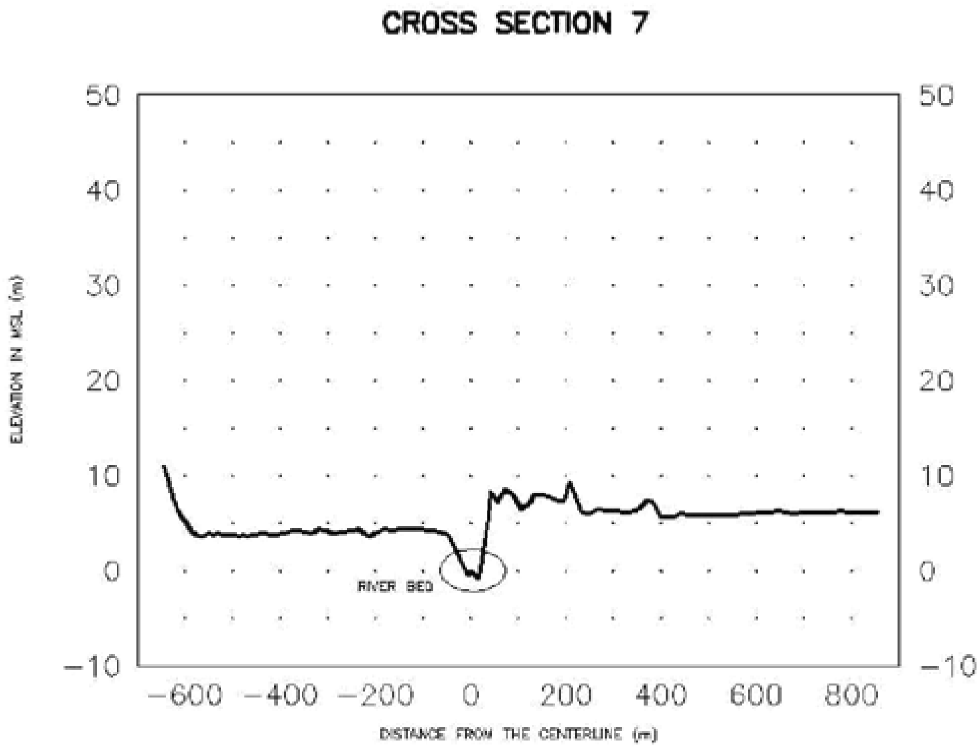


Figure 19. Cross-sections (5 and 6) along Iponan River



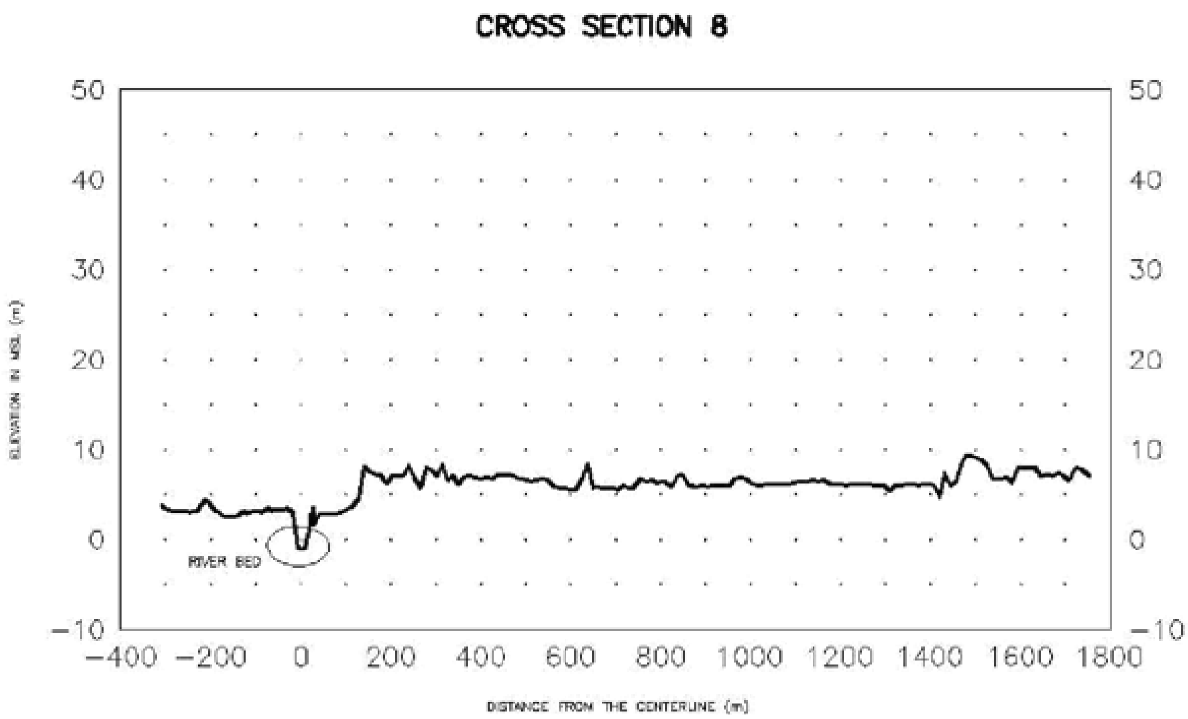


Figure 20. Cross-sections (7 and 8) along Iponan River

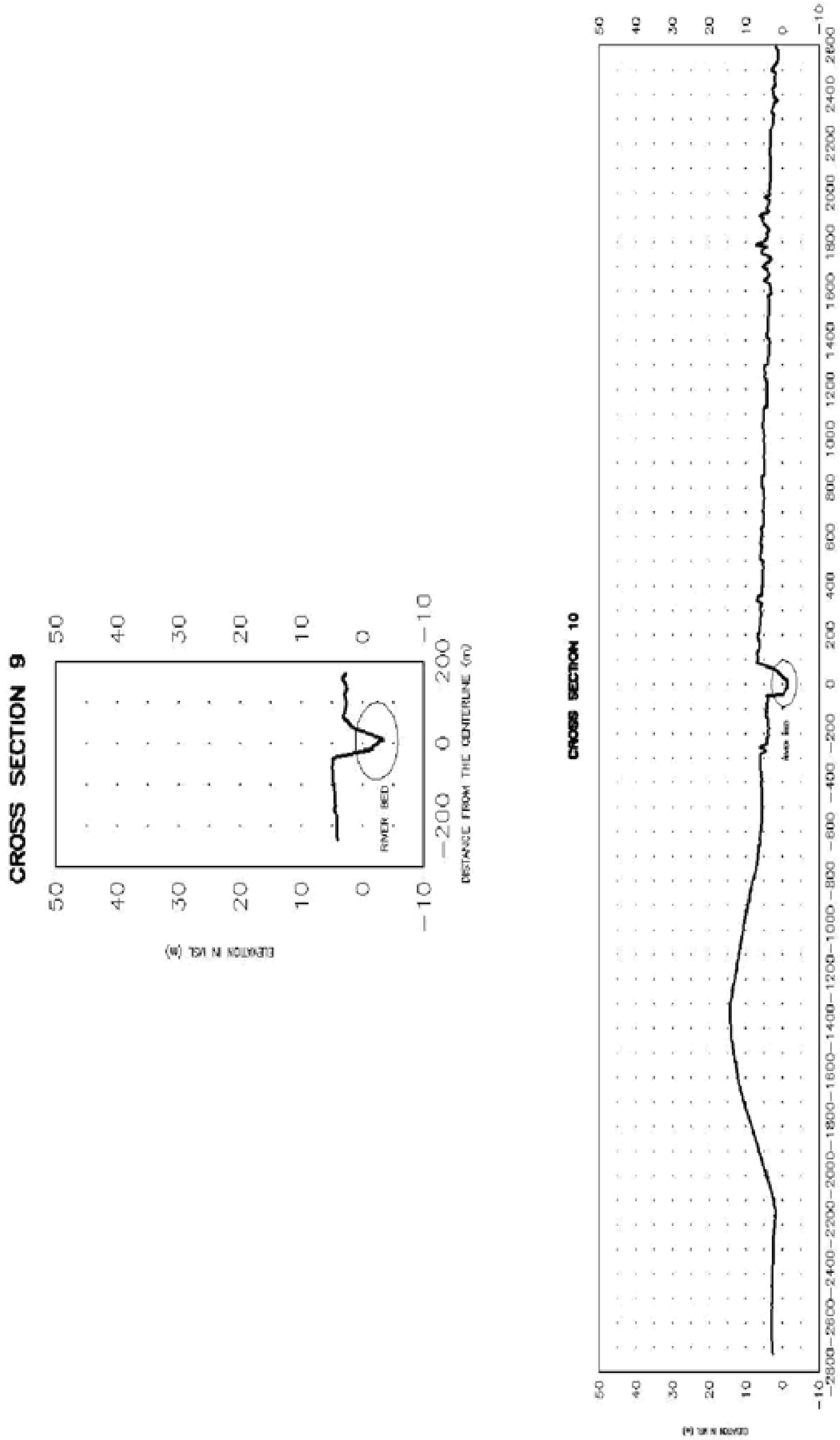


Figure 21. Cross-sections (9 and 10) along Iponan River

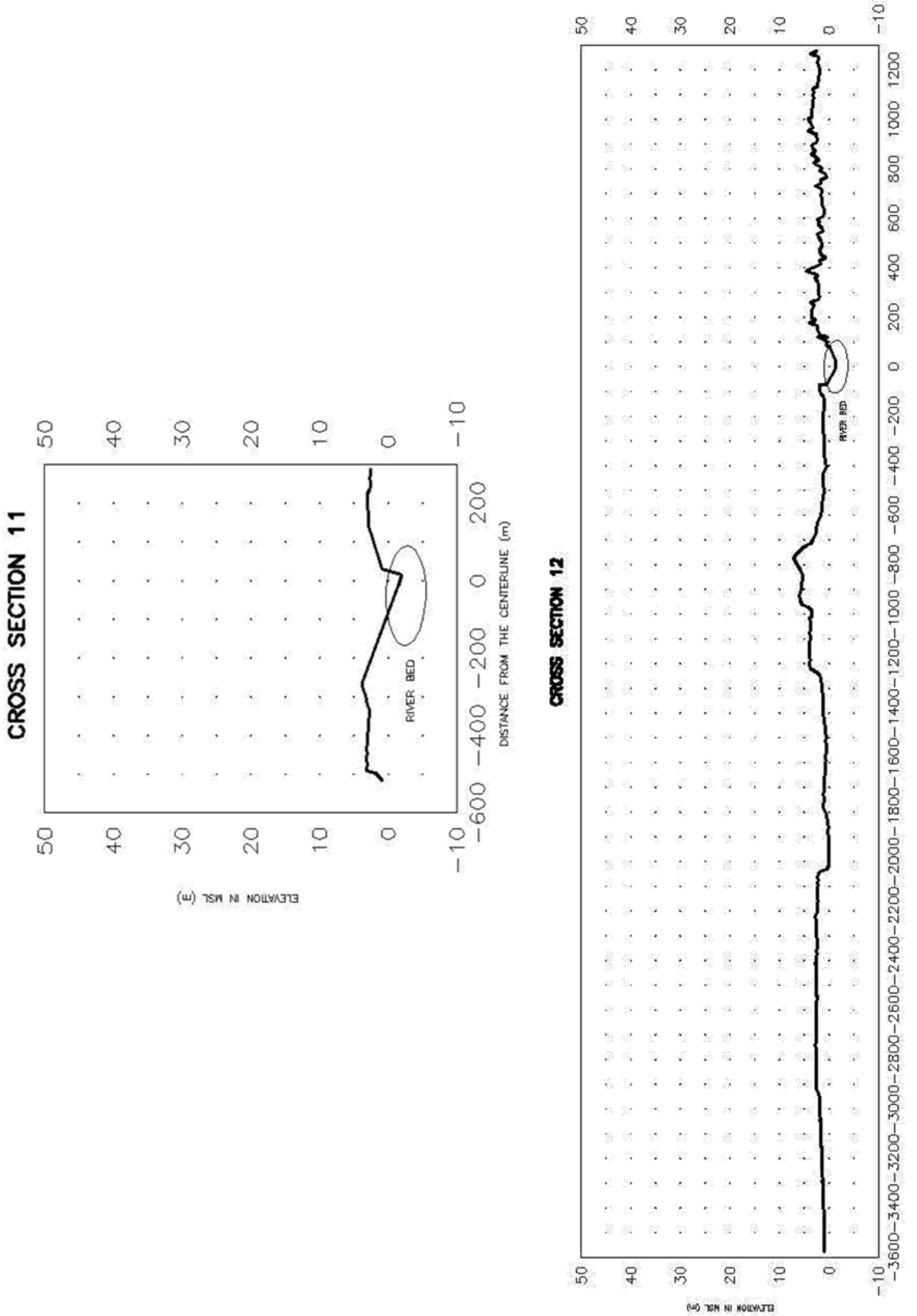


Figure 22. Cross-sections (11 and 12) along Iponan River

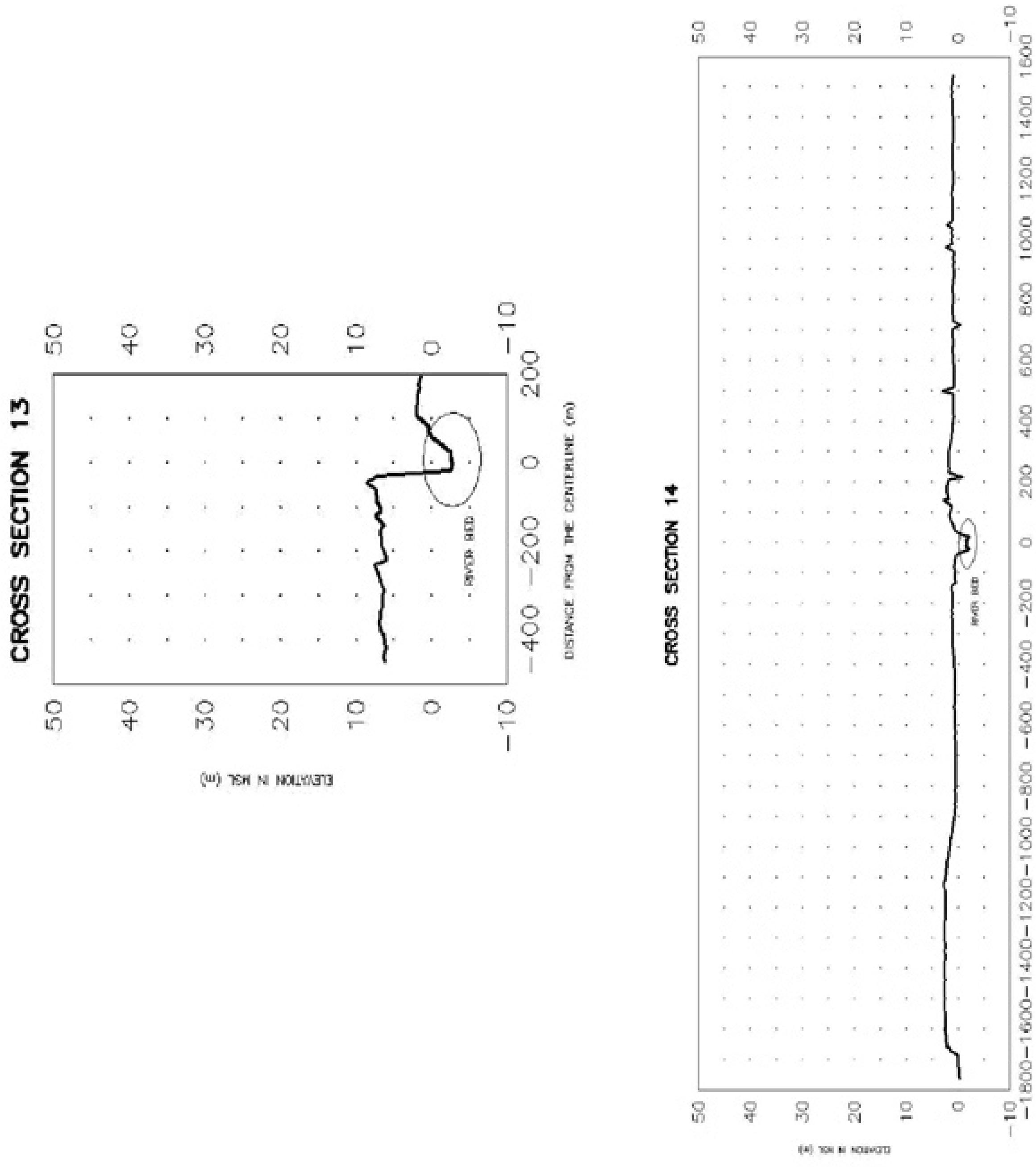


Figure 23. Cross-sections (13 and 14) along Iponan River

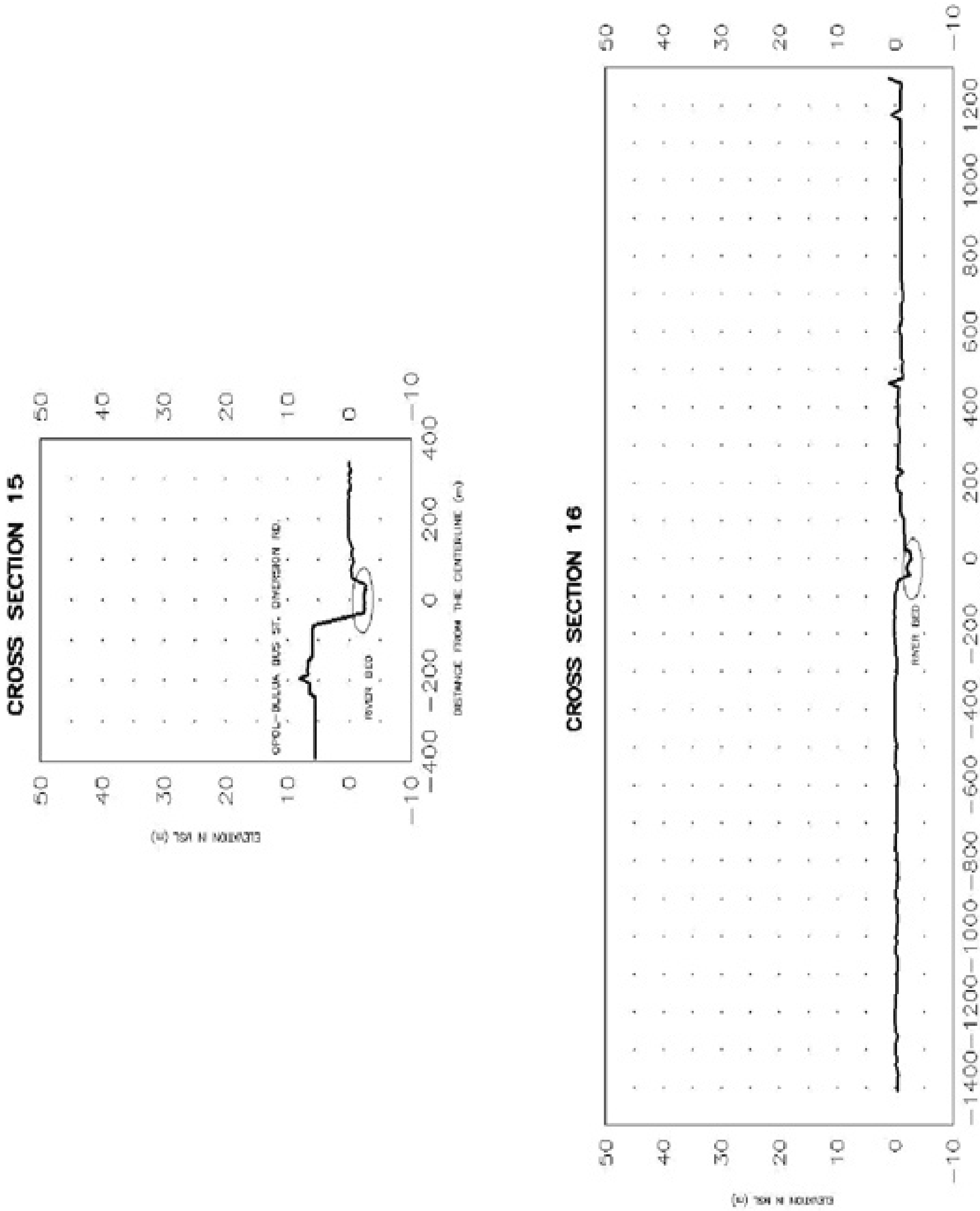


Figure 24. Cross-sections (15 and 16) along Iponan River

Table 2. List of surveyed cross-sections

Cross-section	Number of Points Data Points	Distance from Iponan Bridge (km)	Distance from Opol Bridge (km)
1	46	5.748	7.141
2	131	5.331	6.816
3	142	4.791	6.222
4	113	3.603	5.061
5	150	2.422	3.834
6	211	1.925	3.172
7	134	1.039	2.362
8	315	0.660	1.845
9	569	0.260	1.565
10	460	0.070	1.466
11	329	0.050	0.945
12	237	0.900	0.550
13	43	1.111	0.311
14	44	1.446	0.035
15	48	1.784	0.348
16	63	2.027	0.597
Total	3035		

The list of surveyed cross sections in Iponan River is shown in Table 2. Originally, only twelve cross sections were required but in order to minimize the gaps, it was increased to sixteen (16) cross sections. In consider with the area being susceptible to flooding, several cross sections were shortened.

4.2.2 Profile Survey

Profile survey of Iponan River consist of left and right upper bank and left and right lower bank with an approximate total length of 34.73 km, respectively. The survey was started on May 30, 2012 and ended on June 5, 2012. The start of the survey was in Brgy. Pagatpat down to its flood plain area in Brgy. San Simon. Two (2) GPS receivers were used as rovers TopconTM Hiper Ga and Trimble SPS882, in conducting the survey as shown in Figure 25. The profile plot of Iponan river is shown in Figures 26, 27, 28 and 29.

(a) **(b)**

Figure 25. (a) Right lower bank profile at Brgy. Pagatpat and (b) Left lower bank profile at Brgy. San Simon

IPONAN RIVER PROFILE

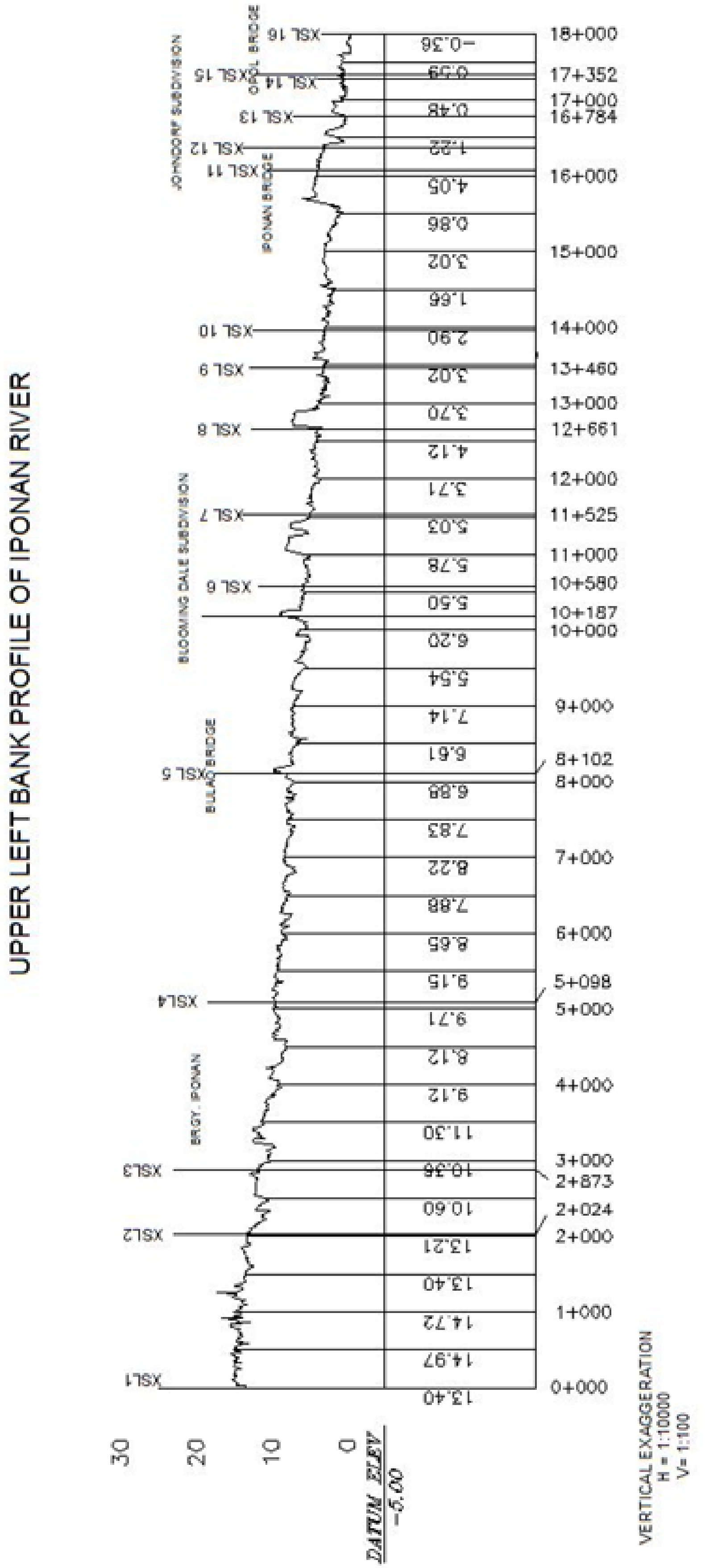


Figure 26. Upper left profile of Iponan River

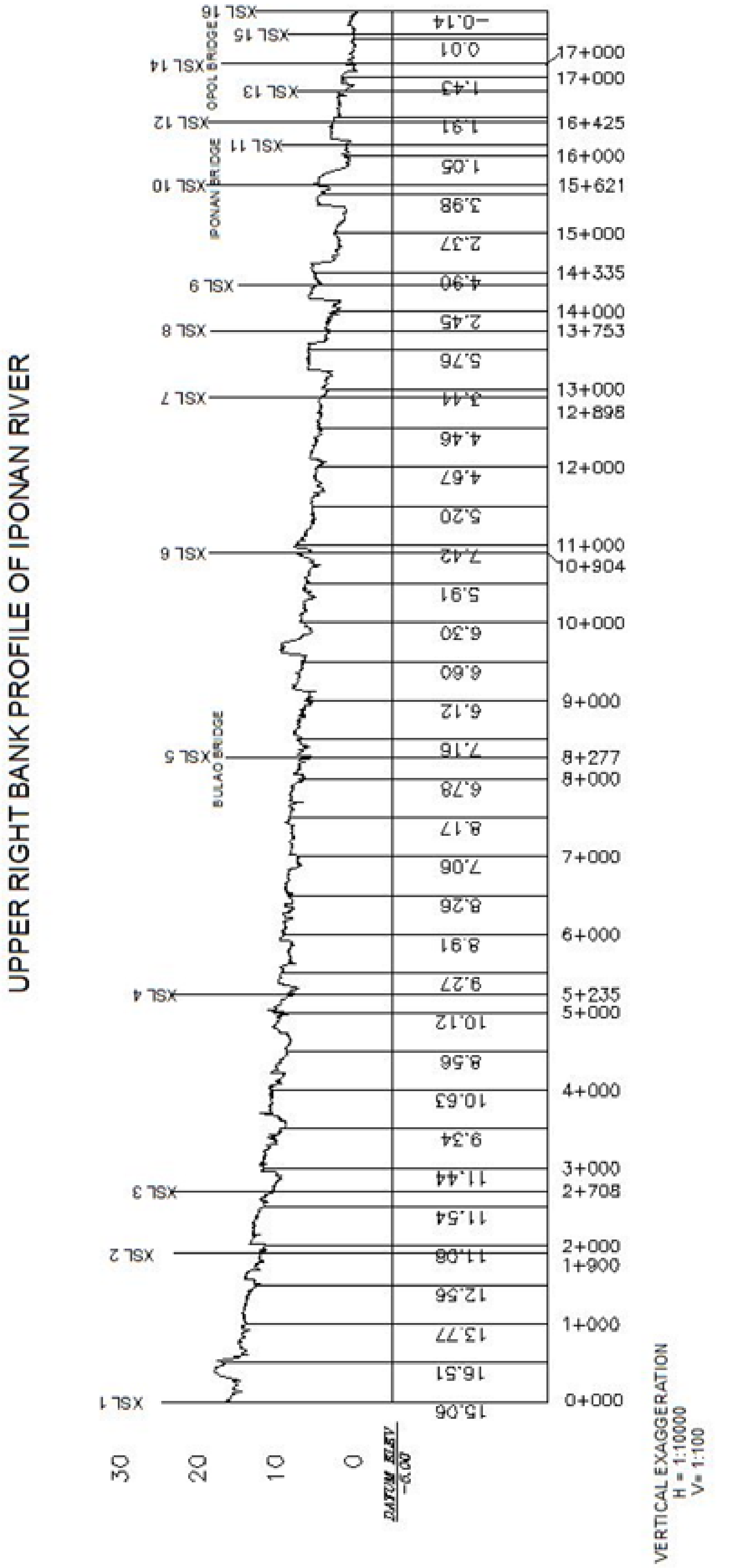


Figure 27. Upper right bank profile of Iponan River

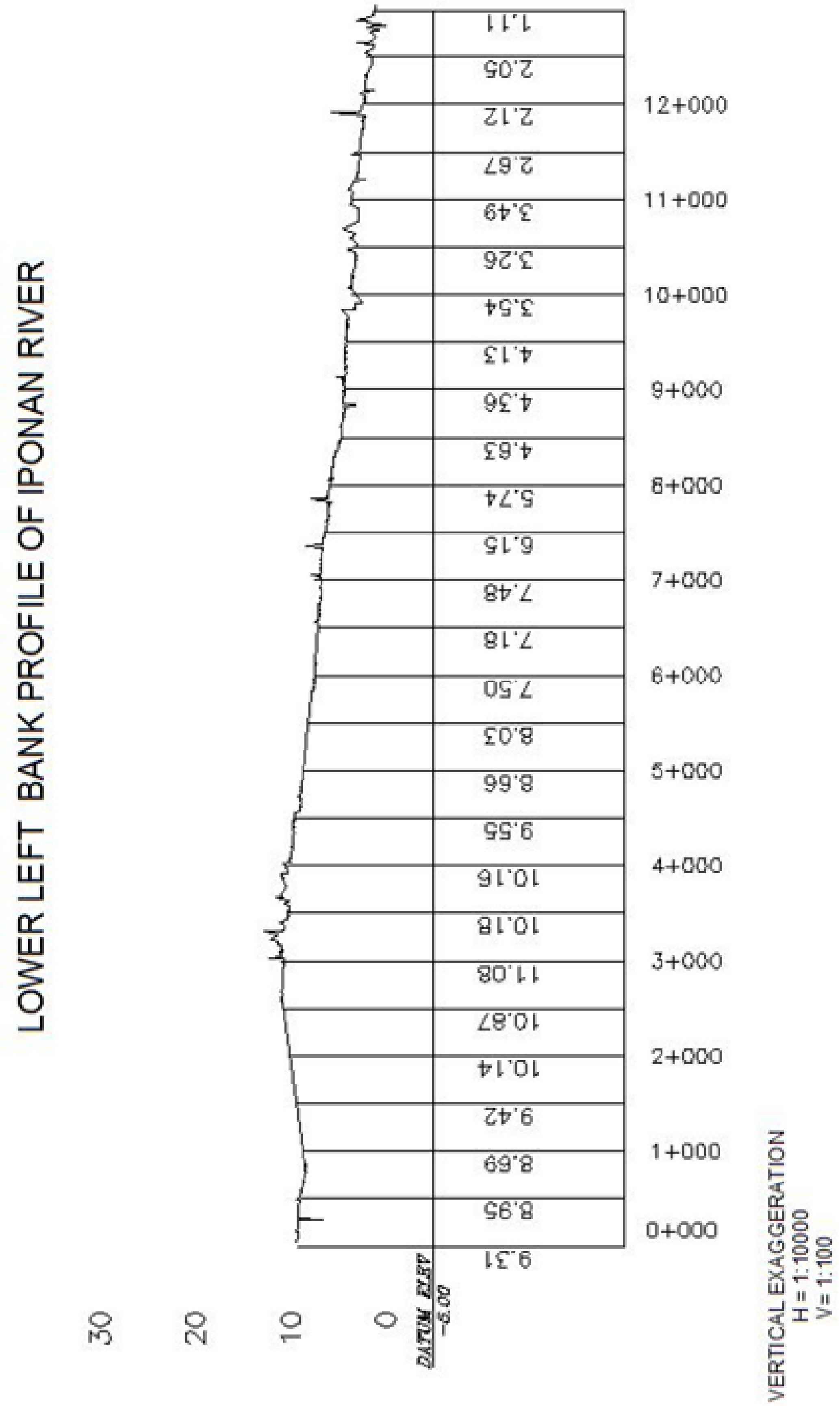


Figure 28. Lower left bank profile of Iponan River

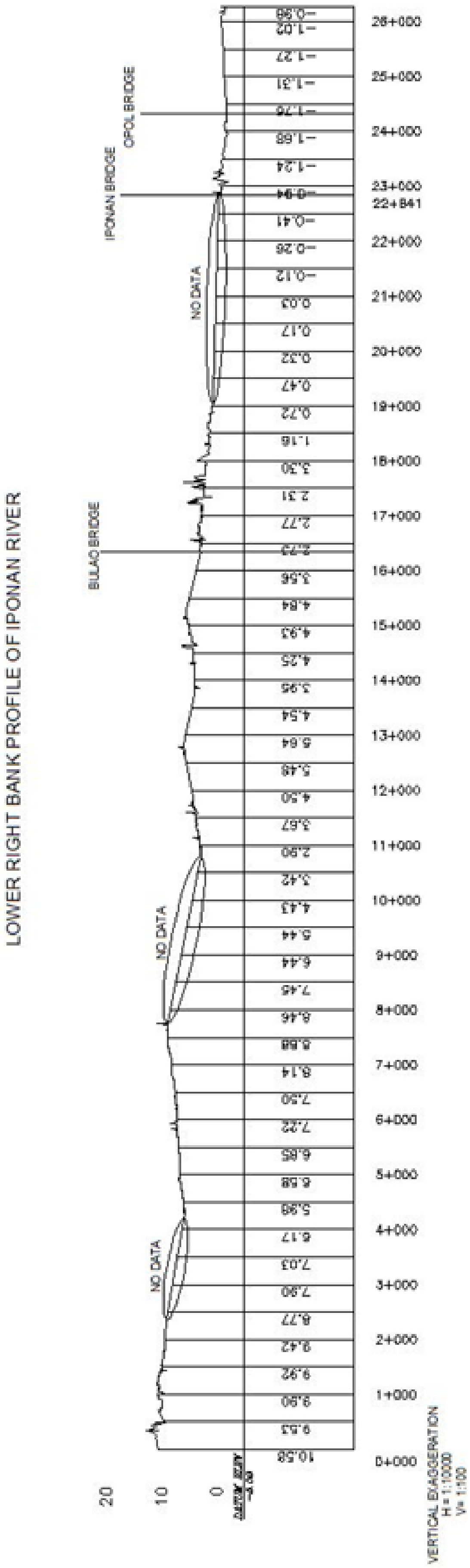


Figure 29. Lower right bank profile of Iponan River

4.3 Bathymetric Survey

The bathymetry of the river channel was surveyed using an echosounding surveying technique. Differential GNSS surveying technique and a Hi-Target HD-370 Digital VF single beam echosounder integrated with Topcon HiperTM Ga GPS receiver were utilized in measuring the depth, eventually obtaining elevation with corresponding horizontal position. Bathymetry setup during the Iponan bathymetry survey is illustrated in Figures 30 and 31.

The entire bathymetry survey took three (4) days to accomplish from May 27 to May 30, 2012. The Bathymetry Team executed the survey using a rubber boat borrowed from the Philippine Coast Guard (PCG) accompanied by two (2) 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 32.

An approximate centerline length of 17.13 km and a zigzag sweep length of 35.04 km were covered starting from downstream in Goking Ville Subdivision up to XS12 at Zone 8, Brgy Bayabas.

Figure 30. Bathymetric survey setup

Figure 31. Bathymetry team with the Philippine Coast Guard personnel

Figure 32. Bathymetry and Deployment team acquiring bathymetry zigzag line from Goking Ville Subdivision to Brgy. Bayabas

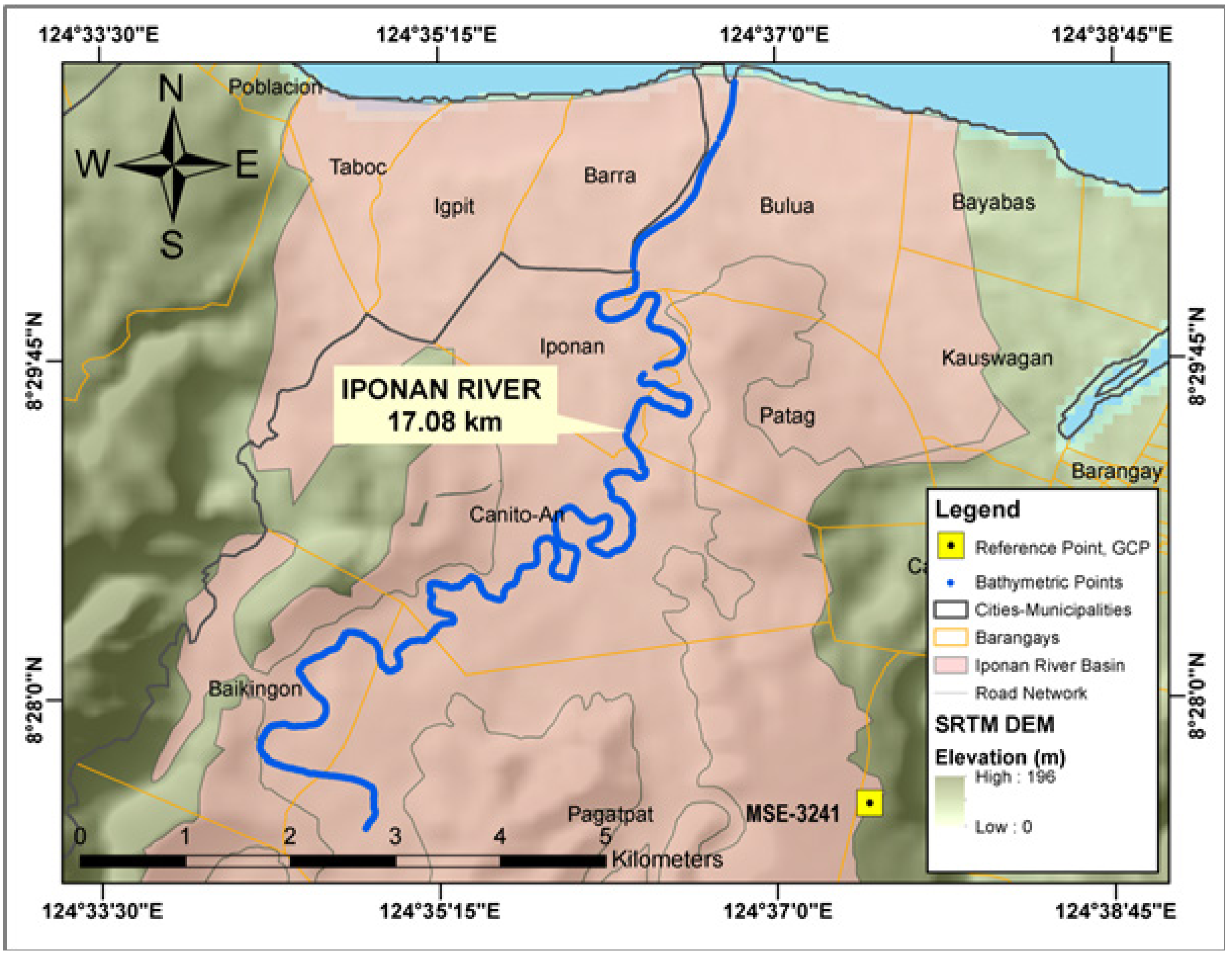


Figure 33. Bathymetric survey coverage in Iponan River

4.4 Hydrometric Survey

Different sensors were deployed on the banks of Iponan 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. Bulao, Cagayan De Oro City using an ADCP, a depth gauge and a rain gauge started on the 28th of May, 2012 and retrieved on the 31st of May, 2012. The ADCP was monitored every morning and on or before 6:00 pm daily 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 Bulao Bridge continued gathering data until its retrieval on June 1, 2012. On the same day, the sensors were deployed for a day in Mandulog River, Iligan City.

Another deployment of sensors was done at GokingVille Subdivision, at Lat 8° 29'02.82126" N and Long 124°36'12.14620" E.

The data gathered from rain gauge shows the distribution of rainfall within the observation period from May 28 to 31, 2012 at Brgy Bulao and June 3 to 4, 2012 at Goking Ville Subdivision. Each sensor has five (5)-minute interval. The first surge of rain, which reached 0.2 mm, was observed on May 31, 2012 at 6:30 am. Highest amount of rain collected occurred on the 31st of May, 2012 at 4.4 mm. Relationships of data gathered within the observation period are illustrated in Figures 34 and 35.

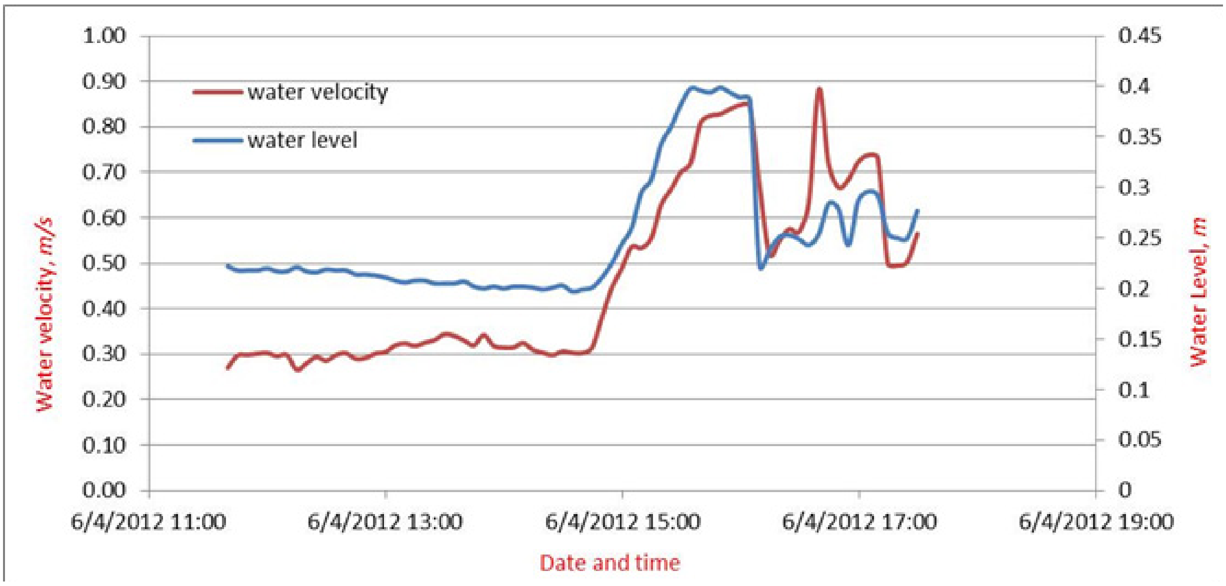


Figure 34. Relationship between velocity and water level

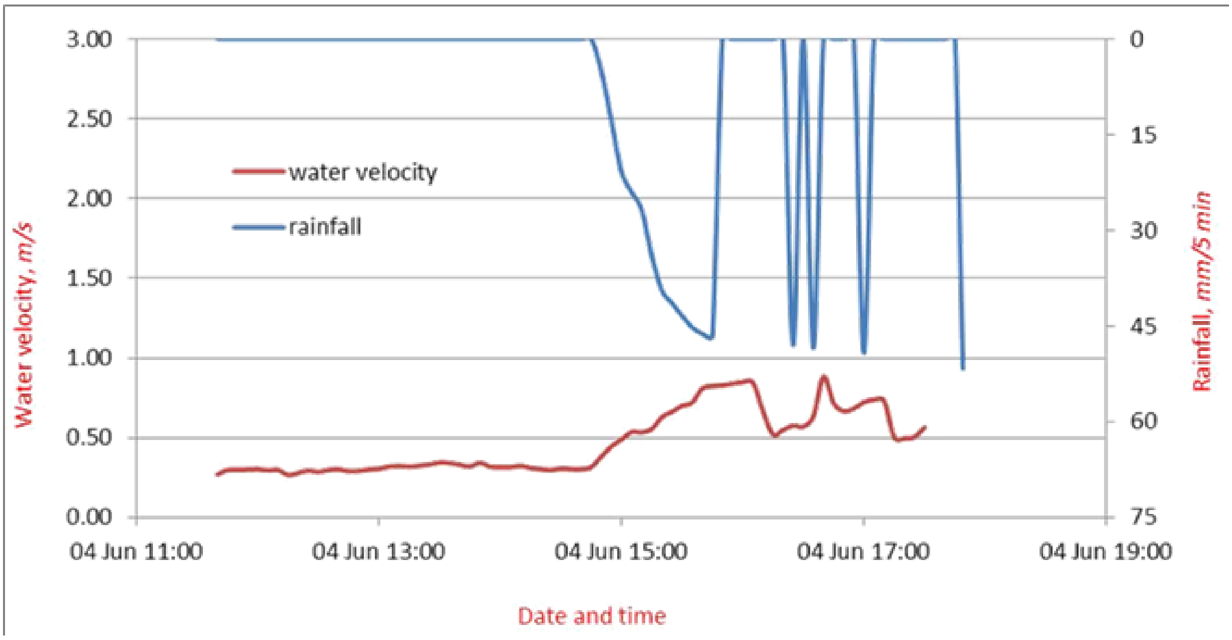


Figure 35. Relationship between velocity and rainfall

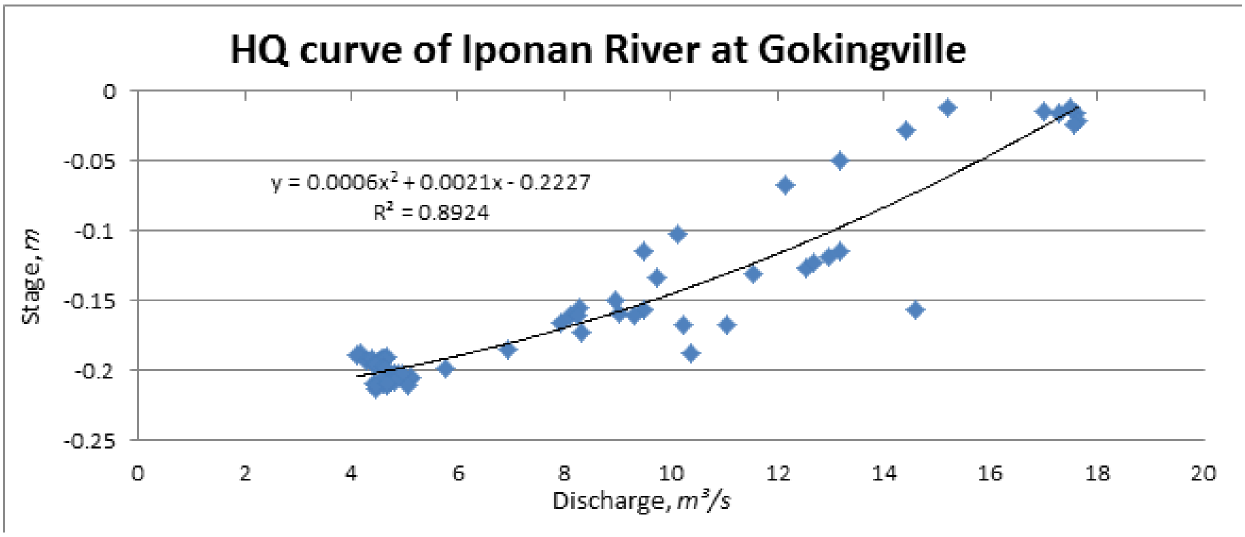


Figure 36. Relationship between stage and discharge at Gokingville Subdivision in. Bulua, Cagayan De Oro City

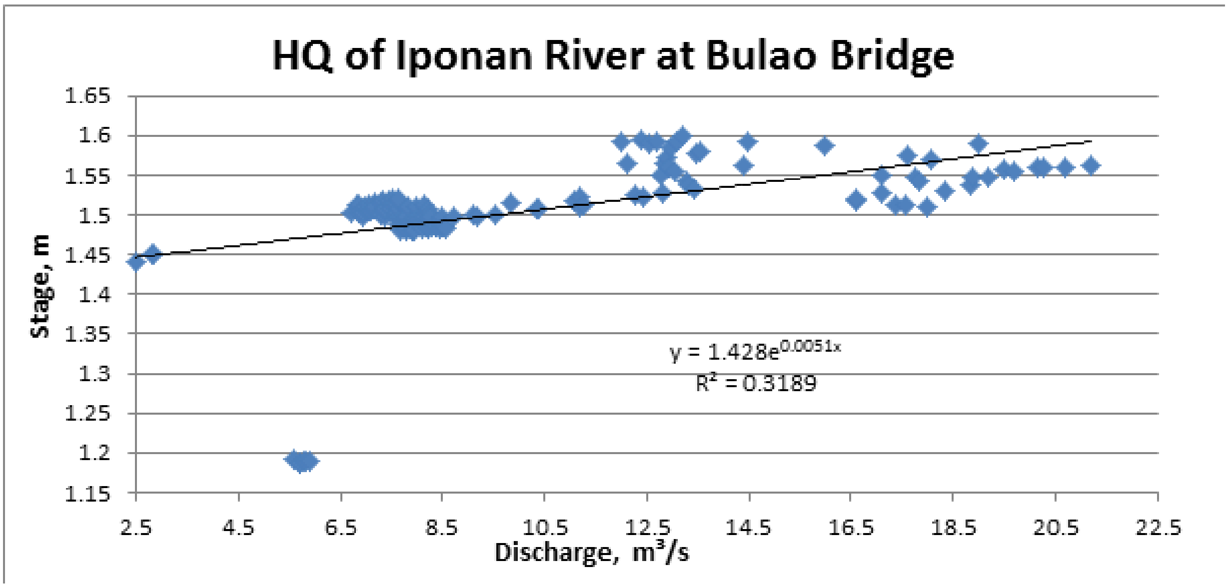


Figure 37. Relationship between stage and discharge at Bulao Bridge in Iponan, Cagayan De Oro City

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 Figures 36 and 37. A value approaching R2 = 1 indicates a good correlation.

Setup of sensors deployment is illustrated in Figures 38, 39 and 40.

SENSORS DEPLOYMENT

Figure 38. Rain gauge and depth gauge deployment at Bulao Bridge

Figure 39. First deployment of Acoustic Doppler Current Profiler at Bulao Bridge

Figure 40. Second deployment of Acoustic Doppler Current Profiler at Goking Ville Subdivision

Table 3. Deployment of sensors along Iponan River in Cagayan De Oro City

Sensor	Location	Deployment	Retrieval	Latitude	Longitude
ADCP, Depth Gauge and Rain Gauge (1)	Bulao Bridge	28-May-12	01-June-12	7° 7'55.98"N	125°34'58.54"E
ADCP, Depth Gauge and Rain Gauge (1)	Gokingville Subdivision	03-June-12	04-June-12	7° 7'54.83"N	125°34'59.02"E

Summary of location of sensor deployment are shown in Table 3 and Figure 41.

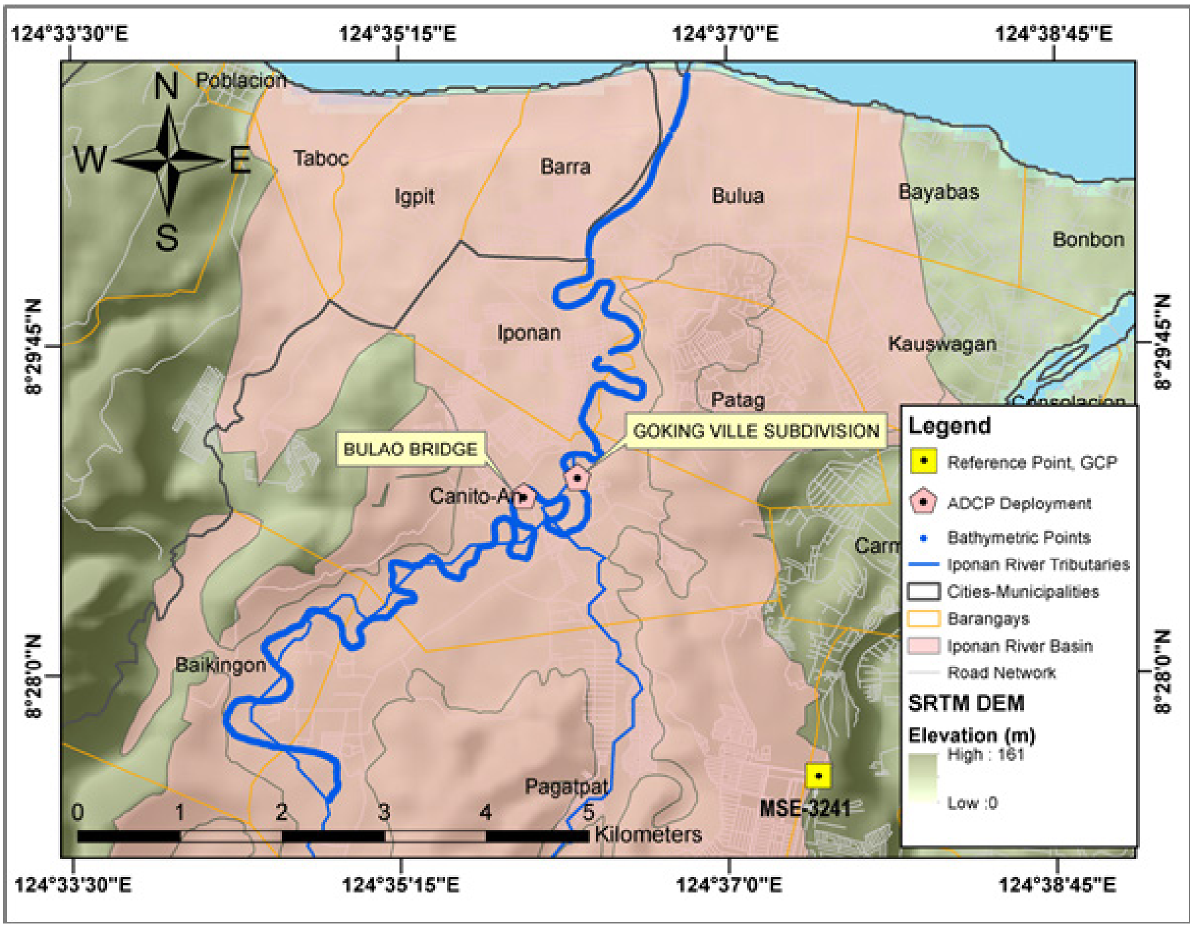


Figure 41. Location of Sensors in Iponan River

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.

Limitation/Problems	Solutions
1) From reconnaissance survey (May 24, 2012) Lower bank profile (Left and right) was rated as not passable	Needs to use rubber boat and walked over to water surface in shallow areas to gathered data
2) On May 27, 2012: after post processing the data of bathymetry, found out that no data on some areas of centerline	Patched up missing data of bathymetric centerlineareas with the additional data on May 29, 2012
3) Delayed transportation of Rubber Boat on May 28, 2012 (the trailer tire went off while on its way to bathymetry site)	Replaced new trailer an hour after the first trailer went off
4) May 28, 2012; The survey team had difficulties establishing a radio connection – unable to change settings to "new base setup"	Call immediately Sitech on how to solve the problem regarding radio connection
5) On May 28, 2012 the propeller of the rubber boat motor used by bathymetry team broke down	Change another rubber boat motor from PCG office
6) May 29, 2012 travel and drop off of teams are time consuming as well as transferring from one cross-section to another (not passable with vehicle)	Hired motorcycle to travel cross-section team to another cross-section site and started early to cope up with the travel and drop off period
7) RTK Base Radio not connecting with the RTK controller (drained battery) on May 30, 2012	Recharged the battery on the same day and on June 1, 2012 used another battery that is fully charged
8) May 30, 2012 inaccessible upper and lower bank profile due to rapids and trees	Needs to deviate routes when not passable and employed local hire to cut grasses

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

Type	Brand	Owner	Quantity
GPS Receivers	Trimble SPS852	SITECH	One (1) unit
	Trimble SPS882	SITECH	One (1) unit
	Topcon HiperGa	UP-TCAGP	Two (2) Rovers, two (2) controllers
	Trimble	UP-TCAGP	One (1) base
Digital Flow Meter		UP- TCAGP	One (1) unit
Digital Level	Topcon DL502	UP-TCAGP	One (1) unit with two (2) level rods
Singlebeam Echosounder	Hi-Target	UP-TCAGP	One (1) unit with accessories
Echosounder (Lowrance)	Ohmex™ Echosounder	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 with accessories
Handheld GNSS	Garmin Oregon 550	UP-TCAGP	Four (4) units
	Magellan		Two (2) units
Laptop	Lenovo	UP-TCAGP	One (1) unit
	Tough Book(MDL)		One (1) unit
	Tough Book (Hypack)		One (1) unit
Depth Gauge	Onset Hobo wares	UP-TCAGP	One (1) unit

Annexes

Type	Brand	Owner	Quantity
Rain Gauge		UP- TCAGP	Two (2) unit
Tripod	Trimble	Sitech	Two (2) units
Tripod		UP-TCAGP	One (1) unit
Prism with Range Poles		UP-TCAGP	One (1) unit
Laser Range Finder	Bushnell	UP-TCAGP	Three (3) units
Installers	SonTek	UP-TCAGP	One (1) unit
	Topcon		One (1) unit
Total Station (Prism Less)		UP-TCAGP	Two (2) units
Toolbox		UP-TCAGP	One (1) unit
Range Poles		UP-TCAGP	Two (2) units

ANNEX C. THE SURVEY TEAM

Data Validation Component	Designation	Name	Agency/Affiliation
	Project Leader	ENGR. LOUIE P. BALICANTA	UP TCAGP
Survey Coordinator	Chief Science Research Specialist (CSRS)	ENGR. JOEMARIE S. CABALLERO	UP TCAGP
Bathymetric Survey Team	Senior Science Research Specialist	ENGR. DEXTER T. LOZANO	UP TCAGP
	Research Associate	ENGR. JMSON J. CALALANG	UP TCAGP
Profile Survey Team	Senior Science Research Specialist	ENGR. BERNARD PAUL D. MARAMOT	UP TCAGP
	Senior Science Research Specialist	ENGR. MELCHOR REY M. NERY	UP TCAGP
Cross Section Survey Team and Sensors Deployment Team	Research Associate	JELINE M. AMANTE	UP TCAGP
	Research Associate	PATRIZCIA MAE P. DELACRUZ	UP TCAGP
	Research Associate	MARY GRACE S. JASON	UP TCAGP
Accounting and Coordination	Research Associate	JOPHINE V. MONTAÑO	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:	**MISAMIS ORIENTAL**				
Station Name:	**MSE-3241**				
Order:	**3rd**			Barangay:	**BARANGAY 10 (POB.)**
Island:	**MINDANAO**				
Municipality:	**CAGAYAN DE ORO CITY (CAPITAL)**				
PRS92 Coordinates					
Latitude:	**8° 27' 31.07607"**	Longitude:	**124° 37' 23.18891"**	Ellipsoidal Hgt:	**109.46700 m.**
WGS84 Coordinates					
Latitude:	**8° 27' 27.49608"**	Longitude:	**124° 37' 28.59587"**	Ellipsoidal Hgt:	**177.05500 m.**
PTM Coordinates					
Northing:	**935289.375 m.**	Easting:	**458499.251 m.**	Zone:	**5**
UTM Coordinates					
Northing:	**935,314.30**	Easting:	**678,684.71**	Zone:	**51**

Location Description

MSE-3241
Is located at the center island along Macapagal Rd., Brgy. 10 (Pob.), Cagayan de Oro City. It is situated between Sungole Bldg. and Super Mart Mall, about 20 m. facing the mall entrance. Mark is the head of a 4 in. copper nail embedded on a 25 cm. x 25 cm. concrete block, with inscriptions "MSE-3241 2007 NAMRIA".

Requesting Party: **UP DREAM/ Melchor Nery**
Pupose: **Reference**
OR Number: **3943540 B**
T.N.: **2013-0311**

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

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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 17, 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: **MISAMIS ORIENTAL**
Station Name: **ME-TGBM**

Island: **Mindanao**	Municipality: **CAGAYAN DE ORO CITY**	Barangay: **MACABALAN**
Elevation: **2.2853 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

TGBM
It is located inside Macabalan Wharf, Port of Cagayan De Oro City. It is on the wharf floor, about 220 cm NE of the tide house and is about 45 cm NW of the concrete gutter.
Mark is the head of a 2" bronze rod set flush on a 10"x 10" cement putty with inscriptions "TGBM 2011 NAMRIA".

Requesting Party:	**Melchor Nery**
Pupose:	**Reference**
OR Number:	**3943536 B**
T.N.:	**2013-0306**

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

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DREAM

Disaster Risk and Exposure Assessment for Mitigation