REGION 11

Hijo 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.

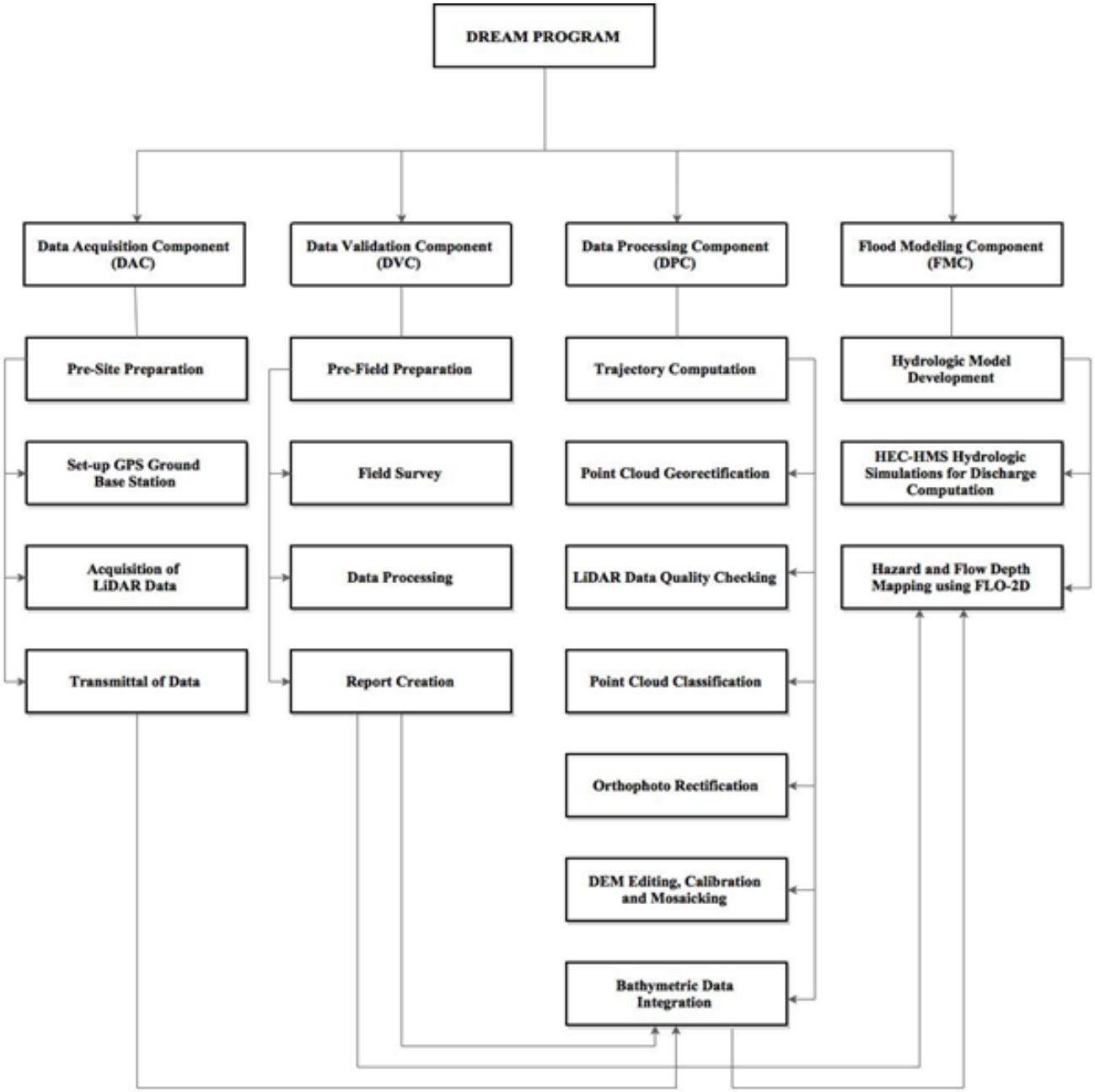


Figure 1. The General Methodological Framework of the Program

The Hijo River Basin

The Hijo River Basin

The Hijo River Baisn is located in the province of Davao del Norte. According to DENR-RCBO, it has a drainage area of 700 square kilometres and an estimated 1,400 million cubic meter annual run-off. Hijo River serves as the boundary line between the municipalities of Tagum and Compostela. With an estimated length of 64 kilometre, it covers the municipalities of Maco, Mabini, Pantukan, Mawab, and Nabunturan (Graciadas, 2012). The basin is as shown in Figure 2.

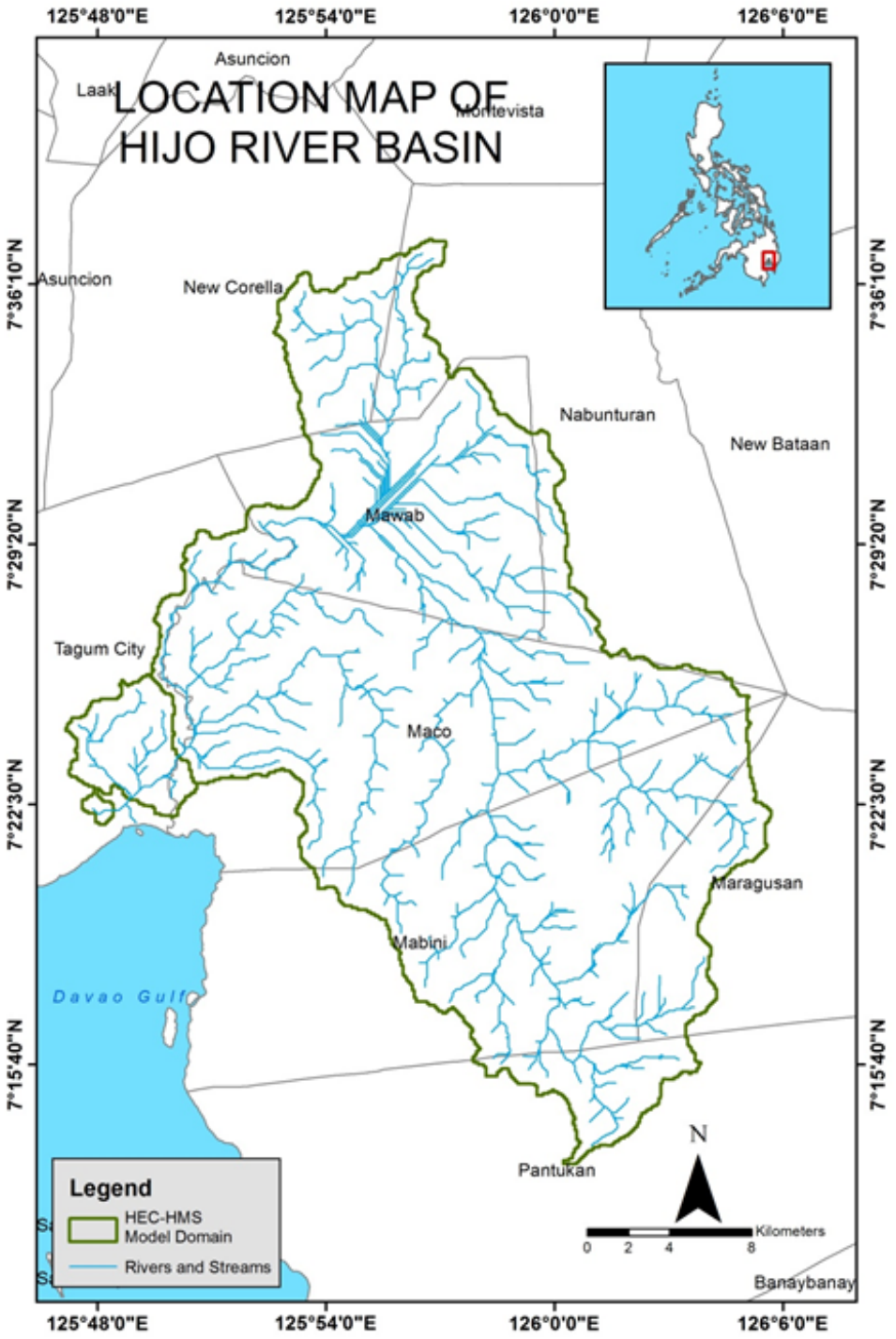
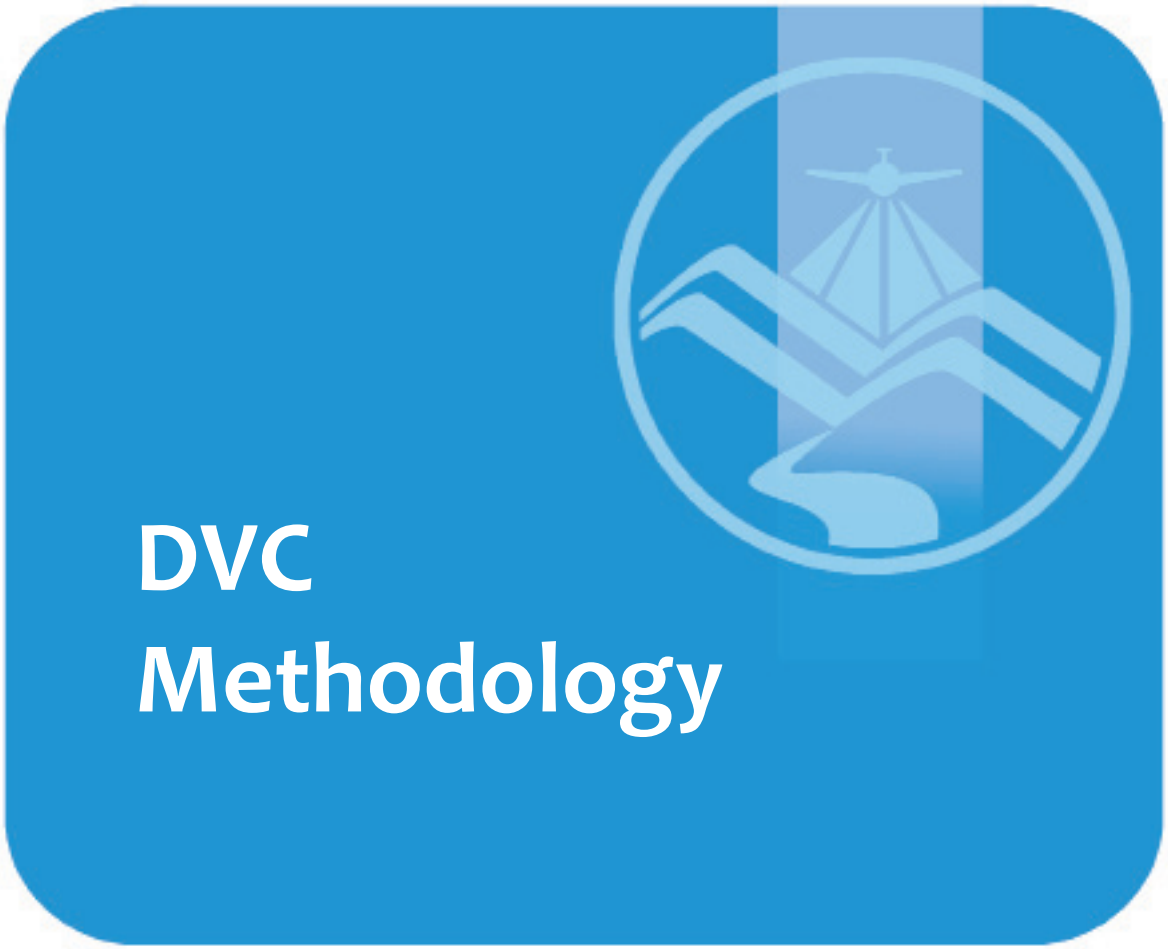


Figure 2. Hijo River Basin Location Map

The Hijo River Basin

Hijo River is a combination of two medium-sized rivers: the Masara River which is located along the Amacan Mountain range and the Tagum River located along the Lingdan Mountain Range. Flowing towards the north-west direction going to the municipality of Mawab, it meanders westward along the National Road and finally, it empties into Davao Gulf located at the southern portion of Brgy. Hijo, Apokon, Tagum City (MD Rio Vista Agri-Ventures, Inc.). It is classified under "Class C" or safe for propagation of fish, recreation, and post-treatment manufacturing processes by DENR (Environmental Management Bureau). Hijo River is used for domestication purposes such as bathing and fishing.

During the early days of January 2014, an estimated number of 3,000 people were affected and were forced to leave their homes due to flooding and landslides in Davao del Norte and Compostela Valley after the nonstop rains caused by a low pressure area affecting Southern Mindanao (News Desk, 2014).



DVC Methodology

DVC Methodology

A set of activities were designed and implemented by DVC with four (4) main activities as shown in Figure 3.

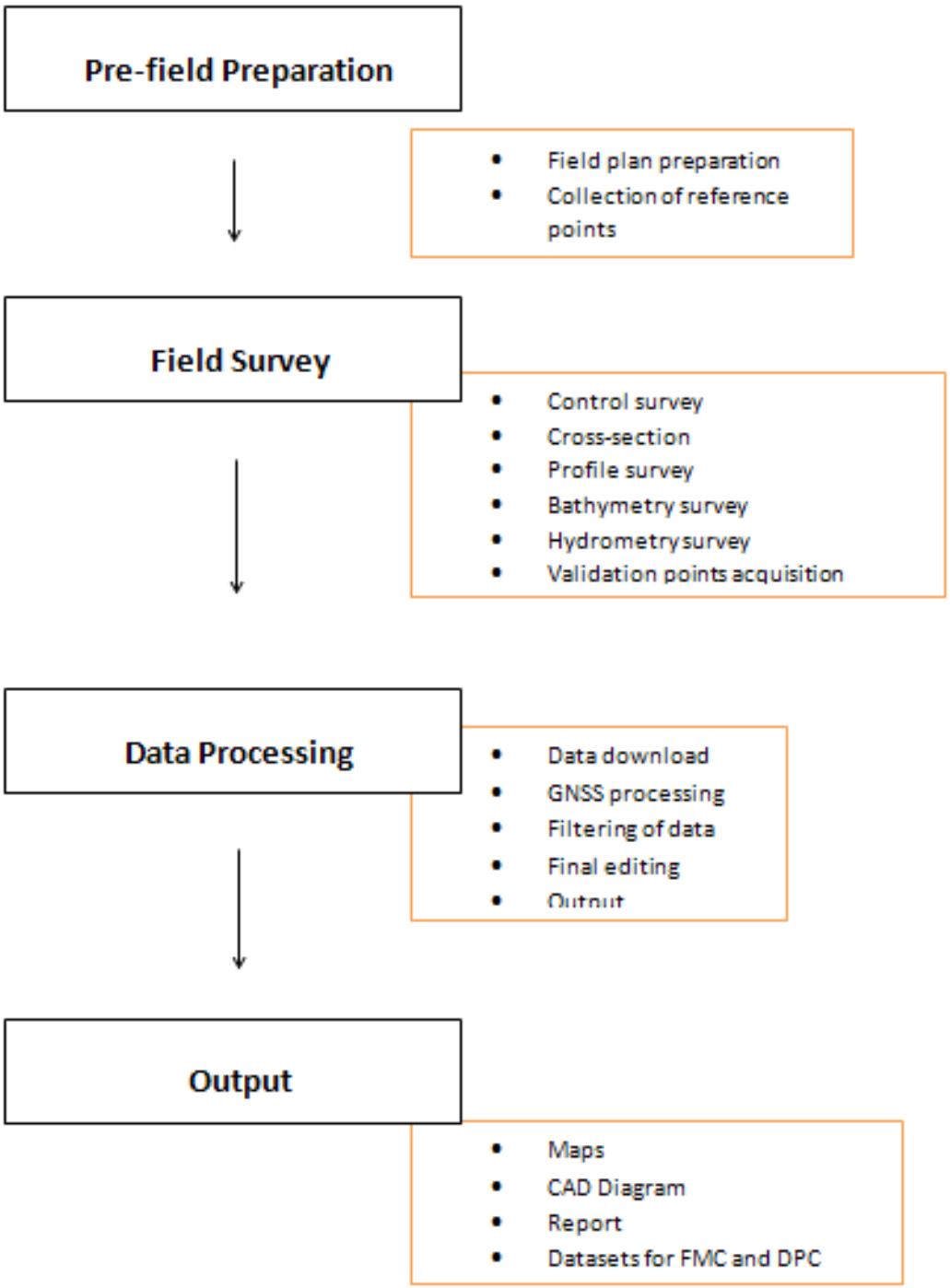


Figure 3. DVC Main Activities

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

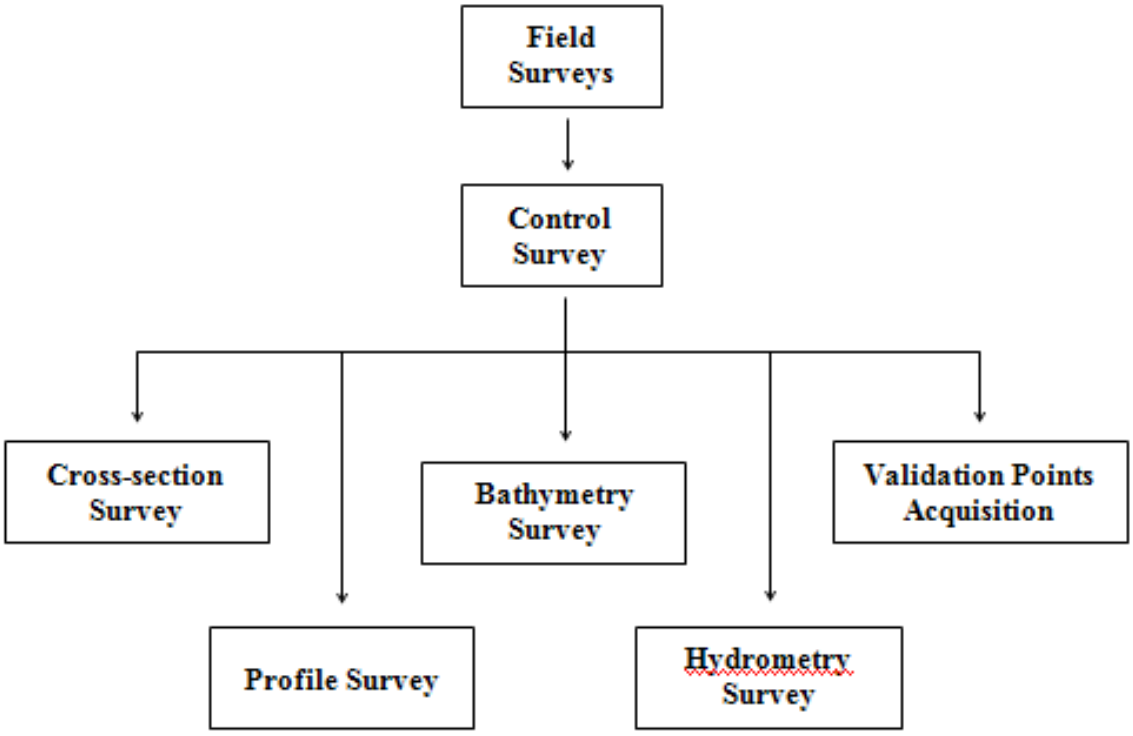


Figure 4. DVC Field Activities

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 5.

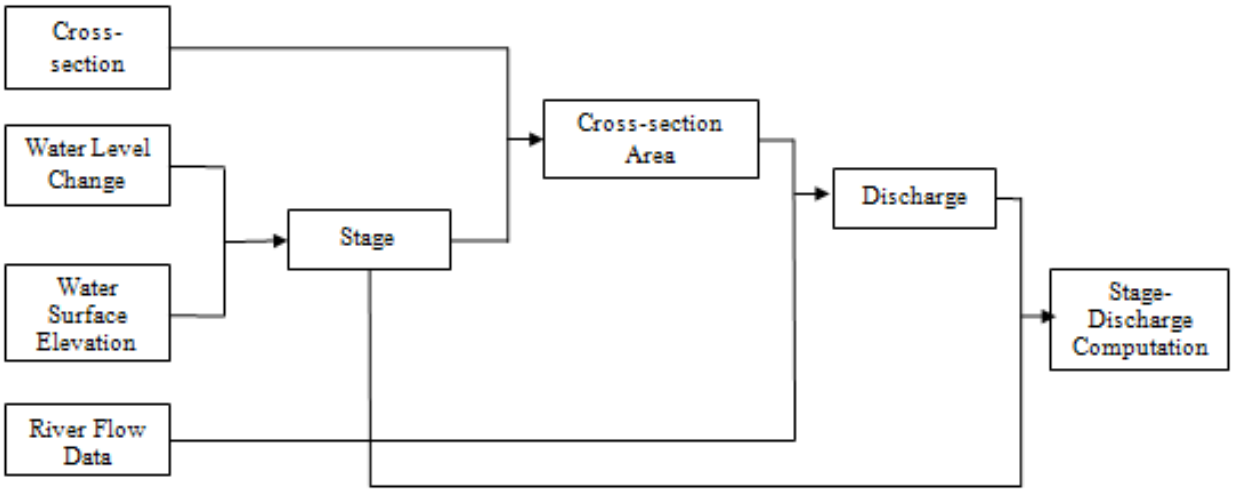


Figure 5. Flow Chart for Stage-Discharge Correlation Computation

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 6.

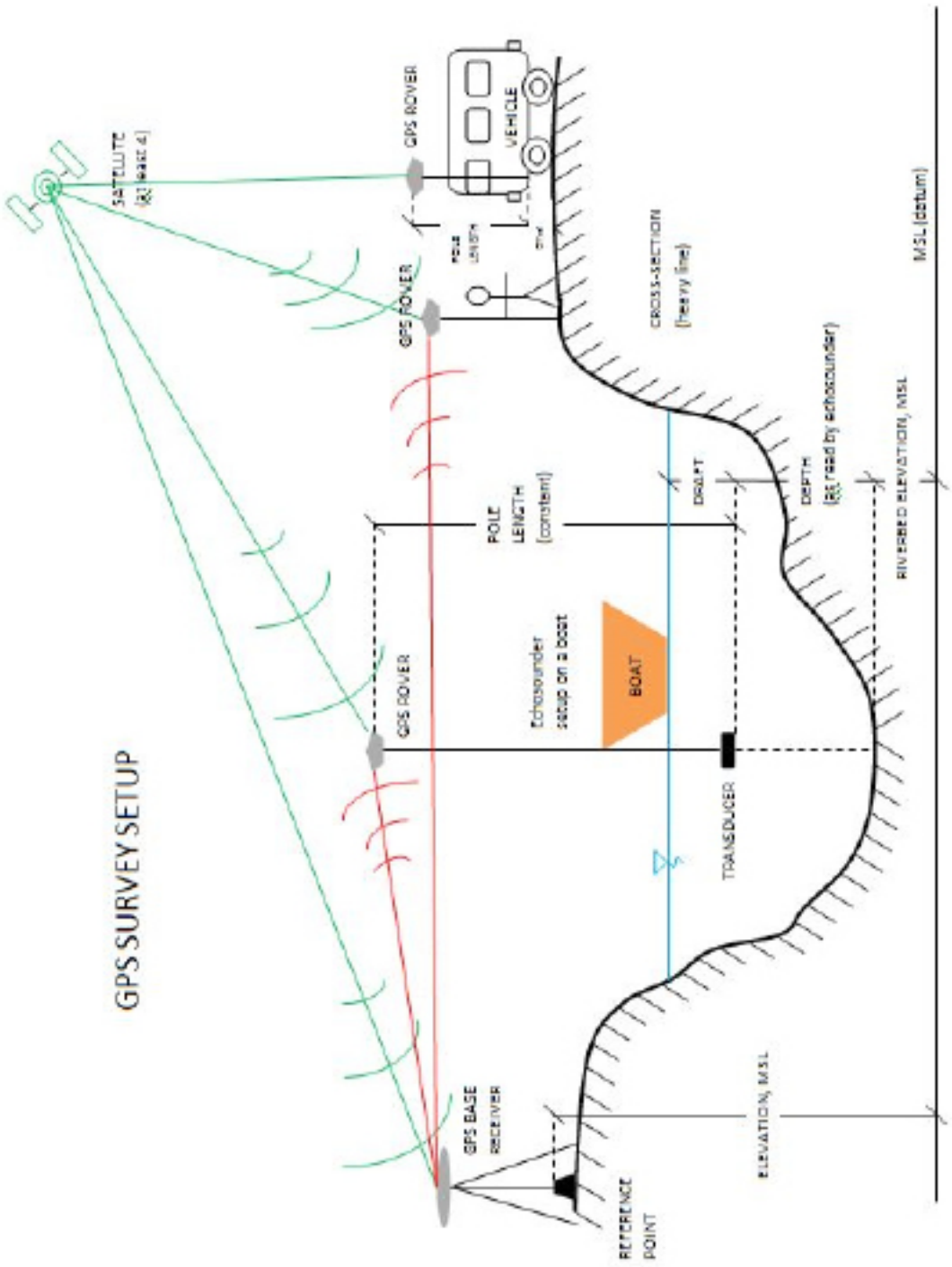


Figure 6. Set-up for GNSS Survey

3.3 Data Processing

Data processing procedures used by DVC are summarized in Figure 7.

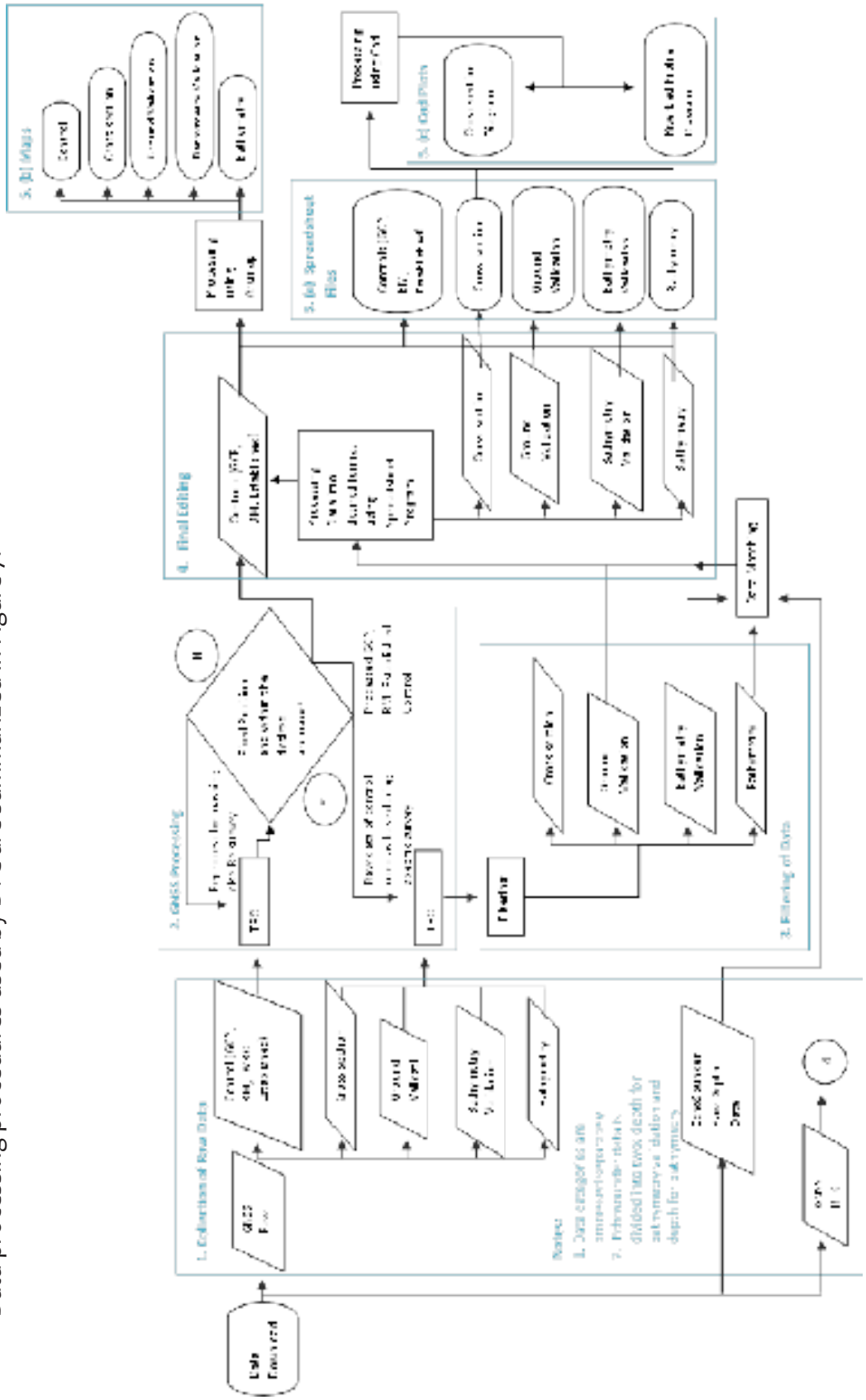


Figure 7. DVC Data Processing Methodology

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

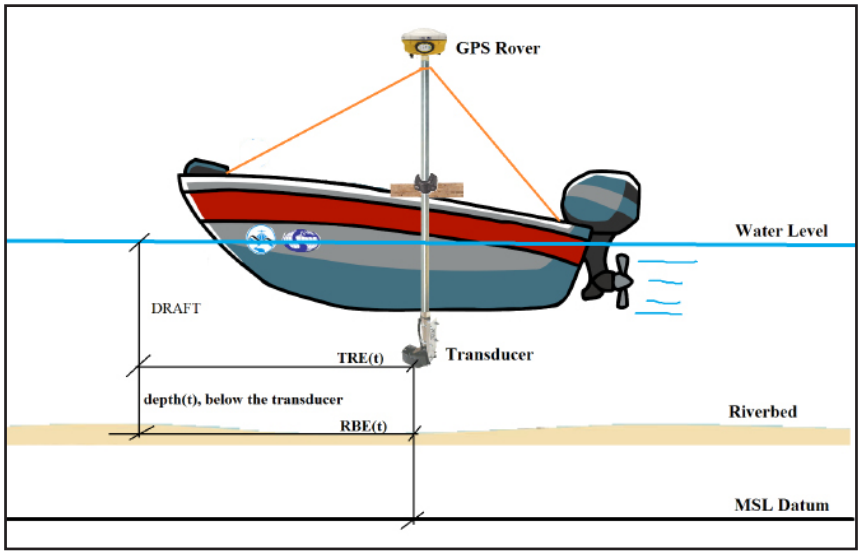


Figure 8. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

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.

DVC Methodology

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.

Hijo River Basin Survey

Hijo River Basin Survey

The survey for Hijo River Basin was conducted on April 23 to May 10, 2013 with the following activities: control, bathymetric and hydrometric surveys, profile and cross-section lines reconnaissance for outsource.

Bathymetric Survey of Hijo River started from the upstream of Brgy. Pandapan, Tagum City down to municipality of Maco, Compostela Valley with a total length of about 16.5 km.

Hijo River consists of 42 delineated cross-section lines with a total length of 40.25 km for both left and right banks starting from Brgy. Pandapan, Tagum City in the upstream down to Brgy. Bucana, Maco near the mouth of the river. The total length of profile lines is about 23-km for its both left and right banks. Ground surveys for both cross-section and profile lines were conducted by LN Realty and Surveying Services on June 14 to July 11, 2013 as described in Annex F.

Another set of fieldwork was conducted on December 6 to 9, 2013 to acquire the cross-section and flow measurement on the bridge with installed Automated Water Level Sensor (AWLS) along Hijo River located in Brgy. Limbo, Maco.

4.1 Control Survey

Three (3) NAMRIA established control points were considered for the static GNSS observations of the three river systems namely: Davao, Hijo and Tagum-Libuganon Rivers. These include a first order benchmark, DV-76 at Guadalupe Bridge, Tagum City; a 1st order reference point, DVS-1, in the Port Area, Sta. Ana Wharf, Davao City and COV-14, a 2nd order reference point in the municipal hall ground of Maco, Compostela Valley. The location of the three (3) base stations are shown in Figure 9 while the GNSS set-up for these controls are shown in Figure 10, Figure 11, Figure 12 and Figure 13.

The reference point, COV-14, served as the GNSS base station for the bathymetry and ground validation survey for aerial LiDAR in Hijo River. It was also used to get the horizontal and vertical coordinates of the established control point, UP-Li, on the approach of the bridge along the Hijo River System as shown in Figure 13. The offset used for referring elevation to MSL was derived from the GNSS Network established for the Hijo River bathymetric, profile, cross-section and hydrometric surveys on April to May 2013.

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.

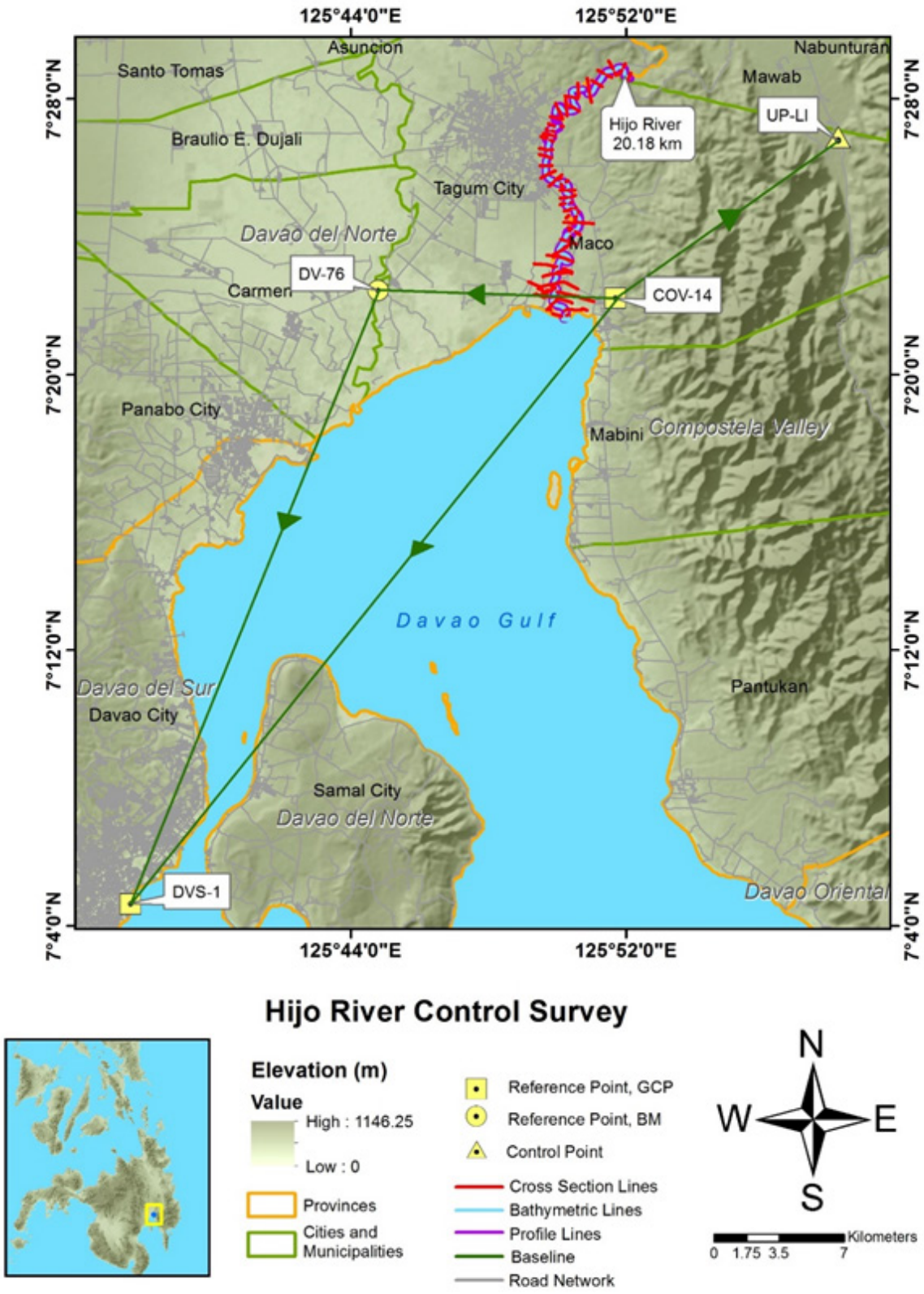


Figure 9. Location of control points

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

Point Name	Order	WGS84 UTM Zone 51N					Elevation in MSL (m)
		Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	
DV-76	1st	7022'26.51282"	125044'48.14113"	75.907	816030.497	803241.596	8.3592
DVS-1	1st	70 04'38.35565"	1250 37'36.76595"	68.456	783116.508	790192.769	0.9742
COV-14	2nd	7022'13.38586"	125051'41.73051"	140.906	815706.706	815937.881	73.2572
UP-Li		7 026'53.03036"	125 0 58'08.85021"	176.413	824382.871	827762.889	108.2712

The GNSS setup for the four (4) control points are illustrated in Figure 10, Figure 11, Figure 12 and Figure 13:

Figure 10. Static observation at DV-76 in Guadalupe Bridge, Tagum City

Figure 11. Static GNSS observation at DVS-1 in Port Area, Sta. Ana Wharf, Davao City

Figure 12. Static GNSS observation at COV-14 in Maco Municipal Hall, Brgy. Poblacion, Maco, Compostela Valley

Figure 13. Static GNSS observation at UP-Li in Brgy. Limbo, Maco

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 by LN Realty and Surveying Services.

Reconnaissance was conducted simultaneously with bathymetric and hydrometric measurements from April 23 to May 8, 2013.

4.2 Reconnaissance of Cross-section and Profile Lines

Ocular inspection of the proposed cross-section and profile lines of Hijo River was the main objective of the team since cross-section and profile surveys were outsourced to LN Realty and Surveying Services.

Each cross-section lines were located using handheld GPS (Garmin Montana™ 650). The summary of reconnaissance for the 42 cross-sections are shown in detail in Annex E. Reconnaissance for profile lines were conducted simultaneously with the bathymetric 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.

4.3 Bathymetric Survey

The entire bathymetry survey took nine (9) days to accomplish from April 29 to May 7, 2013. Hijo River has shallow waters which prohibited the use of rubber boat and echo sounder for the whole length of the river. The bathymetry survey of Hijo River was manually traversed from its upstream in Brgy. Pandapan, Tagum City down to the Municipality of Maco, Compostela Valley as shown in Figure 14. The entire survey covers an approximate length of 16.5 km down to the mouth of the river, exhibited in Figure 15.

Figure 14. Manual Bathymetry team in Hijo River

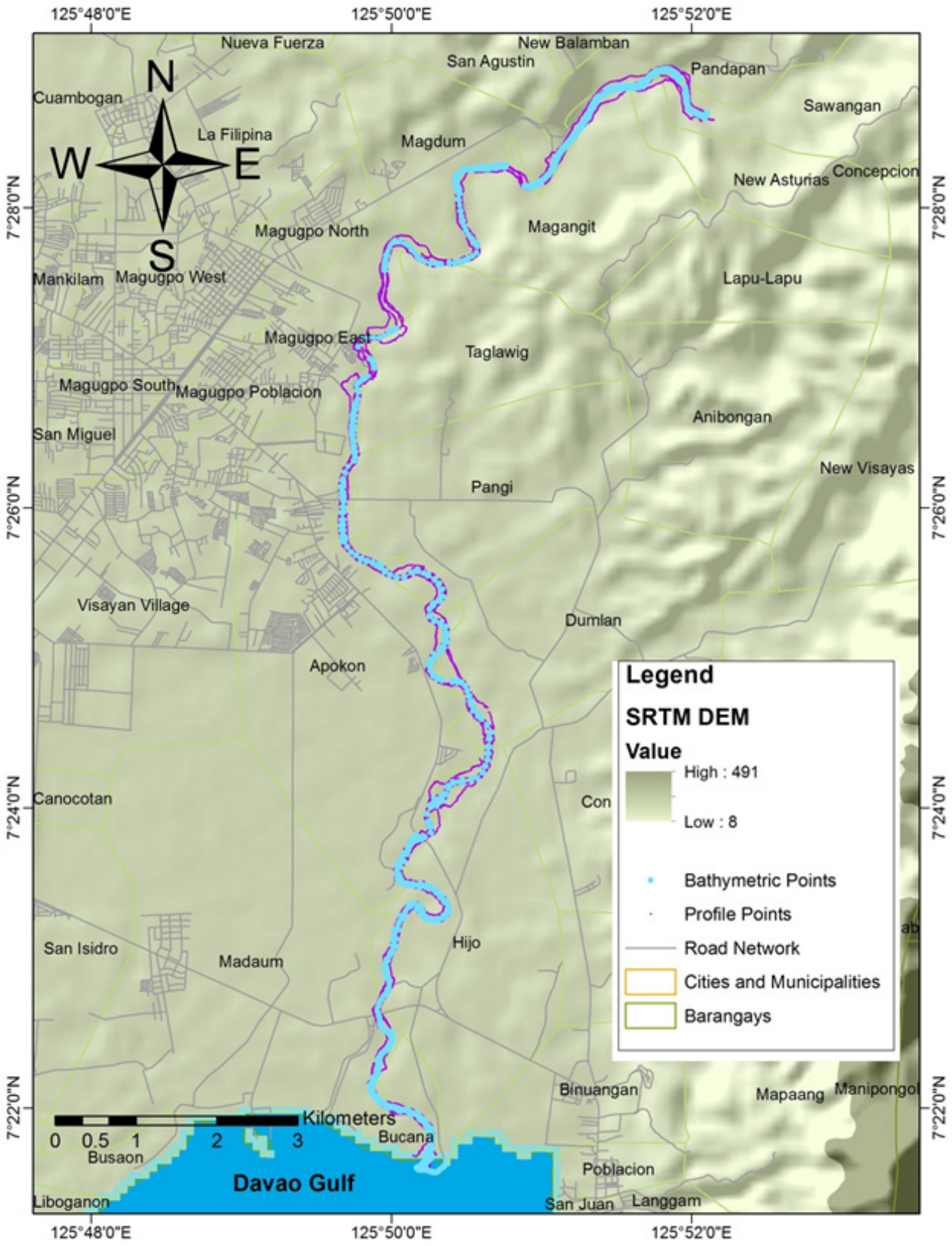


Figure 15. Bathymetric data in Hijo River

4.4 Hydrometric Survey

4.4.1 Hydrometric Sensors Deployment with Stage Discharge Computation

Different sensors were deployed on the banks of Hijo 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.

Deployment of velocity meter and depth gauge in Brgy. Apokon, Tagum City lasted for ten (10) days. Also, a rain gauge was installed near the bridge in Brgy. Apokon as shown in Figure 16. The summary of the location and deployment dates of the sensors used in Hijo are shown in Table 2.

Table 2. Sensor location and deployment dates in Hijo River

Sensor	Location	City / Municipality	Deployment - Start	Deployment - End
Rain Gauge	Brgy. Apokon	Tagum City	April 29, 2013	May 8, 2013
Velocity Meter	Brgy. Apokon	Tagum City	April 29, 2013	May 8, 2013
Depth Gauge	Brgy. Apokon	Tagum City	April 29, 2013	May 8, 2013

The velocity meter and depth gauge at Brgy. Apokon, Tagum City, exhibited in Figure 17, were placed in a crate to ensure its safety from strong river currents. The location of the sensor is shown in Figure 18.

Figure 16. Rain Gauge deployment in Brgy. Apokon, Tagum City

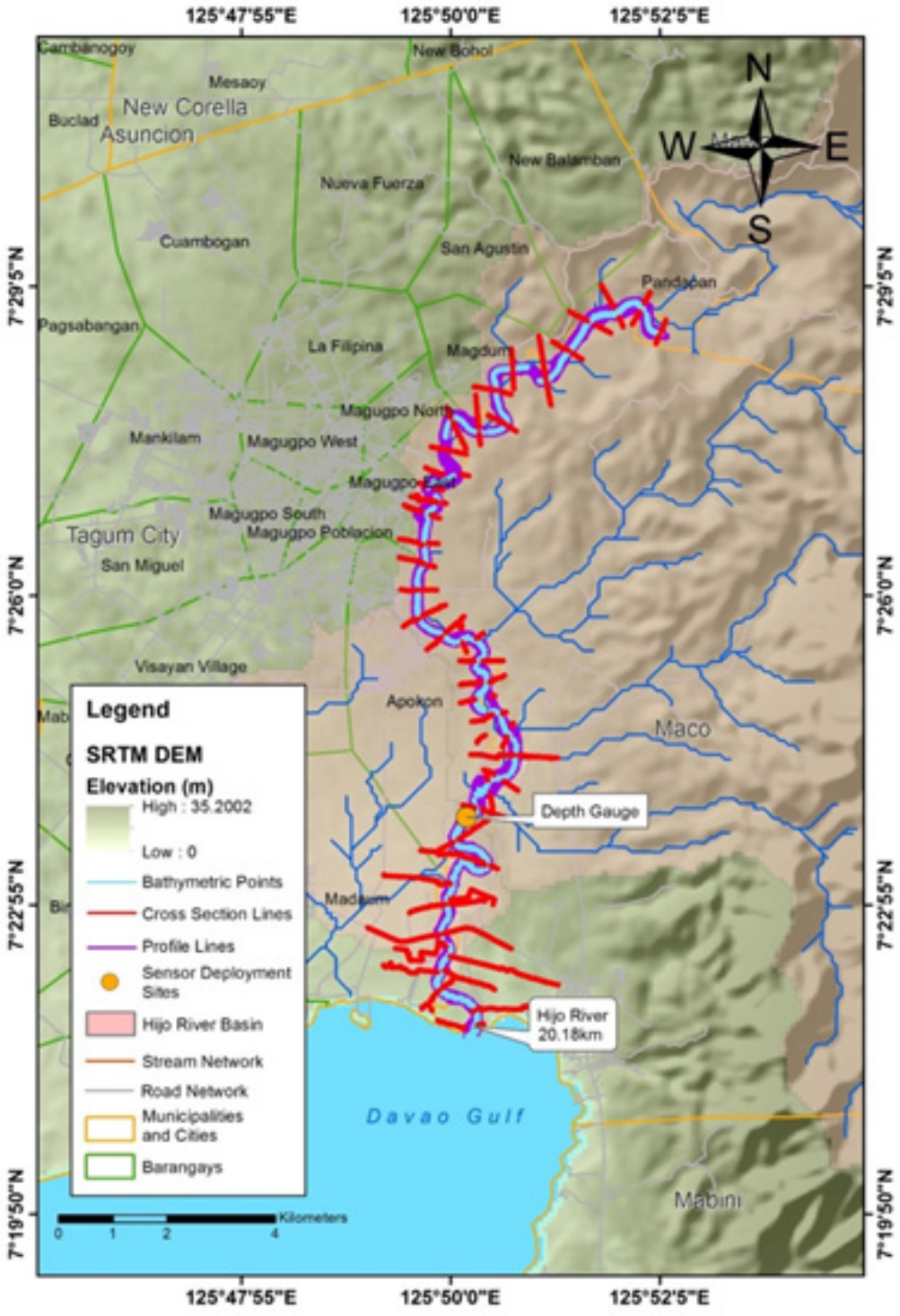


Figure 18. Location of Sensor in Hijo River

The data gathered from the rain gauge shows the distribution of rainfall within the observation period (April 29 to May 5, 2013). The data were recorded every five (5) minutes. The first surge of rainfall, reaching 2.5 mm, was observed 20 minutes after deployment. Rainfall peaked on April 30 at 6 mm. The last observed peak, reaching 2.8 mm, was on May 2 at 7:05 PM. Water level measurements show pronounced variations in the first 3 days that then peaked on the fourth day. Relationships of data gathered within the observation period are illustrated in Figure 19 to Figure 22.

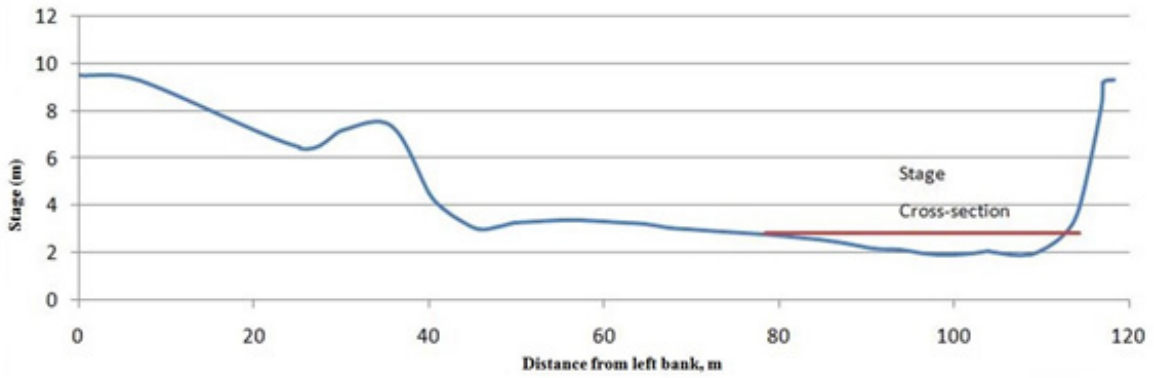


Figure 19. Velocity Meter cross-section survey in Brgy. Apokon, Tagum City

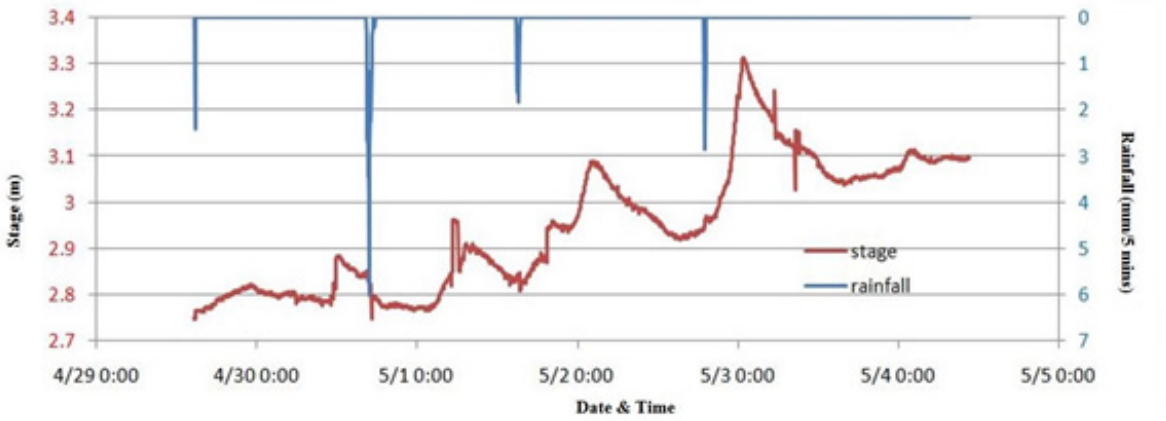


Figure 20. Stage vs rainfall graph for Hijo River within the observation period

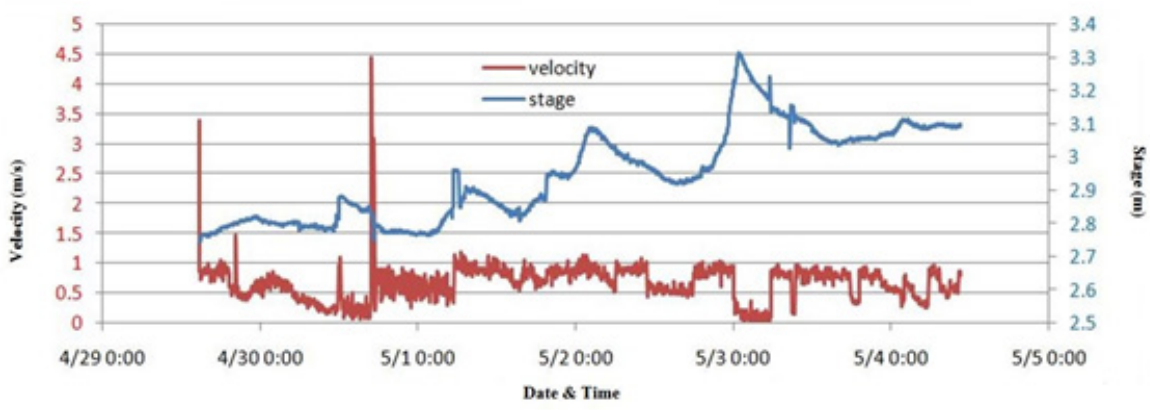


Figure 21. Stage vs velocity graph for Hijo River within the observation period

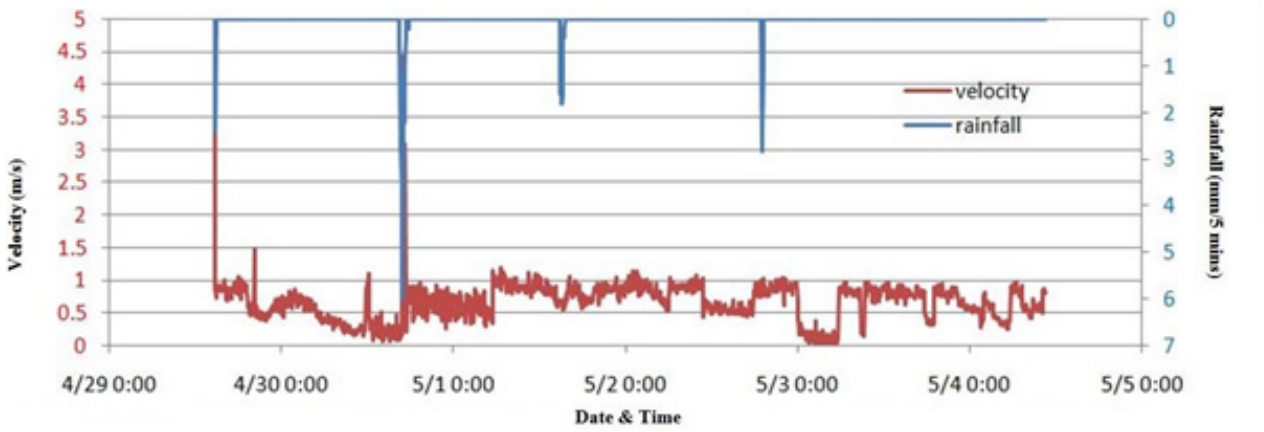


Figure 22. Velocity vs rainfall graph for Hijo River within observation period

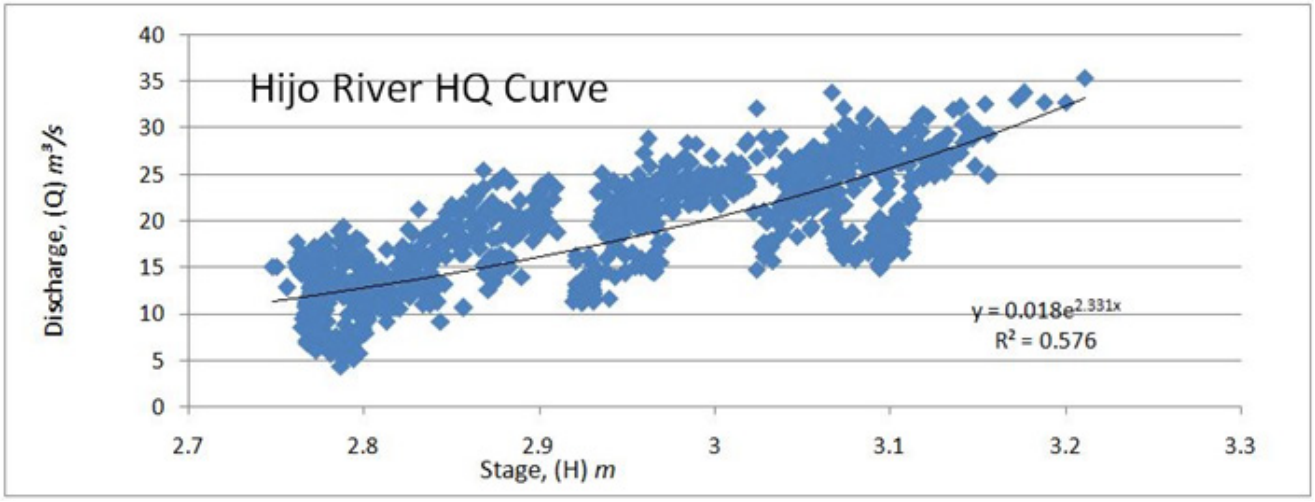


Figure 23. Stage-discharge computation for Brgy. Apokon, Tagum City

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 Figure 23. A value approaching R2 = 1 indicates a good correlation.

4.4.2 Hijo AWLS Survey

Another survey was conducted for the installed AWLS in Brgy. Limbo, Maco, Compostela Valley in order to get its cross-sectional area and water surface elevation in MSL on December 6 to 9, 2013. River velocity was also acquired using a mechanical flow meter.

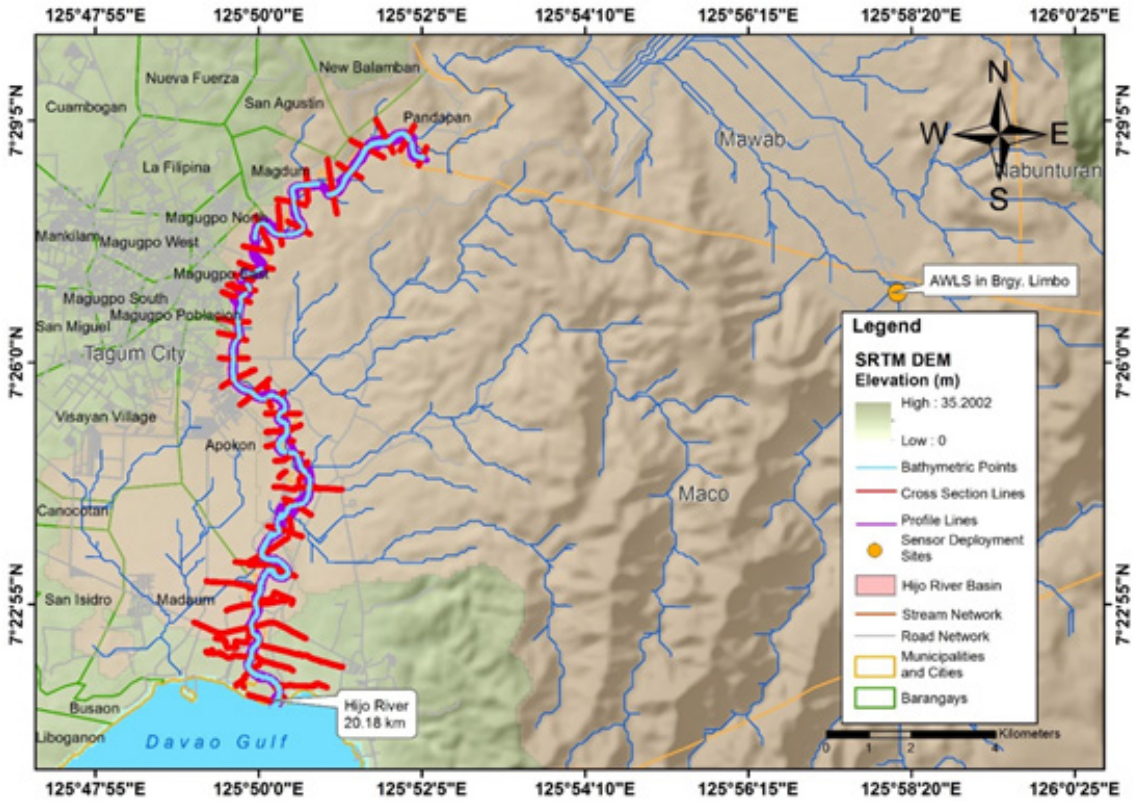


Figure 24. AWLS along Hijo River Network

4.4.2.1 AWLS Cross-section Survey

Cross-section surveys were conducted for the bridges with installed AWLS along the Hijo River System using GNSS PPK survey technique. The elevation of the installed AWLS and the water surface elevation along the banks near the sensor were acquired as well. The summary of data gathered is shown in Table 3.

Table 3. AWLS site in Hijo River System with its respective MSL value

AWLS	Location	Coordinates	AWLS Elevation(m), in MSL	Water Surface Elevation (m), in MSL	Date& Time of Determining the Water Elevation	Image
Brgy. Limbo, Maco	Municipality of Maco	7d26'53.60374" N 125d58'09.40378" E	111.2252	104.35	12/7/2013 03:40 PM	

The diagram of cross-section data gathered for bridges with installed AWLS is illustrated in Figure 25.

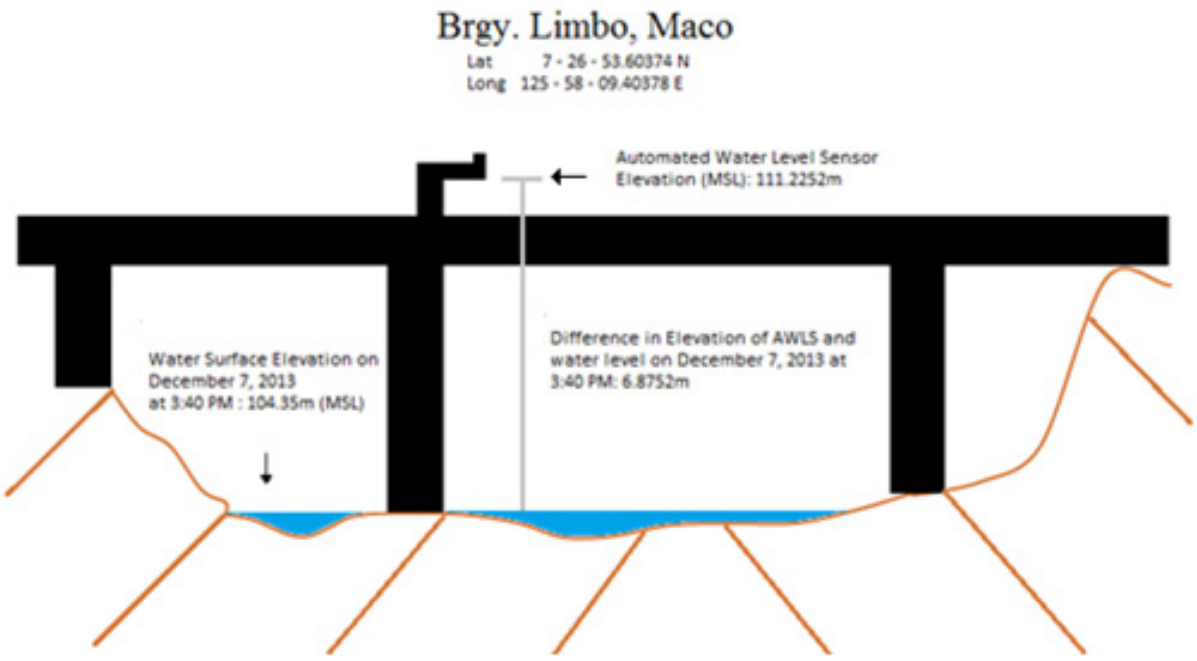


Figure 25. AWLS in Brgy. Limbo, Maco, Compostela Valley

4.4.2.2 Flow Measurements and Stage Discharge Computation in AWLS site of Hijo River

Two (2) local hires living within the vicinity of the bridge were employed to gather flow measurements. Two types of events were recorded by the team – (1) base flow or the normal stream flow, without the influence of a precipitation. In this scenario, local hires were tasked to record the velocity of the river for two hours each in the morning and afternoon for a single day; and (2) the flow of the river during the occurrence of a rain event.

Two rainfall events were needed prior retrieval of the flow meters. In this type of event, the water velocity was recorded for six-hours straight while precipitation was on-going, day and night. Continuous recording of flow measurements were done until two rain events were observed.

River velocity data for Brgy. Limbo, Maco was plotted against rainfall data from an Automatic Rain Gauge (ARG) at the same site. Flow measurements were recorded December 10, 2013 to January 18, 2014 Rainfall peaked on January 4, 2014 where 10.67 mm were recorded from 5:00 to 5:09 PM. A total of 370.71 mm of rainfall were recorded from January 4 to 12, 2014 due to the occurrence of a low pressure area (LPA) over the region.

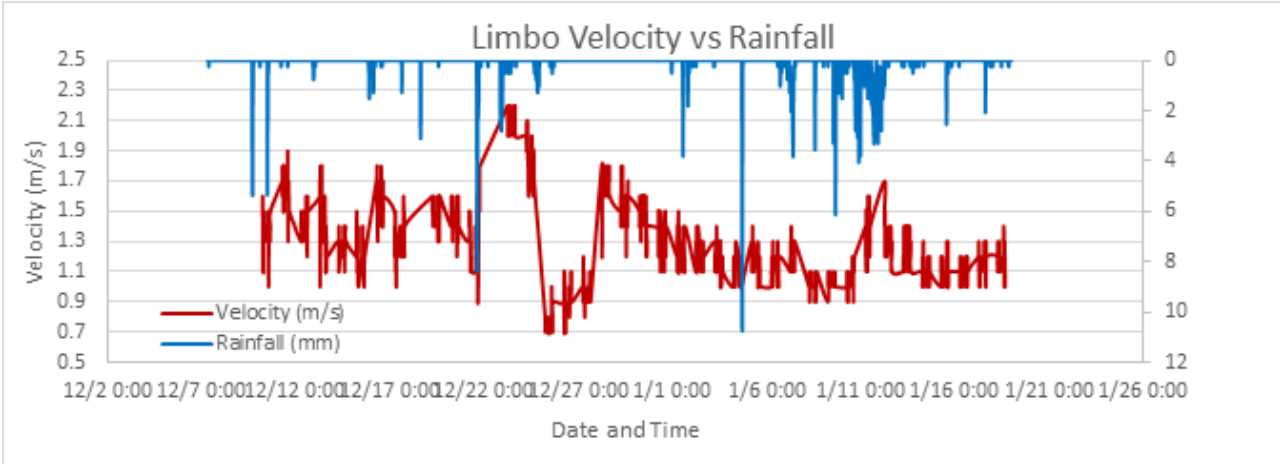


Figure 26. Velocity vs rainfall in Brgy. Limbo, Maco

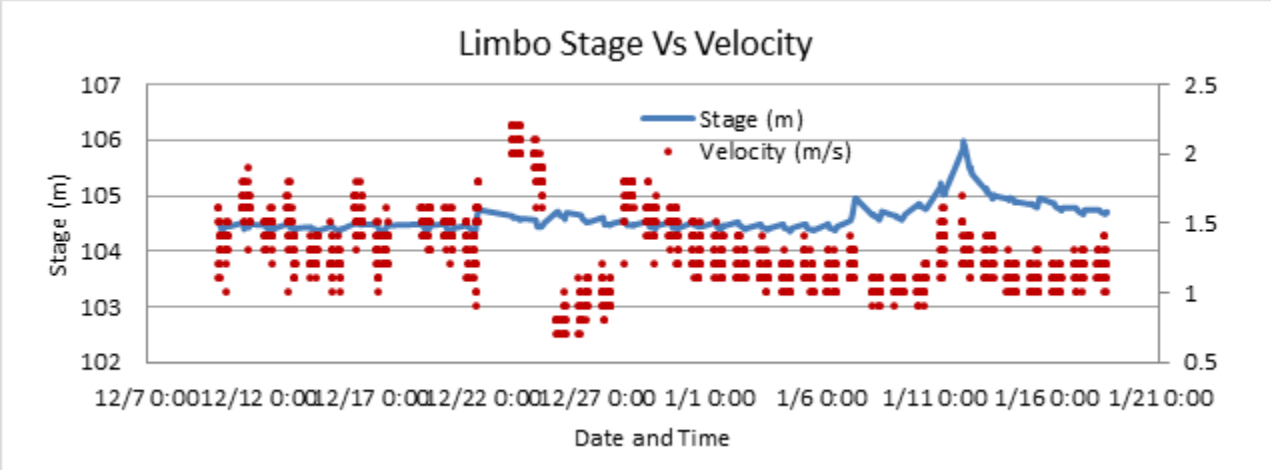


Figure 27. Stage vs velocity in Brgy. Limbo, Maco

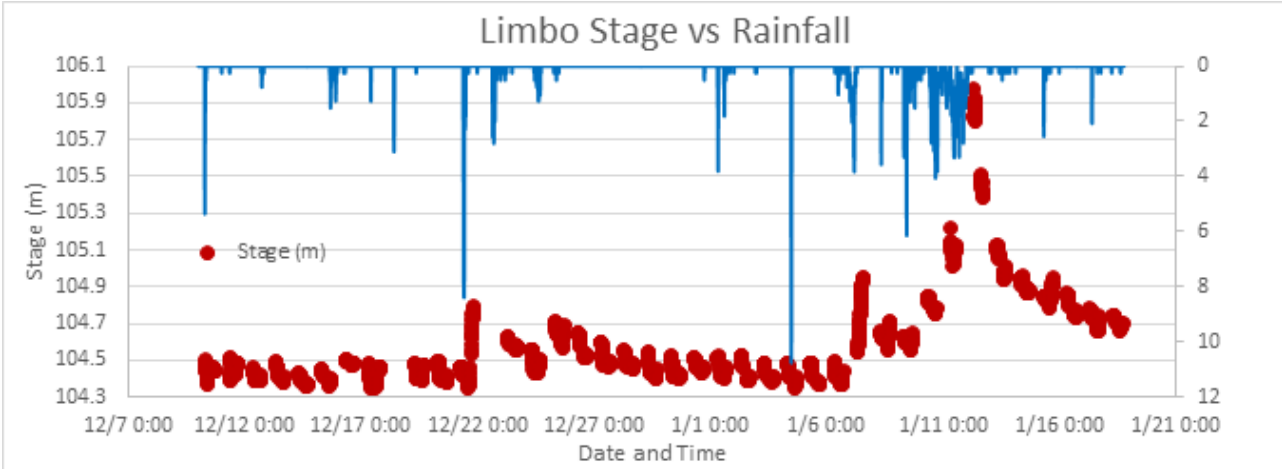


Figure 28. Stage vs rainfall in Brgy. Limbo, Maco

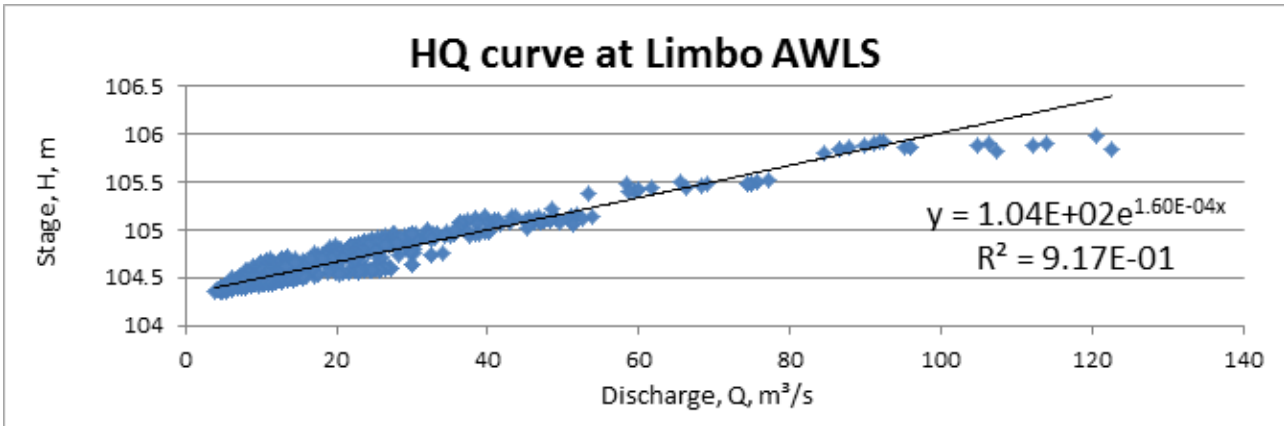


Figure 29. Stage-discharge computation in Brgy. Limbo, Maco

Annexes

Annexes

ANNEX A. PROBLEMS ENCOUNTERED AND RESOLUTIONS APPLIED

Problems Encountered	Remarks	Solutions Applied
Reflected WLMS in Brgy. New Leyte does not exist on site. Locating the sensor was time-consuming	Reflected WLMS in Brgy. New Leyte should be removed from the website, as it was misleading.	The team worked double-time the next day.

Annexes

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

Type	Brand	Serial number	Owner	Quantity
GNSS Receiver (Base)	Trimble SPS852		UP-TCAGP	One (1) unit
External Radio	Trimble		UP-TCAGP	One (1) unit with accesories
GNSS Receiver (Rover)	Trimble SPS882		UP-TCAGP	Six (6) units
GNSS Controller	Trimble TSC3		UP-TCAGP	Three (3) units
Velocity Meter	JFE Advantech		UP- TCAGP	One (1) unit with accessories
Coupler-2B			UP- TCAGP	One (1) unit
Handheld GNSS	Garmin Oregon 650		UP-TCAGP	Four (4) units
	Montana			
Laptops	Dell Latitude E6430ATG		UP-TCAGP	Two (2) units
	DellLatitude E6420		UP-TCAGP	One (1) unit
Depth Gauge	Onset Hoboware		UP-TCAGP	One (1) unit
Rain Gauge	Onset Hoboware		UP-TCAGP	One (1) unit
Singlebeam Echosounder	Ohmex Sonar-mite		UP-TCAGP	One (1) unit with accessories
Range Pole			UP-TCAGP	One (1) unit
Tripod	Trimble		UP-TCAGP	One (1) unit
Bipod	Trimble		UP-TCAGP	Six (6) units
Tribrach	Trimble		UP-TCAGP	One (1) unit
Installers	Hoboware		UP-TCAGP	One (1) unit
	Trimble Business Center		UP-TCAGP	One (1) unit

Annexes

ANNEX C. THE SURVEY TEAM

Data Validation Component Sub-Team	Designation	Name	Agency/Affiliation
Survey Coordinator	Chief Science Research Specialist (CSRS)	Engr. Joemarie S. Caballero	UP TCAGP
Bathymetric Survey/Profile Reconnaissance Team	Senior Science Research Specialist	Engr. Dexter T. Lozano	UP TCAGP
	Research Associate	Engr. JMson J. Calalang	UP TCAGP
Cross Section and Profile Reconnaissance and LiDAR Ground Validation Team	Senior Science Research Specialist	Engr. Bernard Paul Maramot	UP TCAGP
	Senior Science Research Specialist	Engr. Melchor Rey M. Nery	UP TCAGP
	Research Associate	Jojo E. Morillo	UP TCAGP
Sensor Deployment Team	Research Associate	Jeline Amante	UP TCAGP
	Research Associate	Patrizcia Mae P. dela Cruz	UP TCAGP

Annexes

ANNEX D. NAMRIA CERTIFICATION

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

June 11, 2013

CERTIFICATION

To whom it may concern:

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

Province: **DAVAO DEL NORTE**
Station Name: **DV-76**

Island: **Mindanao**	Municipality: **CARMEN**	Barangay: **TUGANAY**
Elevation: **8.3592 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

DV-76 is in the Province of Davao del Norte, City of Carmen, Barangay Tuganay taking the national highway until reaching the Gov. Miranda Bridge. Station is located at the NE abutment of Gov. Miranda at Kilometer Post KM. 1466+881.

Station mark is the head of 4" copper nail set on a drilled hole and cemented flushed on top of a 15x15cm. cement putty with inscriptions "DV-76, 2007 NAMRIA."

Requesting Party: **UP-TCAGP DREAM**
Pupose: **Reference**
OR Number: **3943775B**
T.N.: **2013-0563**

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

9906112013150546

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 26, 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: **DAVAO DEL SUR**
Station Name: **DVS-1**
Order: **1st**

Island: **MINDANAO**
Municipality: **DAVAO CITY**
Barangay: **TOWN PROPER**

PRS92 Coordinates

Latitude: **7° 4' 41.48387"** Longitude: **125° 37' 31.24815"** Ellipsoidal Hgt: **-4.50700 m.**

WGS84 Coordinates

Latitude: **7° 4' 38.36201"** Longitude: **125° 37' 36.77094"** Ellipsoidal Hgt: **68.27510 m.**

PTM Coordinates

Northing: **782663.345 m.** Easting: **569084.935 m.** Zone: **5**

UTM Coordinates

Northing: **783,162.17** Easting: **790,026.11** Zone: **51**

Location Description

DVS-1
From Davao City hall travel southeast along San Pedro street for 400 meters. Upon reaching the "T" intersection of San Pedro street and Quezon boulevard travel for 2.1 kms. up to the cross intersection of roads at Monteverde street, Leon Garcia street and Quezon boulevard. From this intersection turn right to Sta. Ana pier. The station is located on the east side of the new pier; 94 meters Northeast of coast guard house and north of the old pier. Station mark is 0.15 m x 0.01 m in diameter brass rod with cross cut on top, set in a drill hole, centered in a 30 cm x 30 cm cement patty on top of concrete pavement of wharf. Inscribed on top with the station name. All reference marks are 0.15 m x 0.01 m in diameter brass rods with cross cut on top, set in drill holes, centered in cement patty on concrete pavement of wharf. Inscribed on top with the reference mark numbers and arrow pointing to the station.

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3943584 B**
T.N.: **2013-0366**

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

9904262013163513

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

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

April 26, 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: **COMPOSTELA VALLEY**
Station Name: **COV-14**
Order: **2nd**

Island: **MINDANAO**
Municipality: **MACO**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude: **7° 22' 16.56505"** Longitude: **125° 51' 36.23705"** Ellipsoidal Hgt: **68.09600 m.**

WGS84 Coordinates

Latitude: **7° 22' 13.38586"** Longitude: **125° 51' 41.73051"** Ellipsoidal Hgt: **140.90600 m.**

PTM Coordinates

Northing: **815116.743 m.** Easting: **594955.891 m.** Zone: **5**

UTM Coordinates

Northing: **815,751.82** Easting: **815,772.26** Zone: **51**

Location Description

COV-14
"COV-14" is in Barangay Poblacion, Maco, Compostela Valley. TO reach the station travel for about 6 kms. from Tagum CIty towards Maco taking the National Highway until reaching the Municipal Hall Station is located 10m. "SW part of the flagpole. Mark is the head of 4" copper nail embedded in a 0.30 x 0.30 x 1.0 m. concrete monument with the inscription "COV-14 2007 NAMRIA".

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3943584 B**
T.N.: **2013-0365**

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

9904262013163444

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

Xsec Right	Image	Barangay	City or Municipality	Remarks	Comments
1		Pandapan	Tagum City	Traversable	Open area
2		Pandapan	Tagum City	Traversable	High cliff with thick vegetation
3		Pandapan	Tagum City	Traversable	Passes through a community
4		Pandapan	Tagum City	Traversable	Private area, crusher along the line with sudden change of elevation.
5		Pandapan	Tagum City	Traversable	Open area
6		Magdum	Tagum City	Traversable	Passes through a community
7		Magdum	Tagum City	Traversable	Passes through a private property
8		Magdum	Tagum City	Traversable	Coconut trees along the line
9		Magdum	Tagum City	Traversable	Open area

Annexes

10		Magdum	Tagum City	Traversable	Barangay Road passing through some private property
11		Magugpo East	Tagum City	Traversable	Passes through a private property
12		Magugpo East	Tagum City	Traversable	Thick vegetation
13		Magugpo East	Tagum City	Traversable	Thick vegetation
14		Magugpo East	Tagum City	Traversable	Banana Plantation
15		Magugpo East	Tagum City	Traversable	Barangay road
16		Magugpo East	Tagum City	Traversable	Passes through private property
17		Magugpo East	Tagum City	Traversable	Way to hijo riverbanks reforestation
18		Apokon	Tagum City	Traversable	Ends at a Highway
19		Apokon	Tagum City	Traversable	Along the highway

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20		Apokon	Tagum City	Traversable	Passes through a private property
21		Apokon	Tagum City	Traversable	Barangay road
22		Apokon	Tagum City	Traversable	Made alternate route
23		Apokon	Tagum City	Traversable	Banna plantation
24		Apokon	Tagum City	Traversable	Passable full of thick vegetation
25		Apokon	Tagum City	Traversable	Banna Plantation
26		Apokon	Tagum City	Traversable	Durian plantation and Banana plantation
27		Apokon	Tagum City	Traversable	Passes through a Banana Plantation
28		Apokon	Tagum City	Traversable	Passes through a private property
29		Apokon	Tagum City	Traversable	Barangay Road
30		Apokon	Tagum City	Traversable	Passes through a residential houses
31		Apokon	Tagum City	Traversable	Passes through a residential houses
32		Apokon	Tagum City	Traversable	Corn plantation
33		Apokon	Tagum City	Traversable	Residential area

Annexes

34		Apokon	Tagum City	Traversable	Residential area
35		Madaum	Tagum City	Traversable	Banana plantation
36		Madaum	Tagum City	Traversable	Banana plantation
37		Madaum	Tagum City	Traversable	National Road
38		Madaum	Tagum City	Traversable	Banana plantation
39		Madaum	Tagum City	Traversable	Coconut trees and nipa along the line
40		Madaum	Tagum City	Traversable	Coconut trees and nipa along the line
41		Bucana	Tagum City	Traversable	Thick cogon and coconut trees
42		Bucana	Tagum City	Traversable	Nipa along the line

Annexes

Xsec Left	Image	Barangay	City or Municipality	Remarks	Comments
1			Maco	Traversable	Starting in a Cliff with thick vegetation
2			Maco	Traversable	Thick vegetation
3			Maco	Traversable	High cliff & thick vegetation
4			Maco	Traversable	Thick vegetation
5			Maco	Traversable	Thick vegetation
6			Maco	Traversable	Thick vegetation
7			Maco	Traversable	Thick vegetation
8			Maco	Traversable	Thick vegetation
9			Maco	Traversable	Thick vegetation
10			Maco	Traversable	Thick vegetation
11			Maco	Traversable	Passes through private property
12			Maco	Traversable	Passes through private property
13			Maco	Traversable	Passes through private property
14			Maco	Traversable	Thick Vegetation
15			Maco	Traversable	Thick Vegetation
16			Maco	Traversable	Thick Vegetation
17			Maco	Traversable	Thick Vegetation
18			Maco	Traversable	Thick Vegetation
19			Maco	Traversable	Barangay road
20			Maco	Traversable	Banana and coconut plantation

Annexes

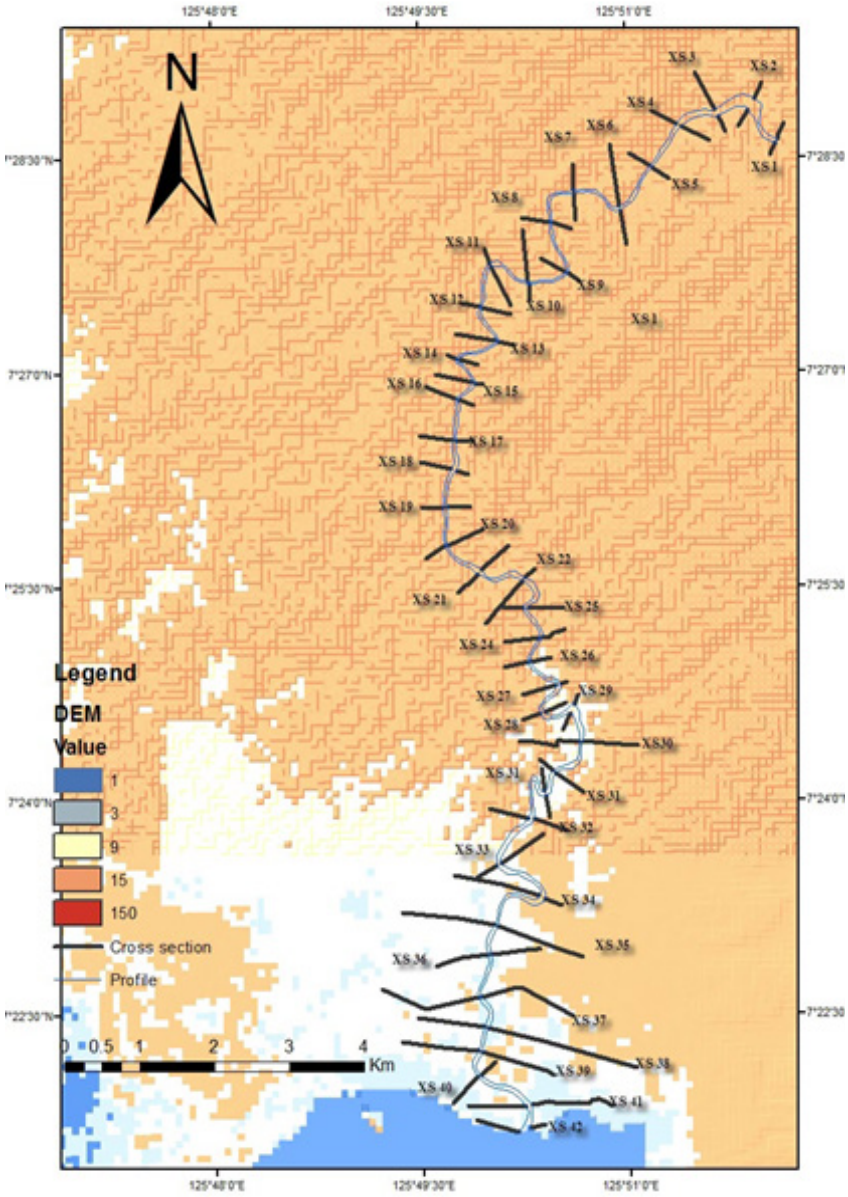
Xsec Left	Image	Barangay	City or Municipality	Remarks	Comments
1			Maco	Traversable	Starting in a Cliff with thick vegetation
2			Maco	Traversable	Thick vegetation
3			Maco	Traversable	High cliff & thick vegetation
4			Maco	Traversable	Thick vegetation
5			Maco	Traversable	Thick vegetation
6			Maco	Traversable	Thick vegetation
7			Maco	Traversable	Thick vegetation
8			Maco	Traversable	Thick vegetation
9			Maco	Traversable	Thick vegetation
10			Maco	Traversable	Thick vegetation
11			Maco	Traversable	Passes through private property
12			Maco	Traversable	Passes through private property
13			Maco	Traversable	Passes through private property
14			Maco	Traversable	Thick Vegetation
15			Maco	Traversable	Thick Vegetation
16			Maco	Traversable	Thick Vegetation
17			Maco	Traversable	Thick Vegetation
18			Maco	Traversable	Thick Vegetation
19			Maco	Traversable	Barangay road
20			Maco	Traversable	Banana and coconut plantation

21			Maco	Traversable	Banana and coconut plantation
22			Maco	Traversable	Banana and coconut plantation
23			Maco	Traversable	Banana and coconut plantation
24			Maco	Traversable	Banana and coconut plantation
25			Maco	Traversable	Open area
26			Maco	Traversable	Banana and coconut plantation
27			Maco	Traversable	Banana and coconut plantation
28			Maco	Traversable	Open area
29			Maco	Traversable	Banana plantation
30			Maco	Traversable	Banana plantation
31			Maco	Traversable	Banana plantation
32			Maco	Traversable	Banana plantation
33			Maco	Traversable	Banana plantation
34			Maco	Traversable	Banana plantation
35			Maco	Traversable	Banana plantation
36			Maco	Traversable	Banana plantation
37			Maco	Traversable	Banana plantation
38			Maco	Traversable	Thick vegetation
39			Maco	Traversable	Passes through a private property
40			Maco	Traversable	
41			Maco	Traversable	Passes through residential areas
42			Maco	Traversable	Barangay road

ANNEX F. OUTSOURCE CROSS-SECTION AND PROFILE

PROFILE AND CROSS SECTION SURVEYS IN HIJO RIVER, DAVAO DEL NORTE

DREAM
Disaster Risk and Exposure Assessment for Mitigation



Prepared by:

LN Realty and Surveying Services
Ram City Homes cor. Employees Village Road,
Libertad, Butuan City

Survey Period: June 14 – July 11, 2013

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Annexes

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DREAM	Disaster Risk and Exposure Assessment for Mitigation
DOST	Department of Science and Technology
LiDAR	Light Detection and Ranging
GE	Geodetic Engineer
DVC	Data Validation Component, DREAM Program
NAMRIA	National Mapping and Resource Information Agency
BM	Bench Mark
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
RTK	Real Time Kinematic

Introduction

Annexes

1.1 Background

- LN Realty and Surveying Services is a contracting agency from Butuan City, Agusan del Norte that is engage in Real Estate Sales and Surveying Services since year 2000 to fulfill the flourishing demand in Land Surveying in the region and in the entire Philippines. It has completed various projects from different government agencies such as National Irrigation Administration (NIA), Department of Agrarian Reform (DAR), National Housing Authority (NHA), and Department of Environment and Natural Resources (DENR) Region XIII, Region VI and Region VIII.

- The University of the Philippines-Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) is conducting a "Nationwide Disaster Risk Exposure and Assessment for Mitigation" (DREAM) research program which aims to acquire elevation and resource data set at sufficient resolution using Light Detection and Range (LiDAR) technology to produce information necessary to support the different phases of disaster management. In order to validate the accuracy of the gathered LiDAR data, ground validation surveys such as cross-section and profile survey, is needed.

- Hijo River is located in Tagum City, Davao del Norte and has a drainage area of 700 sq. km. The upper basin of Hijo river, including the Masara River, Balite Creek, Lingdan River, Calmah Creek, Magdaum Creek and many smaller rivers and streams, in the mountains of southeastern Mindanao. The Hijo River eventually flows south into Davao gulf. The flow of water is relatively stable throughout the year because of the even distribution of the precipitation.

- LN Realty and Surveying Services is tasked by University of the Philippines-Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) to conduct cross-section and profile survey on Hijo River.

1.2 Scope of Work

The scope of work includes the execution of the following activities:

1.2.1 Scope 1: Reconnaissance for Profile and Cross-Section Surveys

1.2.2 Scope 2: Recovery of NAMRIA Control Points and Observation of Established Control Points

1.2.3 Scope 3: Profile Survey of River. Survey of the approximately 23-km longitudinal profile along the banks of Hijo River from Barangay Pandapan downstream to Barangay Madaum for the left bank and Barangay New Astorias downstream to Barangay Bucana for the right bank. The right bank is part of Tagum City while the left bank is in the Municipality of Maco, Compostella valley.

1.2.4 Scope 4: Cross-section Survey. GPS survey on the 42 cross-sectional lines along Hijo River.

1.2.5 Scope 5: Data Processing. This includes processing and adjustments of GNSS data and computations, corrections and plotting of surveyed cross-section and profile survey.

1.3. Professional Staffing and Implementation.

The team tasked to carry out the survey is composed of survey personnel of LN Realty and Surveying Services. A licensed Geodetic Engineer acted as the project component leader. Another geodetic engineer acted as the project chief who supervises the entire survey. Five more members were assigned to conduct cross-section and profile surveys. Below is a picture of the members of the survey team.

Figure 30. Pictures of the members of the survey team

Prior to the actual fieldwork, the survey team conducted a reconnaissance in the area. Reconnaissance was conducted on the 14th day June 2013, and the actual survey was from June 15 to July 11, 2013

Annexes

Field Survey Methodology

Annexes

For the survey project to be accomplished, a step-by-step guide was followed.

2.1 Field Plan

Before the actual field survey, a field plan was prepared by the team. This field plan served as a guide in the implementation of the survey project. The items listed below were the tasks considered in the preparation of a field plan.

2.1.1. Scheduling of Activities
2.1.2. Assignment of each member of the survey team in the implementation of the survey project
2.1.3. Enumeration of the instruments and equipments to be used in the survey project.
2.1.4. Processing of the data gathered.
2.1.5. Preparation of the reports to be submitted to UP-TCAGP.

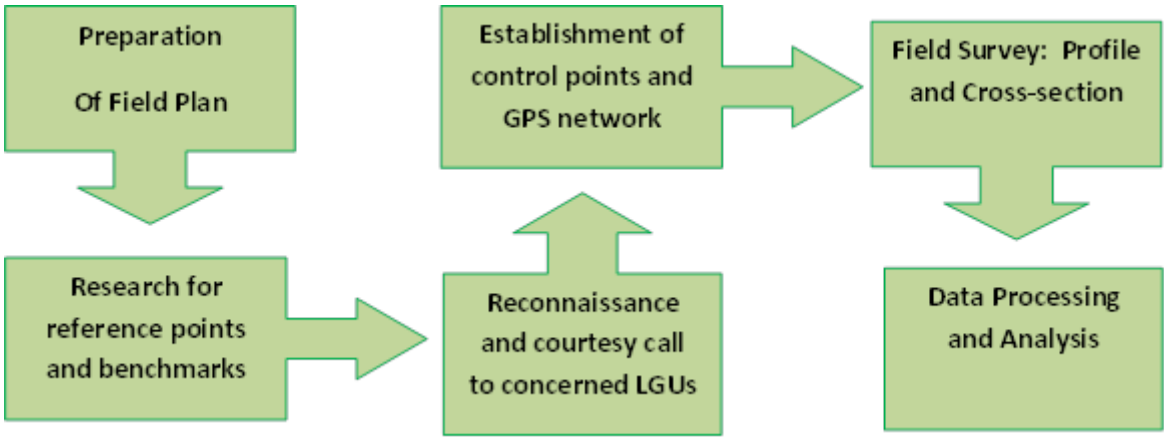

Figure 31. Flowchart of the field survey

2.2 Recovery of NAMRIA Control Points and Observations of Establish

Reference points and benchmarks within the vicinity of the project, relevant in the conduct of the survey were researched. Technical data, locations, descriptions and certifications of these ground control points were sought in the NAMRIA head office, as for these are important in the conduct of GPS survey.

2.3 Reconnaissance

The team conducted a reconnaissance for the cross-section and profile survey. The proposed cross-section and profile data of Hijo River provided by UP-TCAGP were inspected on the ground. Possible routes for the cross section lines and the bank profiles were inspected. The team also searched for previously established benchmarks within proximity of the river which can be used as a reference point for the GPS observation of the newly established control points and establishment of base stations in the GPS survey.

2.4 Establishment of control points and GNSS network

For the survey team to get accurate and precise measurements in the GPS surveying, a static GPS observation was performed. This is needed to derive baselines and provide reference control to be used in the profile and cross-section survey along Hijo River. Base stations were set up in five control points; three reference points, a benchmark and a control points established primarily for this fieldwork (See Figures 32 to 36) namely COV-14 which is located at brgy Poblacion Municipality of Maco, DVA-12 located at Brgy Poblacion Tagum City, DVA-16 located at brgy. Poblacion Carmen City, DV-75 located at brgy Guadalupe Carmen City, and LN-2013 located at Hijo Bride Tagum City. Static observations were simultaneously performed at these three base stations for an hour and a half. The base stations for static observations were as follows:

Figure 32. Static GPS observation in COV-14 in front of Maco Municipal Hall

Figure 33. Static GPS observation in DVA-12 at the center island in front of CENRO office

Figure 34. Static GPS observation in DVA-16 in front of Carmen District Hospital

Figure 35. Static GPS observation in DV-75 which is 100 m away from KM 1468 post along the national highway at Barangay Guadalupe, City of Carmen

Figure 36. Static observation in LN 2013 at Hijo bridge

Annexes

2.5 Ground Survey

2.5.1 Profile Survey

The survey team then proceeded to conduct the profile survey along Hijo River. The left and right banks were measured separately. And the left and right bank were further divided into upper left bank, lower left bank and upper right bank and lower right bank.

The profile team is composed of five persons: one member stayed and observed on the base station while the other four members formed two profile teams with two members each team. In every team, one person held the antenna while the other holds the GPS receiver that receives the GPS signal and RTK radio correction signals for RTK surveying. Each team is deployed on each side of the river bank using a pump boat. For the right bank, the profile started upstream at barangay Pandapan and ended downstream at barangay Madaum. For the left bank, profile survey started from Barangay New Astorias down to Barangay Bucana. A distance of 10 meters is observed between successive profile points. Profiles for the upper left bank, upper right bank, lower left bank and lower right bank were gathered during the survey.

Figure 37. Profile team member walking in a knee deep muddy portion of Hijo River

Figure 38. Profile team recording a reading during the profile survey of Hijo River

2.5.2 Cross-Section Survey

Another set of ground survey was conducted along Hijo River. Cross-sections were surveyed perpendicular to the riverbanks of Hijo River. Just like in profile surveys, the cross-section survey is also composed of two cross-section teams where one person mans the base station set up at a known location. Each cross-section team, using a handheld GPS to locate planned lines, started from the pre-determined starting point and from there, an approximate of 10 meter interval is measured and recorded in the GPS controller..

The antenna used by every cross-section team is connected to a pole so that the reception for radio signals emitted by the RTK base station will be good. In areas, where the proposed cross section line cannot be followed due to some obstructions, either alternative routes were sought that runs parallel to such cross section line or the survey team proceeded to another point of the cross-section line.

Figure 39. Cross-section team conducting a cross-section survey

Figure 40. Cross-section team conducting a cross-section survey

2.6 Data Processing

2.6.1 Cross-section Data

Processing of the cross-section data are as follows:

1. At the end of every field survey, data gathered from GPS receivers were downloaded and pre-processed using Trimble Business Center . The GPS receiver is set first to download from its library.
2. The data from the library is then downloaded to the computer thru a copy paste process.
3. That .lib files are converted to comma delimited (.csv) file format with the following columns: Pt_Name, Longitude, Ellipsoidal Height, Northing, Easting and Elevation.
4. The data is then plotted to AutoCad to remove and clean unwanted data.

The series of figures below shows the variation in the elevation of the cross-sections in Hijo River Flood plain. The cross-sections are plotted from the left to right facing downstream

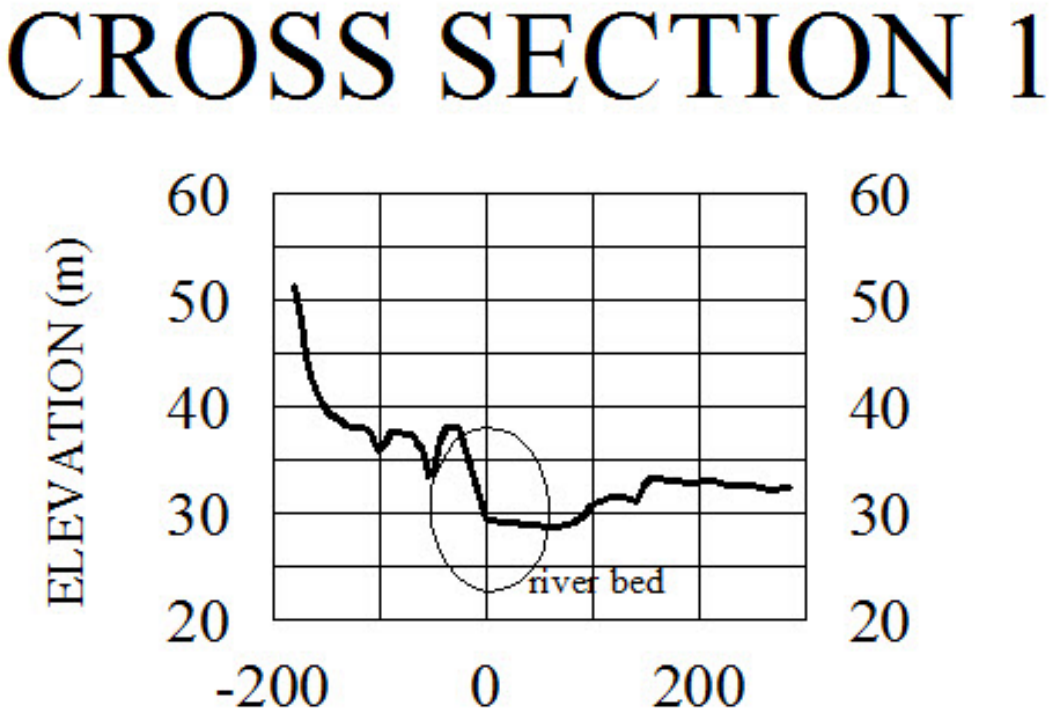

Figure 41. Cross section 1 of Hijo survey area

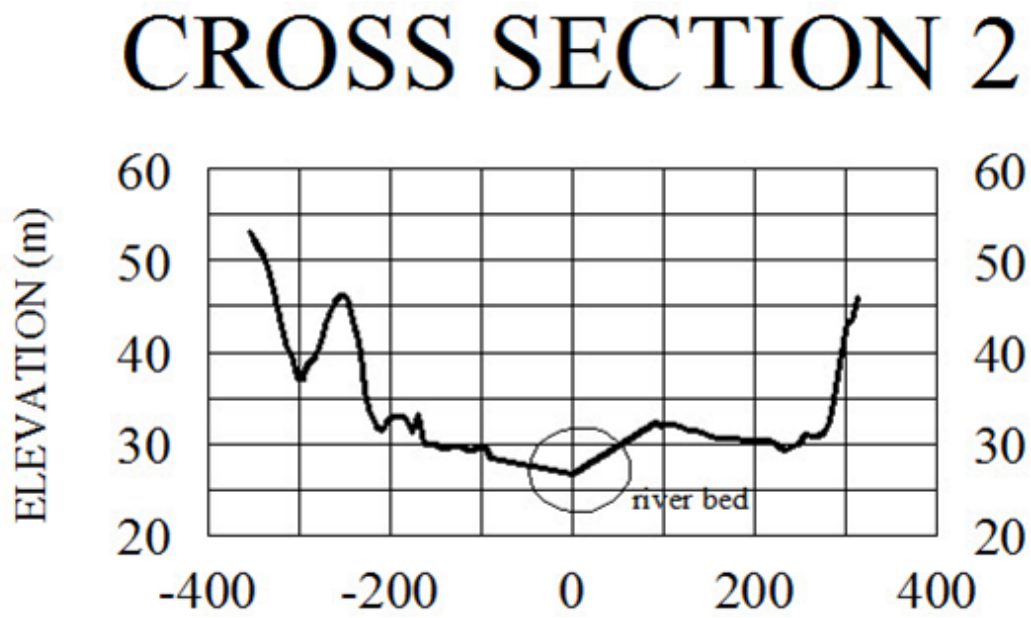

Figure 42. Cross section 2 of Hijo survey area

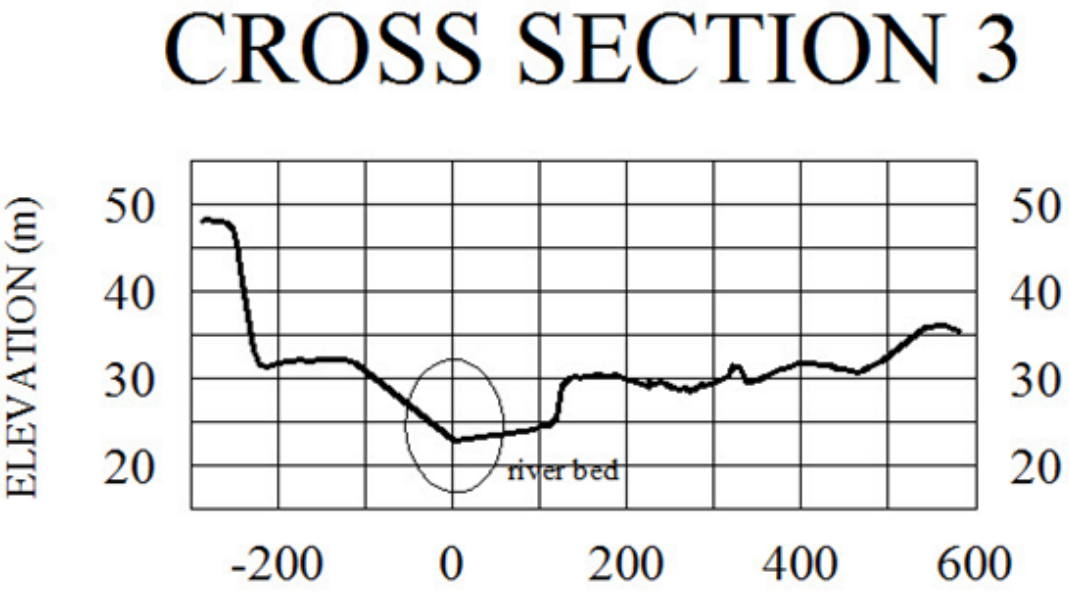

Figure 43. Cross section 3 of Hijo survey area

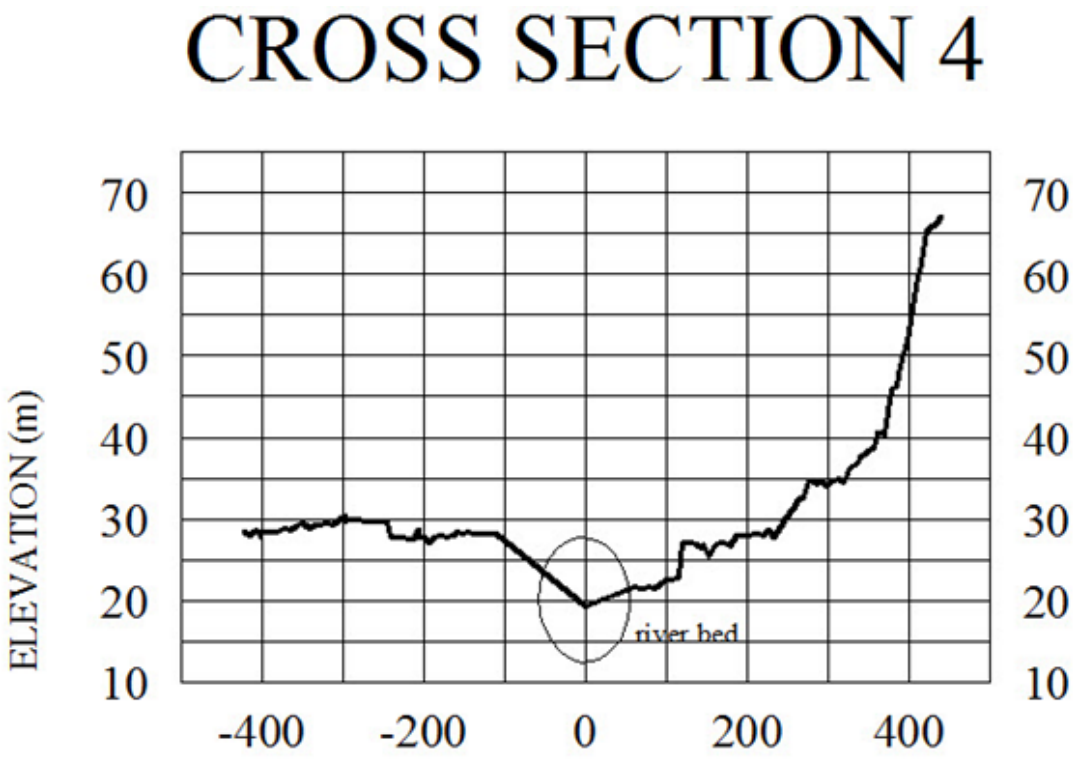

Figure 44. Cross section 4 of Hijo survey area

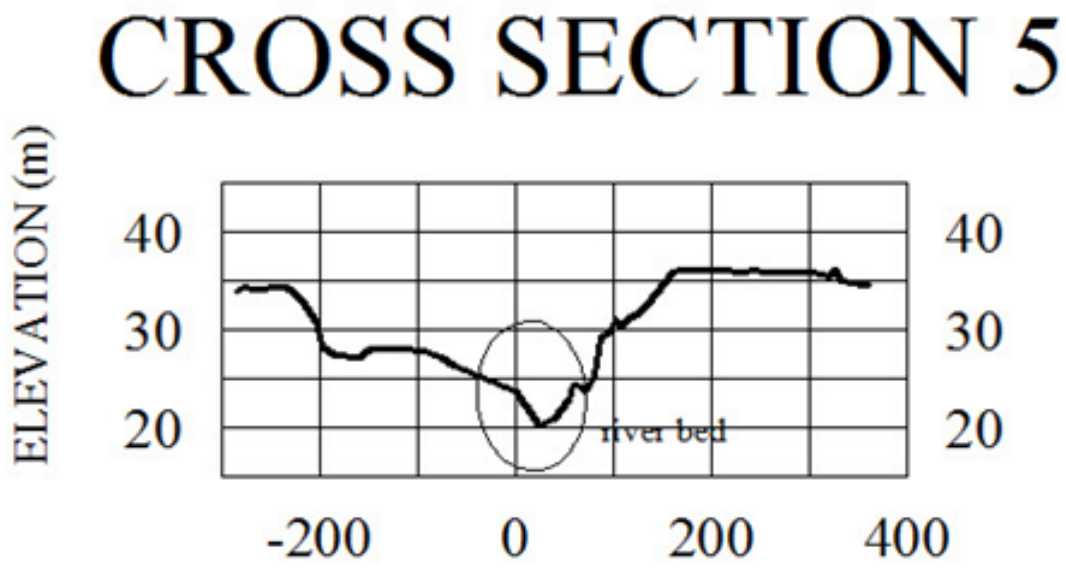

Figure 45. Cross section 5 of Hijo survey area

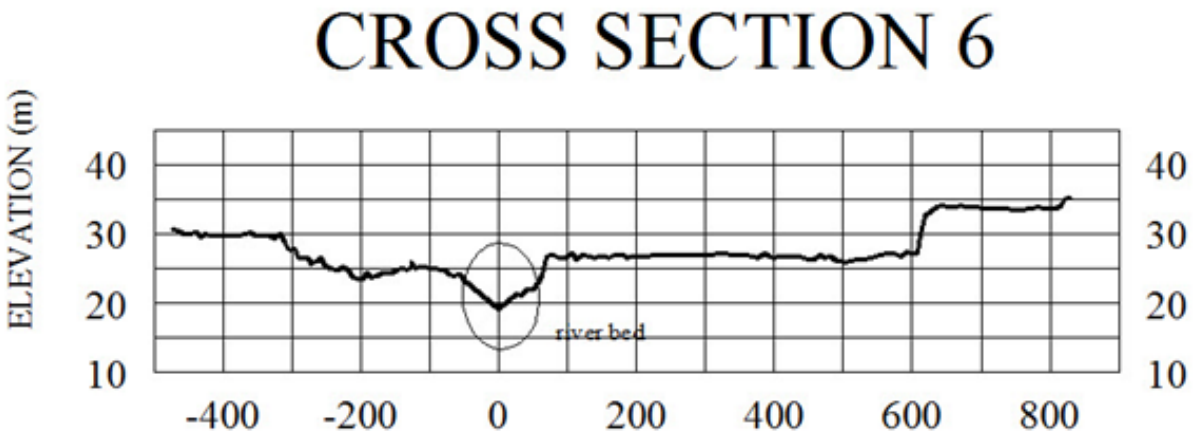

Figure 46. Cross section 6 of Hijo survey area

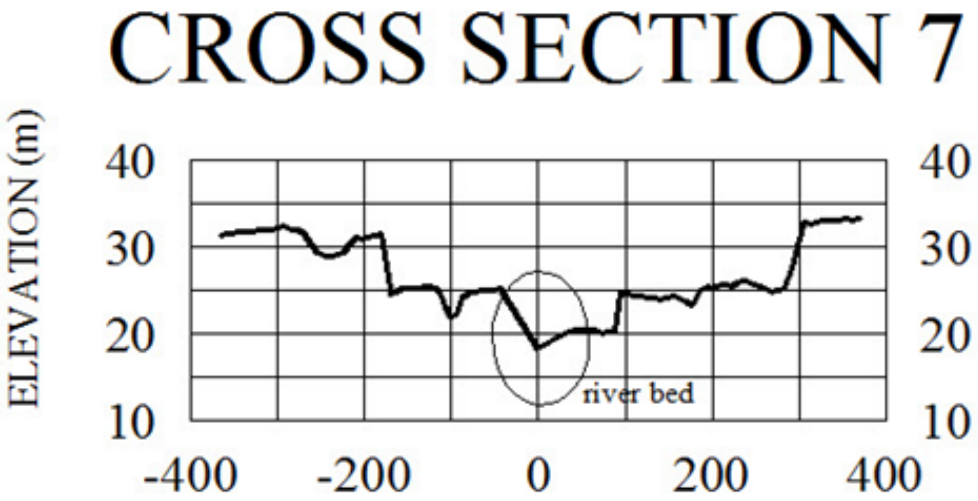

Figure 47. Cross section 7 of Hijo survey area

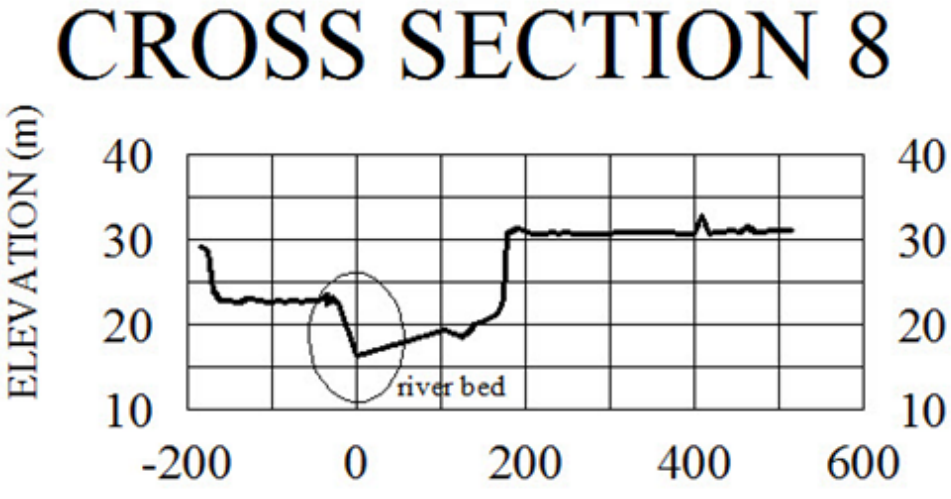

Figure 48. Cross section 8 of Hijo survey area

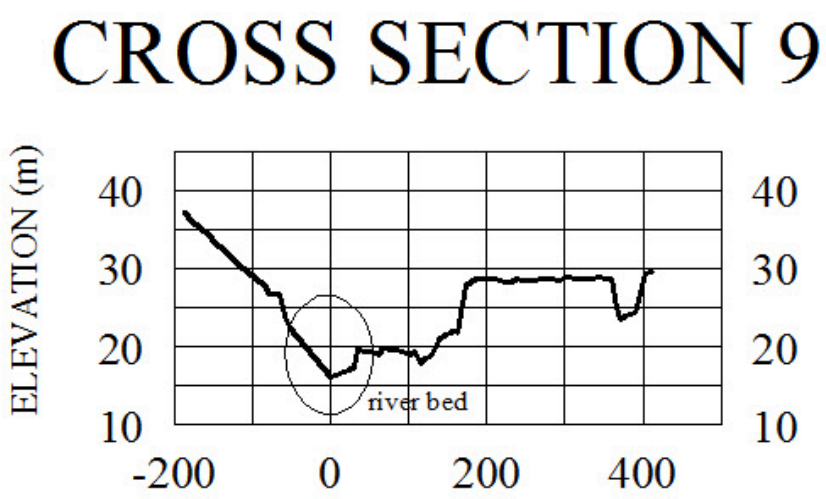

Figure 49. Cross section 9 of Hijo survey area

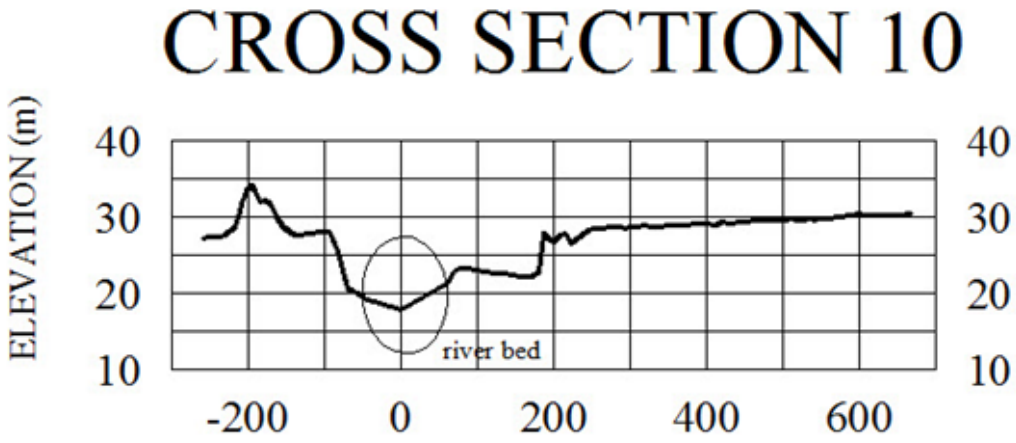

Figure 50. Cross section 10 of Hijo survey area

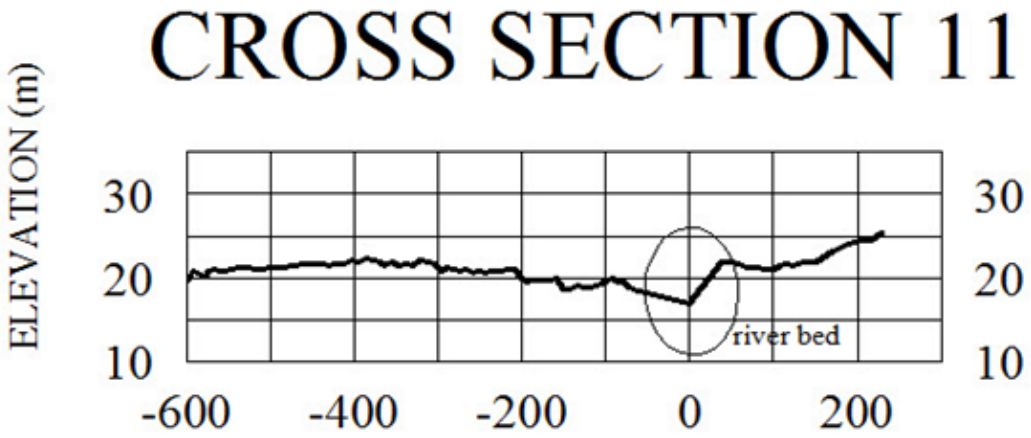

Figure 51. Cross section 11 of Hijo survey area

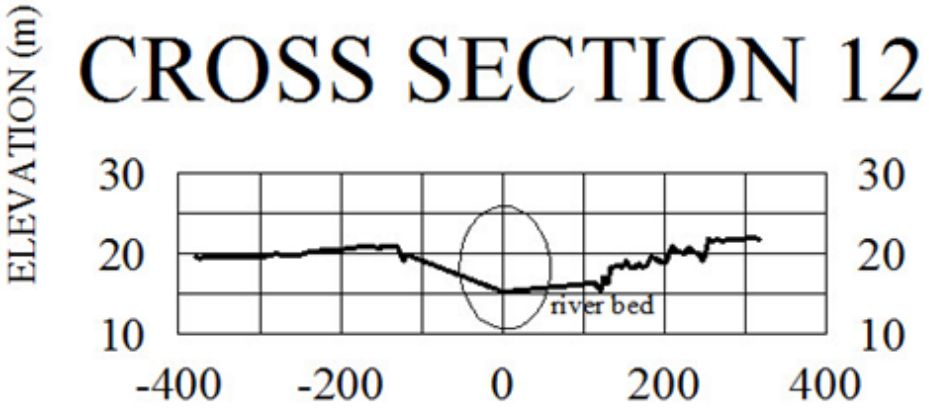

Figure 52. Cross section 12 of Hijo survey area

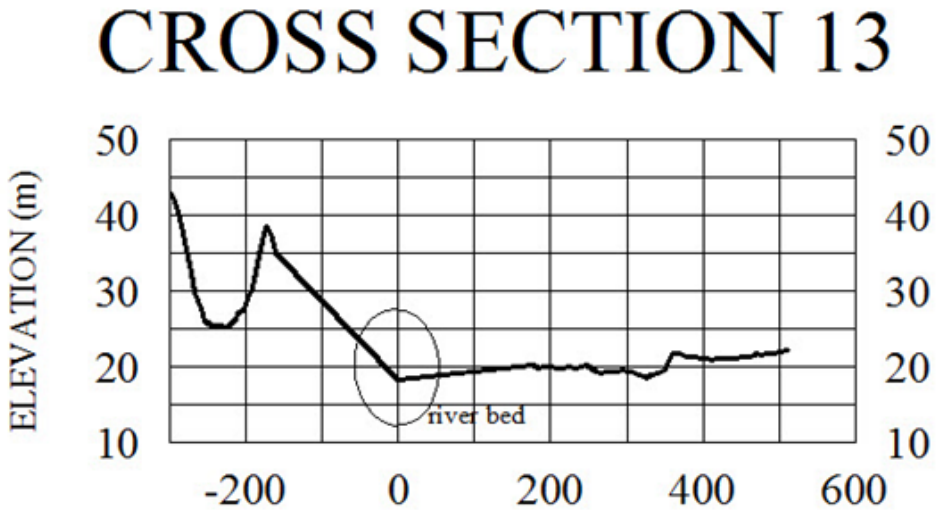

Figure 53. Cross section 13 of Hijo survey area

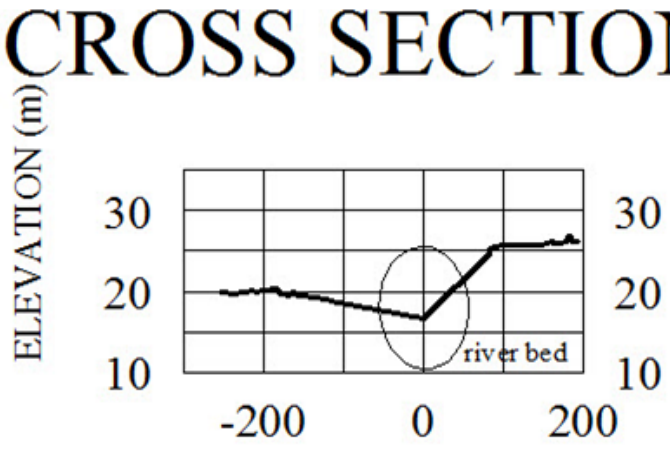

Figure 54. Cross section 14 of Hijo survey area

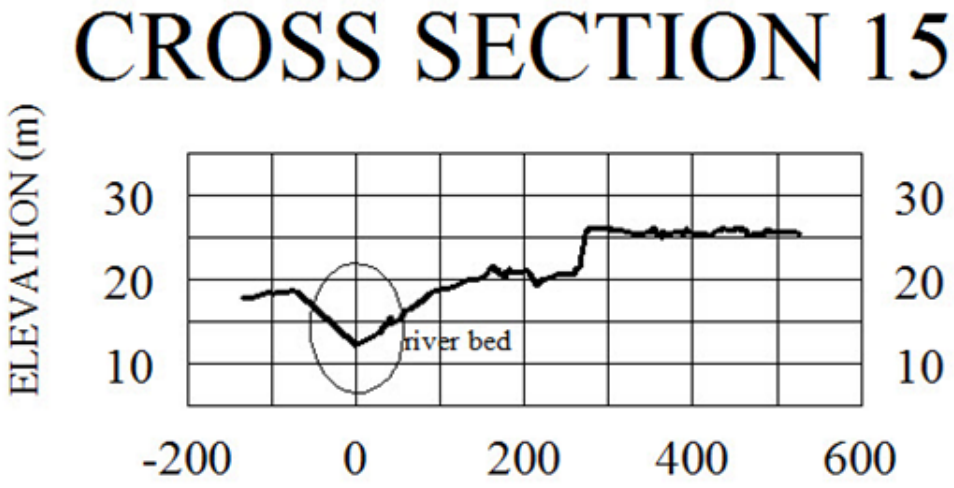

Figure 55. Cross section 15 of Hijo survey area

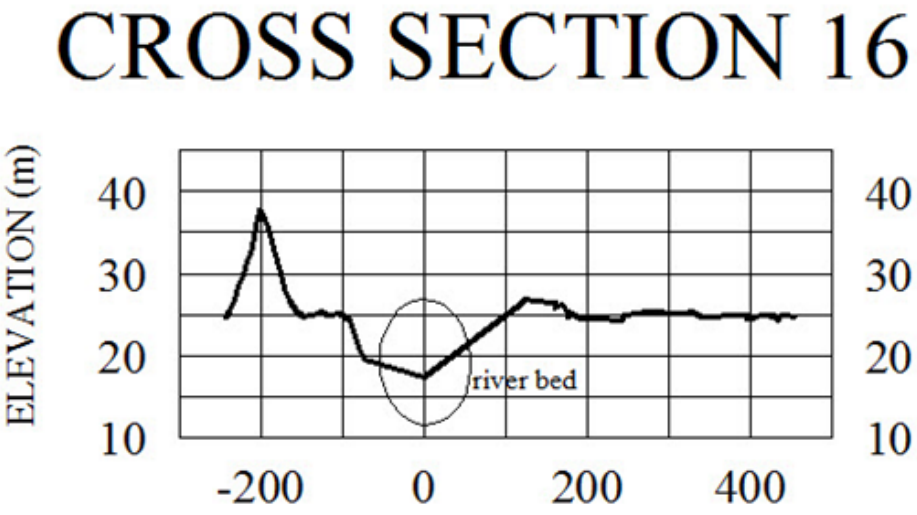

Figure 56. Cross section 16 of Hijo survey area

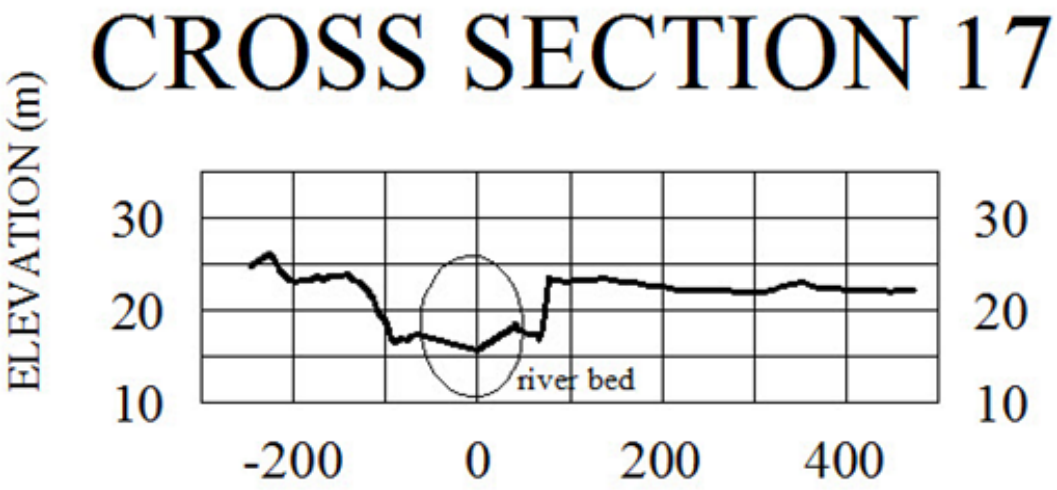

Figure 57. Cross section 17 of Hijo survey area

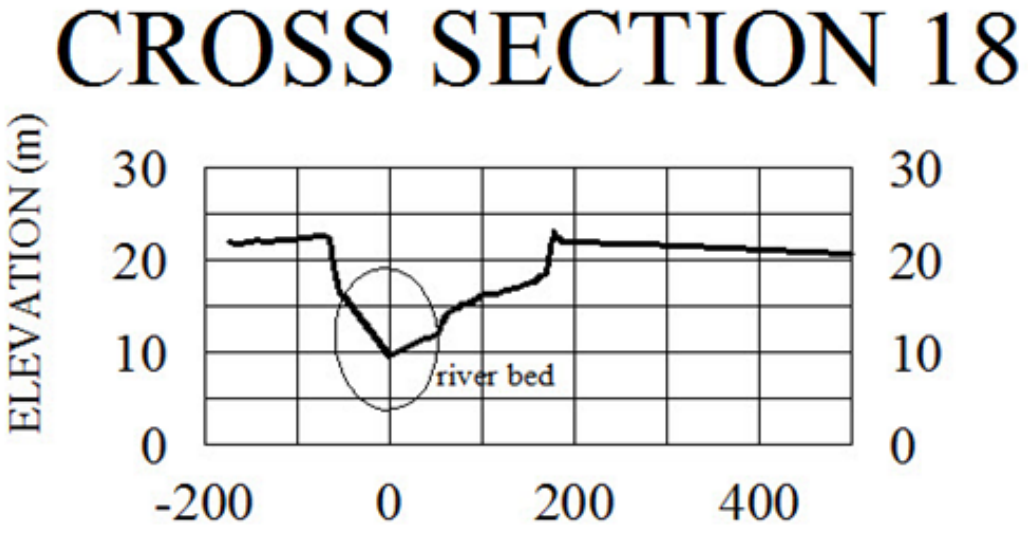

Figure 58. Cross section 18 of Hijo survey area

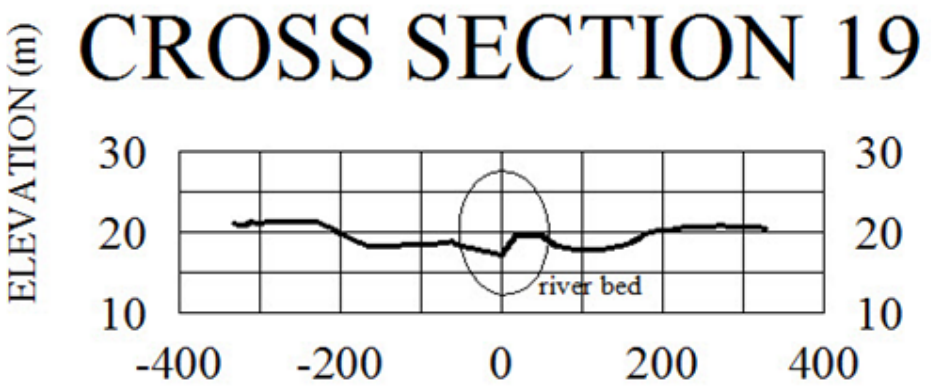

Figure 59. Cross section 19 of Hijo survey area

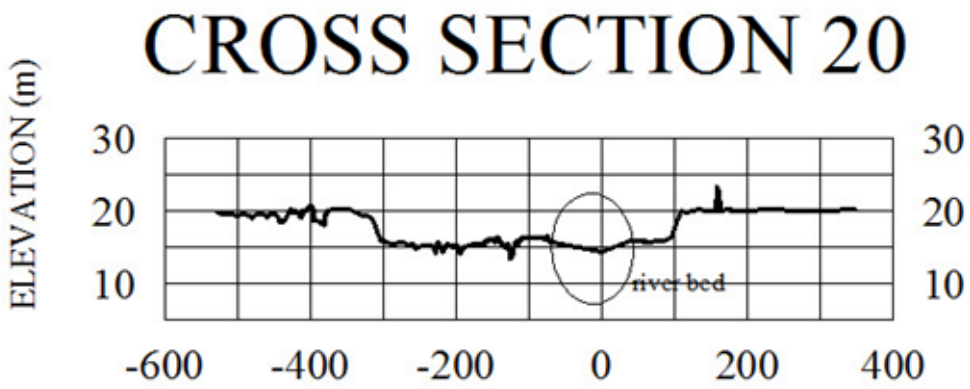

Figure 60. Cross section 20 of Hijo survey area

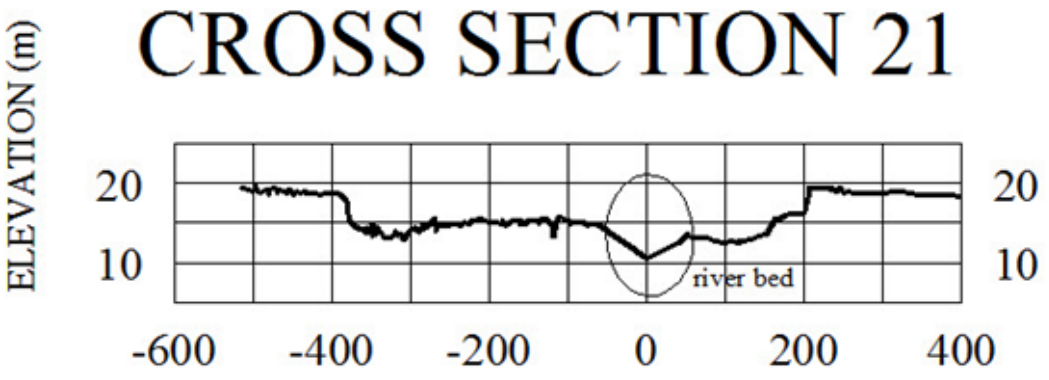

Figure 61. Cross section 21 of Hijo survey area

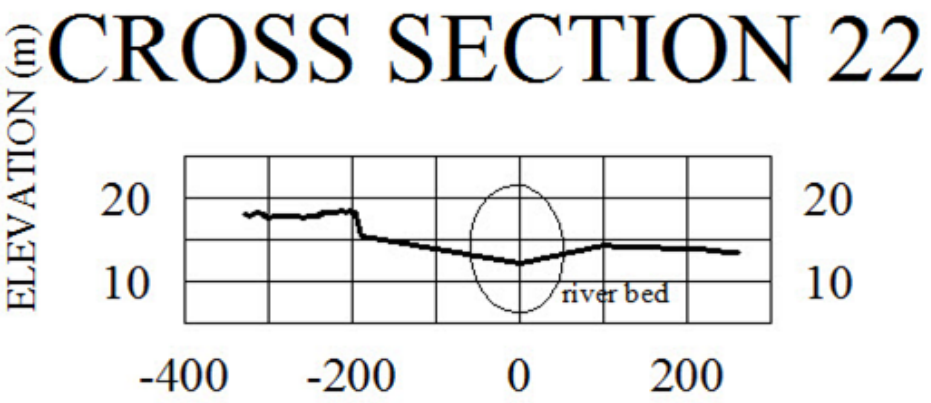

Figure 62. Cross section 22 of Hijo survey area

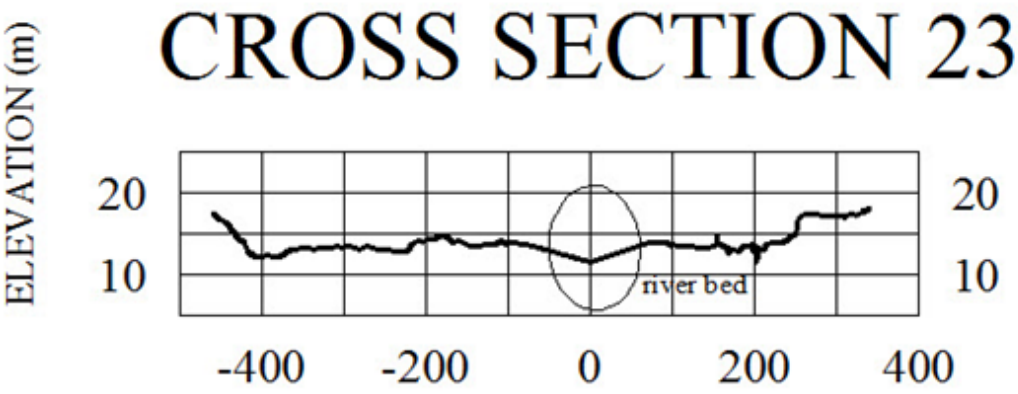

Figure 63. Cross section 23 of Hijo survey area

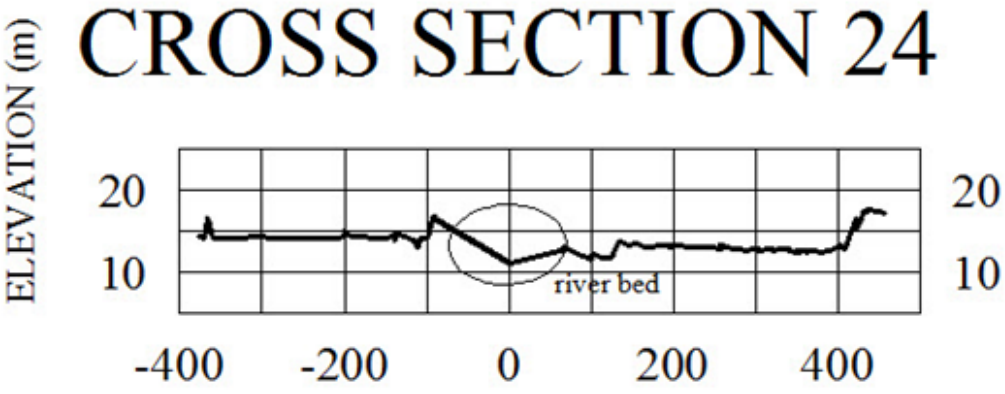

Figure 64. Cross section 24 of Hijo survey area

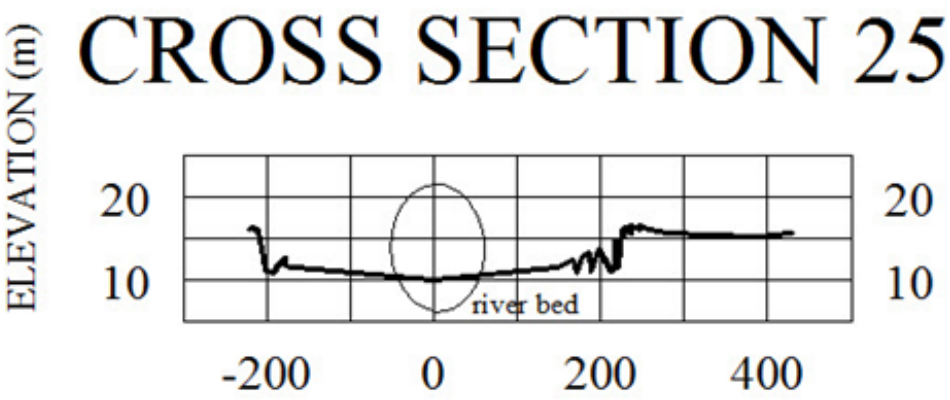

Figure 65. Cross section 25 of Hijo survey area

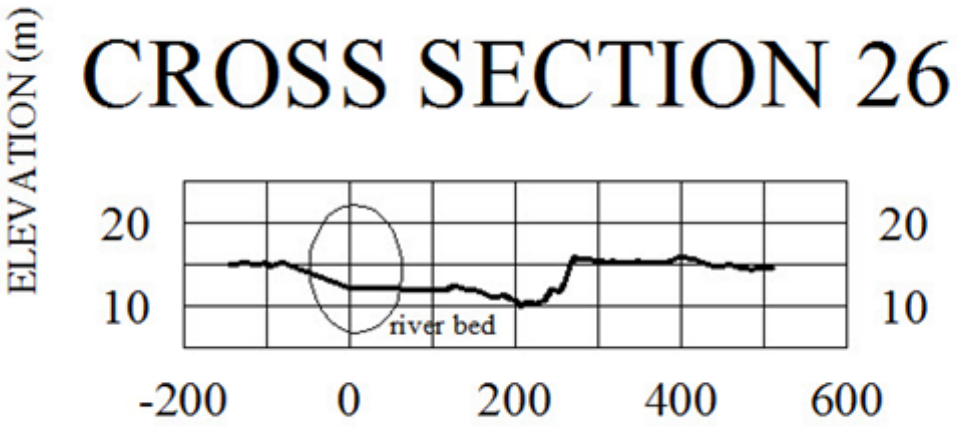

Figure 66. Cross section 26 of Hijo survey area

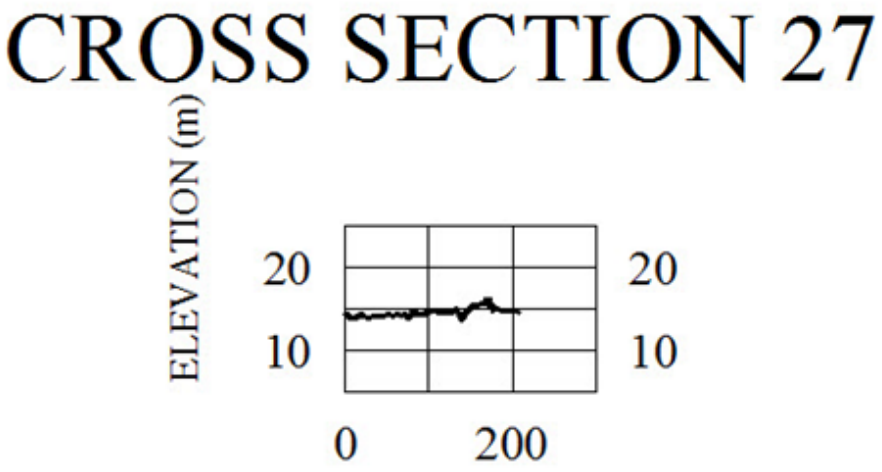

Figure 67. Cross section 27 of Hijo survey area

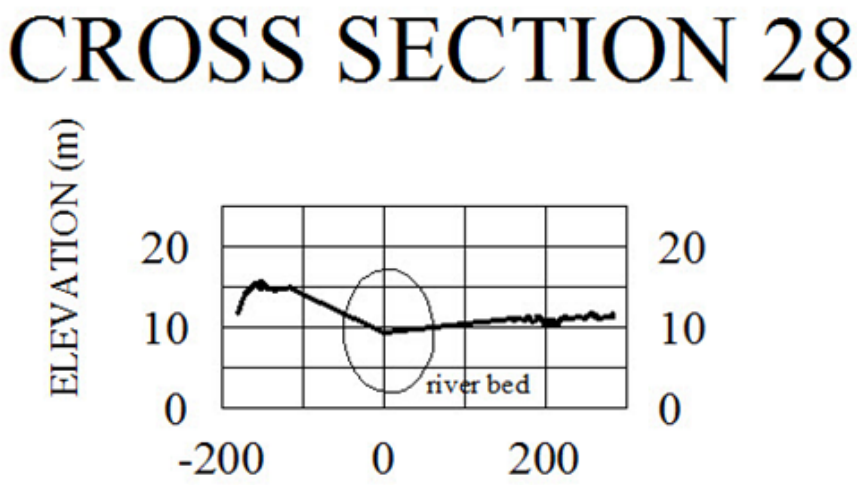

Figure 68. Cross section 28 of Hijo survey area

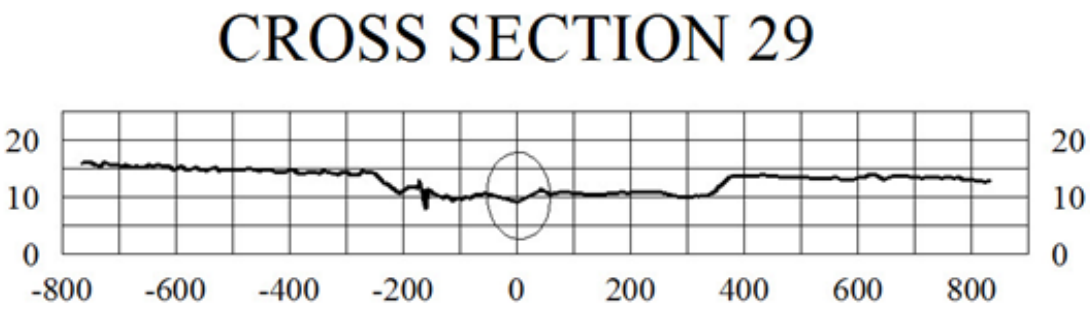

Figure 69. Cross section 29 of Hijo survey area

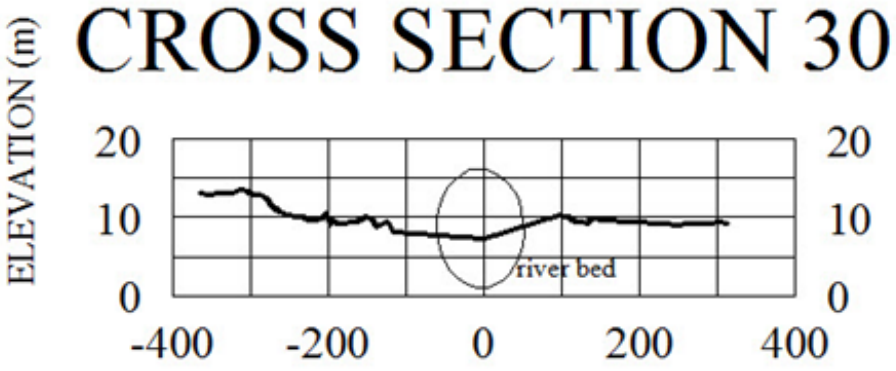

Figure 70. Cross section 30 of Hijo survey area

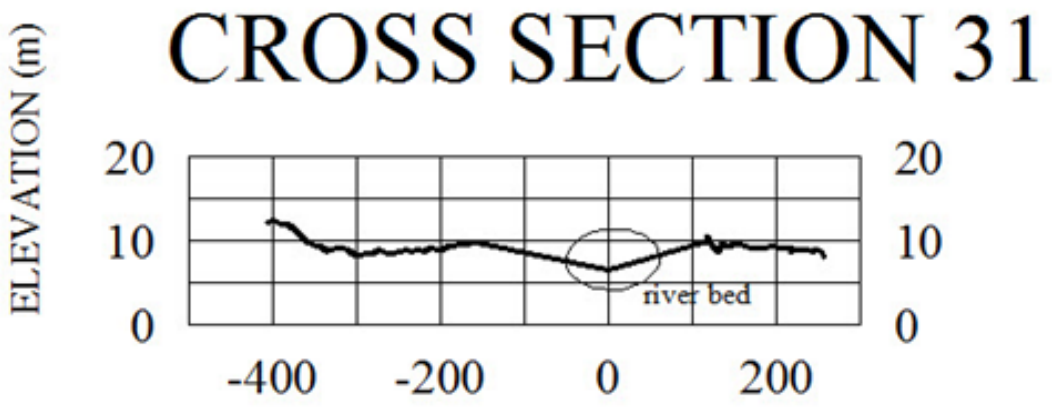

Figure 71. Cross section 31 of Hijo survey area

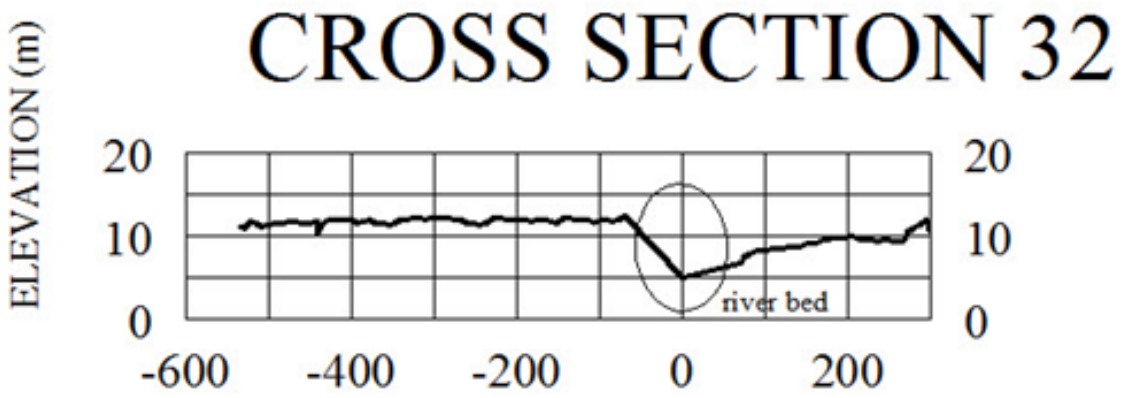

Figure 72. Cross section 32 of Hijo survey area

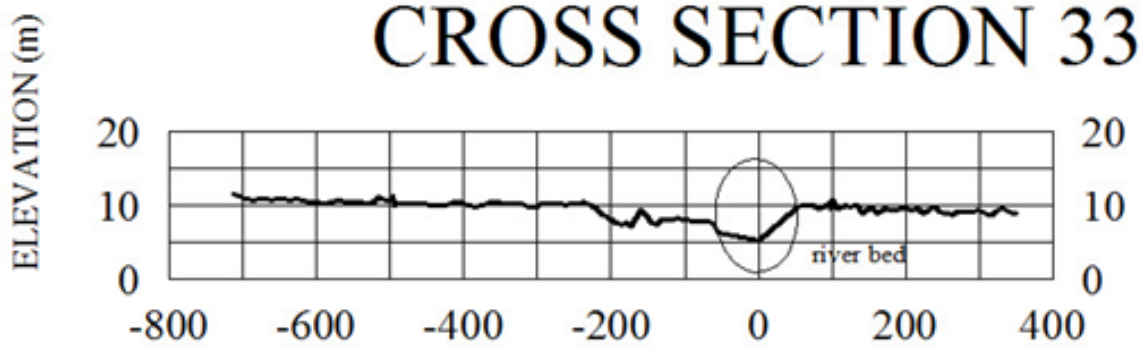

Figure 73. Cross section 33 of Hijo survey area

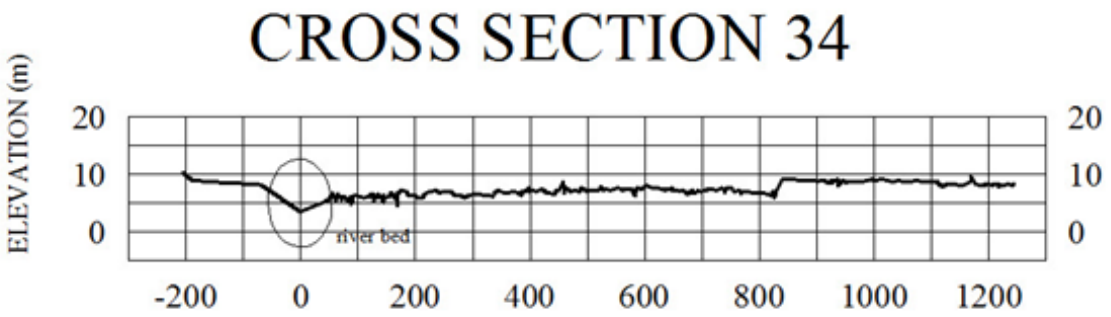

Figure 74. Cross section 34 of Hijo survey area

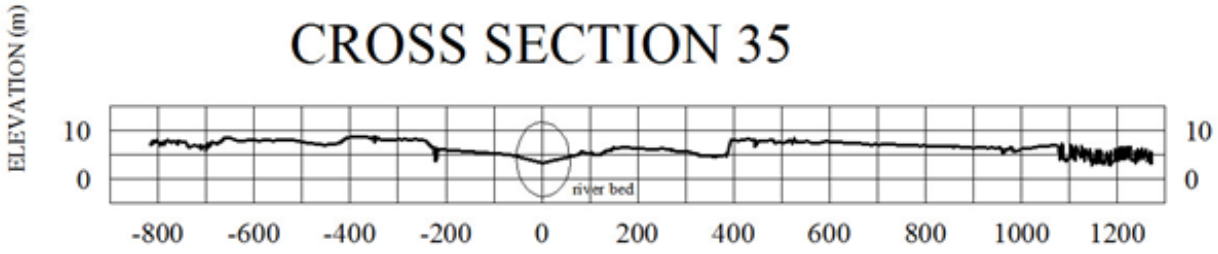

Figure 75. Cross section 35 of Hijo survey area

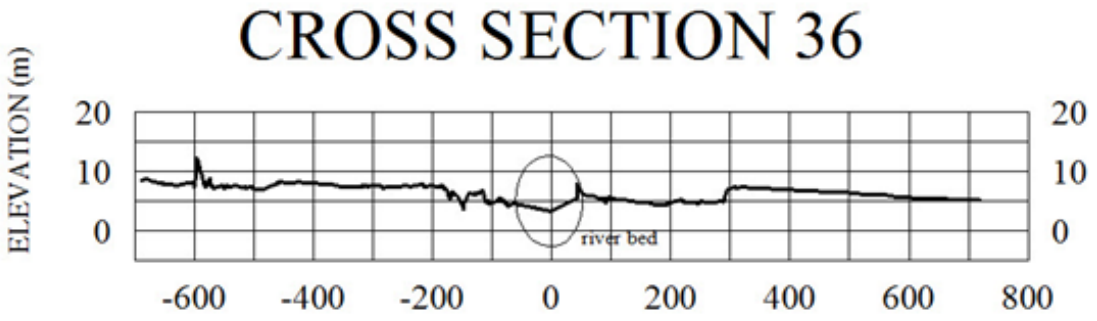

Figure 76. Cross section 36 of Hijo survey area

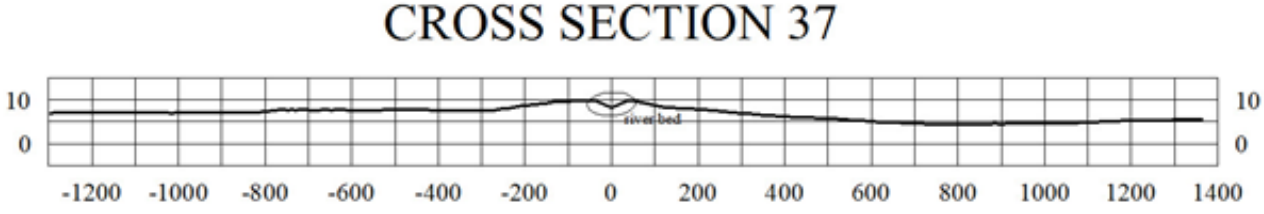

Figure 77. Cross section 37 of Hijo survey area

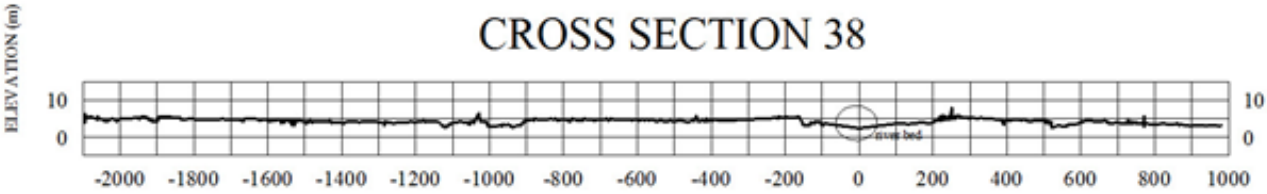

Figure 78. Cross section 38 of Hijo survey area

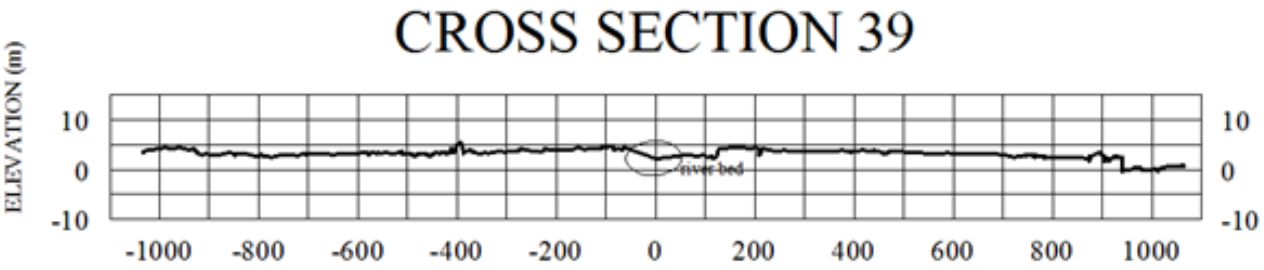

Figure 79. Cross section 39 of Hijo survey area

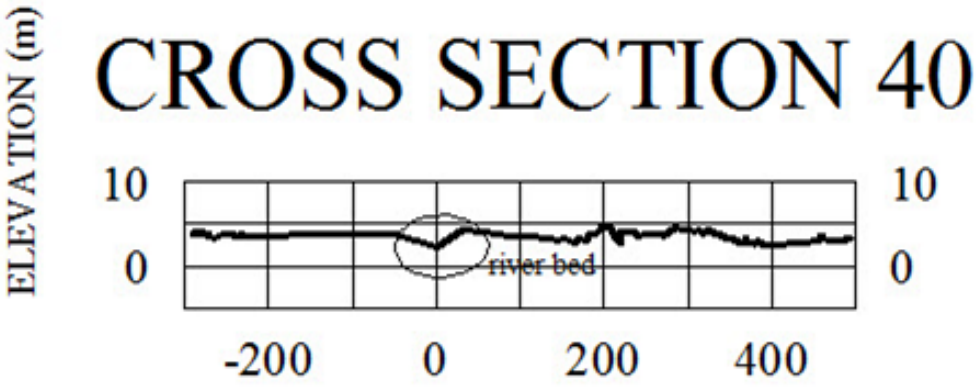

Figure 80. Cross section 40 of Hijo survey area

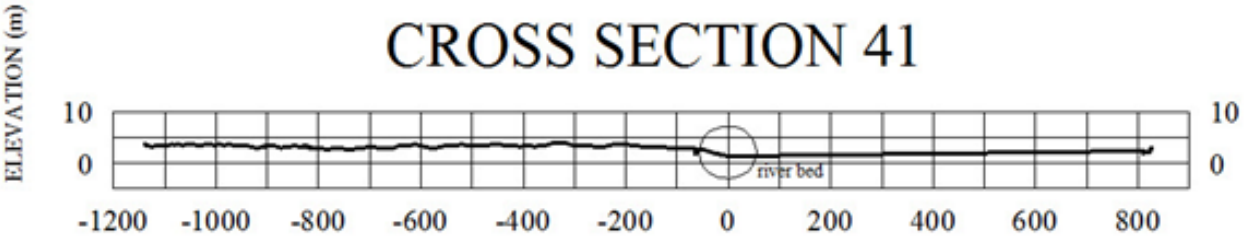

Figure 81. Cross section 41 of Hijo survey area

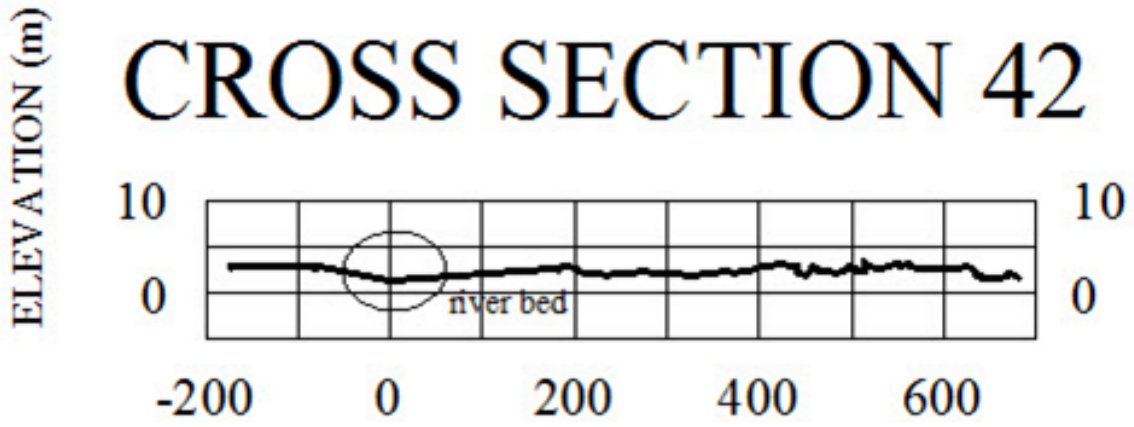

Figure 82. Cross section 42 of Hijo survey area

2.6.2 Profile Data

Processing of profile data is the same as that of in processing of the cross-section data.

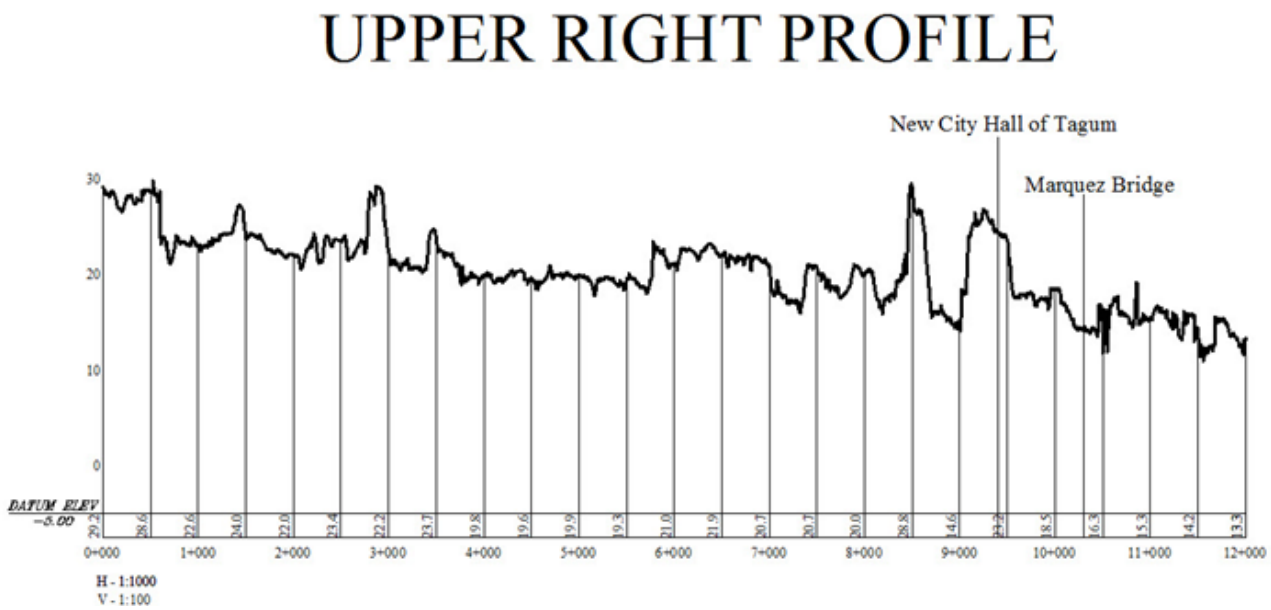

Figure 83. Upper right profile of Hijo river

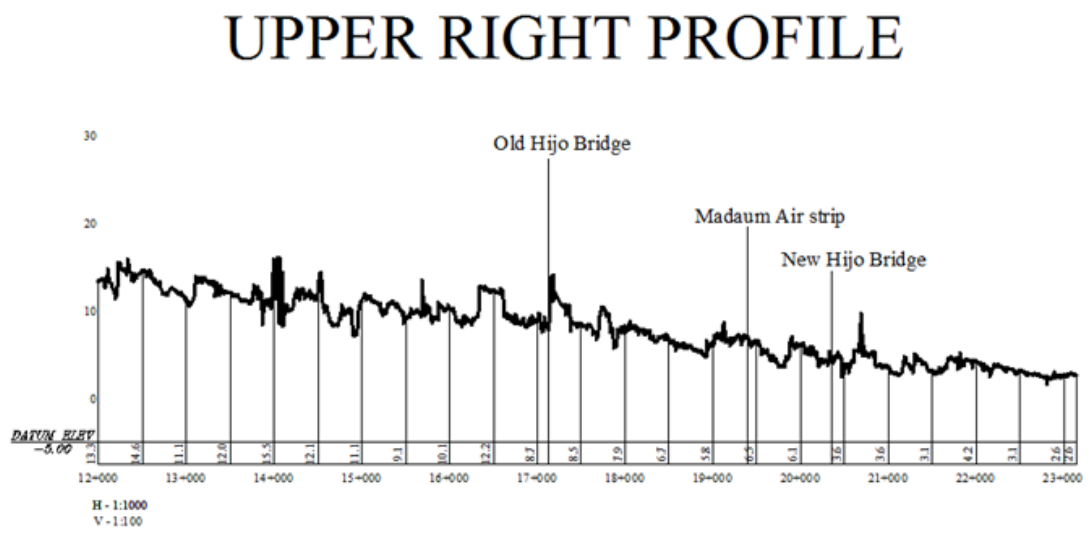

Figure 84. Upper right profile of Hijo river

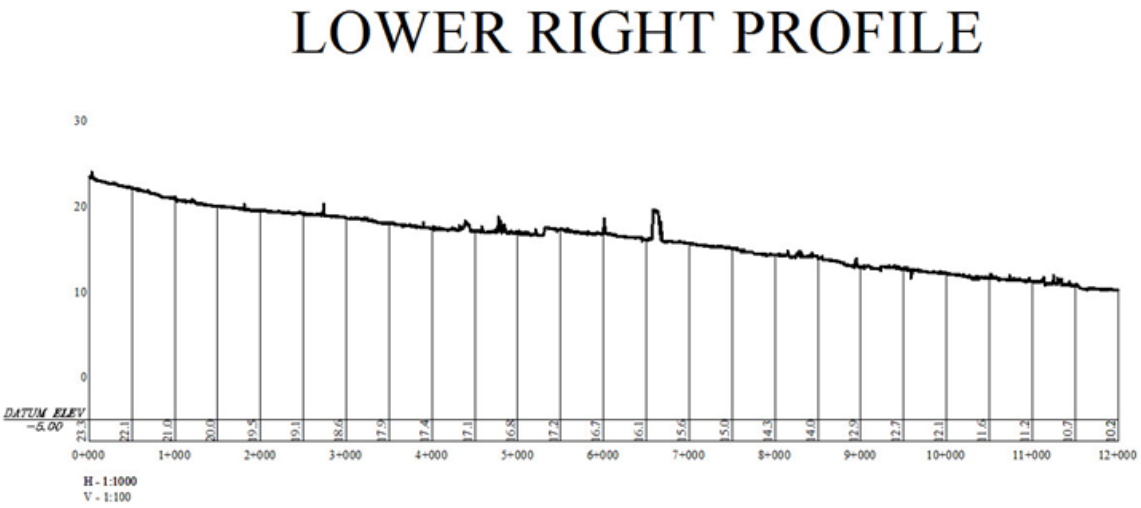

Figure 85. Lower right profile of Hijo river

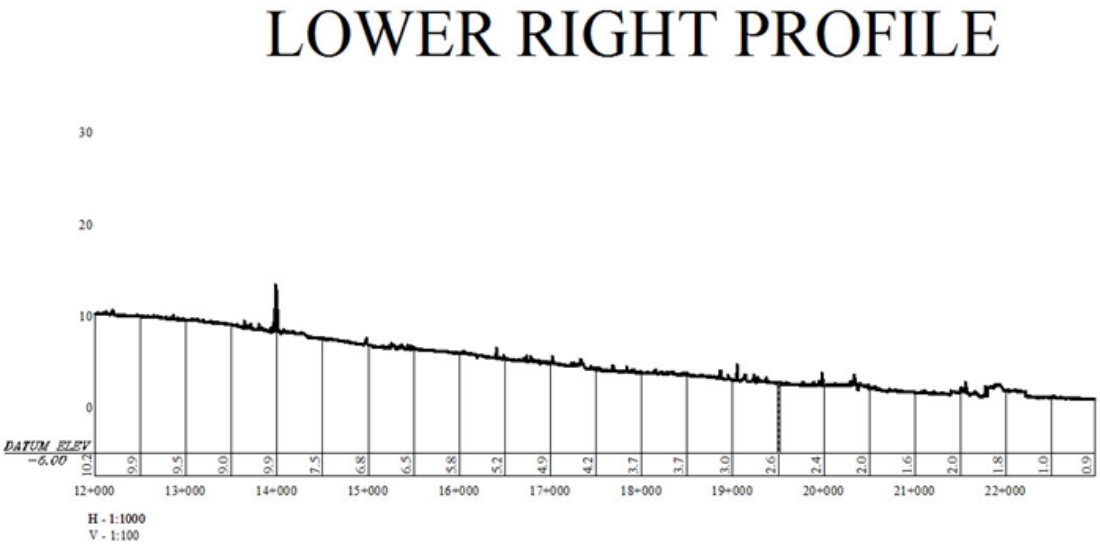

Figure 86. Lower right profile of Hijo river

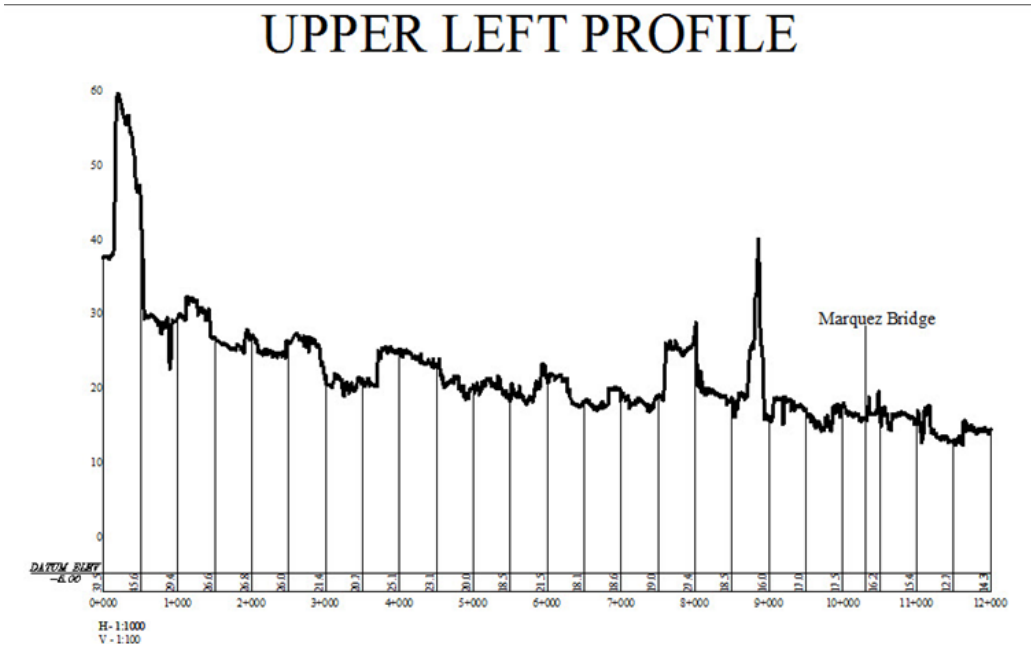

Figure 87. **Upper left profile of Hijo river**

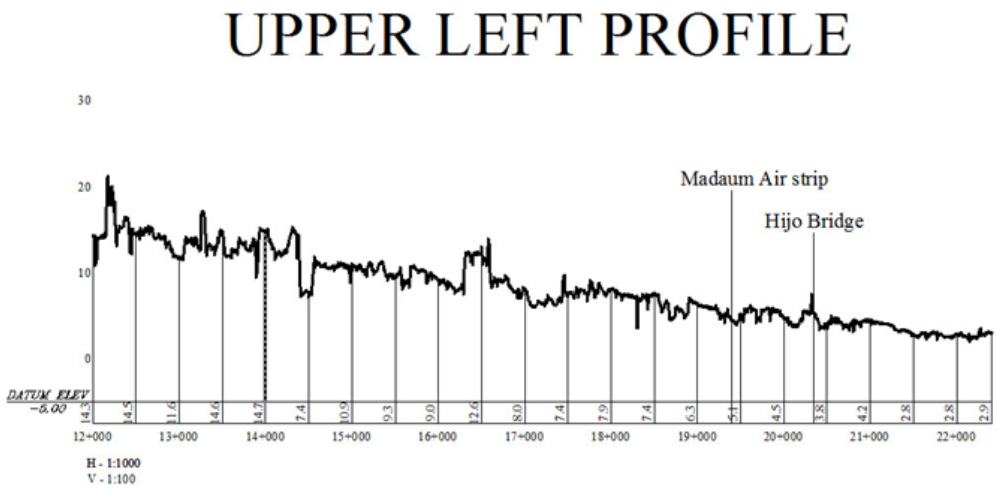

Figure 88. **Upper left profile of Hijo river**

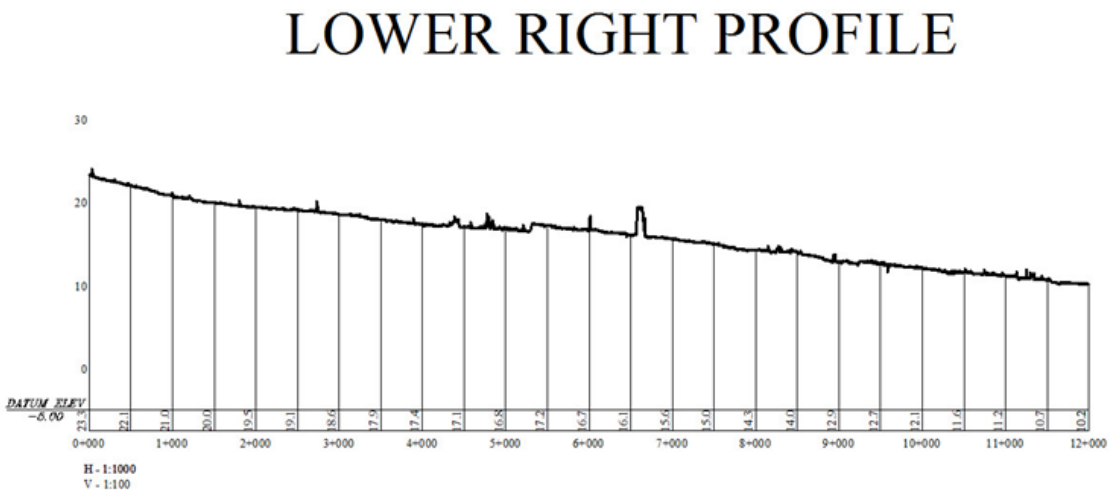

Figure 89. **Lower right profile of Hijo river**

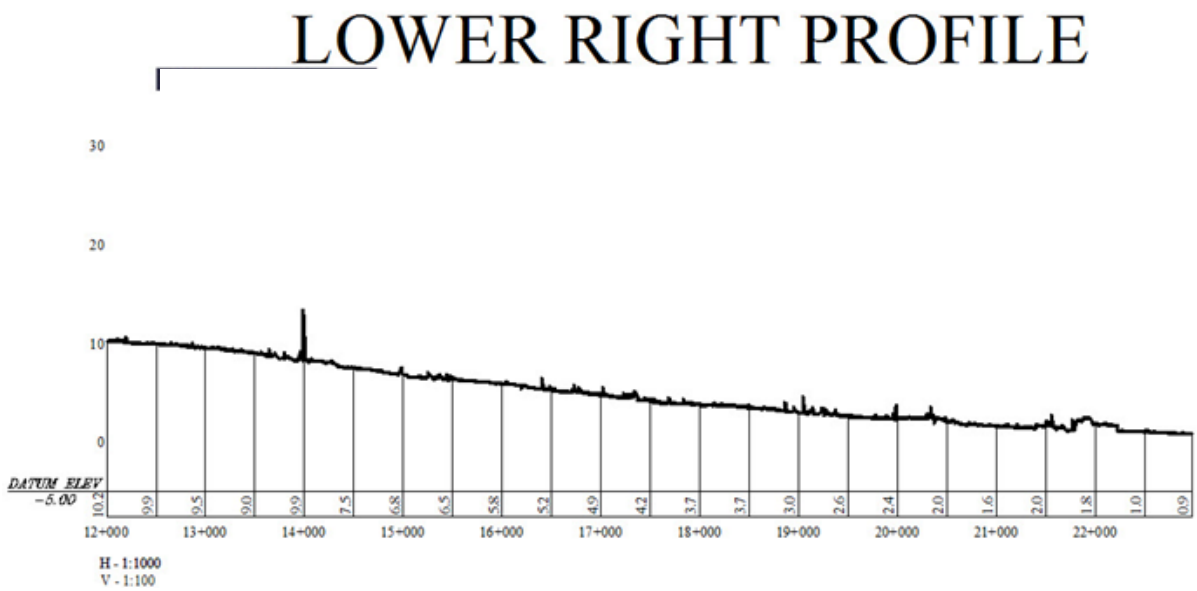

Figure 90. Lower right profile of Hijo river

Annexes


Results and
Discussions

Annexes

Annexes

3.1 Reconnaissance Survey

The team that conducted the reconnaissance on the area reported that most of the proposed routes are passable. For those that are not passable, alternate routes were prepared. Control points that will be used during the survey were identified.

Figure 91. Survey team walking along the left bank of Hijo River

Figure 92. Survey team member walking through a thick cogon grass while checking the cross section line

3.2 Actual Field Survey

The actual field works lasted for 15 days from June 14 to July 11, 2013. The survey team first conducted the profile survey and then the cross-section survey on Hijo River. The succeeding figures show the actual result of the profile and cross-section survey of Hijo River. The table below shows the control points used as base on the entire survey project.

Table 4. Control points used during the Static GPS observation.

Base Station	Order of Accuracy	Latitude	Longitude	Ellipsoidal Height (m)	Northing	Easting	Elevation (MSL)
DVA-12	2nd	7.45117068	125.812696	89.46	824658.95	810313.13	21.8399
COV-14	2nd	7.37038496	125.861591	140.906	815751.82	815772.26	73.3389
DVA-16	1st	7.35263672	125.703551	69.109	813679.24	798322.28	1.5359
DV-75	1st	7.37519509	125.738115	71.285	816153.45	802291.67	3.7959
LN		7.39637235	125.837005	80.429	818565.656	813202.871	12.9069

3.2.1 Profile Survey Results

The profile survey of Hijo River was conducted from June 15- June 29, 2013. The total length covered during the profile survey on each side of the bank is tabulated below. The total number of points that were surveyed on each side of the banks can also be seen below.

Table 5. Total number of points gathered on each bank during the profile survey

Profile	Total No. of Points Gathered
Upper Left	3209
Lower Left	3102
Upper Right	3228
Lower Right	3195
TOTAL	12,734

3.2.2 Cross-Section Survey

The cross-section survey was conducted from June 23-July 10, 2013. The tables and figures in the next pages show the results during the cross-section survey.

Table 6. Total number of points gathered on each cross-section line

Cross-Section	Total No. of Points Surveyed	
	Left	Right
1	29	30
2	49	34
3	27	69
4	52	57
5	32	54
6	64	104
7	47	56
8	31	49
9	16	56
10	33	110
11	72	28
12	50	40
13	26	89
14	59	36
15	12	226
16	28	99
17	31	102
18	21	114
19	38	58
20	216	93
21	251	111
22	22	21
23	58	118
24	82	166
25	11	58
26	22	93
27	0	39
28	64	38
29	210	171
30	78	39
31	68	29
32	128	60
33	172	91

34	16	478
35	271	437
36	400	165
37	258	249
38	309	372
39	284	303
40	72	101
41	308	13
42	48	147
TOTAL	4065	4803

3.3 Problems Encountered and Solutions Applied

The table below shows the problems encountered during the actual fieldwork and solutions undertaken by the survey team.

Table 7. Problems Encountered and Solutions Applied

LIMITATIONS/PROBLEMS			SOLUTIONS
1.)	21-Jun-13	very steep slope from the upper bank to the lower bank	the team used a total station
2.)	25-Jun-13	no field survey in the afternoon because of heavy rain water at the river is high	process data from previous field work
3.)	3-Jul-13	RTK reading float because of obstruction cross section xs5,15,16,17,18,19,29 and 37	Team uses a total station

Figure 93. Very steep slope from upper bank to lower bank

Figure 94. xsr05 ran along a bamboo tree area

Annexes

Annexes

ANNEX A. THE SURVEY TEAM

The cross-section survey was conducted from June 23-July 10, 2013. The tables and figures in the next pages show the results during the cross-section survey.

Cross-Section and Profile Survey Team Members	Designation	Name	Agency/Affiliation
Survey Coordinator		ENGR. JHONNYLO P. ATABAY	LN Realty and Surveying Services
Cross-Section And Profile Survey	Research Associate	BERNARD M. ALFARO	LN Realty and Surveying Services
	Research Associate	MEDARDO M. BONOTAN JR.	LN Realty and Surveying Services
	Research Associate	ROMEO A. DULFO JR.	LN Realty and Surveying Services
	Research Associate	YDJEL D. LOZANO	LN Realty and Surveying Services
	Research Associate	BERT BONOSTRO	Locally Hired
	Research Associate	RAMON MONTEBERDE	Locally Hired
	Research Associate	RANDY MONTEBERDE	Locally Hired
	Research Associate	RAMEL MONTEBERDE	Locally Hired

Annexes

ANNEX B. INSTRUMENTS AND EQUIPMENTS USED

Type	Brand	Owner	No. of Units used
Dual Frequency RTK GPS (base)	South	LN Realty and Surveying Services	Two (2)
Dual Frequency RTK GPS (rover)	South	LN Realty and Surveying Services	Four (4)
handheld GPS	Garmin	LN Realty and Surveying Services	Four (4)
Single Frequency Static GPS	South	LN Realty and Surveying Services	Four (4) sets
Pumpboat		LN Realty and Surveying Services	Two (2)
Laptops	Acer, Asus	LN Realty and Surveying Services	Two (2)
Printer	Canon	LN Realty and Surveying Services	One (1)

Annexes

ANNEX C. LIST OF ACTIVITIES

DAY	ACTIVITY	LOCATION	PERSONS INVOLVED/PARTICIPATED
14-Jun-13	Reconnaissance on the area Recovery of NAMRIA Control Points and reference points	Tagum City	Ramon Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
15-Jun-13	Start of Profile Survey Data Downloading and Processing	Brgy. Apokon, Tagum City Brgy. Pandapan, Tagum City	Ramon Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
16-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Apokon, Tagum City	Ramon Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
17-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. New Astorias, Mun of Maco Brgy. Magdaum, City of Tagum Brgy. Pandapan, City of Tagum	Ramon Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
18-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Magdaum, City of Tagum Brgy. Taglawig, Mun of Maco	Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
19-Jun-13	Continue Profile Survey Static Reading Data Downloading and Processing	Brgy. Taglawig, Mun of Maco Maco Municipal Hall	Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro

20-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Taglawig, Mun of Maco Brgy. Pangi, Mun. of Maco Brgy. Magdaum, City of Tagum	Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
21-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Pangi, Mun. of Maco	Randy Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
22-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Apokon, Tagum City	Randy Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
23-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Apokon, Tagum City	Randy Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
24-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Dumlan, Mun of Maco Brggy. Apokon	Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
25-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Dumlan, Mun of Maco Brgy. Hijo, Mun of Maco	Randy Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
26-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Madaum, Tagum City Brgy. Hijo, Mun of Maco	Randy Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro

27-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Madaum, Tagum City Brgy. Hijo, Mun of Maco	Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
28-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Madaum, Tagum City Brgy. Bucana, Mun of Maco	Randy Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel Lozano Bert Bonostro
29-Jun-13	Continue Profile Survey Data Downloading and Processing	Brgy. Bucana, Mun of Maco	Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
30-Jun-13	Start Cross-Section Survey XSR01, XSR02, XSR03 XSR04, XSR06 Data Downloading and Processing	Brgy. Magdum, Tagum City Brgy. Pandapan, Tagum City	Randy Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
1-Jul-13	Static Observation Data Downloading and Processing	Mun. of Carmen	Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
2-Jul-13	Completed Cross-section Survey XSR01, XSR02 Data Downloading and Processing	Brgy. Magdum, Tagum City Brgy. Pandapan, Tagum City	Randy Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
3-Jul-13	Completed Cross-section Survey XSR03, XSR04, XSR05, XSR06 Data Downloading and Processing	Brgy. Magdum, Tagum City Brgy. Pandapan, Tagum City	Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro

4-Jul-13	Continue Cross-Section Survey XSL03, XSL04, XSL05 XSR07, XSR08, XSR09, XSR10 Data Downloading and Processing	Brgy. New Astorias, Mun of Maco Brgy. Magdum, Tagum City	Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
5-Jul-13	Continue Cross-Section Survey XSL01, XSL02, XSR11, XSR12 Completed XSL03, XSR09, Data Downloading and Processing	Brgy. New Astorias, Mun of Maco Brgy. Magdum, Tagum City	Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
6-Jul-13	Continue and Completed XSL06, XSL07, XSL10, , XSL12, XSL11 Data Downloading and Processing		Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
7-Jul-13	Continue and Completed XSL13, XSL15, XSL16, XSL09 XSL14, XSL08 Data Downloading and Processing		Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
8-Jul-13	Continue and Completed XSL17, XSL18, XSL23 XSL19 Data Downloading and Processing		Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
9-Jul-13	Completed XSL18, XSL23		Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro
10-Jul-13	Completed XSL38 Data Downloading and Processing		Ramel Monteberde Bernard M. Alfaro Romeo A. Dulfo Jr. Medardo Bonotan Sr. Ydjel D. Lozano Bert Bonostro

ANNEX D. CERTIFICATIONS OF BENCHMARK AND CONTROL POINTS USED

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: **COMPOSTELA VALLEY**
Station Name: **COV-14**
Order: **2nd**

Island: **MINDANAO**
Municipality: **MACO**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude:	7° 22' 16.56505"	Longitude:	125° 51' 36.23705"	Ellipsoidal Hgt:	68.09600 m.

WGS84 Coordinates

Latitude:	7° 22' 13.38586"	Longitude:	125° 51' 41.73051"	Ellipsoidal Hgt:	140.90600 m.

PTM Coordinates

Northing:	815116.743 m.	Easting:	594955.891 m.	Zone:	5

UTM Coordinates

Northing:	815,751.82	Easting:	815,772.26	Zone:	51

Location Description

COV-14
"COV-14" is in Barangay Poblacion, Maco, Compostela Valley. TO reach the station travel for about 6 kms. from Tagum City towards Maco taking the National Highway until reaching the Municipal Hall. Station is located 10m SW part of the flagpole. Mark is the head of 4" copper nail embedded in a 0.30 x 0.30 x 1.0 m. concrete monument with the inscription "COV-14 2007 NAMRIA".

Requesting Party: **LN Realty and Surveying Services**
Pupose: **Reference**
OR Number: **3943807 B**
T.N.: **2013-0594**

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

9905202013115703

CERTIFICATION INTERNATIONAL ISO 9001:2008 — CIP/4201/13/09/816

CENTRAL OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. Nos.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. Nos.: (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: **DAVAO DEL NORTE**
Station Name: **DV-75**

Island: **Mindanao**	Municipality: **CARMEN**	Barangay: **GUADALUPE**
Elevation: **3.7959 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

DV-75 is in the Province of Davao del Norte, City of Carmen, Barangay Guadalupe taking the national highway from Davao City going to Tagum City. Station is located 100 m. away from the Kilometer post KM.1488 along the national highway.

Station mark is the head of 4" copper nail set on a drilled hole and cemented flushed on top of a 15x15cm. cemer putty with inscriptions "DV-75, 2007 NAMRIA."

Requesting Party: **LN Realty and Surveying Services**
Pupose: **Reference**
OR Number: **3943807 B**
T.N.: **2013-0597**

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

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

July 01, 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: **DAVAO DEL NORTE**
Station Name: **DVA-16**
Order: 3rd

Island: **MINDANAO**
Municipality: **CARMEN**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude:	7° 21' 12.68080"	Longitude:	125° 42' 7.28940"	Ellipsoidal Hgt:	-3.34300 m.

WGS84 Coordinates

Latitude:	7° 21' 9.49220"	Longitude:	125° 42' 12.78620"	Ellipsoical Hgt:	69.10900 m.

PTM Coordinates

Northing:	813123.766 m.	Easting:	577509.449 m.	Zone:	5

UTM Coordinates

Northing:	813,679.24	Easting:	798,322.26	Zone:	51

Location Description

DVA-16
Is in Poblacion Carmen, Davao del Norte. It is located 200 m. SW of Carmen Municipal Hall. The mark is located at the NE corner of the concrete base of the flag pole situated in front of the Carmen District Hospital. Station mark is a 4" copper nail embedded on a cement putty bearing an inscription "DVA-16, 2000, NAMRIA".

Requesting Party: **LN Realty and Surveying Services**
Pupose: **Reference**
OR Number **3943855B**
T.N.: **2013-0628**

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

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

July 01, 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: **DAVAO DEL NORTE**
Station Name: **DVA-16**
Order: 3rd

Island: **MINDANAO**
Municipality: **CARMEN**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude: **7° 21' 12.66080"** Longitude: **125° 42' 7.28940"** Ellipsoidal Hgt: **-3.34300 m.**

WGS84 Coordinates

Latitude: **7° 21' 9.49220"** Longitude: **125° 42' 12.78620"** Ellipsoical Hgt: **69.10900 m.**

PTM Coordinates

Northing: **813123.766 m.** Easting: **577509.449 m.** Zone: **5**

UTM Coordinates

Northing: **813,679.24** Easting: **798,322.28** Zone: **51**

Location Description

DVA-16
Is in Poblacion, Carmen, Davao del Norte. It is located 200 m. SW of Carmen Municipal Hall. The mark is located at the NE corner of the concrete base of the flag pole situated in front of the Carmen District Hospital. Station mark is a 4" copper nail embedded on a cement putty bearing an inscription "DVA-16, 2000, NAMRIA".

Requesting Party: **LN Realty and Surveying Services**
Pupose: **Reference**
OR Number **3943855B**
T.N.: **2013-0628**

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

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Acknowledgements

Annexes

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

The local residents of Maco and Tagum City for guiding the survey team throughout the field surveys.

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DREAM

Disaster Risk and Exposure Assessment for Mitigation