REGION 4B

Mag-Asawang Tubig River:

DREAM Ground Surveys Report

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY

2015

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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.

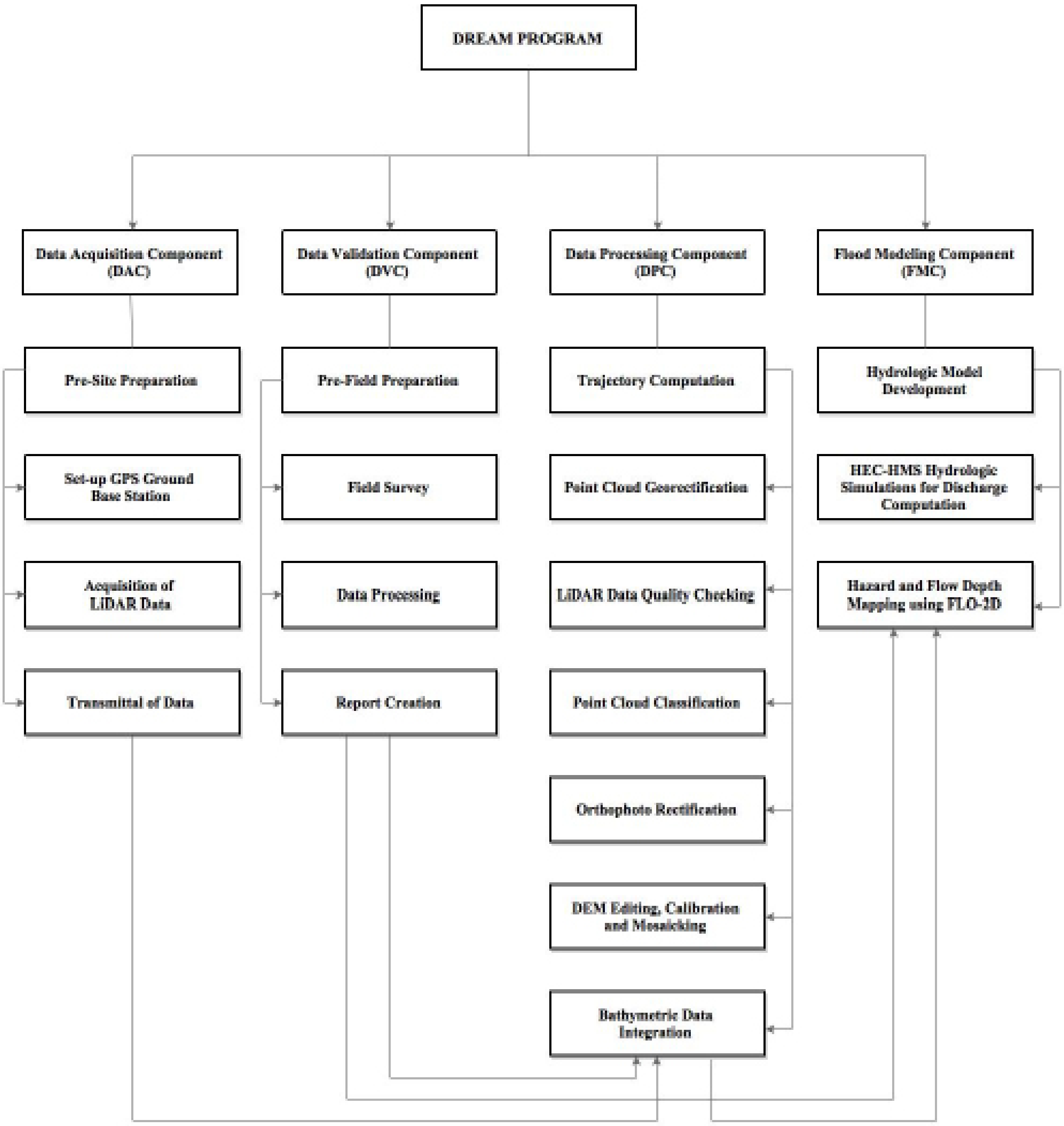


Figure 1. The General Methodological Framework of the Program

The Mag-Asawang Tubig River Basin

The Mag-Asawang Tubig River Basin

The Mag-asawang Tubig River Basin is located in the island of Mindoro, northeast of Palawan. It traverses through Calapan City in Oriental Mindoro and the municipalities of San Teodoro, Baco, Naujan, Victoria and Sablayan. It covers an estimate area of 491 square kilometres.

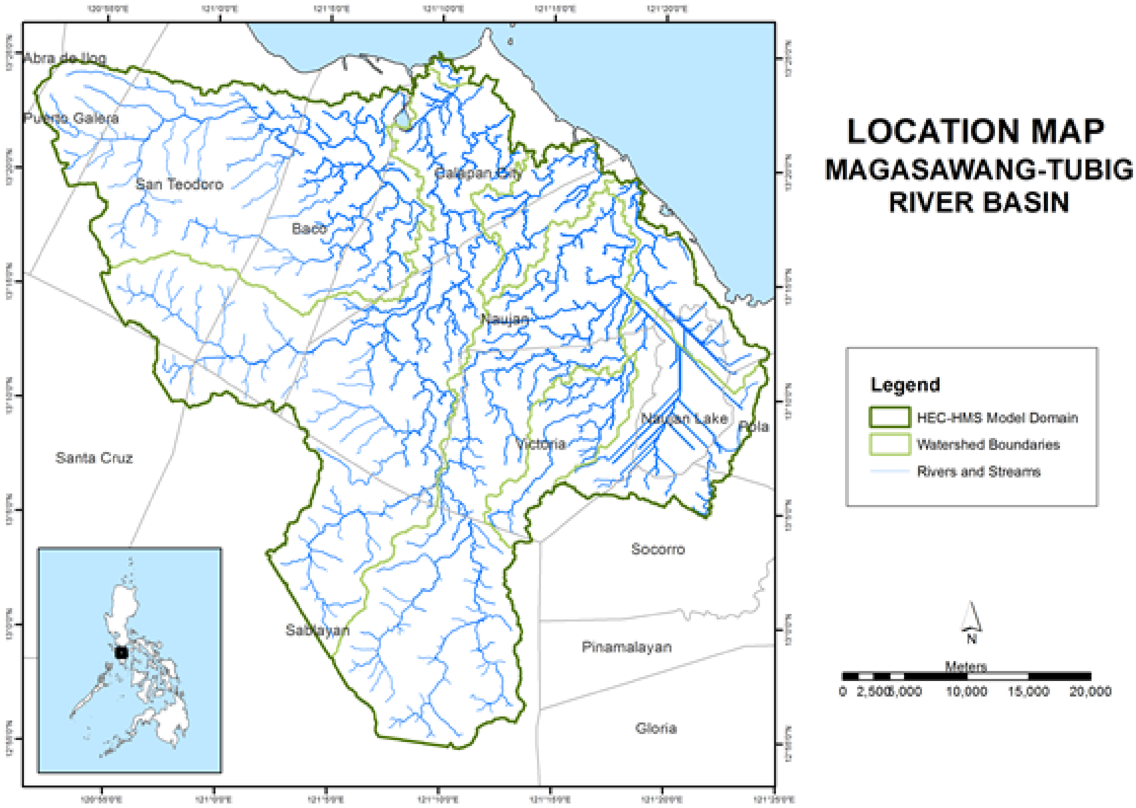


Figure 2. Mag-Asawang Tubig River Basin Location Map

The land and soil characteristics are important parameters used in assigning the roughness coefficient for different areas within the river basin. The roughness coefficient, also called Manning's coefficient, represents the variable flow of water in different land covers (i.e. rougher, restricted flow within vegetated areas, smoother flow within channels and fluvial environments).

The shape files of the soil and land cover were taken from the Bureau of Soils, which is under the Department of Environment and Natural Resources Management, and National Mapping and Resource Information Authority (NAMRIA). The soil and land cover of Mag-Asawang Tubig River Basin are as shown in Figure 3 and Figure 4.

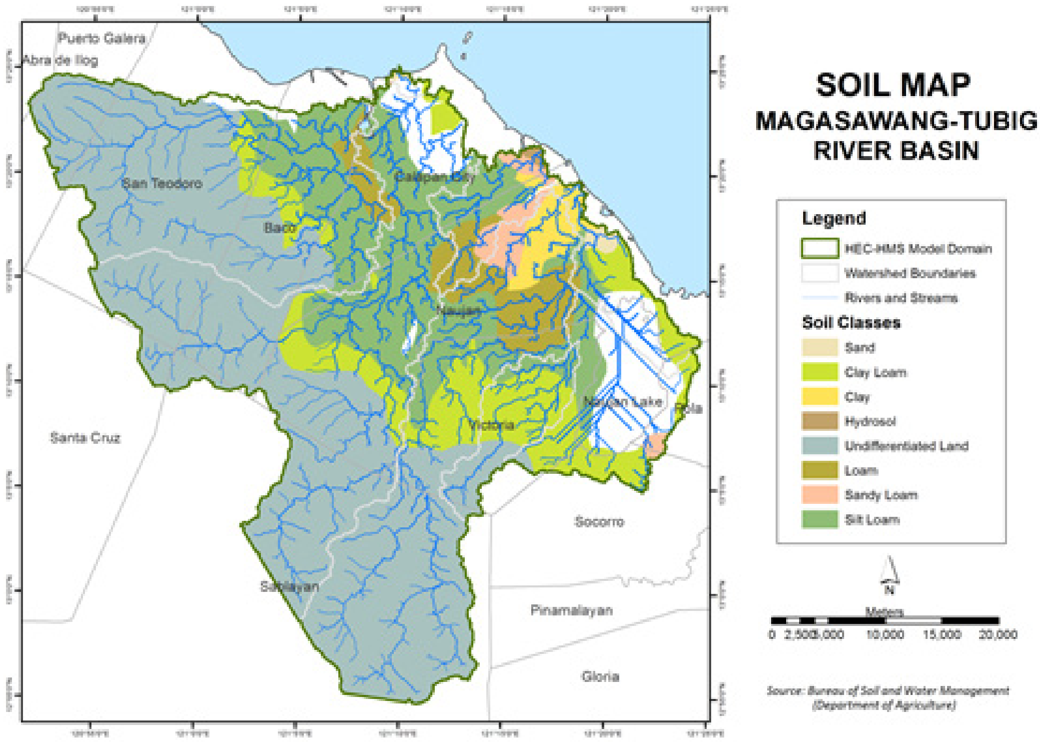


Figure 3. Mag-Asawang Tubig River Basin Soil Map

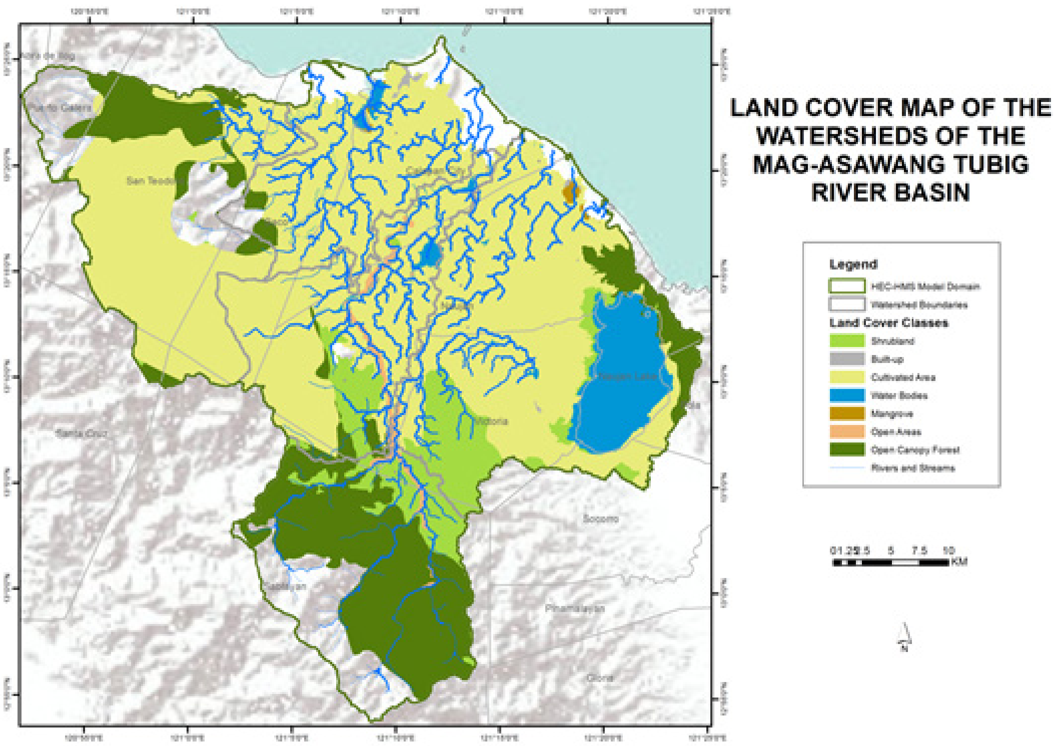


Figure 4. Mag-Asawang Tubig River Basin Land Cover Map

DVC Methodology

DVC Methodology

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

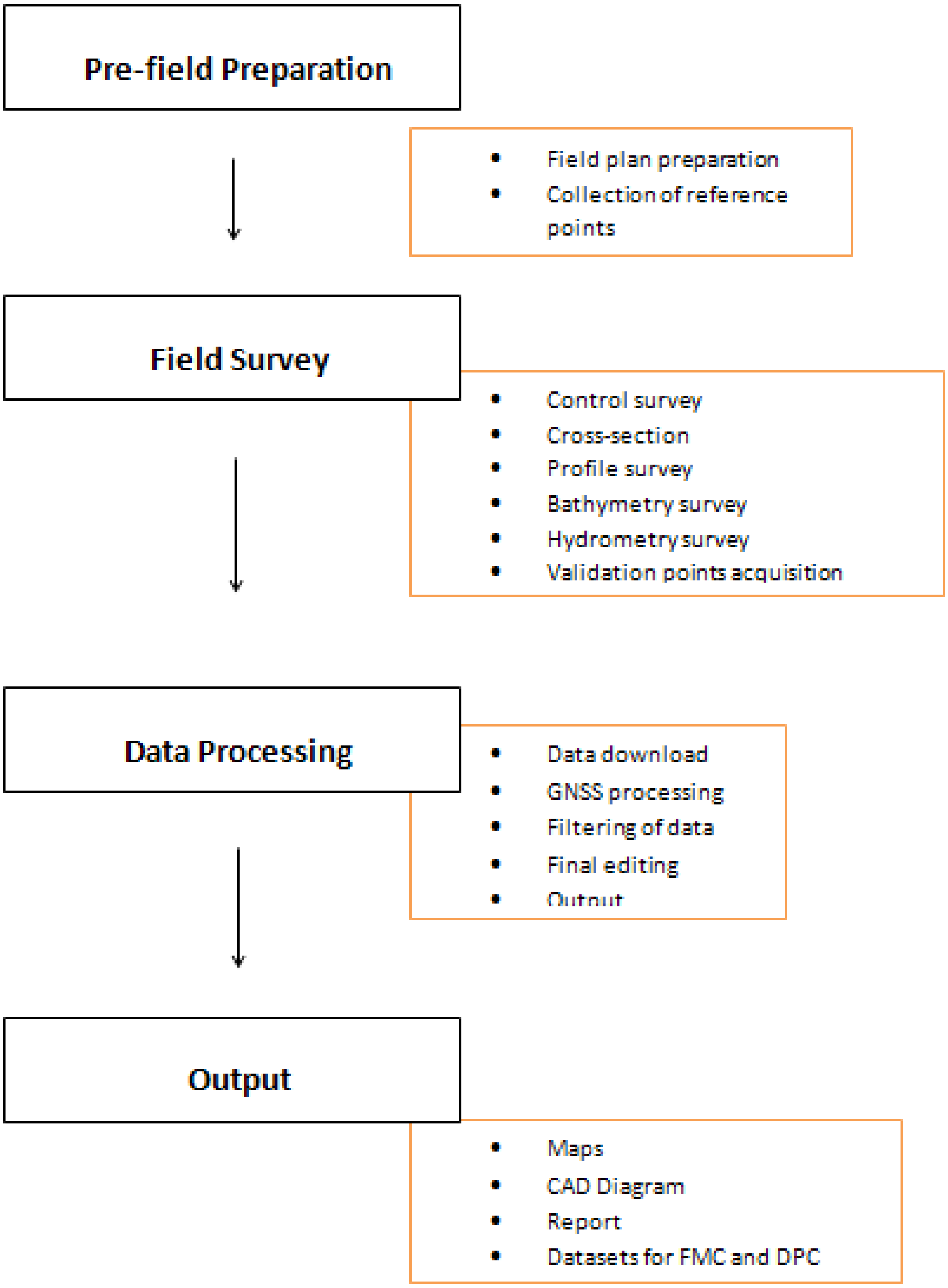


Figure 5. DVC Main Activities

DVC Methodology

3.1 Pre-field Preparation

3.1.1 Preparation of Field Plan

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

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

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

3.1.2 Collection of Reference Points

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

3.2 Field Surveys

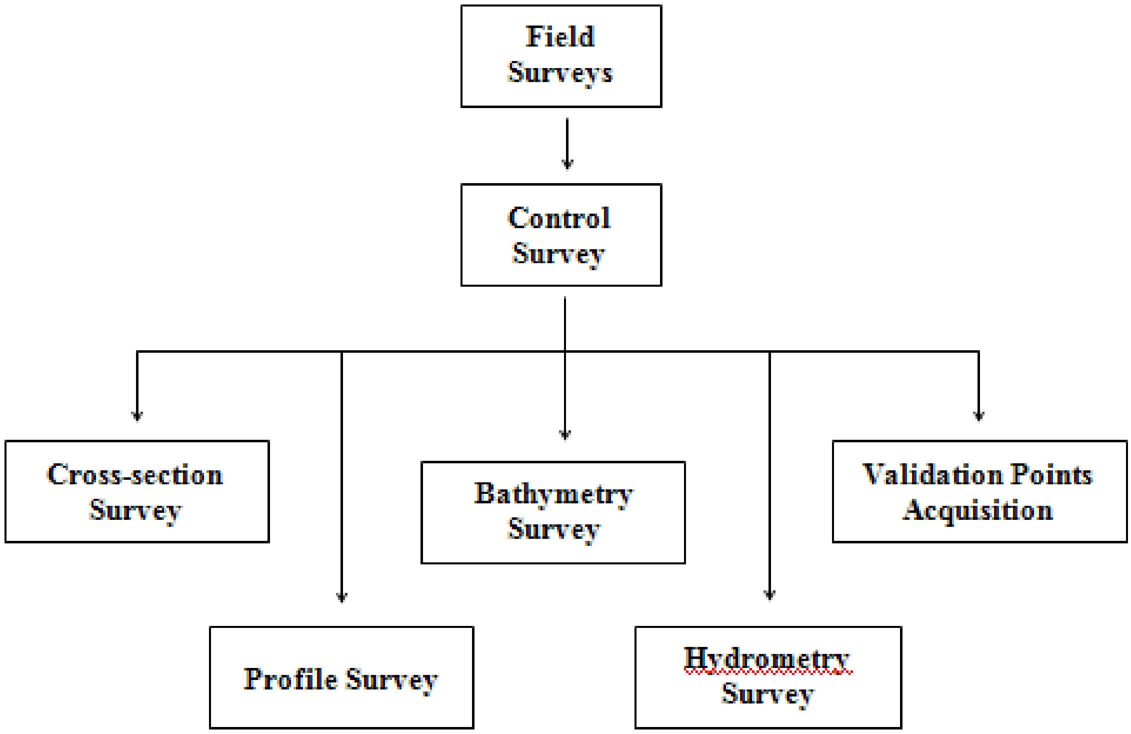


Figure 6. DVC Field Activities

3.2.1 Control Survey

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

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

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

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

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

3.2.2 Cross-section Survey

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

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

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

3.2.3 Profile Surveys

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

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

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

3.2.4 Bathymetric Survey

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

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

3.2.5 Hydrometric Survey

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

The elements of discharge computation are the ff.:

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

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

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

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

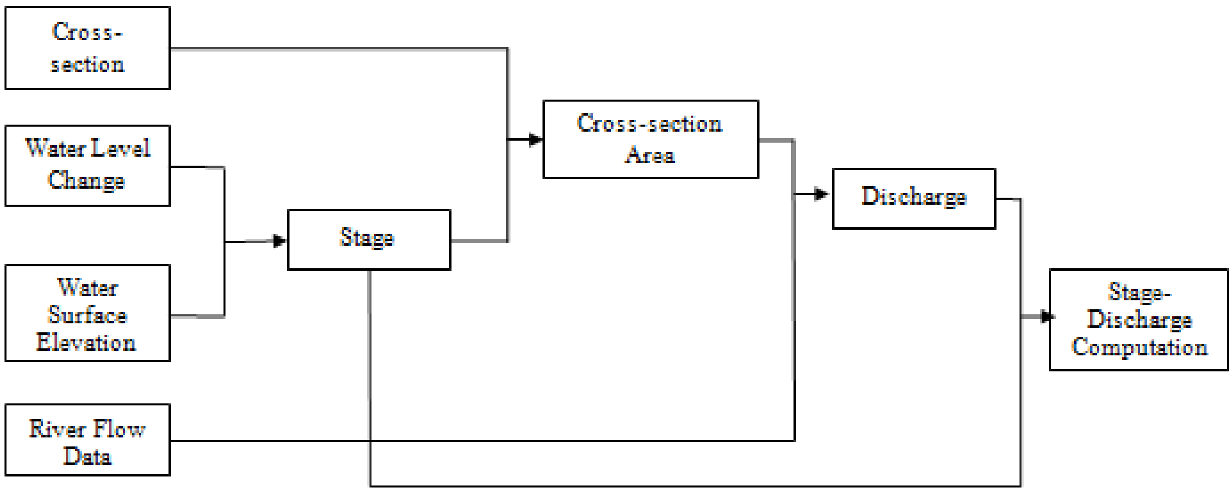


Figure 7. Flow Chart for Stage-Discharge Correlation Computation

3.2.5 Validation Points Acquisition Survey

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

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

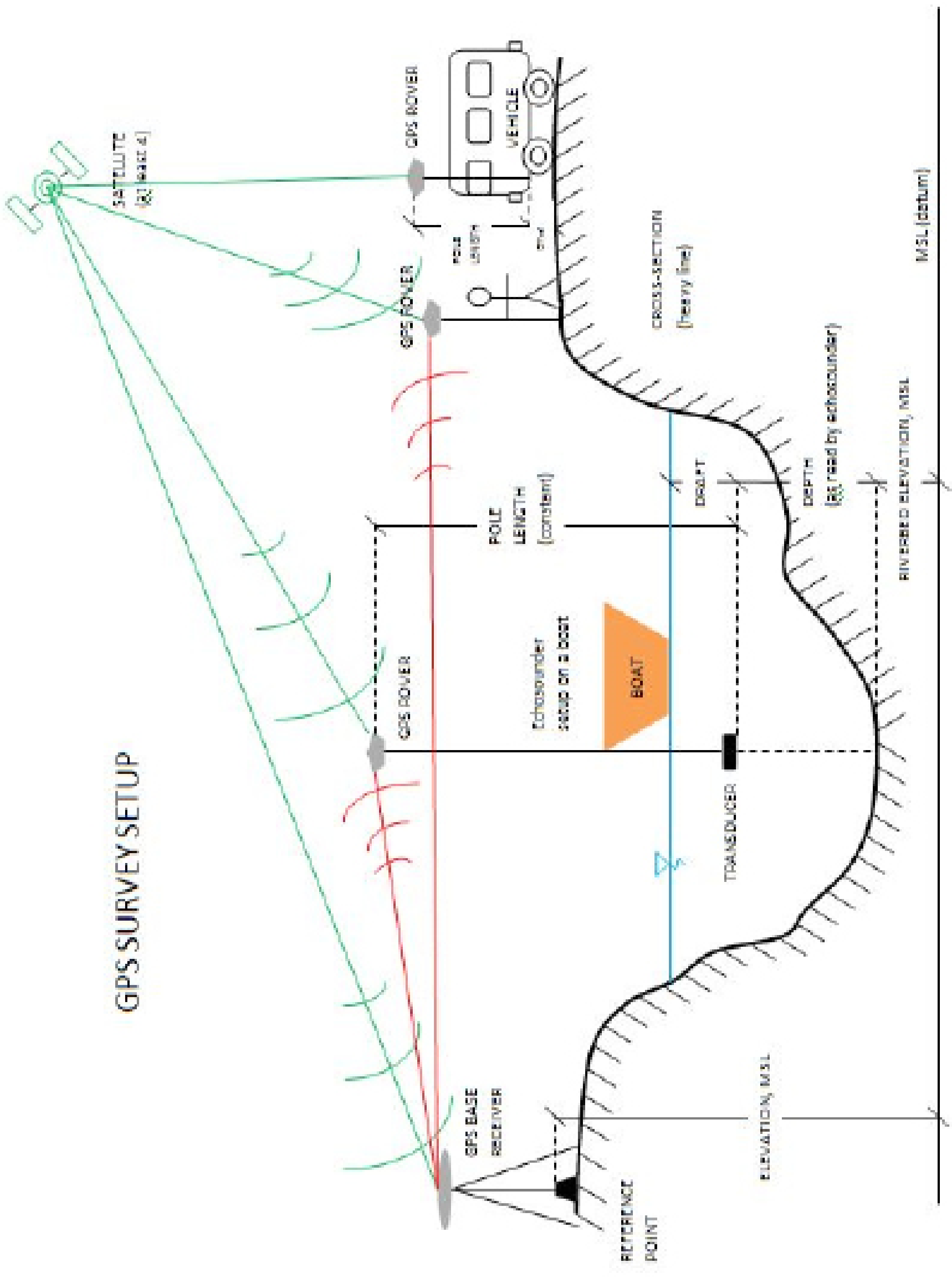


Figure 8. Set-up for GNSS Survey

3.3 Data Processing

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

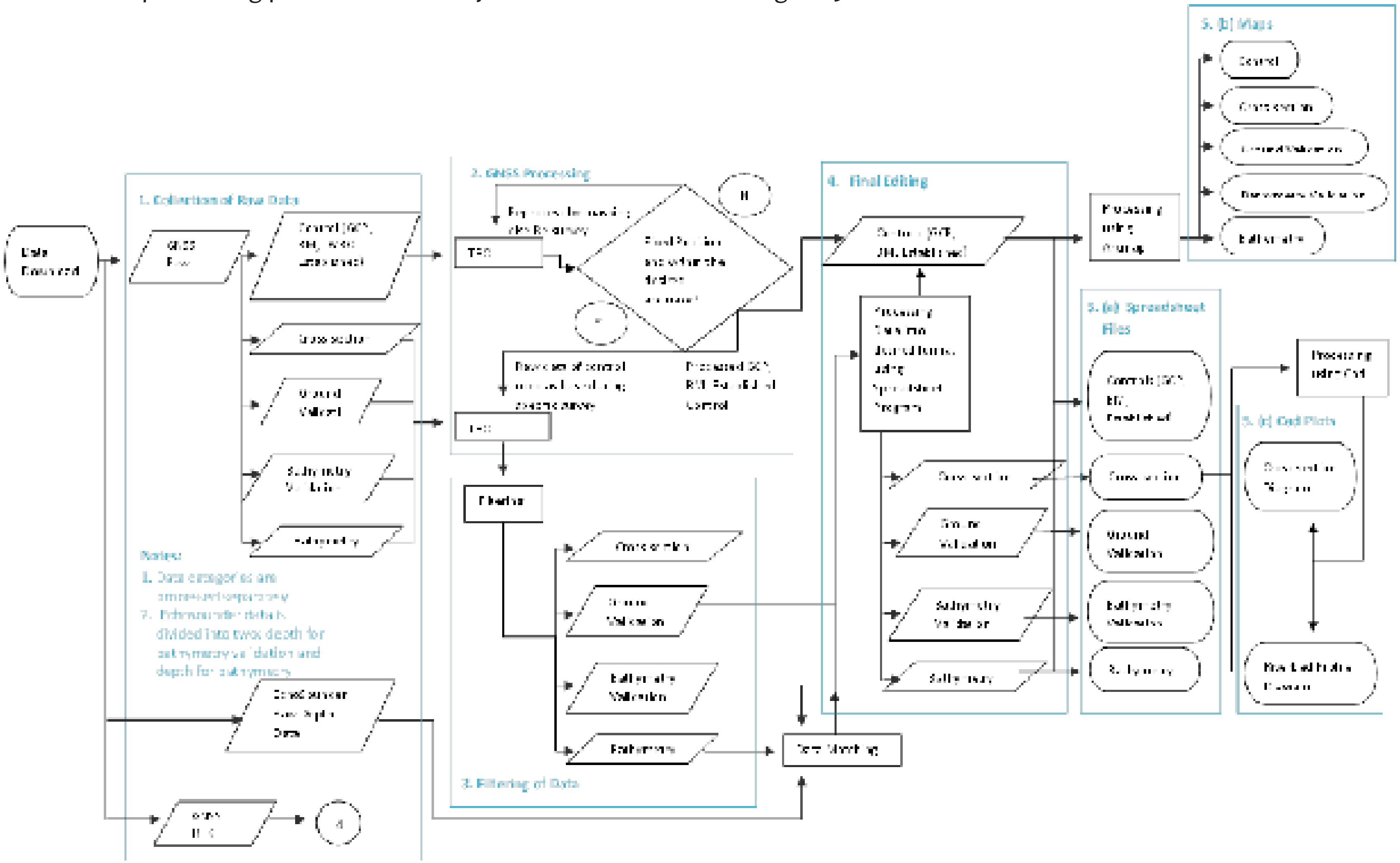


Figure 9. DVC Data Processing Methodology

3.3.1 Collection of Raw Data

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

3.3.2 Data Processing

Processing for GNSS Data

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

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

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

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

Computation for offset:

Equation 1:

$$OFFSET = BM - EGM$$

Computation for BM_ortho:

Equation 2:

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

where:

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

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

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

Depth Data Processing

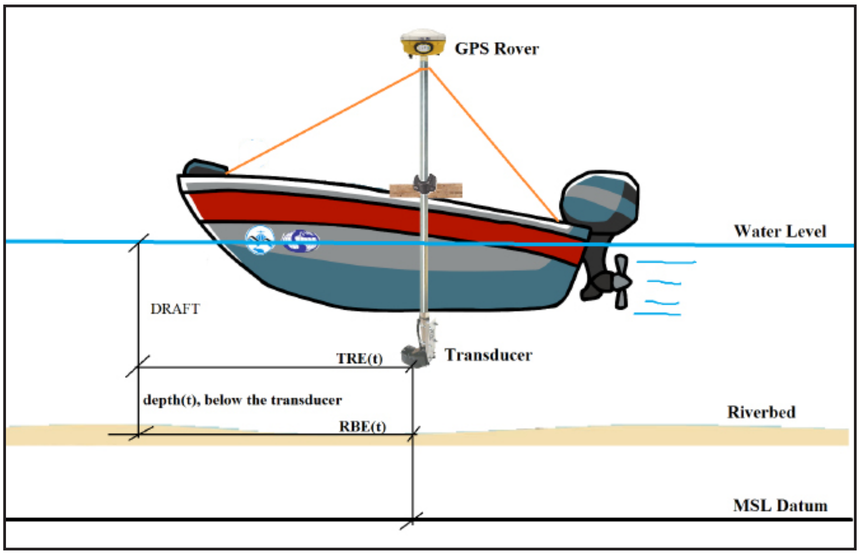


Figure 10. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

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

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

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

Data Matching for Bathymetric Data

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

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

Equation 3:

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

where:

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

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

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

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

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

Hydrometry Data Processing

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

1. **River Flow Data**

a.) ADCP

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

b.) Flow Meter

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

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

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

3. **Water Level Change-Stage**

a.) Depth Gauge

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

b.) AWLS

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

4. **Discharge Computation**

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

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

3.3.3 Filtering of Data

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

3.3.4 Final Editing

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

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

3.3.5 Output

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

Mag-Asawang Tubig River Basin Survey

Mag-Asawang Tubig River Basin Survey

The survey for Mag-Asawang Tubig River Basin was conducted on February 28 to March 11, 2013 with the following activities: control, bathymetric and hydrometric surveys, profile and cross-section lines reconnaissance for outsource.

Bathymetric Survey of Mag-Asawang Tubig started from the upstream of Brgy. San Carlos, Naujan down to Brgy. Nag-Iba II, Oriental Mindoro with a total length of about 22.4 km.

Mag-Asawang Tubig River consists of 18 delineated cross-section lines with a total length of 37.92 km for both left and right banks starting from Brgy. San Carlos, Naujan in the upstream down to Brgy. Nag-Iba II, Oriental Mindoro near the mouth of the river. The total length of profile lines is about 45.97 km for its both left and right banks. Ground surveys for both cross-section and profile lines were conducted by Joint Venture of Rasa Surveying & Realty and H.O. Noveloso on May 16 to June 22, 2013 as described in Annex F.

Another set of fieldwork was conducted on October 8-20, 2013 to acquire the cross-section and sensor elevation of the installed Automated Water Level Sensor (AWLS) and to perform flow data gathering in Cawacat Bridge, Bulalacao, Oriental Mindoro; Sumagui Bridge, Bansud Oriental Mindoro; Bucayao Bridge, Calapan, Oriental Mindoro; Alag Bridge, Baco, Oriental Mindoro and Mag-Asawang Tubig Naujan, Oriental Mindoro.

4.1 Control Survey

Two (2) NAMRIA established control points and an established UP- TCAGP control point were considered for the static GNSS observations of Mag-Asawang Tubig River. These include a first order benchmark MR-178 at Pangalaan bridge; a second order reference point MRE-32 at the compound of Victoria Municipal Hall; and an established control point in Brgy. Barcenaga, Naujan. The GNSS set-up for the three (3) base stations are shown in Figure 12, Figure 13 and Figure 14 while the location of these controls are shown in Figure 11. Established control point in Brgy. Barcenaga, Naujan served as GNSS base station for Mag-Asawang Tubig River bathymetry and ground validation survey for aerial LiDAR.

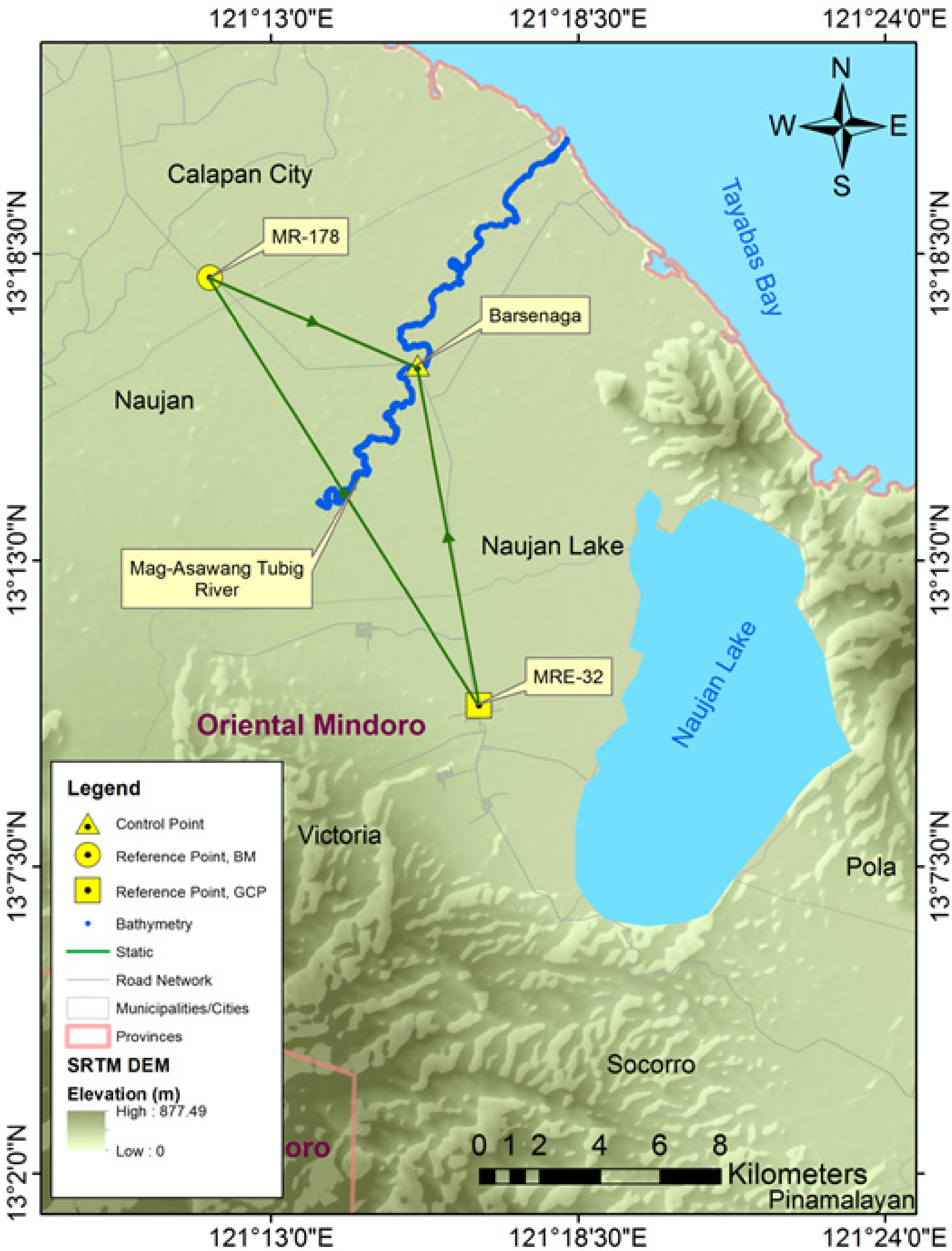


Figure 11. Location of control points

Continuous differential static observations were done simultaneously at these three stations for two hours to provide reference control points for the ground and bathymetric surveys. The horizontal coordinates and elevations of the three (3) control points were computed using Trimble™ Business Center GNSS processing software. The result of control survey for the control points are indicated in Table 1.

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

Point Name	Order	WGS84 UTM Zone 51N					Elevation in MSL (m)
		Latitude	Longitude	Ellipsoid Height (m)	Northing (m)	Easting (m)	
Barsenaga		13d16'29.94775"	121d15'37.52846"	60.391	1468202.741	311541.847	10.5122
MR-178	1st	13d18'04.61273"	121d11'54.11794"	63.722	1471159.795	304837.769	14.1562
MRE-32	2nd	13d10'23.79510"	121d16'43.46244"	67.674	1456936.578	313449.201	17.1752

The GNSS setup for the three (3) control points are illustrated in Figure 12, Figure 13 and Figure 14:

Figure 12. Static GNSS observation at MRE-32 at Victoria, Oriental Mindoro

Figure 13. Static observation at MR-178 at Pangalaan Bridge, Oriental Mindoro

Figure 14. Base set-up at a control point at Brgy. Barcenaga, Naujan, Oriental Mindoro

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 Rasa Surveying & Realty and H.O. Noveloso.

Reconnaissance was conducted simultaneously with bathymetric and hydrometric measurements from February 28 to March 11, 2013.

4.2 Reconnaissance of Cross-section and Profile Lines

Ocular inspection of the proposed cross-section and profile lines of Mag-Asawang Tubig River was the main objective of the team since cross-section and profile surveys were outsourced to Joint Venture of Rasa Surveying & Realty and H.O. Noveloso.

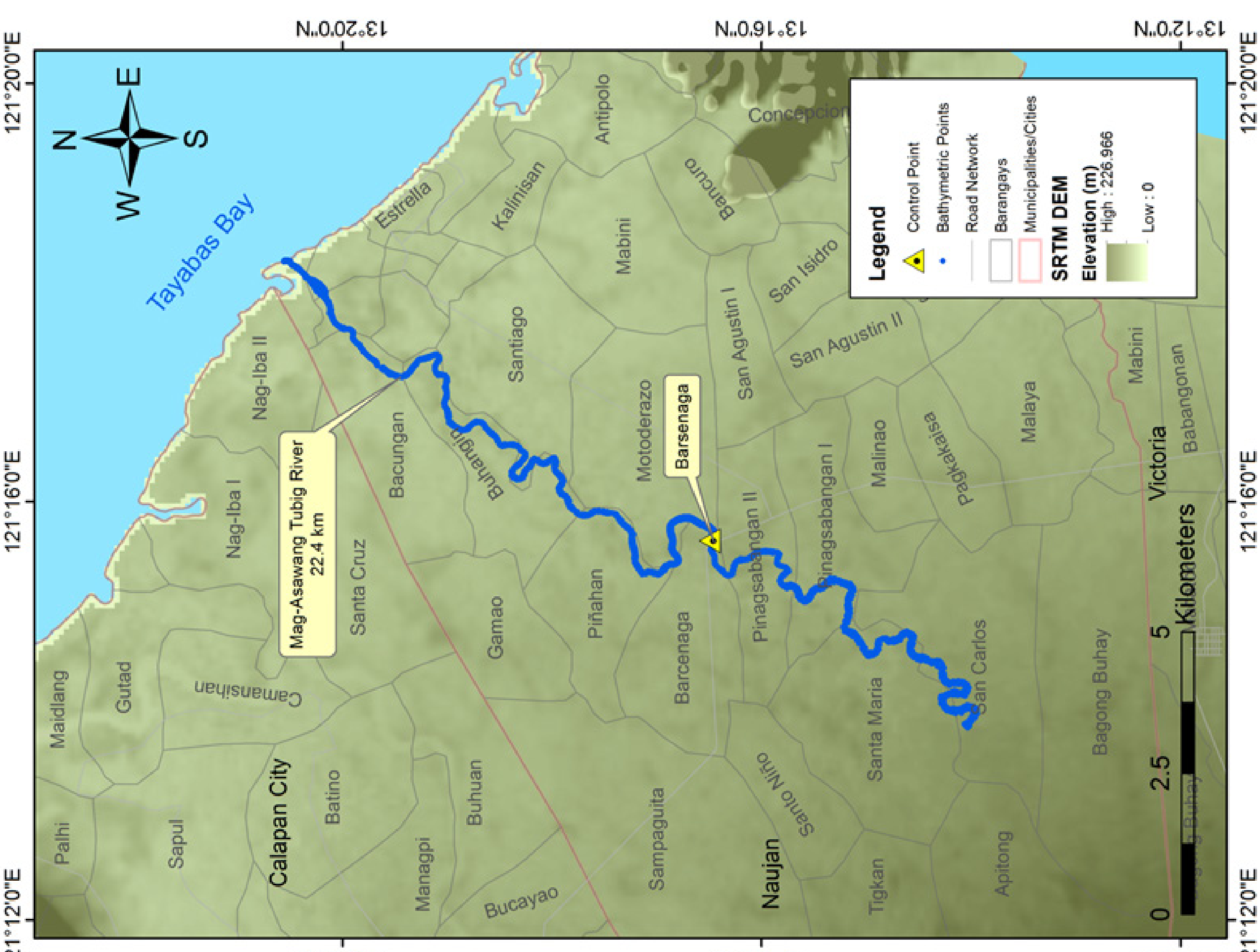
Each cross-section lines were located using handheld GPS (Garmin Montana™ 650). Summary of reconnaissance for the 18 cross-sections are shown in detail in Annex E. Reconnaissance for profile lines were conducted simultaneously with the bathymetric surveys.

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 bathymetry of the river channel was surveyed using an echosounding surveying technique. Differential GNSS surveying technique and an Ohmex™ single beam echosounder were utilized in measuring the depth, eventually obtaining elevation with corresponding horizontal position. Bathymetry setup during the Mag-Asawang Tubig bathymetry survey is illustrated in Figure 15.

The entire bathymetry survey took seven (7) days to accomplish from March 3-9, 2013. The Bathymetry Team executed the survey using a fishing boat rented from the locals in the area. Centerline and zigzag sweep of the survey were performed in order to fully capture the topography of the river. Shallow water impedes the progress of bathymetric survey team. The team covered only an approximate length of 2.6 km using echosounder, the remaining length is surveyed manually by traversing the river by foot. The total length of the river is 22.4 km.



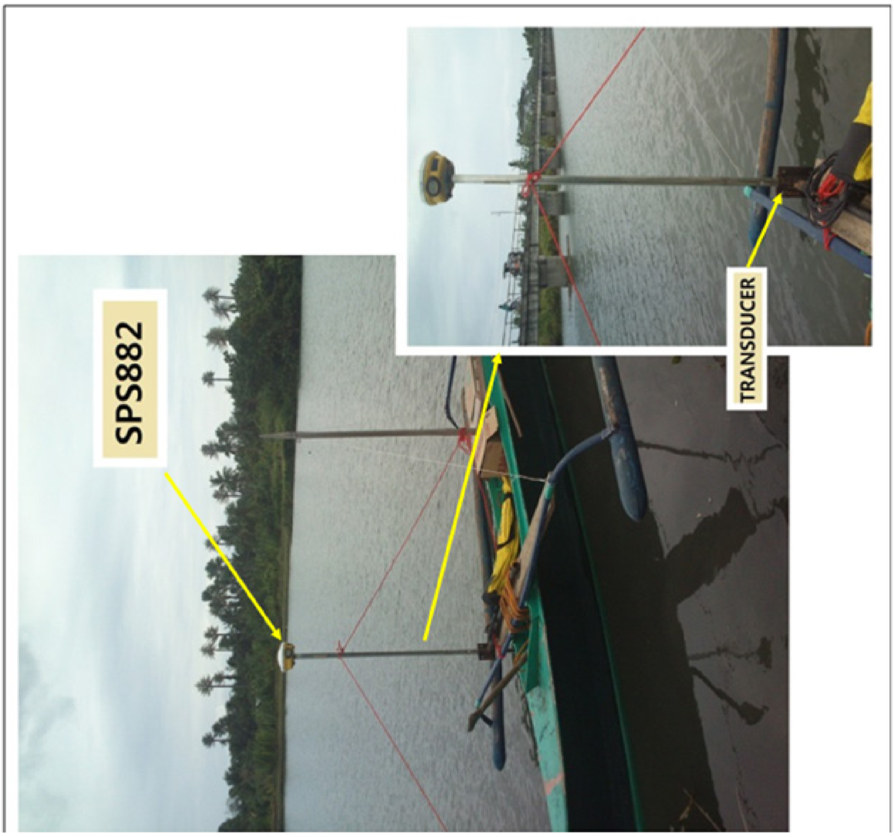


Figure 15. (left) Bathymetry data in Mag-Asawang Tubig River (right) Bathymetric survey setup

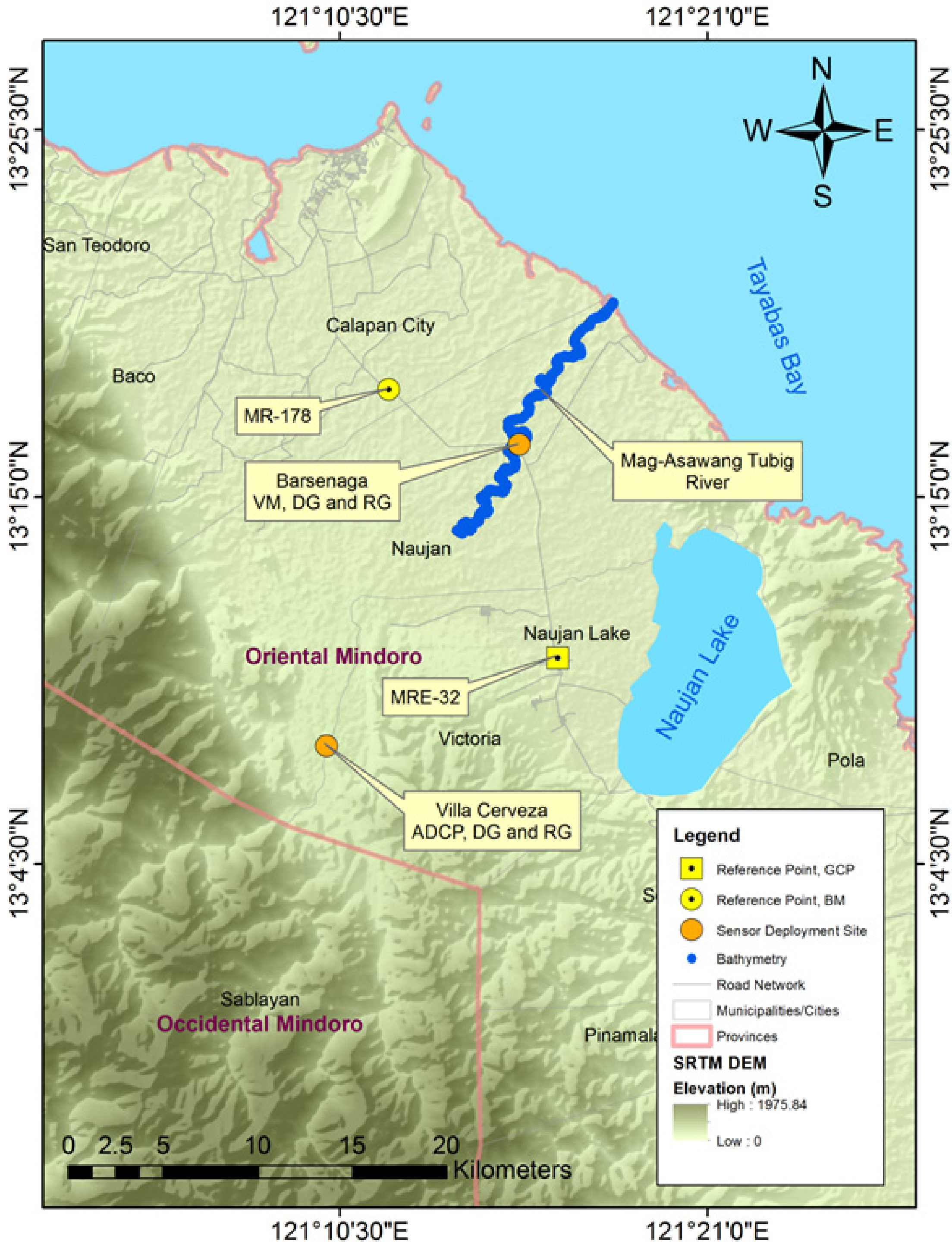


Figure 16. Mag Asawang Tubig River Sensor Locations

4.4 Hydrometric Survey

4.4.1 Hydrometric Sensors Deployment with Stage Discharge Computation

Different sensors were deployed on the banks of Mag-Asawang Tubig 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.

A velocity meter was deployed with a depth gauge and rain gauge in Brgy. Villa Cerveza from March 1-2, 2013 and in Brgy. Barcenaga, Naujan, Oriental Mindoro from March 3-10, 2013. Another survey was conducted and re-deployed the velocity meter with depth gauge and rain gauge in Brgy. Villa Cerveza from October 16-20, 2013.

The data gathered in Brgy. Barcenaga, Naujan, Oriental Mindoro from the rain gauge shows the distribution of rainfall within the observation period from March 3-10, 2013. Each sensor has a five (5)-minute interval. The first surge of rain, which reached 2.5 mm, was observed on March 5, 2013. The highest amount of rain collected occurred March 10, 2013 at 4.3 mm. The graphs in Figure 25 and Figure 20 shows the cross-section, stage, velocity, rainfall and discharge computation of Brgy. Barcenaga, Naujan, Oriental Mindoro and Brgy. Villa Cerveza, respectively. A value approaching R2 = 1 indicates a good correlation.

The summary of the location and deployment dates of the sensors used in Mag-Asawang Tubig River are shown in Table 2.

Table 2. Sensor location and deployment dates in Mag-Asawang Tubig River

Sensor	Location	Municipality	Deployment – Start	Deployment – End	Latitude	Longitude
Velocity Meter	Brgy. Villa Cerveza	Victoria	1-March 16-October	2-March 20-October	13°07’53.05”	121°10’07.73”
Velocity Meter	Brgy. Barcenaga	Naujan	3-March	10-March	13°16’27.2”	121°15’38.9”
Rain Gauge	Brgy. Barcenaga	Naujan	3-March	10-March	13°16’29.8”	121°15’37.9”
Depth Gauge	Brgy. Barcenaga	Naujan	3-March	10-March	13°16’27.2”	121°15’38.9”

The image in Figure 17 and Figure 18 shows the deployment of rain gauge and preparation of the velocity meter and depth gauge at Brgy. Barcenaga, Naujan, Oriental Mindoro, respectively. Velocity Meter with depth gauge were placed in a crate to ensure its safety from strong river currents. The image in Figure 19 and Figure 20 shows the deployment of ADCP and rain gauge at Brgy. Villa Cerveza. The cross-section graph and stage-discharge computation of these sensors are illustrated in Figures 21-30.

Figure 17. Rain Gauge deployment in Brgy. Barcenaga, Naujan Oriental Mindoro

Figure 18. Deployment of velocity meter and depth gauge in Brgy. Barcenaga Naujan Oriental Mindoro

Figure 19. ADCP and Depth Gauge deployed in Brgy. Villa Cerveza

Figure 20. Rain Gauge deployed in Brgy. Villa Cerveza

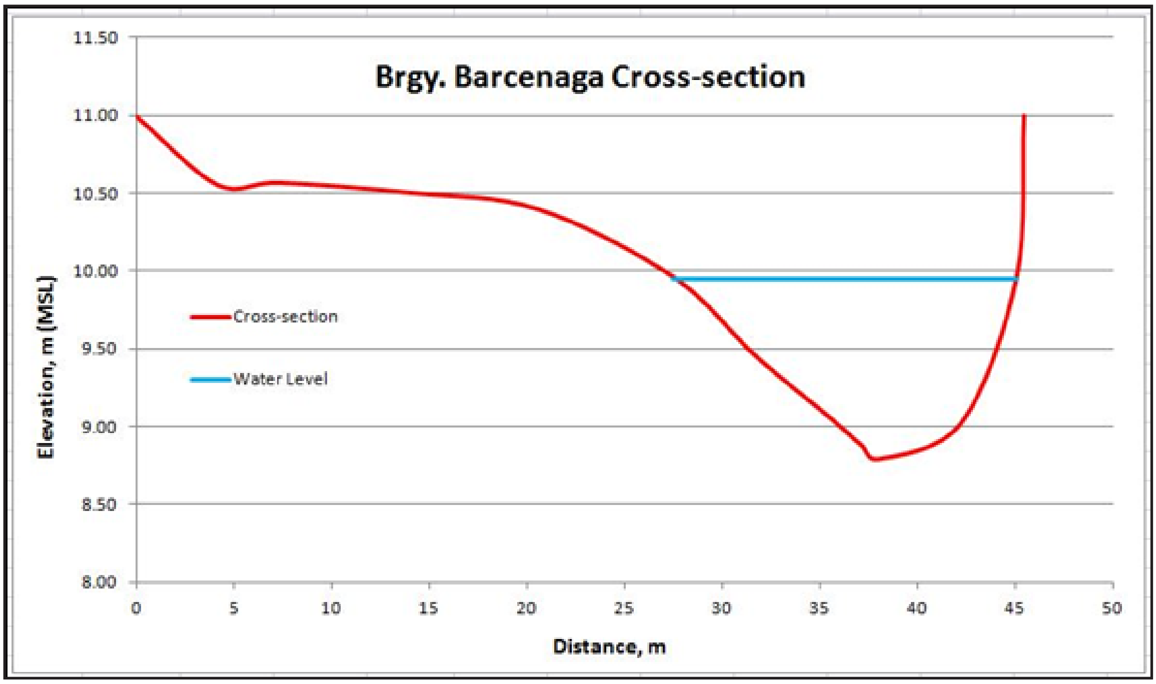


Figure 21. Velocity Meter cross-section survey in Brgy. Barcenaga, Naujan, Oriental Mindoro

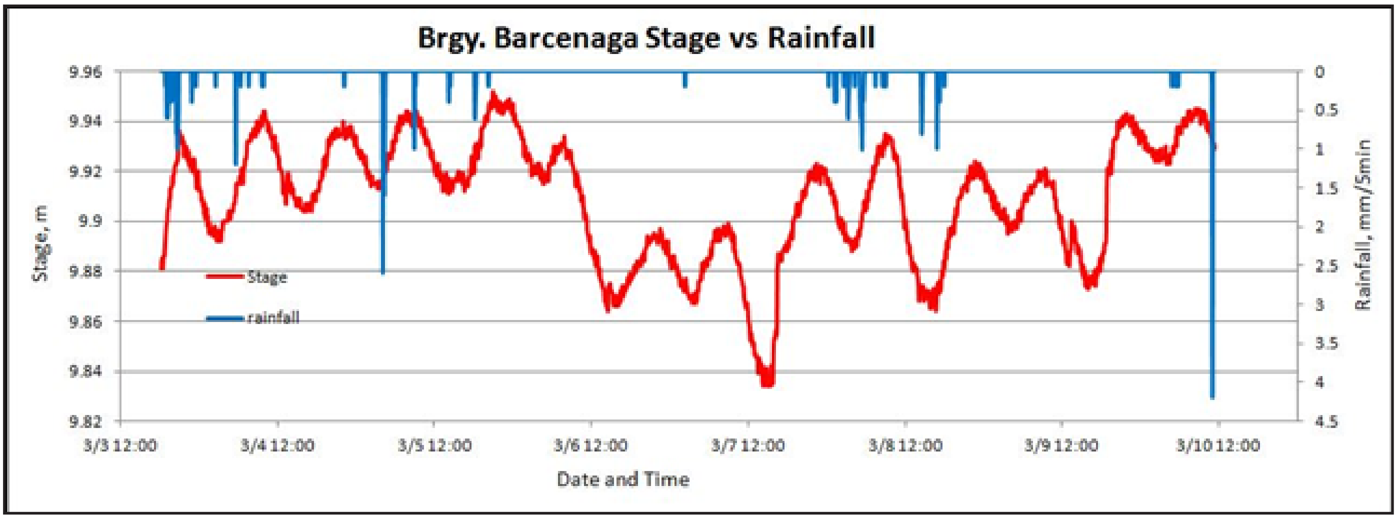


Figure 22. Stage vs Rainfall graph for Brgy. Barcenaga, Oriental Mindoro

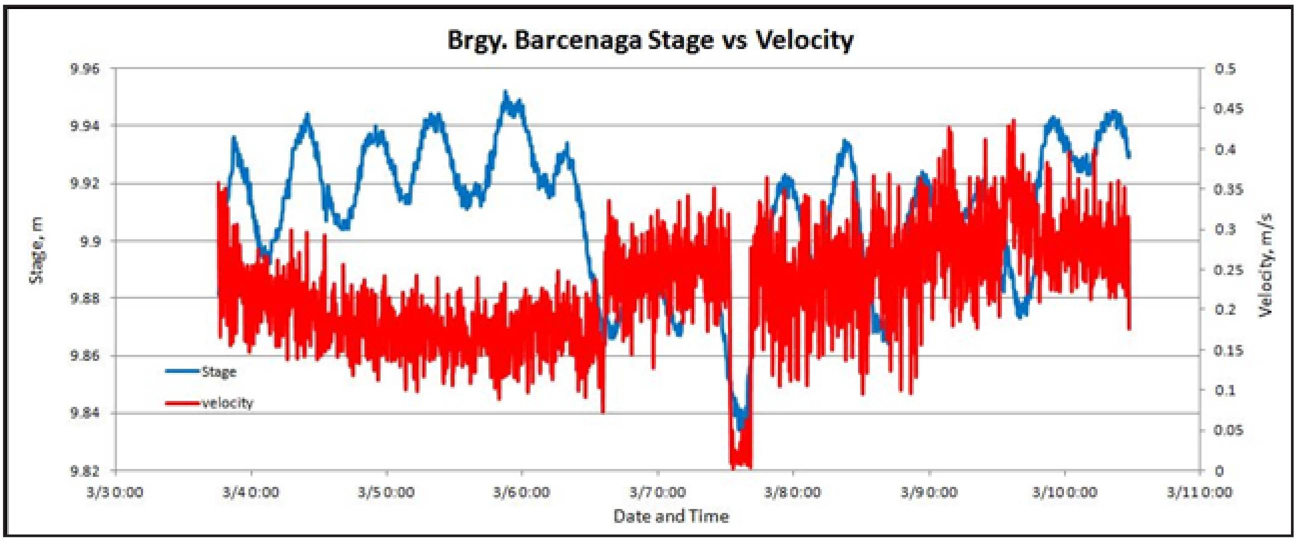


Figure 23. Stage vs Velocity graph for Brgy. Barcenaga, Oriental Mindoro

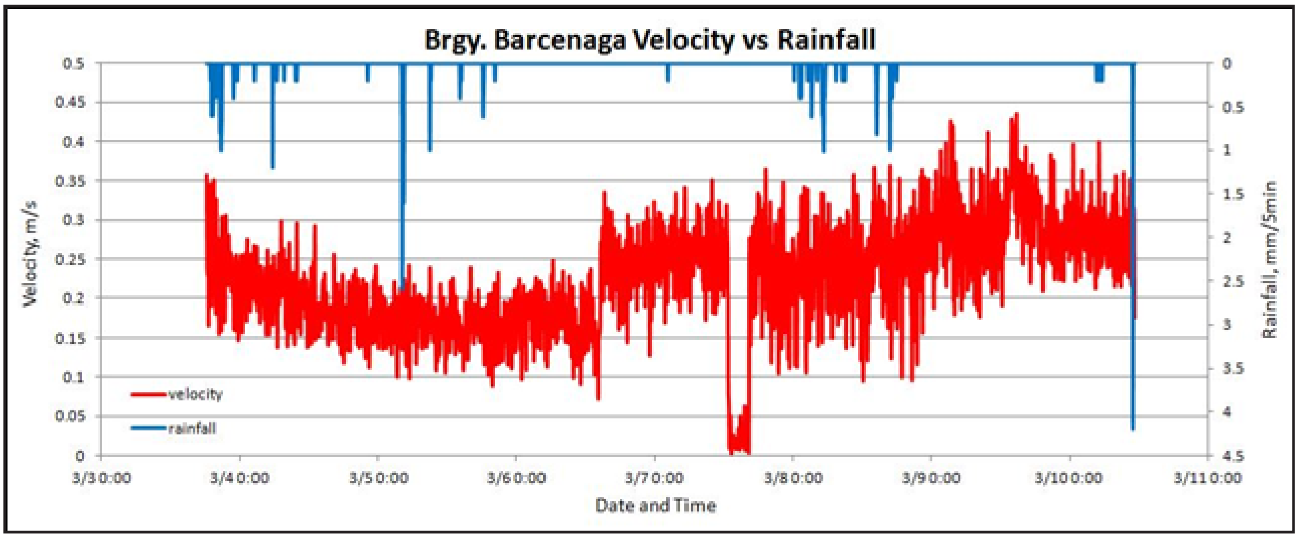


Figure 24. Velocity vs Rainfall graph for Brgy. Barcenaga, Oriental Mindoro

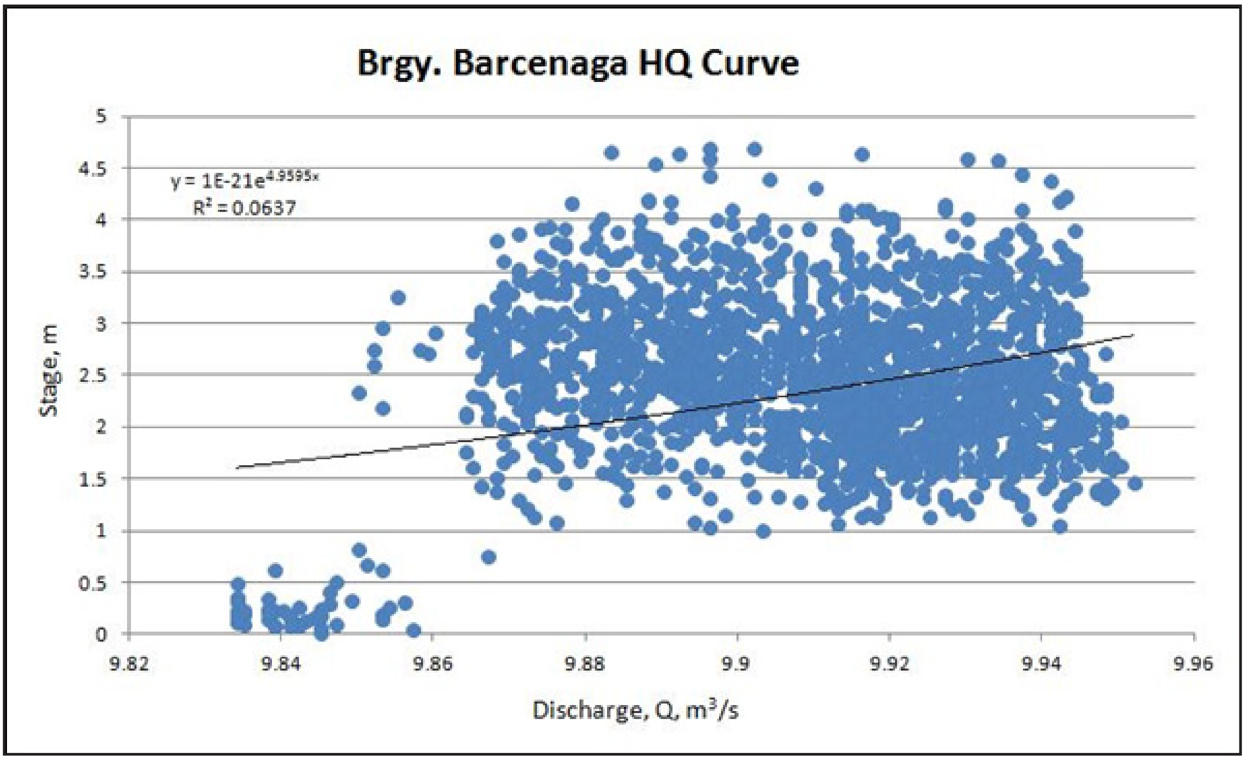


Figure 25. Brgy. Barcenaga, Oriental Mindoro HQ Curve

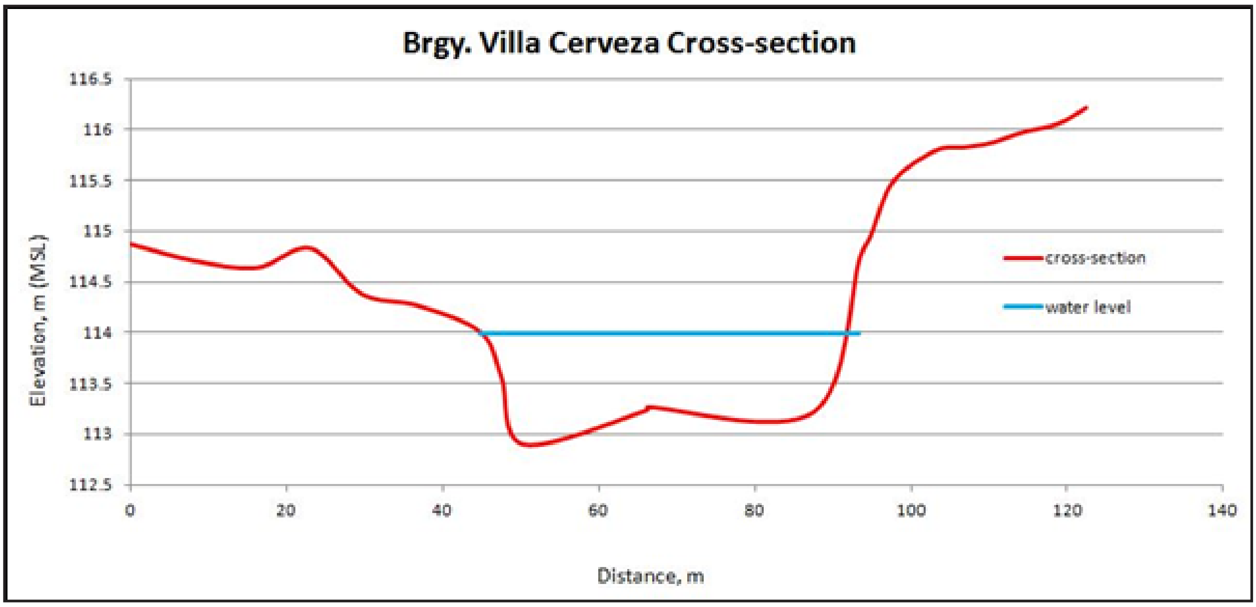


Figure 26. Velocity Meter cross-section survey in Brgy. Villa Cerveza, Oriental Mindoro

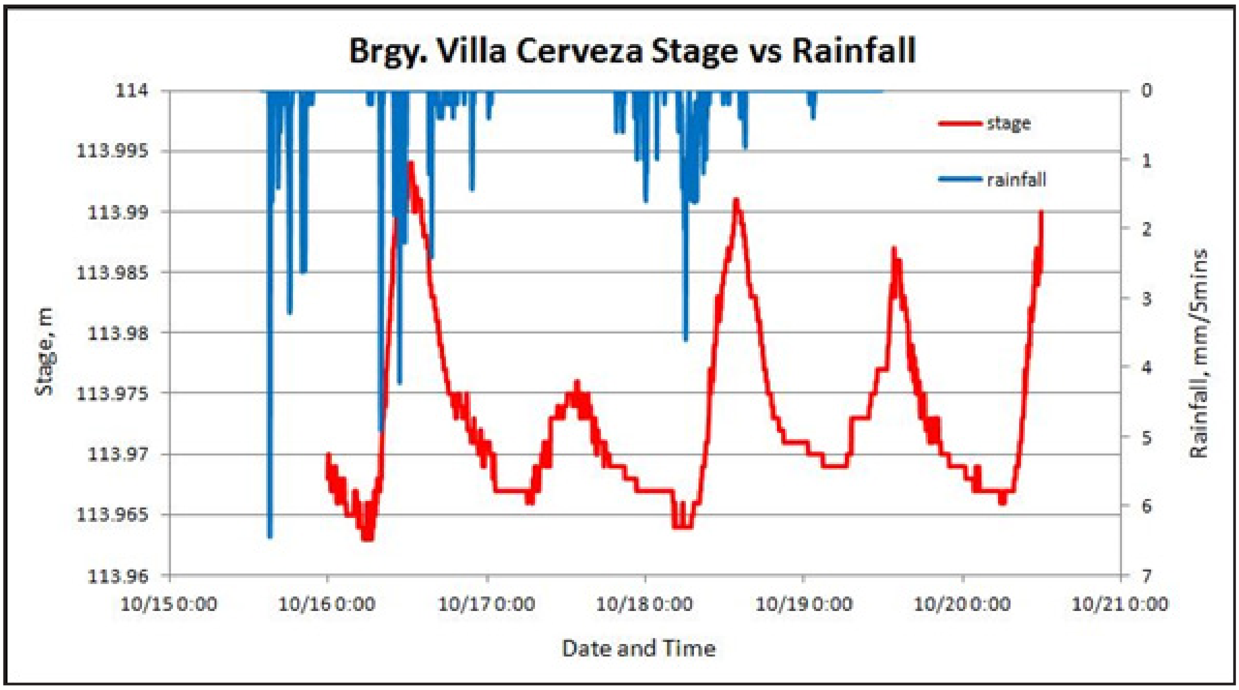


Figure 27. Stage vs Rainfall graph in Brgy. Villa Cerveza, Oriental Mindoro

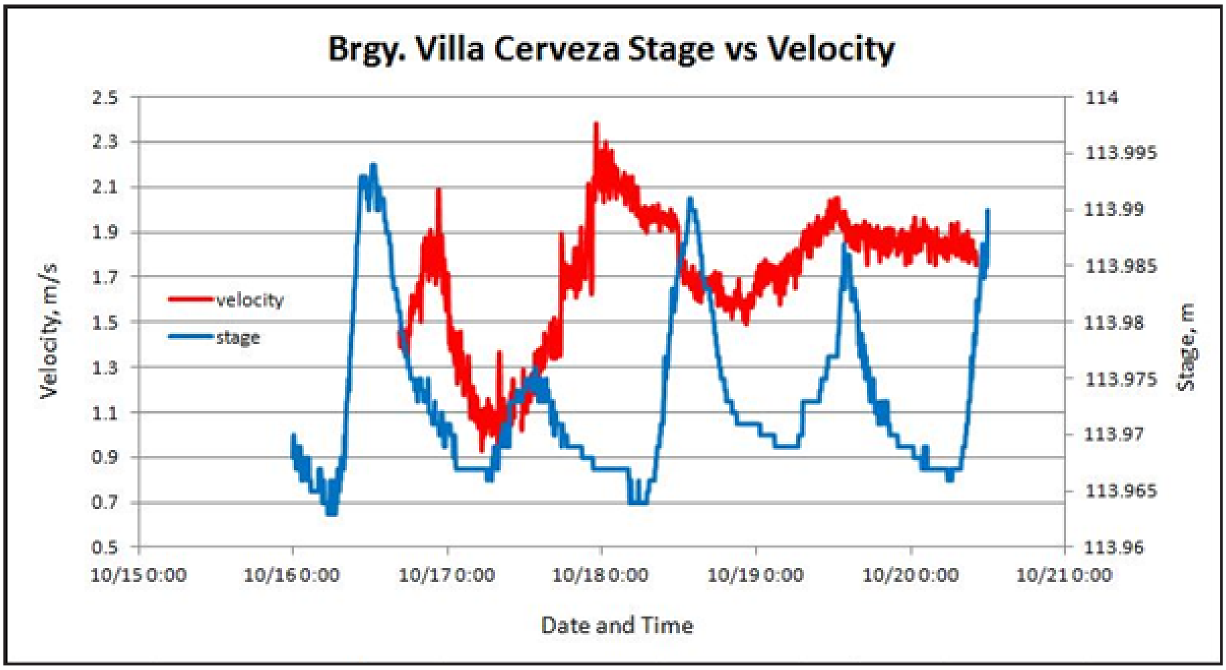


Figure 28. Stage vs Velocity graph in Brgy. Villa Cerveza, Oriental Mindoro

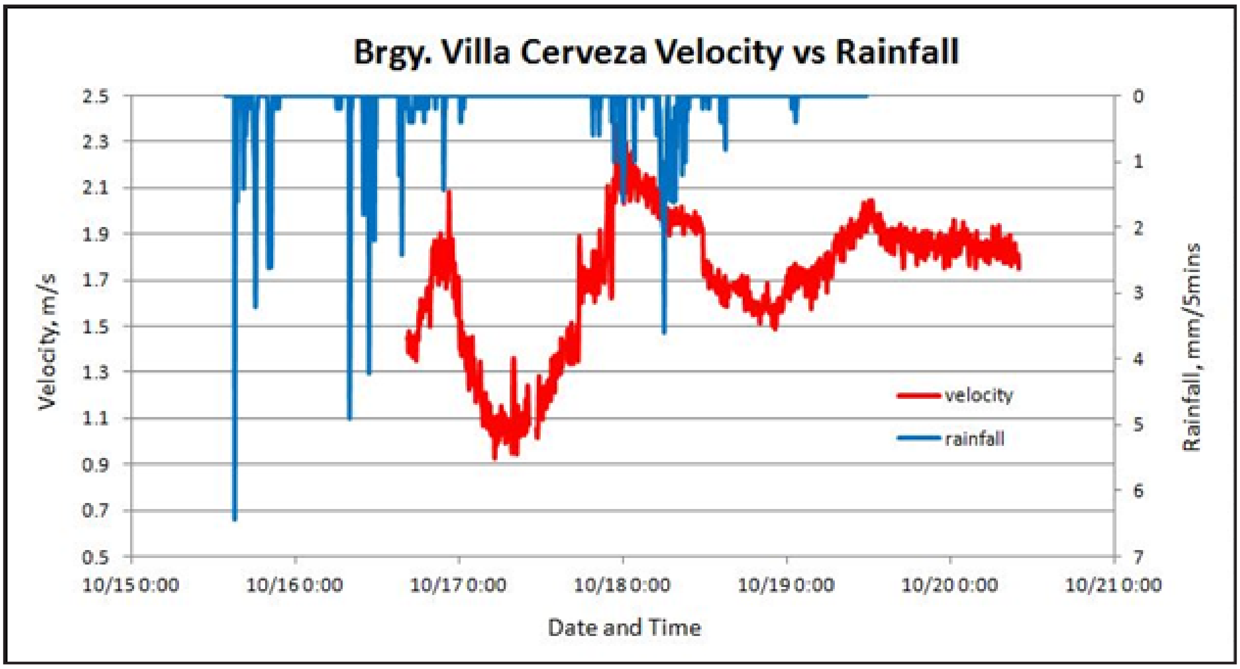


Figure 29. Velocity vs Rainfall graph in Brgy. Villa Cerveza, Oriental Mindoro

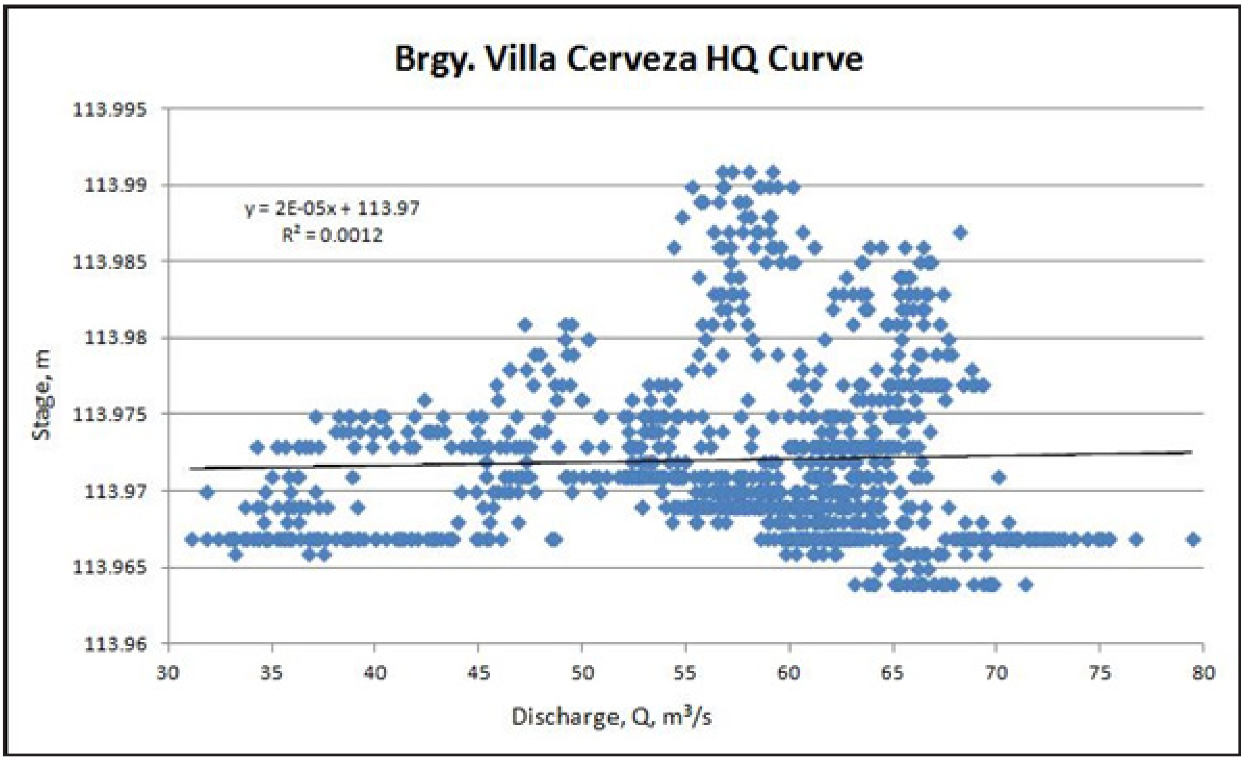


Figure 30. Brgy. Villa Cerveza, Oriental Mindoro HQ Curve

4.4.2 Oriental Mindoro AWLS Survey

Another survey was conducted for the installed AWLS in Oriental Mindoro in order to get its cross-sectional area and water surface elevation in MSL on October 8-20, 2013. River velocity was also acquired using a mechanical flow meter.

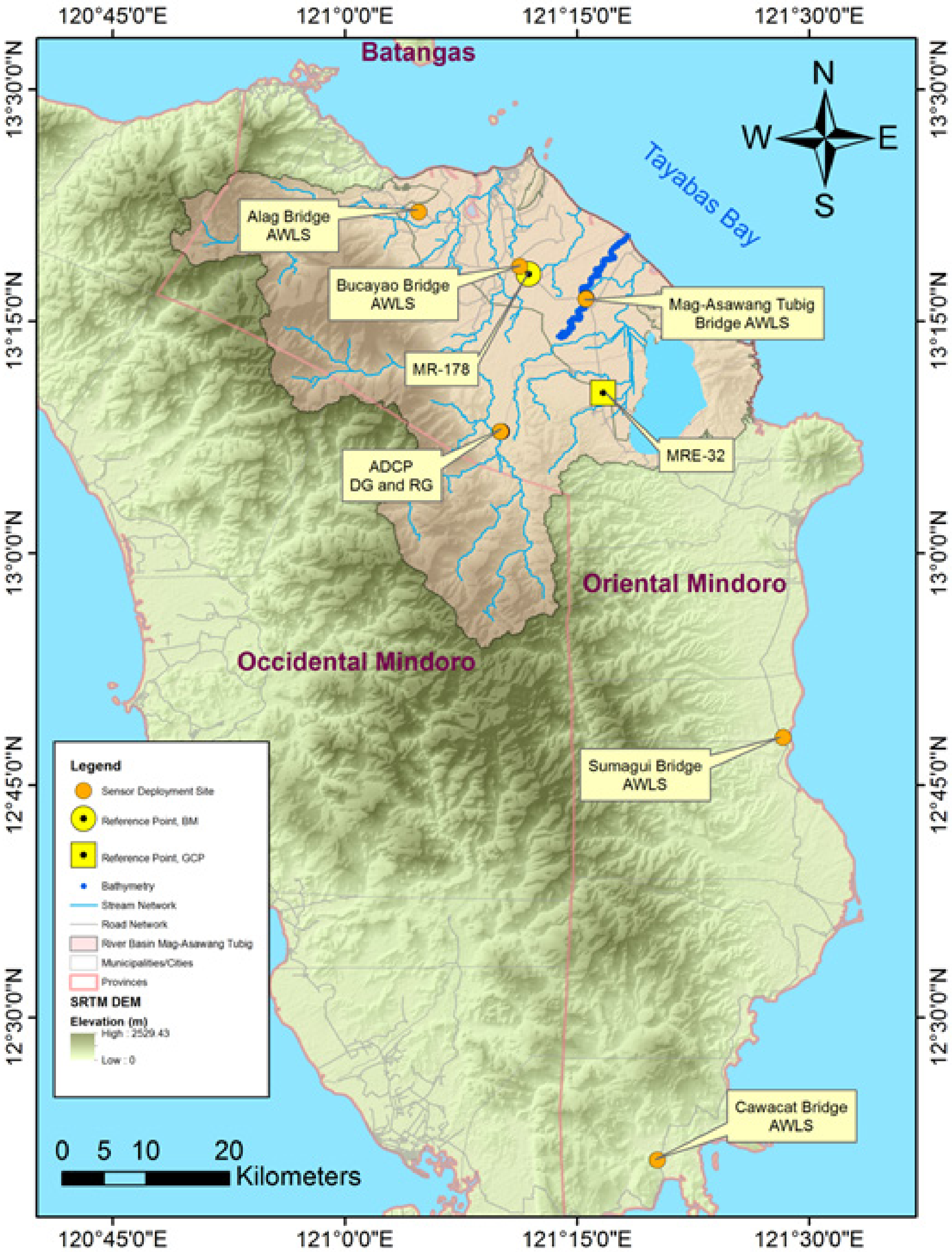


Figure 31. Oriental Mindoro AWLS Survey Extent

4.4.2.1 AWLS Cross-section Survey

Cross-section surveys were conducted for the bridges with installed AWLS along the Mag-Asawang Tubig 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 sites in Mag-Asawang Tubig River System with its respective MSL value.

AWLS	Location	Coordinates	AWLS Elevation (m), MSL	Water Surface Elevation (m), MSL with Date& Time	Image
Sumagui Bridge	Sumagui Bridge, Bansud, Oriental Mindoro	Lat 12 48 06.08270 N Long 121 28 20.72741 E	6.675 m	0.350 m (Oct. 10, 2013 at 6:06 PM)	
Mag-Asawang Tubig Bridge	Mag asawang Tubig, Naujan, Oriental Mindoro	Lat 13 16 26.54238 N Long 121 15 36.74915 E	16.412 m	8.556 m (Oct. 11, 2013 at 11:18 AM)	

Mag-Asawang Tubig River Basin Survey

AWLS	Location	Coordinates	AWLS Elevation (m), MSL	Water Surface Elevation (m), MSL with Date& Time	Image
Alag Bridge	Alag Bridge, Baco, Oriental Mindoro	Lat 13 22 05.[illegible] N Long 121 05 4[illegible] E	10.510 m	1.856 m (Oct. [illegible], 2013 at 10:30 AM)	
Bucayao Bridge	Bucayao Bridge, Calapan, Oriental Mindoro	Lat 13-18-33.94[illegible] N Long 121-[illegible]-49.77[illegible] E	16.375 m	5.[illegible] m (Oct. 11, 2013 at 3:21 PM)	
Cawacat Bridge	Cawacat Bridge, Bulalacao, Oriental Mindoro	Lat 12 20 46.49913 N Long 121 20 13.[illegible] E	7.685 m	1.129 m (Oct. 15, 2013 at 1:33 PM)	

The diagram of cross-section data gathered for bridges with installed AWLS is illustrated in Figures 32-36.

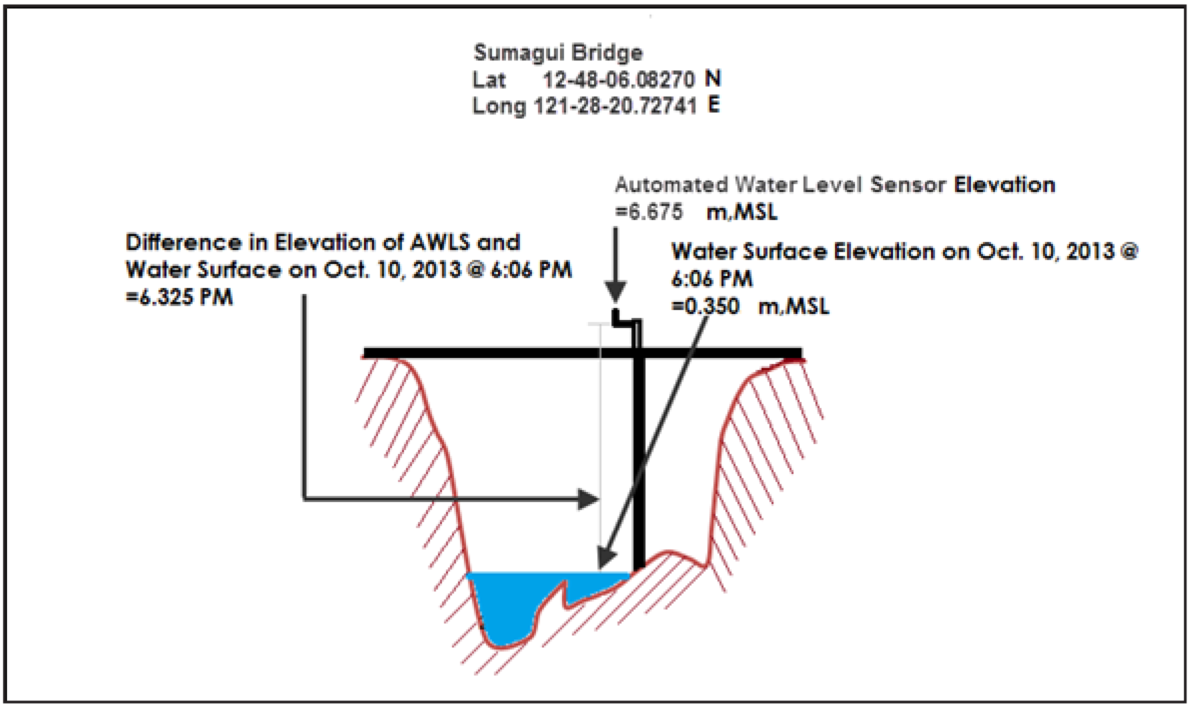


Figure 32. AWLS in Sumagui Bridge, Bansud Oriental Mindoro

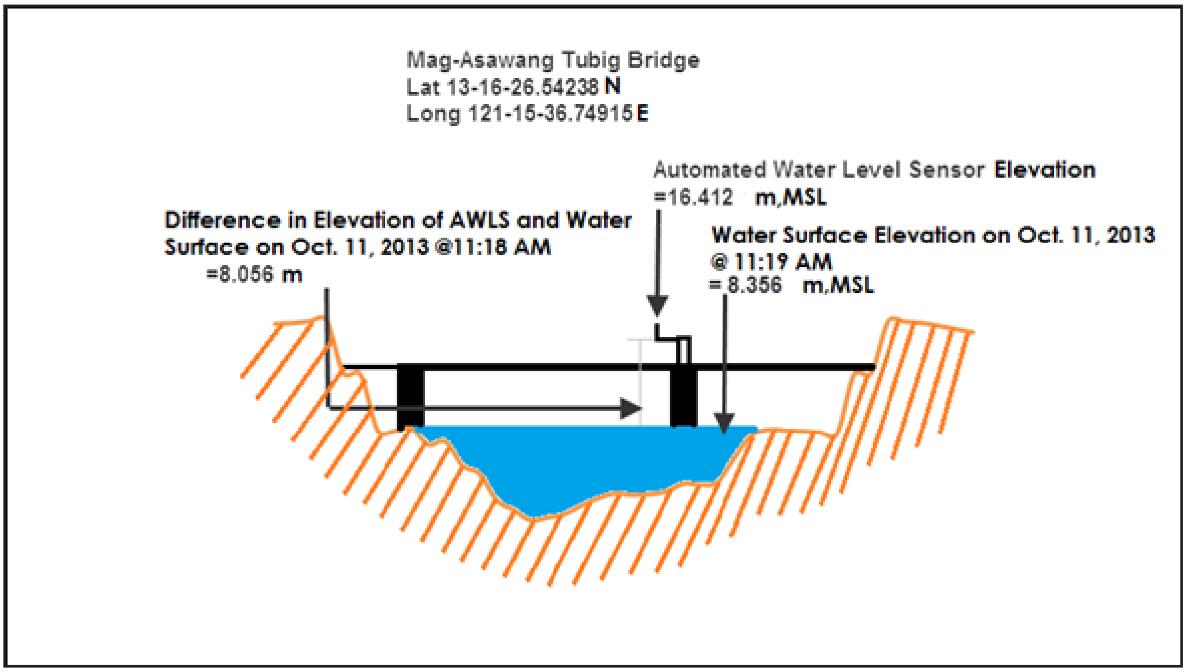


Figure 33. AWLS in Mag-Asawang Tubig Bridge, Naujan Oriental Mindoro

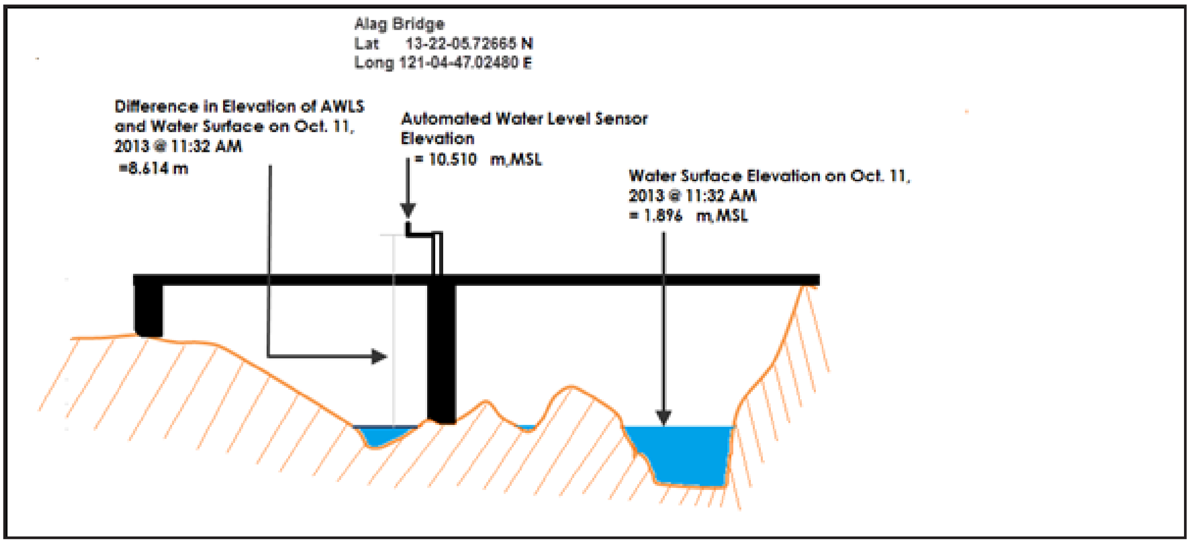


Figure 34. AWLS in Alag Bridge, Baco Oriental Mindoro

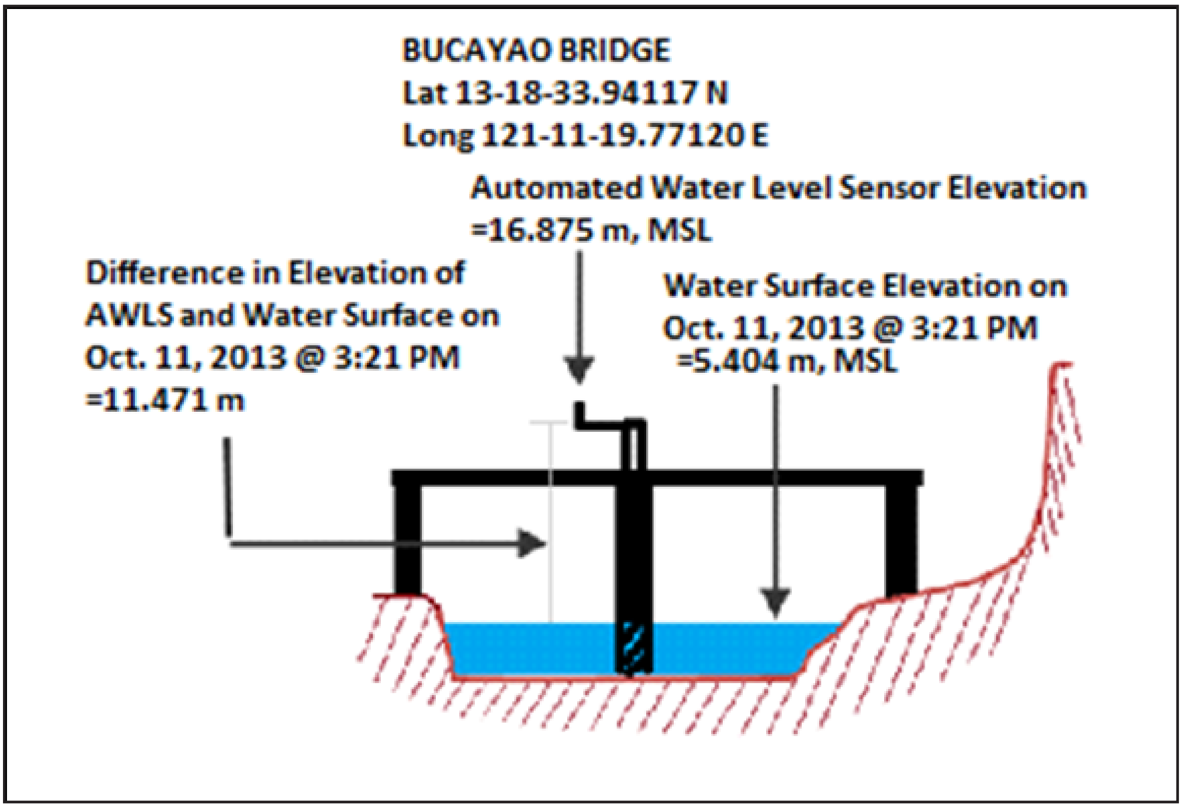


Figure 35. AWLS in Bucayao Bridge, Calapan Oriental Mindoro

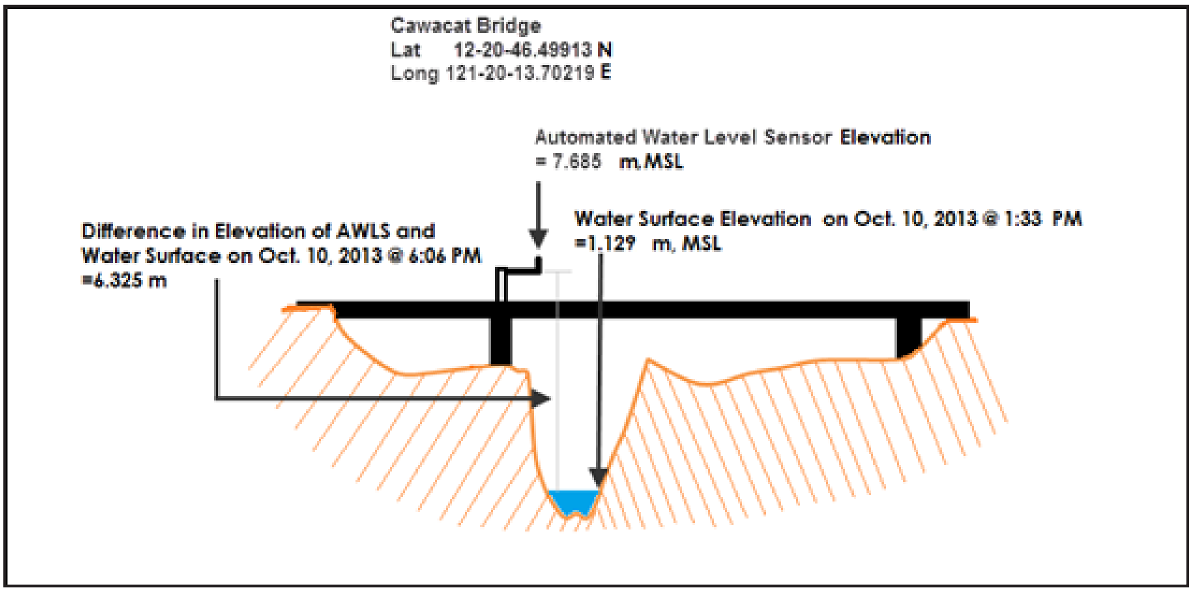


Figure 36. AWLS in Cawacat Bridge, Oriental Mindoro

4.4.2.2 Flow Measurements and Stage Discharge Computation

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. The summary of hydrometry data gathered per bridge location is summarized in Table 4.

Figure 37. Flow measurements using a rotor-type flow meter

Table 4. Summary of AWLS Field Survey

Bridges	Cross Section	Water Level	Flow Measurement	Rainfall	Remarks
Sumagui	✓	✓	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
Mag-Asawang Tubig	✓	No data from repo.pscigrid.gov.ph	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
Alag	✓	No data from repo.pscigrid.gov.ph	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
Bucayao	✓	✓	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.
Cawacat	✓	✓	✓	No data from repo.pscigrid.gov.ph	No rainfall data from repo.pscigrid.gov.ph within the observation period.

A. Sumagui Bridge Stage Discharge Computation

River velocity data for Sumagui Bridge was plotted against water level data from an Automatic Water Level Sensor (AWLS). Flow measurements were recorded for one (1) day October 10, 2013 for three (3) hours observation. No rainfall was observed throughout the duration of survey. The summary of data gathered is illustrated in Figure 38 and Figure 39.

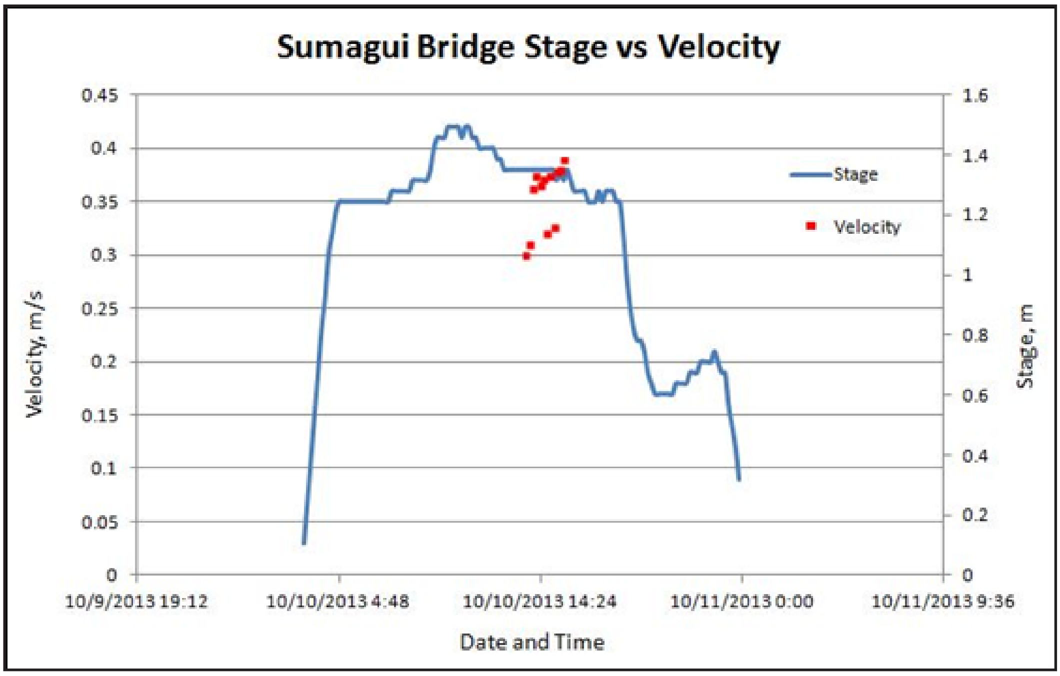


Figure 38. Stage vs Velocity graph for Sumagui Bridge

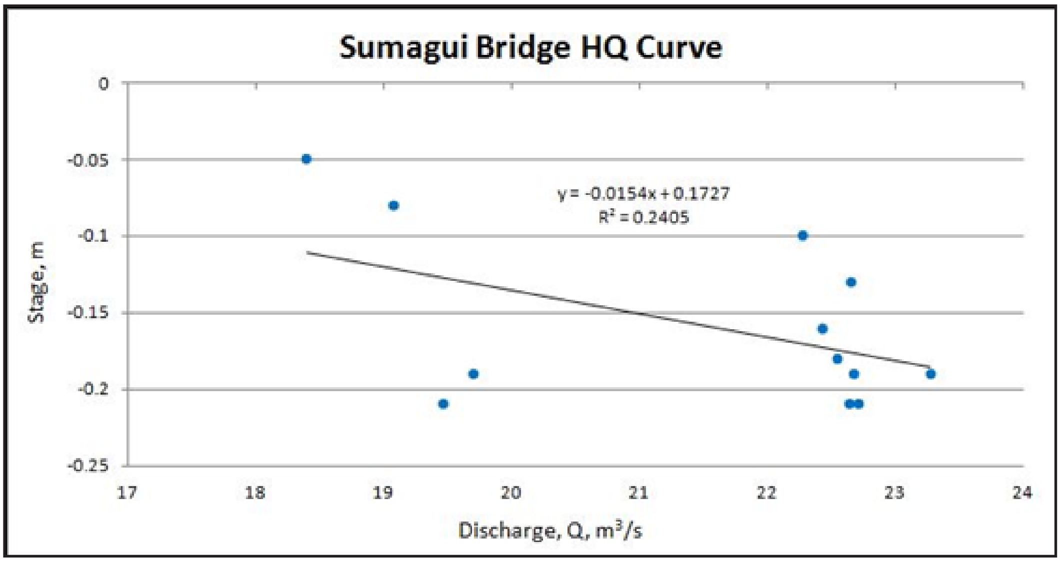


Figure 39. HQ Curve for Sumagui Bridge

B. Mag-Asawang Tubig Bridge Stage Discharge Computation

Flow measurements were recorded for eight (8) days from October 11-18, 2013. No water level and rainfall data extracted from *repo.pscigrid.gov.ph* at Mag-asawang Tubig Bridge. The summary of data gathered is illustrated in Figure 40.

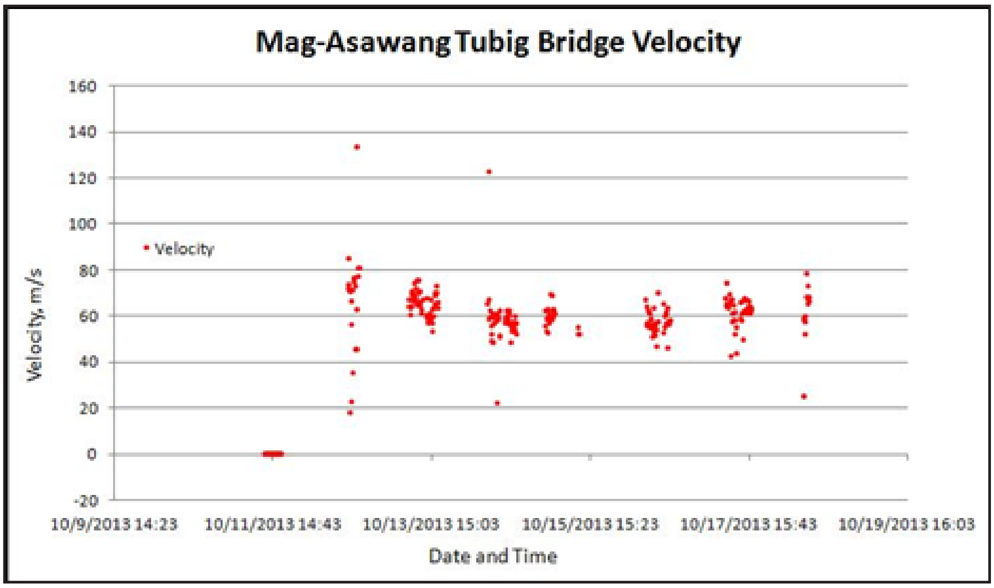


Figure 40. Stage vs Rainfall graph for Mag-Asawang Tubig

C. Alag Bridge Stage Discharge Computation

Flow measurements were recorded for one (1) day October 10, 2013 for three (3) hours observation. No water level and rainfall data extracted from *repo.pscigrid.gov.ph* at Alag Bridge. The summary of data gathered is illustrated in Figure 41.

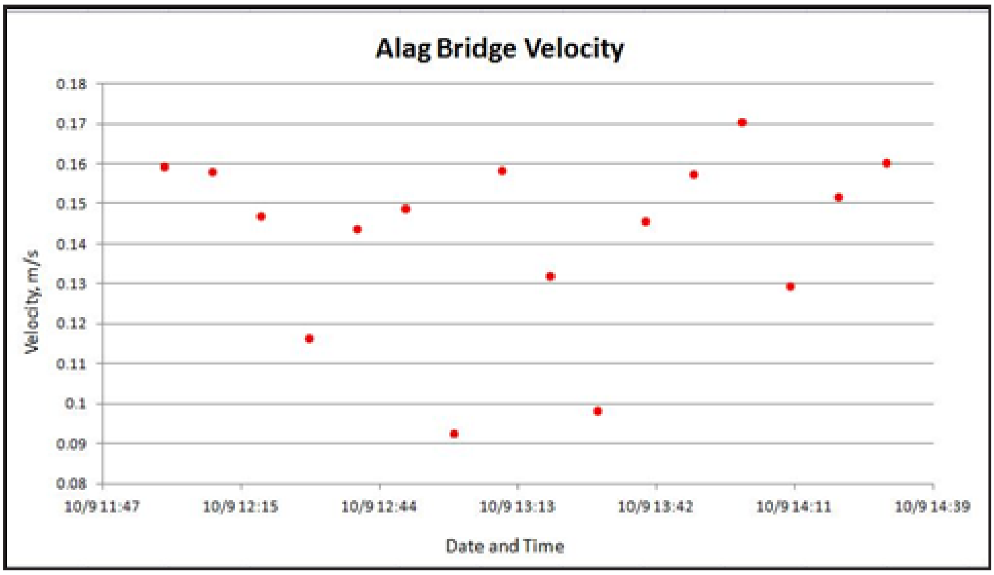


Figure 41. Alag Bridge Velocity graph

D. Bucayao Bridge Stage Discharge Computation

River velocity data for Bucayao Bridge was plotted against water level data from an Automatic Water Level Sensor (AWLS). Flow measurements were recorded for seven (7) days from October 12-18, 2013. No rainfall was observed throughout the duration of survey. The summary of data gathered is illustrated in Figure 42.

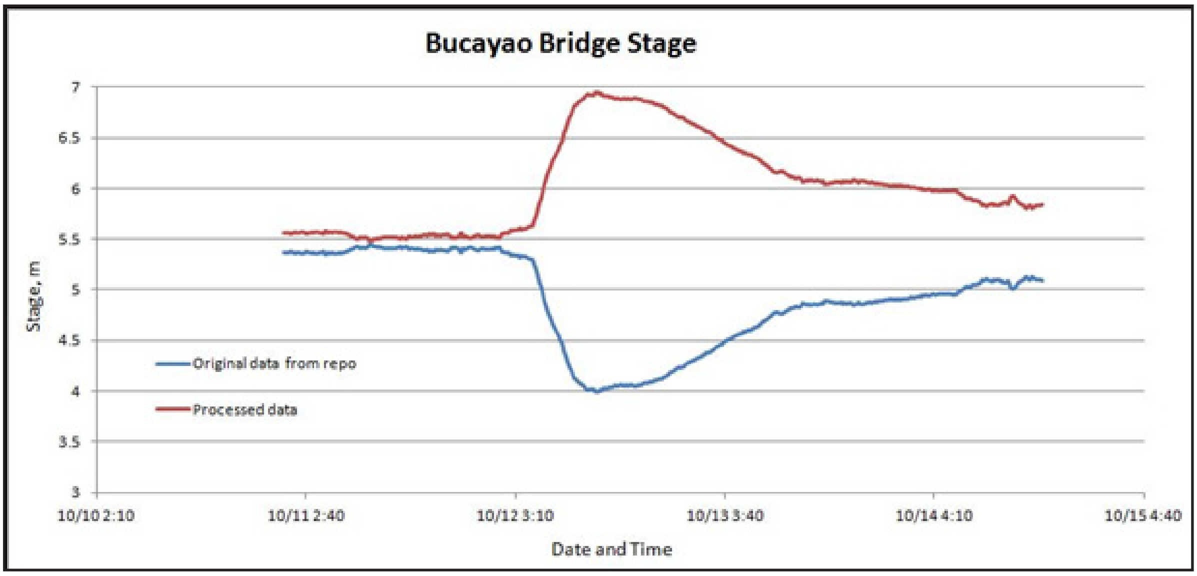


Figure 42. Bucayao Bridge Stage graph

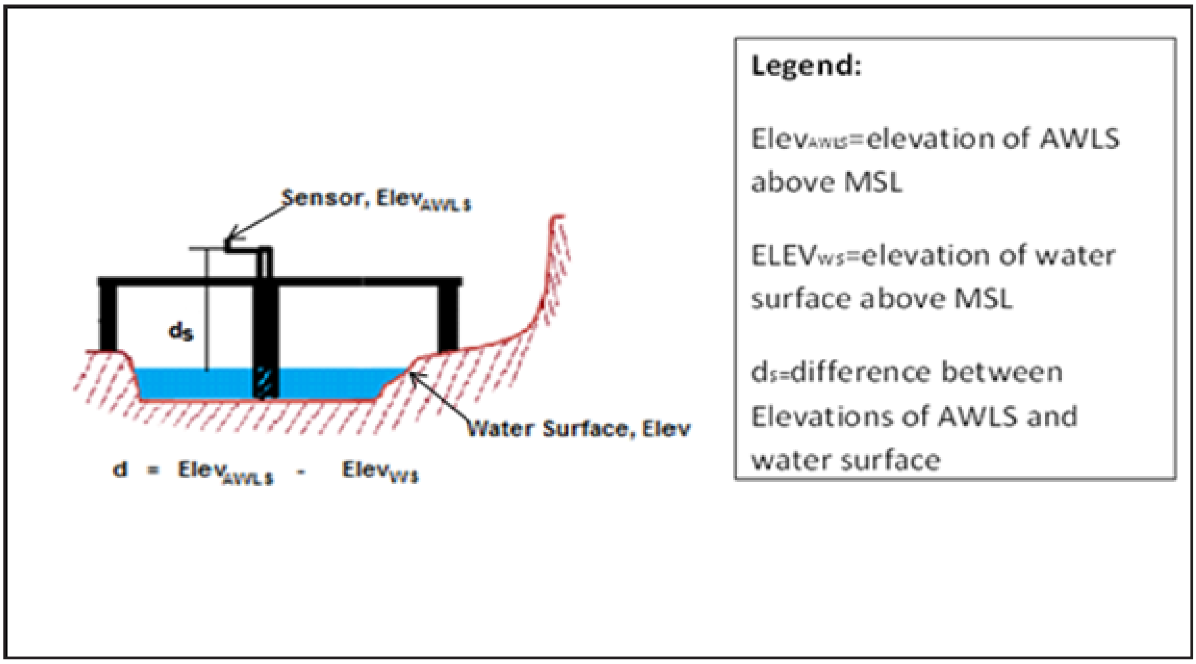


Figure 43. Difference between elevations of AWLS and water surface

Note: The data was extracted from repo.pscigrid.gov.ph. The graph indicates that the water level decreases on October 12, 2013 at 12:00 PM but it is contrary on actual situation. According to Mr. Alvin Retamare from ASTI on an email stated "readings for the GMA sensor are raw data (data shown are sensor readings or distance from sensor to water level-the readings should not be confused with water level referenced to either MSL or riverbed). Hence, there is an inverse relationship because whenever the water rises, the reading will become smaller because when water rises, the distance between water level and sensor becomes shorter. Unfortunately, the DOST RO which installed the sensor has yet to make measurements from riverbed to sensor, called as the reference data, so it can only display the sensor reading at this time. Therefore, the downloaded data from repo. pscigrid.gov.ph were subtracted from the elevation of Bucayao AWLS to obtain water level or stage. The stage data was utilized in calculating discharge.

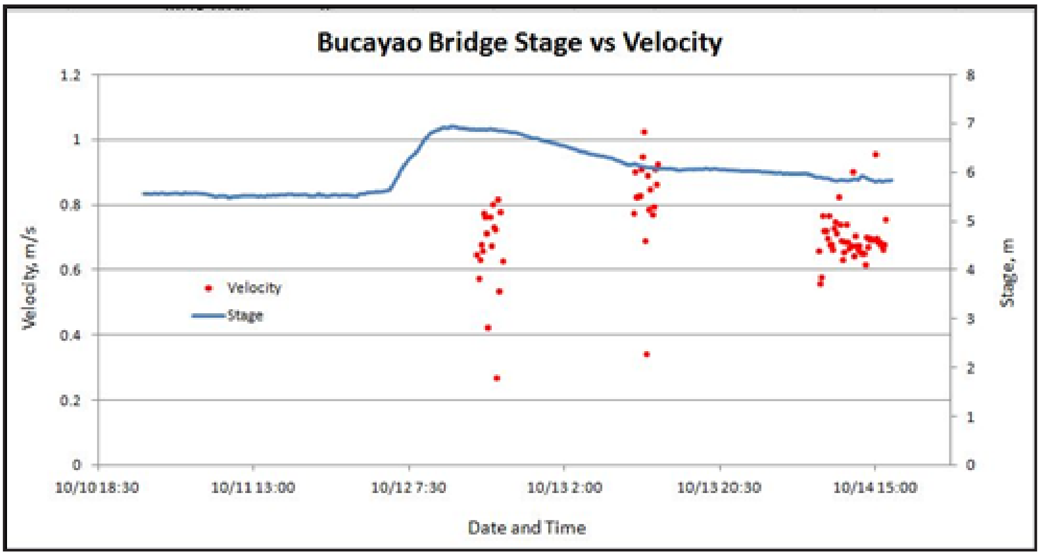


Figure 44. Stage vs Velocity graph for Bucayao Bridge

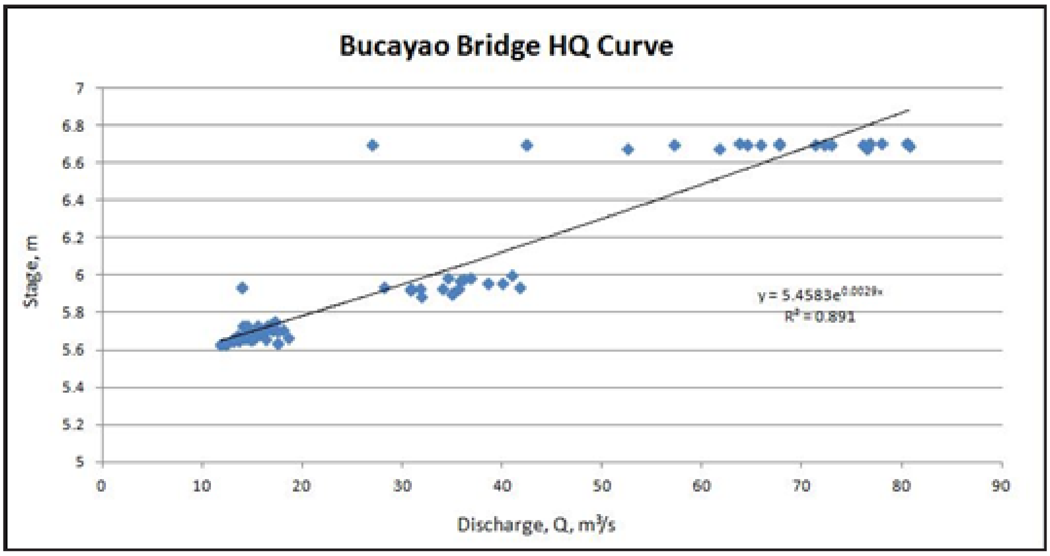


Figure 45. Bucayao Bridge HQ Curve

E. Cawacat Bridge Stage Discharge Computation

River velocity data for Cawacat Bridge was plotted against water level data from an Automatic Water Level Sensor (AWLS). Flow measurements were recorded for one (1) day October 10, 2013 for three (3) hours observation. No rainfall was observed throughout the duration of survey. The summary of data gathered is illustrated in Figure 46 and Figure 47

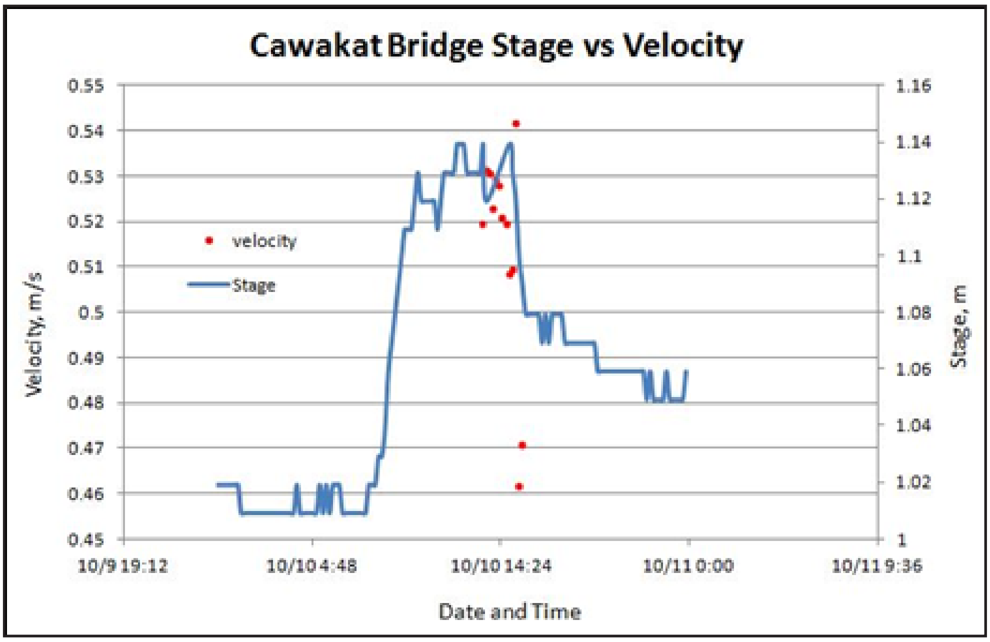


Figure 46. Stage vs Velocity for Cawacat Bridge

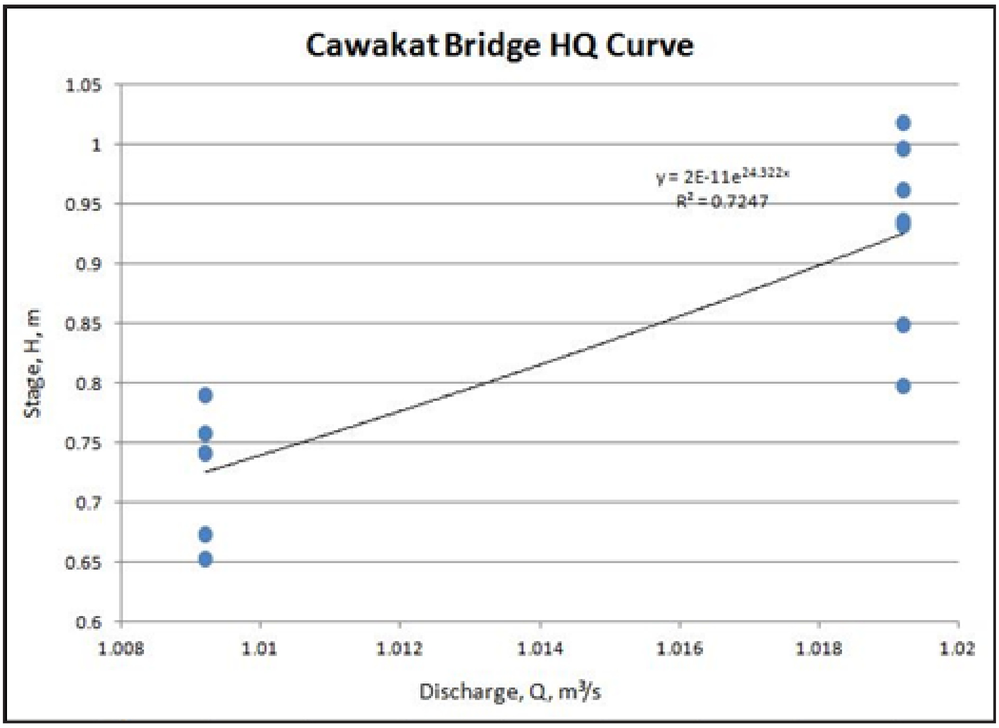


Figure 47. Cawacat Bridge HQ Curve

Annexes

Annexes

ANNEX A. PROBLEMS ENCOUNTERED AND RESOLUTIONS APPLIED

In conducting reconnaissance for both profile and cross section, accessibility of the area is the main issue. Majority of the cross sections in Mag-Asawang Tubig river fall on rice fields and on narrow roads. Renting a motorcycle lessens the burden of impassable pre-defined cross section lines. It made the survey more efficient.

Cross section lines that fall on private properties also made the reconnaissance challenging. The owners themselves were hesitant to let us pass through their properties.

On shallow portions of the river, the BST had to execute with the manual bathymetric. 2.533 kilometers out of 19.8 kilometers of the river was surveyed using an echosounder, the rest was surveyed manually.

Heavy rain was experienced on the time of survey within Mag-Asawang Tubig River but no change in water level.

Figure 48. Tall cogon grass obstructs GNSS signals, some areas are too deep for manual bathymetry survey

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

Type	Brand	Serial number	Owner	Quantity
GPS Receiver (Base)	Trimble™ SPS852		UP-TCAGP	One (1) unit
GPS Receiver (Rover)	Trimble™ SPS882		UP-TCAGP	Three (3) units
GPS Controller	Trimble™ TSC3		UP-TCAGP	Three (3) units
High-Gain Antenna			UP-TCAGP	Three (3) units
Single beam Echo sounder	Hi-Target		UP-TCAGP	One (1) unit with accesso-ries
Coupler-2a and 2b			UP-TCAGP	One (1) unit each
Handheld GPS	Garmin Ore-gon™ 550		UP-TCAGP	Two (2) units
	Garmin Mon-tana™ 650		UP-TCAGP	Two (2) units
AA-Battery Charger	Akari		UP-TCAGP	Two (2) units
Laptops	Lenovo ThinkPad		UP-TCAGP	One (1) unit
	Dell Laptop			One (1) unit
Digital Level	Topcon DL502		UP-TCAGP	One (1) unit with Two (2) level rods
Depth Gauge	Onset Hobo wares		UP-TCAGP	One (1) unit
Rain Gauge			UP-TCAGP	One (1) unit
Echosounder	Ohmex™		UP-TCAGP	One (1) unit
Range Pole	Trimble™		UP-TCAGP	Three (3) units
Tripod	Trimble™		UP-TCAGP	One (1) unit
Bipod	Trimble™		UP-TCAGP	Three (3) units
Tribrack			UP-TCAGP	One (1) unit
LaserRange Finder	Bushnell		UP-TCAGP	One (1) unit
Toolbox			UP-TCAGP	One (1) unit
QINSy donlge			UP-TCAGP	One (1) unit
Transducer	Ohmex™		UP-TCAGP	One (1) unit

ANNEX C. THE SURVEY TEAM

Data Validation Component	Designation	Name	Agency/Affiliation
Survey Supervisor	Senior Science Research Specialist	ENGR. BERNARD PAUL D. MARAMOT	UP TCAGP
Bathymetric Survey Team	Senior Science Research Specialist	ENGR. DEXTER T. LOZANO	UP TCAGP
	Research Associate	ENGR. JMSON J. CALALANG	UP TCAGP
Profile Survey Team	Research Associate	MARK LESTER D. ROJAS	UP TCAGP

ANNEX D. NAMRIA CERTIFICATION

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

April 05, 2013

CERTIFICATION

To whom it may concern:

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

Province: **ORIENTAL MINDORO**
Station Name: **MR-178**

Island: **Luzon** | Municipality: **CITY OF CALAPAN (CAPITAL)** | Barangay:

Elevation: **14.1562 m.** | Order: **1st Order** | Datum: **Mean Sea Level**

Location Description

BM MR-178 is located on Panggalan bridge second approach (km 16+957). It is 5 m from the highway centerline. Mark is the head of a 4" brass nail set in a drilled hole and marked with plate and with inscription MR-178 2007 NAMRIA.

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3943485 B**
T.N.: **2013-0268**

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

9904052013155201

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

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

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

April 05, 2013

CERTIFICATION

To whom it may concern:

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

Province: **ORIENTAL MINDORO**
Station Name: **MRE-32**
Order: **2nd**

Island: **LUZON**
Municipality: **VICTORIA**
Barangay:

	PRS92 Coordinates	
Latitude: **13° 10' 28.85064"**	Longitude: **121° 16' 38.44761"**	Ellipsoidal Hgt: **19.49300 m.**
	WGS84 Coordinates	
Latitude: **13° 10' 23.79251"**	Longitude: **121° 16' 43.46244"**	Ellipsoidal Hgt: **67.64700 m.**
	PTM Coordinates	
Northing: **1456889.419 m.**	Easting: **530055.679 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,457,002.75**	Easting: **313,296.85**	Zone: **51**

Location Description

MRE-32

From Calapan City to Roxas, along Nat'l. Road approx. 34 Km. travel to Victoria Town Proper, 10 Km. from intersection of Naujan, left turn to Shell Gasoline Station, approx. 150 m, right side of road located Mun. Hall of Victoria, Oriental Mindoro. Station is located in Mun. Park in front of Former Mayor Statue, along corner of pathwalk. Mark is the head of a 4 in. cupper nail flushed in a cement block embedded in the ground with inscriptions, "MRE-32, 2007, NAMRIA".

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3943485 B**
T.N.: **2013-0270**

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

CB/4701/12/09/814

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

ANNEX E. RECONNAISSANCE SUMMARY

Cross Section Reconnaissance						
Remarks		Left	XSec	Right		Remarks
PASSABLE		rice field and tall cogon grasses	1	intersects a private property, ends at a river		PASSABLE
PASSABLE		Coconut trees, private farm	2	private compound (mango plantation), intersects a concrete road		PASSABLE
PASSABLE		Falls along a concrete road, starts at a bridge	3	Falls along a concrete road, starts at a bridge		PASSABLE
PASSABLE		Falls on a rough road, rice fields	4	Intersects a concrete road, rice fields and grass land		PASSABLE
PASSABLE		Falls on rice fields	5	Falls on rice fields and rough roads		PASSABLE
PASSABLE		Falls on rice fields and rough roads	6	Rice field, open areas, tall grasses		PASSABLE
PASSABLE		Falls on a private property, rice fields	7	Falls along a rough road and private property		PASSABLE

Annexes

Cross Section Reconnaissance

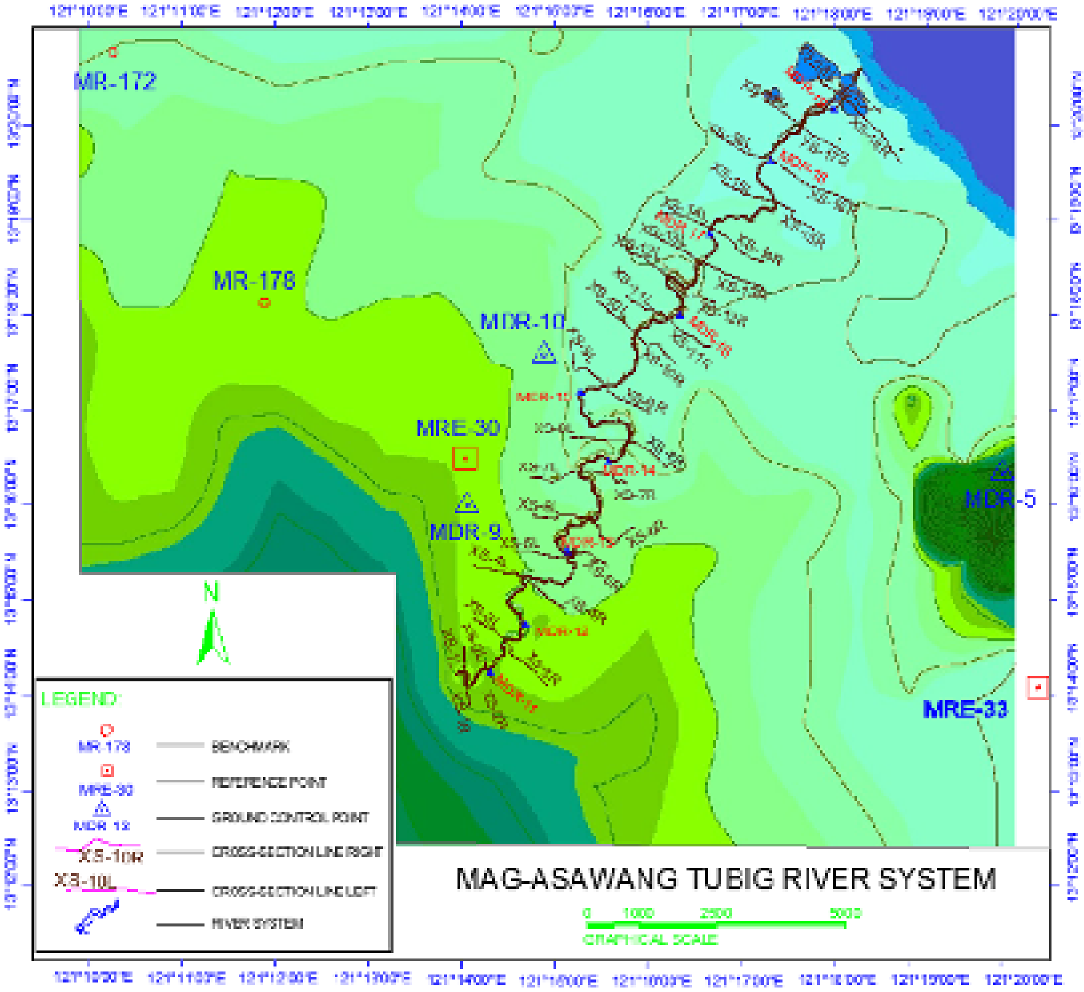
Remarks		Left	XSec	Right		Remarks
PASSABLE		Falls along a roughroad	8	Falls on rice fields and rough roads		PASSABLE
PASSABLE		Rice field and private properties, intersects a rough road	9	Falls on open spaces and rice fields		PASSABLE
PASSABLE		Rice fields and private property	10	Intersects a road, rice fields and open fields		PASSABLE
PASSABLE		Rice fields	11	falls on a rough road, and rice fields		PASSABLE
PASSABLE		intersects a subdivision (Pamahay)	12	falls along a rough road and rice fields		PASSABLE
PASSABLE		falls along a rough road and rice field	13	rice field, falls along a road		PASSABLE
PASSABLE		falls on a rough road, rice fields	14	rice field, intersects a road		PASSABLE
PASSABLE		Rice fields	15	cogon grass and rice fields		PASSABLE

Cross Section Reconnaissance						
Remarks		Left	XSec	Right		Remarks
Minor adjustment to keep the cross section perpendicular to the river profile		cogon grass and rice fields	16	intersects a road, rice fields and buildings		Minor adjustment to keep the cross section perpendicular to the river profile
Minor adjustment to keep the cross section perpendicular to the river profile		Rice fields and tall cogon grasses	17	Rice fields, banana plantation		Minor adjustment to keep the cross section perpendicular to the river profile
Minor adjustment to keep the cross section perpendicular to the river profile		Rice fields and tall cogon grasses	18	Rice fields		Minor adjustment to keep the cross section perpendicular to the river profile

ANNEX F. OUTSOURCE CROSS-SECTION AND PROFILE

PROFILE AND CROSS SECTION SURVEYS IN MAG-ASAWANG TUBIG RIVER, ORIENTAL MINDORO

DREAM
Disaster Risk and Exposure Assessment for Mitigation



Prepared by:

RASA SURVEYING
LAND SURVEY CONSULTANTS

`In joint venture with:

HONS
H.O. NOVELOSO SURVEYING
ENGINEERS•SURVEYORS•CONSULTANTS
Accept all kinds of surveys, Rental of Total Station and GPS

Survey Period: May 16 to June 22, 2013

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DAO	DENR Administrative Order
DOST	Department of Science and Technology
DREAM	Disaster Risk and Exposure Assessment for Mitigation
EGM08	Earth Gravitational Model of 2008
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GCP	Ground Control Point
KM	Kilometer
LMB	Land Management Bureau
LiDAR	Light Detection and Ranging
LGU	Local government unit
MM	Millimeter
NAMRIA	National Mapping and Resource Information Authority
PRS92	Philippine Reference System of 1992
LUB	Left Upper Bank
RUB	Right Upper Bank
LLB	Left Lower Bank
RLB	Right Lower Bank

Introduction

Annexes

1.1 Background

The Disaster Risk and Exposure Assessment for Mitigation (DREAM) Program funded by the Department of Science and Technology Grant-in-Aid (DOST-GIA) and undertaken by the University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP) aims to acquire elevation and resource dataset at information necessary to support the different phases of disaster management.

Disasters bring negative impacts on the socio-economic aspects of a nation. In the Philippines, the effects of disasters include loss of lives and economic opportunities, damages and destructions on infrastructure developments.

Proper Planning and disaster management that provides early warning systems, appropriate policies and procedures are needed to minimize the destructive effects of the different disasters hitting the country. However, this requires sufficient and accurate spatial datasets.

The outputs of the acquired LiDAR data must be within the accuracy standard needed for understanding disaster events such as flood modeling. Because of this, there is a need to conduct validation surveys in order to verify the accuracy of gathered LiDAR data.

1.2 Scope of Work

There are eighteen (18) major river systems that are identified to be flood-prone in the country. One of these river systems is the Mag-Asawang Tubig River System with a catchment area of 468.58 sq. km. which includes the Municipality of Naujan and City of Calapan, Oriental Mindoro.

The work shall include the following:

1.2.1. **Ground Control Survey.** Ground control survey connecting to NAMRIA horizontal and vertical control points shall be done. Each control point that shall be used as reference points must contain horizontal and vertical positions.

1.2.2. **Cross Section Survey.** There are 18 cross-sectional lines with a total distance of 37.92 km.

1.2.3. **Profile Survey.** Profile survey shall consist of left bank and right bank surveys on the upper and the lower part of the river with an extent of 22.84 km and 23.13 km, respectively.

1.2.4. **Data Processing.** This includes processing and adjustments of GNSS data and computations, corrections, and plotting of surveyed cross-sections and profiles.

1.3 Professional Staffing and Implementation

The following are the proposed qualified personnel to be assigned in the project:

Table 5. Proposed Project Leader and Team Leaders for the DREAM project

Name of Personnel with picture	Position	Qualification	Official Function
 Engr. Raymund Arnold S. Alberto	Project Engineer	Licensed Geodetic Engineer with experience as Project Engineer	• Over-all Project management and supervision • Reviews reports and documentations • Coordinates with LGUs and other Stakeholders
 Renato S. Dacono	Technical Staff	College Graduate	• Monitors field operations and prepares progress report • Evaluates outputs of Field Operations Management Group
 Engr. Marvin Andrew A. Caliolio	Chief of Party	Licensed Geodetic Engineer with experience as Chief of Party	• Works at full time for the Project • Deals directly with the End-User • Manages Field Office operations and related activities • Evaluates outputs and consolidate reports • Organizes planning operations with the key personnel for proper scheduling of works
 Bernie Revamonte	Team Leader for Profile Survey	B. S. G. E. Graduate with experience in field operation and Team Management	• Manages Field operations and related activities • Review and validate the output of the profile survey works

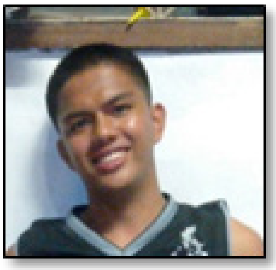
Name of Personnel with picture	Position	Qualification	Official Function
 Franie T. Reyes	Team Leader for Cross-section Survey	B. S. G. E. Graduate with experience in field operation and Team Management	• Manages Field operations and related activities • Review and validate the output of the profile survey works

Table 6. Proposed staff as Instrument Men for the surveying team

Instrument Men with competent skill in operating survey-grade GPS and levelling Instruments. Responsible for Field data gathering and evaluation.			
 Jay Borja	 Nelson Acosta	 Gregorio Costelo	 Julio Balensona
 Marlon Garina	 Ramil Olimpiada	 Dennis Refugia	 Anselor Dumpac
 Joemel Sierra	 Ryan Audrey Basco	 Jeffrey Orbillo	 Jerry D. Domingo

Field Survey Methodology

Annexes

2.1 Field Plan

For the completion of the profile and cross section survey of the Mag-Asawang Tubig, the team followed necessary procedure to ensure the effective delivery of survey reports. Figure No. 49 shows the workflow for the completion of the project. From planning stage, field acquisition, and data processing, a standard practice was implemented.

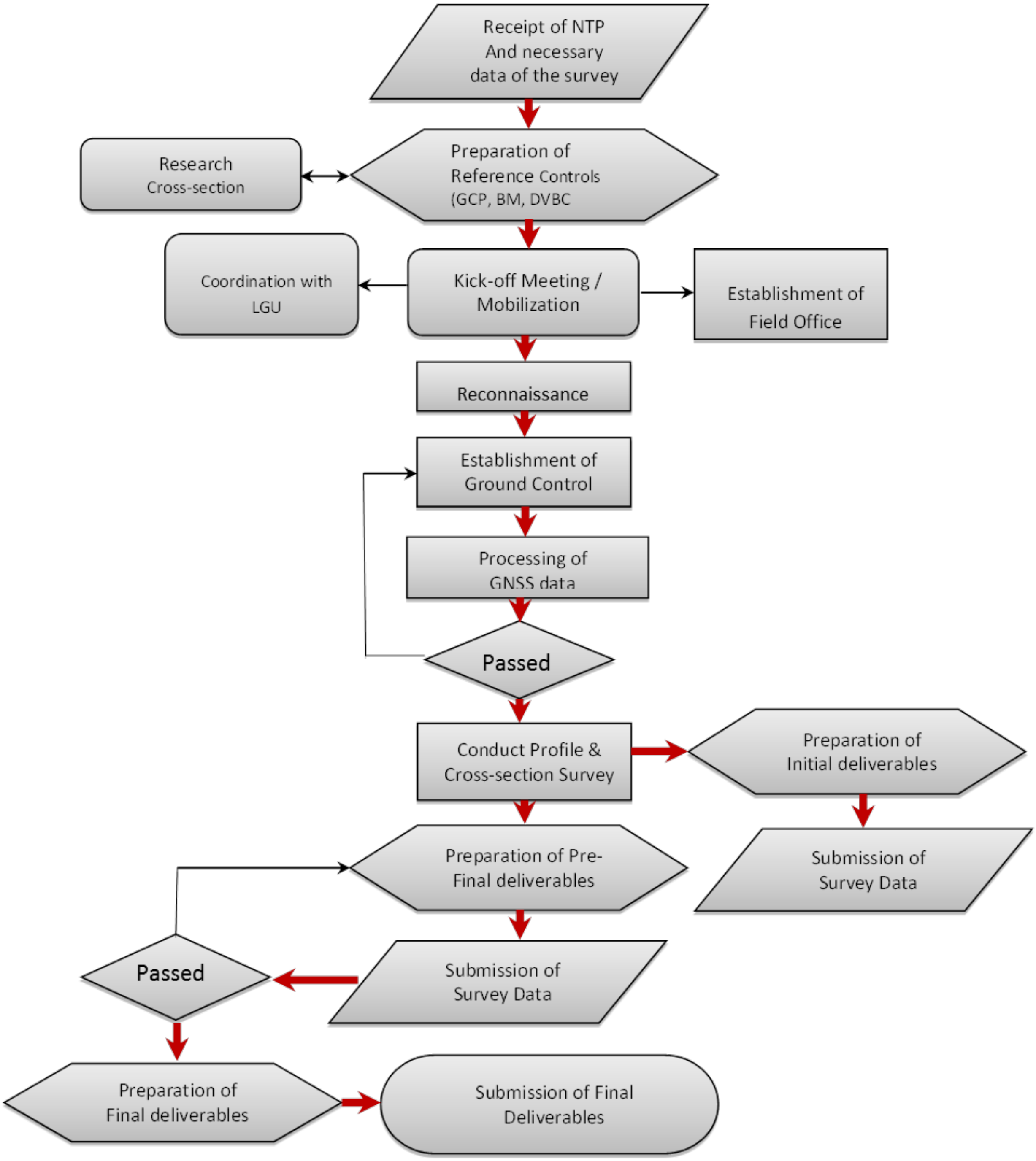


Figure 49. Flowchart showing the processes and overall activities for the field survey of Mag-asawang Tubig

Annexes

Upon receipt of Notice to Proceed together with necessary data e.g. coordinates of the profile and cross-section lines, extent of the project area and endorsement letter for the LGUs, proposed work schedule was prepared. Survey equipment such as survey grade GPS, total stations and digital level were calibrated and checked to ensure it complies with operational standard. Survey teams assigned for the project were briefed about the execution and importance of the project. Preliminary network design of additional Ground Control Points was created using Google earth image.

LOCATION MAP

Figure 50. The Project Site, map of the river system, which was overlayed on Google earth satellite image

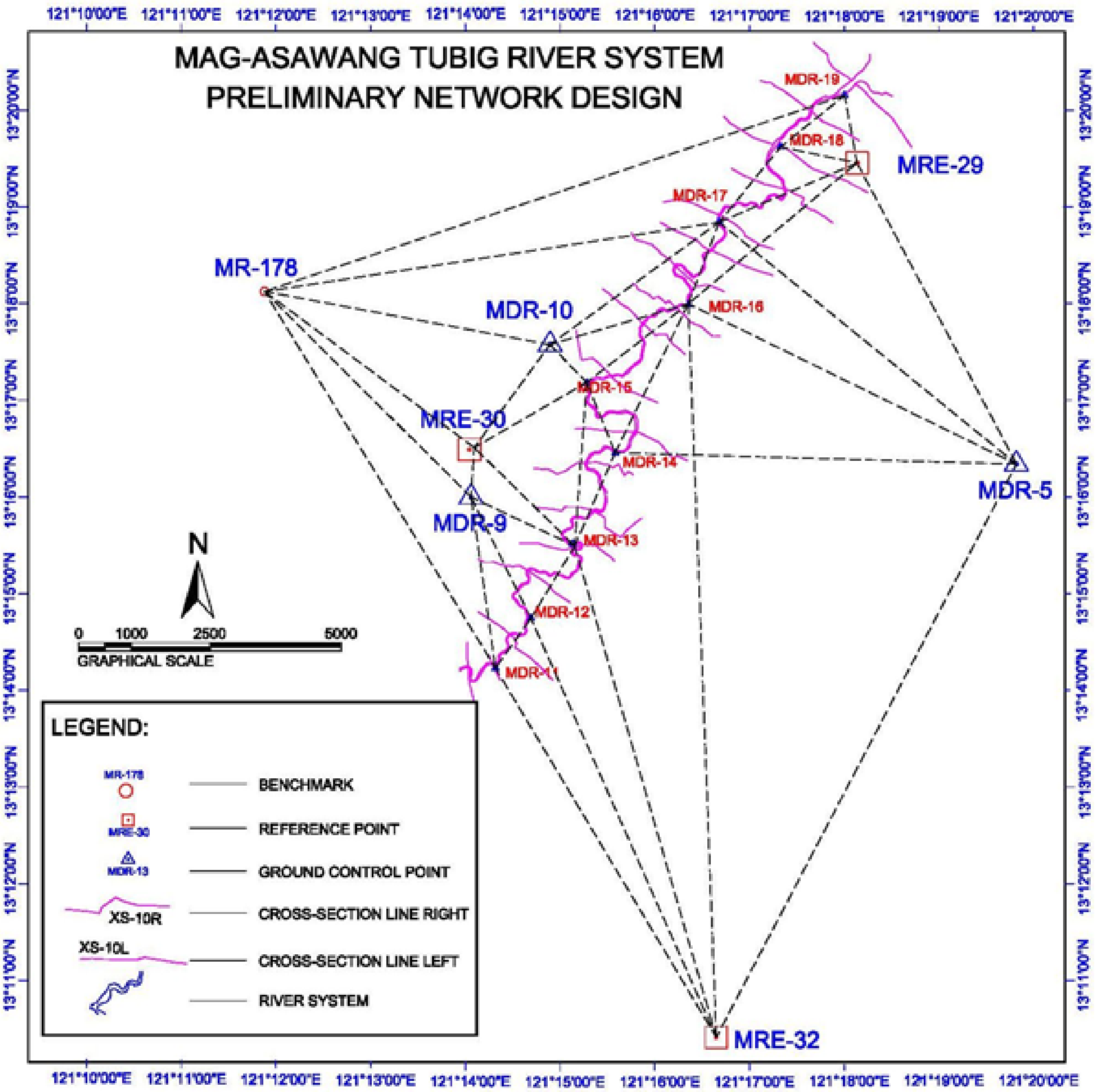


Figure 51. Preliminary Network Design for establishing GCPs

2.2 Research for reference points and benchmarks.

To have a better implementation of field survey of the project area, National Mapping and Resource Information Authority (NAMRIA) controls points with at least 2nd order horizontal accuracy and at least 3rd order vertical accuracy were used as reference points in establishing project controls. These specifications are required, to meet the mapping standard of the government pursuant to the DENR Administrative Order 2007-29 (DAO 07-29) Section 28 and the DENR Memorandum Circular 2010-13 (DMC 10-13) Manual on Land Survey Procedures.

These reference points will be used to control the propagation of systematic error in the adjustment process of establishing ground control points and GNSS network. Higher order reference points provide better accuracy and minimal variances in the positioning of project control.

Using the monuments description sheets from the NAMRIA as the reference guide, the team collected the nearest reference control points from the project area based on its sketch and description using the selection process.

Certifications of reference points and benchmarks were acquired from NAMRIA, See Annex D. These were used to locate NAMRIA established reference points and benchmarks within the survey area during reconnaissance and to determine the geographic coordinates and elevations of recovered reference points for processing.

2.3 Reconnaissance

With the point description secured from NAMRIA, preliminary map, and endorsement letter, the team mobilized to the project area. Reconnaissance was performed to locate available NAMRIA reference points and benchmark within the vicinity of the project area. Location of the proposed GCPs were determined using Navigational GPS and was ensured that it is within the mapping standard as per DAO 07-29. Proposed profile and cross-section lines were verified whether it is passable for RTK survey or it needs clearing activity, in case that designed lines fell in impassable densely vegetated areas. With this process the Team Leader will make any adjustment of the preliminary network design and schedule of GNSS observation.

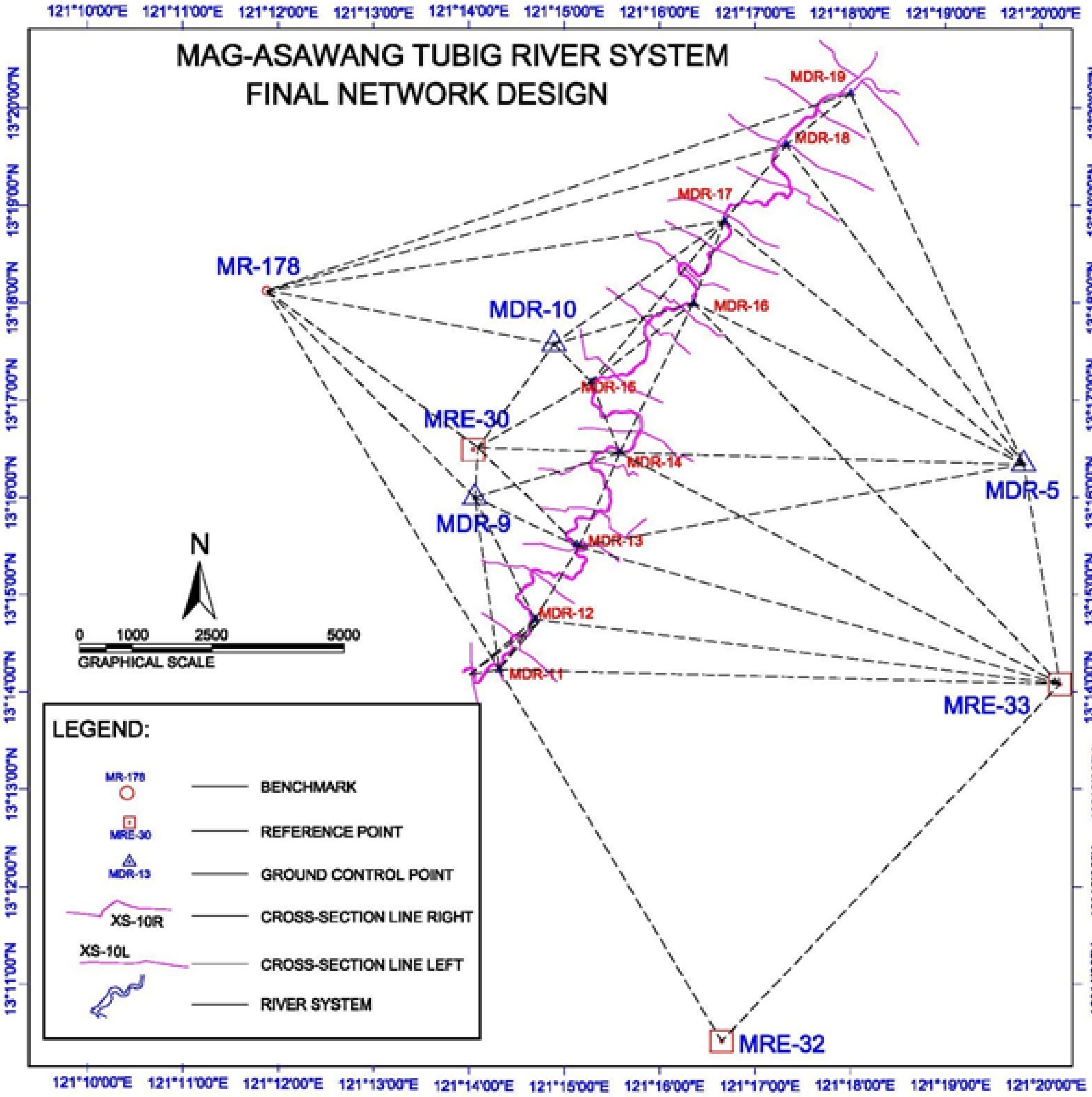


Figure 52. Revised Network Design for establishing GCPs

2.4 Establishment of control points and GNSS network

With the point description secured from NAMRIA, preliminary map, and endorsement letter, the team mobilized to the project area. Reconnaissance was performed to locate available NAMRIA reference points and benchmark within the vicinity of the project area. Location of the proposed GCPs were determined using Navigational GPS and was ensured that it is within the mapping standard as per DAO 07-29. Proposed profile and cross-section lines were verified whether it is passable for RTK survey or it needs clearing activity, in case that designed lines fell in impassable densely vegetated areas. With this process the Team Leader will make any adjustment of the preliminary network design and schedule of GNSS observation.

Annexes

Reference Control

Horizontal Reference Point

Table 7. List of 2nd order Horizontal Reference Point from NAMRIA

List of Reference Points											
	WGS-84						UTM				
Sta. Name	Latitude			Longitude			Ellipsoidal Ht.	Elev. (EGM08)	MSL	Vert. Accuracy	Hor. Accuracy
	dd	mm	ss.ssss	dd	mm	ss.ssss	mmmm.mm	mmmm.mm	mmmm.mm		
MRE-30	13	16	28.6783	121	14	7.5968	64.338	16.835	14.4922	FIXED	FIXED
MRE-32	13	10	23.7925	121	16	43.4624	67.647	19.454	17.1112	FIXED	FIXED
MRE-33	13	14	5.3029	121	20	14.7450	54.044	6.018	3.6752	FIXED	FIXED

Vertical Reference point

Table 8. List of 1st order Benchmark from NAMRIA

List of BM's											
	WGS-84						UTM				
Sta. Name	Latitude			Longitude			Ellipsoidal Ht.	Elev. (EGM08)	MSL	Vert. Accuracy	Hor. Accuracy
	dd	mm	ss.ssss	dd	mm	ss.ssss	mmmm.mm	mmmm.mm	mmmm.mm		
MR-178	13	18	4.6065	121	11	54.1177	63.764	16.499	14.156	0.055	0.02550

MDR-11 NEAR VIEW

MDR-11 FAR VIEW

MDR-15 NEAR VIEW

MDR-15 FAR VIEW

Figure 53. Sample Photographs of the Established Ground Control Points

Each control point was documented and included in the field survey activities as attachments in "ANNEX D". Information such as control point name, geographic coordinates, elevation, sketch, description, monument and panoramic photographs were included in the field sheet.

For the establishment of ground control points, static GPS survey technique was implemented. Three control points from NAMRIA was used as reference stations which provided a closed geometric figure, as a basic requirement of static GPS survey technique. Each session of GNSS survey was conducted with three (3) hours of observation using dual frequency GNSS receivers, with data logging of every five (5) seconds, and having an elevation mask of fifteen (15) degrees to ensure that the GNSS receiver resulted to a fixed solution.

The established ground control points were used as the local control within the project area during the ground survey of profile and cross-section. This is to provide accessible reference control with relative high positional accuracy for the ground survey. Also, traditional survey using total station was used for establishing sub-control point options for areas nearby river banks.

2.5. Ground Surveys

Using the pre-established control points, profile survey was conducted from the pre-determined upstream of the river down to its mouth (downstream). Profile survey consists of traversing the Left Upper Bank (LUB), Left Lower Bank (LLB), Right Upper Bank (RUB), and Right Lower Bank (RLB). Portions of the river where points was measured at a 10m interval using dual frequency GNSS receivers and kinematic survey technique. The route for profile lines may deviate up to 10m from the proposed lines if the planned lines are not passable and additional points were observed to describe apparent changes in elevation. Conventional surveying technique using an electronic total station was used for areas with obstructed satellite signals. Required accuracy of ±20 cm for horizontal and ±10 cm for vertical position must be observed.

The position of the proposed 18 cross-sectional lines was determined using navigational GPS. Provided coordinates was marked with stake to serve as guide for the surveyor during the actual survey. Cross-section started from the upper bank of the river going left side or right side following the path of the nearby roads or goat trails. Similar to profile survey, cross-section points shall not exceed 10m interval between successive points and additional shall be observed to describe apparent changes in elevation along the designed line. Each cross-section was identified sequentially with e.g. XS1, XS2…etc. from upstream to downstream direction. Points for cross-section lines were measured at a 10m interval using dual frequency GNSS receivers and kinematic survey technique. The route for profile lines may deviate up to 10m from the proposed lines if the planned lines are not passable and additional points were observed to describe apparent changes in elevation. Conventional surveying technique using an electronic total station was used for areas with obstructed satellite signals. Required accuracy of ±20 cm for horizontal and ±10 cm for vertical position must be observed.

2.6. Data Processing

2.6.1 GNSS survey

Data obtained from the field was downloaded and processed immediately using Trimble Business Center Software. GNSS raw data was converted to receiver independent exchange format (RINEX) data. Cycle slips and noise on the observed satellites were disabled. Observed reference points were fixed using the certified data from NAMRIA and baseline adjustment was perform to minimize random errors. Geographical coordinates in WGS-84 and PRS-92 as well as UTM coordinates were extracted after the successful baseline adjustment. Mean Sea Level elevations for each GCPs were computed base from the EGM2008 elevation and the certified MSL data of the recovered NAMRIA benchmark. The following accuracy and precision were observed in the final baseline adjustment:

Horizontal Precision <= ±3mm + 0.5ppm x D
Vertical Precision <= ±5mm + 0.5ppm x D

Where: D is the baseline distance from GNSS base station to the established ground control points

2.6.2 Cross-section Survey

After each day of observation, data from the total stations and RTK controller were downloaded and processed to validate and monitor the accuracy and completeness of the survey. Downloaded data was sent thru email to the main office for finalization.
Point data received from the field were imported to Civil3D software to generate cross-section graphs with the required scale 1:2000 for horizontal and 1:100 for vertical. All major structures traversed by the section lines were indicated in the cross-section plan to serve as landmark.

2.6.3 Profile Survey

Same with the cross-section data, Profile point data was imported to Civil3D software to generate Profile Plan with the required scale 1:10,000 for horizontal and 1:100 for vertical. Upper bank profile line was generated following the topmost portion of the river bank, while the lower bank profile line was based on the existing water level during the time of actual field survey. All major structures along the river banks were indicated in the plan like bridges, riprap, etc.

Results and Discussions

Annexes

3.1. Reconnaissance Survey

Reconnaissance Survey started on May 16, 2013. Representatives from the survey team dropped by at the local government of Naujan and City of Calapan for courtesy call and presented the endorsement letter provided by UP DREAM for requisition of necessary permit to initiate the field survey. Twelve (12) teams, where a team is composed of an instrument man and two (2) survey aids, were deployed to investigate and provide preliminary information of the actual working environment of the project area.

Based on the initial assessment, the project area is a relatively flat terrain surrounded by rice and corn fields and sugar cane and banana plantations, as seen in the pictures provided below.

Figure 54. Photos showing the topography of the actual project area

During reconnaissance survey, the team looked for the location of the proposed NAMRIA reference points and benchmark used for the establishment of ground controls, in which one of them, MRE -29 is not recoverable. The duration for the reconnaissance survey lasted for two (2) days.

3.2. Actual Field Survey

Cross-section survey was conducted using the planned cross-section provided by UP DREAM. Coordinates of the points for staking out were extracted from the digital file. Each point was surveyed using a RTK GNSS receiver. Figure 55 shows the proposed or designed cross-section and profile lines of the river. Figure 56 shows the actual cross-section and profile lines as surveyed. Figure 57 shows the comparison between the proposed and actual cross-section and profile lines wherein section lines 1, 2, 3 & 4 have a minimal deviation due to some obstructions and actual conditions on site. Portion of the river alignment differ from the proposed line maybe due to the continues rainfall in the area that caused minor erosion of the river banks.

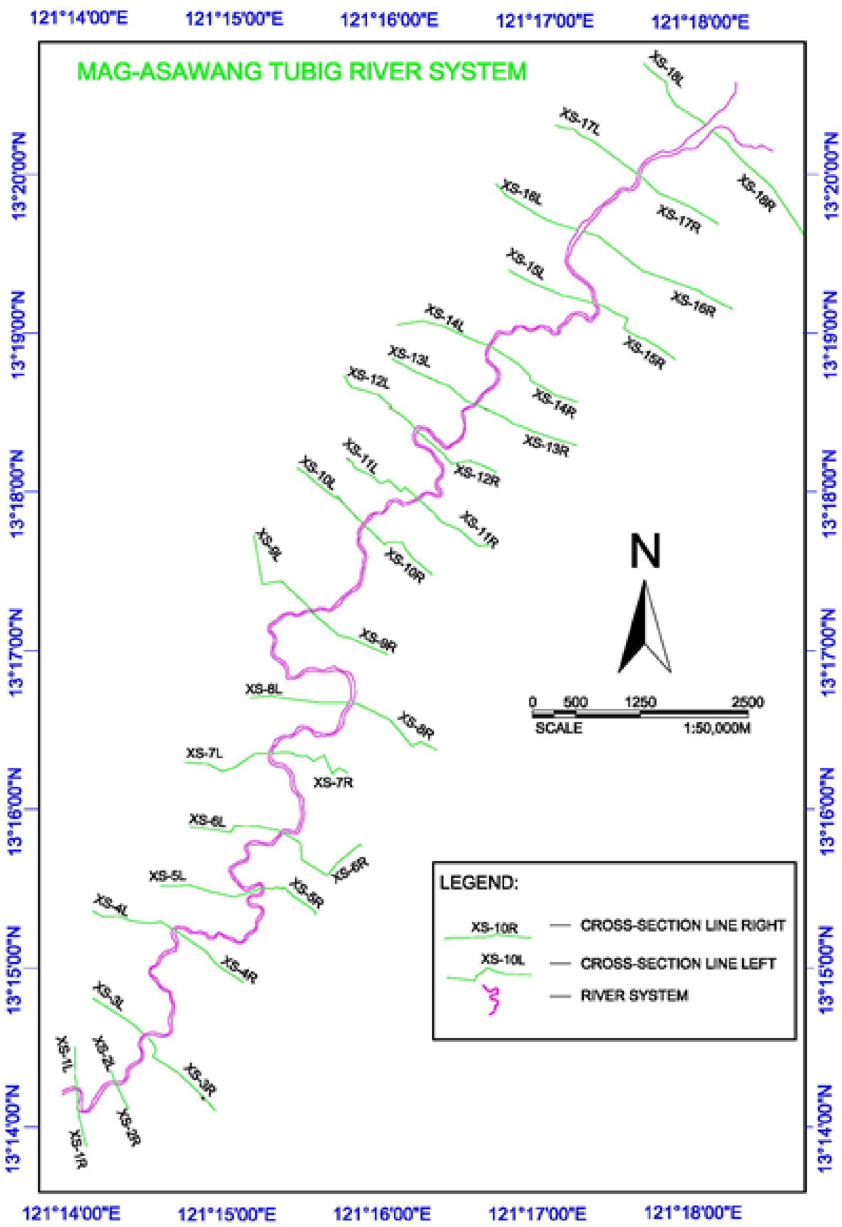


Figure 55. Proposed Cross-Section and Profile line of the River

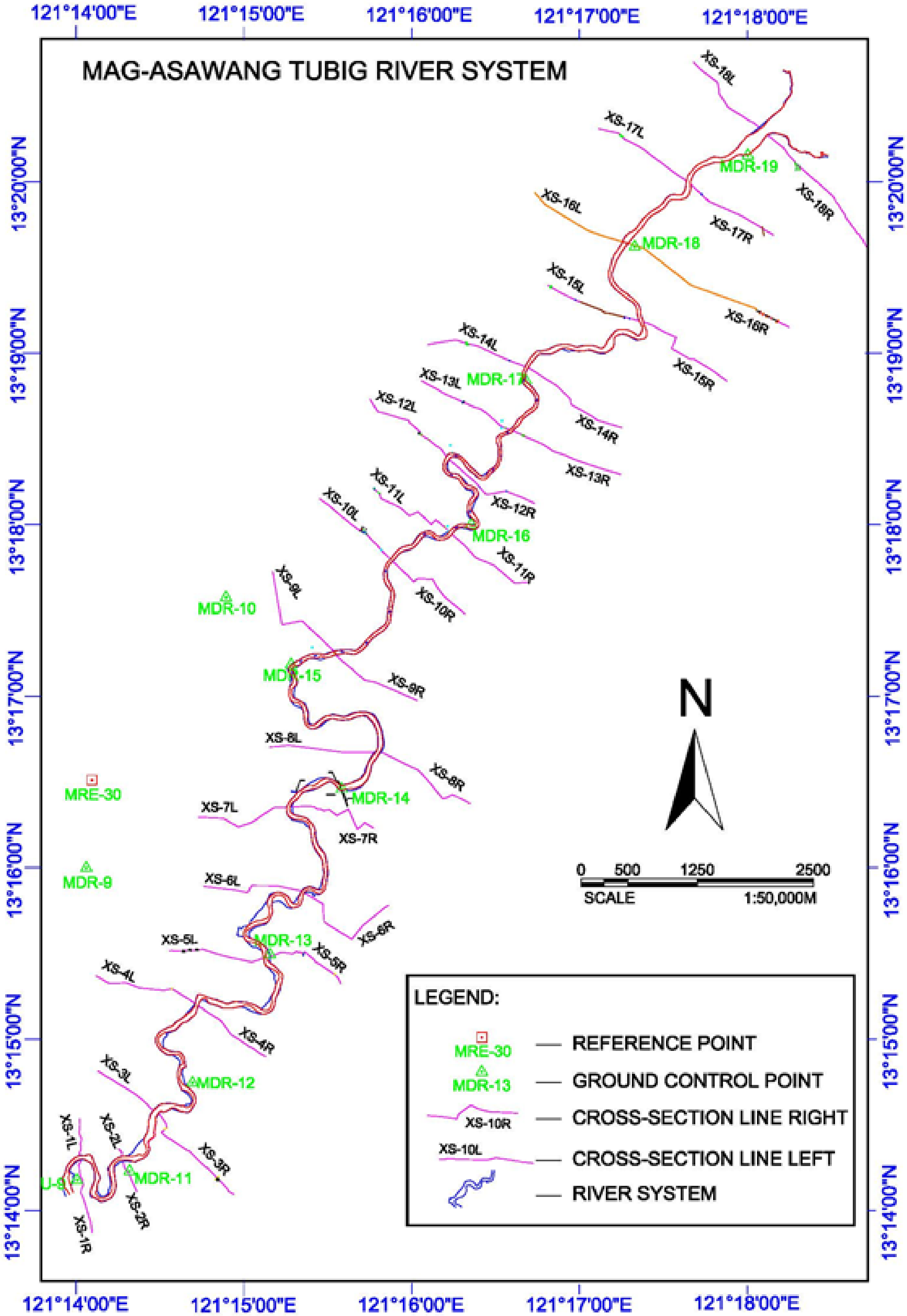


Figure 56. Actual Cross-section ad Profile line

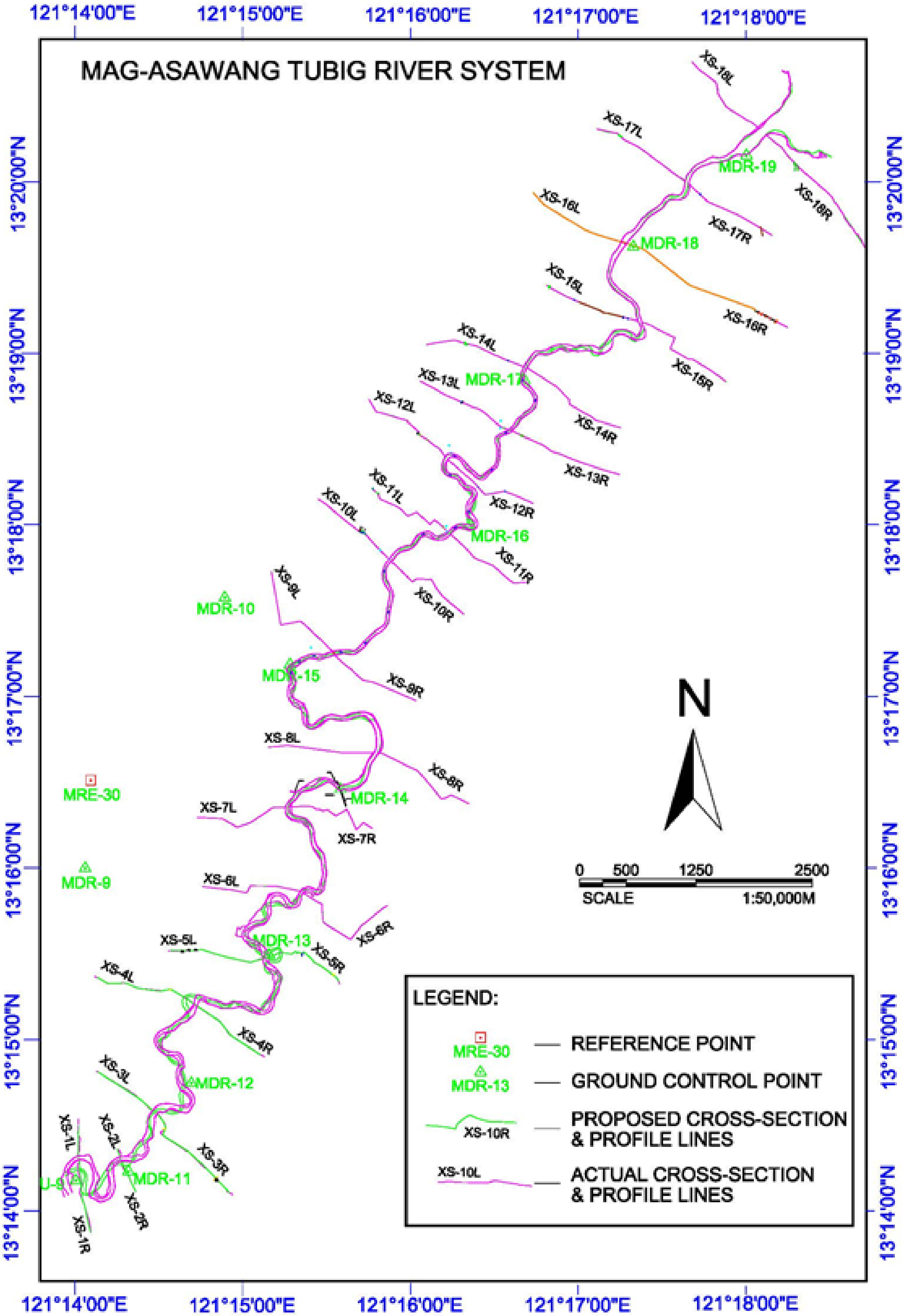


Figure 57. Comparison of the proposed and actual survey lines

Succeeding pages will show the individual maps/ graphs generated Cross Sections and a sample profile of the river (upper right).

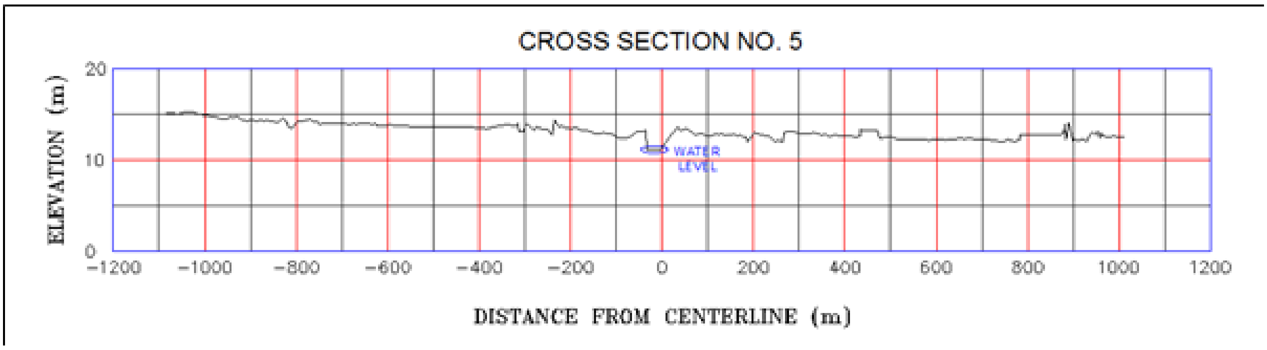


Figure 58. Cross Section # 5

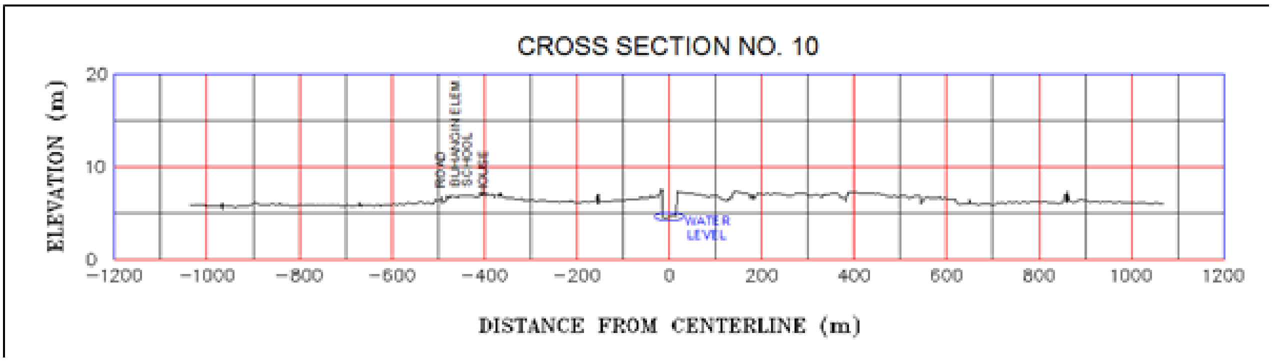


Figure 59. Cross Section # 10

The sample result of cross section of the river, as shown in Figure 58 and Figure 59 validate that the terrain of the river is relatively flat.

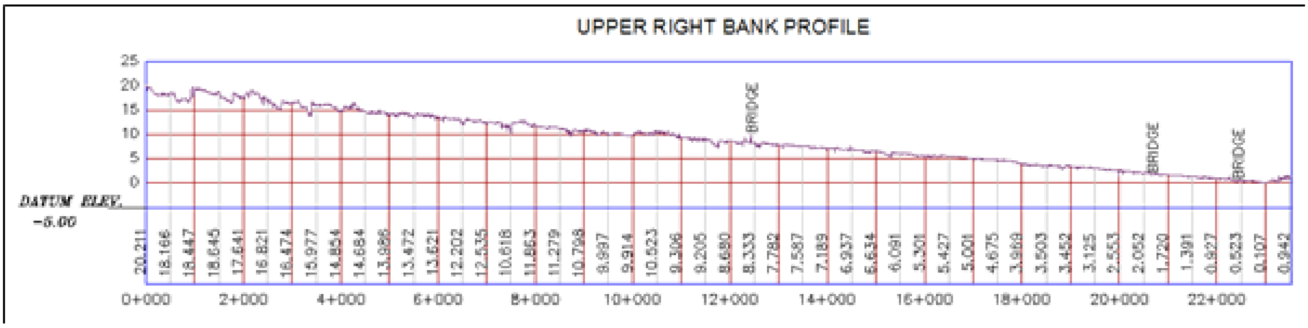


Figure 60. Sample profile of the river (upper right) STA 00+ 000 to STA 23 + 500

3.3. Problems Encountered and Resolutions Applied.

Based on the field survey, from reconnaissance up to the actual field survey, problems encountered by the surveying team are as follows:

Table 9. Problem Encountered and Solution Applied

Problems Encountered		Action Taken
1.	A lot of areas are hard to access due to dense vegetation coverage causing delay and changing of survey approach.	Additional manpower hired to clear heavily vegetated areas. In conjunction with the additional manpower, machineries and materials such grass cutter and jungle bolo were also provided.
2.	Excessive and constant power loss in the area which hinder the transmission of survey data by the field surveyor to the head office for processing and charging of necessary equipment used in the field.	To compensate for the delay due to power outage and weather condition, team continues to work even on Sundays for field work and late at night to finalize the survey data to be sent to head office.
3.	Delay in the projected field work because of unfavorable weather condition in the area.	Overtime on Sundays and extend working hours
4.	Rivers are impassable because of the high water level and current due to continuous rains specifically on the downstream of the river.	Adjustment in the work schedule to extend the duration of field survey.
5.	Some RTK point data were not fixed and does not passed the required accuracy.	Erroneous points caused poor satellite were deleted and not included in the data processing.

Annexes

The report chart showing the weather during the entire survey implementation of the project can be seen in Figure 61. This is documented by the team to as reference for the delay of the survey.

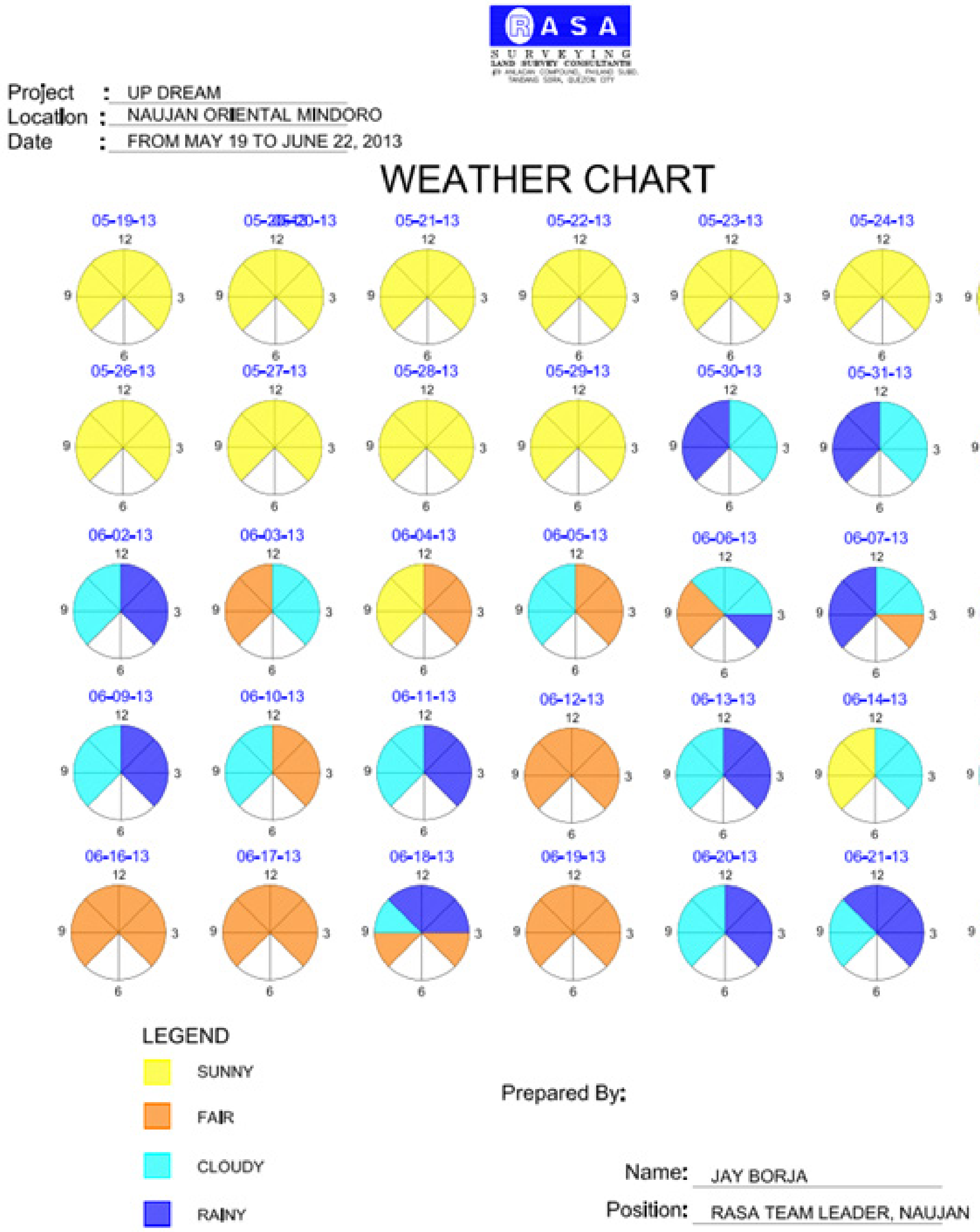


Figure 61. Chart showing the weather on the project during the entire survey

Figure 62. Photographs of the weather condition onsite during the survey

3.4. Processed Data

Tables and Figures showing the summary of all the processed data: the established GCPs, cross section and profile survey data. Copy of all processed and raw data were compiled and were also submitted in digital format.

Table 10 shows the processed ground control points which are adjusted using the Trimble Business Center, GNSS processing and adjustment report can be seen in "Annex E".

Table 10. Adjusted Ground Control Points

List of Ground Control Points													
	WGS-84						UTM						
Sta. Name	Latitude			Longitude			Northing	Easting	Ellipsoidal Ht.	Elev. (EGM08)	MSL	Vert. Acc.	Hor. Acc.
	dd	mm	ss.ssss	dd	mm	ss.ssss	mmmmmmm. mmmm	mmmmmmm. mmmm	mmmm.mm	mmmm.mm	mmmm. mm		
MDR-5	13	16	20.7705	121	19	50.9864	1467868.5880	319169.3190	52.824	5.056	2.713	0.044	0.0205
MDR-9	13	15	57.9074	121	14	5.8248	1467237.4630	308774.4380	66.192	18.643	16.300	0.025	0.0191
MDR-10	13	17	32.9204	121	14	55.0919	1470146.9570	310278.0330	59.648	12.211	9.868	0.032	0.0220
MDR-11	13	14	11.9669	121	14	22.0682	1463978.2410	309240.4740	68.530	20.804	18.461	0.032	0.0191
MDR-12	13	14	42.9989	121	14	44.3014	1464927.2120	309916.5300	66.876	19.179	16.836	0.028	0.0205
MDR-13	13	15	28.0680	121	15	11.6750	1466306.4980	310750.3070	63.671	16.022	13.679	0.024	0.0177
MDR-14	13	16	26.1345	121	15	36.9163	1468085.6820	311522.6010	65.457	17.882	15.539	0.025	0.0170
MDR-15	13	17	9.5967	121	15	18.5479	1469425.2180	310979.0270	58.572	11.081	8.738	0.029	0.0227
MDR-16	13	17	58.9086	121	16	22.5720	1470927.2330	312916.6720	56.193	8.743	6.400	0.039	0.0213
MDR-17	13	18	49.5894	121	16	41.6919	1472480.7500	313502.9240	53.989	6.619	4.276	0.048	0.0241
MDR-18	13	19	36.5731	121	17	20.3194	1473916.6070	314675.4120	54.210	6.905	4.562	0.065	0.0311
MDR-19	13	20	8.8119	121	18	0.5561	1474899.0380	315893.1030	52.481	5.213	2.870	0.074	0.0311

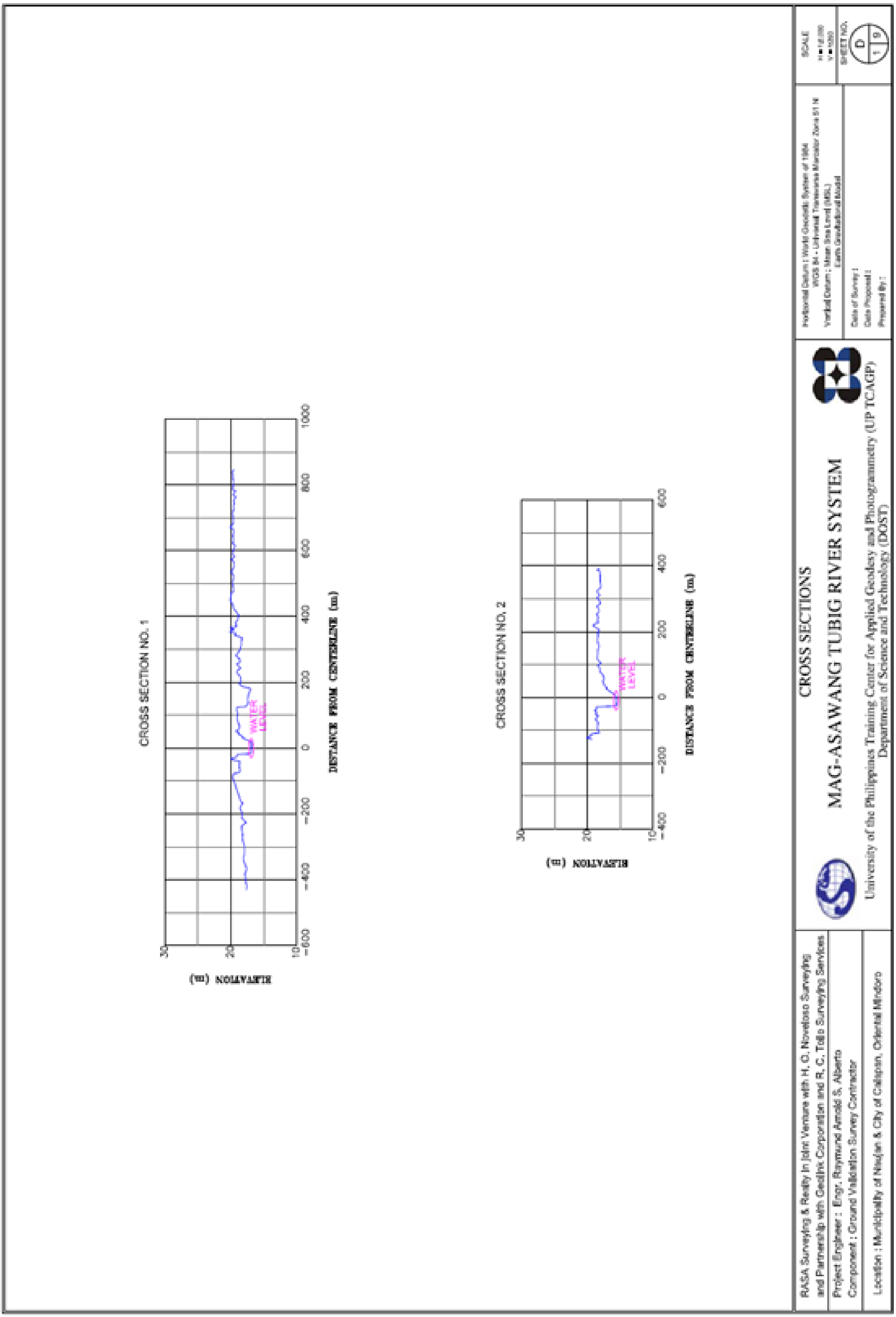
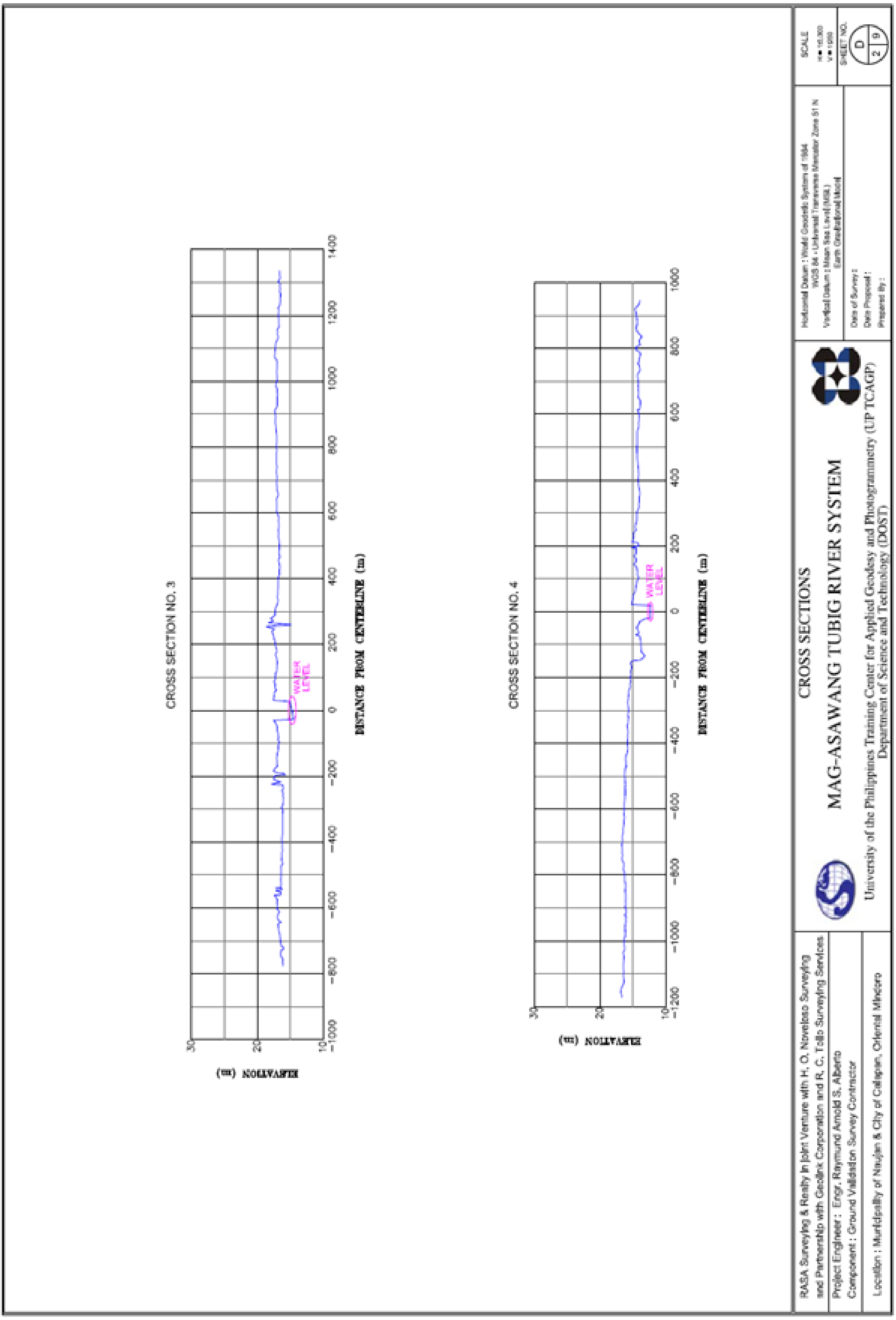
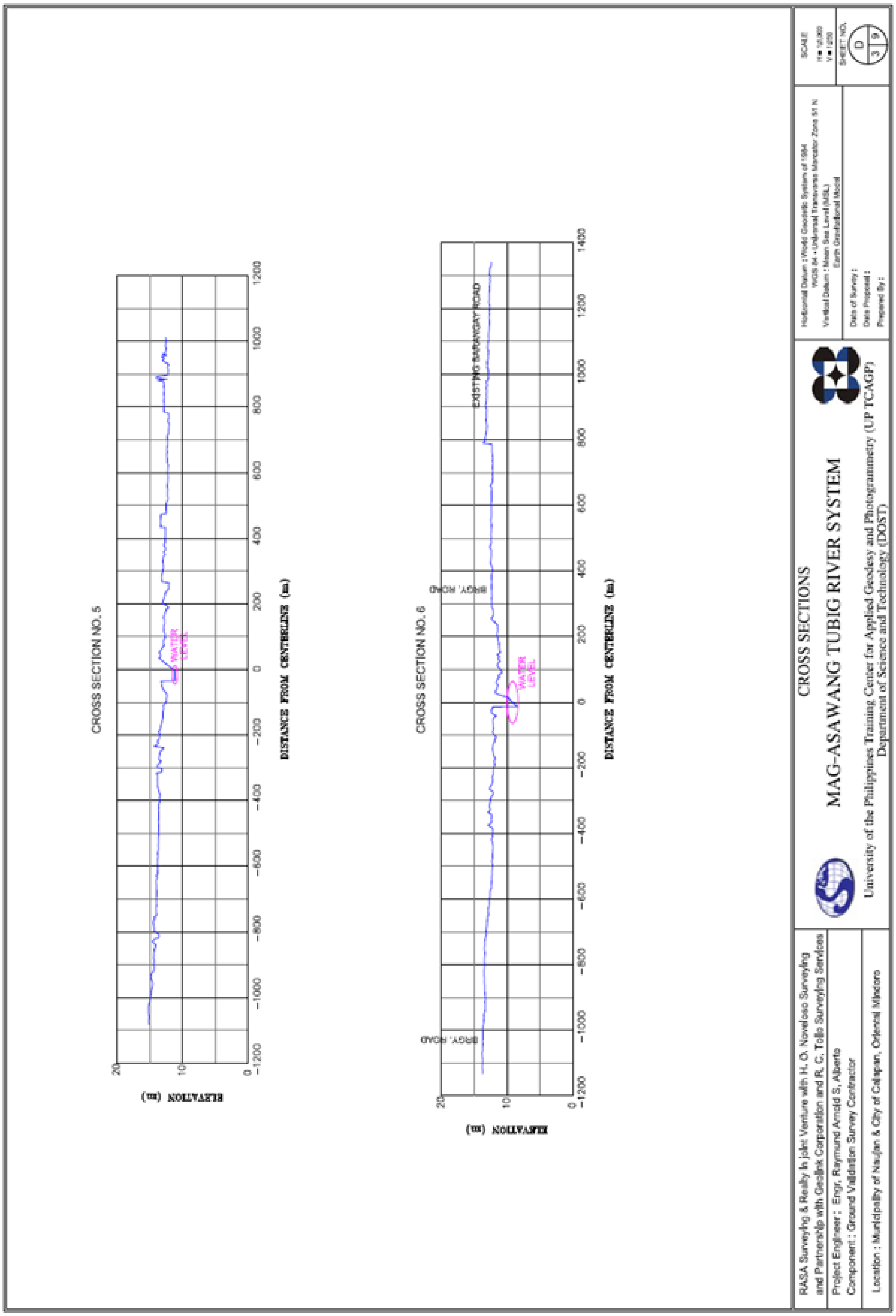


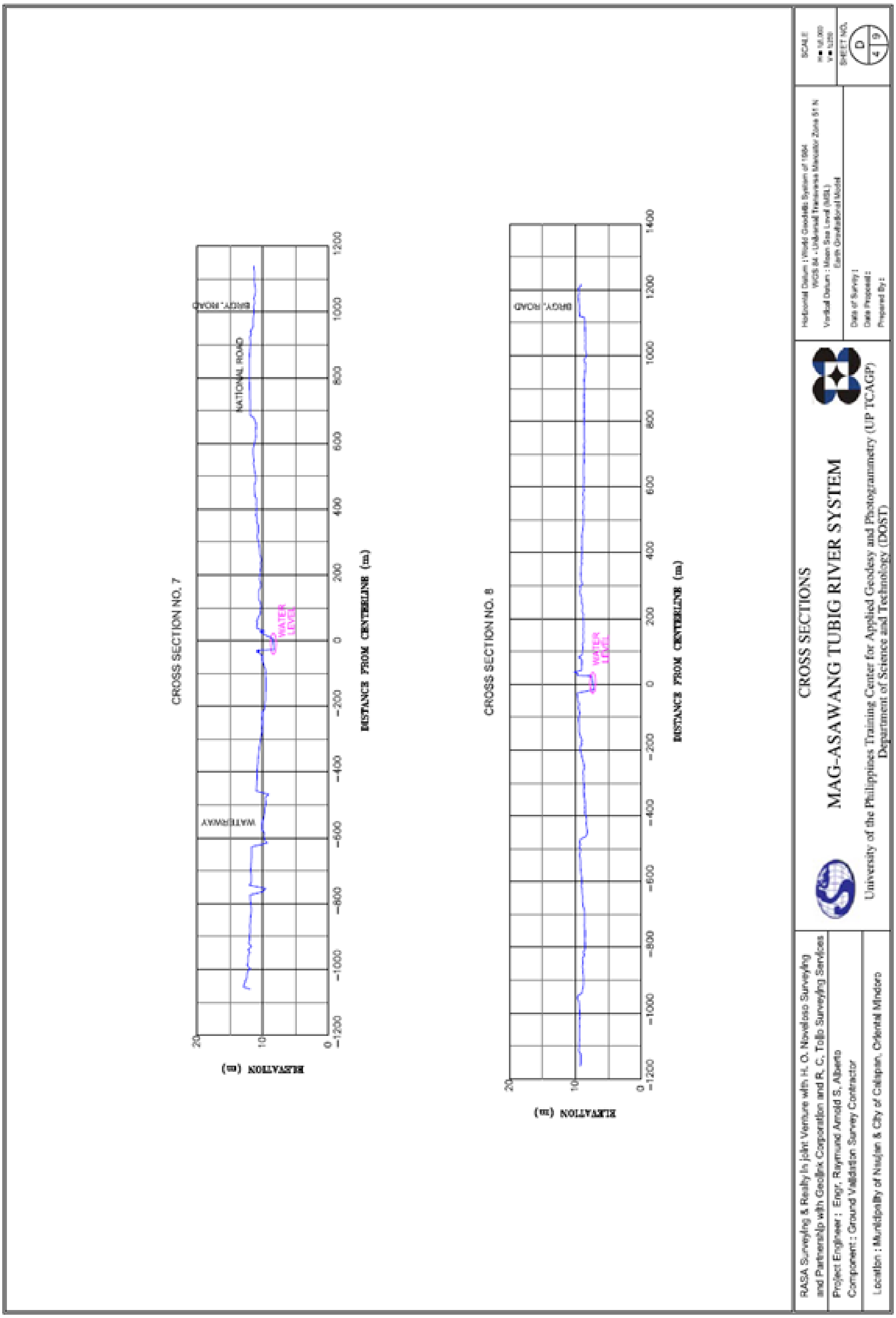
Figure 63. Processed data of River Cross-sections

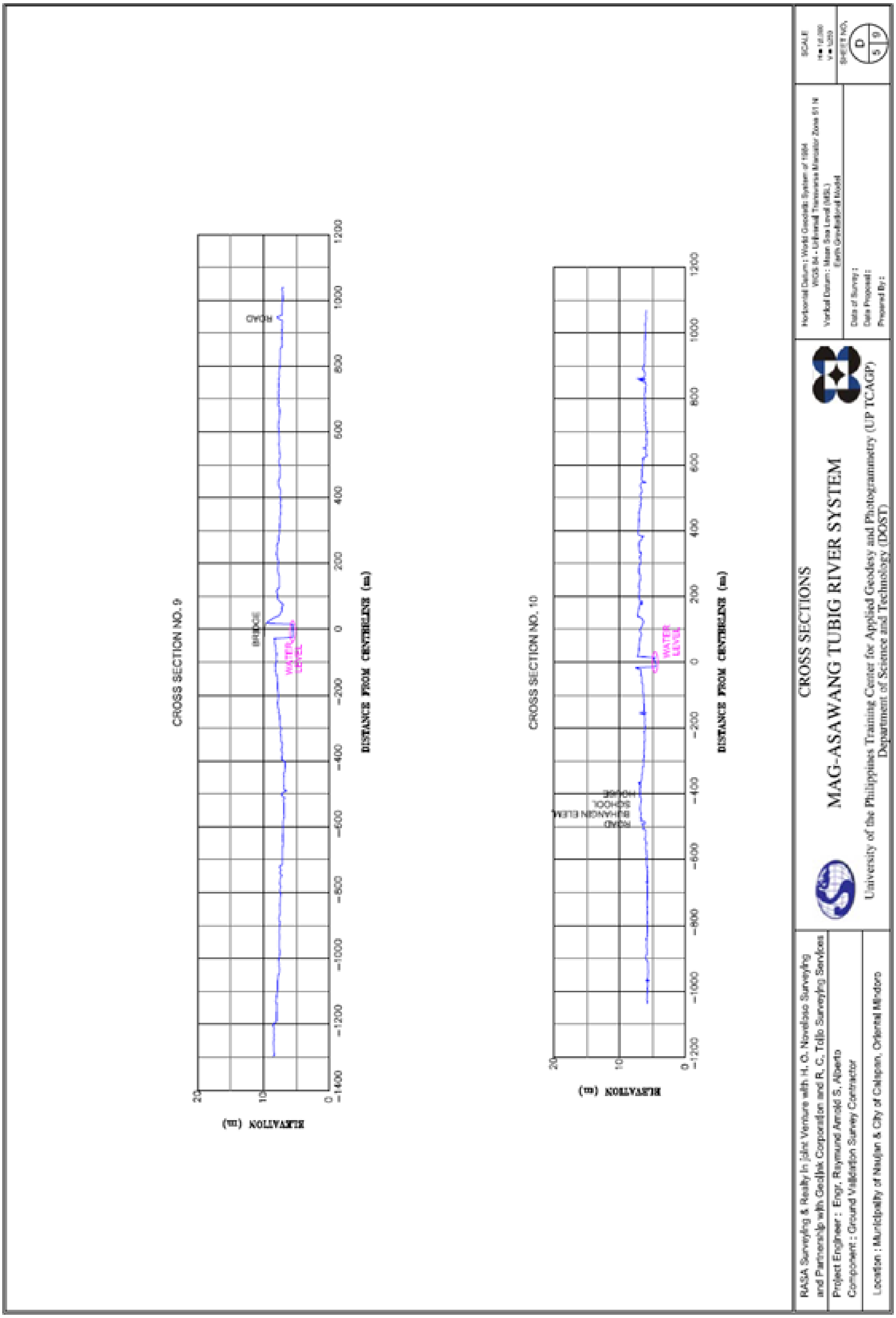


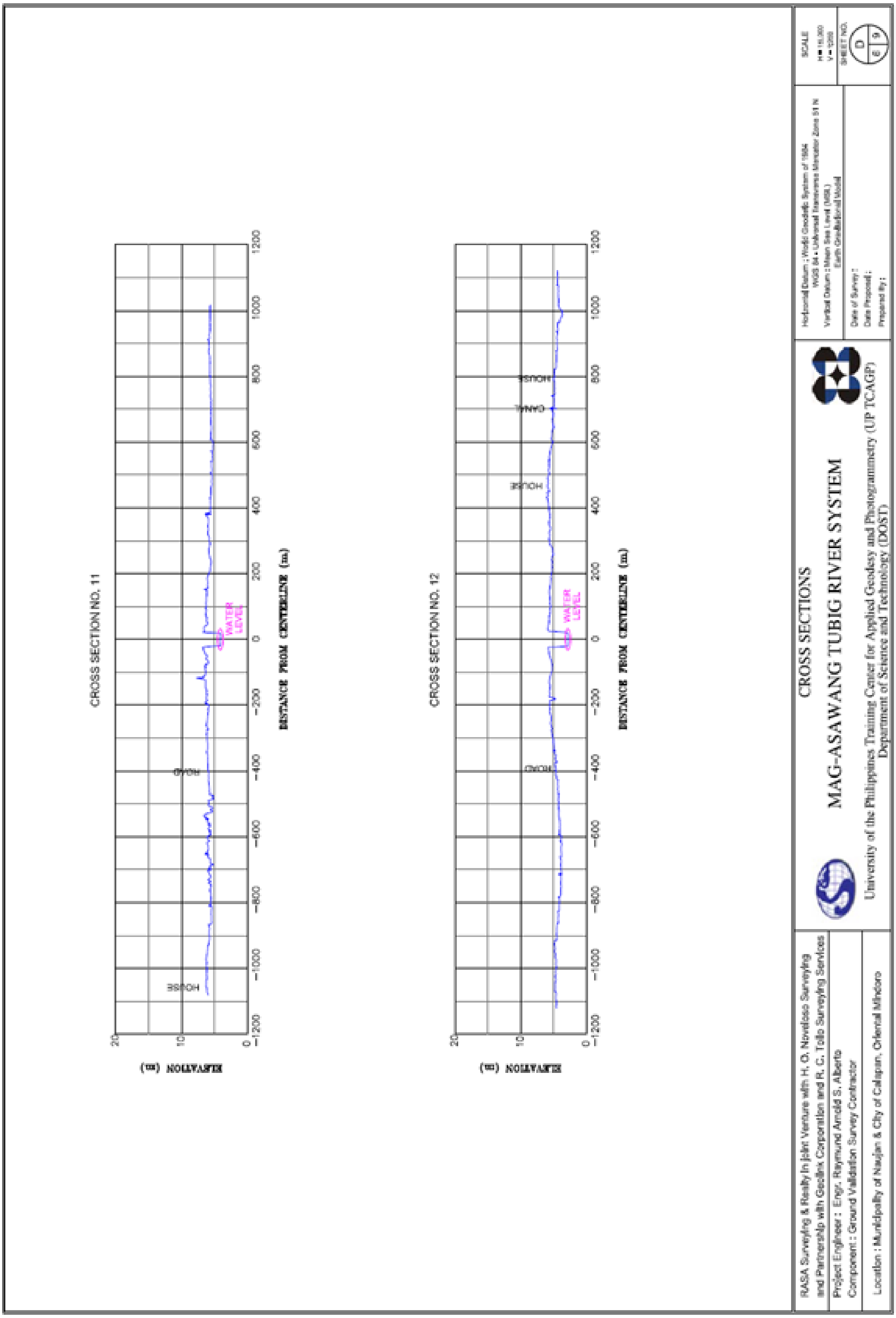
CROSS SECTION NO. 3
CROSS SECTION NO. 4
WATER LEVEL
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
CROSS SECTIONS
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelozo Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro

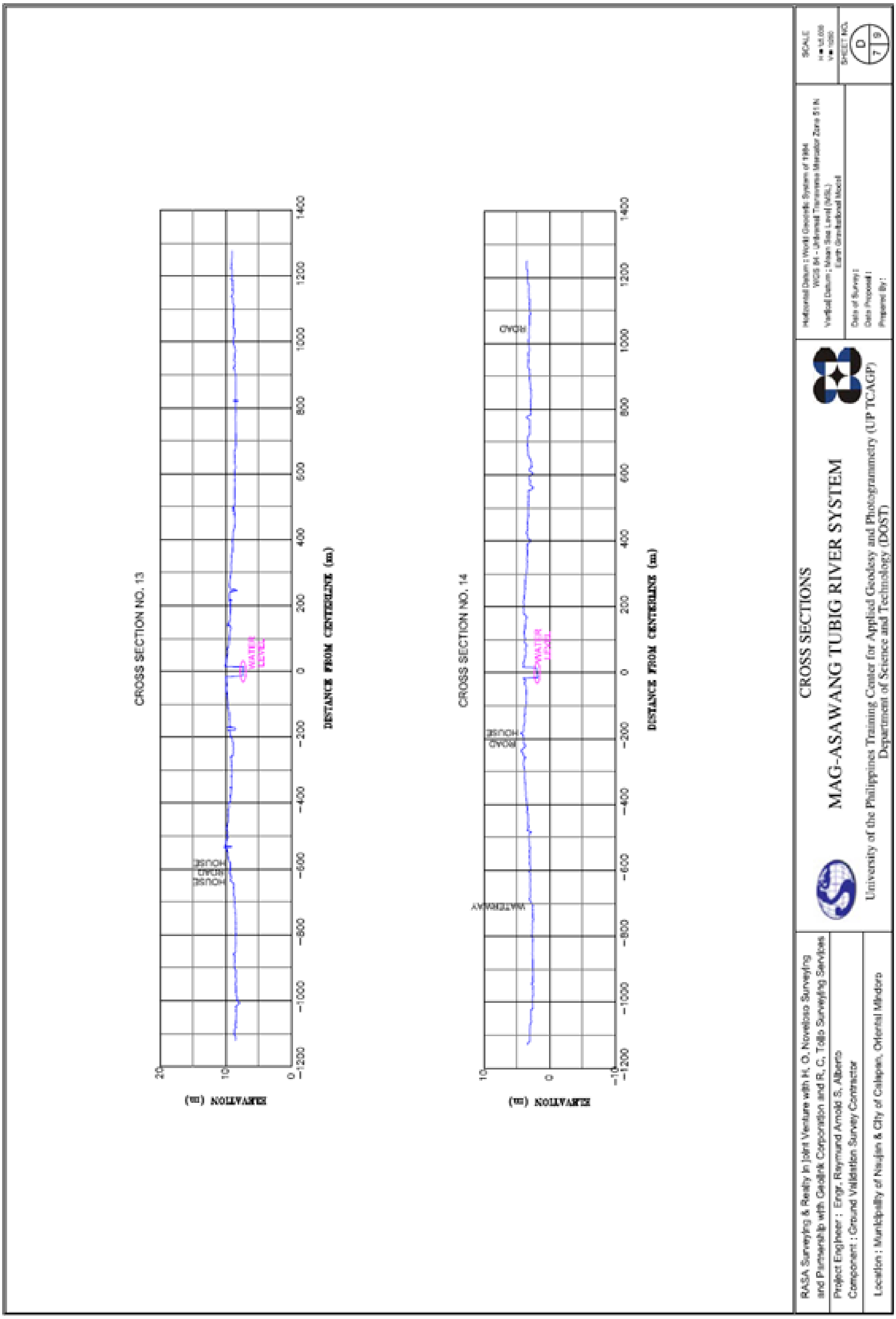


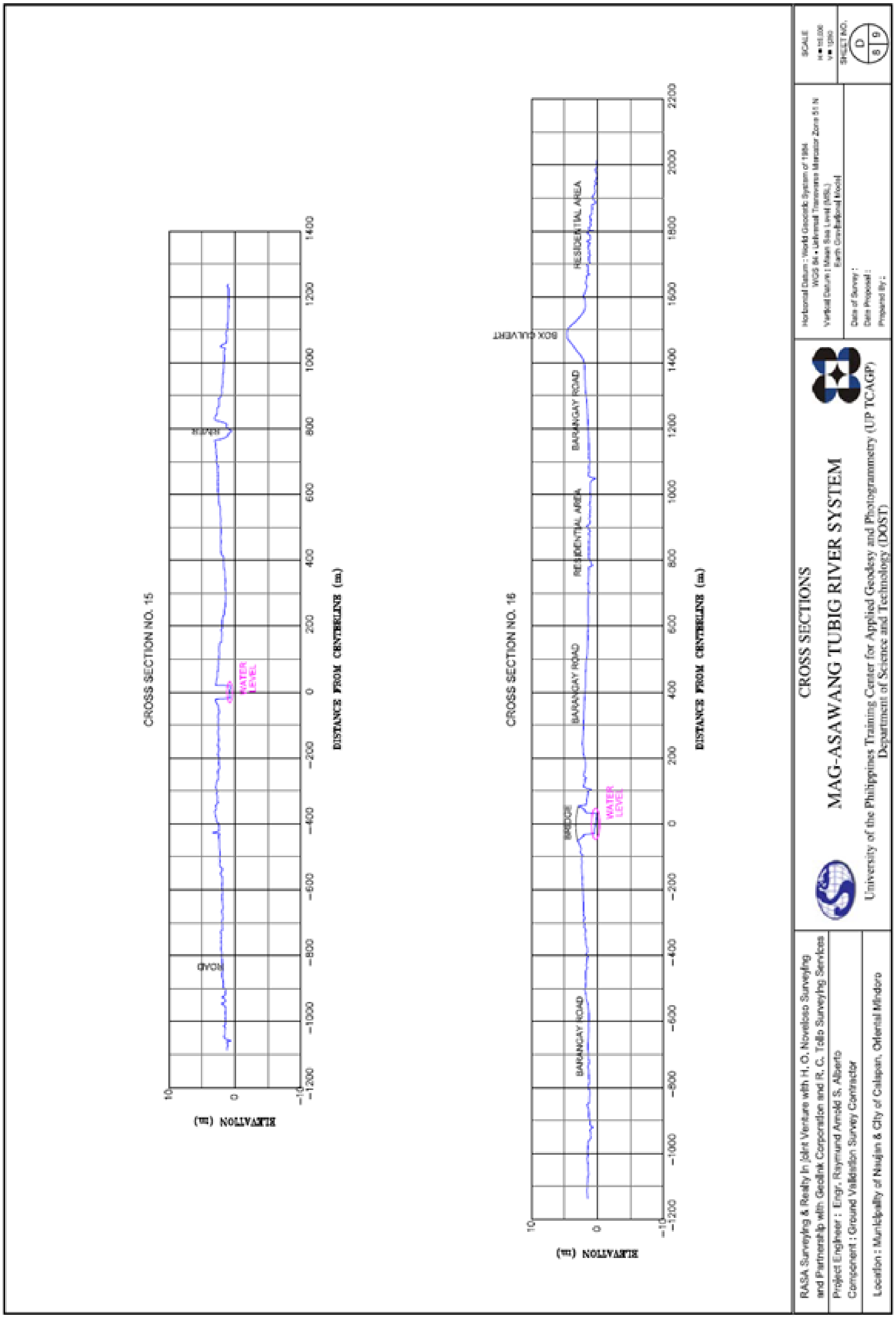
CROSS SECTION NO. 5
CROSS SECTION NO. 6
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
BRGY. ROAD
EXISTING BARANGAY ROAD
CROSS SECTIONS
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Novelozo Surveying and Partnership with Geolink Corporation and R. C. Tello Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposal :
Prepared By :
SCALE
SHEET NO.


CROSS SECTION NO. 7
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
BRGY. ROAD
NATIONAL ROAD
WATER LEVEL
WATERWAY
CROSS SECTION NO. 8
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
BRGY. ROAD
WATER LEVEL
RASA Surveying & Realty In joint Venture with H. O. Navelaso Surveying and Partnership with Geolinx Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
CROSS SECTIONS
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposed :
Prepared By :
SCALE
SHEET NO.
D
4
9


CROSS SECTION NO. 9
BRIDGE
ROAD
WATER LEVEL
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
CROSS SECTION NO. 10
ROAD
BUHANGIN ELEM. SCHOOL
HOUSE
WATER LEVEL
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
CROSS SECTIONS
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro


CROSS SECTION NO. 11
CROSS SECTION NO. 12
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
HOUSE
ROAD
CANAL
CROSS SECTIONS
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tolib Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
Horizontal Datum : World Geodetic System of 1984
Vertical Datum : Mean Sea Level (MSL)
SCALE
SHEET NO.


CROSS SECTION NO. 13
CROSS SECTION NO. 14
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
HOUSE
ROAD
WATERWAY
CROSS SECTIONS
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)



CROSS SECTION NO. 15
CROSS SECTION NO. 16
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
ROAD
BARANGAY ROAD
BRIDGE
RESIDENTIAL AREA
BOX CULVERT
CROSS SECTIONS
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelozo Surveying and Partnership with Geolink Corporation and R. C. Tolib Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposed :
Prepared By :
SCALE
SHEET NO.
D
8 9

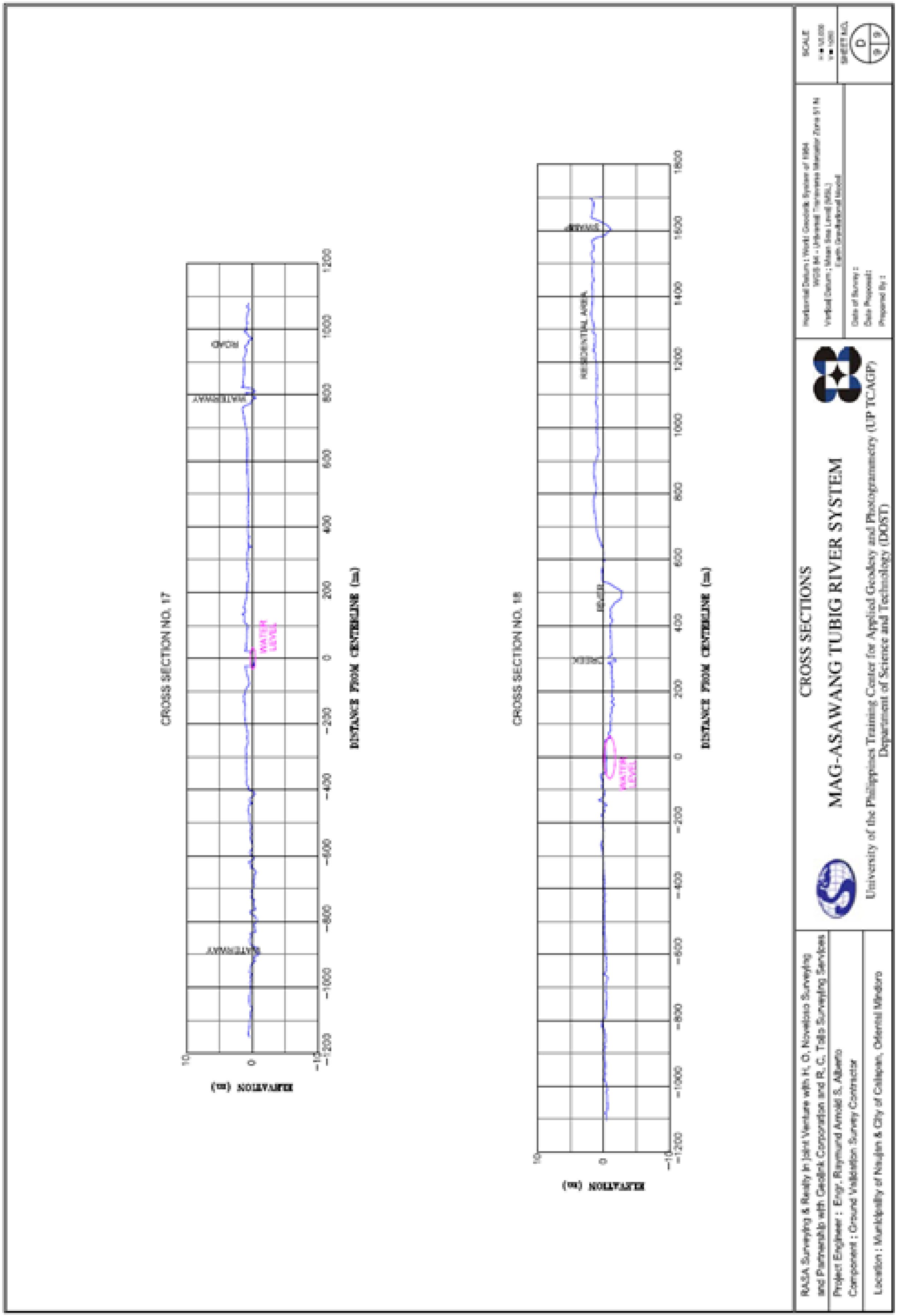
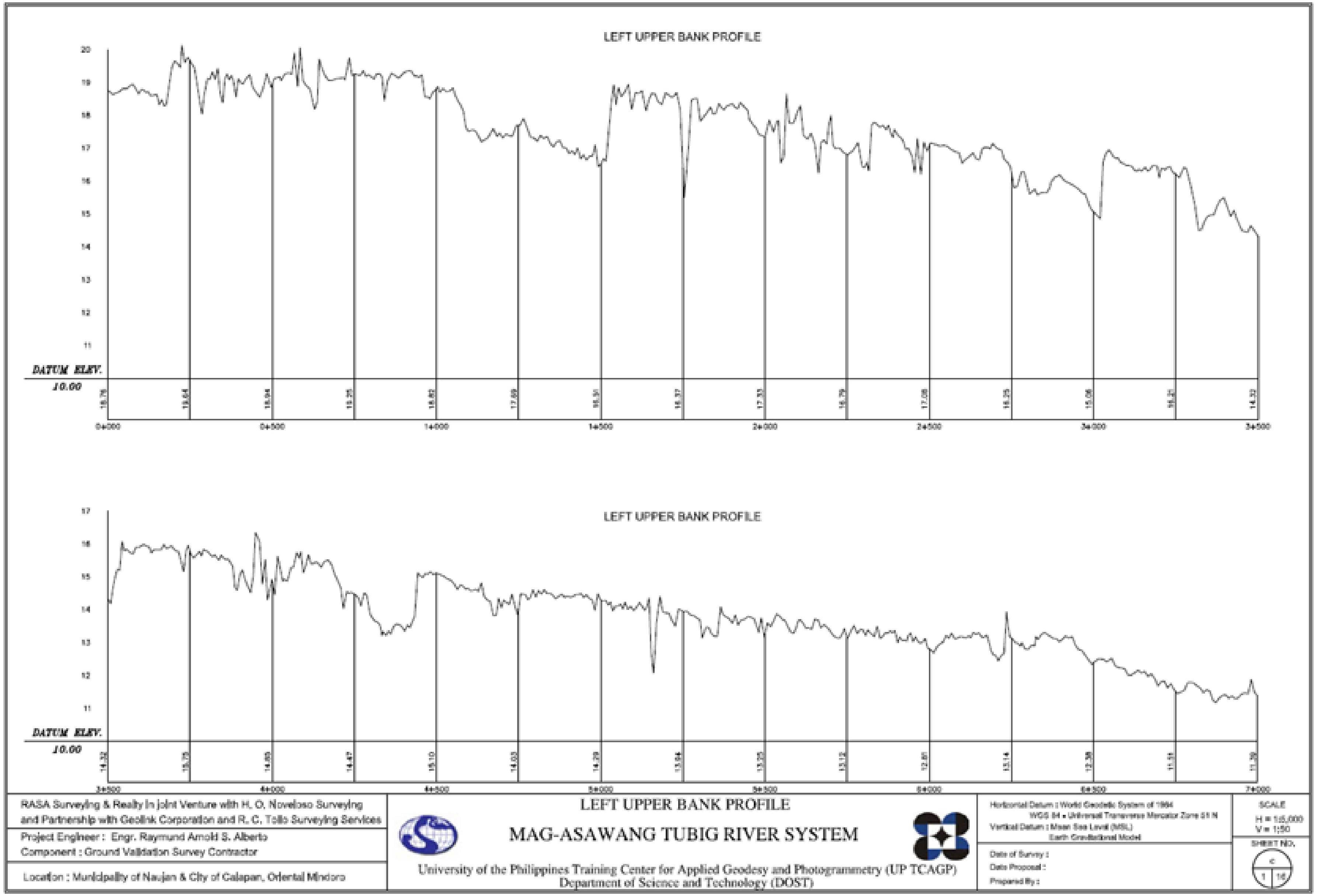
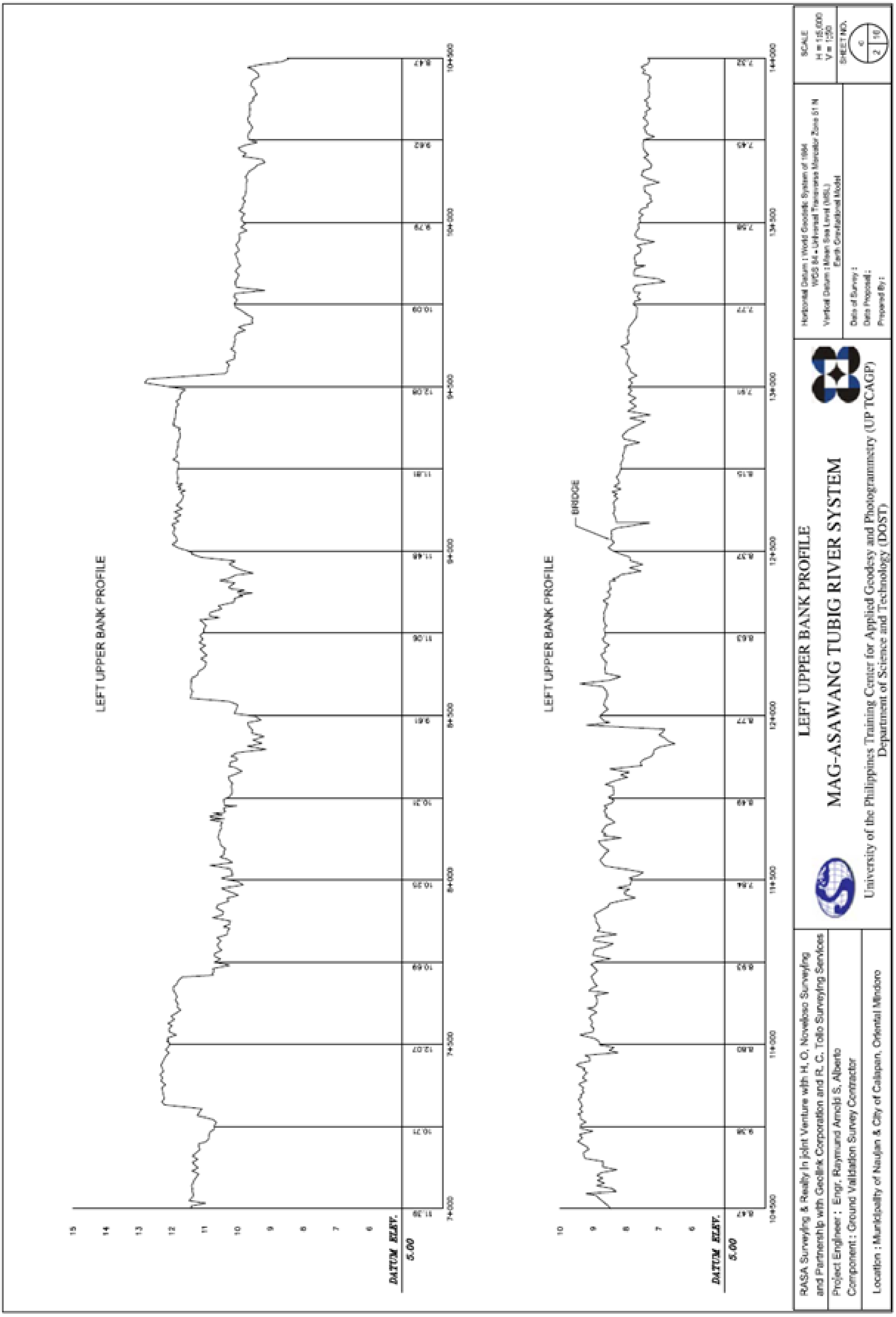
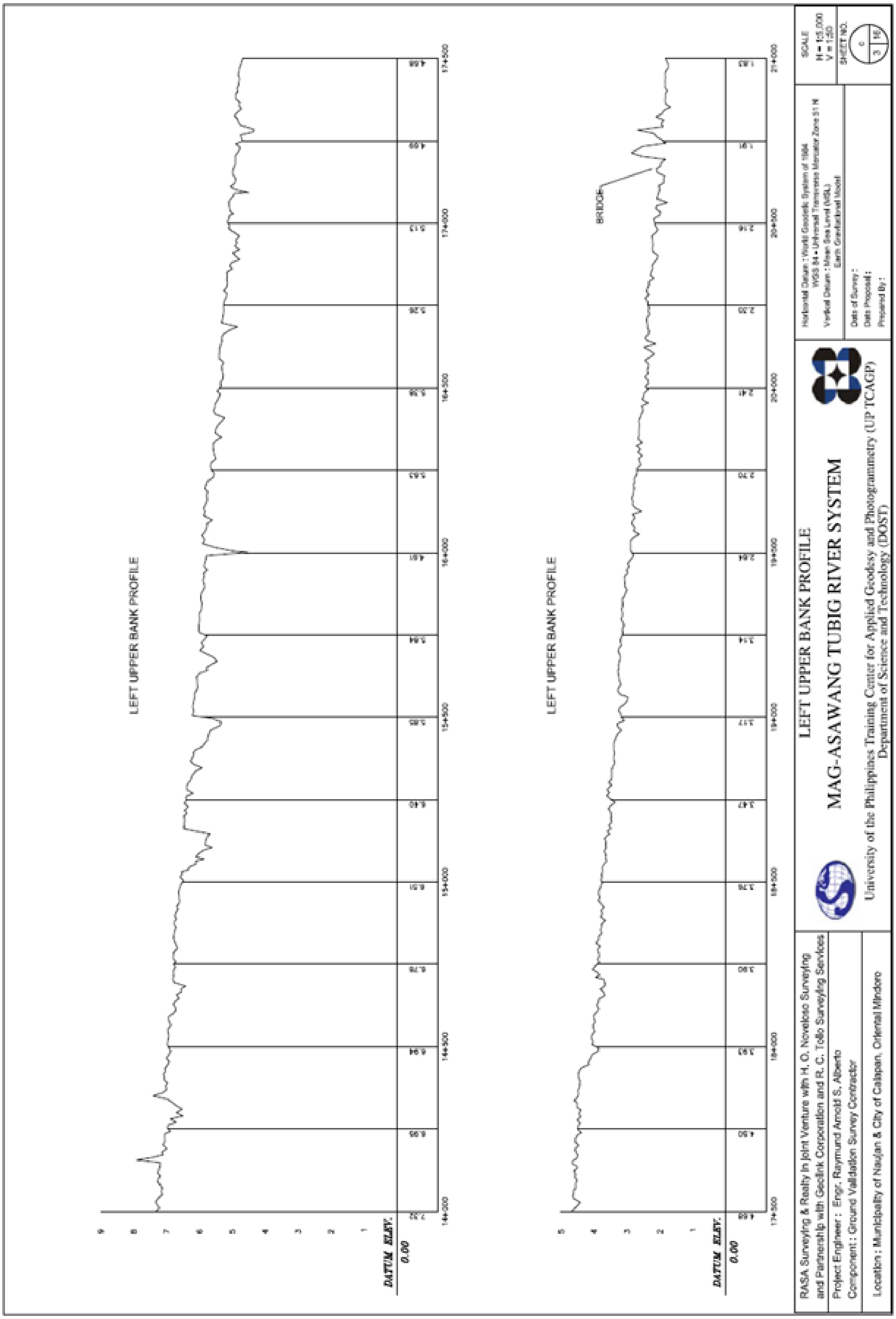

CROSS SECTION NO. 17
CROSS SECTION NO. 18
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
WATERWAY
ROAD
CREEK
RIVER
RESIDENTIAL AREA
SWAMP
CROSS SECTIONS
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro

Figure 64. Processed data for Left Upper Bank Profile of the River




LEFT UPPER BANK PROFILE
LEFT UPPER BANK PROFILE
BRIDGE
DATUM ELEV.
5.00
7+000
7+500
8+000
8+500
9+000
9+500
10+000
10+500
11+000
11+500
12+000
12+500
13+000
13+500
14+000
LEFT UPPER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in joint Venture with H. O. Novelloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposed :
Prepared By :
SCALE
H = 1:5,000
V = 1:50
SHEET NO.


LEFT UPPER BANK PROFILE
LEFT UPPER BANK PROFILE
BRIDGE
DATUM ELEV.
0.00
DATUM ELEV.
0.00
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
LEFT UPPER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 = Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposal :
Prepared By :
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
3
16

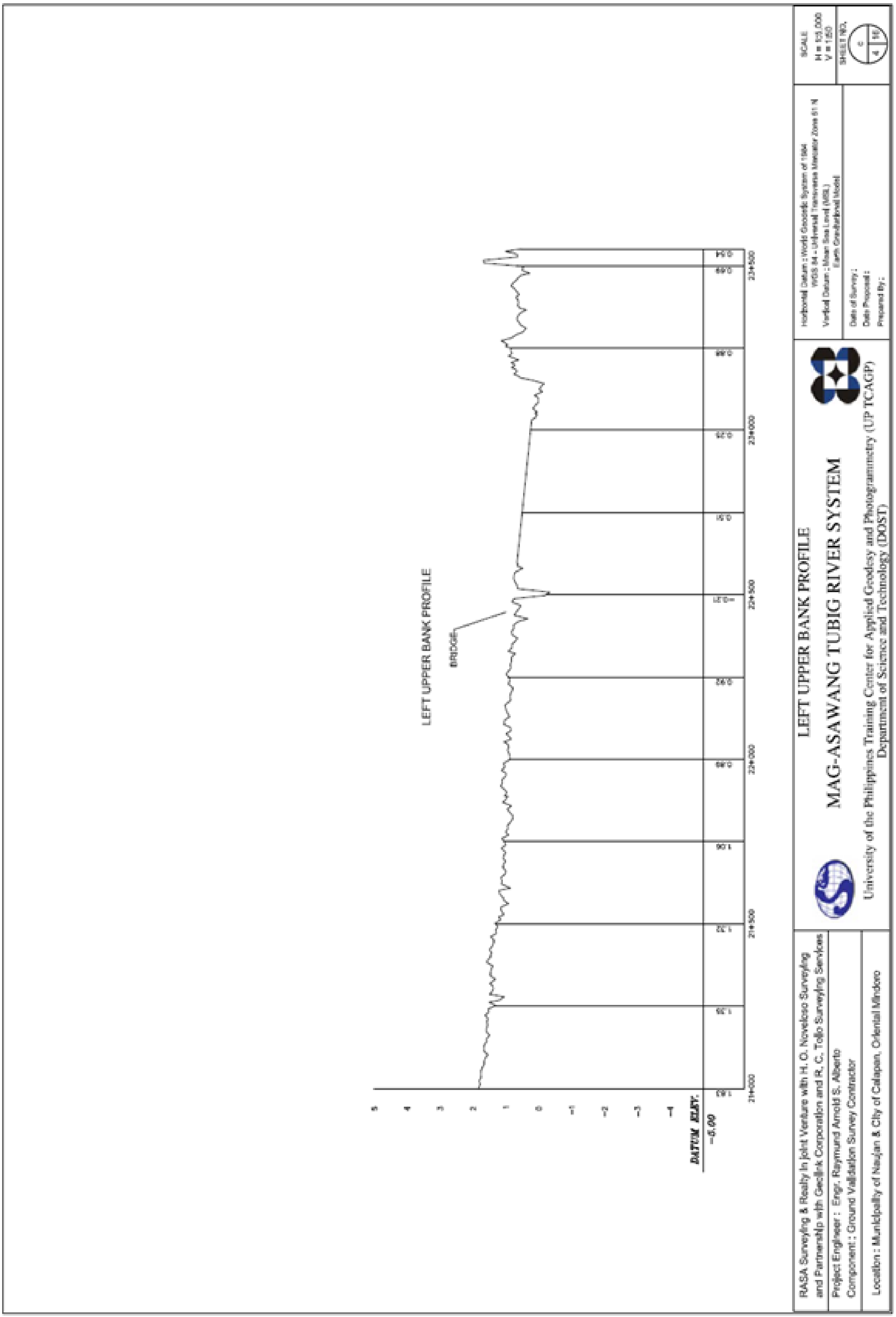
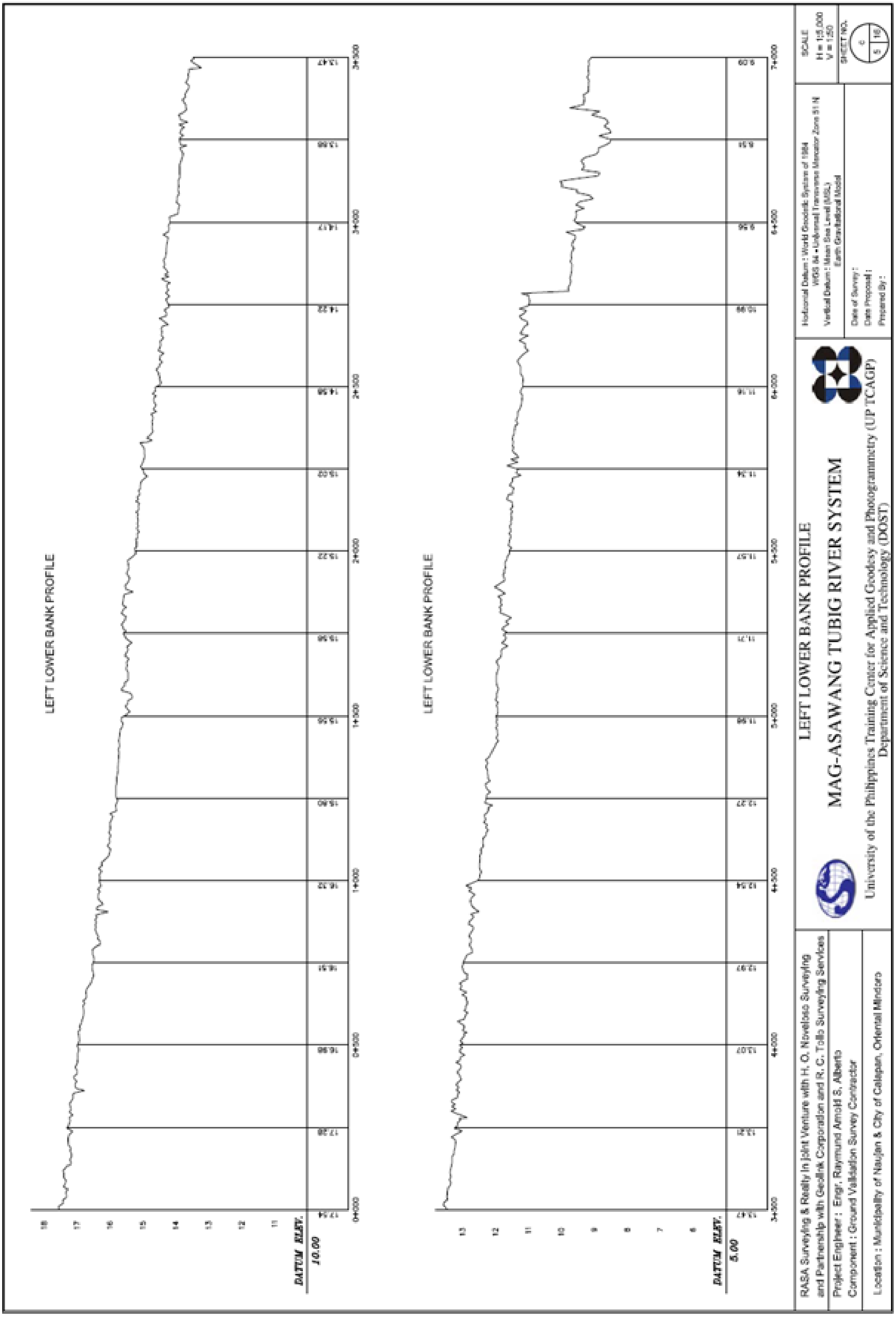
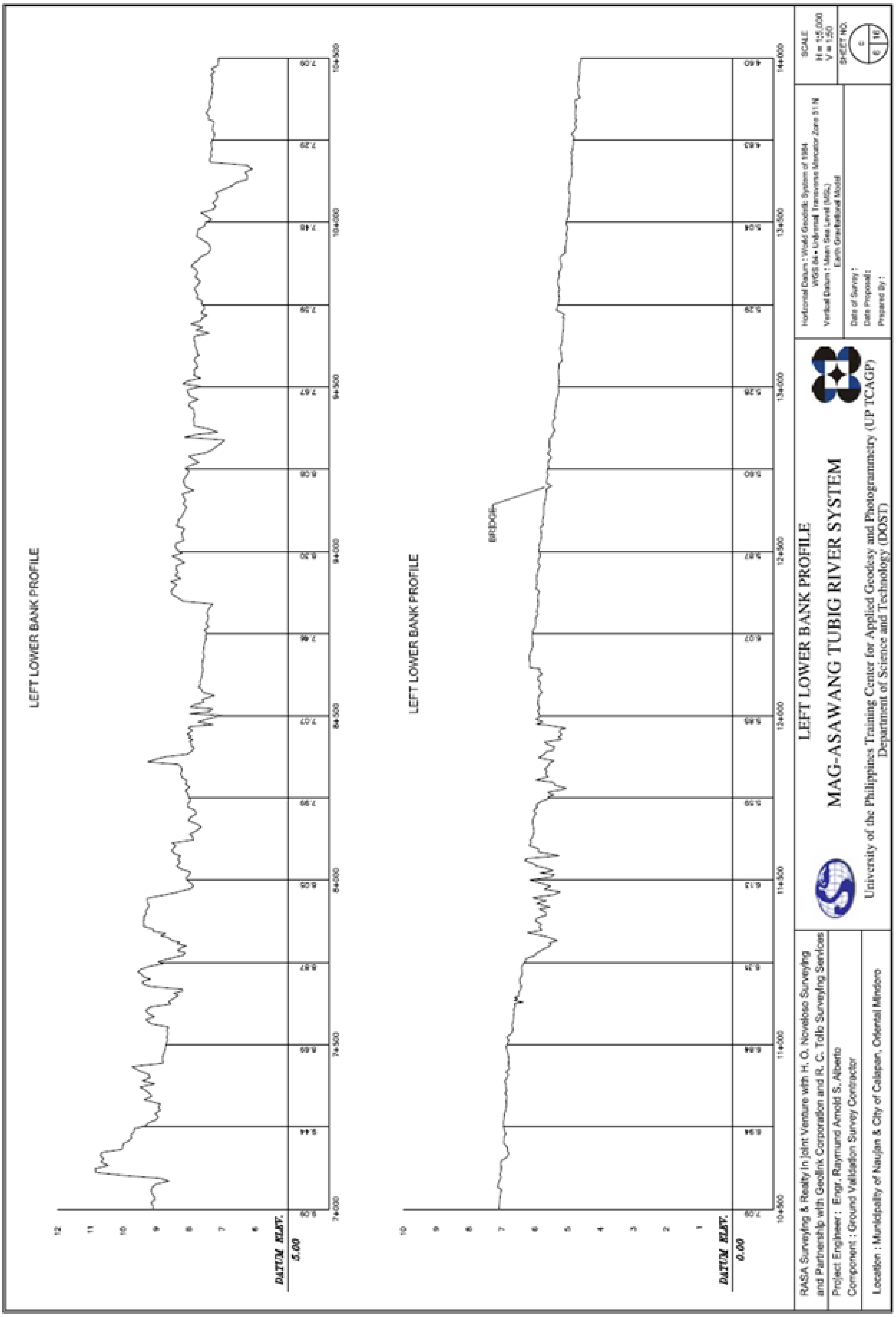
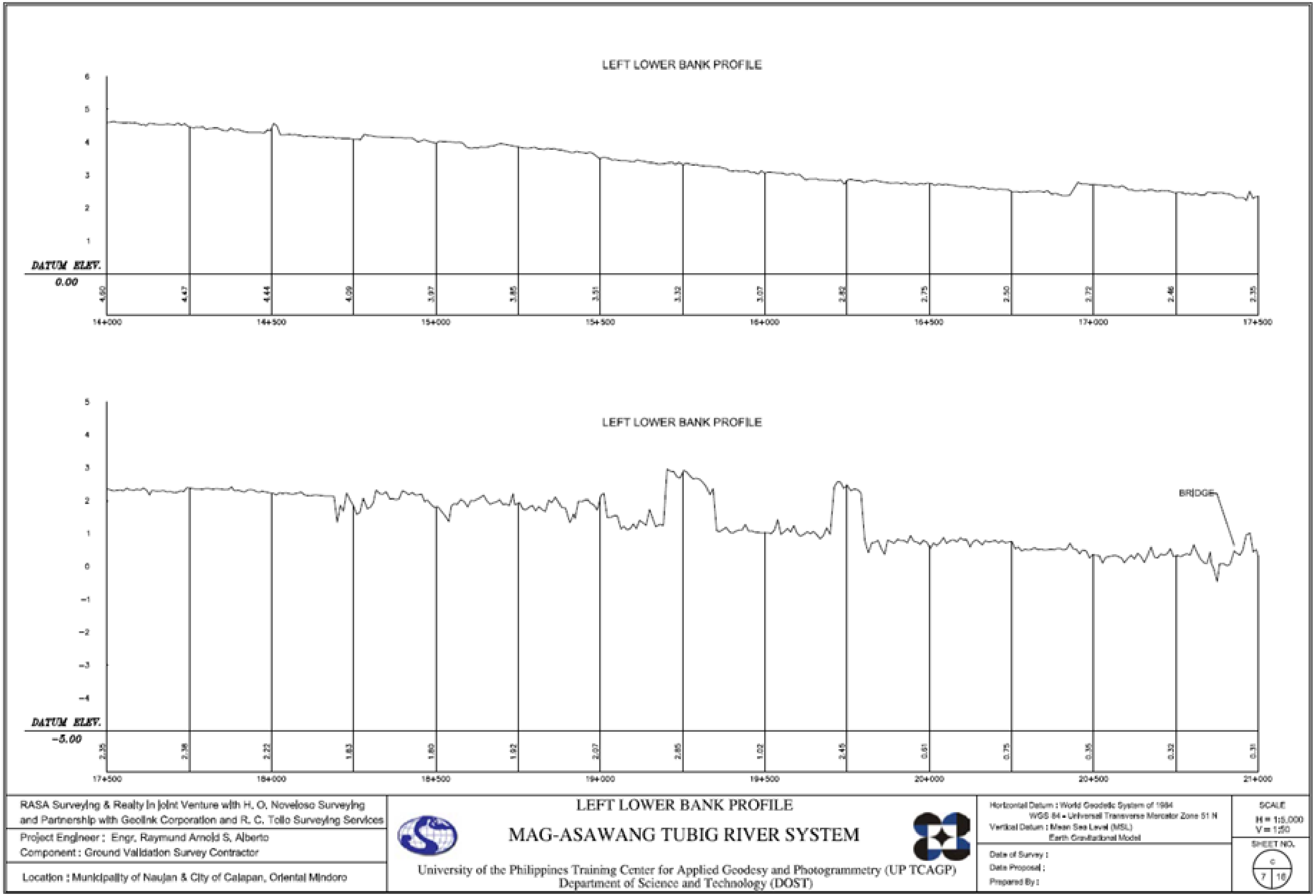
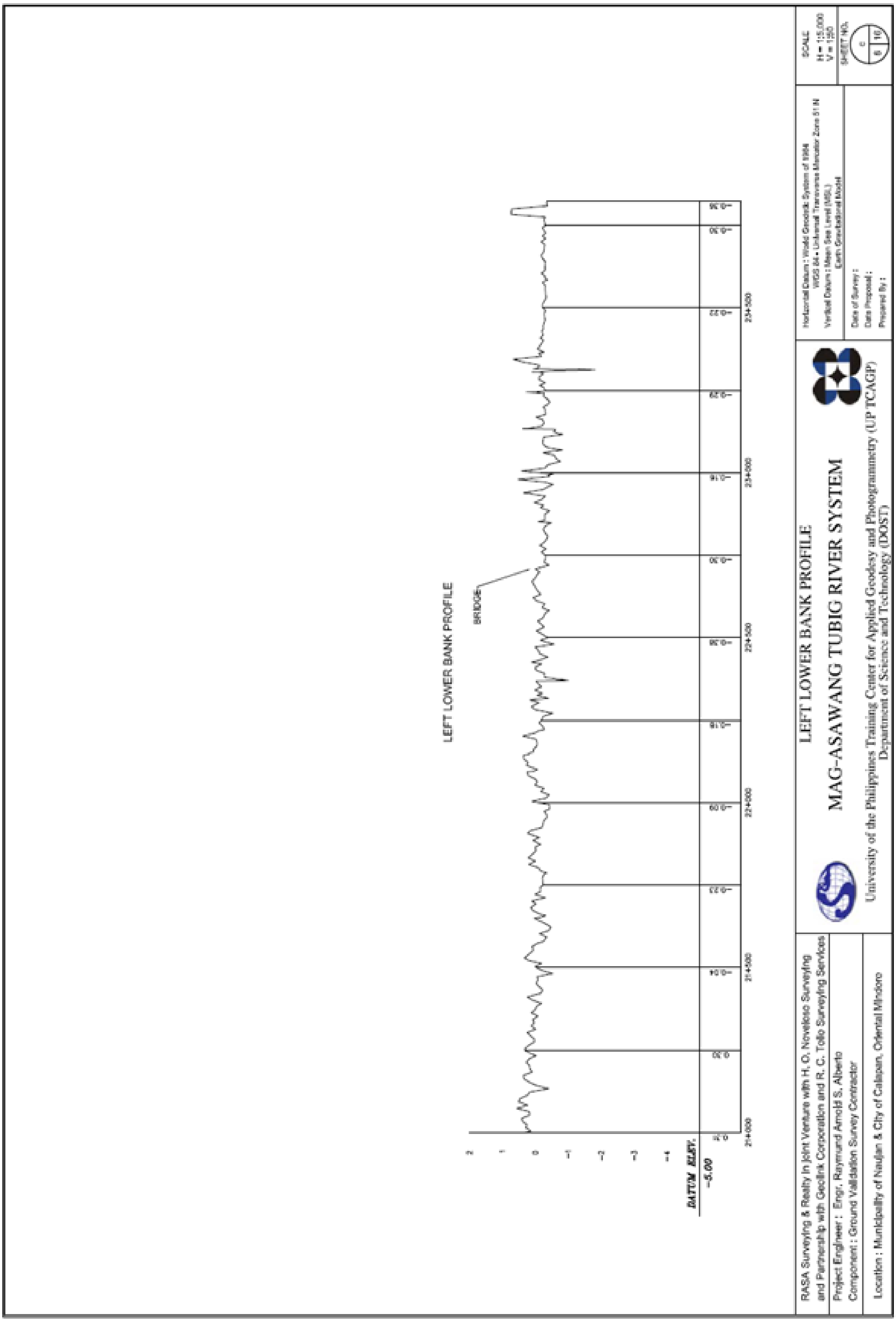

LEFT UPPER BANK PROFILE
BRIDGE
DATUM ELEV.
-5.00
21+000
21+500
22+000
22+500
23+000
23+500
LEFT UPPER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelozo Surveying
and Partnership with Geolink Corporation and R. C. Tolio Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
Horizontal Datum : World Geodetic System of 1984
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposed :
Prepared By :
SCALE
H = 1:5,000
V = 1:50
SHEET NO.

Figure 65. Processed data for Left Lower Bank Profile of the River




LEFT LOWER BANK PROFILE
LEFT LOWER BANK PROFILE
BRIDGE
DATUM ELEV. 5.00
DATUM ELEV. 0.00
LEFT LOWER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
Horizontal Datum : World Geodetic System of 1984
WGS 84 • Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposal :
Prepared By :
SCALE
SHEET NO.


LEFT LOWER BANK PROFILE
DATUM ELEV.
0.00
4.60
4.47
4.44
4.09
3.97
3.85
3.51
3.32
3.07
2.82
2.75
2.50
2.72
2.46
2.35
14+000
14+500
15+000
15+500
16+000
16+500
17+000
17+500
LEFT LOWER BANK PROFILE
BRIDGE
DATUM ELEV.
-5.00
2.35
2.38
2.22
1.83
1.80
1.92
2.07
2.85
1.02
2.45
0.61
0.75
0.35
0.32
0.31
17+500
18+000
18+500
19+000
19+500
20+000
20+500
21+000
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with GeoInk Corporation and R. C. Tolo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
LEFT LOWER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposal :
Prepared By :
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
7
16


LEFT LOWER BANK PROFILE
BRIDGE
DATUM ELEV.
-5.00
21+000
21+500
22+000
22+500
23+000
23+500
LEFT LOWER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelose Surveying
and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposal :
Prepared By :
SCALE
H = 1:5,000
V = 1:50
SHEET NO.

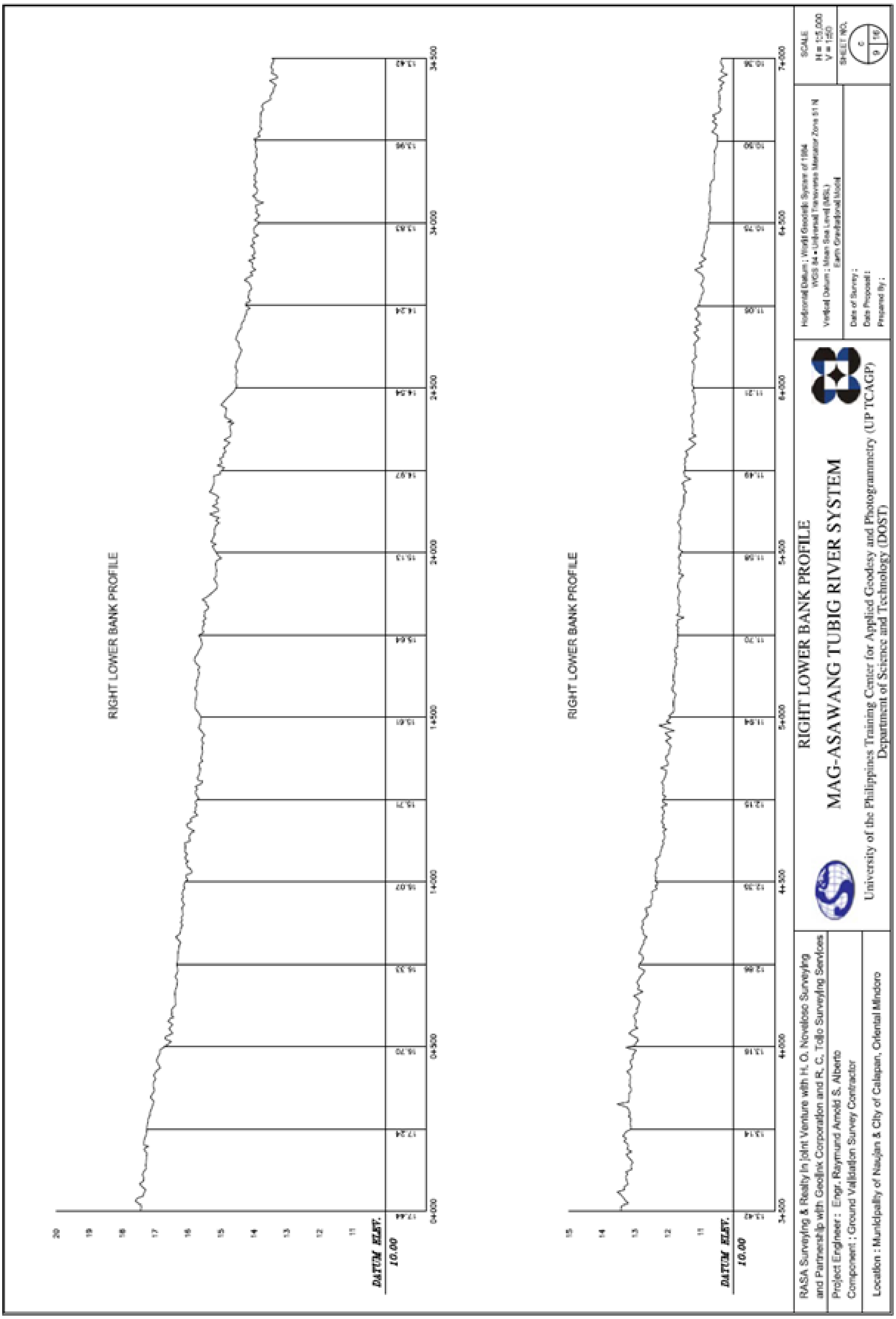
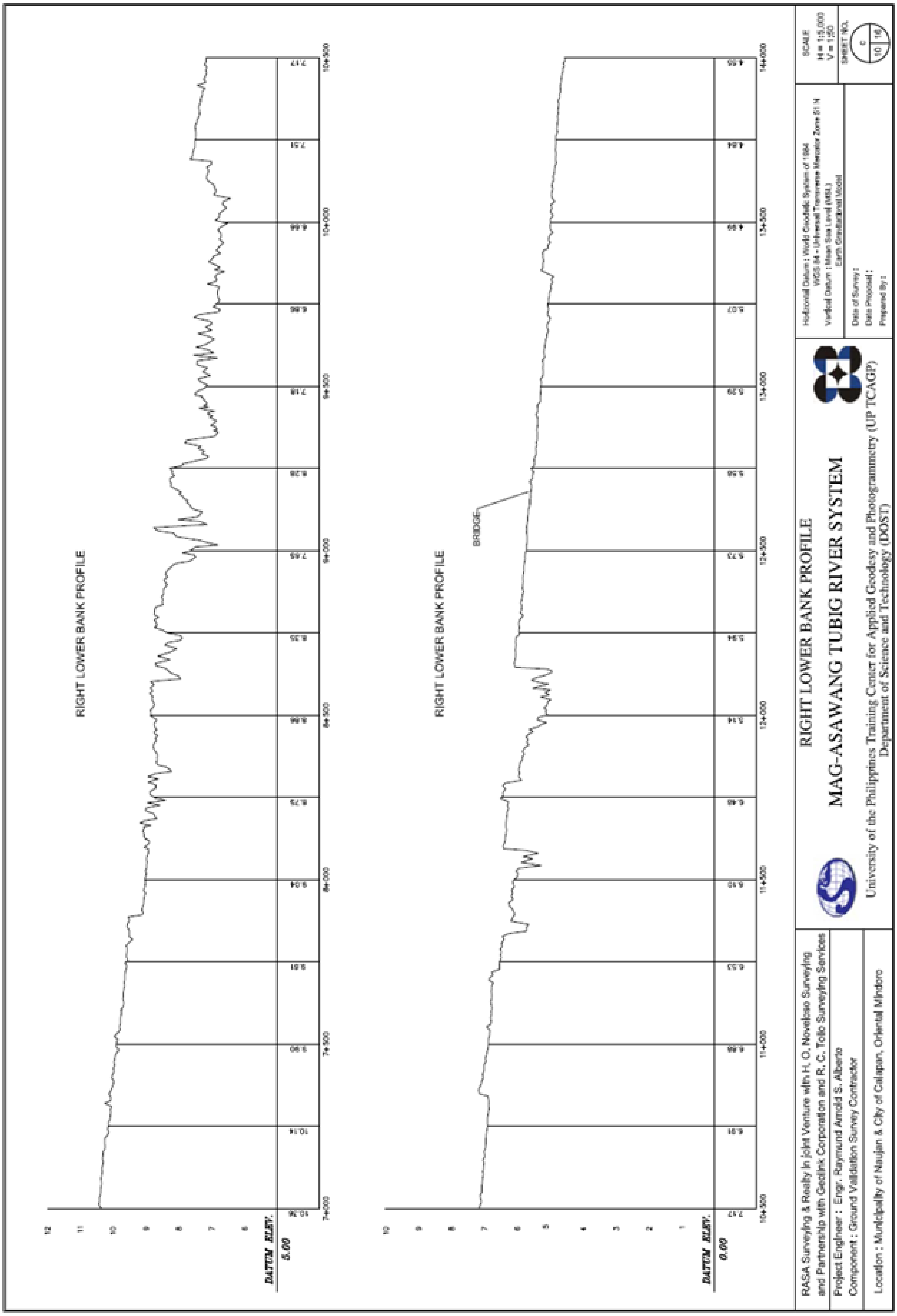
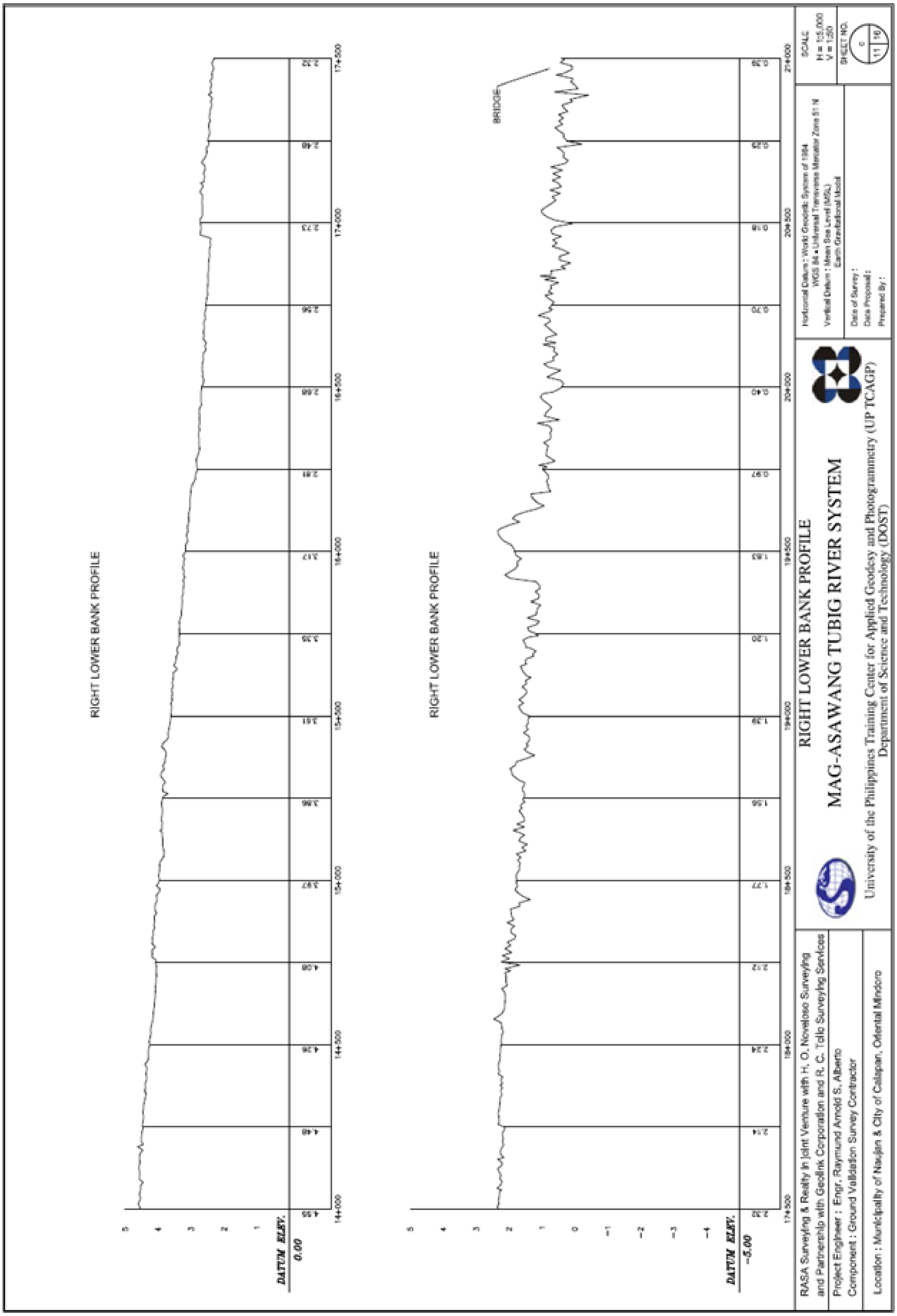


Figure 66. Processed data for Right Lower Bank Profile of the River


RIGHT LOWER BANK PROFILE
RIGHT LOWER BANK PROFILE
BRIDGE
DATUM ELEV. 5.00
DATUM ELEV. 0.00
7+000
7+500
8+000
8+500
9+000
9+500
10+000
10+500
10+500
11+000
11+500
12+000
12+500
13+000
13+500
14+000
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
RIGHT LOWER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposal :
Prepared By :
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
C
10
16


RIGHT LOWER BANK PROFILE
RIGHT LOWER BANK PROFILE
BRIDGE
RIGHT LOWER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tolle Surveying Services
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro

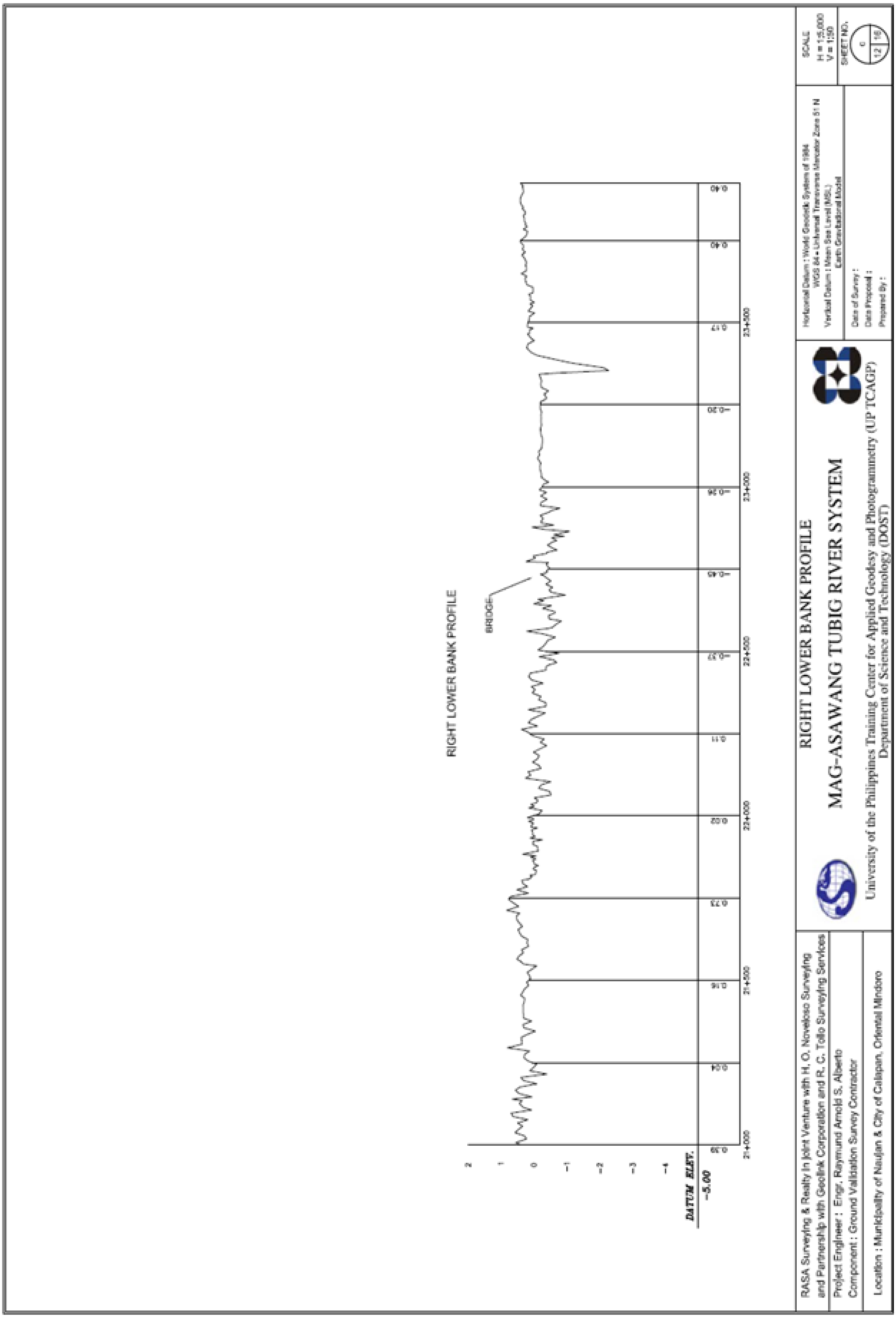
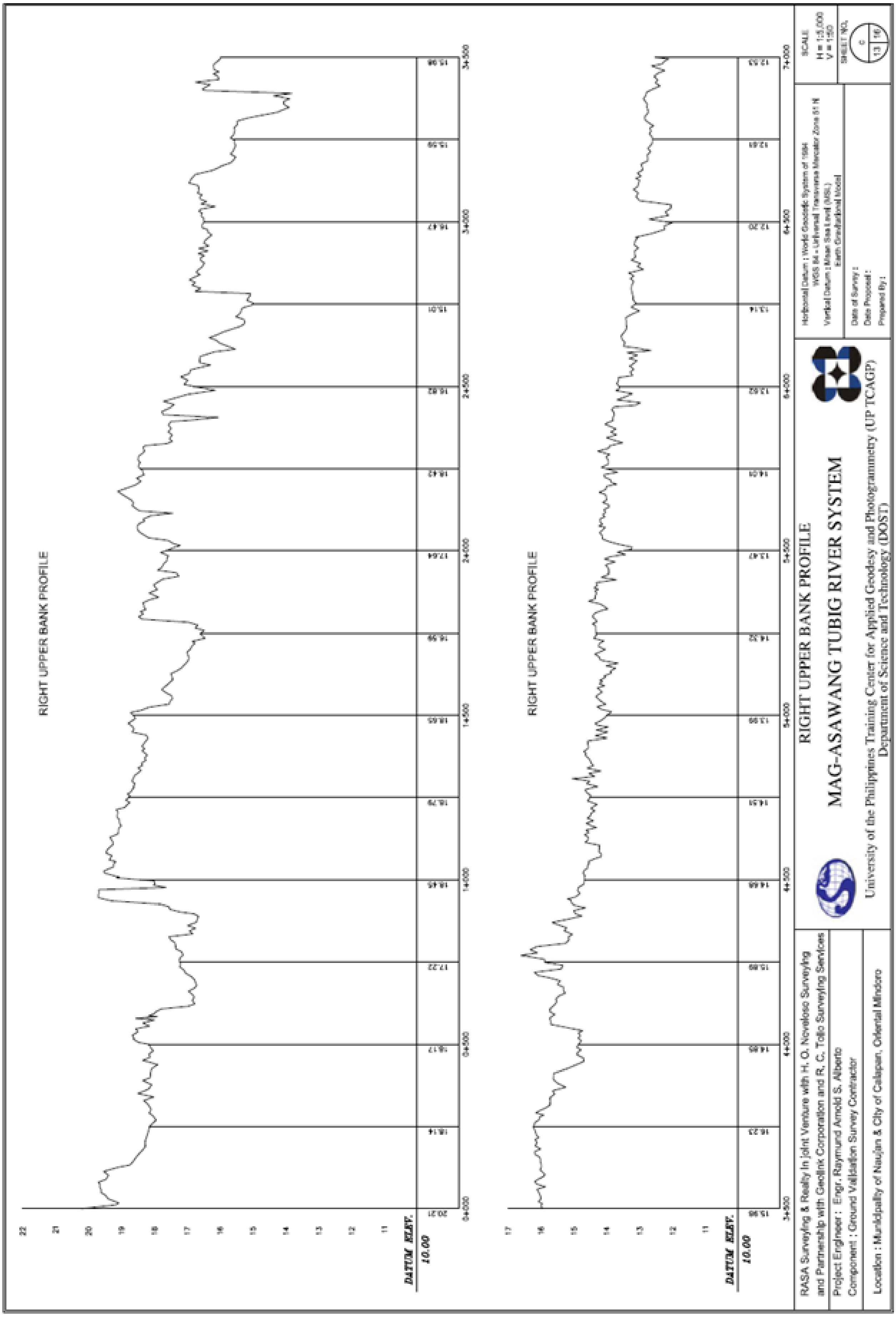
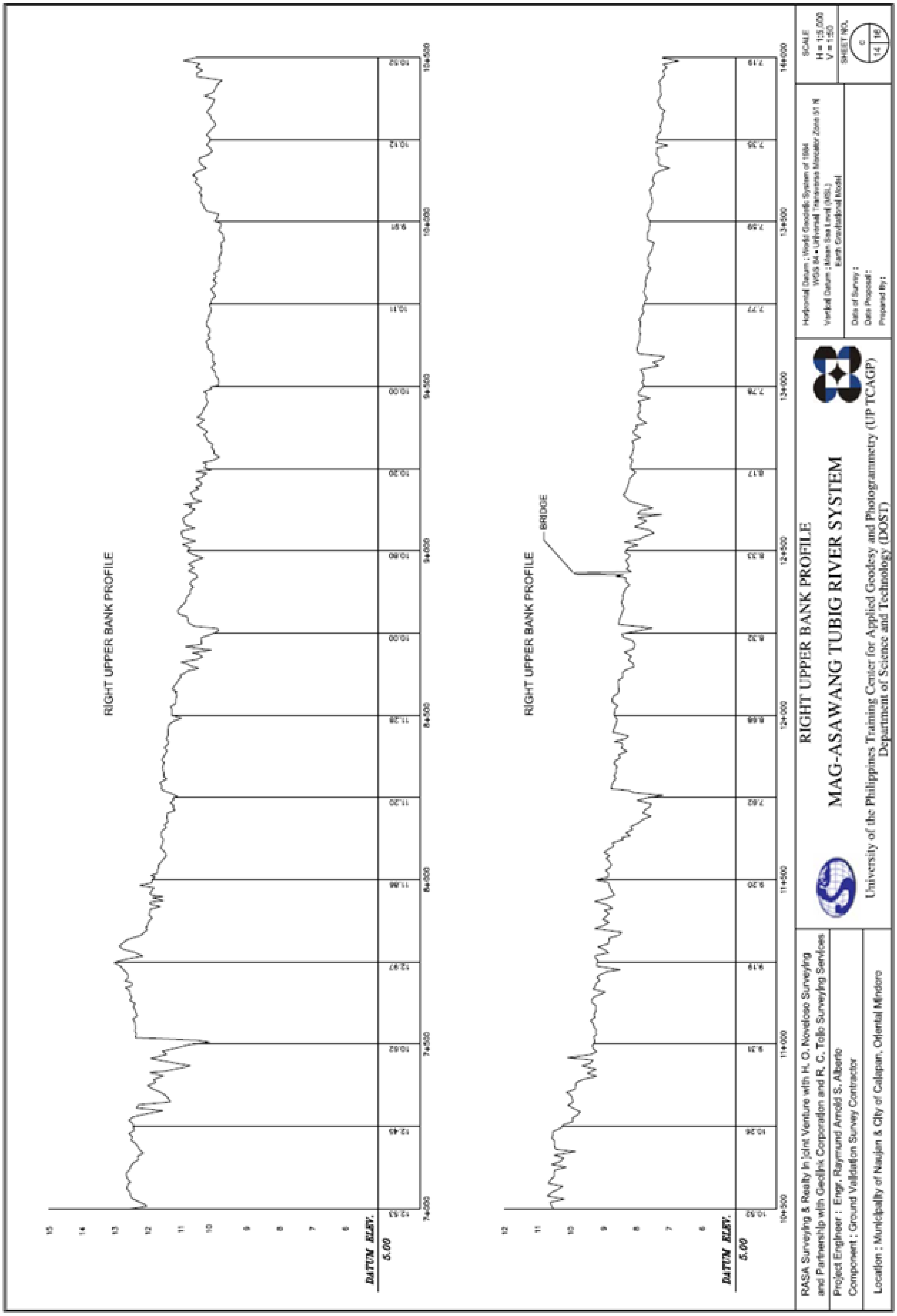
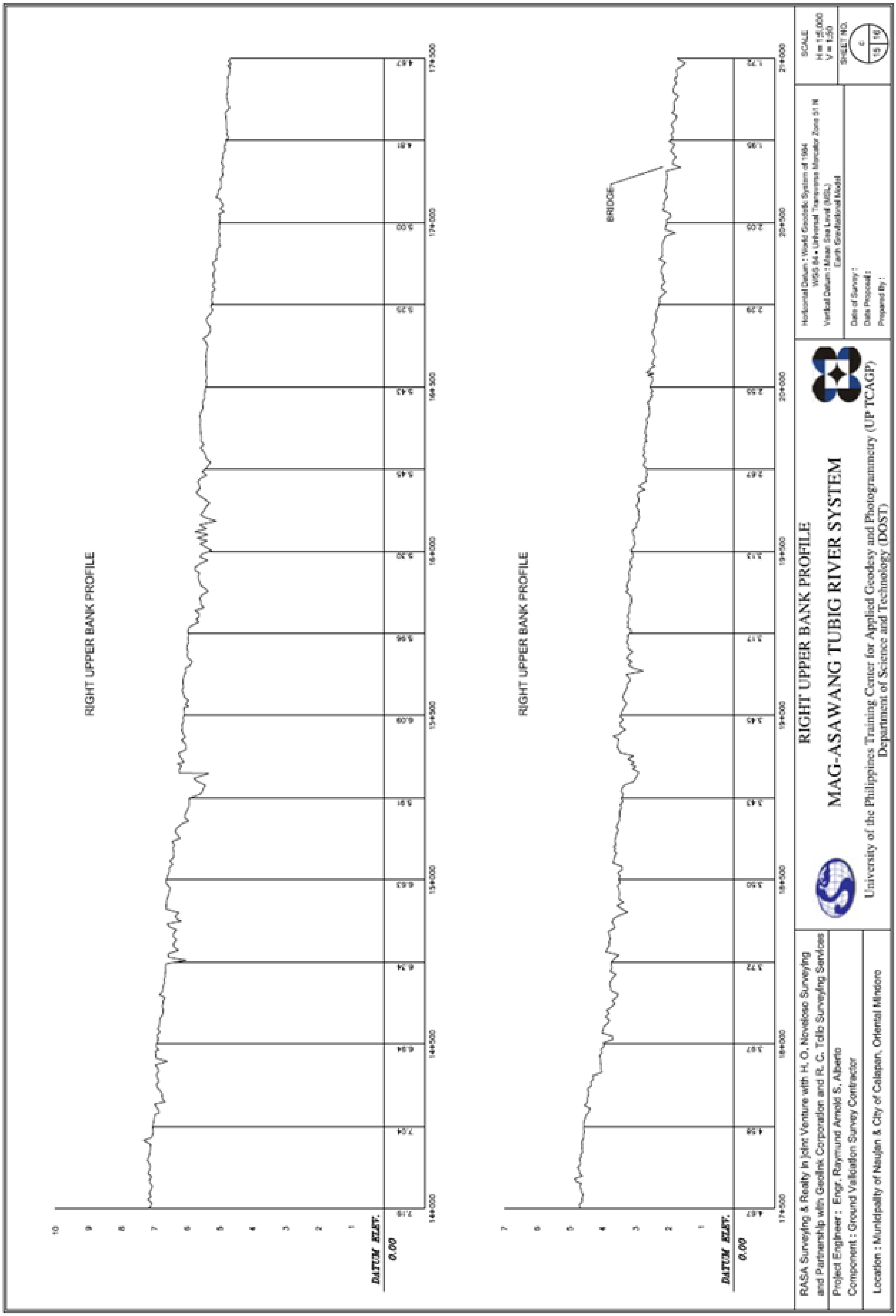
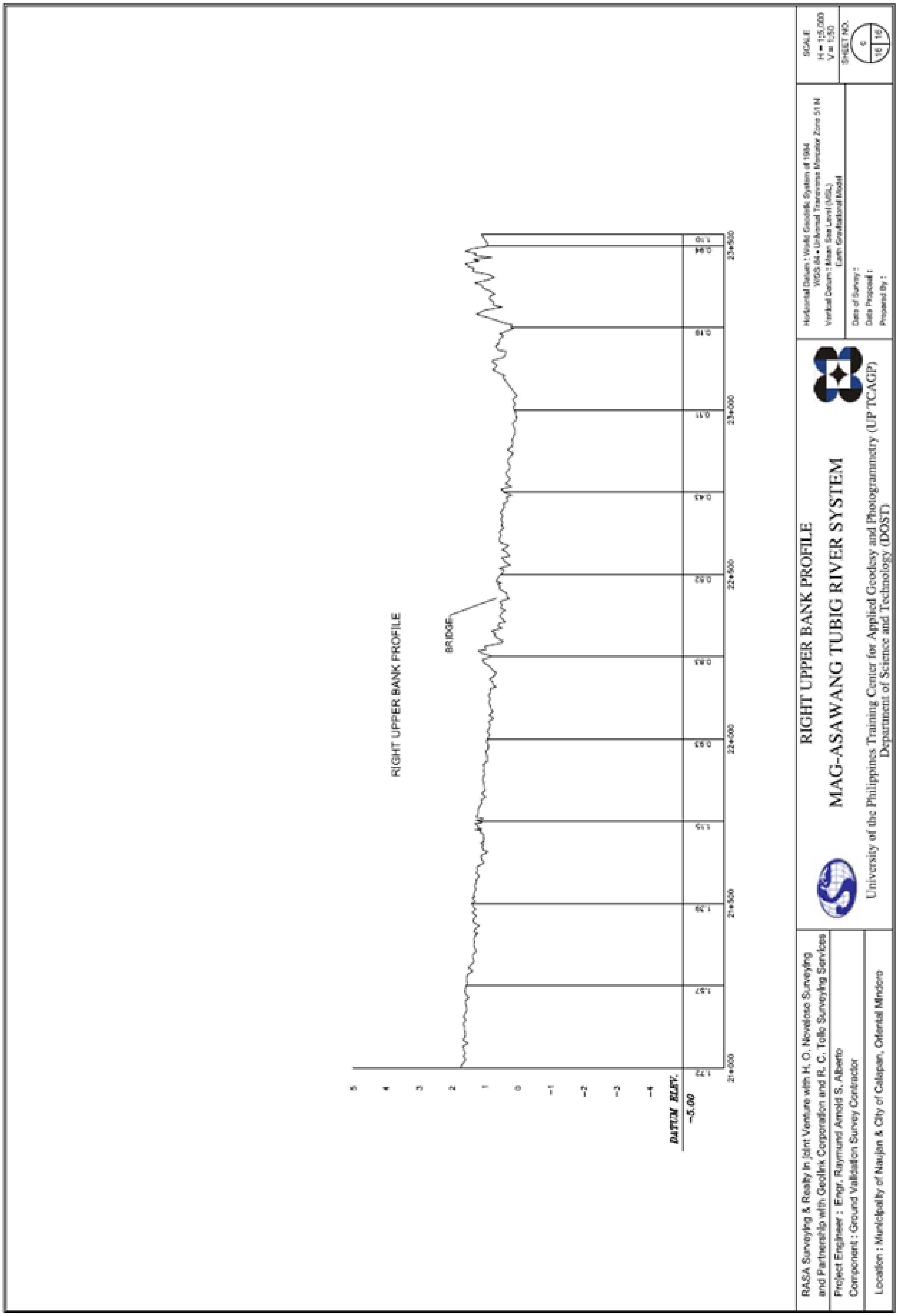

RIGHT LOWER BANK PROFILE
BRIDGE
DATUM ELEV.
-5.00
21+000
21+500
22+000
22+500
23+000
23+500
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
RIGHT LOWER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
SCALE
H = 1:5,000
V = 1:50
SHEET NO.

Figure 67. Processed data for Right Upper Bank Profile of the River




RIGHT UPPER BANK PROFILE
RIGHT UPPER BANK PROFILE
BRIDGE
DATUM ELEV.
5.00
DATUM ELEV.
5.00
RASA Surveying & Realty in joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tollo Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
RIGHT UPPER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)


RIGHT UPPER BANK PROFILE
RIGHT UPPER BANK PROFILE
BRIDGE
DATUM ELEV. 0.00
DATUM ELEV. 0.00
RIGHT UPPER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
RASA Surveying & Realty in Joint Venture with H. O. Novelozo Surveying and Partnership with Geolink Corporation and R. C. Tolib Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
SCALE
H = 1:5,000
V = 1:50
SHEET NO.


RIGHT UPPER BANK PROFILE
BRIDGE
DATUM ELEV. -5.00
5
4
3
2
1
0
-1
-2
-3
-4
1.72
1.57
1.38
1.15
0.93
0.83
0.52
0.43
0.11
0.18
0.84
1.10
21+000
21+500
22+000
22+500
23+000
23+500
RASA Surveying & Realty in Joint Venture with H. O. Noveloso Surveying and Partnership with Geolink Corporation and R. C. Tolle Surveying Services
Project Engineer : Engr. Raymund Arnold S. Alberto
Component : Ground Validation Survey Contractor
Location : Municipality of Naujan & City of Calapan, Oriental Mindoro
RIGHT UPPER BANK PROFILE
MAG-ASAWANG TUBIG RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)
Horizontal Datum : World Geodetic System of 1984
WGS 84 - Universal Transverse Mercator Zone 51 N
Vertical Datum : Mean Sea Level (MSL)
Earth Gravitational Model
Date of Survey :
Date Proposed :
Prepared By :
SCALE
H = 1:5,000
V = 1:50
SHEET NO.
16
16

Annexes

Annexes

ANNEX A. THE SURVEY TEAM

THE SURVEY TEAM		
ITEM #	NAME	DESIGNATION
1	ENGR. RAYMUND ARNOLD S. ALBERTO	PROJECT ENGINEER
2	RENATO S. DACONO	TECHNICAL STAFF
3	ENGR. MARVIN ANDREW A. CALIOLIO	CHIEF OF PARTY
4	BERNIE REVAMONTE	TEAM LEADER FOR PROFILE SURVEY
5	FRANIE T. REYES	TEAM LEADER FOR CROSS-SECTION SURVEY
6	JAY BORJA	INSTRUMENT MAN
7	NELSO ACOSTA	INSTRUMENT MAN
8	GREGORIO COSTELO	INSTRUMENT MAN
9	JULIO BALENSONA	INSTRUMENT MAN
10	MARLON GARINA	INSTRUMENT MAN
11	RAMIL OLIMPIADA	INSTRUMENT MAN
12	DENNIS REFUGIA	INSTRUMENT MAN
13	ANSELOR DUMPAC	INSTRUMENT MAN
14	JOEMEL SIERRA	INSTRUMENT MAN
15	RYAN AUDREY BASCO	INSTRUMENT MAN
16	JEFFREY ORBILLO	INSTRUMENT MAN
17	JERRY D. DOMINGO	INSTRUMENT MAN
18	ERIC ENCINA	DRIVER
19	ERWIN TOLLO	DRIVER
20	JAYPEE NOVELOSO	DRIVER
21	DANIEL ORCA	DRIVER
		24 SURVEY AIDS

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

Equipment	*Quantity*	*Materials*	*Quantity*
Total Station	8	Reference maps	4
GPS (gsx2)	12	Field book	12
Tripod	12	Grass Cutter	1
Range Pole	16	Jungle Bolo	12
Handheld GPS	4		
Camera	8		
Prism	16		
Bubbles	16		
Laptop	4		
Meter Tape	12		
Printer	1		

No.	*Quantity*	*Brand/ Equipment*
1	2	SOKKIA GSR2700 IS RECEIVER (DUAL FREQUENCY)
2	2	EPOCH 25 L1/L2 RECEIVER (DUAL FREQUENCY)
3	4	HI-TARGET V8X RECEIVER (DUAL FREQUENCY)
4	4	HI-TARGET V30 RECEIVER (DUAL FREQUENCY)
5	4	SOKKIA 2030 (PRISMLESS ELECTRONIC TOTAL STATION)
6	2	SANDING (ELECTRONIC TOTAL STATION)
7	1	TOPCON (ELECTRONIC TOTAL STATION)
8	1	HI TARGET (ELECTRONIC TOTAL STATION)
9	2	GPSmap 76CSx HANDHELD GPS (HANDHELD GPS)
10	2	GARMIN HANDHELD GPS (HANDHELD GPS)
11	2	ACER LAPTOP
12	2	SAMSUNG LAPTOP
13	8	DATA COLLECTOR
14		PANTHER BATTERY CHARGER
15		PDL4535 PACIFIC CREST (RTK RADIO TRANSMITTER)
16	3	NIKON COOLPIX CAMERA
17	2	CASIO EXILIM CAMERA
18	3	PANASONIC CAMERA
19	1	EPSON L100

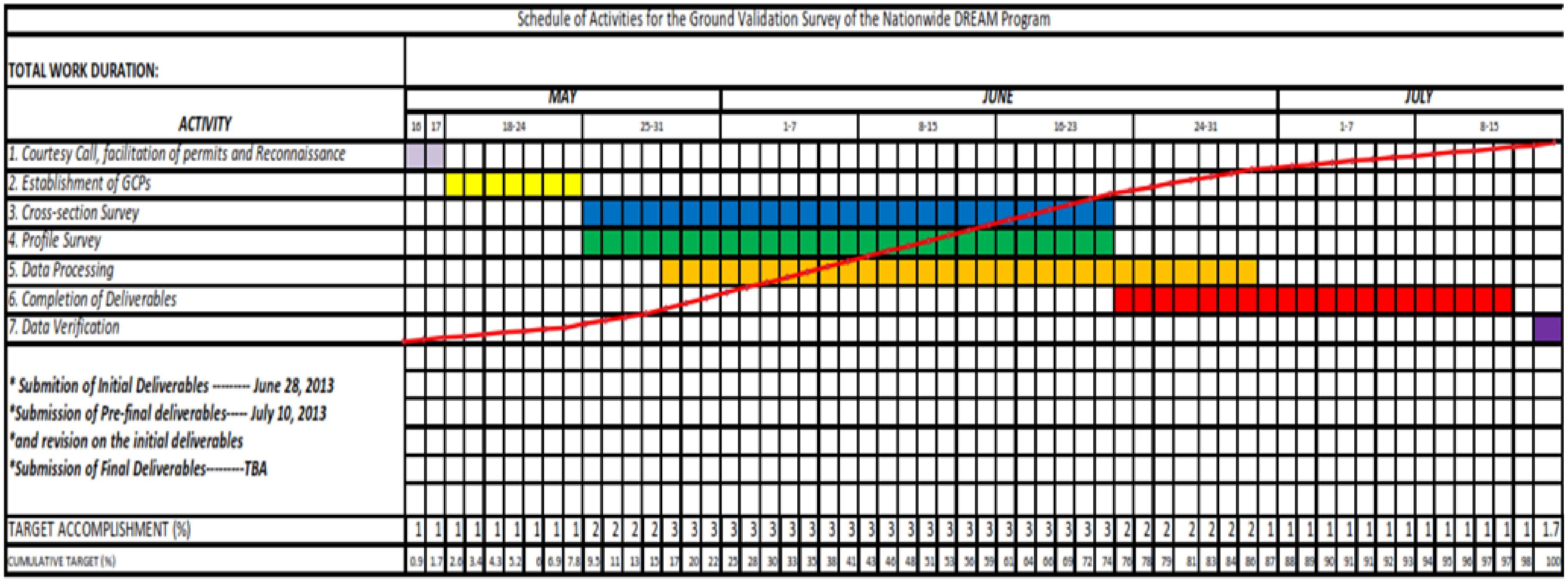
ANNEX C. ACTUAL FIELD SURVEY ACTIVITIES

DATE	ACTIVITY	LOCATION
16-May-13	Travel from Manila Office to Project site	Naujan, Oriental Mindoro
17-May-13	Courtesy Call to Local Government Units	Mun. of Naujan & City of Calapan
18-May-13	Kick-off meeting of the whole team	Field office
19-May-13	Reconnaissance/Establishment of GCPs	Project area
20-May-13	Establishment of GCPs	Project area
21-May-13	GNSS Observation of GCPs	Project area
22-May-13	Establishment of Tertiary control / site clearing	River Banks
23-May-13	River profile / site clearing	River Banks
24-May-13	River profile / site clearing	River Banks
25-May-13	Staking of Section Lines / River Profile	River Banks / Cross-section area
26-May-13	Staking of Section Lines / River Profile	River Banks / Cross-section area
27-May-13	Staking of Section Lines / River Profile / Cross-section	River Banks / Cross-section area
28-May-13	Staking of Section Lines / River Profile / Cross-section	River Banks / Cross-section area
29-May-13	Profile & Cross-section survey	River Banks / Cross-section area
30-May-13	Meeting with the UP-DREAM Team / checking of xs points	River Banks / Cross-section area
31-May-13	Rainy / Checking of Profile points	River Banks / Cross-section area
1-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
2-Jun-13	Profile & Cross-section survey / Rainy	River Banks / Cross-section area
3-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
4-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
5-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
6-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
7-Jun-13	Rainy / no work	River Banks / Cross-section area
8-Jun-13	Rainy / Profile & Cross-section survey	River Banks / Cross-section area
9-Jun-13	Rainy / no work	River Banks / Cross-section area
10-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
11-Jun-13	Profile & Cross-section survey / Rainy	River Banks / Cross-section area
12-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
13-Jun-13	Profile & Cross-section survey / Rainy	River Banks / Cross-section area
14-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
15-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
16-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
17-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
18-Jun-13	Profile & Cross-section survey / Rainy	River Banks / Cross-section area

19-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area
20-Jun-13	Profile & Cross-section survey / Rainy	River Banks / Cross-section area
21-Jun-13	Rainy / no work	River Banks / Cross-section area
22-Jun-13	Profile & Cross-section survey	River Banks / Cross-section area

For Mag-asawang Tubig River Ground Validation		
Activity		No. of Days
1.	Courtesy Call / Reconnaissance	2
2.	Establishment of GCPs	7
3.	Cross-section Survey	27
4.	Profile Survey	27
5.	Data Processing	27
6.	Completion of the Deliverables	22
7.	Data Verification	1
Total Number of Days		**113**

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY
National Engineering Center, University of the Philippines, Quezon City 1101
Tel. Nos.: (+63-2) 981-8770 / (+63-2) 981-8771; Telefax: (+63-2) 920-8924



DREAM
Disaster Risk and Exposure Assessment for Mitigation

ANNEX D. CERTIFIED REFERENCE POINTS AND BENCHMARK

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

May 21, 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: **ORIENTAL MINDORO**
Station Name: **MRE-30**
Order: **2nd**

Island: **LUZON**
Municipality: **NAUJAN**
Barangay: **BARCENAGA**

PRS92 Coordinates

Latitude: **13° 16' 33.76429"**	Longitude: **121° 14' 2.59051"**	Ellipsoidal Hgt: **16.56200 m.**

WGS84 Coordinates

Latitude: **13° 16' 28.67828"**	Longitude: **121° 14' 7.59682"**	Ellipsoidal Hgt: **64.33800 m.**

PTM Coordinates

Northing: **1468097.762 m.**	Easting: **525361.939 m.**	Zone: **3**

UTM Coordinates

Northing: **1,468,249.24**	Easting: **308,682.41**	Zone: **51**

Location Description

MRE-30

From Calapan City to Roxas, along Nat'l. Road approx. 20 Km. from Calapan City Proper, at left side of road located Brgy. Hall of Barcenaga, Naujan Oriental Mindoro, 200 m before reaching Barcenaga Semi Market. Station is located beside directory at the back of brgy. hall. Mark is the head of a 4 in. copper nail flushed in s cement block embedded in the ground with inscriptions, "MRE-30, 2007, NAMRIA".

Requesting Party: **RASA Surveying**
Pupose: **Reference**
OR Number: **3943678B**
T.N.: **2013-0456**

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

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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

CIP/4701/13/09/814

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

May 21, 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: **ORIENTAL MINDORO**
Station Name: **MRE-32**
Order: **2nd**

Island: **LUZON**		Barangay:
Municipality: **VICTORIA**		
	PRS92 Coordinates	
Latitude: **13° 10' 28.85064"**	Longitude: **121° 16' 38.44761"**	Ellipsoidal Hgt: **19.49300 m.**
	WGS84 Coordinates	
Latitude: **13° 10' 23.79251"**	Longitude: **121° 16' 43.46244"**	Ellipsoidal Hgt: **67.64700 m.**
	PTM Coordinates	
Northing: **1456889.419 m.**	Easting: **530065.679 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,457,002.75**	Easting: **313,296.85**	Zone: **51**

Location Description

MRE-32

From Calapan City to Roxas, along Nat'l. Road approx. 34 Km. travel to Victoria Town Proper, 10 Km. from intersection of Naujan, left turn to Shell Gasoline Station, approx. 150 m, right side of road located Mun. Hall of Victoria, Oriental Mindoro. Station is located in Mun. Park in front of Former Mayor Statue, along corner of pathwalk. Mark is the head of a 4 in. copper nail flushed in a cement block embedded in the ground with inscriptions, "MRE-32, 2007, NAMRIA".

Requesting Party: **RASA Surveying**
Pupose: **Reference**
OR Number: **3943678B**
T.N.: **2013-0455**

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

9 9 0 5 2 1 2 0 1 3 1 5 4 1 0 2

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

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

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

May 27, 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: **ORIENTAL MINDORO**
Station Name: **MRE-33**
Order: **2nd**

Island: **LUZON**
Municipality: **NAUJAN**
Barangay: **BAYANI**

PRS92 Coordinates

Latitude: **13° 14' 10.37088"**	Longitude: **121° 20' 9.73576"**	Ellipsoidal Hgt: **5.91100 m.**

WGS84 Coordinates

Latitude: **13° 14' 5.30285"**	Longitude: **121° 20' 14.74497"**	Ellipsoidal Hgt: **54.04400 m.**

PTM Coordinates

Northing: **1463704.129 m.**	Easting: **536419.018 m.**	Zone: **3**

UTM Coordinates

Northing: **1,463,766.93**	Easting: **319,704.68**	Zone: **51**

Location Description

MRE-33

From Calapan City to Roxas, along Nat'l. Road, approx. 22 Km. from Calapan City Proper, is an intersection of Naujan Proper and road leading to Victoria Proper, turn left to road leading to Naujan Proper, approx. 6 Km. located "y" road of Sitio Sampaloc, turn right to Brgy. Road leading to Brgy. Bayani, passed through Brgy. San Agustin 1, Brgy. San Isidro, Brgy. Laguna, all in Mun. of Naujan. Approx. 7.4 Km. right side of road located Brgy. Hall of Bayani, Naujan, Oriental Mindoro. Station is located in corner wall of brgy. hall outside the boundary. Mark is the head of a 4 in. copper nail flushed in a cement block embedded in the ground with inscriptions, "MRE-33, 2007, NAMRIA".

Requesting Party:	**RASA Surveying**
Pupose:	**Reference**
OR Number:	**3943717B**
T.N.:	**2013-0484**

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

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

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

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

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

June 04, 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: **ORIENTAL MINDORO**
Station Name: **MR-178**

Island: **Luzon**	Municipality: **CITY OF CALAPAN (CAPITAL)**	Barangay:
Elevation: **14.1562 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

BM MR-178 is located on Panggalan bridge second approach (km 16+957). It is 5 m from the highway centerline. Mark is the head of a 4" brass nail set in a drilled hole and marked with plate and with inscription MR-178 2007 NAMRIA.

Requesting Party: **RASA Surveying**
Pupose: **Reference**
OR Number: **3943741B**
T.N.: **2013-0521**

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

CIP/4701/12/09/814

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

ANNEX E. ENDORSEMENT LETTERS

Endorsement letter from UP TCAGP for DREAM Project

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY
National Engineering Center, University of the Philippines, Quezon City 1101
Tel. Nos.: (+63-2) 981-8770 / (+63-2) 981-8771; Telefax: (+63-2) 920-8924

May 15, 2013

TO WHOM IT MAY CONCERN

Dear **Maam/Sir:**

The Training Center for Applied Geodesy & Photogrammetry of the University of the Philippines-Diliman (UP-TCAGP) is conducting a research program entitled **"Nationwide Disaster Risk and Exposure Assessment for Mitigation (DREAM)"** supported by the Department of Science and Technology (DOST) Grant-in-Aid Program. It generally aims to acquire a national elevation and resource information dataset in 3D at sufficient detail and resolution from which various base and thematic map features can be extracted. Particularly, we aim to operationalize the development of flood hazard models that would produce updated and detailed flood hazard maps for the major watersheds and river systems in the country.

The Nationwide DREAM Program contracted the Joint Venture of RASA Surveying & Realty and H.O. Noveloso Surveying to conduct the ground validation surveys for LiDAR Mapping. They are tasked to perform the following:

1. Recover the NAMRIA established reference points and benchmarks; and
2. Conduct cross-sectional and profile surveys along the Mag-asawang Tubig River.

With this, we are endorsing herewith the said contractors to your good office the smooth conduct of their surveys.

Thank you very much for your cooperation and generous support to our project. If you have questions about the project, please do not hesitate to contact any of the following:

Engr. Joemarie S. Caballero	Chief Science Research Specialist	0917-546-0346
Engr. Melchor Rey M. Nery	Senior Science Research Specialist	0917-899-7327

Yours truly,

ENGR. LOUIE P. BALICANTA
Project Leader
Nationwide DREAM Program

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Annexes

Endorsement letter from the LGU of Naujan

Republic of the Philippines
Province of Oriental Mindoro
MUNICIPALITY OF NAUJAN
OFFICE OF THE MUNICIPAL MAYOR
Naujan 5204, Oriental Mindoro, Philippines

INDORSEMENT

TO WHOM IT MAY CONCERN:

THIS IS TO RESPECTFULLY INDORSE the Nationwide DREAM Program of the Training Center for Applied Geodesy and Photogrammetry, University of the Philippines, Diliman, Quezon City to conduct the following activities particularly in different barangays traversed by the Mag-Asawang Tubig River in the Municipality of Naujan to wit:

- Recover the NAMRIA established reference points and benchmark; and
- Conduct cross-sectional and profile surveys along the Mag-Asawang Tubig River

Issued this 20th day of May 2013 in Naujan, Oriental Mindoro.

MARIA ANGELES CARANZO-CASUBUAN
Municipal Mayor

ANNEX F. REFERENCE PHOTOGRAPHS

Reconnaissance:

Some photos during reconnaissance

NAMRIA 2nd Order Horizontal Control (left) Part of the Project Area where Palmera are Planted (right)

South view of a tributary of the river near T-4 (inset east view)

Actual Field Survey

Establishing Ground Control

Some Pictures for Cross Section Survey

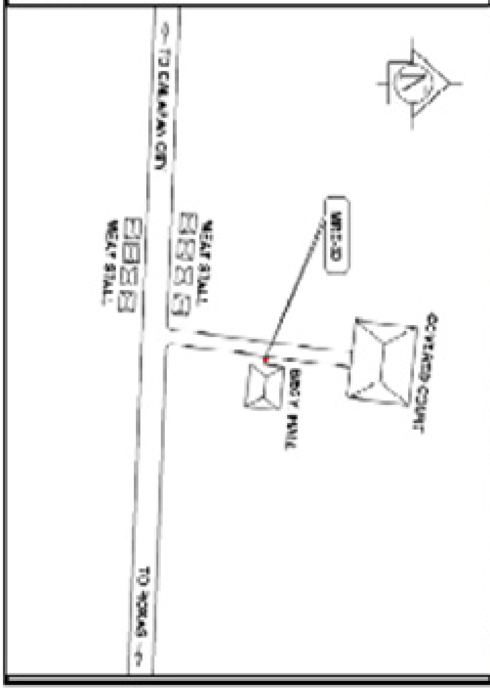
Some Pictures for Profile Survey

Annexes

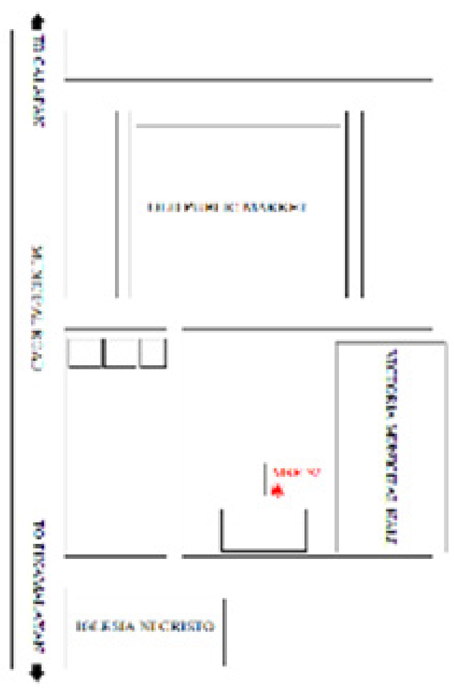
ANNEX G. RECOVERED NAMRIA REFERENCE POINTS

Control Number: MRE -30

Station Name	MRE-30	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°16'33.76429" North
	Longitude	121°14'02.59050" East
	Ellipsoidal Height	16.561m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°16'28.67828" North
	Longitude	121°14'07.59682" East
	Ellipsoidal Height	64.338m
Elevation	14.4922n Above Mean Sea Level	
Description	From Calapan Town proper travel the Nautical Highway for about 24 km until reaching Brgy. Barcenaga, Naujan. The station is situated infront of Brgy. Barcenaga barangay hall.	
Sketch	**Picture**	

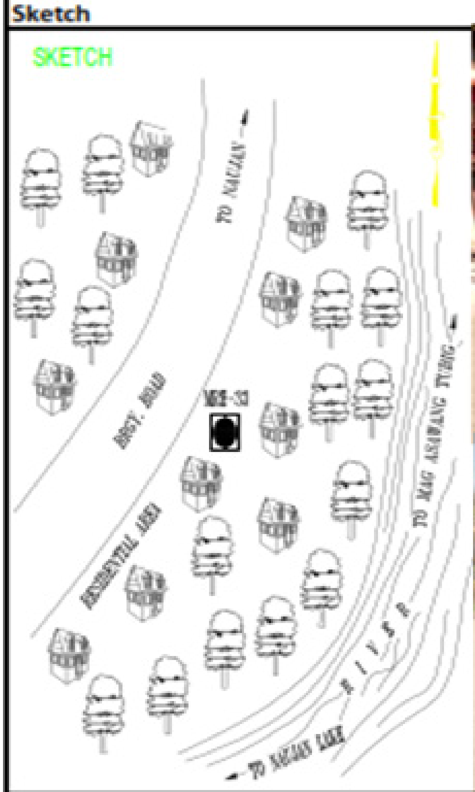


Control Number: MRE -32

Station Name	MRE-32	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13"10"28.85065
	Longitude	121"16"38.44757
	Ellipsoidal Height	19.493
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	121"16"43.46244
	Longitude	13"10"23.79251
	Ellipsoidal Height	67.647
Elevation		
Description	MRE-32 From Calapan City to Roxas, along Nat'l. Road approx. 34 Km. travel to Victoria Town Proper, 10 Km. from intersection of Naujan, turn left to Shell Gasoline Station, approx. 150 m, right side of road located Mun. Hall of Victoria, Oriental Mindoro. The station is located North of Victoria basketball court, infront of the statue of the former Municipal Mayor.	
Sketch	**Picture**	
		

Control Number: MRE- 33

Station Name	MRE 33	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13-14-10.3709
	Longitude	121-20-9.73572
	Ellipsoidal Height	5.911
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13-14-5.30285
	Longitude	121-20-14.74497
	Ellipsoidal Height	54.044
Elevation	3.675m Above Mean Sea Level	
Description	MRE 33 is located at Brgy. Bayani, Naujan, Oriental Mindoro. From Calapan city travel South along Strong Republic Nautical Highway for approximately 22 kms reaching the intersection leading to Naujan Town Proper exactly at Brgy. Curva, Naujan. Take the road for about 8 kms until reaching the intersection heading to Brgy, Bancuro passing Brgys of Dao, and Laguna. The Station is located infront of Brgy. Hall of Bayani outside the fence..	
Sketch	Picture	

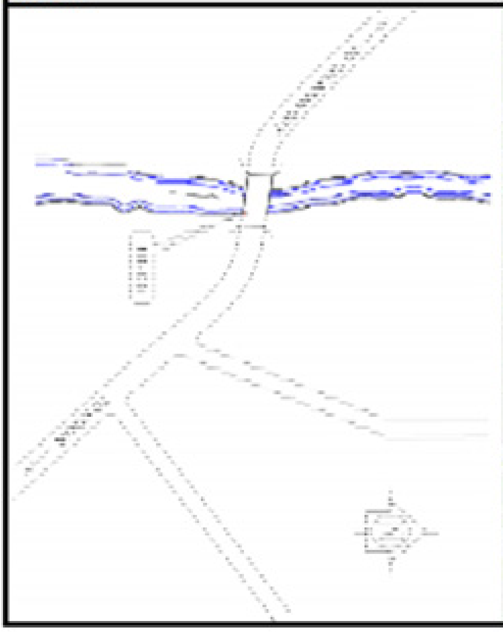


Annexes

ANNEX H. RECOVERED NAMRIA BENCHMARK

Control Number: MR- 178

Station Name	MR-178	
Order of Accuracy		
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°18'09.70192" North
	Longitude	121°11'49.11350" East
	Ellipsoidal Height	16.150m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°18'04.60647" North
	Longitude	121°11'54.11771" East
	Ellipsoidal Height	63.764m
Elevation	14.1562m Above Mean Sea Level	
Description	From Calapan town proper travel the road leading to Naujan for about 17 km until reaching the station. The station is located on the Pangalaan bridge ramp 3 meters from KM 17.	
Sketch	**Picture**	



Annexes

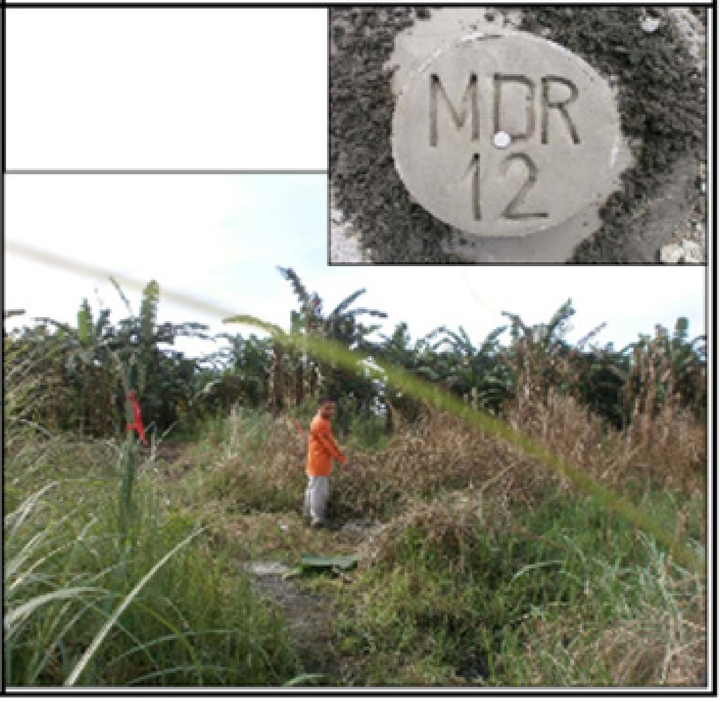
ANNEX I. ESTABLISHED GROUND CONTROL POINT

Control Number: MRE- 11

Station Name	MDR-11	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°14'17.04351" North
	Longitude	121°14'17.05859" East
	Ellipsoidal Height	20.641 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°14'11.96693" North
	Longitude	121°14'22.06816" East
	Ellipsoidal Height	68.530 meters
Elevation	18.4612 meters above Mean Sea Level (MSL)	
Description	From Municipal Hall of Naujan travel about 7 KM's along Municipal road going to the National Hi-way.Travel along the National Hi-way for about 2Kms. Turn right to the crossing of Brgy. Pinagsabangan and travel for about 3Kms along the Brgy. Road until reaching the crossing of Brgy. San Carlos.Turn right to the nia road and travel for about 2Kms towards the Mag-asawang Tubig River, Travel 500m. along the bank of the river going upstream, the monument is located in the property of Mr. Ryan Genabe, 10m. from a nipa hut owned by Mr. Ryan Genabi, 60m. from a second nipa hut and 100m. from the center line of the Mag-asawang Tubig River. Mark is the center of a concrete nail set flush at the center of a 6x20 centimeter concrete monument with inscription "MDR-11".	
Sketch	**Picture**	
		

Control Number: MRE- 12

Station Name	MDR-12	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°14'48.07706" North
	Longitude	121°14'39.29256" East
	Ellipsoidal Height	18.996 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°14'42.99892" North
	Longitude	121°14'44.30135" East
	Ellipsoidal Height	66.876 meters
Elevation	16.8362 meters above Mean Sea Level (MSL)	
Description	From Municipal Hall of Naujan travel about 7 KM's along Municipal road going to the National Hi-way.Travel along the National Hi-way for about 2Kms. Turn right to the crossing of Brgy. Pinagsabangan and travel for about 3Kms along the Brgy. Road until reaching the crossing of Brgy. San Carlos.Turn right and travel for about 1.5Kms along the nia road and turn right to the right of way passing the Mr. Orlando Noblado's residence, turn left and travel for about 250m. along a trail, the monument is located in the property of Mr. Orlando Noblado, 5m. right of the trail and 100m. from the center line of the Mag-asawang Tubig River. Mark is the center of a concrete nail set flush at the center of a 6x20 centimeter concrete monument with inscription "MDR-12".	
Sketch	**Picture**	



Control Number: MRE- 13

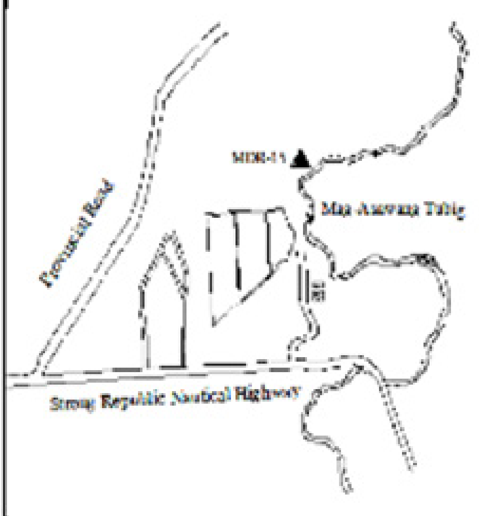
Station Name	MDR-13	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°15'33.14853" North
	Longitude	121°15'06.66735" East
	Ellipsoidal Height	15.806m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°15'28.06802" North
	Longitude	121°15'11.67502" East
	Ellipsoidal Height	63.671m
Elevation	13.6792m Above Mean Sea Level	
Description	From Calapan town proper travel on Nautical highway for about 25 km until reaching Mag-asawang tubig Bridge, continue travelling until reaching an intersection leading to Naujan Cockpit Arena. Turn right on the intersection and continue travelling for about 2 km.	
Sketch	Picture	

Control Number: MRE- 14

Station Name	MDR-14	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°16'31.21831" North
	Longitude	121°15'31.91001" East
	Ellipsoidal Height	17.617m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°16'26.13452" North
	Longitude	121°15'36.91625" East
	Ellipsoidal Height	65.457m
Elevation	15.5392m Above Mean Sea Level	
Description	From Calapan town proper travel the Nautical Highway for about 25 km until reaching the station. The station is located at the ramp of Mag asawang tubig Bridge.	
Sketch	**Picture**	
		

Control Number: MRE- 15

Station Name	MDR-15	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°17'14.68376" North
	Longitude	121°15'13.54263" East
	Ellipsoidal Height	10.777 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°17'09.59666" North
	Longitude	121°15'18.54787" East
	Ellipsoidal Height	58.572 meters
Elevation	8.7382m above Mean Sea Level	
Description	The Station is Located at Barangay Buhangin. From Strong Republic National Highway it is 1,195.02 meter. The Mark is a 4" copper nail driven on 30x30x100 cm. embedded on ground with inscriptions "MDR 15, 2013"	
Sketch	**Picture**	



Control Number: MRE- 16

Station Name	MDR-16	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°18'03.99751" North
	Longitude	121°16'17.56807" East
	Ellipsoidal Height	8.392 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°17'58.90860" North
	Longitude	121°16'22.57203" East
	Ellipsoidal Height	56.193 meters
Elevation	6.4002m Above Mean Sea Level	
Description	The Station is Located at Naujan Landfill Road. From MDR 15 it is 2,435 meter away from MDR-16. The Mark is a 4" copper nail driven on 30x30x100 cm. embedded on ground with inscriptions "MDR 16, 2013"	
Sketch	Picture	

Control Number: MRE- 17

Station Name	MDR-17	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°18'54.68123"North
	Longitude	121°16'36.68921"East
	Ellipsoidal Height	6.212 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°18'49.58938"North
	Longitude	121°16'41.69193"East
	Ellipsoidal Height	53.989 meters
Elevation	4.2762m Above Mean Sea Level	
Description	The Station is Located at Brgy. Santiago it is located at right bank of the river from nipa shed walking distance about 500 meters going to mdr-17 from santiago elem. School to nipa shed more or less is about 800 meters	
Sketch	**Picture**	
		

Control Number: MRE- 18

Station Name	MDR-18	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°19'41.66717"North
	Longitude	121°17'15.31788"East
	Ellipsoidal Height	6.443 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°19'36.57308"North
	Longitude	121°17'20.31942"East
	Ellipsoidal Height	54.210 meters
Elevation	4.5622m Above Mean Sea Level	
Description	MDR 18 is located at Brgy. Nag-Iba II, Naujan Oriental Mindoro the monument is located on the approach of the bridge it is equal to a BBM. From Naujan Proper travel for about 3kms heading to Nag-Iba II Brgy. Proper.	
Sketch	**Picture**	

Control Number: MRE- 19

Station Name	MDR-19	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13°20'13.90715"North
	Longitude	121°17'55.55544"East
	Ellipsoidal Height	4.710 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13°20'08.81185"North
	Longitude	121°18'00.55614"East
	Ellipsoidal Height	52.481 meters
Elevation	2.8702m Above Mean Sea Level	
Description	MDR 19 is located at Brgy. San Antonio, Naujan Oriental Mindoro. To reach the station, From Calapan City, travel South via the Nautical Highway for almost 20kms to Brgy. Curva, Naujan then turn left on the intersection leading to Naujan Town Proper for about 12kms. Continue travel Eastward for 2kms to reach the bridge along Mag-asawang tubig River. it is located at the first approach of the said bridge and about 100m South of San Antonio Brgy. Hall.	
Sketch	**Picture**	
		

ANNEX J. GNSS PROCESSING REPORT

RASA SURVEYING

#9 Anlacan Compound, Philand Drive,

Tandang Sora Quezon City , Philippines

Phone: 029357296

Fax: 029357297

www.rasasurvey.com

technical@rasasurvey.com

Project Information

Name: D:\NATS\2013\UP-DREAM\RIVER\mag-asawang tubig\add gcps.vce

Size: 1 MB

Modified: 5/31/2013 1:32:52 PM (UTC:8)

Time zone: Taipei Standard Time

Reference number:

Description:

Coordinate System

Name: UTM

Datum: WGS 1984

Zone: 51 North (123E)

Geoid: EGM2008

Vertical datum:

Network Adjustment Report

Adjustment Settings

Set-Up Errors

GNSS

Error in Height of Antenna: 0.002 m

Centering Error: 0.003 m

Covariance Display

Horizontal:

Propagated Linear Error [E]: U.S.

Constant Term [C]: 0.000 m

Scale on Linear Error [S]: 1.960

Three-Dimensional

Propagated Linear Error [E]: U.S.

Constant Term [C]: 0.000 m

Scale on Linear Error [S]: 1.960

Adjustment Statistics

Number of Iterations for Successful Adjustment: 2

Network Reference Factor: 1.00

Chi Square Test (95%): Passed

Precision Confidence Level: 95%

Degrees of Freedom: 98

Post Processed Vector Statistics

Reference Factor: 1.00

Redundancy Number: 98.00

A Priori Scalar: 2.66

Control Point Constraints

Point ID Type North σ

(Meter) East σ

(Meter) Height σ

(Meter) Elevation σ

(Meter)

MRE-30 Global Fixed Fixed Fixed

MRE-32 Global Fixed Fixed Fixed

MRE-33 Global Fixed Fixed Fixed

Fixed = 0.000001(Meter)

Adjusted Grid Coordinates

Point ID Northing

(Meter) Northing Error

(Meter) Easting

(Meter) Easting Error

(Meter) Elevation

(Meter) Elevation Error

(Meter) Constraint

MDR-10 1470146.957 0.014 310278.033 0.017 12.211 0.032

MDR-11 1463978.241 0.013 309240.474 0.014 20.804 0.032

MDR-12 1464927.212 0.014 309916.530 0.015 19.179 0.028

MDR-13 1466306.498 0.012 310750.307 0.013 16.022 0.024

MDR-14 1468085.682 0.011 311522.601 0.013 17.882 0.025

MDR-15 1469425.218 0.015 310979.027 0.017 11.081 0.029

MDR-16 1470927.233 0.014 312916.672 0.016 8.743 0.039

MDR-17 1472480.750 0.016 313502.924 0.018 6.619 0.048

MDR-18 1473916.607 0.021 314675.412 0.023 6.905 0.065

MDR-19 1474899.038 0.021 315893.103 0.023 5.213 0.074

MDR-5 1467868.588 0.014 319169.319 0.015 5.056 0.044

MDR-9 1467237.463 0.013 308774.438 0.014 18.643 0.025

MR-178 1471159.603 0.017 304837.761 0.019 16.499 0.055

MRE-30 1468182.742 ? 308834.470 ? 16.835 ? LLh

MRE-32 1456936.499 ? 313449.201 ? 19.454 ? LLh

MRE-33 1463700.803 ? 319856.770 ? 6.018 ? LLh

R-9 1464861.183 0.018 309971.389 0.019 18.739 0.030

U-9 1463880.557 0.019 308671.876 0.020 21.151 0.035

Adjusted Geodetic Coordinates

Point ID Latitude Longitude Height

(Meter) Height Error

(Meter) Constraint

MDR-10 N13°17'32.92044" E121°14'55.09194" 59.648 0.032

MDR-11 N13°14'11.96693" E121°14'22.06816" 68.530 0.032

MDR-12 N13°14'42.99892" E121°14'44.30135" 66.876 0.028

MDR-13 N13°15'28.06802" E121°15'11.67502" 63.671 0.024

MDR-14 N13°16'26.13452" E121°15'36.91625" 65.457 0.025

MDR-15 N13°17'09.59666" E121°15'18.54787" 58.572 0.029

MDR-16 N13°17'58.90860" E121°16'22.57203" 56.193 0.039

MDR-17 N13°18'49.58938" E121°16'41.69193" 53.989 0.048

MDR-18 N13°19'36.57308" E121°17'20.31942" 54.210 0.065

MDR-19 N13°20'08.81185" E121°18'00.55614" 52.481 0.074

MDR-5 N13°16'20.77051" E121°19'50.98641" 52.824 0.044

MDR-9 N13°15'57.90737" E121°14'05.82478" 66.192 0.025

MR-178 N13°18'04.60647" E121°11'54.11771" 63.764 0.055

MRE-30 N13°16'28.67828" E121°14'07.59682" 64.338 ? LLh

MRE-32 N13°10'23.79251" E121°16'43.46244" 67.647 ? LLh

MRE-33 N13°14'05.30285" E121°20'14.74497" 54.044 ? LLh

R-9 N13°14'40.86301" E121°14'46.13888" 66.441 0.030

U-9 N13°14'08.65815" E121°14'03.20586" 68.866 0.035

Adjusted ECEF Coordinates

Point ID X

(Meter) X Error

(Meter) Y

(Meter) Y Error

(Meter) Z

(Meter) Z Error

(Meter) 3D Error

(Meter) Constraint

MDR-10 -3220634.652 0.021 5307726.412 0.030 1456928.230 0.016 0.040

MDR-11 -3220524.178 0.020 5309460.903 0.028 1450919.399 0.015 0.038

MDR-12 -3220982.326 0.019 5308925.607 0.025 1451847.330 0.015 0.035

MDR-13 -3221520.513 0.016 5308224.017 0.021 1453194.762 0.013 0.030

MDR-14 -3221958.481 0.016 5307481.201 0.022 1454932.032 0.013 0.030

MDR-15 -3221323.157 0.020 5307500.090 0.027 1456230.398 0.016 0.037

MDR-16 -3222788.355 0.023 5306200.149 0.034 1457704.687 0.016 0.044

MDR-17 -3223092.969 0.028 5305593.175 0.041 1459219.869 0.019 0.054

MDR-18 -3223913.839 0.037 5304705.392 0.057 1460624.966 0.026 0.072

MDR-19 -3224829.025 0.041 5303879.754 0.064 1461588.623 0.027 0.081

MDR-5 -3228506.901 0.025 5303530.300 0.039 1454768.691 0.017 0.049

MDR-9 -3219717.880 0.017 5309074.445 0.022 1454087.896 0.014 0.031

MR-178 -3215862.540 0.031 5310361.967 0.048 1457876.837 0.021 0.061

MRE-30 -3219649.993 ? 5308859.639 ? 1455007.861 ? ? LLh

MRE-32 -3224994.273 ? 5308620.255 ? 1444092.461 ? ? LLh

MRE-33 -3229614.770 ? 5303974.617 ? 1450716.725 ? ? LLh

R-9 -3221037.202 0.022 5308909.409 0.027 1451783.336 0.019 0.040

U-9 -3220050.873 0.024 5309775.576 0.031 1450820.493 0.020 0.044

Error Ellipse Components

Point ID Semi-major axis

(Meter) Semi-minor axis

(Meter) Azimuth

MDR-10 0.022 0.018 91°

MDR-11 0.018 0.017 87°

MDR-12 0.018 0.017 92°

MDR-13 0.016 0.015 92°

MDR-14 0.016 0.014 90°

MDR-15 0.021 0.019 95°

MDR-16 0.020 0.018 97°

MDR-17 0.022 0.020 93°

MDR-18 0.028 0.027 97°

MDR-19 0.028 0.026 96°

MDR-5 0.019 0.017 90°

MDR-9 0.017 0.016 89°

MR-178 0.024 0.021 87°

R-9 0.024 0.023 91°

U-9 0.025 0.024 87°

Adjusted GPS Observations

Transformation Parameters

Deflection in Latitude: -4.645 sec (95%) 0.781 sec

Deflection in Longitude: 8.461 sec (95%) 1.206 sec

Azimuth Rotation: 0.562 sec (95%) 0.231 sec

Scale Factor: 0.99999674 (95%) 0.00000117

Observation ID Observation A-posteriori Error Residual Standardized

Residual

MDR-12 --> MDR-11 (PV2) Az. 215°03'53" 1.954 sec -0.461 sec -0.260

ΔHt. 1.605 m 0.010 m 0.029 m 3.685

Ellip Dist. 1165.107 m 0.011 m 0.013 m 1.315

MR-178 --> MDR-10 (PV131) Az. 100°07'48" 0.531 sec -0.029 sec -0.082

ΔHt. -3.915 m 0.043 m 0.098 m 3.301

Ellip Dist. 5533.412 m 0.017 m 0.009 m 0.950

MDR-16 --> MDR-17 (PV44) Az. 20°16'39" 1.669 sec 0.169 sec 0.146

ΔHt. -2.146 m 0.017 m 0.012 m 2.477

Ellip Dist. 1660.407 m 0.013 m 0.002 m 0.216

MR-178 --> MDR-18 (PV137) Az. 73°55'47" 0.376 sec -0.606 sec -1.184

ΔHt. -9.088 m 0.050 m 0.107 m 1.292

Ellip Dist. 10216.220 m 0.021 m -0.102 m -2.474

MR-178 --> MDR-11 (PV139) Az. 148°04'30" 0.434 sec -0.132 sec -0.228

ΔHt. 4.787 m 0.046 m -0.111 m -2.012

Ellip Dist. 8423.046 m 0.016 m 0.034 m 2.424

MDR-14 --> MDR-15 (PV143) Az. 337°30'48" 2.064 sec 0.793 sec 0.634

ΔHt. -6.878 m 0.016 m -0.009 m -2.034

Ellip Dist. 1445.570 m 0.014 m -0.004 m -0.406

MDR-9 --> MR-178 (PV141) Az. 314°29'19" 0.571 sec -0.711 sec -1.797

ΔHt. -2.503 m 0.047 m 0.054 m 0.864

Ellip Dist. 5556.707 m 0.015 m -0.025 m -2.004

MDR-12 --> MDR-11 (PV37) Az. 215°03'53" 1.954 sec 0.961 sec 0.538

ΔHt. 1.605 m 0.010 m -0.014 m -1.918

Ellip Dist. 1165.107 m 0.011 m -0.012 m -1.188

MRE-33 --> MDR-11 (PV19) Az. 271°06'59" 0.240 sec -0.188 sec -0.902

ΔHt. 14.055 m 0.032 m 0.068 m 1.865

Ellip Dist. 10619.684 m 0.014 m -0.014 m -1.078

MRE-33 --> MRE-32 (PV18) Az. 223°04'08" 0.231 sec 0.500 sec 1.774

ΔHt. 13.189 m 0.054 m -0.039 m -1.308

Ellip Dist. 9317.219 m 0.011 m 0.020 m 1.852

MDR-11 --> MDR-9 (PV3) Az. 351°27'32" 0.883 sec 1.169 sec 1.737

ΔHt. -2.284 m 0.030 m -0.060 m -1.701

Ellip Dist. 3292.215 m 0.013 m -0.010 m -0.912

MR-178 --> MDR-19 (PV136) Az. 70°53'49" 0.300 sec 0.089 sec 0.570

ΔHt. -10.745 m 0.052 m -0.011 m -0.292

Ellip Dist. 11670.159 m 0.019 m -0.015 m -1.711

MDR-18 --> MDR-17 (PV24) Az. 218°50'24" 1.982 sec -0.054 sec -0.051

ΔHt. -0.302 m 0.036 m -0.009 m -0.751

Ellip Dist. 1853.711 m 0.018 m 0.016 m 1.689

MDR-10 --> MDR-15 (PV62) Az. 135°25'58" 2.915 sec -0.075 sec -0.042

ΔHt. -1.064 m 0.015 m 0.007 m 1.687

Ellip Dist. 1006.090 m 0.014 m -0.002 m -0.249

MDR-14 --> MDR-9 (PV154) Az. 252°26'52" 0.942 sec 0.040 sec 0.057

ΔHt. 0.603 m 0.028 m 0.046 m 1.686

Ellip Dist. 2875.964 m 0.014 m 0.012 m 1.190

MDR-12 --> MDR-9 (PV1) Az. 333°17’31” 1.095 sec 0.064 sec 0.079

ΔHt. -0.680 m 0.029 m -0.021 m -0.615

Ellip Dist. 2577.017 m 0.014 m -0.018 m -1.639

MRE-30 --> MR-178 (PV156) Az. 306°16’27” 0.614 sec 0.144 sec 0.302

ΔHt. -0.672 m 0.047 m 0.046 m 0.652

Ellip Dist. 4983.220 m 0.015 m 0.017 m 1.598

MDR-5 --> MDR-19 (PV31) Az. 334°37’49” 0.462 sec 0.302 sec 1.192

ΔHt. -0.321 m 0.047 m -0.042 m -1.455

Ellip Dist. 7756.273 m 0.017 m -0.003 m -0.283

MR-178 --> MDR-17 (PV134) Az. 80°54’59” 0.330 sec -0.342 sec -1.316

ΔHt. -9.390 m 0.043 m -0.059 m -1.174

Ellip Dist. 8764.885 m 0.017 m 0.012 m 0.429

MDR-19 --> MDR-18 (PV11) Az. 230°42’42” 2.389 sec -0.434 sec -0.387

ΔHt. 1.658 m 0.035 m -0.012 m -1.313

Ellip Dist. 1564.560 m 0.018 m 0.007 m 0.822

MDR-10 --> MDR-17 (PV54) Az. 53°42’16” 0.720 sec 0.064 sec 0.126

ΔHt. -5.475 m 0.023 m -0.032 m -1.295

Ellip Dist. 3980.631 m 0.014 m 0.006 m 0.645

MRE-33 --> MDR-14 (PV148) Az. 297°22’09” 0.269 sec -0.114 sec -0.507

ΔHt. 11.167 m 0.031 m -0.043 m -1.288

Ellip Dist. 9417.140 m 0.013 m 0.003 m 0.211

MDR-13 --> MDR-5 (PV175) Az. 79°05’17” 0.372 sec 0.772 sec 1.250

ΔHt. -10.466 m 0.036 m -0.005 m -0.114

Ellip Dist. 8562.529 m 0.017 m 0.014 m 0.370

MDR-12 --> U-9 (PV38) Az. 229°32'13" 1.892 sec 0.505 sec 0.452

ΔHt. 1.915 m 0.012 m -0.009 m -1.200

Ellip Dist. 1626.162 m 0.015 m -0.005 m -0.567

MDR-13 --> MDR-12 (PV182) Az. 210°45'09" 1.838 sec 0.325 sec 0.284

ΔHt. 3.140 m 0.018 m -0.005 m -1.157

Ellip Dist. 1611.645 m 0.014 m -0.002 m -0.272

MRE-33 --> MDR-16 (PV45) Az. 315°46'35" 0.288 sec -0.234 sec -1.113

ΔHt. 2.024 m 0.034 m 0.010 m 0.322

Ellip Dist. 10019.156 m 0.015 m 0.001 m 0.072

MRE-33 --> MDR-5 (PV30) Az. 350°15'09" 0.752 sec 0.666 sec 1.112

ΔHt. -1.156 m 0.040 m -0.004 m -0.143

Ellip Dist. 4224.101 m 0.014 m 0.000 m 0.027

R-9 --> MDR-11 (PV42) Az. 219°13'01" 2.679 sec 0.578 sec 0.368

ΔHt. 2.038 m 0.012 m -0.008 m -1.102

Ellip Dist. 1146.169 m 0.015 m -0.006 m -0.659

MRE-32 --> MDR-11 (PV4) Az. 328°44'27" 0.354 sec 0.104 sec 0.412

ΔHt. 0.866 m 0.053 m -0.023 m -1.097

Ellip Dist. 8203.324 m 0.014 m 0.006 m 0.644

MDR-11 --> U-9 (PV39) Az. 259°50'56" 5.286 sec -2.247 sec -0.738

ΔHt. 0.310 m 0.012 m 0.006 m 1.030

Ellip Dist. 576.900 m 0.015 m 0.003 m 0.304

MDR-13 --> MDR-9 (PV183) Az. 294°49'39" 1.230 sec -0.932 sec -1.002

ΔHt. 2.460 m 0.027 m 0.024 m 1.006

Ellip Dist. 2184.108 m 0.014 m 0.007 m 0.665

MRE-33 --> MDR-12 (PV20) Az. 276°39'10" 0.263 sec -0.027 sec -0.129

ΔHt. 12.450 m 0.031 m 0.026 m 0.842

Ellip Dist. 10015.403 m 0.014 m -0.012 m -0.967

MDR-16 --> MDR-10 (PV52) Az. 253°07'45" 1.015 sec -0.133 sec -0.185

ΔHt. 3.329 m 0.021 m -0.016 m -0.967

Ellip Dist. 2751.491 m 0.014 m 0.004 m 0.403

MDR-14 --> MDR-13 (PV170) Az. 203°03'54" 1.456 sec 0.944 sec 0.961

ΔHt. -1.857 m 0.017 m 0.000 m 0.113

Ellip Dist. 1939.496 m 0.013 m 0.004 m 0.444

MDR-12 --> R-9 (PV41) Az. 139°52'38" 35.492 sec -13.583 sec -0.665

ΔHt. -0.434 m 0.012 m -0.005 m -0.948

Ellip Dist. 85.841 m 0.015 m -0.004 m -0.508

MDR-15 --> MDR-17 (PV65) Az. 39°09'20" 0.740 sec 0.096 sec 0.200

ΔHt. -4.411 m 0.022 m -0.020 m -0.932

Ellip Dist. 3962.992 m 0.014 m 0.003 m 0.355

MDR-16 --> MDR-5 (PV43) Az. 115°40'12" 0.406 sec 0.039 sec 0.121

ΔHt. -3.180 m 0.035 m -0.030 m -0.849

Ellip Dist. 6960.562 m 0.014 m 0.003 m 0.250

MDR-5 --> MDR-18 (PV32) Az. 323°00'08" 0.488 sec -0.057 sec -0.158

ΔHt. 1.336 m 0.044 m 0.006 m 0.069

Ellip Dist. 7534.749 m 0.018 m -0.011 m -0.819

MRE-33 --> MDR-13 (PV177) Az. 285°35’13” 0.275 sec -0.068 sec -0.311

ΔHt. 9.310 m 0.030 m -0.023 m -0.781

Ellip Dist. 9471.744 m 0.014 m -0.001 m -0.085

MRE-30 --> MDR-9 (PV168) Az. 183°13’44” 3.068 sec -0.808 sec -0.351

ΔHt. 1.831 m 0.025 m -0.006 m -0.725

Ellip Dist. 947.137 m 0.013 m 0.002 m 0.156

MRE-30 --> MDR-10 (PV158) Az. 35°54’29” 1.380 sec -1.052 sec -0.701

ΔHt. -4.587 m 0.029 m 0.012 m 0.568

Ellip Dist. 2437.514 m 0.016 m 0.004 m 0.229

MDR-5 --> MDR-17 (PV29) Az. 308°45’36” 0.401 sec -0.205 sec -0.697

ΔHt. 1.034 m 0.035 m 0.006 m 0.186

Ellip Dist. 7306.064 m 0.014 m -0.004 m -0.409

MRE-30 --> MDR-15 (PV157) Az. 59°30’30” 1.328 sec -2.089 sec -0.695

ΔHt. -5.650 m 0.028 m 0.007 m 0.161

Ellip Dist. 2478.373 m 0.017 m -0.013 m -0.278

MDR-14 --> MDR-16 (PV145) Az. 25°43’58” 0.867 sec 0.275 sec 0.433

ΔHt. -9.143 m 0.021 m 0.013 m 0.676

Ellip Dist. 3164.994 m 0.013 m 0.004 m 0.417

MRE-30 --> MDR-13 (PV169) Az. 133°59’49” 1.058 sec 0.480 sec 0.591

ΔHt. -0.630 m 0.029 m -0.006 m -0.159

Ellip Dist. 2681.434 m 0.014 m 0.005 m 0.472

MRE-30 --> MDR-14 (PV155) Az. 91°39'46" 0.964 sec 0.146 sec 0.182

ΔHt. 1.227 m 0.028 m -0.008 m -0.137

Ellip Dist. 2689.769 m 0.014 m -0.006 m -0.498

MDR-16 --> MDR-15 (PV63) Az. 231°49'15" 1.146 sec -0.088 sec -0.113

ΔHt. 2.266 m 0.019 m -0.007 m -0.487

Ellip Dist. 2451.552 m 0.014 m 0.003 m 0.300

MDR-14 --> MDR-5 (PV146) Az. 91°13'37" 0.363 sec 0.008 sec 0.029

ΔHt. -12.323 m 0.035 m -0.007 m -0.189

Ellip Dist. 7649.657 m 0.014 m 0.001 m 0.054

R-9 --> U-9 (PV40) Az. 232°33'35" 2.032 sec 0.018 sec 0.017

ΔHt. 2.349 m 0.013 m 0.001 m 0.144

Ellip Dist. 1627.917 m 0.016 m -0.001 m -0.079

Covariance Terms

From Point To Point Components A-posteriori Error Horiz. Precision

(PPM) 3D Precision

(PPM)

MDR-10 MDR-15 Az. 135°25'58" 2.920 sec 14.278 14.284

ΔHt. -1.076 m 0.015 m

ΔElev. -1.131 m 0.015 m

Ellip Dist. 1006.087 m 0.014 m

MDR-10 MR-178 Az. 280°08'29" 0.580 sec 3.152 3.154

ΔHt. 4.116 m 0.047 m

ΔElev. 4.288 m 0.047 m

Ellip Dist. 5533.394 m 0.017 m

MDR-10 MRE-30 Az. 215°54'39" 1.395 sec 6.366 6.360

ΔHt. 4.690 m 0.032 m

ΔElev. 4.624 m 0.032 m

Ellip Dist. 2437.506 m 0.016 m

MDR-11 MR-178 Az. 328°05’04” 0.443 sec 1.979 1.981

ΔHt. -4.765 m 0.056 m

ΔElev. -4.305 m 0.056 m

Ellip Dist. 8423.018 m 0.017 m

MDR-11 MRE-32 Az. 148°43’54” 0.359 sec 1.663 1.663

ΔHt. -0.883 m 0.032 m

ΔElev. -1.351 m 0.032 m

Ellip Dist. 8203.297 m 0.014 m

MDR-11 MRE-33 Az. 91°05’38” 0.260 sec 1.364 1.364

ΔHt. -14.486 m 0.032 m

ΔElev. -14.786 m 0.032 m

Ellip Dist. 10619.648 m 0.014 m

MDR-11 R-9 Az. 39°12’55” 2.686 sec 12.940 12.940

ΔHt. -2.088 m 0.014 m

ΔElev. -2.065 m 0.014 m

Ellip Dist. 1146.166 m 0.015 m

MDR-11 U-9 Az. 259°50’55” 5.320 sec 25.784 25.783

ΔHt. 0.336 m 0.012 m

ΔElev. 0.347 m 0.012 m

Ellip Dist. 576.898 m 0.015 m

MDR-12 MDR-11 Az. 215°03’52” 1.951 sec 9.235 9.233

ΔHt. 1.654 m 0.012 m

ΔElev. 1.626 m 0.012 m

Ellip Dist. 1165.103 m 0.011 m

MDR-12 MDR-13 Az. 30°45’02” 1.842 sec 8.535 8.534

ΔHt. -3.205 m 0.019 m

ΔElev. -3.157 m 0.019 m

Ellip Dist. 1611.640 m 0.014 m

MDR-12 MRE-33 Az. 96°37’54” 0.283 sec 1.454 1.455

ΔHt. -12.832 m 0.028 m

ΔElev. -13.160 m 0.028 m

Ellip Dist. 10015.370 m 0.015 m

MDR-12 R-9 Az. 139°52’37” 35.540 sec 173.250 173.263

ΔHt. -0.435 m 0.012 m

ΔElev. -0.439 m 0.012 m

Ellip Dist. 85.841 m 0.015 m

MDR-12 U-9 Az. 229°32’13” 1.905 sec 9.169 9.169

ΔHt. 1.990 m 0.015 m

ΔElev. 1.973 m 0.015 m

Ellip Dist. 1626.156 m 0.015 m

MDR-14 MDR-13 Az. 203°03’54” 1.471 sec 6.721 6.720

ΔHt. -1.785 m 0.020 m

ΔElev. -1.860 m 0.020 m

Ellip Dist. 1939.490 m 0.013 m

MDR-14 MRE-30 Az. 271°40’06” 0.874 sec 4.666 4.666

ΔHt. -1.119 m 0.025 m

ΔElev. -1.046 m 0.025 m

Ellip Dist. 2689.760 m 0.013 m

MDR-15 MDR-14 Az. 157°30’44” 2.071 sec 9.789 9.791

ΔHt. 6.885 m 0.017 m

ΔElev. 6.801 m 0.017 m

Ellip Dist. 1445.565 m 0.014 m

MDR-15 MRE-30 Az. 239°30’46” 1.306 sec 6.620 6.617

ΔHt. 5.766 m 0.029 m

ΔElev. 5.755 m 0.029 m

Ellip Dist. 2478.365 m 0.016 m

MDR-16 MDR-10 Az. 253°07’45” 1.014 sec 5.199 5.198

ΔHt. 3.455 m 0.023 m

ΔElev. 3.468 m 0.023 m

Ellip Dist. 2751.482 m 0.014 m

MDR-16 MDR-14 Az. 205°44'08" 0.896 sec 4.207 4.207

ΔHt. 9.264 m 0.029 m

ΔElev. 9.139 m 0.029 m

Ellip Dist. 3164.984 m 0.013 m

MDR-16 MDR-15 Az. 231°49'15" 1.158 sec 5.621 5.620

ΔHt. 2.379 m 0.023 m

ΔElev. 2.338 m 0.023 m

Ellip Dist. 2451.544 m 0.014 m

MDR-17 MDR-10 Az. 233°42'40" 0.747 sec 3.743 3.742

ΔHt. 5.660 m 0.031 m

ΔElev. 5.593 m 0.031 m

Ellip Dist. 3980.618 m 0.015 m

MDR-17 MDR-15 Az. 219°09'39" 0.774 sec 3.751 3.750

ΔHt. 4.583 m 0.032 m

ΔElev. 4.462 m 0.032 m

Ellip Dist. 3962.979 m 0.015 m

MDR-17 MDR-16 Az. 200°16'43" 1.686 sec 8.001 8.000

ΔHt. 2.204 m 0.020 m

ΔElev. 2.124 m 0.020 m

Ellip Dist. 1660.401 m 0.013 m

MDR-17 MDR-5 Az. 128°44'52" 0.447 sec 2.176 2.177

ΔHt. -1.165 m 0.041 m

ΔElev. -1.563 m 0.041 m

Ellip Dist. 7306.040 m 0.016 m

MDR-17 MR-178 Az. 260°56'05" 0.390 sec 2.196 2.196

ΔHt. 9.776 m 0.056 m

ΔElev. 9.881 m 0.056 m

Ellip Dist. 8764.857 m 0.019 m

MDR-18 MDR-17 Az. 218°50'24" 1.995 sec 9.734 9.730

ΔHt. -0.222 m 0.037 m

ΔElev. -0.287 m 0.037 m

Ellip Dist. 1853.705 m 0.018 m

MDR-18 MDR-19 Az. 50°42'32" 2.406 sec 11.681 11.682

ΔHt. -1.730 m 0.036 m

ΔElev. -1.693 m 0.036 m

Ellip Dist. 1564.555 m 0.018 m

MDR-18 MDR-5 Az. 142°59'33" 0.530 sec 2.589 2.590

ΔHt. -1.387 m 0.053 m

ΔElev. -1.849 m 0.053 m

Ellip Dist. 7534.724 m 0.020 m

MDR-18 MR-178 Az. 253°57'01" 0.431 sec 2.255 2.255

ΔHt. 9.554 m 0.067 m

ΔElev. 9.594 m 0.067 m

Ellip Dist. 10216.187 m 0.023 m

MDR-19 MDR-5 Az. 154°37'23" 0.506 sec 2.405 2.406

ΔHt. 0.343 m 0.059 m

ΔElev. -0.157 m 0.059 m

Ellip Dist. 7756.248 m 0.019 m

MDR-19 MR-178 Az. 250°55'13" 0.368 sec 1.899 1.899

ΔHt. 11.283 m 0.074 m

ΔElev. 11.287 m 0.074 m

Ellip Dist. 11670.121 m 0.022 m

MDR-5 MDR-13 Az. 259°06'20" 0.427 sec 2.228 2.228

ΔHt. 10.848 m 0.049 m

ΔElev. 10.966 m 0.049 m

Ellip Dist. 8562.500 m 0.019 m

MDR-5 MDR-14 Az. 271°14'34" 0.417 sec 2.120 2.121

ΔHt. 12.633 m 0.042 m

ΔElev. 12.826 m 0.042 m

Ellip Dist. 7649.632 m 0.016 m

MDR-5 MDR-16 Az. 295°40'59" 0.465 sec 2.300 2.300

ΔHt. 3.369 m 0.039 m

ΔElev. 3.687 m 0.039 m

Ellip Dist. 6960.539 m 0.016 m

MDR-9 MDR-11 Az. 171°27'28" 0.867 sec 3.992 3.993

ΔHt. 2.338 m 0.031 m

ΔElev. 2.161 m 0.031 m

Ellip Dist. 3292.204 m 0.013 m

MDR-9 MDR-12 Az. 153°17'21" 1.079 sec 5.258 5.260

ΔHt. 0.684 m 0.028 m

ΔElev. 0.536 m 0.028 m

Ellip Dist. 2577.008 m 0.014 m

MDR-9 MDR-13 Az. 114°49'24" 1.241 sec 6.354 6.356

ΔHt. -2.521 m 0.026 m

ΔElev. -2.621 m 0.026 m

Ellip Dist. 2184.101 m 0.014 m

MDR-9 MDR-14 Az. 72°26'31" 0.959 sec 4.807 4.805

ΔHt. -0.735 m 0.029 m

ΔElev. -0.761 m 0.029 m

Ellip Dist. 2875.954 m 0.014 m

MDR-9 MR-178 Az. 314°29'18" 0.604 sec 2.980 2.983

ΔHt. -2.428 m 0.054 m

ΔElev. -2.144 m 0.054 m

Ellip Dist. 5556.689 m 0.017 m

MDR-9 MRE-30 Az. 3°13'43" 3.016 sec 13.557 13.554

ΔHt. -1.854 m 0.025 m

ΔElev. -1.807 m 0.025 m

Ellip Dist. 947.134 m 0.013 m

MR-178 MRE-30 Az. 126°15'56" 0.736 sec 3.654 3.657

ΔHt. 0.574 m 0.055 m

ΔElev. 0.336 m 0.055 m

Ellip Dist. 4983.203 m 0.018 m

MRE-30 MDR-13 Az. 133°59'48" 0.959 sec 4.681 4.684

ΔHt. -0.667 m 0.024 m

ΔElev. -0.814 m 0.024 m

Ellip Dist. 2681.425 m 0.013 m

MRE-32 MRE-33 Az. 43°03'19" 0.000 sec 0.000 0.000

ΔHt. -13.603 m 0.000 m

ΔElev. -13.435 m 0.000 m

Ellip Dist. 9317.188 m 0.000 m

MRE-33 MDR-13 Az. 285°35'12" 0.263 sec 1.366 1.366

ΔHt. 9.627 m 0.024 m

ΔElev. 10.004 m 0.024 m

Ellip Dist. 9471.713 m 0.013 m

MRE-33 MDR-14 Az. 297°22'08" 0.255 sec 1.308 1.309

ΔHt. 11.413 m 0.025 m

ΔElev. 11.863 m 0.025 m

Ellip Dist. 9417.108 m 0.012 m

MRE-33 MDR-16 Az. 315°46'34" 0.303 sec 1.508 1.510

ΔHt. 2.149 m 0.039 m

ΔElev. 2.725 m 0.039 m

Ellip Dist. 10019.123 m 0.015 m

MRE-33 MDR-5 Az. 350°15'09" 0.752 sec 3.285 3.286

ΔHt. -1.220 m 0.044 m

ΔElev. -0.962 m 0.044 m

Ellip Dist. 4224.088 m 0.014 m

U-9 R-9 Az. 52°33'25" 2.050 sec 9.892 9.891

ΔHt. -2.424 m 0.016 m

ΔElev. -2.412 m 0.016 m

Ellip Dist. 1627.912 m 0.016 m

Date: 6/13/2013 10:07:37 AM Project: D:\NATS\2013\UP-DREAM\RIVER\mag-asawang tubig\add gcps.vce Trimble Business Center

Annexes

ANNEX K. TRAVERSE COMPUTATION

T R A V E R S E   C O M P U T A T I O N

Surveyed for:	UP-TCAGP		B. L. No.______________________
Mun. of :	NAUJAN		Case No.______________________
Province of :	OR.MINDORO		Sheet _________ of ______ Sheets
Geodetic Engineer:	R. A. S. ALBERTO		Field Bk. No.______Pages________
Length :	1431.022	N. ERROR : -0.06	E -0.067
Linear Error of Closure:	0.093	Relative 1: 15459.1	

TRAV STA.	AZIMUTH			DISTANCE	LATITUDE Computed	LATITUDE Correction	DEPARTURE Computed	DEPARTURE Correction	COORDINATES Northings	COORDINATES Eastings	Elevation
MDR-11					0.00	0.00	0.00	0.00	1463978.241	309240.474	18.461
R-1	106	5	33	53.225	14.75	0.00	-51.14	0.00	1463992.995	309189.338	18.631
R-2	232	10	36	112.513	69.00	0.00	88.87	0.01	1464061.996	309278.219	18.555
R-3	214	8	52	440.920	364.90	0.02	247.50	0.02	1464426.923	309525.739	17.691
R-4	180	36	13	115.603	115.60	0.01	1.22	0.00	1464542.527	309526.957	17.372
R-5	203	30	24	54.870	50.32	0.00	21.89	0.00	1464592.847	309548.844	17.653
R-6	253	22	23	161.667	46.26	0.00	154.91	0.01	1464639.110	309703.763	16.586
R-7	251	6	16	270.847	87.71	0.01	256.25	0.02	1464726.828	309960.034	17.447
R-8	189	3	57	90.173	89.05	0.01	14.21	0.00	1464815.881	309974.243	16.455
R-9	176	20	33	45.359	45.27	0.00	-2.89	0.00	1464861.151	309971.350	16.396
MDR-12	140	18	32	85.844	66.06	0.00	-54.82	0.00	1464927.212	309916.530	16.836

TRAVERSE LOOP 1

T R A V E R S E   C O M P U T A T I O N

Surveyed for:	UP-DREAM		B. L. No.______________________
Mun. of :	NAUJAN		Case No.______________________
Province of :	OR.MINDORO		Sheet _________ of ______ Sheets
Geodetic Engineer:	R. A. S. ALBERTO		Field Bk. No.______Pages________
Length :	1077.954	N. ERROR : 0.02	E 0.000
Linear Error of Closure:	0.015	Relative 1: 69724.99	

TRAV STA.	AZIMUTH			DISTANCE	LATITUDE Computed	LATITUDE Correction	DEPARTURE Computed	DEPARTURE Correction	COORDINATES Northings	COORDINATES Eastings	Elevation
MDR-11					0.00	0.00	0.00	0.00	1463978.241	309240.474	18.461
U-1	84	44	43	161.607	-14.80	0.00	-160.93	0.00	1463963.440	309079.546	18.515
U-2	341	0	2	53.290	-50.39	0.00	17.35	0.00	1463913.052	309096.895	18.689
U-3	349	0	29	71.108	-69.80	0.00	13.56	0.00	1463843.247	309110.453	18.366
U-4	69	18	48	17.636	-6.23	0.00	-16.50	0.00	1463837.017	309093.954	18.575
U-5	30	34	2	204.575	-176.15	0.00	-104.04	0.00	1463660.867	308989.918	19.169
U-6	104	28	57	173.777	43.46	0.00	-168.26	0.00	1463704.325	308821.662	19.723
U-7	191	55	29	168.511	164.87	0.00	34.82	0.00	1463869.195	308856.481	17.339
U-8	125	59	16	122.727	72.12	0.00	-99.30	0.00	1463941.309	308757.178	18.449
U-9	54	32	32	104.723	-60.75	0.00	-85.30	0.00	1463880.557	308671.876	18.808

TRAVERSE LOOP 2

T R A V E R S E   C O M P U T A T I O N

Surveyed for: UP-DREAM
Mun. of : NAUJAN
Province of : OR.MINDORO
Geodetic Engineer: R. A. S. ALBERTO
Length : 2655.925
Linear Error of Closure: 0.147

N. ERROR : -0.15
Relative 1: 18123.44

B. L. No.________________
Case No.________________
Sheet ________ of _____ Sheets
Field Bk. No._____ Pages_______
E -0.009

TRAV STA.	AZIMUTH	DISTANCE	LATITUDE Com-puted	LATITUDE Correc-tion	DEPARTURE Com-puted	DEPARTURE Correc-tion	COORDINATES Northings	COORDINATES Eastings	Elevation
MDR-12			0.00	0.00	0.00	0.00	1464927.212	309916.530	16.836
R-10	153 28 17	103.207	92.34	0.01	-46.10	0.00	1465019.562	309870.433	16.596
R-11	169 0 55	145.075	142.42	0.01	-27.64	0.00	1465161.992	309842.790	16.417
R-12	160 39 35	52.805	49.82	0.00	-17.49	0.00	1465211.821	309825.302	16.296
R-13	121 14 0	95.707	49.63	0.00	-81.84	0.00	1465261.452	309743.467	16.235
R-14	109 19 40	91.859	30.40	0.00	-86.68	0.00	1465291.858	309656.786	16.294
R-15	160 6 49	120.806	113.60	0.01	-41.09	0.00	1465405.471	309615.693	15.884
R-16	260 8 13	89.177	15.28	0.00	87.86	0.00	1465420.748	309703.552	15.862
R-17	203 36 11	82.477	75.58	0.01	33.02	0.00	1465496.332	309736.576	15.896
R-18	239 13 6	90.894	46.52	0.00	78.09	0.00	1465542.853	309814.666	16.020
R-19	218 22 39	41.463	32.50	0.00	25.74	0.00	1465575.361	309840.408	16.125
R-20	265 45 30	48.487	3.59	0.00	48.35	0.00	1465578.947	309888.762	15.461
R-21	227 45 13	77.360	52.01	0.00	57.27	0.00	1465630.963	309946.029	15.412
R-22	221 54 46	103.132	76.75	0.01	68.89	0.00	1465707.717	310014.921	14.996
R-23	211 55 47	51.592	43.79	0.00	27.29	0.00	1465751.507	310042.207	14.675
R-24	276 50 7	47.841	-5.69	0.00	47.50	0.00	1465745.814	310089.708	14.644
R-25	244 18 58	43.728	18.95	0.00	39.41	0.00	1465764.768	310129.116	14.942
R-26	294 32 49	41.438	-17.21	0.00	37.69	0.00	1465747.554	310166.809	14.395
R-27	291 49 44	67.587	-25.13	0.00	62.74	0.00	1465722.425	310229.551	14.670
R-28	284 31 38	53.593	-13.44	0.00	51.88	0.00	1465708.983	310281.431	14.360
R-29	267 0 36	51.498	2.69	0.00	51.43	0.00	1465711.670	310332.859	14.362

TRAVERSE LOOP 3

Acknowledgements

In behalf of the whole surveying team under the joint venture of RASA SURVEYING AND LAND SURVEY CONSULTANTS and H.O. NOVELOSO SURVEYING we would like take this opportunity to express my profound gratitude and deep regards to all who provide support and significant contribution for the accomplishment of this project.

First and foremost, to Disaster Risk Exposure and Mitigation (DREAM) Project Team, for believing that we are capable of providing the services necessary for the success of the project and for their continuous assistance during the implementation of the project.

For National Mapping and Resource Information Authority (NAMRIA), for providing the locations of the nearest benchmark in the area, which is beneficial in the ground control survey of the project.

For the Local Government of Naujan and Calapan City, Oriental Mindoro, who play the very vital role in the assistance and security of the team during field surveys.

And, for all other individuals, that exerted their effort for the success of completing project.

RASA SURVEYING AND LAND SURVEY CONSULTANTS

and

H.O. NOVELOSO SURVEYIN

DREAM

Disaster Risk and Exposure Assessment for Mitigation