REGION 12

Buayan-Malungon River:

DREAM Ground Surveys Report

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY

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For questions/queries regarding this report, contact:

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

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

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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.

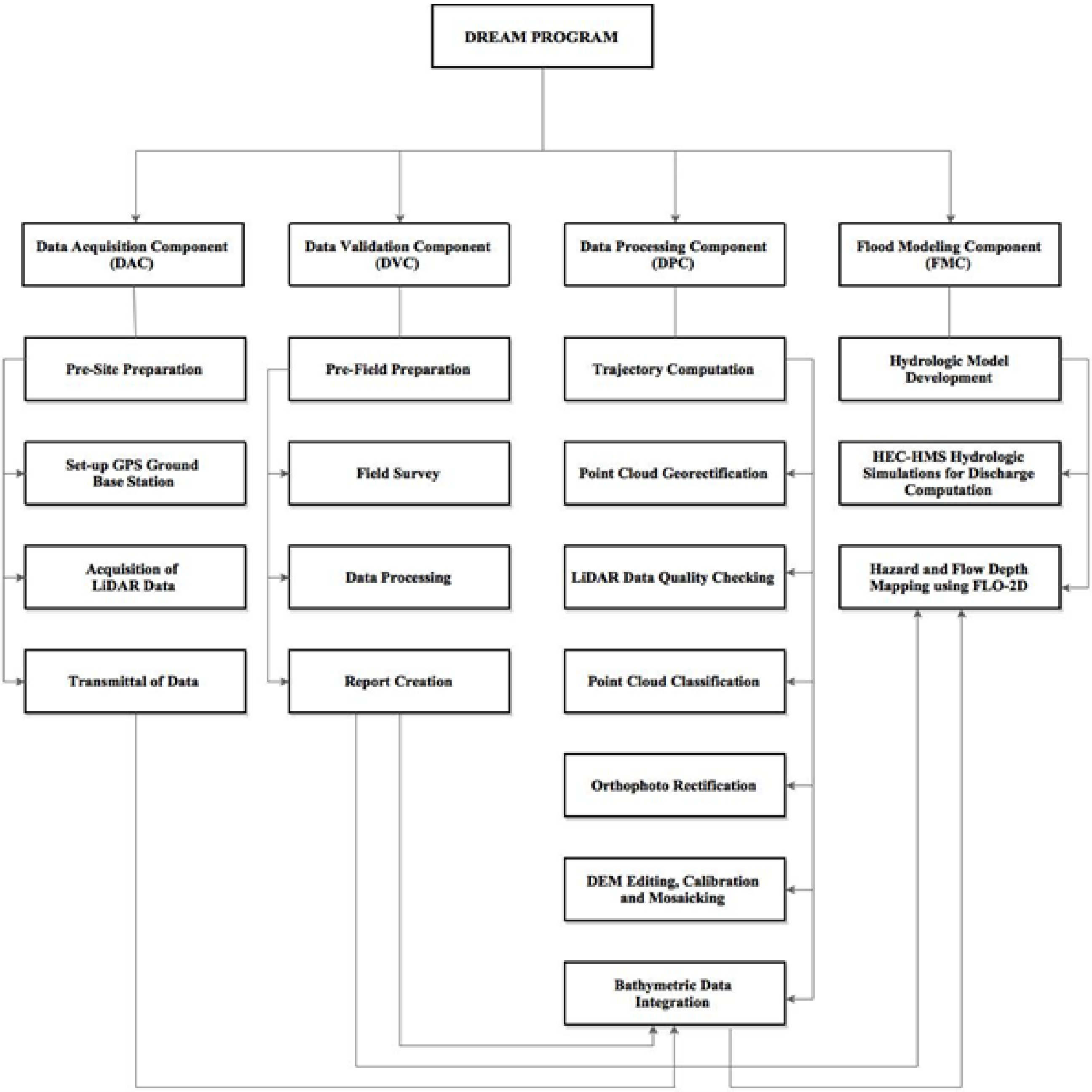


Figure 1. The General Methodological Framework of the Program

The Buayan-Malungon River Basin

The Buayan-Malungon River Basin

The Buayan-Malungon River Basin is located in Central and Southern Mindanao. It traverses through Sarangani, South Cotabato, Davao del Sur, and General Santos City. It is the eighteenth largest river basin in the Philippines. It covers an area of 1,435 square kilometers and travels for 33 kilometers from its source to its mouth. The location of the Buayan-Malungon River Basin is shown in Figure 2.

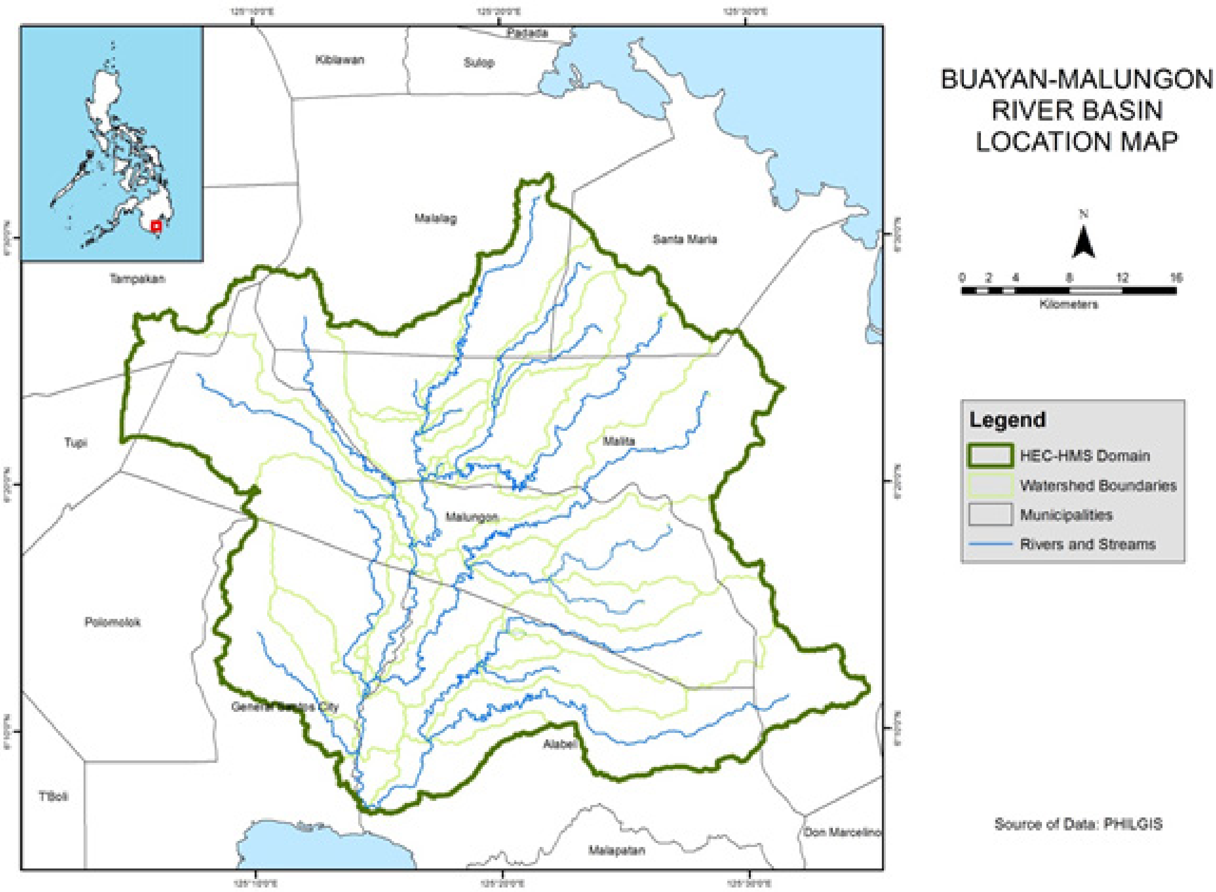


Figure 2. Buayan-Malungon River Basin Location Map

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

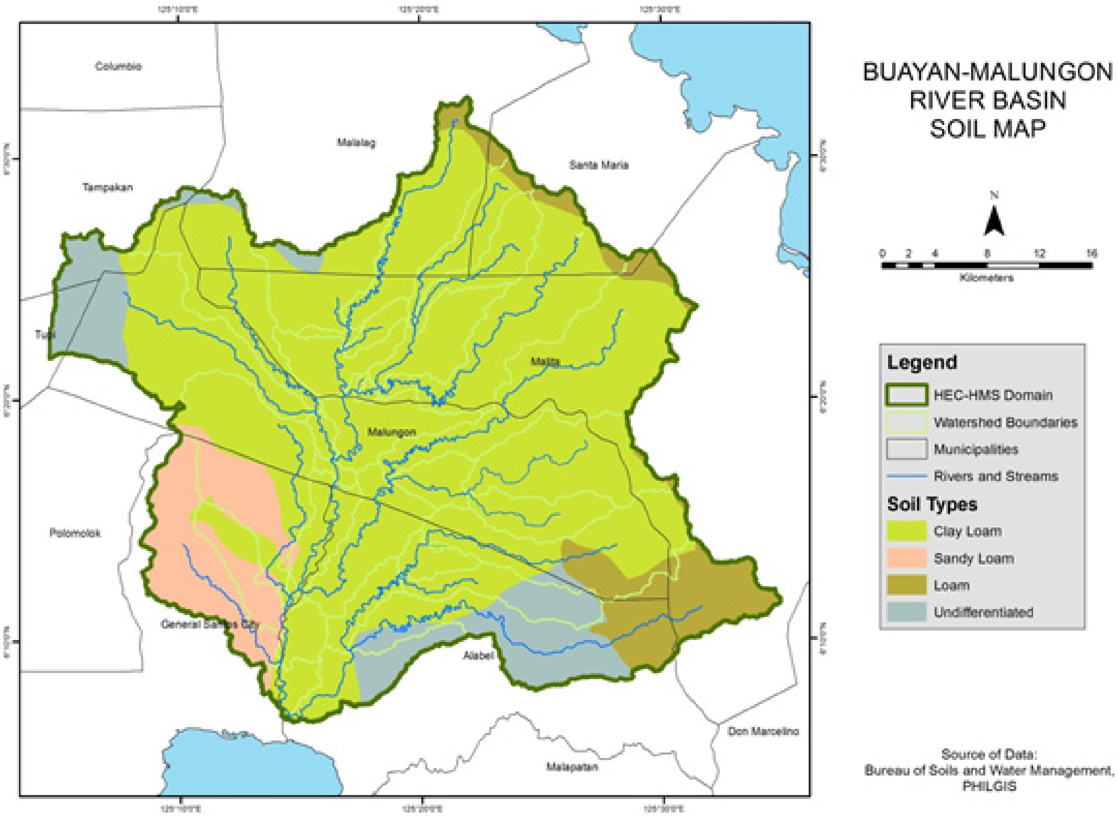


Figure 3. Buayan-Malungon River Basin Soil Map

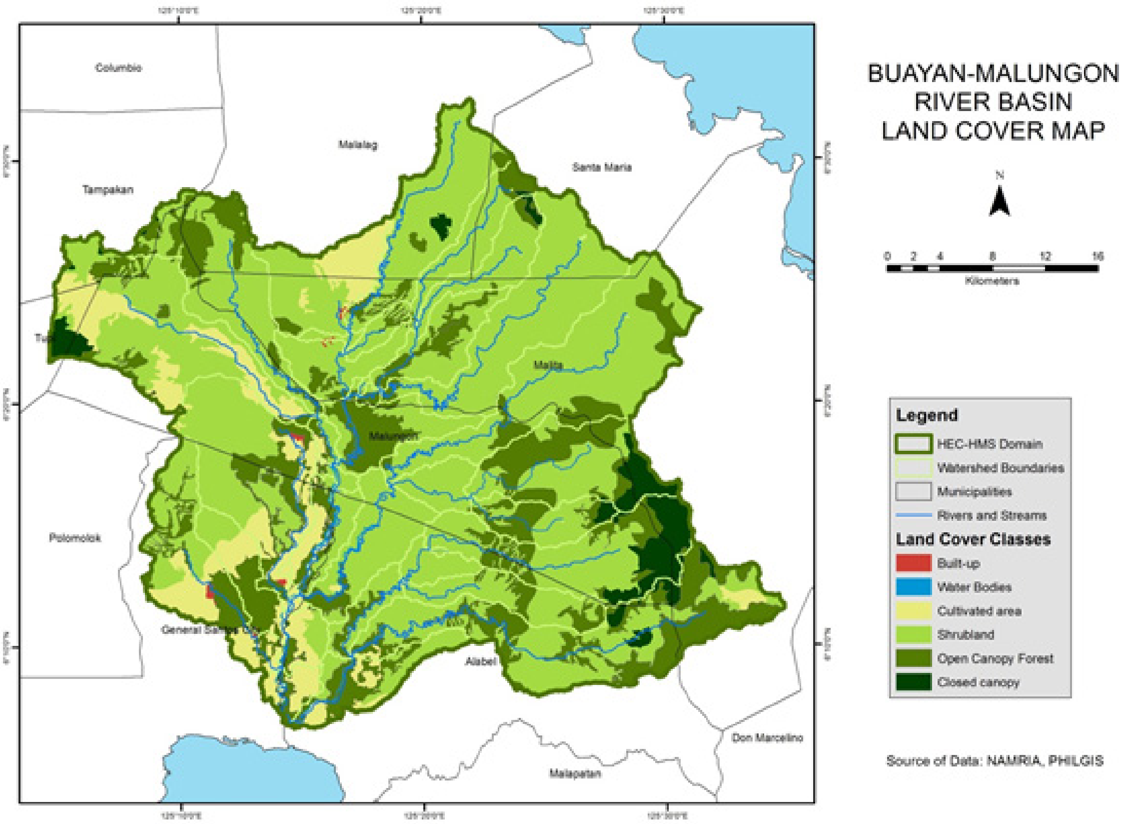


Figure 4. Buayan-Malungon River Basin Land Cover Map

DVC Methodology

DVC Methodology

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

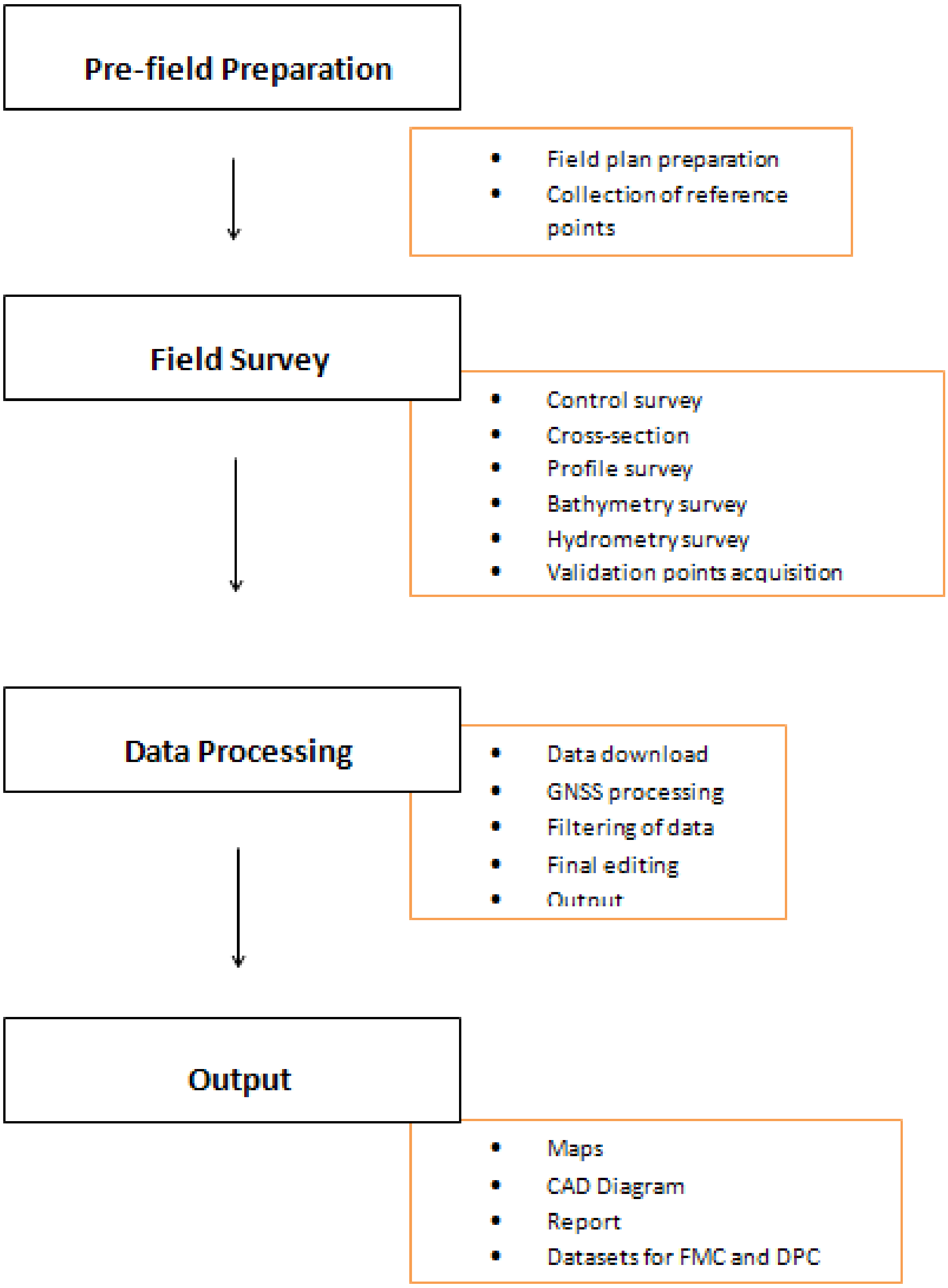


Figure 5. DVC Main Activities

DVC Methodology

3.1 Pre-field Preparation

3.1.1 Preparation of Field Plan

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

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

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

3.1.2 Collection of Reference Points

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

3.2 Field Surveys

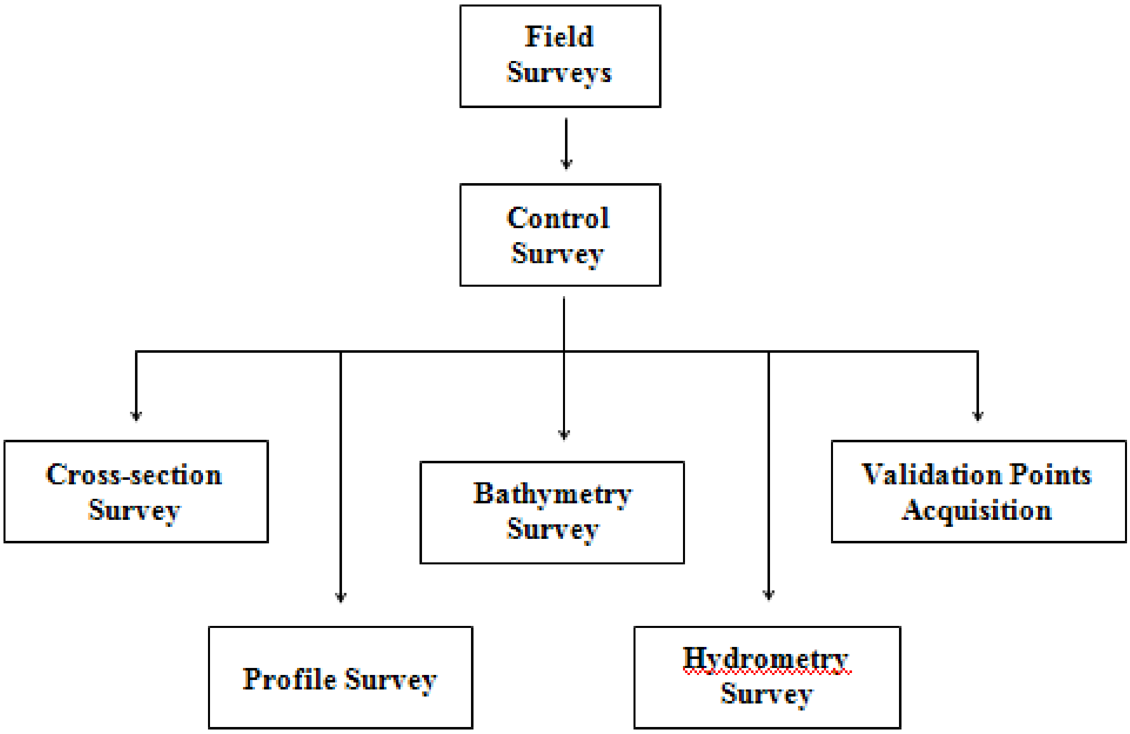


Figure 6. DVC Field Activities

3.2.1 Control Survey

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

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

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

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

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

3.2.2 Cross-section Survey

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

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

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

3.2.3 Profile Surveys

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

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

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

3.2.4 Bathymetric Survey

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

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

3.2.5 Hydrometric Survey

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

The elements of discharge computation are the ff.:

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

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

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

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

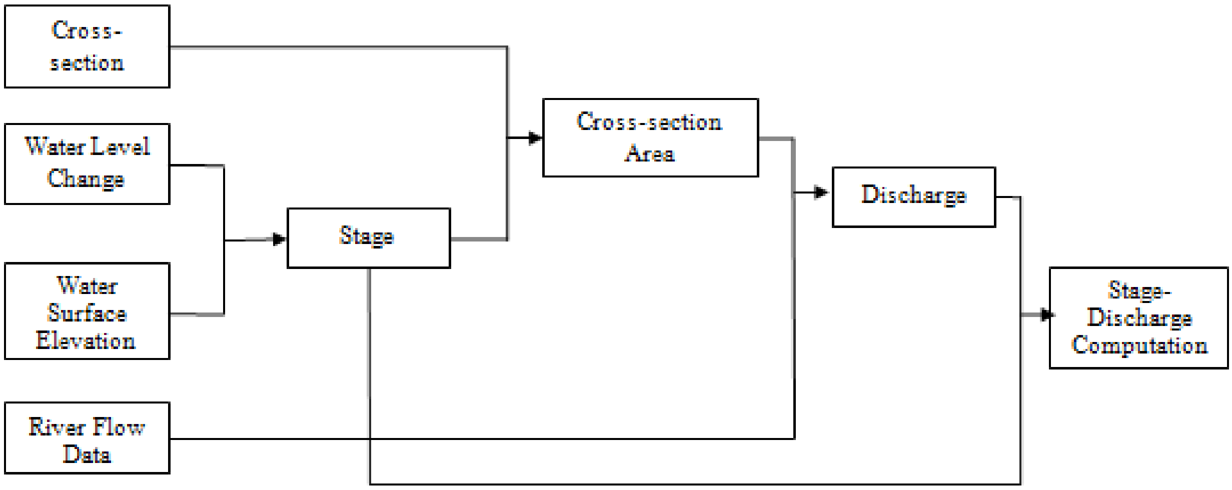


Figure 7. Flow Chart for Stage-Discharge Correlation Computation

3.2.6 Validation Points Acquisition Survey

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

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

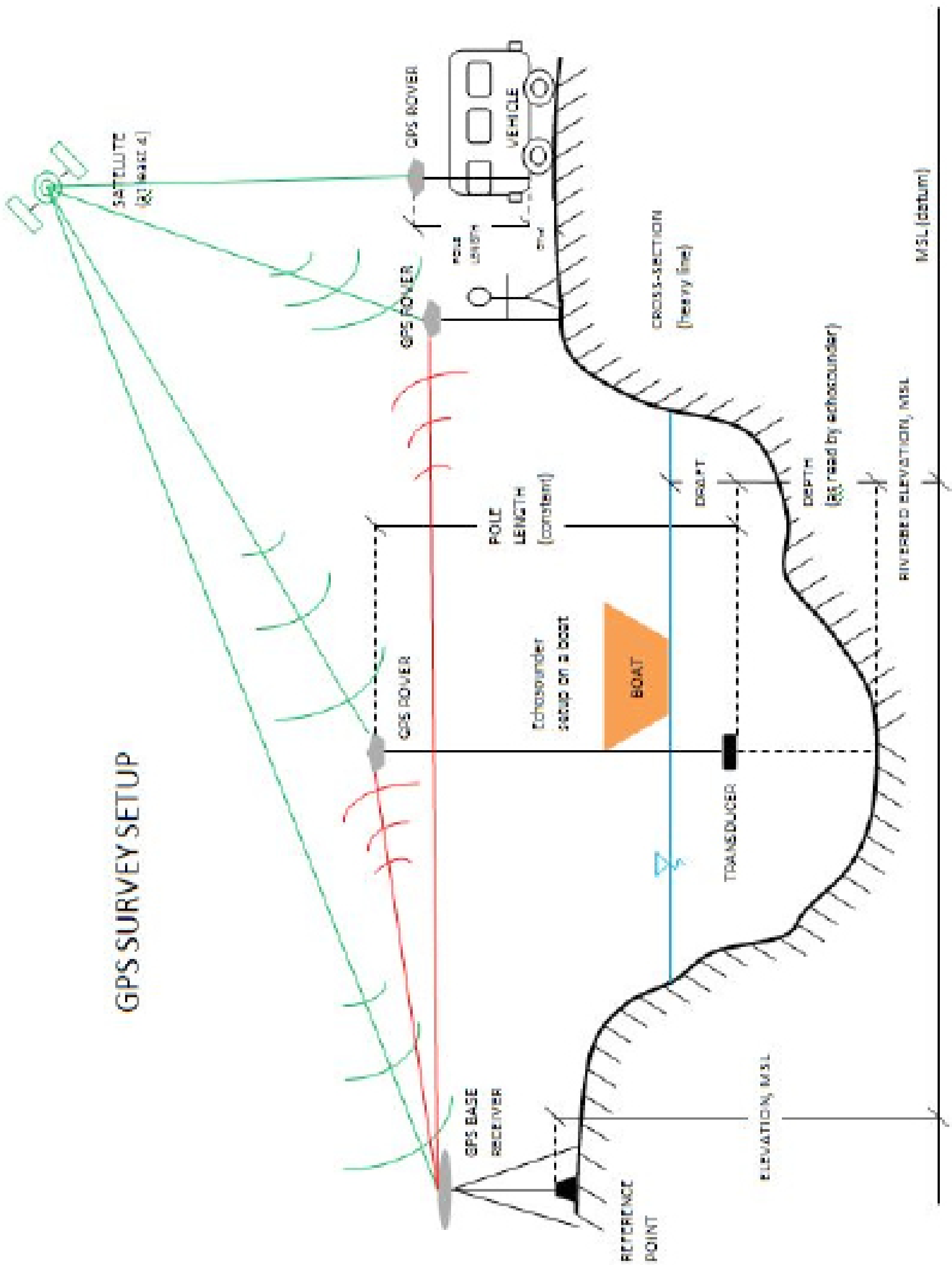


Figure 8. Set-up for GNSS Survey

3.3 Data Processing

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

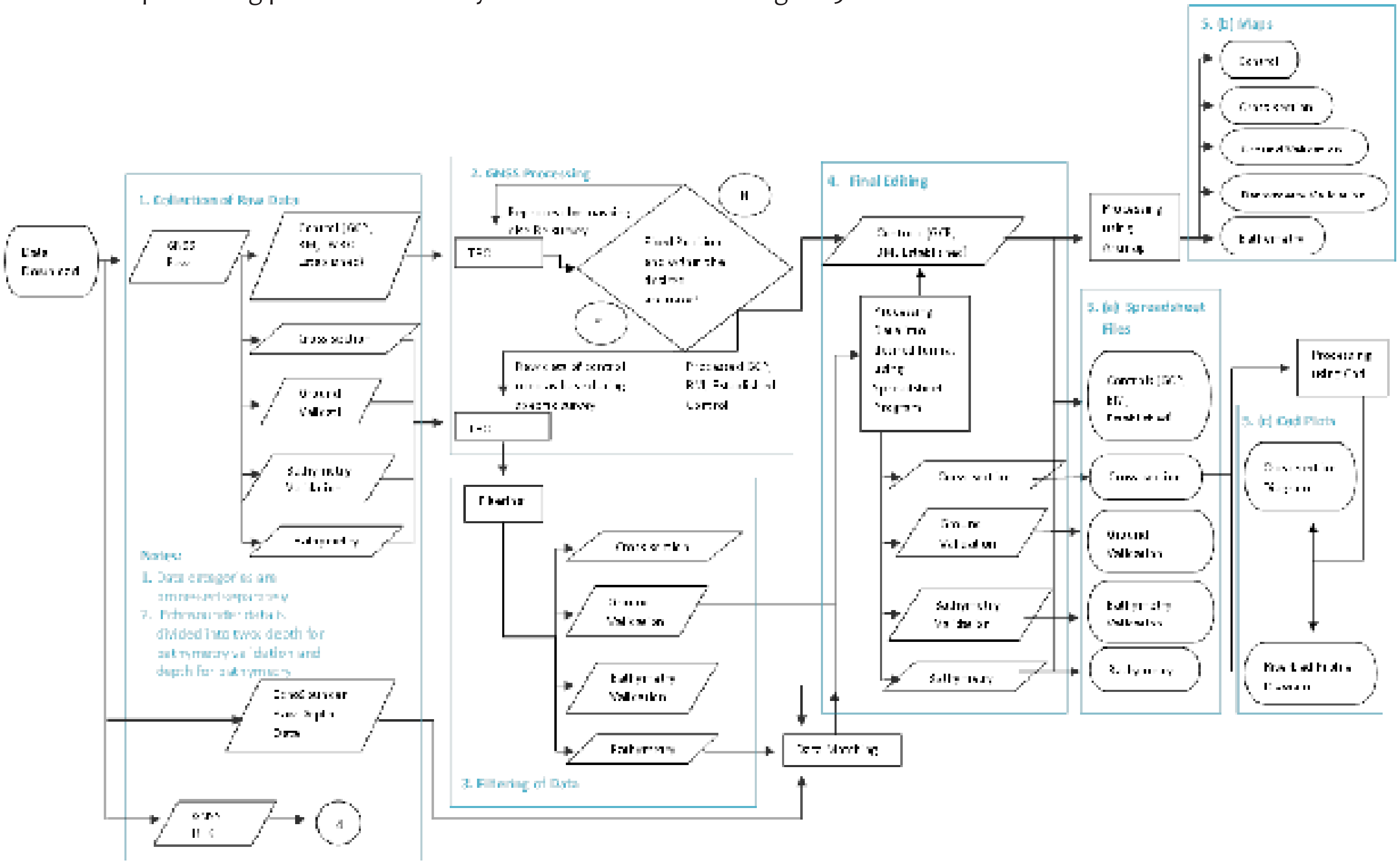


Figure 9. DVC Data Processing Methodology

3.3.1 Collection of Raw Data

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

3.3.2 Data Processing

Processing for GNSS Data

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

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

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

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

Computation for offset:

Equation 1:

$$OFFSET = BM - EGM$$

Computation for BM_ortho:

Equation 2:

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

where:

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

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

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

Depth Data Processing

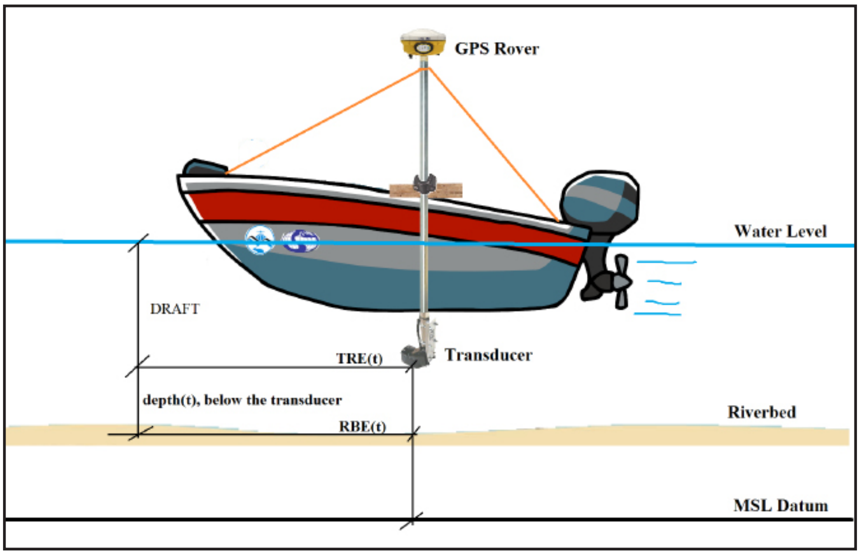


Figure 10. Illustration of Echo Sounder and GPS rover set-up for Bathymetric survey

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

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

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

Data Matching for Bathymetric Data

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

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

Equation 3:

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

where:

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

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

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

DVC Methodology

Hydrometry Data Processing

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

1. **River Flow Data**

a.) ADCP

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

b.) Flow Meter

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

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

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

3. **Water Level Change-Stage**

a.) Depth Gauge

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

b.) AWLS

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

4. **Discharge Computation**

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

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

3.3.3 Filtering of Data

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

3.3.4 Final Editing

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

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

3.3.5 Output

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

Buayan-Malungon River Basin Survey

Buayan-Malungon River Basin Survey

The survey for Buayan-Malungon Basin was conducted on June 11 to 22, 2013. The survey covered a total of three rivers namely: Buayan-Malungon, Makar, and Siluay. Bathymetric surveys, flow measurements, profile and cross-section line reconnaissance for outsource, and AWLS reconnaissance were conducted throughout the extent of the survey period.

Buayan-Malungon, Siluay, and Makar Rivers consists of twenty three (23), sixteen (16), and eighteen (18) delineated cross section lines respectively. The agglomerated length of the profile lines for the three rivers is around 33.64 km. Ground surveys for both the cross-section and profile lines were conducted by RASA Surveying on July 9 – September 2, 2013 as described in Annex F. Reconnaissance for possible sites of AWLS deployment was also conducted during the survey. A separate survey was conducted on May 8, 2014 to gather flow measurement and to deploy the depth gauge and the rain gauge in the Buayan-Malungon River system as described in the subsection *Flow Measurements and Sensor Deployment*.

4.1 Control Survey

Two (2) NAMRIA established control points were occupied for the static GNSS observations of the Buayan-Malungon River system. One is a benchmark, SC-134 located at the approach of Sinawal Bridge, General Santos City; and CTS-43, a second order reference point situated on top of a water tank in Brgy. Tambler, General Santos City. A new established point by DVC, GSC-1, on top of Ice Castle Experience Hotel, served as the base station for the GNSS surveys because of its central location within the survey area, see Figure 11.

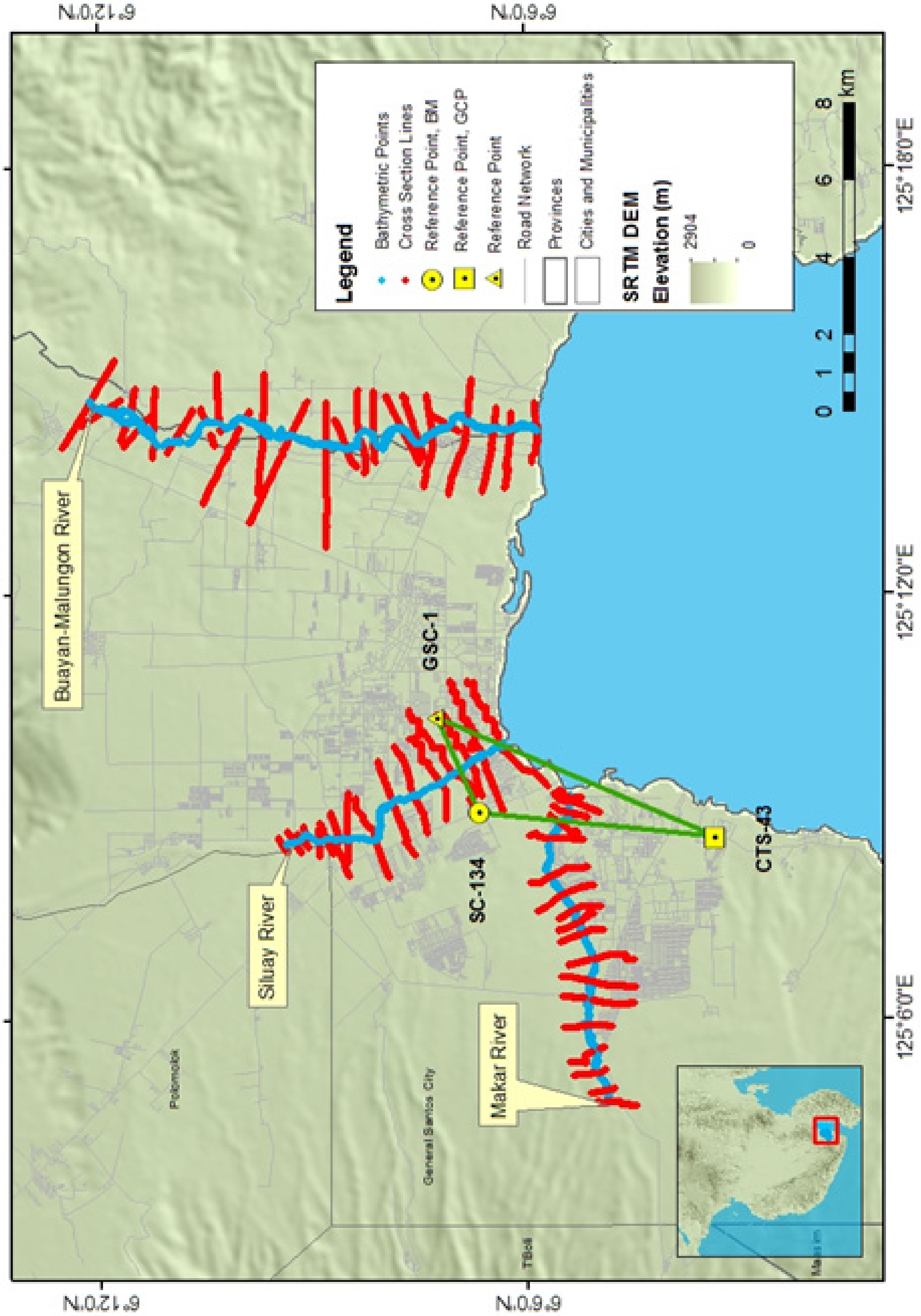


Figure 11. Location of control points

Continuous differential static observations were done simultaneously at the 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 Buayan-Malungon River Survey (Source: NAMRIA, UP-TCAGP)

Point Name	WGS84 UTM Zone 51N					Elevation in MSL (m)
	Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	
CTS-43	6d03'21.48507"	125d08'33.05028"	97.233	669859.338	737140.92	26.713
GSC-1 (established)	6d07'16.67814"	125d10'14.17232"	98.54	677098.698	740222.36	28.053
SC-134	6d06'39.95883"	125d08'54.60317"	101.652	675960.563	737779.631	30.955

The GNSS setup for the three (3) control points are illustrated in Figures 10 to 12:

Figure 12. GNSS base station at SC-134 Brgy. Sinawal, General Santos City

Figure 13. GNSS base station at CTS-43 in Brgy. Tambler, General Santos City

Figure 14. GNSS base station at GSC-1, rooftop of ICE hotel in General Santos City

4.2 Reconnaissance of Cross-section and Profile Lines

Each cross-section line was located using handheld GPS (Garmin Montana™ 650). Summary of reconnaissance for the fifty-seven (57) cross-sections are shown in detail in Annex E. Reconnaissance for profile lines was 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 three rivers was surveyed by traversing the river by foot using a Trimble®™ SPS882 GPS Rover in PPK survey technique because of the shallow waters in Buayan-Malungon and Siluay Rivers as shown in Figure 15. Makar River was surveyed using PPK survey technique in a continuous topo mode as illustrated in Figure 16.

The entire bathymetry of the three rivers took four (4) days to complete from June 16-19, 2013 using GSC-1 as base station.

Figure 15. Manual bathymetric survey using PPK GNSS technique in Buayan-Malungon and Siluay Rivers

Figure 16. Setup of instruments for bathymetric survey using Trimble SPS 882 installed on a vehicle in Makar River.

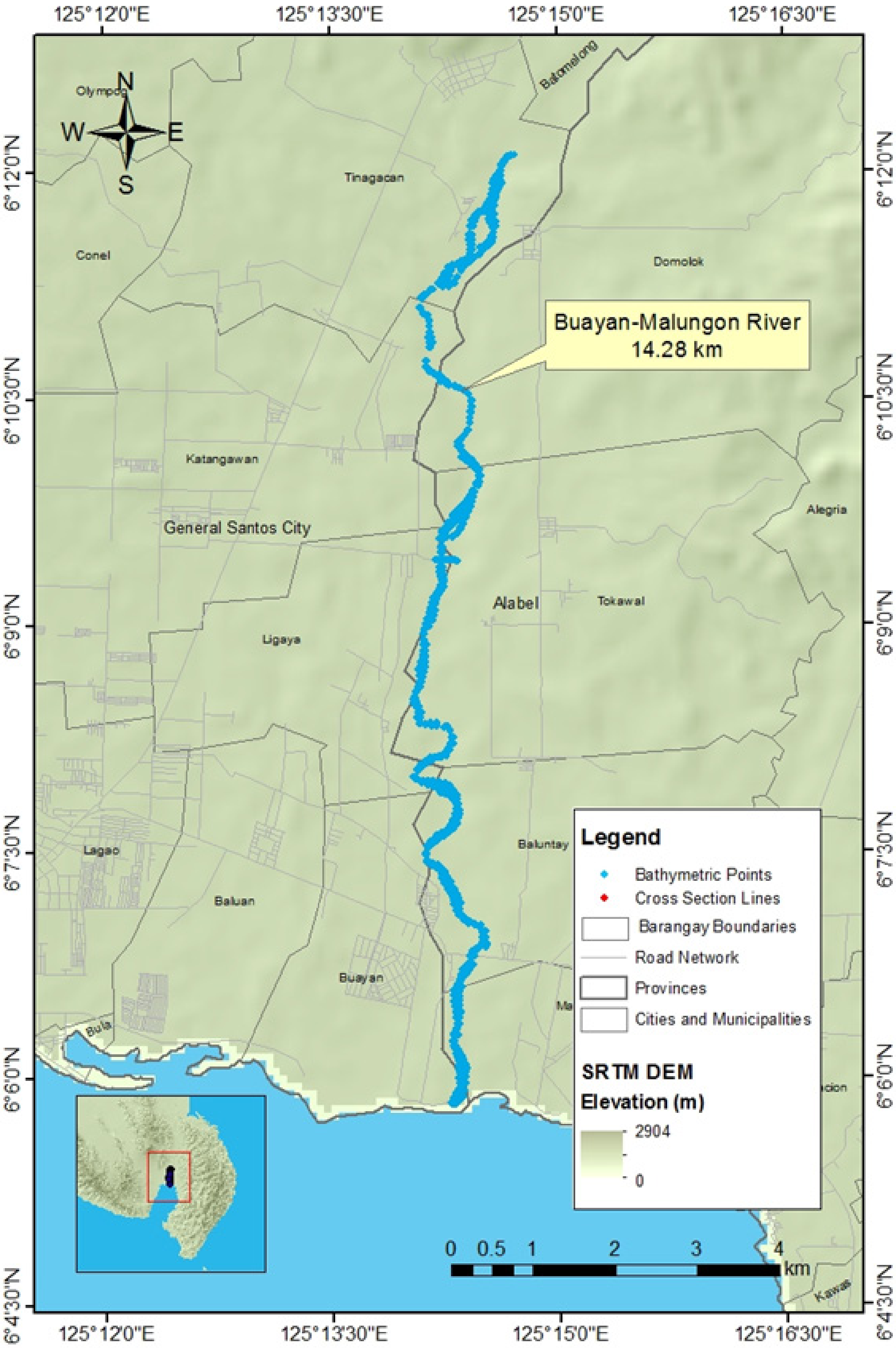


Figure 17. Bathymetry of Buayan-Malungon River

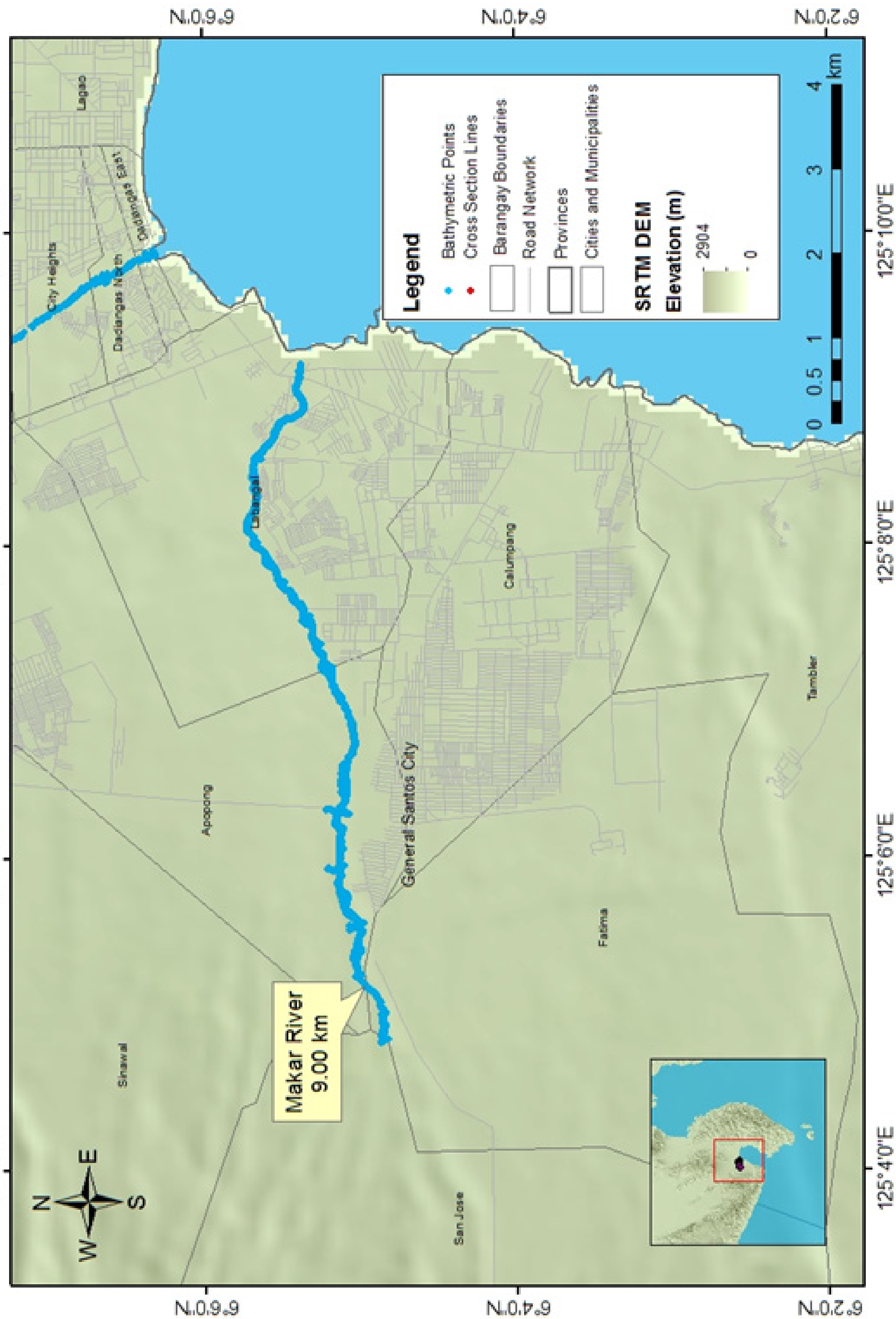


Figure 18. Bathymetry of Makar River

Figure 19. Bathymetry of Siluay River

The varying profile of the riverbed of Buayan, Siluay, and Makar Rivers are shown Figures 20, 21, and 22.

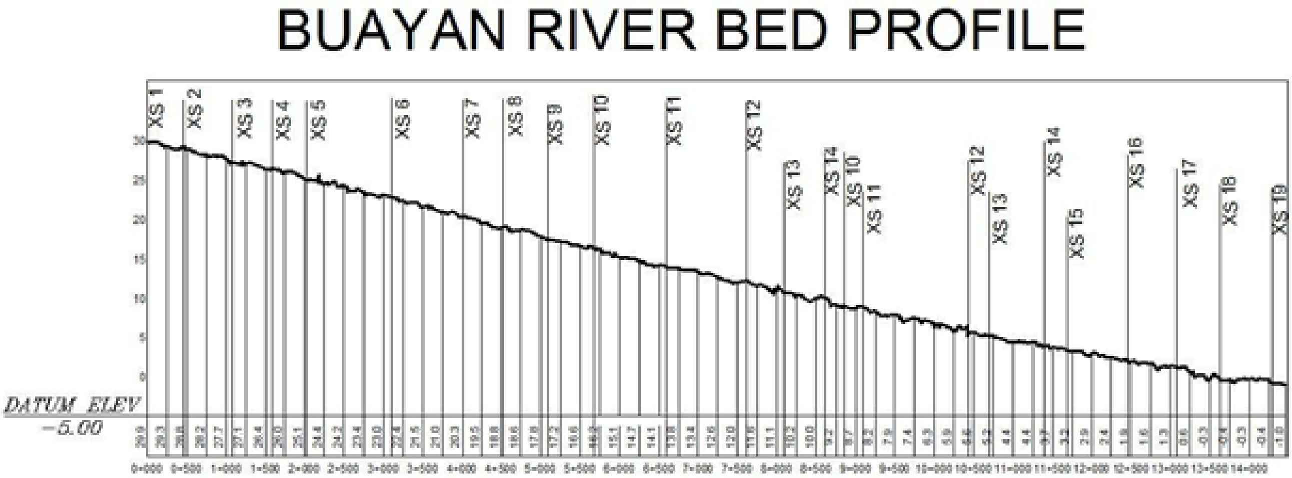


Figure 20. Riverbed Profile of Buayan River

The riverbed profile of Buayan River exhibits a gradual change from the upstream portion in Brgy. Tinagacan, down to the mouth of the river in Brgy. Buayan, General Santos City. The MSL elevation in the upstream portion is recorded at thirty (30) meters while the downstream portion is at around five (5) meters. The profile length for the river surveyed is 14.28 km and traverses eight (8) barangays.

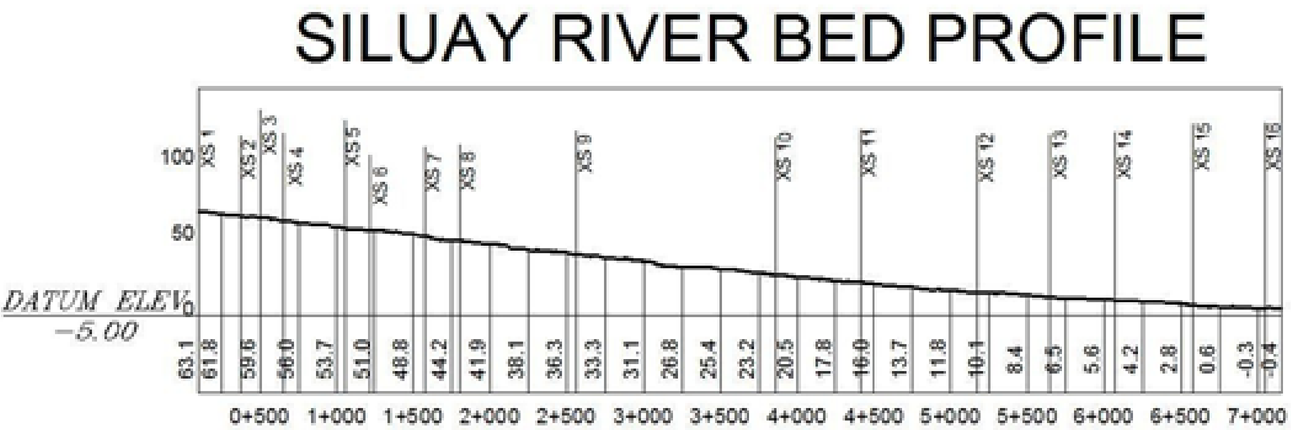


Figure 21. Riverbed Profile of Siluay River

The Siluay riverbed profile survey started in in Brgy. Mabuhay in the upstream going downstream to Brgy. Dadiangas South near the mouth of the river. The riverbed profile survey for the Siluay River traverses a total of five (5) barangay and measures 6.85 km with elevations ranging from five meters to sixty meters.

MAKAR RIVER BED PROFILE

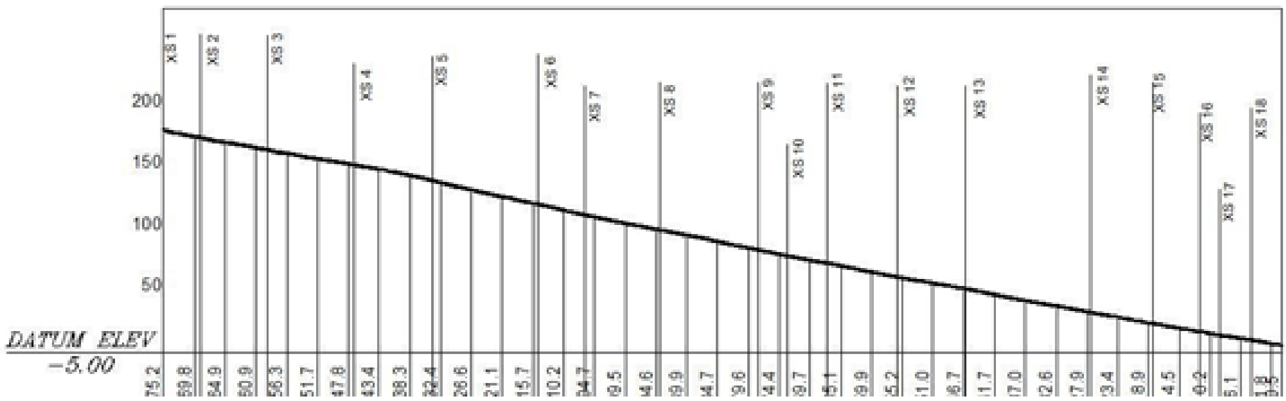


Figure 22. Riverbed Profile of Makar River

The Makar riverbed profile started at Brgy. San Jose in the upstream down to Brgy. Labangal near the mouth of the river. The length of the riverbed profile survey is 9.00 km and traverses four (4) barangays. The Makara riverbed profile is characterized by steep changes in elevation with extremes measuring as high as 175 meters and as low as 10 meters.

4.4 Hydrometric Survey

Different sensors (e.g. Velocity Meter, Rain Gauge, and Depth Gauge) were deployed on the banks of Buayan-Malungon River to obtain specific data (i.e. current speed, rainfall events, changes in water level) at any given time.

Plotting of hydrometric data gathered for water level vs rainfall, velocity vs rainfall and water level vs velocity are shown in figures 23, 24, and 25 respectively.

Data gathered from the rain gauge shows the distribution of rainfall within the observation period from June 15-21, 2013. Data were recorded every five (5) minutes. The only activity of rainfall which reached 0.2 mm, was observed on June, 16 at 12:55 AM.

Data collection in Brgy. Ligaya and Brgy. Tinagacan General Santos City using Velocity Meter, Rain Gauge, and Depth Gauge deployment started on June 15, 2013 and was retrieved on June 21, 2013. The Velocity Meter and the Depth gauge were deployed in Brgy. Ligaya located along the upstream portion of Buayan-Malungon River. The Rain Gauge was deployed at Brgy. Tinagacan. Local hired were employed to monitor the sensors within the vicinity of the deployment site for seven (7) days. Siluay and Makar Rivers were relatively dry throughout the survey period.

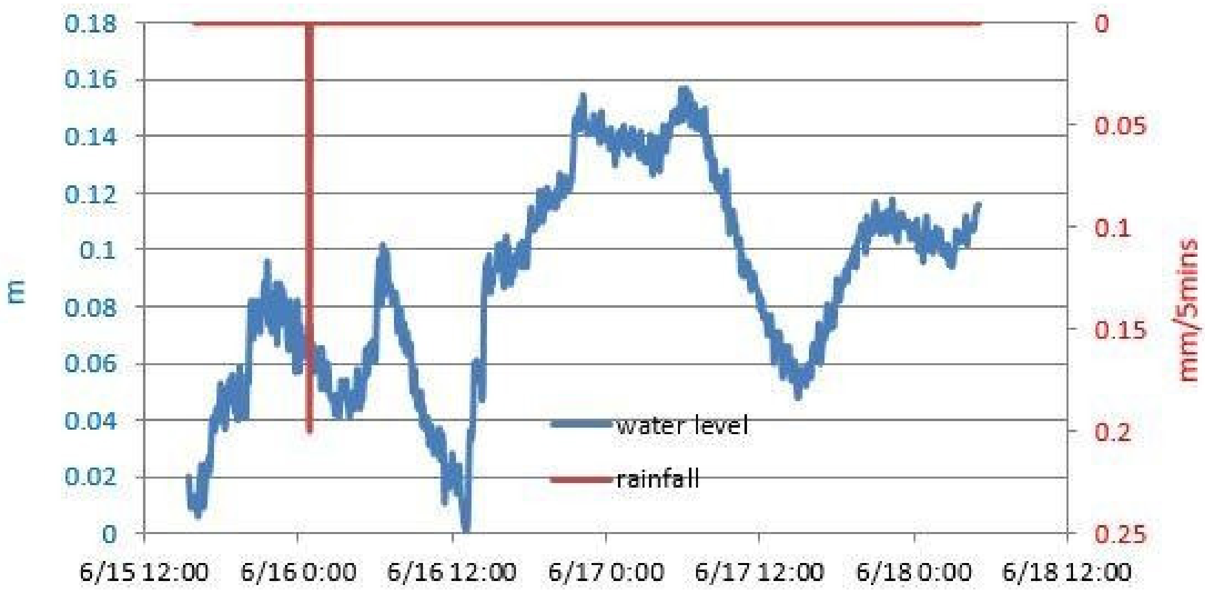


Figure 23. Relationship between water level and rainfall in Buayan River within observation period

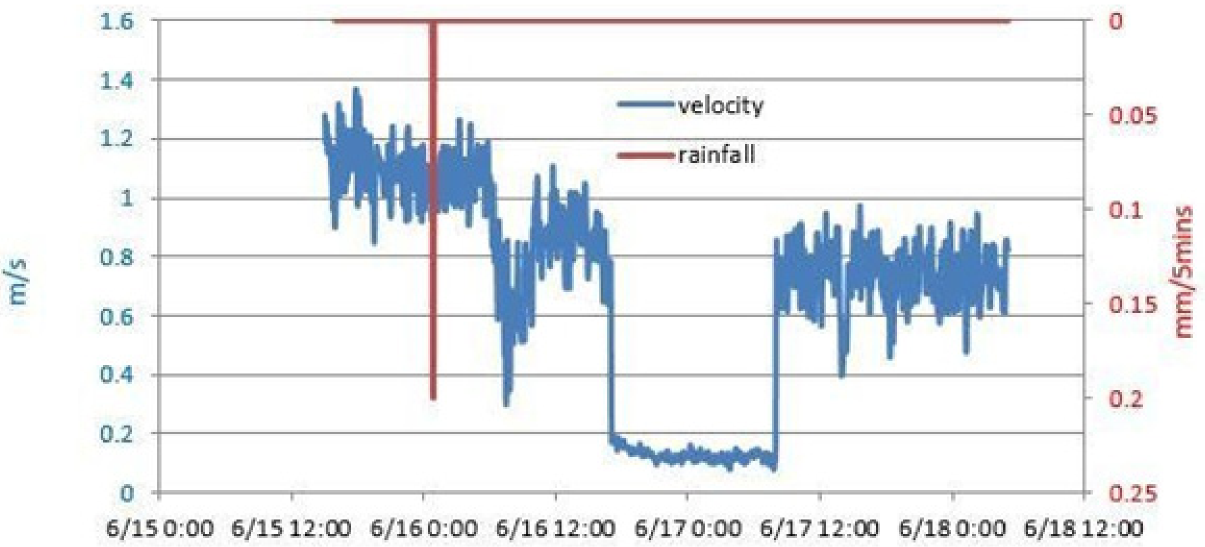


Figure 24. Relationship between water velocity and rainfall of Buayan River within observation period

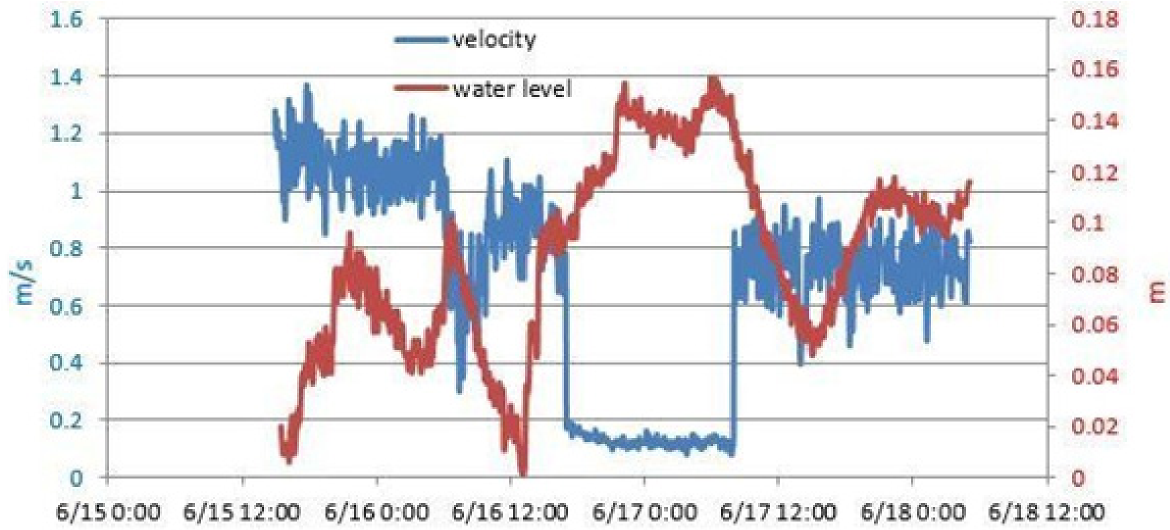


Figure 25. Relationship between water velocity and water level of Buayan River within observation period

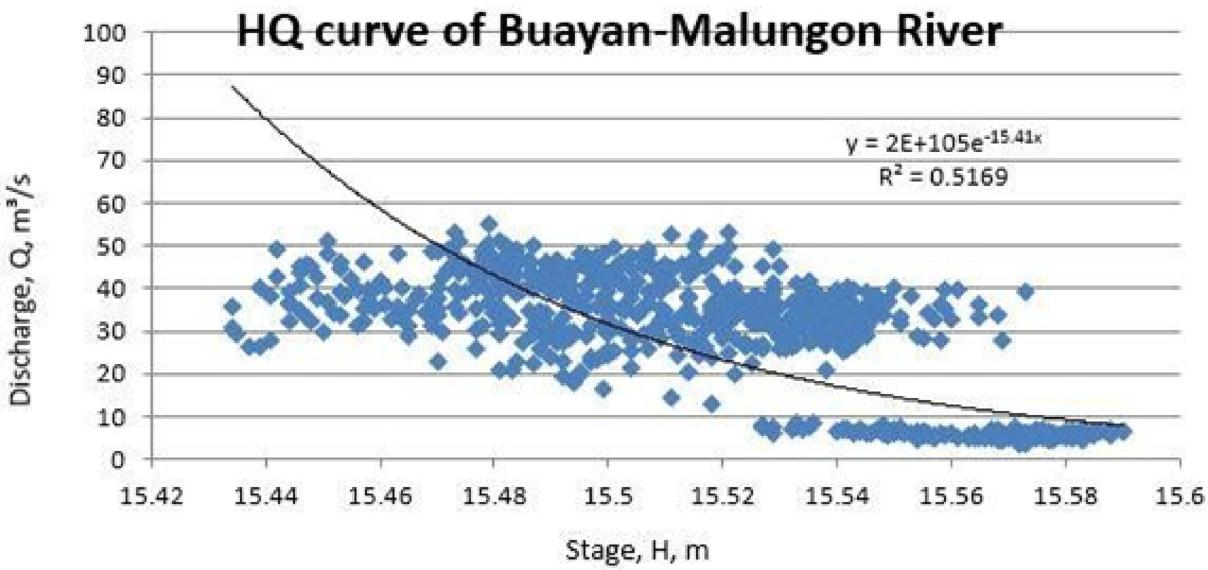


Figure 26. The derived rating curve along Buayan River

The relationship between the stage or water surface elevation referred to MSL and river discharge on a specific area of the river is illustrated in Figure 26. A value approaching R2 = 1 indicates a good correlation.

Setup of sensors deployment is illustrated in Figures 27, and 28.

Figure 27. Deployment of rain gauge in Brgy. Tinagacan, General Santos City

A velocity meter was deployed with a depth gauge in the upstream of Buayan River in Brgy. Ligaya, General Santos City; while the rain gauge was deployed in Brgy. Tinagacan. Local hires were employed to monitor the sensors within the vicinity of the deployment site for seven (7) days. Siluay and Makar Rivers were relatively dry throughout the survey period.

Figure 28. Deployment of velocity meter and depth gauge in Brgy. Ligaya, and temporary rain gauge installation at Brgy. Tinagacan, Buayan River

The summary of location of sensors deployment is shown in Table 2 and Figure 29.

Table 2. Deployment of sensors along Buayan River

Sensor	Location	Deployment	Retrieval	Latitude	Longitude
Velocity Meter	Bgy.Ligaya	June 15, 2013	June 21, 2013	6°11'46.40"N	125°14'25.58"E
Rain Gauge	Brgy. Tinagacan	June 15, 2013	June 21, 2013	6°09'25.82"N	125°14'12.67"E
Depth Gauge	Bgy.Ligaya	June 15, 2013	June 21, 2013	6°11'46.40"N	125°14'25.58"E

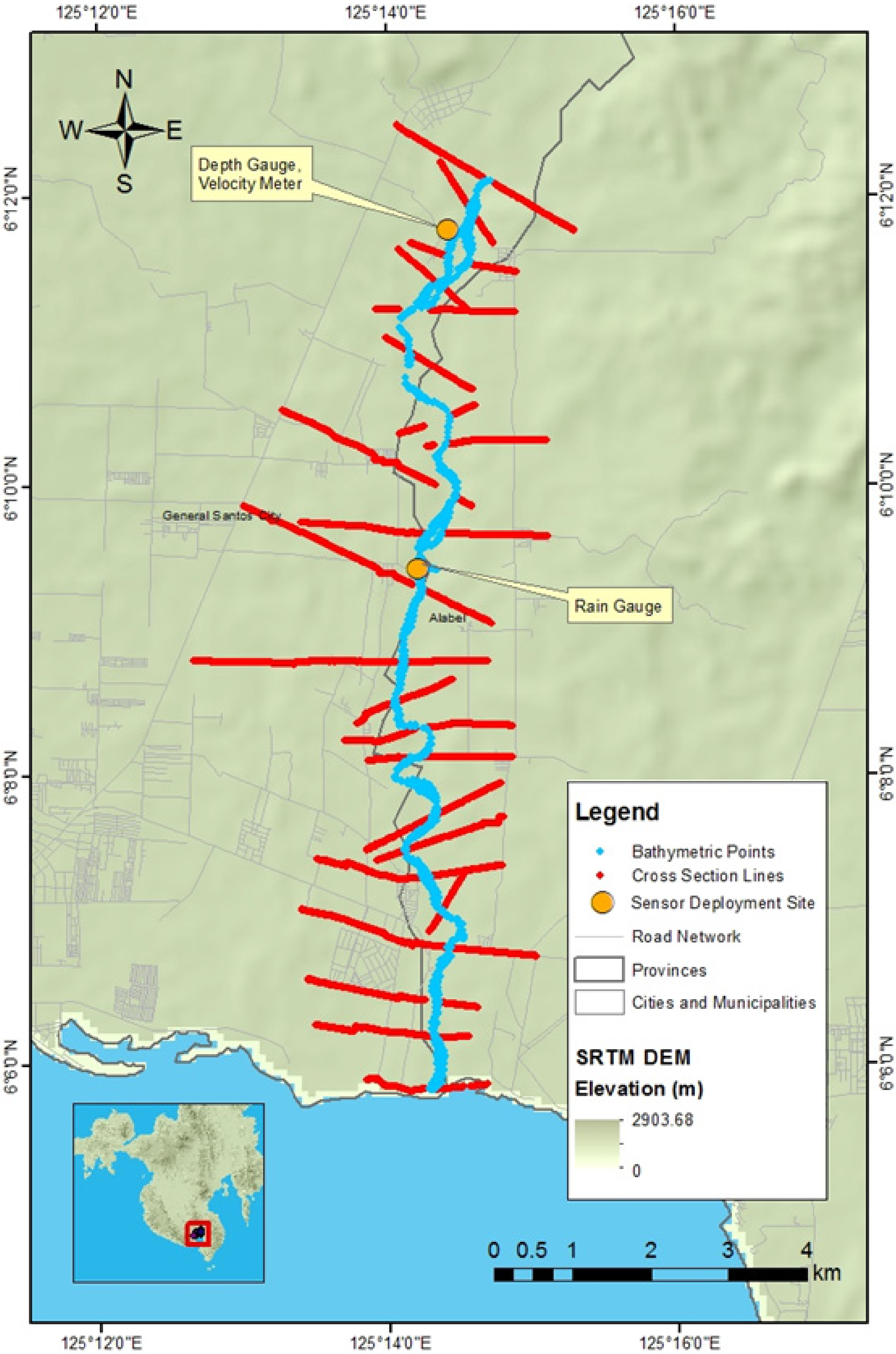


Figure 29. Location of Sensors in Buayan-Malungon River

Two additional field surveys were conducted on December 2-24, 2013, and on May 8 - July 21, 2014 in the Buayan- Malungon River system. The first one was aimed at flow measurements while the latter was concentrated on flow measurement, depth gauge, and rain gauge deployment, locations are summarized in Table 3.

River flow data, rainfall data, and water surface elevation data was gathered for the May 8 – July 21, 2014 survey. The survey team employed two local hires living within the vicinity of the bridge and instructed them on the proper ways of gathering flow data using a propeller type flow meter. Only the flow of the river during the occurrence of rain events was recorded.

The flow data gathering was conducted at Sarangani-Davao del Sur Coastal Road. The depth gauge was also deployed on the same bridge because of the absence of AWLS. The set-up of the rain gauge was at Ampon Bridge. All of the sensors were retrieved on July 21, 2014 after the needed rain event. The location of the bridges, set up of rain gauge, and method of gathering flow of the river are shown below:

Table 3. Location of sensor deployment

Sensor	Location	Deployment	Retrieval	Latitude	Longitude
Flow meter (propeller type)	Sarangani-Davao del Sur Coastal Road, Brgy. Demoloc	May 8, 2014	July 21, 2014	6° 6’48.35’’N	125°14’26.63’’E
Depth gauge	Sarangani-Davao del Sur Coastal Road, Brgy. Demoloc	May 8, 2014	July 21, 2014	6° 6’48.35’’N	125°14’26.63’’E
Rain gauge	Ampon Bridge, Brgy. Baluntay	May 8, 2014	July 21, 2014	6° 20’ 05.79’’ N	125° 16’ 46.28’’ E
Flow meter (propeller type)	Ampon Bridge, Brgy. Baluntay	December 4, 2013	December 24, 2013	6°20’6.80’’N	125°16’47.60’’E
Flow meter (propeller type)	Brgy. Malalag Cogon	December 4, 2013	December 24, 2013	6°19’18.26’’N	125°15’45.98’’E

Figure 30. Instructing the local hires on the proper use of the flow meter

Figure 31. Deployment of rain gauge in Ampon, Malungon

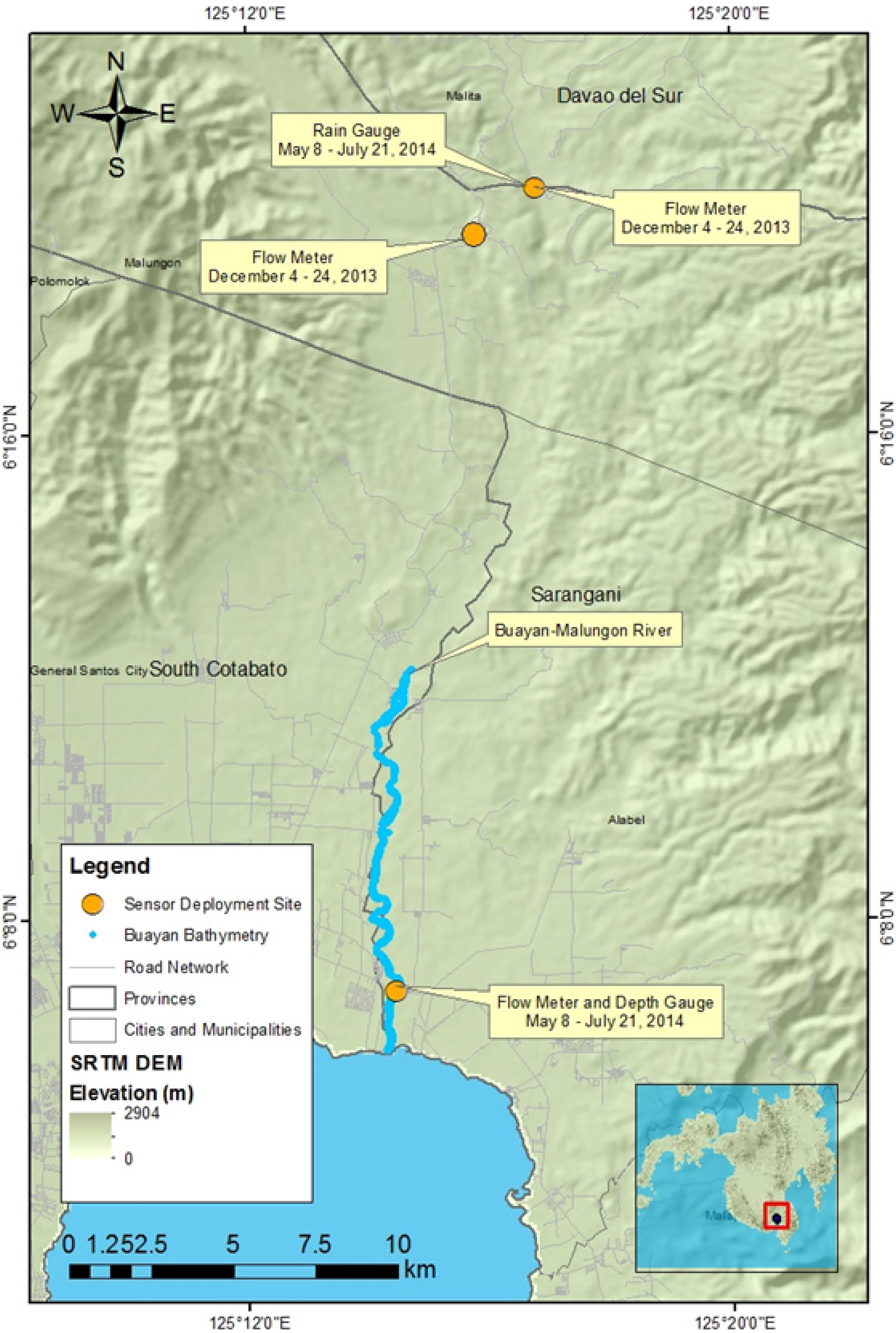


Figure 32. Sensor deployment sites in Buayan River

Flow data in Sarangani-Davao Del Sur Coastal Road Bridge was taken and recorded manually. Prior submerging of flow meter, the counter reading has been recorded. The sensor was submerged for seven (7) minutes then took the reading for three (3) minutes. This completes the 10-minute interval of each reading. Water level or stage was derived from the deployed depth gauge on the same bridge as with the flow meter. The rain gauge was set up on the upstream in Ampon, Malungon to record the amount of rainfall near the catchment of Buayan-Malungon River System. Data gathered by the sensors are shown on the succeeding graphs.

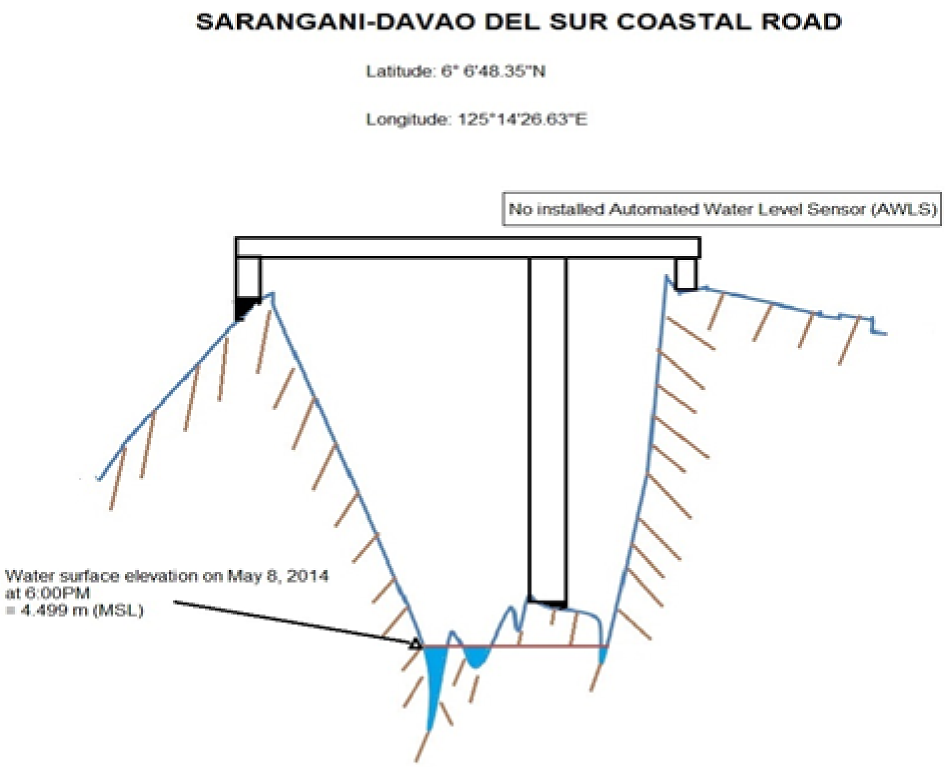


Figure 33. Cross-section diagram of Sarangani-Davao del Sur Bridge

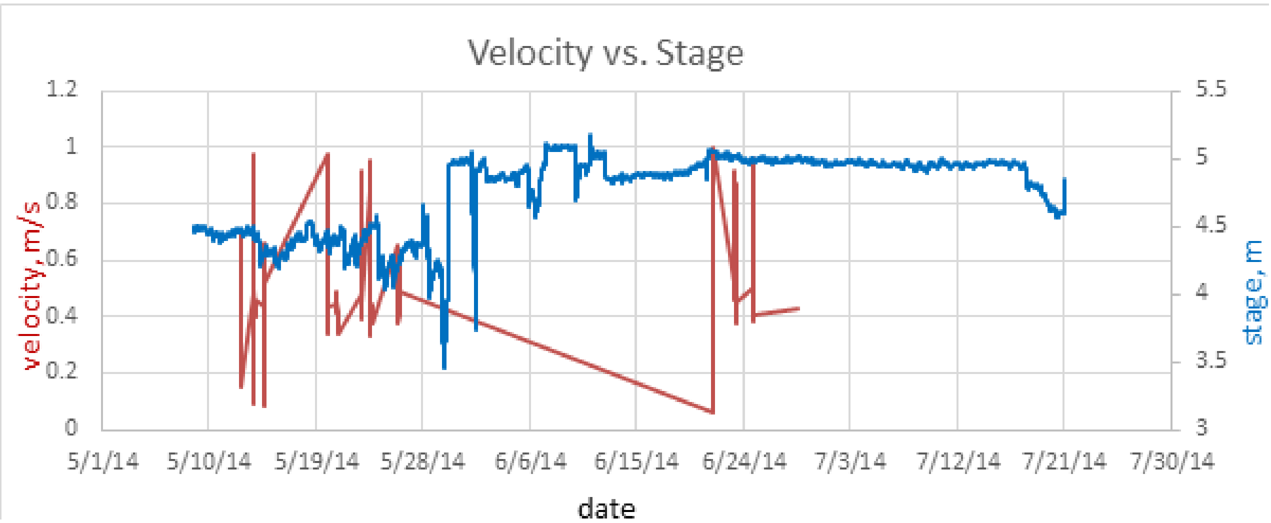


Figure 34. Relationship between velocity and stage in Sarangani-Davao del Sur Coastal Road Bridge

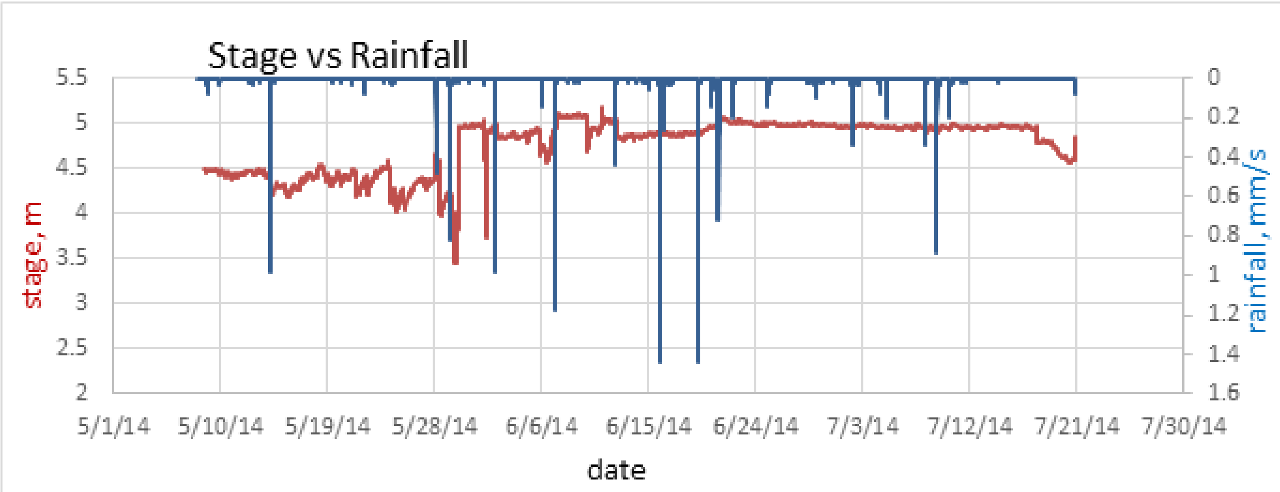


Figure 35. Relationship between stage and rainfall in Sarangani-Davao del Sur Coastal Road Bridge

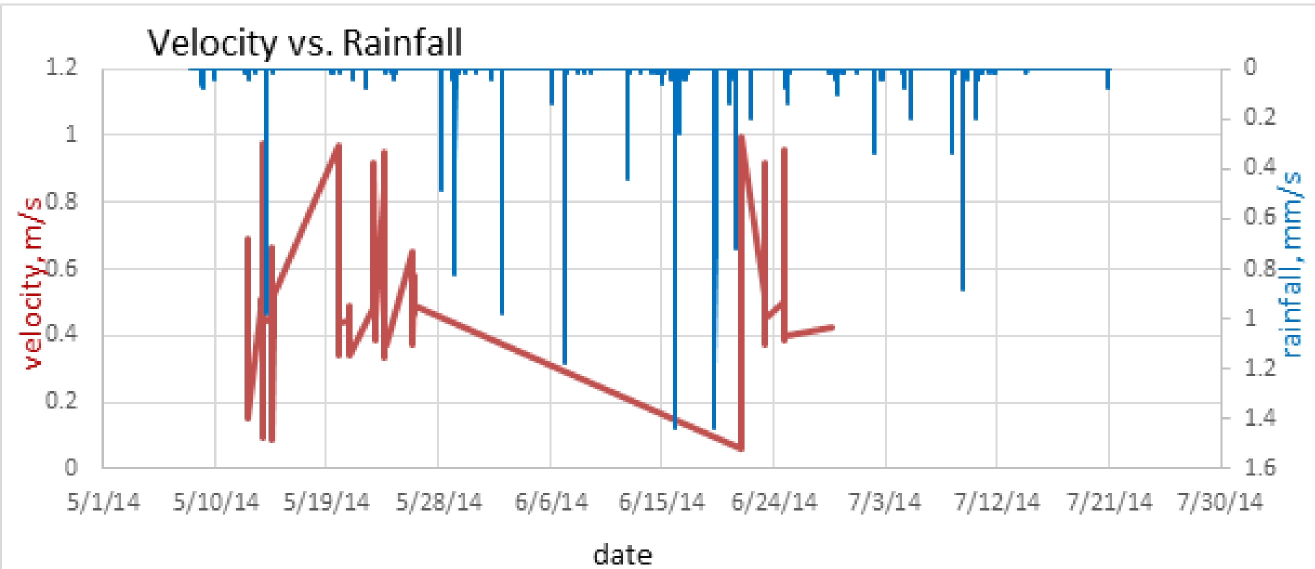


Figure 36. Relationship between velocity and rainfall in Sarangani-Davao Del Sur Coastal Road Bridge

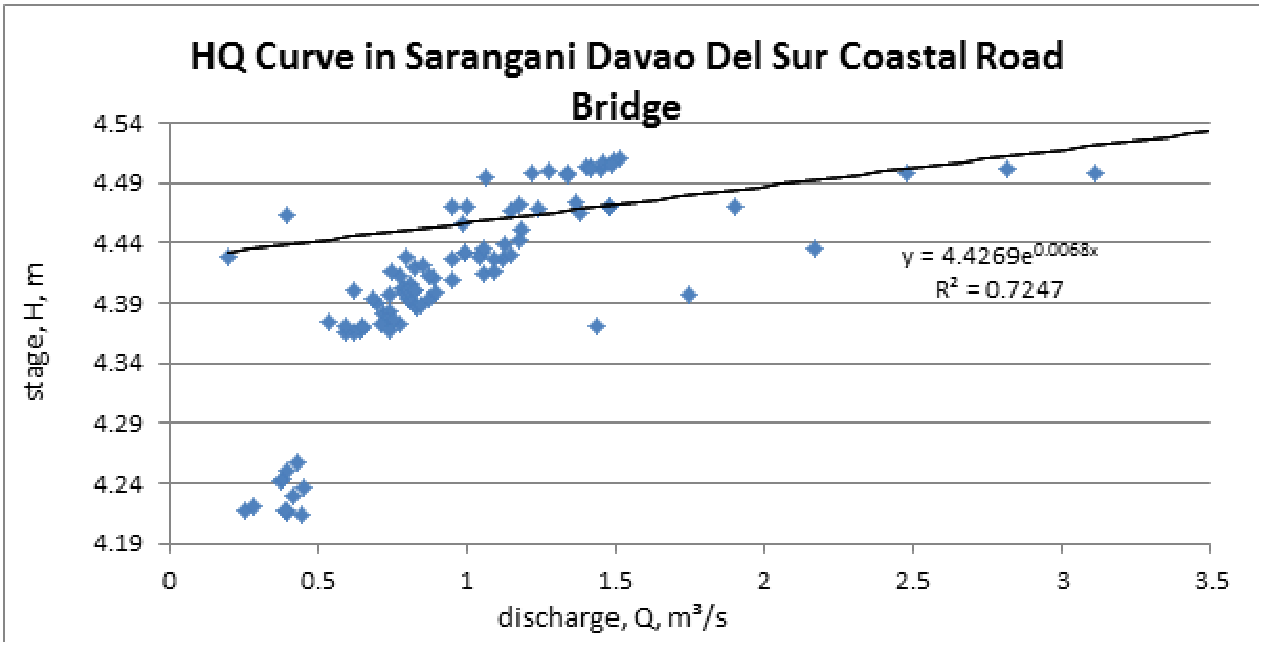


Figure 37. Relationship between stage and discharge in Sarangani-Davao Del Sur Coastal Road Bridge

Flow data in Upper Buayan Bridge and Ampon Bridge were taken and recorded manually. Prior submerging of flow meter, the counter reading has been recorded. The sensor was submerged for seven (7) minutes then took the reading for three (3) minutes. This completes the 10-minute interval of each reading.

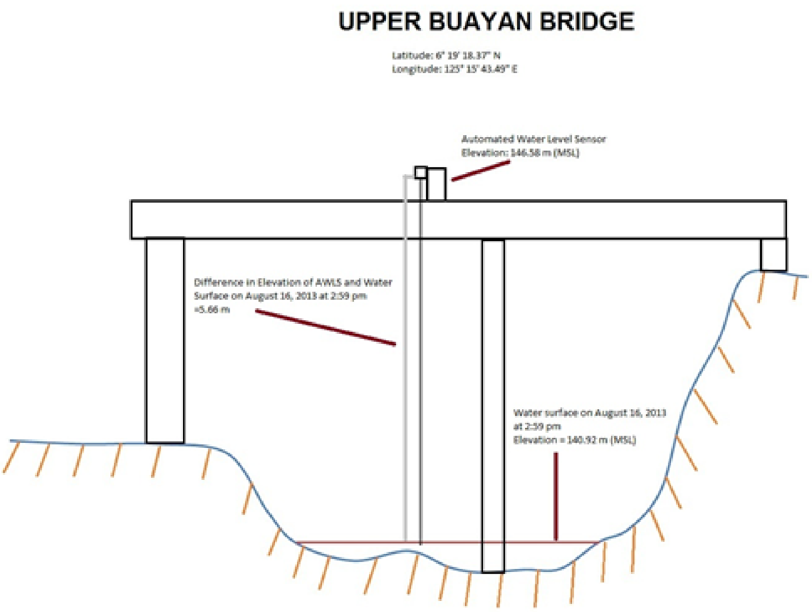


Figure 38. Cross-section diagram of Upper Buayan Bridge

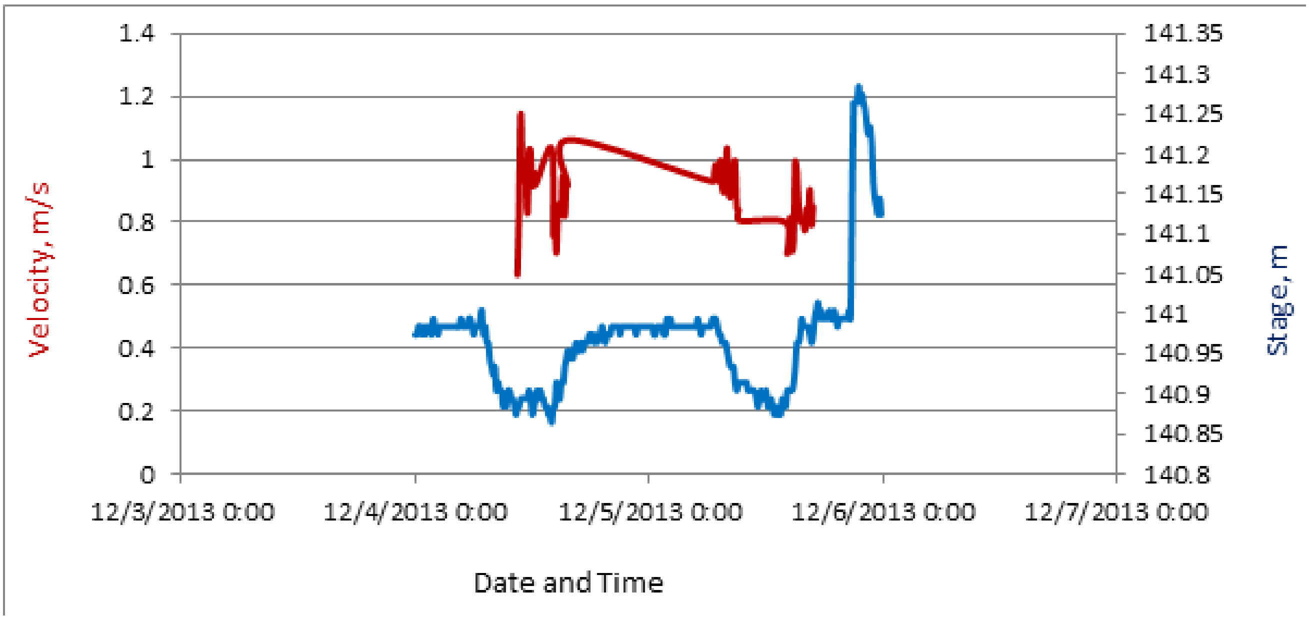


Figure 39. Relationship between velocity and stage in Upper Buayan Bridge

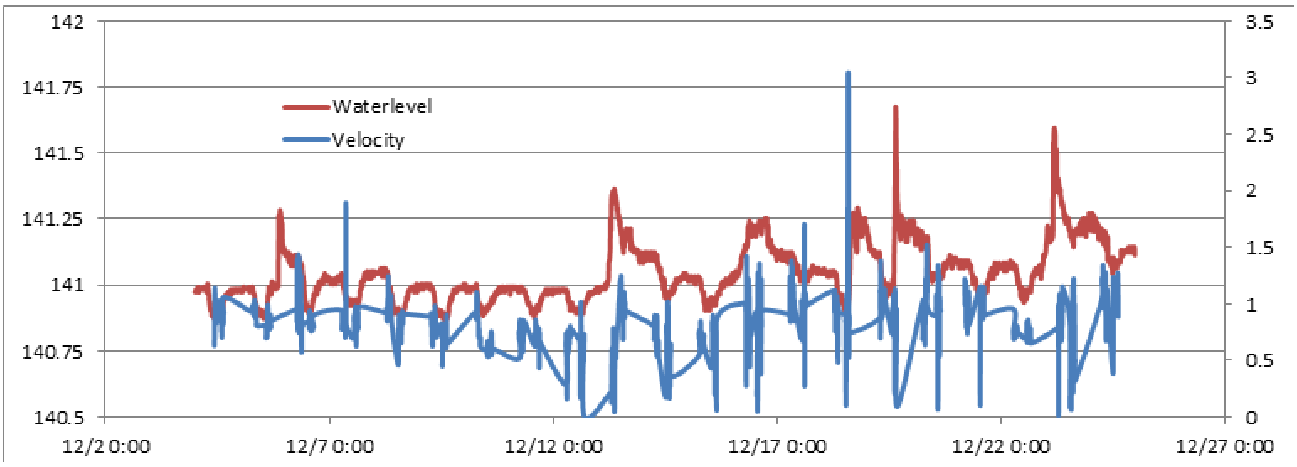


Figure 40. Relationship between water level and velocity in Upper Buayan Bridge

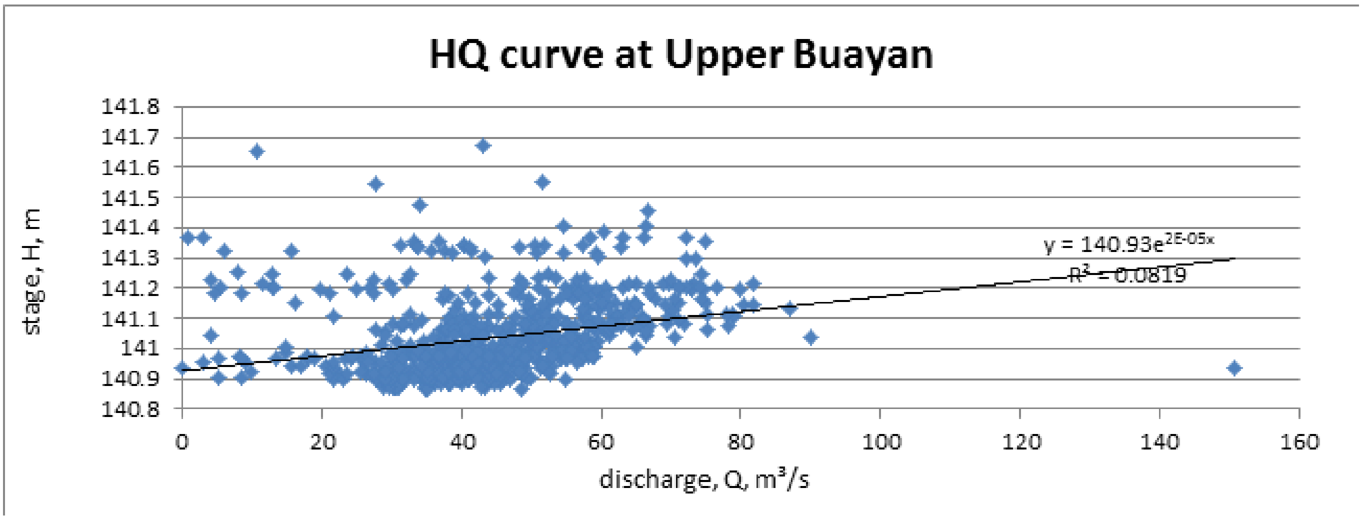


Figure 41. Relationship between stage and discharge in Upper Buayan Bridge

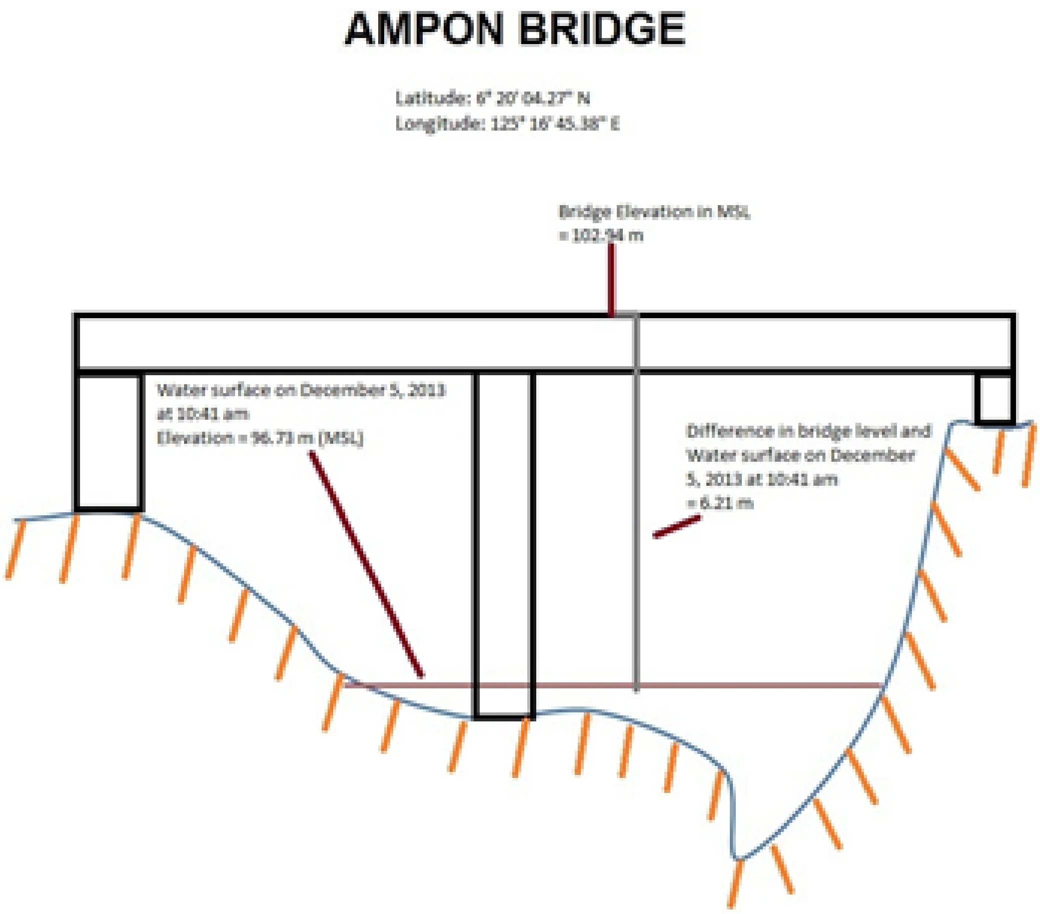


Figure 42. Cross section diagram of Ampon Bridge

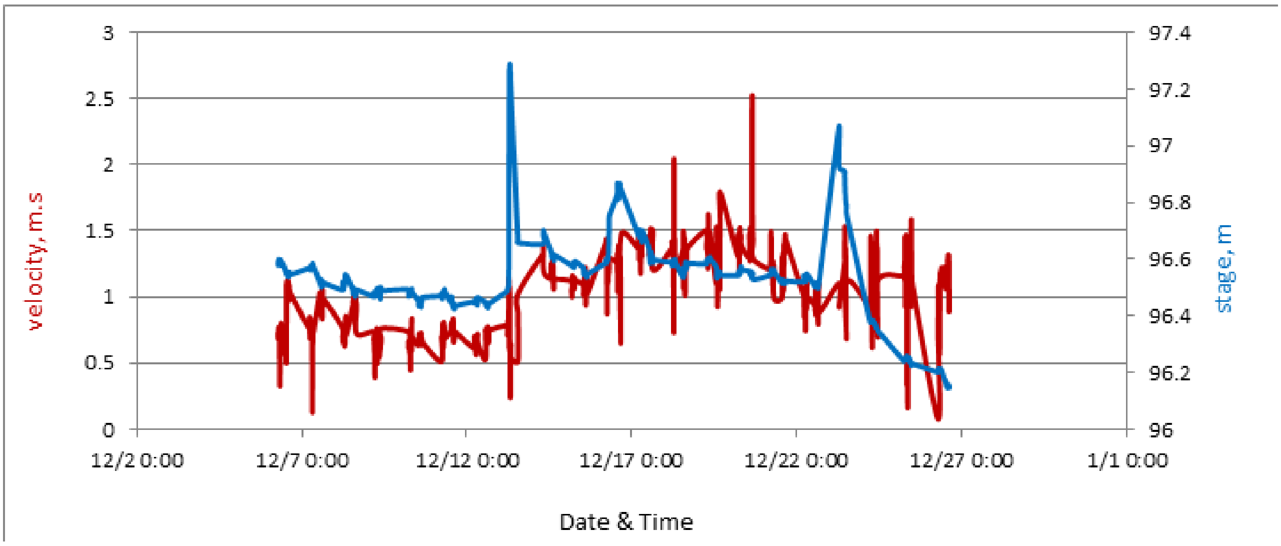


Figure 43. Relationship between velocity and stage in Ampon Bridge

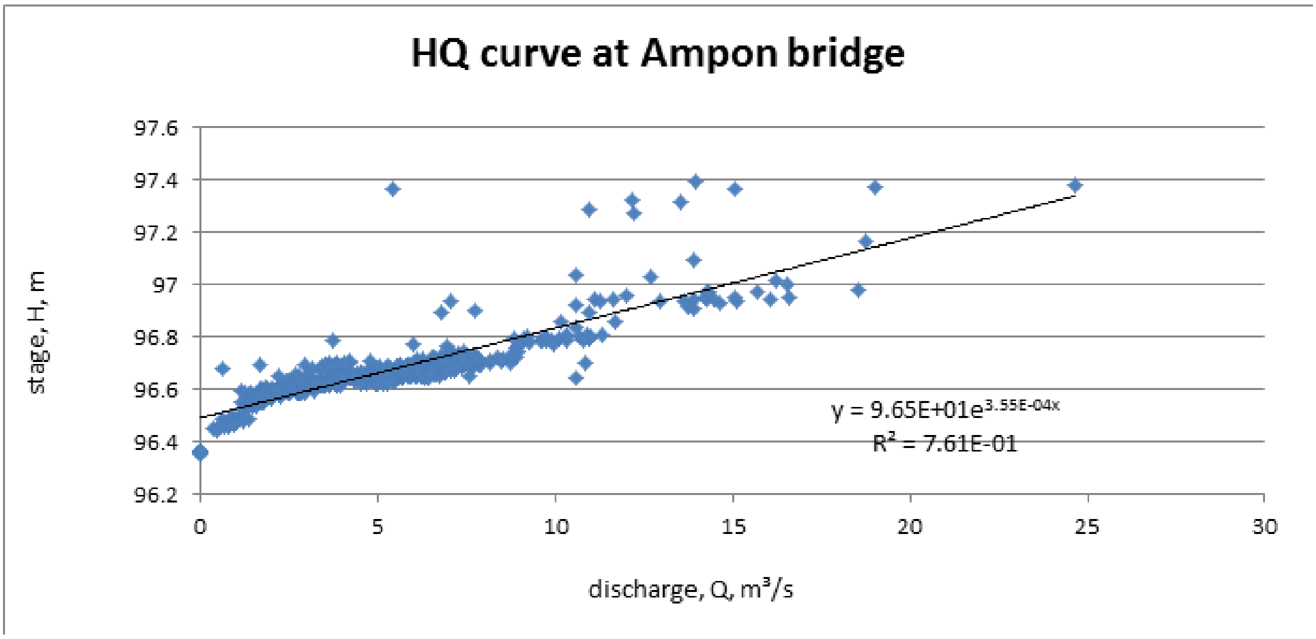


Figure 44. Relationship between stage and discharge in Ampon Bridge

Reconnaissance for possible AWLS installation

AWLS reconnaissance for possible sites of deployment was conducted simultaneously with the flow measurement survey. It was conducted on August 14 – 19, 2015. The following conditions were considered in searching for suitable sites:

1. Cell phone reception availability in the area – the sensors will be sending real time data to respective units through SMS messages. Area shall be checked for available service providers' signal reception
2. Security of the area – AWLS will be installed permanently on the bridges. Such structures should be sturdy and safe enough to withstand incidents such as flooding, earthquake, and thievery.

Eight (8) bridges visited during the survey, seven (7) from which are located just within the survey area while an additional bridge was located in Malungon.

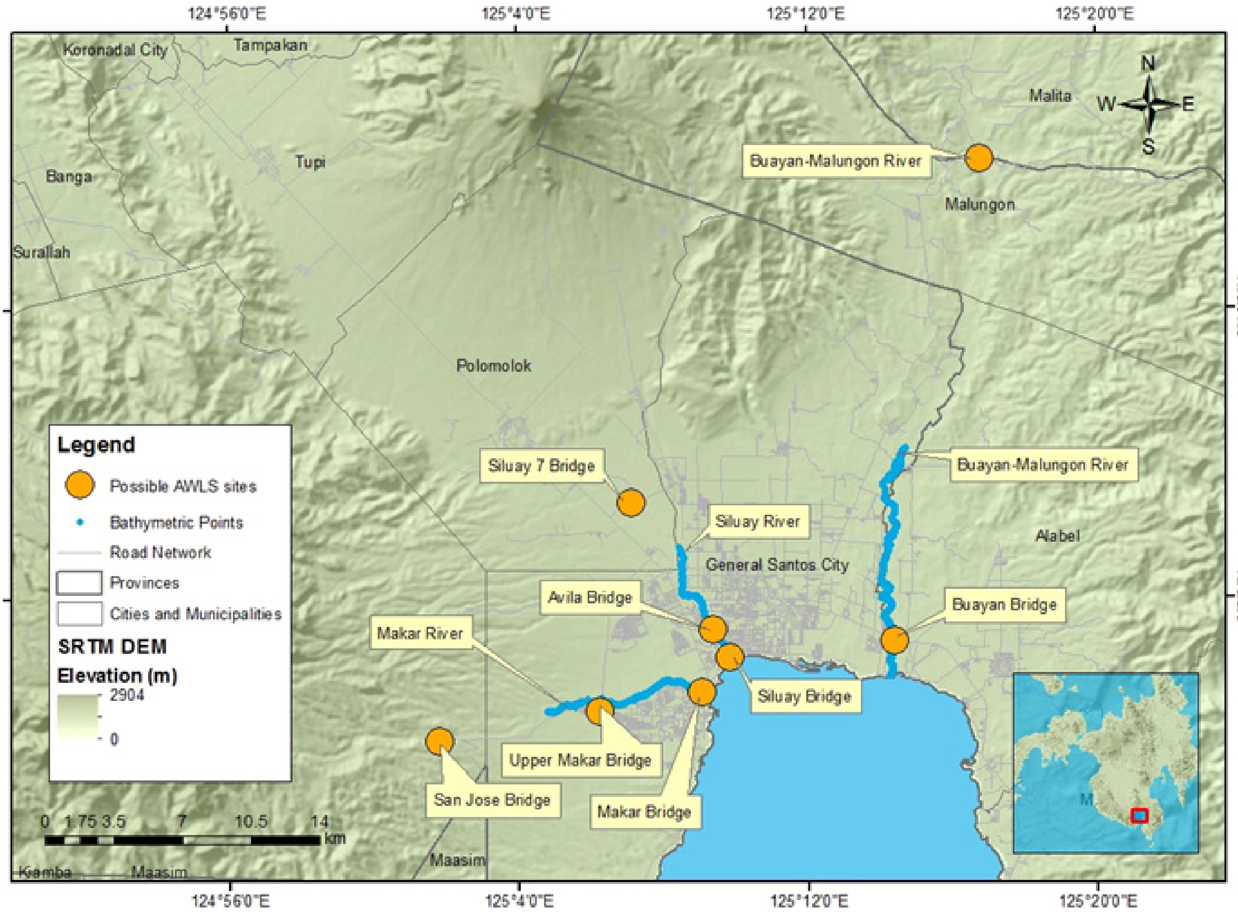


Figure 45. Reconnaissance for possible AWLS site deployment

Bridge	Image	Location	WGS84 Coordinates	Cellular Signal Reception
San Jose Bridge (Makar River)	 	Brgy. San Jose	Latitude: 06° 04' 02.0" Longitude: 125° 01' 49.2"	Has good Smart and Globe signal reception
Upper Makar Bridge (Makar River)	 	Brgy. San Jose	Latitude: 6° 4'52.09" Longitude: 125° 6'14.47"	Has good Smart and Globe signal reception
Makar Bridge (Makar River)	 	Brgy. Labangal	Latitude: 06°05'22.7" Longitude: 125°09'04.0"	Has good Smart and Globe signal reception
Siluay 7 Bridge (Siluay River)		Polomolok	Latitude: 06° 10'36.7" Longitude: 125°07'08.6"	Has good Smart and Globe signal reception
Avila Bridge (Siluay River)	 	Brgy. Labangal	Latitude: 06°07'06.9" Longitude: 125°09'22.6"	Has good Smart and Globe signal reception

Bridge	Image	Location	WGS84 Coordinates	Cellular Signal Reception
Siluay Bridge (Siluay River)	 	General Santos City	Latitude: 06°06'20.8" Longitude: 125°09'50.1"	Has good Smart and Globe signal reception
Buayan Bridge (Buayan River)	 	Brgy. Buayan	Latitude: 06°06'48.5" Longitude: 125°14'25.3"	Has good Smart and Globe signal reception
Buayan-Malungon River		Brgy. Nagpan, Sitio Gulada, Malungon Saranggani	Latitude: 6°20'6.02" Longitude: 125°16'47.06"	Has low Globe signal but talk and text signal reception

Annexes

ANNEX A. PROBLEMS ENCOUNTERED AND RESOLUTIONS APPLIED

In conducting reconnaissance for both profile and cross section, accessibility of the area is the major concern. Some of the proposed cross-section lines in Davao River are inside the private subdivisions while other lines are in areas which are not reachable by vehicles. Contractors must accomplish letters to have an access to perform data gathering inside the premises of the private subdivisions and considered necessary to hike in order to locate areas which are not reachable by vehicles.

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

Limitation/Problems		Solutions
1)	The echosounder was unusable due to the shallow waters of the three rivers	Manual bathymetry by foot, and by vehicle was performed.
2)	Heavy rainfall during the survey period prevented the team from conducting manual bathymetry survey	Reconnaissance for cross-section survey was conducted to utilize time and prevent delays.
3)	Although the target area experienced rain, the rain gauge failed to gather data.	A team will be returning at a later date in the survey area to gather the missing data.

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

Type	Brand	Owner	Quantity
GNSS Receiver (Base)	Trimble SPS852	UP-TCAGP	Two (2) unit
GNSS Receiver (Rover)	Trimble SPS882	UP-TCAGP	Six (6) units
GNSS Controller	Trimble TSC3	UP-TCAGP	Six (6) units
Singlebeam Echosounder	Hi-Target and Ohmex	UP-TCAGP	Two (2) units with accessories
Velocity Meter	JFE Advantech	UP-TCAGP	One (1) unit with accessories
Coupler-2B		UP-TCAGP	One (1) pc
Handheld GNSS	Garmin Oregon 650 Montana	UP-TCAGP	Seven (7) units
Rain Gauge	Onset Hoboware	UP-TCAGP	One (1) pc
Depth Gauge	Onset Hoboware	UP-TCAGP	Two (2) units
Bipod	Trimble	UP-TCAGP	Six (6) pcs
Range Pole		UP-TCAGP	Six (6) pcs
Tripod	Trimble	UP-TCAGP	Three (3) pcs
Digital Level	Topcon	UP-TCAGP	One (1) unit
Level Rod		UP-TCAGP	Two (2) pcs
Installers	Hoboware	UP-TCAGP	One (1) pc
	Trimble Business Center	UP-TCAGP	One (1) pc

ANNEX C. THE SURVEY TEAM

Data Validation Component	Designation	Name	Agency/Affiliation
Survey Coordinator	Senior Science Research Specialist	Engr. Dexter Lozano	UP TCAGP
	Senior Science Research Specialist	Engr. Melchor Nery	UP TCAGP
	Senior Science Research Specialist	Engr. Bernard Paul D. Maramot	UP TCAGP
	Research Associate	Engr. JMson Calalang	UP TCAGP
		Jojo Morillo	UP TCAGP
		Arvin Caro	UP TCAGP
		Patrizcia dela Cruz	UP TCAGP

ANNEX D. NAMRIA CERTIFICATION

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

July 11, 2013

CERTIFICATION

To whom it may concern:

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

Province: **SOUTH COTABATO**
Station Name: **CTS-43**
Order: **2nd**

Island: **MINDANAO**
Municipality: **GENERAL SANTOS CITY (DADIANGAS)**
Barangay: **TAMBLER**

PRS92 Coordinates

Latitude:	**6° 3' 24.37577"**	Longitude:	**125° 8' 27.42848"**	Ellipsoidal Hgt:	**23.82200 m.**

WGS84 Coordinates

Latitude:	**6° 3' 21.48507"**	Longitude:	**125° 8' 33.05028"**	Ellipsoidal Hgt:	**97.23300 m.**

PTM Coordinates

Northing:	**669674.089 m.**	Easting:	**515603.149 m.**	Zone:	**5**

UTM Coordinates

Northing:	**669,904.98**	Easting:	**736,970.33**	Zone:	**51**

Location Description

CTS-43
"CTS-43" is in Barangay Tambler, General Santos City. To reach the station, travel for about 9 kms. from General Santos City towards Barangay Maasin until reaching the Banisil Elementary School. Station is located at the top of the water tank. Mark is the head of 4" copper nail set on a drilled hole and cemented on top of a 30x30 cm. cement putty with the inscription "CTS-43 2007 NAMRIA".

Requesting Party: **UP-DREAM PROGRAM**
Purpose: **Reference**
OR Number: **3943907B**
T.N.: **2013-0675**

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

9907112013141337

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

CP-NPDH/12/09/814

Annexes

ANNEX E. RECONNAISSANCE SUMMARY

Cross-section Left	Image	Barangay	Municipality	Remarks
1		Tinagacan	General Santos City	Traversable
2		Tinagacan	General Santos City	Traversable
3		Tinagacan	General Santos City	Traversable
4		Tinagacan	General Santos City	Traversable
5		Tinagacan	General Santos City	Traversable
6		Domolok	Alabel	Traversable
7		Domolok	Alabel	Traversable

Cross-section Left	Image	Barangay	Municipality	Remarks
8		Domolok	Alabel	Traversable
9		Tokawal	Alabel	Traversable
10		Tokawal	Alabel	Traversable
11		Tokawal	Alabel	Traversable
12		Tokawal	Alabel	Traversable
13		Tokawal	Alabel	Traversable
14		Tokawal	Alabel	Traversable
15		Tokawal	Alabel	Traversable
16		Baluntay	Alabel	Traversable

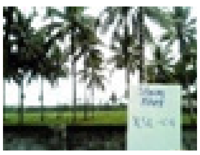
Annexes

Cross-section Left	Image	Barangay	Municipality	Remarks
17		Baluntay	Alabel	Traversable
18		Baluntay	Alabel	Traversable
19		Baluntay	Alabel	Traversable
20		Baluntay	Alabel	Traversable
21		Maribulan	Alabel	Traversable
22		Maribulan	Alabel	Traversable
23		Tokawal	Alabel	Traversable

Annexes

Cross-section Right	Image	Barangay	Municipality	Remarks
1		Tinagacan	General Santos City	Traversable
2		Tinagacan	General Santos City	Traversable
3		Tinagacan	General Santos City	Traversable
4		Tinagacan	General Santos City	Traversable
5	No Photo	Tinagacan	General Santos City	Traversable
6	No Photo	Domolok	Alabel	Traversable
7		Domolok	Alabel	Traversable
8		Domolok	Alabel	Traversable
9		Domolok	Alabel	Traversable
10		Katangawan	General Santos City	Traversable
11		Ligaya	General Santos City	Traversable
12		Ligaya	General Santos City	Traversable

Cross-section Right	Image	Barangay	Municipality	Remarks
13		Ligaya	General Santos City	Traversable
14	No Photo	Ligaya	General Santos City	Traversable
15		Ligaya	General Santos City	Traversable
16		Buayan	General Santos City	Traversable
17		Buayan	General Santos City	Traversable
18		Buayan	General Santos City	Traversable
19		Buayan	General Santos City	Traversable
20		Buayan	General Santos City	Traversable
21		Buayan	General Santos City	Traversable
22		Buayan	General Santos City	Traversable
23		Buayan	General Santos City	Traversable

Cross-section Left	Image	Barangay	Municipality	Remarks
1		Mabuhay	General Santos City	Traversable
2		Mabuhay	General Santos City	Traversable
3		Mabuhay	General Santos City	Traversable
4		Mabuhay	General Santos City	Traversable
5		Mabuhay	General Santos City	Traversable
6		Mabuhay	General Santos City	Traversable
7		Mabuhay	General Santos City	Traversable
8		Mabuhay	General Santos City	Traversable
9		Mabuhay	General Santos City	Traversable
10		San Isidro	General Santos City	Traversable

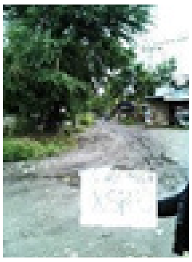
Annexes

Cross-section Left	Image	Barangay	Municipality	Remarks
11		San Isidro	General Santos City	Traversable
12		San Isidro	General Santos City	Traversable
13		City Heights	General Santos City	Traversable
14		City Heights	General Santos City	Traversable
15		City Heights	General Santos City	Traversable
16		Dadiangas East	General Santos City	Traversable

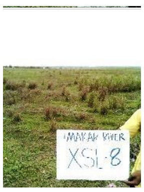
Annexes

Cross-section Right	Image	Barangay	Municipality	Remarks
1		Mabuhay	General Santos City	Traversable
2		Mabuhay	General Santos City	Traversable
3		Mabuhay	General Santos City	Traversable
4		Mabuhay	General Santos City	Traversable
5		Mabuhay	General Santos City	Traversable
6		Mabuhay	General Santos City	Traversable
7		Mabuhay	General Santos City	Traversable
8		Mabuhay	General Santos City	Traversable
9		San Isidro	General Santos City	Traversable

Annexes

Cross-section Left	Image	Barangay	Municipality	Remarks
10		San Isidro	General Santos City	Traversable
11		San Isidro	General Santos City	Traversable
12		City Heights	General Santos City	Traversable
13		City Heights	General Santos City	Traversable
15		City Heights	General Santos City	Traversable
15	No Photo	Dadiangas East	General Santos City	Traversable
16		Dadiangas West	General Santos City	Traversable

Annexes

Cross-section	Image	Barangay	Municipality	Remarks
1		San Jose	General Santos City	Traversable
2		Apopong	General Santos City	Traversable
3		Apopong	General Santos City	Traversable
4		Apopong	General Santos City	Traversable
5		Apopong	General Santos City	Traversable
6		Apopong	General Santos City	Traversable
7		Apopong	General Santos City	Traversable
8		Apopong	General Santos City	Traversable
9		Labangal	General Santos City	Traversable

Annexes

Cross-section	Image	Barangay	Municipality	Remarks
10		Labangal	General Santos City	Traversable
11		Labangal	General Santos City	Traversable
12	No Photo	Labangal	General Santos City	Traversable
13	No Photo	Labangal	General Santos City	Traversable
14	No Photo	Labangal	General Santos City	Traversable
15		Labangal	General Santos City	Traversable
16		Apopong	General Santos City	Traversable
17		Labangal	General Santos City	Traversable
18		Labangal	General Santos City	Traversable

Annexes

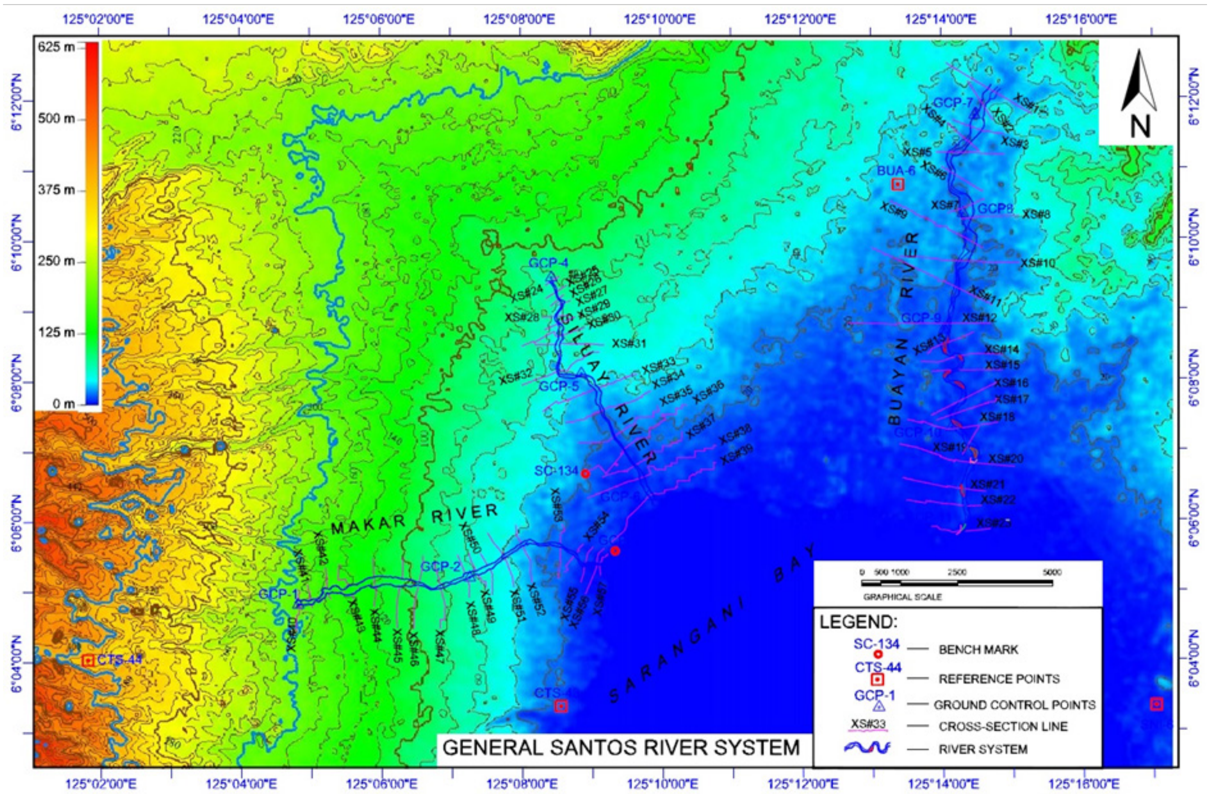
Cross-section	Image	Barangay	Municipality	Remarks
1		Fatima	General Santos City	Traversable
2		Fatima	General Santos City	Traversable
3		Fatima	General Santos City	Traversable
4		Fatima	General Santos City	Traversable
5		Apopong	General Santos City	Traversable
6		Apopong	General Santos City	Traversable
7		Apopong	General Santos City	Traversable
8		Apopong	General Santos City	Traversable

Cross-section	Image	Barangay	Municipality	Remarks
9		Labangal	General Santos City	Traversable
10		Labangal	General Santos City	Traversable
11		Labangal	General Santos City	Traversable
12		Labangal	General Santos City	Traversable
13		Labangal	General Santos City	Traversable
14		Labangal	General Santos City	Traversable
15		Labangal	General Santos City	Traversable
16		Apopong	General Santos City	Traversable
17		Labangal	General Santos City	Traversable
18		Labangal	General Santos City	Traversable

ANNEX F. OUTSOURCE CROSS-SECTION AND PROFILE

PROFILE AND CROSS SECTION SURVEYS OF GENERAL SANTOS RIVER SYSTEM, SOUTH COTABATO

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: July 09 to September 02, 2013

Annexes

Annexes

Annexes

Annexes

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 1: 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

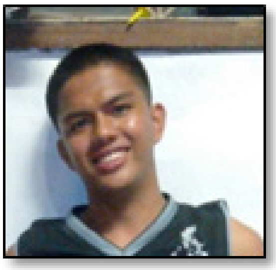
Name of Personnel with picture	Position	Qualification	Official Function
 Franie T. Reyes	Team Leader for Cross-section Survey	B. S. G. E. Graduate with experience in field operation and Team Management	• Manages Field operations and related activities • Review and validate the output of the profile survey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

Table 2: 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

For the completion of the profile and cross section survey of the General Santos River System, the team followed necessary procedure to ensure the effective delivery of survey reports. Figure No. 1 shows the workflow for the completion of the project. From planning stage, field acquisition, and data processing, a standard practice was implemented.

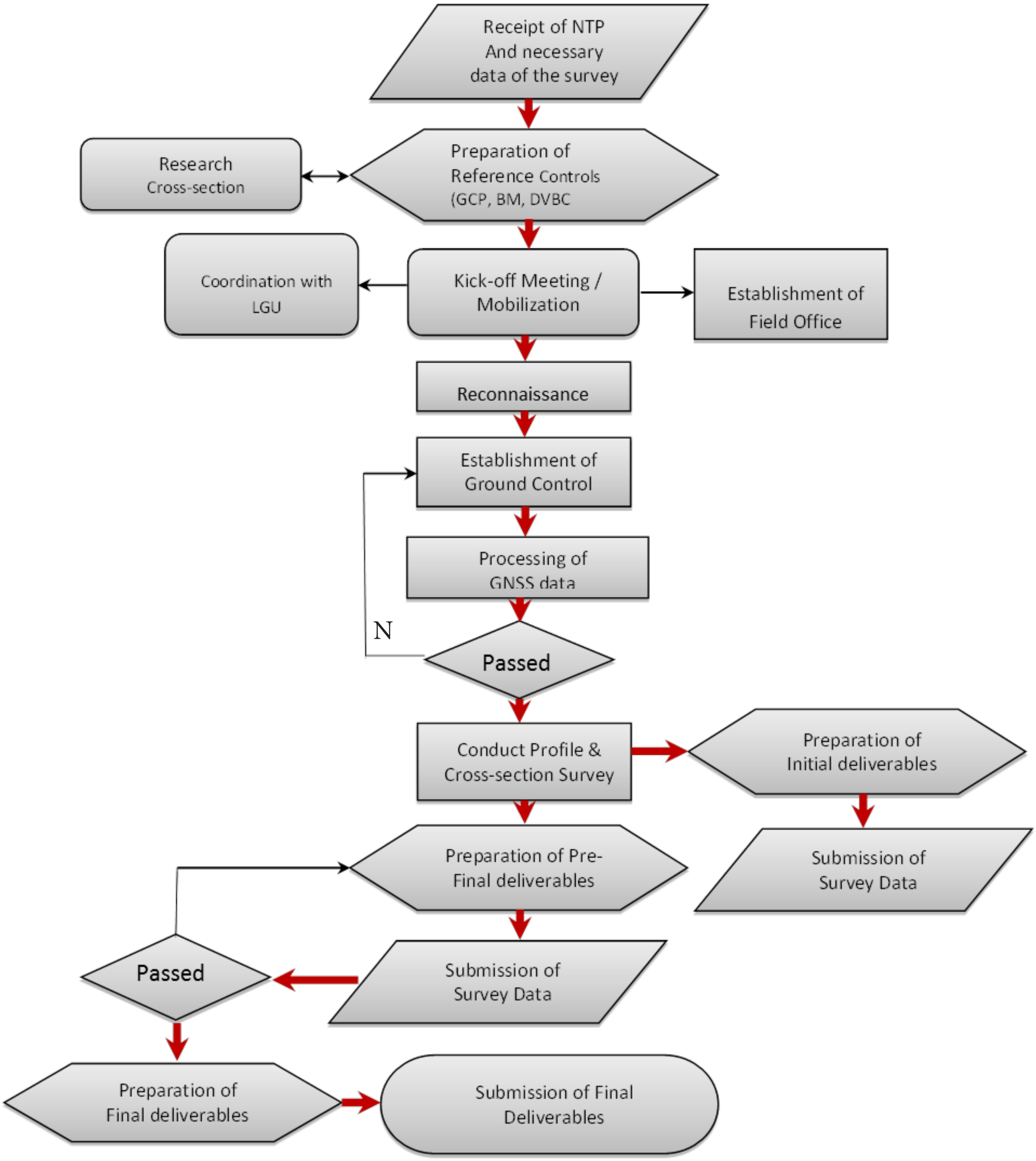


Figure 1: Flowchart showing the processes and overall activities for the field survey of General Santos River System

Annexes

2.1 Field Plan

Upon receipt of preliminary data e.g. coordinates of the profile and cross-section lines, extent of the project area and endorsement letter for the LGUs dated July 1, 2013, proposed work schedule was prepared. Survey equipment such as survey grade GPS, total stations and digital level were calibrated and checked to ensure it davecomplieswith 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.

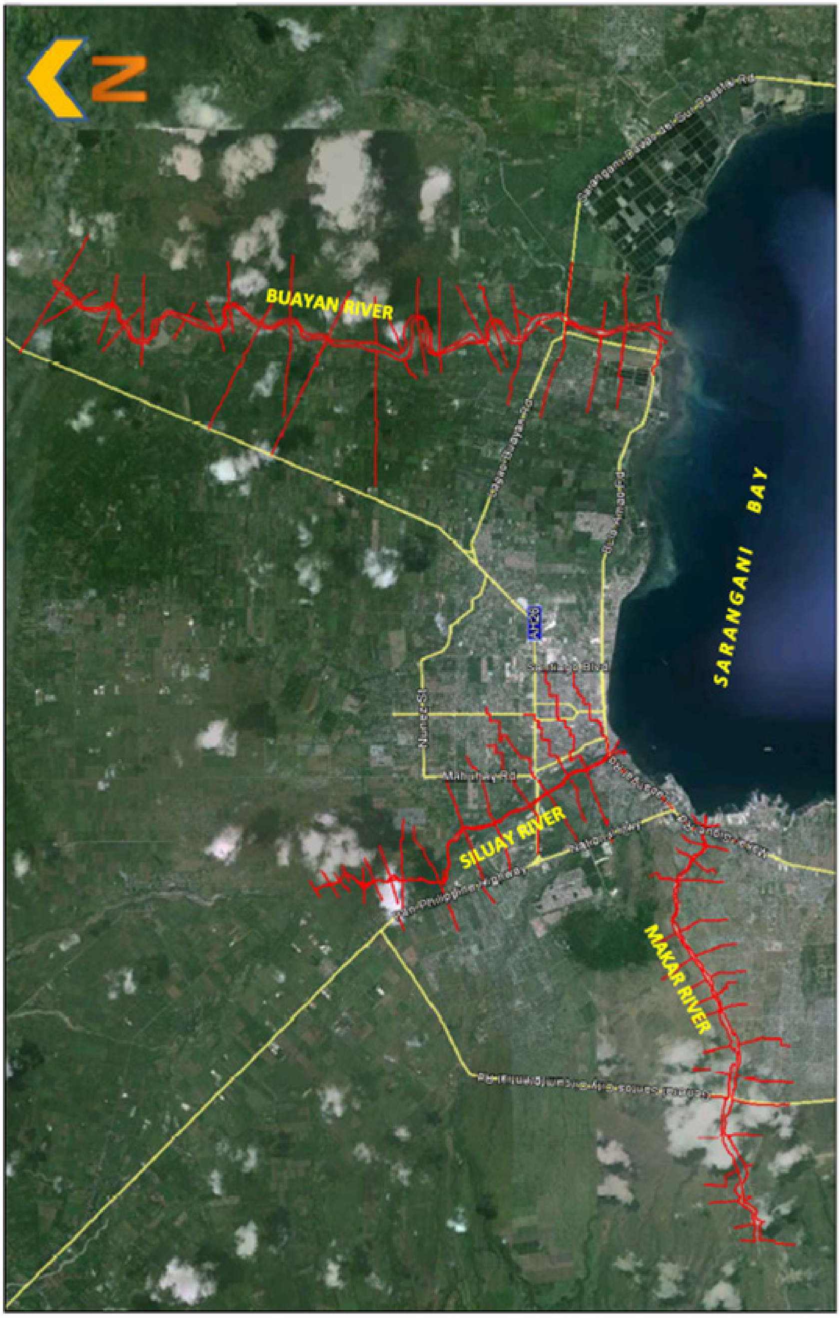


Figure 2: The Project Site, map of the river system, which was overlayed on Google earth satellite image

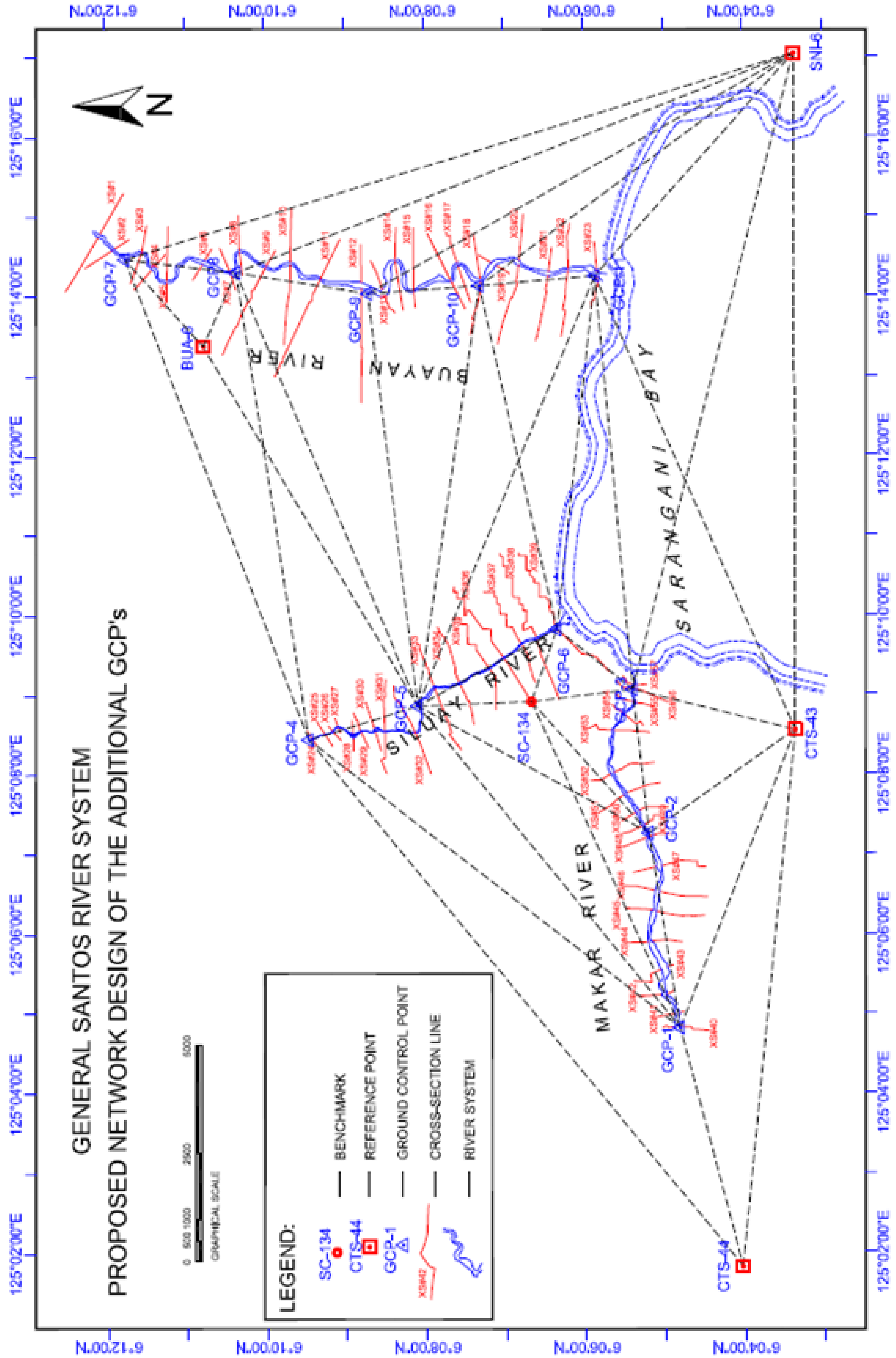


Figure 3: Preliminary Network Design for establishing GCPs

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 were 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 areabased on its sketch and description using the selection process.

Certifications of reference points were acquired from NAMRIA, See AnnexD. 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.

Based on the current record of NAMRIA, there is no available approved benchmark in the project area. There are a lot of newly established benchmark in this area but still under verification. NAMRIA furnished an unadjusted elevation of SC-134 which was used to check reference when connecting to other benchmark away from the project area.

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.

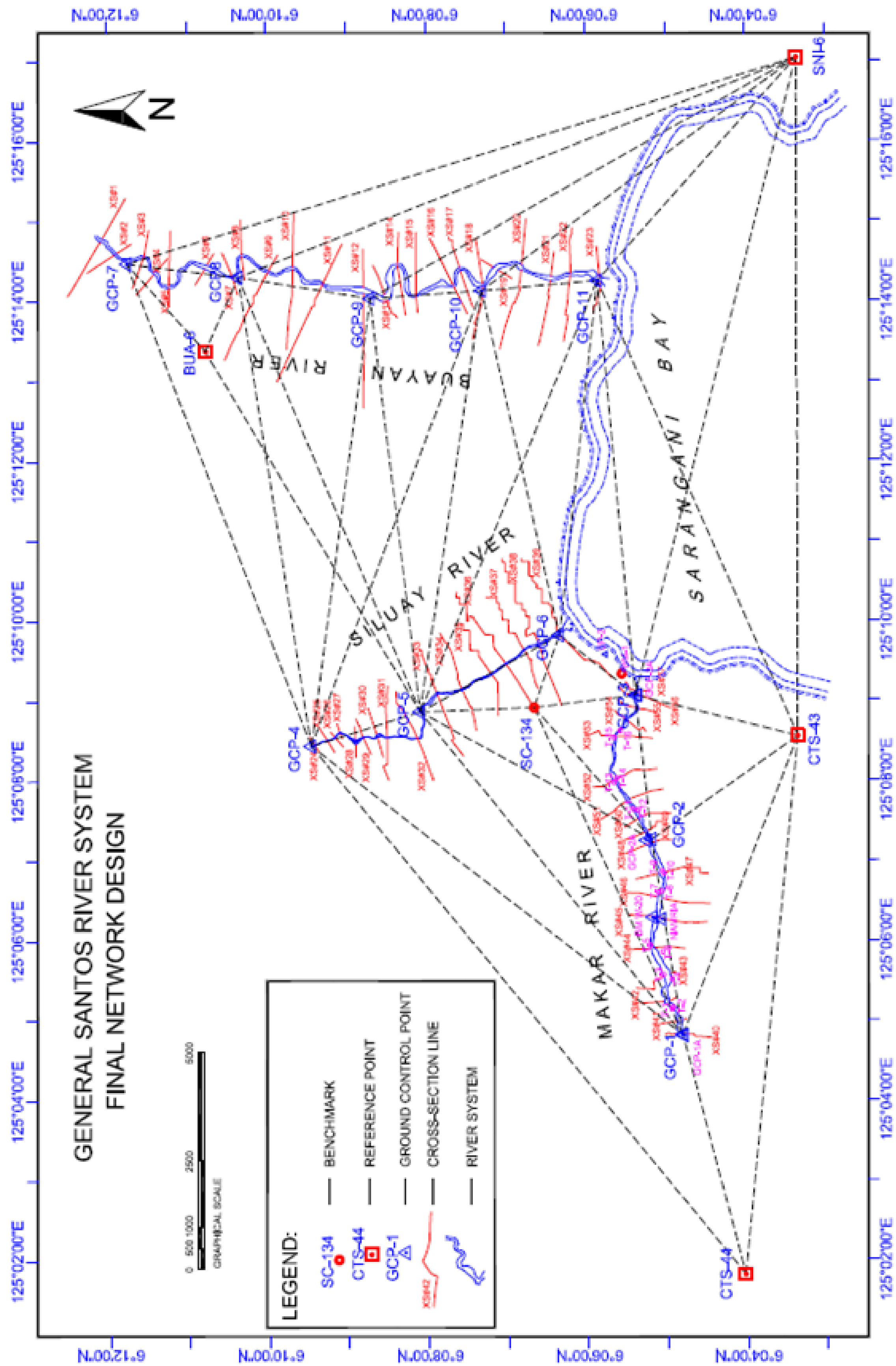


Figure 4: Revised Network Design for establishing GCPs.

2.4 Establishment of control points and GNSS network

The revised network design created during reconnaissance was used in the implementation of field survey for establishing ground control points. The GNSS network was created in such a way that ground control pointswere positionednot more than 10 km away from each other. They were also selected based on criteria such asclearsatellite visibility; stable foundation and negligible ground movement,preferably at a distant from tall natural and man-made obstructions and interferences such as buildings, trees, houses and transmission lines.

Reference Control

Horizontal Reference Point

Table 3: 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		
CTS-43	6	3	21.4851	125	8	33.0503	97.233	26.720	26.878	FIXED	FIXED
CTS-44	6	4	1.9791	125	1	49.1494	431.563	359.596	359.754	FIXED	FIXED
SNI-06	6	3	21.2491	125	17	1.9595	74.215	4.993	5.151	FIXED	FIXED

Vertical Reference point

Table 4: List of 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		
SC-134	6	6	39.9588	125	8	54.6028	101.605	30.905	31.063	0.012	0.00922
BUA-4	6	19	3.2861	125	15	7.7845	266.866	195.701	195.859	FIXED	0.01703

GCP-1 NEAR

GCP-1 FAR

GCP-11 NEAR

GCP-11 FAR

Figure 5: Sample Photographs of the Established Ground Control Points

Each control point wasdocumented 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 photographswere included in the field sheet.

For the establishment of ground control points, static GPS survey techniquewas 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.

Additional sub-control points were also established using GPS static survey to serve as reckoning points for traditional survey using total station in the areas not suitable for RTK survey.

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.

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 were not passable. Additional points were also 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 57 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 were 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 thetotal 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 July 10, 2013. Representatives from the survey team dropped by at the local government General Santos Cityfor courtesy call and presented the endorsement letter provided by UP DREAM for requisition of necessary permit to initiate the field survey. The team met Congressman Manny Pacquiao in his hometown. They discussed to him the objective of the project and he gave his best support for the execution of the said project. 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 has a rolling terrain surrounded by different land classification like in Makar River wherein about 40% of the surrounding areas are residential and the rest are agricultural land. For Siluay River about 70% are residential areas and the other 30% are agricultural areas and in Buayan River it is surrounded by commercial, residential, industrial and agricultural areas, as seen in the pictures below.

Figure 6: Group picture with Congressman Manny Pacquiao

Photos for Makar River

Photos for Siluay River

Photos for Buayan River

Figure 7: Photos showing the topography of the actual project area

During reconnaissance survey, the team looked for the location of the proposed NAMRIA reference points used for the establishment of ground controls, and all preferred reference points were recovered. The duration for the reconnaissance survey lasted for two (2) days.

3.2 Actual Field Survey

Due to the absence of approved benchmark in the area, vertical datum was connected to the previously established Ground Control Points "BUA-4" which is also under the DREAM project. SC-134 was also observed using GNSS static survey together with the other GCPs. The computed elevation was compared to the provided data from NAMRIA and had a difference of 12.10 centimeters. In this case elevation from BUA-4 was used in the execution of the entire project.

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 7 shows the proposed or designed cross-section and profile lines of the river.

Figure 8 shows the actual cross-section and profile lines as surveyed.

And Figure 9 shows the comparison between the proposed and actual cross-section and profile lines wherein section lines 30, 31, 32&36in Siluay River have a minimal deviation due to some obstructions and actual conditions on site. Same with section lines 14 and 22 of Buayan River.About 674 meters length of section line 22 on the left side traverses the MSI compound wherein the security guards did not allow the team to conduct survey works inside the property. Portion of the river alignment differ from the proposed line maybe due to the continuous rainfall in the area that caused minor erosion of the river banks.

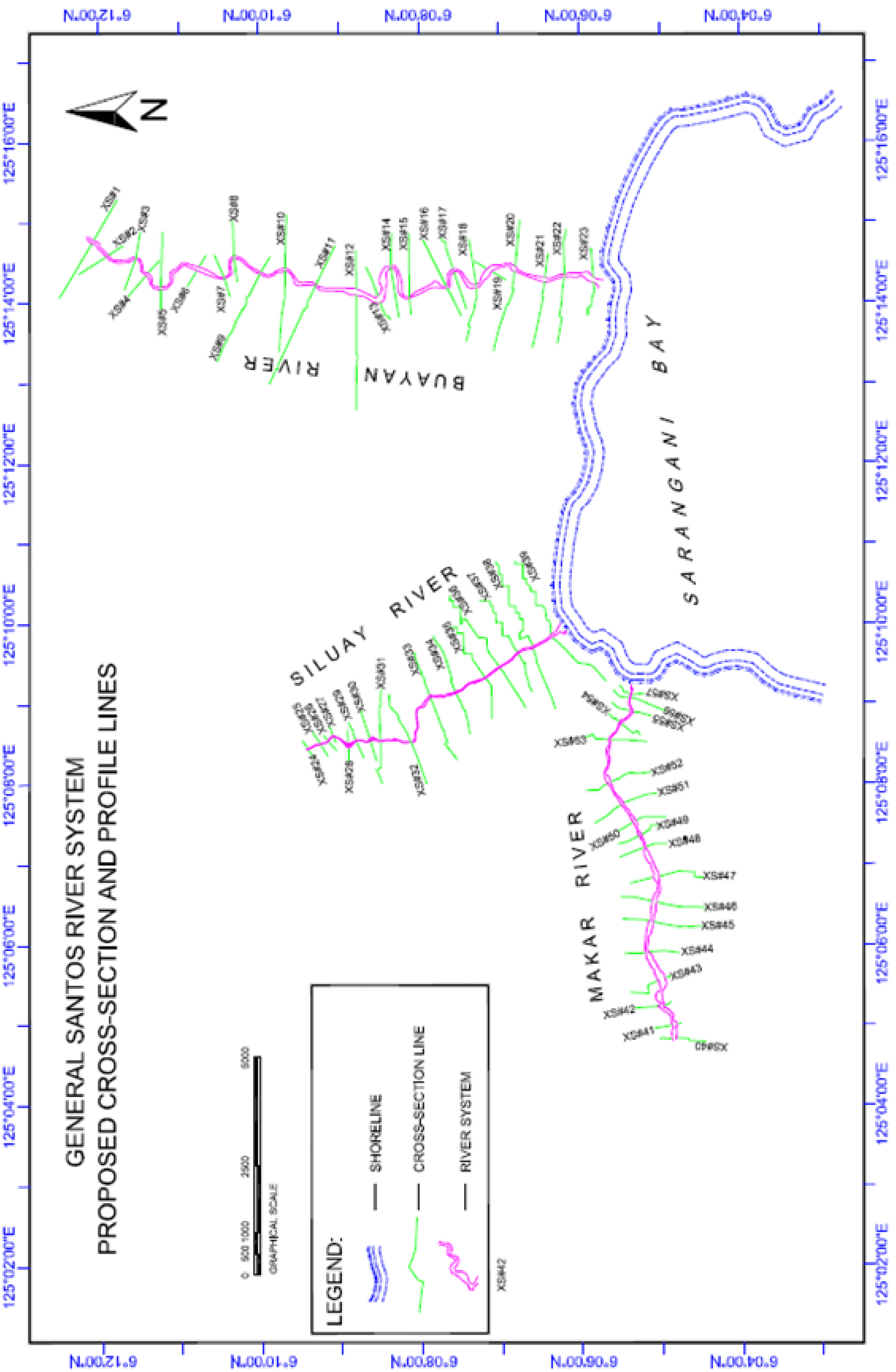


Figure 8: Proposed Cross-Section and Profile line of the River

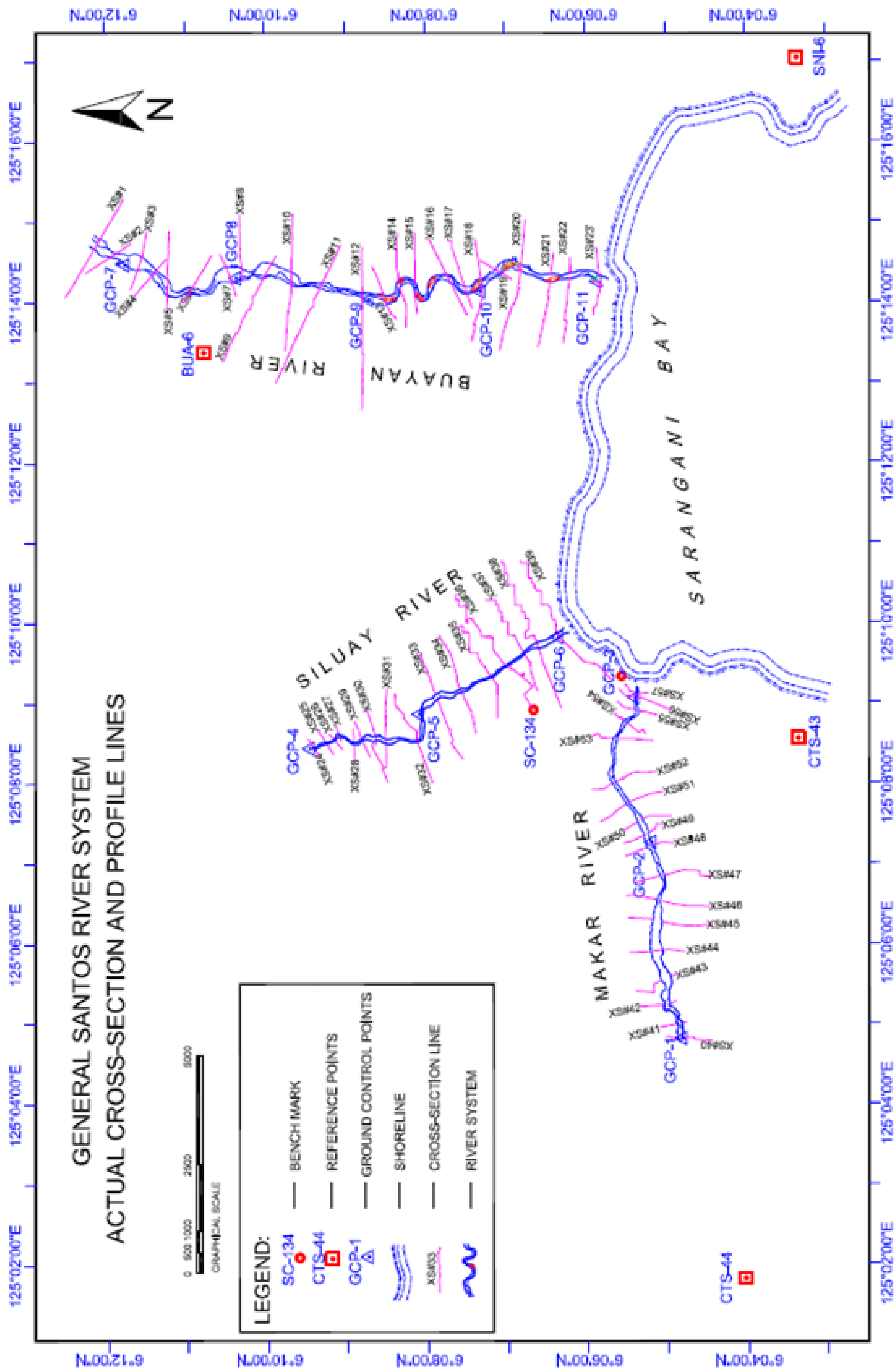


Figure 9: Actual Cross-section and Profile line

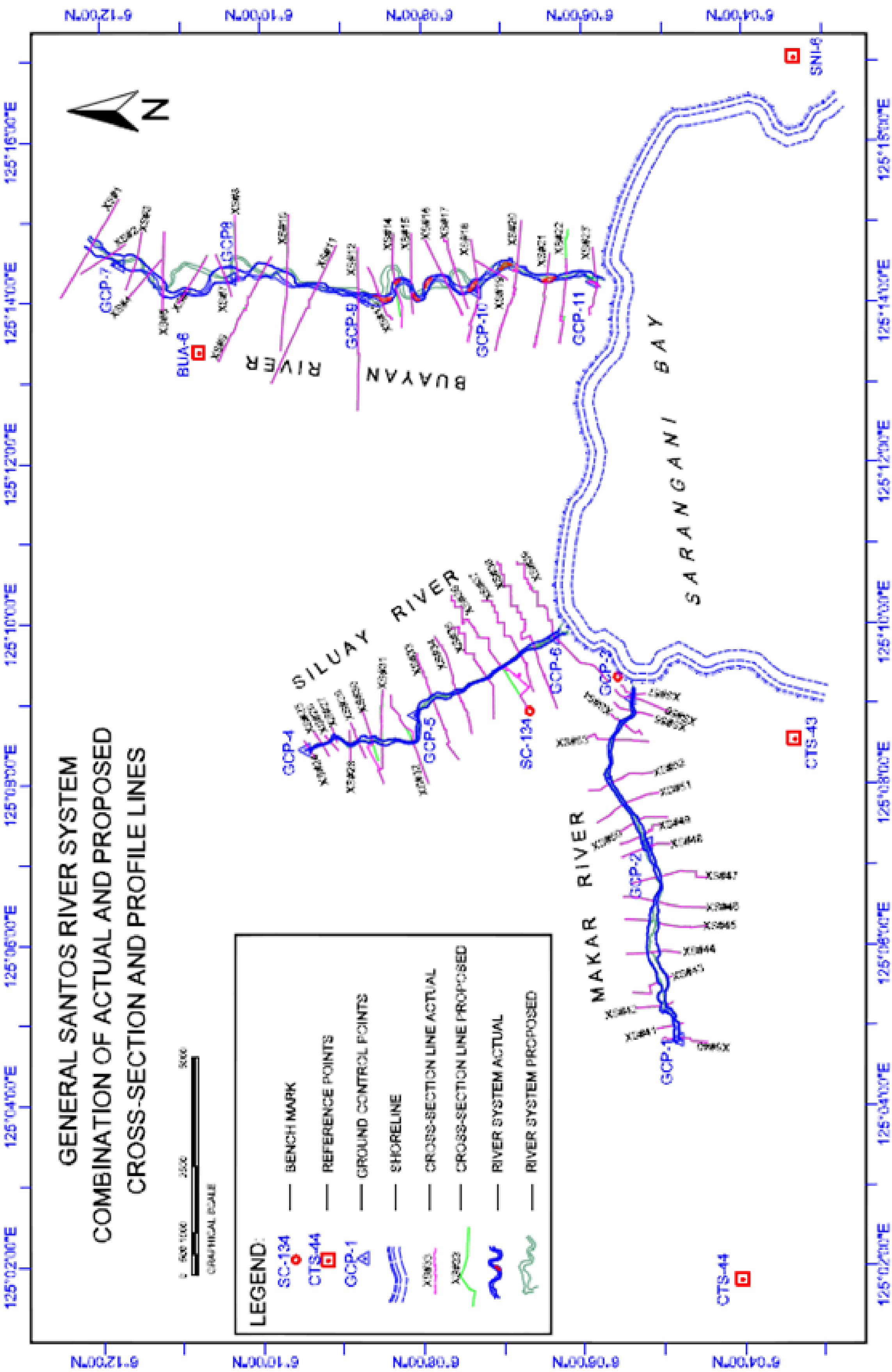


Figure 10: Comparison of the proposed and actual survey lines

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 5: Problem Encountered and Solution Applied

Problems Encountered		Action Taken
1.	A lot of areas were 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.	Hard to secure permits on some barangay officials and subdivision owners.	While waiting for their preferred schedule, the team performs other task for the project.
3.	Delay in the projected field work because of unfavorable weather condition in the area.	Overtime on Sundays and extend working hours
4.	Rivers were 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.
6.	Land owners did not allow our survey team to enter their property even we had secured permits from the barangay officials.	The team hired barangay kagawad who is well-known in the respective areas to serve as guide during the survey.
7.	Most of the time the barangay officials are not available to accompany the survey team to conduct survey works.	Wait for the availability of the barangay officials before conducting survey work on site.

The report chart showing the weather during the entire survey implementation of the project can be seen in Figure 10. This is documented by the team to as reference for the delay of the survey.

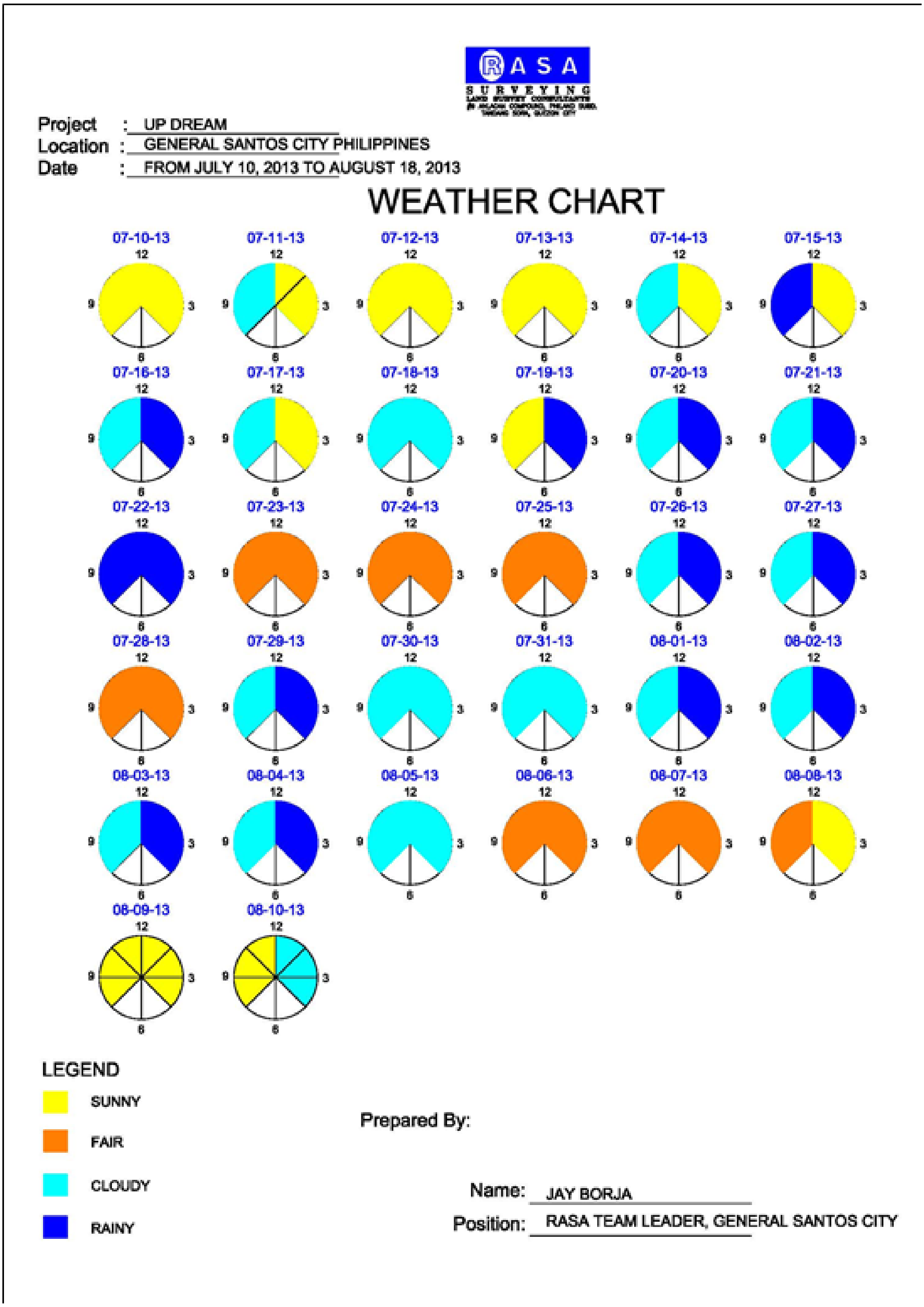
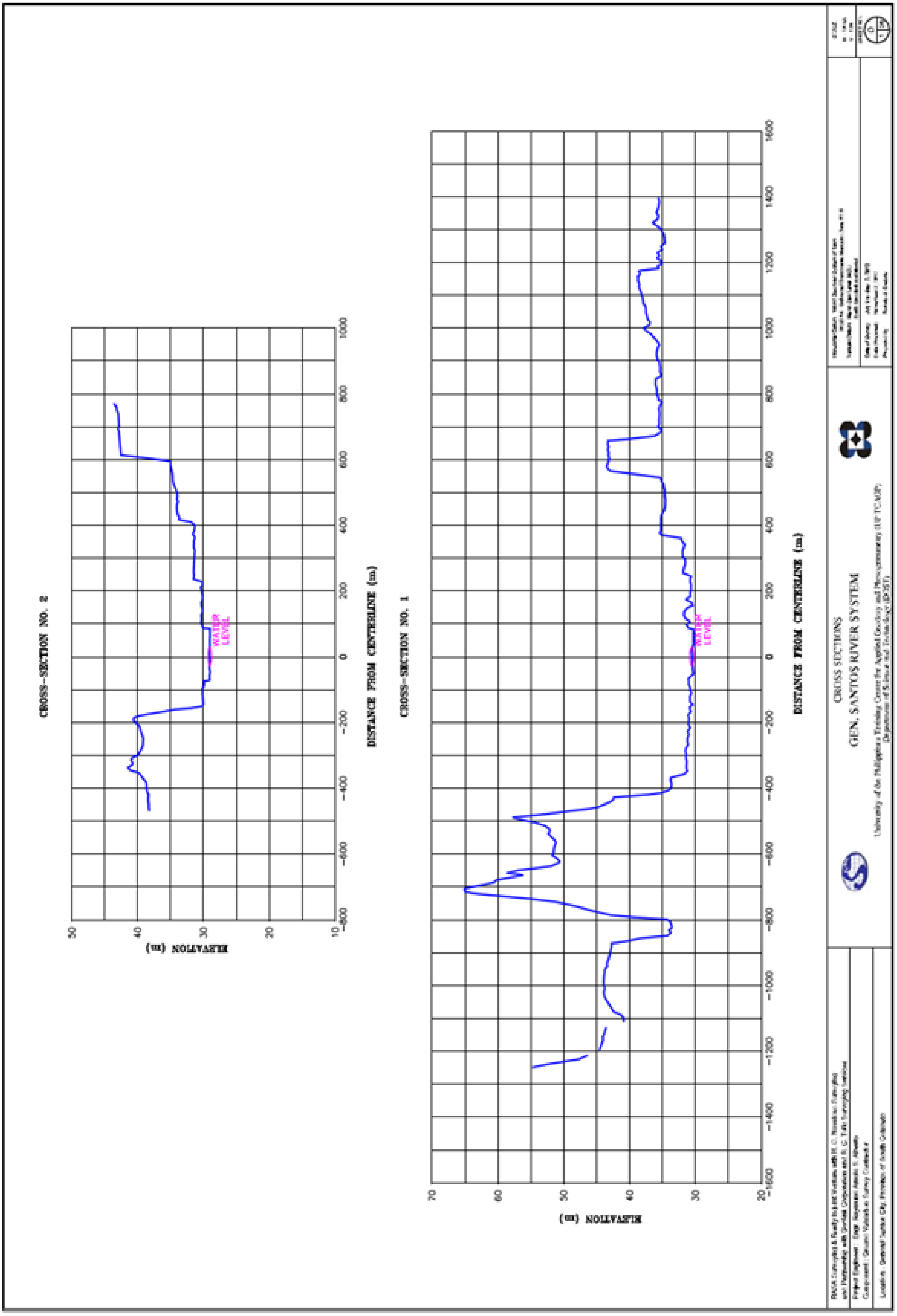


Figure11. Chart showing the weather on the project during the entire survey

Figure 12: 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.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DISTANCE FROM CENTERLINE (m)
WATER LEVEL
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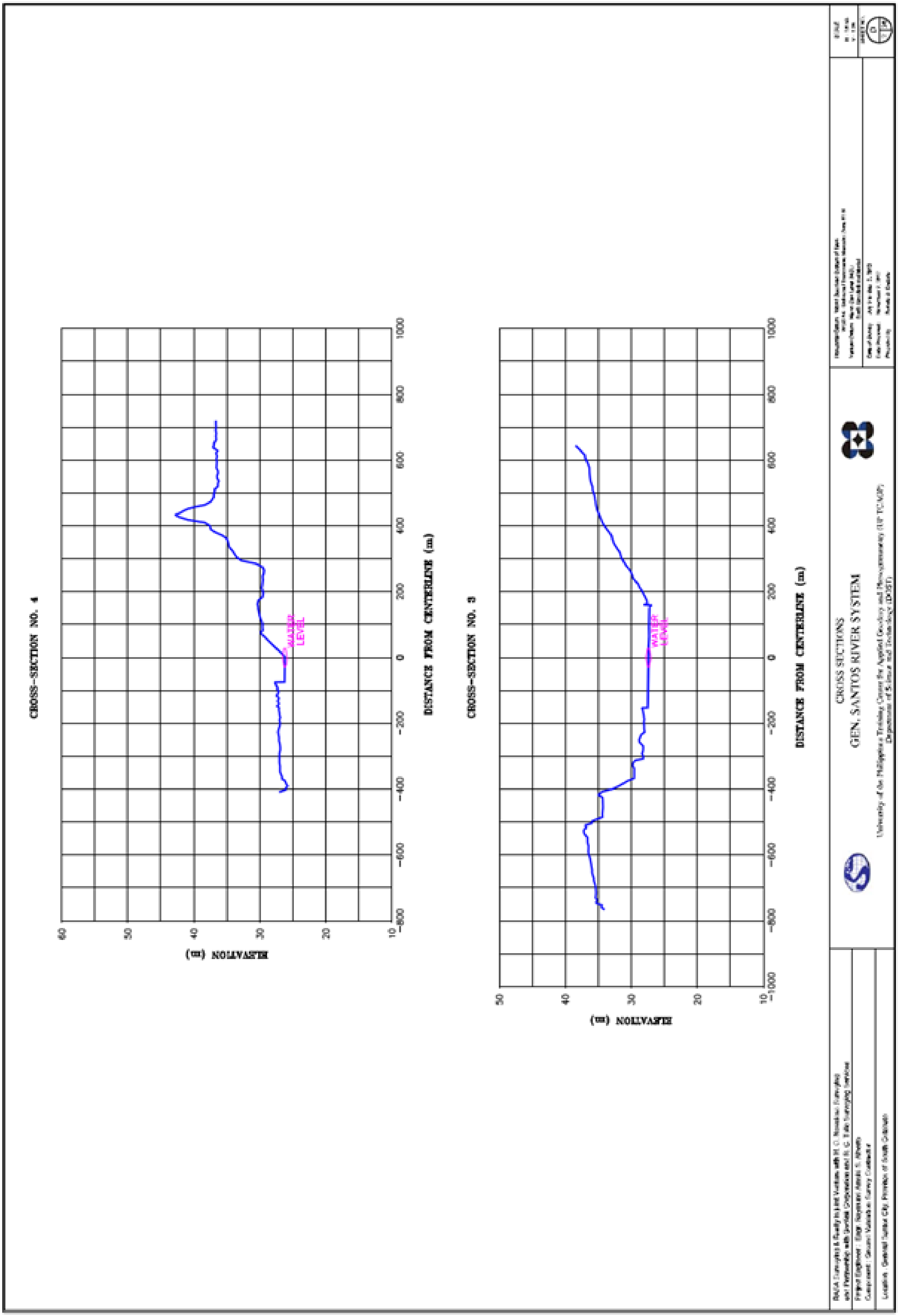
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)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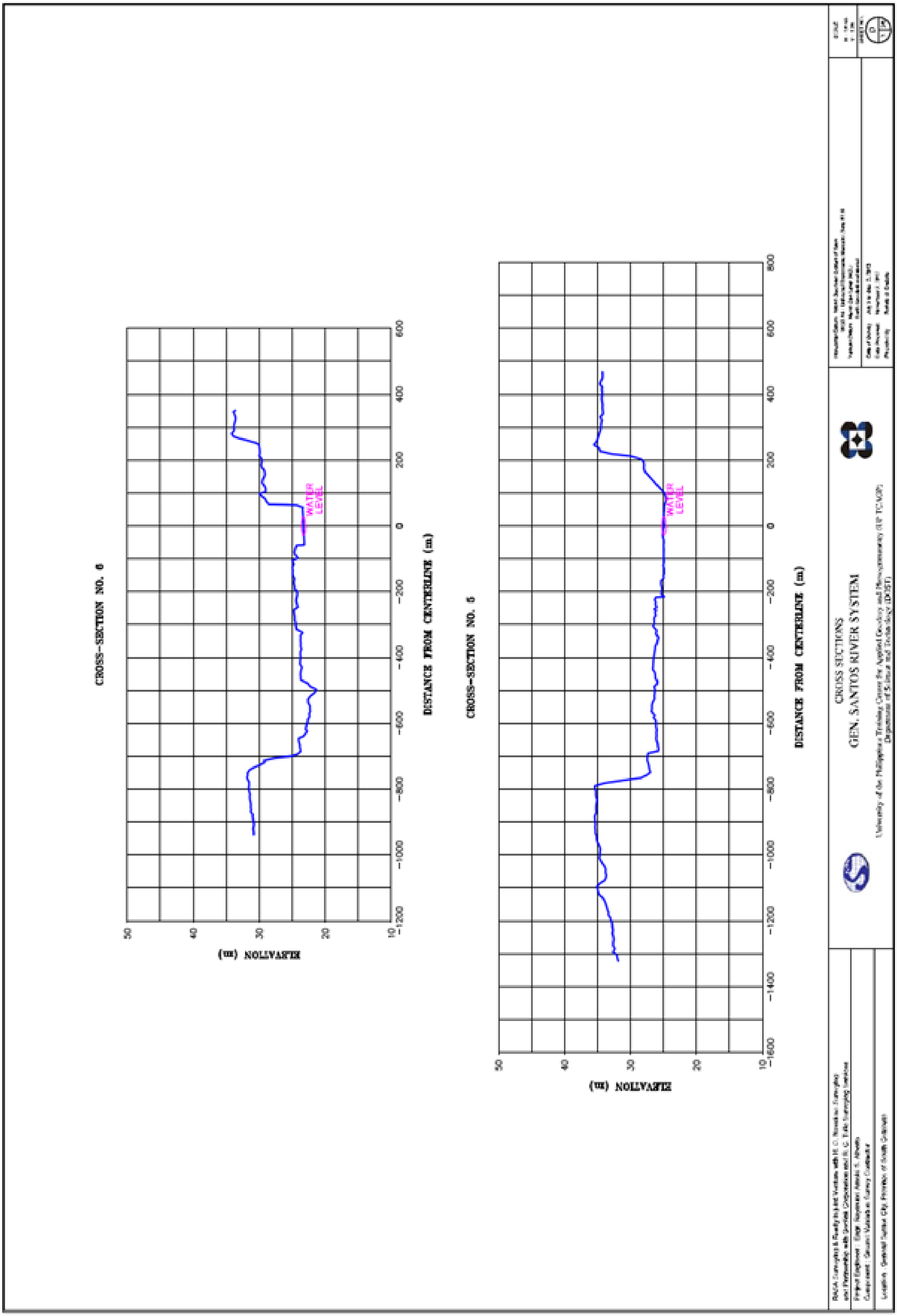
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM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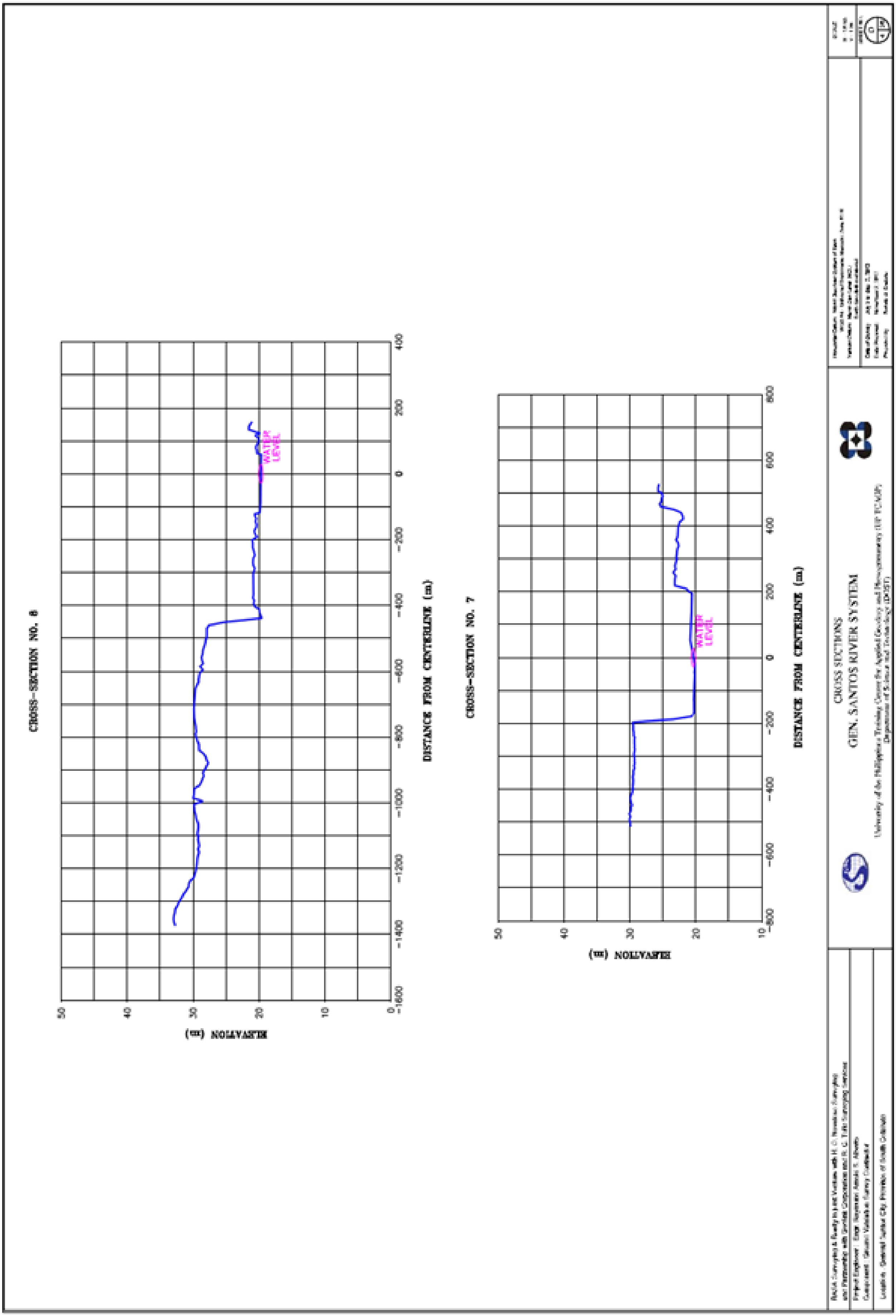
GEN. SANTOS RIVER SYSTEM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WATER LEVEL
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DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
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CROSS SECTIONS
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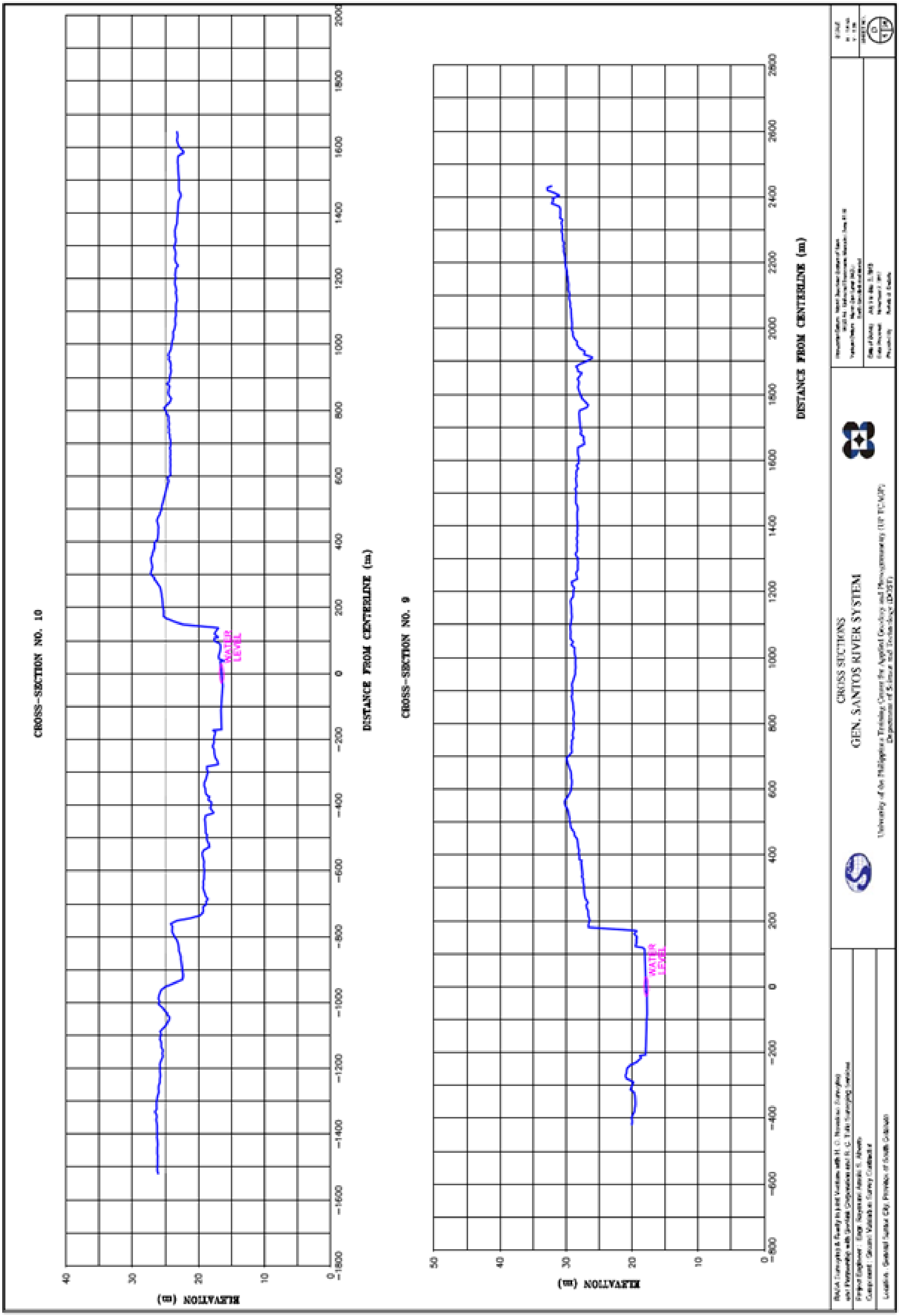
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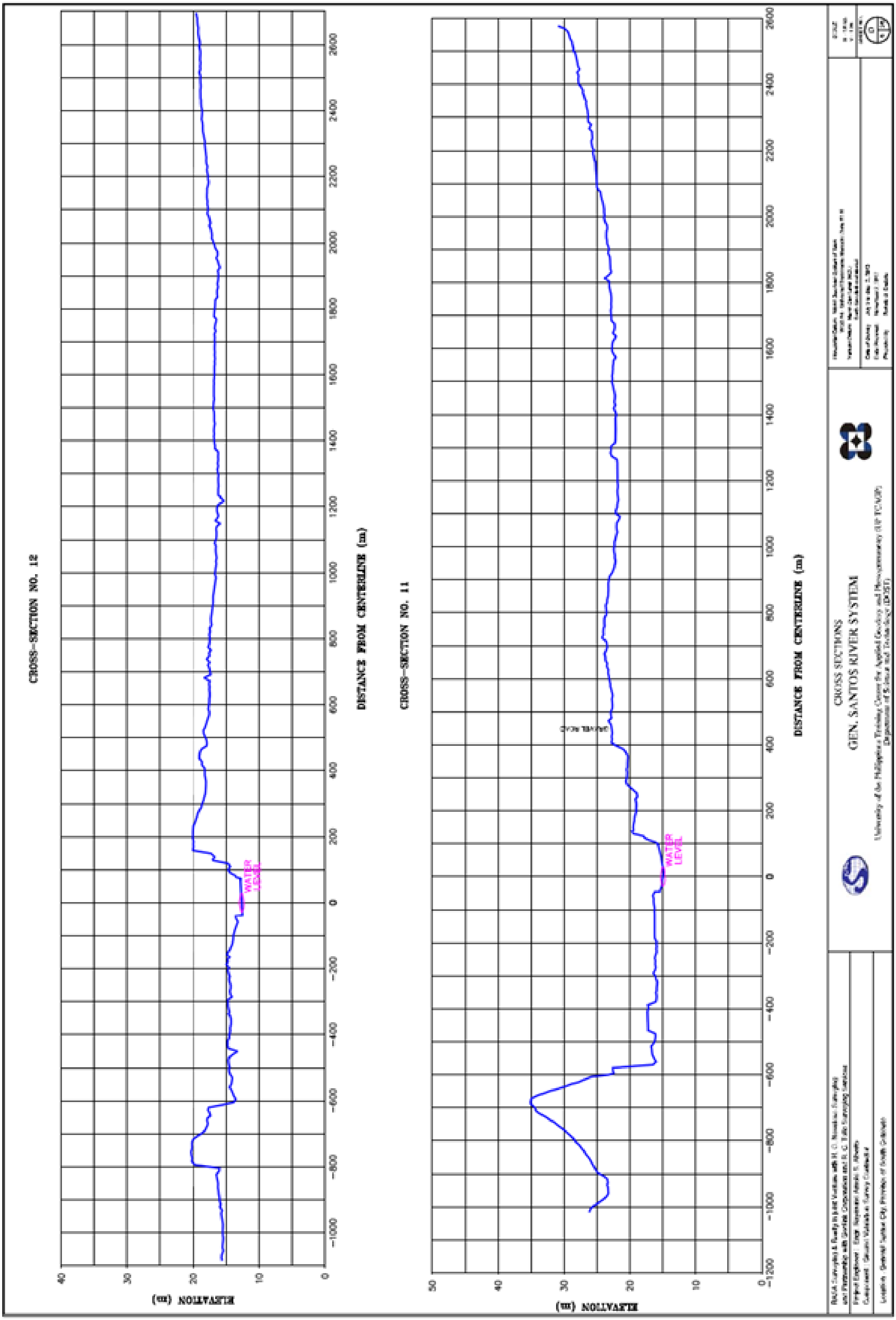
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM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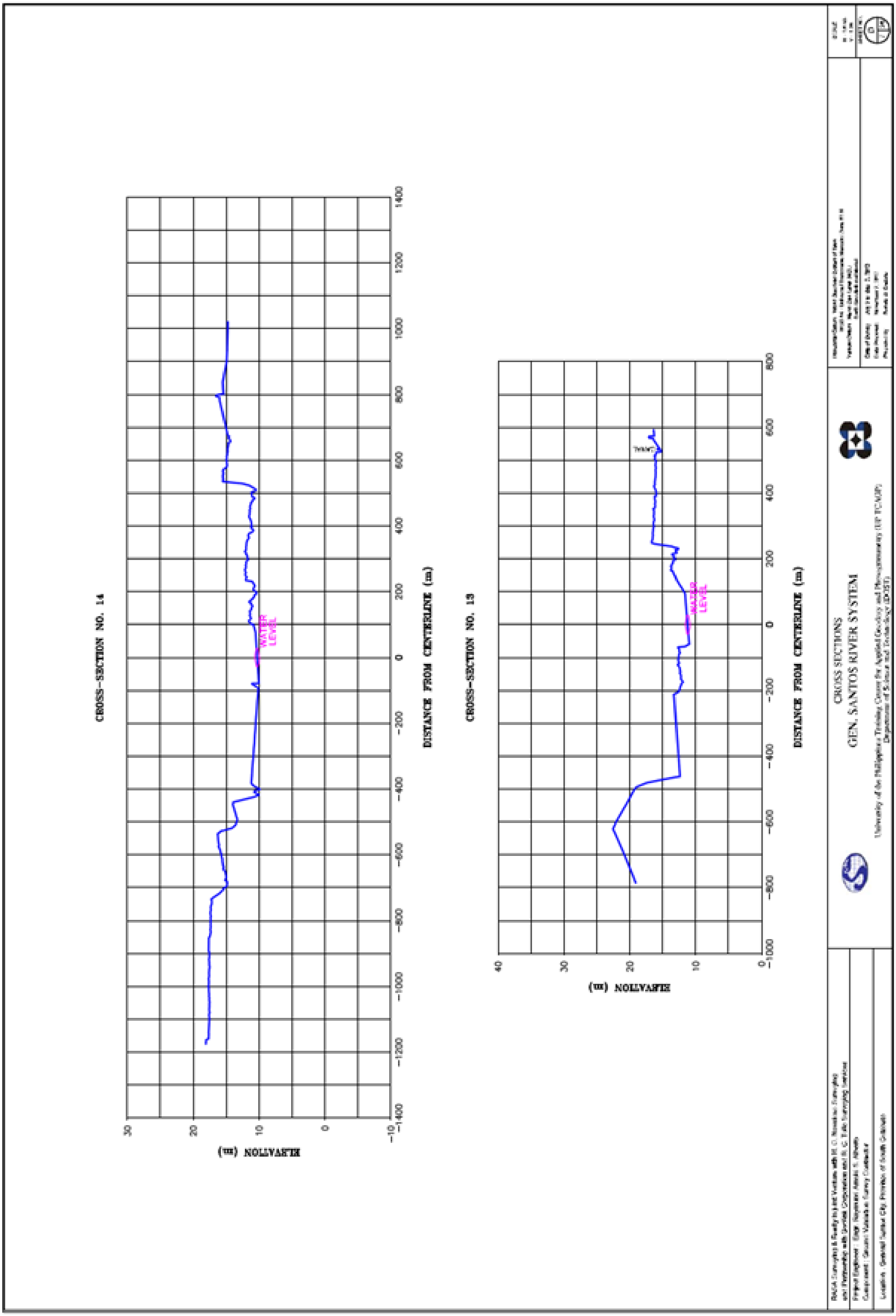
ELEVATION (m)
WATER LEVEL
GRAVEL ROAD
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM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WATER LEVEL
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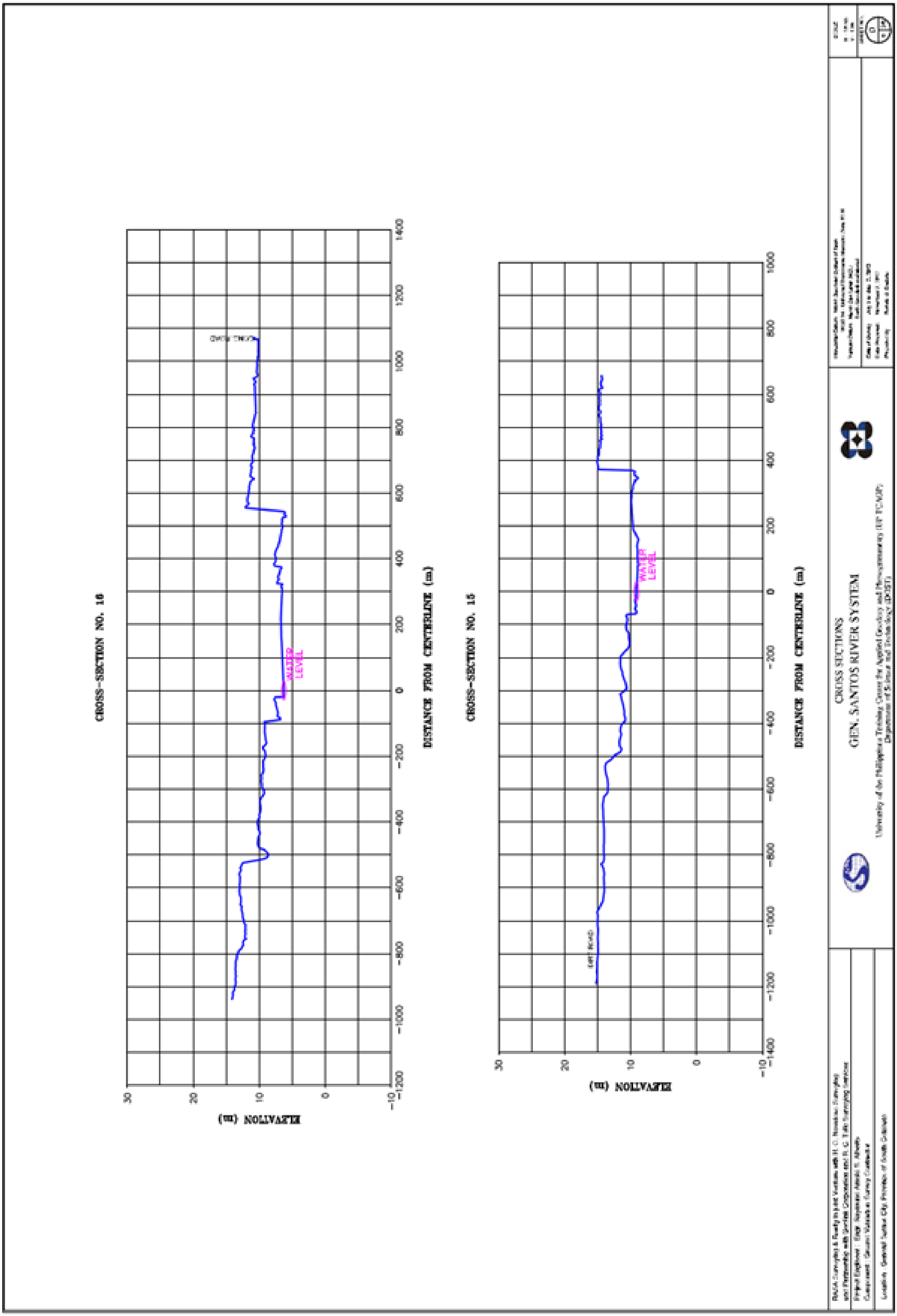
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM



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CROSS-SECTION NO. 15
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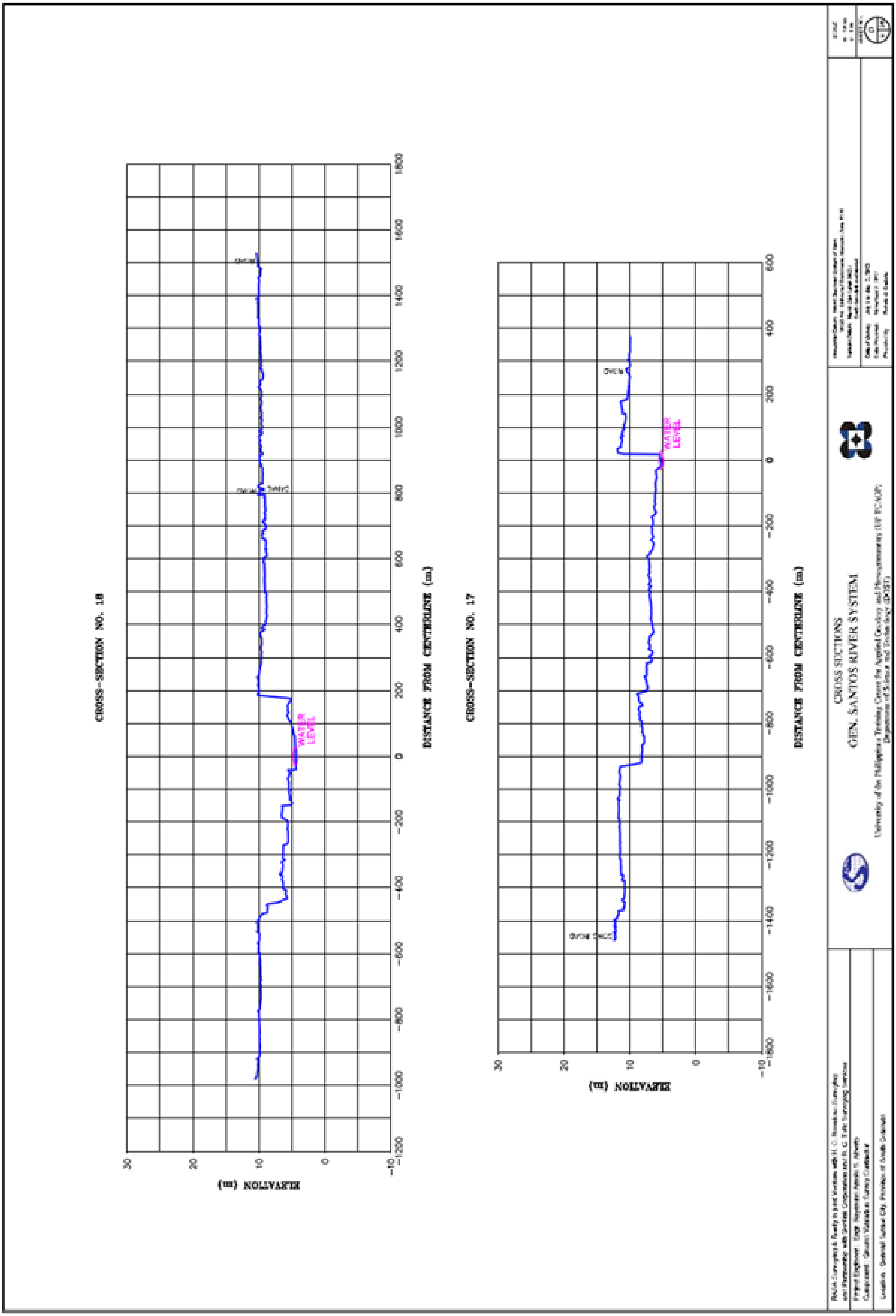
ELEVATION (m)
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM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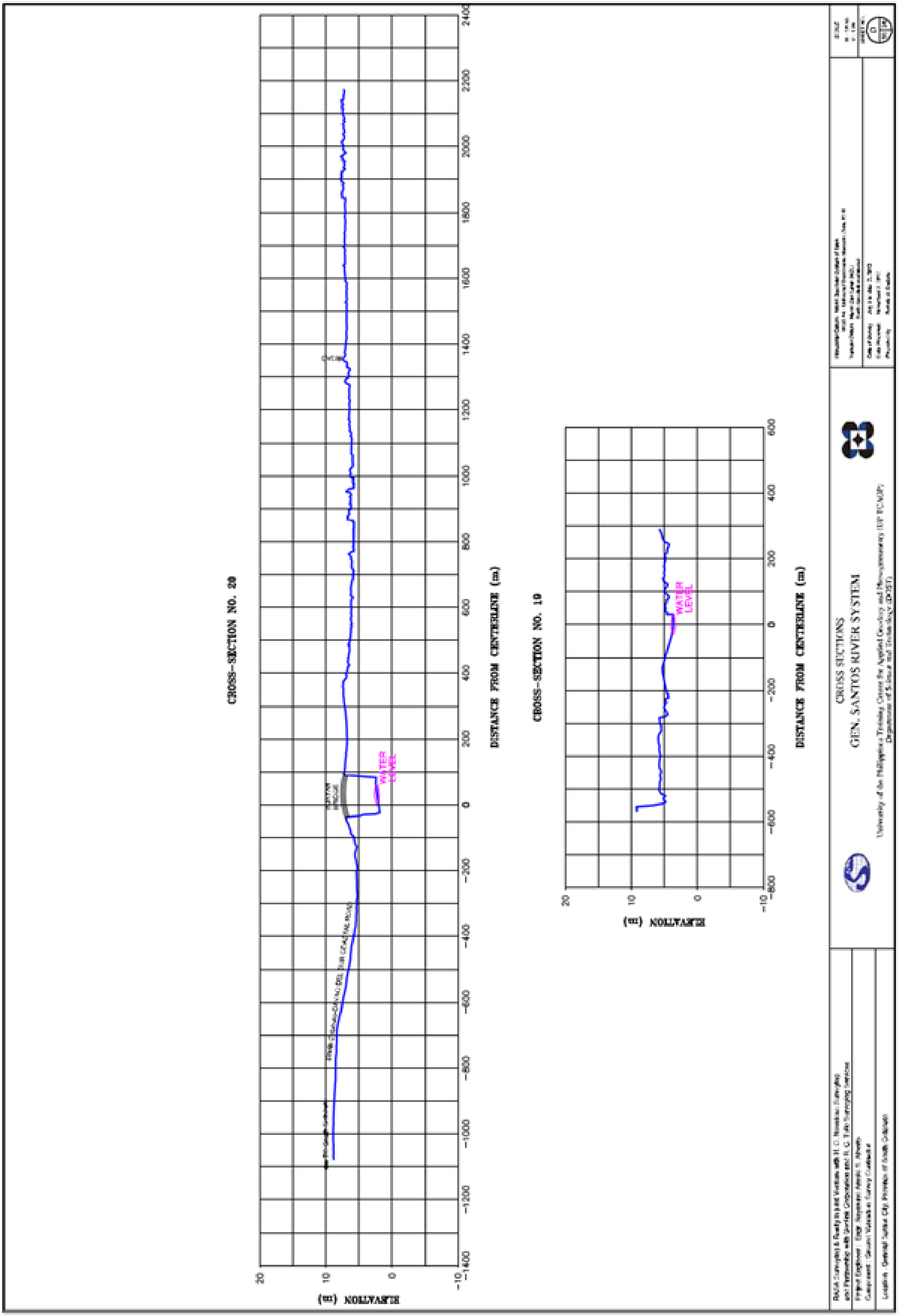
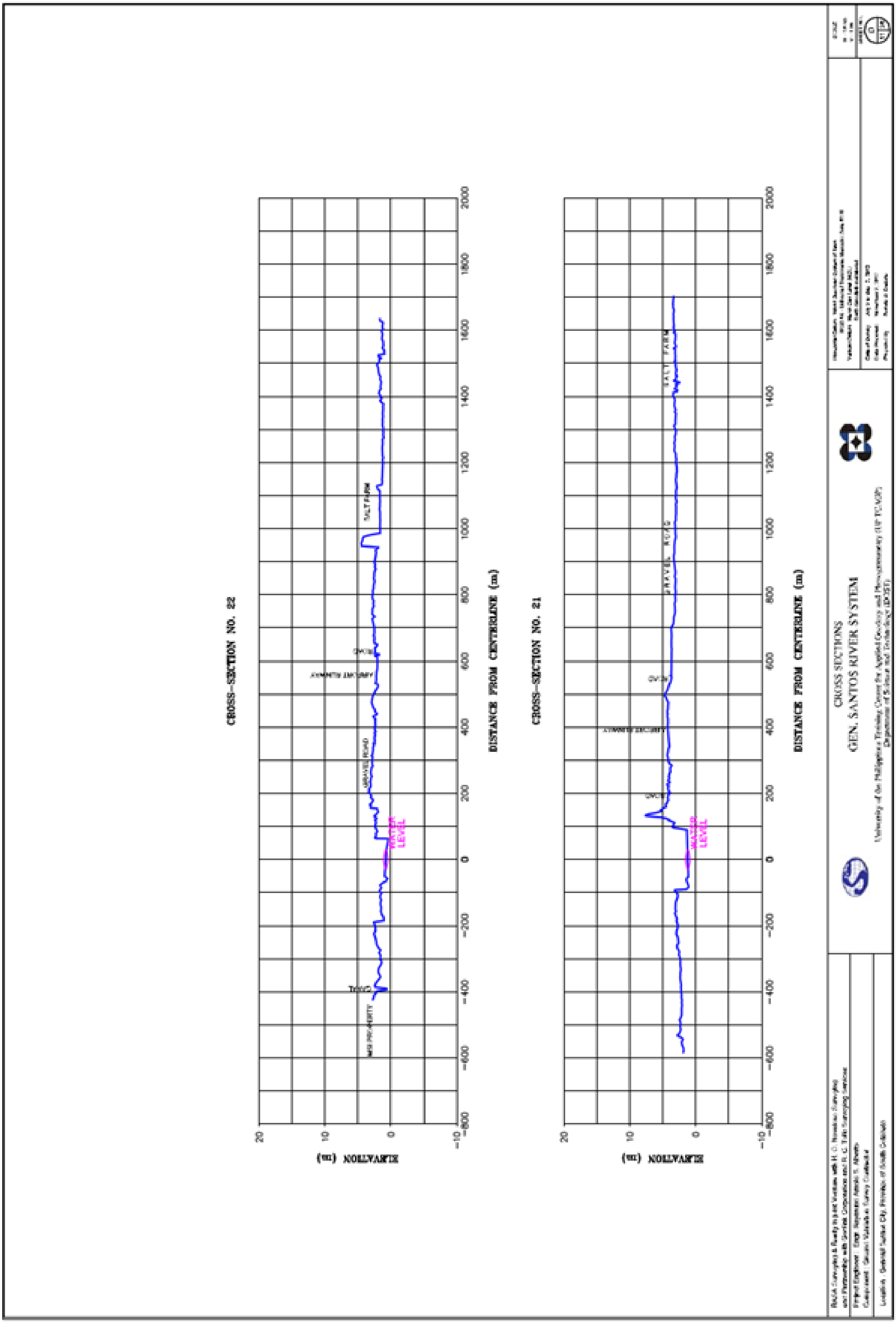
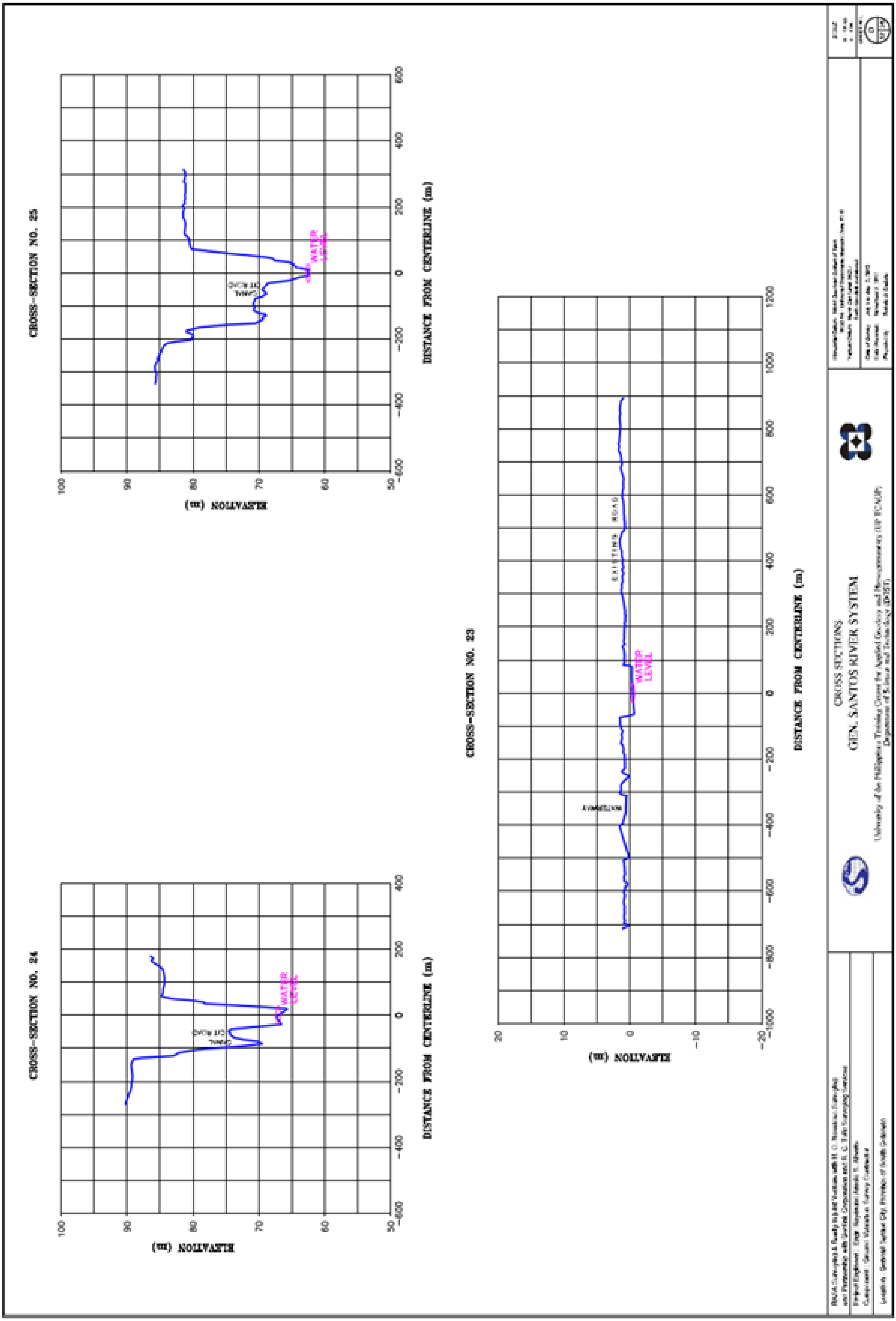
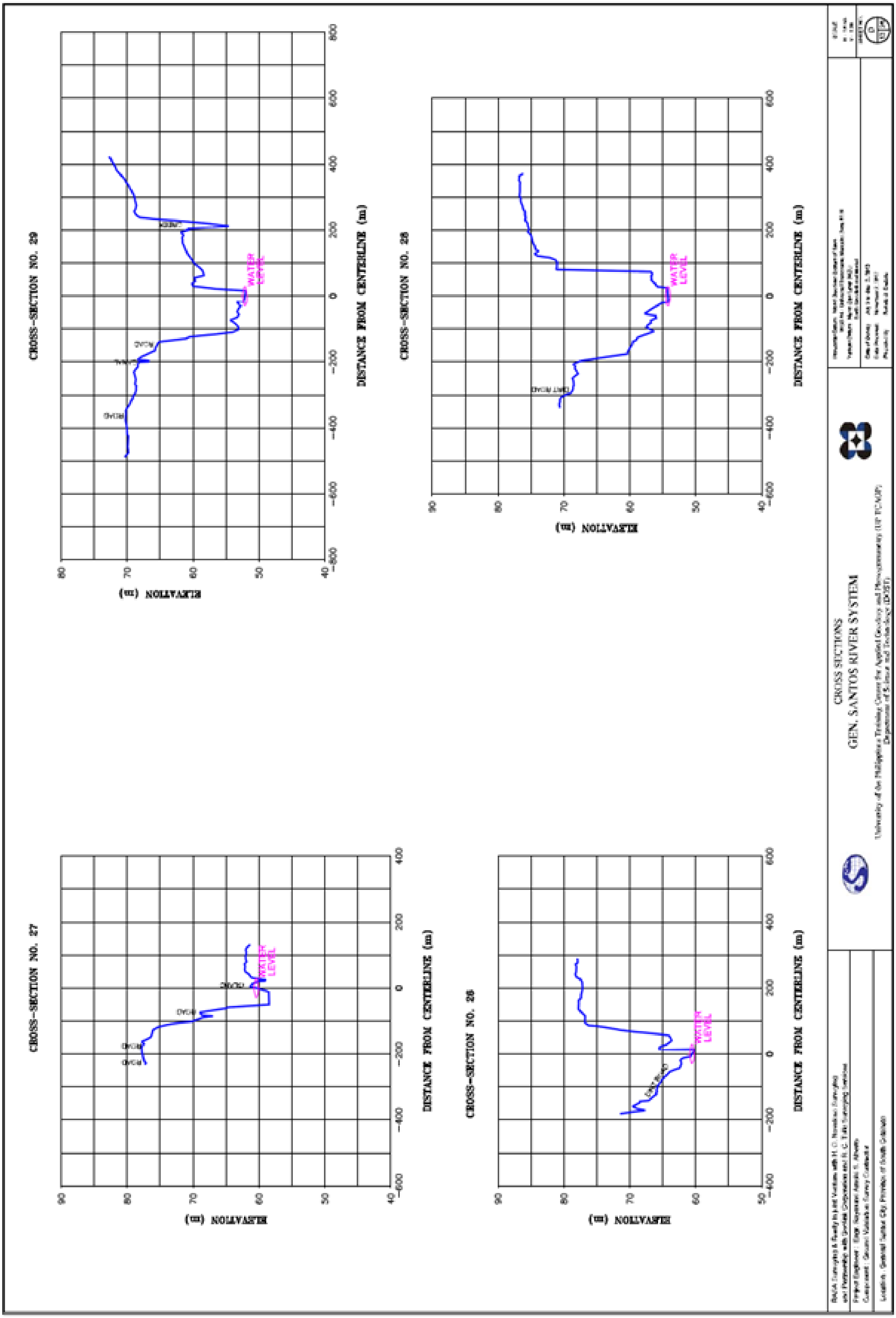
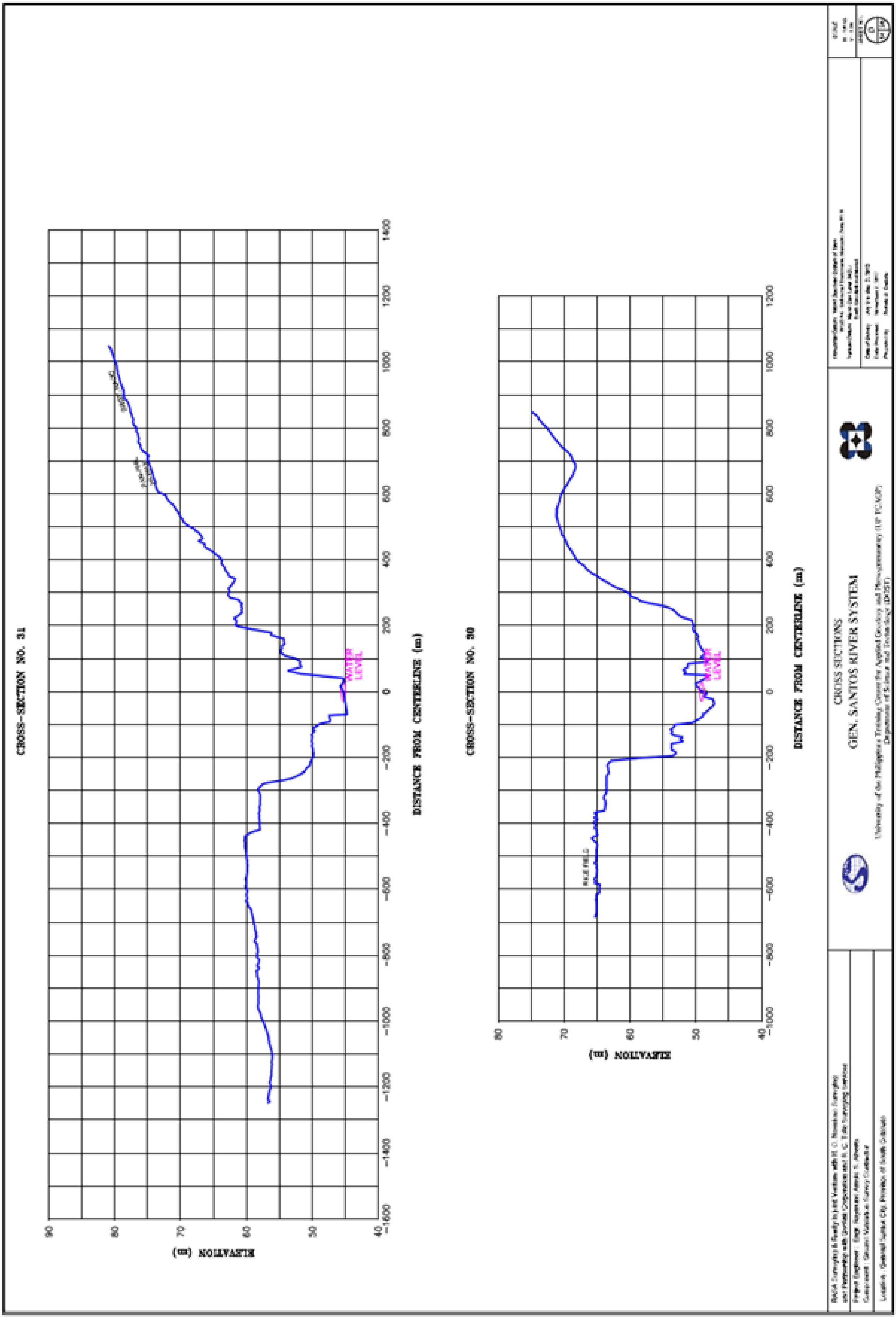
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

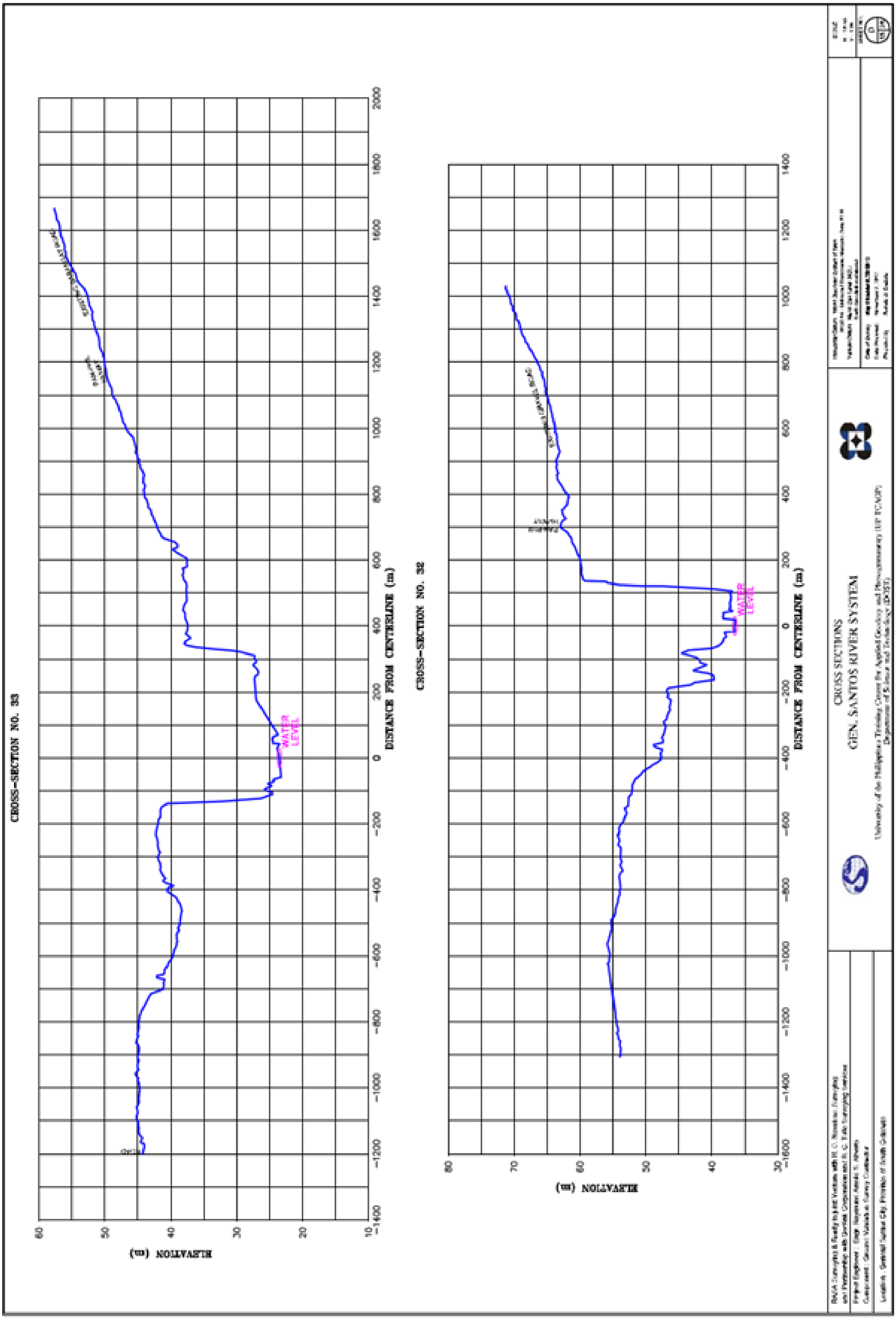

CROSS-SECTION NO. 20
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS-SECTION NO. 19
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

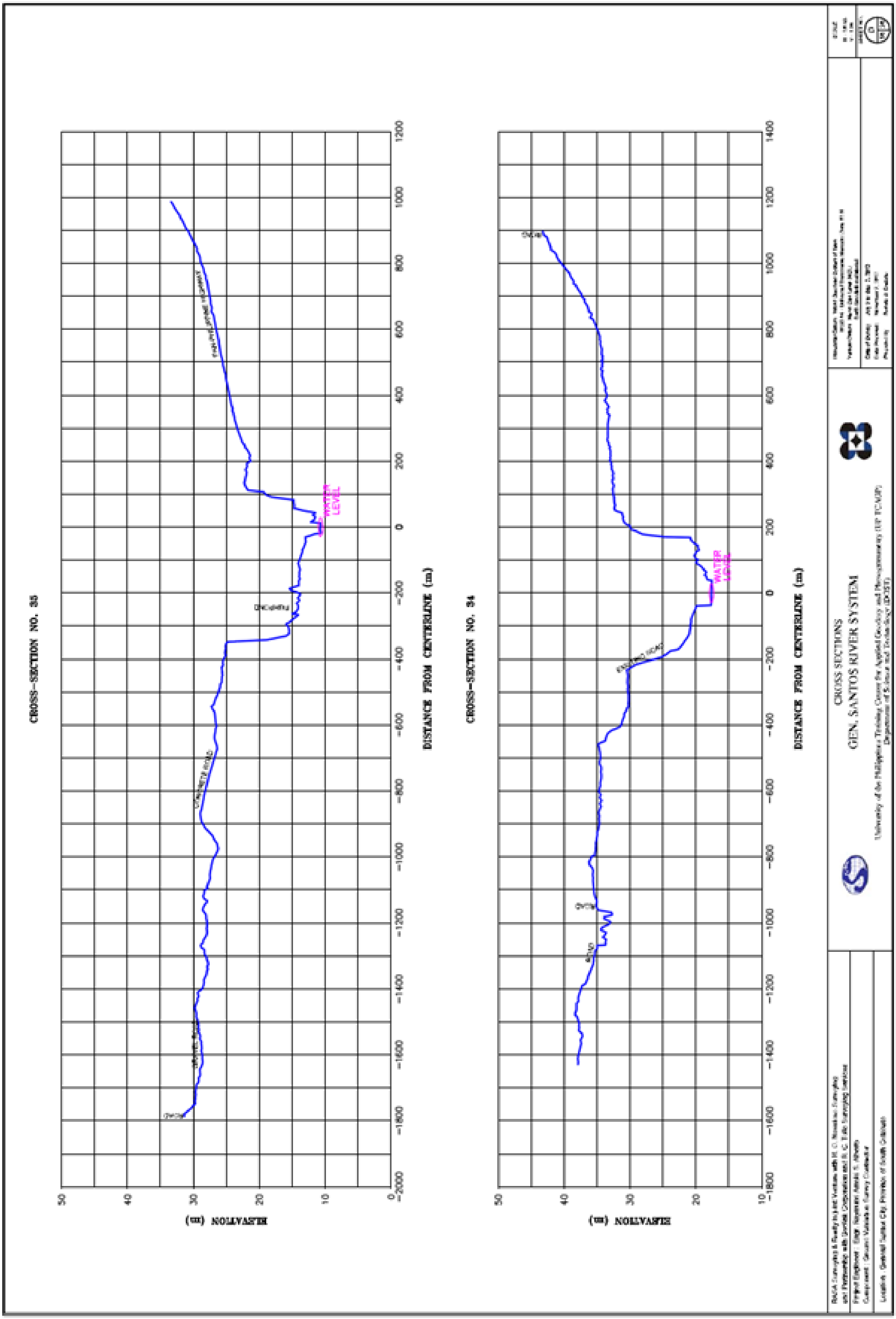

CROSS-SECTION NO. 22
CROSS-SECTION NO. 21
DISTANCE FROM CENTERLINE (m)
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
ELEVATION (m)
WATER LEVEL
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

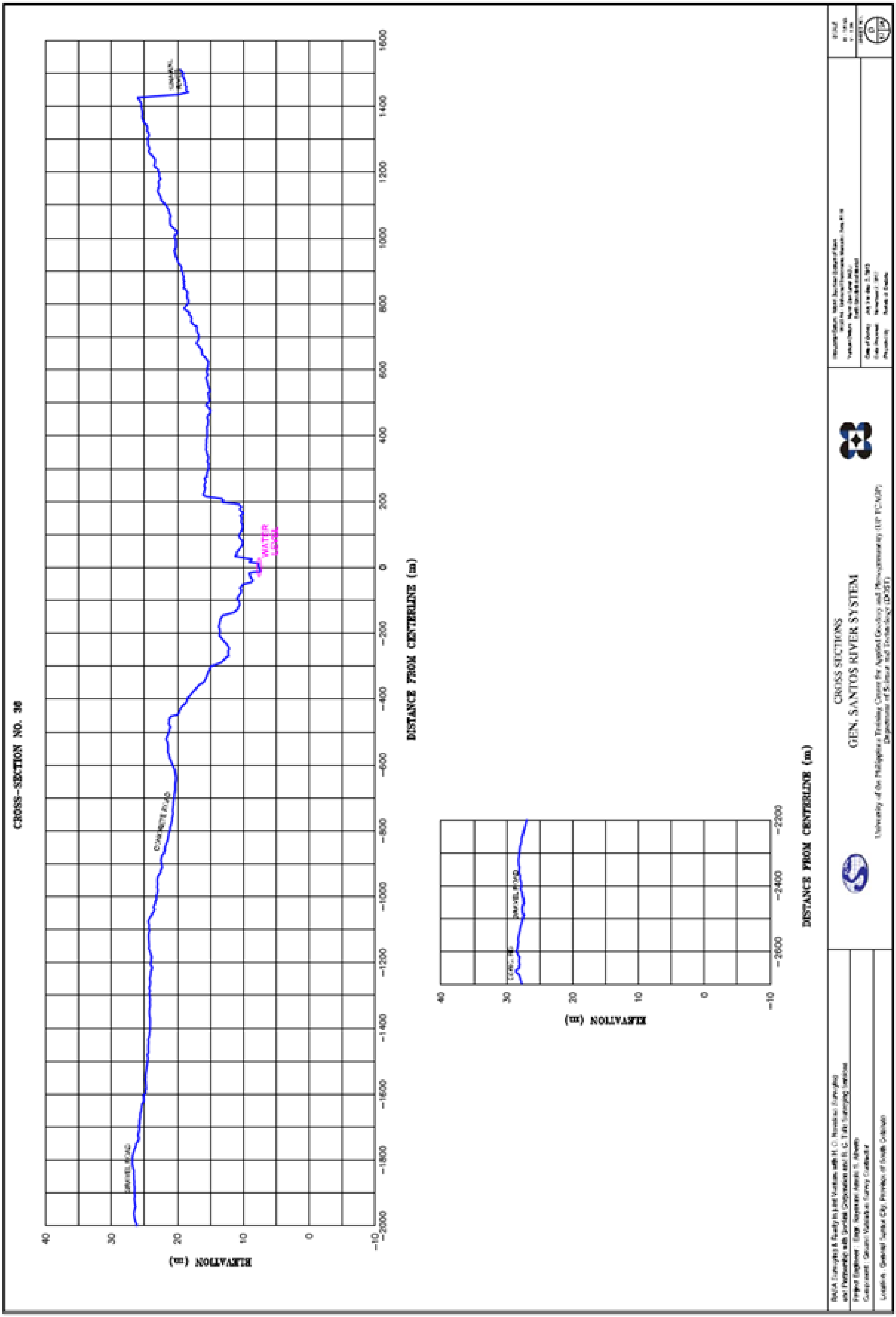

CROSS-SECTION NO. 25
CROSS-SECTION NO. 24
CROSS-SECTION NO. 23
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CANAL
EXISTING ROAD
WATERWAY
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

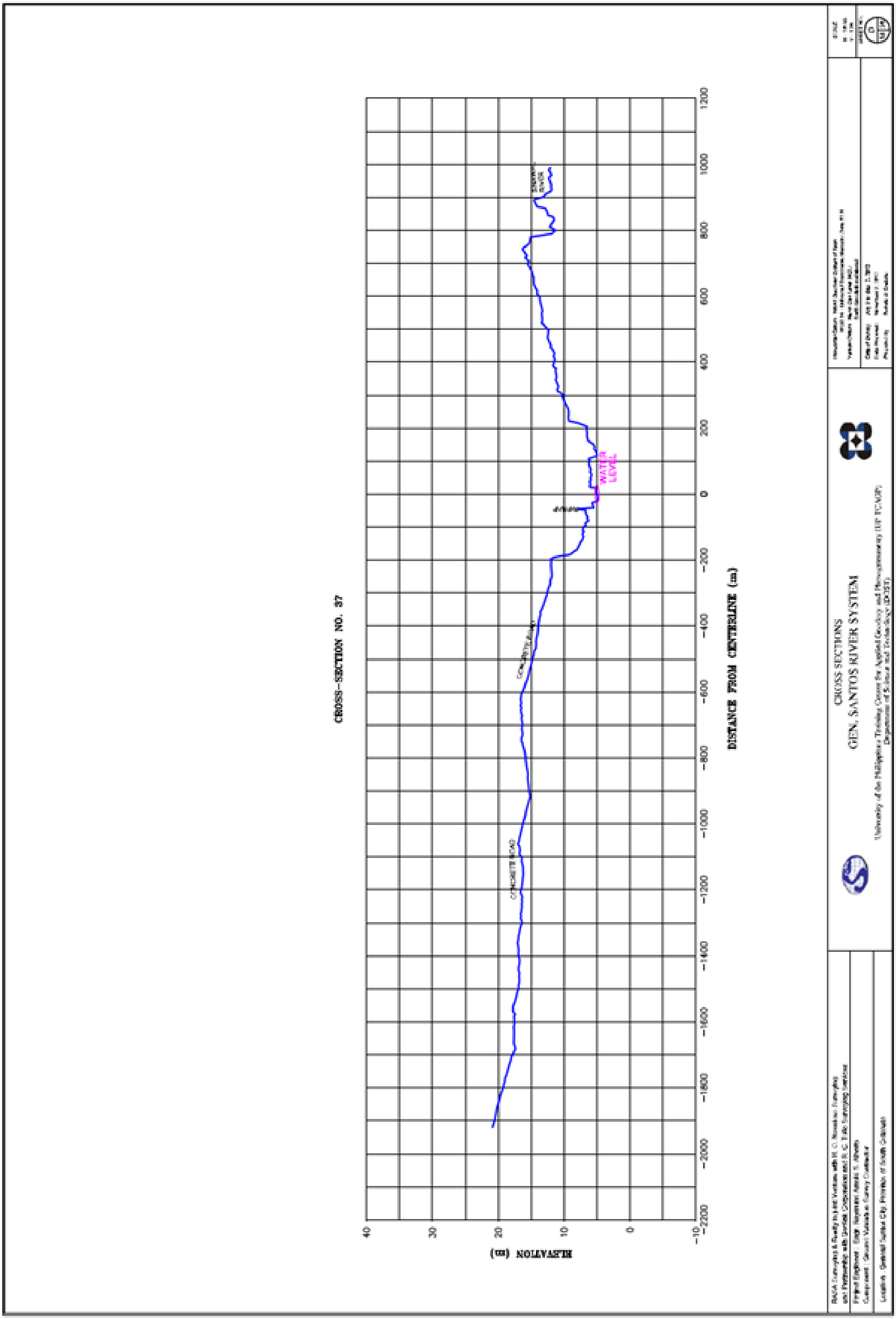

CROSS-SECTION NO. 29
CROSS-SECTION NO. 28
CROSS-SECTION NO. 27
CROSS-SECTION NO. 26
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

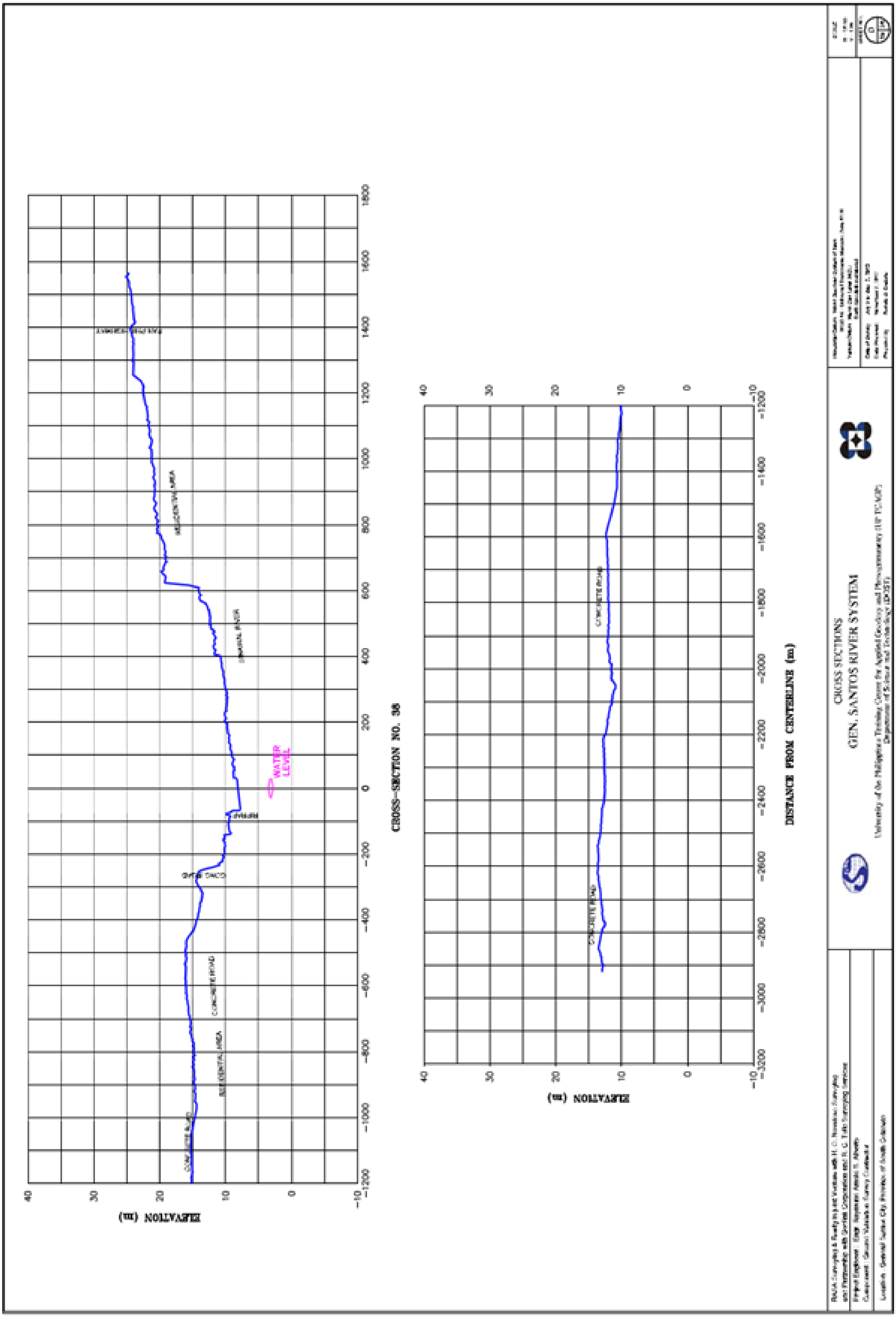

CROSS-SECTION NO. 31
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS-SECTION NO. 30
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

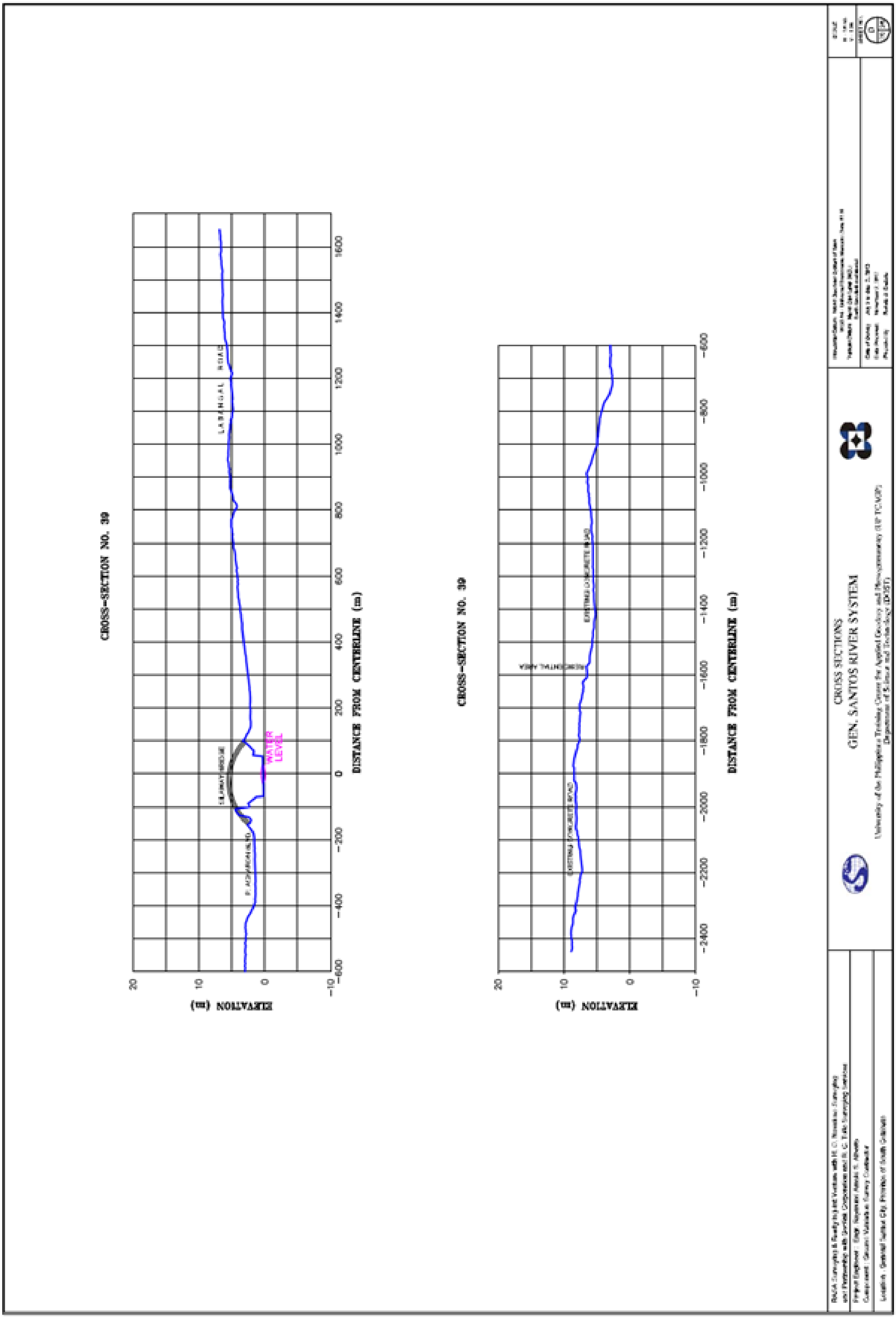

CROSS-SECTION NO. 33
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS-SECTION NO. 32
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

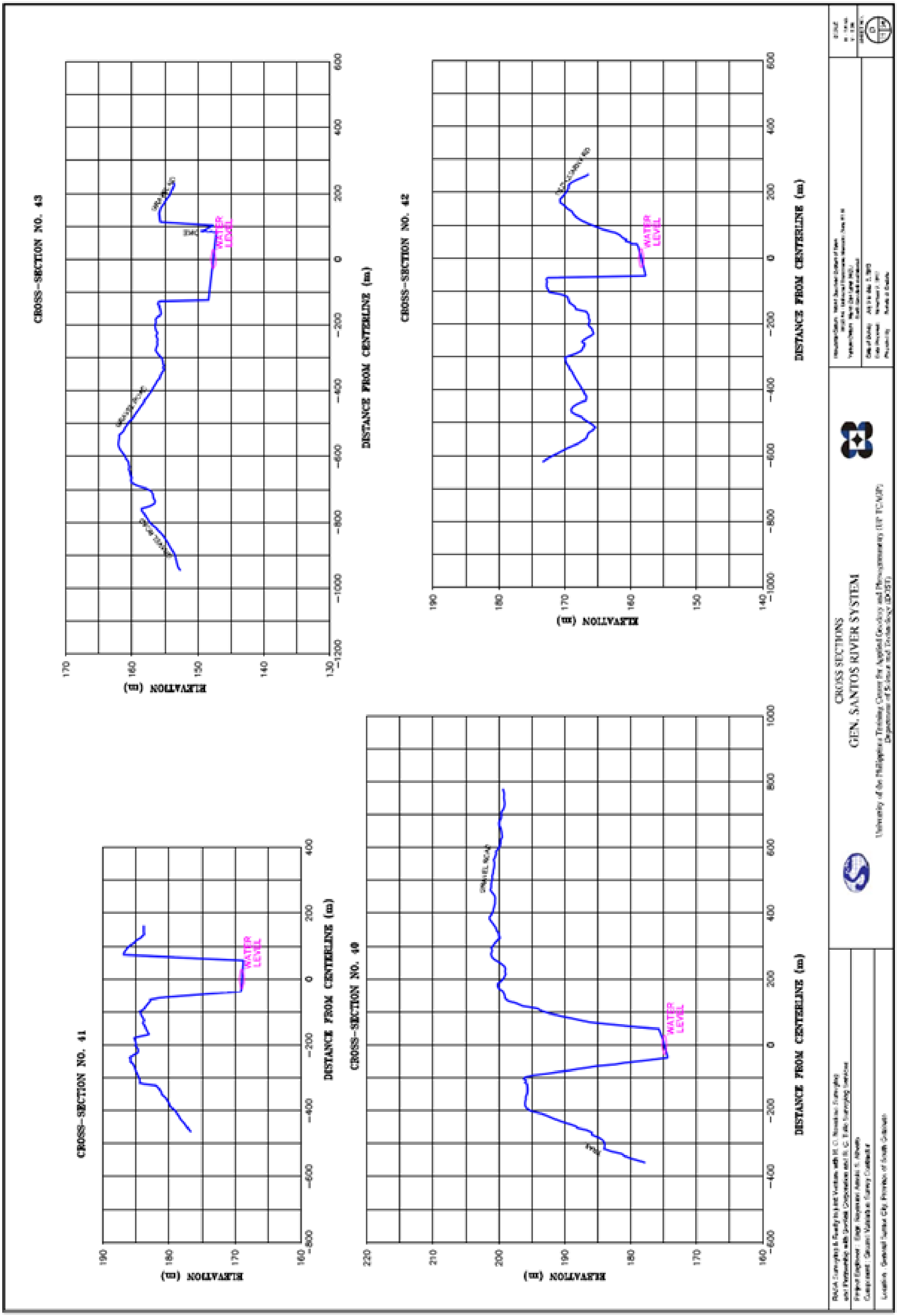

CROSS-SECTION NO. 35
CROSS-SECTION NO. 34
DISTANCE FROM CENTERLINE (m)
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
ELEVATION (m)
WATER LEVEL
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM


CROSS-SECTION NO. 36
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
GRAVEL ROAD
CONCRETE ROAD
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

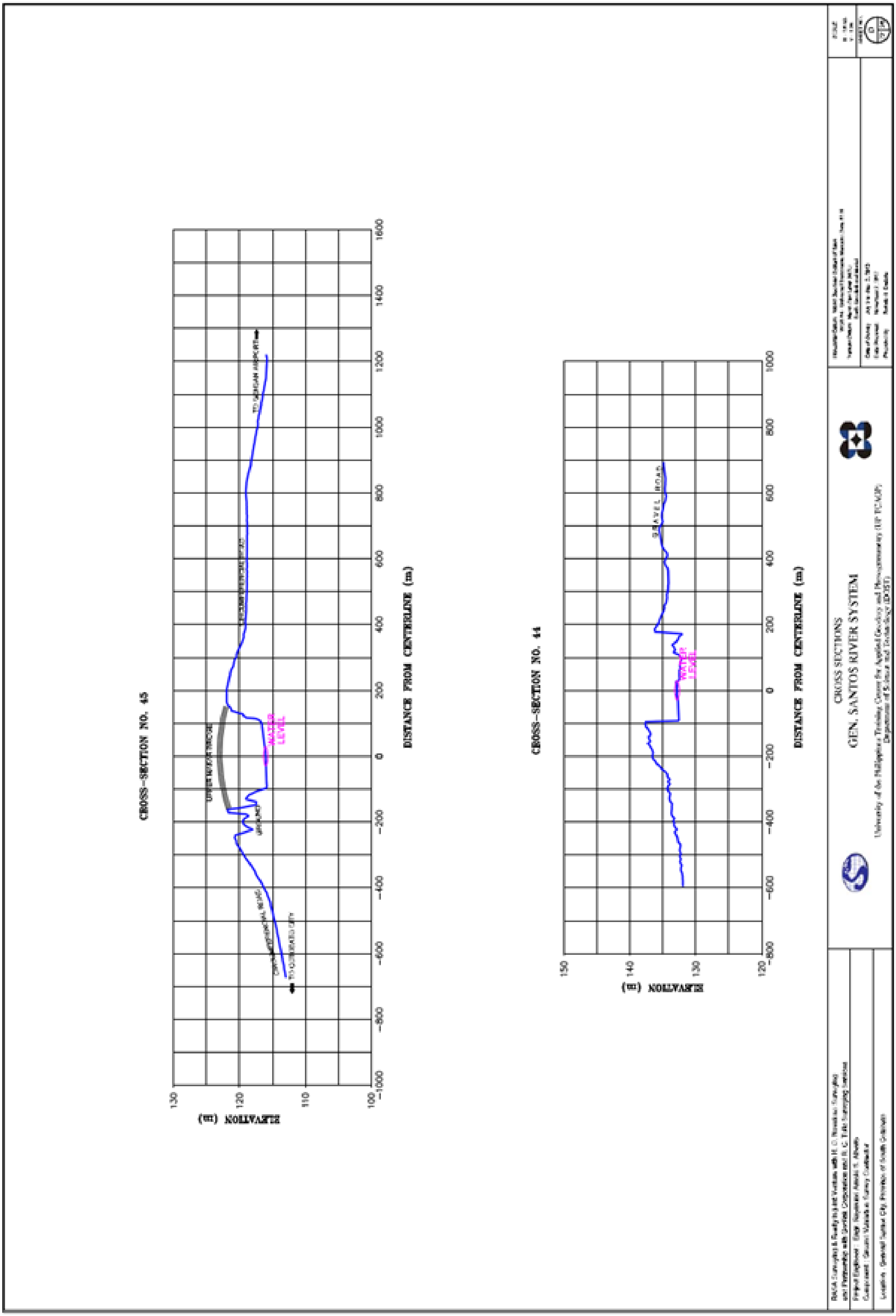

CROSS-SECTION NO. 37
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
WATER LEVEL
CONCRETE ROAD
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

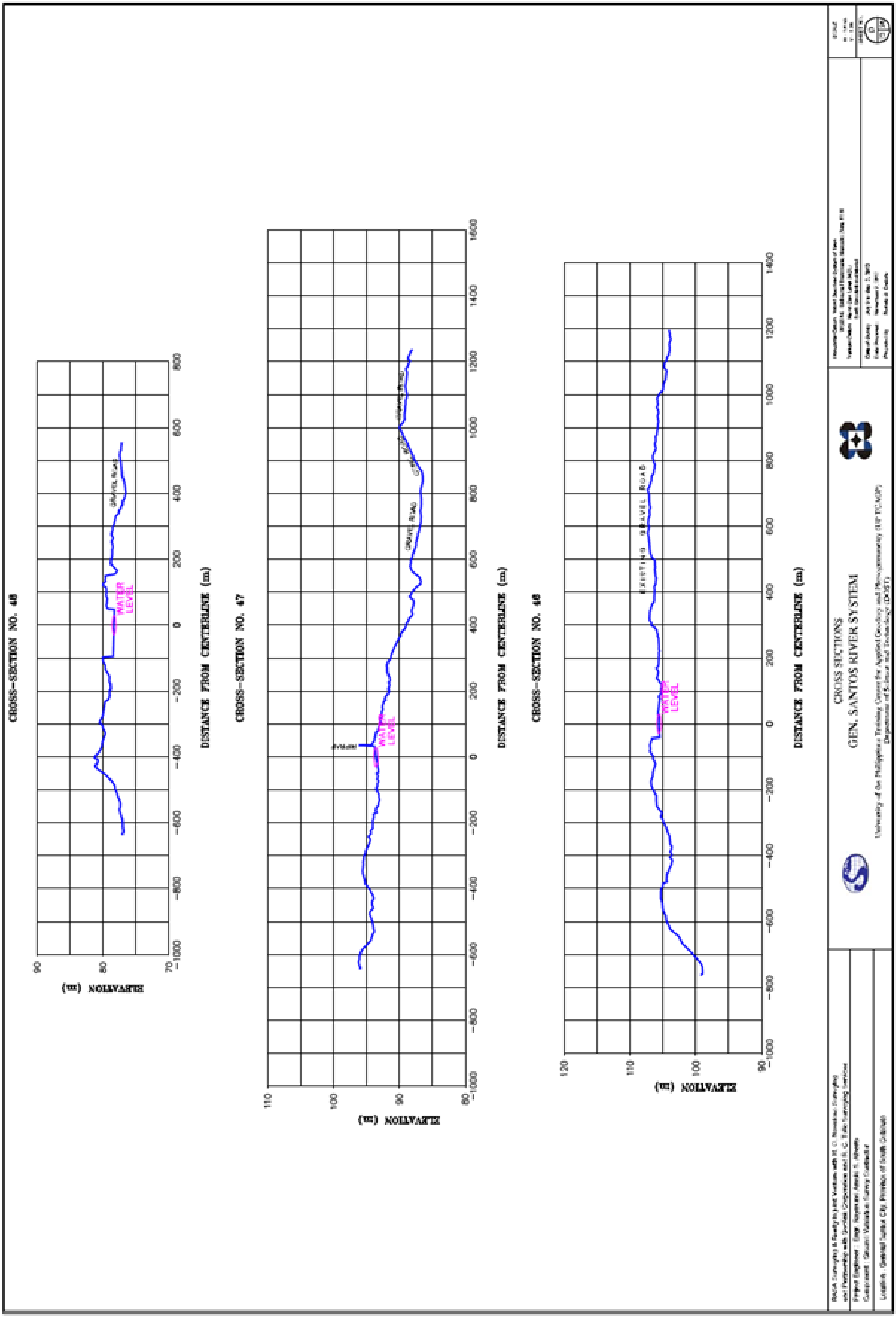

CROSS–SECTION NO. 38
ELEVATION (m)
WATER LEVEL
DISTANCE FROM CENTERLINE (m)
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

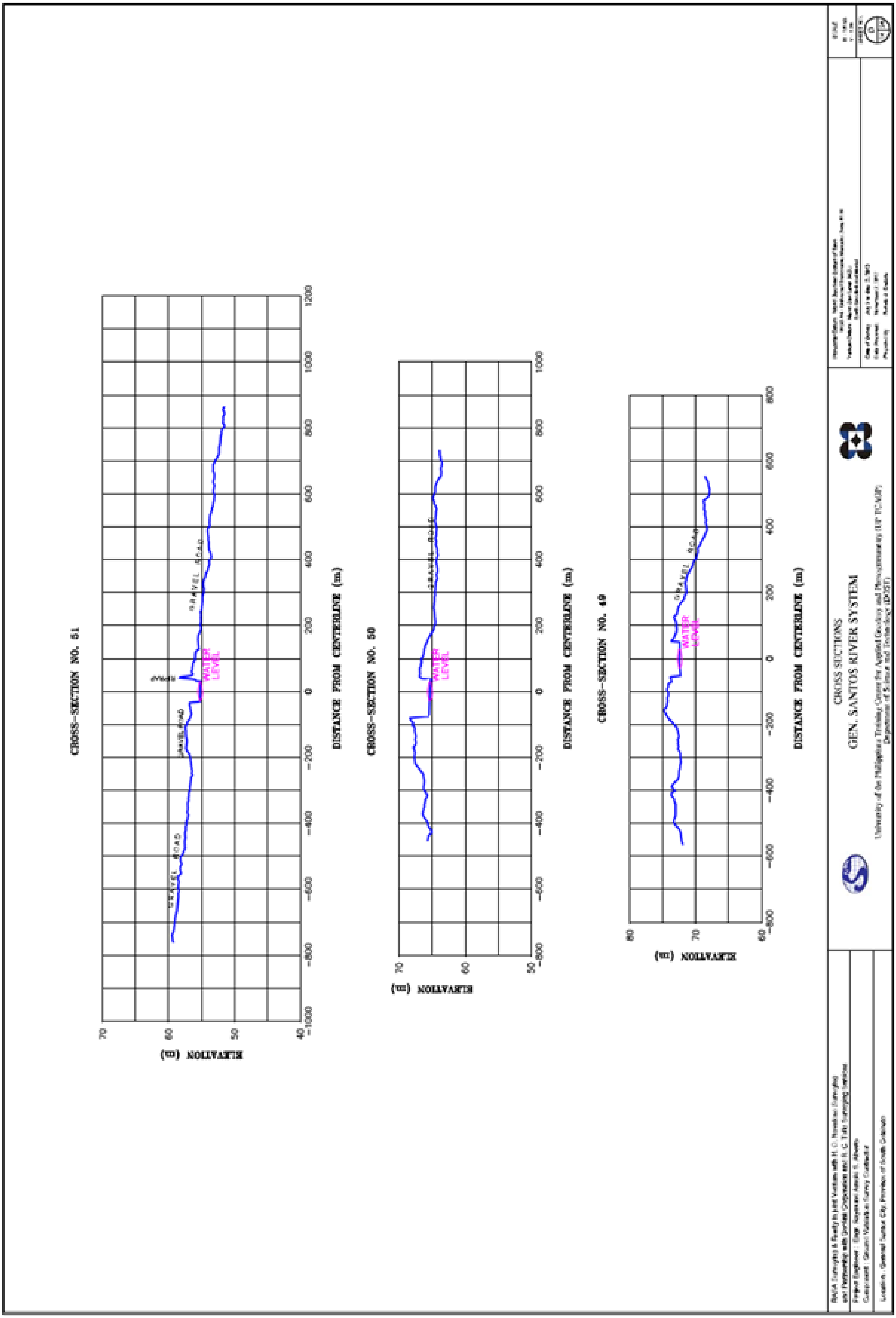

CROSS-SECTION NO. 39
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
CROSS-SECTION NO. 39
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

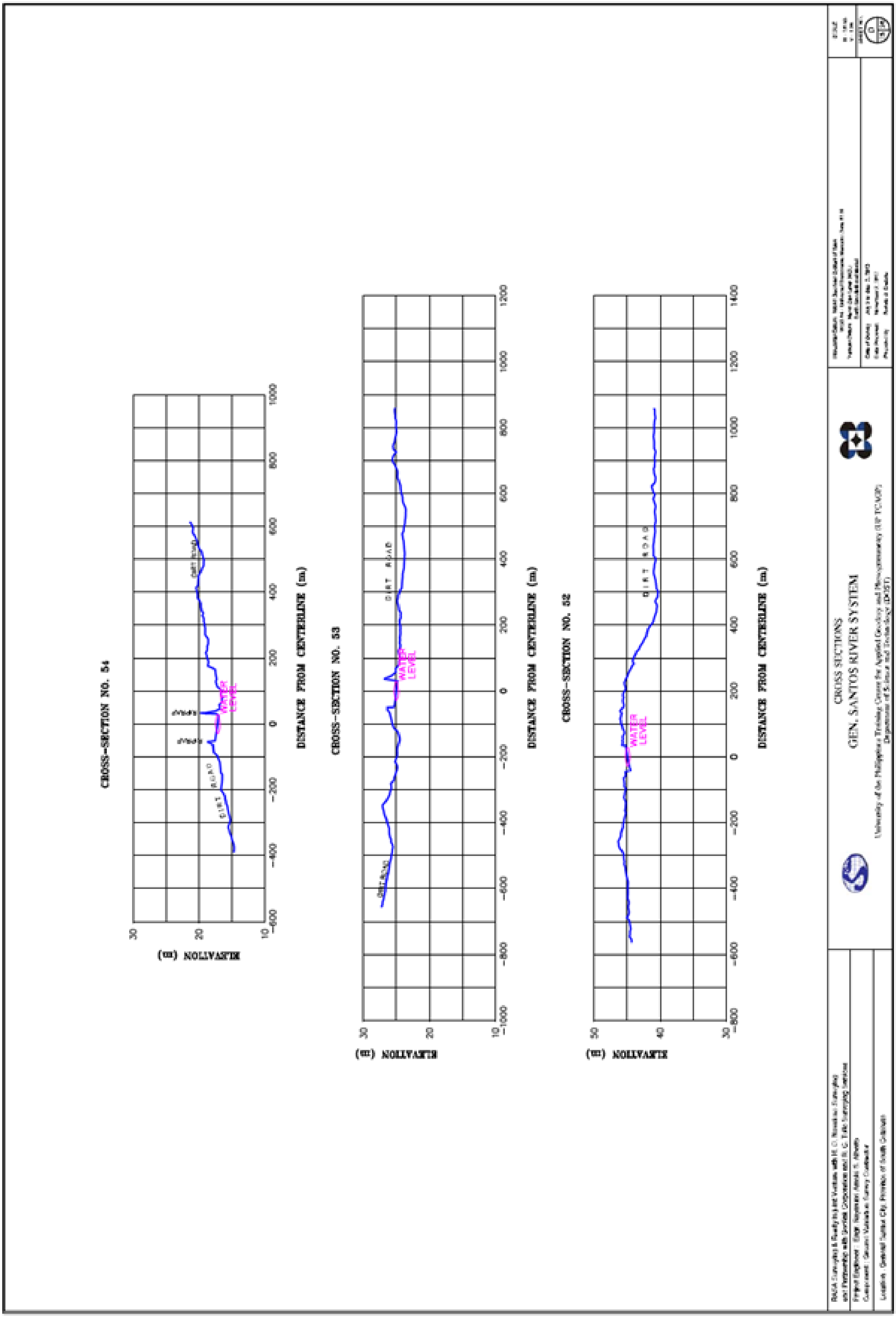


CROSS-SECTION NO. 43
CROSS-SECTION NO. 42
CROSS-SECTION NO. 41
CROSS-SECTION NO. 40
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

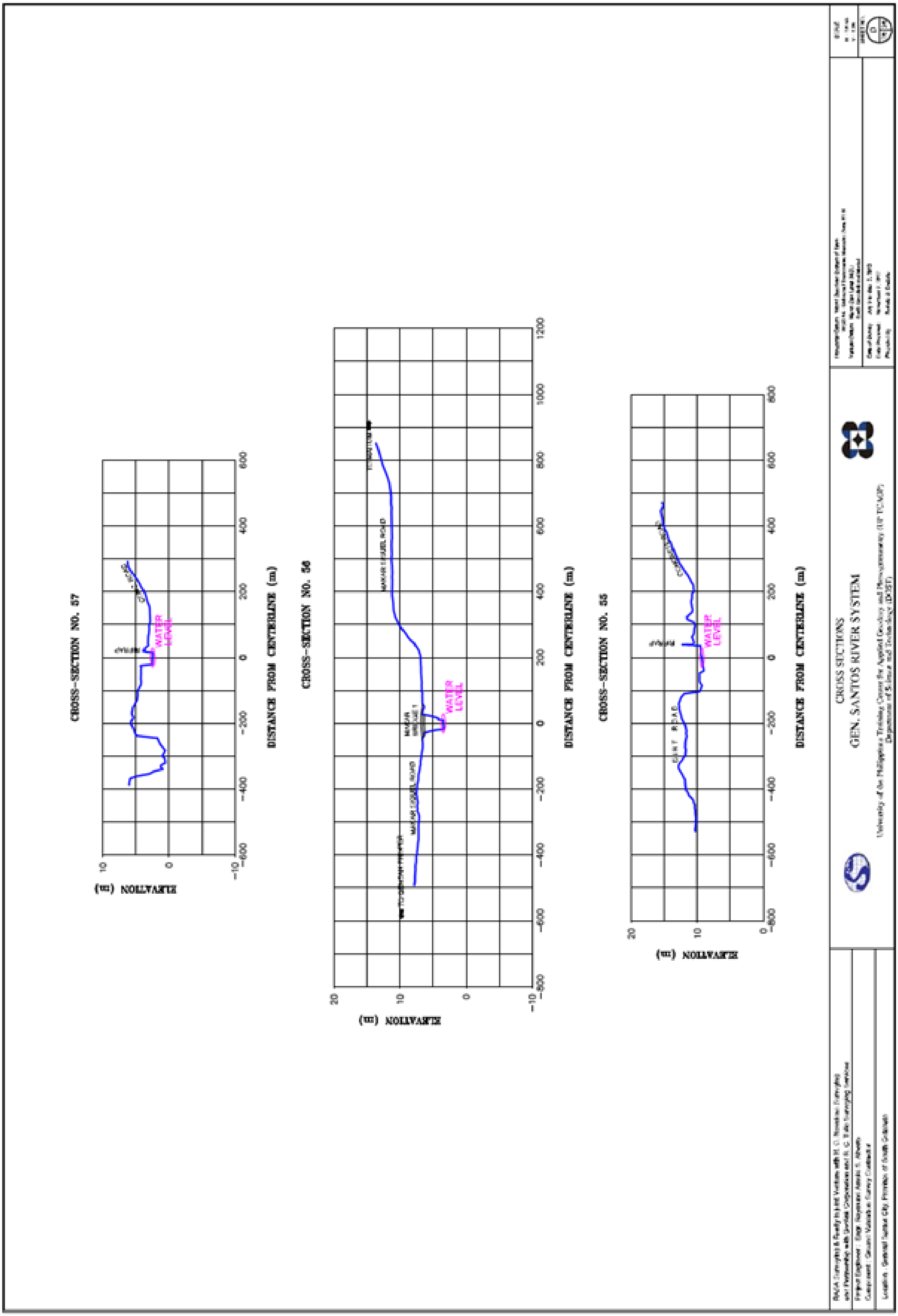

CROSS-SECTION NO. 45
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
CROSS-SECTION NO. 44
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
GRAVEL ROAD
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

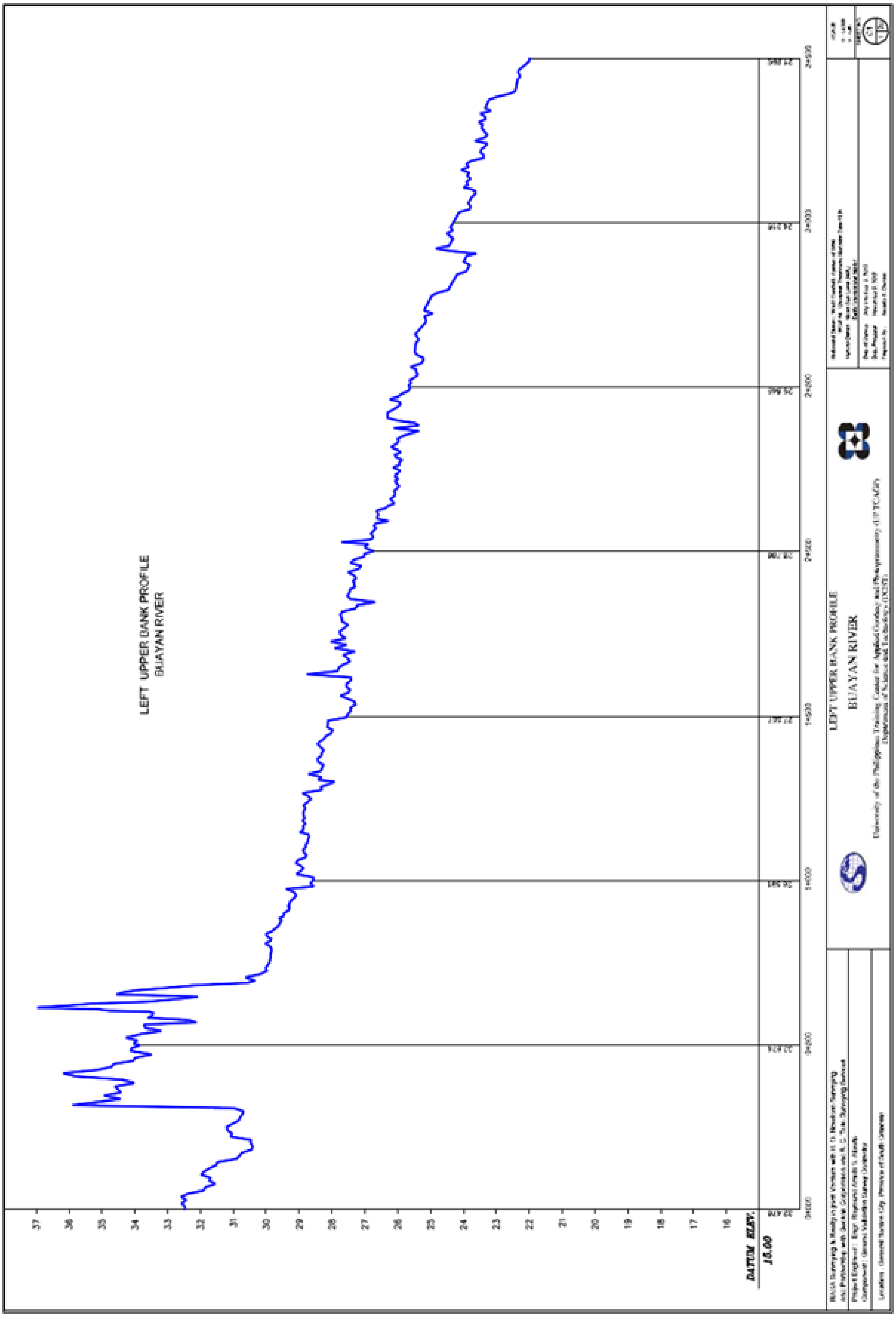

CROSS-SECTION NO. 48
CROSS-SECTION NO. 47
CROSS-SECTION NO. 46
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
GRAVEL ROAD
EXISTING GRAVEL ROAD
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)

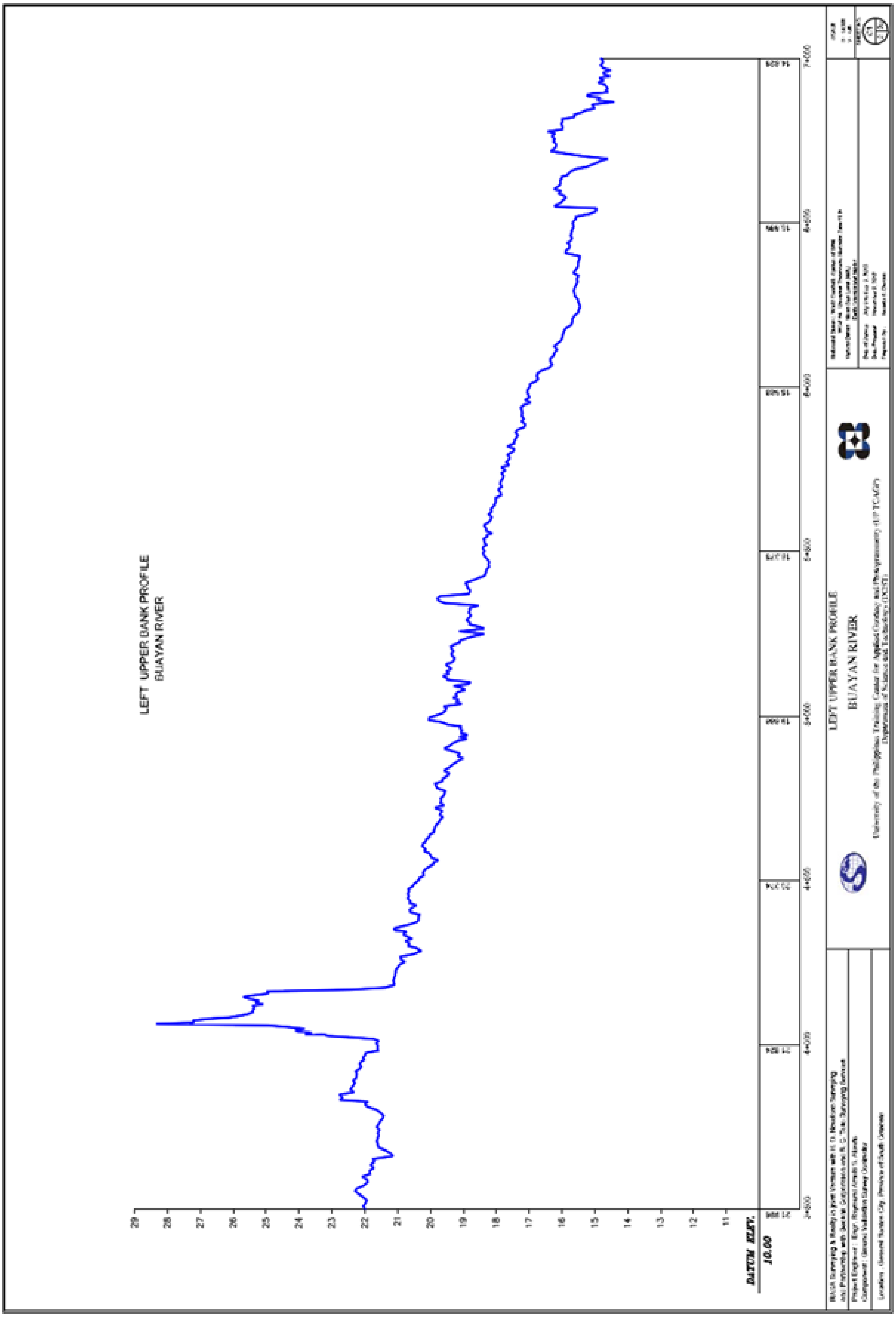

CROSS-SECTION NO. 51
CROSS-SECTION NO. 50
CROSS-SECTION NO. 49
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
GRAVEL ROAD
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

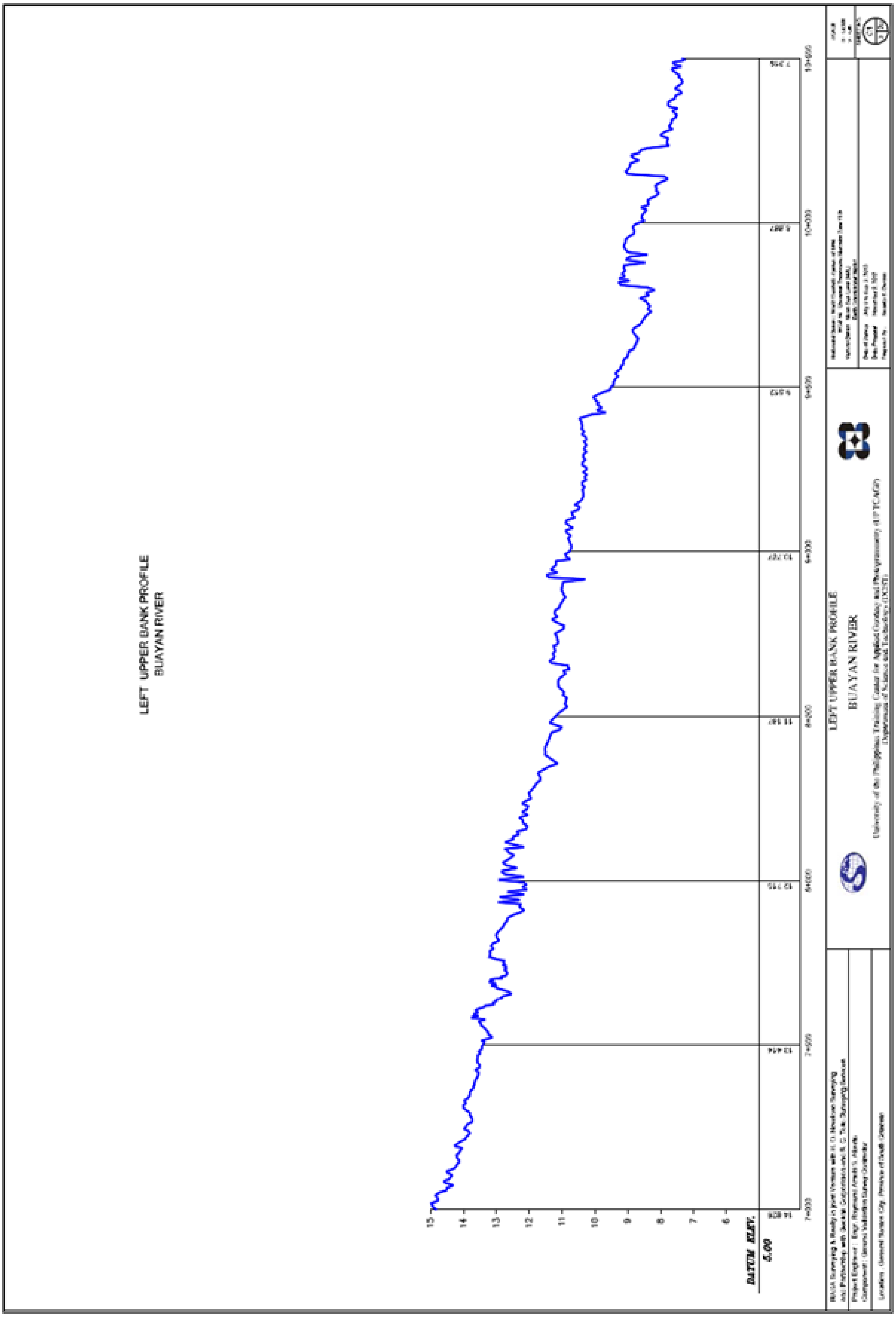


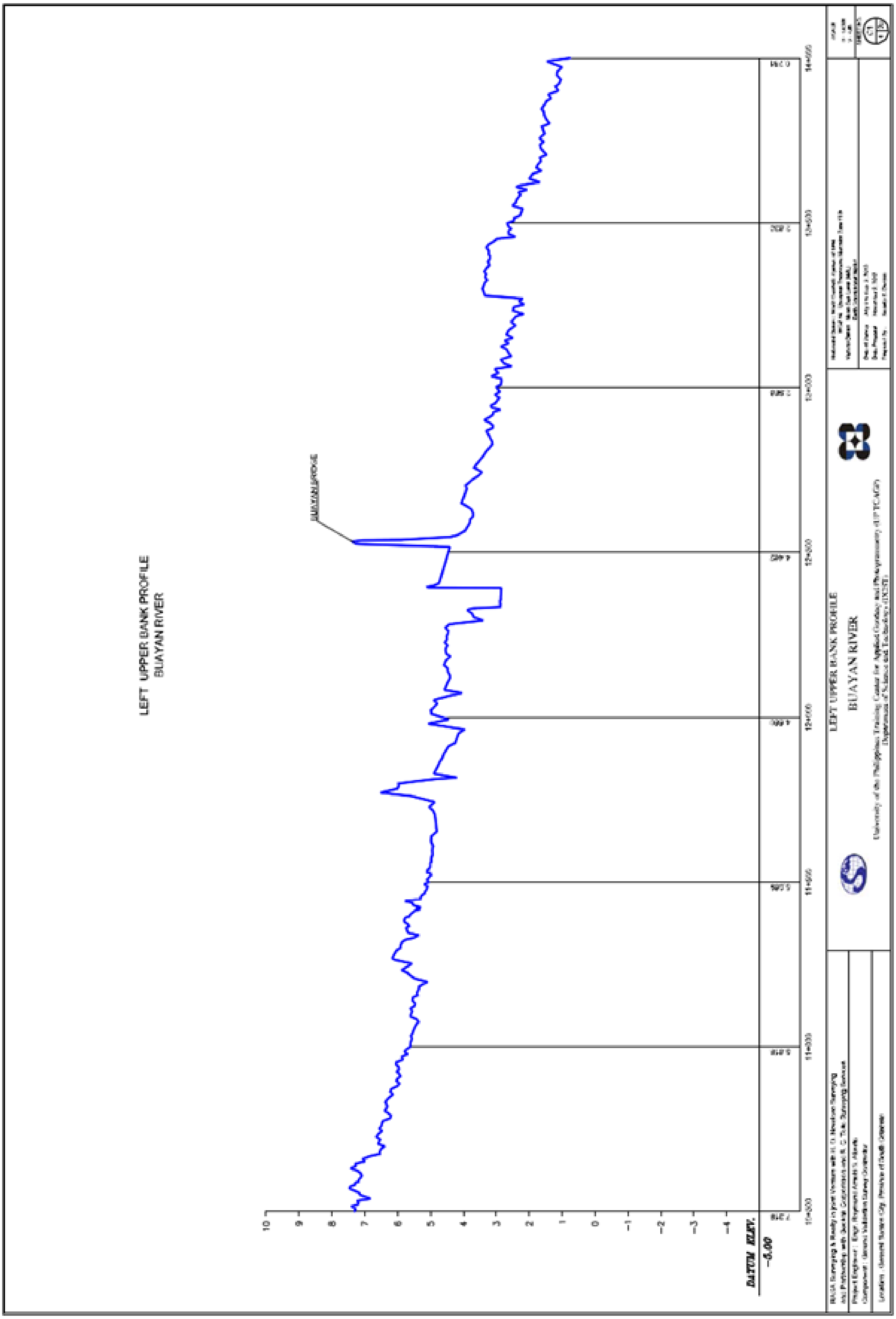
CROSS-SECTION NO. 54
ELEVATION (m)
DISTANCE FROM CENTERLINE (m)
DIRT ROAD
WATER LEVEL
CROSS-SECTION NO. 53
CROSS-SECTION NO. 52
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

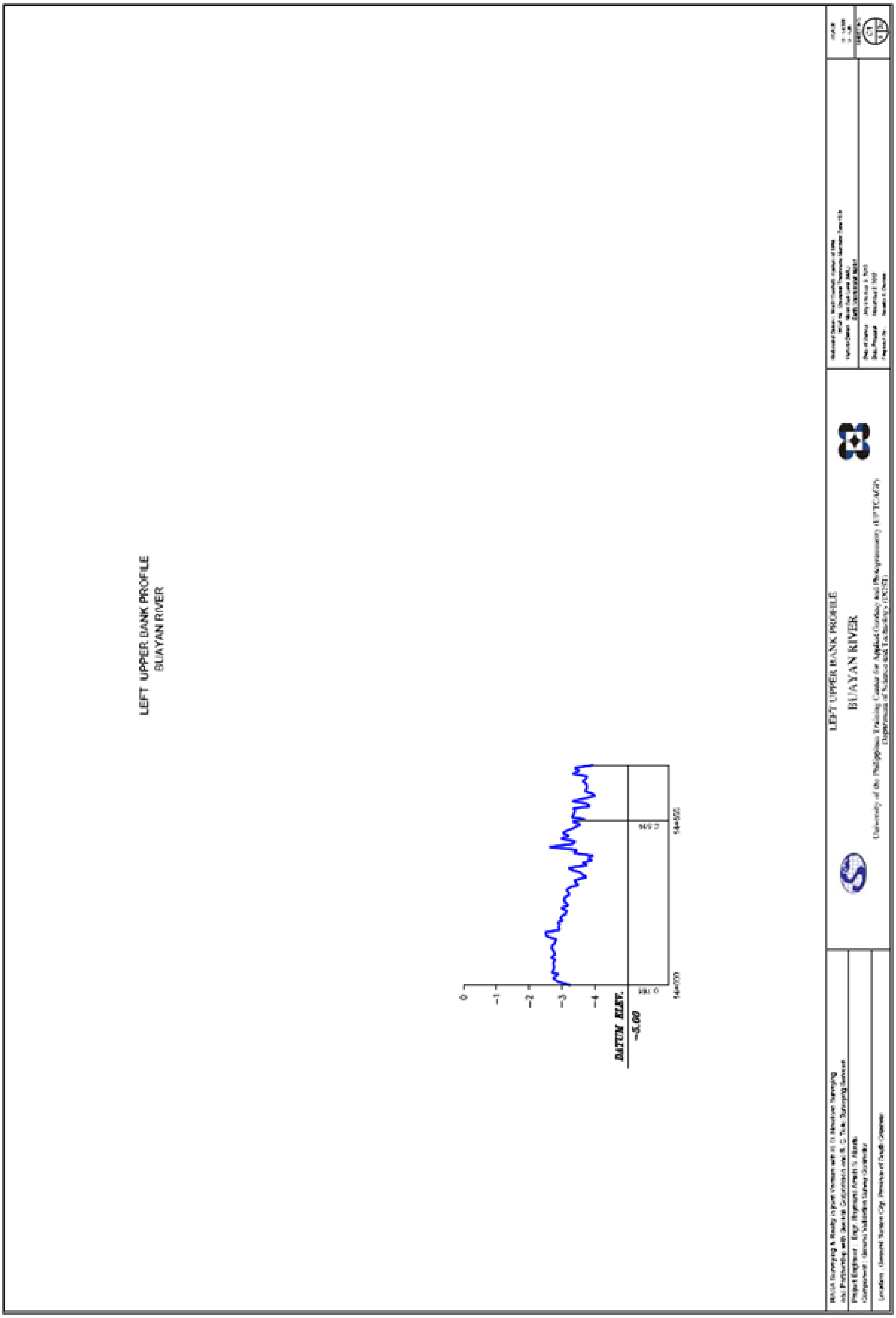

CROSS-SECTION NO. 57
CROSS-SECTION NO. 56
CROSS-SECTION NO. 55
DISTANCE FROM CENTERLINE (m)
ELEVATION (m)
WATER LEVEL
CROSS SECTIONS
GEN. SANTOS RIVER SYSTEM

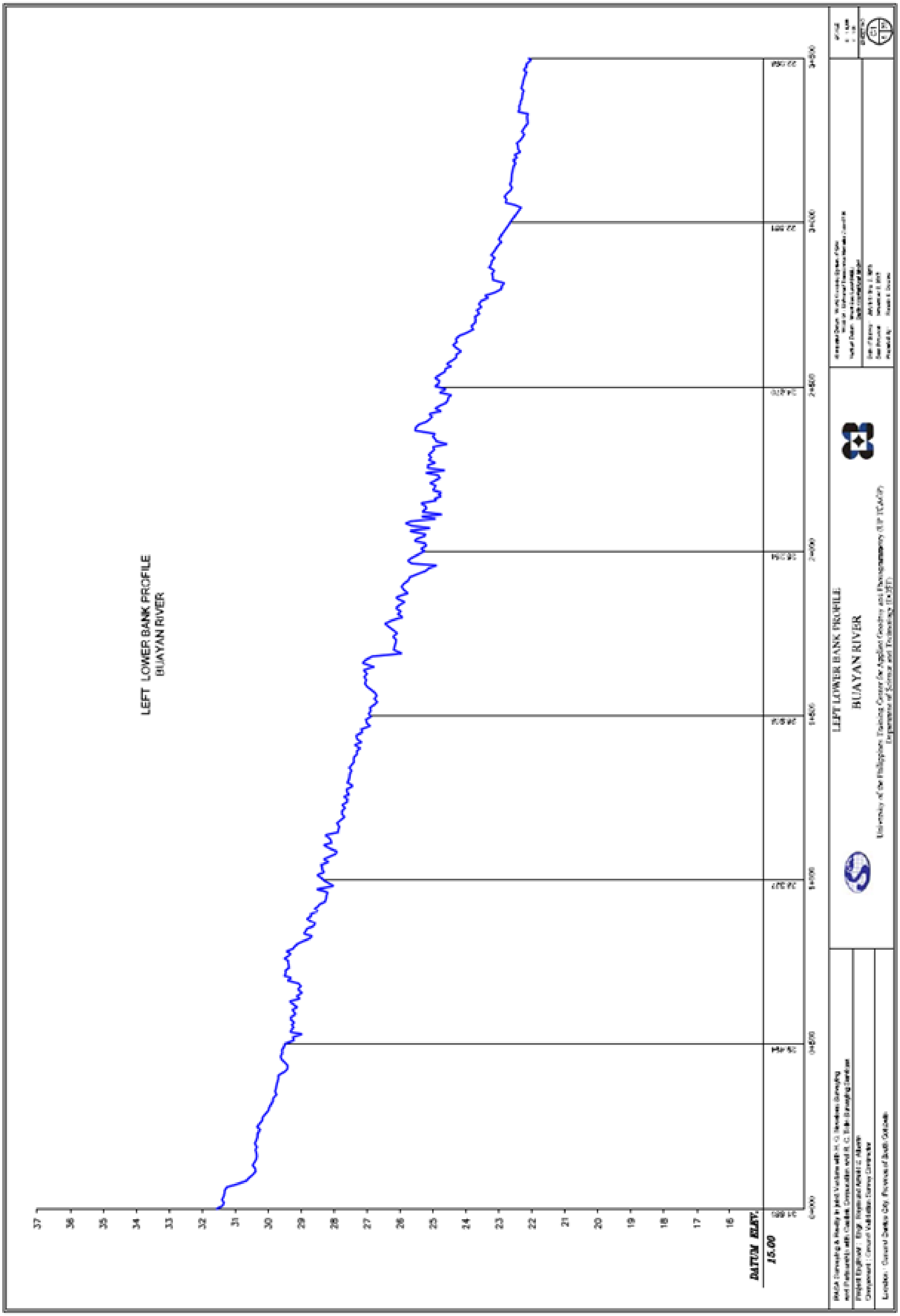

LEFT UPPER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
15.00
LEFT UPPER BANK PROFILE
BUAYAN RIVER
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)

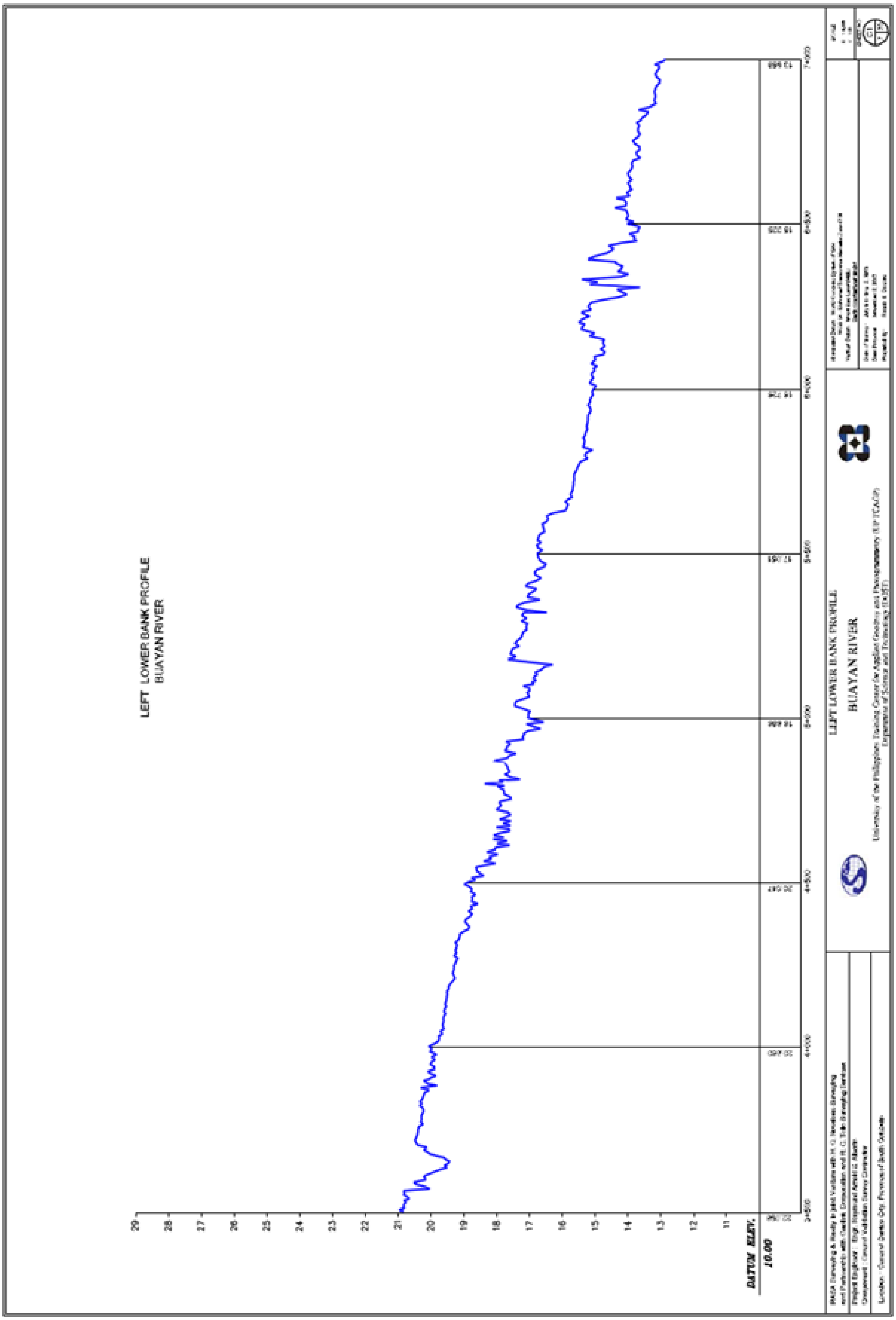

LEFT UPPER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
10.00
LEFT UPPER BANK PROFILE
BUAYAN RIVER

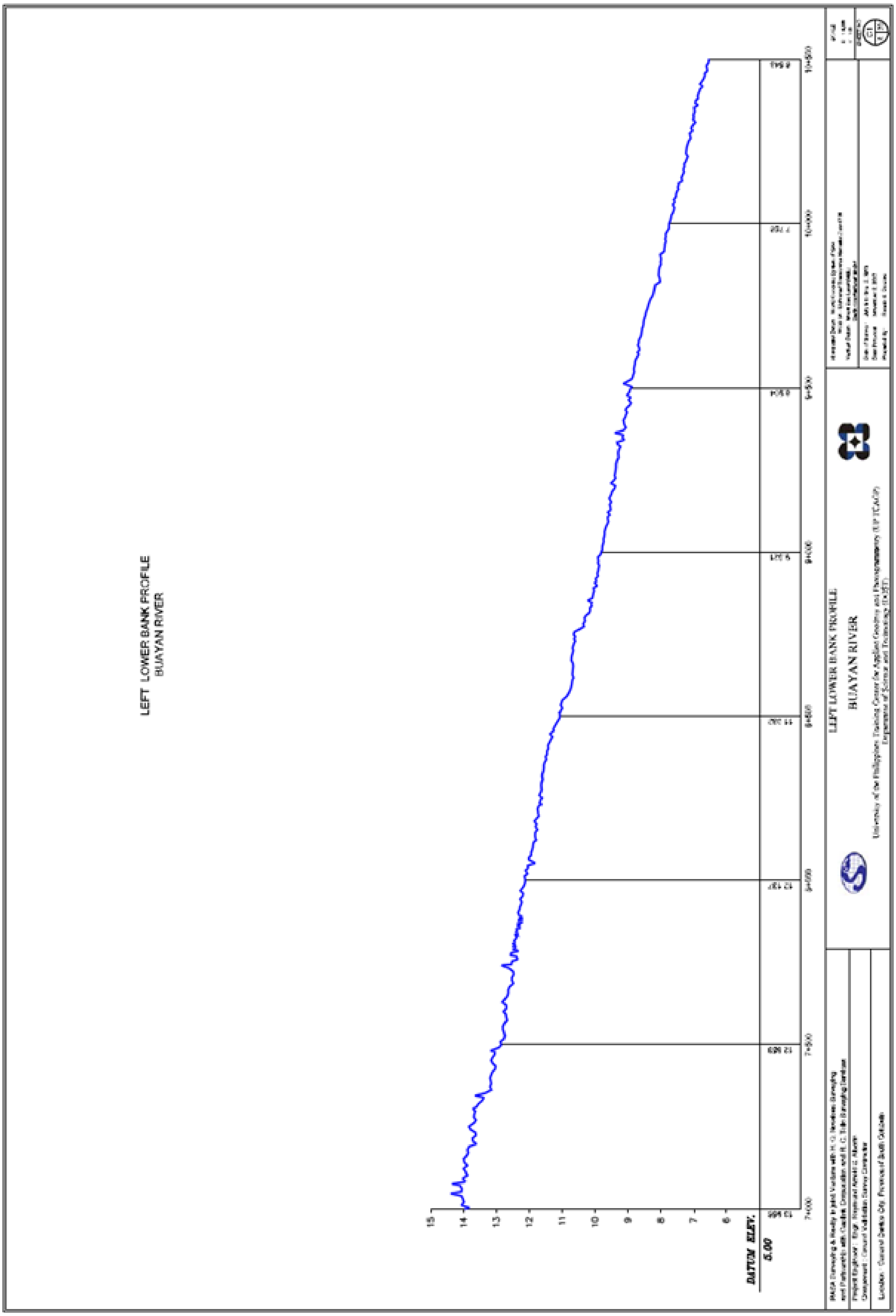

LEFT UPPER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
5.00
LEFT UPPER BANK PROFILE
BUAYAN RIVER

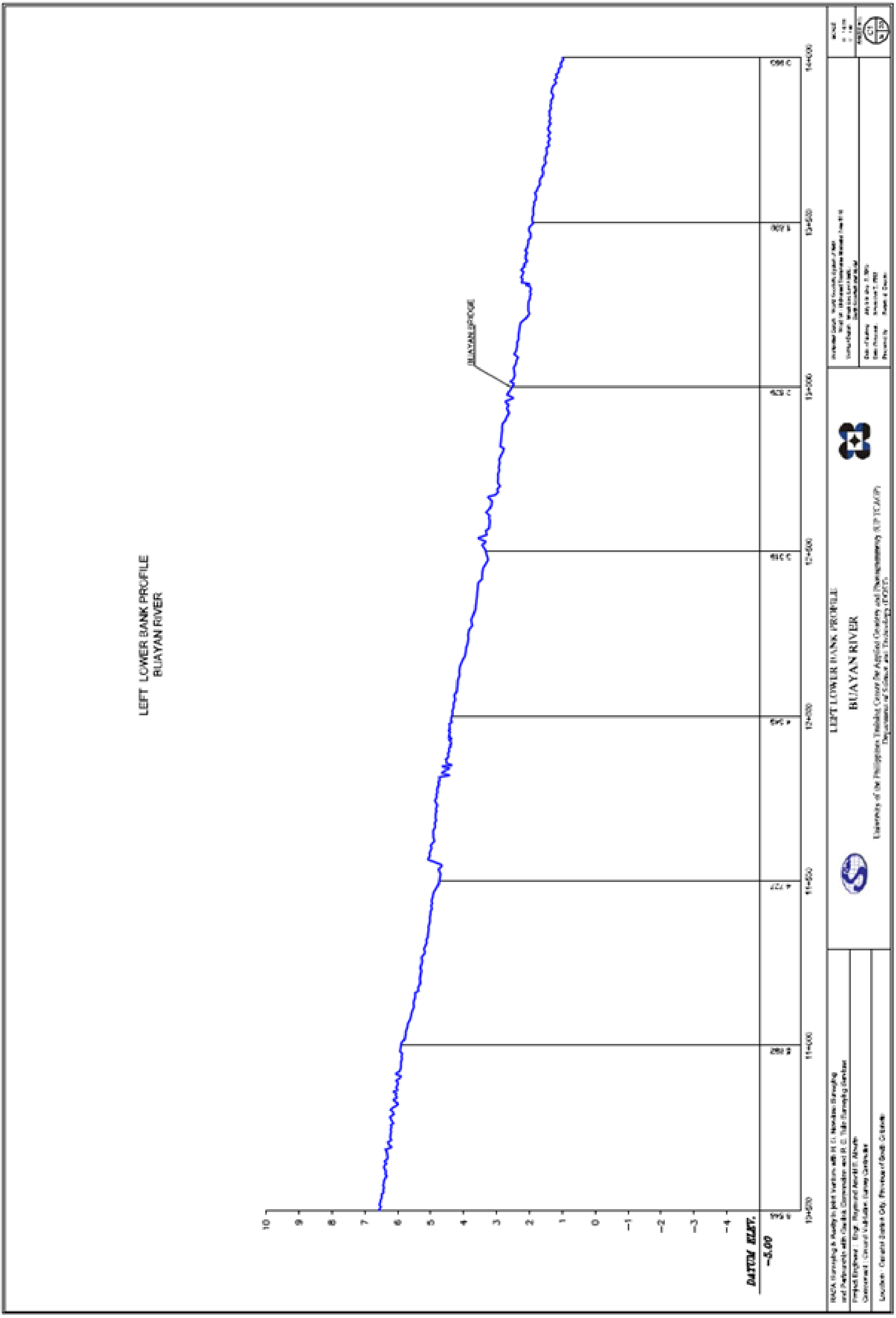

LEFT UPPER BANK PROFILE
BUAYAN RIVER
BUAYAN BRIDGE
DATUM ELEV.
-5.00
LEFT UPPER BANK PROFILE
BUAYAN RIVER

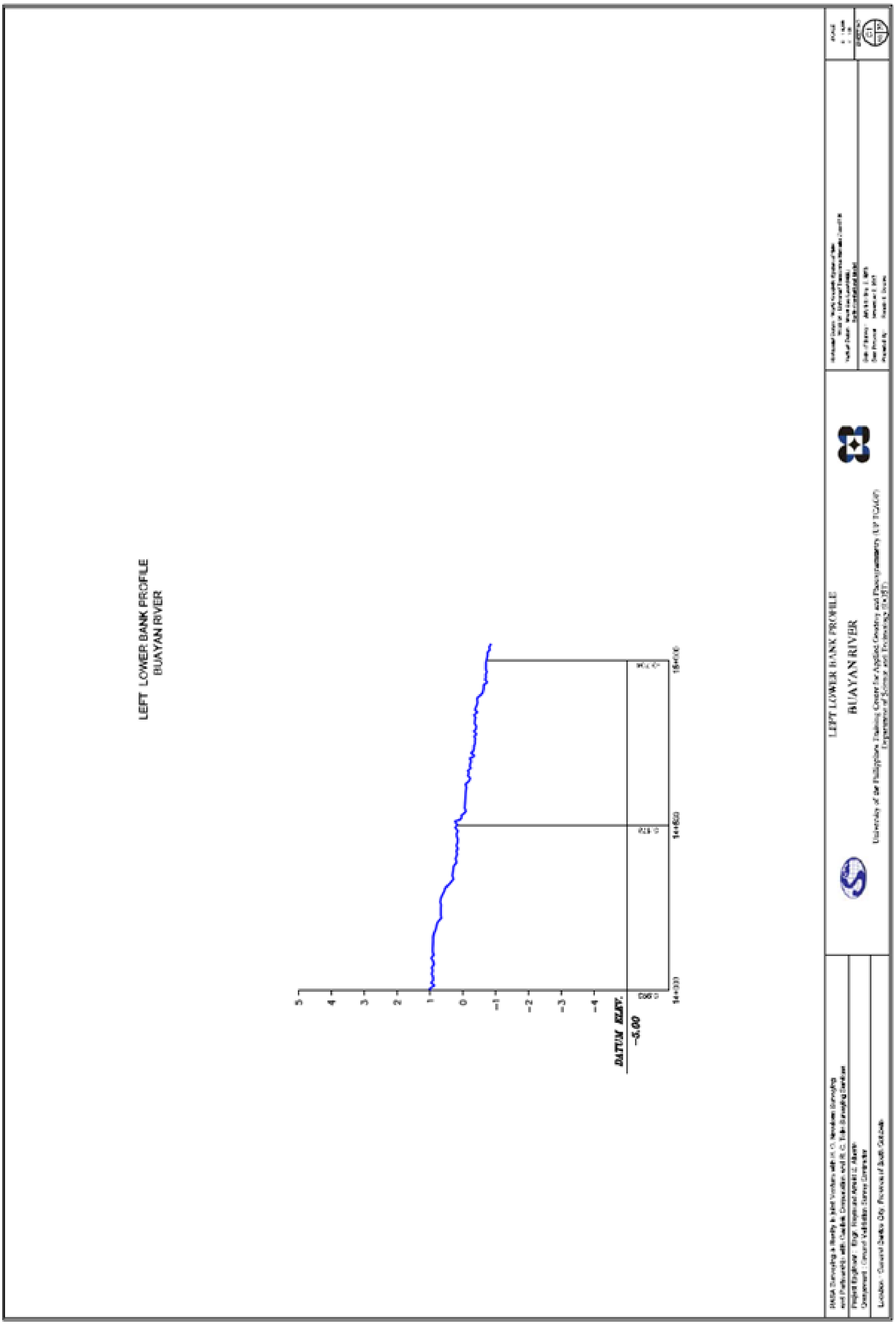

LEFT UPPER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
-5.00
0
-1
-2
-3
-4
LEFT UPPER BANK PROFILE
BUAYAN RIVER

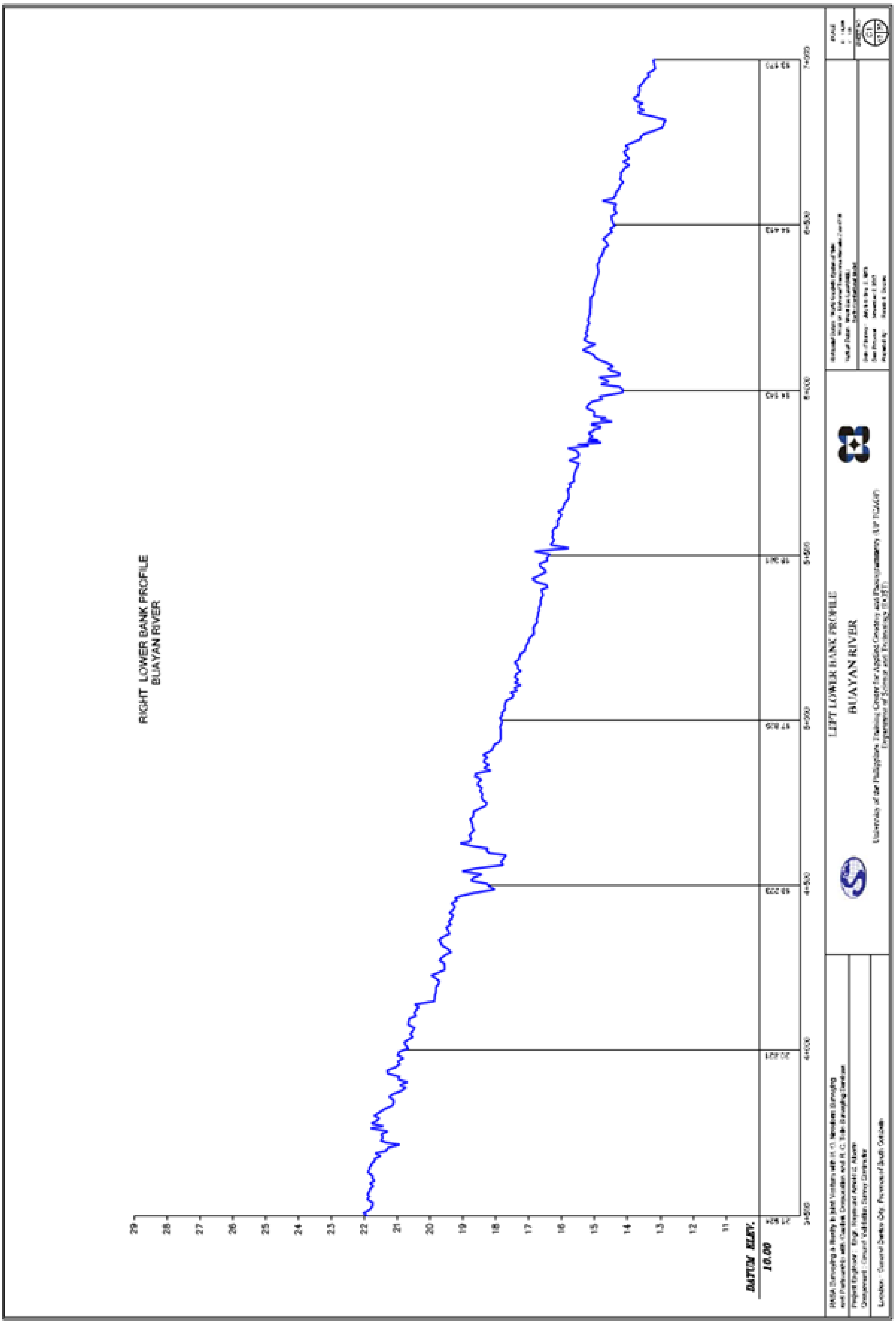

LEFT LOWER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
15.00
LEFT LOWER BANK PROFILE
BUAYAN RIVER

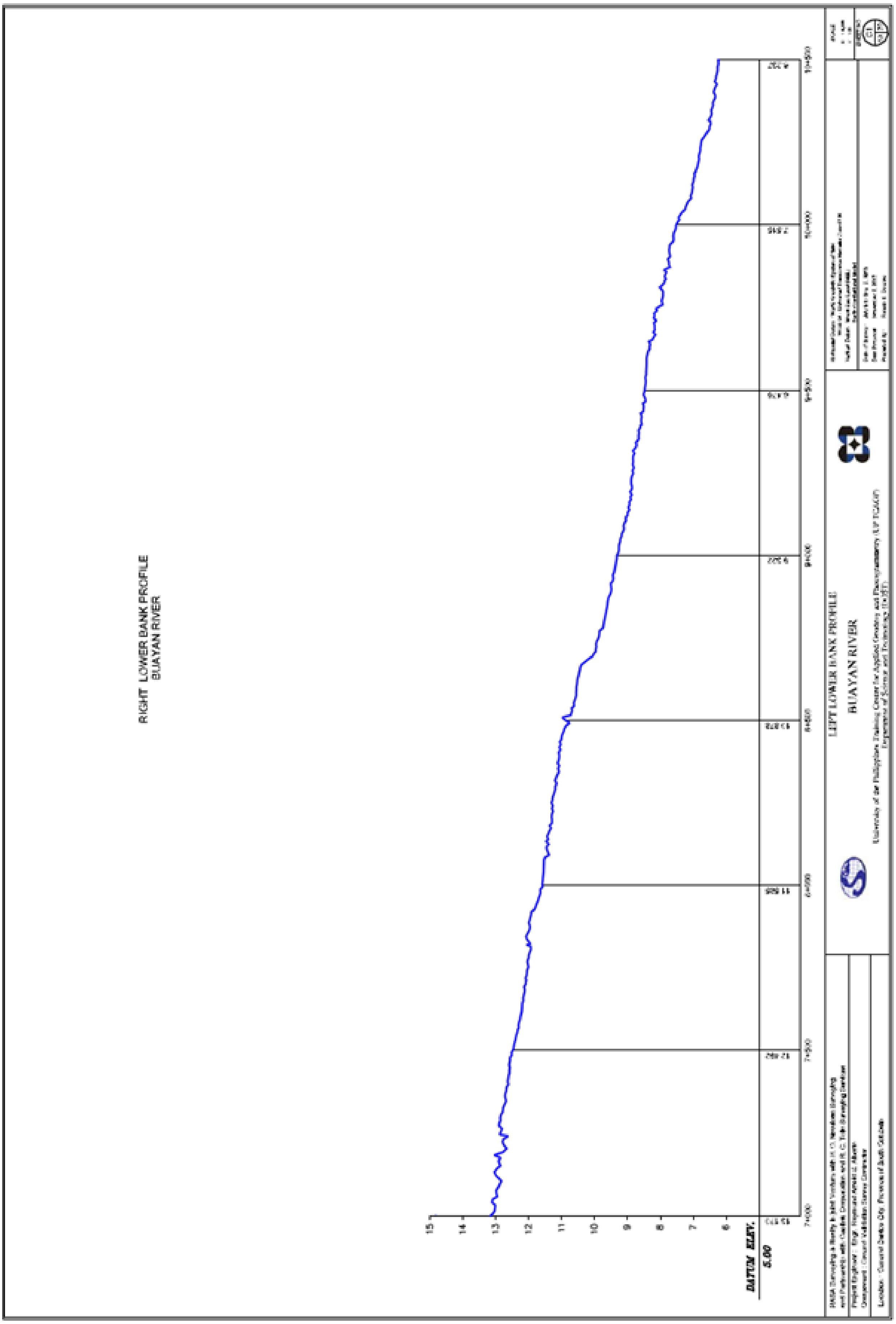

LEFT LOWER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
10.00
LEFT LOWER BANK PROFILE
BUAYAN RIVER

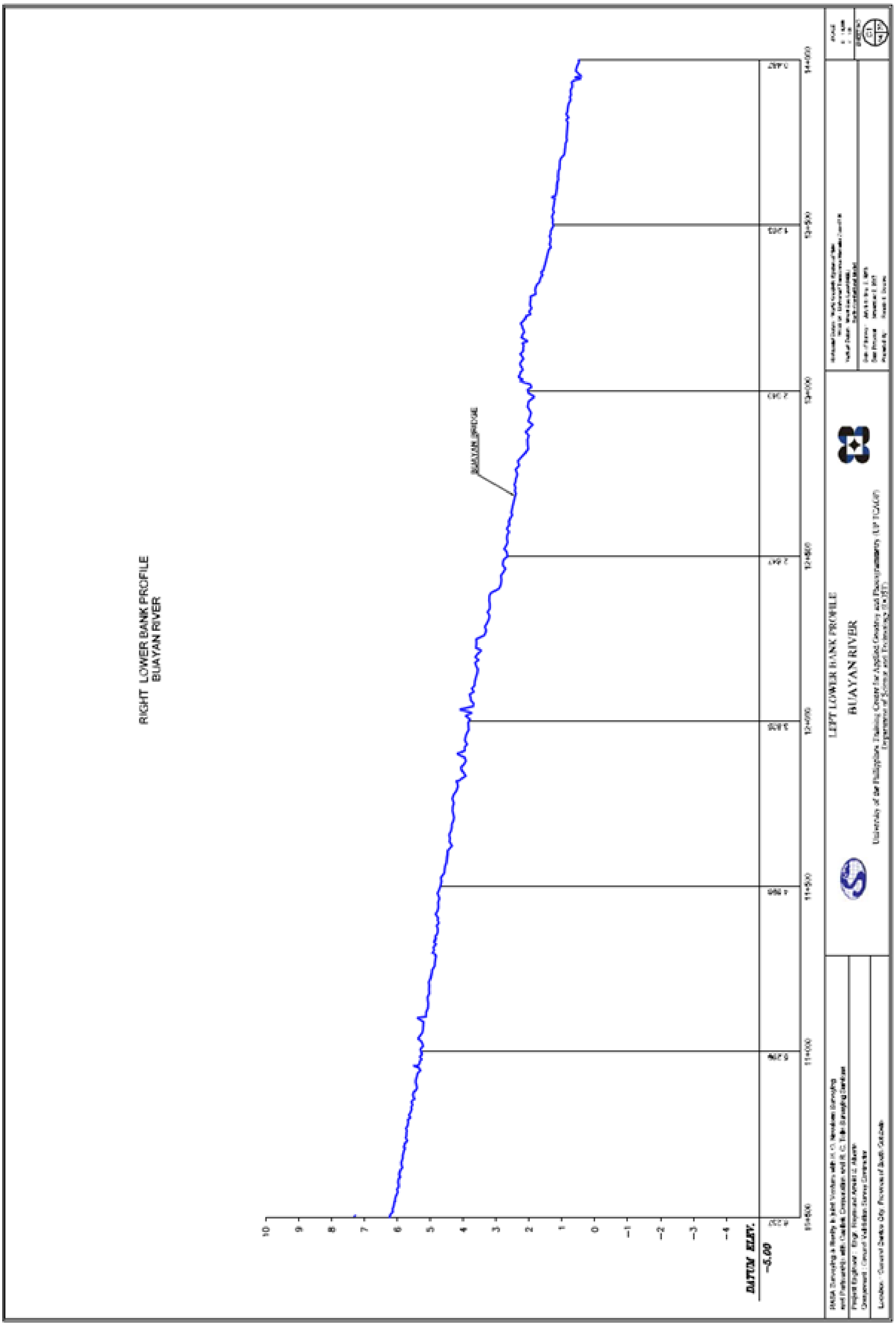

LEFT LOWER BANK PROFILE
BUAYAN RIVER

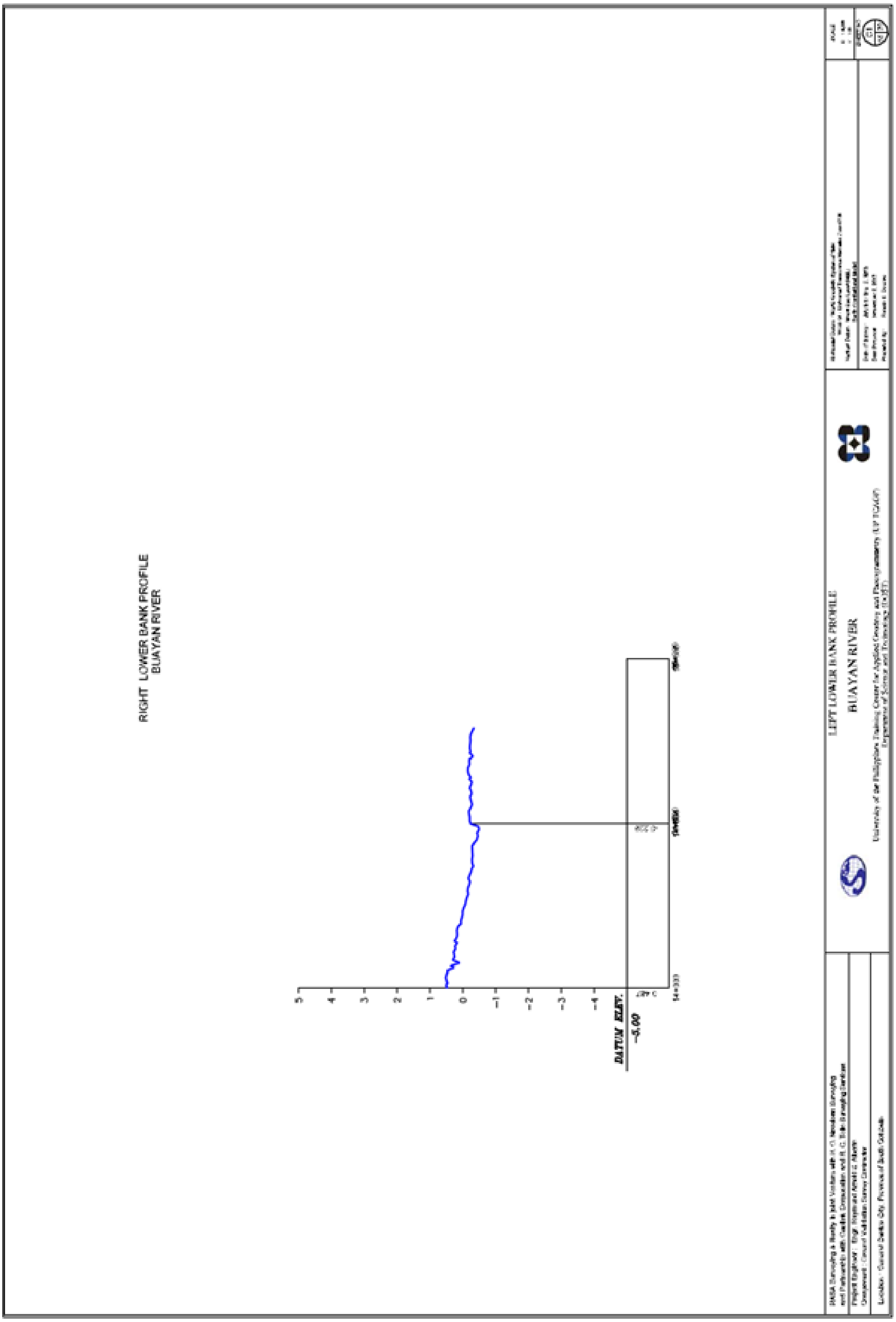

LEFT LOWER BANK PROFILE
BUAYAN RIVER
BUAYAN BRIDGE
DATUM ELEV.
-5.00
LEFT LOWER BANK PROFILE
BUAYAN RIVER

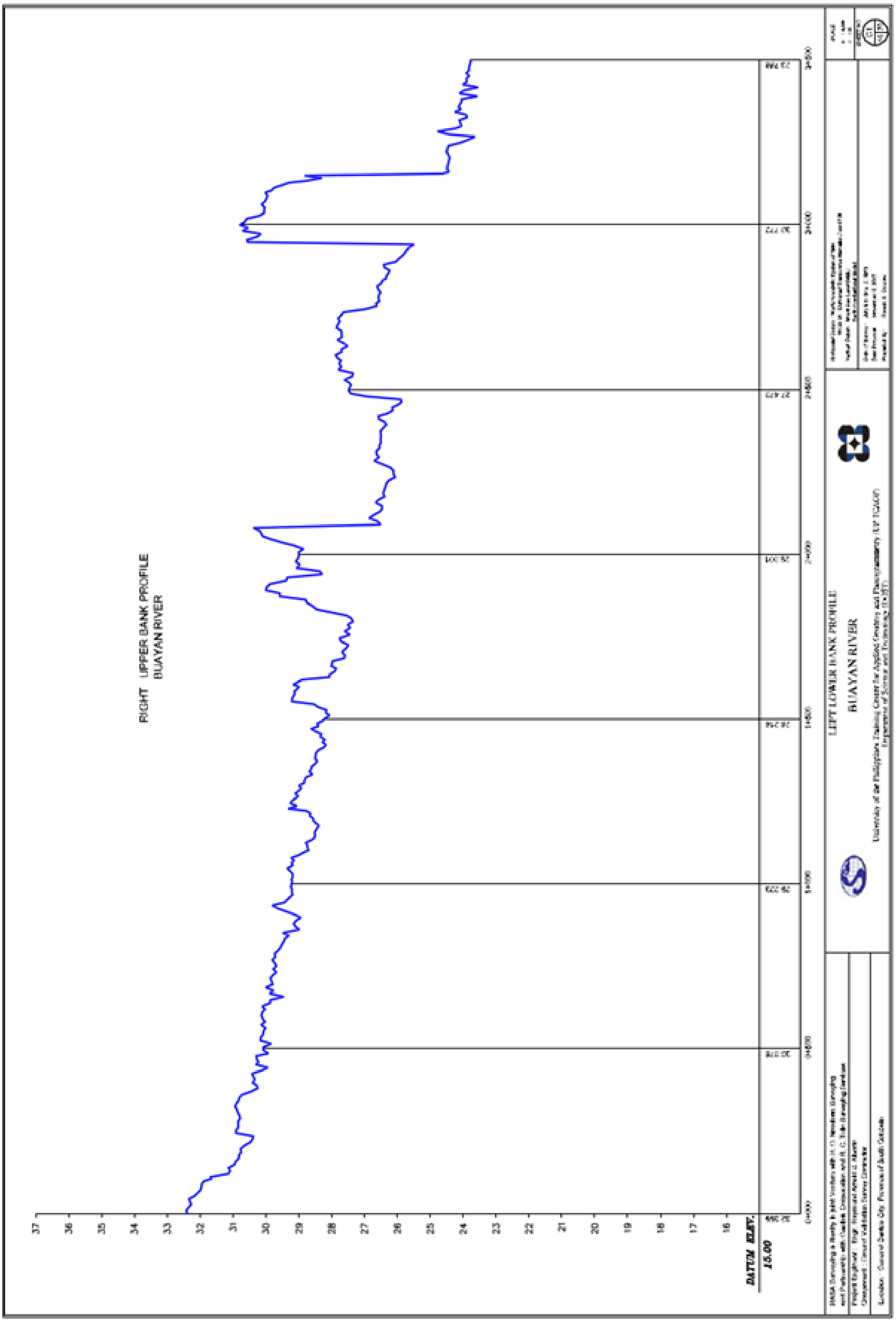

LEFT LOWER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
-5.00
14+000
14+500
15+000
LEFT LOWER BANK PROFILE
BUAYAN RIVER

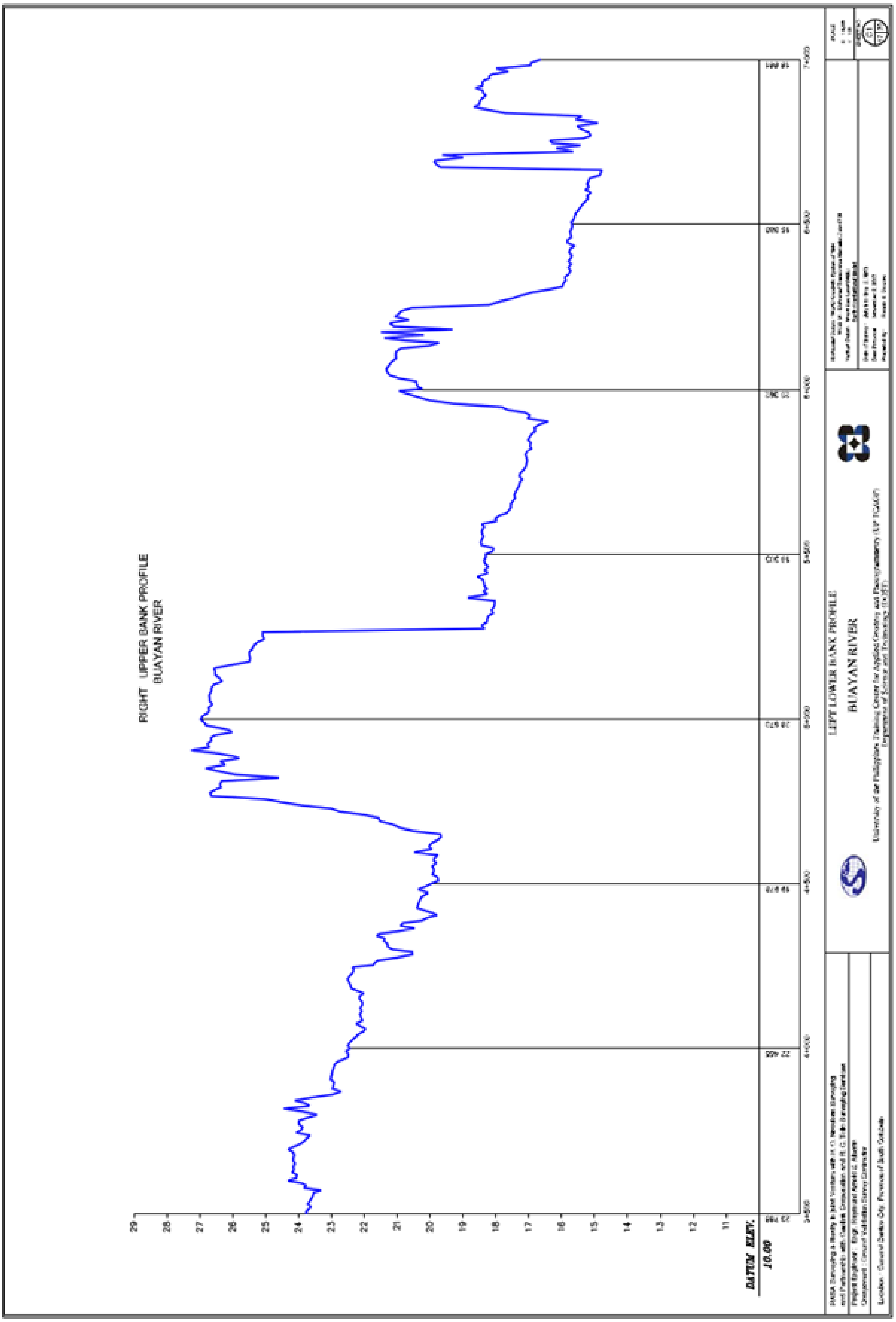

RIGHT LOWER BANK PROFILE
BUAYAN RIVER
LEFT LOWER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
10.00

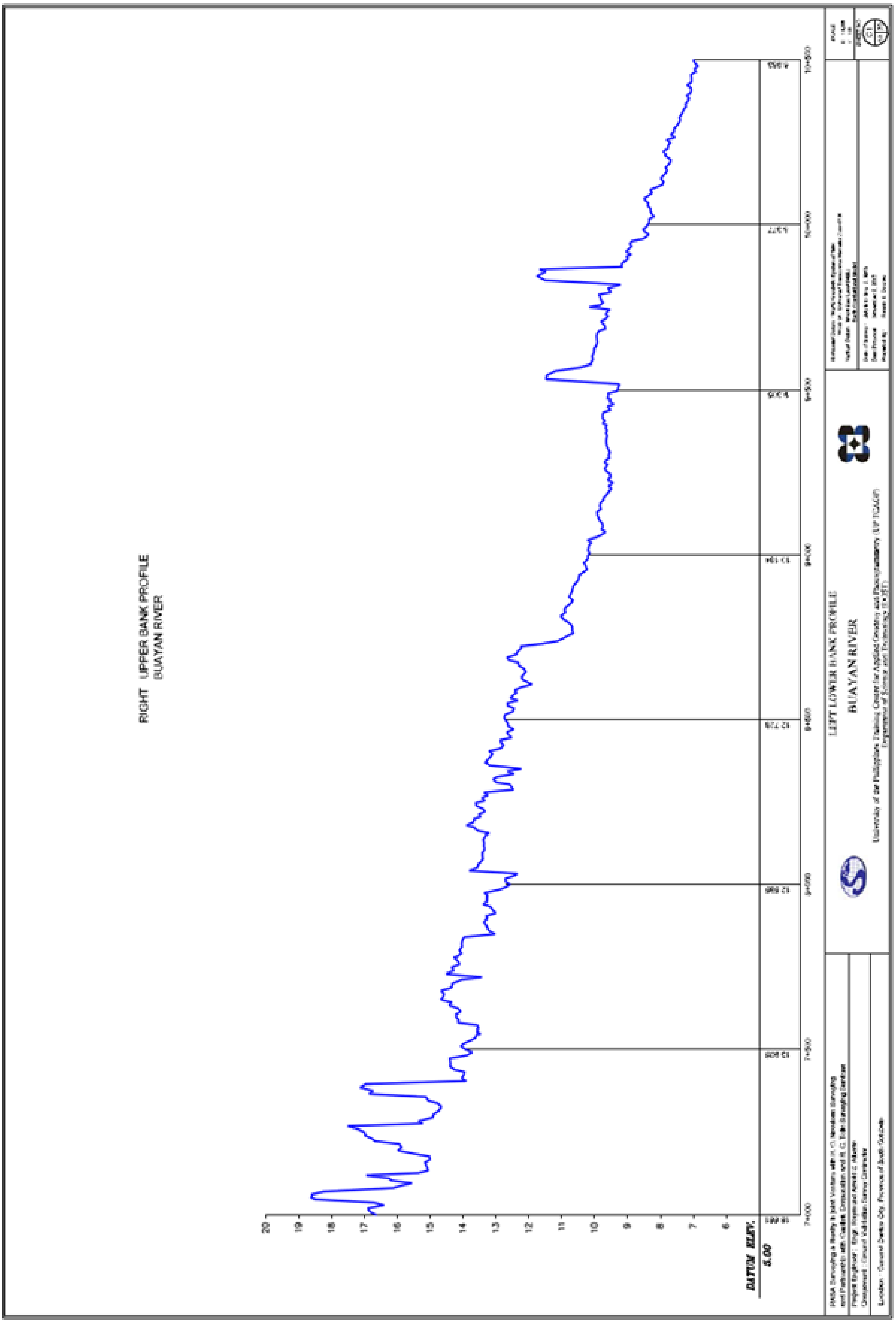

RIGHT LOWER BANK PROFILE
BUAYAN RIVER
LEFT LOWER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
5.00

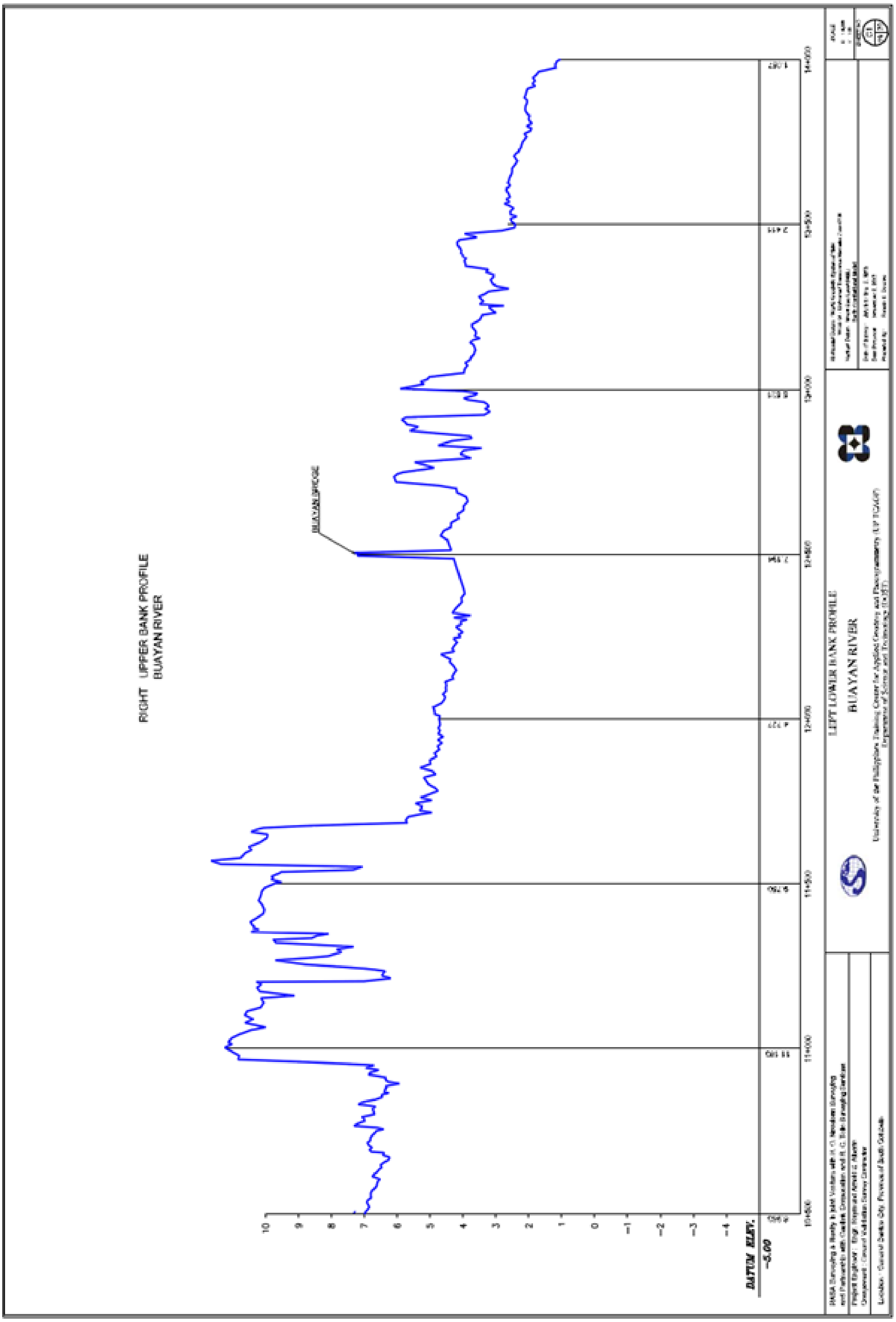

RIGHT LOWER BANK PROFILE
BUAYAN RIVER
BUAYAN BRIDGE
LEFT LOWER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
-5.00

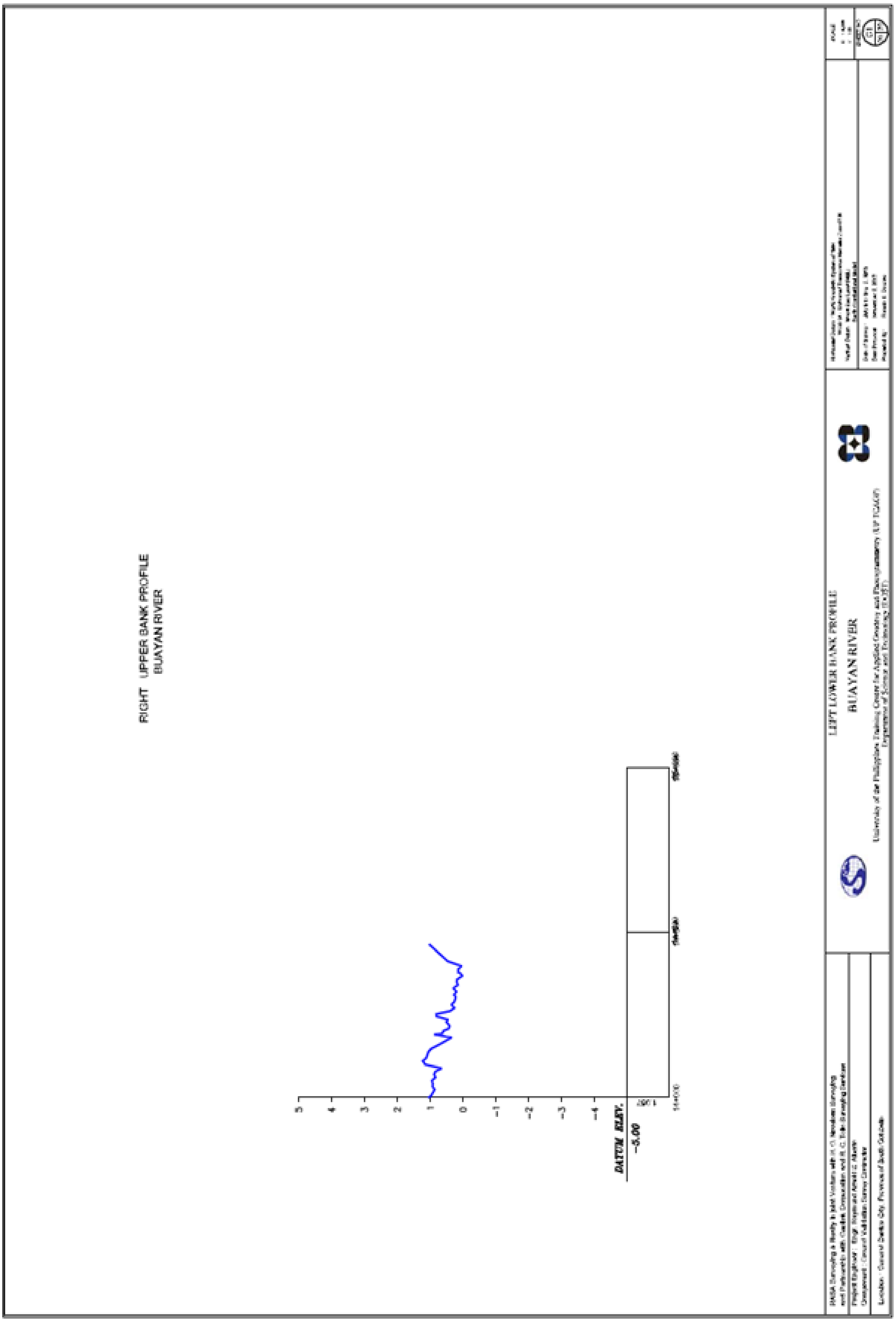

RIGHT LOWER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
-5.00
LEFT LOWER BANK PROFILE
BUAYAN RIVER

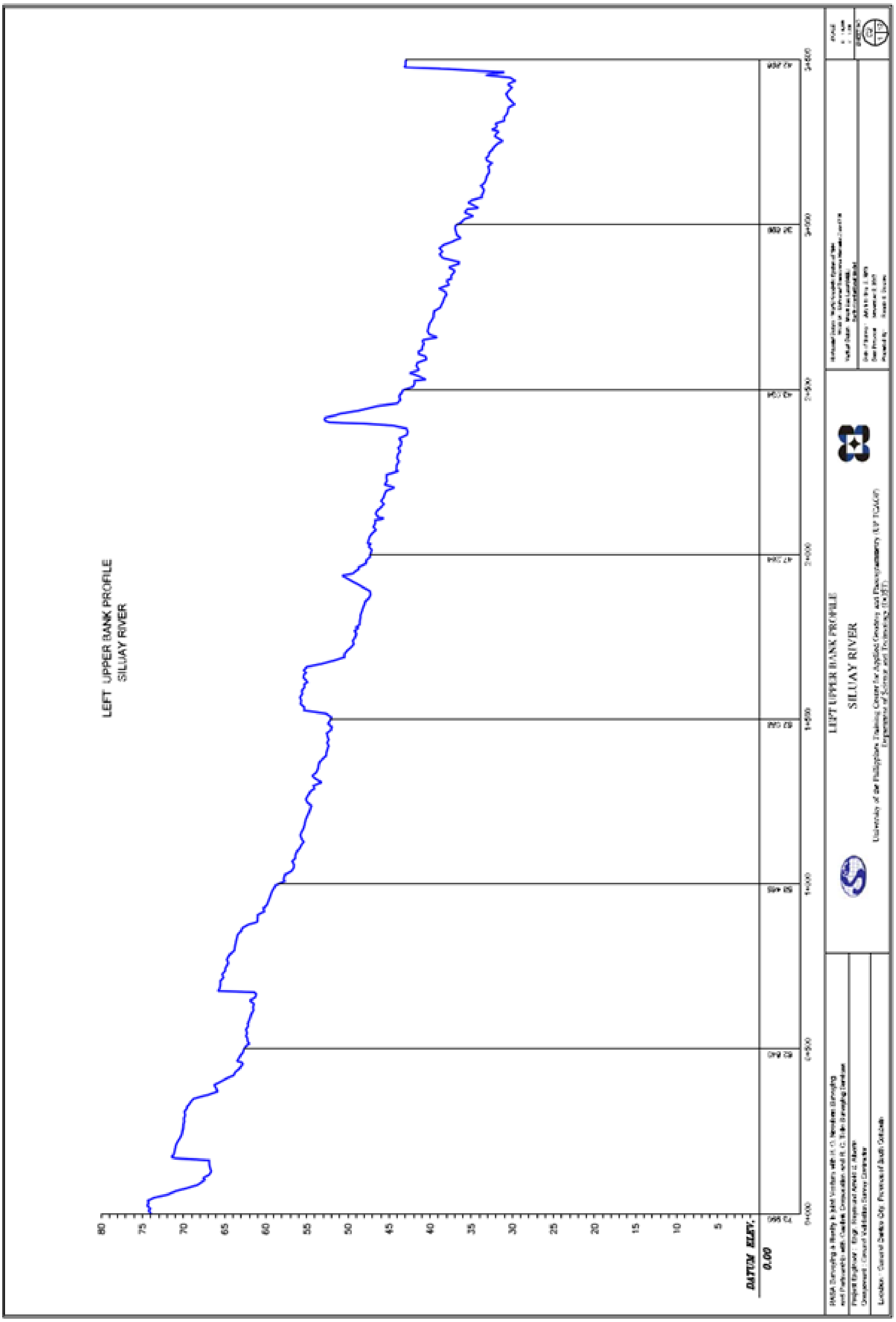

RIGHT UPPER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
15.00
LEFT LOWER BANK PROFILE
BUAYAN RIVER

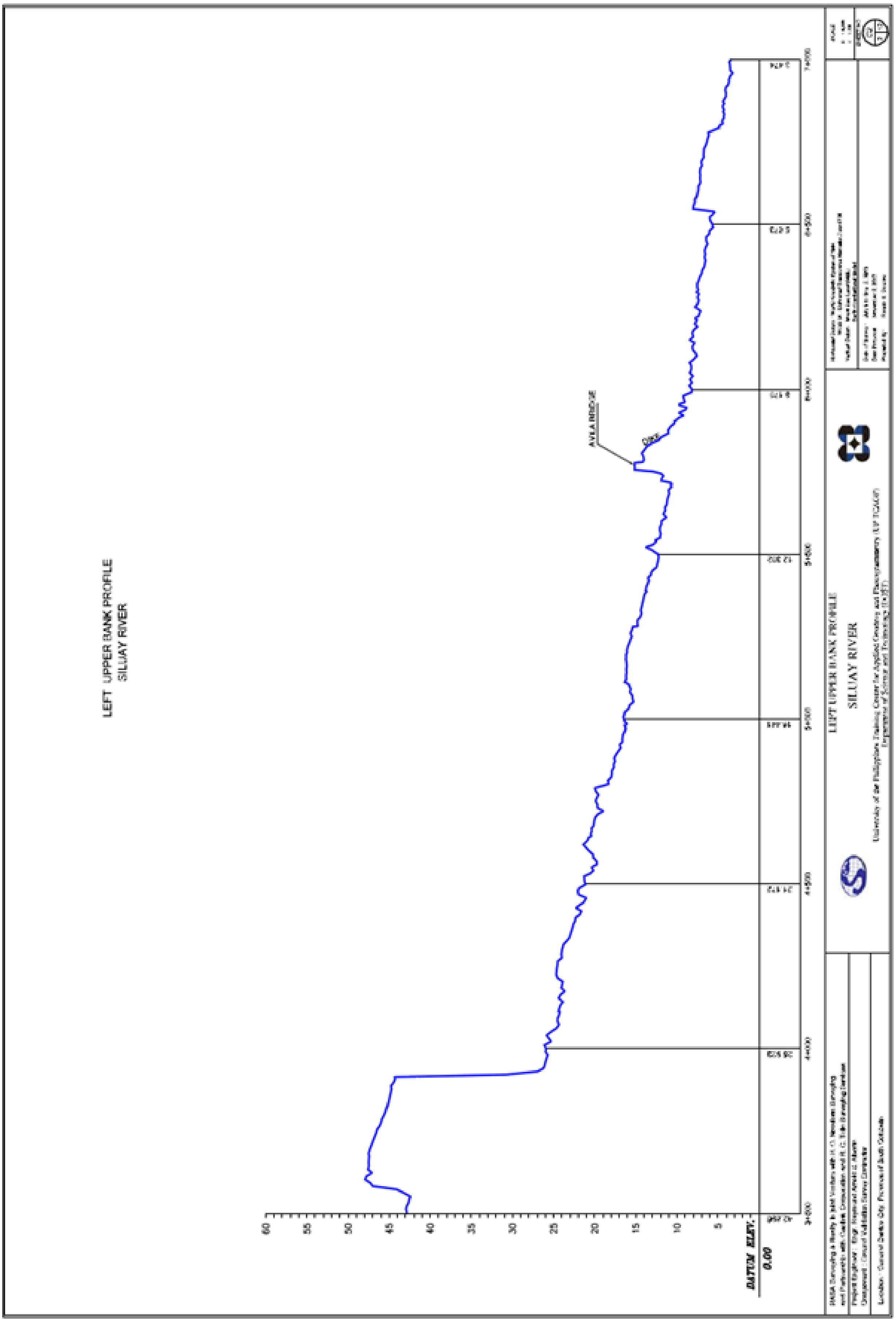

RIGHT UPPER BANK PROFILE
BUAYAN RIVER
LEFT LOWER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
10.00

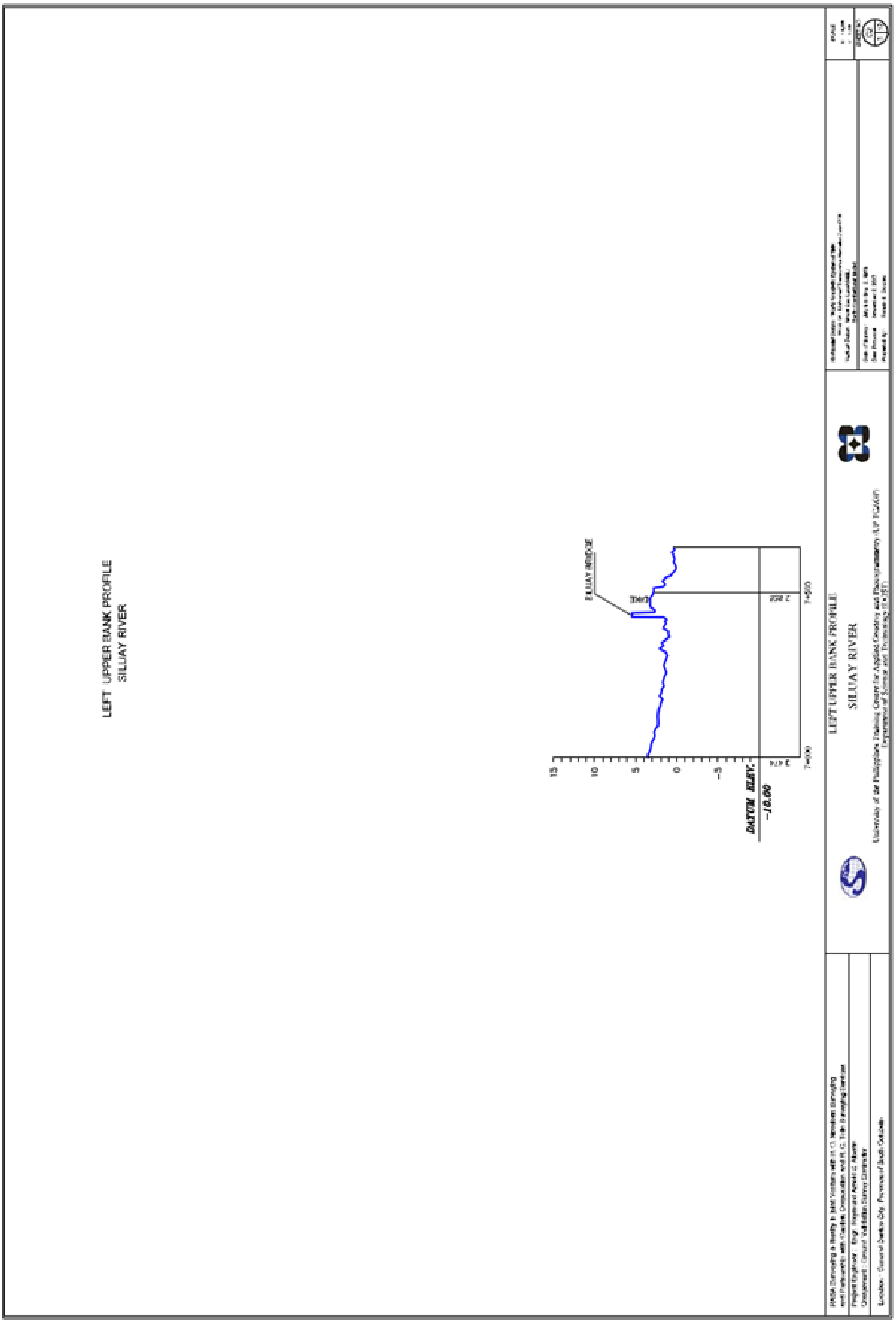

RIGHT UPPER BANK PROFILE
BUAYAN RIVER
LEFT LOWER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
5.00

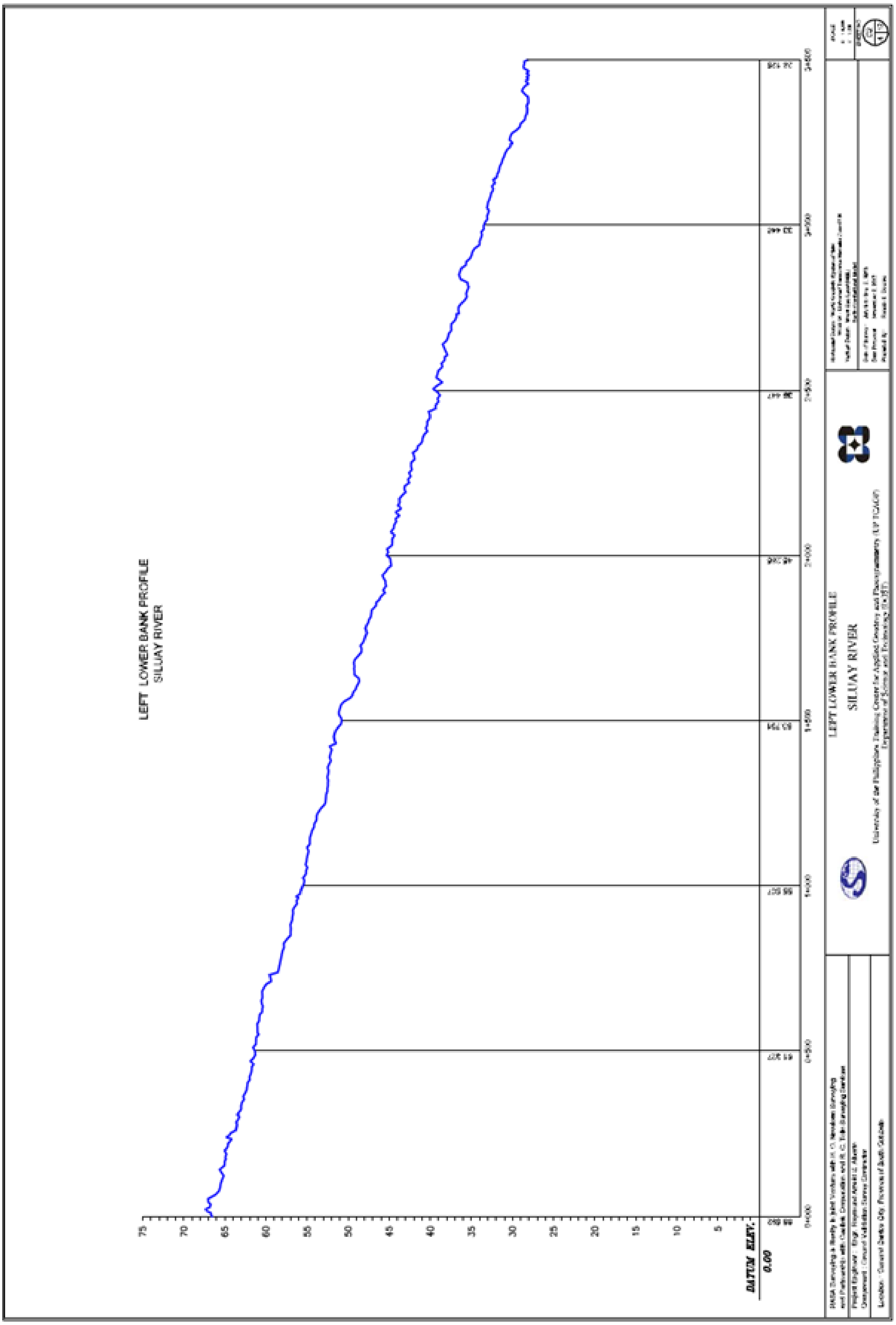

RIGHT UPPER BANK PROFILE
BUAYAN RIVER
BUAYAN BRIDGE
DATUM ELEV.
-5.00
LEFT LOWER BANK PROFILE
BUAYAN RIVER


RIGHT UPPER BANK PROFILE
BUAYAN RIVER
LEFT LOWER BANK PROFILE
BUAYAN RIVER
DATUM ELEV.
-5.00


LEFT UPPER BANK PROFILE
SILUAY RIVER


LEFT UPPER BANK PROFILE
SILUAY RIVER
AVILA BRIDGE
DATUM ELEV.
0.00
60
55
50
45
40
35
30
25
20
15
10
5
LEFT UPPER BANK PROFILE
SILUAY RIVER


LEFT UPPER BANK PROFILE
SILUAY RIVER
SILUAY BRIDGE
DATUM ELEV.
-10.00
LEFT UPPER BANK PROFILE
SILUAY RIVER


LEFT LOWER BANK PROFILE
SILUAY RIVER
DATUM ELEV.
0.00
75
70
65
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55
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45
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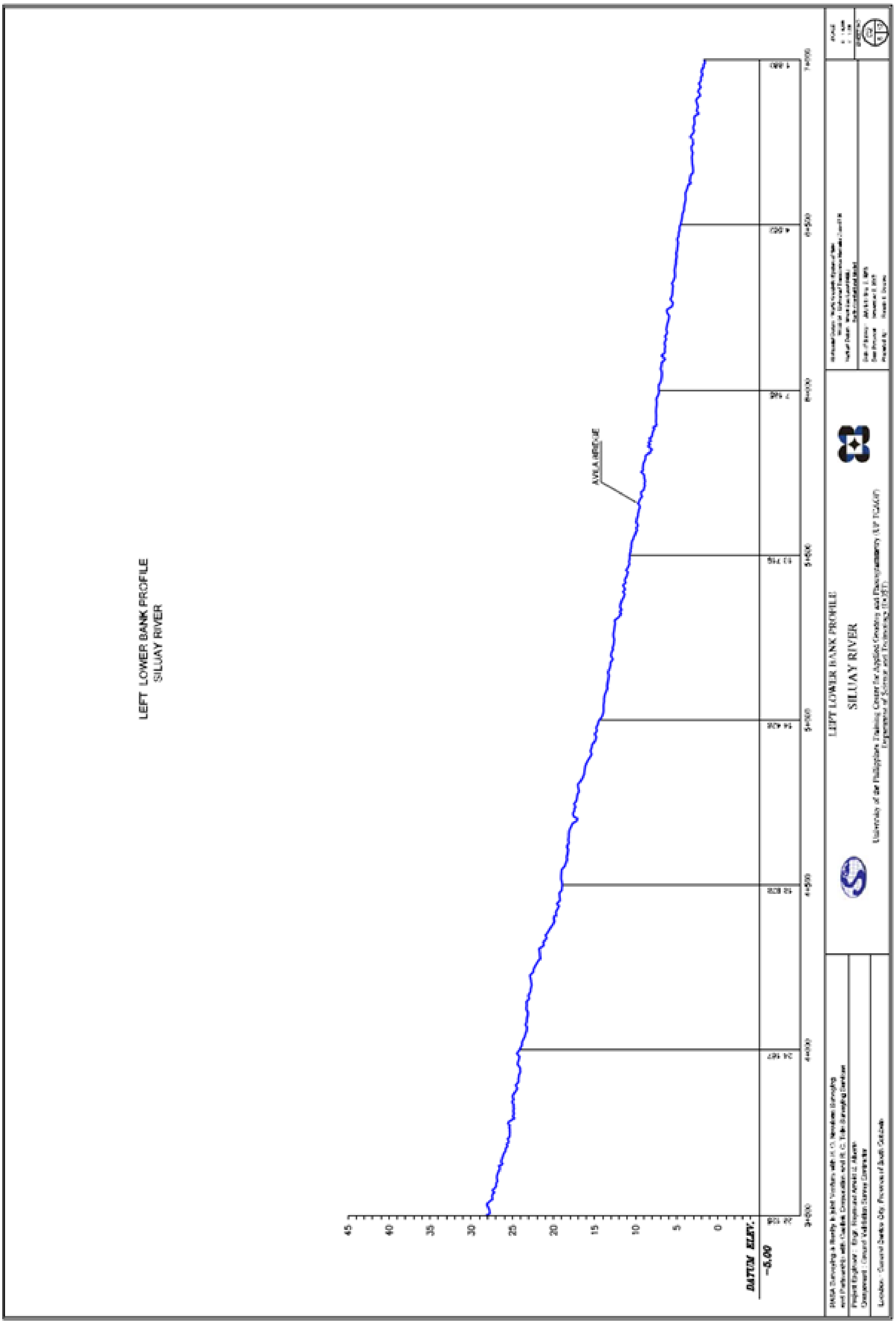
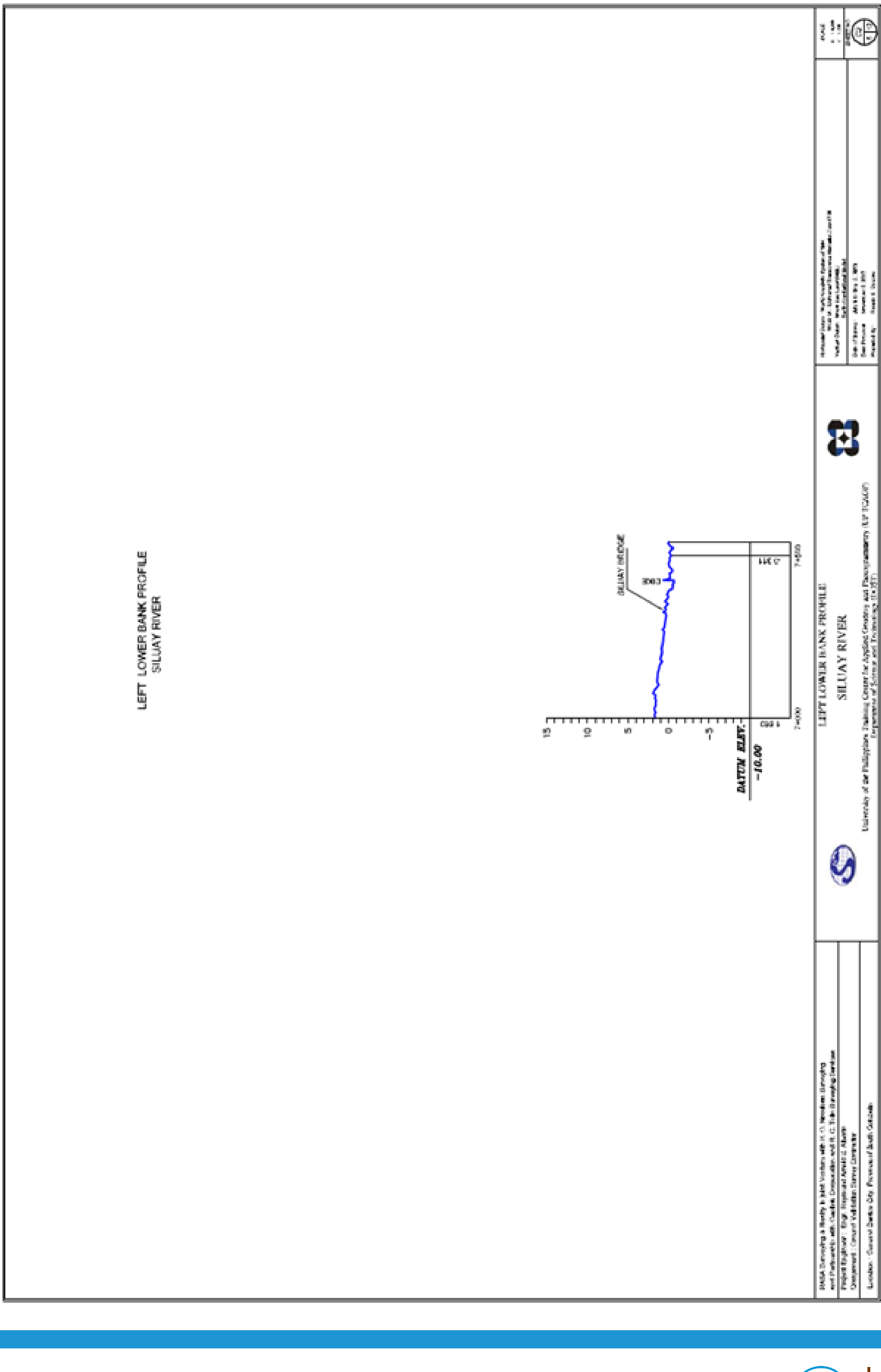
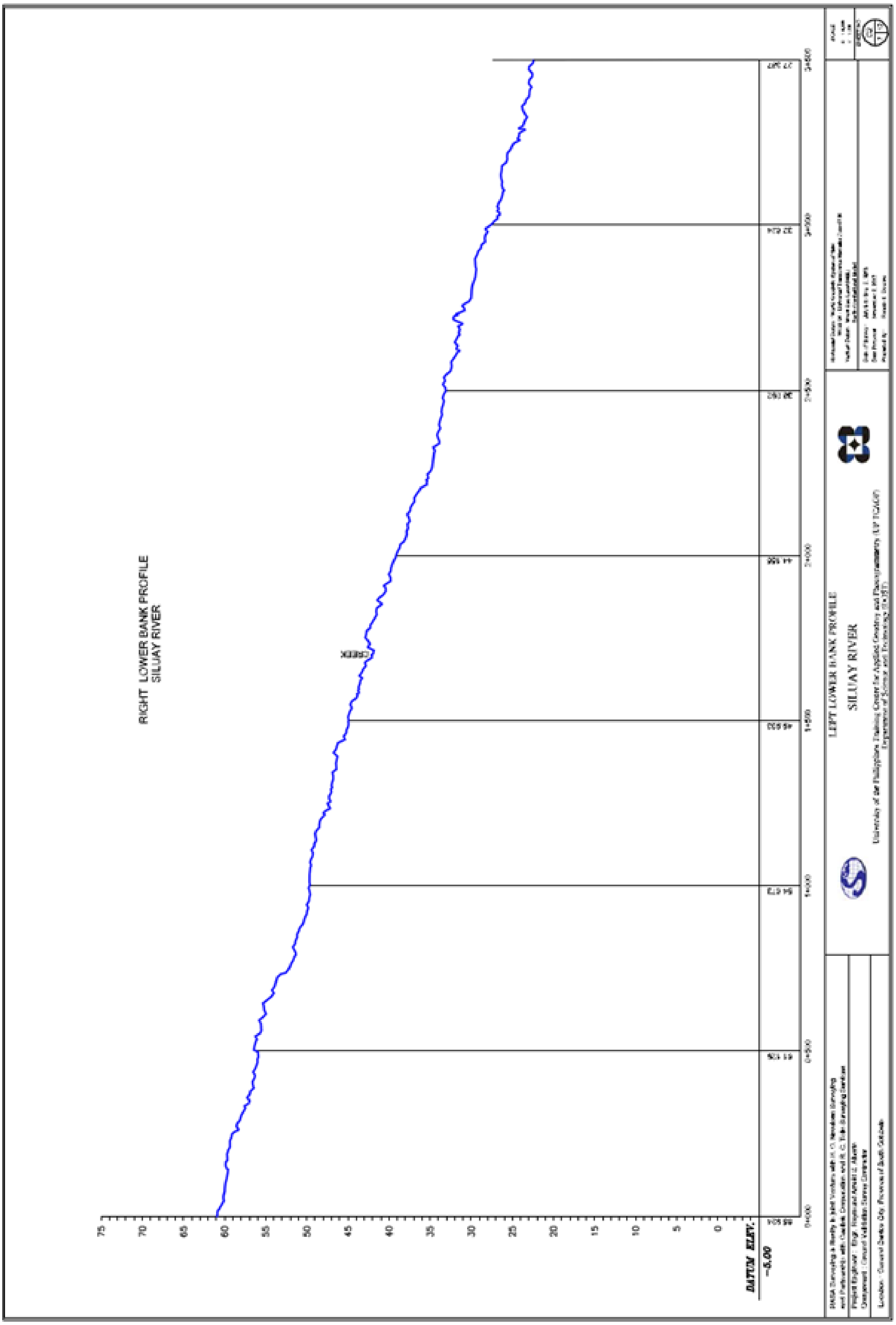
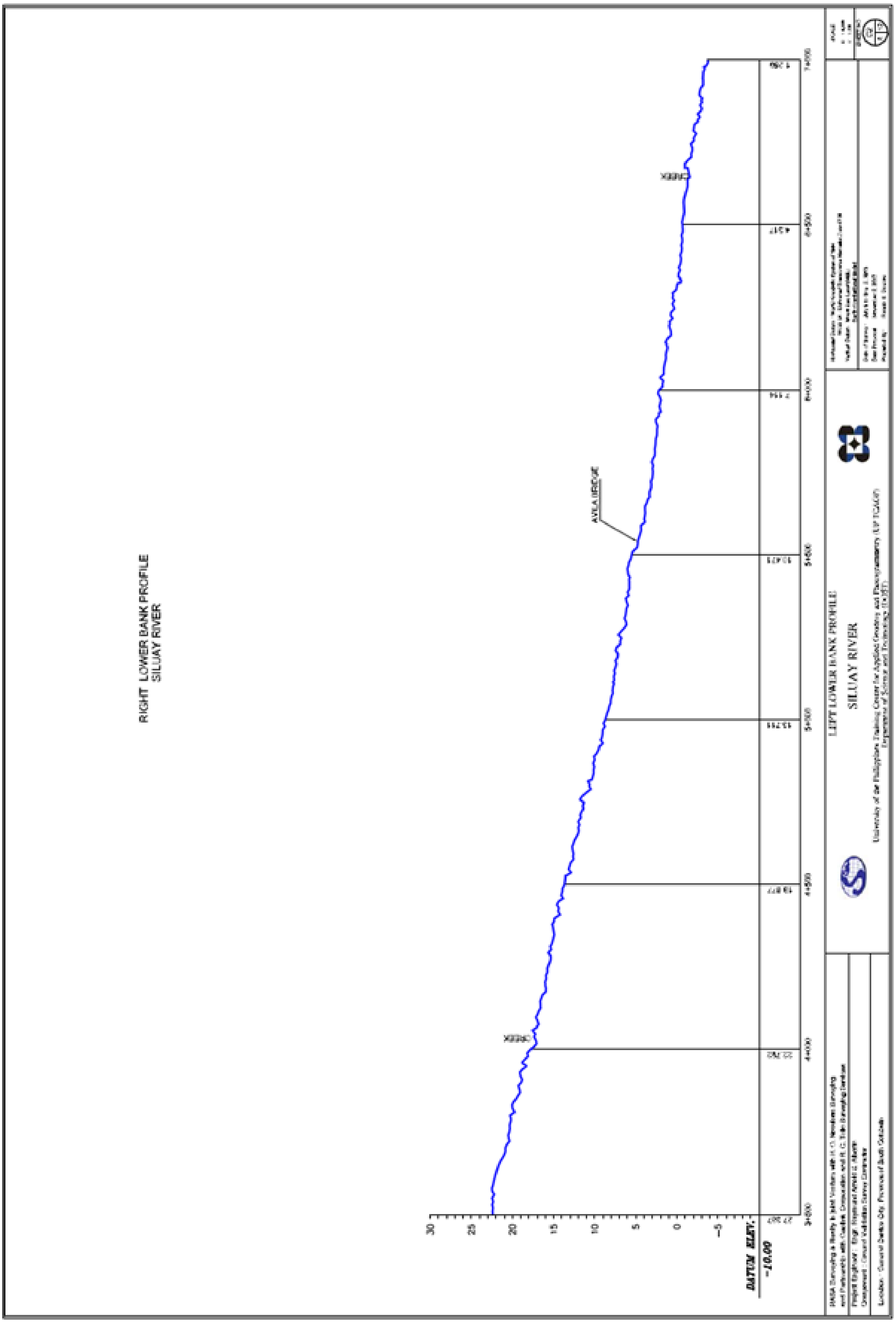
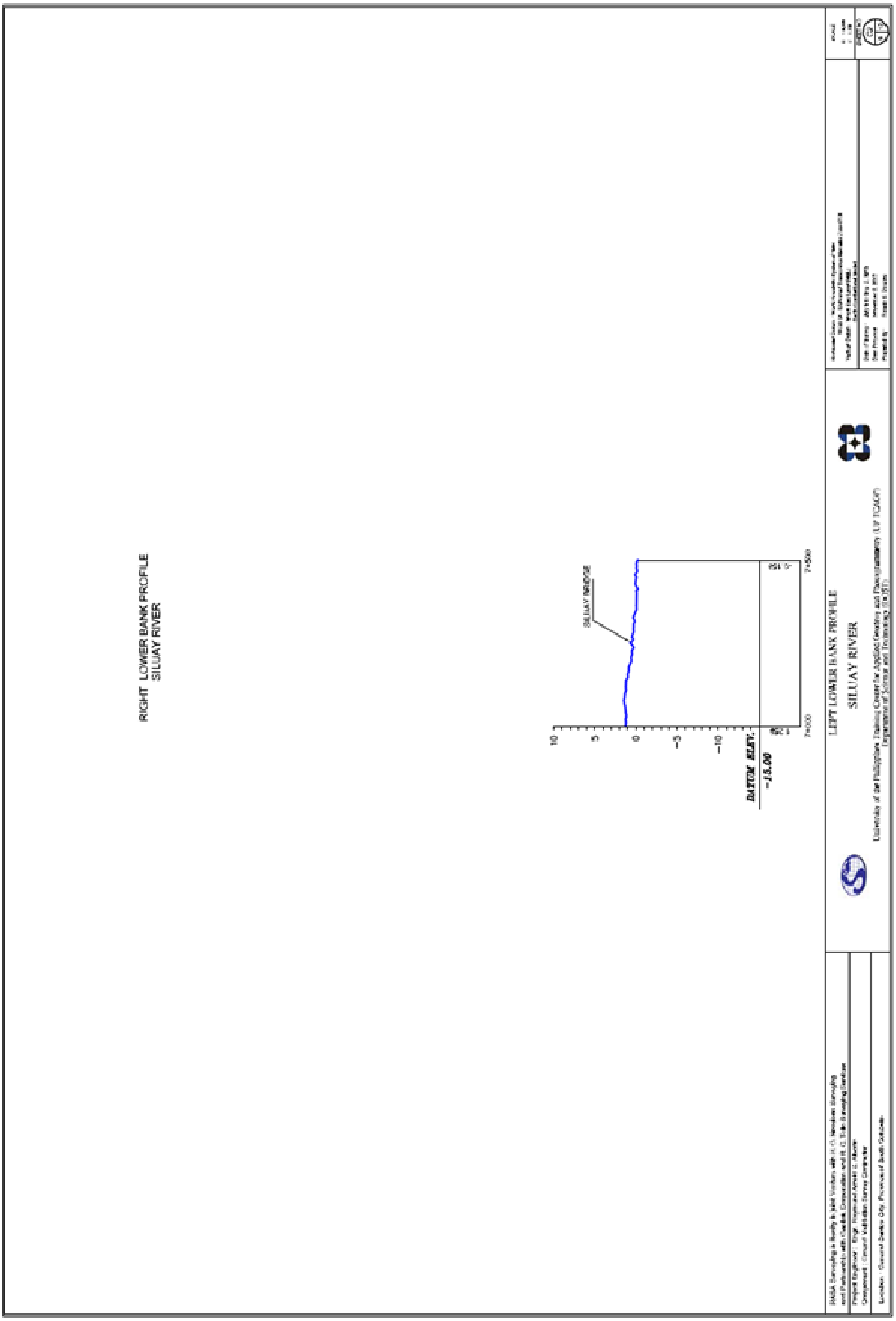
25
20
15
10
5
LEFT LOWER BANK PROFILE
SILUAY RIVER

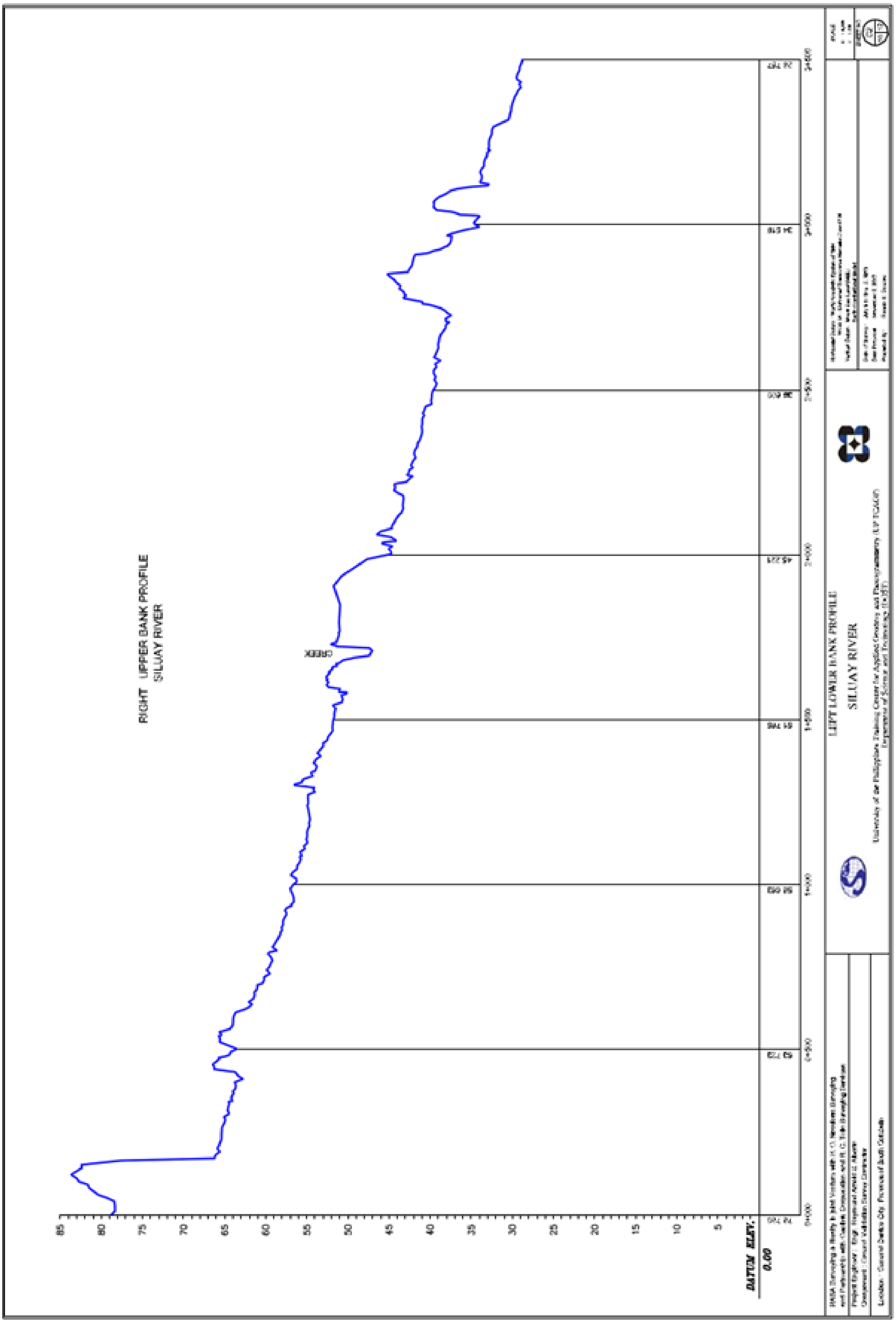

LEFT LOWER BANK PROFILE
SILUAY RIVER
DATUM ELEV.
-5.00
LEFT LOWER BANK PROFILE
SILUAY RIVER

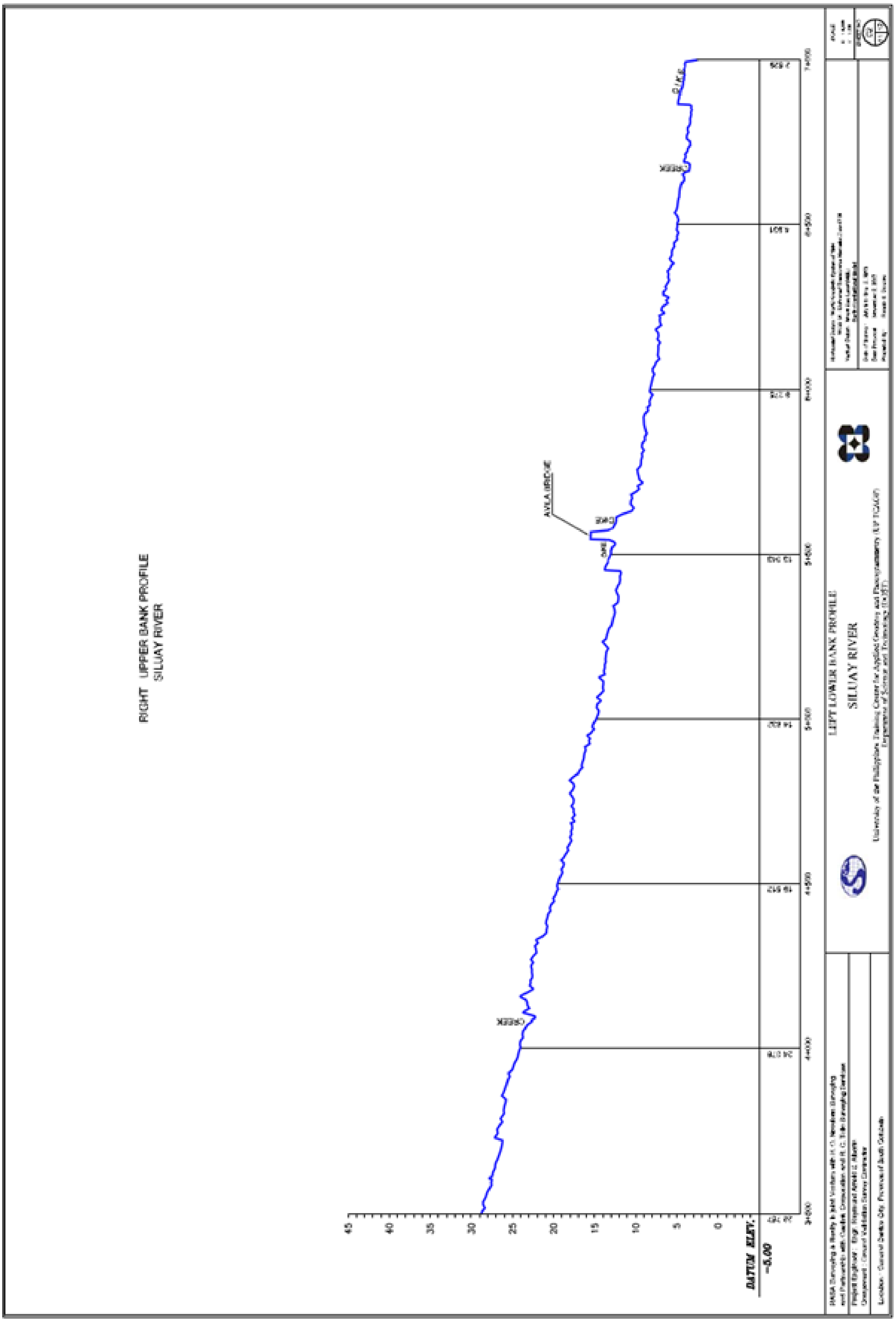

LEFT LOWER BANK PROFILE
SILUAY RIVER
SILUAY BRIDGE
DATUM ELEV.
-10.00
15
10
5
0
-5
LEFT LOWER BANK PROFILE
SILUAY RIVER
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)

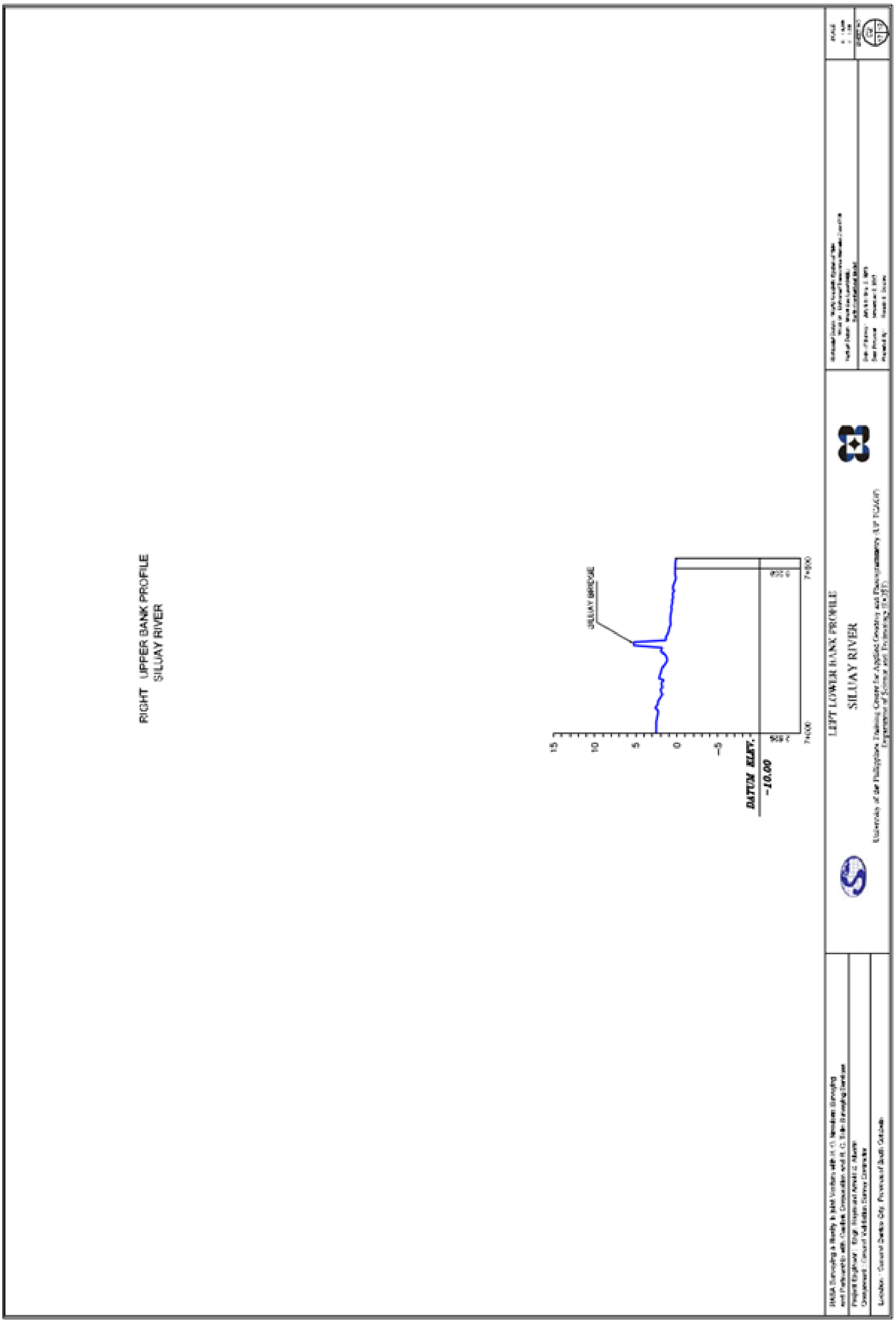

RIGHT LOWER BANK PROFILE
SILUAY RIVER
CREEK
DATUM ELEV.
-5.00
LEFT LOWER BANK PROFILE
SILUAY RIVER

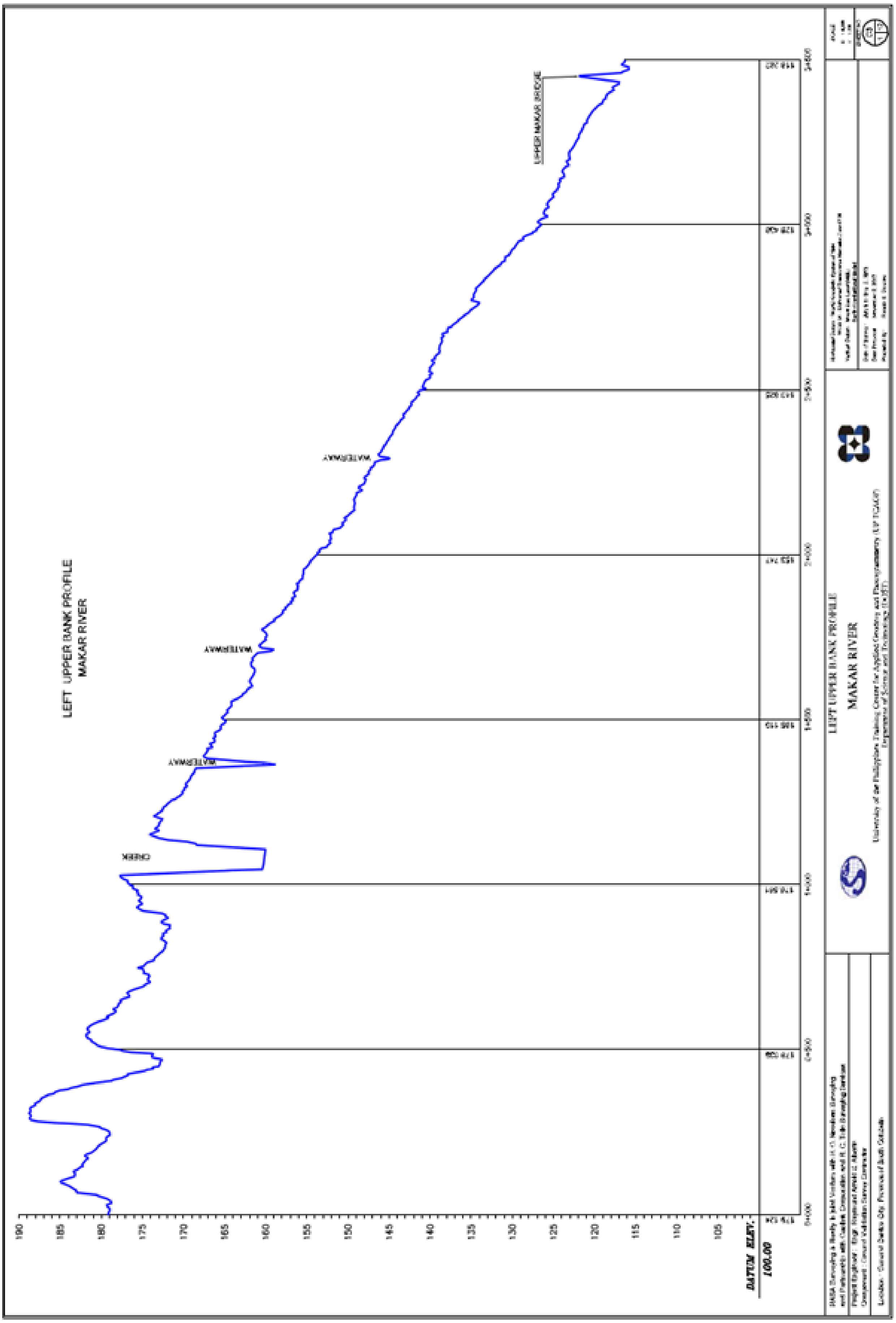

RIGHT LOWER BANK PROFILE
SILUAY RIVER
AVILA BRIDGE
CREEK
CREEK
DATUM ELEV.
-10.00
LEFT LOWER BANK PROFILE
SILUAY RIVER

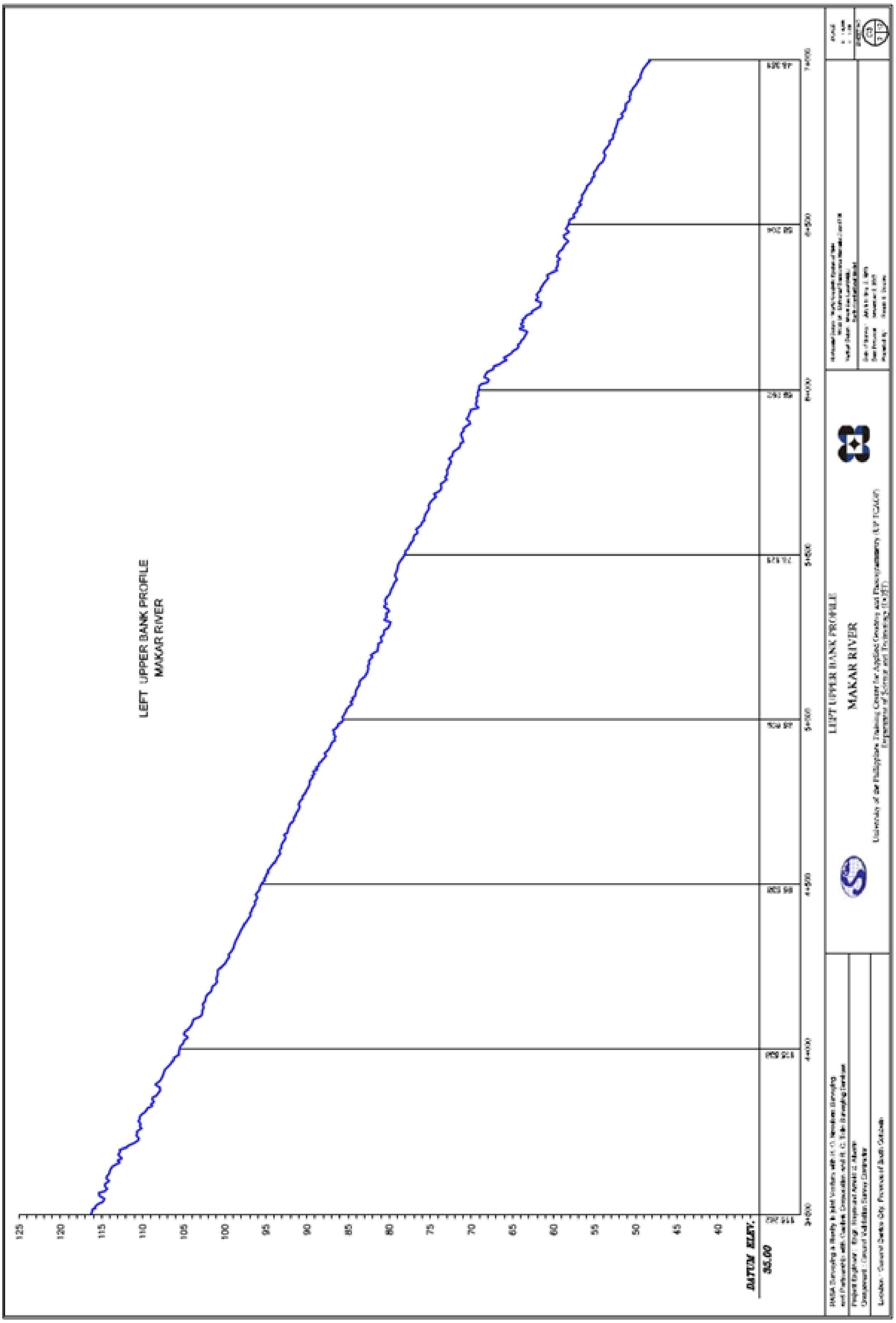

RIGHT LOWER BANK PROFILE
SILUAY RIVER
SILUAY BRIDGE
DATUM ELEV.
-15.00
LEFT LOWER BANK PROFILE
SILUAY RIVER
University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP)
Department of Science and Technology (DOST)


RIGHT UPPER BANK PROFILE
SILUAY RIVER
CREEK
DATUM ELEV.
LEFT LOWER BANK PROFILE
SILUAY RIVER


RIGHT UPPER BANK PROFILE
SILUAY RIVER
AVILA BRIDGE
CREEK
CREEK
DATUM ELEV.
-5.00
LEFT LOWER BANK PROFILE
SILUAY RIVER


RIGHT UPPER BANK PROFILE
SILUAY RIVER
SILUAY BRIDGE
DATUM ELEV.
-10.00
LEFT LOWER BANK PROFILE
SILUAY RIVER


LEFT UPPER BANK PROFILE
MAKAR RIVER
UPPER MAKAR BRIDGE
WATERWAY
WATERWAY
WATERWAY
CREEK
DATUM ELEV.
100.00
LEFT UPPER BANK PROFILE
MAKAR RIVER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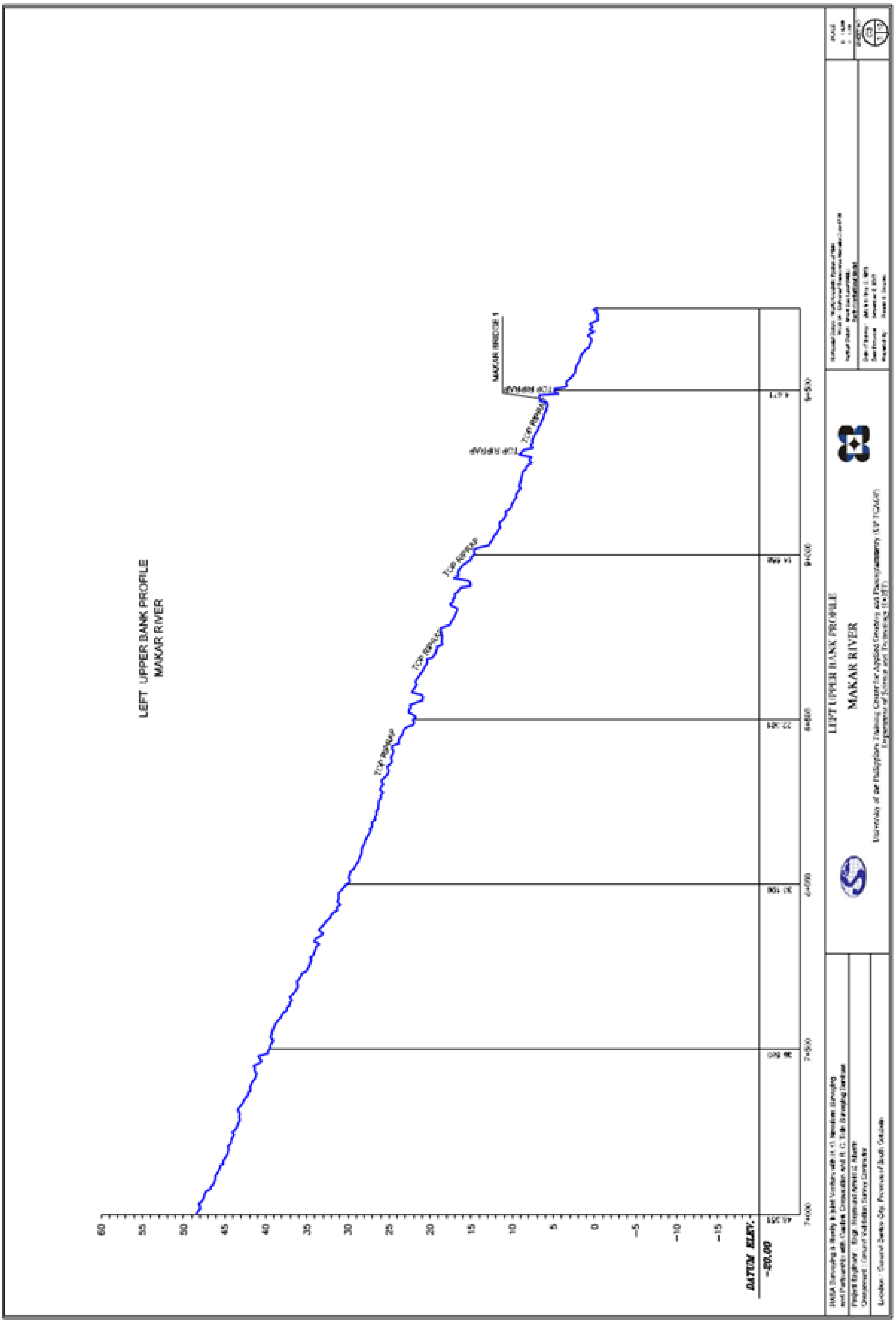
MAKAR RIVER
DATUM ELEV.
35.00
LEFT UPPER BANK PROFILE
MAKAR RIVER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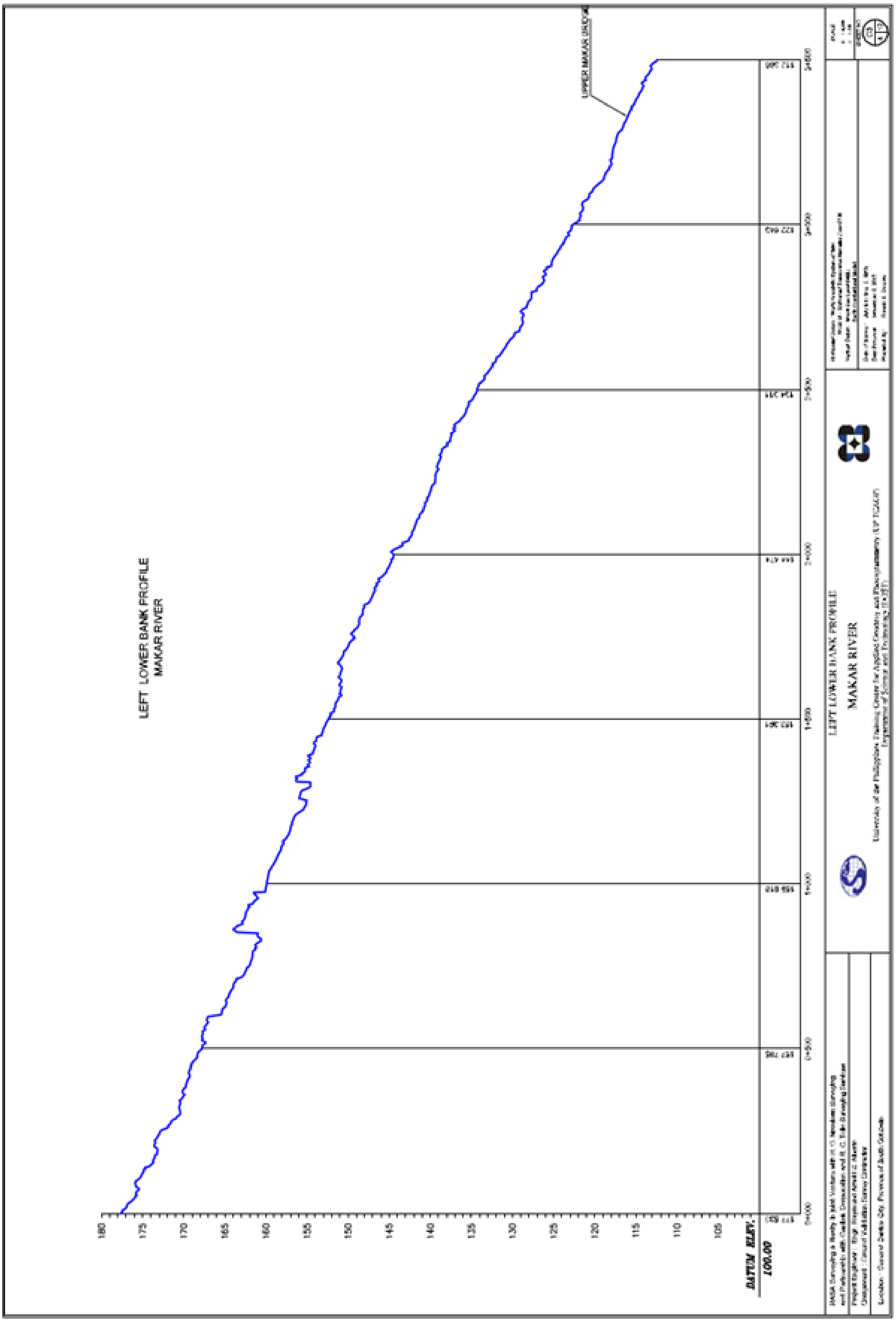
MAKAR RIVER
MAKAR BRIDGE 1
TOP RIPRAP
DATUM ELEV.
-20.00
LEFT UPPER BANK PROFILE
MAKAR RIVER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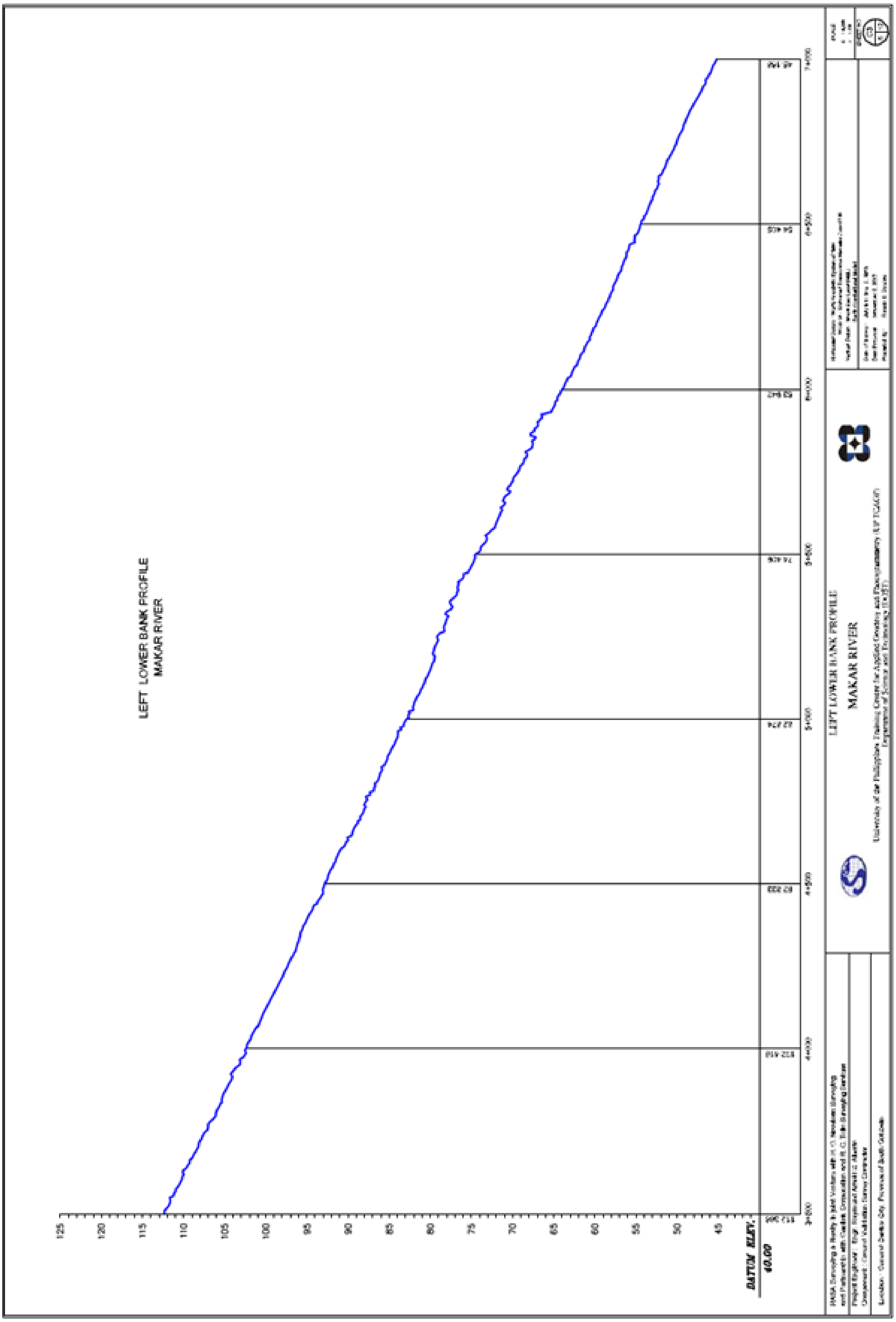
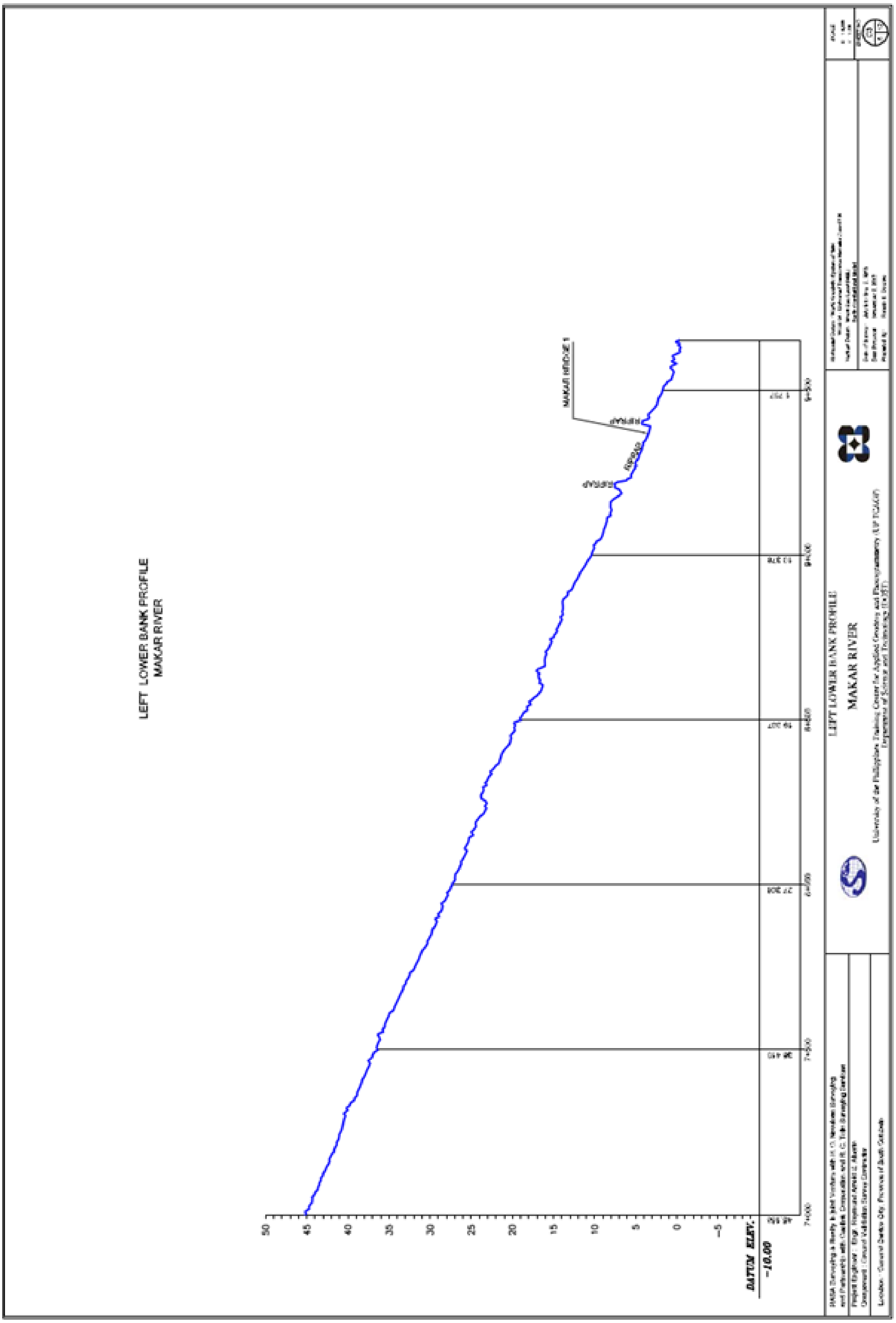
MAKAR RIVER
UPPER MAKAR BRIDGE
DATUM ELEV.
100.00
LEFT LOWER BANK PROFILE
MAKAR RIVER


LEFT LOWER BANK PROFILE
MAKAR RIVER
DATUM ELEV.
40.00
LEFT LOWER BANK PROFILE
MAKAR RIVER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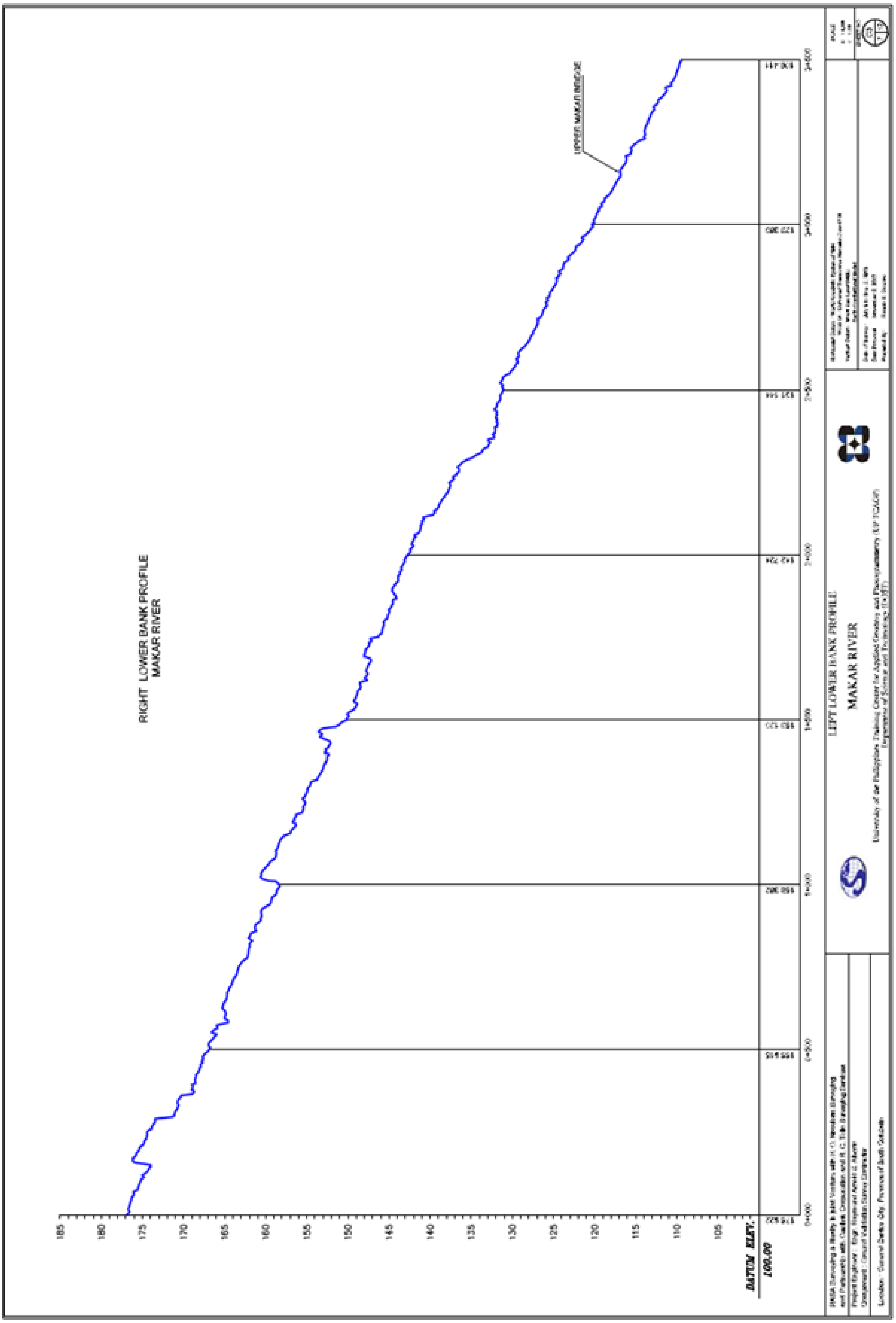
MAKAR RIVER
MAKAR BRIDGE 1
RIPRAP
DATUM ELEV.
-10.00
LEFT LOWER BANK PROFILE
MAKAR RIVER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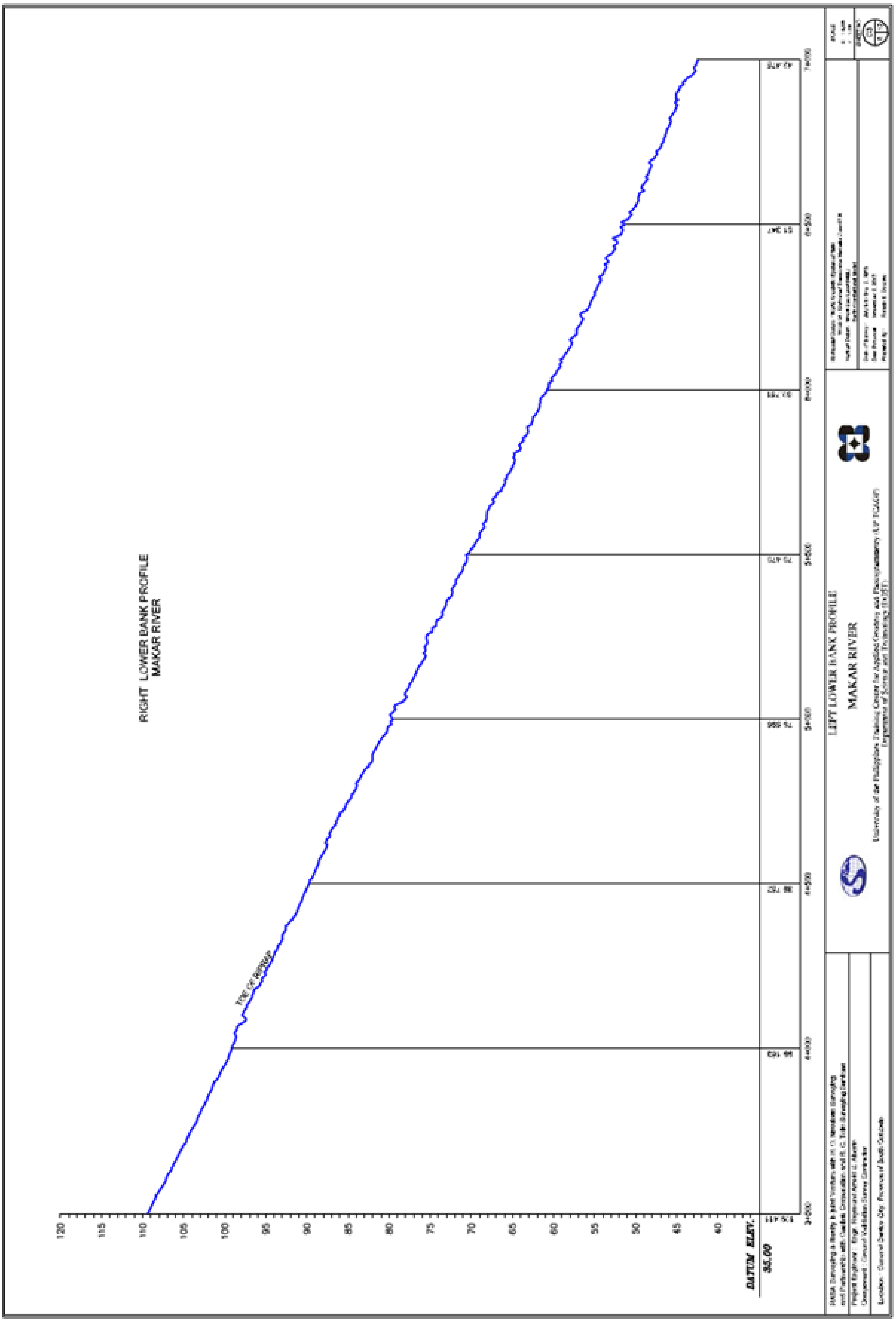
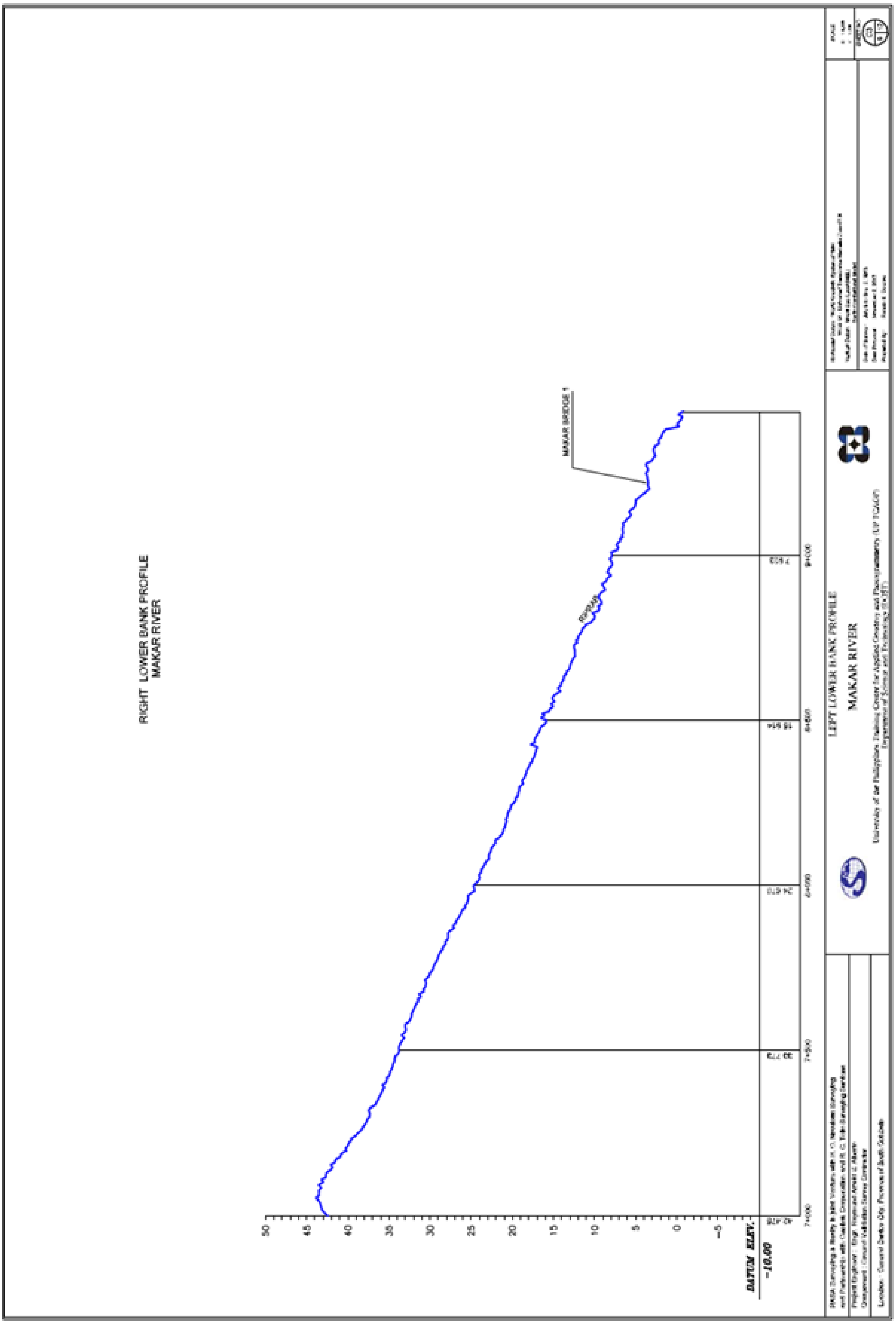
MAKAR RIVER
UPPER MAKAR BRIDGE
DATUM ELEV.
100.00
LEFT LOWER BANK PROFILE
MAKAR RIVER


RIGHT LOWER BANK PROFILE
MAKAR RIVER
LEFT LOWER BANK PROFILE
MAKAR RIVER
DATUM ELEV.
35.00
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40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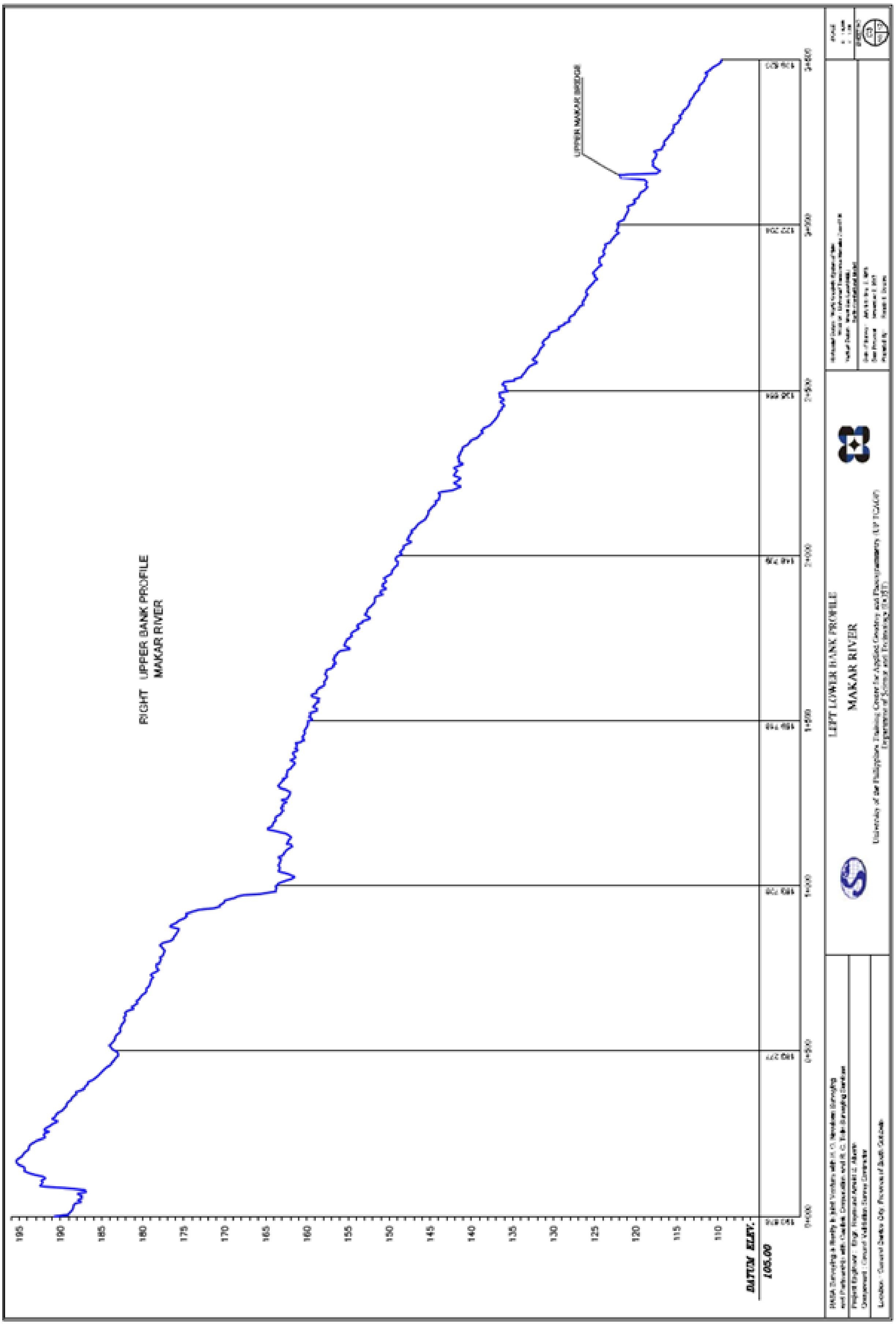
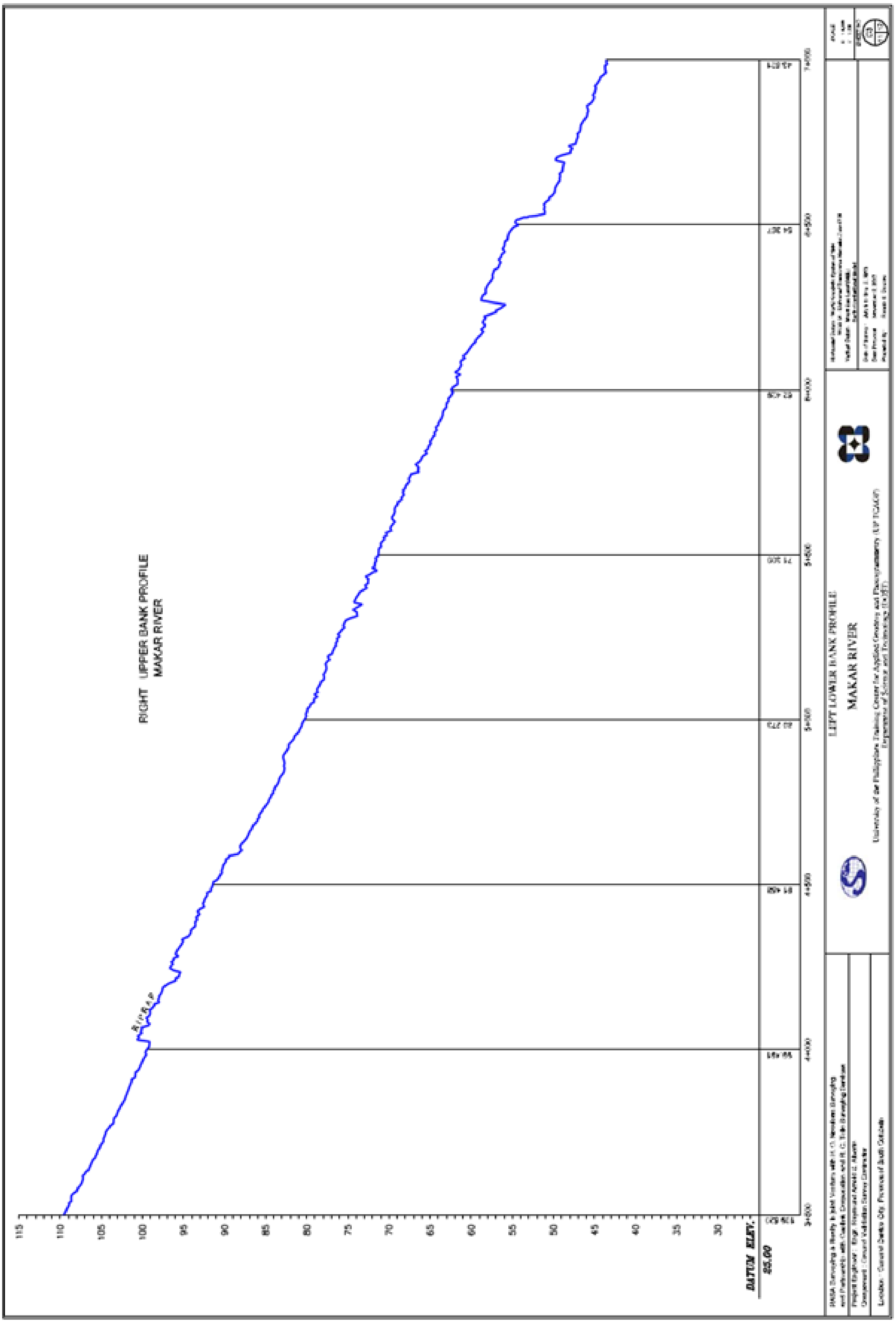
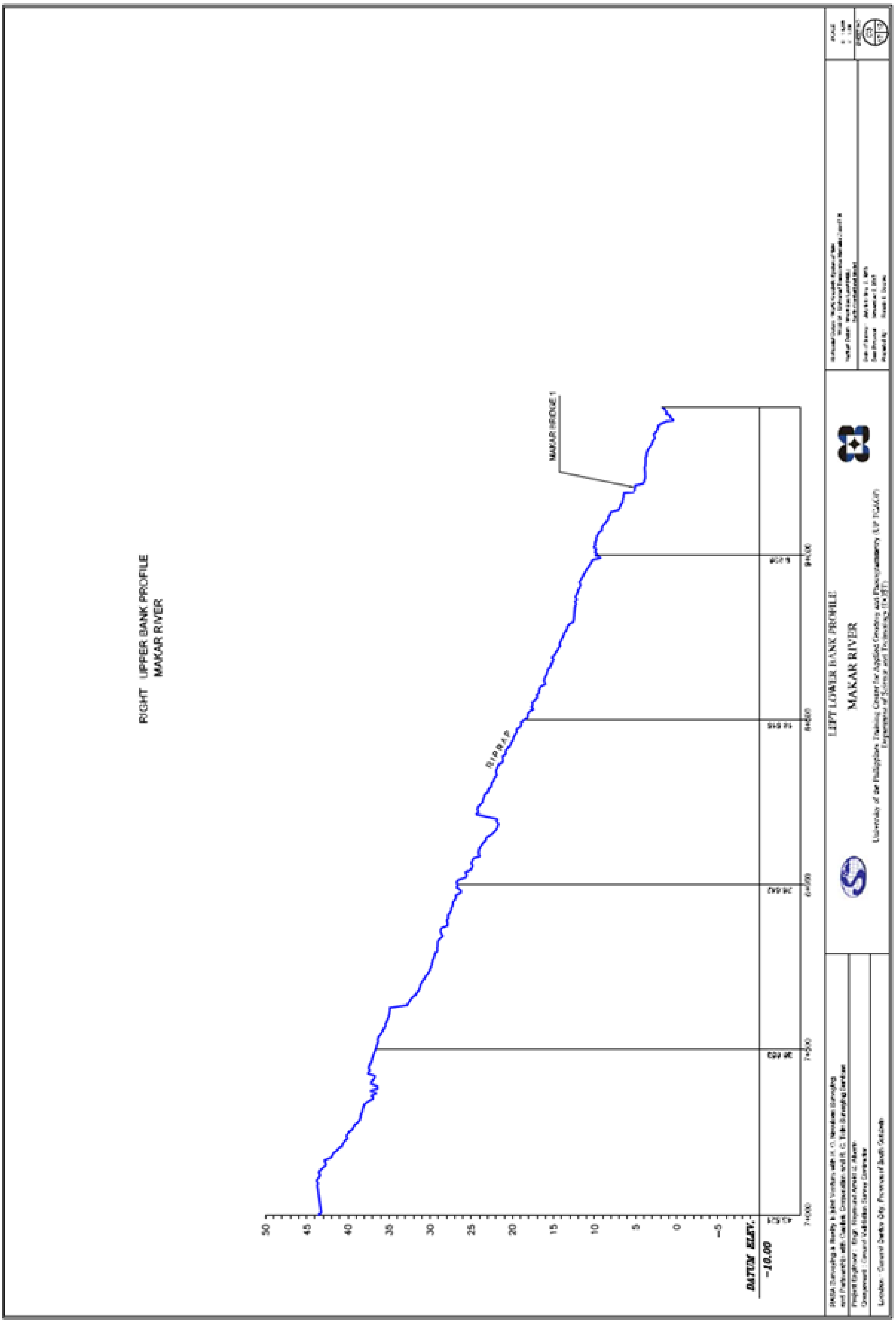
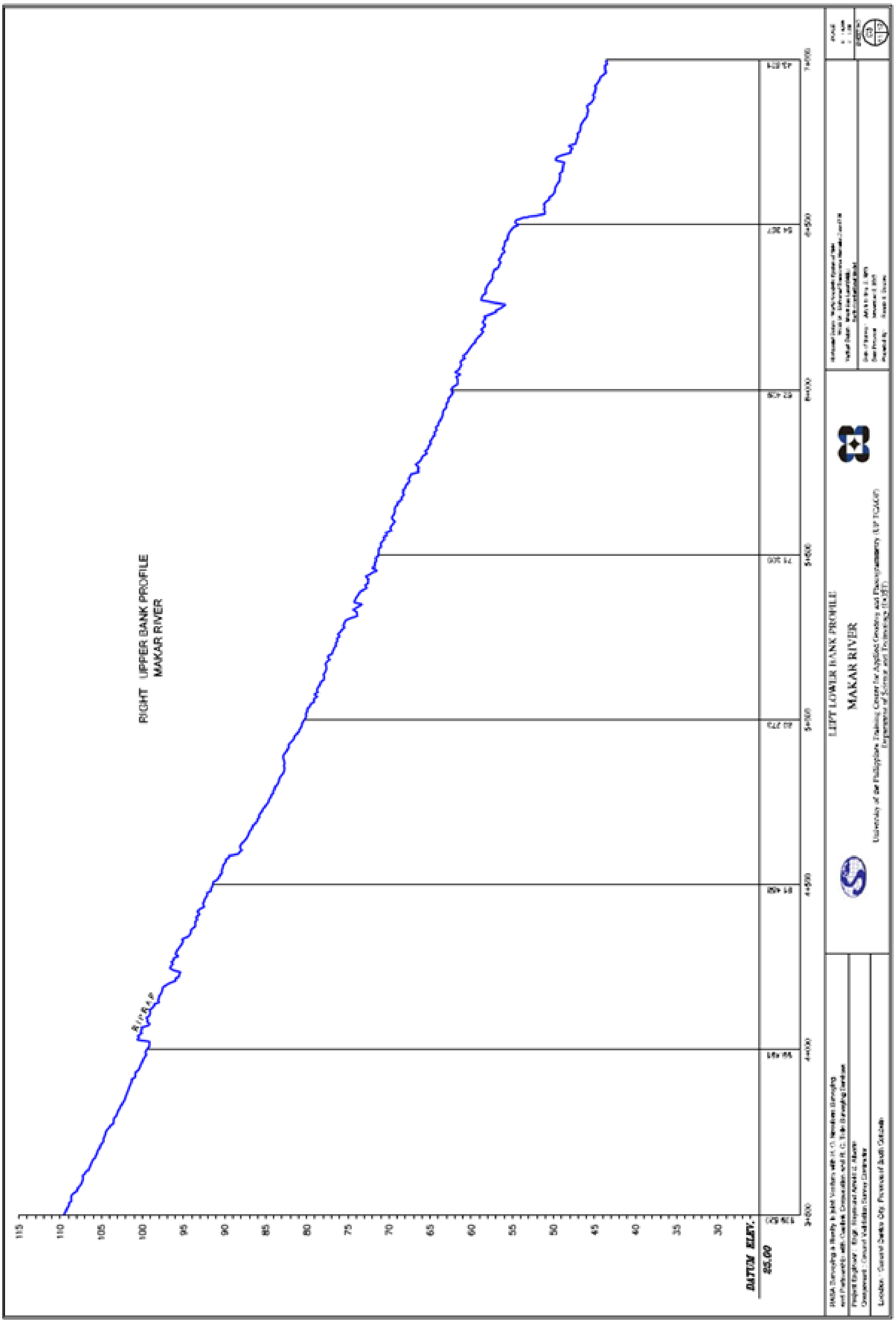
MAKAR RIVER
LEFT LOWER BANK PROFILE
MAKAR RIVER
MAKAR BRIDGE 1
DATUM ELEV.
-10.00
50
45
40
35
30
25
20
15
10
5
0
-5


RIGHT UPPER BANK PROFILE
MAKAR RIVER
UPPER MAKAR BRIDGE
DATUM ELEV.
105.00
LEFT LOWER BANK PROFILE
MAKAR RIVER


RIGHT UPPER BANK PROFILE
MAKAR RIVER
LEFT LOWER BANK PROFILE
MAKAR RIVER
DATUM ELEV. 25.00
RIPRAP



RIGHT UPPER BANK PROFILE
MAKAR RIVER
RIPRAP
MAKAR BRIDGE 1
DATUM ELEV.
-10.00
LEFT LOWER BANK PROFILE
MAKAR RIVER


RIGHT UPPER BANK PROFILE
MAKAR RIVER
RIPRAP
DATUM ELEV.
25.00
LEFT LOWER BANK PROFILE
MAKAR RIVER

Annexes

Table 6 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 6: 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		
GCP-1	6	4	48.8527	125	4	48.8866	672516.9925	730235.5812	259.624	188.271	188.429	0.013	0.0085
GCP-2	6	5	11.8010	125	7	15.5050	673239.6455	734742.4041	148.648	77.749	77.907	0.011	0.0085
GCP-3	6	5	23.6606	125	9	3.6141	673617.2107	738066.1346	77.501	6.901	7.059	0.012	0.0078
GCP-4	6	9	27.6152	125	8	26.0774	681108.7097	736881.7036	146.566	75.562	75.720	0.013	0.0085
GCP-5	6	8	5.5824	125	8	51.5202	678591.1861	737674.2853	113.867	43.059	43.217	0.012	0.0085
GCP-6	6	6	20.7067	125	9	48.8848	675375.6791	739451.5308	72.425	1.906	2.064	0.012	0.0092
GCP-7	6	11	44.9877	125	14	28.2703	685375.8071	748003.0532	99.370	29.126	29.284	0.018	0.0106
GCP-8	6	10	21.3824	125	14	18.1275	682805.3463	747701.9443	90.846	20.774	20.932	0.016	0.0099
GCP-9	6	8	42.1595	125	14	1.8122	679754.1900	747212.9305	82.794	12.851	13.009	0.013	0.0085
GCP-10	6	7	18.2864	125	14	7.4933	677177.5561	747398.4095	80.081	10.272	10.430	0.012	0.0085
GCP-11	6	5	51.2270	125	14	14.9562	674503.2361	747639.0777	71.019	1.295	1.453	0.011	0.0078

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 GROUP 1 (RASA)
5	FRANIE T. REYES	TEAM LEADER FOR GROUP 2 (RCT)
6	JULIETO G. CABILIN	TEAM LEADER FOR GROUP 3 (HONS)
7	JULIO BALENSONA	TEAM LEADER FOR GROUP 4 (GEOLINK)
8	JAY BORJA	INSTRUMENT MAN
9	NELSO ACOSTA	INSTRUMENT MAN
10	GREGORIO COSTELO	INSTRUMENT MAN
11	RAMIL OLIMPIADA	INSTRUMENT MAN
12	DENNIS REFUGIA	INSTRUMENT MAN
13	BRYAN URMENETA	INSTRUMENT MAN/DRIVER
14	RYAN AUDREY BASCO	INSTRUMENT MAN/CADD OPERATOR
15	JEFFERSON F. ORBILLO	INSTRUMENT MAN
16	JAYPEE NOVELOSO	INSTRUMENT MAN
17	RICHARD QUINES	INSTRUMENT MAN
18	JORGE RENE GUERRERO	INSTRUMENT MAN
19	JOHN BRYAN ESCAMILLA	INSTRUMENT MAN
20	HAROLD ARGAO	DRIVER
21	ERWIN TOLLO	DRIVER
22	JERRY D. DOMINGO	DRIVER
		24 SURVEY AIDS

ANNEX B. LIST OF EQUIPMENT AND INSTRUMENTS

ITEM #	EQUIPMENT NAME	SERIAL #
1	HI-TARGET V30ST L1/L2	3000608
2	HI-TARGET V30ST L1/L2	3005333
3	HI-TARGET V30ST L1/L2	3006440
4	HI-TARGET V30ST L1/L2	3011059
5	HI-TARGET V30ST L1/L2	3011154
6	HI-TARGET V30ST L1/L2	3000614
7	HI-TARGET V30ST L1/L2	3000762
8	HI-TARGET V30ST L1/L2	3004252
9	HI-TARGET V30ST L1/L2	3004203
10	SOKKIA GSX2	107310035
11	SOKKIA GSX2	107310052
12	SOKKIA GSX2	107310007
13	EPOCH 25 L1/L2	0726J36433
14	EPOCH 25 L1/L2	0746J55231
15	EPOCH 25 L1/L2	0813J55299
16	EPOCH 25 L1/L2	0813J55657
17	HI-TARGET ZTS 120R	Z 10220
18	HI-TARGET ZTS 120	Z 10553
19	SOKKIA SET 3030R3	35980
20	SOKKIA SET 630R	157615
21	SOKKIA SET 610	206709
22	SANDING STS 755L	SD 12344
23	4 UNITS HANDHELD GPS	NA
24	8 UNITS DIGITAL CAMERA	NA
25	4 UNITS LAPTOP	NA
26	4 UNITS SERVICE VEHICLE	NA

ANNEX C. ACTUAL FIELD SURVEY ACTIVITIES

DATE	ACTIVITY	LOCATION
10-Jul-13	Mobilization	Manila to Gensan
11-Jul-13	Mobilization	Gensan
12-Jul-13	Courtesy Call to Local Government Units	Gen. Santos City
13-Jul-13	Kick-off meeting of the whole team	Field office
14-Jul-13	Reconnaissance/Establishment of GCPs	Project area
15-Jul-13	Establishment of GCPs	Project area
16-Jul-13	Rainy no activity	Project area
17-Jul-13	GNSS Observation of GCPs	Project area
18-Jul-13	GNSS Observation of GCPs secondary controls	Project area
19-Jul-13	Coordination to other concerned LGUs	Project area
20-Jul-13	Rainy no activity	Project area
21-Jul-13	GNSS Observation of GCPs	Project area
22-Jul-13	Rainy no activity	Project area
23-Jul-13	Coordination to other concerned LGUs & Local Residents	Project area
24-Jul-13	Orientation of the Local hired / reconnais-sance of the 3 river system	Project area
25-Jul-13	Staking of Section Lines& Site clearing	Cross-section area
26-Jul-13	Cross-section survey / Rainy	Cross-section area
27-Jul-13	Cross-section survey / Rainy	Cross-section area
28-Jul-13	Cross-section survey	Cross-section area
29-Jul-13	Cross-section survey / Rainy	Cross-section area
30-Jul-13	Cross-section survey /river profile	Makar River, Siluay River &Buayan River
31-Jul-13	Cross-section and profile survey	Makar River, Siluay River &Buayan River
1-Aug-13	Cross-section and profile survey / Rainy	Makar River, Siluay River &Buayan River
2-Aug-13	Cross-section and profile survey / Rainy	Makar River, Siluay River &Buayan River
3-Aug-13	Cross-section and profile survey / Rainy	Makar River, Siluay River &Buayan River
4-Aug-13	Cross-section and profile survey / Rainy	Makar River, Siluay River &Buayan River
5-Aug-13	Cross-section and profile survey	Makar River, Siluay River &Buayan River
6-Aug-13	Cross-section and profile survey	Makar River, Siluay River &Buayan River
7-Aug-13	Cross-section and profile survey	Makar River, Siluay River &Buayan River
8-Aug-13	Cross-section and profile survey	Makar River, Siluay River &Buayan River
9-Aug-13	Cross-section and profile survey	Makar River, Siluay River &Buayan River
10-Aug-13	Cross-section and profile survey	Makar River, Siluay River &Buayan River
11-Aug-13	Cross-section and profile survey	Makar River, Siluay River &Buayan River
12-Aug-13	Cross-section and profile survey	Siluay River &Buayan River

13-Aug-13	Cross-section and profile survey	Siluay River &Buayan River
14-Aug-13	UP-DVC field validation	Makar River
15-Aug-13	Cross-section and profile survey	Siluay River &Buayan River
16-Aug-13	Cross-section and profile survey	Siluay River &Buayan River
17-Aug-13	UP-DVC field validation	Siluay River
18-Aug-13	UP-DVC field validation	Buayan River
19-Aug-13	Cross-section & Profile Survey	Siluay&Buayan River
20-Aug-13	Cross-section & Profile Survey	Siluay&Buayan River
21-Aug-13	Cross-section & Profile Survey	Siluay&Buayan River
22-Aug-13	Cross-section & Profile Survey	Siluay&Buayan River
23-Aug-13	Cross-section Survey	Buayan River
24-Aug-13	Cross-section Survey	Buayan River
25-Aug-13	Cross-section Survey	Buayan River
26-Aug-13	Cross-section Survey	Buayan River
27-Aug-13	Cross-section Survey	Buayan River
28-Aug-13	Cross-section Survey	Buayan River
29-Aug-13	Cross-section Survey	Buayan River
30-Aug-13	Cross-section Survey	Buayan River
31-Aug-13	Cross-section Survey	Buayan River
1-Sep-13	Cross-section Survey	Buayan River
2-Sep-13	Cross-section Survey	Buayan River

ANNEX D. CERTIFIED REFERENCE POINTS AND BENCHMARK

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

July 08, 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: **SOUTH COTABATO**
Station Name: **CTS-43**
Order: **2nd**

Island: **MINDANAO**
Municipality: **GENERAL SANTOS CITY (DADIANGAS)**
Barangay: **TAMBLER**

PRS92 Coordinates

Latitude: **6° 3' 24.37577"** Longitude: **125° 8' 27.42848"** Ellipsoidal Hgt: **23.82200 m.**

WGS84 Coordinates

Latitude: **6° 3' 21.48507"** Longitude: **125° 8' 33.05028"** Ellipsoidal Hgt: **97.23300 m.**

PTM Coordinates

Northing: **669674.089 m.** Easting: **515603.149 m.** Zone: **5**

UTM Coordinates

Northing: **669,904.98** Easting: **736,970.33** Zone: **51**

Location Description

CTS-43
"CTS-43" is in Barangay Tambler, General Santos City. To reach the station travel for about 9 kms. from General Santos City towards Barangay Maasin until reaching the Banisil Elementary School. Station is located at the top of the water tank. Mark is the head of 4" copper nail set on a drilled hole and cemented on top of a 30x30 cm. cement putty with the inscription "CTS-43 2007 NAMRIA".

Requesting Party: **RASA Surveying**
Pupose: **Reference**
OR Number: **3943884B**
T.N.: **2013-0649**

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

9 9 0 7 0 8 2 0 1 3 1 5 0 8 3 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

July 08, 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: **SOUTH COTABATO**

Station Name: **CTS-44**

Order: **2nd**

Island: **MINDANAO**
Municipality: **GENERAL SANTOS CITY (DADIANGAS)**
Barangay: **SAN JOSE**

PRS92 Coordinates

Latitude: **6° 4' 4.88313"**	Longitude: **125° 1' 43.52782"**	Ellipsoidal Hgt: **358.45000 m.**

WGS84 Coordinates

Latitude: **6° 4' 1.97913"**	Longitude: **125° 1' 49.14944"**	Ellipsoidal Hgt: **431.56300 m.**

PTM Coordinates

Northing: **670916.335 m.**	Easting: **503183.355 m.**	Zone: **5**

UTM Coordinates

Northing: **671,101.78**	Easting: **724,542.21**	Zone: **51**

Location Description

CTS-44
"CTS-44" is in Barangay San Jose, General Santos City. To reach the station travel for about 12 kms. from General Santos City taking the Nat'l Highway until reaching the road intersection turn right going to brgy. road of San Jose and travel for about 5 kms. until reaching the junction turn right going to San Jose bridge. Station is located at the abutment of the bridge. Mark is the head of 4" copper nail embedded in a 0.30x0.30x1.0 m. concrete monument with the inscription "CTS-44 2007 NAMRIA".

Requesting Party:	**RASA Surveying**
Pupose:	**Reference**
OR Number:	**3943884B**
T.N.:	**2013-0648**

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

9 9 0 7 0 8 2 0 1 3 1 5 0 7 1 1

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

July 08, 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: **SARANGANI**
Station Name: **SNI-06**
Order: **2nd**

Island: **MINDANAO**
Municipality: **ALABEL (CAPITAL)**
Barangay: **KAWAS**

	PRS92 Coordinates	
Latitude: **6° 3' 24.12668"**	Longitude: **125° 16' 56.33901"**	Ellipsoidal Hgt: **0.45200 m.**
	WGS84 Coordinates	
Latitude: **6° 3' 21.24911"**	Longitude: **125° 17' 1.95945"**	Ellipsoidal Hgt: **74.21500 m.**
	PTM Coordinates	
Northing: **669672.537 m.**	Easting: **531251.968 m.**	Zone: **5**
	UTM Coordinates	
Northing: **669,961.12**	Easting: **752,625.07**	Zone: **51**

Location Description

SNI-6
Station is in Brgy. Kawas, Alabel, Sarangani. To reach the station travel for about 15 kms from General Santos City towards Glan taking the national highway until reaching Kawas Elementary School. Station is located 3 m west of the school's flagpole end corner of a plantbox.

Mark is the head of a 4" copper nail embedded in a 0.30 x 0.30 x 1 m concrete monument with inscription SNI-6 2007 NAMRIA.

Requesting Party: **RASA Surveying**
Pupose: **Reference**
OR Number: **3943884B**
T.N.: **2013-0650**

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

9 9 0 7 0 8 2 0 1 3 1 5 0 8 5 3

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

ANNEX E: ENDORSEMENT LETTERS

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

July 1, 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 Buayan Malungon 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. Dexter T. Lozano	Supervising Science Research Specialist	0917-456-8675

Yours truly,

ENGR. LOUIE P. BALICANTA
Project Leader
Nationwide DREAM Program

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Endorsement letter from UP TCAGP for DREAM Project

ANNEX F: REFERENCE PHOTOGRAPHS

Reconnaissance:

Some photos during reconnaissance

Makar River

Siluay River

Buayan River

Actual Field Survey

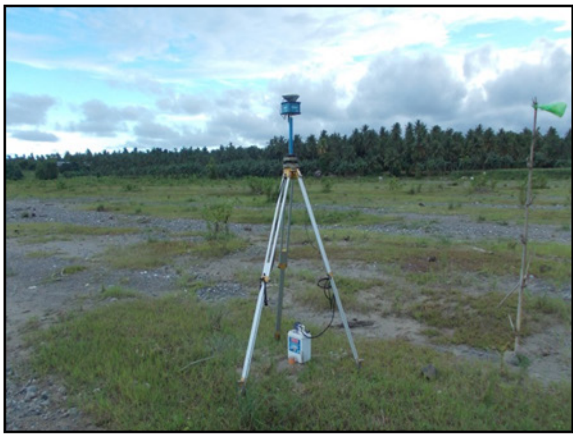
CTS-43

CTS-44

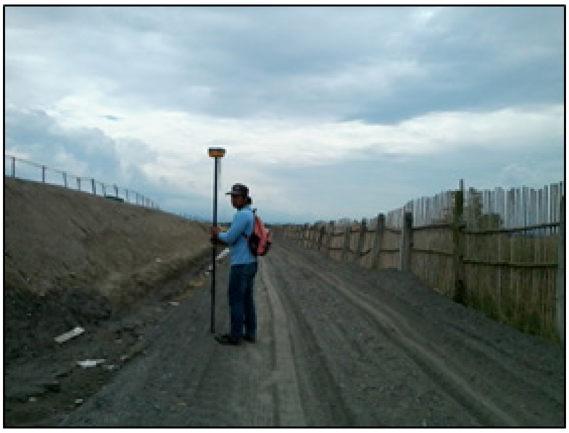
NAMRIA 2nd Order Horizontal Control

Establishment of Ground Control Points










Some Pictures for Cross Section Survey



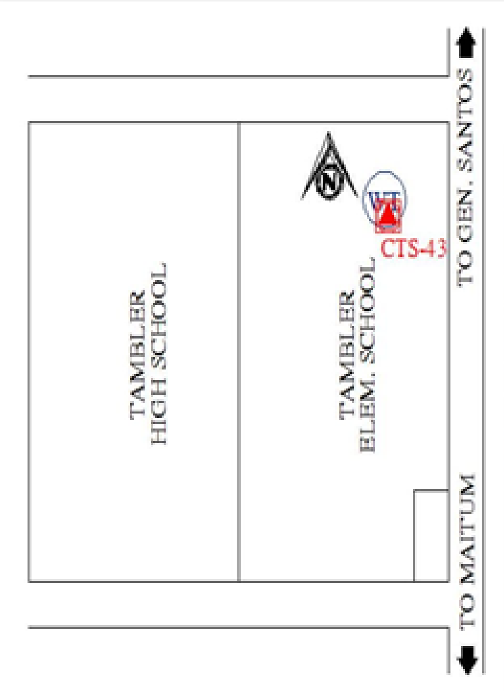





ANNEX G. RECOVERED NAMRIA REFERENCE POINTS

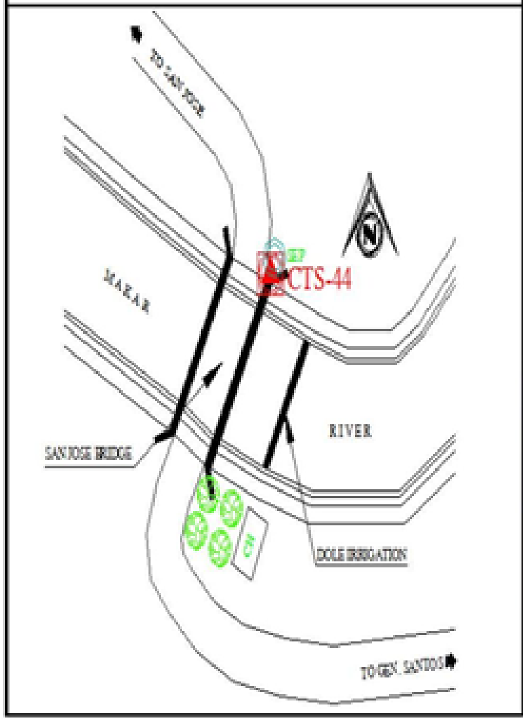
Control Number: CTS-43

Station Name	CTS-43	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°03'24.37577" North
	Longitude	125°08'27.42848" East
	Ellipsoidal Height	23.822 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°03'21.48507" North
	Longitude	125°08'33.05028" East
	Ellipsoidal Height	97.233 meters
Elevation	26.878 meters above Mean Sea Level (MSL)	
Description	From the City Hall of General Santos travel about 7 KM's along P. Acharon boulevard going to Mun. of Maitum passing the crossing going to General Santos Airport to reach the Tambler Elementary School.The monument was a cement putty on the top of the water tank inside the school compound. Mark is the center of a cooper nail set flush at the center of a 30x30 cement putty with inscription "CTS-43, 2007, NAMRIA".	
Sketch	**Picture**	

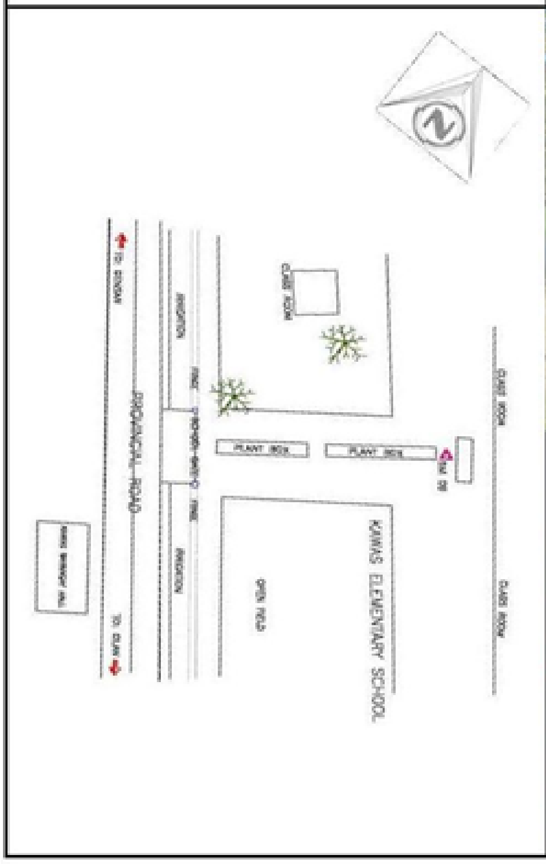


Control Number: CTS-44

Station Name	CTS-44	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°04'04.88313" North
	Longitude	125°01'43.52783" East
	Ellipsoidal Height	358.450 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°04'01.97913" North
	Longitude	125°01'49.14944" East
	Ellipsoidal Height	431.563 meters
Elevation	359.754 meters above Mean Sea Level (MSL)	
Description	From the City Hall of General Santos travel about 6.1 KM's along P. Acharon boulevard going to Mun. of Maitum to reach the crossing going to General Santos Airport.Turn right and travel about 4.65 KM's to reach the Airport Road.Turn right and travel about 380 m. and then turn left and travel for about 8 KM's along the brgy. road going to Brgy. San Jose till reaching the bridge of San Jose.The monument is located on the right wing of the second approach of the bridge and about a meter away from a steel electrical post. Mark is the center of a cooper nail set flush at the center of a 30x30 centimeter concrete monument with inscription "CTS-44, 2007, NAMRIA".	
Sketch	**Picture**	

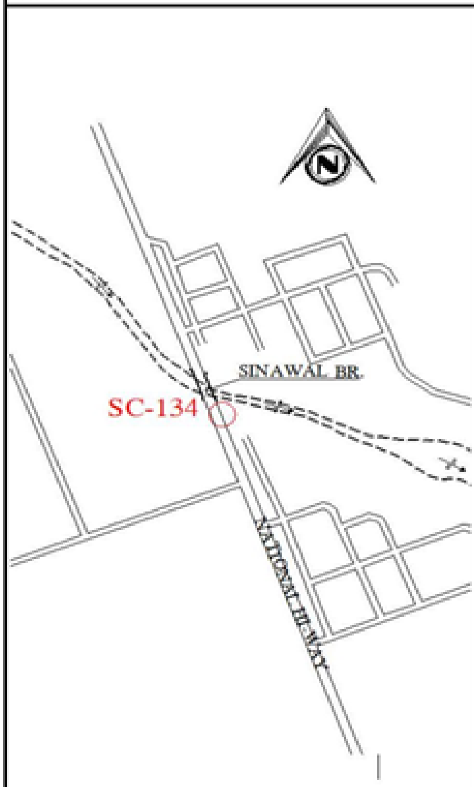
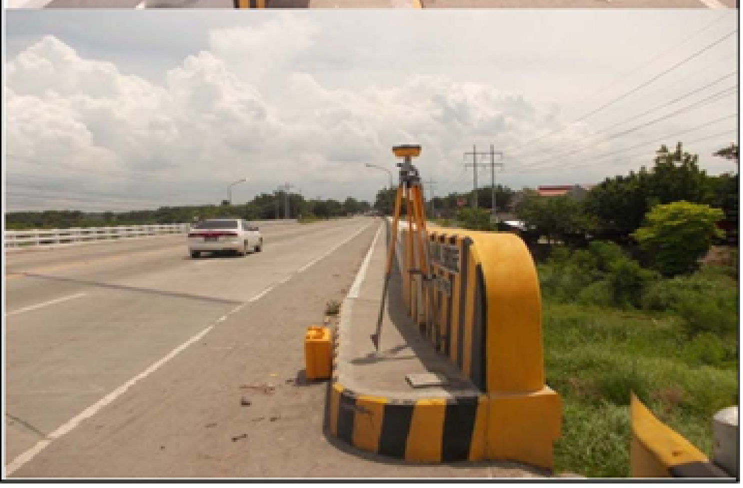


Control Number: SNI-06

Station Name	SNI-06	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°03'24.12667" North
	Longitude	125°16'56.33904" East
	Ellipsoidal Height	0.452 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°03'21.24911" North
	Longitude	125°17'01.95945" East
	Ellipsoidal Height	74.215 meters
Elevation	5.151 meters above Mean Sea Level (MSL)	
Description	From Barangay Lagao of General Santos City travel for about 7 km. to municipality of Alabel, Barangay Kawas, upon reaching Kawas Elementary School about 30 m. behind the gate facing north beside the center island SNI-09 is located.	
Sketch	Picture	
	 	

ANNEX H. RECOVERED NAMRIA BENCHMARK

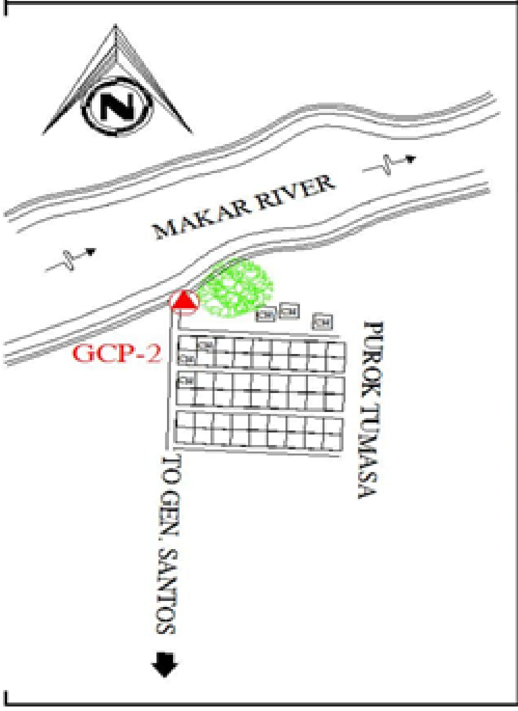
Control Number: SC-134

Station Name	SC-134	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°06'42.86385" N.
	Longitude	125°08'48.98619" E.
	Ellipsoidal Height	28.273 m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°06'39.95877" N.
	Longitude	125°08'54.60282" E.
	Ellipsoidal Height	101.605 m.
Elevation	31.063 meters above Mean Sea Level (MSL)	
Description	SC-134 is located at Brgy. Sinawal, General Santos City. It is on the approach of Sinawal Bridge.From the junction of Makar-Hadano Park, travel the National Highway heading to the PPA in Makar-Gensan wharf/port. You will pass the Sinawal Bridge it is placed on the right approach of the Bridge from the junction.	
Sketch	**Picture**	
	 	

ANNEX I. RECOVERED NAMRIA BENCHMARK

Control Number: GCP-2

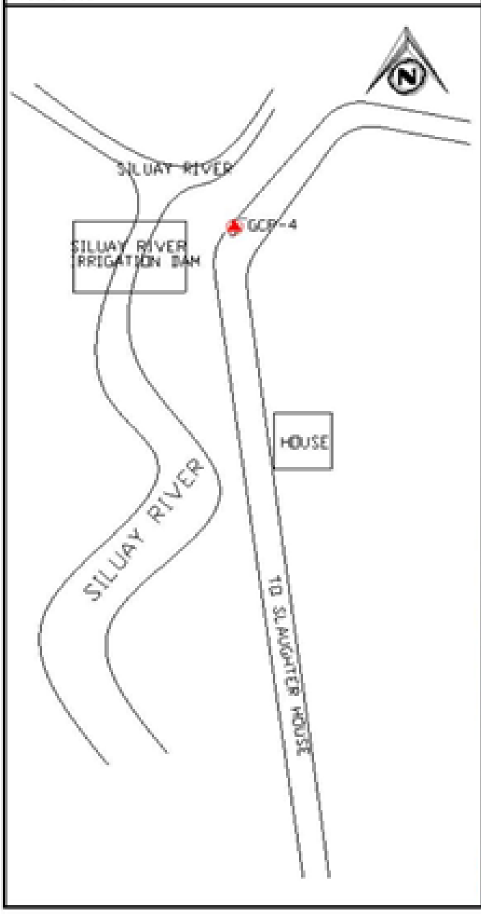
Station Name	GCP-2	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°05'14.70202" North
	Longitude	125°07'09.88590" East
	Ellipsoidal Height	75.343 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°05'11.80104" North
	Longitude	125°07'15.50504" East
	Ellipsoidal Height	148.648 meters
Elevation	77.907 meters above Mean Sea Level (MSL)	
Description	From the City Hall of General Santos travel about 6.1 KM's along P. Acharon boulevard going to Mun. of Maitum to reach the crossing going to General Santos Airport.Turn right and travel about 3.2 KM's and then turn right to the brgy. road right before the fatima market.Travel for about 370m. and then turn right again on the fifth crossing,travelfor about 240m. and then turn left to the first crossing and travel for about 750m. toward north.The monument is located 5m. south of the makar river, 5m. east of the brgy. road and 100m. north of a concrete house. Mark is the center of a concrete nail set flush at the center of a 6x70 centimeter concrete monument with inscription "GCP-2".	
Sketch	**Picture**	



Control Number: GCP-3

Station Name	GCP-3	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°05'26.55971" North
	Longitude	125°08'57.99555" East
	Ellipsoidal Height	4.127 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°05'23.6606" North
	Longitude	125°09'03.61413" East
	Ellipsoidal Height	77.501 meters
Elevation	7.059 meters above Mean Sea Level (MSL)	
Description	From the City Hall of General Santos travel about 3.45 KM's along P. Acharon boulevard going to Mun. of Maitum to reach the Makar Bridge 1.The monument is located on the first approach, right side of the makar bridge. Mark is the center of a concrete nail set flush at the center of a 6x70 centimeter concrete monument with inscription "GCP-3".	
Sketch	**Picture**	

Control Number: GCP-4

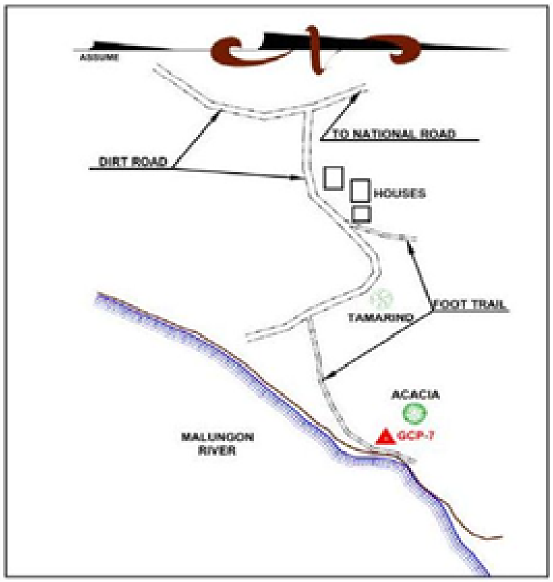
Station Name	GCP-4	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°09'30.53356" N
	Longitude	125°08'20.46506" E
	Ellipsoidal Height	73.335m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°09'27.61516" N
	Longitude	125°08'26.07742" E
	Ellipsoidal Height	146.566 m.
Elevation		75.720 m. aMsl
Description	GCP 4 is located at Brgy. Mabuhay, City of General Santos. It is along the feeder road of Brgy. Mabuhay, about 50m North of the Siluay River Irrigation Dam. From the Pan Philippine Highway travel for about 2.8 kms along Mabuhay road to reach Guinto St., turn right then continue travel for another 1.9 kms upon reaching the end of the road, turn right again on the feeder road. for about 5mins you will reach the Irrigation Dam. The station is about 10m from the road intersection.	
Sketch	**Picture**	
	 	

Control Number: GCP-6

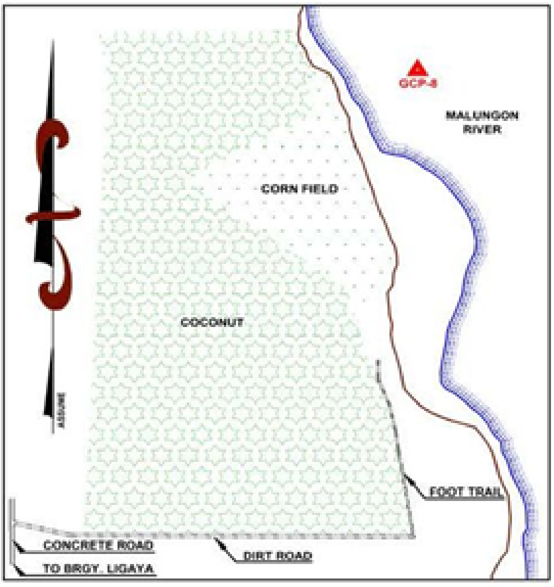
Station Name	GCP 6	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°06'23.60897" N.
	Longitude	125°09'43.26784" E.
	Ellipsoidal Height	-0.953 m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°06'20.70673" N.
	Longitude	125°09'48.88483" E.
	Ellipsoidal Height	72.425 m.
Elevation	2.064 meters above Mean Sea Level (MSL)	
Description	GCP-6 is equal to IBM-1 it is located at the riprap of Siluay Bridge in Brgy. Dadiangas South. From General Santos City Hall, travel for about 700m along Pioneer Ave., then turn right at P. Acharon Blvd., and continue travel for 1km upon reaching Siluay Bridge. The station is right down on the riprap footing of the bridge almost 400m North of Dadiangas coastal area.	
Sketch	**Picture**	

Control Number: GCP-7

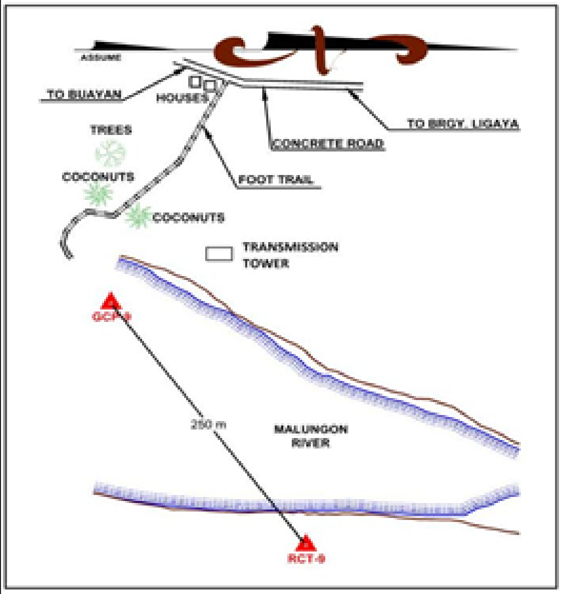
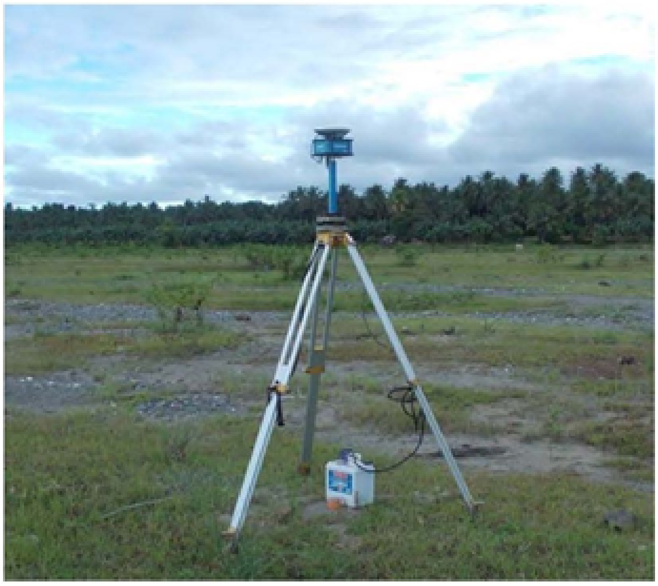
Station Name	GCP-7	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°11'47.90714" N.
	Longitude	125°14'22.66245" E.
	Ellipsoidal Height	25.955 m.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°11'44.98771" N.
	Longitude	125°14'28.27031" E.
	Ellipsoidal Height	99.370 m.
Elevation	29.284 m. above mean sea level (AMSL)	
Description	From General Santos town proper travel the national road leading to Davao for about 14 kilometers, until reaching a intersection with Tamarid tree which leads to Sitio Dampanan, Brgy. Katangawan. Continue travelling for about 1 km until reaching an intersection, turn left on the intersection leads to Malungon river. The station is located 50 meters SE of Bamboo grass and 150 meters SE of Acacia Tree and 50 meters from the river topbank.	
Sketch	Picture	



Control Number: GCP-8

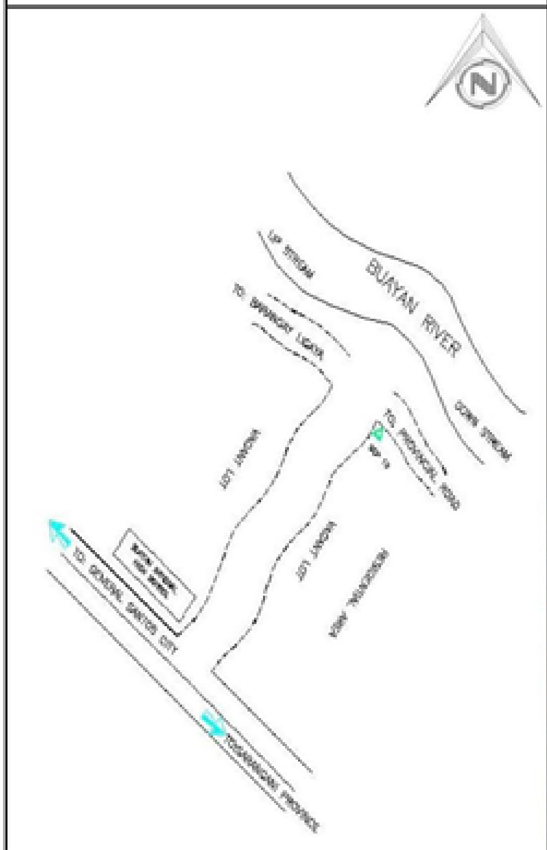
Station Name	GCP-8	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°10'24.29577" N.
	Longitude	125°14'12.51745" E.
	Ellipsoidal Height	17.398 M.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°10'21.38236" N.
	Longitude	125°14'18.12750" E.
	Ellipsoidal Height	90.846 M.
Elevation	20.392 m. above mean seal level (AMSL)	
Description	From General Santos town proper travel the national road leading to Davao for about 9 kilometers. Upon reaching a Petron Gasoline Station turn left on the road leading to Brgy. Ligaya, continue traveling for about 3 kilometers until reaching an intersection. turn left on the Iglesia ni Cristo Church and continue travelling for about 1.3 km. until reaching a road before a Mango Plantation, turn left on the road leading to Malungon River. The station is located 100 meters away from the right top bank with a plastic bag marker on a stake.	
Sketch	**Picture**	
		

Control Number: GCP-9

Station Name	GCP-9	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°08'45.06588" N.
	Longitude	125°13'56.19951" E.
	Ellipsoidal Height	9.309 M.
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°08'42.15951" N.
	Longitude	125°14'01.81216" E.
	Ellipsoidal Height	82.794 M.
Elevation	13.009 m. above mean seal level (AMSL)	
Description	From General Santos town proper travel the national road leading to Davao for about 9 kilometers. Upon reaching a Petron Gasoline Station turn left on the road leading to Brgy. Ligaya, continue traveling for about 3 kilometers until reaching an intersection, turn right on the intersection and continue travelling passing the Brgy. Ligaya Hall. continue travelling for about 1 km until reaching a foot trail which lead to a transmission tower. The station is located 200 m SE of the transmission line.	
Sketch	**Picture**	
		

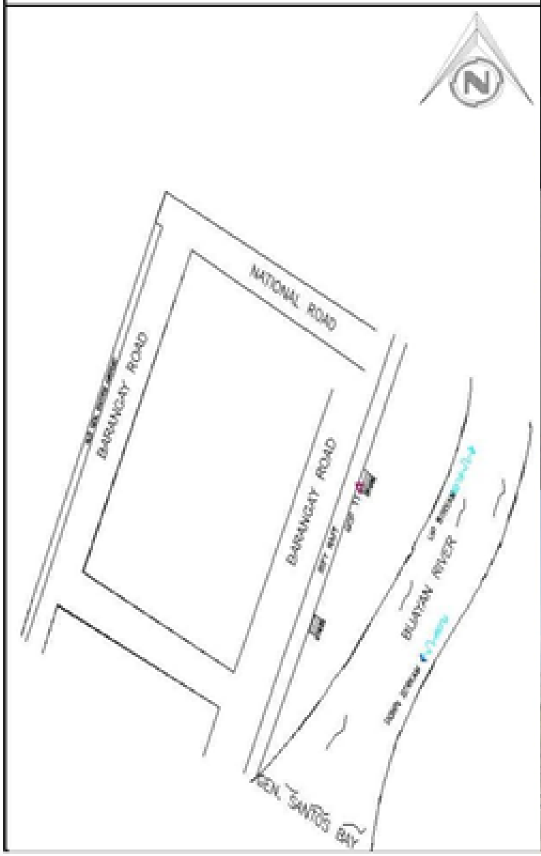
Control Number: GCP-10

Station Name	**GCP - 10**	
Order of Accuracy	**2nd**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	**Latitude**	6°07'21.18629" North
	Longitude	125°14'01.87846" East
	Ellipsoidal Height	6.552 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	**Latitude**	6°07'18.28638" North
	Longitude	125°14'07.49326" East
	Ellipsoidal Height	80.081 meters
Elevation	10.430 meters above Mean Sea Level (MSL)	
Description	From General Santos City travel at 7 km along the national high way to Sarangani Province and turn left in Buayan National High School. from Buayan National High School travel at 560 meters going to Buayan Purok 1A.The Station Mark is the head of a 2 in. concrete nail driven in a 20x20x2 cm. concrete putty with inscriptions, "GCP - 10 2013, UP GEO".	
Sketch	**Picture**	



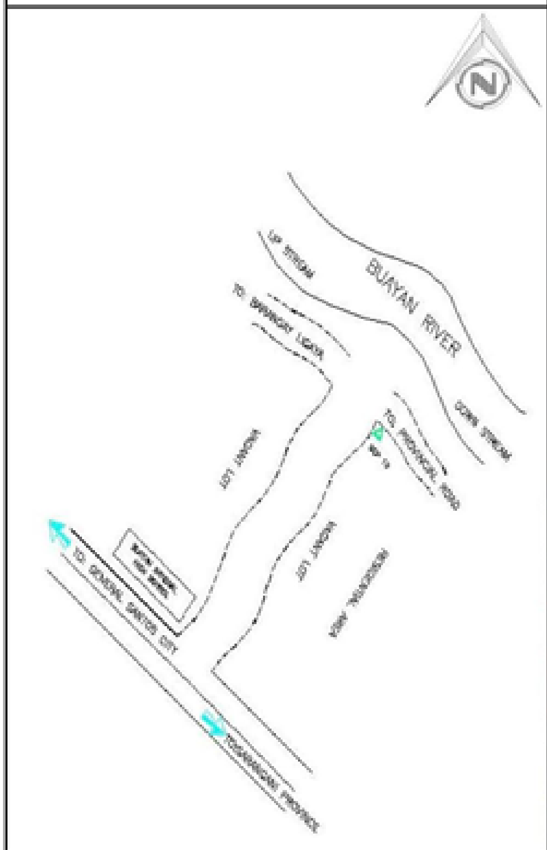
Control Number: GCP-11

Station Name	GCP - 11	
Order of Accuracy		
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°05'54.12020" North
	Longitude	125°14'09.33920" East
	Ellipsoidal Height	-2.557 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°05'51.22703" North
	Longitude	125°14'14.95621" East
	Ellipsoidal Height	71.019 meters
Elevation	1.453 meters above Mean Sea Level (MSL)	
Description	From General Santos City travel at 8 km along the national high way to Sarangani Province and turn right going to Barangay Buayan. From National High Way going to Barangay Buayan 2.70 km.The Station Mark is the head of a 2 in. concrete nail driven in a 20x20x2 cm. concrete putty with inscriptions, "GCP - 11 2013, UP GEO".	
Sketch	Picture	



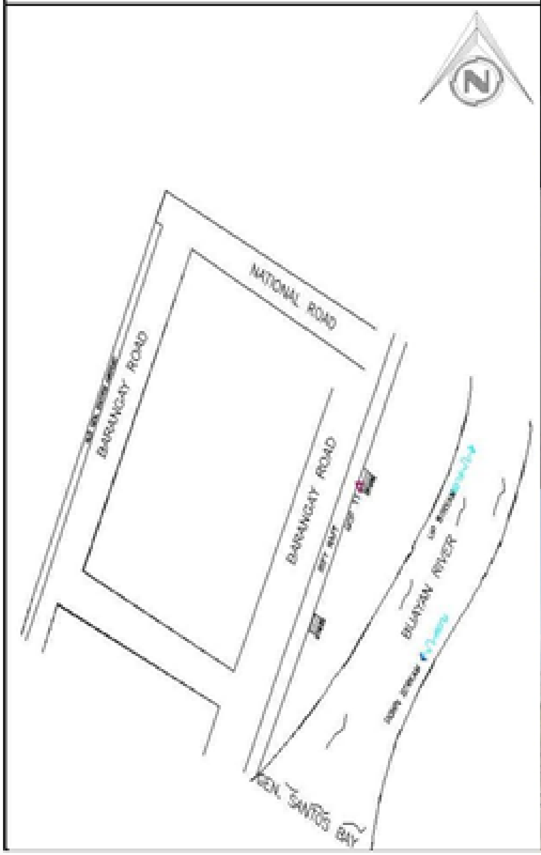
Control Number: GCP-10

Station Name	GCP - 10	
Order of Accuracy	2nd	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°07'21.18629" North
	Longitude	125°14'01.87846" East
	Ellipsoidal Height	6.552 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°07'18.28638" North
	Longitude	125°14'07.49326" East
	Ellipsoidal Height	80.081 meters
Elevation	10.430 meters above Mean Sea Level (MSL)	
Description	From General Santos City travel at 7 km along the national high way to Sarangani Province and turn left in Buayan National High School. from Buayan National High School travel at 560 meters going to Buayan Purok 1A.The Station Mark is the head of a 2 in. concrete nail driven in a 20x20x2 cm. concrete putty with inscriptions, "GCP - 10 2013, UP GEO".	
Sketch	Picture	



Control Number: GCP-11

Station Name	GCP - 11	
Order of Accuracy		
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	6°05'54.12020" North
	Longitude	125°14'09.33920" East
	Ellipsoidal Height	-2.557 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	6°05'51.22703" North
	Longitude	125°14'14.95621" East
	Ellipsoidal Height	71.019 meters
Elevation	1.453 meters above Mean Sea Level (MSL)	
Description	From General Santos City travel at 8 km along the national high way to Sarangani Province and turn right going to Barangay Buayan. From National High Way going to Barangay Buayan 2.70 km.The Station Mark is the head of a 2 in. concrete nail driven in a 20x20x2 cm. concrete putty with inscriptions, "GCP - 11 2013, UP GEO".	
Sketch	Picture	



ANNEX J. GNSS PROCESSING REPORT

RASA SURVEYING
#9 Anlacan Compound, Philand Drive,
TandangSora
Quezon City
Philippines

Phone: 029357296
Fax: 029357297
www.rasasurvey.com
technical@rasasurvey.com

Project Information		Coordinate System	
Name:	D:\NATS\2013\UP-DREAM\RIVER\BUAY-AN-RIVER\GPS\BUAYAN GCP.vce	Name:	UTM
Size:	869 KB	Datum:	WGS 1984
Modified:	7/20/2013 12:54:00 PM (UTC:8)	Zone:	51 North (123E)
Time zone:	Taipei Standard Time	Geoid:	EGM2008
Reference number:		Vertical datum:	
Description:			

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:	99
Post Processed Vector Statistics	
Reference Factor:	1.00
Redundancy Number:	99.00
A Priori Scalar:	1.24

Control Coordinate Comparisons
Values shown are control coordinates minus adjusted coordinates.

Point ID	ΔNorthing (Meter)	ΔEasting (Meter)	ΔElevation (Meter)	ΔHeight (Meter)
BUA-4	0.212	0.293	?	?

Control Point Constraints

Point ID	Type	North σ (Meter)	East σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
BUA-4	Global			Fixed	
CTS-43	Global	Fixed	Fixed	Fixed	
CTS-44	Global	Fixed	Fixed	Fixed	
SNI-06	Global	Fixed	Fixed	Fixed	
Fixed = 0.000001(Meter)					

Adjusted Grid Coordinates

Point ID	Northing (m)	Northing Error (m)	Easting (m)	Easting Error (m)	Elevation (m)	Elevation Error (m)	Constraint
BUA-4	698849.7654	0.011	749160.5292	0.013	195.701	?	h
CTS-43	669859.3383	?	737140.9201	?	26.720	?	LLh
CTS-44	671055.7778	?	724712.9043	?	359.596	?	LLh
GCP-1	672516.9925	0.006	730235.5812	0.006	188.271	0.013	
GCP-10	677177.5561	0.006	747398.4095	0.006	10.272	0.012	
GCP-11	674503.2361	0.005	747639.0777	0.006	1.295	0.011	
GCP-2	673239.6455	0.006	734742.4041	0.006	77.749	0.011	
GCP-3	673617.2107	0.005	738066.1346	0.006	6.901	0.012	
GCP-4	681108.7097	0.006	736881.7036	0.006	75.562	0.013	
GCP-5	678591.1861	0.006	737674.2853	0.006	43.059	0.012	
GCP-6	675375.6791	0.006	739451.5308	0.007	1.906	0.012	
GCP-7	685375.8071	0.007	748003.0532	0.008	29.126	0.018	
GCP-8	682805.3463	0.007	747701.9443	0.007	20.774	0.016	
GCP-9	679754.1900	0.006	747212.9305	0.006	12.851	0.013	
SC-134	675960.5614	0.006	737779.6196	0.007	30.905	0.012	
SNI-06	669915.9150	?	752795.4821	?	4.993	?	LLh

Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Height (m)	Height Error (m)	Constraint
BUA-4	N6°19'03.28606"	E125°15'07.78454"	266.866	?	h
CTS-43	N6°03'21.48507"	E125°08'33.05028"	97.233	?	LLh
CTS-44	N6°04'01.97913"	E125°01'49.14944"	431.563	?	LLh
GCP-1	N6°04'48.85271"	E125°04'48.88662"	259.624	0.013	
GCP-10	N6°07'18.28638"	E125°14'07.49326"	80.081	0.012	
GCP-11	N6°05'51.22703"	E125°14'14.95621"	71.019	0.011	
GCP-2	N6°05'11.80104"	E125°07'15.50504"	148.648	0.011	
GCP-3	N6°05'23.66059"	E125°09'03.61413"	77.501	0.012	
GCP-4	N6°09'27.61516"	E125°08'26.07742"	146.566	0.013	
GCP-5	N6°08'05.58241"	E125°08'51.52020"	113.867	0.012	
GCP-6	N6°06'20.70673"	E125°09'48.88483"	72.425	0.012	
GCP-7	N6°11'44.98771"	E125°14'28.27031"	99.370	0.018	
GCP-8	N6°10'21.38236"	E125°14'18.12750"	90.846	0.016	
GCP-9	N6°08'42.15951"	E125°14'01.81216"	82.794	0.013	
SC-134	N6°06'39.95877"	E125°08'54.60282"	101.605	0.012	
SNI-06	N6°03'21.24911"	E125°17'01.95945"	74.215	?	LLh

Adjusted ECEF Coordinates

Point ID	X (m)	X Error (m)	Y (m)	Y Error (m)	Z (m)	Z Error (m)	3D Error (m)	Constraint
BUA-4	-3659253.3673	?	5177309.1764	?	697204.757	?	?	h
CTS-43	-3651036.3859	?	5186714.2229	?	668423.308	?	?	LLh
CTS-44	-3640988.3762	?	5194018.2825	?	669695.626	?	?	LLh
GCP-1	-3645327.1838	0.008	5190578.9890	0.011	671109.317	0.006	0.015	
GCP-10	-3658986.4541	0.008	5180143.3689	0.011	675654.745	0.006	0.015	
GCP-11	-3659332.9046	0.008	5180236.1016	0.010	672994.600	0.005	0.014	
GCP-2	-3648909.3958	0.008	5187835.1161	0.010	671798.548	0.006	0.014	
GCP-3	-3651565.0054	0.008	5185832.4713	0.011	672153.262	0.006	0.015	
GCP-4	-3650200.5892	0.009	5185899.3244	0.012	679611.938	0.006	0.016	
GCP-5	-3650976.8507	0.008	5185643.0628	0.010	677102.938	0.006	0.014	
GCP-6	-3652592.9830	0.009	5184874.5998	0.011	673895.203	0.006	0.015	
GCP-7	-3659012.1202	0.013	5179072.5624	0.015	683802.342	0.008	0.021	
GCP-8	-3658912.1844	0.011	5179471.5344	0.014	681248.087	0.007	0.019	
GCP-9	-3658686.5189	0.009	5180021.4968	0.011	678216.784	0.006	0.016	

Error Ellipse Components

Point ID	Semi-major axis (m)	Semi-minor axis (m)	Azimuth
BUA-4	0.016	0.014	94°
GCP-1	0.008	0.007	111°
GCP-10	0.008	0.007	94°
GCP-11	0.007	0.007	100°
GCP-2	0.008	0.007	111°
GCP-3	0.007	0.007	110°
GCP-4	0.008	0.008	114°
GCP-5	0.007	0.007	120°
GCP-6	0.008	0.008	108°
GCP-7	0.01	0.009	92°
GCP-8	0.009	0.009	102°
GCP-9	0.008	0.008	99°
SC-134	0.008	0.008	112°

Adjusted GPS Observations

Transformation Parameters			
Deflection in Latitude:	-2.162 sec	(95%)	0.140 sec
Deflection in Longitude:	0.452 sec	(95%)	0.167 sec
Azimuth Rotation:	-0.118 sec	(95%)	0.056 sec
Scale Factor:	0.99999961	(95%)	0.00000030

Observation ID		Observation	A-posteriori Error	Residual	Standardized Residual
BUA-4 --> GCP-7 (PV4)	Az.	185°09'20"	0.146 sec	0.019 sec	0.349
	ΔHt.	-167.640 m	0.025 m	-0.013 m	-0.856
	Ellip Dist.	13518.654 m	0.007 m	0.019 m	4.213
GCP-6 --> SC-134 (PV38)	Az.	289°30'42"	0.735 sec	0.138 sec	0.279
	ΔHt.	29.183 m	0.008 m	-0.006 m	-3.057
	Ellip Dist.	1770.724 m	0.007 m	0.001 m	0.202
GCP-6 --> GCP-10 (PV40)	Az.	77°27'19"	0.159 sec	0.074 sec	0.649
	ΔHt.	7.692 m	0.013 m	0.036 m	2.979
	Ellip Dist.	8145.884 m	0.007 m	0.000 m	0.018
GCP-9 --> GCP-7 (PV5)	Az.	8°14'27"	0.242 sec	-0.260 sec	-1.553
	ΔHt.	16.637 m	0.018 m	0.004 m	0.308
	Ellip Dist.	5674.837 m	0.006 m	0.012 m	2.57
GCP-10 --> GCP-9 (PV14)	Az.	356°07'18"	0.512 sec	-0.284 sec	-0.744
	ΔHt.	2.739 m	0.012 m	0.021 m	2.556
	Ellip Dist.	2582.380 m	0.006 m	0.006 m	1.379

BUA-4 --> GCP-4 (PV34)	**Az.**	214°55'57"	0.095 sec	-0.247 sec	-1.660
	ΔHt.	-120.513 m	0.024 m	-0.040 m	-2.101
	Ellip Dist.	21568.652 m	0.008 m	-0.018 m	-1.884
CTS-43 --> CTS-44 (PV79)	**Az.**	275°43'31"	0.056 sec	-0.108 sec	-1.251
	ΔHt.	334.316 m	0.009 m	0.034 m	2.061
	Ellip Dist.	12482.230 m	0.004 m	-0.010 m	-1.684
SNI-06 --> GCP-11 (PV17)	**Az.**	311°53'57"	0.168 sec	0.013 sec	0.096
	ΔHt.	-3.159 m	0.012 m	-0.002 m	-0.238
	Ellip Dist.	6899.011 m	0.006 m	0.010 m	1.941
SNI-06 --> BUA-4 (PV8)	**Az.**	353°05'08"	0.074 sec	0.136 sec	0.514
	ΔHt.	192.947 m	0.024 m	-0.019 m	-1.009
	Ellip Dist.	29150.225 m	0.007 m	-0.024 m	-1.879
SC-134 --> GCP-3 (PV98)	**Az.**	173°15'27"	0.567 sec	-0.051 sec	-0.122
	ΔHt.	-24.128 m	0.012 m	-0.018 m	-1.765
	Ellip Dist.	2360.092 m	0.006 m	0.003 m	0.71
CTS-44 --> GCP-1 (PV108)	**Az.**	75°23'42"	0.232 sec	-0.124 sec	-0.740
	ΔHt.	-171.912 m	0.015 m	-0.026 m	-1.754
	Ellip Dist.	5711.344 m	0.007 m	0.002 m	0.498
GCP-4 --> GCP-9 (PV35)	**Az.**	97°41'56"	0.110 sec	-0.015 sec	-0.163
	ΔHt.	-63.764 m	0.012 m	-0.016 m	-1.659
	Ellip Dist.	10416.259 m	0.006 m	0.002 m	0.443
GCP-5 --> GCP-7 (PV52)	**Az.**	56°55'52"	0.105 sec	-0.049 sec	-0.610
	ΔHt.	-14.404 m	0.018 m	0.005 m	0.318
	Ellip Dist.	12353.699 m	0.006 m	0.008 m	1.584
SC-134 --> GCP-5 (PV48)	**Az.**	357°56'11"	0.476 sec	-0.144 sec	-0.400
	ΔHt.	12.290 m	0.009 m	-0.009 m	-1.470
	Ellip Dist.	2631.945 m	0.006 m	0.004 m	0.994
SNI-06 --> CTS-43 (PV87)	**Az.**	270°02'02"	0.056 sec	0.094 sec	1.434
	ΔHt.	22.984 m	0.011 m	-0.013 m	-1.311
	Ellip Dist.	15649.302 m	0.005 m	0.004 m	0.752
GCP-9 --> GCP-8 (PV1)	**Az.**	9°20'43"	0.446 sec	0.228 sec	0.749
	ΔHt.	8.085 m	0.014 m	-0.010 m	-1.400
	Ellip Dist.	3088.991 m	0.006 m	0.001 m	0.142
GCP-5 --> GCP-9 (PV54)	**Az.**	83°16'42"	0.118 sec	-0.034 sec	-0.339
	ΔHt.	-31.040 m	0.012 m	-0.013 m	-1.328
	Ellip Dist.	9606.140 m	0.006 m	0.001 m	0.284
BUA-4 --> GCP-8 (PV3)	**Az.**	185°26'22"	0.134 sec	0.043 sec	0.483
	ΔHt.	-176.192 m	0.025 m	0.034 m	1.171
	Ellip Dist.	16104.725 m	0.007 m	0.001 m	0.233

GCP-6 --> GCP-5 (PV46)	**Az.**	331°18'03"	0.335 sec	-0.018 sec	-0.069
	ΔHt.	41.472 m	0.010 m	0.008 m	0.993
	Ellip Dist.	3672.857 m	0.006 m	0.005 m	1.139
GCP-2 --> GCP-5 (PV56)	**Az.**	28°56'32"	0.209 sec	0.024 sec	0.146
	ΔHt.	-34.719 m	0.011 m	-0.010 m	-1.068
	Ellip Dist.	6100.271 m	0.006 m	0.004 m	0.888
CTS-43 --> GCP-11 (PV85)	**Az.**	66°21'52"	0.100 sec	0.092 sec	1.061
	ΔHt.	-26.142 m	0.012 m	0.005 m	0.541
	Ellip Dist.	11475.668 m	0.006 m	0.003 m	0.619
SNI-06 --> GCP-10 (PV11)	**Az.**	323°37'17"	0.135 sec	0.020 sec	0.178
	ΔHt.	5.931 m	0.013 m	0.005 m	0.488
	Ellip Dist.	9044.260 m	0.006 m	0.005 m	1.052
SNI-06 --> GCP-8 (PV10)	**Az.**	338°40'51"	0.097 sec	0.020 sec	0.278
	ΔHt.	16.755 m	0.015 m	0.013 m	0.993
	Ellip Dist.	13854.156 m	0.006 m	-0.003 m	-0.710
CTS-43 --> GCP-1 (PV107)	**Az.**	291°16'36"	0.140 sec	-0.026 sec	-0.195
	ΔHt.	51.446 m	0.011 m	0.001 m	0.097
	Ellip Dist.	4143.602 m	0.006 m	0.003 m	0.727
GCP-2 --> SC-134 (PV59)	**Az.**	48°22'10"	0.326 sec	-0.164 sec	-0.724
	ΔHt.	-47.009 m	0.011 m	0.001 m	0.14
	Ellip Dist.	4076.568 m	0.006 m	0.000 m	-0.038
GCP-4 --> GCP-10 (PV31)	**Az.**	110°43'29"	0.106 sec	-0.011 sec	-0.132
	ΔHt.	-66.503 m	0.013 m	-0.008 m	-0.701
	Ellip Dist.	11223.772 m	0.006 m	0.000 m	-0.097
SNI-06 --> GCP-7 (PV7)	**Az.**	343°01'15"	0.084 sec	0.035 sec	0.541
	ΔHt.	25.307 m	0.019 m	0.010 m	0.412
	Ellip Dist.	16179.582 m	0.006 m	-0.003 m	-0.628
GCP-3 --> GCP-11 (PV99)	**Az.**	84°56'26"	0.127 sec	0.047 sec	0.473
	ΔHt.	-6.451 m	0.013 m	-0.007 m	-0.607
	Ellip Dist.	9610.690 m	0.006 m	0.002 m	0.406
SC-134 --> GCP-1 (PV113)	**Az.**	245°41'36"	0.159 sec	0.045 sec	0.393
	ΔHt.	157.967 m	0.012 m	-0.006 m	-0.573
	Ellip Dist.	8290.510 m	0.006 m	0.000 m	-0.103
GCP-5 --> GCP-11 (PV49)	**Az.**	112°32'03"	0.104 sec	-0.007 sec	-0.084
	ΔHt.	-42.869 m	0.011 m	-0.005 m	-0.519
	Ellip Dist.	10767.183 m	0.006 m	-0.002 m	-0.449
GCP-11 --> GCP-10 (PV16)	**Az.**	355°05'45"	0.487 sec	-0.065 sec	-0.178
	ΔHt.	9.089 m	0.012 m	-0.003 m	-0.407
	Ellip Dist.	2684.166 m	0.006 m	0.002 m	0.519

GCP-1 --> GCP-5 (PV110)	**Az.**	50°59'15"	0.126 sec	0.007 sec	0.068
	ΔHt.	-145.678 m	0.011 m	-0.003 m	-0.305
	Ellip Dist.	9600.993 m	0.006 m	0.002 m	0.467
GCP-6 --> GCP-3 (PV96)	**Az.**	218°27'45"	0.602 sec	-0.174 sec	-0.395
	ΔHt.	5.055 m	0.012 m	0.005 m	0.46
	Ellip Dist.	2237.962 m	0.006 m	0.002 m	0.437
GCP-4 --> GCP-8 (PV36)	**Az.**	81°19'06"	0.114 sec	-0.039 sec	-0.445
	ΔHt.	-55.679 m	0.014 m	0.002 m	0.194
	Ellip Dist.	10948.877 m	0.007 m	-0.001 m	-0.281
GCP-4 --> GCP-1 (PV112)	**Az.**	217°57'07"	0.120 sec	-0.018 sec	-0.195
	ΔHt.	112.954 m	0.013 m	-0.004 m	-0.426
	Ellip Dist.	10859.270 m	0.006 m	0.000 m	0.098
CTS-44 --> GCP-4 (PV70)	**Az.**	50°39'19"	0.095 sec	0.016 sec	0.259
	ΔHt.	-284.866 m	0.017 m	-0.005 m	-0.332
	Ellip Dist.	15780.118 m	0.007 m	-0.002 m	-0.415
GCP-11 --> GCP-6 (PV39)	**Az.**	276°19'13"	0.151 sec	0.005 sec	0.049
	ΔHt.	1.397 m	0.012 m	-0.004 m	-0.388
	Ellip Dist.	8231.150 m	0.007 m	0.001 m	0.194
GCP-5 --> GCP-8 (PV55)	**Az.**	67°26'08"	0.117 sec	-0.029 sec	-0.314
	ΔHt.	-22.955 m	0.014 m	-0.001 m	-0.101
	Ellip Dist.	10873.607 m	0.006 m	-0.001 m	-0.179
GCP-3 --> GCP-2 (PV94)	**Az.**	263°44'51"	0.380 sec	0.041 sec	0.15
	ΔHt.	71.137 m	0.012 m	-0.002 m	-0.225
	Ellip Dist.	3344.133 m	0.007 m	-0.001 m	-0.218
GCP-4 --> GCP-7 (PV33)	**Az.**	69°14'22"	0.108 sec	0.001 sec	0.017
	ΔHt.	-47.127 m	0.018 m	0.000 m	0.032
	Ellip Dist.	11907.968 m	0.006 m	0.001 m	0.22

Covariance Terms

From Point	To Point		Components	A-posteriori Error	Horiz. Precision (Ratio)	3D Precision (Ratio)
BUA-4	GCP-4	**Az.**	214°55'57"	0.107 sec	1 : 2253862	1 : 2250946
		ΔHt.	-120.300 m	0.013 m		
		ΔElev.	-120.140 m	0.013 m		
		Ellip Dist.	21568.644 m	0.010 m		
BUA-4	GCP-7	**Az.**	185°09'20"	0.157 sec	1 : 1656744	1 : 1656828
		ΔHt.	-167.497 m	0.018 m		
		ΔElev.	-166.576 m	0.018 m		
		Ellip Dist.	13518.650 m	0.008 m		
BUA-4	SNI-06	**Az.**	173°04'56"	0.093 sec	1 : 2646805	1 : 2647872
		ΔHt.	-192.651 m	0.000 m		
		ΔElev.	-190.708 m	0.000 m		
		Ellip Dist.	29150.217 m	0.011 m		
CTS-43	GCP-1	**Az.**	291°16'36"	0.154 sec	1 : 1220367	1 : 1213956
		ΔHt.	162.391 m	0.013 m		
		ΔElev.	161.551 m	0.013 m		
		Ellip Dist.	7397.068 m	0.006 m		
CTS-43	GCP-3	**Az.**	14°03'30"	0.313 sec	1 : 713399	1 : 713593
		ΔHt.	-19.732 m	0.012 m		
		ΔElev.	-19.819 m	0.012 m		
		Ellip Dist.	3868.938 m	0.005 m		
CTS-44	CTS-43	**Az.**	95°42'48"	0.000 sec	1:00	1:00
		ΔHt.	-334.330 m	0.000 m		
		ΔElev.	-332.876 m	0.000 m		
		Ellip Dist.	12482.225 m	0.000 m		
CTS-44	GCP-1	**Az.**	75°23'42"	0.206 sec	1 : 970051	1 : 963939
		ΔHt.	-171.939 m	0.013 m		
		ΔElev.	-171.325 m	0.013 m		
		Ellip Dist.	5711.341 m	0.006 m		
GCP-10	GCP-11	**Az.**	175°05'45"	0.489 sec	1 : 451216	1 : 451151
		ΔHt.	-9.062 m	0.012 m		
		ΔElev.	-8.977 m	0.012 m		
		Ellip Dist.	2684.165 m	0.006 m		
GCP-10	GCP-4	**Az.**	290°44'06"	0.113 sec	1 : 1676527	1 : 1674888
		ΔHt.	66.485 m	0.014 m		
		ΔElev.	65.290 m	0.014 m		
		Ellip Dist.	11223.767 m	0.007 m		

GCP-10	GCP-5	**Az.**	278°30'36"	0.121 sec	1 : 1557686	1 : 1556742
		ΔHt.	33.786 m	0.013 m		
		ΔElev.	32.787 m	0.013 m		
		Ellip Dist.	9823.115 m	0.006 m		
GCP-10	GCP-6	Az.	257°27'47"	0.166 sec	1 : 1167379	1 : 1167238
		ΔHt.	-7.656 m	0.013 m		
		ΔElev.	-8.366 m	0.013 m		
		Ellip Dist.	8145.880 m	0.007 m		
GCP-11	CTS-43	Az.	246°22'29"	0.097 sec	1 : 2061420	1 : 2060303
		ΔHt.	26.214 m	0.011 m		
		ΔElev.	25.425 m	0.011 m		
		Ellip Dist.	11475.664 m	0.006 m		
GCP-11	GCP-3	Az.	264°56'59"	0.137 sec	1 : 1402328	1 : 1401828
		ΔHt.	6.481 m	0.014 m		
		ΔElev.	5.606 m	0.014 m		
		Ellip Dist.	9610.686 m	0.007 m		
GCP-11	GCP-5	Az.	292°32'38"	0.117 sec	1 : 1629439	1 : 1628214
		ΔHt.	42.847 m	0.013 m		
		ΔElev.	41.764 m	0.013 m		
		Ellip Dist.	10767.179 m	0.007 m		
GCP-11	GCP-6	Az.	276°19'13"	0.161 sec	1 : 1187566	1 : 1187418
		ΔHt.	1.405 m	0.013 m		
		ΔElev.	0.611 m	0.013 m		
		Ellip Dist.	8231.147 m	0.007 m		
GCP-2	CTS-43	Az.	144°52'00"	0.300 sec	1 : 670479	1 : 669190
		ΔHt.	-51.415 m	0.011 m		
		ΔElev.	-51.029 m	0.011 m		
		Ellip Dist.	4143.601 m	0.006 m		
GCP-2	GCP-1	Az.	261°06'55"	0.276 sec	1 : 715912	1 : 713271
		ΔHt.	110.976 m	0.012 m		
		ΔElev.	110.522 m	0.012 m		
		Ellip Dist.	4563.165 m	0.006 m		
GCP-2	GCP-3	Az.	83°44'39"	0.380 sec	1 : 516171	1 : 513991
		ΔHt.	-71.148 m	0.012 m		
		ΔElev.	-70.848 m	0.012 m		
		Ellip Dist.	3344.131 m	0.006 m		
GCP-4	CTS-44	Az.	230°40'02"	0.082 sec	1 : 2580565	1 : 2578974
		ΔHt.	284.997 m	0.013 m		
		ΔElev.	284.035 m	0.013 m		
		Ellip Dist.	15780.110 m	0.006 m		

GCP-4	GCP-1	**Az.**	217°57'07"	0.128 sec	1 : 1666289	1 : 1665491
		ΔHt.	113.058 m	0.014 m		
		ΔElev.	112.709 m	0.014 m		
		Ellip Dist.	10859.264 m	0.007 m		
GCP-4	GCP-5	**Az.**	162°45'14"	0.423 sec	1 : 506475	1 : 505706
		ΔHt.	-32.699 m	0.010 m		
		ΔElev.	-32.503 m	0.010 m		
		Ellip Dist.	2638.556 m	0.005 m		
GCP-5	GCP-1	**Az.**	230°59'41"	0.128 sec	1 : 1629880	1 : 1627787
		ΔHt.	145.757 m	0.012 m		
		ΔElev.	145.212 m	0.012 m		
		Ellip Dist.	9600.988 m	0.006 m		
GCP-7	GCP-4	**Az.**	249°15'01"	0.113 sec	1 : 1756583	
		Ellip Dist.	9600.988 m	0.006 m		
GCP-5	GCP-2	**Az.**	208°56'43"	0.213 sec	1 : 1020356	1 : 1020368
		ΔHt.	34.782 m	0.011 m		
		ΔElev.	34.690 m	0.011 m		
		Ellip Dist.	6100.269 m	0.006 m		
GCP-6	GCP-3	**Az.**	218°27'45"	0.605 sec	1 : 359735	1 : 359590
		ΔHt.	5.076 m	0.012 m		
		ΔElev.	4.995 m	0.012 m		
		Ellip Dist.	2237.962 m	0.006 m		
GCP-6	GCP-5	**Az.**	331°18'03"	0.340 sec	1 : 608754	1 : 608186
		ΔHt.	41.442 m	0.010 m		
		ΔElev.	41.153 m	0.010 m		
		Ellip Dist.	3672.856 m	0.006 m		
GCP-7	GCP-4	**Az.**	249°15'01"	0.113 sec	1 : 1756583	1 : 1757178
		ΔHt.	47.196 m	0.018 m		
		ΔElev.	46.436 m	0.018 m		
		Ellip Dist.	11907.963 m	0.007 m		
GCP-7	GCP-5	**Az.**	236°56'29"	0.115 sec	1 : 1784964	1 : 1784817
		ΔHt.	14.497 m	0.018 m		
		ΔElev.	13.933 m	0.018 m		
		Ellip Dist.	12353.695 m	0.007 m		
GCP-7	SNI-06	**Az.**	163°00'59"	0.098 sec	1 : 2154178	1 : 2154440
		ΔHt.	-25.155 m	0.018 m		
		ΔElev.	-24.132 m	0.018 m		
		Ellip Dist.	16179.576 m	0.008 m		

GCP-8	BUA-4	**Az.**	5°26'17"	0.145 sec	1 : 1893307	1 : 1893439
		ΔHt.	176.020 m	0.016 m		
		ΔElev.	174.927 m	0.016 m		
		Ellip Dist.	16104.721 m	0.009 m		
GCP-8	GCP-4	**Az.**	261°19'44"	0.118 sec	1 : 1615710	1 : 1613975
		ΔHt.	55.720 m	0.015 m		
		ΔElev.	54.787 m	0.015 m		
		Ellip Dist.	10948.873 m	0.007 m		
GCP-8	GCP-5	**Az.**	247°26'43"	0.125 sec	1 : 1613059	1 : 1612101
		ΔHt.	23.021 m	0.015 m		
		ΔElev.	22.285 m	0.015 m		
		Ellip Dist.	10873.603 m	0.007 m		
GCP-8	GCP-9	**Az.**	189°20'45"	0.449 sec	1 : 499634	1 : 499544
		ΔHt.	-8.052 m	0.014 m		
		ΔElev.	-7.924 m	0.014 m		
		Ellip Dist.	3088.989 m	0.006 m		
GCP-8	SNI-06	**Az.**	158°40'34"	0.108 sec	1 : 1962064	1 : 1962273
		ΔHt.	-16.631 m	0.016 m		
		ΔElev.	-15.781 m	0.016 m		
		Ellip Dist.	13854.151 m	0.007 m		
GCP-9	GCP-10	**Az.**	176°07'17"	0.514 sec	1 : 428695	1 : 428726
		ΔHt.	-2.713 m	0.013 m		
		ΔElev.	-2.579 m	0.013 m		
		Ellip Dist.	2582.379 m	0.006 m		
GCP-9	GCP-4	**Az.**	277°42'32"	0.114 sec	1 : 1665613	1 : 1663749
		ΔHt.	63.772 m	0.013 m		
		ΔElev.	62.711 m	0.013 m		
		Ellip Dist.	10416.255 m	0.006 m		
GCP-9	GCP-5	**Az.**	263°17'15"	0.125 sec	1 : 1565971	1 : 1564967
		ΔHt.	31.073 m	0.012 m		
		ΔElev.	30.208 m	0.012 m		
		Ellip Dist.	9606.136 m	0.006 m		
GCP-9	GCP-7	**Az.**	8°14'27"	0.248 sec	1 : 875658	1 : 875425
		ΔHt.	16.576 m	0.018 m		
		ΔElev.	16.275 m	0.018 m		
		Ellip Dist.	5674.835 m	0.006 m		
GCP-9	SNI-06	**Az.**	150°39'56"	0.114 sec	1 : 1822233	1 : 1822413
		ΔHt.	-8.579 m	0.013 m		
		ΔElev.	-7.858 m	0.013 m		
		Ellip Dist.	11307.562 m	0.006 m		

SC-134	GCP-1	**Az.**	245°41'36"	0.162 sec	1 : 1255613	1 : 1252756
		ΔHt.	158.020 m	0.012 m		
		ΔElev.	157.366 m	0.012 m		
		Ellip Dist.	8290.505 m	0.007 m		
SC-134	GCP-2	**Az.**	228°22'21"	0.329 sec	1 : 642126	1 : 641653
		ΔHt.	47.044 m	0.011 m		
		ΔElev.	46.844 m	0.011 m		
		Ellip Dist.	4076.566 m	0.006 m		
SC-134	GCP-3	**Az.**	173°15'27"	0.568 sec	1 : 380977	1 : 380694
		ΔHt.	-24.104 m	0.012 m		
		ΔElev.	-24.004 m	0.012 m		
		Ellip Dist.	2360.092 m	0.006 m		
SC-134	GCP-5	**Az.**	357°56'11"	0.479 sec	1 : 450740	1 : 450644
		ΔHt.	12.262 m	0.010 m		
		ΔElev.	12.154 m	0.010 m		
		Ellip Dist.	2631.944 m	0.006 m		
SC-134	GCP-6	**Az.**	109°30'36"	0.736 sec	1 : 264689	1 : 264492
		ΔHt.	-29.180 m	0.008 m		
		ΔElev.	-28.999 m	0.008 m		
		Ellip Dist.	1770.724 m	0.007 m		
SNI-06	CTS-43	**Az.**	270°02'02"	0.000 sec	1:00	1:00
		ΔHt.	23.018 m	0.000 m		
		ΔElev.	21.727 m	0.000 m		
		Ellip Dist.	15649.295 m	0.000 m		
SNI-06	GCP-10	**Az.**	323°37'17"	0.136 sec	1 : 1529220	1 : 1529572
		ΔHt.	5.866 m	0.012 m		
		ΔElev.	5.278 m	0.012 m		
		Ellip Dist.	9044.257 m	0.006 m		
SNI-06	GCP-11	**Az.**	311°53'58"	0.161 sec	1 : 1234729	1 : 1235167
		ΔHt.	-3.196 m	0.011 m		
		ΔElev.	-3.698 m	0.011 m		
		Ellip Dist.	6899.008 m	0.006 m		
SNI-06	GCP-3	**Az.**	284°20'50"	0.074 sec	1 : 2585765	1 : 2585469
		ΔHt.	3.286 m	0.012 m		
		ΔElev.	1.908 m	0.012 m		
		Ellip Dist.	15182.023 m	0.006 m		

GCP-8	BUA-4	Az.	5°26'17"	0.145 sec	1 : 1893307	1 : 1893439
		ΔHt.	176.020 m	0.016 m		
		ΔElev.	174.927 m	0.016 m		
		Ellip Dist.	16104.721 m	0.009 m		
GCP-8	GCP-4	Az.	261°19'44"	0.118 sec	1 : 1615710	1 : 1613975
		ΔHt.	55.720 m	0.015 m		
		ΔElev.	54.787 m	0.015 m		
		Ellip Dist.	10948.873 m	0.007 m		
GCP-8	GCP-5	Az.	247°26'43"	0.125 sec	1 : 1613059	1 : 1612101
		ΔHt.	23.021 m	0.015 m		
		ΔElev.	22.285 m	0.015 m		
		Ellip Dist.	10873.603 m	0.007 m		
GCP-8	GCP-9	Az.	189°20'45"	0.449 sec	1 : 499634	1 : 499544
		ΔHt.	-8.052 m	0.014 m		
		ΔElev.	-7.924 m	0.014 m		
		Ellip Dist.	3088.989 m	0.006 m		
GCP-8	SNI-06	Az.	158°40'34"	0.108 sec	1 : 1962064	1 : 1962273
		ΔHt.	-16.631 m	0.016 m		
		ΔElev.	-15.781 m	0.016 m		
		Ellip Dist.	13854.151 m	0.007 m		
GCP-9	GCP-10	Az.	176°07'17"	0.514 sec	1 : 428695	1 : 428726
		ΔHt.	-2.713 m	0.013 m		
		ΔElev.	-2.579 m	0.013 m		
		Ellip Dist.	2582.379 m	0.006 m		
GCP-9	GCP-4	Az.	277°42'32"	0.114 sec	1 : 1665613	1 : 1663749
		ΔHt.	63.772 m	0.013 m		
		ΔElev.	62.711 m	0.013 m		
		Ellip Dist.	10416.255 m	0.006 m		
GCP-9	GCP-5	Az.	263°17'15"	0.125 sec	1 : 1565971	1 : 1564967
		ΔHt.	31.073 m	0.012 m		
		ΔElev.	30.208 m	0.012 m		
		Ellip Dist.	9606.136 m	0.006 m		
GCP-9	GCP-7	Az.	8°14'27"	0.248 sec	1 : 875658	1 : 875425
		ΔHt.	16.576 m	0.018 m		
		ΔElev.	16.275 m	0.018 m		
		Ellip Dist.	5674.835 m	0.006 m		
GCP-9	SNI-06	Az.	150°39'56"	0.114 sec	1 : 1822233	1 : 1822413
		ΔHt.	-8.579 m	0.013 m		
		ΔElev.	-7.858 m	0.013 m		
		Ellip Dist.	11307.562 m	0.006 m		

ANNEX K. SUB-CONTROL POINTS

List of Sub-Control Points											
	WGS-84						UTM				
Sta. Name	Latitude			Longitude			Northing	Easting	Ellipsoidal Ht.	Elev. (EGM08)	MSL
	dd	mm	ss.ssss	dd	mm	ss.ssss	mmmmmmm. mmmm	mmmmmmm. mmmm	mmmm.mm	mmmm.mm	mmmm. mm
BMW-20	6	5	11.0820	125	6	16.9964	673210.5110	732942.9270	192.784	121.692	121.850
GCP-1A	6	4	47.8015	125	4	48.5145	672484.6500	730224.2610	264.850	193.497	193.655
GCP-2A	6	5	15.7046	125	7	14.6648	673359.4870	734716.0890	149.009	78.102	78.260
GCP-3A	6	5	22.0042	125	9	3.9374	673566.3540	738076.2810	77.564	6.966	7.124
NAM-RIA	6	5	4.2272	125	6	15.6338	672999.7250	732901.8390	192.809	121.721	121.879
T-1	6	4	56.8267	125	5	7.9410	672764.2600	730820.6910	243.645	172.346	172.504
T-2	6	4	56.0245	125	5	9.3620	672739.7800	730864.4930	234.040	94.005	162.905
T-3	6	5	3.0994	125	5	33.9943	672960.0950	731621.2660	217.832	61.779	146.767
T-4	6	4	56.6035	125	5	30.7738	672760.1160	731522.9840	228.901	63.112	157.835
T-5	6	5	13.1144	125	5	56.1482	673270.4660	732301.4570	205.873	46.727	134.868
T-6	6	5	3.6046	125	5	51.2223	672977.6740	732151.0850	211.333	45.492	140.324
T-7	6	5	6.7658	125	6	35.8929	673080.1560	733524.6480	174.795	26.635	103.929
T-8	6	5	4.2176	125	6	36.7090	673001.9560	733550.0540	173.045	22.553	102.184
T-9	6	5	3.9047	125	6	51.9240	672994.1710	734018.0660	164.061	162.747	93.251
T-10	6	5	2.5270	125	6	50.4326	672951.6600	733972.3600	164.976	146.609	94.163
T-11	6	5	25.6082	125	7	38.1312	673666.6370	735436.6560	132.624	157.677	61.937
T-12	6	5	22.1225	125	7	37.3908	673559.4420	735414.3040	133.955	134.710	63.270
T-13	6	5	40.2771	125	7	58.3019	674119.8170	736055.2710	117.531	140.166	46.885
T-14	6	5	38.0024	125	8	1.6162	674050.3280	736157.4850	116.284	103.771	45.650
T-15	6	5	40.3828	125	8	31.8690	674127.1570	737087.6870	97.343	102.026	26.793
T-16	6	5	35.2859	125	8	37.1594	673971.1880	737251.0280	93.240	93.093	22.711
XSR-12	6	8	48.3664	125	14	3.9866	679945.2010	747279.0120	83.804	13.857	14.015
XSR-12-A	6	8	42.6824	125	14	1.6116	679770.2330	747206.6950	82.856	12.911	13.069
XSR-13	6	8	29.7444	125	13	57.6387	679372.1470	747086.1630	83.081	13.146	13.304
XSR-13-A	6	8	35.2920	125	13	57.7904	679542.6390	747090.1170	83.065	13.122	13.280
XSR-14	6	8	15.4314	125	14	13.2652	678934.3230	747568.6170	80.481	10.609	10.767
XSR-14-A	6	8	10.3713	125	14	11.4970	678778.6020	747514.8800	79.714	9.845	10.003
XSR-15	6	8	6.9498	125	14	4.7881	678672.6020	747308.9750	79.494	9.612	9.770
XSR-15-A	6	8	7.2664	125	14	2.6981	678682.0640	747244.6530	79.602	9.714	9.872
XSR-16	6	7	59.3425	125	14	5.2031	678438.8870	747322.7130	78.768	8.899	9.057
XSR-16-A	6	8	1.2230	125	14	5.8379	678496.7550	747341.9980	79.537	9.666	9.824

XSR-18	6	7	18.0920	125	14	11.6402	677172.1120	747525.9840	75.334	5.536	5.694
XSR-18-A	6	7	15.2005	125	14	13.8763	677083.5450	747595.1310	74.901	5.111	5.269
XSR-19	6	7	4.6016	125	14	24.5365	676759.2160	747924.3740	73.937	4.184	4.342
XSR-19-A	6	7	6.1810	125	14	25.8161	676807.9140	747963.5290	74.386	4.635	4.793
XSR-20	6	6	47.7148	125	14	23.0708	676240.1050	747881.4530	75.193	5.449	5.607
XSR-20-A	6	6	48.2076	125	14	27.1269	676255.7700	748006.1500	77.013	7.280	7.438
XSR-21	6	6	23.9608	125	14	14.4435	675509.0570	747619.1280	72.650	2.899	3.057
XSR-21-A	6	6	30.8710	125	14	16.1306	675721.6190	747670.1400	72.250	2.499	2.657
XSR-22	6	6	13.3984	125	14	17.0269	675184.8130	747699.9410	72.044	2.309	2.467
XSR-22-A	6	6	14.5299	125	14	16.8131	675219.5560	747693.2210	72.169	2.433	2.591
XSR-23	6	5	52.2453	125	14	17.1765	674534.8100	747707.2400	69.966	0.247	0.405
RCT-1	6	12	7.9986	125	14	40.2262	686084.4767	748367.7473	101.805	31.535	31.693
RCT-2	6	12	2.9749	125	14	43.5610	685930.5329	748470.9543	101.023	30.773	30.931
RCT-3	6	11	23.5843	125	14	18.0100	684716.7596	747690.2847	97.857	27.639	27.797
RCT-4	6	11	20.6119	125	14	20.2289	684625.7076	747758.9110	96.850	26.644	26.802
RCT-5	6	10	33.7841	125	14	15.0126	683186.0414	747604.5444	92.860	22.752	22.910
RCT-6	6	10	29.4850	125	14	21.2987	683054.7443	747798.4272	91.643	21.560	21.718
RCT-7	6	9	54.6083	125	14	22.5457	681983.1654	747841.2820	88.656	18.654	18.812
RCT-8	6	9	47.8010	125	14	21.0233	681773.7850	747795.3406	88.015	18.020	18.178
RCT-9	6	8	46.7036	125	14	8.1169	679894.6379	747406.2558	83.112	13.178	13.336
BM-1	6	5	33.9265	125	9	19.8282	673934.6460	738563.5840	72.135	1.572	1.730
UP-2	6	5	46.1291	125	9	34.4461	674311.4020	739011.6960	71.671	1.139	1.297

ANNEX L: FIELD VERIFICATION AND DATA ADJUSTMENT

Upon receipt of comments and validated data from UP-Team, we immediately verified the old field data against the new data where we found out that the field team used EGM 2008 elevation datum instead of MSL. We calculated the offset values based on this error.

After applying the offset all data were then re-submitted. This offset was primarily applied to Makar River.

Data offset were applied to the following:

Portion of Siluay River and Makar River were applied with offsets. However, no adjustments were made to the profile since all data were found to be within limits. All base points for Makar River were recalculated. For Siluay River, the following sections were recalculates, 24, 25, 26, 27, 29, 30, 33, 34 (no to minima corrections); 35, 36, 37, 38, 39 (applied with double elevation values due to the 0.158 difference with EGM 2008 and MSL).

We then subsequently submitted the report to UP-DREAM. After verification, additional minor errors and data validation were received. After which, teams were immediately dispatched to the field for the period Aug 13 to 15, 2014 (see Annex M for reference).

The corrected and validated data were then again submitted to UP-DREAM. This time, after validation, all data were found to be within the limits and tolerances set in the terms of Reference for the project.

ANNEX M: SITE PHOTOGRAPHS DURING FIELD

Instrument set-up at the Buayan River

Verification at Siluay River

Field verification at Makar River

Instrument set-up at the Buayan River



Acknowledgements

Annexes

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.

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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