HAZARD MAPPING OF THE PHILIPPINES USING LIDAR (PHIL-LIDAR 1)

LiDAR Surveys and Flood Mapping of Binahaan River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
Visayas State University
Department of Science and Technology

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Asian Aerospace Corporation
Ab	abutment
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
ATQ	Antique
AWLS	Automated Water Level Sensor
BA	Bridge Approach
BM	benchmark
CAD	Computer-Aided Design
CN	Curve Number
CSRS	Chief Science Research Specialist
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DOST	Department of Science and Technology
DPPC	Data Pre-Processing Component
DREAM	Disaster Risk and Exposure Assessment for Mitigation [Program]
DRRM	Disaster Risk Reduction and Management
DSM	Digital Surface Model
DTM	Digital Terrain Model
DVBC	Data Validation and Bathymetry Component
FMC	Flood Modeling Component
FOV	Field of View
GiA	Grants-in-Aid
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HC	High Chord
IDW	Inverse Distance Weighted [interpolation method]
IMU	Inertial Measurement Unit
kts	knots
LAS	LiDAR Data Exchange File format
LC	Low Chord
LGU	local government unit
LiDAR	Light Detection and Ranging
LMS	LiDAR Mapping Suite
m AGL	meters Above Ground Level
MMS	Mobile Mapping Suite
MSL	mean sea level
NAMRIA	National Mapping and Resource Information Authority
NSTC	Northern Subtropical Convergence
PAF	Philippine Air Force
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PDOP	Positional Dilution of Precision
PPK	Post-Processed Kinematic [technique]
PRF	Pulse Repetition Frequency
PTM	Philippine Transverse Mercator
QC	Quality Check
QT	Quick Terrain [Modeler]
RA	Research Associate
RIDF	Rainfall-Intensity-Duration-Frequency
RMSE	Root Mean Square Error
SAR	Synthetic Aperture Radar
SCS	Soil Conservation Service
SRTM	Shuttle Radar Topography Mission
SRS	Science Research Specialist
SSG	Special Service Group
TBC	Thermal Barrier Coatings
UP-TCAGP	University of the Philippines – Training Center for Applied Geodesy and Photogrammetry
UTM	Universal Transverse Mercator
WGS	World Geodetic System
VSU	Visayas State University

CHAPTER 1: OVERVIEW OF THE PROGRAM AND BINAHAAN RIVER

Enrico C. Paringit, Dr. Eng. and Engr. Florentino Morales, Jr.

1.1 Background of the Phil-LiDAR 1 Program

The University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) launched a research program in 2014 entitled "Nationwide Hazard Mapping using LiDAR" or Phil-LiDAR 1, supported by the Department of Science and Technology (DOST) Grant-in-Aid (GiA) Program. The program was primarily aimed at acquiring a national elevation and resource dataset at sufficient resolution to produce information necessary to support the different phases of disaster management. Particularly, it targeted 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.

Also, the program was aimed at producing an up-to-date and detailed national elevation dataset suitable for 1:5,000 scale mapping, with 50 cm and 20 cm horizontal and vertical accuracies, respectively. These accuracies were achieved through the use of the state-of-the-art Light Detection and Ranging (LiDAR) airborne technology procured by the project through DOST.

The implementing partner university for the Phil-LiDAR 1 Program is the Visayas State University (VSU). VSU is in charge of processing LiDAR data and conducting data validation reconnaissance, cross section, bathymetric survey, validation, river flow measurements, flood height and extent data gathering, flood modeling, and flood map generation for the 22 river basins in the Eastern Visayas Region . The university is located in Baybay City in the province of Leyte.

1.2 Overview of the Binahaan River Basin

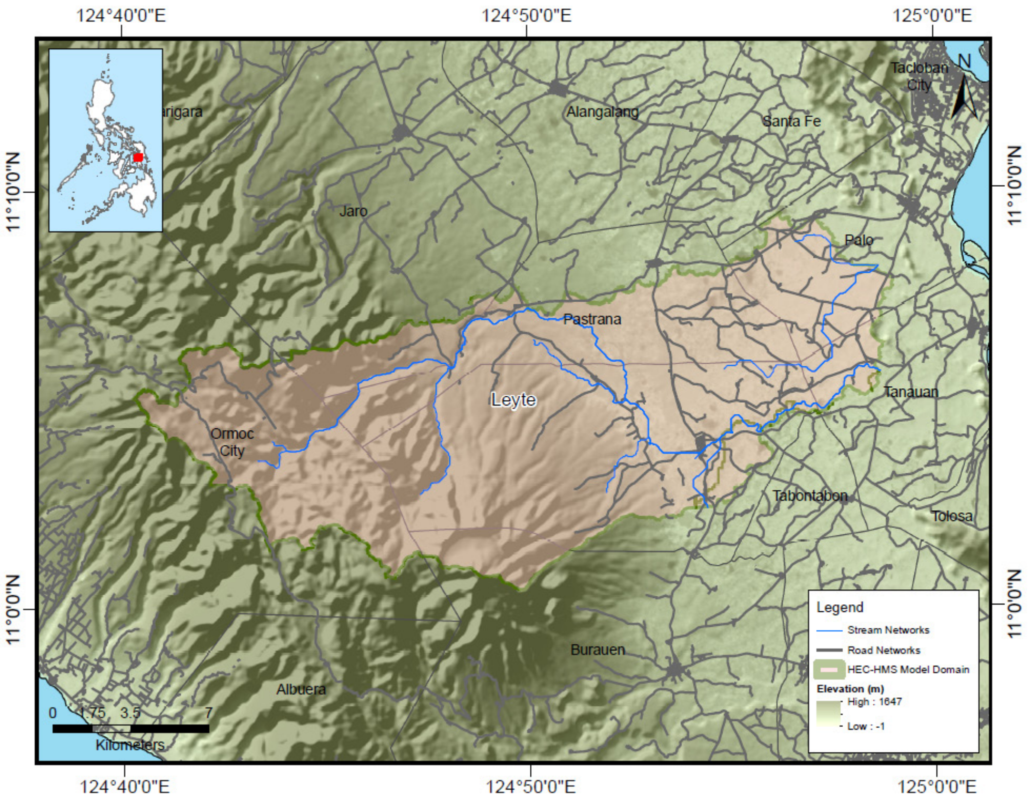

Figure 1. Map of the Binahaan River Basin

CHAPTER 2: LIDAR DATA ACQUISITION OF THE BINAHAAN FLOODPLAIN

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The methods applied in this Chapter were based on the DREAM methods manual (Sarmiento, et al., 2014) and further enhanced and updated in Paringit, et al. (2017).

2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Binahaan floodplain in Leyte province. These missions were planned for 20 lines that run for at most four and a half (4.5) hours including take-off, landing and turning time. The flight planning parameters for the Aquarius and Gemini LiDAR systems used are found in Tables 1 and 2, respectively. Figures 2 and 3 show the flight plans for Binahaan floodplain. Annex 1 shows the technical specification of the Aquarius and Gemini LiDAR systems and the aerial camera.

Table 1. Flight planning parameters for Aquarius LiDAR system

Block Name	Flying Height (m AGL)	Overlap (%)	Field of view (ø)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK34A	690	30	50	70	40	120	5
BLK34B	600	30	50	70	40	120	5
BLK34K	690/650	30	36	50	50	120	5

Table 2. Flight planning parameters for Gemini LiDAR system

Block Name	Flying Height (m AGL)	Overlap (%)	Field of view (ø)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK34A	1200	30	34	100	50	120	5
BLK34B	950	30	40	100	50	120	5
BLK34C	950/700	30	40/50	100	50/40	120	5
BLK34D	650	30	50	100	40	120	5
BLK34E	700	30	50	100	40	120	5
BLK34G	1200/700	30	34/50	100	50/40	120	5

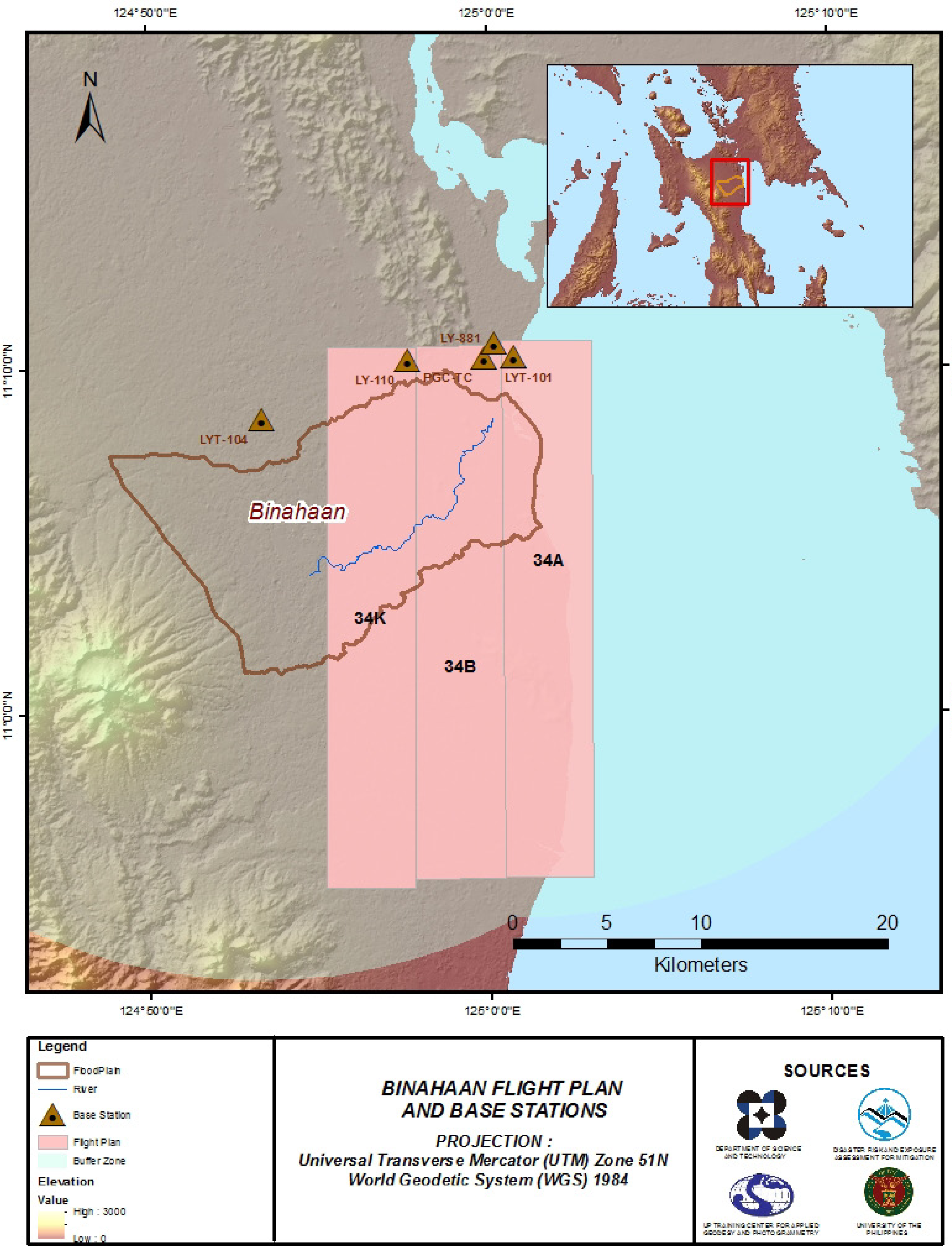

Figure 2. Flight plans and base stations used for Binahaan floodplain for year 2014 survey

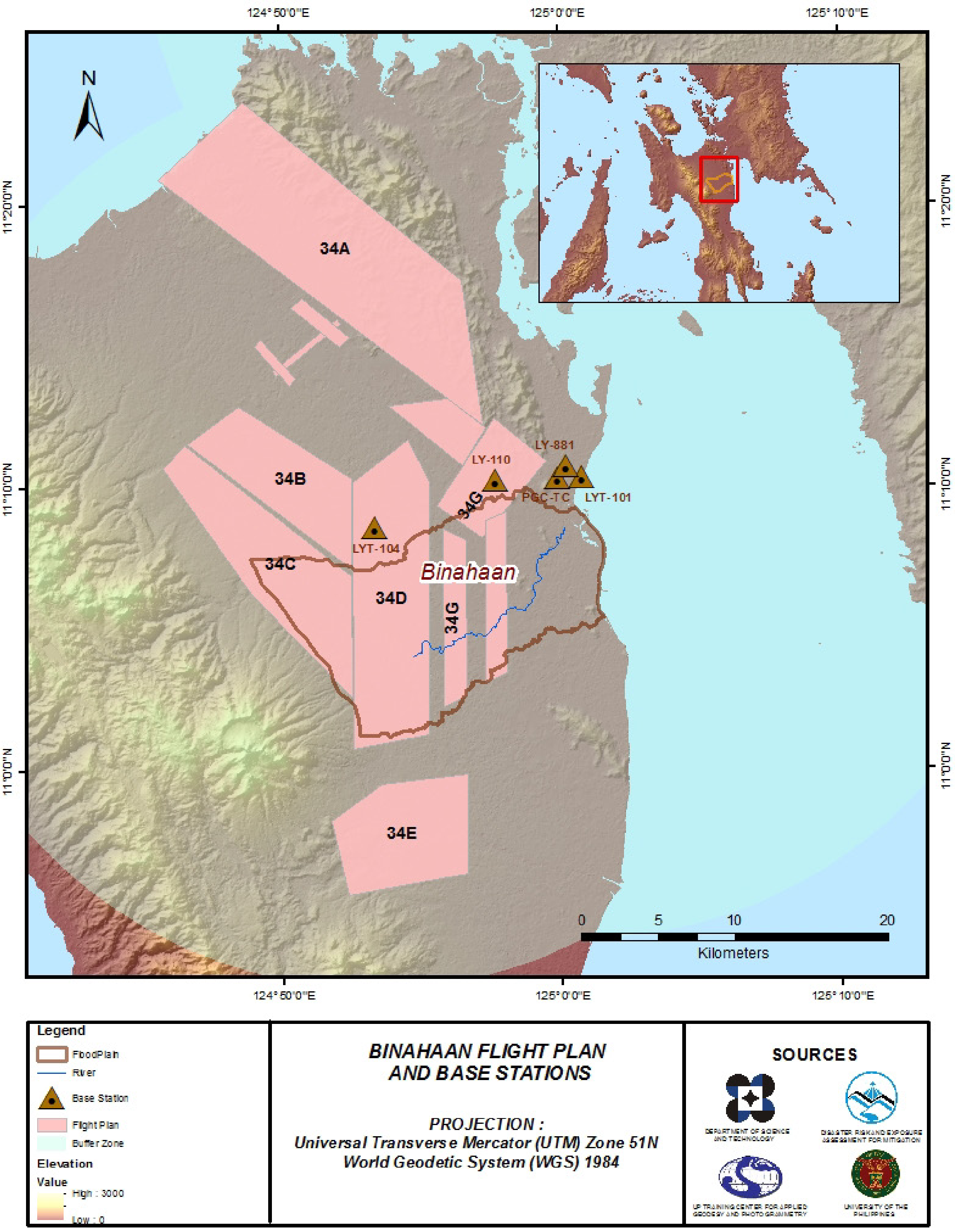

Figure 3. Flight plans and base stations used for Binahaan floodplain for year 2016 survey

2.2 Ground Base Stations

Two (2) NAMRIA second order accuracy ground control points (GCP): LYT-101 and SMR-53 were recovered for use as base station during the survey. LYT-104 is a 3rd order NAMRIA GCP and was re-processed as 2nd order GCP to satisfy the project's accuracy requirement. Also, LY-110 and LY-881 which are high-accuracy benchmarks were used and also re-processed as 2nd order horizontal control point for the project's accuracy. The certifications for the NAMRIA reference points are found in Annex 2 while the baseline processing reports are found in Annex 3. These were used as base stations or reference points during flight operations for the entire duration of the survey (January 26-27 & April 20, 2014 and January 22-24, 2016). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852, SPS 882, and SPS 985. Flight plans and location of base stations used during the aerial LiDAR acquisition in Binahaan floodplain are shown in Figure 2 above.

Figure 4 to Figure 8 show the recovered NAMRIA reference points within the area, while Table 3 to Table 7 show the corresponding details about the following NAMRIA control stations and established points. In addition, Table 8 shows the list of all ground control points occupied in line with their respective mission names and flight numbers, together with the dates of acquisition.

(a)

(b)

Figure 4. (a) GPS set-up over LYT-101 situated within the premises of MacArthur's Landing Memorial Park, Palo, Leyte and (b) NAMRIA reference point LYT-101 as recovered by field team.

Table 3. Details of the recovered NAMRIA horizontal control point LYT-101 used as base station for the LiDAR data acquisition.

Station Name	**LYT-101**	
Order of Accuracy	**2nd Order**	
Relative Error (Horizontal positioning)	**1 in 50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	11° 10' 23.89707" North 125° 0' 38.62071" East 6.58600 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	501,171.719 meters 1,235,497.253 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	11° 10' 19.64869" North 125° 0' 43.78230" East 69.02100 meters
Grid Coordinates, Philippine Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	719,575.03 meters 1,235,811.61 meters

(a) (b)

Figure 5. (a) GPS set-up over LYT-104 located and re-established along rice paddy trail, approximately 90 meters from the centerline, east side of Pastrana-Santa Fe Road, District IV, Pastrana, Leyte and (b) NAMRIA reference point LYT-104 as recovered by the field team.

Table 4. Details of the recovered and re-established NAMRIA horizontal control point LYT-104 used as base station for the LiDAR data acquisition.

Station Name	**LYT-104**	
Order of Accuracy	**2nd Order**	
Relative Error (Horizontal positioning)	**1 in 50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	11° 08’ 38.92234” North 124o 53’ 13.52786” East 33.659 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Easting Northing Ellipsoidal Height	11° 08’ 34.67033” North 124o 53’ 18.69323” East 95.861 meters
Grid Coordinates, Philippine Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Latitude Longitude	706,089.510 meters 1,232,496.838 meters

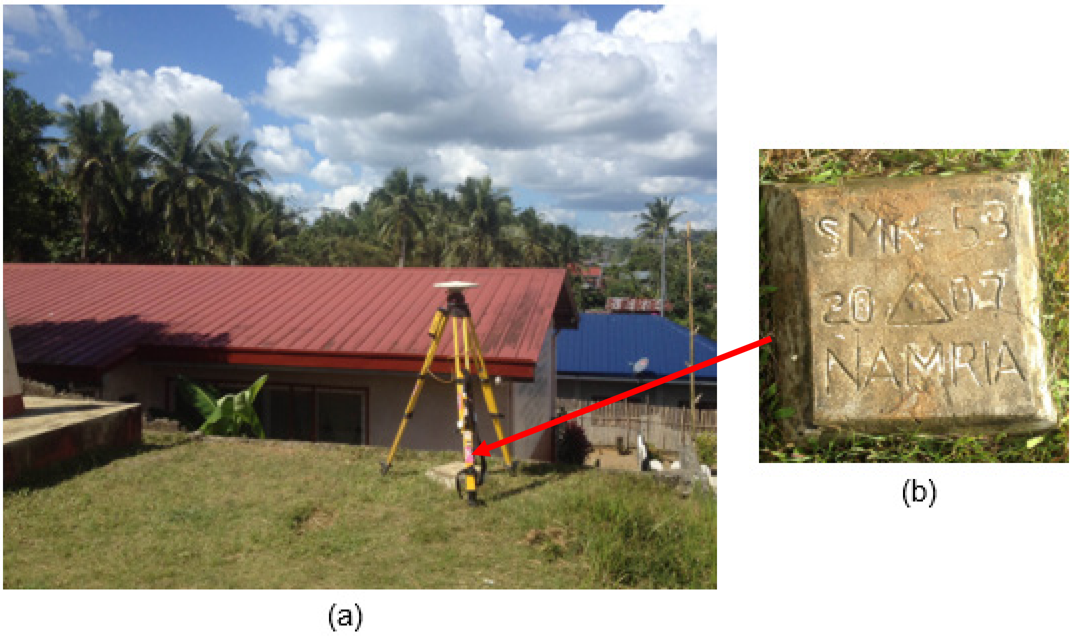

Figure 6. (a) GPS set-up over SMR-53 located near the school building flag pole of San Isidro Elementary, Brgy. San Isidro, Santa Rita and (b) NAMRIA reference point SMR-53 as recovered by the field team.

Table 5. Details of the recovered NAMRIA horizontal control point SMR-53 used as base station for the LiDAR data acquisition.

Station Name	**SMR-53**	
Order of Accuracy	**2nd Order**	
Relative Error (Horizontal positioning)	**1 in 50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	11° 30’ 17.85657” North 125° 1’ 29.837339” East 26.13400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	502,722.403 meters 1,272,180.079 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	11° 30’ 13.52495” North 125° 1’ 34.96980” East 87.78700 meters
Grid Coordinates, Philippine Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	720,874.14 meters 1,272,513.40 meters

(b)

(a)

Figure 7. (a) GPS set-up over established Ground Control Point by the team on the rooftop of Philippine Coast Guard Tacloban Station, Kuta Kankabato, San Jose, Tacloban City and (b) established reference point PGC-TC as recovered by the field team.

Table 6. Details of the established control point PGC-TC used as temporary base station for the LiDAR data acquisition.

Station Name	PCG-TC	
Order of Accuracy	**2nd Order**	
Relative Error (Horizontal positioning)	**1 in 50,000**	
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	11° 10’ 19.64869” North 124° 59’ 53.38556” East 70.882 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	718,144.536 meters 1,244,004.859 meters

(b)

(a)

Figure 8. (a) GPS set-up over LY-110 on a bridge located about 225 meters of km. post 919, road leading to Ormoc City and (b) NAMRIA reference point LY-110 as recovered by the field team

Table 7. Details of the recovered NAMRIA Benchmark LY-110 used as base station for the LiDAR data acquisition.

Station Name	LY-110	
Order of Accuracy	1st Order	
Relative Error (Horizontal positioning)	1 in 100,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	11° 10' 19.48389" North 124° 57' 32.98736" East 14.336 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	11° 10' 15.23095" North 124° 57' 38.14961" East 76.647 meters
Grid Coordinates, Philippine Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	713,942.863 meters 1,234,538.117 meters

(b)

(a)

Figure 9. (a) GPS set-up over LY-881 located at the concrete foundation of Governor Center Welcome sign at the junction of the road going to Ormoc, Samar, Tacloban and MacArthur Landing Memorial Park in Brgy. Pawing, Palo, Leyte and (b) NAMRIA reference point LY-881 as recovered by the field team.

Table 8. Details of the recovered NAMRIA Benchmark LY-881 used as base station for the LiDAR data acquisition.

Station Name	LY-881	
Order of Accuracy	1st Order	
Relative Error (Horizontal positioning)	1 in 100, 000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	11° 10’ 50.05” North 125° 00’ 05.58” East 5.96 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	11° 10’ 45.19178” North 125° 00’ 09.85226” East 68.330 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	718,694.89 meters 1,236,537.244 meters

Table 9. Ground control points used during LiDAR data acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
26-Jan-14	1026A	3BLK33AS34A026A	LYT-101 & PCG-TC
27-Jan-14	1028A	3BLK3433S027A	LYT-101 & PCG-TC
20-Apr-14	1358A	3BLK34F110A	LYT-101 & LY-881
20-Apr-14	1360A	3BLK34KS110B	SMR-53 & LY-881
22-Jan-16	3765G	2BLK34AD022A	LYT-104 & LY-110
23-Jan-16	3769G	2BLK34ADEG023A	LYT-104 & LY-110
23-Jan-16	3771G	2BLK34BCG023B	LYT-104 & LY-110
24-Jan-16	3773G	2BLK34CG024A	LYT-104 & LY-110

2.3 Flight Missions

Eight (8) missions were conducted to complete LiDAR data acquisition in Binahaan Floodplain, for a total of thirty hours and forty-nine minutes (30+49) of flying time for RP-C9122 and RP-C9322. All missions were acquired using Aquarius and Gemini LiDAR systems. The team line-up is shown in Annex 4. Table 10 shows the total area of actual coverage and the corresponding flying hours per mission, while Table 11 presents the actual parameters used during the LiDAR data acquisition. The data transfer sheet, flight logs and flight status reports of each mission are shown in Annex 5, 6, and 7 respectively.

Table 10. Flight missions for LiDAR data acquisition in Binahaan floodplain.

Date Surveyed	Flight Number	Flight Plan Area (km^2)	Surveyed Area (km^2)	Area Surveyed within the Floodplain (km^2)	Area Surveyed Outside the Floodplain (km^2)	No. of Images (Frames)	Flying Hours	
							Hr	Min
26-Jan-14	1026A	136.116	102.515	8.714	93.801	857	2	47
27-Jan-14	1028A	140.342	205.354	52.962	152.392	1546	4	25
20-Apr-14	1358A	137.389	121.293	45.742	75.551	1194	4	11
20-Apr-14	1360A	137.389	71.461	31.446	40.015	670	3	23
22-Jan-16	3765G	248.104	180.764	35.949	144.815	0	4	11
23-Jan-16	3769G	318.850	171.755	57.517	114.238	0	4	12
23-Jan-16	3771G	132.586	150.854	50.805	100.049	0	3	29
24-Jan-16	3773G	117.396	101.527	23.393	78.134	0	4	11
TOTAL		1368.172	1105.523	306.527	798.996	4267	30	49

Table 11. Actual parameters used during LiDAR data acquisition

Flight Number	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (kHz)	Scan Frequency (Hz)	Average Speed (Kts)	Average Turn Time (Minutes)
1026A	690	30	50	70	40	120	5
1028A	690	30	50	70	40	120	5
1358A	690	30	36	50	50	120	5
1360A	650	30	36	50	50	120	5
3765G	1200/650	30	34/50	100	50/40	120	5
3769G	1200/700	30	34/50	100	50/40	120	5
3771G	950	30	40	100	50	120	5
3773G	700	30	50	100	40	120	5

2.4 Survey Coverage

Binahaan floodplain is located in the province of Leyte situated in the municipalities of Tabontabon, Tanauan, Dagami, Pastrana and Palo. LiDAR swath coverage for these flights also covers most parts of the municipalities of Tabontabon, Julita, Tanauan, and Tolosa. The list of municipalities and/or cities surveyed with at least one (1) square kilometer coverage is shown in Table 12. The actual coverage of the LiDAR acquisition for Binahaan Floodplain is presented in Figure 10.

Table 12. List of municipalities and cities surveyed during Bangkerohan floodplain LiDAR survey

Province	Municipality/ City	Area of Municipality/City (km²)	Total Area Surveyed (km²)	Percentage of Area Surveyed
Leyte	Tabontabon	20.457	20.457	100%
	Julita	57.1662	57.1661	100%
	Tanauan	62.7768	62.5662	100%
	Tolosa	28.1734	28.069	100%
	Dulag	63.6486	61.6075	97%
	Palo	65.3368	63.1581	97%
	Santa Fe	57.1452	54.3985	95%
	Pastrana	79.1701	68.0694	86%
	Dagami	134.082	77.8419	58%
	Alangalang	145.445	79.1059	54%
	San Miguel	103.86	49.5369	48%
	Burauen	205.306	69.1689	34%
	Jaro	190.654	58.3608	31%
	Barugo	81.2502	19.901	24%
	Tacloban City	118.458	14.7709	12%
	La Paz	136.017	14.7397	11%
	Babatngon	136.571	7.92537	6%
	Mayorga	39.4544	2.02753	5%
Total		1724.97	808.871	46.89%

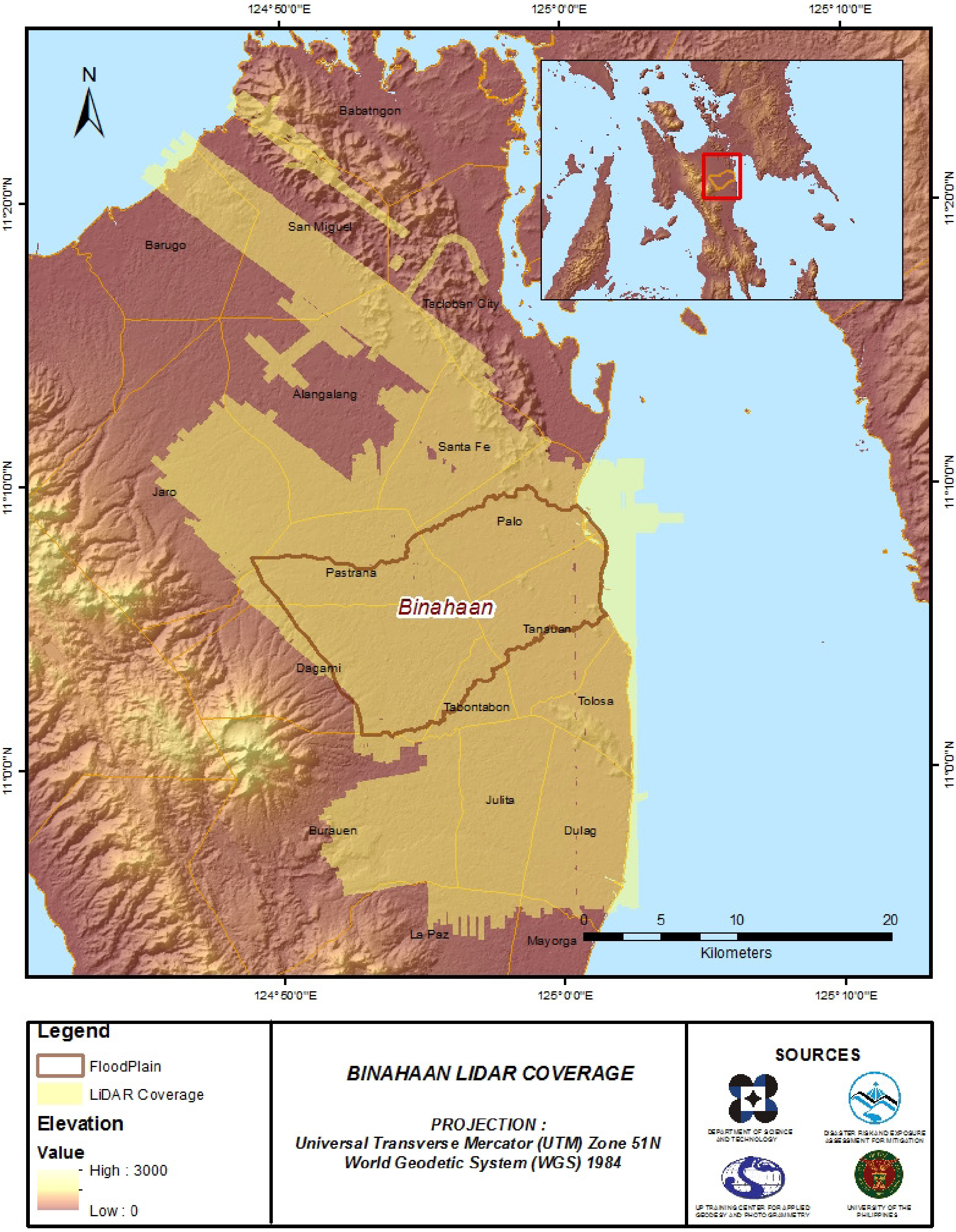

Figure 10. Actual LiDAR survey coverage for Binahaan floodplain.

CHAPTER 3: LIDAR DATA PROCESSING OF THE BINAHAAN FLOODPLAIN

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The methods applied in this Chapter were based on the DREAM methods manual (Sarmiento, et al., 2014) and further enhanced and updated in Paringit, et al. (2017).

3.1 Overview of the LiDAR Data Pre-Processing

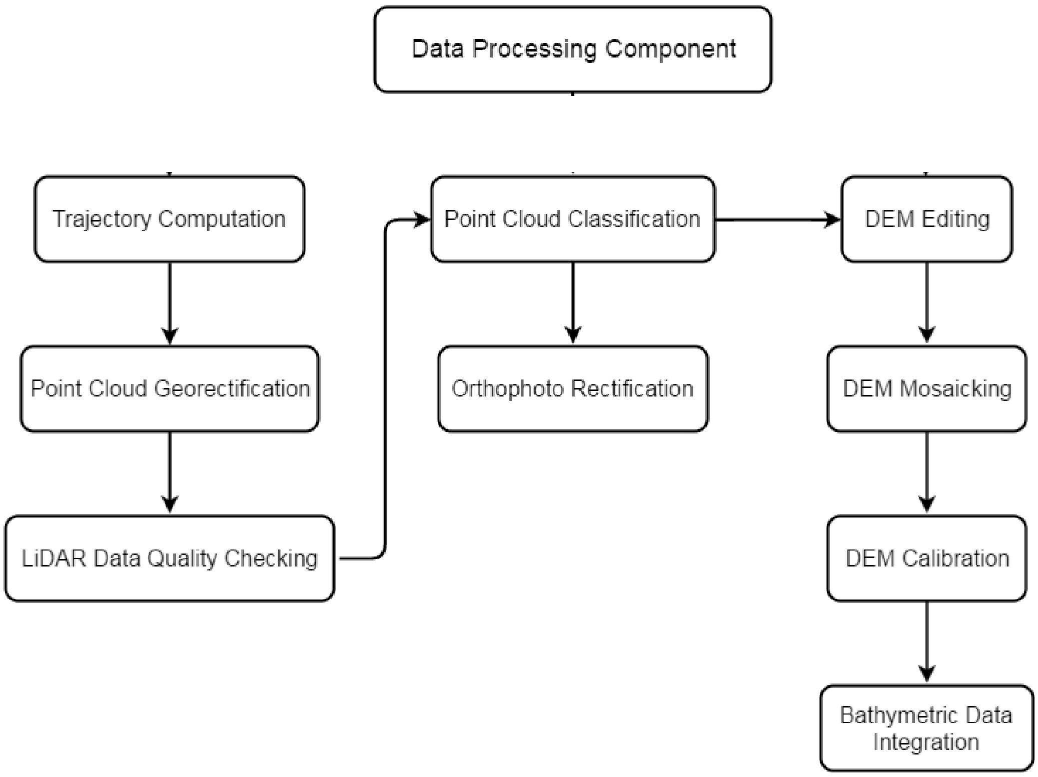

Figure 11. Schematic Diagram for Data Pre-Processing Component

The data transmitted by the Data Acquisition Component are checked for completeness based on the list of raw files required to proceed with the pre-processing of the LiDAR data. Upon acceptance of the LiDAR field data, georeferencing of the flight trajectory is done in order to obtain the exact location of the LiDAR sensor when the laser was shot. Point cloud georectification is performed to incorporate correct position and orientation for each point acquired. The georectified LiDAR point clouds are subject for quality checking to ensure that the required accuracies of the program, which are the minimum point density, vertical and horizontal accuracies, are met. The point clouds are then classified into various classes before generating Digital Elevation Models such as Digital Terrain Model and Digital Surface Model.

Using the elevation of points gathered in the field, the LiDAR-derived digital models are calibrated. Portions of the river that are barely penetrated by the LiDAR system are replaced by the actual river geometry measured from the field by the Data Validation and Bathymetry Component. LiDAR acquired temporally are then mosaicked to completely cover the target river systems in the Philippines. Orthorectification of images acquired simultaneously with the LiDAR data is done through the help of the georectified point clouds and the metadata containing the time the image was captured.

These processes are summarized in the flowchart shown in Figure 11.

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Binahaan floodplain can be found in Annex A-5. Missions flown during the first survey conducted on April 2014 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Aquarius system while missions acquired during the second survey on January 2016 were flown using the Gemini system over Leyte Province. The Data Acquisition Component (DAC) transferred a total of 108.46 Gigabytes of Range data, 1.39 Gigabytes of POS data, 51.30 Megabytes of GPS base station data, and 115.10 Gigabytes of raw image data to the data server on May 28, 2014 for the first survey and February 12, 2016 for the second survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Binahaan was fully transferred on February 12, 2016, as indicated on the Data Transfer Sheets for Binahaan floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 3773G, one of the Binahaan flights, which is the North, East, and Down position RMSE values are shown in Figure 12. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell on January 24, 2016 00:00AM. The y-axis is the RMSE value for that particular position.

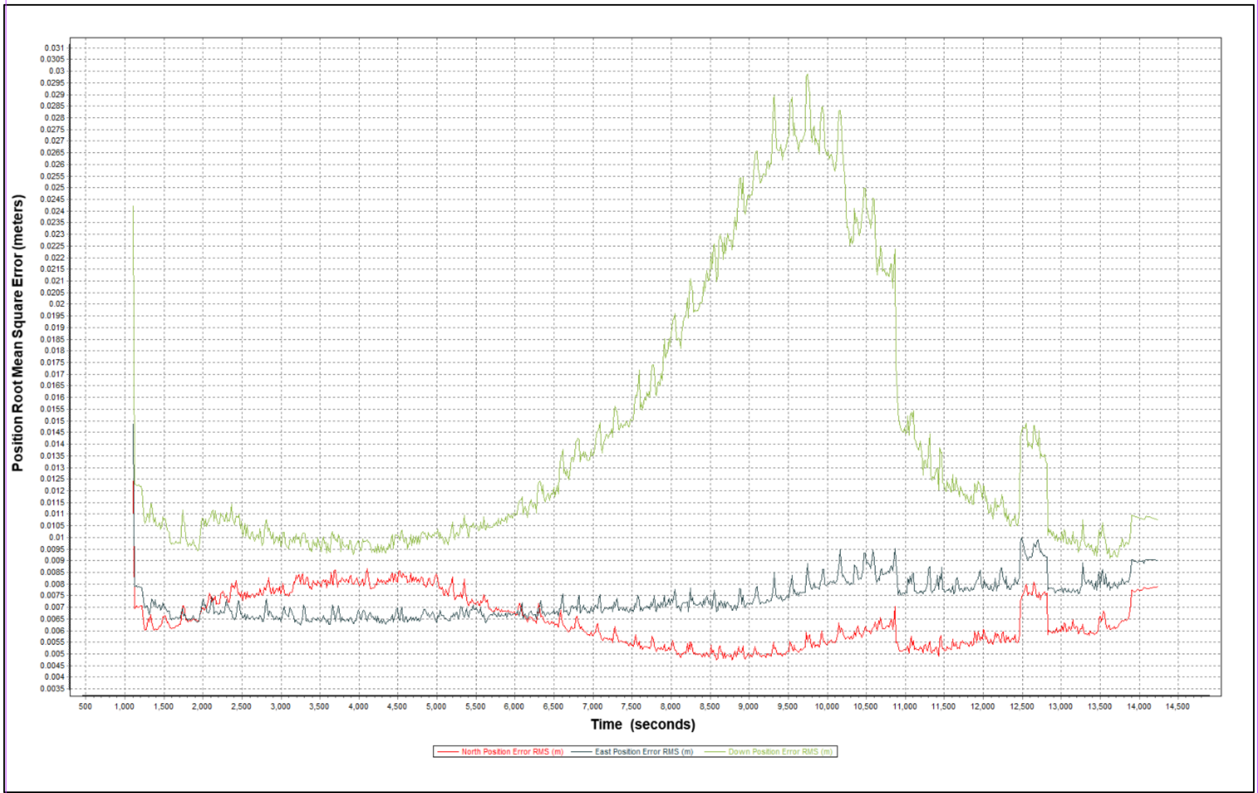

Figure 12. Smoothed Performance Metrics of a Binahaan Flight 3773G.

The time of flight was from 500 seconds to 14500 seconds, which corresponds to morning of January 24, 2016. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 12 shows that the North position RMSE peaks at 0.85 centimeters, the East position RMSE peaks at 1. 00 centimeters, and the Down position RMSE peaks at 3.00 centimeters, which are within the prescribed accuracies described in the methodology.

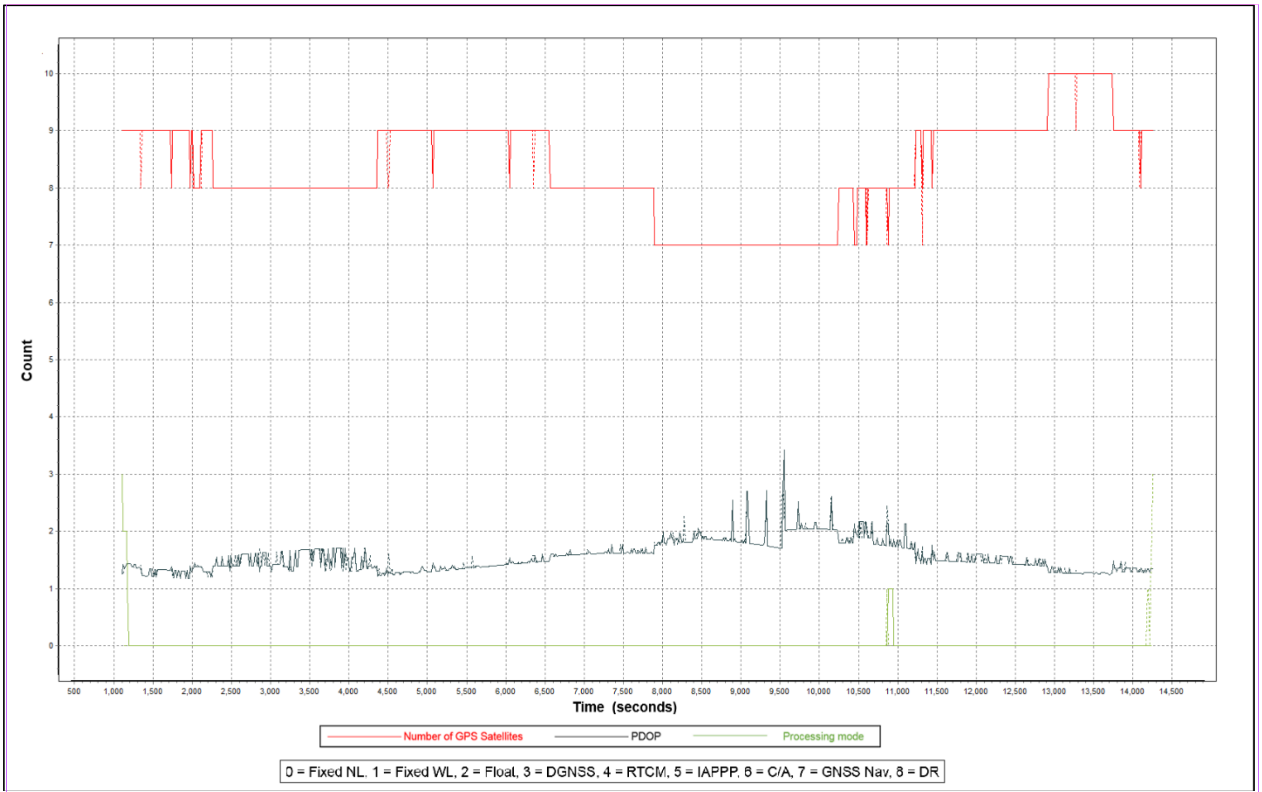

Figure 13. Solution Status Parameters of Binahaan Flight 3773G.

The Solution Status parameters of flight 3773G, one of the Binahaan flights, which indicate the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 13. The graphs indicate that the number of satellites during the acquisition did not go down to 6. Most of the time, the number of satellites tracked was between 7 and 10. The PDOP value also did not go above the value of 4, which indicates optimal GPS geometry. The processing mode remained at 0 for majority of the survey with some peaks up to 3 attributed to the turns performed by the aircraft. The value of 0 corresponds to a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters adhered to the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Binahaan flights is shown in Figure 14.

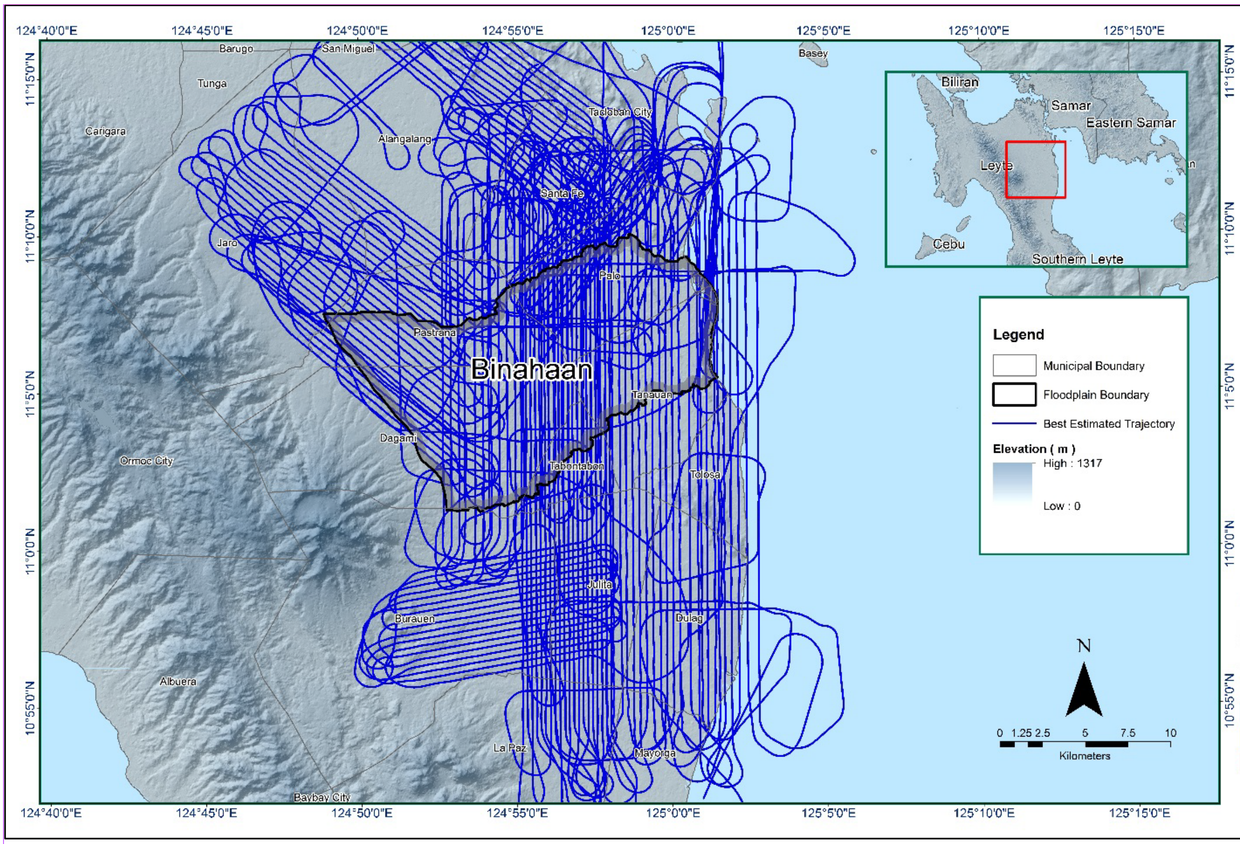

Figure 14. Best estimated trajectory for Binahaan floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 81 flight lines, with each flight line containing one channel, since the Gemini and Aquarius systems both contain one channel only. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Binahaan floodplain are given in Table 13.

Table 13. Self-Calibration Results values for Binahaan flights.

Parameter	Value
Boresight Correction stdev(<0.001degrees)	0.000620
IMU Attitude Correction Roll and Pitch Corrections stdev(<0.001degrees)	0.000999
GPS Position Z-correction stdev(<0.01meters)	0.0071

The optimum accuracy is obtained for all Binahaan flights based on the computed standard deviations of the corrections of the orientation parameters. Standard deviation values for individual blocks are available in the Annex 8. Mission Summary Reports.

3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data is shown in Figure 15. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

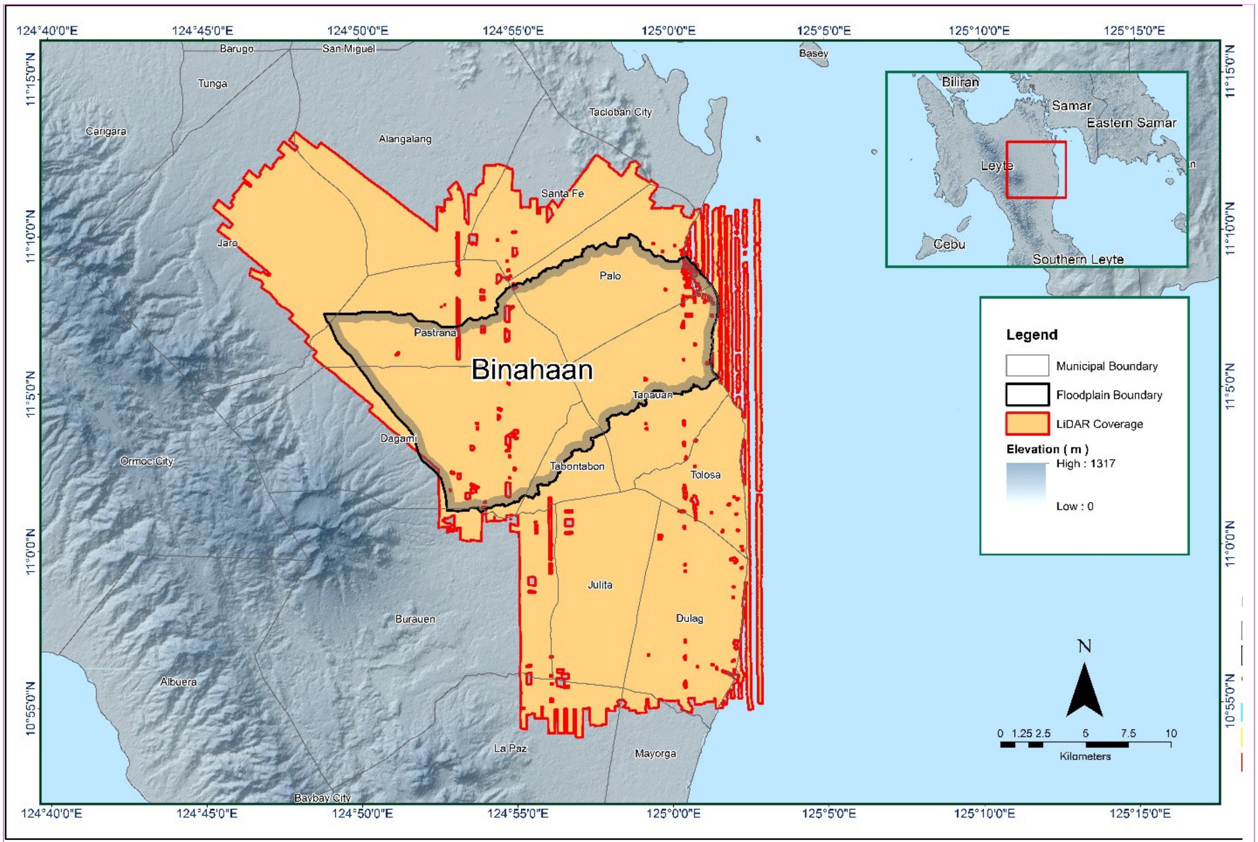

Figure 15. Boundary of the processed LiDAR data on top of a SAR Elevation Data over Binahaan Floodplain

The total area covered by the Binahaan missions is 679.88 sq.km that is comprised of six (6) flight acquisitions grouped and merged into seven (7) blocks as shown in Table 14.

Table 14. List of LiDAR blocks for Binahaan floodplain.

LiDAR Blocks	Flight Numbers	Area (sq. km)
Samar_Leyte Blk34F	1358A	97.51
	1360A	
Leyte_Blk34C	3771G	145.96
	3773G	
Leyte_Blk34F_supplement	3769G	30.86
Leyte_Blk34I	3769G	49.29
Leyte_Blk34J	3765G	62.04
Leyte_Blk34G_supplement	3771G	54.50
	3773G	
Tacloban_1026A	1026A	236.72
	1028A	
TOTAL		**679.88 sq.km**

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location is shown in Figure 16. Since the Gemini and Aquarius systems both employ one channel, we would expect an average value of 1 (blue) for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines.

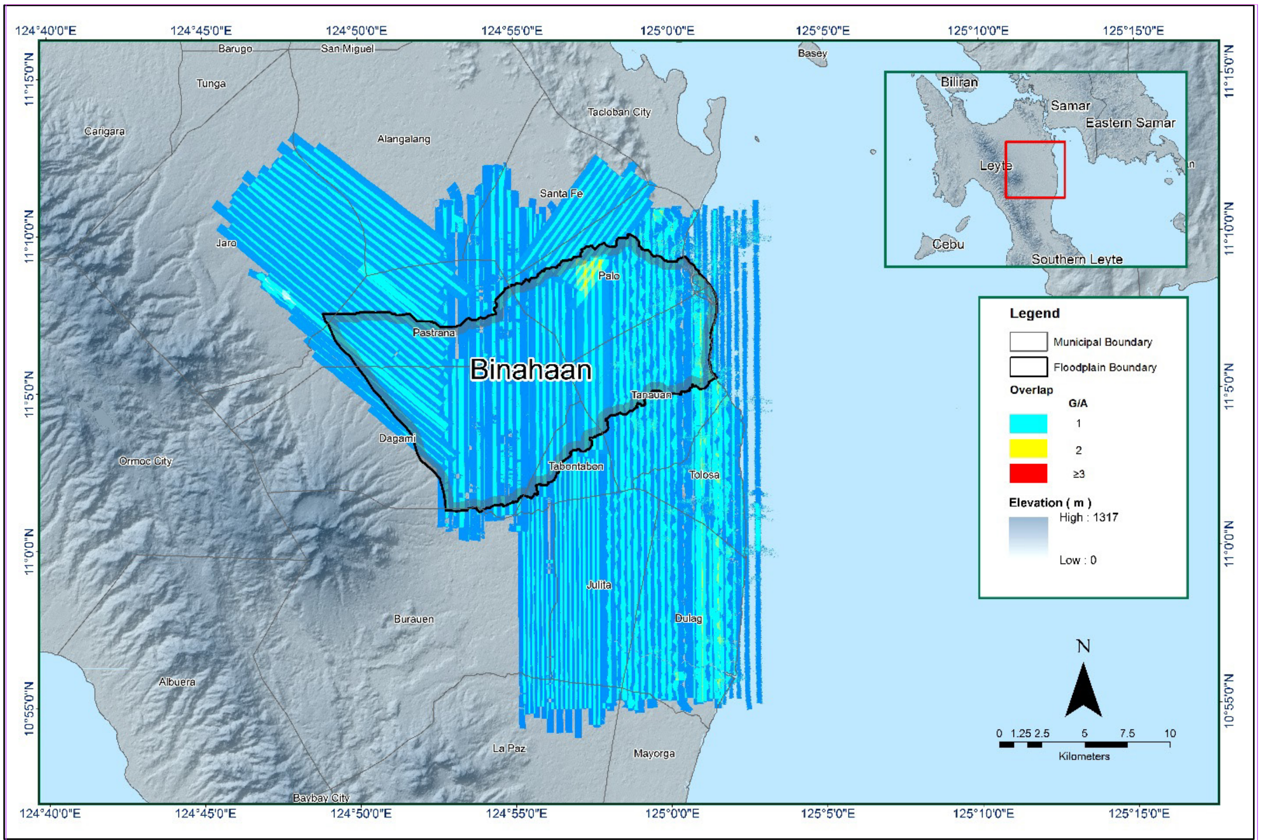

Figure 16. Image of data overlap for Binahaan floodplain.

The overlap statistics per block for the Binahaan floodplain can be found in Annex 8. One pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 27.64% and 53.44% respectively, which passed the 25% requirement.

The density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion is shown in Figure 17. It was determined that all LiDAR data for Binahaan floodplain satisfy the point density requirement, and the average density for the entire survey area is 3.46 points per square meter.

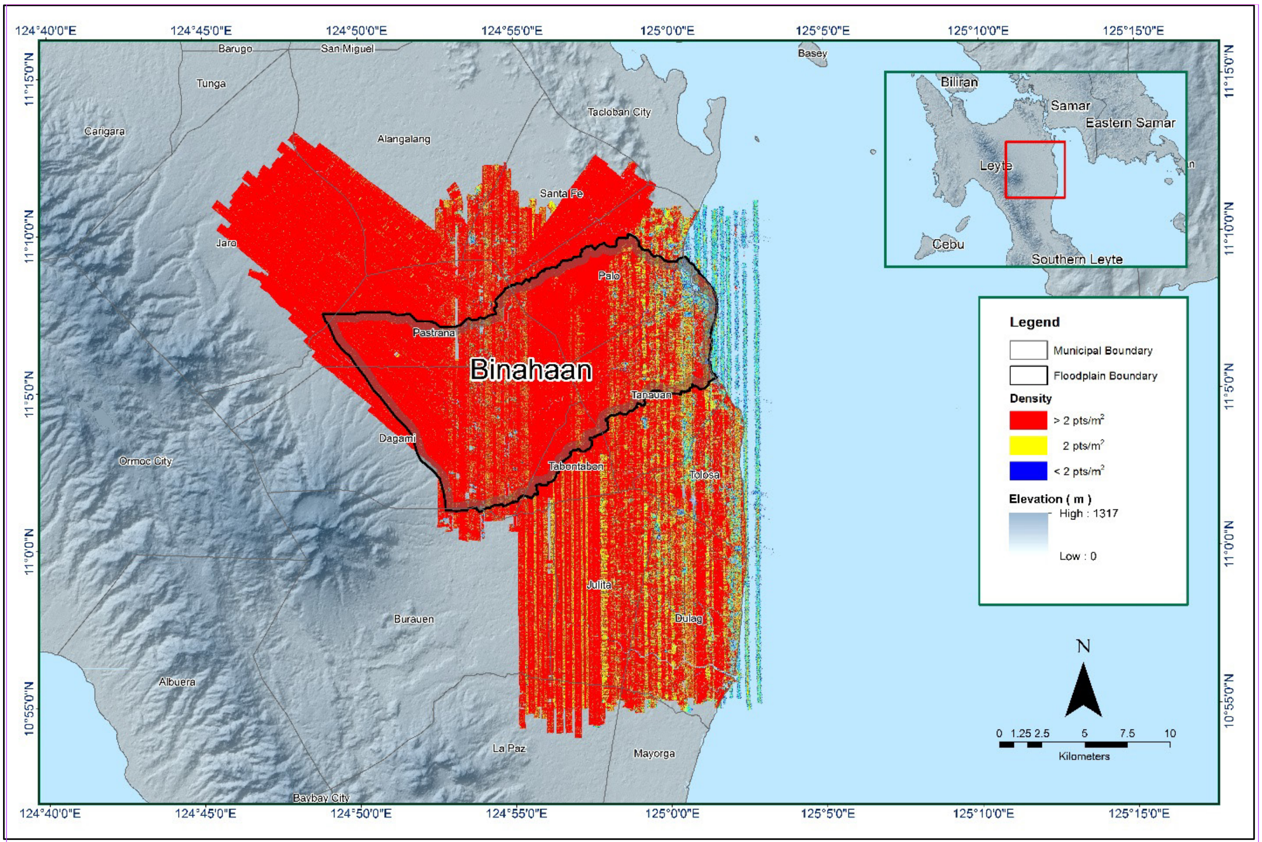

Figure 17. Density map of merged LiDAR data for Binahaan floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 18. The default color range is from blue to red, where bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20m relative to elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m relative to elevations of its adjacent flight line. Areas with bright red or bright blue need to be investigated further using Quick Terrain Modeler software.

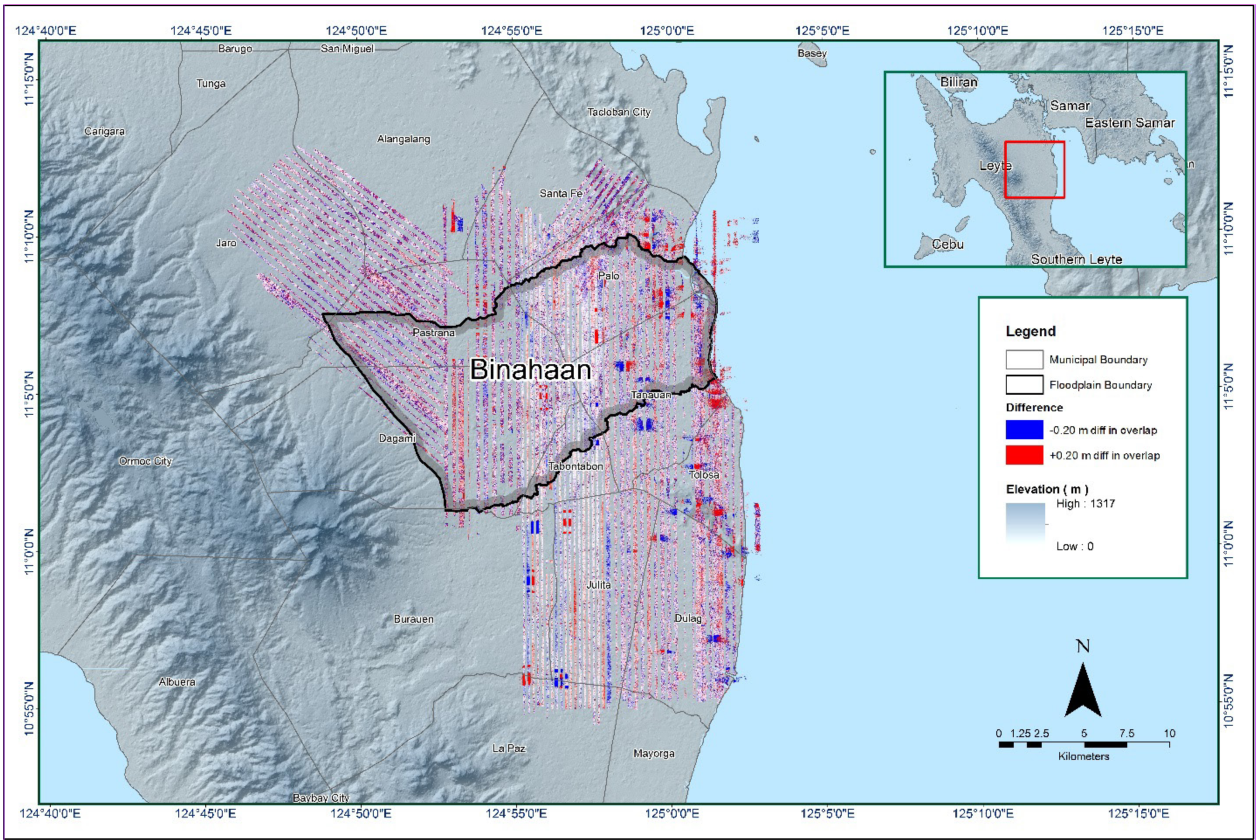

Figure 18. Elevation difference map between flight lines for Binahaan floodplain.

A screen capture of the processed LAS data from a Binahaan flight 3773G loaded in QT Modeler is shown in Figure 19. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

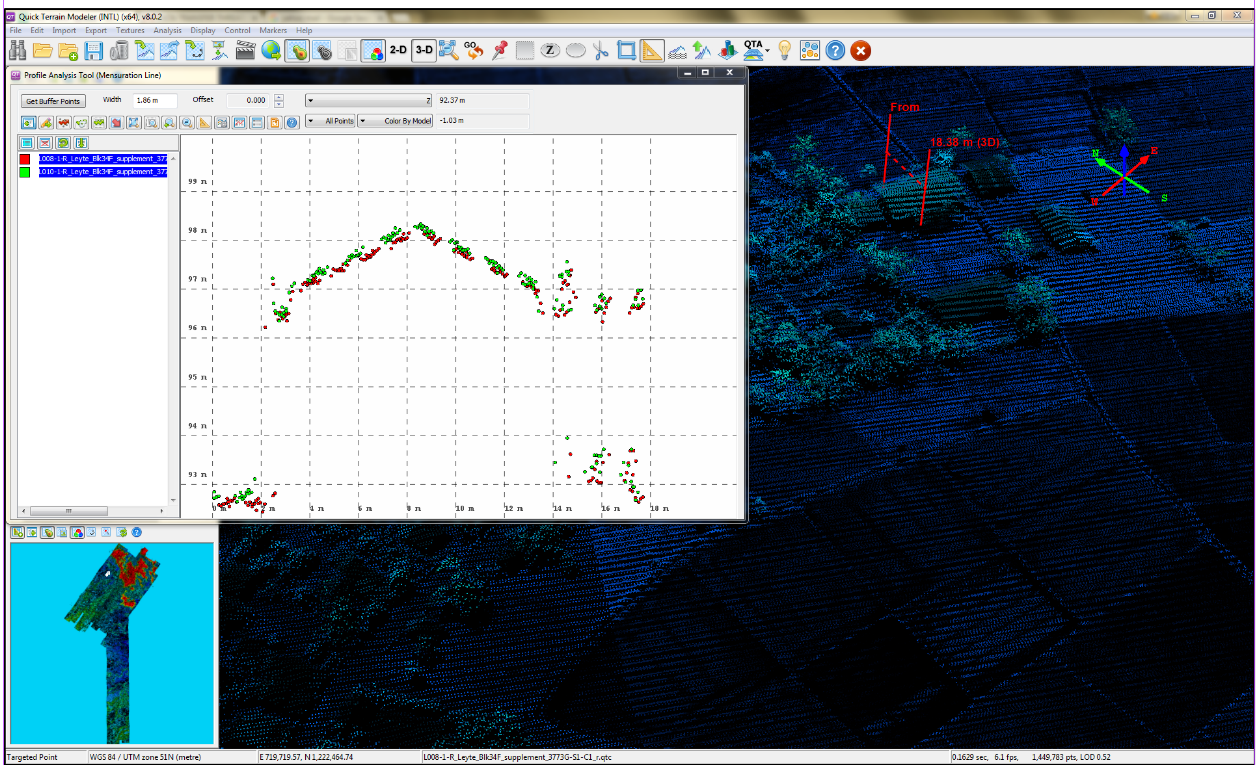

Figure 19. Quality checking for a Binahaan flight 3773G using the Profile Tool of QT Modeler.

3.6 LiDAR Point Cloud Classification and Rasterization

Table 15. Binahaan classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	585,872,460
Low Vegetation	682,978,145
Medium Vegetation	1,214,227,319
High Vegetation	609,560,694
Building	13,035,152

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Binahaan floodplain is shown in Figure 20. A total of 1,362 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 15. The point cloud has a maximum and minimum height of 415.68 meters and 10.90 meters respectively.

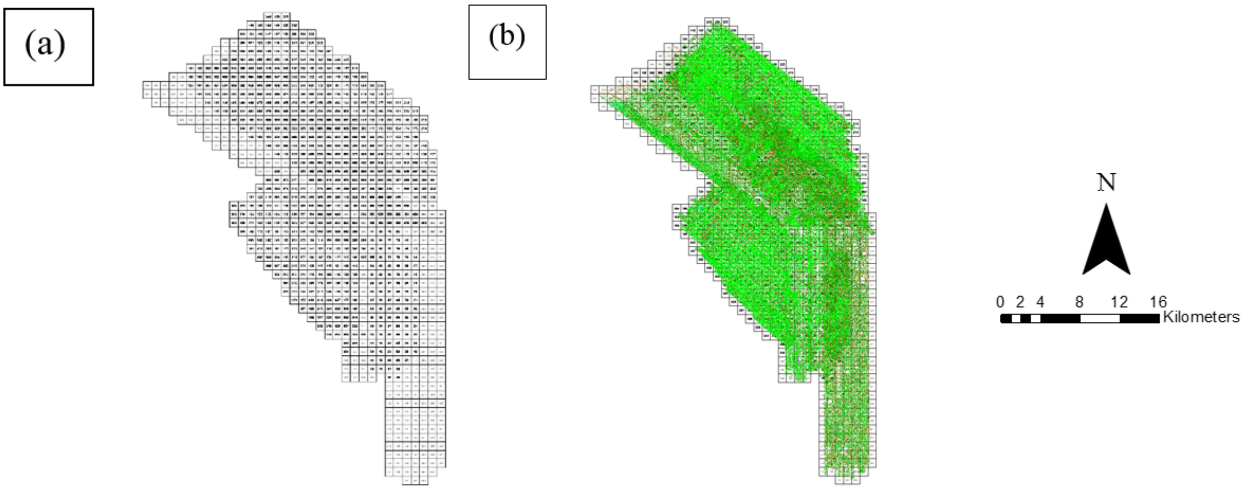

Figure 20. Tiles for Binahaan floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 21. The ground points are in orange, the vegetation is in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below canopy are classified correctly, due to the density of the LiDAR data.

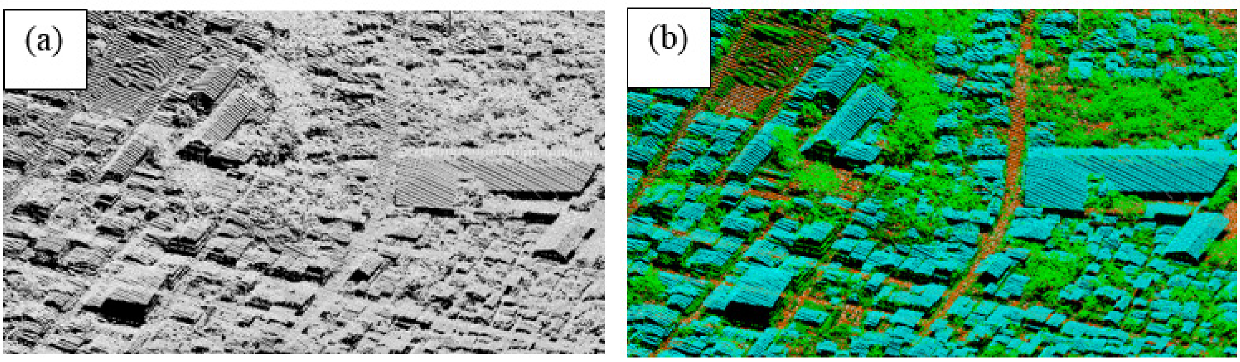

Figure 21. Point cloud before (a) and after (b) classification.

The production of last return (V_ASCII) and the secondary (T_ ASCII) DTM, first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 22. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

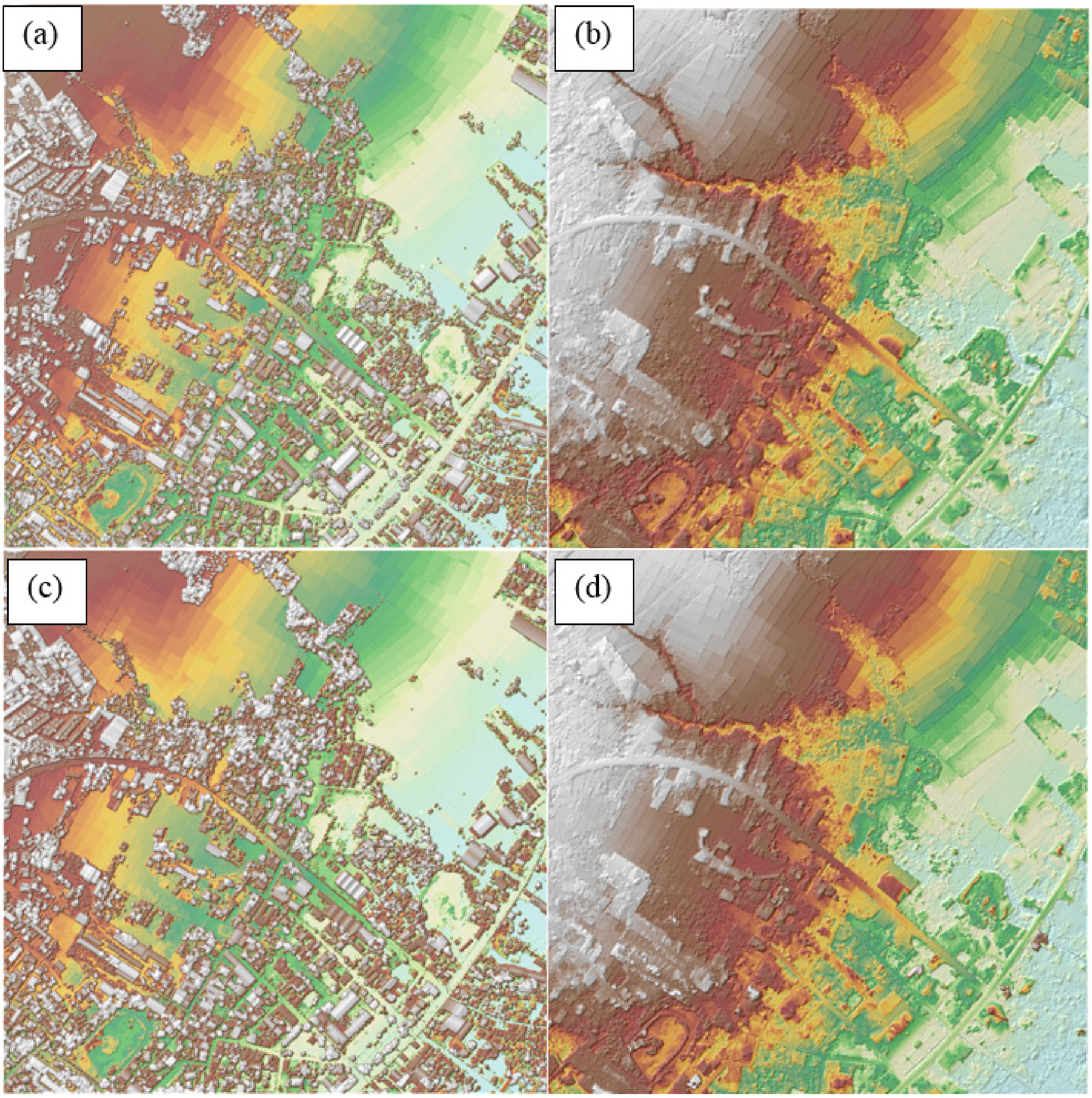

Figure 22. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Binahaan floodplain.

3.7LiDAR Image Processing and Orthophotograph Rectification

The 686 1km by 1km tiles area covered by Binahaan floodplain is shown in Figure 23. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Binahaan floodplain has a total of 483.49 sq.km orthophotogaph coverage comprised of 5,019 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure B-14.

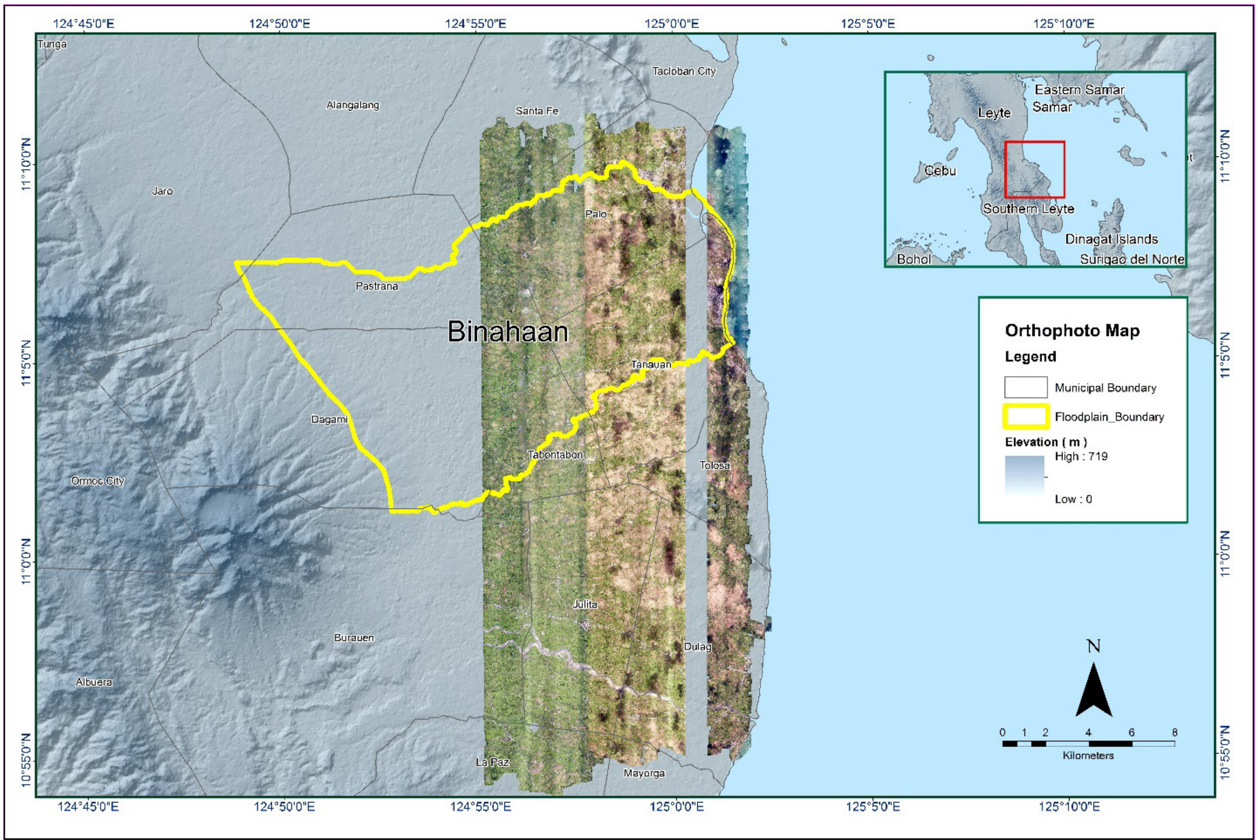

Figure 23. Binahaan floodplain with available orthophotographs.

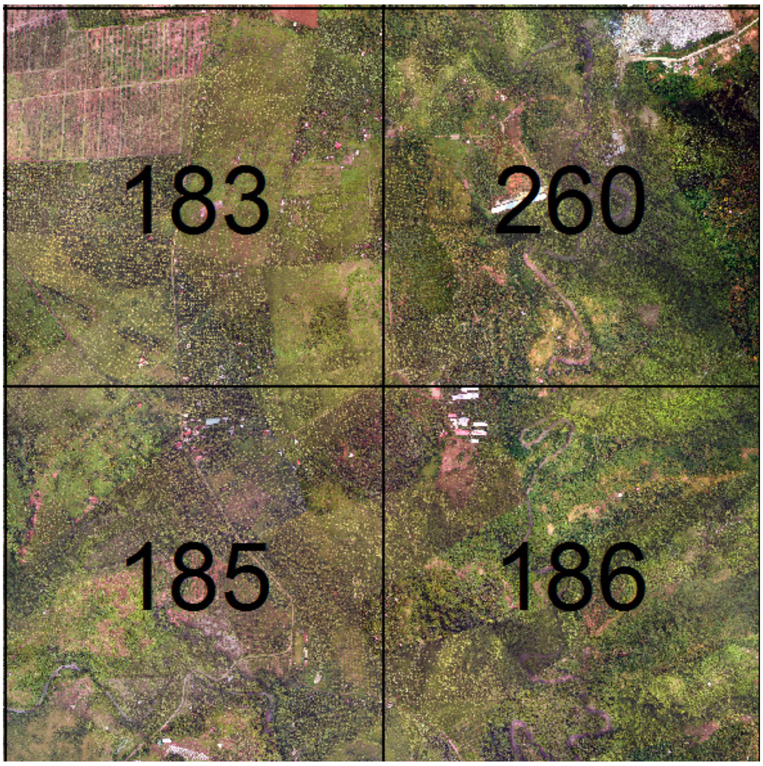

Figure 24. Sample orthophotograph tiles for Binahaan floodplain.

3.8 DEM Editing and Hydro-Correction

Seven (7) mission blocks were processed for Binahaan flood plain. These blocks are composed of SamarLeyte and Leyte blocks with a total area of 679.88 square kilometers. Table 16 shows the name and corresponding area of each block in square kilometers.

Table 16. LiDAR blocks with its corresponding area.

LiDAR Blocks	Area (sq.km)
Samar_Leyte_Blk34D	97.51
Leyte_Blk34C	145.96
Leyte_Blk34F_supplement	30.86
Leyte_Blk34I	49.29
Leyte_Blk34J	62.04
Leyte_Blk34G_ supplement	54.50
Tacloban_1026A	239.72
TOTAL	**679.88 sq.km**

Portions of DTM before and after manual editing are shown in Figure 25. Areas with no data along water bodies has to be interpolated for hydrologic correction. The bridge (Figure 25a) is also considered to be an impedance to the flow of water along the river and has to be removed (Figure 25b). The road (Figure 25c) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 25d) to allow the correct flow of water.

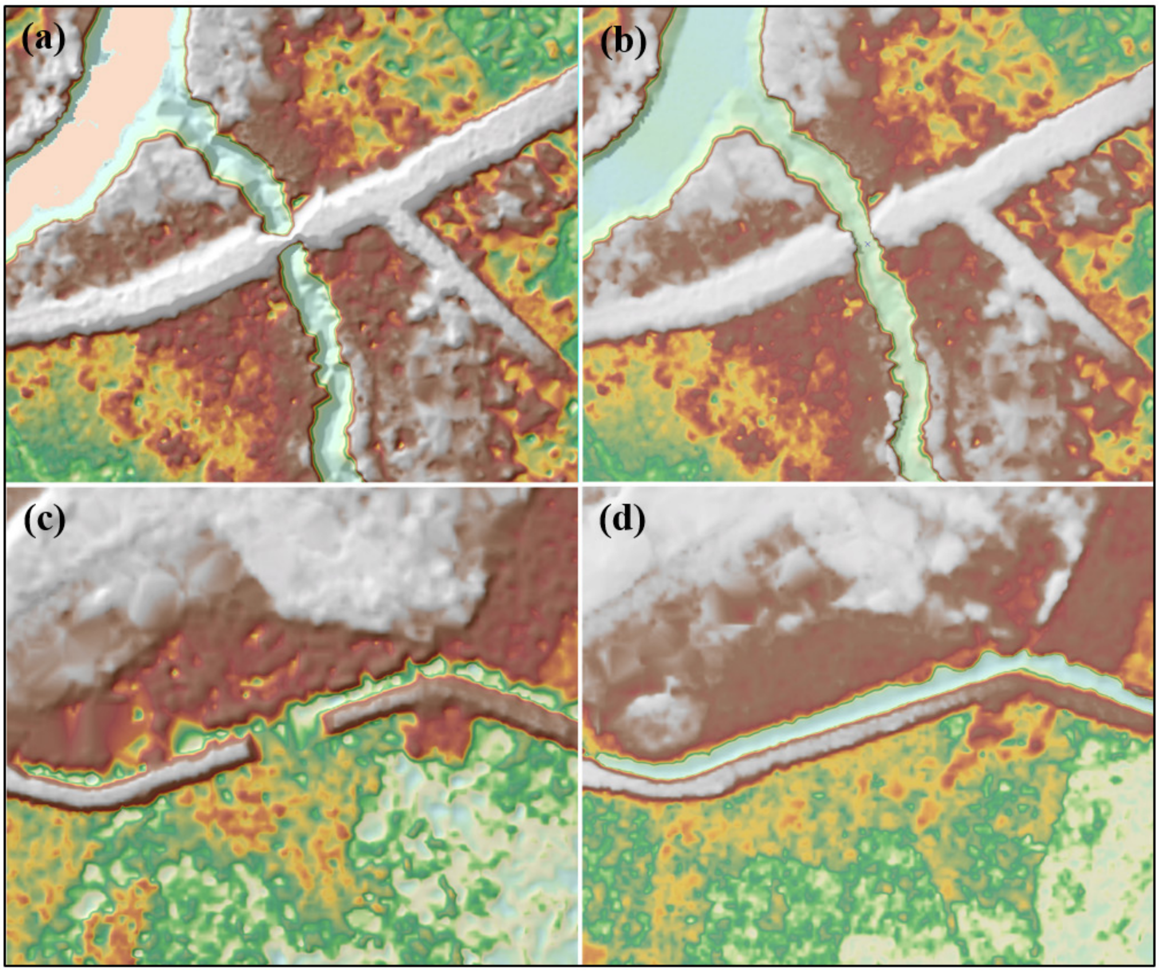

Figure 25. Portions in the DTM of Binahaan floodplain – a bridge before (a) and after (b) manual editing; a paddy field before (c) and after (d) data retrieval.

3.9 Mosaicking of Blocks

No assumed reference block was used in mosaicking because the identified reference for shifting was an existing calibrated Tacloban DEM overlapping with the blocks to be mosaicked. Table 17 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Binahaan flood plain is shown in Figure 26. The entire Binahaan floodplain is 98.65% covered by LiDAR data while portions with no Lidar data were patched with the available IFSAR data.

Table 17. Shift Values of each LiDAR Block of Binahaan floodplain.

Mission Blocks	Shift Values		
	x	y	z
Samar_Leyte_Blk34F	0.00	1.00	-1.01
Leyte_Blk34F_supplement	0.00	1.00	-0.83
Leyte_Blk34I	0.00	0.00	-0.79
Leyte_Blk34J	0.00	-1.00	-1.04
Leyte_Blk34C	0.00	-1.00	-1.13
Leyte_Blk34G_supplement	0.00	0.00	-20.90
Tacloban_1026A	0.00	0.00	0.00

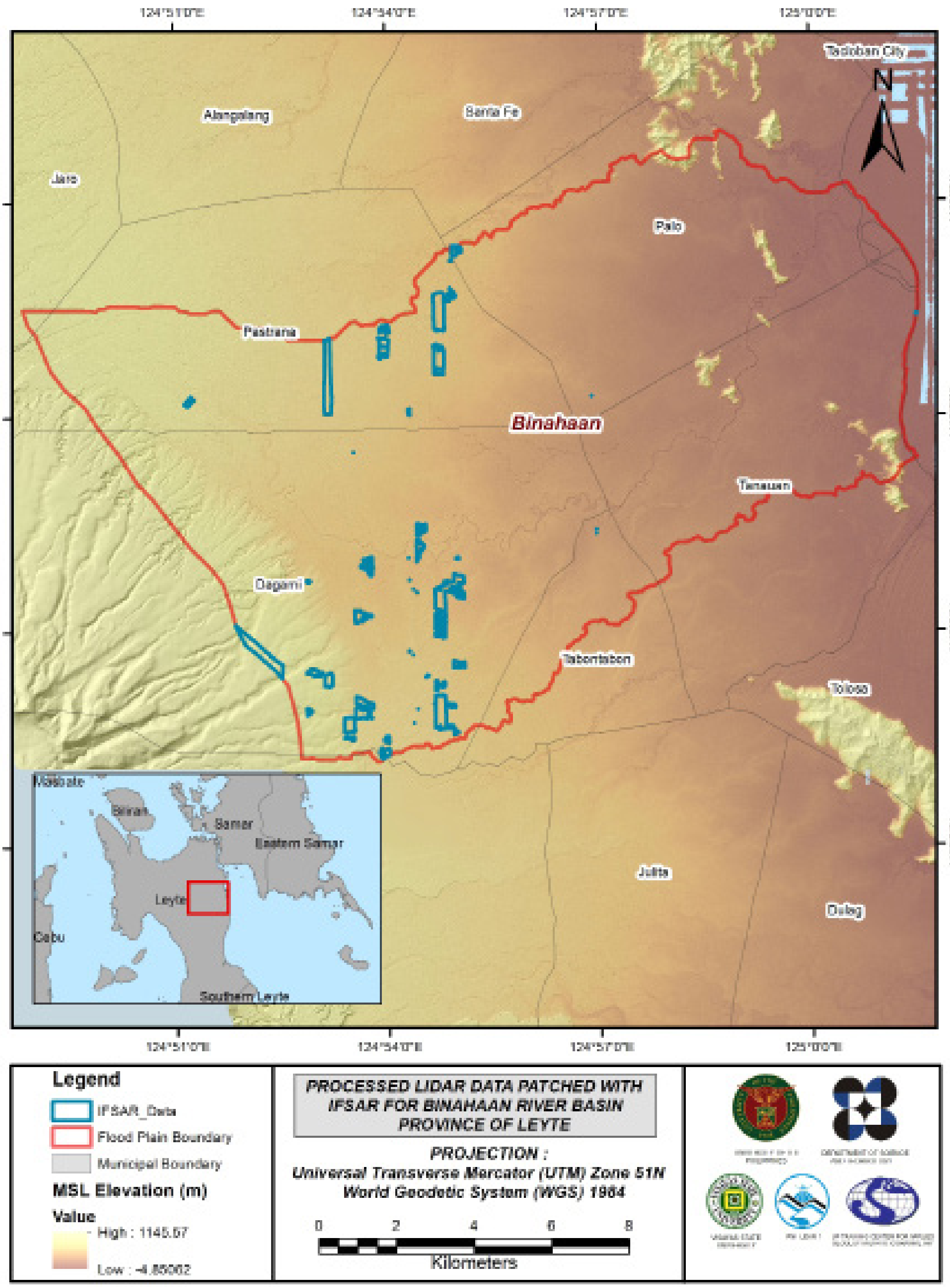

Figure 26. Map of Processed LiDAR Data for Binahaan Flood Plain.

3.10 Calibration and Validation of Mosaicked LiDAR Digital Elevation Model

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Binahaan to collect points with which the LiDAR dataset is validated is shown in Figure 27. A total of 3,602 survey points were gathered for the Binahaan and Guinarona flood plains. However, the point dataset was not used for the calibration of the LiDAR data for Binahaan because during the mosaicking process, each LiDAR block was referred to the calibrated Tacloban DEM. Therefore, the mosaicked DEM of Binahaan can already be considered as a calibrated DEM.

A good correlation between the uncalibrated Tacloban LiDAR DTM and ground survey elevation values is shown in Figure 28. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration points is 0.14 meters with a standard deviation of 0.13 meters. Calibration of Tacloban LiDAR data was done by subtracting the height difference value, 0.14 meters, to Tacloban mosaicked LiDAR data. Table B-6 shows the statistical values of the compared elevation values between Tacloban LiDAR data and calibration data. These values were also applicable to the Binahaan DEM.

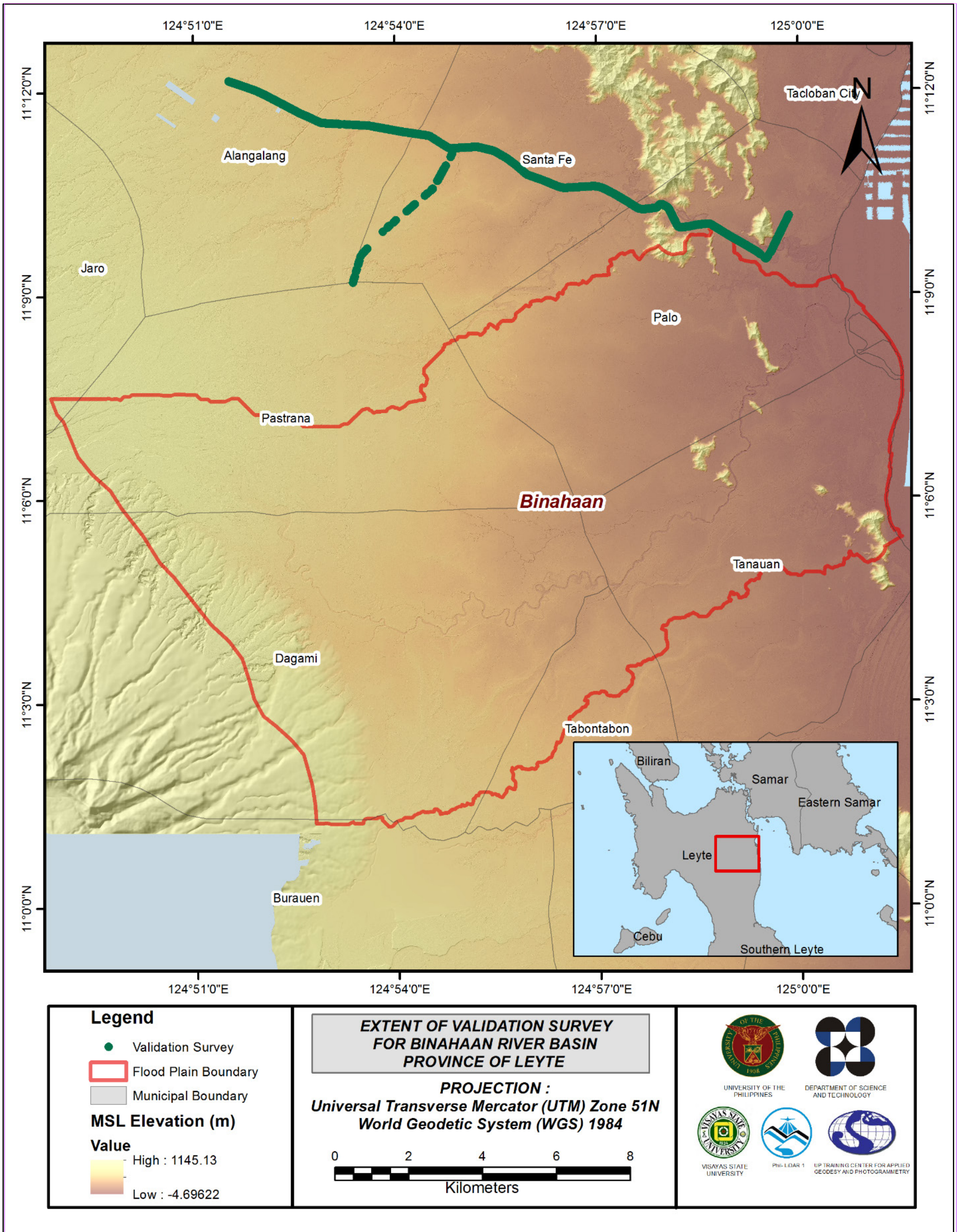

Figure 27. Map of Binahaan Flood Plain with validation survey points in green.

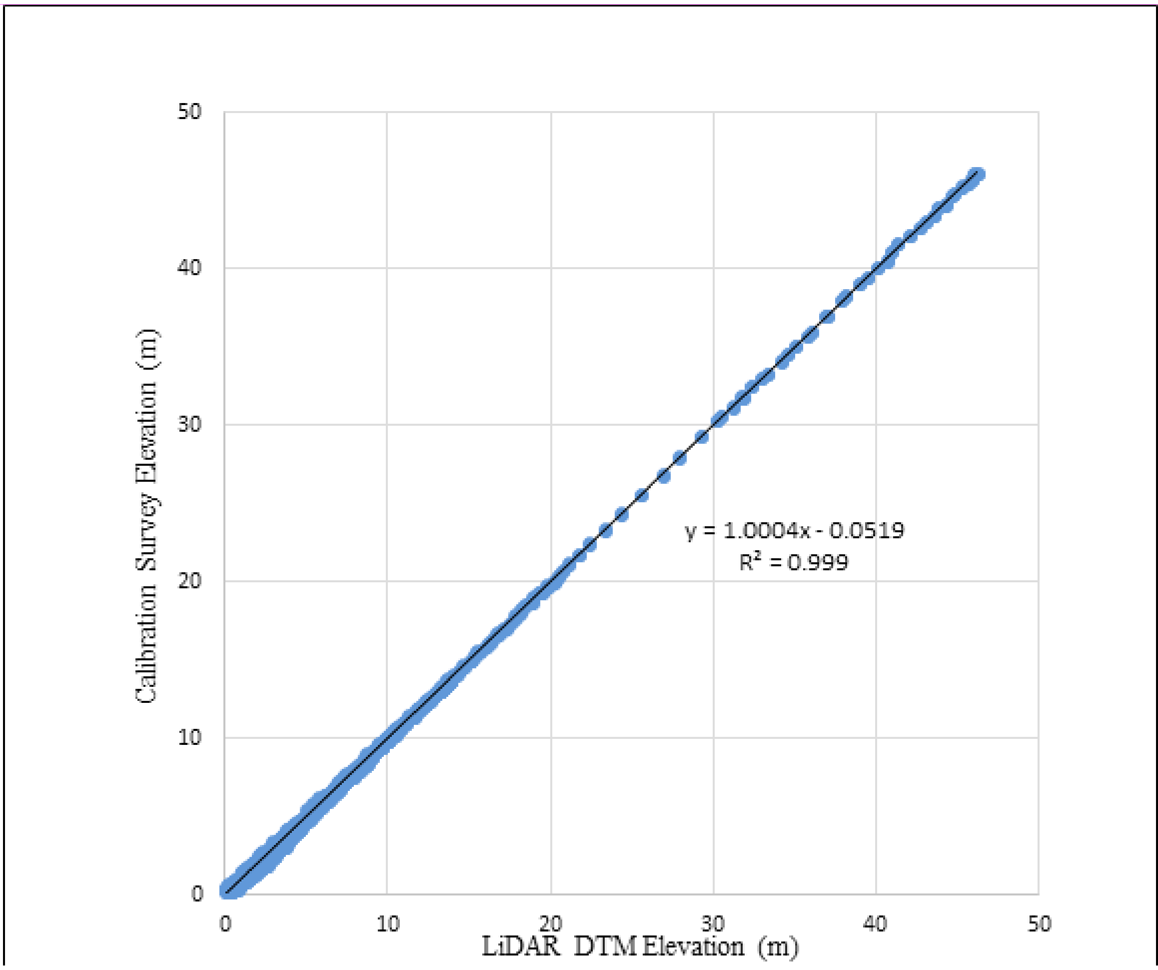

Figure 28. Correlation plot between calibration survey points and LiDAR data.

Table 18. Calibration Statistical Measures.

Calibration Statistical Measures	Value (meters)
Height Difference	0.14
Standard Deviation	0.13
Average	-0.05
Minimum	-0.65
Maximum	0.50

All survey points lie near the Binahaan flood plain and were used for the validation of the calibrated Binahaan DTM. A good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM is shown in Figure 29. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.20 meters with a standard deviation of 0.10 meters, as shown in Table 19.

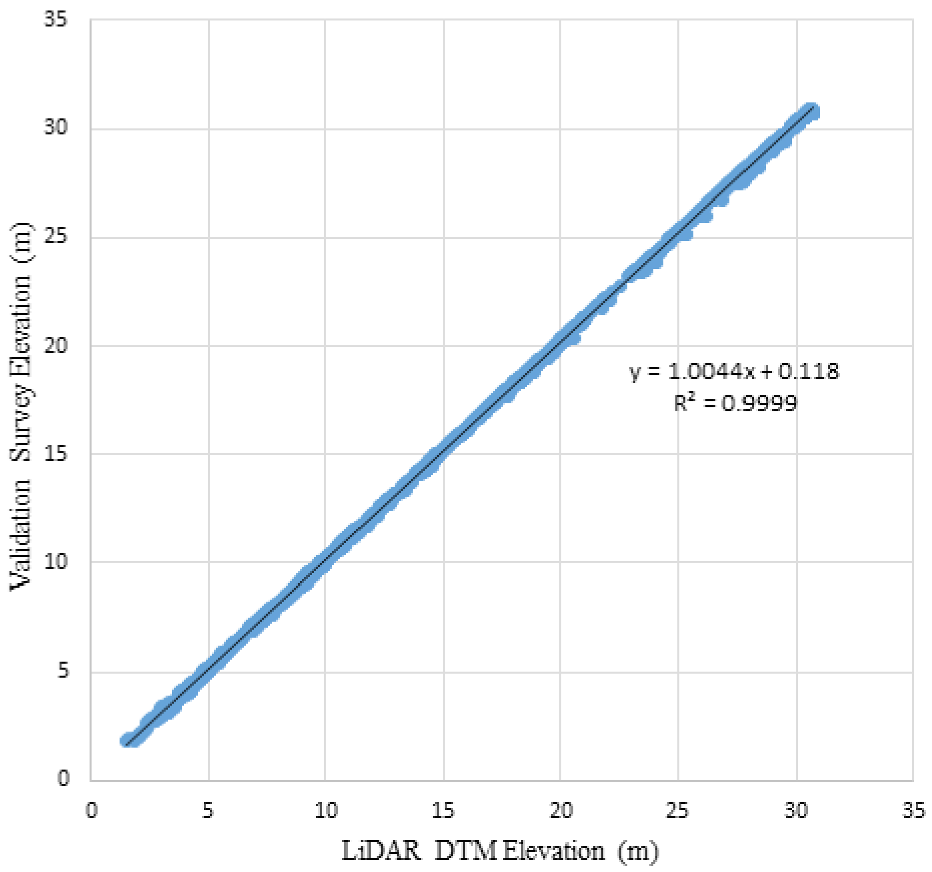

Figure 29. Correlation plot between validation survey points and LiDAR data.

Table 19. Validation Statistical Measures.

Validation Statistical Measures	Value (meters)
RMSE	0.20
Standard Deviation	0.10
Average	0.18
Minimum	-0.20
Maximum	0.34

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, centerline and zigzag data were available for Binahaan with 13,104 bathymetric survey points. The resulting raster surface produced was done by Kernel interpolation with barriers method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.52 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Binahaan integrated with the processed LiDAR DEM is shown in Figure 30.

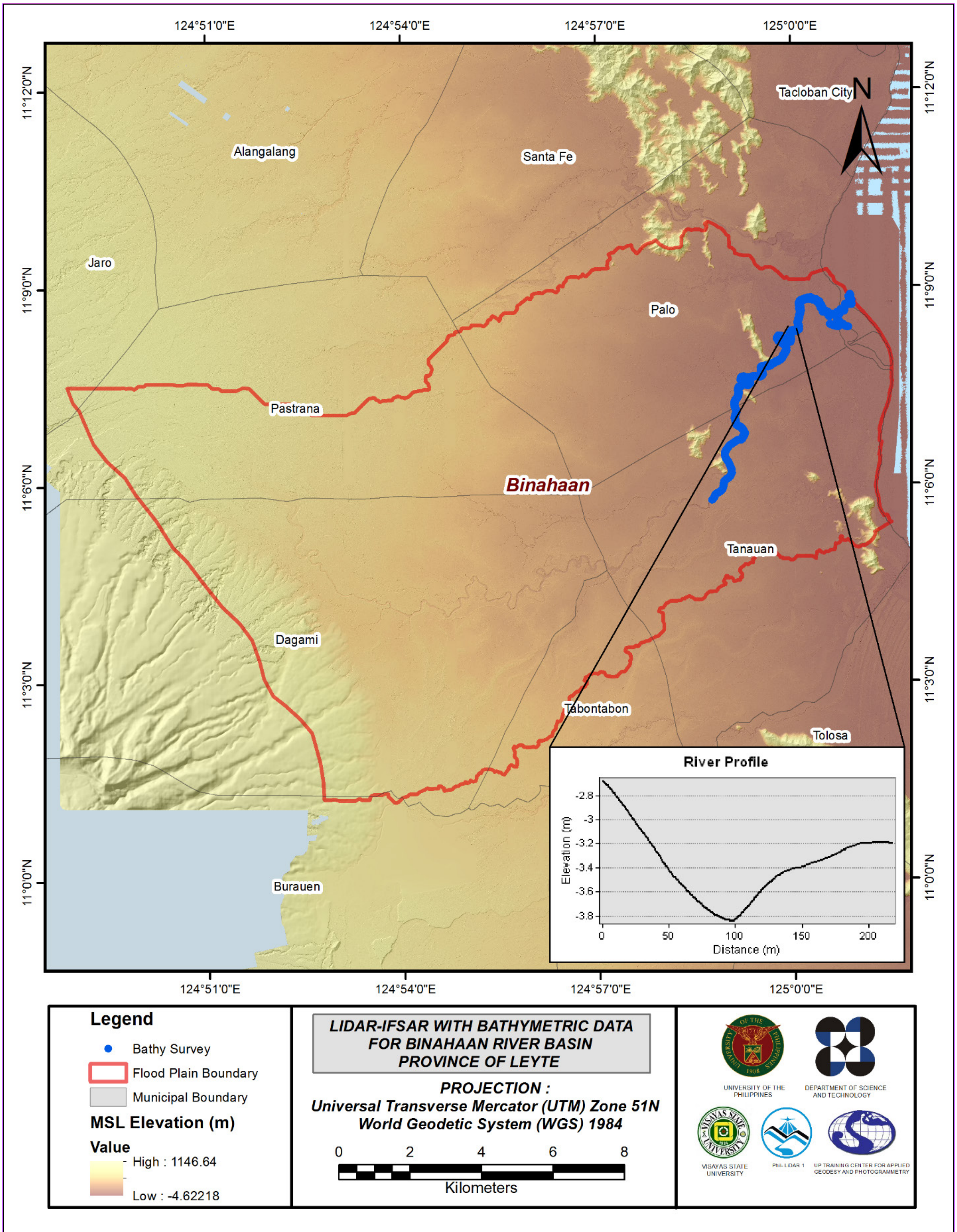

Figure 30. Map of Binahaan Flood Plain with bathymetric survey points shown in blue.

3.12 Feature Extraction

The features salient in flood hazard exposure analysis include buildings, road networks, bridges and water bodies within the floodplain area with 200 m buffer zone. Mosaicked LiDAR DEM with 1 m resolution was used to delineate footprints of building features, which consist of residential buildings, government offices, medical facilities, religious institutions, and commercial establishments, among others. Road networks comprise of main thoroughfares such as highways and municipal and barangay roads essential for routing of disaster response efforts. These features are represented by a network of road centerlines.

3.12.1 Quality Checking of Digitized Features' Boundary

Binahaan floodplain, including its 200 m buffer, has a total area of 421.61 sq km. For this area, a total of 5.0 sq km, corresponding to a total of 4731 building features, are considered for QC. Figure 31 shows the QC blocks for Binahaan floodplain.

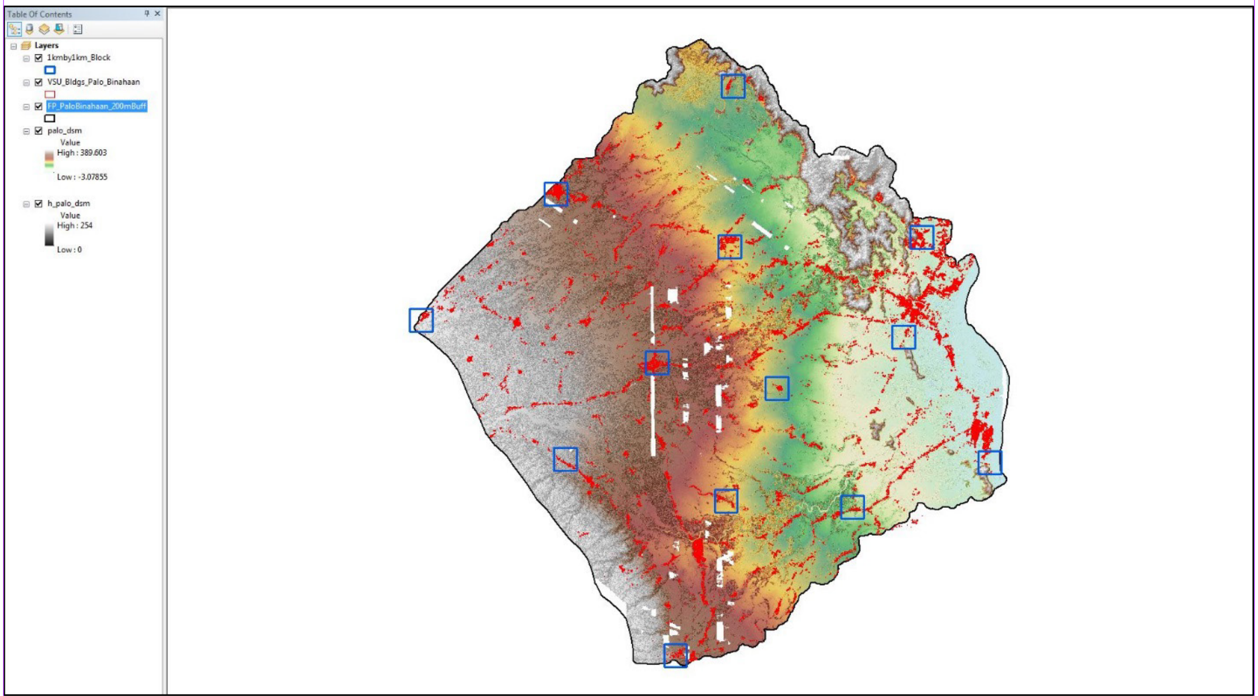

Figure 31. QC blocks for Binahaan building features.

Quality checking of Binahaan building features resulted in the ratings shown in Table 20.

Table 20. Quality Checking Ratings for Binahaan Building Features.

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Binahaan	94.61	94.61	80.89	PASSED

3.12.2 Height Extraction

Height extraction was done for 22,740 building features in Binahaan flood plain. Of these building features, 570 was filtered out after height extraction, resulting to 22,170 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 7.59 m.

3.12.3 Feature Attribution

The digitized features were marked and coded in the field using handheld GPS receivers. The attributes of non-residential buildings were first identified; all other buildings were then coded as residential. An nDSM was generated using the LiDAR DEMs to extract the heights of the buildings. A minimum height of 2 meters was used to filter out the terrain features that were digitized as buildings. Buildings that were not yet constructed during the time of LiDAR acquisition were noted as new buildings in the attribute table.

Table 21 summarizes the number of building features per type. On the other hand, Table 22 shows the total length of each road type, while Table 23 shows the number of water features extracted per type.

Table 21. Building Features Extracted for Binahaan Floodplain.

Facility Type	No. of Features
Residential	20,844
School	588
Market	19
Agricultural/Agro-Industrial Facilities	52
Medical Institutions	45
Barangay Hall	112
Military Institution	0
Sports Center/Gymnasium/Covered Court	12
Telecommunication Facilities	2
Transport Terminal	1
Warehouse	25
Power Plant/Substation	1
NGO/CSO Offices	0
Police Station	3
Water Supply/Sewerage	1
Religious Institutions	126
Bank	0
Factory	19
Gas Station	9
Fire Station	3
Other Government Offices	79
Other Commercial Establishments	217
Abandoned Buildings	12
Total	**22,170**

Table 22. Total Length of Extracted Roads for Binahaan Floodplain.

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/ Municipal Road	Provincial Road	National Road	Others	
Binahaan	233.15	108.41	0	26.54	0.00	**368.10**

Table 23. Number of Extracted Water Bodies for Binahaan Floodplain.

Floodplain	Water Body Type					Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Binahaan	66	0	0	25	2	93

A total of 80 bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

3.12.4 Final Quality Checking of Extracted Features

All extracted ground features were completely given the required attributes. All these output features comprise the flood hazard exposure database for the flood plain. This completes the feature extraction phase of the project.

Figure 32 shows the Digital Surface Model (DSM) of Binahaan flood plain overlaid with its ground features.

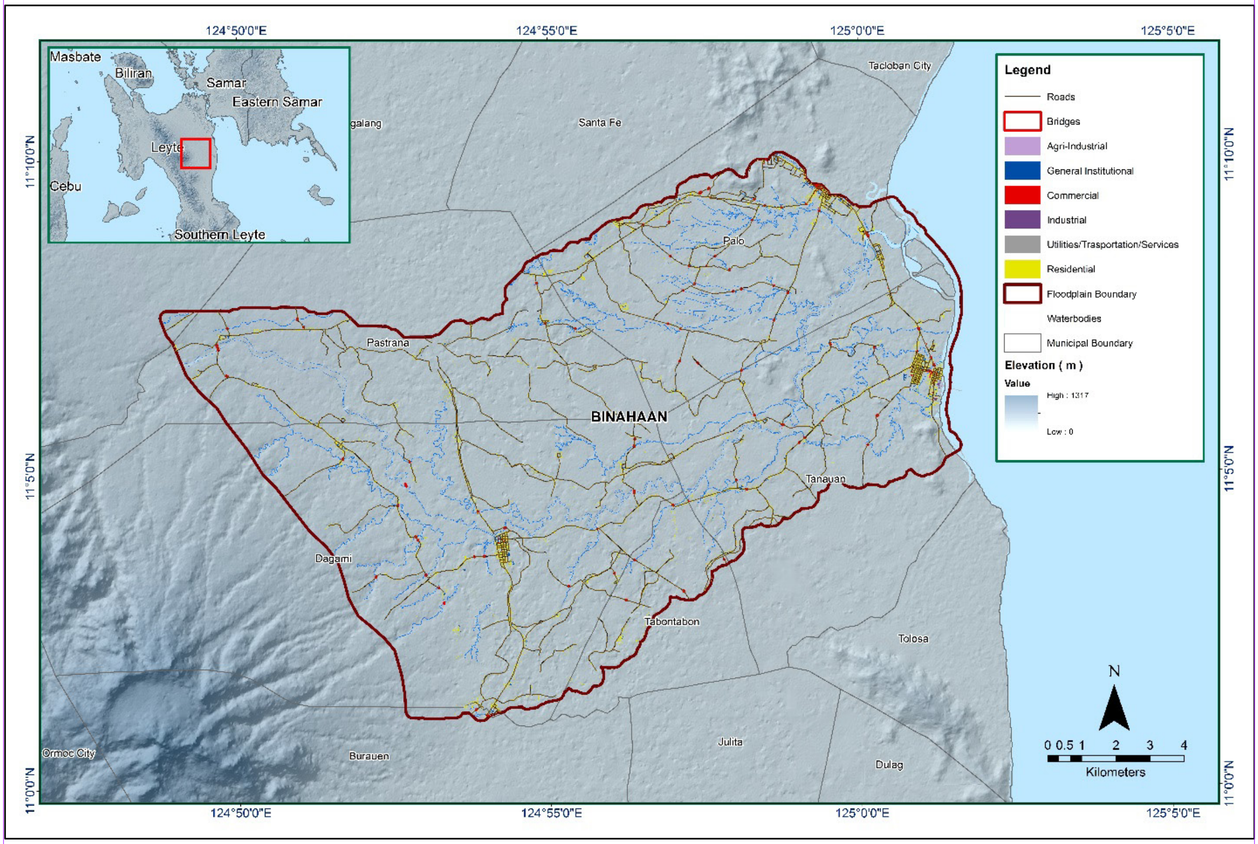

Figure 32. Extracted features for Binahaan floodplain.

CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE BINAHAAN FLOODPLAIN

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The methods applied in this Chapter were based on the DREAM methods manual (Sarmiento, et al., 2014) and further enhanced and updated in Paringit, et al. (2017).

4.1 Summary of Activities

Binahaan River Basin covers the municipalities of Palo, Pastrana, Dagami, Tanauan and Ormoc City in the province of Leyte. The DENR River Basin Control Office identified the basin to have a drainage area of 120 km2 and an estimated 228 million cubic meter (MCM) annual run-off (River Basin Control Office, 2017).

Its main stem, Binahaan River, is part of the 28 river systems in Eastern Visayas Region. According to the 2015 national census of NSO, a total of 7,835 persons are residing within the immediate vicinity of the river which is distributed among eight (8) barangays, from the municipality of Tanauan and Palo (Philippine Statistics Authority, 2016). The town of Tanauan is considered as an agricultural, industrial and ecotourism destination in Eastern Visayas, with most of the resident's income derived from fishing and agriculture. (Carine J. Yi, 2015). On instances of water level rise of Binahaan River, it threatens potable water supply of Tacloban City and other towns near the vicinity affecting 39,000 residents from 130 barangays and submerging 6,300 hectares of farmland (Llanto, 2013). Last December 30, 2014, during the surge of Tropical Storm Seniang, internationally known as Jangmi, five (5) people died as a result of a landslide in the municipality of Tanauan, while thousands of residents were forced to leave their homes for safety reasons.

In line with this, DVBC in partnership with the VSU, conducted a field survey in Binahaan River on April 20-22, August 26-28 and October 17-26, 2016 with the following scope of work: reconnaissance; control survey; cross-section and as-built survey at Sta. Elena Bridge in Brgy. Binongto-An in the Municipality of Tanauan, Leyte; validation points acquisition of about 22.159 km covering the municipalities of Alangalang, Santa Fe and Palo in the province of Leyte; and bathymetric survey from its upstream in Brgy. Binongto-An to the mouth of the river located in Brgy. San Joaquin, in the Municipality of Palo, with an approximate length of 10.756 km using Ohmex™ single beam echo sounder and Trimble® SPS 855 GNSS PPK survey technique.

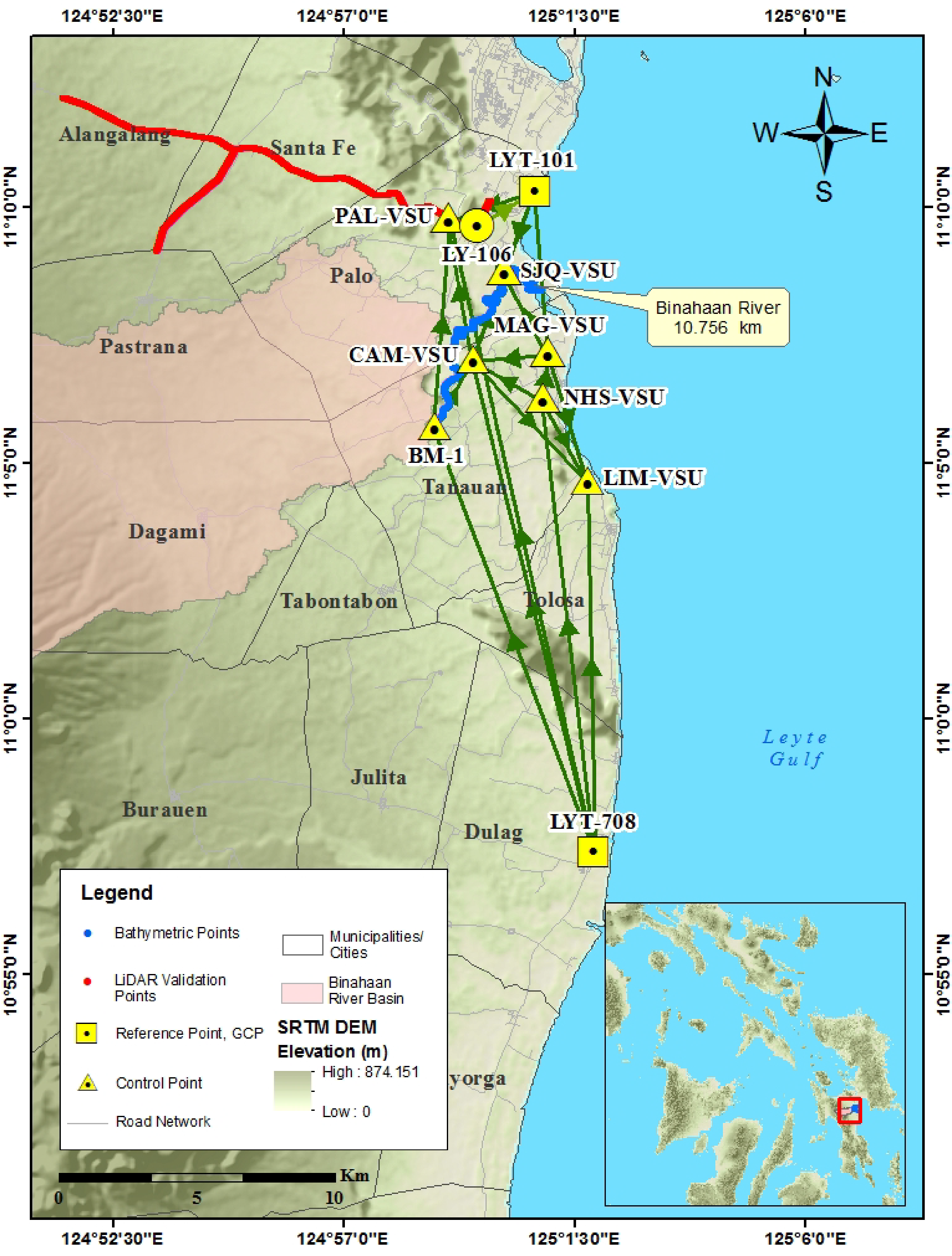


Figure 33. Binahaan River Basin Survey Extent

4.2 Control Survey

A GNSS baseline was established on September 18-21, 2014 occupying the control points LYT-101, a 2nd order GCP in Brgy. Candahug; and LY-1016, a 1st order Benchmark in Brgy. San Miguel, both in Municipality of Palo, Leyte.

The GNSS network used for Binahaan River Basin is composed of nine loops established on April 20-22, 2016 occupying the reference points: LYT-101 from the field survey on September 2014 for Palo River; and LYT-708, a 2nd order GCP in Brgy. Buntay, Municipality of Dulag; all in Leyte.

Six control points were established namely: CAM-VSU, located in front of Camire Elementary School in Brgy. Balud, Municipality of Tanauan; LIM-VSU, located on a riprap along National Road in Brgy. Olot, Municipality of Tolosa; MAG-VSU, located on top of a Mass Grave monument in Brgy. Solano, Municipality of Tanauan; NHS-VSU, located inside Tanauan National High School in Brgy. Sto Niño Poblacion, Municipality of Tanauan; PAL-VSU, located on the top of revetment along Bangon River in Brgy. Arado, Municipality of Palo; and SJQ-VSU, located near the approach of San Joaquin Bridge in Brgy. San Joaquin also in Municipality of Palo; all in Leyte. A JICA established control point namely BM-1, located at the approach of Sta. Elena Bridge in Brgy. Binongtoan, Municipality of Tanauan, was also occupied and used as marker for the survey.

The summary of reference and control points and its location is summarized in Table 24 while the GNSS network established is illustrated in Figure 34.

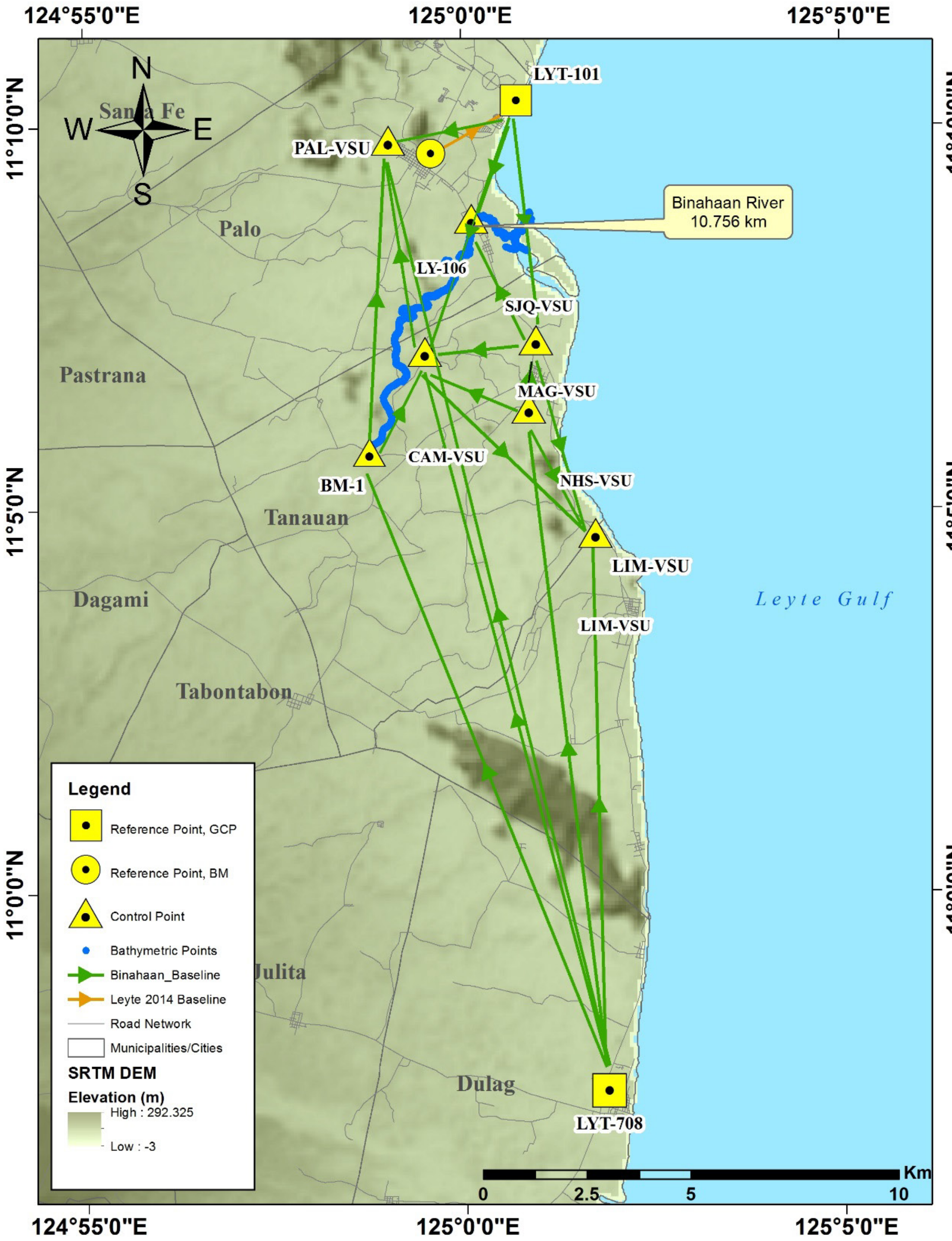


Figure 34. Binahaan River Basin Survey Extent

Table 24. List of Reference and Control Points occupied for Binahaan River Survey (Source: NAMRIA; UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (m)	MSL Elevation (m)	Date established
Control Survey on September 18-21, 2014						
LYT-101	2nd Order, GCP	11°10'19.64869"	125°00'43.78230"	69.218	5.135	
LY-106	1st Order, BM	11°09'38.36968"	124°59'35.93678"	67.850	4.028	
Control Survey on April 20-22, 2016						
LYT-101	2nd Order, GCP	11°10'19.64869"	125°00'43.78230"	69.218	5.135	
LYT-708	2nd Order, GCP	10°57'24.54497"	125°01'52.57808"	67.197	2.594	
CAM-VSU	VSU established	-	-	-	-	
LIM-VSU	VSU established	-	-	-	-	
MAG-VSU	VSU established	-	-	-	-	
NHS-VSU	VSU established	-	-	-	-	
PAL-VSU	VSU established	-	-	-	-	
SJQ-VSU	VSU established	-	-	-	-	

The GNSS set-ups on recovered reference points and established control points in Binahaan River are shown in Figure 35 to Figure 44.

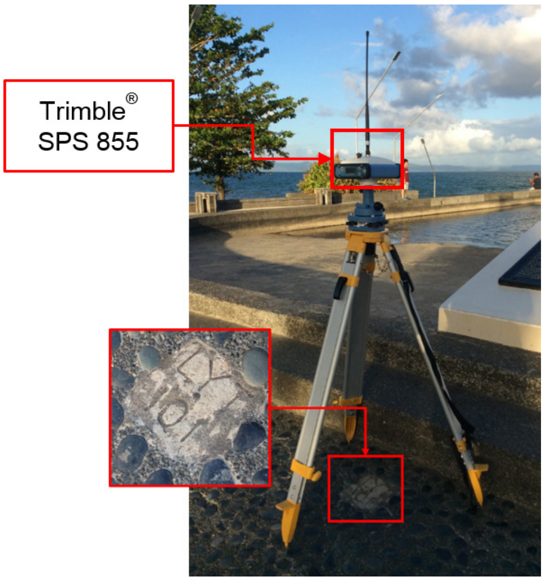


Figure 35. GNSS receiver setup, Trimble® SPS 855, at LYT-101, located in front of Gen. Douglas MacArthur Shrine, Brgy. Candahug, Mun. of Palo, Leyte

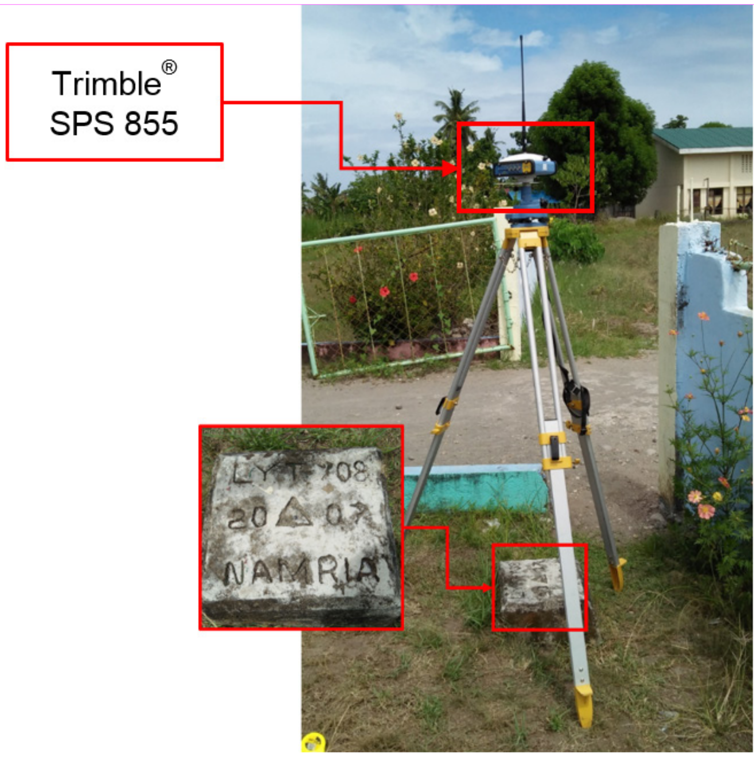


Figure 36. GNSS base set up, Trimble® SPS 855, at LYT-708, located in front of Dulag Elementary School, in Brgy. Buntay, Mun. of Dulag, Leyte

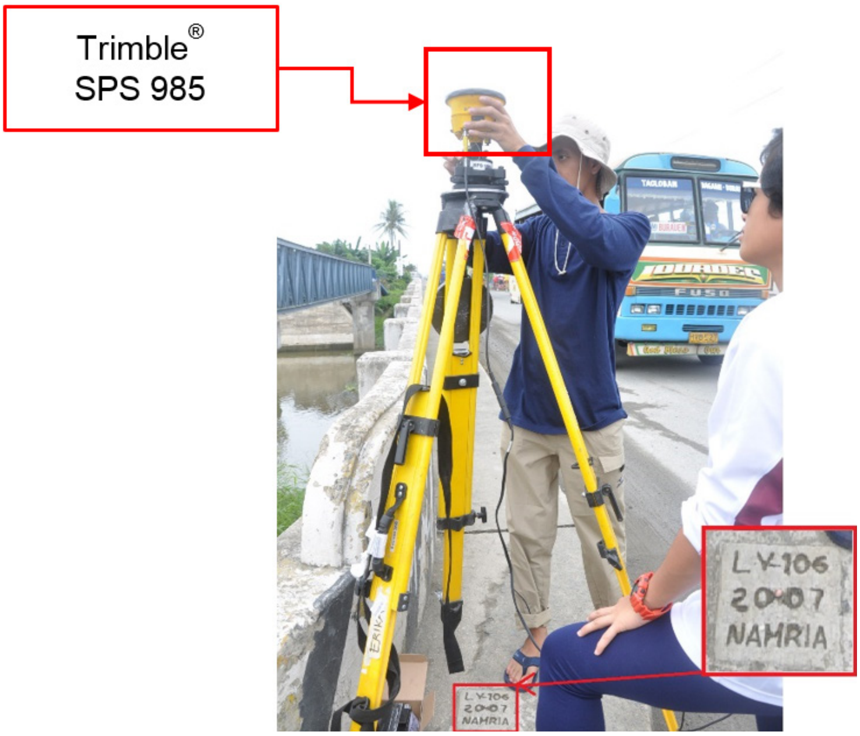


Figure 37. GNSS receiver setup, Trimble® SPS 985 at LY-106, located at the approach of Bernard Reed Bridge in Brgy. San Miguel, Municipality of Palo, Leyte

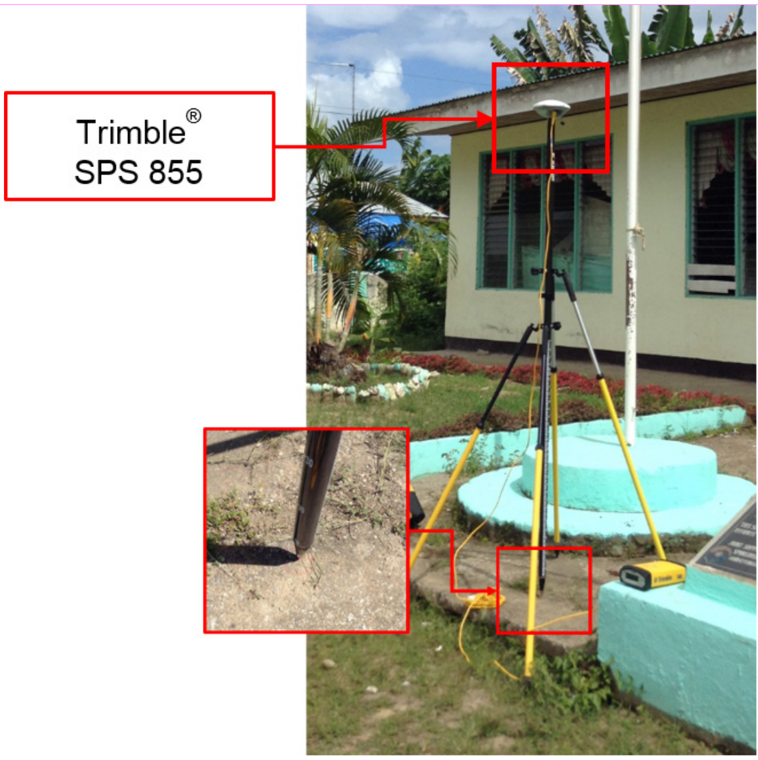


Figure 38. GNSS receiver setup, Trimble® SPS 885, at CAM-VSU, located in front of Camire Elementary School in Brgy. Balud, Municipality of Tanauan, Leyte

Figure 39. GNSS receiver setup, Trimble® SPS 855, at LIM-VSU, located on ariprap along National Road in Brgy. Olot, Municipality of Tolosa, Leyte

Figure 40. GNSS receiver setup, Trimble® SPS 855, at MAG-VSU, located on top of a Mass Grave monument in Brgy. Solano, Municipality of Tanauan, Leyte

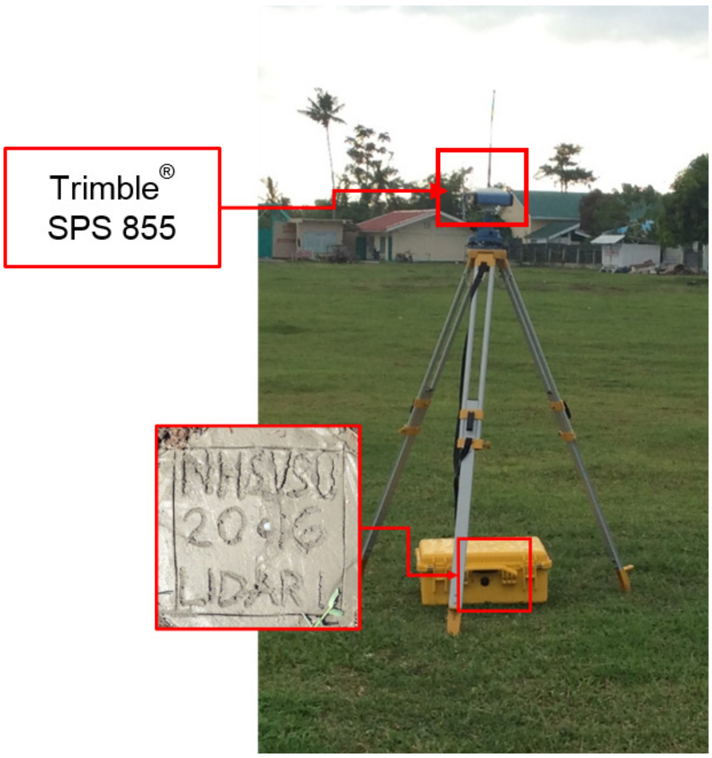


Figure 41. GNSS receiver setup, Trimble® SPS 855, at NHS-VSU, located inside Tanauan National High School, in Brgy. Sto. Niño Poblacion, Municipality of Tanauan, Leyte

Figure 42. GNSS receiver setup, Trimble® SPS 855, at PAL-VSU, located on top of revetment along Bangon River in Brgy. Arado, Municipality of Palo, Leyte

Figure 43. GNSS receiver setup, Trimble® SPS 855, at SJQ-VSU, located near the approach of San Joaquin Bridge, in Brgy. San Joaquin, Municipality of Palo, Leyte

Figure 44. GNSS receiver setup, Trimble® SPS 855, at BM-1, located at the approach of Sta. Elena Bridge, in Brgy. Binongtoan, Municipality of Tanauan, Leyte

4.3 Baseline Processing

GNSS Baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within +/- 20 cm and +/- 10 cm requirement, respectively. In case where one or more baselines did not meet all of these criteria, masking is performed. Masking is done by removing/masking portions of these baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, resurvey is initiated. Baseline processing result of control points in Binahaan River Basin is summarized in Table 25 generated by TBC software.

Table 25. Baseline Processing Summary Report for Binahaan River Survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	Height (Meter)
CAMVSU --- PALVSU (B29)	4-22-2016	Fixed	0.003	0.014	350°27'52"	5150.635	1.128
CAMVSU --- PALVSU (B12)	4-22-2016	Fixed	0.004	0.011	350°27'52"	5150.638	1.123
BM-1 --- CAMVSU (B25)	4-22-2016	Fixed	0.004	0.015	29°25'22"	2760.725	-5.501
LYT-708 --- CAMVSU	4-22-2016	Fixed	0.004	0.011	346°22'27"	18299.173	1.253
MAGVSU --- CAMVSU (B18)	4-21-2016	Fixed	0.003	0.018	264°18'10"	2682.599	1.154
CAMVSU --- LIMVSU (B13)	4-21-2016	Fixed	0.003	0.012	137°02'08"	5986.252	-2.439
NHSVSU --- CAMVSU (B21)	4-21-2016	Fixed	0.003	0.013	298°54'18"	2849.594	3.340
LYT101 --- CAMVSU (B4)	4-22-2016	Fixed	0.004	0.019	200°13'55"	6428.995	-0.749
CAMVSU --- LYT101 (B6)	4-22-2016	Fixed	0.005	0.015	200°13'55"	6429.002	-0.758
CAMVSU --- NHSVSU (B24)	4-22-2016	Fixed	0.002	0.009	298°54'18"	2849.598	3.328
MAGVSU --- CAMVSU (B9)	4-21-2016	Fixed	0.004	0.013	264°18'10"	2682.599	1.137
CAMVSU --- SJQVSU (B1)	4-20-2016	Fixed	0.003	0.011	19°29'20"	3389.643	-2.011
SJQVSU --- CAMVSU (B2)	4-20-2016	Fixed	0.004	0.013	19°29'21"	3389.649	-2.029
BM-1 --- LYT-708 (B27)	4-22-2016	Fixed	0.003	0.012	339°46'15"	16390.757	6.743
BM-1 --- PALVSU (B30)	4-22-2016	Fixed	0.003	0.014	3°50'35"	7500.944	-4.365
NHSVSU --- MAGVSU (B19)	4-21-2016	Fixed	0.002	0.003	6°04'07"	1652.953	2.183
LIMVSU --- LYT-708 (B15)	4-21-2016	Fixed	0.004	0.015	359°00'36"	13404.986	-1.188
LIMVSU --- NHSVSU (B23)	4-21-2016	Fixed	0.003	0.010	152°10'46"	3396.078	0.902
NHSVSU --- LIMVSU (B20)	4-21-2016	Fixed	0.002	0.009	152°10'46"	3396.073	0.911
LYT101 --- PALVSU (B10)	4-22-2016	Fixed	0.004	0.017	252°47'25"	3220.346	0.362
MAGVSU --- LIMVSU (B17)	4-21-2016	Fixed	0.003	0.014	163°07'11"	4856.479	-1.289
MAGVSU --- SJQVSU (B8)	4-20-2016	Fixed	0.005	0.017	332°17'36"	3308.374	-0.908

MAGVSU --- LYT101 (B7)	4-21-2016	Fixed	0.005	0.021	175°34'35"	5783.217	-1.904
SJQVSU --- PALVSU (B11)	4-20-2016	Fixed	0.003	0.012	313°31'12"	2736.111	3.135
LYT101 --- SJQVSU (B3)	4-20-2016	Fixed	0.003	0.014	201°03'21"	3039.944	-2.771
SJQVSU --- LYT101 (B5)	4-20-2016	Fixed	0.006	0.018	201°03'21"	3039.946	-2.793
LYT-708 --- PALVSU (B28)	4-22-2016	Fixed	0.003	0.014	347°16'26"	23439.529	2.400
CAMVSU --- LYT-708 (B26)	4-22-2016	Fixed	0.003	0.014	346°22'27"	18299.172	1.253
LIMVSU --- CAMVSU (B14)	4-21-2016	Fixed	0.004	0.016	137°02'08"	5986.264	-2.449
LYT-708 --- NHSVSU (B22)	4-21-2016	Fixed	0.004	0.013	353°40'57"	16506.862	-2.068

As shown Table 25 a total of thirty (30) baselines were processed coordinate and elevation values of reference point LYT-101; and coordinate values of LYT-708 held fixed. All of them passed the required accuracy.

4.4 Network Adjustment

After the baseline processing procedure, network adjustment is performed using TBC. Looking at the Adjusted Grid Coordinates table of the TBC generated Network Adjustment Report, it is observed that the square root of the sum of the squares of x and y must be less than 20 cm and z less than 10 cm or in equation form:

$$\sqrt{((x_e)^2 + (y_e)^2)} < 20cm \text{ and } z_e < 10\ cm$$

Where:

x_e is the Easting Error,
y_e is the Northing Error, and
z_e is the Elevation Error

for each control point. See the Network Adjustment Report shown in Table 26 to Table 29 for complete details.

The nine (9) control points, LYT-101, LYT-708, CAM-VSU, LIM-VSU, MAG-VSU, NHS-VSU, PAL-VSU, SJQ-VSU and BM-1 were occupied and observed simultaneously to form a GNSS loop. Coordinates of LYT-101 and LYT-708 and elevation values LYT-101 were held fixed during the processing of the control points as presented in Table 26. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 26. Control Point Constraints

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
LYT-101	Grid				Fixed
LYT-101	Global	Fixed	Fixed		
LYT-708	Global	Fixed	Fixed		
Fixed = 0.000001 (Meter)					

The list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 27. All fixed control points have no values for grid and elevation errors.

Table 27. Adjusted Grid Coordinates

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
LYT101	719729.823	?	1235759.250	?	5.135	?	LLe
LYT-708	721979.595	?	1211952.918	?	2.594	0.042	LL
CAM-VSU	717547.159	0.005	1229710.821	0.004	4.347	0.034	
LIM-VSU	721657.091	0.006	1225356.793	0.005	1.646	0.043	
MAG-VSU	720215.141	0.006	1229995.294	0.005	3.080	0.040	
NHS-VSU	720051.512	0.006	1228350.131	0.005	0.872	0.040	
PAL-VSU	716659.636	0.007	1234785.356	0.006	5.614	0.039	
SJQ-VSU	718656.753	0.006	1232914.373	0.005	2.335	0.036	
BM-1	716206.765	0.007	1227296.771	0.006	9.860	0.050	

With the mentioned equation, $\sqrt{((x_e)^2 + (y_e)^2)} < 20cm$ for horizontal and $z_e < 10\ cm$ for the vertical; the computation for the accuracy are as follows:

a. LYT-101

horizontal accuracy	=	Fixed
vertical accuracy	=	Fixed

b. LYT-708

horizontal accuracy	=	Fixed
vertical accuracy	=	4.2 < 10 cm

c. CAM-VSU

horizontal accuracy	=	$\sqrt{((0.8)^2 + (0.6)^2}$
	=	$\sqrt{(0.64 + 0.36)}$
	=	1.00 < 20 cm
vertical accuracy	=	Fixed

d. LIM-VSU

horizontal accuracy	=	$\sqrt{((0.9)^2 + (0.6)^2}$
	=	$\sqrt{(0.81 + 0.36)}$
	=	1.08 < 20 cm
vertical accuracy	=	Fixed

e. MAG-VSU

horizontal accuracy	=	$\sqrt{((1.1)^2 + (0.8)^2}$
	=	$\sqrt{(1.21 + 0.64)}$
	=	1.36 cm < 20 cm
vertical accuracy	=	Fixed

f. NHS-VSU

horizontal accuracy	=	$\sqrt{((0.9)^2 + (0.6)^2}$
	=	$\sqrt{(0.81 + 0.36)}$
	=	1.08 cm < 20 cm
vertical accuracy	=	6.7 cm < 10 cm

g. PAL-VSU

horizontal accuracy	=	$\sqrt{((0.9)^2 + (0.6)^2}$
	=	$\sqrt{(0.81 + 0.36)}$
	=	1.08 cm < 20 cm
vertical accuracy	=	6.7 cm < 10 cm

h. SJQ-VSU

horizontal accuracy	=	$\sqrt{((0.9)^2 + (0.6)^2}$
	=	$\sqrt{(0.81 + 0.36)}$
	=	1.08 cm < 20 cm
vertical accuracy	=	6.7 cm < 10 cm

i. BM-1

horizontal accuracy	=	$\sqrt{((0.9)^2 + (0.6)^2}$
	=	$\sqrt{(0.81 + 0.36)}$
	=	1.08 cm < 20 cm
vertical accuracy	=	6.7 cm < 10 cm

Following the given formula, the horizontal and vertical accuracy result of the two occupied control points are within the required precision.

Table 28. Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
LYT-101	N11°10'19.64869"	E125°00'43.78230"	69.218	?	LLe
LYT-708	N10°57'24.54497"	E125°01'52.57808"	67.197	0.042	LL
CAM-VSU	N11°07'03.32408"	E124°59'30.51751"	68.460	0.034	
LIM-VSU	N11°04'40.74891"	E125°01'44.94709"	66.026	0.043	
MAG-VSU	N11°07'11.99451"	E125°00'58.48218"	67.314	0.040	
NHS-VSU	N11°06'18.50045"	E125°00'52.72365"	65.127	0.040	
PAL-VSU	N11°09'48.63503"	E124°59'02.39537"	69.581	0.039	
SJQ-VSU	N11°08'47.31897"	E125°00'07.78743"	66.437	0.036	
BM-1	N11°05'45.06575"	E124°58'45.82598"	73.947	0.050	

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 28. Based on the result of the computation, the equation is satisfied; hence, the required accuracy for the program was met.

The summary of reference and control points used is indicated in Table 29.

Table 29. Reference and control points used and its location (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	BM Ortho (m)
Control Survey on September 18-21, 2016							
LYT-101	2nd Order, GCP	11°10'19.64869"	125°00'43.78230"	69.218	1235759.250	719729.823	5.135
LY-106	1st Order, BM	12°23'08.14503"	124°37'40.19430"	70.990	1369731.985	676970.194	13.480
Control Survey on April 20-22,2016							
LYT-101	2nd Order, GCP	11°10'19.64869"	125°00'43.78230"	69.218	1235759.250	719729.823	5.135
LYT-708	2nd Order, GCP	10°57'24.54497"	125°01'52.57808"	67.197	1211952.918	721979.595	2.594
CAM-VSU	VSU established	11°07'03.32408"	124°59'30.51751"	68.460	1229710.821	717547.159	4.347
LIM-VSU	VSU established	11°04'40.74891"	125°01'44.94709"	66.026	1225356.793	721657.091	1.646
MAG-VSU	VSU established	11°07'11.99451"	125°00'58.48218"	67.314	1229995.294	720215.141	3.080
NHS-VSU	VSU established	11°06'18.50045"	125°00'52.72365"	65.127	1228350.131	720051.512	0.872
PAL-VSU	VSU established	11°09'48.63503"	124°59'02.39537"	69.581	1234785.356	716659.636	5.614
SJQ-VSU	VSU established	11°08'47.31897"	125°00'07.78743"	66.437	1232914.373	718656.753	2.335
BM-1	Used as Marker	11°05'45.06575"	124°58'45.82598"	73.947	1227296.771	716206.765	9.860

4.5 Cross-section, Bridge As-Built Survey and Water Level Marking

Cross-section and as-built survey were conducted on October 22 and 24, 2016 at the downstream side of Sta. Elena bridge in Brgy. Binongto-An, Municipality of Tanauan, Leyte as shown in Figure 45. A survey grade GNSS receiver Trimble® SPS 882 in PPK survey technique was utilized for this survey as shown in Figure 46.

Figure 45. Sta. Elena Bridge facing downstream

Figure 46. As-Built Survey of Sta. Elena Bridge

The cross-sectional line of Sta. Elena Bridge is about 91 m with thirty-five (35) cross-sectional points using the control point BM-1 as the GNSS base station. The cross-section diagram, planimetric map and the bridge data form are shown in Figure 47 to Figure 49, respectively.

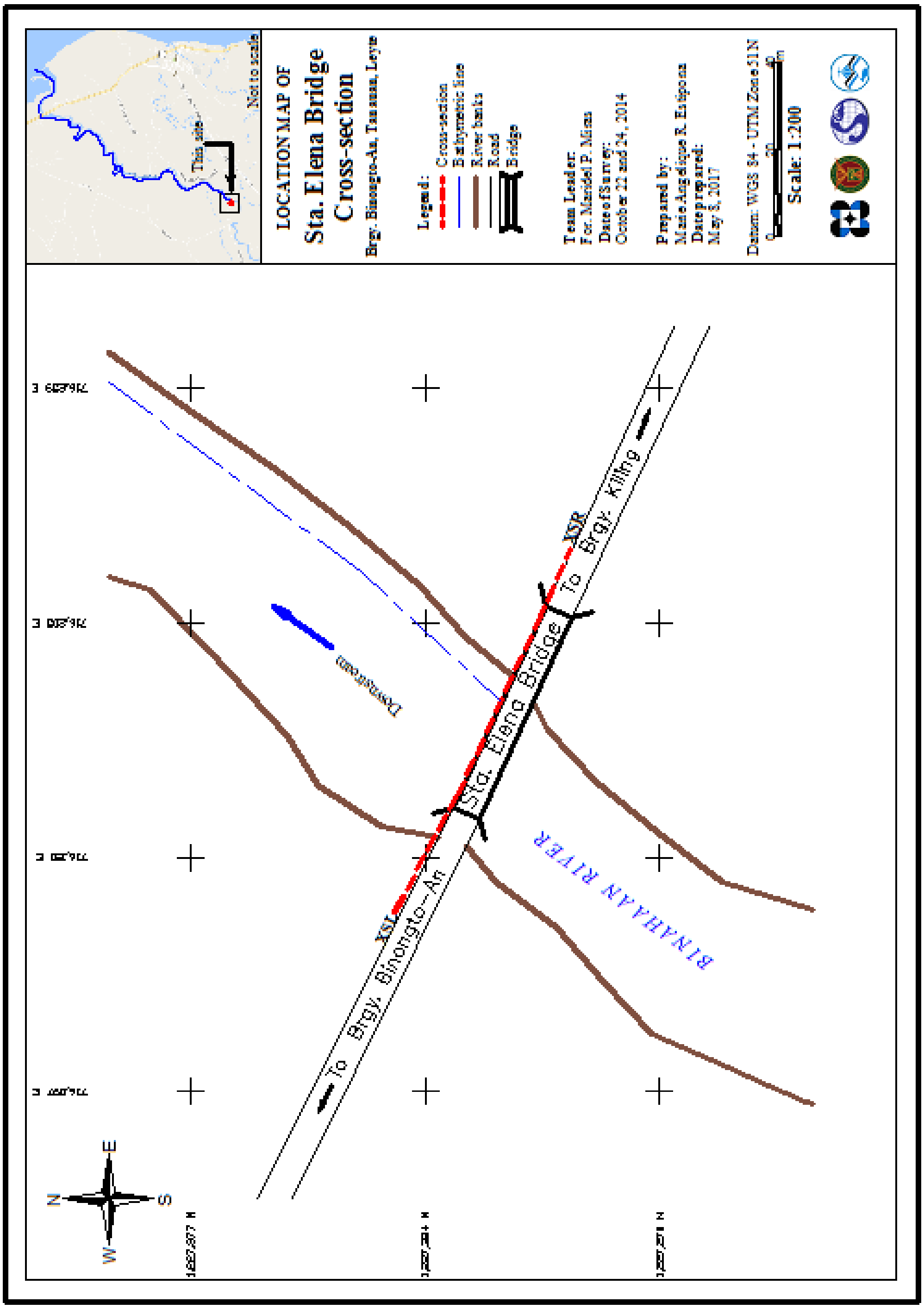


Figure 48 Sta. Elena Bridge, Binahaan River Basin Planimetric map

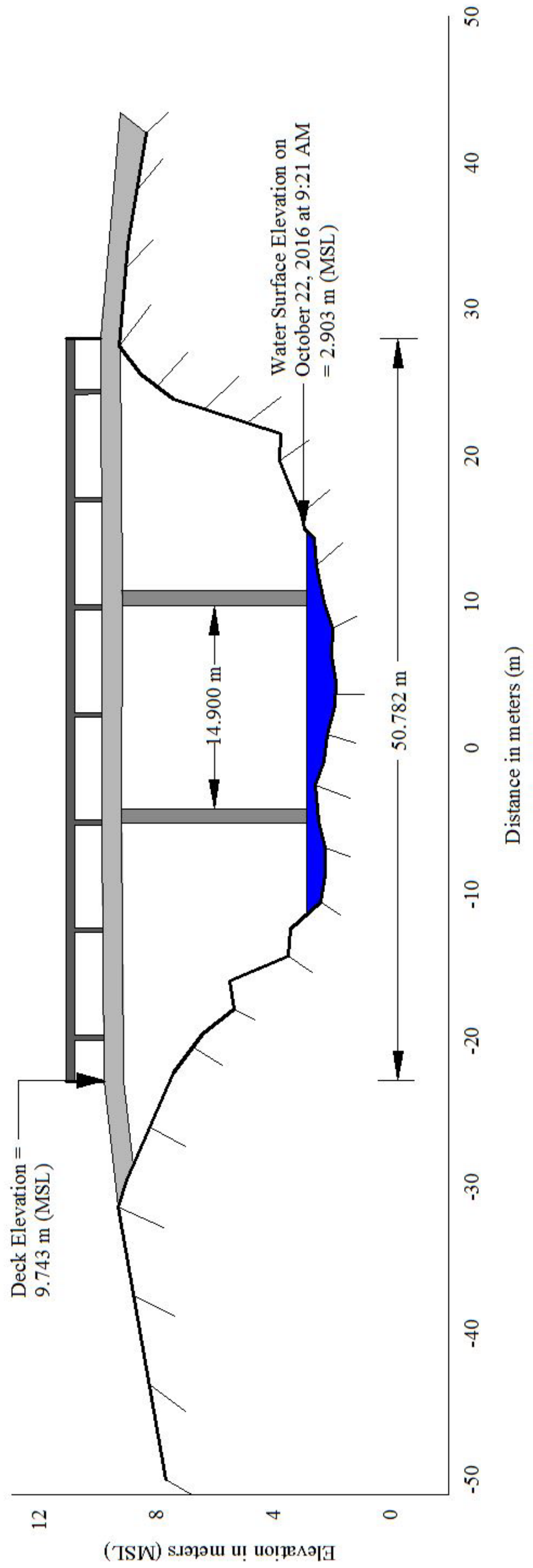
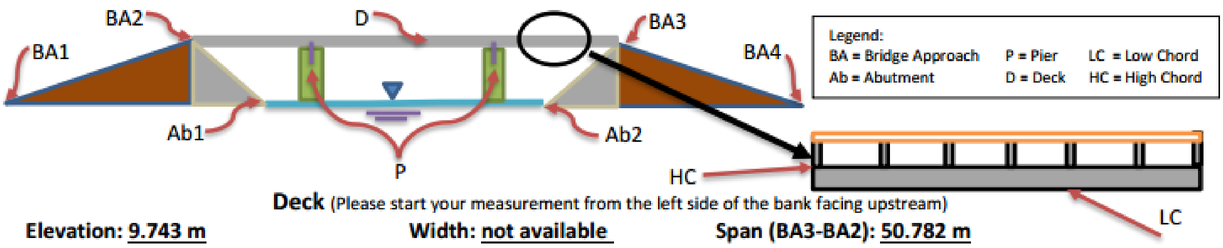


Figure 47. Sta. Elena Bridge cross-section diagram

Bridge Data Form

Bridge Name: Sta. Elena Bridge	**Date:** October 22 and 24, 2016
River Name: Binahaan River	**Time:** 9:21 PM
Location (Brgy, City,Region): Brgy. Binongto-An, Municipality of Tanauan, Leyte	
Survey Team: Maridel P. Miras, Marla Tricia Joy Morris, John Carlo Santos	
Flow condition: average	**Weather Condition:** fair
Latitude: 11˚05'46.17972" N	**Longitude:** 124˚58'43.59755" E



Deck (Please start your measurement from the left side of the bank facing upstream)

Elevation: 9.743 m **Width:** not available **Span (BA3-BA2):** 50.782 m

	Station	High Chord Elevation	Low Chord Elevation
1	Not available	Not available	Not available

Bridge Approach (Please start your measurement from the left side of the bank facing upstream)

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	9.258 m	BA3	59.449 m	9.862 m
BA2	8.667 m	9.743m	BA4	74.811 m	9.166 m

Abutment: Is the abutment sloping? ; If yes, fill in the following information:

	Station (Distance from BA1)	Elevation
Ab1	Not available	Not available
Ab2	Not available	Not available

Pier (Please start your measurement from the left side of the bank facing upstream)

Shape: round Number of Piers: 2 Height of column footing: Not available

	Station (Distance from BA1)	Elevation	Pier Diameter
Pier 1	26.722 m	9.811 m	1.5 m
Pier 2	41.623 m	9.803 m	1.5 m

NOTE: Use the center of the pier as reference to its station

Figure 49. Bridge as-built form of Sta. Elena Bridge

Water surface elevation of Binahaan River was determined by a survey grade GNSS receiver Trimble® SPS 882 in PPK survey technique on October 22, 2016 at 9:21 AM with a value of -2.903 m in MSL as shown in Figure 47. This was translated into marking on the bridge's deck using the same technique as shown in Figure 50. The marking will serve as reference for flow data gathering and depth gauge deployment of the partner HEI responsible for Pambujan River, the Visayas State University.

Figure 50. Water-level markings on Sta. Elena Bridge

4.6. Validation Points Acquisition Survey

Validation points acquisition survey was conducted on September 9 and October 23, 2016 using a survey-grade GNSS Rover receiver, Trimble® SPS 882, mounted at the side of a vehicle as shown in Figure 51. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height was 2.055 m and measured from the ground up to the bottom of notch of the GNSS Rover receiver. The PPK technique utilized for the conduct of the survey was set to continuous topo mode with BM-1 occupied as the GNSS base station in the conduct of the survey.

Figure 51. Validation points acquisition survey set up along Binahaan River Basin

The survey started in Brgy. Guindapunan, Municipality of Palo going west covering nine (9) barangays in Palo, seven (7) barangays in Municipality of Sta. Fe, and another seven (7) barangays in Municipality of Alangalang, and ended in Brgy. Mudboron, Alangalang. The survey gathered a total of 13,816 points with approximate length of 17 km using BM-1 as GNSS base station for the entire extent validation points acquisition survey as illustrated in the map in Figure 52.

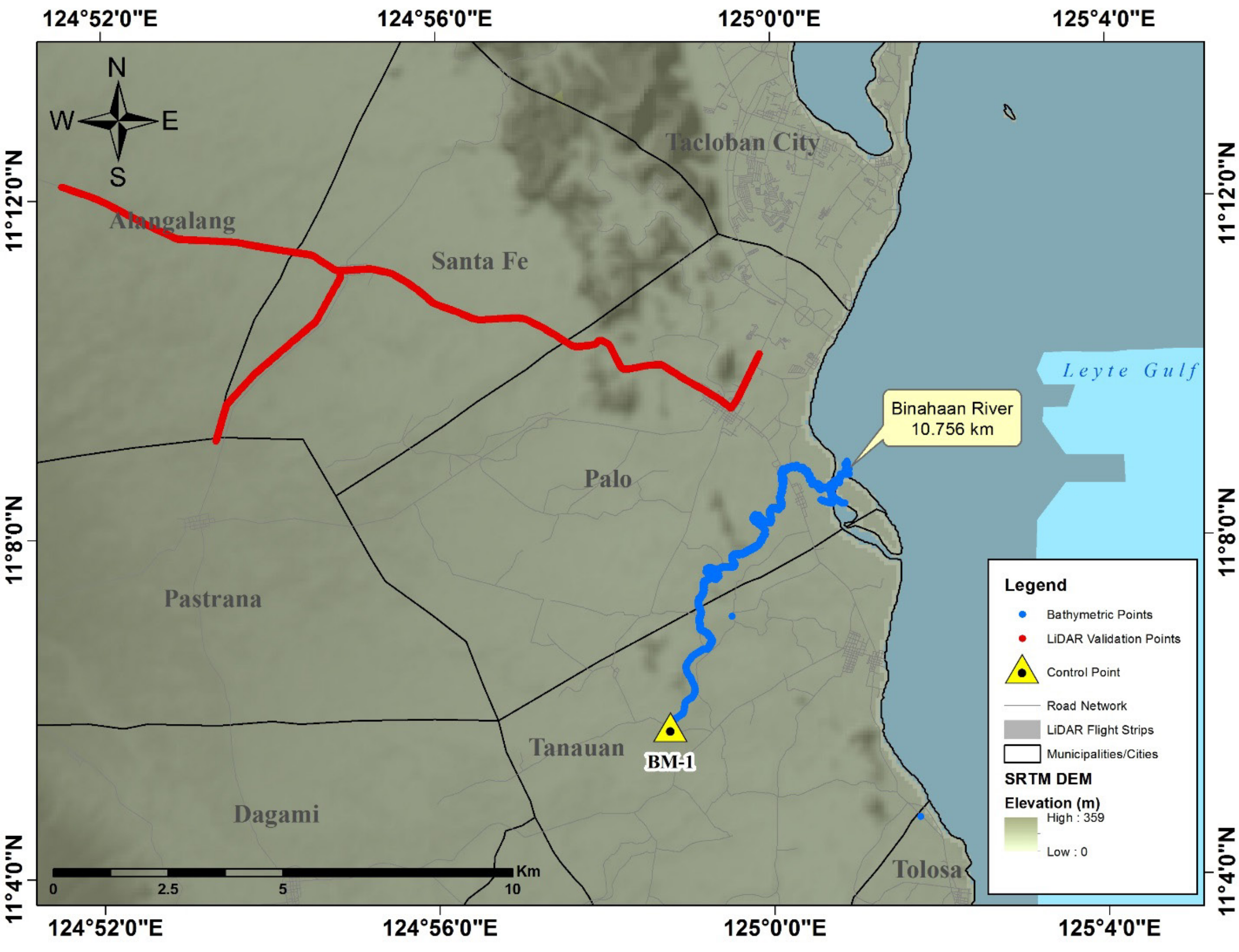


Figure 52. Validation point acquisition survey of Binahaan River basin

4.7 Bathymetric Survey

Bathymetric survey was executed on August 26-28, 2016 using Trimble® SPS 855 in GNSS RTK survey technique and October 22, 2016 using a Trimble® SPS 855 in GNSS PPK survey technique in continuous topo mode as illustrated in Figure 53. The survey started in Brgy. Binongto-An, Municipality of Tanaoan with coordinates 11°05’45.06575”N, 124°58’45.82598”E, and ended at the mouth of the river in Brgy. San Joaquin, Municipality of Palo, with coordinates 11°08’51.31966”N, 125°00’53.38193”E. The control points BM-1, CAM-VSU, LIM-VSU and SJQ-VSU were used as GNSS base stations all throughout the entire survey.

Figure 53. Bathymetric survey using a Trimble® SPS 855 in GNSS RTK survey technique in Binahaan River

The bathymetric survey for Binahaan River gathered a total of 14,212 points covering 10.756 km of the river traversing Barangays Cabarasan Guit and San Joaquin in Municipality of Palo; and barangays Balud, Binongto-An, Cabalagnan, Guindag-An, Kiling, and Sta. Elena, in Municipality of Tanauan. A CAD drawing was also produced to illustrate the riverbed profile of Binahaan River. As shown in Figure 55, the highest and lowest elevation has an 8-m difference. The highest elevation observed was 2.455 m above MSL located in Brgy. Binongto-An, Municipality of Palo; while the lowest was -6.120 m below MSL located in Brgy. San Joaquin, Municipality of Tanauan.

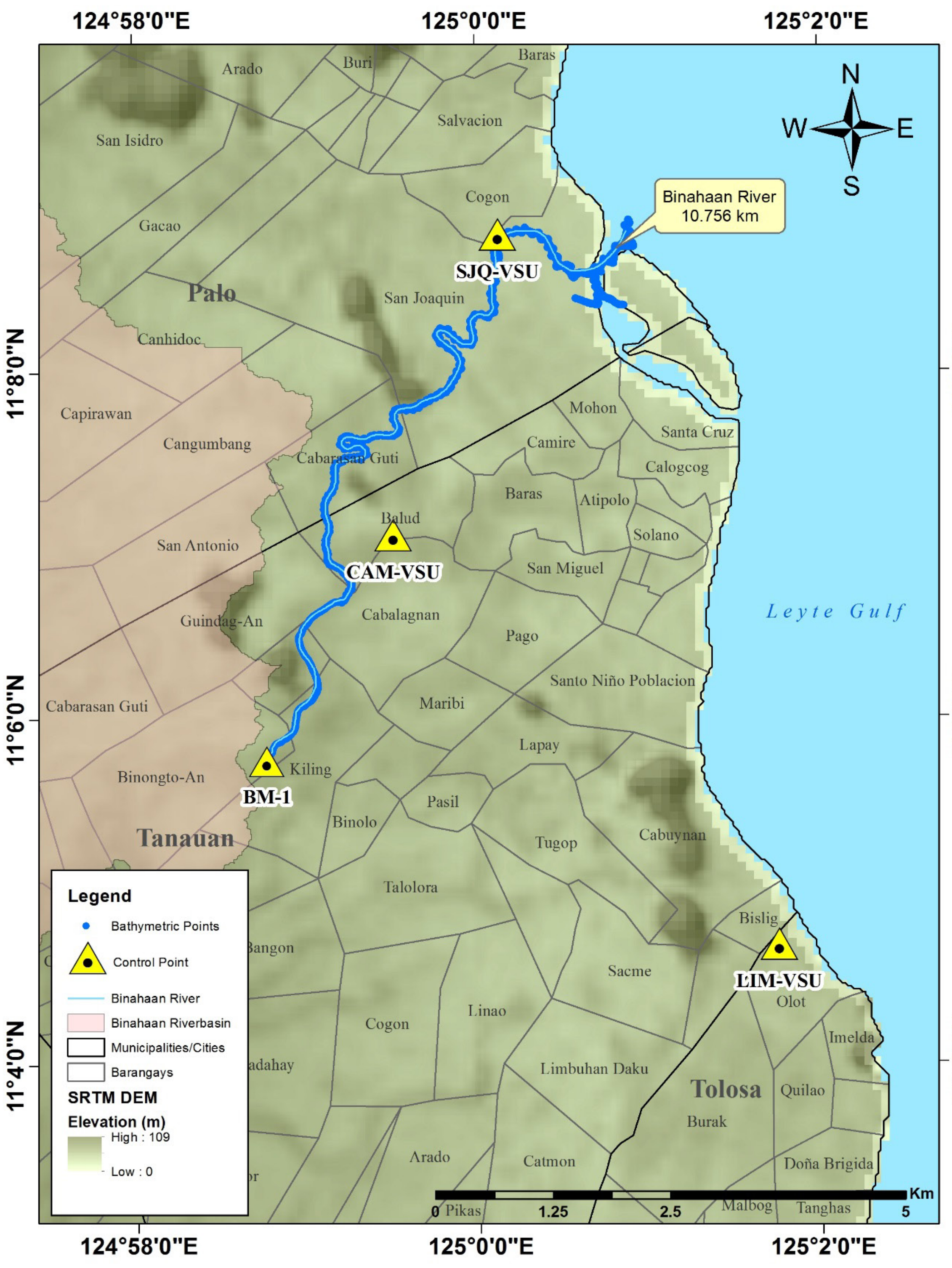


Figure 54. Bathymetric survey of Binahaan River

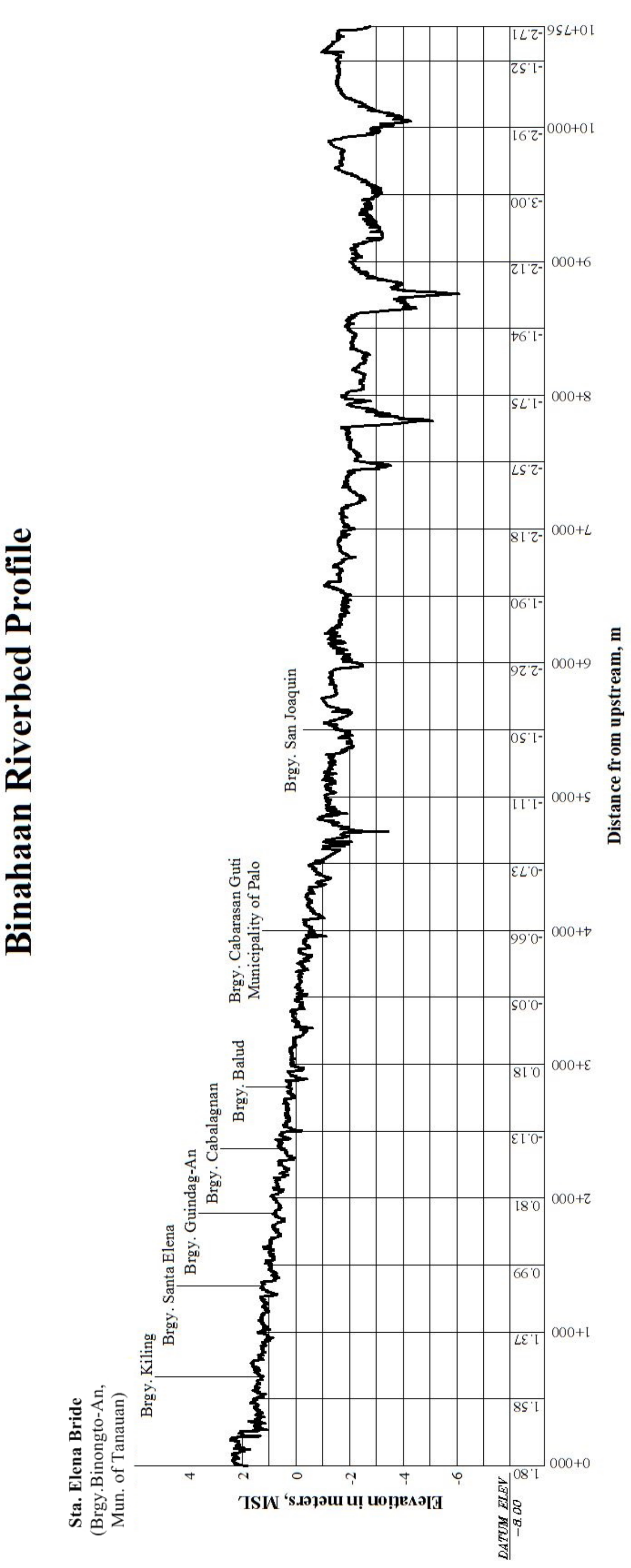


Figure 55. Binahaan Riverbed Profile

CHAPTER 5: RESULTS AND DISCUSSION FMC

Dr. Alfredo Mahar Lagmay, Christopher Uichanco, Sylvia Sueno, Marc Moises, Hale Ines, Miguel del Rosario, Kenneth Punay, and Neil Tingin

The methods applied in this Chapter were based on the DREAM methods manual (Balicanta, et al., 2014) and further enhanced and updated in Paringit, et al. (2017).

5.1 Data Used for Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

5.1.2 Precipitation

Precipitation data was taken from the four automatic rain gauges (ARGs) deployed by the VSU Flood Modeling Component (FMC) team. The ARGs were installed in Abaca, Cabingtan, Lourdes and Paraiso, Tanauan Leyte (Figure 60). The precipitation data collection started from December 16, 2016 at 18:00 to December 19, 2016 at 20:00 with 10 minutes recording interval.

The total precipitation in Abaca ARG was 81.1 mm. It has a peak rainfall of 12.4 mm on 18 December 2015 1:15 PM. The lag time between the peak rainfall and discharge is 22 hours and 5 minutes, as seen in Figure 61. For Cabingtan ARG, total rain for this event is 238.3 mm. Peak rainfall of 15 mm was recorded on 17 December 2015 1:00 AM. The lag time between the peak rainfall and discharge is 46 hours and 20 minutes. For Lourdes ARG, total rainfall for this event is 101.8 mm. Peak rainfall of 20.6 mm was recorded on 18 December 2015 1:15 PM. The lag time between the peak rainfall and discharge is 22 hours and 5 minutes. For Paraiso ARG, total rainfall for this event is 71 mm. Peak rainfall of 7.5 mm was recorded on 18 December 2015 4:15 AM. The lag time between the peak rainfall and discharge is 19 hours and 5 minutes.

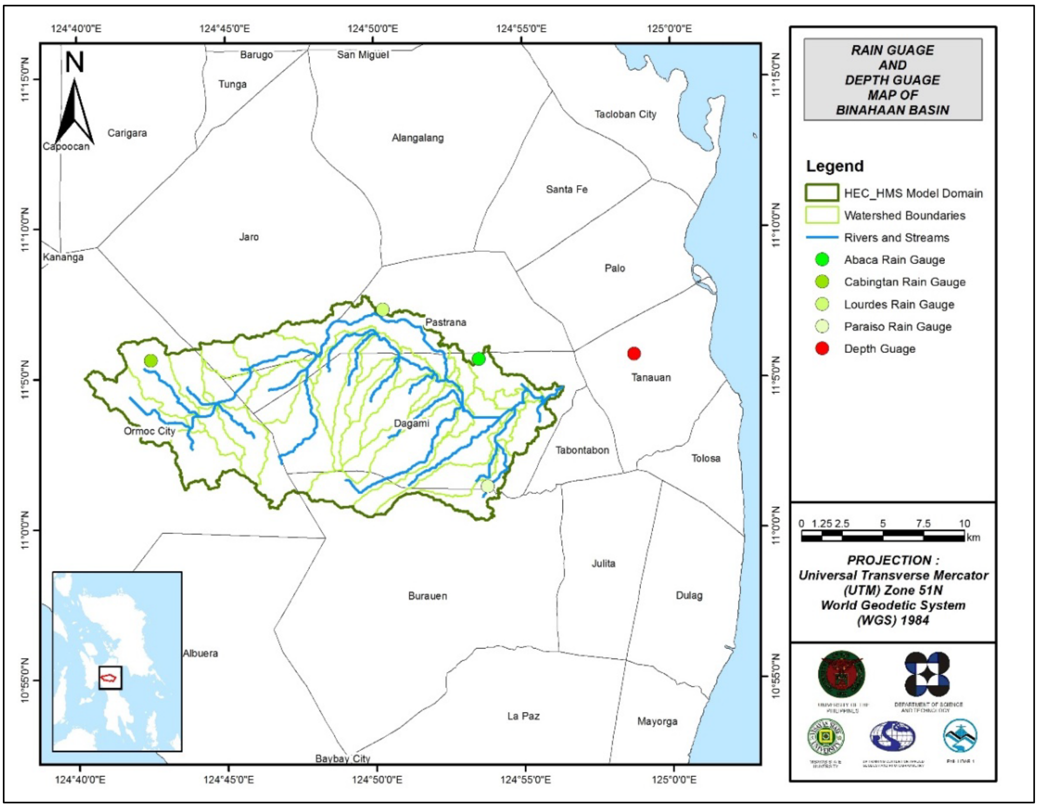


Figure 56. The location map of Binahaan HEC-HMS model used for calibration

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Sta. Elena Bridge, Tanauan, Leyte (11°5'45.42"N, 124°58'44.68"E). It gives the relationship between the observed water levels at Sta. Elena Bridge and outflow of the watershed at this location.

For Sta. Elena Bridge, the rating curve is expressed as Q = 8.5835H2 – 4.9298H – 37.983 as shown in Figure 58.

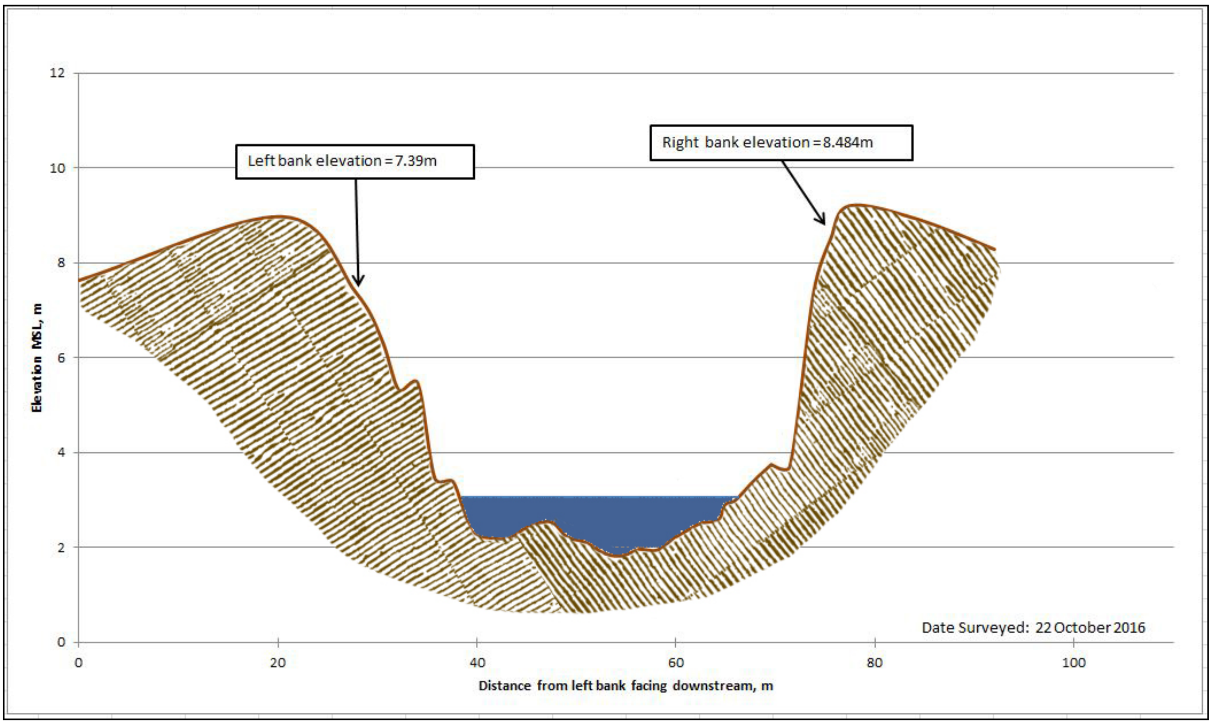


Figure 57. Cross-Section Plot of Sta. Elena Bridge

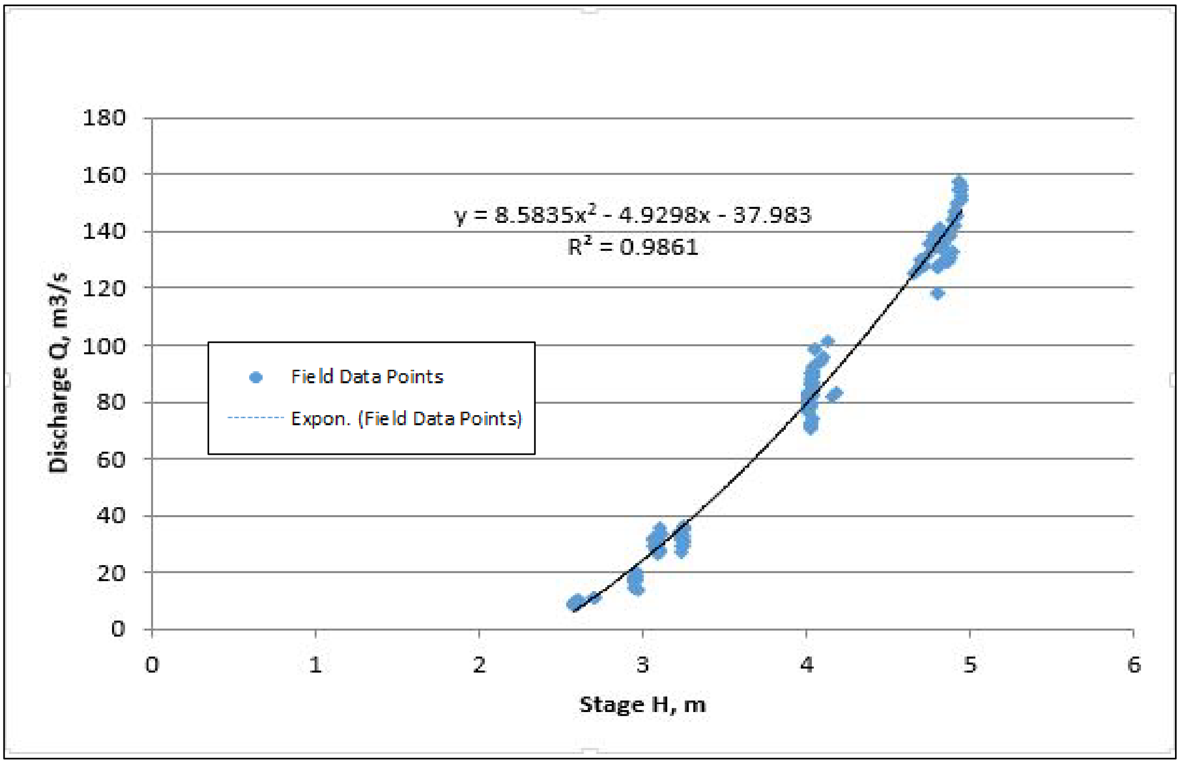


Figure 58. Rating Curve at Sta. Elena Bridge, Binahaan, Samar

This rating curve equation was used to compute the river outflow at Sta. Elena Bridge for the calibration of the HEC-HMS model.

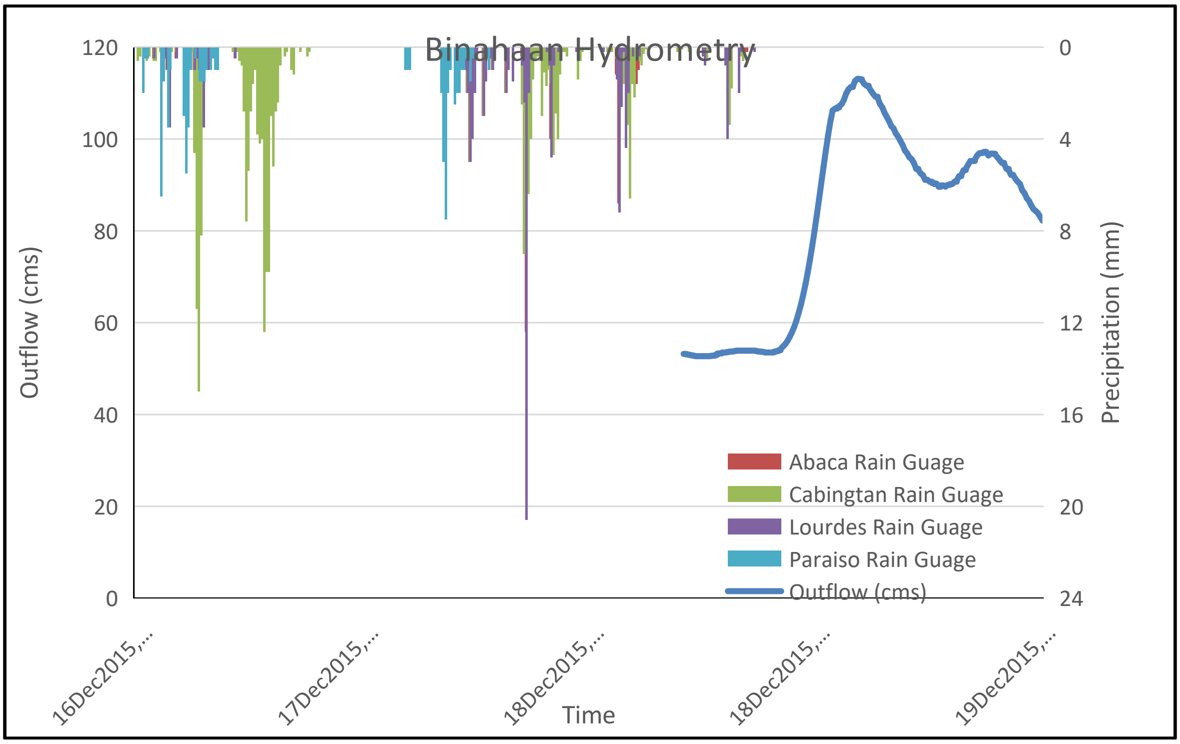


Figure 59. Rainfall and outflow data at Binahaan used for modeling

5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Tacloban Rain Gauge. The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and re-arranging the value in such a way certain peak value will be attained at a certain time. This station chosen based on its proximity to the Binahaan watershed. The extreme values for this watershed were computed based on a 59-year record.

Table 30. RIDF values for Tacloban Rain Gauge computed by PAGASA

T (yrs)	10 min	20 min	30 min	1 hr	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
2	17.8	26.9	33.6	42.8	59.7	70.5	87.2	104	120.6
5	24.3	36.7	45.7	57.4	80.7	95.2	117.9	140.6	161.4
10	28.5	43.2	53.7	67.1	94.6	111.5	138.2	164.9	188.4
15	30.9	46.8	58.3	72.5	102.5	120.7	149.6	178.6	203.7
20	32.6	49.4	61.4	76.3	108	127.1	157.7	188.1	214.3
25	33.9	51.4	63.9	79.3	112.2	132.1	163.8	195.5	222.6
50	37.9	57.5	71.4	88.3	125.2	147.4	182.9	218.2	247.9
100	41.8	63.5	78.9	97.3	138.2	162.5	201.8	240.8	273

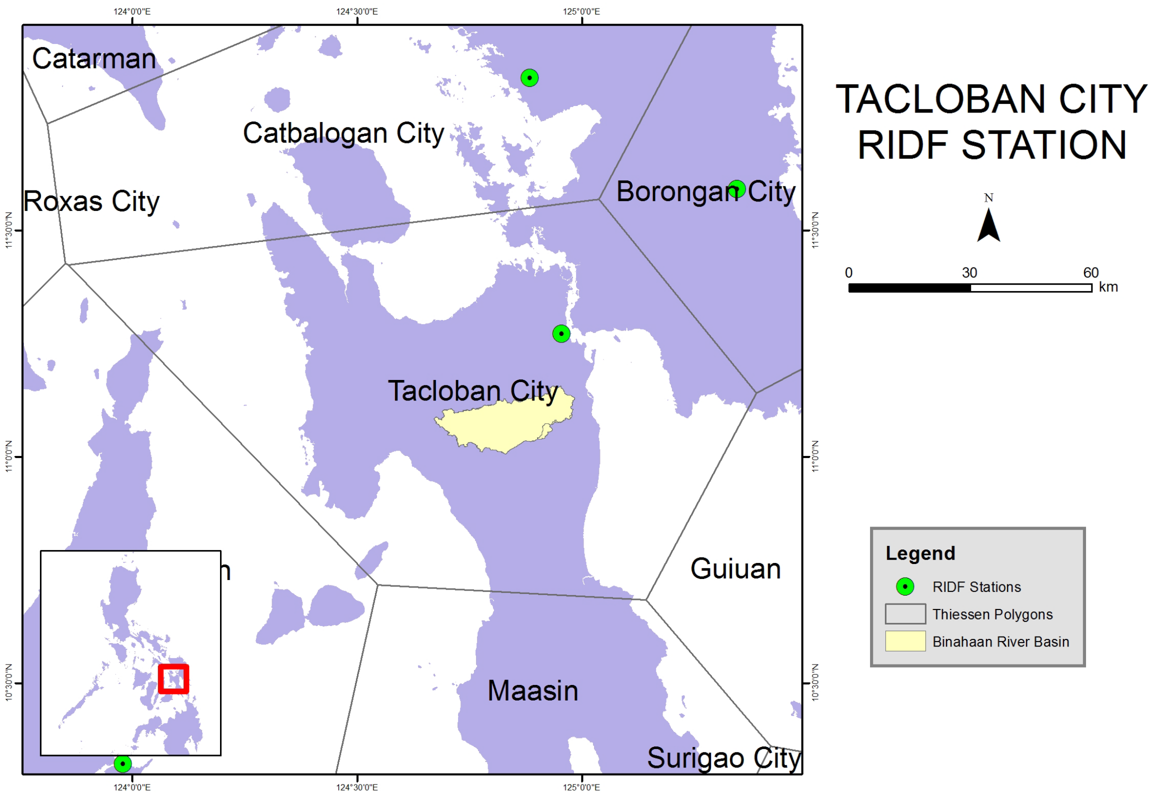


Figure 60. Location of Tacloban RIDF Station relative to Binahaan River Basin

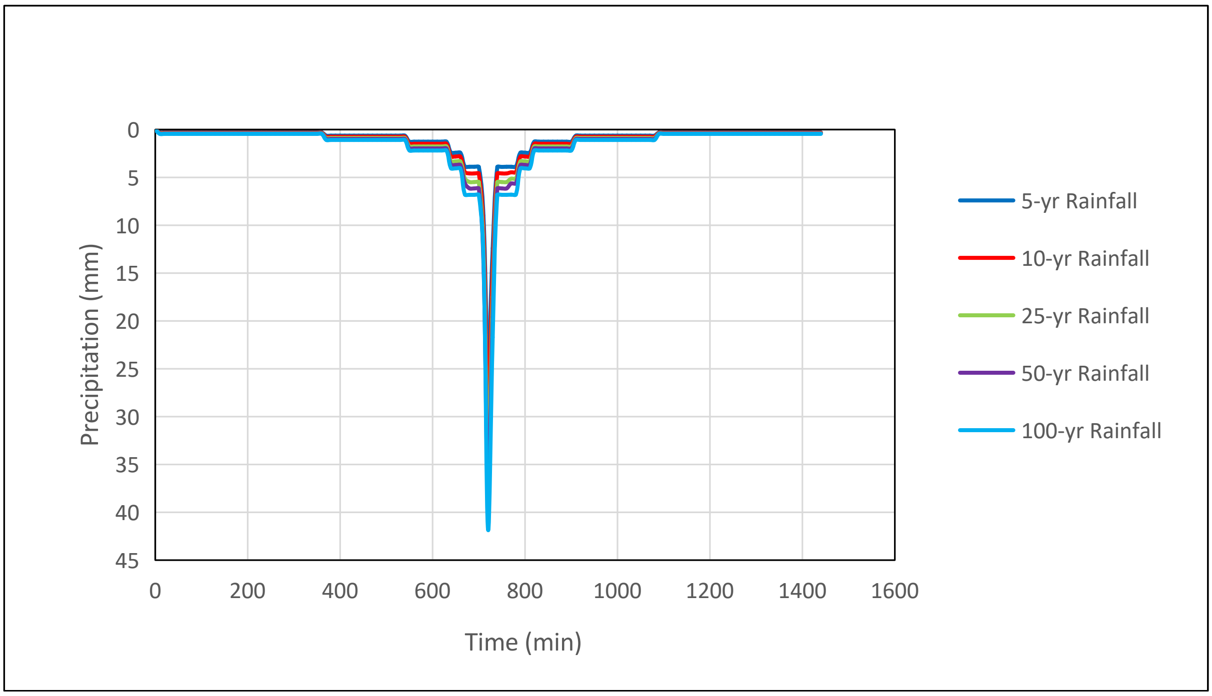


Figure 61. Synthetic storm generated for a 24-hr period rainfall for various return periods

5.3 HMS Model

The soil shapefile was taken on 2004 from the Bureau of Soils; this is under the Department of Environment and Natural Resources Management. The land cover shape file is from the National Mapping and Resource Information Authority (NAMRIA). The soil and land cover of the Binahaan River Basin are shown in Figures 62 and 63, respectively.

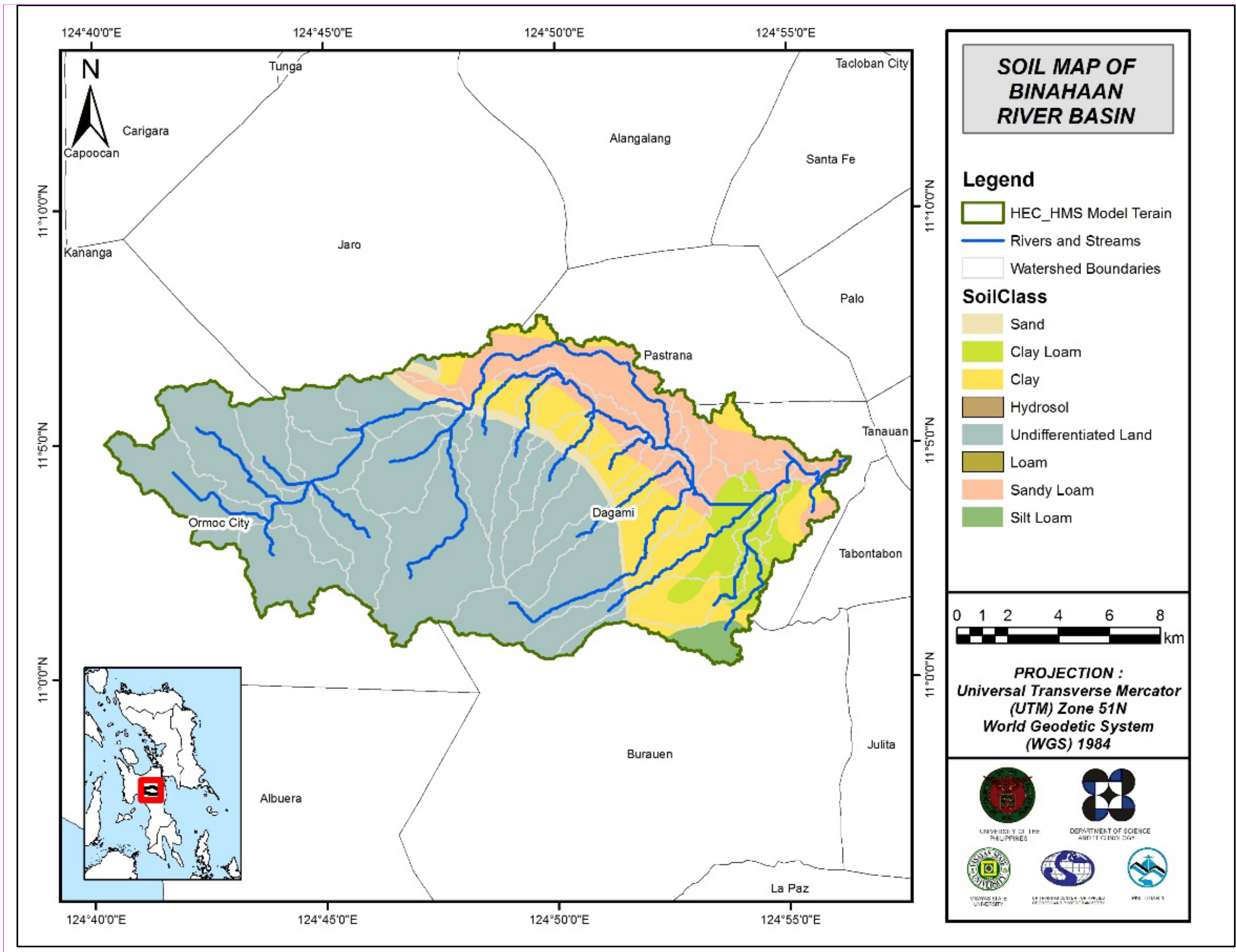


Figure 62. Soil Map of Binahaan River Basin

The land cover data was generated in 2003 from the National Mapping and Resource information Authority (NAMRIA), DENR. Figure 63 shows the Land Cover inside Binahaan River Basin. The land cover map of Binahaan River Basin was used as another factor for the estimation of the CN and watershed lag parameters of the rainfall-runoff model.

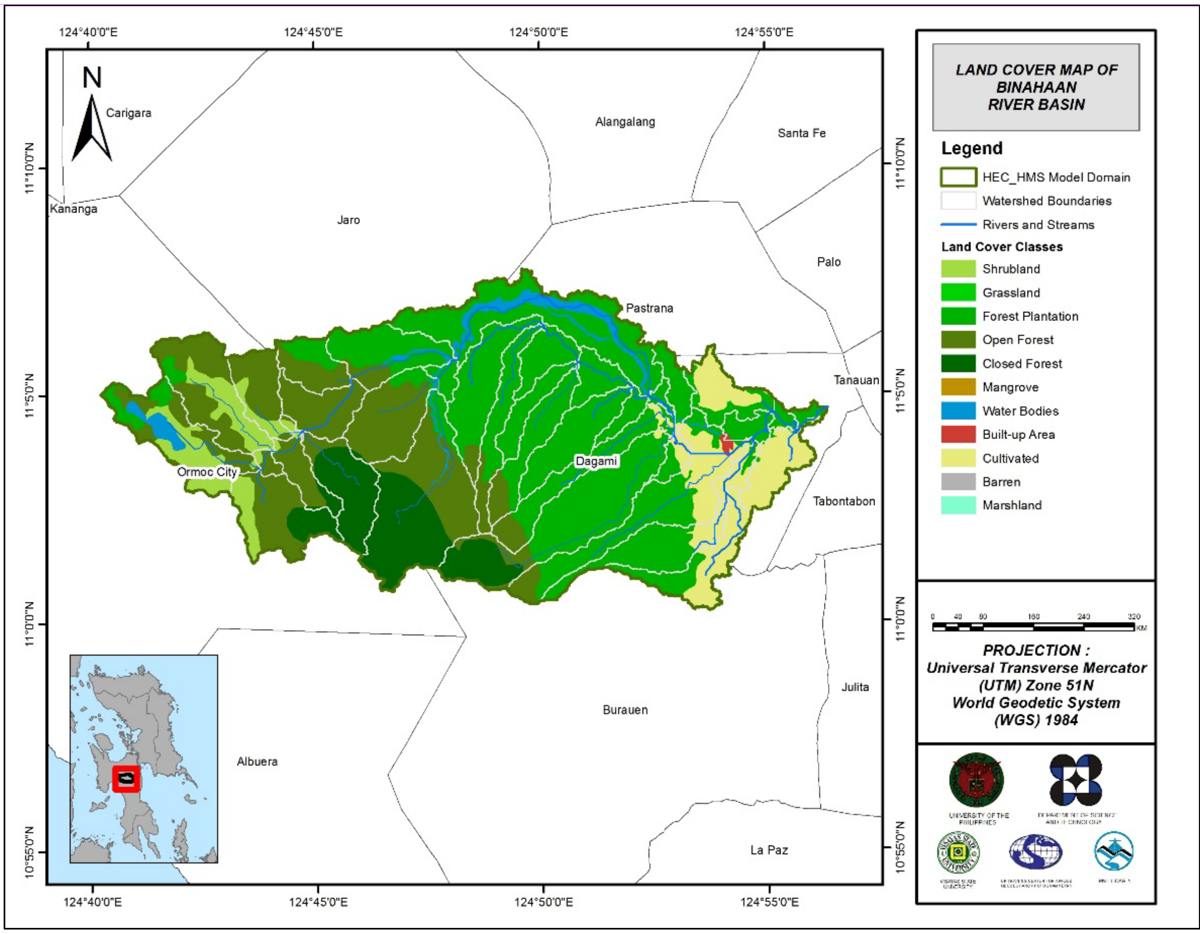


Figure 63. Land Cover Map of Binahaan River Basin

For Binahaan, the soil class identified were sand, clay loam, clay, undifferentiated land, sandy loam, and silt loam. The land cover types identified were shrubland, grassland, forest plantation, open forest, closed forest, and cultivated.

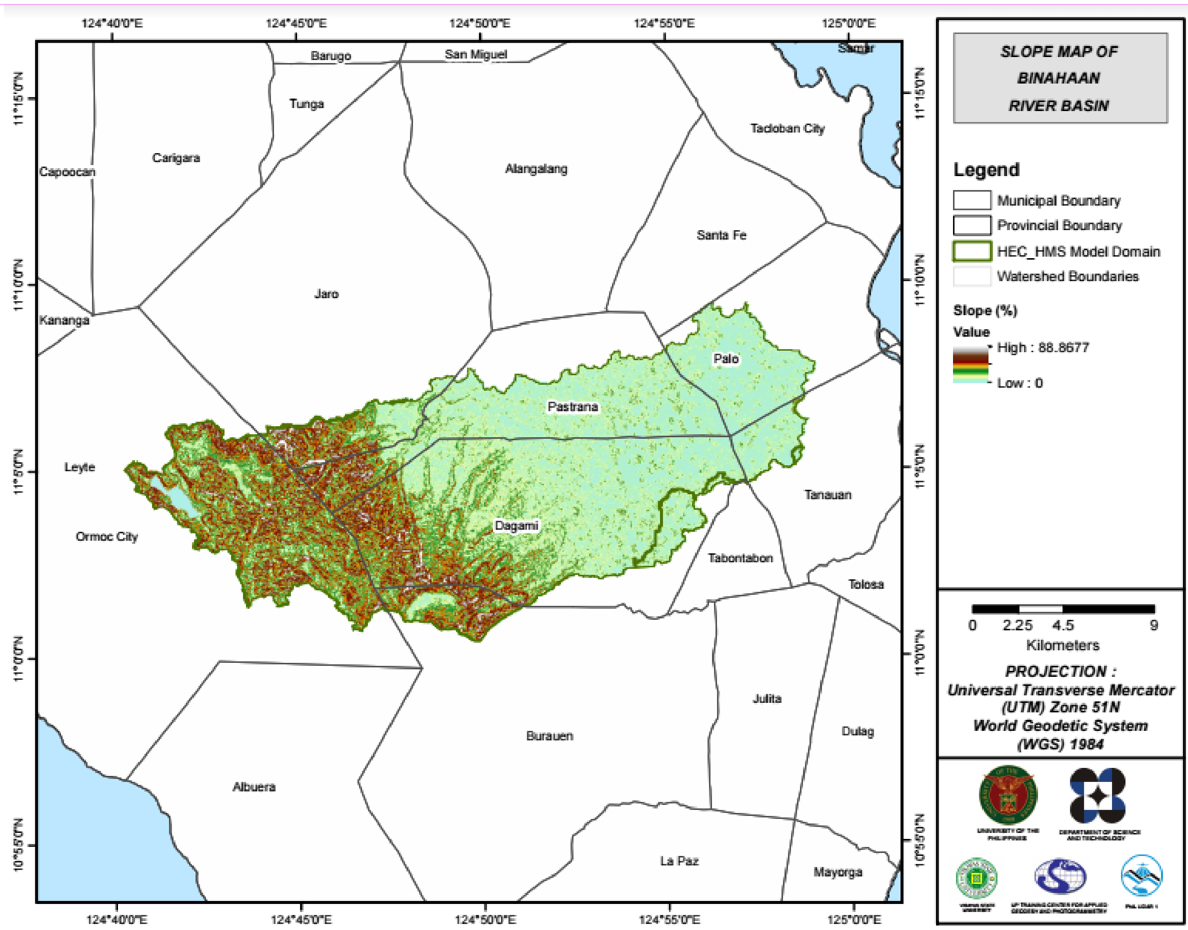


Figure 64. Slope Map of Binahaan River Basin

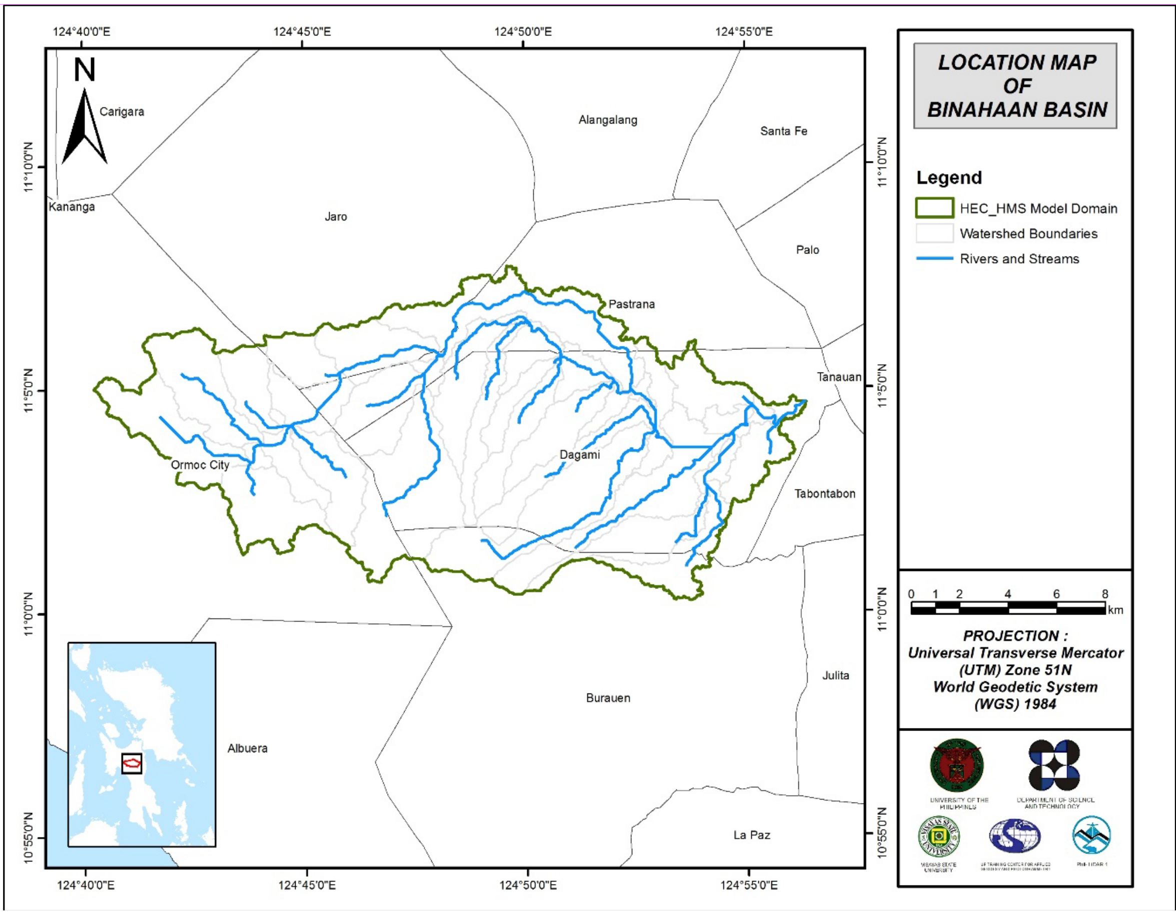


Figure 65. Stream Delineation Map of Binahaan River Basin

Using the SAR-based DEM, the Binahaan basin was delineated and further subdivided into subbasins. The model consists of 39 sub basins, 19 reaches, and 19 junctions. The main outlet is Sta. Elena Bridge. This basin model is illustrated in Figure 66.

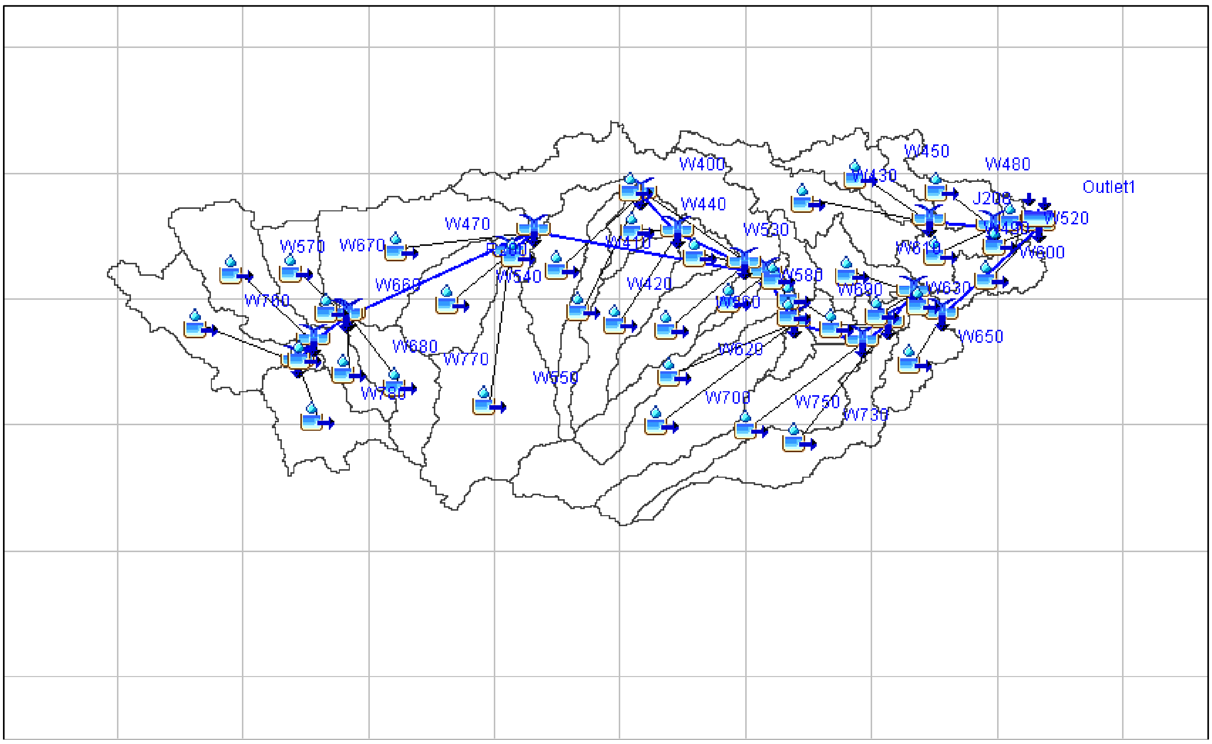


Figure 66. The Binahaan river basin model generated using HEC-HMS

5.4 Cross-section Data

Riverbed cross-sections of the watershed are crucial in the HEC-RAS model setup. The cross-section data for the HEC-RAS model was derived using the LiDAR DEM data. It was defined using the Arc GeoRAS tool and was post-processed in ArcGIS.

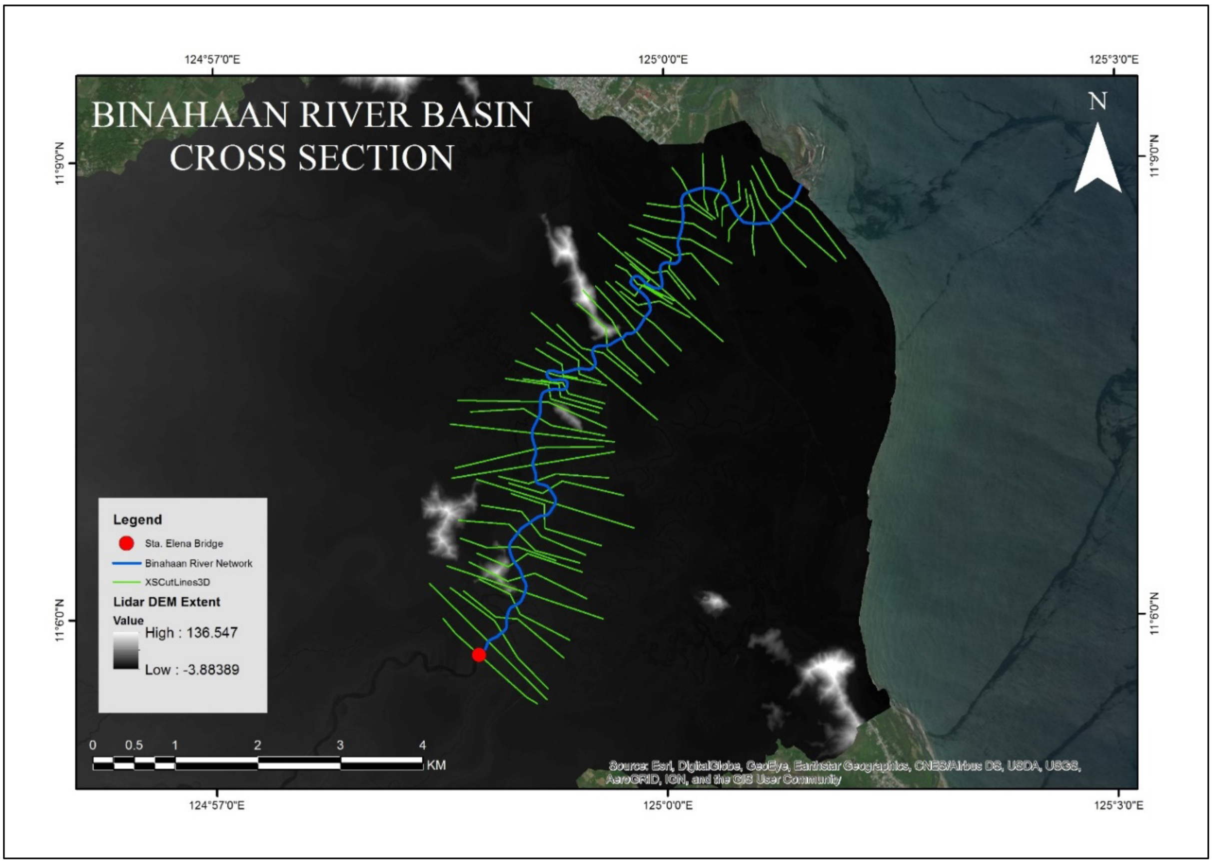


Figure 67. River cross-section of Binahaan River generated through Arcmap HEC GeoRAS tool

5.5 Flo 2D Model

The automated modelling process allows for the creation of a model with boundaries that are almost exactly coincidental with that of the catchment area. As such, they have approximately the same land area and location. The entire area is divided into square grid elements, 10 meter by 10 meter in size. Each element is assigned a unique grid element number which serves as its identifier, then attributed with the parameters required for modelling such as x-and y-coordinate of centroid, names of adjacent grid elements, Manning coefficient of roughness, infiltration, and elevation value. The elements are arranged spatially to form the model, allowing the software to simulate the flow of water across the grid elements and in eight directions (north, south, east, west, northeast, northwest, southeast, southwest).

Based on the elevation and flow direction, it is seen that the water will generally flow from the west of the model to the east, following the main channel. As such, boundary elements in those particular regions of the model are assigned as inflow and outflow elements respectively.

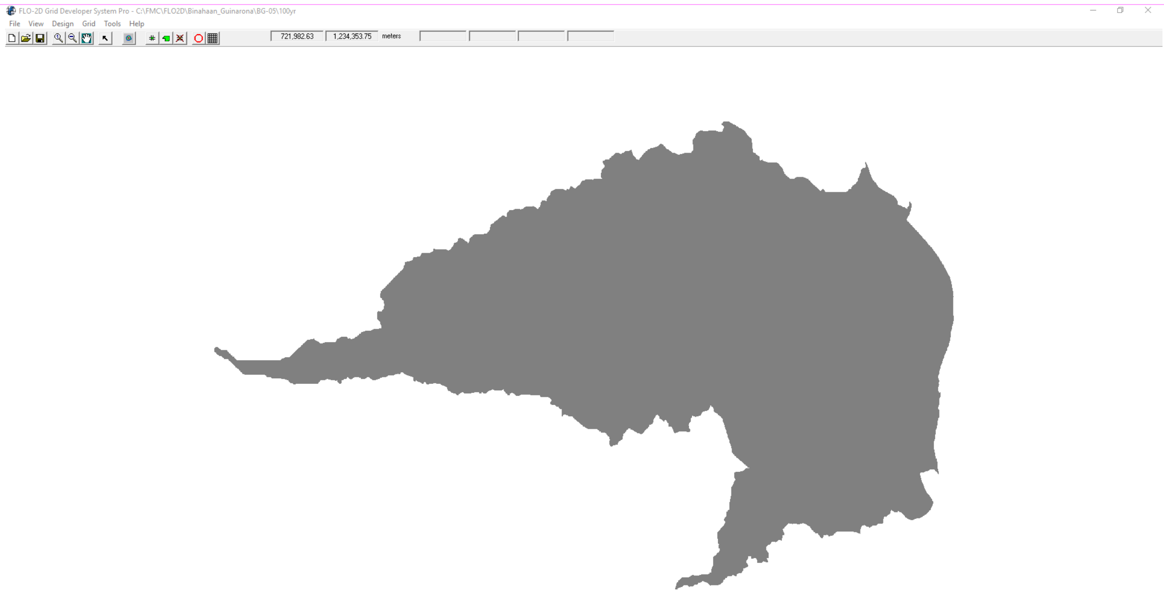


Figure 68. Screenshot of subcatchment with the computational area to be modeled in FLO-2D GDS Pro

he simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 54.51257 hours. After the simulation, FLO-2D Mapper Pro is used to transform the simulation results into spatial data that shows flood hazard levels, as well as the extent and inundation of the flood. Assigning the appropriate flood depth and velocity values for Low, Medium, and High creates the following food hazard map. Most of the default values given by FLO-2D Mapper Pro are used, except for those in the Low hazard level. For this particular level, the minimum h (Maximum depth) is set at 0.2 m while the minimum vh (Product of maximum velocity (v) times maximum depth (h)) is set at 0 m^2/s.

The creation of a flood hazard map from the model also automatically creates a flow depth map depicting the maximum amount of inundation for every grid element. The legend used by default in Flo-2D Mapper is not a good representation of the range of flood inundation values, so a different legend is used for the layout. In this particular model, the inundated parts cover a maximum land area of 77 535 744.00 m^2.

There is a total of 37 293 755.25 m^3 of water entering the model. Of this amount, 20 278 785.44 m^3 is due to rainfall while 17 014 969.81 m^3 is inflow from other areas outside the model. 11 670 205.00 m^3 of this water is lost to infiltration and interception, while 24 880 022.57 m^3 is stored by the flood plain. The rest, amounting up to 743 534.13 m^3, is outflow.

5.6 Results of HMS Calibration

After calibrating the Binahaan HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 69 shows the comparison between the two discharge data.

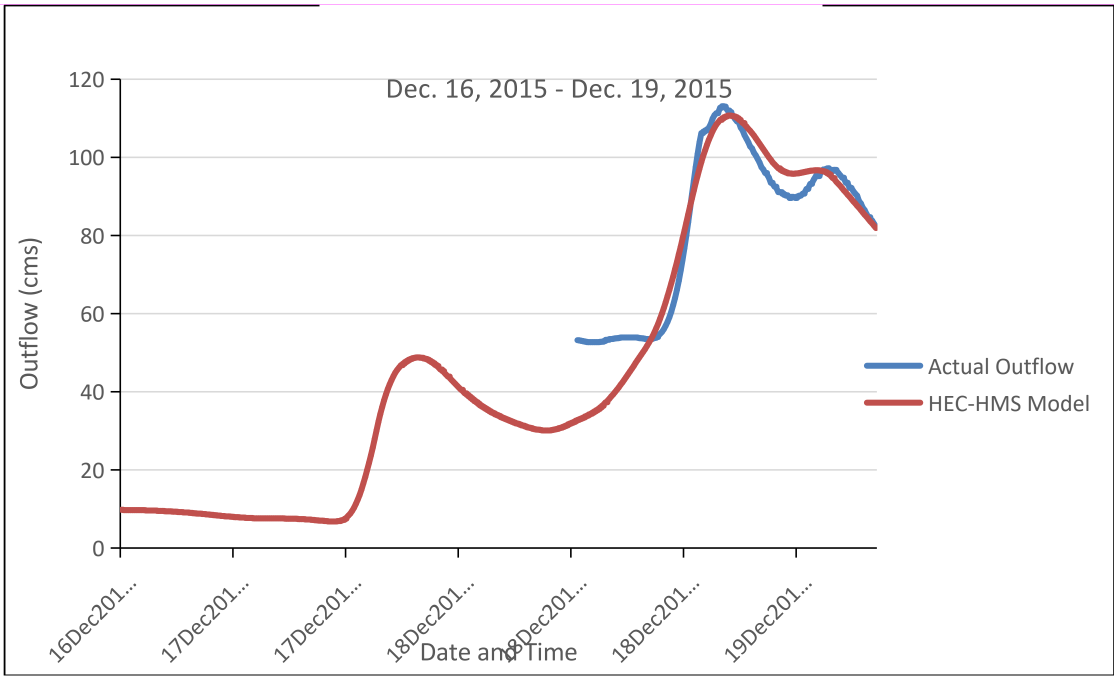


Figure 69. Outflow Hydrograph of Binahaan produced by the HEC-HMS model compared with observed outflow

Enumerated in Table 31 are the adjusted ranges of values of the parameters used in calibrating the model.

Table 31. Range of Calibrated Values for Binahaan

Basin/Reach Characteristic	Method	Parameter	Range of Calibrated Values
Loss	SCS Curve number	Initial Abstraction (mm)	17 - 82
		Curve Number	38-74
Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.7-11
		Storage Coefficient (hr)	1 -18
Baseflow	Recession	Recession Constant	0.4
		Ratio to Peak	0.65
Routing	Muskingum-Cunge	Slope	0.0001-0.2
		Manning's n	0.04

Initial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as initial abstraction decreases. The range of values from 17mm to 82mm means that there is average amount of infiltration or rainfall interception by vegetation.

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range of 38 to 74 for curve number is lower than the advisable curve number for Philippine watersheds depending on the soil and land cover of the area.

Time of concentration and storage coefficient are the travel time and index of temporary storage of runoff in a watershed. The range of calibrated values from 0.7 hours to 18 hours determines the reaction time of the model with respect to the rainfall. The peak magnitude of the hydrograph also decreases when these parameters are increased.

Recession constant is the rate at which baseflow recedes between storm events and ratio to peak is the ratio of the baseflow discharge to the peak discharge. Recession constant of 0.4 indicates that the basin is likely to quickly go back to its original discharge and instead, will be higher. Ratio to peak of 0.65 indicates a milder receding limb of the outflow hydrograph.

Manning's roughness coefficient of 0.04 corresponds to the common roughness Binahaan watershed, which is determined to be cultivated with mature field crops (Brunner, 2010).

Table 32. Summary of the Efficiency Test of Binahaan HMS Model

RMSE	4.9
r2	0.99
NSE	0.87
PBIAS	2.48
RSR	0.37

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 4.9 (m^3/s).

The Pearson correlation coefficient (r^2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.99.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.87.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is 2.48.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.37.

5.7 Calculated outflow hydrographs and discharge values for different rainfall return periods

5.7.1 Hydrograph using the Rainfall Runoff Mode

The summary graph (Figure 12) shows the Binahaan outflow using the Tacloban Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAG-ASA) data. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

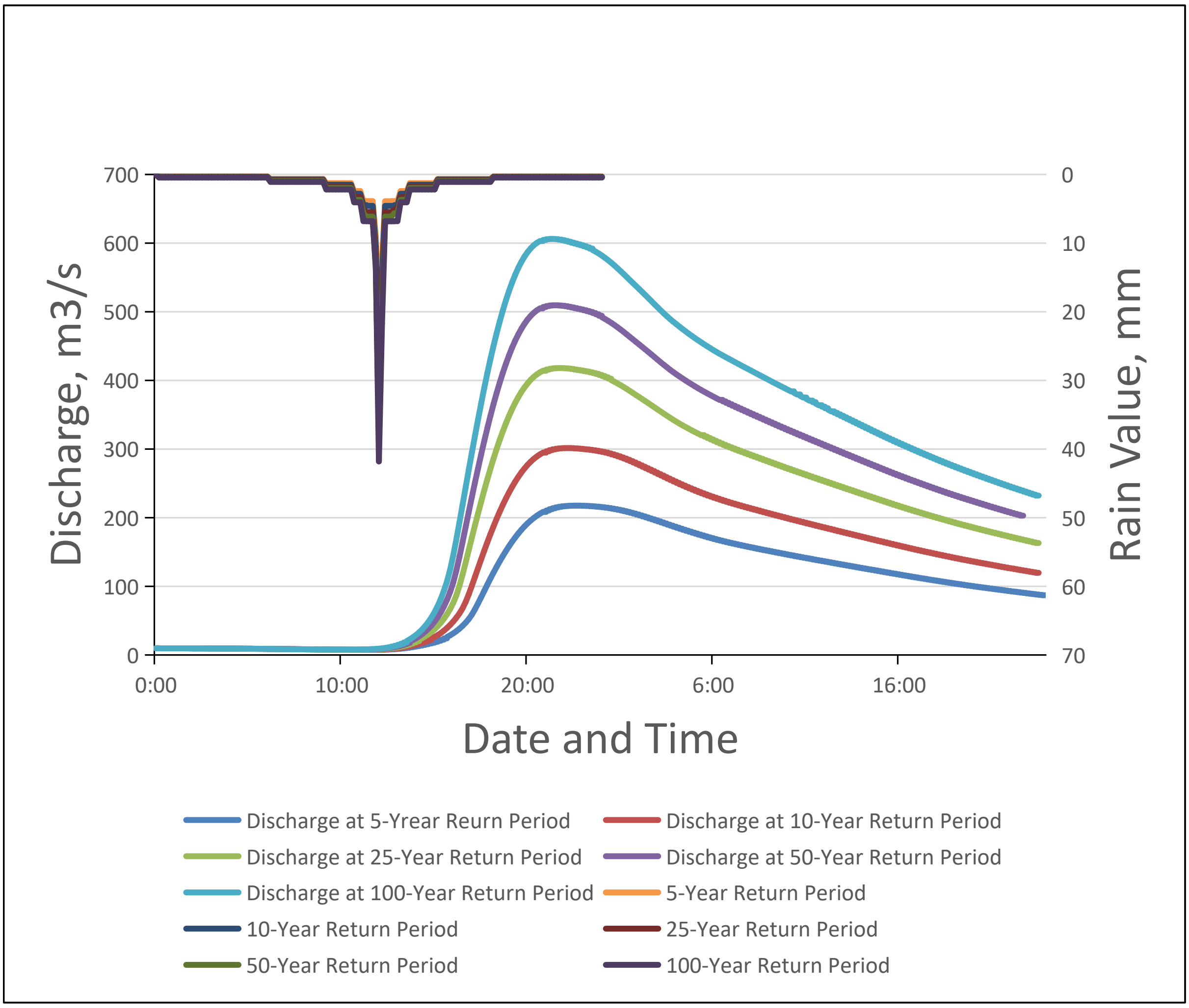


Figure 70. Outflow hydrograph at Binahaan Station generated using Tacloban RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Binahaan discharge using the Tacloban Rainfall Intensity-duration-Frequency curves (RIDF) in five different return periods is shown in Table 33.

Table 33. Peak values of the Binahaan HEC-HMS Model outflow using the Tacloban RIDF

RIDF Period	Total Precipitation (mm)	Peak Rainfall (mm)	Peak Outflow (m^3/s)	Time to Peak
5-Year	161.4	24.3	217.6	22 hours,30 minutes
10-Year	188.4	28.5	301.4	22 hours, 10 minutes
25-Year	222.6	33.9	418.0	21 hours, 40 minutes
50-Year	247.9	37.9	509.4	20 hours, 20 minutes
100-Year	273.0	41.8	606.1	20 hours, 10 minutes

5.8 River Analysis (RAS) Model Simulation

The HEC-RAS Flood Model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. For this publication, only a sample output map river was to be shown, since only the DVC base flow was calibrated. The sample generated map of Binahaan River using the calibrated HMS base flow is shown in Figure 71.

Figure 71. Sample output of Binahaan RAS Model

5.9 Flood Hazard and Flow Depth

The resulting hazard and flow depth maps have a 10m resolution. Figure 72 to Figure 77 shows the 5-, 25-, and 100-year rain return scenarios of the Binahaan floodplain.

[insert Municipalities affected in Binahaan floodplain]

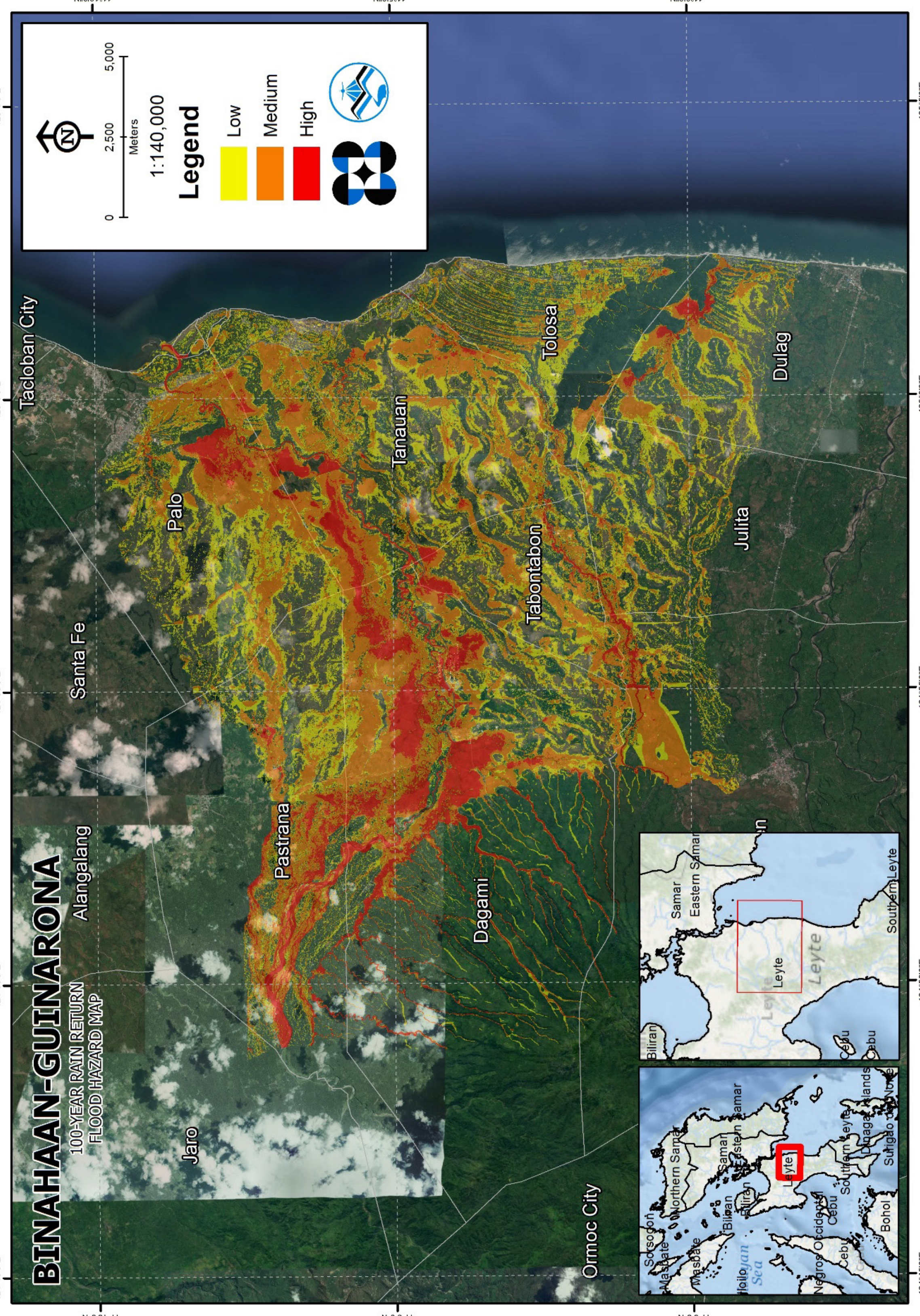


Figure 72. 100-year Rain Return Flood Hazard Map for Binahaan-Guinarona Floodplain

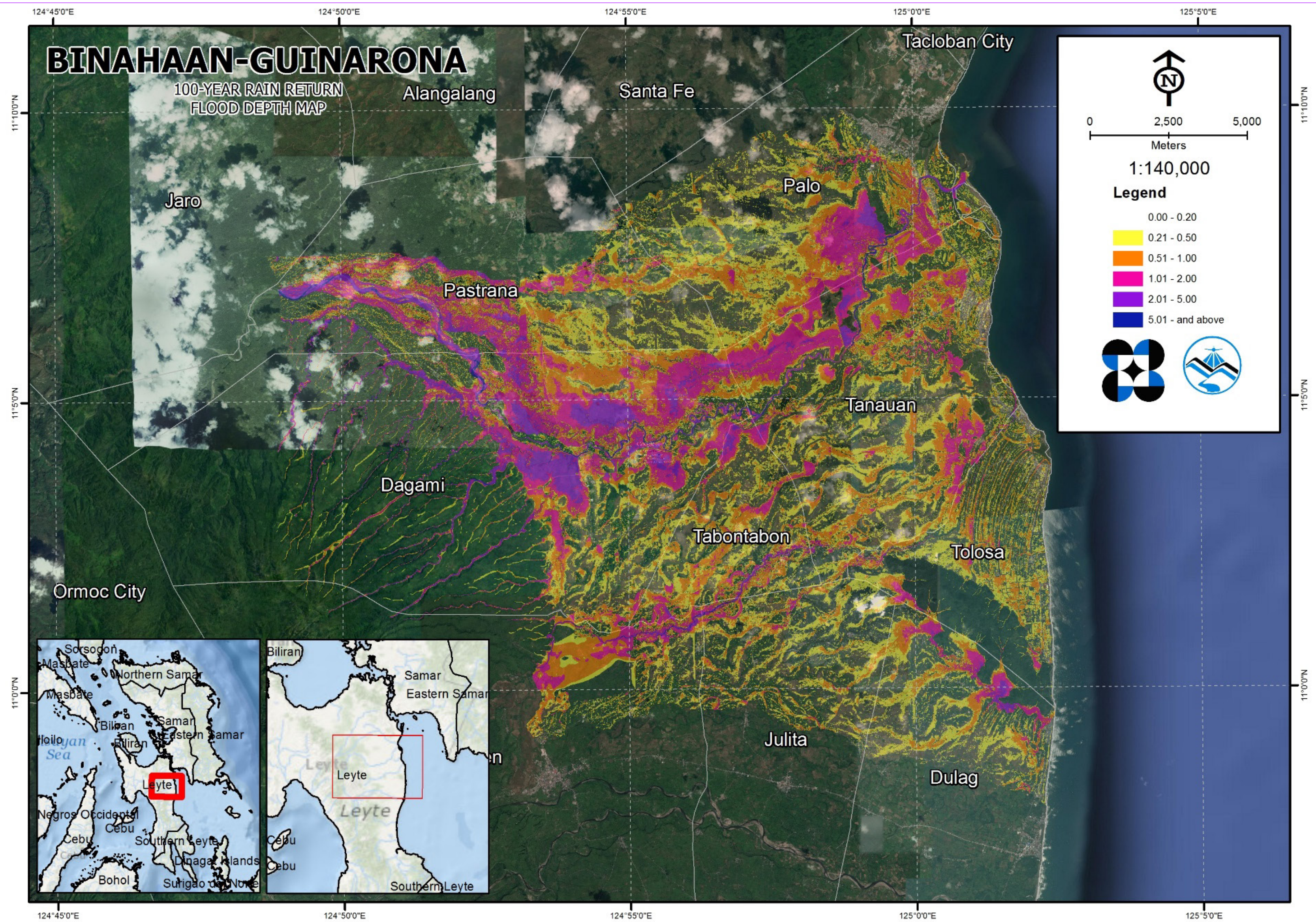


Figure 73. 100-year Rain Return Flood Depth Map for Binahaan-Guinarona Floodplain

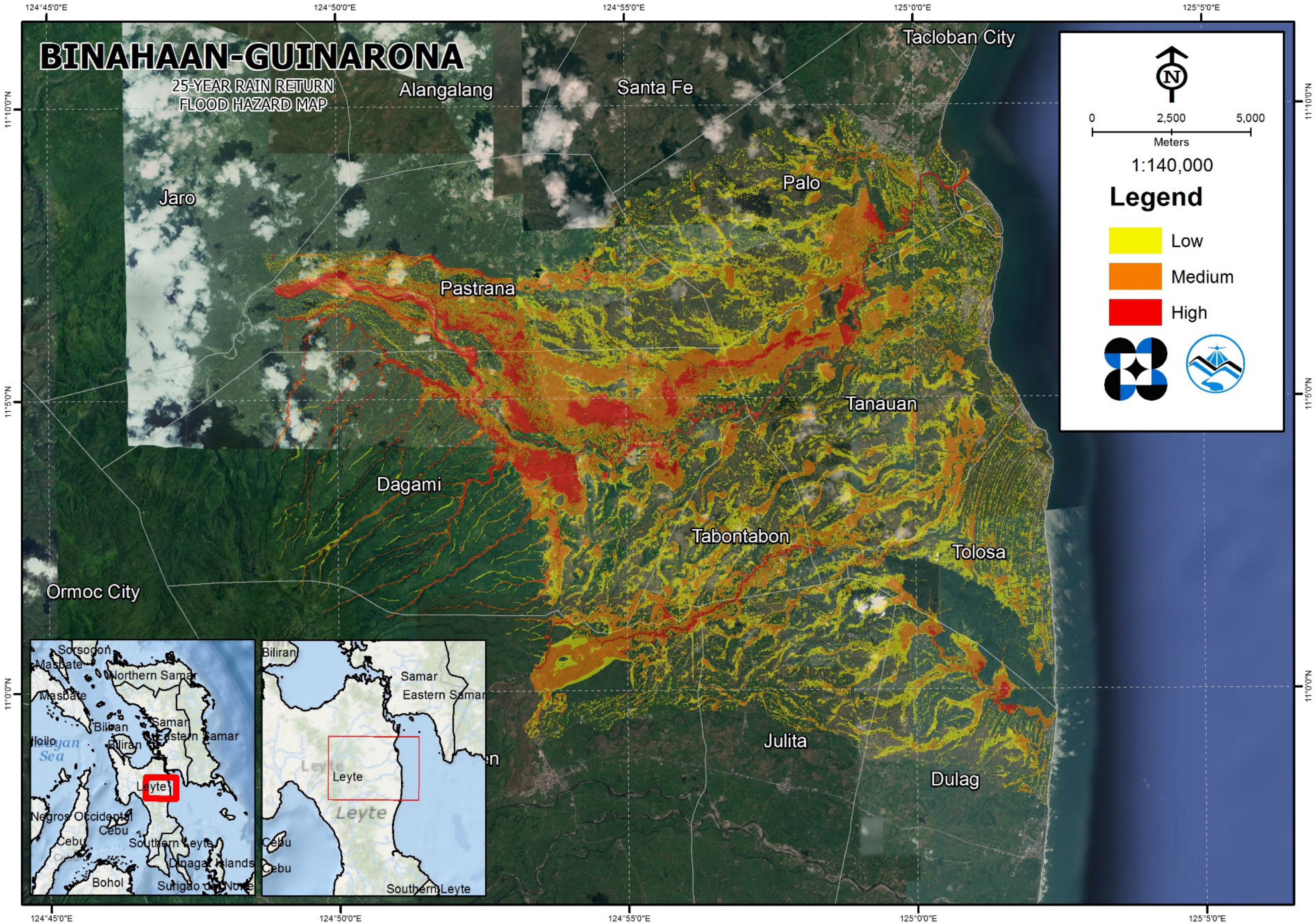


Figure 74. 25-year Rain Return Flood Hazard Map for Binahaan-Guinarona Floodplain

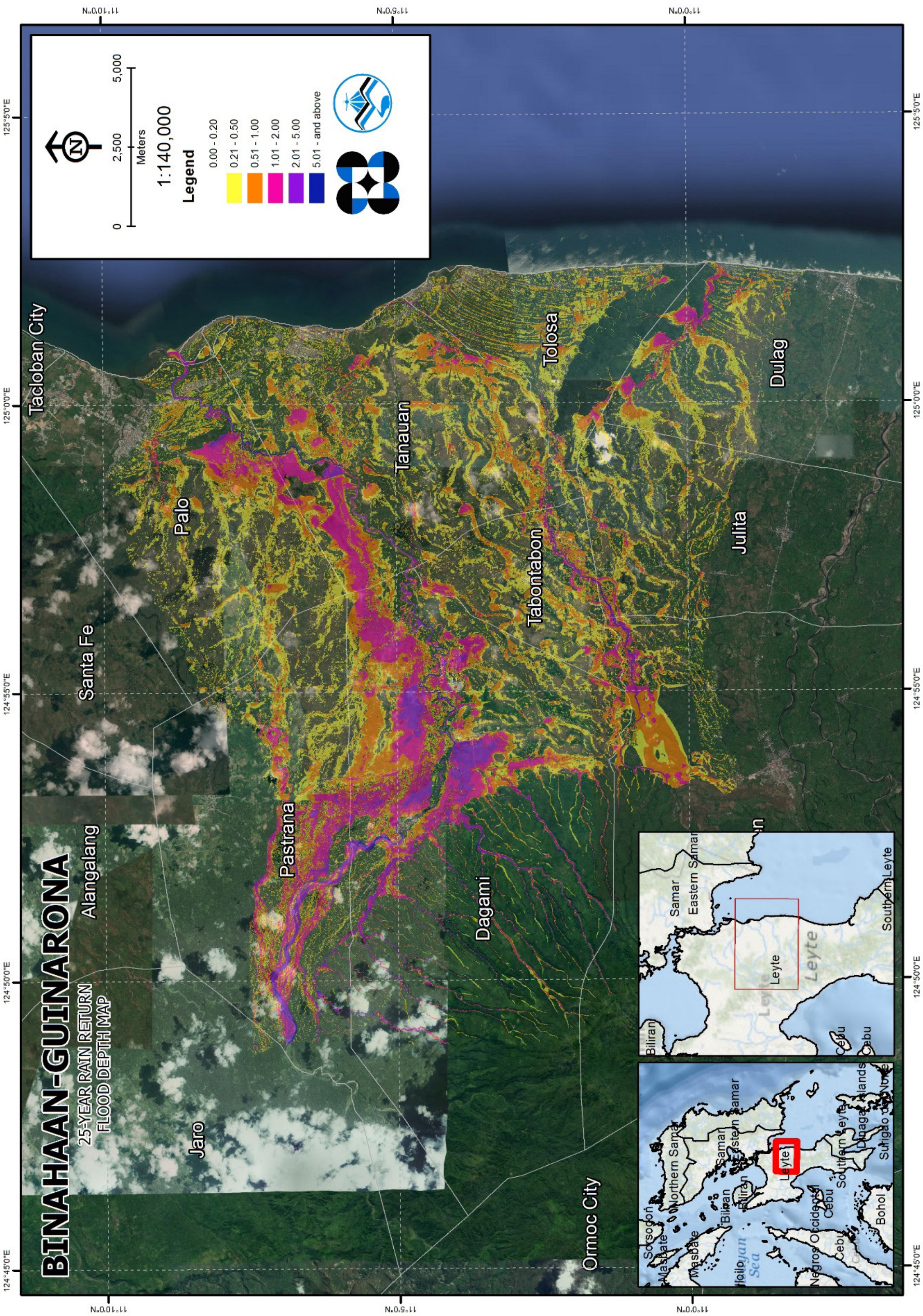


Figure 75. 25-year Rain Return Flood Depth Map for Binahaan-Guinarona Floodplain

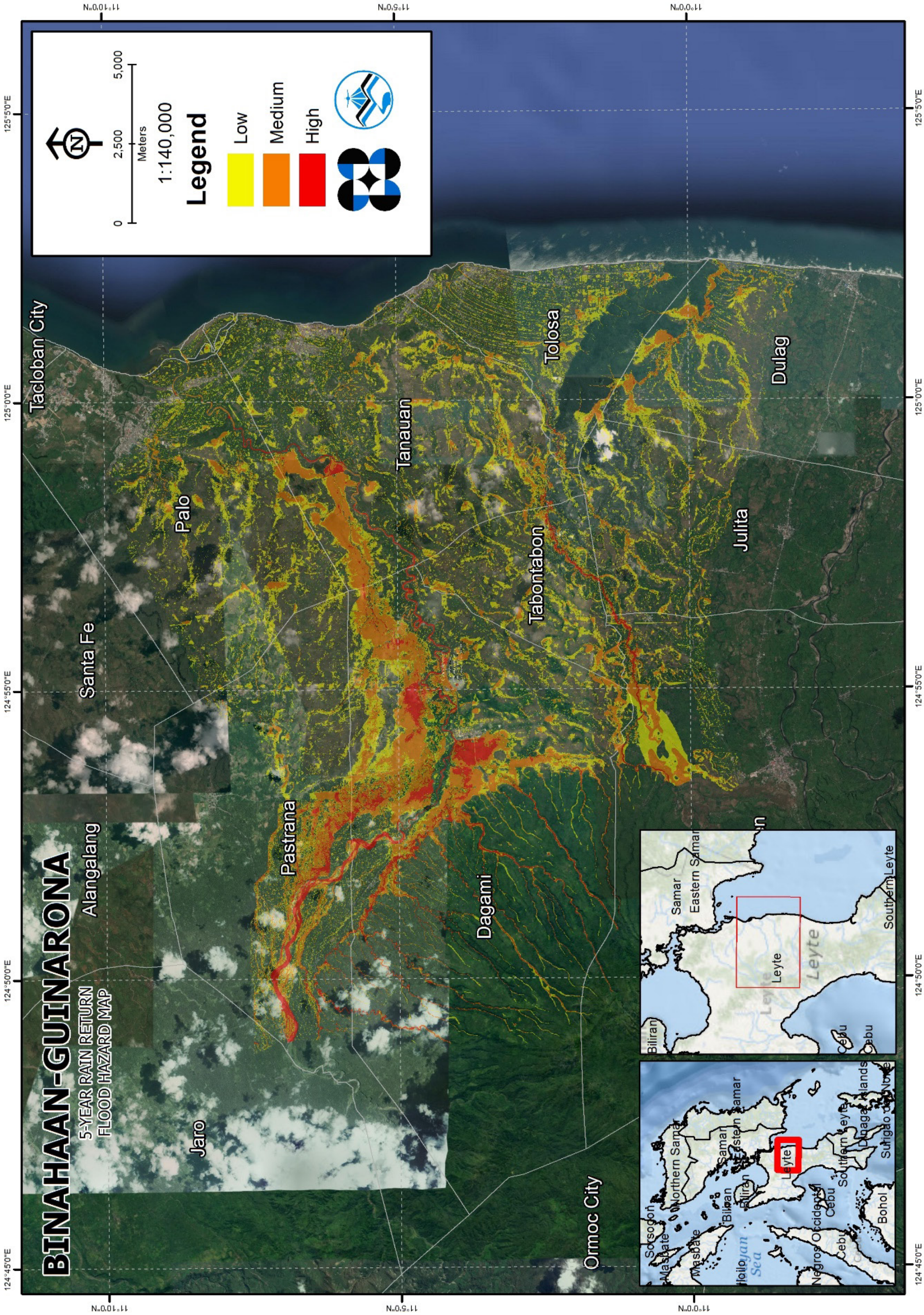


Figure 76. 5-year Rain Return Flood Hazard Map for Binahaan-Guinarona Floodplain

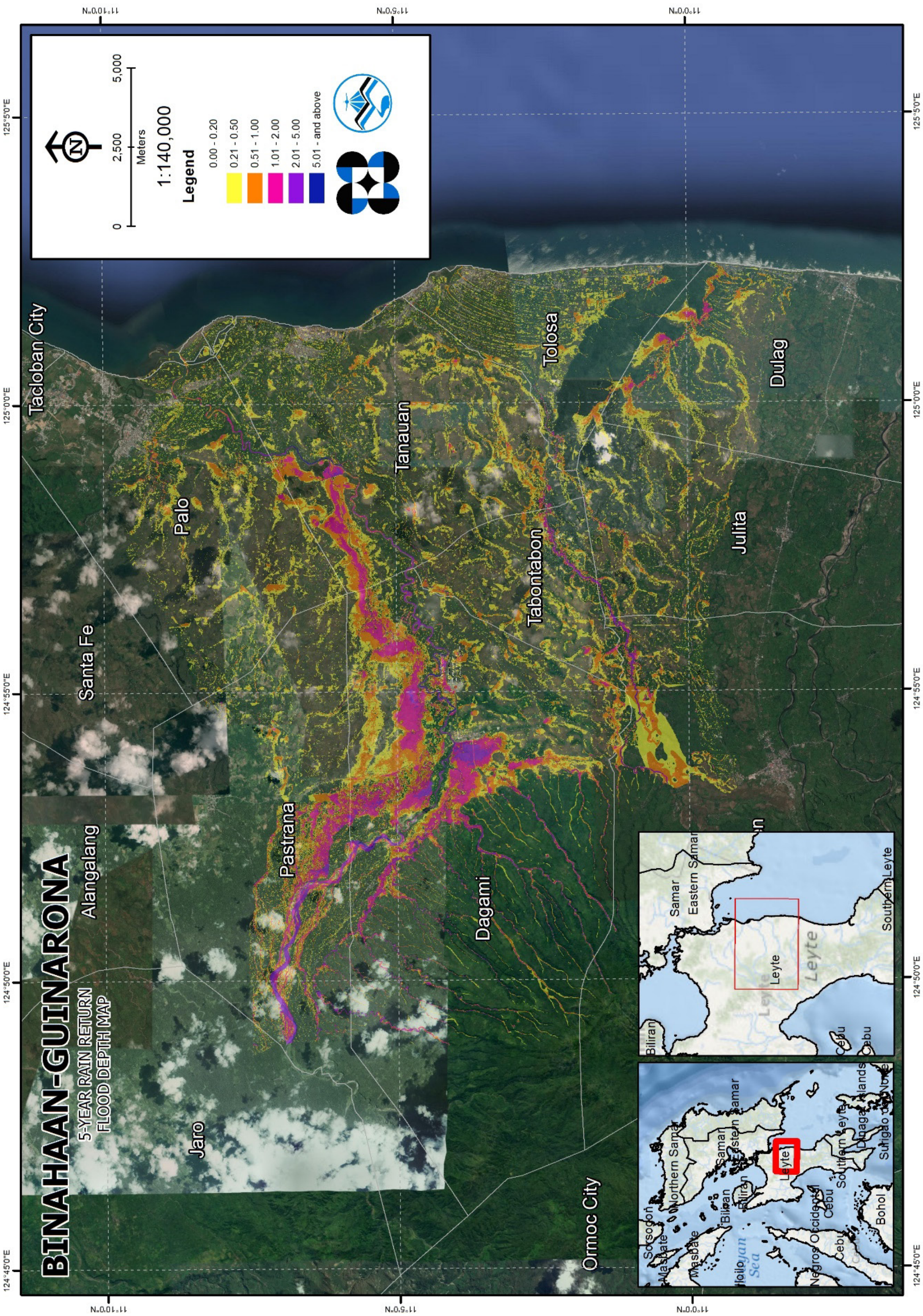


Figure 77. 5-year Rain Return Flood Depth Map for Binahaan-Guinarona Floodplain

5.10 Inventory of Areas Exposed to Flooding

Affected barangays in Binahaan river basin, grouped by municipality, are listed below. For the said basin, 7 municipality consisting of 54 barangays are expected to experience flooding when subjected to 5-yr rainfall return period.

For the 5-year return period, 0.09% of the municipality of Burauen with an area of 205.31 sq. km. will experience flood levels of less than 0.20 meters and 0.006% of the area will experience flood levels of 0.51 to 1 meter. Listed in Table 34 are the affected areas in square kilometres by flood depth per barangay.

Table 34. Affected Areas in Burauen, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Burauen (in sq. km.)		
		Buri	Cadahunan	Tambis
Affected Area (sq. km.)	0.03-0.20	0.054	0.11	0.029
	0.21-0.50	0	0	0
	0.51-1.00	0.013	0	0
	1.01-2.00	0	0	0
	2.01-5.00	0	0	0
	> 5.00	0	0	0

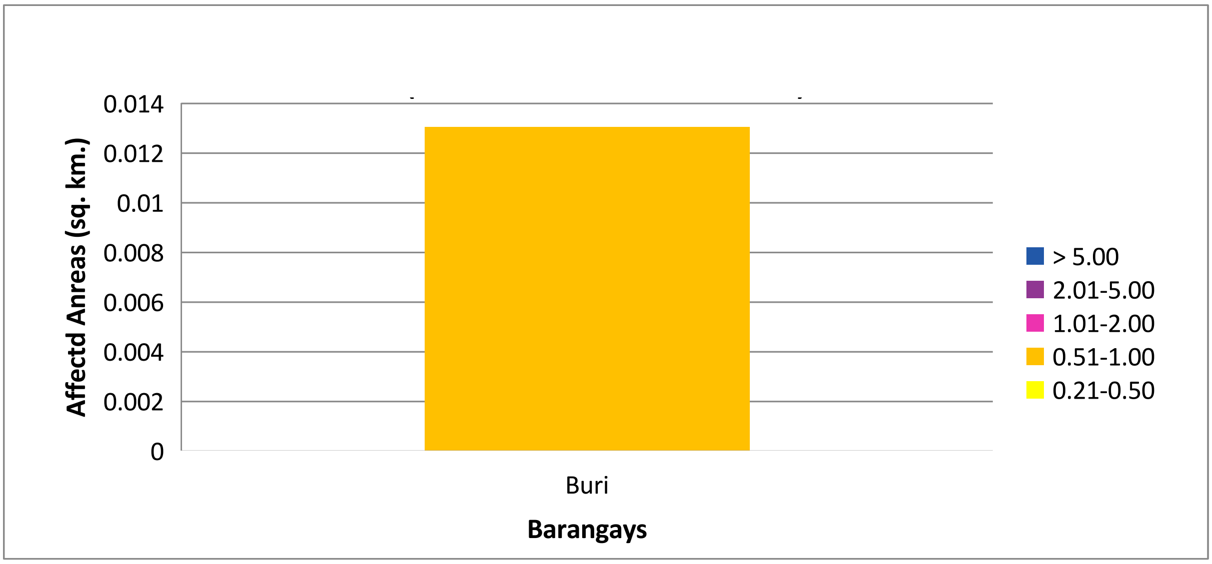


Figure 78. Affected Areas in Binahaan, Eastern Samar during 5-Year Rainfall Return Period

For the municipality of Dagami, with an area of 134.08 sq. km., 31.62% will experience flood levels of less 0.20 meters. 7.39% of the area will experience flood levels of 0.21 to 0.50 meters while 6.59%, 5.34%, 1.26%, and 0.11% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 35 are the affected areas in square kilometres by flood depth per barangay.

Table 35. Affected Areas in Dagami, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Abaca	Abre	Balilit	Balugo	Banayon	Bayabas	Bolirao	Buenavista	Buntay	Caanislagan
Affected Area (sq. km.)	0.03-0.20	1.07	0.047	0.2	0.1	2.77	1.12	0.79	0.28	0.74	0.49
	0.21-0.50	0.8	0.067	0.21	0.049	0.7	0.23	0.24	0.016	0.31	0.047
	0.51-1.00	0.61	0.2	0.32	0.31	0.2	0.033	0.032	0.018	0.4	0.0074
	1.01-2.00	0.038	0.36	0.19	0.69	0.023	0	0	0.019	0.96	0.032
	2.01-5.00	0.014	0.14	0.0094	0.015	0	0	0	0.012	0.076	0.024
	> 5.00	0	0	0	0	0	0	0	0	0.00026	0

Table 36. Affected Areas in Dagami, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Cabariwan	Cabuloran	Cabunga-An	Calipayan	Calsadahay	Caluctogan	Calutan	Camono-An	Candagara	Canlingga
Affected Area (sq. km.)	0.03-0.20	0.31	0.85	1.67	1.09	0.9	0.41	0.92	0.98	0.0017	0.0047
	0.21-0.50	0.072	0.2	0.26	0.086	0.21	0.58	0.16	0.019	0	0.00061
	0.51-1.00	0.0097	0.054	0.23	0.08	0.054	0.44	0.086	0.048	0	0.021
	1.01-2.00	0	0.0077	0.12	0.18	0.001	0.23	0	0.027	0	0.093
	2.01-5.00	0	0	0.0076	0.046	0	0.0066	0	0.0021	0	0.3
	> 5.00	0	0	0	0	0	0	0	0	0	0.0013

Table 37. Affected Areas in Dagami, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Cansamada East	Cansamada West	Capulhan	Digahongan	Guinarona	Hiabangan	Hilabago	Hinabuyan	Hinologan	Hitumnog
Affected Area (sq. km.)	0.03-0.20	1.4	0.49	0.34	0.52	0.54	0.73	0.76	1.13	0.79	0.52
	0.21-0.50	0.23	0.15	0.061	0.093	0.16	0.12	0.14	0.9	0.26	0.13
	0.51-1.00	0.093	0.18	0.074	0.023	0.052	0.27	0.17	0.56	0.11	0.22
	1.01-2.00	0.056	0.12	0.063	0.017	0.0061	0.35	0.14	0.18	0.0079	0.044
	2.01-5.00	0.12	0.021	0.046	0.042	0.0079	0.051	0.062	0.0032	0.0082	0
	> 5.00	0	0	0	0	0	0	0	0	0	0

Table 38. Affected Areas in Dagami, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Katipunan	Lapu-lapu Poblacion	Lobe-Lobe East	Los Martires	Lusad Poblacion	Macaalang	Maliwaliw	Maragondong	Ormocay	Palacio
Affected Area (sq. km.)	0.03-0.20	3.16	0.046	0.51	0.44	0.044	0.74	2.34	0.67	0.24	1.72
	0.21-0.50	0.099	0.026	0.087	0.11	0.0075	0.036	0.35	0.15	0.04	0.39
	0.51-1.00	0.13	0.015	0.017	0.095	0	0.032	0.13	0.18	0	0.51
	1.01-2.00	0.11	0	0	0.049	0.019	0.022	0.024	0.19	0	0.43
	2.01-5.00	0.022	0.011	0	0.031	0	0	0	0.12	0	0.14
	> 5.00	0	0	0	0.04	0	0	0	0.0022	0	0

Table 39. Affected Areas in Dagami, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Panda	Paraiso	Patoc	Poponton	Rizal	Salvacion	Sampaguita	Sampao East Poblacion	Sampao West Poblacion	San Antonio Poblacion
Affected Area (sq. km.)	0.03-0.20	0.17	2.06	0.42	0.063	1.2	1.6	0.78	0.08	0.071	0.058
	0.21-0.50	0.14	0.096	0.12	0.17	0.016	0.086	0.11	0.04	0.012	0.019
	0.51-1.00	0.22	0.045	0.082	0.64	0.025	0.043	0.016	0.0099	0.016	0
	1.01-2.00	0.21	0.034	0.073	0.29	0.04	0.036	0.0079	0	0.025	0
	2.01-5.00	0.023	0	0.047	0.0079	0.017	0.047	0	0	0.0000024	0.0065
	> 5.00	0	0	0.034	0	0	0	0	0	0	0

Table 40. Affected Areas in Dagami, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		San Benito	San Jose Poblacion	San Roque Poblacion	Santo Domingo	Sawahon	Sirab	Sta. Mesa Poblacion	Tagkip	Talinhugon	Tin-Ao
Affected Area (sq. km.)	0.03-0.20	0.34	0.028	0.044	0.83	0.58	0.26	0.092	0.8	0.22	0.31
	0.21-0.50	0.2	0.025	0.0013	0.1	0.078	0.086	0.021	0.14	0.066	0.26
	0.51-1.00	0.26	0.0026	0.0042	0.03	0.21	0.12	0.014	0.28	0.05	0.37
	1.01-2.00	0.099	0.005	0	0.043	0.22	0.071	0	0.45	0.072	0.28
	2.01-5.00	0.0046	0	0.015	0.0032	0.0079	0.023	0	0.11	0.013	0.0079
	> 5.00	0	0.014	0	0	0	0.036	0	0.011	0.0032	0

Table 41. Affected Areas in Dagami, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)	
		Tunga Poblacion	Tuya
Affected Area (sq. km.)	0.03-0.20	0.017	0.45
	0.21-0.50	0.0018	0.15
	0.51-1.00	0.00015	0.047
	1.01-2.00	0.0075	0.000013
	2.01-5.00	0	0
	> 5.00	0.000045	0

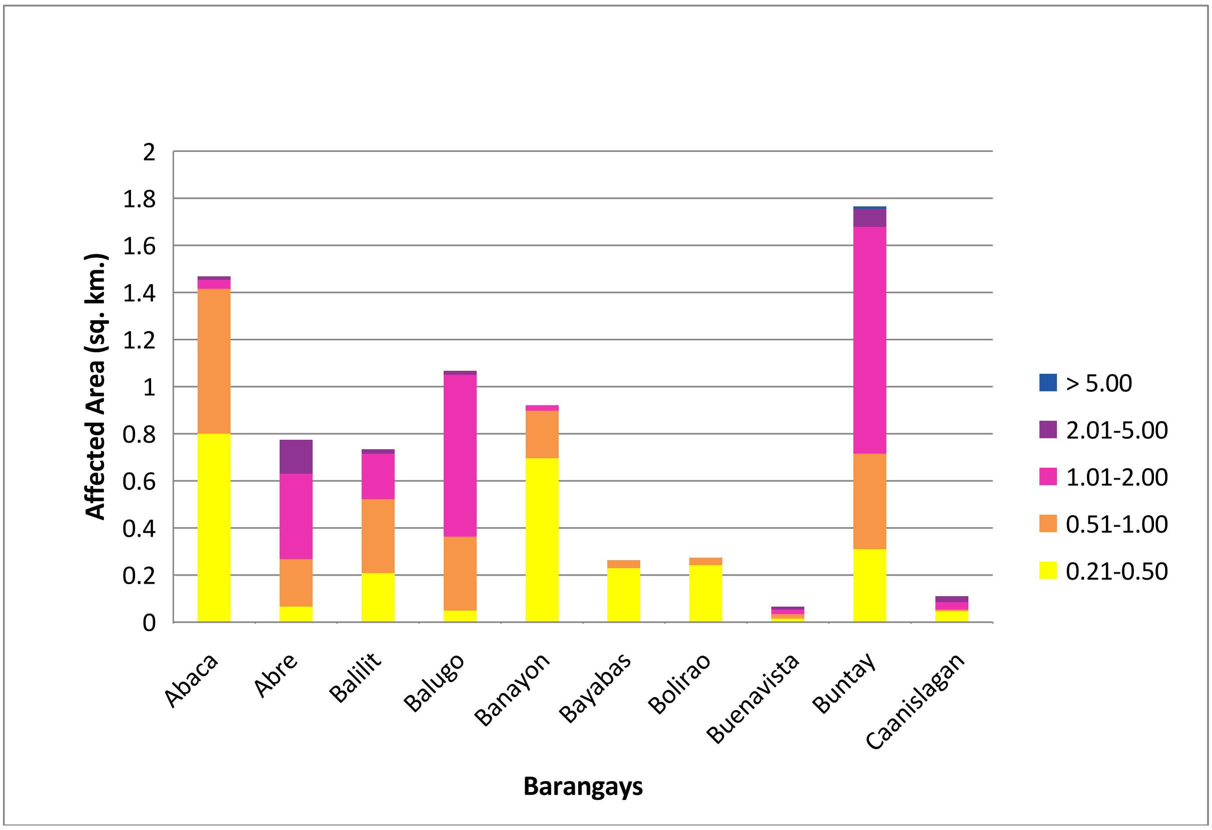


Figure 79. Affected Areas in Binahaan, Eastern Samar during 5-Year Rainfall Return Period

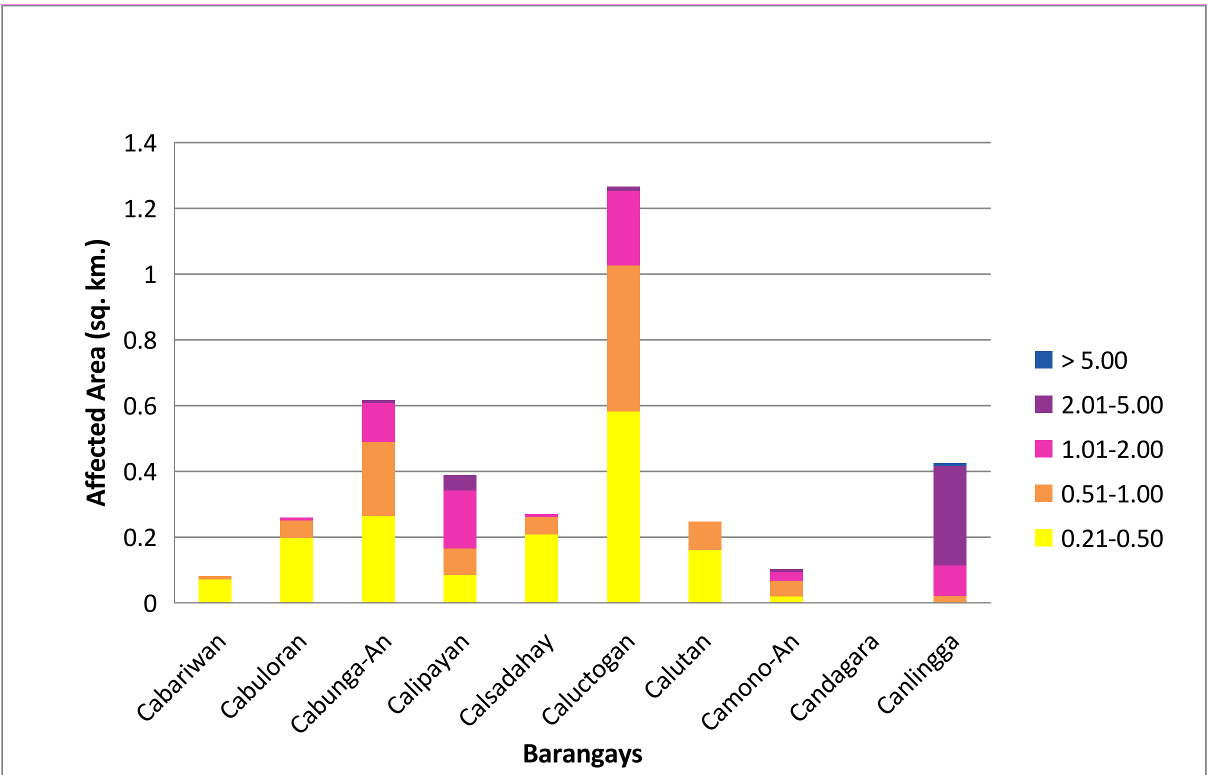


Figure 80. Affected Areas in Binahaan, Eastern Samar during 5-Year Rainfall Return Period

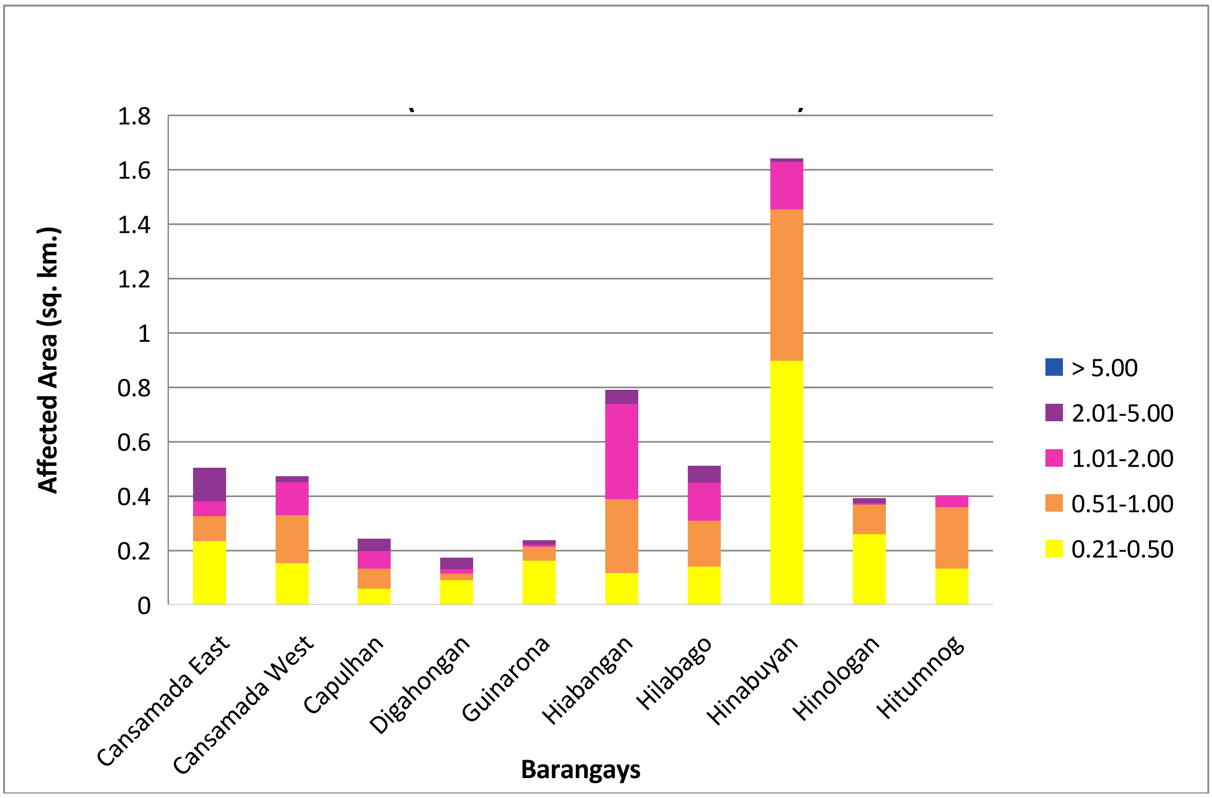


Figure 81. Affected Areas in Binahaan, Eastern Samar during 5-Year Rainfall Return Period

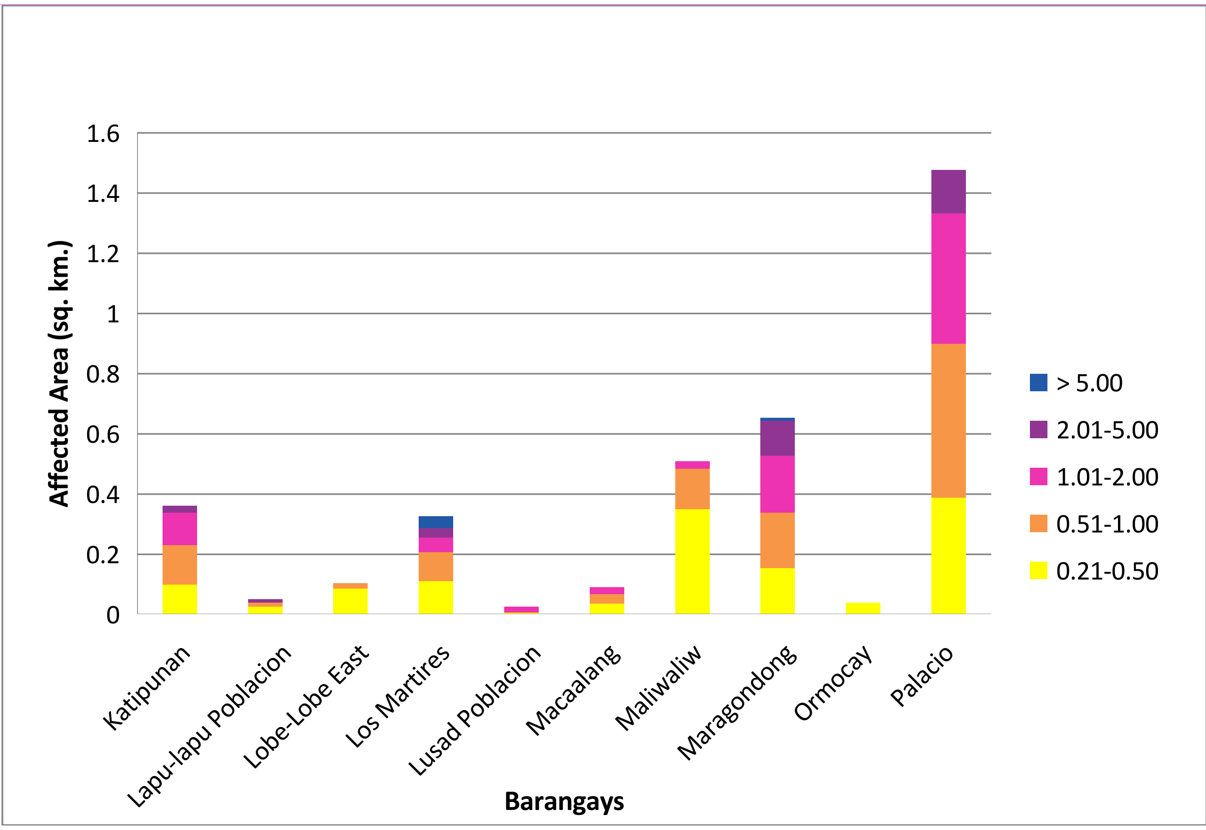


Figure 82. Affected Areas in Binahaan, Eastern Samar during 5-Year Rainfall Return Period

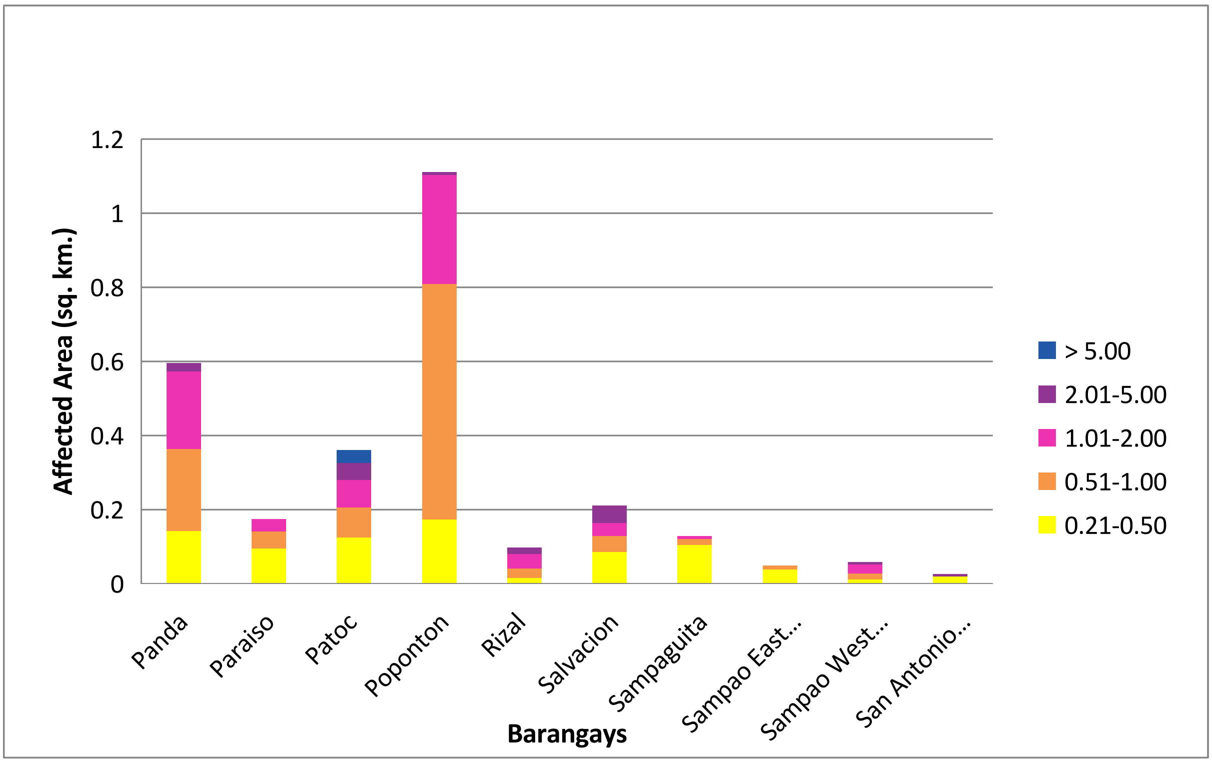


Figure 83. Affected Areas in Binahaan, Eastern Samar during 5-Year Rainfall Return Period

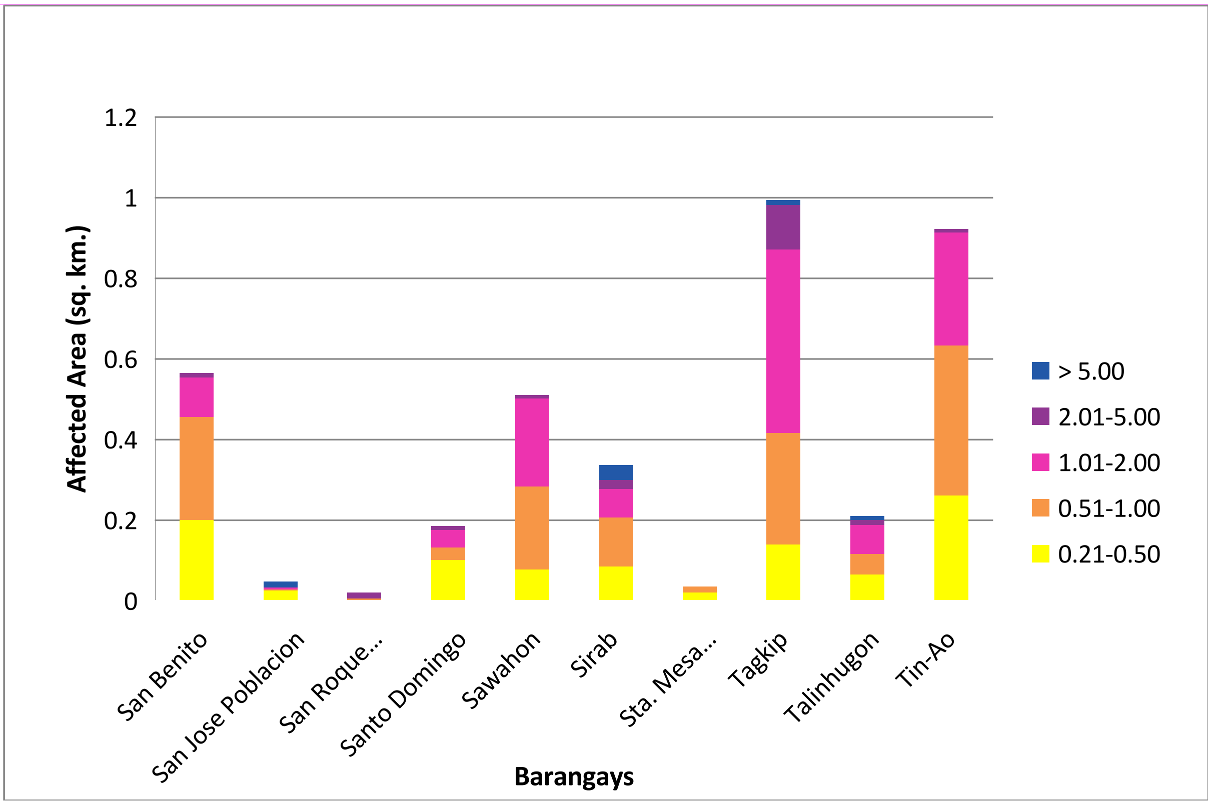


Figure 84. Affected Areas in Binahaan, Eastern Samar during 5-Year Rainfall Return Period

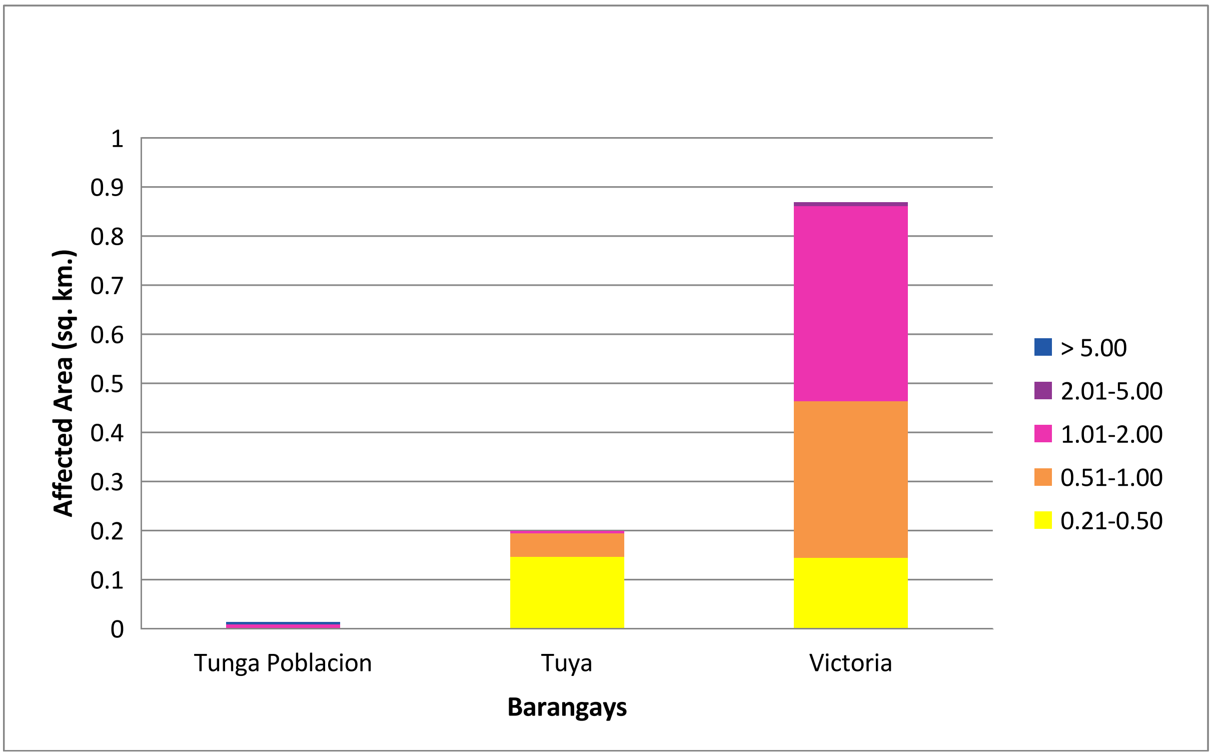


Figure 85. Affected Areas in Binahaan, Eastern Samar during 5-Year Rainfall Return Period

For the municipality of Jaro, with an area of 190.65 sq. km., 0.09% will experience flood levels of less 0.20 meters. 0.02% of the area will experience flood levels of 0.21 to 0.50 meters while 0.004%, 0.004%, 0%, and 0.004% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 42 are the affected areas in square kilometres by flood depth per barangay.

Table 42. Affected Areas in Jaro, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)
		Parasan
Affected Area (sq. km.)	0.03-0.20	0.18
	0.21-0.50	0.038
	0.51-1.00	0.0079
	1.01-2.00	0.0079
	2.01-5.00	0
	> 5.00	0.0079

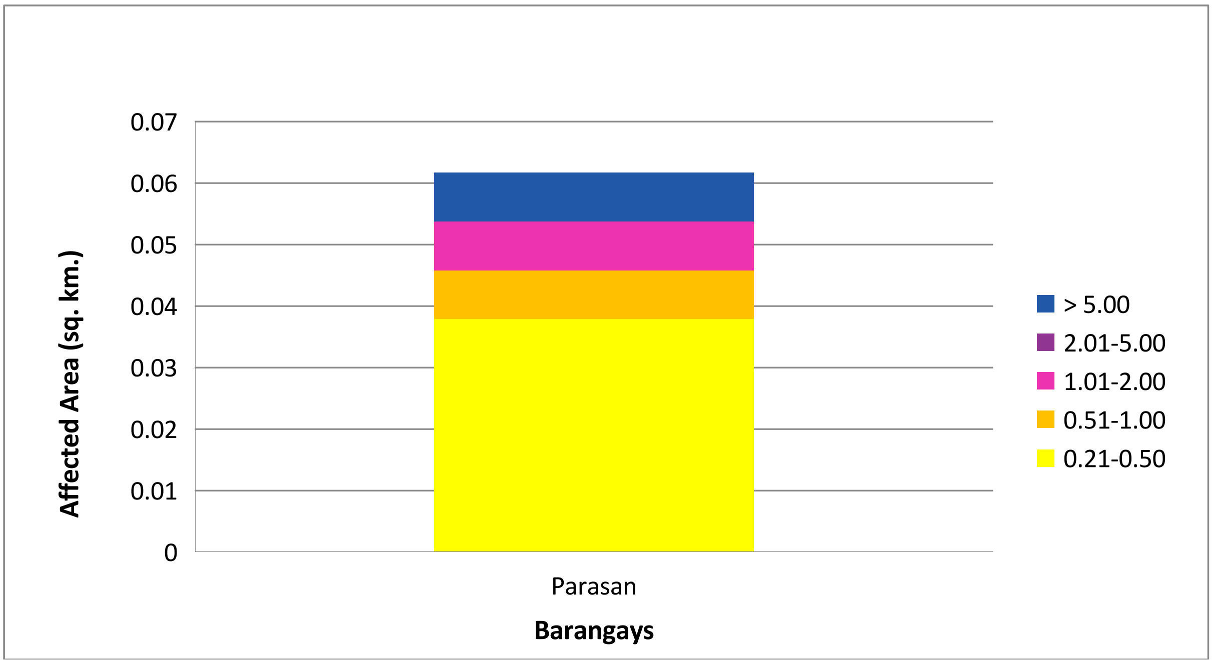


Figure 86. Affected Areas in Jaro, Leyte Samar during 5-Year Rainfall Return Period

For the municipality of Palo, with an area of 65.34 sq. km., 53.26% will experience flood levels of less 0.20 meters. 11.10% of the area will experience flood levels of 0.21 to 0.50 meters while 2.25%, 0.27%, and 0.097% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 43 are the affected areas in square kilometres by flood depth per barangay.

Table 43. Affected Areas in Palo, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Palo (in sq. km.)							
		Anahaway	Arado	Cabarasan Daku	Cabarasan Guti	Cangumbang	Canhidoc	Capirawan	Castilla
Affected Area (sq. km.)	0.03-0.20	1.2	0.57	2.6	1.04	3.66	1.46	2.49	2.54
	0.21-0.50	0.11	0.071	0.58	0.19	1.35	0.31	0.47	0.35
	0.51-1.00	0	0.013	0.063	0.075	0.41	0.036	0.0092	0.032
	1.01-2.00	0	0	0	0.023	0.017	0	0	0
	2.01-5.00	0	0	0	0.056	0	0	0	0
	> 5.00	0	0	0	0	0	0	0	0

Table 44. Affected Areas in Palo, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Palo (in sq. km.)						
		Cavite East	Cavite West	Cogon	Gacao	Libertad	Naga-Naga	Salvacion
Affected Area (sq. km.)	0.03-0.20	0.09	0.14	0.6	2.71	0.0086	0.057	0.12
	0.21-0.50	0	0.0079	0.12	0.61	0.0022	0	0.008
	0.51-1.00	0	0	0.018	0.13	0	0.0046	0.002
	1.01-2.00	0	0	0.00016	0.024	0	0	0
	2.01-5.00	0	0	0	0	0	0	0
	> 5.00	0	0	0	0	0	0	0

Table 45. Affected Areas in Palo, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Palo (in sq. km.)						
		San Agustin	San Antonio	San Isidro	San Joaquin	Santa Cruz	Tacuranga	Teraza
Affected Area (sq. km.)	0.03-0.20	2.38	1.14	2.46	6.46	0.089	0.7	2.29
	0.21-0.50	0.43	0.35	0.47	1.32	0.0079	0.22	0.27
	0.51-1.00	0.032	0.15	0.054	0.33	0.029	0.055	0.028
	1.01-2.00	0	0.027	0	0.071	0	0.016	0
	2.01-5.00	0	0	0	0.0079	0	0	0
	> 5.00	0	0	0	0	0	0	0

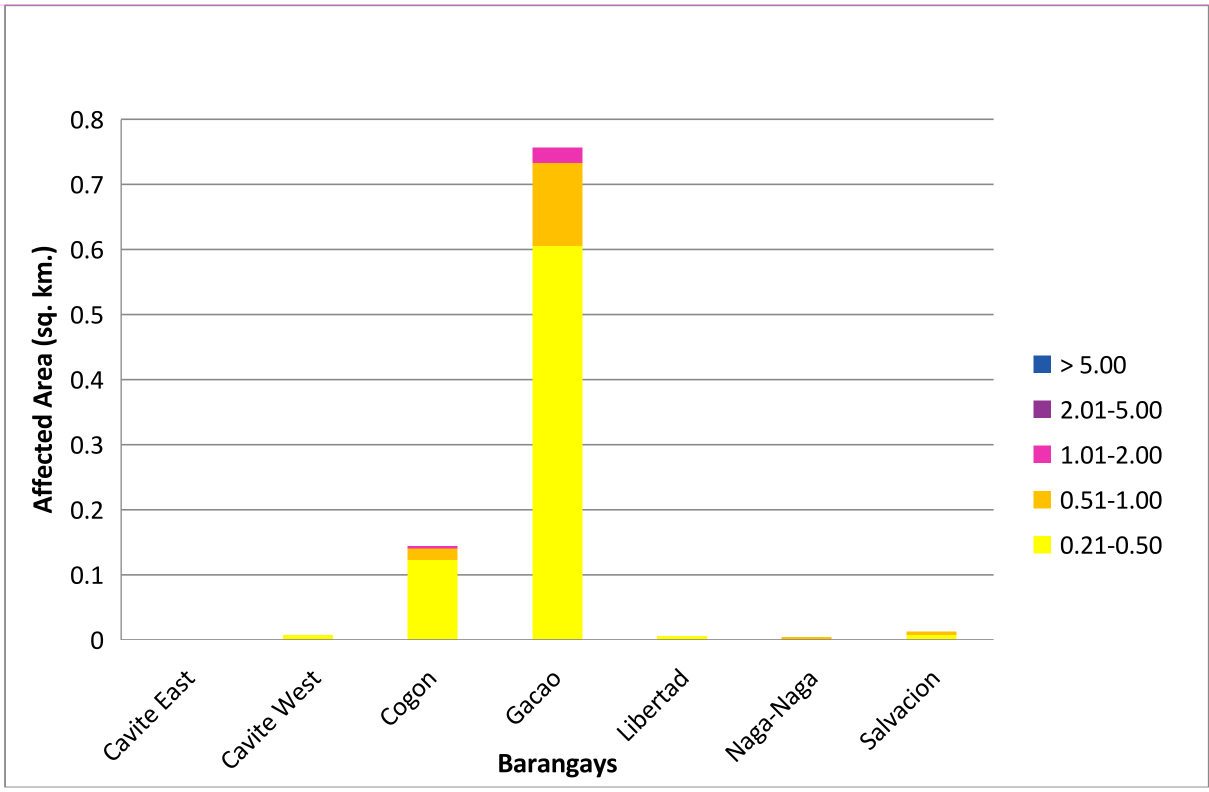


Figure 87. Affected Areas in Palo, Leyte Samar during 5-Year Rainfall Return Period

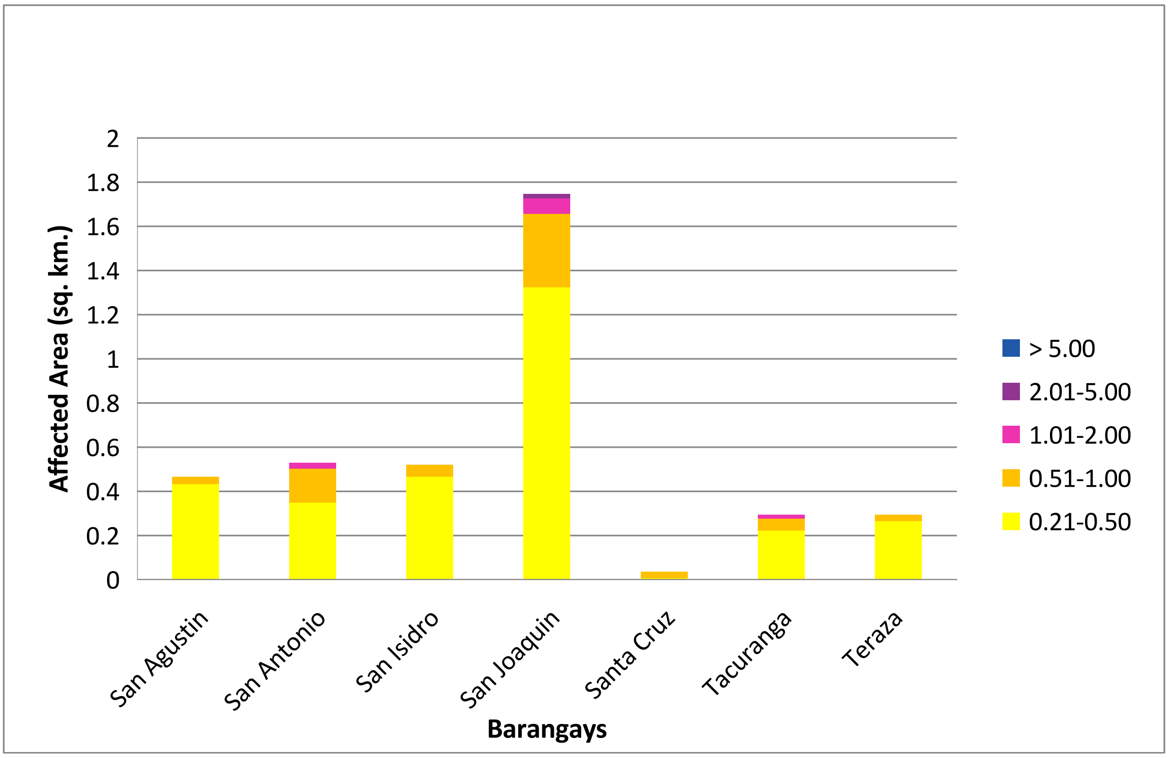


Figure 88. Affected Areas in Palo, Leyte Samar during 5-Year Rainfall Return Period

For the municipality of Pastrana, with an area of 79.17 sq. km., 32.53% will experience flood levels of less 0.20 meters. 6.90% of the area will experience flood levels of 0.21 to 0.50 meters while 3.84%, 3.17%, 1.13%, and 0.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 46 are the affected areas in square kilometres by flood depth per barangay.

Table 46. Affected Areas in Pastrana, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Pastrana (in sq. km.)							
		Aringit	Bahay	Cabaohan	Cancaraja	Caninoan	Capilla	Colawen	Dumarag
Affected Area (sq. km.)	0.03-0.20	1.24	2.64	0.51	0.0073	1.21	0.87	2.34	1.44
	0.21-0.50	0.65	0.75	0.061	0.00009	0.19	0.2	0.35	0.14
	0.51-1.00	0.65	0.53	0.03	0	0.016	0.077	0.0024	0.025
	1.01-2.00	0.55	0.57	0	0	0	0.016	0	0
	2.01-5.00	0.076	0.24	0	0	0	0	0	0
	> 5.00	0	0	0	0	0	0	0	0

Table 47. Affected Areas in Pastrana, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Pastrana (in sq. km.)							
		Lanawan	Lourdes	Macalpiay	Manaybanay	Maricum	Sapsap	Tingib	Yapad
Affected Area (sq. km.)	0.03-0.20	3.26	2.56	1.58	0.95	1.78	0.78	1.79	2.8
	0.21-0.50	0.39	0.41	0.45	0.12	0.24	0.31	0.38	0.81
	0.51-1.00	0.016	0.26	0.33	0.017	0	0.15	0.26	0.67
	1.01-2.00	0	0.25	0.14	0	0	0	0.21	0.78
	2.01-5.00	0	0.19	0.11	0	0	0	0.26	0.021
	> 5.00	0	0.0079	0	0	0	0	0.016	0

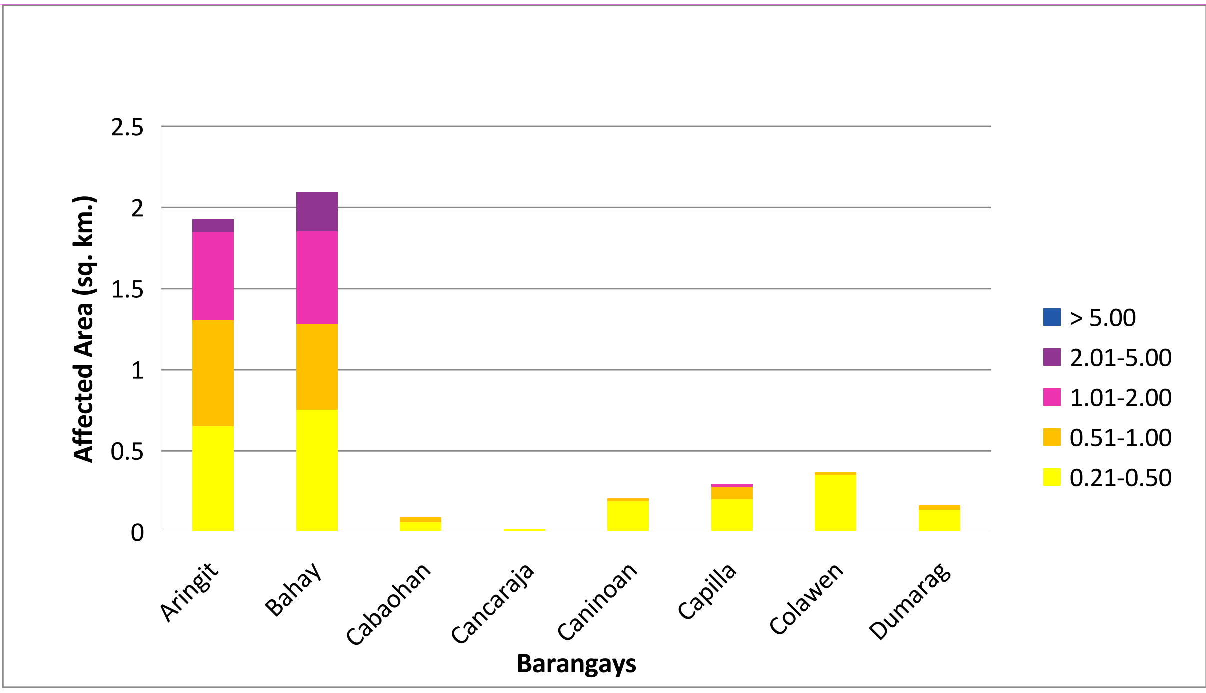


Figure 89. Affected Areas in Pastrana, Leyte during 25-Year Rainfall Return Period

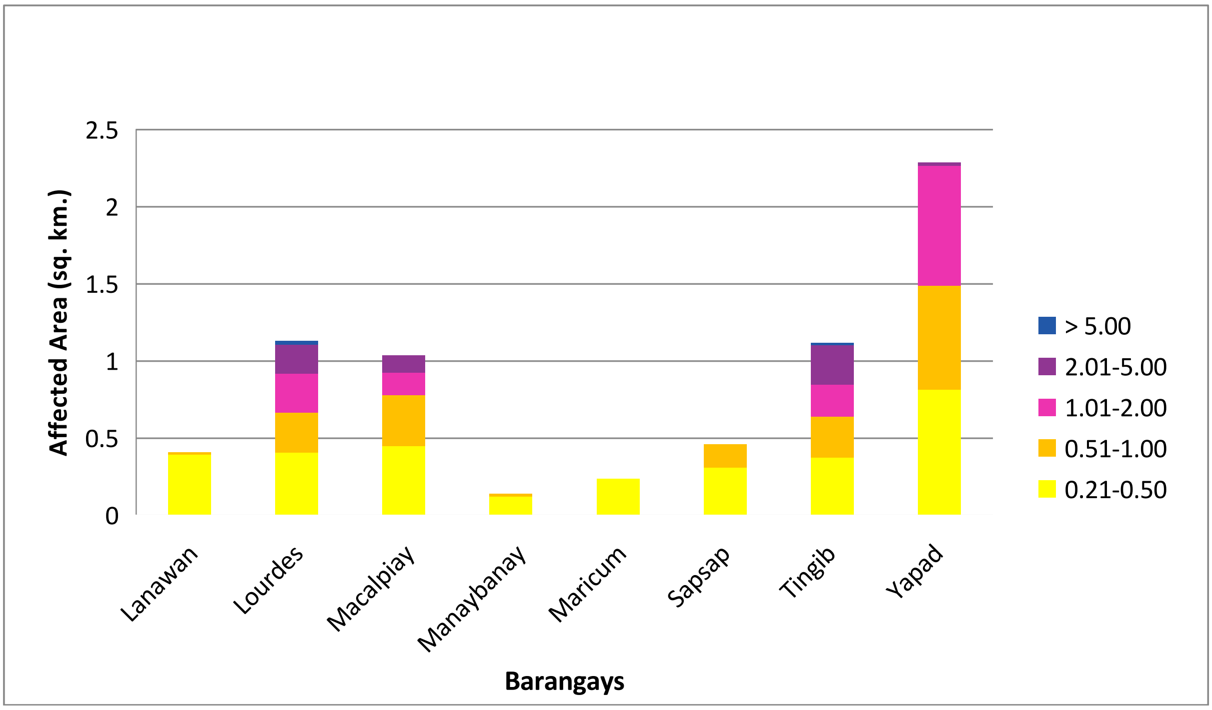


Figure 90. Affected Areas in Pastrana, Leyte during 25-Year Rainfall Return Period

For the municipality of Tabontabon, with an area of 20.46 sq. km., 32.47% will experience flood levels of less 0.20 meters. 6.93% of the area will experience flood levels of 0.21 to 0.50 meters while 1.73%, 0.116%, and 0.08% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 48 are the affected areas in square kilometres by flood depth per barangay.

Table 48. Affected Areas in Tabontabon, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tabontabon (in sq. km.)						
		Belisong	Cambucao	Capahuan	Guingawan	Jabong	Mercadohay	Mering
Affected Area (sq. km.)	0.03-0.20	1.44	0.76	0.71	1.29	1.1	1.11	0.23
	0.21-0.50	0.3	0.16	0.12	0.24	0.27	0.28	0.048
	0.51-1.00	0.055	0.0079	0.056	0.092	0.11	0.013	0.017
	1.01-2.00	0	0.0079	0	0.016	0	0	0
	2.01-5.00	0	0	0	0.017	0	0	0
	> 5.00	0	0	0	0	0	0	0

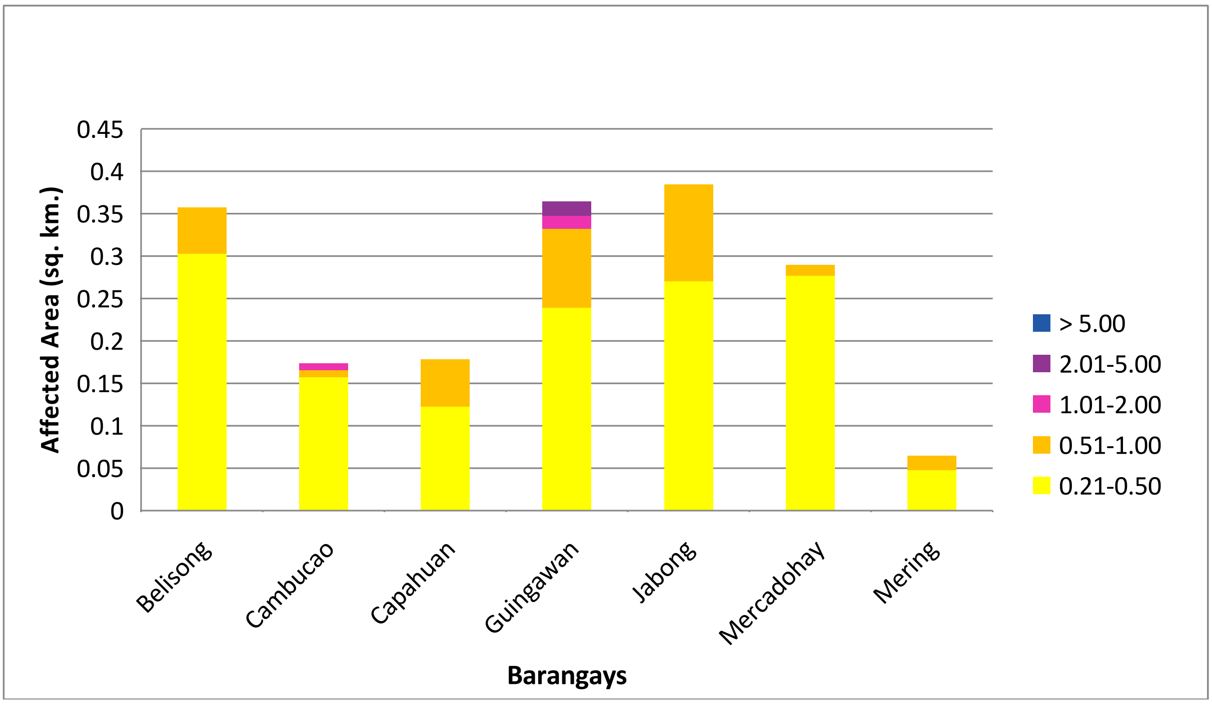


Figure 91. Affected Areas in Tabontabon, Leyte during 5-Year Rainfall Return Period

For the municipality of Tanauan, with an area of 62.78 sq. km., 41.50% will experience flood levels of less 0.20 meters. 9.69% of the area will experience flood levels of 0.21 to 0.50 meters while 4.53%, 1.97%, 0.29%, and 0.06% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 49 are the affected areas in square kilometres by flood depth per barangay.

Table 49. Affected Areas in Tanauan, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)								
		Amanluran	Atipolo	Balud	Bangon	Bantagan	Baras	Binolo	Binongto-An	Buntay
Affected Area (sq. km.)	0.03-0.20	0.32	0.39	0.95	1.09	0.42	0.89	0.38	1.5	0.13
	0.21-0.50	0.032	0.12	0.22	0.16	0.044	0.12	0.13	0.3	0.069
	0.51-1.00	0	0.0079	0.043	0.031	0.018	0.03	0	0.5	0
	1.01-2.00	0	0	3.7E-07	0	0.0052	0	0	0.32	0
	2.01-5.00	0	0	0.015	0	0	0	0	0.05	0
	> 5.00	0	0	0	0	0	0	0	0	0

Table 50. Affected Areas in Tanauan, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)								
		Cabalagnan	Cabarasan Guti	Cabuynan	Cahumayhumayan	Calogcog	Calsadahay	Camire	Canramos	Catigbian
Affected Area (sq. km.)	0.03-0.20	1.51	0.83	1.22	0.51	0.56	0.11	0.49	0.21	0.46
	0.21-0.50	0.36	0.36	0.26	0.14	0.086	0.017	0.2	0.011	0.12
	0.51-1.00	0.078	0.48	0.095	0.087	0	0	0.016	0	0.04
	1.01-2.00	0	0.43	0.0079	0.0068	0	0	0	0	0.022
	2.01-5.00	0	0	0	0.0019	0	0	0	0	0
	> 5.00	0.016	0	0	0	0	0	0	0	0

Table 51. Affected Areas in Tanauan, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)							
		Guindag-An	Guingawan	Hilagpad	Kiling	Lapay	Licod	Magay	Maghulod
Affected Area (sq. km.)	0.03-0.20	1.15	0.44	0.65	1.26	0.84	0.057	0.21	0.49
	0.21-0.50	0.35	0.067	0.06	0.39	0.12	0.012	0.04	0.052
	0.51-1.00	0.57	0.0076	0	0.16	0.059	0.0076	0	0.0079
	1.01-2.00	0.11	0.018	0	0.021	0	0	0	0
	2.01-5.00	0.00076	0.041	0	0.029	0	0	0	0
	> 5.00	0.0079	0	0	0.0031	0	0	0	0

Table 52. Affected Areas in Tanauan, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)							
		Malaguicay	Maribi	Mohon	Pago	Pasil	Sacme	Salvador	San Isidro
Affected Area (sq. km.)	0.03-0.20	0.39	0.63	0.37	0.93	0.3	0.022	1.21	0.71
	0.21-0.50	0.051	0.15	0.092	0.19	0.089	0	0.22	0.4
	0.51-1.00	0.0079	0.024	0	0.041	0.045	0	0.041	0.35
	1.01-2.00	0	0	0	0	0	0	0.011	0.2
	2.01-5.00	0	0	0	0	0	0	0	0.006
	> 5.00	0	0	0	0	0	0	0	0

Table 53. Affected Areas in Tanauan, Leyte during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)							
		San Miguel	San Roque	Santa Cruz	Santa Elena	Santo Niño Poblacion	Solano	Talolora	Tugop
Affected Area (sq. km.)	0.03-0.20	0.55	0.46	0.86	0.28	1.32	0.23	1.19	0.87
	0.21-0.50	0.11	0.08	0.21	0.063	0.21	0.07	0.21	0.3
	0.51-1.00	0.016	0.00031	0	0.039	0.055	0	0.0057	0.033
	1.01-2.00	0	0	0	0.09	0	0	0	0
	2.01-5.00	0	0	0	0.04	0	0	0	0
	> 5.00	0	0	0	0.013	0	0	0	0

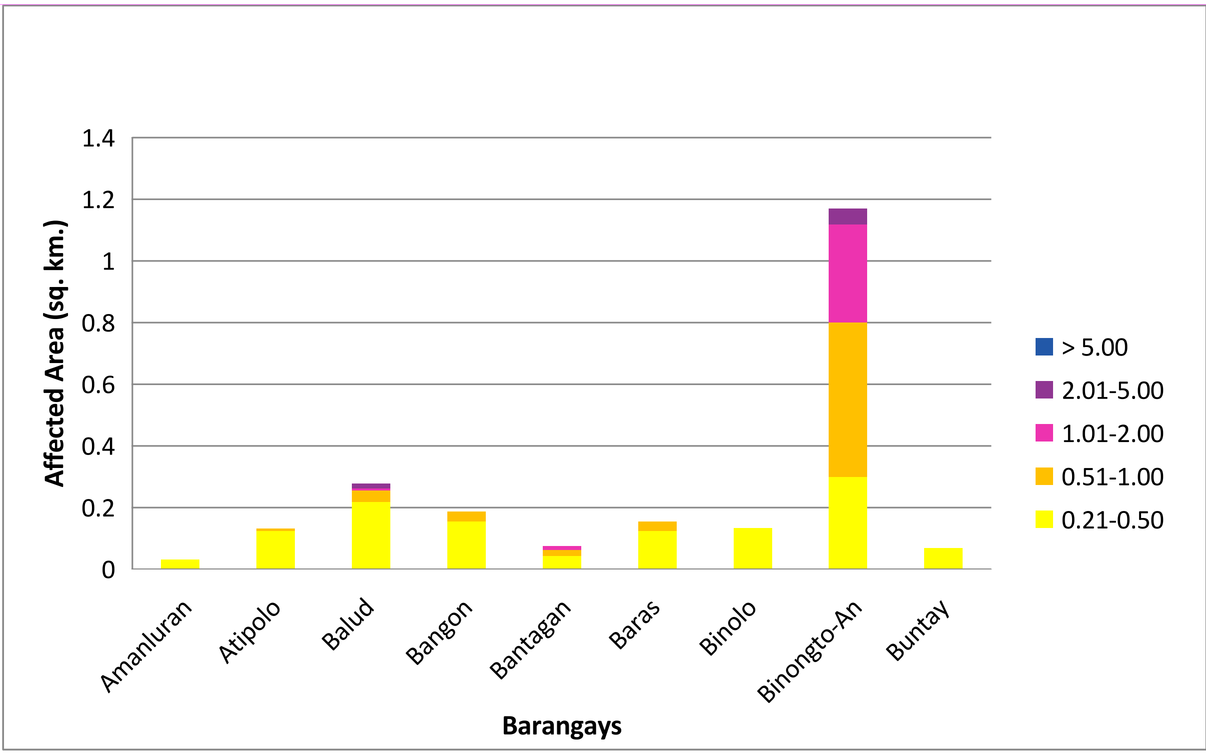


Figure 92. Affected Areas in Tanauan during 5-Year Rainfall Return Period

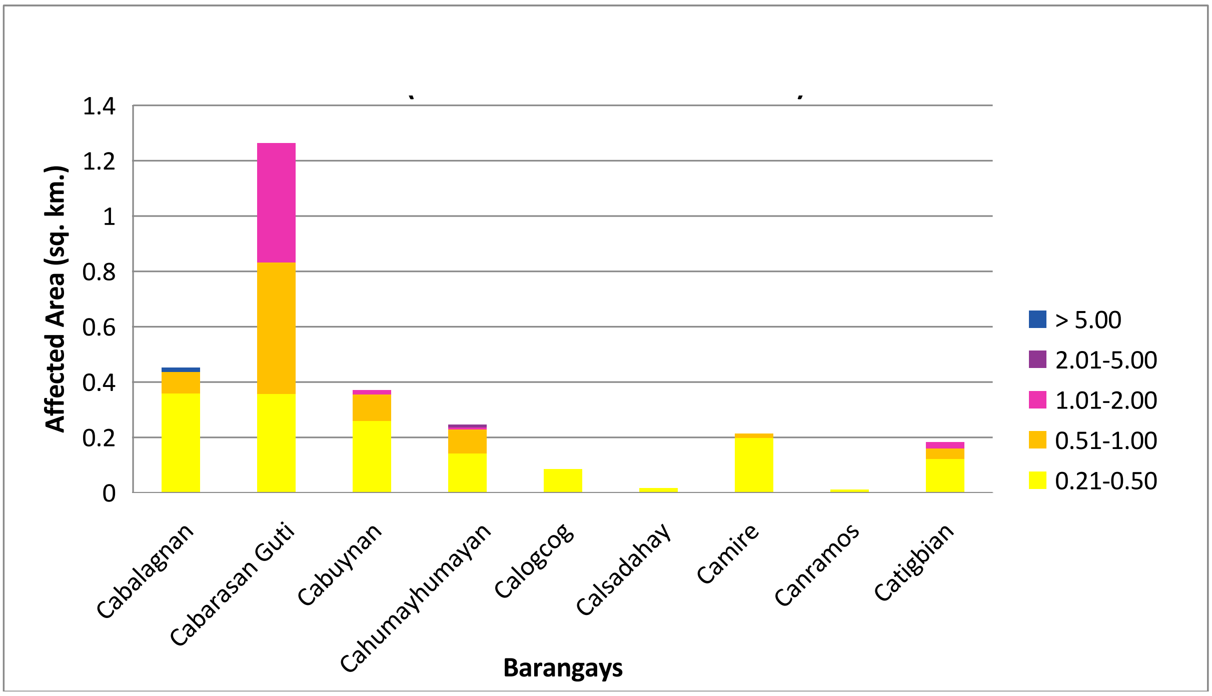


Figure 93. Affected Areas in Tanauan during 5-Year Rainfall Return Period

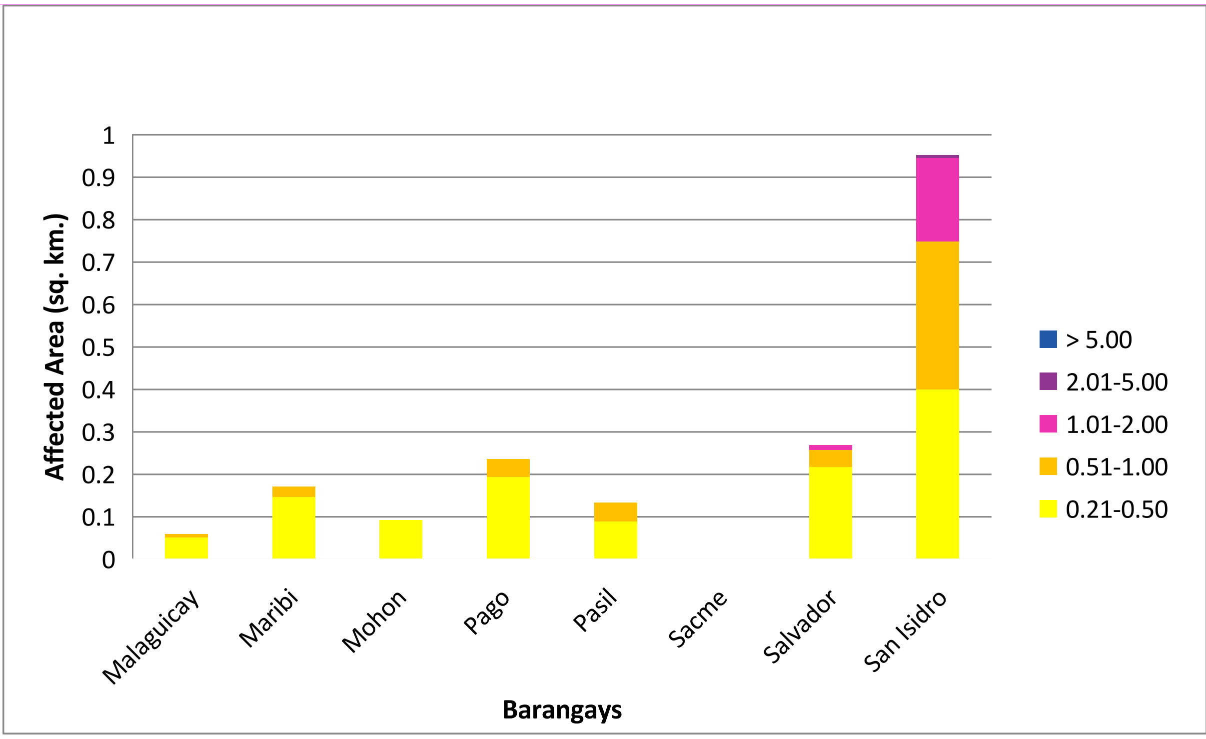


Figure 94. Affected Areas in Tanauan during 5-Year Rainfall Return Period

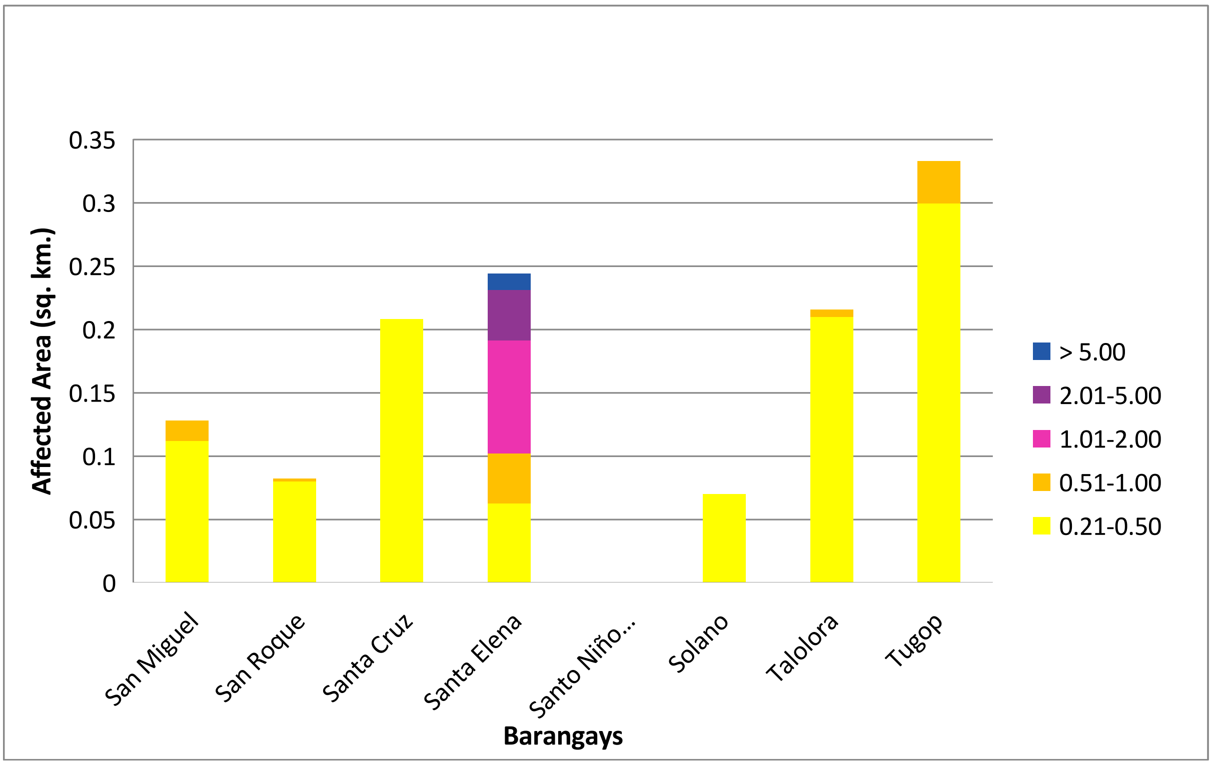


Figure 95. Affected Areas in Tanauan during 5-Year Rainfall Return Period

For the 25-year return period, 0.08% of the municipality of Burauen with an area of 205.31 sq. km. will experience flood levels of less 0.20 meters. 0.003% of the area will experience flood levels of 0.21 to 0.50 meters while 0.011% of the area will experience flood depths of 0.51 to 1 meter. Listed in Table 54 are the affected areas in square kilometres by flood depth per barangay.

Table 54. Affected Areas in Burauen, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Burauen (in sq. km.)		
		Buri	Cadahunan	Tambis
Affected Area (sq. km.)	0.03-0.20	0.045	0.11	0.019
	0.21-0.50	0.0044	0.0018	0
	0.51-1.00	0.02	0.002	0
	1.01-2.00	0.000041	0.0008	0
	2.01-5.00	0	0	0
	> 5.00	0	0	0

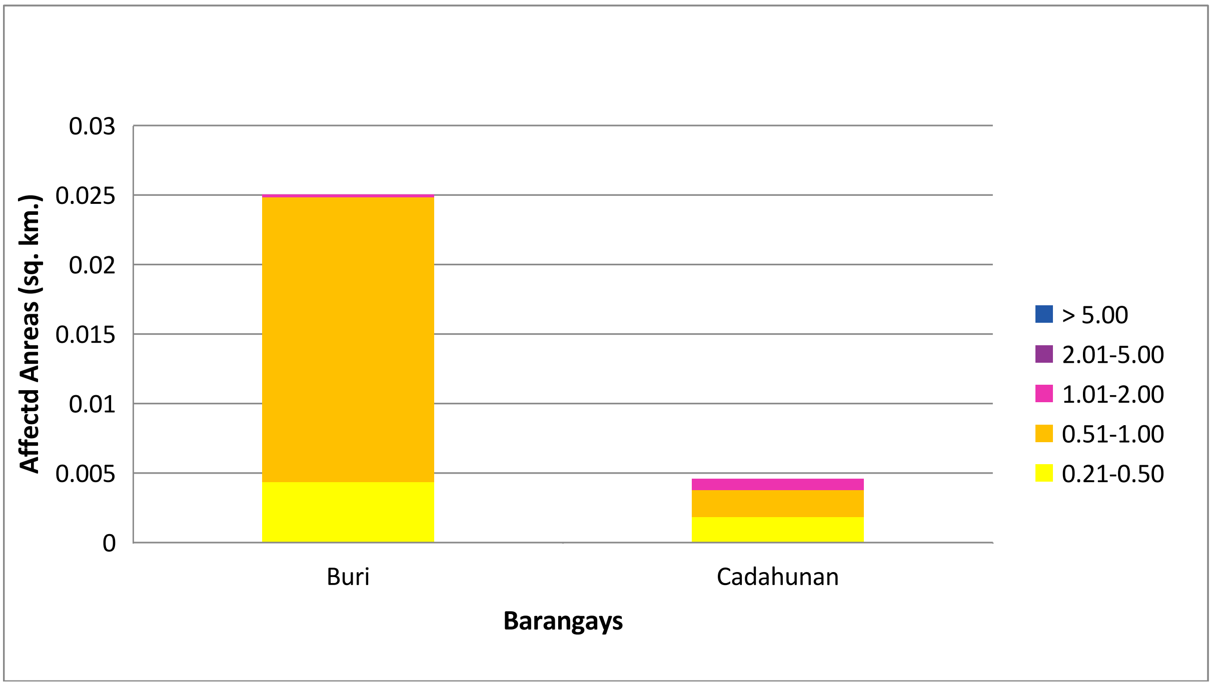


Figure 96. Affected Areas in Burauen during 25-Year Rainfall Return Period

For the municipality of Dagami, with an area of 134.08 sq. km., 25.38% will experience flood levels of less 0.20 meters. 7.13% of the area will experience flood levels of 0.21 to 0.50 meters while 8.25%, 8.18%, 3.17%, and 0.20% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 55 are the affected areas in square kilometres by flood depth per barangay.

Table 55. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Abaca	Abre	Balilit	Balugo	Banayon	Bayabas	Bolirao	Buenavista	Buntay	Caanislagan
Affected Area (sq. km.)	0.03-0.20	0.48	0.036	0.079	0.064	1.96	0.97	0.66	0.27	0.36	0.42
	0.21-0.50	0.72	0.027	0.093	0.022	0.78	0.35	0.34	0.028	0.27	0.064
	0.51-1.00	1.15	0.085	0.3	0.068	0.54	0.052	0.068	0.012	0.41	0.034
	1.01-2.00	0.17	0.39	0.43	0.57	0.37	0.0012	0.0001	0.013	0.74	0.043
	2.01-5.00	0.013	0.28	0.02	0.45	0.041	0	0	0.013	0.72	0.041
	> 5.00	0	0	0.00055	0.0004	0	0	0	0.0002	0	0.00055

Table 56. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Cabariwan	Cabuloran	Cabunga-An	Calipayan	Calsadahay	Caluctogan	Calutan	Camono-An	Candagara	Canlingga
Affected Area (sq. km.)	0.03-0.20	0.22	0.71	1.69	1.08	0.62	0.14	0.67	1	0.00002	0.0016
	0.21-0.50	0.086	0.2	0.23	0.05	0.24	0.32	0.24	0.029	0	0.00041
	0.51-1.00	0.076	0.12	0.18	0.059	0.17	0.82	0.21	0.02	0	0.0027
	1.01-2.00	0.016	0.083	0.16	0.15	0.13	0.37	0.054	0.016	0	0.031
	2.01-5.00	0.00033	7.3E-06	0.025	0.13	0.011	0.031	0	0.017	0	0.39
	> 5.00	0	0	0	0.0019	0	0	0	0.0038	0	0.00018

Table 57. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Cansamada East	Cansamada West	Capulhan	Digahongan	Guinarona	Hiabangan	Hilabago	Hinabuyan	Hinologan	Hitumnog
Affected Area (sq. km.)	0.03-0.20	1.19	0.29	0.26	0.27	0.45	0.73	0.66	0.41	0.61	0.47
	0.21-0.50	0.29	0.15	0.057	0.1	0.23	0.051	0.09	0.74	0.32	0.082
	0.51-1.00	0.19	0.23	0.054	0.12	0.061	0.14	0.16	1.02	0.2	0.18
	1.01-2.00	0.089	0.22	0.1	0.15	0.02	0.44	0.23	0.57	0.031	0.2
	2.01-5.00	0.14	0.036	0.096	0.04	0.0035	0.15	0.13	0.02	0.007	0.00071
	> 5.00	0.018	0.029	0.013	0.02	0	0.0006	0.0013	0	0	0

Table 58. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Katipunan	Lapu-lapu Poblacion	Lobe-Lobe East	Los Martires	Lusad Poblacion	Macaalang	Maliwaliw	Maragondong	Ormocay	Palacio
Affected Area (sq. km.)	0.03-0.20	3.11	0.034	0.44	0.26	0.0084	0.75	1.99	0.57	0.21	1.48
	0.21-0.50	0.15	0.018	0.11	0.14	0.024	0.028	0.54	0.099	0.04	0.35
	0.51-1.00	0.094	0.021	0.057	0.16	0.011	0.018	0.25	0.26	0.026	0.49
	1.01-2.00	0.092	0.014	0.0052	0.12	0.0051	0.021	0.065	0.23	0.00053	0.54
	2.01-5.00	0.085	0.0093	0	0.053	0.022	0.016	0.00079	0.14	0	0.33
	> 5.00	0.0025	0	0	0.025	0	0.0004	0	0.022	0	0

Table 59. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Panda	Paraiso	Patoc	Poponton	Rizal	Salvacion	Sampaguita	Sampao East Poblacion	Sampao West Poblacion	San Antonio Poblacion
Affected Area (sq. km.)	0.03-0.20	0.12	1.95	0.29	0.029	1.16	1.55	0.67	0.014	0.02	0.048
	0.21-0.50	0.059	0.12	0.1	0.074	0.029	0.081	0.2	0.022	0.033	0.018
	0.51-1.00	0.17	0.076	0.13	0.39	0.029	0.068	0.03	0.069	0.028	0.013
	1.01-2.00	0.36	0.07	0.12	0.66	0.038	0.052	0.015	0.025	0.023	0.0025
	2.01-5.00	0.062	0.011	0.1	0.019	0.048	0.061	0	0	0.019	0.0014
	> 5.00	0.00077	0	0.034	0	0.0017	0.0089	0	0	0	0.00067

Table 60. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		San Benito	San Jose Poblacion	San Roque Poblacion	Santo Domingo	Sawahon	Sirab	Sta. Mesa Poblacion	Tagkip	Talinhugon	Tin-Ao
Affected Area (sq. km.)	0.03-0.20	0.12	0.014	0.037	0.75	0.5	0.11	0.0077	0.47	0.15	0.12
	0.21-0.50	0.15	0.014	0.0073	0.13	0.049	0.098	0.012	0.23	0.064	0.14
	0.51-1.00	0.3	0.019	0.0065	0.049	0.17	0.15	0.054	0.32	0.069	0.38
	1.01-2.00	0.3	0.012	0.0022	0.049	0.32	0.15	0.053	0.53	0.13	0.56
	2.01-5.00	0.032	0.0088	0.01	0.031	0.05	0.041	0	0.22	0.0059	0.037
	> 5.00	0.0001	0.0081	0.002	0	0	0.045	0	0.033	0.0014	0

Table 61. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Burauen (in sq. km.)		
		Tunga Poblacion	Tuya	Victoria
Affected Area (sq. km.)	0.03-0.20	0.012	0.26	0.011
	0.21-0.50	0.0039	0.2	0.031
	0.51-1.00	0.0012	0.18	0.25
	1.01-2.00	0.0058	0.0084	0.59
	2.01-5.00	0.003	0	0.041
	> 5.00	0	0	0

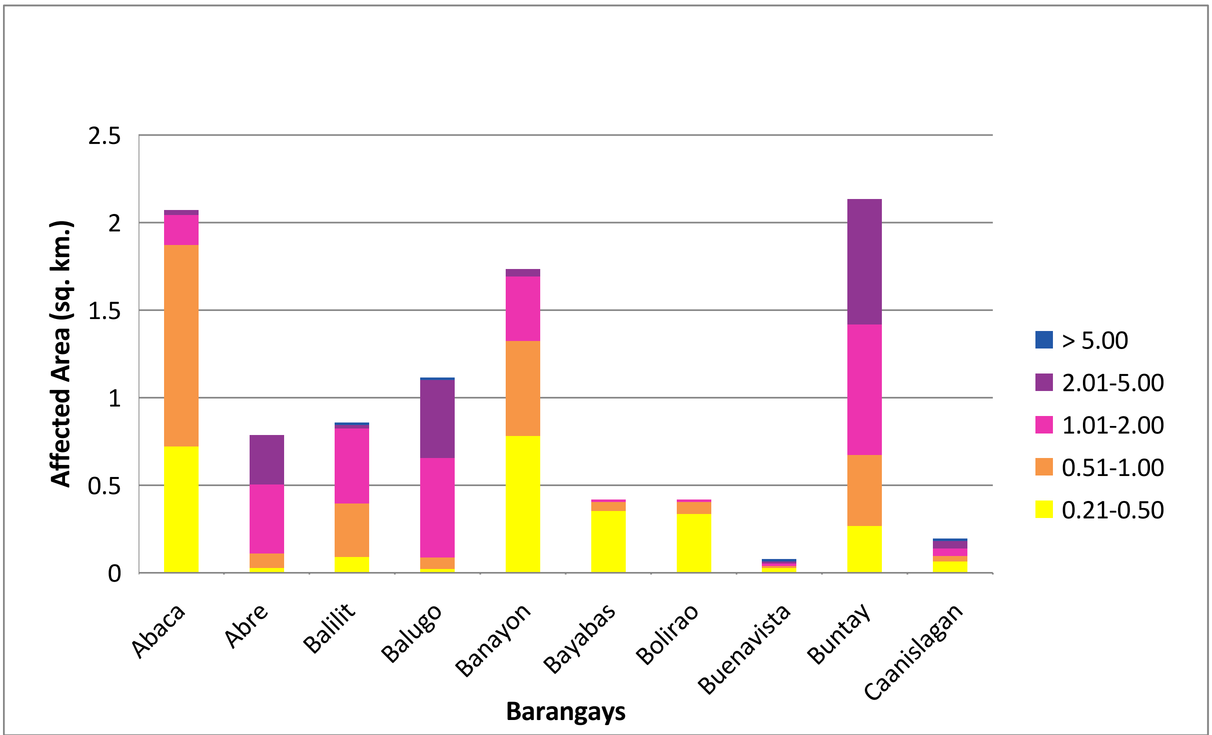


Figure 97. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

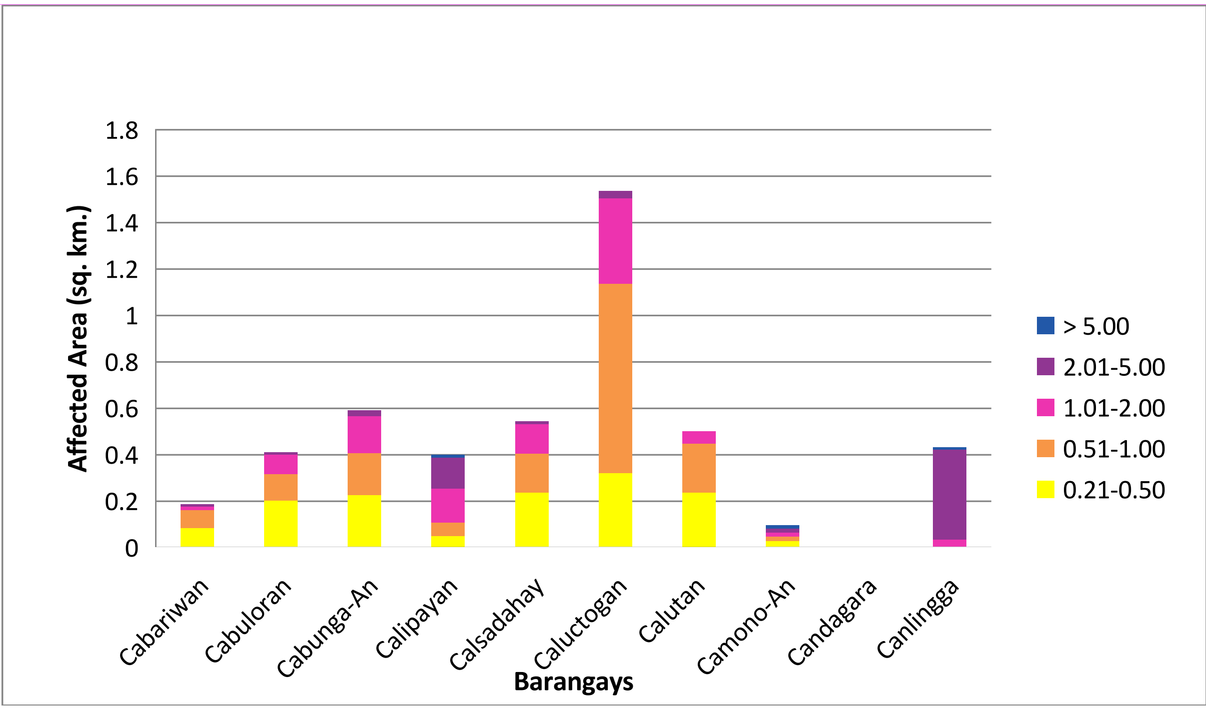


Figure 98. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

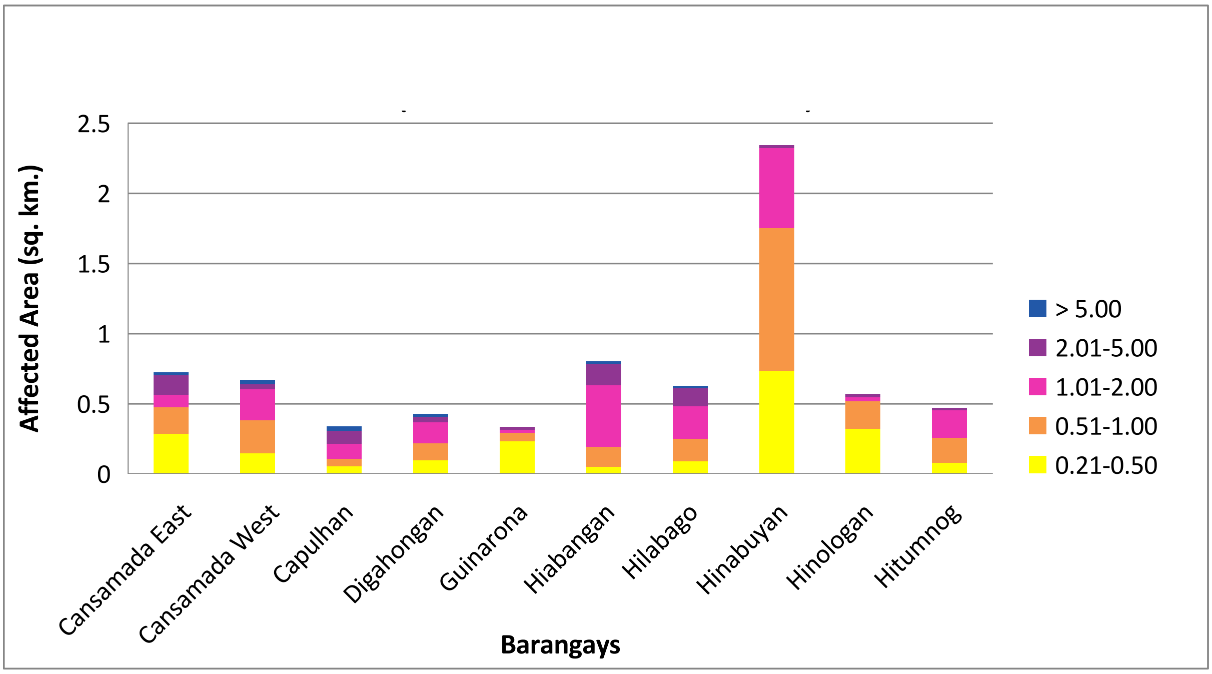


Figure 99. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

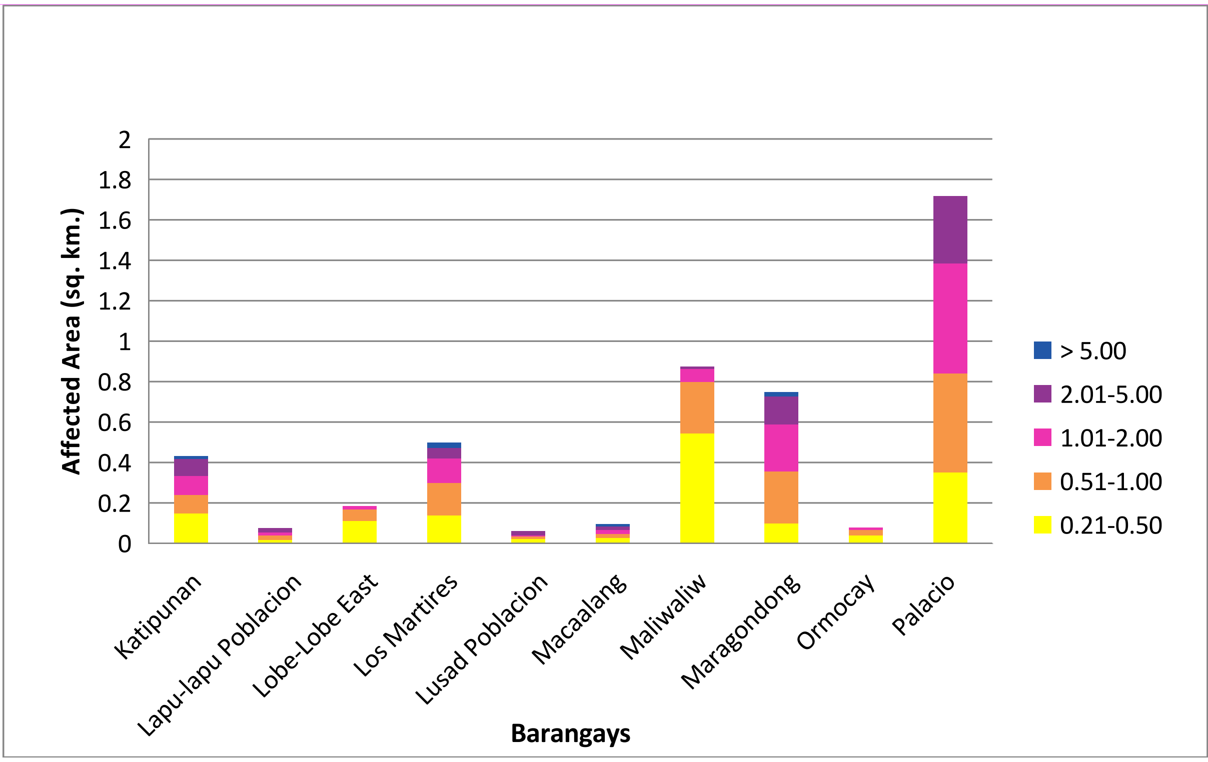


Figure 100. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

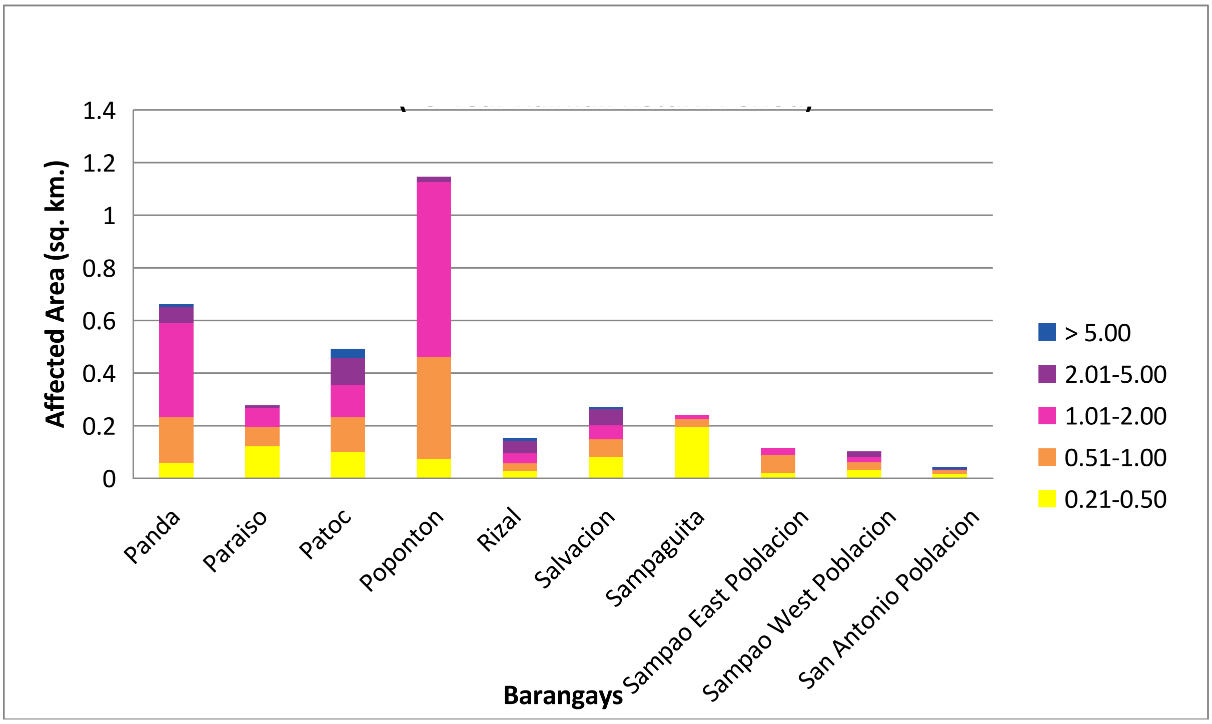


Figure 101. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

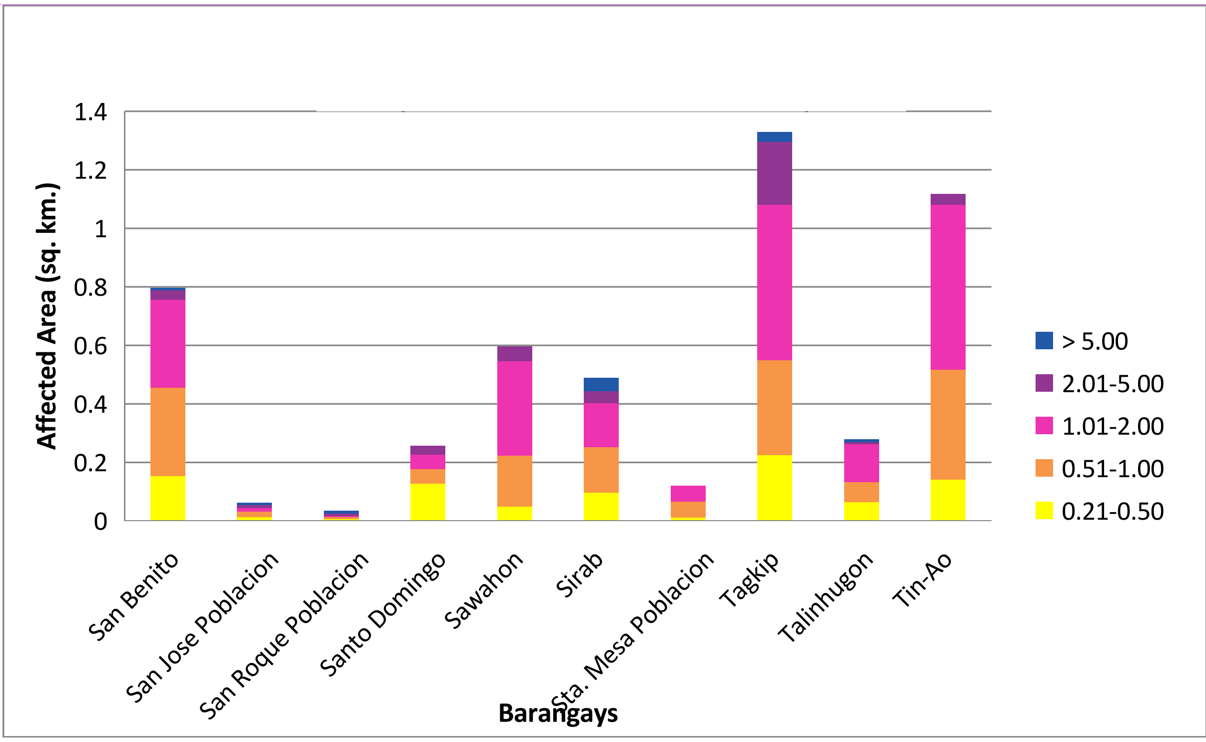


Figure 102. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

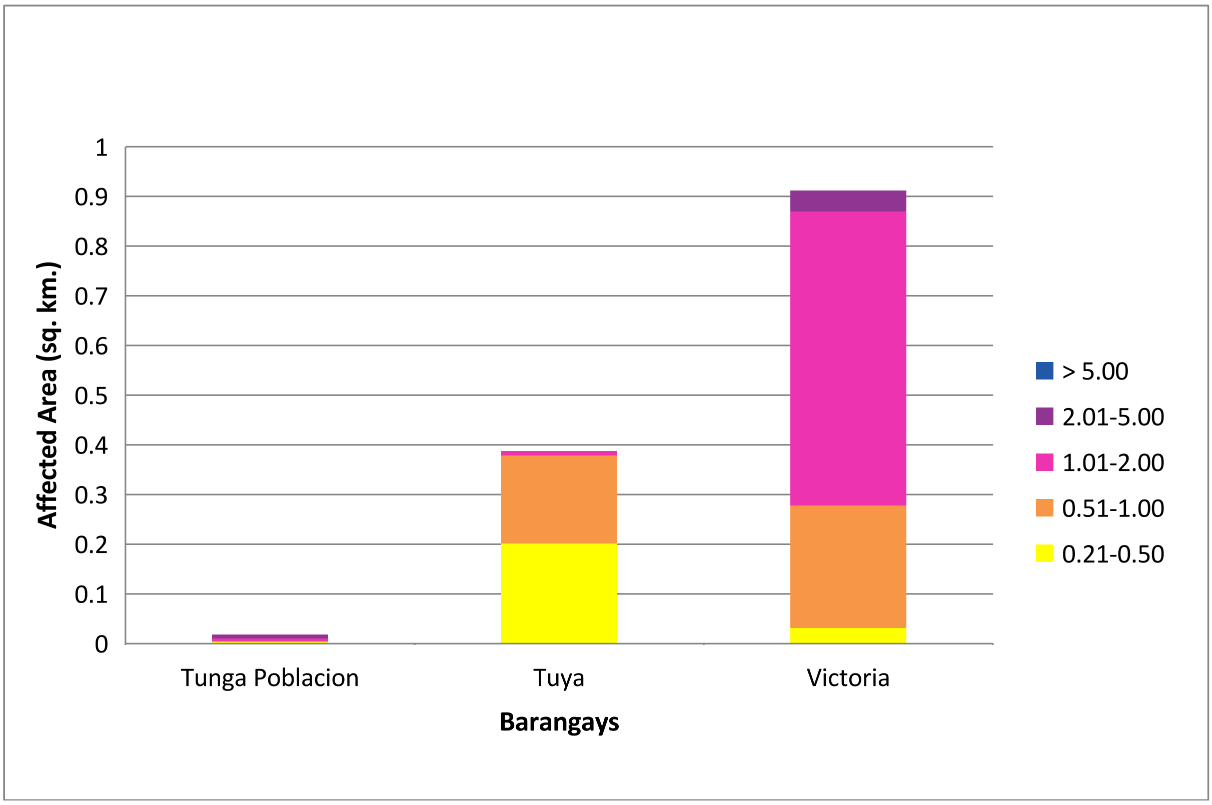


Figure 103. Affected Areas in Dagami, Leyte during 25-Year Rainfall Return Period

For the municipality of Jaro, with an area of 190.65 sq. km., 0.086% will experience flood levels of less 0.20 meters. 0.023% of the area will experience flood levels of 0.21 to 0.50 meters while 0.009%, 0.003%, 0.002%, and 0.0003% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 62 are the affected areas in square kilometres by flood depth per barangay.

Table 62. Affected Areas in Jaro, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)
		Parasan
Affected Area (sq. km.)	0.03-0.20	0.16
	0.21-0.50	0.044
	0.51-1.00	0.018
	1.01-2.00	0.006
	2.01-5.00	0.0043
	> 5.00	0.0007

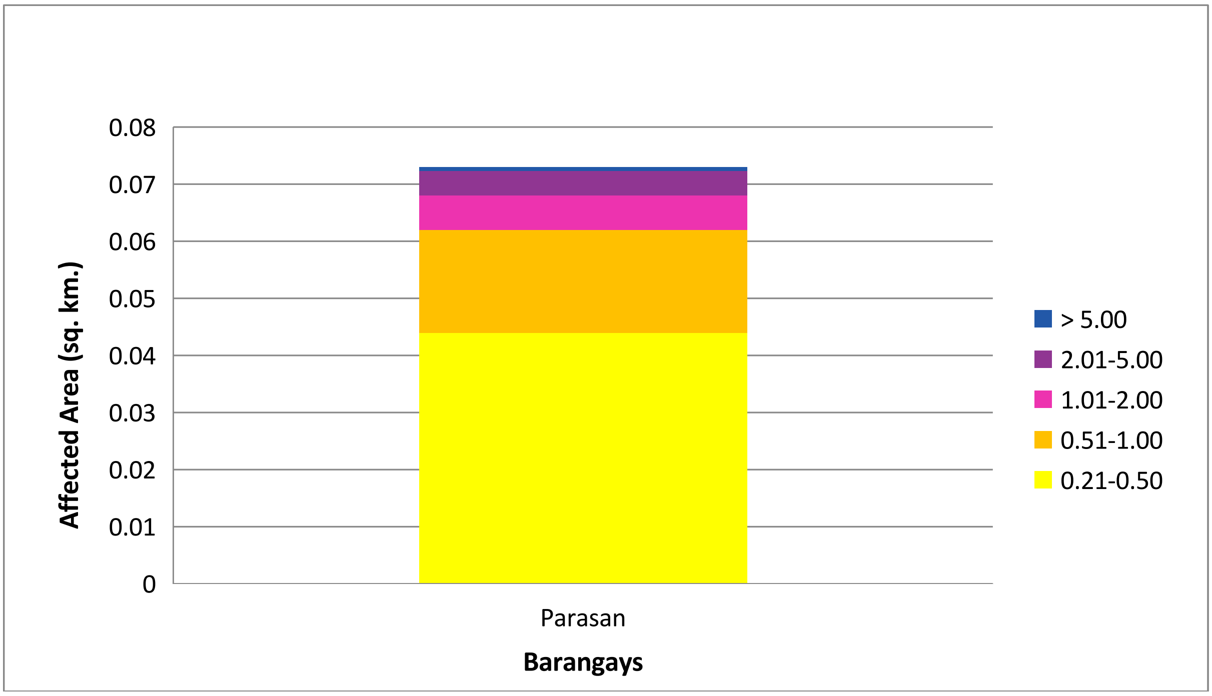


Figure 104. Affected Areas in Jaro, Leyte during 25-Year Rainfall Return Period

For the municipality of Palo, with an area of 65.34 sq. km., 40.17% will experience flood levels of less 0.20 meters. 17.43% of the area will experience flood levels of 0.21 to 0.50 meters while 6.64%, 2.56%, 0.52%, and 0.12% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 63 are the affected areas in square kilometres by flood depth per barangay.

Table 63. Affected Areas in Palo, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Palo (in sq. km.)							
		Anahaway	Arado	Cabarasan Daku	Cabarasan Guti	Cangumbang	Canhidoc	Capirawan	Castilla
Affected Area (sq. km.)	0.03-0.20	1.14	0.53	1.99	0.4	1.84	1.09	1.92	2.31
	0.21-0.50	0.19	0.14	1.06	0.22	1.68	0.56	0.99	0.57
	0.51-1.00	0.02	0.018	0.19	0.34	1.16	0.16	0.06	0.11
	1.01-2.00	0	0.00014	0.0025	0.3	0.7	0.0003	0.0001	0.0024
	2.01-5.00	0	0	0	0.046	0.065	0	0	0.0002
	> 5.00	0	0	0	0.069	0	0	0	0

Table 64. Affected Areas in Palo, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Palo (in sq. km.)						
		Cavite East	Cavite West	Cogon	Gacao	Libertad	Naga-Naga	Salvacion
Affected Area (sq. km.)	0.03-0.20	0.083	0.12	0.46	2.22	0.011	0.047	0.12
	0.21-0.50	0.016	0.041	0.22	0.94	0.0064	0.011	0.024
	0.51-1.00	0.0017	0.0019	0.087	0.28	0.0006	0.016	0.0022
	1.01-2.00	0	0	0.0008	0.032	0	0.0025	0.00048
	2.01-5.00	0	0	0	0	0	0	0
	> 5.00	0	0	0	0	0	0	0

Table 65. Affected Areas in Palo, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Palo (in sq. km.)						
		San Agustin	San Antonio	San Isidro	San Joaquin	Santa Cruz	Tacuranga	Teraza
Affected Area (sq. km.)	0.03-0.20	1.86	0.43	2.14	4.92	0.075	0.57	1.96
	0.21-0.50	0.79	0.48	0.74	1.9	0.025	0.21	0.6
	0.51-1.00	0.19	0.51	0.11	0.84	0.026	0.17	0.032
	1.01-2.00	0.012	0.25	0.0048	0.31	0.0054	0.044	0
	2.01-5.00	0.0001	0	0	0.23	0	0.0001	0
	> 5.00	0	0	0	0.008	0	0	0

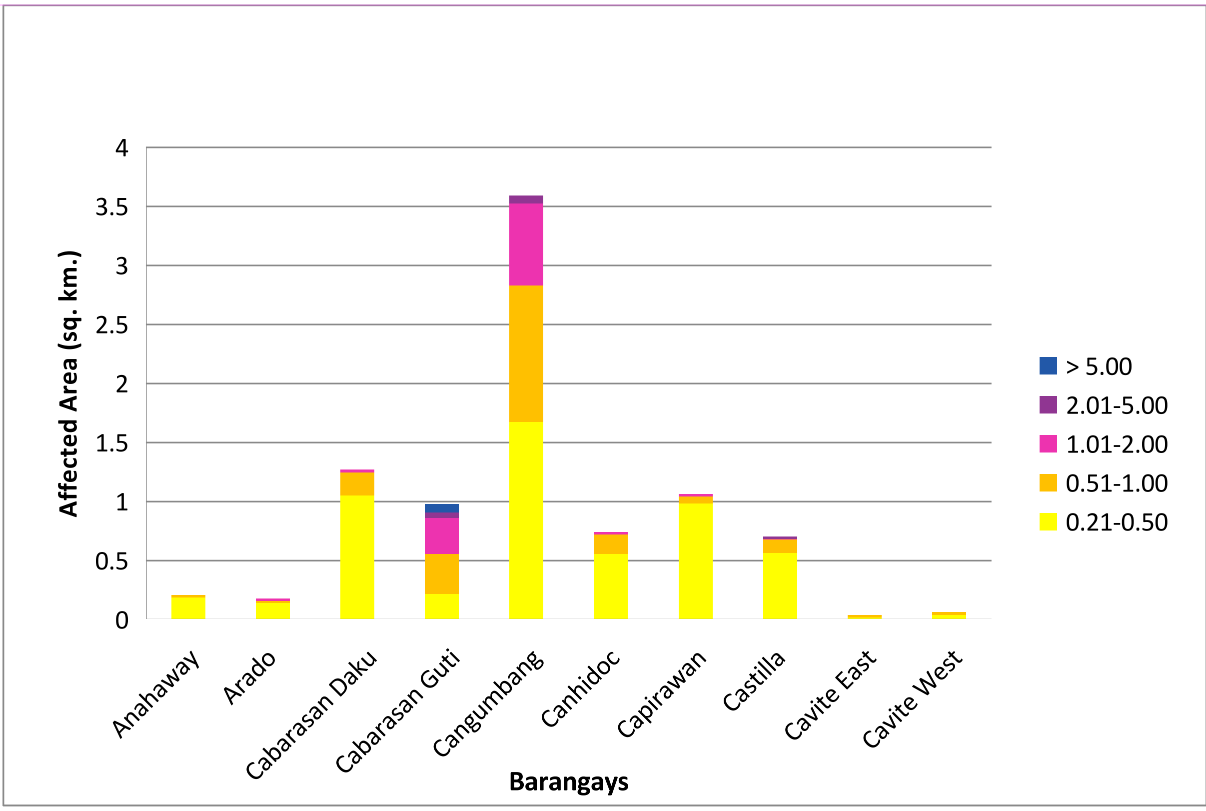


Figure 105. Affected Areas in Palo, Leyte during 25-Year Rainfall Return Period

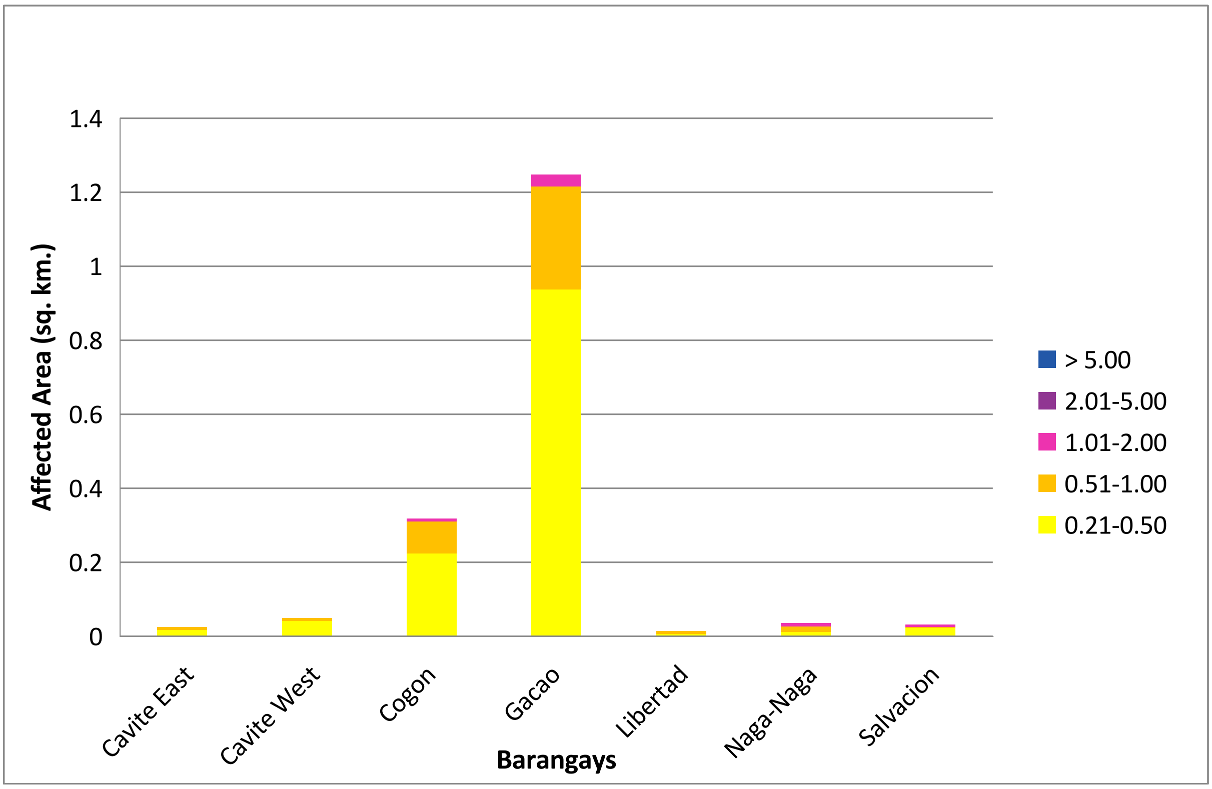


Figure 106. Affected Areas in Palo, Leyte during 25-Year Rainfall Return Period

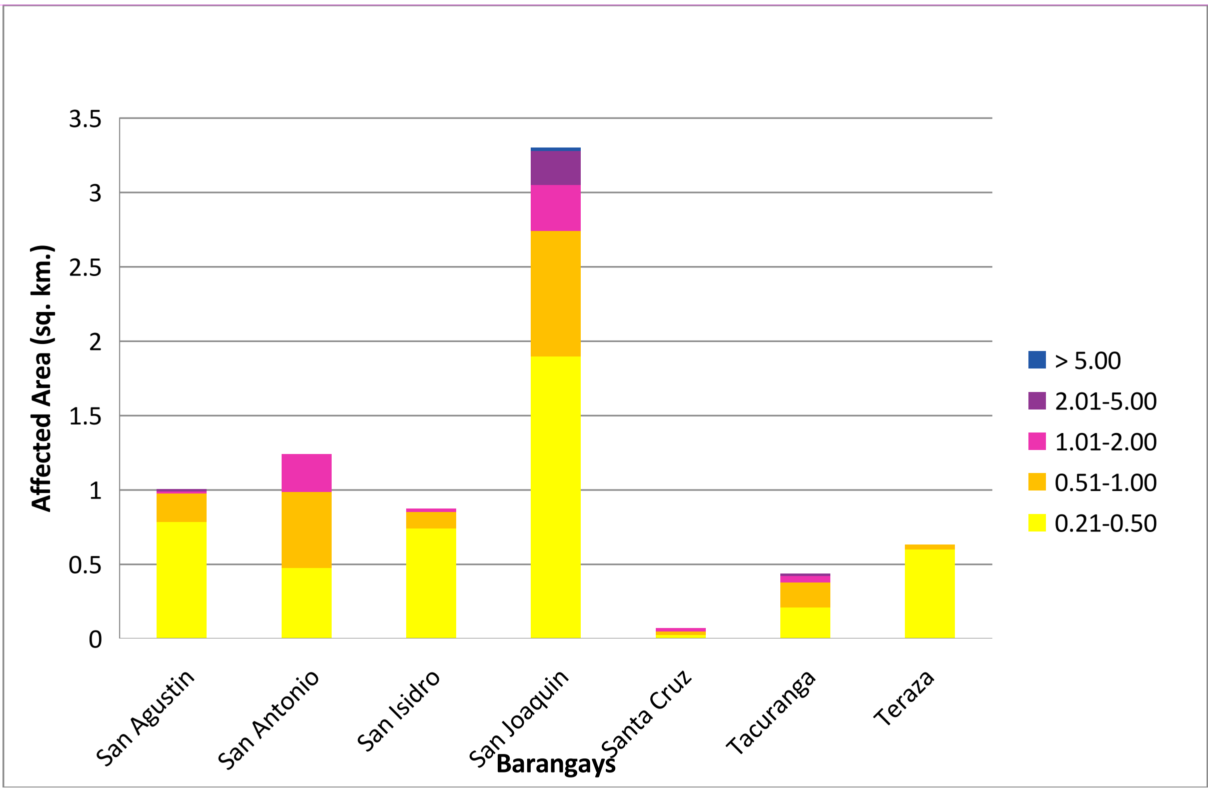


Figure 107. Affected Areas in Palo, Leyte during 25-Year Rainfall Return Period

For the municipality of Pastrana, with an area of 79.17 sq. km., 23.40% will experience flood levels of less 0.20 meters. 9.37% of the area will experience flood levels of 0.21 to 0.50 meters while 6.90%, 5.90%, 2.18%, and 0.09% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 and 5 meters, and more than 5 meters, respectively. Listed in Table 66 are the affected areas in square kilometres by flood depth per barangay.

Table 66. Affected Areas in Pastrana, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Pastrana (in sq. km.)							
		Aringit	Bahay	Cabaohan	Cancaraja	Caninoan	Capilla	Colawen	Dumarag
Affected Area (sq. km.)	0.03-0.20	0.89	1.77	0.42	0.0071	0.89	0.44	1.67	0.89
	0.21-0.50	0.43	0.7	0.11	0.00042	0.31	0.25	0.85	0.51
	0.51-1.00	0.75	0.92	0.037	0.0001	0.19	0.29	0.16	0.15
	1.01-2.00	0.87	0.94	0.0069	0	0.028	0.2	0.015	0.057
	2.01-5.00	0.28	0.47	0	0	0.0002	0.0051	0.0031	0
	> 5.00	0.0001	0.0011	0	0	0	0	0	0

Table 67. Affected Areas in Pastrana, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Pastrana (in sq. km.)							
		Lanawan	Lourdes	Macalpiay	Manaybanay	Maricum	Sapsap	Tingib	Yapad
Affected Area (sq. km.)	0.03-0.20	2.61	2.02	1.16	0.81	1.48	0.44	1.47	1.55
	0.21-0.50	0.88	0.39	0.41	0.23	0.53	0.21	0.37	1.23
	0.51-1.00	0.17	0.49	0.44	0.054	0.01	0.36	0.36	1.09
	1.01-2.00	0.0018	0.46	0.42	0.0004	0	0.28	0.34	1.06
	2.01-5.00	0	0.32	0.16	0	0	0.0057	0.34	0.15
	> 5.00	0	0.014	0.015	0	0	0	0.039	0

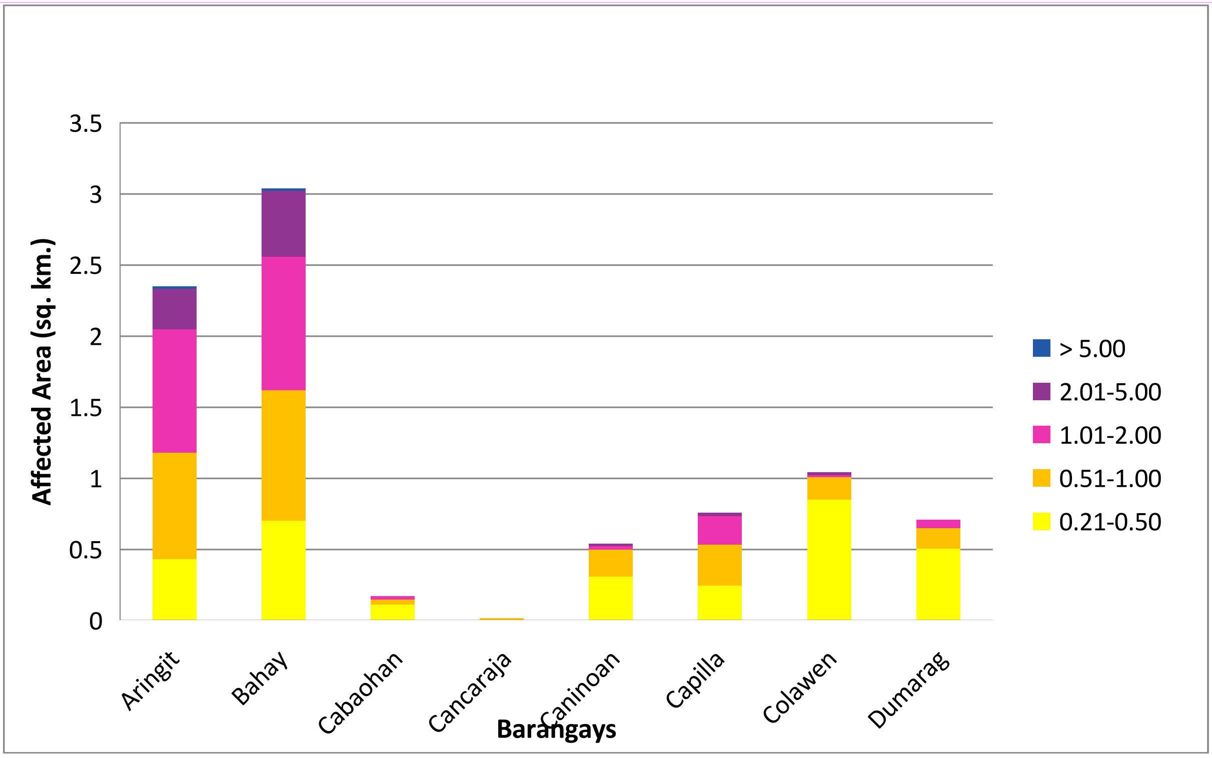


Figure 108. Affected Areas in Pastrana, Leyte during 25-Year Rainfall Return Period

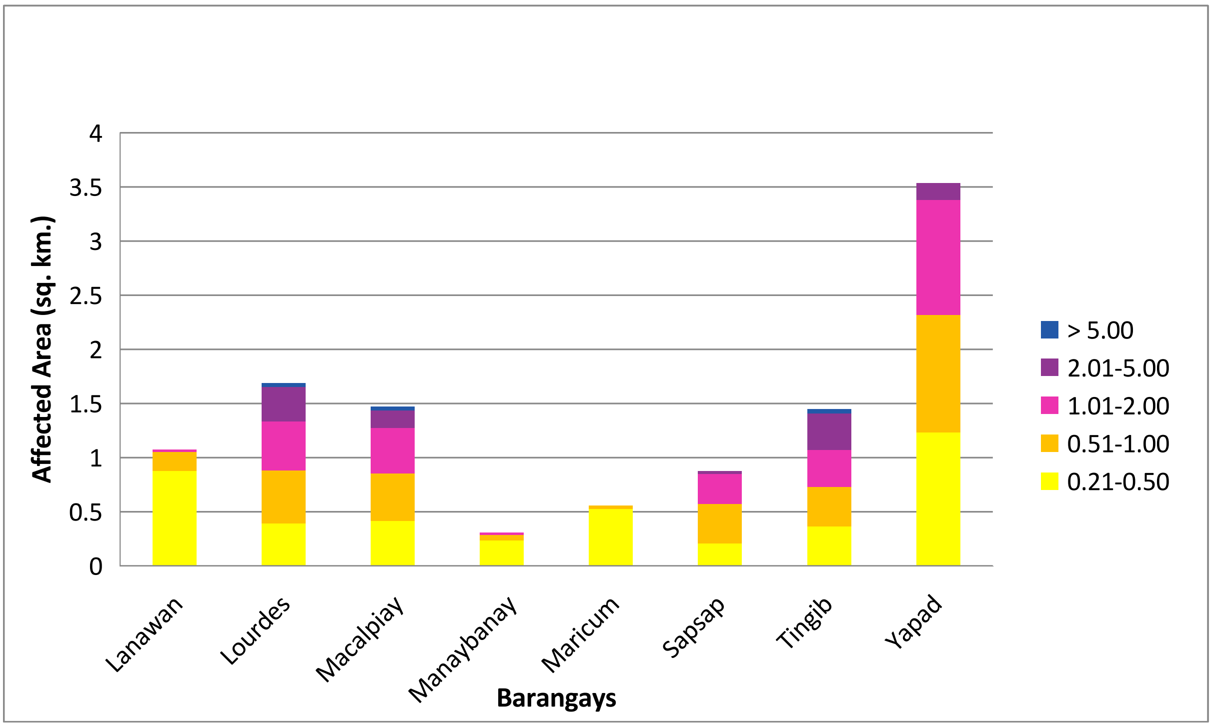


Figure 109. Affected Areas in Pastrana, Leyte during 25-Year Rainfall Return Period

For the municipality of Tabontabon, with an area of 20.46 sq. km., 26.87% will experience flood levels of less 0.20 meters. 9.40% of the area will experience flood levels of 0.21 to 0.50 meters while 3.92%, 3.92%, 1.00%, and 0.035% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 68 are the affected areas in square kilometres by flood depth per barangay.

Table 68. Affected Areas in Tabontabon, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tabontabon (in sq. km.)						
		Belisong	Cambucao	Capahuan	Guingawan	Jabong	Mercadohay	Mering
Affected Area (sq. km.)	0.03-0.20	1.21	0.65	0.67	1	0.83	0.96	0.19
	0.21-0.50	0.5	0.22	0.11	0.26	0.39	0.37	0.063
	0.51-1.00	0.074	0.041	0.088	0.22	0.26	0.077	0.035
	1.01-2.00	0.00034	0.014	0.02	0.16	0.005	0	0.0003
	2.01-5.00	0	0	0	0.0071	0	0	0
	> 5.00	0	0	0	0	0	0	0

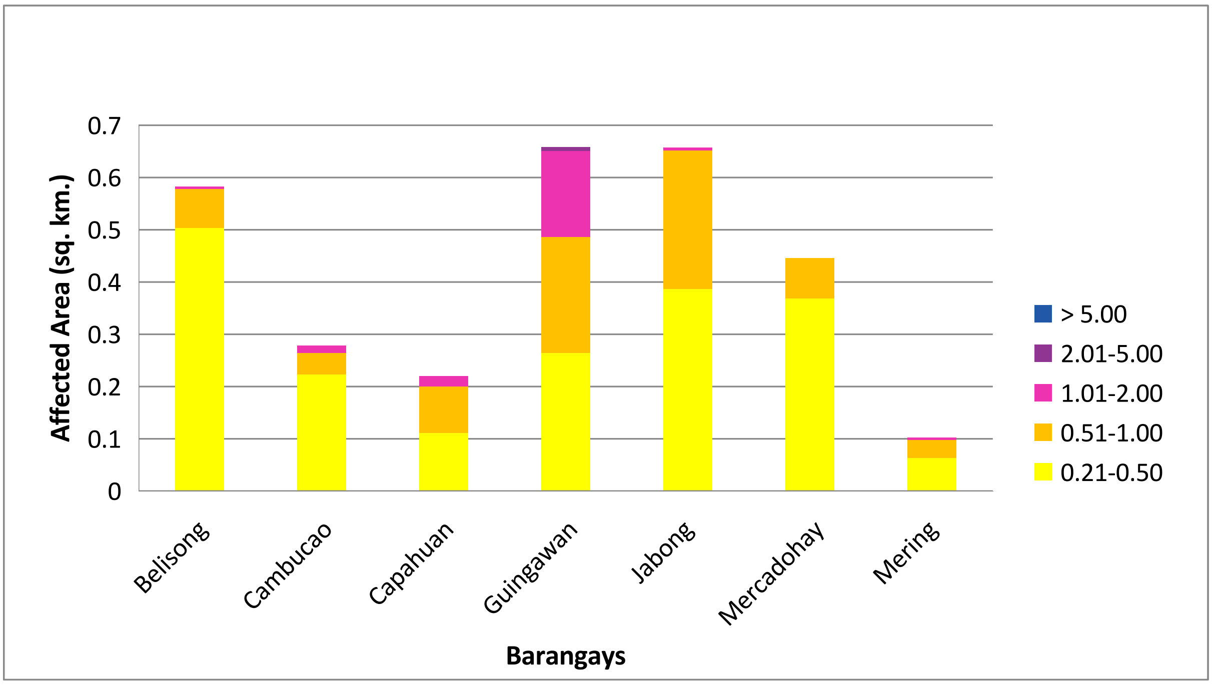


Figure 110. Affected Areas in Tabontabon, Leyte during 25-Year Rainfall Return

For the municipality of Tanauan, with an area of 62.78 sq. km., 32.93% will experience flood levels of less 0.20 meters. 12.80% of the area will experience flood levels of 0.21 to 0.50 meters while 8.37%, 5.91%, 0.59%, and 0.13% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 69 are the affected areas in square kilometres by flood depth per barangay.

Table 69. Affected Areas in Tanauan, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)								
		Amanluran	Atipolo	Balud	Bangon	Bantagan	Baras	Binolo	Binongto-An	Buntay
Affected Area (sq. km.)	0.03-0.20	0.29	0.31	0.7	0.92	0.39	0.66	0.31	1.15	0.13
	0.21-0.50	0.054	0.16	0.26	0.34	0.072	0.21	0.17	0.26	0.067
	0.51-1.00	0.0014	0.045	0.2	0.04	0.021	0.16	0.029	0.44	0.0059
	1.01-2.00	0	0.0013	0.042	0.00028	0.0027	0.012	0.0002	0.68	0
	2.01-5.00	0	0	0.0052	0	0	0	0	0.13	0
	> 5.00	0	0	0.025	0	0	0	0	0.0031	0

Table 70. Affected Areas in Tanauan, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)								
		Cabalagnan	Cabarasan Guti	Cabuynan	Cahumayhumayan	Calogcog	Calsadahay	Camire	Canramos	Catigbian
Affected Area (sq. km.)	0.03-0.20	0.52	0.38	1.12	0.39	0.46	0.074	0.41	0.18	0.4
	0.21-0.50	0.45	0.4	0.25	0.087	0.17	0.044	0.22	0.037	0.15
	0.51-1.00	0.65	0.45	0.15	0.16	0.025	0.0078	0.07	0.00078	0.083
	1.01-2.00	0.32	0.87	0.068	0.087	0.00055	0	0	0	0.009
	2.01-5.00	0.0022	0.0025	0	0.021	0	0	0	0	0.0041
	> 5.00	0.01	0	0	0	0	0	0	0	0

Table 71. Affected Areas in Tanauan, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)							
		Guindag-An	Guingawan	Hilagpad	Kiling	Lapay	Licod	Magay	Maghulod
Affected Area (sq. km.)	0.03-0.20	0.71	0.4	0.49	0.83	0.71	0.052	0.18	0.41
	0.21-0.50	0.27	0.064	0.21	0.44	0.13	0.02	0.068	0.13
	0.51-1.00	0.47	0.023	0.009	0.45	0.12	0.0044	0.0025	0.01
	1.01-2.00	0.72	0.025	0	0.11	0.053	0	0.0002	0.0003
	2.01-5.00	0.016	0.055	0	0.029	0	0	0	0
	> 5.00	0.0079	0	0	0.019	0	0	0	0

Table 72. Affected Areas in Tanauan, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)							
		Malaguicay	Maribi	Mohon	Pago	Pasil	Sacme	Salvador	San Isidro
Affected Area (sq. km.)	0.03-0.20	0.25	0.35	0.34	0.63	0.21	0.017	1.03	0.41
	0.21-0.50	0.11	0.23	0.11	0.36	0.13	0.0022	0.32	0.33
	0.51-1.00	0.077	0.18	0.015	0.15	0.095	0.0005	0.095	0.43
	1.01-2.00	0.006	0.049	0.0006	0.023	0.00035	0	0.033	0.48
	2.01-5.00	0	0	0	0.0002	0	0	0.0002	0.019
	> 5.00	0	0	0	0	0	0	0	0

Table 73. Affected Areas in Tanauan, Leyte during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)							
		San Miguel	San Roque	Santa Cruz	Santa Elena	Santo Niño Poblacion	Solano	Talolora	Tugop
Affected Area (sq. km.)	0.03-0.20	0.39	0.41	0.78	0.23	1.08	0.19	1.04	0.75
	0.21-0.50	0.17	0.12	0.25	0.038	0.37	0.1	0.34	0.33
	0.51-1.00	0.098	0.025	0.071	0.068	0.14	0.011	0.042	0.12
	1.01-2.00	0.011	0.002	0.00095	0.086	0.015	0	0	0.0054
	2.01-5.00	0.0001	0	0	0.089	0	0	0	0
	> 5.00	0	0	0	0.019	0	0	0	0

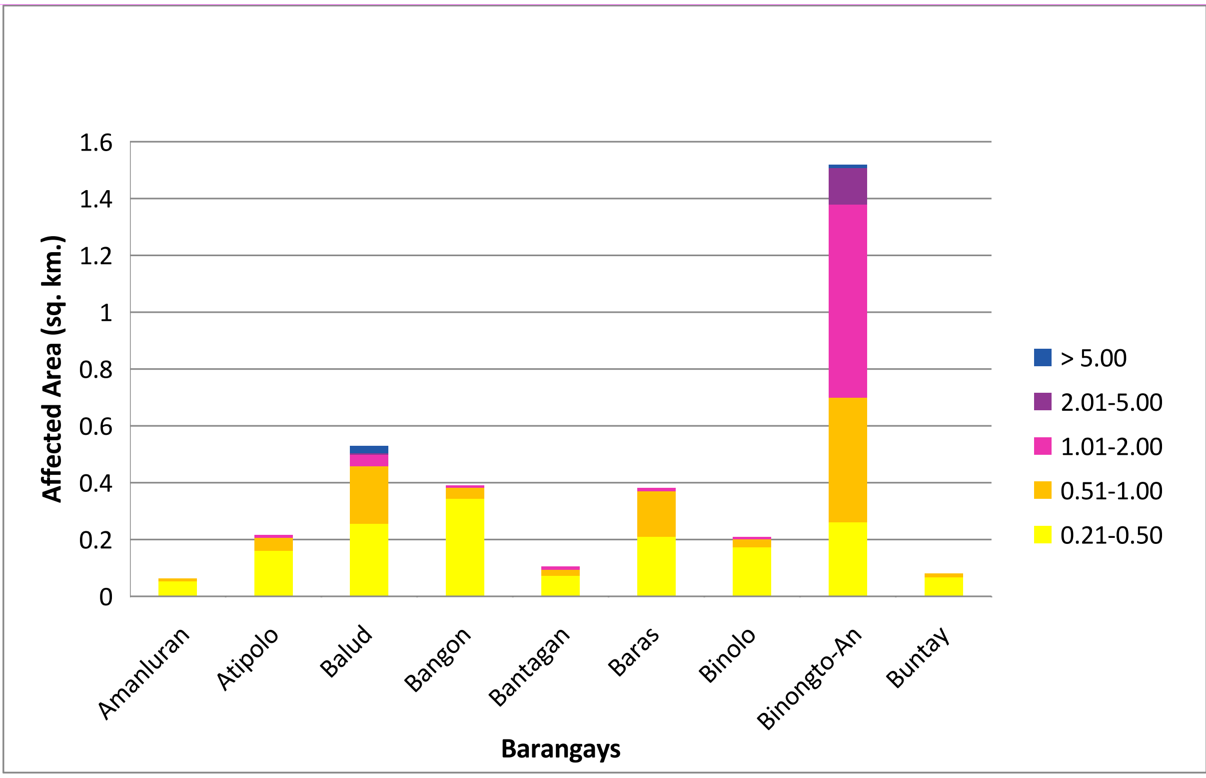


Figure 111. Affected Areas in Tanauan, Leyte during 25-Year Rainfall Return Period

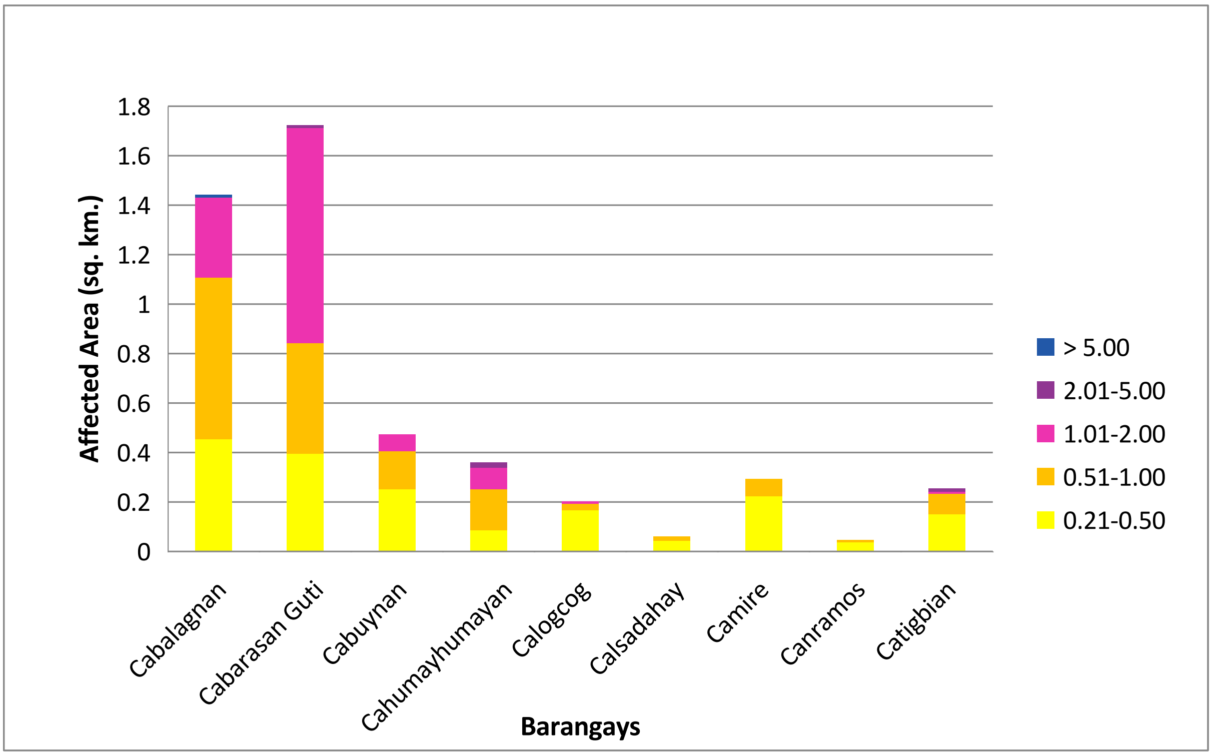


Figure 112. Affected Areas in Tanauan, Leyte during 25-Year Rainfall Return Period

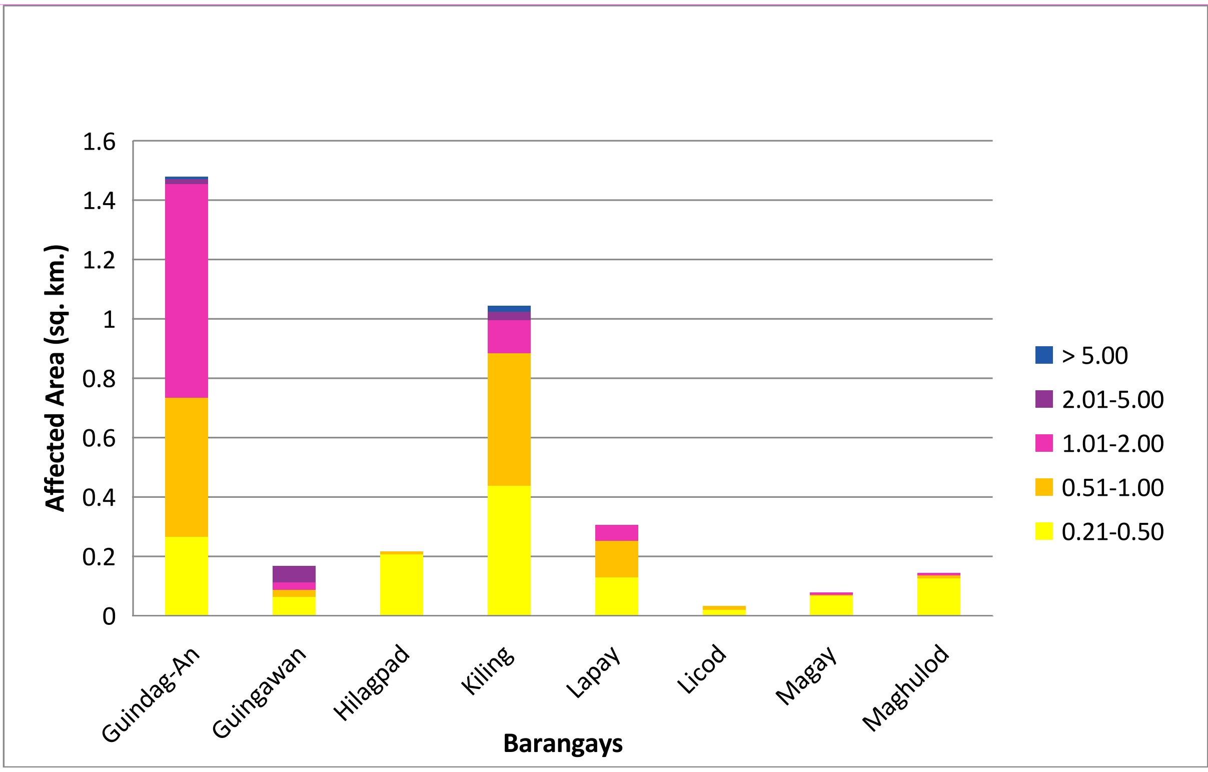


Figure 113. Affected Areas in Tanauan, Leyte during 25-Year Rainfall Return Period

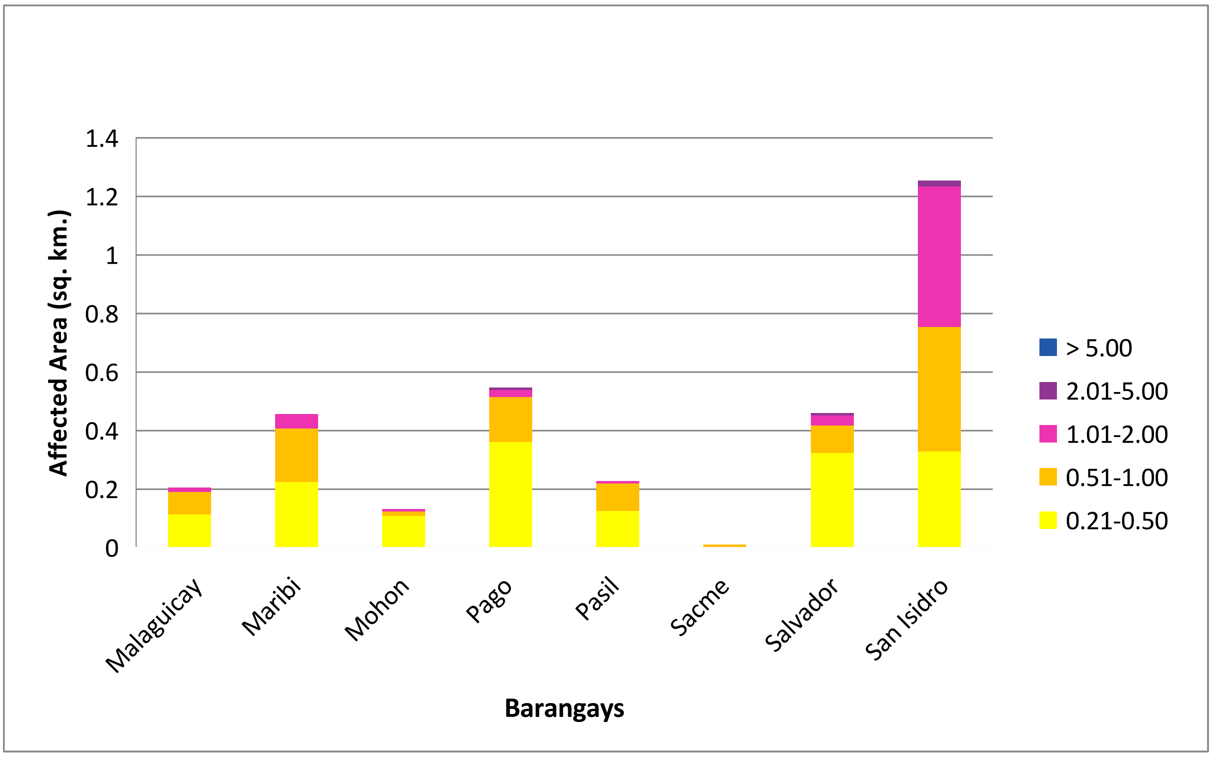


Figure 114. Affected Areas in Tanauan, Leyte during 25-Year Rainfall Return Period

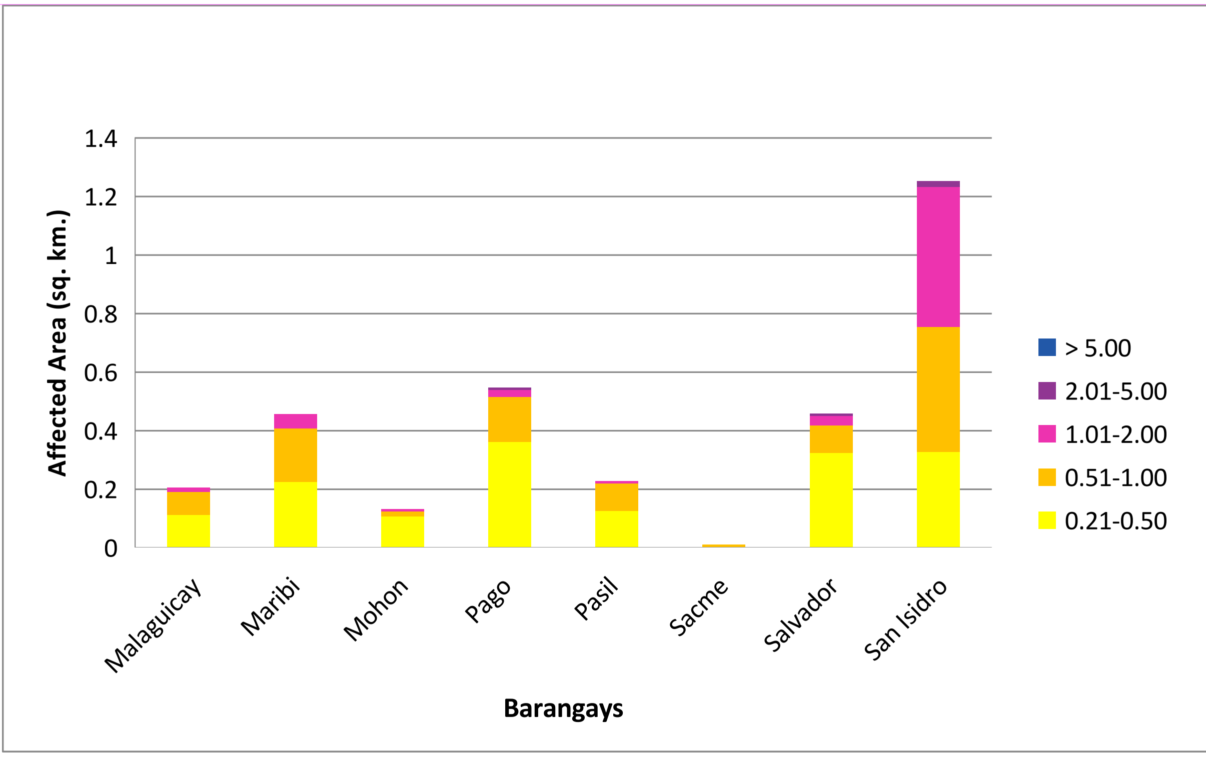


Figure 115. Affected Areas in Tanauan, Leyte during 25-Year Rainfall Return Period

For the 100-year return period, 0.003% of the municipality of Burauen with an area of 205.31 sq. km. will experience flood levels of 0.21 to 0.50 meters while 0.011%, 0.0012% of the area will experience flood depths of 0.51 to 1 meter, and 1.01 to 2 meters. Listed in Table 74 are the affected areas in square kilometres by flood depth per barangay.

Table 74. Affected Areas in Burauen, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Burauen (in sq. km.)		
		Buri	Cadahunan	Tambis
Affected Area (sq. km.)	0.03-0.20	0.044	0.11	0.019
	0.21-0.50	0.0038	0.0019	0
	0.51-1.00	0.021	0.0019	0
	1.01-2.00	0.00093	0.0016	0
	2.01-5.00	0	0	0
	> 5.00	0	0	0

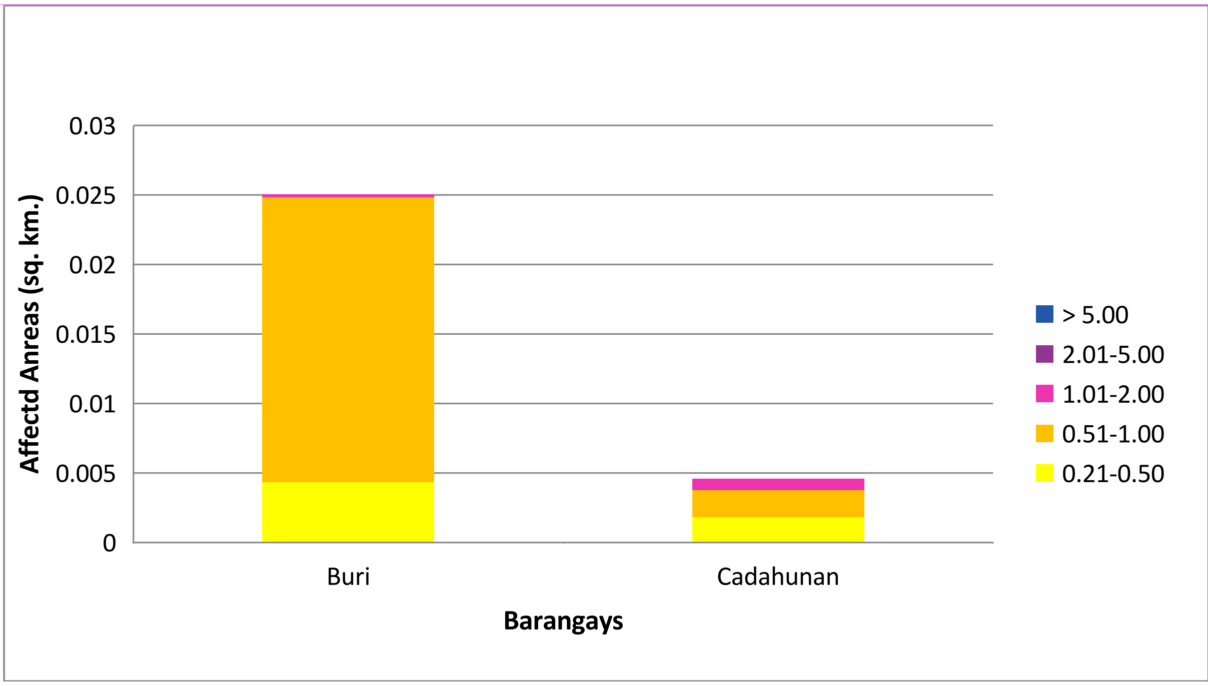


Figure 116. Affected Areas in Burauen, Leyte during 100-Year Rainfall Return Period

For the municipality of Dagami, with an area of 134.08 sq. km., 21.99% will experience flood levels of less 0.20 meters. 6.50% of the area will experience flood levels of 0.21 to 0.50 meters while 8.61%, 9.86%, 5.07%, and 0.28% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 75 are the affected areas in square kilometres by flood depth per barangay.

Table 75. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Abaca	Abre	Balilit	Balugo	Banayon	Bayabas	Bolirao	Buenavista	Buntay	Caanislagan
Affected Area (sq. km.)	0.03-0.20	0.15	0.03	0.04	0.041	1.53	0.86	0.55	0.27	0.2	0.4
	0.21-0.50	0.69	0.017	0.055	0.017	0.78	0.42	0.4	0.028	0.19	0.075
	0.51-1.00	1.29	0.048	0.2	0.034	0.63	0.094	0.12	0.015	0.45	0.029
	1.01-2.00	0.39	0.34	0.56	0.27	0.57	0.0044	0.0005	0.013	0.59	0.049
	2.01-5.00	0.017	0.39	0.064	0.8	0.18	0	0	0.017	1.07	0.052
	> 5.00	0	0	0.0019	0.0008	0	0	0	0.001	0	0.0024

Table 76. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Cabariwan	Cabuloran	Cabunga-An	Calipayan	Calsadahay	Caluctogan	Calutan	Camono-An	Candagara	Canlingga
Affected Area (sq. km.)	0.03-0.20	0.17	0.64	1.63	1.06	0.35	0.074	0.56	0.99	0.00002	0.001
	0.21-0.50	0.084	0.19	0.23	0.051	0.2	0.17	0.25	0.033	0	0.00058
	0.51-1.00	0.083	0.13	0.19	0.05	0.26	0.83	0.22	0.021	0	0.001
	1.01-2.00	0.059	0.14	0.2	0.1	0.28	0.56	0.13	0.019	0	0.019
	2.01-5.00	0.0026	0.0071	0.039	0.2	0.075	0.046	0.0001	0.018	0	0.4
	> 5.00	0	0	0.00015	0.0052	0	0	0	0.0063	0	0.00018

Table 77. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Cansamada East	Cansamada West	Capulhan	Digahongan	Guinarona	Hiabangan	Hilabago	Hinabuyan	Hinologan	Hitumnog
Affected Area (sq. km.)	0.03-0.20	0.67	0.21	0.22	0.19	0.39	0.7	0.63	0.17	0.52	0.45
	0.21-0.50	0.29	0.14	0.06	0.1	0.25	0.053	0.073	0.39	0.32	0.064
	0.51-1.00	0.36	0.24	0.061	0.11	0.096	0.079	0.13	1.24	0.27	0.14
	1.01-2.00	0.37	0.29	0.099	0.19	0.025	0.41	0.25	0.93	0.053	0.25
	2.01-5.00	0.15	0.049	0.13	0.079	0.0057	0.28	0.18	0.042	0.008	0.025
	> 5.00	0.061	0.036	0.016	0.024	0	0.0011	0.0024	0.0002	0	0

Table 78. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Katipunan	Lapu-lapu Poblacion	Lobe-Lobe East	Los Martires	Lusad Poblacion	Macaalang	Maliwaliw	Maragondong	Ormocay	Palacio
Affected Area (sq. km.)	0.03-0.20	3.06	0.026	0.41	0.16	0.001	0.73	1.77	0.53	0.19	1.38
	0.21-0.50	0.16	0.014	0.13	0.13	0.013	0.033	0.65	0.08	0.048	0.27
	0.51-1.00	0.096	0.024	0.071	0.19	0.027	0.021	0.32	0.22	0.029	0.52
	1.01-2.00	0.099	0.023	0.0078	0.17	0.0058	0.021	0.11	0.29	0.0016	0.59
	2.01-5.00	0.11	0.01	0	0.077	0.023	0.022	0.0018	0.17	0	0.44
	> 5.00	0.0057	0	0	0.028	0	0.00075	0	0.025	0	0.0005

Table 79. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		Panda	Paraiso	Patoc	Poponton	Rizal	Salvacion	Sampaguita	Sampao East Poblacion	Sampao West Poblacion	San Antonio Poblacion
Affected Area (sq. km.)	0.03-0.20	0.1	1.91	0.23	0.014	1.14	1.51	0.61	0.0037	0.0088	0.036
	0.21-0.50	0.03	0.13	0.1	0.039	0.033	0.09	0.25	0.01	0.02	0.011
	0.51-1.00	0.12	0.082	0.1	0.24	0.027	0.076	0.039	0.043	0.046	0.026
	1.01-2.00	0.4	0.078	0.18	0.73	0.037	0.051	0.02	0.072	0.021	0.0087
	2.01-5.00	0.12	0.024	0.12	0.15	0.06	0.079	0	0.0001	0.027	0.0012
	> 5.00	0.0018	0	0.04	0	0.0037	0.013	0	0	0	0.0012

Table 80. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)									
		San Benito	San Jose Poblacion	San Roque Poblacion	Santo Domingo	Sawahon	Sirab	Sta. Mesa Poblacion	Tagkip	Talinhugon	Tin-Ao
Affected Area (sq. km.)	0.03-0.20	0.053	0.0075	0.032	0.71	0.48	0.066	0.0015	0.33	0.081	0.056
	0.21-0.50	0.09	0.0082	0.0066	0.15	0.031	0.058	0.0051	0.2	0.05	0.071
	0.51-1.00	0.27	0.024	0.0084	0.059	0.1	0.16	0.024	0.35	0.087	0.29
	1.01-2.00	0.41	0.015	0.0049	0.037	0.37	0.21	0.094	0.58	0.14	0.69
	2.01-5.00	0.075	0.012	0.0092	0.054	0.11	0.063	0.0031	0.28	0.057	0.14
	> 5.00	0.0001	0.0085	0.0033	0	0	0.048	0	0.041	0.0016	0.0001

Table 81. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Burauen (in sq. km.)		
		Tunga Poblacion	Tuya	Victoria
Affected Area (sq. km.)	0.03-0.20	0.0074	0.17	0.0056
	0.21-0.50	0.0059	0.15	0.01
	0.51-1.00	0.0041	0.29	0.15
	1.01-2.00	0.0035	0.038	0.54
	2.01-5.00	0.0053	0.0001	0.22
	> 5.00	0	0	0.0001

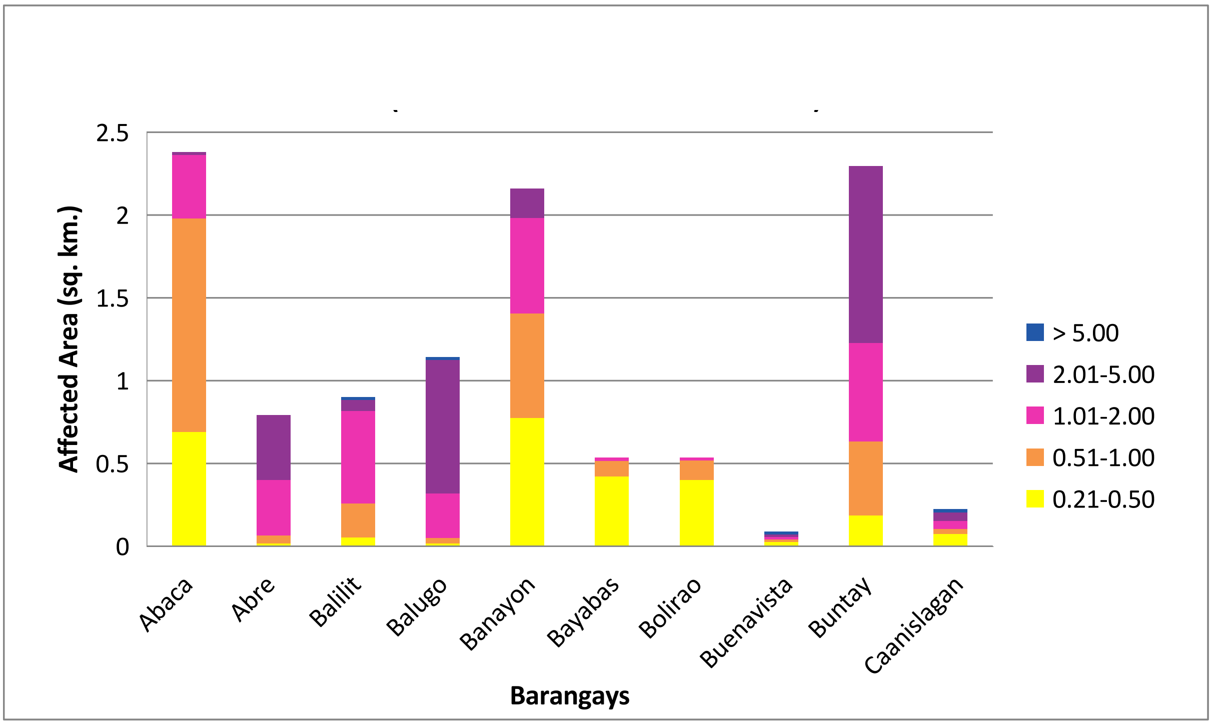


Figure 117. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

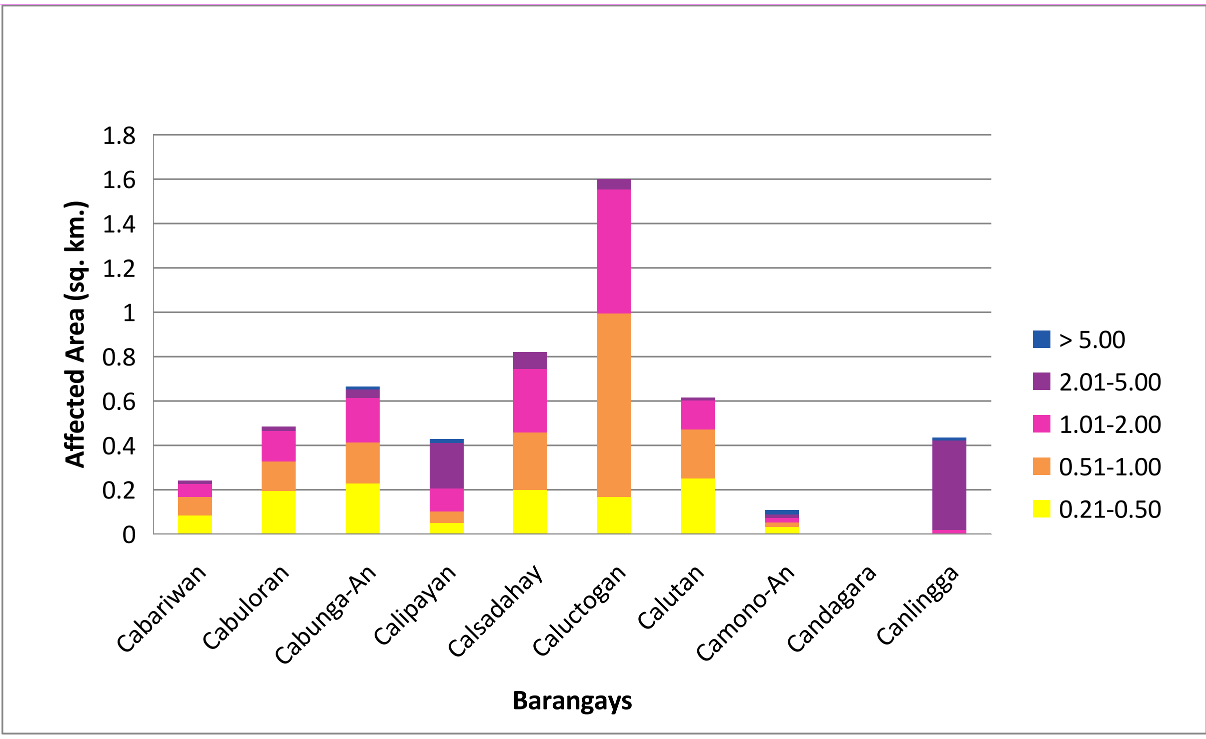


Figure 118. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

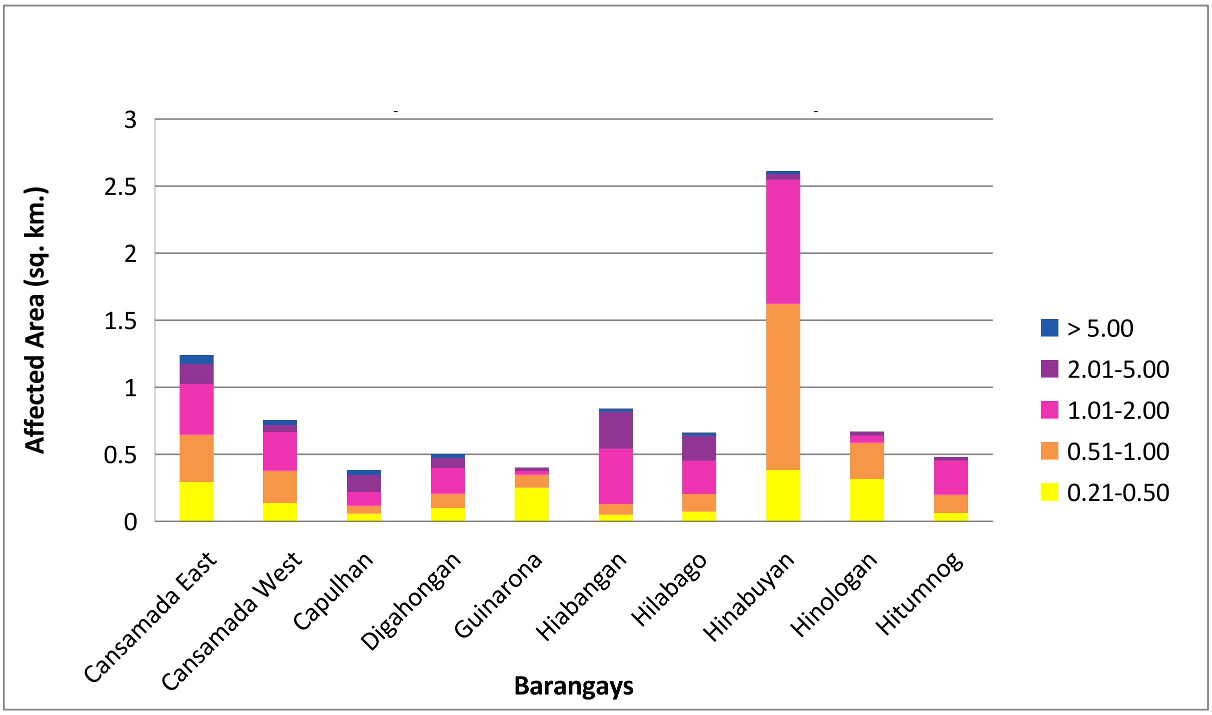


Figure 119. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

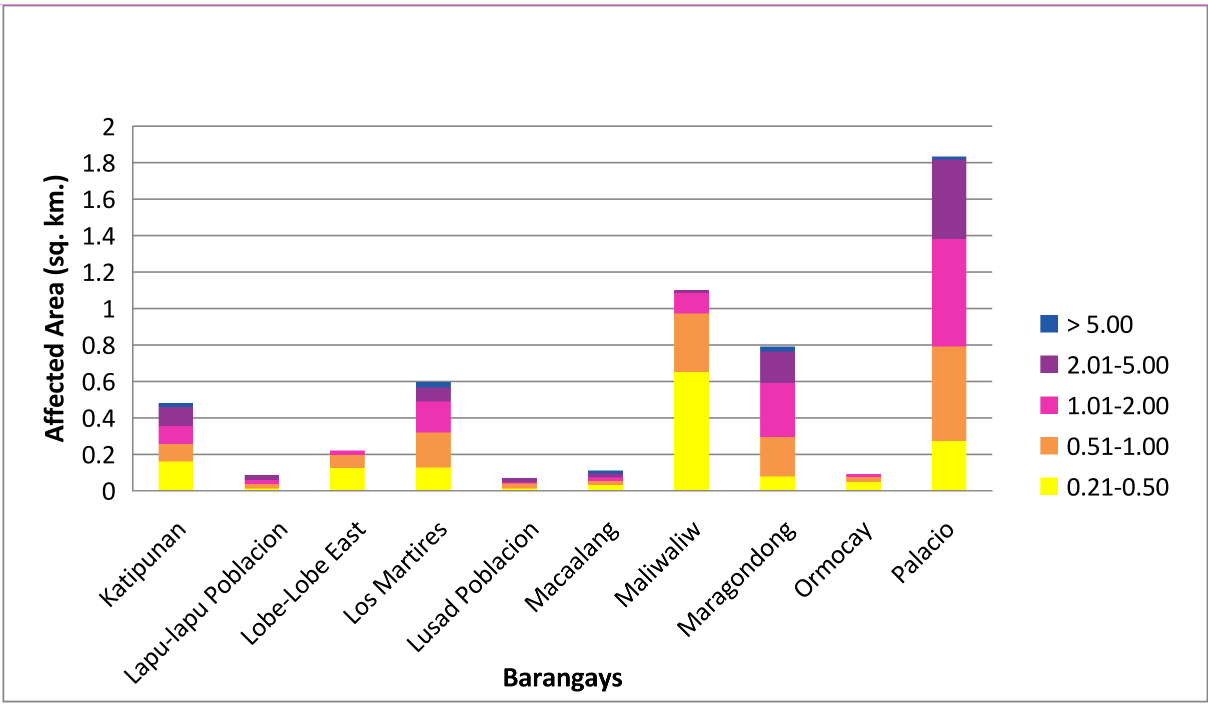


Figure 120. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

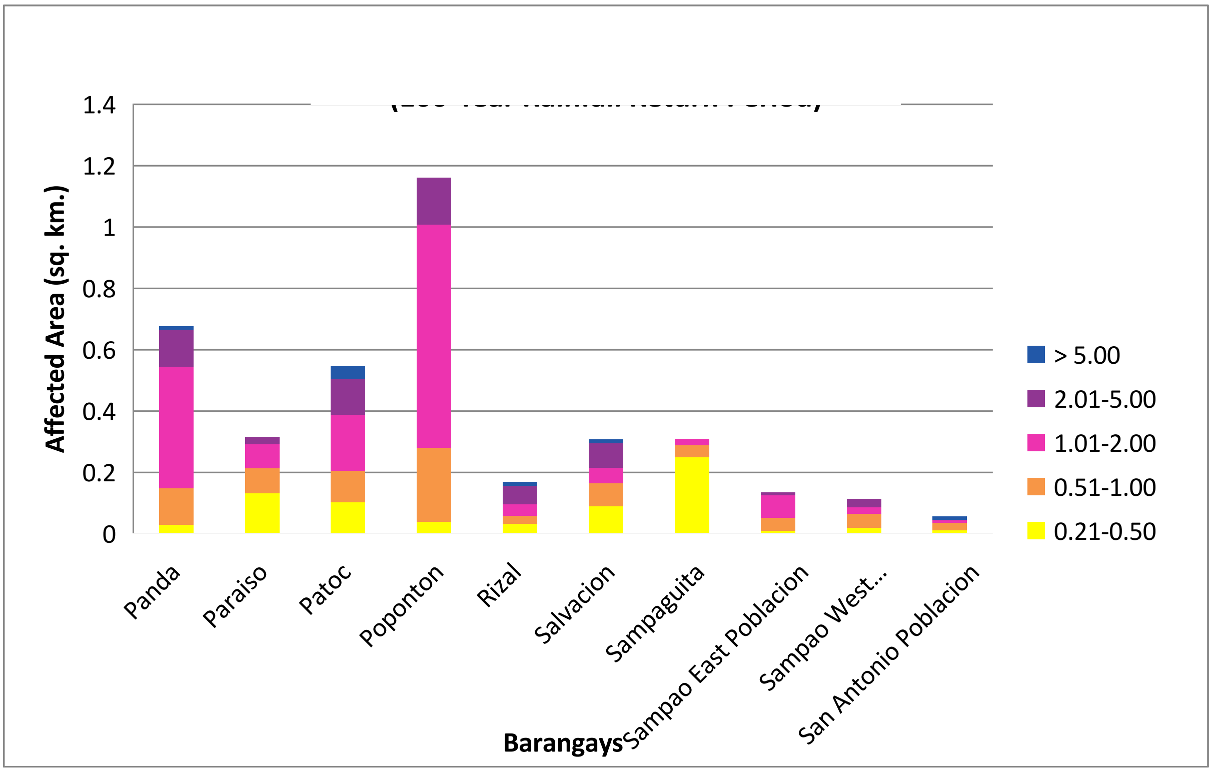


Figure 121. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

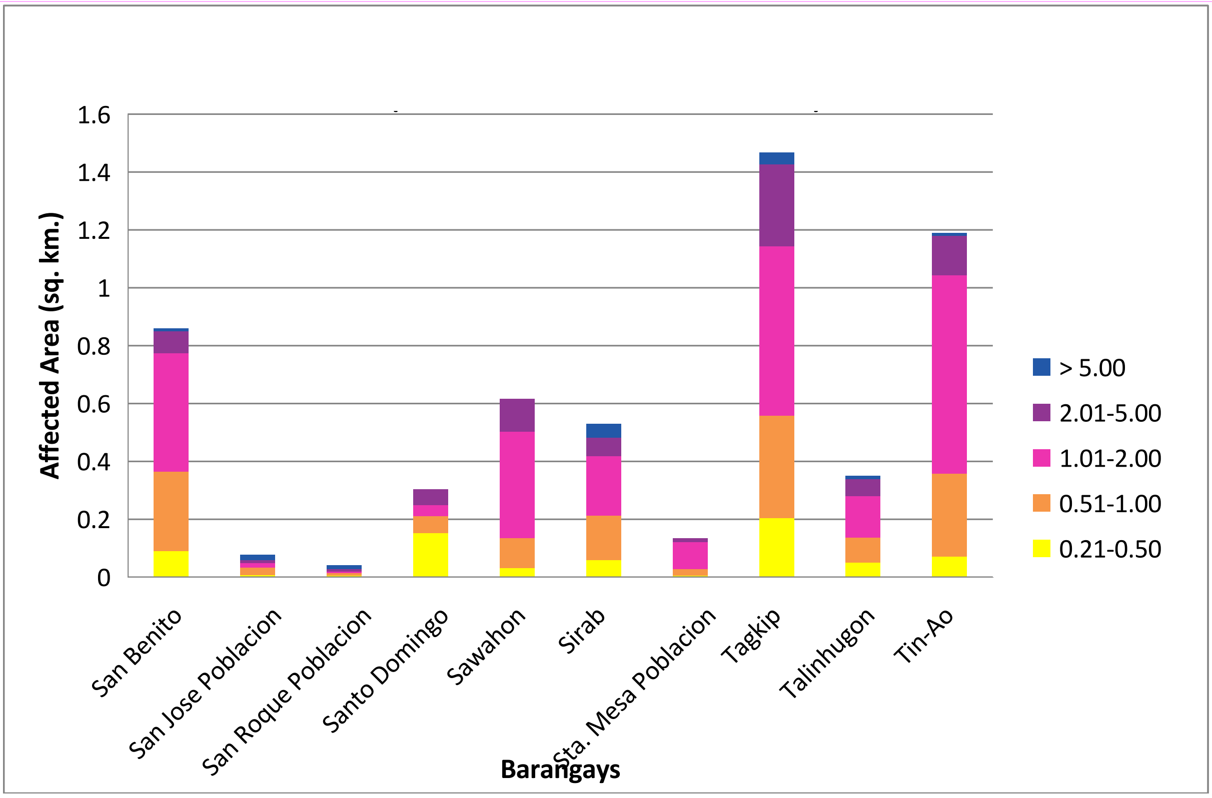


Figure 122. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

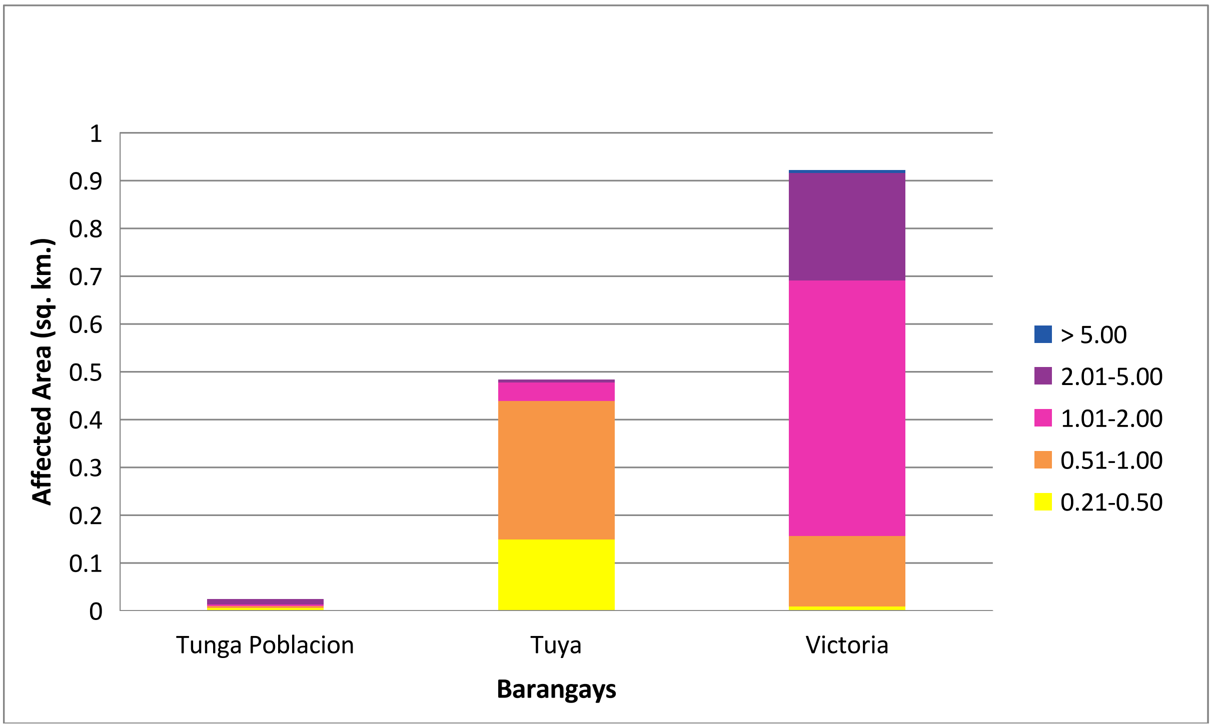


Figure 123. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

For the municipality of Jaro, with an area of 190.65 sq. km., 0.075% will experience flood levels of less 0.20 meters. 0.03% of the area will experience flood levels of 0.21 to 0.50 meters while 0.013%, 0.004%, 0.0026%, and 0.0004% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 82 are the affected areas in square kilometres by flood depth per barangay.

Table 82. Affected Areas in Jaro, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Dagami (in sq. km.)
		Parasan
Affected Area (sq. km.)	0.03-0.20	0.14
	0.21-0.50	0.056
	0.51-1.00	0.024
	1.01-2.00	0.0074
	2.01-5.00	0.0049
	> 5.00	0.0008

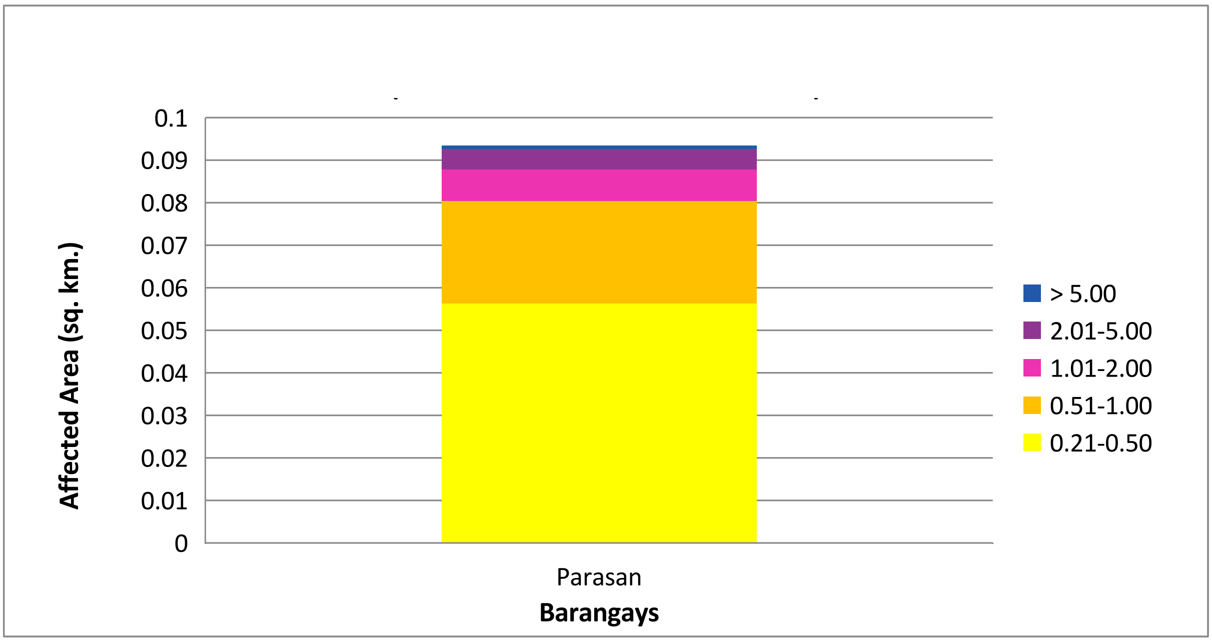


Figure 124. Affected Areas in Dagami, Leyte during 100-Year Rainfall Return Period

For the municipality of Palo, with an area of 65.34 sq. km., 29.83% will experience flood levels of less 0.20 meters. 18.11% of the area will experience flood levels of 0.21 to 0.50 meters while 11.38%, 6.78%, 1.17%, and 0.156% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 83 are the affected areas in square kilometres by flood depth per barangay.

Table 83. Affected Areas in Palo, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Palo (in sq. km.)							
		Anahaway	Arado	Cabarasan Daku	Cabarasan Guti	Cangumbang	Canhidoc	Capirawan	Castilla
Affected Area (sq. km.)	0.03-0.20	1.06	0.49	1.51	0.19	0.77	0.66	1.36	2.08
	0.21-0.50	0.26	0.18	1.15	0.12	1.38	0.46	1.35	0.73
	0.51-1.00	0.031	0.026	0.51	0.31	1.4	0.52	0.25	0.17
	1.01-2.00	0.0002	0.0009	0.067	0.58	1.56	0.17	0.0067	0.0052
	2.01-5.00	0	0	0	0.1	0.33	0	0	0.0002
	> 5.00	0	0	0	0.078	0	0	0	0

Table 84. Affected Areas in Palo, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Palo (in sq. km.)							
		Cavite East	Cavite West	Cogon	Gacao	Libertad	Naga-Naga	Salvacion	San Agustin
Affected Area (sq. km.)	0.03-0.20	0.076	0.1	0.35	1.86	0.0091	0.042	0.1	1.43
	0.21-0.50	0.022	0.06	0.2	1.11	0.0069	0.011	0.032	0.95
	0.51-1.00	0.0034	0.0034	0.19	0.46	0.0018	0.017	0.0052	0.43
	1.01-2.00	4.4E-07	0	0.028	0.044	0	0.0067	0.0011	0.037
	2.01-5.00	0	0	0	0.0003	0	0	0	0.00017
	> 5.00	0	0	0	0	0	0	0	0

Table 85. Affected Areas in Palo, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Palo (in sq. km.)						
		San Agustin	San Antonio	San Isidro	San Joaquin	Santa Cruz	Tacuranga	Teraza
Affected Area (sq. km.)	0.03-0.20	1.43	0.094	1.87	3.21	0.061	0.49	1.68
	0.21-0.50	0.95	0.26	0.93	1.54	0.025	0.21	0.85
	0.51-1.00	0.43	0.76	0.19	1.83	0.03	0.23	0.065
	1.01-2.00	0.037	0.56	0.0086	1.27	0.015	0.067	0
	2.01-5.00	0.00017	0.00044	0	0.33	0	0.0029	0
	> 5.00	0	0	0	0.025	0	0	0

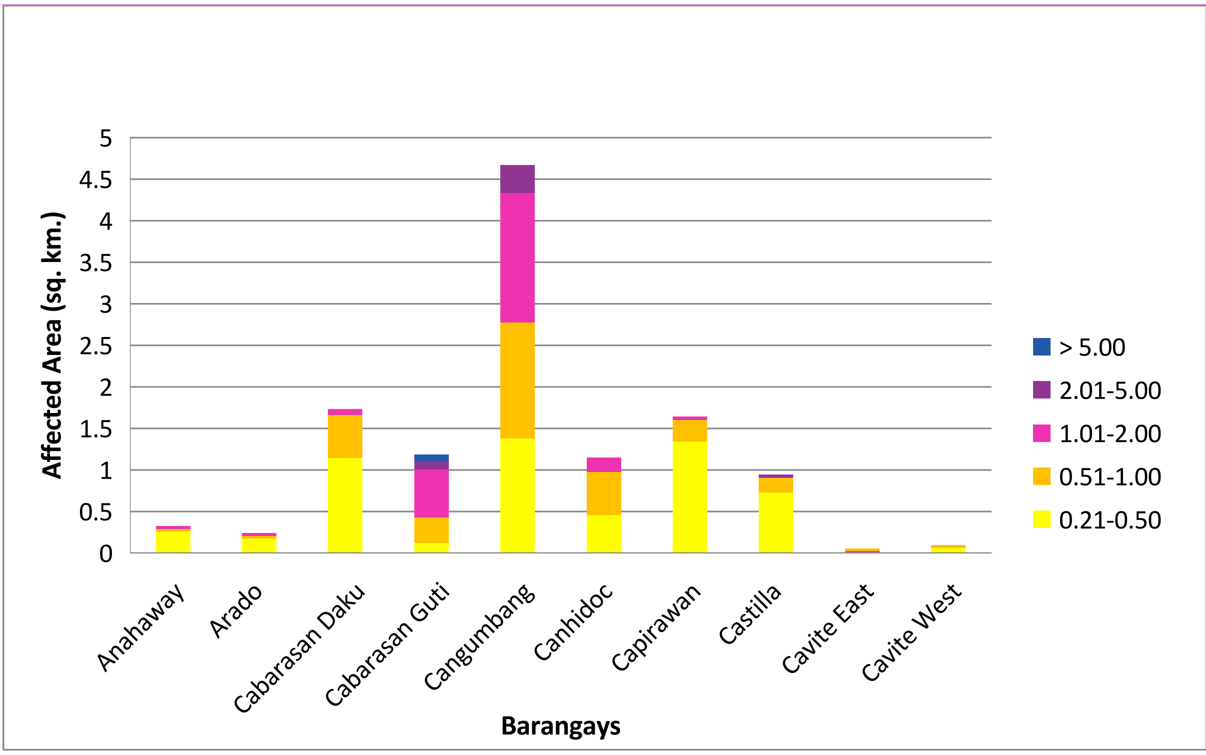


Figure 125. Affected Areas in Palo, Leyte during 100-Year Rainfall Return Period

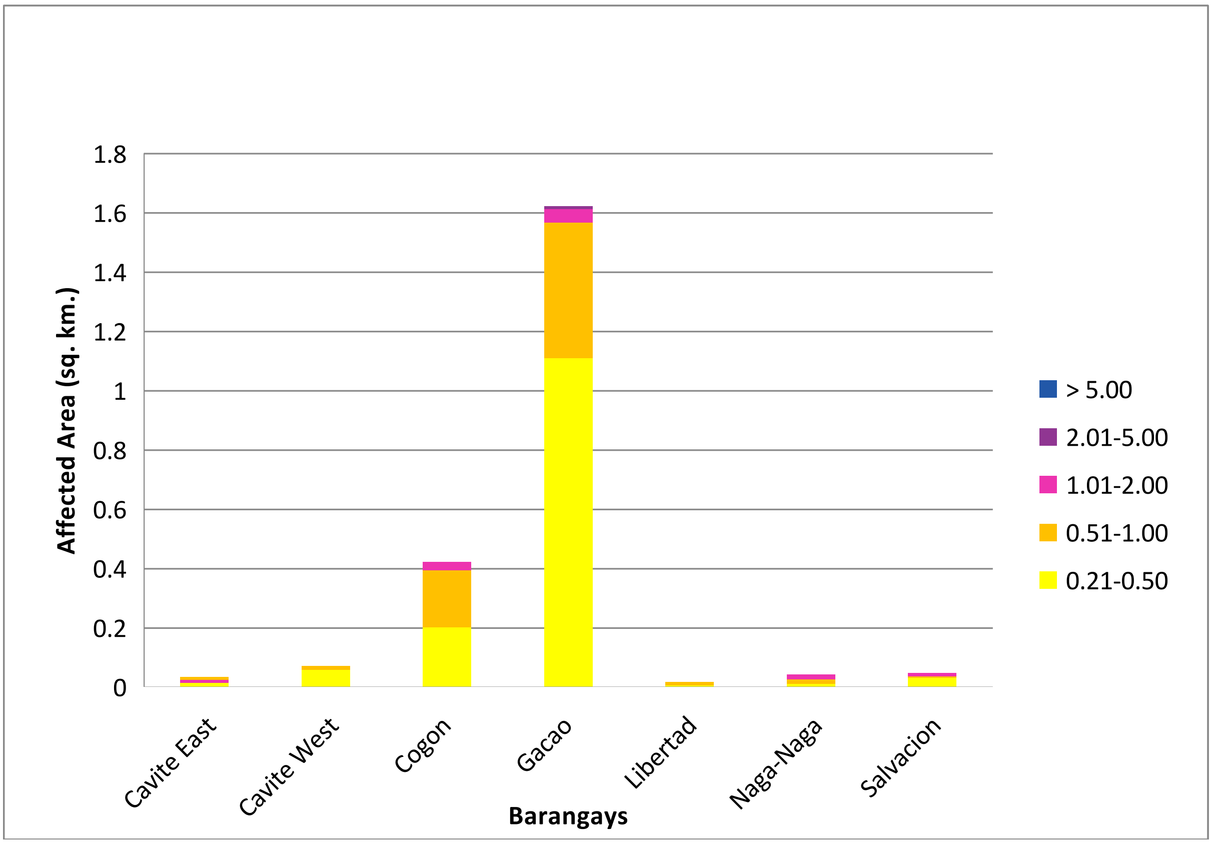


Figure 126. Affected Areas in Palo, Leyte during 100-Year Rainfall Return Period

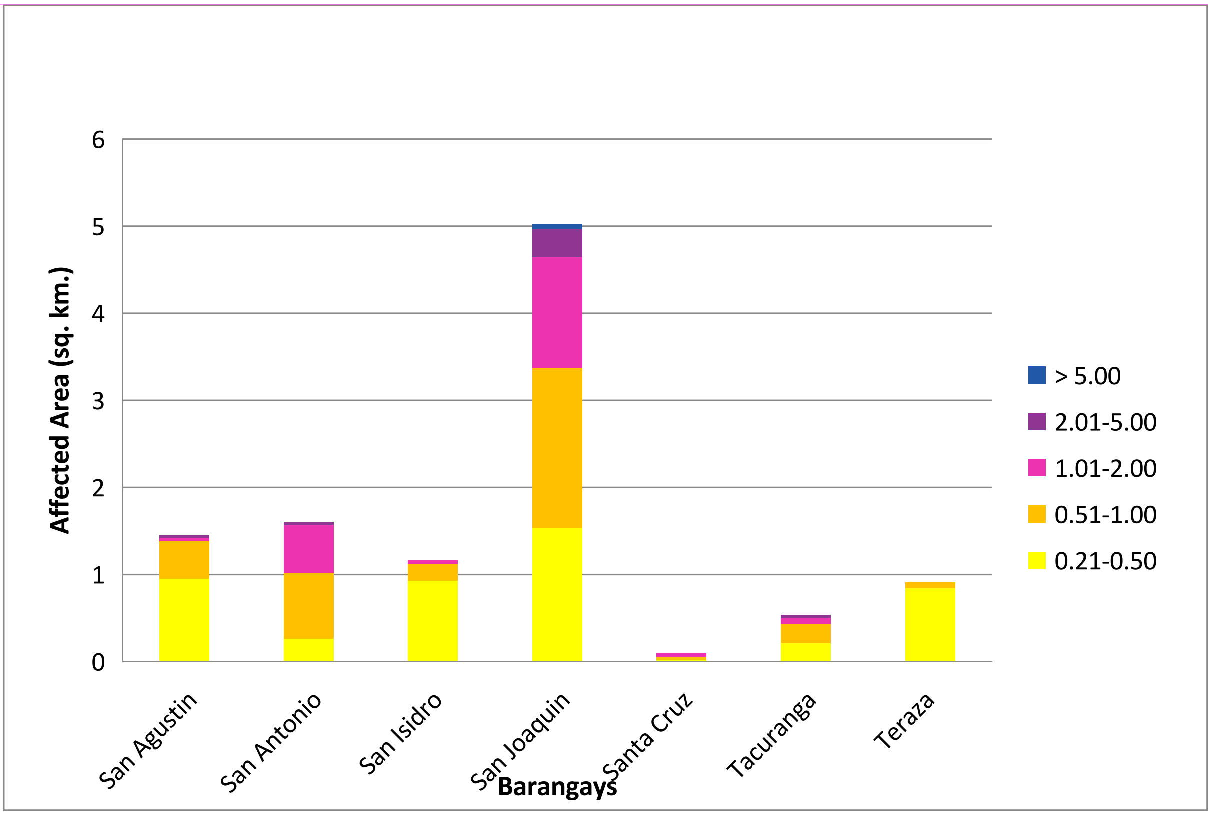


Figure 127. Affected Areas in Palo, Leyte during 100-Year Rainfall Return Period

For the municipality of Pastrana, with an area of 79.17 sq. km., 19.08% will experience flood levels of less 0.20 meters. 9.93% of the area will experience flood levels of 0.21 to 0.50 meters while 8.27%, 7.53%, 2.88%, and 0.14% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to meters, and more than 5 meters, respectively. Listed in Table 86 are the affected areas in square kilometres by flood depth per barangay.

Table 86. Affected Areas in Pastrana, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Pastrana (in sq. km.)							
		Aringit	Bahay	Cabaohan	Cancaraja	Caninoan	Capilla	Colawen	Dumarag
Affected Area (sq. km.)	0.03-0.20	0.69	1.45	0.37	0.007	0.68	0.3	1.29	0.61
	0.21-0.50	0.38	0.62	0.14	0.00052	0.33	0.19	0.98	0.67
	0.51-1.00	0.73	0.95	0.049	0.0001	0.32	0.37	0.39	0.22
	1.01-2.00	1.02	1.18	0.015	0	0.089	0.31	0.034	0.096
	2.01-5.00	0.4	0.6	0.001	0	0.0017	0.014	0.0039	0.00023
	> 5.00	0.0001	0.0017	0	0	0	0	0	0

Table 87. Affected Areas in Pastrana, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Pastrana (in sq. km.)							
		Lanawan	Lourdes	Macalpiay	Manaybanay	Maricum	Sapsap	Tingib	Yapad
Affected Area (sq. km.)	0.03-0.20	2.23	1.85	1.02	0.63	1.24	0.34	1.31	1.08
	0.21-0.50	1.05	0.37	0.4	0.34	0.73	0.19	0.37	1.09
	0.51-1.00	0.37	0.48	0.44	0.12	0.045	0.27	0.38	1.43
	1.01-2.00	0.013	0.58	0.53	0.0056	0	0.48	0.41	1.21
	2.01-5.00	0	0.38	0.21	0	0	0.013	0.38	0.28
	> 5.00	0	0.028	0.022	0	0	0	0.06	0

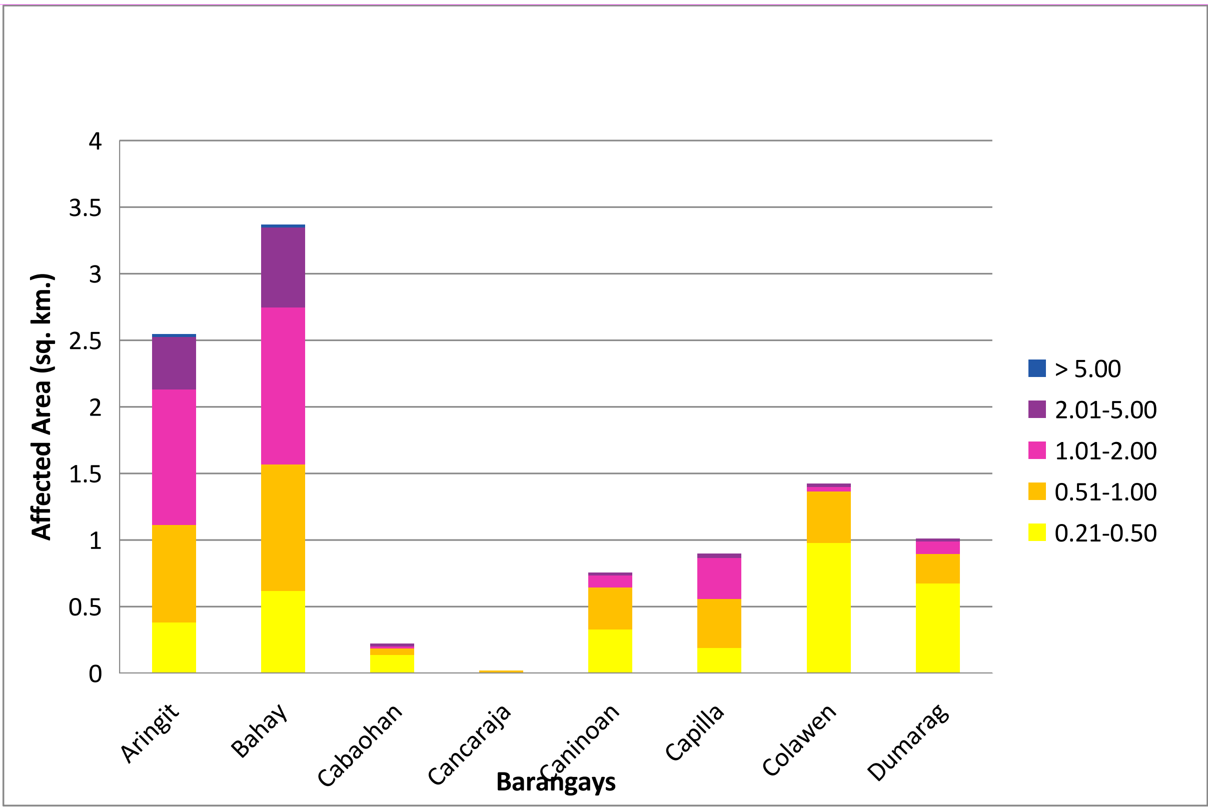


Figure 128. Affected Areas in Pastrana, Leyte during 100-Year Rainfall Return Period

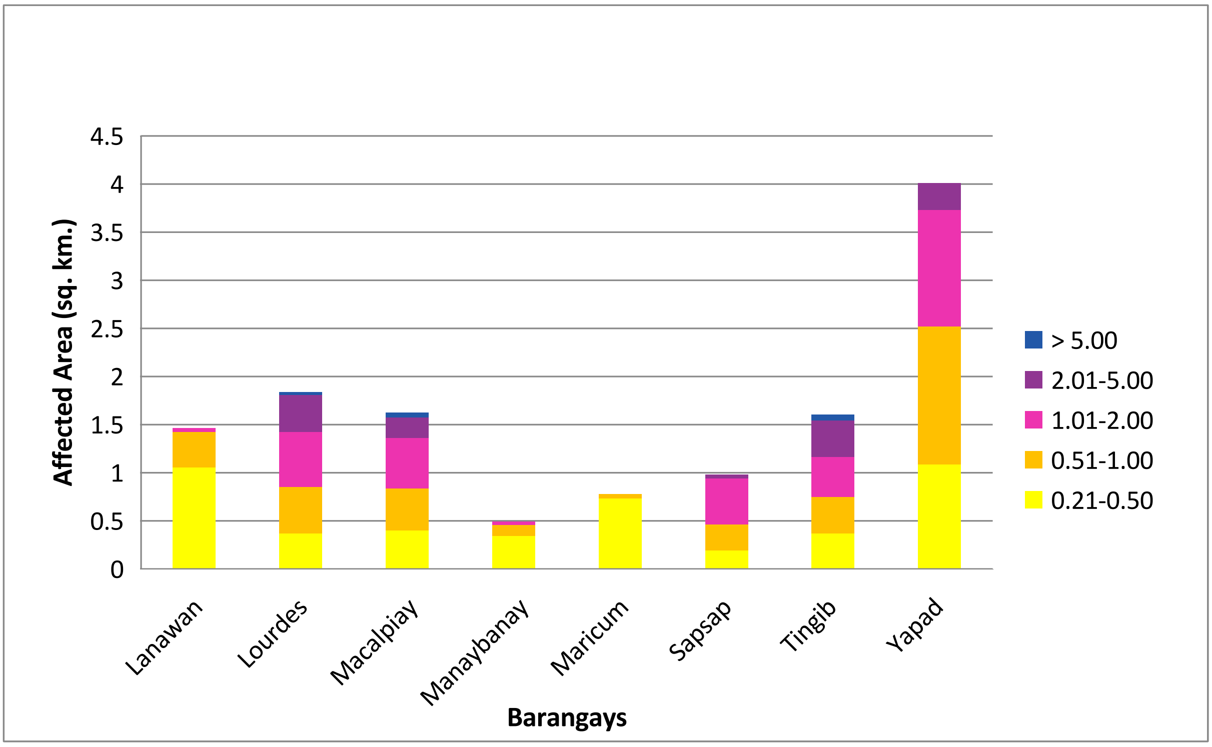


Figure 129. Affected Areas in Pastrana, Leyte during 100-Year Rainfall Return Period

For the municipality of Tabontabon, with an area of 20.46 sq. km., 21.53% will experience flood levels of less 0.20 meters. 10.25% of the area will experience flood levels of 0.21 to 0.50 meters while 5.44%, 3.09%, 0.91% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 88 are the affected areas in square kilometres by flood depth per barangay.

Table 88. Affected Areas in Tabontabon, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tabontabon (in sq. km.)						
		Belisong	Cambucao	Capahuan	Guingawan	Jabong	Mercadohay	Mering
Affected Area (sq. km.)	0.03-0.20	0.99	0.57	0.6	0.57	0.68	0.83	0.16
	0.21-0.50	0.6	0.26	0.13	0.2	0.41	0.44	0.061
	0.51-1.00	0.19	0.076	0.1	0.2	0.37	0.13	0.05
	1.01-2.00	0.011	0.017	0.055	0.5	0.024	0.0002	0.026
	2.01-5.00	0	0	0.0001	0.19	0	0	0
	> 5.00	0	0	0	0	0	0	0

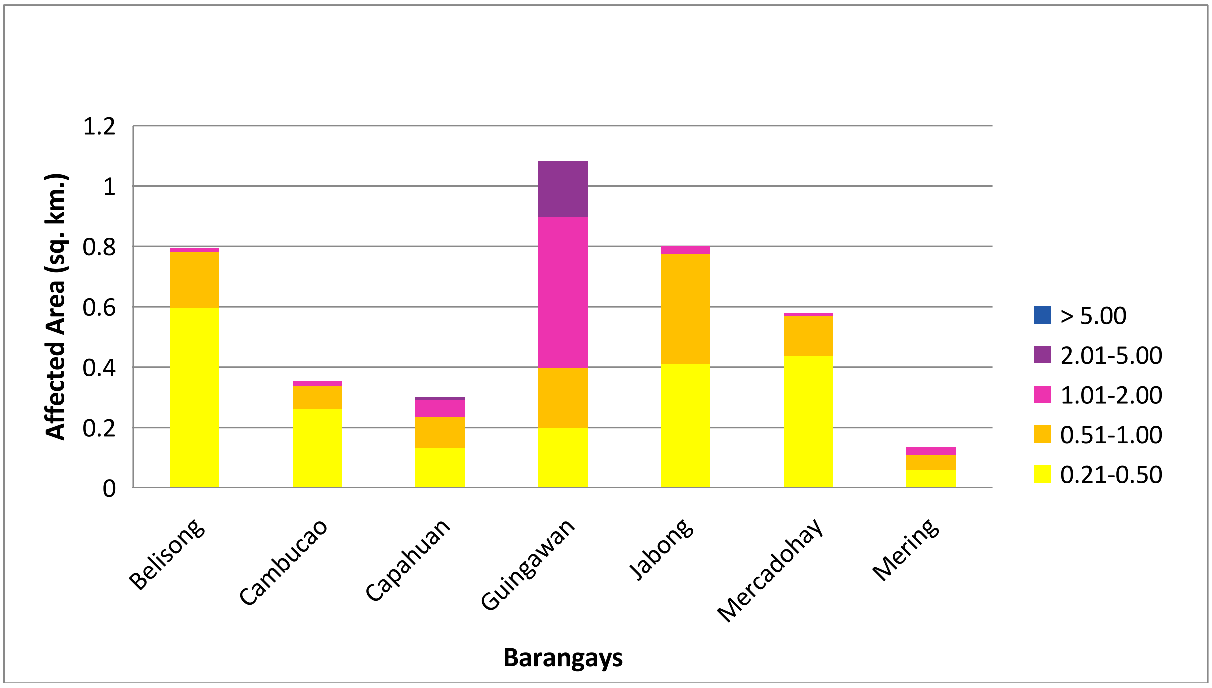


Figure 130. Affected Areas in Tabontabon, Leyte during 100-Year Rainfall Return Period

For the municipality of Tanauan, with an area of 62.78 sq. km., 25.07% will experience flood levels of less 0.20 meters. 12.76% of the area will experience flood levels of 0.21 to 0.50 meters while 11.38%, 10.10%, 1.21%, and 0.22% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 89 are the affected areas in square kilometres by flood depth per barangay.

Table 89. Affected Areas in Tanauan, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)								
		Amanluran	Atipolo	Balud	Bangon	Bantagan	Baras	Binolo	Binongto-An	Buntay
Affected Area (sq. km.)	0.03-0.20	0.26	0.12	0.4	0.8	0.36	0.5	0.24	0.97	0.11
	0.21-0.50	0.073	0.085	0.21	0.42	0.092	0.17	0.19	0.28	0.077
	0.51-1.00	0.0095	0.18	0.33	0.073	0.032	0.26	0.075	0.34	0.017
	1.01-2.00	0	0.14	0.25	0.0017	0.0071	0.11	0.0004	0.9	0
	2.01-5.00	0	0	0.0061	0	0	0	0	0.17	0
	> 5.00	0	0	0.025	0	0	0	0	0.0031	0

Table 90. Affected Areas in Tanauan, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)								
		Cabalagnan	Cabarasan Guti	Cabuynan	Cahumayhumayan	Calogcog	Calsadahay	Camire	Canramos	Catigbian
Affected Area (sq. km.)	0.03-0.20	0.41	0.18	1.05	0.29	0.4	0.067	0.13	0.15	0.24
	0.21-0.50	0.36	0.27	0.19	0.11	0.22	0.041	0.11	0.051	0.12
	0.51-1.00	0.71	0.52	0.19	0.11	0.042	0.017	0.17	0.016	0.12
	1.01-2.00	0.47	1.03	0.15	0.22	0.0011	0	0.3	0.0029	0.11
	2.01-5.00	0.0034	0.09	0.0002	0.013	0	0	0	0	0.05
	> 5.00	0.01	0	0	0.011	0	0	0	0	0

Table 91. Affected Areas in Tanauan, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)							
		Guindag-An	Guingawan	Hilagpad	Kiling	Lapay	Licod	Magay	Maghulod
Affected Area (sq. km.)	0.03-0.20	0.6	0.29	0.4	0.65	0.54	0.028	0.12	0.32
	0.21-0.50	0.22	0.087	0.27	0.44	0.15	0.018	0.11	0.16
	0.51-1.00	0.34	0.072	0.031	0.5	0.14	0.018	0.018	0.041
	1.01-2.00	0.86	0.04	0	0.23	0.18	0.012	0.0015	0.024
	2.01-5.00	0.17	0.042	0	0.034	0.008	0	0	0
	> 5.00	0.008	0.038	0	0.019	0	0	0	0

Table 92. Affected Areas in Tanauan, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)							
		Malaguicay	Maribi	Mohon	Pago	Pasil	Sacme	Salvador	San Isidro
Affected Area (sq. km.)	0.03-0.20	0.15	0.24	0.27	0.36	0.14	0.014	0.84	0.24
	0.21-0.50	0.14	0.22	0.15	0.31	0.12	0.0039	0.38	0.25
	0.51-1.00	0.13	0.25	0.04	0.4	0.17	0.0012	0.2	0.42
	1.01-2.00	0.023	0.089	0.0016	0.1	0.0034	0	0.056	0.68
	2.01-5.00	0	0.0001	0	0.00062	1.4E-09	0	0.0008	0.058
	> 5.00	0	0	0	0	0	0	0	0.0054

Table 93. Affected Areas in Tanauan, Leyte during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Affected Barangays in Tanauan (in sq. km.)							
		San Miguel	San Roque	Santa Cruz	Santa Elena	Santo Niño Poblacion	Solano	Talolora	Tugop
Affected Area (sq. km.)	0.03-0.20	0.093	0.37	0.71	0.21	0.8	0.15	0.89	0.63
	0.21-0.50	0.16	0.14	0.27	0.035	0.41	0.089	0.45	0.34
	0.51-1.00	0.3	0.042	0.12	0.06	0.32	0.034	0.081	0.21
	1.01-2.00	0.13	0.0035	0.0029	0.084	0.07	0.026	0	0.025
	2.01-5.00	0.00018	0	0	0.11	0.00028	0	0	0
	> 5.00	0	0	0	0.02	0	0	0	0

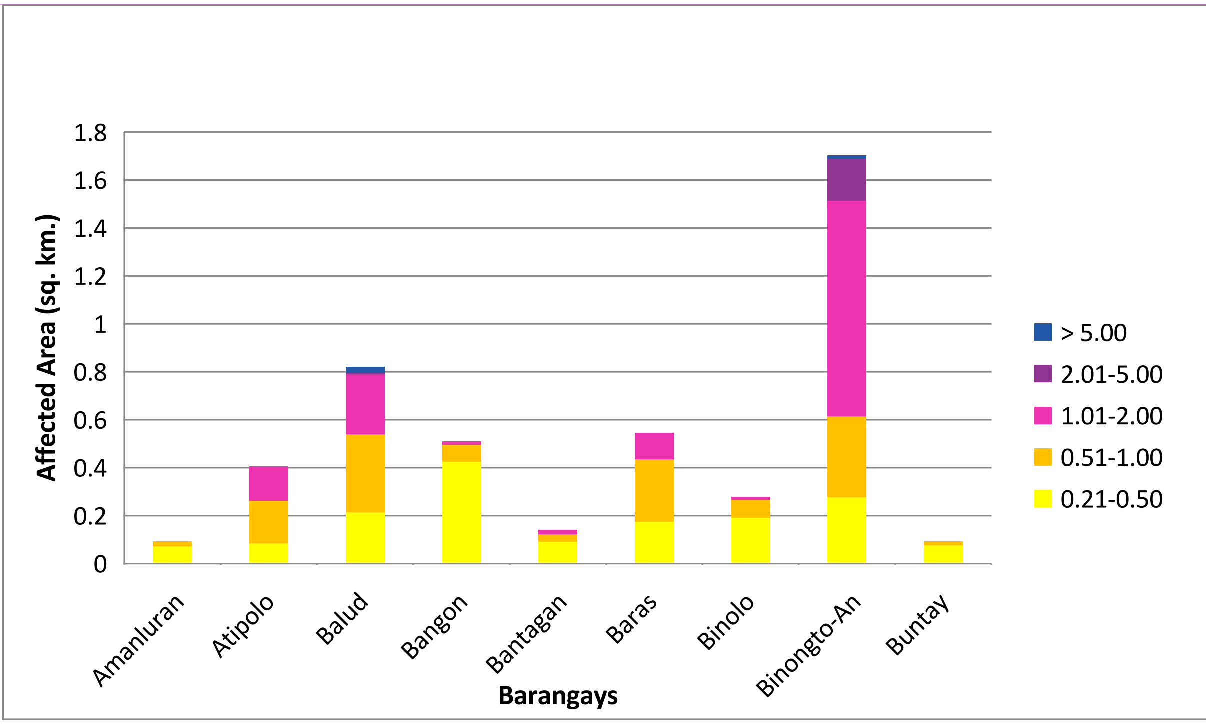


Figure 131. Affected Areas in Tanauan, Leyte during 100-Year Rainfall Return Period

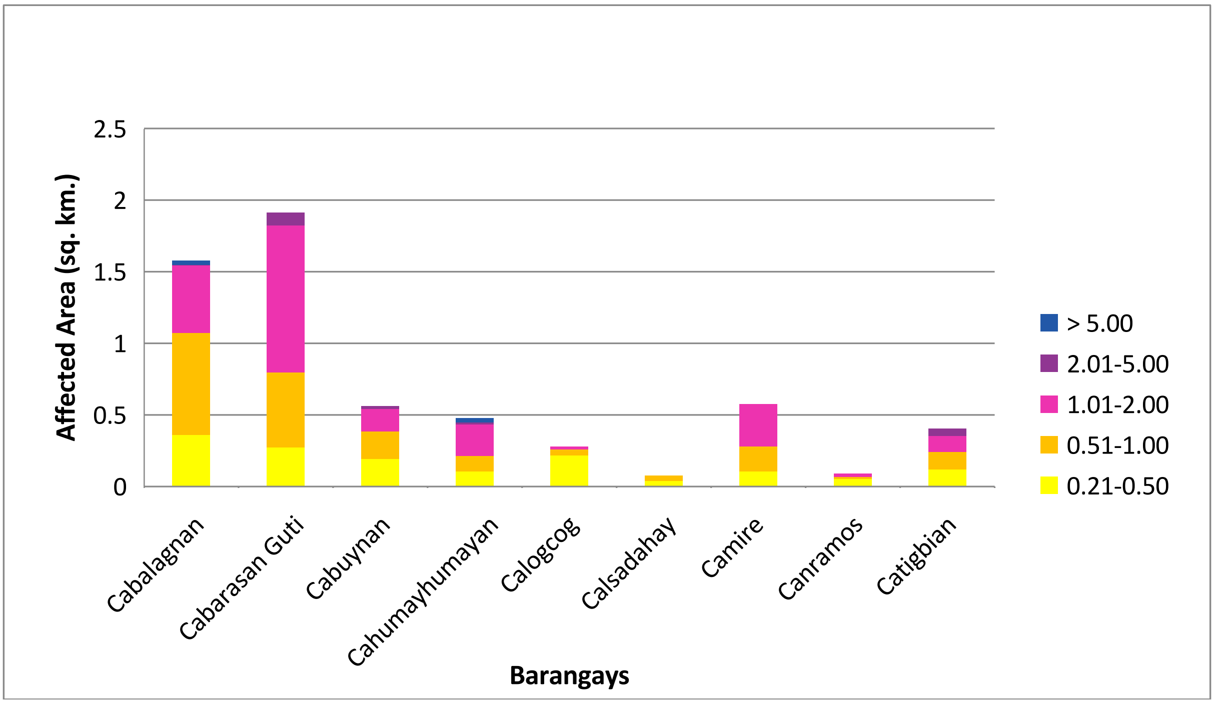


Figure 132. Affected Areas in Tanauan, Leyte during 100-Year Rainfall Return Period

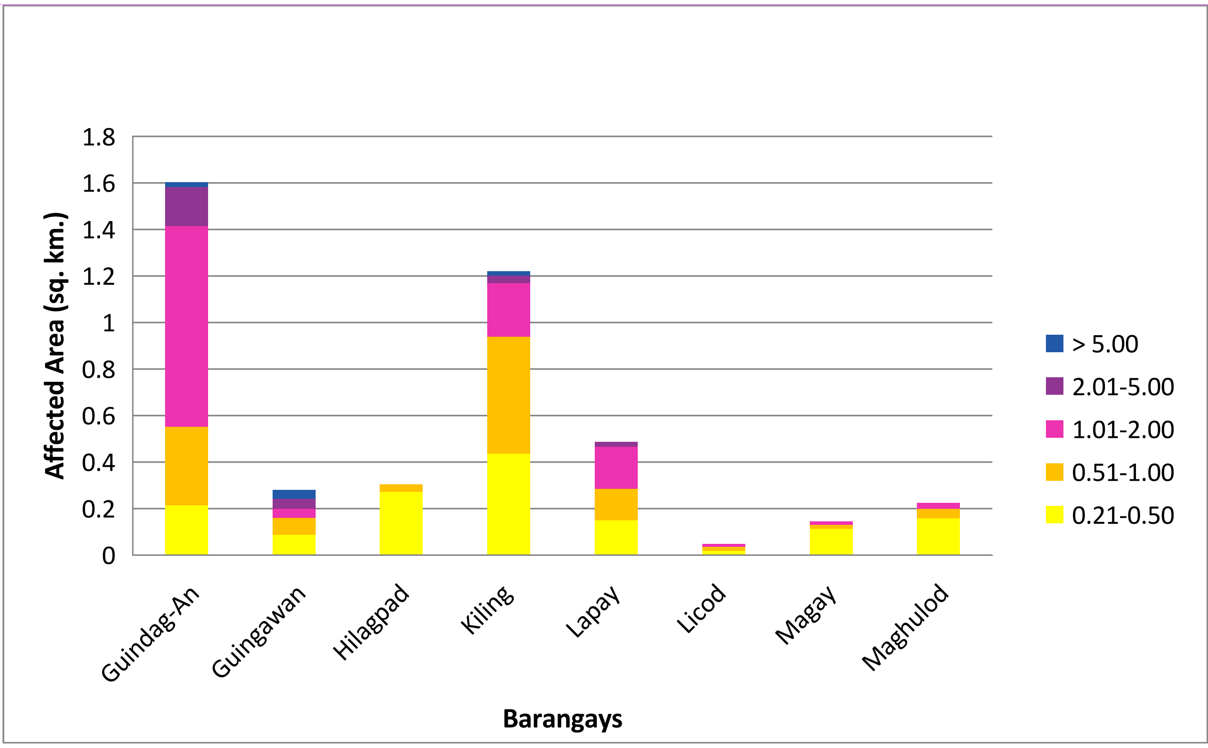


Figure 133. Affected Areas in Tanauan, Leyte during 100-Year Rainfall Return Period

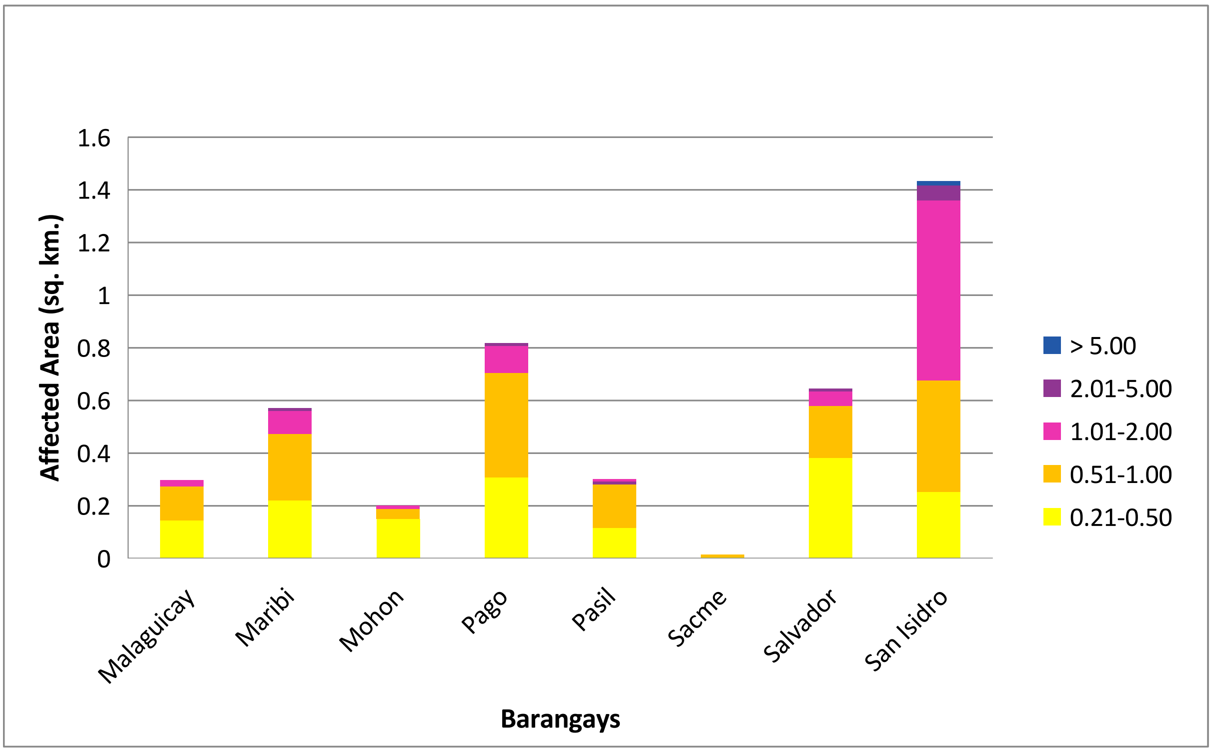


Figure 134. Affected Areas in Tanauan, Leyte during 100-Year Rainfall Return Period

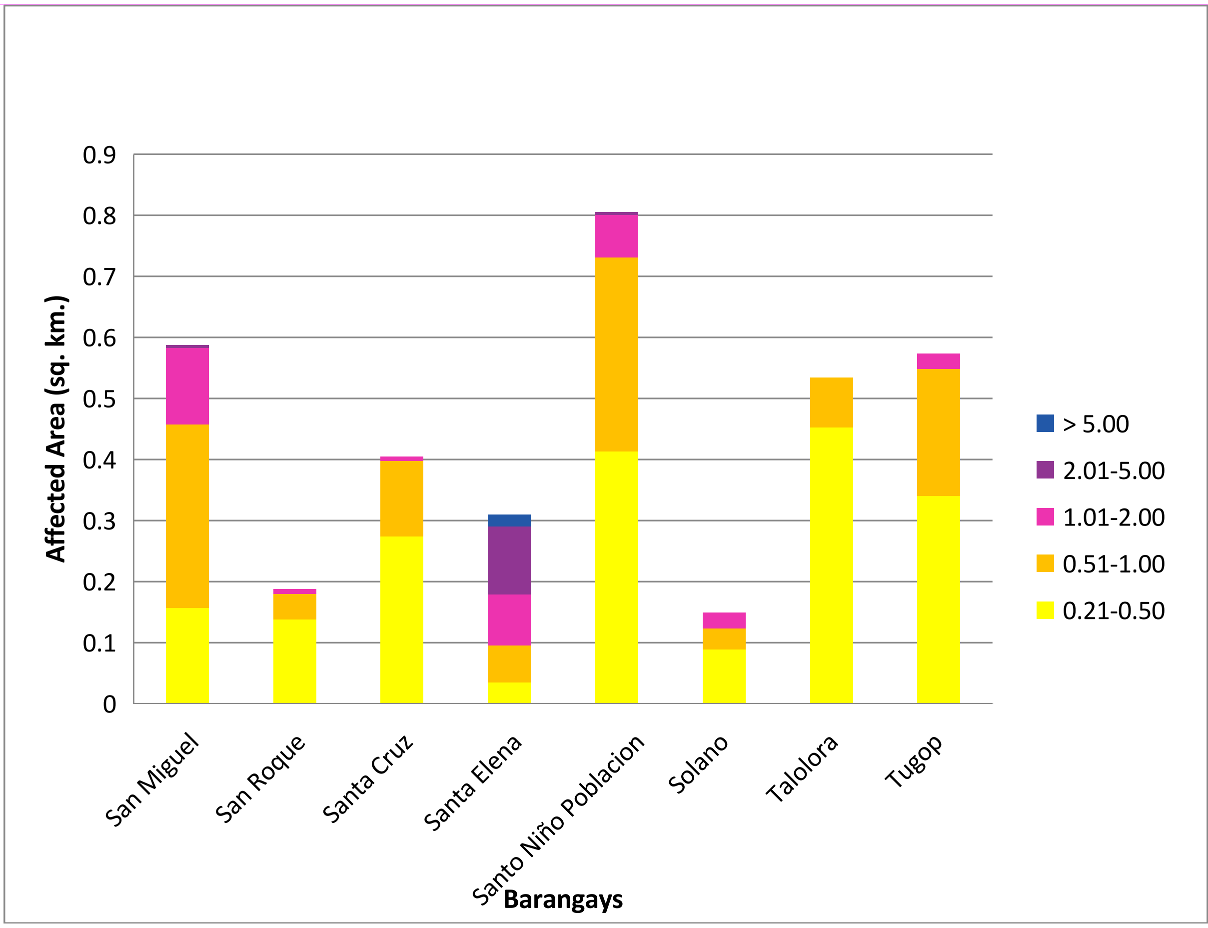


Figure 135. Affected Areas in Tanauan, Leyte during 100-Year Rainfall Return Period

Among the barangays in the municipality of Burauen, Cadahunan is projected to have the highest percentage of area that will experience flood levels at 0.08%. Meanwhile, Buri posted the second highest percentage of area that may be affected by flood depths at 0.05%.

Among the barangays in the municipality of Dagami, Banayon is projected to have the highest percentage of area that will experience flood levels at 2.75%. Meanwhile, Katipunana posted the second highest percentage of area that may be affected by flood depths at 2.63%.

Among the barangays in the municipality of Jaro, Parasan is projected to have the highest percentage of area that will experience flood levels at 0.18%.

Among the barangays in the municipality of Palo, San Joaquin is projected to have the highest percentage of area that will experience flood levels at 6.12%. Meanwhile, Cangumbang posted the second highest percentage of area that may be affected by flood depths at 4.05%.

Among the barangays in the municipality of Pastrana, Yapad is projected to have the highest percentage of area that will experience flood levels 3.80%. Meanwhile, Bahay posted the second highest percentage of area that may be affected by flood depths at 3.58%.

Among the barangays in the municipality of Tabontabon, Belisong is projected to have the highest percentage of area that will experience flood levels at 1.33%. Meanwhile, Guingawan posted the second highest percentage of area that may be affected by flood depths at 1.23%.

Among the barangays in the municipality of Tanauan, Binongto-An is projected to have the highest percentage of area that will experience flood levels at 1.99%. Meanwhile, Guindag-An posted the second highest percentage of area that may be affected by flood depths at 1.63%.

Moreover, the generated flood hazard maps for the Binahaan Floodplain were used to assess the vulnerability of the educational and medical institutions in the floodplain. Using the flood depth units of PAG-ASA for hazard maps - “Low”, “Medium”, and “High” - the affected institutions were given their individual assessment for each Flood Hazard Scenario (5 yr, 25 yr, and 100 yr).

Table 94. Area covered by each warning level with respect to the rainfall scenario

Warning Level	Area Covered in sq. km		
	5 year	25 year	100 year
Low	57.09	71.53	73.35
Medium	34.32	61.63	81.75
High	8.64	17.74	27.79

Of the 144 identified Educational Institutions in Binahaan Flood plain, 26 schools were assessed to be exposed to the Low level flooding during a 5 year scenario while 11 schools were assessed to be exposed to Medium level flooding. In the 25 year scenario, 32 schools were assessed to be exposed to the Low level flooding while 25 schools were assessed to be exposed to Medium level flooding and 2 schools were assessed to be exposed to High level flooding in the same scenario. For the 100 year scenario, 33 schools were assessed for Low level flooding and 29 schools for Medium level flooding. In the same scenario, 7 schools were assessed to be exposed to High level flooding. See Annex 12 for a detailed enumeration of schools inside Binahaan floodplain.

Of the 37 identified Medical Institutions in Binahaan Flood plain, 8 were assessed to be exposed to the Low level flooding during a 5 year scenario while 1 were assessed to be exposed to Medium level flooding in the same scenario. In the 25 year scenario, 9 were assessed to be exposed to the Low level flooding while 8 were assessed to be exposed to Medium level flooding. For the 100 year scenario, 9 schools were assessed for Low level flooding and 10 for Medium level flooding. In the same scenario, 2 schools were assessed to be exposed to High level flooding, which is a health center in Brgy. Los Martines and Cangumbang. See Annex 13 for a detailed enumeration of medical insitutions inside Binahaan floodplain.

5.11 Flood Validation

In order to check and validate the extent of flooding in different river systems, there is a need to perform validation survey work. Field personnel gather secondary data regarding flood occurrence in the area within the major river system in the Philippines.

From the Flood Depth Maps produced by Phil-LiDAR 1 Program, multiple points representing the different flood depths for different scenarios are identified for validation.

The validation personnel will then go to the specified points identified in a river basin and will gather data regarding the actual flood level in each location. Data gathering can be done through a local DRRM office to obtain maps or situation reports about the past flooding events or interview some residents with knowledge of or have had experienced flooding in a particular area.

After which, the actual data from the field will be compared to the simulated data to assess the accuracy of the Flood Depth Maps produced and to improve on what is needed.
The flood validation consists of 195 points randomly selected all over the Binahaan flood plain. The points were grouped depending on the RIDF return period of the event.

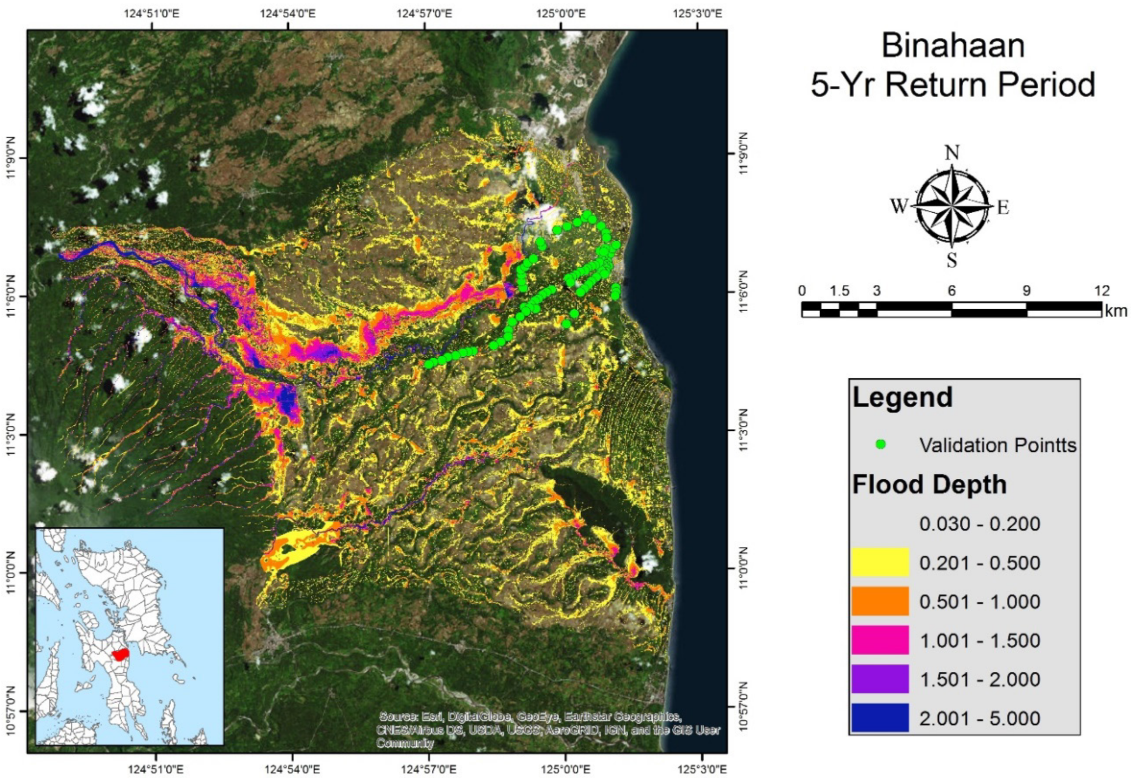


Figure 136. Validation points for 5-year Flood Depth Map of Binahaan Floodplain

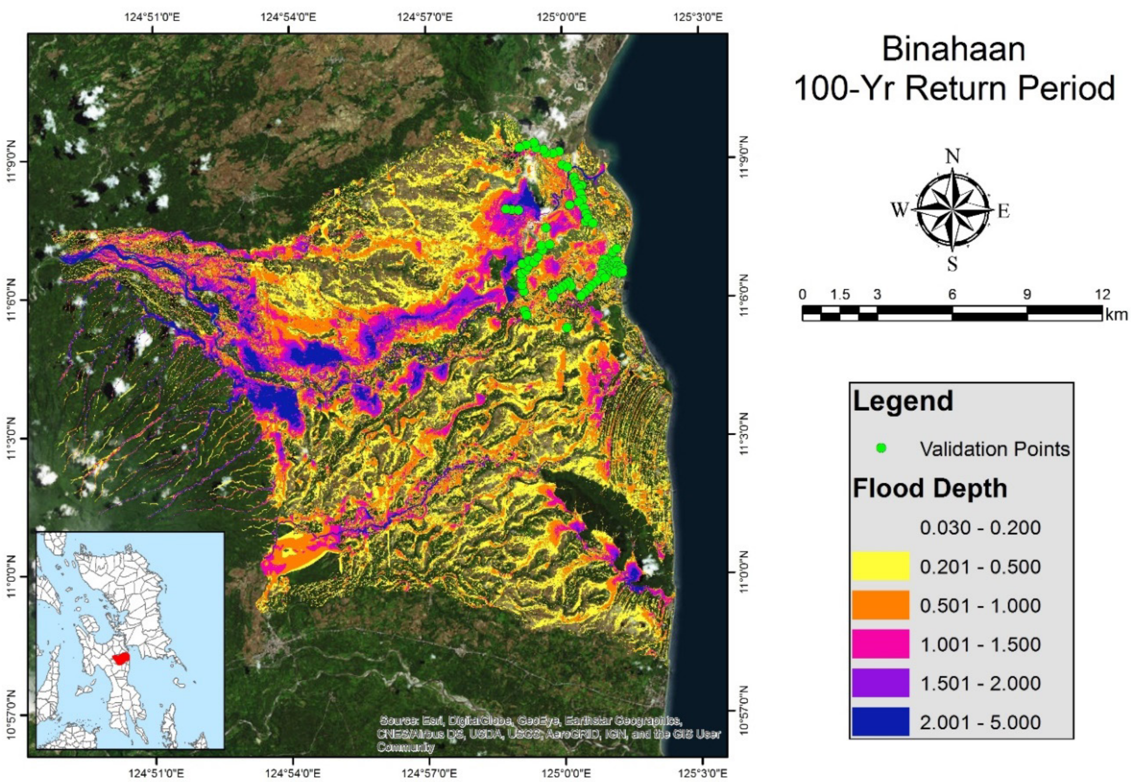


Figure 137. Validation points for 100-year Flood Depth Map of Binahaan Floodplain

The RMSE value for each flood depth map is listed in the table below:

Table 95. RMSE values for each return period of flood depth map

Return Period	RMSE
5-year	0.77
100-year	2.63

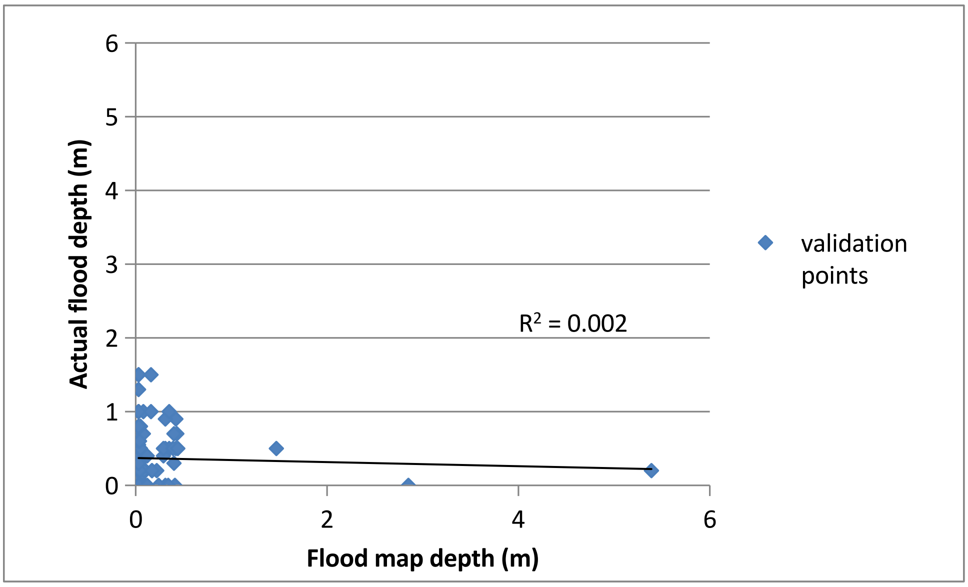


Figure 138. Flood map depth vs actual flood depth for 5-year return period

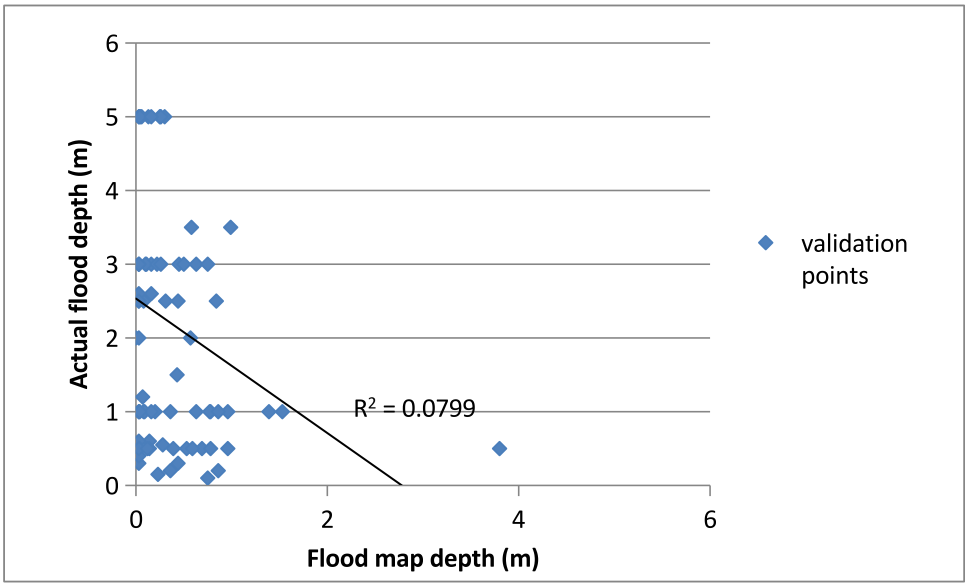


Figure 139 Flood map depth vs actual flood depth for 100-year return period

Table 96. Actual Flood Depth vs Simulated Flood Depth in Binahaan

MAINIT-TUBAY BASIN		Modeled Flood Depth (m)						
		0-0.20	0.21-0.50	0.51-1.00	1.01-2.00	2.01-5.00	>5.00	Total
Actual Flood Depth (m)	0-0.20	48	7	2	0	1	1	59
	0.21-0.50	24	10	5	1	1	0	41
	0.51-1.00	25	7	5	2	0	0	39
	1.01-2.00	7	1	1	0	0	0	9
	2.01-5.00	30	11	5	0	0	0	46
	>5.00	0	0	0	0	0	1	1
	Total	134	36	18	3	2	2	195

The overall accuracy generated by the flood model is estimated at 32.82%, with 64 points correctly matching the actual flood depths. In addition, there were 46 points estimated one level above and below the correct flood depths while there were 34 points and 51 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 20 points were overestimated while a total of 111 points were underestimated in the modelled flood depths of Binahaan.

Table 97. Summary of Accuracy Assessment in Binahaan

	No. of Points	%
Correct	64	**32.82**
Overestimated	20	**10.26**
Underestimated	111	**56.92**
Total	195	**100**

REFERENCES

Ang M.O., Paringit E.C., et al. 2014. DREAM Data Processing Component Manual. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

Balicanta L.P., Paringit E.C., et al. 2014. DREAM Data Validation Component Manual. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

Brunner, G. H. 2010a. HEC-RAS River Analysis System Hydraulic Reference Manual. Davis, CA: U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center.

Lagmay A.F., Paringit E.C., et al. 2014. DREAM Flood Modeling Component Manual. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

Paringit E.C, Balicanta L.P., Ang, M.O., Sarmiento, C. 2017. Flood Mapping of Rivers in the Philippines Using Airborne Lidar: Methods. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

Sarmiento C., Paringit E.C., et al. 2014. DREAM Data Acquisition Component Manual. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

UP TCAGP 2016, Acceptance and Evaluation of Synthetic Aperture Radar Digital Surface Model (SAR DSM) and Ground Control Points (GCP). Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

ANNEXES

Annex 1. OPTECH Technical Specification of the Aquarius And Gemini Lidar Sensors and the D8900 Aerial Camera

AQUARIUS

Parameter	Specification
Operational altitude	300-600 m AGL
Laser pulse repetition rate	33, 50. 70 kHz
Scan rate	0-70 Hz
Scan half-angle	0 to ± 25 ˚
Laser footprint on water surface	30-60 cm
Depth range	0 to > 10 m (for k < 0.1/m)
Topographic mode	
Operational altitude	300-2500
Range Capture	Up to 4 range measurements, including 1st, 2nd, 3rd, and last returns
Intensity capture	12-bit dynamic measurement range
Position and orientation system	POS AVTM 510 (OEM) includes embedded 72-channel GNSS receiver (GPS and GLONASS)
Data Storage	Ruggedized removable SSD hard disk (SATA III)
Power	28 V, 900 W, 35 A
Image capture	5 MP interline camera (standard); 60 MP full frame (optional)
Full waveform capture	12-bit Optech IWD-2 Intelligent Waveform Digitizer (optional)
Dimensions and weight	Sensor:250 x 430 x 320 mm; 30 kg; Control rack: 591 x 485 x 578 mm; 53 kg
Operating temperature	0-35˚C
Relative humidity	0-95% no-condensing

GEMINI

Parameter	Specification
Operational envelope (1,2,3,4)	150-4000 m AGL, nominal
Laser wavelength	1064 nm
Horizontal accuracy (2)	1/5,500 x altitude, (m AGL)
Elevation accuracy (2)	<5-35 cm, 1 σ
Effective laser repetition rate	Programmable, 33-167 kHz
Position and orientation system	POS AV™ AP50 (OEM); 220-channel dual frequency GPS/GNSS/Galileo/L-Band receiver
Scan width (WOV)	Programmable, 0-50˚
Scan frequency (5)	Programmable, 0-70 Hz (effective)
Sensor scan product	1000 maximum
Beam divergence	Dual divergence: 0.25 mrad (1/e) and 0.8 mrad (1/e), nominal
Roll compensation	Programmable, ±5˚ (FOV dependent)
Range capture	Up to 4 range measurements, including 1st, 2nd, 3rd, and last returns
Intensity capture	Up to 4 intensity returns for each pulse, including last (12 bit)
Video Camera	Internal video camera (NTSC or PAL)
Image capture	Compatible with full Optech camera line (optional)
Full waveform capture	12-bit Optech IWD-2 Intelligent Waveform Digitizer (optional)
Data storage	Removable solid state disk SSD (SATA II)
Power requirements	28 V; 900 W;35 A(peak)
Dimensions and weight	Sensor: 260 mm (w) x 190 mm (l) x 570 mm (h); 23 kg Control rack: 650 mm (w) x 590 mm (l) x 530 mm (h); 53 kg
Operating temperature	-10˚C to +35˚C (with insulating jacket)
Relative humidity	0-95% no-condensing

D-8900 AERIAL CAMERA

Parameter	Specification
Camera Head	
Sensor type	60 Mpix full frame CCD, RGB
Sensor format (H x V)	8, 984 x 6, 732 pixels
Pixel size	6µm x 6 µm
Frame rate	1 frame/2 sec.
FMC	Electro-mechanical, driven by piezo technology (patented)
Shutter	Electro-mechanical iris mechanism 1/125 to 1/500++ sec. f-stops: 5.6, 8, 11, 16
Lenses	50 mm/70 mm/120 mm/210 mm
Filter	Color and near-infrared removable filters
Dimensions (H x W x D)	200 x 150 x 120 mm (70 mm lens)
Weight	~4.5 kg (70 mm lens)
Controller Unit	
Computer	Mini-ITX RoHS-compliant small-form-factor embedded computers with AMD TurionTM 64 X2 CPU 4 GB RAM, 4 GB flash disk local storage IEEE 1394 Fire wire interface
Removable storage unit	~500 GB solid state drives, 8,000 images
Power consumption	~8 A, 168 W
Dimensions	2U full rack; 88 x 448 x 493 mm
Weight	~15 kg
Image Pre-Processing Software	
Capture One	Radiometric control and format conversion, TIFF or JPEG
Image output	8,984 x 6,732 pixels 8 or 16 bits per channel (180 MB or 360 MB per image)

Annex 2. NAMRIA Certificates of Reference Points Used

1. LYT-101

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

January 20, 2014

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: **LEYTE**
Station Name: **LYT-101**
Order: **2nd**

Island: **VISAYAS**
Municipality: **PALO**
Barangay:

		PRS92 Coordinates			
Latitude:	**11° 10' 23.89707"**	Longitude:	**125° 0' 38.62071"**	Ellipsoidal Hgt:	**6.58600 m.**
		WGS84 Coordinates			
Latitude:	**11° 10' 19.64869"**	Longitude:	**125° 0' 43.78230"**	Ellipsoidal Hgt:	**69.02100 m.**
		PTM Coordinates			
Northing:	**1235497.253 m.**	Easting:	**501171.719 m.**	Zone:	**5**
		UTM Coordinates			
Northing:	**1,235,811.61**	Easting:	**719,575.03**	Zone:	**51**

Location Description

LYT-101
Station is located in the province of Leyte, municipality of Palo. From Tacloban City travel SE to McArthur Park. The point is located infront of Gen. Douglas McArthur Shrine and is approximately 10 m away and adjacent to center of lower step. Station mark is a concrete nail on center of a 20 x 20 cm. cement putty on the concrete ground.

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795097 A**
T.N.: **2014-94**

RUEL DM. BELEN, MNSA
Director, Mapping And Geodesy Branch

9 9 0 1 2 0 2 0 1 4 1 4 3 7 3 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

2. SMR-53

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

April 23, 2014

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: **SAMAR (WESTERN SAMAR)**
Station Name: **SMR-53**
Order: **2nd**

Island: **VISAYAS**
Municipality: **SANTA RITA**
Barangay: **SAN ISIDRO**

PRS92 Coordinates

Latitude: **11° 30' 17.85657"** Longitude: **125° 1' 29.83739"** Ellipsoidal Hgt: **26.13400 m.**

WGS84 Coordinates

Latitude: **11° 30' 13.52495"** Longitude: **125° 1' 34.96980"** Ellipsoidal Hgt: **87.78700 m.**

PTM Coordinates

Northing: **1272180.079 m.** Easting: **502722.403 m.** Zone: **5**

UTM Coordinates

Northing: **1,272,513.40** Easting: **720,874.14** Zone: **51**

Location Description

SMR-53
From Tacloban City Proper, travel about 45 km. north going to Brgy. San.Isidro. The NAMRIA monument was located about 15 m. west inside the San Isidro Elementary School, and almost near at the school building and flag pole about 5 m. north. Mark is the head of a 4" copper nail flushed in a cement block embedded in the ground with inscriptions "SMR-53; 2007; NAMRIA."

Requesting Party: **Engr. Christopher Cruz/ UP-DREAM**
Pupose: **Reference**
OR Number: **8796021 A**
T.N.: **2014-920**

RUEL DM. BELEN, MNSA
Director, Mapping And Geodesy Branch

9904232014154927

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

CIP/4701/12/09/814

3. LY-110

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

January 27, 2016

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: **LEYTE**
Station Name: **LY-110**

Island: **Visayas**	Municipality: **PALO**	Barangay: **LIBERTAD**
Elevation: **12.9339 +/- 0.03 m.**	Order: **1st Order**	Datum: **Mean Sea Level**
Latitude:	Longitude:	

Location Description

LY-110
Is in the Province of Leyte, Municipality of Palo, Brgy. Libertad. it is about 225m West of km post 919, 4.15 North of Centerline of the road leading to Ormoc, at the Northwest end of a 42.0m long bridge. A 24 minutes drive from Tacloban City going to South to Ormoc on a bridge located about 225 meters of km post 919. Mark is a 4" copper nail, drilled on hole on top of concrete footwalk at the top of culvert headwall and cemented flush with inscription "LY-110 2007 NAMRIA".

Requesting Party:	**UP DREAM**
Purpose:	**Reference**
OR Number:	**8089687 I**
T.N.:	**2016-0240**

RUEL DM. BELEN, MNSA
Director, Mapping And Geodesy Branch

9 9 0 1 2 7 2 0 1 6 1 5 1 2 0 1

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

4. LY-881

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

April 23, 2014

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: **LEYTE**
Station Name: **LY-881**

Island: **Visayas**	Municipality: **PALO**	Barangay: **PAWING**
Elevation: **4.6195 m.**	Order: **1st Order**	Datum: **Mean Sea Level**

Location Description

BM-LY-881 is in the Province of Leyte, Municipality of Palo, Brgy. Pawing along the Tacloban-Ormoc National Highway. The station is located at the concrete foundation of Governor Center Welcome sign at the junction of the road going to Ormoc, Samar, Tacloban and Mac Arthur Landing Memorial Park.

Mark is the head of a 4 in. copper nail set flush on a 15 cm. x 15 cm. cementt putty with inscriptions "LY-881, 2008, NAMRIA".
Re-computed March 2014

Requesting Party: **Engr. Christopher Cruz/ UP-DREAM**
Pupose: **Reference**
OR Number: **8796021 A**
T.N.: **2014-923**

RUEL DM. BELEN, MNSA
Director, Mapping And Geodesy Branch

9 9 0 4 2 3 2 0 1 4 1 5 5 0 1 6

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.4. LYT-741

Annex 3. Baseline Processing Reports of Reference Points Used

1. LY-104

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SMR-53 --- LYT-104 (B1)	SMR-53	LYT-104	Fixed	0.008	0.017	200°40'31"	42653.401	7.525
SMR-53 --- LYT-104 (B2)	SMR-53	LYT-104	Fixed	0.004	0.016	200°40'31"	42653.384	7.601

Acceptance Summary

Processed	Passed	Flag	Fail
2	2	0	0

Vector Components (Mark to Mark)

From:	SMR-53				
Grid		Local		Global	
Easting	720874.133 m	Latitude	N11°30'17.85656"	Latitude	N11°30'13.52495"
Northing	1272513.396 m	Longitude	E125°01'29.83738"	Longitude	E125°01'34.96980"
Elevation	24.750 m	Height	26.134 m	Height	87.787 m

To:	LYT-104				
Grid		Local		Global	
Easting	706089.510 m	Latitude	N11°08'38.92234"	Latitude	N11°08'34.67033"
Northing	1232496.838 m	Longitude	E124°53'13.52786"	Longitude	E124°53'18.69323"
Elevation	32.311 m	Height	33.659 m	Height	95.861 m

Vector					
ΔEasting	-14784.623 m	NS Fwd Azimuth	200°40'31"	ΔX	7839.600 m
ΔNorthing	-40016.558 m	Ellipsoid Dist.	42653.401 m	ΔY	15051.644 m
ΔElevation	7.561 m	ΔHeight	7.525 m	ΔZ	-39131.928 m

Standard Errors

Vector errors:					
σ ΔEasting	0.003 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.006 m
σ ΔNorthing	0.002 m	σ Ellipsoid Dist.	0.002 m	σ ΔY	0.007 m
σ ΔElevation	0.009 m	σ ΔHeight	0.009 m	σ ΔZ	0.002 m

2. LY-110

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
LYT 104 --- LY 110 (B1)	LYT 104	LY 110	Fixed	0.004	0.013	68°33'52"	8457.064	-19.323
LY 110 --- LYT 104 (B2)	LYT 104	LY 110	Fixed	0.004	0.015	68°33'52"	8457.047	-19.343

Acceptance Summary

Processed	Passed	Flag	Fail
2	2	0	0

Vector Components (Mark to Mark)

From:	LYT 104				
Grid		Local		Global	
Easting	706089.510 m	Latitude	N11°08'38.92234"	Latitude	N11°08'34.67033"
Northing	1232496.838 m	Longitude	E124°53'13.52786"	Longitude	E124°53'18.69323"
Elevation	32.311 m	Height	33.659 m	Height	95.861 m

To:	LY 110				
Grid		Local		Global	
Easting	713942.863 m	Latitude	N11°10'19.48389"	Latitude	N11°10'15.23095"
Northing	1235638.117 m	Longitude	E124°57'32.98736"	Longitude	E124°57'38.14961"
Elevation	12.819 m	Height	14.336 m	Height	76.647 m

Vector					
ΔEasting	7853.353 m	NS Fwd Azimuth	68°33'52"	ΔX	-6101.546 m
ΔNorthing	3141.279 m	Ellipsoid Dist.	8457.064 m	ΔY	-5012.598 m
ΔElevation	-19.492 m	ΔHeight	-19.323 m	ΔZ	3027.816 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.004 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.002 m	σ ΔY	0.005 m
σ ΔElevation	0.007 m	σ ΔHeight	0.007 m	σ ΔZ	0.002 m

3. LY-881

LY-881 - LYT-101 (1:48:33 PM-5:01:31 PM) (S1)

Baseline observation:	LY-881 --- LYT-101 (B1)
Processed:	6/10/2014 4:31:22 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.002 m
Vertical precision:	0.003 m
RMS:	0.000 m
Maximum PDOP:	6.041
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	5/6/2014 1:48:59 PM (Local: UTC+8hr)
Processing stop time:	5/6/2014 5:01:31 PM (Local: UTC+8hr)
Processing duration:	03:12:32
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	LYT-101				
Grid		Local		Global	
Easting	719575.001 m	Latitude	N11°10'23.89752"	Latitude	N11°10'19.64869"
Northing	1235811.576 m	Longitude	E125°00'38.62063"	Longitude	E125°00'43.78230"
Elevation	4.934 m	Height	6.587 m	Height	69.021 m

To:	LY-881				
Grid		Local		Global	
Easting	718540.093 m	Latitude	N11°10'49.44332"	Latitude	N11°10'45.19188"
Northing	1236589.610 m	Longitude	E125°00'04.69148"	Longitude	E125°00'09.85261"
Elevation	4.367 m	Height	5.992 m	Height	68.386 m

Vector					
ΔEasting	-1034.909 m	NS Fwd Azimuth	307°19'31"	ΔX	930.803 m
ΔNorthing	778.034 m	Ellipsoid Dist.	1294.498 m	ΔY	465.453 m
ΔElevation	-0.567 m	ΔHeight	-0.594 m	ΔZ	769.860 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.001 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.001 m
σ ΔElevation	0.001 m	σ ΔHeight	0.001 m	σ ΔZ	0.001 m

LY-881 - LYT-101 (5:43:03 AM-10:33:20 AM) (S2)

Baseline observation:	LY-881 --- LYT-101 (B2)
Processed:	6/10/2014 5:01:18 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.002 m
Vertical precision:	0.002 m
RMS:	0.000 m
Maximum PDOP:	2.796
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	4/20/2014 5:44:20 AM (Local: UTC+8hr)
Processing stop time:	4/20/2014 10:33:20 AM (Local: UTC+8hr)
Processing duration:	04:49:00
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	LYT-101				
Grid		Local		Global	
Easting	719575.001 m	Latitude	N11°10'23.89752"	Latitude	N11°10'19.64869"
Northing	1235811.576 m	Longitude	E125°00'38.62063"	Longitude	E125°00'43.78230"
Elevation	4.934 m	Height	6.587 m	Height	69.021 m

To:	LY-881				
Grid		Local		Global	
Easting	718540.071 m	Latitude	N11°10'49.44311"	Latitude	N11°10'45.19167"
Northing	1236589.604 m	Longitude	E125°00'04.69077"	Longitude	E125°00'09.85190"
Elevation	4.254 m	Height	5.879 m	Height	68.273 m

Vector					
ΔEasting	-1034.930 m	NS Fwd Azimuth	307°19'29"	ΔX	930.883 m
ΔNorthing	778.028 m	Ellipsoid Dist.	1294.511 m	ΔY	465.376 m
ΔElevation	-0.680 m	ΔHeight	-0.707 m	ΔZ	769.831 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.001 m
σ ΔNorthing	0.000 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.001 m
σ ΔElevation	0.001 m	σ ΔHeight	0.001 m	σ ΔZ	0.000 m

Annex 4. The Survey Team

<table>
<tr><th>Date Acquisition Component Sub-team</th><th>Designation</th><th>Name</th><th>Agency/Affiliation</th></tr>
<tr><td>PHIL-LiDAR 1</td><td>Program Leader</td><td>ENRICO C. PARINGIT, D. ENG</td><td>UP-TCAGP</td></tr>
<tr><td>Data Acquisition Component Leader</td><td>Data Component Project Leader –I</td><td>ENGR. CZAR JAKIRI S. SARMIENTO</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="2">Survey Supervisor</td><td>Chief Science Research Specialist (CSRS)</td><td>ENGR. CHRISTOPHER CRUZ</td><td>UP-TCAGP</td></tr>
<tr><td>Supervising Science Research Specialist (Supervising SRS)</td><td>ENGR. LOVELYN ASUNCION</td><td>UP-TCAGP</td></tr>
<tr><td colspan="4">FIELD TEAM</td></tr>
<tr><td rowspan="11">LiDAR Operation</td><td>Supervising SRS</td><td>LOVELY GRACIA ACUÑA</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="3">Senior Science Research Specialist (SSRS)</td><td>JULIE PEARL MARS</td><td>UP-TCAGP</td></tr>
<tr><td>ENGR. GEROME HIPOLITO</td><td>UP-TCAGP</td></tr>
<tr><td>PAULINE JOANNE ARCEO</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="7">Research Associate (RA)</td><td>ENGR. DAN CHRISTOFFER ALDOVINO</td><td>UP-TCAGP</td></tr>
<tr><td>FAITH JOY SABLE</td><td>UP-TCAGP</td></tr>
<tr><td>MARY CATHERINE ELIZABETH BALIGUAS</td><td>UP-TCAGP</td></tr>
<tr><td>ENGR. IRO NIEL ROXAS</td><td>UP-TCAGP</td></tr>
<tr><td>ENGR. LARAH KRISELLE PARAGAS</td><td>UP-TCAGP</td></tr>
<tr><td>GRACE SINADJAN</td><td>UP-TCAGP</td></tr>
<tr><td>JONATHAN ALMALVEZ</td><td>UP-TCAGP</td></tr>
<tr><td>Ground Survey, Data download and transfer</td><td>RA</td><td>JERIEL PAUL ALAMBAN, GEOL..</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="6">LiDAR Operation</td><td rowspan="2">Airborne Security</td><td>SSG. RAYMUND DOMINE</td><td>PHILIPPINE AIR FORCE (PAF)</td></tr>
<tr><td>SSG. RANDY SISON</td><td>PAF</td></tr>
<tr><td rowspan="4">Pilot</td><td>CAPT. JACKSON JAVIER</td><td>ASIAN AEROSPACE CORPORATION (AAC)</td></tr>
<tr><td>CAPT. NEIL ACHILLES AGAWIN</td><td>AAC</td></tr>
<tr><td>CAPT. ALBERT PAUL LIM</td><td>AAC</td></tr>
<tr><td>CAPT. RANDY LAGCO</td><td>AAC</td></tr>
</table>

Annex 5. Data Transfer Sheet for Binahaan Floodplain

1. 1026A, 1028A

DATA TRANSFER SHEET

Feb. 3, 2014

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS	LOGS	POS	RAW IMAGES	MISSION LOG FILE	RANGE	DIGITIZER	BASE STATION(S)	SERVER LOCATION
Jan 26, 2014	1026A	3BLK34AS026B	AQUARIUS	N/A	980 KB	137 MB	55.2 GB	436 KB	11.6 GB	17.2 GB	20.0 MB	Z:\Airborne_Raw\1026A
Jan 27, 2014	1028A	3BLK34ABS027A	AQUARIUS	N/A	1.57 MB	267 MB	101 GB	783 KB	22.5 GB	30.1 GB	14.6 MB	Z:\Airborne_Raw\1028A

Received from

Name/Signature JP ALAMBAN

Position RA

Date

Received by

Name/Signature JOIDA F. PRIETO

Position SSRS

Date

Verified by

Name/Signature JOIDA F. PRIETO

Position SSRS

Date

Page 1

2. 1358A, 1360A

DATA TRANSFER SHEET
5/22/2014 (Leyte Ongoing)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
4/20/2014	1358A	3BLK34F110A	AQUARIUS	NA	NA	1.17MB	243MB	63.3/10.7GB	3/510/87KB	14.1GB	NA	12.1MB	1KB	1KB	6KB	773/12KB	Z:\Airborne_Raw\1358A
4/20/2014	1360A	3BLK34FS110B	AQUARIUS	NA	NA	7.75MB	174MB	41.1GB	206KB	8.26GB	NA	11.3MB	1KB	1KB	6KB	649/12KB	Z:\Airborne_Raw\1360A
4/22/2014	1366A	3BLK34E112A	AQUARIUS	NA	NA	1.37MB	257MB	95.5GB	418/1/263KB	14.9GB	NA	8.53MB	1KB	1KB	5KB	889/10KB	Z:\Airborne_Raw\1366P
5/11/2014	1442A	3BLK33GS131A	AQUARIUS	NA	NA	5.86MB	275MB	108GB	59/697KB	16.6GB	NA	14.3MB	1KB	1KB	NA	2652KB	Z:\Airborne_Raw\1442A
5/11/2014	1444A	3BLK33GSH131B	AQUARIUS	NA	NA	2.82MB	254MB	79.3GB	1/1/515/1/139KB	15.2GB	229GB	14.3MB	1KB	1KB	5/5KB	2813/700KB	Z:\Airborne_Raw\1444A
5/13/2014	1450A	3BLK33HS133A	AQUARIUS	NA	NA	906KB	132MB	34.1GB	257KB	6.07GB	87.0GB	10.5MB	1KB	1KB	5KB	1019KB	Z:\Airborne_Raw\1450A
5/13/2014	1452A	3BLK33HSES133B	AQUARIUS	NA	NA	2.33MB	233MB	47.1GB	1/415KB	9.57GB	86.8GB	11.2MB	1KB	1KB	6/10KB	512KB	Z:\Airborne_Raw\1452A
5/14/2014	1454A	3BLK34D134A	AQUARIUS	NA	NA	1.88MB	268MB	15.7/71.5GB	23/102/517KB	14.6GB	206GB	8.41MB	1KB	1KB	5/2KB	1522KB	Z:\Airborne_Raw\1454A
5/14/2014	1456A	3BLK34C134B	AQUARIUS	NA	NA	0.98MB	212MB	66.6GB	278/226KB	11.6GB	58.6GB	7.92MB	1KB	1KB	5KB	641KB	Z:\Airborne_Raw\1456P
5/15/2014	1460A	3BLK35CD135B	AQUARIUS	NA	NA	1.24MB	273MB	74.8GB	622KB	14.7GB	235GB	11.4MB	1KB	1KB	5/5KB	476/807KB	Z:\Airborne_Raw\1460A
5/16/2014	1462A	3BLK35DSE136A	AQUARIUS	NA	NA	1.29MB	275MB	91.2GB	685KB	15.2GB	NA	11.6MB	1KB	1KB	5/4KB	842KB	Z:\Airborne_Raw\1462A
5/16/2014	1464A	3BLK35ES136B	AQUARIUS	NA	NA	1.20MB	251MB	76.9GB	637KB	14.0GB	NA	11.4MB	1KB	1KB	4KB	786KB	Z:\Airborne_Raw\1464A

Received from

Name: Dan Aldovino
Position: Research Associate
Signature:

Received by

Name: JOIDA F. PRIETO
Position: SSRS
Signature:
5/28/2014

3. 3765G, 3769G, 3771G, 3773G

DATA TRANSFER SHEET
Leyte 2/11/16

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
22-Jan	3765G	2BLK34AD022A	gemini	NA	93	690	255	na	na	25.2	na	4.38	1KB	1KB	23/57/22/58/ 21/55/21/21	na	Z:\DAC\RAW DATA
22-Jan-16	3767G	2BLK34AG022B	gemini	NA	75	490	204	na	na	19.1	na	3.4	1KB	1KB	57/11	na	Z:\DAC\RAW DATA
23-Jan-16	3769G	2BLK34ADEG023A	gemini	NA	82	670	260	na	na	23.8	na	9.58	1KB	1KB	na	na	Z:\DAC\RAW DATA
23-Jan-16	3771G	2BLK34BCG023B	gemini	NA	77	526	212	na	na	20.3	na	9.2	1KB	1KB	57/22	na	Z:\DAC\RAW DATA
24-Jan-16	3773G	2BLK34CG024A	gemini	NA	63	582	248	na	na	16.8	na	4.74	1KB	1KB	27/26/59	na	Z:\DAC\RAW DATA

Received from

Name C. JOAQUIN
Position
Signature

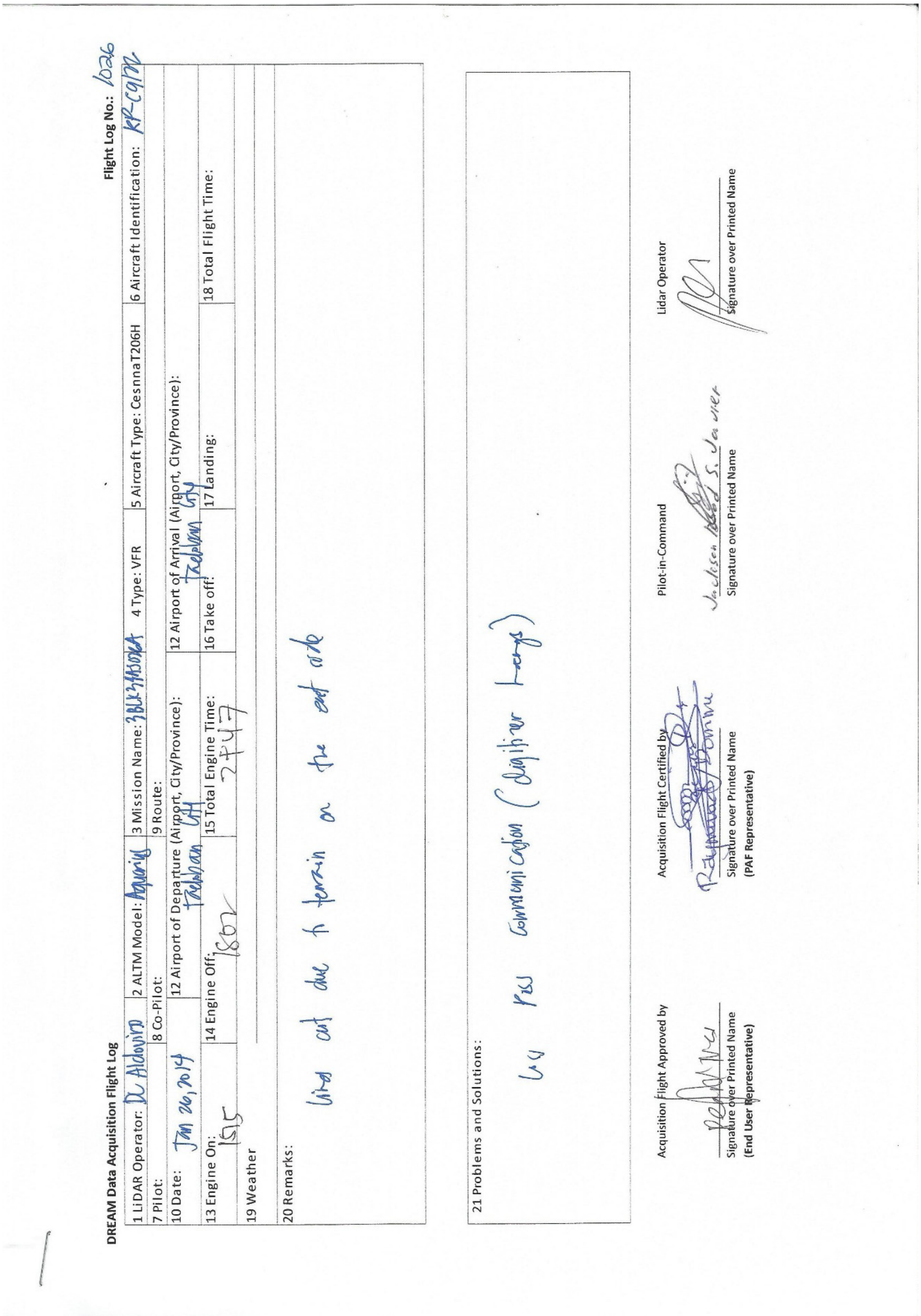
Received by

Name AC Bongat 2/12/16
Position SSRS
Signature

16-09

Annex 6. Flight Logs

1. Flight Log for 1026A Mission



DREAM Data Acquisition Flight Log — **Flight Log No.:** 1026

1 LiDAR Operator: DL Aldovino	2 ALTM Model: Aquarius	3 Mission Name: 3BLK34A5026A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9122
7 Pilot:	8 Co-Pilot:	9 Route:			
10 Date: Jan 26, 2014	12 Airport of Departure (Airport, City/Province): Tacloban City		12 Airport of Arrival (Airport, City/Province): Tacloban City		
13 Engine On: 1515	14 Engine Off: 1802	15 Total Engine Time: 2+47	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

lines cut due to terrain on the east side

21 Problems and Solutions:

Low pass communication (digitizer logs)

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	Raymund Dominic — Signature over Printed Name (PAF Representative)	Jackson [illegible] S. Javier — Signature over Printed Name	Signature over Printed Name

2. Flight Log for 1028A Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1028

1 LiDAR Operator: DC Alduino	2 ALTM Model: Aquarius	3 Mission Name: 3BLK34AB027A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9122
7 Pilot:	8 Co-Pilot:	9 Route:			
10 Date: Jan 27, 2014	12 Airport of Departure (Airport, City/Province): Tacloban City		12 Airport of Arrival (Airport, City/Province): Tacloban City		
13 Engine On: 906	14 Engine Off: 1331	15 Total Engine Time: 4+25	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

Successful Flight

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	Raymund Dominic — Signature over Printed Name (PAF Representative)	JEFFREY [illegible] ALAJAR — Signature over Printed Name	Signature over Printed Name

3. Flight Log for 1358A Mission

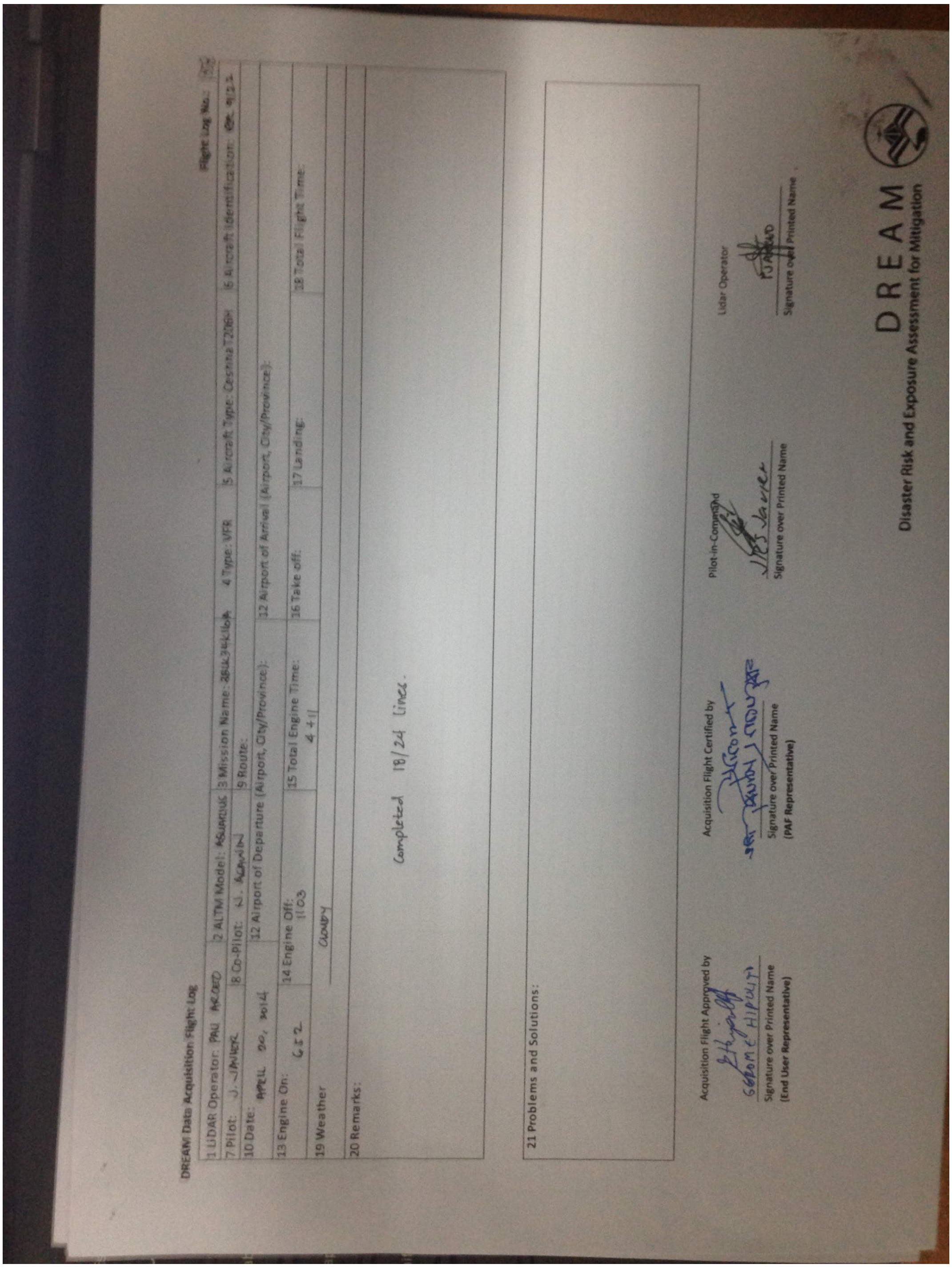
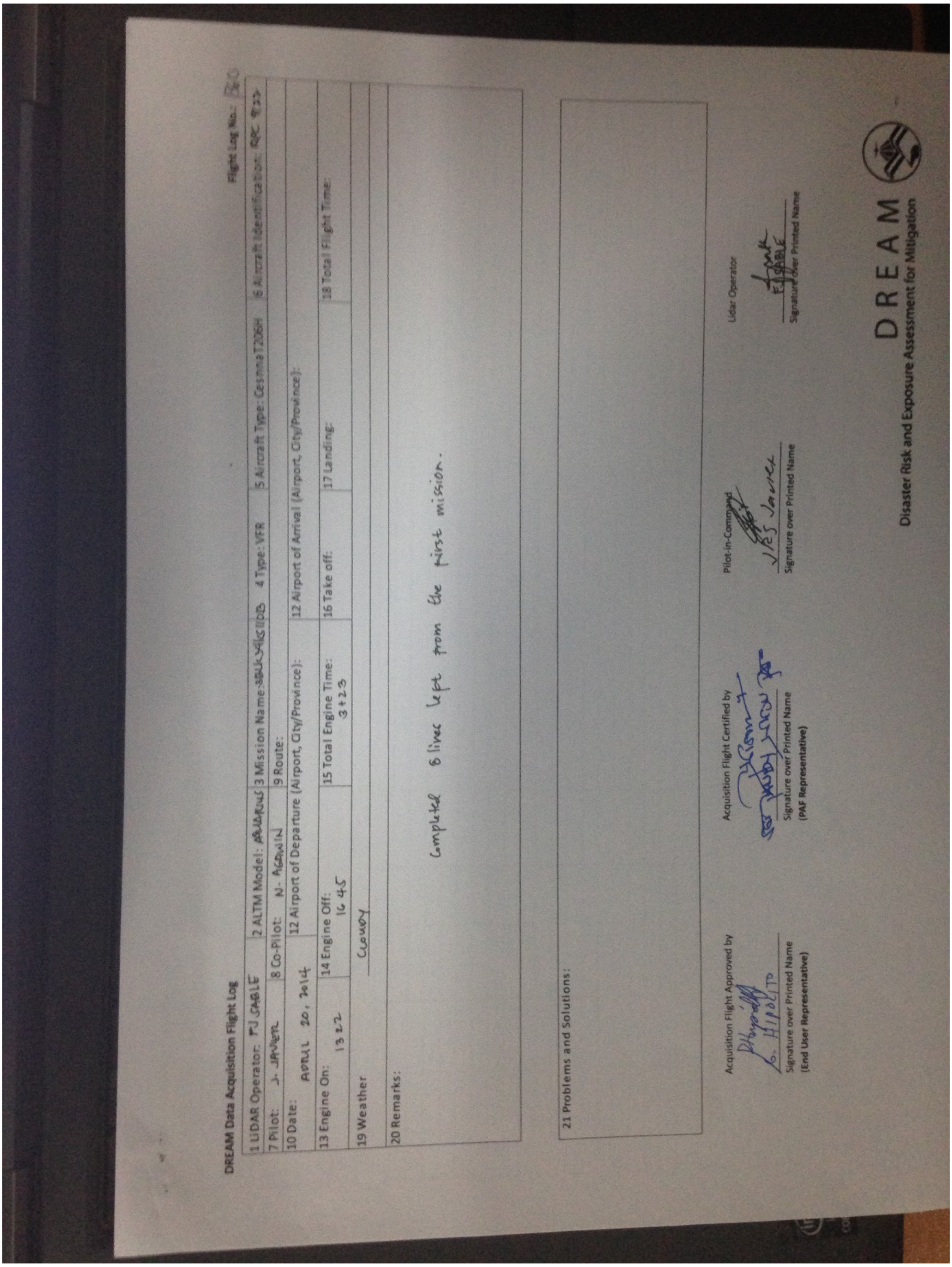


Figure A-6.3. Flight Log for Mission 3781G

4. Flight Log for 1360A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: [illegible]

1 LIDAR Operator: FJ Sable	2 ALTM Model: Aquarius	3 Mission Name: 3BLK34KS110B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RPC 9122
7 Pilot: J. Javier	8 Co-Pilot: N. Agawin	9 Route:			
10 Date: April 20, 2014	12 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1322	14 Engine Off: 1645	15 Total Engine Time: 3+23	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Cloudy					

20 Remarks:

Completed 8 lines left from the first mission.

21 Problems and Solutions:

Acquisition Flight Approved by
Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by
Signature over Printed Name
(PAF Representative)

Pilot-in-Command
J. Javier
Signature over Printed Name

Lidar Operator
FJ Sable
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

5. Flight Log for 3765G Mission

Flight Log No.: 3765

PHIL-LIDAR 1 Data Acquisition Flight Log

1 LiDAR Operator: J. Almalvez	2 ALTM Model: Gemini	3 Mission Name: 2BLK34AD022A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9022
7 Pilot: Albert Lim	8 Co-Pilot: Randy Lagco	9 Route: TACLOBAN LOCAL			
10 Date: 1-22-16	12 Airport of Departure (Airport, City/Province): TACLOBAN		12 Airport of Arrival (Airport, City/Province): TACLOBAN		
13 Engine On: 8:02 AM	14 Engine Off: 12:13 PM	15 Total Engine Time: 4+11	16 Take off: 07:57	17 Landing: 12:08	18 Total Flight Time: 4+01
19 Weather: Partly cloudy					

20 Flight Classification

20.a Billable
- ✓ Acquisition Flight
- o Ferry Flight
- o System Test Flight
- o Calibration Flight

20.b Non Billable
- o Aircraft Test Flight
- o AAC Admin Flight
- o Others: ____

20.c Others
- o LiDAR System Maintenance
- o Aircraft Maintenance
- o Phil-LiDAR Admin Activities

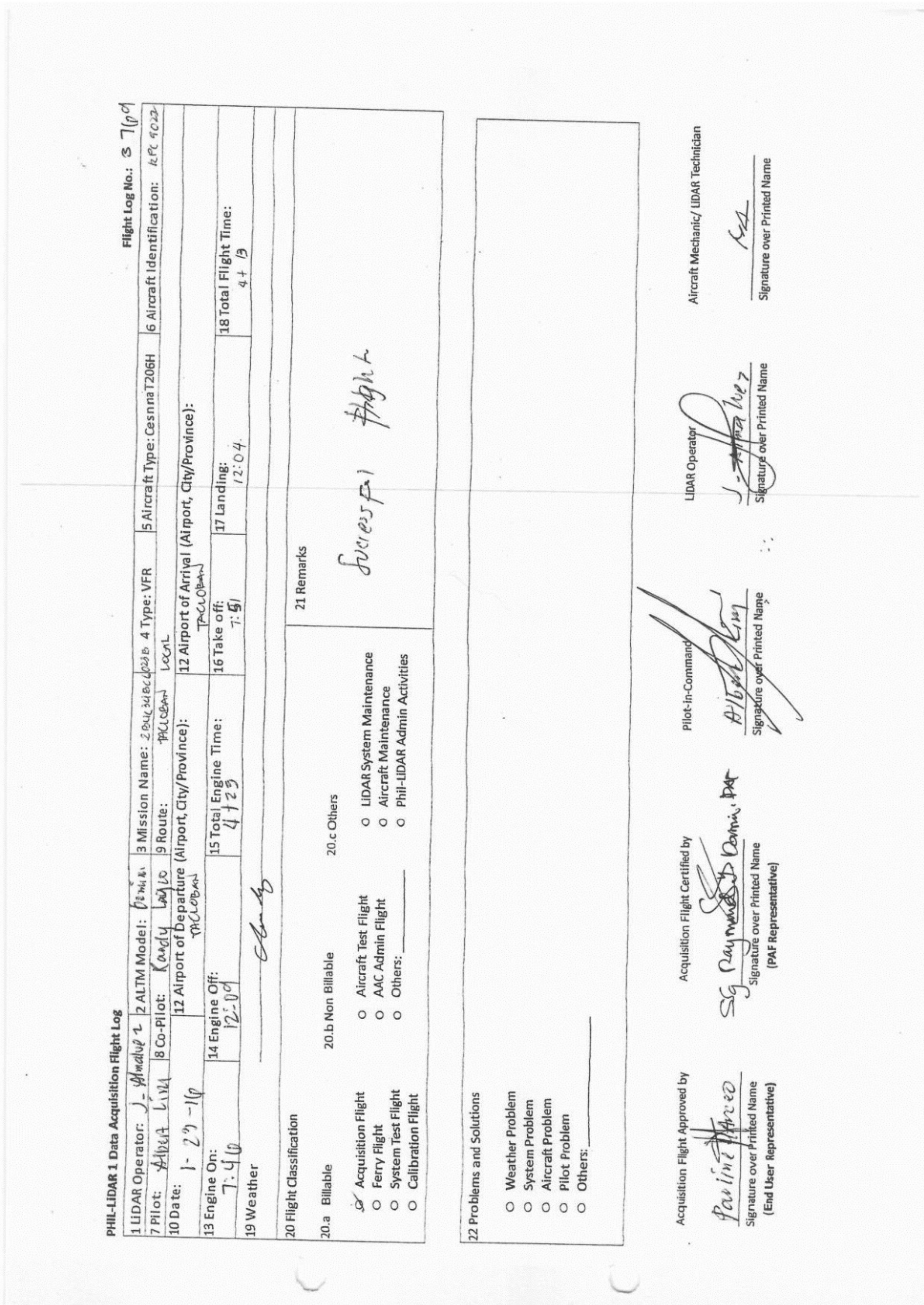
21 Remarks

A.M.
Successful flight.

22 Problems and Solutions
- o Weather Problem
- o System Problem
- o Aircraft Problem
- o Pilot Problem
- o Others: ____

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LiDAR Operator	Aircraft Mechanic/ LiDAR Technician
Pauline Arceo	SSg Raymund Dominic PAF	Albert Lim	J. Almalvez	NA
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

6. Flight Log for 3769G Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 3769

1 LiDAR Operator: J. Almalvez	2 ALTM Model: Gemini	3 Mission Name: 2BLK36BCL029B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RPC 9022
7 Pilot: Albert Lim	8 Co-Pilot: Randy Lagco	9 Route: TACLOBAN LOCAL			
10 Date: 1-29-16	12 Airport of Departure (Airport, City/Province): TACLOBAN		12 Airport of Arrival (Airport, City/Province): TACLOBAN		
13 Engine On: 7:46	14 Engine Off: 12:09	15 Total Engine Time: 4+23	16 Take off: 7:51	17 Landing: 12:04	18 Total Flight Time: 4+13
19 Weather: Cloudy					

20 Flight Classification

20.a Billable
- ☑ Acquisition Flight
- ○ Ferry Flight
- ○ System Test Flight
- ○ Calibration Flight

20.b Non Billable
- ○ Aircraft Test Flight
- ○ AAC Admin Flight
- ○ Others: ____________

20.c Others
- ○ LiDAR System Maintenance
- ○ Aircraft Maintenance
- ○ Phil-LiDAR Admin Activities

21 Remarks

Successful flight

22 Problems and Solutions
- ○ Weather Problem
- ○ System Problem
- ○ Aircraft Problem
- ○ Pilot Problem
- ○ Others: ____________

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LIDAR Operator	Aircraft Mechanic/ LIDAR Technician
Paulino Arceo	SSg Raymund D. Domingo PAF	Albert Lim	J. Almalvez	
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

7. Flight Log for 3771G Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 3771

1 LiDAR Operator: L. Sinadjan	2 ALTM Model: GEMINI	3 Mission Name: 2BLK34AOE023A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RPC 9022
7 Pilot: Albert Lim	8 Co-Pilot: Randy Lagos	9 Route: Tacloban Local			
10 Date: 1-23-16	12 Airport of Departure (Airport, City/Province): Tacloban		12 Airport of Arrival (Airport, City/Province): Tacloban		
13 Engine On: 14:15	14 Engine Off: 17:44	15 Total Engine Time: 3+29	16 Take off: 14:20	17 Landing: 17:39	18 Total Flight Time: 3+19
19 Weather: Cloudy					

20 Flight Classification

20.a Billable
- ✓ Acquisition Flight
- o Ferry Flight
- o System Test Flight
- o Calibration Flight

20.b Non Billable
- o Aircraft Test Flight
- o AAC Admin Flight
- o Others: ____________

20.c Others
- o LiDAR System Maintenance
- o Aircraft Maintenance
- o Phil-LiDAR Admin Activities

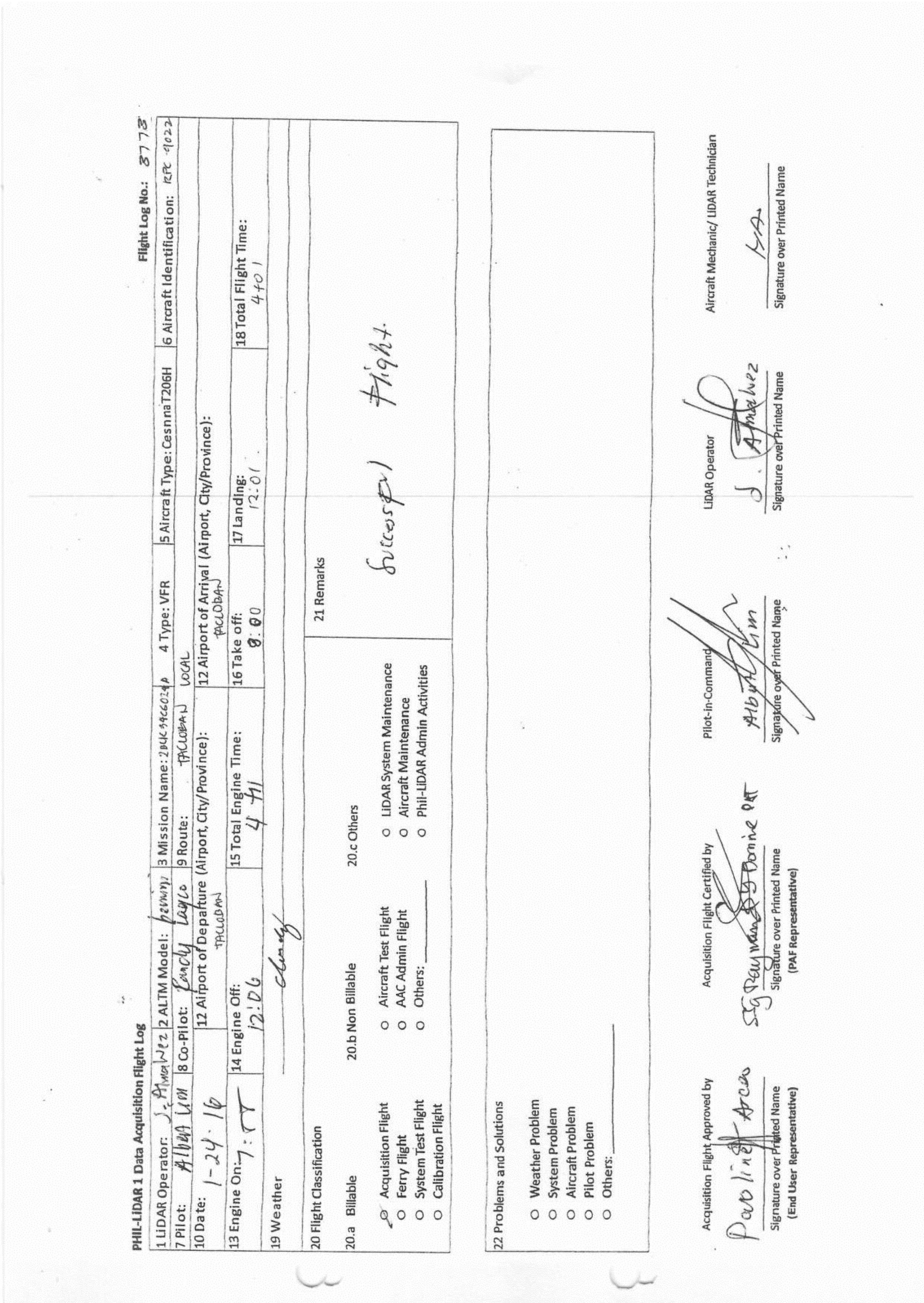
21 Remarks

Successful flight.

22 Problems and Solutions
- o Weather Problem
- o System Problem
- o Aircraft Problem
- o Pilot Problem
- o Others: ____________

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LiDAR Operator	Aircraft Mechanic/ LiDAR Technician
Paulineth Arceo	SSg Raymund Y. Domin PAF	Albert Lim	L. Sinadjan	N/A
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

8. Flight Log for 3773G Mission


PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 3773

1 LiDAR Operator: J. Almalvez
2 ALTM Model: Gemini
3 Mission Name: 2BLK34CG024A
4 Type: VFR
5 Aircraft Type: CesnnaT206H
6 Aircraft Identification: RPC-9022
7 Pilot: Albert Lim
8 Co-Pilot: Randy Layco
9 Route: TACLOBAN LOCAL
10 Date: 1-24-16
12 Airport of Departure (Airport, City/Province): TACLOBAN
12 Airport of Arrival (Airport, City/Province): TACLOBAN
13 Engine On: 7:55
14 Engine Off: 12:06
15 Total Engine Time: 4+11
16 Take off: 8:00
17 Landing: 12:01
18 Total Flight Time: 4+01
19 Weather: cloudy

20 Flight Classification

20.a Billable
- Acquisition Flight (marked)
- Ferry Flight
- System Test Flight
- Calibration Flight

20.b Non Billable
- Aircraft Test Flight
- AAC Admin Flight
- Others: ____

20.c Others
- LiDAR System Maintenance
- Aircraft Maintenance
- Phil-LiDAR Admin Activities

21 Remarks: Successful flight.

22 Problems and Solutions
- Weather Problem
- System Problem
- Aircraft Problem
- Pilot Problem
- Others: ____

Acquisition Flight Approved by: Paulino Arceo — Signature over Printed Name (End User Representative)

Acquisition Flight Certified by: SSg Raymund [illegible] PAF — Signature over Printed Name (PAF Representative)

Pilot-in-Command: Albert Lim — Signature over Printed Name

LiDAR Operator: J. Almalvez — Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician: — Signature over Printed Name

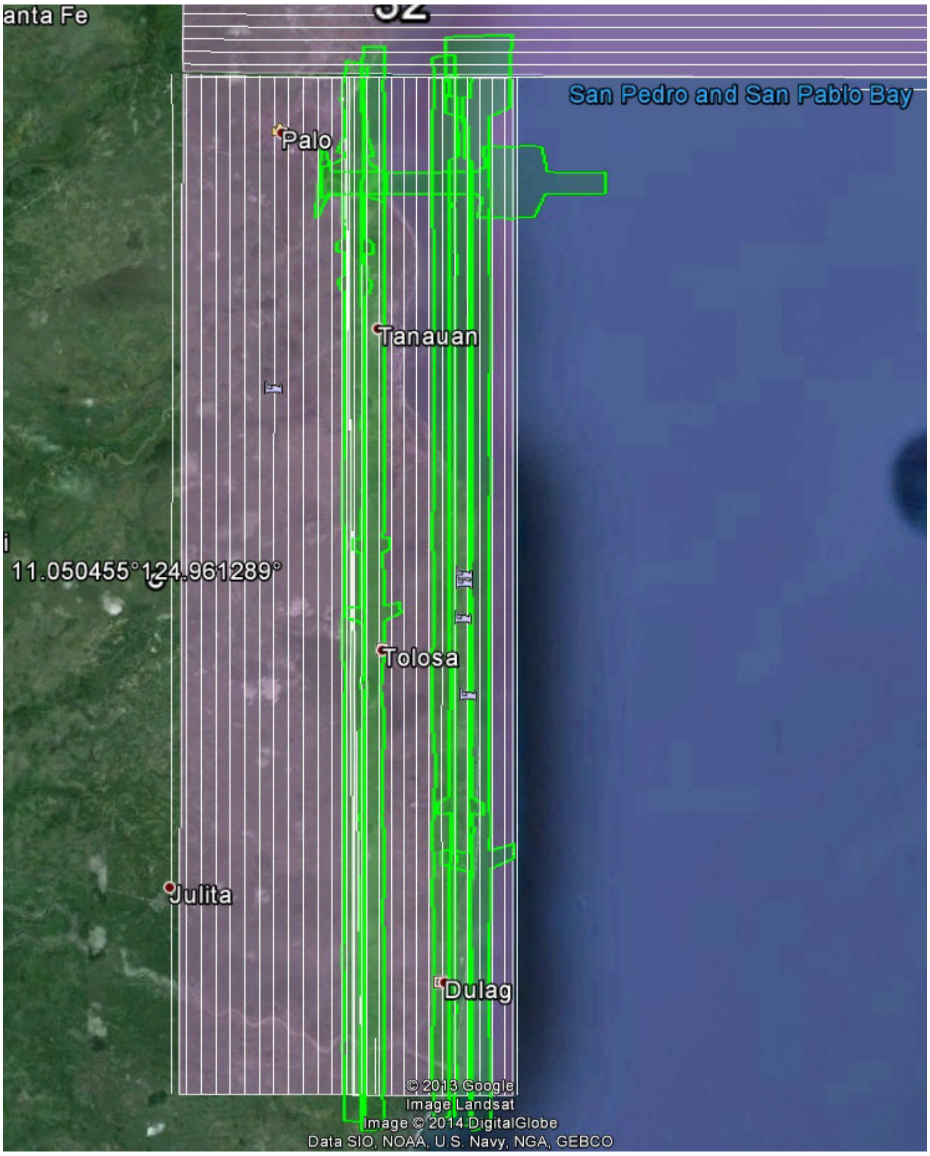
Annex 7. Flight Status

FLIGHT STATUS REPORT
Tacloban / Leyte
January 26-27& April 20, 2014; January 22-24, 2016

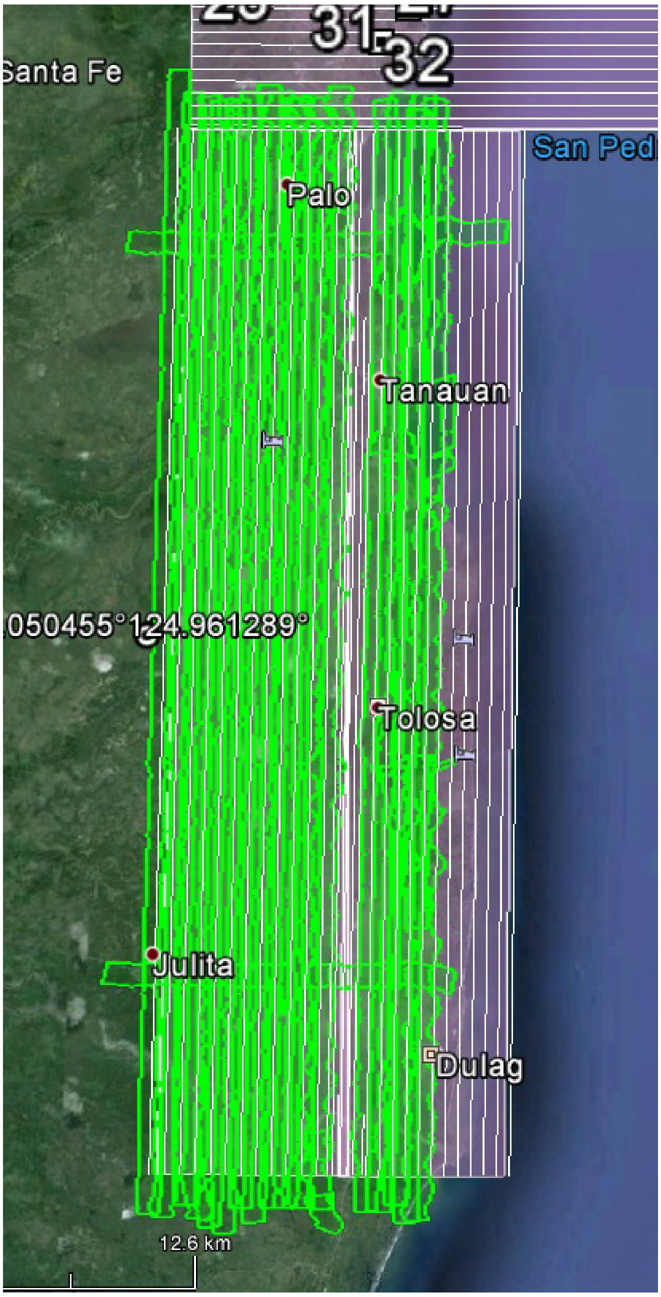
FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1026A	BLK34A	3BLK34AS026A	DC ALDOVINO	26 JAN 14	Completed 8 flight lines over BLK34A. Loss POS comm(digitizer hanged) Lines cut due to terrain on the east side
1028A	BLK34A	3BLK 34ABS027A	DC ALDOVINO	27 JAN 14	Completed remaining flight lines over BLK34A.
1358A	BLK34F	3BLK34F110A	PJ ARCEO	20 APR 14	Completed 18/ 24 lines over BLK34F.
1360A	BLK34F	3BLK34FS110B	FJ SABLE	20 APR 14	Completed mission 8 lines left from the morning flight.
3765G	BLK34A BLK34D	2BLK34AD022A	J.Almalvez	Jan. 22, 2016	Surveyed 7 lines at BLK34D and 10 lines at BLK34A.
3769G	BLK34A BLK34D BLK34E BLK34G	2BLK34ADEG023A	J.Almalvez	Jan. 23, 2016	Completed BLK34A, BLK34D and BLK 34E. Surveyed 6 lines at BLK34G.
3771G	BLK34B BLK34C BLK34G	2BLK34BCG023B	G. Sinadjan	Jan. 23, 2016	Completed BLK34B. Surveyed 10 lines at BLK34C and 4 lines at BLK34G.
3773G	BLK34C BLK34G	2BLK34CG024A	J. Almalvez	Jan. 24, 2016	Completed BLK34C and BLK34G.

SWATH PER FLIGHT MISSION

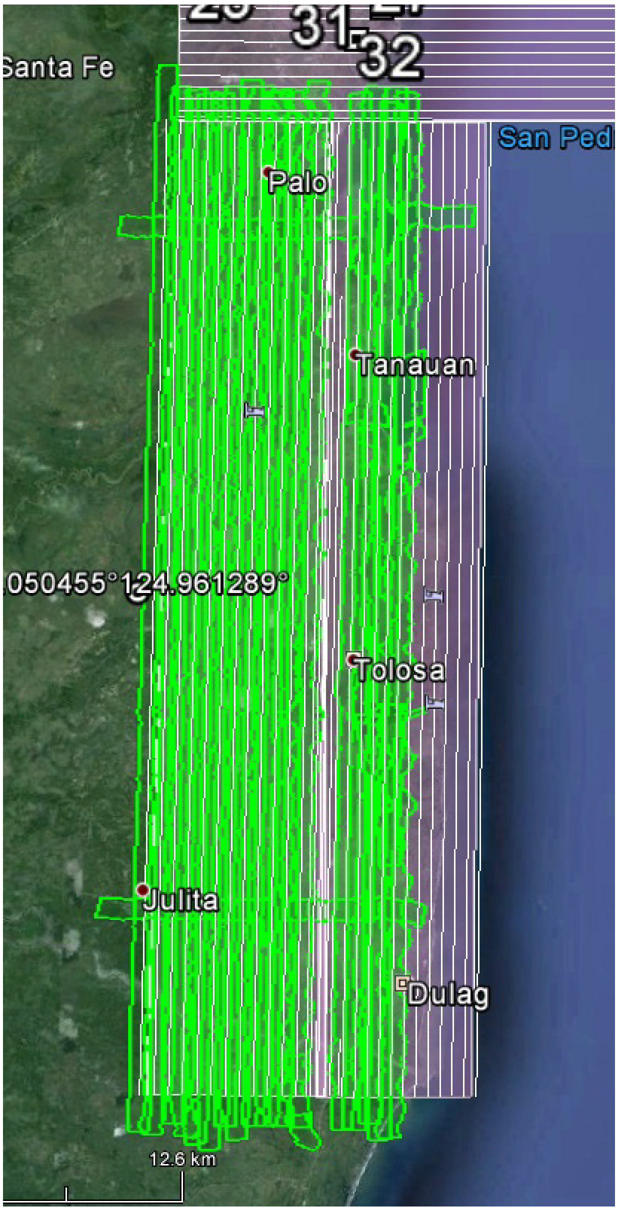
Flight No. : 1026A
Area: BLK34A AND BLK 34B
Mission Name: 3BLK34AS026B
Parameters: Alt: 600m; Scan Fz: 40; Scan angle: 25; Overlap: 40



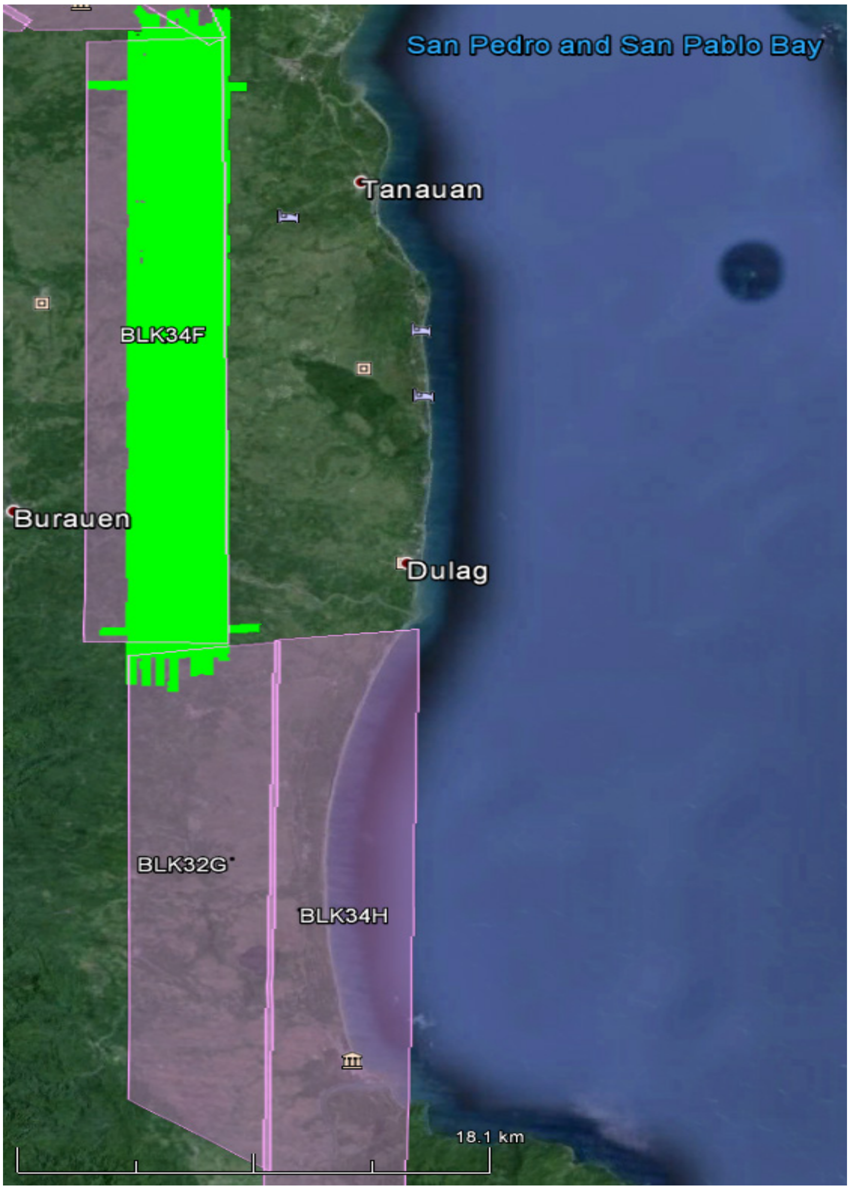
Flight No. :	1026A
Area:	BLK33B AND BLK34A
Mission Name:	3BLK34ABS027A
Parameters:	Alt: 600m; Scan Fz: 40; Scan angle: 25; Overlap: 40



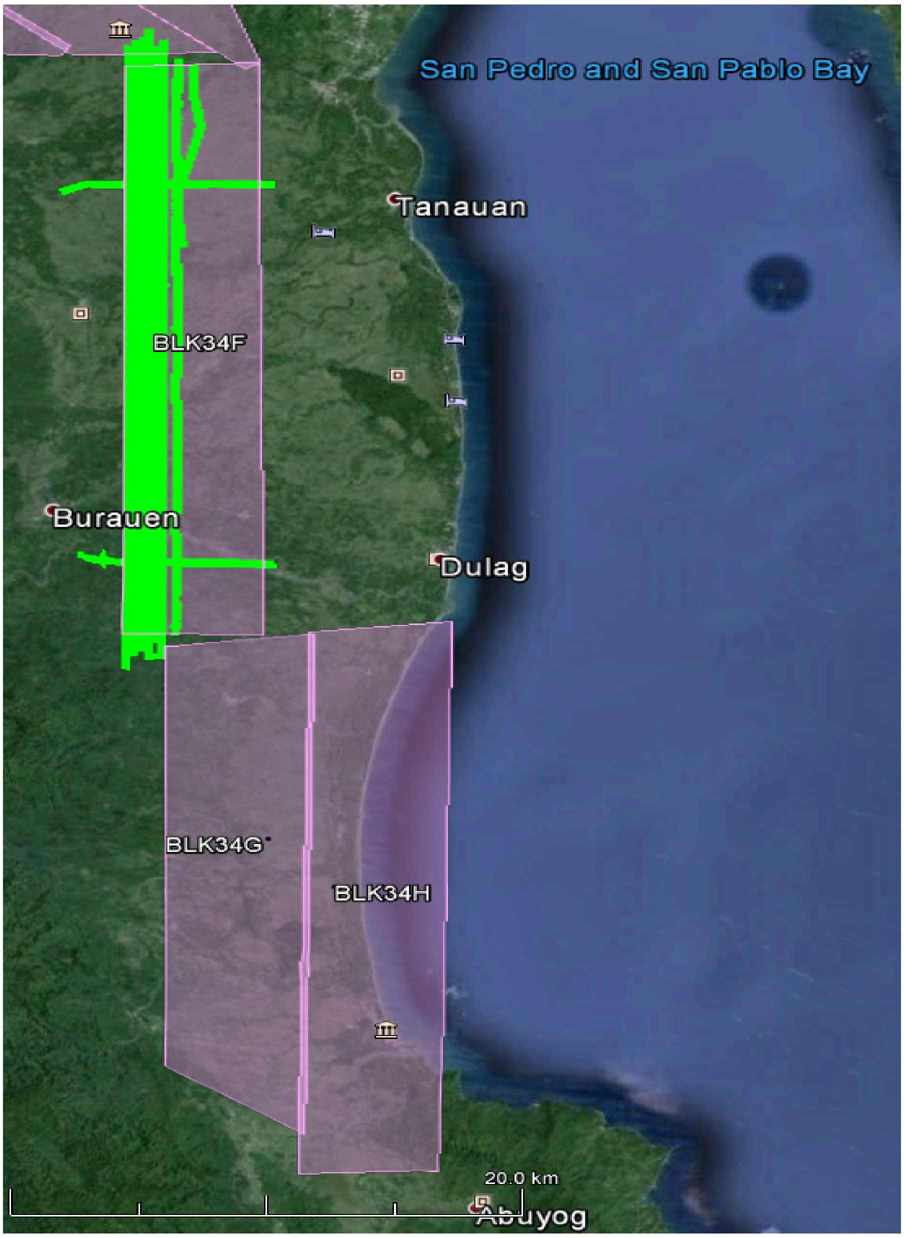
Flight No. :	1028A
Area:	BLK34A AND BLK34B
Mission Name:	3BLK 34ABS027A
Parameters:	Alt: 600m; Scan Fz: 40; Scan angle: 25; Overlap: 40%



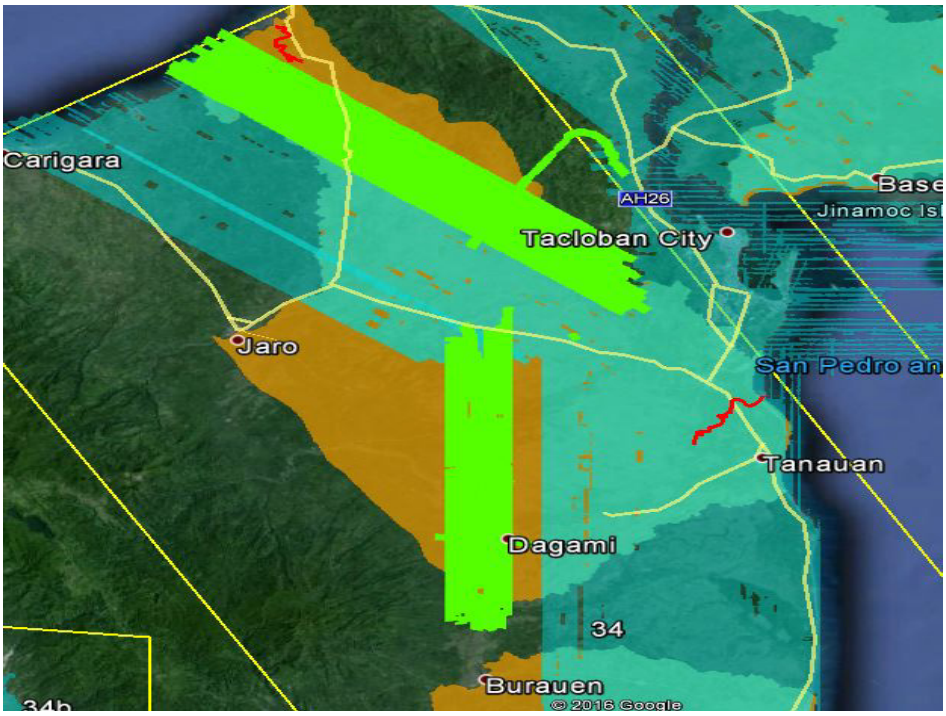
Flight No. :	1358A		
Area:	BLK34F		
Mission Name:	3BLK34F110A		
Total Area:	122.03 sq km		
Altitude:	600m		
PRF:	50 kHz	SCF:	50 Hz
Lidar FOV:	18 deg	Sidelap:	30%



Flight No. :	1360A		
Area:	BLK34K		
Mission Name:	3BLK34K110B		
Total Area:	74.498 sq km		
Altitude:	600m		
PRF:	50 kHz	SCF:	50 Hz
Lidar FOV:	18 deg	Sidelap:	30%

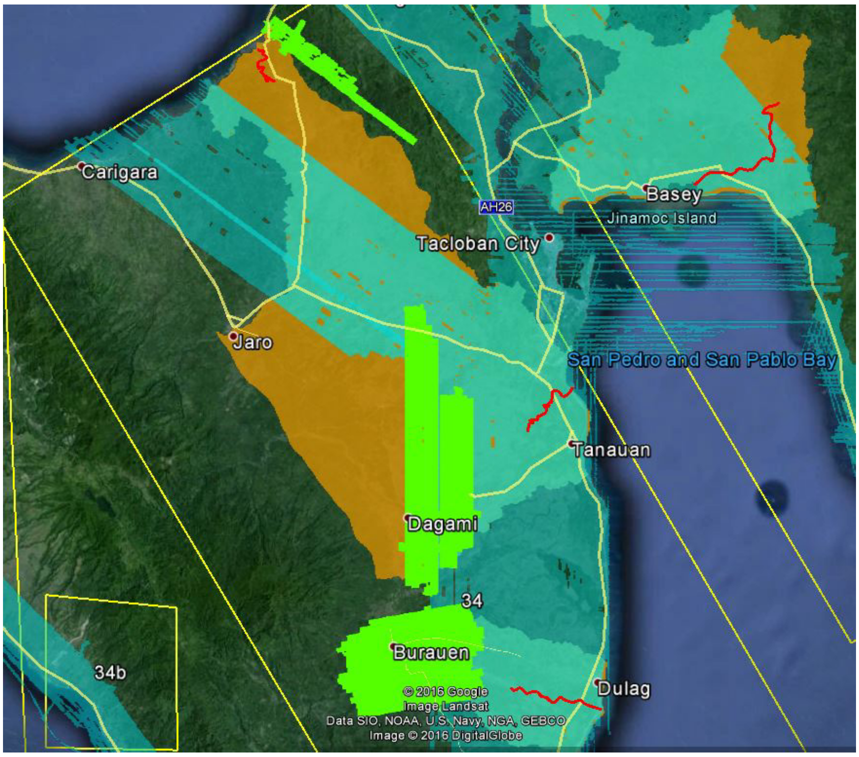


FLIGHT NO.:	3765G		
AREA:	Leyte		
MISSION NAME:	2BLK34AD022A		
ALT:	1100m & 600m	SCAN FREQ: 50	SCAN ANGLE: 17
SURVEYED AREA:	172.8		



START	STOP	LINE#	ALT	PRF	FREQ	ANGLE	MP	DIV	RC	MPM	HDG	Plan File
00:33:39.345	00:33:51.77	20	818	100	50.00	17.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@1100LYT104.pln
00:39:03.043	00:44:47.236	20	1212	100	50.00	17.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@1100LYT104.pln
00:46:57.49	00:53:03.348	23	1216	100	50.00	17.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@1100LYT104.pln
00:56:12.181	01:01:35.629	19	1207	100	50.00	17.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@1100LYT104.pln
01:03:47.493	01:09:54.181	22	1220	100	50.00	17.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@1100LYT104.pln
01:13:33.354	01:18:56.742	18	1203	100	50.00	17.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@1100LYT104.pln
01:25:27.664	01:31:11.217	23	945	100	50.00	20.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@850LYT104.pln
01:37:39.524	01:43:47.442	28	632	100	40.00	25.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@600LYT104.pln
01:57:05.277	01:58:31.191	28	592	100	40.00	25.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@600LYT104.pln
02:07:24.673	02:15:05.335	71	691	100	40.00	25.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@600LYT104.pln
02:17:23.449	02:25:59.311	67	686	100	40.00	25.00	OFF	NAR	ON	OFF	127.03	LEYTE_New@600LYT104.pln
02:31:41.644	02:34:33.843	70	654	100	40.00	25.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@600LYT104.pln
02:31:41.644	02:35:58.793	70	685	100	40.00	25.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@600LYT104.pln
02:39:50.507	02:47:20.039	70	672	100	40.00	25.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@600LYT104.pln
02:49:39.738	02:57:59.426	68	661	100	40.00	25.00	OFF	NAR	ON	OFF	127.03	LEYTE_New@600LYT104.pln
03:00:26.88	03:08:07.342	69	659	100	40.00	25.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@600LYT104.pln
03:00:26.88	03:08:19.227	69	663	100	40.00	25.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@600LYT104.pln
03:10:15.317	03:18:12.774	72	675	100	40.00	25.00	OFF	NAR	ON	OFF	127.03	LEYTE_New@600LYT104.pln
03:20:49.349	03:28:01.001	73	678	100	40.00	25.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@600LYT104.pln
03:30:11.401	03:37:48.178	74	659	100	40.00	25.00	OFF	NAR	ON	OFF	127.03	LEYTE_New@600LYT104.pln
03:40:37.743	03:47:28.916	75	640	100	40.00	25.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@600LYT104.pln
03:49:24.55	03:56:58.098	76	658	100	40.00	25.00	OFF	NAR	ON	OFF	127.03	LEYTE_New@600LYT104.pln

FLIGHT NO.:	3769G		
AREA:	Leyte		
MISSION NAME:	2BLK34ADEG023A		
ALT:	1100 m & 600m	SCAN FREQ: 50	SCAN ANGLE: 17
SURVEYED AREA:	167.25km²		



START	STOP	LINE#	ALT	PRF	FREQ	ANGLE	MP	DIV	RC	MPM	HDG	Plan File
00:22:31.78	00:26:20.698	72	1211	100	50.00	17.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@1100LYT104.pln
00:28:37.812	00:31:16.126	73	1193	100	50.00	17.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@1100LYT104.pln
00:35:24.269	00:37:33.159	74	1224	100	50.00	17.00	OFF	NAR	ON	OFF	307.03	LEYTE_New@1100LYT104.pln
00:40:39.812	00:41:30.702	74	1207	100	50.00	17.00	OFF	NAR	ON	OFF	127.01	LEYTE_New@1100LYT104.pln
00:48:05.129	00:53:46.931	24	1205	100	50.00	17.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@1100LYT104.pln
00:55:33.871	01:01:07.443	28	1208	100	50.00	17.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@1100LYT104.pln
01:03:10.442	01:08:58.935	25	1205	100	50.00	17.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@1100LYT104.pln
01:10:53.874	01:16:49.566	27	1212	100	50.00	17.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@1100LYT104.pln
01:19:28.82	01:25:08.443	26	1212	100	50.00	17.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@1100LYT104.pln
01:29:09.126	01:30:14.996	24	1192	100	50.00	17.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@1100LYT104.pln
01:36:23.963	01:39:08.327	2	690	100	40.00	25.00	OFF	NAR	ON	OFF	260.00	LEYTE_New@600LYT104.pln
01:40:33.271	01:43:43.215	8	661	100	40.00	25.00	OFF	NAR	ON	OFF	80.00	LEYTE_New@600LYT104.pln
01:44:58.119	01:47:39.883	3	683	100	40.00	25.00	OFF	NAR	ON	OFF	260.00	LEYTE_New@600LYT104.pln
01:49:25.737	01:52:23.296	7	695	100	40.00	25.00	OFF	NAR	ON	OFF	80.00	LEYTE_New@600LYT104.pln
01:54:07.941	01:56:51.769	4	684	100	40.00	25.00	OFF	NAR	ON	OFF	260.00	LEYTE_New@600LYT104.pln
01:58:40.714	02:01:44.517	9	718	100	40.00	25.00	OFF	NAR	ON	OFF	80.00	LEYTE_New@600LYT104.pln
02:03:20.157	02:06:08.861	5	683	100	40.00	25.00	OFF	NAR	ON	OFF	260.00	LEYTE_New@600LYT104.pln
02:08:12.91	02:11:24.969	10	679	100	40.00	25.00	OFF	NAR	ON	OFF	80.00	LEYTE_New@600LYT104.pln
02:12:56.988	02:15:43.177	6	692	100	40.00	25.00	OFF	NAR	ON	OFF	260.00	LEYTE_New@600LYT104.pln
02:17:57.036	02:21:14.385	15	704	100	40.00	25.00	OFF	NAR	ON	OFF	80.00	LEYTE_New@600LYT104.pln
02:22:41.799	02:25:42.018	11	682	100	40.00	25.00	OFF	NAR	ON	OFF	260.00	LEYTE_New@600LYT104.pln
02:22:41.799	02:25:42.018	11	681	100	40.00	25.00	OFF	NAR	ON	OFF	260.00	LEYTE_New@600LYT104.pln
02:26:59.208	02:30:06.887	16	713	100	40.00	25.00	OFF	NAR	ON	OFF	80.00	LEYTE_New@600LYT104.pln
02:31:32.886	02:34:31.04	12	674	100	40.00	25.00	OFF	NAR	ON	OFF	260.00	LEYTE_New@600LYT104.pln
02:38:46.379	02:41:45.777	17	682	100	40.00	25.00	OFF	NAR	ON	OFF	80.00	LEYTE_New@600LYT104.pln
02:43:14.947	02:46:16.721	13	683	100	40.00	25.00	OFF	NAR	ON	OFF	260.00	LEYTE_New@600LYT104.pln
02:47:39.07	02:50:12.384	18	686	100	40.00	25.00	OFF	NAR	ON	OFF	80.00	LEYTE_New@600LYT104.pln
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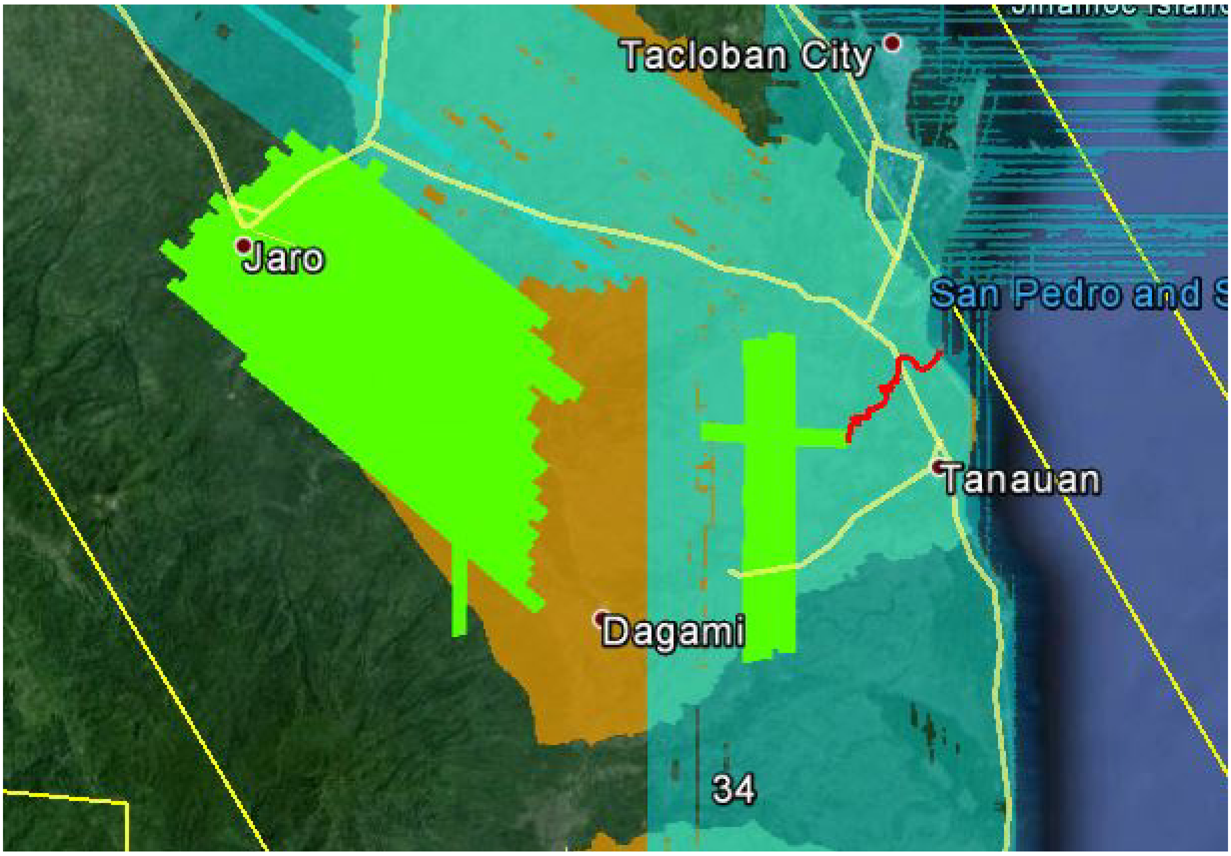
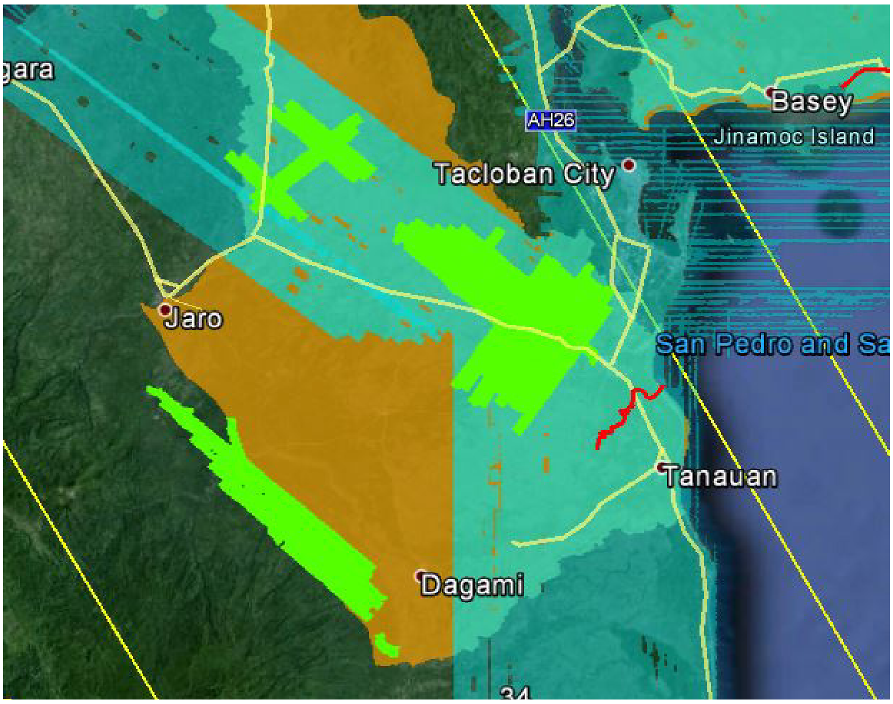
02:58:54.526	03:01:12.241	19	679	100	40.00	25.00	OFF	NAR	ON	OFF	80.00	LEYTE_New@600LYT104.pln
03:04:38.069	03:06:50.924	19	702	100	40.00	25.00	OFF	NAR	ON	OFF	80.00	LEYTE_New@600LYT104.pln
03:11:20.722	03:15:25.216	88	691	100	40.00	25.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@600LYT104.pln
03:16:32.95	03:19:39.779	93	688	100	40.00	25.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@600LYT104.pln
03:21:01.809	03:25:02.922	89	669	100	40.00	25.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@600LYT104.pln
03:25:59.182	03:29:14.811	92	692	100	40.00	25.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@600LYT104.pln
03:30:41.01	03:34:40.869	90	681	100	40.00	25.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@600LYT104.pln
03:36:02.318	03:39:28.072	91	694	100	40.00	25.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@600LYT104.pln
03:41:36.076	03:42:46.301	88	641	100	40.00	25.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@600LYT104.pln

FLIGHT NO.: 3771G
AREA: Leyte
MISSION NAME: 2BLK34BCG023B
ALT: 850 m SCAN FREQ: 50 SCAN ANGLE: 20
SURVEYED AREA: 143.4 km²



START	STOP	LINE#	ALT	PRF	FREQ	ANGLE	MP	DIV	RC	MPM	HDG	Plan File
06:35:50.577	06:39:05.031	92	957	100	50.00	20.00	OFF	NAR	ON	OFF	133.03	LEYTE_New@850LYT104.pln
06:41:21.246	06:44:51.86	91	940	100	50.00	20.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@850LYT104.pln
06:47:00.754	06:50:13.578	90	957	100	50.00	20.00	OFF	NAR	ON	OFF	180.00	LEYTE_New@850LYT104.pln
06:52:20.328	06:55:54.407	89	948	100	50.00	20.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@850LYT104.pln
06:59:06.001	07:01:55.615	43	946	100	50.00	20.00	OFF	NAR	ON	OFF	308.02	LEYTE_New@850LYT104.pln
07:04:23.724	07:07:40.653	42	970	100	50.00	20.00	OFF	NAR	ON	OFF	308.02	LEYTE_New@850LYT104.pln
07:09:27.792	07:12:48.761	41	949	100	50.00	20.00	OFF	NAR	ON	OFF	128.02	LEYTE_New@850LYT104.pln
07:14:45.411	07:19:03.689	40	995	100	50.00	20.00	OFF	NAR	ON	OFF	128.02	LEYTE_New@850LYT104.pln
07:14:45.411	07:19:03.689	40	998	100	50.00	20.00	OFF	NAR	ON	OFF	128.02	LEYTE_New@850LYT104.pln
07:22:30.443	07:26:26.447	39	947	100	50.00	20.00	OFF	NAR	ON	OFF	308.02	LEYTE_New@850LYT104.pln
07:29:17.041	07:31:04.62	39	958	100	50.00	20.00	OFF	NAR	ON	OFF	308.02	LEYTE_New@850LYT104.pln
07:34:35.484	07:38:18.518	38	933	100	50.00	20.00	OFF	NAR	ON	OFF	128.02	LEYTE_New@850LYT104.pln
07:40:19.587	07:44:00.311	37	940	100	50.00	20.00	OFF	NAR	ON	OFF	308.02	LEYTE_New@850LYT104.pln
07:46:35.415	07:50:29.218	36	943	100	50.00	20.00	OFF	NAR	ON	OFF	128.02	LEYTE_New@850LYT104.pln
07:53:02.767	07:56:56.151	35	946	100	50.00	20.00	OFF	NAR	ON	OFF	308.02	LEYTE_New@850LYT104.pln
07:59:03.52	08:03:27.419	34	952	100	50.00	20.00	OFF	NAR	ON	OFF	128.02	LEYTE_New@850LYT104.pln
08:05:49.663	08:09:57.871	60	949	100	50.00	20.00	OFF	NAR	ON	OFF	310.02	LEYTE_New@850LYT104.pln
08:12:18.735	08:16:57.524	59	965	100	50.00	20.00	OFF	NAR	ON	OFF	130.02	LEYTE_New@850LYT104.pln
08:19:25.488	08:24:05.456	58	944	100	50.00	20.00	OFF	NAR	ON	OFF	130.02	LEYTE_New@850LYT104.pln
08:26:08.015	08:30:54.088	57	944	100	50.00	20.00	OFF	NAR	ON	OFF	130.02	LEYTE_New@850LYT104.pln
08:33:10.808	08:37:45.911	56	951	100	50.00	20.00	OFF	NAR	ON	OFF	310.02	LEYTE_New@850LYT104.pln
08:39:57.74	08:45:00.053	55	973	100	50.00	20.00	OFF	NAR	ON	OFF	130.02	LEYTE_New@850LYT104.pln
08:46:48.528	08:48:48.057	61	956	100	50.00	20.00	OFF	NAR	ON	OFF	310.02	LEYTE_New@850LYT104.pln
08:50:51.951	08:53:44.495	61	951	100	50.00	20.00	OFF	NAR	ON	OFF	310.02	LEYTE_New@850LYT104.pln
08:56:35.949	09:01:09.127	54	917	100	50.00	20.00	OFF	NAR	ON	OFF	310.02	LEYTE_New@850LYT104.pln
09:03:11.426	09:08:11.744	53	958	100	50.00	20.00	OFF	NAR	ON	OFF	130.02	LEYTE_New@850LYT104.pln
09:10:28.919	09:14:22.267	52	962	100	50.00	20.00	OFF	NAR	ON	OFF	310.02	LEYTE_New@850LYT104.pln
09:20:26.535	09:22:07.164	91	949	100	50.00	20.00	OFF	NAR	ON	OFF	360.00	LEYTE_New@850LYT104.pln

FLIGHT NO.: 3773G
AREA: Leyte
MISSION NAME: 2BLK34CG024A
ALT: 600 m SCAN FREQ: 40 SCAN ANGLE: 25
SURVEYED AREA: 90.6 km^2



START	STOP	LINE#	ALT	PRF	FREQ	ANGLE	MP	DIV	RC	MPM	HDG	Plan File
00:41:26.291	00:45:37.304	54	673	100	40.00	25.00	OFF	NAR	ON	OFF	129.99	leyteVOIDSnew@600.pln
00:47:19.499	00:47:47.129	50	670	100	40.00	25.00	OFF	NAR	ON	OFF	309.99	leyteVOIDSnew@600.pln
00:48:00.128	00:49:49.973	50	642	100	40.00	25.00	OFF	NAR	ON	OFF	309.99	leyteVOIDSnew@600.pln
00:55:27.525	00:59:52.439	55	680	100	40.00	25.00	OFF	NAR	ON	OFF	129.99	leyteVOIDSnew@600.pln
01:02:18.758	01:06:11.696	53	626	100	40.00	25.00	OFF	NAR	ON	OFF	309.99	leyteVOIDSnew@600.pln
01:11:13.674	01:14:14.473	51	635	100	40.00	25.00	OFF	NAR	ON	OFF	129.99	leyteVOIDSnew@600.pln
01:16:42.357	01:20:10.02	52	670	100	40.00	25.00	OFF	NAR	ON	OFF	309.99	leyteVOIDSnew@600.pln
01:20:49.76	01:21:04.42	54	673	100	40.00	25.00	OFF	NAR	ON	OFF	310.00	leyteVOIDSnew@600.pln
01:24:38.359	01:25:37.498	54	664	100	40.00	25.00	OFF	NAR	ON	OFF	130.00	leyteVOIDSnew@600.pln
01:30:49.756	01:32:51.7	50	665	100	40.00	25.00	OFF	NAR	ON	OFF	129.99	leyteVOIDSnew@600.pln
01:37:16.759	01:39:56.043	131	686	100	40.00	25.00	OFF	NAR	ON	OFF	36.01	leyteVOIDSnew@600.pln
01:41:54.187	01:44:07.646	136	677	100	40.00	25.00	OFF	NAR	ON	OFF	216.01	leyteVOIDSnew@600.pln
01:46:06.62	01:48:48.959	132	723	100	40.00	25.00	OFF	NAR	ON	OFF	36.01	leyteVOIDSnew@600.pln
01:50:32.703	01:52:38.423	137	724	100	40.00	25.00	OFF	NAR	ON	OFF	216.01	leyteVOIDSnew@600.pln
01:54:26.957	01:56:40.186	133	675	100	40.00	25.00	OFF	NAR	ON	OFF	36.01	leyteVOIDSnew@600.pln
01:58:22.395	02:00:28.59	138	677	100	40.00	25.00	OFF	NAR	ON	OFF	216.01	leyteVOIDSnew@600.pln
02:02:11.674	02:04:57.128	134	683	100	40.00	25.00	OFF	NAR	ON	OFF	36.01	leyteVOIDSnew@600.pln
02:06:30.502	02:08:37.931	139	682	100	40.00	25.00	OFF	NAR	ON	OFF	216.01	leyteVOIDSnew@600.pln
02:10:13.101	02:12:54.015	135	693	100	40.00	25.00	OFF	NAR	ON	OFF	36.01	leyteVOIDSnew@600.pln
02:14:21.569	02:16:27.344	140	681	100	40.00	25.00	OFF	NAR	ON	OFF	216.01	leyteVOIDSnew@600.pln
02:18:30.538	02:21:11.317	141	693	100	40.00	25.00	OFF	NAR	ON	OFF	36.01	leyteVOIDSnew@600.pln
02:23:48.796	02:25:34.795	141	729	100	40.00	25.00	OFF	NAR	ON	OFF	36.01	leyteVOIDSnew@600.pln
02:28:25.509	02:30:35.513	120	692	100	40.00	25.00	OFF	NAR	ON	OFF	130.00	leyteVOIDSnew@600.pln
02:32:05.188	02:34:04.657	124	675	100	40.00	25.00	OFF	NAR	ON	OFF	310.00	leyteVOIDSnew@600.pln
02:35:54.016	02:38:07.216	121	691	100	40.00	25.00	OFF	NAR	ON	OFF	130.00	leyteVOIDSnew@600.pln
02:39:35.88	02:41:22.769	125	706	100	40.00	25.00	OFF	NAR	ON	OFF	310.00	leyteVOIDSnew@600.pln
02:42:45.769	02:44:49.598	122	695	100	40.00	25.00	OFF	NAR	ON	OFF	130.00	leyteVOIDSnew@600.pln
02:46:19.373	02:47:57.102	126	697	100	40.00	25.00	OFF	NAR	ON	OFF	310.00	leyteVOIDSnew@600.pln
02:50:03.911	02:52:14.036	123	677	100	40.00	25.00	OFF	NAR	ON	OFF	130.00	leyteVOIDSnew@600.pln
02:54:49.325	02:56:02.074	123	667	100	40.00	25.00	OFF	NAR	ON	OFF	128.98	leyteVOIDSnew@600.pln
02:58:39.883	03:00:18.348	145	698	100	40.00	25.00	OFF	NAR	ON	OFF	308.98	leyteVOIDSnew@600.pln
03:01:59.887	03:03:42.777	143	685	100	40.00	25.00	OFF	NAR	ON	OFF	308.98	leyteVOIDSnew@600.pln
03:05:27.966	03:07:08.375	144	689	100	40.00	25.00	OFF	NAR	ON	OFF	315.00	leyteVOIDSnew@600.pln
03:08:34.69	03:09:55.629	149	707	100	40.00	25.00	OFF	NAR	ON	OFF	315.00	leyteVOIDSnew@600.pln
03:11:43.889	03:13:06.778	148	667	100	40.00	25.00	OFF	NAR	ON	OFF	315.00	leyteVOIDSnew@600.pln
03:15:53.122	03:17:54.942	152	709	100	40.00	25.00	OFF	NAR	ON	OFF	231.49	leyteVOIDSnew@600.pln
03:20:17.491	03:22:19.975	153	686	100	40.00	25.00	OFF	NAR	ON	OFF	231.49	leyteVOIDSnew@600.pln
03:28:30.043	03:29:27.943	85	629	100	40.00	25.00	OFF	NAR	ON	OFF	307.01	leyteVOIDSnew@600.pln

Annex 8. Mission Summary Reports

Flight Area	Samar-Leyte
Mission Name	Blk34F
Inclusive Flights	1358A, 1360A
Range data size	22.36 GB
Base data size	417 MB
POS data size	115.1 GB
Image	May 28, 2014
Transfer date	March 04, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	2.9
RMSE for East Position (<4.0 cm)	3.5
RMSE for Down Position (<8.0 cm)	5.5
Boresight correction stdev (<0.001deg)	0.000685
IMU attitude correction stdev (<0.001deg)	0.002555
GPS position stdev (<0.01m)	0.0083
Minimum % overlap (>25)	43.14%
Ave point cloud density per sq.m. (>2.0)	3.13
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	221
Maximum Height	268.28 m
Minimum Height	66.43 m
Classification (# of points)	
Ground	127,167,999
Low vegetation	167,959,671
Medium vegetation	145,772,139
High vegetation	22,065,261
Building	1,152,046
Orthophoto	Yes
Processed by	Engr. Analyn Naldo, Engr. Chelou Prado, Jovy Narisma

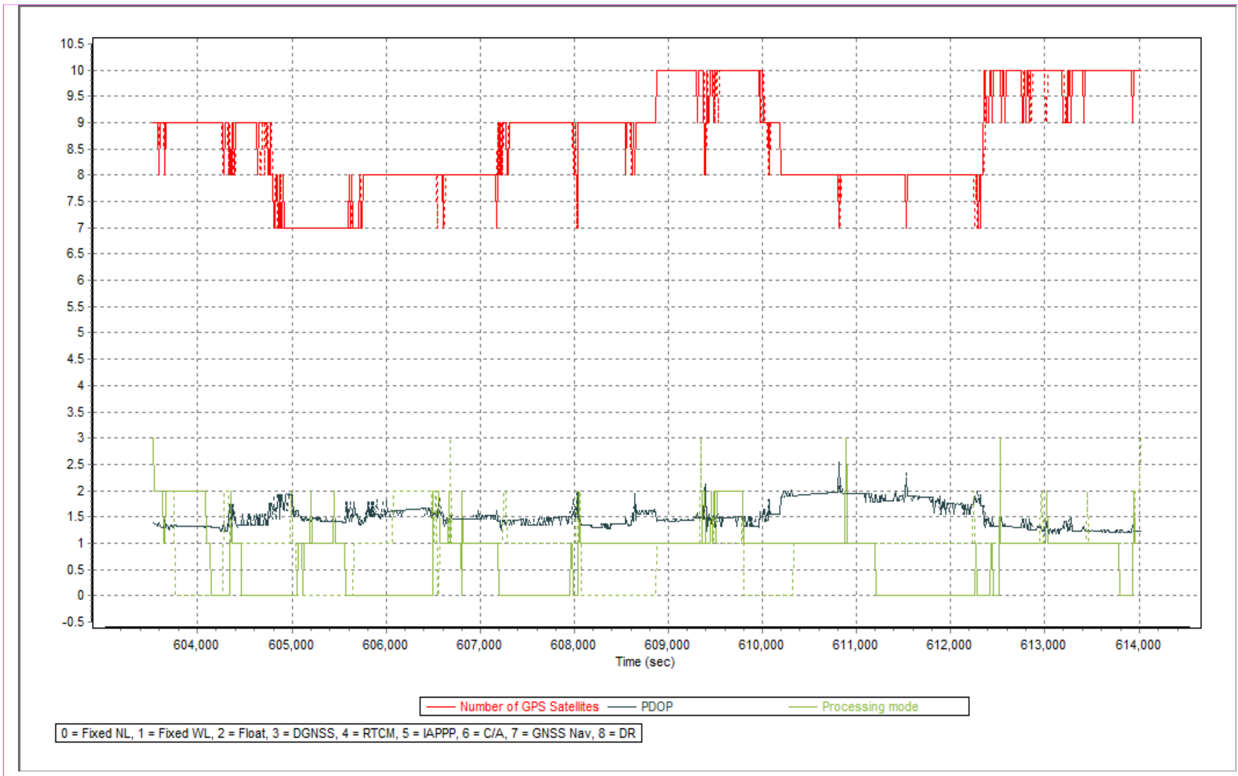


Figure 1.1.1. Solution Status

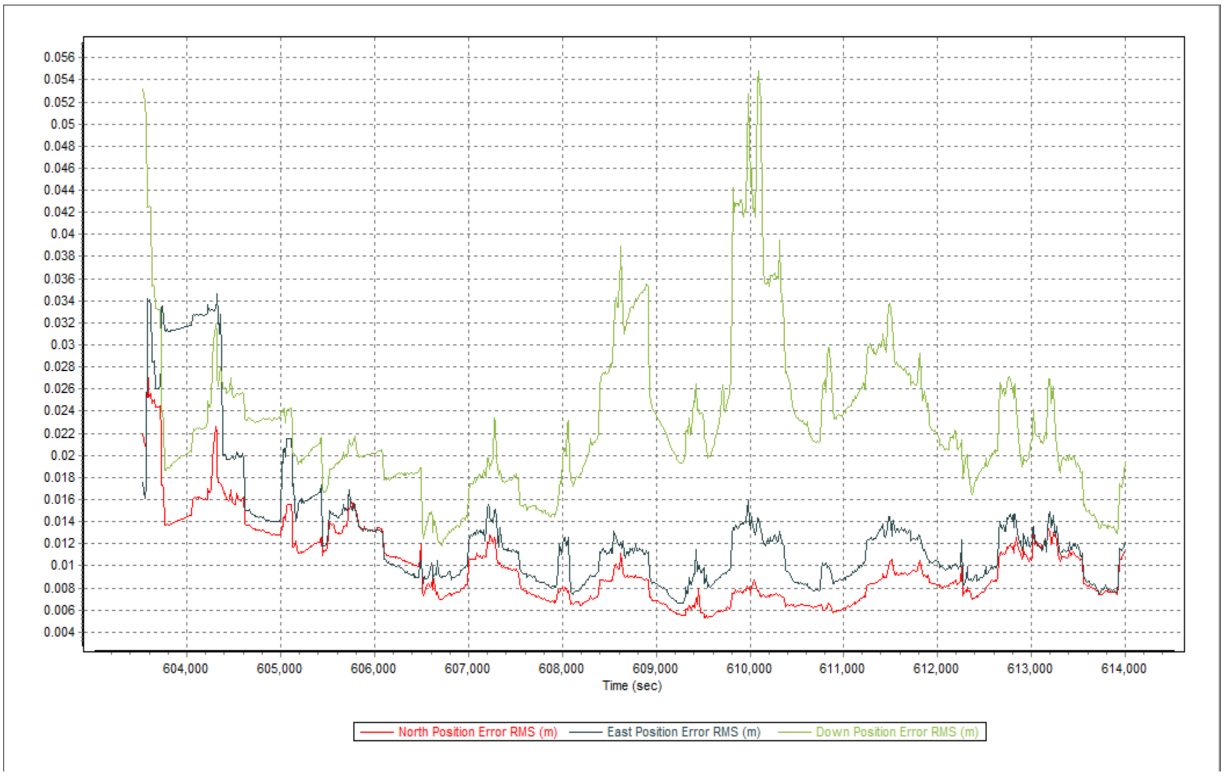


Figure 1.1.2. Smoothed Performance Metrics Parameters

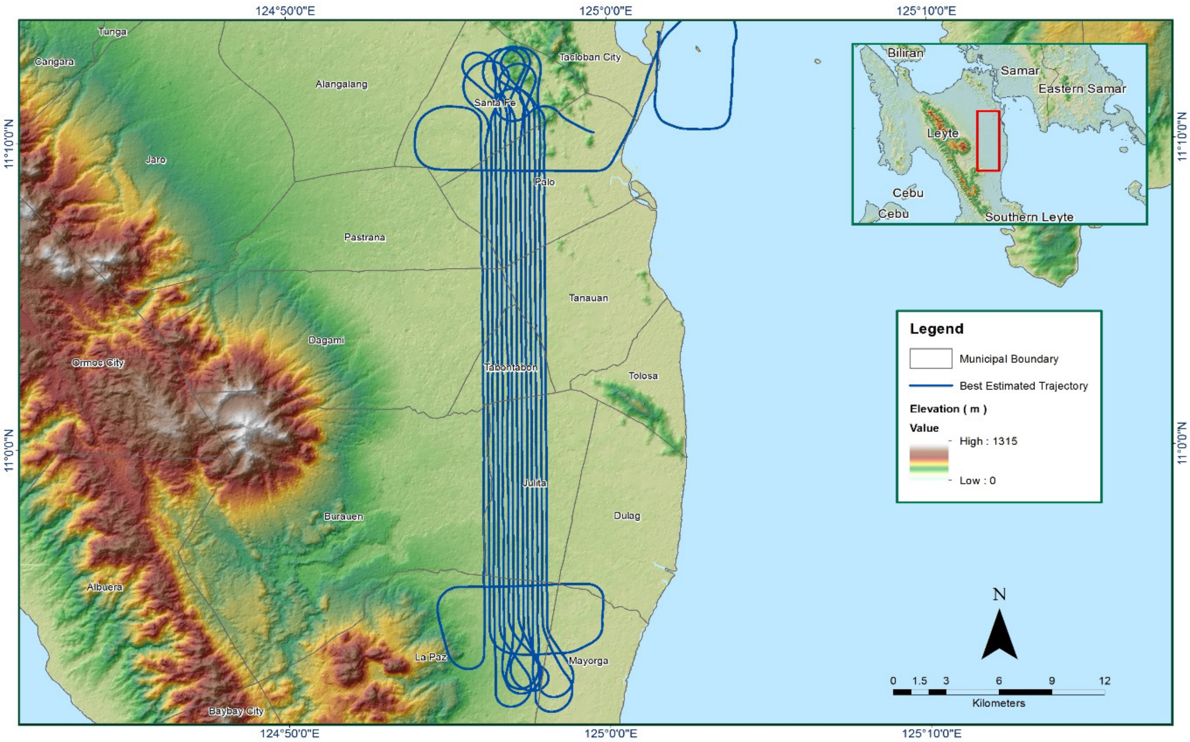


Figure 1.1.3. Best Estimated Trajectory

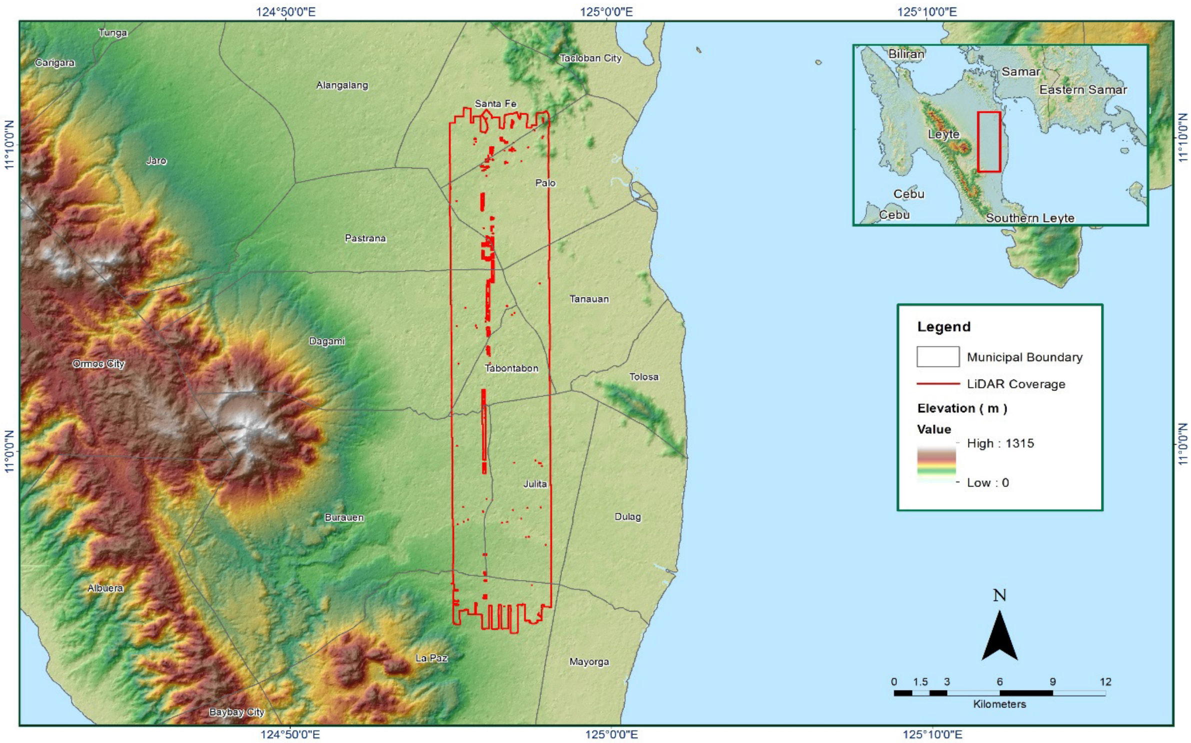


Figure 1.1.4. Coverage of LiDAR data

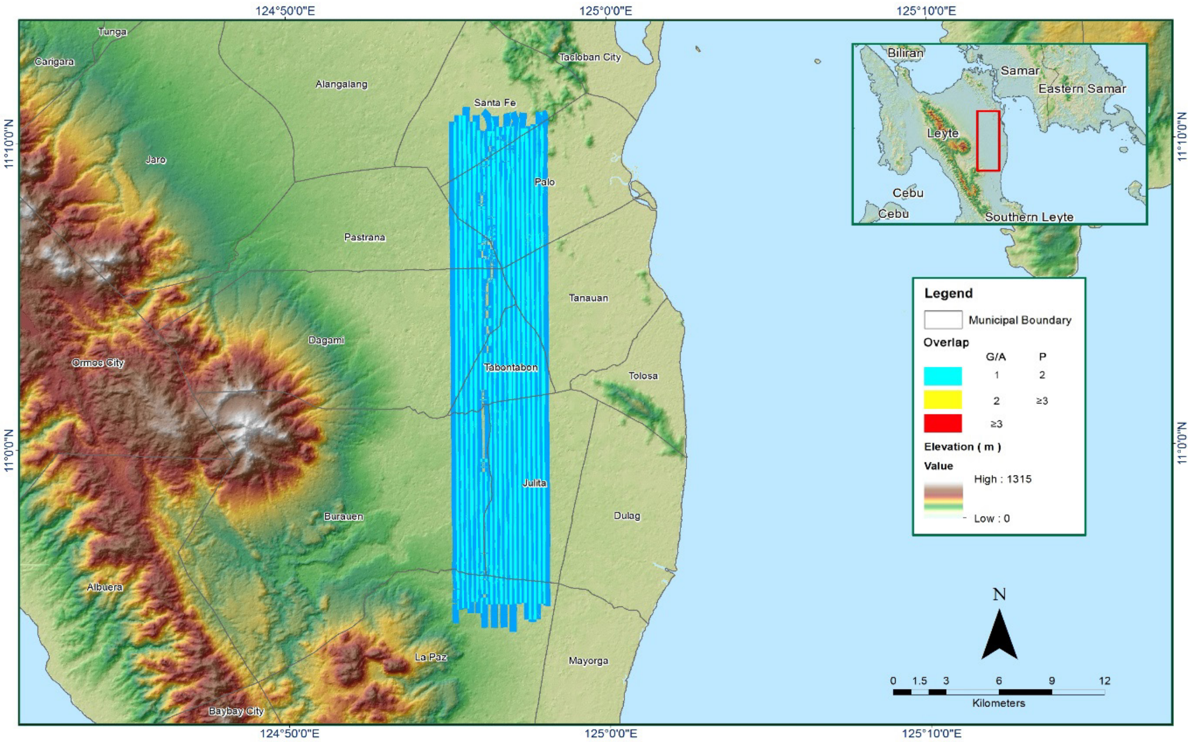


Figure 1.1.5. Image of data overlap

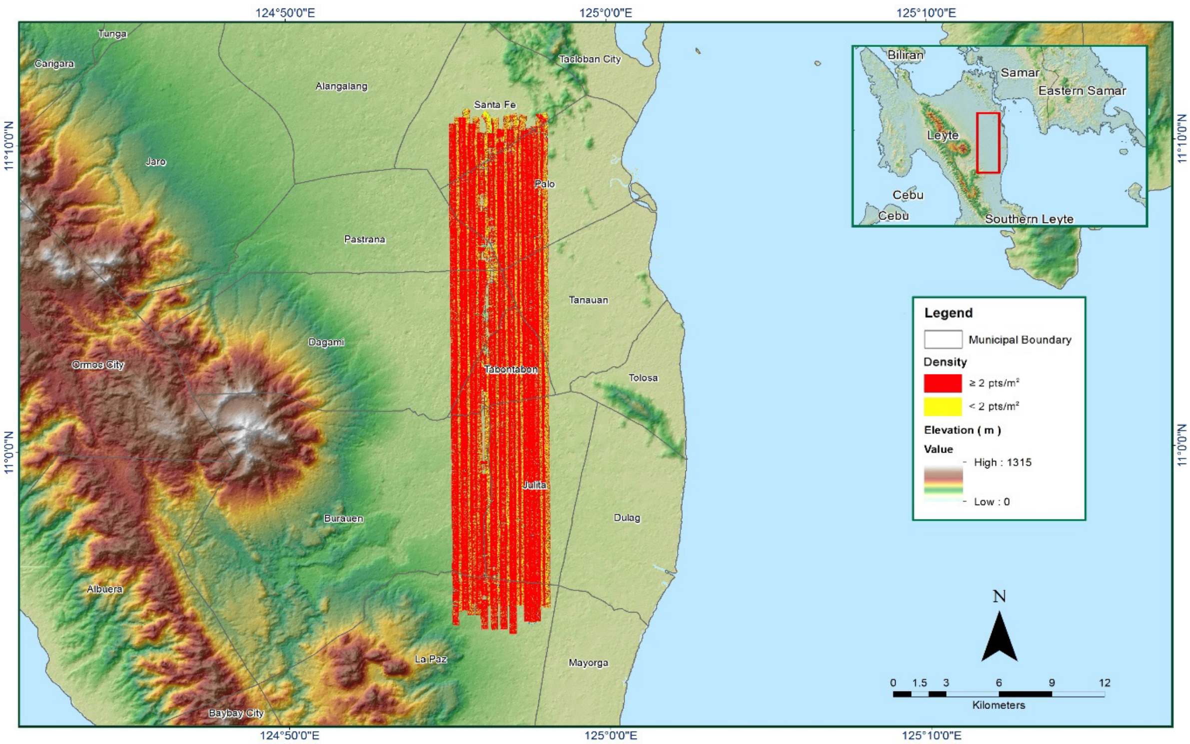


Figure 1.1.6. Density map of merged LiDAR data

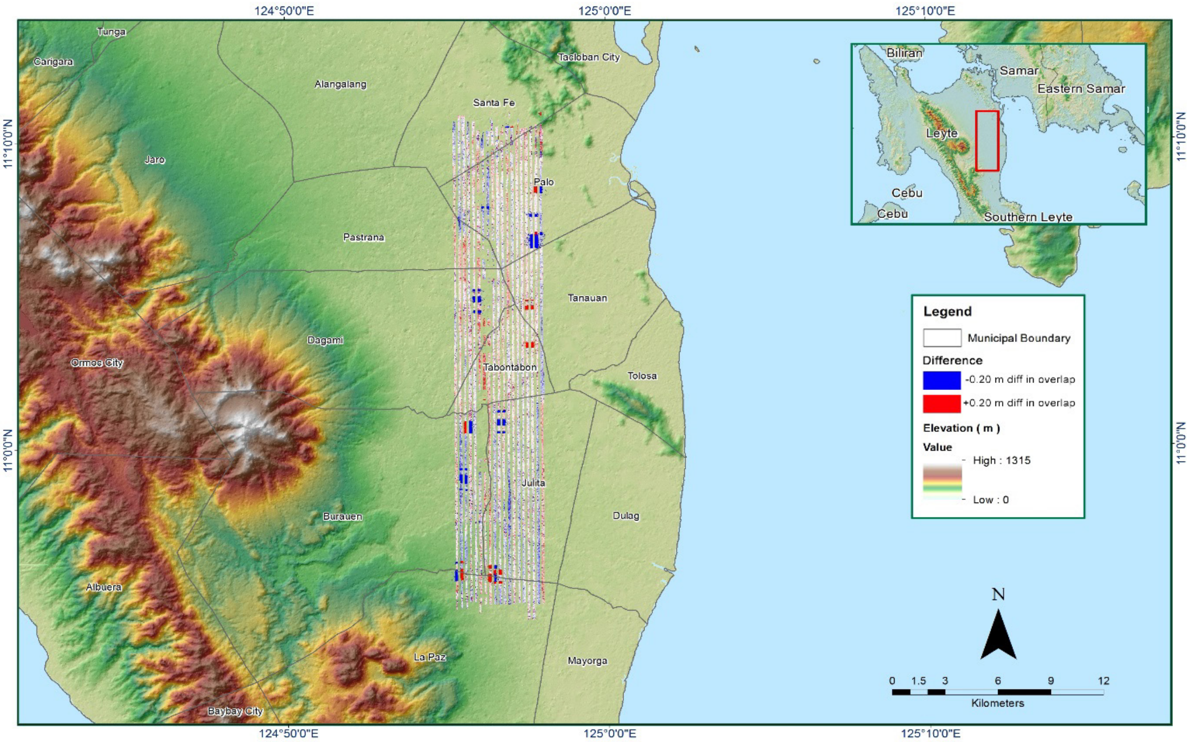


Figure 1.1.7. Elevation difference between flight lines

Flight Area	Leyte
Mission Name	34C
Inclusive Flights	3773G, 3771G
Range data size	37.1
Base data size	460
POS	13.94
Image	n/a
Transfer date	February 12, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	0.8
RMSE for East Position (<4.0 cm)	1.0
RMSE for Down Position (<8.0 cm)	2.8
Boresight correction stdev (<0.001deg)	0.000620
IMU attitude correction stdev (<0.001deg)	0.004668
GPS position stdev (<0.01m)	0.0133
Minimum % overlap (>25)	35.68
Ave point cloud density per sq.m. (>2.0)	4.41
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	190
Maximum Height	293.50 m
Minimum Height	85.36 m
Classification (# of points)	
Ground	73,091,228
Low vegetation	68,546,439
Medium vegetation	272,398,780
High vegetation	231,908,658
Building	3,024,175
Orthophoto	No
Processed by	Engr. Analyn Naldo, Aljon Araneta, Maria Tamsyn Malabanan

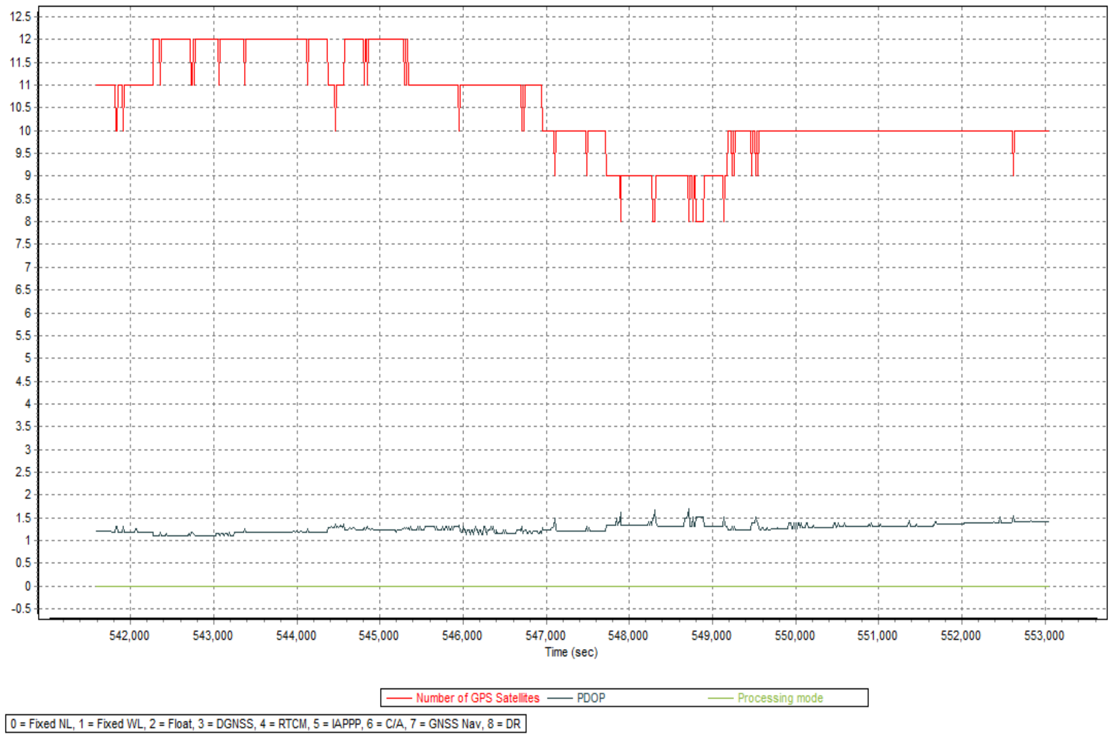


Figure 1.2.1. Solution Status

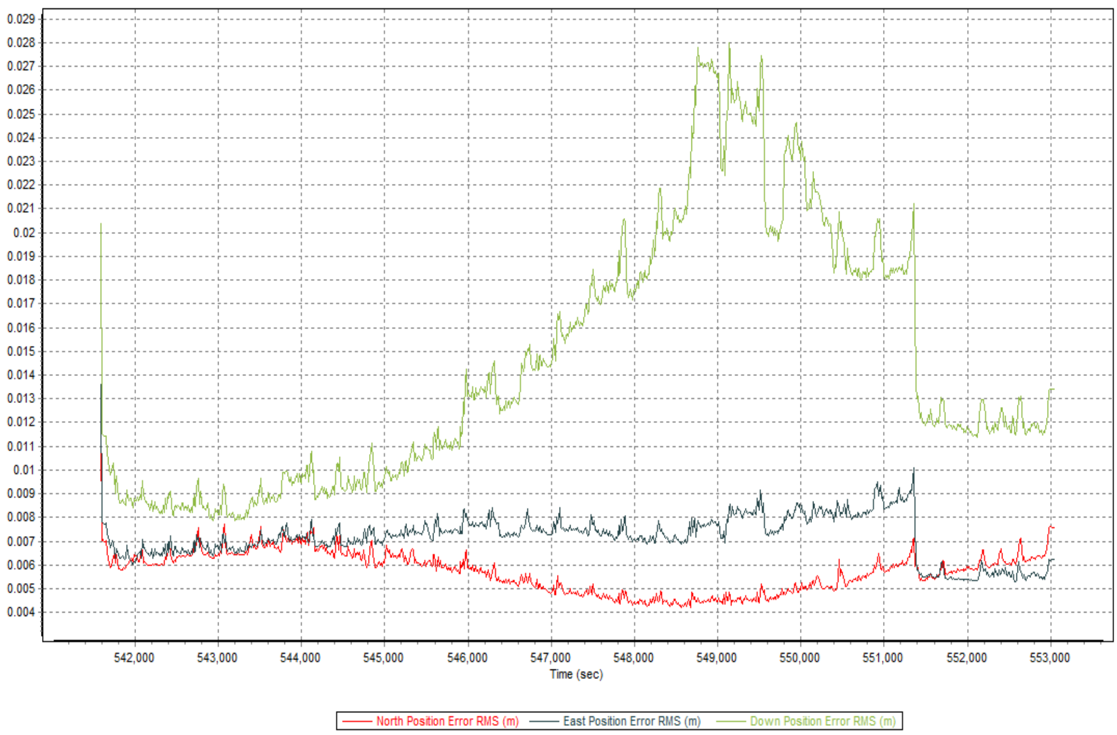


Figure 1.2.2. Smoothed Performance Metric Parameters

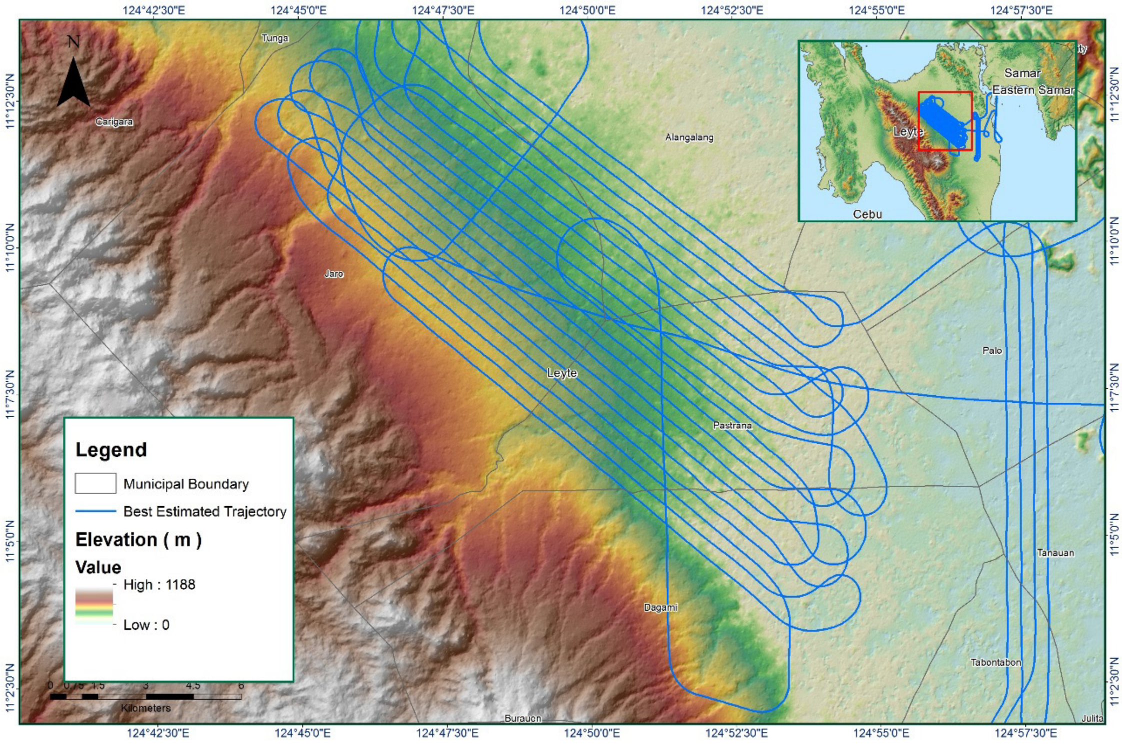


Figure 1.2.3. Best Estimated Trajectory

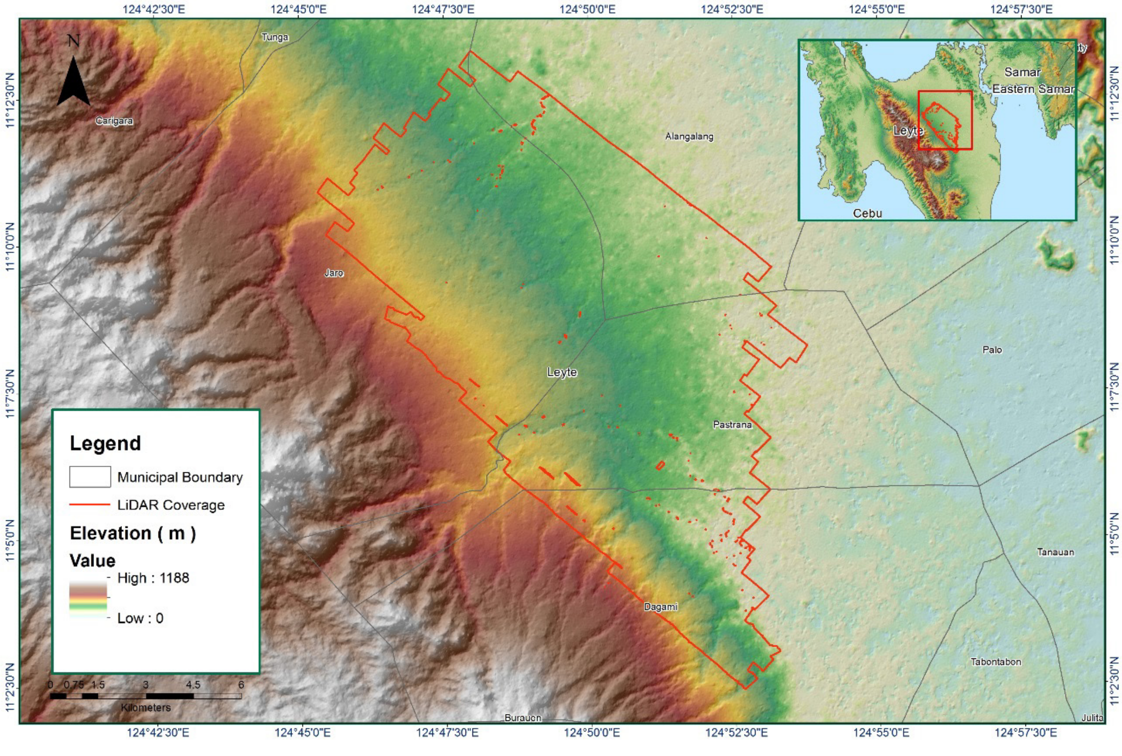


Figure 1.2.4. Coverage of LiDAR Data

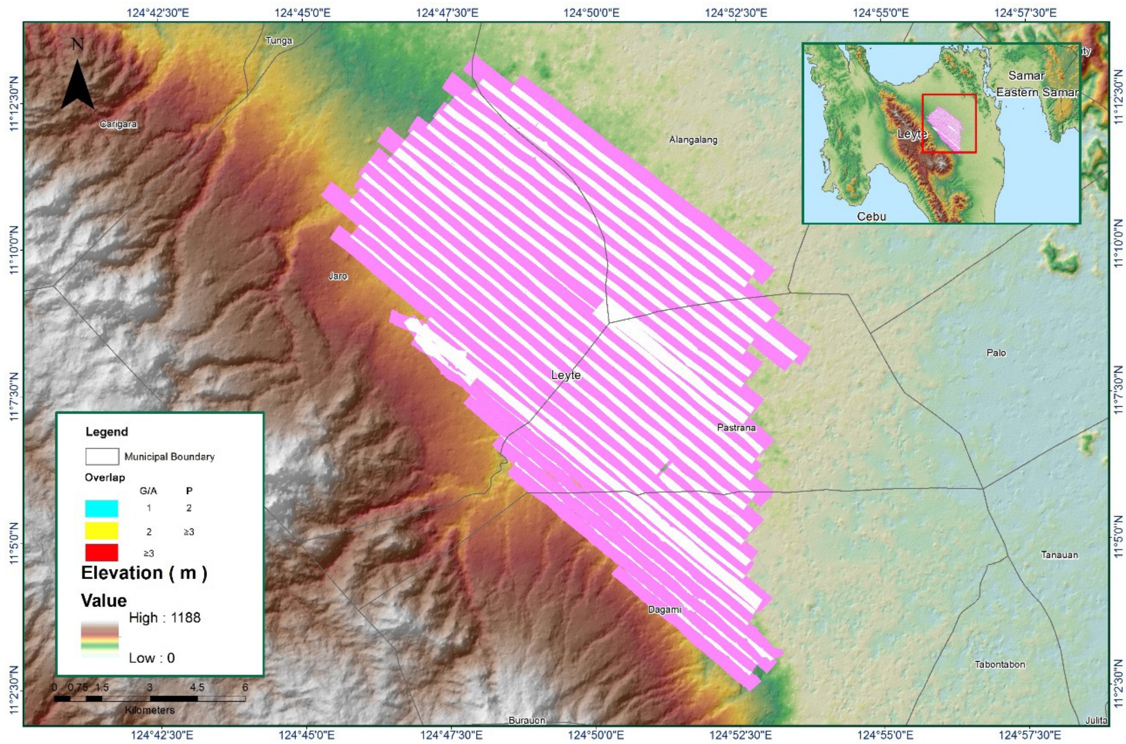


Figure 1.2.5. Image of data overlap

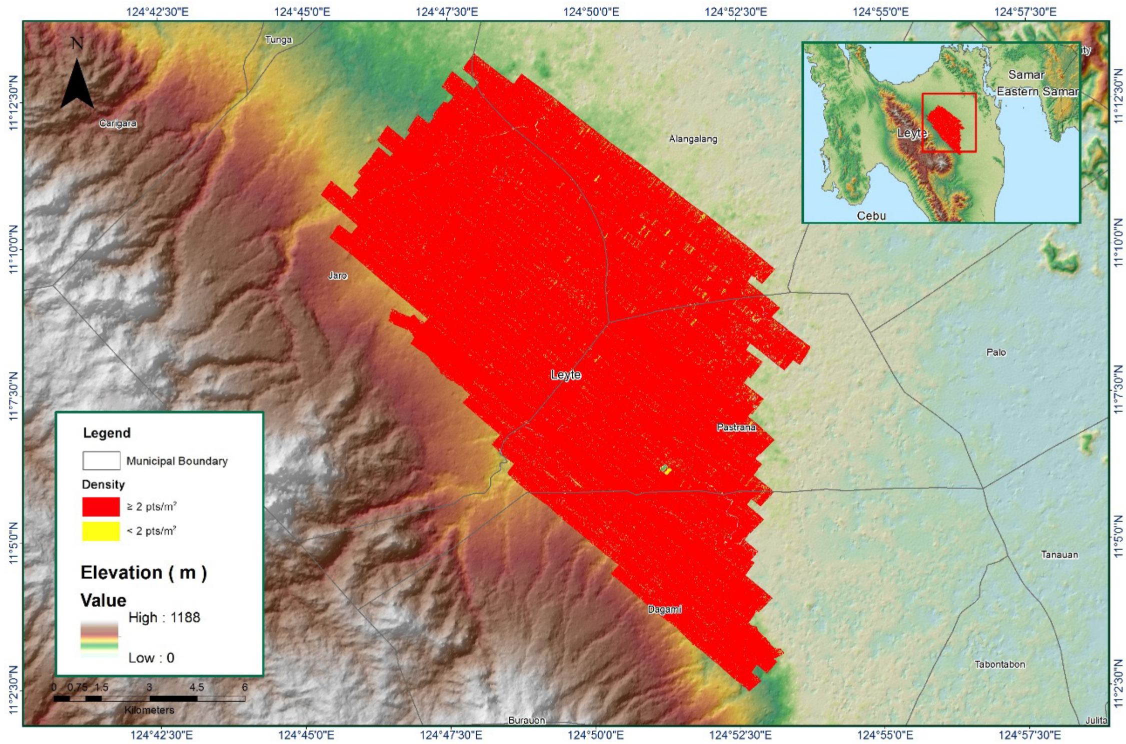


Figure 1.2.6. Density map of merged LiDAR data

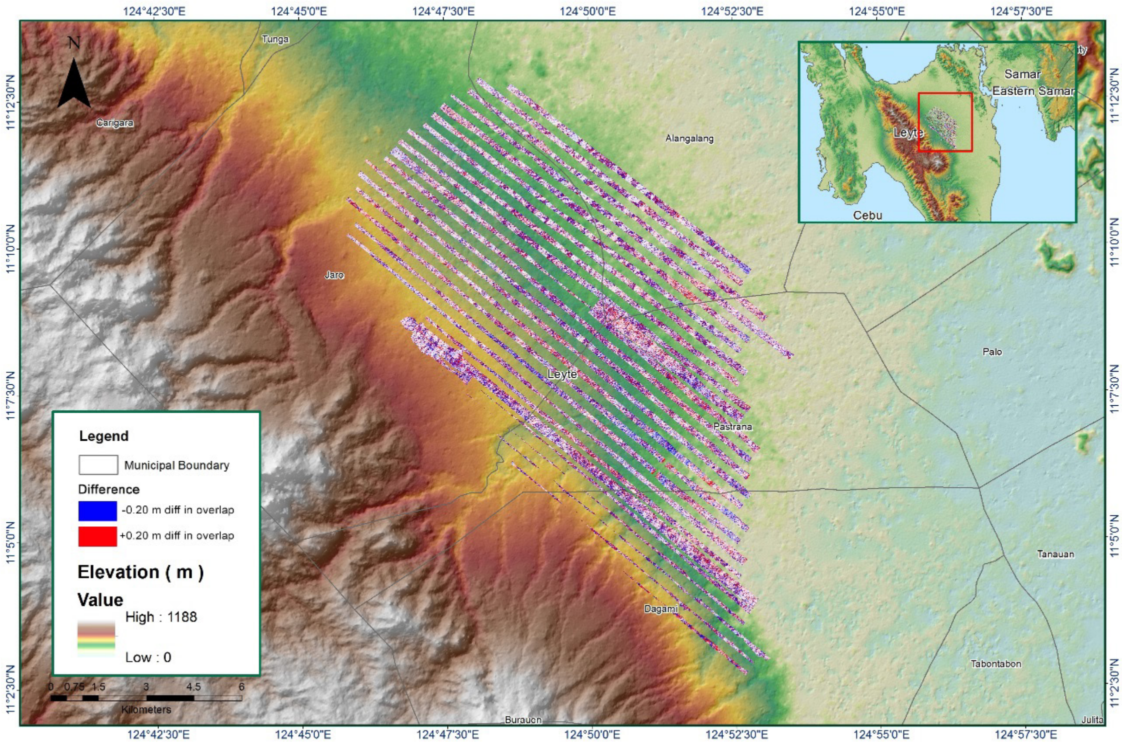


Figure 1.2.7. Elevation difference between flight lines

Flight Area	Leyte
Mission Name	34F_Supplement
Inclusive Flights	3769G
Range data size	23.8
Base data size	260
POS	9.58
Image	n/a
Transfer date	February 12, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.1
RMSE for East Position (<4.0 cm)	1.2
RMSE for Down Position (<8.0 cm)	3.3
Boresight correction stdev (<0.001deg)	0.001727
IMU attitude correction stdev (<0.001deg)	0.003293
GPS position stdev (<0.01m)	0.0093
Minimum % overlap (>25)	34.59
Ave point cloud density per sq.m. (>2.0)	4.21
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	42
Maximum Height	113.49 m
Minimum Height	23.29 m
Classification (# of points)	
Ground	18,006,877
Low vegetation	36,840,877
Medium vegetation	52,391,046
High vegetation	16,595,035
Building	484,590
Orthophoto	No
Processed by	Engr. Kenneth Solidum, Engr. Edgardo Gubatanga Jr., Engr. Krisha Marie Bautista

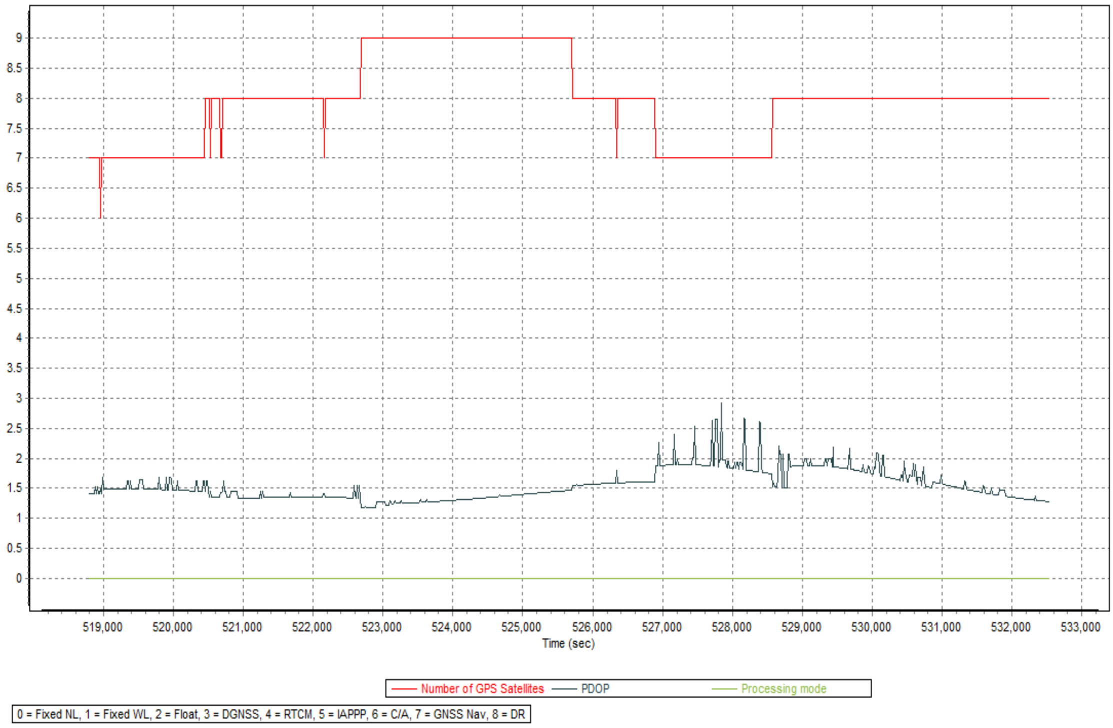


Figure 1.3.1. Solution Status

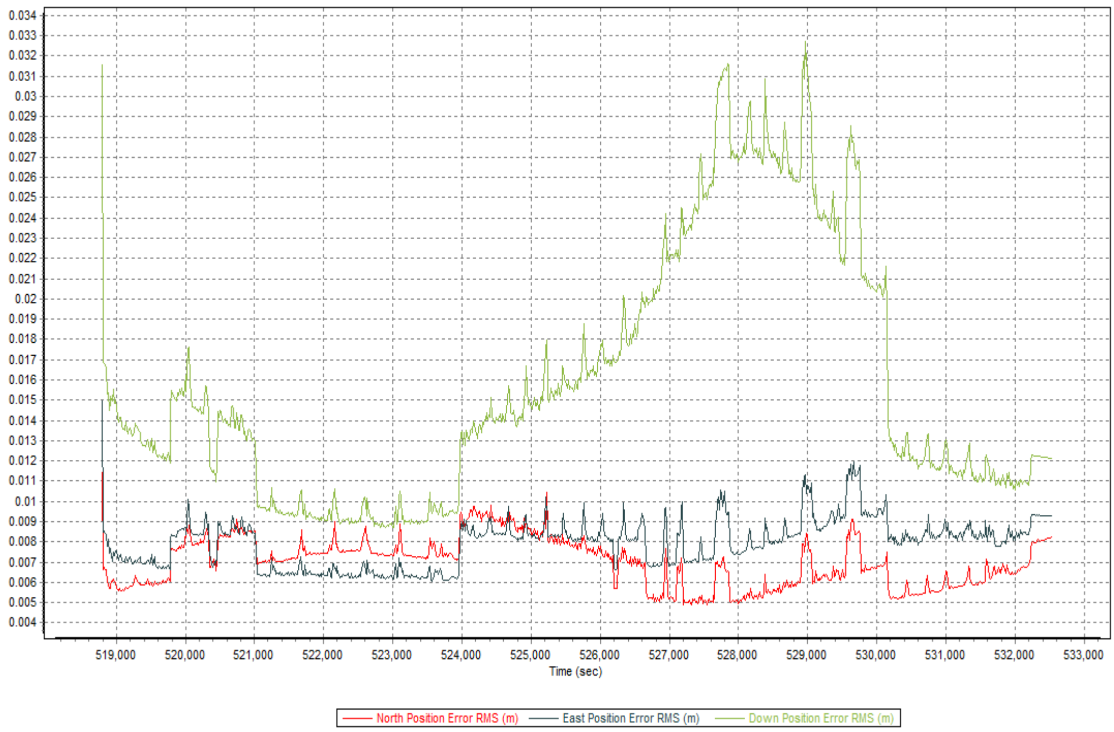


Figure 1.3.2. Smoothed Performance Metric Parameters

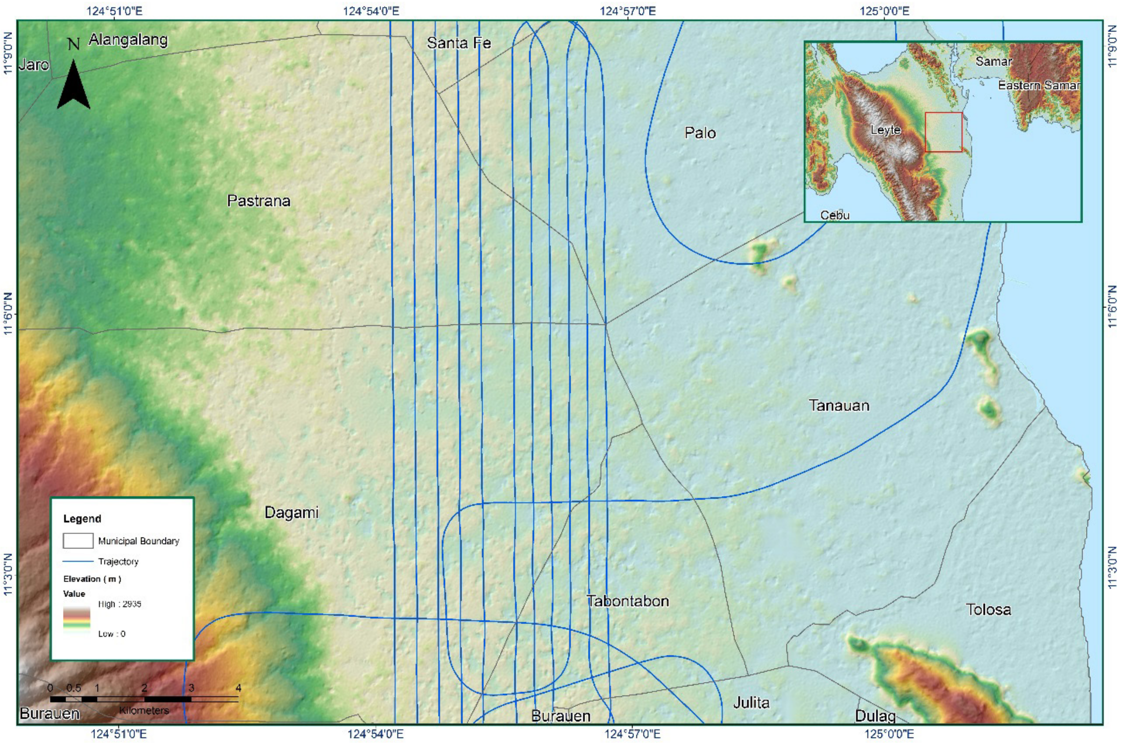


Figure 1.3.3. Best Estimated Trajectory

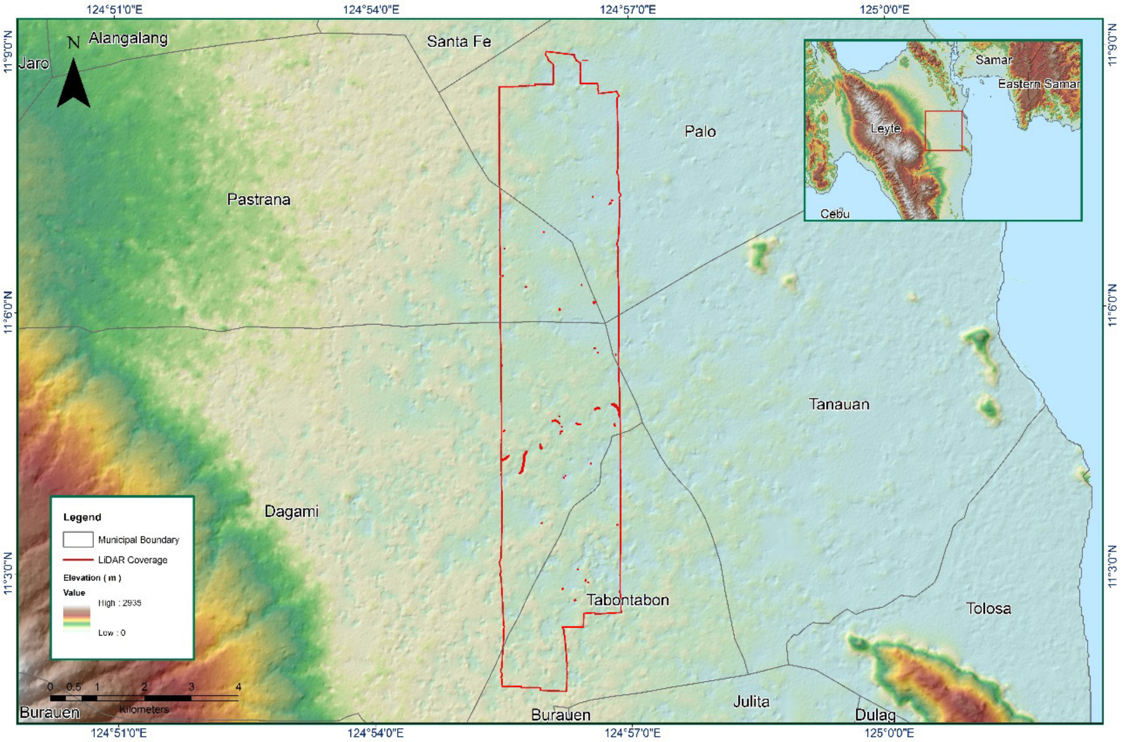


Figure 1.3.4. Coverage of LiDAR Data

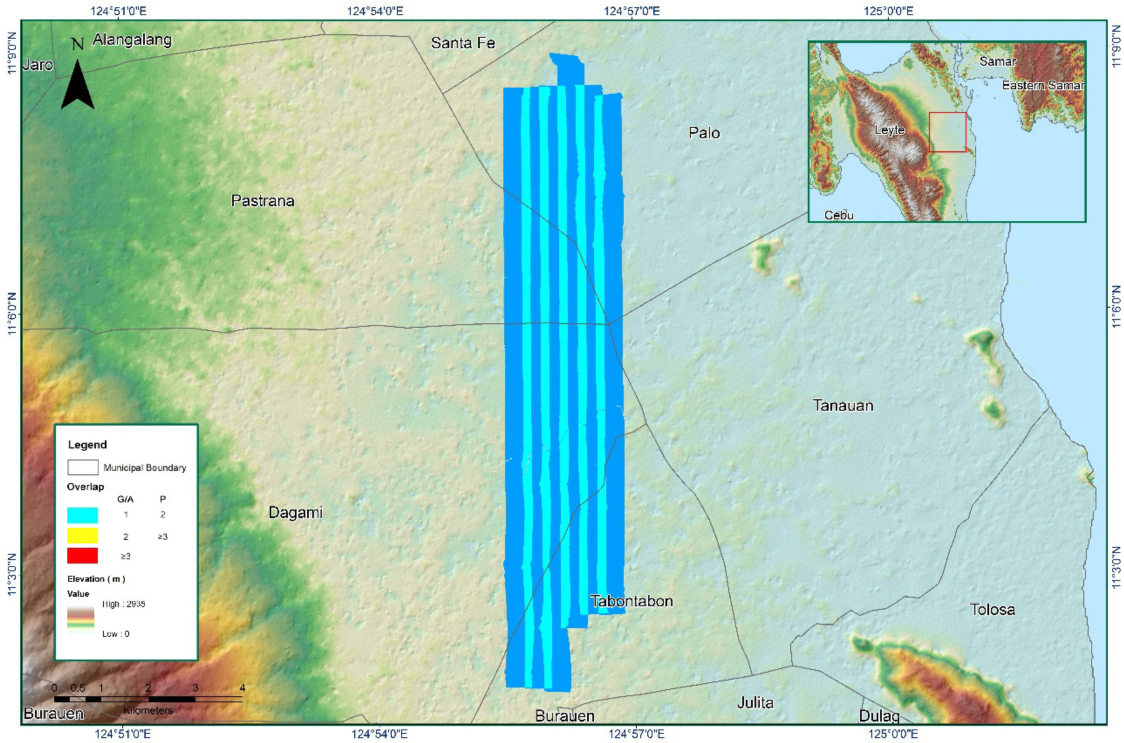


Figure 1.3.5. Image of data overlap

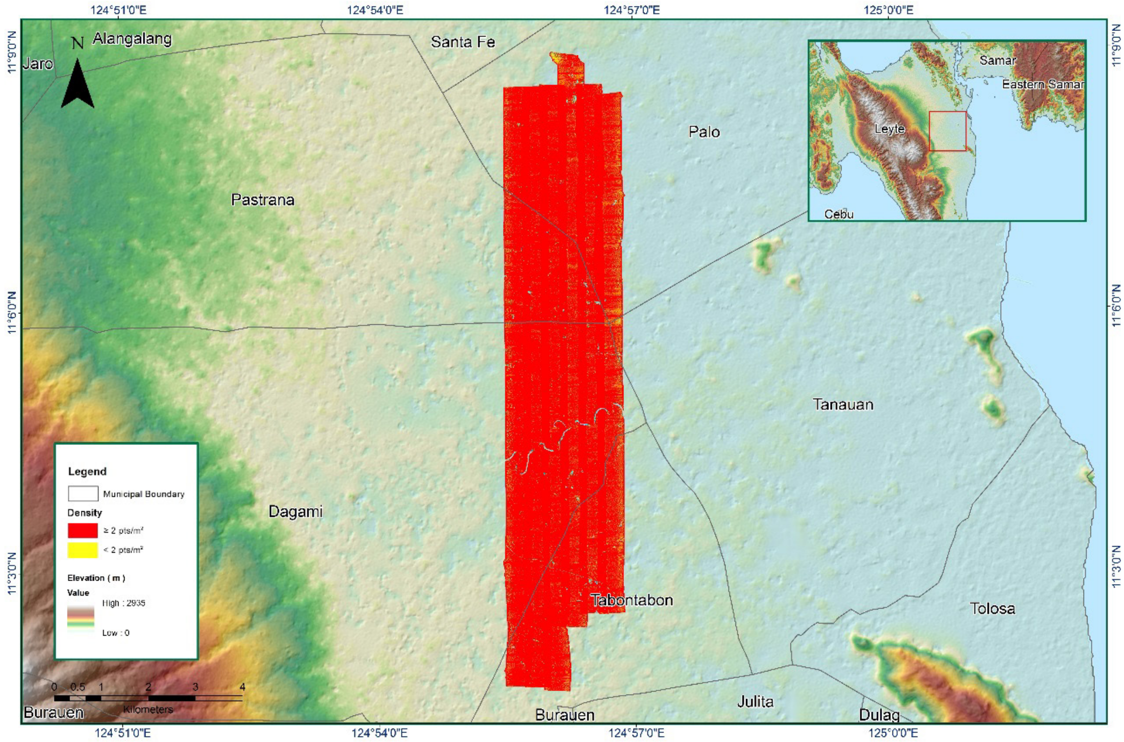


Figure 1.3.6. Density map of merged LiDAR data

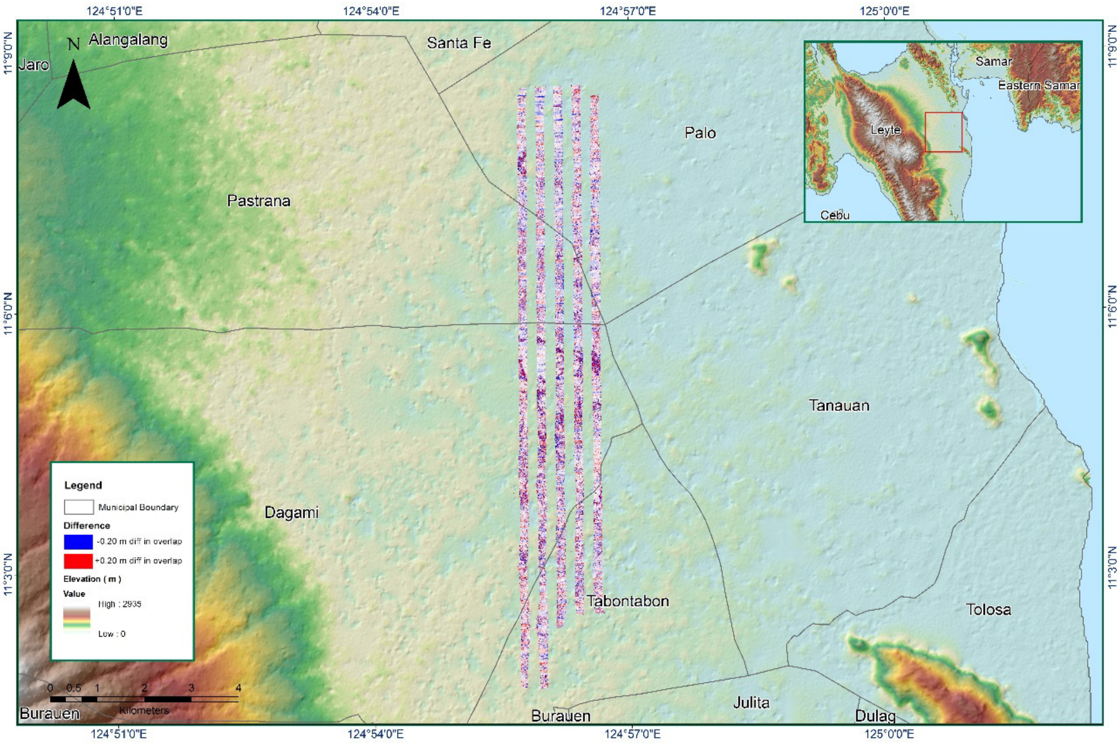


Figure 1.3.7. Elevation difference between flight lines

Flight Area	Leyte
Mission Name	Blk34I
Inclusive Flights	3769G
Range data size	23.8
Base data size	260
POS	9.58
Image	n/a
Transfer date	February 12, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.1
RMSE for East Position (<4.0 cm)	1.2
RMSE for Down Position (<8.0 cm)	3.3
Boresight correction stdev (<0.001deg)	0.003871
IMU attitude correction stdev (<0.001deg)	0.003796
GPS position stdev (<0.01m)	0.0138
Minimum % overlap (>25)	27.82
Ave point cloud density per sq.m. (>2.0)	3.21
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	86
Maximum Height	266.62 m
Minimum Height	75.43 m
Classification (# of points)	
Ground	20,398,103
Low vegetation	20,790,546
Medium vegetation	70,517,058
High vegetation	26,392,425
Building	302,229
Orthophoto	No
Processed by	Engr. Kenneth Solidum, Engr. Mark Joshua Salvacion, Kathryn Claudyn Zarate

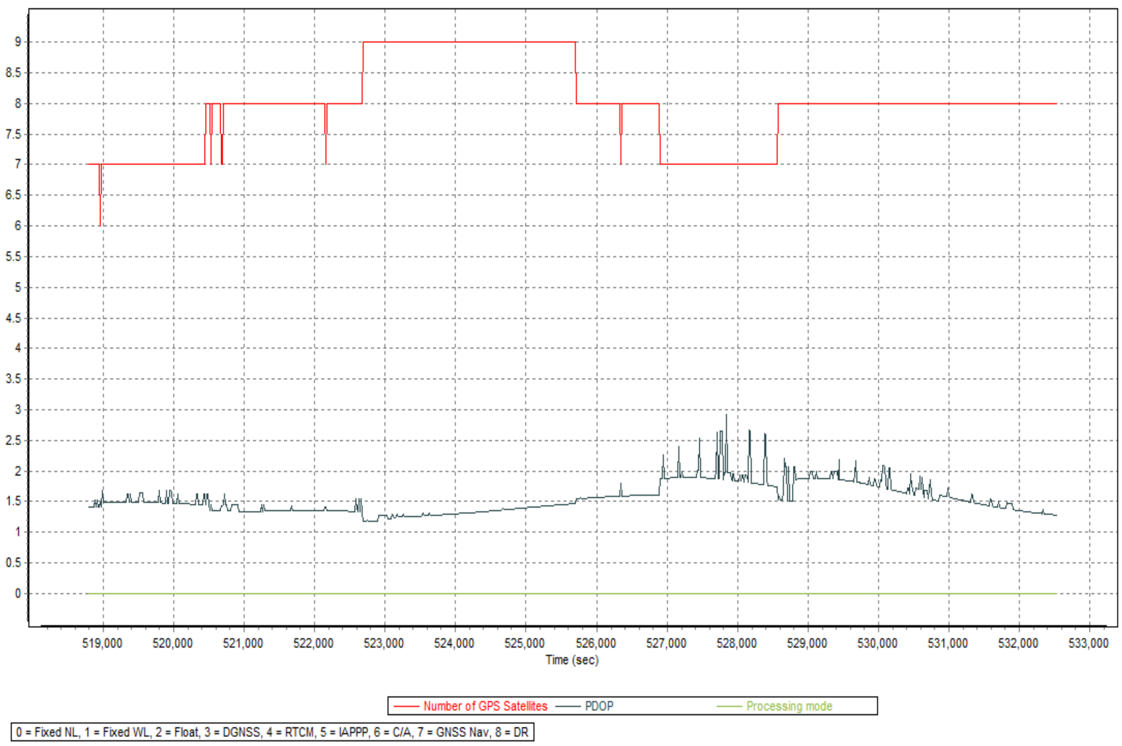


Figure 1.4.1. Solution Status

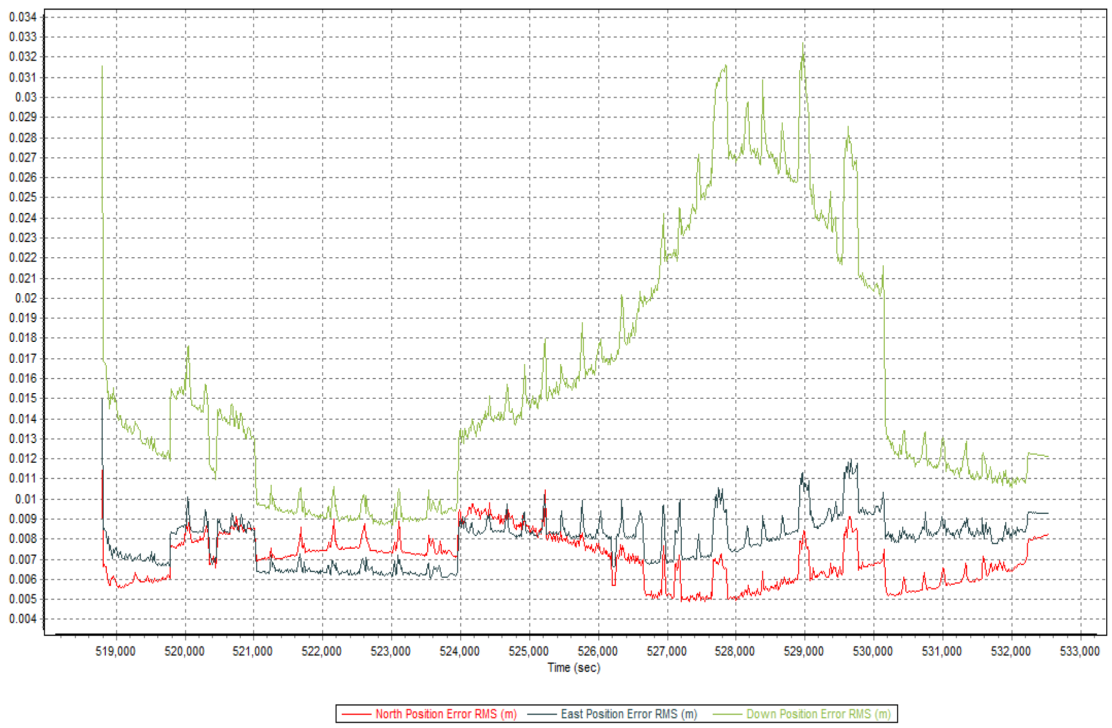


Figure 1.4.2. Smoothed Performance Metric Parameters

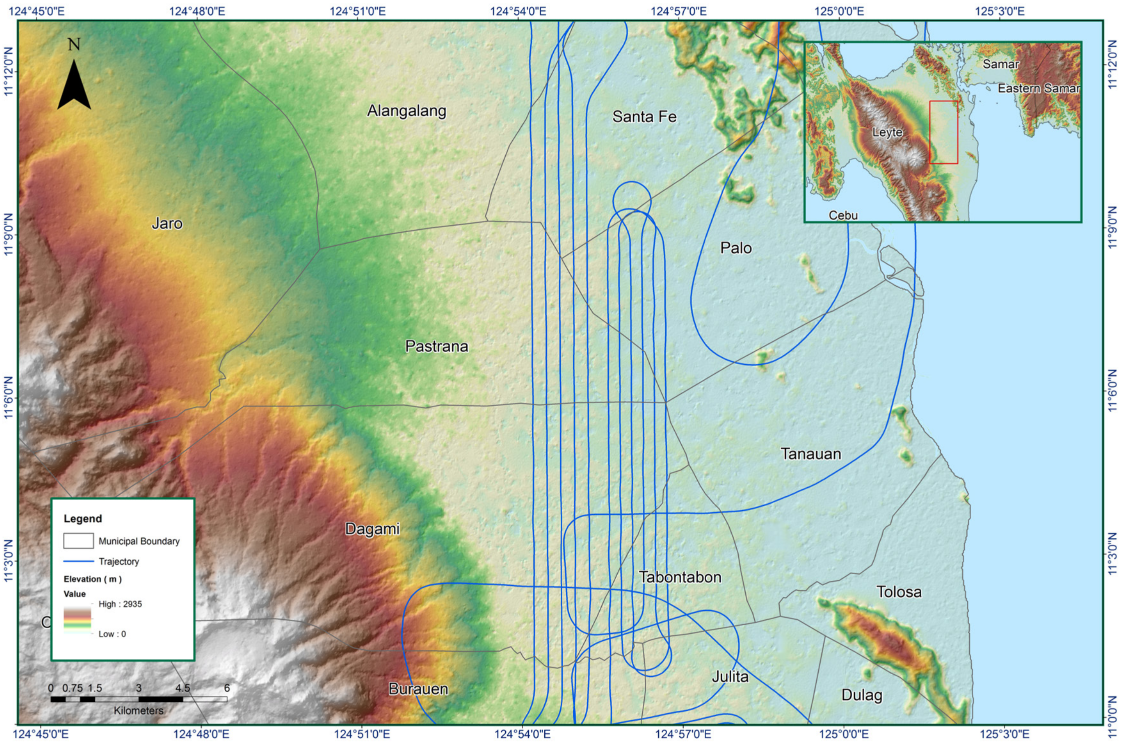


Figure 1.4.3. Best Estimated Trajectory

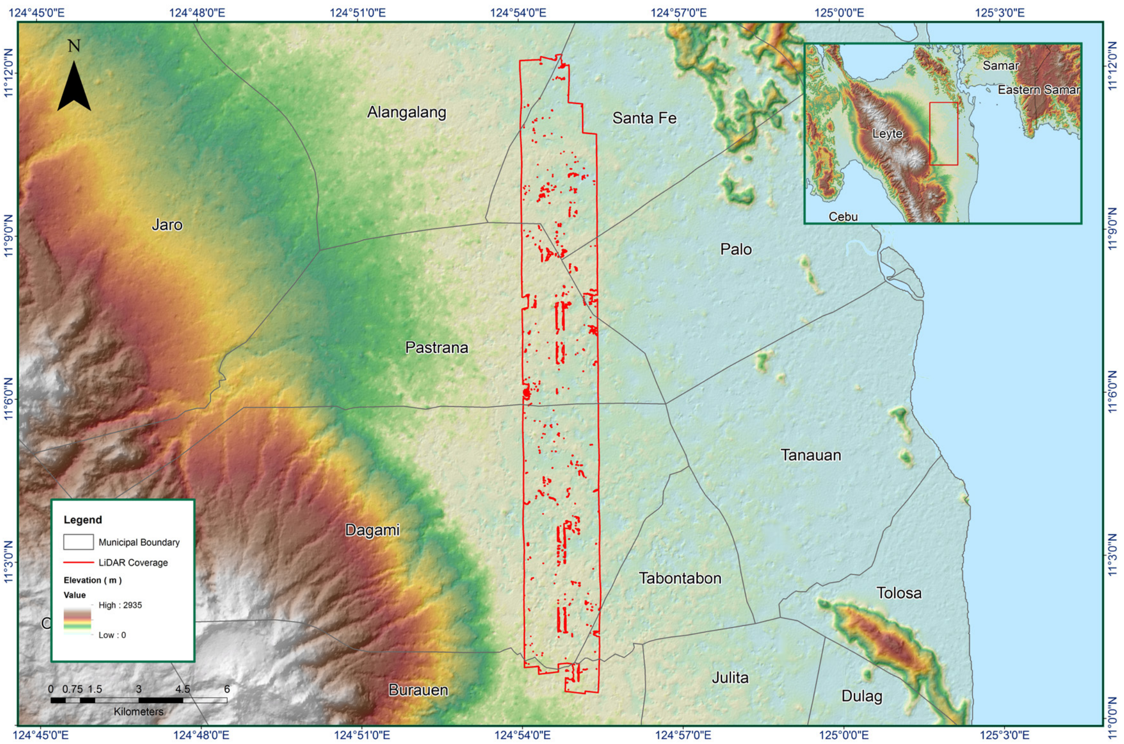


Figure 1.4.4. Coverage of LiDAR Data

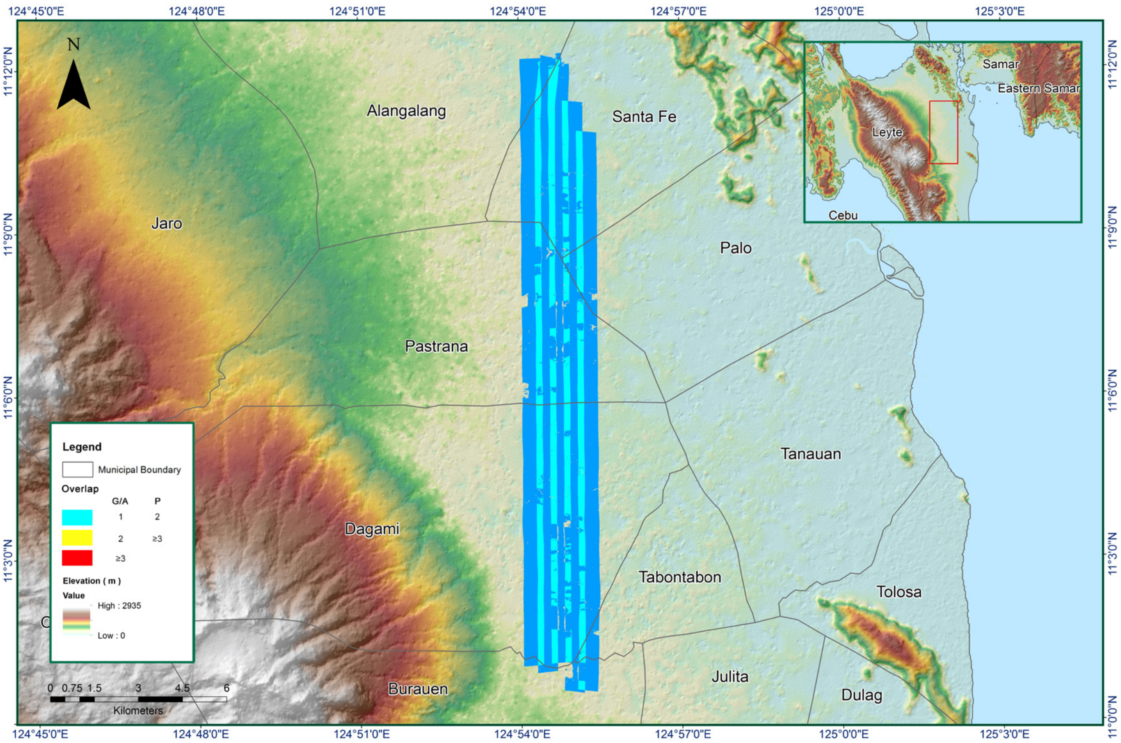


Figure 1.4.5. Image of data overlap

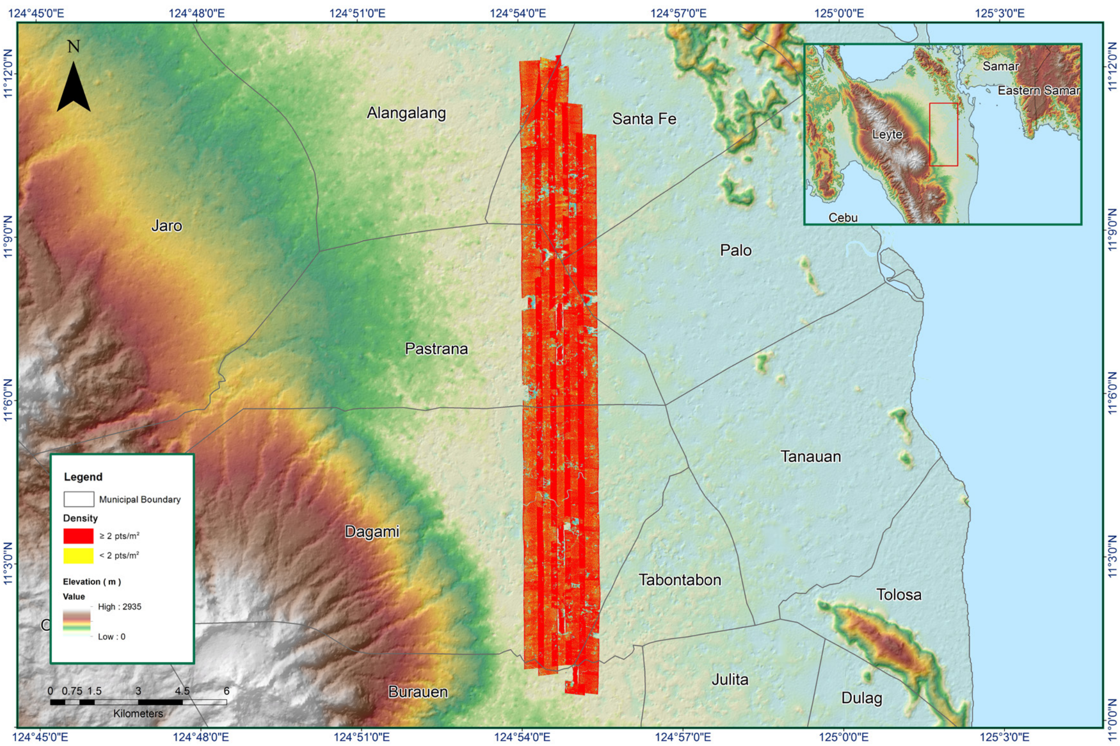


Figure 1.4.6. Density map of merged LiDAR data

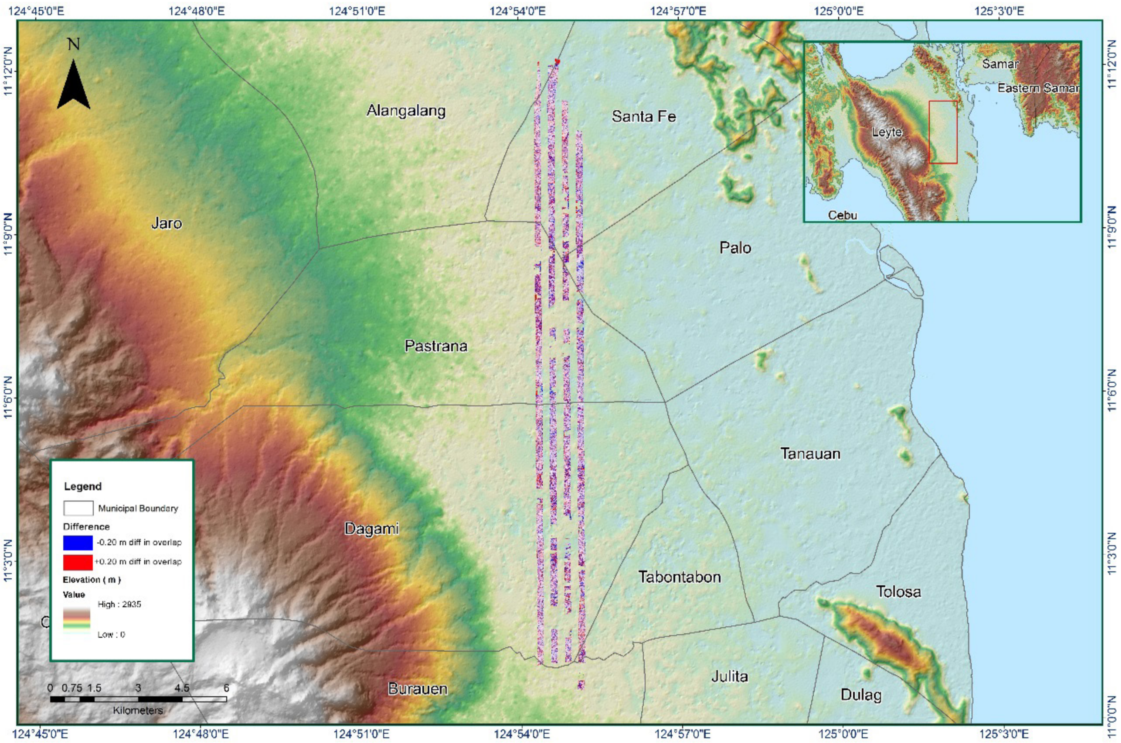


Figure 1.4.7. Elevation difference between flight lines

Flight Area	Leyte
Mission Name	Blk34J
Inclusive Flights	3765G
Range data size	25.2
Base data size	255
POS	4.38
Image	n/a
Transfer date	February 12, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.7
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	6.0
Boresight correction stdev (<0.001deg)	0.003377
IMU attitude correction stdev (<0.001deg)	0.001525
GPS position stdev (<0.01m)	0.0017
Minimum % overlap (>25)	27.64
Ave point cloud density per sq.m. (>2.0)	3.52
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	108
Maximum Height	246.28 m
Minimum Height	78.27 m
Classification (# of points)	
Ground	23,439,051
Low vegetation	27,359,793
Medium vegetation	97,600,486
High vegetation	50,609,486
Building	826,294
Orthophoto	No
Processed by	Engr. Sheila Maye Santillan, Engr. Ma. Joanne Balaga, Marie Denise Bueno

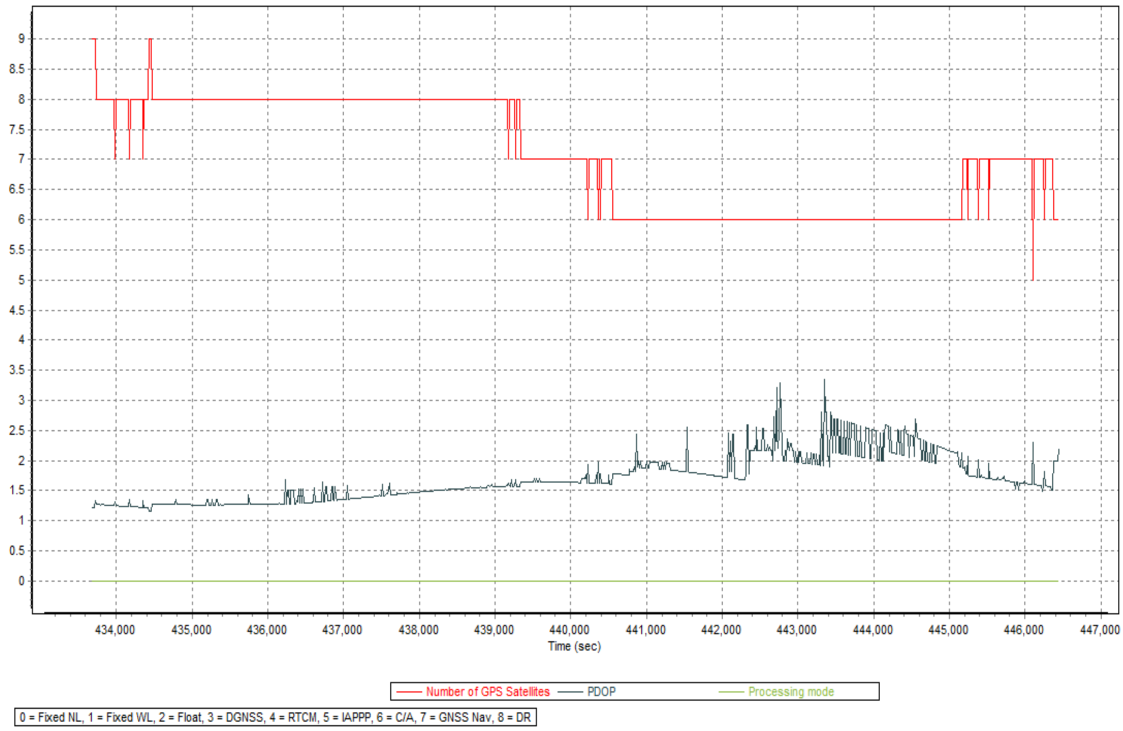


Figure 1.5.1. Solution Status

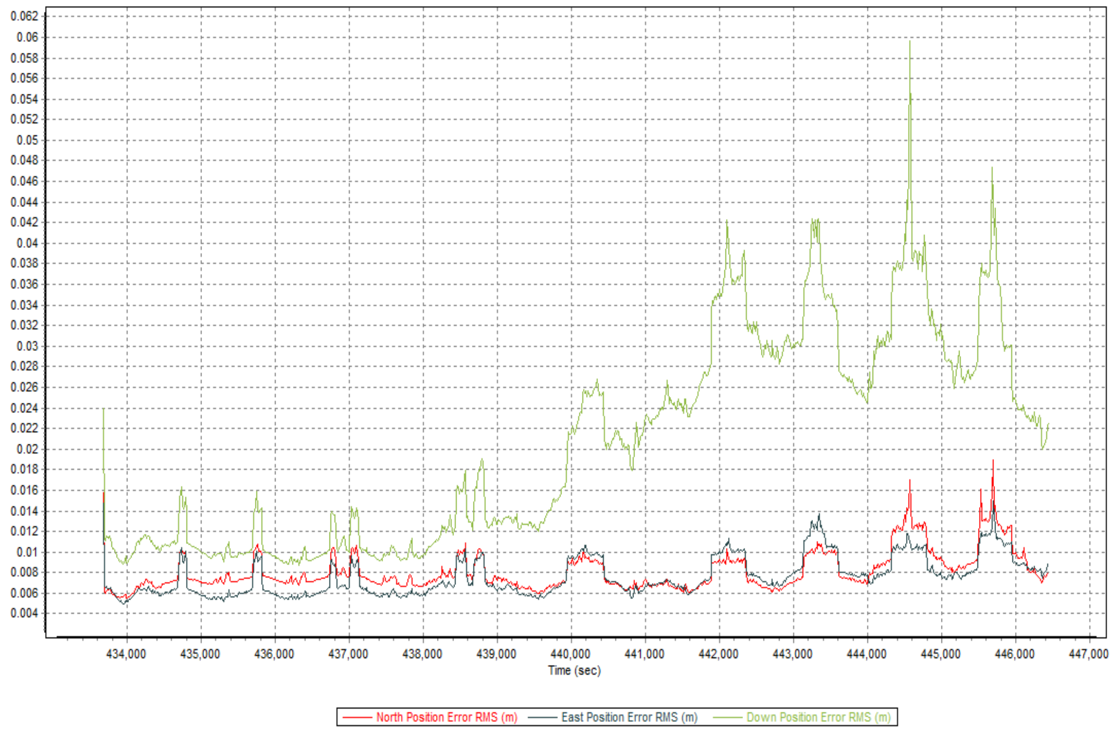


Figure 1.5.2. Smoothed Performance Metric Parameters

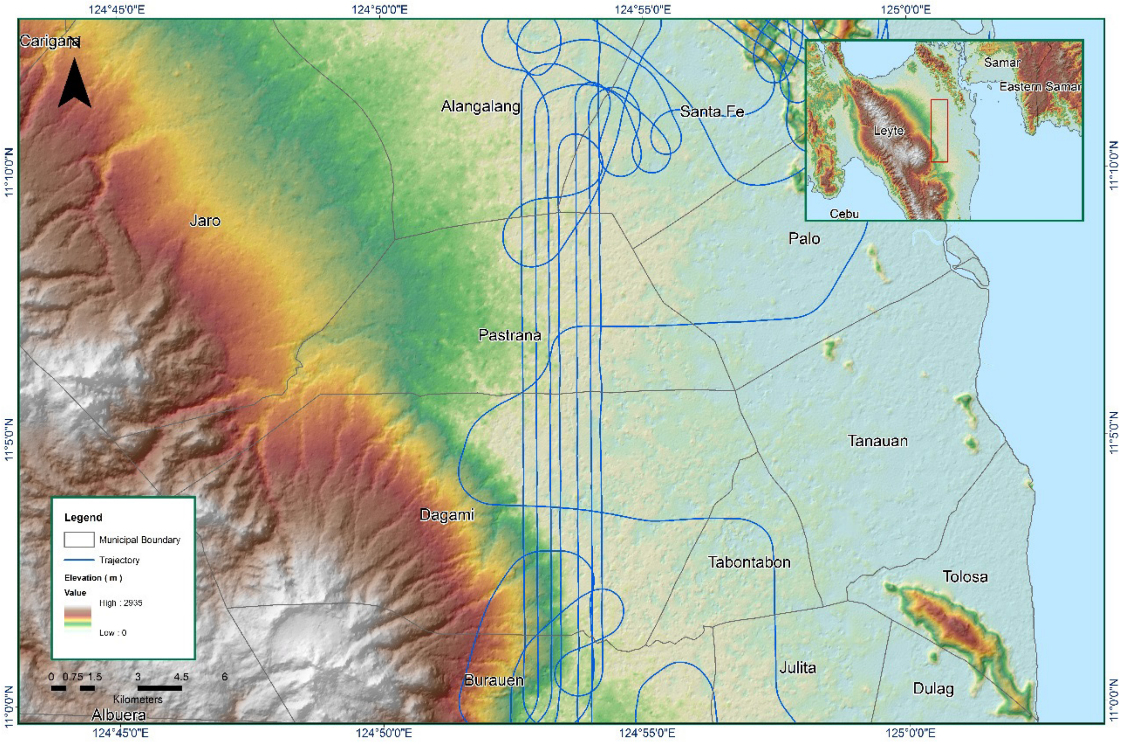


Figure 1.5.3. Best Estimated Trajectory

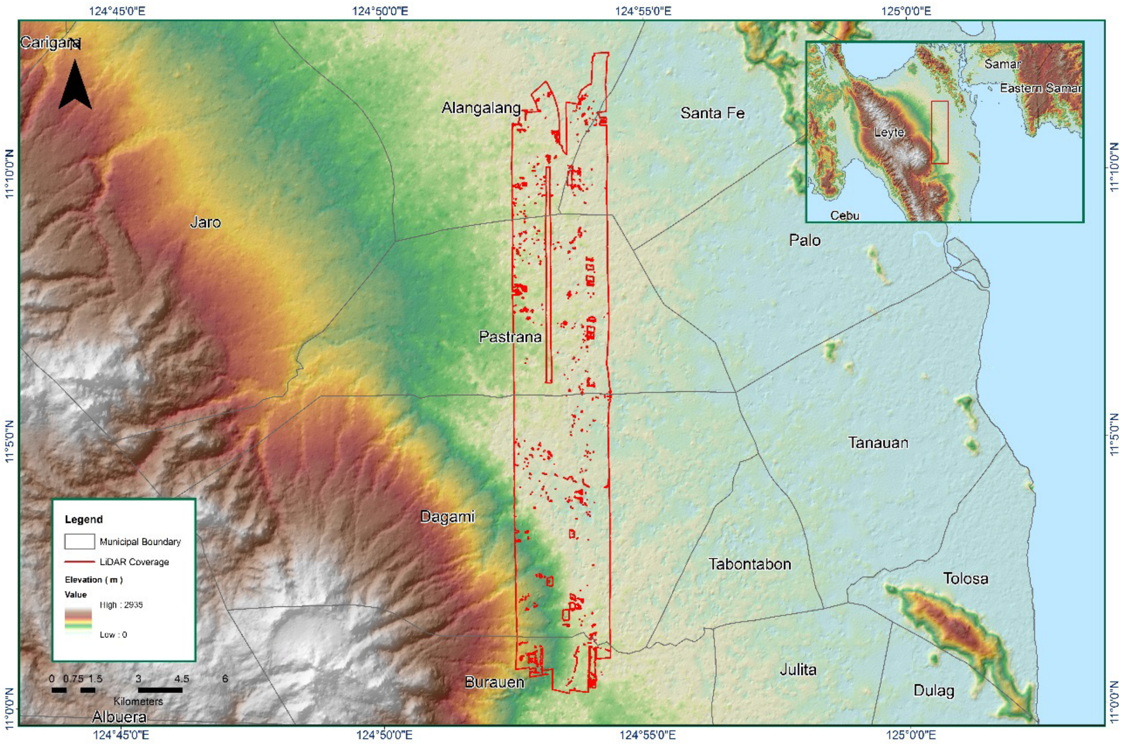


Figure 1.5.4. Coverage of LiDAR Data

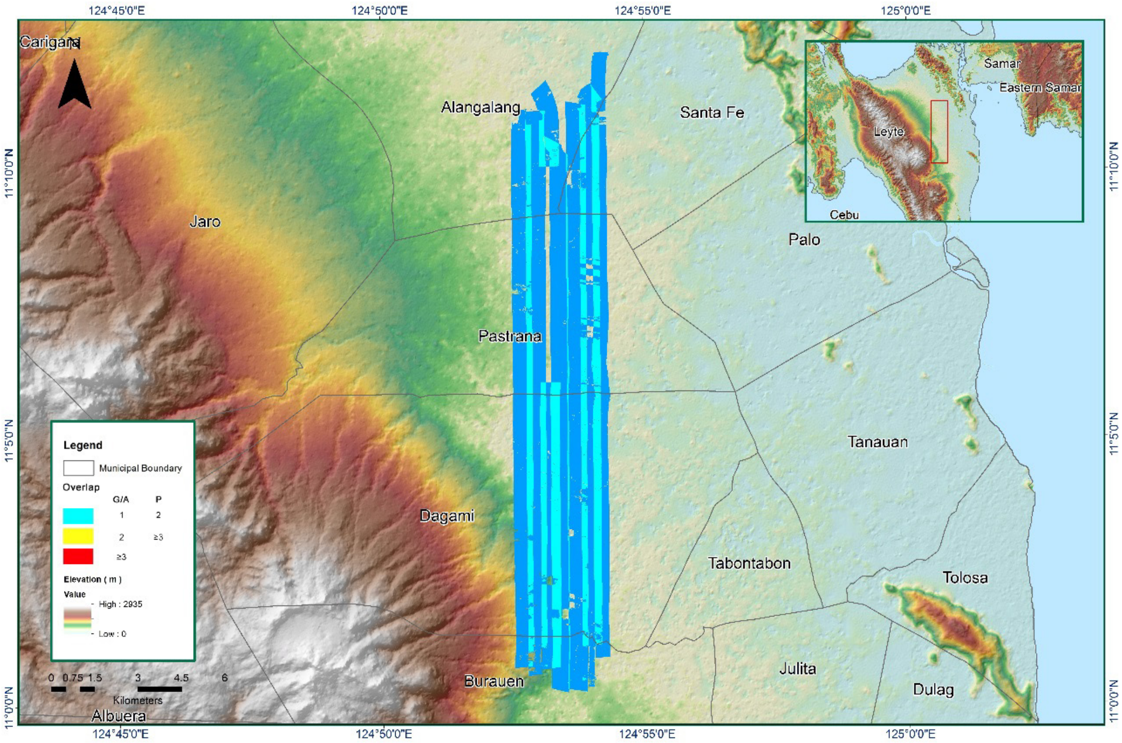


Figure 1.5.5. Image of data overlap

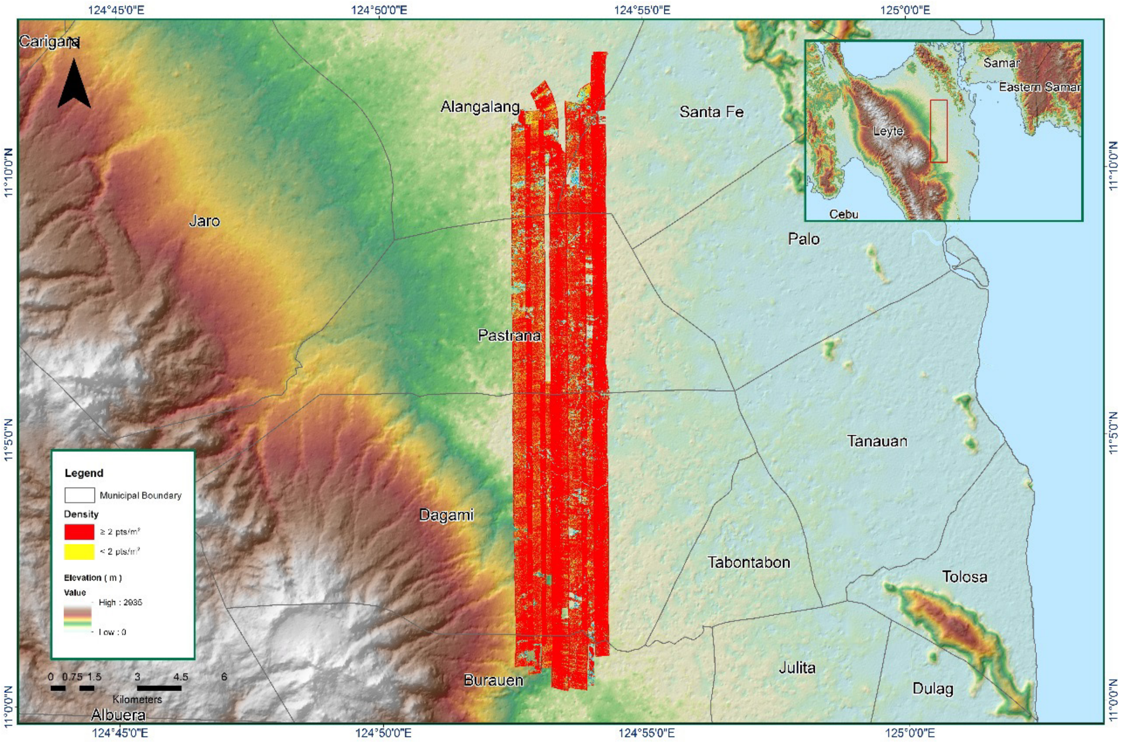


Figure 1.5.6. Density map of merged LiDAR data

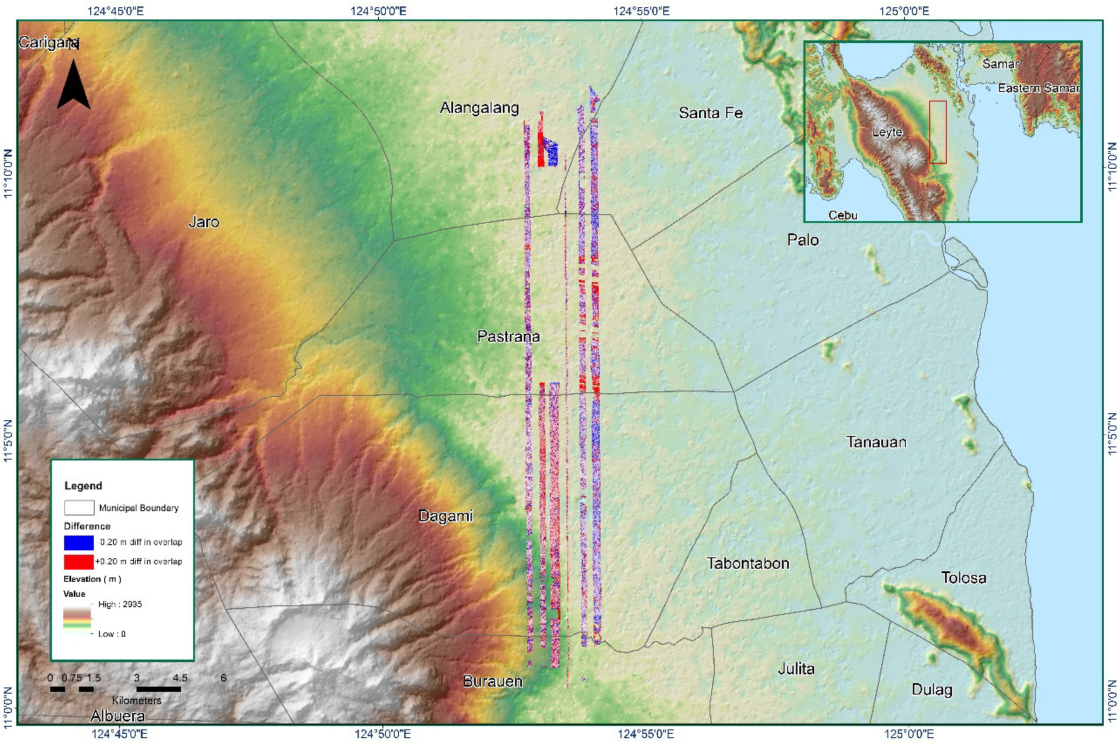


Figure 1.5.7. Elevation difference between flight lines

Flight Area	Leyte
Mission Name	Blk34G_Supplement
Inclusive Flights	3773G
Range data size	16.8
Base data size	248
POS	4.74
Image	n/a
Transfer date	February 12, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.0
RMSE for East Position (<4.0 cm)	1.3
RMSE for Down Position (<8.0 cm)	3.0
Boresight correction stdev (<0.001deg)	0.000314
IMU attitude correction stdev (<0.001deg)	0.000292
GPS position stdev (<0.01m)	0.0020
Minimum % overlap (>25)	38.70
Ave point cloud density per sq.m. (>2.0)	4.35
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	77
Maximum Height	331.30 m
Minimum Height	84.63 m
Classification (# of points)	
Ground	30,109,919
Low vegetation	49,355,383
Medium vegetation	102,195,429
High vegetation	45,790,210
Building	1,350,028
Orthophoto	No
Processed by	Engr. Regis Guhiting, Engr. Jovelle Anjeanette Canlas, Engr. Monalyne Rabino

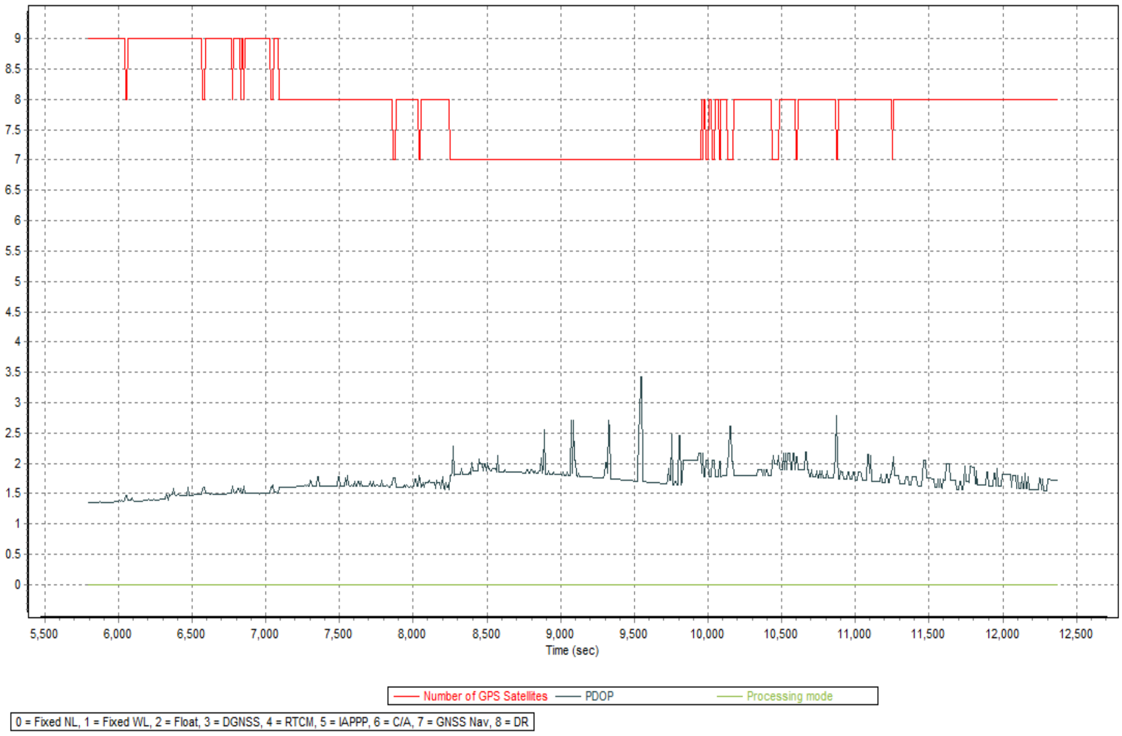


Figure 1.6.1. Solution Status

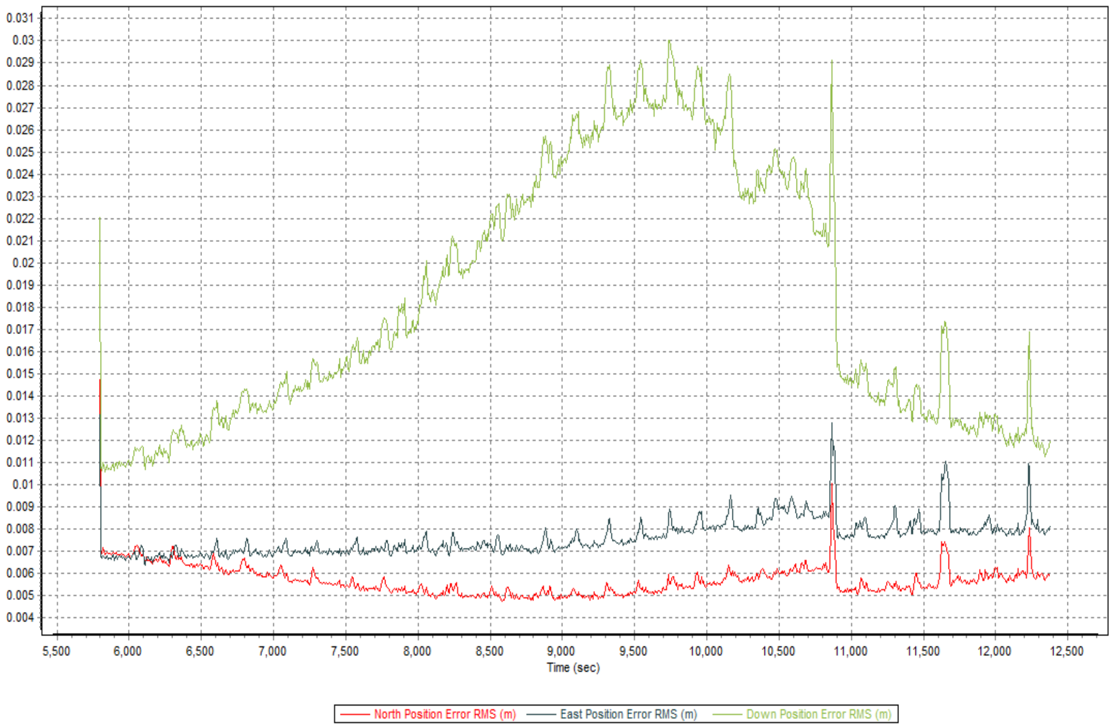


Figure 1.6.2. Smoothed Performance Metric Parameters

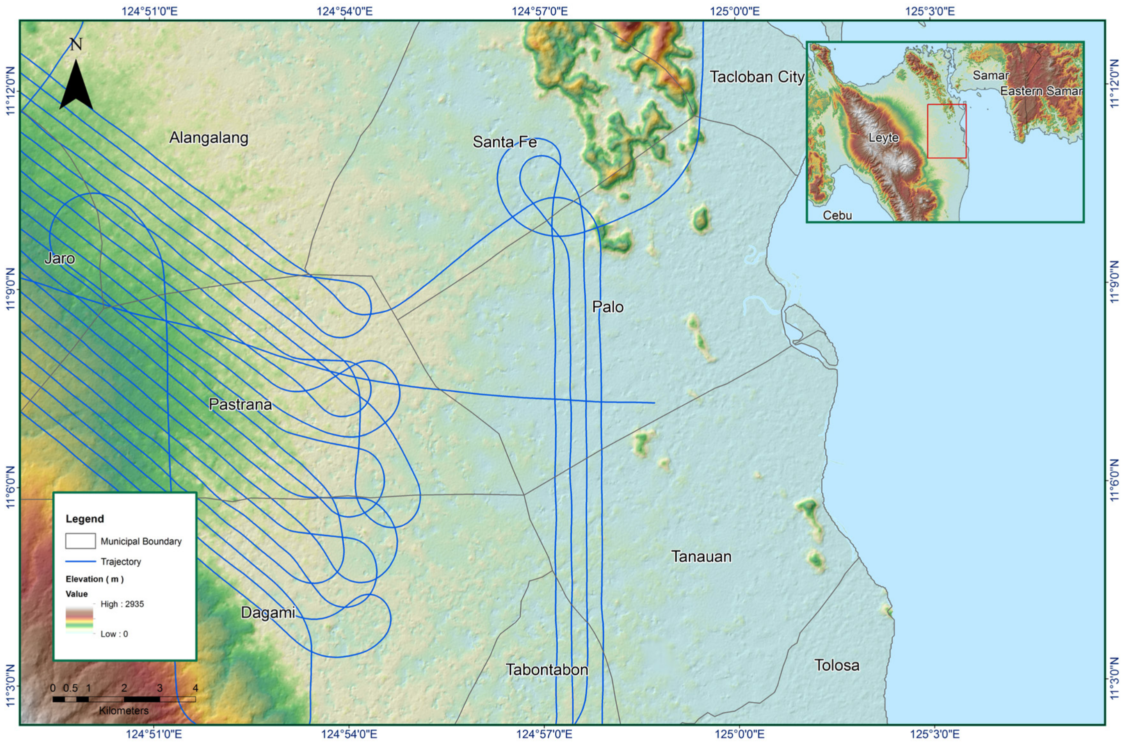


Figure 1.6.3. Best Estimated Trajectory

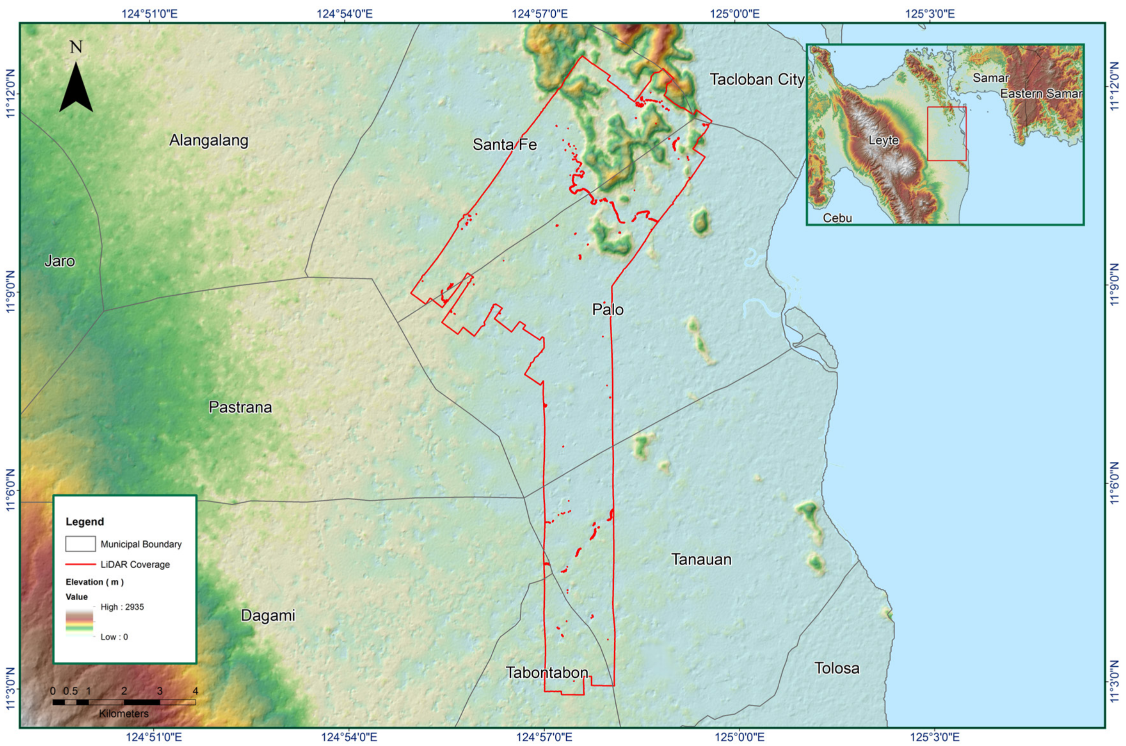


Figure 1.6.4. Coverage of LiDAR Data

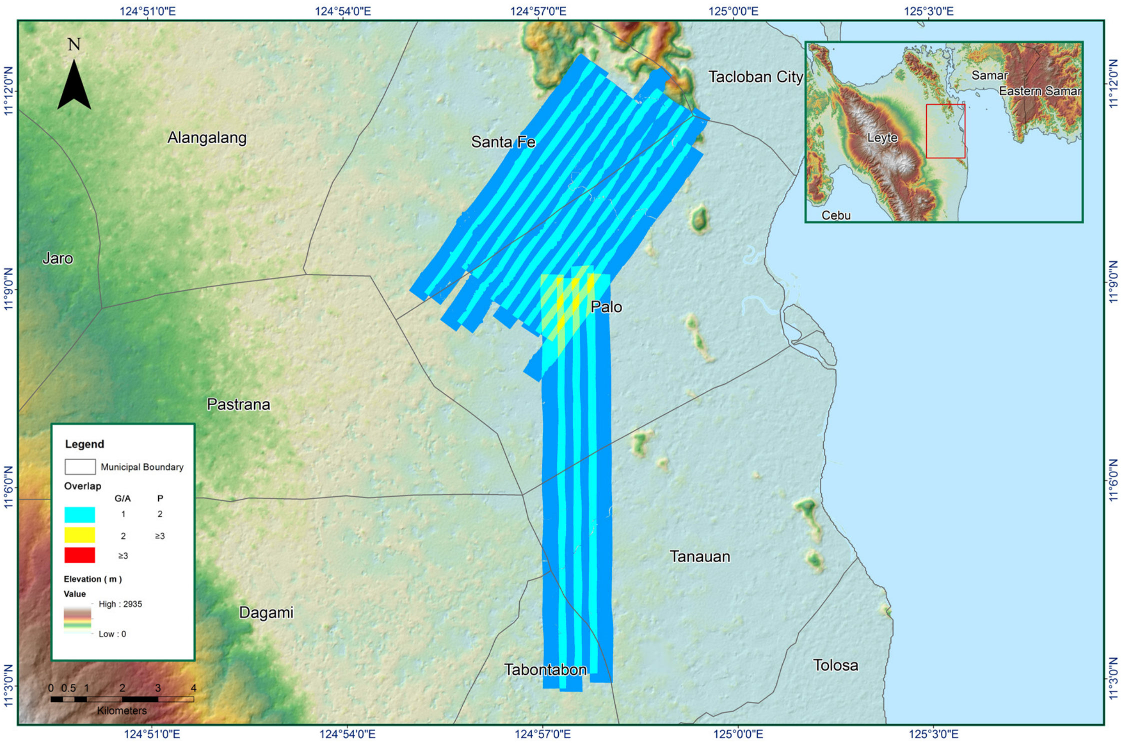


Figure 1.6.5. Image of data overlap

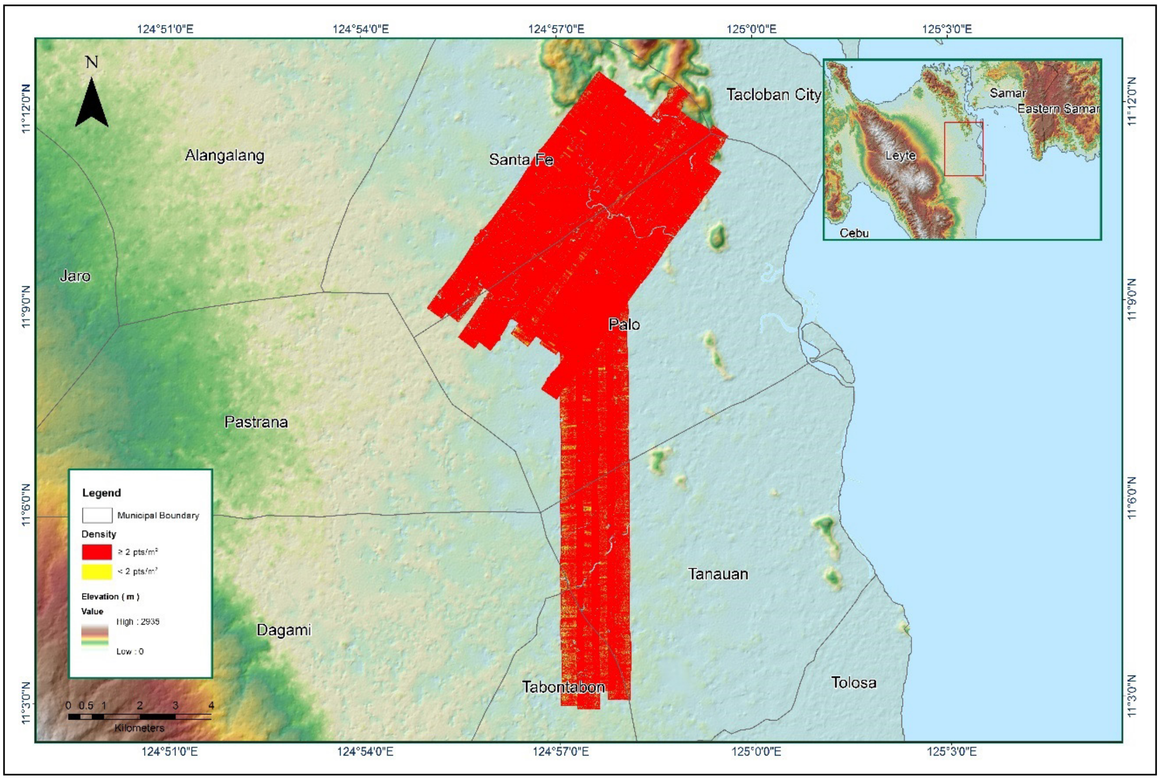


Figure 1.6.6. Density map of merged LiDAR data

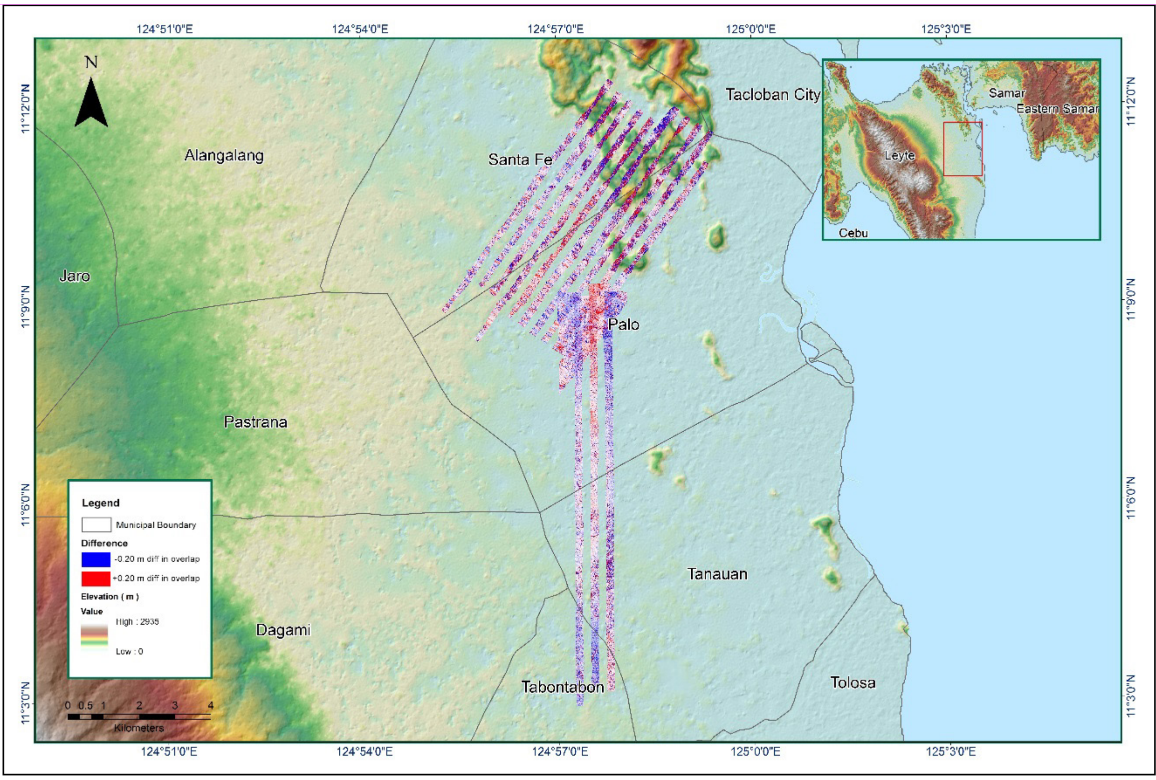


Figure 1.6.7. Elevation difference between flight lines

Flight Area	Tacloban
Mission Name	1026A
Inclusive Flights	1026A
Range data size	11.6 GB
Base data size	137 MB
POS	55.2 GB
Image	February 3, 2014
Transfer date	
Solution Status	
Number of Satellites (>6)	YES
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.6
RMSE for East Position (<4.0 cm)	1.8
RMSE for Down Position (<8.0 cm)	3.1
Boresight correction stdev (<0.001deg)	0.000559
IMU attitude correction stdev (<0.001deg)	0.007980
GPS position stdev (<0.01m)	0.0379
Minimum % overlap (>25)	42.17%
Ave point cloud density per sq.m. (>2.0)	2.33
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	314
Maximum Height	386.42 m
Minimum Height	42.55 m
Classification (# of points)	
Ground	83,757,366
Low vegetation	78,700,823
Medium vegetation	165,907,507
High vegetation	4,928,508
Building	1,722,190
Orthophoto	Yes
Processed by	Engr. Jennifer Saguran, Engr. Christy Lubiano, Ryan Nicholai Dizon

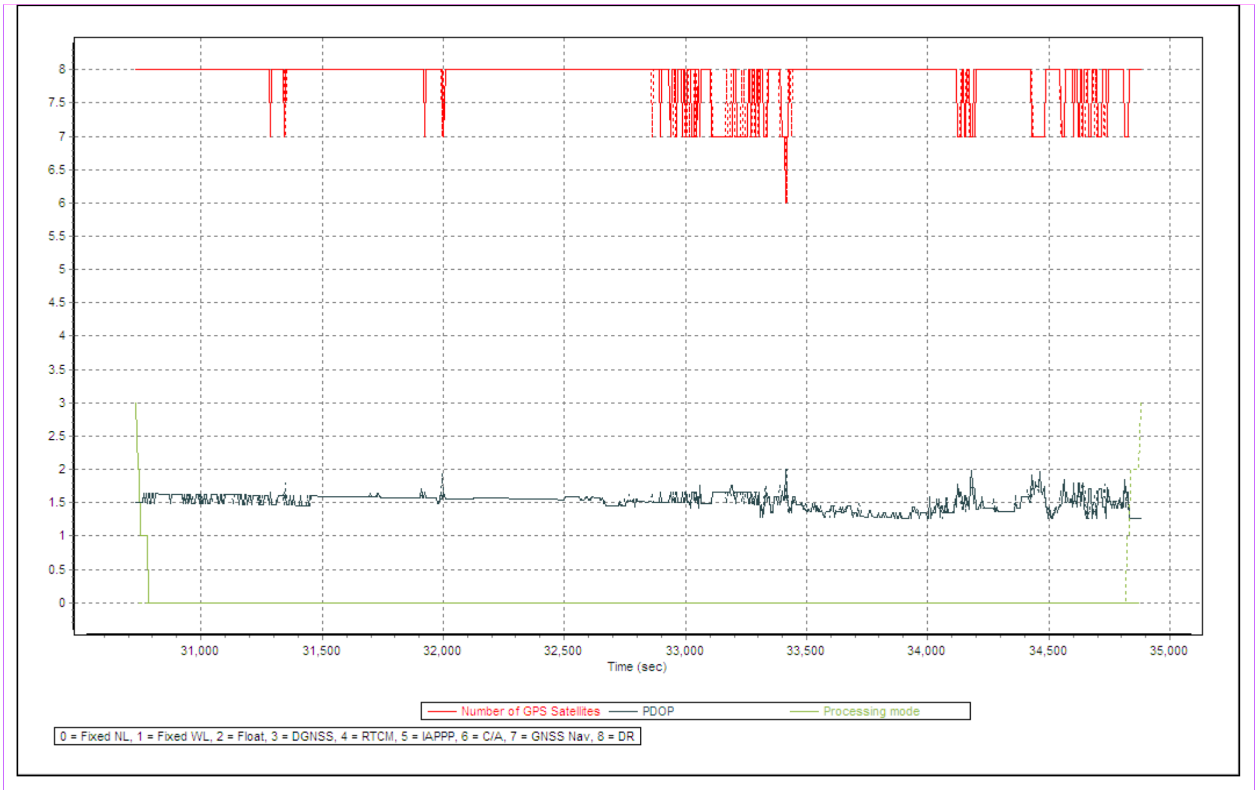


Figure 1.7.1. Solution Status

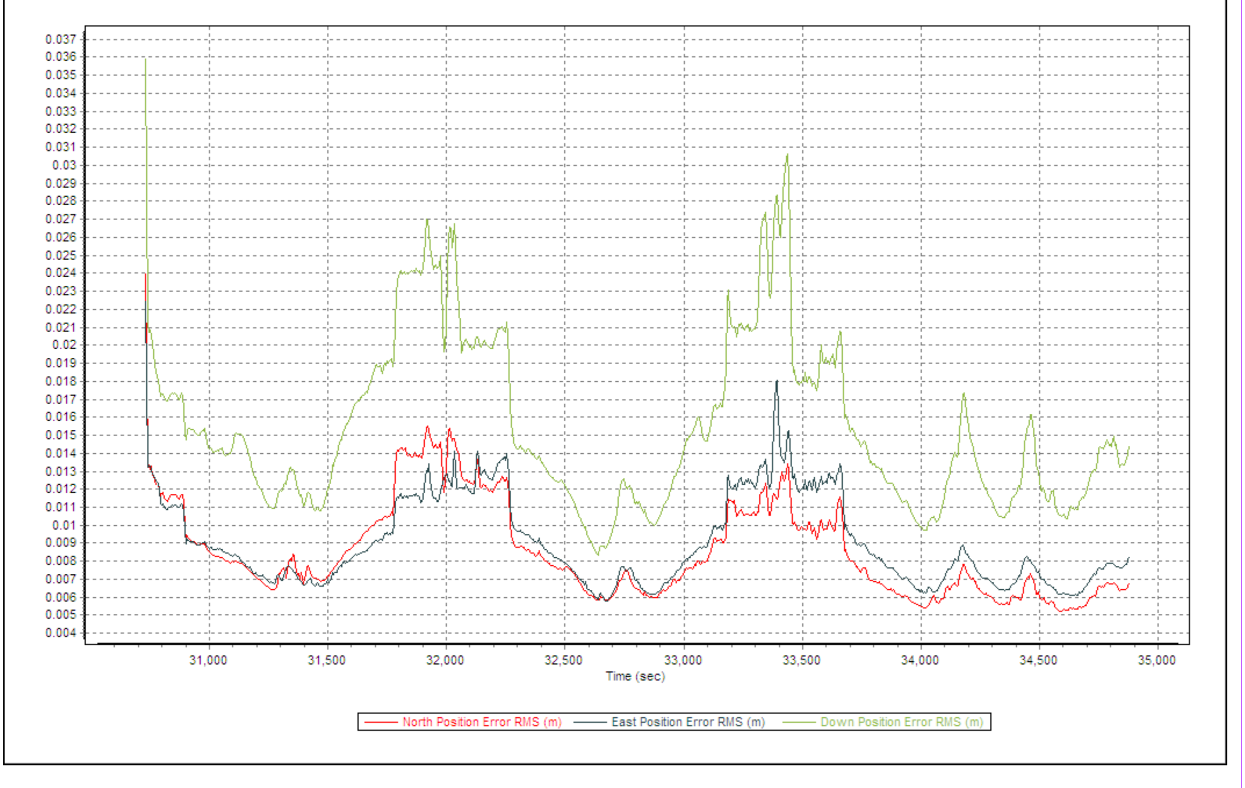


Figure 1.7.2. Smoothed Performance Metrics Parameters

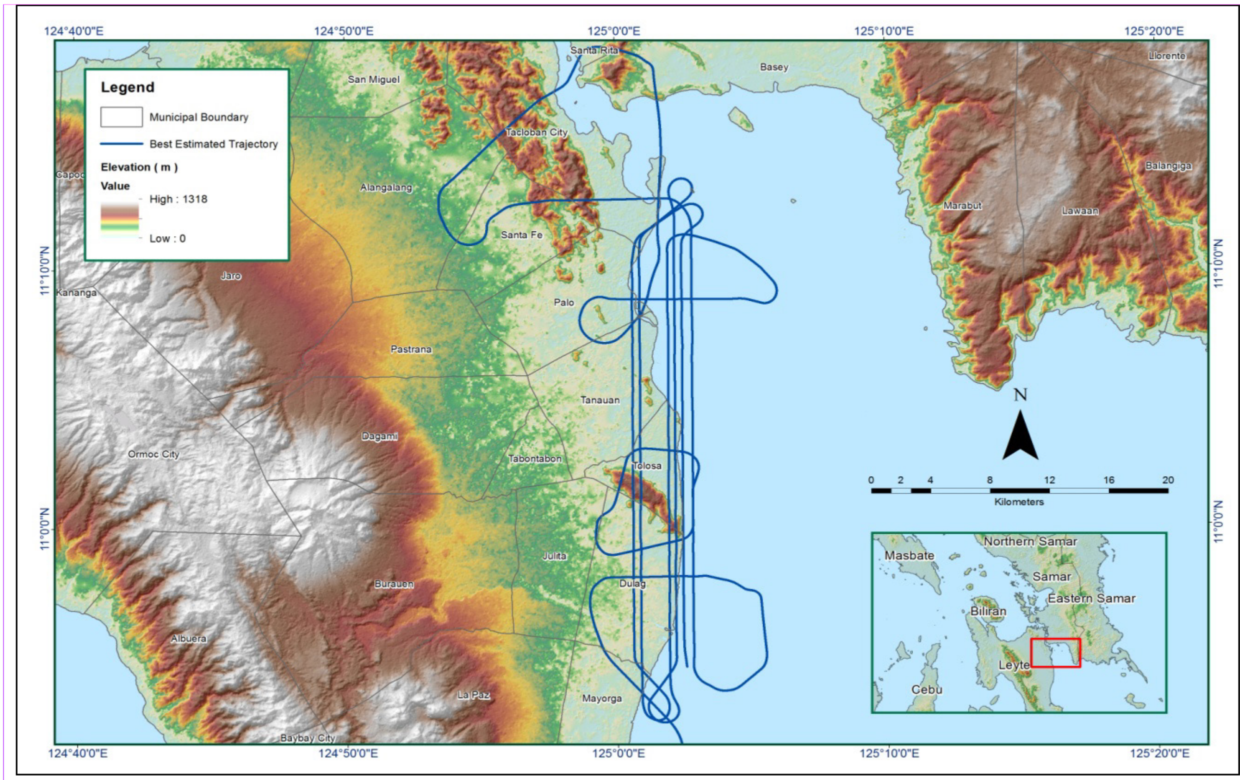


Figure 1.7.3. Best Estimated Trajectory

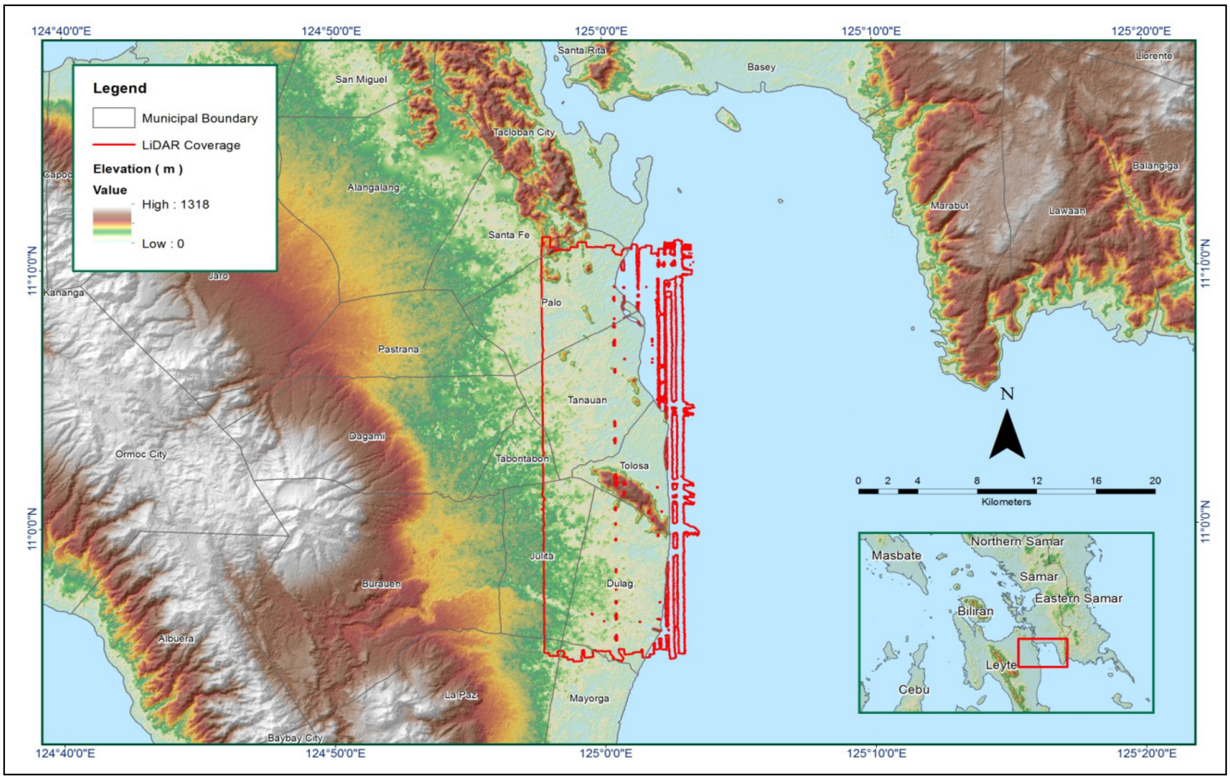


Figure 1.7.4. Coverage of LiDAR data

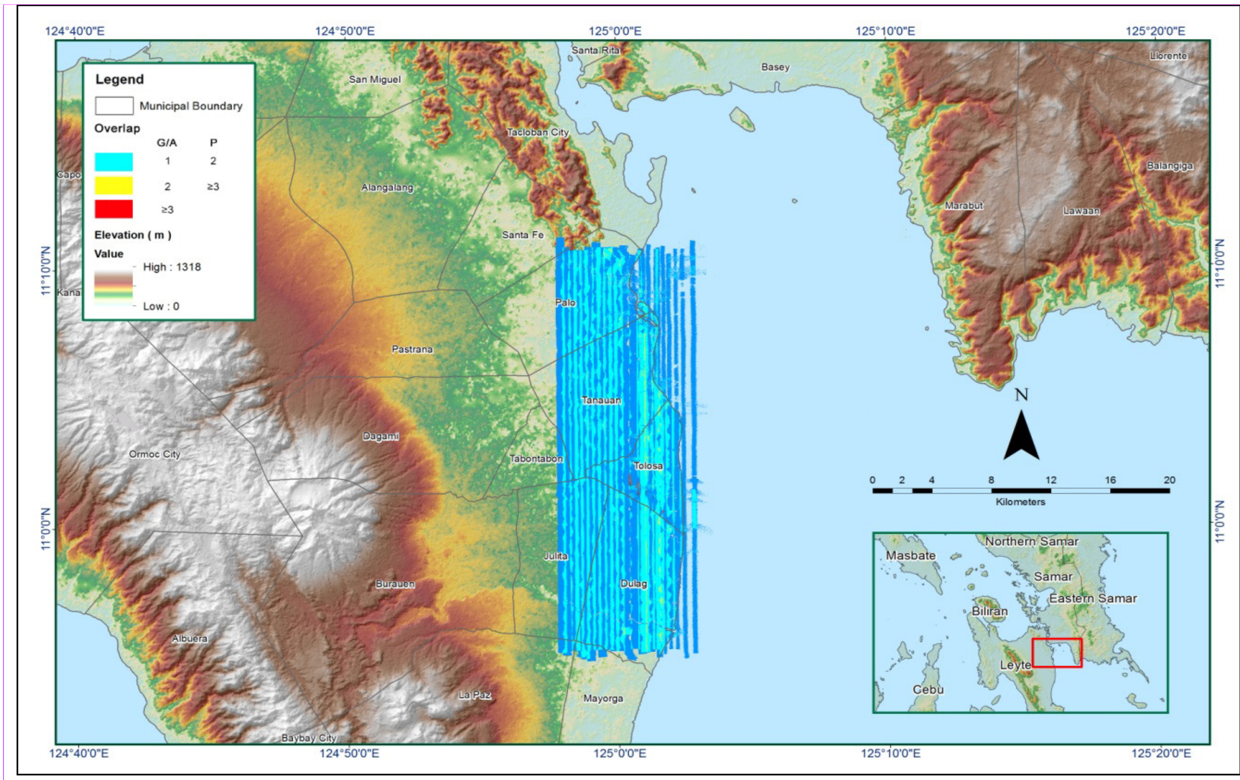


Figure 1.7.5. Image of data overlap

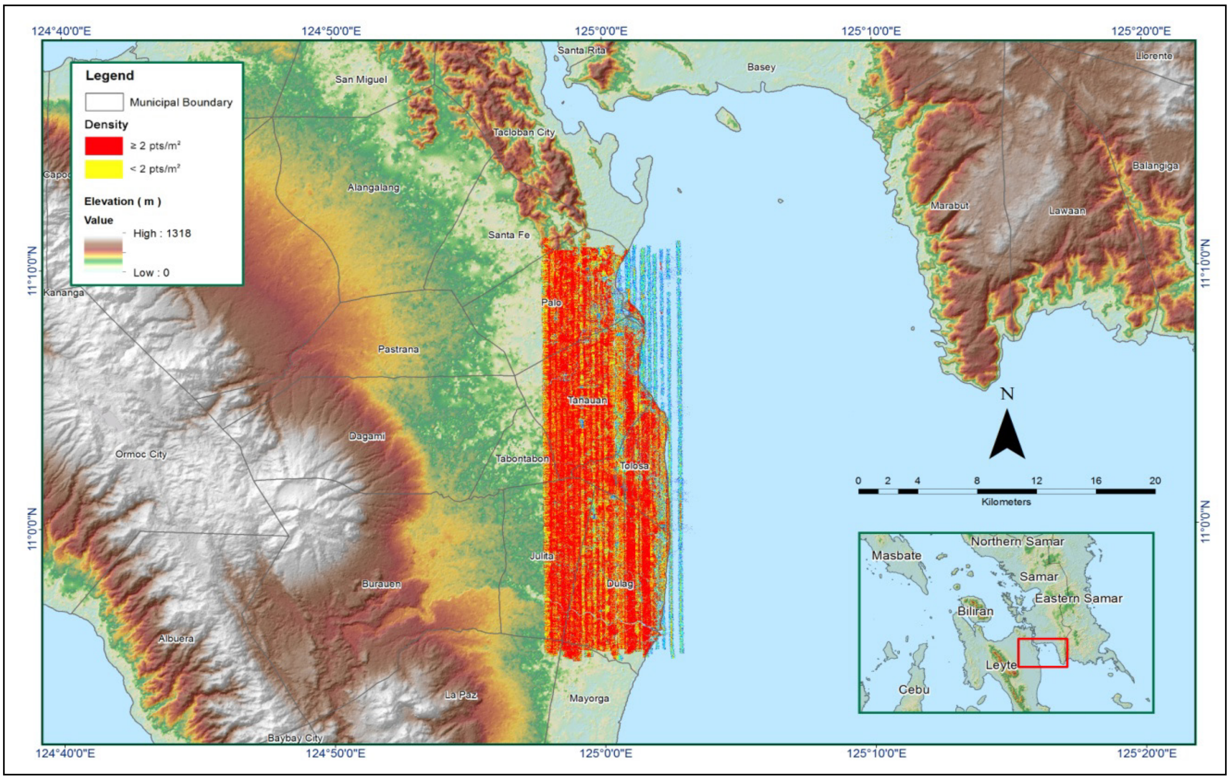


Figure 1.7.6. Density map of merged LiDAR data

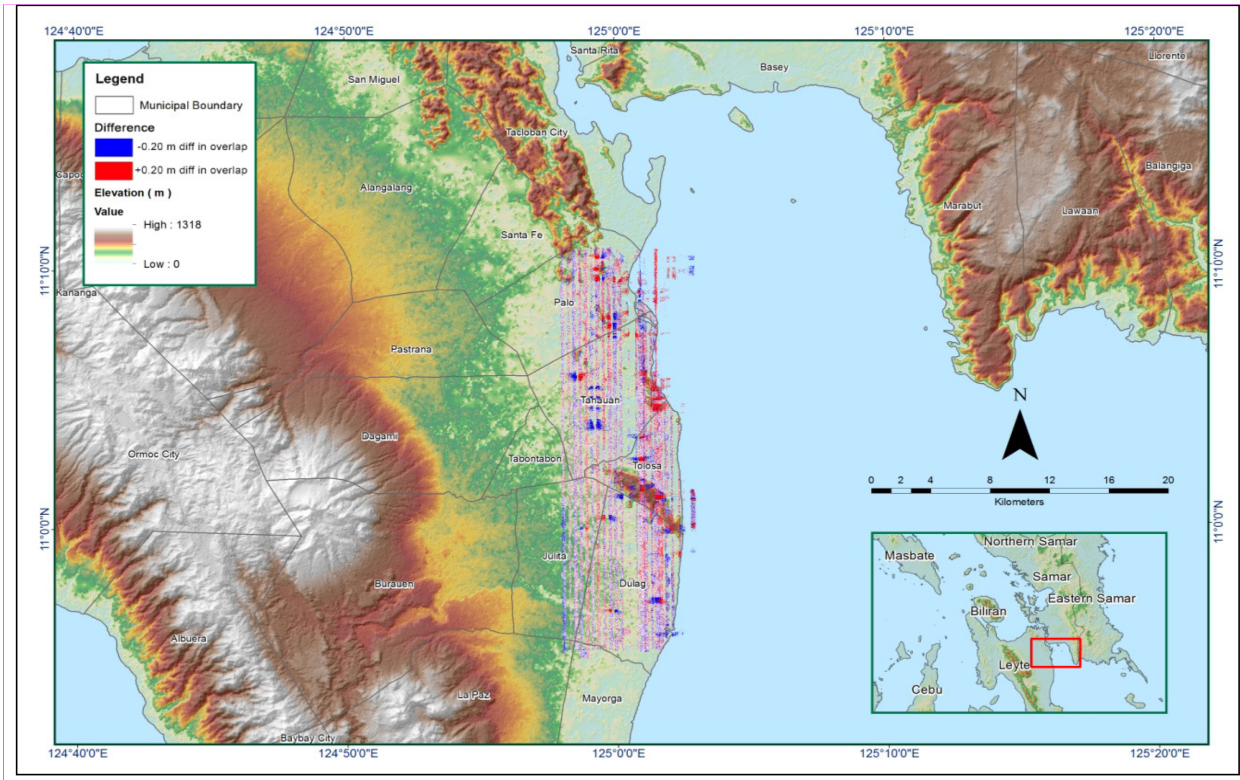


Figure 1.7.7. Elevation difference between flight lines

Annex 9. Binahaan Model Basin Parameters

Table A-9.1. Bangkerohan Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W780	57.53	46.89	0	2.9895	4.8789	Discharge	0.25	0.4	Ratio to Peak	0.65
W770	57.23	47.02	0	3.155	5.149	Discharge	0.25	0.4	Ratio to Peak	0.65
W760	46.61	52.15	0	3.8084	6.2152	Discharge	0.25	0.4	Ratio to Peak	0.65
W750	26.79	65.48	0	2.4932	4.0689	Discharge	0.25	0.4	Ratio to Peak	0.65
W740	61.60	45.19	0	0.95771	1.563	Discharge	0.25	0.4	Ratio to Peak	0.65
W730	21.54	70.23	0	2.8169	4.5972	Discharge	0.25	0.4	Ratio to Peak	0.65
W720	32.24	61.17	0	4.6503	7.5893	Discharge	0.25	0.4	Ratio to Peak	0.65
W710	58.71	46.39	0	11.194	18.269	Discharge	0.25	0.4	Ratio to Peak	0.65
W700	39.23	56.43	0	4.5775	7.4705	Discharge	0.25	0.4	Ratio to Peak	0.65
W690	49.39	50.71	0	2.6992	4.4052	Discharge	0.25	0.4	Ratio to Peak	0.65
W680	53.82	48.56	0	1.8986	3.0985	Discharge	0.25	0.4	Ratio to Peak	0.65
W670	54.87	48.07	0	2.3299	3.8024	Discharge	0.25	0.4	Ratio to Peak	0.65
W660	56.98	47.13	0	0.68845	1.1236	Discharge	0.25	0.4	Ratio to Peak	0.65
W650	22.71	69.11	0	3.7627	6.1407	Discharge	0.25	0.4	Ratio to Peak	0.65
W640	82.49	38.11	0	4.9681	8.108	Discharge	0.25	0.4	Ratio to Peak	0.65
W630	58.06	46.67	0	6.1397	10.02	Discharge	0.25	0.4	Ratio to Peak	0.65
W620	42.90	54.22	0	3.5288	5.759	Discharge	0.25	0.4	Ratio to Peak	0.65
W610	42.18	54.63	0	6.088	9.9356	Discharge	0.25	0.4	Ratio to Peak	0.65
W600	57.39	46.95	0	10.235	16.703	Discharge	0.25	0.4	Ratio to Peak	0.65
W590	59.10	46.22	0	3.961	6.4644	Discharge	0.25	0.4	Ratio to Peak	0.65
W580	45.66	52.66	0	2.181	3.5594	Discharge	0.25	0.4	Ratio to Peak	0.65

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W570	55.23	47.91	0	3.5501	5.7937	Discharge	0.25	0.4	Ratio to Peak	0.65
W560	37.58	57.48	0	2.6842	4.3806	Discharge	0.25	0.4	Ratio to Peak	0.65
W550	53.01	48.94	0	4.4823	7.3151	Discharge	0.25	0.4	Ratio to Peak	0.65
W540	48.65	51.08	0	2.2923	3.741	Discharge	0.25	0.4	Ratio to Peak	0.65
W530	56.42	47.38	0	2.8028	4.5742	Discharge	0.25	0.4	Ratio to Peak	0.65
W520	23.05	68.79	0	1.8111	2.9556	Discharge	0.25	0.4	Ratio to Peak	0.65
W510	37.76	57.37	0	2.5065	4.0906	Discharge	0.25	0.4	Ratio to Peak	0.65
W500	35.52	58.85	0	1.3617	2.2223	Discharge	0.25	0.4	Ratio to Peak	0.65
W490	22.78	69.04	0	4.5628	7.4465	Discharge	0.25	0.4	Ratio to Peak	0.65
W480	17.58	74.29	0	5.4408	8.8793	Discharge	0.25	0.4	Ratio to Peak	0.65
W470	46.93	51.98	0	3.8894	6.3475	Discharge	0.25	0.4	Ratio to Peak	0.65
W460	20.56	71.19	0	1.4964	2.442	Discharge	0.25	0.4	Ratio to Peak	0.65
W450	18.35	73.46	0	4.2971	7.0129	Discharge	0.25	0.4	Ratio to Peak	0.65
W440	38.20	57.08	0	2.2868	3.732	Discharge	0.25	0.4	Ratio to Peak	0.65
W430	32.80	60.77	0	9.1437	14.9225986	Discharge	0.25	0.4	Ratio to Peak	0.65
W420	39.99	55.96	0	3.2976	5.3816	Discharge	0.25	0.4	Ratio to Peak	0.65
W410	39.39	56.33	0	3.8192	6.2329	Discharge	0.25	0.4	Ratio to Peak	0.65
W400	47.83	51.51	0	7.8716	12.846	Discharge	0.25	0.4	Ratio to Peak	0.65

Annex 10. Binahaan Model Reach Parameters

Table A-10.1. Bangkerohan Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R60	Automatic Fixed Interval	2389.4	0.0100759	0.04	Trapezoid	3.92	1
R70	Automatic Fixed Interval	1134.5	0.004525	0.04	Trapezoid	5.09	1
R80	Automatic Fixed Interval	994.97	0.0041201	0.04	Trapezoid	11.874	1
R90	Automatic Fixed Interval	2889.1	0.000985811	0.04	Trapezoid	12.824	1
R100	Automatic Fixed Interval	1173.7	0.0082618	0.04	Trapezoid	21.658	1
R110	Automatic Fixed Interval	2869.8	0.0076027	0.04	Trapezoid	6.05	1
R120	Automatic Fixed Interval	13567	0.0100412	0.04	Trapezoid	13.14	1
R140	Automatic Fixed Interval	1219.1	0.0096697	0.04	Trapezoid	65.99	1
R180	Automatic Fixed Interval	1665.8	0.000162183	0.04	Trapezoid	49.62	1
R190	Automatic Fixed Interval	6208.7	0.0018722	0.04	Trapezoid	55.698	1
R200	Automatic Fixed Interval	8315.7	0.0256506	0.04	Trapezoid	20.834	1
R210	Automatic Fixed Interval	98.995	0.246	0.04	Trapezoid	17.648	1
R240	Automatic Fixed Interval	2183.4	0.0013572	0.04	Trapezoid	28.59	1
R250	Automatic Fixed Interval	42.426	0.10865	0.04	Trapezoid	22.186	1
R260	Automatic Fixed Interval	1767.8	0.0015823	0.04	Trapezoid	28.698	1
R290	Automatic Fixed Interval	1624.7	0.0288398	0.04	Trapezoid	16.432	1
R300	Automatic Fixed Interval	2845.4	0.0026938	0.04	Trapezoid	27.408	1
R310	Automatic Fixed Interval	1143.4	0.000348011	0.04	Trapezoid	26.302	1
R340	Automatic Fixed Interval	1229.4	0.0445488	0.04	Trapezoid	13.82	1

Annex 11. Binahaan Field Validation Points

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event	Date of Occurrence	Rain Return /Scenario
	Lat	Long						
279	11.11397998	125.0172459	0.029999999	1	-0.97	Ruby	2014	5Yr
279	11.11397998	125.0172459	0.029999999	1.5	-1.47	Senyang	2015	5Yr
323	11.11125075	125.0162571	0.029999999	0.2	-0.17	Ruby	2014	5Yr
333	11.11125075	125.0162571	0.029999999	0.2	-0.17	Ruby	2014	5Yr
343	11.11325428	125.0148665	0.219999999	0.2	0.02	Ruby	2014	5Yr
353	11.11175166	125.0142932	0.090000004	0.2	-0.11	Ruby	2014	5Yr
363	11.11096535	125.0149336	0.100000001	0.2	-0.1	Senyang	2015	5Yr
363	11.11096535	125.0149336	0.100000001	0.2	-0.1	Ruby	2014	5Yr
373	11.1102549	125.0158984	0.029999999	0.1	-0.07	Senyang	2015	5Yr
373	11.1102549	125.0158984	0.029999999	0.2	-0.17	Ruby	2014	5Yr
383	11.1094131	125.0168057	0.090000004	0.2	-0.11	Senyang	2015	5Yr
383	11.1094131	125.0168057	0.090000004	0.2	-0.11	Ruby	2014	5Yr
393	11.10932065	125.0155588	0.170000002	0.2	-0.03	Senyang	2015	5Yr
393	11.10932065	125.0155588	0.170000002	0.2	-0.03	Ruby	2014	5Yr
403	11.10990311	125.014658	0.029999999	0.4	-0.37	Senyang	2015	5Yr
416	11.10906593	125.0143104	0.029999999	0.4	-0.37	Senyang	2015	5Yr
423	11.10818733	125.0151437	0.039999999	0.2	-0.16	Senyang	2015	5Yr
433	11.10843334	125.0158722	0.029999999	0.3	-0.27	Senyang	2015	5Yr
433	11.10843334	125.0158722	0.029999999	0.2	-0.17	Ruby	2014	5Yr
443	11.10741167	125.0157733	0.029999999	0.4	-0.37	Senyang	2015	5Yr
453	11.10718427	125.0147769	0.039999999	0.5	-0.46	Senyang	2015	5Yr
463	11.10792087	125.0139871	0.029999999	0.5	-0.47	Senyang	2015	5Yr
473	11.10639713	125.0135057	0.029999999	0.7	-0.67	Senyang	2015	5Yr
483	11.10658723	125.0152808	0.079999998	0.7	-0.62	Senyang	2015	5Yr
633	11.10177551	125.0193146	0.090000004	0	0.09	Heavy Rain		5Yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event	Date of Occurrence	Rain Return /Scenario
	Lat	Long						
643	11.10012755	125.0194403	0.029999999	0	0.03	Heavy Rain		5Yr
653	11.09875292	125.0191131	0.409999996	0	0.41	Heavy Rain		5Yr
683	11.1054887	125.0122471	0.419999987	0.9	-0.48	Senyang	2015	5Yr
683	11.1054887	125.0122471	0.419999987	0.5	-0.08	Ruby	2014	5Yr
693	11.10405707	125.0103673	0.310000002	0.9	-0.59	Senyang	2015	5Yr
693	11.10405707	125.0103673	0.310000002	0.5	-0.19	Ruby	2014	5Yr
703	11.10279459	125.0092351	0.029999999	1.3	-1.27	Senyang	2015	5Yr
715	11.10132909	125.0078159	0.029999999	1	-0.97	Senyang	2015	5Yr
723	11.10013627	125.0064154	0.079999998	1	-0.92	Senyang	2015	5Yr
733	11.11087985	125.0131878	0.310000002	0	0.31	Heavy Rain		5Yr
743	11.10982608	125.0116627	0.239999995	0	0.24	Heavy Rain		5Yr
753	11.10948946	125.0104046	0.050000001	0	0.05	Heavy Rain		5Yr
763	11.10879293	125.0089616	0.029999999	0	0.03	Heavy Rain		5Yr
773	11.10794661	125.0081046	0.029999999	0	0.03	Heavy Rain		5Yr
815	11.10749482	125.0063204	0.029999999	0	0.03	Heavy Rain		5Yr
823	11.1066081	125.0046225	0.029999999	0	0.03	Heavy Rain		5Yr
833	11.10565776	125.003353	0.029999999	0	0.03	Heavy Rain		5Yr
843	11.10526389	125.0020128	0.349999994	1	-0.65	Ruby	2014	5Yr
843	11.10526389	125.0020128	0.349999994	0.5	-0.15	Senyang	2015	5Yr
853	11.10375792	125.0027908	0.029999999	0.4	-0.37	Ruby	2014	5Yr
903	11.10109968	124.995776	0.029999999	0.55	-0.52	Ruby	2014	5Yr
923	11.10011523	124.9939592	0.029999999	0.4	-0.37	Senyang	2015	5Yr
933	11.09916237	124.9922758	0.119999997	0.4	-0.28	Senyang	2015	5Yr
943	11.09781741	124.9909108	0.289999992	0.4	-0.11	Senyang	2015	5Yr
943	11.09781741	124.9909108	0.289999992	0.5	-0.21	Ruby	2014	5Yr
953	11.09707503	124.9896329	0.039999999	0.5	-0.46	Senyang	2015	5Yr
963	11.09566586	124.9882384	0.430000007	0.7	-0.27	Senyang	2015	5Yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event	Date of Occurrence	Rain Return /Scenario
	Lat	Long						
973	11.09421437	124.989936	0.029999999	0	0.03	Heavy Rain		5Yr
1004	11.10179521	124.9854417	1.470000029	0.5	0.97	Heavy Rain	2013	5Yr
1015	11.10417852	124.9847289	0.389999986	0.5	-0.11	Heavy Rain	2013	5Yr
1024	11.10661187	124.9847838	0.439999998	0.5	-0.06	Heavy Rain	2013	5Yr
1034	11.10848079	124.9845098	0.029999999	0.5	-0.47	Heavy Rain	2013	5Yr
1043	11.10957395	124.9862549	0.029999999	0.5	-0.47	Heavy Rain	2013	5Yr
1053	11.11085739	124.987036	5.389999866	0.2	5.19	Heavy Rain	2013	5Yr
1083	11.11239689	124.9892547	0.039999999	0.2	-0.16	Heavy Rain	2013	5Yr
1106	11.11682229	124.9923462	0.029999999	0	0.03	Heavy Rain		5Yr
1193	11.11495983	125.0136541	0.029999999	0.8	-0.77	Senyang	2015	5Yr
1203	11.1183742	124.9918328	0.029999999	0.5	-0.47	Heavy Rain	2013	5Yr
1233	11.12255492	124.9979818	0.039999999	0	0.04	Heavy Rain		5Yr
1233	11.12255492	124.9979818	0.039999999	0	0.04	Heavy Rain		5Yr
1243	11.12396317	125.0016927	0.029999999	0	0.03	Heavy Rain		5Yr
1253	11.12548113	125.0053814	0.340000004	0	0.34	Heavy Rain		5Yr
1263	11.12700487	125.0082362	0.029999999	0.3	-0.27	Heavy Rain	2013	5Yr
1614	11.12812721	125.0090425	0.100000001	0	0.1	Heavy Rain		5Yr
1623	11.0949415	124.9856753	0.400000006	0.7	-0.3	Senyang	2015	5Yr
1623	11.0949415	124.9856753	0.400000006	0.3	0.1	Ruby	2014	5Yr
1633	11.09458032	124.9876189	0.029999999	0.3	-0.27	Senyang	2015	5Yr
1643	11.09322706	124.9862979	0.050000001	0.8	-0.75	Senyang	2015	5Yr
1643	11.09322706	124.9862979	0.050000001	0.5	-0.45	Ruby	2014	5Yr
1653	11.09139813	124.9841679	0.039999999	0	0.04	Heavy Rain		5Yr
1663	11.08960155	124.9812698	0.029999999	0	0.03	Heavy Rain		5Yr
1673	11.08648575	124.9798997	0.029999999	0	0.03	Heavy Rain		5Yr
1683	11.08427569	124.9797039	0.090000004	0	0.09	Heavy Rain		5Yr
1693	11.08239789	124.9771053	0.059999999	0	0.06	Heavy Rain		5Yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event	Date of Occurrence	Rain Return /Scenario
	Lat	Long						
1703	11.08103592	124.9744707	0.029999999	0	0.03	Heavy Rain		5Yr
1714	11.12643256	125.0109596	0.029999999	0.3	-0.27	Heavy Rain	2013	5Yr
1715	11.07910917	124.9669365	0.029999999	0	0.03	Heavy Rain		5Yr
1723	11.07888931	124.9649711	0.029999999	0	0.03	Heavy Rain		5Yr
1733	11.07850886	124.963114	0.029999999	0	0.03	Heavy Rain		5Yr
1743	11.07748643	124.9604841	0.029999999	0	0.03	Heavy Rain		5Yr
1753	11.07688964	124.9576005	2.849999905	0	2.85	Heavy Rain		5Yr
1763	11.07587703	124.9554026	0.029999999	0	0.03	Heavy Rain		5Yr
1773	11.07519834	124.9523218	0.050000001	0	0.05	Heavy Rain		5Yr
1783	11.07431925	124.9505879	0.029999999	0	0.03	Heavy Rain		5Yr
1814	11.12397473	125.0141253	0.029999999	0	0.03	Heavy Rain		5Yr
2014	11.12149612	125.0158581	0.119999997	0	0.12	Heavy Rain		5Yr
2114	11.11974866	125.0160491	0.029999999	0.8	-0.77	Senyang	2015	5Yr
2314	11.11594479	125.0182016	0.029999999	1	-0.97	Ruby	2014	5Yr
2314	11.11594479	125.0182016	0.029999999	1.5	-1.47	Senyang	2015	5Yr
2414	11.11714767	125.0196056	0.159999996	1	-0.84	Ruby	2014	5Yr
2414	11.11714767	125.0196056	0.159999996	1.5	-1.34	Senyang	2015	5Yr
2493	11.09236029	125.0040599	0.029999999	0.6	-0.57	Senyang	2015	5Yr
2503	11.08863914	125.0011535	0.039999999	0.6	-0.56	Senyang	2015	5Yr
2513	11.11596817	125.0155706	0.029999999	0.8	-0.77	Senyang	2015	5Yr
2612	11.11466303	125.0150776	0.029999999	0.8	-0.77	Senyang	2015	5Yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event	Date of Occurrence	Rain Return /Scenario
	Lat	Long						
278	11.1496174	125.000758	0.08	2.5	-2.4	Yolanda	Nov.2013	100Yr
279	11.11398	125.017246	0.03	2.5	-2.5	Yolanda	Nov.2013	100Yr
283	11.1128301	125.016791	0.31	2.5	-2.2	Yolanda	Nov.2013	100Yr
293	11.1121422	125.018298	0.45	3	-2.6	Yolanda	Nov.2013	100Yr
303	11.1126991	125.019601	0.63	3	-2.4	Yolanda	Nov.2013	100Yr
315	11.14755	124.999769	0.44	2.5	-2.1	Yolanda	Nov.2013	100Yr
316	11.110934	125.017983	0.16	2.6	-2.4	Yolanda	Nov.2013	100Yr
323	11.1112508	125.016257	0.03	5	-5	Yolanda	2013	100Yr
333	11.1123155	125.015445	0.03	5	-5	Yolanda	2013	100Yr
343	11.1132543	125.014866	0.25	5	-4.8	Yolanda	2013	100Yr
353	11.1117517	125.014293	0.25	5	-4.8	Yolanda	2013	100Yr
363	11.1109654	125.014934	0.03	5	-5	Yolanda	2013	100Yr
373	11.1102549	125.015898	0.13	5	-4.9	Yolanda	2013	100Yr
383	11.1094131	125.016806	0.04	5	-5	Yolanda	2013	100Yr
393	11.1093207	125.015559	0.26	5	-4.7	Yolanda	2013	100Yr
403	11.1099031	125.014658	0.11	3	-2.9	Yolanda	2013	100Yr
415	11.1467303	125.001722	0.03	2.5	-2.5	Yolanda	Nov.2013	100Yr
416	11.1090659	125.01431	0.03	3	-3	Yolanda	2013	100Yr
423	11.1081873	125.015144	0.03	3	-3	Yolanda	2013	100Yr
433	11.1084333	125.015872	0.3	5	-4.7	Yolanda	2013	100Yr
443	11.1074117	125.015773	0.03	3	-3	Yolanda	2013	100Yr
453	11.1071843	125.014777	0.1	3	-2.9	Yolanda	2013	100Yr
463	11.1079209	125.013987	0.16	3	-2.8	Yolanda	2013	100Yr
473	11.1063971	125.013506	0.03	3	-3	Yolanda	2013	100Yr
483	11.1065872	125.015281	0.1	3	-2.9	Yolanda	2013	100Yr
493	11.1107831	125.02006	0.03	2.6	-2.6	Yolanda	Nov.2013	100Yr
564	11.1430692	125.004068	0.03	3	-3	Yolanda	Nov.2013	100Yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event	Date of Occurrence	Rain Return /Scenario
	Lat	Long						
614	11.1414449	125.004522	0.03	3	-3	Yolanda	Nov.2013	100Yr
683	11.1054887	125.012247	0.69	0.5	0.19	Yolanda	2013	100Yr
693	11.1040571	125.010367	0.96	0.5	0.46	Yolanda	2013	100Yr
703	11.1027946	125.009235	0.14	0.6	-0.46	Yolanda	2013	100Yr
714	11.1404095	125.005009	0.75	3	-2.3	Yolanda	Nov.2013	100Yr
715	11.1013291	125.007816	0.03	0.6	-0.57	Yolanda	2013	100Yr
723	11.1001363	125.006415	0.03	0.5	-0.47	Yolanda	2013	100Yr
843	11.1052639	125.002013	0.53	0.5	0.03	Yolanda	2013	100Yr
853	11.1037579	125.002791	0.28	0.55	-0.27	Yolanda	2013	100Yr
863	11.1043712	125.000754	0.03	0.3	-0.27	Yolanda	2013	100Yr
873	11.1034599	124.999555	0.36	0.2	0.16	Yolanda	2013	100Yr
883	11.10244	124.998478	0.86	0.2	0.66	Yolanda	2013	100Yr
893	11.10203	124.997052	0.75	0.1	0.65	Yolanda	2013	100Yr
903	11.1010997	124.995776	0.23	0.15	0.08	Yolanda	2013	100Yr
914	11.1400315	125.006882	0.5	3	-2.5	Yolanda	Nov.2013	100Yr
915	11.0998394	124.996188	0.59	0.5	0.09	Yolanda	2013	100Yr
1004	11.1017952	124.985442	0.43	1.5	-1.1	Yolanda	Nov.2013	100Yr
1014	11.1391732	125.005744	0.03	3	-3	Yolanda	Nov.2013	100Yr
1015	11.1041785	124.984729	0.78	1	-0.22	Yolanda	Nov.2013	100Yr
1024	11.1066119	124.984784	0.77	1	-0.23	Yolanda	Nov.2013	100Yr
1034	11.1084808	124.98451	0.03	1	-0.97	Yolanda	Nov.2013	100Yr
1043	11.109574	124.986255	0.2	1	-0.8	Yolanda	Nov.2013	100Yr
1053	11.1108574	124.987036	3.8	0.5	3.3	Yolanda	Nov.2013	100Yr
1063	11.1118497	124.984932	0.78	0.5	0.28	Yolanda	Nov.2013	100Yr
1073	11.1129657	124.987334	0.04	0.5	-0.46	Yolanda	Nov.2013	100Yr
1083	11.1123969	124.989255	0.08	1	-0.92	Yolanda	Nov.2013	100Yr
1093	11.1144059	124.990637	0.03	0.4	-0.37	Yolanda	2013	100Yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event	Date of Occurrence	Rain Return /Scenario
	Lat	Long						
1105	11.1524295	124.998686	0	2	-2	Yolanda	Nov.2013	100Yr
1106	11.1168223	124.992346	0.03	0.5	-0.47	Yolanda	Nov.2013	100Yr
1114	11.1371408	125.006461	0.22	3	-2.8	Yolanda	Nov.2013	100Yr
1203	11.1183742	124.991833	0.39	0.5	-0.11	Yolanda	Nov.2013	100Yr
1214	11.134976	125.007174	0.03	3	-3	Yolanda	Nov.2013	100Yr
1215	11.1188058	124.995015	0.14	0.5	-0.36	Yolanda	2013	100Yr
1263	11.1270049	125.008236	0.84	2.5	-1.7	Yolanda	Nov.2013	100Yr
1273	11.1329699	125.002478	0.99	3.5	-2.5	Yolanda	Nov.2013	100Yr
1303	11.1248579	124.993708	0.03	1	-0.97	Yolanda	2013	100Yr
1314	11.1341319	125.005763	0.26	3	-2.7	Yolanda	Nov.2013	100Yr
1315	11.1516294	124.996359	0.03	1	-0.97	Yolanda	2013	100Yr
1323	11.1517692	124.993801	0.36	1	-0.64	Yolanda	2013	100Yr
1343	11.1531083	124.992934	0.09	1	-0.91	Yolanda	2013	100Yr
1353	11.1537482	124.990141	0.16	1	-0.84	Yolanda	2013	100Yr
1363	11.1556228	124.989474	0.96	1	-0.04	Yolanda	2013	100Yr
1373	11.1548047	124.986633	0.04	1	-0.96	Yolanda	2013	100Yr
1383	11.1538402	124.984153	0.63	1	-0.37	Yolanda	2013	100Yr
1414	11.1318916	125.007764	0.03	3	-3	Yolanda	Nov.2013	100Yr
1453	11.1314344	124.981296	0.86	1	-0.14	Yolanda	2013	100Yr
1463	11.1317209	124.979116	1.53	1	0.53	Yolanda	2013	100Yr
1473	11.1312819	124.983649	1.39	1	0.39	Yolanda	2013	100Yr
1514	11.1297115	125.008485	0.03	3	-3	Yolanda	Nov.2013	100Yr
1614	11.1281272	125.009042	0.58	3.5	-2.9	Yolanda	Nov.2013	100Yr
1623	11.0949415	124.985675	0.44	0.3	0.14	Yolanda	2013	100Yr
1643	11.0932271	124.986298	0.07	1.2	-1.1	Yolanda	2013	100Yr
1714	11.1264326	125.01096	0.03	2	-2	Yolanda	Nov.2013	100Yr
2314	11.1159448	125.018202	0.03	2.5	-2.5	Yolanda	Nov.2013	100Yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event	Date of Occurrence	Rain Return /Scenario
	Lat	Long						
2414	11.1171477	125.019606	0.57	2	-1.4	Yolanda	Nov.2013	100Yr
2503	11.0886391	125.001154	0.12	0.5	-0.38	Yolanda	2013	100Yr
5012	11.1106034	125.020988	0.03	5	-5	Yolanda	Nov.2013	100Yr
5112	11.109963	125.021679	0.26	5	-4.7	Yolanda	Nov.2013	100Yr
5212	11.1092791	125.020284	0.06	5	-4.9	Yolanda	Nov.2013	100Yr
5312	11.1086732	125.019228	0.05	5	-4.9	Yolanda	Nov.2013	100Yr
5412	11.1081602	125.020605	0.04	5	-5	Yolanda	Nov.2013	100Yr
5512	11.1084964	125.02169	0.16	5	-4.8	Yolanda	Nov.2013	100Yr

Annex 12. Educational Institutions Affected in Binahaan Flood Plain

LEYTE				
DAGAMI				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Abaca Elementary School	Abaca	Medium	Medium	Medium
Balilit Elementary School	Balilit	Medium	Medium	High
Day Care Center	Balilit	Medium	Medium	High
Canlingga Elementary School	Balugo	Low	Low	Medium
Banayon Elementary School	Banayon	Low	Low	Low
Day Care Center	Banayon			
Bolirao Elementary School	Bolirao			
Patoc Elementary School	Caanislagan			
Dagami South Central School	Cabariwan		Low	Medium
Sta. Mesa National High School	Cabariwan			
Day Care Center	Cabuloran			
Palacio Elementary School	Cabunga-An	Medium	Medium	Medium
Calutan Primary School	Calutan			
Day Care Center	Calutan			
Day Care Center	Cansamada East	Low	Low	Medium
Cansamada West Elementary School	Digahongan		Low	Medium
Hinulogan Elementary School	Guinarona	Low	Low	Low
Day Care Center	Hiabangan			
Hiabangan Elementary School	Hiabangan			
Day Care Center	Hilabago	Low	Medium	Medium
Day Care Center	Hitumnog			
Guinarona Elementary School	Lobe-Lobe East	Low	Low	Low
Guinarona National High School	Lobe-Lobe East			
Day Care Center	Los Martires	Low	High	High
Dagami North Central School	Lusad Poblacion		Medium	Medium
Cabuloran Elementary School	Maliwaliw			
Day Care Center	Maliwaliw			
Maliwaliw Elementary School	Maliwaliw	Low	Low	Low
Maragongdong Elementary School	Maragondong	Medium	Medium	Medium
Canlingga Elementary School	Palacio	Medium	Medium	Medium
Hitomnog Elementary School	Palacio		Low	Low

Day Care Center	Patoc			Low
Caloctogan Elementary School	Poponton	Medium	Medium	Medium
Day Care Center	Poponton	Medium	High	High
Dagami South Central School	Sampao East Poblacion	Low	Medium	Medium
St. Joseph High School - Dagami	San Jose Poblacion			
Day Care Center (New)	Santo Domingo	Low	Low	Low
Day Care Center (Old)	Santo Domingo		Low	Low
Patoc National High School	Santo Domingo	Low	Low	Low
Day Care Center	Sawahon			
Maragongdong Elementary School	Sawahon	Medium	Medium	Medium
St. Joseph High School - Dagami	Tunga Poblacion		Low	Medium

LEYTE				
PALO				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Anahaway Elementary School	Anahaway			
Anahaway National High School	Anahaway			
Cabarasan Daku Elementary School	Cabarasan Daku			
Day Care Center	Cabarasan Daku			
Cabarasan Guti Primary School	Cabarasan Guti			
Cangumbang Elementary School	Cangumbang		Medium	High
Day Care Center	Cangumbang	Low	Medium	High
Canhidoc Elementary School	Canhidoc			
Brgy. Castilla, Day Care Center	Castilla			
Castilla Elementary School	Castilla			
Palo National High School	Cavite West			Low
Capirawan Elementary School	Gacao		Low	Low
Day Care Center	Gacao			
Gacao Elementary School	Gacao	Low	Low	Medium
Day Care Center	Naga-Naga			
St. Mary Academy	Naga-Naga			
Naga-Naga Elementary School	Salvacion			
Day Care Center	San Agustin			
San Agustin Elementary School	San Agustin			Low
San Antonio Elementary School	San Antonio		Low	Low

Gacao Elementary School	San Isidro		Low	Low
Brgy. Tacuranga, Day Care Center	San Joaquin			Low
Day Care Center	San Joaquin		Medium	Medium
San Joaquin Central School	San Joaquin			
Tacuranga Elementary School	San Joaquin	Low	Low	Medium
St. Mary Academy	Santa Cruz			

LEYTE				
PASTRANA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Bahay Elementary School	Bahay			
Calipayan Elementary School	Bahay			
Day Care Center	Bahay			
Macalpiay Elementary School	Bahay	Low	Medium	Medium
Macalpiay National High School	Bahay		Medium	Medium
Sto. Domingo Primary School	Bahay	Low	Low	Low
Cabaohan Primary School	Cabaohan			
Day Care Center	Cabaohan			
Day Care Center	Caninoan	Low	Low	Low
Manaybanay National High School	Caninoan		Low	Low
Capilla Primary School	Capilla	Medium	Medium	Medium
Colawen Elementary School	Colawen			
Day Care Center	Colawen			
Lanawan Elementary School	Lanawan			
Lourdes Primary School	Macalpiay		Medium	Medium
Manaybanay National High School	Manaybanay			Low
Aringit Elementary School	Sapsap			
Day Care Center	Sapsap			
Sapsap Elementary School	Sapsap			Low
Day Care Center	Tingib		Low	Low
Tingib Elementary School	Tingib	Medium	Medium	High
Day Care Center	Yapad			
Yapad Elementary School	Yapad	Low	Medium	Medium

LEYTE				
TABONTABON				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Maghulod Elementary School	Belisong			
Capahuan Elementary School	Capahuan			
Guingawan Elementary School	Guingawan		Low	Medium
Belisong Primary School	Mercadohay	Low	Medium	Medium
Day Care Center	Mercadohay			
Jabong Elementary School	Mercadohay			
Piggery	Mercadohay	Low	Low	Low
Brgy. Maghulod Day Care Center	Mering	Low	Low	Low
Day Care Center	Mering			
Maghulod Elementary School	Mering			

LEYTE				
TANAUAN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Brgy. Camire Day Care Center	Balud		Low	Medium
Camire Elementary School	Balud			
Brgy. Bantagan Day Care Center	Bantagan			
Binongto-an Day Care Center	Binongto-An			
Binongto-an Primary School	Binongto-An			
Brgy. Sta. Elena Day Care Center	Binongto-An			
Sta. Elena Elementary School	Binongto-An		Low	Low
Assumption Academy	Buntay			
Brgy. Baras Day Care Center	Cabalagnan	Low	Low	Low
Brgy. Cabalagnan Day Care Center	Cabalagnan	Low	Low	Low
Cabalagnan Primary School	Cabalagnan		Low	Low
Brgy. Bangon Day Care Center	Calsadahay	Low	Low	Medium
Brgy. Muhon Day Care Center	Camire			Medium
Muhon Elementary School	Camire			Low
Eastern Visayas State University - Tanauan	Canramos			
Tanauan Central School	Canramos			
Tanauan School of Craftsmanship & Home Industries	Canramos			

Cahumayhumayan Elementary School	Catigbian			
Brgy. Guindagan Day Care Center	Guindag-An	Low	Medium	Medium
Guindagan Elementary School	Guindag-An	Low	Medium	Medium
Brgy. Catigbi-an Day Care Center	Maghulod			
Malaguicay Elementary School	Malaguicay		Medium	Medium
Brgy. Maribi Day Care Center	Maribi		Low	Low
Maribi Elementary School	Maribi		Medium	Medium
Eastern Visayas State University - Tanauan	Pago			Low
Brgy. Kiling Day Care Center	Salvador			
Brgy. Salvador Day Care Center	Salvador			
Kiling Elementary School	Salvador			
Kiling National High Schoo	Salvador			Low
Kiling National High School	Salvador			
Salvador Elementary School	Salvador			Low
Brgy. Sn. Isidro Day Care Center	San Isidro		Low	Medium
San Isidro Elementary School	San Isidro		Low	Low
San Roque Elementary School	San Roque			
Eastern Visayas State University - Tanauan	Santo Niño Poblacion			Low
International Christian Academy School	Santo Niño Poblacion			
Sto. Niño Elementary School	Santo Niño Poblacion		Low	Low
Sto.Niño de Tanauan School for Basic Education IN	Santo Niño Poblacion	Low	Low	Low
Tanauan II Central School	Santo Niño Poblacion			
Tanauan National High School	Santo Niño Poblacion	Low	Low	Low
Tanauan School of Craftsmanship & Home Industries	Santo Niño Poblacion	Low	Low	Low

Annex 13. Medical Institutions Affected in Binahaan Flood Plain

LEYTE				
DAGAMI				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Health Center	Balugo			
Brgy. Health Center	Caanislagan			
Guinarona Health Center	Lobe-Lobe East	Medium	Medium	Medium
Health Center	Los Martires		Medium	High
Dagami Rural Health Unit	Lusad Poblacion		Low	Medium
Brgy. Health Center	Maliwaliw			
Dagami RHU & TB DOTS Facility	Sampao East Poblacion	Low	Medium	Medium
Brgy. Health Center	Santo Domingo		Low	Low
Bud-Oy's Birthing Clinic	Sta. Mesa Poblacion	Low	Medium	Medium
Dagami RHU & TB DOTS Facility	Sta. Mesa Poblacion		Medium	Medium
St. Bernadeth Medical Clinic	Sta. Mesa Poblacion	Low	Medium	Medium
Dagami Rural Health Unit	Tunga Poblacion			Low

LEYTE				
PALO				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Brgy. Health Center	Anahaway		Low	Low
Brgy. Health Station	Anahaway			
Brgy. Health Center	Cabarasan Daku			
Cangumbang Health Center	Cangumbang	Low	Medium	High
Brgy. Health Center	Gacao			
Brgy. Health Center	San Agustin			
7th Angel Family Health Care & Maternity Clini	San Joaquin	Low	Low	Medium
Brgy. Health Center	San Joaquin			Low
Brgy. Tacuranga, Health Center	San Joaquin			
Canhidoc Health Center	San Joaquin			
Feeding Center	San Joaquin			Low
Brgy. Health Center	Tacuranga			

LEYTE				
PASTRANA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Brgy. Castilla, Health Center	Cabaohan			
Lanawan, Health Center	Caninoan			
Health Center	Tingib		Low	Medium

LEYTE				
TABONTABON				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Health Center	Guingawan			Medium
Brgy. Maghulod Health Center	Mering	Low	Low	Low

LEYTE				
TANAUAN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Brgy. Camire Health Center	Balud			
Brgy. Cabalagnan Health Center	Cabalagnan		Low	Low
Rural Health Unit	Canramos	Low	Low	Low
Verzosa Medical Clinic/ Optical Clinic	Canramos			
Brgy. Guindagan Health Center	Guindag-An	Low	Medium	Medium
Brgy. Salvador Birthing Clinic	Salvador		Low	Low
Rural Health Unit	San Roque			
Cumpio Midwife Clinic	Santo Niño Poblacion			