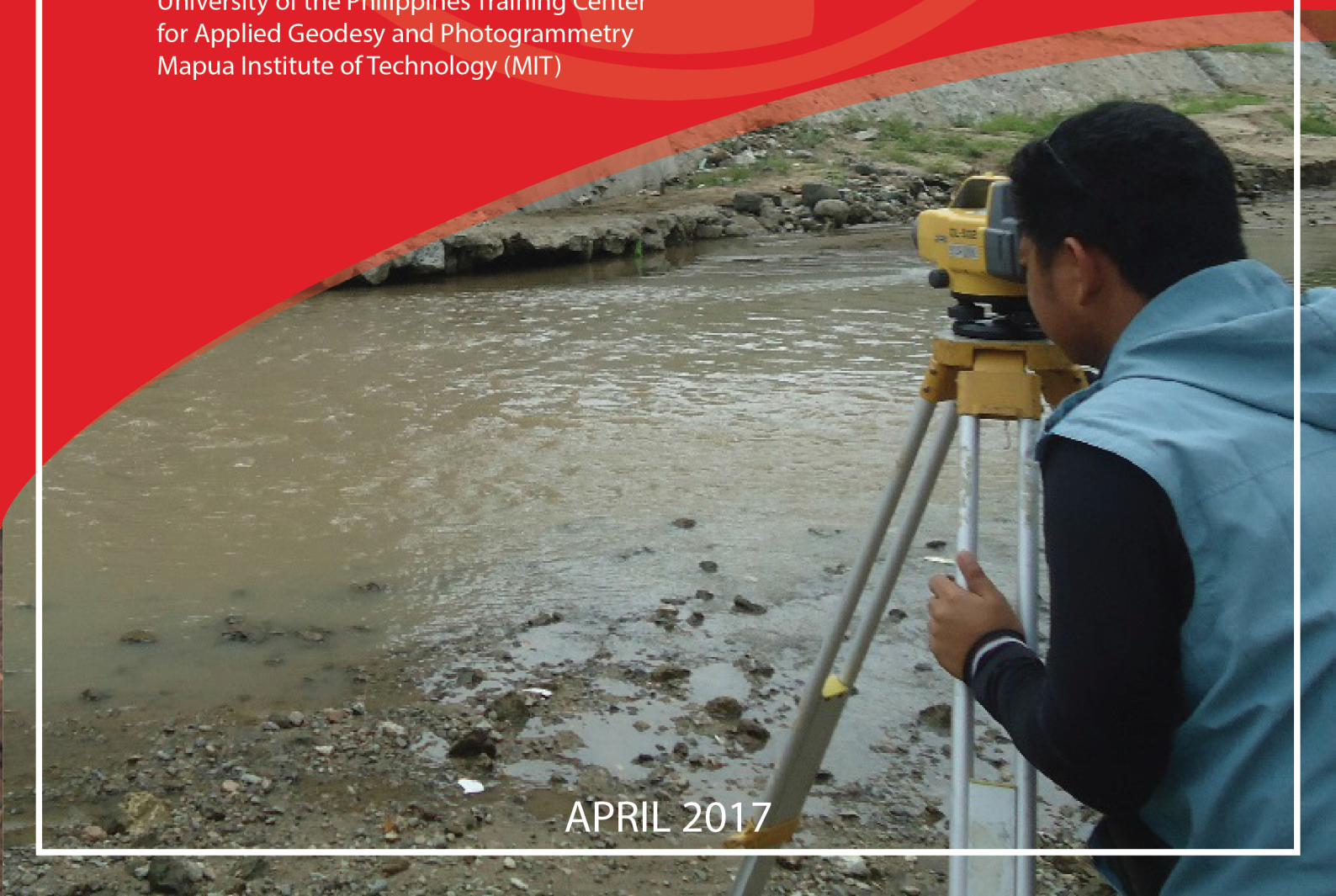
Hazard Mapping of the Philippines Using LIDAR (Phil-LIDAR 1)

LiDAR Surveys and Flood Mapping of Bolbok River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
Mapua Institute of Technology (MIT)



APRIL 2017

Published by the UP Training Center for Applied Geodesy and Photogrammetry (TCAGP)
College of Engineering
University of the Philippines – Diliman
Quezon City
1101 PHILIPPINES

This research project is supported by the Department of Science and Technology (DOST) as part of its Grants-in-Aid (GIA) Program and is to be cited as:

E. C. Paringit and F. A. Uy (eds.) (2017), LiDAR Surveys and Flood Mapping of Bolbok River, Quezon City: University of the Philippines Training Center on Applied Geodesy and Photogrammetry-260pp.

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National Library of the Philippines
ISBN: 978-621-430-044-0

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AAC	Asian Aerospace Corporation
Ab	abutment
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
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
UPB	University of the Philippines Baguio
UP-TCAGP	University of the Philippines – Training Center for Applied Geodesy and Photogrammetry
UTM	Universal Transverse Mercator
WGS	World Geodetic System

CHAPTER 1: OVERVIEW OF THE PROGRAM AND BOLBOK RIVER

Enrico C. Paringit, Dr. Eng., Dr. Francis Aldrine A. Uy, and Engr. Fibor Tan

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 entitled "Nationwide Hazard Mapping using LiDAR in 2014" or Phil-LiDAR 1, supported by the Department of Science and Technology (DOST) Grants-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 methods applied in this report are thoroughly described in a separate publication entitled "FLOOD MAPPING OF RIVERS IN THE PHILIPPINES USING AIRBORNE LIDAR: METHODS (Paringit, et. al. 2017) available separately.

The implementing partner university for the Phil-LiDAR 1 Program is the University of the Philippines Baguio (UPB). UPB 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 26 river basins in the Southern Tagalog Region. The university is located in the City of Manila in Metro Manila.

1.2 Overview of the Bolbok River Basin

The Bolbok River Basin is one of the major river networks in the province of Batangas. It transects both the municipalities of Rosario and San Juan. The Bolbok watershed mainly covers a portion of Rosario which extends to smaller area in San Juan, Batangas, where its outlet is located. The river basin helps immensely in the agricultural aspect of the nearby cities, along the river path, a number of suburbs, farms, and rice field are located that very much depend on the water supplied by the Bolbok river.

A reticent river like the Bolbok River with its narrow watershed looks and seems peaceful at first glance, but it is a site of occasional flash floods because it is a frequent pathway of severe typhoons. San Juan is often affected by flooding because of its downstream location. Even if higher banks were constructed to prevent an overflow of the river, it is still insufficient, because soil erosion still affects the banks of the river and destroys properties nearby. Many residents opted to move to safer areas in nearby cities, but some chose to stay, believing and trusting that a solution can be made by the government to prevent disastrous flood events from happening again.

In order to prevent or at least minimize the effects of the flooding hazard to the people and properties in the river basin, a combination of several technologies have been employed to produce flood hazard maps. The first is Light Detection And Ranging (LiDAR), which primarily contains elevation values . From these, one can infer the presence of waterbodies (such as rivers, streams, ponds, and lakes) and structures (such as roads, bridges, and buildings). Next, important data such as discharge and rainfall events gathered through fieldworks are used as input to hydrologic model to generate hydrographs. The generated outputs, along with LiDAR data, will then be input for the river hydraulic model. The final output for these processes will be flood hazard maps of the floodpalin which are expected to help the surrounding local government units

(LGUs) mitigate the effects of typhoons and heavy rains.

Bolbok River Basin covers portions of the Municipalities of San Juan, Rosario, Padre Garcia and Lipa City in Batangas and San Antonio in Quezon. It is one of the 421 river basins identified by the DENR River Basin Control Office (RBCO) in the Philippines. The drainage of Bolbok River has a total area of 105 km^2 with an estimated run-off of 168 million cubic meters (MCM).

Bolbok River, also known as Lawaye River, is located in the northern part of San Juan, Batangas. It is considered as one of the major rivers of San Juan, Batangas. Areas near the river are highly susceptible to flooding. During heavy rains, areas within the river get flooded for several hours with flood waters reaching a one (1) m height. On October 2012, the Municipality of San Juan underwent a state of calamity due to heavy rainfalls brought by Typhoon Ofel. The typhoon caused Bolbok River to rise that flooded 30 of the 42 barangays of San Juan.

CHAPTER 2: LIDAR DATA ACQUISITION OF THE BOLBOK FLOODPLAIN

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The methods applied in this chapter were based on the DREAM methods manual (Ang, 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 Bolbok Floodplain in CALABARZON. These missions were planned for 11 lines that run for at most four (4) hours including take-off, landing and turning time. The flight planning parameters for the LiDAR system is found in Table 1. Figure 1 shows the flight plan for Bolbok Floodplain.

Table 1. Flight planning parameters for Pegasus LiDAR System.

Block Name	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK 18Q	1000	30	50	200	30	130	5
BLK 18QR	1000	20	50	200	30	130	5
BLK 18O	1000	20	50	200	30	130	5
BLK 18S	1000	20	50	200	30	130	5
BLK 18TS	1000	15	50	200	30	130	5
BLK 18W	1000	30	50	200	30	130	5
BLK 18V	1000	30	50	200	30	130	5
BLK 18U	1000	30	50	200	30	130	5
BLK 18T	1000	30	50	200	30	130	5
BLK 18P	1000	30	50	200	30	130	5

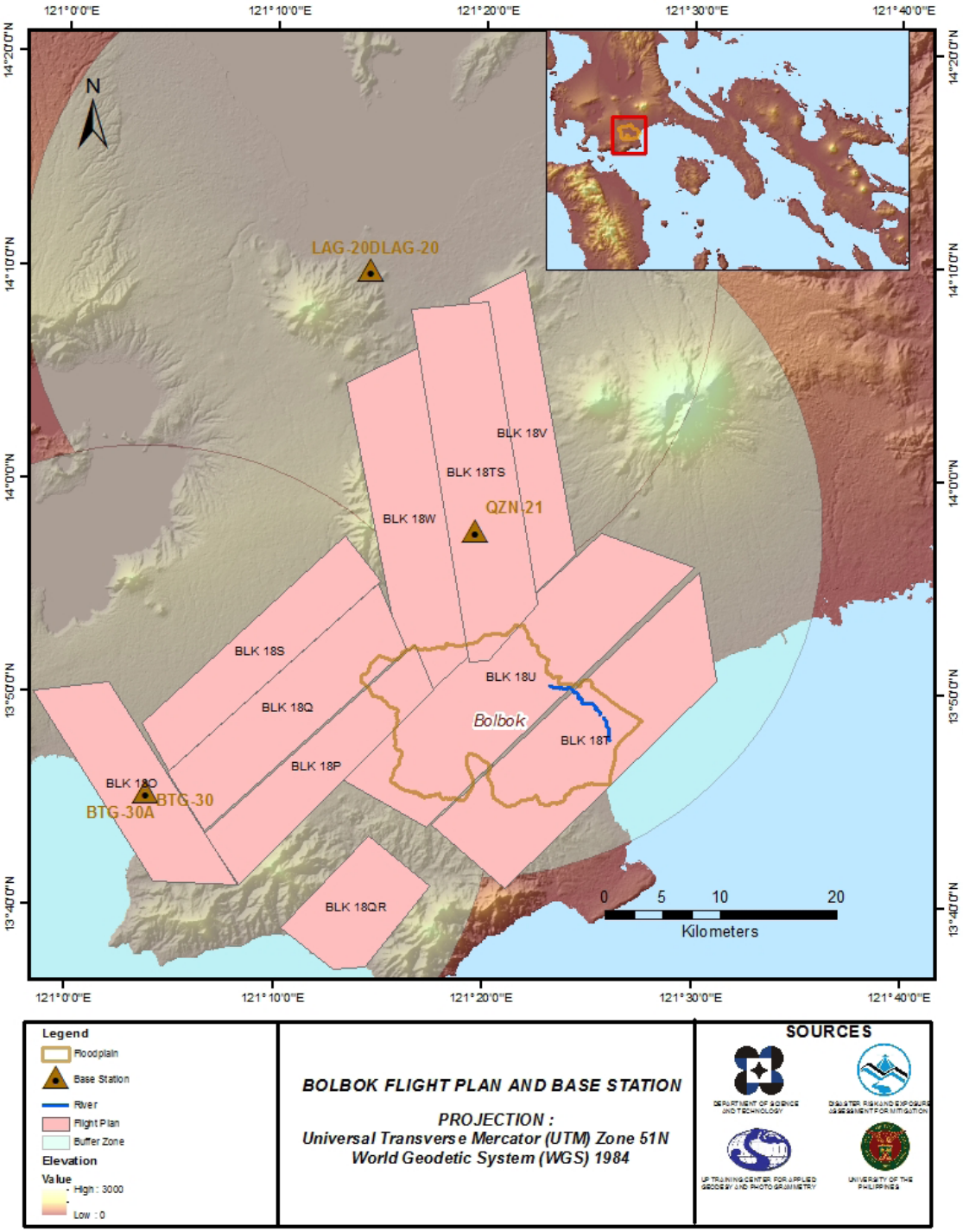

Figure 1. Flight plan and base stations used for Bolbok Floodplain.

2.2 Ground Base Stations

The project team was able to recover three (3) NAMRIA ground control points: BTG-30 and QZN-21 which are of second (2nd) order accuracy and LAG-20 which is of third (3rd) order accuracy. The project team also established two (2) ground control points LAG-20D and BTG-30A. The certifications for the NAMRIA reference points are found in Annex 2 while the baseline processing reports for the established ground control points are found in Annex 3. These were used as base stations during flight operations for the entire duration of the survey (February 10-14, 2014 and August 27-September 5, 2015). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852 and TRIMBLE SPS 882. Flight plans and location of base stations used during the aerial LiDAR acquisition in Bolbok floodplain are shown in

Figure 1.

Figure 2 to Figure 5 show the recovered NAMRIA reference points within the area. In addition, Table 2 to Table 6 show the details about the NAMRIA reference points while Table 7 shows the list of all ground control points occupied during the acquisition together with the dates the corresponding dates of utilization.

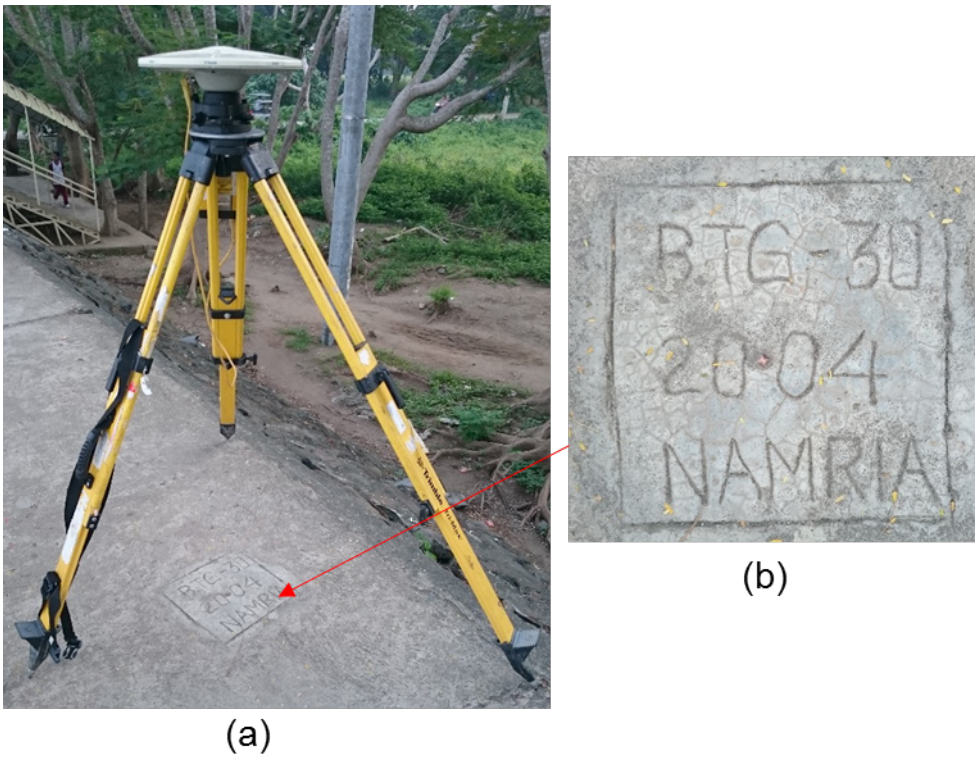

Figure 2. GPS set-up over BTG-30 in the vicinity of Brgy. Pallocan, Batangas City (a) and NAMRIA reference point BTG-30 (b) as recovered by the field team.

Table 2. Details of the recovered NAMRIA horizontal control point BTG-30 used as base station for the LiDAR Acquisition.

Station Name	BTG-30	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	13° 45’ 23.09640” North 121° 03’ 43.87175” East 21.056 meters
Grid Coordinates Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	506735.366 meters 1521220.652 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 45’17.88182” North 121° 03’ 48.83762” East 53.872 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS1992)	Easting Northing	290477.09 meters 1521536.18 meters

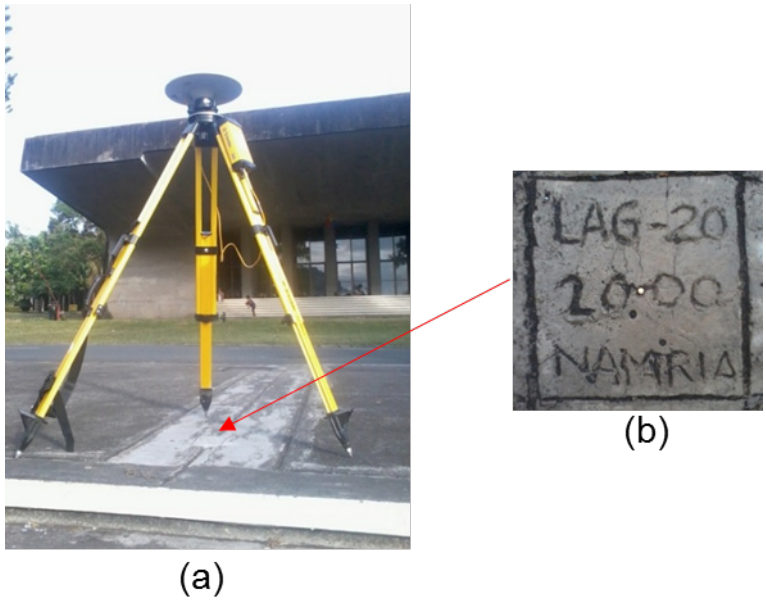

Figure 3. GPS set-up over LAG-20 near the freedom park in UP Los Baños (a) and NAMRIA reference point LAG-20 (b) as recovered by the field team.

Table 3. Details of the recovered NAMRIA horizontal control point LAG-20 used as base station for the LiDAR Acquisition.

Station Name	LAG-20	
Order of Accuracy	3rd	
Relative Error (horizontal positioning)	1:20,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	14° 9' 53.86904" North 121° 14' 20.35180" East 39.91400 meters
Grid Coordinates Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	525799.268 meters 1566435.481 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	14°9 '48.57270" North 121°14'25.28172"East 85.26600 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS1992)	Easting Northing	309934.22 meters 1566588.99 meters

Figure 4. LAG-20D as established inside the UP Los Baños compound near LAG-20.

Table 4. Details of the established control point with processed coordinates LAG-20D used as base station for the LiDAR Acquisition.

Station Name	LAG-20D	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	14° 9’ 53.86923” 121° 14’ 20.35184” 39.914 meters
Grid Coordinates Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	309934.222 meters 1566588.991 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	14° 9’ 48.57270” 121° 14’ 25.28172” 85.266 meters

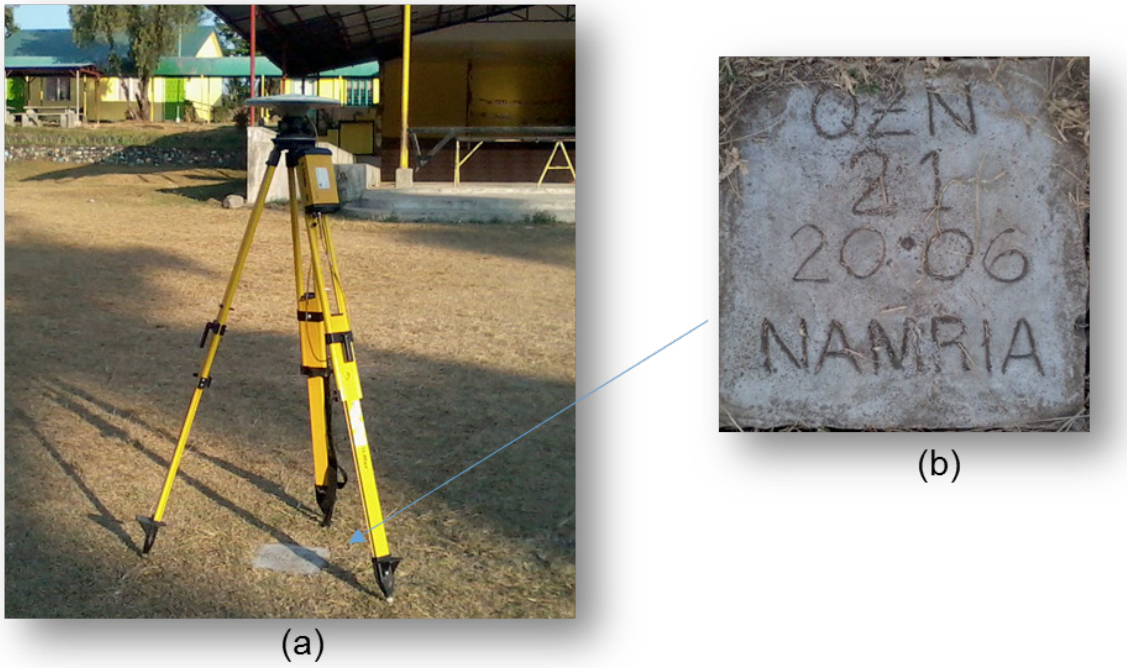

Figure 5. GPS set-up over QZN-21 inside Paaralang Elementarya ng Silangang Tiaong of Brgy. Poblacion III, Tiaong, Quezon Province (a) and NAMRIA reference point QZN-21 (b) as recovered by the field team.

Table 5. Details of the recovered NAMRIA horizontal control point QZN-21 used as base station for the LiDAR Acquisition.

Station Name	QZN-21	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	13° 57’ 44.31576” North 121° 19’ 27.34822” East 51.25800 meters
Grid Coordinates Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	535036.042 meters 1544027.063 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 57’ 39.07397” North 121° 19’ 32.29499” East 97.38200 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	318981.12 meters 1544101.56 meters

Table 6. Details of the established control point with processed coordinates BTG-30A used as base station for the LiDAR Acquisition.

Station Name	BTG-30A	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	13° 45’ 22.94284” 121° 3’ 43.84397” 7.898 meters
Grid Coordinates Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	290476.221 meters 1521531.468 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 45’ 17.72826” 121° 3’ 48.80985” 53.950 meters

Table 7. Ground control points used during LiDAR data acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
10 Feb 2014	1091P	1BLK18W41A	QZN-21
11 Feb 2014	1095P	1BLK18U42A	QZN-21
12 Feb 2014	1099P	1BLK18US43A	QZN-21
13 Feb 2014	1103P	1BLK18VWS44A	QZN-21
13 Feb 2014	1105P	1BLK18T44B	QZN-21
14 Feb 2014	1107P	1BLK18QRS45A	QZN-21
14 Feb 2014	1109P	1BLK18US45B	QZN-21
27 Aug 2015	3345P	1BLK18TS239A	LAG-20 and LAG-20D
27 Aug 2015	3347P	1BLK18TS239B	LAG-20 and LAG-20D
29 Aug 2015	3353P	1BLK18QRS241A	BTG-30 and BTG-30A
5 Sept 2015	3381P	1BLK18OS248A	BTG-30 and BTG-30A

2.3 Flight Missions

Eleven (11) missions were conducted to complete the LiDAR Data Acquisition in Bolbok Floodplain, for a total of thirty nine hours and forty two minutes (39+42) of flying time for RP-C9022. All missions were acquired using the Pegasus LiDAR system. Table 8 shows the total area of actual coverage and the corresponding flying hours per mission, while Table 9 presents the actual parameters used during the LiDAR data acquisition.

Table 8. Flight missions for LiDAR data acquisition in Bolbok floodplain.

Date Surveyed	Flight Number	Flight Plan Area (km2)	Surveyed Area (km2)	Area Surveyed within the Floodplain (km2)	Area Surveyed Outside Floodplain (km2)	No. of Images (Frames)	Flying Hours	
							Hr	Min
10 Feb 2014	1091P	338.52	243.78	18.67	225.11	512	3	49
11 Feb 2014	1095P	396.51	163.19	59.89	103.30	4	3	59
12 Feb 2014	1099P	396.51	222.93	76.36	146.57	3	3	53
13 Feb 2014	1103P	338.52	249.86	19.23	230.63	NA	3	44
13 Feb 2014	1105P	396.51	284.48	86.82	197.66	NA	3	36
14 Feb 2014	1107P	254.05	161.35	25.00	136.35	297	3	35
14 Feb 2014	1109P	396.51	189.47	74.43	115.04	NA	3	11
27 Aug 2015	3345P	367.7	199.87	9.04	190.83	NA	3	34
27 Aug 2015	3347P	367.7	106.5	0.27	106.23	NA	2	21
29 Aug 2015	3353P	367.7	171.88	48.03	123.85	NA	3	55
5 Sept 2015	3381P	497.6	200.92	46.28	154.64	NA	4	05
TOTAL		4117.83	2195.23	464.02	1729.21	816	39	42

Table 9. Actual parameters used during LiDAR data acquisition.

Flight Number	Flying Height (m AGL)	Overlap (%)	FOV (θ)	PRF (Hz)	Scan Frequency (kHz)	Average Speed (kts)	Average Turn Time (Minutes)
1091P	1000	30	50	200	30	130	5
1095P	1000	30	50	200	30	130	5
1103P	1000	30	50	200	30	130	5
1099P	1000	30	50	200	30	130	5
1105P	1000	30	50	200	30	130	5
1107P	1000	30	50	200	30	130	5
1109P	1000	30	50	200	30	130	5
3345P	1000	15	50	200	30	130	5
3347P	1000	15	50	200	30	130	5
3353P	1000	20	50	200	30	130	5
3381P	1000	20	50	200	30	130	5

2.4 Survey Coverage

Bolbok Floodplain is located along the provinces of Batangas, Laguna and Quezon with majority of the floodplain situated within the municipalities of Batangas. The municipality of Tiaong in Quezon and municipality of Rosario in Batangas were mostly covered during the LiDAR acquisition. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 10. The actual coverage of the LiDAR acquisition for Bolbok floodplain is presented in Figure 6.

Table 10. List of Municipalities/Cities Surveyed during Bolbok Floodplain LiDAR survey

Province	Municipality/City	Area of Municipality/ City (km2)	Total Area Surveyed(km2)	Percentage of Area Surveyed
Batangas	Rosario	197.03	178.00	90.34%
	San Juan	236.84	150.07	63.36%
	Padre Garcia	40.70	22.64	55.63%
	Lobo	199.87	101.72	50.89%
	Ibaaan	69.11	15.10	21.84%
	Batangas City	274.48	17.61	6.42%
	Lipa City	202.79	2.03	1.00%
Laguna	San Pablo City	180.93	158.32	87.51%
	Calauan	79.44	44.18	55.61%
	Alaminos	60.56	15.05	24.85%
	Calamba City	130.70	17.42	13.33%
	Bay	40.8	4.83	11.83%
	Cabuyao	45.70	5.05	11.04%
	Nagcarlan	81.20	8.50	10.47%
	Rizal	24.02	1.43	5.95%
Quezon	Tiaong	109.12	106.39	97.51%
	San Antonio	60.34	49.44	81.94%
	Candelaria	158.33	107.444	67.85%
	Sariaya	198.91	109.71	55.16%
	Dolores	61.28	26.10	42.58%
TOTAL		2452.15	1141.03	46.53%

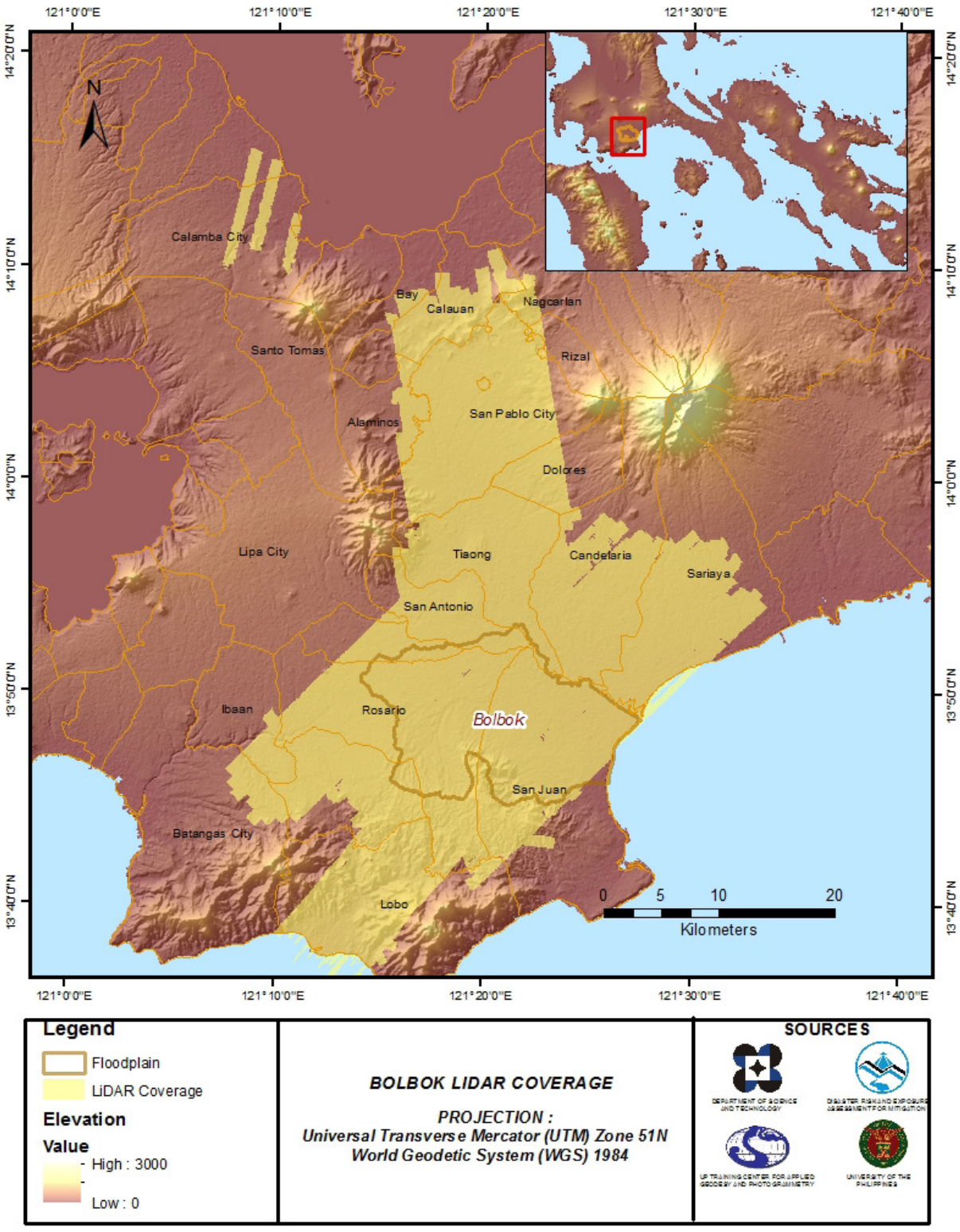

Figure 6. Actual LiDAR survey coverage for Bolbok floodplain.

CHAPTER 3: LIDAR DATA PROCESSING OF THE BOLBOK FLOODPLAIN

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

3.1 Overview of the LIDAR Data Pre-Processing

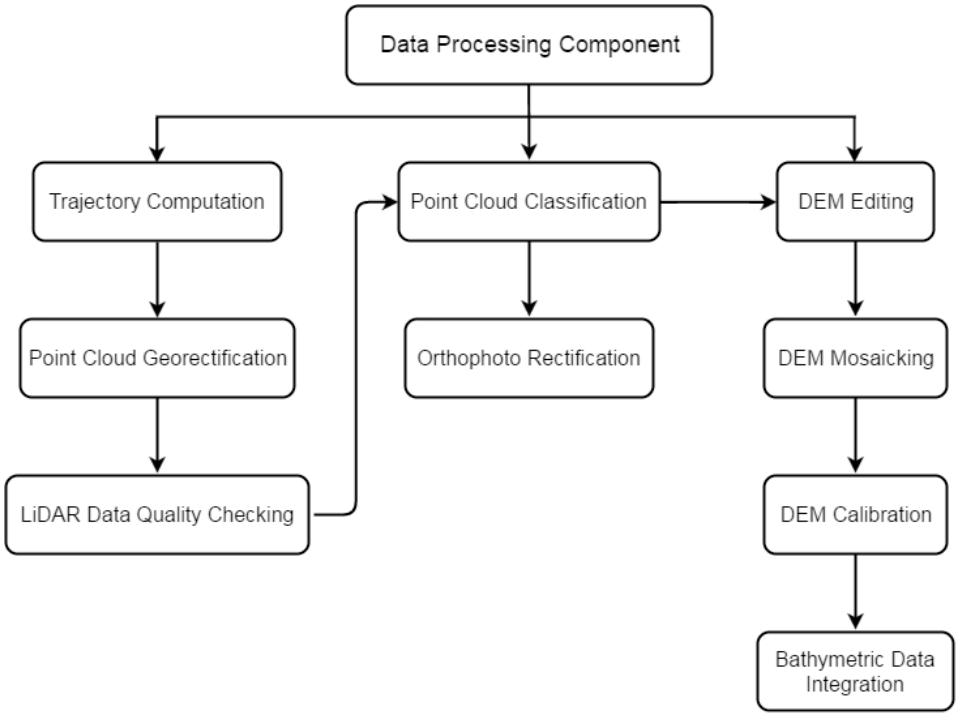


Figure 7. Schematic Diagram for Data Pre-Processing Component

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 7.

3.2 **Transmittal** of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Bolbok floodplain can be found in Annex 5. Missions flown for all surveys conducted on February 2014, October 2014 and August 2015 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system over Rosario, Batangas. The Data Acquisition Component (DAC) transferred a total of 209.26 Gigabytes of Range data, 2.31 Gigabytes of POS data, 116.59 Megabytes of GPS base station data, and 49.57 Gigabytes of raw image data to the data server on February 28, 2014 for the first survey and October 4, 2014 for the second survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Bolbok was fully transferred on September 11, 2015, as indicated on the Data Transfer Sheets for Bolbok floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 3345P, one of the Bolbok flights, which is the North, East, and Down position RMSE values are shown in Figure 8. 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 August 23, 2015 00:00AM. The y-axis is the RMSE value for that particular position.

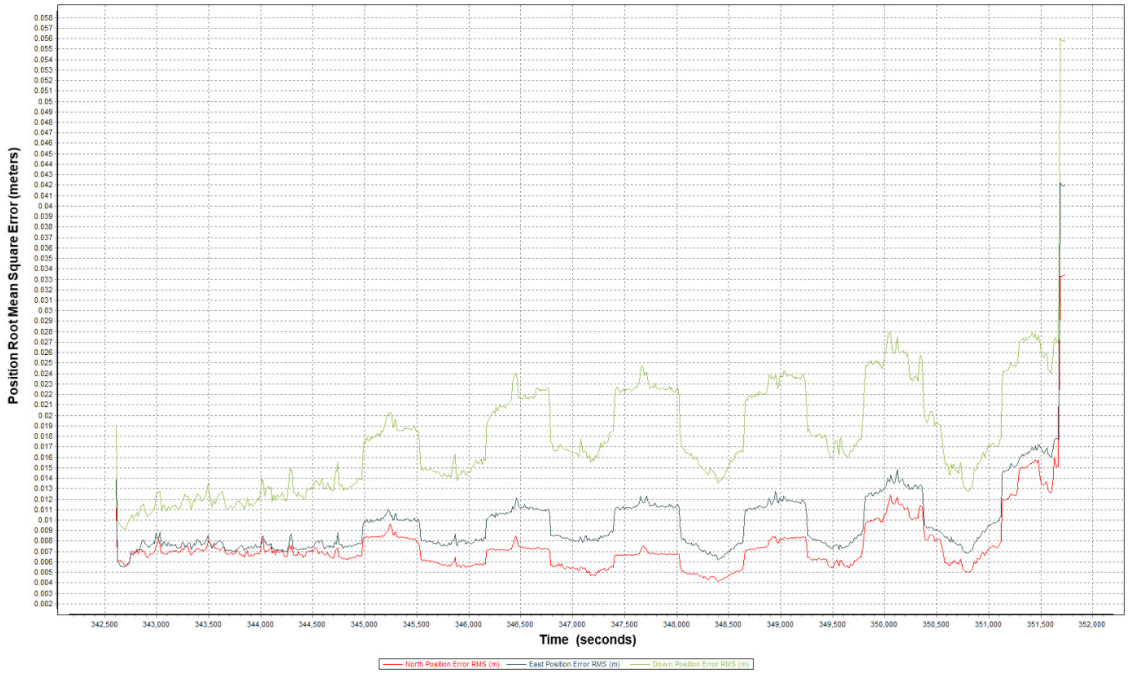


Figure 8. Smoothed Performance Metrics of a Bolbok Flight 3345P.

The time of flight was from 342500 seconds to 352000 seconds, which corresponds to afternoon of August 27, 2015. 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 8 shows that the North position RMSE peaks at 1.60 centimeters, the East position RMSE peaks at 1. 70 centimeters, and the Down position RMSE peaks at 2.80 centimeters, which are within the prescribed accuracies described in the methodology.

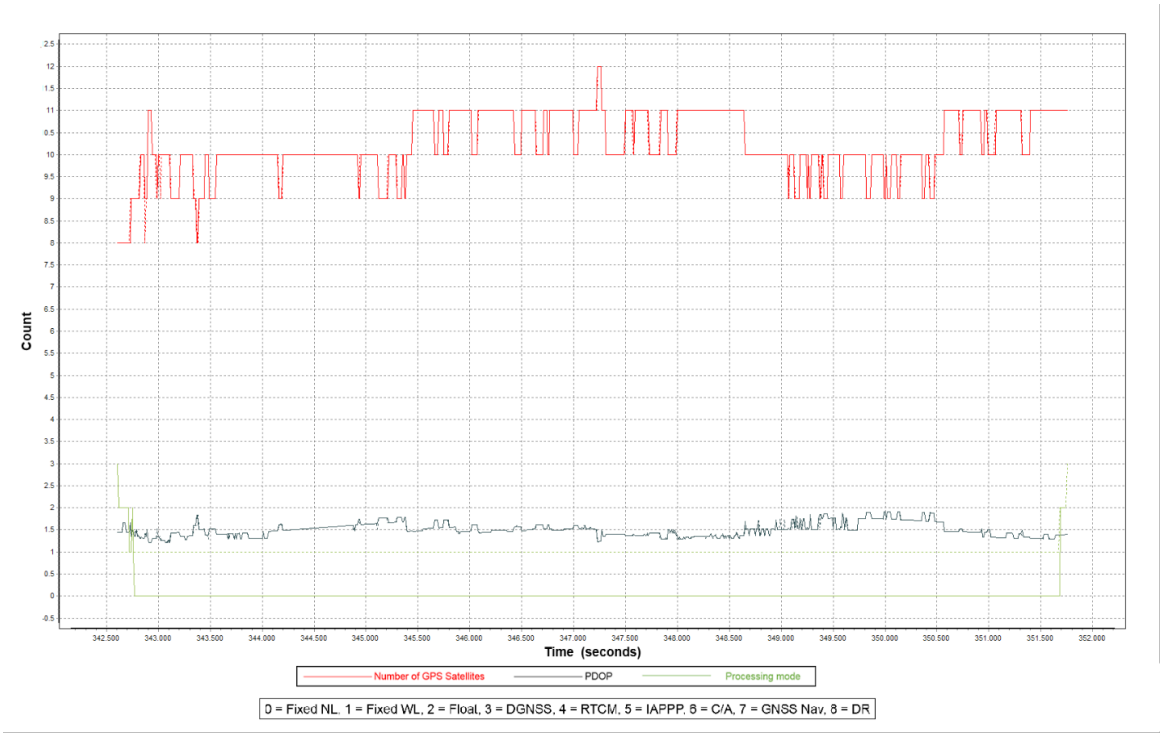


Figure 9. Solution Status Parameters of Bolbok Flight 3345P.

The Solution Status parameters of flight 3345P, one of the Bolbok flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 9. The graphs indicate that the number of satellites during the acquisition did not go down to 7. Majority of the time, the number of satellites tracked was between 8 and 12. The PDOP value also did not go above the value of 2, which indicates optimal GPS geometry. The processing mode stayed at the value of 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 Bolbok flights is shown in Figure 10.

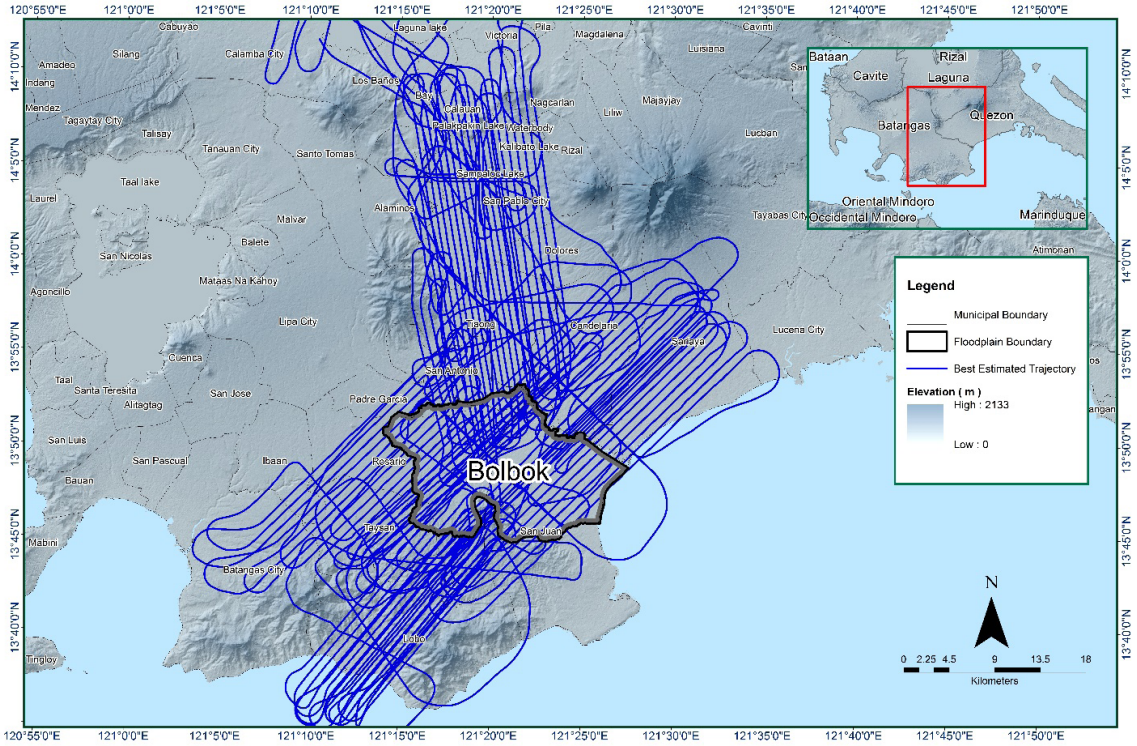


Figure 10. Best Estimated Trajectory for Bolbok floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 103 flight lines, with each flight line containing two channels, since the Pegasus system contain two channels. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Bolbok floodplain are given in Table 11.

Table 11. Self-Calibration Results values for Bolbok flights.

Parameter	Absolute Value	Computed Value
Boresight Correction stdev	(<0.001degrees)	0.000210
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.000570
GPS Position Z-correction stdev	(<0.01meters)	0.0017

The optimum accuracy is obtained for all Bolbok 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 Quality Checking

The boundary of the processed LiDAR data on top of a SAR Elevation Data over Bolbok Floodplain is shown in Figure 11. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

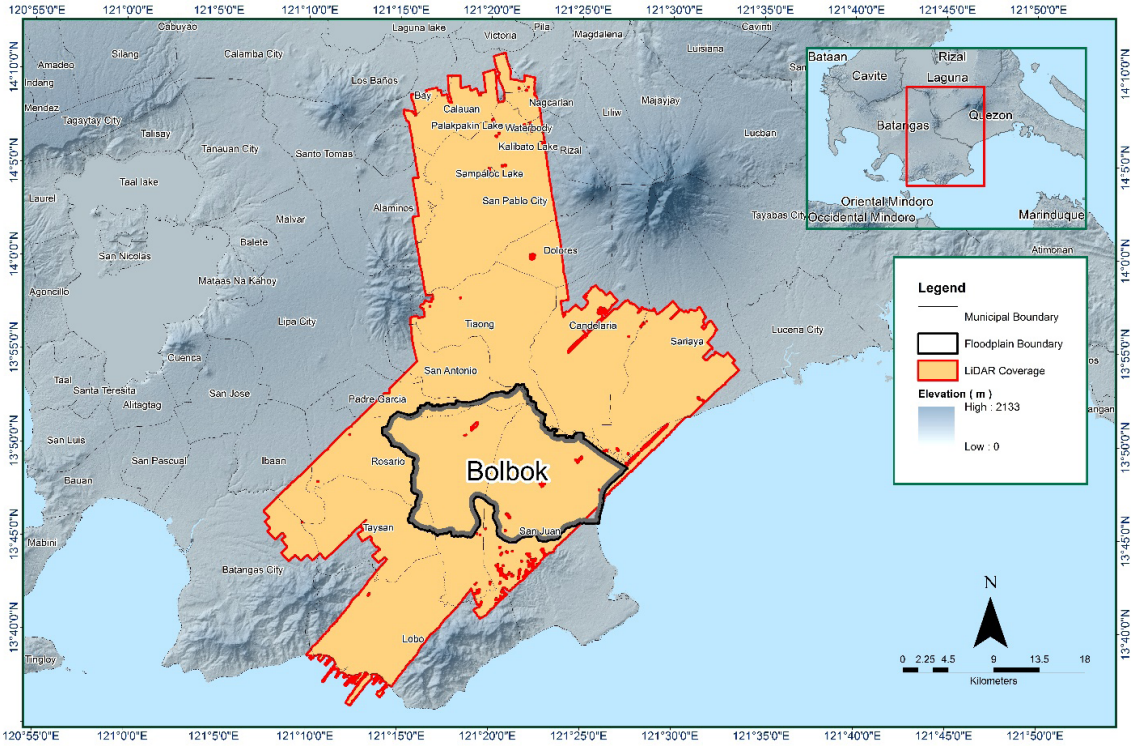


Figure 11. Boundary of the processed LiDAR data over Bolbok Floodplain

The total area covered by the Bolbok missions is 1964.69 sq.km that is comprised of eleven (11) flight acquisitions grouped and merged into ten (10) blocks as shown in Table 12.

Table 12. List of LiDAR blocks for Bolbok floodplain.

LiDAR Blocks	Flight Numbers	Area (sq. km)
CALABARZON_Blk18U_additional	3353P	121.54
CALABARZON_Blk18U_additional2	3353P	54.48
CALABARZON_Blk18U_supplement	3381P	181.43
CALABARZON_Blk18W_additional	3345P 3347P	258.51
Laguna_Blk18T	1105P	265.65
Laguna_Blk18U_supplement	1109P	179.72
Laguna_Blk18U	1095P 1099P	269.98
Laguna_Blk18VW_supplement	1103P	232.87
Laguna_Blk18W	1091P	241.90
Batangas_Blk18QR_supplement1	1107P	158.61
TOTAL		1964.69 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 12. Since the Pegasus system employs two channels, we would expect an average value of 2 (blue) for areas where there is limited overlap, and a value of 3 (yellow) or more (red) for areas with three or more overlapping flight lines.

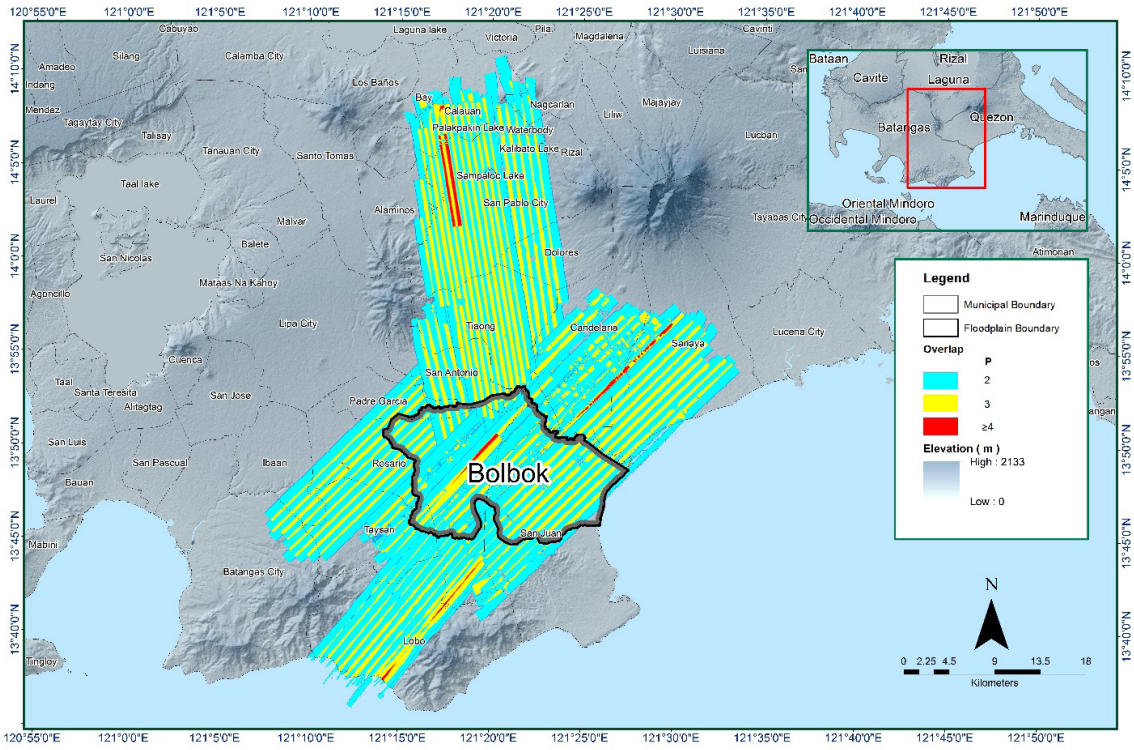


Figure 12. Image of data overlap for Bolbok floodplain.

The overlap statistics per block for the Bolbok 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 28.71% and 51.19% respectively, which passed the 25% requirement.

The pulse 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 13. It was determined that all LiDAR data for Bolbok floodplain satisfy the point density requirement, and the average density for the entire survey area is 2.41 points per square meter.

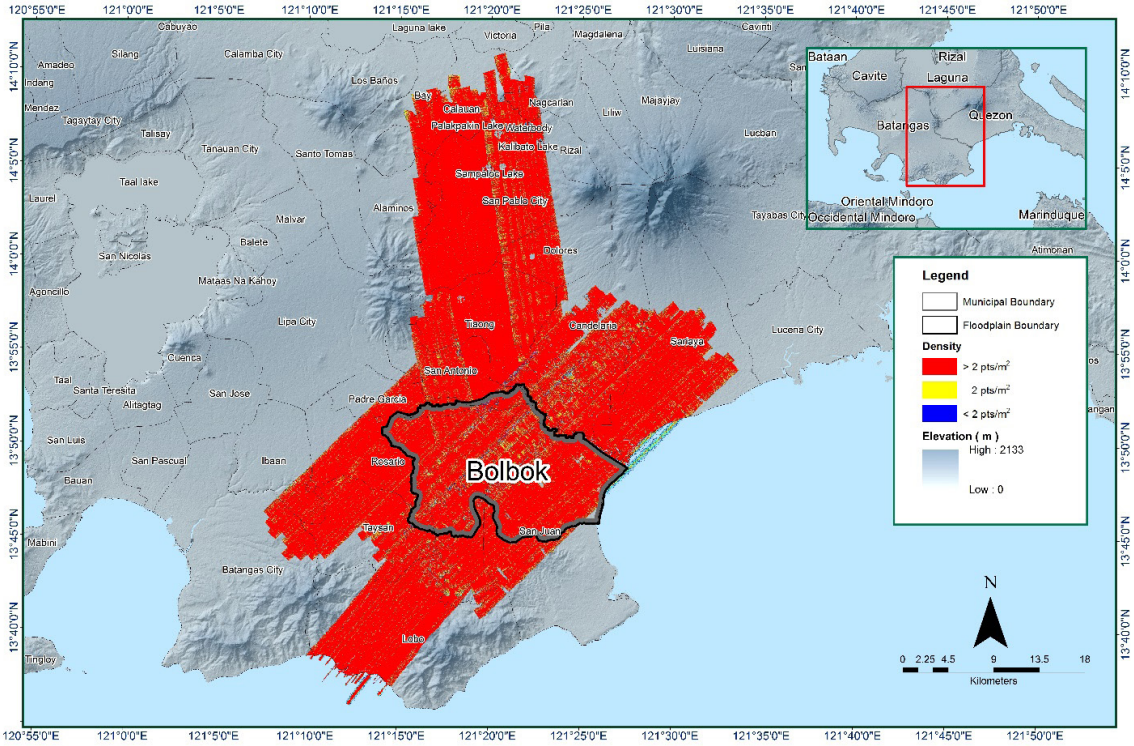


Figure 13. Pulse density map of merged LiDAR data for Bolbok floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 14. 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.

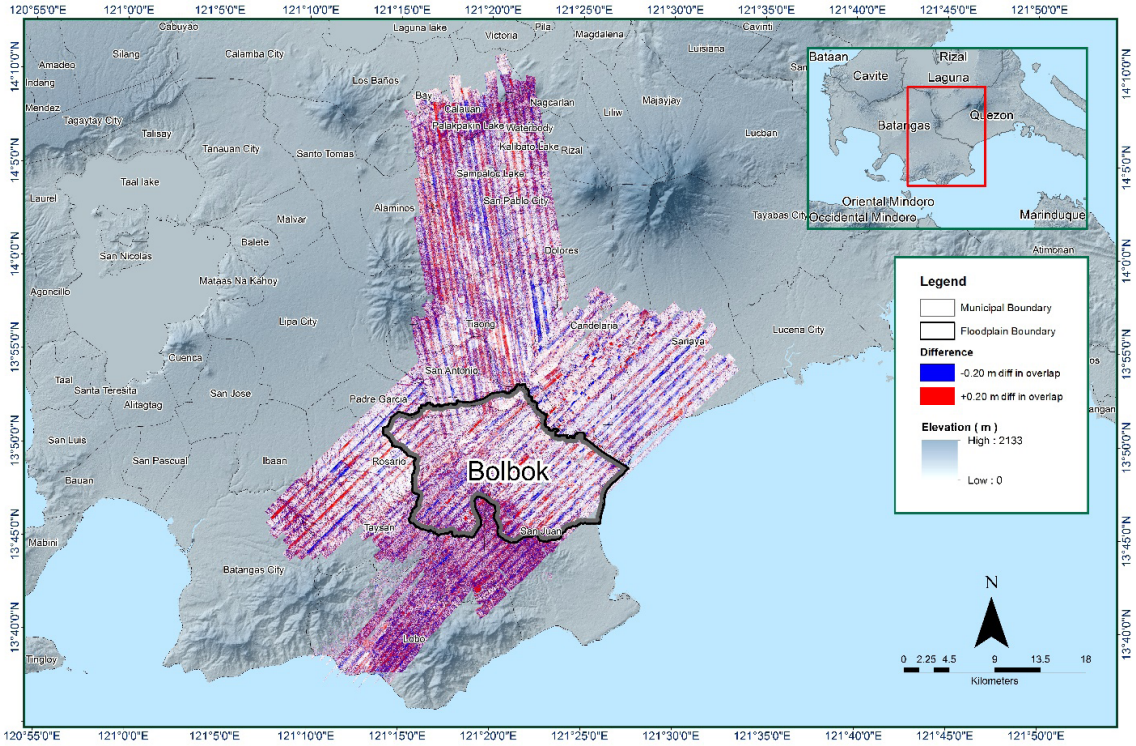


Figure 14. Elevation difference map between flight lines for Bolbok floodplain.

A screen capture of the processed LAS data from a Bolbok flight 3345P loaded in QT Modeler is shown in Figure 15. 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.

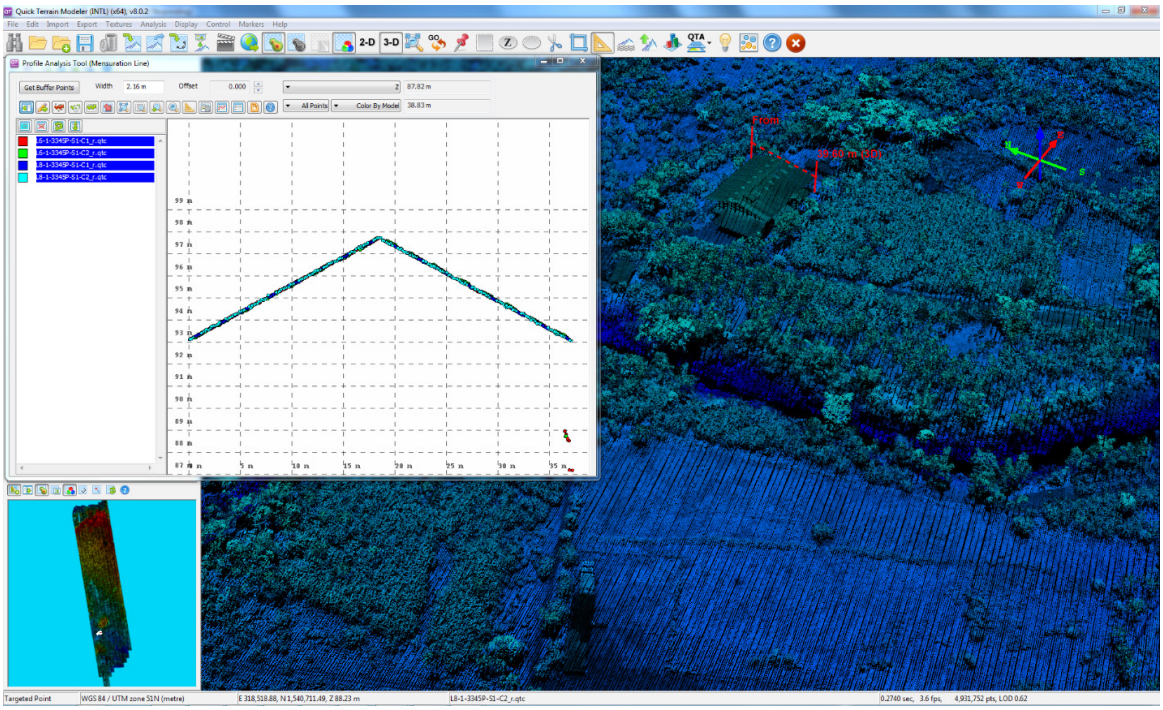


Figure 15. ***Quality checking for a Bolbok flight 3345P using the Profile Tool of QT Modeler.***

3.6 LiDAR Point Cloud Classification and Rasterization

Table 13. Bolbok classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	1,548,871,836
Low Vegetation	1,442,696,585
Medium Vegetation	1,688,489,159
High Vegetation	2,385,761,793
Building	153,375,548

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Bolbok floodplain is shown in Figure 16. A total of 2,662 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 13. The point cloud has a maximum and minimum height of 749.60 meters and 33.16 meters respectively.

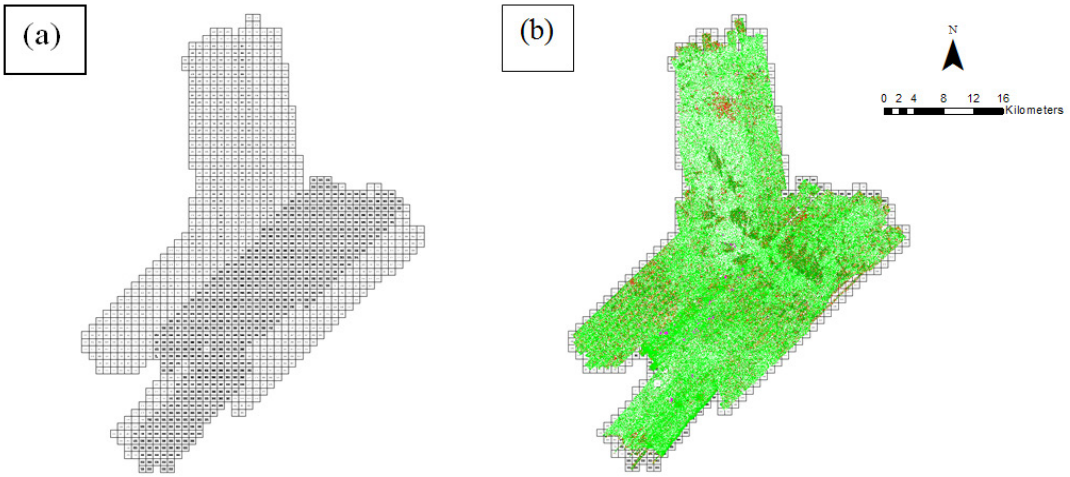


Figure 16. Tiles for Bolbok floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 17. 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.

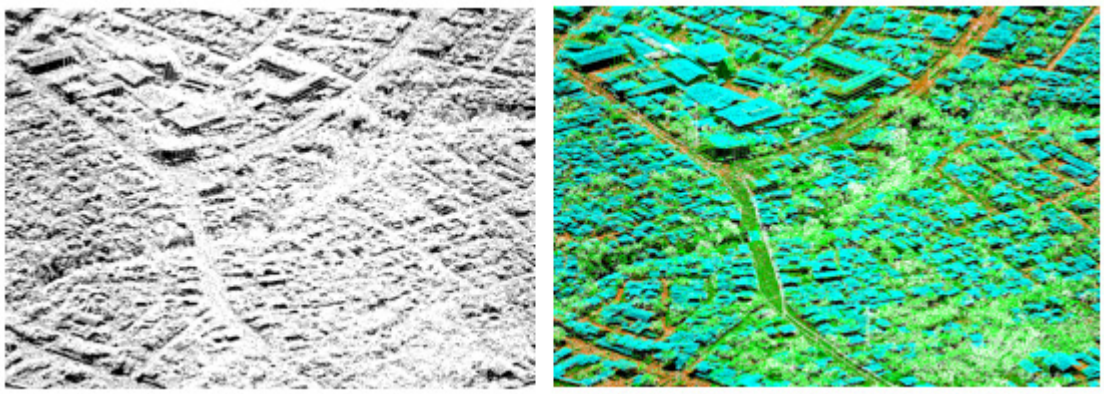


Figure 17. Point cloud before (a) and after (b) classification.

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 18. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

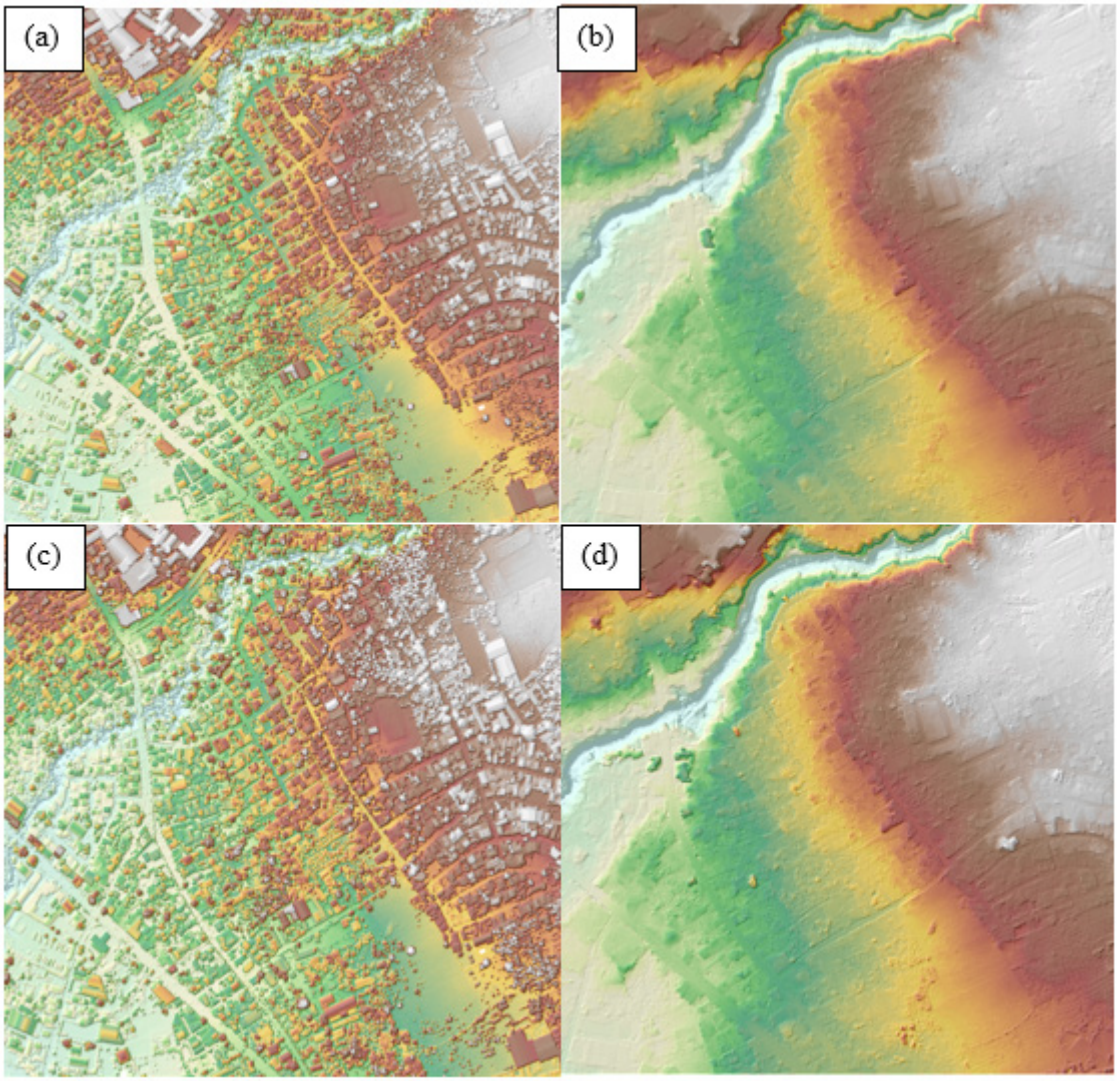


Figure 18. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Bolbok floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 573 1km by 1km tiles area covering the Bolbok floodplain is shown in Figure 19. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The block covering the Bolbok floodplain has a total of 377.65 sq.km orthophotogaph coverage comprised of 751 images. However, the block does not have a complete set of orthophotographs and no orthophotographs cover the area of the Bolbok floodplain. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 20.

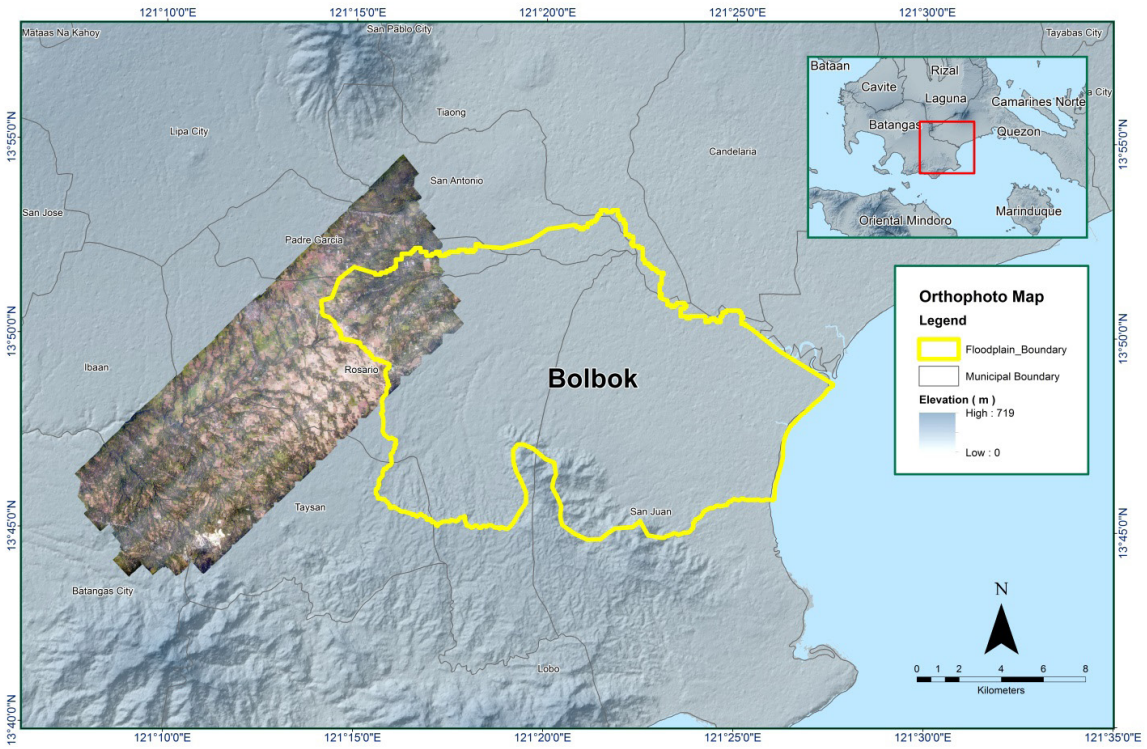


Figure 19. Bolbok floodplain with available orthophotographs.

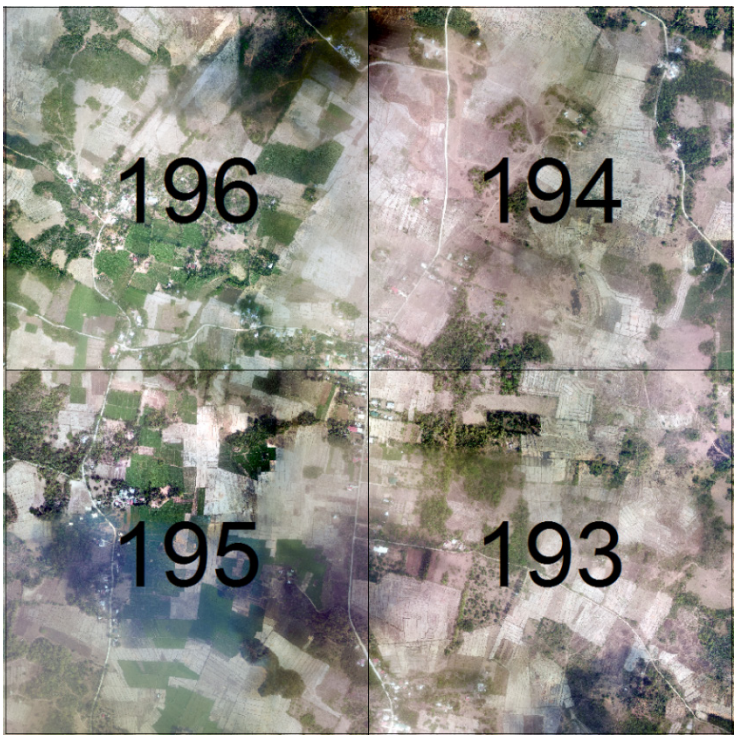


Figure 20. Sample orthophotograph tiles for Bolbok floodplain.

3.8 DEM Editing and Hydro-Correction

Ten (10) mission blocks were processed for Bolbok flood plain. These blocks are composed of CALABARZON, Batangas and Laguna blocks with a total area of 1,964.69 square kilometers. Table 14 shows the name and corresponding area of each block in square kilometers.

Table 14. LiDAR blocks with its corresponding area.

LiDAR Blocks	Area (sq.km)
CALABARZON_Blk18U_additional	121.54
CALABARZON_Blk18U_additional2	54.48
CALABARZON_Blk18U_supplement	181.43
CALABARZON_Blk18W_additional	258.51
Laguna_Blk18T	265.65
Laguna_Blk18U_supplement	179.72
Laguna_Blk18U	269.98
Laguna_Blk18VW_supplement	232.87
Laguna_Blk18W	241.90
Batangas_Blk18QR_supplement1	158.61
TOTAL	1964.69 sq.km

Portions of DTM before and after manual editing are shown in Figure 21. The bridge (Figure 21a) is also considered to be an impedance to the flow of water along the river and has to be removed (Figure 21b) in order to hydrologically correct the river. The paddy field (Figure 21c) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 21d) to allow the correct flow of water.

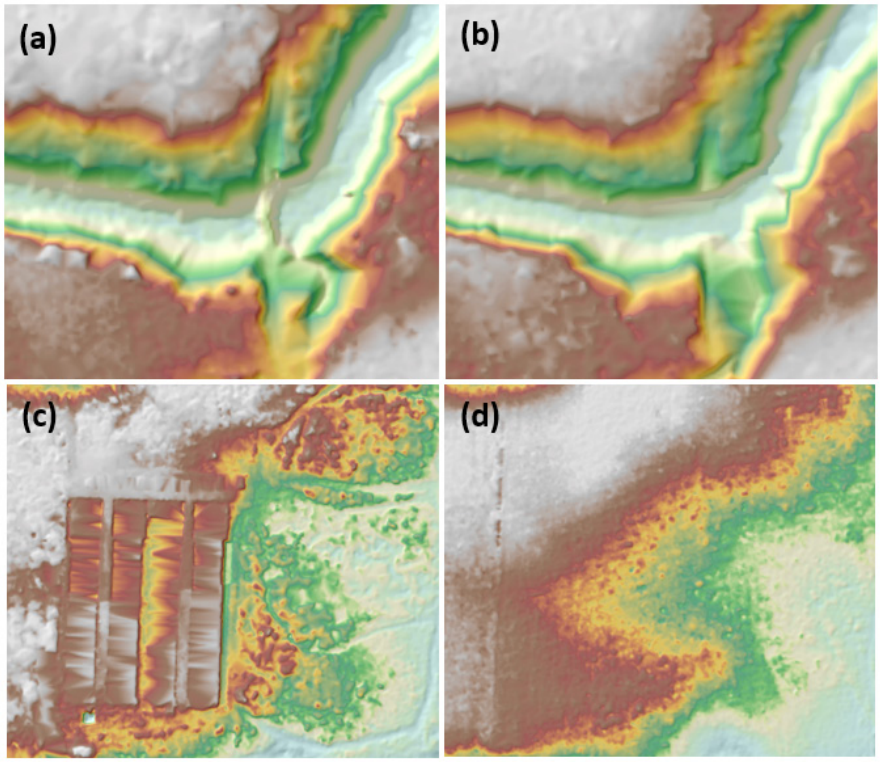


Figure 21. Portions in the DTM of Bolbok floodplain – a bridge before (a) and after (b) manual editing; a paddy field before (c) and after (d) data retrieval; and a building before (e) and after (f) manual editing.

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 15 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Bolbok floodplain is shown in Figure 22. It can be seen that the entire Bolbok floodplain is 99.38% covered by LiDAR data.

Table 15. Shift Values of each LiDAR Block of Bolbok floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
CALABARZON_Blk18U_additional	0.00	0.00	0.00
CALABARZON_Blk18U_additional2	0.00	0.00	0.00
CALABARZON_Blk18U_supplement	0.00	0.00	0.00
CALABARZON_Blk18W_additional	0.00	0.00	0.50
Laguna_Blk18T	0.00	0.00	-0.15
Laguna_Blk18U_supplement	0.00	0.00	0.00
Laguna_Blk18U	0.00	0.00	-0.19
Laguna_Blk18VW_supplement	0.00	0.00	-0.27
Laguna_Blk18W	0.00	0.00	0.00
Batangas_Blk18QR_supplement1	0.00	0.00	-0.12

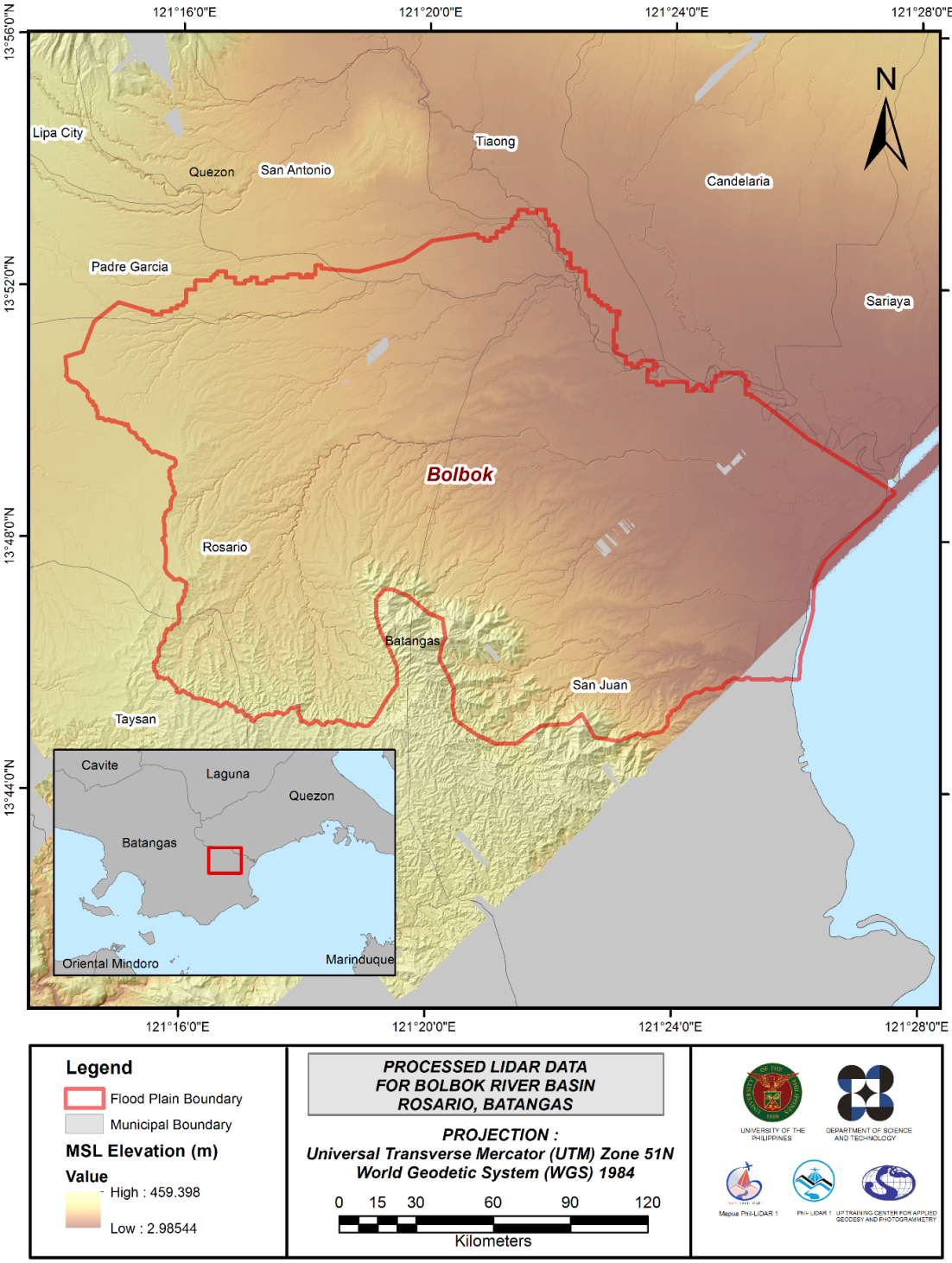


Figure 22. Map of Processed LiDAR Data for Bolbok Flood Plain.

3.10 Calibration and Validation of Mosaicked LiDAR DEM

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Bolbok to collect points with which the LiDAR dataset is validated is shown in Figure 23. A total of 24,251 survey points were gathered for all the flood plains within the provinces of CALABARZON wherein the Bolbok floodplain is located. Random selection of 80% of the survey points, resulting to 19,401 points, was used for calibration. Calibration of Bolbok LiDAR data was done by subtracting the height difference value, 3.08 meters, to Bolbok mosaicked LiDAR data. Table 16 shows the statistical values of the compared elevation values between LiDAR data and calibration data.

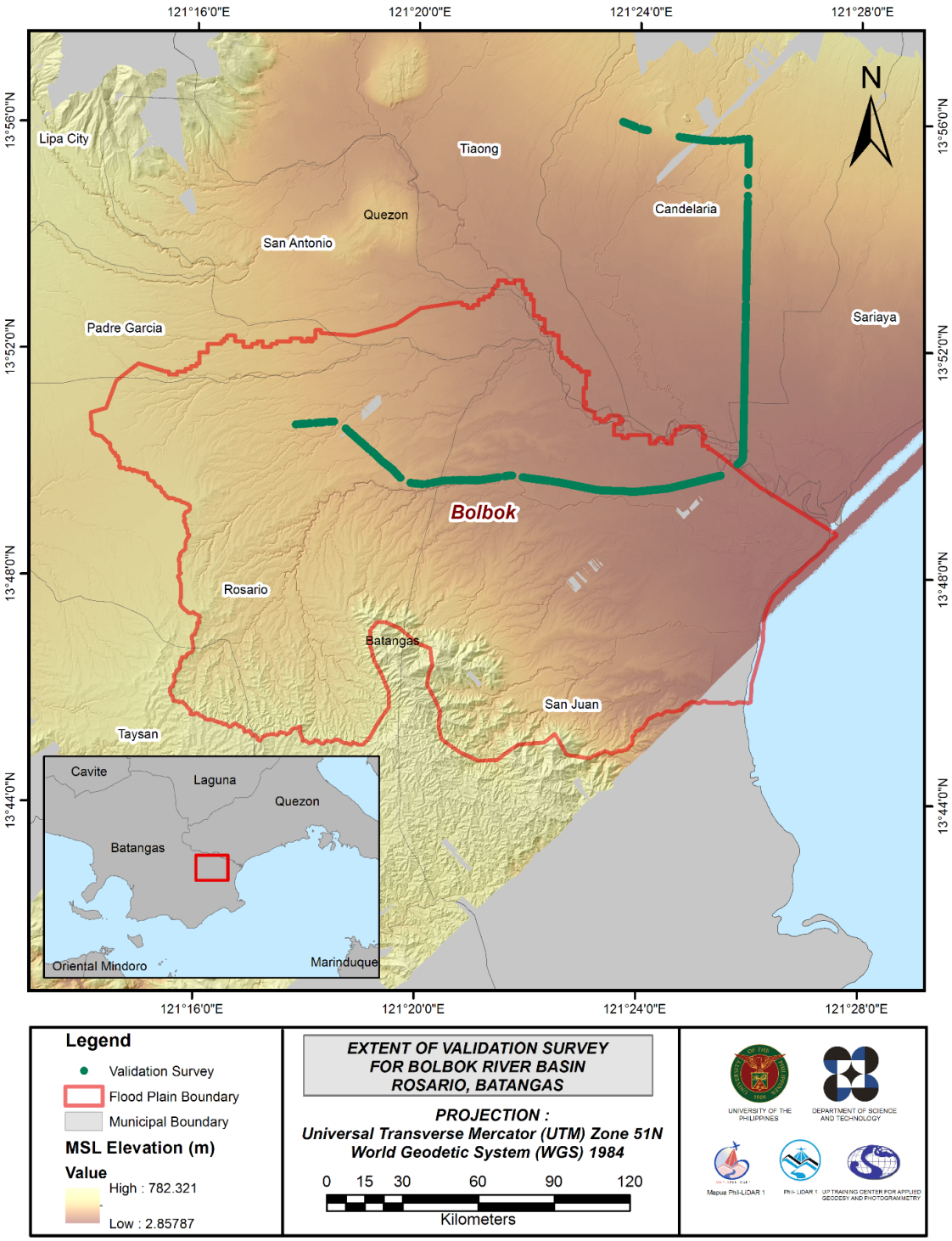


Figure 23. Map of Bolbok Flood Plain with validation survey points in green.

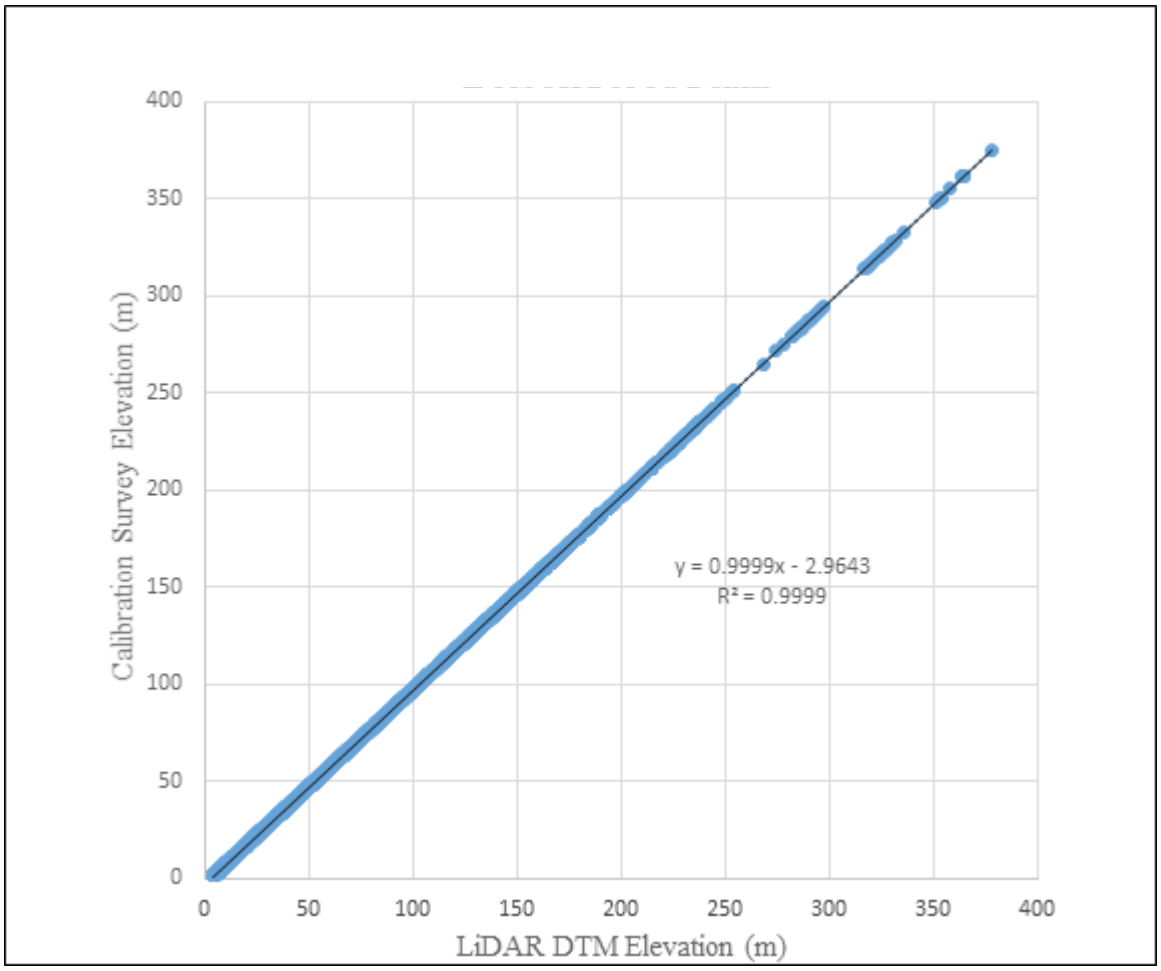


Figure 24. Correlation plot between calibration survey points and LiDAR data.

Table 16. Calibration Statistical Measures.

Calibration Statistical Measures	Value (meters)
Height Difference	2.97
Standard Deviation	0.20
Average	-2.97
Minimum	-3.48
Maximum	-2.40

The remaining 20% of the total survey points were intersected to the flood plain, resulting to 257 points, were used for the validation of calibrated Bolbok 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 25. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.14 meters with a standard deviation of 0.09 meters, as shown in Table 17.

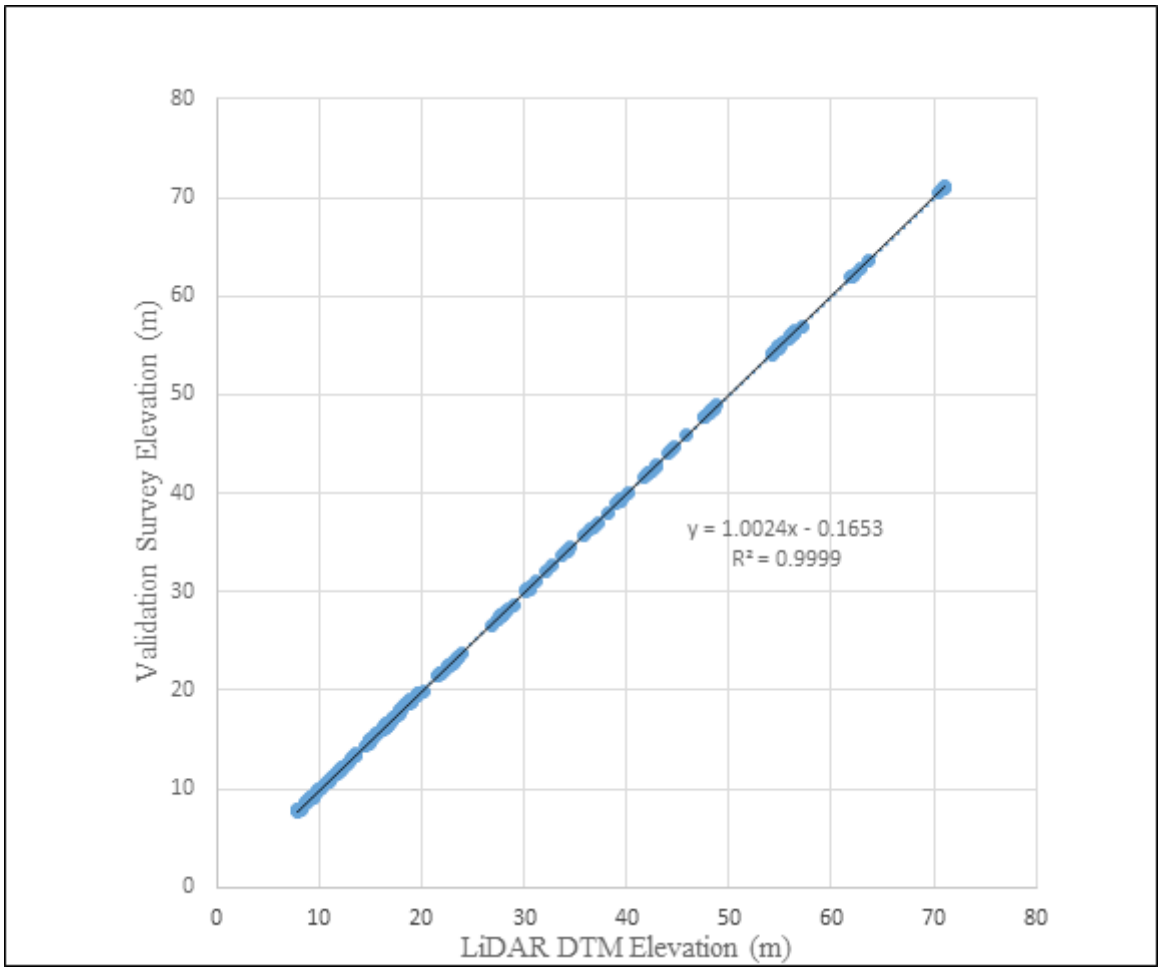


Figure 25. Correlation plot between validation survey points and LiDAR data.

Table 17. Validation Statistical Measures.

Validation Statistical Measures	Value (meters)
RMSE	0.14
Standard Deviation	0.09
Average	-0.10
Minimum	-0.37
Maximum	0.17

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, only centerline data was available for Bolbok with 14,717 bathymetric survey points. The resulting raster surface produced was done by Inverse Distance Weighted (IDW) interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.25 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Bolbok integrated with the processed LiDAR DEM is shown in Figure 26.

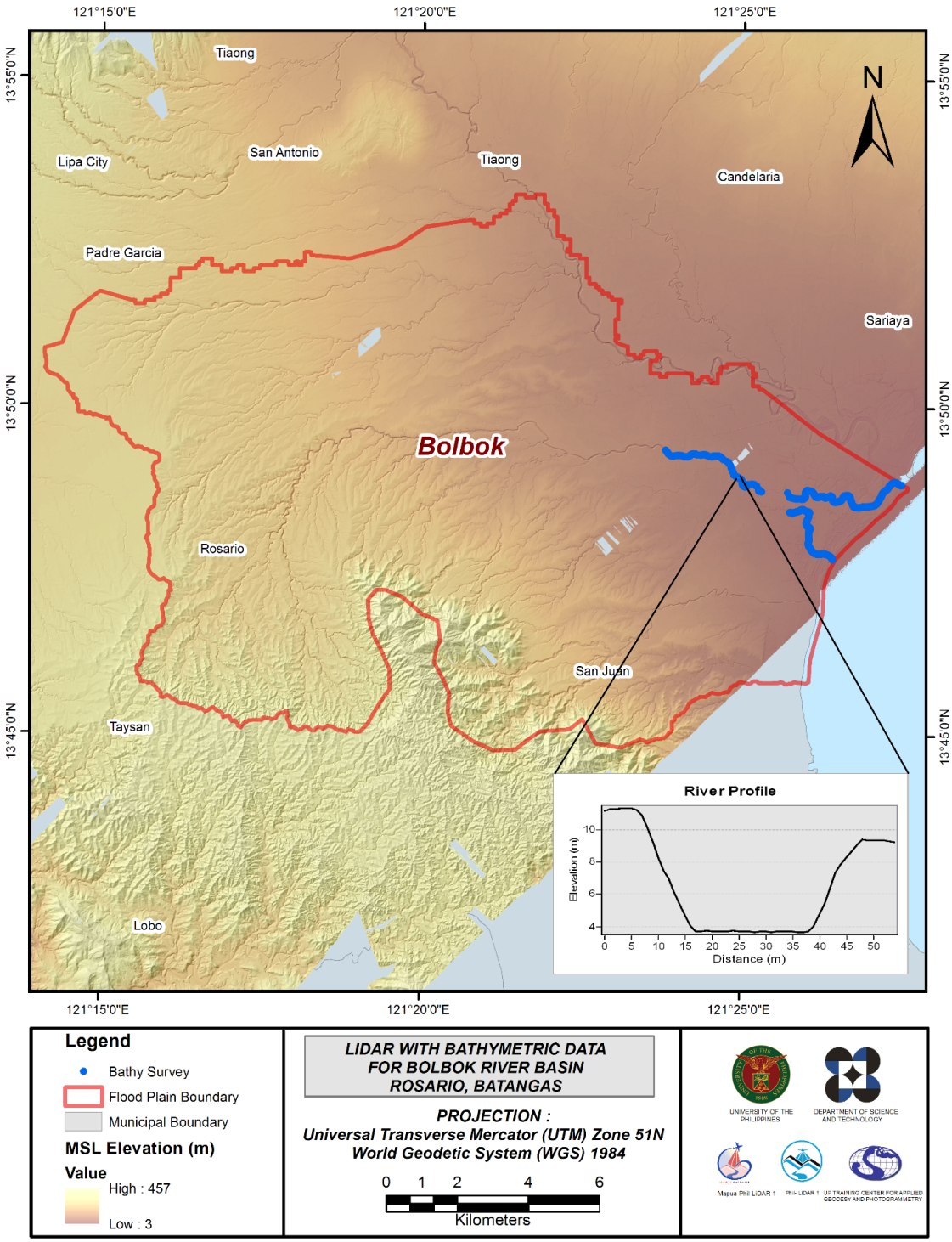


Figure 26. Map of Bolbok Flood Plain with bathymetric survey points shown in blue.

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 (QC) of Digitized Features' Boundary

Bolbok floodplain, including its 200 m buffer, has a total area of 251.70 sq km. For this area, a total of 8.0 sq km, corresponding to a total of 1,884 building features, are considered for QC. Figure 27 shows the QC blocks for Bolbok floodplain.

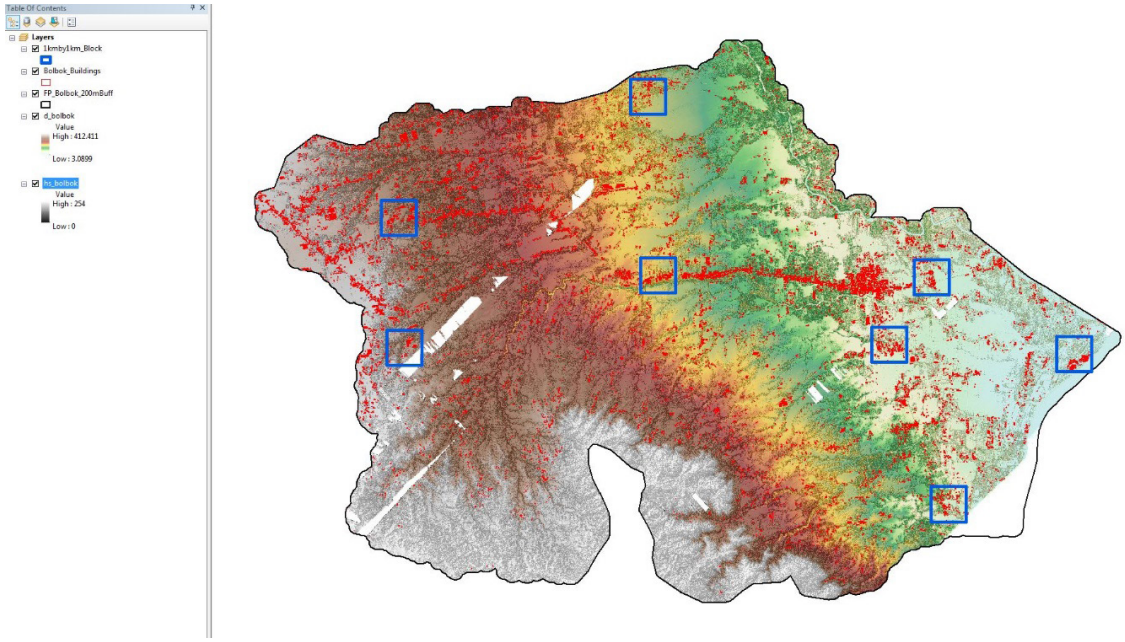


Figure 27. QC blocks for Bolbok building features.

Quality checking of Bolbok building features resulted in the ratings shown in Table 18.

Table 18. Quality Checking Ratings for Bolbok Building Features.

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Bolbok	98.49	100.00	97.20	PASSED

3.12.2 Height Extraction

Height extraction was done for 27,958 building features in Bolbok floodplain. Of these building features, 1,605 was filtered out after height extraction, resulting to 26,353 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 10.37 m.

3.12.3 Feature Attribution

The attributes were obtained by field data gathering. GPS devices were used to determine the coordinates of important features. These points are uploaded and overlaid in ArcMap and are then integrated with the shapefiles.

Table 19 summarizes the number of building features per type. On the other hand, Table 20 shows the total length of each road type, while Table 21 shows the number of water features extracted per type.

Table 19. Building Features Extracted for Bolbok Floodplain.

Facility Type	No. of Features
Residential	25583
School	353
Market	11
Agricultural/Agro-Industrial Facilities	58
Medical Institutions	20
Barangay Hall	31
Military Institution	0
Sports Center/Gymnasium/Covered Court	7
Telecommunication Facilities	0
Transport Terminal	1
Warehouse	61
Power Plant/Substation	0
NGO/CSO Offices	0
Police Station	2
Water Supply/Sewerage	2
Religious Institutions	45
Bank	7
Factory	60
Gas Station	19
Fire Station	0
Other Government Offices	7
Other Commercial Establishments	86
Total	26,353

Table 20. Total Length of Extracted Roads for Bolbok Floodplain.

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Bolbok	217.26	178.53	23.22	9.95	0.00	428.96

Table 21. Number of Extracted Water Bodies for Bolbok Floodplain.

Floodplain	**Water Body Type**					**Total**
	Rivers/ Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Bolbok	20	0	1	0	0	**21**

A total of 94 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 floodplain. This completes the feature extraction phase of the project.

Figure 28 shows the Digital Surface Model (DSM) of Bolbok floodplain overlaid with its ground features.

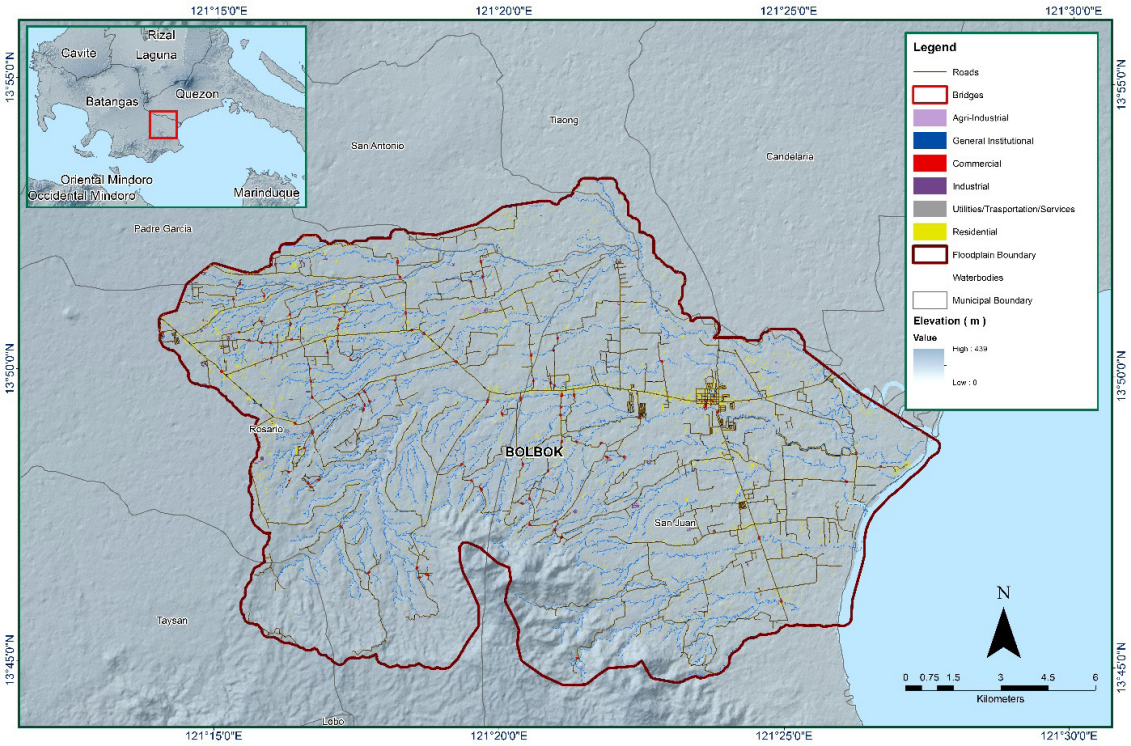


Figure 28. Extracted features for Bolbok floodplain.

CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE BOLBOK RIVER BASIN

Engr. Louie P. Balicanta, Engr. Joemarie S. Caballero, Ms. Patrizcia Mae. P. dela Cruz, Engr. Dexter T. Lozano, For. Dona Rina Patricia C. Tajora, Elaine Bennet Salvador, For. Rodel C. Alberto

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

4.1 Summary of Activities

The Data Validation and Bathymetry Component (DVBC) conducted field surveys in Bolbok River on May 15-22, 2014 and on September 2-6, 2014 with the following scope of work: control survey and cross-section of the bridge; bathymetric survey; and ground validation for Bolbok River Basin. The bathymetric survey started from the mouth of the river in Brgy. Catmon, San Juan, Batangas going upstream to Brgy. Mabalanoy, San Juan, Batangas. The survey covered an estimated total length of 8.5 km.

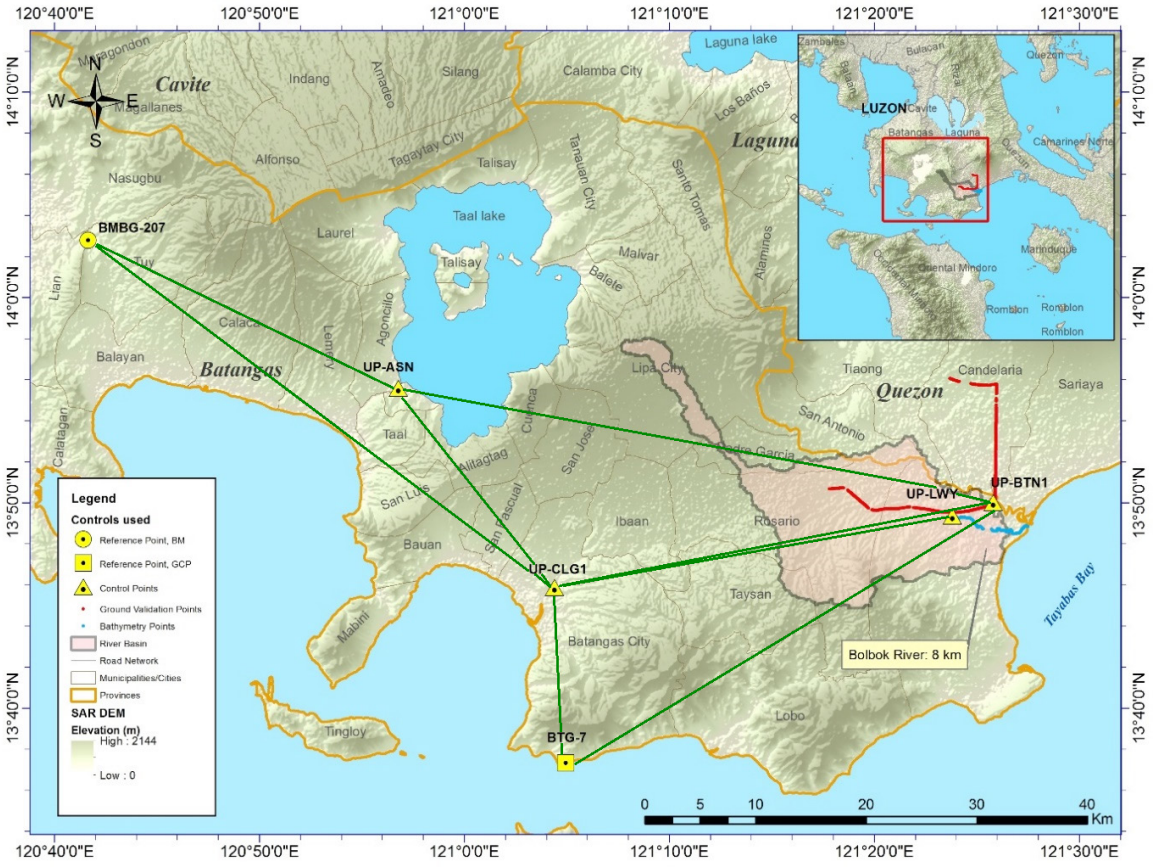


Figure 29. Survey extent for Bolbok River Basin

4.2 Control Survey

The GNSS network for this survey is composed of six (6) loops established on May 14 – 22, 2016 occupying the following reference points: BG-207, a first order BM in Brgy. Sabang, Municipality of Tuy; and BTG-7, a first order GCP located in Brgy. Dela Paz, Batangas City.

Five (5) control points were established at the approach of bridges namely UP-BTN at Bantilan Bridge in Brgy. UP-LOBO at Lobo Bridge in Brgy. Lagadlarin, Municipality of Lobo; UP-ASN at San Nicholas Bridge in Brgy. Poblacion, Municipality of San Nicholas, UP-CLG at Calumpang Bridge in Brgy. Kumintang Ibaba, Batangas City and UP-LWY at Lawaye Bridge in Brgy. Calitcalit, Municipality of San Juan.

The summary of reference and control points and its location is summarized in Table 22 while the GNSS network established is illustrated in Figure 30.

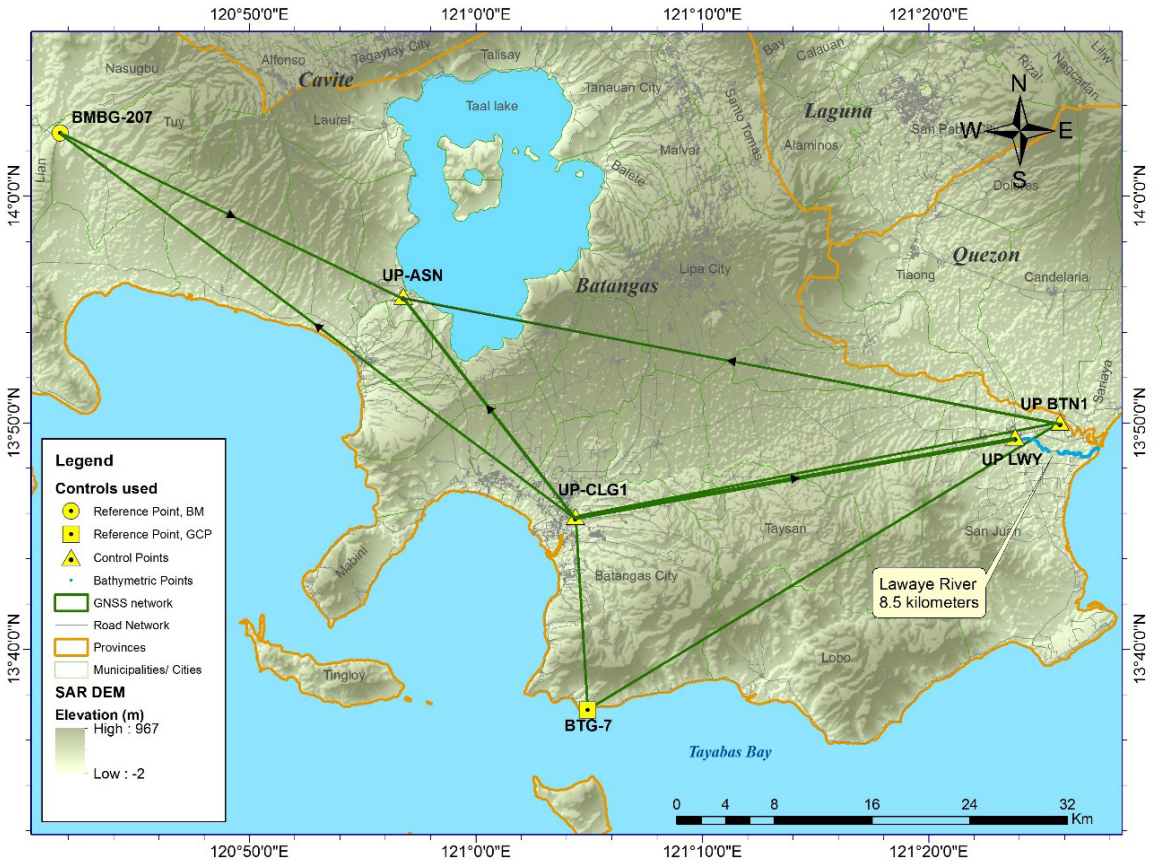


Figure 30. GNSS Network of Bolbok River Basin Field Survey

Table 22. List of Reference and Control Points used in Batangas Fieldwork on May 21, 2014 (Source: NAMRIA and UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (m)	MSL Elevation (m)	Date Established
BG207	1st Order	-	-	65.606	22.502	2008
BTG-7	1st Order	13°37'19.49611"	121°04'56.32756"	66.192	-	1992
UP-ASN	UP Established	-	-	-	-	5-22-2014
UP-BTN	UP Established	-	-	-	-	5-21-2014
UP-CLG1	UP Established	-	-	-	-	5-21-2014
UP-LOBO	UP Established	-	-	-	-	5-21-2014
UP-LWY1	UP Established					5-22-2014

The GNSS set up on reference and established control points in Batangas are shown on Figure 31 to 37.

Figure 31. GNSS receiver, Trimble® SPS 985, set-up at BG-207 at Palico Bridge, Brgy. Luntal, Nasugbu, Batangas

Figure 32. GNSS receiver, Trimble® SPS 985, set-up at BTG-7 in Dela Paz Lighthouse in Brgy. Dela Paz, Batangas City, Batangas

Figure 33. GNSS receiver, Trimble® SPS 882, set-up at UP-ASN at San Nicholas Bridge, Brgy. Poblacion, San Nicholas, Batangas

Figure 34. GNSS base receiver, Trimble® SPS 852, set-up at UP-BTN at Bantilan Bridge, Brgy. Manggalang Banitilan, Sariaya, Quezon

Figure 35. GNSS base receiver, Trimble® SPS 852, set-up at UP-CLG1 in Calumpang Bridge, Brgy. Cumint-ang Ibaba, Batangas City, Batangas

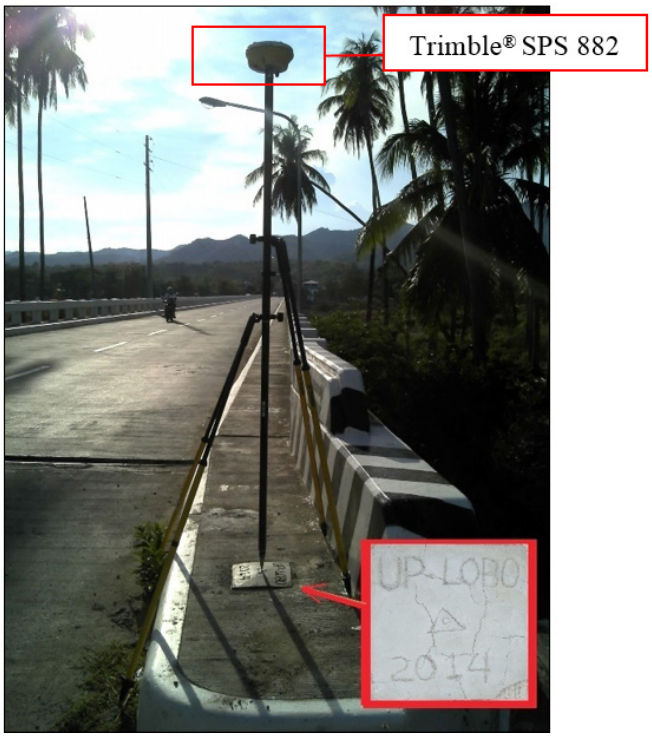


Figure 36. GNSS base receiver, Trimble® SPS 882, set-up at UP-LOBO, in Lobo Bridge, Brgy. Lagadlarin, Lobo, Batangas

Figure 37. GNSS receiver, Trimble® SPS 882, set-up at UP-LWY1 at Lawaye Bridge, Brgy. Calitcalit-Mabalanoy, San Juan, Batangas

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 Bolbok River Basin is summarized in Table C2 generated by TBC software.

Table 23. Baseline Processing Report for Bolbok River Basin Static Survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
UPCLG --- BTG7 (B11)	5-22-2014	Fixed	0.003	0.013	356°25'22"	15777.353	-8.962
BTG7 --- UPLOBO (B14)	5-22-2014	Fixed	0.008	0.037	80°16'20"	14501.810	-9.895
UPCLG --- UPBTN (B8)	5-21-2014	Fixed	0.004	0.018	78°44'11"	39325.812	-1.938
UPCLG --- UPBTN (B10)	5-21-2014	Fixed	0.023	0.082	78°44'11"	39325.931	-1.993
UPCLG --- UPBTN (B9)	5-21-2014	Fixed	0.018	0.032	78°44'11"	39326.011	-1.988
UPCLG --- BMBG207 (B7)	5-21-2014	Fixed	0.008	0.021	307°20'38"	51500.583	8.348
UPCLG --- UPLWY (B15)	5-22-2014	Fixed	0.004	0.015	79°31'48"	35577.341	6.690
UPCLG --- UPASN (B6)	5-21-2014	Fixed	0.005	0.020	322°34'54"	22553.641	-5.613

UPCLG --- UPLOBO (B12)	5-22-2014	Fixed	0.006	0.026	131°01'52"	20253.372	-0.954
UPBTN --- BMBG207 (B2)	5-21-2014	Fixed	0.066	0.086	286°35'24"	82928.558	10.191
BTG7 --- UPBTN (B5)	5-21-2014	Fixed	0.004	0.018	58°03'54"	44287.329	-10.884
BTG7 --- UPBTN (B3)	5-21-2014	Fixed	0.017	0.070	58°03'54"	44287.367	-10.925
BTG7 --- UPBTN (B4)	5-21-2014	Fixed	0.011	0.024	58°03'54"	44287.360	-10.823
UPBTN --- UPLOBO (B13)	5-22-2014	Fixed	0.011	0.045	228°04'35"	31344.157	0.983
BMBG207 --- UPLWY (B17)	5-22-2014	Fixed	0.015	0.033	107°58'47"	79868.067	-1.689
BMBG207 --- UPASN (B1)	5-21-2014	Fixed	0.005	0.022	115°58'50"	30324.834	-14.030
UPLWY --- UPASN (B16)	5-21-2014	Fixed	0.011	0.021	283°18'29"	50016.834	-12.285

As shown in Table 23, a total of seventeen (17) baselines were processed with reference elevation of point BG-207 and coordinates of BTG-7 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:

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

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 24 to Table 26 for the complete details.

The seven (7) control points, BG-207, BTG-7, UP-ASN, UP-BTN, UP-CLG, UP-LOBO and UP-LWY were occupied and observed simultaneously to form a GNSS loop. Coordinates of point BTG-7 and elevation value of BG-207 were held fixed during the processing of the control points as presented in Table 24. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 24. Control Point Constraints

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
BG-207	Grid				Fixed
BTG-7	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 25. The fixed control point BG-207 and BTG-7, has no values for standard elevation and coordinates error, respectively.

Table 25. Adjusted Grid Coordinates

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
MBG207	250979.768	0.014	1554083.399	0.009	22.502	?	e
BTG7	292538.897	?	1506749.028	?	20.801	0.072	LL
UPASN	278117.299	0.013	1540530.569	0.008	7.619	0.060	
UPBTN	330309.700	0.008	1529876.941	0.006	9.361	0.075	
UPCLG	291679.224	0.007	1522505.093	0.005	12.287	0.058	
UPLOBO	306852.492	0.014	1509086.720	0.008	10.498	0.094	
UPLWY	326716.786	0.013	1528689.759	0.008	18.019	0.064	

The network is fixed at reference points BG-207 and BTG-7 for elevation and coordinate values, respectively. With the mentioned equation , for horizontal; and for the vertical; the computation for the accuracy for the controls are as follows:

a. BG-207

horizontal accuracy = $\sqrt{((1.4)^2 + (0.9)^2}$
= $\sqrt{(1.96 + 0.81)}$
= 1.66 cm < 20 cm
vertical accuracy = Fixed

b. BTG-7

horizontal accuracy = Fixed
vertical accuracy = 7.2 cm

c. UP-ASN

horizontal accuracy = $\sqrt{((1.3)^2 + (0.8)^2}$
= $\sqrt{(1.69 + 0.64)}$
= 1.53 cm < 20 cm
vertical accuracy = 6.0 cm

d. UP-BTN

horizontal accuracy = $\sqrt{((0.8)^2 + (0.6)^2}$
= $\sqrt{(0.64 + 0.36)}$
= 1.0 cm < 20 cm
vertical accuracy = 7.5 cm

e. UP-CLG

horizontal accuracy = $\sqrt{((0.7)^2 + (0.5)^2}$
= $\sqrt{(0.49 + 0.25)}$
= 0.86 cm < 20 cm
vertical accuracy = 5.8 cm

f. UP-LOB

horizontal accuracy = $\sqrt{((1.4)^2 + (0.8)^2}$
= $\sqrt{(1.96 + 0.64)}$
= 1.48 cm < 20 cm
vertical accuracy = 9.4 cm

g. UP-LWY

horizontal accuracy = $\sqrt{((1.3)^2 + (0.8)^2}$
= $\sqrt{(1.69 + 0.64)}$
= 1.52 cm < 20 cm
vertical accuracy = 6.4 cm

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

Table 26. Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Ellipsoidal Height	Height Error (Meter)	Constraint
BMBG207	N14°02'47.32674"	E120°41'38.93608"	65.606	?	e
BTG7	N13°37'19.49611"	E121°04'56.32756"	66.192	0.072	LL
UPASN	N13°55'34.60792"	E120°56'47.03882"	51.610	0.060	
UPBTN	N13°50'00.87917"	E121°25'47.84870"	55.321	0.075	
UPCLG	N13°45'51.87502"	E121°04'23.55781"	57.236	0.058	
UPLOBO	N13°38'39.10157"	E121°12'51.89916"	56.291	0.094	
UPLWY	N13°49'21.47536"	E121°23'48.47095"	63.917	0.064	

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 26. 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 27.

Table 27. Reference and control points and its location (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoid Height (m)	Northing (m)	Easting (m)	Elevation in MSL (m)
BG207	1st Order	14°02'47.32674"	120°41'38.93608"	65.606	1554083	250979.8	22.502
BTG-7	1st Order	13°37'19.49611"	121°04'56.32756"	66.192	1506749	292538.9	20.801
UP-ASN	UP Established	13°55'34.60792"	120°56'47.03882"	51.61	1540531	278117.3	7.619
UP-BTN	UP Established	13°50'00.87917"	121°25'47.84870"	55.321	1529877	330309.7	9.361
UP-CLG1	UP Established	13°45'51.87502"	121°04'23.55781"	57.236	1522505	291679.2	12.287
UP-LOBO	UP Established	13°38'39.10157"	121°12'51.89916"	56.291	1509087	306852.5	10.498
UP-LWY1	UP Established	13°49'21.47536"	121°23'48.47095"	63.917	1528690	326716.8	18.019

4.5 Cross-section and Bridge As-Built survey and Water Level Marking

Cross section survey was done on May 19, 2014 at the upstream side of Lawaye Bridge in Brgy. Poblacion, San Juan City, Batangas using a GNSS receiver, Trimble® SPS 882, in PPK survey technique. The cross-sectional line for Lawaye Bridge is about 150 m with 15 points acquired using UP-LWY as the GNSS base station. Figure 38 and Figure 39 shows the location map and summary of gathered cross-section data.

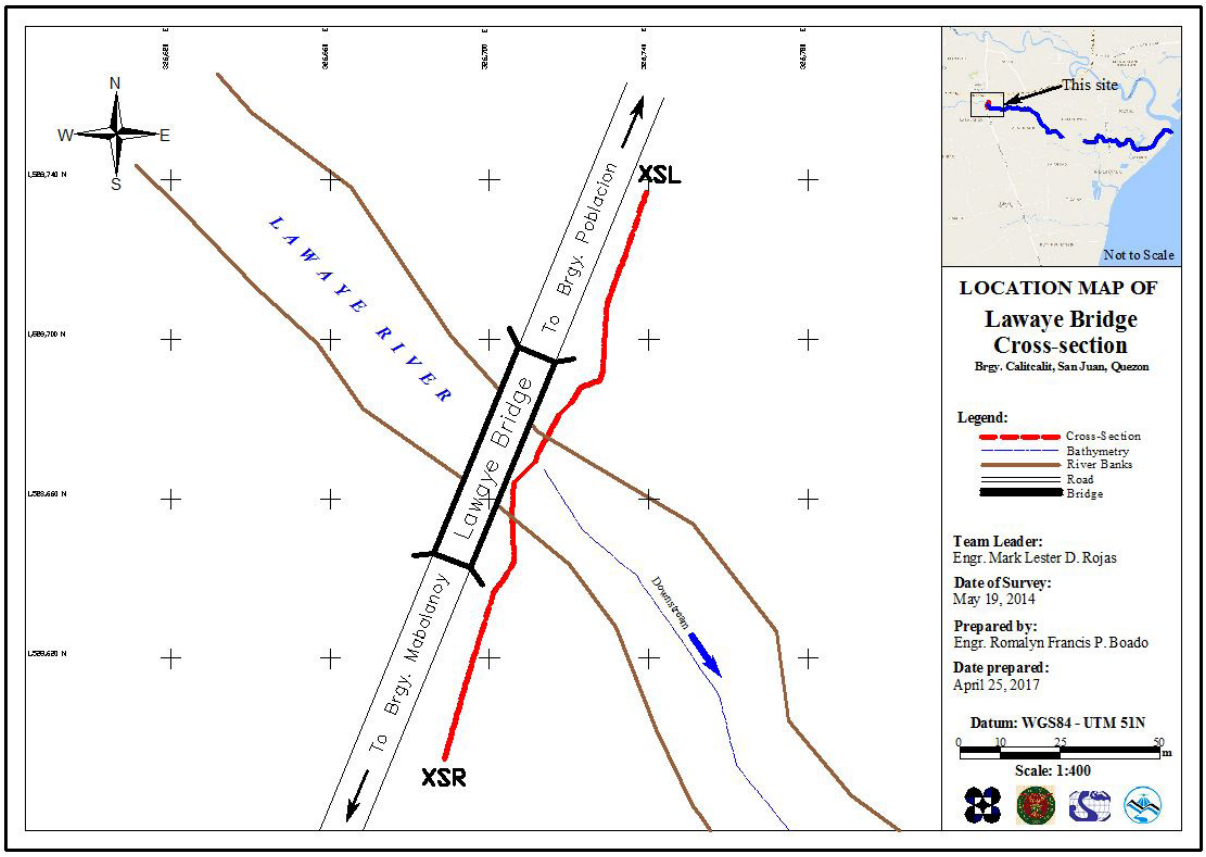


Figure 38. Lawaye bridge location map.

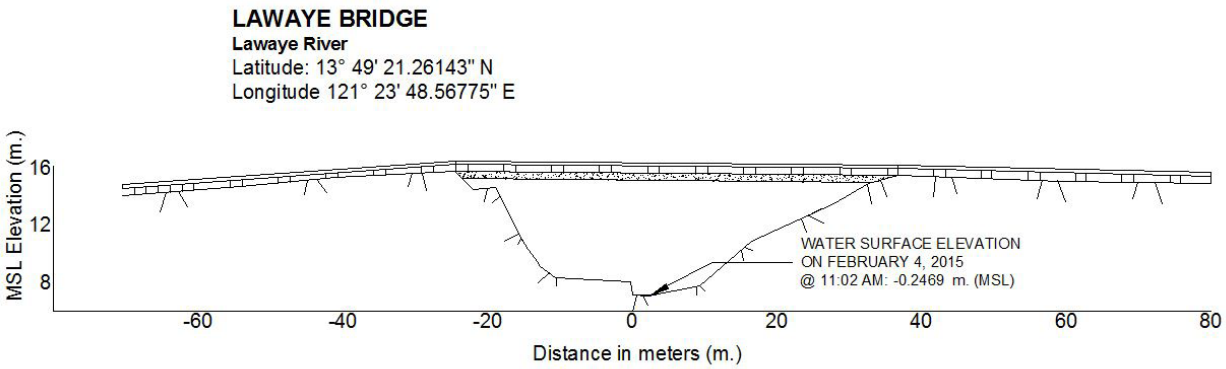


Figure 39. Lawaye Bridge cross section diagram

Meanwhile, bridge elevation marking was done on September 5, 2014 in Lawaye Bridge, Poblacion, San Juan City, Batangas. Water level elevation was determined using a GNSS receiver in PPK survey technique on February 4, 2015. The obtained elevation was translated using a digital level, Topcon DL 500, to mark abutment of the bridge as shown in Figure 40 and Figure 41.

Figure 40. Levelling setup for the MSL elevation marking at the abutment of Lawaye Bridge

Figure 41. Lawaye Bridge elevation marking

4.6 Validation Points Acquisition Survey

Validation points acquisition survey was conducted on November 8, 2014 using a survey-grade GNSS Rover receiver, Trimble® SPS 882, mounted on a pole which was attached in front of the vehicle. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height was 2.09 m measured from the ground up to the bottom of the notch of the GNSS Rover receiver. The survey was conducted using PPK technique on a continuous topography mode using UP-BT1 as base station.

Figure 42. The occupied GNSS base station, UP-BTN1, in Bantilan Bridge, San Juan, Batangas

Acquisition of validation points started from Brgy. Tipaz, San Juan, Batangas and traversed major roads going north to Brgy. Bucal Sur, Candelaria, and ended in Brgy. Alupay, Rosario, Batangas. The control point, UP-BTN1 was occupied as the GNSS base station in the conduct of the survey. The survey acquired 2,835 ground validation points with an approximate length of 30 km, as illustrated in Figure 43.

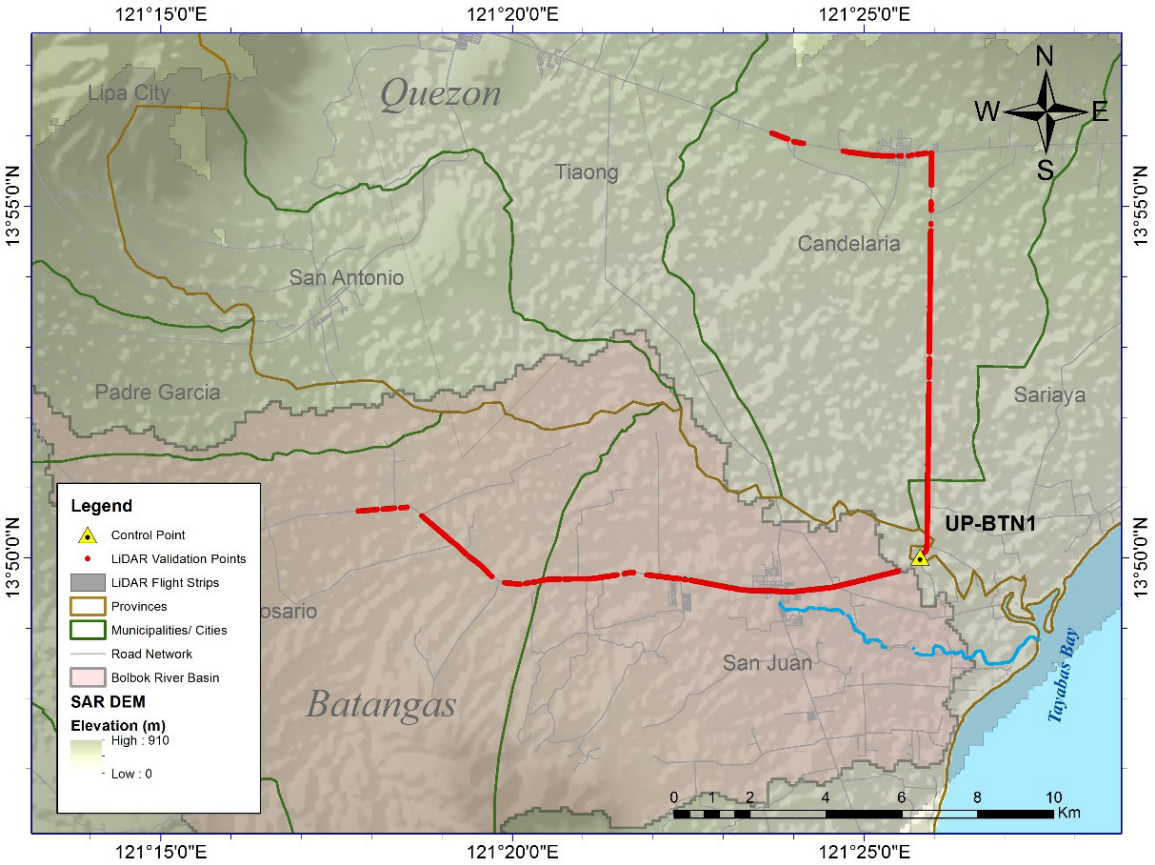


Figure 43. Validation points acquisition survey along Bolbok River Basin

4.7 River Bathymetric Survey

Bathymetric survey was conducted on September 4, 2014 using Trimble® SPS 882 in GNSS PPK survey technique and an Ohmex™ Single Beam Echosounder mounted on a pole attaced to a boat as shown in Figure 44. The survey started in Brgy. Pinagbayanan, San Juan City with coordinates 13°48'39.34976" 121°26'15.11734", down to the mouth of the river in Brgy. Catmon, also in San Juan City with coordinates 13°48'49.72249" 121°27'29.46670".

Figure 44. Setup of OHMEX™ Echo Sounder with GNSS rover receiver, Trimble® SPS 882, in a boat in Bolbok River

Manual bathymetric survey on the other hand was conducted on September 3, 2014 using Trimble® SPS 882 in GNSS PPK survey technique as shown in Figure 45. The survey began at the upstream portion of the river in Brgy. Poblacion, San Juan City with coordinates 13°49'21.47543" 121°23'48.47171", walked down the river, and ended at the starting point of bathymetric survey using boat.

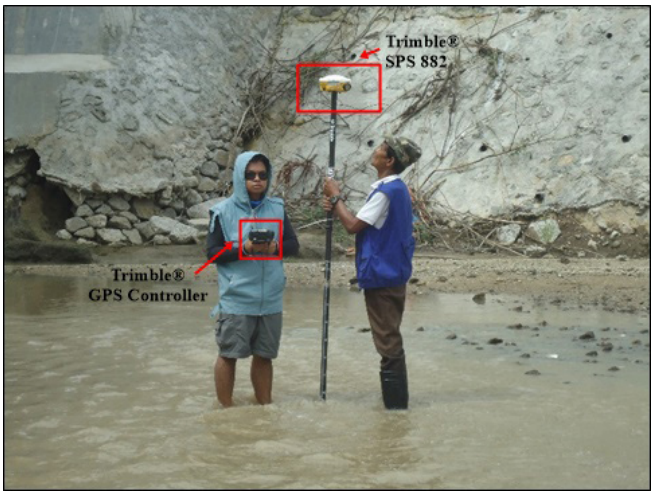


Figure 45. Manual bathymetry on the shallow parts of Bolbok River using Trimble® SPS 882

Bathymetric survey covered an estimated length of 8.5 km with a total of 3,378 bathymetric points gathered using the control point UP-LWY as the GNSS base station. A CAD drawing was also produced to illustrate the Lawaye riverbed profile. As shown in Figure 47, there was no abrupt change in elevation along the river from downstream 8.5 kilometers going upstream. The highest and lowest elevation observed was 9.128 m in MSL in the upstream portion and -15.092 m below MSL near the mouth of the river, respectively.

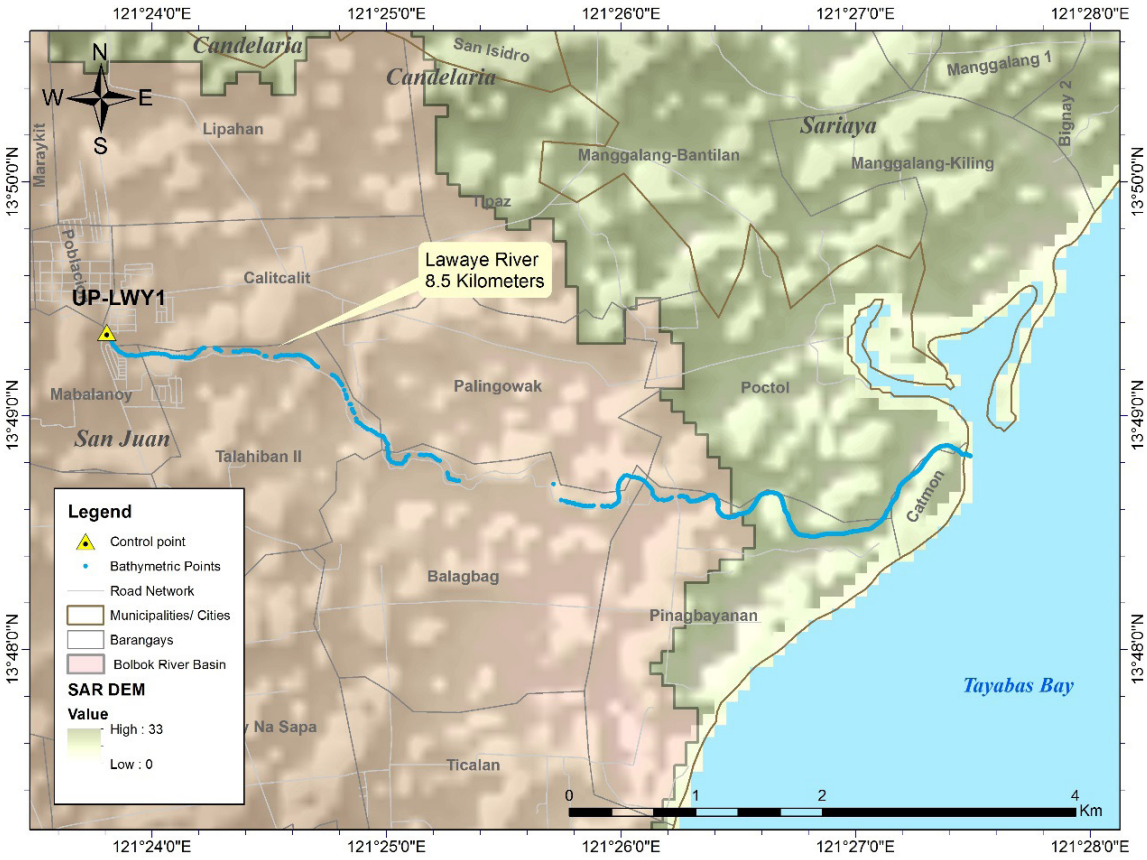


Figure 46. Bathymetric points gathered along Lawaye River

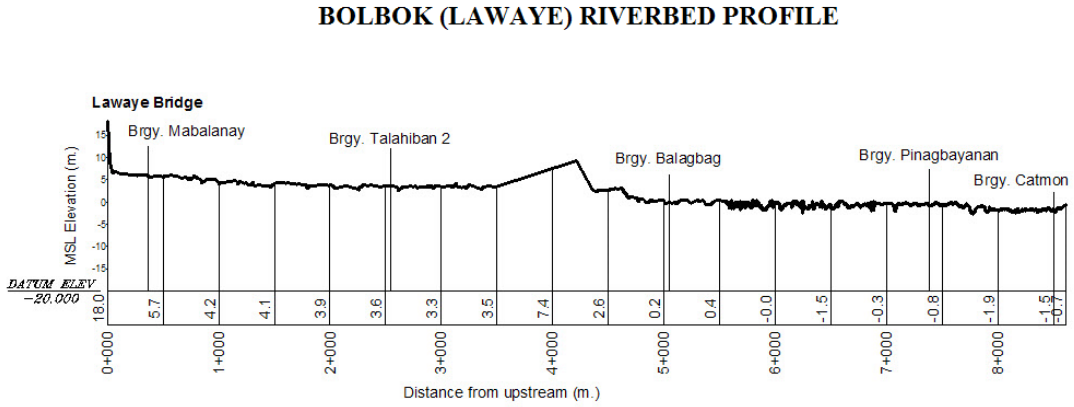


Figure 47. Riverbed profile of Bolbok River

CHAPTER 5: FLOOD MODELING AND MAPPING

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

The methods applied in this chapter were based on the DREAM methods manual (Ang, 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

Components and data that affect the hydrologic cycle of the river basin was monitored, collected, and analyzed. These include the rainfall, water level, and flow in a certain period of time.

5.1.2 Precipitation

Precipitation data was taken from two automatic rain gauges (ARGs) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). This rain gauge is the Sapangan ARG (13°47'2.52"N, 121°17'60.00"E), located in Rosario, Batangas (Figure 48). The precipitation data collection started from September 25, 2016 at 00:00 AM to September 25, 2016 at 23:45AM with a 15-minute recording interval.

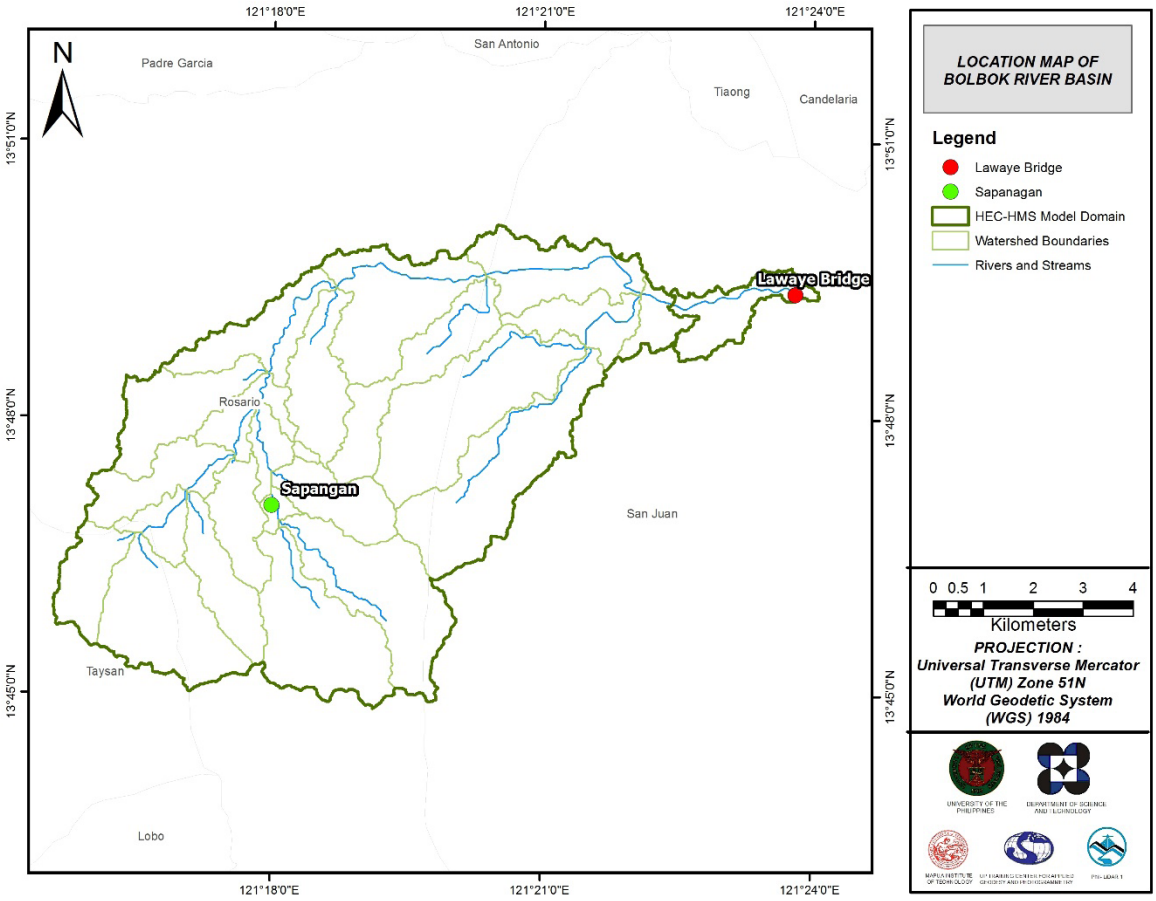


Figure 48. The location map of rain gauges used for the calibration of the Bolbok HEC-HMS Model.

For Bolbok Rain Gauge, total rain for the event is 25 mm. Peak rain of 12.5 mm was recorded on 25 September 2016. The lag time between the peak rainfall and discharge is 4 hours and 20 minutes, as seen in Figure 51.

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Lawaye Bridge, San Juan, Batangas (13°49'21.48"N, 121°23'48.25"E). It gives the relationship between the observed water levels from the Lawaye Bridge using depth gage and outflow of the watershed got using the flow meter at this location. It is expressed in the form of the following equation:

$$Q=a^{nh}$$

where, Q : Discharge (m^3/s),

h : Gauge height (reading from deployed depth gage at Bridge of Promise), and;

a and n : Constants.

For Lawaye Bridge, the rating curve is expressed as $Q = 0.000053e^{1.403789h}$ as shown in Figure 50.

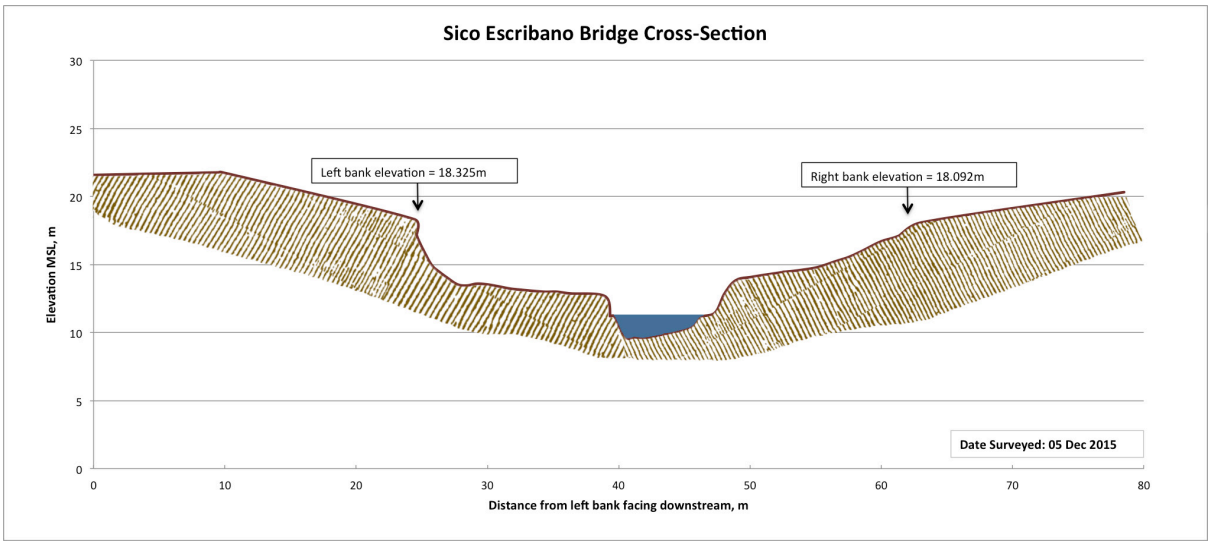


Figure 49. Cross-Section Plot of Lawaye (Sico Escribano) Bridge

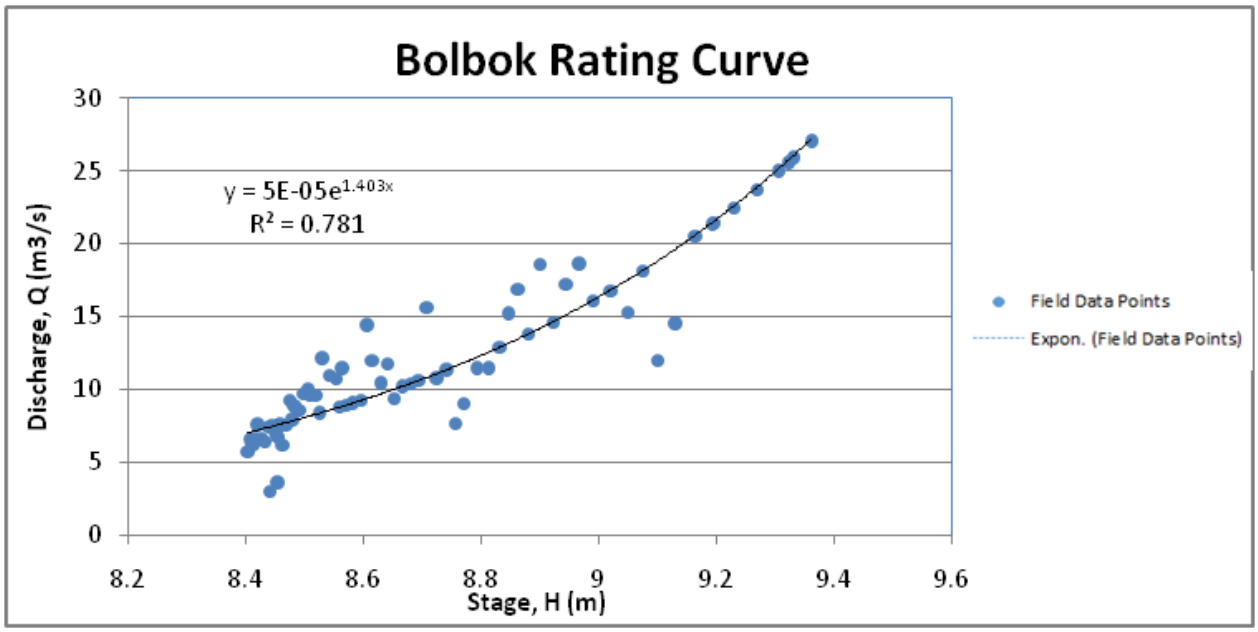


Figure 50. Rating Curve at Lawaye Bridge San Juan, Batangas.

This rating curve equation was used to compute the river outflow at Lawaye Bridge for the calibration of the HEC-HMS model shown in Figure 48. Peak discharge is 27.084 cms at 18:20, September 25, 2016.

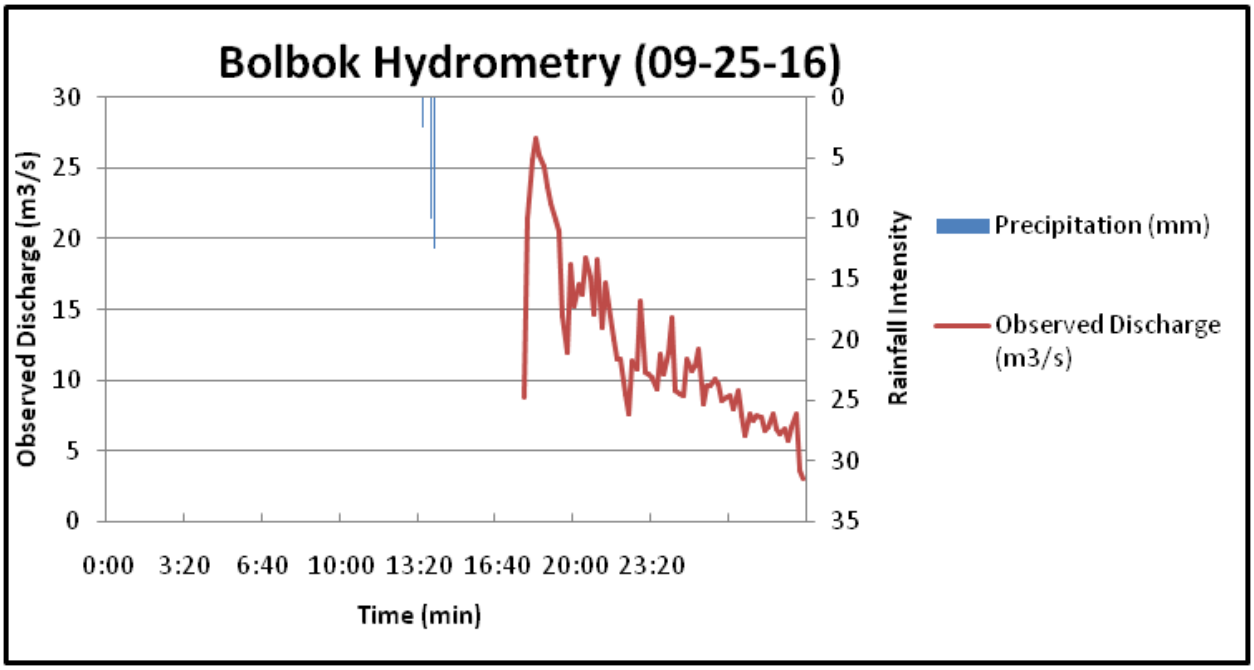


Figure 51. Rainfall and outflow data at Bolbok used for modeling.

5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Ambulong Gauge. This station chosen based on its proximity to the Bolbok watershed. The extreme values for this watershed were computed based on a 54-year record.

Table 28. RIDF values for Ambulong Rain Gauge computed by PAGASA

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION									
T (yrs)	10 mins	20 mins	30 mins	1 hr	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
2	22.7	35.5	36.3	50.2	68.2	80.1	104.1	125.7	150.8
5	27.9	45.5	53.8	74.2	103.4	122.5	159.7	192.9	226.7
10	34.2	52.1	65.4	90.1	126.7	150.6	196.5	237.3	276.9
15	37.8	57.4	71.9	99	139.8	166.4	217.3	262.4	305.3
20	40.3	61	76.5	105.3	149	177.5	231.9	280	325.1
25	42.2	63.9	80	110.1	156.1	186	243.1	293.5	340.4
50	48.1	72.6	90.9	125	178	212.3	277.6	335.2	387.5
100	54	81.2	101.6	139.8	199.7	238.4	311.8	376.6	434.3

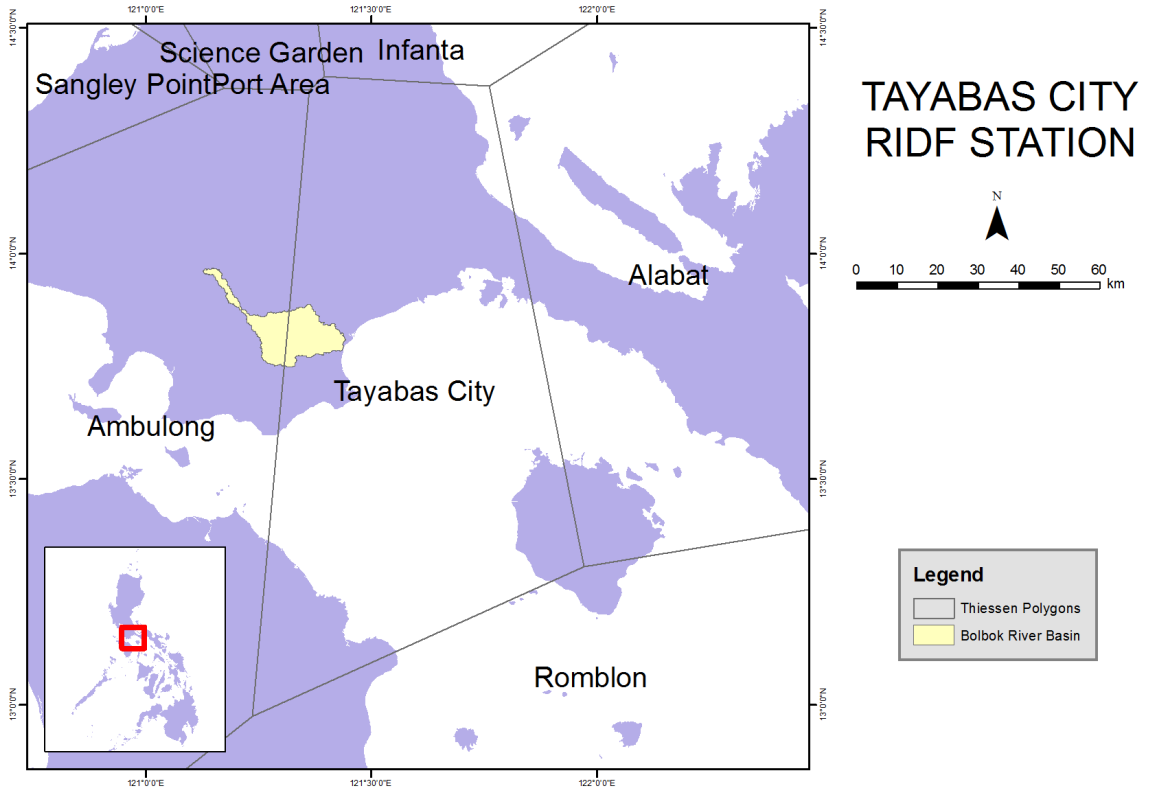


Figure 52. Ambulong RIDF location relative to Bolbok River Basin

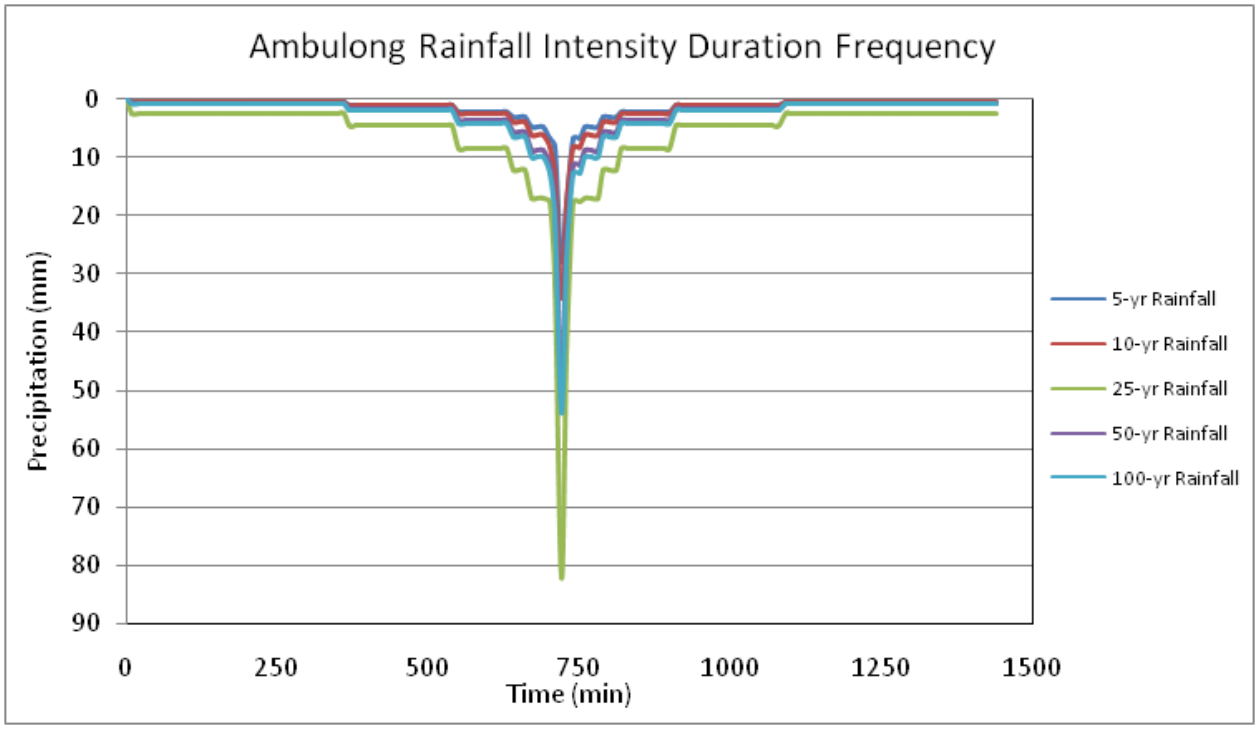


Figure 53. Synthetic storm generated for a 24-hr period rainfall for various return periods

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 (DENR). The land cover shape file is from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Bolbok River Basin are shown in Figures 54 and 55, respectively.

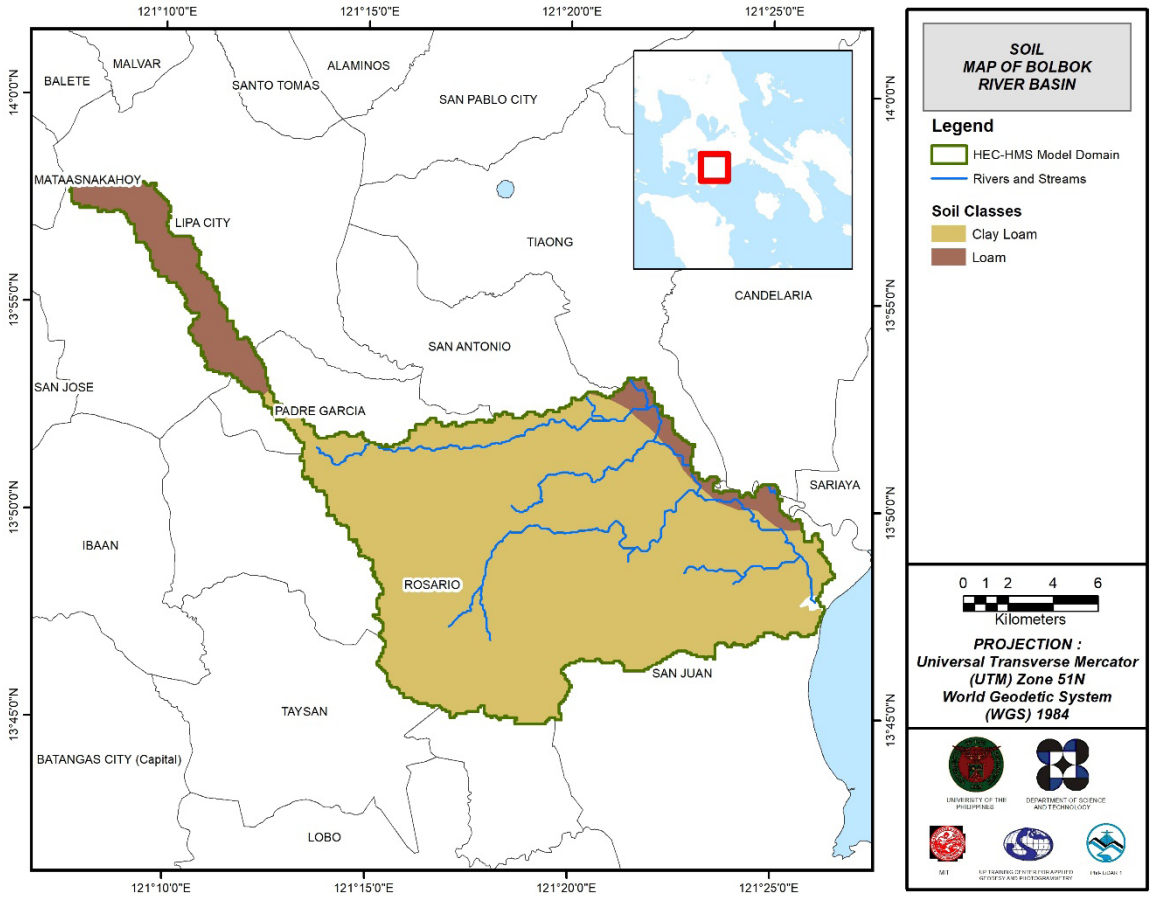


Figure 54. Soil Map of Bolbok River Basin

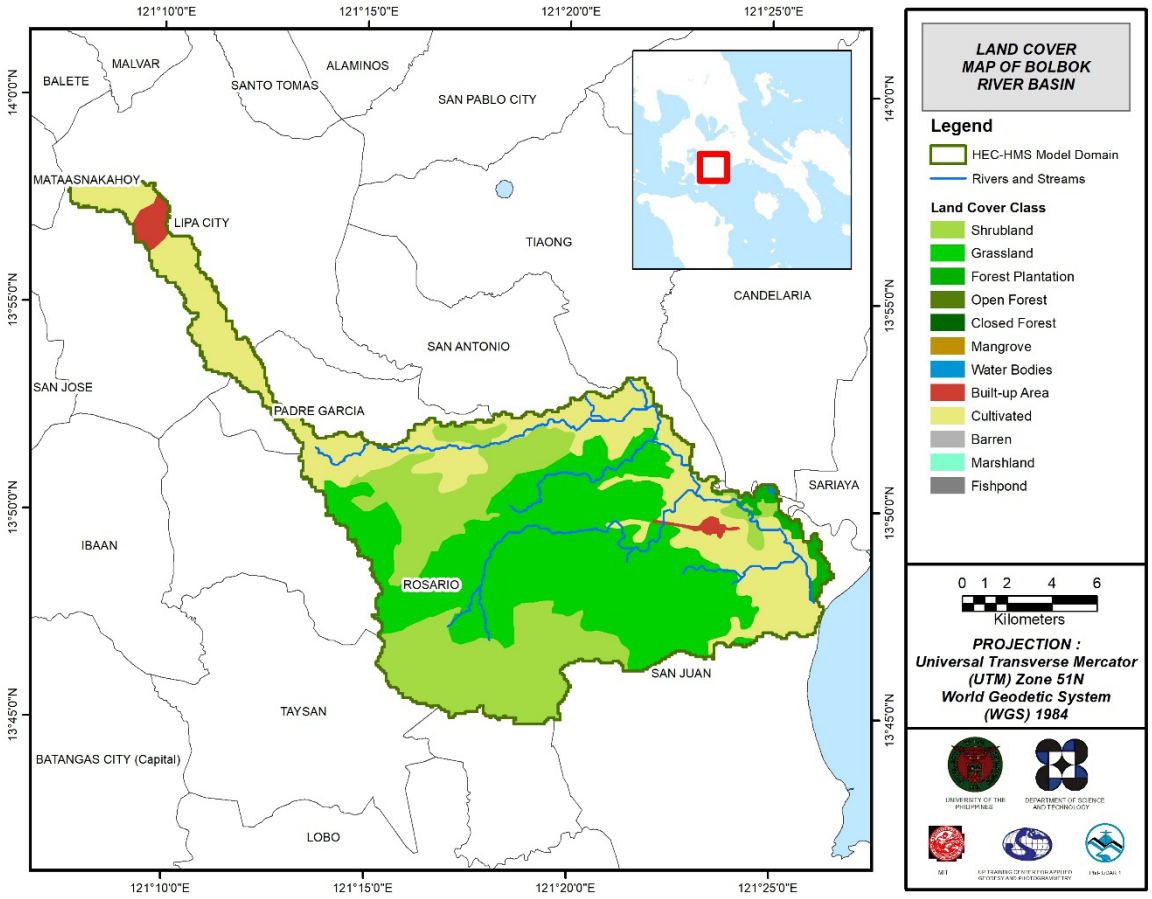


Figure 55. Land Cover Map of Bolbok River Basin

For Bolbok, the soil classes identified were clay loam and loam. The land cover types identified were brushland, built-up areas, cultivated areas, grassland, mangroves and tree plantations.

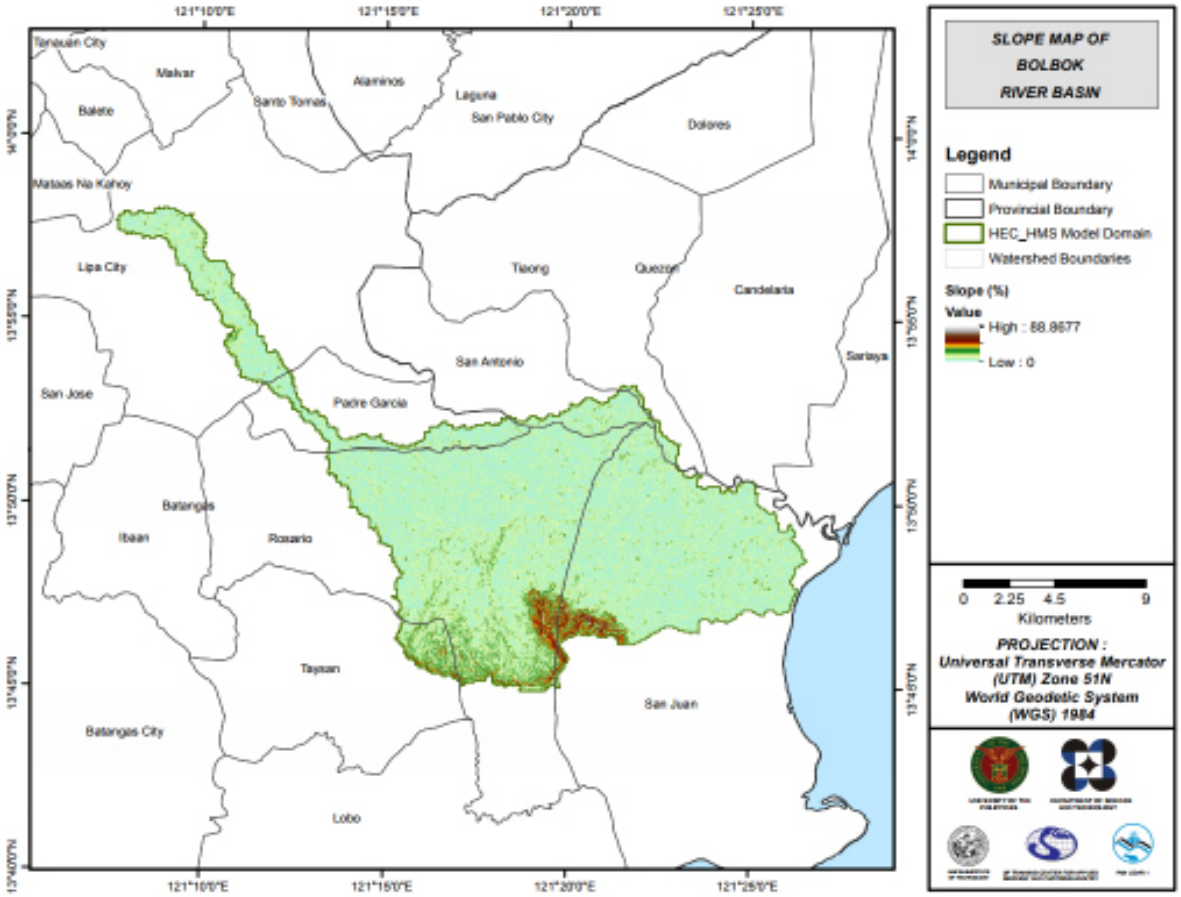


Figure 56. Slope Map of Bolbok River Basin

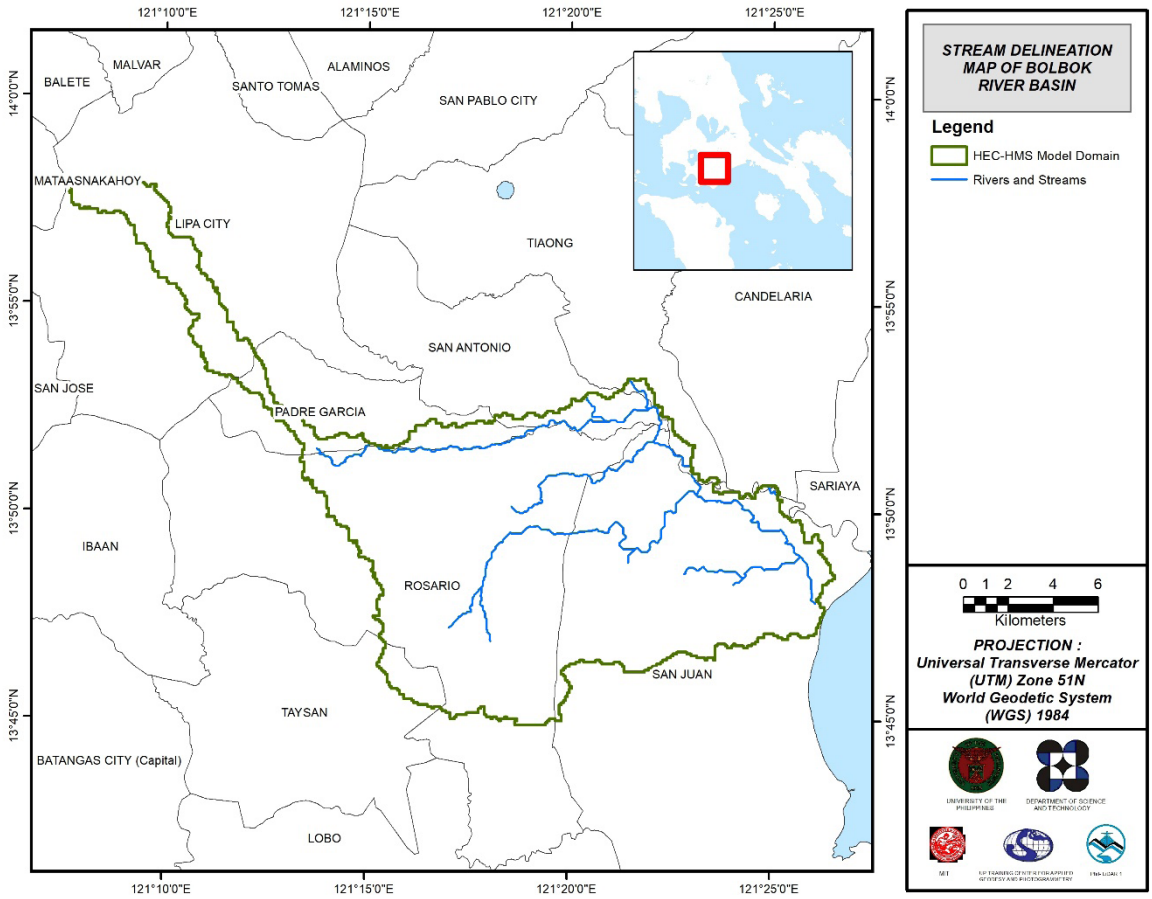


Figure 57. Stream delineation map of Bolbok river basin

The Bolbok basin model consists of 23 sub basins, 11 reaches, and 12 junctions. The main outlet is at the northeasternmost tip of the watershed. This basin model is illustrated in Figure 6. The basins were identified based on soil and land cover characteristic of the area. Precipitation was taken from an installed Rain Gauge near and inside the river basin. Finally, it was calibrated using the data from actual discharge flow gathered in the Lawaye Bridge.

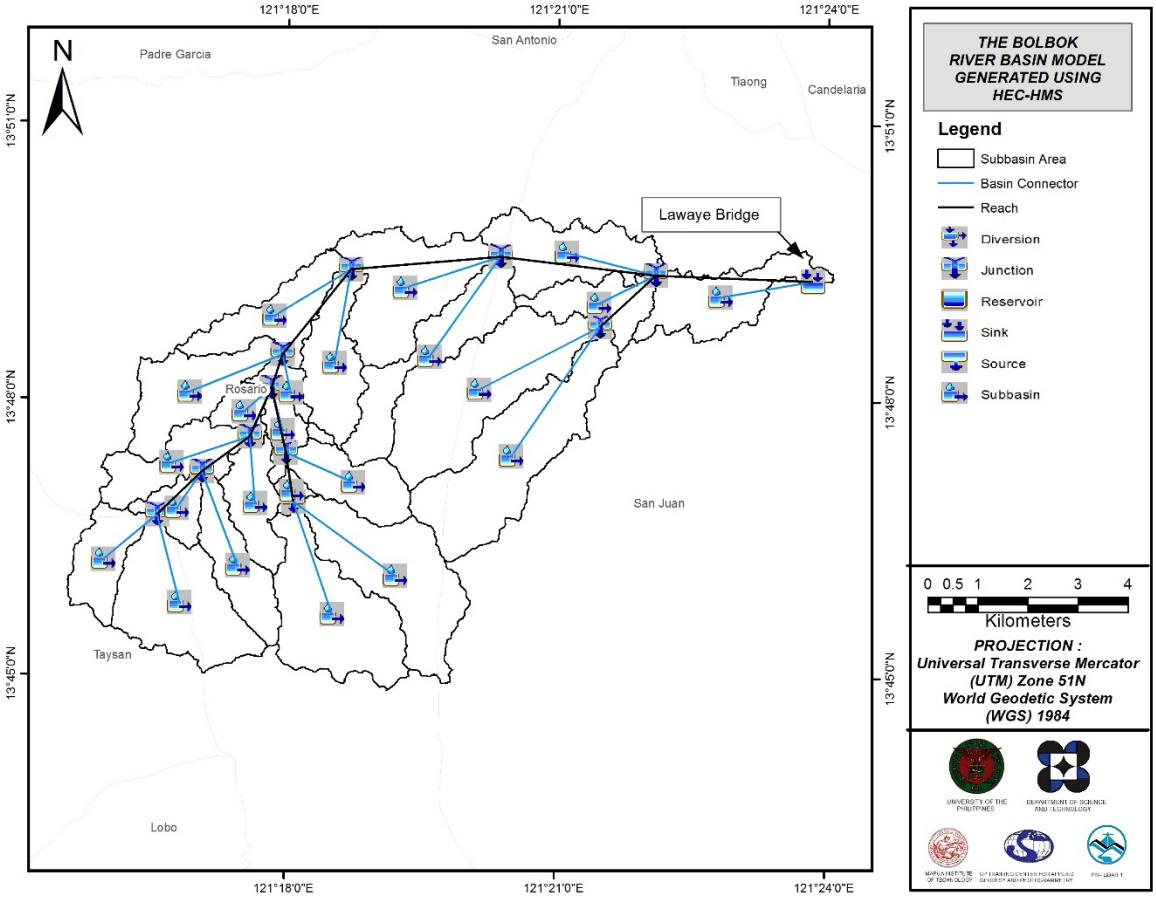


Figure 58. The Bolbok River Basin Model Domain generated by HEC-HMS.

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.

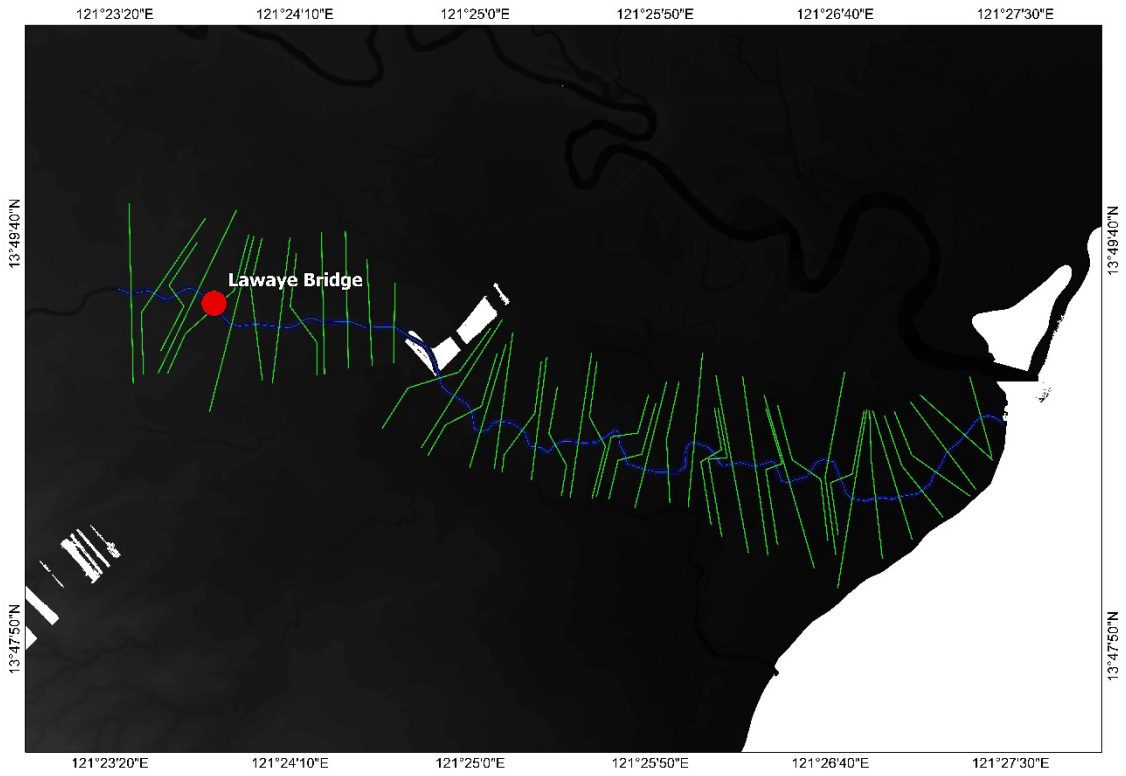


Figure 59. River cross-section of Bolbok River generated through Arcmap HEC GeoRAS tool

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 north of the model to the west , following the main channel. As such, boundary elements in those particular regions of the model are assigned as inflow and outflow elements respectively.

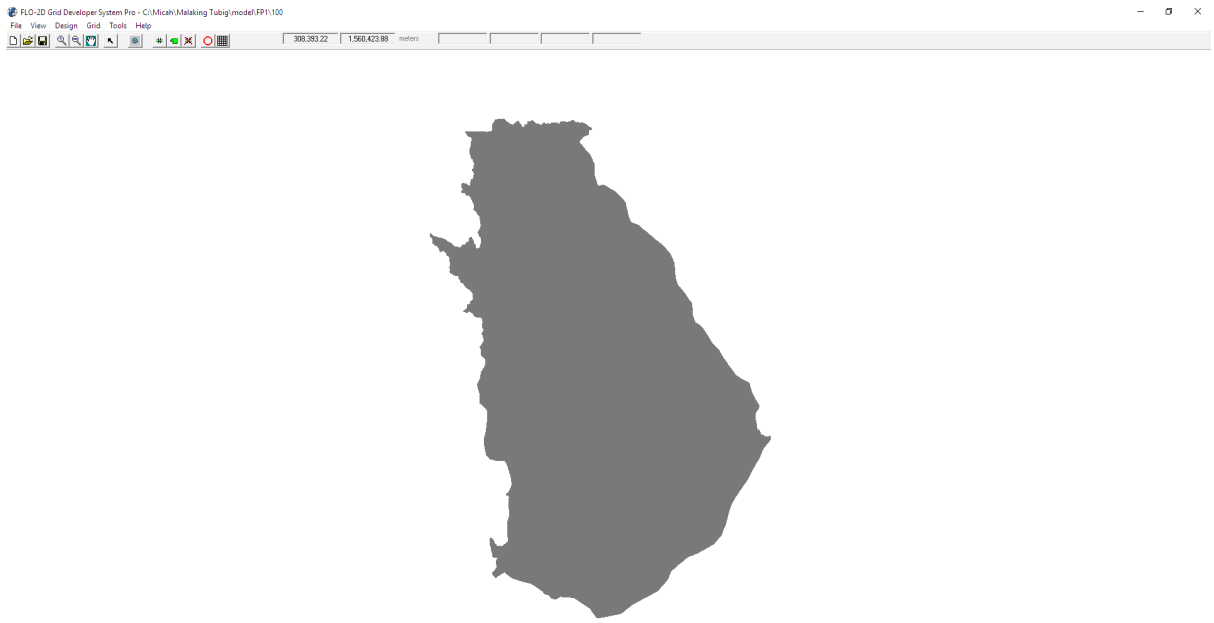


Figure 60. Screenshot of subcatchment with the computational area to be modeled in FLO-2D GDS Pro

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 106.15173 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.

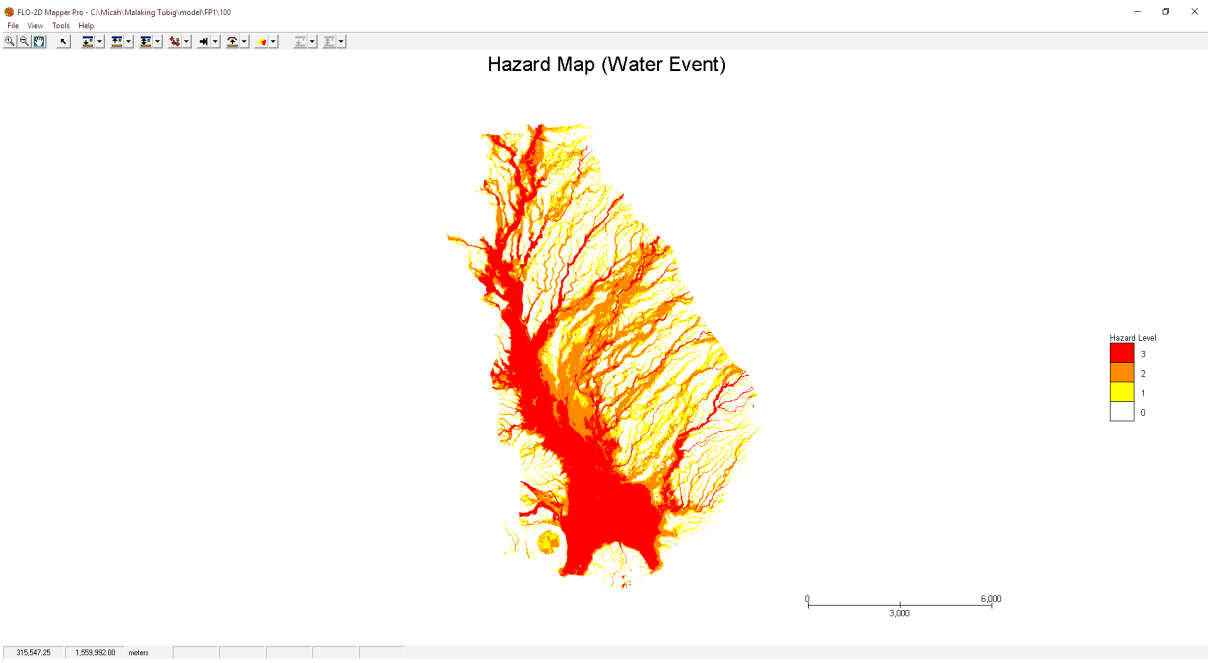


Figure 61. Generated 100-year rain return hazard map from FLO-2D Mapper

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 57251400.00 m^2.

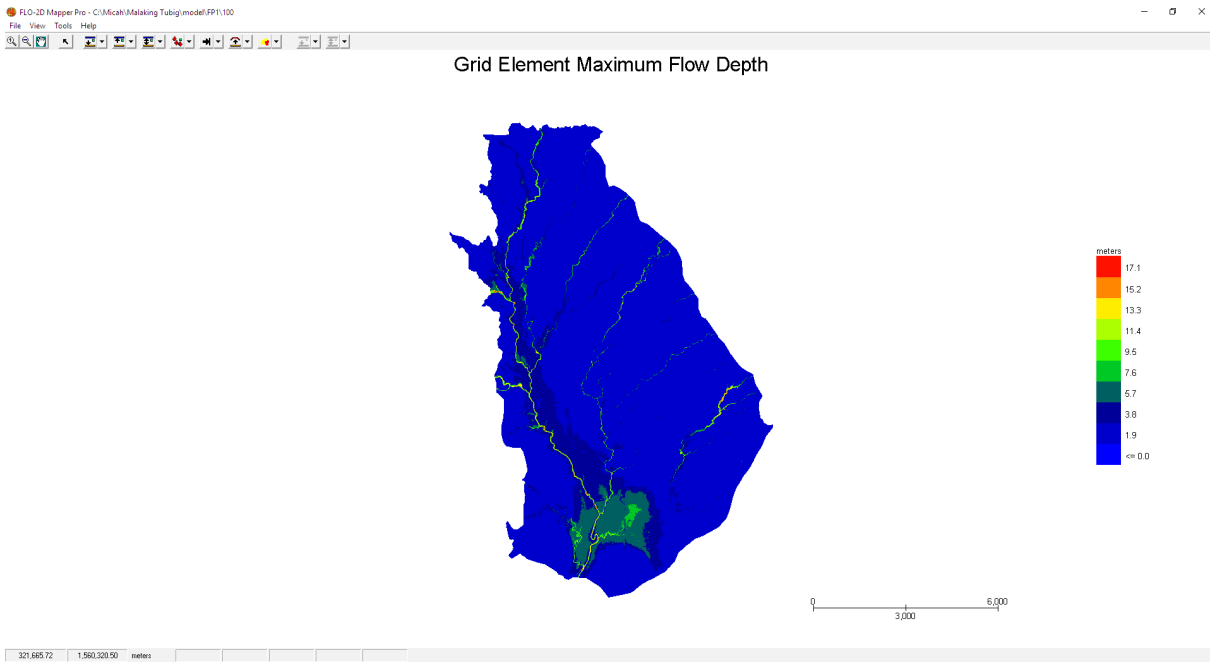


Figure 62. Generated 100-year rain return flow depth map from FLO-2D Mapper

There is a total of 114184147.59 m^3 of water entering the model. Of this amount, 47500660.78 m^3 is due to rainfall while 66683486.80 m^3 is inflow from other areas outside the model. 14608467.00 75 m^3 of this water is lost to infiltration and interception, while 14400968.56 m^3 is stored by the flood plain. The rest, amounting up to 84934093.68 m^3, is outflow.

5.6 Results of HMS Calibration

After calibrating the Bolbok HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 63 shows the comparison between the two discharge data.

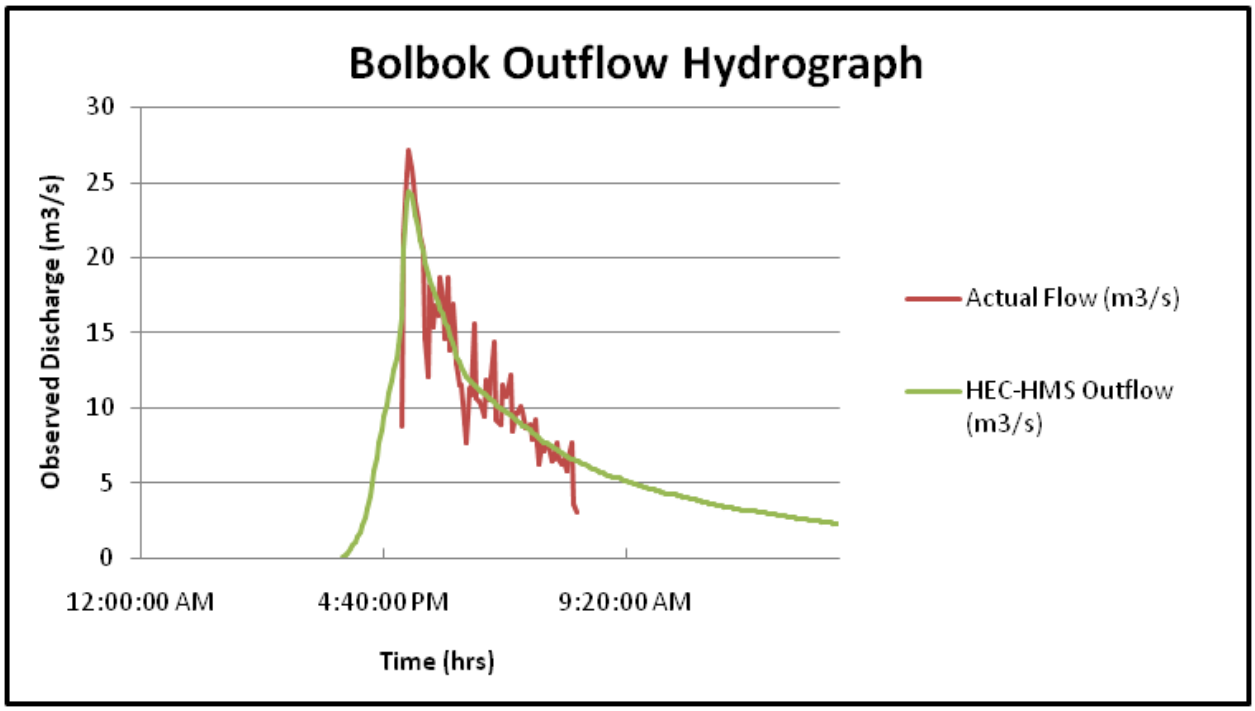


Figure 63. Outflow Hydrograph of Bolbok produced by the HEC-HMS model compared with observed outflow.

Enumerated in Table 29 are the adjusted ranges of values of the parameters used in calibrating the model.

Table 29. Range of Calibrated Values for Bolbok River Basin

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	1.14 – 10.46
			Curve Number	66.39 – 99
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	1.058 – 12.39
			Storage Coefficient (hr)	1.33 – 6.47
	Baseflow	Recession	Recession Constant	0.034 – 1
			Ratio to Peak	0.060 – 0.88
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.0048 – 0.18

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 1.14mm to 10.46mm means that there is a minimal 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 curve numbers for the watershed's subbasins are from 66.39 to 99. For Bolbok, the soil classes identified were clay loam and loam. The land cover types identified were brushland, built-up areas, cultivated areas, grassland, mangroves and tree plantations.

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 0.034 hours to 12.39 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. The Recession Constant in this basin ranges from 0.034 to 1 and the Ratio to Peak from 0.060 to 0.88. The receding limb of the outflow hydrograph could be characterized as moderately quick to return to its original discharge values.

Manning's roughness coefficient ranging from 0.0048 to 0.18 corresponds to the common roughness in Bolbok watershed.

Table 30. Summary of the Efficiency Test of Bolbok HMS Model

RMSE	15.08
r^2	0.85
NSE	0.71
PBIAS	1.56
RSR	0.53

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 15.08.

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 0.85.

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 0.71.

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 1.56.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains avalue of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.53.

5.7 Calculated Outflow hydrographys and Discharge Values for different Rainfall Return Periods

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 64) shows the Bolbok outflow using the Ambulong 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.

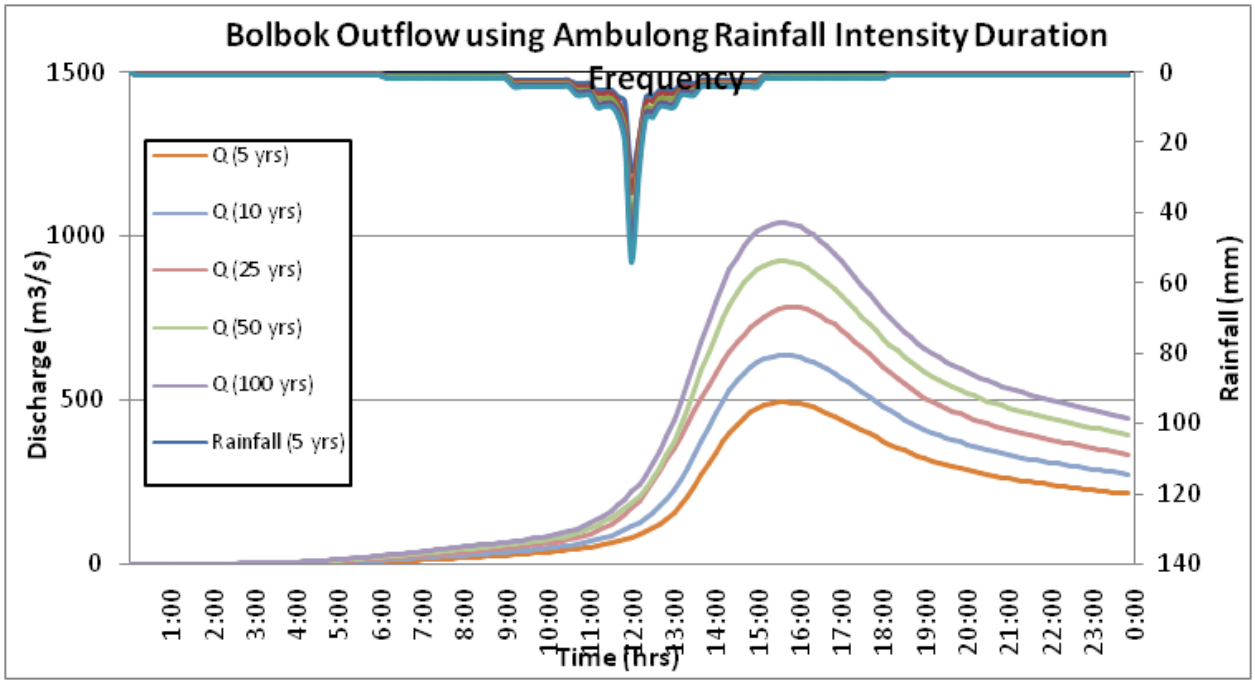


Figure 64. Outflow hydrograph at Bolbok Station generated using Ambulong RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Bolbok River discharge using the Ambulong Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 31.

Table 31. Peak values of the Bolbok HECHMS Model outflow using the Ambulong RIDF.

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m 3/s)	Time to Peak
5-Year	209.4	28.3	492.8	15 hours, 40 minutes
10-Year	276.9	34.2	635.9	15 hours, 40 minutes
25-Year	340.4	42.2	783.1	15 hours, 50 minutes
50-Year	387.5	48.1	922.2	15 hours, 30 minutes
100-Year	434.3	54	1040.9	15 hours, 30 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 Flood Acquisition and Validation Component (MIT-FAVC) base flow was calibrated. The sample generated map of Bolbok River using the calibrated HMS base flow is shown in Figure 64.

Figure 65. Sample output of Bolbok RAS Model

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 66 to Figure 71 shows the 5-, 25-, and 100-year rain return scenarios of the Malaking-Ilog-Bolbok floodplain.

Table 32. Municipalities affected in Malaking-Ilog-Bolbok floodplain

Municipality	Total Area	Area Flooded	% Flooded
San Pablo	184.81	2.992	1.62%
Padre Garcia	39.28	2.41	6.12%
Sariaya	213.78	8.94	4.18%
San Juan	237.55	32.099	13.51%
Tiaong	118.93	20.22	17.00%
Alaminos	59.65	0.66	1.11%
Dolores	65.96	0.66	1.01%
Candelaria	136.74	11.028	8.07%
Rosario	199.04	7.96	4.00%
San Antonio	62.38	5.70	9.14%

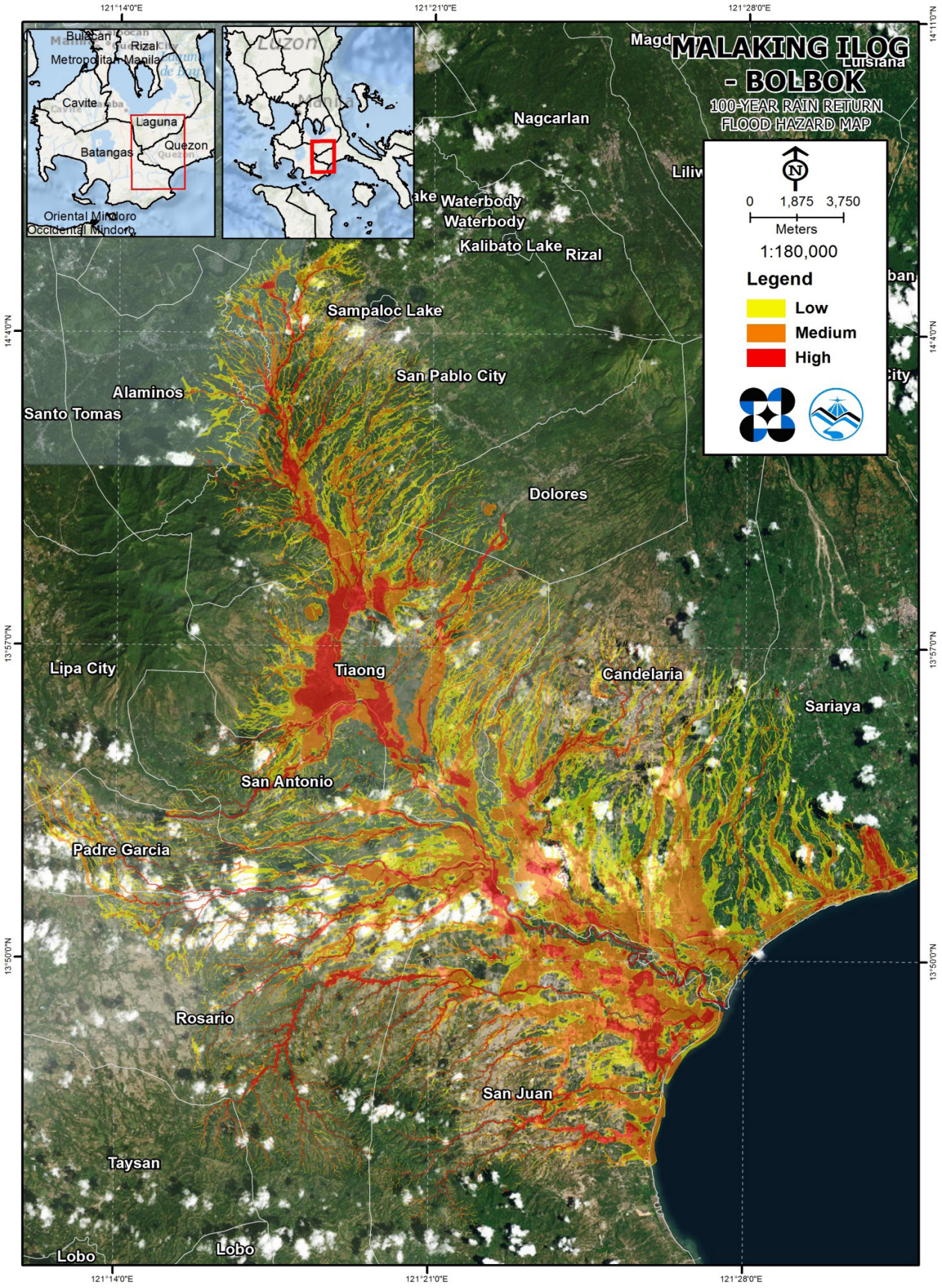


Figure 66. 100-year Hazard Map for Malaking Ilog-Bolbok Floodplain

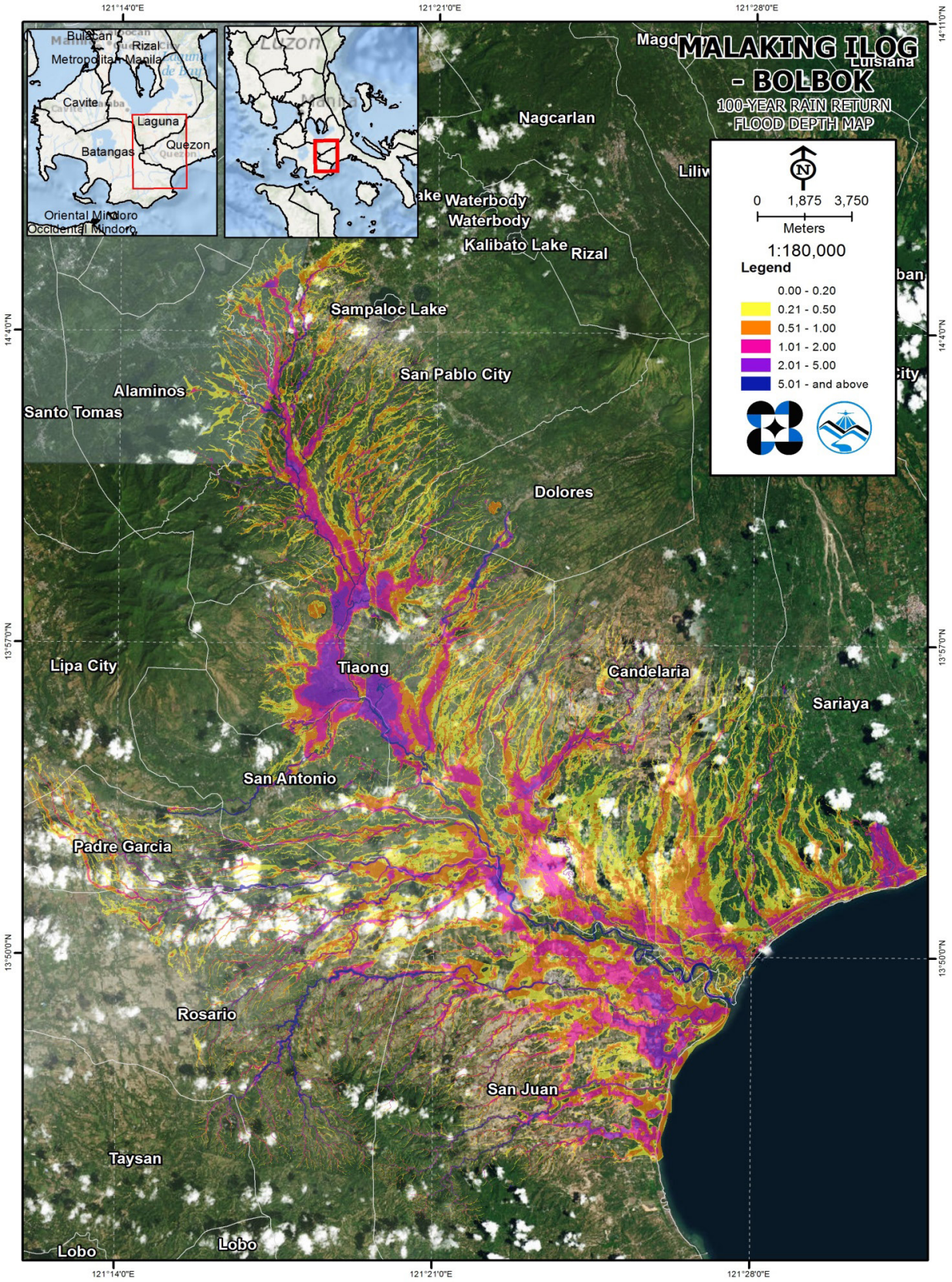


Figure 67. 100-year Flow Depth Map for Malaking Ilog-Bolbok Floodplain

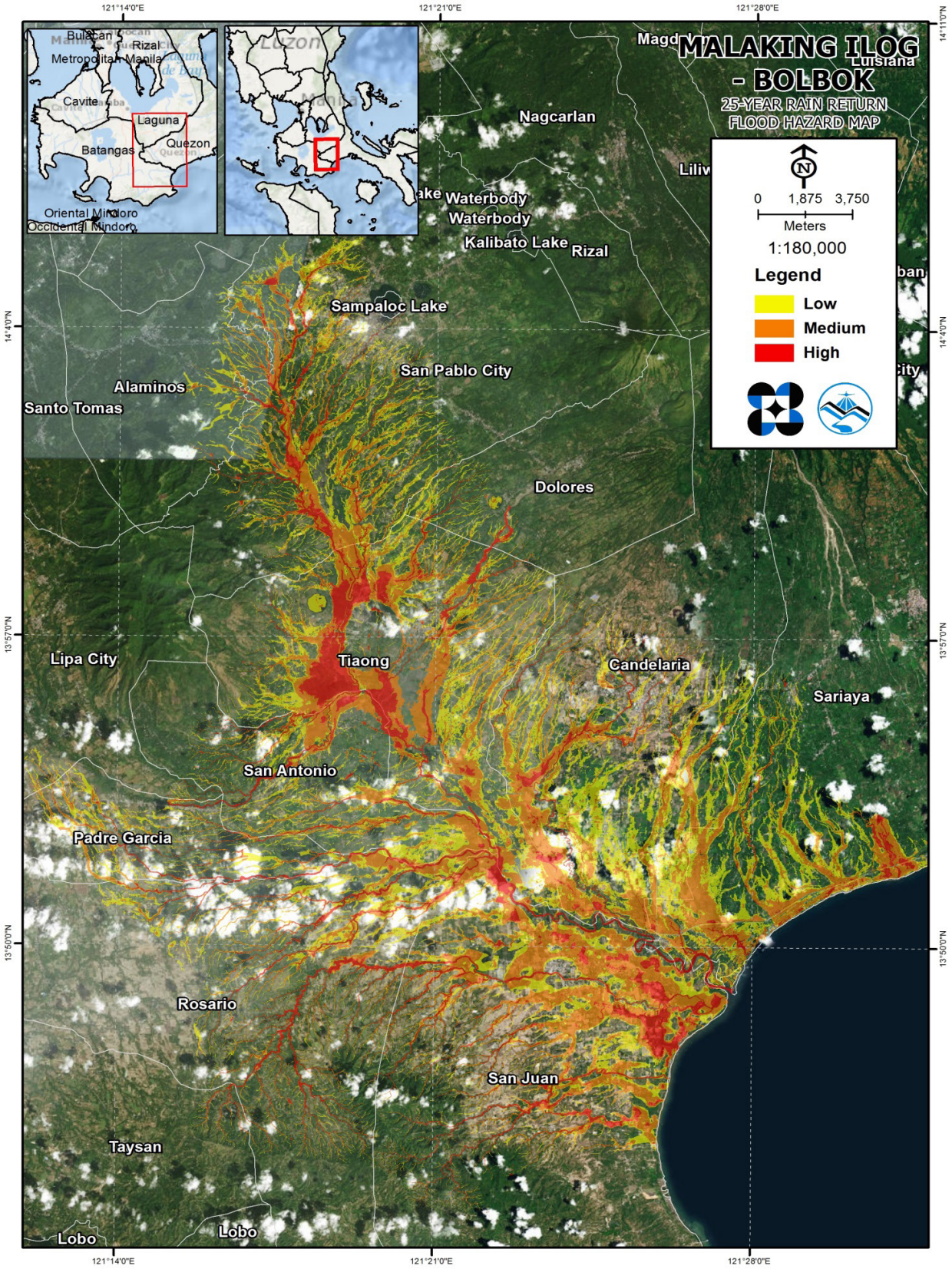


Figure 68. 25-year Hazard Map for Malaking Ilog-Bolbok Floodplain

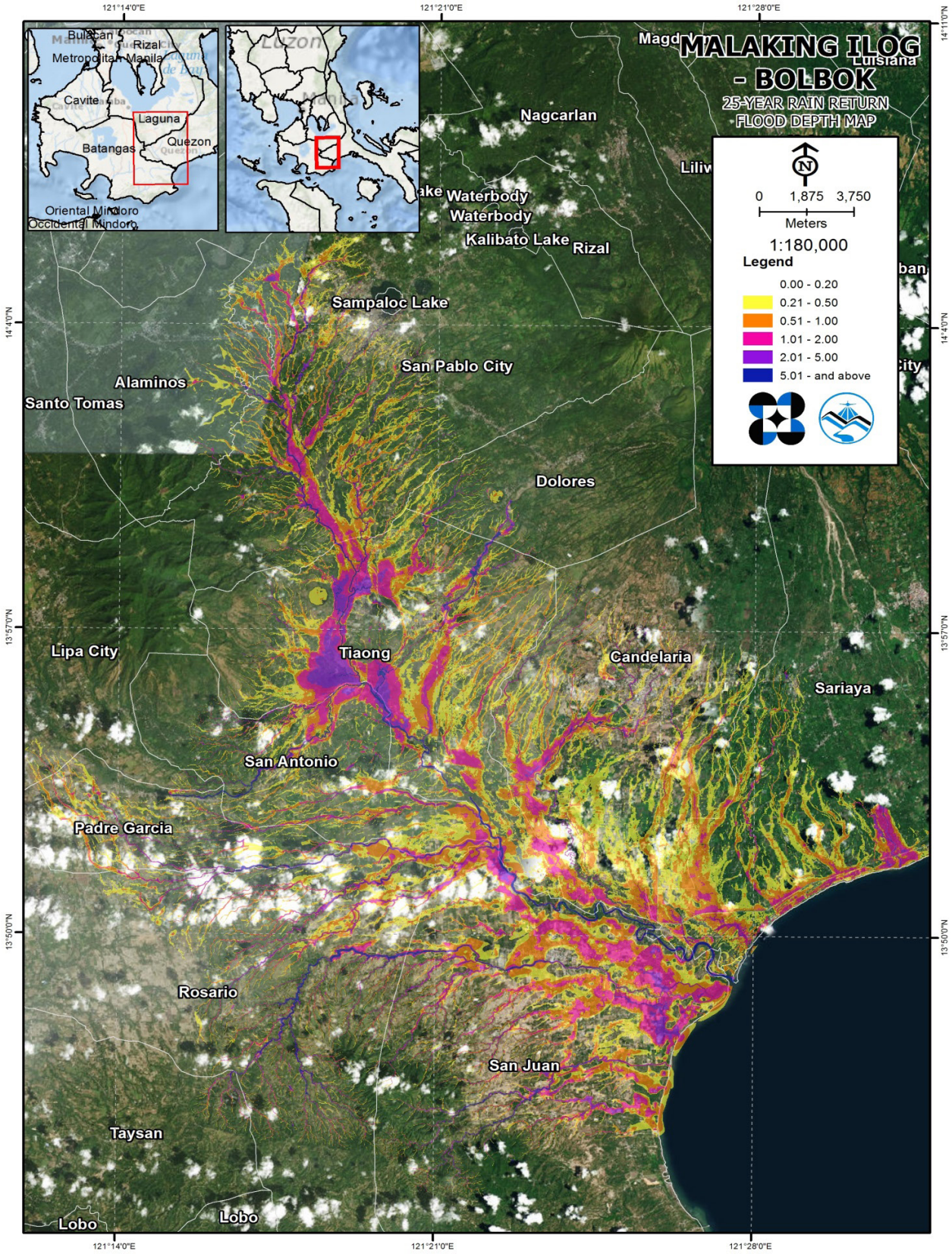


Figure 69. 25-year Flow Depth Map for Malaking Ilog-Bolbok Floodplain

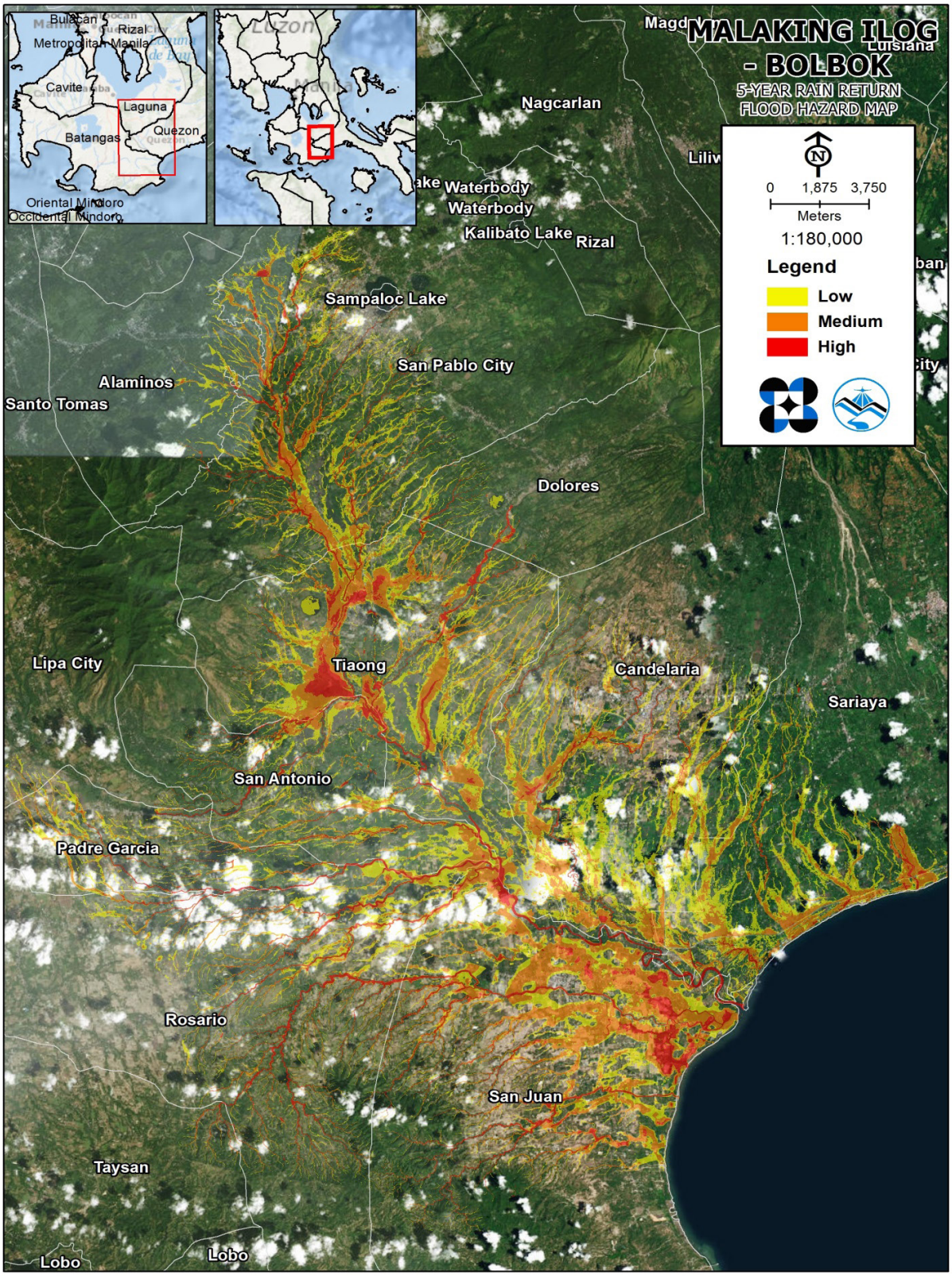


Figure 70. 5-year Hazard Map for Malaking Ilog-Bolbok Floodplain

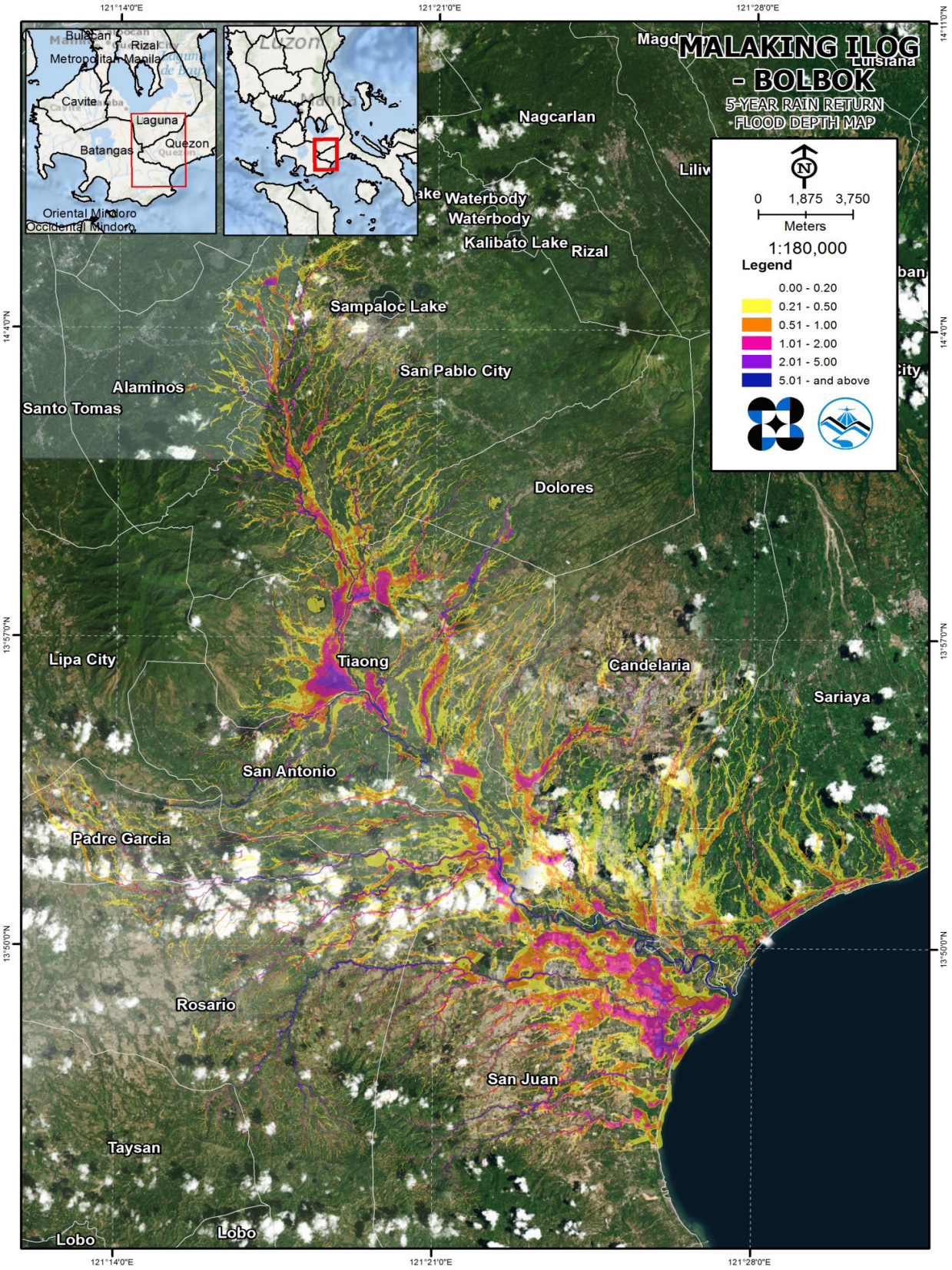


Figure 71. 5-year Flow Depth Map for Malaking Ilog-Bolbok Floodplain

5.10 Inventory of Areas Exposed to Flooding of Affected Areas

Listed below are the barangays affected by the Malaking-Ilog and Bolbok River Basins, grouped accordingly by municipality. For the said basin, ten (10) municipalities consisting of 228 barangays are expected to experience flooding when subjected to a 5-year rainfall return period.

For the 5-year return period, 2.70% of the municipality of San Pablo City with an area of 184.81 sq. km. will experience flood levels of less than 0.20 meters. 0.40% of the area will experience flood levels of 0.21 to 0.50 meters while 0.18%, 0.10%, 0.07%, and 0.04% 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 the table are the affected areas in square kilometers by flood depth per barangay.

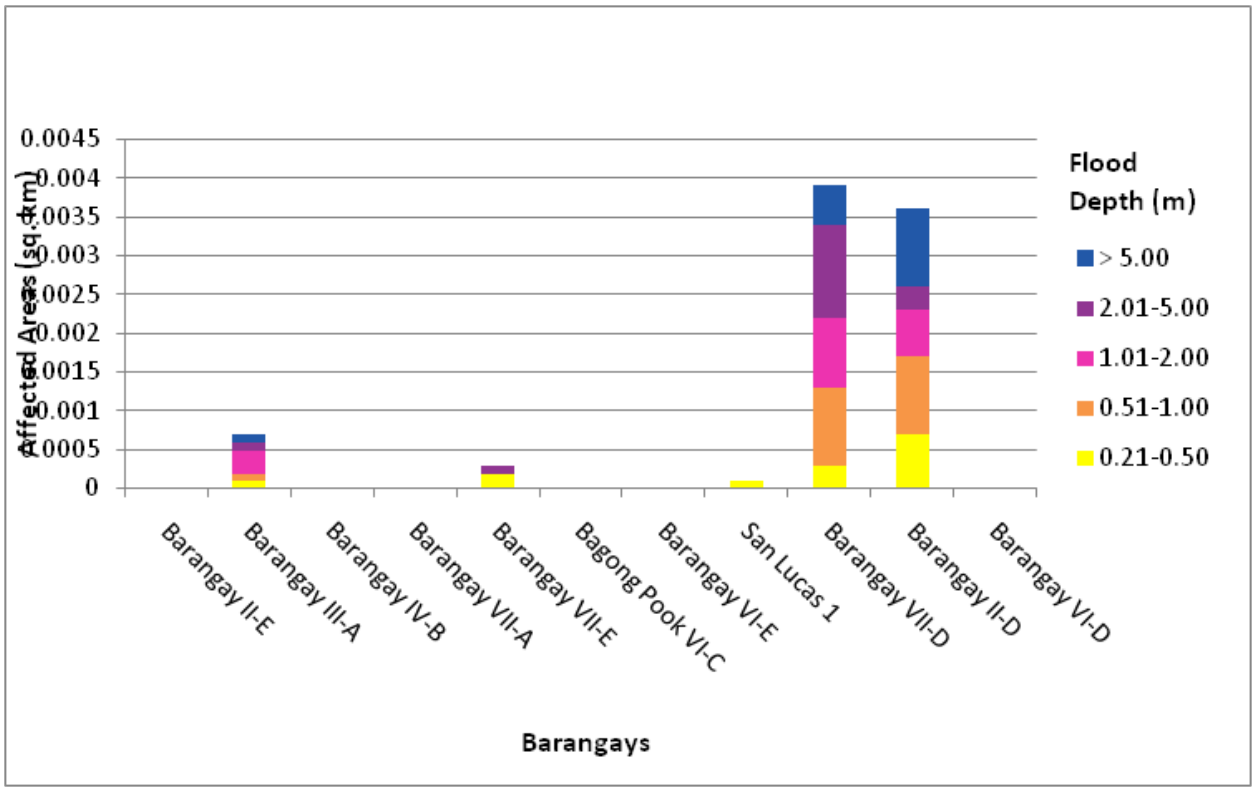
Table 33. Affected areas in San Pablo City, Laguna during a 5-Year Rainfall Return Period.

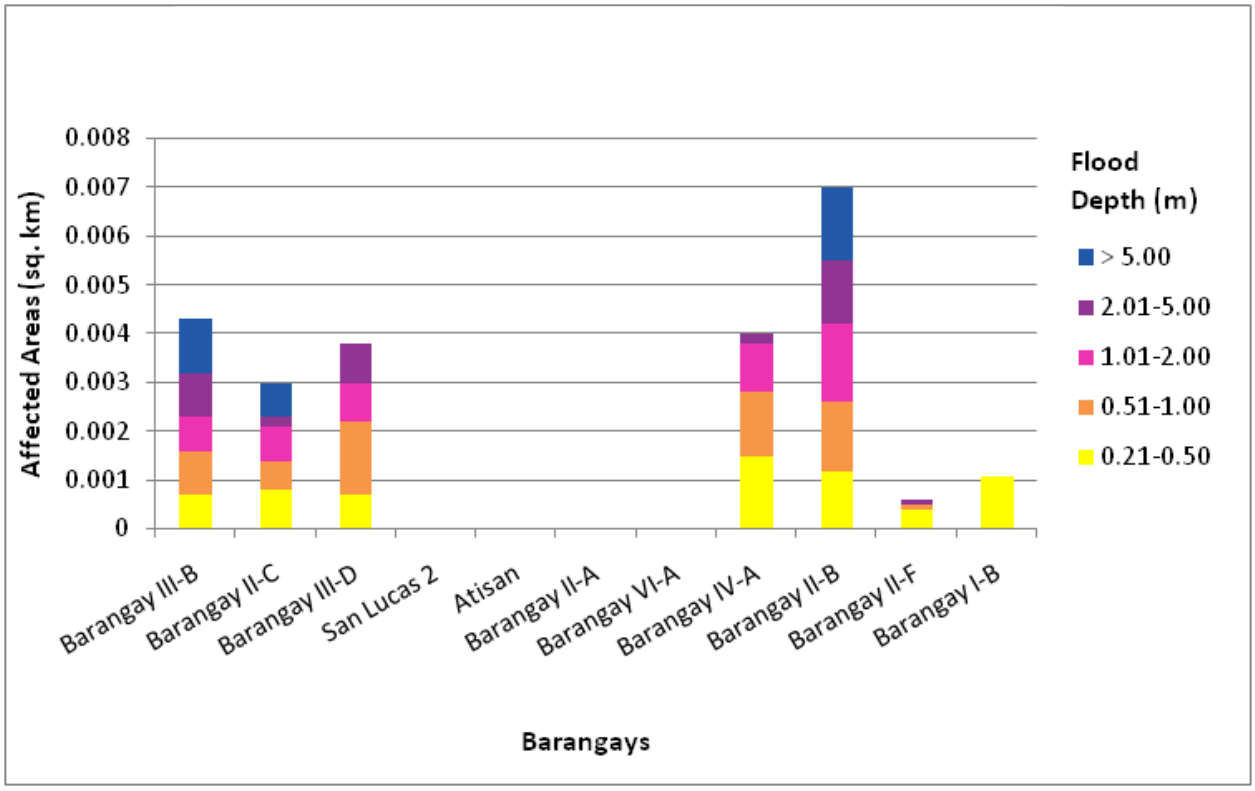
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay II-E	Barangay III-A	Barangay IV-B	Barangay VII-A	Barangay VII-E	Bagong Pook VI-C	Barangay VI-E	San Lucas 1	Barangay VII-D	Barangay II-D	Barangay VI-D
0.03-0.20	0.0012	0.0004	0.0001	0.0009	0.0003	0.0007	0.0004	0.0005	0.0014	0.002	0.0036
0.21-0.50	0	0.0001	0	0	0.0002	0	0	0.0001	0.0003	0.0007	0
0.51-1.00	0	0.0001	0	0	0	0	0	0	0.001	0.001	0
1.01-2.00	0	0.0003	0	0	0	0	0	0	0.0009	0.0006	0
2.01-5.00	0	0.0001	0	0	0.0001	0	0	0	0.0012	0.0003	0
> 5.00	0	0.0001	0	0	0	0	0	0	0.0005	0.001	0

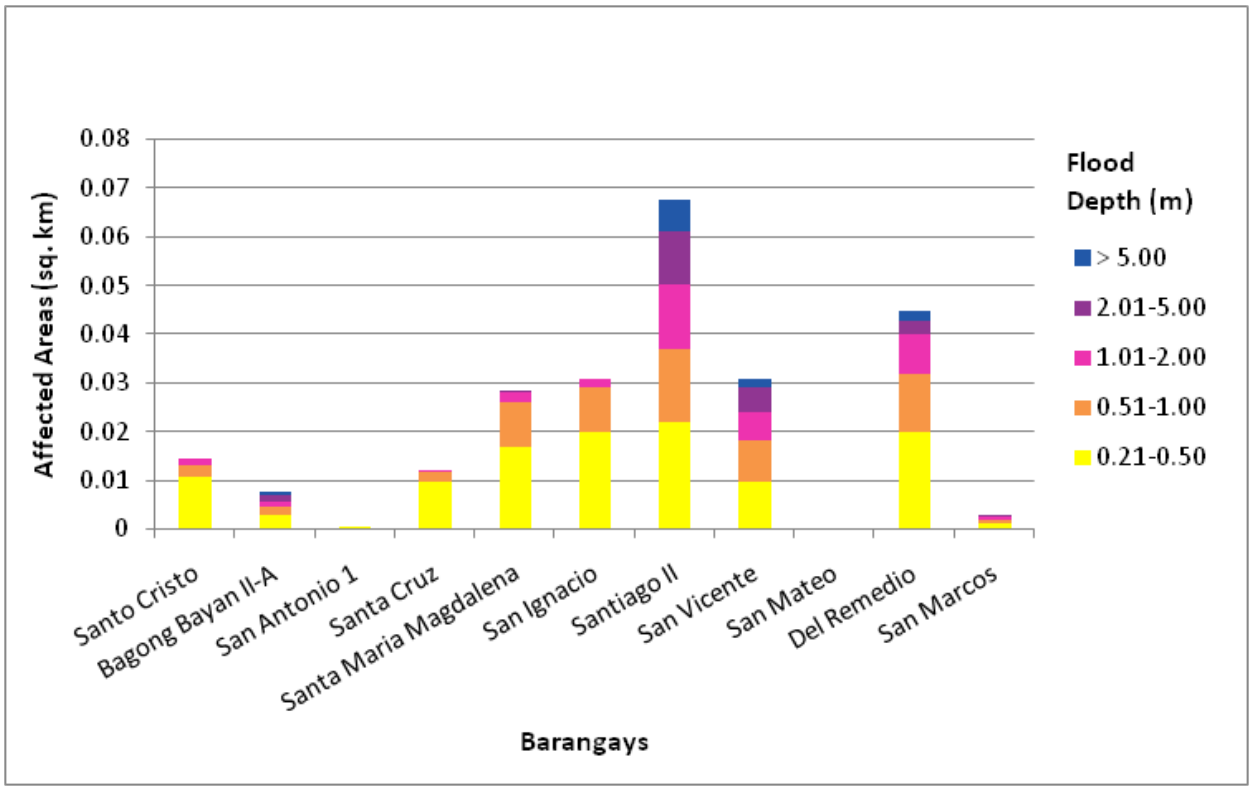
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay III-B	Barangay II-C	Barangay III-D	San Lucas 2	Atisan	Barangay II-A	Barangay VI-A	Barangay IV-A	Barangay II-B	Barangay II-F	Barangay I-B
0.03-0.20	0.001	0.002	0.0025	0.0026	0.0034	0.0068	0.0046	0.0018	0.0066	0.027	0.031
0.21-0.50	0.0007	0.0008	0.0007	0	0	0	0	0.0015	0.0012	0.0004	0.0011
0.51-1.00	0.0009	0.0006	0.0015	0	0	0	0	0.0013	0.0014	0.0001	0
1.01-2.00	0.0007	0.0007	0.0008	0	0	0	0	0.001	0.0016	0	0
2.01-5.00	0.0009	0.0002	0.0008	0	0	0	0	0.0002	0.0013	0.0001	0
> 5.00	0.0011	0.0007	0	0	0	0	0	0	0.0015	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santo Cristo	Bagong Bayan II-A	San Antonio 1	Santa Cruz	Santa Maria Magdalena	San Ignacio	Santiago II	San Vicente	San Mateo	Del Remedio	San Marcos
0.03-0.20	0.026	0.065	0.08	0.066	0.094	0.097	0.078	0.11	0.12	0.14	0.22
0.21-0.50	0.011	0.003	0.0004	0.0099	0.017	0.02	0.022	0.0097	0.0001	0.02	0.0015
0.51-1.00	0.0022	0.0019	0	0.0021	0.0091	0.0093	0.015	0.0085	0	0.012	0.0007
1.01-2.00	0.0013	0.0009	0	0.0002	0.0024	0.0016	0.013	0.0058	0	0.008	0.0007
2.01-5.00	0	0.0012	0	0	0.0001	0	0.011	0.0051	0	0.0028	0.0001
> 5.00	0	0.0009	0	0	0	0	0.0065	0.0019	0	0.0018	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santa Ana	San Francisco	San Gabriel	San Gregorio	San Antonio 2	San Juan	San Roque	Santa Monica	San Rafael	Soledad	Santa Felomina
0.03-0.20	0.38	0.16	0.23	0.3	0.22	0.37	0.37	0.43	0.37	0.64	0.33
0.21-0.50	0.028	0.024	0.015	0.011	0.031	0.05	0.023	0.07	0.15	0.063	0.15
0.51-1.00	0.016	0.024	0.0098	0.0092	0.0047	0.016	0.014	0.051	0.055	0.015	0.043
1.01-2.00	0.014	0.013	0.009	0.0095	0.0014	0.015	0.0072	0.039	0.023	0.009	0
2.01-5.00	0.0082	0.0045	0.0064	0.0069	0.0001	0.013	0.0009	0.031	0.017	0.0083	0
> 5.00	0.0014	0.0028	0.0062	0.0061	0	0.008	0	0.018	0.016	0.0074	0


0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Affected Areas (sq. km)
Barangay II-E
Barangay III-A
Barangay IV-B
Barangay VII-A
Barangay VII-E
Bagong Pook VI-C
Barangay VI-E
San Lucas 1
Barangay VII-D
Barangay II-D
Barangay VI-D
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Affected Areas (sq. km)
Barangay III-B
Barangay II-C
Barangay III-D
San Lucas 2
Atisan
Barangay II-A
Barangay VI-A
Barangay IV-A
Barangay II-B
Barangay II-F
Barangay I-B
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50



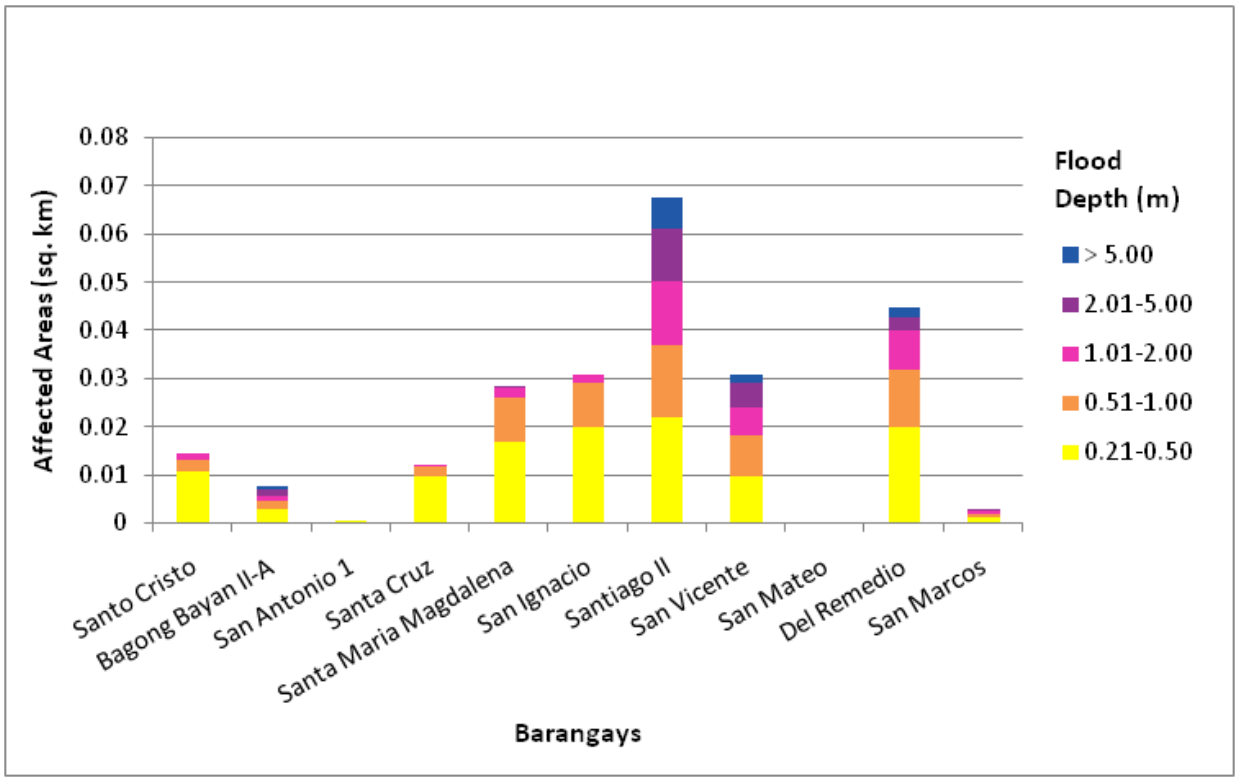


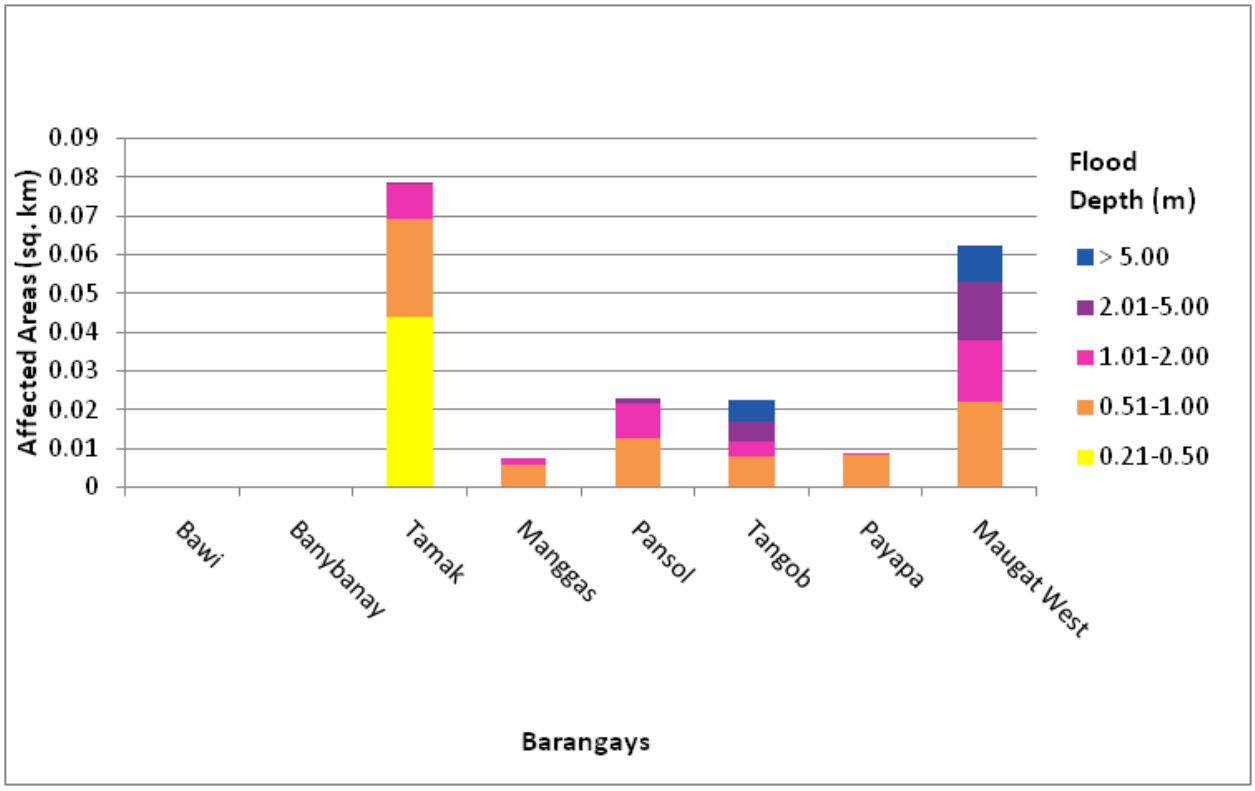
Figure 72. Affected areas in San Pablo City, Laguna during a 5-Year Rainfall Return Period.

For the 5-year return period, 8.02% of the municipality of Padre Garcia with an area of 39.28 sq. km. will experience flood levels of less than 0.20 meters. 1.32% of the area will experience flood levels of 0.21 to 0.50 meters while 0.58%, 0.34%, 0.21%, and 0.14% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 34. Affected areas in Padre Garcia, Batangas during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)							
	Bawi	Banybanay	Tamak	Manggas	Pansol	Tangob	Payapa	Maugat West
0.03-0.20	0.0077	0	0.053	0.12	0.14	0.16	0.19	0.19
0.21-0.50	0.0004	0	0.044	0.0077	0.018	0.024	0.0089	0.046
0.51-1.00	0	0	0.025	0.006	0.013	0.008	0.0084	0.022
1.01-2.00	0	0	0.0094	0.0016	0.0087	0.0038	0.0004	0.016
2.01-5.00	0	0	0.0002	0	0.0015	0.0053	0	0.015
> 5.00	0	0	0	0	0	0.0053	0	0.0092

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)							
	Bawi	Banybanay	Tamak	Manggas	Pansol	Tangob	Payapa	Maugat West
0.03-0.20	0.0077	0	0.053	0.12	0.14	0.16	0.19	0.19
0.21-0.50	0.0004	0	0.044	0.0077	0.018	0.024	0.0089	0.046
0.51-1.00	0	0	0.025	0.006	0.013	0.008	0.0084	0.022
1.01-2.00	0	0	0.0094	0.0016	0.0087	0.0038	0.0004	0.016
2.01-5.00	0	0	0.0002	0	0.0015	0.0053	0	0.015
> 5.00	0	0	0	0	0	0.0053	0	0.0092



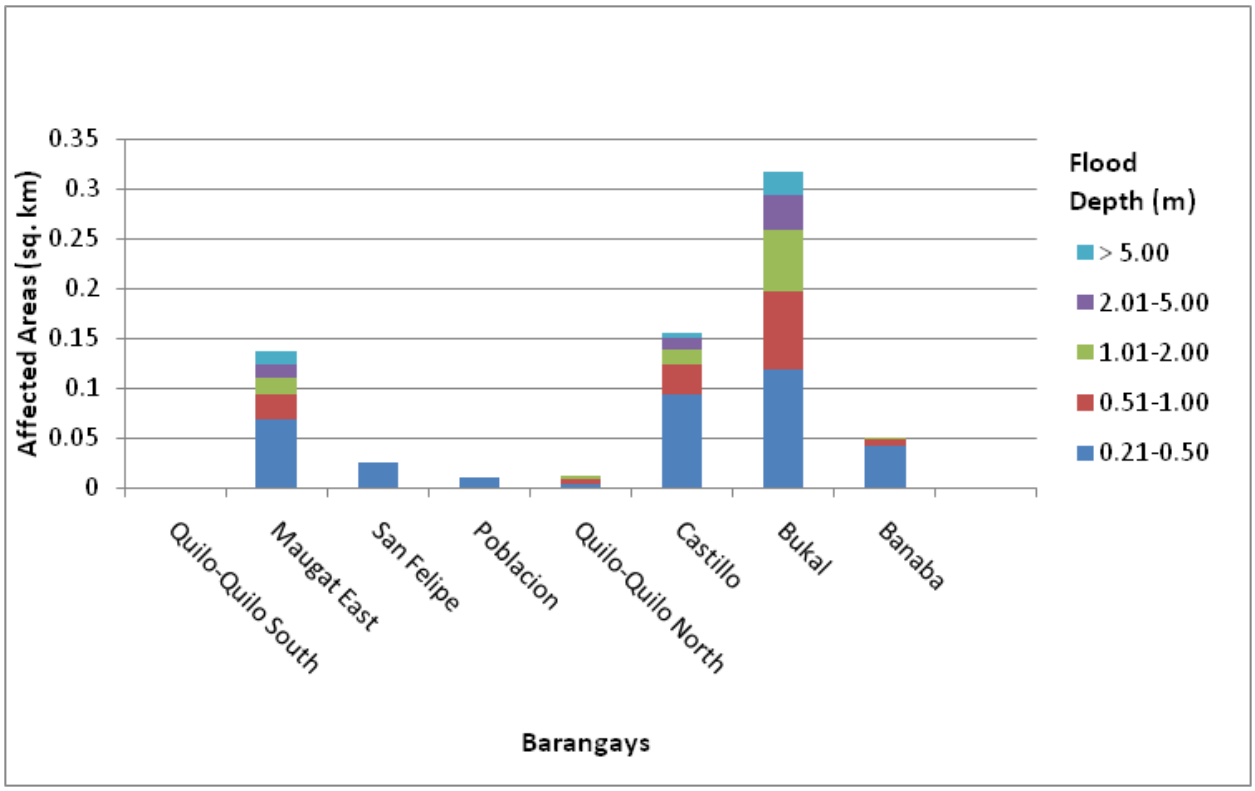


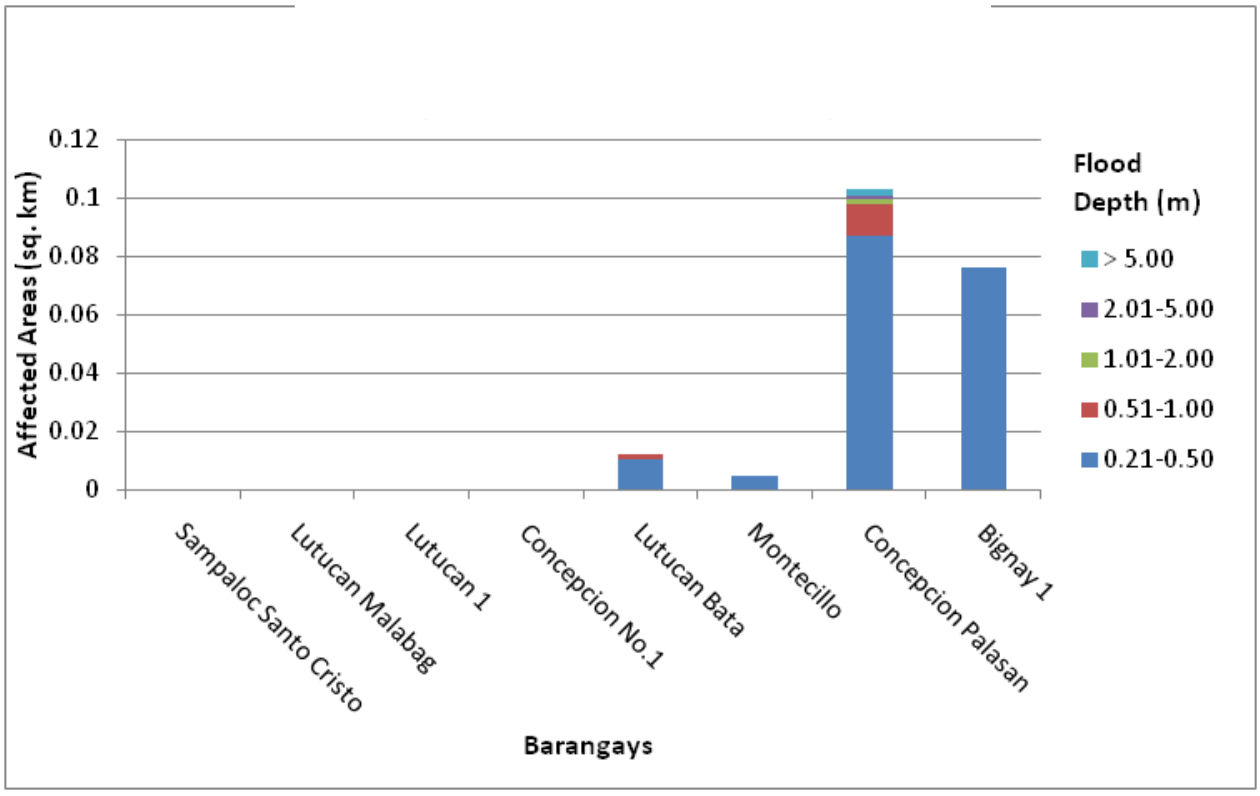
Figure 73. Affected areas in Padre Garcia, Batangas during a 5-Year Rainfall Return Period.

For the 5-year return period, 41.78% of the municipality of Sariaya with an area of 213.78 sq. km. will experience flood levels of less than 0.20 meters. 6.40% of the area will experience flood levels of 0.21 to 0.50 meters while 0.91%, 0.24%, 0.11%, and 0.25% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 35. Affected areas in Sariaya, Quezon during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)							
	Sampaloc Santo Cristo	Lutucan Malabag	Lutucan 1	Concep-cion No.1	Lutucan Bata	Montecillo	Concepcion Palasan	Bignay 1
0.03-0.20	0.001	0.029	0.01	0	0.21	0.52	0.9	1.29
0.21-0.50	0	0	0	0	0.011	0.0054	0.087	0.076
0.51-1.00	0	0	0	0	0.0013	0	0.011	0
1.01-2.00	0	0	0	0	0	0	0.0013	0
2.01-5.00	0	0	0	0	0	0	0.0011	0
> 5.00	0	0	0	0	0	0	0.0028	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)						
	Mang-galang 1	Mang-galang-Kil-ing	Guis-guis-Talon	Mang-galang Tulo-Tulo	Mang-galang-Ban-tilan	Guis-guis-San Roque	Bignay 2
0.03-0.20	1.49	1.27	1.22	2.68	2.96	1.12	2.71
0.21-0.50	0.17	0.25	0.3	0.064	0.44	0.95	0.16
0.51-1.00	0.037	0.045	0.024	0.0002	0.098	0.14	0.0019
1.01-2.00	0.0048	0.0019	0.0022	0	0.03	0.053	0
2.01-5.00	0	0.0005	0.0001	0	0.018	0.023	0
> 5.00	0	0.0086	0	0	0.075	0.01	0



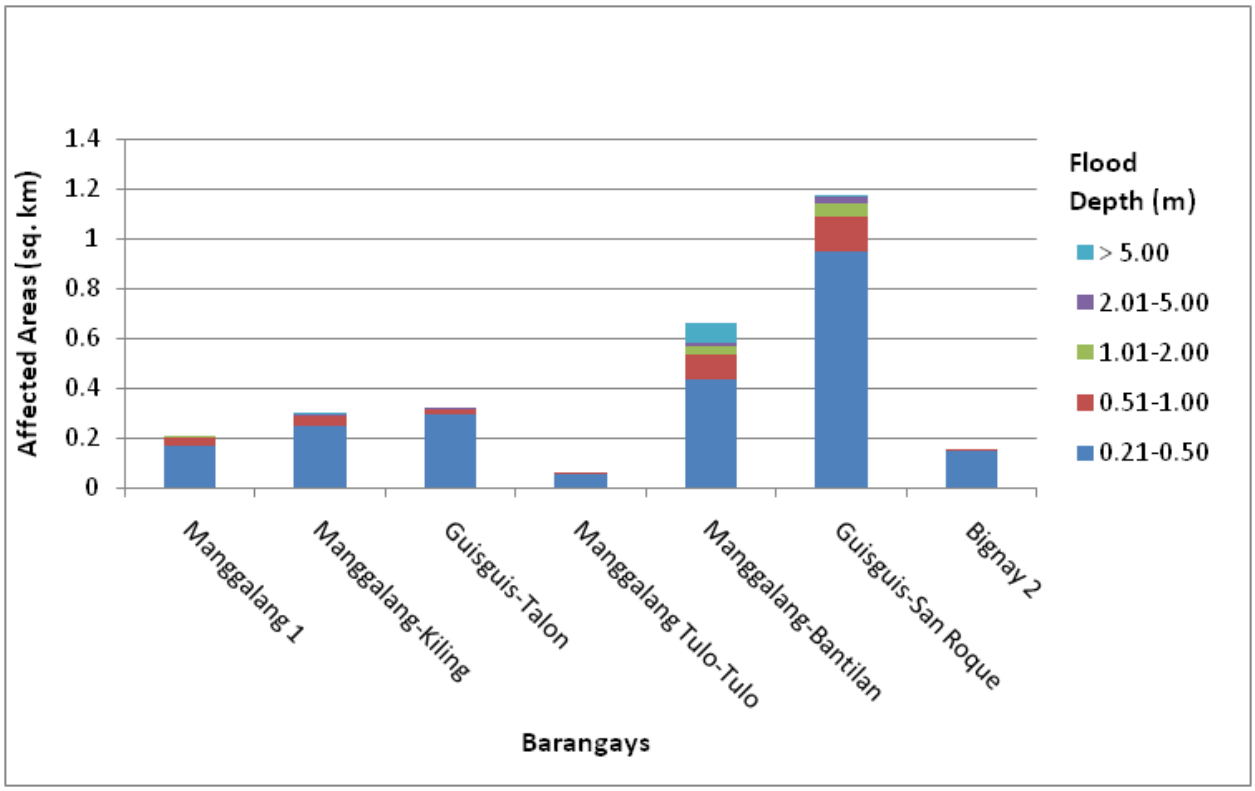


Figure 74. Affected areas in Sariaya, Quezon during a 5-Year Rainfall Return Period.

For the 5-year return period, 12.77% of the municipality of San Juan with an area of 237.55 sq. km. will experience flood levels of less than 0.20 meters. 4.08% of the area will experience flood levels of 0.21 to 0.50 meters while 0.91%, 0.33%, 0.16%, and 0.16% 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 the table are the affected areas in square kilometers by flood depth per barangay.

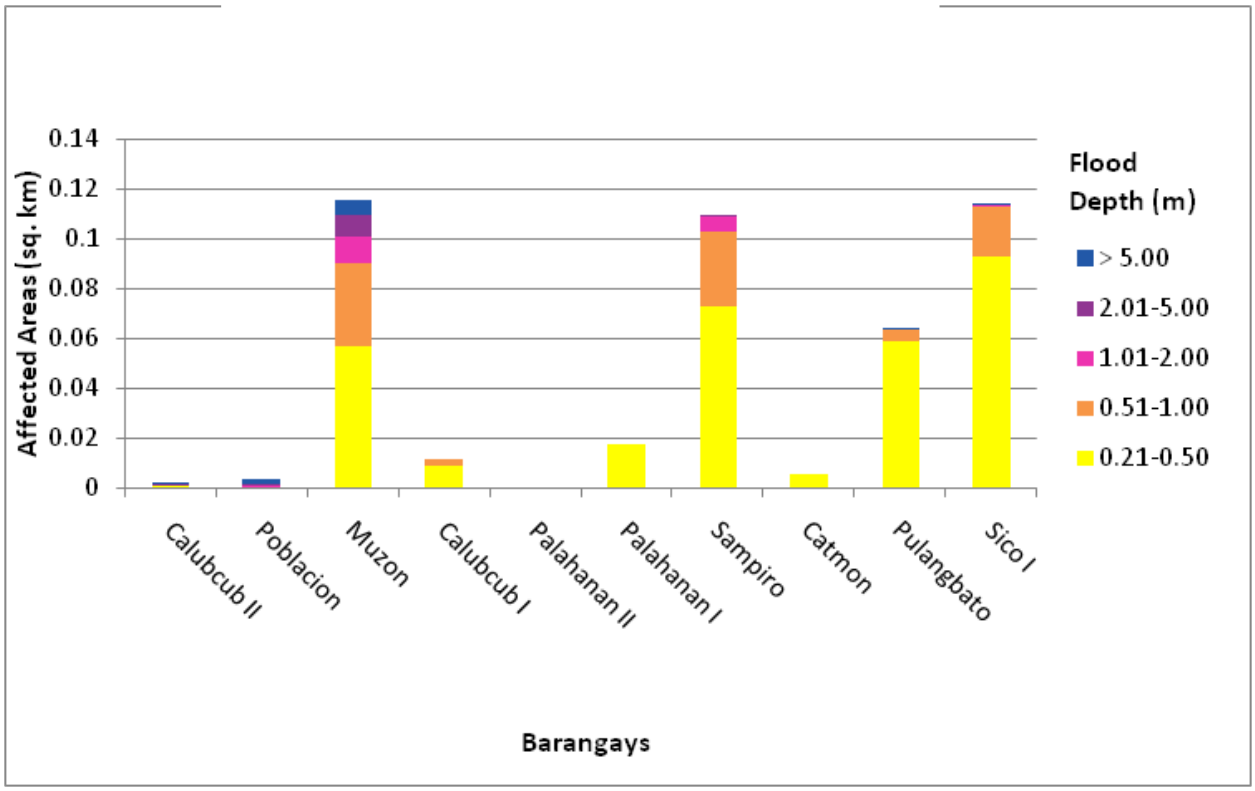
Table 36. Affected areas in San Juan, Batangas during a 5-Year Rainfall Return Period.

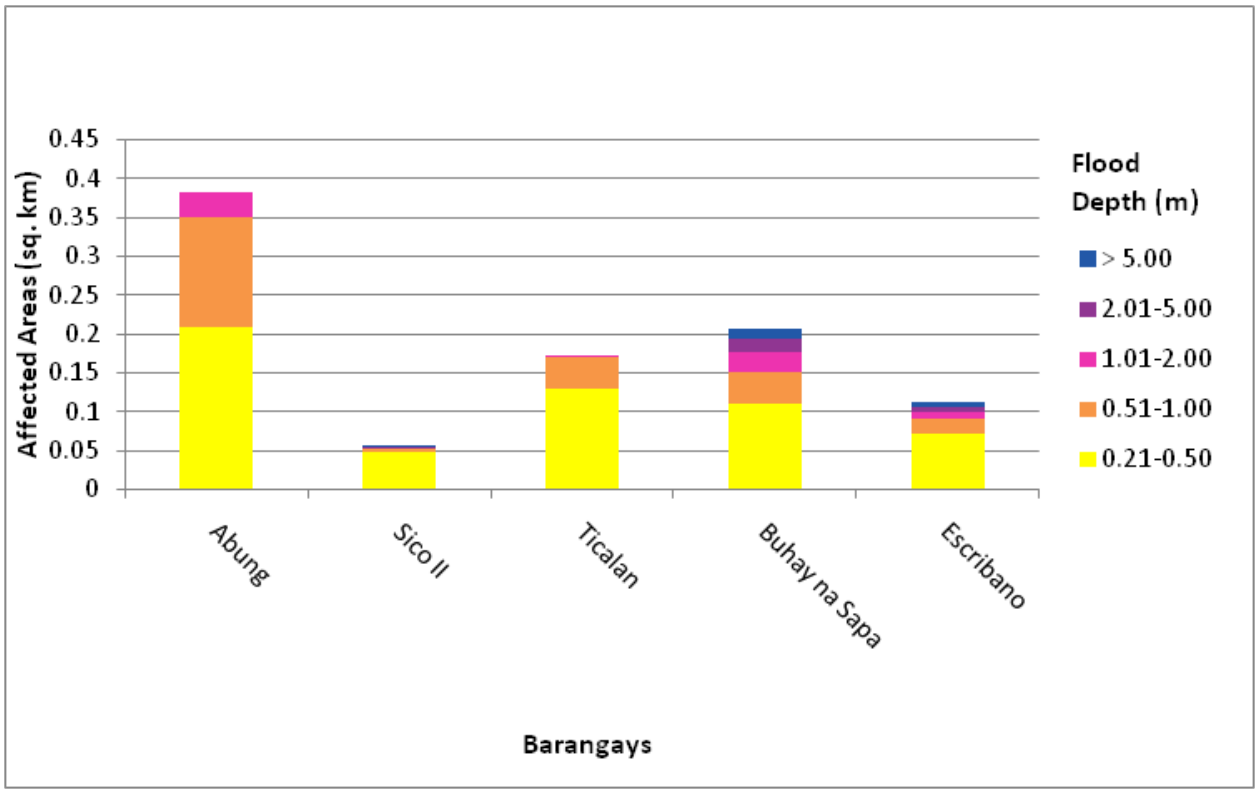
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Calub-cub II	Pobla-cion	Muzon	Calub-cub I	Palahan-an II	Palahan-an I	Sampiro	Catmon	Pulang-bato	Sico I
0.03-0.20	0.0099	0.02	0.062	0.24	0.12	0.17	0.15	0.23	0.27	0.59
0.21-0.50	0.0012	0.0005	0.057	0.0095	0.0004	0.018	0.073	0.0056	0.059	0.093
0.51-1.00	0.0008	0.0007	0.033	0.0022	0	0	0.03	0	0.0052	0.02
1.01-2.00	0.0001	0.0004	0.011	0	0	0	0.0055	0	0.0001	0.0004
2.01-5.00	0.0002	0.0006	0.0088	0	0	0	0.0008	0	0	0.0004
> 5.00	0.0002	0.0019	0.0057	0	0	0	0	0	0.0001	0.0003

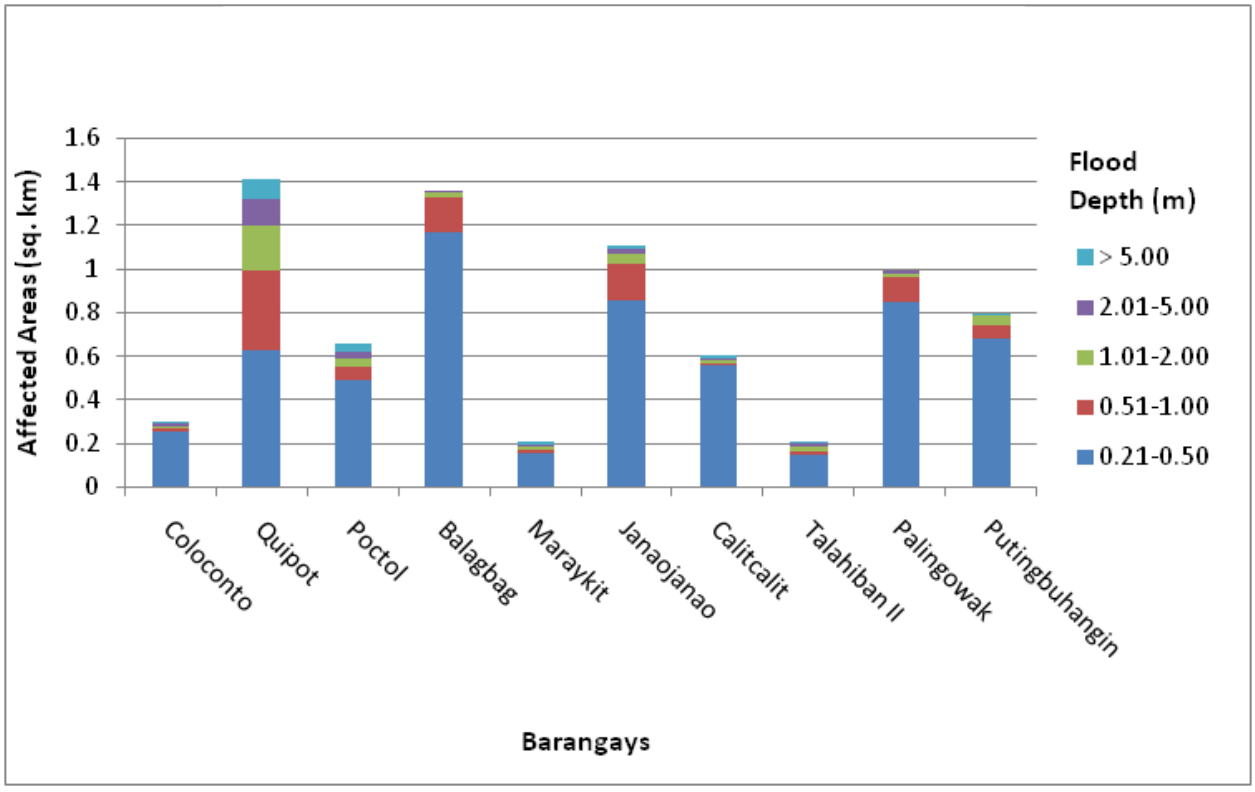
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Abung	Sico II	Ticalan	Buhay na Sapa	Escriba-no	Sapan-gan	Mabala-noy	Pinag-bayanan	Libato	Tipaz
0.03-0.20	0.28	0.81	0.65	0.79	0.67	0.78	0.84	1.07	1.59	0.88
0.21-0.50	0.21	0.05	0.13	0.11	0.073	0.29	0.025	0.88	0.4	0.53
0.51-1.00	0.14	0.0038	0.042	0.042	0.019	0.096	0.011	0.33	0.21	0.11
1.01-2.00	0.032	0.0016	0.0016	0.026	0.0078	0.03	0.011	0.028	0.11	0.057
2.01-5.00	0	0.0011	0	0.016	0.0073	0.0057	0.011	0	0.053	0.038
> 5.00	0	0.0005	0	0.012	0.0065	0.0003	0.014	0	0.027	0.011

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Colocon-to	Quipot	Poctol	Balag-bag	Maraykit	Janao-janao	Calitcalit	Tala-hiban II	Palin-gowak	Putingbu-hangin
0.03-0.20	1.23	1.47	1.67	1.16	1.42	1.6	1.16	1.56	1.37	3.04
0.21-0.50	0.26	0.63	0.49	1.17	0.16	0.86	0.56	0.15	0.85	0.68
0.51-1.00	0.013	0.36	0.067	0.16	0.013	0.16	0.011	0.02	0.11	0.065
1.01-2.00	0.0099	0.21	0.033	0.023	0.013	0.046	0.011	0.017	0.028	0.049
2.01-5.00	0.0094	0.12	0.029	0.0022	0.013	0.025	0.01	0.017	0.0016	0.0018
> 5.00	0.0077	0.094	0.04	0	0.012	0.019	0.012	0.0056	0	0.0001

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)	
	Talahiban I	Lipahan
0.03-0.20	2.21	2.22
0.21-0.50	0.39	0.48
0.51-1.00	0.075	0.011
1.01-2.00	0.01	0.0097
2.01-5.00	0.001	0.01
> 5.00	0	0.1




0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Affected Areas (sq. km)
Abung
Sico II
Ticalan
Buhay na Sapa
Escribano
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Affected Areas (sq. km)
Coloconto
Quipot
Poctol
Balagbag
Maraykit
Janaojanao
Calitcalit
Talahiban II
Palingowak
Putingbuhangin
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

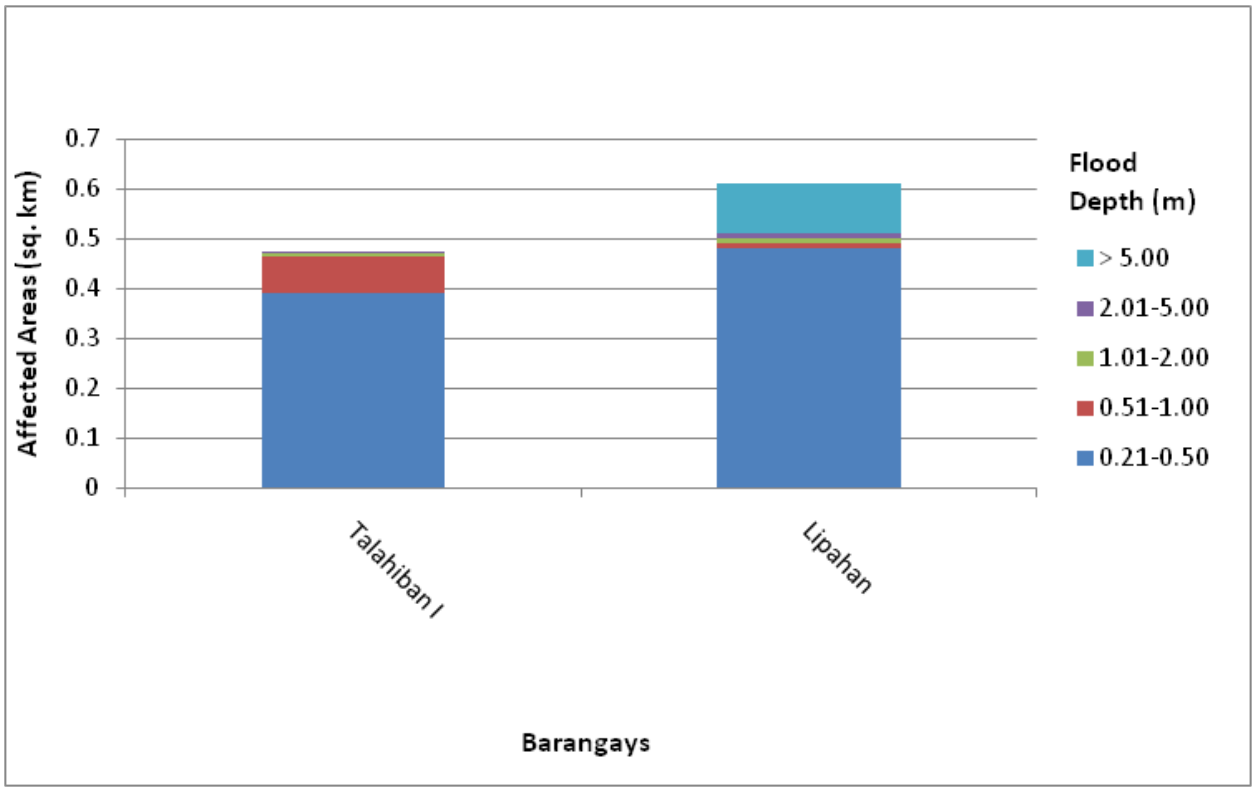


Figure 75. Affected areas in San Juan, Batangas during a 5-Year Rainfall Return Period.

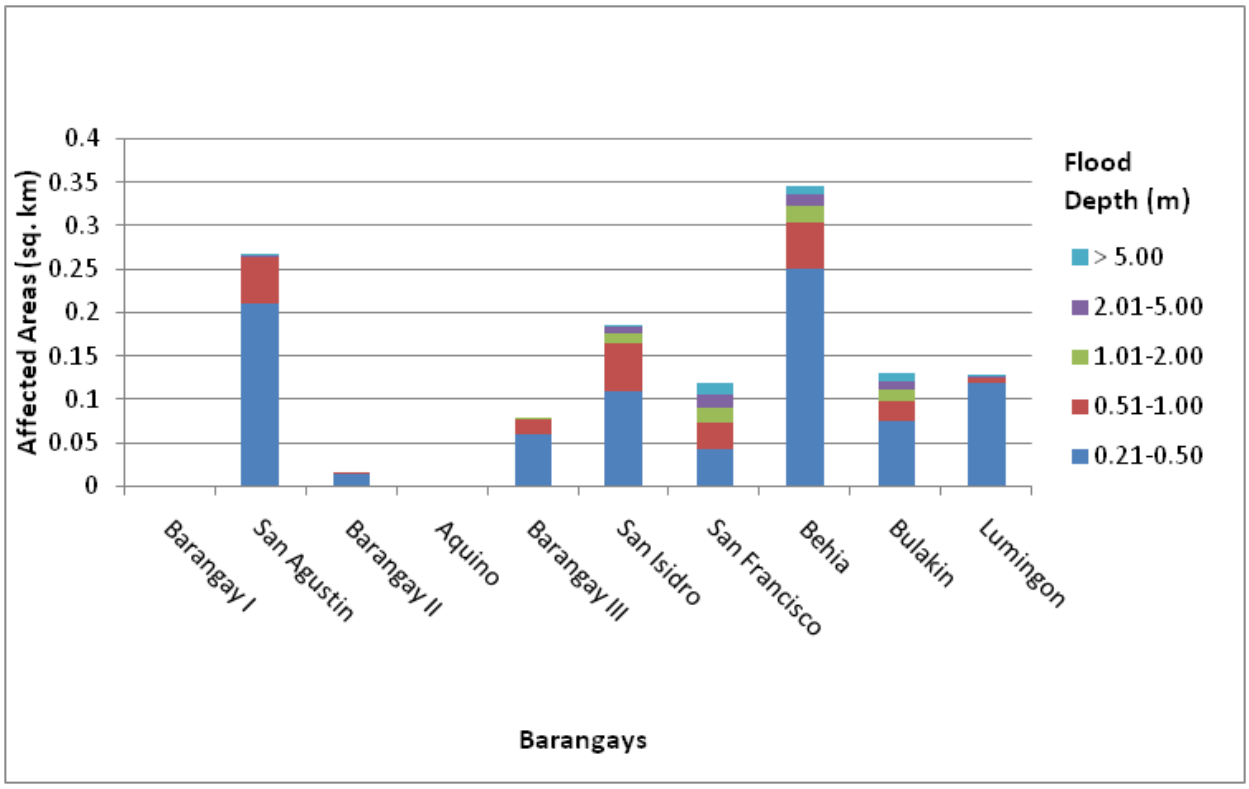
For the 5-year return period, 10.23% of the municipality of Tiaong with an area of 118.93 sq. km. will experience flood levels of less than 0.20 meters. 3.19% of the area will experience flood levels of 0.21 to 0.50 meters while 1.37%, 0.59%, 0.17%, and 0.11% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

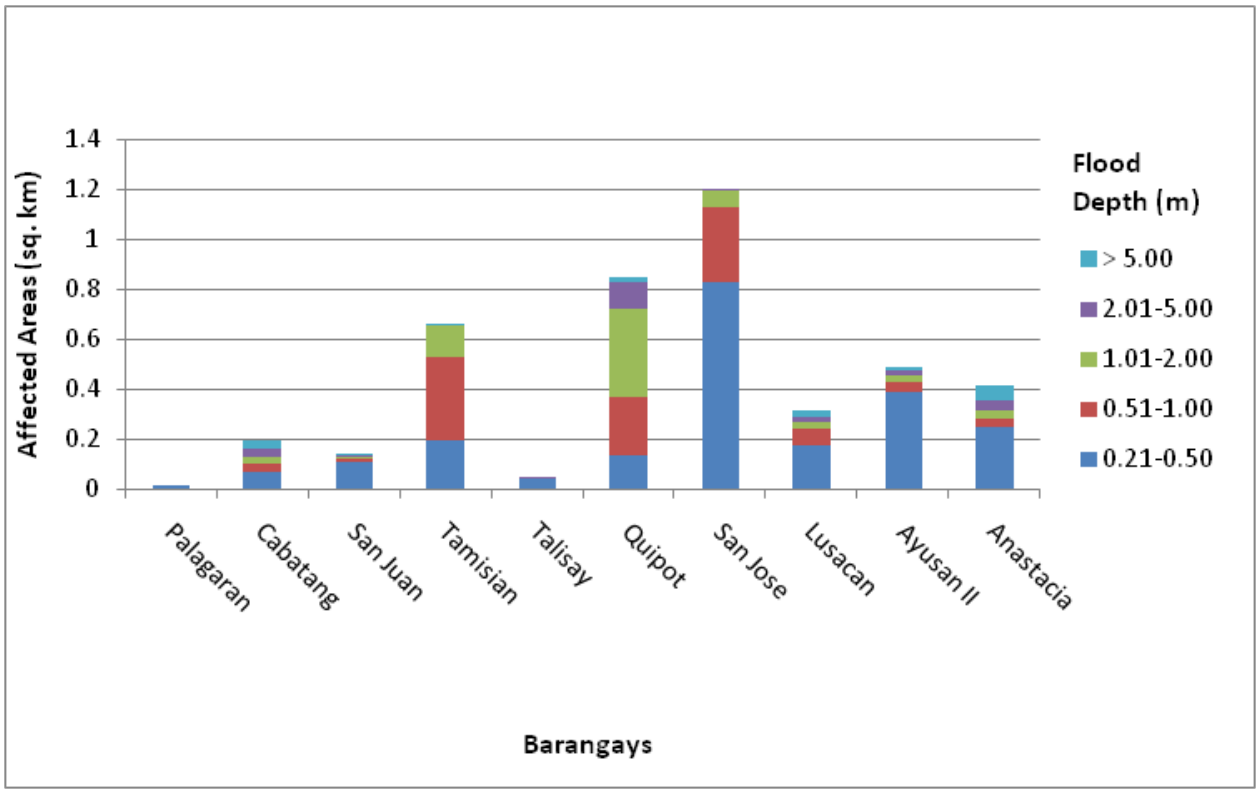
Table 37. Affected areas in Tiaong. Quezon during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Baran-gay I	San Agustin	Barangay II	Aquino	Barangay III	San Isidro	San Fran-cisco	Behia	Bulakin	Lumin-gon
0.03-0.20	0.012	0.25	0.02	0.043	0.072	0.13	0.5	0.5	0.59	0.37
0.21-0.50	0.0013	0.21	0.016	0.0017	0.06	0.11	0.044	0.25	0.075	0.12
0.51-1.00	0	0.053	0.0008	0.0006	0.018	0.054	0.029	0.054	0.023	0.0043
1.01-2.00	0	0.002	0	0.0003	0.0008	0.013	0.018	0.019	0.014	0.0018
2.01-5.00	0	0.0012	0	0.0001	0	0.0067	0.015	0.012	0.01	0.0017
> 5.00	0	0.0019	0	0	0	0.0019	0.013	0.0095	0.008	0.0012

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Palagaran	Cabatang	San Juan	Tamisian	Talisay	Quipot	San Jose	Lusacan	Ayusan II	Anastacia
0.03-0.20	0.49	0.75	0.72	0.47	1.05	0.29	1.81	1.12	0.78	0.92
0.21-0.50	0.021	0.074	0.11	0.2	0.045	0.14	0.83	0.18	0.39	0.25
0.51-1.00	0	0.033	0.016	0.33	0.0053	0.23	0.3	0.066	0.041	0.037
1.01-2.00	0	0.026	0.0075	0.13	0.0005	0.35	0.071	0.025	0.024	0.029
2.01-5.00	0	0.03	0.0065	0.0039	0.0003	0.11	0.0004	0.022	0.021	0.042
> 5.00	0	0.036	0.0056	0.0002	0	0.019	0	0.025	0.016	0.057

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Paiisa	Bula	Tagbakin	Lagalag	San Pedro	Cabay	Del Rosario	Bukal	Ayusan I	Lalig
0.03-0.20	1.03	0.56	1.49	1.45	0.84	2.18	2.33	0.93	1.13	1.47
0.21-0.50	0.071	0.47	0.2	0.12	0.48	0.29	0.37	0.58	1.01	0.87
0.51-1.00	0.0023	0.22	0.0068	0.02	0.23	0.0015	0.011	0.58	0.65	0.23
1.01-2.00	0.0003	0.079	0.0039	0.0029	0.047	0.0017	0.0063	0.42	0.056	0.048
2.01-5.00	0	0.012	0.0019	0.0028	0.024	0.002	0.0042	0.039	0.022	0.011
> 5.00	0	0.0087	0.0001	0.0028	0.015	0.002	0.0031	0.0098	0.02	0.0084


Affected Areas (sq. km)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Barangay I
San Agustin
Barangay II
Aquino
Barangay III
San Isidro
San Francisco
Behia
Bulakin
Lumingon
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


Affected Areas (sq. km)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Palagaran
Cabatang
San Juan
Tamisian
Talisay
Quipot
San Jose
Lusacan
Ayusan II
Anastacia
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

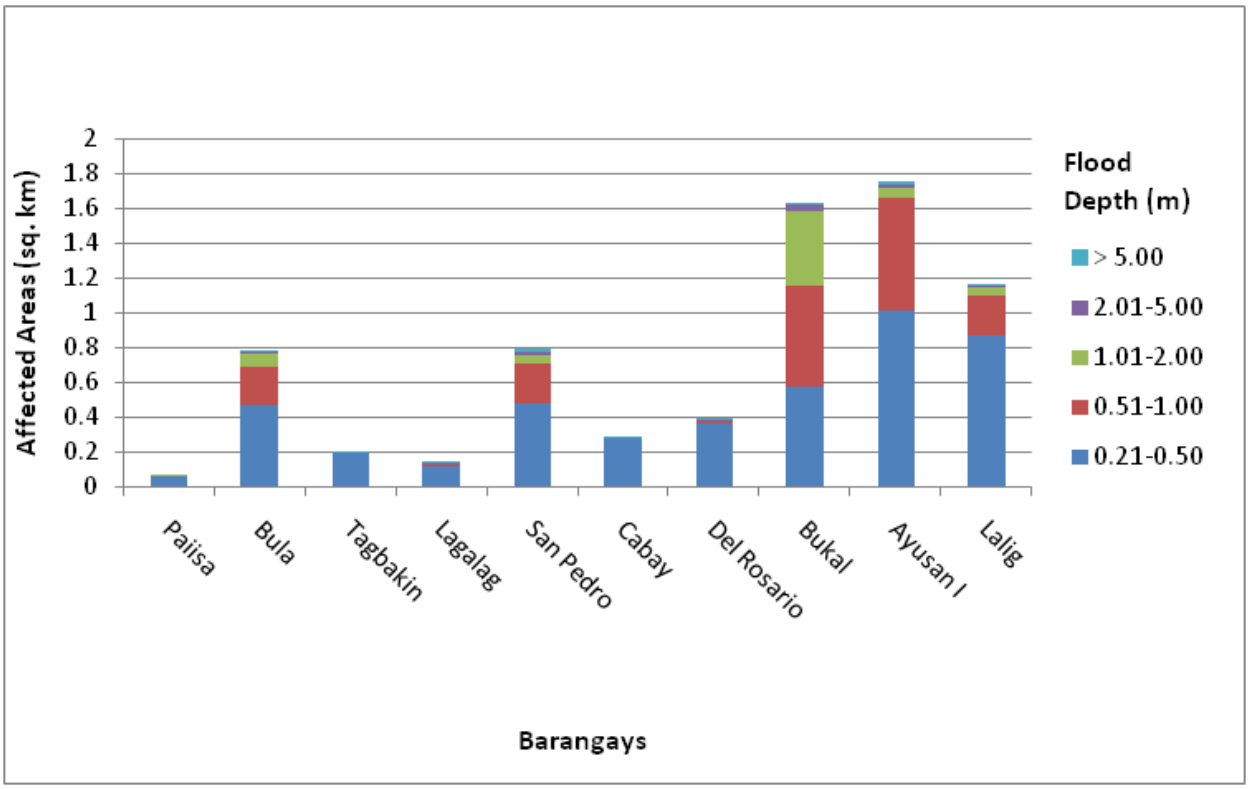


Figure 76. Affected areas in Tiaong. Quezon during a 5-Year Rainfall Return Period.

For the 5-year return period, 1.61% of the municipality of Alaminos with an area of 59.65 sq. km. will experience flood levels of less than 0.20 meters. 0.27% of the area will experience flood levels of 0.21 to 0.50 meters while 0.04%, 0.01%, 0.01%, and 0.01% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 38. Affected areas in Alaminos, Laguna during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Alaminos (in sq. km.)					
	San Miguel	Del Carmen	San Agustin	San Gregorio	San Roque	San Benito
0.03-0.20	0.0058	0.029	0.041	0.085	0.24	0.56
0.21-0.50	0.0006	0	0	0.022	0.019	0.12
0.51-1.00	0	0	0	0.009	0.0079	0.0088
1.01-2.00	0	0	0	0.0024	0.0054	0.0009
2.01-5.00	0	0	0	0	0.0045	0
> 5.00	0	0	0	0	0.0047	0

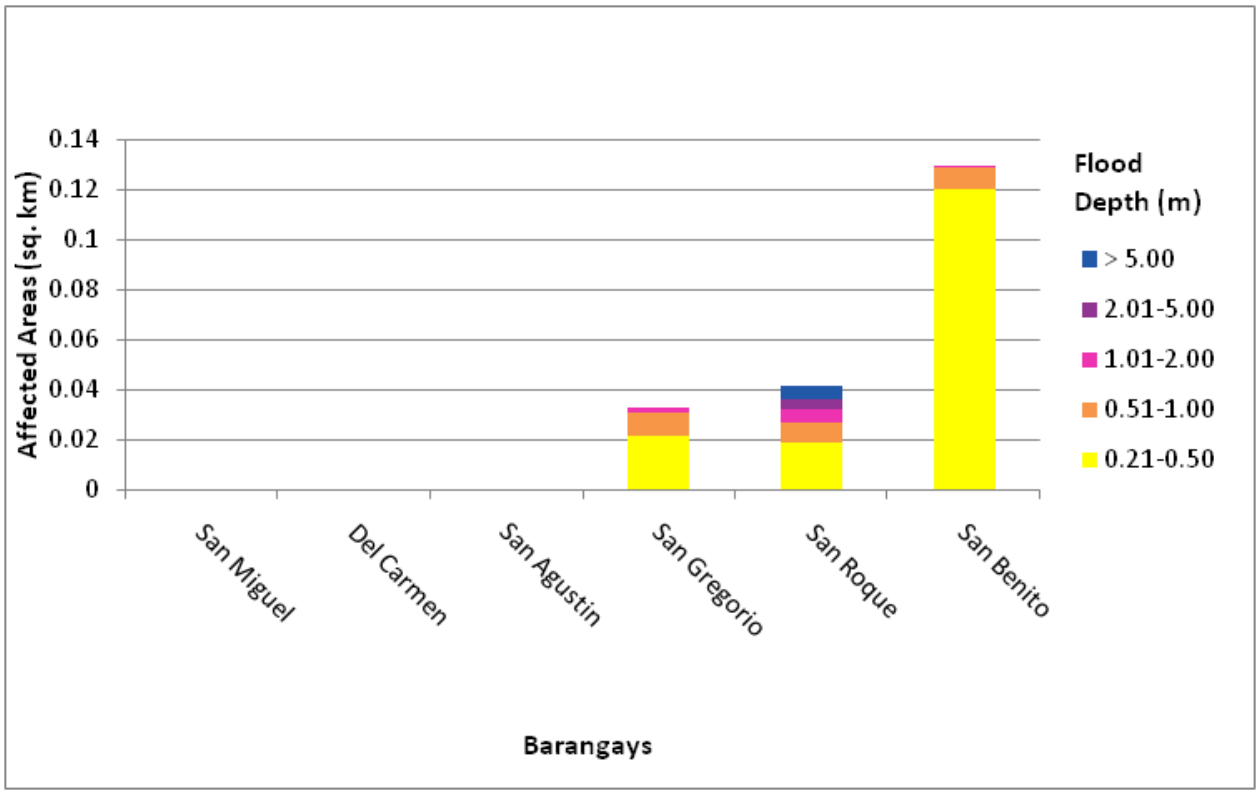


Figure 77. Affected areas in Alaminos, Laguna during a 5-Year Rainfall Return Period.

For the 5-year return period, 1.19% of the municipality of Dolores with an area of 65.96 sq. km. will experience flood levels of less than 0.20 meters. 0.24% of the area will experience flood levels of 0.21 to 0.50 meters while 0.17%, 0.11%, 0.08%, and 0.07% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 39. Affected areas in Dolores, Quezon during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Dolores (in sq. km.)				
	Antonino	Dagatan	San Mateo	Bungoy	Putol
0.03-0.20	0.0034	0.0842	0.0474	0.3589	0.2895
0.21-0.50	0.0007	0.0071	0.0157	0.0909	0.045
0.51-1.00	0	0.0048	0.0061	0.0668	0.0367
1.01-2.00	0	0.0027	0.0007	0.0491	0.0187
2.01-5.00	0	0.0033	0	0.0368	0.0142
> 5.00	0	0.0051	0	0.0319	0.0086

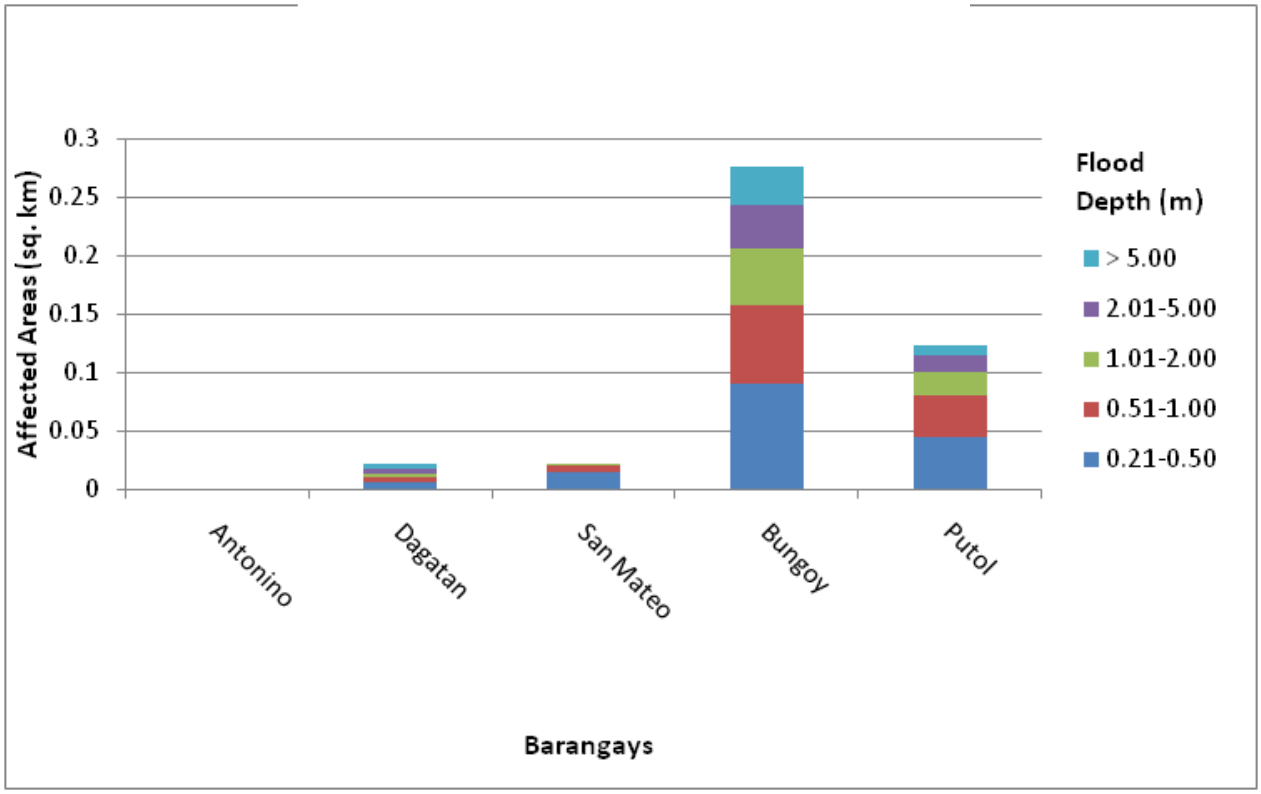


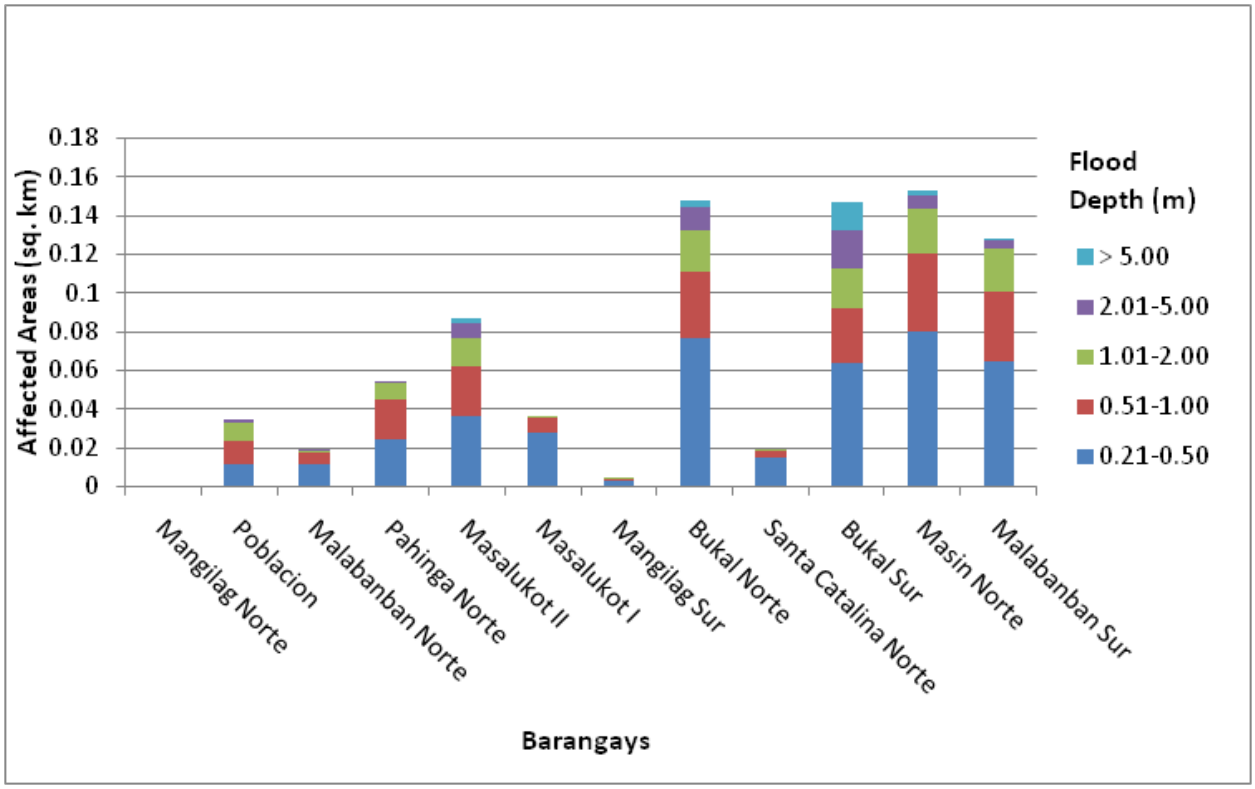
Figure 78. Affected areas in Dolores, Quezon during a 5-Year Rainfall Return Period.

For the 5-year return period, 16.28% of the municipality of Candelaria with an area of 136.74 sq. km. will experience flood levels of less than 0.20 meters. 2.19% of the area will experience flood levels of 0.21 to 0.50 meters while 0.37%, 0.22%, 0.12%, and 0.07% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 40. Affected areas in Candelaria, Quezon during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)											
	Mangilag Norte	Pobla-cion	Malabanban Norte	Pahinga Norte	Masalu-kot II	Masalu-kot I	Mangilag Sur	Bukal Norte	Santa Catalina Norte	Bukal Sur	Masin Norte	Malaban-ban Sur
0.03-0.20	0.0043	0.04	0.081	0.11	0.091	0.12	0.24	0.28	0.38	0.43	0.36	0.72
0.21-0.50	0.0004	0.012	0.012	0.025	0.037	0.028	0.0035	0.077	0.015	0.064	0.08	0.065
0.51-1.00	0	0.012	0.0058	0.02	0.025	0.0086	0.0012	0.034	0.0047	0.028	0.04	0.036
1.01-2.00	0	0.0092	0.0018	0.0092	0.015	0.0005	0.0006	0.021	0.0003	0.021	0.023	0.022
2.01-5.00	0	0.0016	0.0001	0.0005	0.0076	0	0	0.012	0	0.019	0.0073	0.0043
> 5.00	0	0	0	0	0.0023	0	0	0.0033	0	0.015	0.0028	0.0007

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)								
	Masin Sur	Pahinga Sur	San Andres	Buenavista West	Kinati-han II	Kinati-han I	Santa Catali-na Sur	Buenavista East	San Isidro
0.03-0.20	0.56	0.96	1.13	0.85	2.02	1.85	6.02	1.96	4.06
0.21-0.50	0.12	0.093	0.066	0.37	0.28	0.25	0.054	0.53	0.81
0.51-1.00	0.026	0.038	0.021	0.027	0.023	0.032	0.0052	0.04	0.076
1.01-2.00	0.018	0.037	0.0058	0.012	0.021	0.027	0.0001	0.012	0.043
2.01-5.00	0.014	0.025	0.002	0.011	0.0091	0.02	0	0.0033	0.021
> 5.00	0.012	0.02	0	0.0044	0.0033	0.011	0	0.0001	0.016



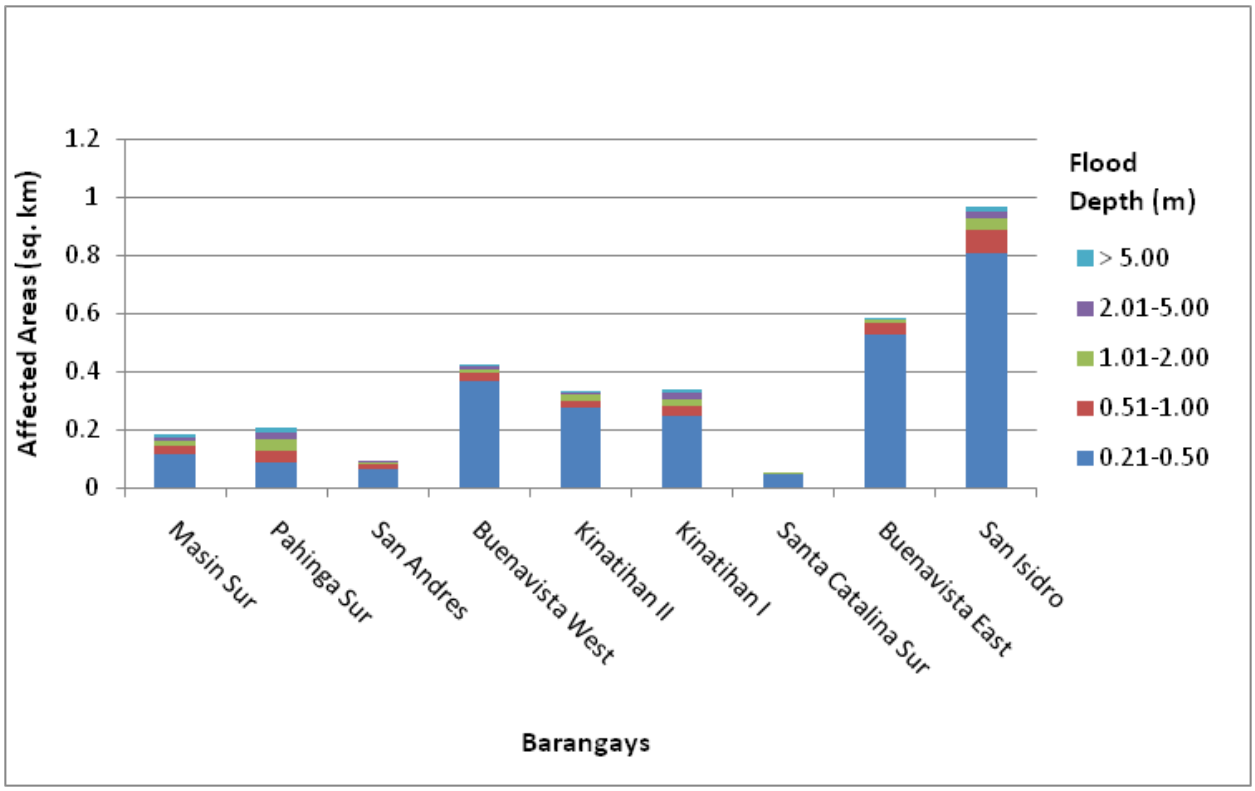


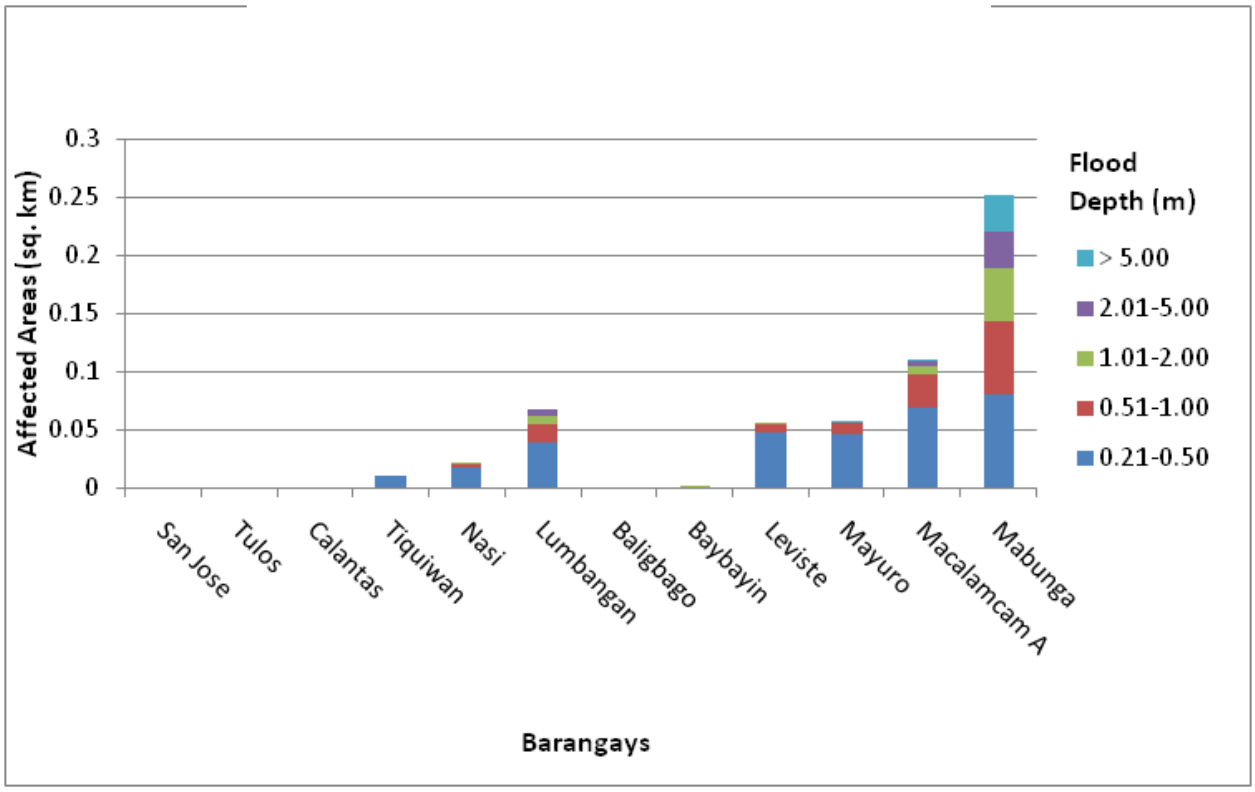
Figure 79. Affected areas in Candelaria, Quezon during a 5-Year Rainfall Return Period.

For the 5-year return period, 7.31% of the municipality of Rosario with an area of 199.04 sq. km. will experience flood levels of less than 0.20 meters. 1.72% of the area will experience flood levels of 0.21 to 0.50 meters while 0.72%, 0.40%, 0.24%, and 0.16% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 41. Affected areas in Rosario, Batangas during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)											
	San Jose	Tulos	Calan-tas	Tiqui-wan	Nasi	Lumban-gan	Baligba-go	Bayba-yin	Leviste	Ma-yuro	Macalamcam A	Mabun-ga
0.03-0.20	0.017	0.0036	0.0055	0.057	0.11	0.11	0	0.17	0.17	0.21	0.29	0.22
0.21-0.50	0	0	0	0.011	0.019	0.04	0	0.0014	0.049	0.047	0.07	0.081
0.51-1.00	0	0	0	0	0.0042	0.015	0	0.0009	0.0074	0.01	0.028	0.063
1.01-2.00	0	0	0	0	0.0001	0.0069	0	0.0009	0.001	0.0008	0.0076	0.045
2.01-5.00	0	0	0	0	0	0.0062	0	0	0	0.0003	0.0034	0.032
> 5.00	0	0	0	0	0	0	0	0	0	0.0007	0.0016	0.031

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)										
	San Isidro	Bay-awang	Maba-to	Macalamcam B	Alupya	Natu	Maligaya	San Carlos	Salao	Pinagsibaan	Putingkahoy
0.03-0.20	0.29	0.31	0.71	1.4	0	0.54	0.55	0.65	1.34	1.34	1.5
0.21-0.50	0.1	0.16	0.23	0.11	0	0.11	0.21	0.21	0.14	0.21	0.55
0.51-1.00	0.039	0.08	0.091	0.041	0	0.018	0.097	0.11	0.064	0.11	0.2
1.01-2.00	0.026	0.063	0.053	0.031	0	0.0002	0.064	0.047	0.041	0.069	0.088
2.01-5.00	0.012	0.044	0.035	0.026	0	0.0005	0.049	0.0037	0.023	0.051	0.043
> 5.00	0.0073	0.031	0.027	0.018	0	0.0004	0.041	0	0.012	0.019	0.033



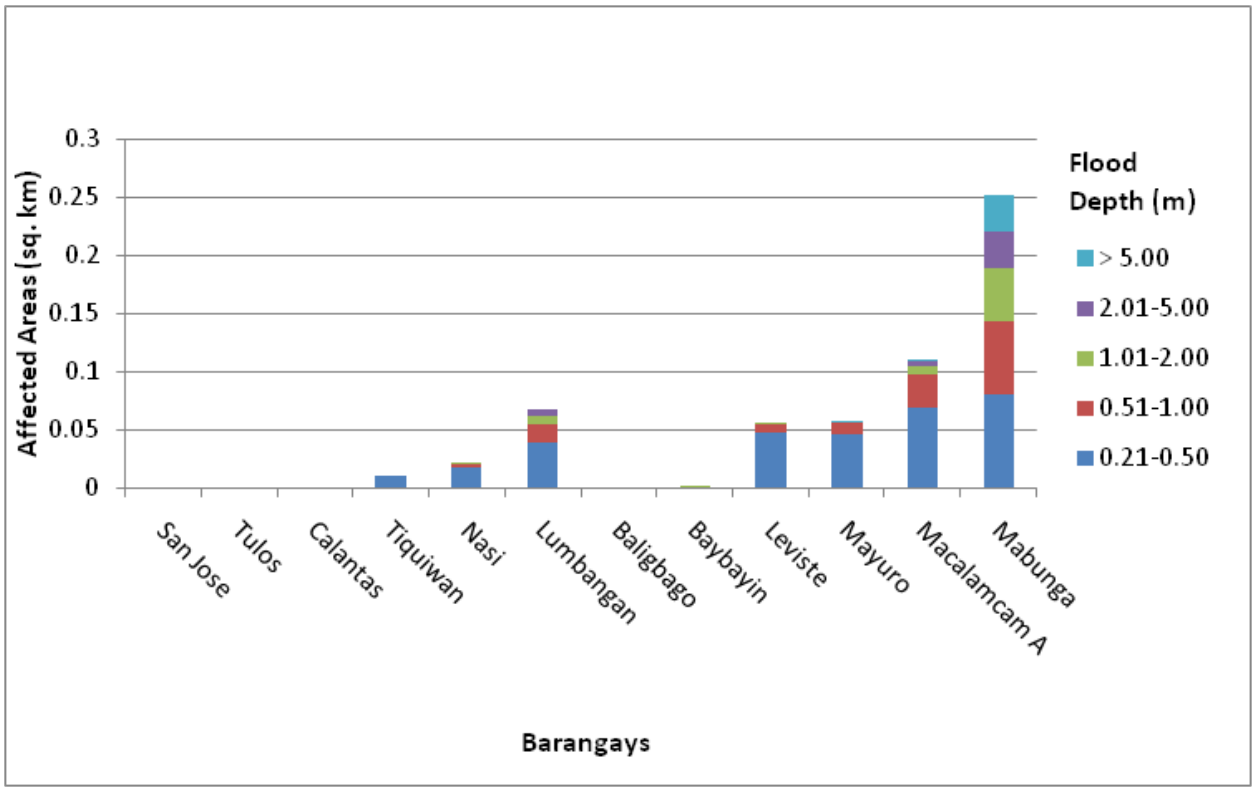


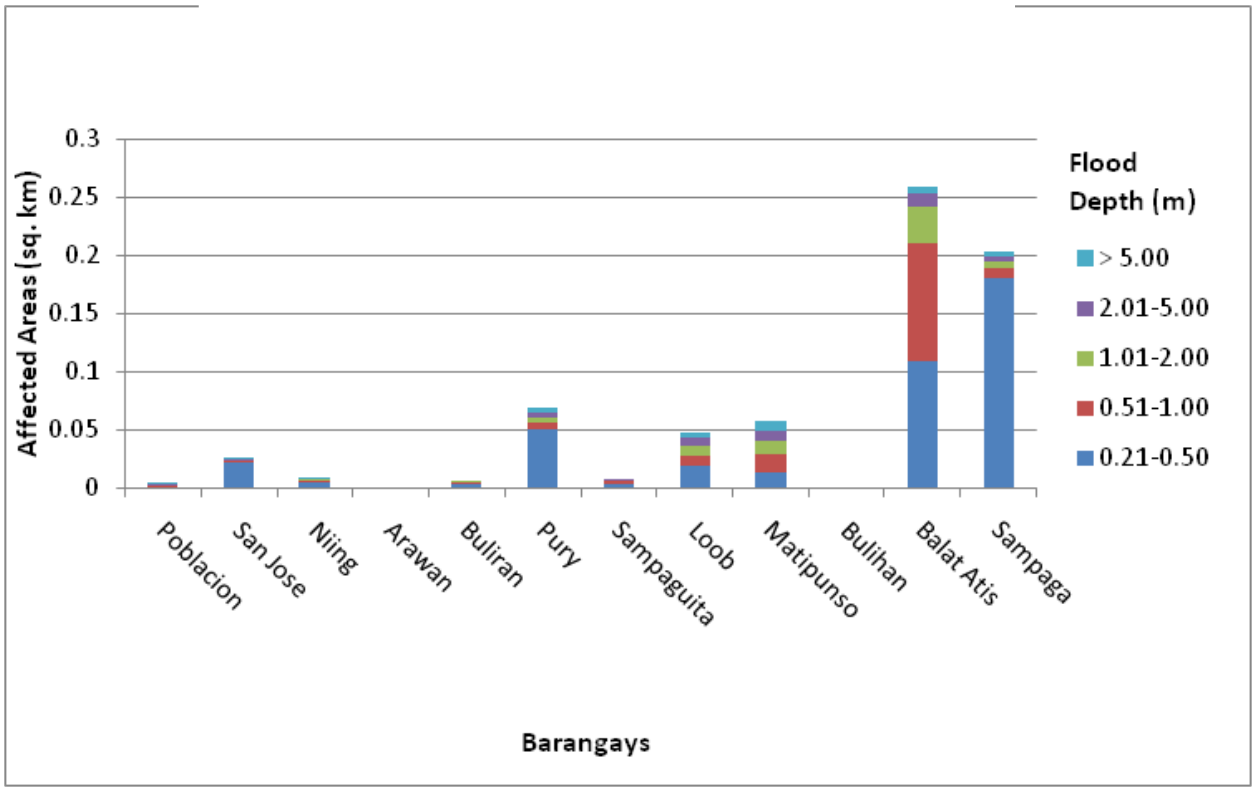
Figure 80. Affected areas in Rosario, Batangas during a 5-Year Rainfall Return Period.

For the 5-year return period, 5.26% of the municipality of San Antonio with an area of 62.38 sq. km. will experience flood levels of less than 0.20 meters. 1.04% of the area will experience flood levels of 0.21 to 0.50 meters while 0.47%, 0.37%, 0.15%, and 0.08% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 42. Affected areas in San Antonio, Quezon during a 5-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)											
	Poblacion	San Jose	Niing	Arawan	Buliran	Pury	Sampaguita	Loob	Matipunso	Bulihan	Balat Atis	Sampaga
0.03-0.20	0.011	0.15	0.067	0	0.075	0.47	0.087	0.11	0.027	0	0.11	0.5
0.21-0.50	0.002	0.024	0.0062	0	0.0057	0.051	0.0041	0.02	0.014	0	0.11	0.18
0.51-1.00	0.0009	0.0007	0.0017	0	0.0003	0.0055	0.0026	0.0086	0.016	0	0.1	0.0093
1.01-2.00	0.0009	0.0007	0.0013	0	0.0005	0.005	0.0015	0.0085	0.011	0	0.032	0.0049
2.01-5.00	0.0003	0.0003	0.0006	0	0	0.0036	0.0001	0.0063	0.0093	0	0.011	0.0043
> 5.00	0.0011	0.0008	0.0005	0	0	0.0041	0	0.0052	0.0087	0	0.0057	0.0046

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)							
	Callejon	Magsaysay	Corzaon	Sinturisan	Bagong Niing	Briones	Pulo	Manuel Del Valle, Sr.
0.03-0.20	0.86	0.6	0	0.69	0.66	0.97	0.31	1.49
0.21-0.50	0.075	0.067	0	0.092	0.11	0.2	0.34	0.12
0.51-1.00	0.033	0.026	0	0.037	0.038	0.07	0.25	0.048
1.01-2.00	0.023	0.02	0	0.011	0.02	0.037	0.29	0.04
2.01-5.00	0.022	0.014	0	0.0047	0.018	0.025	0.074	0.016
> 5.00	0.009	0.0064	0	0.0004	0.022	0.021	0.012	0.0093



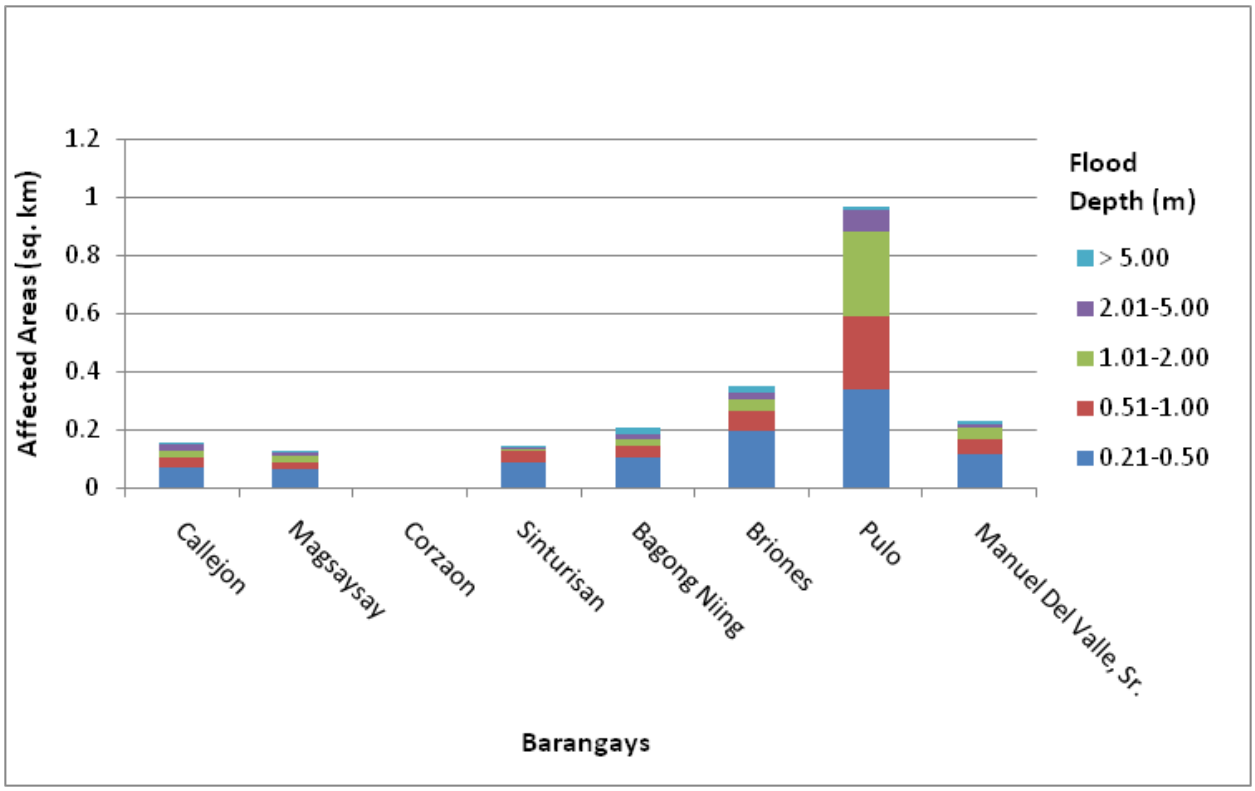


Figure 81. Affected areas in San Antonio, Quezon during a 5-Year Rainfall Return Period.

For the 25-year return period, 1.99% of the municipality of San Pablo City with an area of 184.81 sq. km. will experience flood levels of less than 0.20 meters. 0.32% of the area will experience flood levels of 0.21 to 0.50 meters while 0.15%, 0.08%, 0.06%, and 0.04% 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 the table are the affected areas in square kilometers by flood depth per barangay.

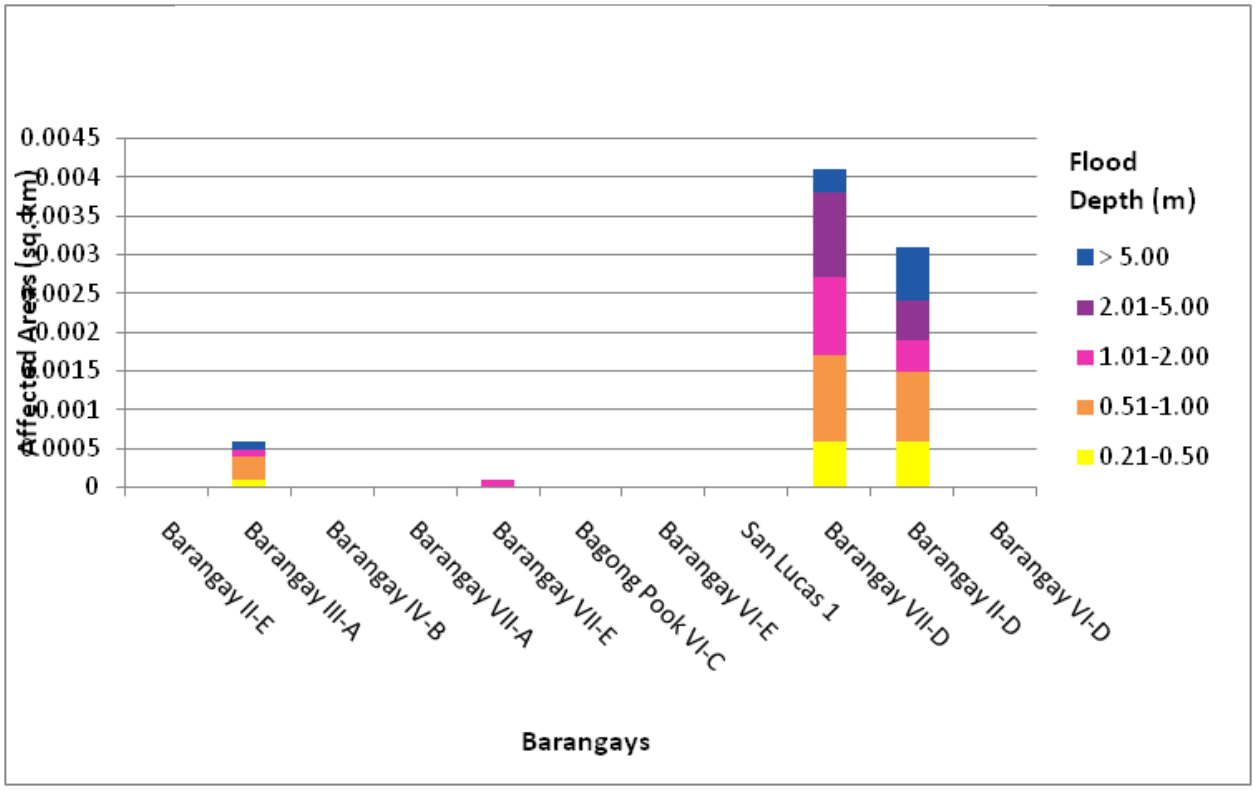
Table 43. Affected areas in San Pablo City, Laguna during a 25-Year Rainfall Return Period.

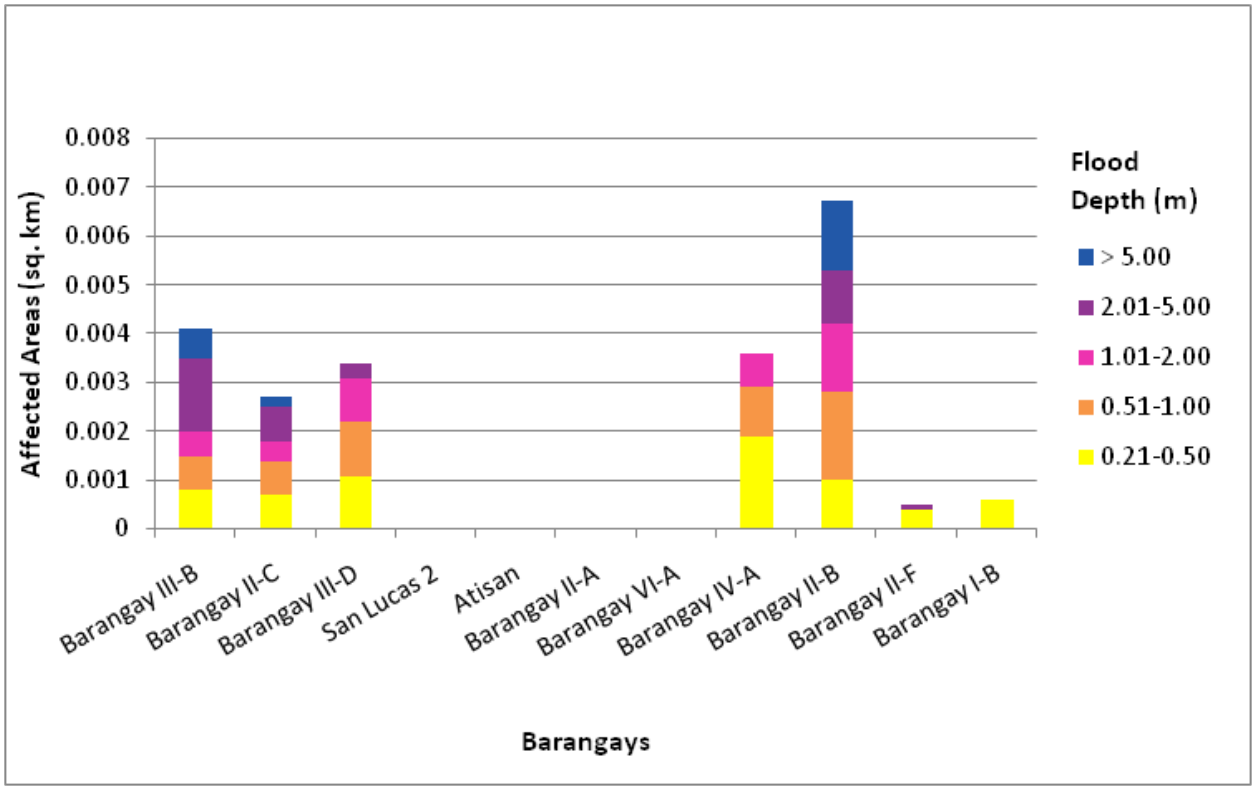
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay II-E	Barangay III-A	Barangay IV-B	Barangay VII-A	Barangay VII-E	Bagong Pook VI-C	Barangay VI-E	San Lucas 1	Barangay VII-D	Barangay II-D	Barangay VI-D
0.03-0.20	0.0004	0.0002	0.0001	0.0005	0.0004	0.0004	0.0002	0.0004	0.0004	0.0017	0.0025
0.21-0.50	0	0.0001	0	0	0	0	0	0	0.0006	0.0006	0
0.51-1.00	0	0.0003	0	0	0	0	0	0	0.0011	0.0009	0
1.01-2.00	0	0.0001	0	0	0.0001	0	0	0	0.001	0.0004	0
2.01-5.00	0	0	0	0	0	0	0	0	0.0011	0.0005	0
> 5.00	0	0.0001	0	0	0	0	0	0	0.0003	0.0007	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay III-B	Barangay II-C	Barangay III-D	San Lucas 2	Atisan	Barangay II-A	Barangay VI-A	Barangay IV-A	Barangay II-B	Barangay II-F	Baran-gay I-B
0.03-0.20	0.001	0.0013	0.002	0.0022	0.0025	0.0045	0.0034	0.0016	0.0059	0.022	0.027
0.21-0.50	0.0008	0.0007	0.0011	0	0	0	0	0.0019	0.001	0.0004	0.0006
0.51-1.00	0.0007	0.0007	0.0011	0	0	0	0	0.001	0.0018	0	0
1.01-2.00	0.0005	0.0004	0.0009	0	0	0	0	0.0007	0.0014	0	0
2.01-5.00	0.0015	0.0007	0.0003	0	0	0	0	0	0.0011	0.0001	0
> 5.00	0.0006	0.0002	0	0	0	0	0	0	0.0014	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santo Cristo	Bagong Bayan II-A	San Antonio 1	Santa Cruz	Santa Maria Magdalena	San Ignacio	Santiago II	San Vicente	San Mateo	Del Remedio	San Marcos
0.03-0.20	0.024	0.049	0.046	0.044	0.067	0.071	0.062	0.079	0.098	0.12	0.16
0.21-0.50	0.009	0.0027	0.0004	0.009	0.016	0.019	0.023	0.0099	0.0001	0.018	0.0018
0.51-1.00	0.002	0.0015	0	0.0013	0.0072	0.0063	0.014	0.0074	0	0.01	0.0008
1.01-2.00	0.0009	0.0004	0	0.0002	0.0011	0.0009	0.012	0.0055	0	0.0069	0.0014
2.01-5.00	0	0.0014	0	0	0	0	0.0074	0.0046	0	0.002	0
> 5.00	0	0.0012	0	0	0	0	0.0029	0.0008	0	0.0016	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santa Ana	San Francisco	San Gabriel	San Gregorio	San Antonio 2	San Juan	San Roque	Santa Monica	San Rafael	Soledad	Santa Felomina
0.03-0.20	0.22	0.12	0.16	0.2	0.16	0.25	0.27	0.3	0.3	0.47	0.33
0.21-0.50	0.026	0.026	0.011	0.0099	0.022	0.033	0.021	0.061	0.11	0.052	0.1
0.51-1.00	0.016	0.021	0.01	0.0092	0.0037	0.015	0.013	0.056	0.034	0.012	0.027
1.01-2.00	0.013	0.009	0.0068	0.0079	0.0008	0.016	0.0063	0.027	0.021	0.0091	0
2.01-5.00	0.0065	0.0038	0.0065	0.0082	0.0001	0.013	0.0005	0.029	0.017	0.0086	0
> 5.00	0.001	0.0018	0.0078	0.0048	0	0.0062	0	0.012	0.016	0.0074	0


0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Affected Areas (sq. km)
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50
Barangay II-E
Barangay III-A
Barangay IV-B
Barangay VII-A
Barangay VII-E
Bagong Pook VI-C
Barangay VI-E
San Lucas 1
Barangay VII-D
Barangay II-D
Barangay VI-D
Barangays


0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Affected Areas (sq. km)
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50
Barangay III-B
Barangay II-C
Barangay III-D
San Lucas 2
Atisan
Barangay II-A
Barangay VI-A
Barangay IV-A
Barangay II-B
Barangay II-F
Barangay I-B
Barangays

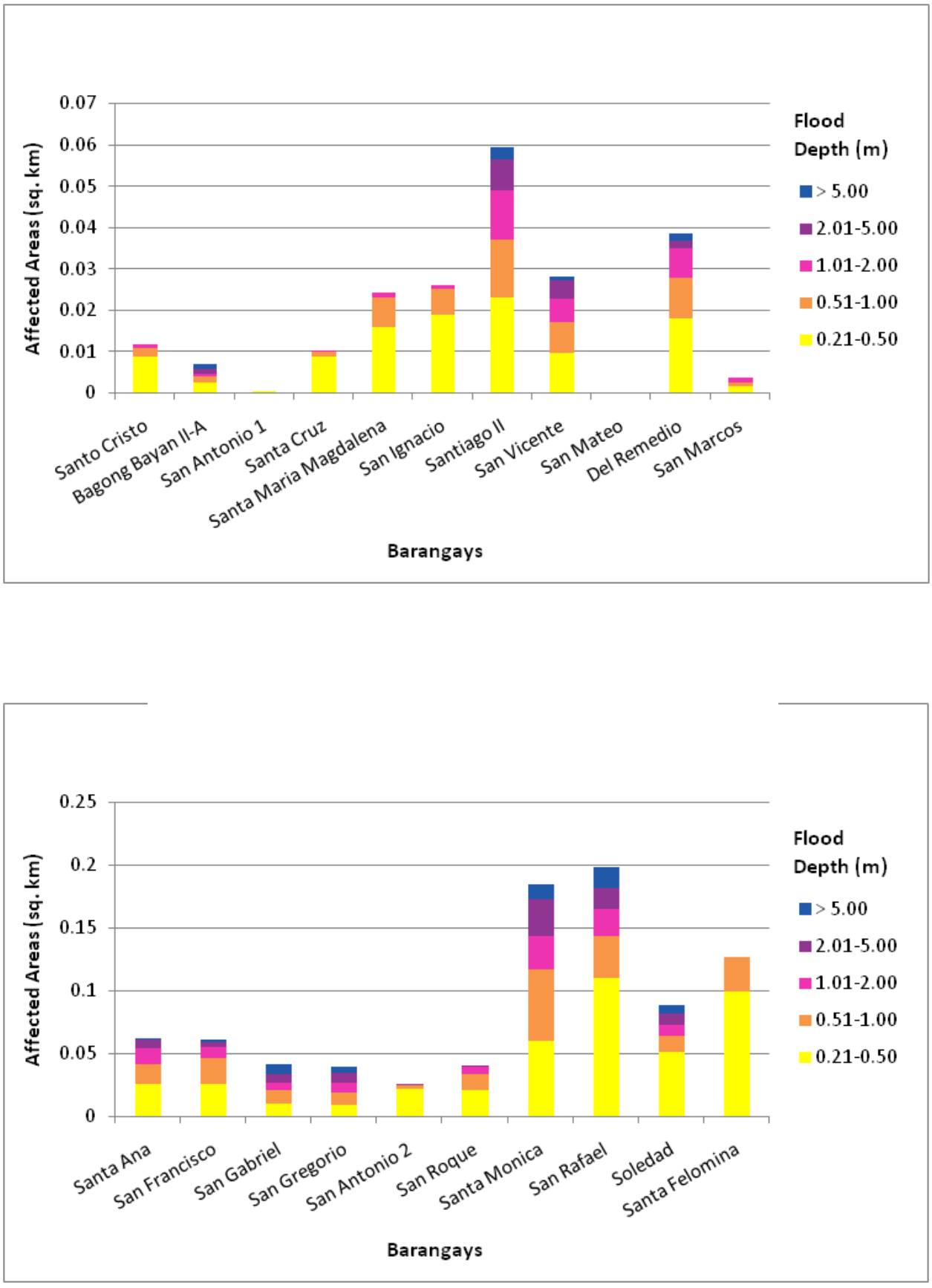


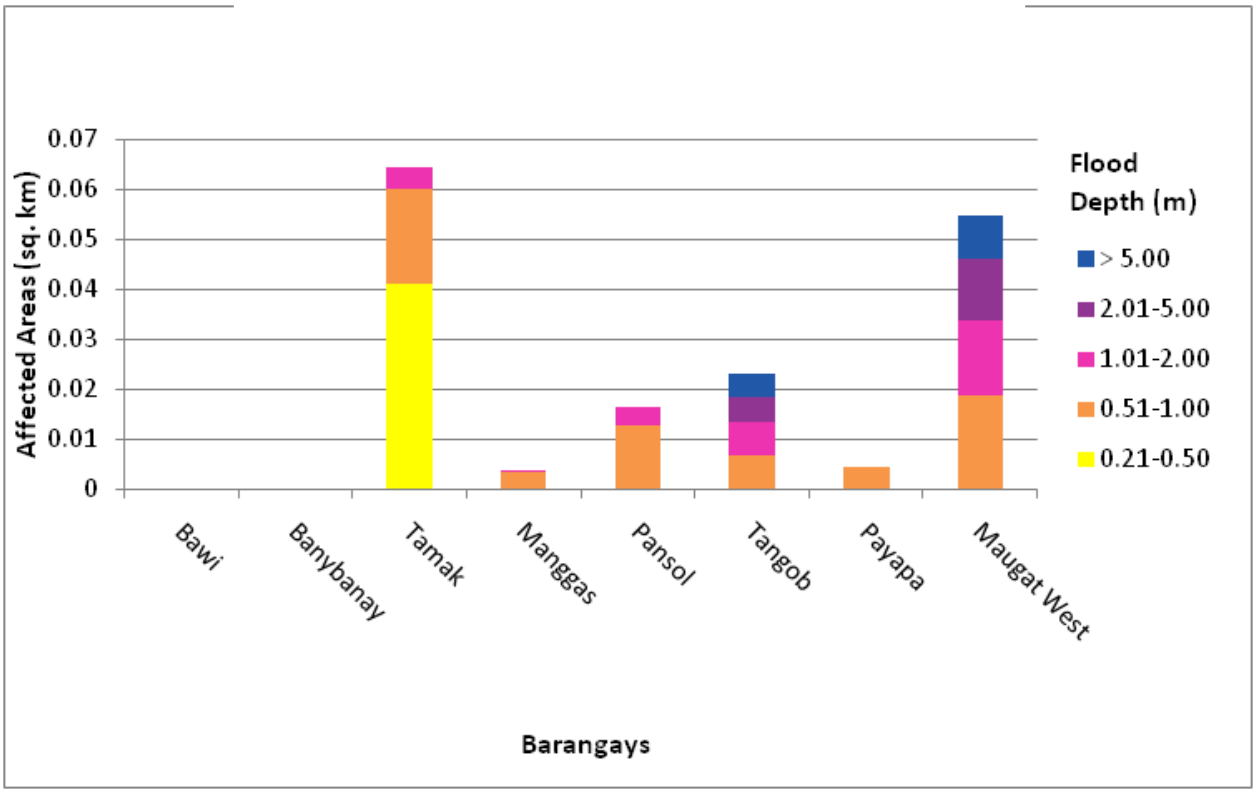
Figure 82. Affected areas in San Pablo City, Laguna during a 25-Year Rainfall Return Period.

For the 25-year return period, 6.45% of the municipality of Padre Garcia with an area of 39.28 sq. km. will experience flood levels of less than 0.20 meters. 1.07% of the area will experience flood levels of 0.21 to 0.50 meters while 0.51%, 0.26%, 0.16%, and 0.10% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 44. Affected areas in Padre Garcia, Batangas during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)							
	Bawi	Banybanay	Tamak	Manggas	Pansol	Tangob	Payapa	Maugat West
0.03-0.20	0.0069	0	0.05	0.087	0.11	0.13	0.16	0.14
0.21-0.50	0.0002	0	0.041	0.0095	0.017	0.017	0.0097	0.032
0.51-1.00	0	0	0.019	0.0037	0.013	0.0069	0.0045	0.019
1.01-2.00	0	0	0.0045	0.0002	0.0036	0.0067	0	0.015
2.01-5.00	0	0	0	0	0	0.005	0	0.012
> 5.00	0	0	0	0	0	0.0046	0	0.0088

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)								
	Quilo-Quilo South	Maugat East	San Felipe	Poblacion	Quilo-Quilo North	Castillo	Bukal	Banaba	
0.03-0.20	0.15	0.18	0.16	0.22	0.23	0.23	0.3	0.38	0
0.21-0.50	0	0.061	0.016	0.0058	0.0048	0.074	0.1	0.032	0
0.51-1.00	0	0.022	0	0	0.0044	0.023	0.08	0.0044	0
1.01-2.00	0	0.013	0	0	0.0001	0.013	0.046	0	0
2.01-5.00	0	0.014	0	0	0	0.0095	0.024	0	0
> 5.00	0	0.014	0	0	0	0.0037	0.01	0	0



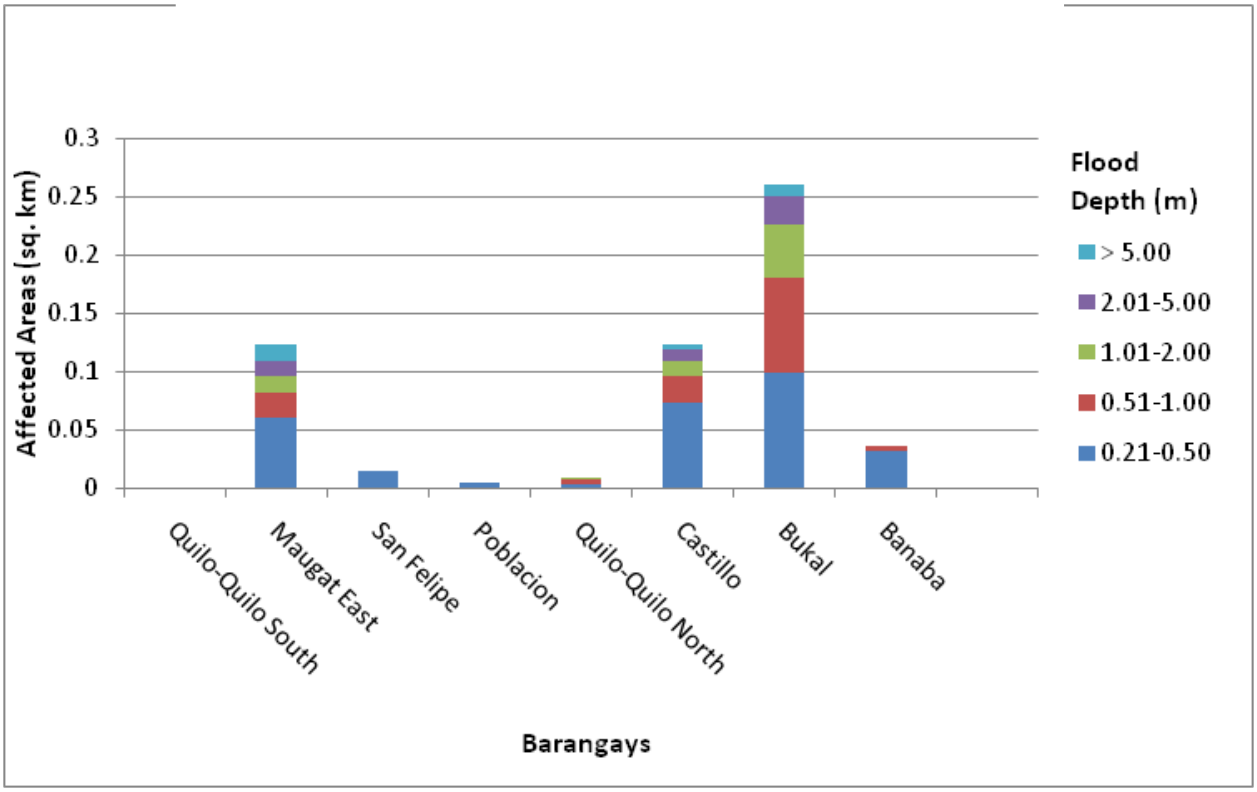


Figure 83. Affected areas in Padre Garcia, Batangas during a 25-Year Rainfall Return Period.

For the 25-year return period, 33.71% of the municipality of Sariaya with an area of 213.78 sq. km. will experience flood levels of less than 0.20 meters. 3.86% of the area will experience flood levels of 0.21 to 0.50 meters while 0.54%, 0.18%, 0.11%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 45. Affected areas in Sariaya, Quezon during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)							
	Sampaloc Santo Cristo	Lutucan Malabag	Lutucan 1	Concepcion No.1	Lutucan Bata	Montecillo	Concepcion Palasan	Bignay 1
0.03-0.20	0.0008	0.014	0.008	0	0.16	0.36	0.66	0.98
0.21-0.50	0	0	0	0	0.0086	0.0028	0.064	0.052
0.51-1.00	0	0	0	0	0.0008	0	0.0047	0
1.01-2.00	0	0	0	0	0	0	0.0012	0
2.01-5.00	0	0	0	0	0	0	0.0026	0
> 5.00	0	0	0	0	0	0	0.0012	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)								
	Manggalang 1	Manggalang-Kiling	Guisguis-Talon	Manggalang Tulo-Tulo	Manggalang-Bantilan	Guisguis-San Roque	Bignay 2		
0.03-0.20	0.99	0.94	1.09	2.09	2.41	1.37	2.17	0	0
0.21-0.50	0.13	0.17	0.19	0.018	0.22	0.57	0.091	0	0
0.51-1.00	0.024	0.023	0.0061	0.0001	0.065	0.086	0.0013	0	0
1.01-2.00	0.0028	0.0008	0.0004	0	0.027	0.037	0	0	0
2.01-5.00	0	0.0011	0	0	0.023	0.018	0	0	0
> 5.00	0	0.012	0	0	0.066	0.007	0	0	0

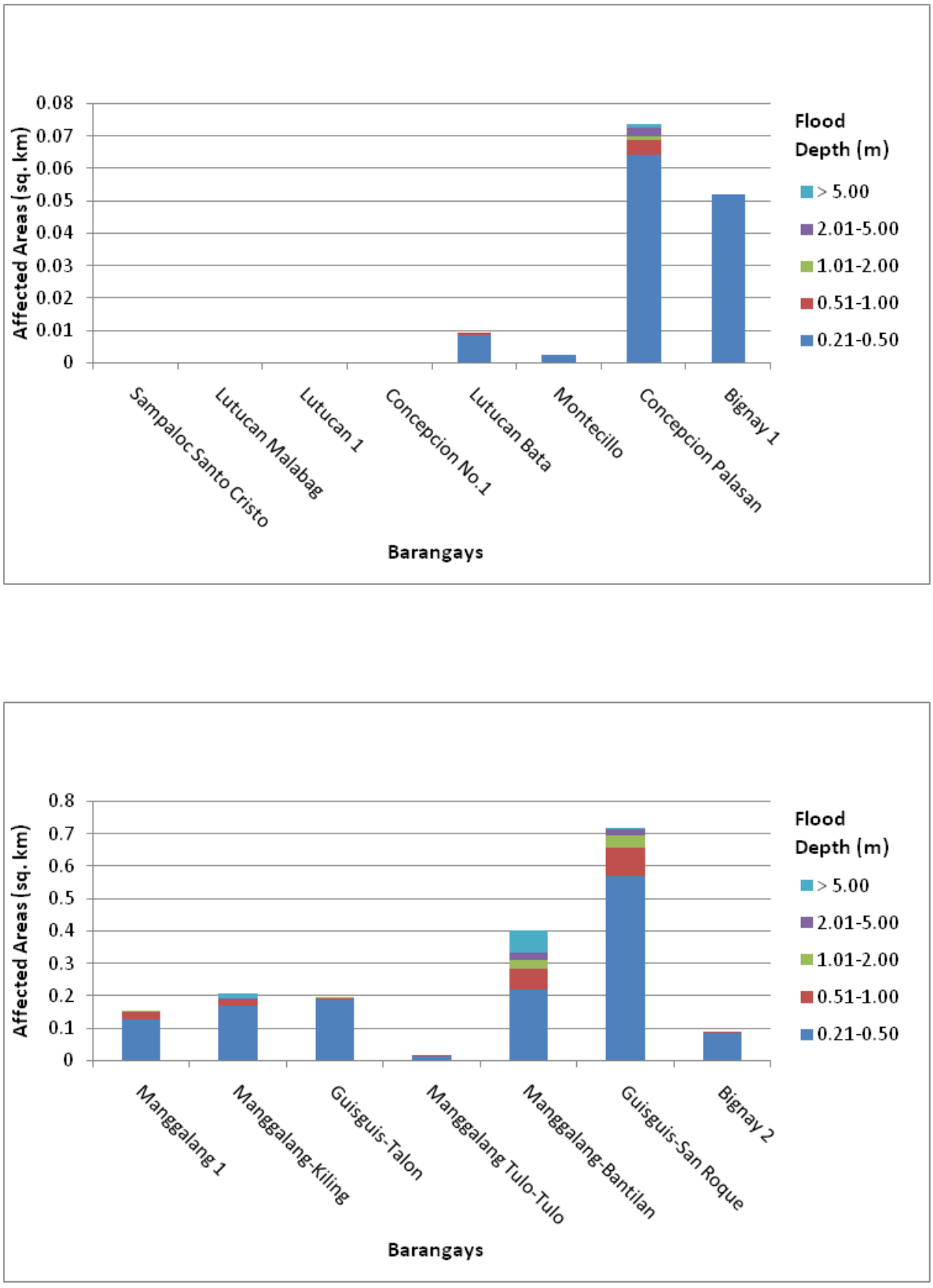


Figure 84. Affected areas in Sariaya, Quezon during a 25-Year Rainfall Return Period.

For the 25-year return period, 11.78% of the municipality of San Juan with an area of 237.55 sq. km. will experience flood levels of less than 0.20 meters. 3.14% of the area will experience flood levels of 0.21 to 0.50 meters while 0.72%, 0.24%, 0.13%, and 0.14% 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 the table are the affected areas in square kilometers by flood depth per barangay.

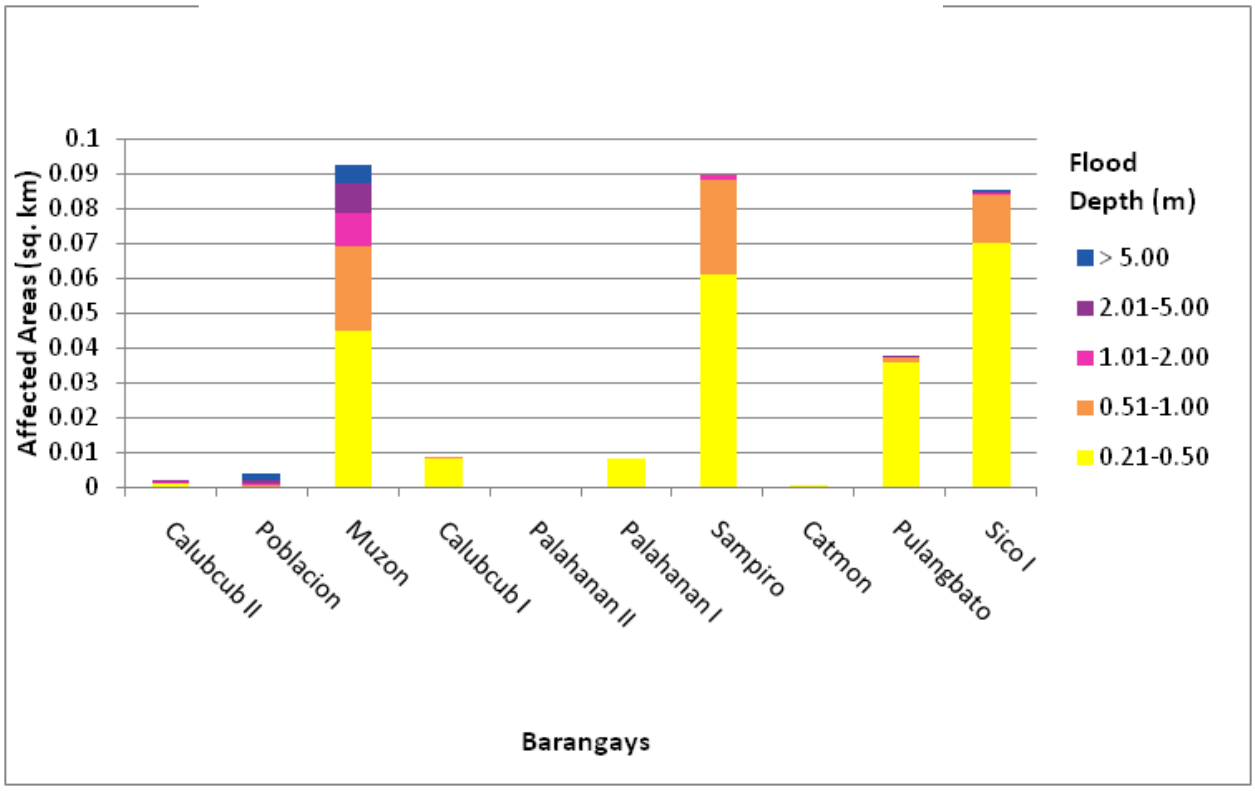
Table 46. Affected areas in San Juan, Batangas during a 25-Year Rainfall Return Period.

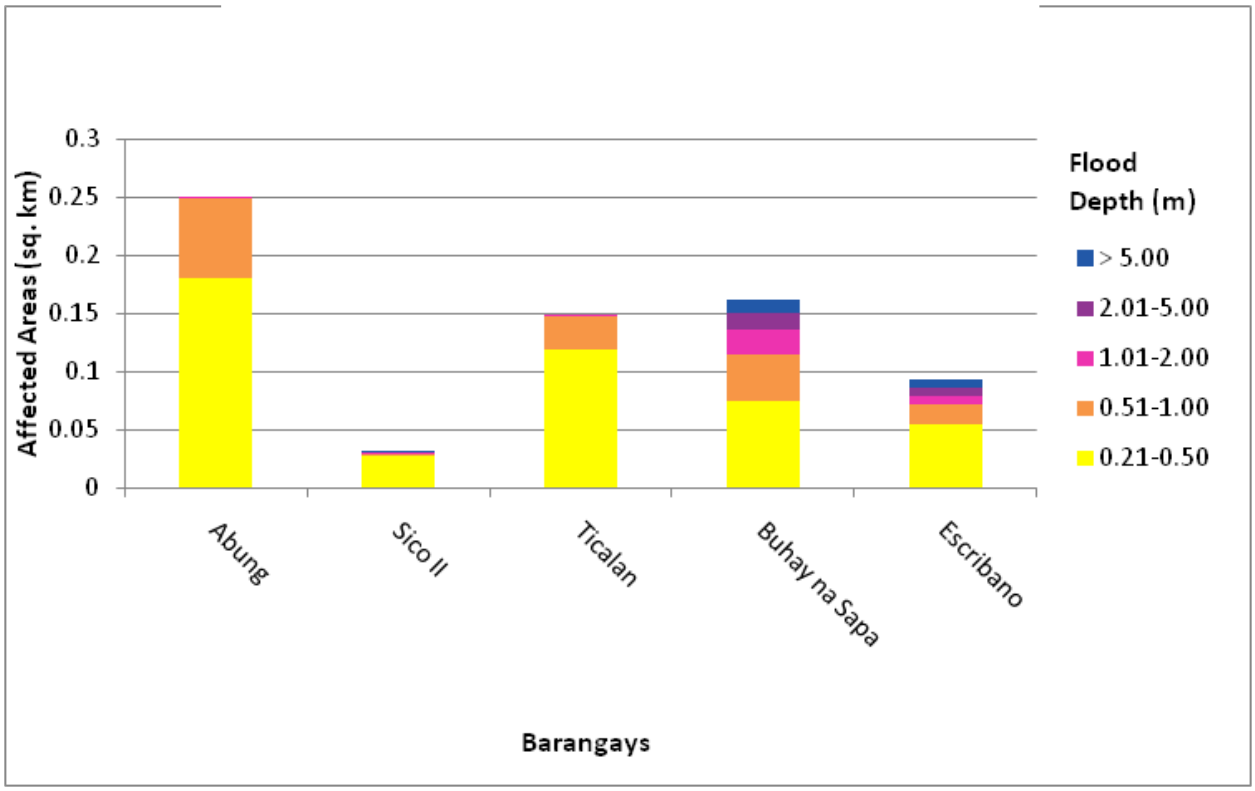
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Calubcub II	Poblacion	Muzon	Calubcub I	Palahanan II	Palahanan I	Sampiro	Catmon	Pulangbato	Sico I
0.03-0.20	0.0084	0.012	0.068	0.15	0.091	0.13	0.14	0.22	0.24	0.4
0.21-0.50	0.0014	0.0005	0.045	0.0084	0	0.0084	0.061	0.001	0.036	0.07
0.51-1.00	0.0003	0.0007	0.024	0.0005	0	0	0.027	0	0.0018	0.014
1.01-2.00	0.0003	0.0004	0.0097	0	0	0	0.0015	0	0	0.0004
2.01-5.00	0.0002	0.0006	0.0083	0	0	0	0	0	0.0001	0.0004
> 5.00	0	0.0019	0.0054	0	0	0	0	0	0	0.0003

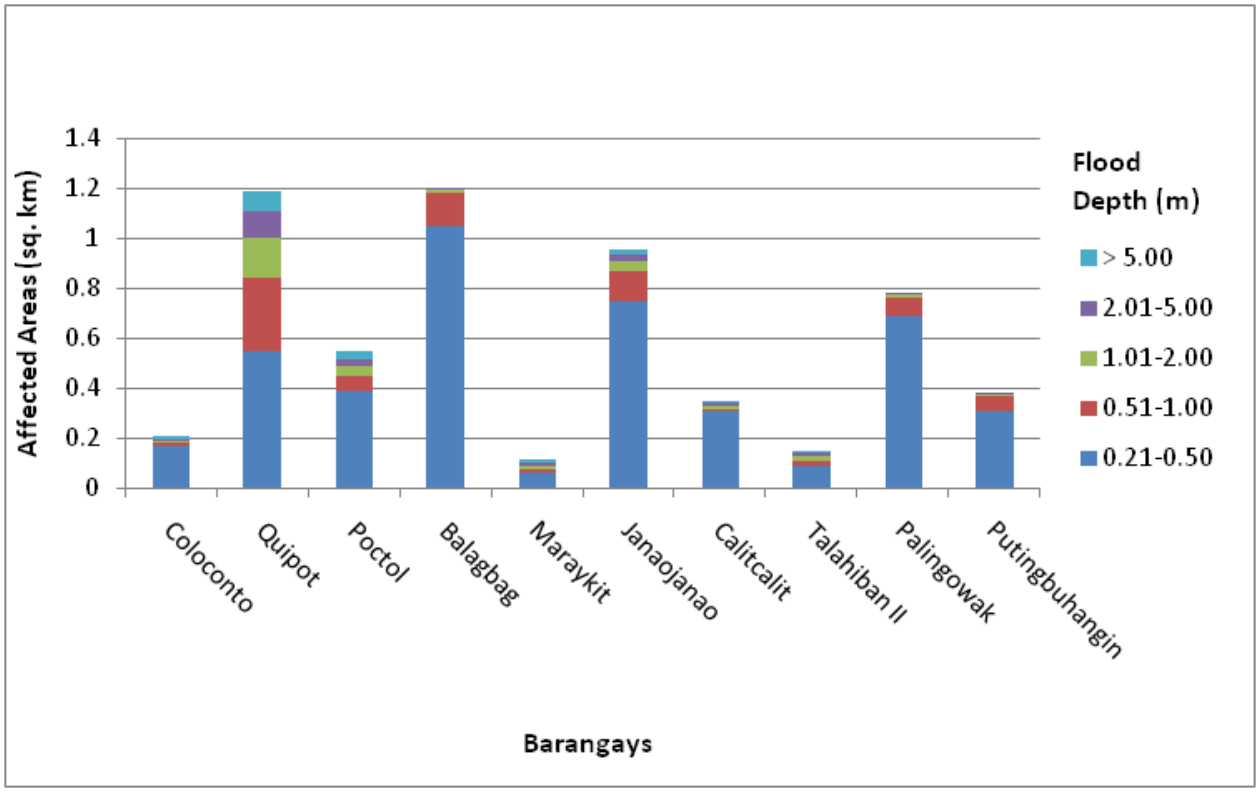
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Abung	Sico II	Ticalan	Buhay na Sapa	Escribano	Sapangan	Mabalanoy	Pinagbayanan	Libato	Tipaz
0.03-0.20	0.29	0.58	0.49	0.62	0.64	0.74	0.78	1.01	1.35	0.99
0.21-0.50	0.18	0.028	0.12	0.076	0.055	0.26	0.021	0.82	0.36	0.34
0.51-1.00	0.07	0.0017	0.028	0.039	0.018	0.069	0.011	0.27	0.19	0.1
1.01-2.00	0.0007	0.0015	0.0013	0.021	0.0069	0.018	0.011	0.0093	0.089	0.047
2.01-5.00	0	0.001	0	0.015	0.0071	0.0011	0.01	0	0.046	0.012
> 5.00	0	0.0004	0	0.011	0.007	0	0.014	0	0.023	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Coloconto	Quipot	Poctol	Balagbag	Maraykit	Janaojanao	Calitcalit	Talahiban II	Palingowak	Putingbuhangin
0.03-0.20	1.22	1.34	1.38	1.17	1.41	1.55	1.32	1.52	1.45	2.55
0.21-0.50	0.17	0.55	0.39	1.05	0.066	0.75	0.31	0.093	0.69	0.31
0.51-1.00	0.013	0.29	0.062	0.13	0.013	0.12	0.011	0.019	0.073	0.059
1.01-2.00	0.01	0.16	0.041	0.018	0.013	0.042	0.011	0.018	0.019	0.018
2.01-5.00	0.0092	0.11	0.022	0.0019	0.014	0.023	0.01	0.016	0.0016	0.0004
> 5.00	0.0078	0.076	0.034	0	0.012	0.02	0.011	0.0054	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)	
	Talahiban I	Lipahan
0.03-0.20	2.11	2.01
0.21-0.50	0.28	0.31
0.51-1.00	0.052	0.011
1.01-2.00	0.0046	0.0093
2.01-5.00	0.0004	0.0093
> 5.00	0	0.095




Affected Areas (sq. km)
0.3
0.25
0.2
0.15
0.1
0.05
0
Abung
Sico II
Ticalan
Buhay na Sapa
Escribano
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


Affected Areas (sq. km)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Coloconto
Quipot
Poctol
Balagbag
Maraykit
Janaojanao
Calitcalit
Talahiban II
Palingowak
Putingbuhangin
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

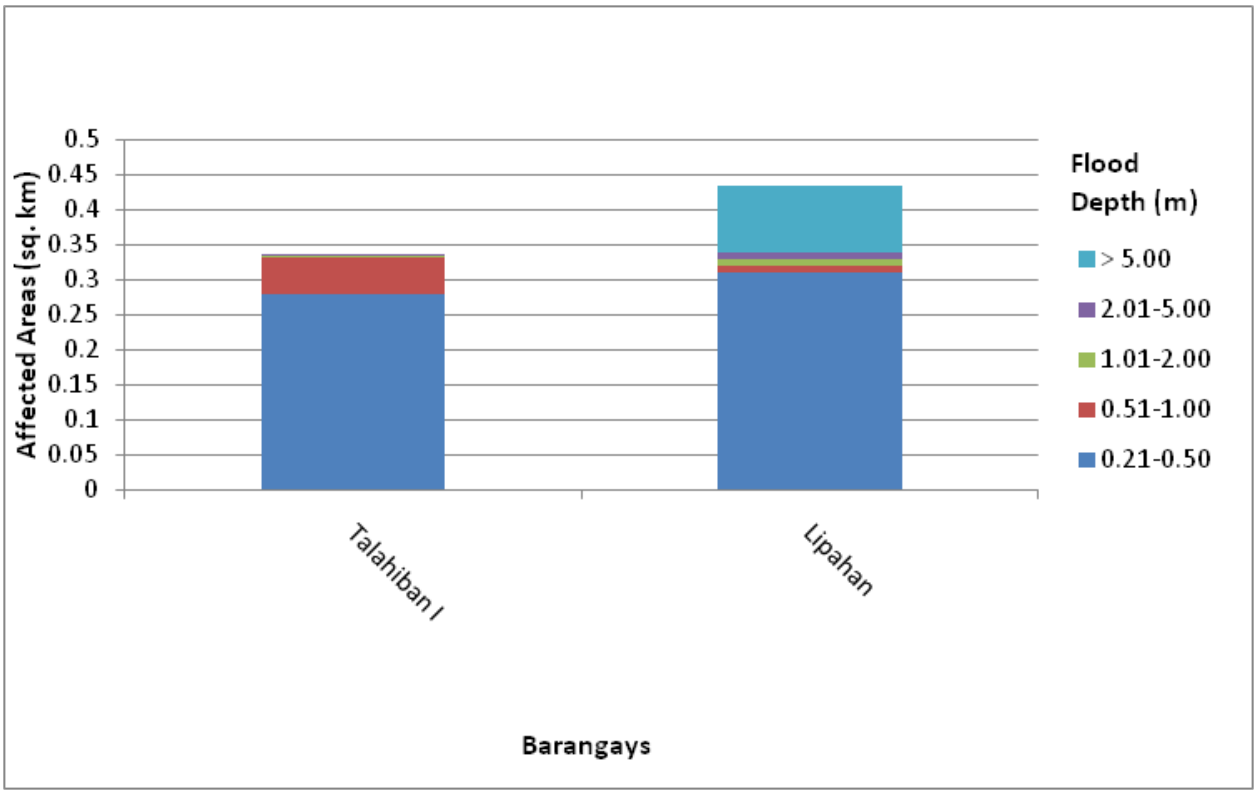


Figure 85. Affected areas in San Juan, Batangas during a 25-Year Rainfall Return Period.

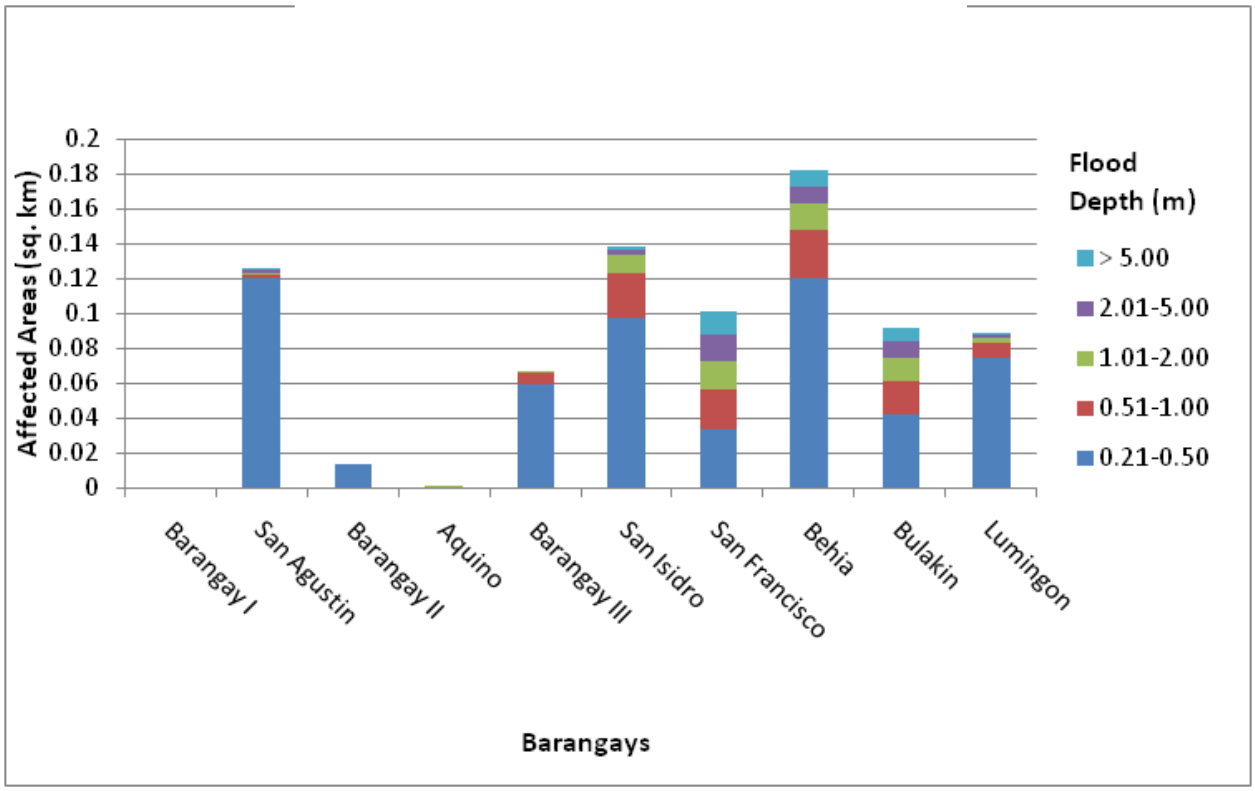
For the 25-year return period, 9.00% of the municipality of Tiaong with an area of 118.93 sq. km. will experience flood levels of less than 0.20 meters. 2.60% of the area will experience flood levels of 0.21 to 0.50 meters while 1.00%, 0.26%, 0.13%, and 0.09% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

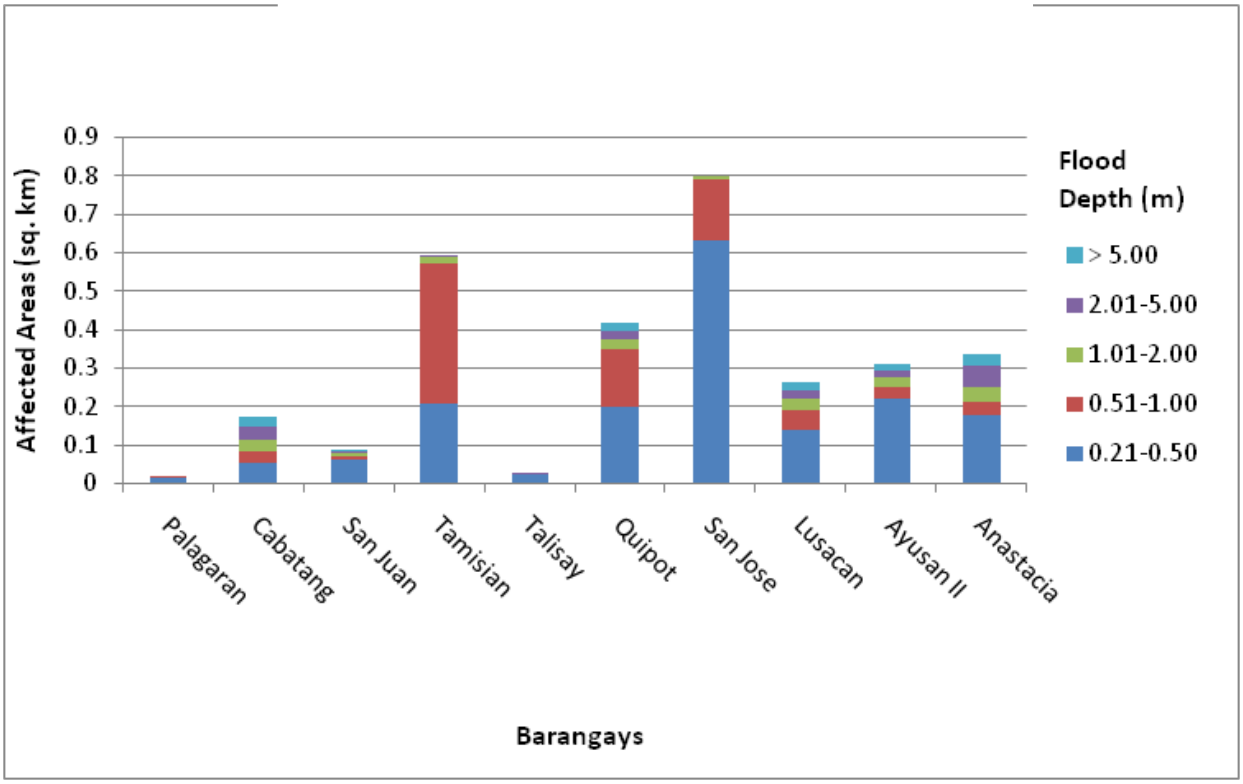
Table 47. Affected areas in Tiaong. Quezon during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Barangay I	San Agustin	Barangay II	Aquino	Barangay III	San Isidro	San Francisco	Behia	Bulakin	Lumingon
0.03-0.20	0.0096	0.19	0.016	0.033	0.063	0.28	0.34	0.47	0.45	0.38
0.21-0.50	0.0001	0.12	0.013	0.0014	0.06	0.098	0.034	0.12	0.043	0.075
0.51-1.00	0	0.0022	0	0.0006	0.0069	0.025	0.023	0.028	0.019	0.0084
1.01-2.00	0	0.0013	0	0.0003	0.0003	0.011	0.016	0.015	0.013	0.0032
2.01-5.00	0	0.0015	0	0	0	0.0029	0.015	0.0097	0.0095	0.0018
> 5.00	0	0.0012	0	0	0	0.0019	0.013	0.0096	0.0072	0.001

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Palagaran	Cabatang	San Juan	Tamisian	Talisay	Quipot	San Jose	Lusacan	Ayusan II	Anastacia
0.03-0.20	0.45	0.55	0.53	0.43	0.82	0.73	1.47	0.89	0.88	0.81
0.21-0.50	0.023	0.057	0.062	0.21	0.027	0.2	0.63	0.14	0.22	0.18
0.51-1.00	0.0002	0.03	0.011	0.36	0.0025	0.15	0.16	0.053	0.033	0.035
1.01-2.00	0	0.027	0.0076	0.021	0.0003	0.027	0.0056	0.027	0.023	0.037
2.01-5.00	0	0.037	0.006	0.0024	0.0001	0.02	0	0.022	0.02	0.054
> 5.00	0	0.026	0.0031	0	0	0.023	0	0.024	0.016	0.031

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Paiisa	Bula	Tagbakin	Lagalag	San Pedro	Cabay	Del Rosario	Bukal	Ayusan I	Lalig
0.03-0.20	0.93	0.62	1.21	1.21	0.68	1.62	1.85	0.91	1.15	1.4
0.21-0.50	0.065	0.4	0.08	0.082	0.52	0.16	0.14	0.6	1.03	0.78
0.51-1.00	0.0021	0.21	0.0066	0.006	0.096	0.0023	0.0092	0.61	0.34	0.15
1.01-2.00	0.0003	0.031	0.0039	0.0029	0.031	0.0014	0.006	0.26	0.032	0.022
2.01-5.00	0	0.01	0.0015	0.0026	0.019	0.0004	0.0039	0.03	0.02	0.0094
> 5.00	0	0.009	0	0.0028	0.014	0.0006	0.0036	0.0071	0.02	0.0084


Affected Areas (sq. km)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Barangay I
San Agustin
Barangay II
Aquino
Barangay III
San Isidro
San Francisco
Behia
Bulakin
Lumingon
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


Affected Areas (sq. km)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Palagaran
Cabatang
San Juan
Tamisian
Talisay
Quipot
San Jose
Lusacan
Ayusan II
Anastacia
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

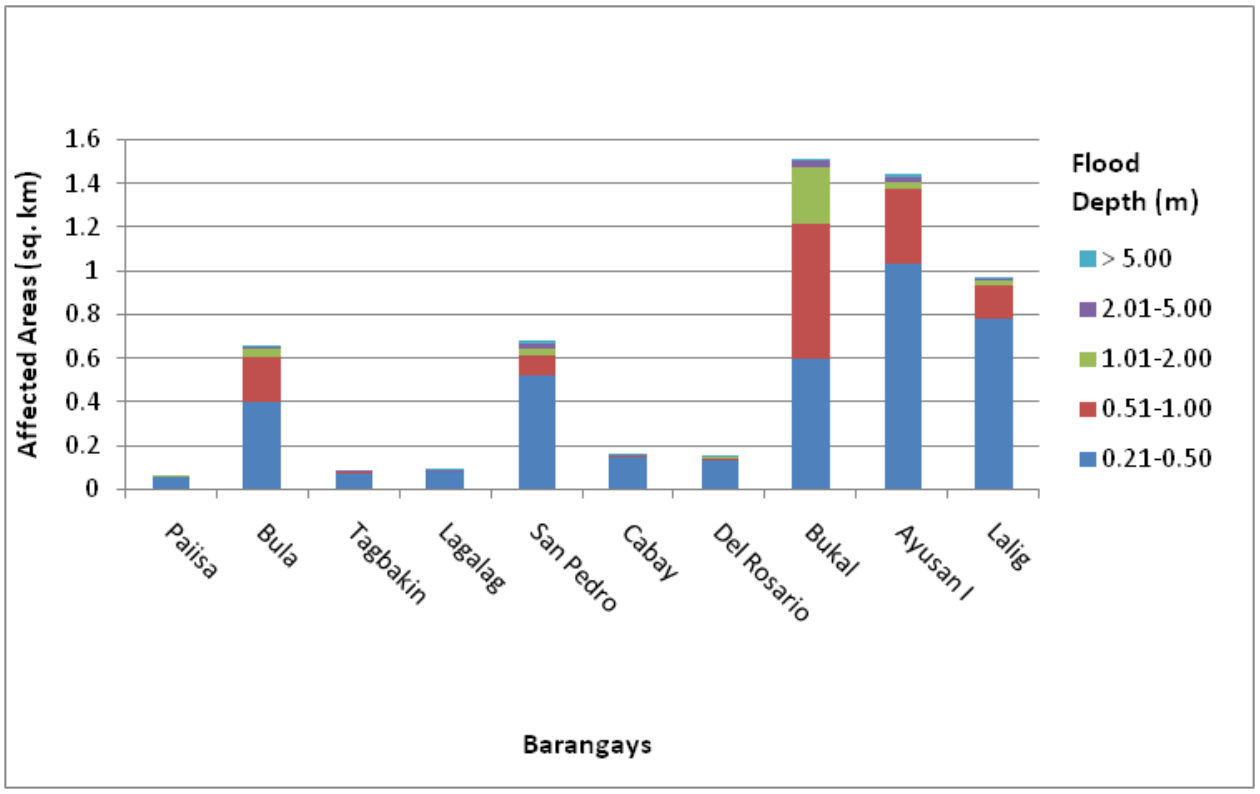


Figure 86. Affected areas in Tiaong. Quezon during a 25-Year Rainfall Return Period.

For the 25-year return period, 1.35% of the municipality of Alaminos with an area of 59.65 sq. km. will experience flood levels of less than 0.20 meters. 0.16% of the area will experience flood levels of 0.21 to 0.50 meters while 0.03%, 0.01%, 0.01%, and 0.00% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 48. Affected areas in Alaminos, Laguna during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Alaminos (in sq. km.)					
	San Miguel	Del Carmen	San Agustin	San Gregorio	San Roque	San Benito
0.03-0.20	0.0059	0.019	0.025	0.067	0.17	0.52
0.21-0.50	0.0002	0	0	0.02	0.016	0.058
0.51-1.00	0	0	0	0.0065	0.007	0.0047
1.01-2.00	0	0	0	0.0008	0.0051	0.0004
2.01-5.00	0	0	0	0	0.0048	0
> 5.00	0	0	0	0	0.0028	0

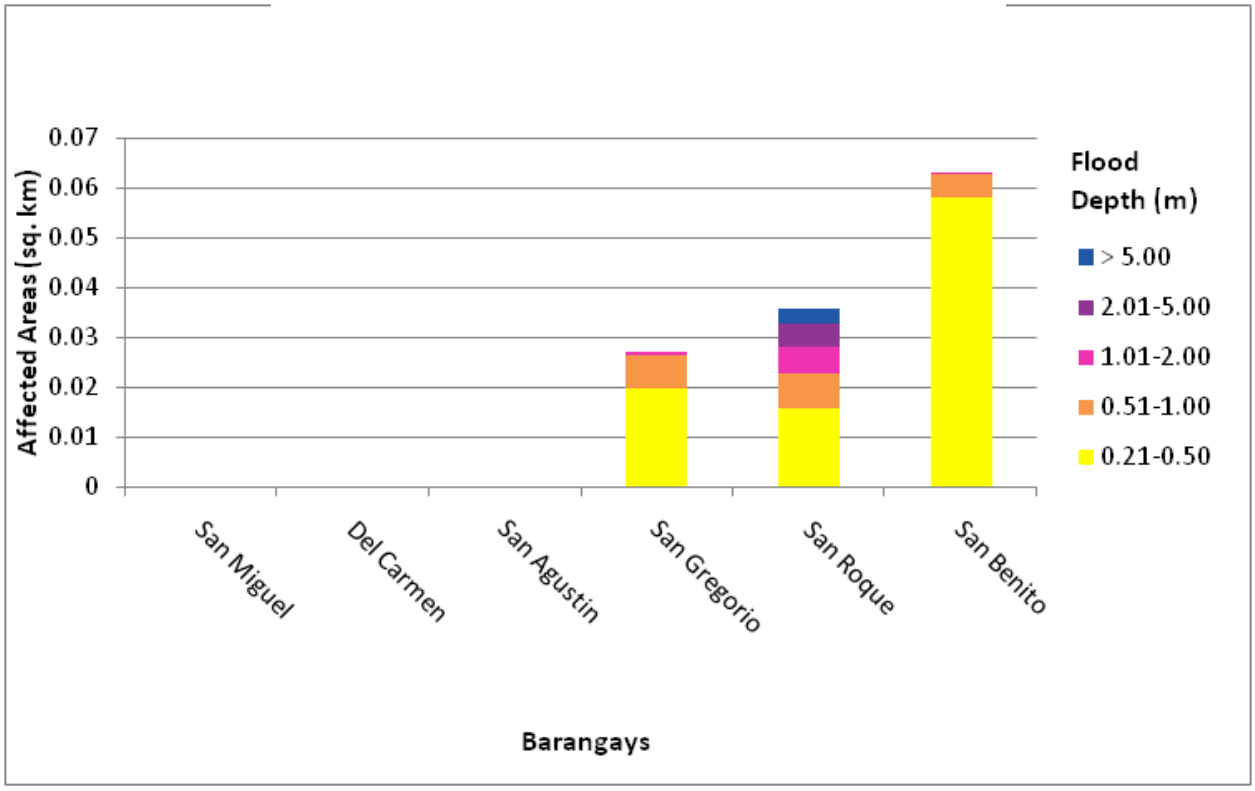


Figure 87. Affected areas in Alaminos, Laguna during a 25-Year Rainfall Return Period.

For the 25-year return period, 0.77% of the municipality of Dolores with an area of 65.96 sq. km. will experience flood levels of less than 0.20 meters. 0.22% of the area will experience flood levels of 0.21 to 0.50 meters while 0.16%, 0.10%, 0.08%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 49. Affected areas in Dolores, Quezon during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Dolores (in sq. km.)				
	Antonino	Dagatan	San Mateo	Bungoy	Putol
0.03-0.20	0.0031	0.0374	0.0344	0.2095	0.2218
0.21-0.50	0.0006	0.0073	0.0132	0.081	0.0461
0.51-1.00	0	0.0036	0.0043	0.062	0.0341
1.01-2.00	0	0.0037	0	0.0479	0.0168
2.01-5.00	0	0.0055	0	0.0351	0.0107
> 5.00	0	0.0027	0	0.0129	0.001

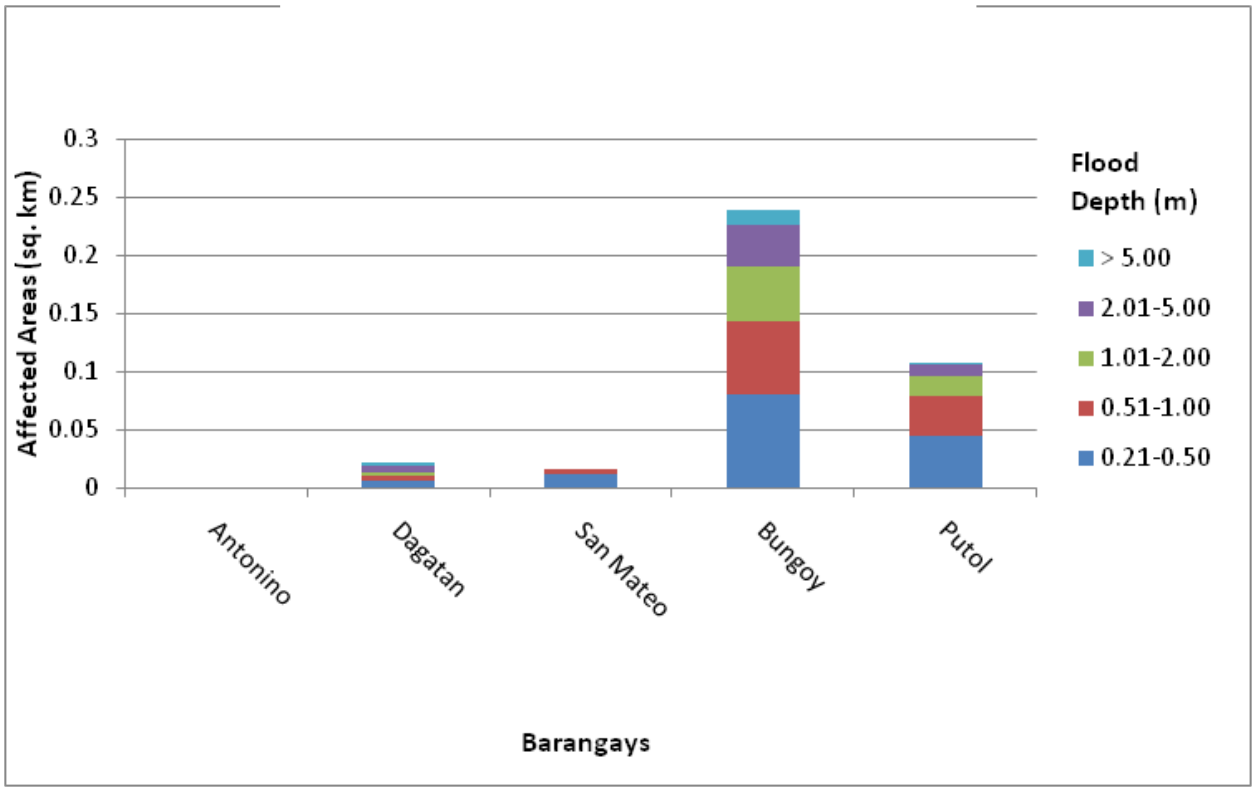


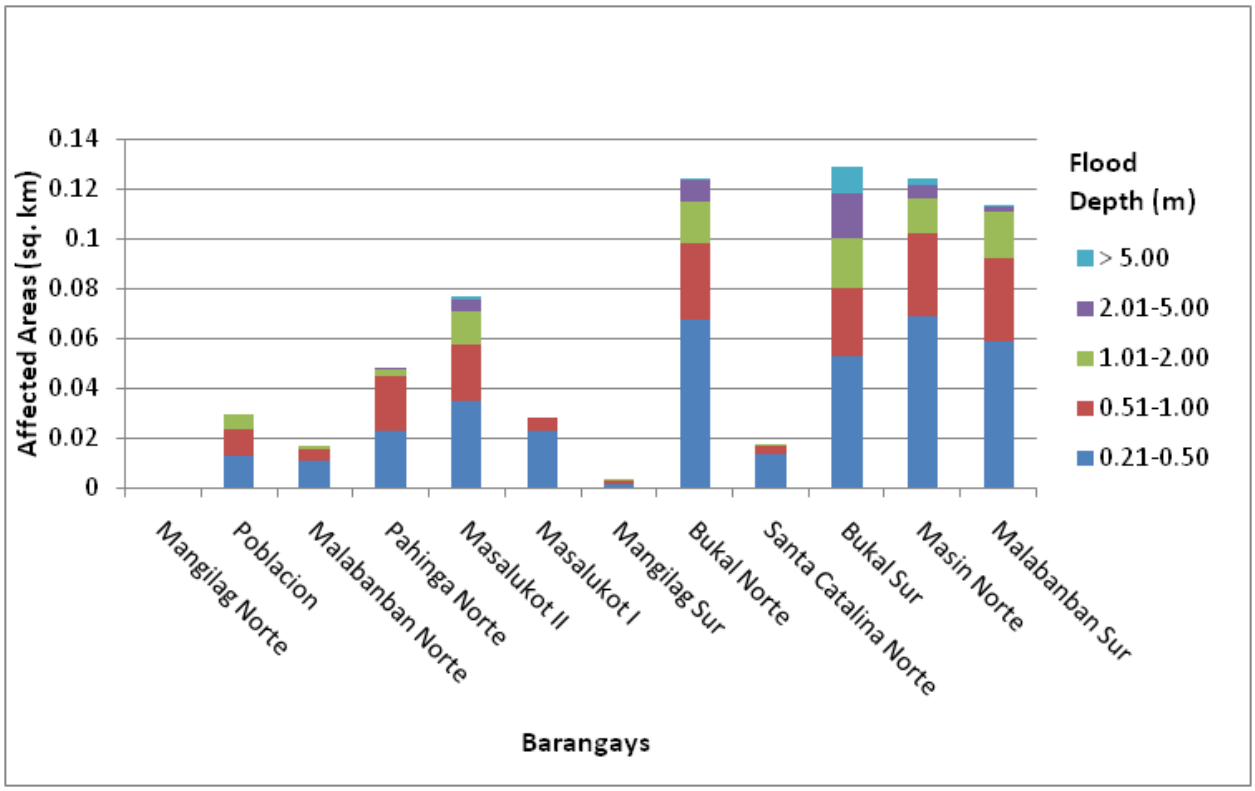
Figure 88. Affected areas in Dolores, Quezon during a 25-Year Rainfall Return Period.

For the 25-year return period, 12.18% of the municipality of Candelaria with an area of 136.74 sq. km. will experience flood levels of less than 0.20 meters. 1.30% of the area will experience flood levels of 0.21 to 0.50 meters while 0.31%, 0.19%, 0.10%, and 0.05% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 50. Affected areas in Candelaria, Quezon during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)											
	Mangilag Norte	Poblacion	Malabanban Norte	Pahinga Norte	Masalukot II	Masalukot I	Mangilag Sur	Bukal Norte	Santa Catalina Norte	Bukal Sur	Masin Norte	Malabanban Sur
0.03-0.20	0.0041	0.025	0.057	0.074	0.081	0.098	0.16	0.24	0.32	0.33	0.28	0.51
0.21-0.50	0.0003	0.013	0.011	0.023	0.035	0.023	0.0023	0.068	0.014	0.053	0.069	0.059
0.51-1.00	0	0.011	0.0051	0.022	0.023	0.0053	0.0012	0.03	0.0037	0.027	0.033	0.033
1.01-2.00	0	0.0058	0.0012	0.0029	0.013	0	0.0006	0.017	0.0002	0.02	0.014	0.019
2.01-5.00	0	0	0	0.0005	0.0048	0	0	0.0085	0	0.018	0.0054	0.002
> 5.00	0	0	0	0	0.0011	0	0	0.0003	0	0.011	0.0024	0.0004

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)								
	Masin Sur	Pahinga Sur	San Andres	Buenavista West	Kinatihan II	Kinatihan I	Santa Catalina Sur	Buenavista East	San Isidro
0.03-0.20	0.45	0.7	0.83	0.85	1.61	1.51	3.53	1.69	3.3
0.21-0.50	0.08	0.074	0.045	0.23	0.15	0.083	0.038	0.35	0.36
0.51-1.00	0.022	0.036	0.018	0.018	0.023	0.032	0.0046	0.027	0.052
1.01-2.00	0.018	0.037	0.0047	0.012	0.02	0.027	0	0.011	0.036
2.01-5.00	0.013	0.023	0.0015	0.01	0.0088	0.019	0	0.0029	0.013
> 5.00	0.008	0.018	0	0.0029	0.0031	0.01	0	0.0001	0.0078



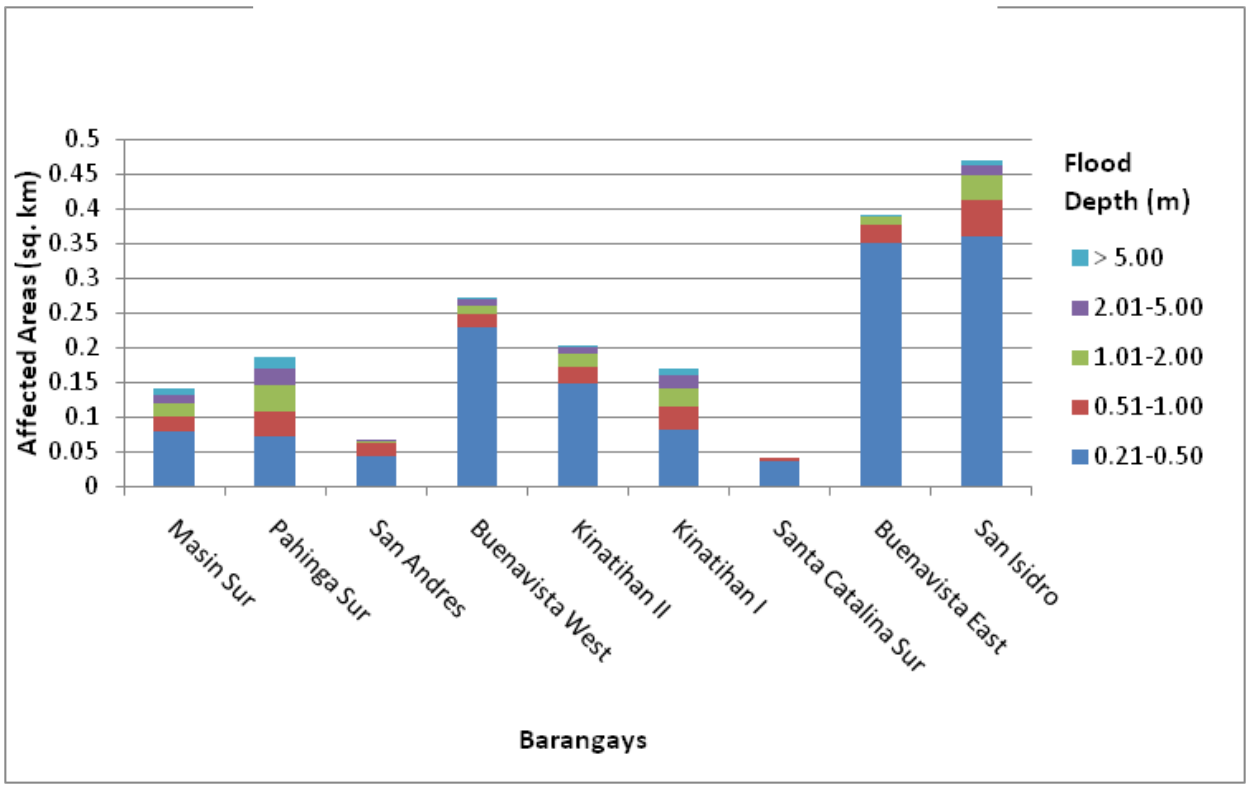


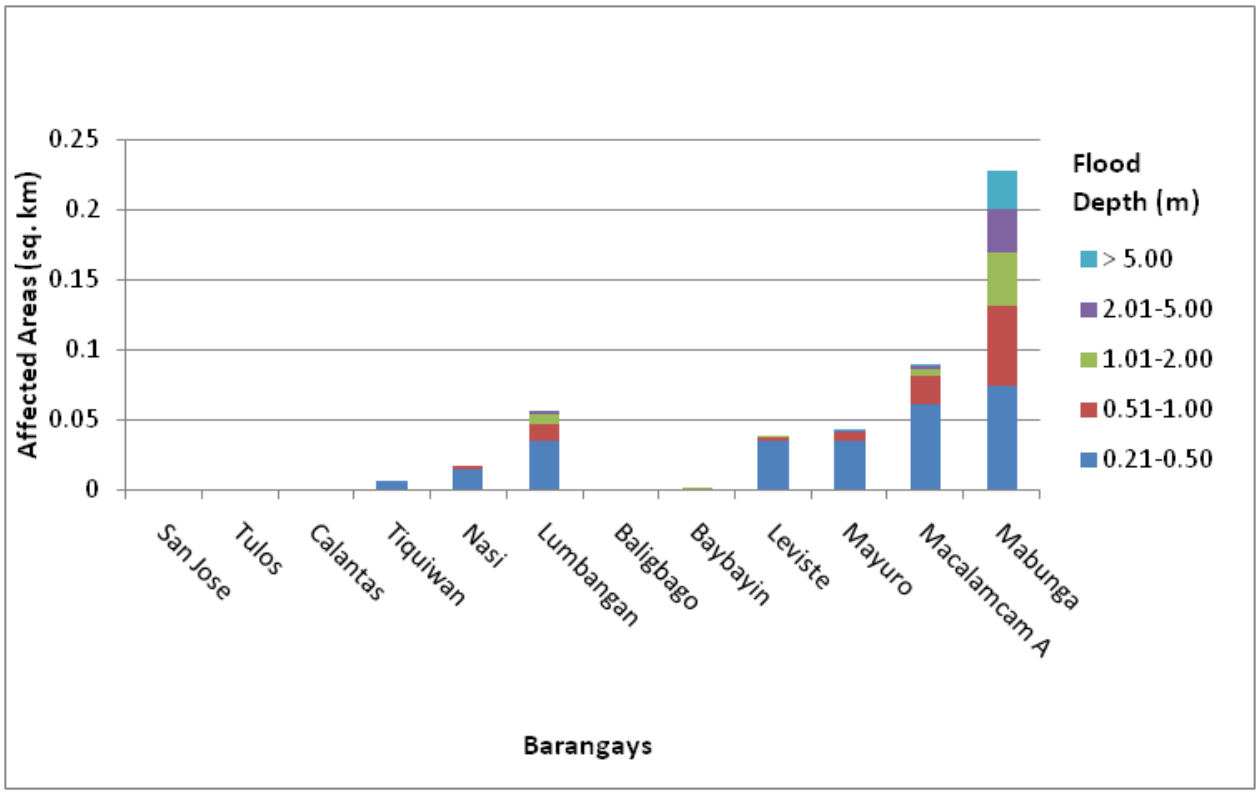
Figure 89. Affected areas in Candelaria, Quezon during a 25-Year Rainfall Return Period.

For the 25-year return period, 6.16% of the municipality of Rosario with an area of 199.04 sq. km. will experience flood levels of less than 0.20 meters. 1.37% of the area will experience flood levels of 0.21 to 0.50 meters while 0.58%, 0.31%, 0.19%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 51. Affected areas in Rosario, Batangas during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)											
	San Jose	Tulos	Calantas	Tiquiwan	Nasi	Lumbangan	Baligbago	Baybayin	Leviste	Mayuro	Macalamcam A	Mabunga
0.03-0.20	0.0078	0.003	0.0049	0.048	0.094	0.099	0	0.13	0.16	0.18	0.22	0.19
0.21-0.50	0	0	0	0.0075	0.015	0.035	0	0.0012	0.035	0.036	0.062	0.075
0.51-1.00	0	0	0	0	0.0024	0.012	0	0.0012	0.0042	0.0063	0.02	0.056
1.01-2.00	0	0	0	0	0	0.0075	0	0.0003	0.0002	0.0005	0.0045	0.038
2.01-5.00	0	0	0	0	0	0.0022	0	0	0	0.0002	0.0025	0.031
> 5.00	0	0	0	0	0	0	0	0	0	0.0007	0.0016	0.028

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)										
	San Isidro	Bayawang	Mabato	Macalamcam B	Alupya	Natu	Maligaya	San Carlos	Salao	Pinagsibaan	Putingkahoy
0.03-0.20	0.26	0.28	0.55	1.14	0	0.48	0.5	0.56	1.1	1.07	1.35
0.21-0.50	0.086	0.13	0.18	0.083	0	0.084	0.17	0.18	0.12	0.18	0.4
0.51-1.00	0.034	0.07	0.07	0.036	0	0.007	0.069	0.08	0.055	0.11	0.16
1.01-2.00	0.018	0.043	0.037	0.031	0	0.0002	0.045	0.024	0.042	0.065	0.061
2.01-5.00	0.0093	0.031	0.027	0.025	0	0.0002	0.039	0	0.018	0.038	0.039
> 5.00	0.0047	0.021	0.025	0.017	0	0.0004	0.021	0	0.011	0.014	0.032



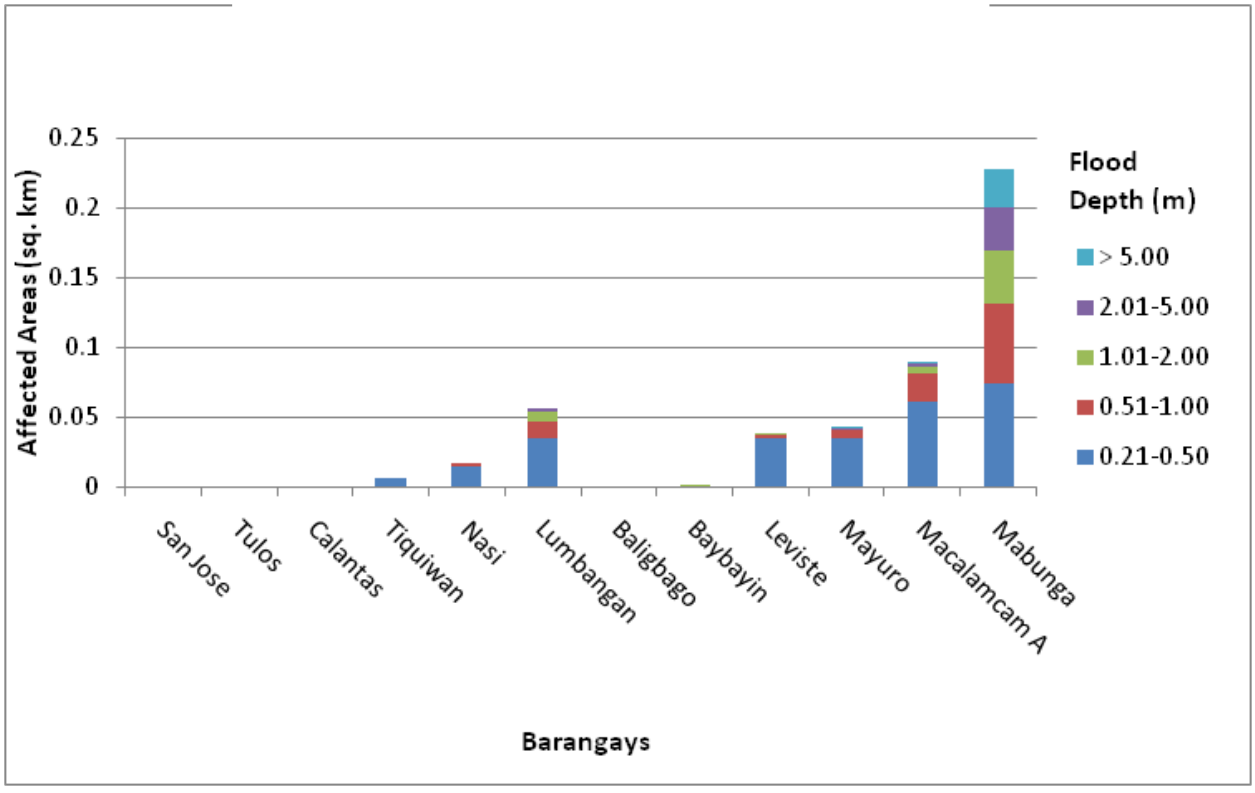


Figure 90. Affected areas in Rosario, Batangas during a 25-Year Rainfall Return Period.

For the 25-year return period, 5.42% of the municipality of San Antonio with an area of 62.38 sq. km. will experience flood levels of less than 0.20 meters. 0.97% of the area will experience flood levels of 0.21 to 0.50 meters while 0.42%, 0.18%, 0.11%, and 0.08% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 52. Affected areas in San Antonio, Quezon during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)											
	Poblacion	San Jose	Niing	Arawan	Buliran	Pury	Sampaguita	Loob	Matipunso	Bulihan	Balat Atis	Sampaga
0.03-0.20	0.017	0.17	0.12	0.087	0.18	0.46	0.12	0.13	0.18	0.17	0.16	0.54
0.21-0.50	0.0026	0.021	0.017	0.017	0.0037	0.035	0.0025	0.015	0.038	0.06	0.15	0.1
0.51-1.00	0.0009	0.0007	0.0074	0.0064	0.0007	0.0056	0.0026	0.0081	0.028	0.023	0.064	0.009
1.01-2.00	0.0009	0.0007	0.0017	0.0046	0.0001	0.0049	0.0008	0.0077	0.016	0.01	0.014	0.0046
2.01-5.00	0.0002	0.0004	0.0006	0.0025	0	0.0036	0	0.0062	0.012	0.0031	0.0061	0.004
> 5.00	0.0011	0.0007	0.0005	0.0019	0	0.0041	0	0.0052	0.0096	0.0003	0.0071	0.0055

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)							
	Callejon	Magsaysay	Corzaon	Sinturisan	Bagong Niing	Briones	Pulo	Manuel Del Valle, Sr.
0.03-0.20	0.55	0.46	0	0.59	0.76	0.71	0.67	1.34
0.21-0.50	0.056	0.055	0	0.073	0.13	0.16	0.29	0.1
0.51-1.00	0.028	0.025	0	0.026	0.056	0.058	0.18	0.049
1.01-2.00	0.023	0.019	0	0.0078	0.028	0.033	0.036	0.038
2.01-5.00	0.02	0.012	0	0.0015	0.021	0.025	0.012	0.014
> 5.00	0.0068	0.0063	0	0.0004	0.022	0.019	0.01	0.0097

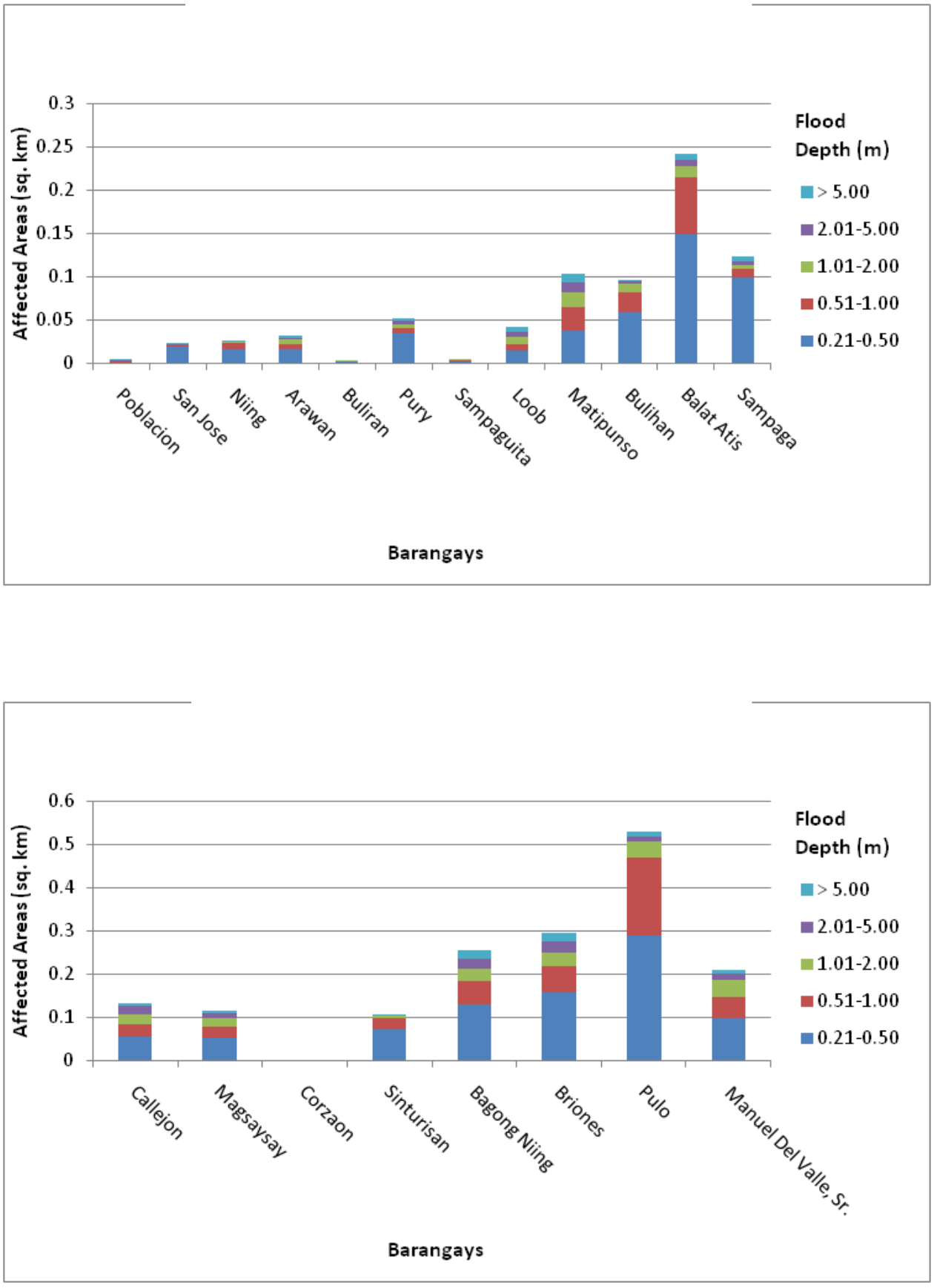


Figure 91. Affected areas in San Antonio, Quezon during a 25-Year Rainfall Return Period.

For the 100-Year return period, 2.70% of the municipality of San Pablo City with an area of 184.81 sq. km. will experience flood levels of less than 0.20 meters. 0.40% of the area will experience flood levels of 0.21 to 0.50 meters while 0.18%, 0.10%, 0.07%, and 0.04% 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 the table are the affected areas in square kilometers by flood depth per barangay.

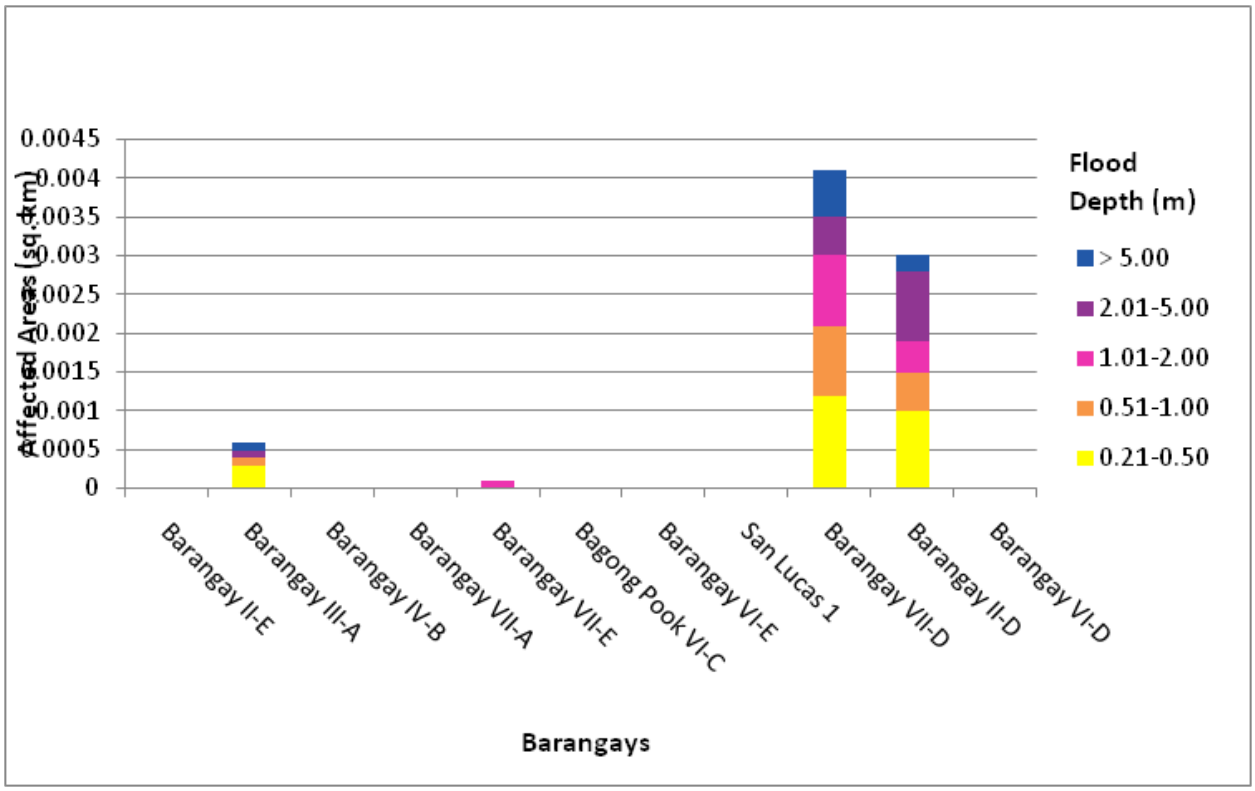
Table 53. Affected areas in San Pablo City, Laguna during a 100-Year Rainfall Return Period.

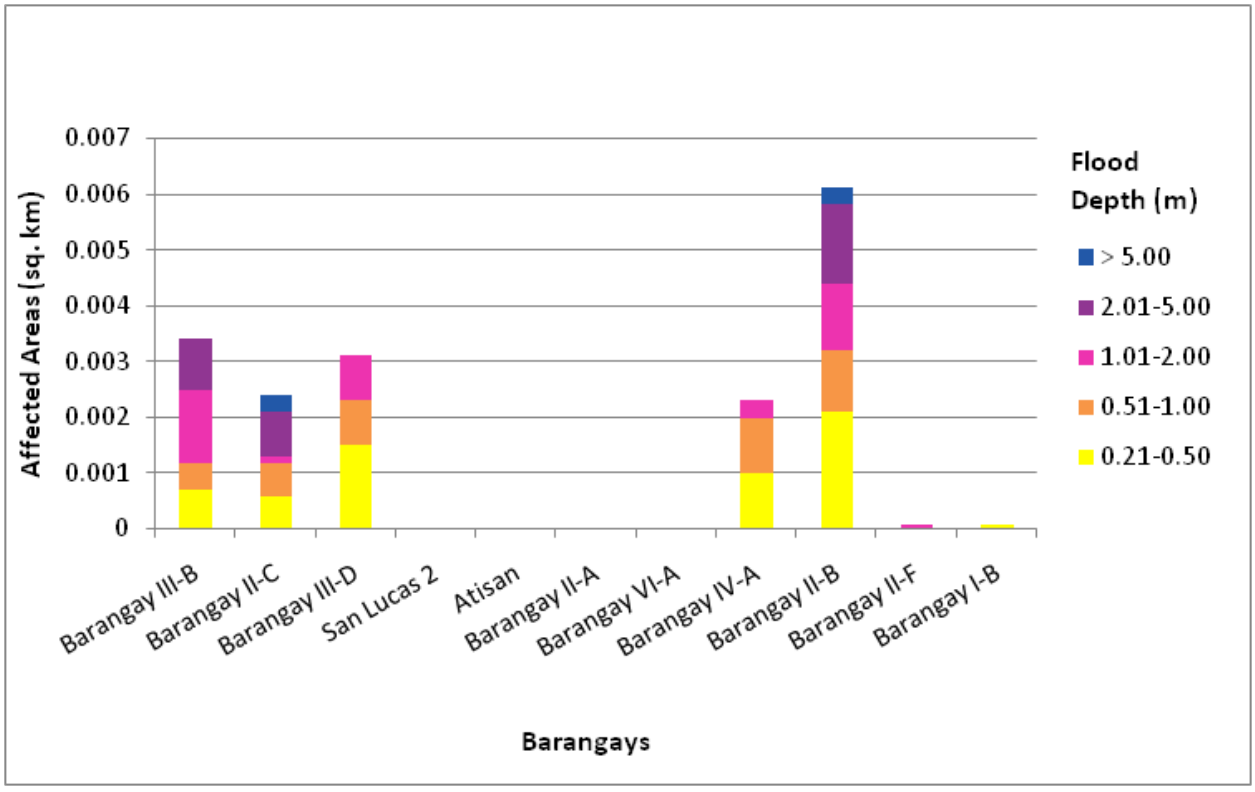
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay II-E	Barangay III-A	Barangay IV-B	Barangay VII-A	Barangay VII-E	Bagong Pook VI-C	Barangay VI-E	San Lucas 1	Barangay VII-D	Barangay II-D	Barangay VI-D
0.03-0.20	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0004	0.0008	0.0008
0.21-0.50	0	0.0003	0	0	0	0	0	0	0.0012	0.001	0
0.51-1.00	0	0.0001	0	0	0	0	0	0	0.0009	0.0005	0
1.01-2.00	0	0	0	0	0.0001	0	0	0	0.0009	0.0004	0
2.01-5.00	0	0.0001	0	0	0	0	0	0	0.0005	0.0009	0
> 5.00	0	0.0001	0	0	0	0	0	0	0.0006	0.0002	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Barangay III-B	Barangay II-C	Barangay III-D	San Lucas 2	Atisan	Barangay II-A	Barangay VI-A	Barangay IV-A	Barangay II-B	Barangay II-F	Barangay I-B
0.03-0.20	0.0009	0.0011	0.0012	0.0015	0.0016	0.002	0.002	0.0021	0.0031	0.014	0.021
0.21-0.50	0.0007	0.0006	0.0015	0	0	0	0	0.001	0.0021	0	0.0001
0.51-1.00	0.0005	0.0006	0.0008	0	0	0	0	0.001	0.0011	0	0
1.01-2.00	0.0013	0.0001	0.0008	0	0	0	0	0.0003	0.0012	0.0001	0
2.01-5.00	0.0009	0.0008	0	0	0	0	0	0	0.0014	0	0
> 5.00	0	0.0003	0	0	0	0	0	0	0.0003	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santo Cristo	Bagong Bayan II-A	San Antonio 1	Santa Cruz	Santa Maria Magdalena	San Ignacio	Santiago II	San Vicente	San Mateo	Del Remedio	San Marcos
0.03-0.20	0.021	0.03	0.031	0.033	0.042	0.048	0.048	0.05	0.054	0.068	0.069
0.21-0.50	0.0065	0.002	0.0003	0.0068	0.014	0.017	0.022	0.0088	0	0.012	0.0017
0.51-1.00	0.0016	0.0003	0	0.001	0.0053	0.004	0.013	0.0068	0	0.0096	0.001
1.01-2.00	0.0004	0.0014	0	0.0001	0.0004	0.0004	0.0081	0.0054	0	0.0037	0.0008
2.01-5.00	0	0.0012	0	0	0	0	0.0028	0.0025	0	0.0012	0
> 5.00	0	0.0008	0	0	0	0	0.0012	0.0002	0	0.0012	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Pablo City (in sq. km.)										
	Santa Ana	San Francisco	San Gabriel	San Gregorio	San Antonio 2	San Juan	San Roque	Santa Monica	San Rafael	Soledad	Santa Felomina
0.03-0.20	0.072	0.075	0.09	0.091	0.11	0.13	0.14	0.16	0.17	0.26	0.26
0.21-0.50	0.023	0.026	0.0094	0.0097	0.017	0.018	0.016	0.064	0.055	0.031	0.082
0.51-1.00	0.014	0.014	0.0068	0.0082	0.0029	0.016	0.01	0.033	0.022	0.01	0.0085
1.01-2.00	0.011	0.0056	0.0067	0.0071	0.0004	0.015	0.0039	0.025	0.014	0.0074	0
2.01-5.00	0.0023	0.0024	0.0082	0.006	0	0.0098	0	0.011	0.017	0.0077	0
> 5.00	0.0001	0	0.0053	0.0024	0	0.0047	0	0.0082	0.01	0.0079	0


0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Affected Areas (sq. km)
Barangay II-E
Barangay III-A
Barangay IV-B
Barangay VII-A
Barangay VII-E
Bagong Pook VI-C
Barangay VI-E
San Lucas 1
Barangay VII-D
Barangay II-D
Barangay VI-D
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Affected Areas (sq. km)
Barangay III-B
Barangay II-C
Barangay III-D
San Lucas 2
Atisan
Barangay II-A
Barangay VI-A
Barangay IV-A
Barangay II-B
Barangay II-F
Barangay I-B
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

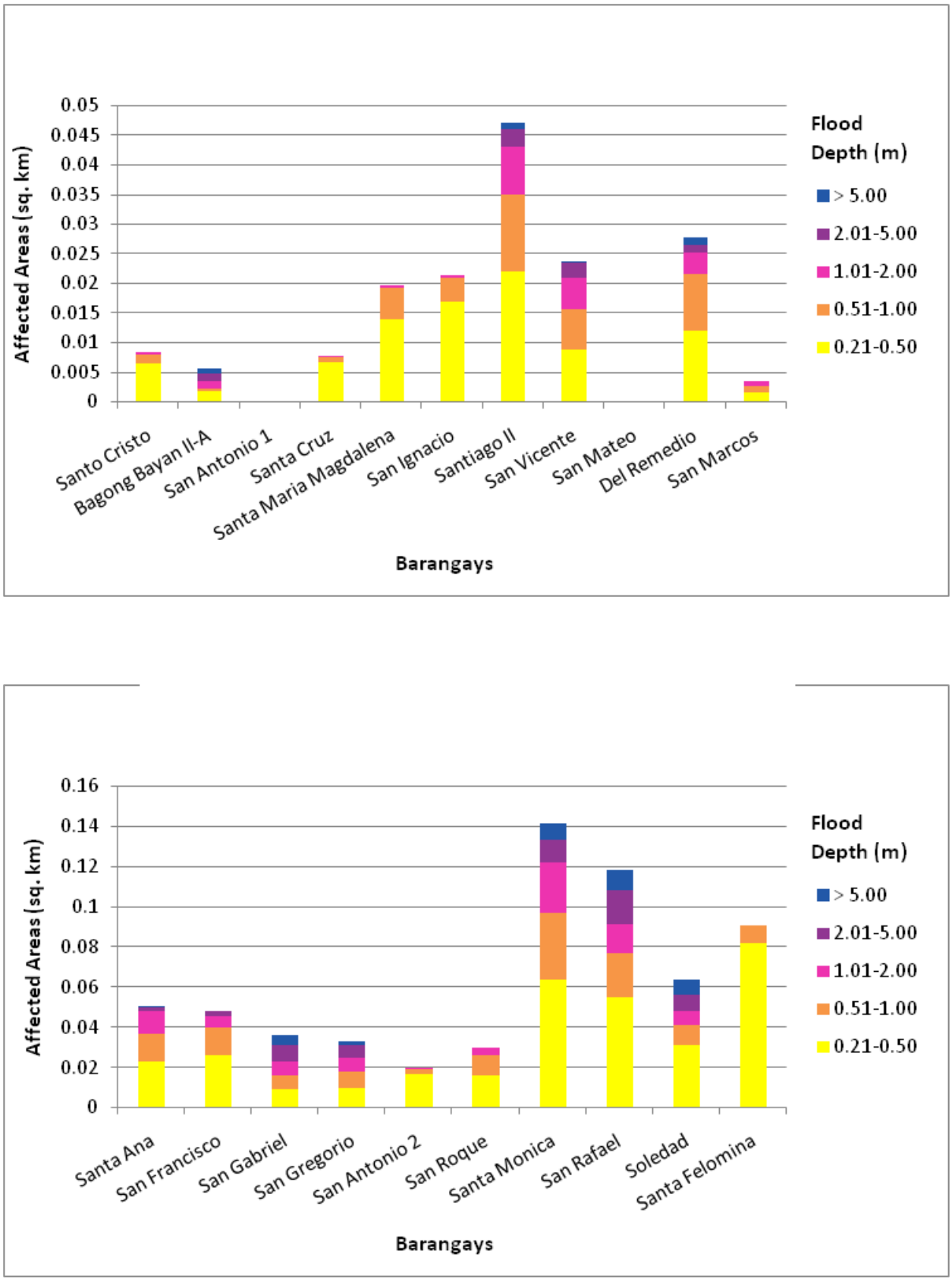


Figure 92. Affected areas in San Pablo City, Laguna during a 100-Year Rainfall Return Period.

For the 100-year return period, 4.56% of the municipality of Padre Garcia with an area of 39.28 sq. km. will experience flood levels of less than 0.20 meters. 0.84% of the area will experience flood levels of 0.21 to 0.50 meters while 0.33%, 0.18%, 0.11%, and 0.10% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 54. Affected areas in Padre Garcia, Batangas during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)							
	Bawi	Banybanay	Tamak	Manggas	Pansol	Tangob	Payapa	Maugat West
0.03-0.20	0.0054	0	0.05	0.053	0.077	0.087	0.098	0.1
0.21-0.50	0	0	0.032	0.0078	0.016	0.012	0.0088	0.023
0.51-1.00	0	0	0.008	0.0007	0.0057	0.0066	0.0004	0.016
1.01-2.00	0	0	0	0	0	0.0056	0	0.011
2.01-5.00	0	0	0	0	0	0.0038	0	0.0083
> 5.00	0	0	0	0	0	0.005	0	0.01

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Padre Garcia (in sq. km.)							
	Quilo-Quilo South	Maugat East	San Felipe	Poblacion	Quilo-Quilo North	Castillo	Bukal	Banaba
0.03-0.20	0.11	0.13	0.13	0.14	0.15	0.19	0.22	0.25
0.21-0.50	0	0.047	0.0055	0.0015	0.0055	0.051	0.1	0.019
0.51-1.00	0	0.018	0	0	0.0013	0.017	0.057	0.0006
1.01-2.00	0	0.014	0	0	0	0.013	0.026	0
2.01-5.00	0	0.015	0	0	0	0.0066	0.011	0
> 5.00	0	0.016	0	0	0	0.0046	0.0048	0

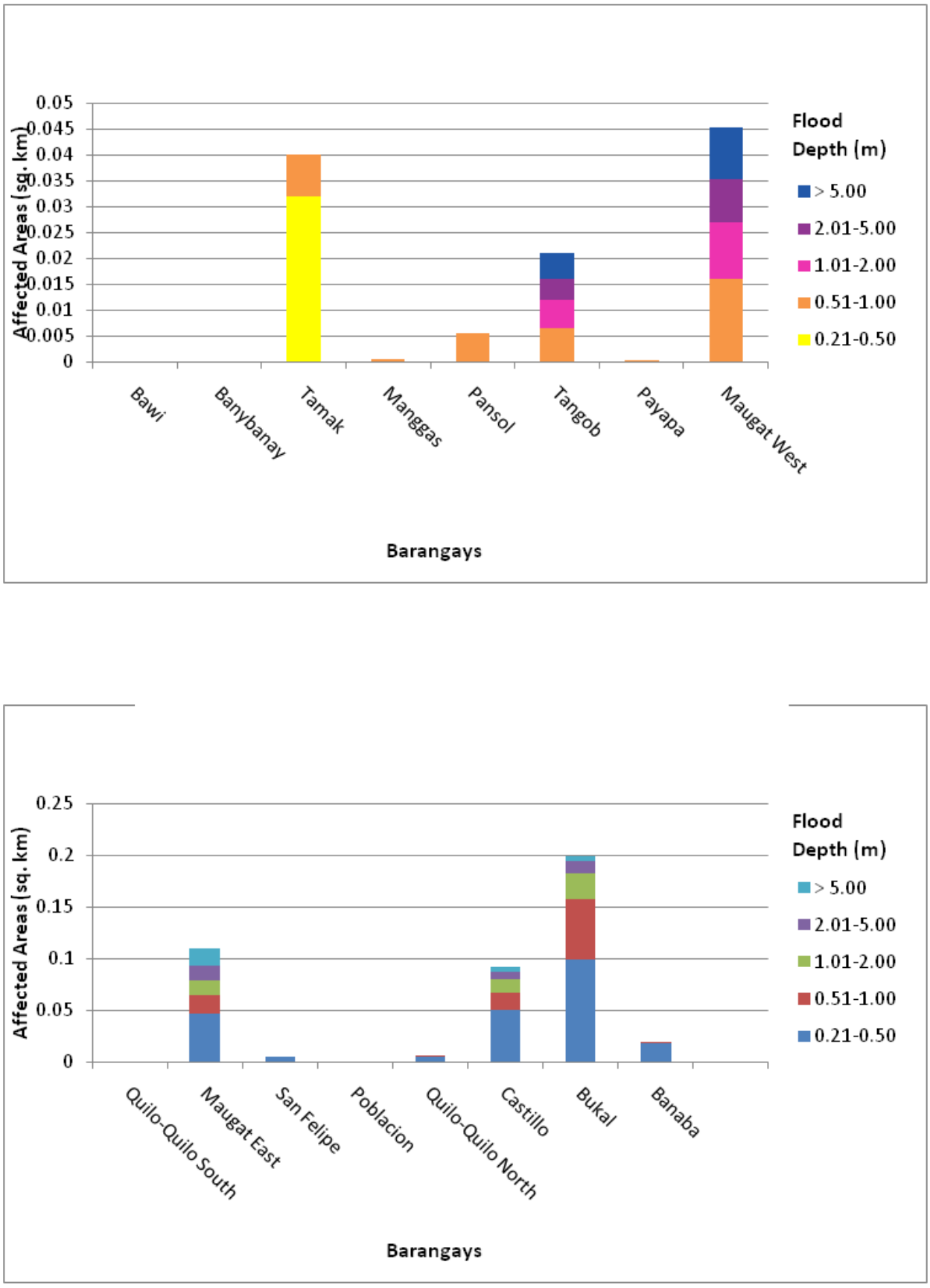


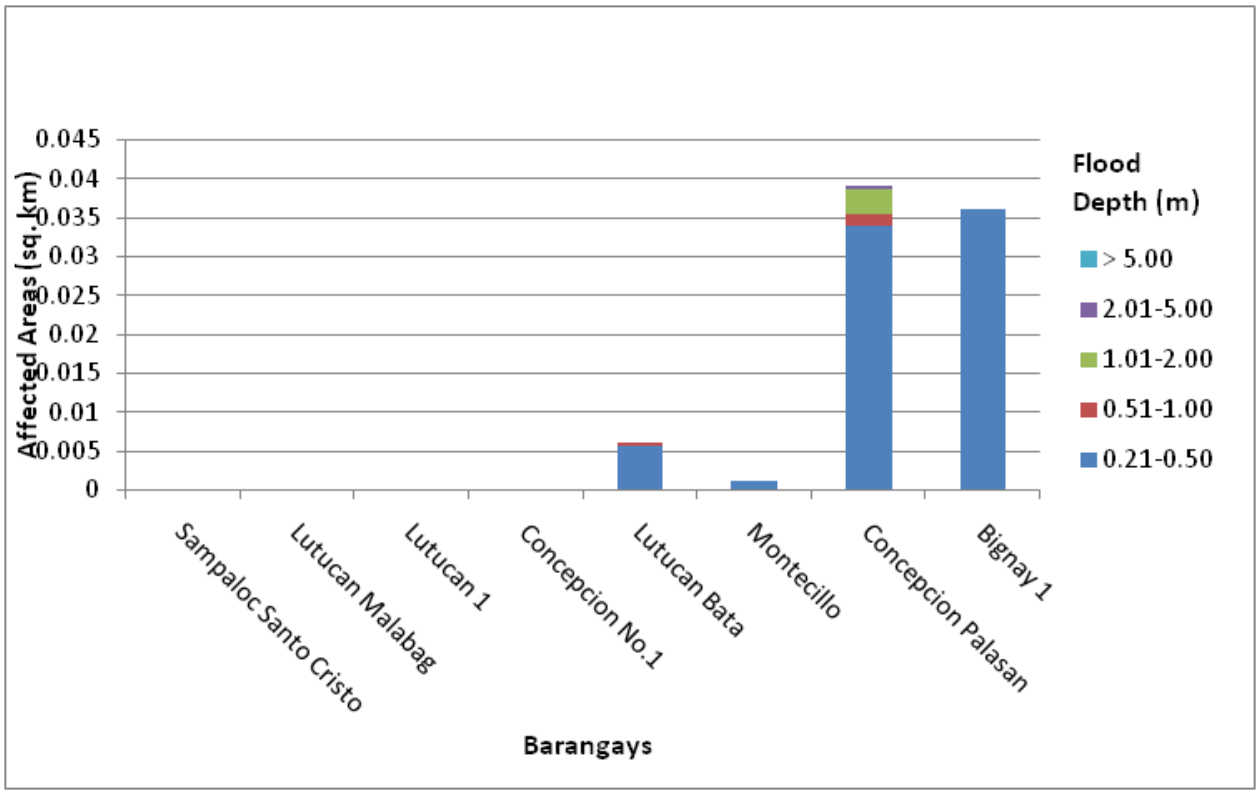
Figure 93. Affected areas in Padre Garcia, Batangas during a 100-Year Rainfall Return Period.

For the 100-year return period, 20.39% of the municipality of Sariaya with an area of 213.78 sq. km. will experience flood levels of less than 0.20 meters. 1.71% of the area will experience flood levels of 0.21 to 0.50 meters while 0.31%, 0.22%, 0.09%, and 0.04% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 55. Affected areas in Sariaya, Quezon during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)							
	Sampaloc Santo Cristo	Lutucan Malabag	Lutucan 1	Concepcion No.1	Lutucan Bata	Montecillo	Concepcion Palasan	Bignay 1
0.03-0.20	0.0007	0.0046	0.0054	0	0.1	0.18	0.41	0.52
0.21-0.50	0	0	0	0	0.0058	0.0012	0.034	0.036
0.51-1.00	0	0	0	0	0.0004	0	0.0015	0
1.01-2.00	0	0	0	0	0	0	0.0032	0
2.01-5.00	0	0	0	0	0	0	0.0003	0
> 5.00	0	0	0	0	0	0	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Sariaya (in sq. km.)						
	Manggalang 1	Manggalang-Kiling	Guisguis-Talon	Manggalang Tulo-Tulo	Manggalang-Bantilan	Guisguis-San Roque	Bignay 2
0.03-0.20	0.52	0.57	0.7	0.85	1.16	1.37	1.62
0.21-0.50	0.08	0.11	0.054	0.0036	0.14	0.16	0.048
0.51-1.00	0.011	0.0072	0.0011	0.0001	0.052	0.049	0.0009
1.01-2.00	0.0009	0.012	0.0002	0	0.05	0.02	0
2.01-5.00	0	0	0	0	0.019	0.015	0
> 5.00	0	0	0	0	0.008	0.0062	0



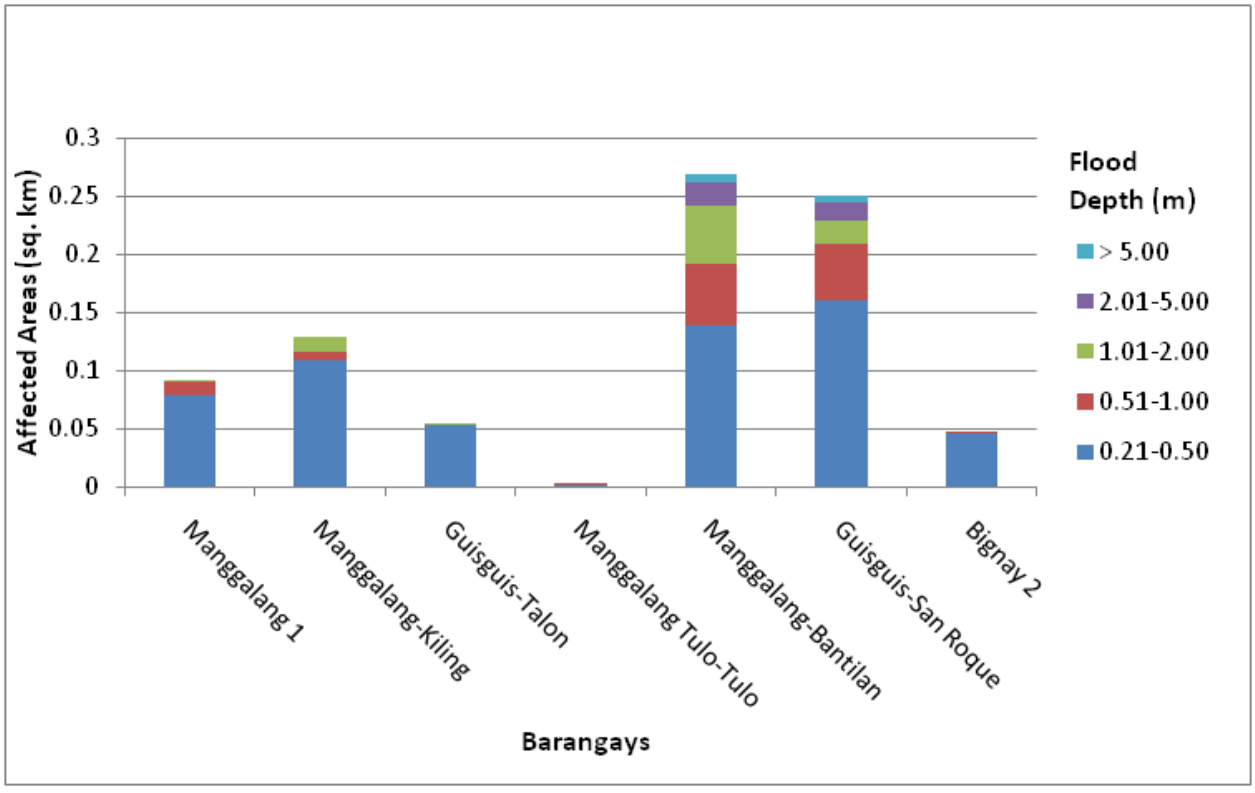


Figure 94. Affected areas in Sariaya, Quezon during a 100-Year Rainfall Return Period.

For the 100-year return period, 10.27% of the municipality of San Juan with an area of 237.55 sq. km. will experience flood levels of less than 0.20 meters. 2.33% of the area will experience flood levels of 0.21 to 0.50 meters while 0.50%, 0.19%, 0.11%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

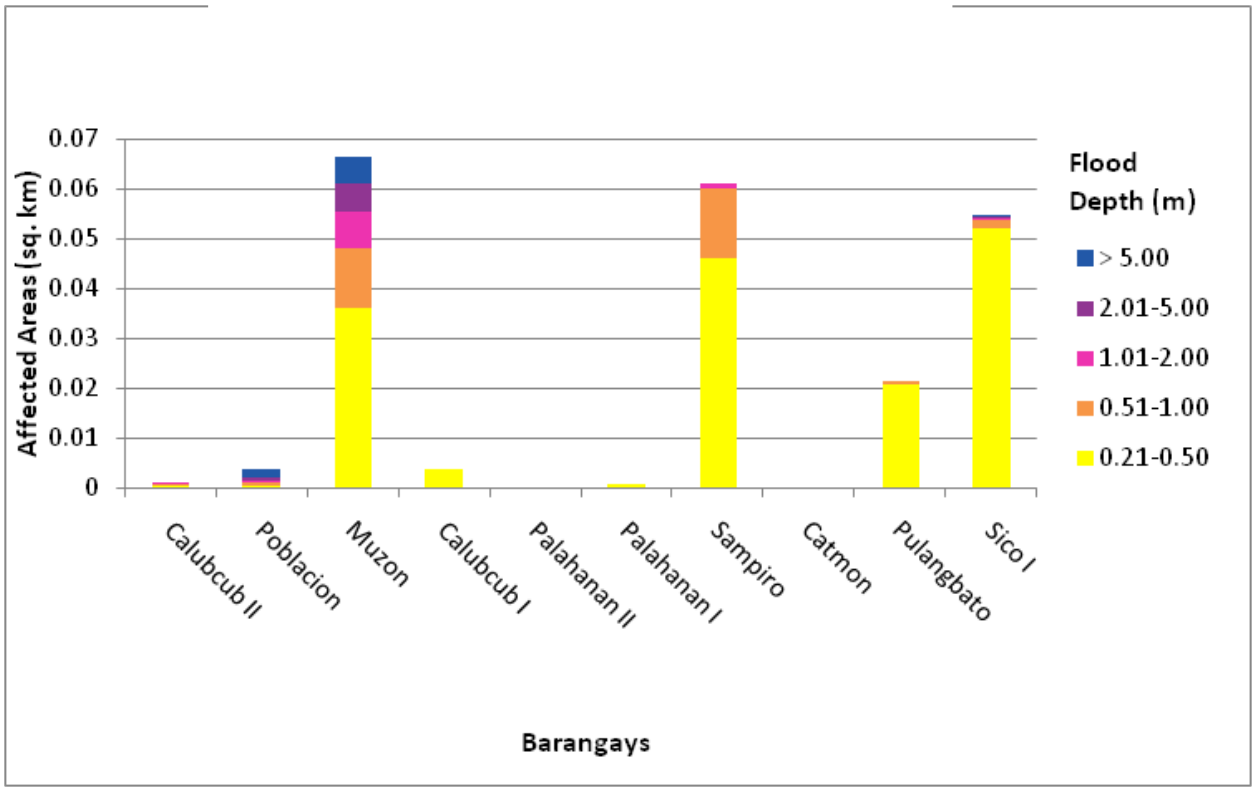
Table 56. Affected areas in San Juan, Batangas during a 100-Year Rainfall Return Period.

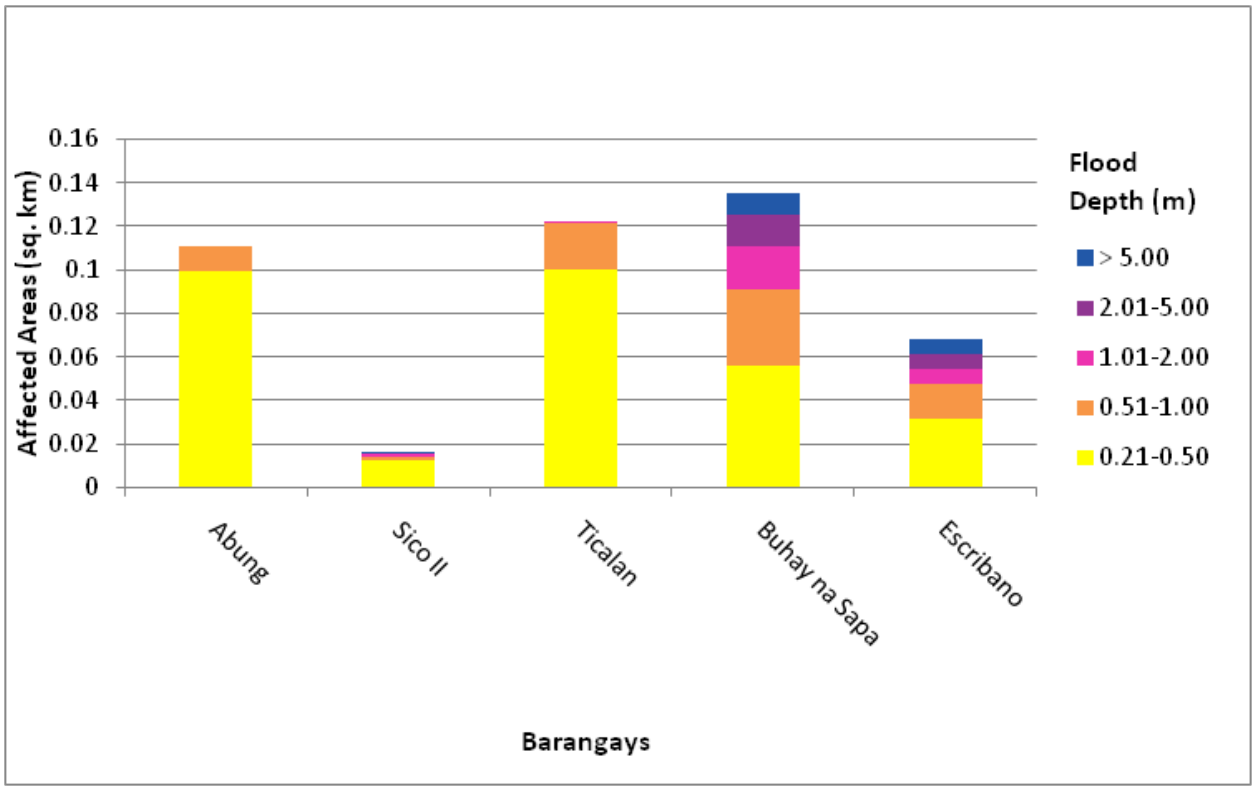
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Calubcub II	Poblacion	Muzon	Calubcub I	Palahanan II	Palahanan I	Sampiro	Catmon	Pulangbato	Sico I
0.03-0.20	0.0066	0.0082	0.038	0.062	0.063	0.089	0.13	0.17	0.19	0.22
0.21-0.50	0.0006	0.0005	0.036	0.0039	0	0.0009	0.046	0	0.021	0.052
0.51-1.00	0.0004	0.0007	0.012	0	0	0	0.014	0	0.0004	0.0017
1.01-2.00	0.0002	0.0006	0.0073	0	0	0	0.0012	0	0	0.0004
2.01-5.00	0	0.0005	0.0058	0	0	0	0	0	0	0.0004
> 5.00	0	0.0018	0.0052	0	0	0	0	0	0	0.0003

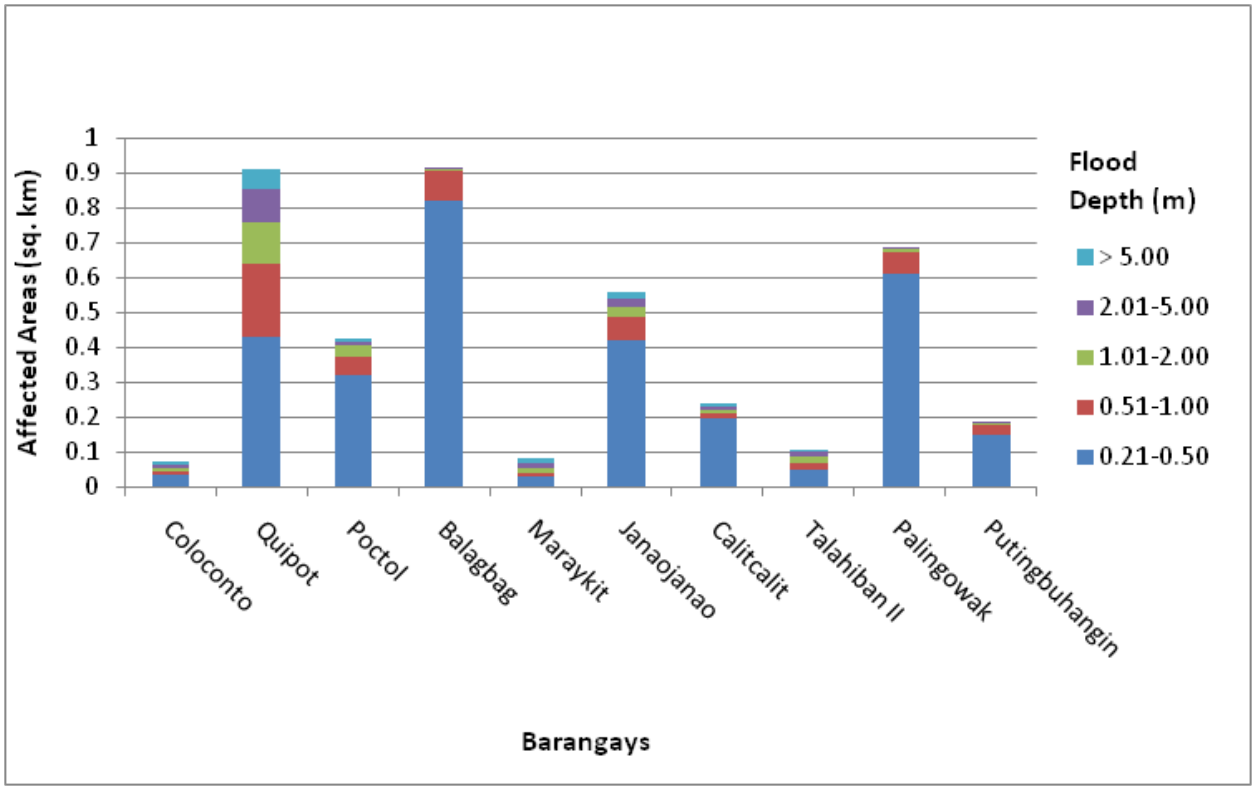
Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Abung	Sico II	Ticalan	Buhay na Sapa	Escribano	Sapangan	Mabalanoy	Pinagbayanan	Libato	Tipaz
0.03-0.20	0.28	0.34	0.43	0.48	0.57	0.63	0.66	0.95	0.95	0.96
0.21-0.50	0.099	0.013	0.1	0.056	0.032	0.2	0.016	0.76	0.29	0.34
0.51-1.00	0.012	0.0014	0.021	0.035	0.016	0.041	0.012	0.18	0.15	0.1
1.01-2.00	0	0.0015	0.0011	0.02	0.0067	0.0049	0.011	0.0035	0.07	0.034
2.01-5.00	0	0.0009	0	0.014	0.0071	0.0002	0.0099	0	0.038	0.0007
> 5.00	0	0.0002	0	0.01	0.0065	0	0.014	0	0.016	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)									
	Coloconto	Quipot	Poctol	Balagbag	Maraykit	Janaojanao	Calitcalit	Talahiban II	Palingowak	Putingbuhangin
0.03-0.20	1.14	1.16	1.26	1.28	1.3	1.33	1.36	1.4	1.49	1.63
0.21-0.50	0.036	0.43	0.32	0.82	0.031	0.42	0.2	0.053	0.61	0.15
0.51-1.00	0.012	0.21	0.056	0.083	0.013	0.067	0.011	0.019	0.063	0.03
1.01-2.00	0.01	0.12	0.031	0.011	0.013	0.031	0.012	0.019	0.013	0.0099
2.01-5.00	0.0095	0.091	0.012	0.0017	0.015	0.021	0.01	0.014	0.0015	0.0001
> 5.00	0.0085	0.059	0.0079	0	0.012	0.019	0.011	0.0047	0	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Juan (in sq. km.)	
	Talahiban I	Lipahan
0.03-0.20	1.9	1.92
0.21-0.50	0.19	0.2
0.51-1.00	0.026	0.011
1.01-2.00	0.0009	0.0095
2.01-5.00	0	0.0093
> 5.00	0	0.095




Affected Areas (sq. km)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Abung
Sico II
Ticalan
Buhay na Sapa
Escribano
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


Affected Areas (sq. km)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Coloconto
Quipot
Poctol
Balagbag
Maraykit
Janaojanao
Calitcalit
Talahiban II
Palingowak
Putingbuhangin
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

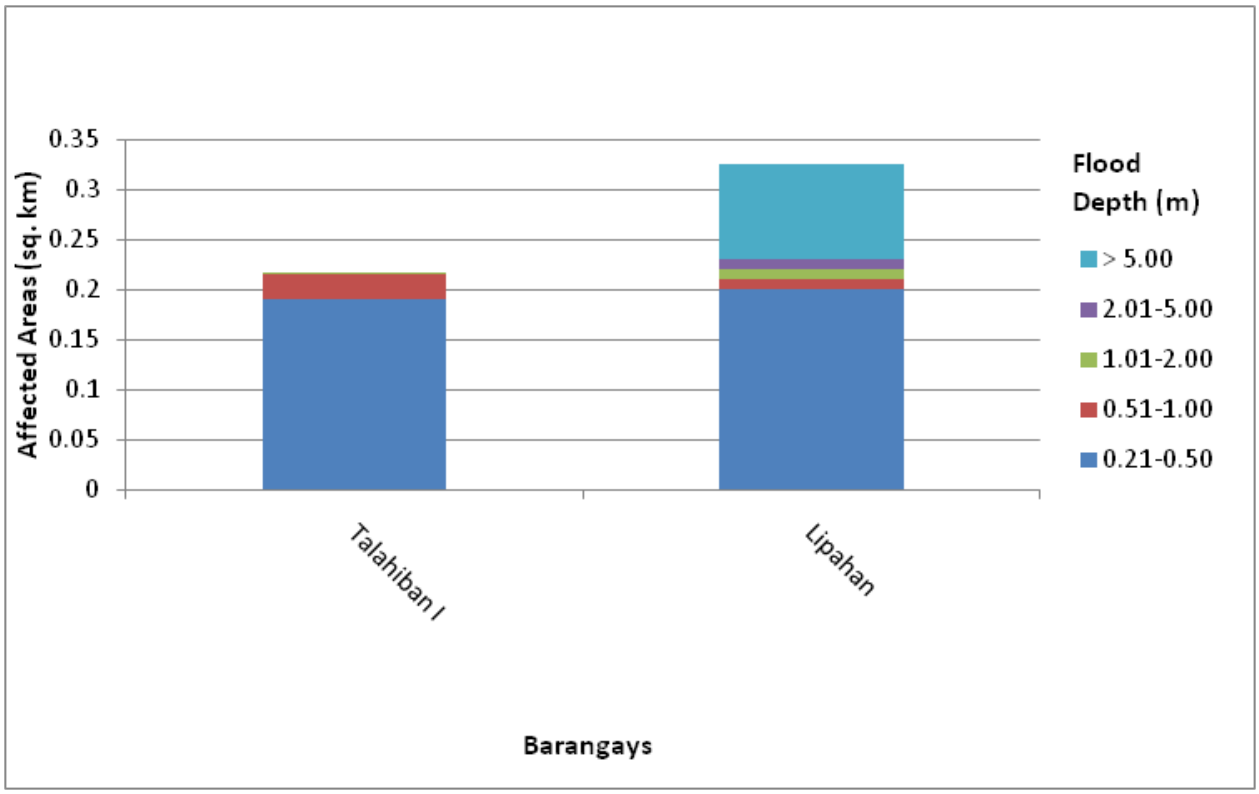


Figure 95. Affected areas in San Juan, Batangas during a 100-Year Rainfall Return Period.

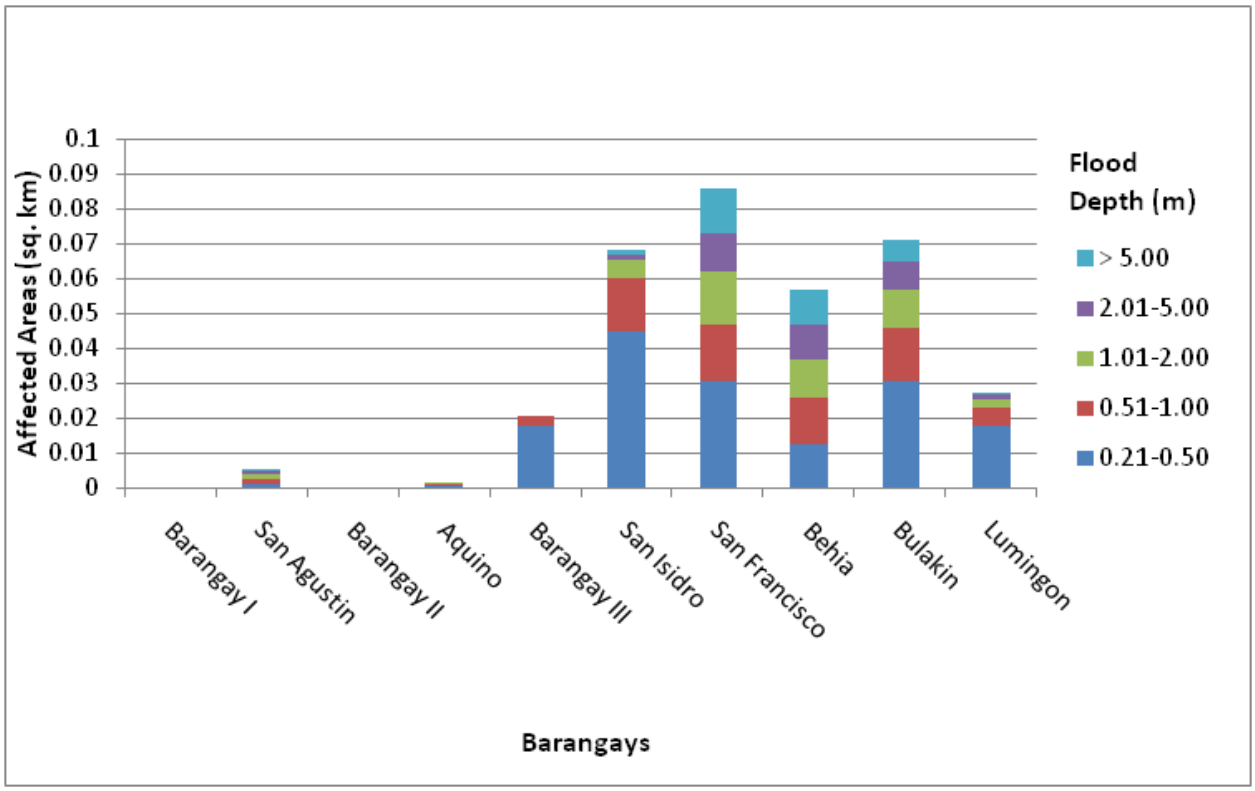
For the 100-year return period, 6.67% of the municipality of Tiaong with an area of 118.93 sq. km. will experience flood levels of less than 0.20 meters. 1.26% of the area will experience flood levels of 0.21 to 0.50 meters while 0.29%, 0.13%, 0.09%, and 0.07% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

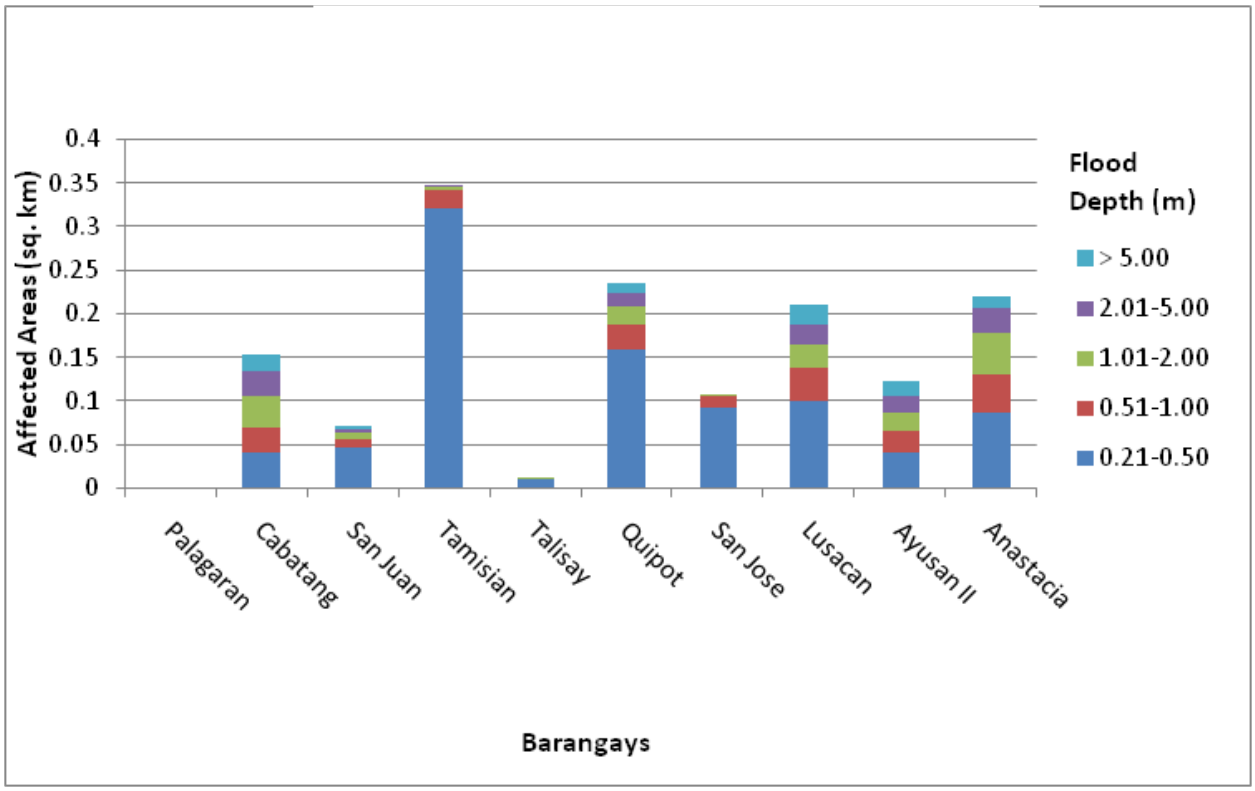
Table 57. Affected areas in Tiaong. Quezon during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Barangay I	San Agustin	Barangay II	Aquino	Barangay III	San Isidro	San Francisco	Behia	Bulakin	Lumingon
0.03-0.20	0.0015	0.0037	0.014	0.024	0.063	0.15	0.21	0.23	0.25	0.29
0.21-0.50	0	0.0013	0	0.0013	0.018	0.045	0.031	0.013	0.031	0.018
0.51-1.00	0	0.0014	0	0.0002	0.0029	0.015	0.016	0.013	0.015	0.0053
1.01-2.00	0	0.0017	0	0.0003	0	0.0052	0.015	0.011	0.011	0.0021
2.01-5.00	0	0.0008	0	0	0	0.0018	0.011	0.01	0.0081	0.0017
> 5.00	0	0.0006	0	0	0	0.0013	0.013	0.01	0.0059	0.0005

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Palagaran	Cabatang	San Juan	Tamisian	Talisay	Quipot	San Jose	Lusacan	Ayusan II	Anastacia
0.03-0.20	0.3	0.3	0.38	0.43	0.47	0.48	0.56	0.61	0.66	0.72
0.21-0.50	0.002	0.041	0.047	0.32	0.012	0.16	0.093	0.1	0.041	0.088
0.51-1.00	0.0001	0.03	0.009	0.021	0.0008	0.027	0.014	0.039	0.026	0.042
1.01-2.00	0	0.035	0.008	0.0043	0.0003	0.022	0.0013	0.026	0.021	0.049
2.01-5.00	0	0.028	0.0047	0.0008	0	0.015	0	0.022	0.019	0.027
> 5.00	0	0.019	0.0024	0	0	0.011	0	0.023	0.016	0.013

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Tiaong (in sq. km.)									
	Paiisa	Bula	Tagbakin	Lagalag	San Pedro	Cabay	Del Rosario	Bukal	Ayusan I	Lalig
0.03-0.20	0.73	0.78	0.81	0.83	0.86	0.89	0.89	1.03	1.41	1.46
0.21-0.50	0.016	0.24	0.02	0.05	0.13	0.055	0.02	0.62	0.35	0.43
0.51-1.00	0.0003	0.052	0.0067	0.004	0.035	0.0013	0.0085	0.23	0.035	0.031
1.01-2.00	0.0003	0.011	0.003	0.0026	0.021	0.0008	0.005	0.031	0.021	0.0099
2.01-5.00	0	0.0095	0.0015	0.0026	0.014	0.0005	0.0033	0.0084	0.02	0.0081
> 5.00	0	0.01	0	0.0028	0.0069	0.0003	0.0044	0.0047	0.017	0.0075


Affected Areas (sq. km)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Barangay I
San Agustin
Barangay II
Aquino
Barangay III
San Isidro
San Francisco
Behia
Bulakin
Lumingon
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50


Affected Areas (sq. km)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Palagaran
Cabatang
San Juan
Tamisian
Talisay
Quipot
San Jose
Lusacan
Ayusan II
Anastacia
Barangays
Flood Depth (m)
> 5.00
2.01-5.00
1.01-2.00
0.51-1.00
0.21-0.50

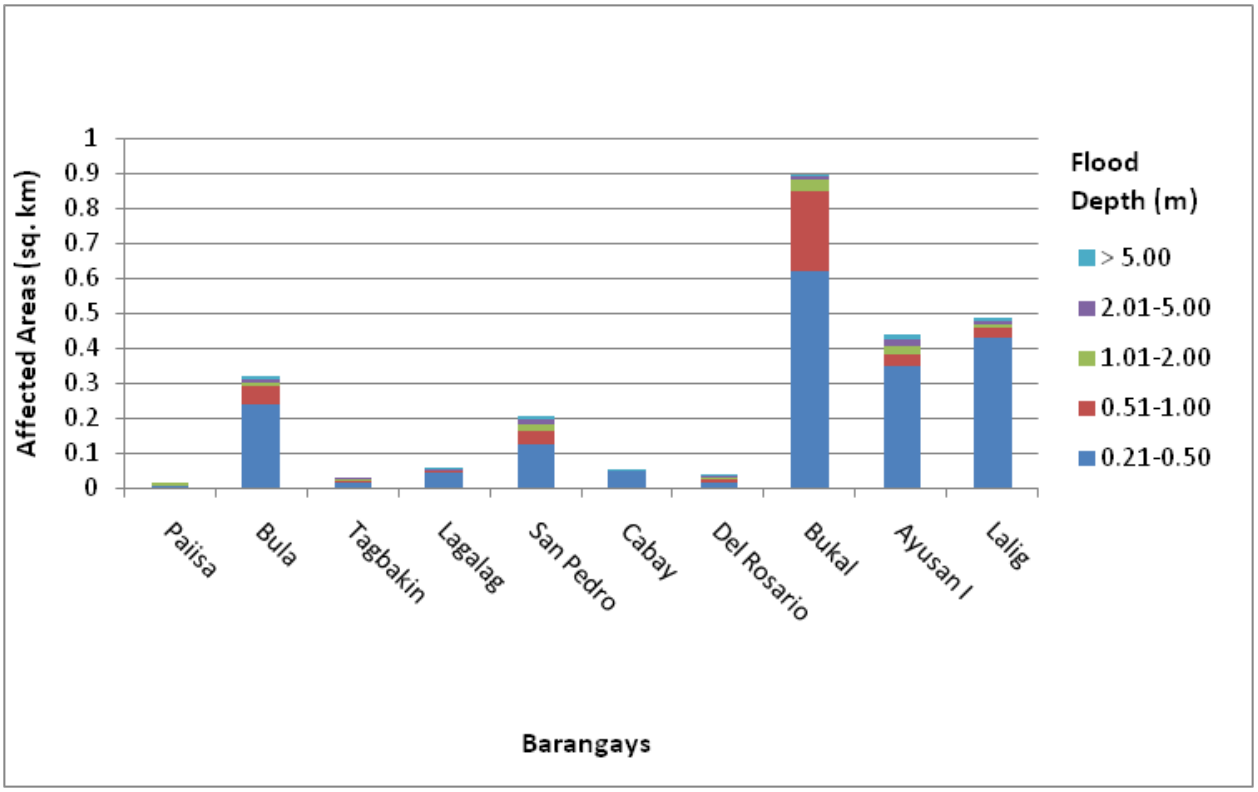


Figure 96. Affected areas in Tiaong. Quezon during a 100-Year Rainfall Return Period.

For the 100-year return period, 0.99% of the municipality of Alaminos with an area of 59.65 sq. km. will experience flood levels of less than 0.20 meters. 0.08% of the area will experience flood levels of 0.21 to 0.50 meters while 0.02%, 0.01%, 0.00%, and 0.00% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 58. Affected areas in Alaminos, Laguna during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Alaminos (in sq. km.)					
	San Miguel	Del Carmen	San Agustin	San Gregorio	San Roque	San Benito
0.03-0.20	0.0049	0.011	0.014	0.053	0.12	0.39
0.21-0.50	0	0	0	0.016	0.01	0.02
0.51-1.00	0	0	0	0.0037	0.0064	0.0022
1.01-2.00	0	0	0	0	0.005	0
2.01-5.00	0	0	0	0	0.0028	0
> 5.00	0	0	0	0	0.0027	0

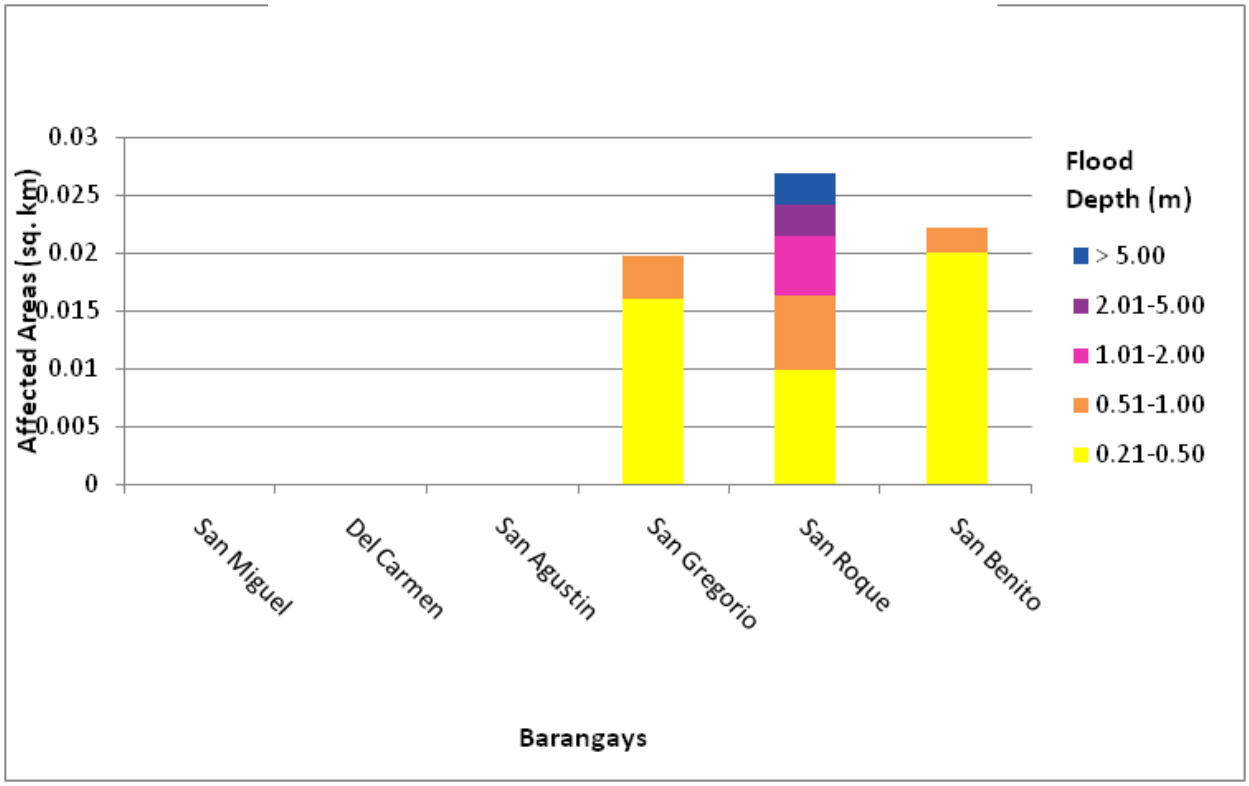


Figure 97. Affected areas in Alaminos, Laguna during a 100-Year Rainfall Return Period.

For the 100-year return period, 0.53% of the municipality of Dolores with an area of 65.96 sq. km. will experience flood levels of less than 0.20 meters. 0.22% of the area will experience flood levels of 0.21 to 0.50 meters while 0.15%, 0.08%, 0.02%, and 0.01% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 59. Affected areas in Dolores, Quezon during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Dolores (in sq. km.)				
	Antonino	Dagatan	San Mateo	Bungoy	Putol
0.03-0.20	0.0032	0.0171	0.0285	0.1458	0.1537
0.21-0.50	0.0001	0.0057	0.0098	0.0815	0.0473
0.51-1.00	0	0.0043	0.0012	0.0646	0.0292
1.01-2.00	0	0.0061	0	0.0309	0.015
2.01-5.00	0	0.0016	0	0.0116	0.0024
> 5.00	0	0	0	0.0033	0.0003

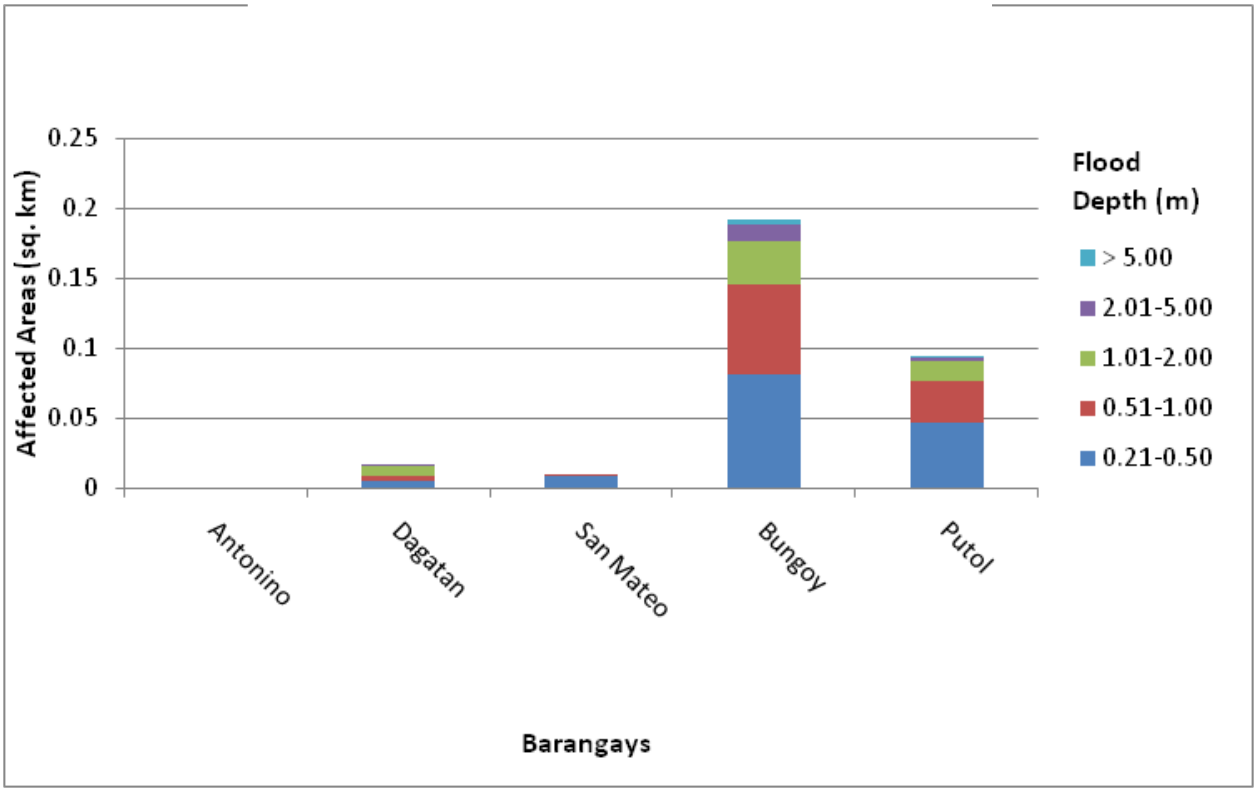


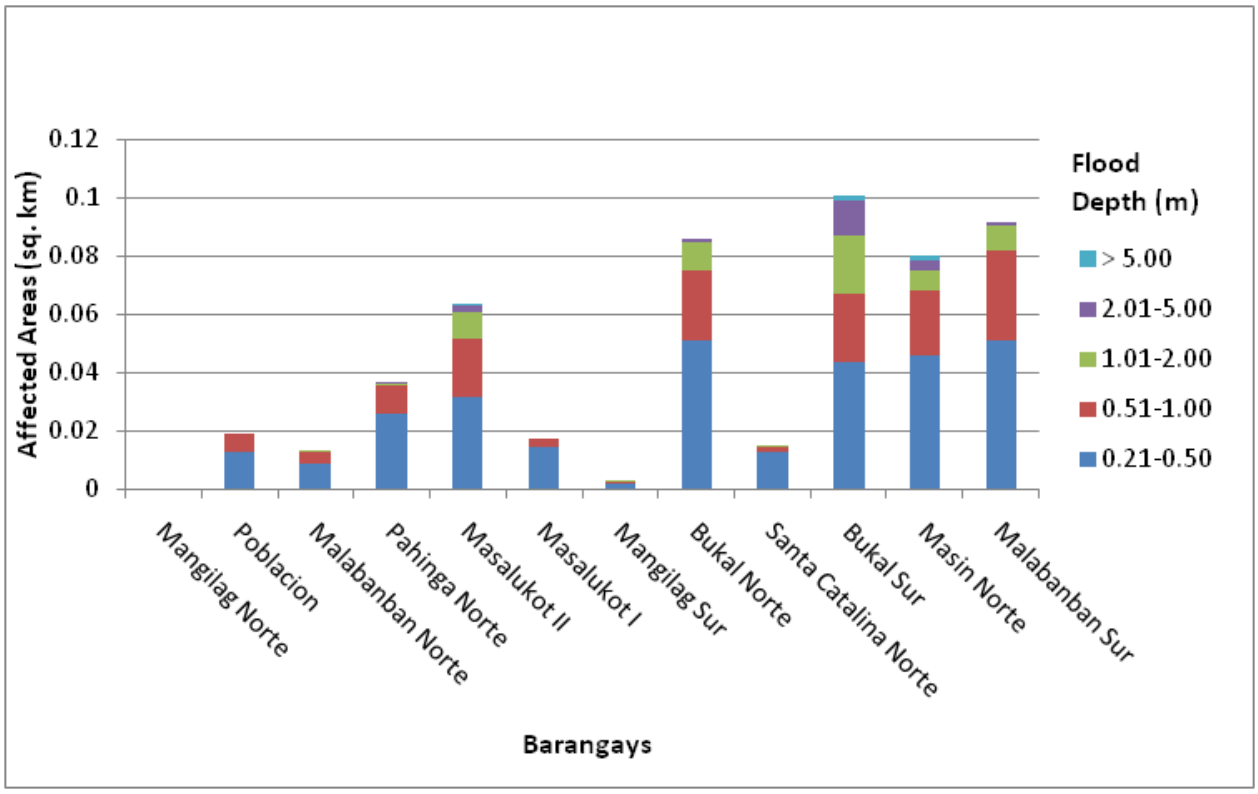
Figure 98. Affected areas in Dolores, Quezon during a 100-Year Rainfall Return Period.

For the 100-year return period, 6.90% of the municipality of Candelaria with an area of 136.74 sq. km. will experience flood levels of less than 0.20 meters. 0.64% of the area will experience flood levels of 0.21 to 0.50 meters while 0.26%, 0.16%, 0.07%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 60. Affected areas in Candelaria, Quezon during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)											
	Mangilag Norte	Pobla-cion	Malabanban Norte	Pahinga Norte	Masalu-kot II	Masalu-kot I	Mangilag Sur	Bukal Norte	Santa Catalina Norte	Bukal Sur	Masin Norte	Malaban-ban Sur
0.03-0.20	0.0036	0.018	0.025	0.052	0.07	0.077	0.093	0.18	0.19	0.21	0.22	0.24
0.21-0.50	0.0001	0.013	0.0093	0.026	0.032	0.015	0.0022	0.051	0.013	0.044	0.046	0.051
0.51-1.00	0	0.0065	0.0041	0.0097	0.02	0.0025	0.0011	0.024	0.0023	0.023	0.022	0.031
1.01-2.00	0	0	0.0005	0.0006	0.0087	0	0.0002	0.01	0.0001	0.02	0.0072	0.0086
2.01-5.00	0	0	0	0.0004	0.0023	0	0	0.001	0	0.012	0.0032	0.0009
> 5.00	0	0	0	0	0.0007	0	0	0	0	0.0016	0.0019	0

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Candelaria (in sq. km.)								
	Masin Sur	Pahinga Sur	San Andres	Buenavista West	Kinati-han II	Kinati-han I	Santa Catali-na Sur	Buenavista East	San Isidro
0.03-0.20	0.31	0.37	0.48	0.72	0.8	0.86	1.12	1.2	2.2
0.21-0.50	0.04	0.043	0.034	0.057	0.037	0.036	0.019	0.15	0.16
0.51-1.00	0.021	0.034	0.013	0.013	0.023	0.027	0.0034	0.021	0.05
1.01-2.00	0.014	0.036	0.0026	0.012	0.02	0.028	0	0.0098	0.034
2.01-5.00	0.0055	0.022	0.0009	0.0096	0.0083	0.022	0	0.0018	0.012
> 5.00	0.0045	0.014	0	0.001	0.0031	0.011	0	0	0.0074



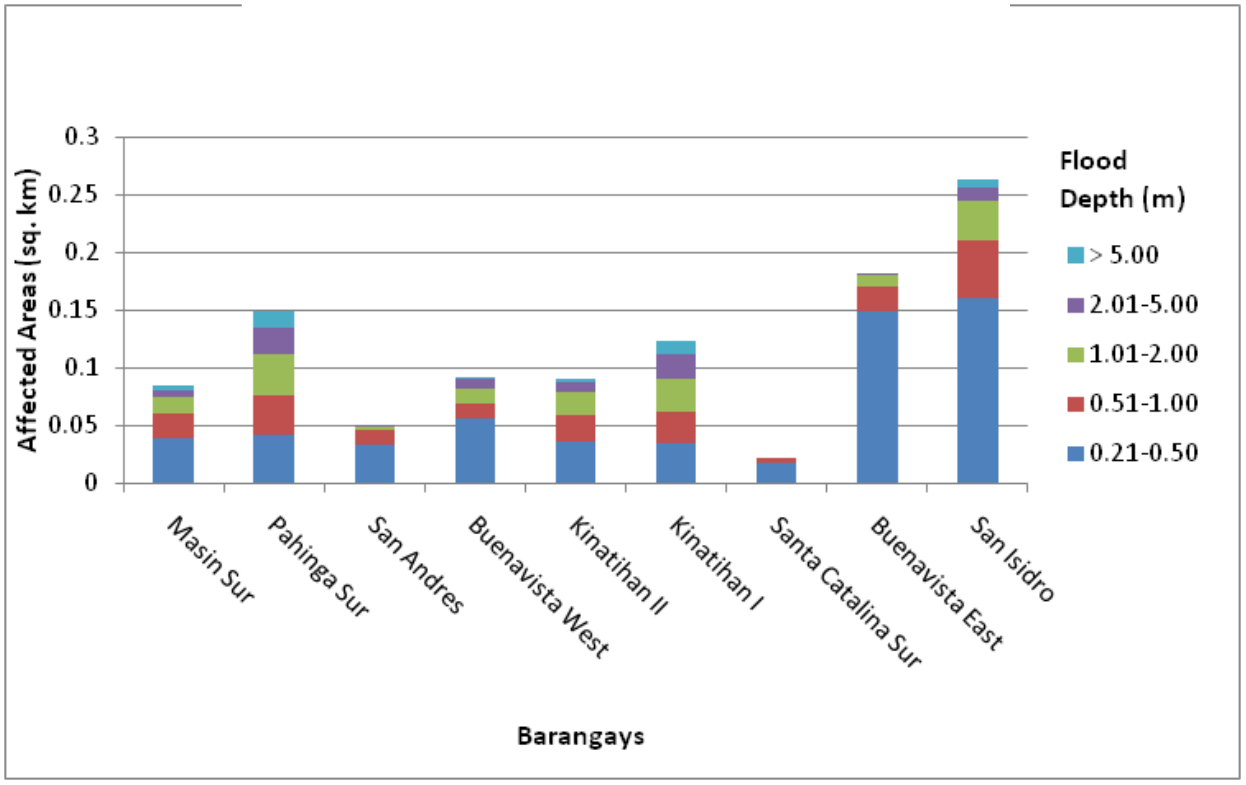


Figure 99. Affected areas in Candelaria, Quezon during a 100-Year Rainfall Return Period.

For the 100-year return period, 3.97% of the municipality of Rosario with an area of 199.04 sq. km. will experience flood levels of less than 0.20 meters. 0.97% of the area will experience flood levels of 0.21 to 0.50 meters while 0.40%, 0.23%, 0.15%, and 0.10% 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 61. Affected areas in Rosario, Batangas during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)											
	San Jose	Tulos	Calantas	Tiquiwan	Nasi	Lumbangan	Baligbago	Baybayin	Leviste	Mayuro	Macalamcam A	Mabunga
0.03-0.20	0.0014	0.0025	0.0037	0.038	0.075	0.083	0	0.091	0.14	0.15	0.15	0.17
0.21-0.50	0	0	0	0.0027	0.0095	0.028	0	0.001	0.02	0.023	0.047	0.069
0.51-1.00	0	0	0	0	0.0006	0.011	0	0.001	0.0016	0.0022	0.011	0.045
1.01-2.00	0	0	0	0	0	0.0058	0	0	0	0.0006	0.0034	0.032
2.01-5.00	0	0	0	0	0	0	0	0	0	0.0007	0.0021	0.029
> 5.00	0	0	0	0	0	0	0	0	0	0.0008	0.0023	0.025

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in Rosario (in sq. km.)										
	San Isidro	Bayawang	Mabato	Macalamcam B	Alupya	Natu	Maligaya	San Carlos	Salao	Pinagsibaan	Putingkahoy
0.03-0.20	0.23	0.24	0.35	0.36	0	0.4	0.42	0.47	0.57	0.6	0.89
0.21-0.50	0.068	0.1	0.13	0.055	0	0.046	0.11	0.14	0.08	0.15	0.25
0.51-1.00	0.024	0.052	0.045	0.034	0	0.0004	0.047	0.042	0.046	0.089	0.094
1.01-2.00	0.012	0.035	0.029	0.027	0	0.0004	0.04	0.0002	0.036	0.049	0.039
2.01-5.00	0.0073	0.024	0.022	0.025	0	0.0002	0.018	0	0.016	0.028	0.03
> 5.00	0.0035	0.018	0.023	0.016	0	0.0003	0.015	0	0.0056	0.011	0.022

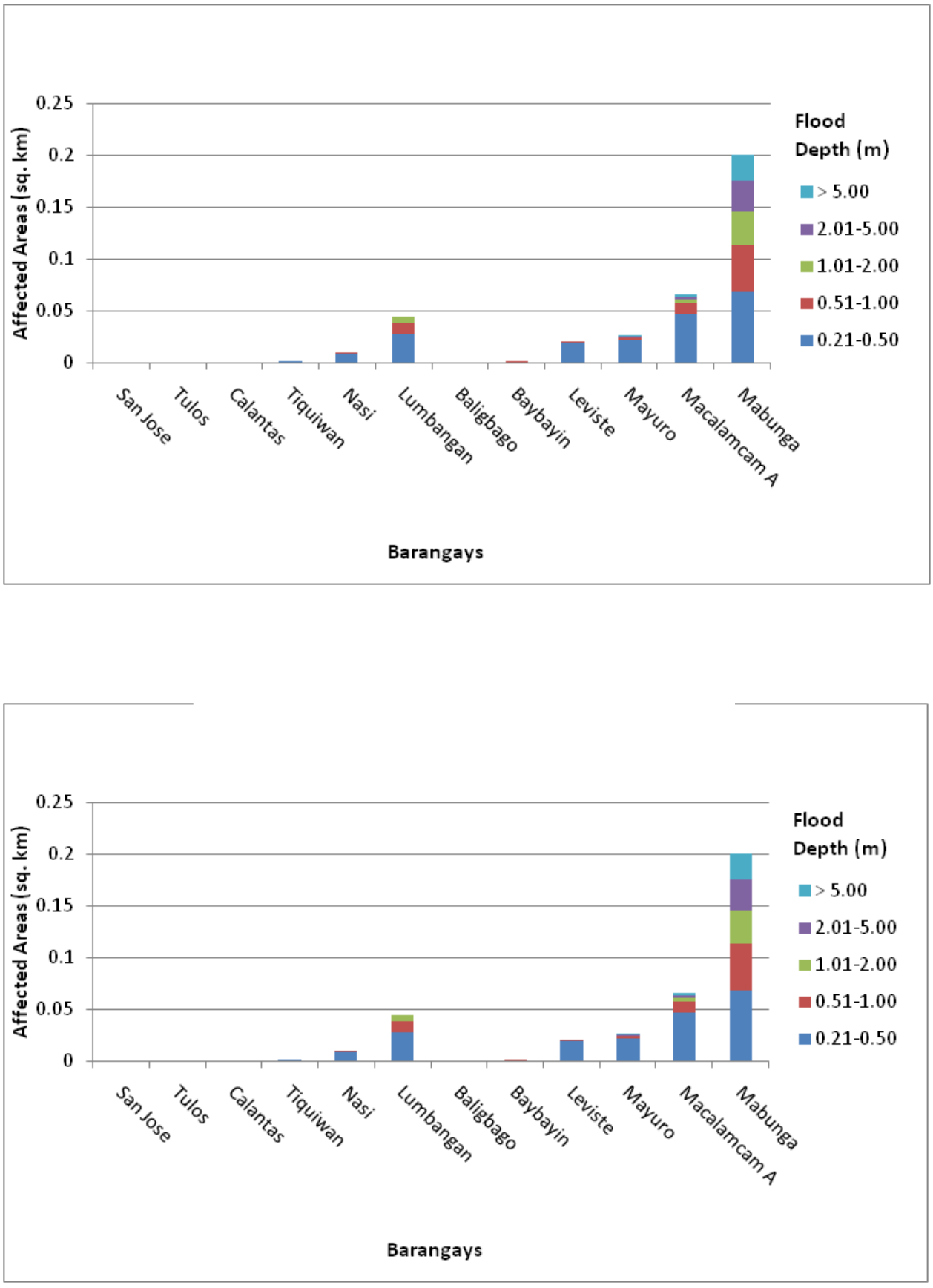


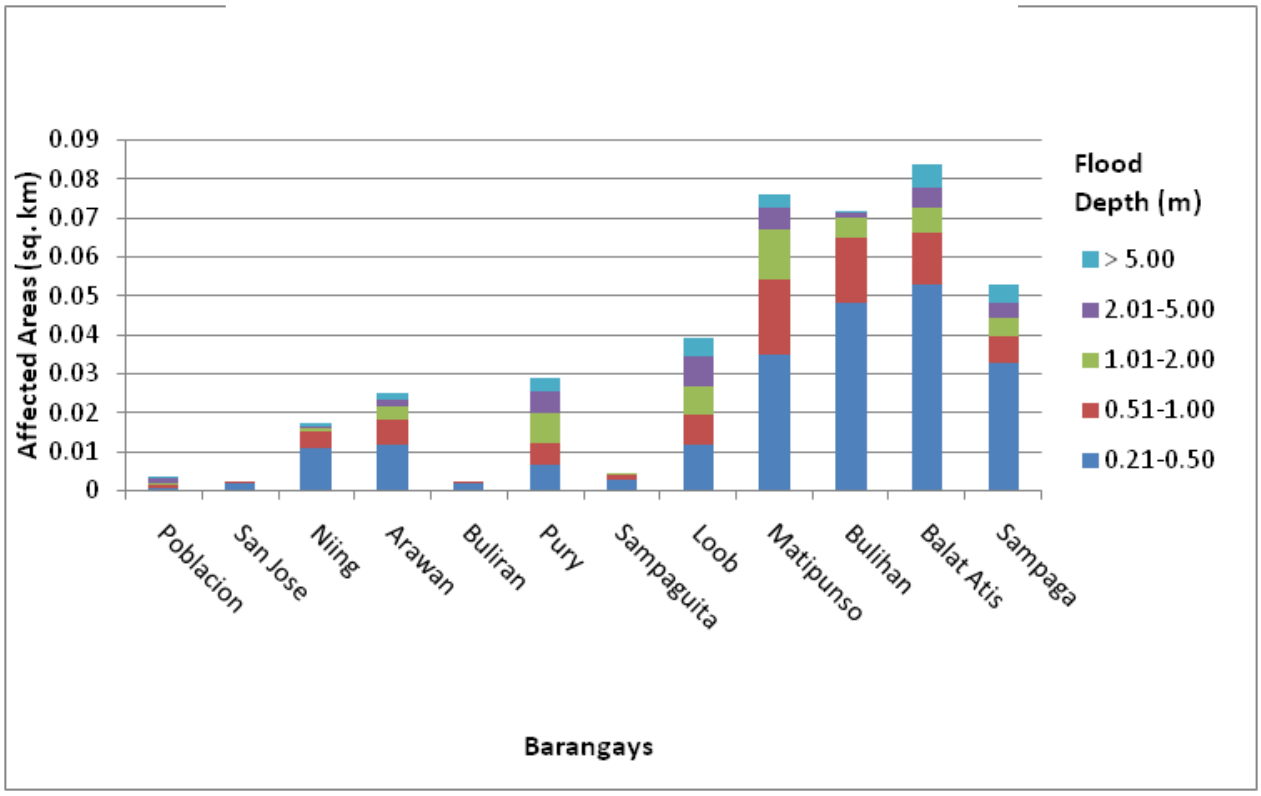
Figure 100. Affected areas in Rosario, Batangas during a 100-Year Rainfall Return Period.

For the 100-year return period, 3.07% of the municipality of San Antonio with an area of 62.38 sq. km. will experience flood levels of less than 0.20 meters. 0.59% of the area will experience flood levels of 0.21 to 0.50 meters while 0.22%, 0.14%, 0.09%, 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 the table are the affected areas in square kilometers by flood depth per barangay.

Table 62. Affected areas in San Antonio, Quezon during a 100-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)											
	Poblacion	San Jose	Niing	Arawan	Buliran	Pury	Sampaguita	Loob	Matipunso	Bulihan	Balat Atis	Sampaga
0.03-0.20	0.0058	0.052	0.057	0.07	0.085	0.089	0.09	0.1	0.13	0.15	0.16	0.19
0.21-0.50	0.0009	0.002	0.011	0.012	0.0022	0.0069	0.0031	0.012	0.035	0.048	0.053	0.033
0.51-1.00	0.0008	0.0006	0.0045	0.0063	0.0004	0.0055	0.0014	0.0078	0.019	0.017	0.013	0.0065
1.01-2.00	0.0004	0	0.0007	0.0034	0	0.0076	0.0001	0.007	0.013	0.0049	0.0066	0.0048
2.01-5.00	0.0011	0	0.0006	0.0019	0	0.0058	0	0.0076	0.0057	0.0018	0.005	0.0038
> 5.00	0.0005	0	0.0009	0.0014	0	0.003	0	0.0049	0.0032	0.0001	0.006	0.0047

Affected Area (sq. km.) by flood depth (in m.)	Area of affected barangays in San Antonio (in sq. km.)							
	Callejon	Magsay-say	Corza-on	Sinturi-san	Bagong Niing	Bri-ones	Pulo	Manuel Del Valle, Sr. Manuel Del Valle, Sr.
0.03-0.20	0.2	0.31	0	0.37	0.4	0.43	0.44	0.87
0.21-0.50	0.039	0.038	0	0.053	0.093	0.092	0.2	0.068
0.51-1.00	0.024	0.024	0	0.014	0.042	0.04	0.019	0.05
1.01-2.00	0.023	0.016	0	0.0021	0.03	0.032	0.011	0.033
2.01-5.00	0.017	0.0092	0	0.0004	0.023	0.023	0.0098	0.011
> 5.00	0.0037	0.0044	0	0	0.016	0.013	0.0088	0.0095



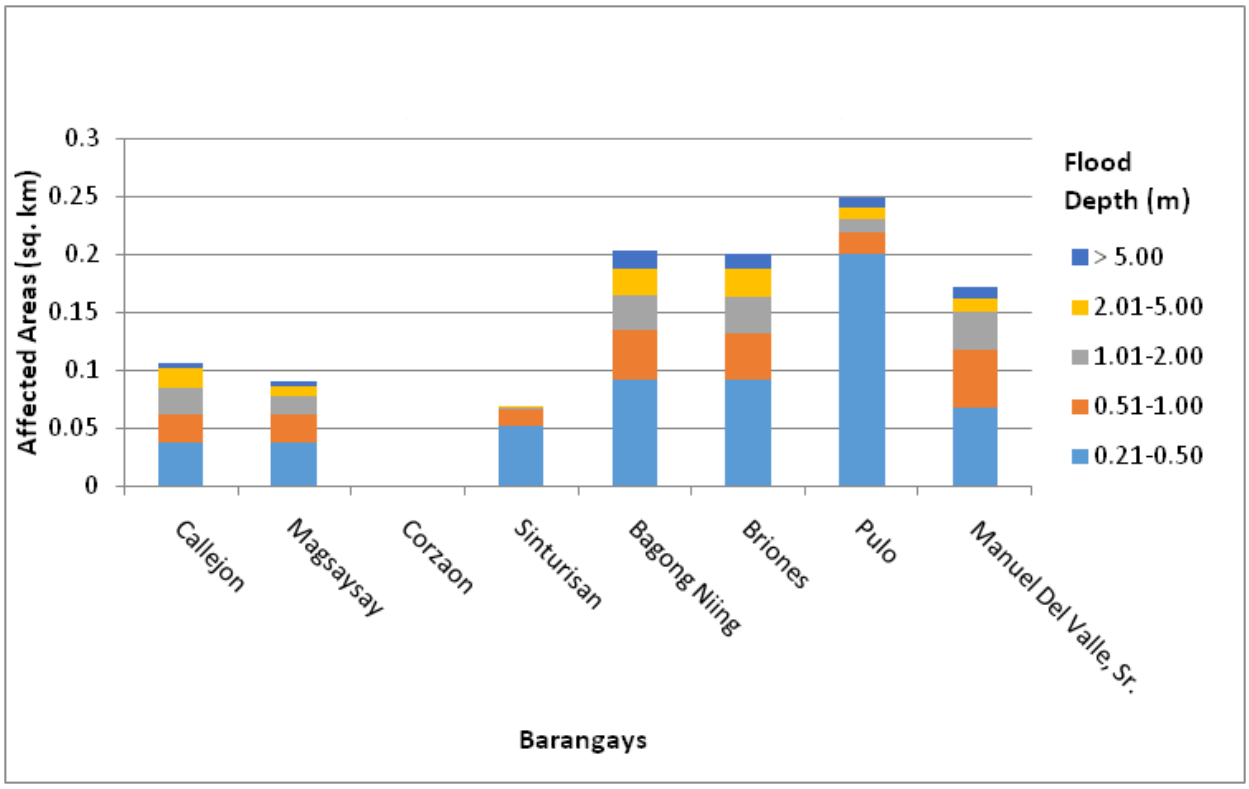


Figure 101. Affected areas in San Antonio, Quezon during a 100-Year Rainfall Return Period.

Moreover, the generated flood hazard maps for the Malaking-Ilog 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-year, 25-year, and 10-year).

Table 63. Areas covered by each warning level with respect to the rainfall scenarios

Warning Level	Area Covered in sq. km.		
	5 year	25 year	100 year
Low	105.065	113.49	116.25
Medium	77.82	110.85	132.36
High	26.54	41.24	52.23
TOTAL	209.43	265.58	300.84

Of the 236 identified Education Institute in Malaking Ilog Flood plain, forty-eight (48) schools were discovered exposed to Low-level flooding during a 5-year scenario, while eleven (11) schools were found exposed to Medium-level flooding in the same scenario.

In the 25-year scenario, sixty-four (64) schools were found exposed to Low-level flooding, while nineteen (19) schools were discovered exposed to Medium-level flooding. Bulakin Elementary School in Bula, Tiaong was discovered exposed to High-level flooding.

For the 100-year scenario, sixty-two (62) schools were discovered exposed to Low-level flooding , while thirty (30) schools were exposed to Medium-level flooding. In the same scenario, two (2) schools were found exposed to High-level flooding; both of which are located in Barangay Bula, Tiaong.

Apart from this, fifty-four (54) Medical Institutions were identified in the Malaking Ilog Floodplain, with ten (10) assessed as exposed to low-level flooding and two (2) exposed to medium-level flooding.

For the 25-year scenario, fourteen (14) were identified as exposed to low-level flooding while three (3) were exposed to medium-level flooding.

For the 100-year scenario, fourteen (14) were identified as exposed to low-level flooding while five (5) were exposed to medium-level flooding.

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 points in the flood map versus its corresponding validation depths are shown in Figure 77.

The flood validation consists of 201 points randomly selected all over the Malaking-Ilog flood plain (Figure 36). Comparing it with the flood depth map of the nearest storm event, the map has an RMSE value of 0.22m. Table 42 shows a contingency matrix of the comparison.

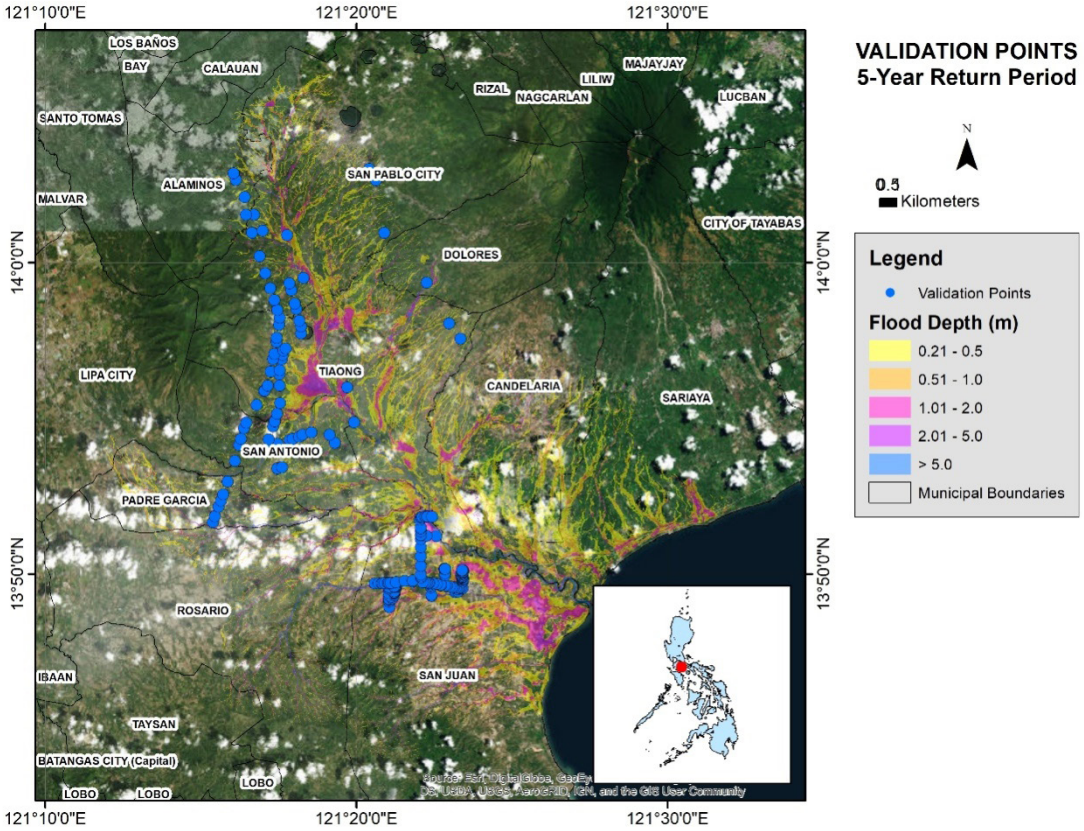


Figure 102. Validation points for 5-year Flood Depth Map of Malaking-Ilog-Bolbok Floodplain

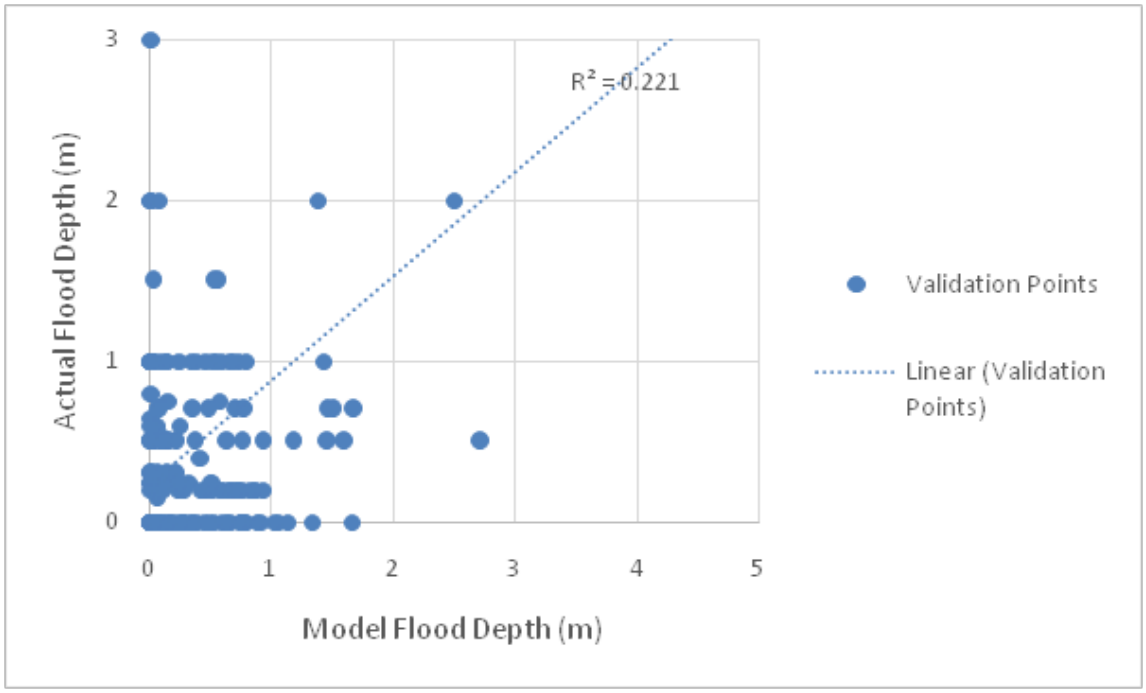


Figure 103. Flood map depth vs actual flood depth

Table 64. Actual Flood Depth vs Simulated Flood Depth

Actual Flood Depth (m)	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
0-0.20	62	14	28	5	0	0	109
0.21-0.50	19	9	4	3	1	0	36
0.51-1.00	20	7	10	4	0	0	41
1.01-2.00	4	0	2	1	1	0	8
2.01-5.00	3	0	0	1	3	0	7
> 5.00	0	0	0	0	0	0	0
Total	108	30	44	14	5	0	201

The overall accuracy generated by the flood model is estimated at 42.29% with 85 points correctly matching the actual flood depths. In addition, there were 45 points estimated one level above and below the correct flood depths while there were 51 points and 13 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 4 points were overestimated while a total of 56 points were underestimated in the modelled flood depths of Malaking Ilog.

Table 65. Summary of Accuracy Assessment in Bolbok River Basin

	No. of Points	%
Correct	85	42.29
Overestimated	60	29.85
Underestimated	56	27.86
Total	201	100.00

REFERENCES

Ang M.C., 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.

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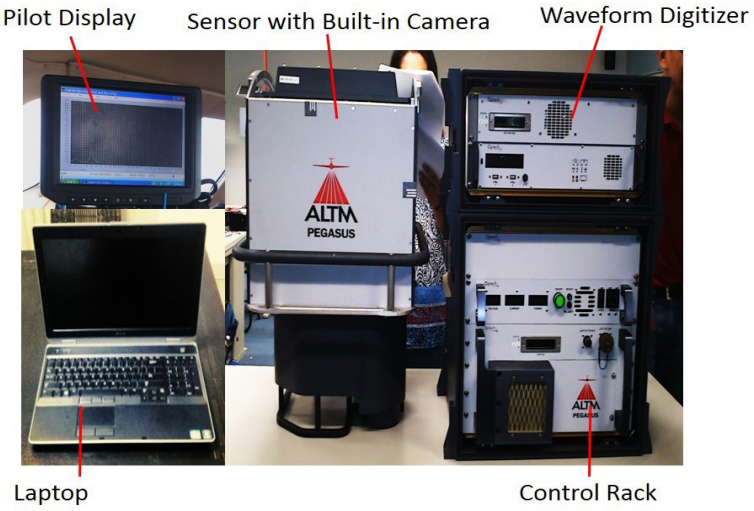
Paringit, E.C., Balicanta, L.P., Ang, M.C., Lagmay, A.F., Sarmiento, C. 2017, Flood Mapping of Rivers in the Philippines Using Airborne LiDAR: Methods. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

Sarmiento C.J.S., Paringit E.C., et al. 2014. DREAM Data Aquisition 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 PEGASUS SENSOR



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

ANNEX 2. NAMRIA CERTIFICATES OF REFERENCE POINTS USED

1. BTG-30

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

February 19, 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: **BATANGAS**
Station Name: **BTG-30**
Order: **2nd**

Island: **LUZON**
Municipality: **BATANGAS CITY (CAPITAL)**
Barangay: **PALLOCAN**

PRS92 Coordinates

Latitude: **13° 45' 23.09641"** Longitude: **121° 3' 43.87174"** Ellipsoidal Hgt: **7.82000 m.**

WGS84 Coordinates

Latitude: **13° 45' 17.88182"** Longitude: **121° 3' 48.83762"** Ellipsoidal Hgt: **53.87200 m.**

PTM Coordinates

Northing: **1521226.725 m.** Easting: **506725.034 m.** Zone: **3**

UTM Coordinates

Northing: **1,521,536.18** Easting: **290,477.09** Zone: **51**

Location Description

BTG-30
Is in the vicinity of Brgy. Pallocan, Batangas City along the E side dike of Calumpang River, on the N side of Calumpang Bridge. It is about 0.67 m. WNW of the E edge of the dike, 1.3 m. ENE of the center of the concrete balluster and 50 m. NNE of the N side of the said bridge. Mark is the head of a 4" copper nail centered and embedded on top of a 30 cm. x 30 cm. cement putty set flushed to the pavement with inscriptions, "BTG-30 2004 NAMRIA".

Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8795394 A**
T.N.: **2014-354**

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

9902192014140909

CERTIFICATION INTERNATIONAL ISO 9001:2008 — ACCREDITED PAB — 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. LAG-20

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

February 04, 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: **LAGUNA**
Station Name: **LAG-20**
Order: **3rd**

Island: **LUZON**
Municipality: **LOS BAÑOS**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude: **14° 9' 53.86904"** Longitude: **121° 14' 20.35180"** Ellipsoidal Hgt: **39.91400 m.**

WGS84 Coordinates

Latitude: **14° 9' 48.57270"** Longitude: **121° 14' 25.28172"** Ellipsoidal Hgt: **85.26600 m.**

PTM Coordinates

Northing: **1566435.481 m.** Easting: **525799.268 m.** Zone: **3**

UTM Coordinates

Northing: **1,566,588.99** Easting: **309,934.22** Zone: **51**

Location Description

LAG-20
Is located inside the UP Los Baños compound 25 m. NW from the Umali Hall building along Sanggumay Rd.; at the center of a concrete pavement, 0.7 m. from the edge of the stairs. Mark is a 2 mm. dia. brass rod centered on a 0.13 m. x 0.13 m. cement putty with inscription "LAG-20 NAMRIA 2000"

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795255 A**
T.N.: **2014-199**

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

9902042014125958

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

3. QZN-21

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

February 13, 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: **QUEZON**
Station Name: **QZN-21**
Order: **2nd**

Island: **LUZON**
Municipality: **TIAONG**
Barangay: **POBLACION III**

PRS92 Coordinates

Latitude: **13° 57' 44.31576"** Longitude: **121° 19' 27.34822"** Ellipsoidal Hgt: **51.25800 m.**

WGS84 Coordinates

Latitude: **13° 57' 39.07397"** Longitude: **121° 19' 32.29499"** Ellipsoidal Hgt: **97.38200 m.**

PTM Coordinates

Northing: **1544027.063 m.** Easting: **535036.042 m.** Zone: **3**

UTM Coordinates

Northing: **1,544,101.56** Easting: **318,981.12** Zone: **51**

Location Description

QZN-21
From Tiaong Municipal Hall, travel along the highway going to Lucena, then turn left to Dia St. until reaching Paaralang Elementarya ng Silangang Tiaong. Station is located on the open ground of the said school, 30 m. NE from the entrance gate. It is approx. 21 m. WNW from the NW corner post in front of the stage and 13.4 m. ESE from the concrete wall of the school. Mark is the head of a 4 in. copper nail centered on a 30 cm. x 30 cm. concrete monument flushed on the ground, with inscriptions "QZN-21 2006 NAMRIA".

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **8795355 A**
T.N.: **2014-320**

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

9902132014164652

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

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

ANNEX 3. BASELINE PROCESSING REPORT

1. BTG-30A

Vector Components (Mark to Mark)

From:	BTG-30				
Grid		Local		Global	
Easting	290477.094 m	Latitude	N13°45'23.09641"	Latitude	N13°45'17.88182"
Northing	1521536.181 m	Longitude	E121°03'43.87174"	Longitude	E121°03'48.83762"
Elevation	8.942 m	Height	7.820 m	Height	53.872 m

To:	BTG-30A				
Grid		Local		Global	
Easting	290476.221 m	Latitude	N13°45'22.94284"	Latitude	N13°45'17.72826"
Northing	1521531.468 m	Longitude	E121°03'43.84397"	Longitude	E121°03'48.80985"
Elevation	9.020 m	Height	7.898 m	Height	53.950 m

Vector					
ΔEasting	-0.872 m	NS Fwd Azimuth	190°01'30"	ΔX	0.096 m
ΔNorthing	-4.713 m	Ellipsoid Dist.	4.793 m	ΔY	1.457 m
ΔElevation	0.078 m	ΔHeight	0.078 m	ΔZ	-4.566 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	σ NS fwd Azimuth	0°01'04"	σ ΔX	0.002 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.002 m
σ ΔElevation	0.002 m	σ ΔHeight	0.002 m	σ ΔZ	0.001 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000028549		
Y	-0.0000013015	0.0000050551	
Z	-0.0000007107	0.0000014041	0.0000011085

2

2. LAG-20D

Vector Components (Mark to Mark)

From:	LAG-20				
Grid		Local		Global	
Easting	309934.222 m	Latitude	N14°09'53.86923"	Latitude	N14°09'48.57270"
Northing	1566588.991 m	Longitude	E121°14'20.35184"	Longitude	E121°14'25.28172"
Elevation	39.976 m	Height	39.914 m	Height	85.266 m

To:	LAG-20D				
Grid		Local		Global	
Easting	309932.197 m	Latitude	N14°09'53.95582"	Latitude	N14°09'48.65929"
Northing	1566591.667 m	Longitude	E121°14'20.28364"	Longitude	E121°14'25.21352"
Elevation	39.990 m	Height	39.929 m	Height	85.281 m

Vector					
ΔEasting	-2.025 m	NS Fwd Azimuth	322°27'32"	ΔX	2.079 m
ΔNorthing	2.677 m	Ellipsoid Dist.	3.356 m	ΔY	0.516 m
ΔElevation	0.015 m	ΔHeight	0.015 m	ΔZ	2.584 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'26"	σ ΔX	0.001 m
σ ΔNorthing	0.000 m	σ Ellipsoid Dist.	0.000 m	σ ΔY	0.001 m
σ ΔElevation	0.001 m	σ ΔHeight	0.001 m	σ ΔZ	0.000 m

Aposteriori Covariance Matrix (Meter²)

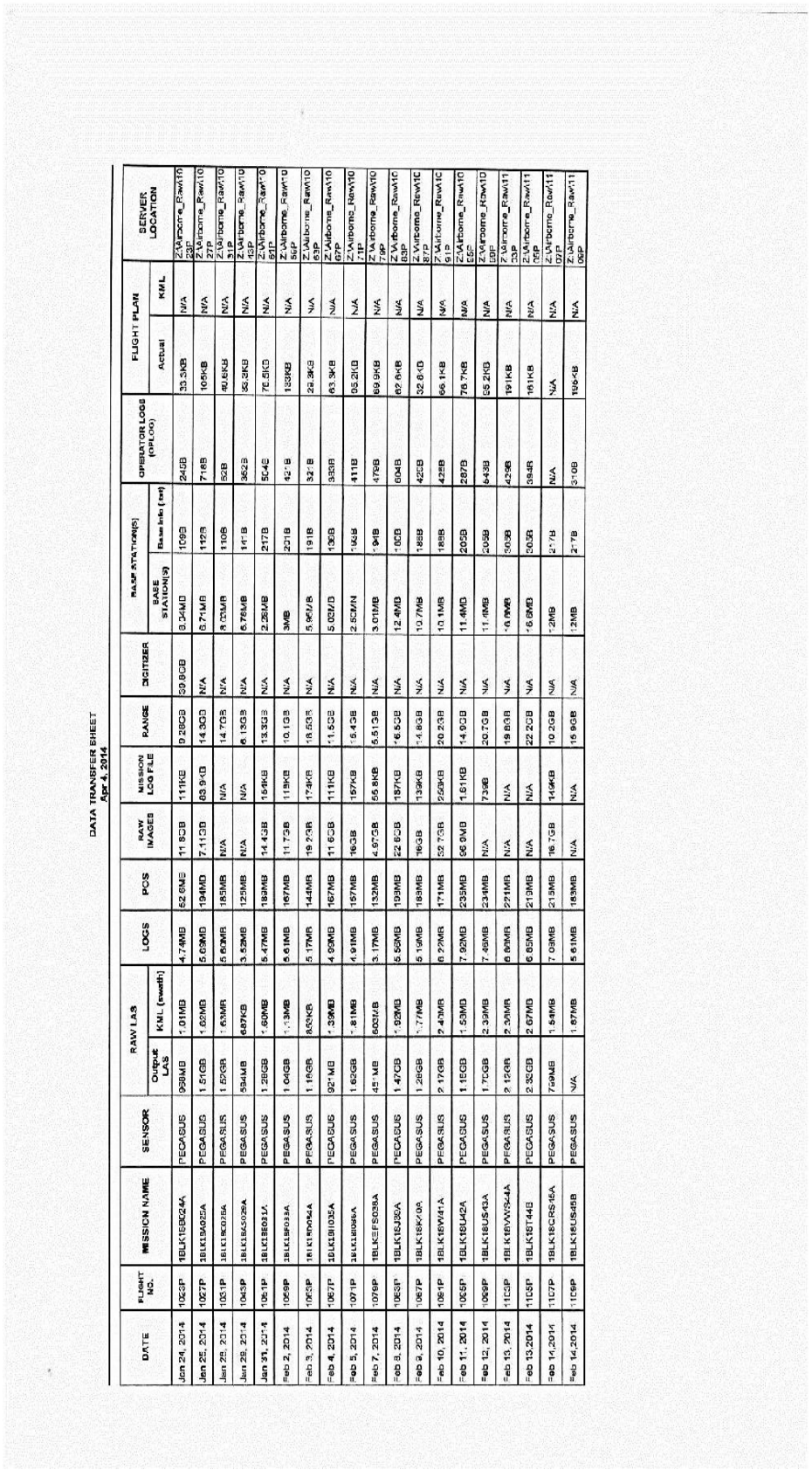
	X	Y	Z
X	0.0000004804		
Y	-0.0000002580	0.0000005806	
Z	-0.0000000914	0.0000001643	0.0000001374

2

ANNEX 4. THE SURVEY TEAM

Data Acquisition Component Sub-team	Designation	Name	Agency/Affiliation
PHIL-LIDAR 1	Program Leader	ENRICO C. PARINGIT, D.ENG	UP-TCAGP
Data Acquisition Component Leader	Data Component Project Leader –I	ENGR. CZAR JAKIRI S. SARMIENTO	UP TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP TCAGP
	Supervising Science Research Specialist (Supervising SRS)	LOVELY GRACIA ACUNA	UP TCAGP
		ENGR. LOVELYN ASUNCION	UP TCAGP
FIELD TEAM			
LiDAR Operation	Senior Science Research Specialist (SSRS)	JASMINE ALVIAR	UP TCAGP
		LOVELY ACUÑA	UP TCAGP
	Research Associate(RA)	ENGR. GRACE SINADJAN	UP TCAGP
		ENGR. IRO ROXAS	UP TCAGP
		ENGR. LARAH PARAGAS	UP TCAGP
		REMEDIOS VILLANUEVA	UP TCAGP
		KRISTINE JOY ANDAYA	UP TCAGP
Ground Survey	Research Associate(RA)	ENGR. GEF SORIANO	UP TCAGP
		ENGR. KENNETH QUISADO	UP TCAGP
		FRANK NICOLAS ILEJAY	UP TCAGP
		ENGR. CHRISTOPHER JOAQUIN	UP TCAGP
		ENGR. RENAN PUNTO	UP TCAGP
		JERIEL PAUL ALAMBAN	UP TCAGP
LiDAR Operation	Airborne Security	SSG. LEE JAY PUNZALAN	PHILIPPINE AIR FORCE (PAF)
	Pilot	CAPT. MARK TANGONAN	ASIAN AEROSPACE CORP (AAC)
		CAPT. JUSTINE JOYA	ASIAN AEROSPACE CORP (AAC)

ANNEX 5. DATA TRANSFER SHEET FOR BOLBOK FLOODPLAIN FLIGHTS



DATA TRANSFER SHEET
Apr 4, 2014

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS	RAW IMAGES	MISSION LOG FILE	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (GPL.log)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base info (.txt)		Actual	KML	
Jan 24, 2014	1026P	1BLK16BK24A	PEGASUS	958MB	1.01MB	4.74MB	52.6MB	11.8GB	111KB	9.28GB	30.8GB	3.24MB	109B	24GB	33.3KB	N/A	Z:\Airborne_Raw\10 23P
Jan 25, 2014	1027P	1BLK19A025A	PEGASUS	1.51GB	1.62MB	5.69MB	194MB	7.11GB	83.9KB	14.3GB	N/A	5.71MB	112B	71GB	105KB	N/A	Z:\Airborne_Raw\10 27P
Jan 28, 2014	1031P	1BLK19C025A	PEGASUS	1.50GB	1.63MB	5.62MB	185MB	N/A	N/A	14.7GB	N/A	8.03MB	110B	5GB	40.6KB	N/A	Z:\Airborne_Raw\10 31P
Jan 29, 2014	1043P	1BLK18A029A	PEGASUS	594MB	687KB	3.52MB	125MB	N/A	N/A	6.13GB	N/A	5.76MB	141B	362B	35.2KB	N/A	Z:\Airborne_Raw\10 43P
Jan 31, 2014	1061P	1BLK18E031A	PEGASUS	1.28GB	1.60MB	5.47MB	189MB	14.4GB	154KB	13.3GB	N/A	2.25MB	217B	5C4B	76.5KB	N/A	Z:\Airborne_Raw\10 61P
Feb 2, 2014	1059P	2BLK18F033A	PEGASUS	1.04GB	1.13MB	5.61MB	167MB	11.7GB	119KB	10.1GB	N/A	3MB	221B	42 B	133KB	N/A	Z:\Airborne_Raw\10 59P
Feb 3, 2014	1063P	1BLK18H044A	PEGASUS	1.11GB	809KB	5.17MB	144MB	19.2GB	174KB	18.83B	N/A	5.95MB	191B	32 B	29.3KB	N/A	Z:\Airborne_Raw\10 63P
Feb 4, 2014	1067P	1BLK18I035A	PEGASUS	921MB	1.33MB	4.93MB	167MB	11.6GB	111KB	11.5GB	N/A	5.02MB	130B	33B	43.3KB	N/A	Z:\Airborne_Raw\10 67P
Feb 5, 2014	1071P	2BLK18I036A	PEGASUS	1.62GB	1.81MB	4.91MB	157MB	16GB	157KB	15.4GB	N/A	2.52MB	194B	41 B	55.2KB	N/A	Z:\Airborne_Raw\10 71P
Feb 7, 2014	1079P	1BLK18F039A	PEGASUS	457MB	603KB	3.17MB	132MB	4.57GB	55.8KB	5.51GB	N/A	3.01MB	194B	47 B	69.9KB	N/A	Z:\Airborne_Raw\10 79P
Feb 8, 2014	1083P	1BLK18J30A	PEGASUS	1.47GB	1.92MB	5.58MB	193MB	22.6GB	187KB	16.5GB	N/A	12.4MB	180B	60 B	82.6KB	N/A	Z:\Airborne_Raw\10 83P
Feb 9, 2014	1087P	1BLK18K10A	PEGASUS	1.28GB	1.77MB	5.13MB	183MB	16GB	139KB	14.8GB	N/A	10.7MB	188B	42 B	32.8KB	N/A	Z:\Airborne_Rew\1C 87P
Feb 10, 2014	1091P	1BLK18W41A	PEGASUS	2.17GB	2.40MB	6.22MB	171MB	23.7GB	256KB	20.2GB	N/A	10.1MB	188B	42 B	56.1KB	N/A	Z:\Airborne_Rew\1C 91P
Feb 11, 2014	1095P	1BLK18U42A	PEGASUS	1.15GB	1.53MB	7.92MB	235MB	56.9MB	1.61KB	14.9GB	N/A	11.4MB	205B	28 B	76.7KB	N/A	Z:\Airborne_Raw\10 95P
Feb 12, 2014	1099P	1BLK18U543A	PEGASUS	1.7GB	2.39MB	7.49MB	234MB	N/A	739B	20.7GB	N/A	11.4MB	209B	64 B	85.2KB	N/A	Z:\Airborne_Raw\10 99P
Feb 13, 2014	1103P	1BLK18VW34A	PEGASUS	2.12GB	2.36MB	6.88MB	221MB	N/A	N/A	19.8GB	N/A	6.8MB	303B	42 B	191KB	N/A	Z:\Airborne_Raw\11 03P
Feb 13,2014	1105P	1BLK18T44B	PEGASUS	2.3GB	2.67MB	6.85MB	213MB	N/A	N/A	22.2GB	N/A	6.8MB	202B	38 B	161KB	N/A	Z:\Airborne_Raw\11 05P
Feb 14,2014	1107P	1BLK18CRS45A	PEGASUS	749MB	1.54MB	7.08MB	213MB	16.7GB	149KB	10.2GB	N/A	12MB	217B	N/A	N/A	N/A	Z:\Airborne_Raw\11 07P
Feb 14,2014	1109P	1BLK18U545B	PEGASUS	N/A	1.87MB	5.61MB	183MB	N/A	N/A	15.9GB	N/A	12MB	217B	31 0B	196KB	N/A	Z:\Airborne_Raw\11 09P

DATA TRANSFER SHEET - Calabarzon
28-02-2016

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(KB)	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	
2014-02-17	1119	1BLK18O48A	Pegasus	1.03 GB	41.59 KB	10.21 MB	250.41 MB	21.51 GB	N/A	15.9 GB	0 B	11.71 MB	213 B	520 B	0 B	1119	Z:\DAC\RAWDATA\1119P
2014-02-18	1125	1BLK18S49B	Pegasus	374.68 MB	2.04 MB	4.87 MB	144.98 MB	0 B	N/A	5.58 GB	0 B	12.67 MB	213 B	282 B	0 B	1125	Z:\DAC\RAWDATA\1125P
2014-02-14	1107	1BLK18QRS45A	Pegasus	799.94 MB	0 B	8.64 MB	215.81 MB	16.73 GB	N/A	10.24 GB	0 B	12.04 MB	217 B	N/A	0 B	1107	Z:\DAC\RAWDATA\1107P
2014-02-20	1133	1BLK18Y51B	Pegasus	1.07 GB	474.66 KB	6.13 MB	169.15 MB	18.92 GB	N/A	12.17 GB	0 B	13.22 MB	133 B	265 B	0 B	1133	Z:\DAC\RAWDATA\1133P
2014-02-20	1131	1BLK18Z51A	Pegasus	1.84 GB	92.25 KB	10.23 MB	219.99 MB	30.31 GB	N/A	20.02 GB	90.46 GB	13.22 MB	133 B	310 B	0 B	1131	Z:\DAC\RAWDATA\1131P

Received from

Name R. PUNTO group
Position NA
Signature

Received by

Name AC Bongat group DPPC
Position SSR5
Signature ACBongat 2/28/16

DATA TRANSFER SHEET
Calabarzon 9/10/15

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	
17-Aug	3307P	1BLK18JS229B	Pegasus	972	756	6.66	171	na	na	9.59	na	18.4	1KB	1KB	1/42	na	Z:\DAC\RAW DATA
18-Aug	3309P	1BLK18AsS230A	Pegasus	1.17	757	7.65	202	na	na	11.9	na	19.4	1KB	1KB	88	na	Z:\DAC\RAW DATA
3-Sep	3373P	1BLK18OS246A	Pegasus	1.81	2.06	9.59	212	na	na	18.2	na	7.67	1KB	1KB	1	na	Z:\DAC\RAW DATA
4-Sep	3377P	1BLK18JS247A	Pegasus	1.29	777	8.1	196	na	na	13.4	na	6.43	1KB	1KB	61.6	na	Z:\DAC\RAW DATA
5-Sep	3381P	1BLK18OS248A	Pegasus	2.12	1.54	10.3	256	na	na	20.6	na	9.05	1KB	1KB	59/59	na	Z:\DAC\RAW DATA

Received from

Name C. Joaquin
Position RA
Signature

Received by

Name AC Bongat 9/11/15
Position SSRS
Signature

DATA TRANSFER SHEET
CALABARZON 9/7/2015

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	
15-Aug	3299P	1BLK18KS227A	PEGASUS	535	614	5.45	143	na	na	10.4	na	3.73	1KB	1KB	222	NA	Z:\DAC\RAW DATA
26-Aug	3341P	1BLK18AbS238A	PEGASUS	1.49	NA	10.1	240	na	na	16.1	na	7.02	1KB	1KB	69	NA	Z:\DAC\RAW DATA
26-Aug	3343P	1BLK18AcS238B	PEGASUS	1.84	NA	9.44	214	na	na	17.9	na	5.96	1KB	1KB	59	NA	Z:\DAC\RAW DATA
27-Aug	3345P	1BLK18TS239A	PEGASUS	2.5	NA	7.11	177	na	na	22.5	na	5.99	1KB	1KB	NA	NA	Z:\DAC\RAW DATA
27-Aug	3347P	1BLK18TS239B	PEGASUS	0.99	NA	6.27	152	na	na	9.85	na	4.13	1KB	1KB	NA	NA	Z:\DAC\RAW DATA
29-Aug	3353P	1BLK18QRS241A	PEGASUS	1.91	NA	10.3	246	na	na	18.8	na	7.19	1KB	1KB	87.1	NA	Z:\DAC\RAW DATA
1-Sep	3365P	1BLK18BCS244A	PEGASUS	1.92	NA	8.57	192	na	na	18.2	na	8.61	1KB	1KB	41	NA	Z:\DAC\RAW DATA
2-Sep	3369P	1BLK18CS245A	PEGASUS	1.34	NA	7.43	154	na	na	13.5	na	35	1KB	1KB	54	NA	Z:\DAC\RAW DATA

Received from

Name C. JOAQUIN
Position RA
Signature

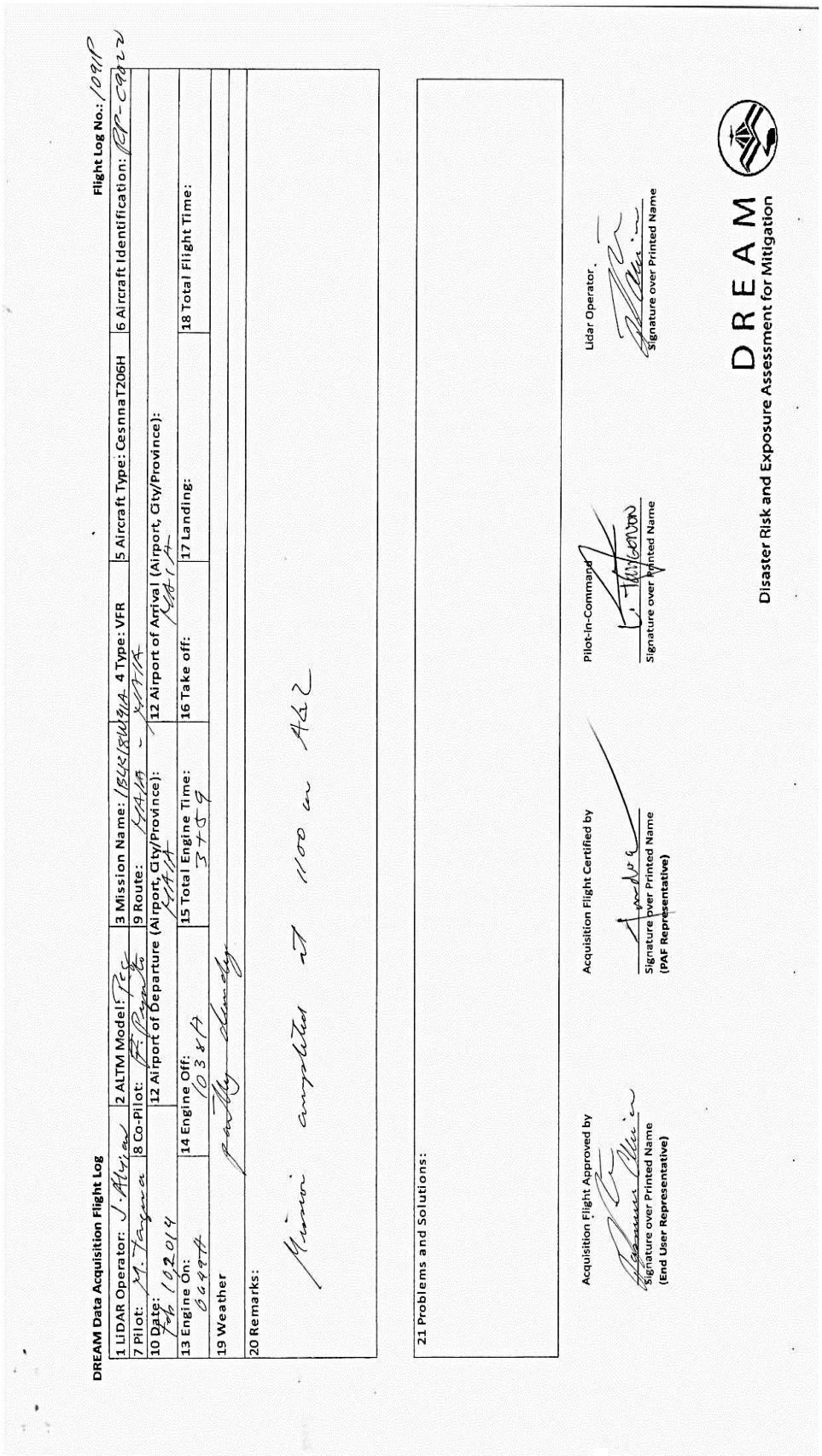
Received by

Name JOIDA F. PRIETO
Position SSRA
Signature 7/8/15

IC-2

ANNEX 6. FLIGHT LOGS

1. Flight log for 1091P Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1091P

1 LiDAR Operator: J. Alviar	2 ALTM Model: 72	3 Mission Name: BLK1BULUA	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C4072
7 Pilot: M. Tagaca	8 Co-Pilot:	9 Route: KAPA - KAPA			
10 Date: Feb. 10 2014	11 Airport of Departure (Airport, City/Province): KAPA		12 Airport of Arrival (Airport, City/Province): KAPA		
13 Engine On: 0949H	14 Engine Off: 1038H	15 Total Engine Time: 3+59	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Partly cloudy				
20 Remarks: Mission completed at 1100 in ALZ					
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

Signature over Printed Name

Lidar Operator

Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

2. Flight log for 1095P Mission

DREAM Data Acquisition Flight Log — Flight Log No.: 1095P

1 LiDAR Operator: R. Punto	2 ALTM Model: Peg	3 Mission Name: 1BLK18 442A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: M. Tangonan	8 Co-Pilot: F. De Ocampo	9 Route: NAIA – NAIA			
10 Date: Feb 11, 204	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 0612H	14 Engine Off: 1011 H	15 Total Engine Time: 3+59	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	partly cloudy				

20 Remarks:

Data acquired but with major voids due to heavy build up

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operater
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	C. Tangonan — Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

3. Flight Log for 1099P Mission

DREAM Data Acquisition Flight Log — Flight Log No.: 1099P

1 LiDAR Operator: R. Punto	2 ALTM Model: Peg	3 Mission Name: 1BLK18US43A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9022
7 Pilot: M. Tangonan	8 Co-Pilot: M. Agawin	9 Route: MAIA - MAIA			
10 Date: Feb 12, 2014	12 Airport of Departure (Airport, City/Province): MAIA		12 Airport of Arrival (Airport, City/Province): MAIA		
13 Engine On: 0639H	14 Engine Off: 1032H	15 Total Engine Time: 3+53	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: ~~[illegible] cloudy~~					
20 Remarks: Data acquired but w/ major voids due to heavy build ups					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	M. Tangonan Signature over Printed Name	R. Punto Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

4. Flight log for 1103P Mission

DREAM Data Acquisition Flight Log — Flight Log No.: 1103P

1 LiDAR Operator: J. Alviar	2 ALTM Model: Peg	3 Mission Name: 1BLK18W549A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: M. Tangonan	8 Co-Pilot: M. Agawin	9 Route: NAIA NAIA			
10 Date: Feb 13, 2014	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 0555H	14 Engine Off: 0939H	15 Total Engine Time: 3+44	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	partly cloudy				

20 Remarks:

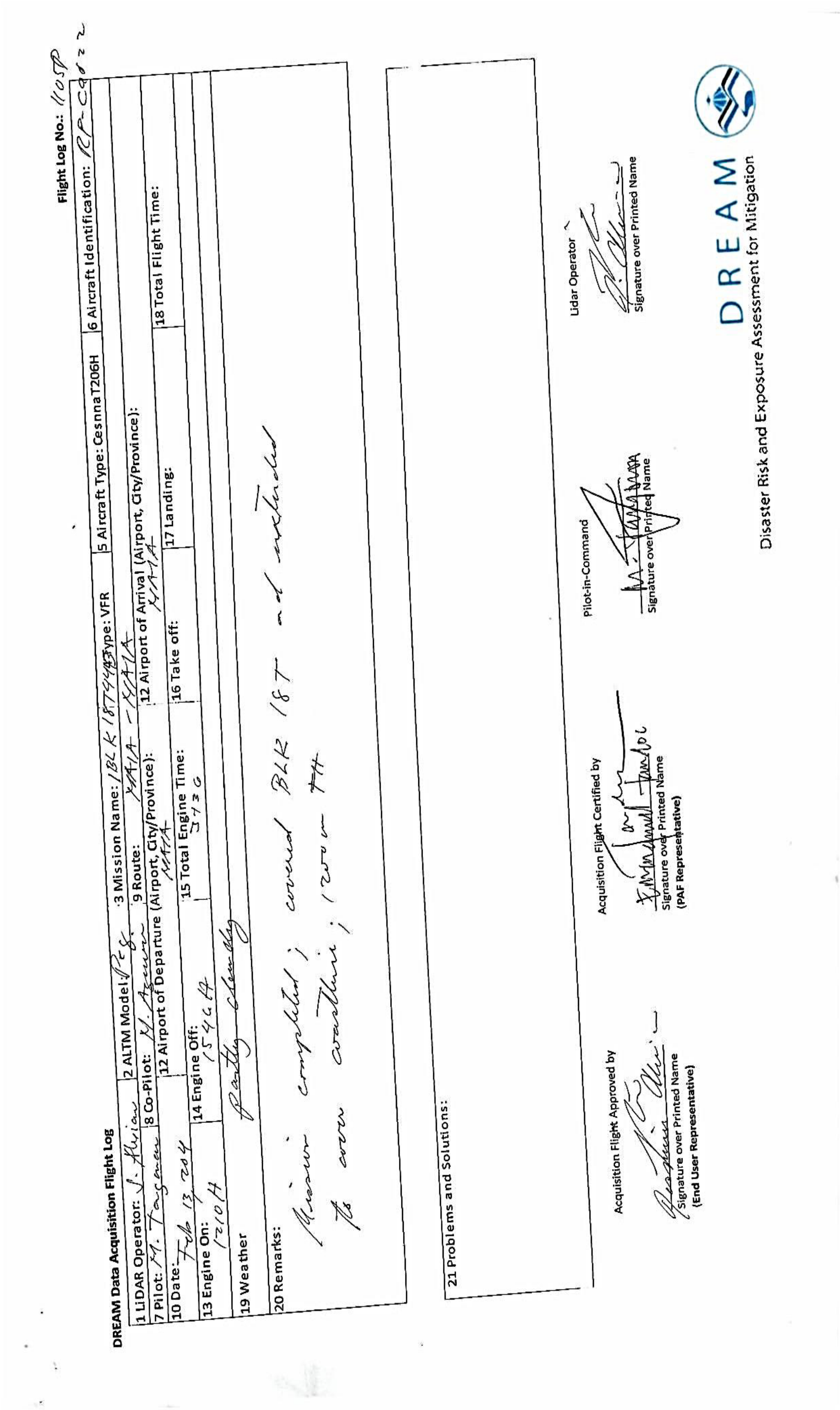
Mission completed; covered in BLK 18V plus covered additional (additional) area adjacent to BLK 18W; 1200 m FH

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

5. Flight Log for 1105P Mission


Flight Log No.: 1105P

DREAM Data Acquisition Flight Log

1 LiDAR Operator: J. Alviar | 2 ALTM Model: Peg. | 3 Mission Name: 1BLK18T44B | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RP-C9022

7 Pilot: M. Tangonan | 8 Co-Pilot: M. Aquino | 9 Route: NAIA - NAIA

10 Date: Feb 13, 2014 | 12 Airport of Departure (Airport, City/Province): NAIA | 12 Airport of Arrival (Airport, City/Province): NAIA

13 Engine On: 1210H | 14 Engine Off: 1546H | 15 Total Engine Time: 3+36 | 16 Take off: | 17 Landing: | 18 Total Flight Time:

19 Weather: partly cloudy

20 Remarks: Mission completed; covered BLK 18T and extended to cover coastline; 1200m FH

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
Signature over Printed Name

Lidar Operator
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

6. Flight Log for 1107P Mission

Flight Log No.: 1107P

DREAM Data Acquisition Flight Log

1 LiDAR Operator: R. Punto	2 ALTM Model: Peg	3 Mission Name: 1BLK18Q RS45A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9022
7 Pilot: M. Tangonan	8 Co-Pilot: F. Punto	9 Route: MAIA - MAIA			
10 Date: Feb 14, 2014	12 Airport of Departure (Airport, City/Province): MAIA		12 Airport of Arrival (Airport, City/Province): MAIA		
13 Engine On: 0618A	14 Engine Off: 0950A	15 Total Engine Time: 3+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: partly cloudy					

20 Remarks:

Mission completed; changed orientation of flight lines to avoid PAF base restriction in Lipa

21 Problems and Solutions:

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

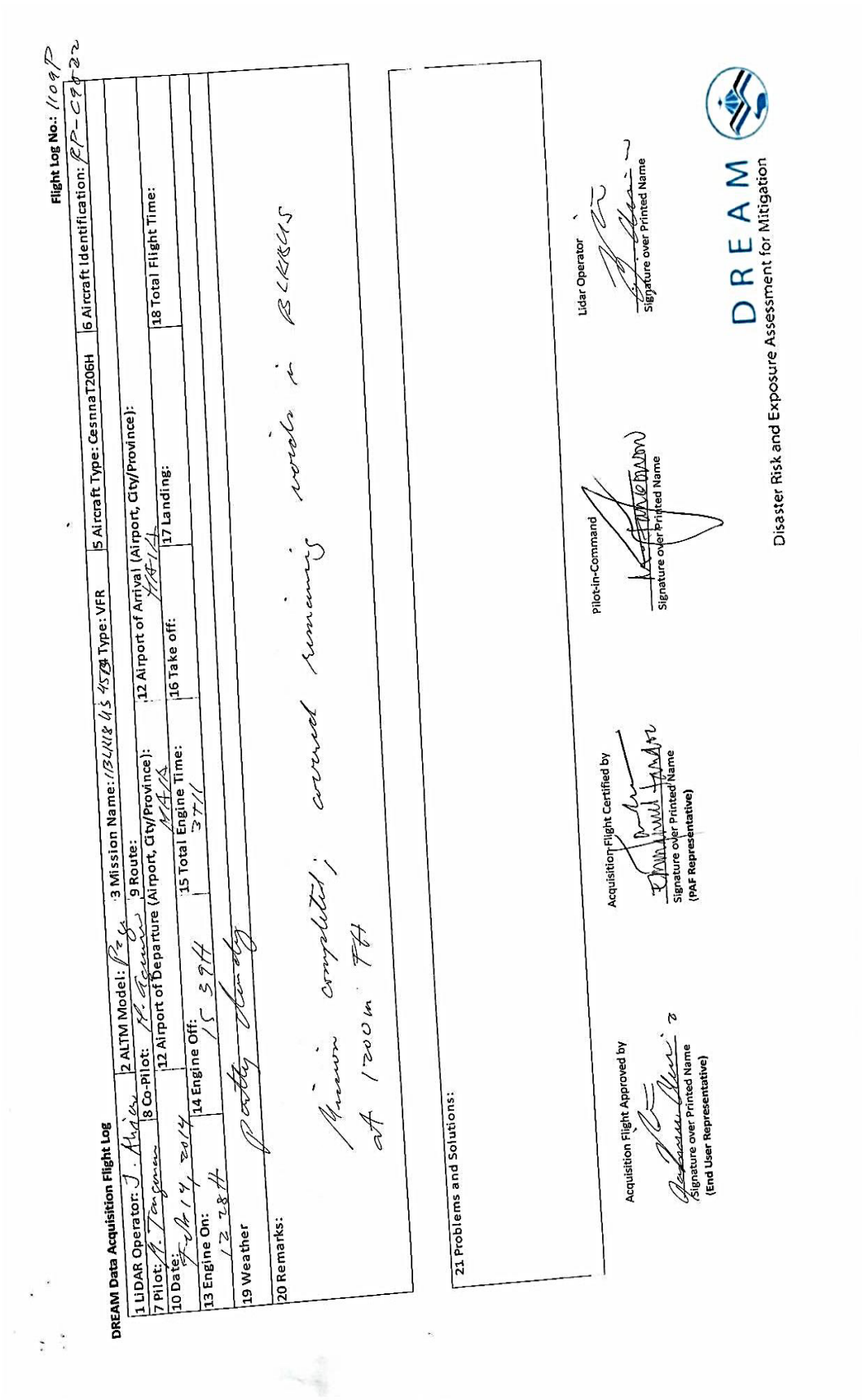
Acquisition Flight Certified by
Emmanuel Fandoc
Signature over Printed Name
(PAF Representative)

Pilot-in-Command
M. Tangonan
Signature over Printed Name

Lidar Operator
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

7. Flight Log for 1109P Mission



Flight Log No.: 1109P

DREAM Data Acquisition Flight Log

1 LiDAR Operator: J. Aviles	2 ALTM Model: Pegasus	3 Mission Name: 13WU18 WS 45	4 Type: VFR
5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C8922		
7 Pilot: A. Tangonan	8 Co-Pilot: M. Escueta	9 Route:	
10 Date: 2/4/2014	11 Airport of Departure (Airport, City/Province): MAC/A	12 Airport of Arrival (Airport, City/Province): MAC/A	
13 Engine On: 12:28 H	14 Engine Off: 15:39 H	15 Total Engine Time: 3+11	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly Cloudy			

20 Remarks:

Mission completed; returned Remaining route in BICOLS at 1200m FH

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
Signature over Printed Name

Lidar Operator
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

8. Flight Log for 3345P Mission

Data Acquisition Flight Log | **Flight Log No.:** 3345P

1 LiDAR Operator: LK PARAGAS/ K Andaya	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK18TS239A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: M. Tangonan	8 Co-Pilot: J. Mooney	9 Route: NAIA - NAIA			
10 Date: AUG. 27, 2015	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 0622H	14 Engine Off: 0956H	15 Total Engine Time: 3+34	16 Take off: 0627H	17 Landing: 0951H	18 Total Flight Time: 3+24
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

Successful

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/ Technician
J. Alviar	Lee Jay Punzalan	M.L. Tangonan	KJ Andaya	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

9. Flight Log for 3347P Mission

Data Acquisition Flight Log

Flight Log No.: 3347P

1 LiDAR Operator: G. SINADJAN	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK18TS239B	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9022
7 Pilot: M. Tangonan	8 Co-Pilot: J. Mooney	9 Route: NAIA – NAIA			
10 Date: AUG. 27, 2015	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 1414H	14 Engine Off: 1645H	15 Total Engine Time: 2+31	16 Take off: 1409H	17 Landing: 1639H	18 Total Flight Time: 2+21
19 Weather: partly 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

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/ Technician
J. Alviar	LEE JAY PUNZALAN	M.L. TANGONAN	G. SINADJAN	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

10. Flight Log for 3353P Mission

Data Acquisition Flight Log

Flight Log No.: 3353 P

1 LiDAR Operator: MR VILLANUEVA	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK18QRS241A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: M. Tangonan	8 Co-Pilot: J. Mooney	9 Route: NAIA - NAIA			
10 Date: AUG. 29, 2015	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 0631H	14 Engine Off: 1026H	15 Total Engine Time: 3+55	16 Take off: 0636H	17 Landing: 1021H	18 Total Flight Time: 3+45
19 Weather: partly 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

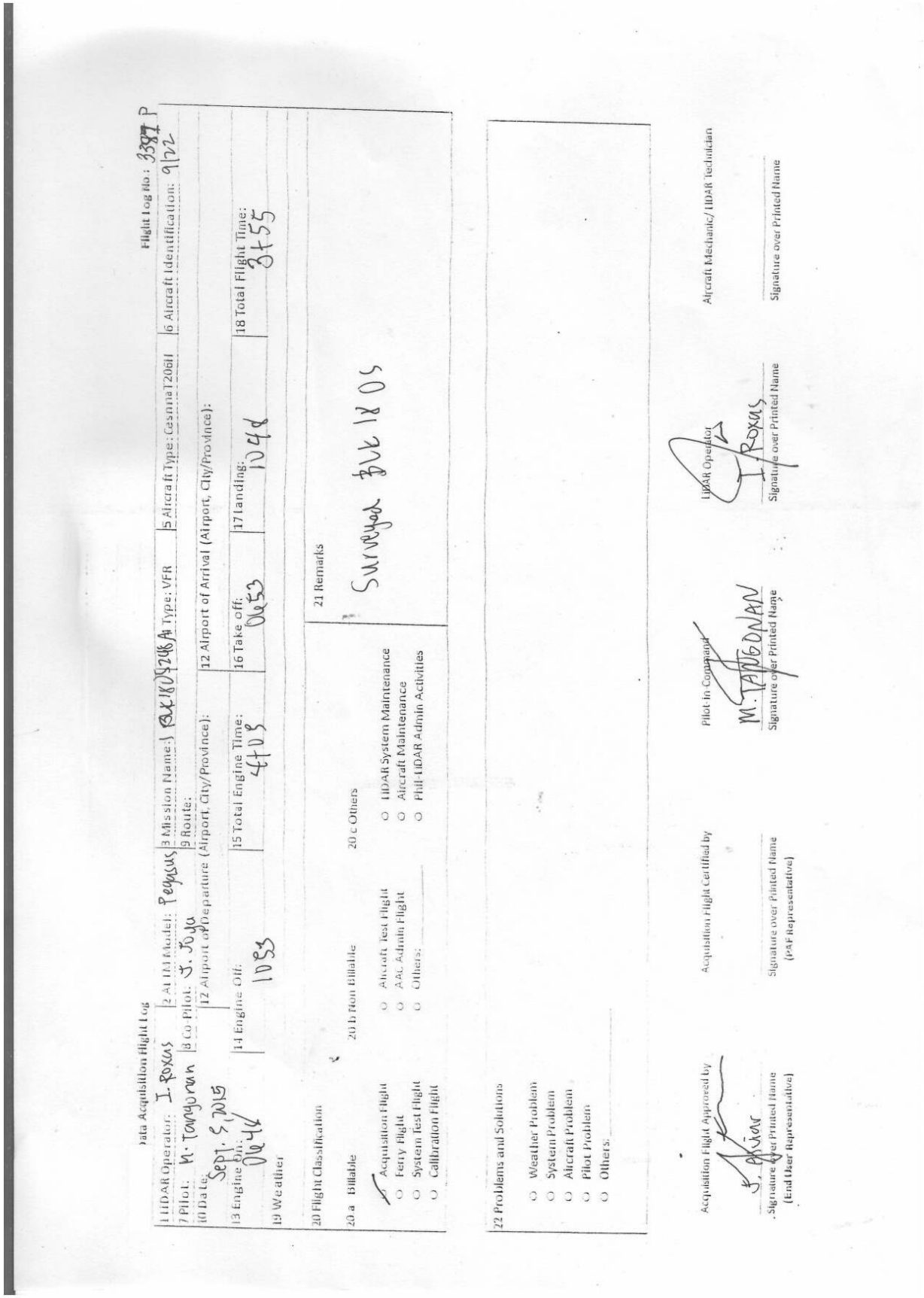
Successful

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/ Technician
J. Alviar	Lee Jay Punzalan	M.L Tangonan	M.A Villanueva	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

11. Flight Log for 3381P Mission



Data Acquisition Flight Log

Flight Log No.: 3381 P

1 LiDAR Operator: I. Roxas	2 ALTM Model: Pegasus	3 Mission Name: BX18U9248A Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: M. Tamayoman	8 Co Pilot: J. Roja	9 Route:		
10 Date: Sept. 5, 2015	11 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):	
13 Engine On: 0946	14 Engine Off: 1053	15 Total Engine Time: 4+05	16 Take off: 0953	17 Landing: 1048
19 Weather				18 Total Flight Time: 2+55

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

Survey BX 18 05

22 Problems and Solutions

- ○ Weather Problem
- ○ System Problem
- ○ Aircraft Problem
- ○ Pilot Problem
- ○ Others: _____

Acquisition Flight Approved by

Signature over Printed Name (End User Representative)

Acquisition Flight Certified by

Signature over Printed Name (PAF Representative)

Pilot-In-Command

M. TAMAYOMAN

Signature over Printed Name

LiDAR Operator

I. ROXAS

Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician

Signature over Printed Name

ANNEX 7. FLIGHT STATUS REPORT

CALABARZON

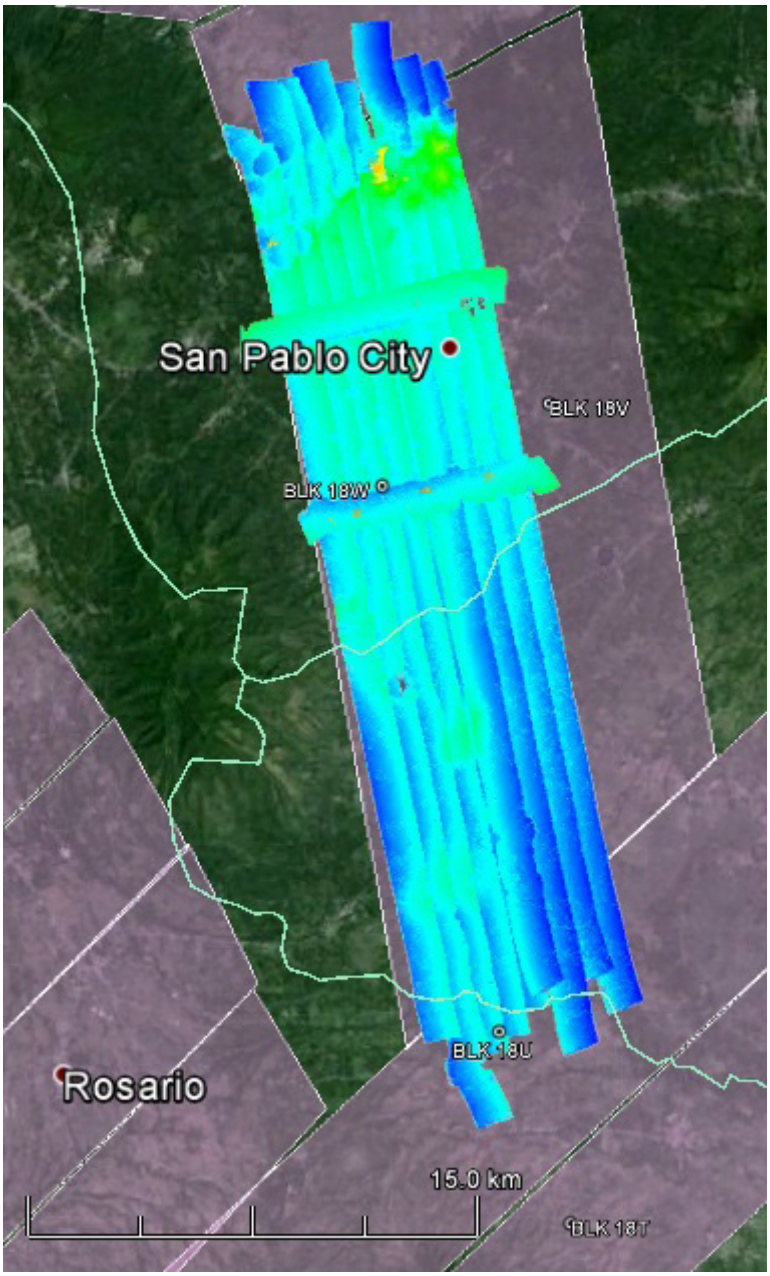
(FEBRUARY 10-14, 2014 AND AUGUST 27-SEPTEMBER 5, 2015)

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1091P	BLK 18WV	1BLK18W41A	J. Alviar	10 Feb 2014	Mission completed at 1100m AGL
1095P	BLK 18UT	1BLK18U42A	R. Punto	11 Feb 2014	Data acquired but with major voids due to heavy build up in the area
1099P	BLK 18UTS	1BLK18US43A	R. Punto	12 Feb 2014	Data acquired but with major voids due to heavy build up in the area
1103P	BLK 18VWS	1BLK18VWS44A	J. Alviar	13 Feb 2014	Mission completed in BLK 18V plus covered additional area adjacent to BLK 18W; 1200m Flying height
1105P	BLK18T	1BLK18T44B	J. Alviar	13 Feb 2014	Mission completed; covered BLK 18T and extended to cover coastline; 1200m flying height
1107P	BLK 18PQ	1BLK18QRS45A	R. Punto	14 Feb 2014	Mission completed; changed orientation of flight plan to avoid PAF base restriction in Lipa; 1200m flying height
1109P	BLK 18UTS	1BLK18US45B	J. Alviar	14 Feb 2014	Mission completed; covered remaining voids in BLK 18US at 1200m flying height
3345P	BLK 18TS	1BLK18TS239A	LK PARAGAS	27 Aug 2015	Calibration flight Experienced POSAV error Without Digitizer and Camera
3347P	BLK 18TS	1BLK18TS239B	G. SINADJAN	27 Aug 2015	Finished area TS Hazy with precipitation at the end of survey Without Digitizer and Camera
3353P	BLK 18QRS	1BLK18QRS241A	MR VILLANUEVA	29 Aug 2015	Mission Completed Without Digitizer and Camera
3381P	BLK18O	1BLK18OS248A	I.Roxas	5 Sept 2015	.386 FILE FOR POS (BECAME VIRTUAL DEVICE DRIVER; PREVIOUSLY REPORTED; CASE PENDING. No Digi and Camera

LAS BOUNDARIES PER FLIGHT

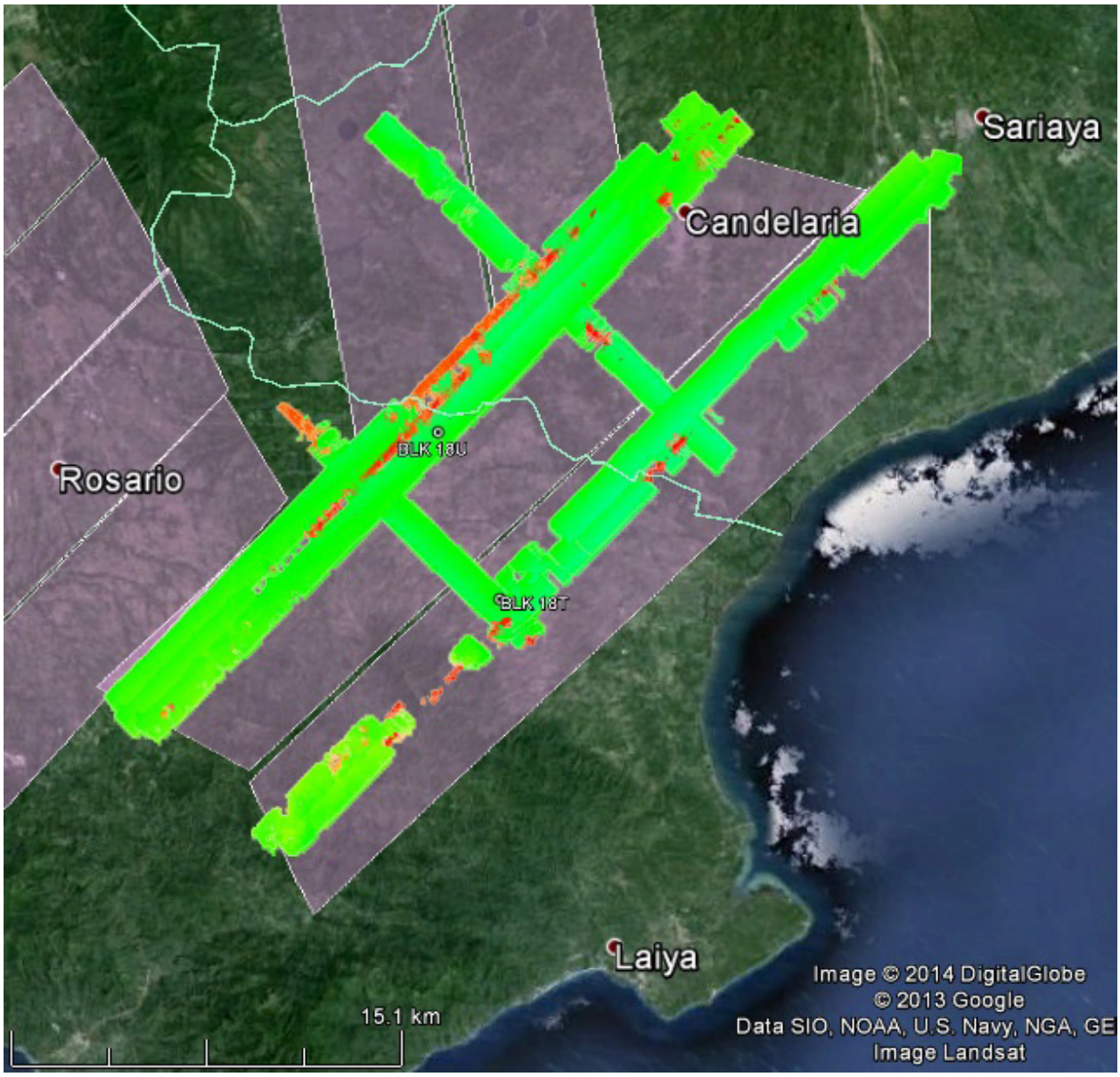
Flight No. : 1091P
Area: BLK 18WV
Mission Name: 1BLK18W41A

LAS



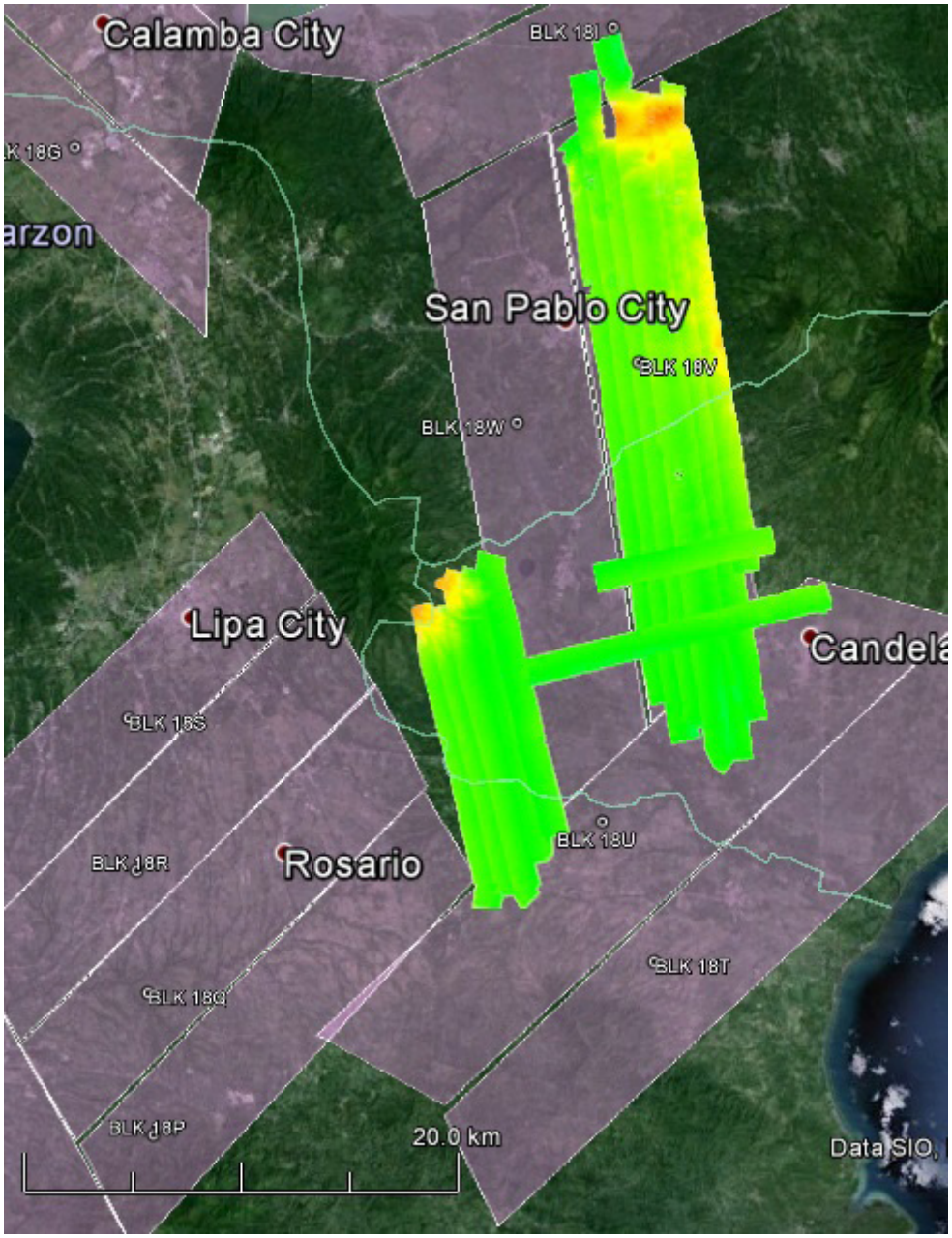
Flight No. : 1095P
Area: BLK 18UT
Mission Name: 1BLK18U42A

LAS



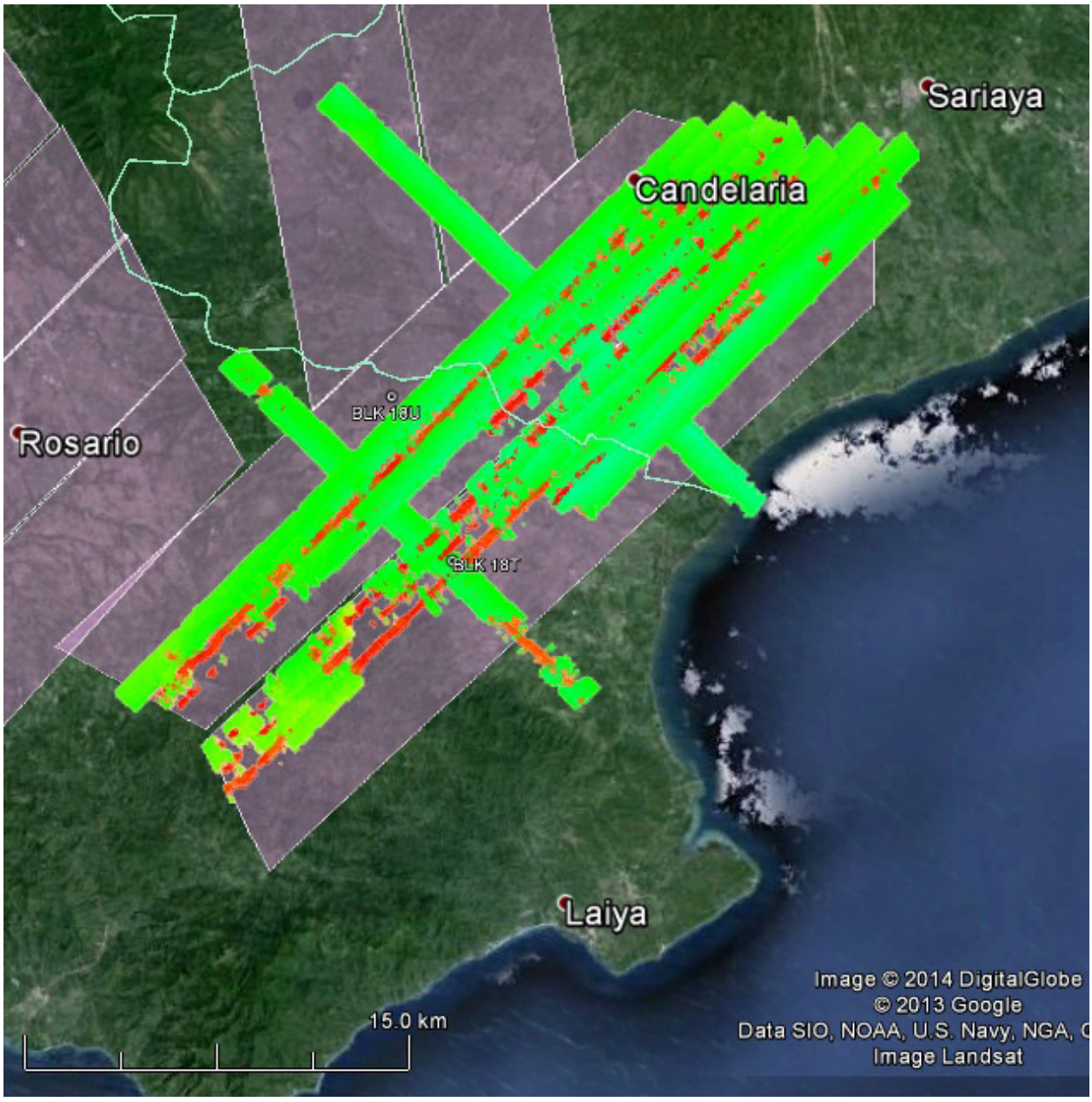
Flight No. : 1103P
Area: BLK 18VWS
Mission Name: 1BLK18VWS44A

LAS



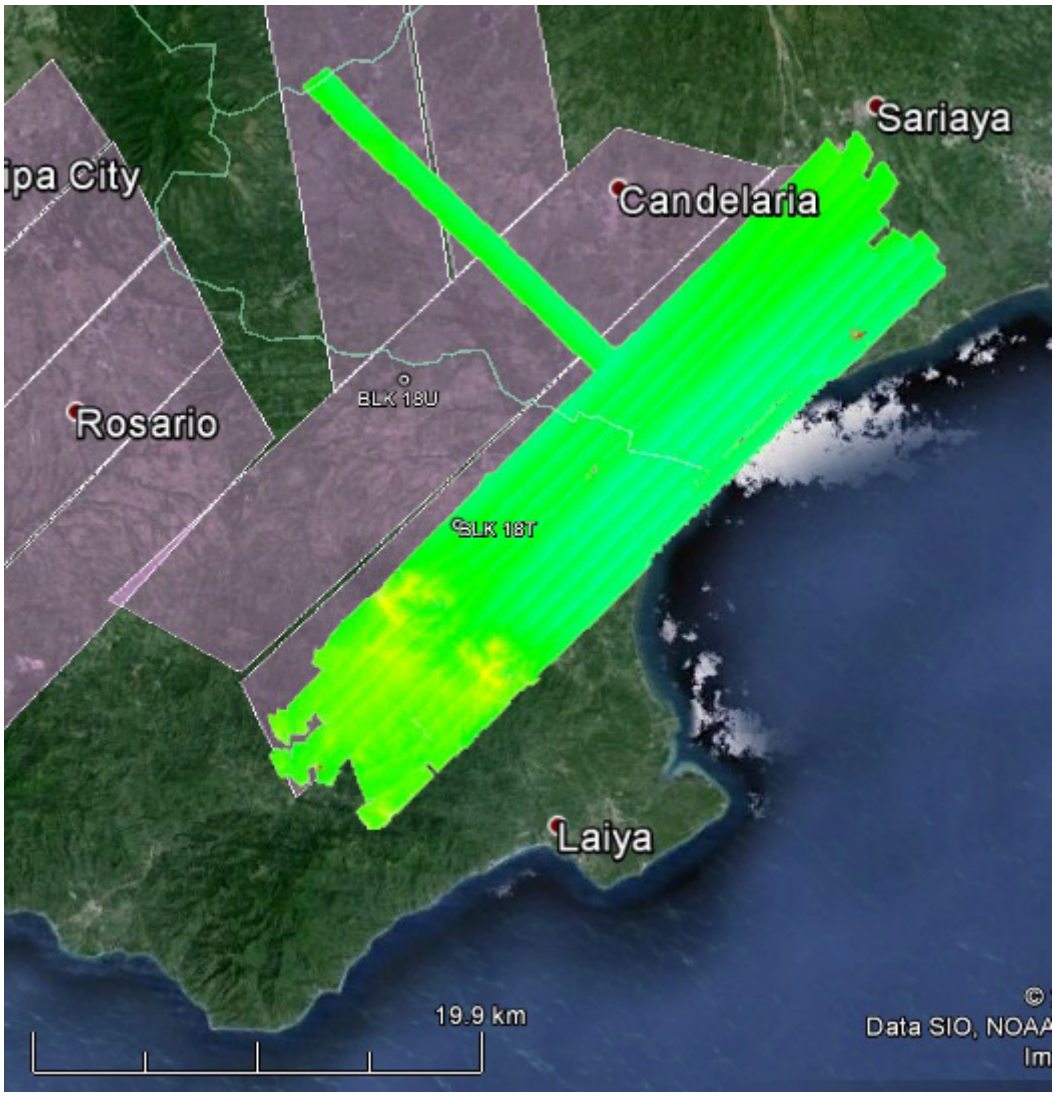
Flight No. : 1099P
Area: BLK 18UTS
Mission Name: 1BLK18US43A

LAS



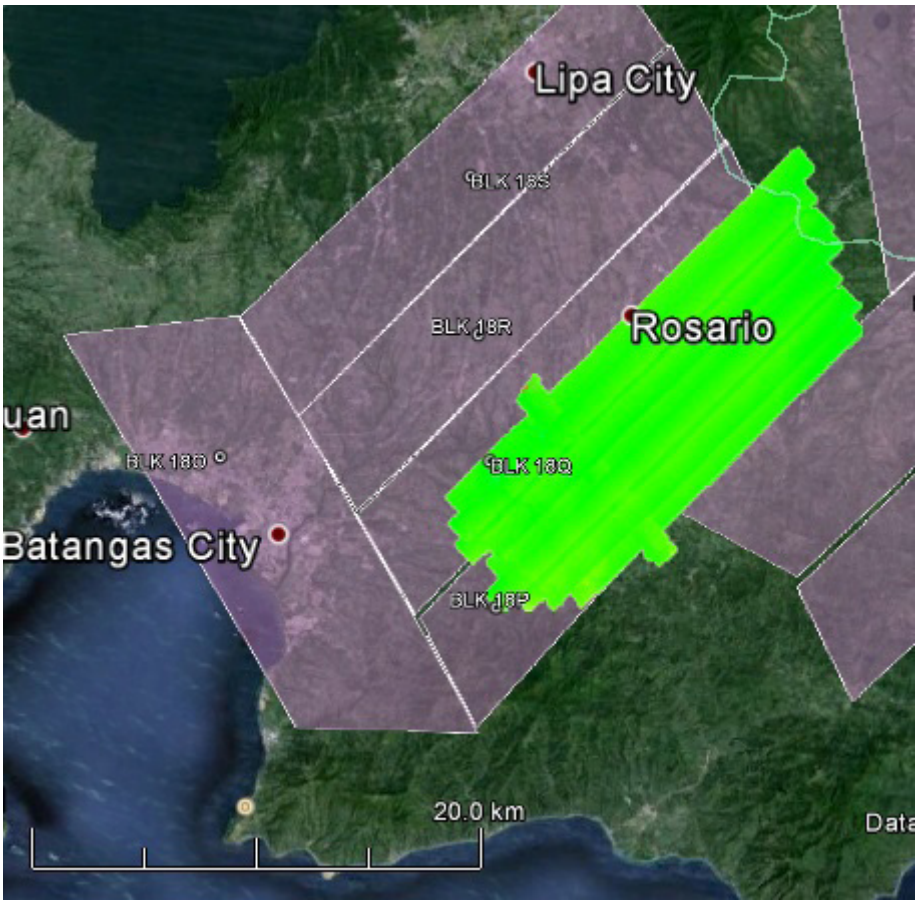
Flight No. : 1105P
Area: BLK 18T
Mission Name: 1BLK18TS44B

LAS



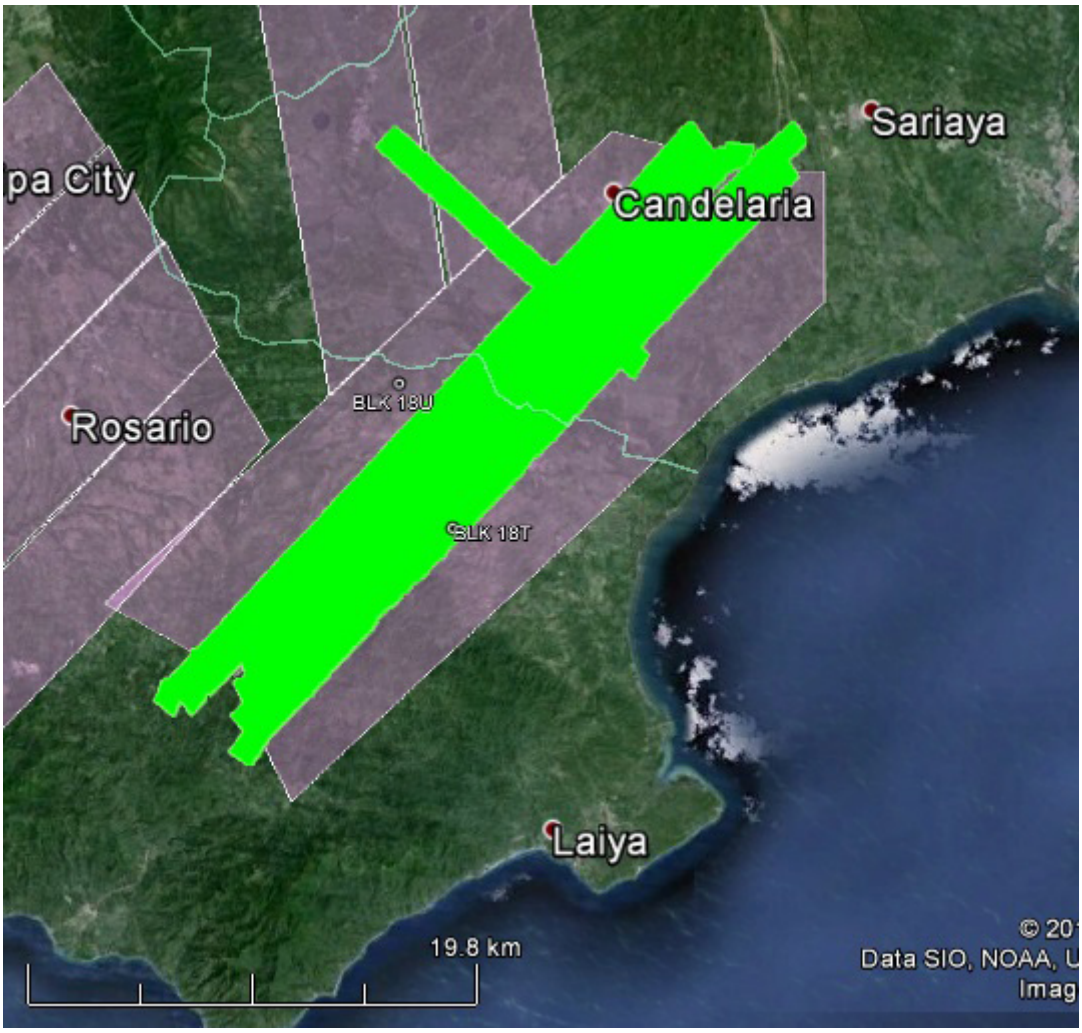
Flight No. : 1107P
Area: BLK 18PQ
Mission Name: 1BLK18QRS45A

LAS



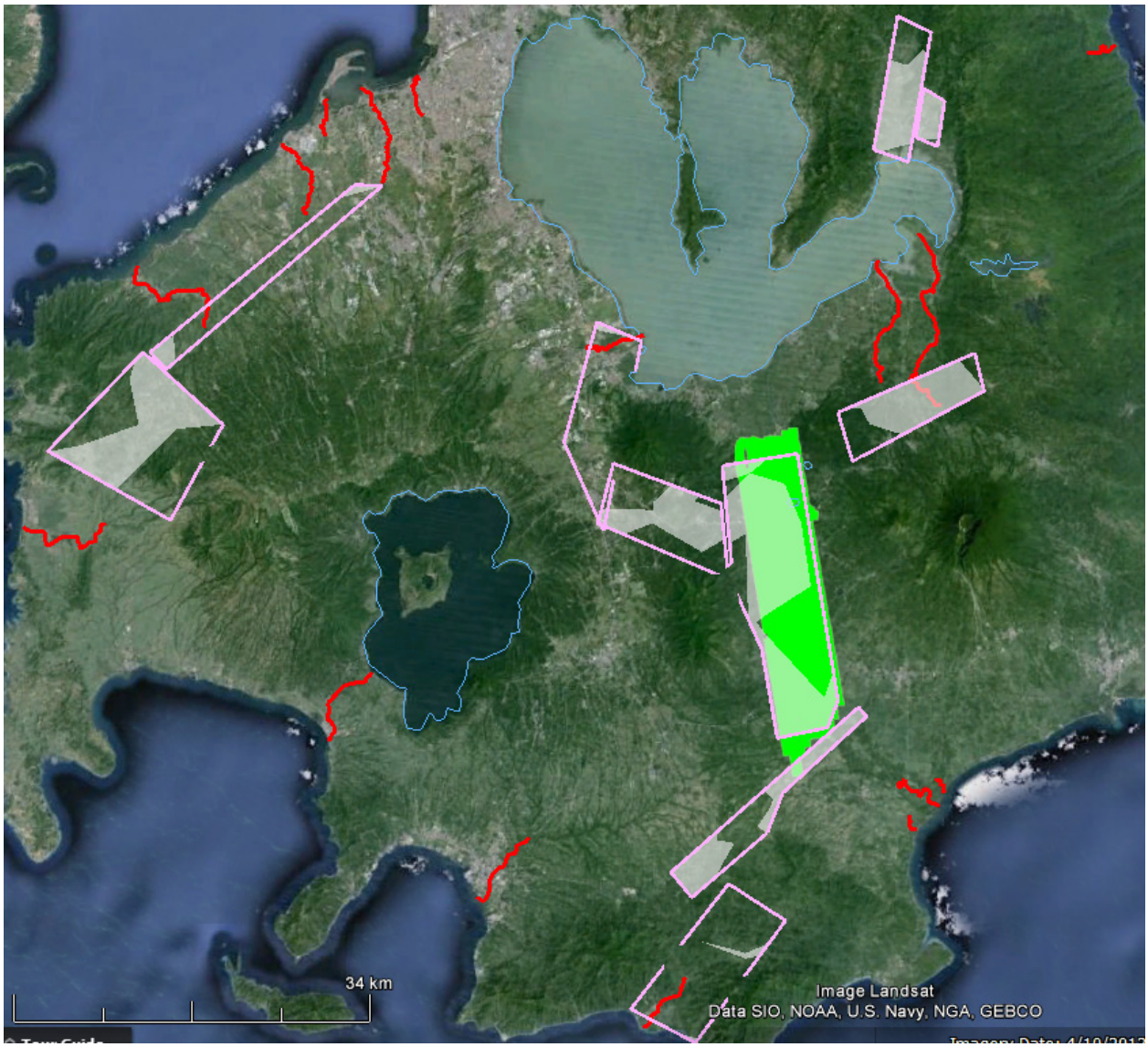
Flight No. : 1109P
Area: BLK 18UTS
Mission Name: 1BLK18US45B

LAS



Flight No. : 3345P
Area: BLK 18TS
Mission Name: 1BLK18TS239A
Area: 200.3 sq. km
Parameters: Altitude: 1000; Scan Frequency: 30; Scan Angle: 25; Overlap: 15%

LAS

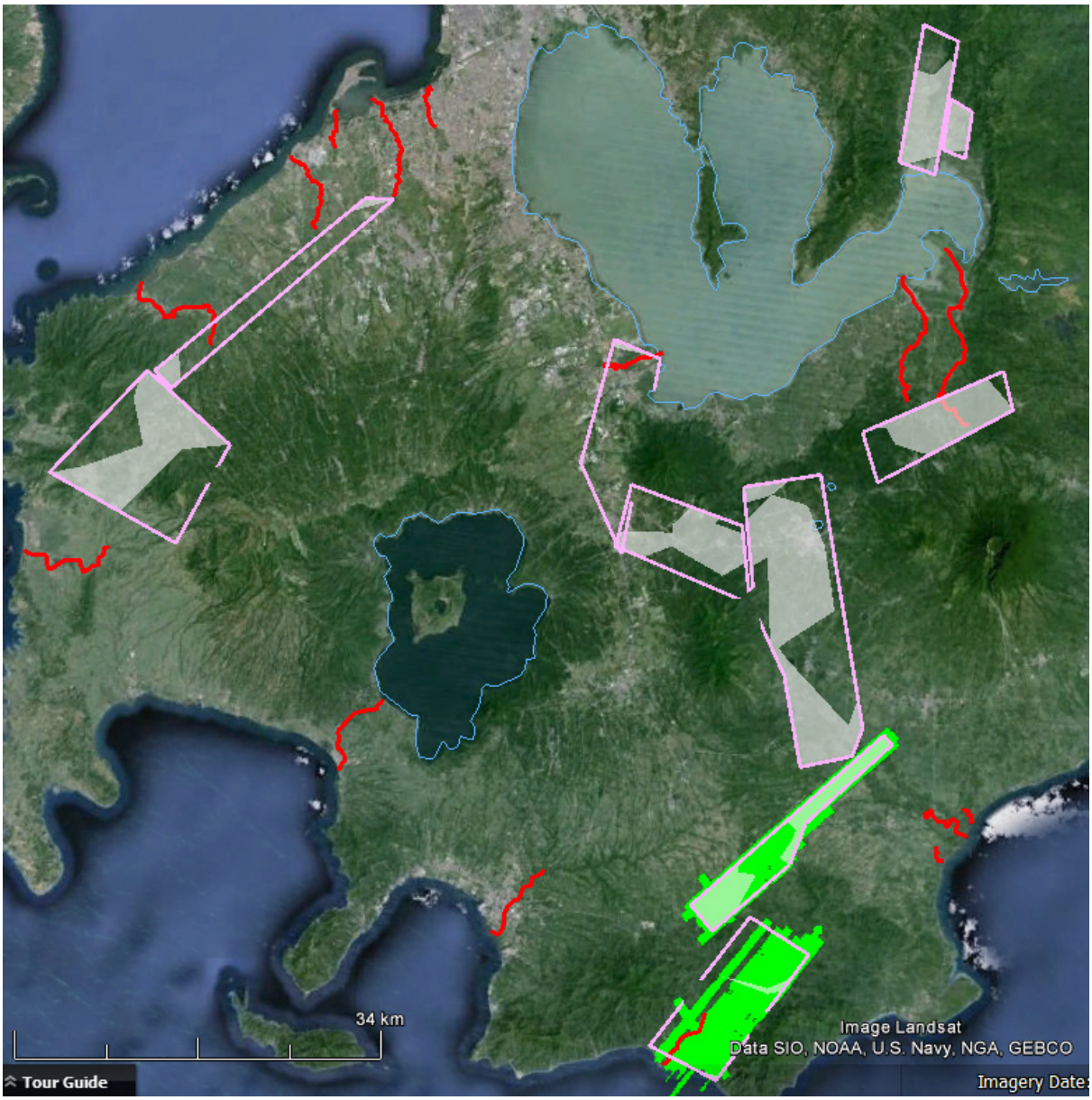


Flight No. : 3347P
Area: BLK 18TS
Mission Name: 1BLK18TS239B
Area: 81.0 sq.km
Parameters: Altitude: 1000; Scan Frequency: 30; Scan Angle: 25; Overlap: 15%

LAS

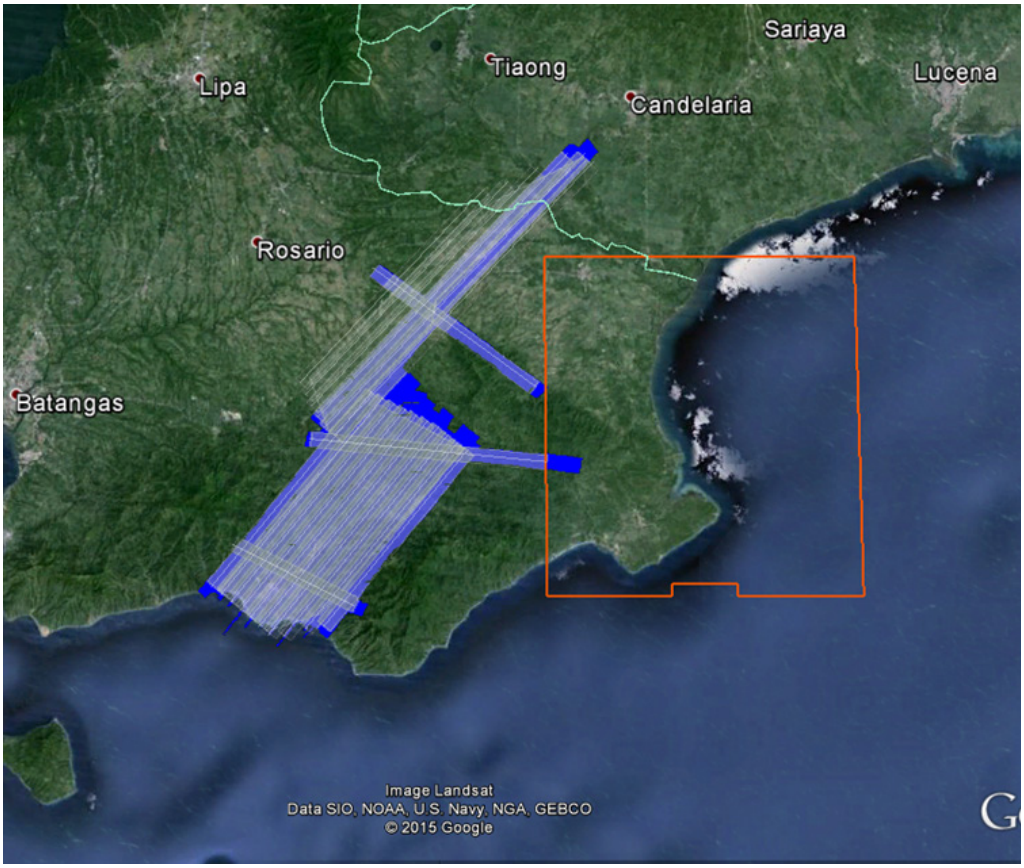
Flight No. : 3353P
Area: BLK 18 QRS
Mission Name: 1BLK18QRS241A
Area: 169 sq. km
Parameters: Altitude: 1000; Scan Frequency: 30; Scan Angle: 25; Overlap: 20%

LAS



Flight No. :	3381P
Area:	BLK 18
Mission Name:	1BLK18OS248A
Area:	213.4 sq.km
Parameters: Altitude:	1000; Scan Frequency: 30; Scan Angle: 25; Overlap: 20%

LAS



ANNEX 8. MISSION SUMMARY REPORT

Flight Area	CALABARZON
Mission Name	**Blk18U_additional**
Inclusive Flights	3353P
Range data size	18.8 GB
POS	246 MB
Image	N/A
Transfer date	09/08/2015
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)	1.2
RMSE for East Position (<4.0 cm)	1.6
RMSE for Down Position (<8.0 cm)	3.4
Boresight correction stdev (<0.001deg)	0.000181
IMU attitude correction stdev (<0.001deg)	0.000961
GPS position stdev (<0.01m)	0.0026
Minimum % overlap (>25)	34.18%
Ave point cloud density per sq.m. (>2.0)	3.13
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	192
Maximum Height	749.60 m
Minimum Height	48.73 m
Classification (# of points)	
Ground	79,218,508
Low vegetation	47,266,805
Medium vegetation	163,471,309
High vegetation	423,404,180
Building	12,745,086
Orthophoto	No
Processed by	Engr. Abigail Joy Ching, Aljon Rie Araneta, Engr. Melissa Fernandez96

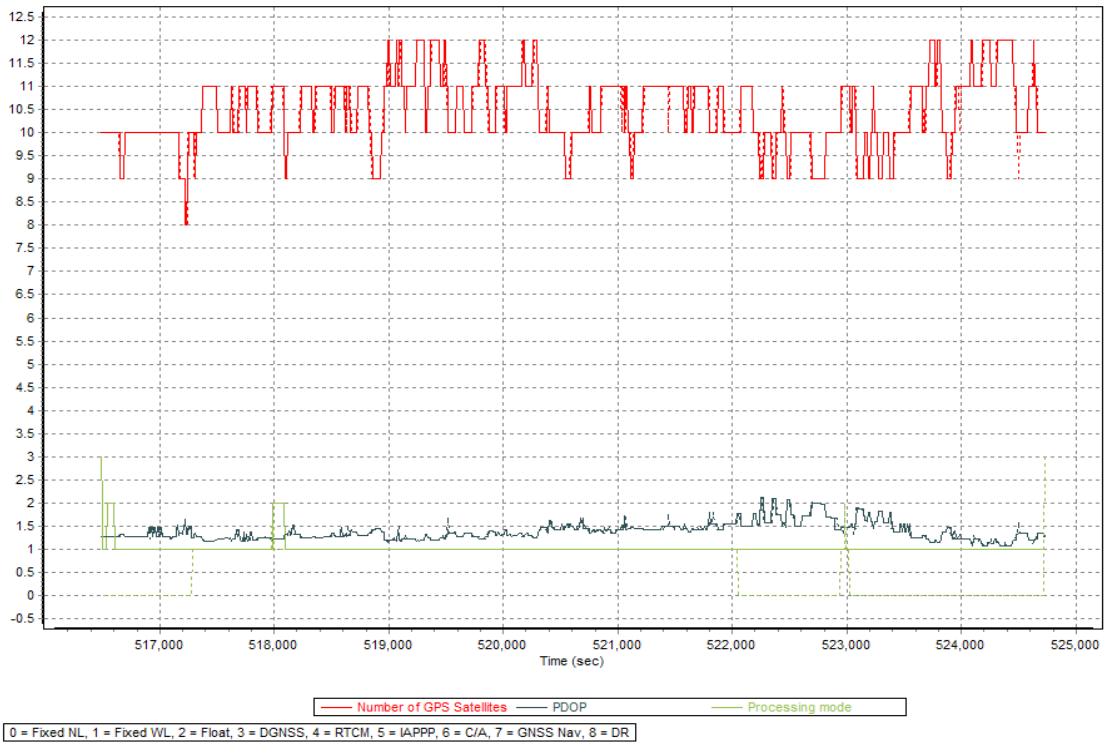


Figure 1.1.1. Solution Status

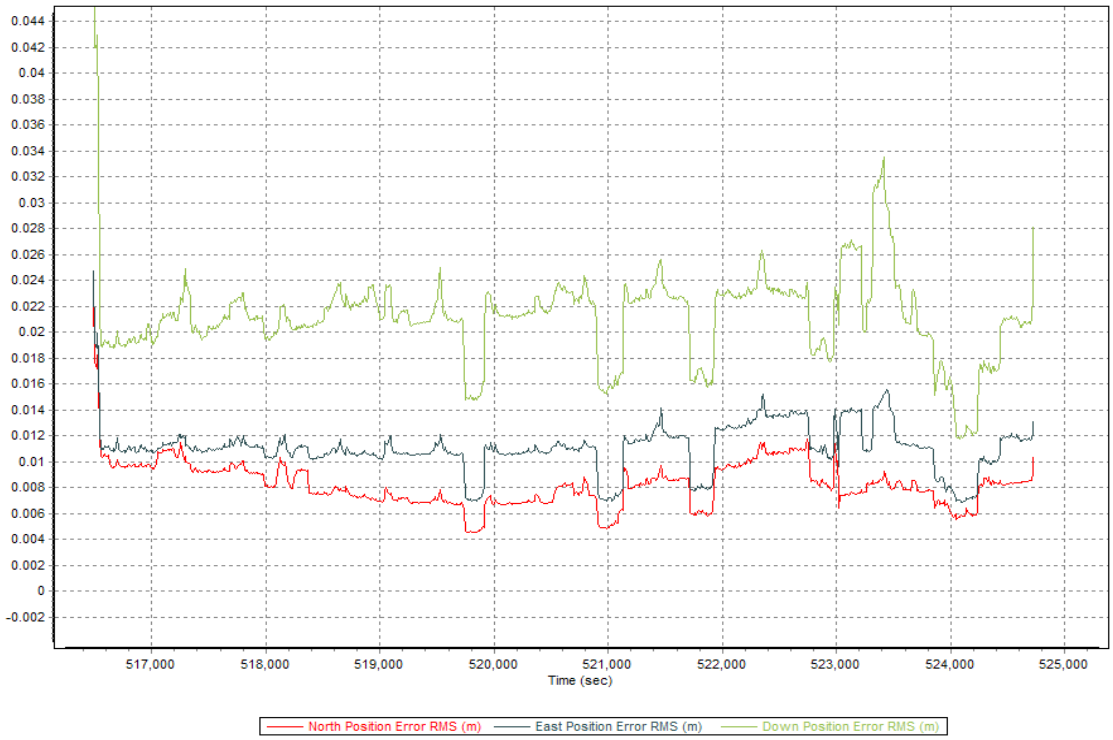


Figure 1.1.2. Smoothed Performance Metrics Parameters

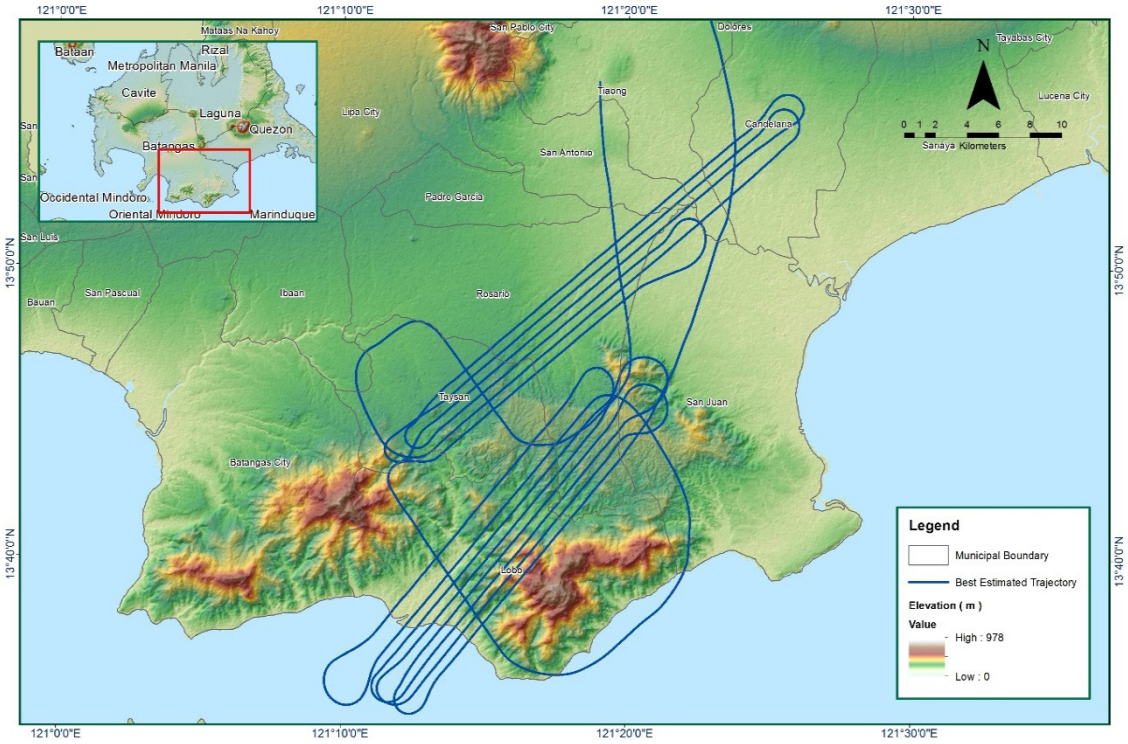


Figure 1.1.3. Best Estimated Trajectory

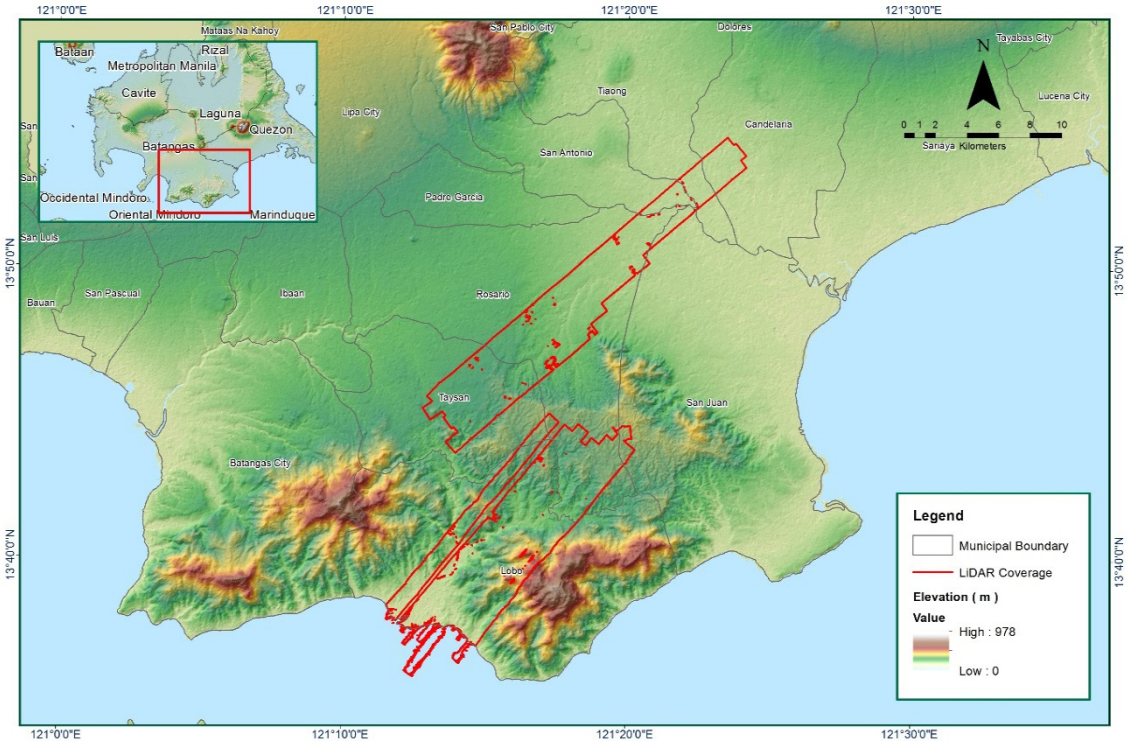


Figure 1.1.4. Coverage of LiDAR data

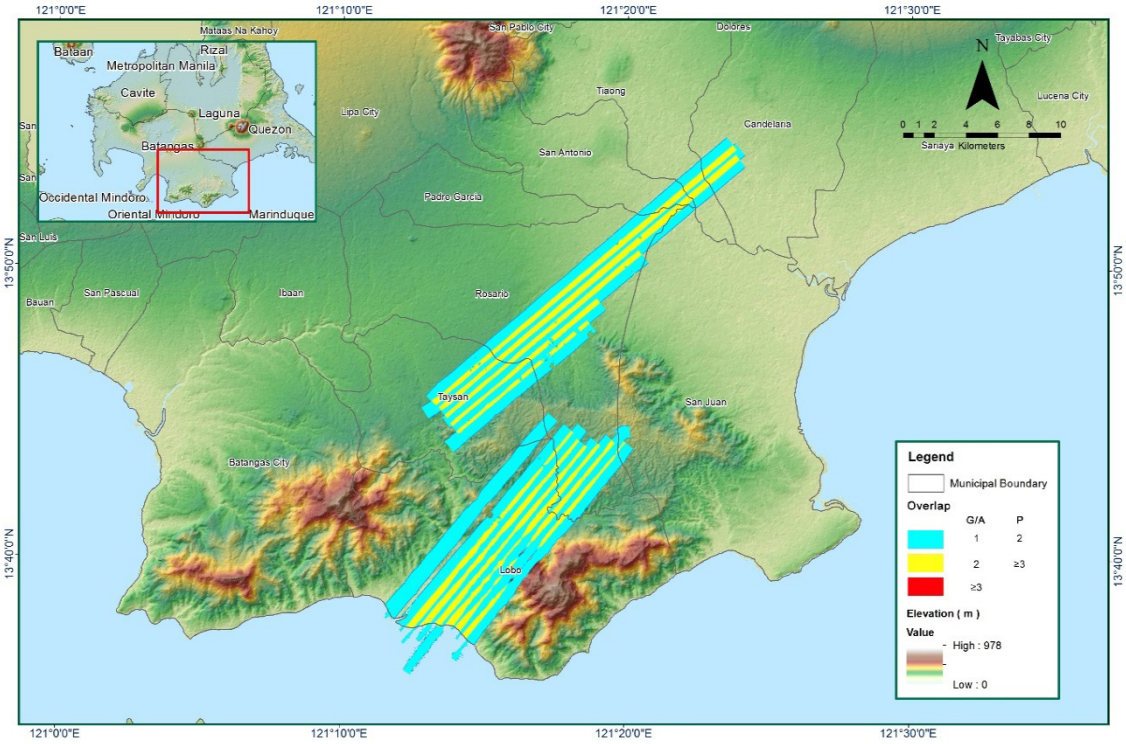


Figure 1.1.5. Image of data overlap

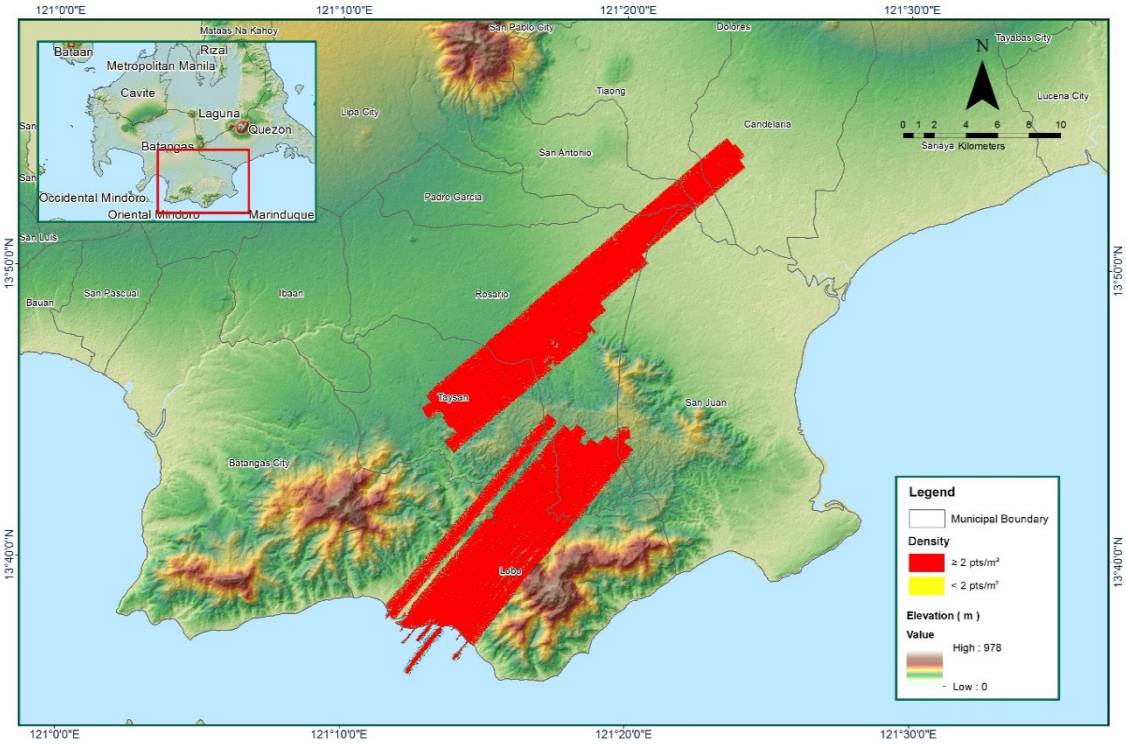


Figure 1.1.6. Density map of merged LiDAR data

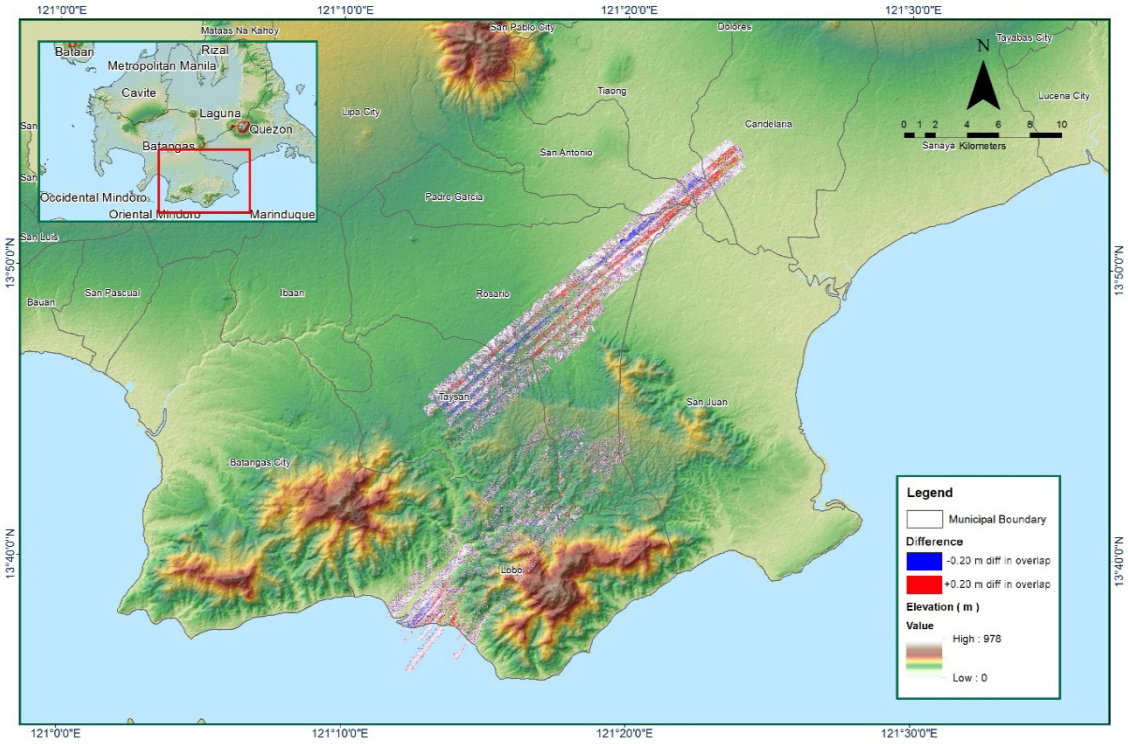


Figure 1.1.7. Elevation difference between flight lines

Flight Area	Calabarzon
Mission Name	**Blk18U_additional2**
Inclusive Flights	3353P
Range data size	18.8 GB
POS	246 MB
Image	N/A
Transfer date	September 08, 201
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)	1.2
RMSE for East Position (<4.0 cm)	1.6
RMSE for Down Position (<8.0 cm)	3.4
Boresight correction stdev (<0.001deg)	0.000181
IMU attitude correction stdev (<0.001deg)	0.000961
GPS position stdev (<0.01m)	0.0026
Minimum % overlap (>25)	28.76%
Ave point cloud density per sq.m. (>2.0)	2.12
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	96
Maximum Height	675.31 m
Minimum Height	56.06 m
Classification (# of points)	
Ground	44,442,219
Low vegetation	23,699,835
Medium vegetation	49,151,202
High vegetation	77,592,096
Building	3,236,522
Orthophoto	No
Processed by	Engr. Abigail Joy Ching, Engr. Edgardo Gubatanga Jr., Marie Denise Bueno

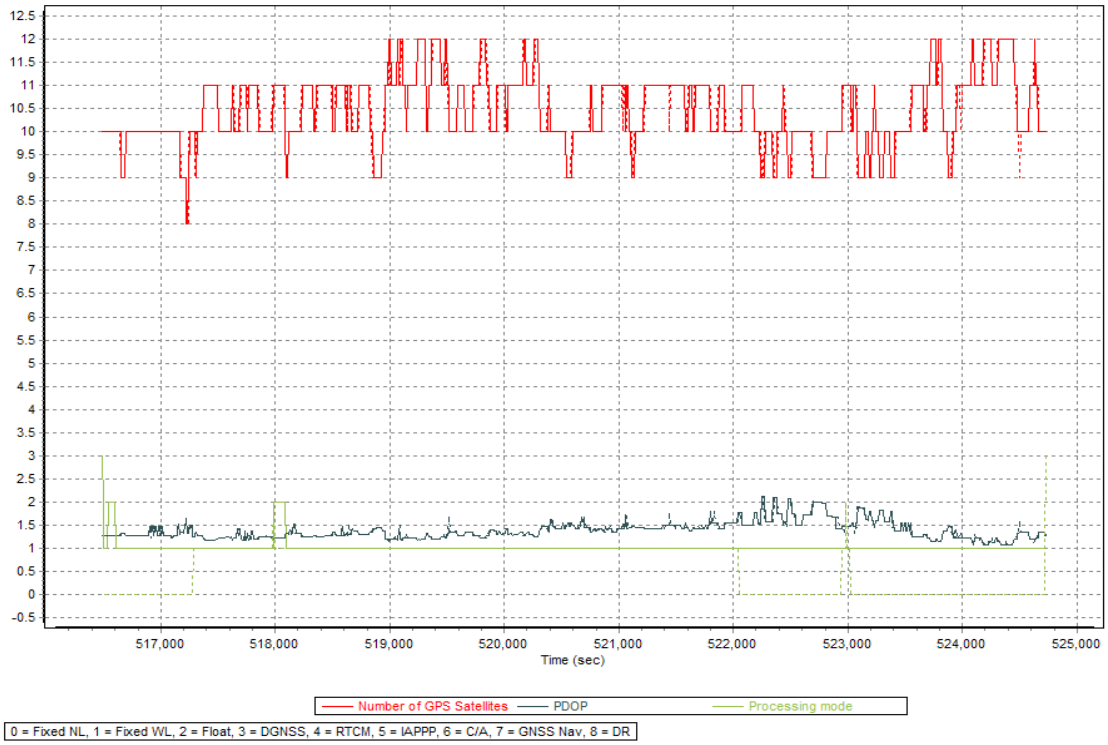


Figure 1.2.1. Solution Status

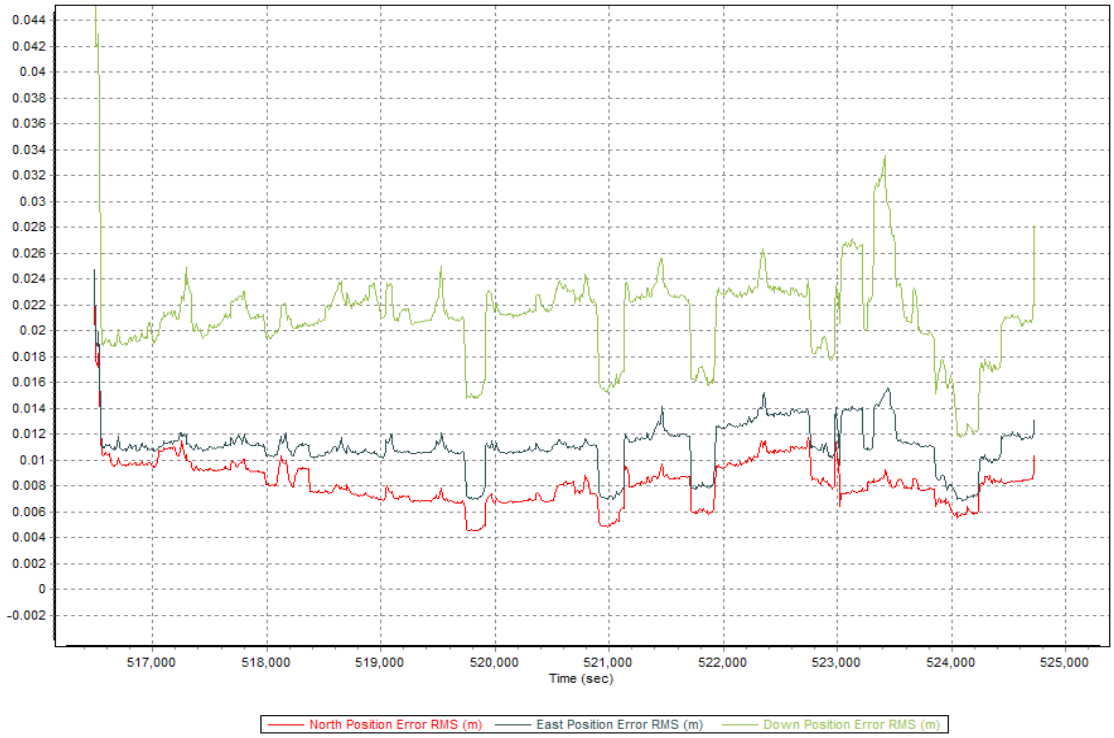


Figure 1.2.2. Smoothed Performance Metrics Parameters

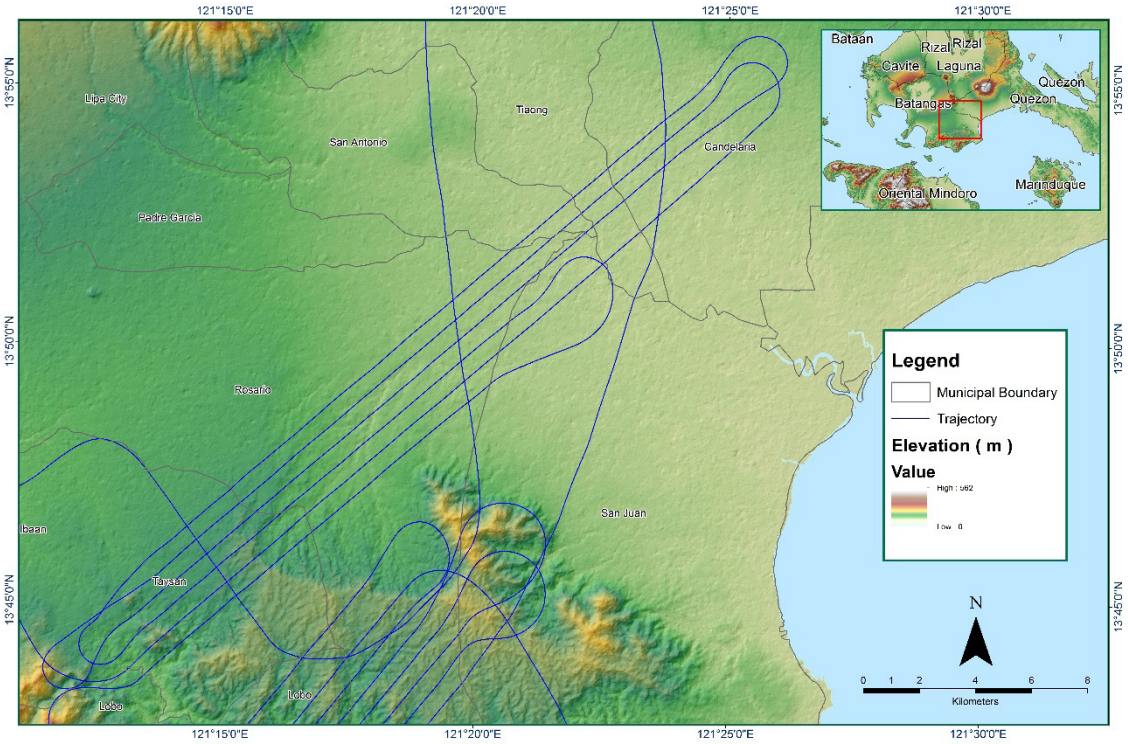


Figure 1.2.3. Best Estimated Trajectory

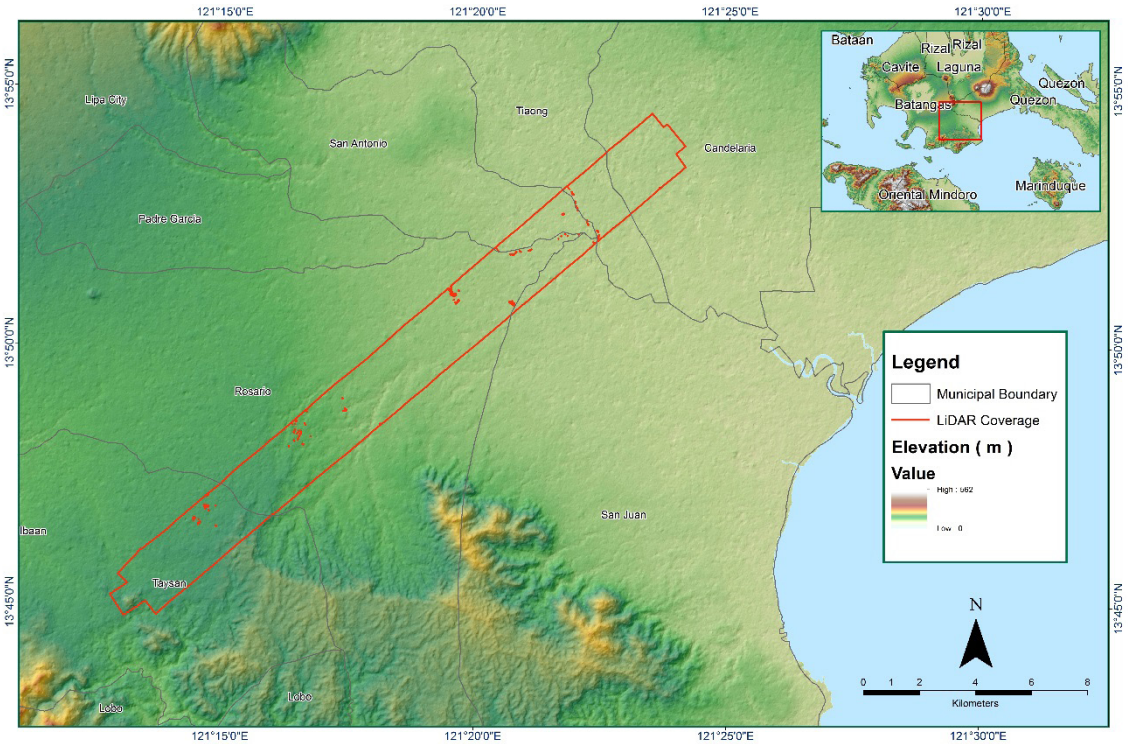


Figure 1.2.4. Coverage of LiDAR data

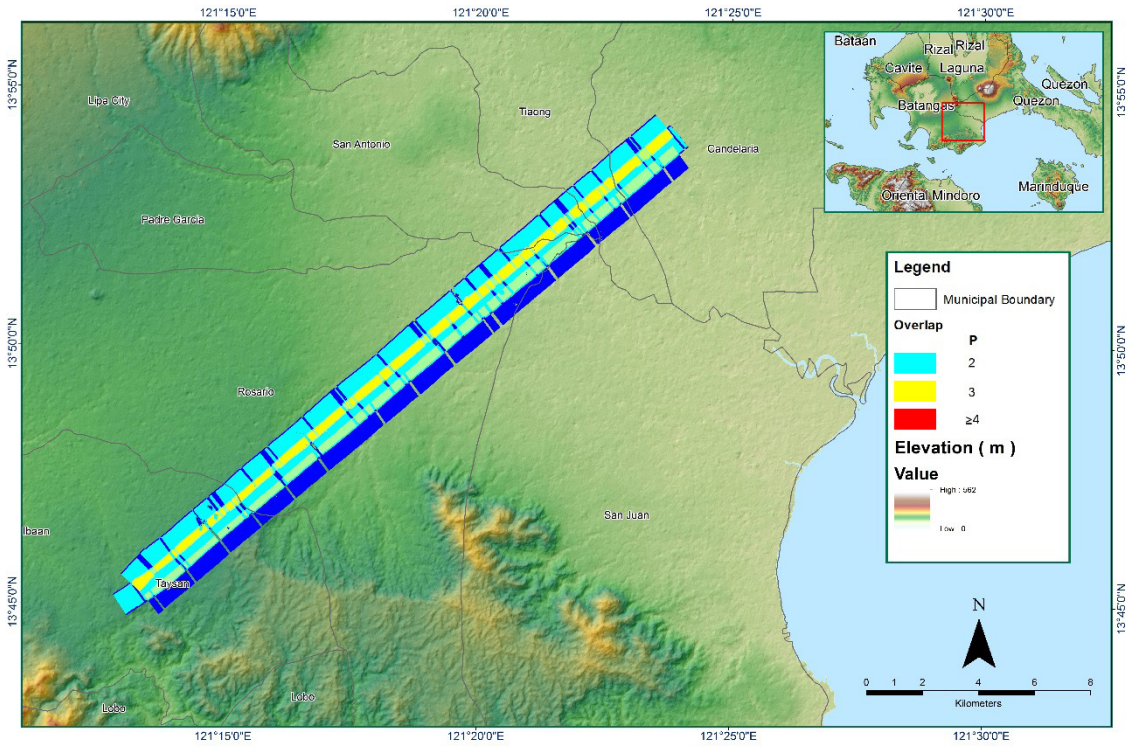


Figure 1.2.5. Image of data overlap

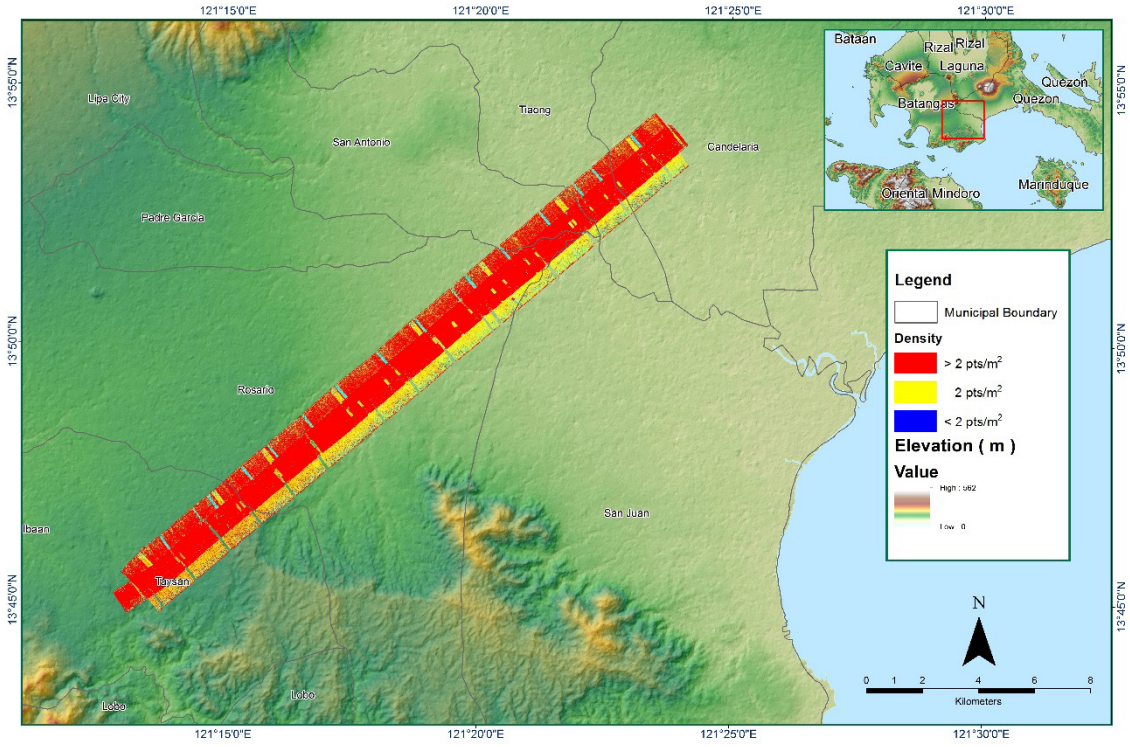


Figure 1.2.6. Density map of merged LiDAR data

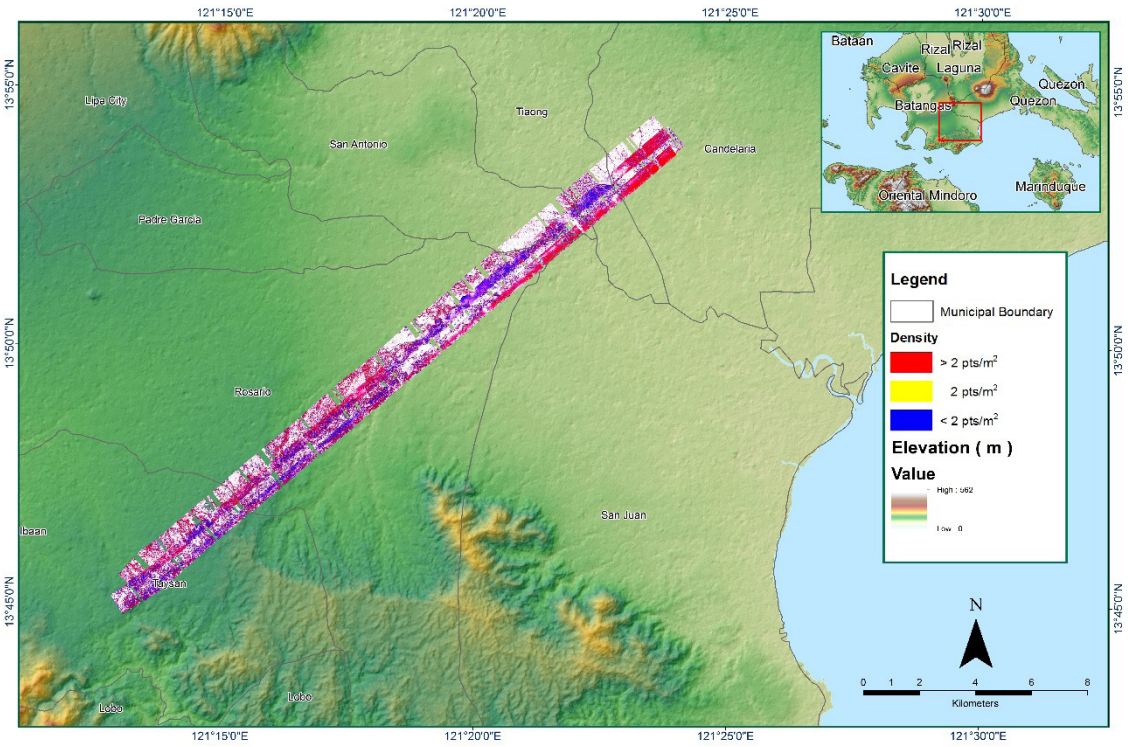


Figure 1.2.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18U_supplement**
Inclusive Flights	3381P
Range data size	20.6 GB
POS	256 MB
Image	N/A
Transfer date	09/11/2015
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)	1.1
RMSE for East Position (<4.0 cm)	2.0
RMSE for Down Position (<8.0 cm)	3.3
Boresight correction stdev (<0.001deg)	0.000232
IMU attitude correction stdev (<0.001deg)	0.000478
GPS position stdev (<0.01m)	0.0073
Minimum % overlap (>25)	33.91%
Ave point cloud density per sq.m. (>2.0)	3.00
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	248
Maximum Height	1142.15 m
Minimum Height	33.16 m
Classification (# of points)	
Ground	116,430,535
Low vegetation	71,532,461
Medium vegetation	215,467,664
High vegetation	328,004,432
Building	10,242,231
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Engr. Melanie Hingpit, Jovy Ann Narisma

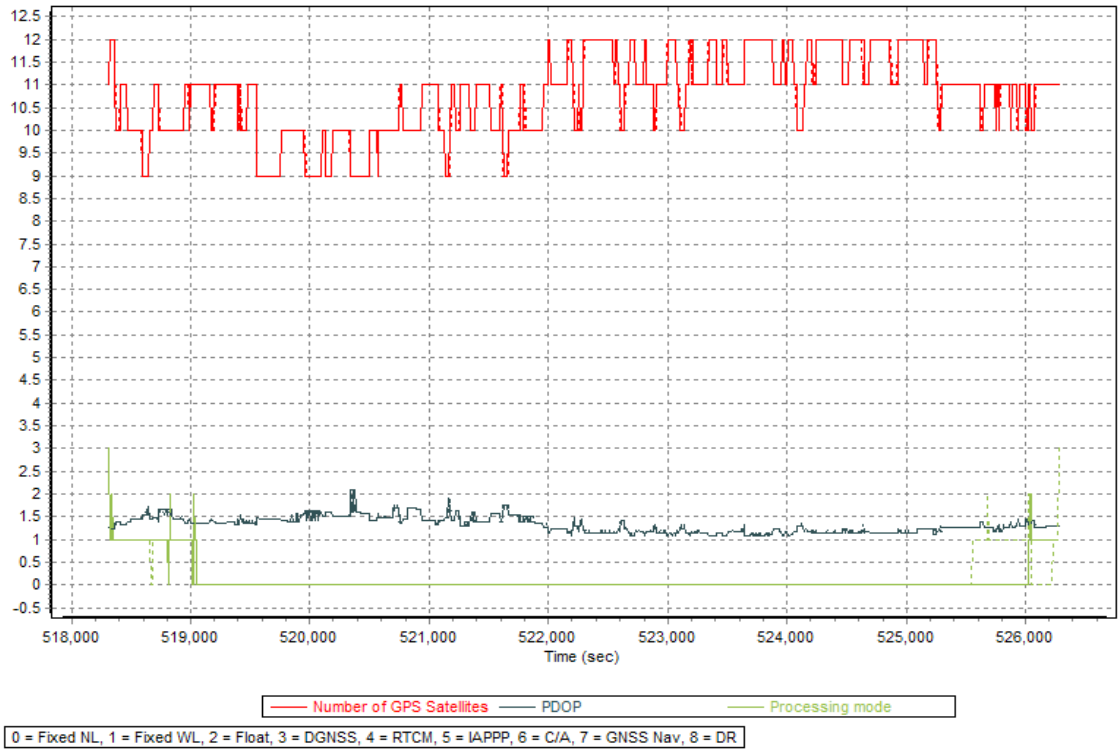


Figure 1.3.1. Solution Status

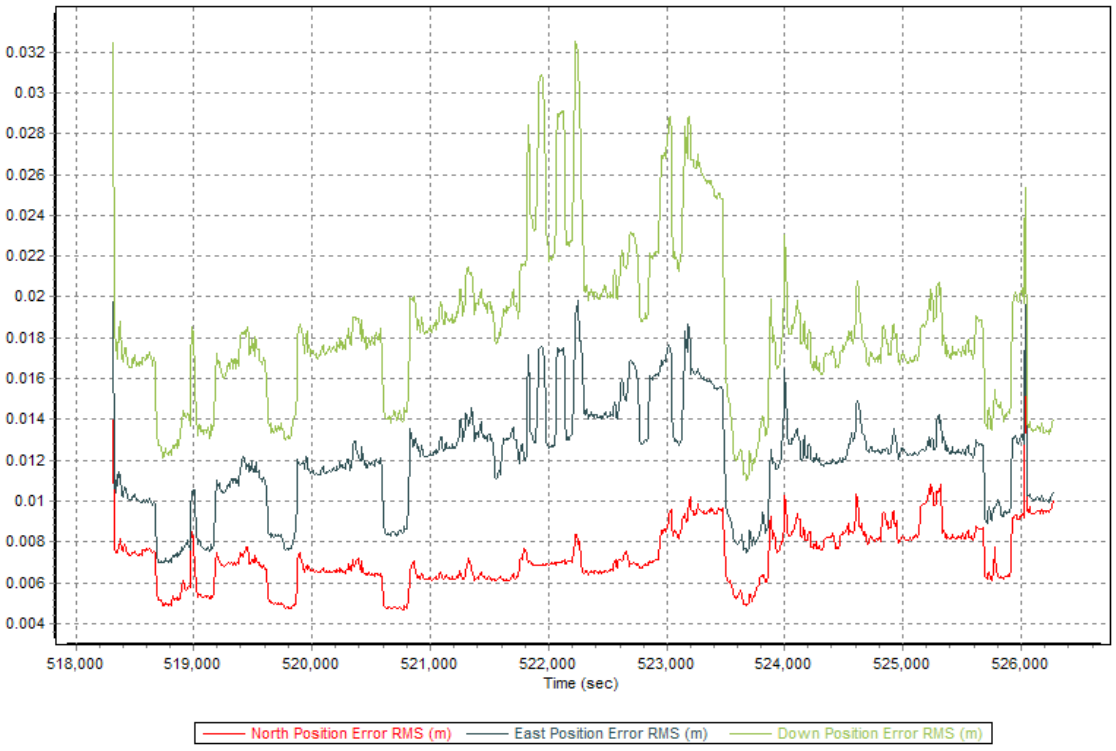


Figure 1.3.2. Smoothed Performance Metrics Parameters

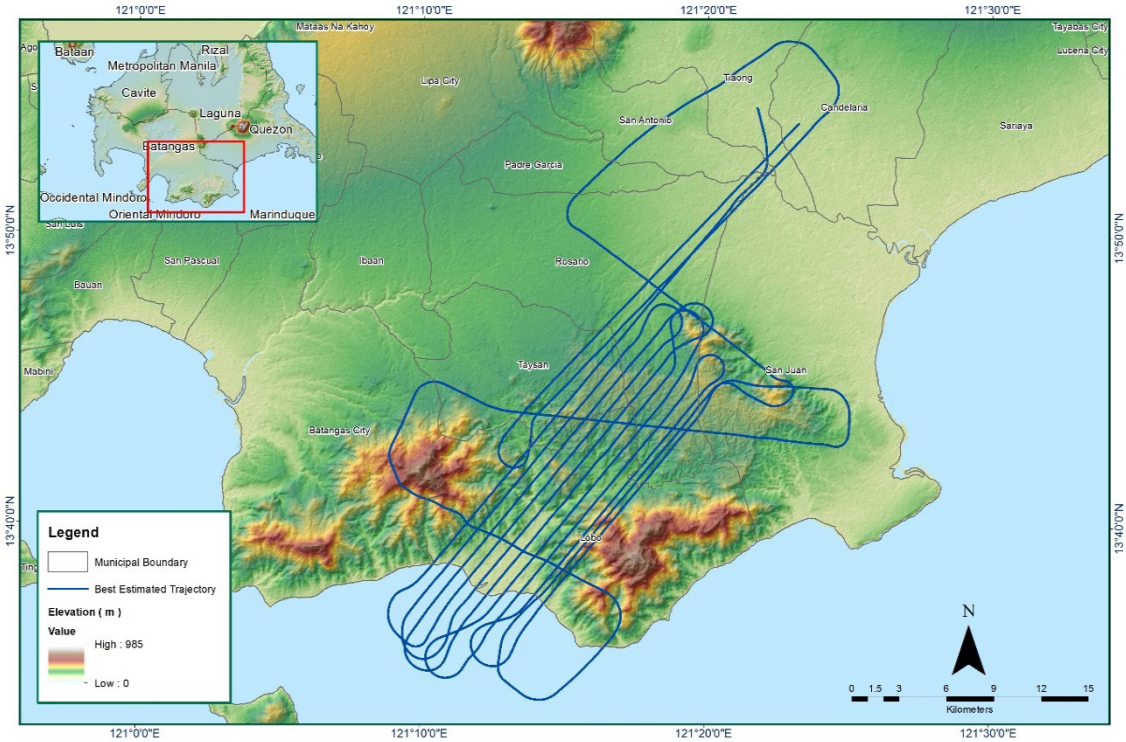


Figure 1.3.3. Best Estimated Trajectory

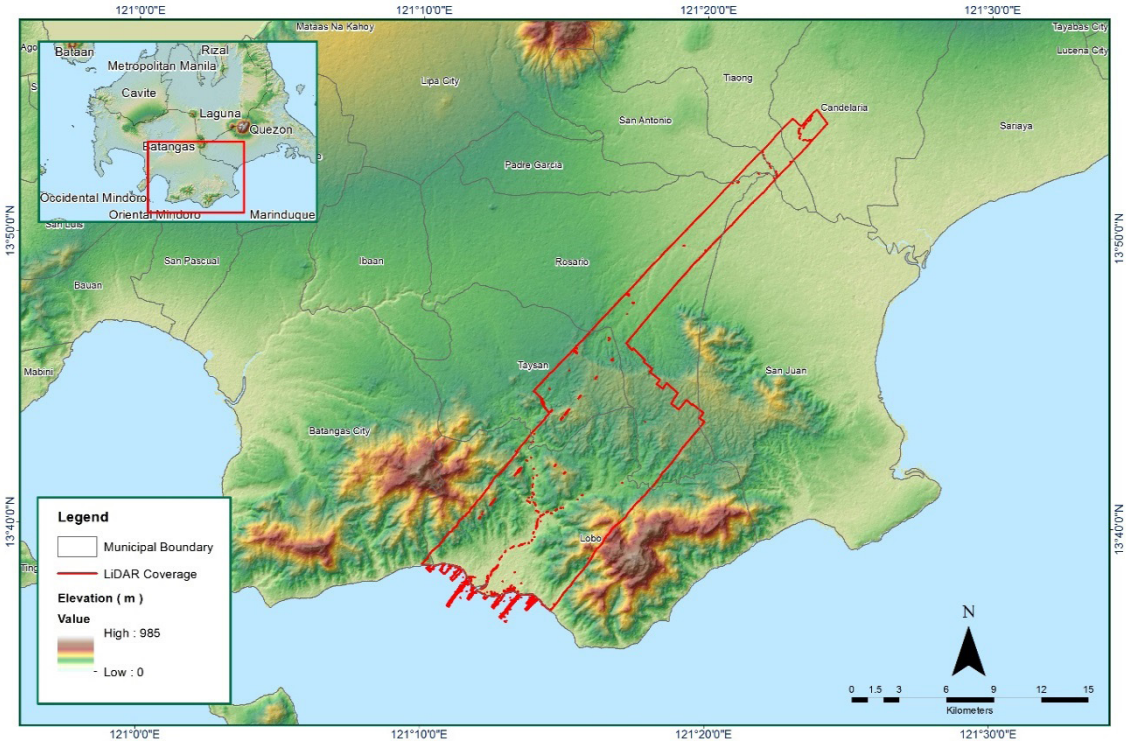


Figure 1.3.4. Coverage of LiDAR data

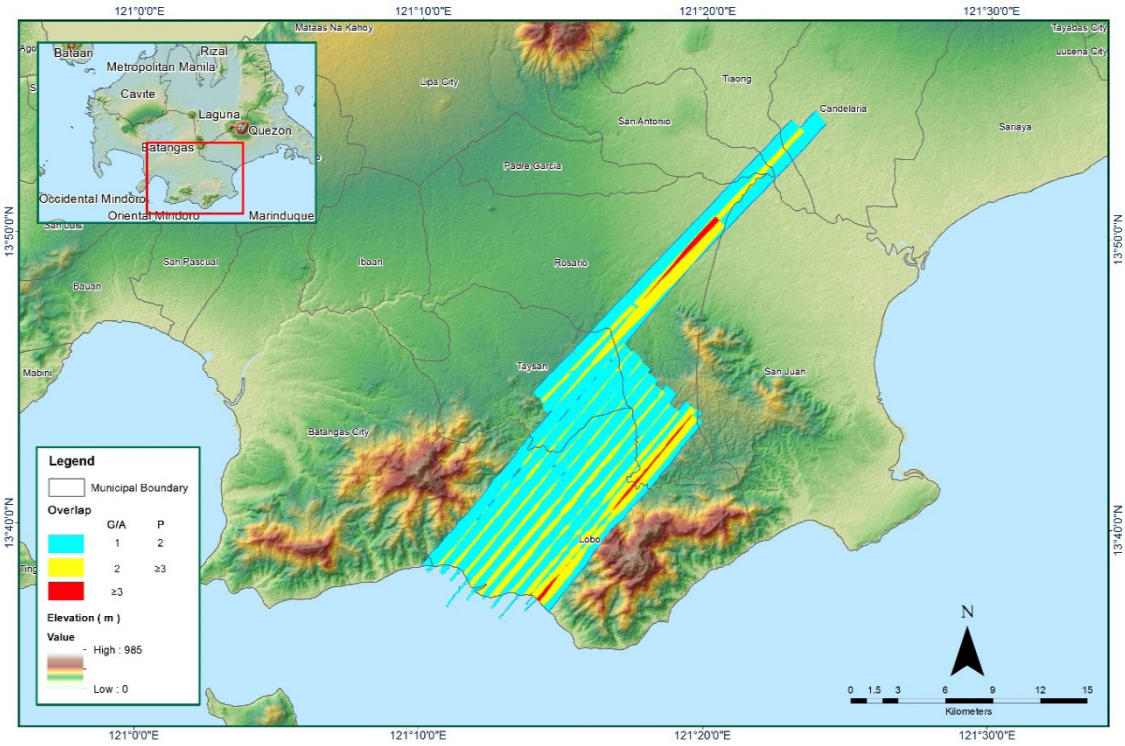


Figure 1.3.5. Image of data overlap

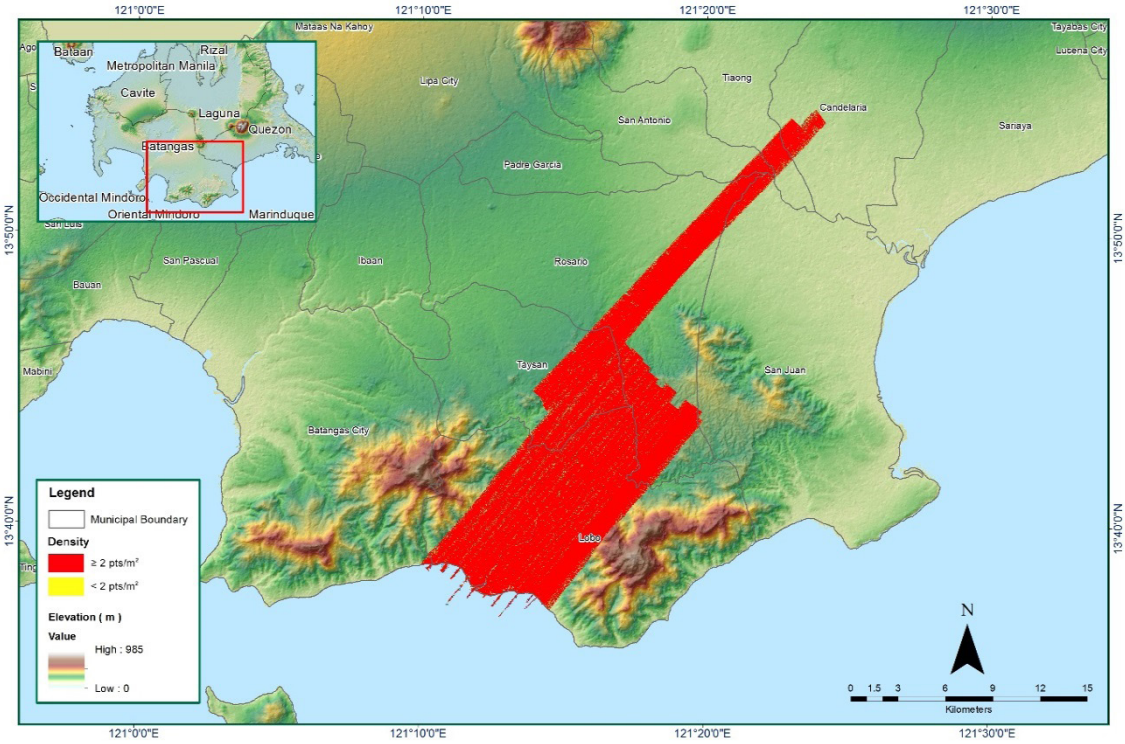


Figure 1.3.6. Density map of merged LiDAR data

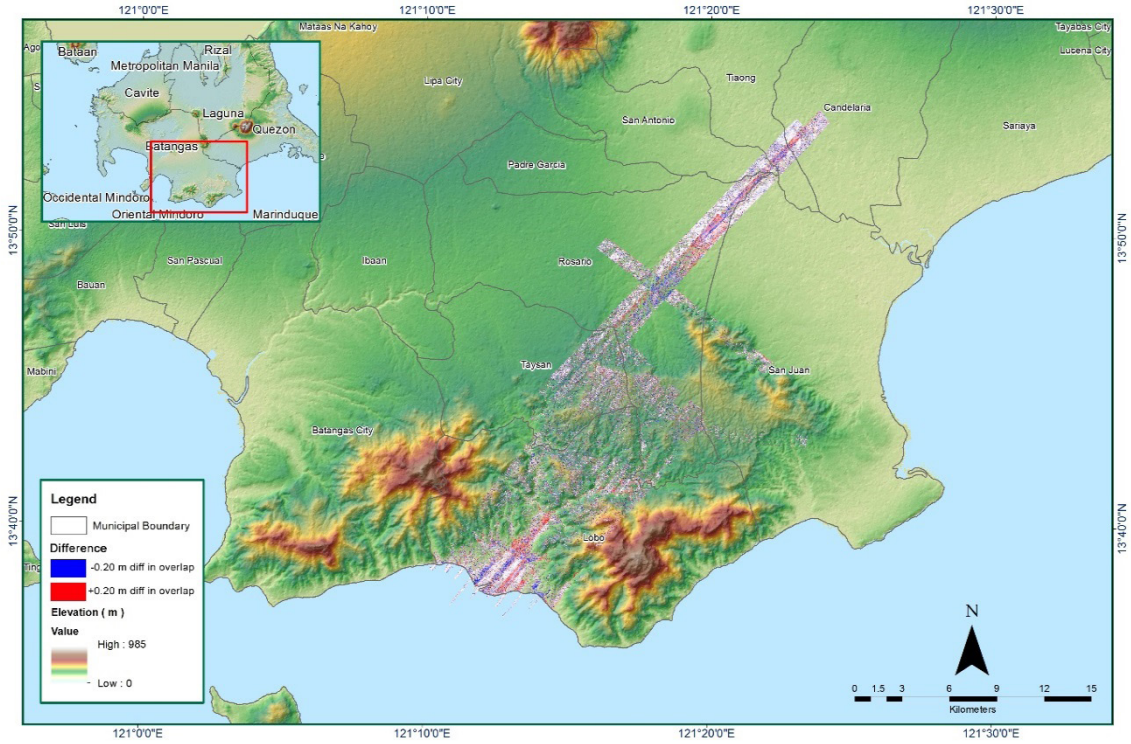


Figure 1.3.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18W_additional**
Inclusive Flights	3345P, 3347P
Range data size	32.35 GB
POS	329 MB
Image	N/A
Transfer date	9/8/2015
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)	1.7
RMSE for Down Position (<8.0 cm)	2.8
Boresight correction stdev (<0.001deg)	0.000210
IMU attitude correction stdev (<0.001deg)	0.000571
GPS position stdev (<0.01m)	0.0017
Minimum % overlap (>25)	51.19%
Ave point cloud density per sq.m. (>2.0)	3.19
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	310
Maximum Height	559.57 m
Minimum Height	59.37 m
Classification (# of points)	
Ground	255,896,595
Low vegetation	250,448,090
Medium vegetation	363,614,645
High vegetation	276,078,698
Building	39,501,449
Orthophoto	No
Processed by	Engr. Sheila-Maye Santillan, Engr. Chelou Prado, Engr. Melissa Fernandez

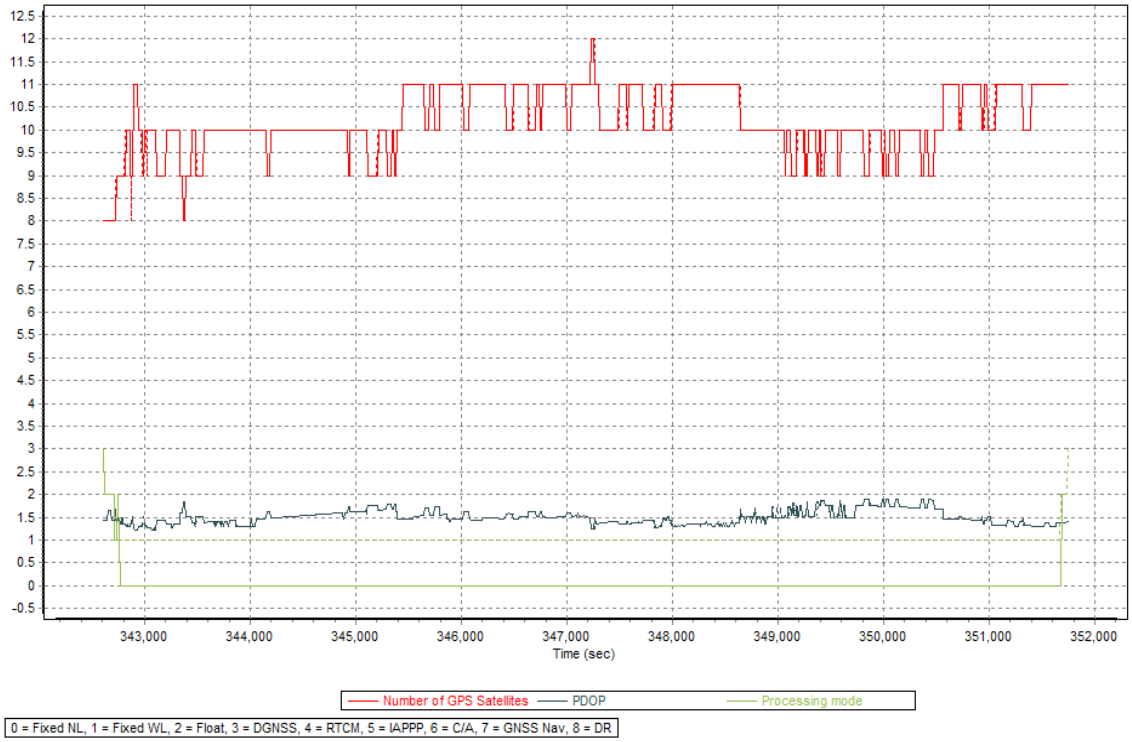


Figure 1.4.1. Solution Status

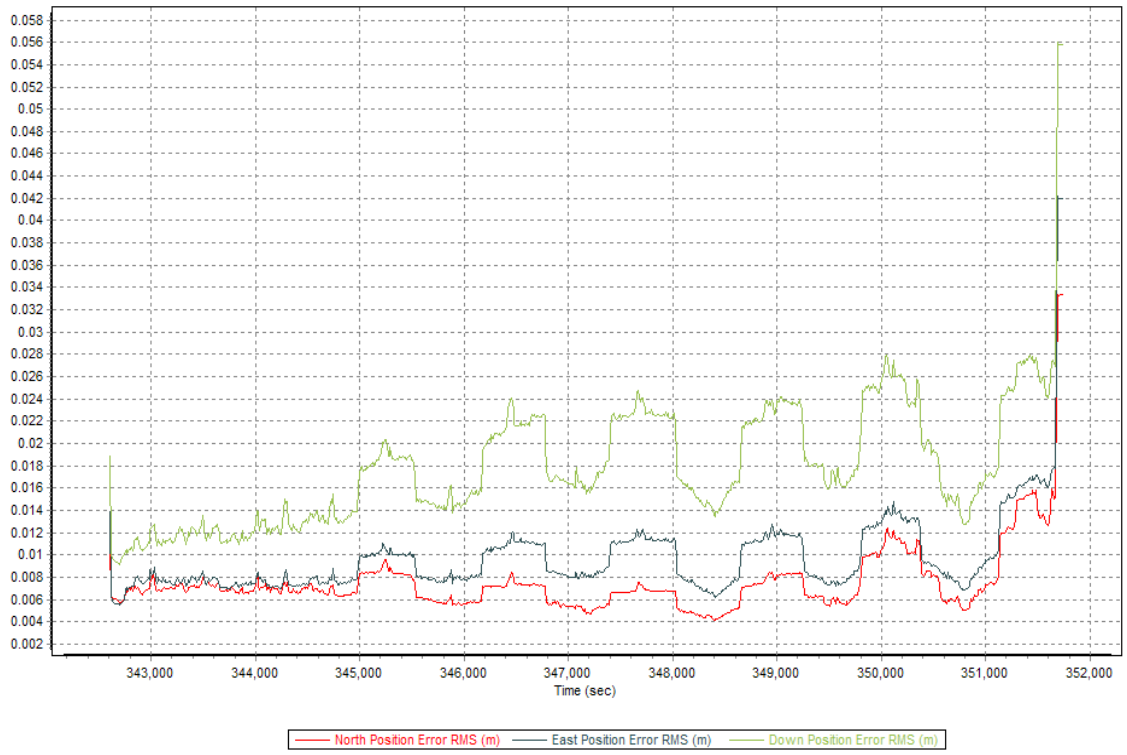


Figure 1.4.2. Smoothed Performance Metrics Parameters

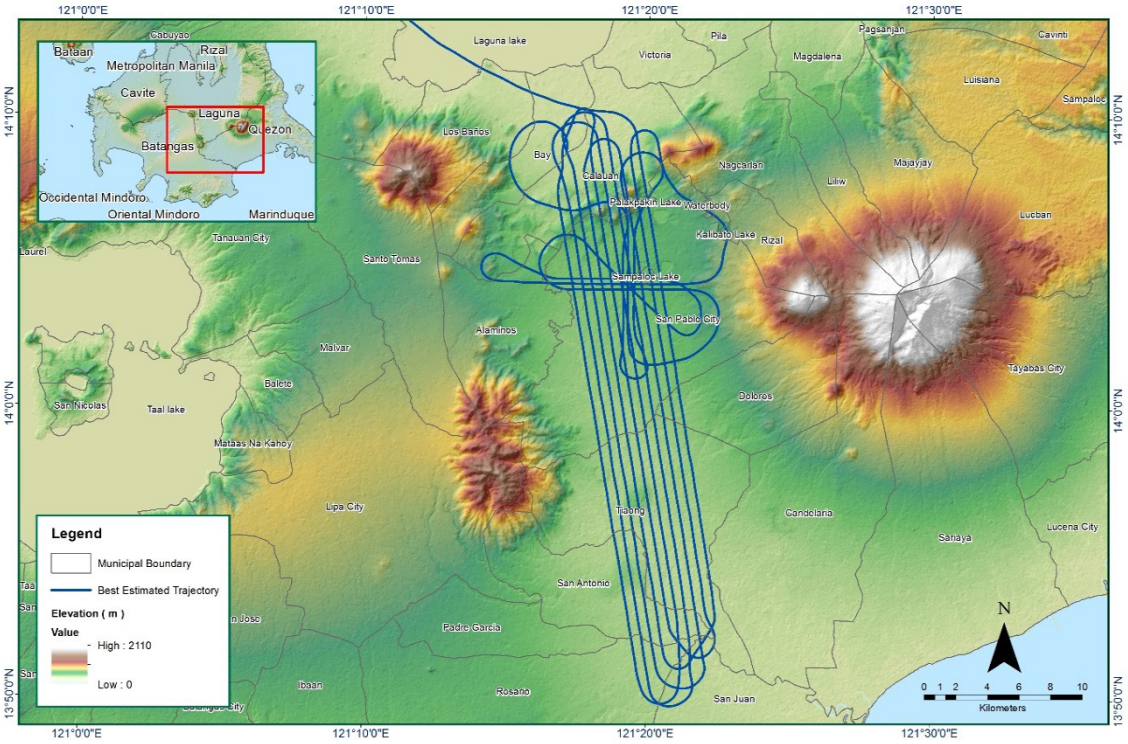


Figure 1.4.3. Best Estimated Trajectory

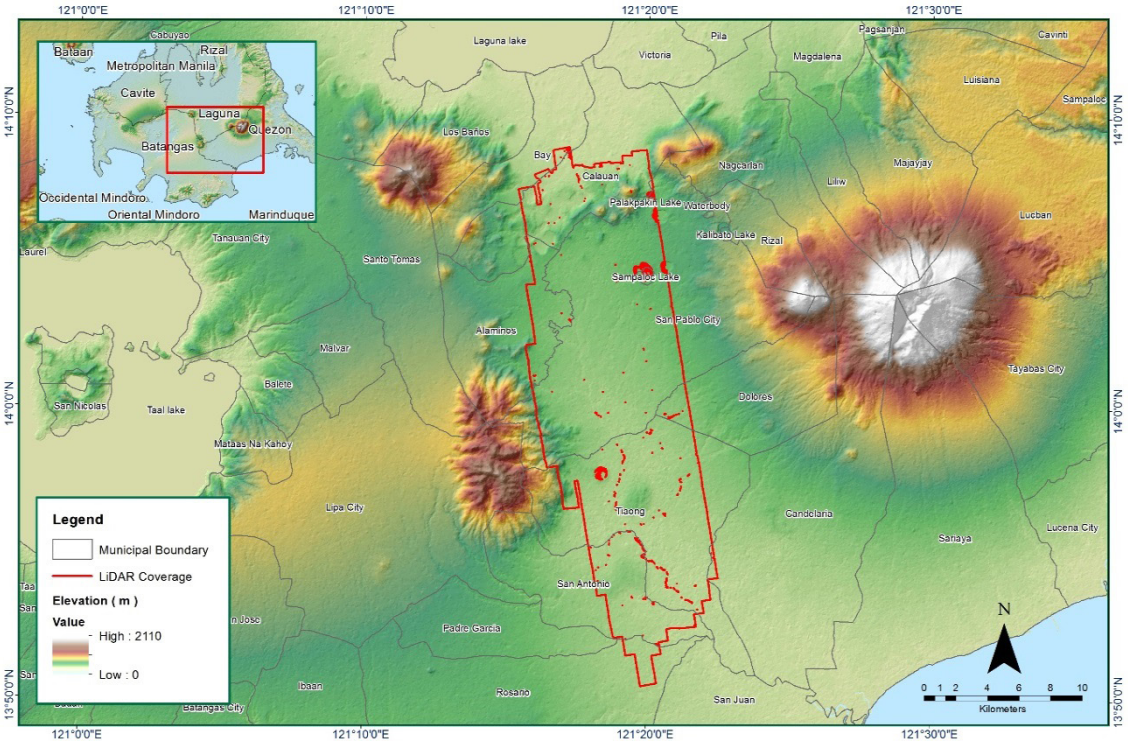


Figure 1.4.4. Coverage of LiDAR data

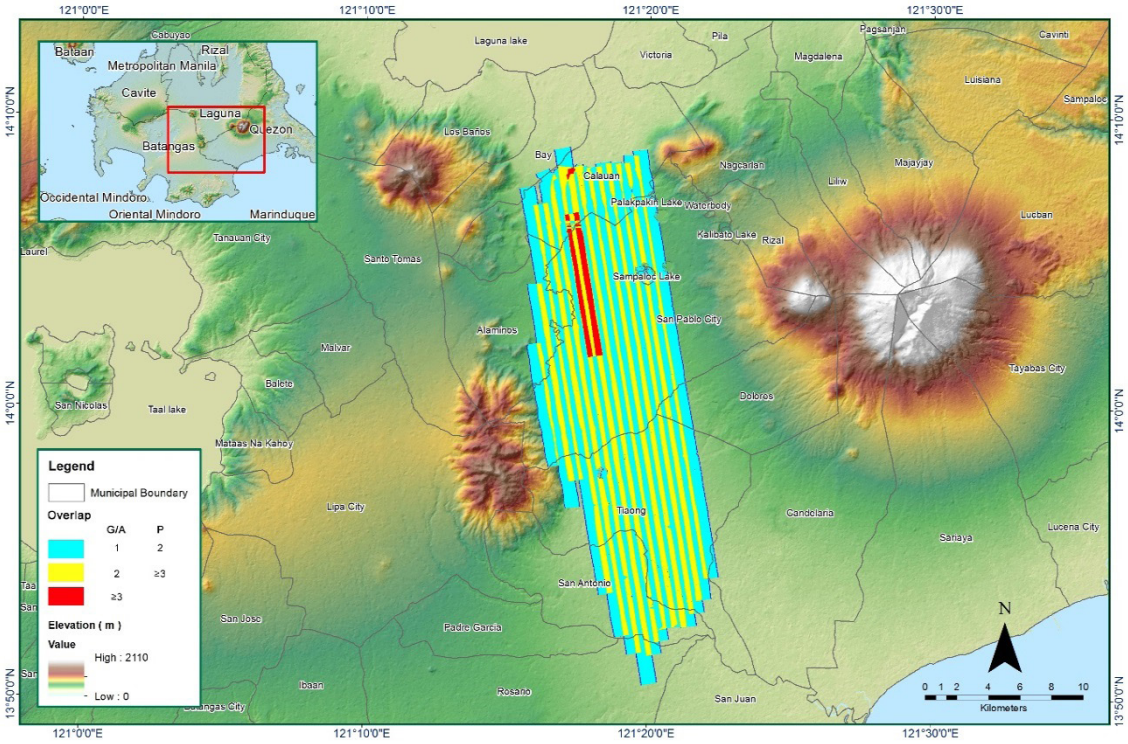


Figure 1.4.5. Image of data overlap

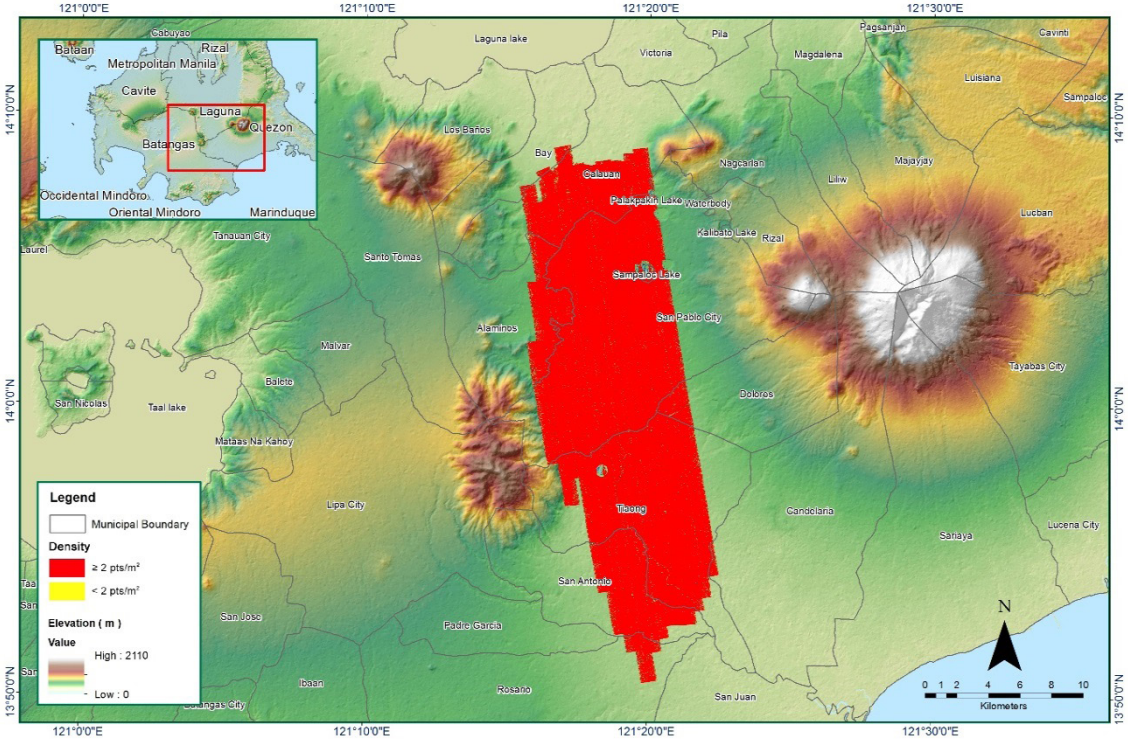


Figure 1.4.6. Density map of merged LiDAR data

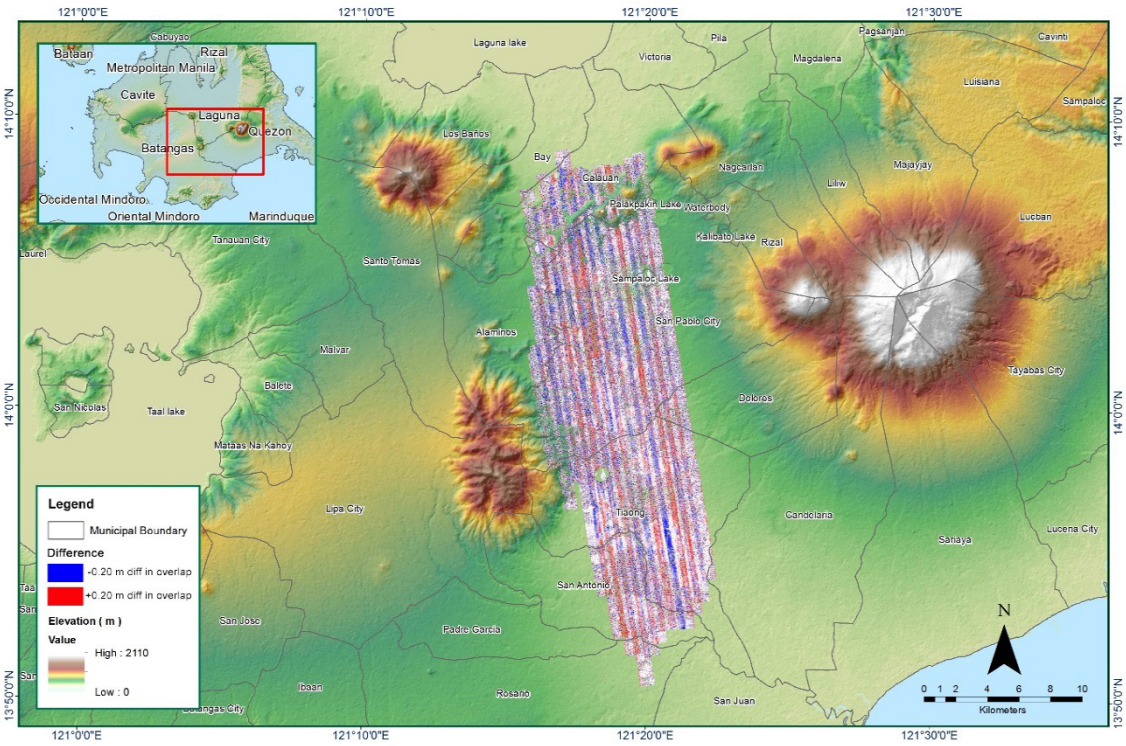


Figure 1.4.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18T**
Inclusive Flights	1105P
Range data size	22.2 GB
POS	219 MB
Image	N/A
Transfer date	04/23/2014
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)	1.7
RMSE for East Position (<4.0 cm)	1.7
RMSE for Down Position (<8.0 cm)	4.0
Boresight correction stdev (<0.001deg)	0.000443
IMU attitude correction stdev (<0.001deg)	0.001044
GPS position stdev (<0.01m)	0.0025
Minimum % overlap (>25)	33.79%
Ave point cloud density per sq.m. (>2.0)	2.05
Elevation difference between strips (<0.20 m)	Yess
Number of 1km x 1km blocks	339
Maximum Height	517.47 m
Minimum Height	48.70 m
Classification (# of points)	
Ground	196,485,951
Low vegetation	185,130,359
Medium vegetation	161,015,365
High vegetation	284,515,283
Building	11,560,170
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Celina Rosete, Engr. Jeffrey Delica

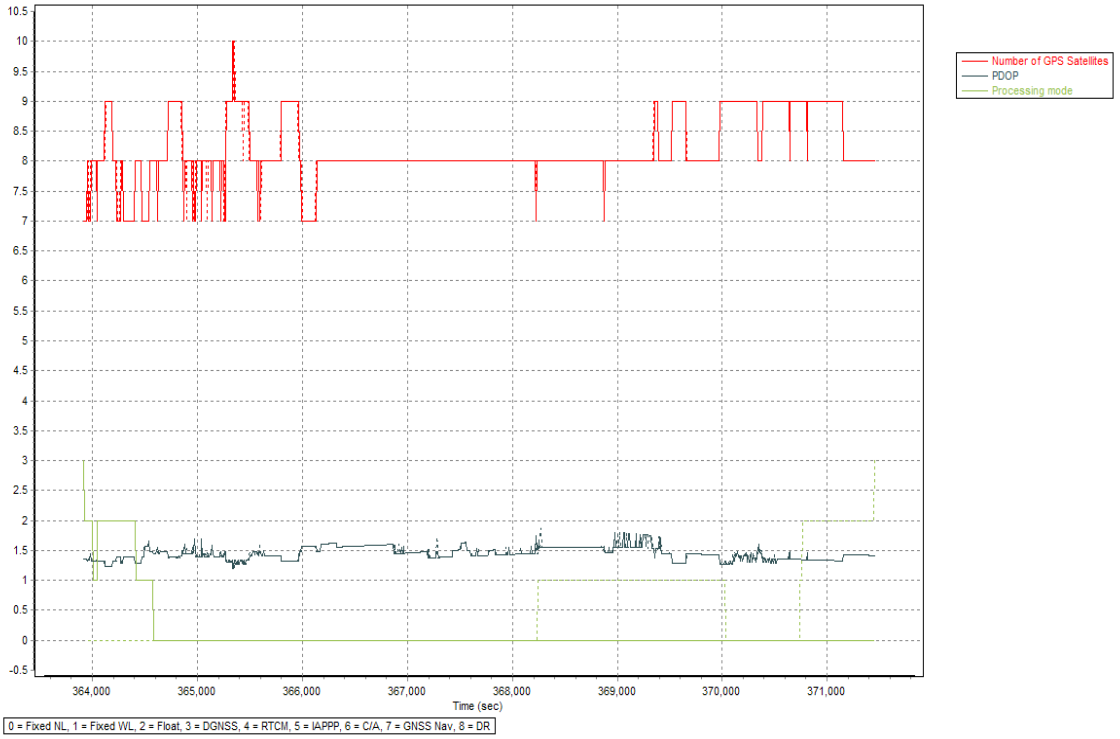


Figure 1.5.1. Solution Status

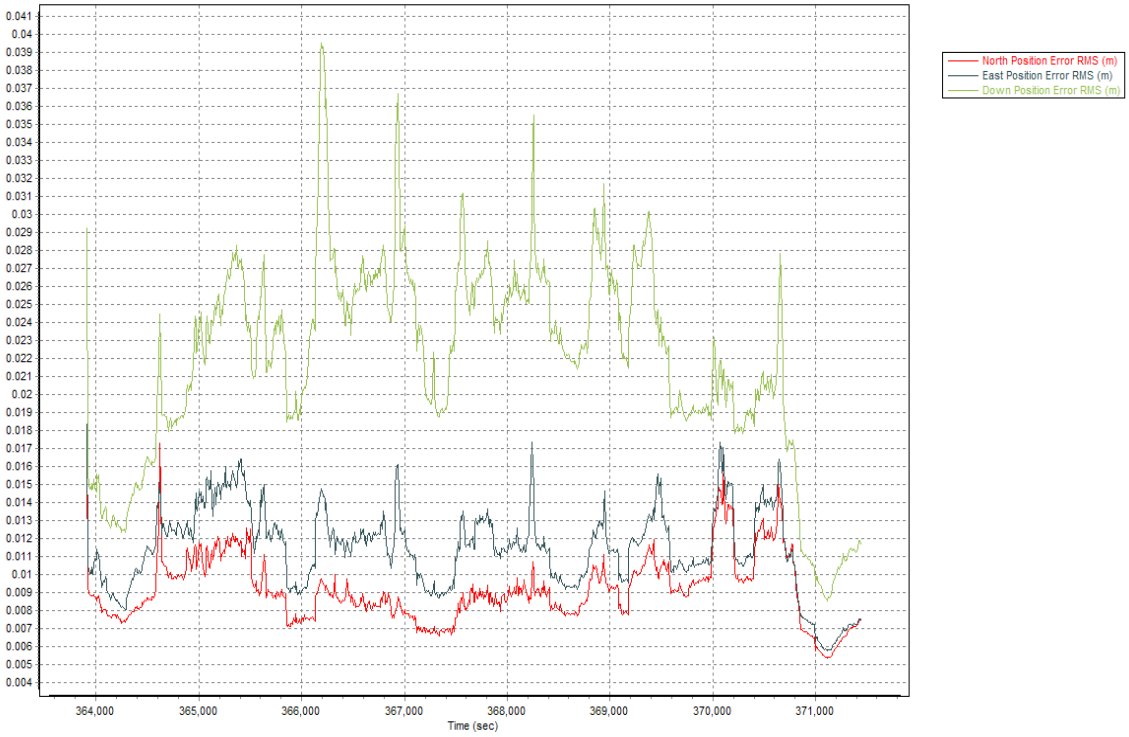


Figure 1.5.2. Smoothed Performance Metrics Parameters

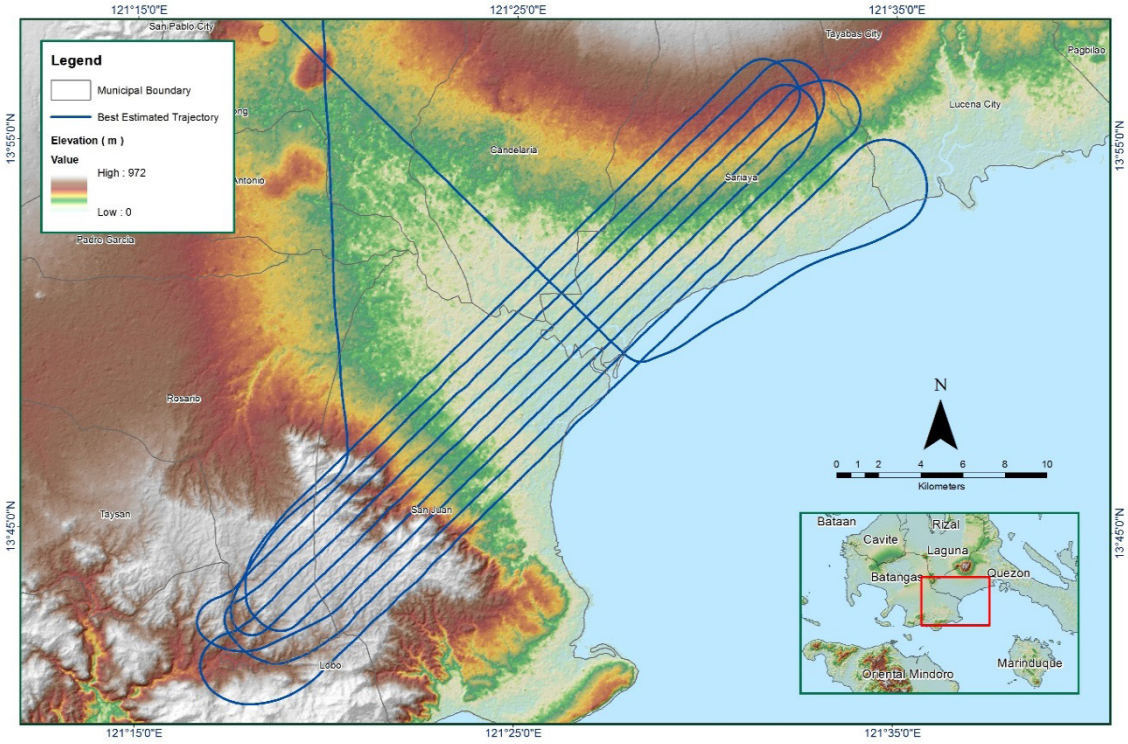


Figure 1.5.3. Best Estimated Trajectory

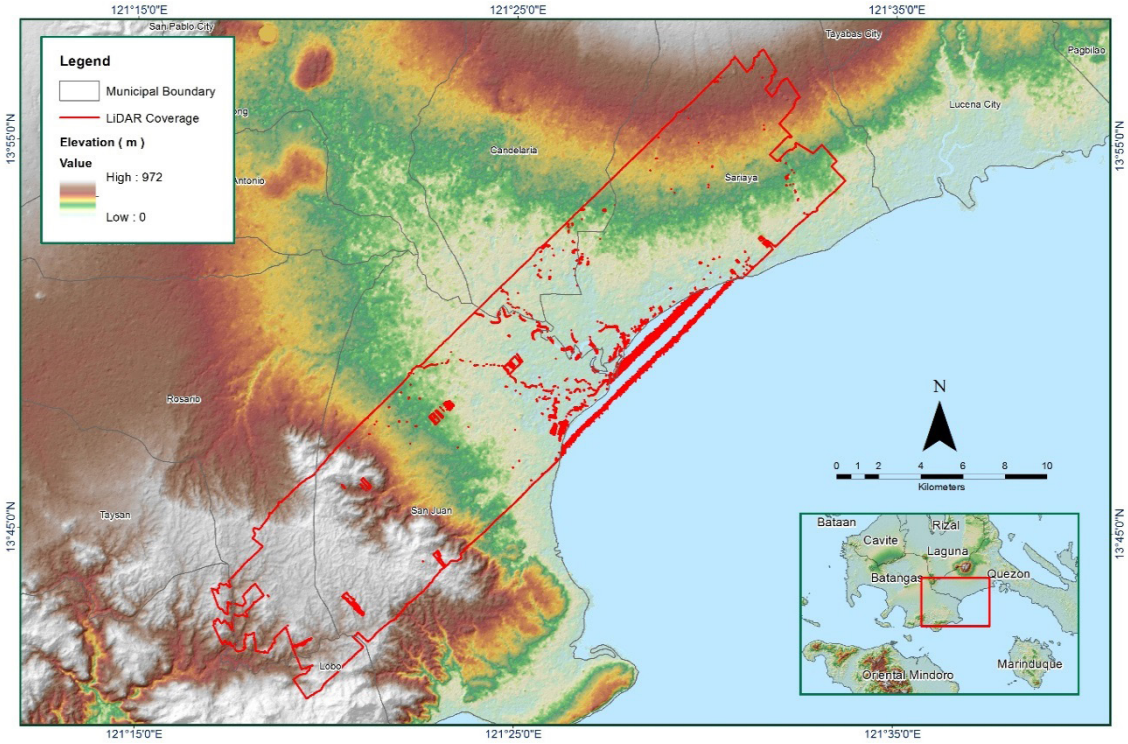


Figure 1.5.4. Coverage of LiDAR data

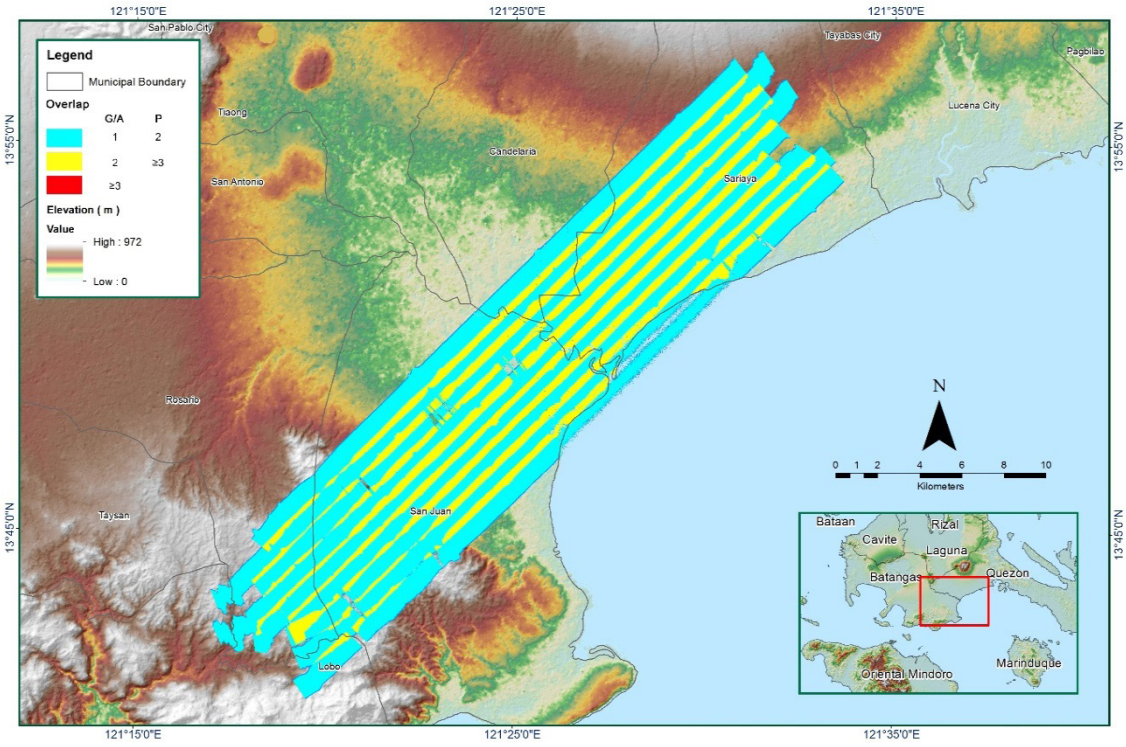


Figure 1.5.5. Image of data overlap

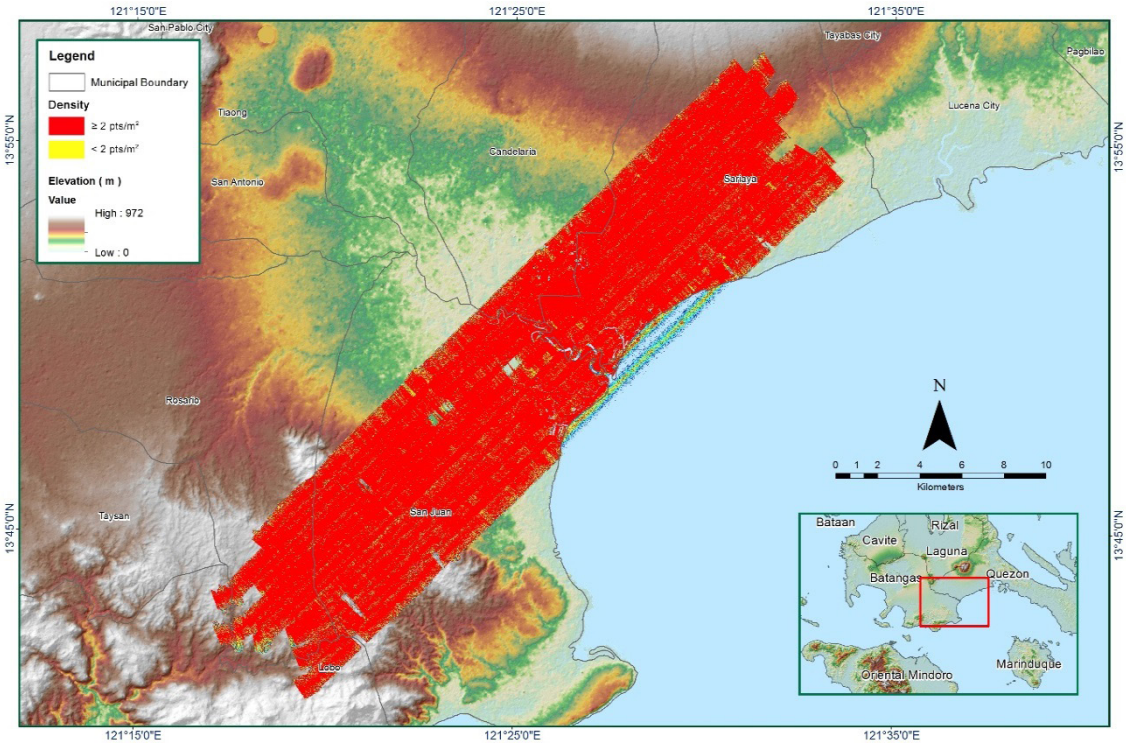


Figure 1.5.6. Density map of merged LiDAR data

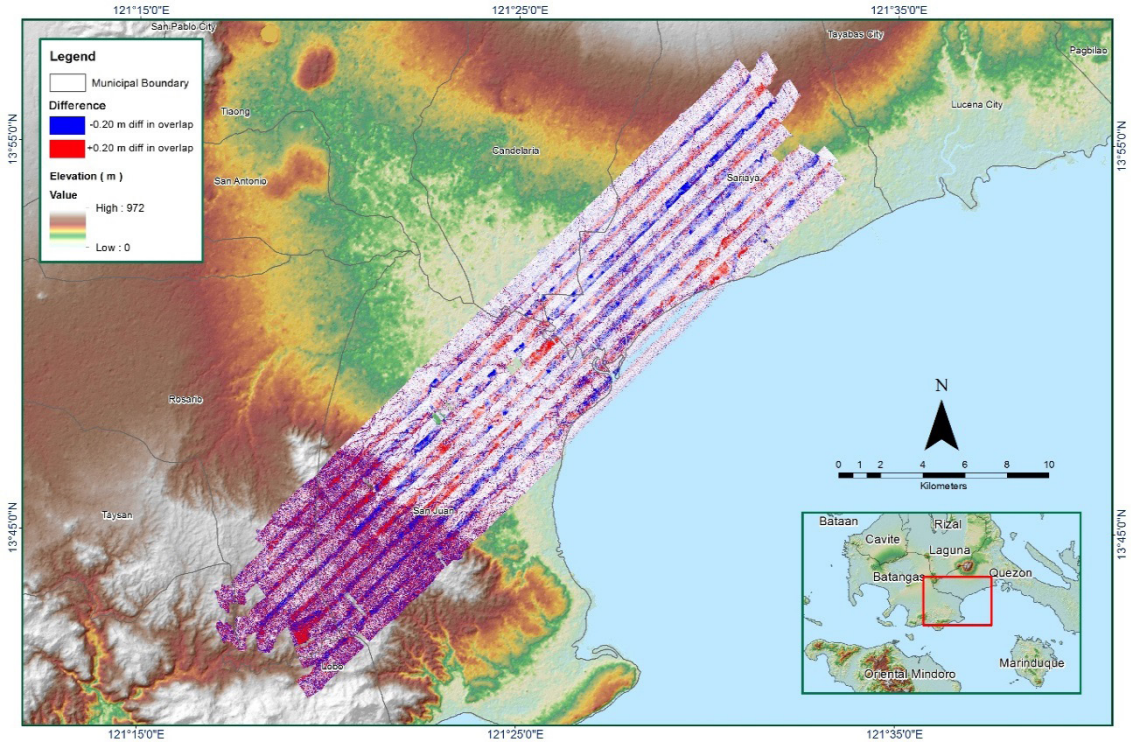


Figure 1.5.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18U_supplement**
Inclusive Flights	1109P
Range data size	15.9 GB
POS	183 MB
Image	N/A
Transfer date	04/23/2014
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)	1.4
RMSE for East Position (<4.0 cm)	2.2
RMSE for Down Position (<8.0 cm)	4.0
Boresight correction stdev (<0.001deg)	0.000377
IMU attitude correction stdev (<0.001deg)	0.000547
GPS position stdev (<0.01m)	0.0016
Minimum % overlap (>25)	32.26%
Ave point cloud density per sq.m. (>2.0)	1.93
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	245
Maximum Height	504.30 m
Minimum Height	49.31 m
Classification (# of points)	
Ground	137,187,219
Low vegetation	134,794,804
Medium vegetation	120,998,488
High vegetation	169,074,924
Building	9,822,052
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Engr. Abigail Joy Ching, Engr. Harmond Santos, Jovy Ann Narisma

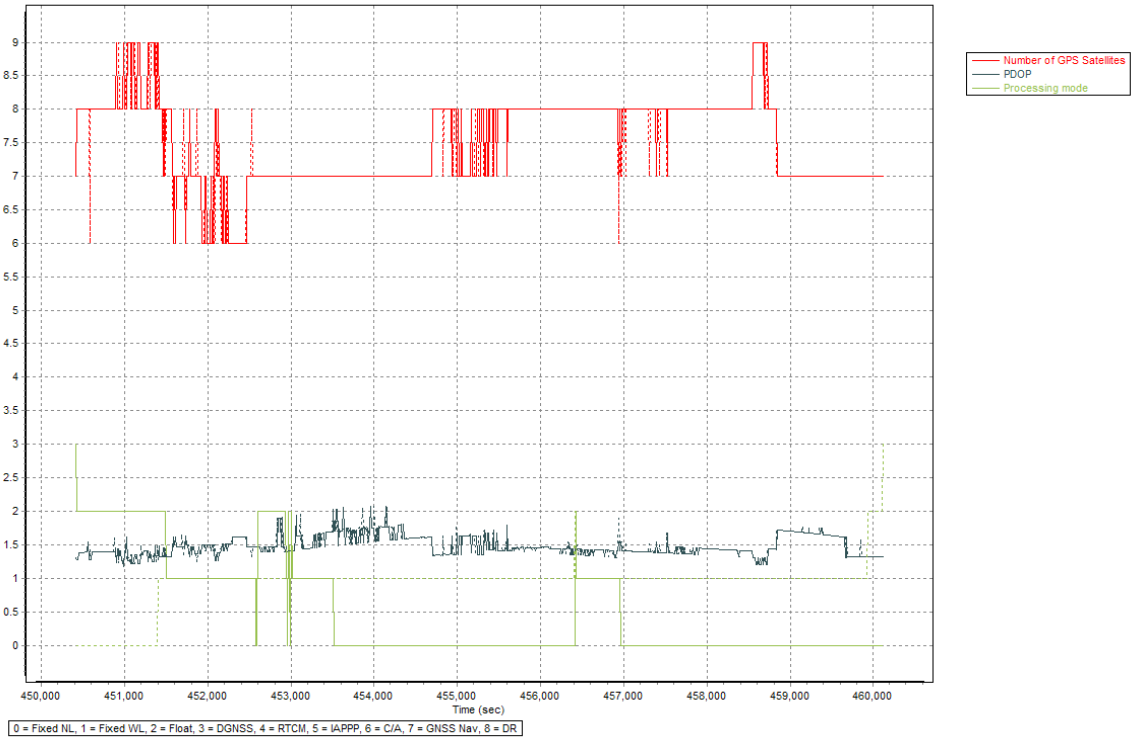


Figure 1.6.1. Solution Status

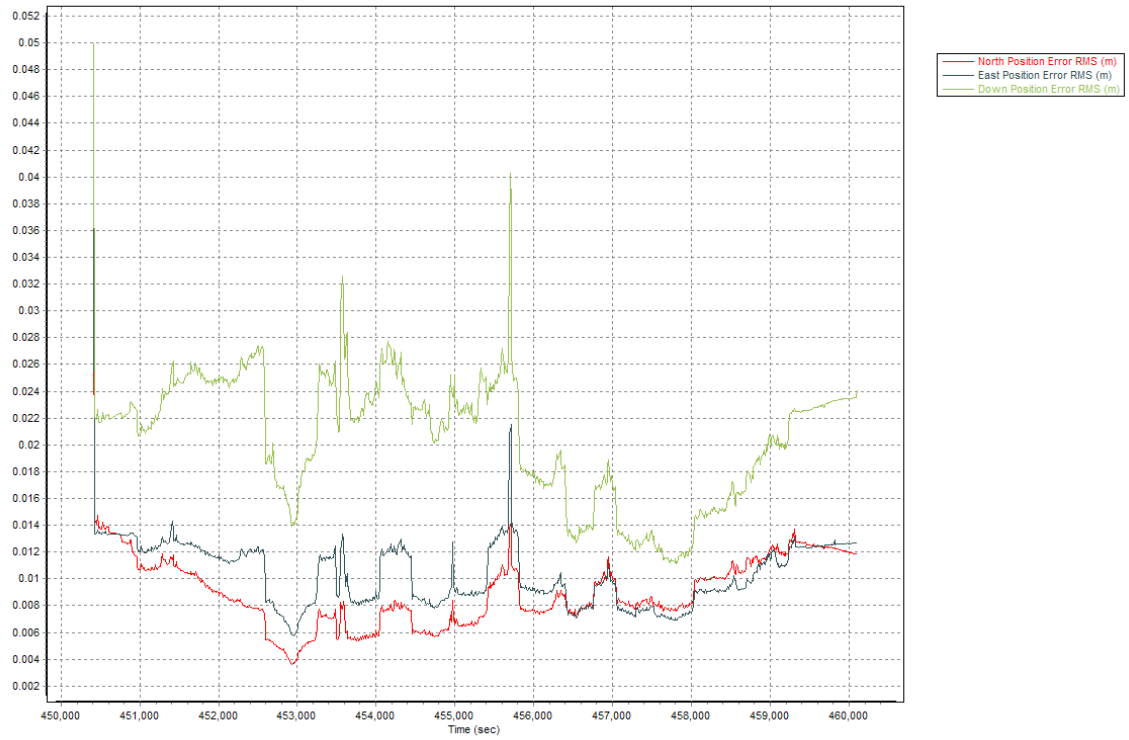


Figure 1.6.2. Smoothed Performance Metrics Parameters

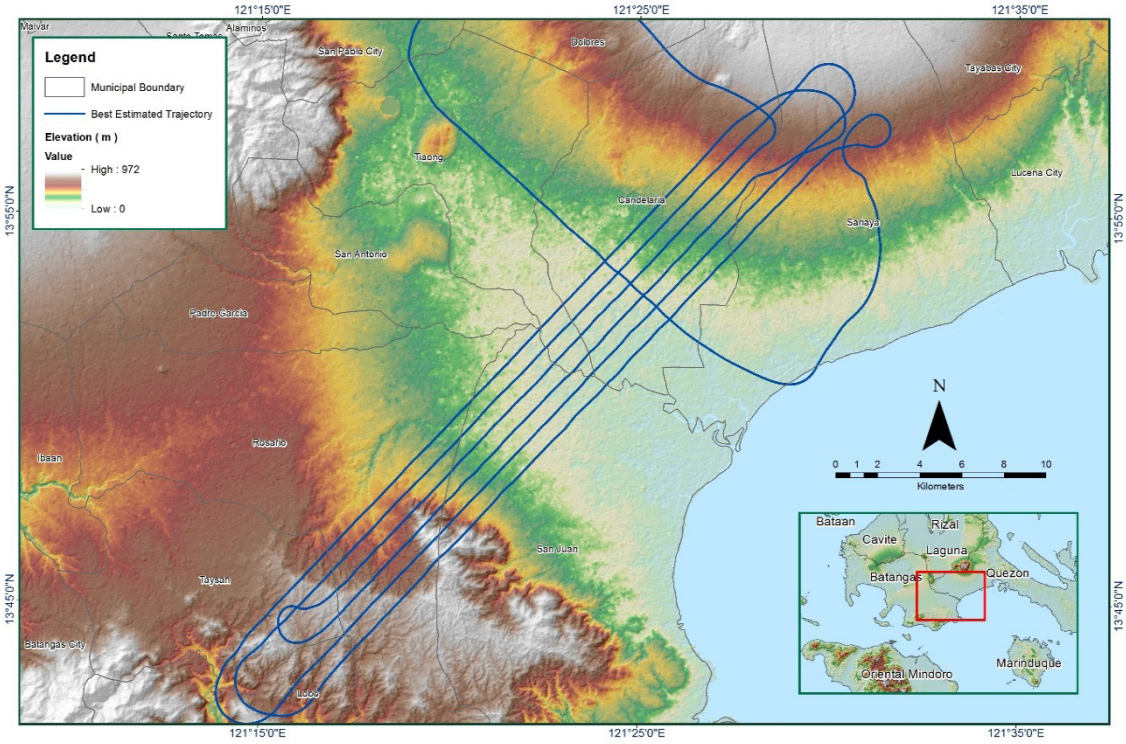


Figure 1.6.3. Best Estimated Trajectory

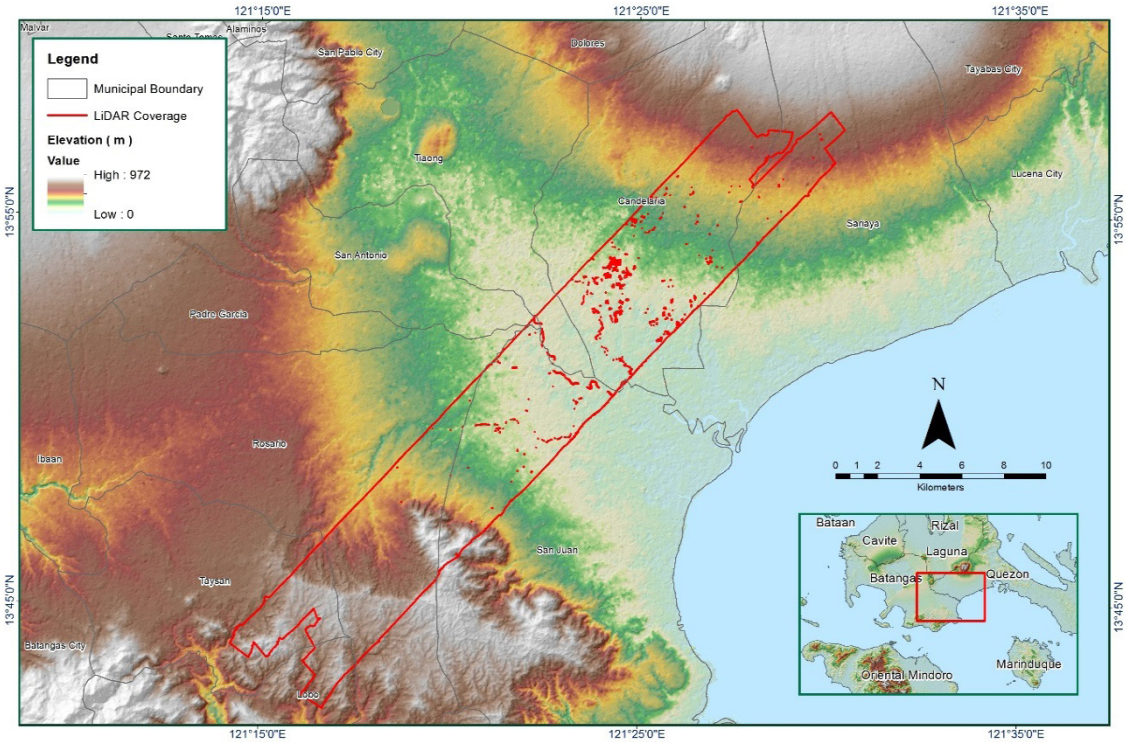


Figure 1.6.4. Coverage of LiDAR data

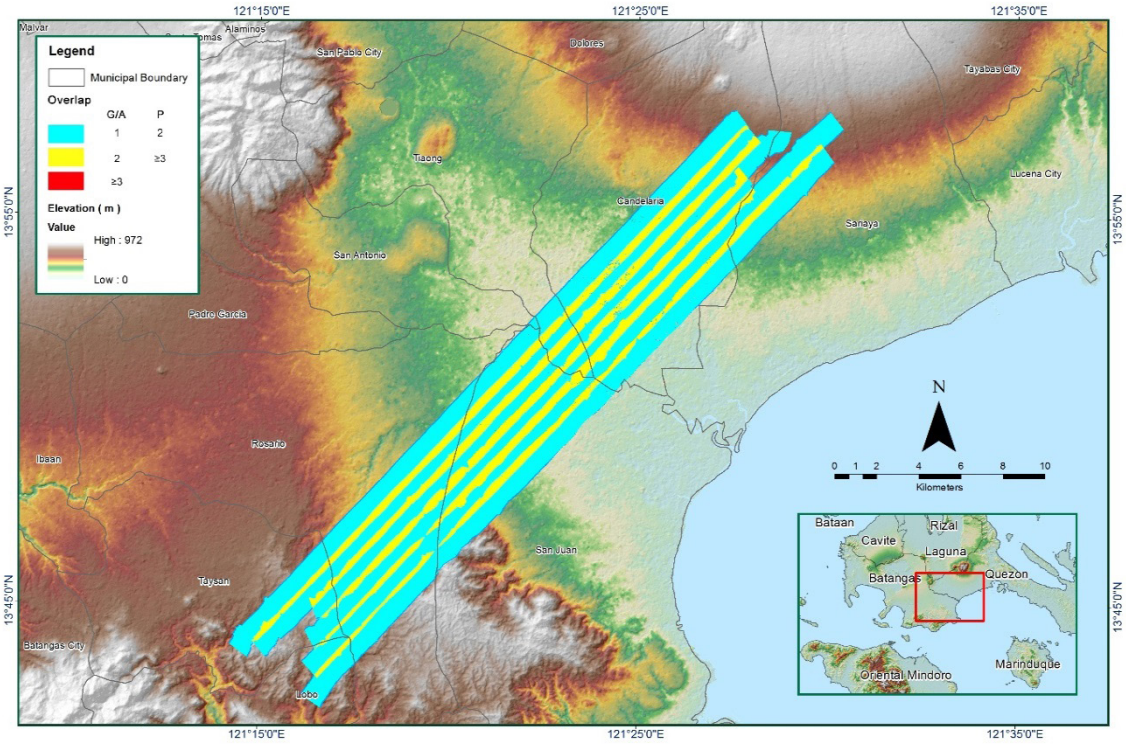


Figure 1.6.5. Image of data overlap

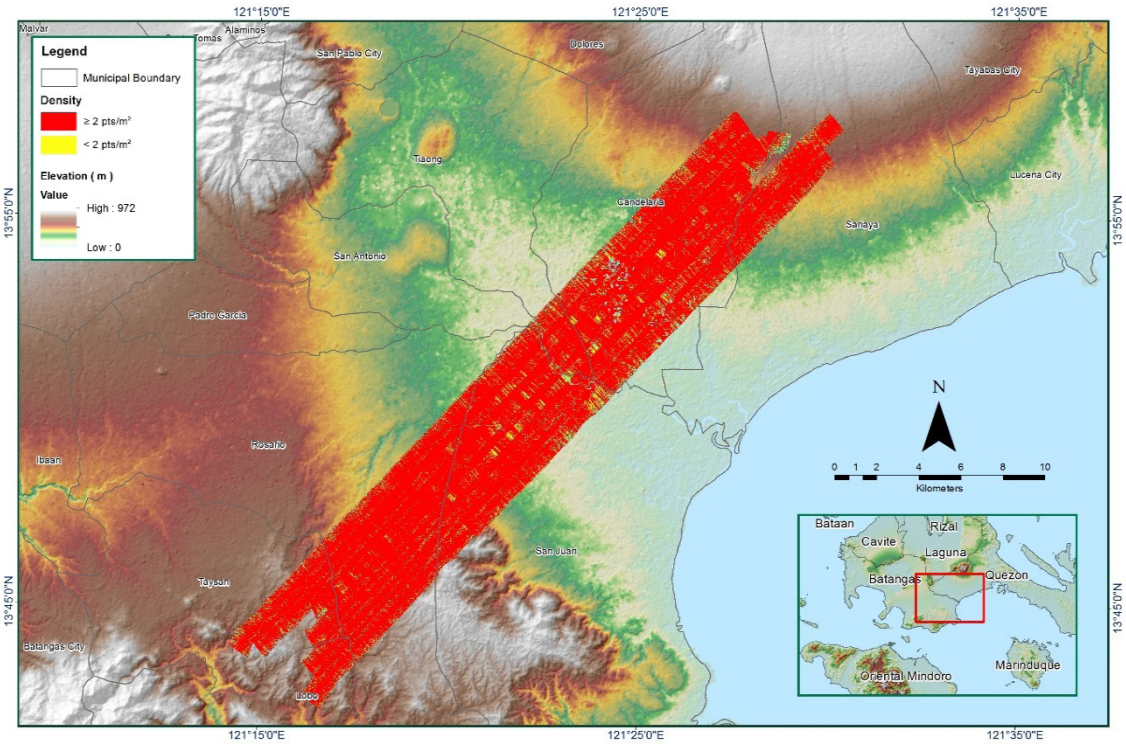


Figure 1.6.6. Density map of merged LiDAR data

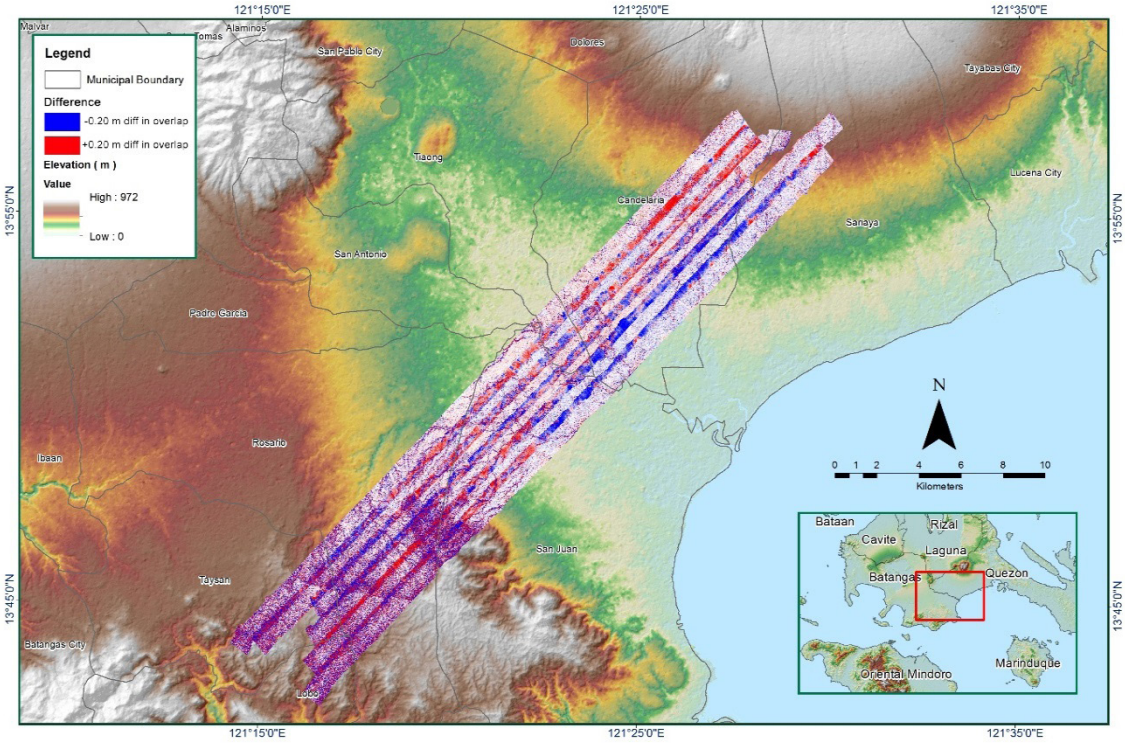


Figure 1.6.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18U**
Inclusive Flights	1095P; 1099P
Range data size	35.6 GB
POS	469 MB
Image	96.9 MB
Transfer date	04/23/2014
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)	1.6
RMSE for East Position (<4.0 cm)	2.7
RMSE for Down Position (<8.0 cm)	4.5
Boresight correction stdev (<0.001deg)	0.000440
IMU attitude correction stdev (<0.001deg)	0.001048
GPS position stdev (<0.01m)	0.0020
Minimum % overlap (>25)	28.21%
Ave point cloud density per sq.m. (>2.0)	2.36
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	418
Maximum Height	1240.04 m
Minimum Height	48.96 m
Classification (# of points)	
Ground	210,036,267
Low vegetation	216,673,271
Medium vegetation	165,265,018
High vegetation	231,122,835
Building	15,950,043
Orthophoto	No
Processed by	Victoria Maria Rejuso, Engr. Charmaine Cruz, Jovy Ann Narisma

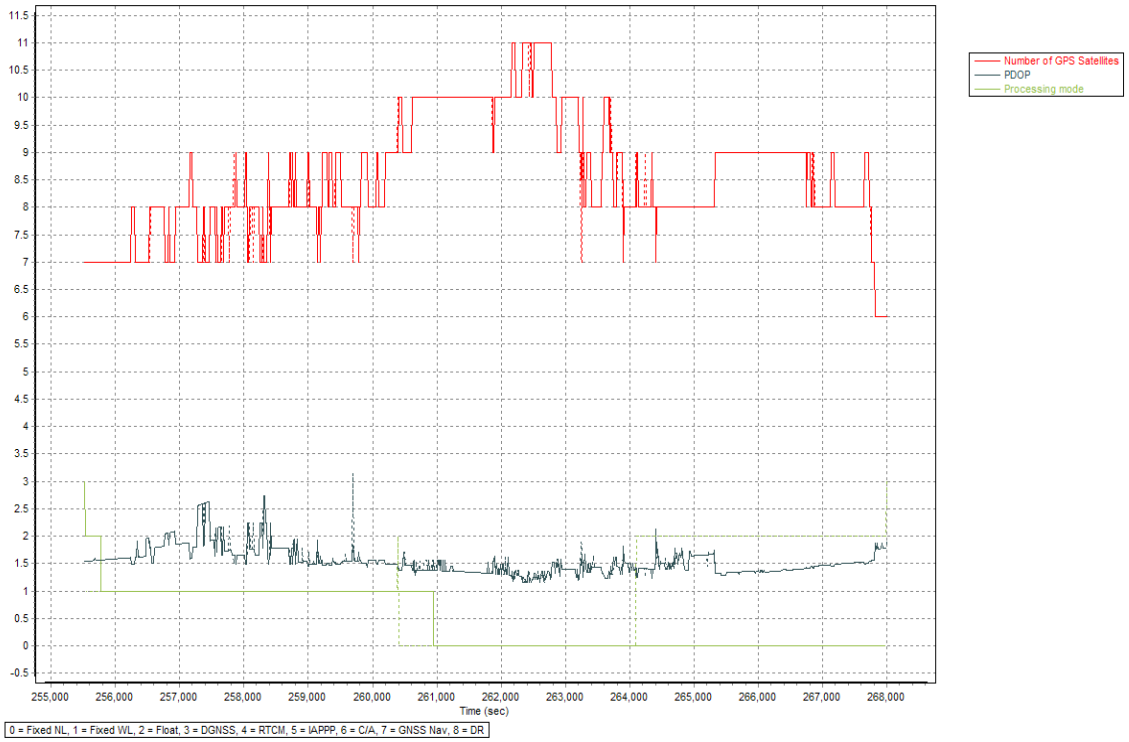


Figure 1.7.1. Solution Status

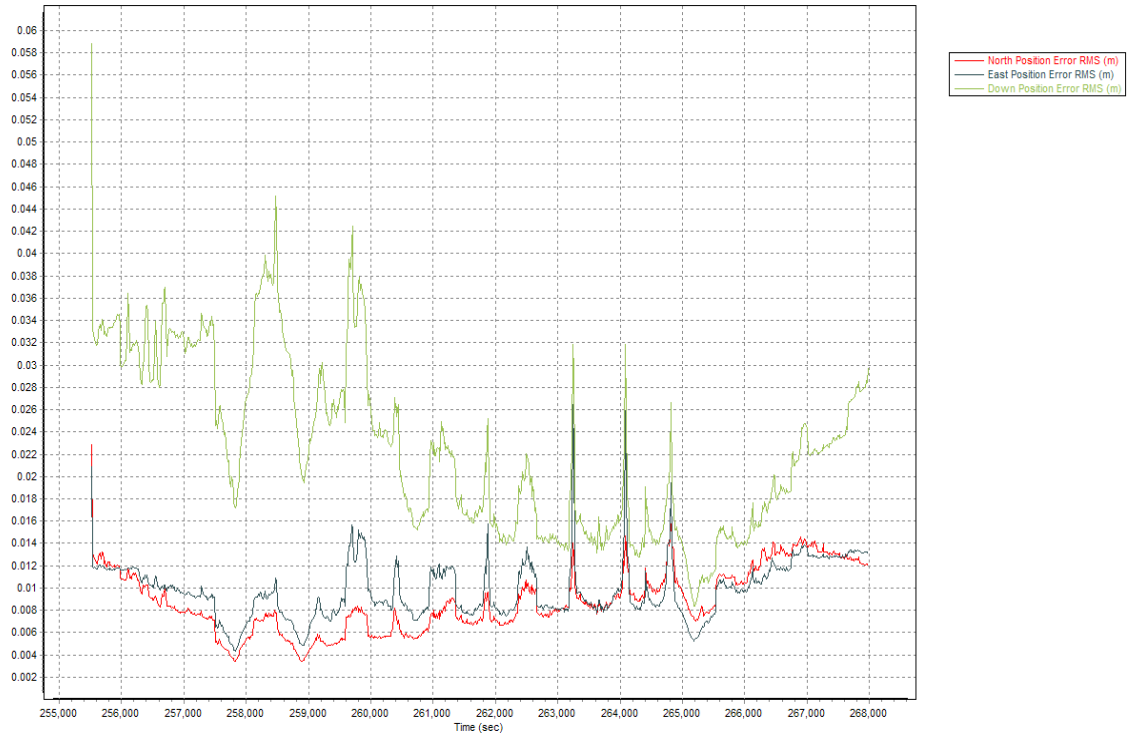


Figure 1.7.2. Smoothed Performance Metrics Parameters

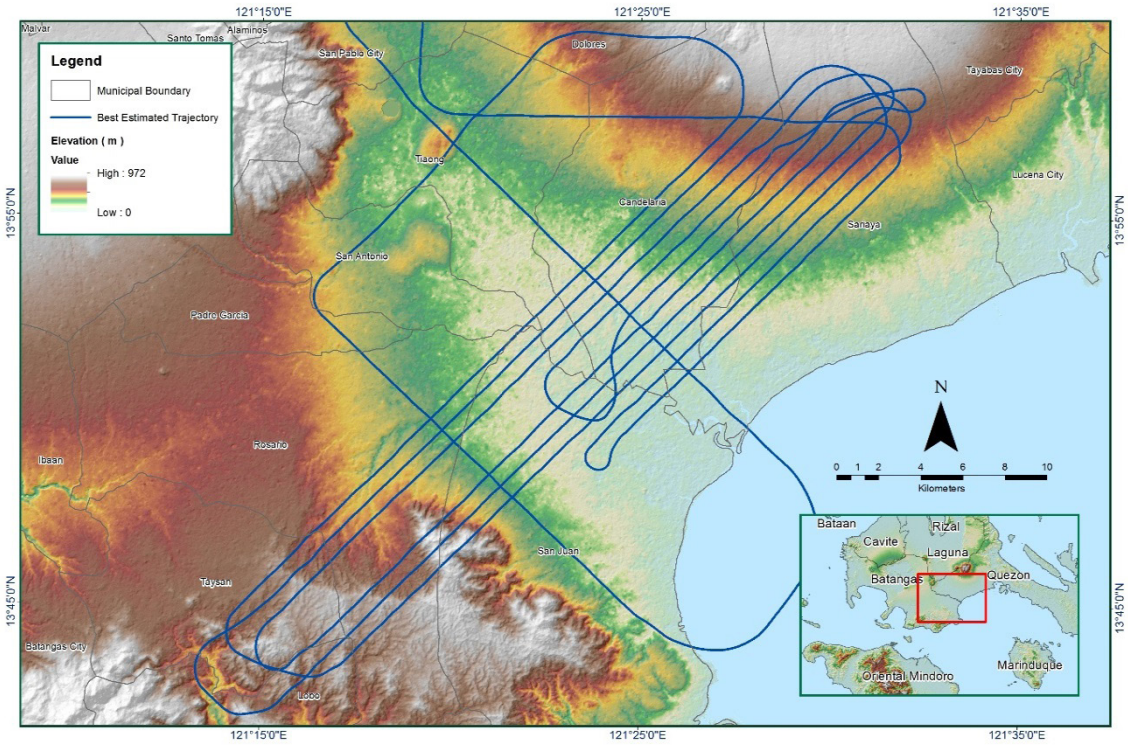


Figure 1.7.3. Best Estimated Trajectory

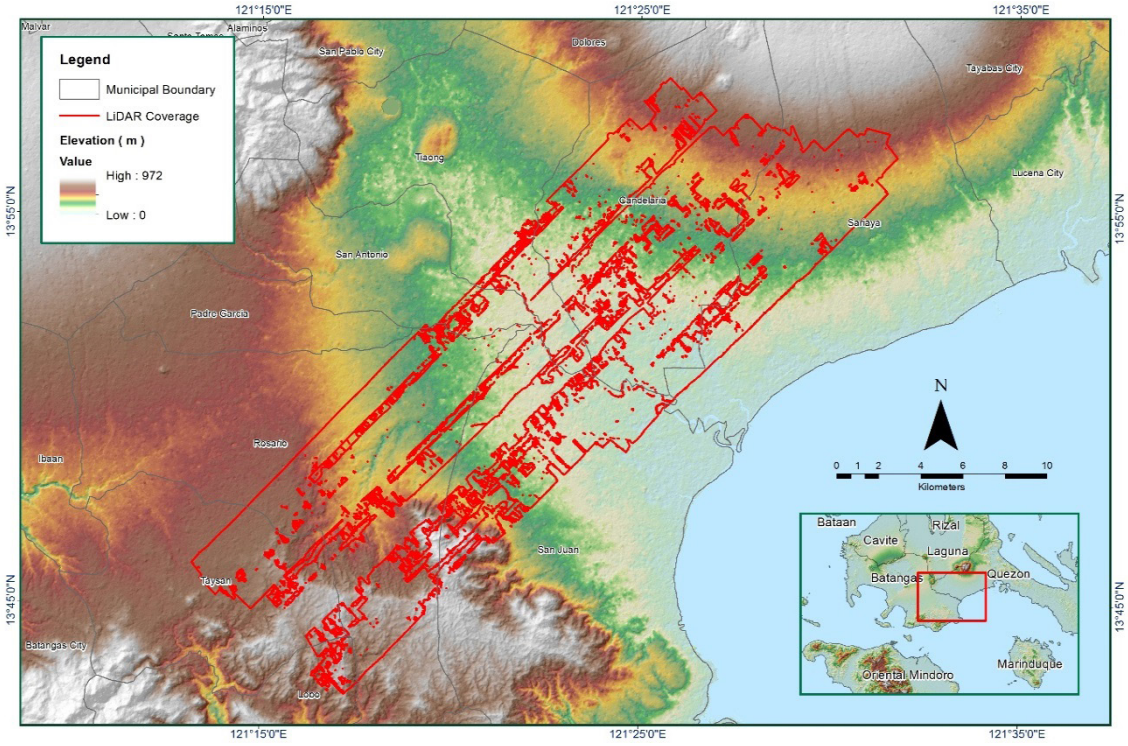


Figure 1.7.4. Coverage of LiDAR data

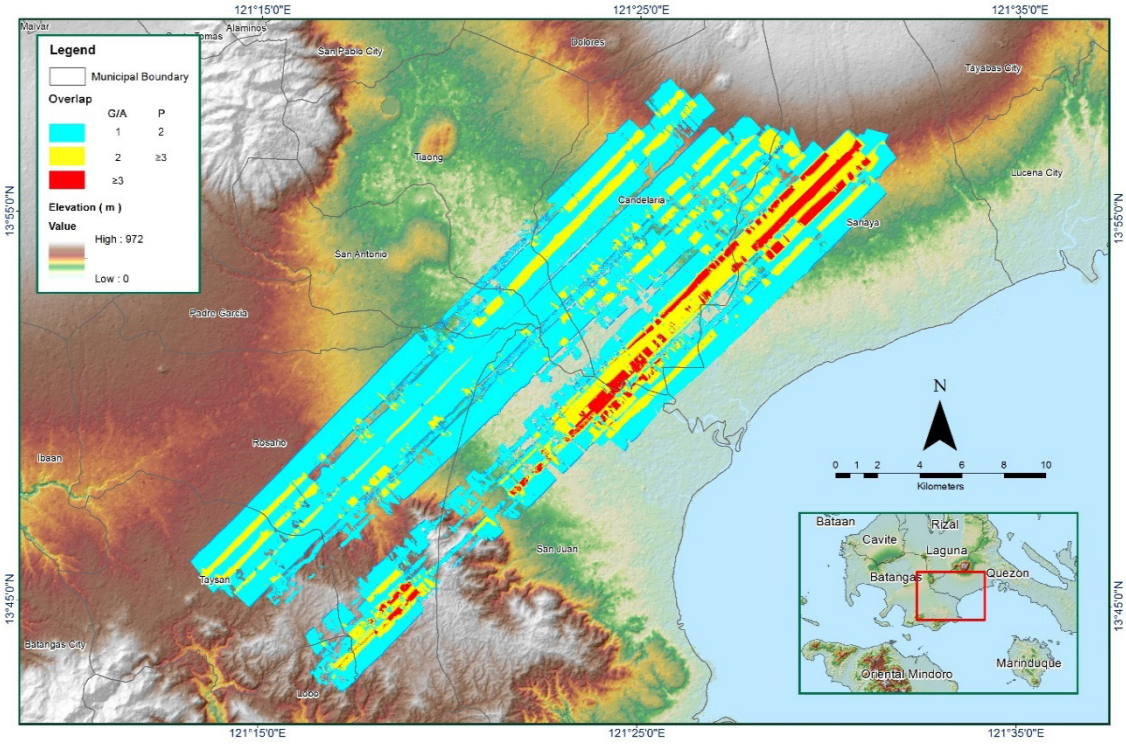


Figure 1.7.5. Image of data overlap

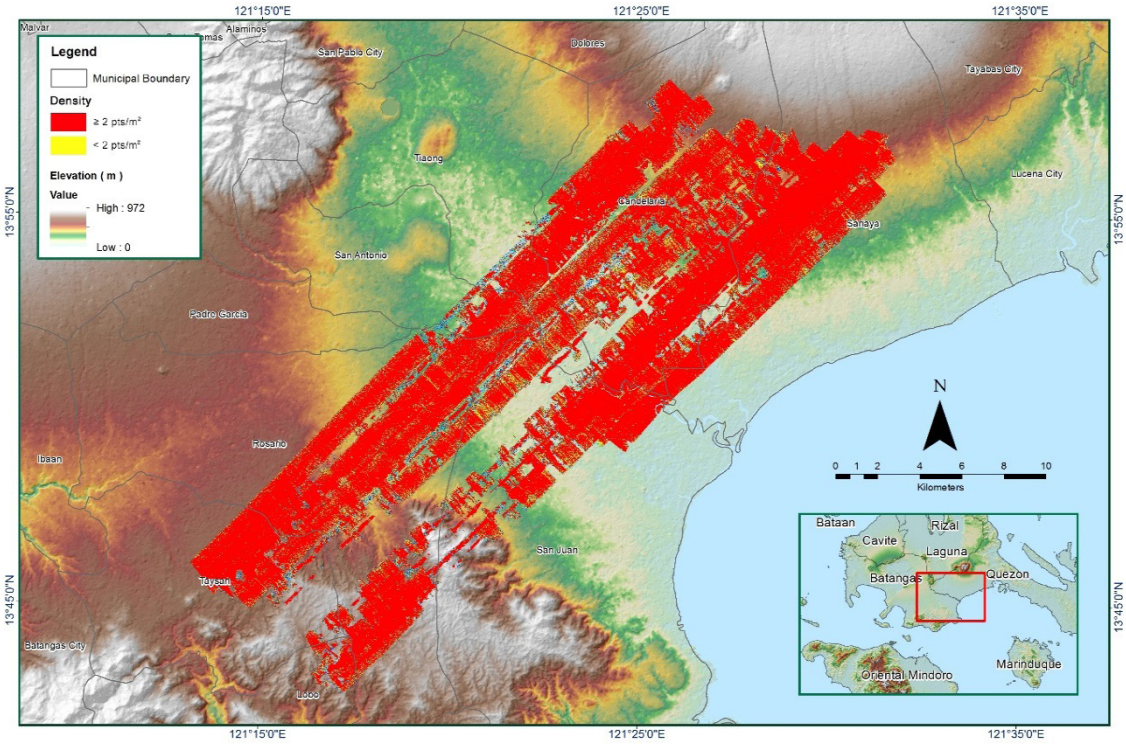


Figure 1.7.6. Density map of merged LiDAR data

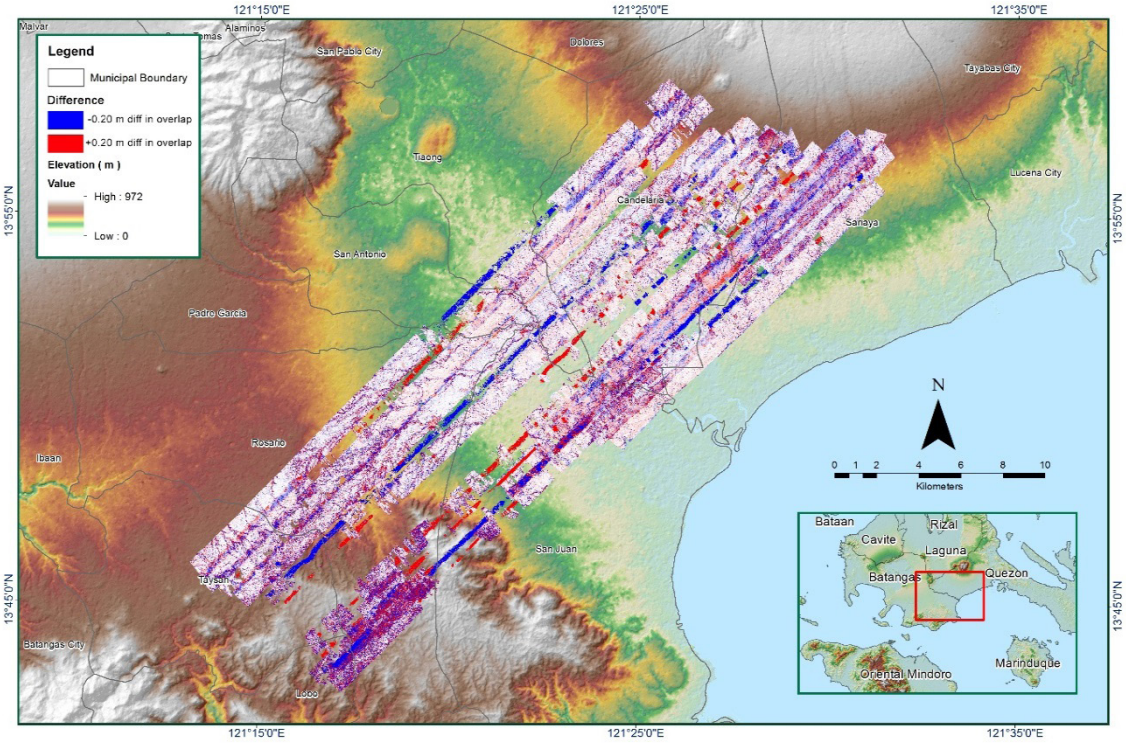


Figure 1.7.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18VW_supplement**
Inclusive Flights	1103P
Range data size	19.8 GB
POS	221 MB
Image	N/A
Transfer date	04/23/2014
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)	0.9
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	5.5
Boresight correction stdev (<0.001deg)	0.000547
IMU attitude correction stdev (<0.001deg)	0.001657
GPS position stdev (<0.01m)	0.0086
Minimum % overlap (>25)	34.32%
Ave point cloud density per sq.m. (>2.0)	2.15
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	305
Maximum Height	712.23 m
Minimum Height	59.56 m
Classification (# of points)	
Ground	171,488,434
Low vegetation	168,868,841
Medium vegetation	161,212,850
High vegetation	246,176,725
Building	12,644,487
Orthophoto	No
Processed by	Engr. Kenneth Solidum, Engr. Christy Lubiano, Ailyn Biñas

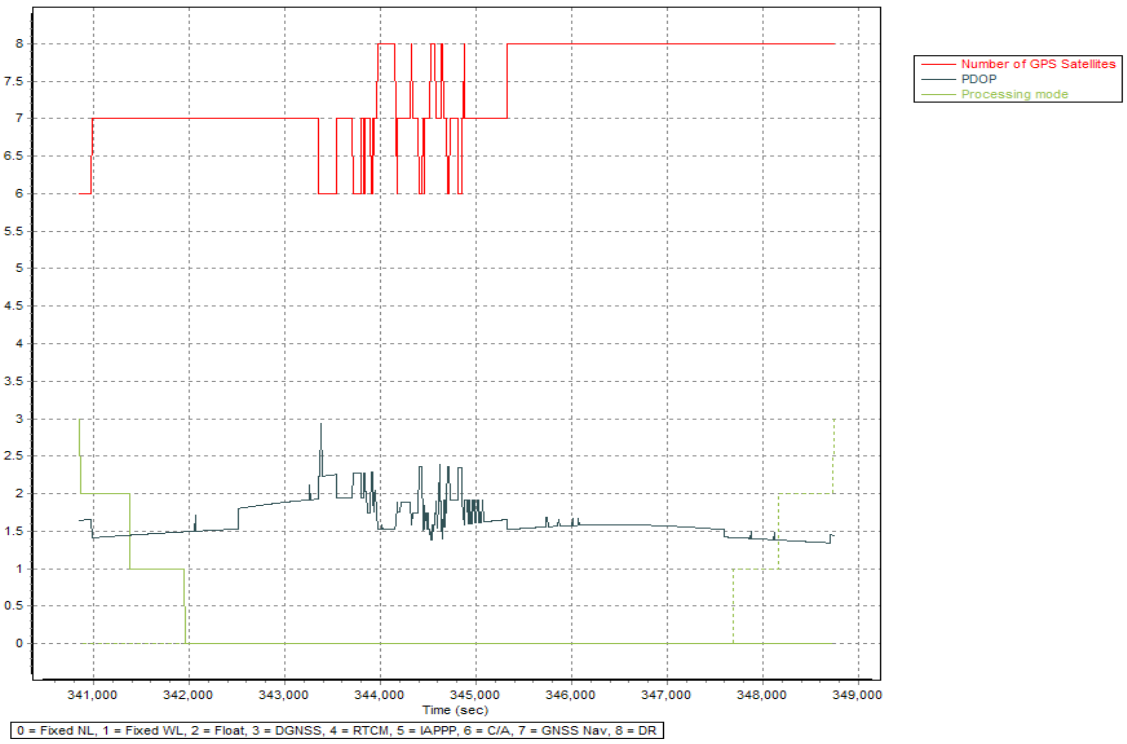


Figure 1.8.1. Solution Status

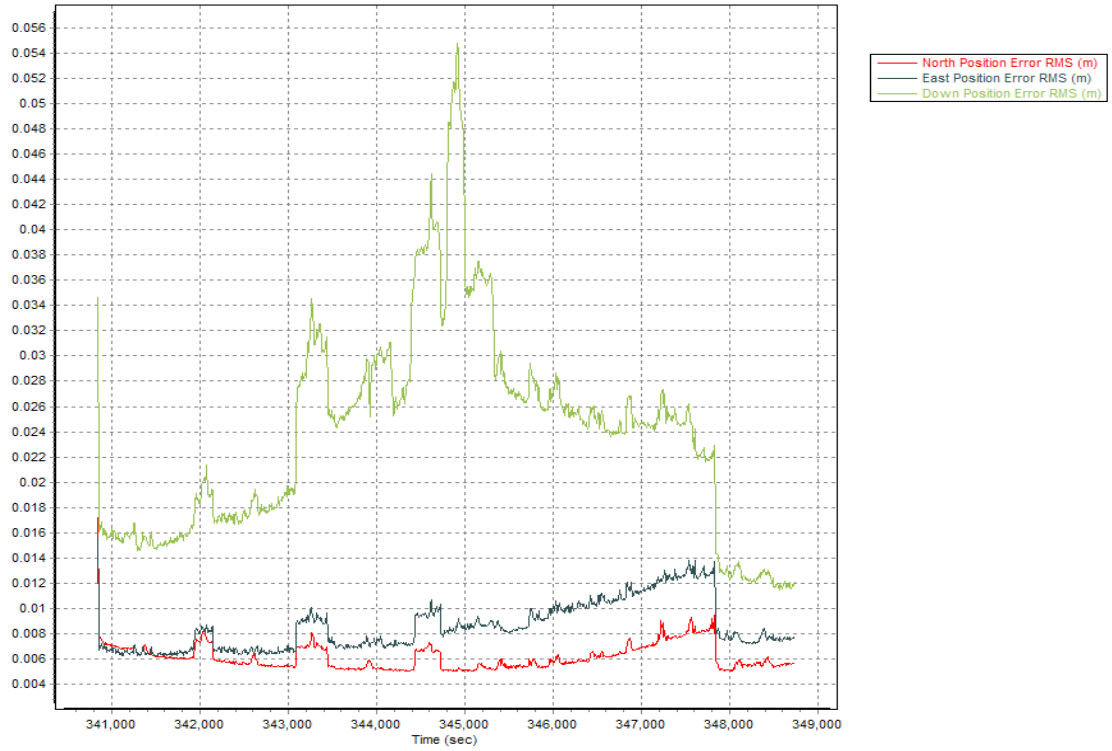


Figure 1.8.2. Smoothed Performance Metrics Parameters

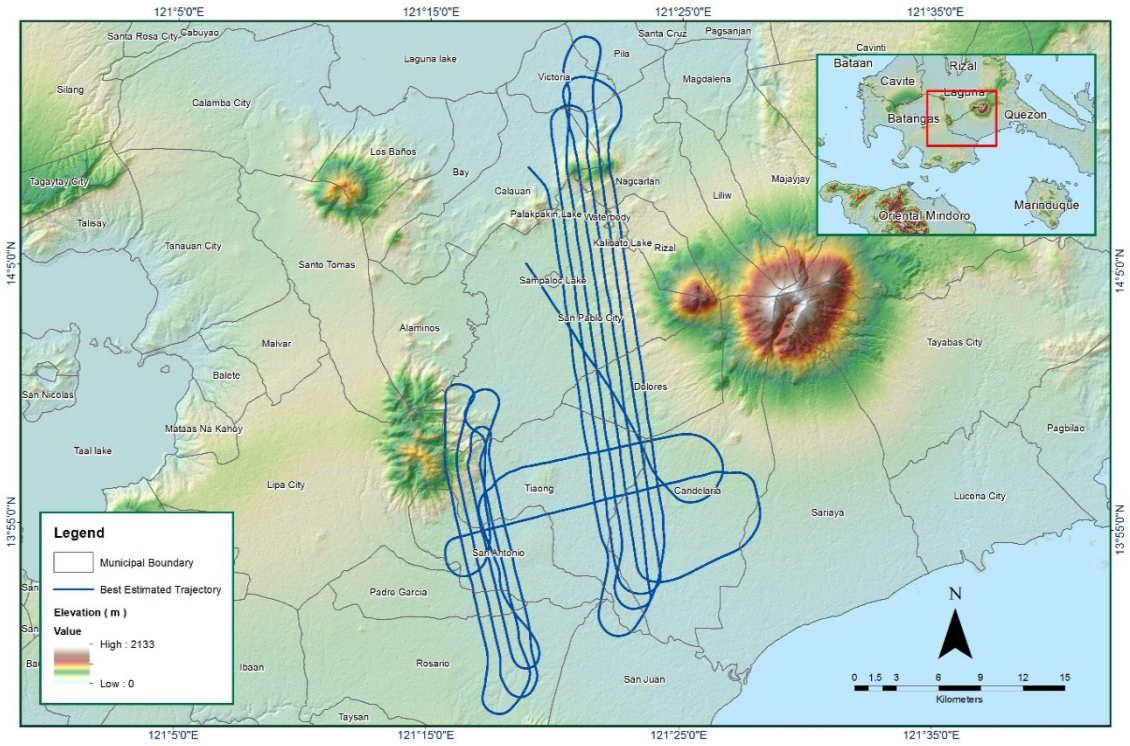


Figure 1.8.3. Best Estimated Trajectory

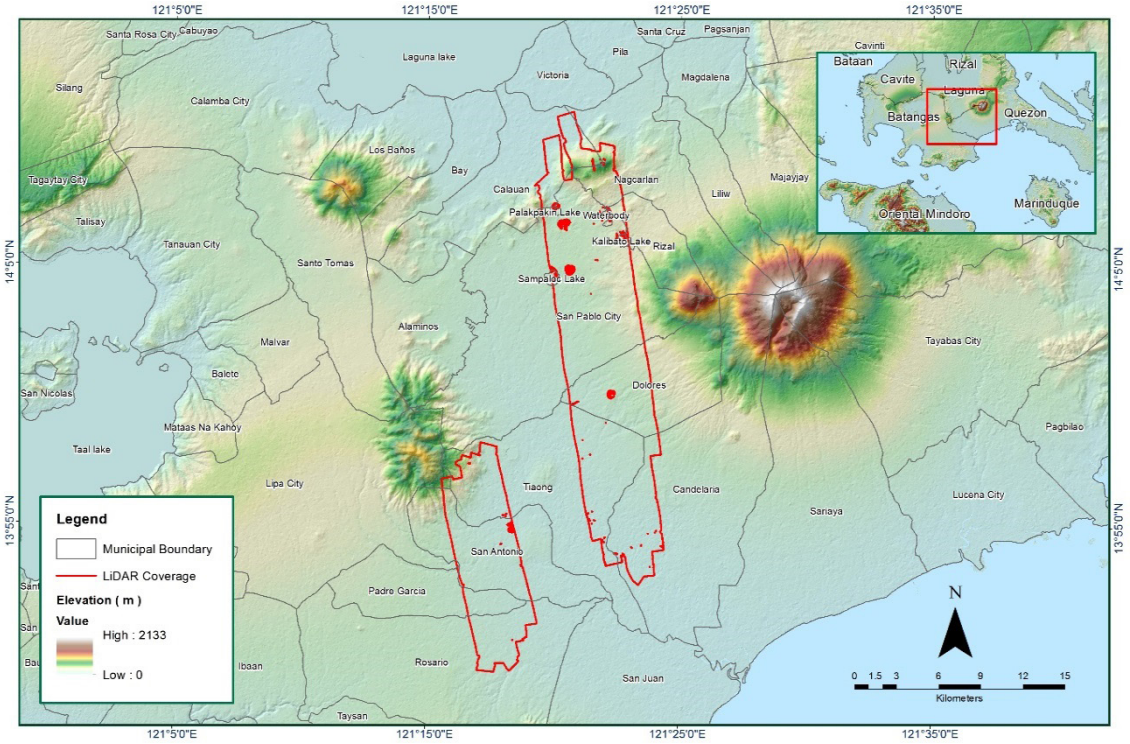


Figure 1.8.4. Coverage of LiDAR data

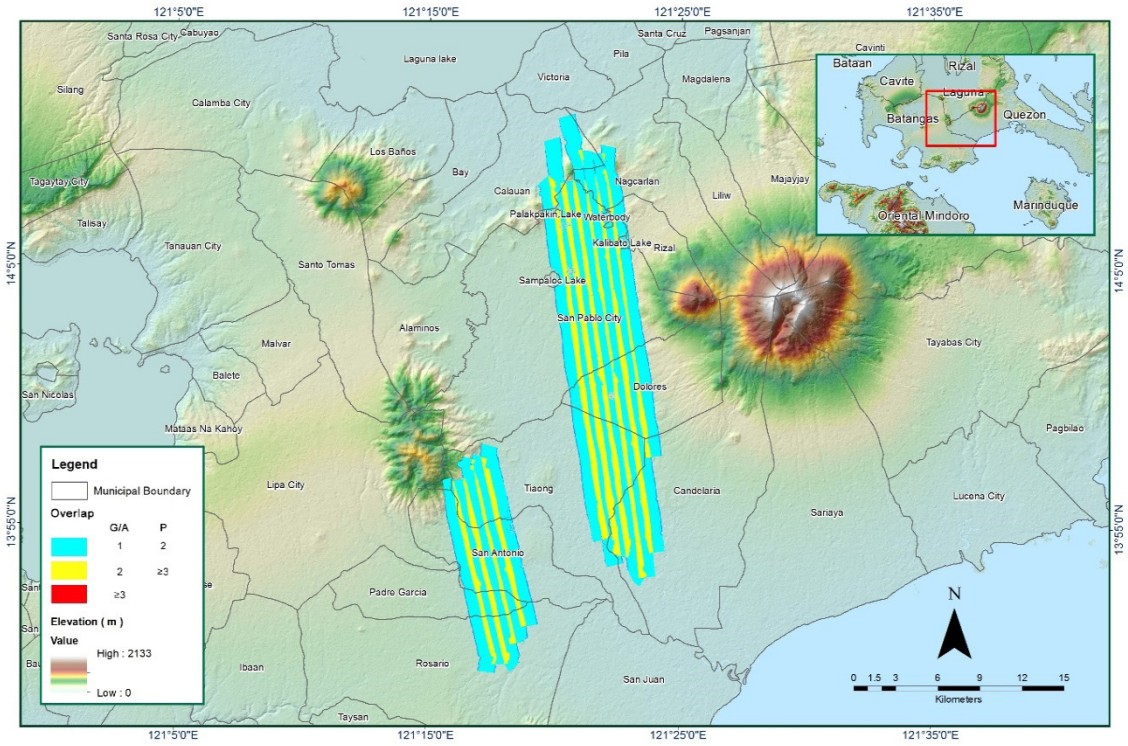


Figure 1.8.5. Image of data overlap

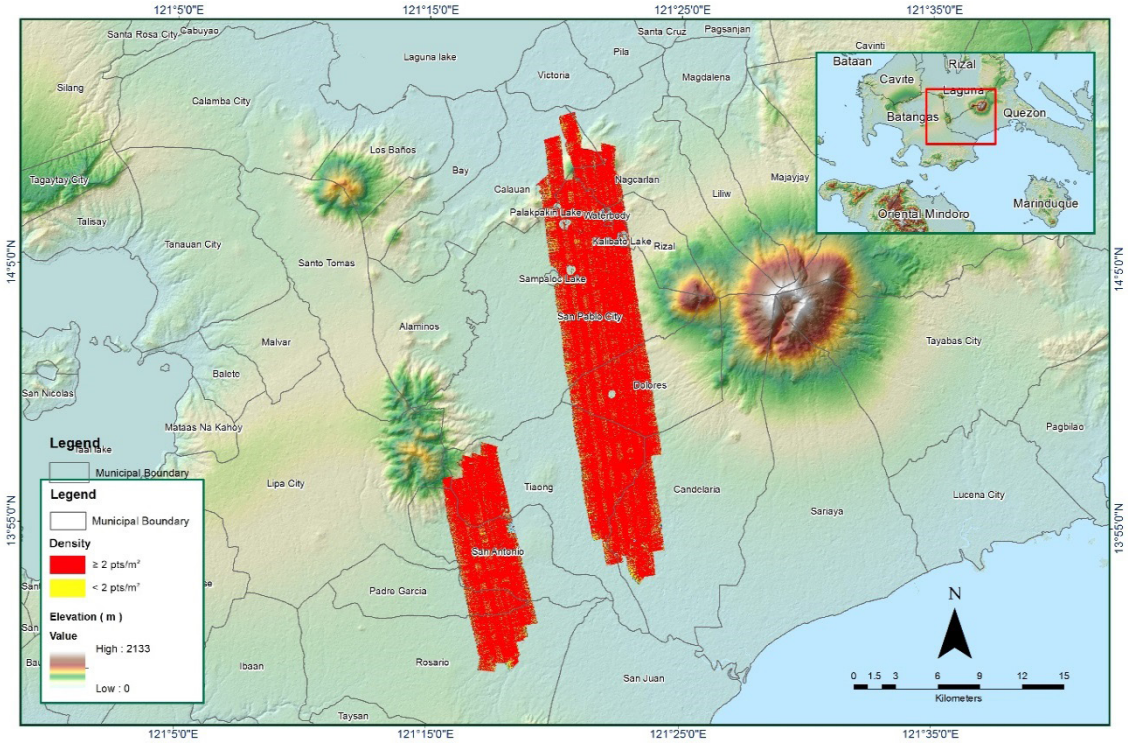


Figure 1.8.6. Density map of merged LiDAR data

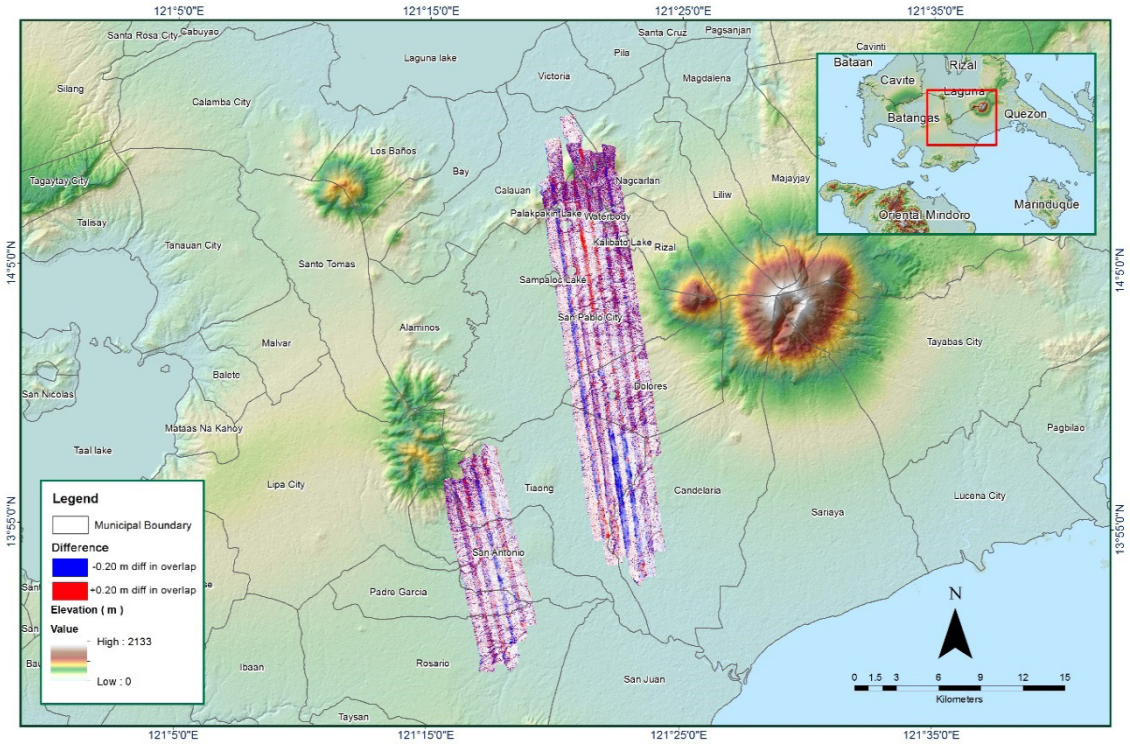


Figure 1.8.7. Elevation difference between flight lines

Flight Area	CALABARZON
Mission Name	**Blk18W**
Inclusive Flights	1091P
Range data size	20.2 GB
POS	171 MB
Image	32.7 GB
Transfer date	04/23/2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	No
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.2
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	3.7
Boresight correction stdev (<0.001deg)	0.000300
IMU attitude correction stdev (<0.001deg)	0.000519
GPS position stdev (<0.01m)	0.0020
Minimum % overlap (>25)	44.87%
Ave point cloud density per sq.m. (>2.0)	2.22
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	305
Maximum Height	540.55 m
Minimum Height	53.13 m
Classification (# of points)	
Ground	199,914,206
Low vegetation	203,235,338
Medium vegetation	155,157,978
High vegetation	200,761,579
Building	25,340,833
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Christy Lubiano, Engr. Gladys Mae Apat

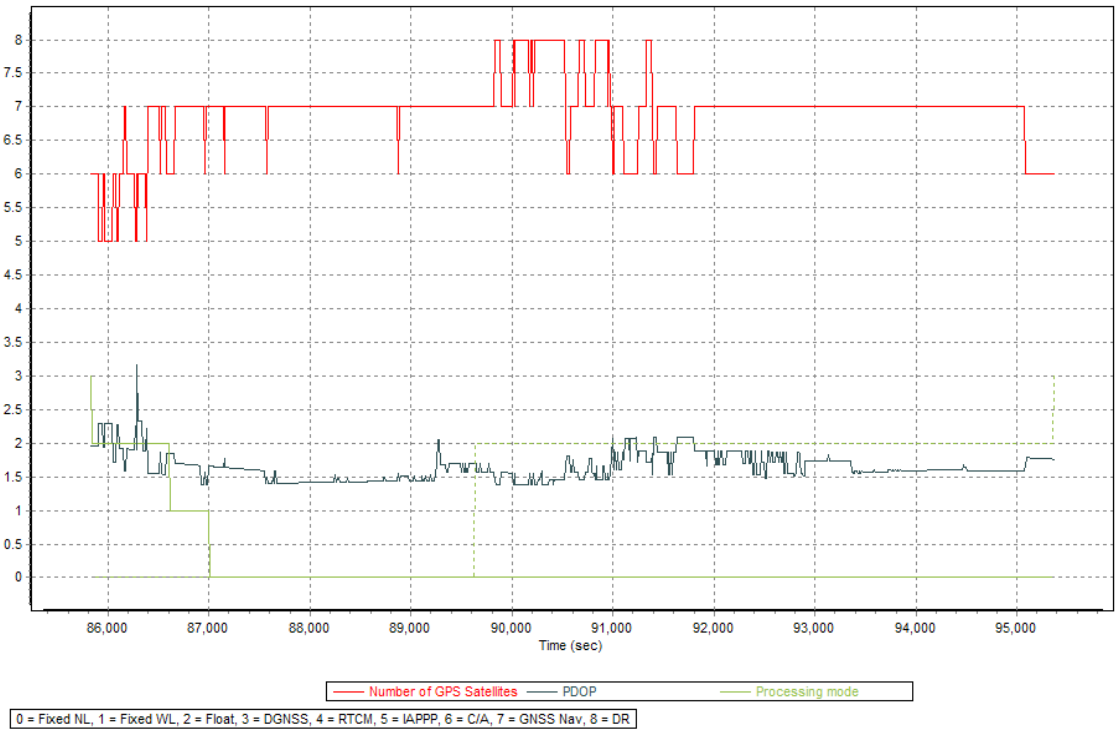


Figure 1.9.1. Solution Status

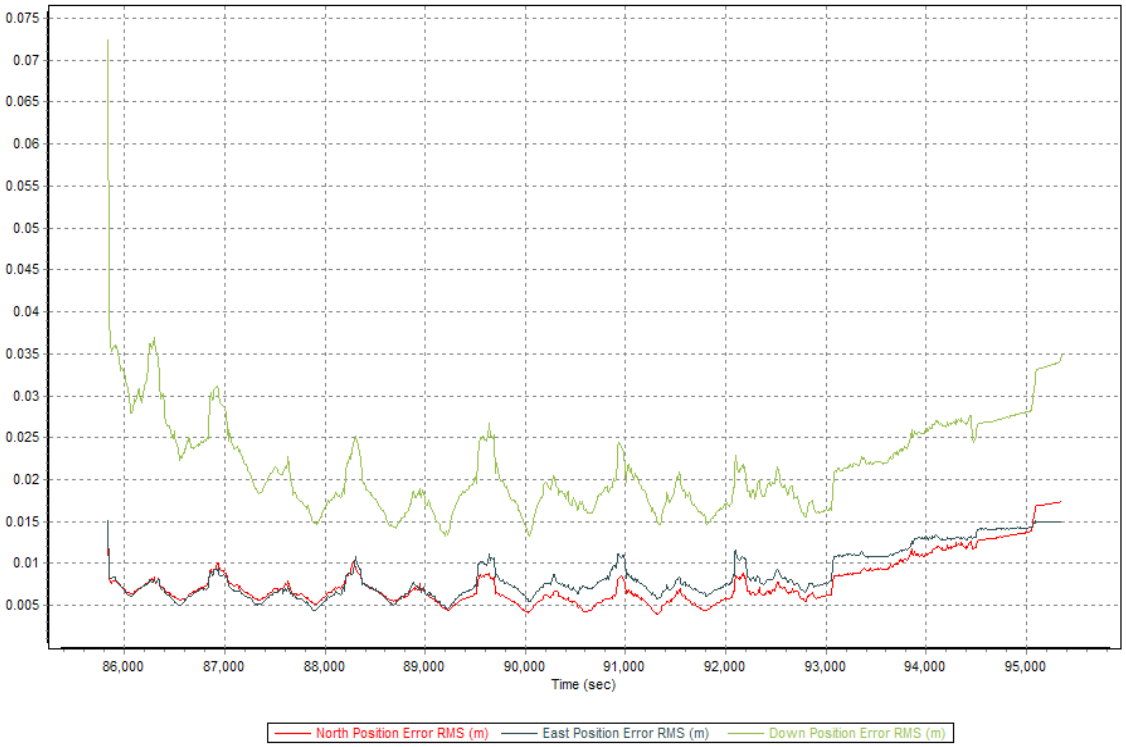


Figure 1.9.2. Smoothed Performance Metrics Parameters

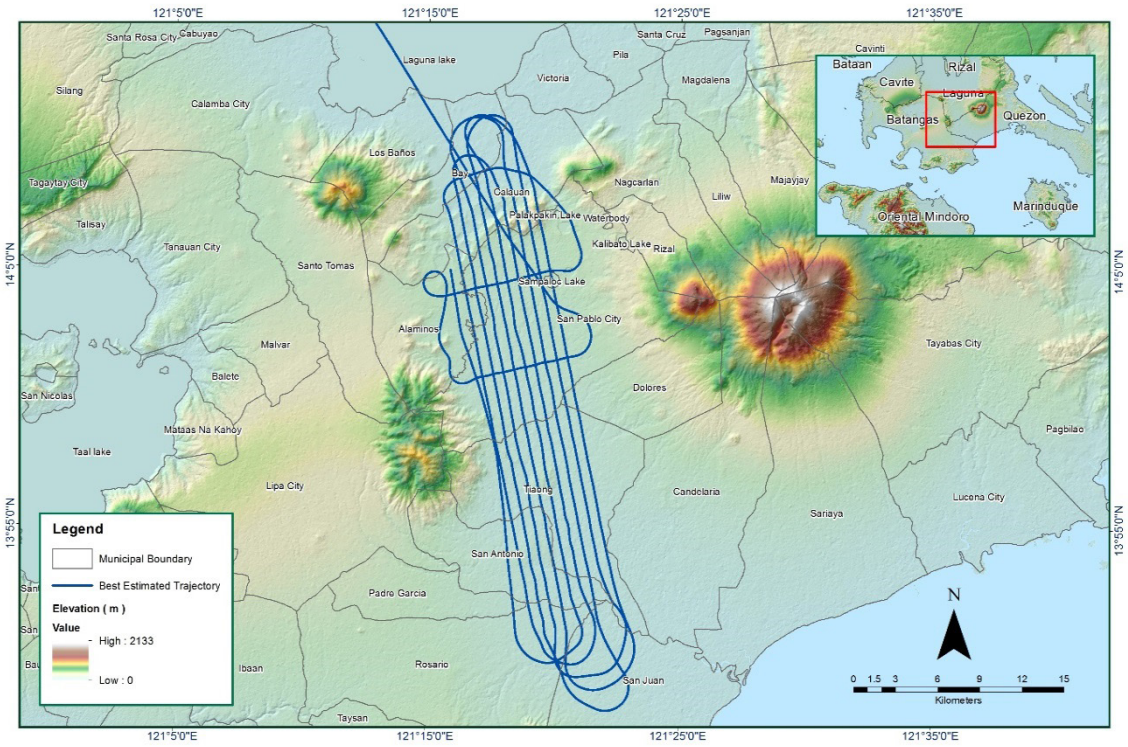


Figure 1.9.3. Best Estimated Trajectory

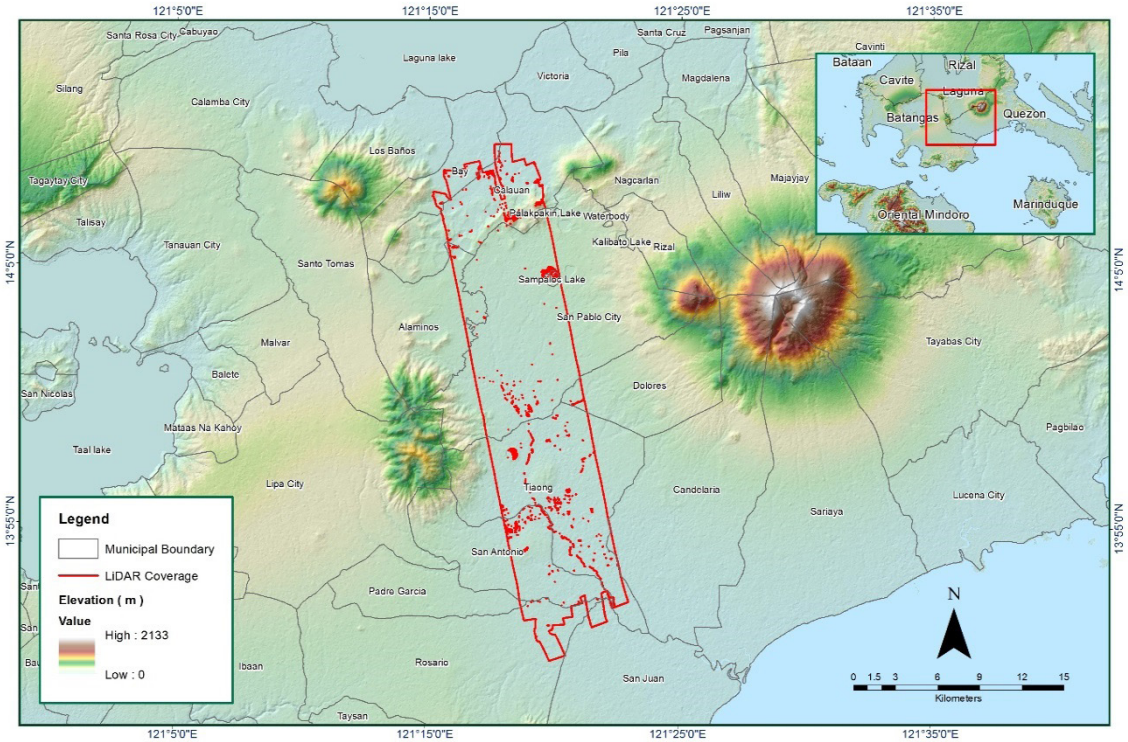


Figure 1.9.4. Coverage of LiDAR data

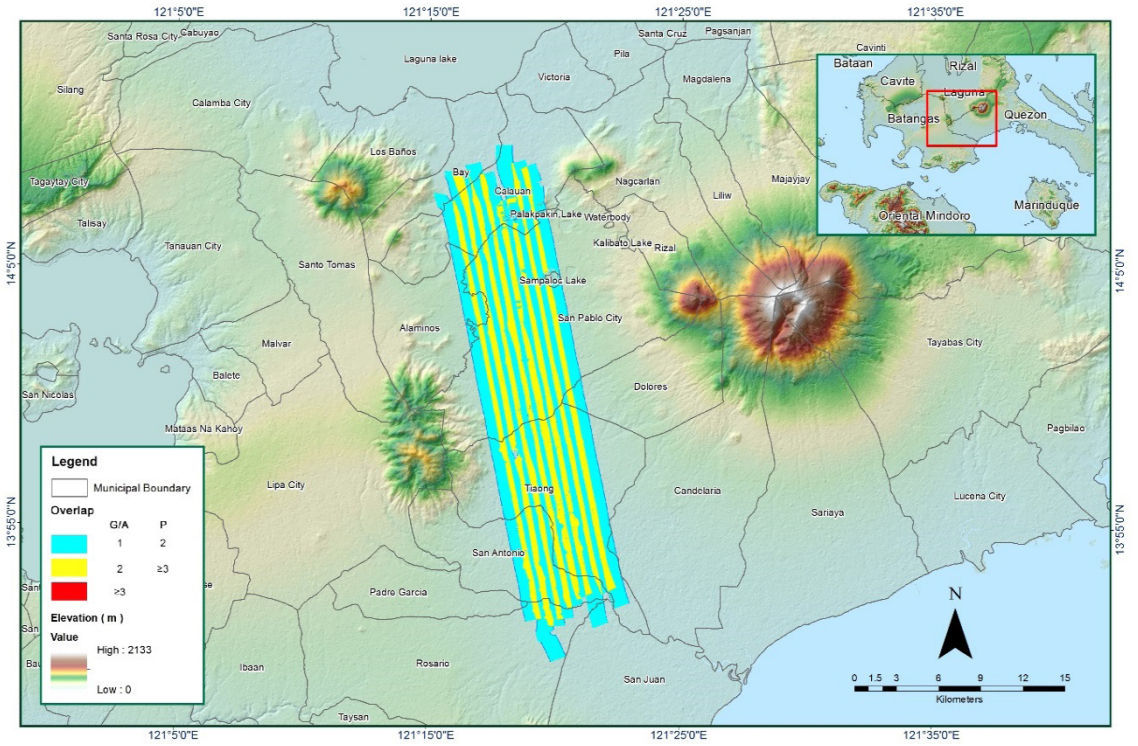


Figure 1.9.5. Image of data overlap

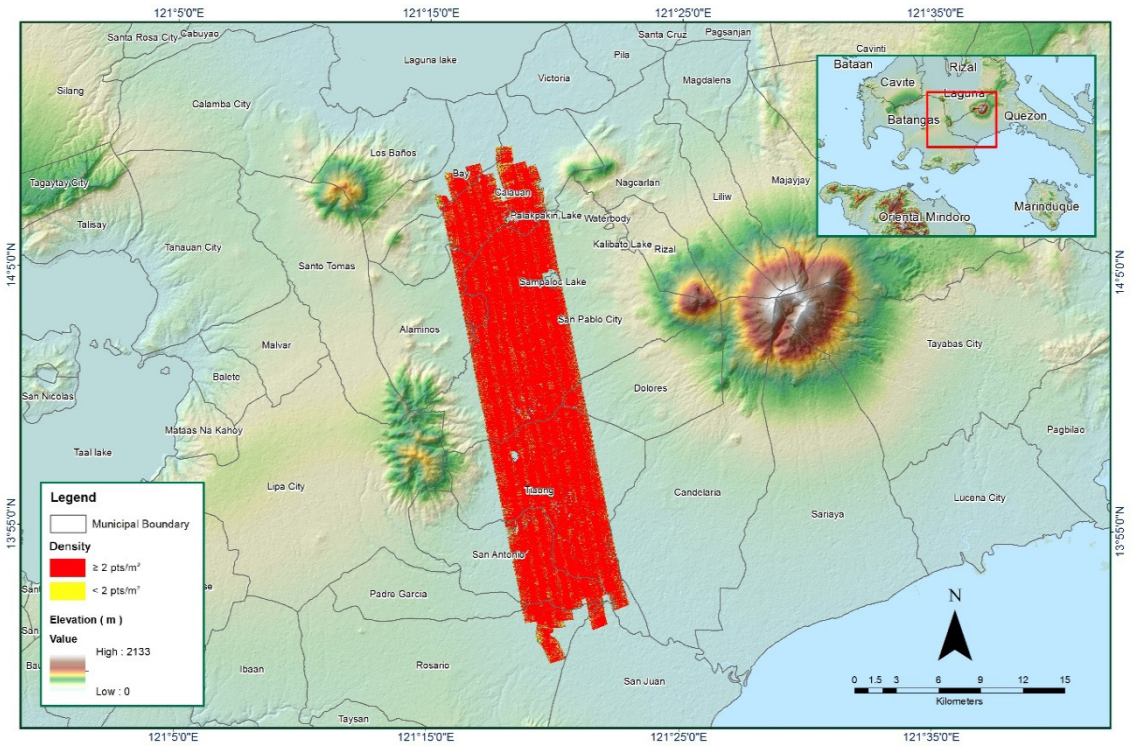


Figure 1.9.6. Density map of merged LiDAR data

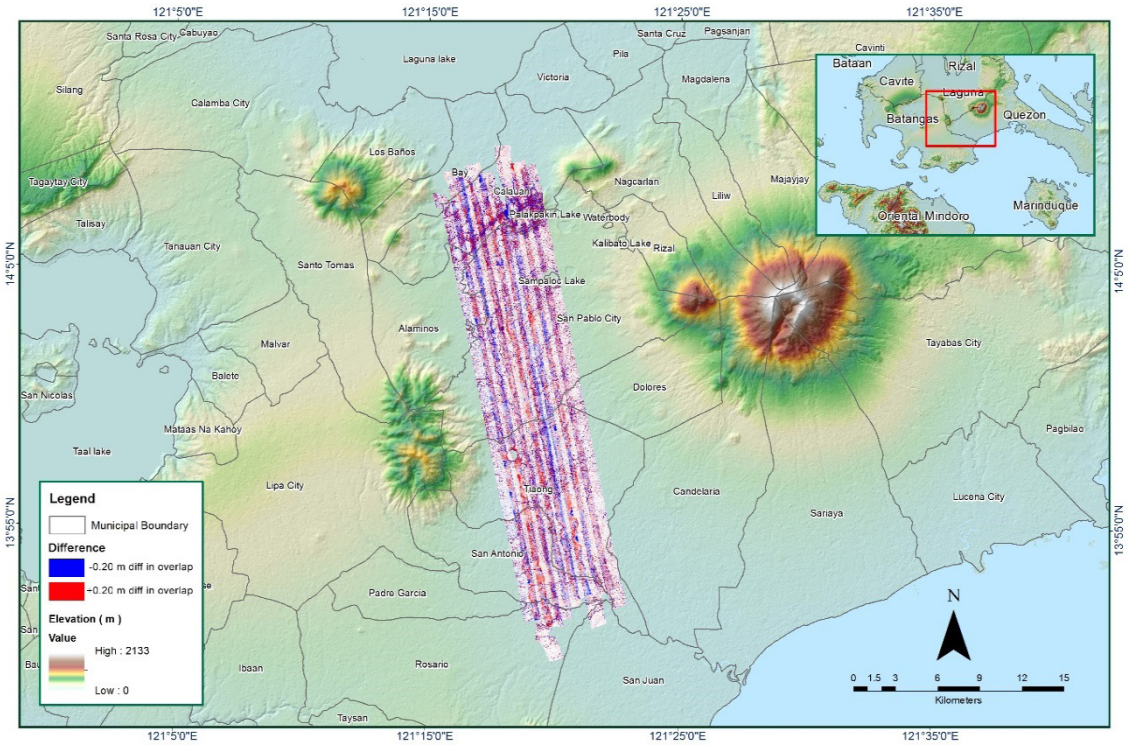


Figure 1.9.7. Elevation difference between flight lines

Flight Area	Batangas
Mission Name	**Blk18QR_supplement1**
Inclusive Flights	1107P
Range data size	10.2 GB
POS data size	215 MB
Base data size	12 MB
Image	16.7 GB
Transfer date	April 14, 2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	0.96
RMSE for East Position (<4.0 cm)	1.25
RMSE for Down Position (<8.0 cm)	5.13
Boresight correction stdev (<0.001deg)	0.000544
IMU attitude correction stdev (<0.001deg)	0.001183
GPS position stdev (<0.01m)	0.0102
Minimum % overlap (>25)	33.45
Ave point cloud density per sq.m. (>2.0)	1.97
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	203
Maximum Height	424.07 m
Minimum Height	37.25 m
Classification (# of points)	
Ground	127,864,102
Low vegetation	116,063,635
Medium vegetation	96,973,073
High vegetation	155,630,114
Building	11,308,922
Orthophoto	Yes
Processed by	Engr. Jennifer Saguran, Engr. Melanie Hingpit, Ailyn Biñas

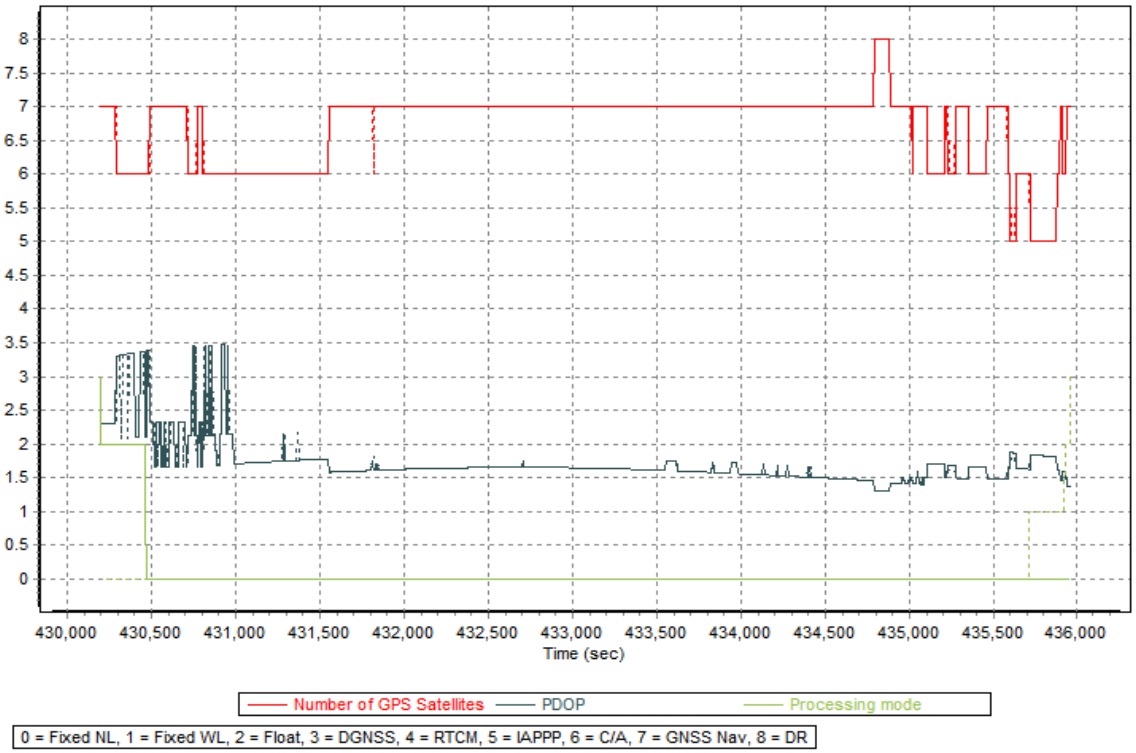


Figure 1.10.1. Solution Status

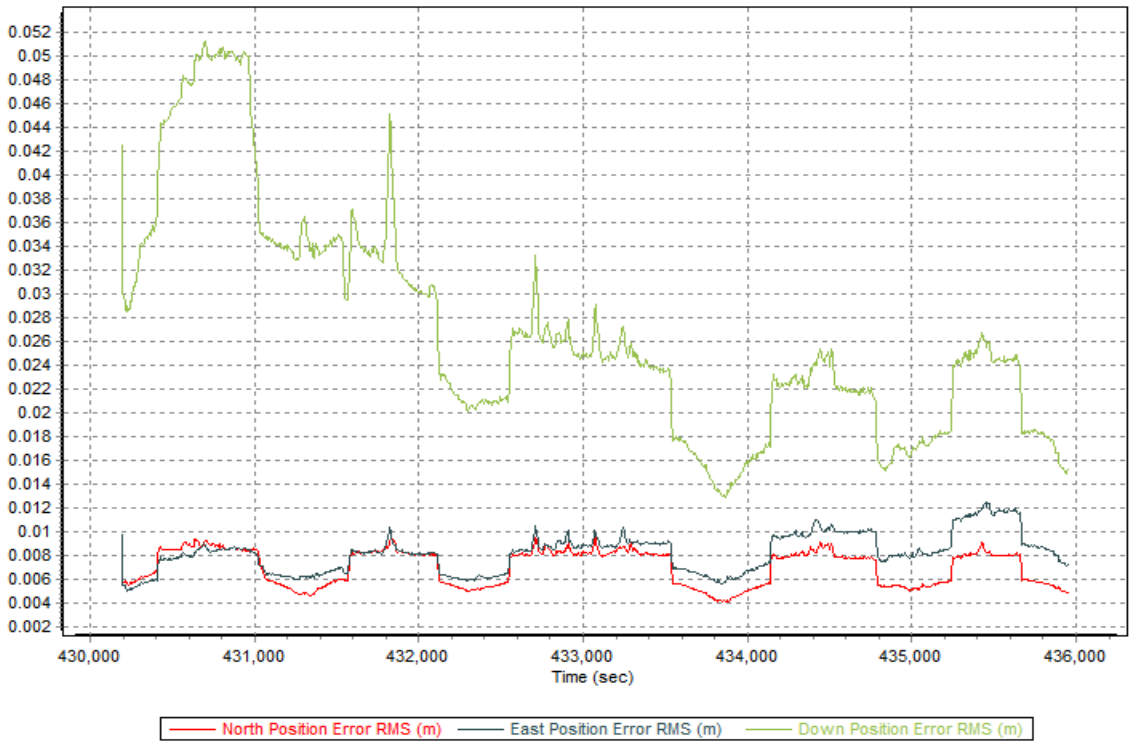


Figure 1.10.2. Smoothed Performance Metric Parameters

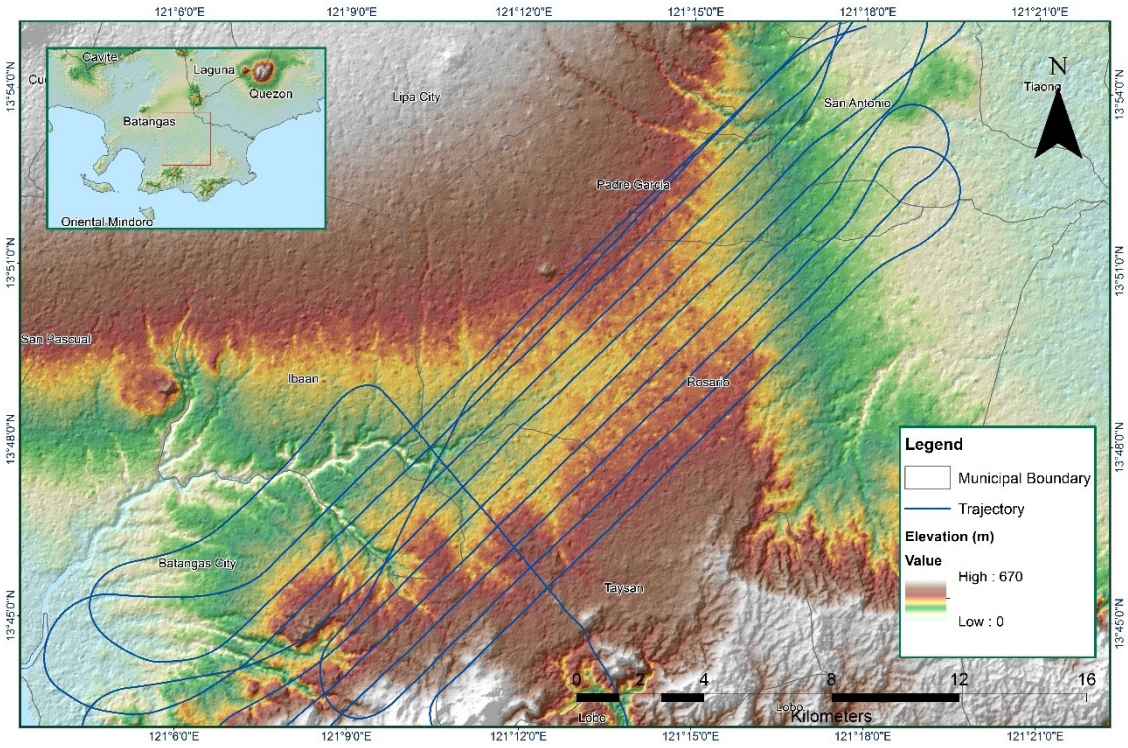


Figure 1.10.3. Best Estimated Trajectory

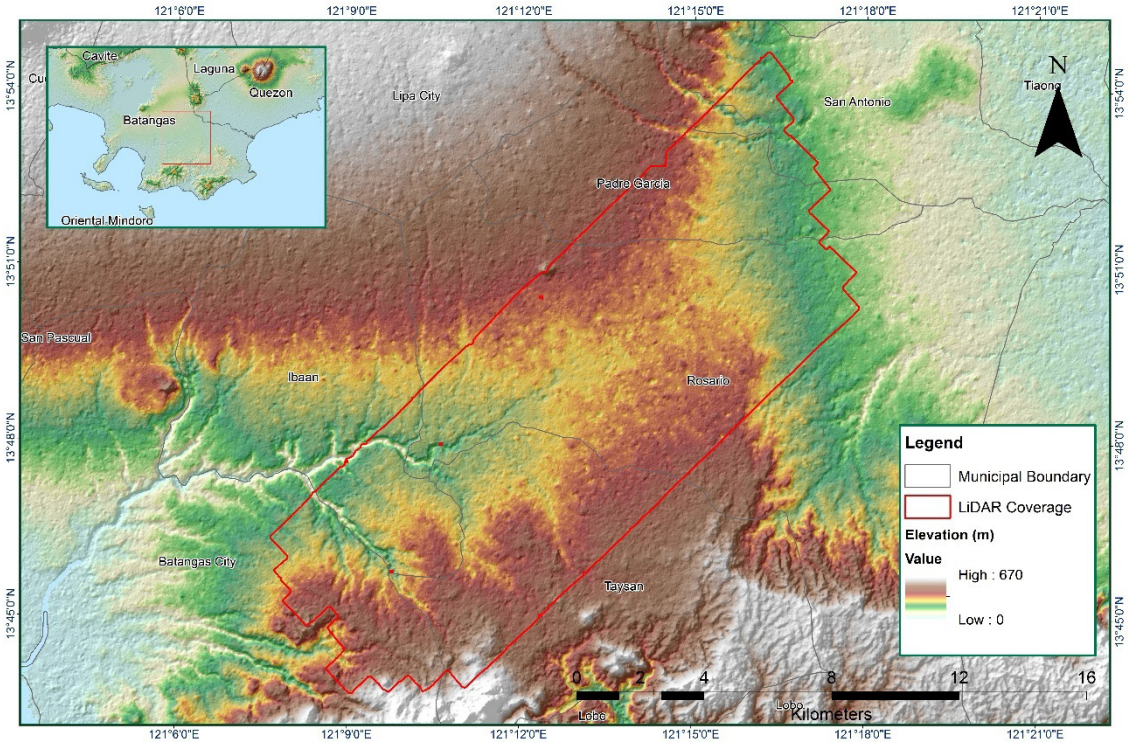


Figure 1.10.4. Coverage of LiDAR Data

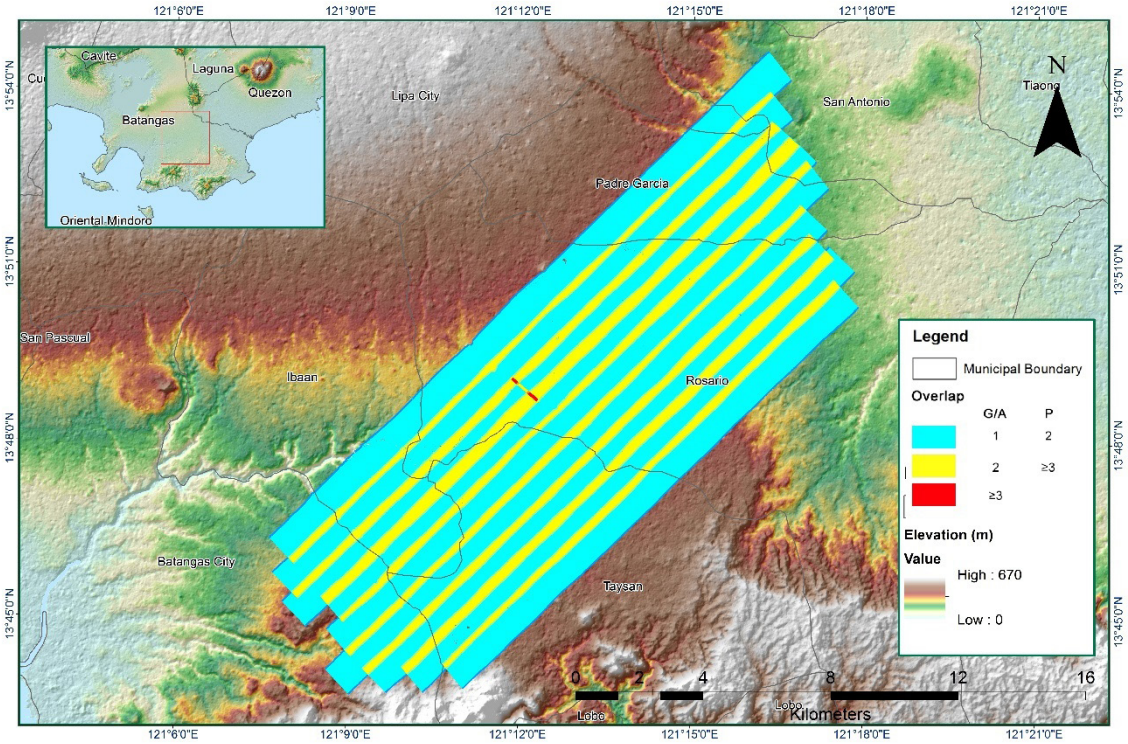


Figure 1.10.5. Image of data overlap

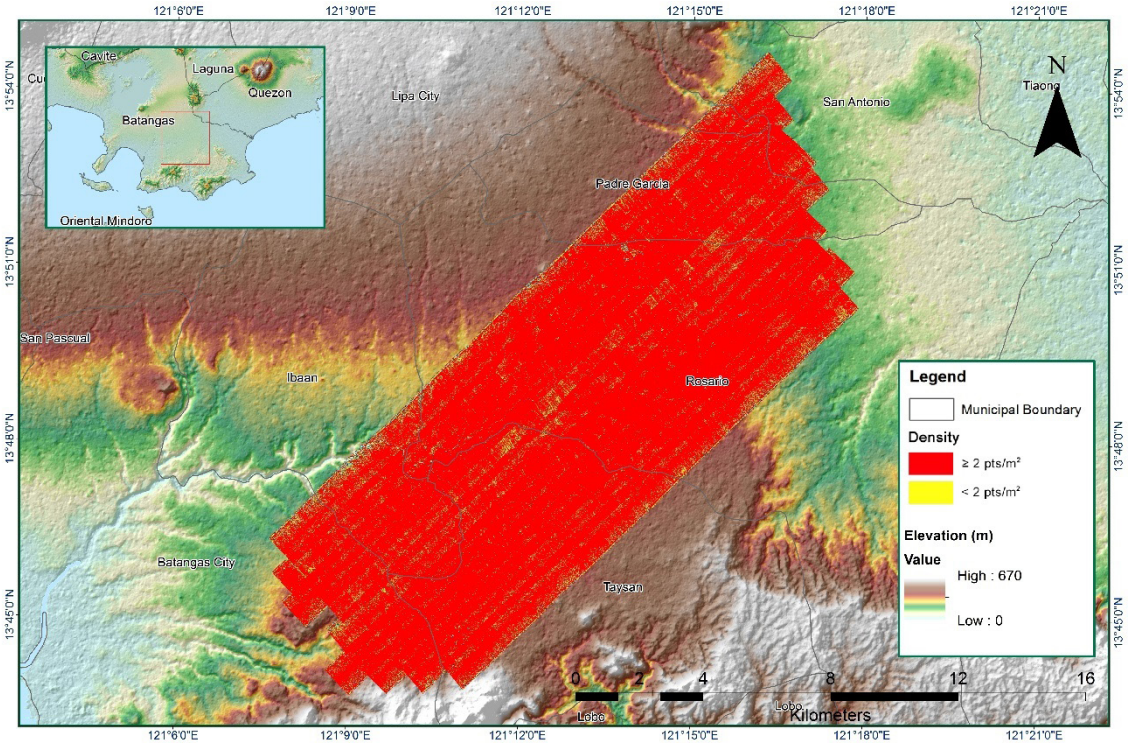


Figure 1.10.6. Density map of merged LiDAR data

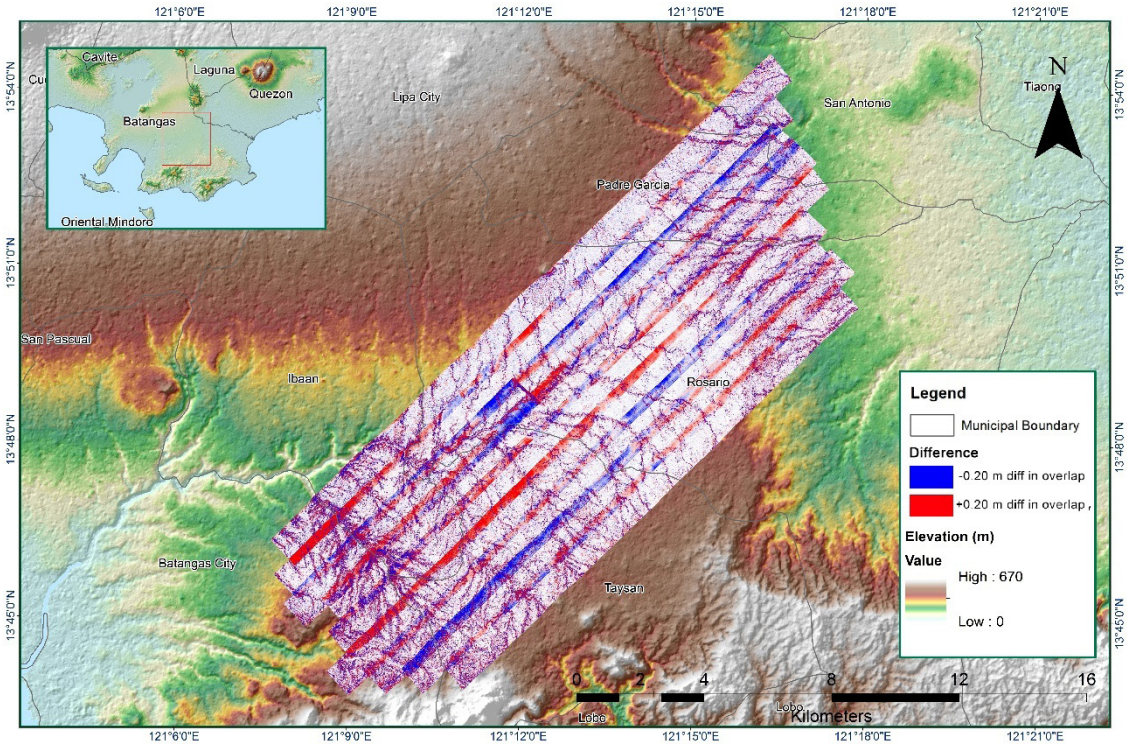


Figure 1.10.7. Elevation difference between flight lines

ANNEX 9. Bolbok 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
W240	3.7502	98.934	0	4.5469	6.4656	Discharge	0	0.11959	Ratio to Peak	0.13943
W250	3.3191	97.711	0	6.2717	1.5282	Discharge	0	0.11665	Ratio to Peak	0.33897
W260	3.8967	70.095	0	3.5718	5.9251	Discharge	0	0.081325	Ratio to Peak	0.8765
W270	2.9573	78.28	0	3.3569	3.4524	Discharge	0	0.17149	Ratio to Peak	0.73708
W280	2.4577	99	0	4.8511	1.7026	Discharge	0	0.25269	Ratio to Peak	0.46254
W290	3.0472	78.899	0	4.0563	4.4984	Discharge	0	0.25836	Ratio to Peak	0.065844
W300	2.3903	91.908	0	12.394	2.481	Discharge	0	0.05675	Ratio to Peak	0.0911
W310	8.5051	76.134	0	4.1876	1.8855	Discharge	0	0.25208	Ratio to Peak	0.55462
W320	5.2566	72.831	0	3.832	2.8919	Discharge	0	0.3878	Ratio to Peak	0.58112
W330	2.8406	66.389	0	2.8972	3.0275	Discharge	0	0.25722	Ratio to Peak	0.73233
W340	3.147	99	0	2.7239	3.403	Discharge	0	0.038202	Ratio to Peak	0.49583
W350	1.1442	76.145	0	2.2434	2.3561	Discharge	0	0.034415	Ratio to Peak	0.2242
W360	1.3489	76.933	0	2.5226	4.6837	Discharge	0	0.079012	Ratio to Peak	0.059519
W370	6.2997	76.921	0	1.9999	2.8275	Discharge	0	0.033726	Ratio to Peak	0.33147
W380	5.0122	82.149	0	1.9081	1.9139	Discharge	0	0.17149	Ratio to Peak	0.43552
W390	3.4495	66.939	0	1.5868	2.2397	Discharge	0	0.055349	Ratio to Peak	0.49907
W400	3.2401	77.817	0	1.7206	4.0221	Discharge	0	0.12322	Ratio to Peak	0.47291
W410	3.8218	83.659	0	1.7727	1.327	Discharge	0	0.56125	Ratio to Peak	0.44078
W420	9.7808	78.894	0	1.8132	1.9762	Discharge	0	0.57875	Ratio to Peak	0.54265
W430	4.6929	75.548	0	1.9287	2.5402	Discharge	0	0.16732	Ratio to Peak	0.31985
W440	10.129	76.724	0	1.9203	4.8696	Discharge	0	0.26941	Ratio to Peak	0.80544
W450	4.5624	78.492	0	1.0577	3.6295	Discharge	0	0.11383	Ratio to Peak	0.42543
W460	10.462	73	0	1.9131	3.1262	Discharge	0	1	Ratio to Peak	0.5

ANNEX 10. Bolbok Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R10	Automatic Fixed Interval	3667.4	0.003734	0.042502	Trapezoid	20	1
R20	Automatic Fixed Interval	4005.6	0.002282	0.023741	Trapezoid	20	1
R30	Automatic Fixed Interval	3723.1	0.002281	0.018206	Trapezoid	20	1
R50	Automatic Fixed Interval	2080.4	0.003589	0.014403	Trapezoid	20	1
R70	Automatic Fixed Interval	3041.8	0.001519	0.023609	Trapezoid	20	1
R100	Automatic Fixed Interval	949.83	0.015108	0.18468	Trapezoid	20	1
R110	Automatic Fixed Interval	1274	0.016614	0.057605	Trapezoid	20	1
R130	Automatic Fixed Interval	1558.8	0.01308	0.019885	Trapezoid	20	1
R150	Automatic Fixed Interval	1312.7	0.005655	0.004753	Trapezoid	20	1
R170	Automatic Fixed Interval	1078.7	0.011416	0.015873	Trapezoid	20	1
R180	Automatic Fixed Interval	1453.4	0.00787	0.008756	Trapezoid	20	1

ANNEX 11. Bolbok Field Validation

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Latitude	Longitude					
1	13.763473	121.406469	0.05	0	-0.05	Glenda/ July 15,2014	5-Year
2	13.76442	121.408607	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
3	13.767886	121.415832	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
4	13.773522	121.268546	0.04	0	-0.04	Glenda/ July 15,2014	5-Year
5	13.774356	121.268245	0.04	0	-0.04	Glenda/ July 15,2014	5-Year
6	13.776135	121.267035	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
8	13.777296	121.266353	0.34	0	-0.34	Glenda/ July 15,2014	5-Year
9	13.777385	121.39892	0.05	0	-0.05	Glenda/ July 15,2014	5-Year
10	13.777946	121.4339	0.36	0	-0.36	Glenda/ July 15,2014	5-Year
11	13.779356	121.42807	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
13	13.780541	121.414407	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
14	13.780708	121.412881	0.43	0	-0.43	Glenda/ July 15,2014	5-Year
15	13.780729	121.41535	0.42	0	-0.42	Glenda/ July 15,2014	5-Year
16	13.781809	121.423296	0.59	0	-0.59	Glenda/ July 15,2014	5-Year
17	13.781906	121.421345	0.04	0	-0.04	Glenda/ July 15,2014	5-Year
18	13.78228	121.404208	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
19	13.782563	121.404374	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
20	13.782844	121.406204	0.61	0	-0.61	Glenda/ July 15,2014	5-Year
21	13.783084	121.267005	0.72	0	-0.72	Glenda/ July 15,2014	5-Year
22	13.783536	121.410163	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
24	13.788092	121.436544	1.86	0	-1.86	Glenda/ July 15,2014	5-Year
25	13.788712	121.28659	0.06	0	-0.06	Glenda/ July 15,2014	5-Year
26	13.788721	121.286634	0.07	3	2.93	Glenda/ July 15,2014	5-Year
27	13.789492	121.286496	0.83	0	-0.83	Glenda/ July 15,2014	5-Year
28	13.789608	121.274983	0.32	0	-0.32	Glenda/ July 15,2014	5-Year
29	13.789969	121.406005	0.99	0	-0.99	Glenda/ July 15,2014	5-Year
30	13.790194	121.421433	0.14	0	-0.14	Glenda/ July 15,2014	5-Year
31	13.790899	121.411754	0.08	0	-0.08	Glenda/ July 15,2014	5-Year
32	13.791126	121.2861	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
33	13.791256	121.414656	0.18	0	-0.18	Glenda/ July 15,2014	5-Year
34	13.791315	121.421527	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
35	13.791897	121.419066	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
37	13.792479	121.426609	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
38	13.792797	121.2635	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
39	13.797134	121.313464	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
40	13.798602	121.404948	0.56	0	-0.56	Glenda/ July 15,2014	5-Year
41	13.800846	121.374928	0.05	0	-0.05	Glenda/ July 15,2014	5-Year
42	13.801886	121.372138	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
43	13.801898	121.368845	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
44	13.802871	121.371352	0.03	0	-0.03	Glenda/ July 15,2014	5-Year

45	13.803242	121.418152	0.67	0	-0.67	Glenda/ July 15,2014	5-Year
46	13.803456	121.380941	0.77	0	-0.77	Glenda/ July 15,2014	5-Year
48	13.80568	121.318987	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
49	13.807909	121.316893	0.27	0	-0.27	Glenda/ July 15,2014	5-Year
50	13.808068	121.408145	0.49	0	-0.49	Glenda/ July 15,2014	5-Year
51	13.808536	121.404371	0.07	0	-0.07	Glenda/ July 15,2014	5-Year
52	13.808741	121.391333	0.22	0	-0.22	Glenda/ July 15,2014	5-Year
53	13.808798	121.38988	0.28	0	-0.28	Glenda/ July 15,2014	5-Year
54	13.809279	121.398013	0.18	0	-0.18	Glenda/ July 15,2014	5-Year
55	13.809518	121.403707	0.95	0	-0.95	Glenda/ July 15,2014	5-Year
56	13.810019	121.394161	0.91	0	-0.91	Glenda/ July 15,2014	5-Year
57	13.810352	121.399493	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
58	13.810508	121.403035	0.05	0	-0.05	Glenda/ July 15,2014	5-Year
59	13.811375	121.401641	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
60	13.812705	121.43678	0.14	0	-0.14	Glenda/ July 15,2014	5-Year
61	13.815378	121.351167	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
62	13.816349	121.322503	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
63	13.819648	121.26578	0.04	0	-0.04	Glenda/ July 15,2014	5-Year
64	13.820267	121.396755	0.13	0	-0.13	Glenda/ July 15,2014	5-Year
65	13.820376	121.325865	4.97	0	-4.97	Glenda/ July 15,2014	5-Year
66	13.821065	121.397132	0.08	0	-0.08	Glenda/ July 15,2014	5-Year
67	13.822799	121.282438	0.04	0	-0.04	Glenda/ July 15,2014	5-Year
68	13.823059	121.434992	0.05	0	-0.05	Glenda/ July 15,2014	5-Year
69	13.823666	121.39106	0.64	0	-0.64	Glenda/ July 15,2014	5-Year
70	13.824464	121.261658	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
71	13.824918	121.390763	0.92	0	-0.92	Glenda/ July 15,2014	5-Year
72	13.824954	121.40305	1.22	0	-1.22	Glenda/ July 15,2014	5-Year
73	13.825198	121.287914	0.4	0	-0.4	Glenda/ July 15,2014	5-Year
74	13.825536	121.402769	1.14	0	-1.14	Glenda/ July 15,2014	5-Year
75	13.82556	121.247744	0.59	0	-0.59	Glenda/ July 15,2014	5-Year
76	13.82577	121.404373	0.11	0	-0.11	Glenda/ July 15,2014	5-Year
77	13.825799	121.405123	0.95	0	-0.95	Glenda/ July 15,2014	5-Year
78	13.825984	121.433254	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
79	13.826074	121.407243	0.12	0	-0.12	Glenda/ July 15,2014	5-Year
80	13.826404	121.384006	0.26	0	-0.26	Glenda/ July 15,2014	5-Year
81	13.826746	121.397004	0.21	0	-0.21	Glenda/ July 15,2014	5-Year
82	13.826752	121.410305	0.06	0	-0.06	Glenda/ July 15,2014	5-Year
83	13.826808	121.291709	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
84	13.826932	121.2588	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
85	13.827501	121.378474	0.07	0	-0.07	Glenda/ July 15,2014	5-Year
86	13.827536	121.331049	0.94	0	-0.94	Glenda/ July 15,2014	5-Year
87	13.827886	121.375372	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
88	13.828183	121.34181	0.87	0	-0.87	Glenda/ July 15,2014	5-Year
89	13.828325	121.347015	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
90	13.828858	121.368961	0.62	0	-0.62	Glenda/ July 15,2014	5-Year
91	13.828983	121.389415	0.44	0	-0.44	Glenda/ July 15,2014	5-Year

93	13.829226	121.357916	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
94	13.829689	121.255488	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
96	13.829989	121.392949	0.08	0	-0.08	Glenda/ July 15,2014	5-Year
97	13.829996	121.42326	0.45	0	-0.45	Glenda/ July 15,2014	5-Year
98	13.830542	121.393118	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
99	13.83056	121.299246	0.05	0	-0.05	Glenda/ July 15,2014	5-Year
100	13.830562	121.295557	0.25	0	-0.25	Glenda/ July 15,2014	5-Year
101	13.830643	121.395026	0.07	0	-0.07	Glenda/ July 15,2014	5-Year
102	13.830823	121.426295	0.12	0	-0.12	Glenda/ July 15,2014	5-Year
103	13.830851	121.407767	0.33	1	0.67	Glenda/ July 15,2014	5-Year
104	13.831255	121.395895	0.8	0	-0.8	Glenda/ July 15,2014	5-Year
105	13.831875	121.429835	0.07	0	-0.07	Glenda/ July 15,2014	5-Year
106	13.832032	121.252872	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
107	13.832137	121.393325	0.76	0	-0.76	Glenda/ July 15,2014	5-Year
108	13.832534	121.303686	0.25	0	-0.25	Glenda/ July 15,2014	5-Year
109	13.832713	121.408845	0.08	0	-0.08	Glenda/ July 15,2014	5-Year
110	13.83288	121.255161	0.51	0	-0.51	Glenda/ July 15,2014	5-Year
111	13.83298	121.406201	0.27	0	-0.27	Glenda/ July 15,2014	5-Year
112	13.833132	121.24761	0.35	0	-0.35	Glenda/ July 15,2014	5-Year
113	13.833402	121.30719	1.25	0	-1.25	Glenda/ July 15,2014	5-Year
114	13.833567	121.251177	0.21	0	-0.21	Glenda/ July 15,2014	5-Year
115	13.833631	121.395111	0.1	1	0.9	Glenda/ July 15,2014	5-Year
116	13.83373	121.395055	0.72	0	-0.72	Glenda/ July 15,2014	5-Year
117	13.833752	121.25755	0.44	0	-0.44	Glenda/ July 15,2014	5-Year
118	13.833815	121.408537	1.66	0	-1.66	Glenda/ July 15,2014	5-Year
119	13.834228	121.395024	0.17	0	-0.17	Glenda/ July 15,2014	5-Year
120	13.834364	121.409053	0.07	0	-0.07	Glenda/ July 15,2014	5-Year
121	13.834702	121.312528	0.04	0	-0.04	Glenda/ July 15,2014	5-Year
122	13.836385	121.318751	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
123	13.837374	121.367964	0.04	0	-0.04	Glenda/ July 15,2014	5-Year
124	13.838545	121.268957	0.04	0	-0.04	Glenda/ July 15,2014	5-Year
125	13.838648	121.367963	0.05	0	-0.05	Glenda/ July 15,2014	5-Year
126	13.83968	121.269056	0.09	0	-0.09	Glenda/ July 15,2014	5-Year
127	13.839876	121.243696	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
129	13.842062	121.280149	0.07	0	-0.07	Glenda/ July 15,2014	5-Year
130	13.843159	121.240186	0.09	0	-0.09	Glenda/ July 15,2014	5-Year
131	13.843598	121.288974	0.08	0	-0.08	Glenda/ July 15,2014	5-Year
132	13.843646	121.287238	0.09	0	-0.09	Glenda/ July 15,2014	5-Year
133	13.84415	121.293874	0.13	0	-0.13	Glenda/ July 15,2014	5-Year
134	13.844668	121.237951	0.14	0	-0.14	Glenda/ July 15,2014	5-Year
135	13.844756	121.301878	0.27	0	-0.27	Glenda/ July 15,2014	5-Year
136	13.84739	121.319178	0.12	0	-0.12	Glenda/ July 15,2014	5-Year
137	13.84915	121.324253	0.46	0	-0.46	Glenda/ July 15,2014	5-Year
138	13.850171	121.327511	0.21	0	-0.21	Glenda/ July 15,2014	5-Year
139	13.850296	121.328347	0.08	0	-0.08	Glenda/ July 15,2014	5-Year
140	13.85041	121.329213	0.11	0	-0.11	Glenda/ July 15,2014	5-Year

141	13.850534	121.330049	0.3	0	-0.3	Glenda/ July 15,2014	5-Year
142	13.850746	121.331239	1.64	0	-1.64	Glenda/ July 15,2014	5-Year
143	13.850948	121.332186	0.37	0	-0.37	Glenda/ July 15,2014	5-Year
144	13.859363	121.344453	0.04	0	-0.04	Glenda/ July 15,2014	5-Year
145	13.862602	121.349711	0.08	0	-0.08	Glenda/ July 15,2014	5-Year
146	13.863389	121.344665	0.1	0	-0.1	Glenda/ July 15,2014	5-Year
147	13.863452	121.342849	0.08	0	-0.08	Glenda/ July 15,2014	5-Year
148	13.863484	121.343481	0.26	0	-0.26	Glenda/ July 15,2014	5-Year
149	13.863486	121.344376	0.09	1	0.91	Glenda/ July 15,2014	5-Year
150	13.863512	121.344019	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
151	13.863874	121.30641	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
152	13.863908	121.306013	0.5	0	-0.5	Glenda/ July 15,2014	5-Year
153	13.867728	121.334571	0.94	0	-0.94	Glenda/ July 15,2014	5-Year
154	13.867941	121.300511	0.79	0	-0.79	Glenda/ July 15,2014	5-Year
155	13.872914	121.321437	0.97	0	-0.97	Glenda/ July 15,2014	5-Year
156	13.873803	121.323622	0.96	0	-0.96	Glenda/ July 15,2014	5-Year
157	13.874754	121.300344	1.1	0	-1.1	Glenda/ July 15,2014	5-Year
158	13.825815	121.404328	0.81	0	-0.81	Glenda/ July 15,2014	5-Year
159	13.826106	121.404209	1.26	0	-1.26	Glenda/ July 15,2014	5-Year
160	13.8248	121.407747	0.04	0	-0.04	Glenda/ July 15,2014	5-Year
161	13.836449	121.417739	0.95	0	-0.95	Glenda/ July 15,2014	5-Year
162	13.826351	121.409359	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
163	13.826006	121.407203	0.47	0	-0.47	Glenda/ July 15,2014	5-Year
164	13.828785	121.418982	0.35	1	0.65	Glenda/ July 15,2014	5-Year
165	13.829643	121.422446	0.03	1	0.97	Glenda/ July 15,2014	5-Year
166	13.825991	121.405586	0.35	0	-0.35	Glenda/ July 15,2014	5-Year
167	13.831198	121.423943	0.89	2	1.11	Glenda/ July 15,2014	5-Year
168	13.830737	121.423872	0.73	2	1.27	Glenda/ July 15,2014	5-Year
169	13.812816	121.42659	0.63	1	0.37	Glenda/ July 15,2014	5-Year
170	13.839846	121.398472	0.56	1	0.44	Glenda/ July 15,2014	5-Year
171	13.840853	121.396846	0.3	1	0.7	Glenda/ July 15,2014	5-Year
172	13.842973	121.396991	0.42	1	0.58	Glenda/ July 15,2014	5-Year
173	13.827065	121.412168	0.1	1	0.9	Glenda/ July 15,2014	5-Year
174	13.834507	121.405136	1.01	1	-0.01	Glenda/ July 15,2014	5-Year
175	13.836459	121.403731	0.03	1	0.97	Glenda/ July 15,2014	5-Year
176	13.837587	121.403096	1.21	1	-0.21	Glenda/ July 15,2014	5-Year
177	13.839071	121.402289	0.45	1	0.55	Glenda/ July 15,2014	5-Year
178	13.839503	121.400533	0.03	1	0.97	Glenda/ July 15,2014	5-Year
179	13.821787	121.414009	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
180	13.816727	121.414746	3.04	0	-3.04	Glenda/ July 15,2014	5-Year
181	13.825832	121.411563	0.03	0	-0.03	Glenda/ July 15,2014	5-Year
182	13.812572	121.421986	0.09	1	0.91	Glenda/ July 15,2014	5-Year
183	13.813411	121.420719	0.63	1	0.37	Glenda/ July 15,2014	5-Year
184	13.812566	121.424879	1.55	2	0.45	Glenda/ July 15,2014	5-Year
185	13.814001	121.419459	0.64	4	3.36	Glenda/ July 15,2014	5-Year
186	13.813939	121.417506	0.66	5	4.34	Glenda/ July 15,2014	5-Year

187	13.834381	121.423303	3.57	0	-3.57	Glenda/ July 15,2014	5-Year
188	13.825815	121.404328	1	0.5	-0.5	Glenda/ July 15,2014	5-Year
189	13.826106	121.404209	1.26	0.5	-0.76	Glenda/ July 15,2014	5-Year
190	13.8248	121.407747	1.18	0.5	-0.68	Glenda/ July 15,2014	5-Year
191	13.828049	121.416082	1.22	0.5	-0.72	Glenda/ July 15,2014	5-Year
192	13.836449	121.417739	0.66	0.5	-0.16	Glenda/ July 15,2014	5-Year
193	13.826351	121.409359	0.95	1.5	0.55	Glenda/ July 15,2014	5-Year
194	13.826006	121.407203	0.96	1.5	0.54	Glenda/ July 15,2014	5-Year
195	13.828785	121.418982	1.65	1	-0.65	Glenda/ July 15,2014	5-Year
196	13.829643	121.422446	0.7	1	0.3	Glenda/ July 15,2014	5-Year
197	13.825991	121.405586	1.14	0	-1.14	Glenda/ July 15,2014	5-Year
198	13.831198	121.423943	0.05	2	1.95	Glenda/ July 15,2014	5-Year
199	13.827497	121.413906	0.79	0.5	-0.29	Glenda/ July 15,2014	5-Year
200	13.812816	121.42659	0.21	1	0.79	Glenda/ July 15,2014	5-Year
201	13.839846	121.398472	0.42	1	0.58	Glenda/ July 15,2014	5-Year
202	13.840853	121.396846	0.37	1	0.63	Glenda/ July 15,2014	5-Year
203	13.842973	121.396991	0.03	1	0.97	Glenda/ July 15,2014	5-Year
204	13.845156	121.396346	0.04	1	0.96	Glenda/ July 15,2014	5-Year
205	13.827065	121.412168	1.74	1	-0.74	Glenda/ July 15,2014	5-Year
206	13.834507	121.405136	0.38	1	0.62	Glenda/ July 15,2014	5-Year
207	13.836459	121.403731	0.42	1	0.58	Glenda/ July 15,2014	5-Year
208	13.837587	121.403096	0.39	1	0.61	Glenda/ July 15,2014	5-Year
209	13.839071	121.402289	0.12	1	0.88	Glenda/ July 15,2014	5-Year
210	13.839503	121.400533	0.3	1	0.7	Glenda/ July 15,2014	5-Year
211	13.83387	121.40571	0.51	1	0.49	Glenda/ July 15,2014	5-Year
212	13.821787	121.414009	0.29	0.3	0.01	Glenda/ July 15,2014	5-Year
213	13.816727	121.414746	0.05	0.2	0.15	Glenda/ July 15,2014	5-Year
214	13.825832	121.411563	0.59	0.3	-0.29	Glenda/ July 15,2014	5-Year
215	13.812572	121.421986	1.02	1	-0.02	Glenda/ July 15,2014	5-Year
216	13.812688	121.423875	0.03	1	0.97	Glenda/ July 15,2014	5-Year
217	13.813411	121.420719	0.45	1	0.55	Glenda/ July 15,2014	5-Year
218	13.812587	121.425503	0.03	2	1.97	Glenda/ July 15,2014	5-Year
219	13.813939	121.417506	0.16	5	4.84	Glenda/ July 15,2014	5-Year
220	13.833646	121.423517	0.03	1.5	1.47	Glenda/ July 15,2014	5-Year
221	13.834381	121.423303	0.11	1.5	1.39	Glenda/ July 15,2014	5-Year
222	13.835921	121.423301	0.03	1.5	1.47	Glenda/ July 15,2014	5-Year
223	13.836003	121.422207	0.63	1.5	0.87	Glenda/ July 15,2014	5-Year
224	13.836052	121.419889	1.55	1.5	-0.05	Glenda/ July 15,2014	5-Year
225	13.836018	121.418524	0.64	1.5	0.86	Glenda/ July 15,2014	5-Year
226	13.832928	121.423813	3.16	1.5	-1.66	Glenda/ July 15,2014	5-Year
227	13.832025	121.42382	0.03	1	0.97	Glenda/ July 15,2014	5-Year

ANNEX 12. Educational Institutions Affected in Bolbok Floodplain

Batangas				
San Juan				
Building	Barangay	5-year	25-year	100-year
Abung Elementary School	Abung	None	None	None
Balagbag Elementary School	Balagbag	None	None	None
Day Care Center	Balagbag	None	None	None
Batangas State University	Buhay Na Sapa	Low	Low	Medium
Paaralang Elementarya ng Buhay Na Sapa	Buhay Na Sapa	Low	Low	Low
Calit-Calit Elementary School	Calitcalit	Medium	Medium	Medium
San Juan East Central School	Calitcalit	Medium	Medium	Medium
Paaralang Elementary Ng Marcal	Coloconto	Medium	Medium	Medium
Escribano Elementary School	Escribano	None	None	None
Day Care Center	Janaojanao	None	None	None
Red Bakery	Janaojanao	None	None	None
Paaralang Elementary Ng Palahanan 1	Libato	Low	Low	Medium
Paaralang Elementary Ng Palahanan 2	Libato	None	None	None
Day Care Center	Lipahan	Medium	Medium	Medium
Lipahan National High School	Lipahan	Medium	Medium	Medium
San Juan East Central School	Lipahan	Medium	Medium	Medium
Memorial National High School	Mabalanoy	Medium	Medium	Medium
Paaralang Elementary Ng Palahanan 2	Palahanan I	None	None	None
Palingowak Elementary School	Palingowak	Medium	Medium	Medium
Day Care Center	Pinagbayanan	None	Low	Low
Paaralang Elementary Ng Catmon	Pinagbayanan	None	None	Low
Pinagbayanan Elementary School	Pinagbayanan	Medium	Medium	Medium
Batangas Eastern College	Poblacion	None	None	None
Joseph Marello Institute	Poblacion	None	None	None
San Juan Children'S Center	Poblacion	None	None	None
San Juan Church	Poblacion	None	None	Low
San Juan Parochial High School	Poblacion	Low	Low	Low
San Juan West Central School	Poblacion	None	None	None
Day Care Center	Putingbuhangin	Low	Medium	Medium
Puting Buhangin Elementary School	Putingbuhangin	Low	Low	Medium
Quipot Elementary School	Putingbuhangin	None	Low	Medium
Day Care Center	Quipot	None	None	None
Quipot Elementary School	Quipot	None	Low	Medium
Day Care Center	Sapangan	None	None	Low
Pacita Ramos Mendoza Memorial National School	Sapangan	None	None	None
Sapangan Elementary School	Sapangan	None	None	None
Day Care Center	Sico I	None	Low	None
Sico I National High School	Sico I	Low	Low	None

Paaralang Elementary Ng Pal-Sico	Sico II	Low	Medium	None
Talahiban 1St Elementary School	Talahiban I	None	None	None
Batangas State University	Talahiban II	Medium	Medium	Medium
Day Care Center	Talahiban II	Low	Medium	Medium
Tipas Elementary School	Tipaz	None	None	None
Tipas National High School	Tipaz	None	None	None

Rosario				
Building	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Rosario	Alupay	None	None	None
Rosario	Alupay	None	None	None
Rosario	Alupay	None	None	None
Rosario	Bayawang	None	None	None
Rosario	Baybayin	None	None	None
Rosario	Baybayin	None	None	None
Rosario	Baybayin	None	None	None
Rosario	Mabunga	None	None	None
Rosario	Maligaya	None	None	None
Rosario	Mayuro	None	None	None
Rosario	Mayuro	None	None	None
Rosario	Natu	None	None	None
Rosario	Putingkahoy	None	None	None
Rosario	Putingkahoy	None	None	None
Rosario	Putingkahoy	None	None	None
Rosario	San Isidro	None	None	None

Padre Garcia				
Building	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Day Care Center	Bukal	None	None	None
Paaralang Elementarya Ng Bukal	Bukal	None	None	None
Day Care Center	Maugat East	None	None	Low
Paaralang Elementarya ng Magsaysay	Maugat East	None	None	None
Paaralang Elementarya ng Maugat Silangan	Maugat East	None	None	Low
Domingo Elementary School	Maugat West	None	None	None

Taysan				
Building	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Leviste Elementary School	San Isidro	None	None	None

Quezon				
San Antonio				
Building	Barangay	Rainfall Scenario		
		5-year	25-year	100-year

Callejon Elementary School	Briones	None	None	None
Day Care Center	Briones	Low	Low	Low
Barangay Hall	Manuel Del Valle, Sr.	Low	Low	Low
Del Valle Elementary School	Manuel Del Valle, Sr.	Low	Low	Low

Sariaya				
Building	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Tipas National High School	Manggalang-Bantilan	None	None	None

ANNEX 13. Medical Institutions Affected in Bolbok Floodplain

Batangas				
San Juan				
Building	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
San Juan Doctors Hospital	Calitcalit	Medium	Medium	Medium
Duque General Hospital	Mabalanoy	Medium	Medium	Medium
Health Care	Poblacion	None	None	None
Divine Care Hospital	Sico II	Low	Low	None
San Juan District Hospital	Talahiban I	None	Low	Low
San Juan District Hospital	Talahiban II	Low	Low	Low

Rosario				
Building	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Rosario II Birthing Home	Alupay	None	None	None
Health Center	Mayuro	None	None	None

Batangas				
Padre Garcia				
Building	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Health Center	Maugat East	None	None	Low