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

LiDAR Surveys and Flood Mapping of Pansipit River

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

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For questions/queries regarding this report, contact:

Dr. Francis Aldrine A. Uy
Project Leader, Phil-LiDAR 1 Program
MAPUA Institute of Technology
City of Manila, Philippines 1002
E-mail: faauy@mapua.edu.ph

Enrico C. Paringit, Dr. Eng.
Program Leader, Phil-LiDAR 1 Program
University of the Philippines Diliman
Quezon City, Philippines 1101
E-mail: ecparingit@up.edu.ph

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Asian Aerospace Corporation
Ab	abutment
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
ATQ	Antique
AWLS	Automated Water Level Sensor
BA	Bridge Approach
BM	benchmark
CAD	Computer-Aided Design
CN	Curve Number
CSRS	Chief Science Research Specialist
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DOST	Department of Science and Technology
DPPC	Data Pre-Processing Component
DREAM	Disaster Risk and Exposure Assessment for Mitigation [Program]
DRRM	Disaster Risk Reduction and Management
DSM	Digital Surface Model
DTM	Digital Terrain Model
DVBC	Data Validation and Bathymetry Component
FMC	Flood Modeling Component
FOV	Field of View
GiA	Grants-in-Aid
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HC	High Chord
IDW	Inverse Distance Weighted [interpolation method]
IMU	Inertial Measurement Unit
kts	knots
LAS	LiDAR Data Exchange File format
LC	Low Chord
LGU	local government unit
LiDAR	Light Detection and Ranging
LMS	LiDAR Mapping Suite
m AGL	meters Above Ground Level
MIT	Mapua Institute of Technology
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
UPC	University of the Philippines Cebu
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 PANSIPIT 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 in 2014 entitled "Nationwide Hazard Mapping using LiDAR" 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).

The implementing partner university for the Phil-LiDAR 1 Program is the Mapua Institute of Technology (MIT). MIT 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 Intramuros in Manila.

1.2 Overview of the Pansipit River Basin

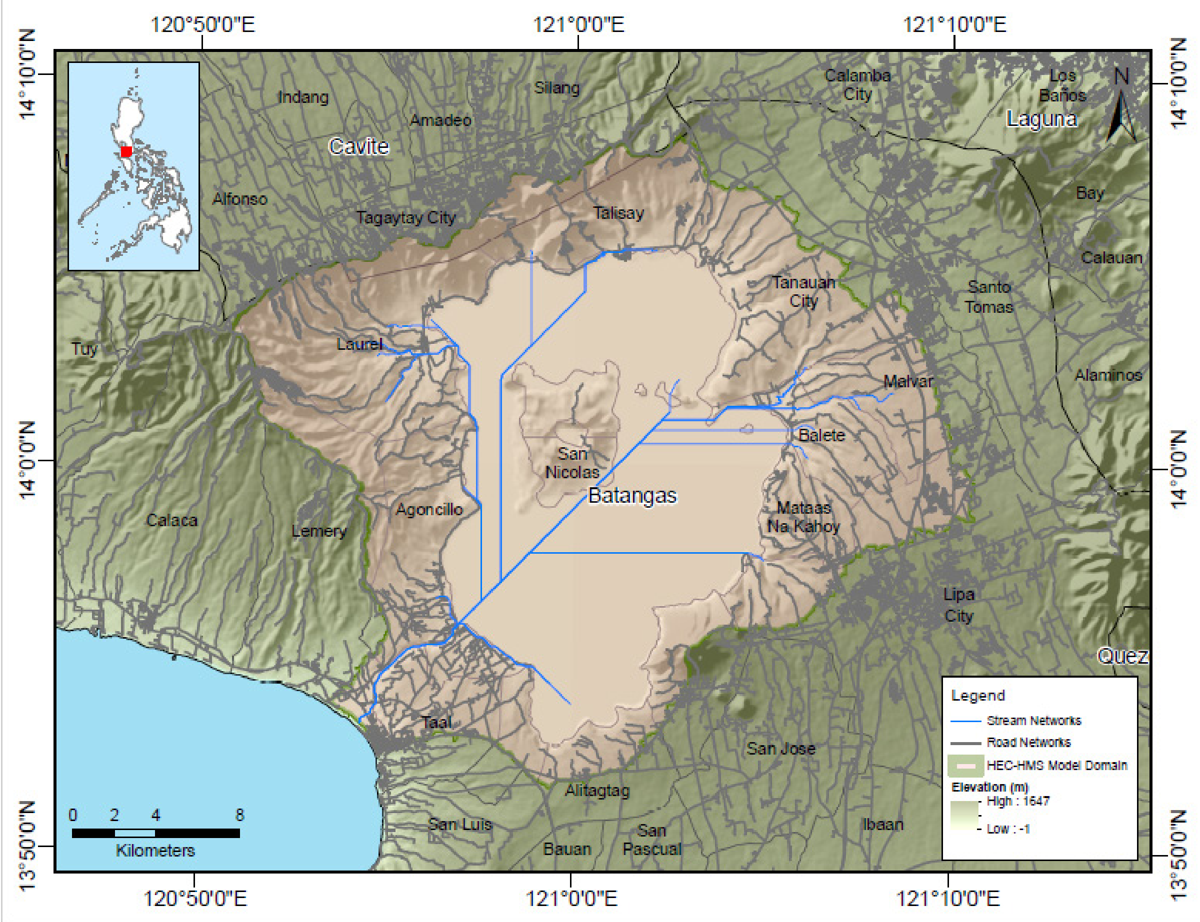


Figure 1. Overview of Pansipit River Basin (in brown)

The Pansipit River Basin is one of the major river networks in the Province of Batangas. This network of tributaries discharge to the Taal Lake and drains through the Pansipit River along the municipalities of San Nicolas, Agoncillo, and Taal to the Philippine Sea. The Taal Lake in this watershed was once part of the ocean hundreds of years ago. A series of eruptions from the Taal volcano covered the area, isolating it from the ocean and creating the lake that is now one of the country's most popular destinations. The river basin helps immensely in the agricultural industry of the municipalities and nearby cities around it and also offers an abundant source of aquatic resources from the lake and a supply of water for the people, their rice fields, and crops.

The river basin is a frequent pathway of severe typhoons and, because of this, flooding is a perennial problem in the nearby municipalities and surrounding municipalities. It is especially hazardous for the downstream area of the river in the municipalities of Lemery and Taal. In 2014, Typhoon Glenda flooded the downstream area, destroying a lot of crops and properties, and left the city littered with debris.

In order to prevent or at least minimize the effects of the flooding for the people and crops in the river basin, a combination of several technologies have been employed to produce a flood hazard map. 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, werealso used as inputs for the river hydraulic model. The final output for these processes was the flood hazard maps of the floodplain, one that the local government units (LGUs) can benefit from.

CHAPTER 2: LIDAR DATA ACQUISITION OF THE PANSIPIT FLOODPLAIN

Engr. Louie P. Balicanta, Engr. Christopher Cruz, Lovely Gracia Acuña, Engr. Gerome Hipolito, Ms. Pauline Joanne G. Arceo, and Engr. Gef F. Soriano

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

2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Pansipit floodplain in Batangas. These missions were planned for 12 lines that run for at most three (3) hours including take-off, landing and turning time. The flight planning parameters for Gemini and Pegasus LiDAR systems are found in Table 1 and Table 2, respectively. Figure 2 shows the flight plan for Pansipit floodplain.

Table 1. Flight planning parameters for Gemini 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)
BLK18SB	1000	30	40	100	20	130	5
BLK18SC	1000	30	40	100	20	130	5
BLK18SD	750	30	50	166	40	130	5
BLK18SF	1000	30	40	100	50	130	5
BLK18SG	1000	30	40	100	20	130	5
BLK18SJ	750	40	40	167	50	130	5
BLK18SK	750	30	50	166	40	130	5
BLK18SM	850	30	40	125	50	130	5

Table 2. 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)
BLK18X	1000	30	50	200	30	130	5
BLK18OS	1000	30	50	200	30	130	5

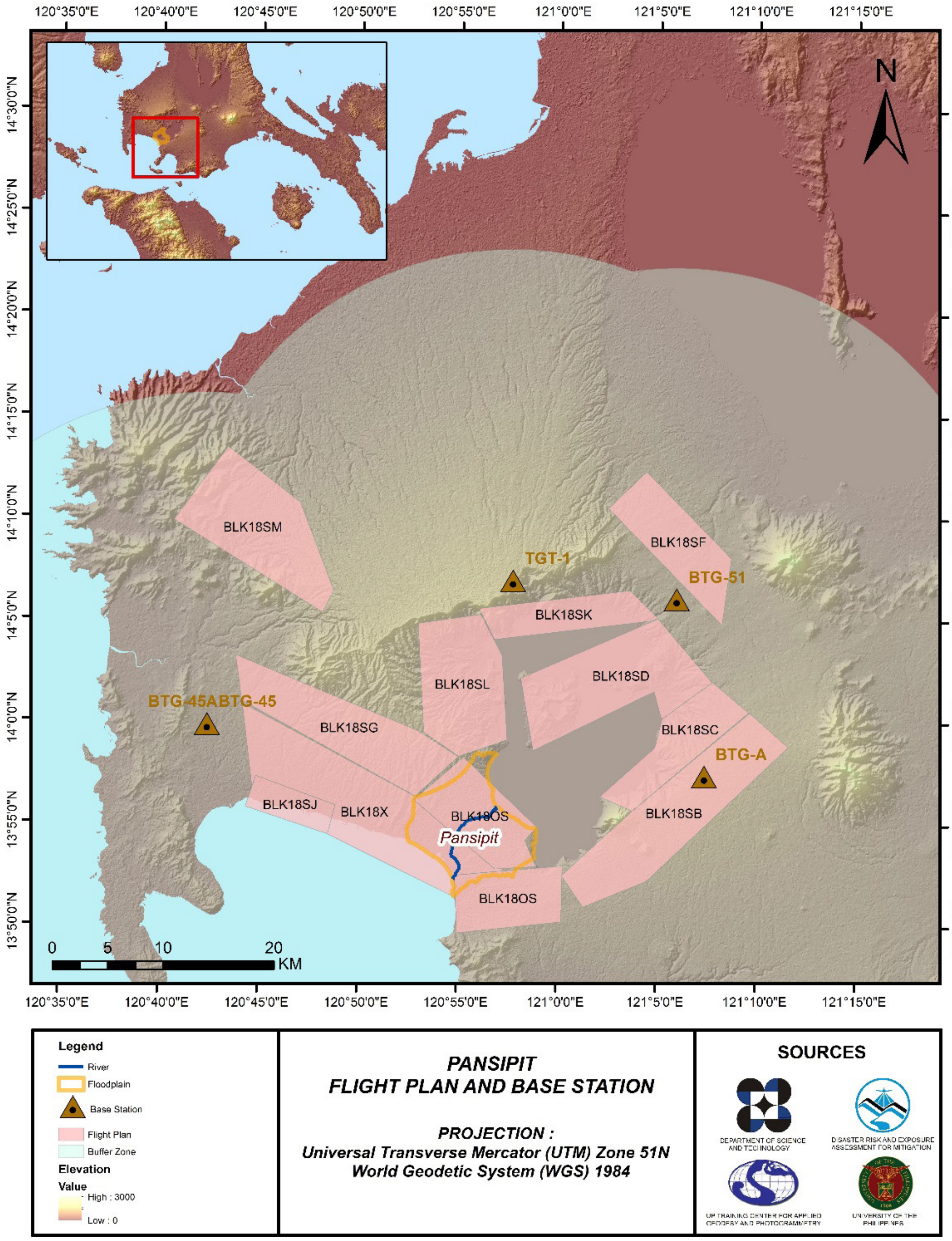
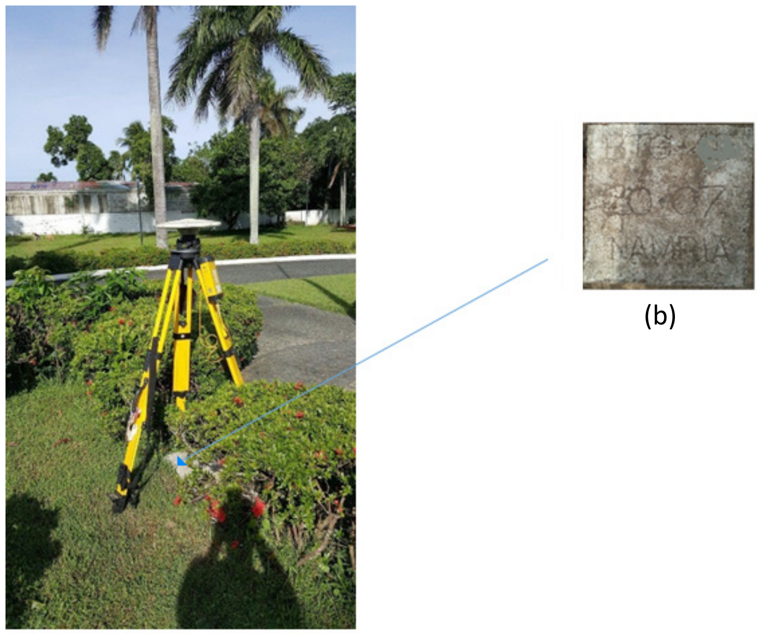


Figure 2. Flight plans and base stations used for Pansipit floodplain

2.2 Ground Base Stations

The project team was able to recover three (3) NAMRIA ground control points: BTG-51, BTG-30, and BTG-45, which are of second (2nd) order accuracy. The project team also established four (4) ground control points: BTG-30A, BTG-45A, BTG-A and TGT-1. The certifications for the NAMRIA base stations 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 22, 2014, SEPTEMBER 3, 2016, and DECEMBER 29, 2015 – JANUARY 8, 2016). 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 Pansipit floodplain are shown in Figure 2.

Figure 3 and Figure 4 show the recovered NAMRIA reference point within the area. In addition, Table 3 to Table 9 show the details about the following NAMRIA reference point and established points, while Table 10 shows the list of all ground control points occupied during the acquisition together with the dates they are utilized during the survey.



(b)

(a)

Figure 3. GPS set-up over BTG-51 inside the vicinity of Mabini Shrine in Brgy, Talaga, Tanuan City, Batangas (a) NAMRIA reference point BTG-51 (b) as recovered by the field team

Table 3. Details of the recovered NAMRIA horizontal control point BTG-51 used as base station for the LiDAR Acquisition

Station Name	BTG-51	
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° 06' 8.57112" North 121° 05' 52.31002 "East 152.36900 meters
Grid Coordinates Philippine Transverse Mercator Zone 5 (PTM Zone 3 PRS 92)	Easting Northing	510567.544 meters 1559501.067 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	14° 06' 3.27790" North (b) 121° 05' 57.24592" East 197.55100 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	1559783.81 meters 294641.94 meters

Figure 4. GPS set-up over BTG-45 inside Santiago De Guzman Elementary School of Brgy. Malibu, Tuy, Batangas Province (a) and NAMRIA reference point BTG-45 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point BTG-45 used as base station for the LiDAR Acquisition

Station Name	BTG-45	
Order of Accuracy	2^{nd}	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	13° 59’ 52.18294” North 120° 42’ 18.96476” East 48.43000 meters
Grid Coordinates Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	468159.677 meters 1547952.281 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 59’ 46.88216” North 120° 42’ 23.91169” East 92.94300 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	252125.62 meters 1548591.80 meters

Table 5. 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	2^{nd}	
Relative Error (horizontal positioning)	1 in 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 PRS 1992)	Easting Northing	290477.094 meters 1521536.181 meters

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

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' 22.92484" North 121° 3' 43.84397" East 7.896 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	290476.321 meters 1521531.468 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 45' 17.72826" North 121° 3' 48.80985" East 53.950 meters

Table 7. Details of the recovered NAMRIA horizontal control point BTG-A used as base station for the LiDAR Acquisition

Station Name	BTG-A	
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' 27.65020" North 121° 7' 18.59698 " East 373.826 meters
Grid Coordinates Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	297103.192 meters 1543753.102 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 57' 22.39320" North 121° 7' 23.54499" East 419.466 meters

Table 8. Details of the recovered NAMRIA horizontal control point TGT-1 used as base station for the LiDAR Acquisition

Station Name	TGT-1	
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° 07' 00.06528" North 120° 57' 38.31871 " East 613.37000 meters
Grid Coordinates Philippine Transverse Mercator Zone 5 (PTM Zone 3 PRS 92)	Easting Northing	279835.821 meters 1561490.819 meters

Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	14° 06’ 54.75787” North 120° 57’ 43.25375” East 93.60200 meters

Table 9. Details of the established ground control point BTG-45A used as base station for the LiDAR Acquisition

Station Name	BTG-45A	
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° 59’ 51.95603” North 120° 42’ 18.98286 ” East 49.08900 meters
Grid Coordinates Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92)	Easting Northing	252126.100 meters 1548584.818 meters
Geographic Coordinates World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	13° 59’ 46.65526” North 120° 42’ 23.92980” East 93.60200 meters

Table 10. Ground control points used during LiDAR data acquisition.

Date Surveyed	Flight Number	Mission Name	Ground Control Points
February 22, 2014	1139P	1BLK18X53A	BTG-45, BTG-45A
September 5, 2016	3373P	1BLK18OS246A	BTG-30, BTG-30a
December 29, 2015	3671G	2BLK18SBC363B	BTG-51, BTG-A
December 30, 2015	3673G	2BLK18S364A	BTG-51, BTG-A
January 6, 2016	3677G	2BLK18SK006A	BTG-51, BTG-A
January 6, 2016	3679G	2BLK18SD006B	BTG-51, BTG-A
January 8, 2016	3685G	2BLK18SGS008A	BTG-51, BTG-A
January 8, 2016	3687G	2BLK18SGS008B	BTG-51, BTG-A
January 9, 2016	3691G	2BLK18V3009B	BTG-51, BTG-A
January 16, 2016	3693G	2BLK18SCB106A	BTG-51, TGT-1

2.3 Flight Missions

Ten (10) missions were conducted to complete the LiDAR Data Acquisition in Pansipit Floodplain, for a total of twenty seven hours and thirty three minutes (27+33) of flying time for RP-C9022 and RP-C9122. All missions were acquired using the Pegasus and Gemini LiDAR systems. Table 11 shows the total area of actual coverage and the corresponding flying hours per mission, while Table 12 presents the actual parameters used during the LiDAR data acquisition.

Table 11. Flight Missions for LiDAR Data Acquisition in Pansipit Floodplain

Date Surveyed	Flight Number	Flight Plan Area (km^2)	Surveyed Area (km^2)	Area Surveyed within the Floodplain (km^2)	Area Surveyed Outside the Floodplain (km^2)	No. of Images (Frames)	Flying Hours	
							Hr	Min
February 22, 2014	1139P	169.68	269.50	42.01	227.49	472	3	56
September 5, 2016	3373P	107.08	162.36	61.40	100.96	NA	3	28
December 29, 2015	3671G	52.75	68.65	-	68.65	NA	1	58
December 30, 2015	3673G	354.42	363.82	2.78	361.04	NA	3	29
January 6, 2016	3677G	145.18	160.74	-	160.74	NA	2	17
January 6, 2016	3679G	21.88	27.25	-	27.25	NA	2	17
January 8, 2016	3685G	152.31	197.06	3.53	193.54	NA	3	41
January 8, 2016	3687G	189.94	127.71	3.61	124.10	NA	2	59
January 9, 2016	3691G	83.76	56.32	6.51	49.81	NA	2	23
January 16, 2016	3693G	52.75	49.11	-	49.11	NA	1	5
TOTAL		1329.75	1482.52	119.84	1362.69	472	27	33

Table 12. Actual Parameters used during LiDAR Data Acquisition

Flight Number	Flying Height (m AGL)	Overlap (%)	FOV (θ)	PRF (khz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
1139P	1200	30	50	200	30	130	5
3373P	1000	30	50	200	30	130	5
3671G	1000	30	40	100	20	130	5
3673G	1000	30	40	100	20	130	5
3677G	750	30	50	166	40	130	5
3679G	750	40	40	167	50	130	5
3685G	1000	30	40	100	50	130	5
3687G	1000	40	40	100	50	130	5
3691G	850	30	40	125	50	130	5
3693G	850	30	40	125	50	130	5

2.4 Survey Coverage

Pansipit Floodplainis located in the province of Batangas. The municipalities of Agoncillo, Mataas Na Kahoy, San Nicolas, Taal, Santa Teresita, Balete, Lemery, Alitagtag, and Laurel was fully covered during the survey. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 13. The actual coverage of the LiDAR acquisition for Pansipit Floodplain is presented in Figure 5.

Table 13. List of Municipalities/Cities Surveyed during Pansipit Floodplain LiDAR survey

Province	Municipality/City	Area of Municipality/ City (km²)	Total Area Surveyed (km²)	Percentage of Area Surveyed
Batangas	Agoncillo	39.54	39.54	100%
	Mataas Na Kahoy	17.59	17.59	100%
	San Nicolas	18.15	18.15	100%
	Taal	29.37	29.37	100%
	Santa Teresita	12.67	12.66	100%
	Balete	22.02	21.80	99%
	Lemery	82.32	71.26	87%
	Alitagtag	27.03	22.29	82%
	Laurel	69.53	56.47	81%
	Calaca	117.85	92.04	78%
	Cuenca	27.91	21.65	78%
	San Luis	42.04	27.94	66%
	Tanauan City	111.77	70.98	64%
	Talisay	49.78	28.26	57%
	Malvar	35.93	19.28	54%
	Taal lake	241.24	117.49	49%
	Balayan	94.45	42.30	45%
	Tuy	92.55	37.29	40%
	Lipa City	202.79	55.96	28%
	San Jose	60.70	15.54	26%
	Lian	91.27	16.49	18%
	Santo Tomas	92.08	10.11	11%
	Nasugbu	266.83	20.94	8%
	Bauan	51.31	3.40	7%
Cavite	Maragondon	147.39	51.64	35%
	Magallanes	69.07	18.65	27%
	General Emilio Aguinaldo	39.39	10.44	26%
	Naic	76.11	16.55	22%
	Tagaytay City	61.41	8.57	14%
	Indang	88.65	3.60	4%
	Silang	154.00	2.60	2%
Laguna	Calamba City	130.68	26.57	20%
	Cabuyao	45.70	1.22	3%
Total		2709.12	1008.64	37.23%

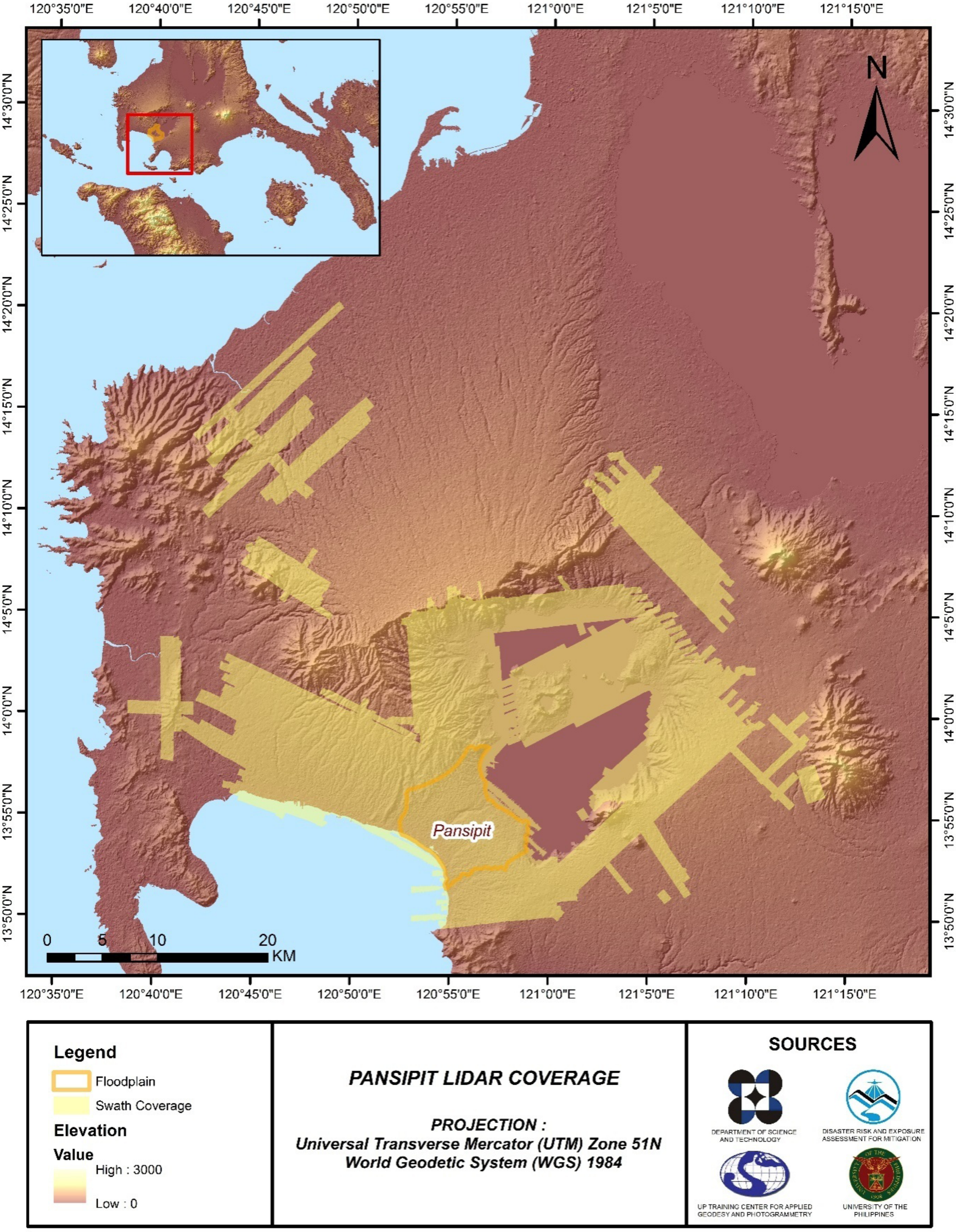


Figure 5. Actual LiDAR survey coverage for Pansipit floodplain

CHAPTER 3: LIDAR DATA PROCESSING FOR PANSIPIT FLOODPLAIN

Engr. Ma. Rosario Concepcion O. Ang, Engr. John Louie D. Fabila, Engr. Sarah Jane D. Samalburo , Engr. Joida F. Prieto , Engr. Melissa F. Fernandez , Engr. Ma. Ailyn L. Olanda, Engr. Sheila-Maye F. Santillan, Engr. Velina Angela S. Bemida , Engr. Ezzo Marc C. Hibionada, and Ziarre Anne P. Mariposa

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 LiDAR Data Processing for Pansipit Floodplain

3.1.1 Overview of the LiDAR Date Pre-Processing

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 6.

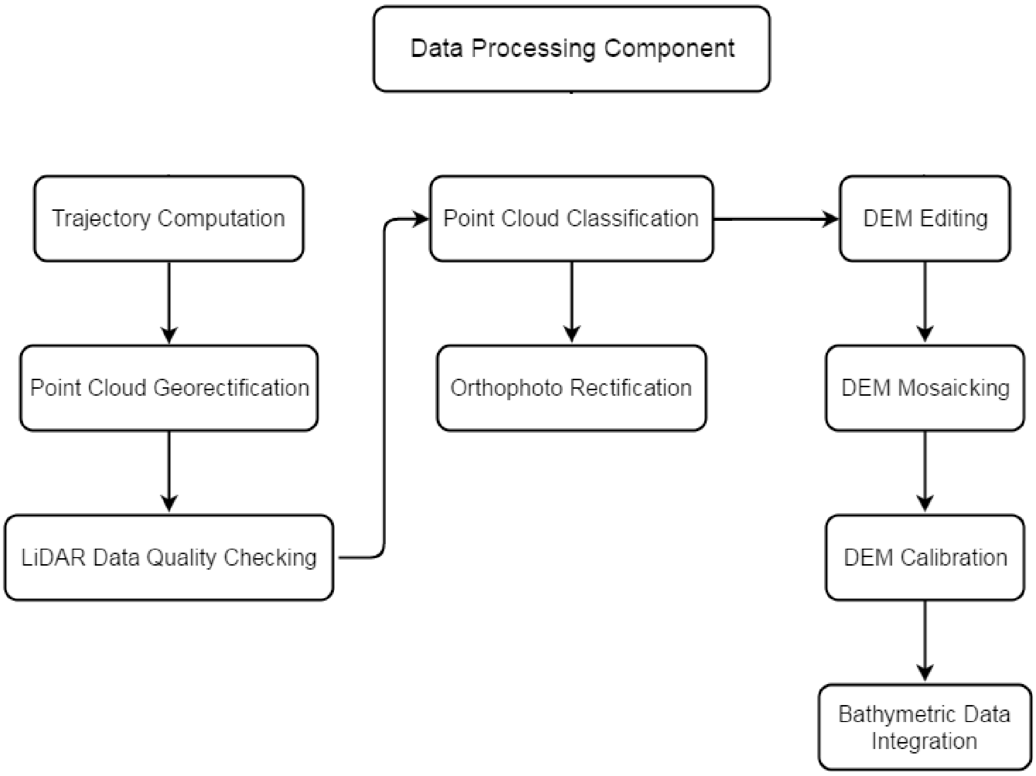


Figure 6.Schematic Diagram for Data Pre-Processing Component

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Pansipit floodplain can be found in Annex 5. Missions flown during the first survey conducted on September 2015used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system while missions acquired during the second survey on December 2015 were flown using the Gemini system over CALABARZON. The Data Acquisition Component (DAC) transferred a total of 171.22 Gigabytes of Range data, 1.58 Gigabytes of POS data, 150.66 Megabytes of GPS base station data, and 29.3 Gigabytes of raw image data to the data server on September 3, 2015 for the first survey and December 29, 2015 for the second survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Pansipit was fully transferred on January 20, 2016, as indicated on the Data Transfer Sheets for Pansipit floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 3687G, one of the Pansipit flights, which is the North, East, and Down position RMSE values are shown in Figure 7. 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 onJanuary 8, 2016 00:00AM. The y-axis is the RMSE value for that particular position.

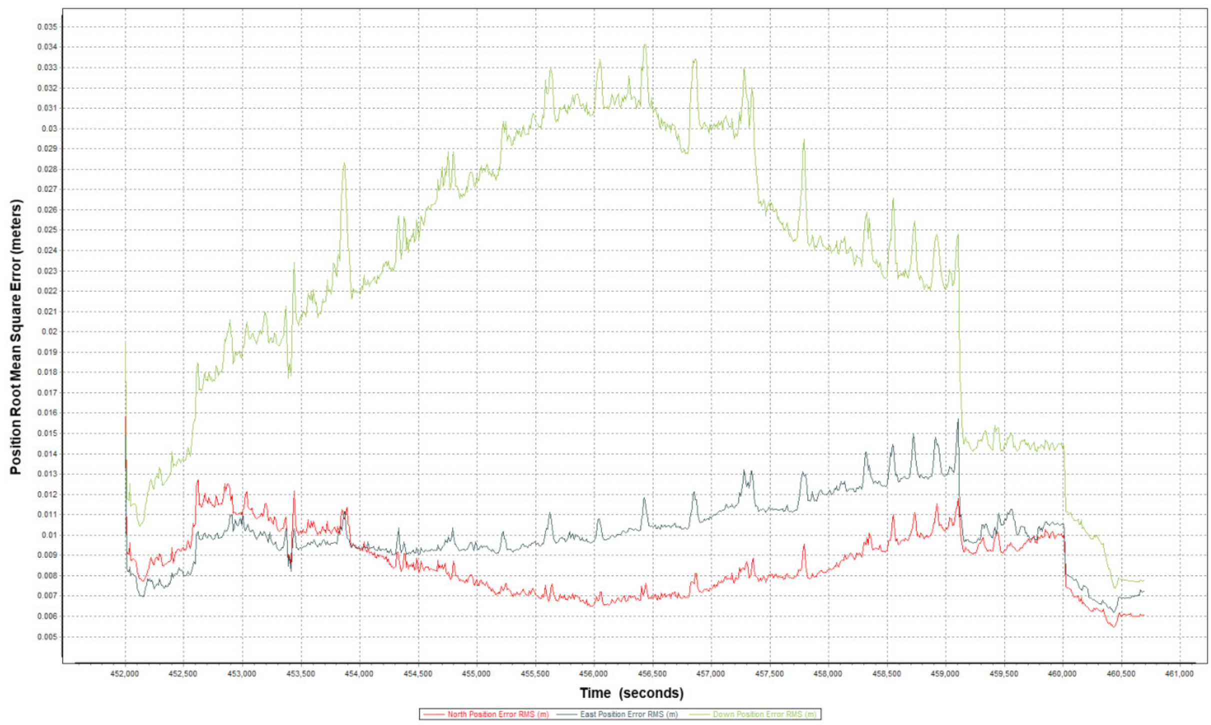


Figure 7. Smoothed Performance Metrics of Pansipit Flight 3687G

The time of flight was from 452000 seconds to 461000 seconds, which corresponds to afternoon of January 8, 2016. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 7 shows that the North position RMSE peaks at 1.30 centimeters, the East position RMSE peaks at 1.60 centimeters, and the Down position RMSE peaks at 3.40 centimeters, which are within the prescribed accuracies described in the methodology.

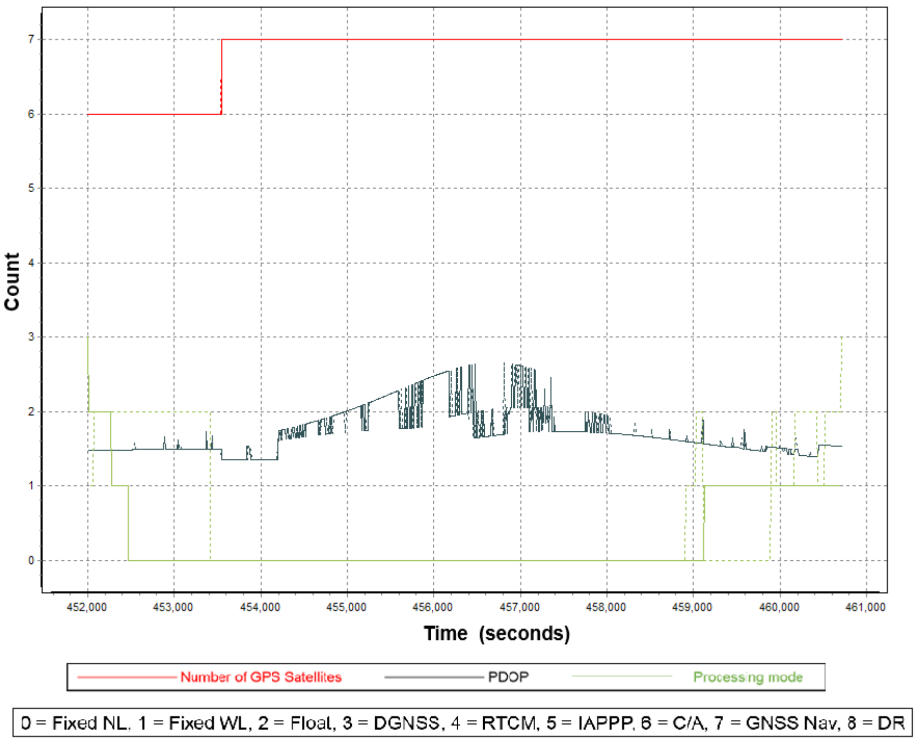


Figure 8. Solution Status Parameters of Pansipit Flight 3687G

The Solution Statusparameters of flight 3687G, one of the Pansipitflights, which indicate the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 8. The graphs indicate that the number of satellites during the acquisition did go down to 6. Most of the time, the number of satellites tracked was between 6 and 7.2.The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode remained at 0 for majority of the survey with some peaks up to 1 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 Pansipit flights is shown in Figure 9.

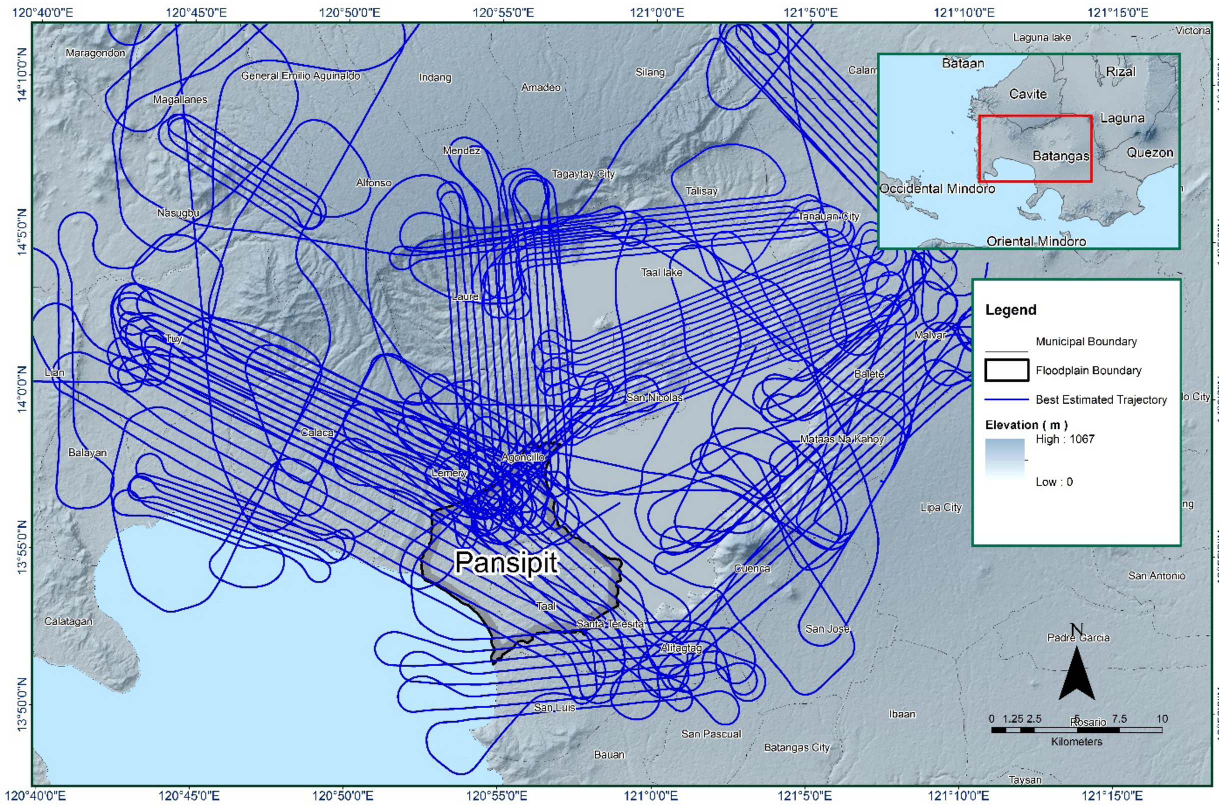


Figure 9. The best estimated trajectory of the LiDAR missions conducted over the Pansipit floodplain

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 127flight lines, with each flight line containing one channel, since the Gemini system contain one channel only and 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 Pansipit floodplain are given in Table 14.

Table 14. Self-Calibration Results values for Pansipit flights

Parameter	Acceptable Value	Computed Value
Boresight Correction stdev	(<0.001degrees)	0.000888
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.000938
GPS Position Z-correction stdev	(<0.01meters)	0.0097

Optimum accuracy was obtained for all Pansipit flights, based on the computed standard deviations of the corrections of the orientation parameters. The standard deviation values for the individual blocks are available in Annex 8: Mission Summary Reports.

3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data is shown in Figure 10. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

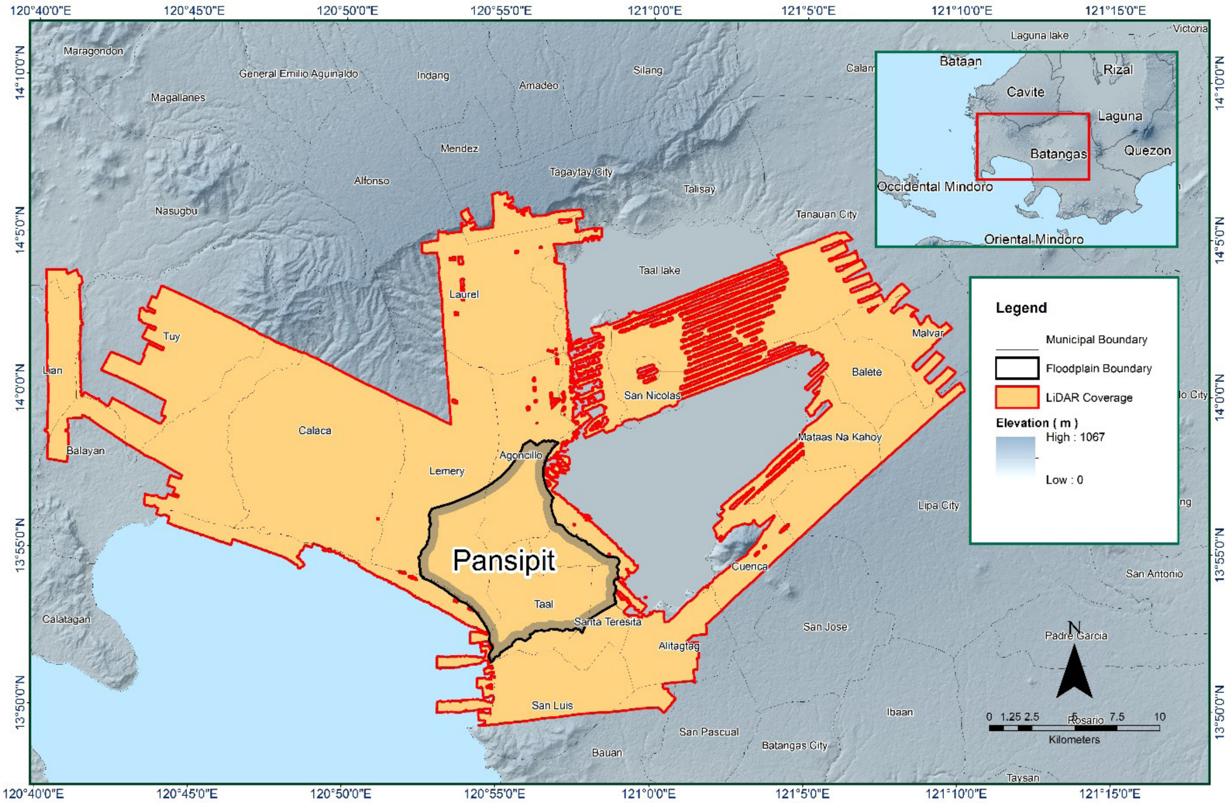


Figure 10. Boundary of the processed LiDAR data on top of a SAR Elevation Data over Pansipit Floodplain.

The total area covered by the Pansipit missions is 902.17 sq.km that is comprised of ten (10) flight acquisitions grouped and merged into twelve (12) blocks as shown in Table 15.

Table 15. List of LiDAR blocks for Pansipit floodplain

LiDAR Blocks	Flight Numbers	Area (sq. km)
CALABARZON_Blk18O_supplement	3373P	157.66
Batangas_Blk18SL	3673G	96.40
Batangas_Blk18SL_additional	3691G	12.00
Batangas_Blk18SGa	3687G	99.64
Batangas_Blk18SGb	3685G	93.64
Batangas_Blk18SG_additional	3679G	30.99
Batangas_Blk18SJ	3679G	25.04
Batangas_Blk18SC	3671G	65.98
Batangas_Blk18SC_supplement	3693G	41.10
Batangas_Blk18SD	3677G	86.28
Batangas_Blk18SK_supplement	3691G	15.37
Batangas_Blk18X	1139P	178.07
TOTAL		**902.17 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 11. Since the Gemini system employs one channel, we would expect an average value of 1 (blue) for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines. While for the Pegasus system which 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.

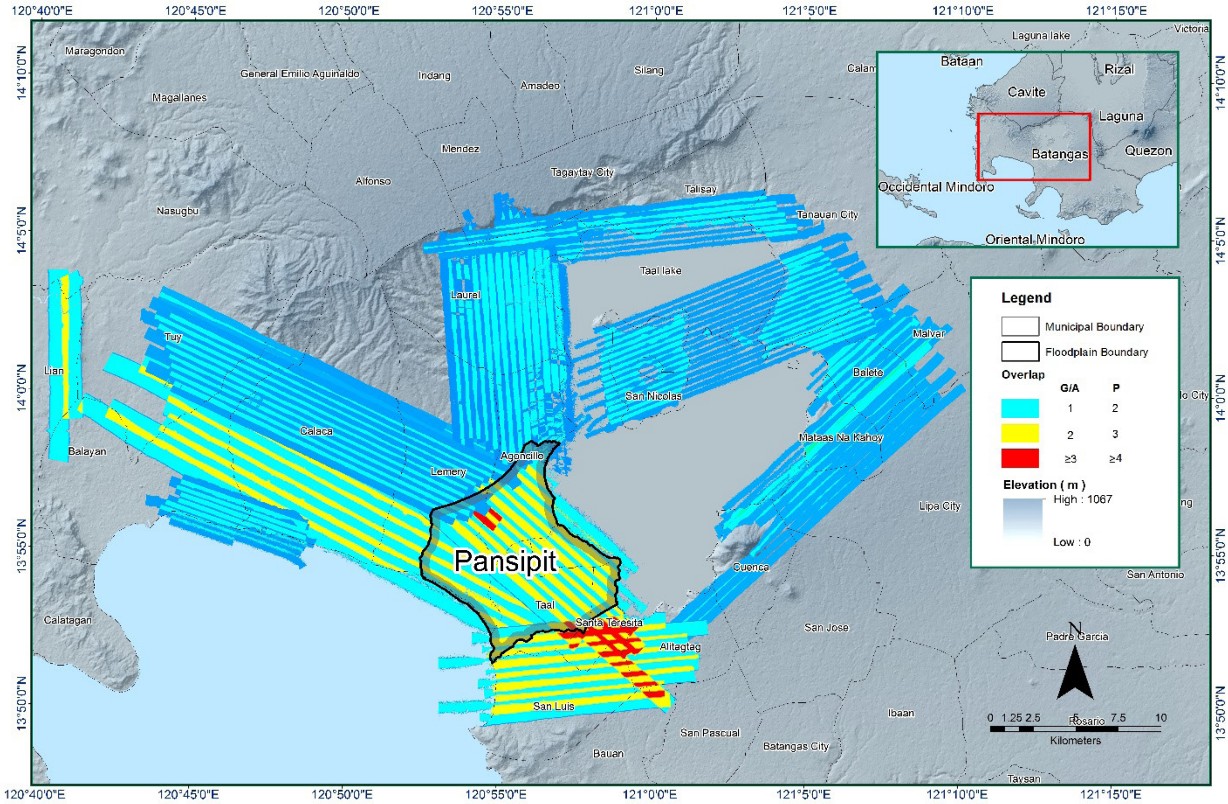


Figure 11. Image of data overlap for Pansipit floodplain

The overlap statistics per block for the Pansipit 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 26.74% and 48.55%respectively, which passed the 25% requirement.

The density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion is shown in Figure 12. It was determined that all LiDAR data for Pansipit floodplain satisfy the point density requirement, and the average density for the entire survey area is 4.33 points per square meter.

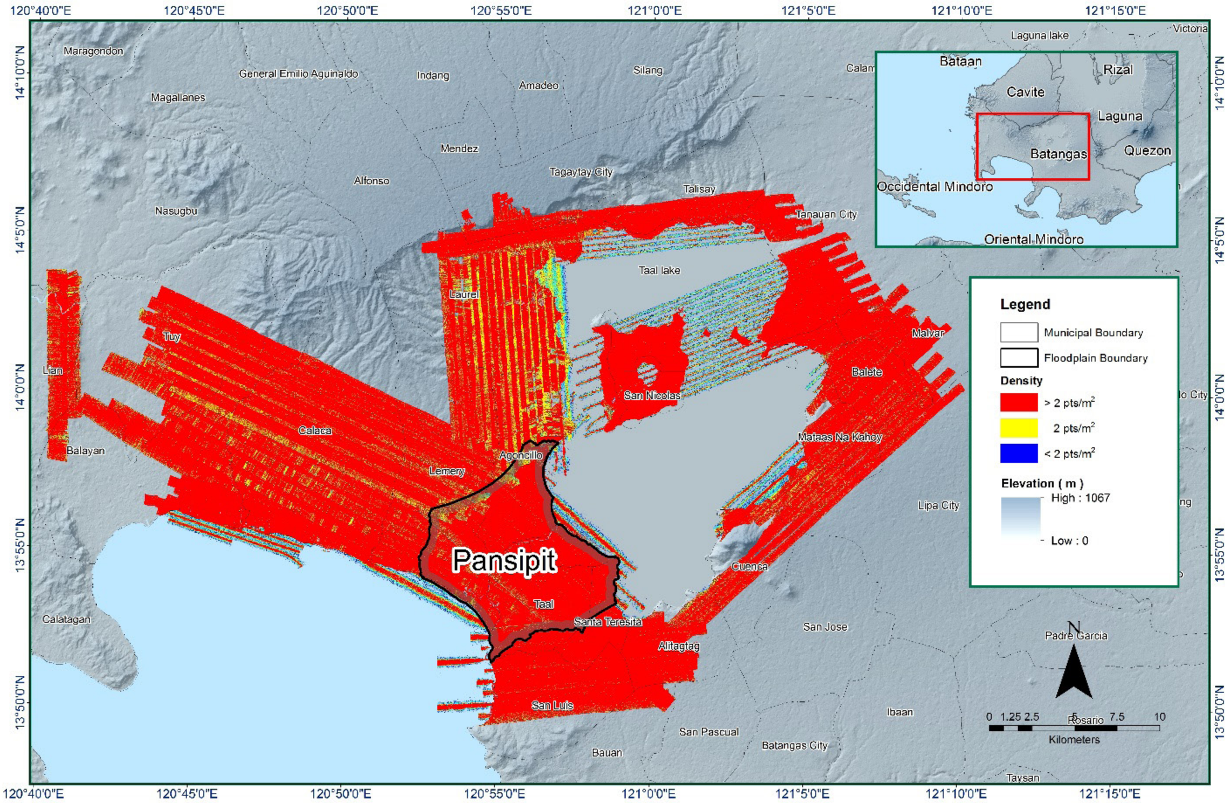


Figure 12. Density map of merged LiDAR data for Pansipit floodplain

The elevation difference between overlaps of adjacent flight lines is shown in Figure 13. 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.

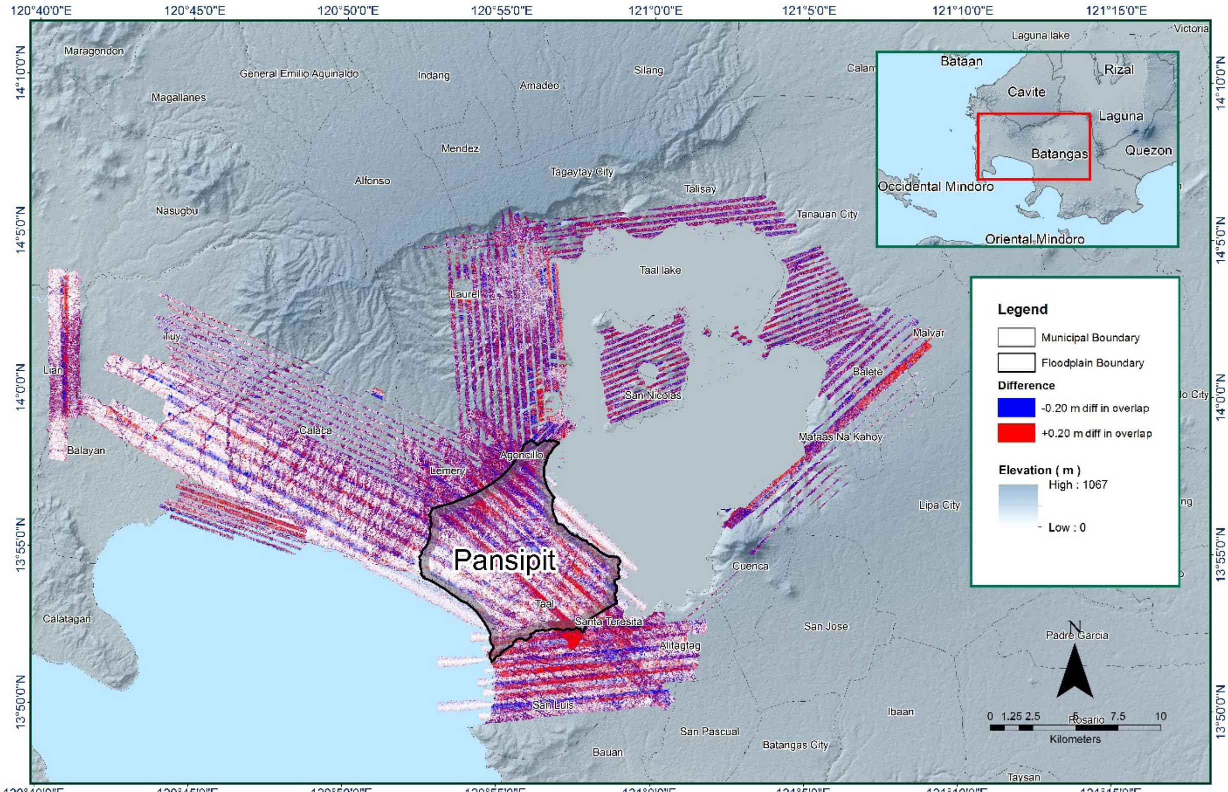


Figure 13. Elevation difference map between flight lines for Pansipit floodplain

A screen capture of the processed LAS data from a Pansipit flight 3687G loaded in QT Modeler is shown in Figure 14. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed yellow 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. reprocessing was done for this LiDAR dataset.

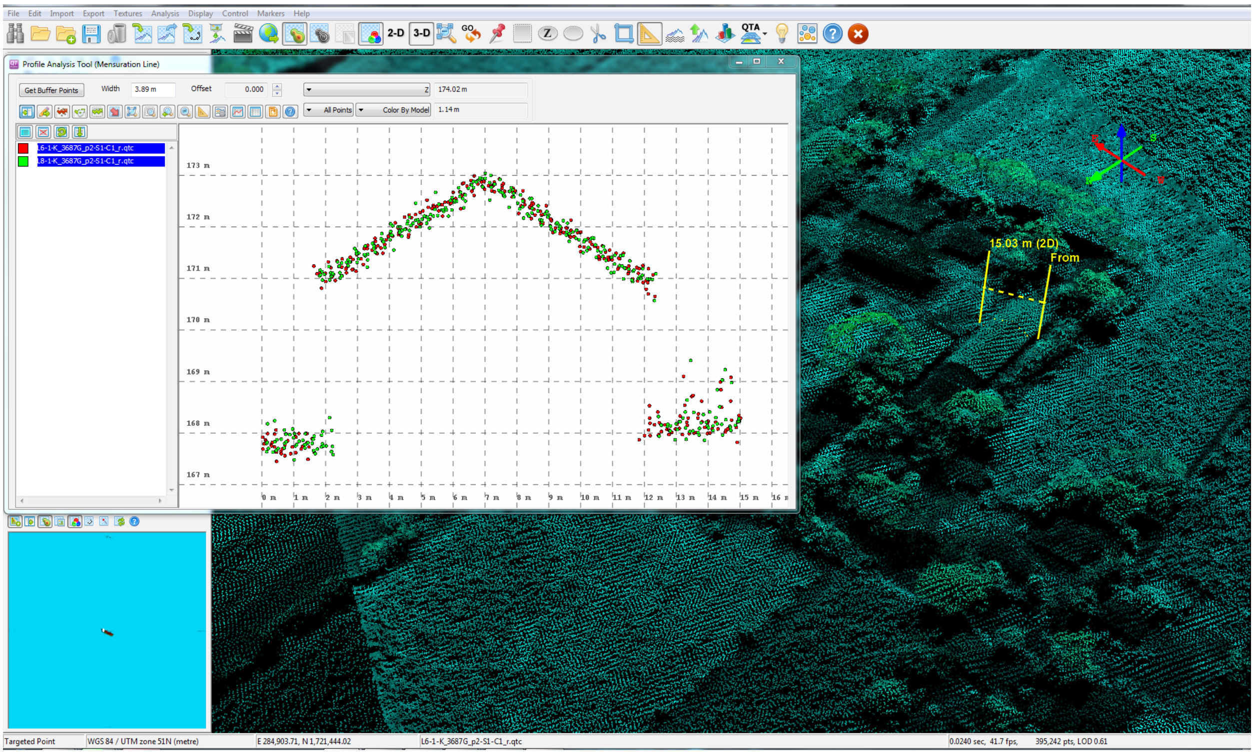


Figure 14. Quality checking for a Pansipit flight 3687G using the Profile Tool of QT Modeler

3.6 LiDAR Point Cloud Classification and Rasterization

Table 16. Pansipit classification results in TerraScan

Pertinent Class	Total Number of Points
Ground	482,346,947
Low Vegetation	1,113,469,615
Medium Vegetation	1,276,470,444
High Vegetation	1,536,245,191
Building	64,144,017

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Pansipit floodplain is shown in Figure 15. A total of 1,380 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 16. The point cloud has a maximum and minimum height of 779.19 meters and 30.39 meters respectively.

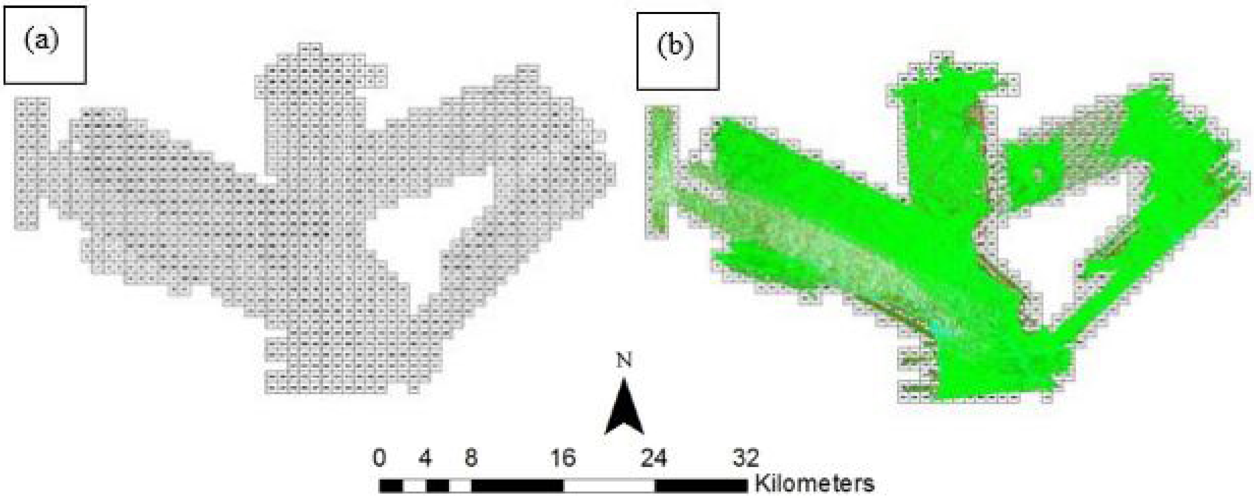


Figure 15. Tiles for Pansipit floodplain (a) and classification results (b) in TerraScan

An isometric view of an area before and after running the classification routines is shown in Figure 16. 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.

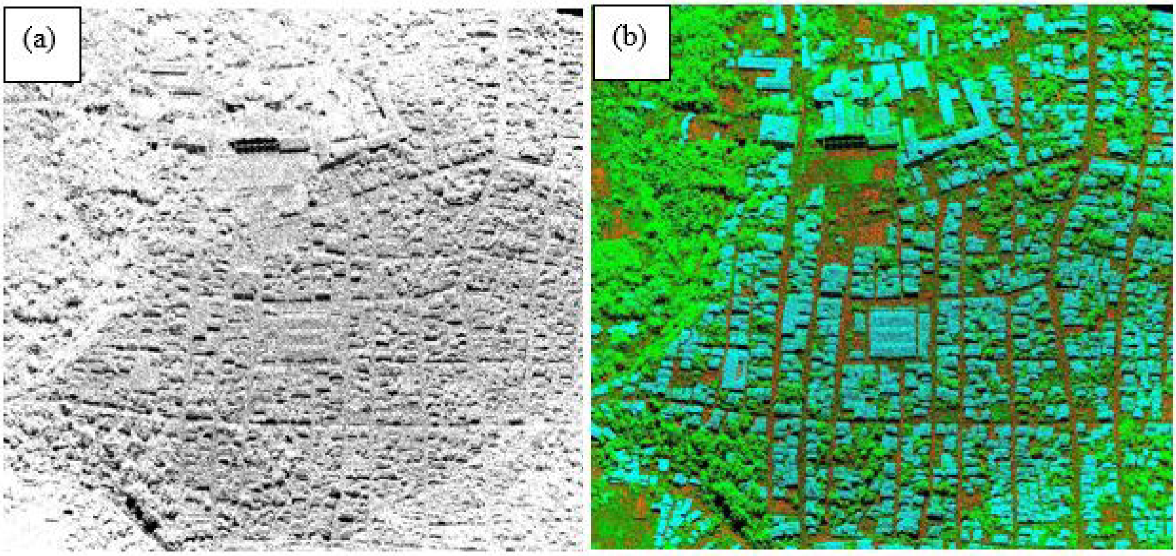


Figure 16. Point cloud before (a) and after (b) classification

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

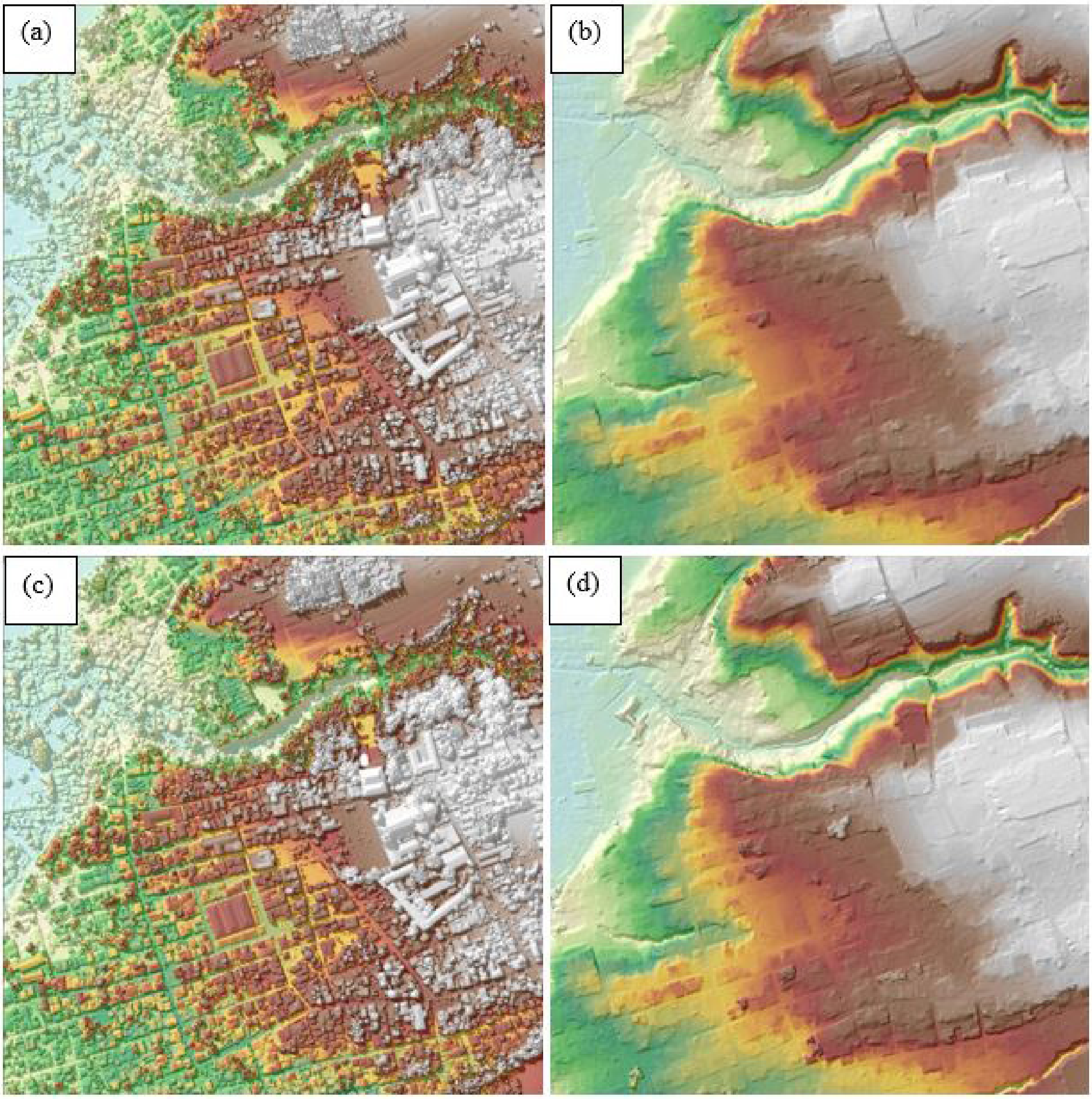


Figure 17. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Pansipit floodplain

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 222 1km by 1km tiles area covered by Pansipit floodplain is shown in Figure 18. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Pansipit floodplain survey attained a total of 173.132 km2 in orthophotogaph coverage, comprised of 324images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 19.

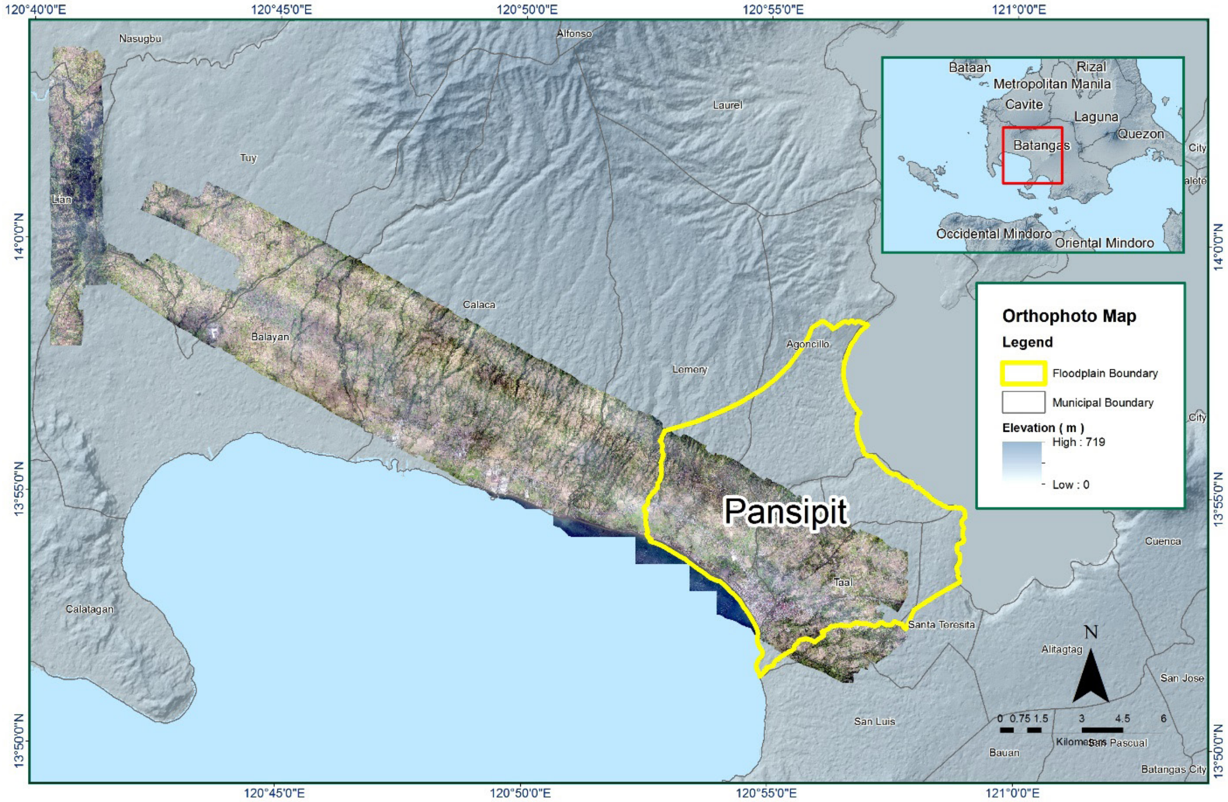


Figure 18. Pansipit floodplain with available orthophotographs

Figure 19. Sample orthophotograph tiles for Pansipit floodplain

3.8 DEM Editing and Hydro-Correction

Twelve (12) mission blocks were processed for Pansipit flood plain. These blocks are composed of CALABARZON and Batangas blocks with a total area of 902.17 square kilometers. Table 17 shows the name and corresponding area of each block in square kilometers.

Table 17. LiDAR blocks with its corresponding area

LiDAR Blocks	Area (sq.km)
CALABARZON_Blk18O_supplement	157.66
Batangas_Blk18SL	96.40
Batangas_Blk18SL_additional	12.00
Batangas_Blk18SGa	99.64
Batangas_Blk18SGb	93.64
Batangas_Blk18SG_additional	30.99
Batangas_Blk18SJ	25.04
Batangas_Blk18SC	65.98
Batangas_Blk18SC_supplement	41.10
Batangas_Blk18SD	86.28
Batangas_Blk18SK_supplement	15.37
Batangas_Blk18X	178.07
TOTAL	**902.17 sq.km**

Portions of DTM before and after manual editing are shown in Figure 20. The bridge (Figure 20a) is also considered to be an impedance to the flow of water along the river and has to be removed (Figure 20b) in order to hydrologically correct the river. The hilly area (Figure 20c) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 20d) to allow the correct flow of water. Another example is a building that is still present in the DTM after classification (Figure 20e) and has to be removed through manual editing (Figure 20f).

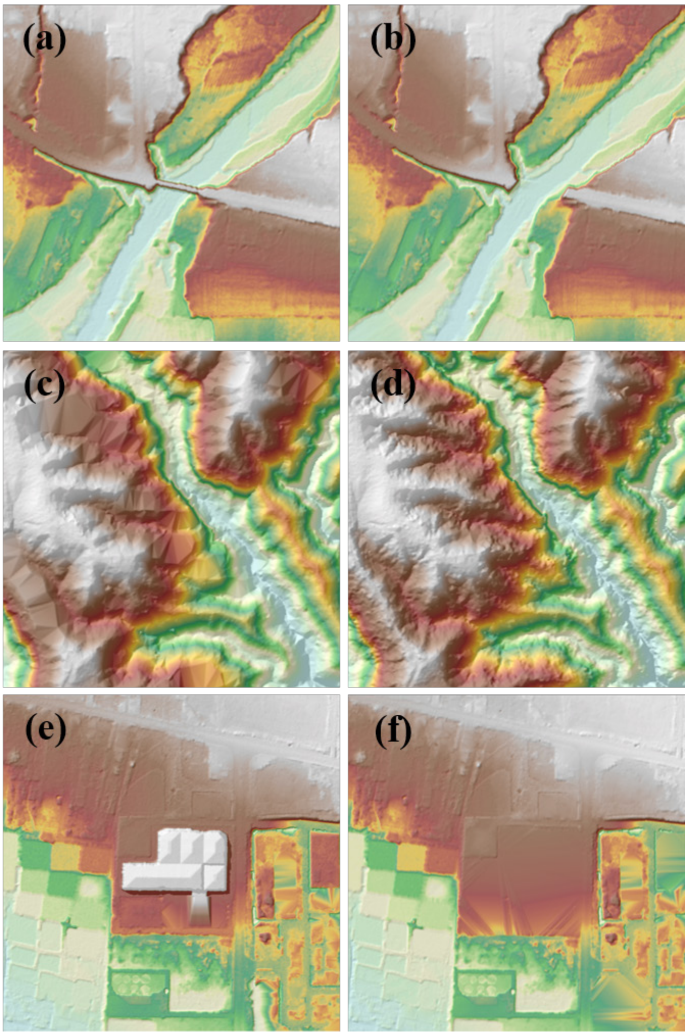


Figure 20. Portions in the DTM of Pansipit floodplain – a bridge before (a) and after (b) manual editing; a hilly area before (c) and after (d) data retrieval; and a building before (e) and after (f) manual editing.

3.9 Mosaicking of Blocks

Batangas_Blk18Z was used as the reference block at the start of mosaicking because it was referred to a base station with an acceptable order of accuracy. Table 18 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Pansipit floodplain is shown in Figure 21. It can be seen that the entire Pansipit floodplain is 99.935% covered by LiDAR data.

Table 18. Shift Values of each LiDAR Block of Pansipit floodplain

Mission Blocks	Shift Values (meters)		
	x	y	z
CALABARZON_Blk18O_supplement	0	0	-2.4
Batangas_Blk18SL	0.00	0.00	0.00
Batangas_Blk18SL_additional	0.00	0.00	0.00
Batangas_Blk18SGa	0.00	0.00	0.00
Batangas_Blk18SGb	-0.65	-3.95	0.00
Batangas_Blk18SG_additional	0.00	0.00	0.00
Batangas_Blk18SJ	0.33	3.04	0.00
Batangas_Blk18SC	0.00	0.00	0.00
Batangas_Blk18SC_supplement	0.00	0.00	0.00
Batangas_Blk18SD	0.00	0.00	0.00
Batangas_Blk18SK_supplement	0.00	0.00	0.00
Batangas_Blk18X	0.00	0.00	0.00

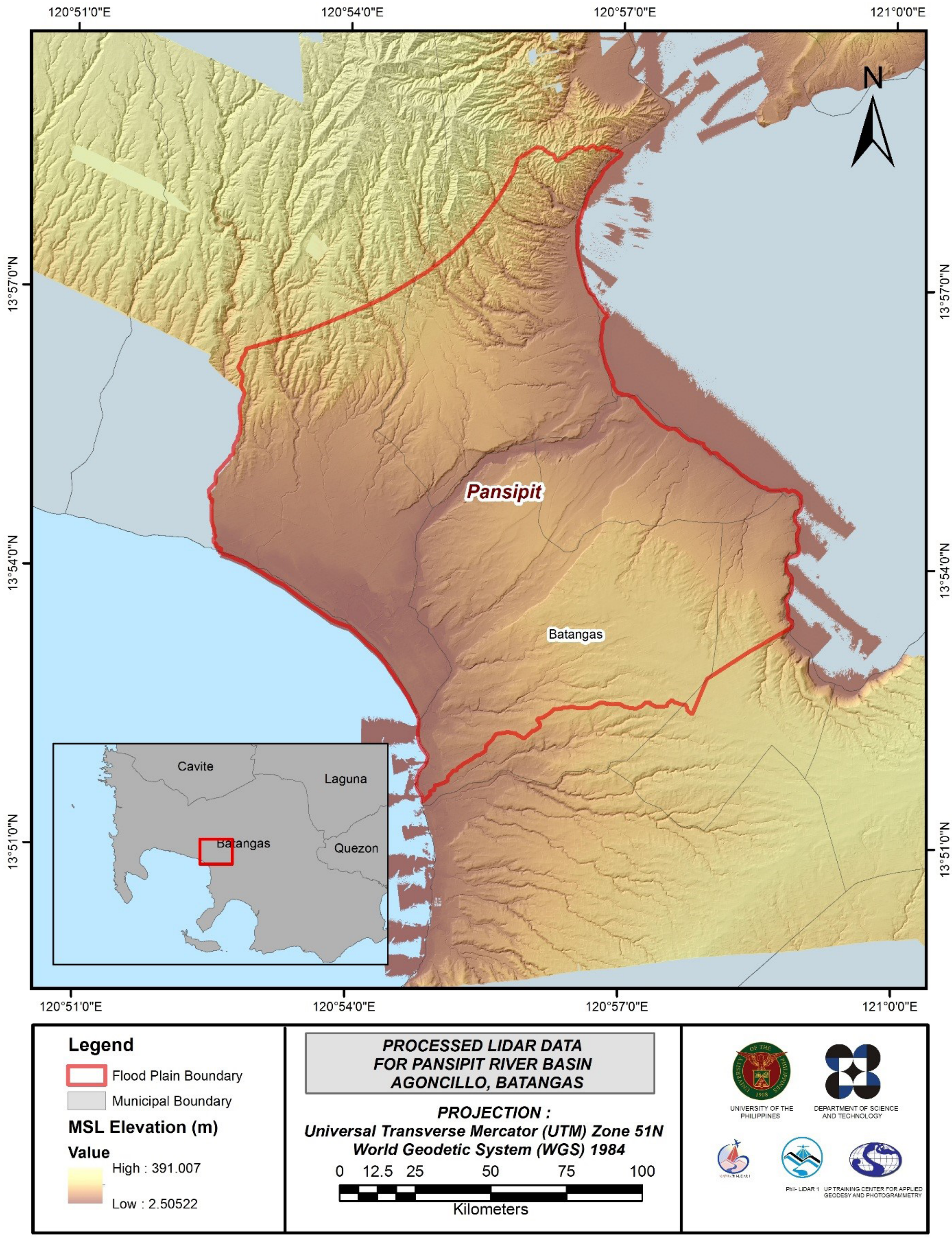


Figure 21. Map of Processed LiDAR Data for Pansipit Flood Plain.

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 Pansipit to collect points with which the LiDAR dataset is validated is shown in Figure 22. A total of 24,251 survey points were gathered for all the flood plains within the provinces of CALABARZON wherein the Pansipit floodplain is located. Random selection of 80% of the survey points, resulting to 19,401 points, was used for calibration.

A good correlation between the uncalibrated mosaicked LiDAR DTM and ground survey elevation values is shown in Figure 23. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration points is 2.97 meters with a standard deviation of 0.20 meters. Calibration of the LiDAR data was done by subtracting the height difference value, 2.97 meters, to the mosaicked LiDAR data. Table 19 shows the statistical values of the compared elevation values between the LiDAR data and calibration data.

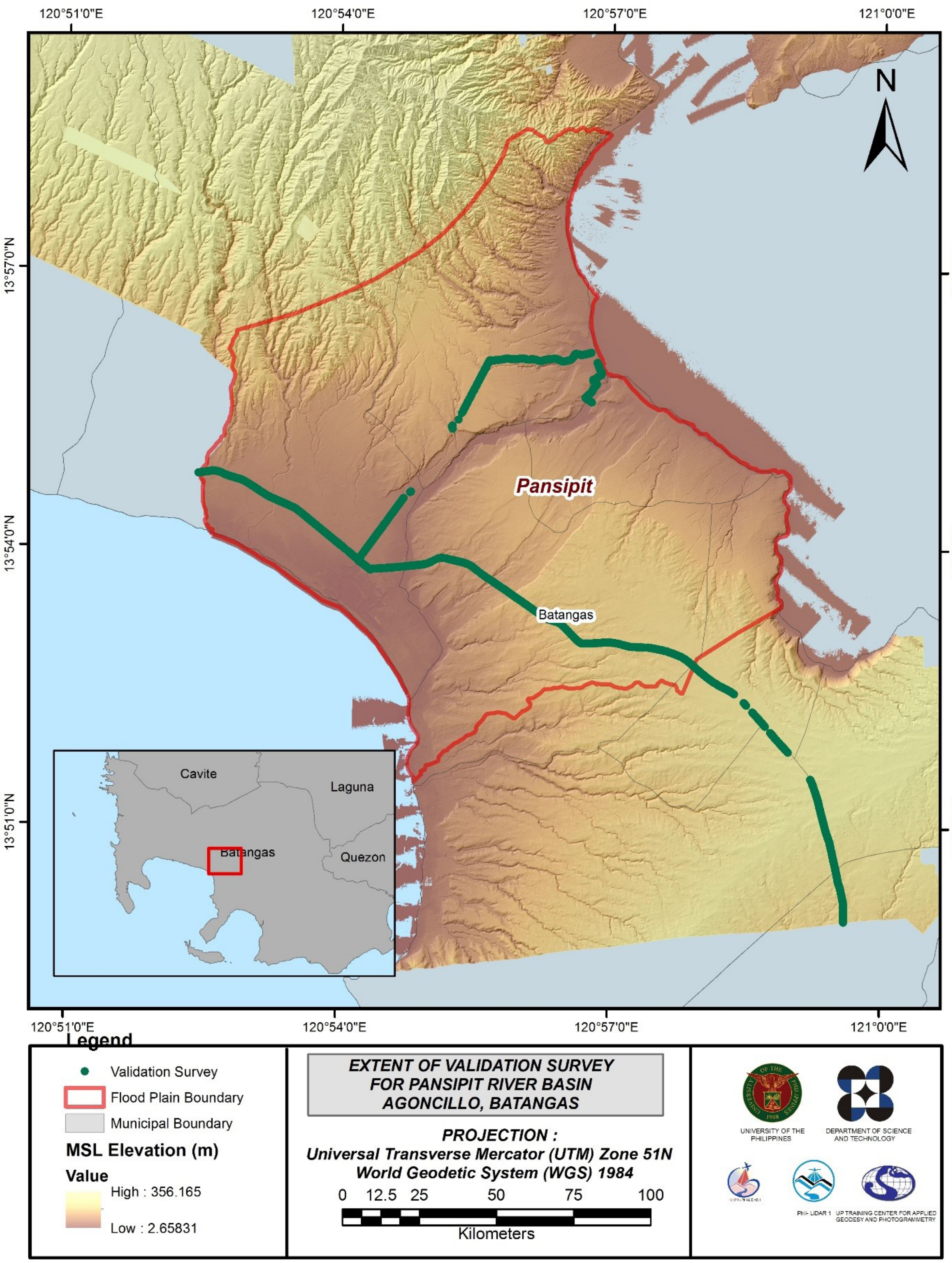


Figure 22. Map of Pansipit Flood Plain with validation survey points in green

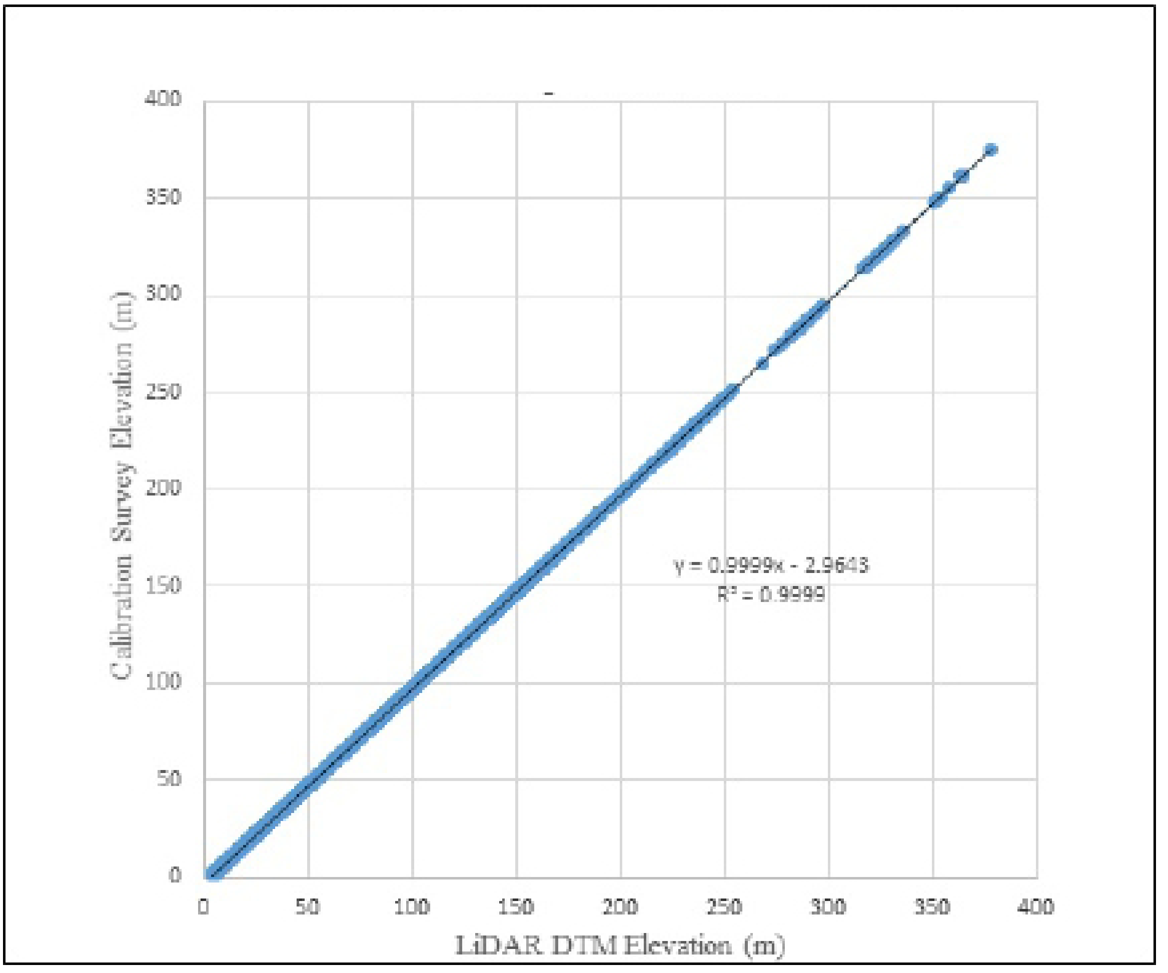


Figure 23. Correlation plot between calibration survey points and LiDAR data

Table 19. 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 330 points, were used for the validation of calibrated Pansipit 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 24. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.11 meters with a standard deviation of 0.11 meters, as shown in Table 19.

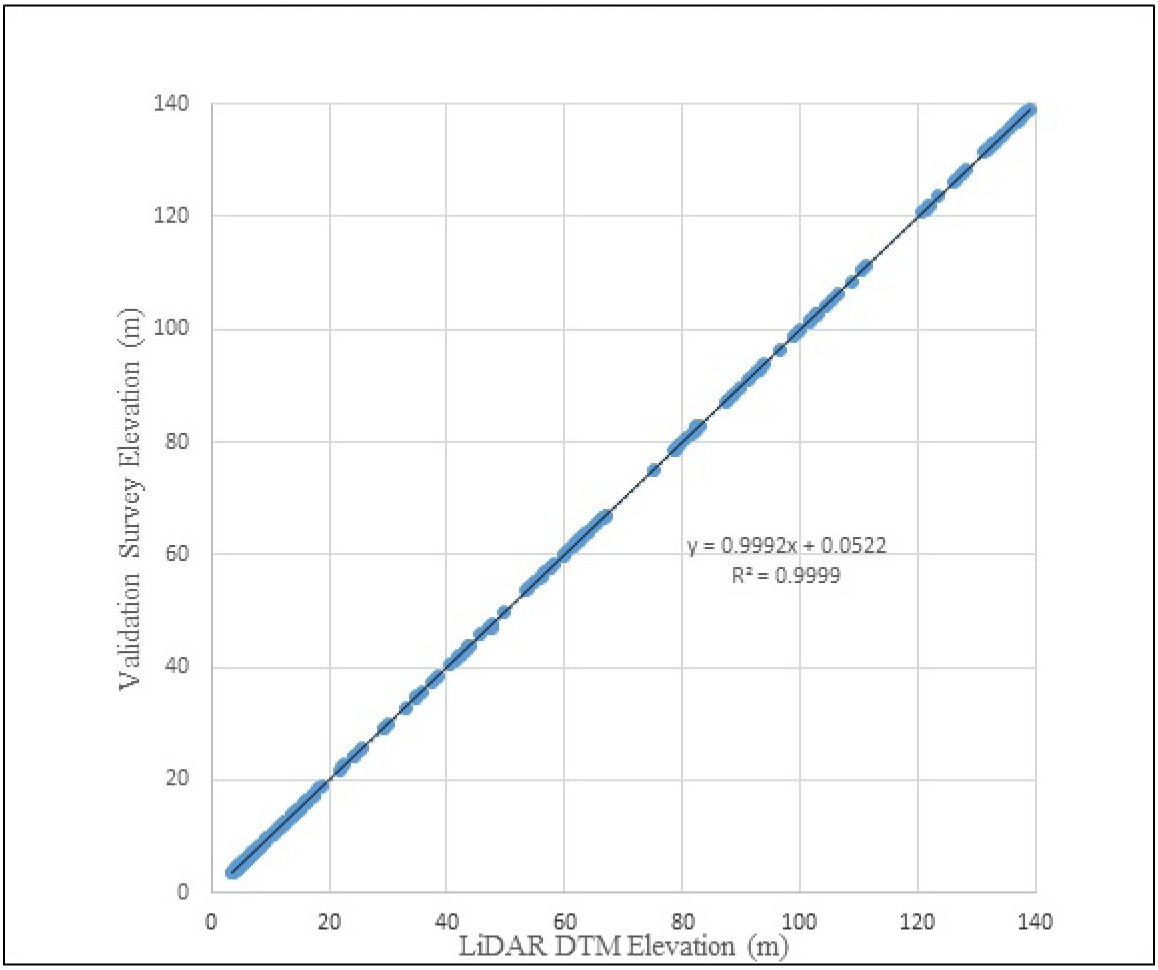


Figure 24. Correlation plot between validation survey points and LiDAR data

Table 20. Validation Statistical Measures

Validation Statistical Measures	Value (meters)
RMSE	0.11
Standard Deviation	0.11
Average	0.02
Minimum	-0.42
Maximum	0.51

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, only centerline data was available for Pansipit with 5,505 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 0.07 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Pansipit integrated with the processed LiDAR DEM is shown in Figure 25.

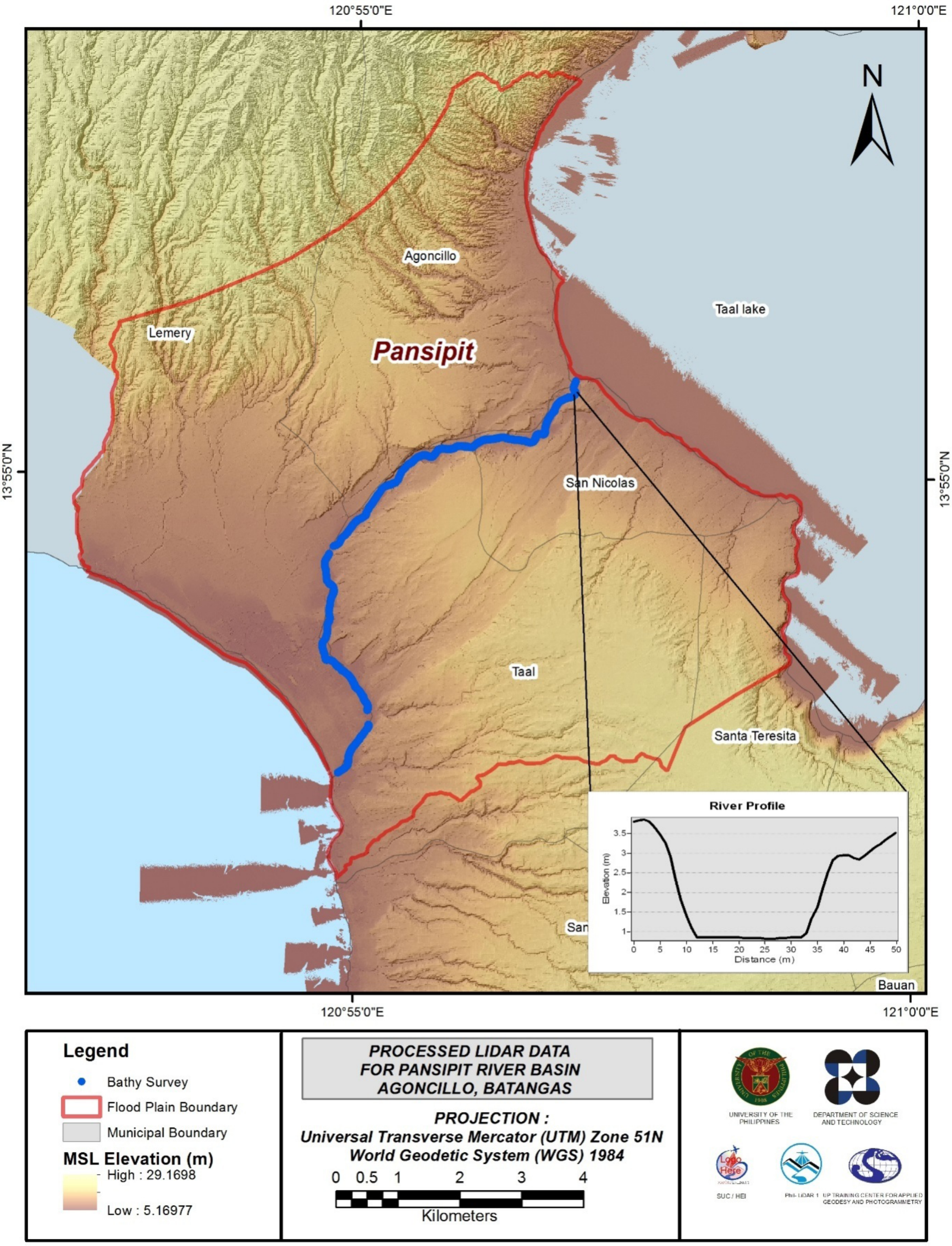


Figure 25. Map of Pansipit Flood Plain with bathymetric survey points shown in blue

3.12 Feature Extraction

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

3.12.1 Quality Checking of Digitized Features' Boundary

Pansipit floodplain, including its 200 m buffer, has a total area of 87.35sq km. For this area, a total of 5.0 sq km, corresponding to a total of 3,295 building features, are considered for QC. Figure 26 shows the QC blocks for Pansipit floodplain.

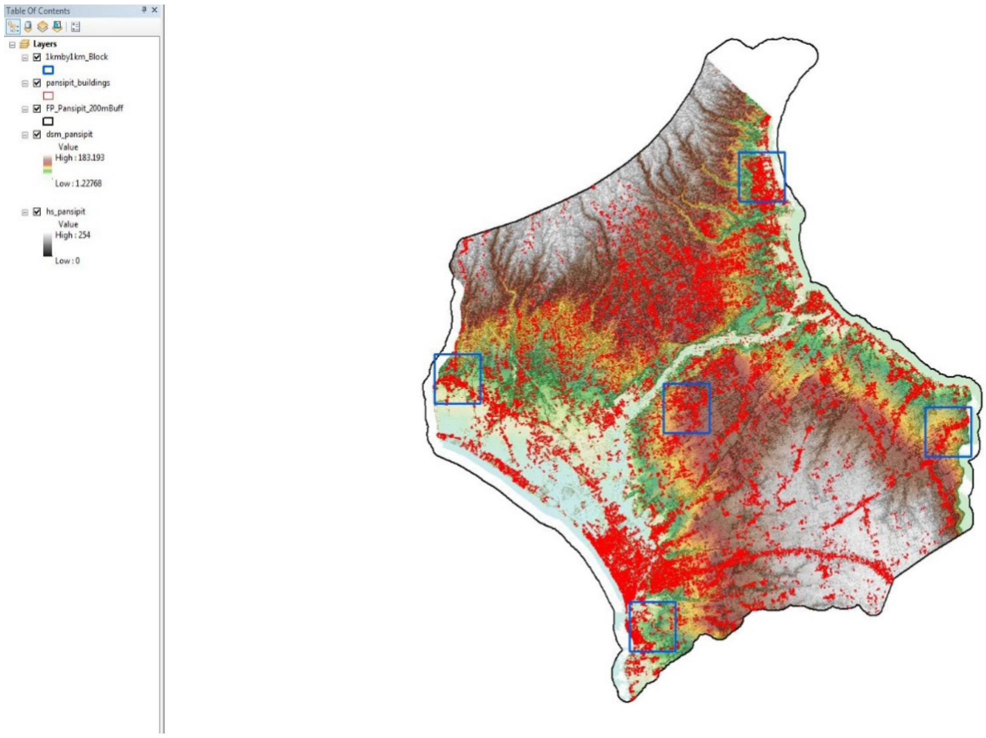


Figure 26. Blocks (in blue)of Pansipit building features that were subjected to QC

Quality checking of Pansipit building features resulted in the ratings shown in Table 21.

Table 21. Quality Checking Ratings for Pansipit Building Features

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Pansipit	99.60	100	98.75	PASSED

3.12.2 Height Extraction

Height extraction was done for 37,024 building features in Pansipit floodplain. Of these building features, none was filtered out after height extraction, resulting to 34,483 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 12.70 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 22 summarizes the number of building features per type. On the other hand, Table 23 shows the total length of each road type, while Table 24 shows the number of water features extracted per type.

Table 22. Building Features Extracted for Pansipit Floodplain

Facility Type	No. of Features
Residential	33,784
School	312
Market	97
Agricultural/Agro-Industrial Facilities	4
Medical Institutions	32
Barangay Hall	55
Military Institution	0
Sports Center/Gymnasium/Covered Court	17
Telecommunication Facilities	3
Transport Terminal	3
Warehouse	1
Power Plant/Substation	0
NGO/CSO Offices	2
Police Station	4
Water Supply/Sewerage	8
Religious Institutions	68
Bank	21
Factory	0
Gas Station	27
Fire Station	1
Other Government Offices	17
Other Commercial Establishments	27
Total	**34,483**

Table 23. Total Length of Extracted Roads for Pansipit Floodplain

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Pansipit	267.08	54.34	37.37	0.00	0.00	**358.79**

Table 24. Number of Extracted Water Bodies for Pansipit Floodplain

Floodplain	Water Body Type					Total
	Rivers/ Streams	Lakes/ Ponds	Sea	Dam	Fish Pen	
Pansipit	27	1	1	0	0	**29**

A total of 44 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 27 shows the Digital Surface Model (DSM) of Pansipit floodplain overlaid with its ground features.

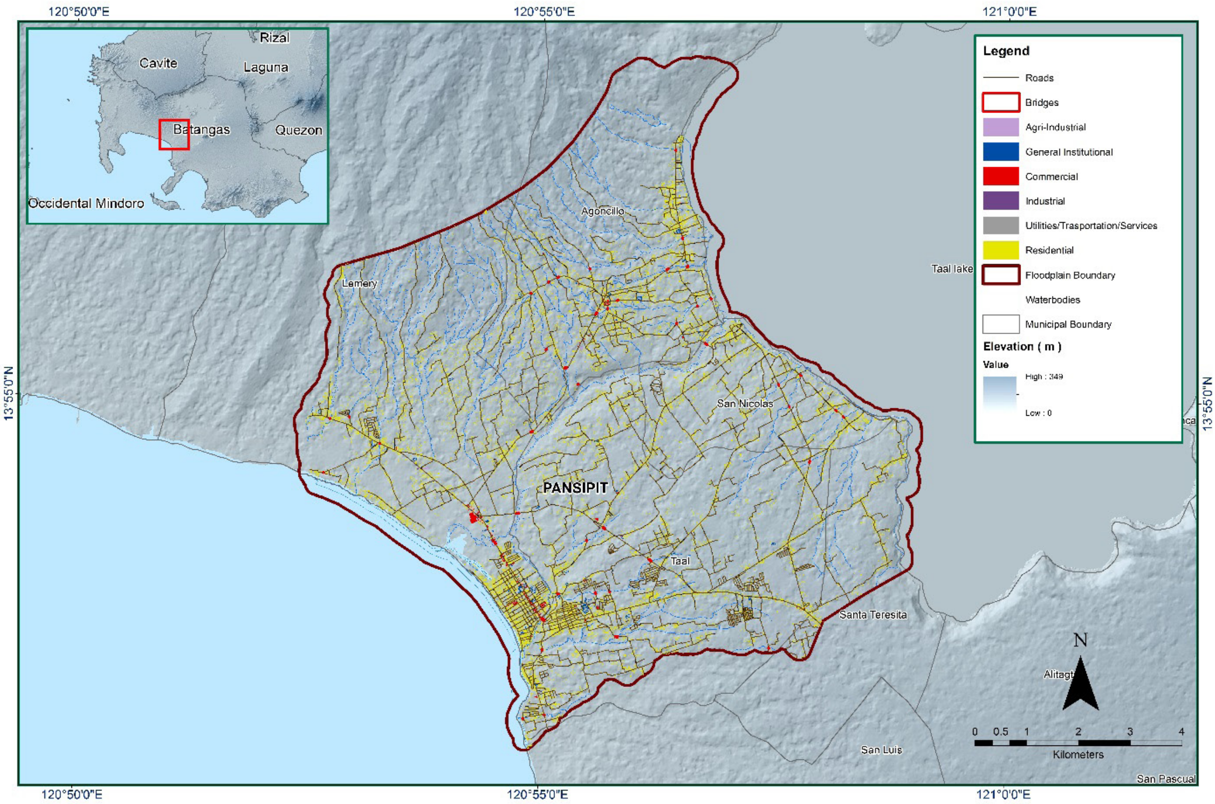


Figure 27. Extracted features for Pansipit floodplain

CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE PANSIPIT 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, and For. Rodel C. Alberto

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

4.1 Summary of Activities

The project team conducted three (3) field surveys in Pansipit River. The first one was conducted from May 14 to 22, 2014 with the following scope of work: reconnaissance; control survey for the establishment of a control point; and bridge cross-section. The second one was conducted from August 26 to 30, 2014 with the following scope of work: ground validation data acquisition of about 34 km; and bathymetric survey from Brgy. Poblacion, San Niclolas, Batangas to the mouth of the river in Brgy. Butong, Taal, Batangas with an estimated length of 25.03 km using an OHMEX™ Single Beam Echo Sounder and GNSS PPK survey technique. The last one was on September 5, 2014 with the following scope of work: water level marking at one of the piers of San Nicolas Bridge.

4.2 Control Survey

The GNSS network for this survey is composed of six (6) loops established on May 14 – 22, 2014 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 25 while the GNSS network established is illustrated in Figure 28.

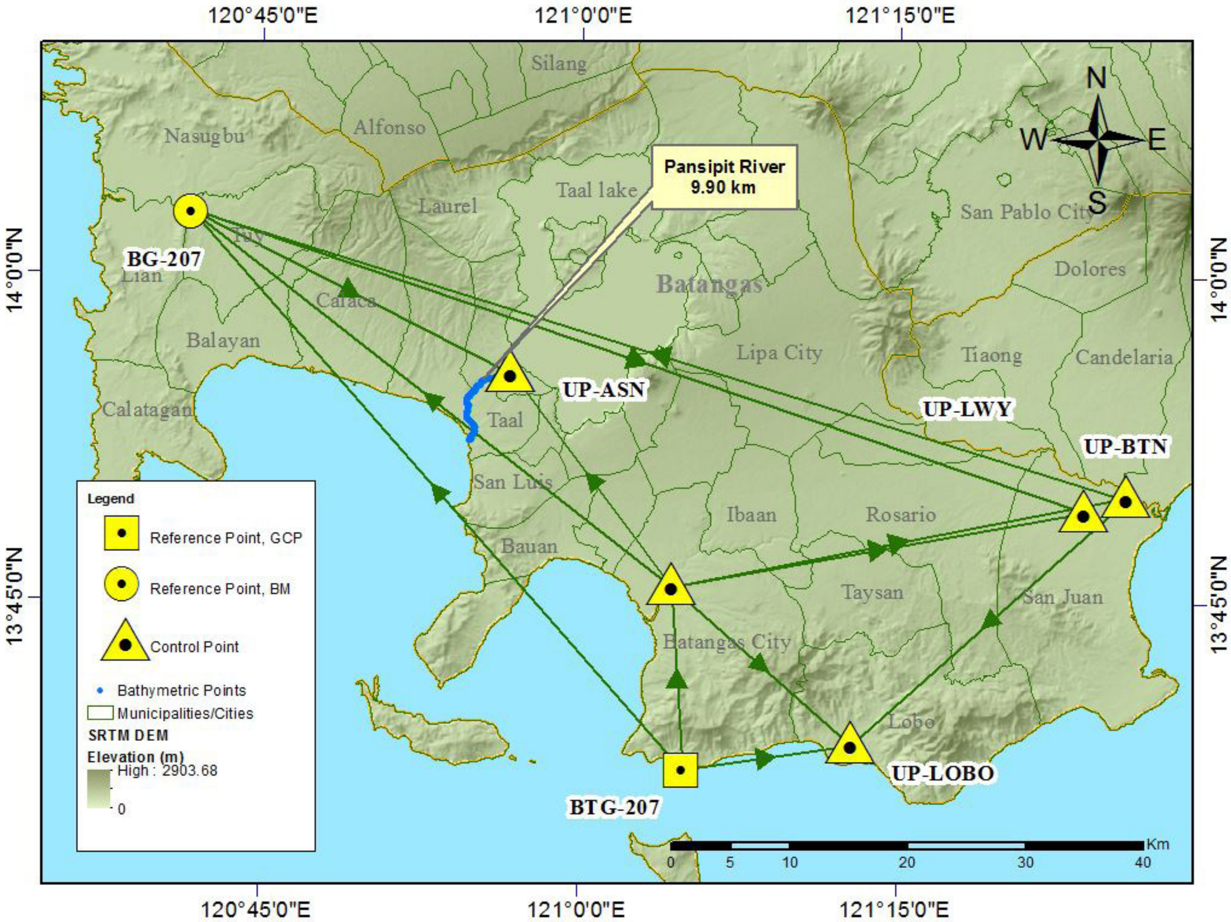


Figure 28. GNSS network of Pansipit River field survey

Table 25. List of Reference and Control Points used in Pansipit River Survey (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 in Figure 29 to 35.

Figure 29.GNSS receiver, Trimble® SPS 985, set-up at BG-207 at Palico Bridge, Brgy. Luntal, Nasugbu, Batangas

Figure 30.GNSS receiver, Trimble® SPS 985, set-up at BTG-7 in Dela Paz Lighthouse in Brgy. Dela Paz, Batangas City, Batangas

Figure 31.GNSS receiver, Trimble® SPS 882, set-up at UP-ASN at San Nicholas Bridge, Brgy. Poblacion, San Nicholas, Batangas

Figure 32.GNSS base receiver, Trimble® SPS 852, set-up at UP-BTN at Bantilan Bridge, Brgy. Manggalang Banitilan, Sariaya, Quezon

Figure 33.GNSS base receiver, Trimble® SPS 852, set-up at UP-CLG1 in Calumpang Bridge, Brgy. Cumintang Ibaba, Batangas City, Batangas

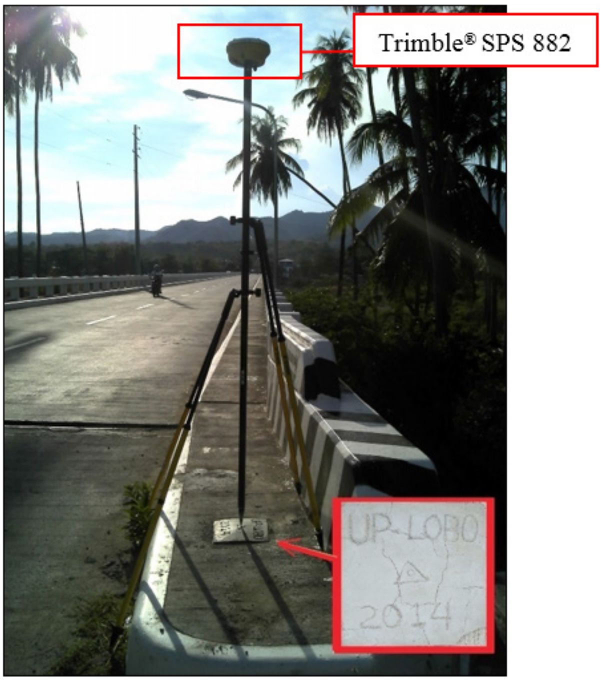


Figure 34.GNSS base receiver, Trimble® SPS 882, set-up at UP-LOBO, in Lobo Bridge, Brgy. Lagadlarin, Lobo, Batangas

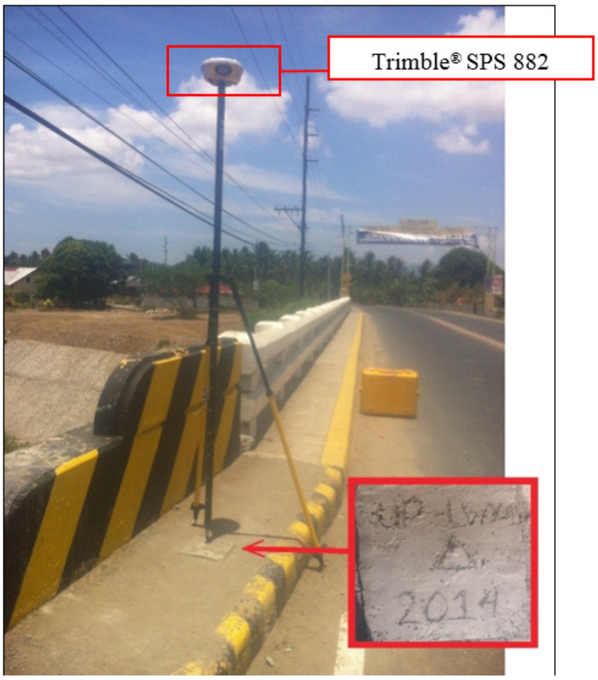


Figure 35.GNSS receiver, Trimble® SPS 882, set-up at UP-LWY1 at Lawaye Bridge, Brgy. Calitcalit-Mabalanoy, San Juan, Batangas

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 Pansipit River Basin is summarized in Table 26 generated by TBC software.

Table 26. Baseline Processing Report for Pansipit 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)	5-22-2014	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)	5-22-2014	Fixed	0.011	0.021	283°18'29"	50016.834	-12.285

As shown in Table 26, 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:

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

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

for each control point. See the Network Adjustment Report shown in Table 27 to 30 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 27. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 27. 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 28. The fixed control point BG-207 and BTG-7, has no values for standard elevation and coordinates error, respectively.

Table 28. 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:

BG-207

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

vertical accuracy = Fixed

BTG-7

horizontal accuracy = Fixed

vertical accuracy = 7.2 cm

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

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

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

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

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 29. 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 29. Based on the result of the computation, the accuracy condition is satisfied; hence, the required accuracy for the program was met.

The summary of reference and control points used is indicated in Table 30.

Table 30. 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 and as-built survey were performed on May 22, 2014 at the downstream side of San Nicolas Bridge in Brgy. Poblacion, Municipality of San Nicolas, Batangas with the aid of interns from the UP Diliman Department of Geodetic Engineering. The survey was conducted with the application of PPK technique using a survey grade GPS, Trimble® SPS 882, as shown in Figure 36.

Figure 36. Cross Section survey at San Nicolas Bridge in Brgy. Poblacion, San Nicolas, Batangas

A total of 16 points were gathered along San Nicolas Bridge with a length of 154.93 m as exhibited in Figure 37. The control point UP-ASN was used as the GNSS base station all throughout the survey. The location map andcross-section diagram form are shown in Figures 37 and 38, respectively.

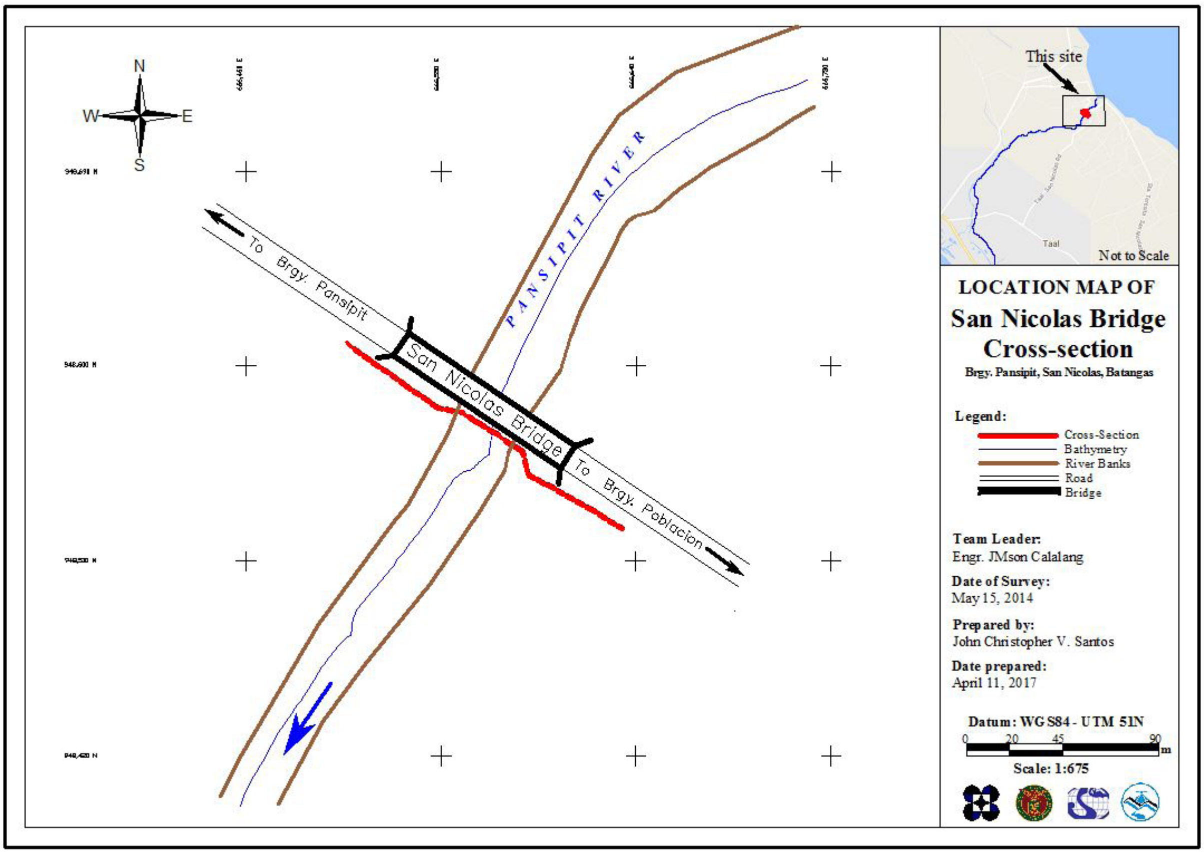


Figure 37. San Nicolas bridge cross-section location map

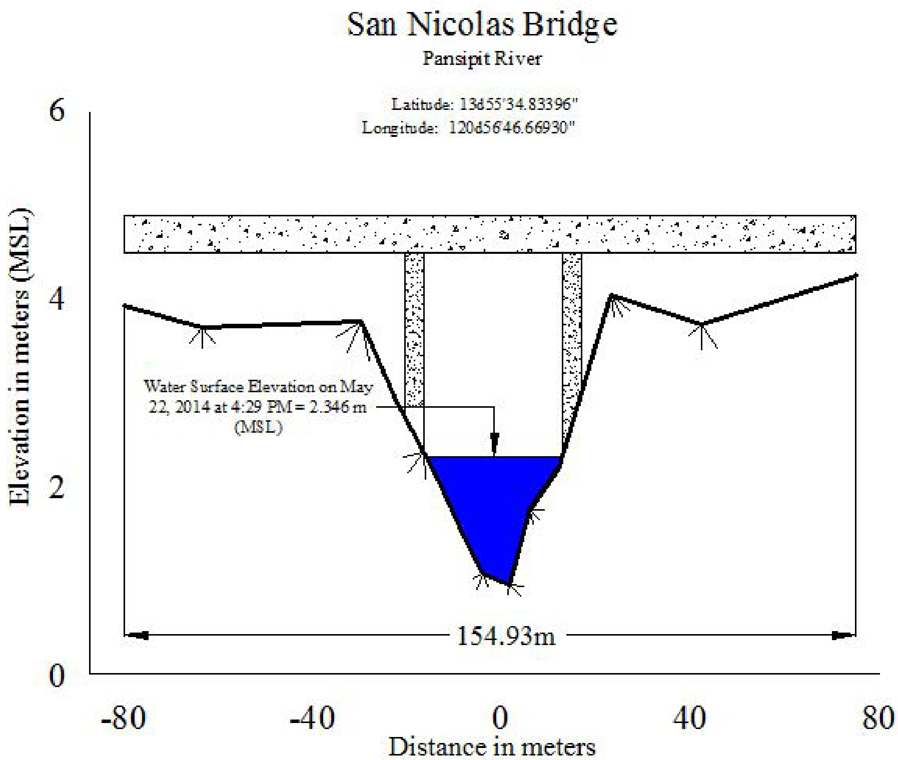


Figure38.San Nicolas Bridge cross-section diagram

Water surface elevation marking was done on September 5, 2014, three (3) months after the cross-section survey. One of the piers was marked with MSL values using yellow paint, as seen in Figure 39, to serve as reference for depth gauge deployment and flow data gathering activities of Mapúa Institute of Technology PHIL-LiDAR 1.

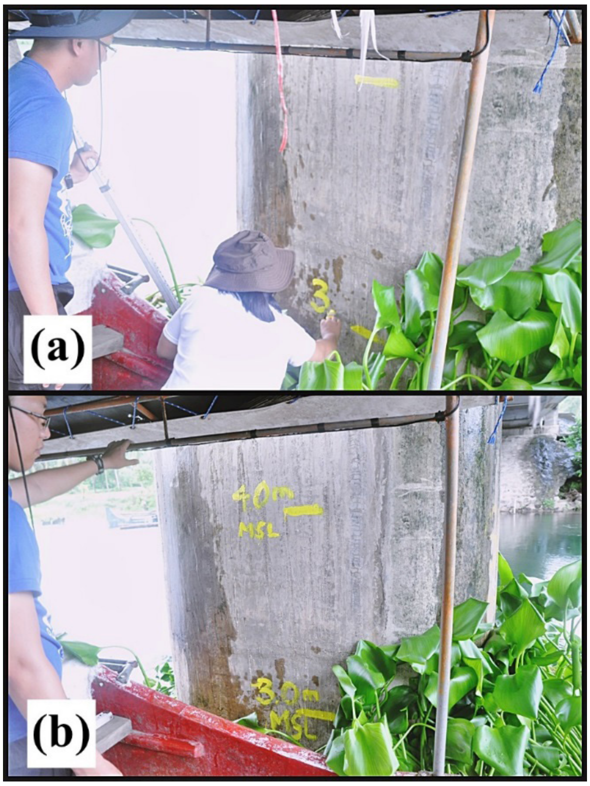


Figure 39. Water Level Marking at San Nicolas Bridge (a) Painting of MSL indicator on one of the piers of San Nicolas Bridge (b) Finished water level markings

4.6 Validation Points Acquisition Survey

Validation points acquisition survey was conducted on August 28, 2014 using Trimble® SPS 882 attached on the top of a vehicle, utilizing continuous Topographic Method in a PPK Survey Technique, as shown in Figure 40. The height of instrument was measured and noted a 1.53 m distance from the ground up to the bottom of the notch. Points were gathered along major concrete roads with the aid of a vehicle which moved at a speed of 20 to 40 kph, cutting across the flight strips of the DAC with the aid of available topographic maps and Google Earth™ images.

Figure 40. Validation points acquisition survey setup: A Trimble® SPS 882 is attached on top of a vehicle

The distance surveyed is approximately 41 km from the Municipality of San Nicolas to Lemery and from the Municipality of Balayan to Batangas City. UP-ASN was used as a base station during the conduct of the ground validation survey. The map in shows the extent of the ground validation survey which acquired 3,577 ground validation points with an approximate length of 41 km using the base station UP-ASN.

Figure 41. Pansipit river survey validation map

4.7 River Bathymetric Survey

The bathymetric survey was conducted on August 28, 2014 using Trimble® SPS 882 GNSS receiver utilizing continuous topo mode in PPK survey technique and a Hi-Target™ Single Beam Echo Sounder mounted on a rubber boat as shown in Figure 42.A GPS receiver, Trimble® SPS 985, was setup at UP-ASN which served as the base station all throughout the suvrey. The survey began in Taal Lake, in Brgy. Pansipit with coordinates 13°55’50.36165”120°56’57.69819”moved toward the entrance of the river in Brgy. Poblacion, San Nicolas, Batangas, and reached up to the mouth of the river in Brgy. Butong, Lemery, Batangas with coordinate 13°52’24.27677”120°54’52.45541.

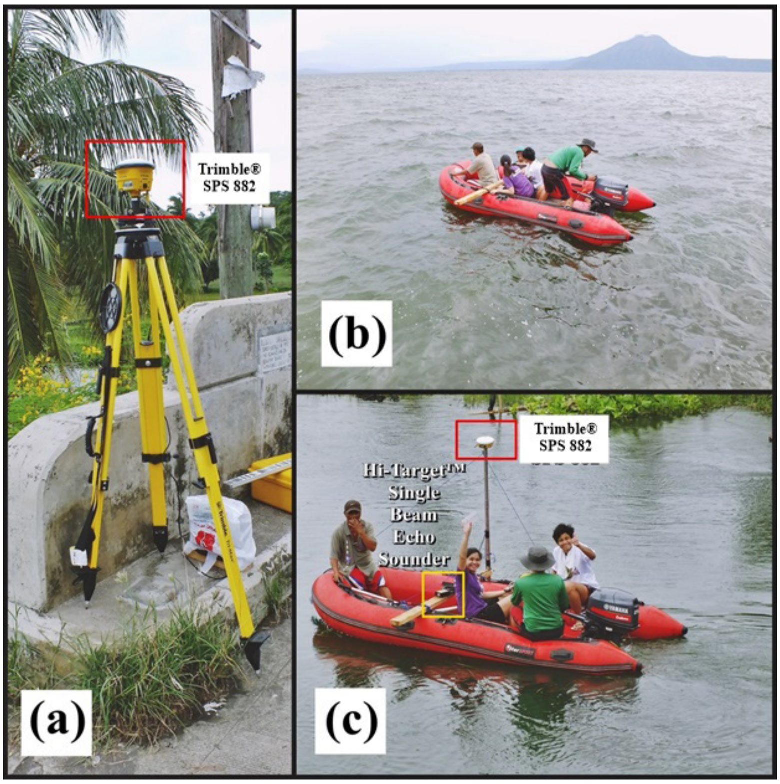


Figure 42. Bathymetric survey setup (a) Base station at UP-ASN using Trimble® SPS 895 , (b) Navigating Taal Lake before reaching Pansipit River, (c) Surveying with the help of installed Hi-Target™ Single Beam Echo Sounder and a mounted Trimble® SPS 882 GNSS receiver

A total of 6,807 bathymetry points were gathered starting from the upstream in Brgy. Poblacion, San Nicolas down to Brgy. Butong in Lemeryas shown Figure 43. A CAD drawing was also produced to illustrate the riverbed profile of Pansipit river. As shown in Figure 44, there isan elevation drop of 11.8 m in MSL was observed within the approximate distance of 9 km. The highest elevation observed was 4.306 m in MSL located in Brgy. Calangay, Municipality of San Nicolas, while the lowest elevation observed was -4.219 m below MSL located in Brgy. Poblacion 5, Municipalty of Taal.

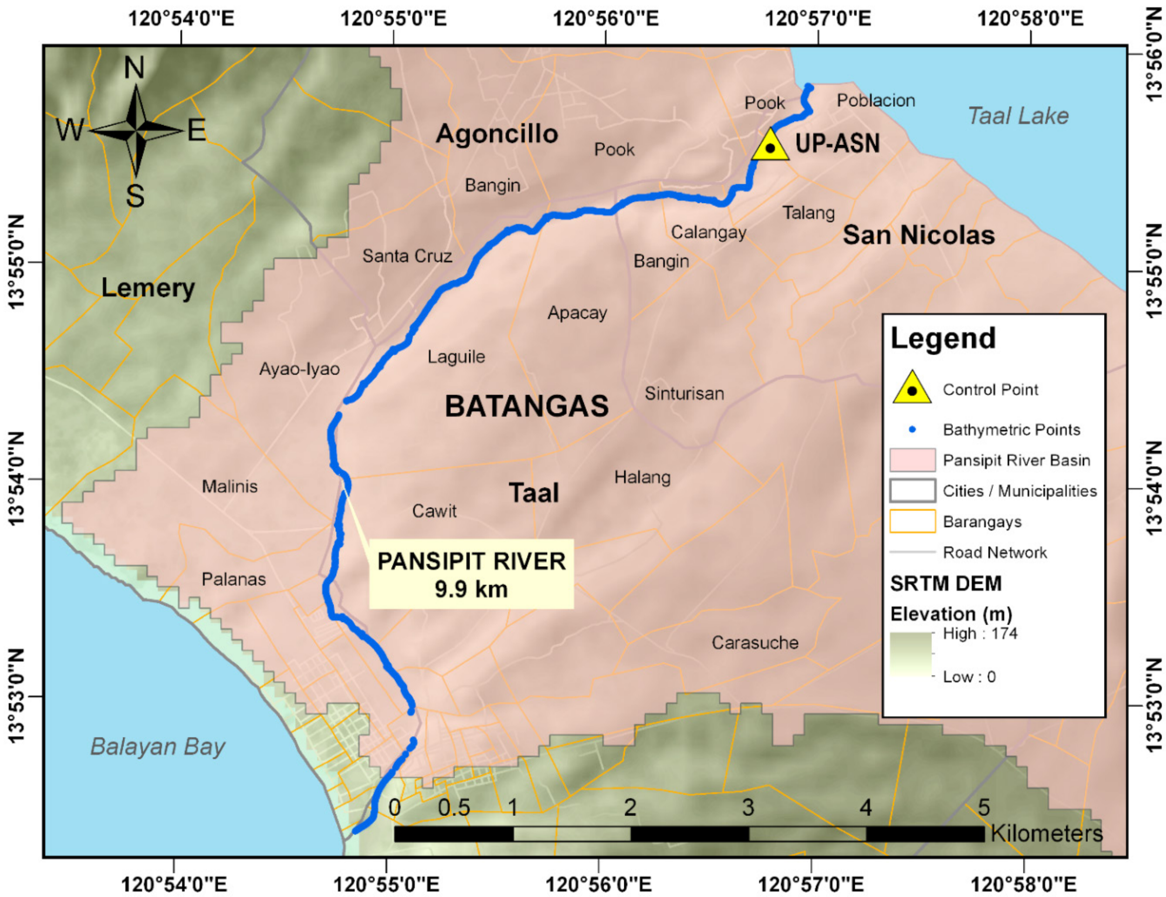


Figure 43.Bathymetric points gathered along Pansipit River

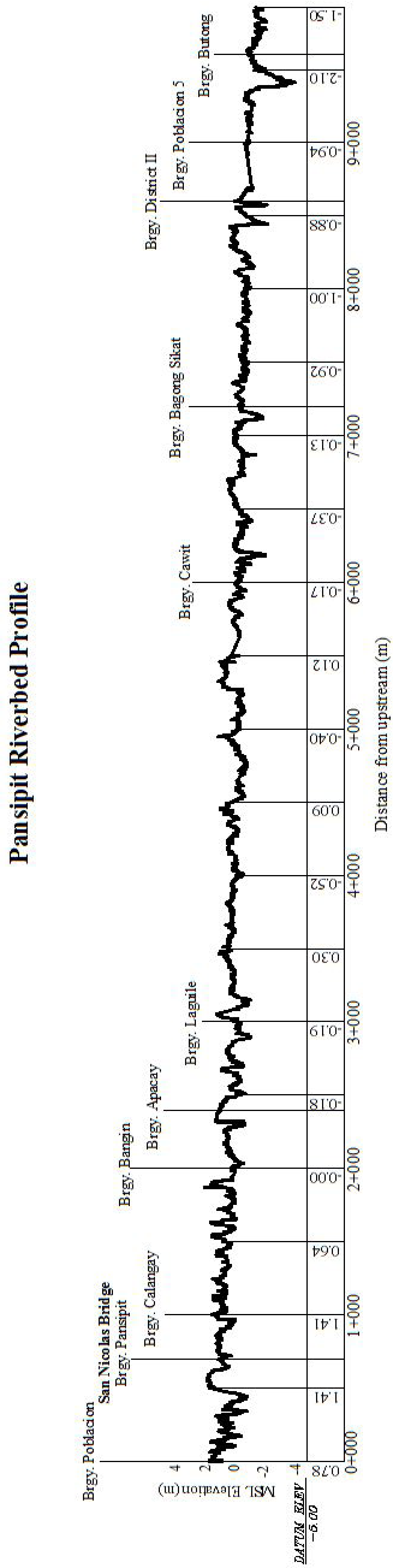


Figure 44. Riverbed Profile of Pansipit River

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 (Lagmay, 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

All data that affect the hydrologic cycle of the river basin was monitored, collected, and analyzed. Rainfall, water level, and flow in a certain period of time, which may affect the hydrologic cycle of the Pansipit River Basin were monitored, collected, and analyzed.

5.1.2 Precipitation

Precipitation data was taken from an automatic rain gauge (ARG) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). This rain gauge is the Balete ARG (14° 1'4.30"N, 121° 7'43.97"E), located in Balete, Batangas (Figure 45). The precipitation data collection started from September 27, 2016 at 00:00 AM to September 27, 2016 at 23:45AM with a 15-minute recording interval.

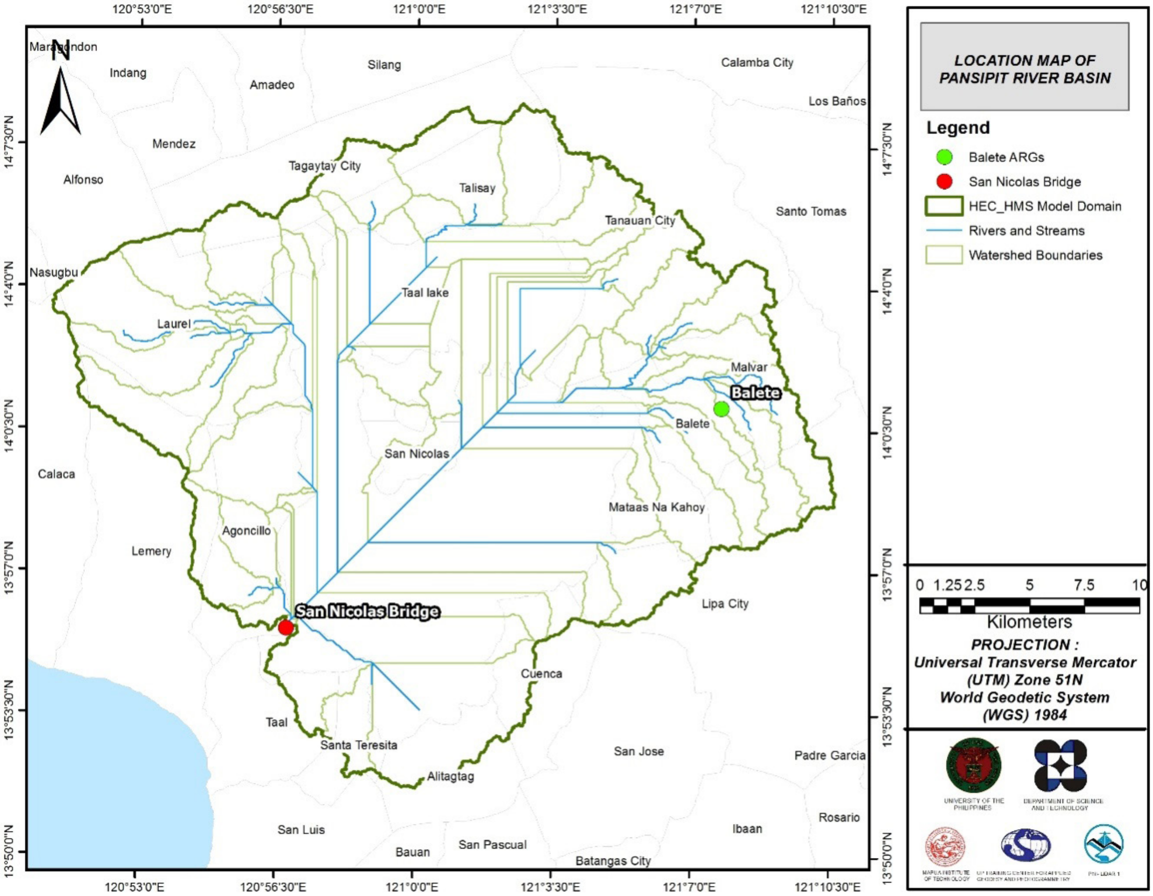


Figure 45. The location map of rain gauges used for the calibration of the Pansipit HEC-HMS Model

For Balete Rain Gauge, total rain for the event is 13.8 mm. Peak rain of 5.4 mm was recorded on 27 September 2016. The lag time between the peak rainfall and discharge is 5 hours, as seen in Figure 7.

5.1.3 Rating Curves and River Outflow

A rating curve was developed at San Nicolas Bridge, San Juan, Batangas (13°55’34.83”N, 120°56’46.67”E). It gives the relationship between the observed water levels from the San Nicolas Bridge using depth gage, and outflow of the watershed using flow meter at this location. It is expressed in the form of the following equation:

Q=anh

where, Q : Discharge (m3/s),

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

a and n : Constants.

For San Nicolas Bridge, the rating curve is expressed as Q = 0.00047e4.22799h as shown in Figure 3.

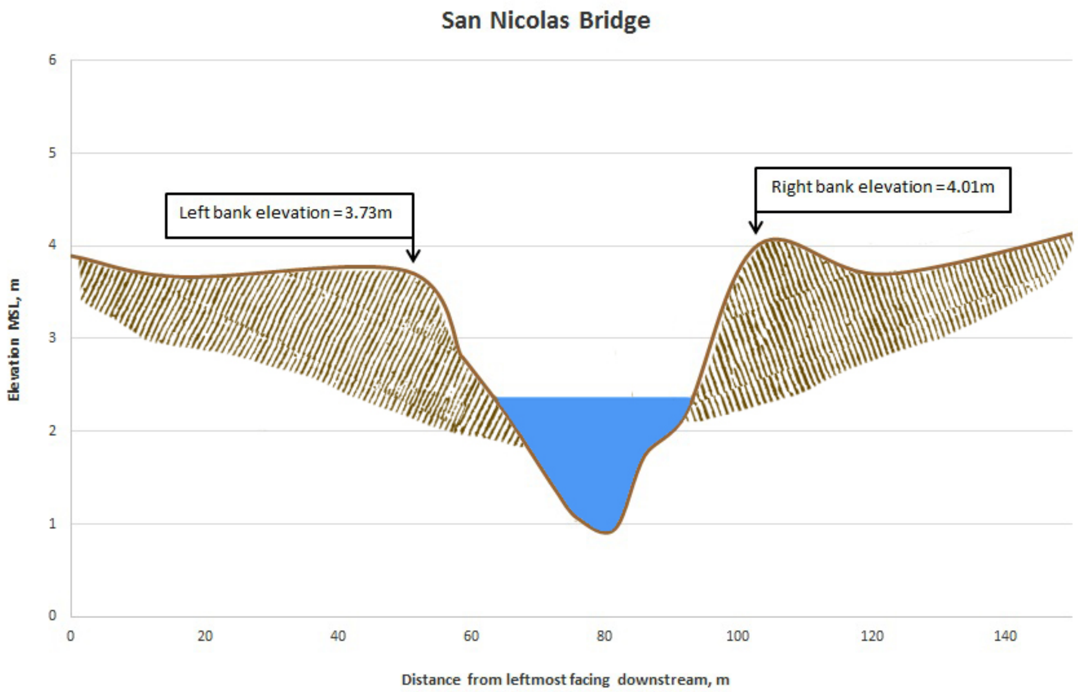


Figure 46. Cross-Section Plot of San Nicolas Bridge

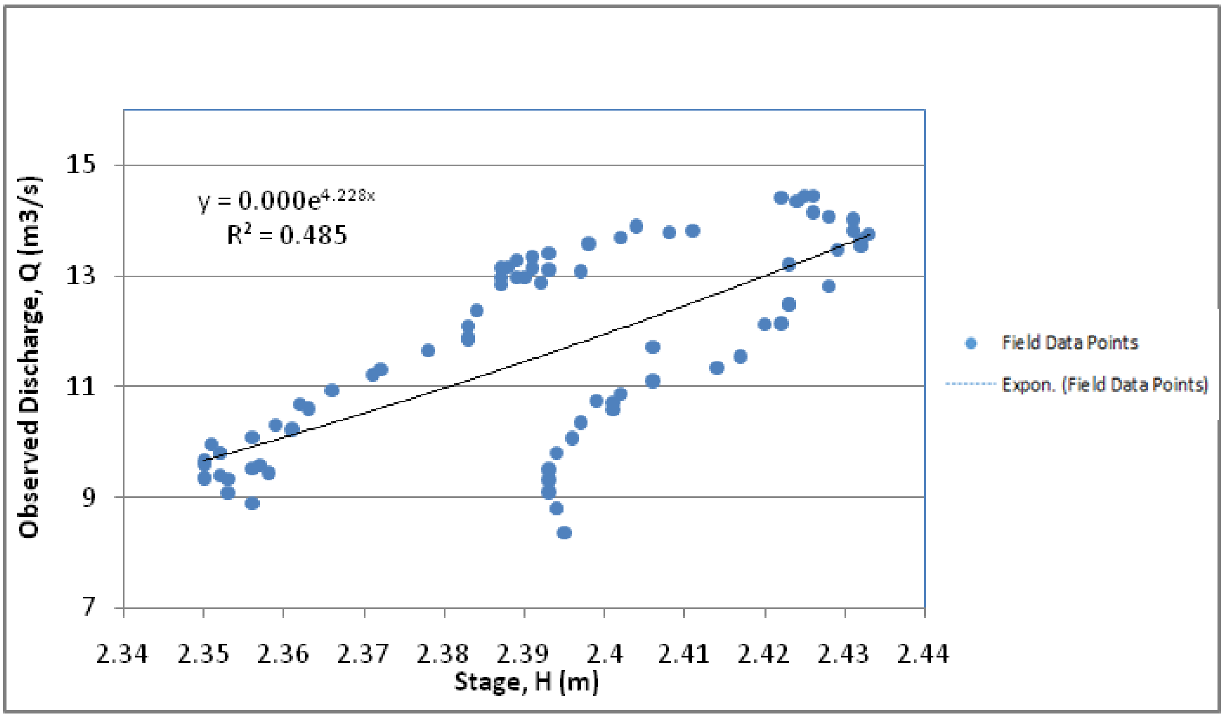


Figure 47. Rating Curve at San Nicolas Bridge San Juan, Batangas

This rating curve equation was used to compute the river outflow at San Nicolas Bridge for the calibration of the HEC-HMS model shown in Figure 48. Peak discharge is 14.50 m3/s at 4:00, September 28, 2016.

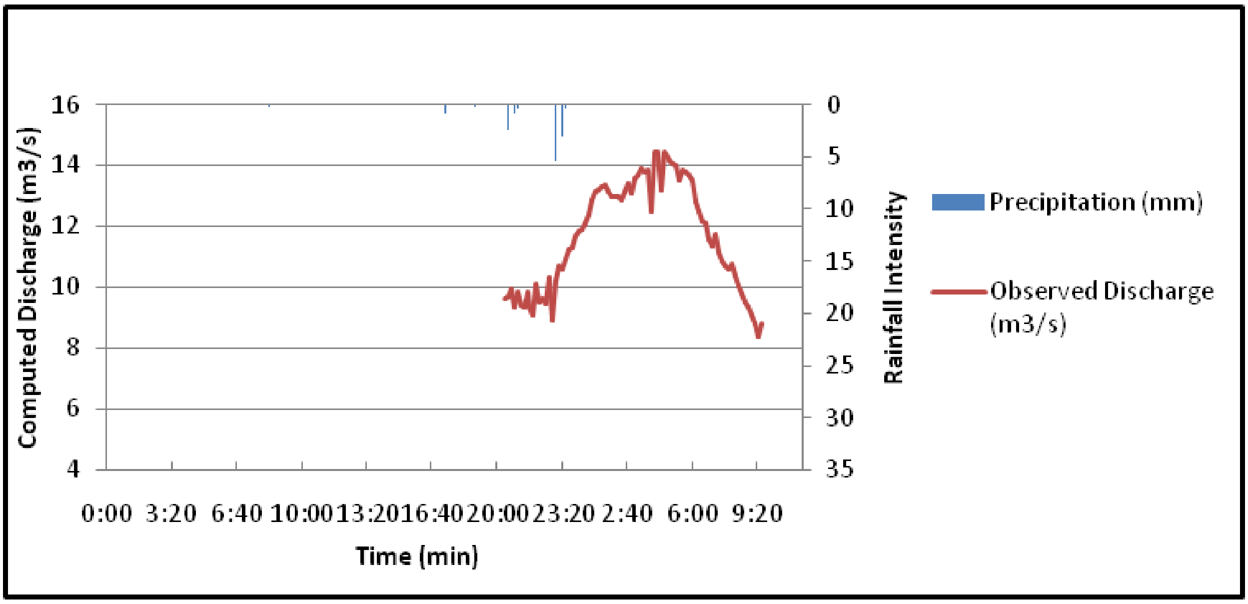


Figure 48. Rainfall and outflow data at Pansipit used for modeling.

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 Pansipit watershed. The extreme values for this watershed were computed based on a 54-year record.

Table 31. 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

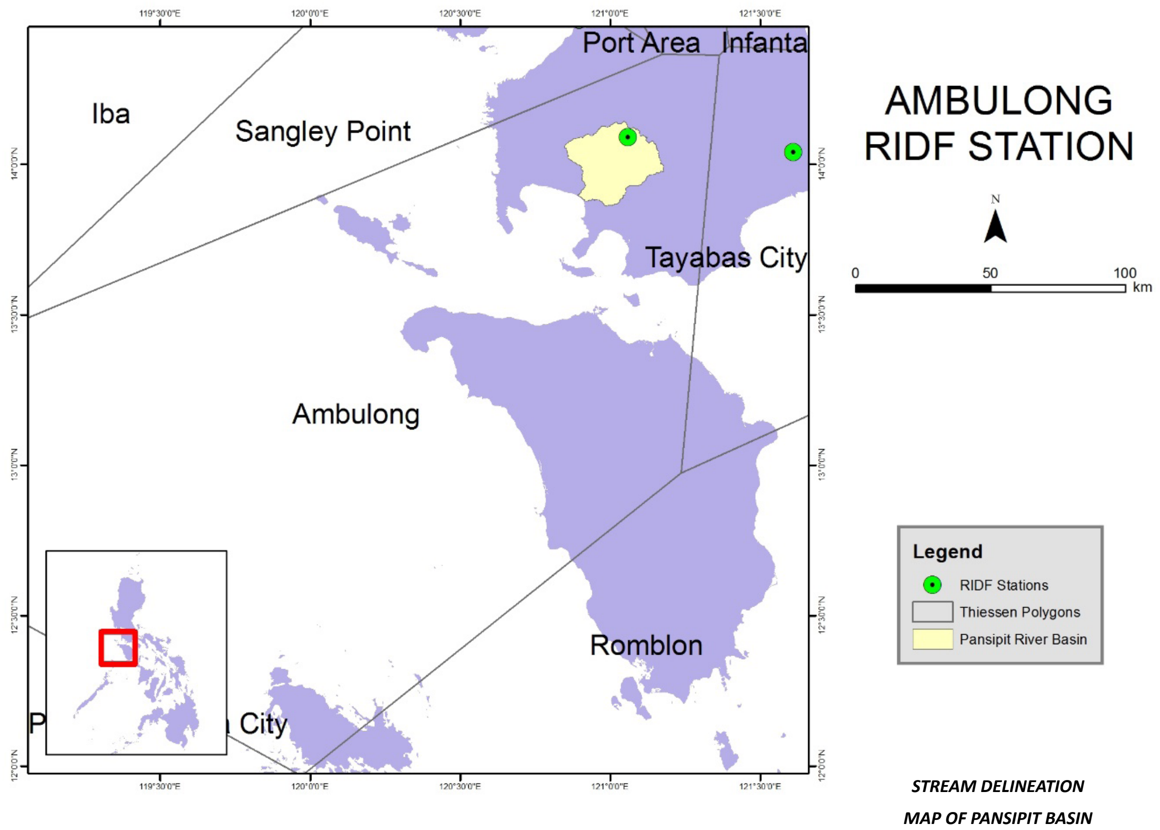


Figure 49. Location of Ambulong RIDF relative to Pansipit River Basin

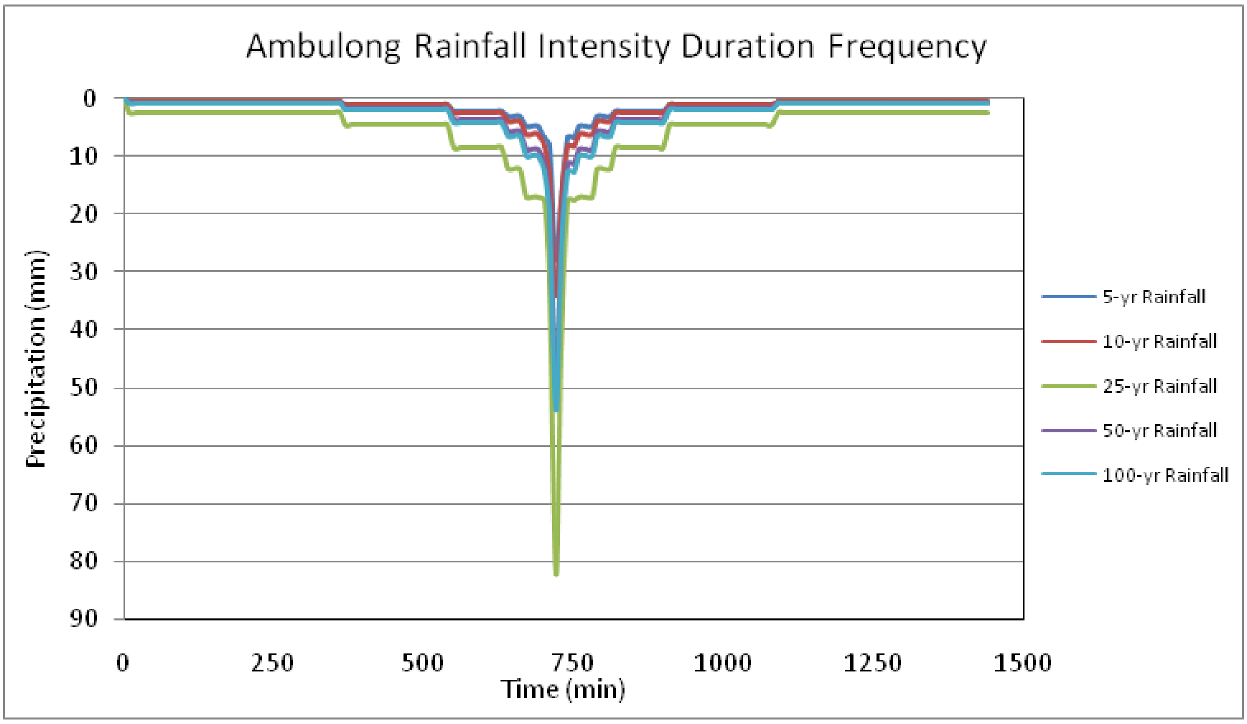


Figure 50. Synthetic storm generated for a 24-hr period rainfall for various return periods

5.3 HMS Model

The soil shapefile (dated pre-2004) was taken from the Bureau of Soils and Water Management under the Department of Agriculture. The land cover dataset is from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Pansipit River Basin are shown in Figures 51 and 52, respectively.

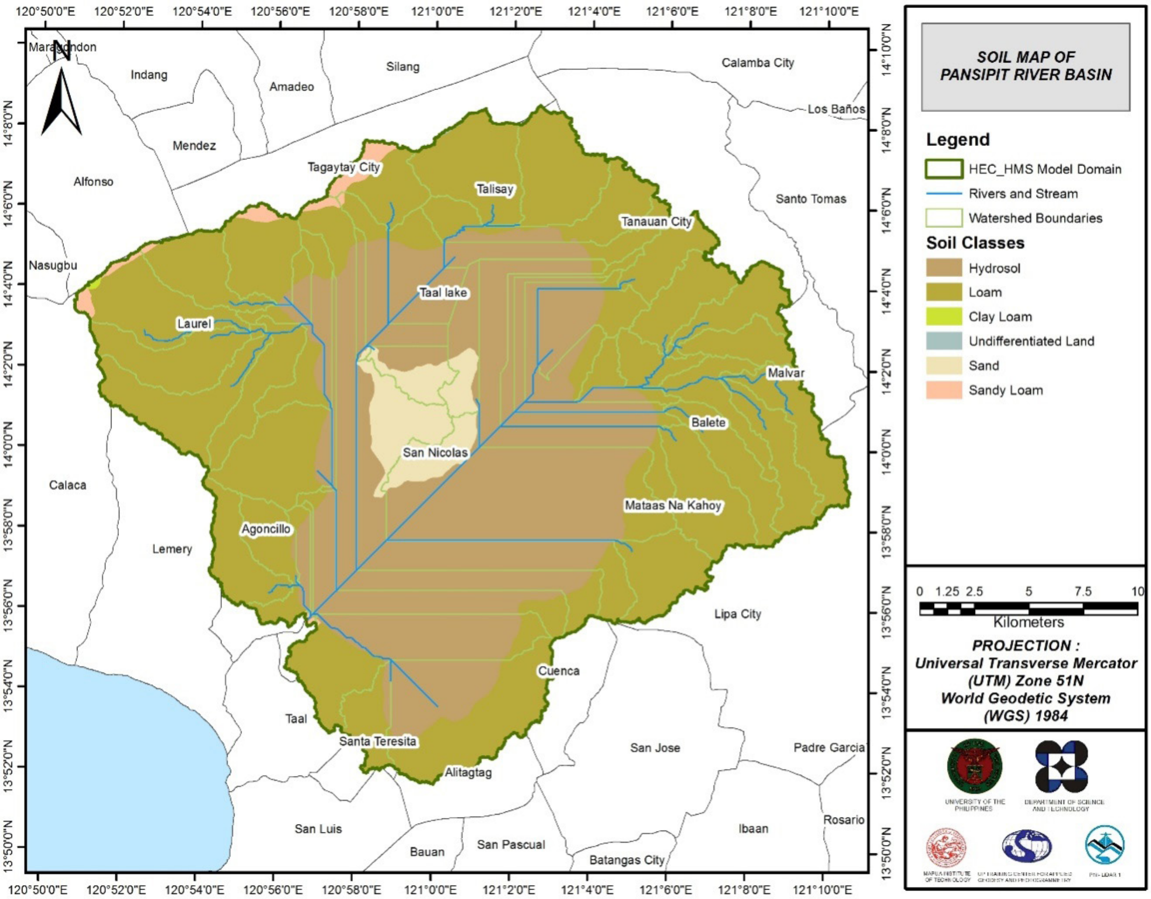


Figure 51. Soil Map of Pansipit River Basin

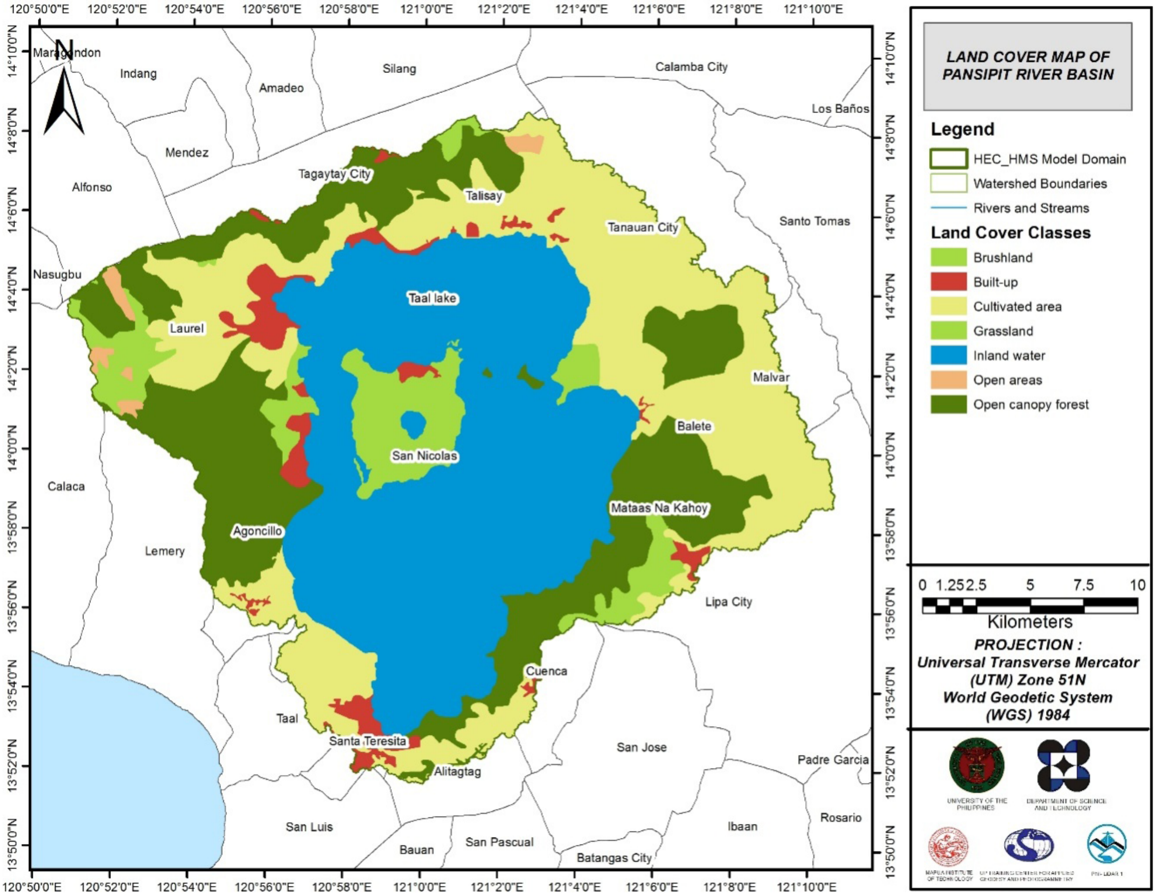


Figure 52. Land Cover Map of Pansipit River Basin (source: NAMRIA)

For Pansipit, the soil classes identified werehydrosols, loam, clay loam, sand, sandy loam, and mountain soil. The land cover types identified were brushland, built-up areas, cultivated areas, grassland, inland water, open areas and open canopy forest.

[insert Slope Map]

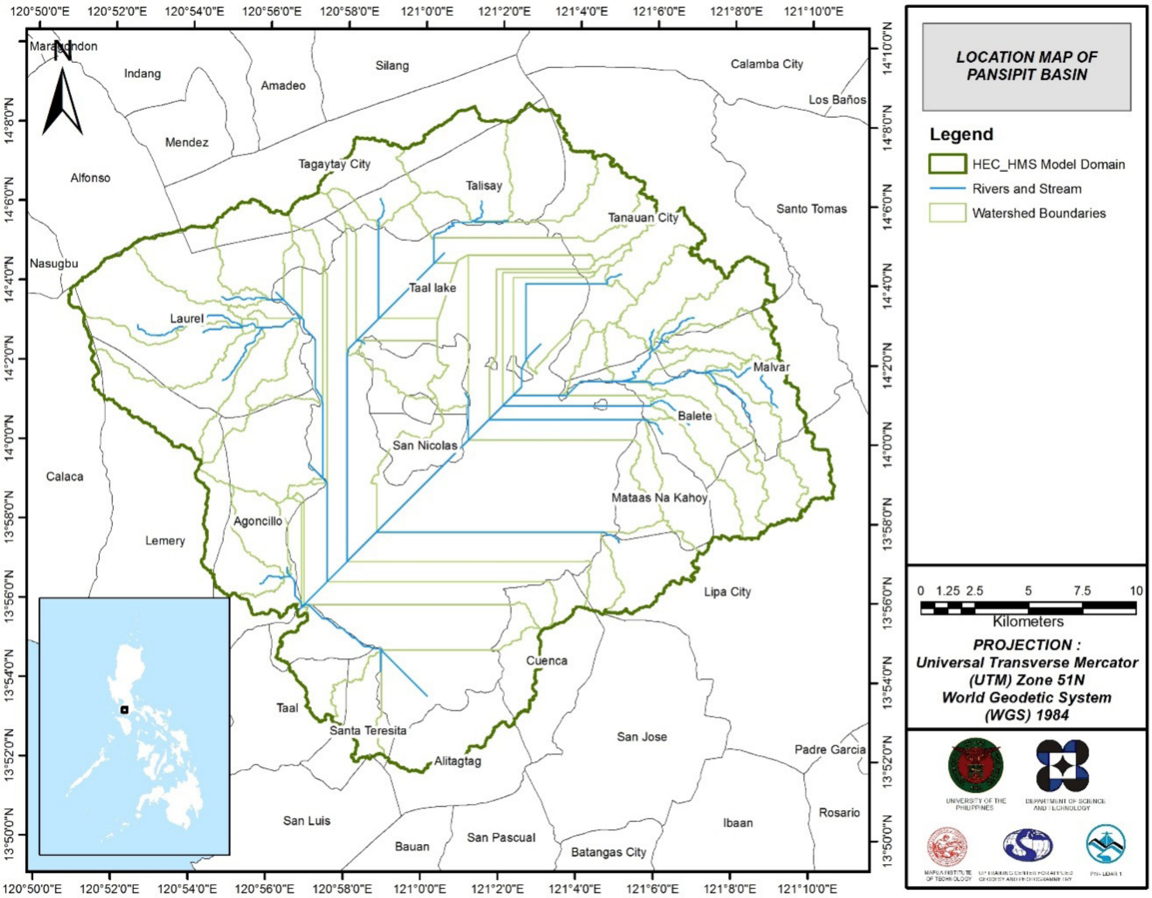


Figure 53. Stream delineation map of Pansipit river basin

The Pansipit basin model consists of 67 sub basins, 33 reaches, and 25 junctions.The main outlet is at the southwesternmost tip of the watershed. This basin model is illustrated in Figure 54. 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 San Nicolas Bridge.

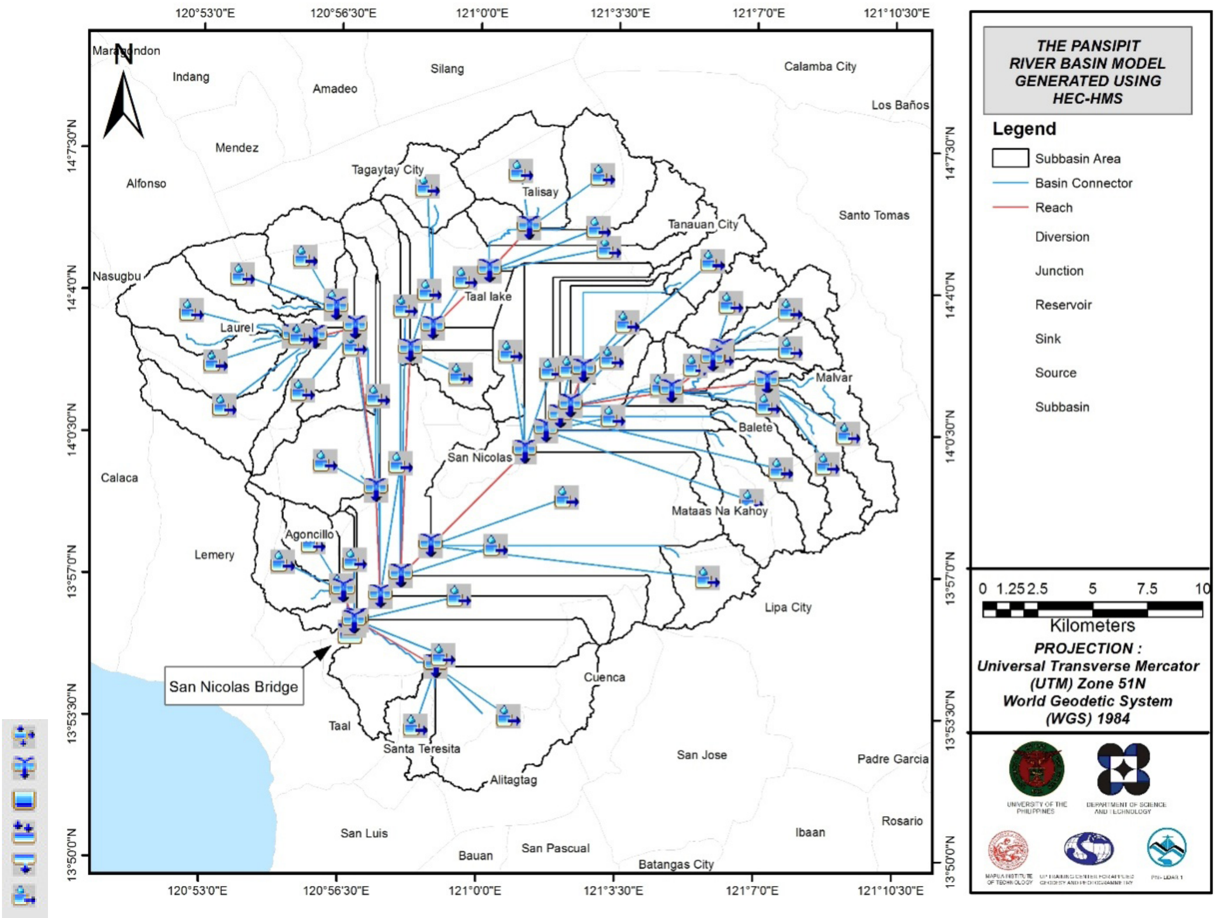


Figure 54. The Pansipit River Basin Model Domain generated by HEC-HMS

5.4 Cross-section Data

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

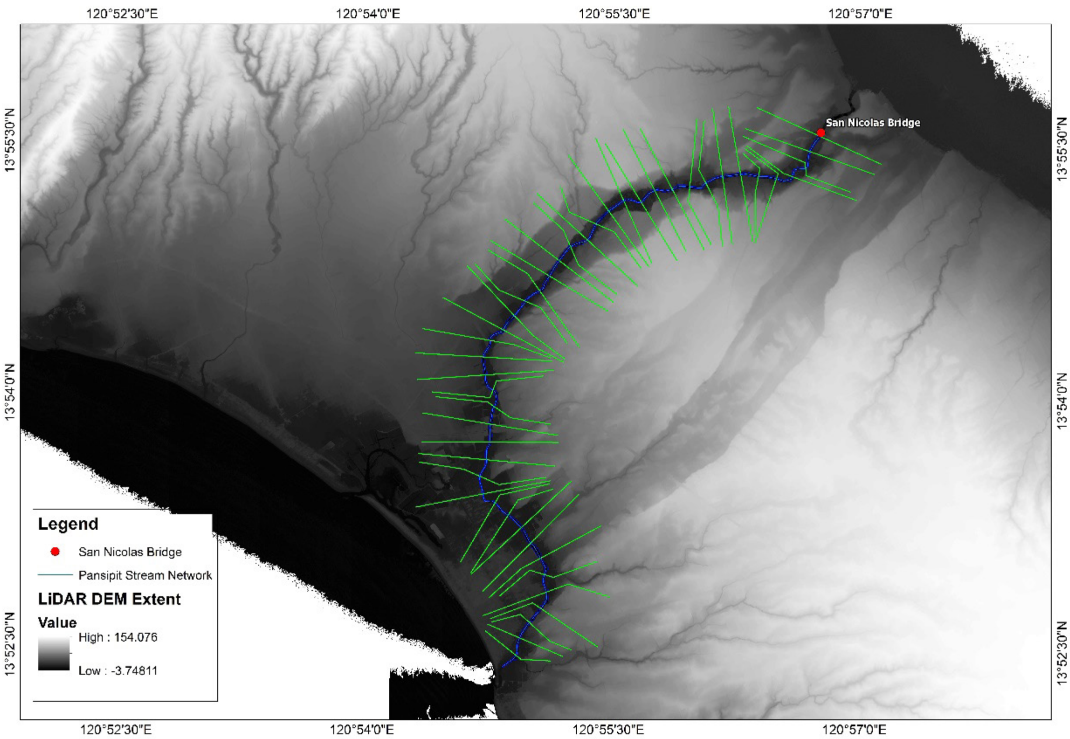


Figure 55. River cross-section of Pansipit River generated through Arcmap HEC GeoRAS tool

5.5 Flo 2D Model

Figure 56. Screenshot of subcatchment with the computational area to be modeled in FLO-2D GDS Pro

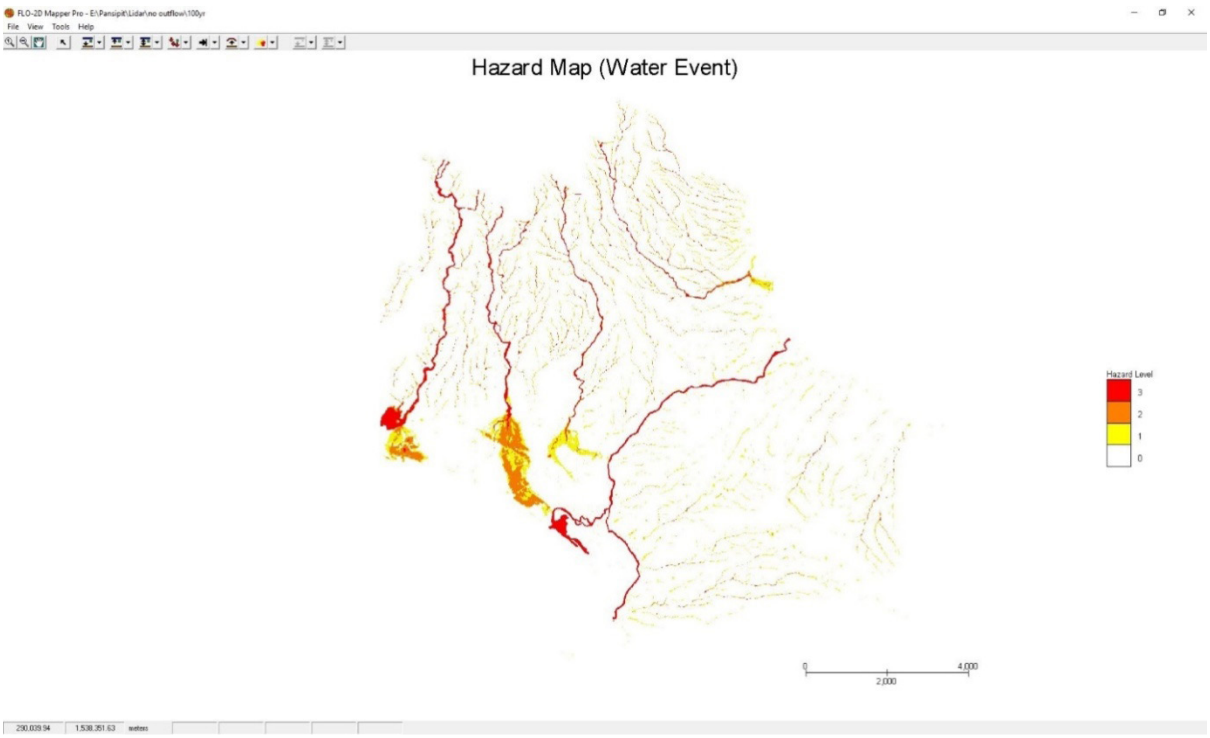


Figure 57. Generated 100-year rain return hazard map from FLO-2D Mapper

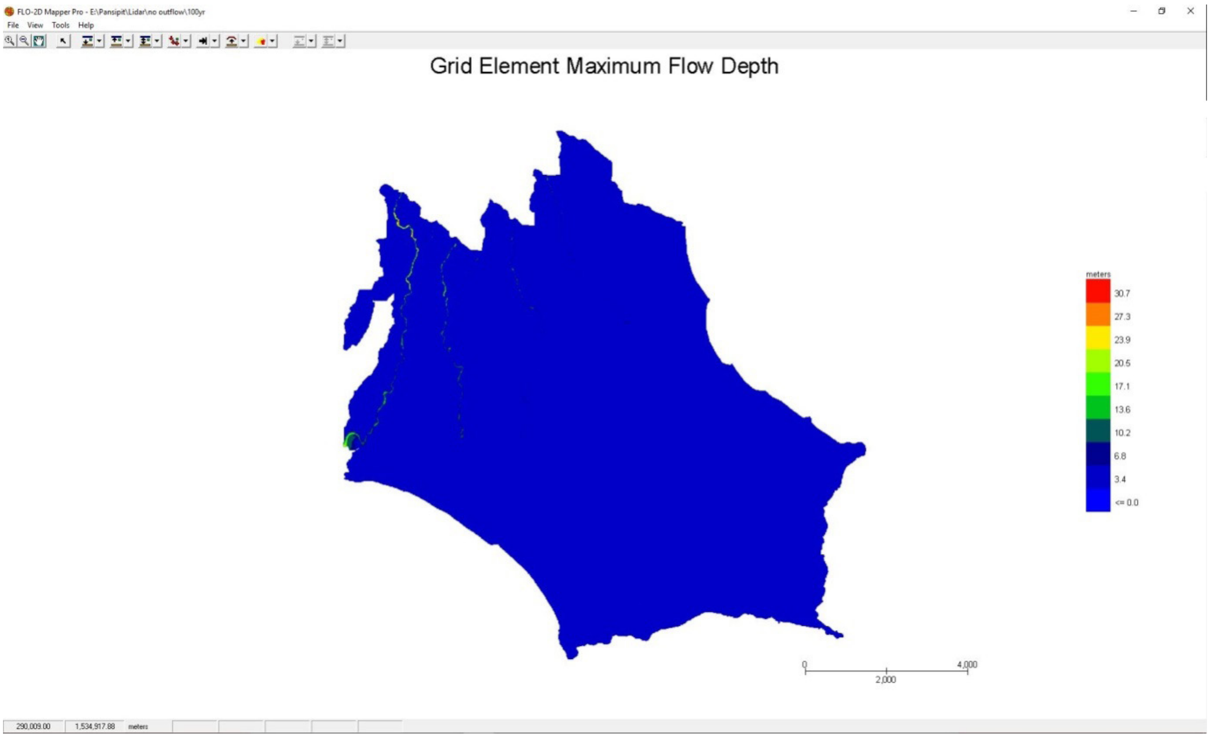


Figure 58. Generated 100-year rain return flow depth map from FLO-2D Mapper

5.6 Results of HMS Calibration

After calibrating the Pansipit HEC-HMS river basin model, its accuracy was measured against the observed values (see Annex 8. Pansipit Model Basin Parameters). Figure 59 shows the comparison between the two discharge data.

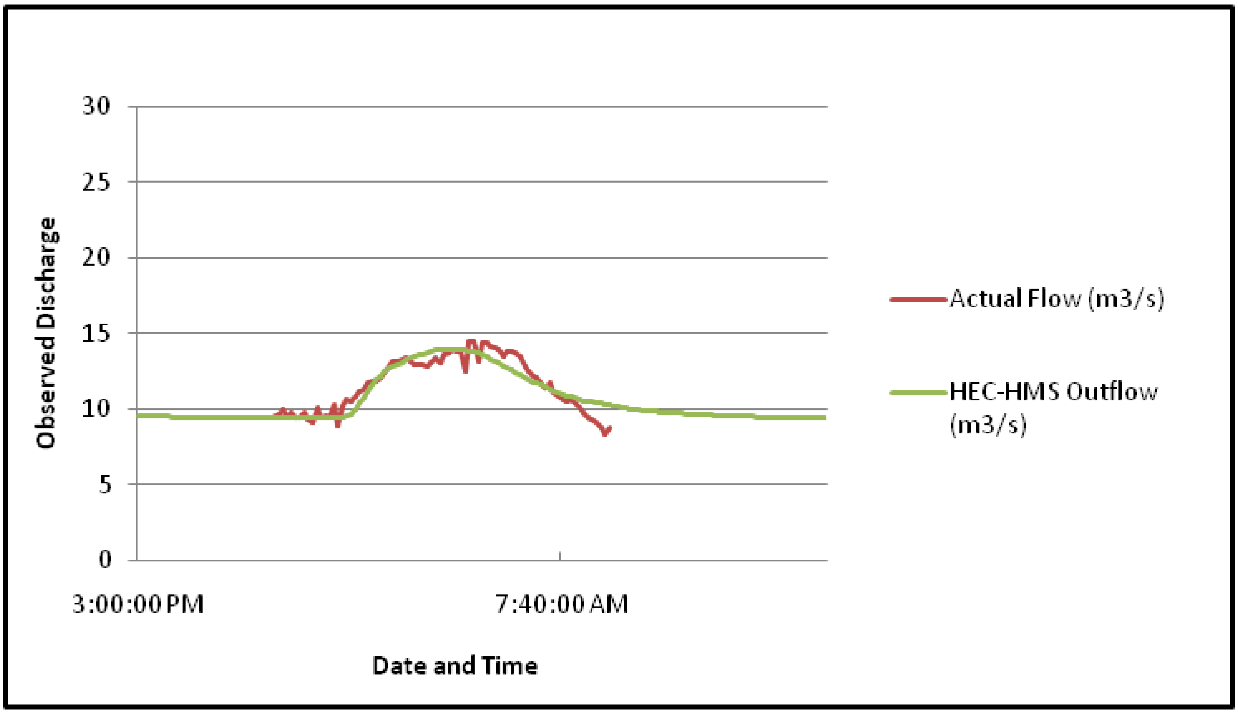


Figure 59. Outflow Hydrograph of Pansipit produced by the HEC-HMS model compared with observed outflow

Table 32. Range of Calibrated Values for Pansipit

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	0.77 – 23.46
			Curve Number	17.56 – 60.25
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.14 – 27.67
			Storage Coefficient (hr)	0.16 – 45.16
	Baseflow	Recession	Recession Constant	0.12 – 1.00
			Ratio to Peak	0.22 – 0.58
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.00020 – 0.0034

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 0.77mm to 23.46mm means that there is minimal to moderate 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. For Pansipit, the soil classes identified were hydrosols, loam, clay loam, sand, sandy loam, and mountain soil. The land cover types identified were brushland, built-up areas, cultivated areas, grassland, inland water, open areas and open canopy forest.

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 0.14 hours to 45.16 hours determines the reaction time of the model with respect to the rainfall. The peak magnitude of the hydrograph also decreases when these parameters are increased.

Recession constant is the rate at which baseflow recedes between storm events and ratio to peak is the ratio of the baseflow discharge to the peak discharge. Recession constant of 0.12 – 1.00 indicates that the basin is unlikely to quickly go back to its original discharge and instead, will be higher. Ratio to peak of 0.22 – 0.58 indicates a moderately receding limb of the outflow hydrograph.

Table 33. Summary of the Efficiency Test of Pansipit HMS Model

RMSE	0.7
r^2	0.48
NSE	0.85
PBIAS	0.30
RSR	0.39

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 0.7 m3/s.

The Pearson correlation coefficient (r2) 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 0.48.

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 0.85.

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 0.30.

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 0.39.

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

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 60) shows the Pansipit 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.

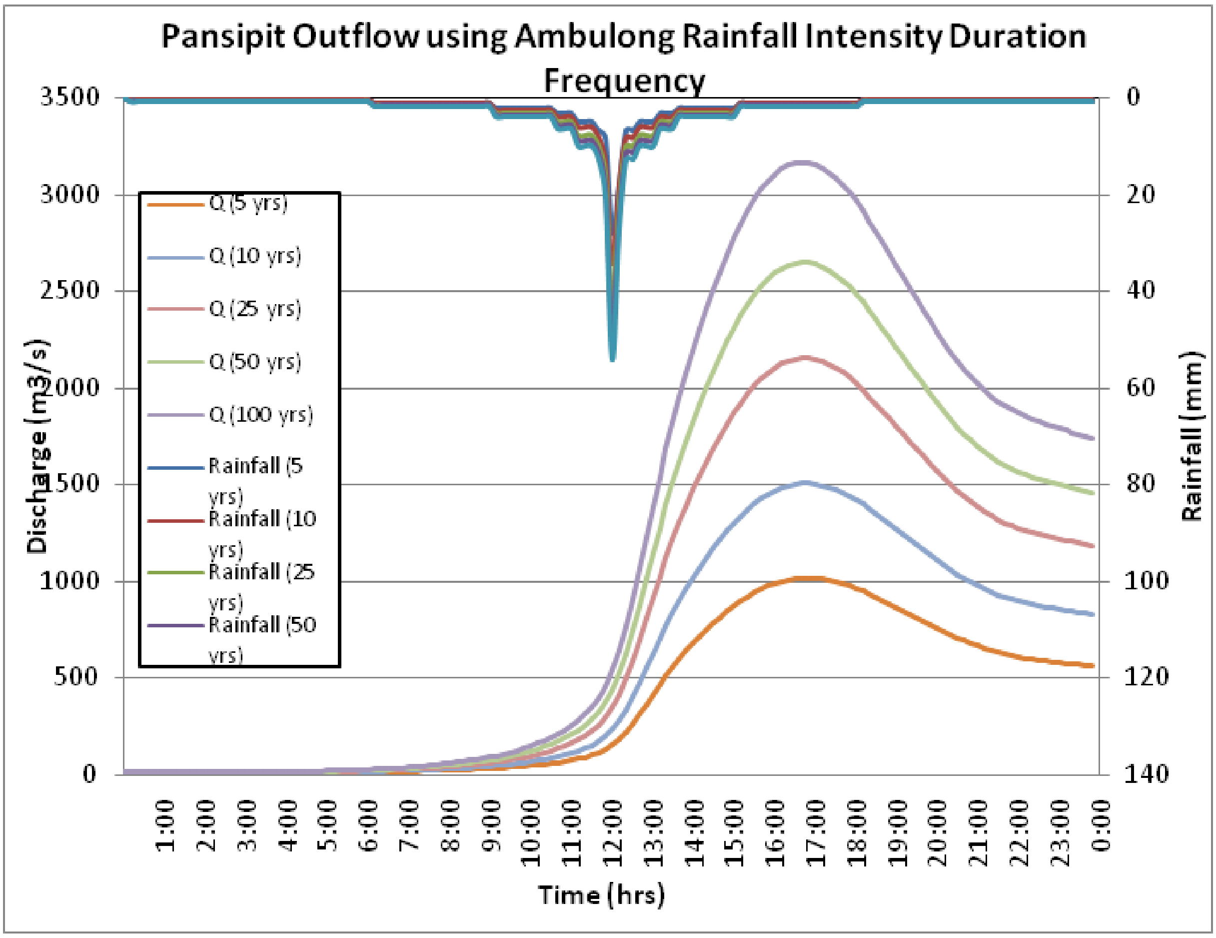


Figure 60. Outflow hydrograph at Pansipit Station generated using Ambulong RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Pansipit River discharge using the Ambulong Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 34.

Table 34. Peak values of the Pansipit 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	1015.7	16 hours, 50 minutes
10-Year	276.9	34.2	1505.5	16 hours, 50 minutes
25-Year	340.4	42.2	2152	16 hours, 40 minutes
50-Year	387.5	48.1	2648.8	16 hours, 40 minutes
100-Year	434.3	54	3166.8	16 hours, 40 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 Pansipit River using the calibrated HMS base flow is shown in Figure 61.

Figure 61. Sample output of Pansipit RAS Model

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 62 to Figure 67 shows the 5-, 25-, and 100-year rain return scenarios of the Pansipit floodplain.

Table 35. Municipalities affected in Pansipit floodplain

Municipality	Total Area	Area Flooded	% Flooded
Lemery	72.15	37.85	52.46%
Santa Teresita	15.37	3.59	23.37%
Agoncillo	48.8	19.2	40.82%
San Nicolas	21.34	8.19	38.36%
Taal	27.07	25.058	92.57%

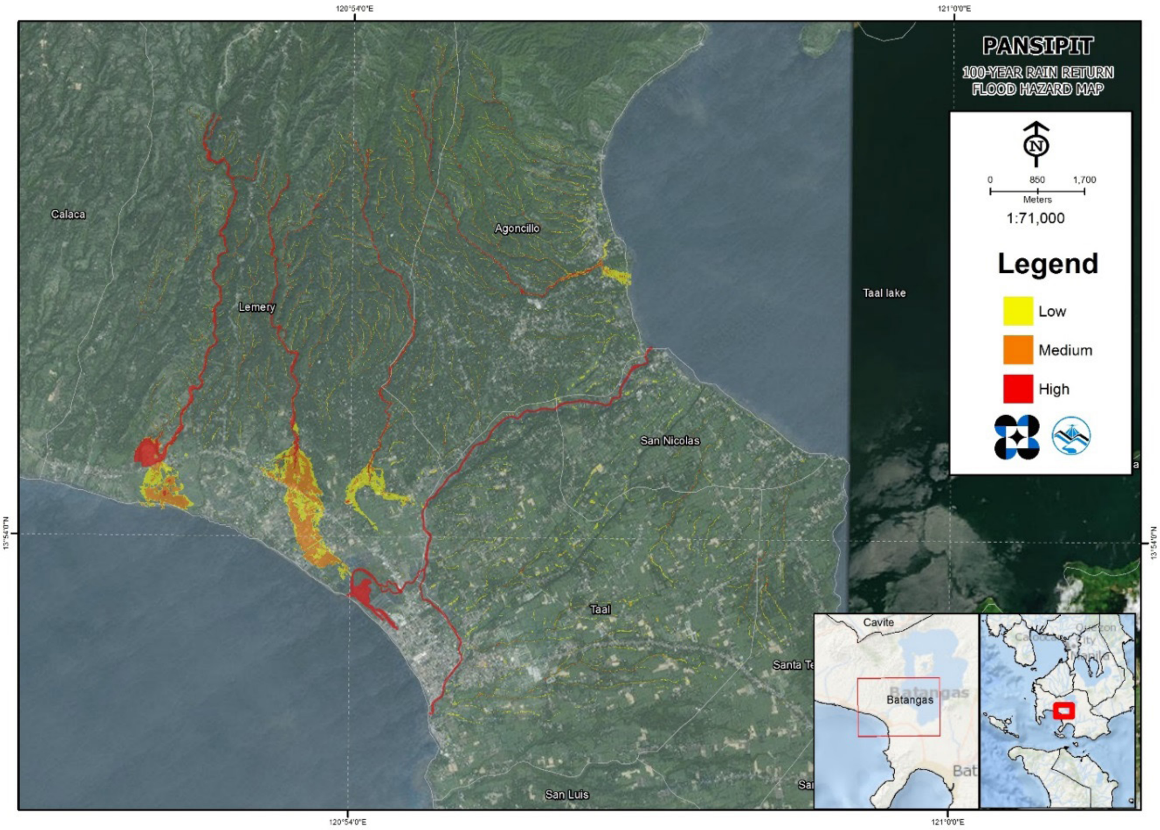


Figure 62. 100-year Flood Hazard Map for Pansipit Floodplain

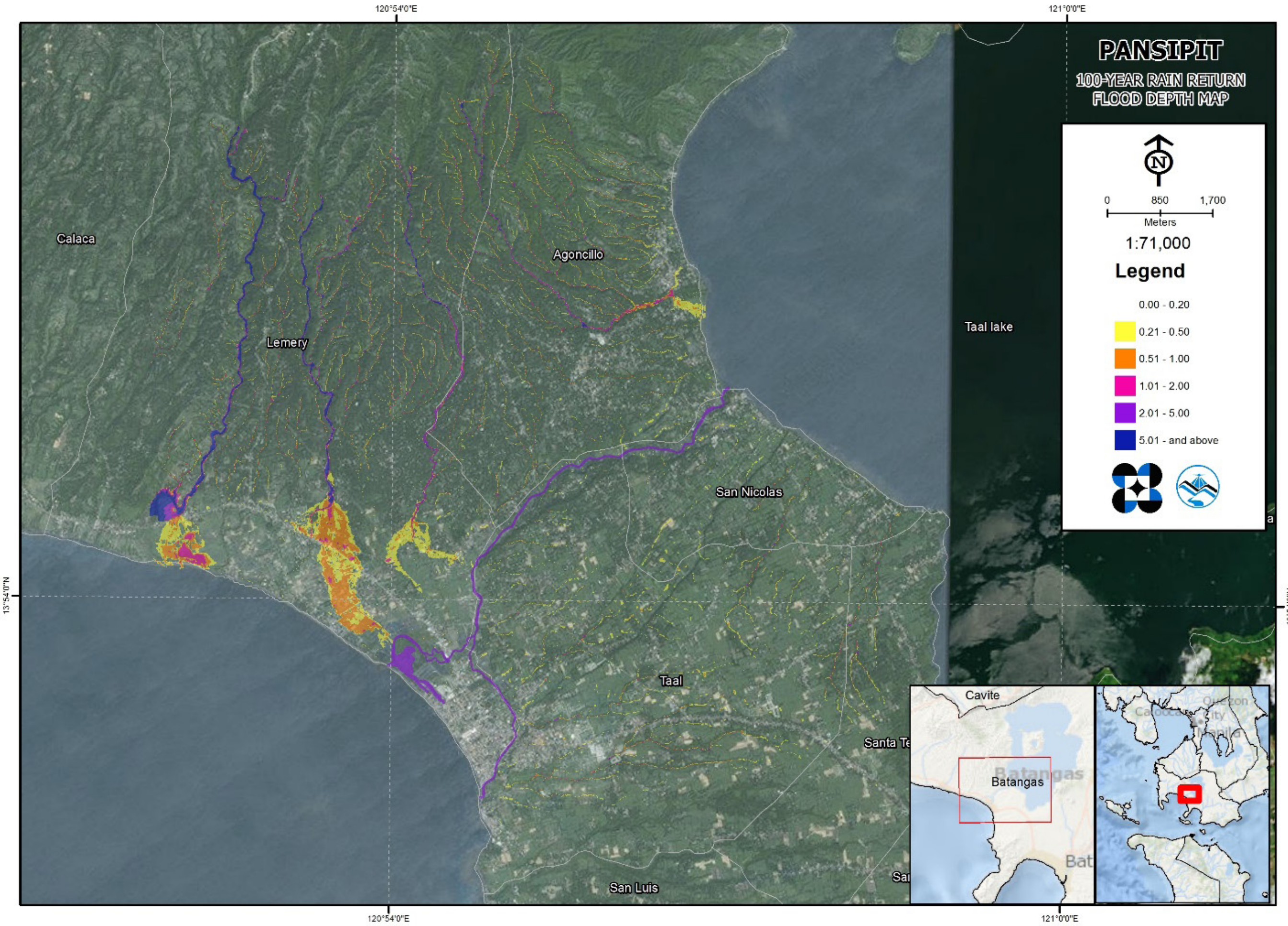


Figure 63. 100-year Flow Depth Map for Pansipit Floodplain

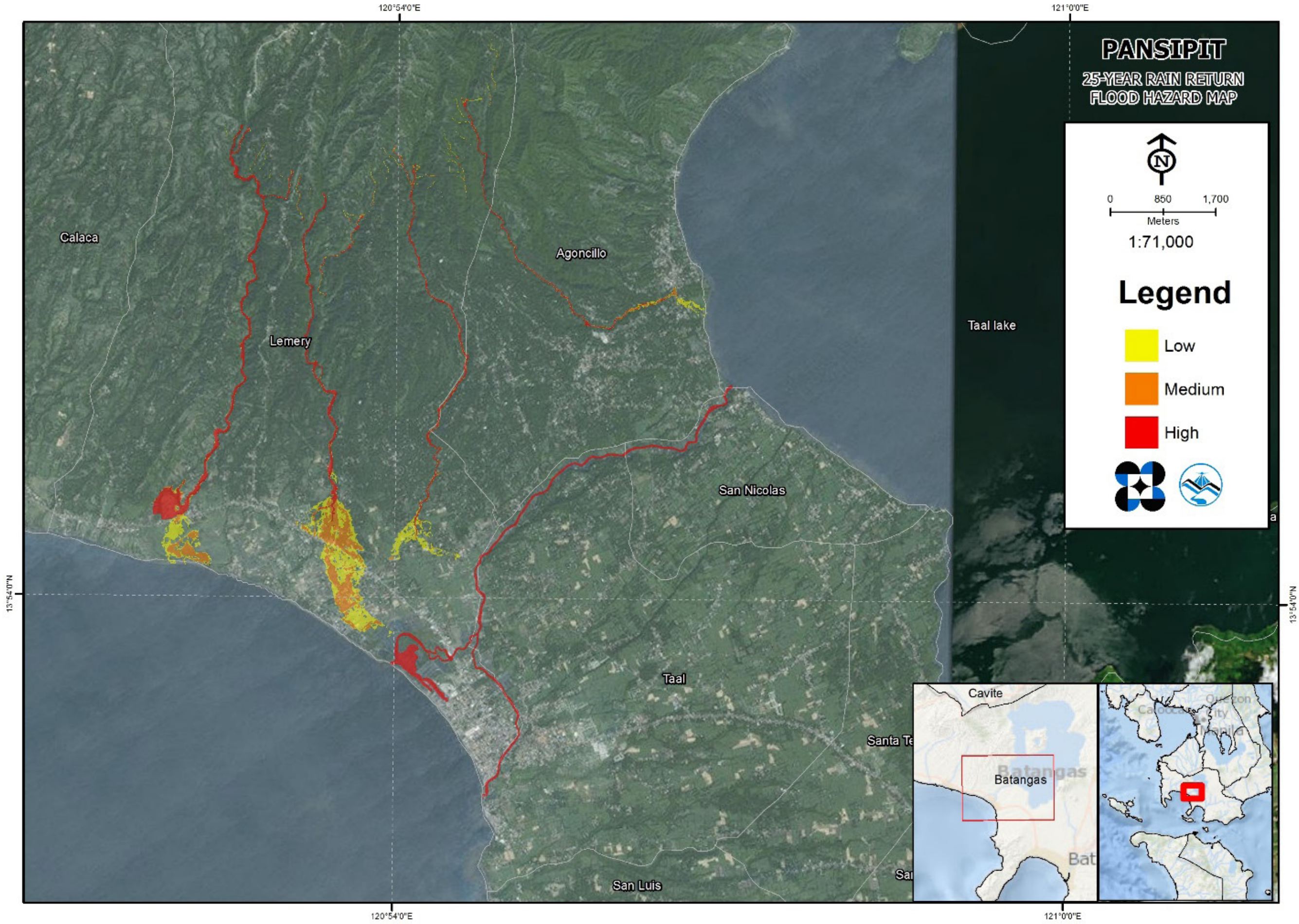


Figure 64. 25-year Flood Hazard Map for Pansipit Floodplain

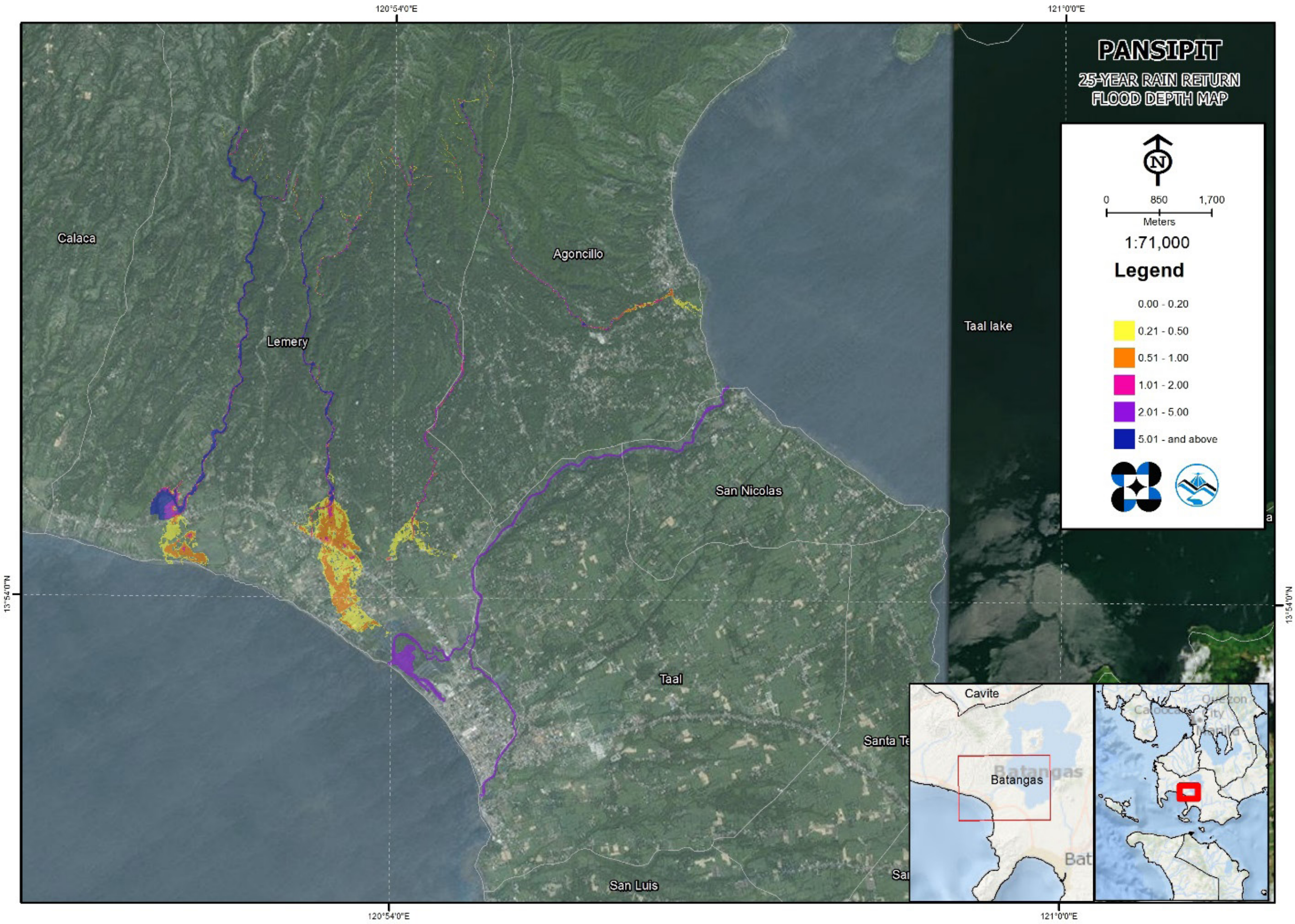


Figure 65. 25-year Flow Depth Map for Pansipit Floodplain

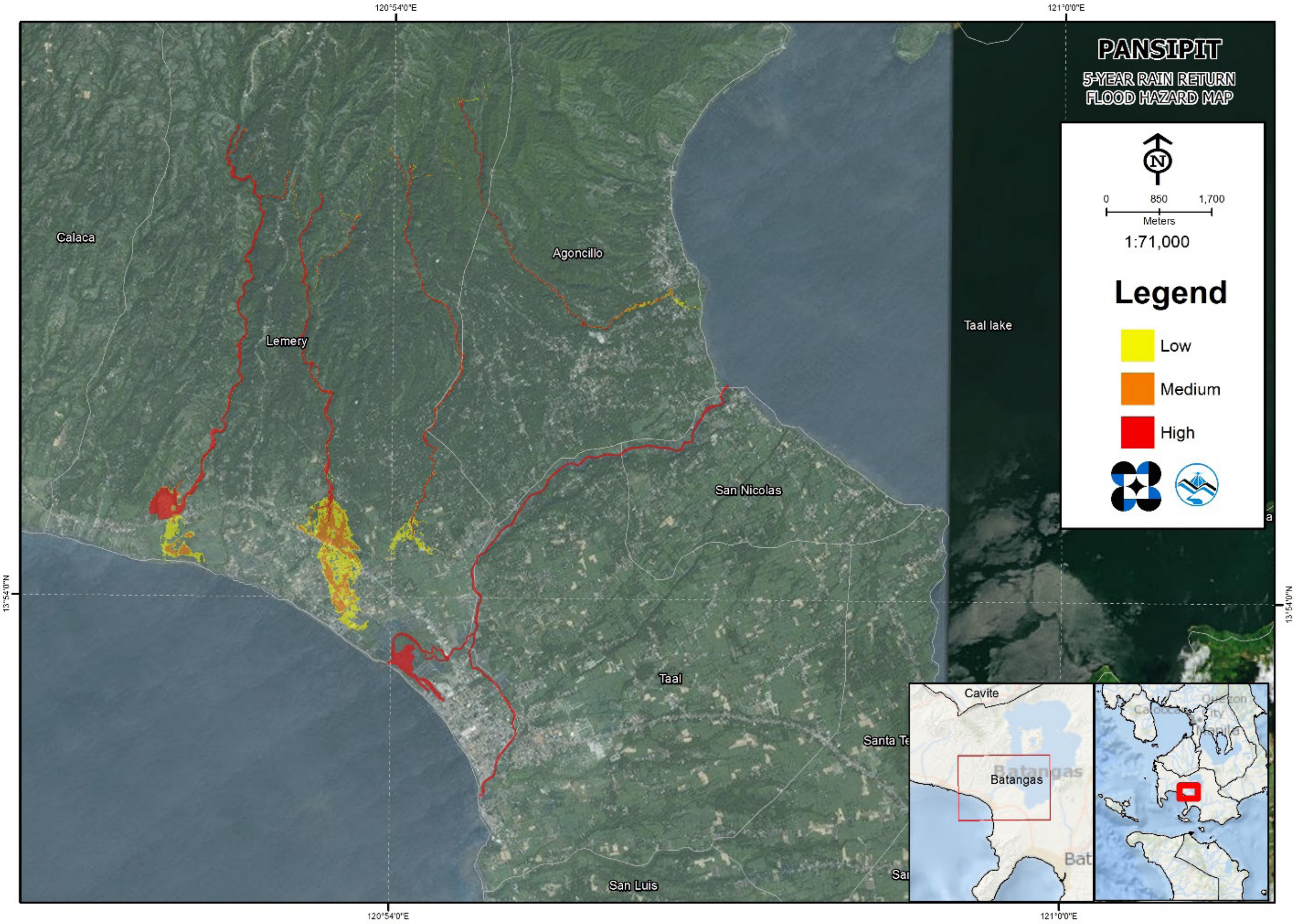


Figure 66. 5-year Flood Hazard Map for Pansipit Floodplain

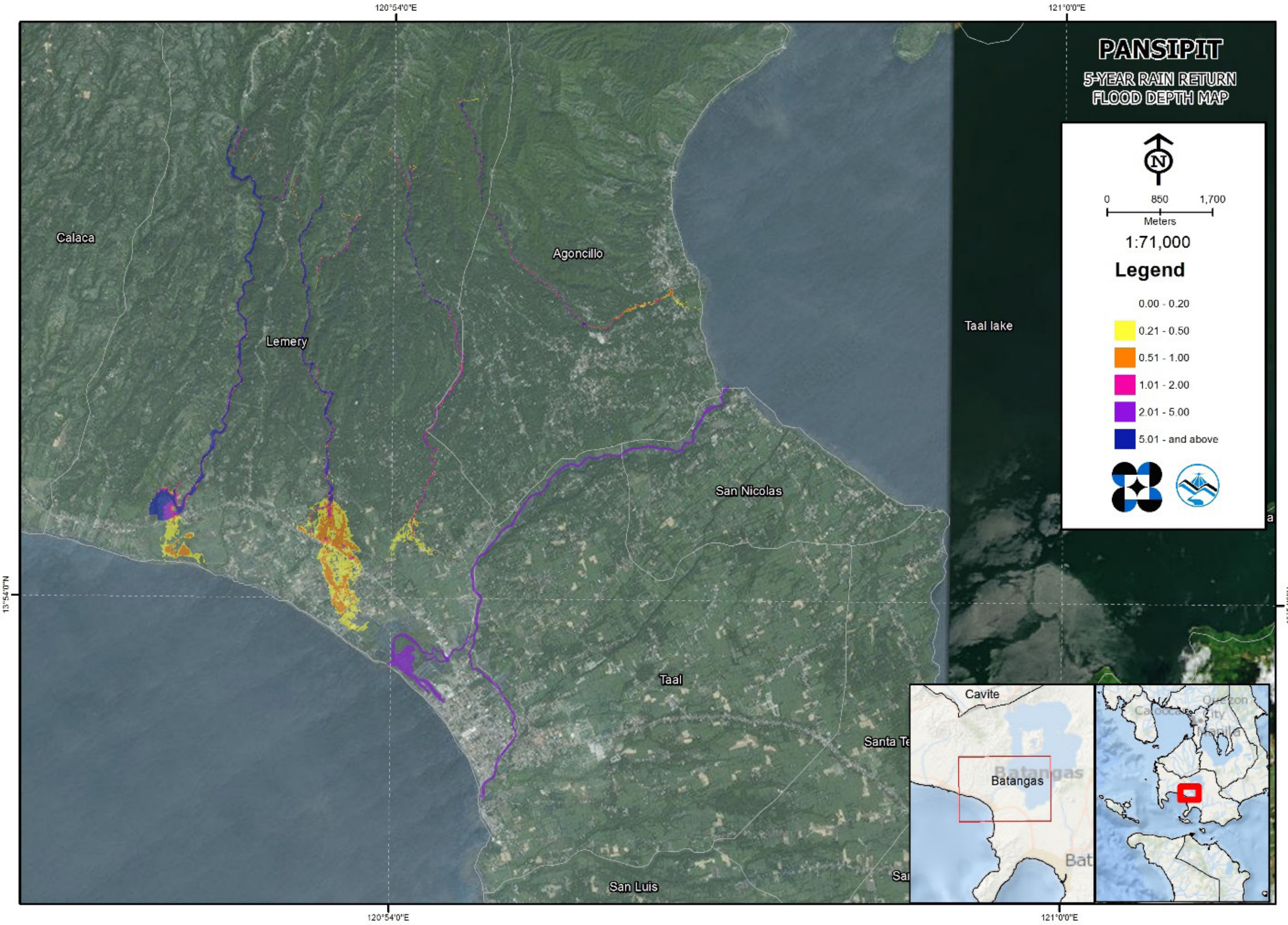


Figure 67. 5-year Flow Depth Map for Pansipit Floodplain

5.10 Inventory of Areas Exposed to Flooding

Listed below are the barangays affected by the Pansipit River Basin, grouped accordingly by municipality. For the said basin, four (4) municipalities consisting of 140 barangays are expected to experience flooding when subjected to a 5-year rainfall return period (see Annex 11 and 12 for the list of educational and health institutions affected by flooding in the Pansipit floodplain).

For the 5-year return period, 48.90% of the municipality of Lemery with an area of 72.15 sq. km. will experience flood levels of less than 0.20 meters. 1.16% of the area will experience flood levels of 0.21 to 0.50 meters while 0.69%, 0.21%, 0.88%, and 0.66% 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 Lemery, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)										
		Anak-Dagat	Aruma-han	Ayao-Iyao	Bagong Pook	Bagong Sikat	Balanga	Bukal	Cahilan I	Cahilan II	Dayapan	District I
Affected Area (sq. km.)	1	0.11	0.12	2.2	1.13	0.25	1.34	0.17	0.95	1.2	1.46	0.14
	2	0	0	0.05	0.0014	0	0	0.079	0.0012	0	0.0016	0
	3	0	0	0.013	0.0019	0	0	0.12	0.0038	0.0012	0.0033	0
	4	0	0	0.015	0.0024	0	0	0.0023	0.0094	0.0026	0.0098	0
	5	0	0	0.029	0.0048	0.037	0	0	0.018	0.0072	0.027	0.00059
	6	0	0	0	0.0034	0	0	0	0.002	0	0.051	0

Table 37. Affected areas in Lemery, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)										
		District II	District III	District IV	Dita	Gulod	Lucky	Magui-han	Mahabang Dahilig	Mahaya-hay	Maigsing Dahilig	Maligaya
Affected Area (sq. km.)	1	0.058	0.22	0.082	3.38	1.56	0.11	0.13	0.92	0.61	0.46	0.053
	2	0	0	0	0.00066	0.0011	0	0	0.0045	0	0.0003	0
	3	0	0	0	0.00063	0.0019	0	0	0.0053	0	0.0004	0
	4	0	0	0	0.0019	0.0059	0	0	0.0072	0	0.0011	0
	5	0.0079	0	0.00084	0.004	0.016	0	0	0.014	0	0.0043	0
	6	0	0	0	0.004	0.062	0	0	0.035	0	0.016	0

Table 38. Affected areas in Lemery, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)										
		Malinis	Masalisi	Mataas Na Bayan	Matin-gain I	Matin-gain II	Nonong Casto	Palanas	Payapa Ibaba	Payapa Ilaya	Rizal	Sambal Ibaba
Affected Area (sq. km.)	1	2.1	0.36	0.94	1.4	1.5	0.75	0.59	1.62	0.25	0.026	0.14
	2	0.13	0.0033	0.13	0.093	0.0047	0.25	0	0.019	0.0007	0	0
	3	0.04	0.0032	0.062	0.058	0.0036	0.15	0	0.0087	0.0003	0	0
	4	0	0.005	0.022	0.019	0.0056	0.0052	0	0.0095	0.0001	0	0
	5	0.0057	0.0075	0.071	0.01	0.019	0	0.17	0.013	0	0	0.0011
	6	0	0.0065	0.15	0.013	0.026	0	0	0.018	0	0	0

Table 39. Affected areas in Lemery, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)									
		Sambal Ilaya	San Isidro Ibaba	San Isidro Itaas	San-galang	Sinisian East	Talaga	Tubigan	Tubuan	Wawa Ibaba	Wawa Ilaya
Affected Area (sq. km.)	1	0.3	2.09	4.06	0.27	0.039	0.27	0.94	0.92	0.0075	0.056
	2	0	0.0051	0.014	0	0.00012	0.0006	0.044	0	0	0
	3	0	0.0062	0.0096	0	0.000074	0.0017	0.0055	0	0	0
	4	0	0.0098	0.017	0	0	0.0011	0.00062	0	0	0
	5	0.076	0.028	0.041	0.013	0.00025	0.0037	0.0009	0	0.00047	0.00077
	6	0	0.053	0.024	0	0.000005	0.015	0	0	0	0

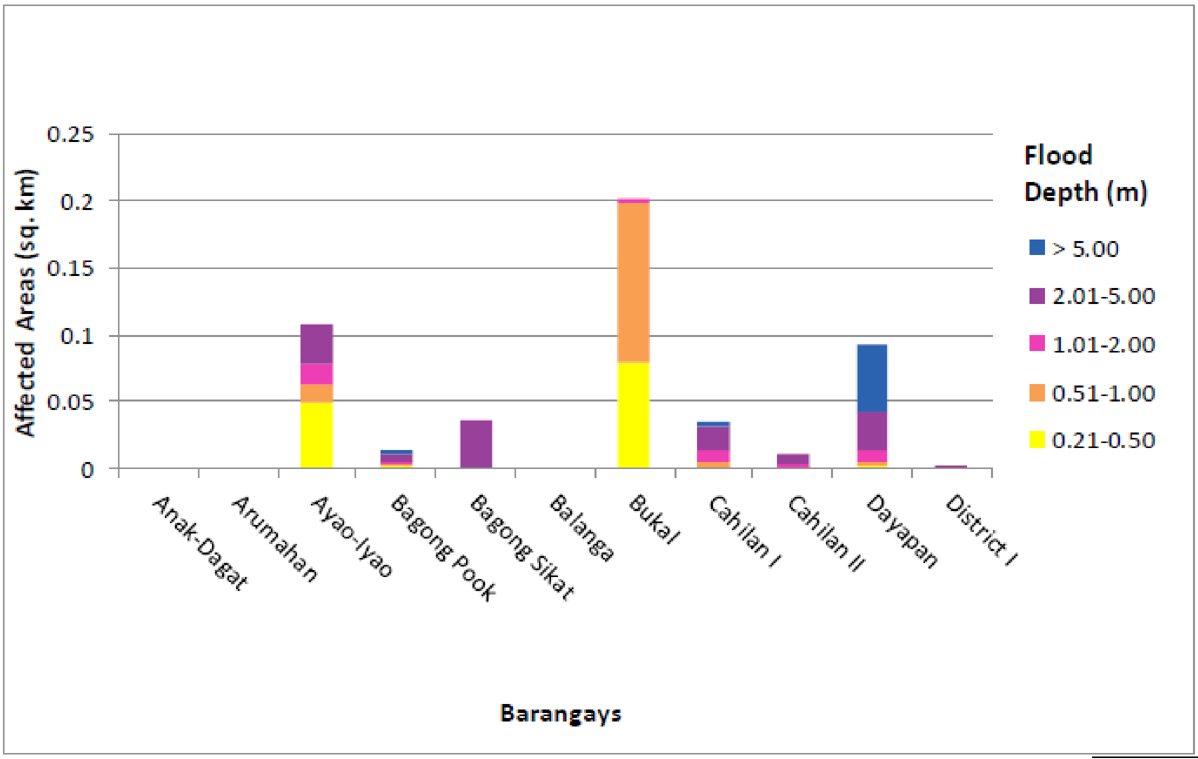


Figure 68. Affected areas in Lemery, Batangas during a 5-Year Rainfall Return Period

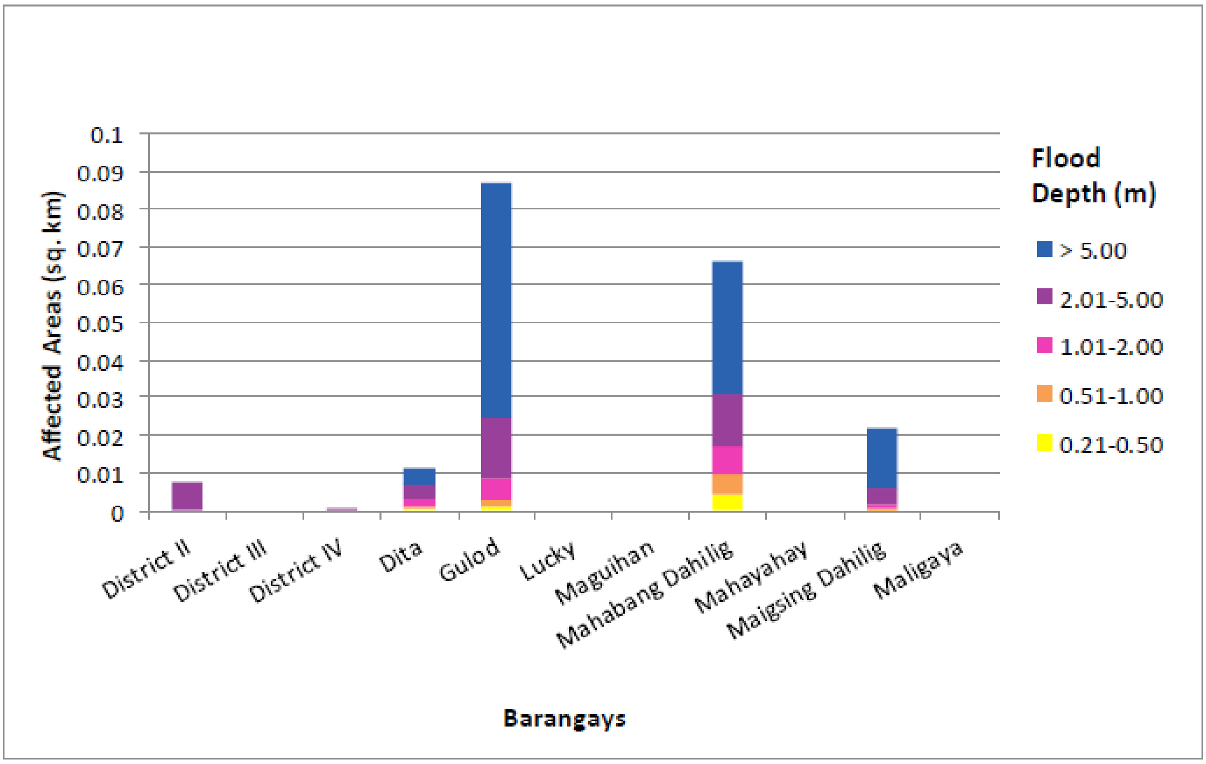


Figure 69. Affected areas in Lemery, Batangas during a 5-Year Rainfall Return Period

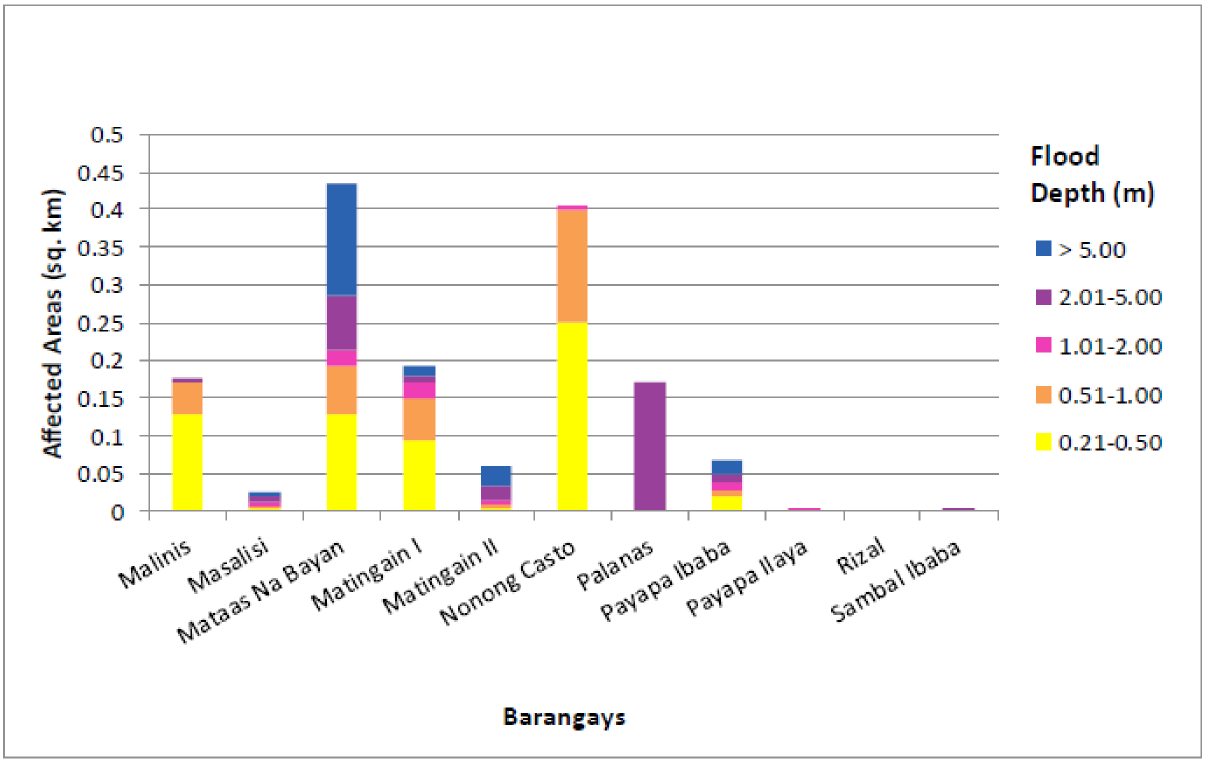


Figure 70. Affected areas in Lemery, Batangas during a 5-Year Rainfall Return Period

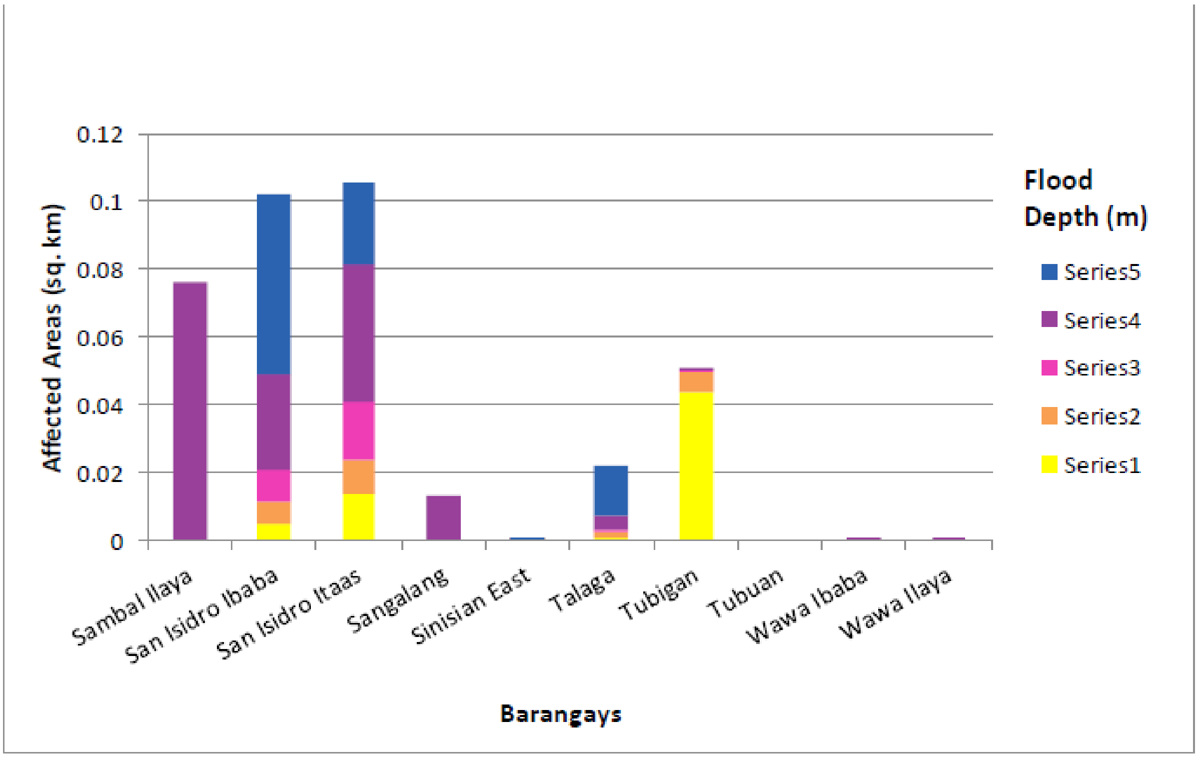


Figure 71. Affected areas in Lemery, Batangas during a 5-Year Rainfall Return Period

For the 5-year return period, 23.41% of the municipality of Santa Teresita with an area of 15.37 sq. km. will experience flood levels of less than 0.20 meters. 0.00% of the area will experience flood levels of 0.21 to 0.50 meters while 0.00%, 0.00%, 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 40. Affected areas in Santa Teresita, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Santa Teresita (in sq. km.)										
		Antipolo	Bihis	Burol	Calum-ala	Pobla-cion I	Pobla-cion II	Pobla-cion III	Saimsim	Sinipian	Tambo Ibaba	Tambo Ilaya
Affected Area (sq. km.)	1	0.25	0.031	0.74	0.4	0.001	0.053	0.003	0.93	0.64	0.13	0.42
	2	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0

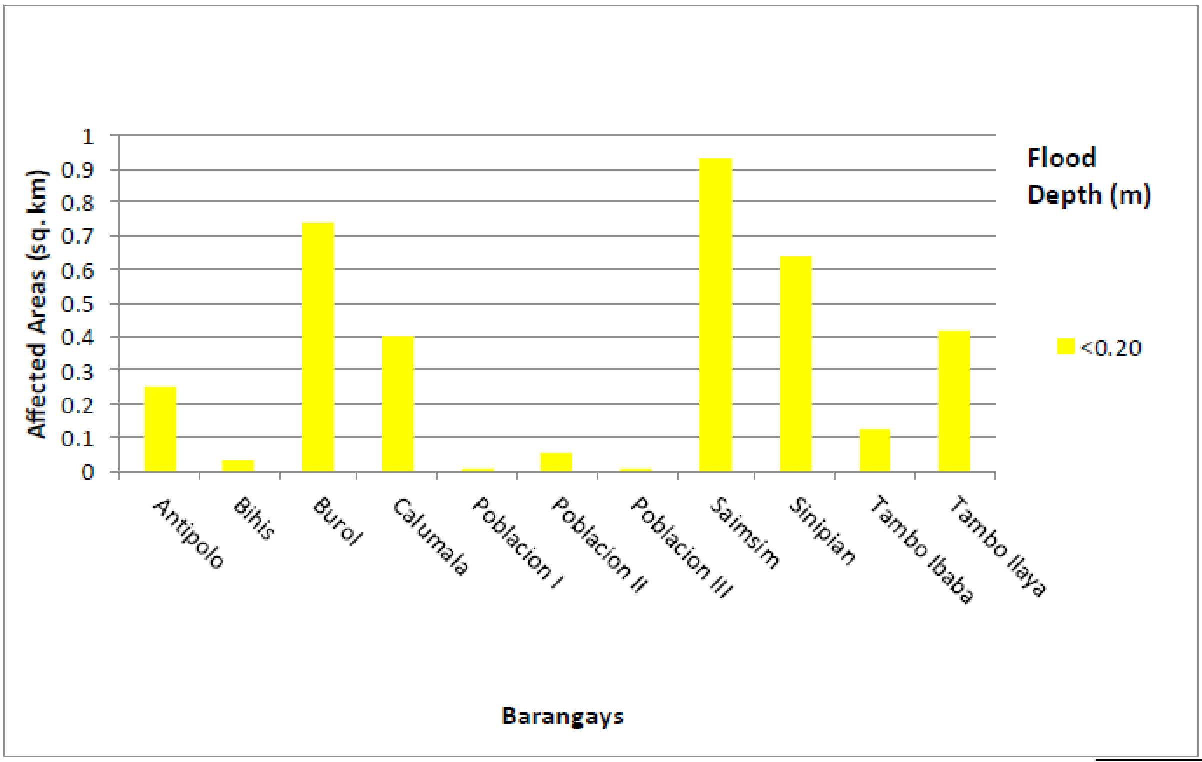


Figure 72. Areas affected by flooding in Santa Teresita, Batangas for a 5-Year Return Period rainfall event

For the 5-year return period, 40.43% of the municipality of Agoncillo with an area of 48.8 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 0.07%, 0.09%, 0.09%, 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 41. Affected areas in Agoncillo, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Agoncillo (in sq. km.)								
		Adia	Bagong Sikat	Balan-gon	Bangin	Barigon	Coral Na Munti	Guitna	Mabini	Pamiga
Affected Area (sq. km.)	1	1.04	0.98	1.26	1.37	2.28	1.75	0.25	1.28	0.47
	2	0	0.0087	0.0013	0	0	0.00086	0	0.00063	0
	3	0	0.013	0.0023	0	0	0.0013	0	0.0017	0
	4	0	0.012	0.0074	0	0	0.0043	0	0.0066	0
	5	0	0.011	0.0076	0	0	0.0057	0	0.0075	0
	6	0	0.0017	0	0	0	0.0002	0	0	0

Table 42. Affected areas in Agoncillo, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Agoncillo (in sq. km.)									
		Panhu-lan	Pansipit	Pobla-cion	Pook	San Jacinto	San Te-odoro	Santa Cruz	Santo Tomas	Subic Ibaba	Subic Ilaya
Affected Area (sq. km.)	1	0.44	0.4	0.58	1.82	2.08	0.2	0.86	0.43	1.4	0.84
	2	0.025	0	0	0	0.0017	0	0	0	0.00044	0
	3	0.0097	0	0	0	0.0033	0	0	0	0.00059	0
	4	0.0047	0	0	0	0.0066	0	0	0	0.00079	0
	5	0.0002	0.00066	0	0	0.013	0	0	0	0	0
	6	0	0	0	0	0.0018	0	0	0	0	0

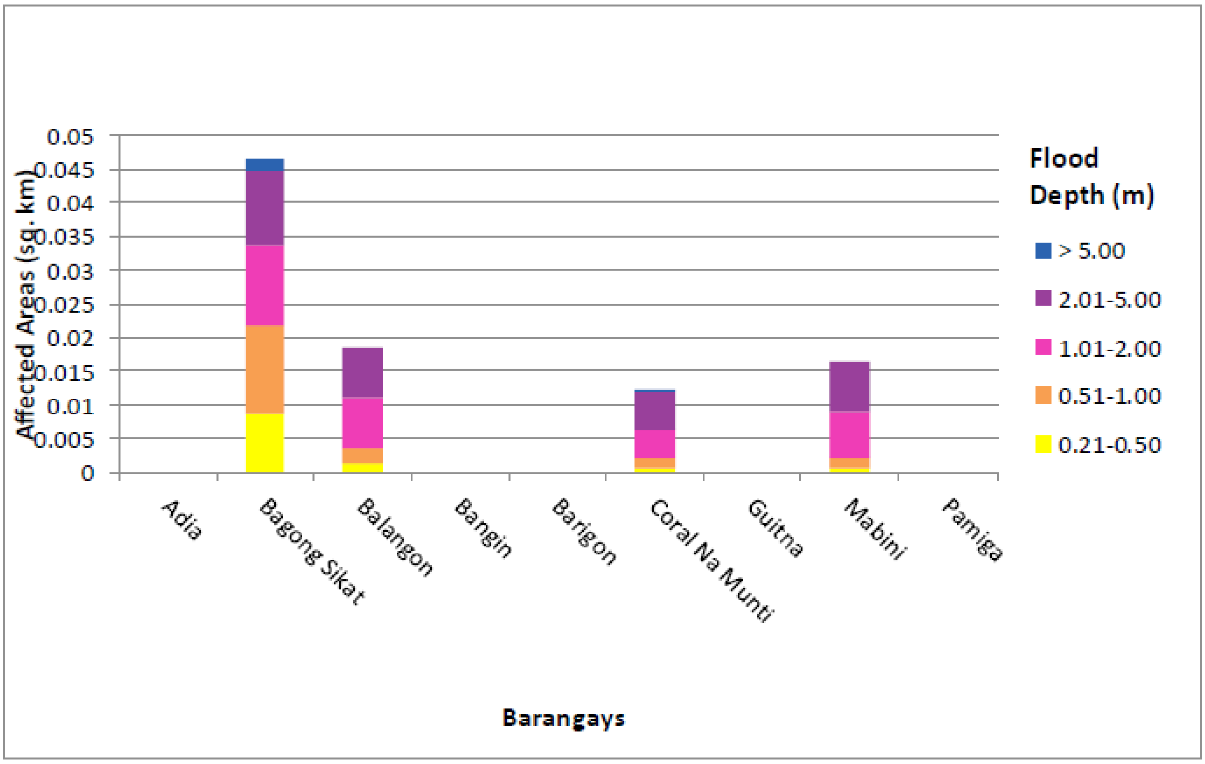


Figure 73. Areas affected by flooding in Agoncillo, Batangas for a 5-Year Return Period rainfall event

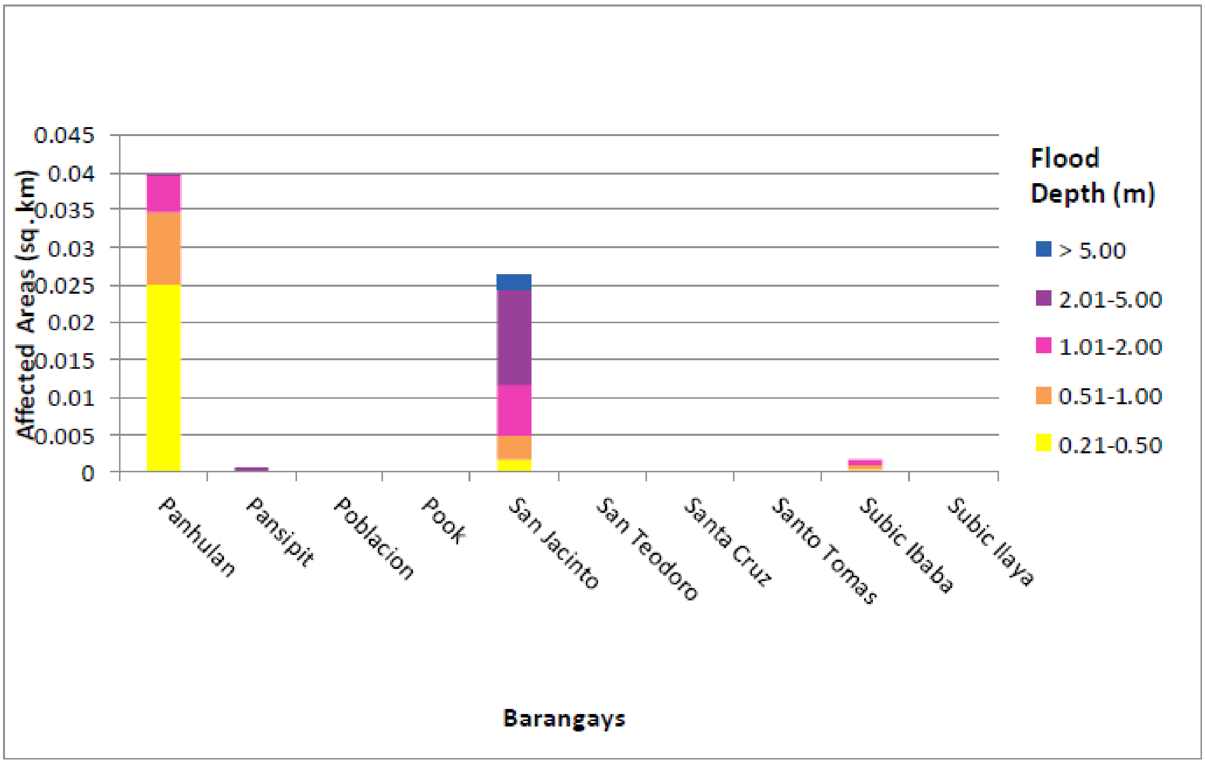


Figure 74. Areas affected by flooding in Agoncillo, Batangas for a 5-Year Return Period rainfall event

For the 5-year return period, 38.00% of the municipality of San Nicolas with an area of 21.34 sq. km. will experience flood levels of less than 0.20 meters. 0.00% of the area will experience flood levels of 0.21 to 0.50 meters while 0.00%, 0.00%, 0.44%, 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 43. Affected areas in San Nicolas, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in San Nicolas (in sq. km.)									
		Abelo	Balete	Ba-luk-Ba-luk	Bancoro	Bangin	Calangay	Hipit	Maabud North	Maabud South	Munlaw-in
Affected Area (sq. km.)	1	0.5	0.45	0.23	0.66	0.44	0.55	0.35	0.62	0.4	0.72
	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0.016	0.021	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0

Table 44. Affected areas in San Nicolas, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in San Nicolas (in sq. km.)					
		Pansipit	Pobla-cion	Santo Niño	Sinturi-san	Tagud-tod	Talang
Affected Area (sq. km.)	1	0.24	0.73	0.31	1.21	0.26	0.44
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	0.026	0.03	0	0	0	0
	6	0	0	0	0	0	0

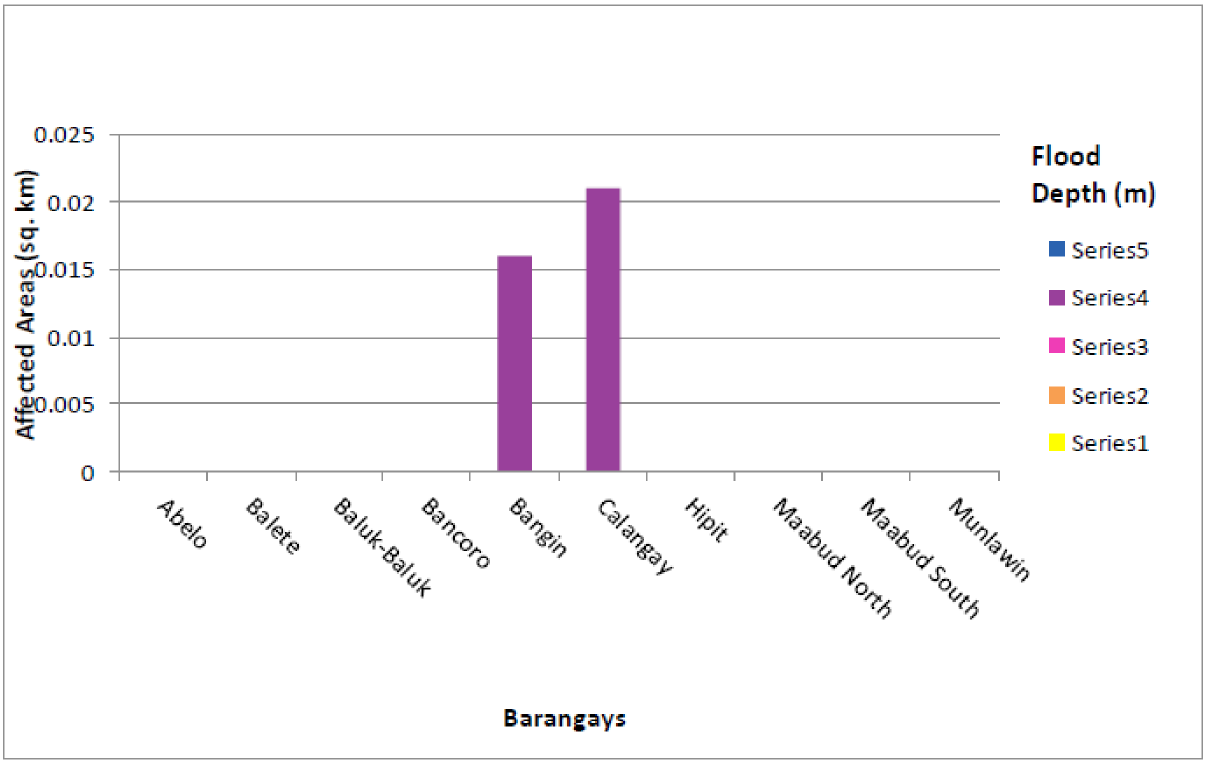


Figure 75. Areas affected by flooding in San Nicolas, Batangas for a 5-Year Return Period rainfall event.

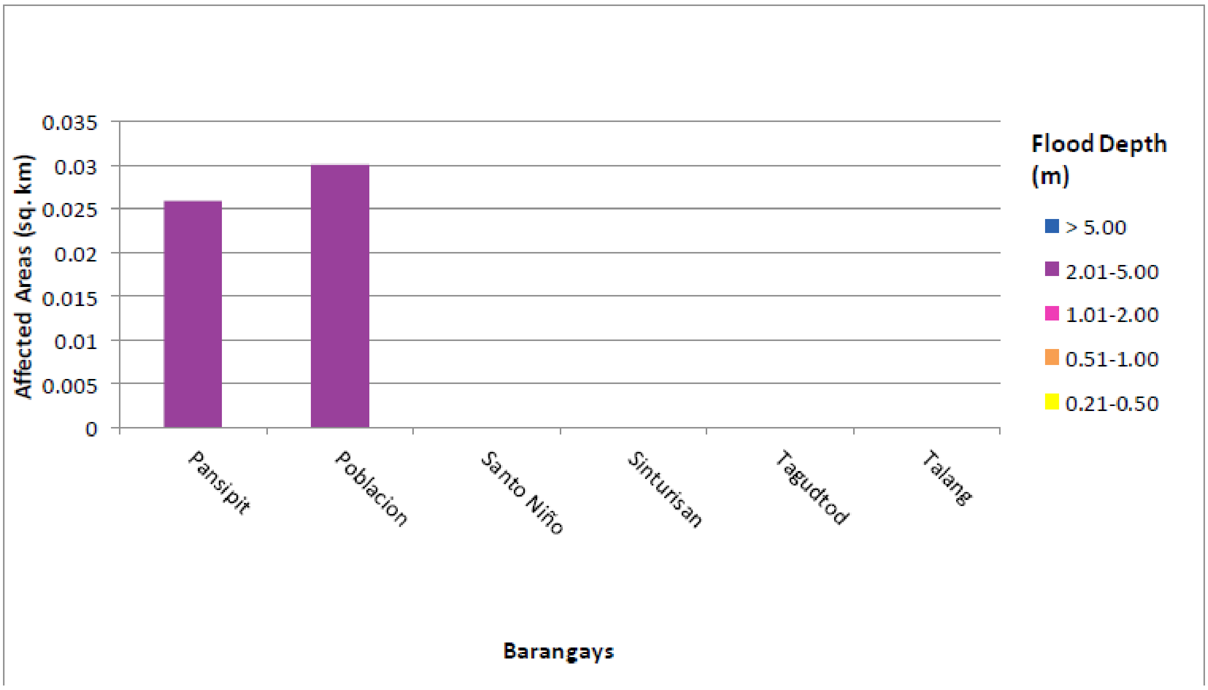


Figure 76. Areas affected by flooding in San Nicolas, Batangas for a 5-Year Return Period rainfall event.

For the 5-year return period, 91.72% of the municipality of Taal with an area of 27.07 sq. km. will experience flood levels of less than 0.20 meters. 0.00% of the area will experience flood levels of 0.21 to 0.50 meters while 0.00%, 0.00%, 0.78%, 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 45. Affected areas in Taal, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)								
		Apacay	Balisong	Bihis	Bolbok	Buli	Butong	Cara-suche	Cawit	Caysasay
Affected Area (sq. km.)	1	1.63	0.88	1.2	0.82	0.56	0.85	0.86	1.81	0.21
	2	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0
	5	0.023	0	0	0	0	0.021	0	0.037	0
	6	0	0	0	0	0	0	0	0	0

Table 46. Affected areas in Taal, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)								
		Cubam-ba	Cultihan	Gahol	Halang	Iba	Imamawo	Ipil	Laguile	Latag
Affected Area (sq. km.)	1	1.57	1.11	0.53	1.53	0.91	0.59	0.36	2.51	0.56
	2	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0.097	0
	6	0	0	0	0	0	0	0	0	0

Table 47. Affected areas in Taal, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)								
		Luntal	Ma-habang Lodlod	Niogan	Pobla-cion 1	Pobla-cion 10	Pobla-cion 11	Pobla-cion 12	Pobla-cion 13	Pobla-cion 14
Affected Area (sq. km.)	1	1.17	1.17	0.22	0.098	0.028	0.056	0.031	0.037	0.055
	2	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0

Table 48. Affected areas in Taal, Batangas during a 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)												
		Pobla-cion 2	Pobla-cion 3	Pobla-cion 4	Pobla-cion 5	Pobla-cion 6	Pobla-cion 7	Pobla-cion 8	Pobla-cion 9	Pook	Seiran	Tatlong Maria	Tierra Alta	Tulo
Affected Area (sq. km.)	1	0.032	0.12	0.1	0.088	0.024	0.046	0.15	0.094	0.75	0.67	0.13	0.22	1.05
	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0.0036	0.019	0	0	0	0	0	0.0053	0.0058	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0	0

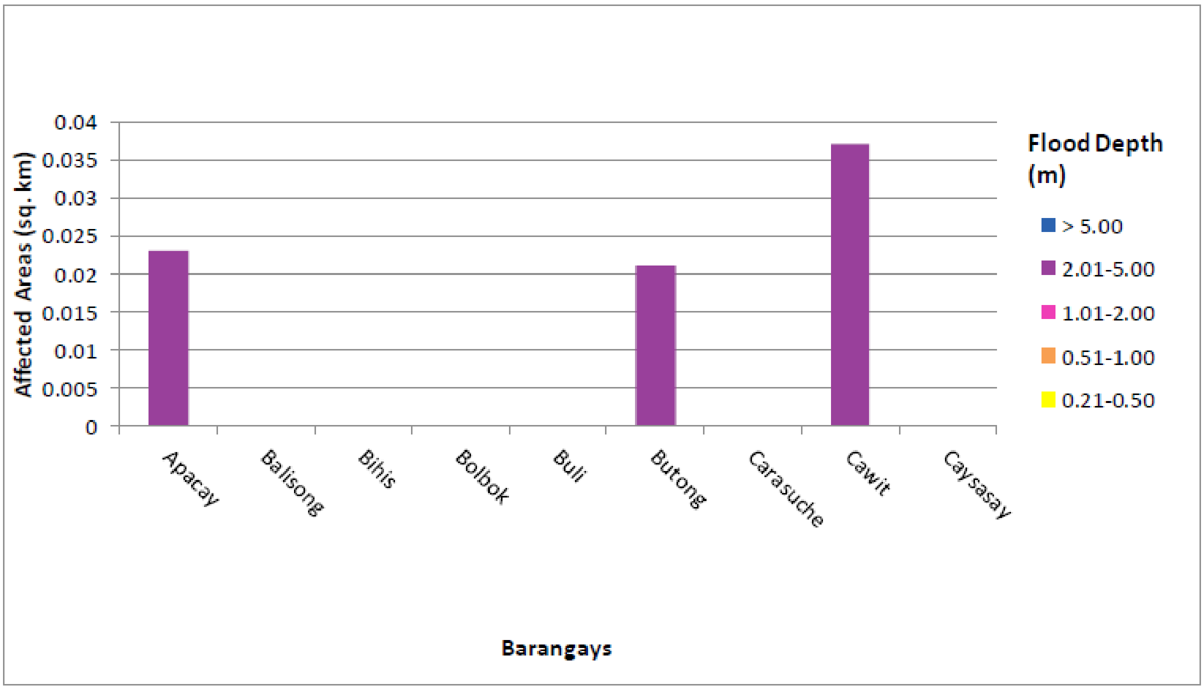


Figure 77. Areas affected by flooding in Taal, Batangas for a 5-Year Return Period rainfall event

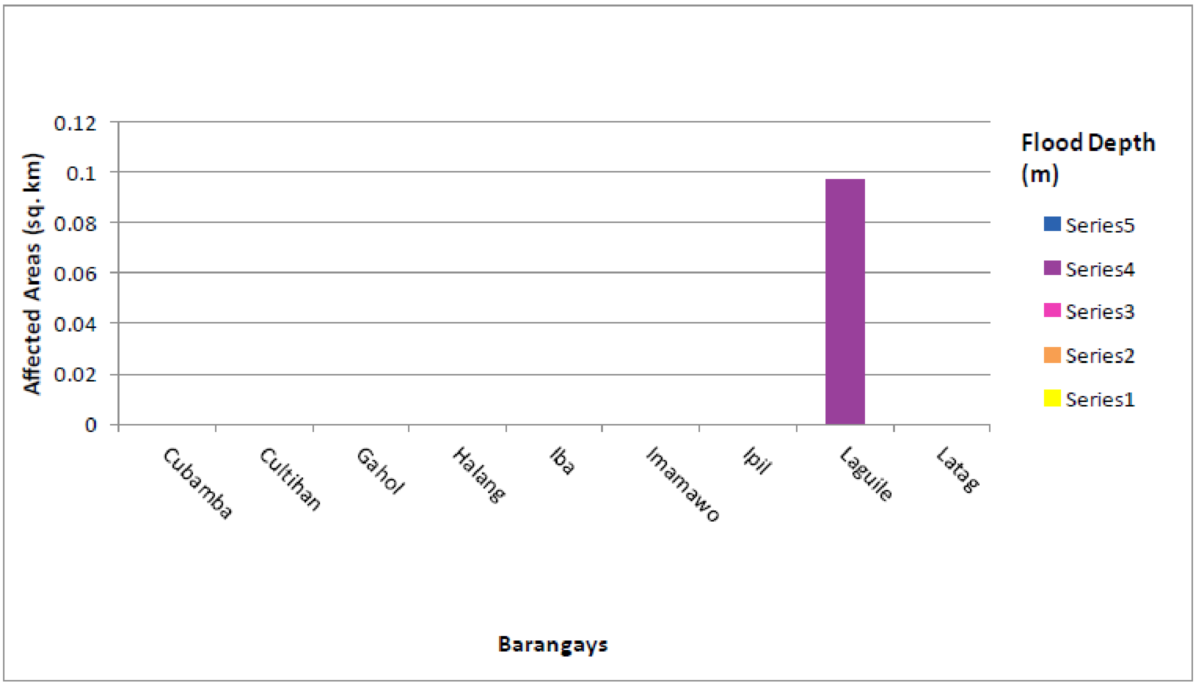


Figure 78. Areas affected by flooding in Taal, Batangas for a 5-Year Return Period rainfall event

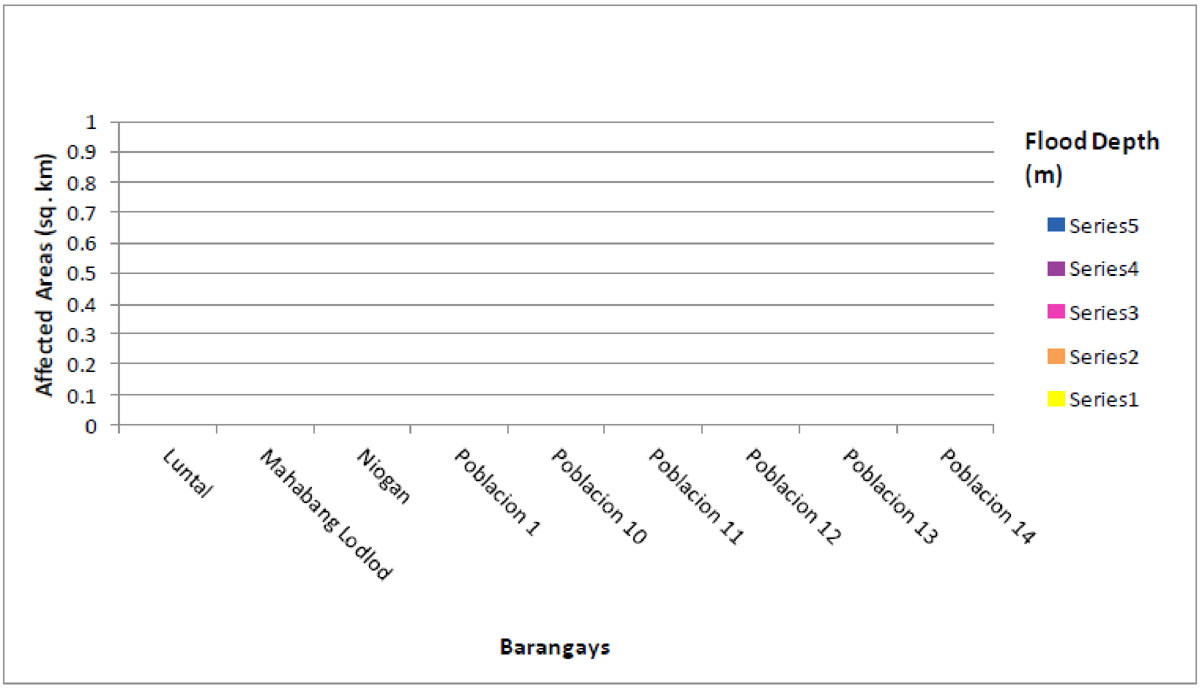


Figure 79. Areas affected by flooding in Taal, Batangas for a 5-Year Return Period rainfall event

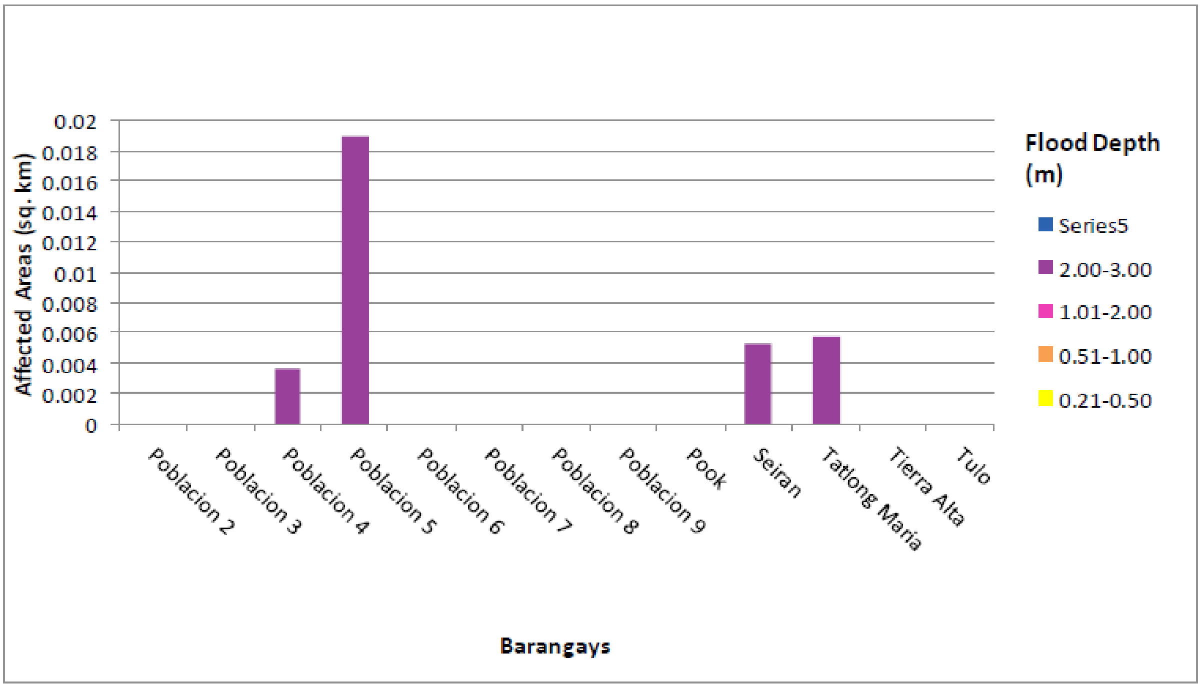


Figure 80. Areas affected by flooding in Taal, Batangas for a 5-Year Return Period rainfall event

For the 25-year return period, 48.47% of the municipality of Lemery with an area of 72.15 sq. km. will experience flood levels of less than 0.20 meters. 1.29% of the area will experience flood levels of 0.21 to 0.50 meters while 0.93%, 0.23%, 0.89%, and 0.67% 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 Lemery, Batangas during a 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)										
		Anak-Dagat	Aruma-han	Ayao-Iyao	Bagong Pook	Bagong Sikat	Balanga	Bukal	Cahilan I	Cahilan II	Dayapan	District I
Affected Area (sq. km.)	1	0.11	0.12	2.18	1.12	0.25	1.34	0.17	0.95	1.2	1.46	0.14
	2	0	0	0.071	0.0023	0	0	0.072	0.00091	0.0002	0.001	0
	3	0	0	0.014	0.0023	0	0	0.13	0.0038	0.0008	0.0041	0
	4	0	0	0.016	0.0023	0	0	0.0033	0.0087	0.0025	0.0092	0
	5	0	0	0.03	0.0049	0.037	0	0	0.019	0.0077	0.027	0.00059
	6	0	0	0	0.0037	0	0	0	0.002	0	0.052	0

Table 50. Affected areas in Lemery, Batangas during a 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)										
		District II	District III	District IV	Dita	Gulod	Lucky	Magui-han	Ma-habang Dahilig	Mahaya-hay	Maigsing Dahilig	Maligaya
Affected Area (sq. km.)	1	0.058	0.22	0.082	3.38	1.56	0.11	0.13	0.92	0.61	0.46	0.053
	2	0	0	0	0.00068	0.002	0	0	0.0049	0	0.0003	0
	3	0	0	0	0.00073	0.0018	0	0	0.0055	0	0.0004	0
	4	0	0	0	0.0018	0.0058	0	0	0.0075	0	0.0013	0
	5	0.0079	0	0.00084	0.004	0.016	0	0	0.014	0	0.0042	0
	6	0	0	0	0.0042	0.062	0	0	0.035	0	0.016	0

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

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)										
		Malinis	Masalisi	Mata-as Na Bayan	Matin-gain I	Matin-gain II	Nonong Casto	Palanas	Payapa Ibaba	Payapa Ilaya	Rizal	Sambal Ibaba
Affected Area (sq. km.)	1	2.01	0.36	0.85	1.39	1.49	0.73	0.59	1.6	0.25	0.026	0.14
	2	0.17	0.0062	0.15	0.095	0.0081	0.23	0	0.029	0.0023	0	0
	3	0.089	0.0036	0.12	0.065	0.0037	0.19	0	0.012	0.0002	0	0
	4	0.0014	0.0051	0.027	0.02	0.0059	0.0065	0	0.012	0.0004	0	0
	5	0.0057	0.0074	0.073	0.01	0.019	0	0.17	0.014	0.0002	0	0.0011
	6	0	0.0065	0.15	0.013	0.027	0	0	0.018	0	0	0

Table 52. Affected areas in Lemery, Batangas during a 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)									
		Sambal Ilaya	San Isidro Ibaba	San Isidro Itaas	San-galang	Sinisian East	Talaga	Tubigan	Tubuan	Wawa Ibaba	Wawa Ilaya
Affected Area (sq. km.)	1	0.3	2.08	4.04	0.27	0.039	0.27	0.93	0.92	0.0075	0.056
	2	0	0.0047	0.021	0	0	0.0014	0.058	0	0	0
	3	0	0.0072	0.012	0	0.00012	0.0019	0.0062	0	0	0
	4	0	0.01	0.019	0	0.000074	0.0011	0.00062	0	0	0
	5	0.076	0.029	0.041	0.013	0.00023	0.0037	0.0009	0	0.00047	0.00077
	6	0	0.054	0.025	0	0.000021	0.015	0	0	0	0

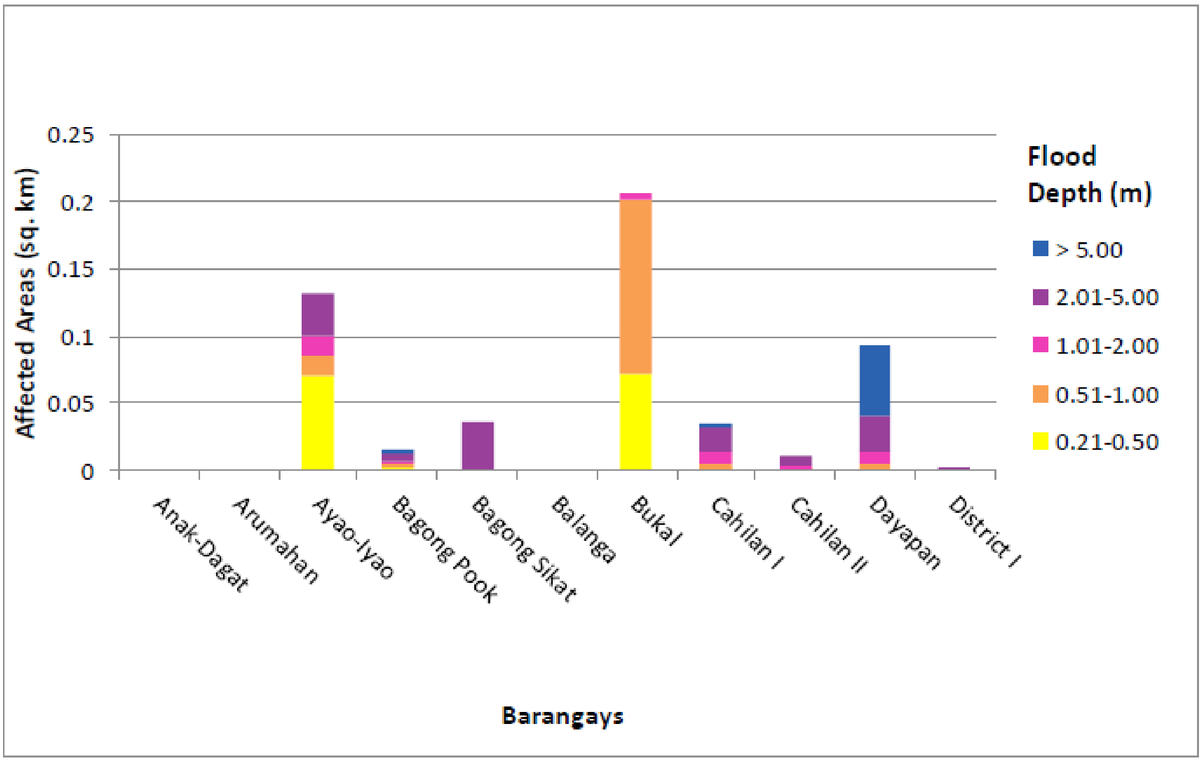


Figure 81. Affected areas in Lemery, Batangas during a 25-Year Rainfall Return Period.

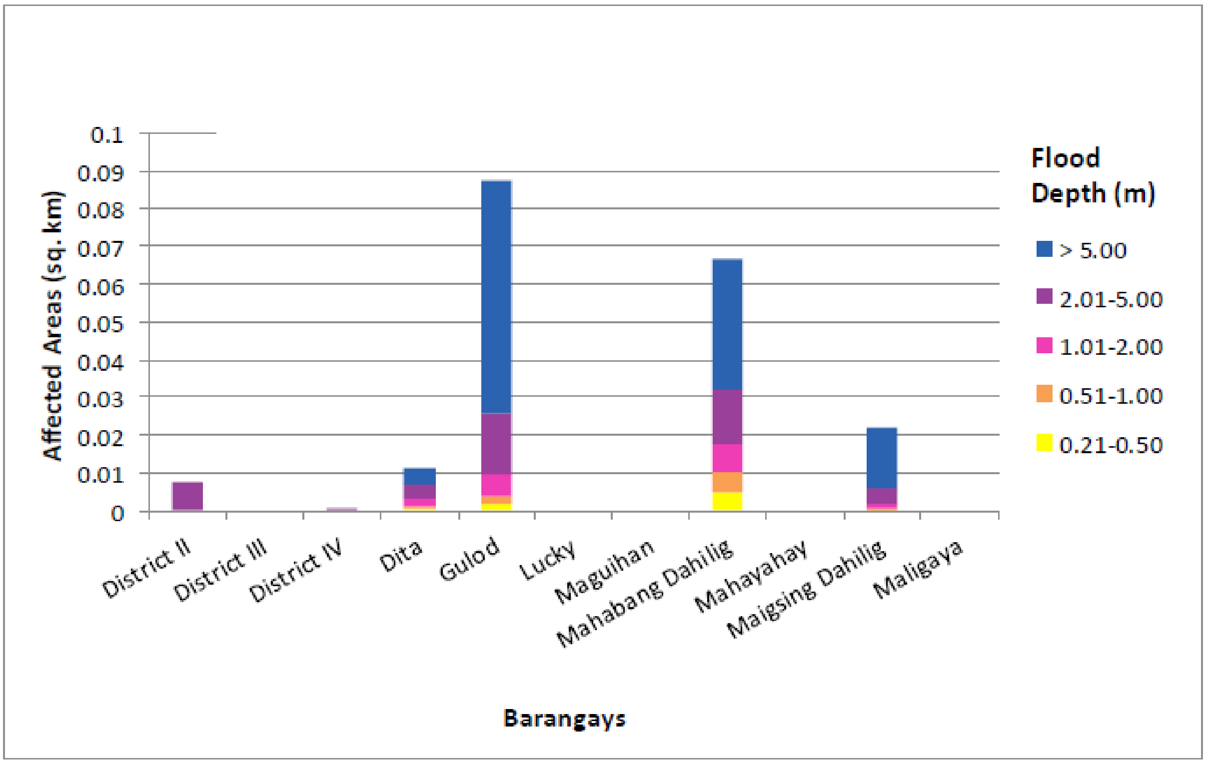


Figure 82. Affected areas in Lemery, Batangas during a 25-Year Rainfall Return Period.

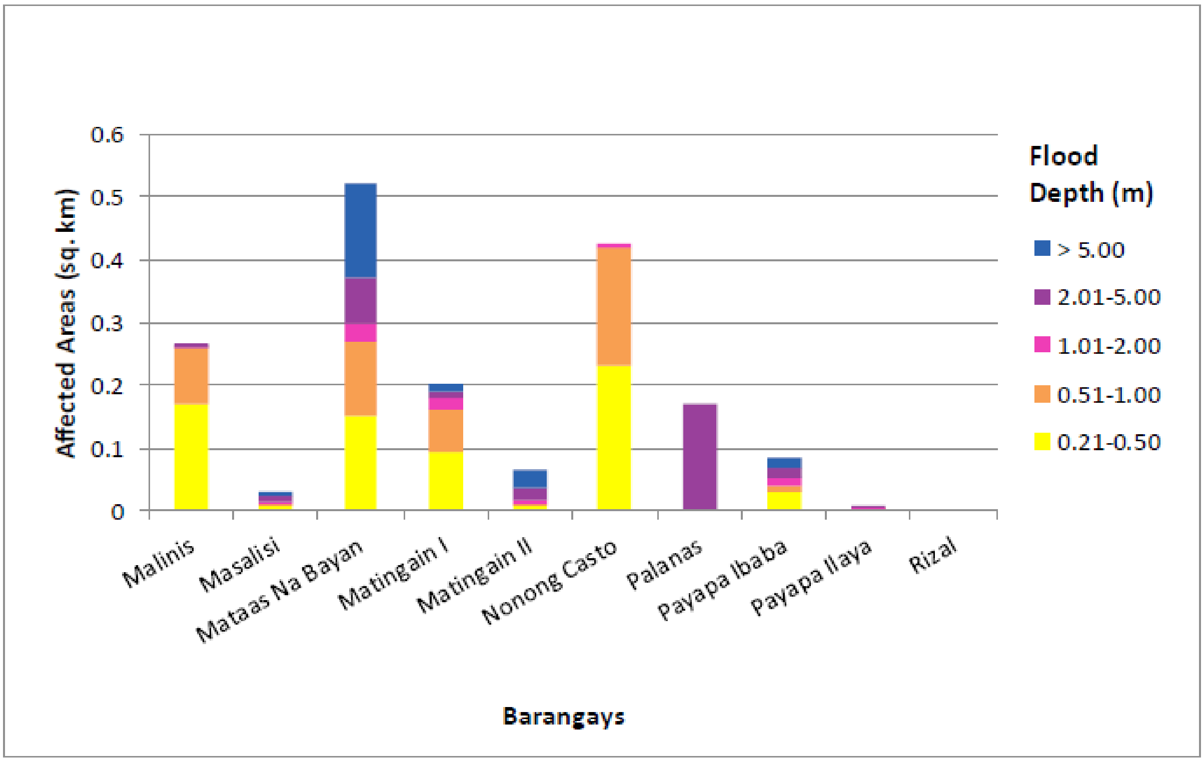


Figure 83. Affected areas in Lemery, Batangas during a 25-Year Rainfall Return Period.

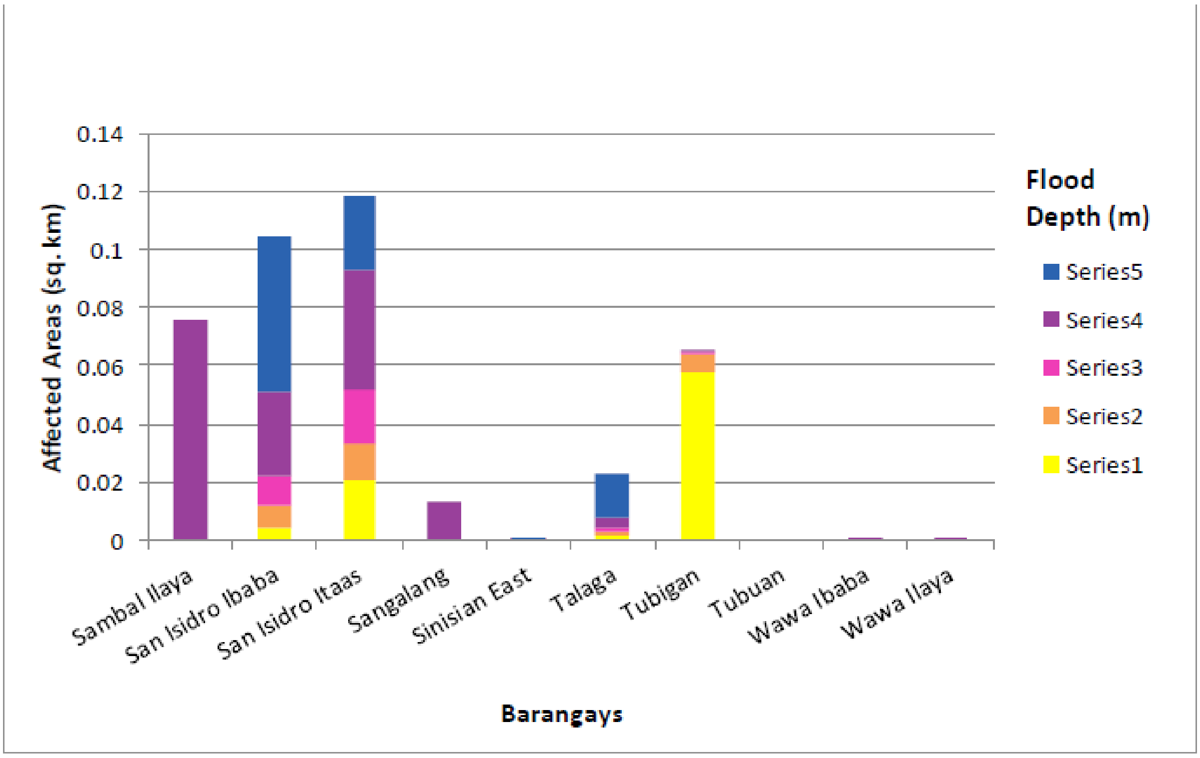


Figure 84. Affected areas in Lemery, Batangas during a 25-Year Rainfall Return Period.

For the 25-year return period, 23.41% of the municipality of Santa Teresita with an area of 15.37 sq. km. will experience flood levels of less than 0.20 meters. 0.00% of the area will experience flood levels of 0.21 to 0.50 meters while 0.00%, 0.00%, 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 53. Affected areas in Santa Teresita, Batangas during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Santa Teresita (in sq. km.)										
		Antipolo	Bihis	Burol	Calum-ala	Pobla-cion I	Pobla-cion II	Pobla-cion III	Saimsim	Sinipian	Tambo Ibaba	Tambo Ilaya
Affected Area (sq. km.)	1	0.25	0.031	0.74	0.4	0.001	0.053	0.003	0.93	0.64	0.13	0.42
	2	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0

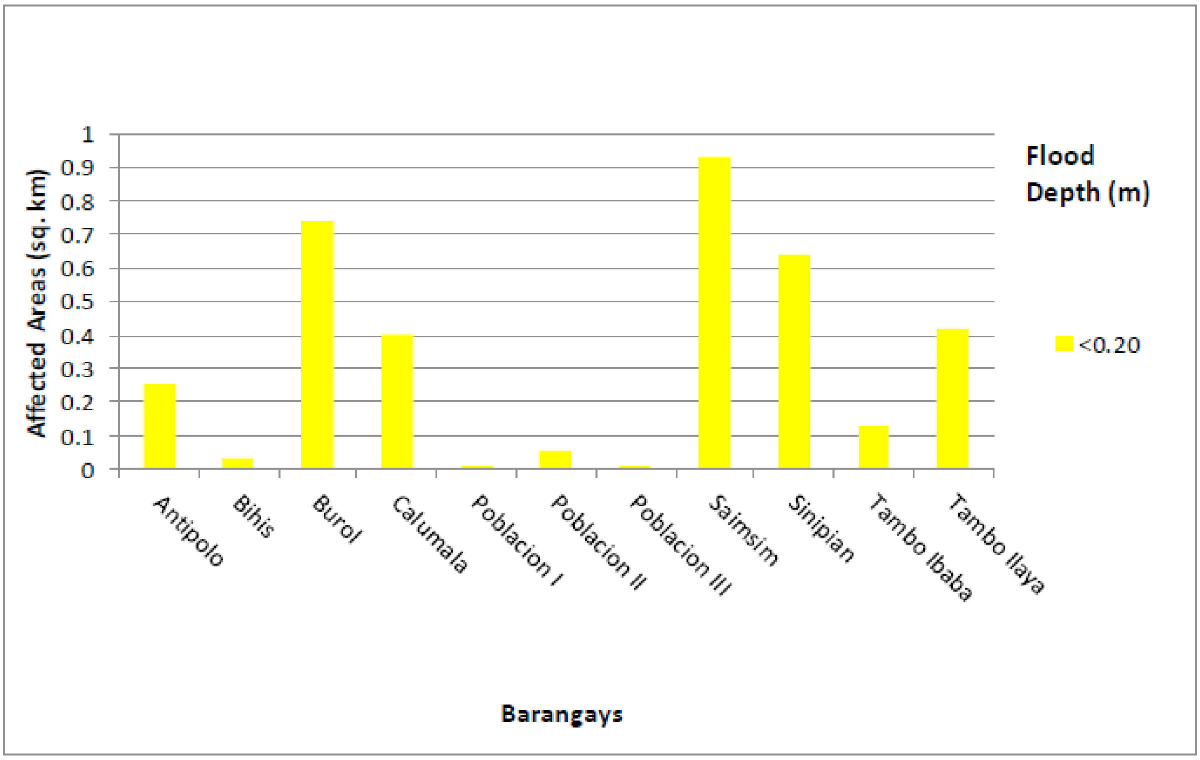


Figure 85. Areas affected by flooding in Santa Teresita, Batangas for a 25-Year Return Period rainfall event

For the 25-year return period, 40.39% of the municipality of Agoncillo with an area of 48.8 sq. km. will experience flood levels of less than 0.20 meters. 0.11% of the area will experience flood levels of 0.21 to 0.50 meters while 0.07%, 0.09%, 0.10%, 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 54. Affected areas in Agoncillo, Batangas during a 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Agoncillo (in sq. km.)								
		Adia	Bagong Sikat	Balan-gon	Bangin	Barigon	Coral Na Munti	Guitna	Mabini	Pamiga
Affected Area (sq. km.)	1	1.04	0.97	1.26	1.37	2.28	1.75	0.25	1.28	0.47
	2	0	0.0079	0.0021	0	0	0.00093	0	0.00073	0
	3	0	0.014	0.0018	0	0	0.0016	0	0.0014	0
	4	0	0.014	0.0071	0	0	0.0039	0	0.0065	0
	5	0	0.011	0.0087	0	0	0.0062	0	0.008	0
	6	0	0.0019	0	0	0	0.0002	0	0	0

Table 55. Affected areas in Agoncillo, Batangas during a 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Agoncillo (in sq. km.)									
		Panhu-lan	Pansipit	Pobla-cion	Pook	San Jacinto	San Te-odoro	Santa Cruz	Santo Tomas	Subic Ibaba	Subic Ilaya
Affected Area (sq. km.)	1	0.43	0.4	0.58	1.82	2.08	0.2	0.86	0.43	1.4	0.84
	2	0.039	0	0	0	0.0017	0	0	0	0.00044	0
	3	0.013	0	0	0	0.0031	0	0	0	0.00049	0
	4	0.0062	0	0	0	0.0067	0	0	0	0.00099	0
	5	0.0002	0.00066	0	0	0.013	0	0	0	0	0
	6	0	0	0	0	0.0018	0	0	0	0	0

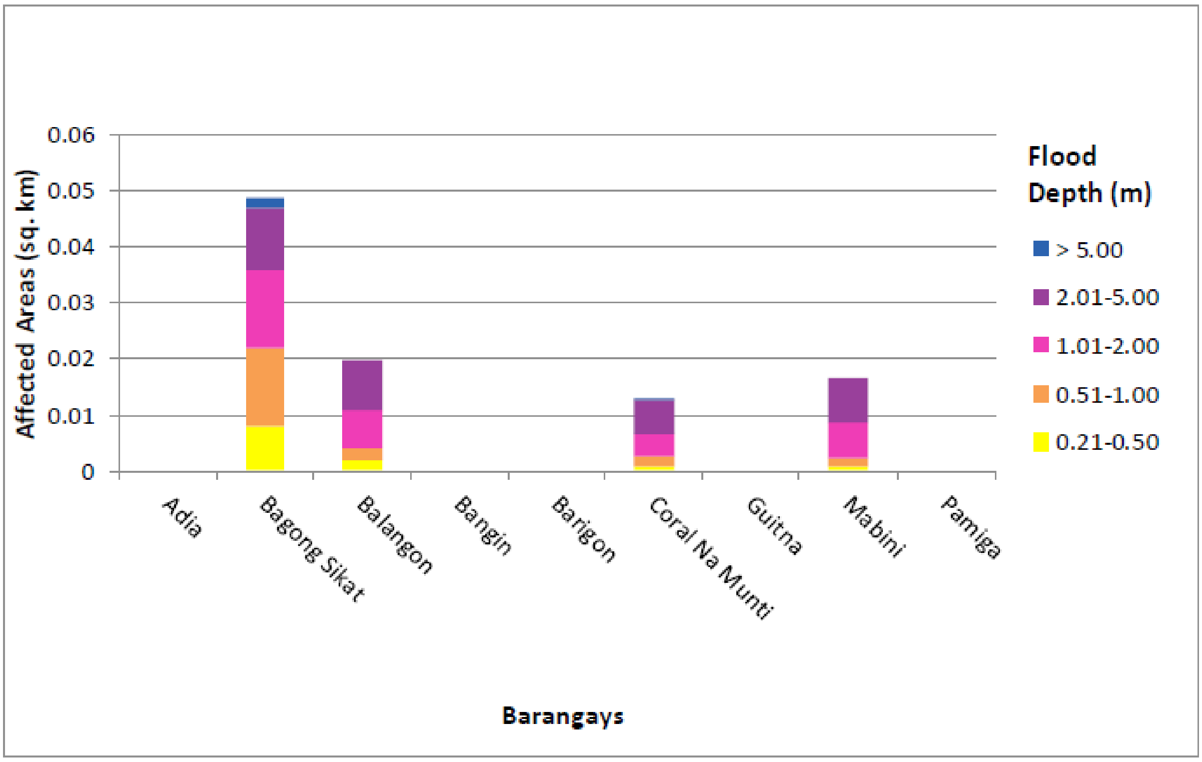


Figure 86. Areas affected by flooding in Agoncillo, Batangas for a 25-Year Return Period rainfall event.

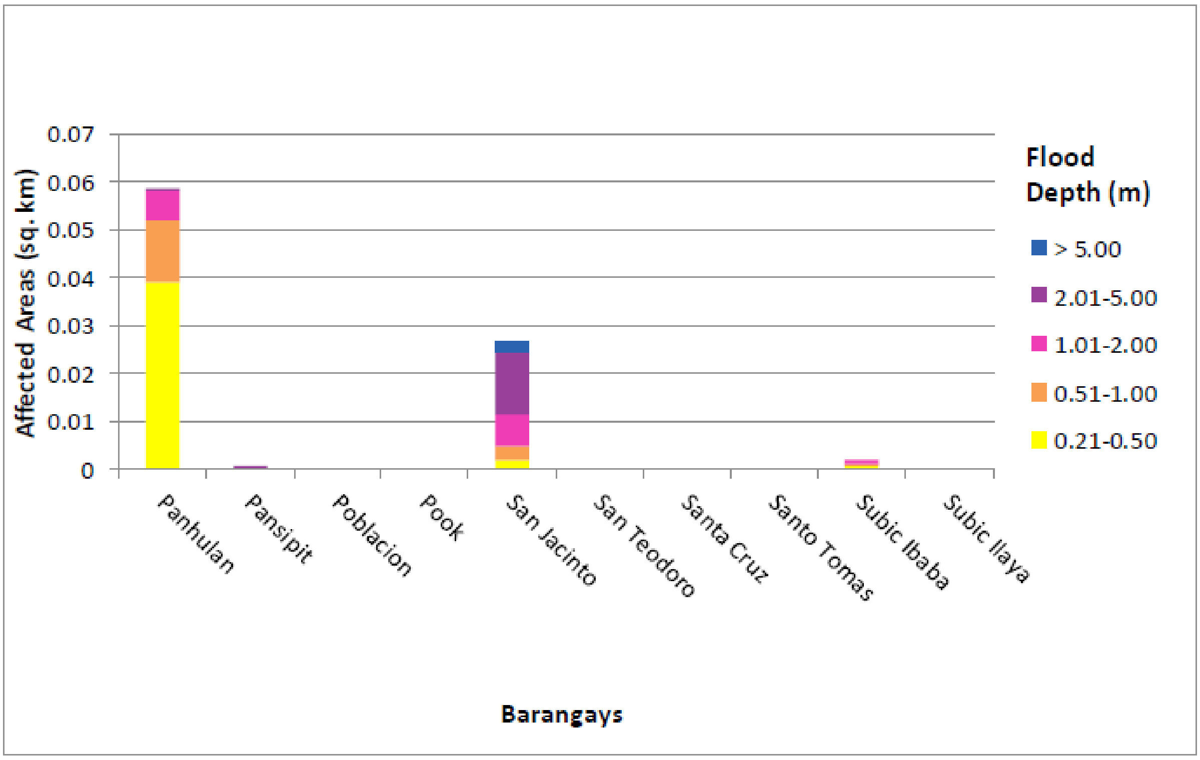


Figure 87. Areas affected by flooding in Agoncillo, Batangas for a 25-Year Return Period rainfall event.

For the 25-year return period, 38.00% of the municipality of San Nicolas with an area of 21.34 sq. km. will experience flood levels of less than 0.20 meters. 0.00% of the area will experience flood levels of 0.21 to 0.50 meters while 0.00%, 0.00%, 0.44%, 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 56. Affected areas in San Nicolas, Batangas during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in San Nicolas (in sq. km.)									
		Abelo	Balete	Ba-luk-Ba-luk	Bancoro	Bangin	Calangay	Hipit	Maabud North	Maabud South	Munlaw-in
Affected Area (sq. km.)	1	0.5	0.45	0.23	0.66	0.44	0.55	0.35	0.62	0.4	0.72
	2	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0.016	0.021	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0

Table 57. Affected areas in San Nicolas, Batangas during a 25-Year Rainfall Return Period.

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in San Nicolas (in sq. km.)					
		Pansipit	Pobla-cion	Santo Niño	Sinturi-san	Tagud-tod	Talang
Affected Area (sq. km.)	1	0.24	0.73	0.31	1.21	0.26	0.44
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	0.026	0.03	0	0	0	0
	6	0	0	0	0	0	0

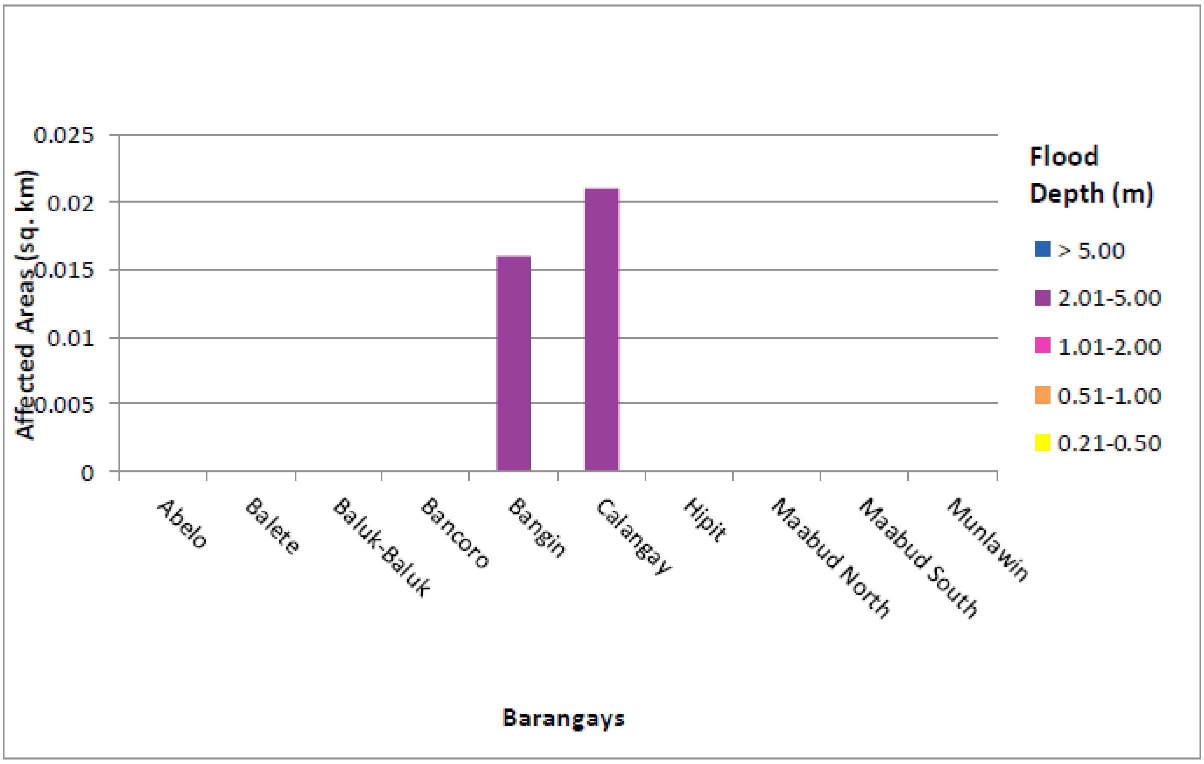


Figure 88. Areas affected by flooding in San Nicolas, Batangas for a 25-Year Return Period rainfall event.

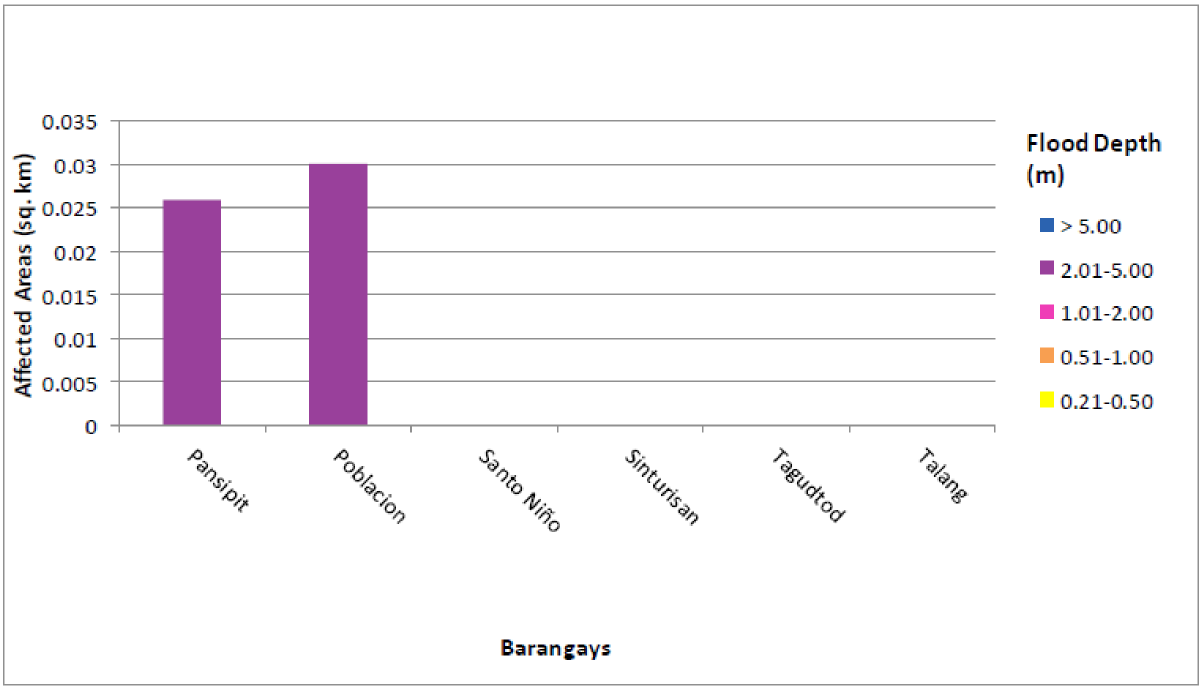


Figure 89. Areas affected by flooding in San Nicolas, Batangas for a 25-Year Return Period rainfall event.

For the 25-year return period, 91.72% of the municipality of Taal with an area of 27.07 sq. km. will experience flood levels of less than 0.20 meters. 0.00% of the area will experience flood levels of 0.21 to 0.50 meters while 0.00%, 0.00%, 0.78%, 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 Taal, Batangas during a 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)								
		Apacay	Balisong	Bihis	Bolbok	Buli	Butong	Carasuche	Cawit	Caysasay
Affected Area (sq. km.)	1	1.63	0.88	1.2	0.82	0.56	0.85	0.86	1.81	0.21
	2	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0
	5	0.023	0	0	0	0	0.021	0	0.037	0
	6	0	0	0	0	0	0	0	0	0

Table 59. Affected areas in Taal, Batangas during a 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)								
		Cubamba	Cultihan	Gahol	Halang	Iba	Imamawo	Ipil	Laguile	Latag
Affected Area (sq. km.)	1	1.57	1.11	0.53	1.53	0.91	0.59	0.36	2.51	0.56
	2	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0.097	0
	6	0	0	0	0	0	0	0	0	0

Table 60. Affected areas in Taal, Batangas during a 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)								
		Luntal	Mahabang Lodlod	Niogan	Pobla-cion 1	Pobla-cion 10	Pobla-cion 11	Pobla-cion 12	Pobla-cion 13	Pobla-cion 14
Affected Area (sq. km.)	1	1.17	1.17	0.22	0.098	0.028	0.056	0.031	0.037	0.055
	2	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0

Table 61. Affected areas in Taal, Batangas during a 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)												
		Pobla-cion 2	Pobla-cion 3	Pobla-cion 4	Pobla-cion 5	Pobla-cion 6	Pobla-cion 7	Pobla-cion 8	Pobla-cion 9	Pook	Seiran	Tatlong Maria	Tierra Alta	Tulo
Affected Area (sq. km.)	1	0.032	0.12	0.1	0.088	0.024	0.046	0.15	0.094	0.75	0.67	0.13	0.22	1.05
	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0.0036	0.019	0	0	0	0	0	0.0053	0.0058	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0	0

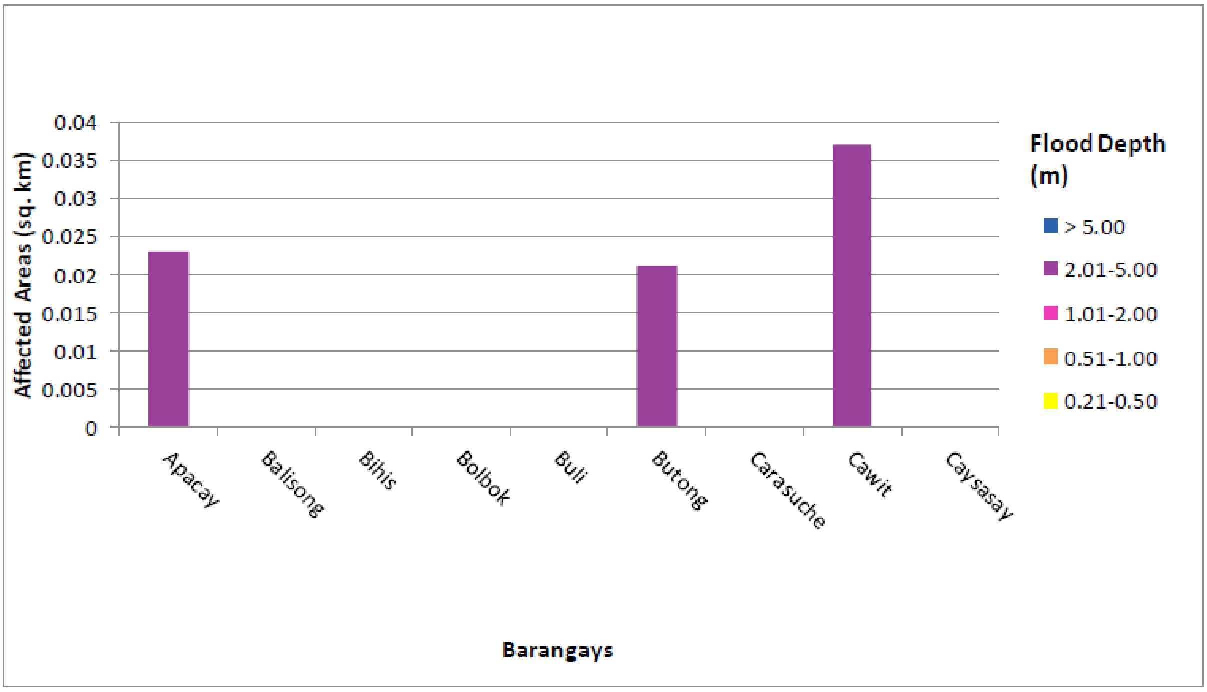


Figure 90. Areas affected by flooding in Taal, Batangas for a 25-Year Return Period rainfall event.

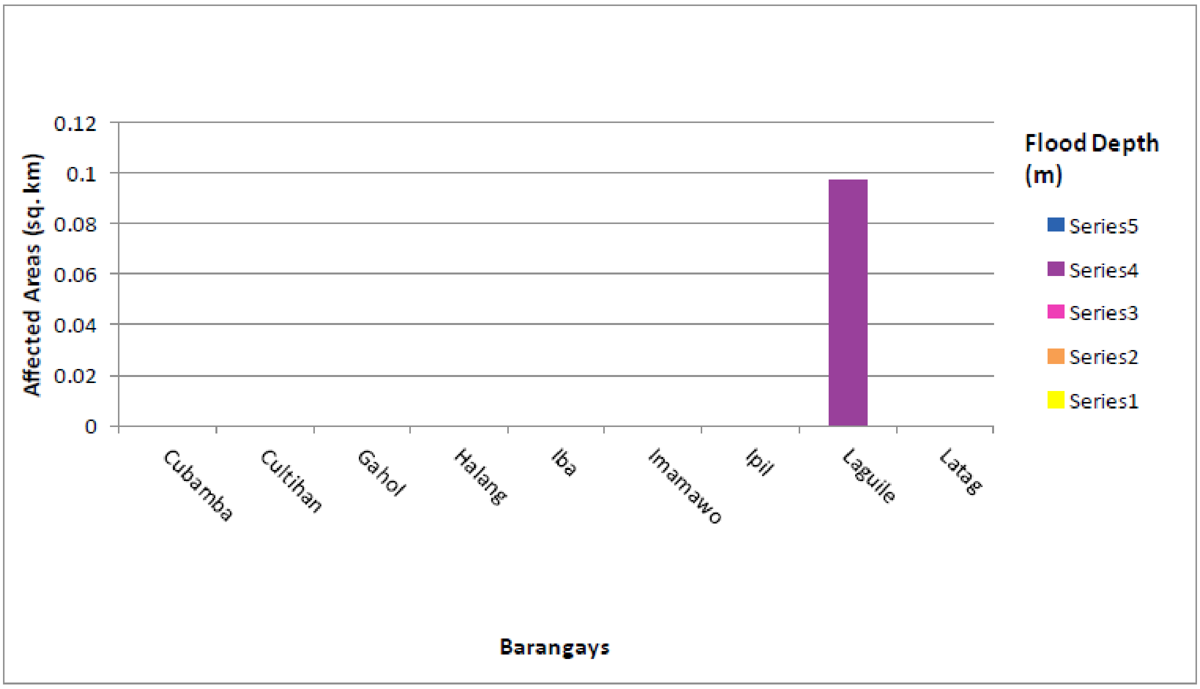


Figure 91. Areas affected by flooding in Taal, Batangas for a 25-Year Return Period rainfall event.

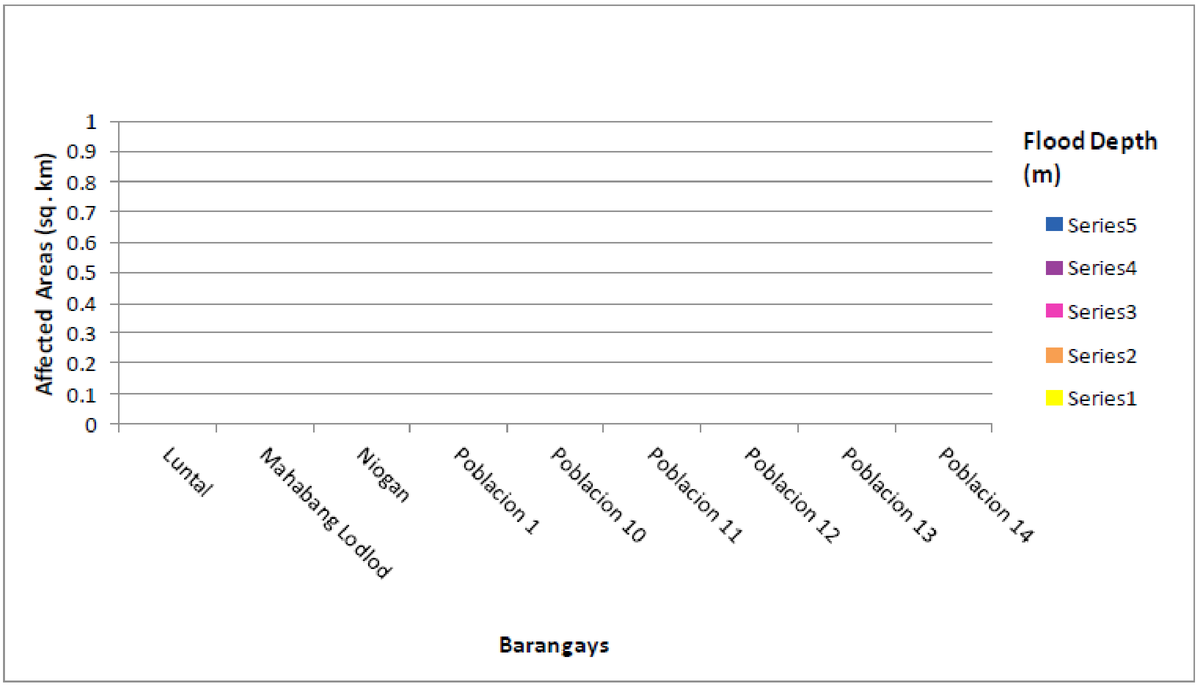


Figure 92. Areas affected by flooding in Taal, Batangas for a 25-Year Return Period rainfall event.

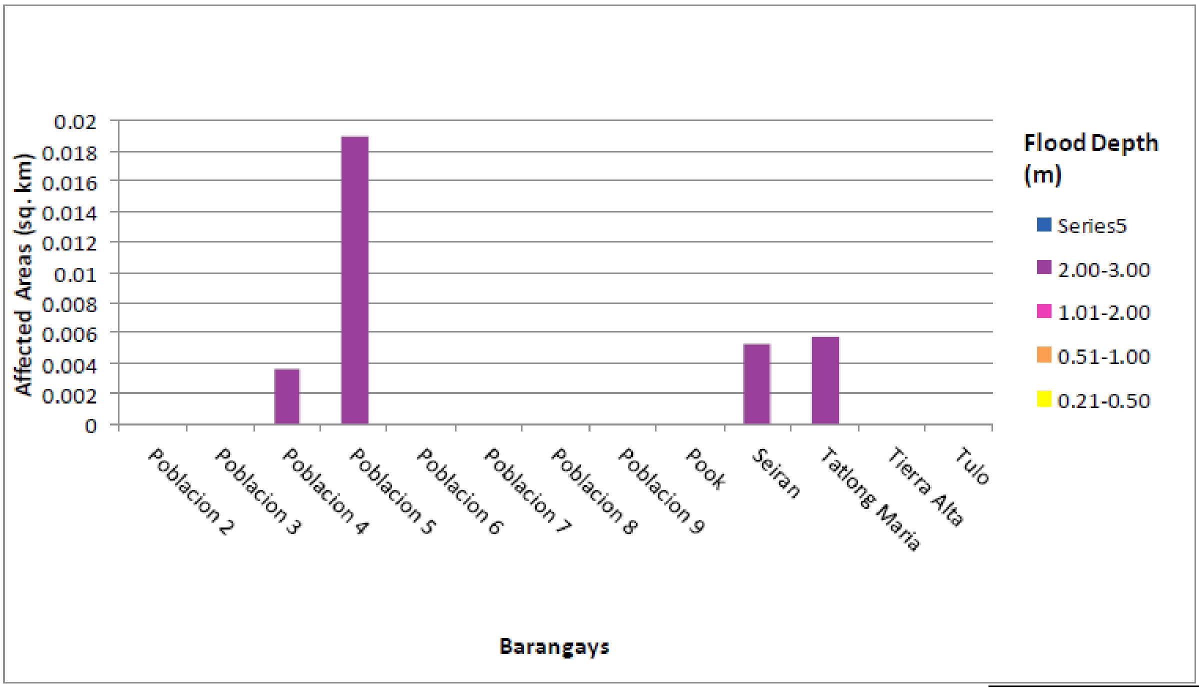


Figure 93. Areas affected by flooding in Taal, Batangas for a 25-Year Return Period rainfall event.

For the 100-year return period, 46.57% of the municipality of Lemery with an area of 72.15 sq. km. will experience flood levels of less than 0.20 meters. 2.17% of the area will experience flood levels of 0.21 to 0.50 meters while 1.52%, 0.54%, 0.96%, and 0.69% 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 Lemery, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)										
		Anak-Dagat	Aruma-han	Ayao-Iyao	Bagong Pook	Bagong Sikat	Balanga	Bukal	Cahilan I	Cahilan II	Dayapan	District I
Affected Area (sq. km.)	1	0.12	0.12	2.04	1.08	0.24	1.33	0.16	0.92	1.18	1.41	0.14
	2	0.0002	0.0016	0.18	0.025	0.0057	0.02	0.06	0.015	0.013	0.026	0.0002
	3	0	0.00004	0.027	0.011	0.001	0.0026	0.14	0.0089	0.0058	0.012	0.000031
	4	0	0.0004	0.017	0.01	0.0002	0	0.0054	0.015	0.0038	0.016	0.000017
	5	0	0.0002	0.036	0.006	0.037	0	0	0.021	0.0096	0.028	0.00059
	6	0	0	0.0001	0.0038	0	0	0	0.002	0.0004	0.054	0

Table 63. Affected areas in Lemery, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)										
		District II	District III	District IV	Dita	Gulod	Lucky	Magui-han	Ma-habang Dahilig	Mahaya-hay	Maigsing Dahilig	Maligaya
Affected Area (sq. km.)	1	0.055	0.22	0.082	3.21	1.51	0.11	0.13	0.9	0.59	0.44	0.053
	2	0.0017	0.0008	0.00035	0.098	0.033	0	0.0002	0.018	0.013	0.0066	0
	3	0.0011	0	0	0.038	0.011	0	0	0.009	0.0049	0.0059	0
	4	0	0	0	0.024	0.011	0	0	0.0093	0.0021	0.0032	0
	5	0.0079	0	0.00084	0.012	0.019	0	0	0.015	0.00053	0.0046	0
	6	0	0	0	0.0044	0.063	0	0	0.035	0	0.017	0

Table 64. Affected areas in Lemery, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)										
		Malinis	Masalisi	Mata-as Na Bayan	Matin-gain I	Matin-gain II	Nonong Casto	Palanas	Payapa Ibaba	Payapa Ilaya	Rizal	Sambal Ibaba
Affected Area (sq. km.)	1	1.88	0.35	0.71	1.34	1.44	0.7	0.58	1.56	0.24	0.027	0.14
	2	0.18	0.0098	0.18	0.12	0.037	0.2	0.013	0.045	0.0069	0	0.0003
	3	0.2	0.0044	0.14	0.083	0.018	0.24	0	0.026	0.0045	0	0
	4	0.0062	0.0059	0.11	0.023	0.015	0.014	0	0.02	0.0014	0	0
	5	0.0063	0.0075	0.071	0.011	0.02	0	0.17	0.02	0.0006	0	0.0011
	6	0	0.0065	0.16	0.013	0.028	0	0	0.018	0	0	0

Table 65. Affected areas in Lemery, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Lemery (in sq. km.)									
		Sambal Ilaya	San Isidro Ibaba	San Isidro Itaas	San-galang	Sinisian East	Talaga	Tubigan	Tubuan	Wawa Ibaba	Wawa Ilaya
Affected Area (sq. km.)	1	0.3	2	3.88	0.27	0.039	0.26	0.9	0.88	0.0084	0.058
	2	0.0017	0.049	0.1	0.0024	0.000051	0.0061	0.079	0.018	0	0
	3	0	0.024	0.053	0	0.00012	0.0024	0.014	0.01	0	0.000038
	4	0	0.023	0.045	0	0.000074	0.0021	0.00041	0.0078	0	0.000045
	5	0.076	0.036	0.052	0.013	0.00019	0.0038	0.0012	0.0032	0.00047	0.00077
	6	0	0.056	0.025	0	0.00006	0.015	0	0	0	0

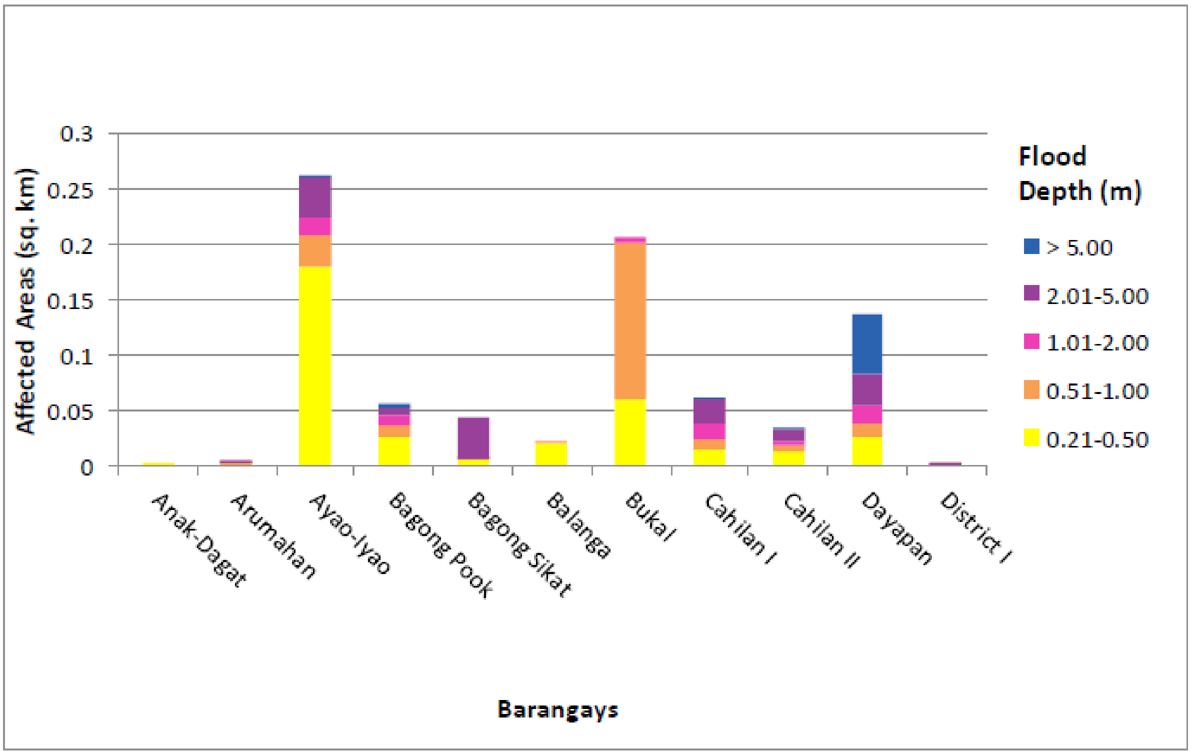


Figure 94. Affected areas in Lemery, Batangas during a 100-Year Rainfall Return Period.

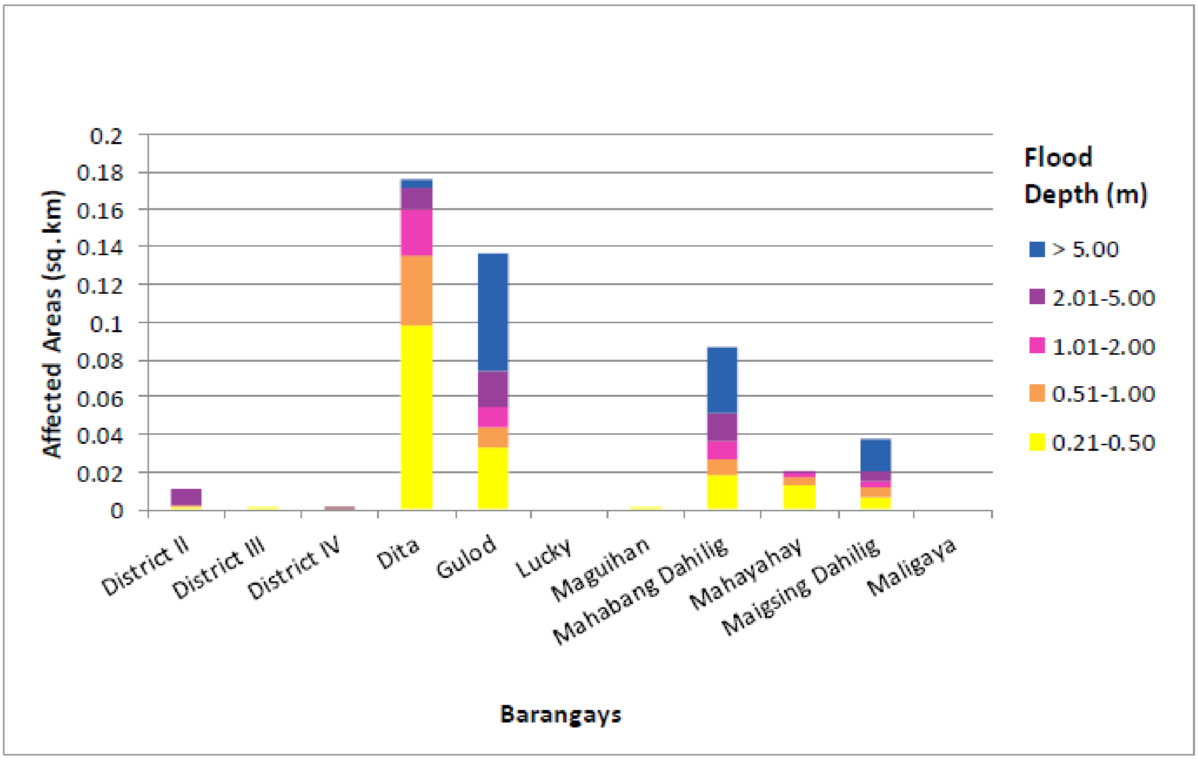


Figure 95. Affected areas in Lemery, Batangas during a 100-Year Rainfall Return Period.

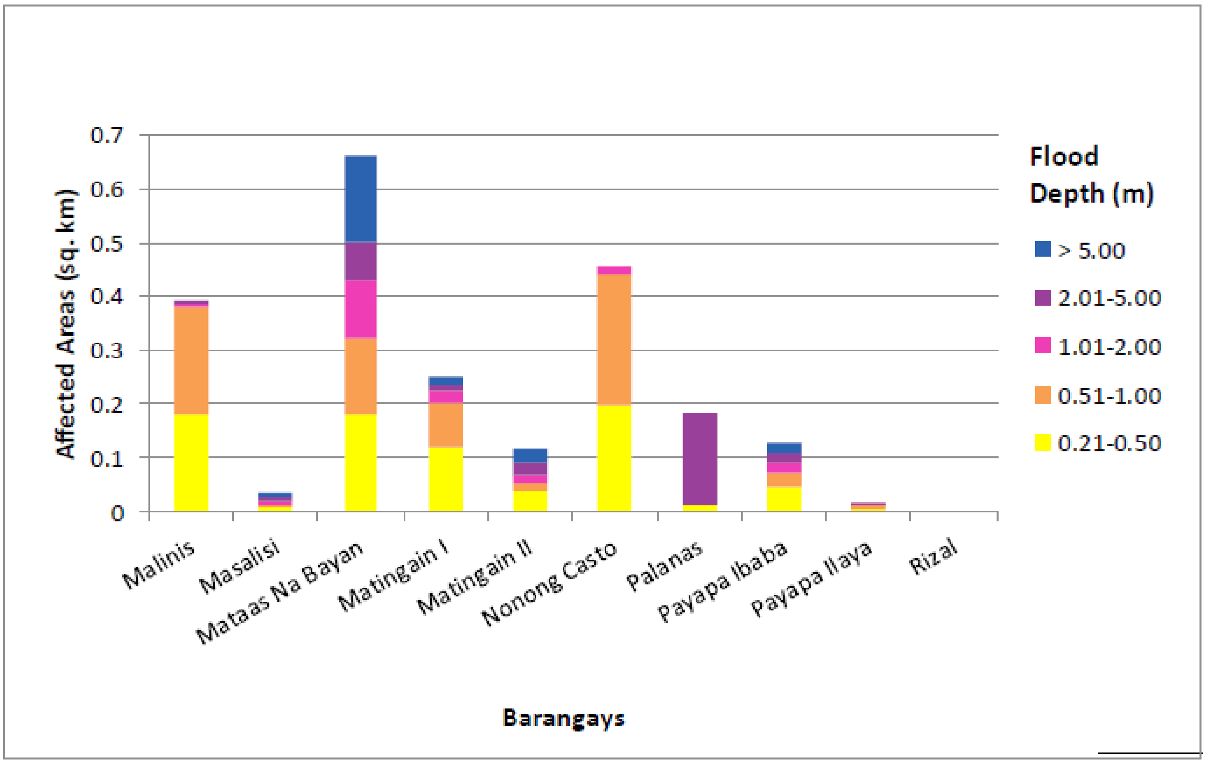


Figure 96. Affected areas in Lemery, Batangas during a 100-Year Rainfall Return Period.

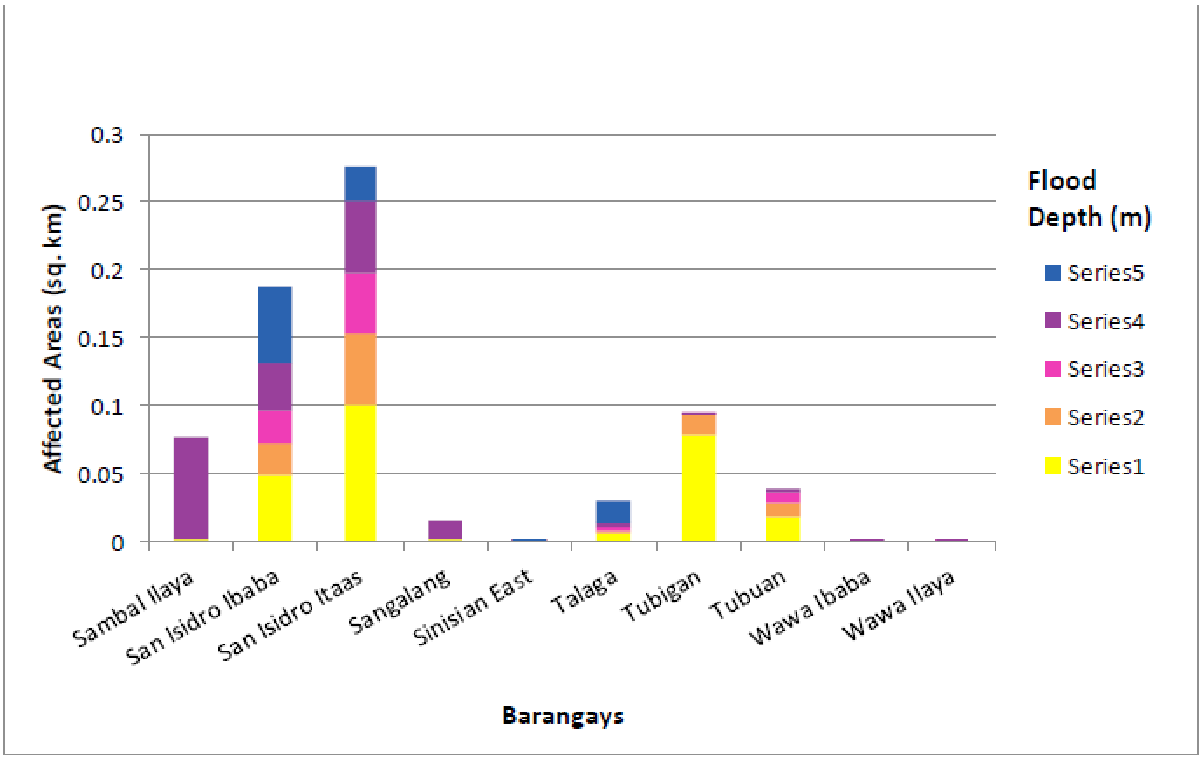


Figure 97. Affected areas in Lemery, Batangas during a 100-Year Rainfall Return Period.

For the 100-year return period, 22.88% of the municipality of Santa Teresita with an area of 15.37 sq. km. will experience flood levels of less than 0.20 meters. 0.35% of the area will experience flood levels of 0.21 to 0.50 meters while 0.06%, 0.05%, 0.02%, 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 66. Affected areas in Santa Teresita, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Santa Teresita (in sq. km.)										
		Antipolo	Bihis	Burol	Calum-ala	Pobla-cion I	Pobla-cion II	Pobla-cion III	Saimsim	Sinipian	Tambo Ibaba	Tambo Ilaya
Affected Area (sq. km.)	1	0.25	0.031	0.7	0.39	0.001	0.052	0.003	0.92	0.64	0.13	0.4
	2	0.0008	0	0.023	0.011	0	0.0002	0	0.0054	0.0011	0.0035	0.0092
	3	0	0	0.0052	0.0002	0	0	0	0.0022	0	0.0003	0.0019
	4	0	0	0.0034	0.0001	0	0	0	0.0027	0	0.0001	0.0017
	5	0	0	0.0019	0	0	0	0	0.001	0	0	0.0002
	6	0	0	0.0002	0	0	0	0	0	0	0	0

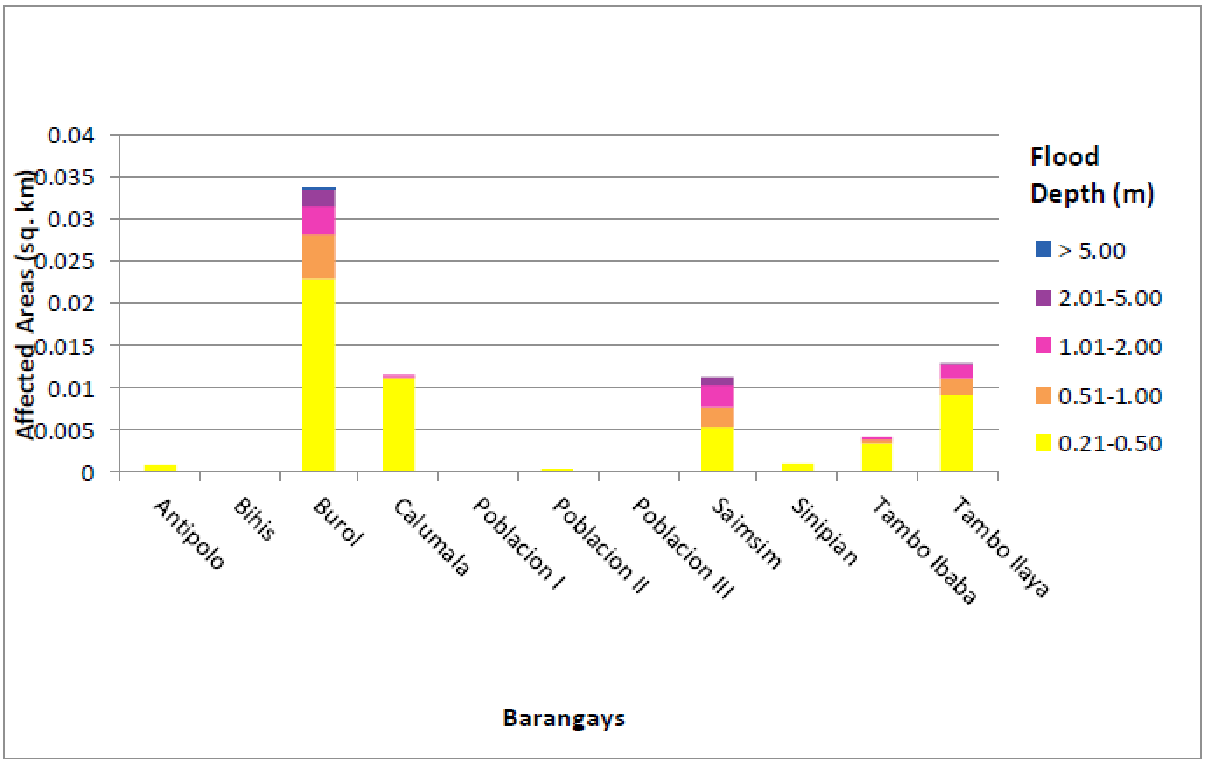


Figure 98. Areas affected by flooding in Santa Teresita, Batangas for a 100-Year Return Period rainfall event.

For the 100-year return period, 38.77% of the municipality of Agoncillo with an area of 48.8 sq. km. will experience flood levels of less than 0.20 meters. 1.17% of the area will experience flood levels of 0.21 to 0.50 meters while 0.43%, 0.27%, 0.17%, 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 67. Affected areas in Agoncillo, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Agoncillo (in sq. km.)								
		Adia	Bagong Sikat	Balan-gon	Bangin	Barigon	Coral Na Munti	Guitna	Mabini	Pamiga
Affected Area (sq. km.)	1	0.99	0.93	1.22	1.35	2.16	1.68	0.24	1.25	0.46
	2	0.038	0.026	0.024	0.013	0.065	0.049	0.0056	0.02	0.0074
	3	0.011	0.025	0.011	0.0088	0.028	0.017	0.0016	0.0085	0.0036
	4	0.0052	0.027	0.0091	0.0025	0.015	0.014	0	0.0074	0.0022
	5	0.0022	0.014	0.012	0.0002	0.01	0.0093	0	0.0097	0.0002
	6	0	0.0032	0	0	0.0005	0.00031	0	0	0

Table 68. Affected areas in Agoncillo, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Agoncillo (in sq. km.)									
		Panhu-lan	Pansipit	Pobla-cion	Pook	San Jacinto	San Te-odoro	Santa Cruz	Santo Tomas	Subic Ibaba	Subic Ilaya
Affected Area (sq. km.)	1	0.37	0.38	0.57	1.78	1.97	0.2	0.84	0.42	1.32	0.79
	2	0.073	0.011	0.0065	0.037	0.056	0.0036	0.016	0.013	0.069	0.037
	3	0.024	0.0008	0.0022	0.0074	0.028	0	0.0069	0.002	0.01	0.013
	4	0.011	0.0001	0.00034	0.0031	0.022	0	0.0033	0.00011	0.0033	0.0048
	5	0.0021	0.00066	0	0.0001	0.021	0	0.0006	0	0.00044	0.0006
	6	0	0	0	0	0.002	0	0	0	0	0

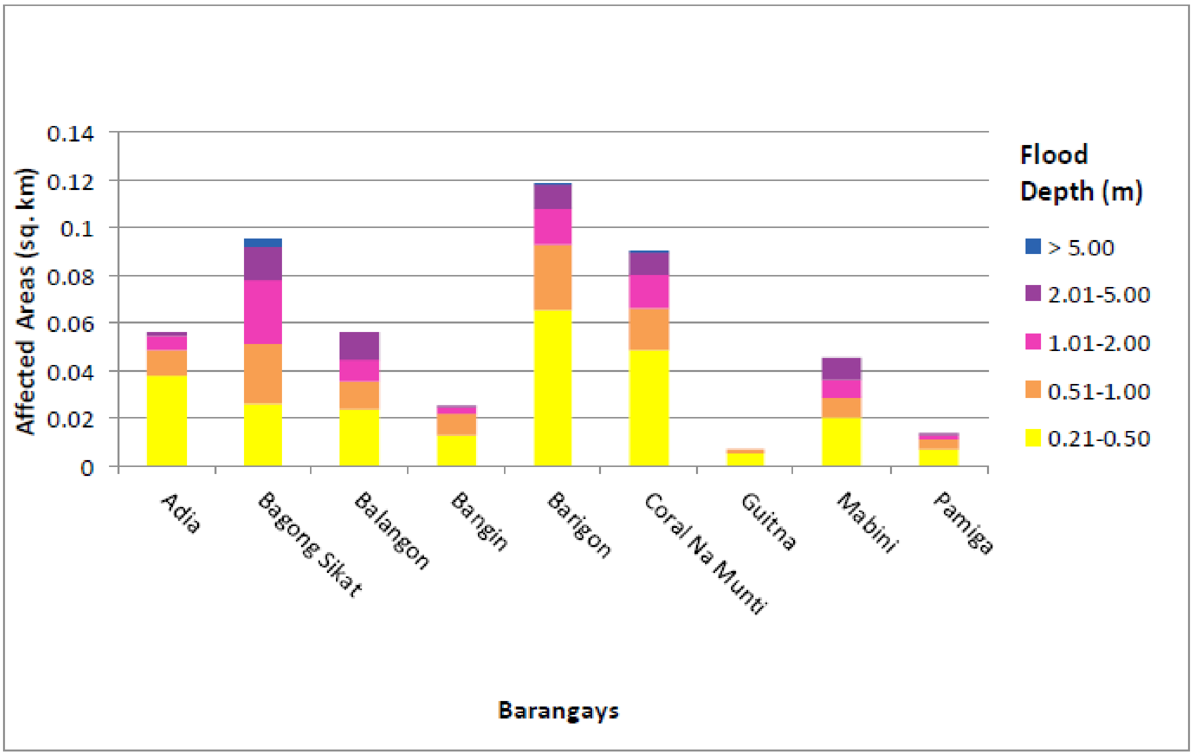


Figure 99. Affected areas in Agoncillo, Batangas during a 100-Year Rainfall Return Period

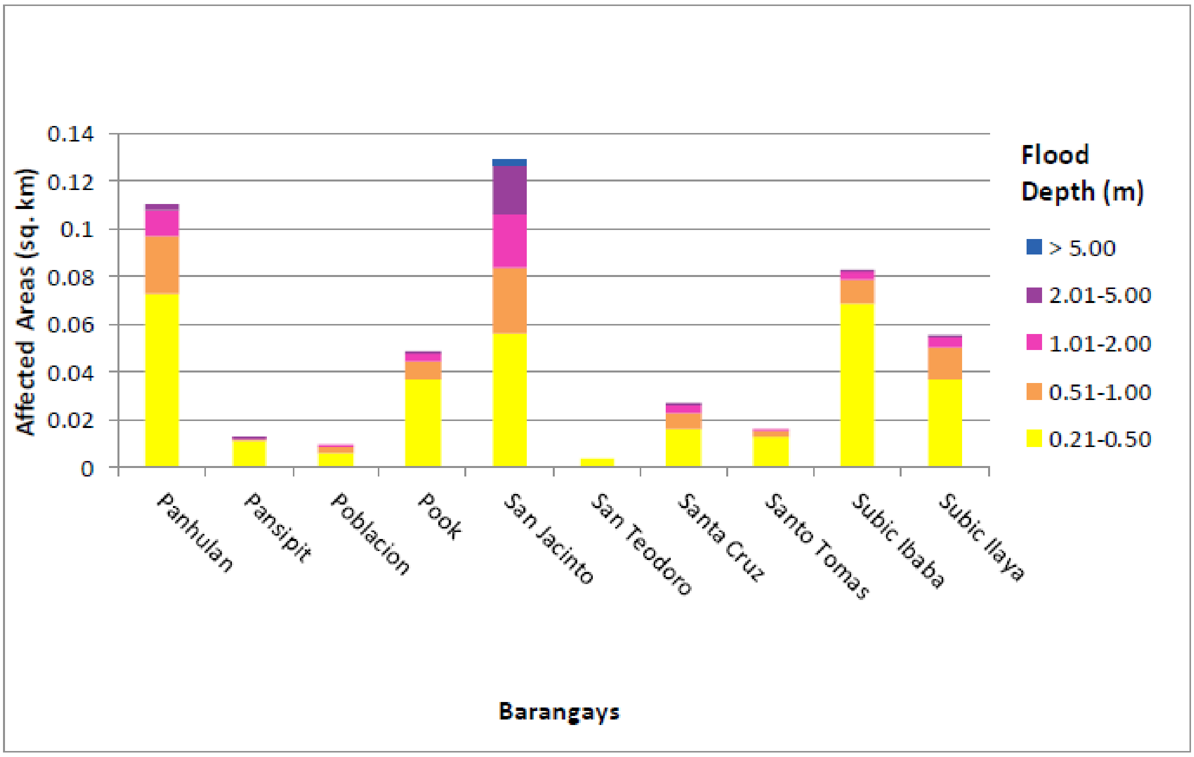


Figure 100. Affected areas in Agoncillo, Batangas during a 100-Year Rainfall Return Period

For the 100-year return period, 37.25% of the municipality of San Nicolas with an area of 21.34 sq. km. will experience flood levels of less than 0.20 meters. 0.55% of the area will experience flood levels of 0.21 to 0.50 meters while 0.09%, 0.02%, 0.44%, 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 69. Areas affected by flooding in San Nicolas, Batangas for a 100-Year Return Period rainfall event

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in San Nicolas (in sq. km.)									
		Abelo	Balete	Ba-luk-Ba-luk	Bancoro	Bangin	Calangay	Hipit	Maabud North	Maabud South	Munlaw-in
Affected Area (sq. km.)	1	0.5	0.45	0.23	0.65	0.43	0.53	0.35	0.61	0.39	0.71
	2	0.011	0.0036	0.0011	0.0039	0.0071	0.0082	0.000036	0.0072	0.0055	0.0044
	3	0	0.0005	0	0.0015	0.0035	0.0037	0.000095	0.002	0.0013	0.0014
	4	0	0.0001	0	0.0008	0.0006	0	0.000092	0.00072	0.0016	0.001
	5	0	0	0	0	0.016	0.021	0	0.0002	0.0014	0.0001
	6	0	0	0	0	0	0	0	0	0	0

Table 70. Affected areas in San Nicolas, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in San Nicolas (in sq. km.)					
		Pansipit	Pobla-cion	Santo Niño	Sinturi-san	Tagud-tod	Talang
Affected Area (sq. km.)	1	0.22	0.71	0.3	1.19	0.25	0.43
	2	0.013	0.015	0.0051	0.025	0.0028	0.0044
	3	0.0012	0.0022	0	0.00013	0.0017	0
	4	0	0.0001	0	0	0.0002	0
	5	0.026	0.03	0	0	0	0
	6	0	0	0	0	0	0

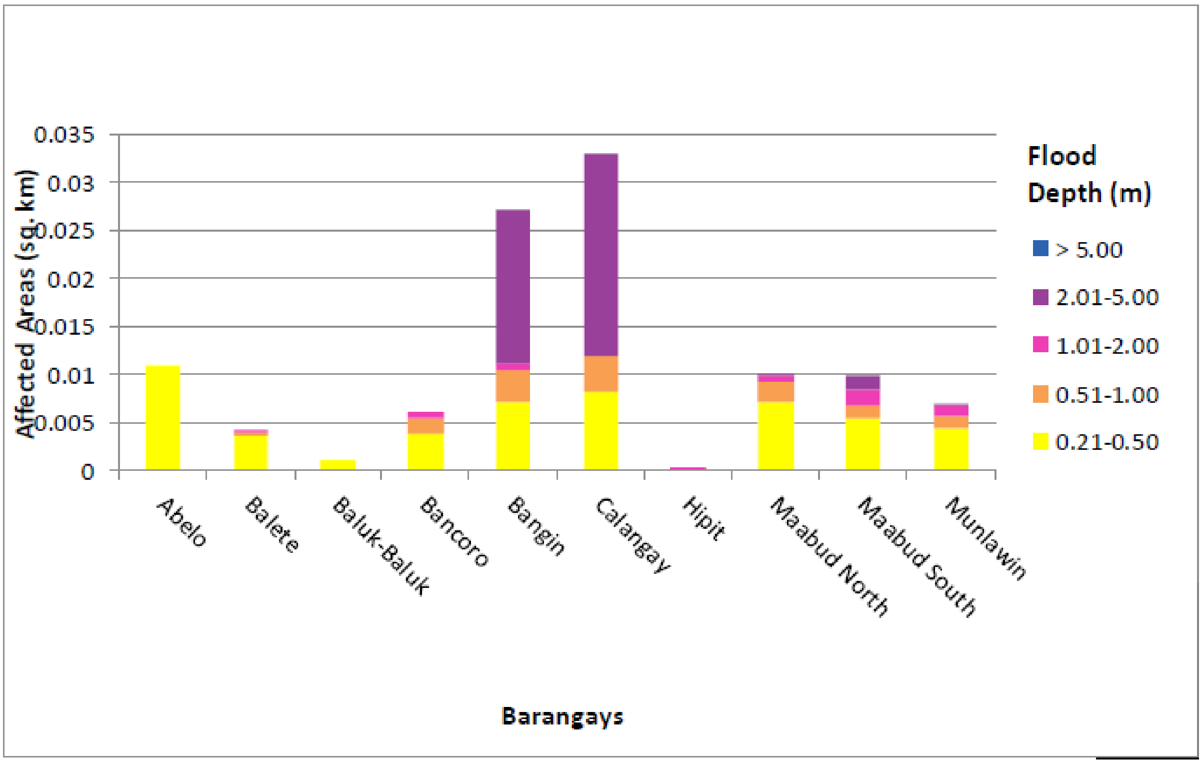


Figure 101. Areas affected by flooding in San Nicolas, Batangas for a 100-Year Return Period rainfall event.

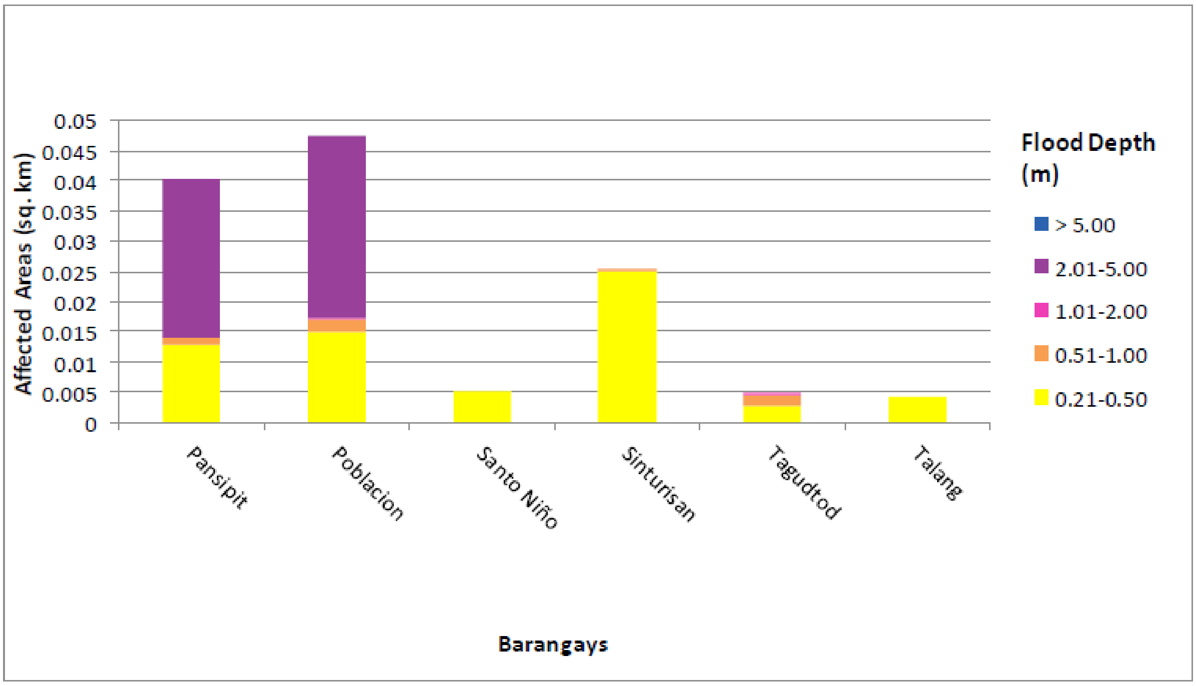


Figure 102. Areas affected by flooding in San Nicolas, Batangas for a 100-Year Return Period rainfall event.

For the 100-Year return period, 91.72% of the municipality of Taal with an area of 27.07 sq. km. will experience flood levels of less than 0.20 meters. 0.00% of the area will experience flood levels of 0.21 to 0.50 meters while 0.00%, 0.00%, 0.78%, 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 71. Affected areas in Taal, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)								
		Apacay	Balisong	Bihis	Bolbok	Buli	Butong	Carasuche	Cawit	Caysasay
Affected Area (sq. km.)	1	1.61	0.84	1.18	0.81	0.55	0.83	0.83	1.76	0.21
	2	0.013	0.026	0.019	0.013	0.0075	0.024	0.028	0.045	0.00063
	3	0.006	0.0057	0.0014	0.0004	0.0013	0.0048	0.0028	0.0064	0
	4	0.0008	0.0026	0.0009	0	0	0.00055	0.00031	0.001	0
	5	0.023	0.00052	0	0	0	0.021	0	0.037	0
	6	0	0	0	0	0	0	0	0	0

Table 72. Affected areas in Taal, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)								
		Cubamba	Cultihan	Gahol	Halang	Iba	Imamawo	Ipil	Laguile	Latag
Affected Area (sq. km.)	1	1.54	1.09	0.5	1.48	0.88	0.56	0.35	2.44	0.54
	2	0.027	0.019	0.019	0.047	0.02	0.017	0.0078	0.055	0.018
	3	0.0037	0.004	0.0023	0.0031	0.0063	0.0061	0.0027	0.018	0.0015
	4	0.0002	0.0032	0.0029	0.0014	0.0035	0.0038	0.0022	0.0024	0.0013
	5	0	0.0003	0.0018	0.0008	0.0002	0.0008	0.0007	0.097	0.0002
	6	0	0	0	0	0	0.0003	0	0	0

Table 73. Affected areas in Taal, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)								
		Luntal	Mahabang Lodlod	Niogan	Poblacion 1	Poblacion 10	Poblacion 11	Poblacion 12	Poblacion 13	Poblacion 14
Affected Area (sq. km.)	1	1.14	1.13	0.21	0.095	0.028	0.054	0.031	0.037	0.052
	2	0.026	0.031	0.0037	0.0028	0.00011	0.0015	0	0.0002	0.0011
	3	0.004	0.0063	0.0008	0.00038	0	0.0002	0	0	0.0011
	4	0.00057	0.0037	0.0005	0	0	0	0	0	0.0006
	5	0.000058	0.0006	0.00053	0	0	0	0	0	0.00085
	6	0	0	0	0	0	0	0	0	0

Table 74. Affected areas in Taal, Batangas during a 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)		Area of affected barangays in Taal (in sq. km.)												
		Pobla-cion 2	Pobla-cion 3	Pobla-cion 4	Pobla-cion 5	Pobla-cion 6	Pobla-cion 7	Pobla-cion 8	Pobla-cion 9	Pook	Seiran	Tatlong Maria	Tierra Alta	Tulo
Affected Area (sq. km.)	1	0.03	0.11	0.095	0.081	0.023	0.046	0.14	0.094	0.74	0.64	0.13	0.22	1.04
	2	0.0012	0.0032	0.0029	0.0061	0.0002	0.00016	0.0049	0	0.0097	0.019	0.006	0.0027	0.012
	3	0	0.00077	0.0011	0.00083	0	0	0.0001	0	0.0019	0.0021	0.000039	0.00043	0.00031
	4	0	0.00021	0	0.00044	0	0	0	0	0.0004	0.0016	0	0	0.00039
	5	0	0	0.0036	0.019	0	0	0	0	0.0001	0.0053	0.0058	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0	0

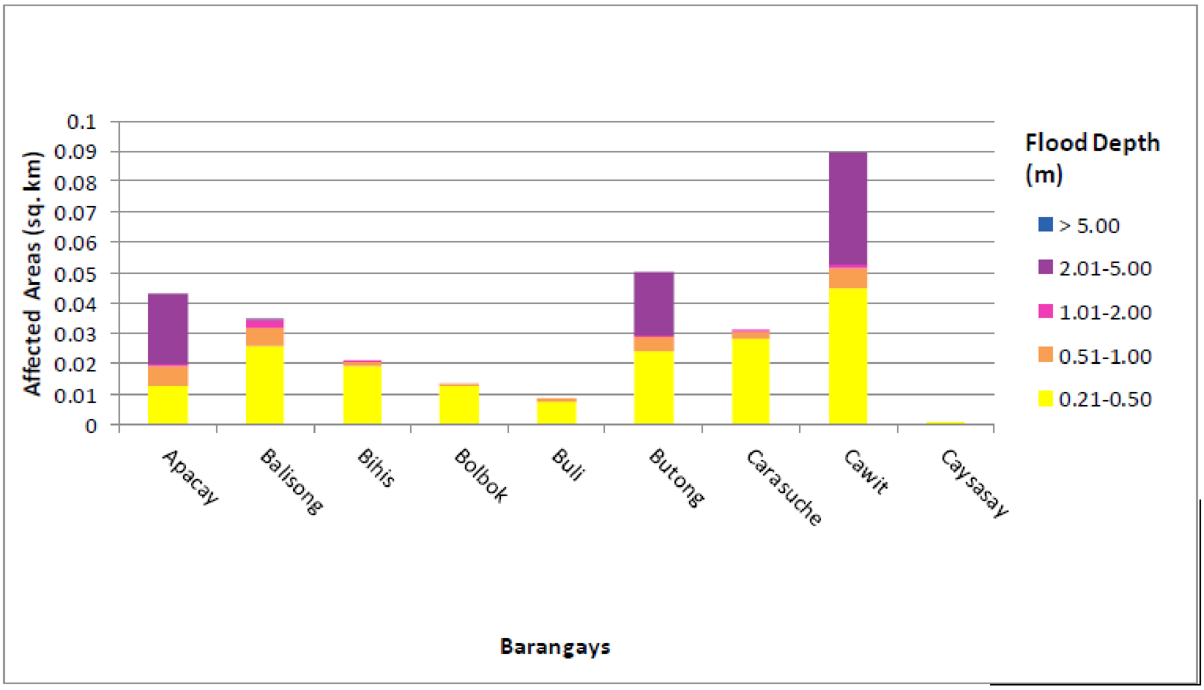


Figure 103. Areas affected by flooding in Taal, Batangas for a 100-Year Return Period rainfall event

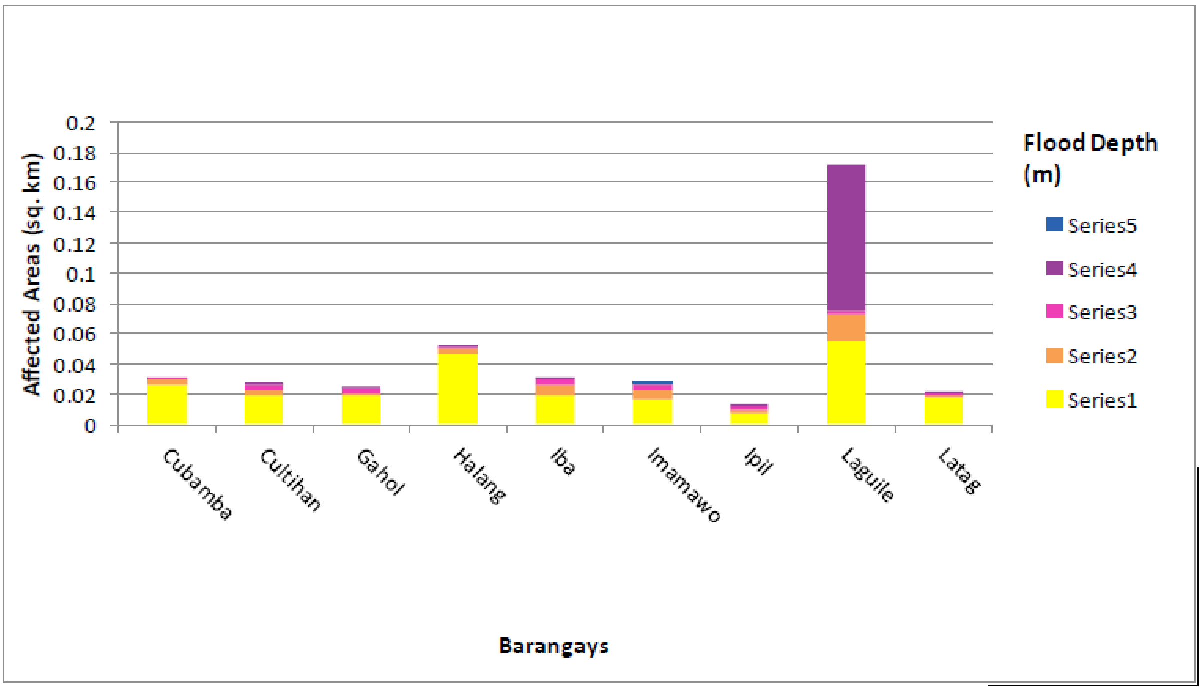


Figure 104. Areas affected by flooding in Taal, Batangas for a 100-Year Return Period rainfall event

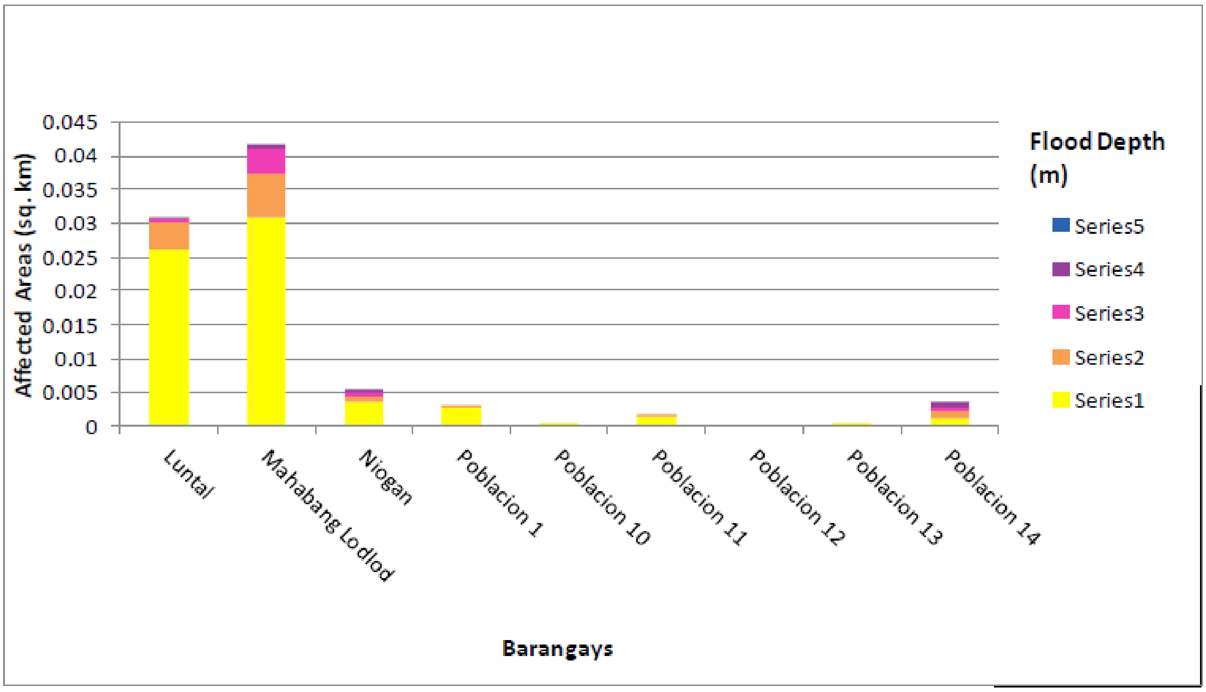


Figure 105. Areas affected by flooding in Taal, Batangas for a 100-Year Return Period rainfall event

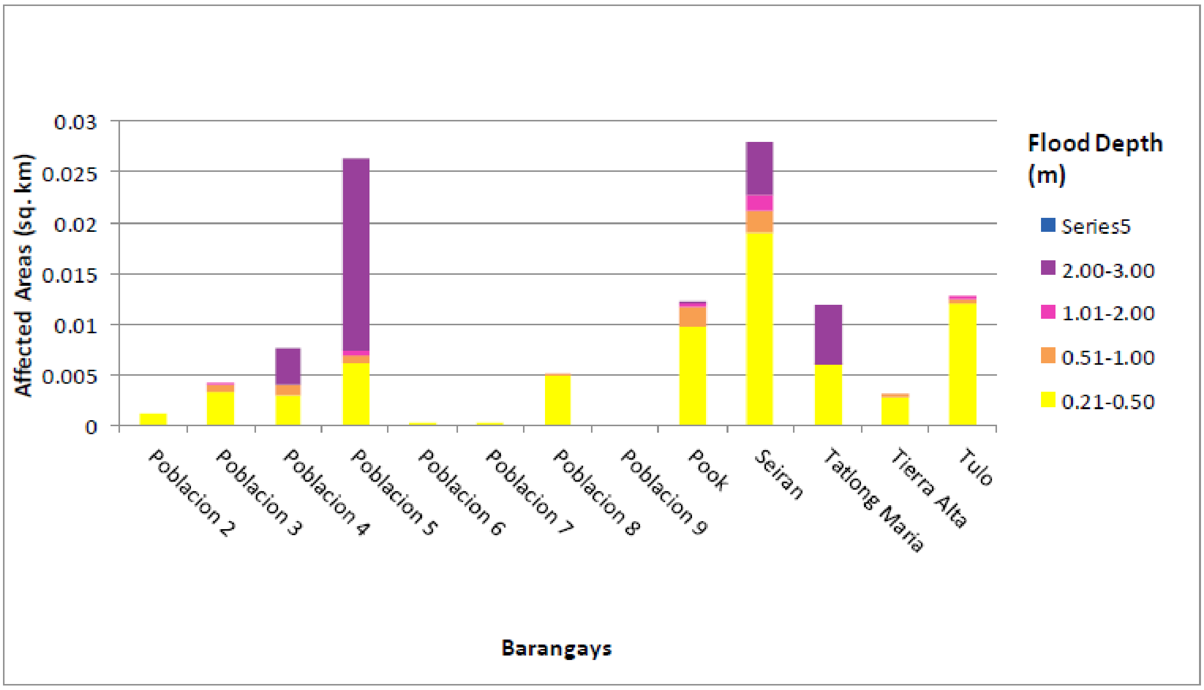


Figure 106. Areas affected by flooding in Taal, Batangas for a 100-Year Return Period rainfall event

Moreover, the generated flood hazard maps for the Pansipit 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 75. 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	13.15	11.41	10.31
Medium	18.1	21.55	22.03
High	6.3	12.41	17.24
TOTAL	37.55	45.37	49.58

Of the 66 identified Education Institutes in Pansipit Flood plain, one (1) school was discovered exposed to Low-level flooding during a 5-year scenario, while two (2) schools were found exposed to Medium-level flooding in the same scenario.

In the 25-year scenario, one (1) school was found exposed to Low-level flooding, while two (2) schools were discovered exposed to Medium-level flooding.

For the 100-year scenario, one (1) school was discovered exposed to Low-level flooding , while two (2) schools were exposed to Medium-level flooding. In the same scenario, one (1) school was found exposed to high level flood hazards.

Apart from this, twenty-five (25) medical institutions were identified in Pansipit flood plain, but only Iba Health Care Center 1 in Brgy. Iba, Taal Municipality was exposed to low flood hazard levels for the 100-year scenario.

5.11 Flood Validation

In order to check and validate the extent of flooding in different river systems, a validation survey work was performed. Field personnel gathered 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 were identified for validation.

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

After which, the actual data from the field were compared to the simulated data to assess the accuracy of the Flood Depth Maps produced and to improve on what is needed.

The flood validation consists of 336 points randomly selected all over the Pansipit flood plain. It has an RMSE value of 1.3067. The flood validation points are found in Annex 10.

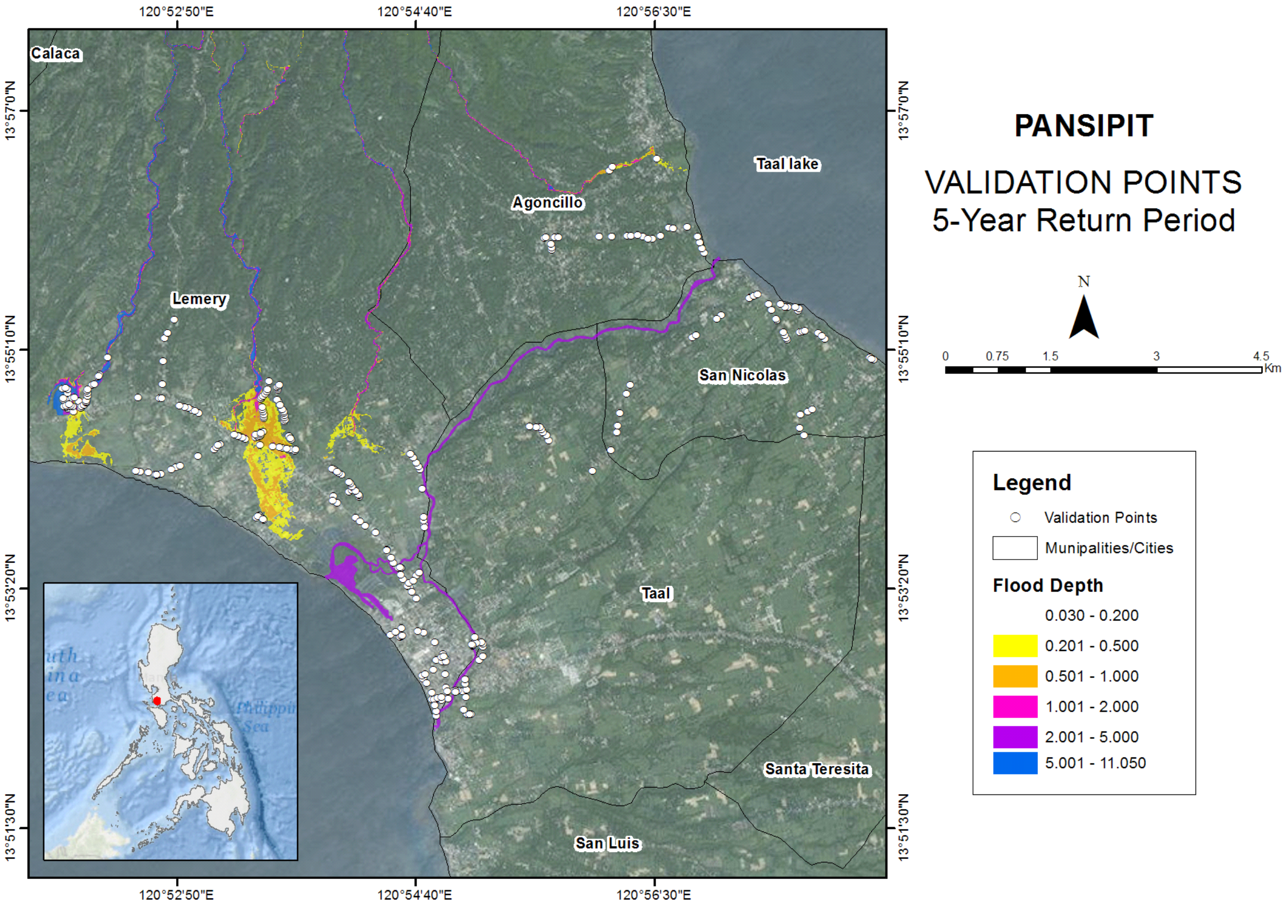


Figure 107. Validation points for 5-year Flood Depth Map of Pansipit Floodplain

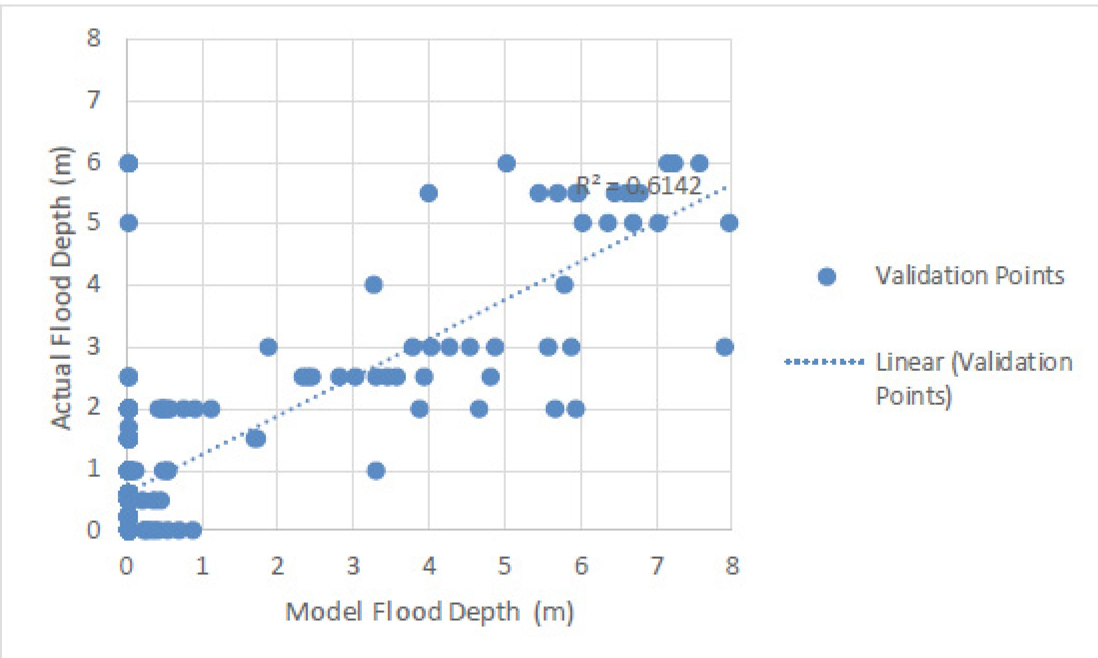


Figure 108. Flood map depth vs actual flood depth

Table 76. Actual Flood Depth vs Simulated Flood Depth in Pansipit

PANSIPIT BASIN		Modeled Flood Depth (m)						
0-0.20		0.21-0.50	0.51-1.00	1.01-2.00	2.01-5.00	> 5.00	Total	
Actual Flood Depth (m)	0-0.20	83	5	3	0	0	0	91
	0.21-0.50	78	3	0	0	0	0	81
	0.51-1.00	68	1	2	0	1	0	72
	1.01-2.00	31	2	6	3	2	2	46
	2.01-5.00	4	0	0	1	16	9	30
	> 5.00	3	0	0	0	1	12	16
	Total	267	11	11	4	20	23	336

The overall accuracy generated by the flood model is estimated at 35.42% with 119 points correctly matching the actual flood depths. In addition, there were 102 points estimated one level above and below the correct flood depths while there were 76 points and 38 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 195 points were underestimated in the modelled flood depths of Pansipit.

Table 77. Summary of Accuracy Assessment in Pansipit

	No. of Points	%
Correct	119	**35.42**
Overestimated	22	**6.55**
Underestimated	195	**58.04**
Total	336	**100.00**

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ANNEXES

Annex 1.Technical Specifications of the LIDAR Sensors used in the Pansipit Floodplain Survey

1. PEGASUS SENSOR

Table A-1.1. Parameters and Specification of the Pegasus Sensor

Parameter	Specification
Operational envelope (1,2,3,4)	150-5000 m AGL, nominal
Laser wavelength	1064 nm
Horizontal accuracy (2)	1/5,500 x altitude, 1σ
Elevation accuracy (2)	< 5-20 cm, 1σ
Effective laser repetition rate	Programmable, 100-500 kHz
Position and orientation system	POS AV ™AP50 (OEM)
Scan width (FOV)	Programmable, 0-75 ˚
Scan frequency (5)	Programmable, 0-140 Hz (effective)
Sensor scan product	800 maximum
Beam divergence	0.25 mrad (1/e)
Roll compensation	Programmable, ±37˚ (FOV dependent)
Vertical target separation distance	<0.7 m
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)
Image capture	5 MP interline camera (standard); 60 MP full frame (optional)
Full waveform capture	12-bit Optech IWD-2 Intelligent Waveform Digitizer
Data storage	Removable solid state disk SSD (SATA II)
Power requirements	28 V, 800 W, 30 A
Dimensions and weight	Sensor: 630 x 540 x 450 mm; 65 kg;
	Control rack: 650 x 590 x 490 mm; 46 kg
Operating Temperature	-10°C to +35°C
Relative humidity	0-95% non-condensing

2. GEMINI SENSOR

Table A-1.2. Parameters and Specification of Gemini 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 Certification of Reference Points Used in the LIDAR Survey

1. BTG-51

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

January 05, 2016

CERTIFICATION

To whom it may concern:

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

Province: **BATANGAS**
Station Name: **BTG-51**
Order: **2nd**

Island: **LUZON**	Barangay: **TALAGA**	
Municipality: **TANAUAN**	MSL Elevation:	
	PRS92 Coordinates	
Latitude: **14° 6' 8.57112"**	Longitude: **121° 5' 52.31002"**	Ellipsoidal Hgt: **152.36900 m.**
	WGS84 Coordinates	
Latitude: **14° 6' 3.27790"**	Longitude: **121° 5' 57.24592"**	Ellipsoidal Hgt: **197.55100 m.**
	PTM / PRS92 Coordinates	
Northing: **1559501.067 m.**	Easting: **510567.544 m.**	Zone: **3**
	UTM / PRS92 Coordinates	
Northing: **1,559,783.81**	Easting: **294,641.94**	Zone: **51**

Location Description

BTG-51
From Star Expressway Exit, Tanauan City, turn right to Talisay and continue traveling W until reaching the Y-road. Station is located inside the Mabini Shrine, approx. 100 m. from the right side of the road. It is situated approx. 2 m. S of the flagpole, about 15 m. N from the gate of the said shrine. Mark is the head of a 4 in. copper nail centered and embedded on a 30 cm. x 30 cm. concrete block flushed on the ground, with inscriptions "BTG-51 2007 NAMRIA".

Requesting Party:	**DOST-PCIEERD**
Purpose:	**Reference**
OR Number:	**8089513 I**
T.N.:	**2016-0018**

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

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

CIP/4701/12/09/814

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

FigureA-2.1. BTG-51

2. 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**		Barangay: **PALLOCAN**
Municipality: **BATANGAS CITY (CAPITAL)**		
	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
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

Figure A-2.2. BTG-30

3. BTG-45

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

March 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: **BATANGAS**
Station Name: **BTG-45**
Order: **2nd**

Island: **LUZON**
Municipality: **TUY**
Barangay: **MALIBU**

PRS92 Coordinates

Latitude: **13° 59' 52.18294"**	Longitude: **120° 42' 18.96476"**	Ellipsoidal Hgt: **48.43000 m.**

WGS84 Coordinates

Latitude: **13° 59' 46.88216"**	Longitude: **120° 42' 23.91169"**	Ellipsoidal Hgt: **92.94300 m.**

PTM Coordinates

Northing: **1547952.281 m.**	Easting: **468159.677 m.**	Zone: **3**

UTM Coordinates

Northing: **1,548,591.80**	Easting: **252,125.62**	Zone: **51**

Location Description

BTG-45
From Tuy Town Proper, travel S on the road going to Balayan, then turn right to the road going to Brgy. Malibu. Station is located on the NW side of a fenced garden and about 10 m. W of the school bldg. of Santiago De Guzman Elem. School. Mark is the head of a 4 in. copper nail centered and embedded on a 30 cm. x 30 cm. concrete block, with inscriptions "BTG-45 2007 NAMRIA".

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795470 A**
T.N.: **2014-444**

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

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

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

Figure A-2.3. BTG-45

Annex 3.Baseline Processing Reports of Control Points used in the LIDAR Survey

1. BTG-A

Table A-3.1. BTG-A

Project information		Coordinate System	
Name:		Name:	UTM
Size:		Datum:	PRS 92
Modified:	10/12/2012 4:40:11 PM (UTC:-6)	Zone:	51 North (123E)
Time zone:	Mountain Standard Time	Geoid:	EGMPH
Reference number:		Vertical datum:	
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
BTG-51 --- BTG-A (B1)	BTG-51	BTG-A	Fixed	0.003	0.013	170°48'36"	16216.677	221.457
BTG-51 --- BTG-A (B2)	BTG-51	BTG-A	Fixed	0.004	0.017	170°48'36"	16216.637	221.577
BTG-51 --- BTG-A (B3)	BTG-51	BTG-A	Fixed	0.003	0.012	170°48'36"	16216.621	221.544
TGT-1 --- BTG-A (B4)	BTG-A	TGT-1	Fixed	0.008	0.017	315°18'50"	24750.750	239.384
BTG-51 --- TGT-1 (B5)	BTG-51	TGT-1	Fixed	0.009	0.018	276°06'46"	14901.801	460.990
BTG-A --- TGT-1 (B6)	BTG-A	TGT-1	Fixed	0.005	0.019	315°18'50"	24750.733	239.429
BTG-51 --- TGT-1 (B7)	BTG-51	TGT-1	Fixed	0.005	0.017	276°06'46"	14901.814	461.001
TGT-2 --- TGT-1 (B8)	TGT-2	TGT-1	Fixed	0.005	0.008	183°02'45"	3.316	0.124
BTG-A --- TGT-2 (B9)	TGT-2	BTG-A	Fixed	0.006	0.017	135°16'50"	24752.968	-239.298
BTG-51 --- TGT-2 (B10)	BTG-51	TGT-2	Fixed	0.007	0.017	276°07'32"	14901.989	460.964
TGT-1 --- TGT-2 (B11)	TGT-2	TGT-1	Fixed	0.003	0.004	182°17'41"	3.293	0.187
BTG-A --- TGT-2 (B12)	TGT-2	BTG-A	Fixed	0.004	0.017	135°16'50"	24752.942	-239.320
BTG-51 --- TGT-2 (B13)	BTG-51	TGT-2	Fixed	0.005	0.017	276°07'32"	14901.994	460.970
BTG-51 --- BTG-A (B14)	BTG-51	BTG-A	Fixed	0.020	0.025	170°48'36"	16216.661	221.703
TGT-2 --- BTG-A (B15)	TGT-2	BTG-A	Fixed	0.065	0.038	135°16'50"	24753.003	-239.177
BTG-51 --- TGT-2 (B16)	BTG-51	TGT-2	Fixed	0.004	0.013	276°07'31"	14901.990	460.994

1

Acceptance Summary

Processed	Passed	Flag	Fail
16	16	0	0

BTG-51 - BTG-A (10:17:13 AM-4:00:13 PM) (S1)

Baseline observation:	BTG-51 --- BTG-A (B1)
Processed:	1/6/2016 4:11:57 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.003 m
Vertical precision:	0.013 m
RMS:	0.003 m
Maximum PDOP:	1.859
Ephemeris used:	Broadcast
Antenna model:	NGS Absolute
Processing start time:	12/21/2015 10:17:33 AM (Local: UTC+8hr)
Processing stop time:	12/21/2015 4:00:13 PM (Local: UTC+8hr)
Processing duration:	05:42:40
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	BTG-51				
Grid		**Local**		**Global**	
Easting	294641.947 m	**Latitude**	N14°06'08.57113"	**Latitude**	N14°06'03.27790"
Northing	1559783.810 m	**Longitude**	E121°05'52.31001"	**Longitude**	E121°05'57.24592"
Elevation	152.867 m	**Height**	152.369 m	**Height**	197.551 m

To:	BTG-A				
Grid		**Local**		**Global**	
Easting	297103.192 m	**Latitude**	N13°57'27.65020"	**Latitude**	N13°57'22.39320"
Northing	1543753.102 m	**Longitude**	E121°07'18.59698"	**Longitude**	E121°07'23.54499"
Elevation	374.449 m	**Height**	373.826 m	**Height**	419.468 m

Vector					
ΔEasting	2461.246 m	**NS Fwd Azimuth**	170°48'36"	**ΔX**	-4333.540 m
ΔNorthing	-16030.708 m	**Ellipsoid Dist.**	16216.677 m	**ΔY**	2168.834 m
ΔElevation	221.582 m	**ΔHeight**	221.457 m	**ΔZ**	-15477.964 m

2

2. BTG-30A

Table A-3.2. BTG-30A

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
BTG-30 --- BTG-30A (B2)	BTG-30	BTG-30A	Fixed	0.004	0.005	190°01'30"	4.793	0.078

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

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

3. BTG-45A

Table A-3.3. BTG-45A

Project Information		Coordinate System	
Name:		Name:	UTM
Size:		Datum:	PRS 92
Modified:	10/12/2012 4:40:11 PM (UTC:-6)	Zone:	51 North (123E)
Time zone:	Mountain Standard Time	Geoid:	EGMPH
Reference number:		Vertical datum:	
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
BTG-45 --- BTG-45A (B1)	BTG-45	BTG-45A	Fixed	0.001	0.001	175°32'41"	6.995	0.659

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

BTG-45 - BTG-45A (7:15:33 AM-11:52:39 AM) (S1)

Baseline observation:	BTG-45 --- BTG-45A (B1)
Processed:	9/2/2015 11:37:56 AM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.001 m
Vertical precision:	0.001 m
RMS:	0.000 m
Maximum PDOP:	2.331
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	9/1/2015 7:15:33 AM (Local: UTC+8hr)
Processing stop time:	9/1/2015 11:52:39 AM (Local: UTC+8hr)
Processing duration:	04:37:06
Processing interval:	1 second

4. TGT-1

Table A-3.4. TGT-1

TGT-1 - BTG-A (8:02:03 AM-12:33:59 PM) (S4)

Baseline observation:	TGT-1 --- BTG-A (B4)
Processed:	1/6/2016 4:19:10 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.008 m
Vertical precision:	0.017 m
RMS:	0.021 m
Maximum PDOP:	2.798
Ephemeris used:	Broadcast
Antenna model:	NGS Absolute
Processing start time:	12/22/2015 8:02:03 AM (Local: UTC+8hr)
Processing stop time:	12/22/2015 12:33:59 PM (Local: UTC+8hr)
Processing duration:	04:31:56
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	BTG-A				
Grid		Local		Global	
Easting	297103.192 m	Latitude	N13°57'27.65020"	Latitude	N13°57'22.39320"
Northing	1543753.102 m	Longitude	E121°07'18.59698"	Longitude	E121°07'23.54499"
Elevation	374.473 m	Height	373.850 m	Height	419.492 m

To:	TGT-1				
Grid		Local		Global	
Easting	279835.803 m	Latitude	N14°07'00.06415"	Latitude	N14°06'54.75674"
Northing	1561490.784 m	Longitude	E120°57'38.31809"	Longitude	E120°57'43.25314"
Elevation	614.013 m	Height	613.234 m	Height	658.040 m

Vector					
ΔEasting	-17267.390 m	NS Fwd Azimuth	315°18'50"	ΔX	16999.982 m
ΔNorthing	17737.682 m	Ellipsoid Dist.	24750.750 m	ΔY	5522.228 m
ΔElevation	239.540 m	ΔHeight	239.384 m	ΔZ	17124.706 m

Annex 4. The LIDAR Survey Team Composition

Table A-4.1. The LIDAR Survey Team Composition

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
		ENGR. LOUIE P. BALICANTA	UP TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP TCAGP
	Supervising Science Research Specialist (SSRS)	LOVELY GRACIA ACUNA	UP TCAGP
		ENGR. LOVELYN ASUNCION	UP TCAGP
FIELD TEAM			
LiDAR Operation	Senior Science Research Specialist (SSRS)	JASMINE ALVIAR	UP TCAGP
		JULIE PEARL MARS	UP TCAGP
	Research Associate (RA)	JONALYN GONZALES	UP TCAGP
	RA	ENGR. IRO NIEL ROXAS	
		ENGR. LARAH KRISELLE PARAGAS	UP TCAGP
		KRISTINE JOY ANDAYA	UP TCAGP
		FAITH JOY SABLE	UP TCAGP
		ENGR. CHRISTOPHER JOAQUIN	UP TCAGP
		MA. VERLINA TONGA	UP TCAGP
		ENGR. KENNETH QUISADO	UP TCAGP
Ground Survey, Data Download and Transfer	Research Associate	ENGR. RENAN PUNTO	UP TCAGP
		ENGR. DAN ALDOVINO	UP TCAGP
LiDAR Operation	Airborne Security	TSG. JULIUS RENDON	PHILIPPINE AIR FORCE (PAF)
		TSG. BENJIE CARBOLLEDO	PHILIPPINE AIR FORCE (PAF)
		SSG. RAYMUND DOMINE	PHILIPPINE AIR FORCE (PAF)
	Pilot	CAPT. MARK TANGONAN	ASIAN AEROSPACE CORP (AAC)
		CAPT. RAUL CZ SAMAR II	AAC
		CAPT. FRANCO PEPITO	AAC

Annex 5. Data Transfer Sheet for Pansipit Floodplain

Feb 15,2014	1111P	1BLK18RS46A	PEGASUS	1.39GB	1.74MB	6.22MB	194MB	19.7GB	172KB	14.7GB	N/A	10.9MB	215B	569B	71KB	N/A	Z:\Airborne_Raw\1111P
Feb 17,2014	1119P	1BLK18O48A	PEGASUS	1.02GB	1.95MB	8.25MB	250MB	21.5GB	195KB	16.8GB	N/A	11.7MB	213MB	520B	41KB	N/A	Z:\Airborne_Raw\1119P
Feb 18, 2014	1123P	1BLK18OS49A	PEGASUS	1.38GB	1.81MB	6.46MB	193MB	N/A	N/A	14.7GB	N/A	12.5MB	213B	504B	43KB	N/A	Z:\Airborne_Raw\1123P
Feb 18,2014	1125P	1BLK18S49B	PEGASUS	374MB	665KB	4.21MB	144MB	N/A	N/A	5.57GB	N/A	12.6MB	213B	282B	79.7KB	N/A	Z:\Airborne_Raw\1125P
Feb 19, 2014	1127P	1BLK18S50A	PEGASUS	985MB	1.54MB	5.26MB	190MB	N/A	N/A	12.1GB	N/A	6.85MB	218B	507B	67.1KB	N/A	Z:\Airborne_Raw\1127P
Feb 20, 2014	1131P	1BLK18Z51A	PEGASUS	1.84GB	2.39MB	7.83MB	219MB	30.3GB	234KB	20GB	90.4GB	13.2MB	133B	310B	91.9KB	N/A	Z:\Airborne_Raw\1131P
Feb 20,2014	1133P	1BLK18Z51B	PECASUS	1.06GB	1.41MB	4.71MB	169MB	18.9GB	140KB	12.1GB	N/A	13.2MB	133B	265B	91.5KB	N/A	Z:\Airborne_Raw\1133P
Feb 21, 2014	1135P	1BLK18Y52A	PEGASUS	1.54GB	2.04MB	7.95MB	235MB	7.41GB	117KB	17.4GB	33.9GB	7.52MB	133B	335B	91.9KB	N/A	Z:\Airborne_Raw\1135P
Feb 22,2014	1139P	1BLK18X53A	PEGASUS	2.19GB	2.45MB	7.52MB	233MB	29.3GB	239KB	21GB	N/A	6.71MB	133B	0B	147KB	N/A	Z:\Airborne_Raw\1139P
Feb 22, 2014	1141P	1BLK18S53B	PEGASUS	1.65GB	1.80MB	7.25MB	219MB	24GB	176KB	15.4GB	N/A	6.25MB	157B	410B	171KB	N/A	Z:\Airborne_Raw\1141P
28-Jan	1039P	1BLK18B028A	PEGASUS	2.05	35KB	11.8	165	NA	NA	19.1	NA	7.43	141B	242B	40.5	NA	Z:\Airborne_Raw\1039P

Received from
Name CHRIS [illegible]
Position
Signature

Received by
Name JOIDA F. PRIETO
Position SSRS
Signature

Figure A-5.1. Transfer Sheet for Pansipit Floodplain - A

DATA TRANSFER SHEET

01/06/2016 Batangas

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	
12/22/2015	3002P	1BLK18SB356A	PEGASUS	2.71	1195	10.6	185	41.7	310	25.3	NA	27.5	1KB	1KB	137/134	NA	Z:\DAC\RAWDATA
12/29/2015	3669G	2BLK18SBC363A	GEMINI	NA	198	861	151	NA	NA	14.9	NA	7.42	1KB	1KB	NA	NA	Z:\DAC\RAWDATA
12/29/2015	3671G	2BLK18SBC363B	GEMINI	NA	96	473	85	NA	NA	7.41	NA	7.42	1KB	1KB	11	NA	Z:\DAC\RAWDATA
12/30/2015	3673G	2BLK18S364A	GEMINI	NA	221	1.28	195	NA	NA	16.6	NA	11.4	1KB	1KB	17	NA	Z:\DAC\RAWDATA

Received from

Name Kristine Andaya

Position RA

Signature

Received by

Name JOIDA F. PRIETO

Position SupSRS

Signature

01/06/2016

3002P

16-02

Figure A-5.2. Transfer Sheet for Pansipit Floodplain - B

DATA TRANSFER SHEET
01/06/2016 Batangas

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	
1/16/2016	3693G	2BLK18SCB106A	GEMINI	NA	88	1.6	82.9	NA	NA	7.98	NA	8.36	1KB	1KB	4	NA	Z:\DAC\RAWDATA

Received from

Name

Position

Signature

Received by

Name

Position

Signature

Figure A-5.3. Transfer Sheet for Pansipit Floodplain - C

DATA TRANSFER SHEET
Batangas 1/13/16

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
21-Dec 1	3000P	1BLK18SB355A	pegasus	736	656	3.8	107	11.1	85	7.11	na	11.1	1KB	1KB	100	na	Z:\DAC\RAW DATA
6-Jan 6	3677G	2BLK18SK006A	GEMINI	NA	322	699	157	NA	NA	38.7	na	27.2	0KB	1KB	11	na	Z:\DAC\RAW DATA
6-Jan 7	3679G	2BLK18SDG006B	GEMINI	NA	60	401	131	NA	NA	12.8	na	27.2	0KB	1KB	5/3	na	Z:\DAC\RAW DATA
7-Jan 8	3681G	2BLK18SM007A	GEMINI	NA	226	0	209	NA	NA	24	na	18.5	0KB	1KB	NA	na	Z:\DAC\RAW DATA
8-Jan 9	3685G	2BLK18SF008A	GEMINI	NA	99	786	185	NA	NA	24.4	na	20.9	0KB	1KB	4/2	na	Z:\DAC\RAW DATA
8-Jan 10	3687G	2BLK18SGS008B	GEMINI	NA	214	0	172	NA	NA	17.2	na	20.9	0KB	1KB	4/20	na	Z:\DAC\RAW DATA
9-Jan 11	3689G	2BLK18SV009A	GEMINI	NA	201	1.54	219	NA	NA	16.3	na	12.9	0KB	1KB	23	na	Z:\DAC\RAW DATA
9-Jan 12	3691G	2BLK18SVV009B	GEMINI	NA	12.8	440	124	NA	NA	6.93	na	12.9	0KB	1KB	10	na	Z:\DAC\RAW DATA

Received from
Name C. Joaquin
Position
Signature

Received by
Name AC Bongat
Position SSRA
Signature 1/15/16

II-05

Figure A-5.4. Transfer Sheet for Pansipit Floodplain - D

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 [signature]

Received by

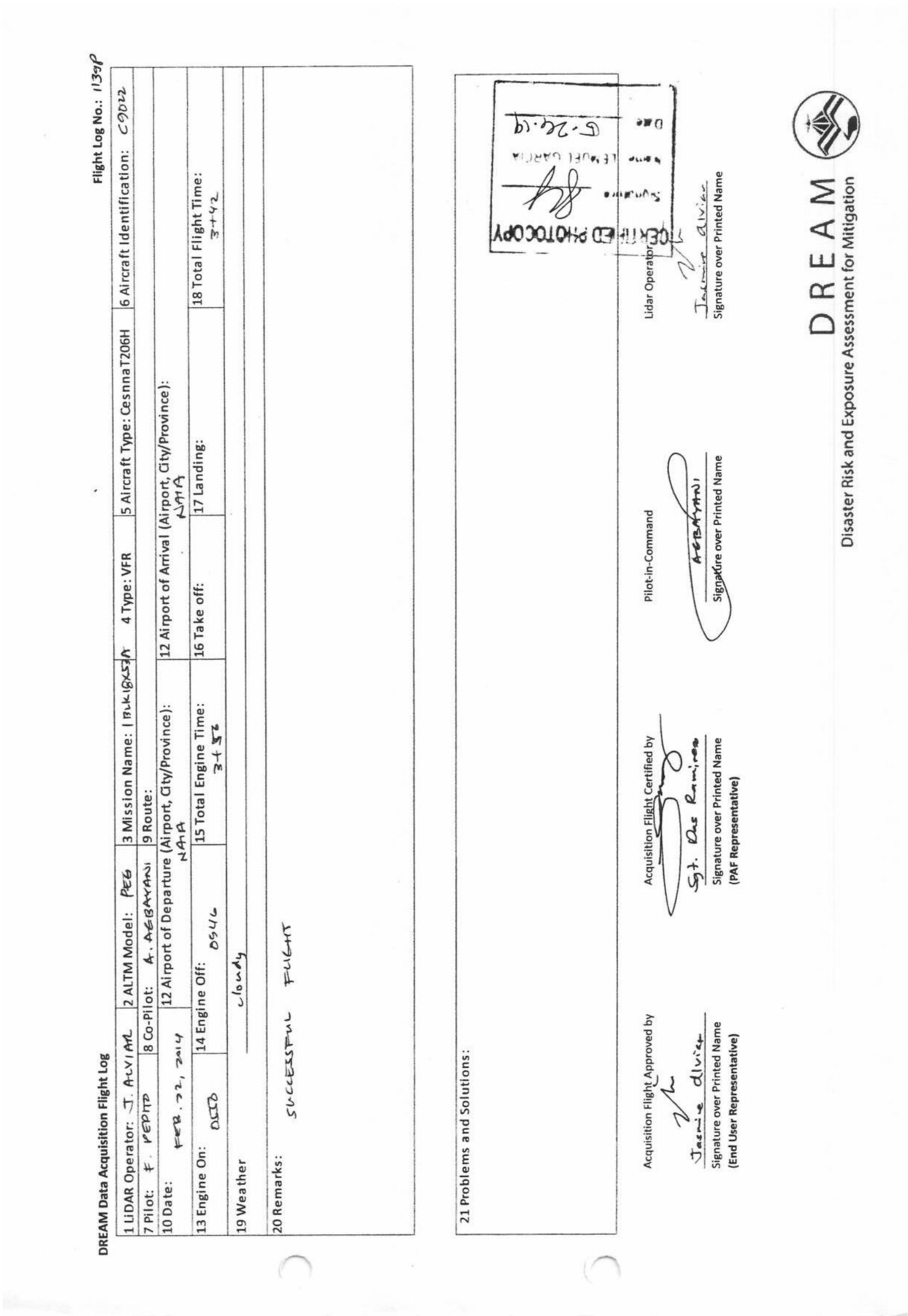
Name AC Bongat 9/11/15
Position SSRS
Signature [signature]

15-25

Figure A-5.5. Transfer Sheet for Pansipit Floodplain - E

Annex 6. Flight logs for the flight missions

1. Flight log for Mission1139P



DREAM Data Acquisition Flight Log — Flight Log No.: 1139P

1 LIDAR Operator: J. ALVIAR	2 ALTM Model: PEG	3 Mission Name: 1BLK16CS53A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: C9022
7 Pilot: F. PEPITO	8 Co-Pilot: A. AEBAYANI	9 Route:			
10 Date: FEB. 22, 2014	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 0510	14 Engine Off: 0546	15 Total Engine Time: 3+56	16 Take off:	17 Landing:	18 Total Flight Time: 3+42
19 Weather: cloudy					
20 Remarks: SUCCESSFUL FLIGHT					

21 Problems and Solutions:

Acquisition Flight Approved by: Jasmine Alviar — Signature over Printed Name (End User Representative)

Acquisition Flight Certified by: Sgt. Ras Ramirez — Signature over Printed Name (PAF Representative)

Pilot-in-Command: A. AEBAYANI — Signature over Printed Name

Lidar Operator: Jasmine Alviar — Signature over Printed Name

CERTIFIED PHOTOCOPY — Signature: — Name: LEMUEL GARCIA — Date: 5-26-14

DREAM Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.1. Flight log for Mission 1139P

2. Flight log for Mission3373P

Data Acquisition Flight Log — Flight Log No.: 3373P

1 LiDAR Operator: G. SINADJAN	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK18OS246A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9022
7 Pilot: M. Tangonan	8 Co-Pilot: J. Moiney	9 Route: NAIA - NAIA			
10 Date: SEPT. 3, 2015	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 0630H	14 Engine Off: 0958H	15 Total Engine Time: 3+28	16 Take off: 0635H	17 Landing: 0953H	18 Total Flight Time: 3+18
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

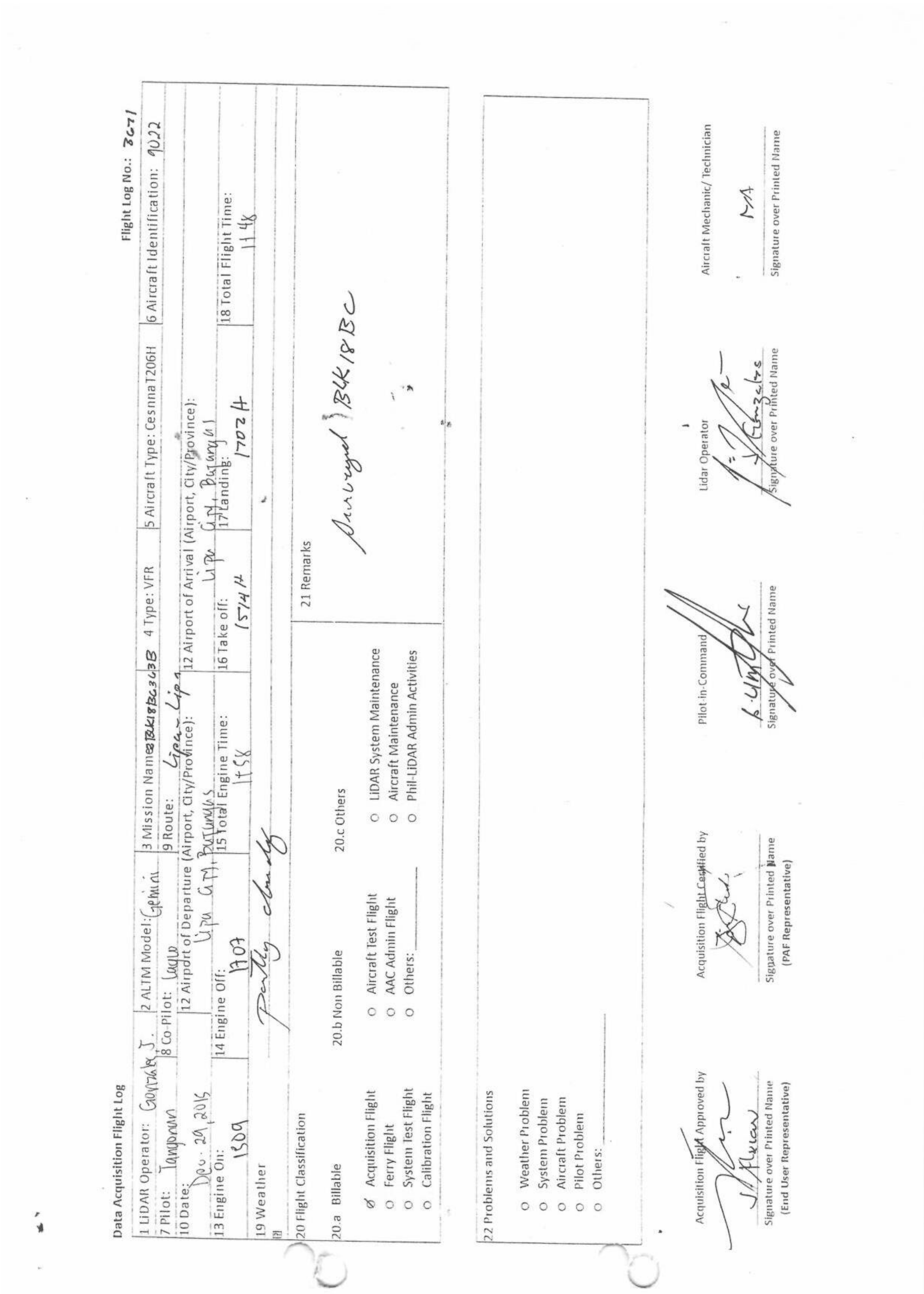
22 Problems and Solutions

- ○ 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
[signature]	LEE JAY PUNZALAN	ML 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

Figure A-6.2. Flight log for Mission 3373P

3. Flight Log for Mission3671G



Data Acquisition Flight Log

Flight Log No.: 3671

1 LiDAR Operator: Gonzales J.	2 ALTM Model: Gemini	3 Mission Name: 3BLK18BC363B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: Tangonan	8 Co-Pilot: Lagua	9 Route: Lipa - Lipa			
10 Date: Dec. 29, 2015	12 Airport of Departure (Airport, City/Province): Lipa City, Batangas		12 Airport of Arrival (Airport, City/Province): Lipa City, Batangas		
13 Engine On: 1509	14 Engine Off: 1707	15 Total Engine Time: 1+58	16 Take off: 1514H	17 Landing: 1702H	18 Total Flight Time: 1+48
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

Surveyed BLK18BC

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

Acquisition Flight Approved by: J. Alvian — Signature over Printed Name (End User Representative)

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

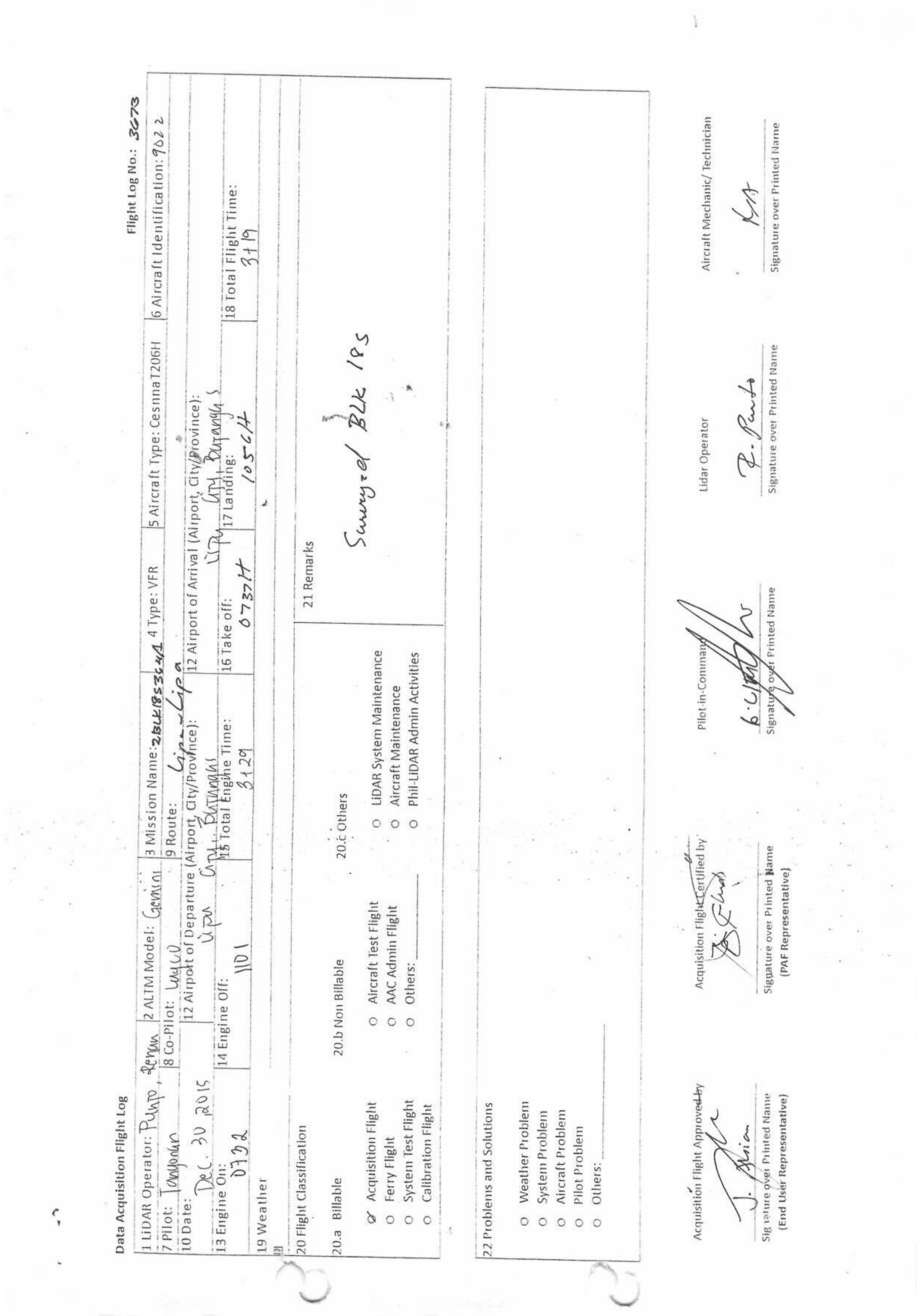
Pilot-in-Command: Signature over Printed Name

Lidar Operator: J. Gonzales — Signature over Printed Name

Aircraft Mechanic/ Technician: MA — Signature over Printed Name

Figure A-6.3. Flight Log for Mission 3671G

4. Flight log for Mission3673G



Data Acquisition Flight Log — Flight Log No.: 3673

1 LiDAR Operator: Punto, Renan	2 ALTM Model: Gemini	3 Mission Name: 2BLK18S364A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9022
7 Pilot: Jonggolan	8 Co-Pilot: Lugo	9 Route: Lipa - Lipa			
10 Date: Dec. 30, 2015	12 Airport of Departure (Airport, City/Province): Lipa City, Batangas		12 Airport of Arrival (Airport, City/Province): Lipa City, Batangas		
13 Engine On: 0732	14 Engine Off: 1101	15 Total Engine Time: 3+29	16 Take off: 0737H	17 Landing: 1056H	18 Total Flight Time: 3+19
19 Weather					

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

Surveyed BLK 18S

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

Acquisition Flight Approved by: J. Alvia — Signature over Printed Name (End User Representative)

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

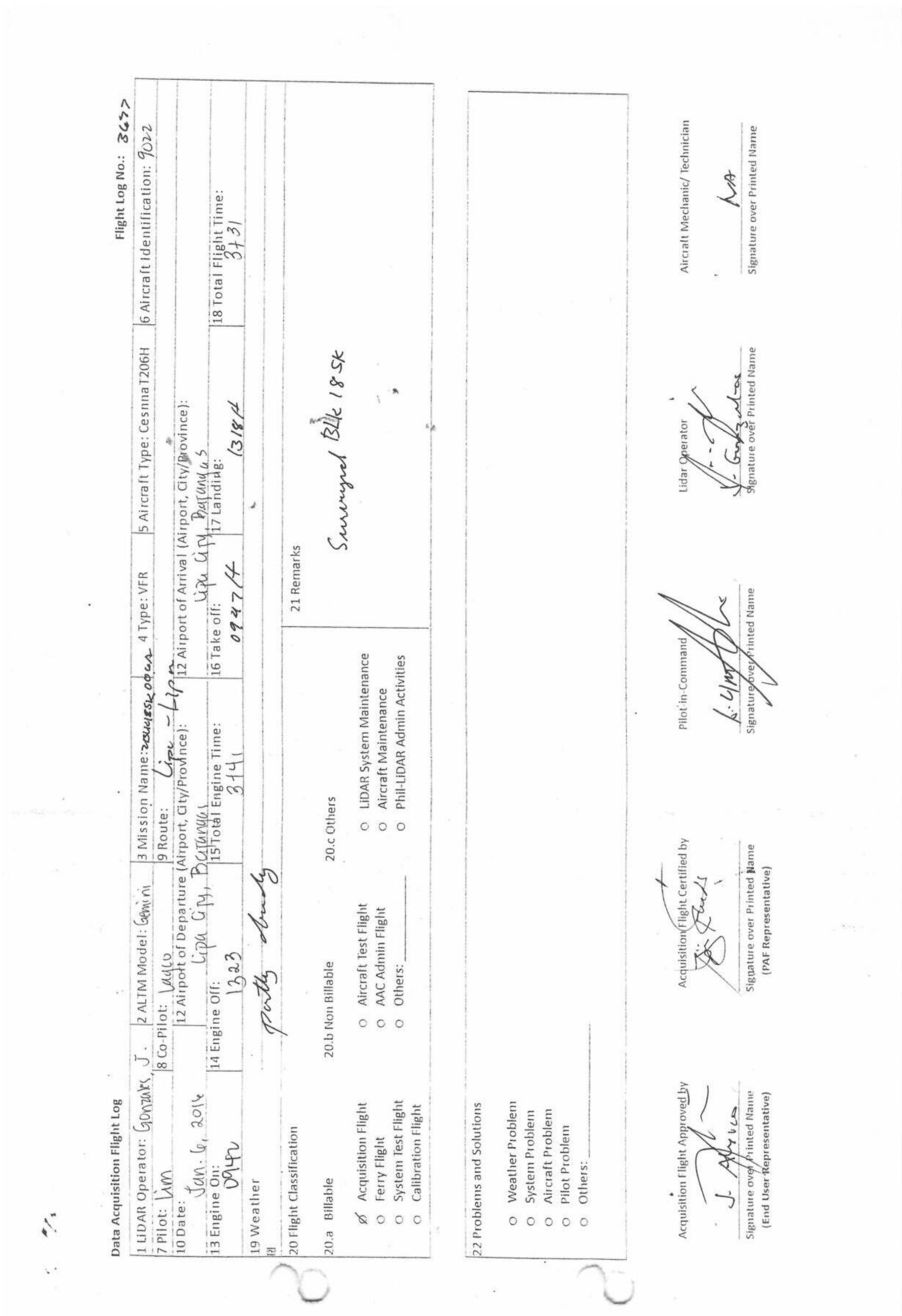
Pilot-in-Command: Signature over Printed Name

Lidar Operator: R. Punto — Signature over Printed Name

Aircraft Mechanic/ Technician: Signature over Printed Name

Figure A-6.4. Flight log for Mission 3673G

5. Flight log for Mission3677P



Data Acquisition Flight Log

Flight Log No.: 3677

1 LiDAR Operator: Gonzales, J.	2 ALTM Model: Gemini	3 Mission Name: [illegible]	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9022
7 Pilot: Lim	8 Co-Pilot: Laylo	9 Route: Lipa - Lipa			
10 Date: Jan. 6, 2016	12 Airport of Departure (Airport, City/Province): Lipa City, Batangas		12 Airport of Arrival (Airport, City/Province): Lipa City, Batangas		
13 Engine On: 0942	14 Engine Off: 1323	15 Total Engine Time: 3+41	16 Take off: 0947	17 Landing: 1318	18 Total Flight Time: 3+31
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

Surveyed BLK 18SK

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

Acquisition Flight Approved by: J. Alviar — Signature over Printed Name (End User Representative)

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

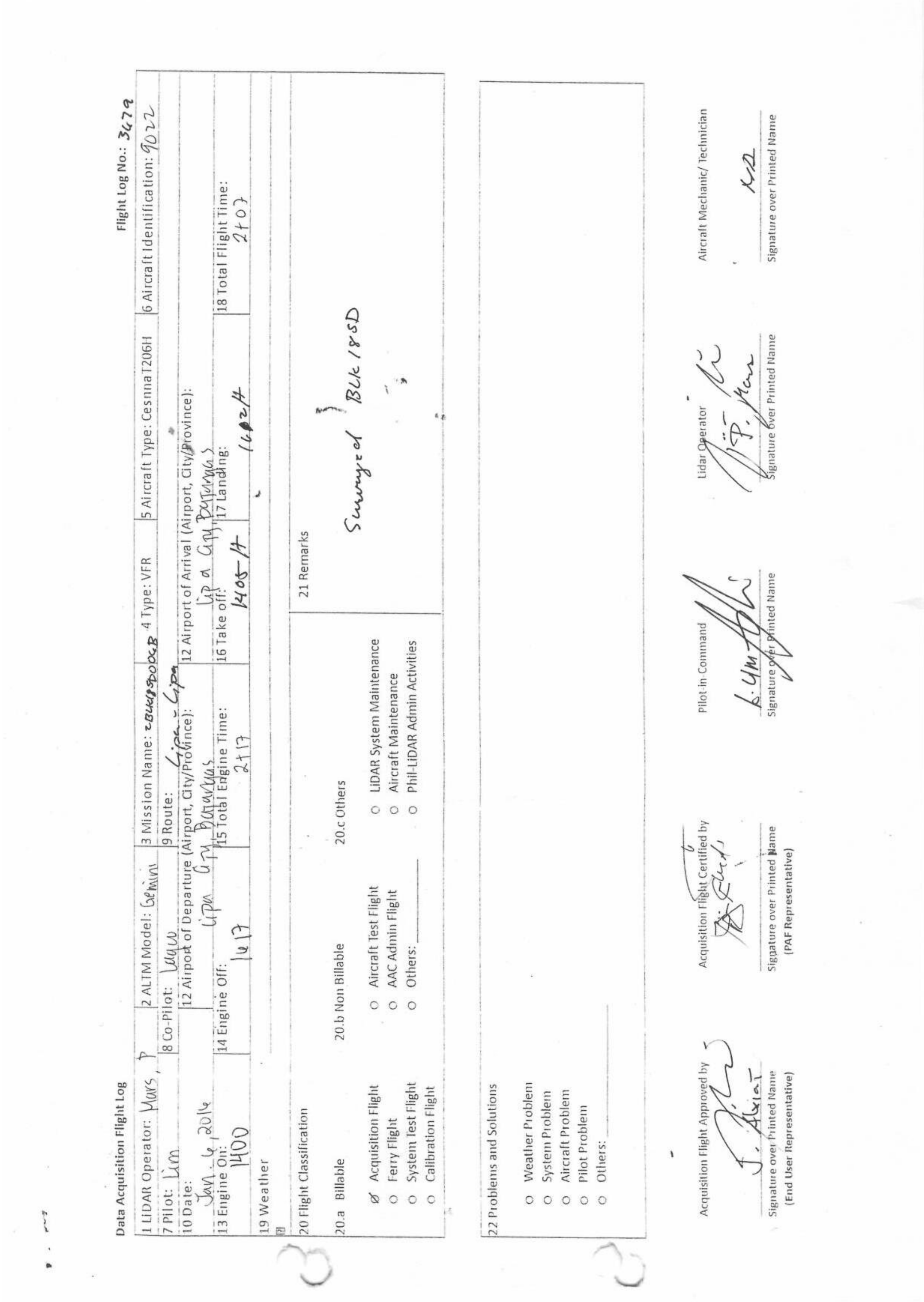
Pilot-in-Command: [illegible] — Signature over Printed Name

Lidar Operator: J. Gonzales — Signature over Printed Name

Aircraft Mechanic/ Technician: [illegible] — Signature over Printed Name

Figure A-6.5. Flight log for Mission 3677P

6. Flight log for Mission3679G

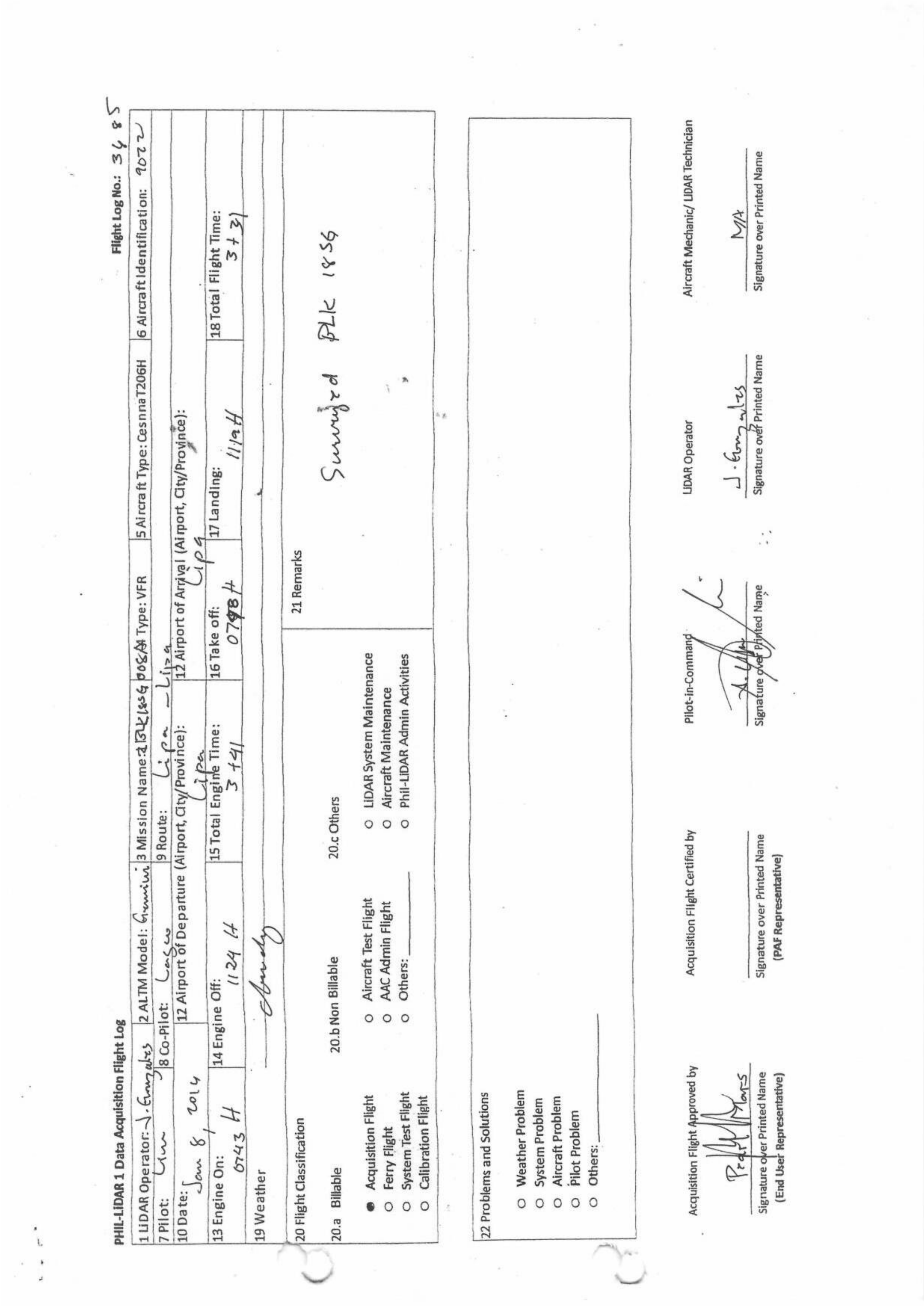

Data Acquisition Flight Log — Flight Log No.: 3679

1 LiDAR Operator: Mars, P
2 ALTM Model: Gemini
3 Mission Name: 2BLK18SD006B
4 Type: VFR
5 Aircraft Type: Cesnna T206H
6 Aircraft Identification: 9022
7 Pilot: Lim
8 Co-Pilot: Uyaw
9 Route: Lipa - Lipa
10 Date: Jan. 6, 2016
12 Airport of Departure (Airport, City/Province): Lipa City Batangas
12 Airport of Arrival (Airport, City/Province): Lipa City Batangas
13 Engine On: 1400
14 Engine Off: 1617
15 Total Engine Time: 2+17
16 Take off: 1405 H
17 Landing: 1602 H
18 Total Flight Time: 2+07
19 Weather
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: Surveyed BLK 18SD
22 Problems and Solutions: ○ Weather Problem; ○ System Problem; ○ Aircraft Problem; ○ Pilot Problem; ○ Others:

Acquisition Flight Approved by — J. Alviar — Signature over Printed Name (End User Representative)
Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)
Pilot-in-Command — L. Lim — Signature over Printed Name
Lidar Operator — P. Mars — Signature over Printed Name
Aircraft Mechanic/ Technician — Signature over Printed Name

Figure A-6.6. Flight log for Mission 3679G

7. Flight Log for Mission3685G



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 3685

1 LIDAR Operator: J. Gonzales	2 ALTM Model: Gemini	3 Mission Name: 2BLK18S6068A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9022
7 Pilot:	8 Co-Pilot:	9 Route: Lipa – Lipa			
10 Date: Jan 8, 2014	12 Airport of Departure (Airport, City/Province): Lipa	12 Airport of Arrival (Airport, City/Province): Lipa			
13 Engine On: 0743 H	14 Engine Off: 1124 H	15 Total Engine Time: 3+41	16 Take off: 0748 H	17 Landing: 1119 H	18 Total Flight Time: 3+31
19 Weather: Cloudy					

20 Flight Classification

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

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

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

21 Remarks

Surveyed BLK 18S6

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)

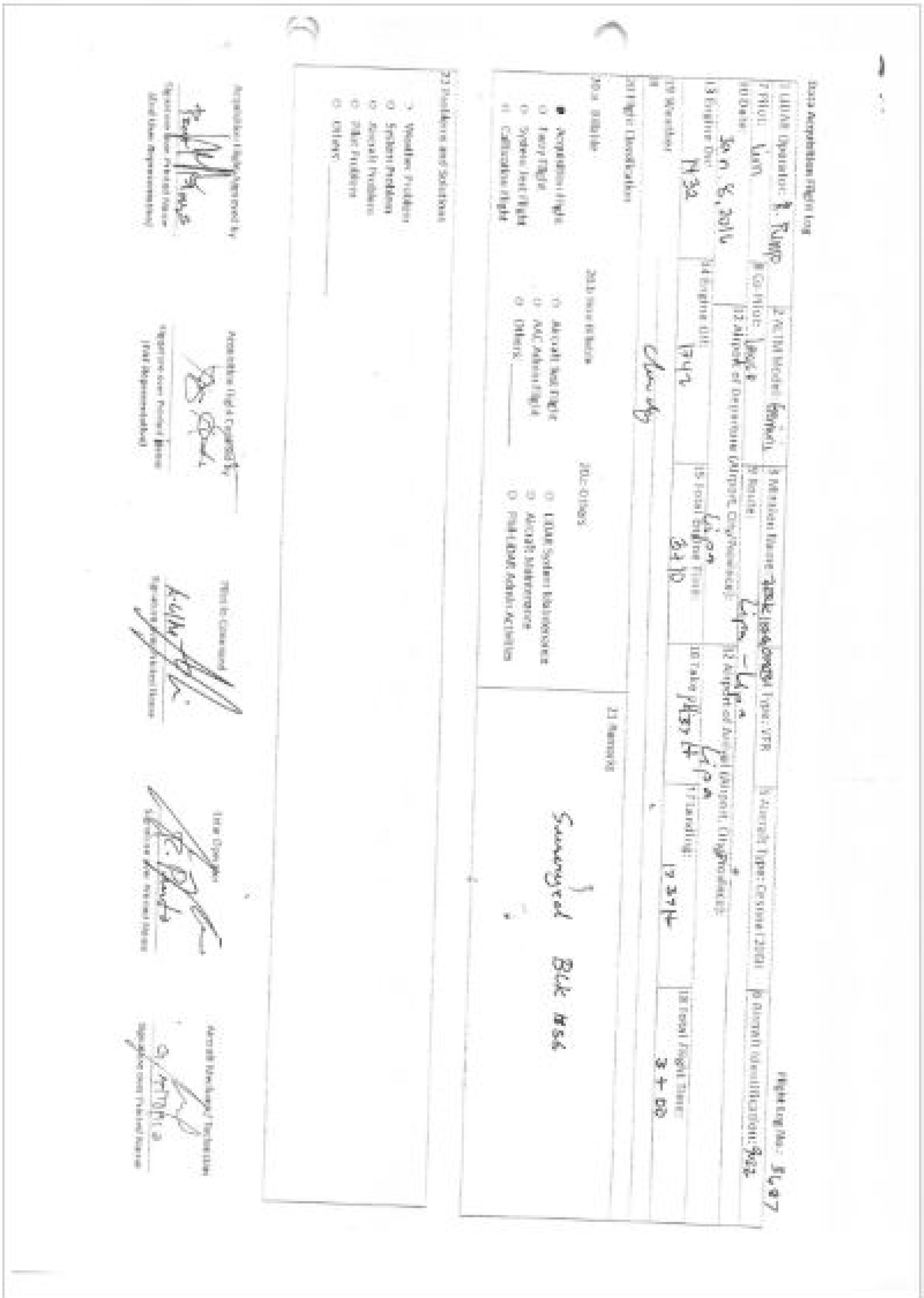
Pilot-in-Command — Signature over Printed Name

LIDAR Operator — J. Gonzales — Signature over Printed Name

Aircraft Mechanic/ LIDAR Technician — N/A — Signature over Printed Name

Figure A-6.7. Flight Log for Mission 3685G

8. Flight Log for Mission3687G


Data Acquisition Flight Log

Flight Log No.: 3687

10 Date: Jan 6, 2016

14 Engine Off: 1742

17 Landing: 1737H

18 Total Flight Time: 3+00

19 Weather: Cloudy

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 Problems and Solutions

○ Weather Problem

○ System Problem

○ Aircraft Problem

○ Pilot Problem

○ Others

22 Remarks: Surveyed Blk #56

Acquisition Flight Approved by

Acquisition Flight Certified by

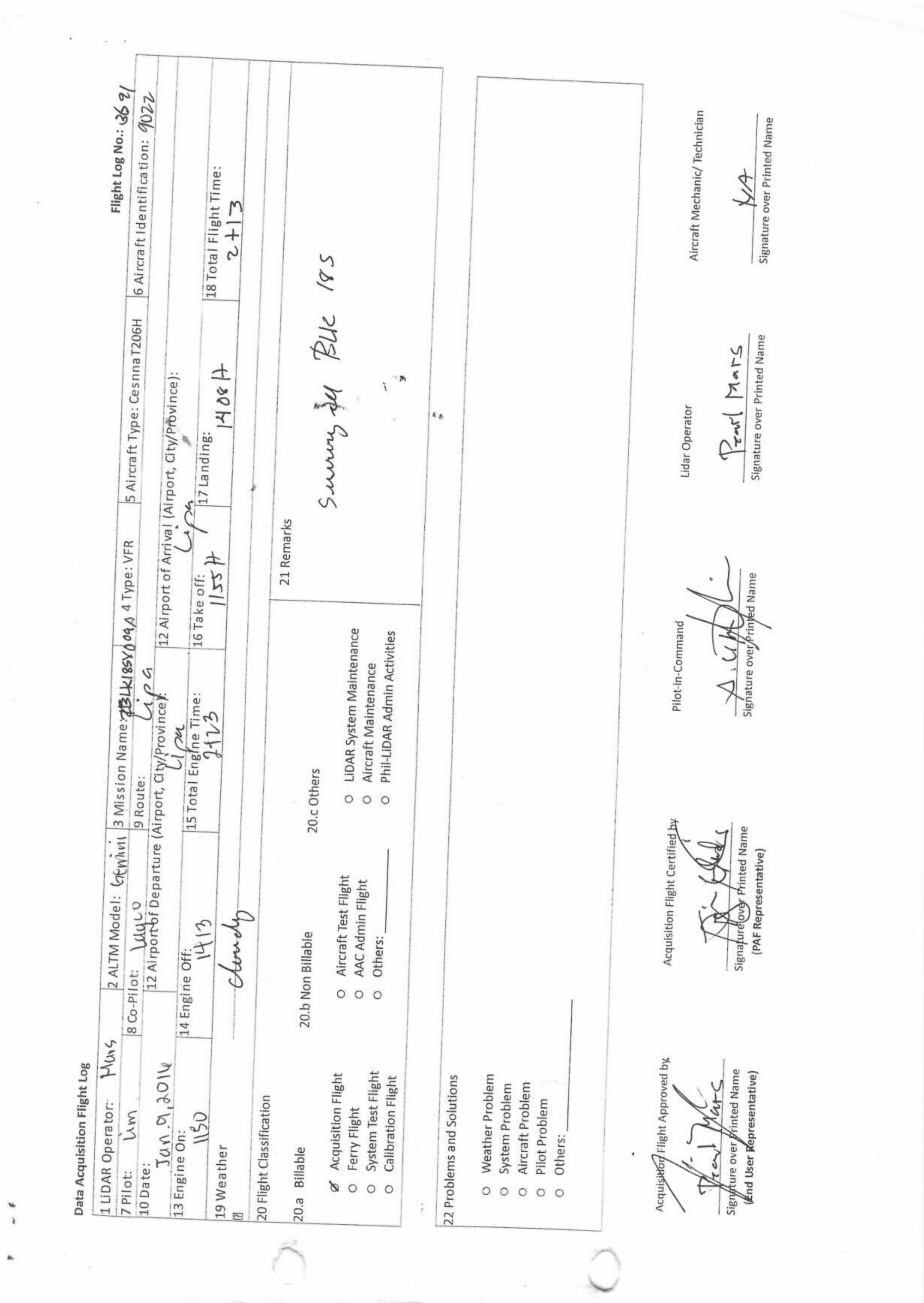
Pilot-in-Command

LiDAR Operator

Aircraft Mechanic/ Technician

Figure A-6.8. Flight Log for Mission 3687G

9. Flight Log for Mission3691G



Data Acquisition Flight Log

Flight Log No.: 3691

1 LiDAR Operator: Mars	2 ALTM Model: Gemini	3 Mission Name: 3BLK18SV009A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9022
7 Pilot: Um	8 Co-Pilot: Lugeo	9 Route: Lipa			
10 Date: Jan.9,2016	12 Airport of Departure (Airport, City/Province): Lipa		12 Airport of Arrival (Airport, City/Province): Lipa		
13 Engine On: 1150	14 Engine Off: 1413	15 Total Engine Time: 2+23	16 Take off: 1155H	17 Landing: 1408H	18 Total Flight Time: 2+13
19 Weather: cloudy					

20 Flight Classification

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

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

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

21 Remarks

Surveyed Blk 18S

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)

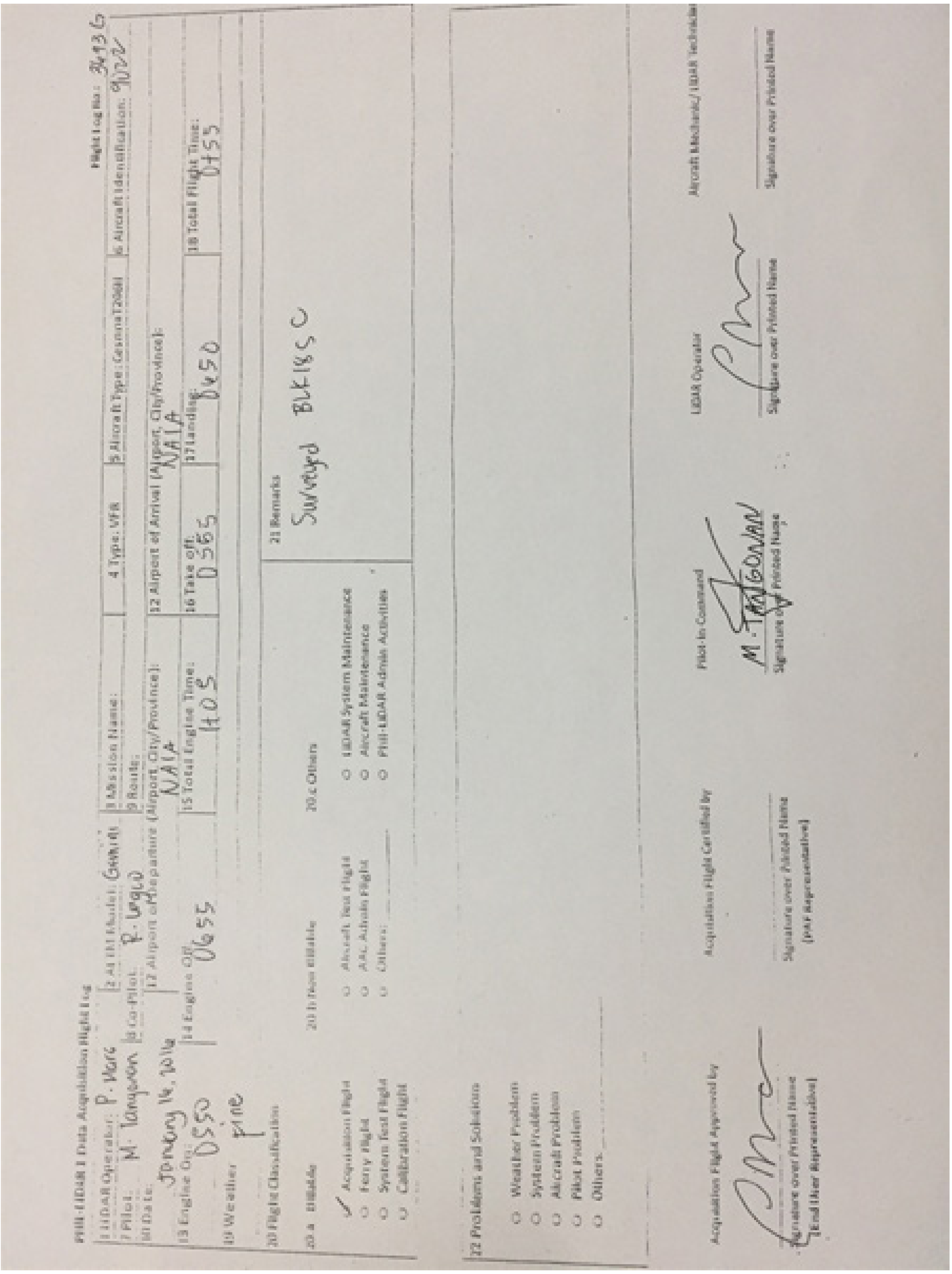
Pilot-in-Command: Signature over Printed Name

Lidar Operator: Pearl Mars — Signature over Printed Name

Aircraft Mechanic/ Technician: N/A — Signature over Printed Name

Figure A-6.9. Flight Log for Mission 3691G

10. Flight Log for Mission3693G



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 3693G

1 LiDAR Operator: P. Marc	2 ALTM Model: Gemini	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9022
7 Pilot: M. Tangonan	8 Co-Pilot: R. Lagco	9 Route:			
10 Date: January 14, 2016	12 Airport of Departure (Airport, City/Province): NAIA		12 Airport of Arrival (Airport, City/Province): NAIA		
13 Engine On: 0550	14 Engine Off: 0655	15 Total Engine Time: 1+05	16 Take off: 0555	17 Landing: 0650	18 Total Flight Time: 0+55
19 Weather: fine					

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

Surveyed BLK18S C

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. TANGONAN — Signature over Printed Name

LiDAR Operator: Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician: Signature over Printed Name

Figure A-6.10. Flight Log for Mission 3693G

Annex 7. Flight status reports

CALABARZON

(FEBRUARY 22, 2014; SEPTEMBER 3, 2016; DECEMBER 29, 2015 – JANUARY 8, 2016)

Table A-7.1. Flight Status Report

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1139P	BLK 18X & (ABCY)s	1BLK18X53A	J ALVIAR	Feb 22, 2014	Surveyed gaps in southern Cavite, voids in BLK 18Z and covered BLK 18X at 1200m flying height
3373P	BLK 18OS	1BLK18OS246A	G SINADJAN	SEPT 3, 2016	Line cut due to air traffic Experienced POSAV error Without Digitizer and Camera
3671G	BLK 18SBC CUENCA	2BLK18BC363B	J GONZALES	DEC 29, 2015	SURVEYED BLK 18SBC
3673G	BLK 18SG, 18SB LAUREL, LIPA, CUENCA	2BLK18S363A	R PUNTO	DEC 30, 2015	SURVEYED BLK 18SG, GAPS IN BLK 18SB
3677G	BLK 18SK, SD TALISAY TAAL	2BLK18SK006A	JGONZALES	JAN 6, 2016	SURVEYED BLK 18SKD
3679G	BLK 18G, SD CALACA BALAYAN	2BLK18SDG006B	P.MARS	JAN 6, 2016	SURVEYED BLK 18SGJ
3681G	BLK 18SM	2BLK18SM007A	RPUNO	JAN 7, 2016	SURVEYED BLK 18SM
3685G	BLK 18SG, SF CALAMBA CALACA	2BLK18SF008A	J GONZALES	JAN 8, 2016	SURVEYED BLK 18SF, 18SG
3687G	BLK18SG, SM	2BLK18SGS008B	R PUNTO	JAN 8, 2016	SURVEYED BLK 18SG GAPS IN BLK 18SM
3691G	GAPS IN BLK18KLB	2BLK18SVV009B	PMARS	JAN 9, 2016	SURVEYED IN GAPS IN BLK18SKL
3693G	BLK18SC	2BLK18SCB016A	P MARS	JAN 16, 2016	SURVEYED IN BLK18SC

SWATH PER FLIGHT MISSION

Flight No. : 1139P
Area: BLK 18X & (ABCY)s
Mission Name: 1BLK18S53A

LAS

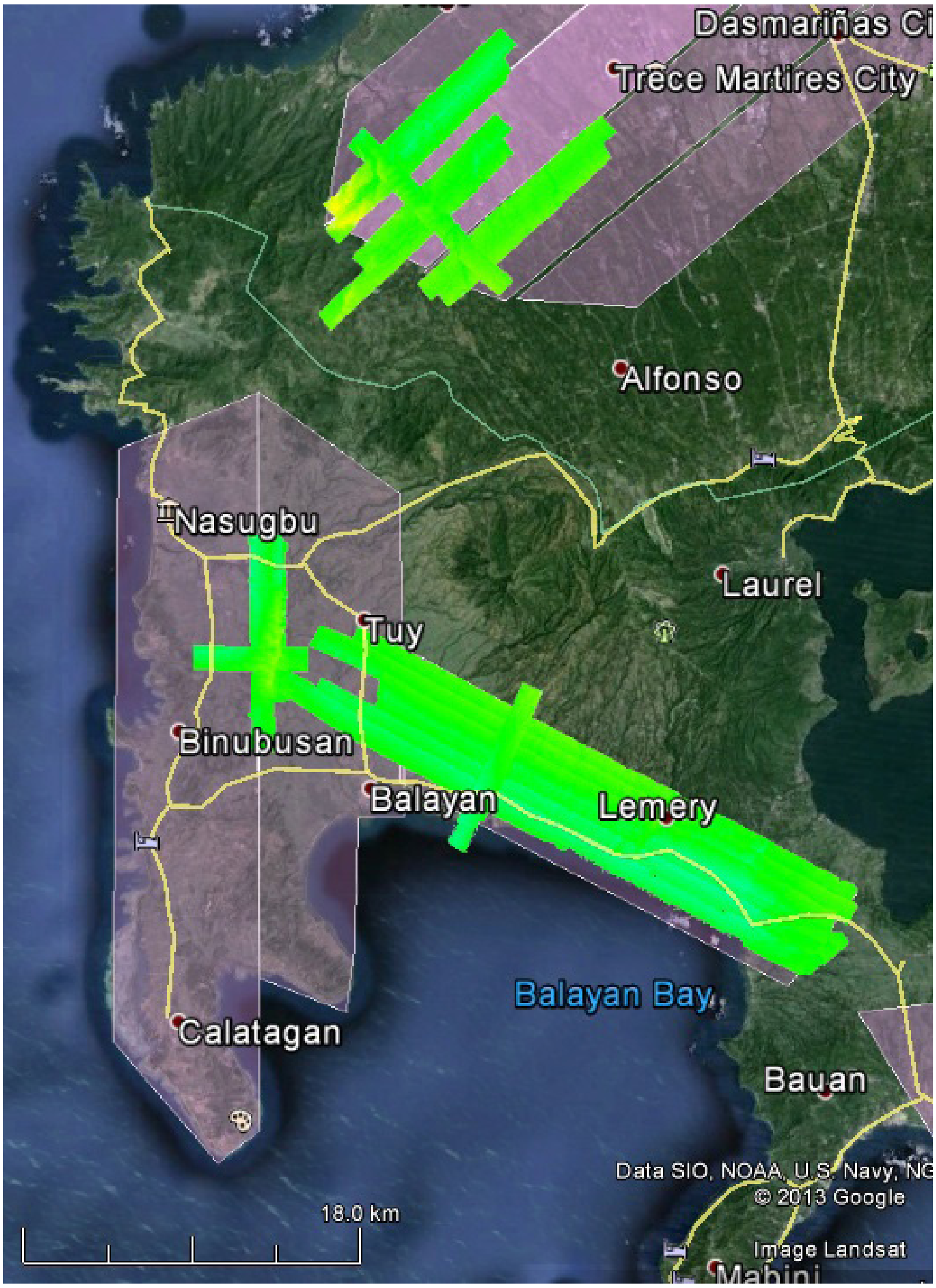


Figure A-7.1. Swath for Flight No. 1139P

Flight No. :	3373P		
Area:	BLK 18		
Mission Name:	1BLK18OS246A		
Parameters:	PRF: 200kHz,	Scan Angle: 25deg,	Overlap: 30%

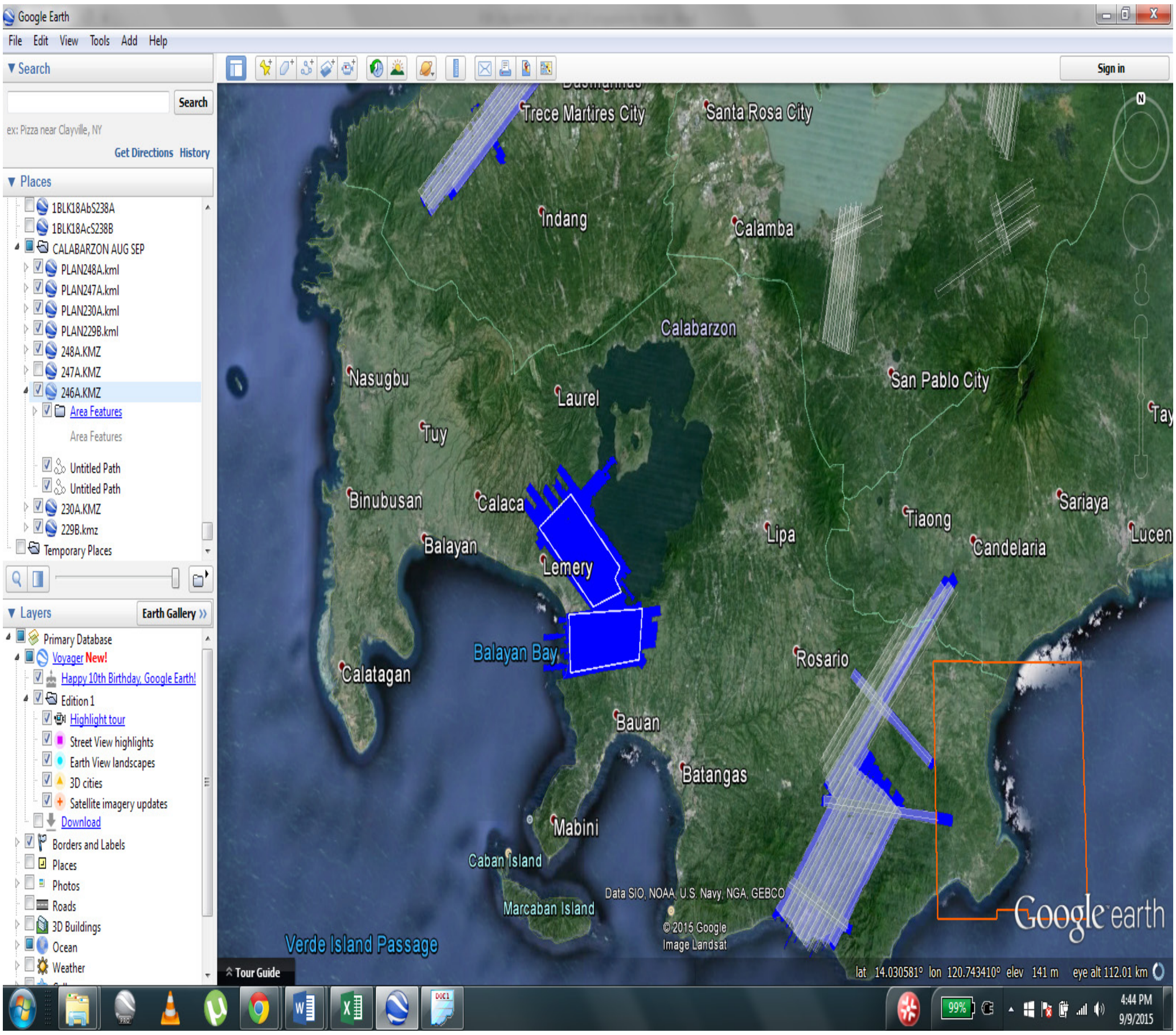


Figure A-7.2. Swath for Flight No. 3373P

Flight No. :	3671G		
Area:	BLK 18SBC		
Mission Name:	1BLK18SBC363B		
Parameters:	PRF: 100kHz,	Scan Angle: 20deg,	Overlap: 30%

LAS/SWATH

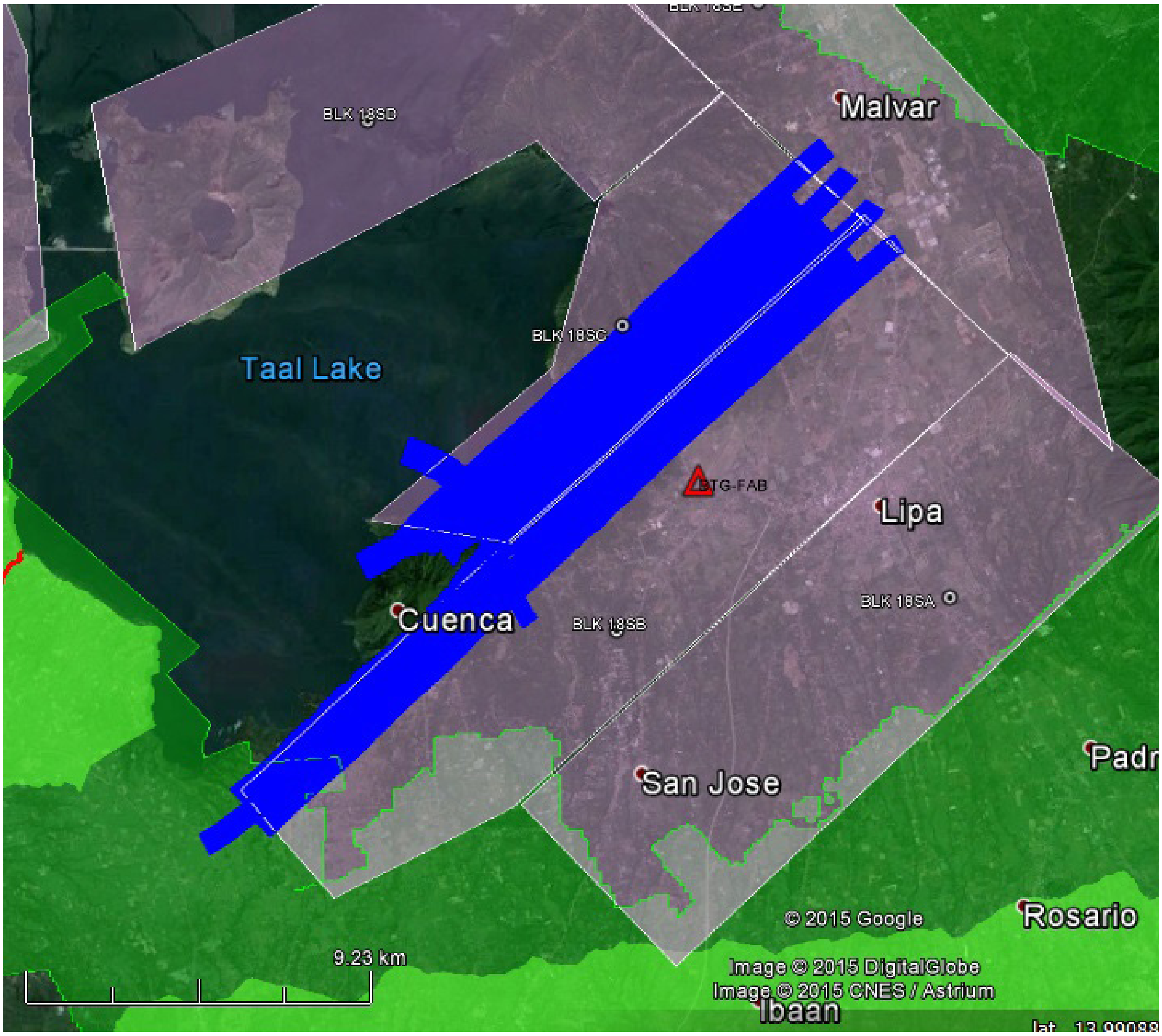


Figure A-7.3. Swath for Flight No. 3671G

Flight No. :	3673G		
Area:	BLK 18SG, 18SBS		
Mission Name:	1BLK18S364A		
Parameters:	PRF: 100 kHz,	Scan Angle: 20deg,	Overlap: 30%

LAS/SWATH

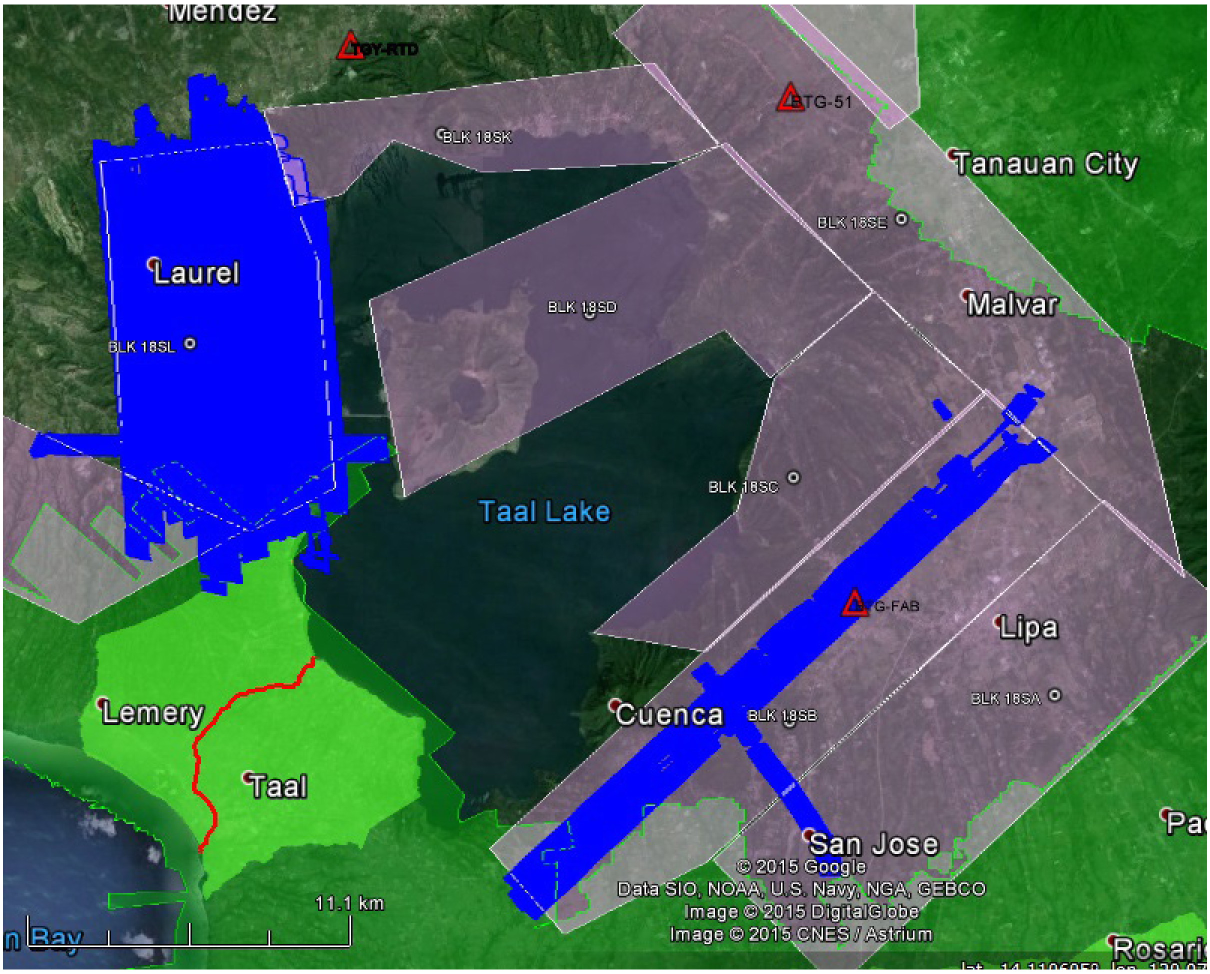


Figure A-7.4. Swath for Flight No. 3673G

Flight No. :	3677G		
Area:	BLK 18SK, SD		
Mission Name:	2BLK18SK006A		
Parameters:	PRF: 166 kHz,	Scan Angle: 25deg,	Overlap: 30%

LAS/SWATH

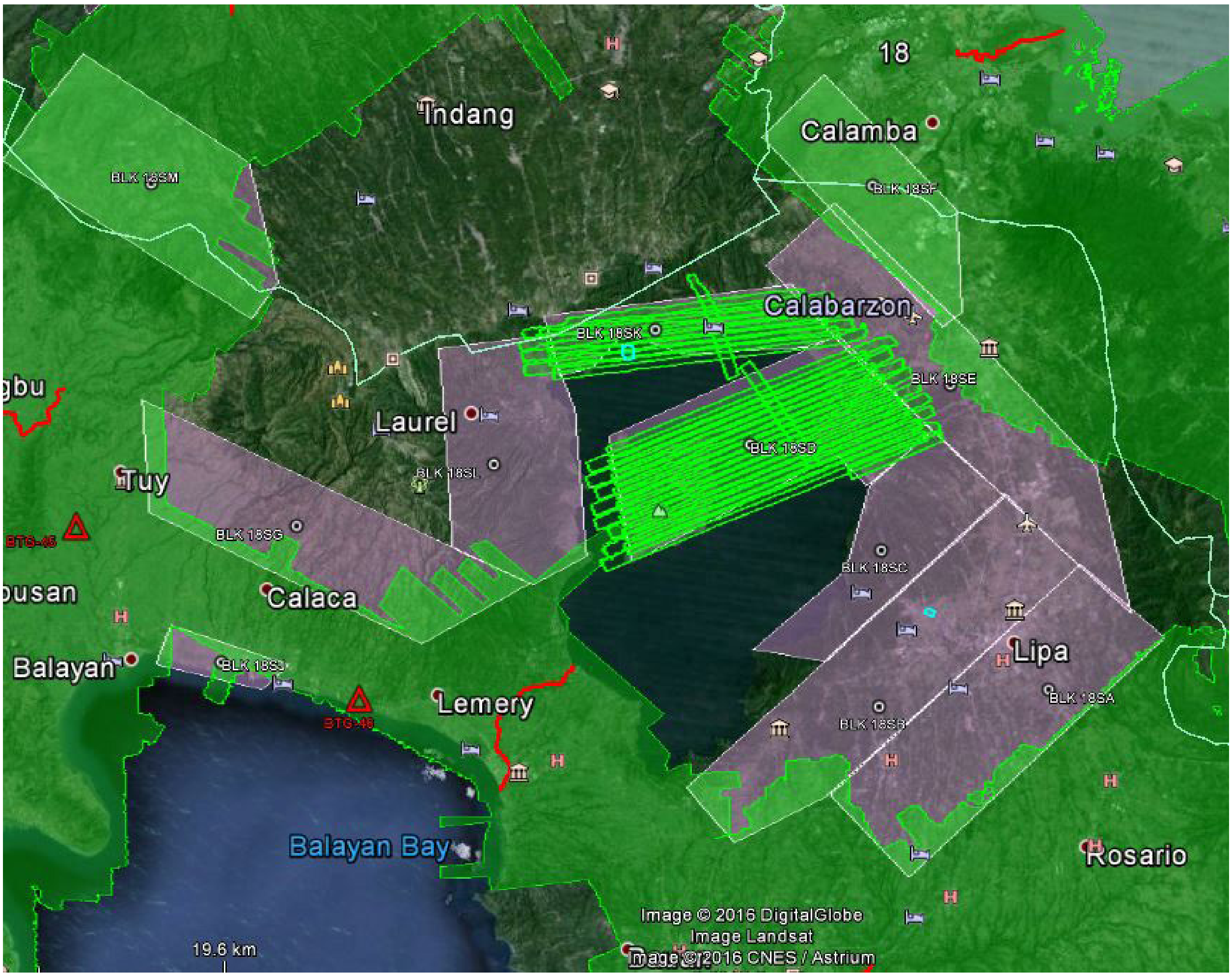


Figure A-7.5. Swath for Flight No. 3677G

Flight No. :	3679G		
Area:	BLK 18G, SD		
Mission Name:	2BLK18SDG006B		
Parameters:	PRF: 167 kHz,	Scan Angle: 20deg,	Overlap: 40%

LAS/SWATH

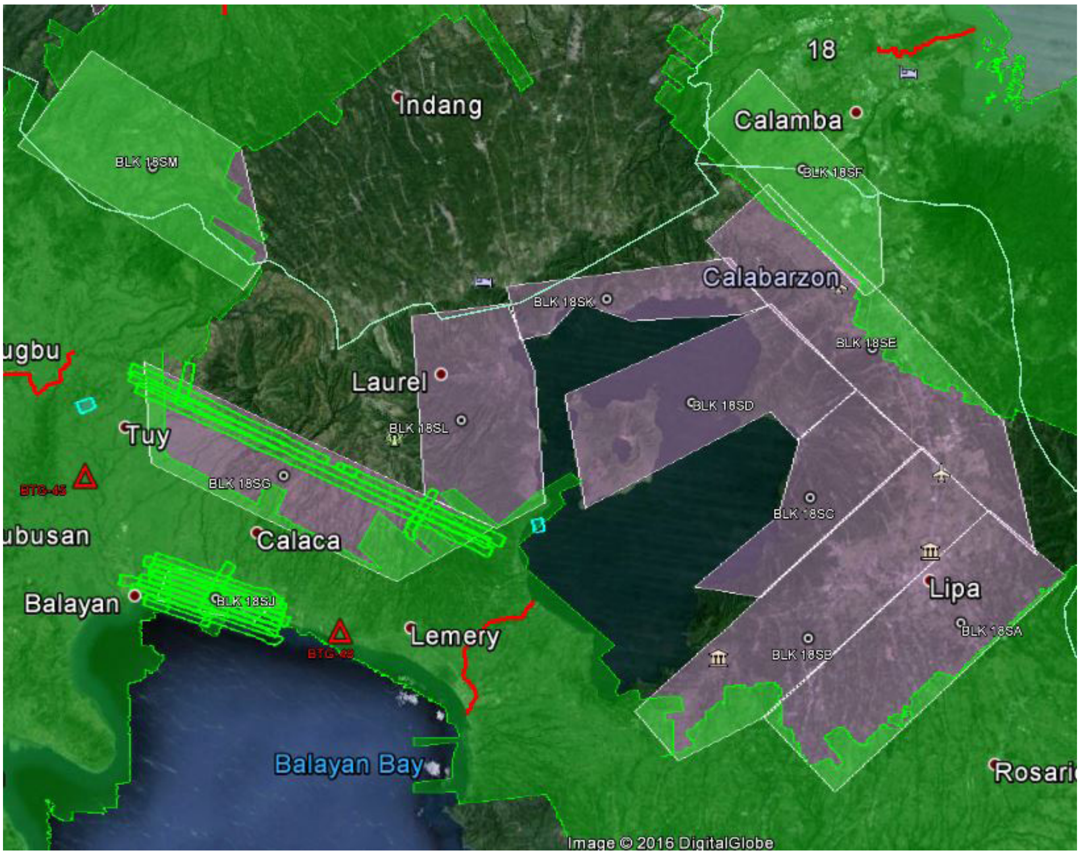


Figure A-7. 6. Swath for Flight No. 3679G

Flight No. : 3685G
Area: BLK 18SG, SF
Mission Name: 2BLK18SF008A
Parameters: PRF: 100 kHz, Scan Angle: 20deg, Overlap: 30%

LAS/SWATH

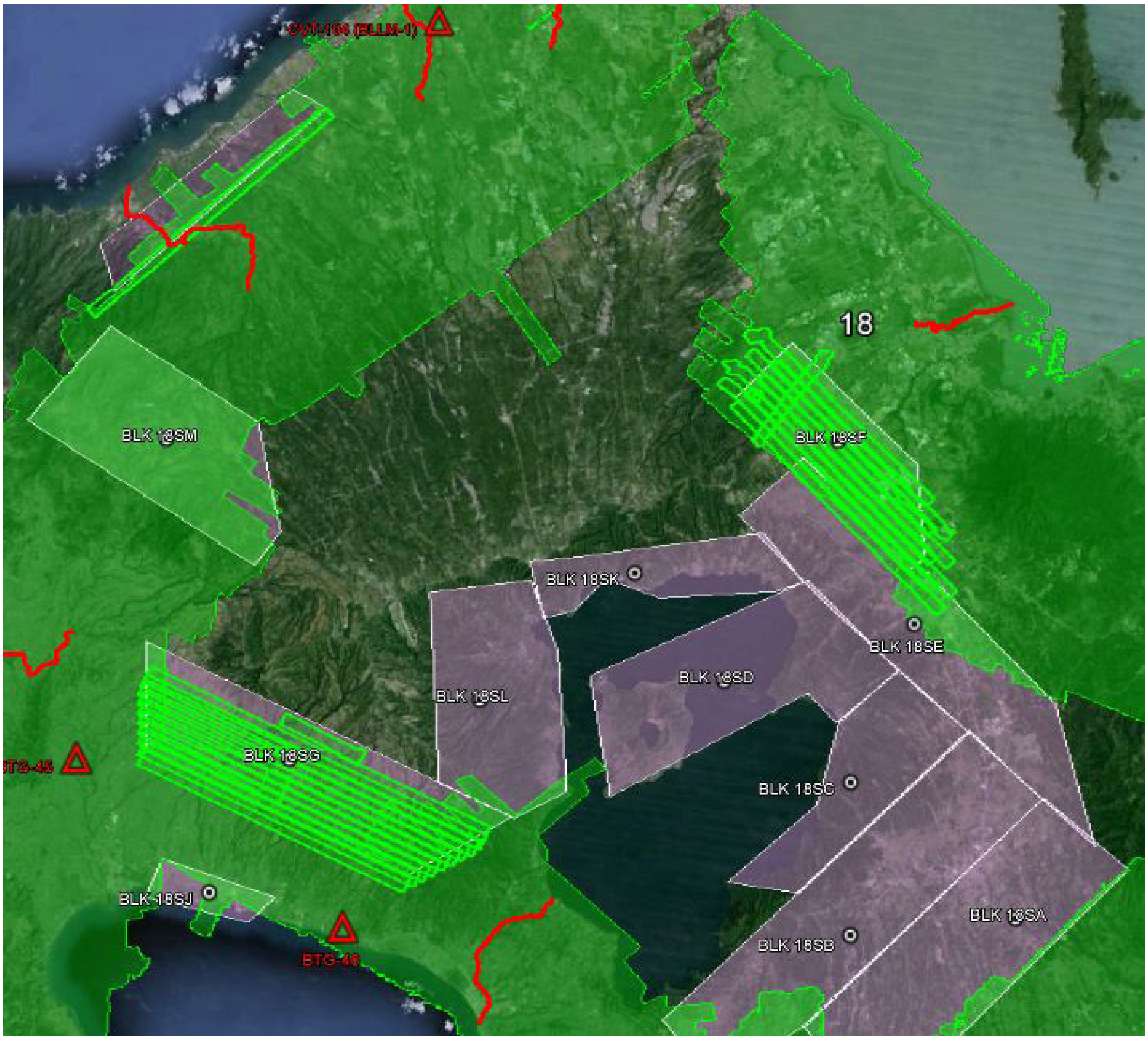


Figure A-7.7. Swath for Flight No. 3685G

Flight No. :	3687G		
Area:	BLK18SG, SM		
Mission Name:	2BLK18SGS008B		
Parameters:	PRF: 100 kHz,	Scan Angle: 20deg,	Overlap: 40%

LAS/SWATH

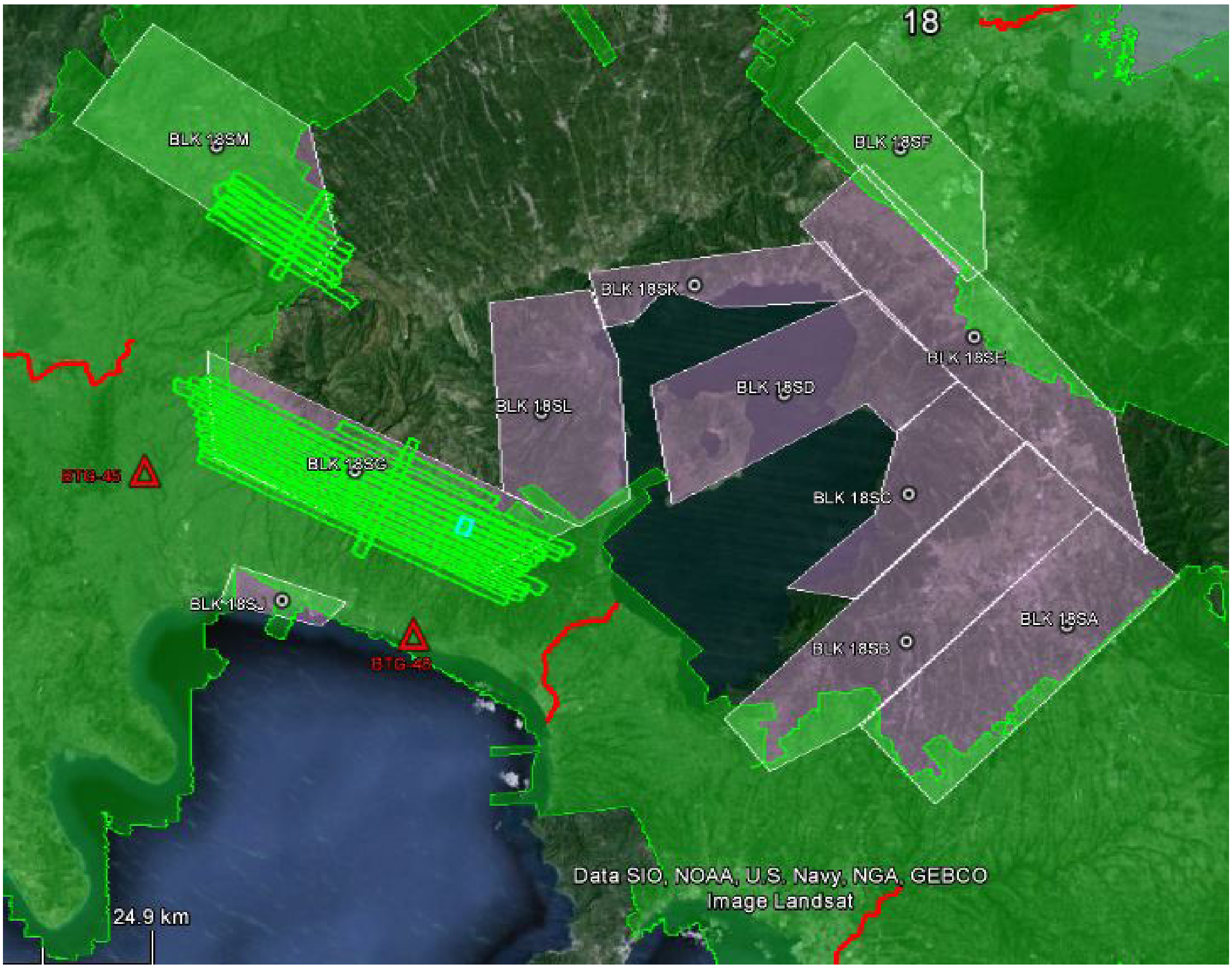


Figure A-7.8. Swath for Flight No. 3687G

Flight No. :	3691G
Area:	BLK 18SG, SF
Mission Name:	2BLK18SVV009B
Parameters:	PRF: 125 kHz, Scan Angle: 20deg, Overlap: 30%

LAS/SWATH

Figure A-7.9. Swath for Flight No. 3691G

Flight No. :	3693G		
Area:	BLK 18SC		
Mission Name:	2BLK18SCB016a		
Parameters:	PRF: 125 kHz,	Scan Angle: 20deg,	Overlap: 30%

LAS/SWATH

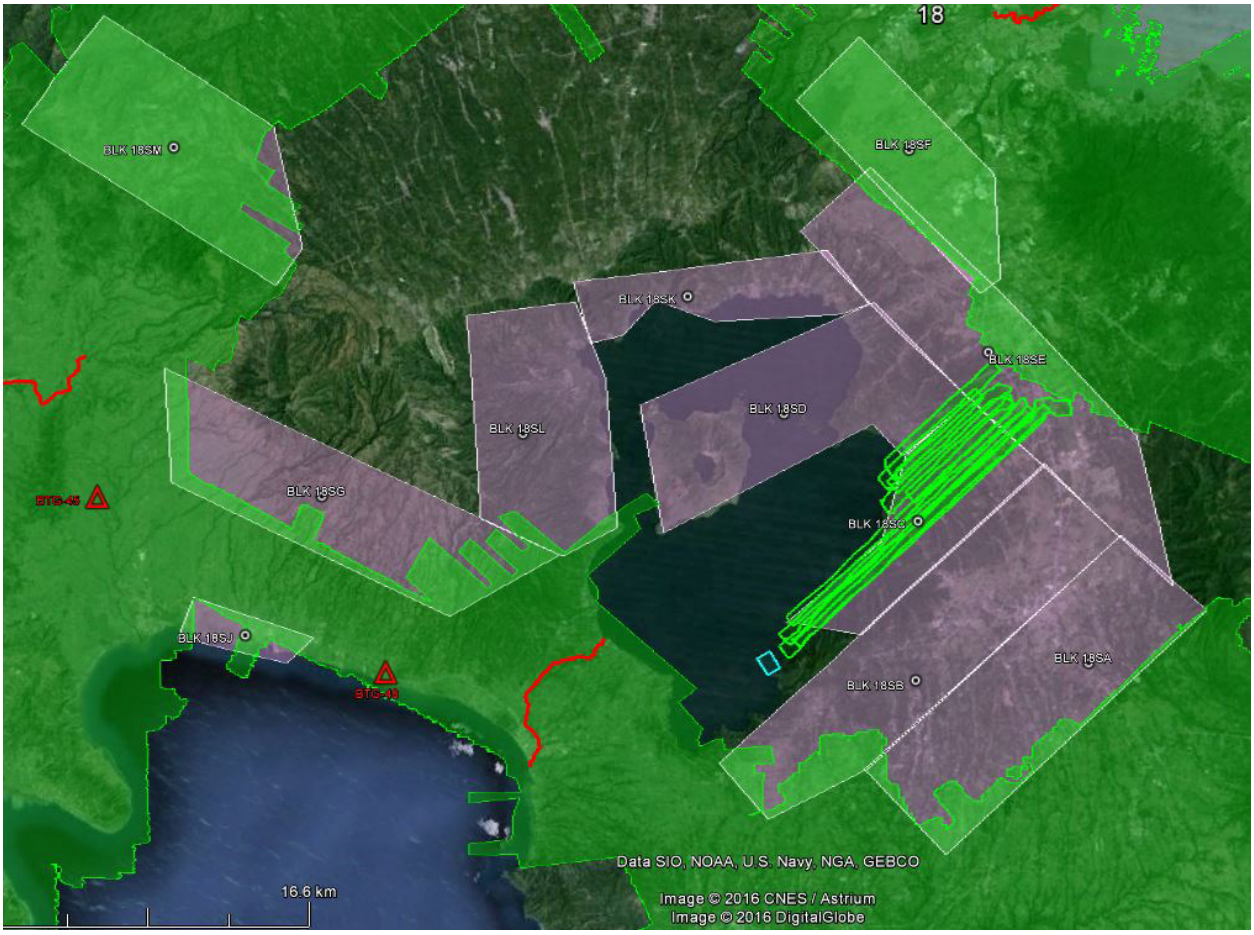


Figure A-7.10. Swath for Flight No. 3693G

ANNEX 8. Mission Summary Report

Flight Area	CALABARZON
Mission Name	**Blk18O_supplement**
Inclusive Flights	3373P
Range data size	18.2 GB
Base data size	7.67 MB
POS	212 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)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.1
RMSE for East Position (<4.0 cm)	1.8
RMSE for Down Position (<8.0 cm)	3.2
Boresight correction stdev (<0.001deg)	0.000181
IMU attitude correction stdev (<0.001deg)	0.001510
GPS position stdev (<0.01m)	0.0089
Minimum % overlap (>25)	48.55%
Ave point cloud density per sq.m. (>2.0)	3.11
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	215
Maximum Height	449.37 m
Minimum Height	45.80 m
Classification (# of points)	
Ground	102,457,419
Low vegetation	872,607,733
Medium vegetation	298,801,478
High vegetation	403,604,018
Building	35,659,618
Orthophoto	No
Processed by	Engr. AnalynNaldo, Engr. Mark Joshua Salvacion, JovyNarisma

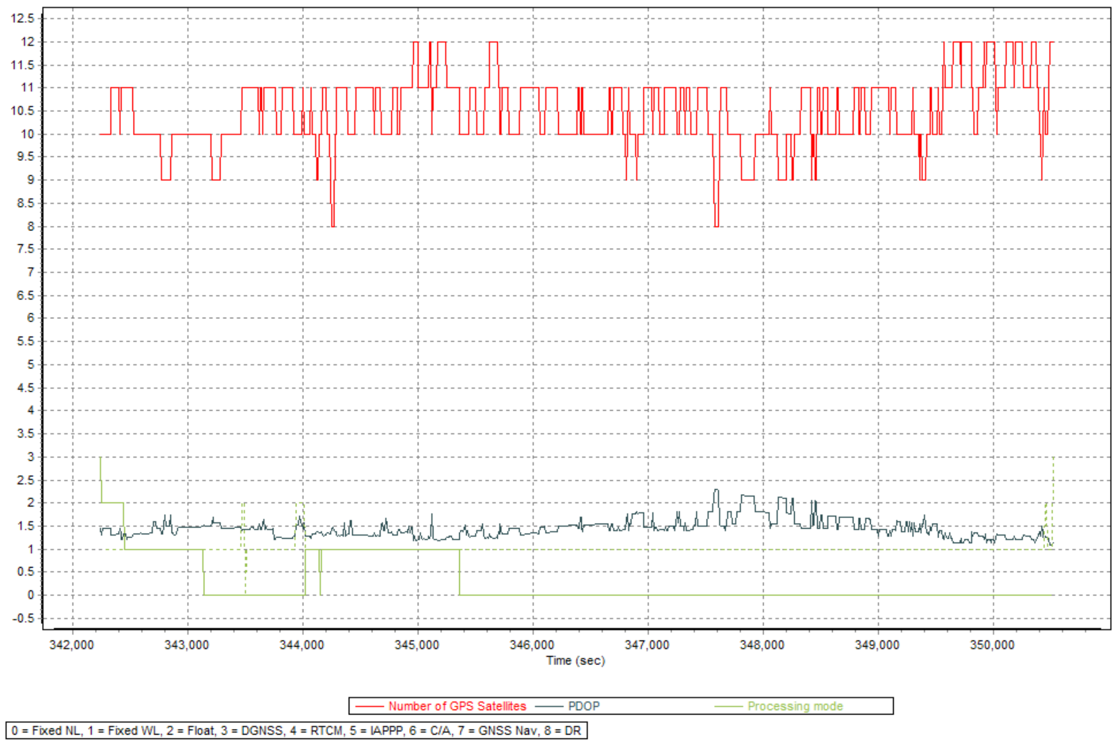


Figure 1.1.1. Solution Status

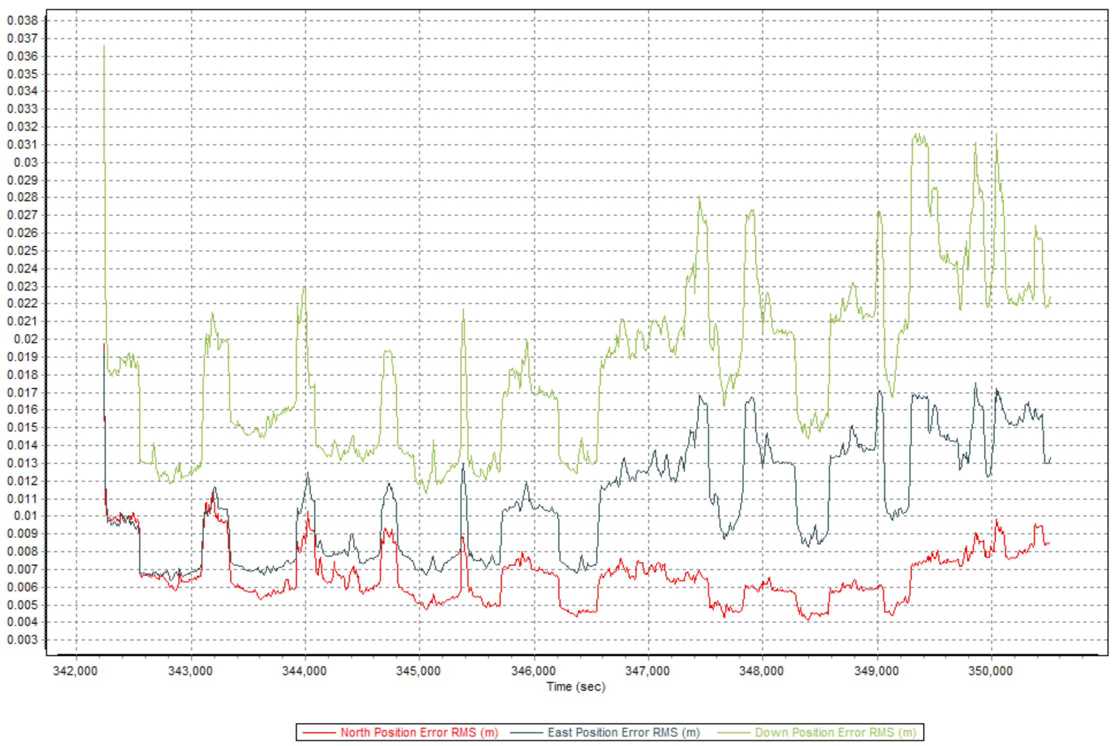


Figure 1.1.2. Smoothed Performance Metrics Parameters

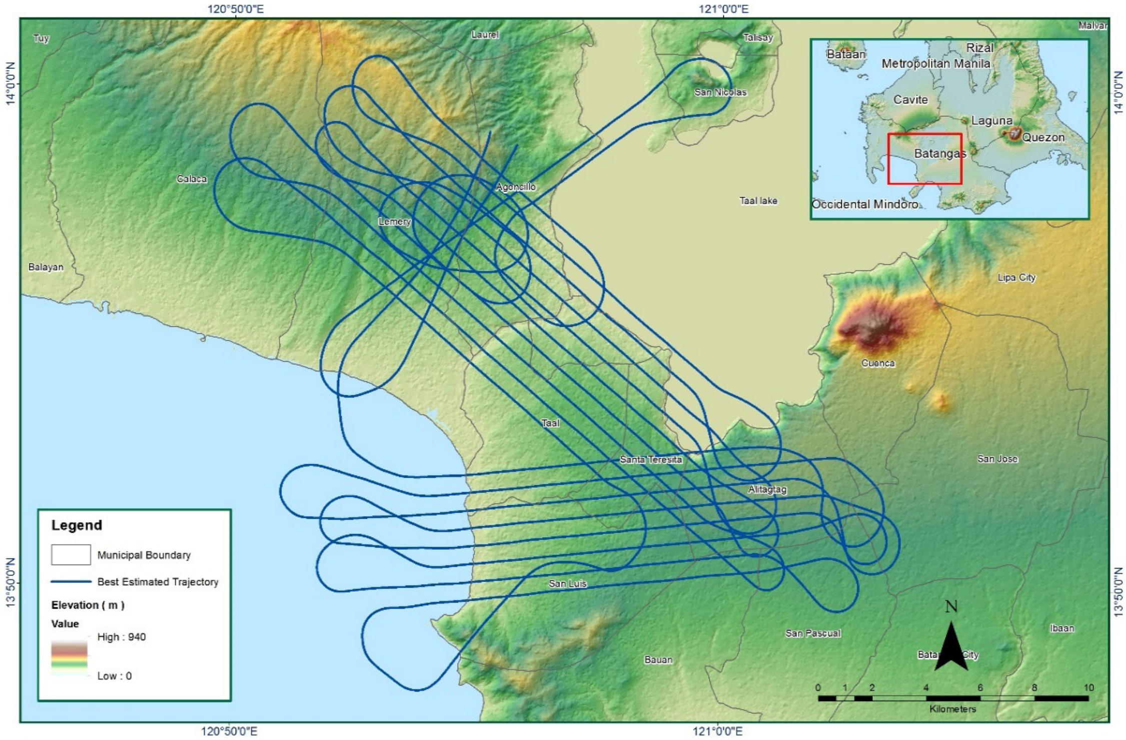


Figure 1.1.3. Best Estimated Trajectory

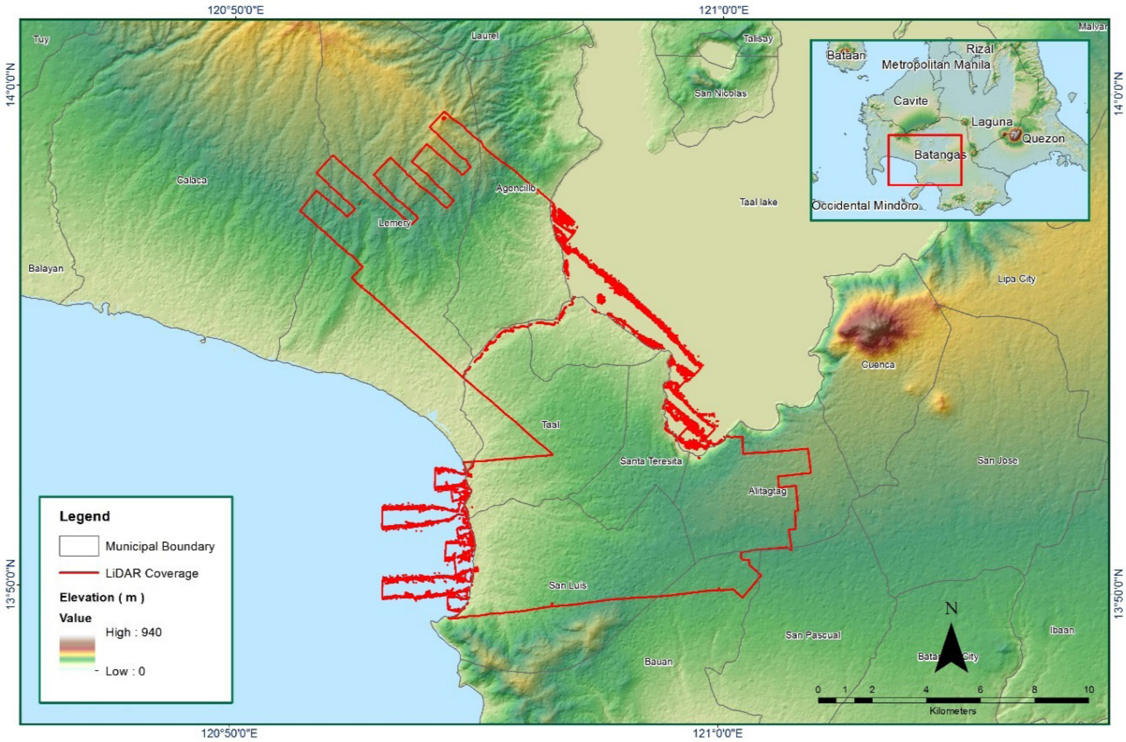


Figure 1.1.4. Coverage of LiDAR data

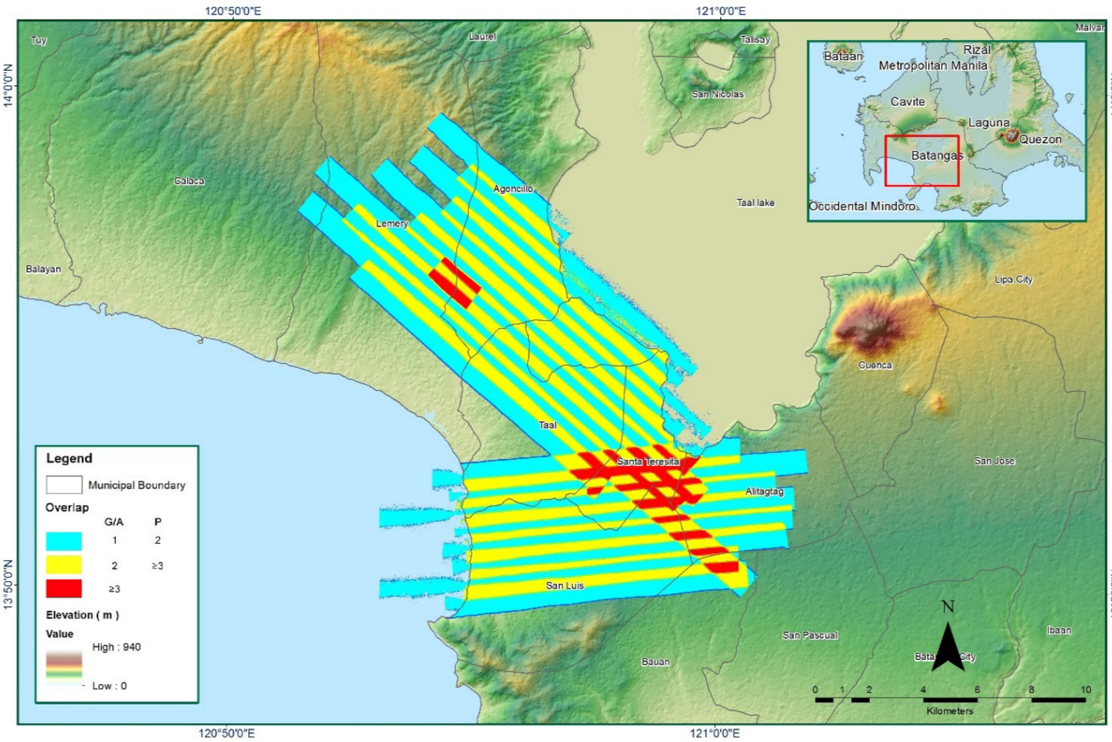


Figure 1.1.5. Image of data overlap

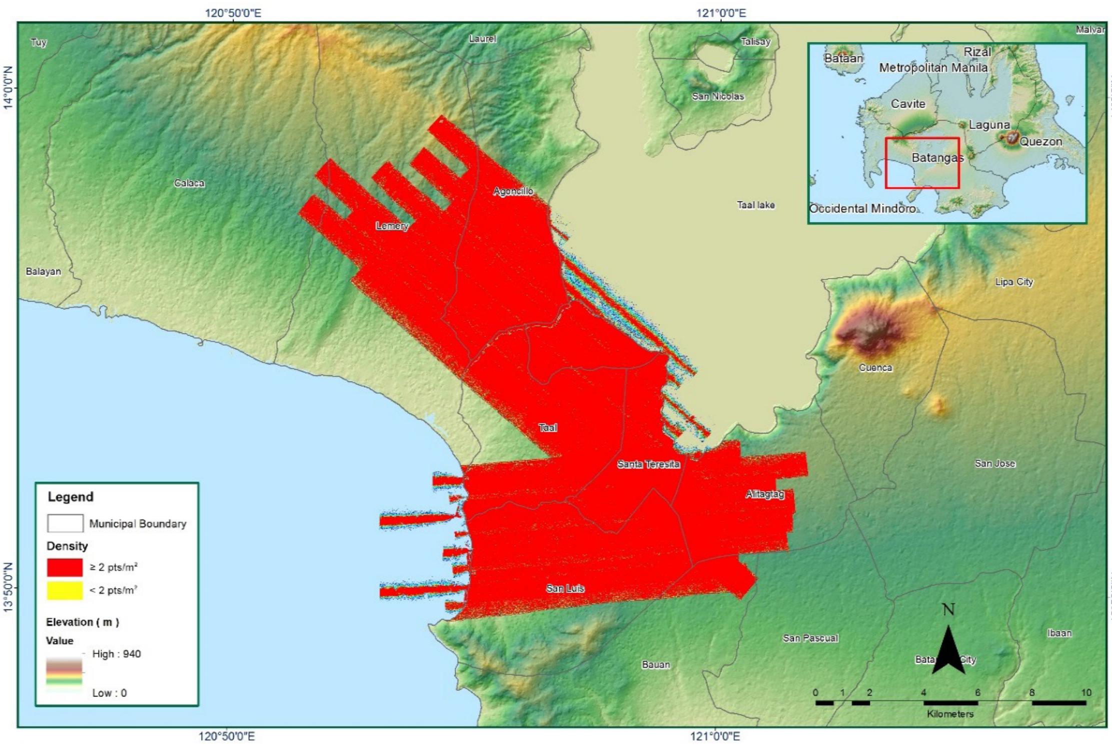


Figure 1.1.6. Density map of merged LiDAR data

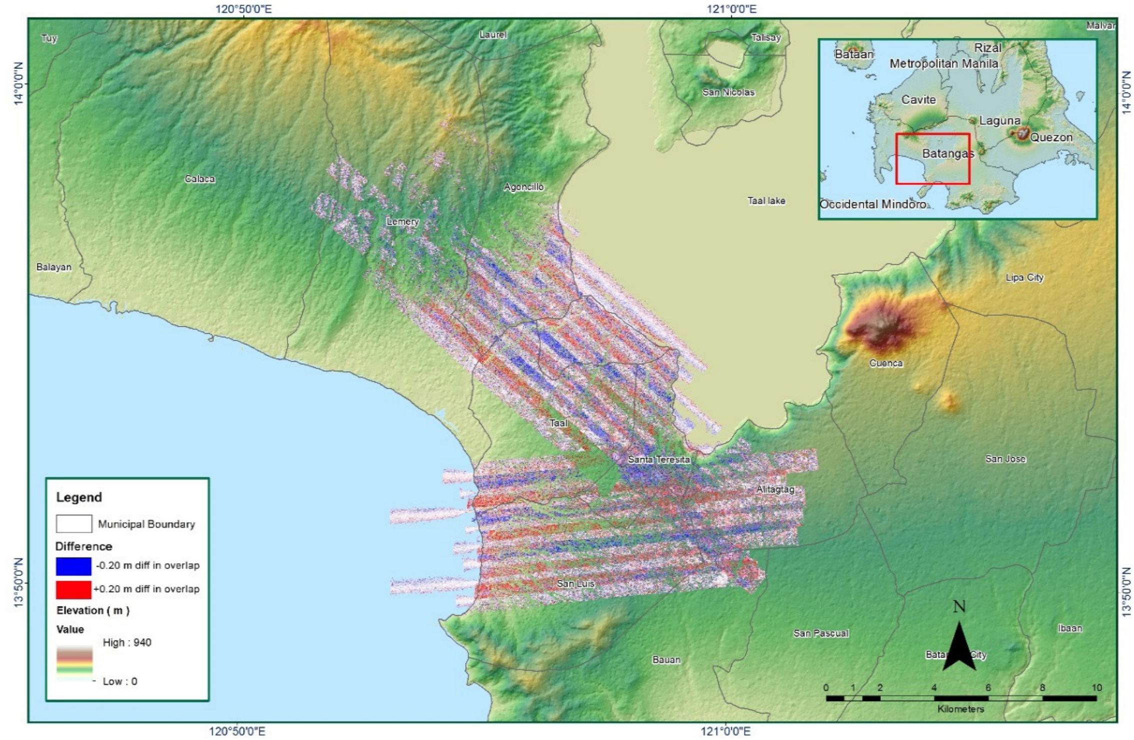


Figure 1.1.7. Elevation difference between flight lines

Flight Area	Batangas
Mission Name	**Blk18_SL**
Inclusive Flights	3673G
Range data size	16.6 GB
Base data size	11.4 MB
POS	195 MB
Image	NA
Transfer date	January 6, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.324
RMSE for East Position (<4.0 cm)	1.672
RMSE for Down Position (<8.0 cm)	4.09
Boresight correction stdev (<0.001deg)	0.000293
IMU attitude correction stdev (<0.001deg)	0.001442
GPS position stdev (<0.01m)	0.0090
Minimum % overlap (>25)	48.66 %
Ave point cloud density per sq.m. (>2.0)	4.07
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	139
Maximum Height	737.42 m
Minimum Height	48.60 m
Classification (# of points)	
Ground	38,856,112
Low vegetation	13,390,708
Medium vegetation	66,638,185
High vegetation	176,991,914
Building	2,449,810
Orthophoto	No
Processed by	Engr. Kenneth Solidum, Engr. Edgardo Gubatanga, Jr., Kathryn Claudine Zarate

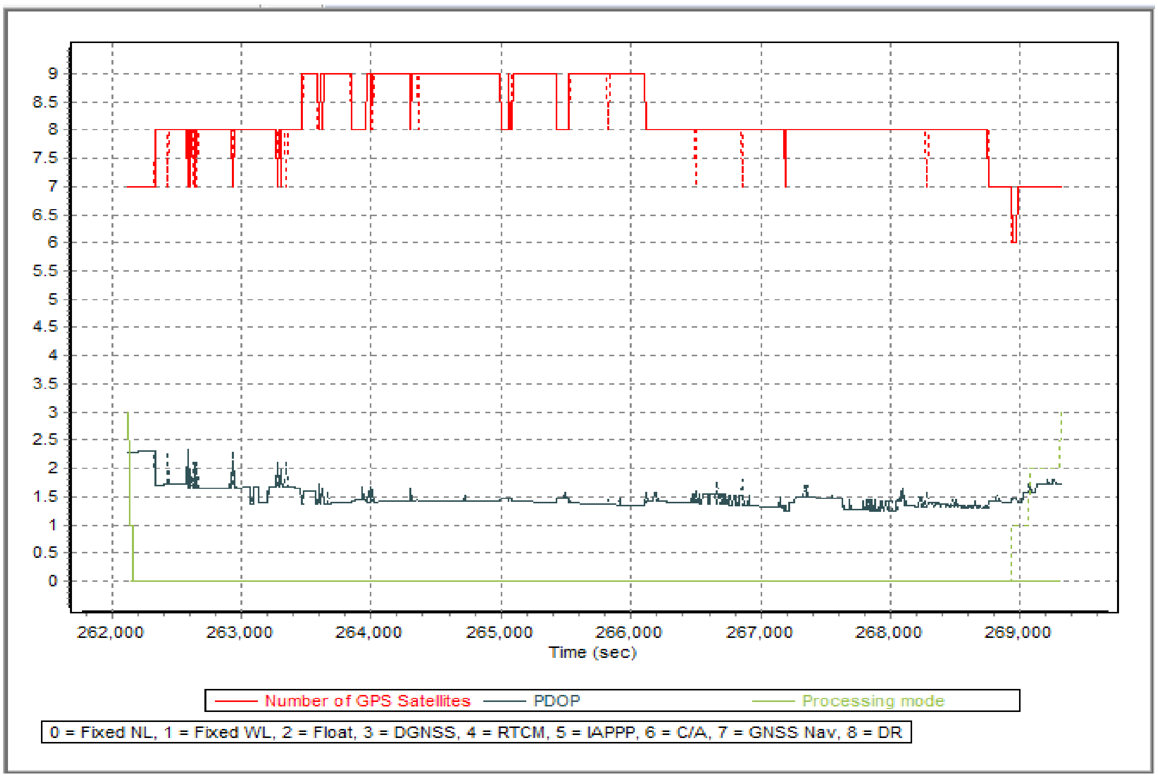


Figure 1.2.1. Solution Status

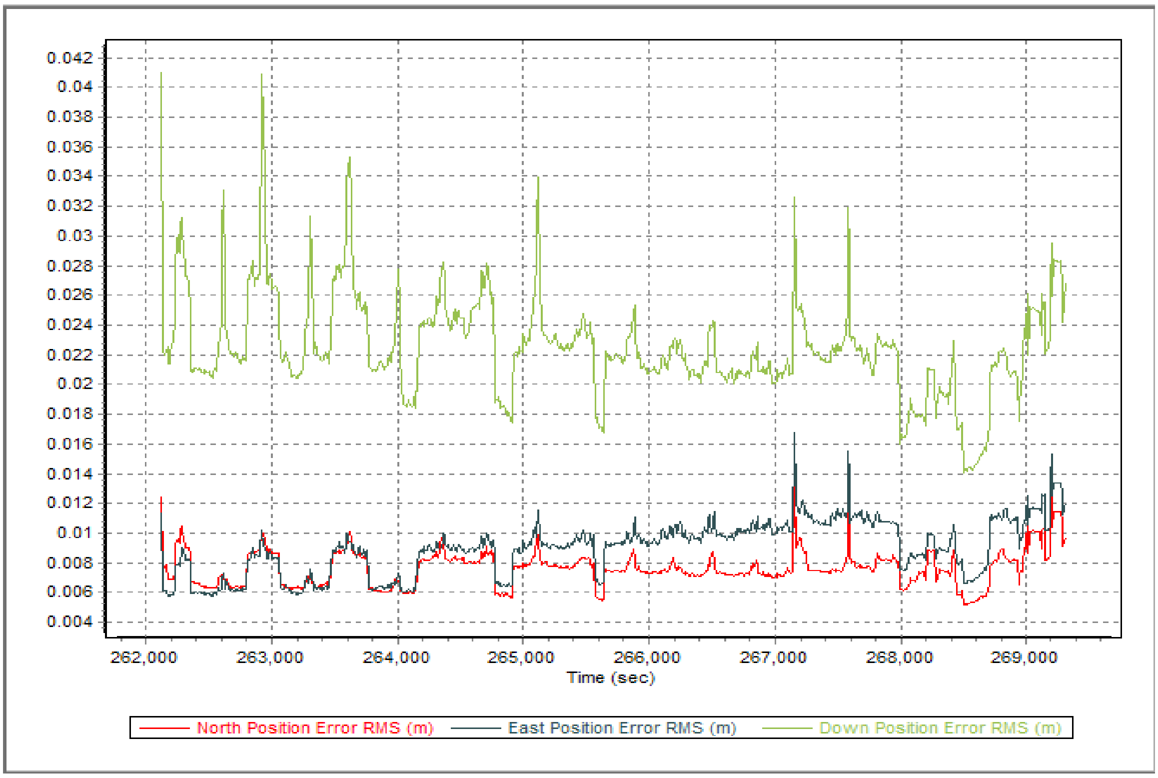


Figure 1.2.2. Smoothed Performance Metric Parameters

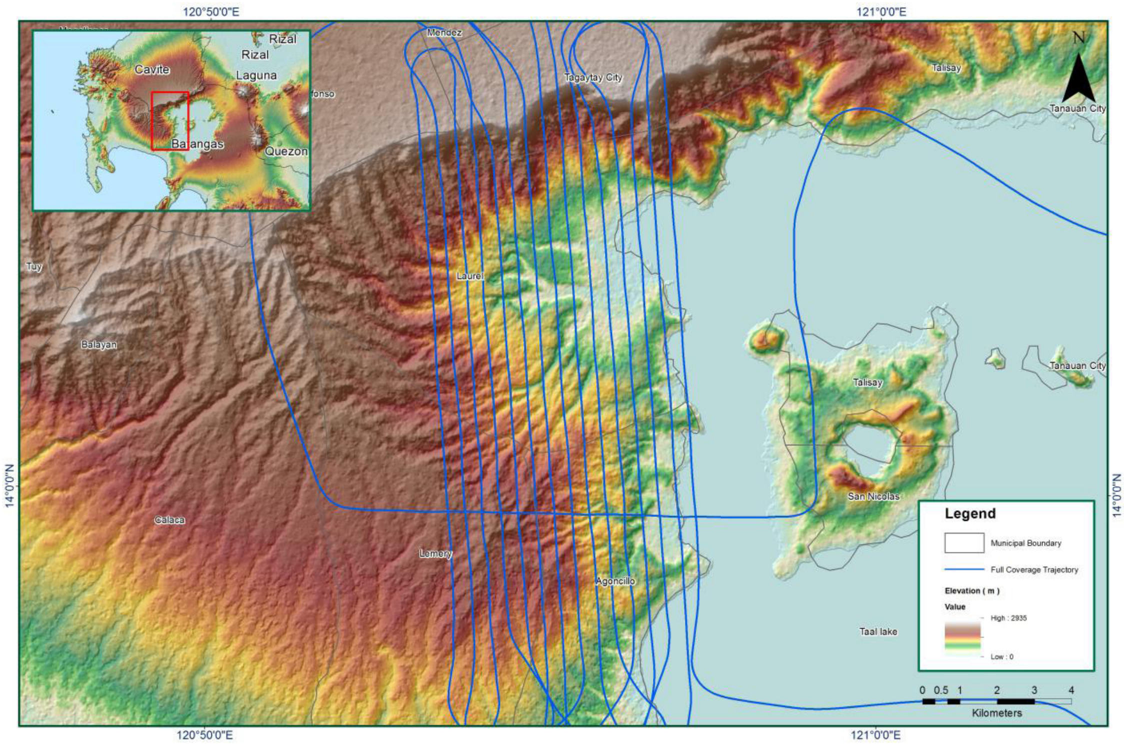


Figure 1.2.3. Best Estimate Trajectory

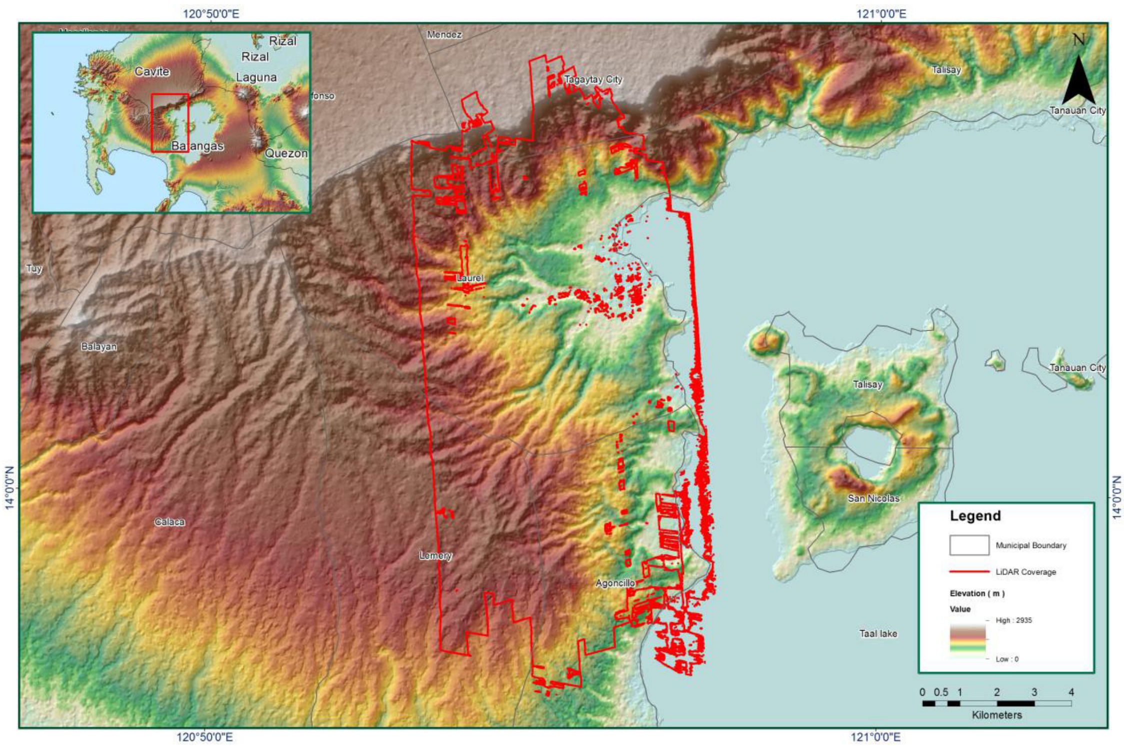


Figure 1.2.4. Coverage of LiDAR data

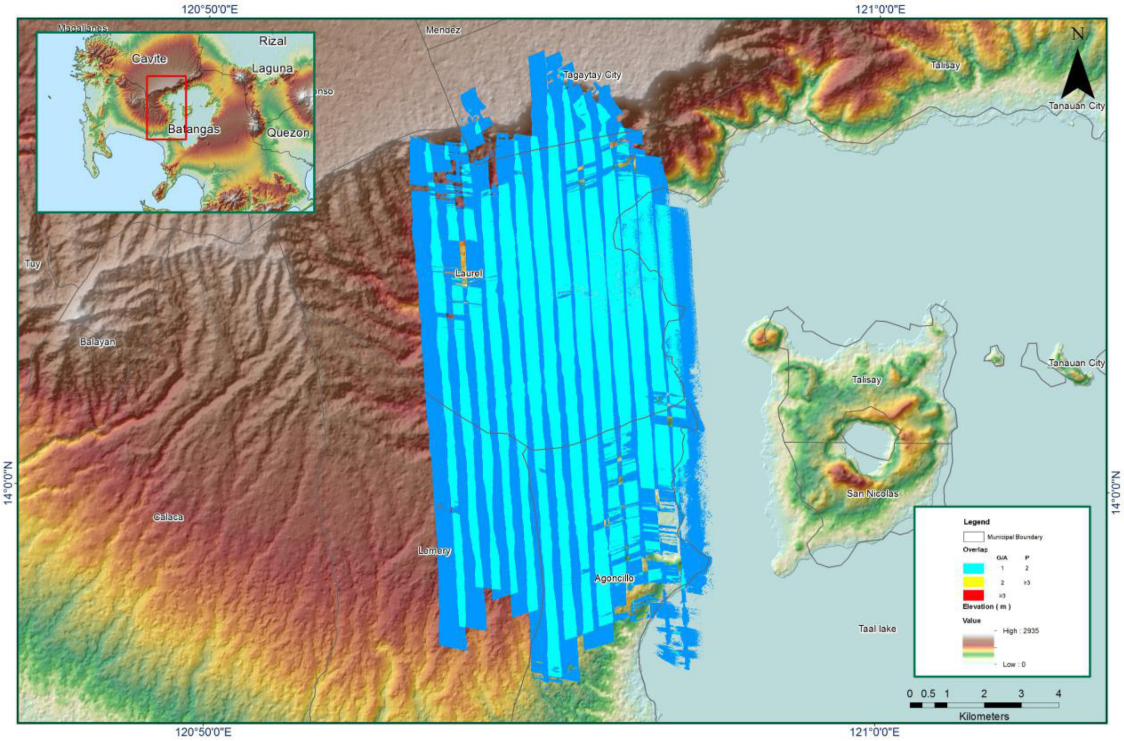


Figure 1.2.5. Image of data overlap

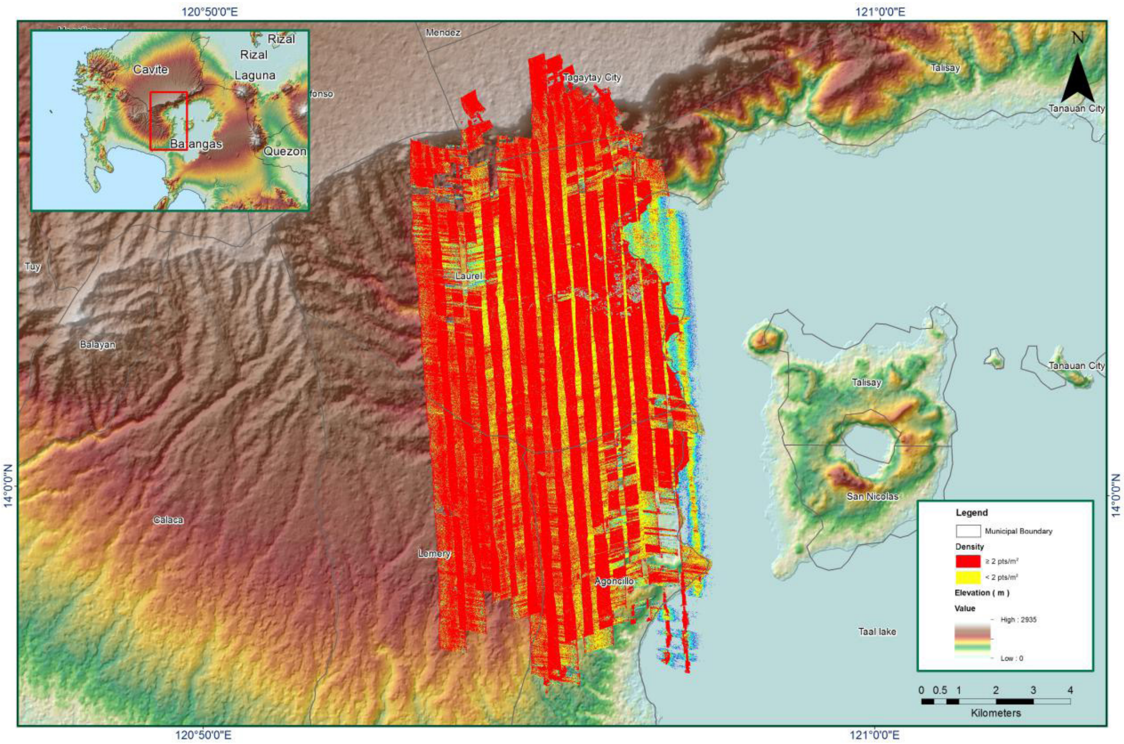


Figure 1.2.6. Density Map of merged LiDAR data

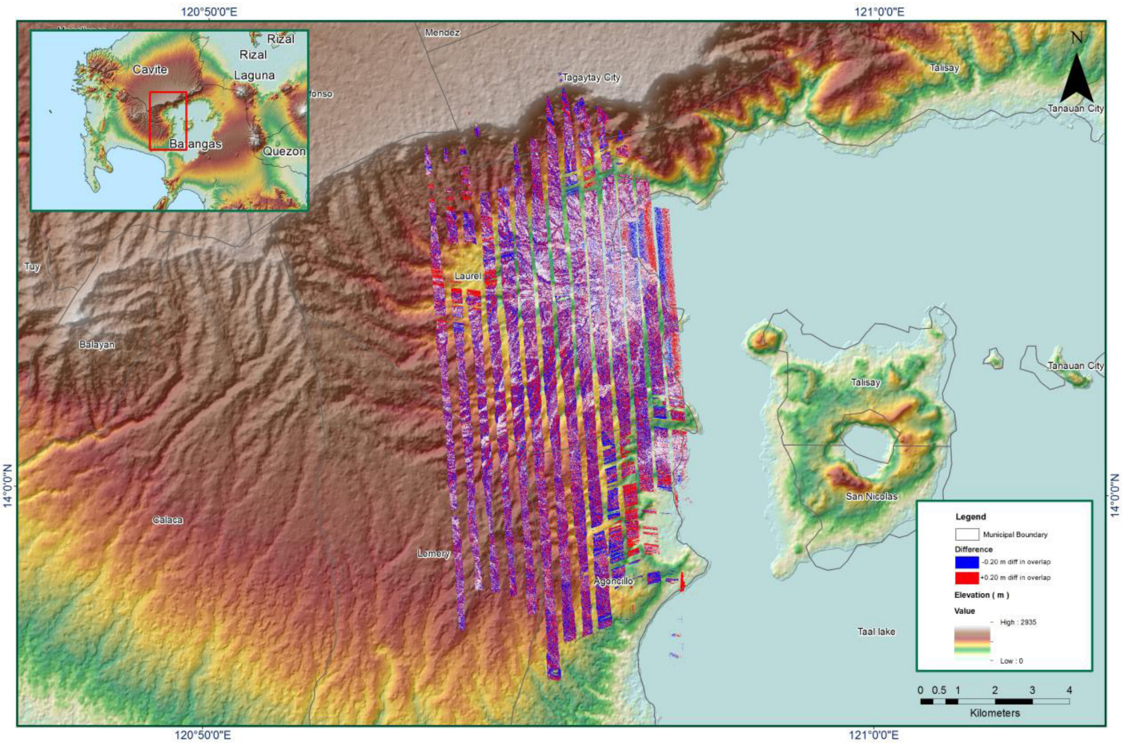


Figure 1.2.7. Elevation Difference Between flight lines

Flight Area	**Batangas**
Mission Name	**Blk18_SL_additional**
Inclusive Flights	3691G
Range data size	6.93 GB
Base data size	12.9 MB
POS	124 MB
Image	NA
Transfer date	January 15, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.138
RMSE for East Position (<4.0 cm)	1.344
RMSE for Down Position (<8.0 cm)	2.192
Boresight correction stdev (<0.001deg)	0.004743
IMU attitude correction stdev (<0.001deg)	0.006674
GPS position stdev (<0.01m)	0.0032
Minimum % overlap (>25)	46.12%
Ave point cloud density per sq.m. (>2.0)	4.36
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	28
Maximum Height	253.64 m
Minimum Height	49.27 m
Classification (# of points)	
Ground	4,592,195
Low vegetation	1,798,070
Medium vegetation	11,111,123
High vegetation	27,351,777
Building	324,192
Orthophoto	No
Processed by	Engr. Sheila-Maye Santillan, Engr. Edgardo Gubatanga, Jr., Engr. Krisha Marie Bautista

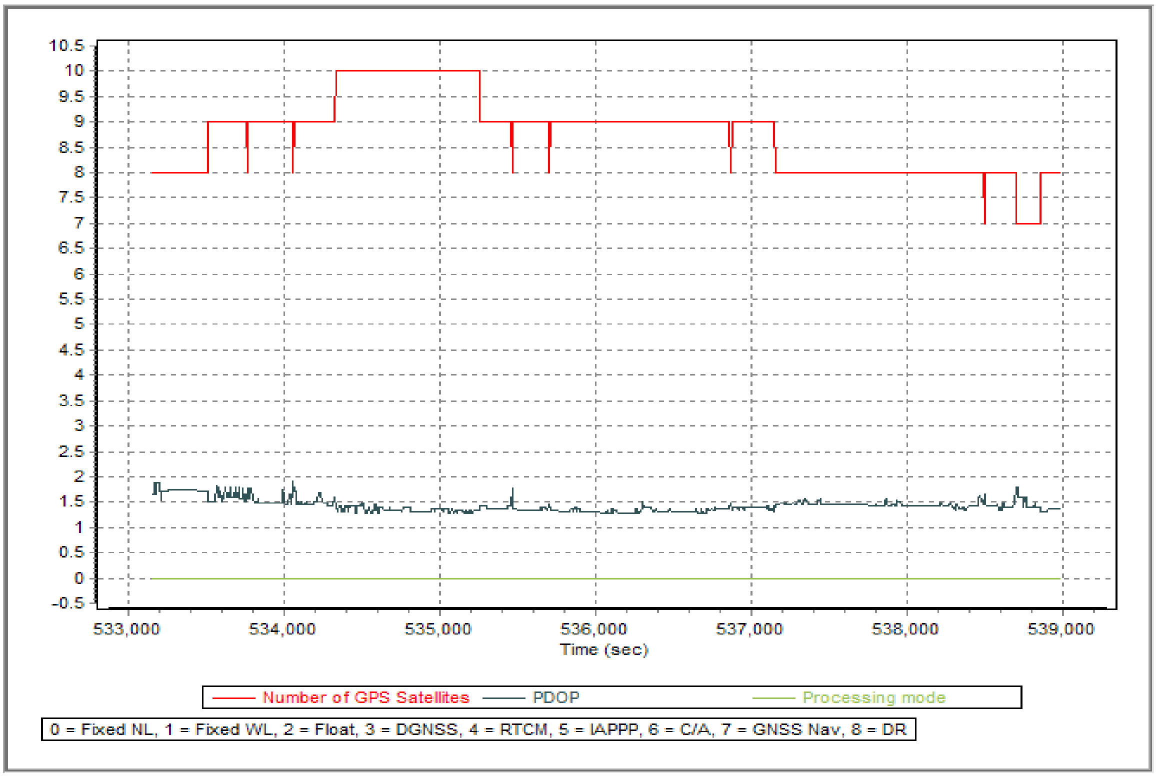


Figure 1.3.1. Smoothed Solution Status

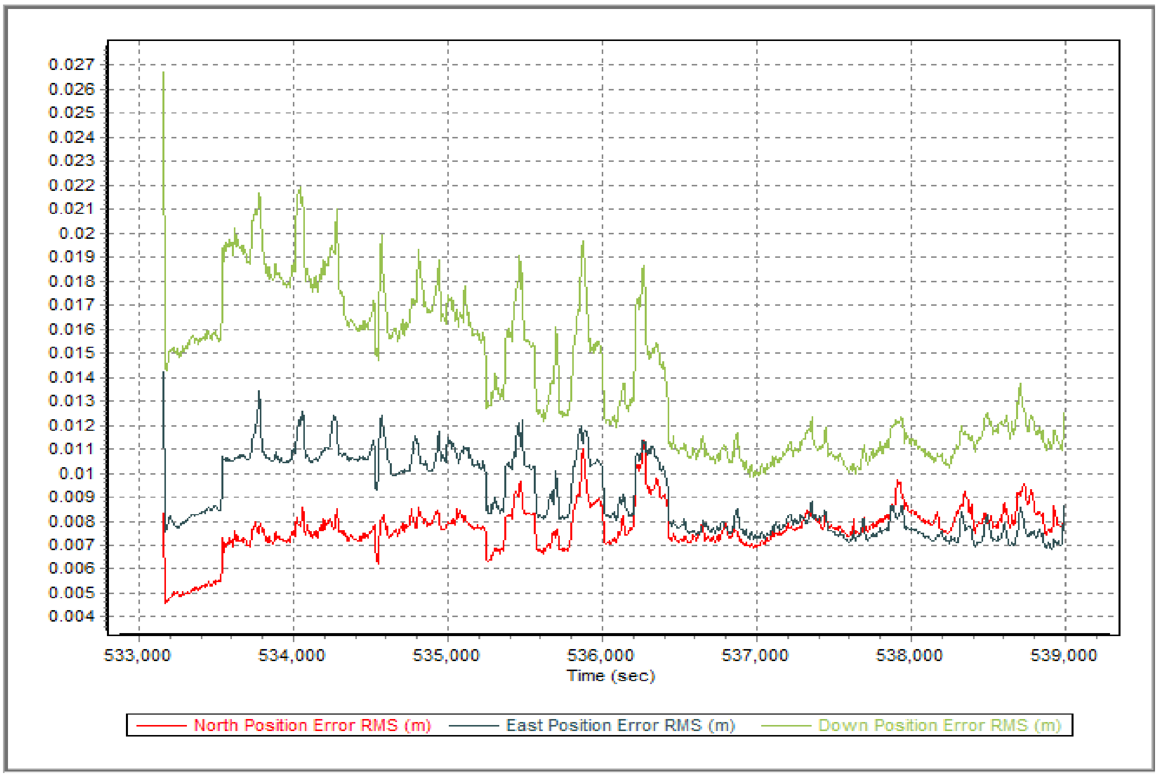


Figure 1.3.2. Smoothed Performance Metric Parameters

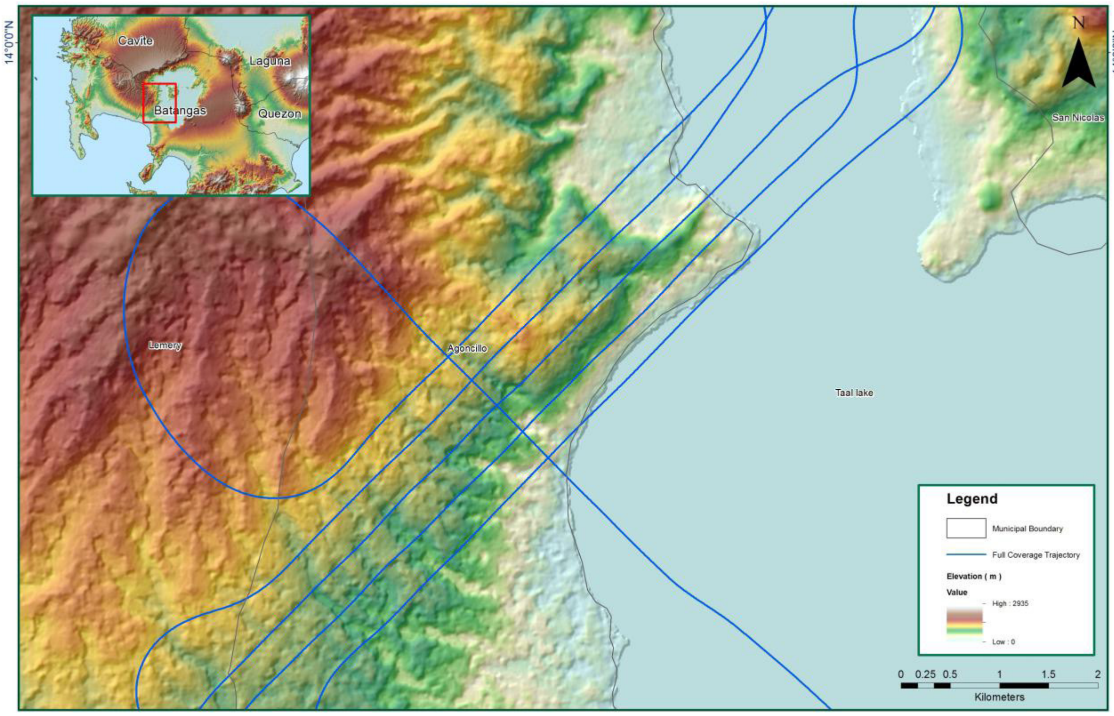


Figure 1.3.3. Best Estimate Trajectory

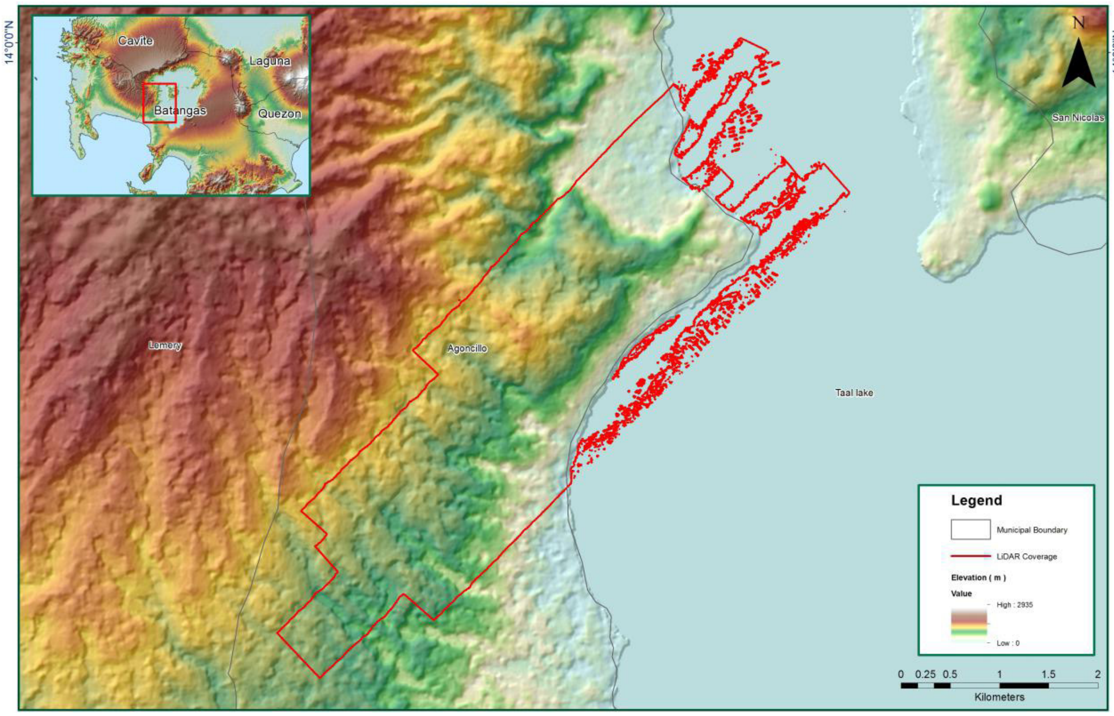


Figure 1.3.4. Coverage of LiDAR data

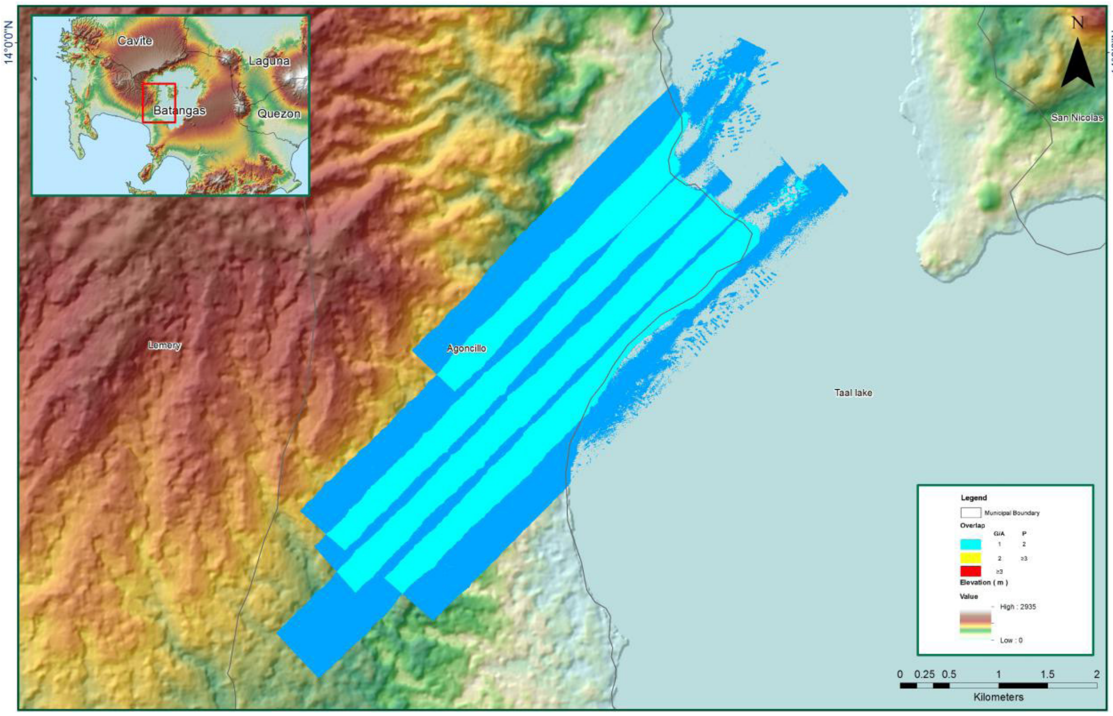


Figure 1.3.5. Image of data overlap

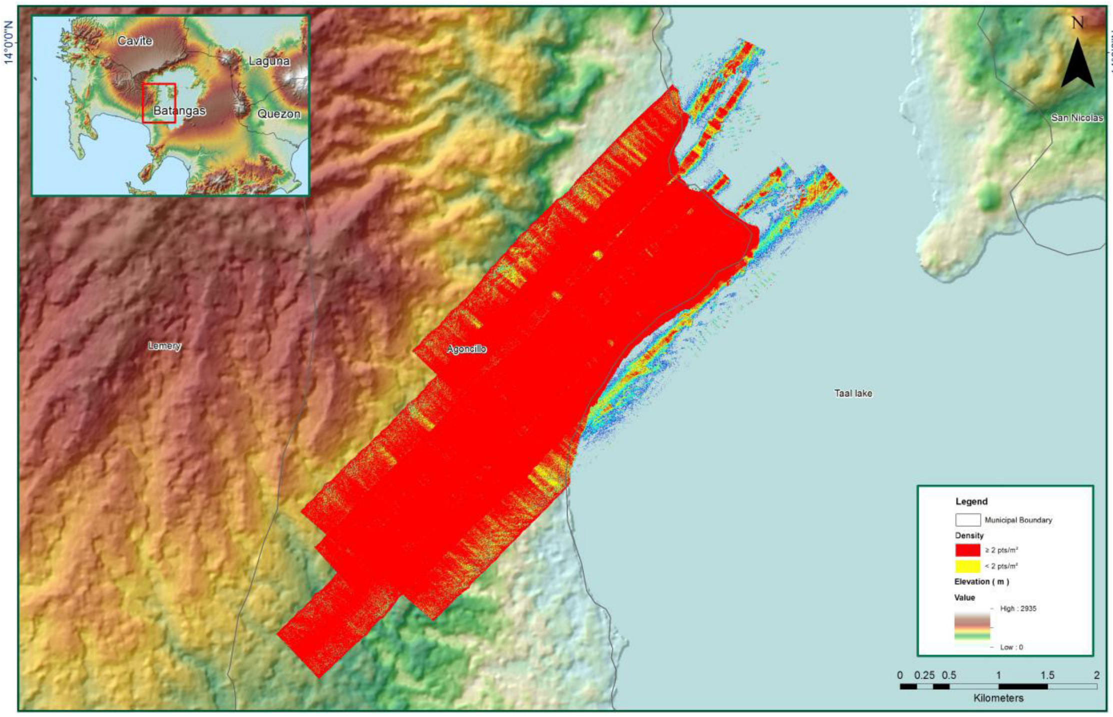


Figure 1.3.6. Density Map of merged LiDAR data

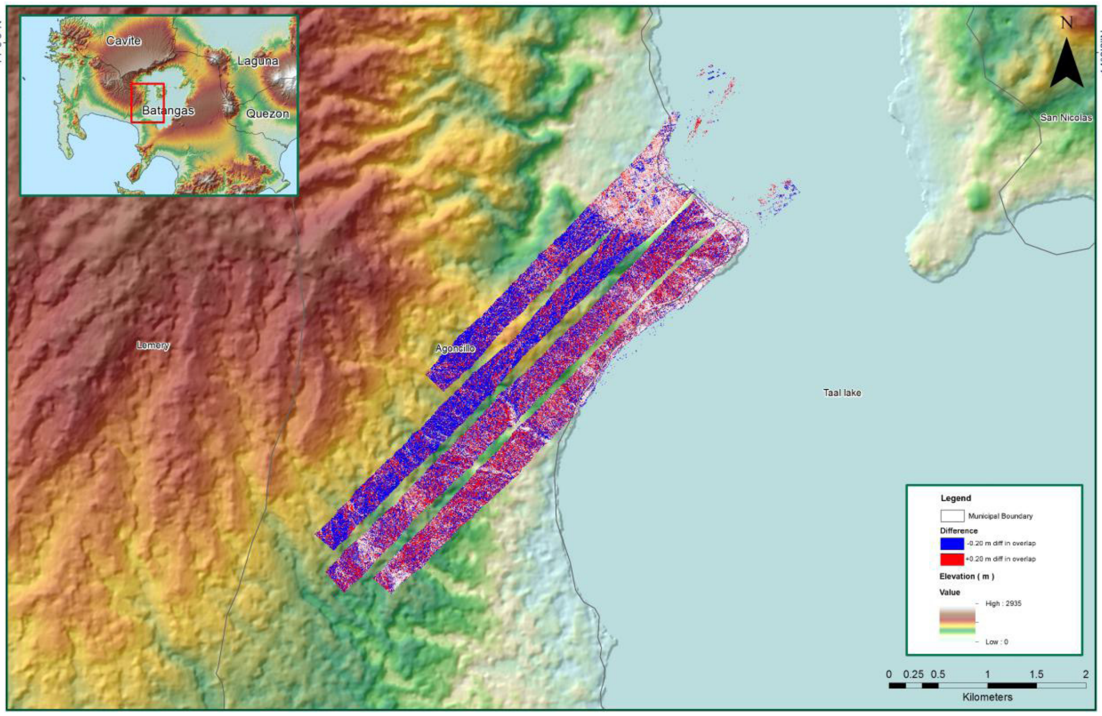


Figure 1.3.7. Elevation Difference Between flight lines

Flight Area	Batangas
Mission Name	**Blk18_SGa**
Inclusive Flights	3687G
Range data size	17.2 GB
Base data size	20.9 MB
POS	172 MB
Image	NA
Transfer date	January 15, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.271
RMSE for East Position (<4.0 cm)	1.572
RMSE for Down Position (<8.0 cm)	3.414
Boresight correction stdev (<0.001deg)	0.000888
IMU attitude correction stdev (<0.001deg)	0.002194
GPS position stdev (<0.01m)	0.0097
Minimum % overlap (>25)	35.38%
Ave point cloud density per sq.m. (>2.0)	3.8
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	141
Maximum Height	417.30 m
Minimum Height	81.82 m
Classification (# of points)	
Ground	25,787,288
Low vegetation	60,651,992
Medium vegetation	355,371,443
High vegetation	273,161,795
Building	32,404,871
Orthophoto	No
Processed by	Engr. Regis Guhiting, Engr. Edgardo Gubatanga, Jr., JovyNarisma

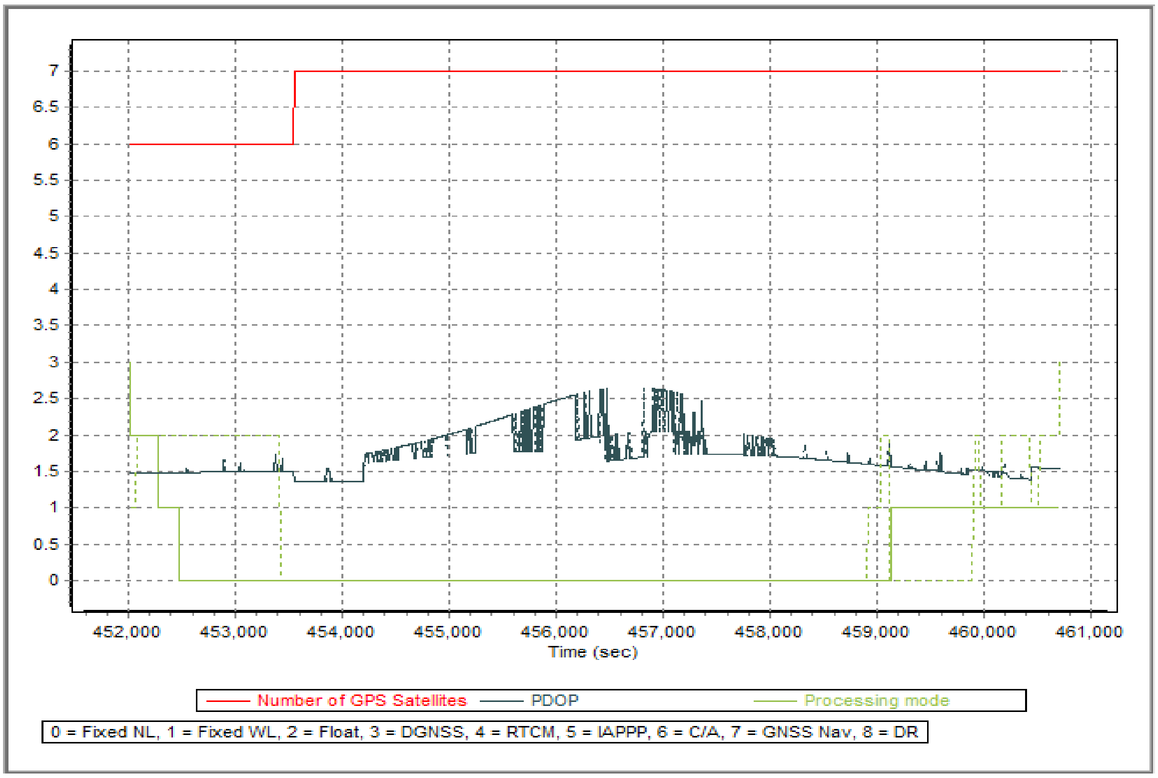


Figure 1.4.1. Solution Status

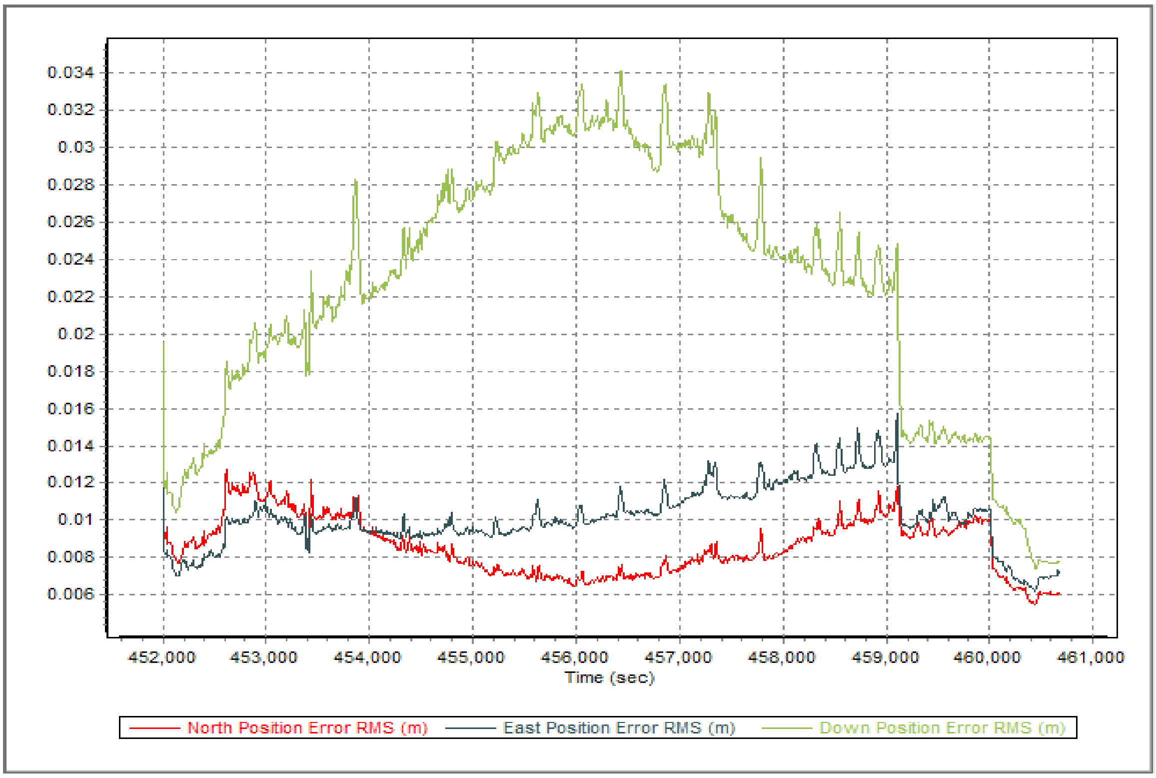


Figure 1.4.2. Smoothed Performance Metric Parameters

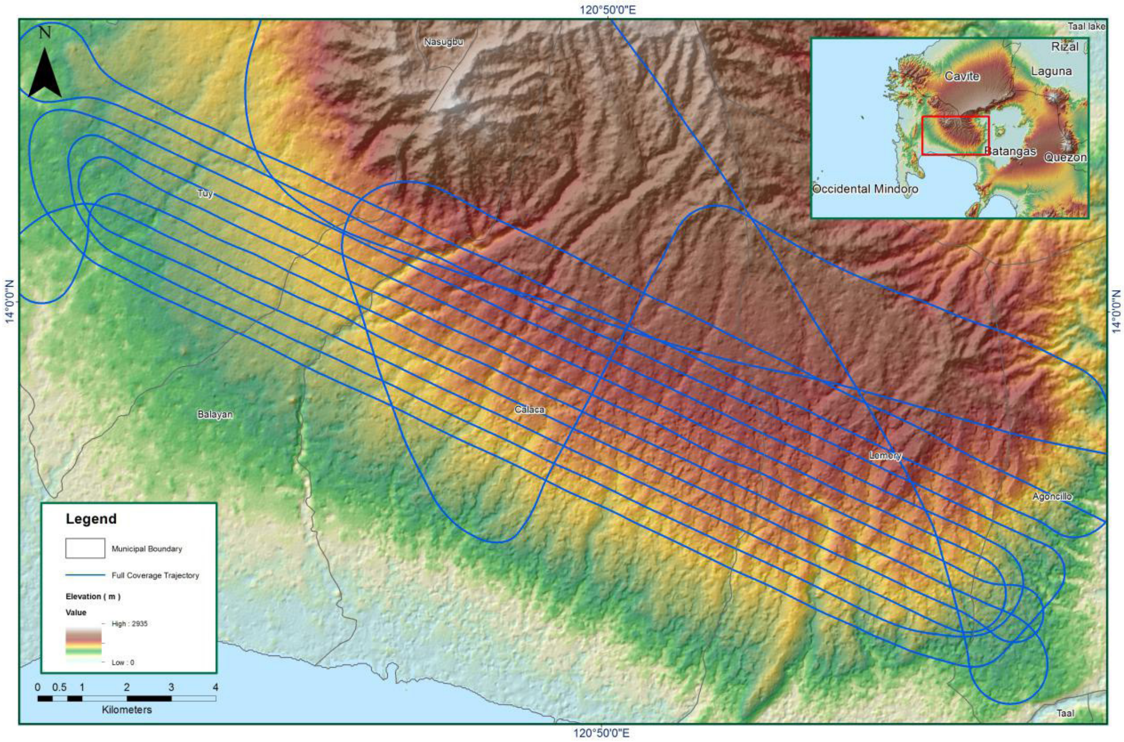


Figure 1.4.3. Best Estimate Trajectory

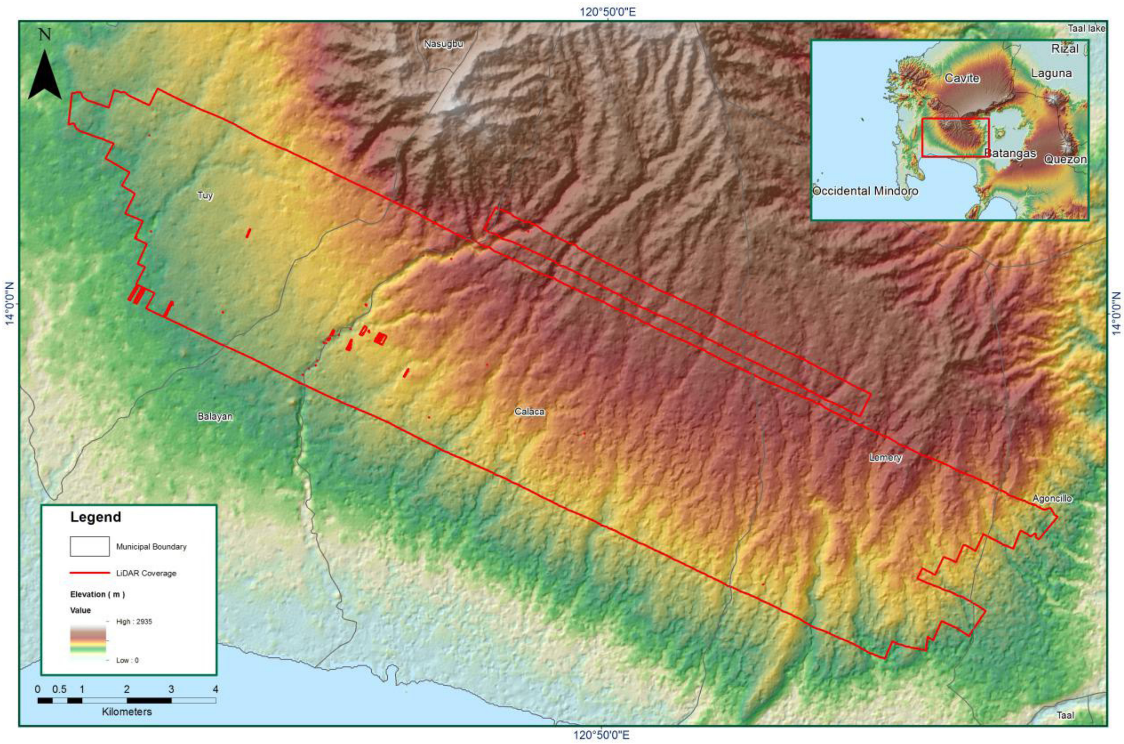


Figure 1.4.4. Coverage of LiDAR data

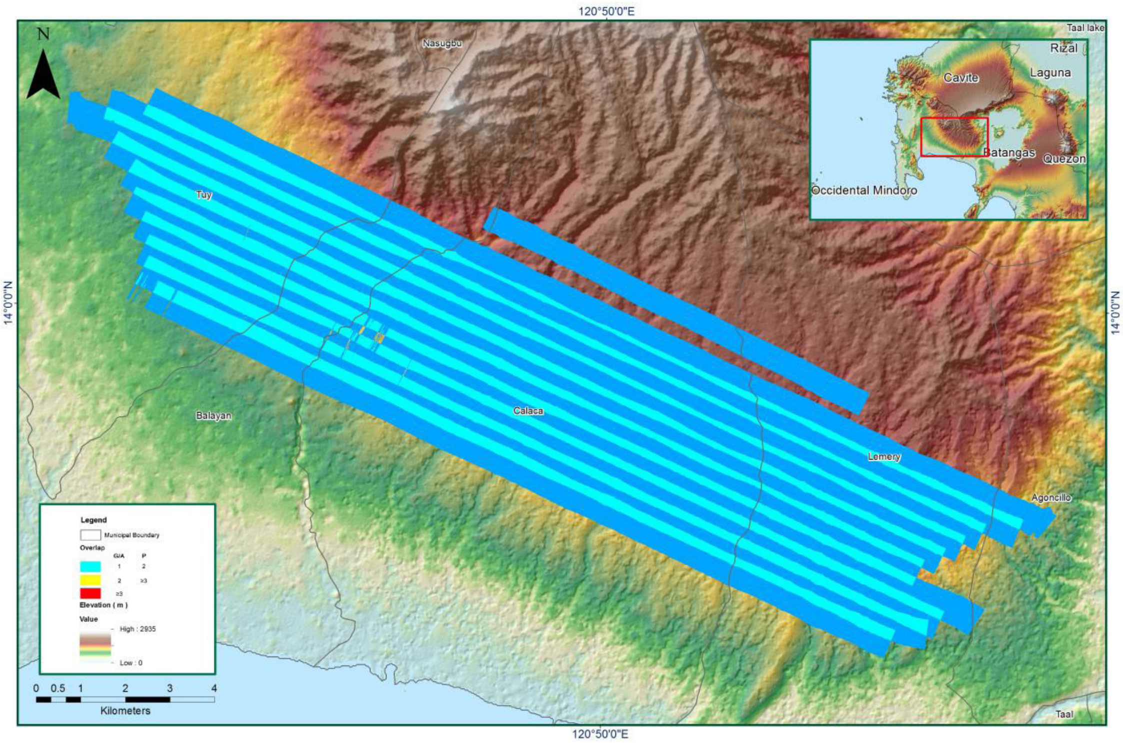


Figure 1.4.5. Image of data overlap

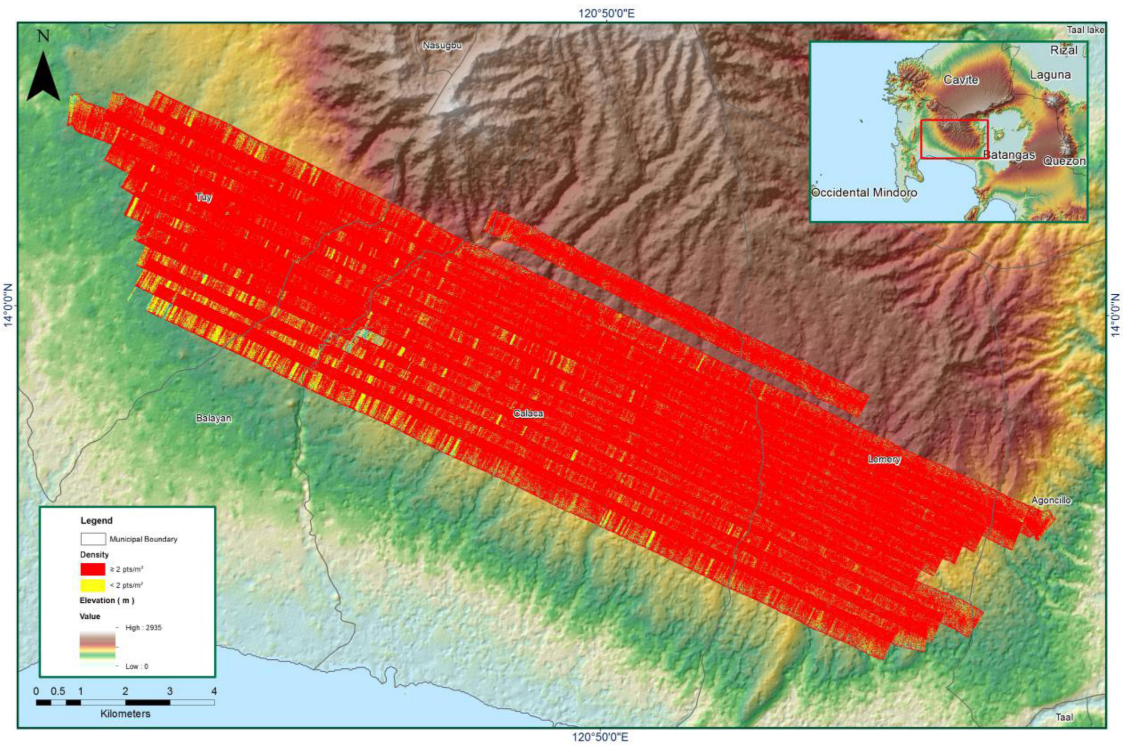


Figure 1.4.6. Density Map of merged LiDAR data

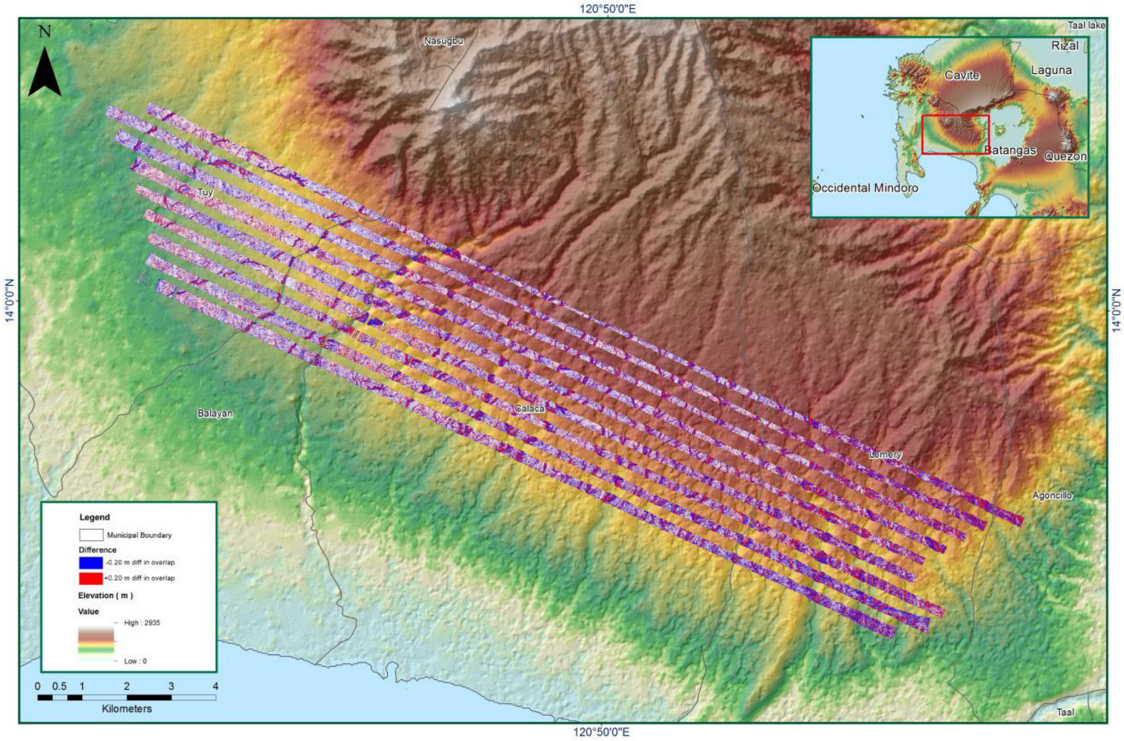


Figure 1.4.7. Elevation Difference Between flight lines

Flight Area	Batangas
Mission Name	**Blk18_SGb**
Inclusive Flights	3685G
Range data size	24.4 GB
Base data size	20.9 MB
POS	185 MB
Image	NA
Transfer date	January 15, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	0.9832
RMSE for East Position (<4.0 cm)	0.7895
RMSE for Down Position (<8.0 cm)	1.421
Boresight correction stdev (<0.001deg)	NA
IMU attitude correction stdev (<0.001deg)	NA
GPS position stdev (<0.01m)	NA
Minimum % overlap (>25)	13.26
Ave point cloud density per sq.m. (>2.0)	3.69
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	135
Maximum Height	500.91 m
Minimum Height	65.60 m
Classification (# of points)	
Ground	33,097,103
Low vegetation	25,611,785
Medium vegetation	157,156,268
High vegetation	126,487,134
Building	327,955
Orthophoto	No
Processed by	Engr. Kenneth Solidum, Engr. Merven Matthew Natino, Engr. Krisha Marie Bautista

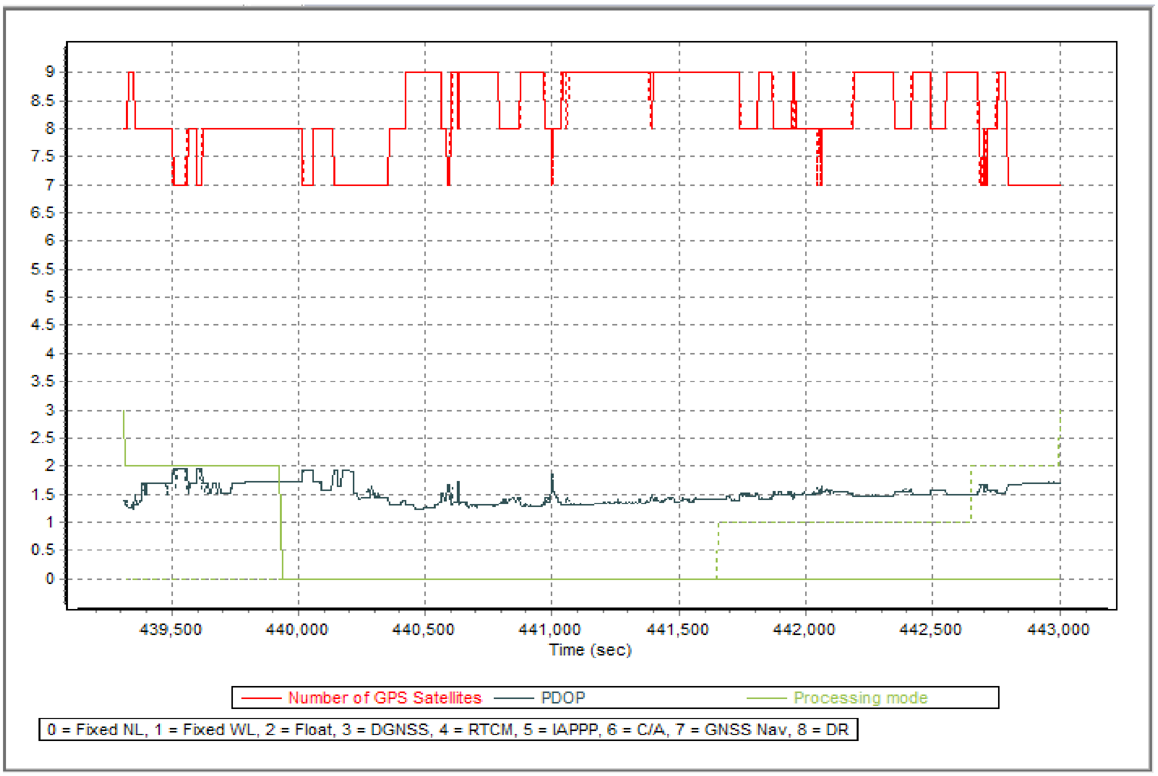


Figure 1.5.1. Solution Status

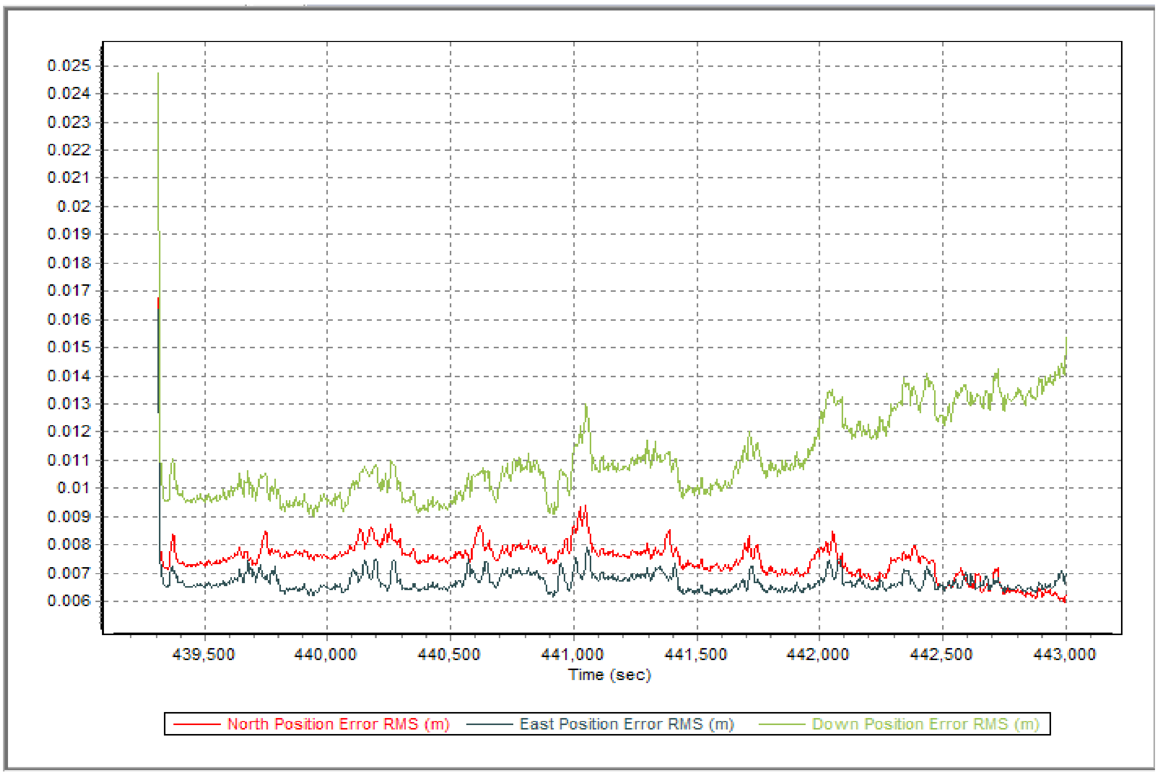


Figure 1.5.2. Smoothed Performance Metric Parameters

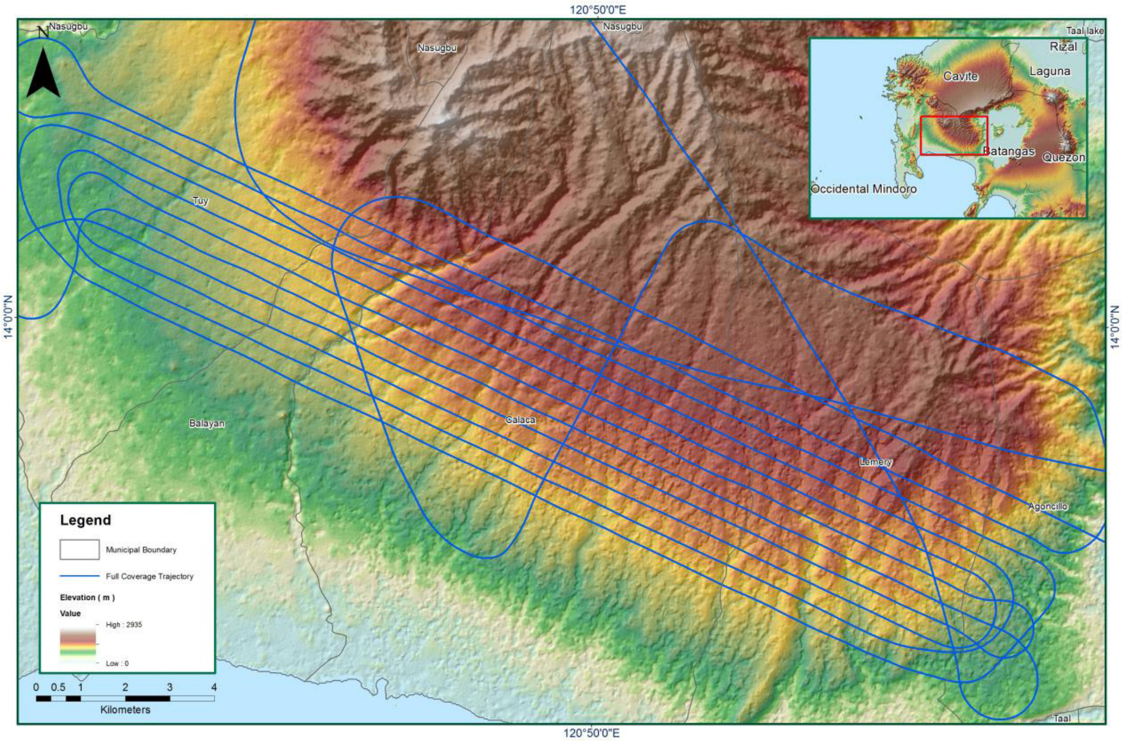


Figure 1.5.3. Best Estimate Trajectory

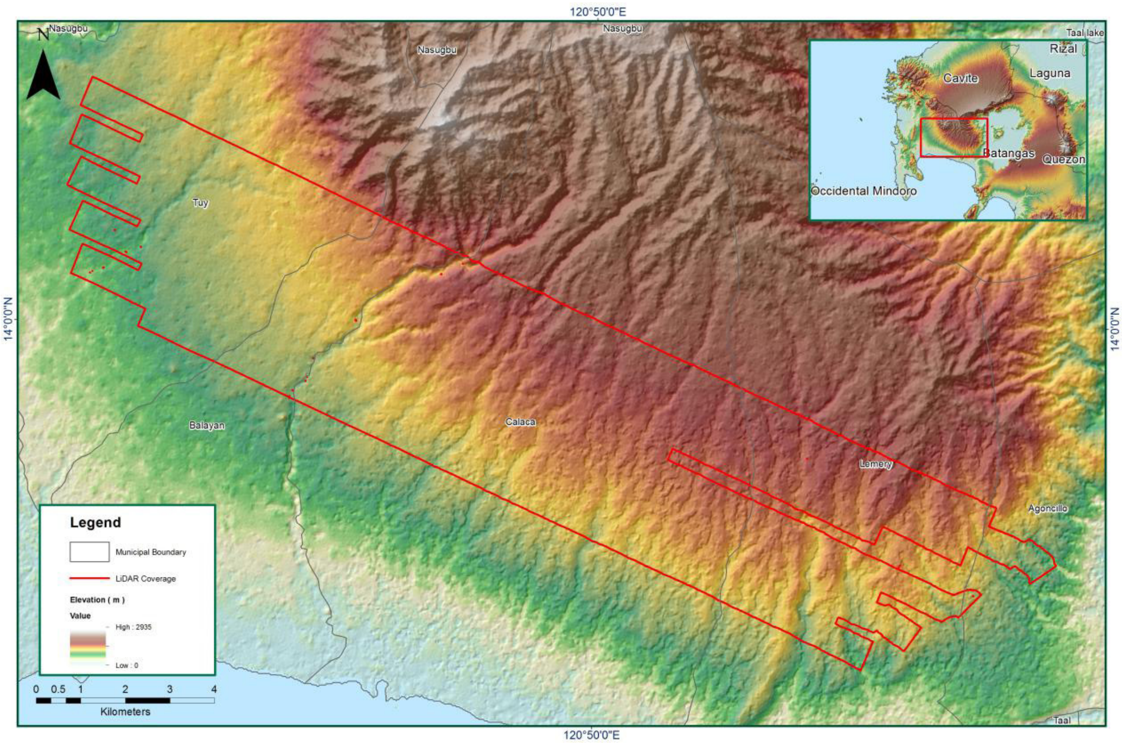


Figure 1.5.4. Coverage of LiDAR data

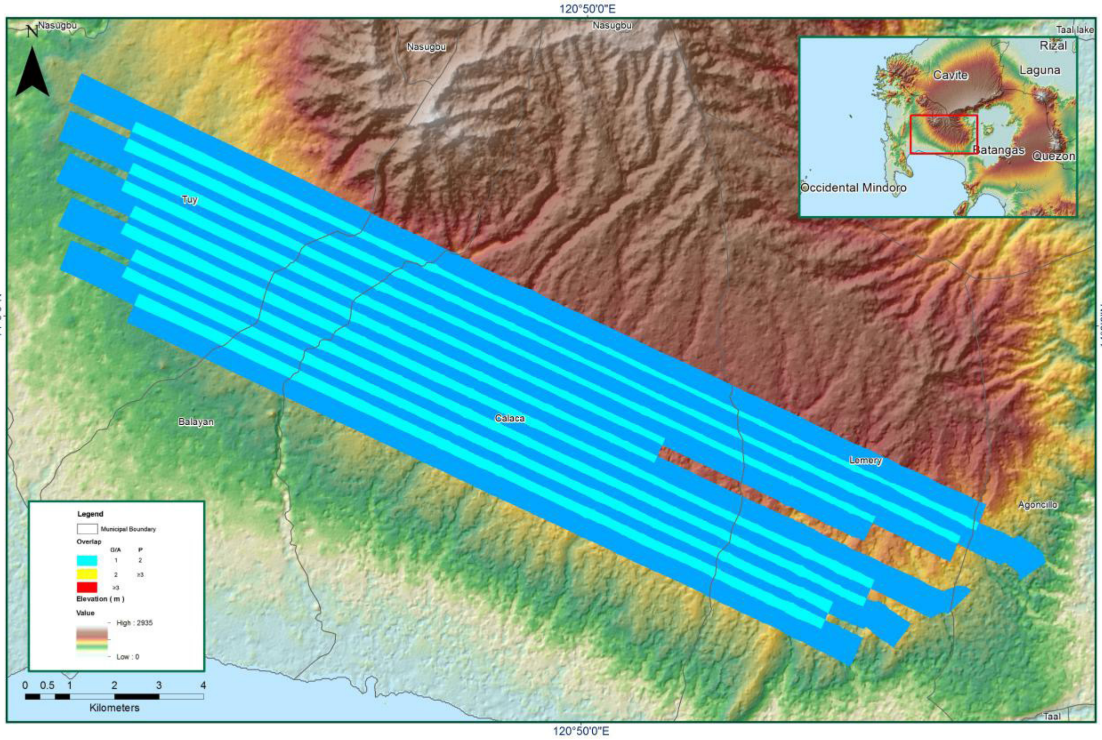


Figure 1.5.5. Image of data overlap

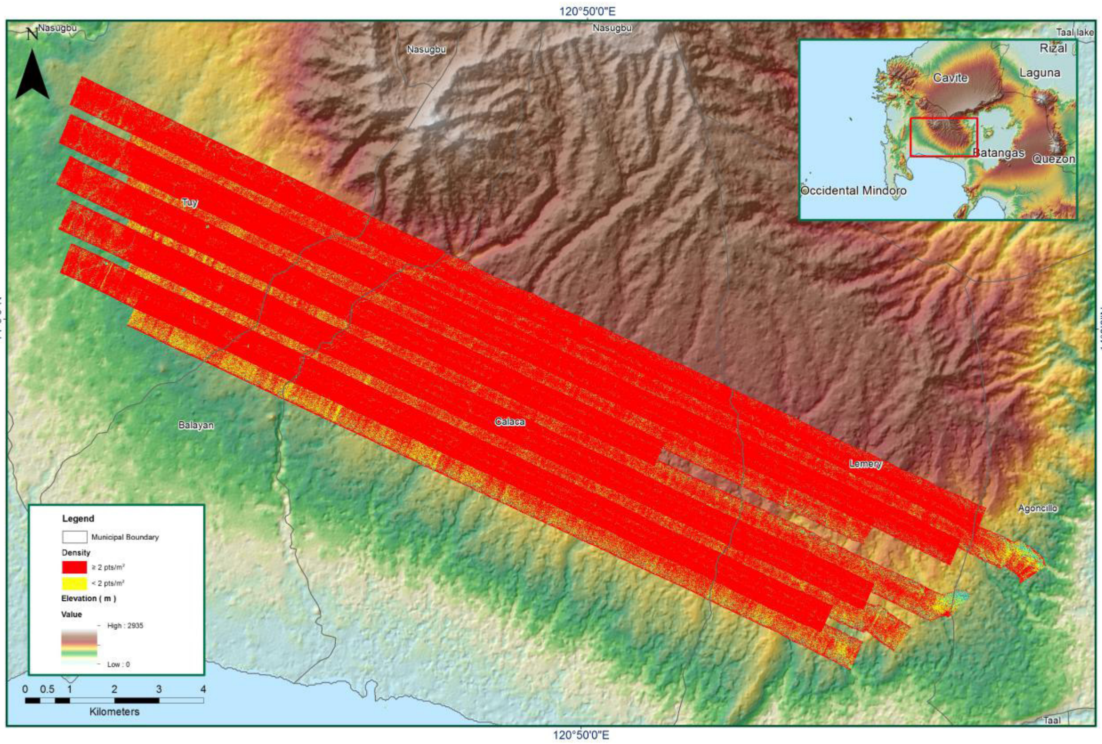


Figure 1.5.6. Density Map of merged LiDAR data

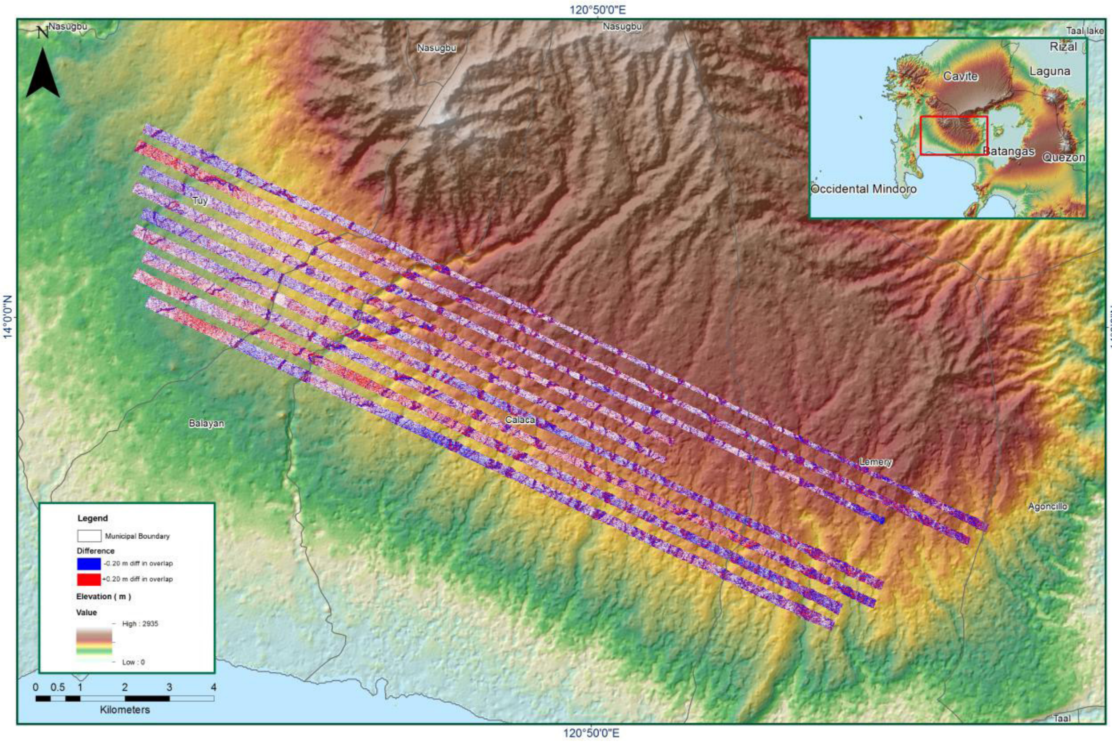


Figure 1.5.7. Elevation Difference Between flight lines

Flight Area	Batangas
Mission Name	**Blk18_SG_additional**
Inclusive Flights	3679G
Range data size	12.8 GB
Base data size	27.2 MB
POS	131 MB
Image	NA
Transfer date	January 15, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.40
RMSE for East Position (<4.0 cm)	2.115
RMSE for Down Position (<8.0 cm)	5.33
Boresight correction stdev (<0.001deg)	0.005160
IMU attitude correction stdev (<0.001deg)	0.015986
GPS position stdev (<0.01m)	0.0156
Minimum % overlap (>25)	14.29%
Ave point cloud density per sq.m. (>2.0)	5.98
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	66
Maximum Height	481.08 m
Minimum Height	66.84 m
Classification (# of points)	
Ground	18,665,956
Low vegetation	15,228,294
Medium vegetation	63,218,237
High vegetation	76,995,124
Building	805,560
Orthophoto	No
Processed By	Engr. Kenneth Solidum, Engr. Edgardo Gubatanga, Jr., Engr. Melissa Fernandez

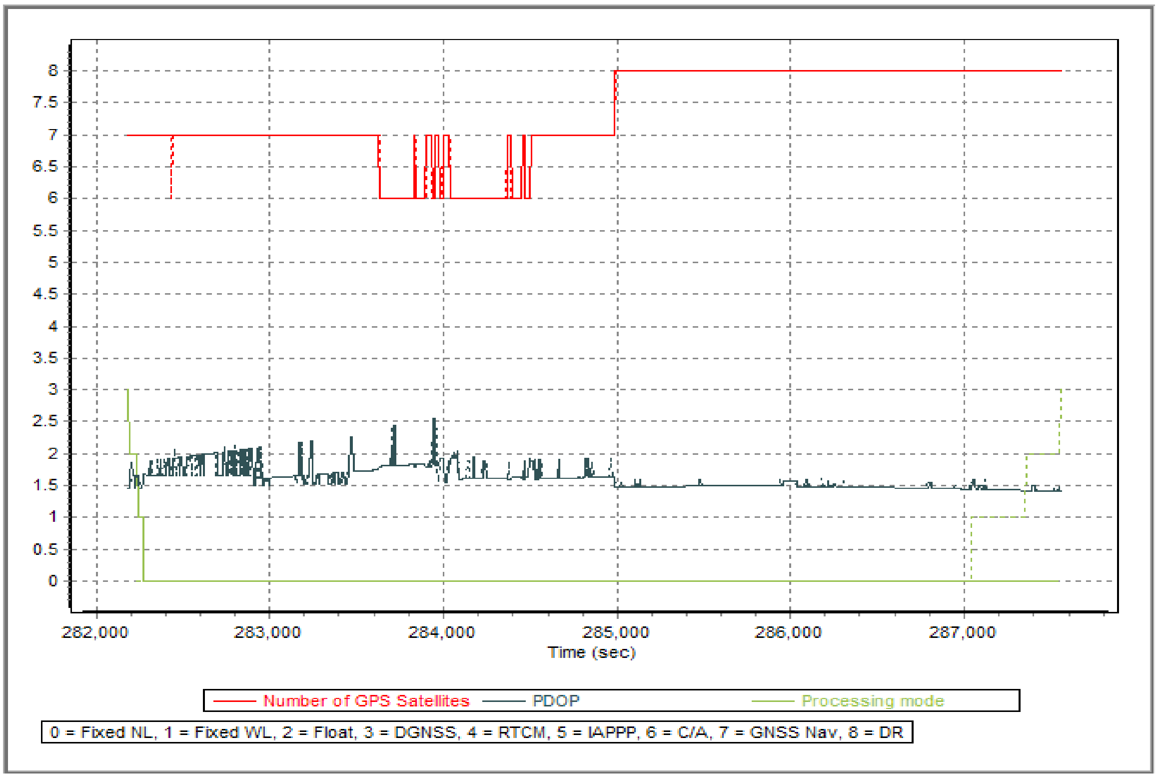


Figure 1.6.1. Solution Status

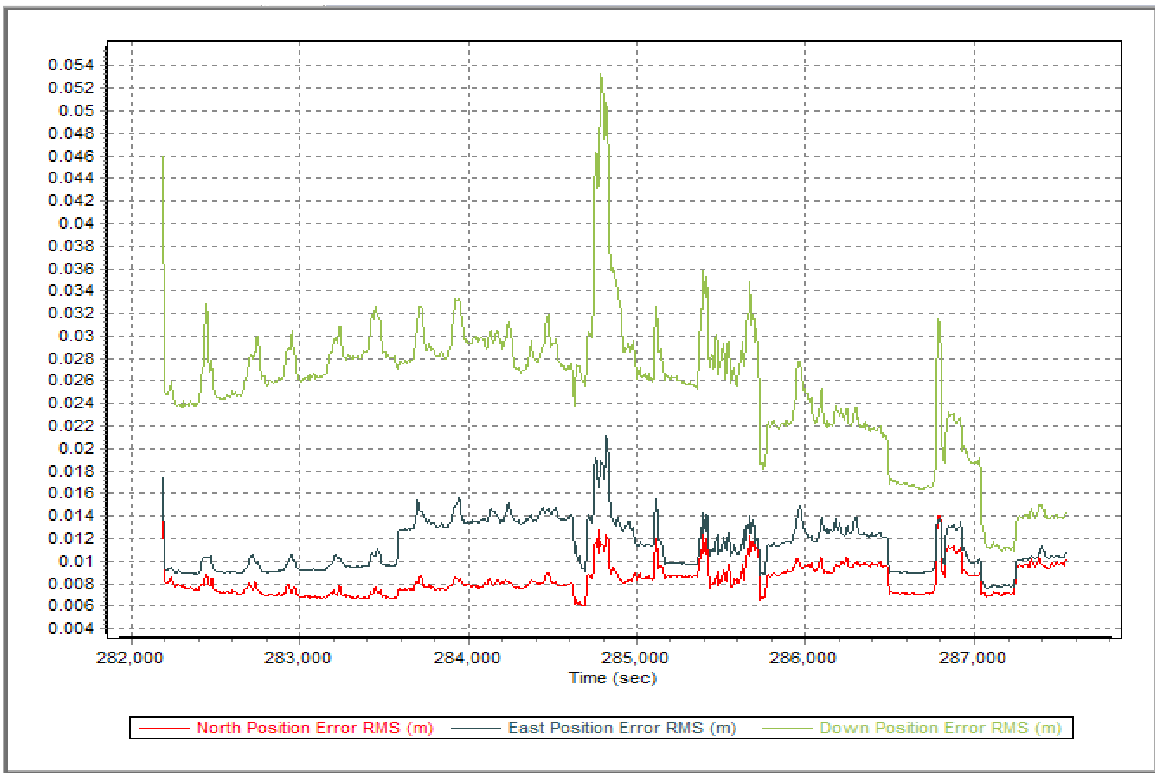


Figure 1.6.2. Smoothed Performance Metric Parameters

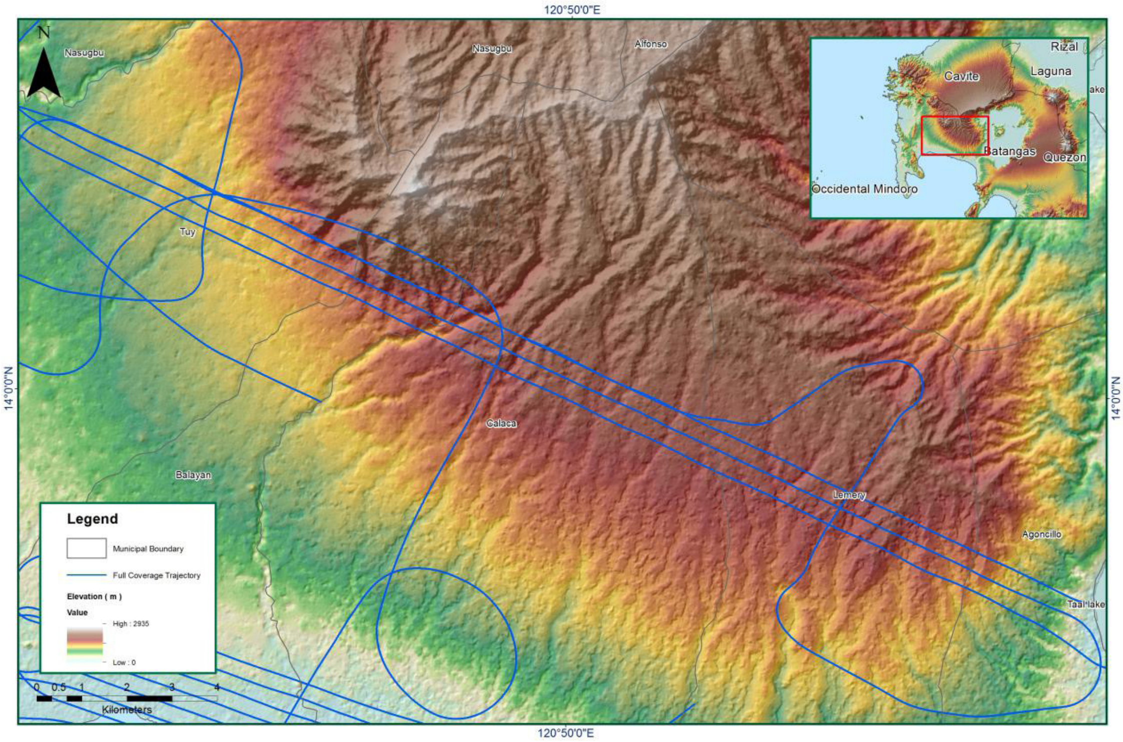


Figure 1.6.3. Best Estimate Trajectory

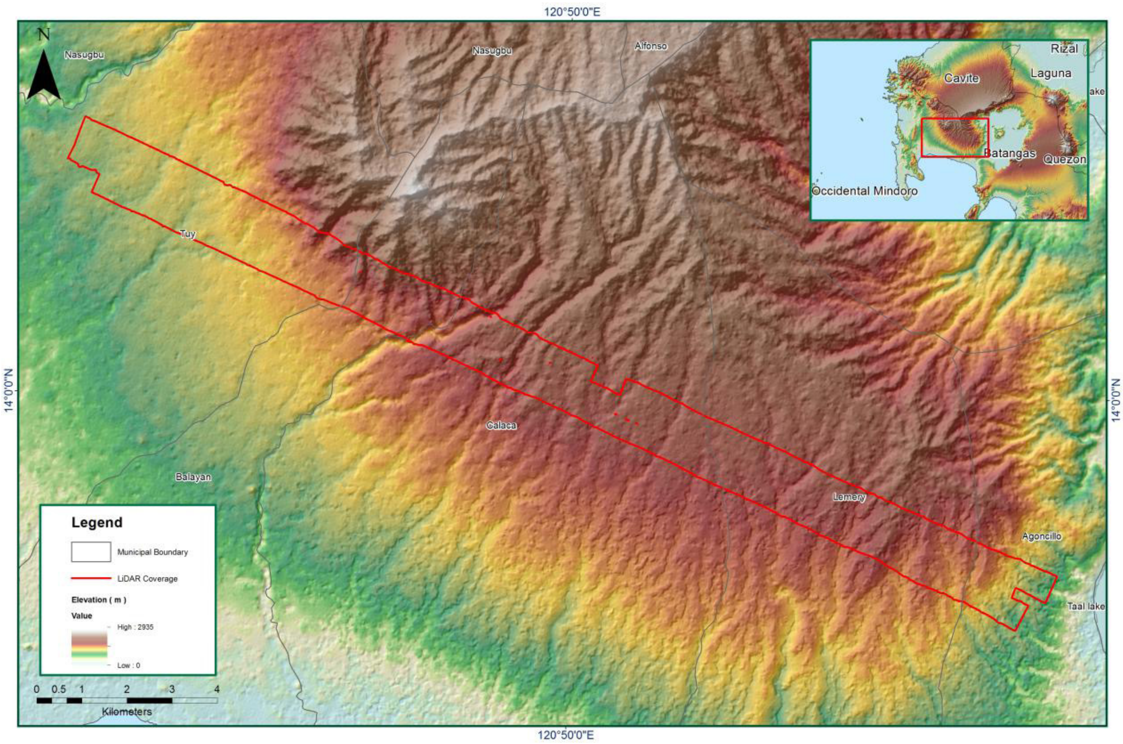


Figure 1.6.4. Coverage of LiDAR data

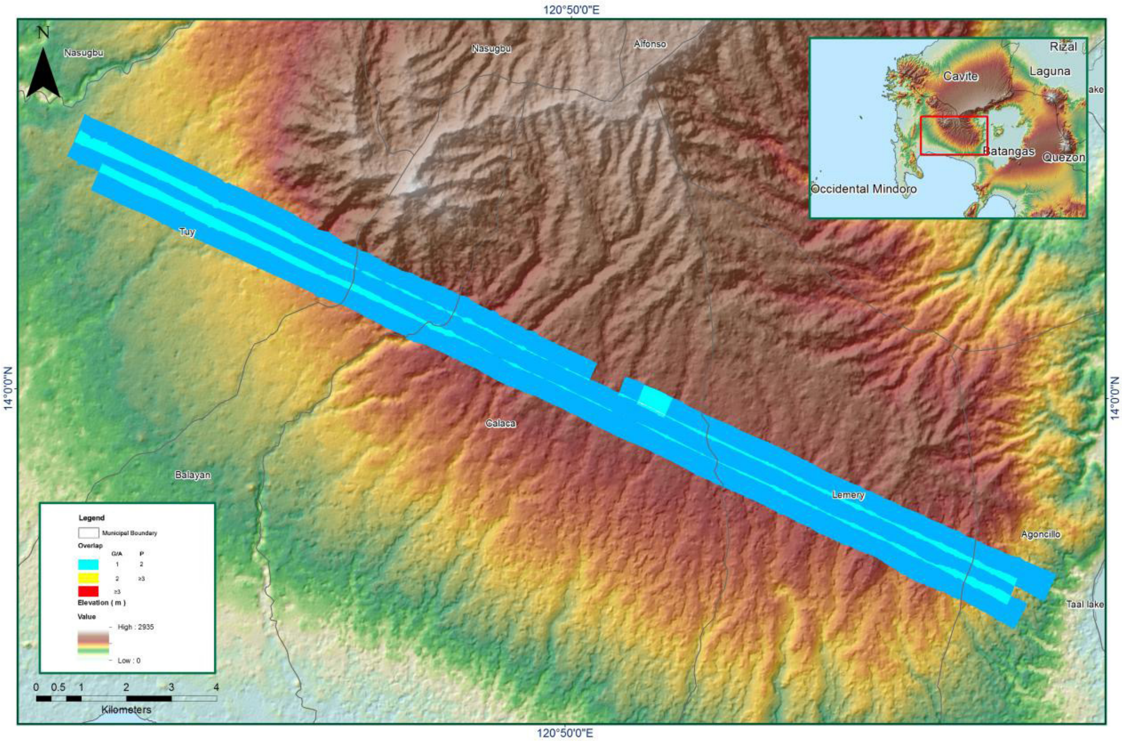


Figure 1.6.5. Image of data overlap

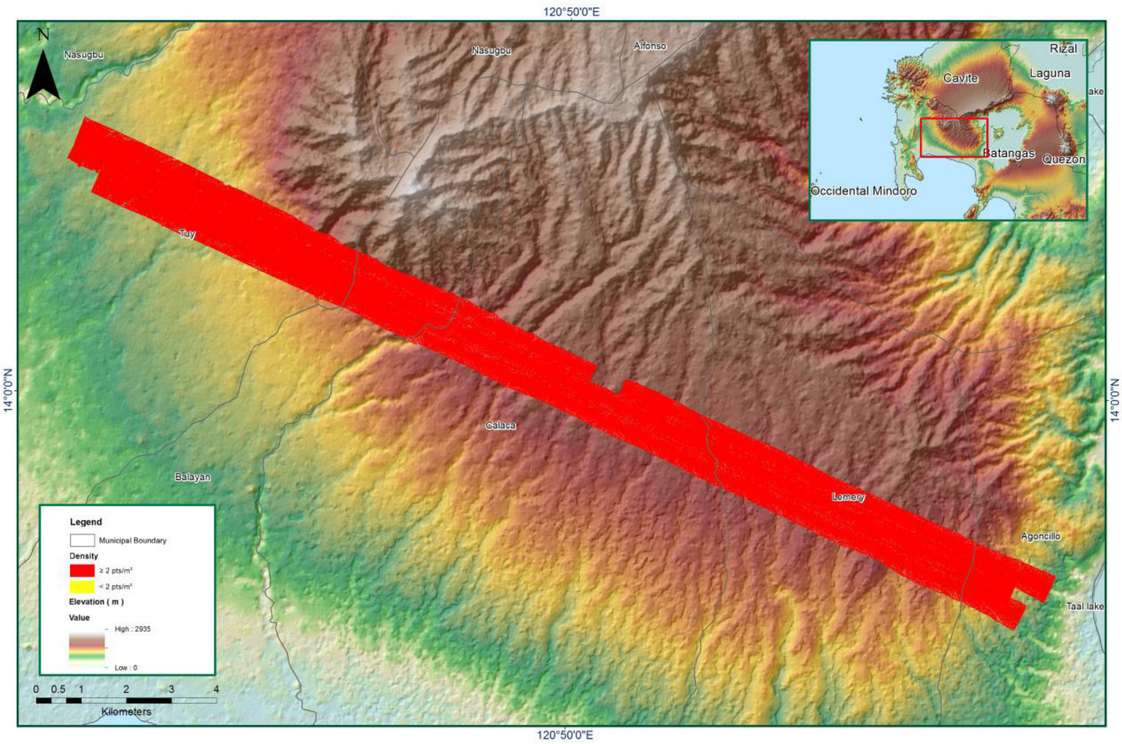


Figure 1.6.6. Density Map of merged LiDAR data

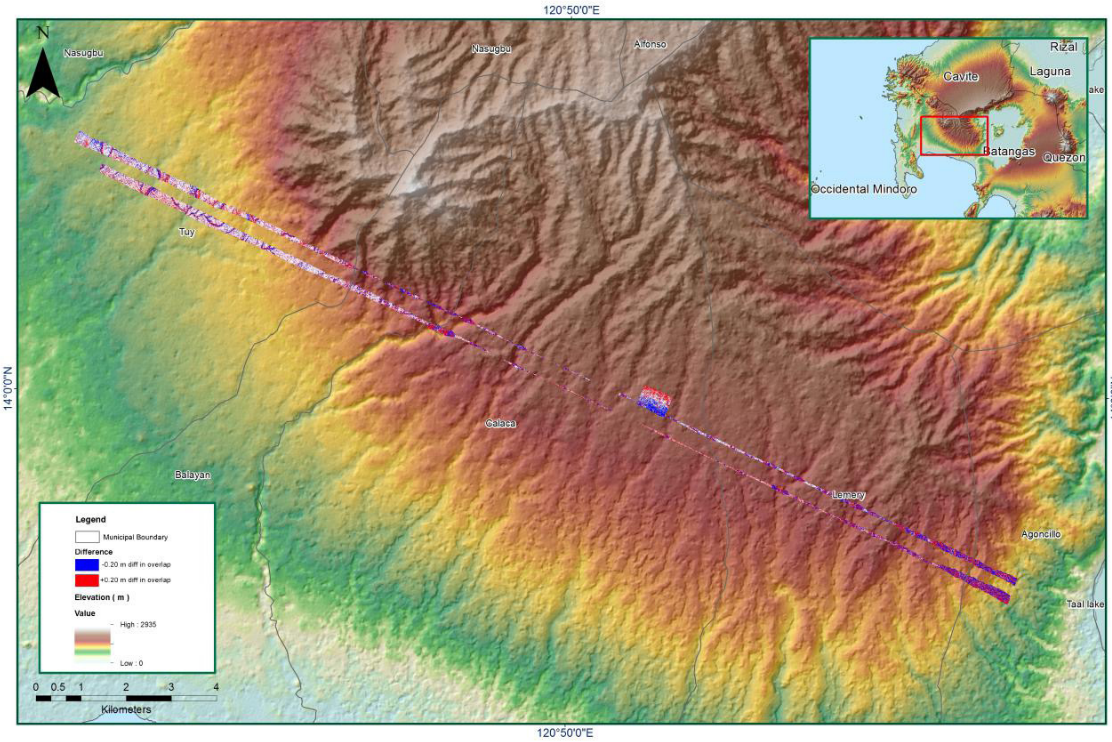


Figure 1.6.7. Elevation Difference Between flight lines

Flight Area	**Batangas**
Mission Name	**Blk18_SJ**
Inclusive Flights	3679G
Range data size	3679G
Base data size	12.8 GB
POS	27.2 MB
Image	131 MB
Transfer date	NA
	January 15, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.40
RMSE for East Position (<4.0 cm)	2.115
RMSE for Down Position (<8.0 cm)	5.33
Boresight correction stdev (<0.001deg)	NA
IMU attitude correction stdev (<0.001deg)	NA
GPS position stdev (<0.01m)	NA
Minimum % overlap (>25)	44.00%
Ave point cloud density per sq.m. (>2.0)	5.27
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	42
Maximum Height	108.92 m
Minimum Height	41.77 m
Classification (# of points)	
Ground	6,481,197
Low vegetation	4,667,448
Medium vegetation	90,559,680
High vegetation	22,658,677
Building	105,352
Orthophoto	No
Processed By	Engr. Kenneth Solidum, Engr. Edgardo Gubatanga, Jr., Marie Denise Bueno

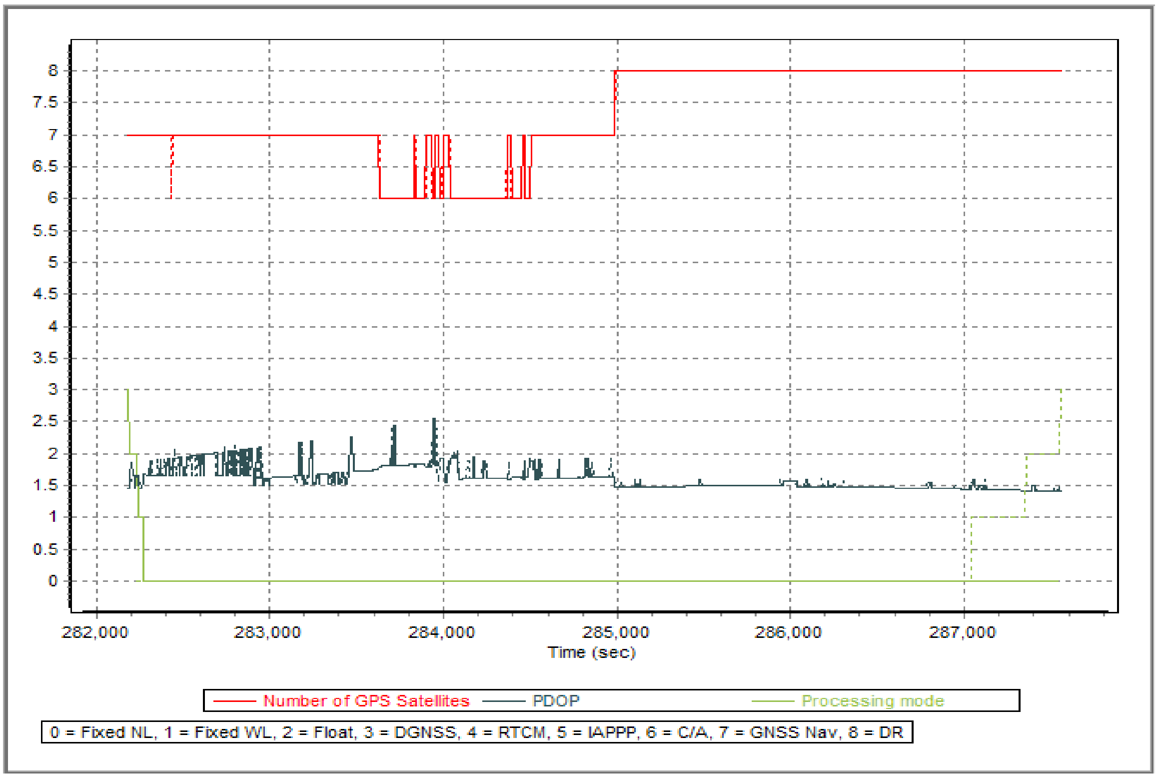


Figure 1.7.1. Solution Status

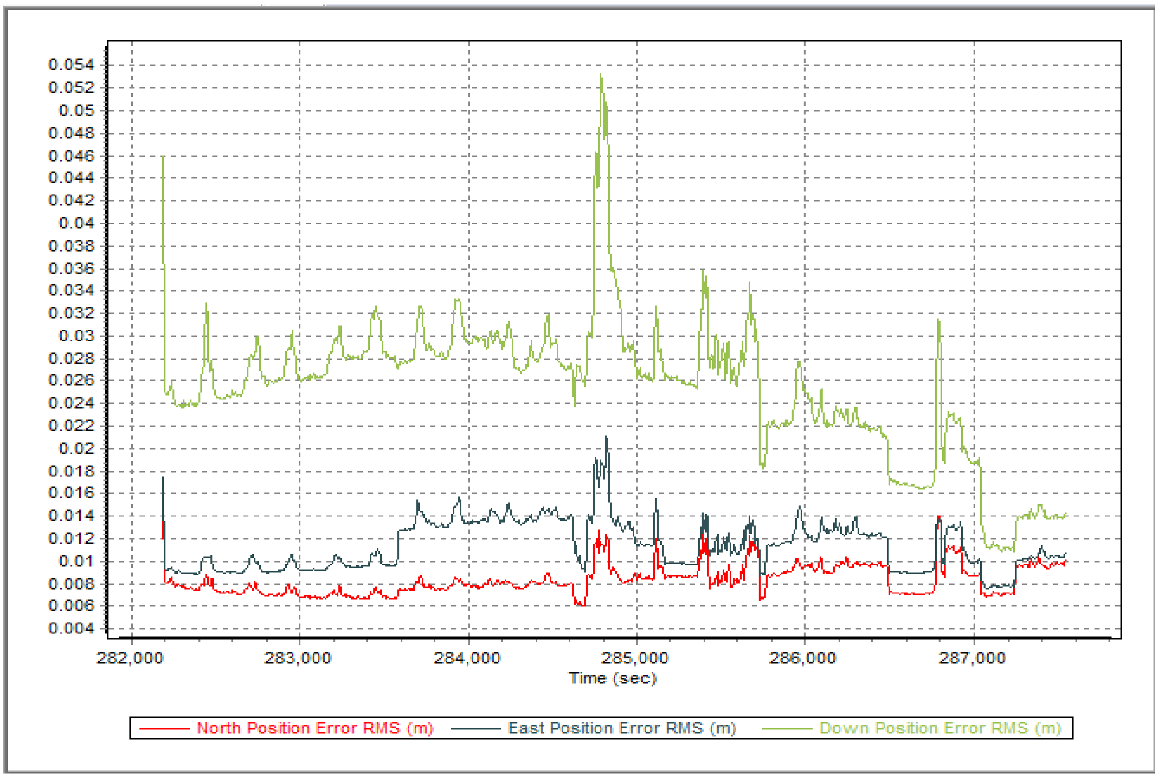


Figure 1.7.2. Smoothed Performance Metric Parameters

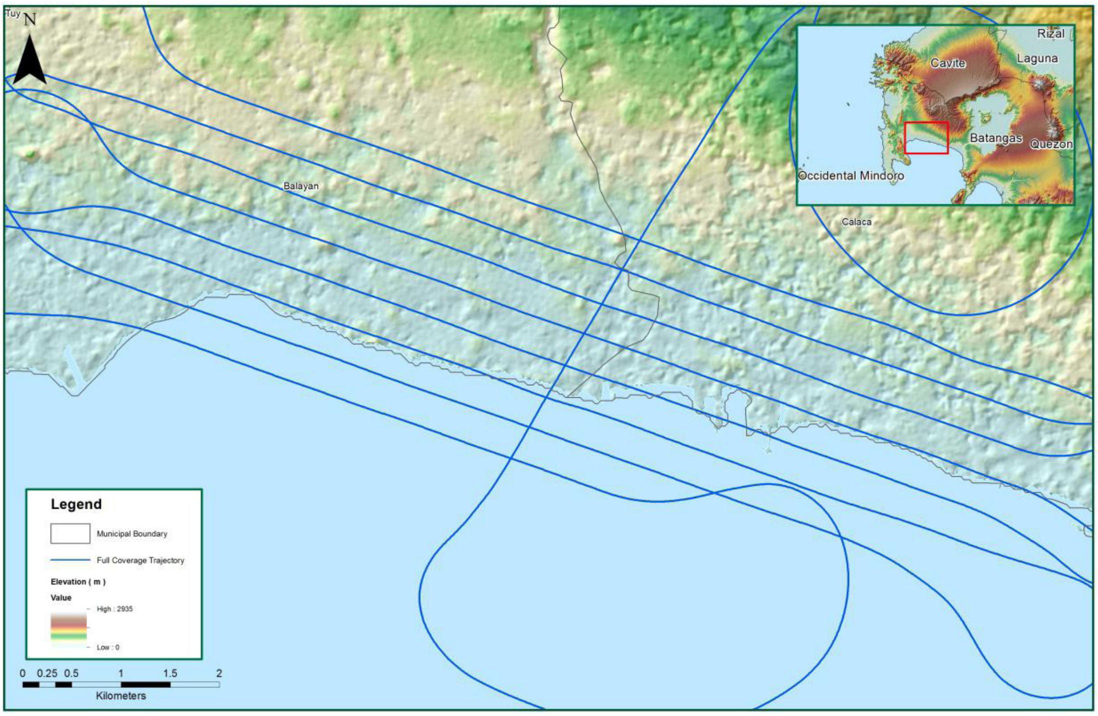


Figure 1.7.3. Best Estimate Trajectory

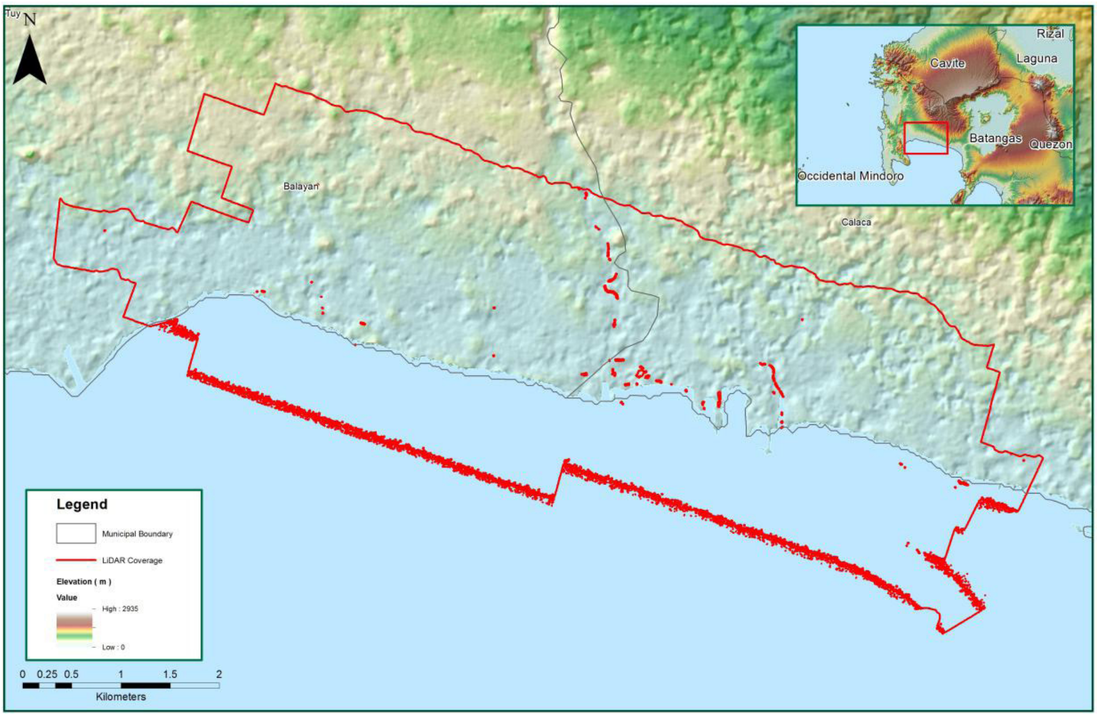


Figure 1.7.4. Coverage of LiDAR data

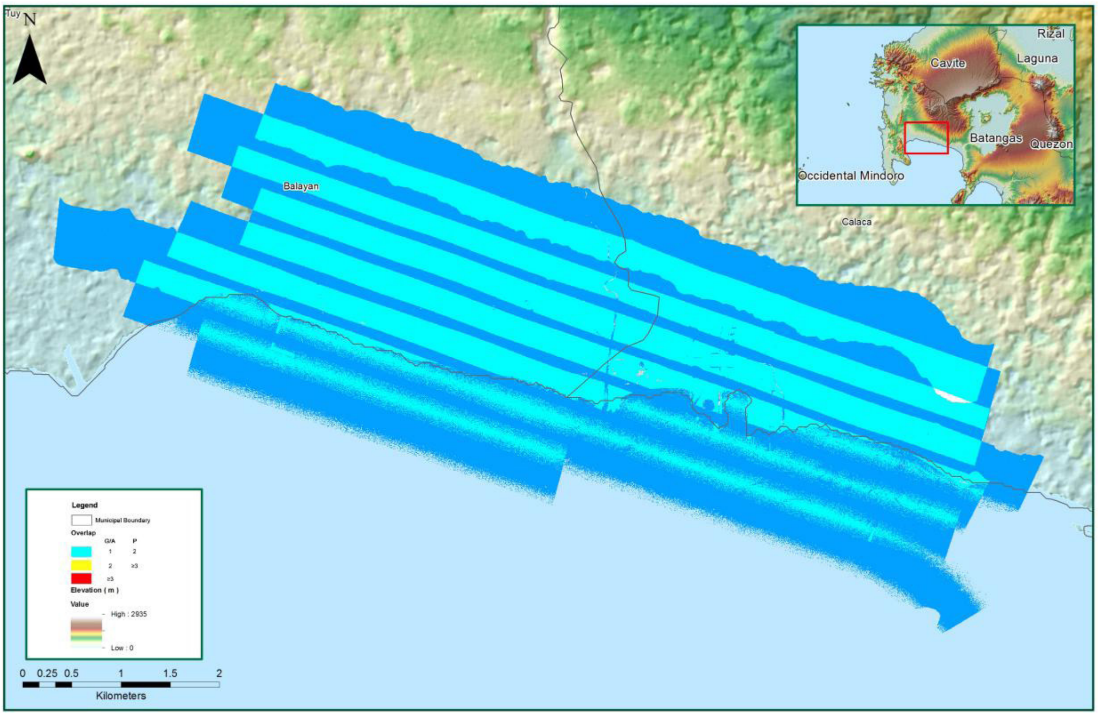


Figure 1.7.5. Image of data overlap

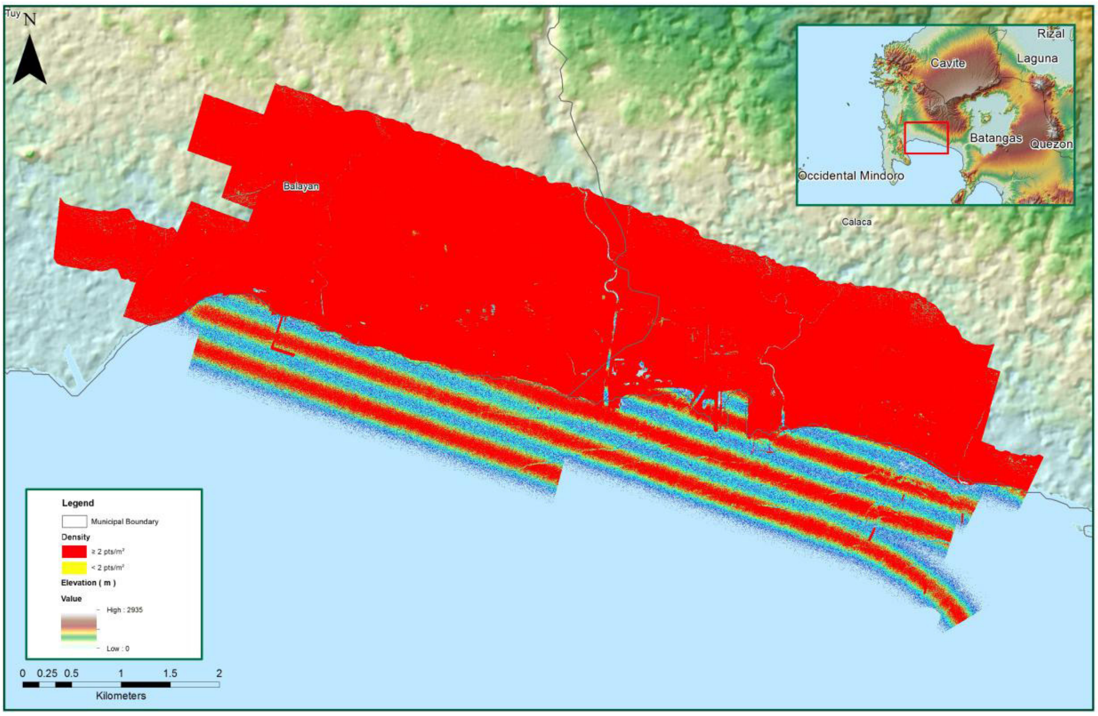


Figure 1.7.6. Density Map of merged LiDAR data

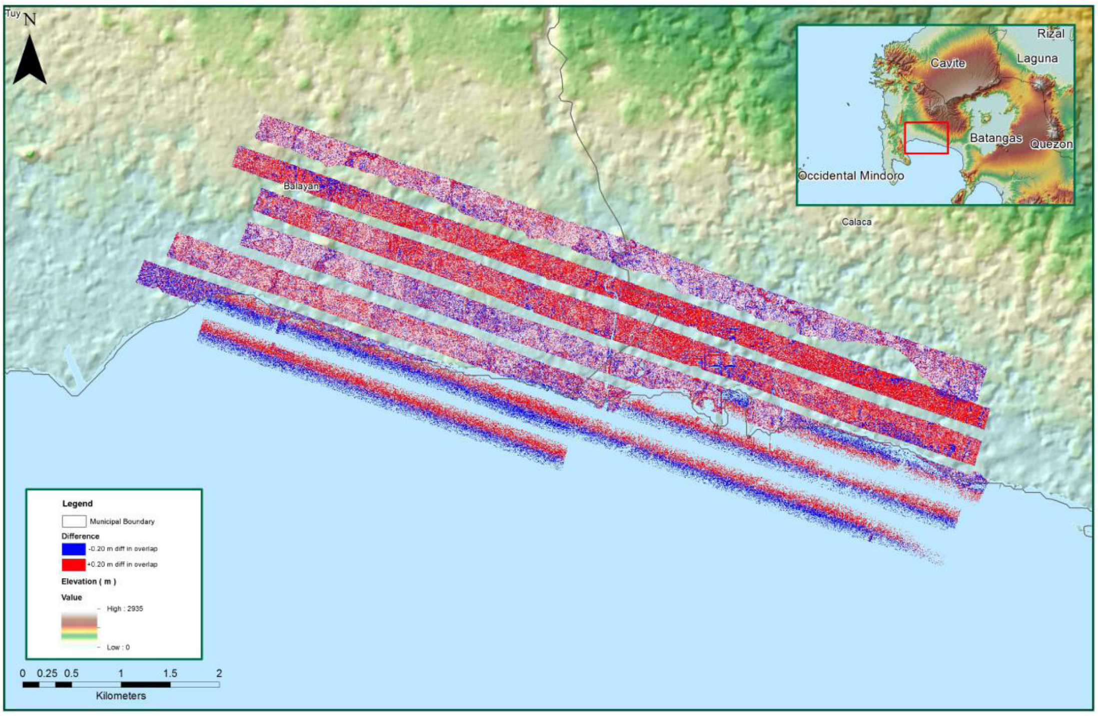


Figure 1.7.7. Elevation Difference Between flight lines

Flight Area	Batangas
Mission Name	**Blk18_SC**
Inclusive Flights	3671G
Range data size	7.41 GB
Base data size	7.42 MB
POS	85 MB
Image	NA
Transfer date	January 6, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	0.8015
RMSE for East Position (<4.0 cm)	0.8839
RMSE for Down Position (<8.0 cm)	1.236
Boresight correction stdev (<0.001deg)	0.001711
IMU attitude correction stdev (<0.001deg)	0.002627
GPS position stdev (<0.01m)	0.0018
Minimum % overlap (>25)	1.04%
Ave point cloud density per sq.m. (>2.0)	3.75
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	113
Maximum Height	779.19 m
Minimum Height	49.56 m
Classification (# of points)	
Ground	36,956,676
Low vegetation	15,958,180
Medium vegetation	46,648,268
High vegetation	133,227,835
Building	5,156,617
Orthophoto	No
Processed by	Engr. Don Matthew Banatin, Engr. Edgardo Gubatanga, Jr., Engr. Elainne Lopez

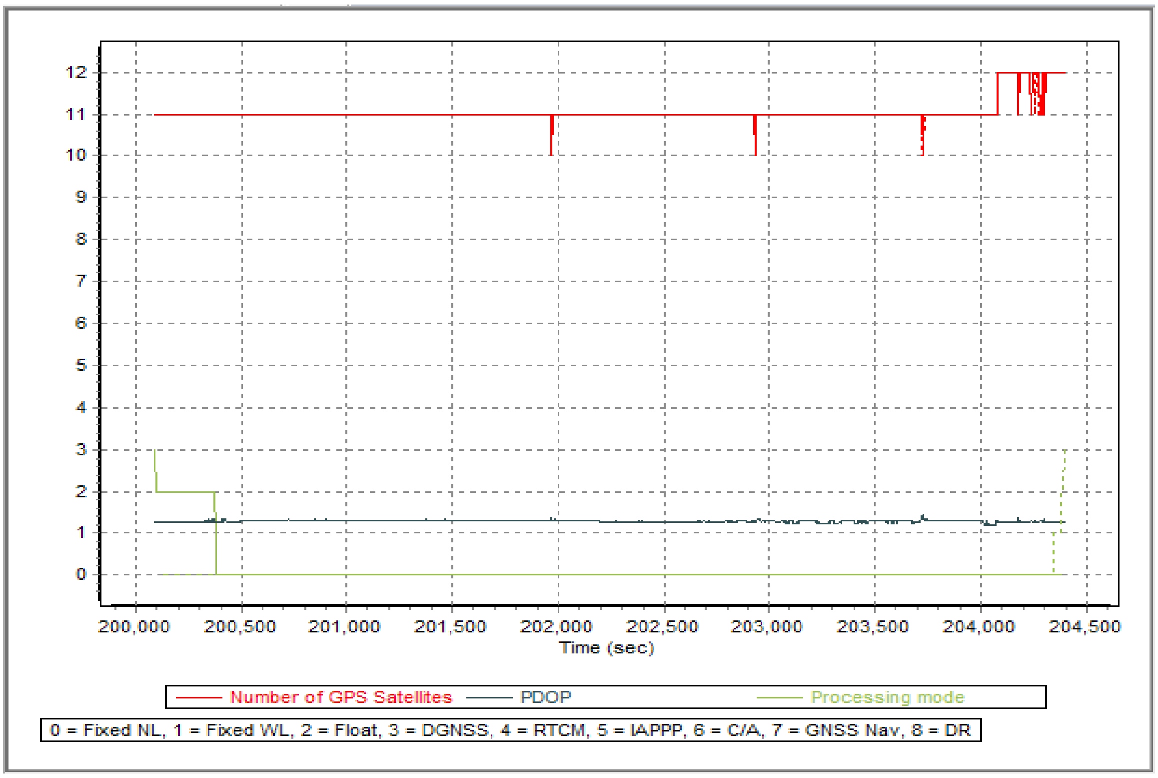


Figure 1.8.1. Solution Status

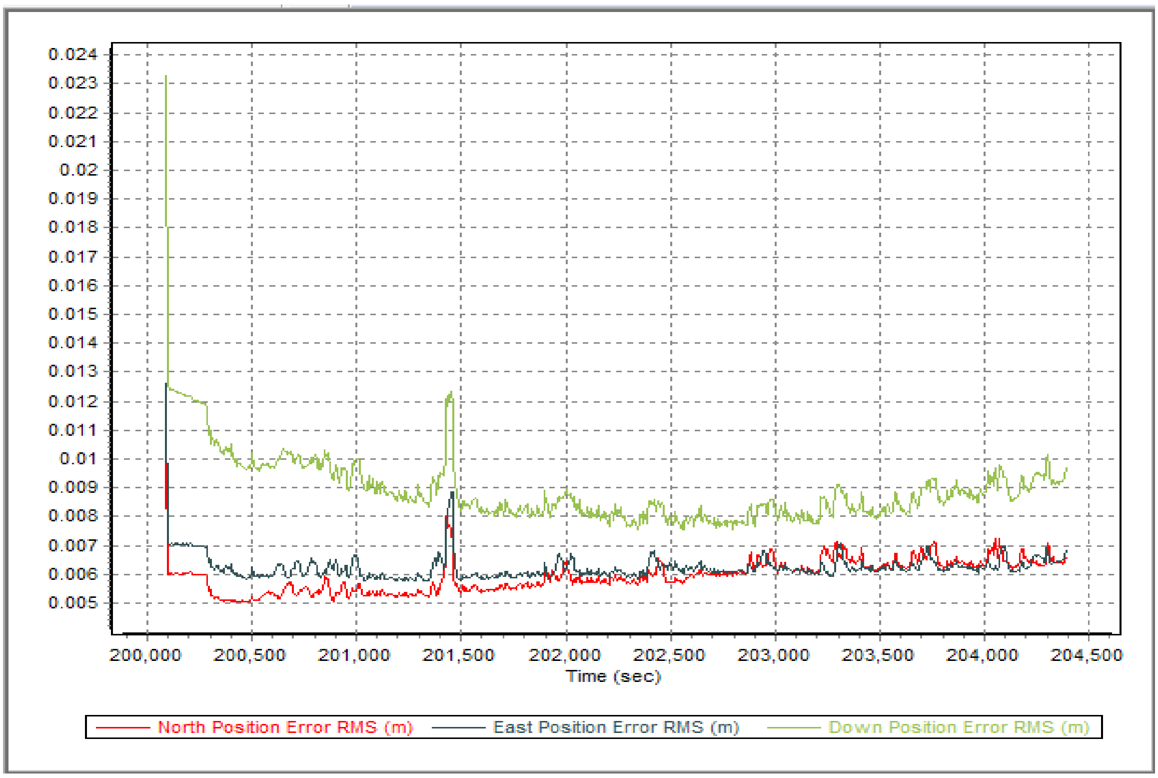


Figure 1.8.2. Smoothed Performance Metric Parameters

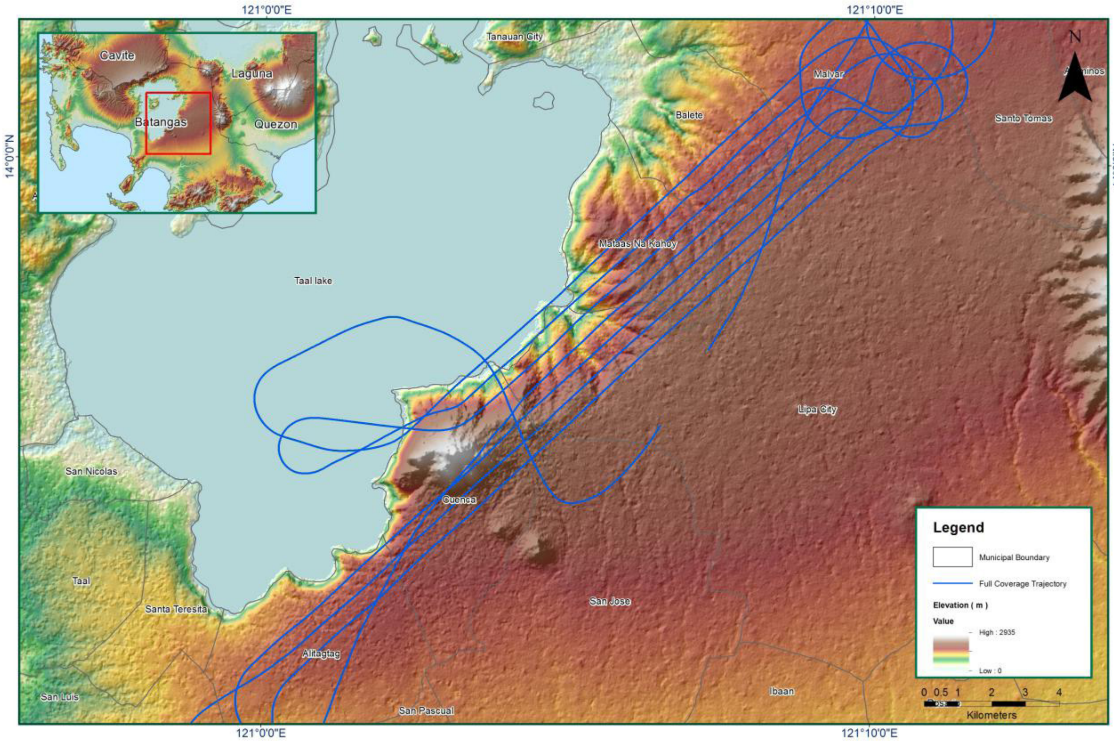


Figure 1.8.3. Best Estimate Trajectory

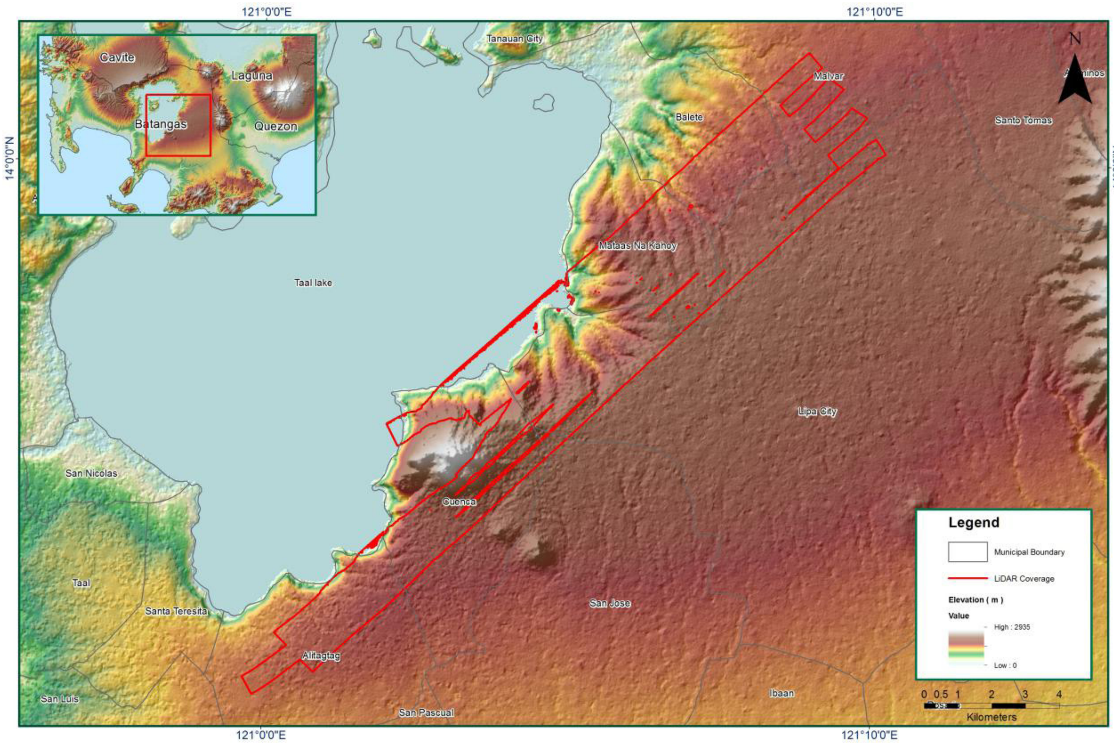


Figure 1.8.4. Coverage of LiDAR data

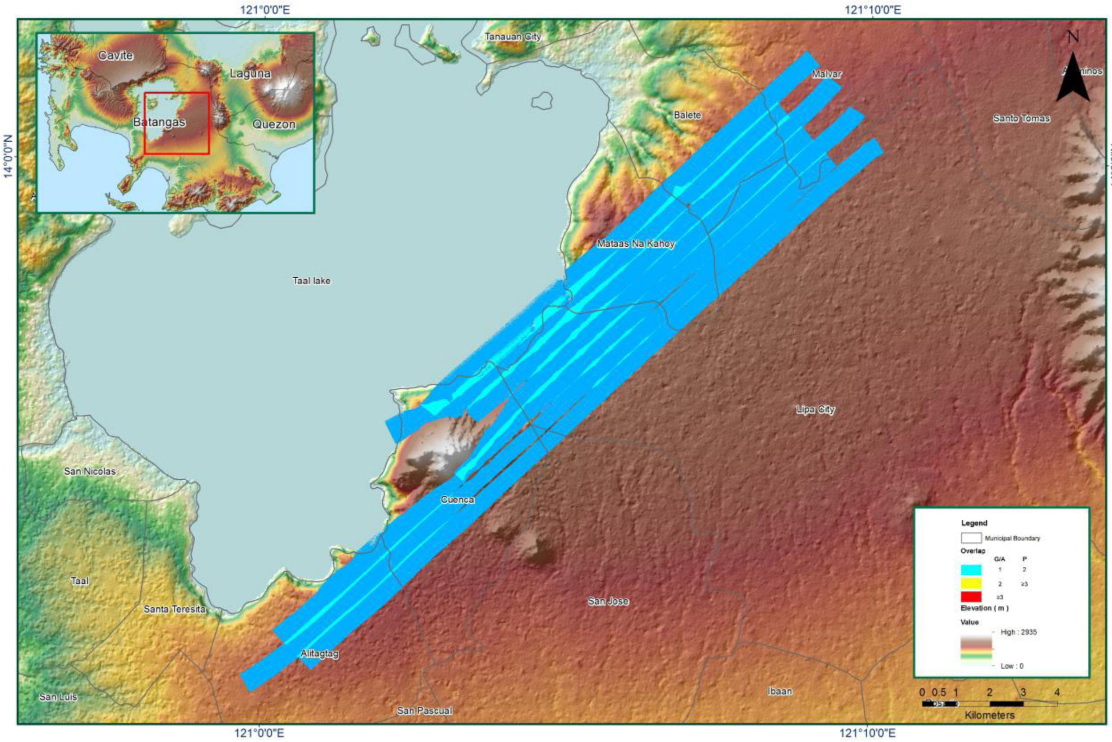


Figure 1.8.5. Image of data overlap

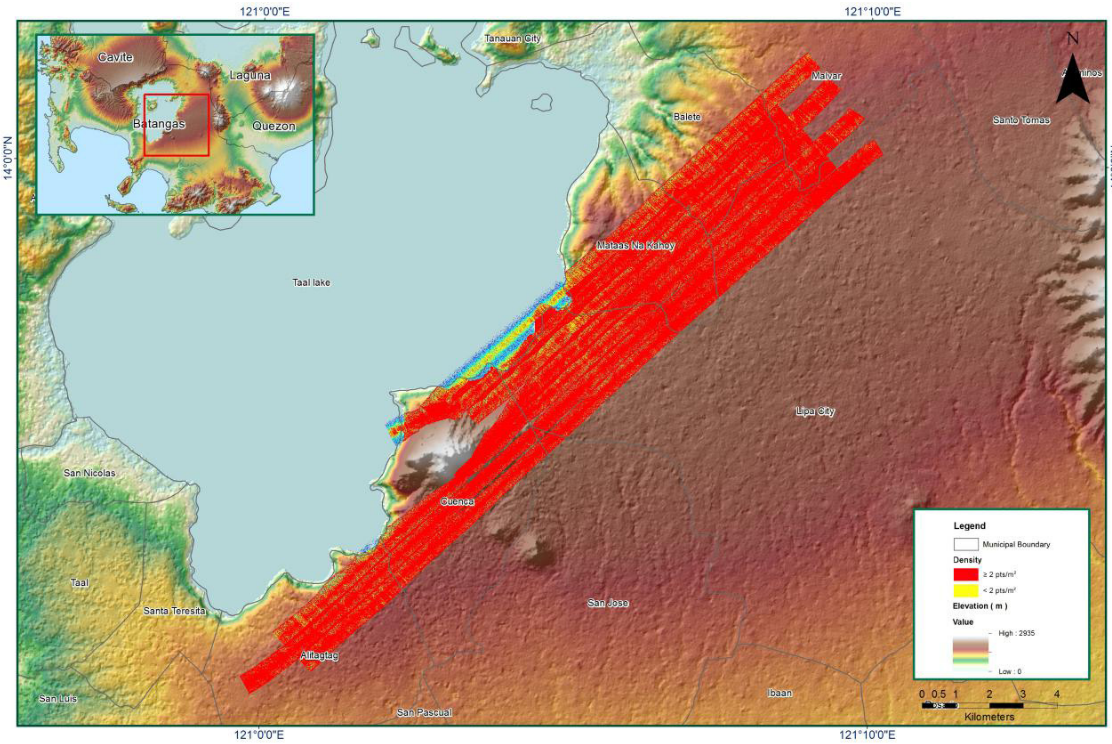


Figure 1.8.6. Density Map of merged LiDAR data

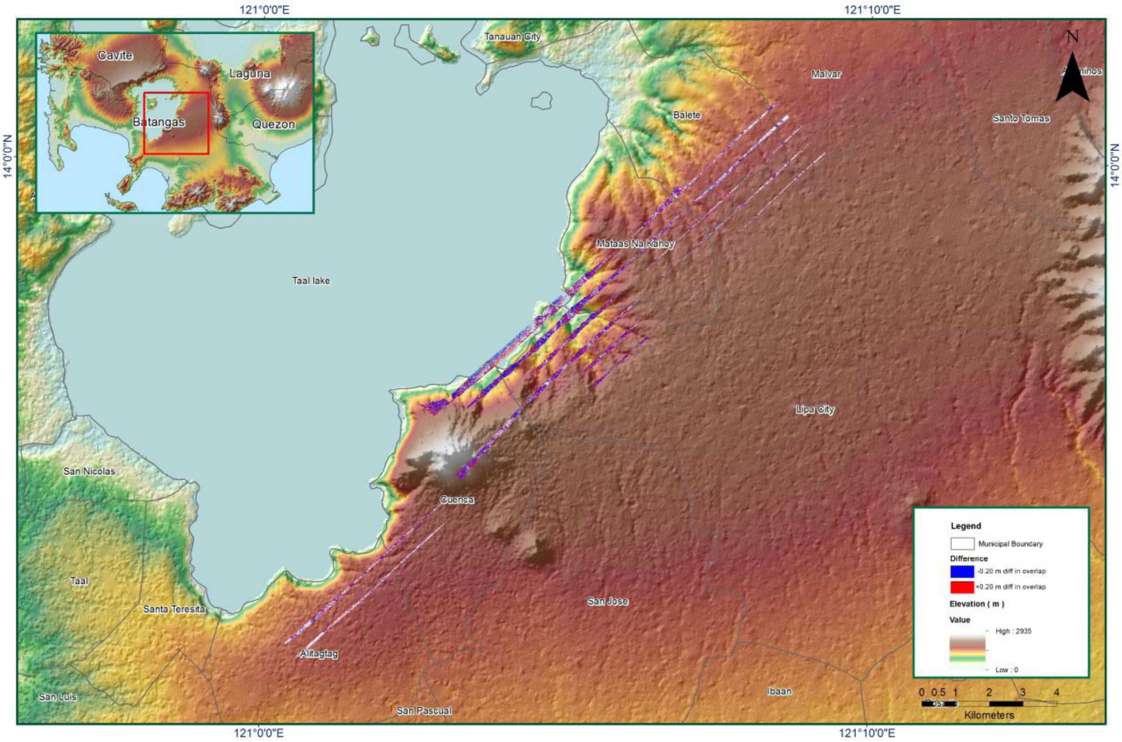


Figure 1.8.7. Elevation Difference Between flight lines

Flight Area	Batangas
Mission Name	**Blk18SC_supplement**
Inclusive Flights	3693G
Range data size	7.98 GB
Base data size	8.36 MB
POS	82.9 MB
Image	NA
Transfer date	January 20, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	0.6823
RMSE for East Position (<4.0 cm)	0.6974
RMSE for Down Position (<8.0 cm)	1.6279
Boresight correction stdev (<0.001deg)	NA
IMU attitude correction stdev (<0.001deg)	NA
GPS position stdev (<0.01m)	NA
Minimum % overlap (>25)	38.51%
Ave point cloud density per sq.m. (>2.0)	4.78
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	78
Maximum Height	553.45 m
Minimum Height	48.17 m
Classification (# of points)	
Ground	9,620,275
Low vegetation	5,386,146
Medium vegetation	79,015,481
High vegetation	95,038,735
Building	344,062
Orthophoto	No

Processed by	Engr. Regis Guhiting, Engr. Merven Matthew Natino, JovyNarisma

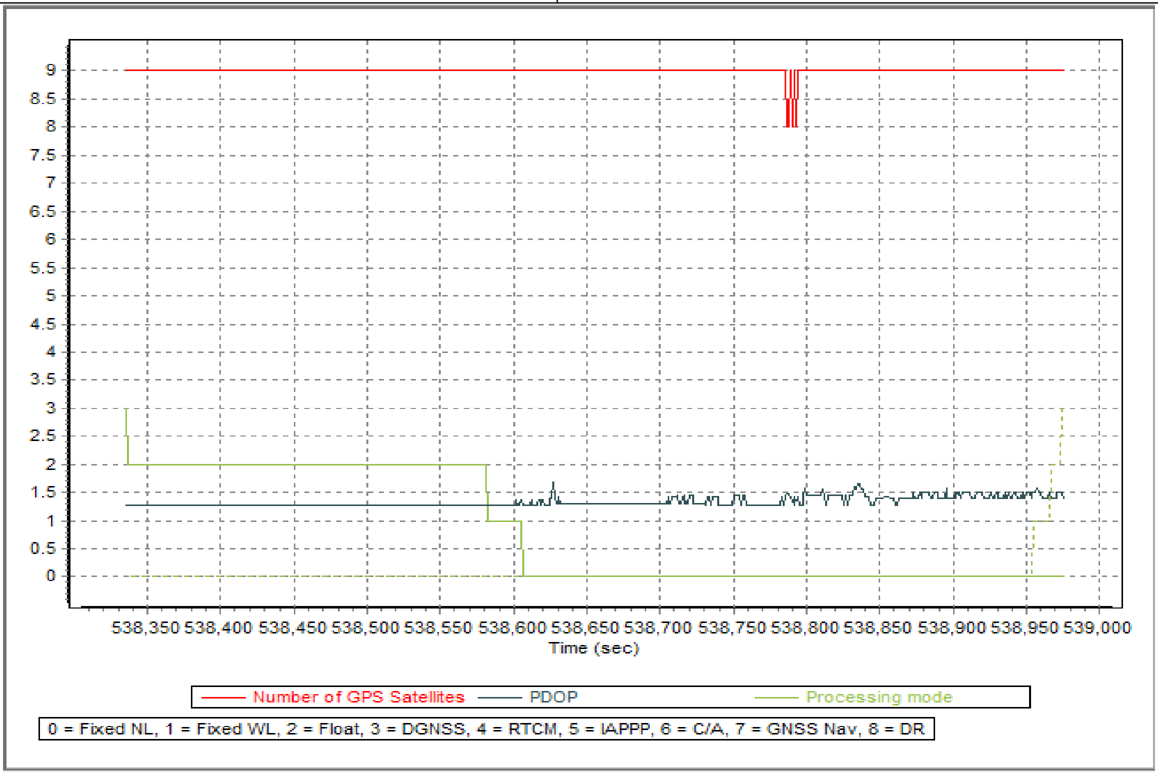


Figure 1.9.1. Solution Status

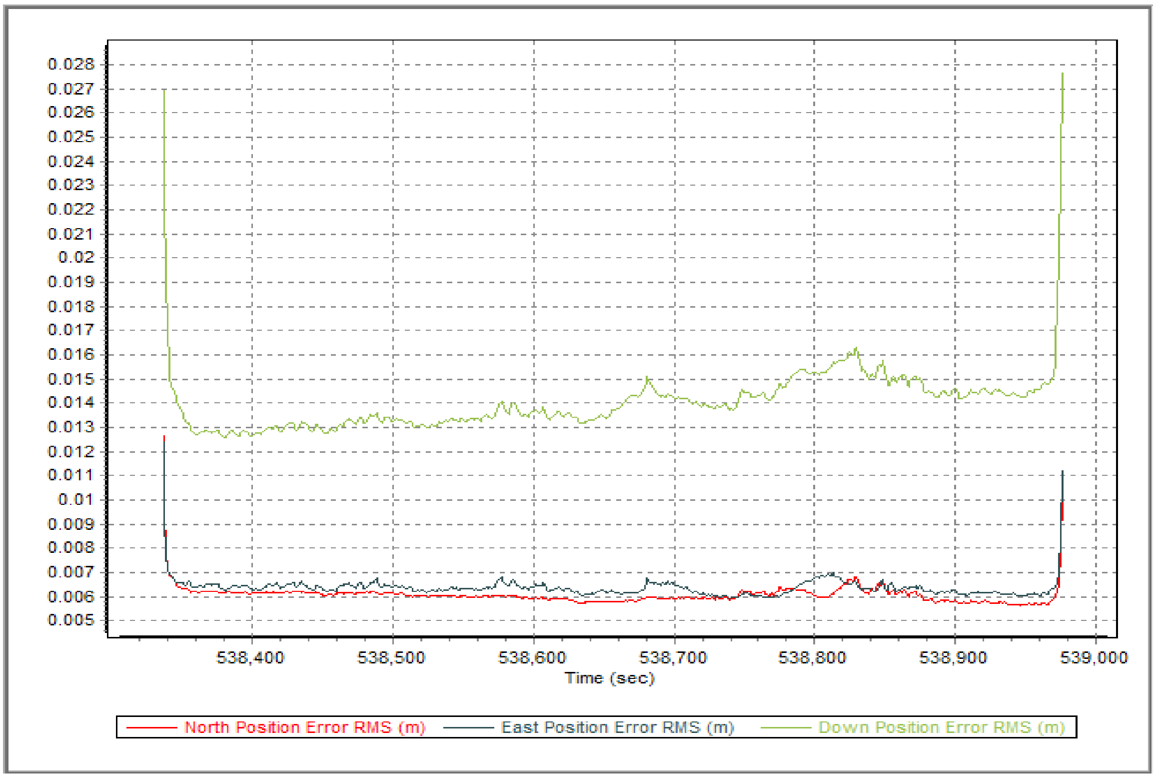


Figure 1.9.2. Smoothed Performance Metric Parameters

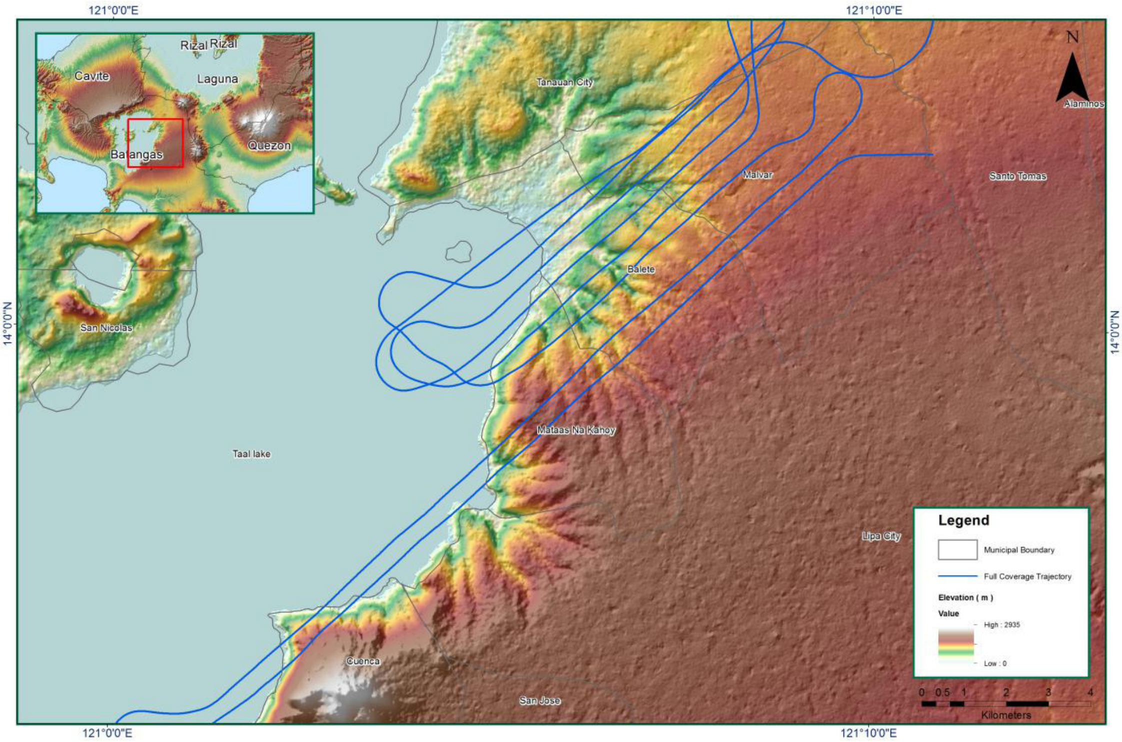


Figure 1.9.3. Best Estimate Trajectory

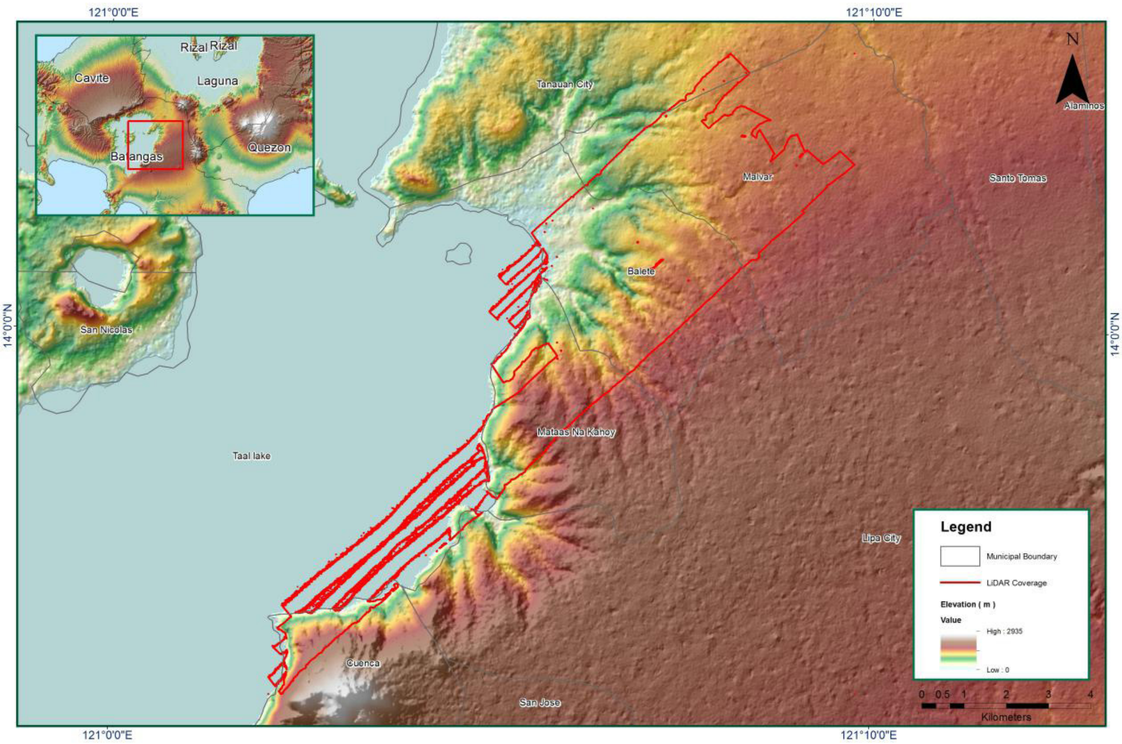


Figure1.9.4. Coverage of LiDAR data

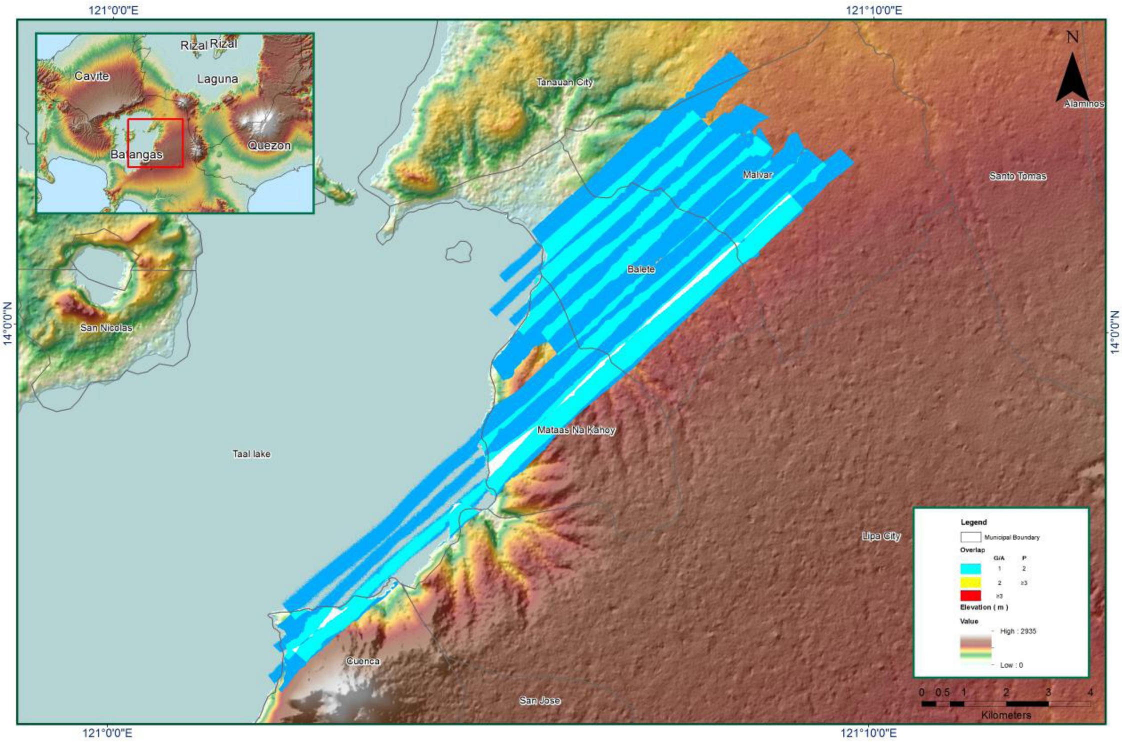


Figure 1.9.5. Image of data overlap

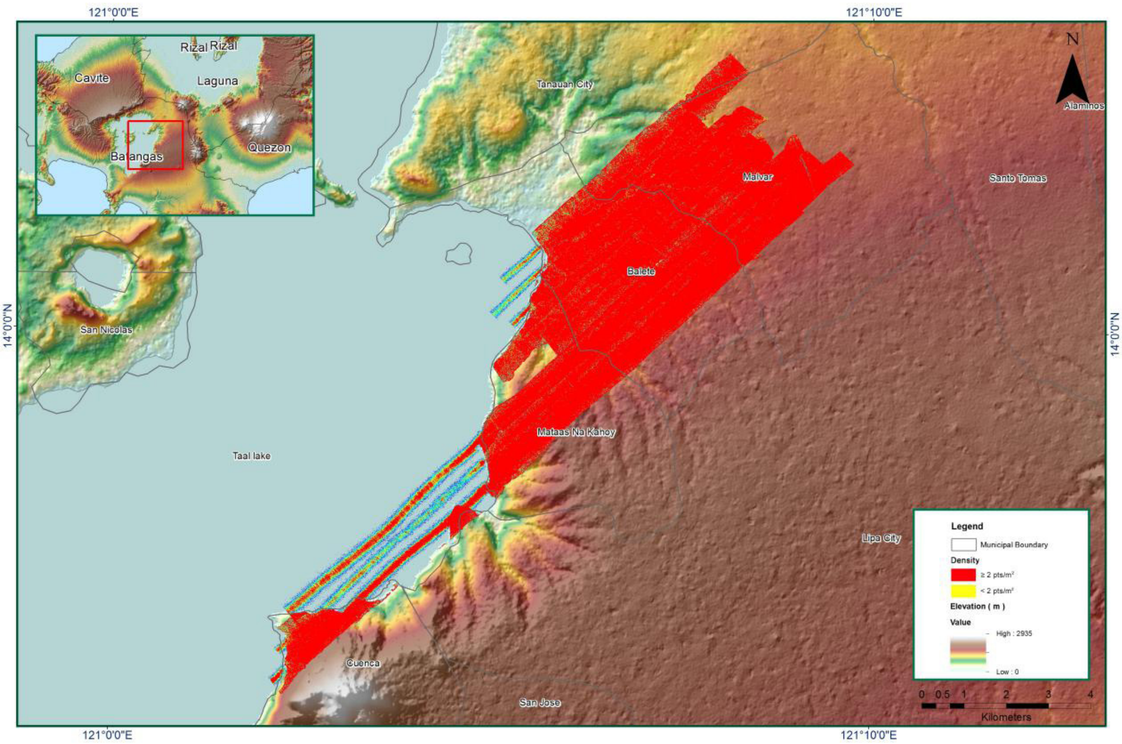


Figure 1.9.6. Density Map of merged LiDAR data

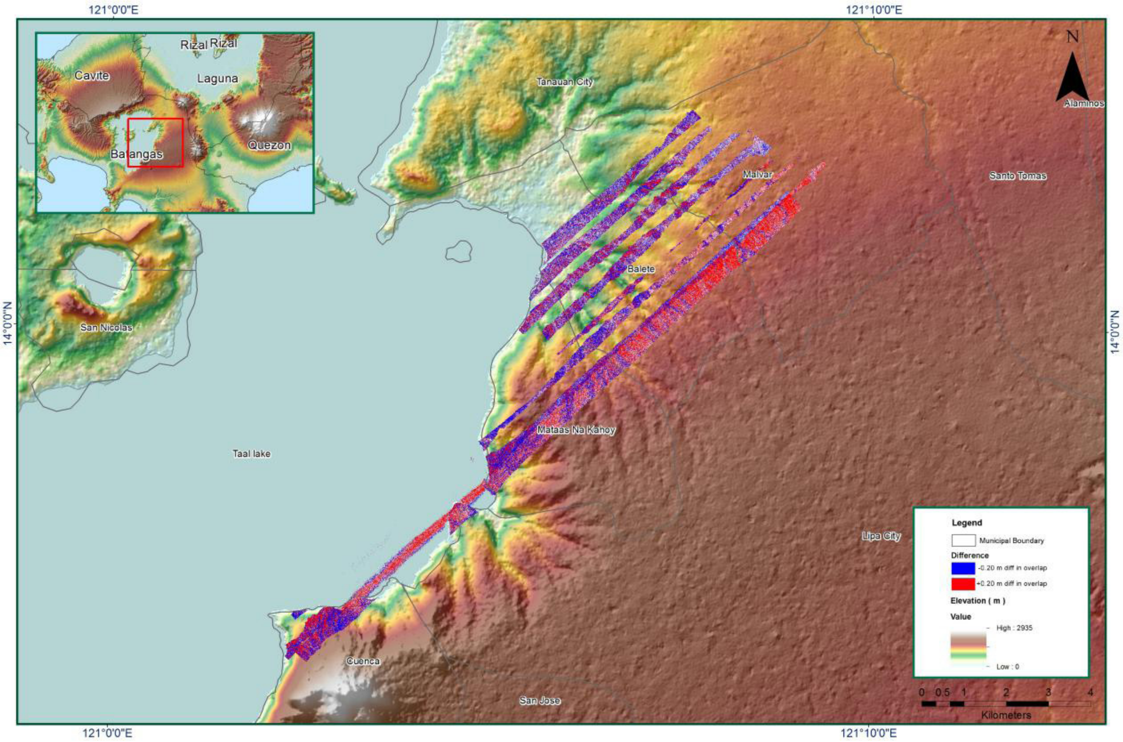


Figure 1.9.7. Elevation Difference Between flight lines

Flight Area	Batangas
Mission Name	**Blk18_SD**
Inclusive Flights	3677G
Range data size	38.7 GB
Base data size	27.2 MB
POS	157 MB
Image	NA
Transfer date	January 15, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.316
RMSE for East Position (<4.0 cm)	1.534
RMSE for Down Position (<8.0 cm)	3.56
Boresight correction stdev (<0.001deg)	NA
IMU attitude correction stdev (<0.001deg)	NA
GPS position stdev (<0.01m)	NA
Minimum % overlap (>25)	29.49%
Ave point cloud density per sq.m. (>2.0)	5.4
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	142
Maximum Height	357.33 m
Minimum Height	35.93 m
Classification (# of points)	
Ground	23,921,261
Low vegetation	5,511,136
Medium vegetation	187,063,336
High vegetation	188,358,347
Building	861
Orthophoto	No
Processed by	Engr. Don Matthew Banatin, Engr. Edgardo Gubatanga, Jr., JovyNarisma

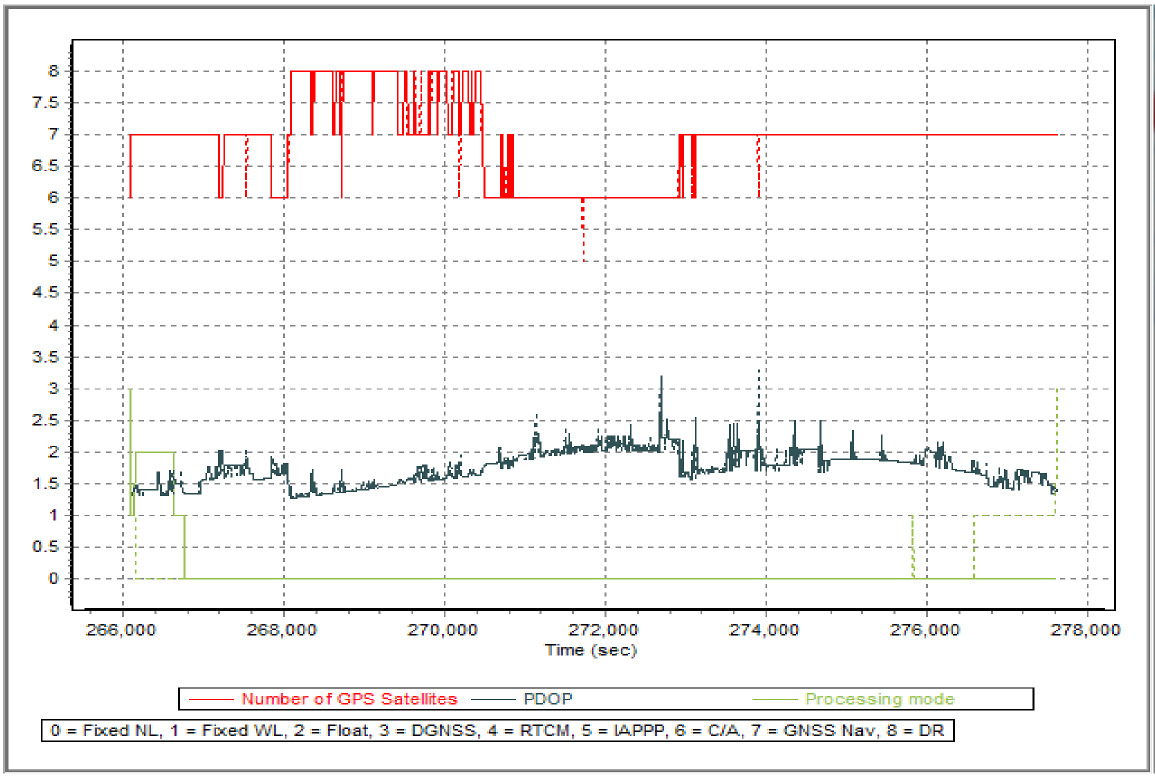


Figure 1.10.1. Solution Status

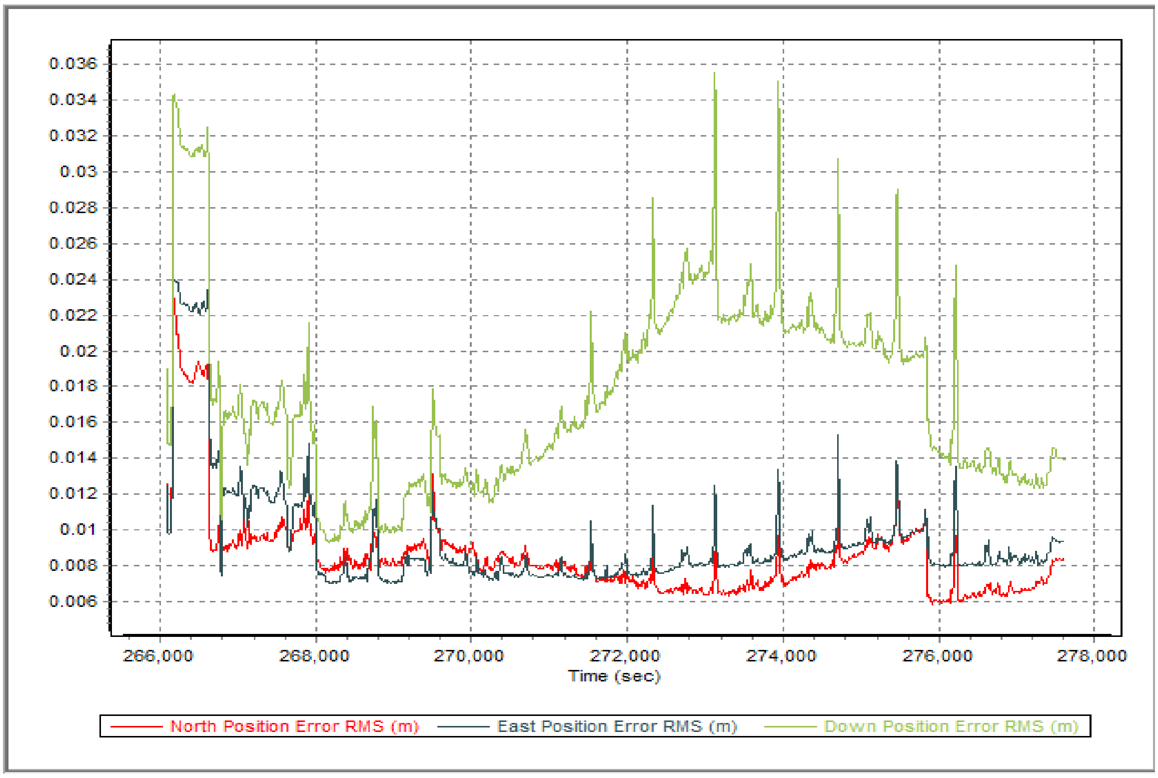


Figure 1.10.2. Smoothed Performance Metric Parameters

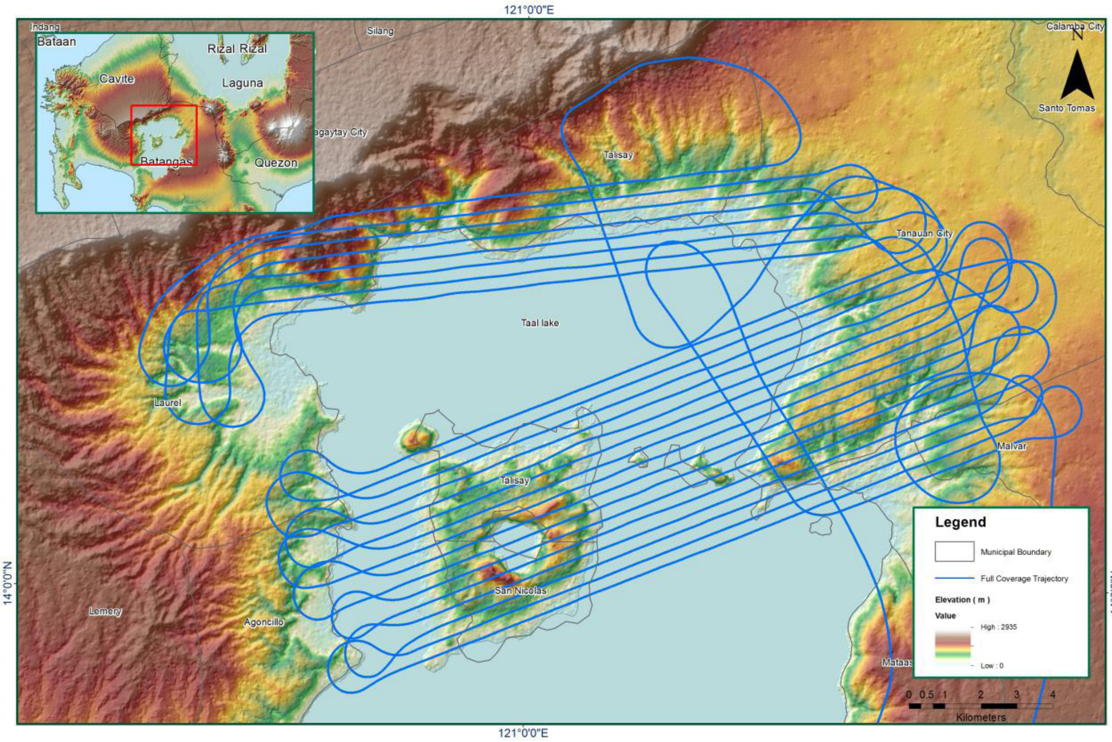


Figure 1.10.3. Best Estimate Trajectory

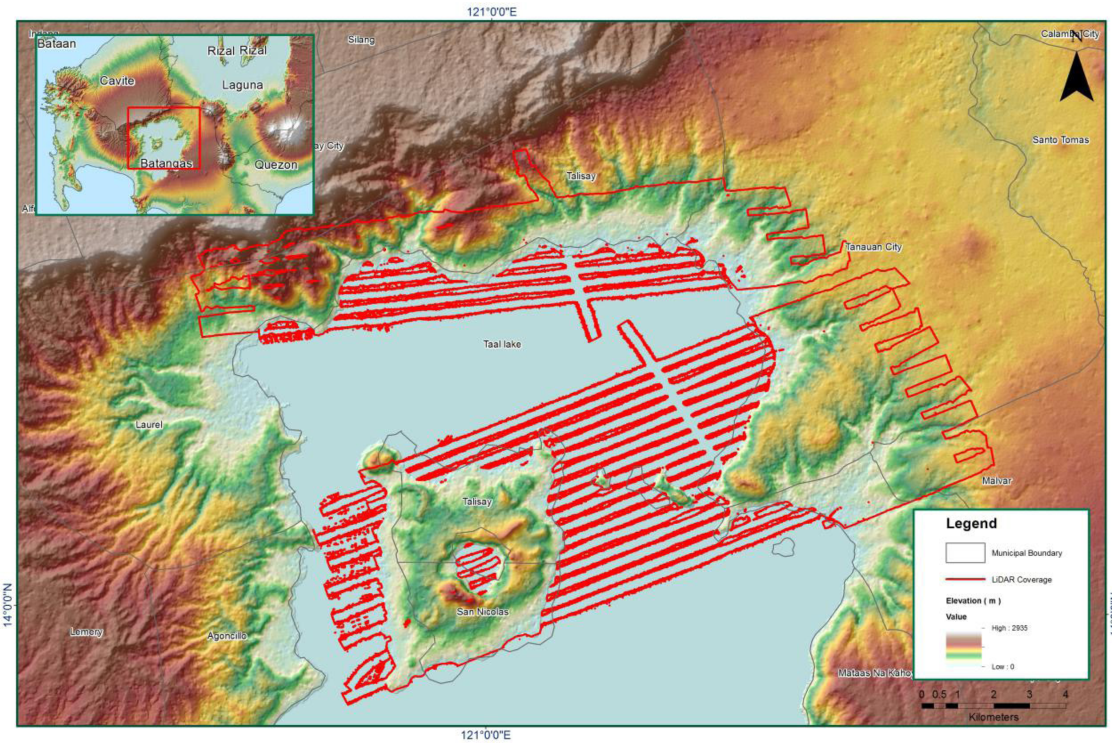


Figure 1.10.4. Coverage of LiDAR data

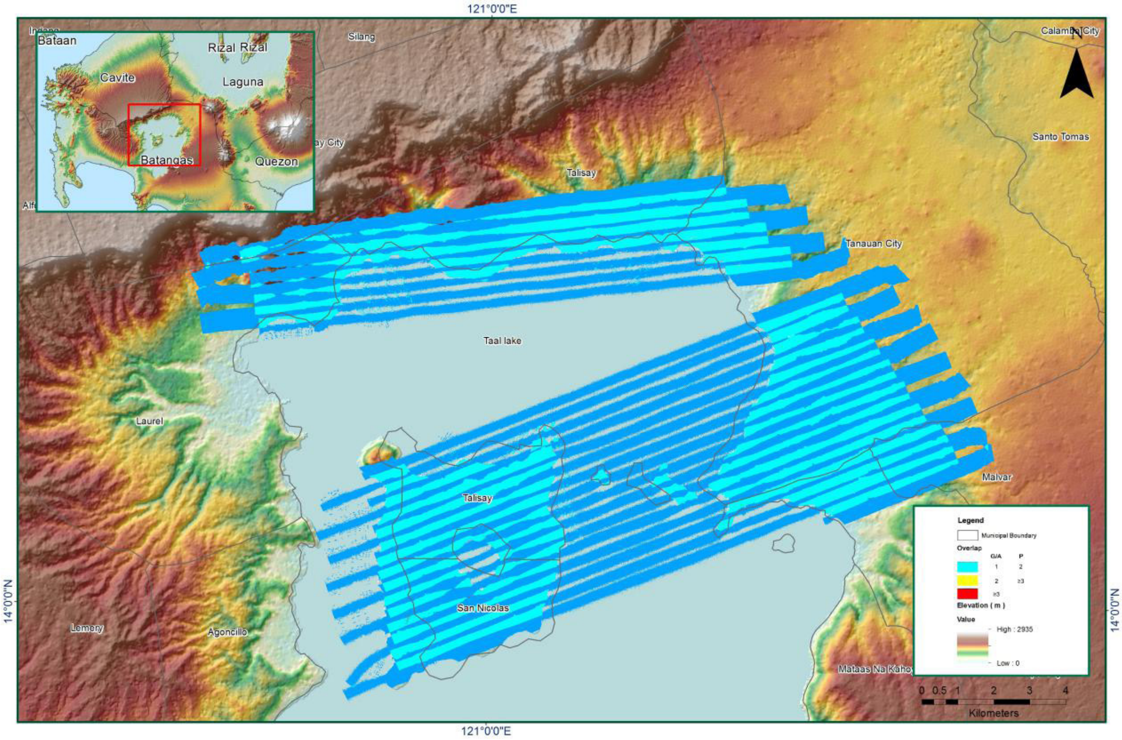


Figure 1.10.5. Image of data overlap

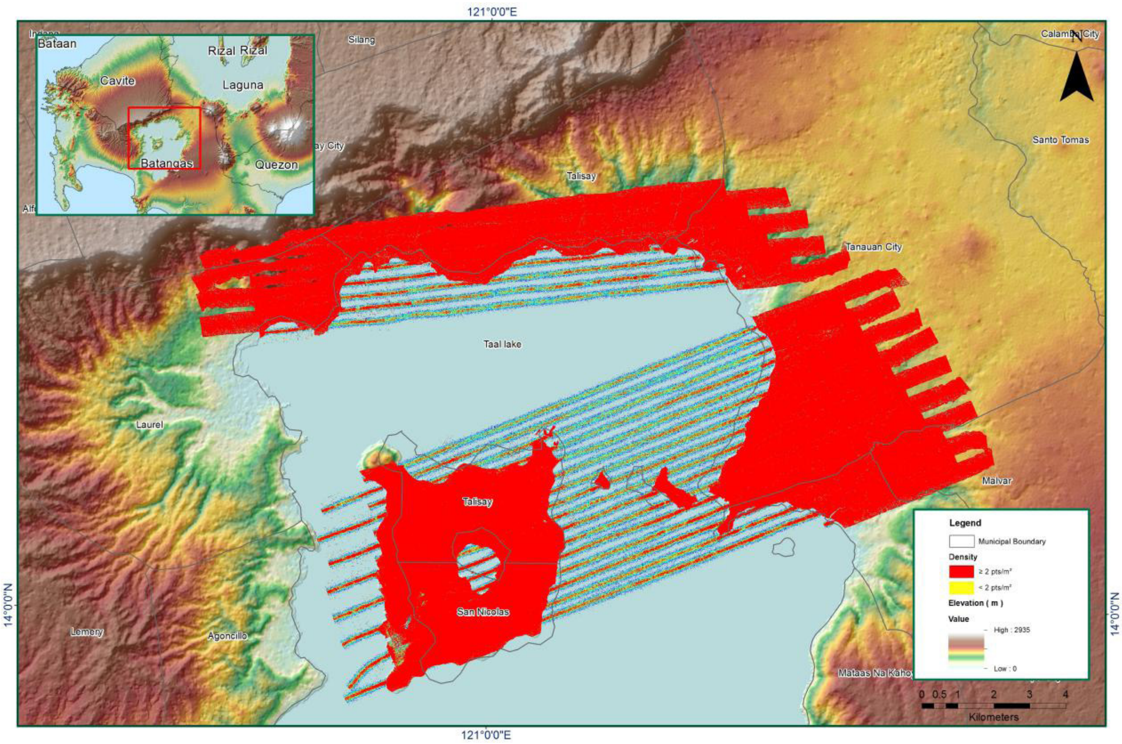


Figure 1.10.6. Density Map of merged LiDAR data

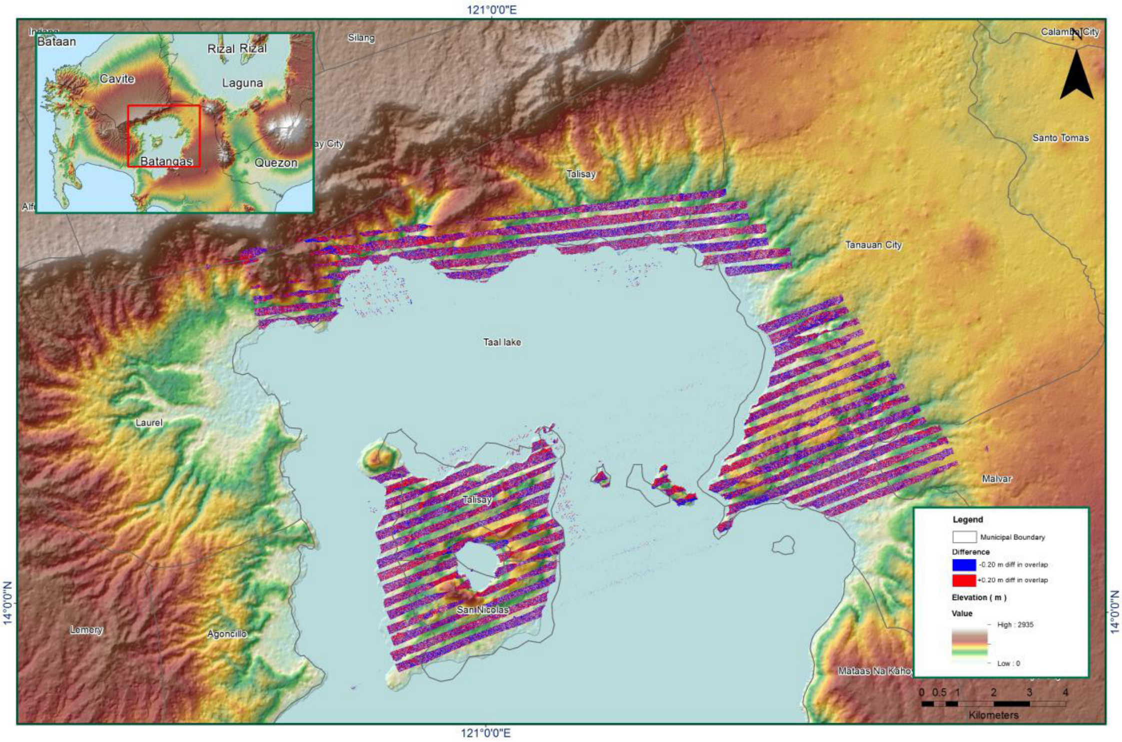


Figure 1.10.7. Elevation Difference Between flight lines

Flight Area	**Batangas**
Mission Name	**Blk18_SK_supplement**
Inclusive Flights	3691G
Range data size	6.93 GB
Base data size	12.9 MB
POS	124 MB
Image	NA
Transfer date	January 15, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.037
RMSE for East Position (<4.0 cm)	1.268
RMSE for Down Position (<8.0 cm)	3.76
Boresight correction stdev (<0.001deg)	0.004743
IMU attitude correction stdev (<0.001deg)	0.006199
GPS position stdev (<0.01m)	0.0025
Minimum % overlap (>25)	26.74%
Ave point cloud density per sq.m. (>2.0)	5.65
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	35
Maximum Height	734.44 m
Minimum Height	49.14 m
Classification (# of points)	
Ground	7,168,271
Low vegetation	2,764,694
Medium vegetation	13,456,626
High vegetation	54,931,225
Building	878,864
Orthophoto	No
Processed by	Engr. Sheila-Maye Santillan, Engr. Edgardo Gubatanga, Jr., Alex John Escobido

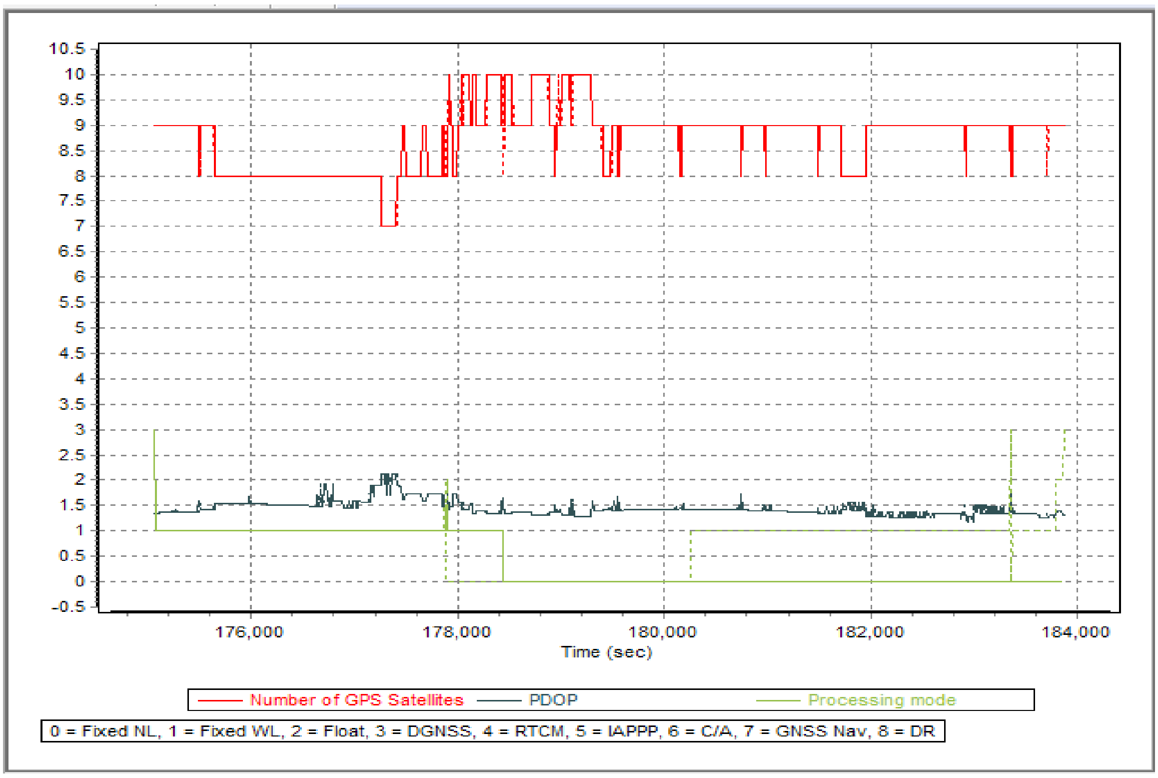


Figure 1.11.1. Solution Status

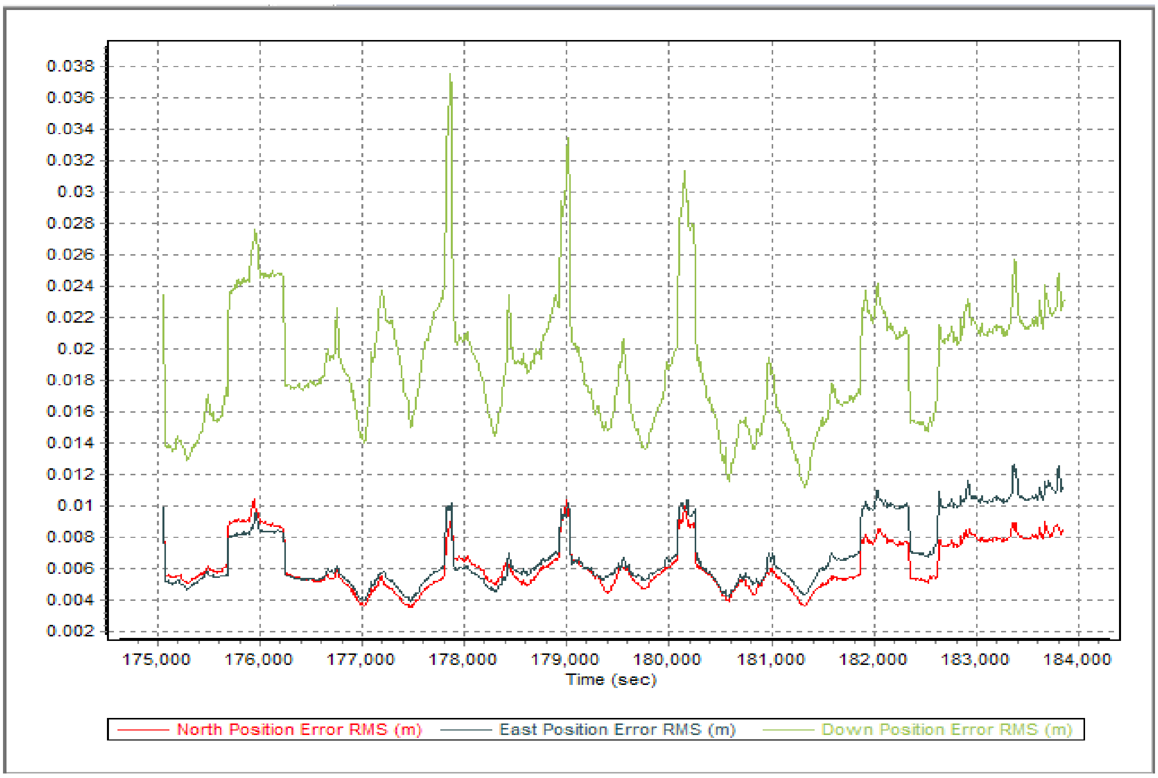


Figure 1.11.2. Smoothed Performance Metric Parameters

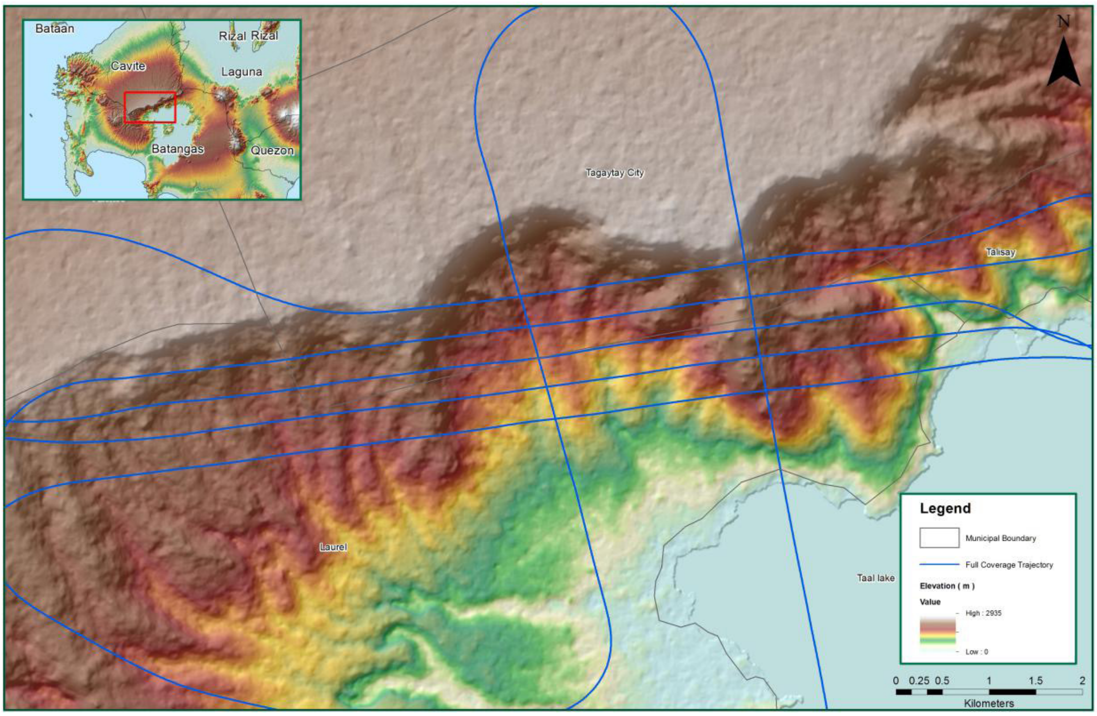


Figure 1.11.3. Best Estimate Trajectory

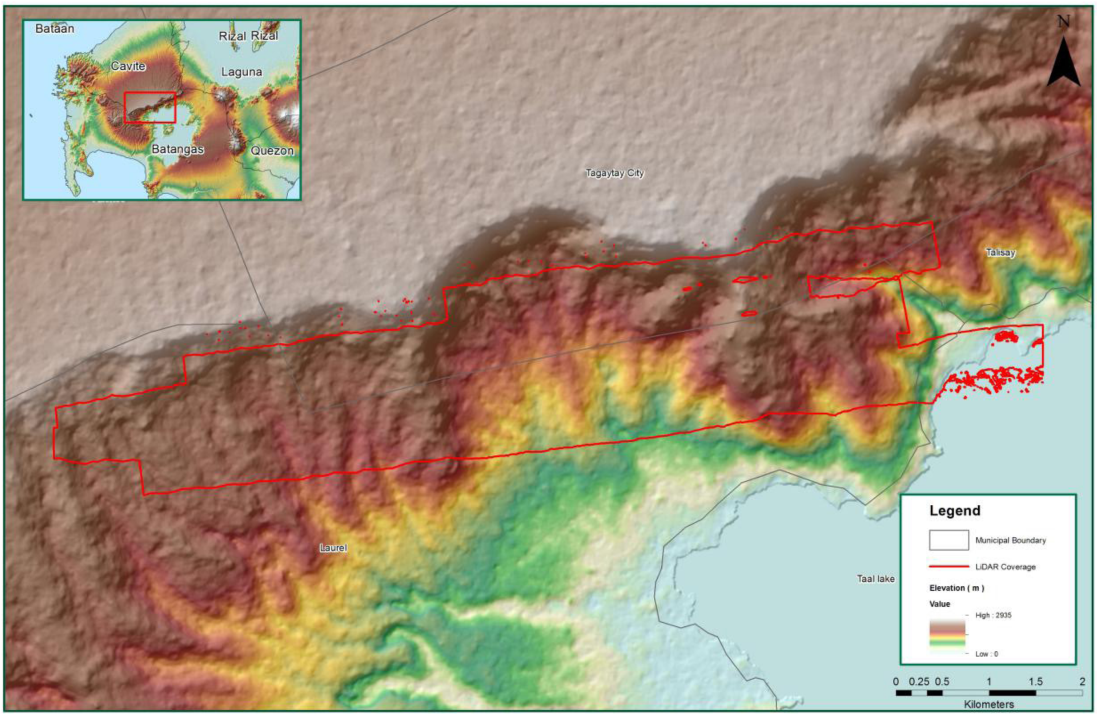


Figure 1.11.4. Coverage of LiDAR data

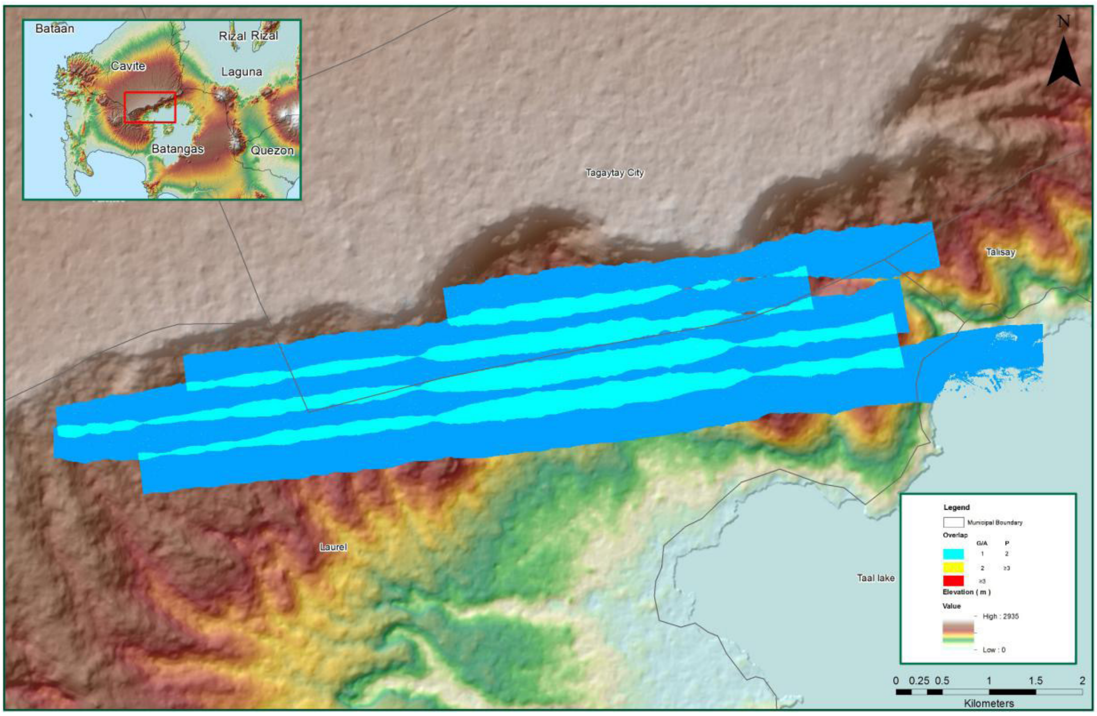


Figure 1.11.5. Image of data overlap

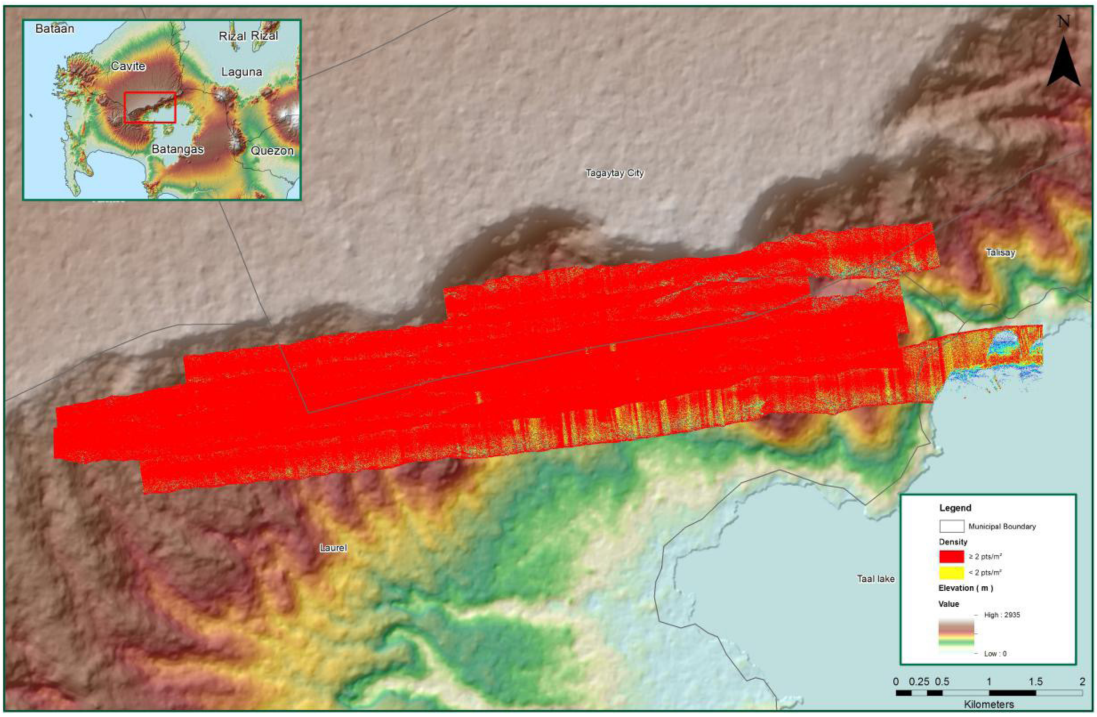


Figure 1.11.6. Density Map of merged LiDAR data

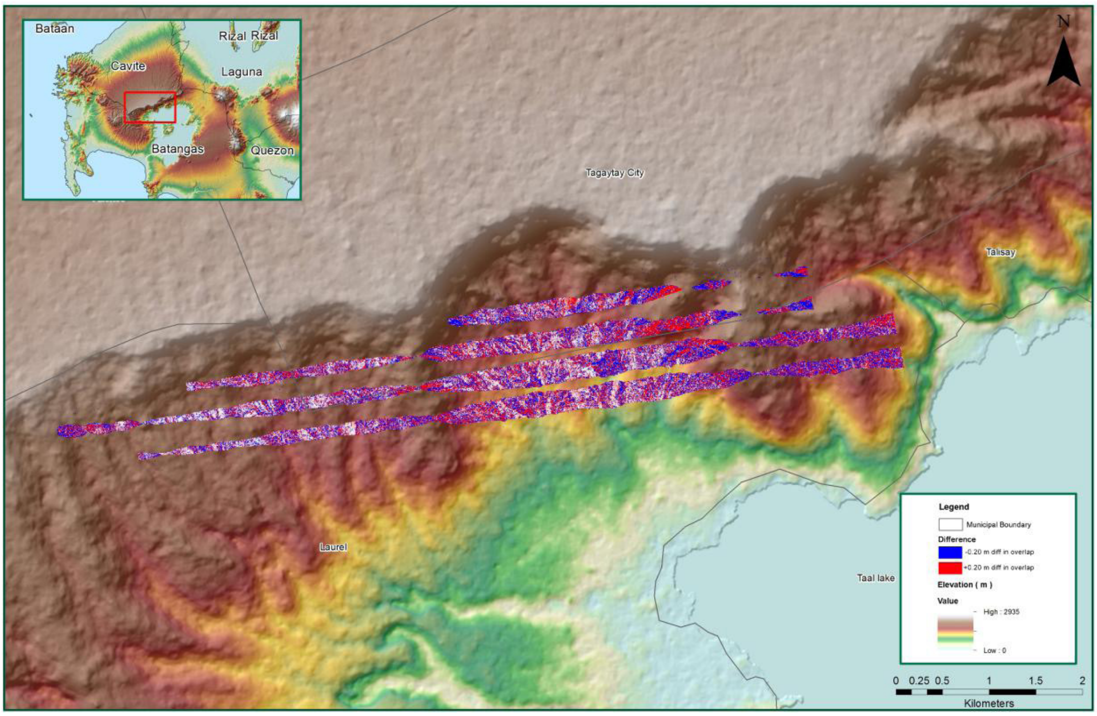


Figure 1.11.7. Elevation Difference Between flight lines

Flight Area	**BATANGAS**
Mission Name	**Blk18X**
Inclusive Flights	1137P
Range data size	21.0 GB
Base data size	6.71 MB
POS	238 MB
Image	29.3 GB
Transfer date	04/23/2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.0
RMSE for East Position (<4.0 cm)	1.3
RMSE for Down Position (<8.0 cm)	5.0
Boresight correction stdev (<0.001deg)	0.000588
IMU attitude correction stdev (<0.001deg)	0.003259
GPS position stdev (<0.01m)	0.0030
Minimum % overlap (>25)	30.34%
Ave point cloud density per sq.m. (>2.0)	2.10
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	248
Maximum Height	
Minimum Height	30.39 m
	338.28 m
Classification (# of points)	
Ground	152,060,482
Low vegetation	125,728,402
Medium vegetation	130,120,793
High vegetation	115,395,158
Building	17,658,970
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Melanie Hingpit, Engr. Gladys Mae Apat

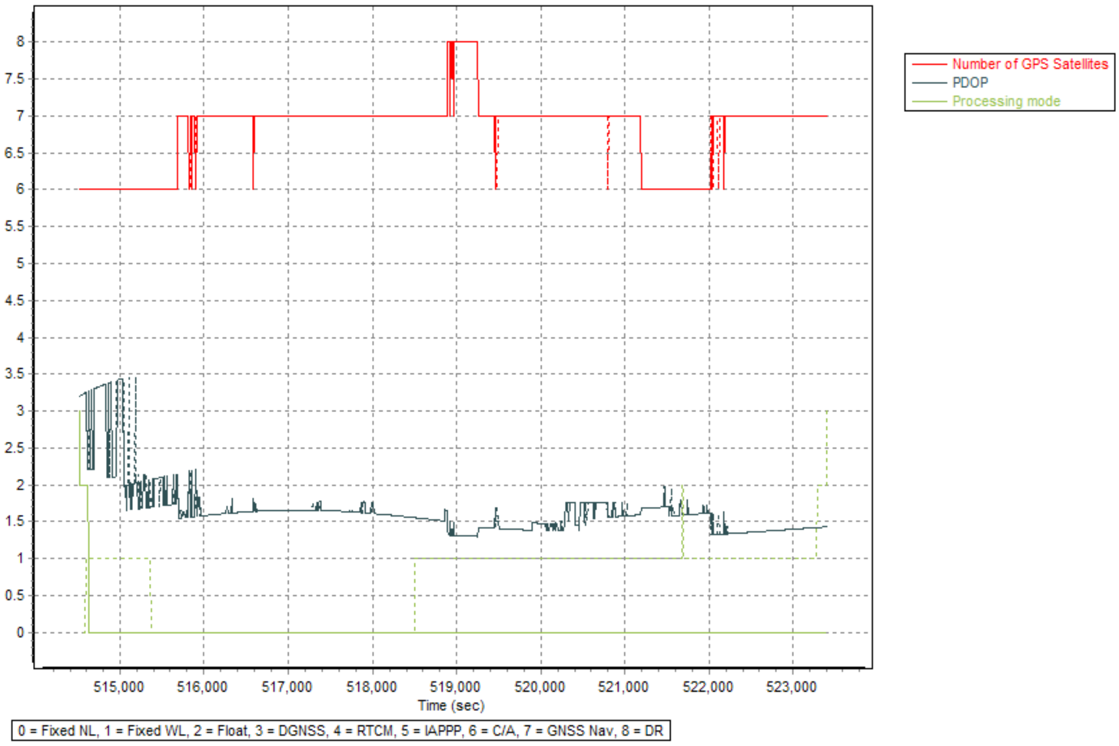


Figure 1.12.1. Solution Status

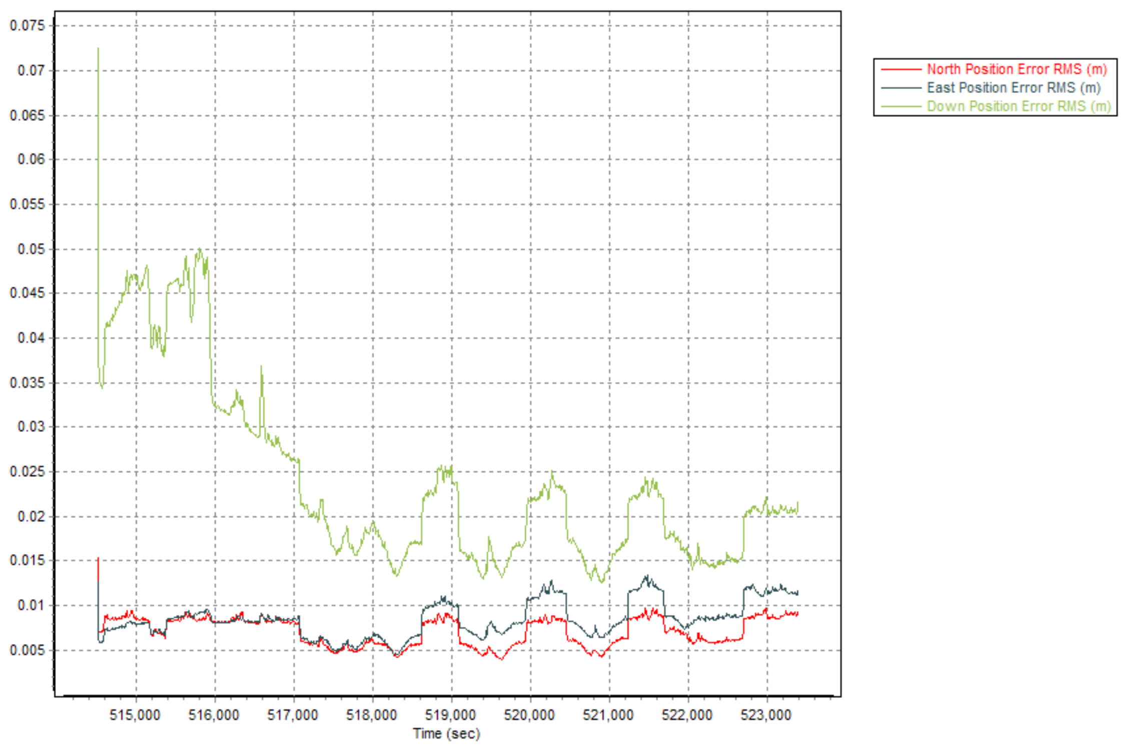


Figure 1.12.2. Smoothed Performance Metrics Parameters

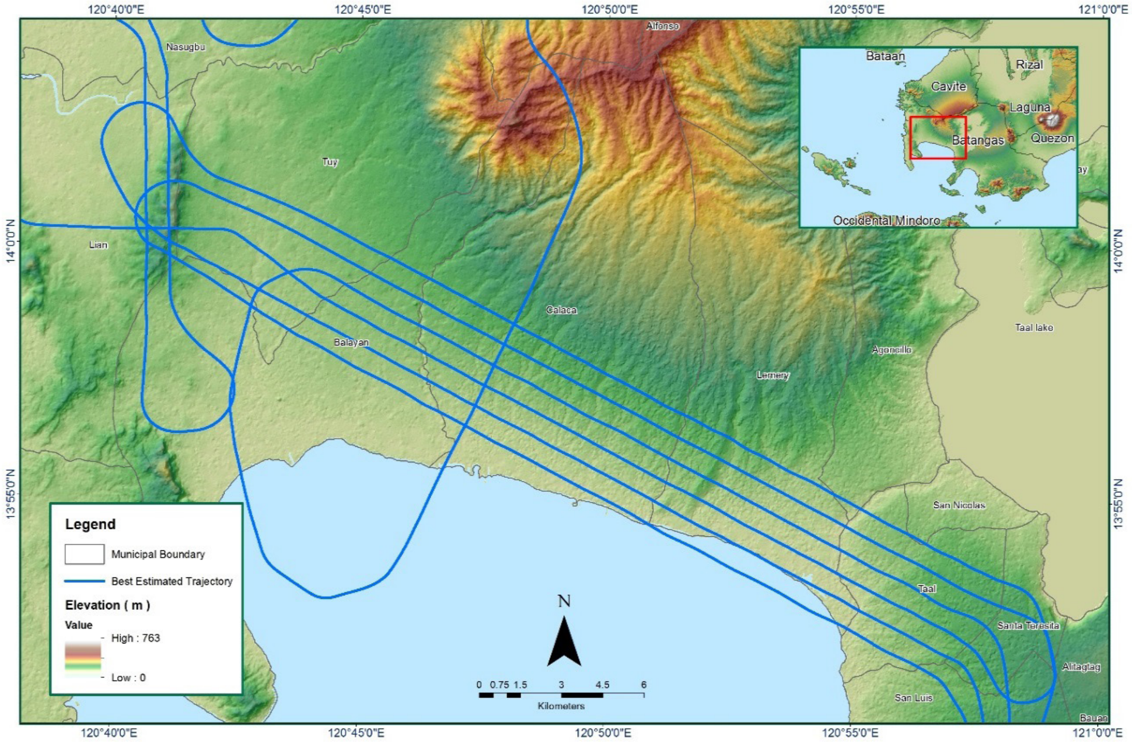


Figure 1.12.3. Best Estimated Trajectory

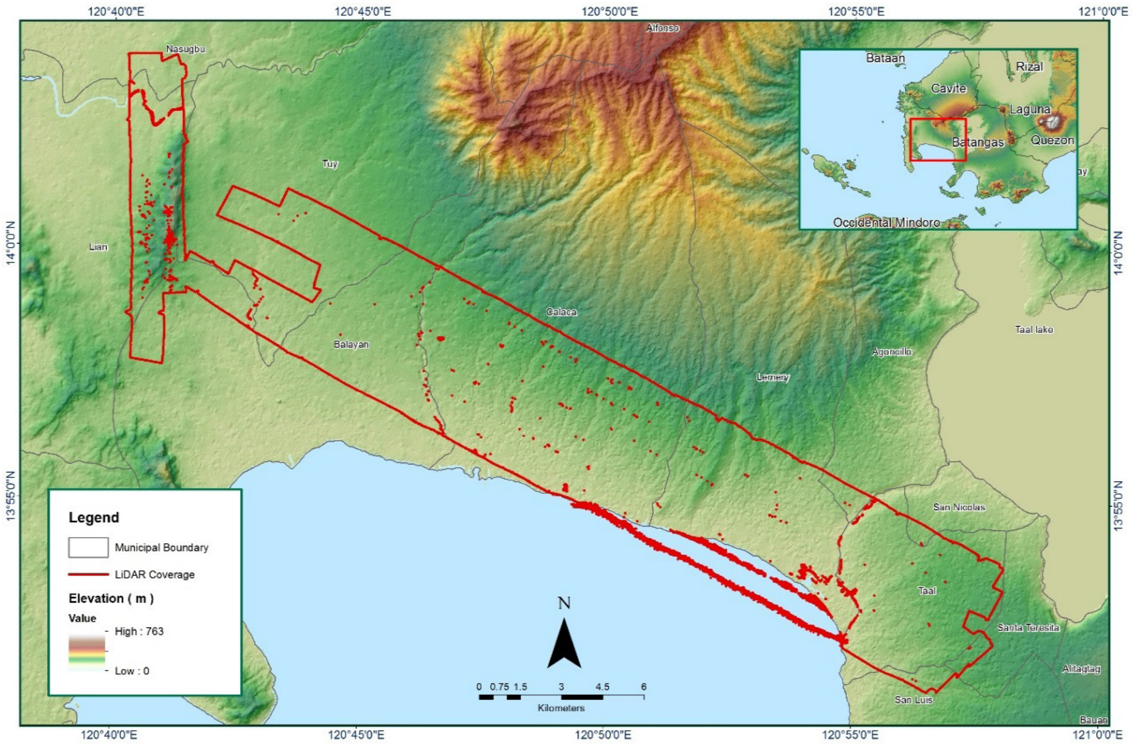


Figure 1.12.4. Coverage of LiDAR data

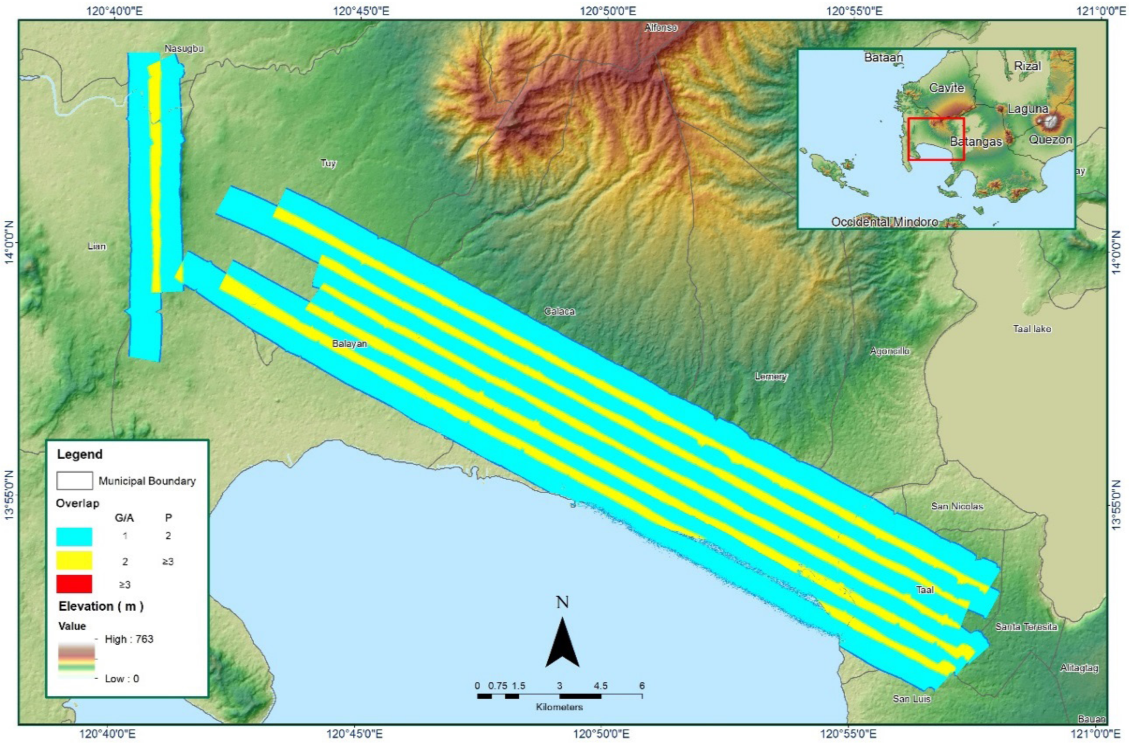


Figure 1.12.5. Image of data overlap

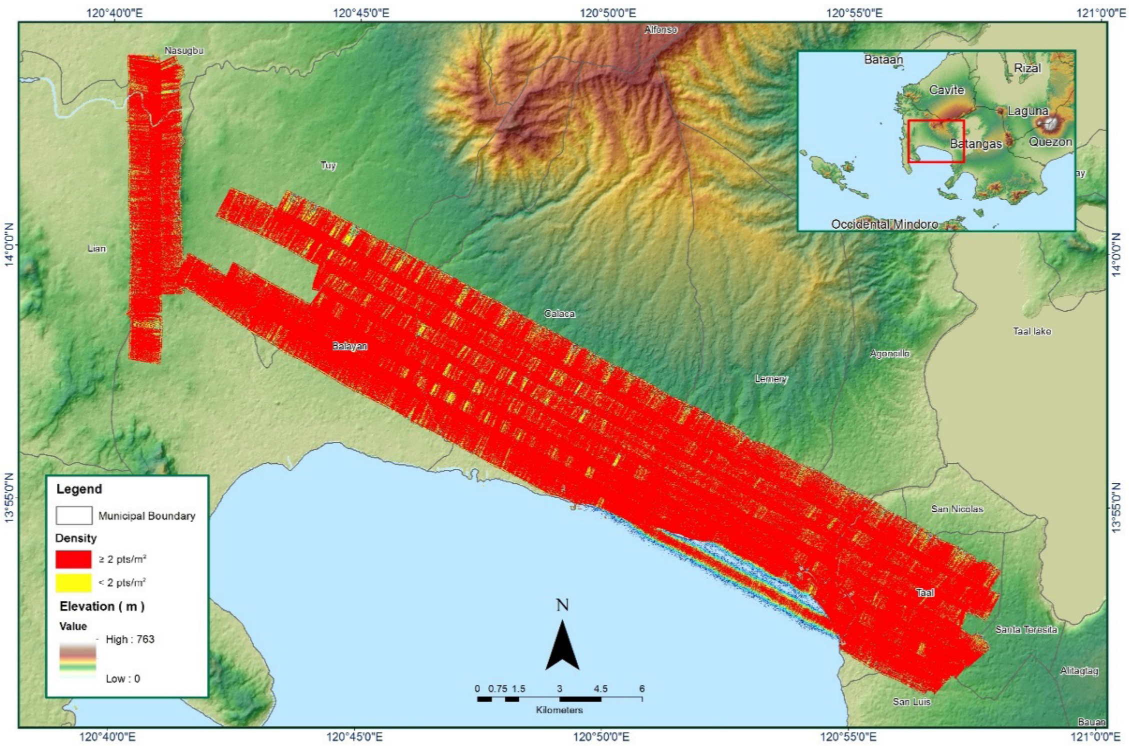


Figure 1.12.6. Density map of merged LiDAR data

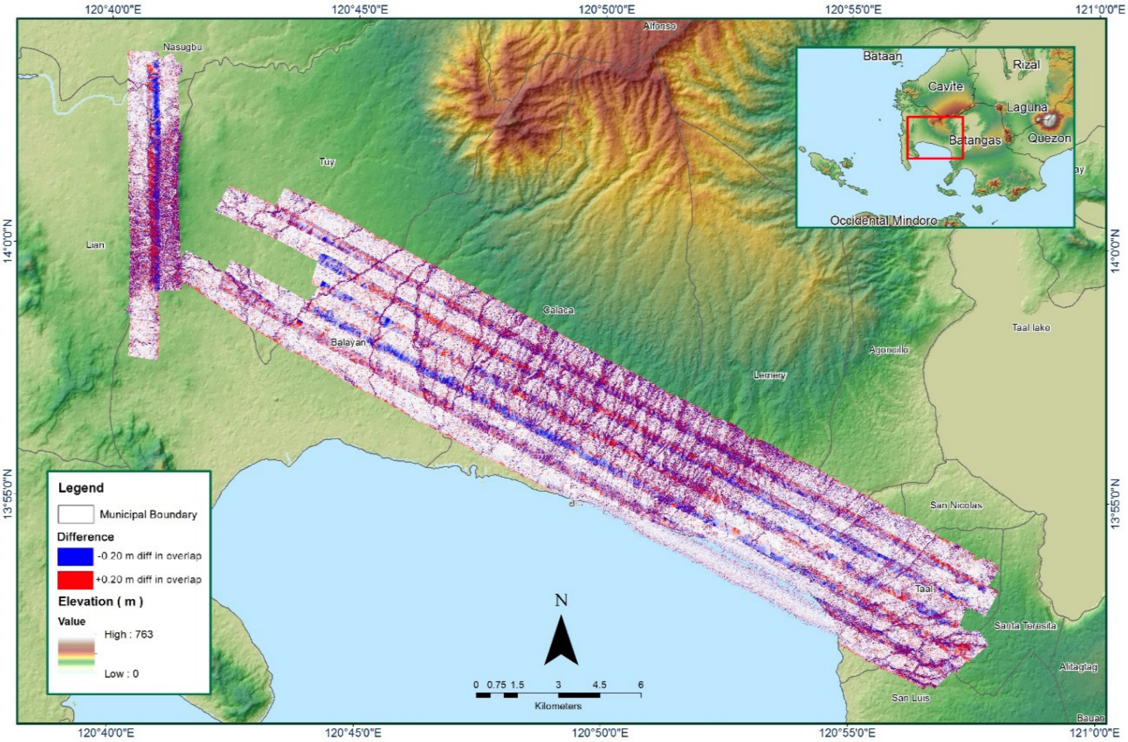


Figure 1.12.7. Elevation difference between flight lines

Annex 9. Pansipit Model Basin Parameters

Table A-8.1. Pansipit 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
W1000	1.8519	33.5	0	0.51888	1.2391	Discharge	0.2054	0.99934	Ratio to Peak	0.5
W1010	1.0636	42.1055	0	4.4295	3.2181	Discharge	0.049315	0.6681	Ratio to Peak	0.22409
W1020	2.7621	37.558	0	3.6092	3.9983	Discharge	0.12748	0.66667	Ratio to Peak	0.32504
W520	3.7421	60.246	0	6.3118	4.0371	Discharge	0.006493	0.20413	Ratio to Peak	0.32013
W530	4.7753	32.0245	0	1.7121	3.8827	Discharge	0.15087	0.82518	Ratio to Peak	0.4706
W540	2.6189	38.188	0	5.7169	2.6418	Discharge	0.17633	0.8232	Ratio to Peak	0.47541
W550	1.525	39.1945	0	5.0951	2.441	Discharge	0.21515	0.94755	Ratio to Peak	0.4694
W560	1.5565	39.02	0	4.9978	2.3936	Discharge	0.15057	0.98	Ratio to Peak	0.46825
W570	2.3362	39.054	0	0.56889	2.0608	Discharge	0.04897	0.11833	Ratio to Peak	0.41507
W580	1.5597	39.0025	0	5.8945	1.9258	Discharge	0.18753	0.9916	Ratio to Peak	0.5
W590	3.0127	36.729	0	1.0809	2.7133	Discharge	0.089398	0.17009	Ratio to Peak	0.57647
W600	5.4661	35.0055	0	1.2712	4.6352	Discharge	0.041552	0.97498	Ratio to Peak	0.43406
W610	1.2509	40.9655	0	1.2177	1.9555	Discharge	0.15397	0.93044	Ratio to Peak	0.33092
W620	4.9927	31.4525	0	6.0115	2.8347	Discharge	0.12067	0.44177	Ratio to Peak	0.45762
W630	4.4364	36.861	0	5.5617	2.6252	Discharge	0.1971	0.99865	Ratio to Peak	0.5

W640	2.373	34.9895	0	5.8637	1.8384	Discharge	0.16089	0.70091	Ratio to Peak	0.48075
W650	2.1482	31.829	0	5.9261	1.6877	Discharge	0.39244	0.99863	Ratio to Peak	0.5
W660	3.2449	36.2455	0	2.1369	3.6671	Discharge	0.079847	1	Ratio to Peak	0.44292
W670	0.77159	43.8795	0	0.49326	0.2574	Discharge	0.091743	0.67827	Ratio to Peak	0.5
W680	6.2782	33.235	0	4.9011	2.3114	Discharge	0.10202	0.64317	Ratio to Peak	0.48136
W690	5.2879	30.2975	0	5.0217	3.5366	Discharge	0.96938	0.9545	Ratio to Peak	0.5
W700	1.7129	38.178	0	0.84144	2.9081	Discharge	0.3231	0.9787	Ratio to Peak	0.5
W710	5.2611	35.144	0	5.1999	3.66	Discharge	0.037508	1	Ratio to Peak	0.5
W720	5.945	24.411	0	5.9116	3.7633	Discharge	0.65871	0.96698	Ratio to Peak	0.5
W730	2.5226	38.161	0	0.14407	0.15675	Discharge	0.21091	0.97083	Ratio to Peak	0.5
W740	1.6308	34.8825	0	5.0807	2.3445	Discharge	0.56353	0.97605	Ratio to Peak	0.5
W750	3.0525	40.343	0	5.3674	4.3914	Discharge	0.12623	0.92376	Ratio to Peak	0.57327
W760	1.6579	38.4695	0	2.1119	2.4993	Discharge	0.18398	0.98319	Ratio to Peak	0.5
W770	1.9947	36.7485	0	5.884	2.5509	Discharge	0.095743	0.94224	Ratio to Peak	0.4802
W780	2.4419	38.888	0	6.8677	2.2041	Discharge	0.33082	0.98328	Ratio to Peak	0.5
W790	2.9263	37.2515	0	5.5374	5.3169	Discharge	0.013035	0.93543	Ratio to Peak	0.37694
W800	5.7118	29.7895	0	6.3747	3.2096	Discharge	0.52917	0.99	Ratio to Peak	0.5
W810	2.383	38.668	0	6.025	2.8497	Discharge	0.20652	0.9957	Ratio to Peak	0.5
W820	23.459	17.561	0	27.669	45.156	Discharge	0.12629	0.97862	Ratio to Peak	0.5
W830	2.2739	42.34	0	6.3661	3.2053	Discharge	0.5976	0.99831	Ratio to Peak	0.5
W840	5.138	35.6385	0	6.4347	2.204	Discharge	0.18813	0.99891	Ratio to Peak	0.5
W850	3.0251	39.9015	0	5.5668	2.7361	Discharge	0.12711	0.99073	Ratio to Peak	0.5
W860	4.9103	31.757	0	6.4904	16.292	Discharge	0.17934	1	Ratio to Peak	0.5
W870	4.8313	31.9375	0	7.1285	3.5891	Discharge	0.11441	1	Ratio to Peak	0.5
W880	14.451	23.388	0	13.675	22.318	Discharge	0.10086	1	Ratio to Peak	0.5

W890	4.9976	30.9675	0	5.8701	2.7018	Discharge	0.18809	0.99942	Ratio to Peak	0.5
W900	3.8123	34.5825	0	7.3946	12.566	Discharge	7.39E-05	0.6515	Ratio to Peak	0.5
W910	15.468	22.543	0	10.131	16.534	Discharge	0.000267	0.65147	Ratio to Peak	0.5
W920	6.3809	28.631	0	6.2422	10.607	Discharge	0.10849	1	Ratio to Peak	0.5
W930	4.5862	32.5415	0	7.2291	5.4597	Discharge	0.067968	1	Ratio to Peak	0.57212
W940	2.3045	31.0095	0	1.3	2.1217	Discharge	0.1756	1	Ratio to Peak	0.5
W950	4.3285	32.9015	0	5.8782	2.7596	Discharge	0.2409	1	Ratio to Peak	0.5
W960	1.8533	37.686	0	1.0091	2.2769	Discharge	0.14448	0.99073	Ratio to Peak	0.49
W970	5.1707	30.668	0	5.7784	2.4684	Discharge	0.10623	1	Ratio to Peak	0.5
W980	2.5037	30	0	6.5424	2.1439	Discharge	0.093214	1	Ratio to Peak	0.5
W990	3.7673	38.4615	0	2.4552	2.8382	Discharge	0.022903	0.024483	Ratio to Peak	0.50692

Annex 10. Pansipit Model Reach Parameters

Table A-9.1. Pansipit Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R100	Automatic Fixed Interval	1158.4	0.008591	0.00063	Trapezoid	30	1
R110	Automatic Fixed Interval	1998.1	0.00917	0.000627	Trapezoid	30	1
R140	Automatic Fixed Interval	1456.6	0.004	0.000427	Trapezoid	30	1
R190	Automatic Fixed Interval	670.83	0.001882	0.000922	Trapezoid	30	1
R230	Automatic Fixed Interval	3405.6	0.001156	0.000922	Trapezoid	30	1
R240	Automatic Fixed Interval	4883.8	0.018158	0.000427	Trapezoid	30	1
R250	Automatic Fixed Interval	1844.4	0.004	0.000627	Trapezoid	30	1
R260	Automatic Fixed Interval	4863.4	0.003563	0.000642	Trapezoid	30	1
R270	Automatic Fixed Interval	678.82	0.004	0.000627	Trapezoid	30	1
R290	Automatic Fixed Interval	905.1	0.004	0.000922	Trapezoid	30	1
R30	Automatic Fixed Interval	3845.8	0.004752	0.000917	Trapezoid	30	1
R340	Automatic Fixed Interval	1371.8	0.004	0.000427	Trapezoid	30	1
R360	Automatic Fixed Interval	7803.5	0.004	0.000922	Trapezoid	30	1
R370	Automatic Fixed Interval	6038.7	0.004	0.00029	Trapezoid	30	1
R390	Automatic Fixed Interval	10438	0.004	0.000427	Trapezoid	30	1
R400	Automatic Fixed Interval	1937.5	0.004	0.000627	Trapezoid	30	1
R420	Automatic Fixed Interval	4902.8	0.002889	0.00029	Trapezoid	30	1
R430	Automatic Fixed Interval	1315.2	0.004	0.000922	Trapezoid	30	1
R450	Automatic Fixed Interval	1527.4	0.004	0.000627	Trapezoid	30	1

R460	Automatic Fixed Interval	1637.1	0.004263	0.00029	Trapezoid	30	1
R470	Automatic Fixed Interval	155.56	0.05129	0.000198	Trapezoid	30	1
R480	Automatic Fixed Interval	497.49	0.004	0.00029	Trapezoid	30	1
R490	Automatic Fixed Interval	4474	0.004	0.003382	Trapezoid	30	1
R70	Automatic Fixed Interval	1216.2	0.004	0.000427	Trapezoid	30	1
R90	Automatic Fixed Interval	3648.7	0.004	0.00029	Trapezoid	30	1

Annex 11. Pansipit Field Validation Points

Table A-10.1. Pansipit Field Validation Points

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
1	13.923184	120.957407	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
2	13.907810	120.928171	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
3	13.908430	120.927897	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
4	13.908828	120.927368	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
5	13.909260	120.927218	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
6	13.909557	120.927031	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
7	13.920701	120.958668	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
8	13.920857	120.958627	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
9	13.921325	120.958365	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
10	13.921620	120.960327	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
11	13.921665	120.958186	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
12	13.932184	120.928559	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
13	13.932476	120.928524	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
14	13.908294	120.888586	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
15	13.908388	120.888483	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
16	13.908896	120.891313	0.38	0	0.1444	Typhoon Glenda/ July 19,2014	5-Year
17	13.908965	120.891599	0.24	0	0.0576	Typhoon Glenda/ July 19,2014	5-Year
18	13.872611	120.913783	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
19	13.908463	120.960855	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
20	13.933912	120.940212	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
21	13.933958	120.938246	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
22	13.934016	120.938732	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
23	13.934096	120.939527	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year

24	13.909476	120.926518	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
25	13.909570	120.925742	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
26	13.920823	120.963561	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
27	13.909432	120.960313	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
28	13.911117	120.960382	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
29	13.911505	120.961310	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
30	13.911812	120.961941	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
31	13.913173	120.878311	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
32	13.915040	120.878645	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
33	13.920878	120.878961	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
34	13.921569	120.879321	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
35	13.911297	120.883328	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
36	13.911741	120.882475	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
37	13.911980	120.881976	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
38	13.912102	120.881551	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
39	13.913210	120.878527	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
40	13.923277	120.880170	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
41	13.907960	120.889259	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
42	13.931790	120.948087	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
43	13.932342	120.947812	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
44	13.933106	120.947518	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
45	13.923833	120.950253	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
46	13.932941	120.928447	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
47	13.933703	120.927618	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
48	13.933815	120.928943	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
49	13.933838	120.929428	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year

50	13.933839	120.927819	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
51	13.933624	120.941397	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
52	13.933634	120.940908	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
53	13.933859	120.947218	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
54	13.935054	120.943481	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
55	13.914967	120.938594	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
56	13.921604	120.962681	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
57	13.921726	120.960661	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
58	13.921860	120.960961	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
59	13.920980	120.946541	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
60	13.921300	120.946997	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
61	13.923377	120.949655	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
62	13.873170	120.913788	0.03	0	0.0009	Typhoon Glenda/ July 19,2014	5-Year
63	13.923384	120.957287	0.03	0.2	0.0289	Typhoon Glenda/ July 19,2014	5-Year
64	13.925235	120.956370	0.03	0.2	0.0289	Typhoon Glenda/ July 19,2014	5-Year
65	13.896090	120.906013	0.03	0.2	0.0289	Typhoon Glenda/ July 19,2014	5-Year
66	13.896907	120.904685	0.03	0.2	0.0289	Typhoon Glenda/ July 19,2014	5-Year
67	13.890527	120.911227	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
68	13.890912	120.911521	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
69	13.890945	120.911567	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
70	13.904399	120.880396	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
71	13.874840	120.915244	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
72	13.887568	120.911147	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
73	13.889008	120.910298	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
74	13.889206	120.910078	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
75	13.889645	120.910223	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year

76	13.889897	120.910799	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
77	13.879590	120.914519	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
78	13.879837	120.914972	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
79	13.880142	120.914765	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
80	13.880514	120.914616	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
81	13.882063	120.913577	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
82	13.883257	120.912151	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
83	13.897622	120.891668	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
84	13.897997	120.890726	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
85	13.879729	120.919224	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
86	13.880248	120.919685	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
87	13.881445	120.919714	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
88	13.881811	120.919687	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
89	13.882001	120.919558	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
90	13.882051	120.919579	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
91	13.875543	120.913148	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
92	13.882644	120.909066	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
93	13.882807	120.909292	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
94	13.882840	120.909422	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
95	13.883002	120.907904	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
96	13.883848	120.909329	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
97	13.874082	120.913555	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
98	13.874599	120.914398	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
99	13.874711	120.913137	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
100	13.874748	120.913495	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
101	13.874921	120.913967	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year

102	13.875045	120.914387	0.03	0.25	0.0484	Typhoon Glenda/ July 19,2014	5-Year
103	13.905902	120.910648	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
104	13.903458	120.877699	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
105	13.903464	120.877980	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
106	13.903735	120.876877	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
107	13.903840	120.875837	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
108	13.903932	120.875271	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
109	13.904629	120.880915	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
110	13.907303	120.886017	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
111	13.924409	120.960133	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
112	13.906877	120.894015	0.36	0.5	0.0196	Typhoon Glenda/ July 19,2014	5-Year
113	13.906960	120.893609	0.45	0.5	0.0025	Typhoon Glenda/ July 19,2014	5-Year
114	13.908247	120.894944	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
115	13.908405	120.894865	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
116	13.910265	120.894288	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
117	13.910457	120.894385	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
118	13.910791	120.894284	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
119	13.872804	120.917661	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
120	13.872821	120.917743	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
121	13.872844	120.918179	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
122	13.873371	120.917228	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
123	13.876267	120.914996	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
124	13.877964	120.914872	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
125	13.881919	120.918690	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
126	13.890104	120.909528	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
127	13.879750	120.913727	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year

128	13.877495	120.912143	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
129	13.898223	120.891103	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
130	13.899855	120.901011	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
131	13.900679	120.900610	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
132	13.901261	120.902539	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
133	13.907085	120.892832	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
134	13.892192	120.908254	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
135	13.893892	120.907359	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
136	13.926104	120.953975	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
137	13.890680	120.909196	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
138	13.906517	120.895665	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
139	13.906650	120.895070	0.06	0.5	0.1936	Typhoon Glenda/ July 19,2014	5-Year
140	13.906657	120.895752	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
141	13.906761	120.894619	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
142	13.907952	120.895131	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
143	13.908110	120.895063	0.03	0.5	0.2209	Typhoon Glenda/ July 19,2014	5-Year
144	13.924534	120.956702	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
145	13.903464	120.878074	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
146	13.903587	120.878438	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
147	13.881917	120.918630	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
148	13.881951	120.918884	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
149	13.879523	120.914549	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
150	13.879600	120.914996	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
151	13.880095	120.914416	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
152	13.880237	120.914686	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
153	13.921154	120.963182	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year

154	13.877401	120.912088	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
155	13.877768	120.911972	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
156	13.877948	120.912283	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
157	13.878531	120.913348	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
158	13.897934	120.891354	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
159	13.898111	120.890867	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
160	13.901452	120.902967	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
161	13.892820	120.907926	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
162	13.893743	120.907395	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
163	13.925985	120.953874	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
164	13.926284	120.954425	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
165	13.926531	120.954915	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
166	13.875787	120.917045	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
167	13.875856	120.916526	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
168	13.875929	120.917594	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
169	13.876722	120.917479	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
170	13.877321	120.917415	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
171	13.875026	120.917567	0.03	0.6	0.3249	Typhoon Glenda/ July 19,2014	5-Year
172	13.924651	120.960180	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
173	13.924893	120.959778	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
174	13.897112	120.912197	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
175	13.897573	120.912161	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
176	13.898037	120.912135	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
177	13.904132	120.879778	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
178	13.912755	120.893534	0.09	1	0.8281	Typhoon Glenda/ July 19,2014	5-Year
179	13.913062	120.893374	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year

180	13.872806	120.918037	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
181	13.914292	120.893469	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
182	13.914489	120.893416	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
183	13.914650	120.893395	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
184	13.914763	120.893585	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
185	13.914958	120.893621	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
186	13.915359	120.892312	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
187	13.903943	120.900848	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
188	13.904087	120.900672	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
189	13.904211	120.900379	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
190	13.913162	120.891314	0.56	1	0.1936	Typhoon Glenda/ July 19,2014	5-Year
191	13.913304	120.891409	0.55	1	0.2025	Typhoon Glenda/ July 19,2014	5-Year
192	13.896741	120.912224	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
193	13.875697	120.916142	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
194	13.875823	120.916222	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
195	13.875847	120.916059	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
196	13.875847	120.916196	0.03	1	0.9409	Typhoon Glenda/ July 19,2014	5-Year
197	13.924872	120.958784	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
198	13.924923	120.958417	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
199	13.901660	120.911899	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
200	13.891576	120.908984	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
201	13.903393	120.877933	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
202	13.903459	120.877924	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
203	13.918180	120.969718	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
204	13.918405	120.969214	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
205	13.918428	120.969311	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year

206	13.897742	120.891599	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
207	13.897913	120.903429	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
208	13.901822	120.903054	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
209	13.891490	120.908959	0.03	1.5	2.1609	Typhoon Glenda/ July 19,2014	5-Year
210	13.897448	120.904015	0.03	1.7	2.7889	Typhoon Glenda/ July 19,2014	5-Year
211	13.881545	120.918396	0.03	2	3.8809	Typhoon Glenda/ July 19,2014	5-Year
212	13.881658	120.918351	0.03	2	3.8809	Typhoon Glenda/ July 19,2014	5-Year
213	13.881728	120.918324	0.03	2	3.8809	Typhoon Glenda/ July 19,2014	5-Year
214	13.882709	120.918702	0.03	2	3.8809	Typhoon Glenda/ July 19,2014	5-Year
215	13.900650	120.903933	0.03	2	3.8809	Typhoon Glenda/ July 19,2014	5-Year
216	13.900751	120.903852	0.03	2	3.8809	Typhoon Glenda/ July 19,2014	5-Year
217	13.900925	120.903747	0.03	2	3.8809	Typhoon Glenda/ July 19,2014	5-Year
218	13.901379	120.903420	0.03	2	3.8809	Typhoon Glenda/ July 19,2014	5-Year
219	13.903408	120.901572	0.03	2.5	6.1009	Typhoon Glenda/ July 19,2014	5-Year
220	13.903645	120.901275	0.03	2.5	6.1009	Typhoon Glenda/ July 19,2014	5-Year
221	13.903826	120.901060	0.03	2.5	6.1009	Typhoon Glenda/ July 19,2014	5-Year
222	13.911881	120.867195	2.82	2.5	0.1024	Typhoon Glenda/ July 19,2014	5-Year
223	13.912482	120.866412	3.57	2.5	1.1449	Typhoon Glenda/ July 19,2014	5-Year
224	13.913135	120.866542	3.3	2.5	0.64	Typhoon Glenda/ July 19,2014	5-Year
225	13.913194	120.866910	2.35	2.5	0.0225	Typhoon Glenda/ July 19,2014	5-Year
226	13.911901	120.866505	4.28	3	1.638401	Typhoon Glenda/ July 19,2014	5-Year
227	13.912037	120.866358	4.56	3	2.4336	Typhoon Glenda/ July 19,2014	5-Year
228	13.912061	120.868236	4.87	3	3.4969	Typhoon Glenda/ July 19,2014	5-Year
229	13.912750	120.866363	3.8	3	0.64	Typhoon Glenda/ July 19,2014	5-Year
230	13.913027	120.866207	4.03	3	1.0609	Typhoon Glenda/ July 19,2014	5-Year
231	13.911939	120.868260	3.27	4	0.5329	Typhoon Glenda/ July 19,2014	5-Year

232	13.912540	120.868842	5.8	4	3.240001	Typhoon Glenda/ July 19,2014	5-Year
233	13.912230	120.868458	5.45	5.5	0.0025	Typhoon Glenda/ July 19,2014	5-Year
234	13.912436	120.868126	4.01	5.5	2.220099	Typhoon Glenda/ July 19,2014	5-Year
235	13.912814	120.867972	5.71	5.5	0.0441	Typhoon Glenda/ July 19,2014	5-Year
236	13.913064	120.865990	5.98	5.5	0.2304	Typhoon Glenda/ July 19,2014	5-Year
237	13.913245	120.865954	6.8	5.5	1.69	Typhoon Glenda/ July 19,2014	5-Year
238	13.913915	120.866541	6.6	5.5	1.21	Typhoon Glenda/ July 19,2014	5-Year
239	13.914327	120.866541	5.94	5.5	0.1936	Typhoon Glenda/ July 19,2014	5-Year
240	13.914464	120.865901	6.7	5.5	1.44	Typhoon Glenda/ July 19,2014	5-Year
241	13.914541	120.866284	6.45	5.5	0.9025	Typhoon Glenda/ July 19,2014	5-Year
242	13.913020	120.868942	7.26	6	1.587601	Typhoon Glenda/ July 19,2014	5-Year
243	13.914019	120.869052	7.57	6	2.464901	Typhoon Glenda/ July 19,2014	5-Year
244	13.914956	120.869631	7.15	6	1.3225	Typhoon Glenda/ July 19,2014	5-Year
245	13.916260	120.870642	5.03	6	0.9409	Typhoon Glenda/ July 19,2014	5-Year
246	13.873967	120.913605	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
247	13.875680	120.916202	0.03	1.5	2.1609	Typhoon Yolanda/ Nov. 9,2013	5-Year
248	13.875757	120.915188	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
249	13.876820	120.912543	0.03	0.25	0.0484	Typhoon Yolanda/ Nov. 9,2013	5-Year
250	13.883362	120.908534	0.03	0.25	0.0484	Typhoon Yolanda/ Nov. 9,2013	5-Year
251	13.883487	120.911420	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
252	13.888433	120.910574	0.03	0.25	0.0484	Typhoon Yolanda/ Nov. 9,2013	5-Year
253	13.891510	120.909258	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
254	13.891526	120.909243	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
255	13.891558	120.909102	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
256	13.900177	120.900458	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
257	13.901967	120.902953	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year

258	13.902270	120.902709	0.03	1.5	2.1609	Typhoon Yolanda/ Nov. 9,2013	5-Year
259	13.902503	120.902569	0.03	1.5	2.1609	Typhoon Yolanda/ Nov. 9,2013	5-Year
260	13.903884	120.933776	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
261	13.904152	120.911627	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
262	13.904539	120.911432	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
263	13.905015	120.911168	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
264	13.905585	120.910849	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
265	13.905776	120.883226	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
266	13.906067	120.910388	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
267	13.906564	120.936171	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
268	13.906682	120.885347	0.03	6	35.6409	Typhoon Yolanda/ Nov. 9,2013	5-Year
269	13.906968	120.885587	0.03	6	35.6409	Typhoon Yolanda/ Nov. 9,2013	5-Year
270	13.907199	120.891193	0.43	0	0.1849	Typhoon Yolanda/ Nov. 9,2013	5-Year
271	13.907221	120.885819	0.03	6	35.6409	Typhoon Yolanda/ Nov. 9,2013	5-Year
272	13.908156	120.888884	0.03	2	3.8809	Typhoon Yolanda/ Nov. 9,2013	5-Year
273	13.908217	120.890572	0.91	2	1.1881	Typhoon Yolanda/ Nov. 9,2013	5-Year
274	13.908307	120.890895	0.89	0	0.7921	Typhoon Yolanda/ Nov. 9,2013	5-Year
275	13.908324	120.891020	0.72	0	0.5184	Typhoon Yolanda/ Nov. 9,2013	5-Year
276	13.908359	120.891170	0.55	0	0.3025	Typhoon Yolanda/ Nov. 9,2013	5-Year
277	13.908395	120.888337	0.03	2	3.8809	Typhoon Yolanda/ Nov. 9,2013	5-Year
278	13.908533	120.890570	0.78	2	1.4884	Typhoon Yolanda/ Nov. 9,2013	5-Year
279	13.908550	120.891260	0.31	0	0.0961	Typhoon Yolanda/ Nov. 9,2013	5-Year
280	13.908604	120.887845	0.03	2	3.8809	Typhoon Yolanda/ Nov. 9,2013	5-Year
281	13.908743	120.891297	0.25	0	0.0625	Typhoon Yolanda/ Nov. 9,2013	5-Year
282	13.908888	120.936843	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
283	13.909698	120.936986	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year

284	13.910638	120.891693	0.48	2	2.3104	Typhoon Yolanda/ Nov. 9,2013	5-Year
285	13.910851	120.891661	0.51	2	2.2201	Typhoon Yolanda/ Nov. 9,2013	5-Year
286	13.911033	120.894278	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
287	13.911133	120.891621	0.57	2	2.0449	Typhoon Yolanda/ Nov. 9,2013	5-Year
288	13.911329	120.894240	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
289	13.911348	120.937291	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
290	13.911489	120.891549	0.43	2	2.4649	Typhoon Yolanda/ Nov. 9,2013	5-Year
291	13.911546	120.894201	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
292	13.911557	120.867244	1.74	1.5	0.0576	Typhoon Yolanda/ Nov. 9,2013	5-Year
293	13.911585	120.882799	0.03	5	24.7009	Typhoon Yolanda/ Nov. 9,2013	5-Year
294	13.911759	120.891498	0.6	2	1.96	Typhoon Yolanda/ Nov. 9,2013	5-Year
295	13.911838	120.894057	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
296	13.912086	120.891428	0.51	2	2.2201	Typhoon Yolanda/ Nov. 9,2013	5-Year
297	13.912165	120.866594	3.45	2.5	0.9025	Typhoon Yolanda/ Nov. 9,2013	5-Year
298	13.912166	120.868343	5.58	3	6.6564	Typhoon Yolanda/ Nov. 9,2013	5-Year
299	13.912214	120.867150	1.72	1.5	0.0484	Typhoon Yolanda/ Nov. 9,2013	5-Year
300	13.912220	120.866039	4.82	2.5	5.382401	Typhoon Yolanda/ Nov. 9,2013	5-Year
301	13.912225	120.866297	3.95	2.5	2.1025	Typhoon Yolanda/ Nov. 9,2013	5-Year
302	13.912265	120.866860	2.47	2.5	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
303	13.912273	120.880828	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
304	13.912343	120.868590	5.87	3	8.236899	Typhoon Yolanda/ Nov. 9,2013	5-Year
305	13.912396	120.893735	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
306	13.912418	120.866669	3.03	2.5	0.2809	Typhoon Yolanda/ Nov. 9,2013	5-Year
307	13.912681	120.868887	5.66	2	13.3956	Typhoon Yolanda/ Nov. 9,2013	5-Year
308	13.912762	120.868929	5.93	2	15.4449	Typhoon Yolanda/ Nov. 9,2013	5-Year
309	13.912906	120.868934	7.03	5	4.120901	Typhoon Yolanda/ Nov. 9,2013	5-Year

310	13.913273	120.867355	2.4	2.5	0.01	Typhoon Yolanda/ Nov. 9,2013	5-Year
311	13.913348	120.875508	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
312	13.913490	120.869041	6.38	5	1.9044	Typhoon Yolanda/ Nov. 9,2013	5-Year
313	13.913498	120.891575	0.49	1	0.2601	Typhoon Yolanda/ Nov. 9,2013	5-Year
314	13.913779	120.938103	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
315	13.913827	120.891833	0.13	1	0.7569	Typhoon Yolanda/ Nov. 9,2013	5-Year
316	13.913874	120.869101	7.92	3	24.2064	Typhoon Yolanda/ Nov. 9,2013	5-Year
317	13.914045	120.892012	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
318	13.914120	120.868996	3.9	2	3.61	Typhoon Yolanda/ Nov. 9,2013	5-Year
319	13.914347	120.869045	3.3	1	5.29	Typhoon Yolanda/ Nov. 9,2013	5-Year
320	13.914388	120.892171	0.03	1	0.9409	Typhoon Yolanda/ Nov. 9,2013	5-Year
321	13.915035	120.869915	6.05	5	1.1025	Typhoon Yolanda/ Nov. 9,2013	5-Year
322	13.915934	120.870387	4.67	2	7.1289	Typhoon Yolanda/ Nov. 9,2013	5-Year
323	13.916107	120.870494	6.69	5	2.8561	Typhoon Yolanda/ Nov. 9,2013	5-Year
324	13.917982	120.878796	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
325	13.918131	120.969832	0.03	1.5	2.1609	Typhoon Yolanda/ Nov. 9,2013	5-Year
326	13.918284	120.969514	0.03	1.5	2.1609	Typhoon Yolanda/ Nov. 9,2013	5-Year
327	13.918416	120.871684	7.98	5	8.8804	Typhoon Yolanda/ Nov. 9,2013	5-Year
328	13.925219	120.957863	0.03	1.5	2.1609	Typhoon Yolanda/ Nov. 9,2013	5-Year
329	13.933847	120.936226	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
330	13.933892	120.934598	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
331	13.933940	120.942505	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
332	13.934919	120.944094	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
333	13.935137	120.945929	0.03	0	0.0009	Typhoon Yolanda/ Nov. 9,2013	5-Year
334	13.942305	120.935924	1.13	2	0.7569	Typhoon Yolanda/ Nov. 9,2013	5-Year
335	13.942764	120.936310	1.88	3	1.2544	Typhoon Yolanda/ Nov. 9,2013	5-Year

336	13.943839	120.942033	0.23	0.5	0.0729	Typhoon Yolanda/ Nov. 9,2013	5-Year
				RMSE	1.306669		

Annex 12. Educational Institutions Affected by Flooding in Pansipit Flood Plain

Table A-11.1. Educational Institutions in Agoncillo, Batangas affected by flooding in Pansipit Flood Plain

Batangas				
Agoncillo				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Bernardo Ondo Memorial Elementary School	Bagong Sikat			
Balangon Elementary School	Balangon			
Breath of Life Academy Batangas	Balangon			
Aurelio Solis Learning Center	Bangin			
Pook Elementary School	Bangin			
Coral Na Munti Elementary School	Mabini			
Coral Na Munti National High School	Mabini			
Pamiga Elementary School	Pamiga			
Panhulan Elementary School	Panhulan			
Pansipit Elementary School	Pansipit			
Agoncillo Central School	Poblacion			
Agoncillo College Inc.	Poblacion			
Agoncillo Montessory High School	Poblacion			
Day Care Center	Pook			
Day Care Center	Santa Cruz			
Subic Elementary School	Subic Ibaba			
Subic Ilaya National High School	Subic Ibaba			

Table A-11.2. Educational Institutions in Lemery, Batangas affected by flooding in Pansipit Flood Plain

Batangas				
Lemery				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Ayao Iyao Elementary School	Ayao-Iyao	Low	Low	Medium
Day Care Center	Cahilan I			
Day Care Center	Cahilan II			
Dionisio P. Vito Memorial National High School	Cahilan II			
Dita Elementary School	Cahilan II			
Esteban E. Vito Memorial Elementary School	Cahilan II			
College of St. Jerome Damaica	District I			
Ruperto Ventoranza Central School	District I			
Batangas State University - Lemery Campus	District III			
Lemery Pilot Elem. School	District III			
Lemery Pilot Elementary School	District III			
Day Care Center	Dita			
Dita Elementary School	Dita			
St. Mary's Educational Institute	Maguihan			
Mahayahay Elementary School	Mahayahay			

Bukal Elementary School	Matingain I			Low
Doña Matilde Memorial School	Matingain I			
San Isidro Labac Elementary School	Matingain II			
Bukal Elementary School	Nonong Casto	Medium	Medium	Medium
Day Care Center	Nonong Casto	Medium	Medium	High
Christian Knights Academy	Palanas			
Ruperto Ventoranza Central School	Rizal			
Sambal Elementary School	Sambal Ibaba			
Ruperto Ventoranza Central School	Wawa Ilaya			

Table A-11.3. Educational Institutions in Taal, Batangas affected by flooding in Pansipit Flood Plain

Batangas				
Taal				
Building Name	Barangay	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
Apacay Elementary School	Apacay			
Day Care Center	Bolbok			
Tulo Elementary School	Carasuche			
Gov. Vicente Noble Memorial Elementary School	Cawit			
Aguedo L. Asinas Memorial Elementary School	Caysasay			
Cubamba-Gahol Elementary School	Cubamba			
Cultihan-Bolbok Elementary School	Cultihan			
Halang Elementary School	Halang			
Apacay Elementary School	Laguile			
Balisong Elementary School	Latag			
Daycare Center	Luntal			
Buli Elementary School	Mahabang Lodlod			
Taal Central School	Niogan			
Our Lady of Caysasay Academy	Poblacion 11			
Rizal College of Taal	Poblacion 11			
Taal Central School	Poblacion 11			
Taal Central School	Poblacion 14			
Our Lady of Caysasay Academy	Poblacion 7			
Rizal College of Taal	Poblacion 7			
Balisong Elementary School	Pook			
Isabelo Baleros Memorial Elementary School	Seiran			
Aguedo L. Asinas Memorial Elementary School	Tatlong Maria			
Balisong Elem. School	Tierra Alta			
Luntal Elementary School	Tulo			
Tulo Elementary School	Tulo			

Annex 13. Health Institutions Affected in Pansipit Flood Plain

Table A-12.1. Health Institutions in Agoncillo, Batangas affected by flooding in Pansipit Flood Plain

Batangas				
Agoncillo				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Health Center	Bangin			

Table A-12.1. Health Institutions in Lemery, Batangas affected by flooding in Pansipit Flood Plain

Batangas				
Lemery				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Health Center	Ayao-Iyao			
Lemery Doctors Medical Center	District I			
Health Center	District III			
Metro Lemery Medical Center	District III			
Our Lady of Caysasay Medical Center	District III			
Salazar Polyclinic	District III			
St. Martin General Hospital	District III			
Metro Lemery Medical Center	District IV			
Our Lady of Caysasay Medical Center	Lucky			
Liezl Medrano Luciano Clinic	Maguihan			
Little Angels Medical Hospital	Maguihan			
St. Martin General Hospital	Maguihan			
Batangas Provincial Hospital	Malinis			
Little Angels Medical Hospital	Sangalang			

Table A-12.1. Health Institutions in Taal, Batangas affected by flooding in Pansipit Flood Plain

Batangas				
Taal				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Polymedic Hospital and Medical Center	Carasuche			
Iba Health Care Center 1	Iba			Low
Iba Health Care Center 2	Iba			
Imamawo Health Center	Ipil			
Health Center	Laguile			
ALB Medical Clinic	Niogan			
Rural Health Unit	Niogan			
San Martin Medical Clinic	Niogan			