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

LiDAR Surveys and Flood Mapping of Balili River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
Mindanao State University-Iligan Institute of Technology

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LIST OF ACRONYMS AND ABBREVIATIONS

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

CHAPTER 1: OVERVIEW OF THE PROGRAM AND BALILI RIVER

Prof. Alan E. Milano and Enrico C. Paringit, Dr. Eng.

1.1 Background of the Phil-LIDAR 1 Program

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

The program was also 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 titled Flood Mapping of Rivers in the Philippines Using Airborne LiDAR: Methods (Paringit et al.,2017) available separately.

The implementing partner university for the Phil-LiDAR 1 Program is the Mindanao State University – Iligan Institute of Technology (MSU-IIT). MSU-IIT 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 16 river basins in Northern Mindanao. The university is located in Iligan City in the province of Lanao del Norte.

1.2 Overview of the Balili River Basin

Balili River Basin is situated in Northern Mindanao at the territory of Lanao del Norte under Region 10. It traverses the barangays of Lapinig, Concepcion, Balili, Sta. Cruz, and Suso in the Municipality of Kapatagan, Lanao del Norte. The Balili I River Basin has a drainage area of 272.564 km^2. Its main stem, Balili River, is among the sixteen (16) river systems in Northern Mindanao. The fundamental waterway, Sta. Cruz River, which is utilized as a part of outlining the basin navigates inside the region of Kapatagan. Sta. Cruz River hails from Aurora and flows down Tipolo,passes the upland barangays of Kahayagan, Durano, Tulatulahan, San Isidro and jumps over Sta. Cruz Falls, and joins finally in Panguil Bay.

As one of the 22 locales in the area of Lanao del Norte, Region 10, Kapatagan has a total land region of approximately 25,048.41 hectares which join those that are as of now being tested by the Municipality of Lala with a vague zone of 759 hectares. Kapatagan is arranged inside the grid headings of 123° 42' and 123° 49' north longitude and 7° 49' and 7° 56' east degree and is constrained by the locale of Lala and Panguil Bay on the North; Municipality of Baroy and Salvador on the East; Municipality of Sapad in the Southeast; Municipality of Sultan Naga Dimaporo in the South and the range of Zamboanga del Sur on the Western and Northwestern part.

As far as rise, the region is viewed as warm marsh with its most noteworthy height just up to 300 meters above ocean level. On the southern and eastern sides of region are mountains which fill in as regular boundaries shielding the region from tropical storms. Counterbalancing the mountain is the nearness of level beach front grounds and valley. Kapatagan has come moving fields.

The whole area of the delineated river basin traverses through the municipalities of Kapatagan and Sultan Naga Dimaporo of Lanao del Norte and the municipality of Aurora of Zamboanga del Sur province where the outlet of the river basin is situated, specifically at Brgy. Balili. Balili River Basin has an estimated area of 271.266 square kilometers with an estimated drainage area of 57.16 square kilometers and travels 17.92 from its source to its outlet and 27.12 kilometers from its source to its mouth in the Panguil Bay. A total of 53,418 features were extracted within the floodplain which belongs to the municipalities and cities within the flood prone area.

According to the 2015 national census of PSA, a total of 9,950 persons are residing in the barangays that are within the immediate vicinity of the river. The economy of the province of Lanao del Norte largely rests on fishery and agriculture which include production of copra, rice, corn, fruits, and aquaculture products (Province of Lanao del Norte, 2017). On January 12, 2017, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) issued a yellow warning flood level in the province of Lanao del Norte due to continuous heavy rains that caused floods in the province(Catoto, 2017).

The whole Province of Lanao del Norte has been put under "readiness status" last August 6, 2015 when 579 people or 130 families were influenced by blaze surges generated by the "habagat." Lanao del Norte Governor Mohammad Khalid Dimaporo issued Provincial Disaster Risk Reduction and Management Council (PDRRMC) Advisory No. 2 to the whole territory with its part regions and barangays, guiding them to be under "readiness status." No less than 130 families were influenced by glimmer surges brought on by the flooding of, no less than, three streams. Generally influenced are three puroks in Lapinig, Kapatagan, and the neighboring town of Maranding.

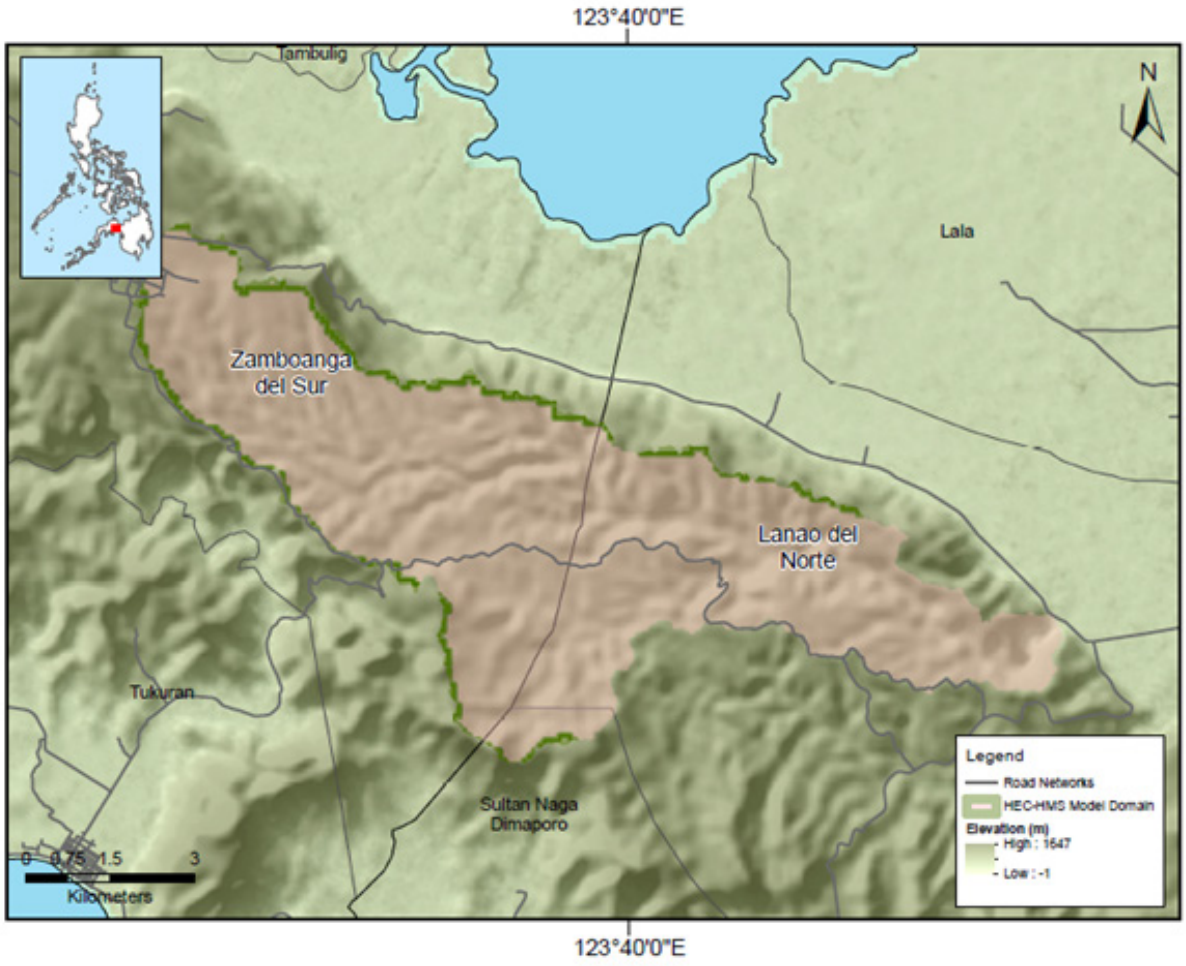


Figure 1. Map of the Balili River Basin (in brown)

Under the condition of readiness status, common, metropolitan and barangay DRRMC maintained the 24-hour operation focuses in their individual zones. All levels of government units and teams was requested to expand every single conceivable mean of data and attention to alarm puroks and groups considered high-hazard to surge, particularly those situated along the waterways, coastlines, and those arranged in low-lying ranges.

Dimaporo brought up that all territories with late history of flooding must exercise twofold readiness and to be set up for conceivable clearing.Furthermore, he coordinated fisherfolk to cease from going to ocean until pronounced safe to do as such.

Under readiness status, concerned organizations are commanded to distinguish safe zones and courses and accessible vehicles for conceivable clearing. They additionally educated families and people to plan crisis sacks, and sustenance, water, and solution arrangements useful for the following 72 hours (http://cnnphilippines.com).

CHAPTER 2: LIDAR DATA ACQUISITION OF THE BALILI FLOODPLAIN

Engr. Louie P. Balicanta, Engr. Christopher Cruz, Lovely Gracia Acuña, Engr. Gerome Hipolito, Ms. Julie Pearl S. Mars, Ms. Kristine Joy P. Andaya

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 Balili Floodplain in Zamboanga del Norte. Each flight mission has an average of 14 lines and run for at most four and a half (4.5) hours including take-off, landing, and turning time. The parameter used in the LiDAR system for acquisition is found in Table 1. Figure 2 shows the flight plans for Balili Floodplain.

Table 1. Flight Planning Parameters for Pegasus LiDAR System

Block Name	Flying Height (m AGL)	Overlap (%)	Field of view (ø)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK70B	1000	30	50	200	30	130	5
BLK71ABC	1200	30	50	200	30	130	5
BLK71C	1000	30	50	200	30	130	5
BLK71E	800/1100/ 1200	30	50	200	30	130	5
BLK71Es	1100	30	50	200	30	130	5
BLK71ext	1000	30	50	200	30	130	5
BLK71F	1000	30	50	200	30	130	5
BLK71G	900	30	50	200	30	130	5
BLK76A	1200	30	50	200	30	130	5
BLK 76C	1100	30	50	200	30	130	5
BLK 76D	1100/ 1200	30	50	200	30	130	5
BLK 76I	1200	30	50	200	30	130	5
BLK 76M	1000/1200	30	50	200	30	130	5

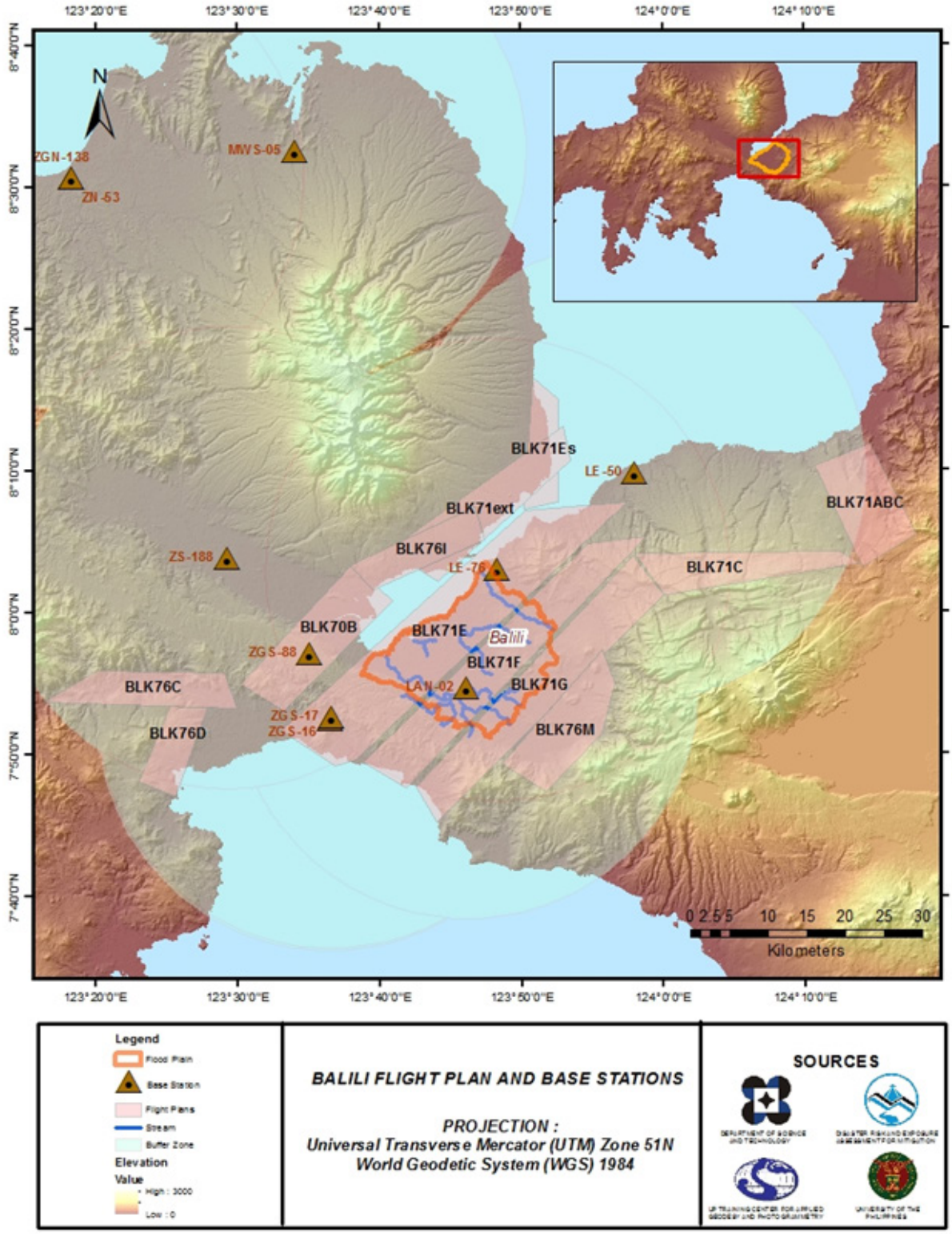


Figure 2. Flight plans and base stations for Balili Floodplain

2.2 Ground Base Stations

The project team was able to recover five (5) NAMRIA ground control points: LAN-02 , ZGS-88, ZGS-16, ZGS-17, and ZGN-138 which are of second (2nd) order accuracy and four (4) bench mark points: ZN_53, LE-50, ZS-188, and LE-76. The certifications for the NAMRIA reference points and processing report for the established points are found in ANNEX 2. These were used as base stations during flight operations for the entire duration of the survey (May 29-July 10, 2014; February 4-March 4, 2016; November 18-December 2, 2016). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 882, SPS 852, SPS 985 and Topcon GR-5. Flight plans and location of base stations used during the aerial LiDAR acquisition in Balili Floodplain are shown in Figure 2. The list of team members is shown in ANNEX 4.

Figure 3 to Figure 11 show the recovered NAMRIA control stations within the area. Table 2 to Table 10 present the details about the following NAMRIA control stations and established points. Meanwhile, Table 11 listsall ground control points occupied during the acquisition together with the dates they are utilized during the survey.

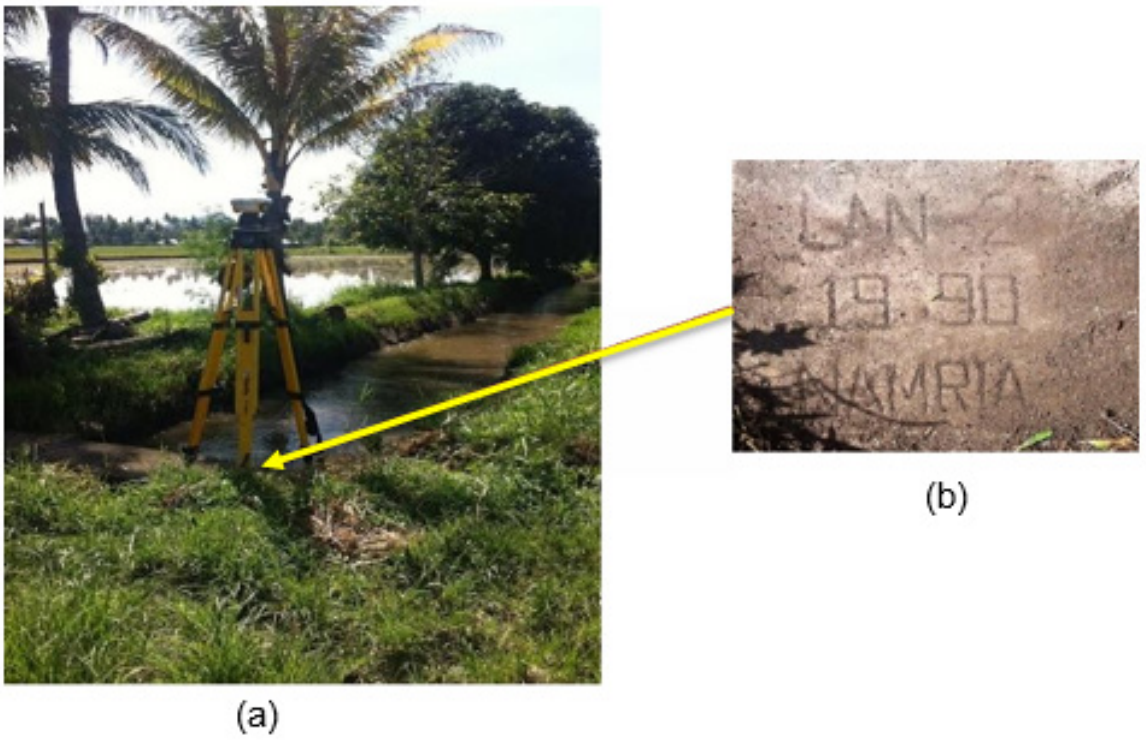


Figure 3. a) GPS set-up overLAN-02 ontop of a concrete irrigation canal water gate in Brgy. Pinoyak, Lala, Lanao del Norte. b) NAMRIA reference point LAN-02 as recovered by the field team

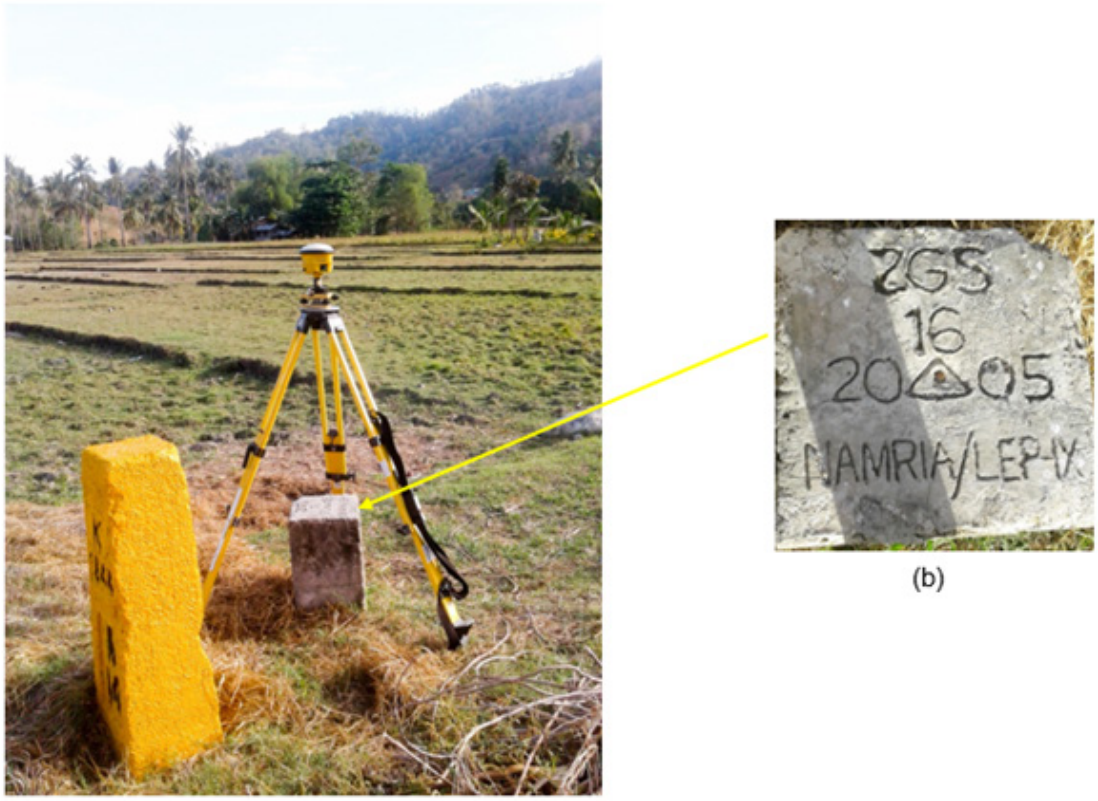
Table 2. Details of the recovered NAMRIA horizontal control point LAN-02 used as base station for the LiDAR acquisition

Station Name	**LAN-02**	
Order of Accuracy	**1st**	
Relative Error (Horizontal positioning)	**1:100,000**	
Geographic Coordinates, Philippine Reference 0f 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	7°54'46.07859"North 123°46'0.85333"East 17.35400meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	364025.74meters 875110.149meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	7°54'42.56546"North 123°46'6.31720"East 83.92120meters
Grid Coordinates, Philippine Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	584533.45meters 874680.35meters

Figure 4. a) GPS set-up overZGS-88 ona center island in Puroy Saray, Aurora, Zamboanga del Sur. b) NAMRIA reference point ZGS-88 as recovered by the field team

Table 3. Details of the recovered NAMRIA horizontal control point ZGS-88 used as base station for the LiDAR acquisition

Station Name	**ZGS-88**	
Order of Accuracy	**2nd**	
Relative Error (Horizontal positioning)	**1:50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	7°57'13.25316"North 123°34'56.50093"East 258.34500meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	564207.26meters 879474.685meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	7°57'9.71271"North 123°35'1.96243"East 324.37300meters
Grid Coordinates, Philippine Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	564184.79meters 879166.85meters



(a) (b)

Figure 5. GPS set-up over ZGS-16(a) in Purok Nangka, Brgy. Baclay, Tukuran, Zamboanga del Sur and NAMRIA reference point ZGS-16 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point ZGS-16 used as base station for the LiDAR acquisition

Station Name	**ZGS-16**	
Order of Accuracy	**2Nd**	
Relative Error (horizontal positioning)	**1:50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	7° 52’ 35.53106”North 123° 36’ 23.39905” East 18.17800 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Latitude Longitude Ellipsoidal Height	566881.259 meters 8708554.959 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	7° 52’ 29.01321” North 123° 36’ 28.86762” East 84.42000 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992	Easting Northing	566857.85 meters 870550.15 meters

(a)

(b)

Figure 6. GPS set-up over ZGS-17(a) in Purok Kasoy, Brgy. Baclay, Tukuran, Zamboanga del Sur and NAMRIA reference point ZGS-17 (b) as recovered by the field team

Table 5. Details of the recovered NAMRIA horizontal control point ZGS-17 used as base station for the LiDAR acquisition

Station Name	**ZGS-17**	
Order of Accuracy	**2rd**	
Relative Error (horizontal positioning)	**1:50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	7° 52' 42.71658"North 123° 36' 29.22049"East 29.68400 meters
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Easting Northing	567059.131 meters 871168.108 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	7° 2' 39.19813" North 123° 36' 34.68878" East 95.92400 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	567035.66 meters 870863.18 meters

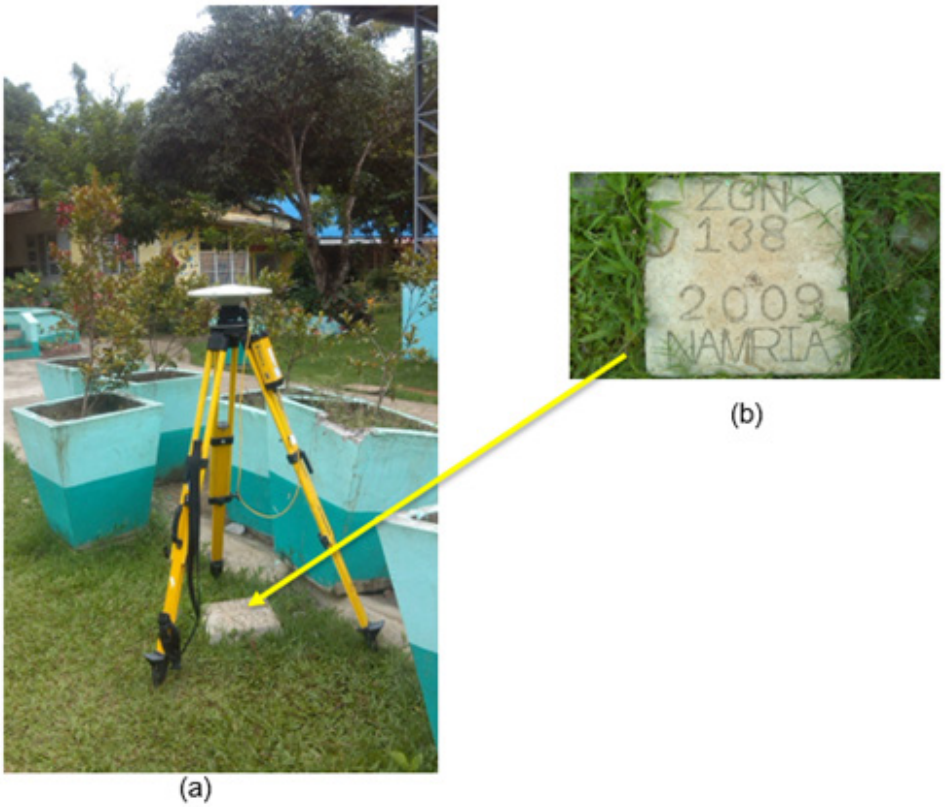


Figure 7. GPS set-up over ZGN-138(a) in Katupinan Zamboanga del Norte and NAMRIA reference point ZGN-138 (b) as recovered by the field team

Table 6. Details of the recovered NAMRIA horizontal control point ZGN-138 used as base station for the LiDAR acquisition

Station Name	**ZGN-138**	
Order of Accuracy	**2rd**	
Relative Error (horizontal positioning)	**1:50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	8° 30’ 40.65974”North 122° 18’ 14.44217”East 6.715 meters
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Easting Northing	533471.036 meters 941106.14 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8° 30’ 36.94779” North 123° 18’ 19.85548”East 70.925 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	533459.32 meters 940776.74 meters

Figure 8. GPS set-up over ZN-53 at Brgy. Daanglungsod, Katipunan, Zamboanga del Norte (a) reference point ZN-53 (b) as recovered by the field team

Table 7. Details of the benchmark ZN- 53 used as base station for the LiDAR acquisition

Station Name	**VZN-53**	
Order of Accuracy	**2nd**	
Relative Error (horizontal positioning)	**1:50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	8°30'41.04428"North 123°18'14.33457"East 7.072 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8°30'37.33230" North 123°18'19.74787"East 71.282 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	533456.022 meters 940788.542 meters

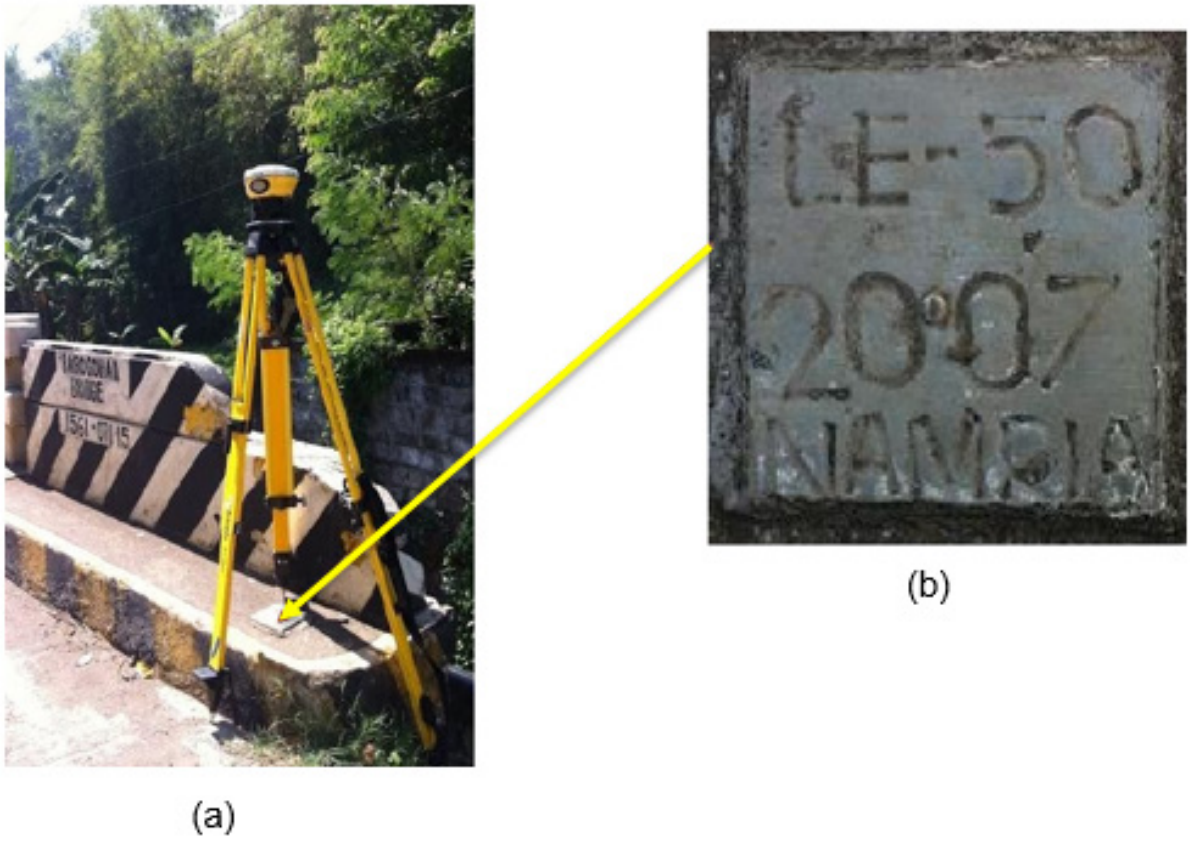


Figure 9. a) GPS set-up overLE-50 on the Barogohan Bridge in Maigo, Lanao del Norte; b) NAMRIA bench mark LE-50 as recovered by the field team

Table 8. Details of the recovered benchmark point LE-50 used as base station for the LiDAR acquisition

Station Name	**LE-50**	
Order of Accuracy	**1st**	
Relative Error (horizontal positioning)	**1:100,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	8°9'54.972"North 123°57'50.357"East 6.91meters
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Easting Northing	385831.49meters 902974.41meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8°09'51.11024"North 123°57'55.36634"East 73.452 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	606345.902meters 902577.426meters

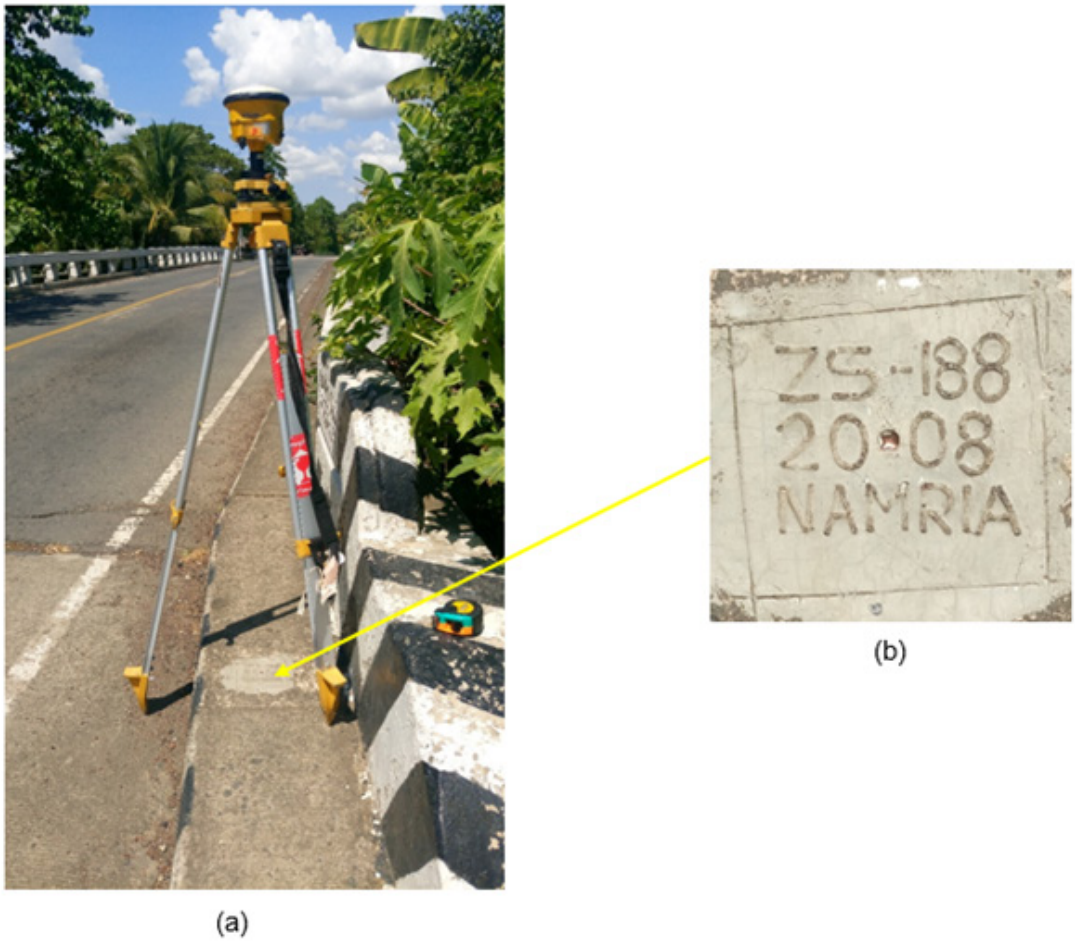


Figure 10. a) GPS set-up overZS-188 at Dipolo Bridge in Brgy. Licomo, Molave, Zamboanga del Sur; b) NAMRIA bench mark ZS-188 as recovered by the field team

Table 9. Details of the recovered NAMRIA benchmarkZS-188 used as base station for the LiDAR Acquisition.

Station Name	**ZS-188**	
Order of Accuracy	**1st**	
Relative Error (horizontal positioning)	**1:100,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	8°03'56.69408"North 123°29'12.15500"East 19.832 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8°03'53.11537" North 123°29'17.60722"East 85.400 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	553627.634 meters 891542.089 meters

Figure 11. a) GPS set-up overLE-76 at Bulod Bridge in Brgy. Bulod, Tubud, Lanao del Norte. b) NAMRIA bench mark Le-76 as recovered by the field team.

Table 10. Details of the recovered NAMRIA benchmarkLE-76 used as base station for the LiDAR Acquisition.

Station Name	**LE-76**	
Order of Accuracy	**1st**	
Relative Error (horizontal positioning)	**1:100,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	8° 03' 05.36825" North 123° 48' 12.37307" East 9.355 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8° 03' 01.82183" North 123° 48' 17.82405" East 75.717 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	588,530.790 meters 890,021.013 meters

Table 11. Ground control points used during the LiDAR data acquisition.

Date Surveyed	Flight Number	Mission Name	Ground Control Points
June 4, 2014	1549P	1BLK 71D155A	LAN-02 and LE-50
June 8, 2014	1565P	1BLK71B159A	LAN-02 and LE-50
June 20, 2014	1613P	1BLK71G171A	LAN-02 and LE-50
July 3, 2014	1665P	1BLK71ES184A	LAN-02 and LE-50
July 5, 2014	1673P	1BLK71ES186A	LAN-02 and ZGS-88
July 6, 2014	1677P	1BLK71S187A	LAN-02 and ZGS-88
July 8, 2014	1685P	1BLK71S189A	LAN-02 and LE-50
July 9, 2014	1689P	1BLK71S190A	LE-50 and LE-76
February 12, 2016	23084P	1BLK76JKLCs043A	ZGS-16 and ZS-188
February 13, 2016	23088P	1BLK76ILM044A	ZGS-16 and ZS-188
February 17, 2016	23104P	1BLK76DLM048A	ZGS-16 and ZS-188
February 23, 2016	23128P	1BLK70B054A	ZGS-16 and ZGS-17
December 1, 2016	23602P	1BLK76AB336A	ZGN-138 and ZN-53

2.3 Flight Missions

Twelve (12) missions were conducted to complete LiDAR data acquisition in Balili Floodplain, for a total of 50 hours and 20 minutes (50+20) of flying time for RP-C9022. All missions were acquired using the Pegasus system. Table 12 shows the total area of actual coverage per mission and the flying hours per mission and Table 13 presents the actual parameters used during the LiDAR data acquisition.

Table 12. Flight missions for LiDAR data acquisition in Balili Floodplain

Date Surveyed	Flight Number	Flight Plan Area (km2)	Surveyed Area (km2)	Area Surveyed within the Floodplain (km2)	Area Surveyed Outside the Floodplain (km2)	No. of Images (Frames)	Flying Hours	
							Hr	Min
June 4, 2014	1549P	404.99	202.34	65.36	136.98	_	4	24
June 8, 2014	1565P	238.51	117.70	52.35	65.35	324	2	53
June 20, 2014	1613P	240.61	246.62	79.13	167.49	936	4	06
July 3, 2014	1665P	59.24	42.73	42.73	0	_	2	59
July 5, 2014	1673P	142.27	125.28	21.51	103.77	330	2	55
July 6, 2014	1677P	73.20	45.22	45.22	0	170	2	35
July 8, 2014	1685P	335.86	184.57	64.79	119.78	569	4	05
July 9, 2014	1689P	109.30	202.18	54.27	147.91	_	4	17
February 12, 2016	23084P	167.89	299.63	83.16	216.47	652	4	17
February 13, 2016	23088P	112.09	231.36	25.29	206.07	536	4	23
February 17, 2016	23104P	185.72	170.14	31.46	138.68	396	4	34
February 23, 2016	23128P	139.43	198.99	17.66	181.33	5	4	17
December 1, 2016	23602P	68.58	130.56	7.23	123.33	_	4	35
TOTAL		**2277.69**	**2197.32**	**590.16**	**1607.16**	**3918**	**50**	**20**

Table 10. Actual parameters used during the LiDAR data acquisition of the Balili Floodplain.

Flight Number	Flying Height (m AGL)	Overlap (%)	FOV (θ)	PRF (khz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
1549P	800	30	50	200	30	130	5
1565P	1000	30	50	200	30	130	5
1613P	900	30	50	200	30	130	5
1665P	1100	30	50	200	30	130	5
1673P	1000	30	50	200	30	130	5
1677P	1000	30	50	200	30	130	5
1685P	1000	30	50	200	30	130	5
1689P	1200	30	50	200	30	130	5
23084P	1100	30	50	200	30	130	5
23088P	1200	30	50	200	30	130	5
23104P	1000/ 1200	30	50	200	30	130	5
23128P	1000	30	50	200	30	130	5
23602P	1200	30	50	200	30	130	5

2.4 Survey Coverage

Balili Floodplain is located in the provinces of Lanao del Norte and Zamboanga del Sur with the floodplain situated within the municipalities of Aurora, Baroy, Kapatagan, Lala, Salvador, Sapad and Tubod. The list of municipalities and cities surveyed with at least one (1) square kilometer coverage, is shown in Table 14. The actual coverage of the LiDAR acquisition for Balili Floodplain is presented in Figure 12.

Table 14. List of municipalities and cities surveyed in Balili Floodplain LiDAR survey

Province	Municipality/ City	Area of Municipality/ City (km2)	Total Area Surveyed (km2)	Percentage of Area Surveyed
Lanao del Norte	Baloi	65.18	18.65	29%
	Baroy	62.08	59.89	96%
	Iligan City	650.87	16.26	2%
	Balili	184.77	168.01	91%
	Kolambugan	70.70	55.74	79%
	Lala	125.18	120.21	96%
	Linamon	22.21	2.29	10%
	Magsaysay	83.06	64.44	78%
	Maigo	126.36	26.13	21%
	Matungao	52.50	2.50	5%
	Nunungan	418.22	61.20	15%
	Pantao Ragat	71.36	2.55	4%
	Pantar	50.19	4.71	9%
	Poona Piagapo	88.11	3.86	4%
	Salvador	46.46	46.18	99%
	Sapad	65.13	42.90	66%
	Sultan Naga Dimaporo	143.65	54.42	38%
	Tagoloan	25.06	1.77	7%
	Tangcal	118.94	7.23	6%
	Tubod	121.94	108.14	89%
Misamis Occidental	Bonifacio	103.87	9.76	9%
	Clarin	113.99	12.37	11%
	Ozamis City	149.44	39.45	26%
	Tangub City	141.82	54.81	39%
	Tudela	108.93	3.45	3%
Zamboanga del Sur	Tambulig	142.93	27.88	20%
	Tukuran	119.01	64.90	55%
	Aurora	162.22	100.06	62%
	Dumalinao	108.64	2.51	2%
	Kumalarang	143.51	51.18	36%
	Labangan	176.44	59.97	34%
	Pagadian City	279.33	70.86	25%
	Sominot	97.75	2.19	2%
Zamboanga Sibugay	Buug	134.89	2.99	2%
Total		4574.74	1369.46	29.94

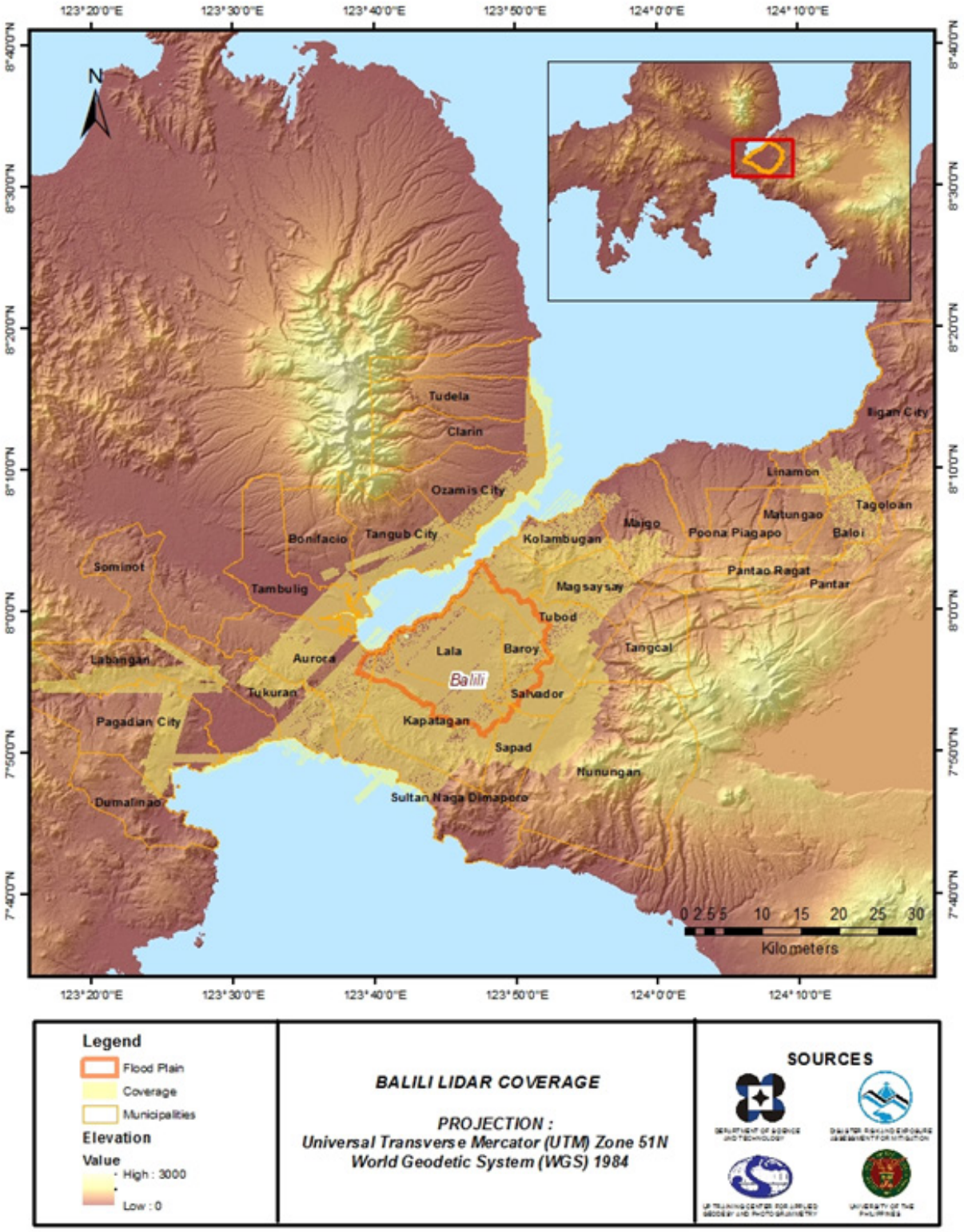


Figure 12. Actual LiDAR data acquisition for Balili Floodplain

CHAPTER 3: LIDAR DATA PROCESSING FOR BALILI FLOODPLAIN

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

3.1 Overview of the LiDAR Data Pre-Processing

The data transmitted by the Data Acquisition Component were 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 was done in order to obtain the exact location of the LiDAR sensor when the laser was shot. Point cloud georectification was performed to incorporate correct position and orientation for each point acquired. The georectified LiDAR point clouds were subject for quality checking to ensure that the required accuracies of the program, which included the minimum point density, vertical and horizontal accuracies, were met. The point clouds were 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 were calibrated. Portions of the river that were barely penetrated by the LiDAR system were replaced by the actual river geometry measured from the field by the Data Validation and Bathymetry Component. LiDAR acquired temporally were then mosaicked to completely cover the target river systems in the Philippines. Orthorectification of images acquired simultaneously with the LiDAR data was 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 13.

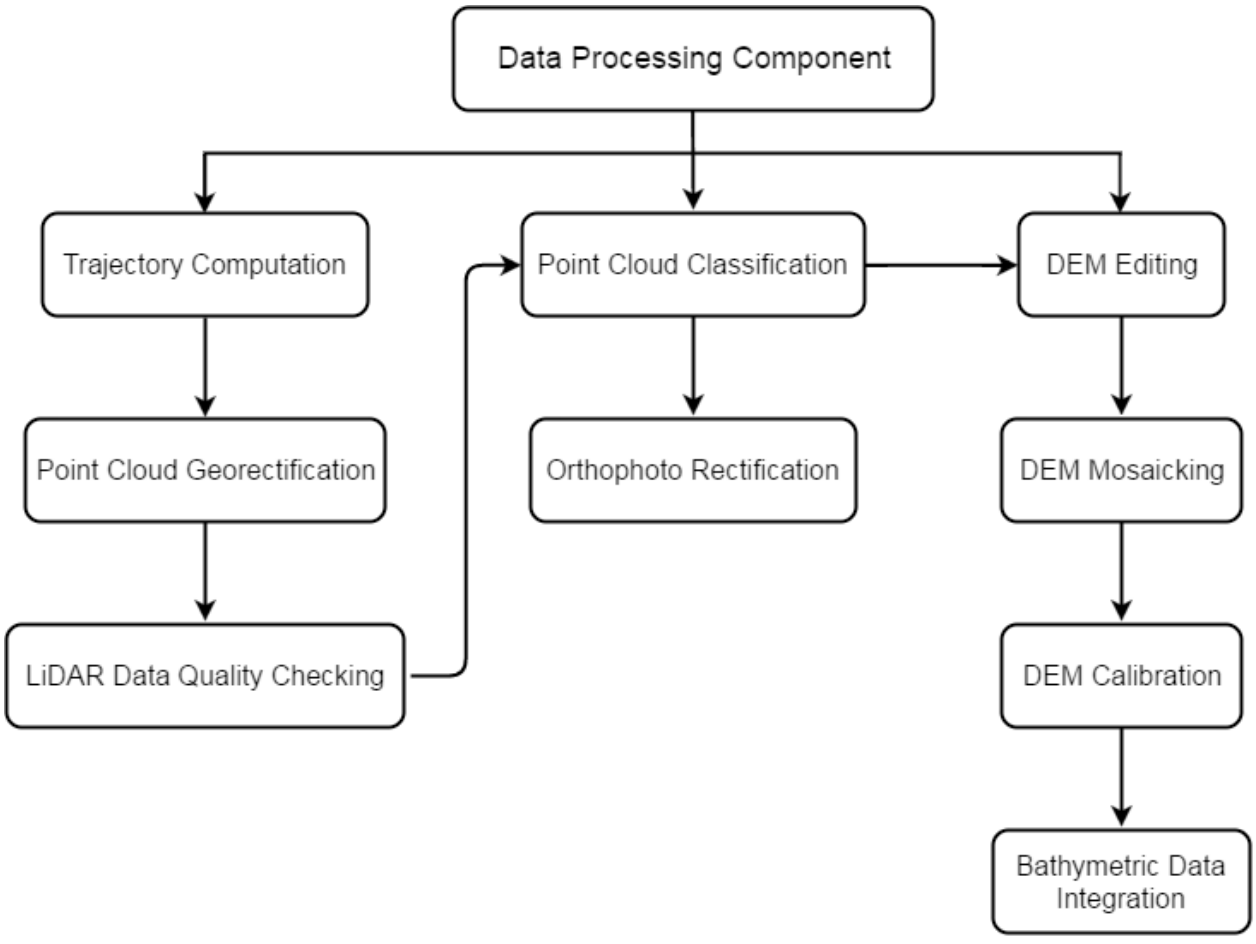


Figure 13. Schematic diagram for Data Pre-processing Component.

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Balili Floodplain can be found in ANNEX 5. Missions flown during the first survey conducted on June 2014 and the second survey on February 2016 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system over Pagadian, Dipolog and Northern Mindanao. The Data Acquisition Component (DAC) transferred a total of 277.97 Gigabytes of Range data, 3.11 Gigabytes of POS data, 445.13 Megabytes of GPS base station data, and 651.81 Gigabytes of raw image data to the data server on June 4, 2014 for the first survey and February 12, 2016 for the second survey. The Data Pre-Processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Balili was fully transferred on March 1, 2016 as indicated on the Data Transfer Sheets for Balili Floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metricparameters of the computed trajectory for flight 1549P, one of the Balili flights, which is the North, East, and Down position RMSE values, are shown in Figure 14. 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 onJune 23, 2014 00:00AM. The y-axis is the RMSE value for that particular position.

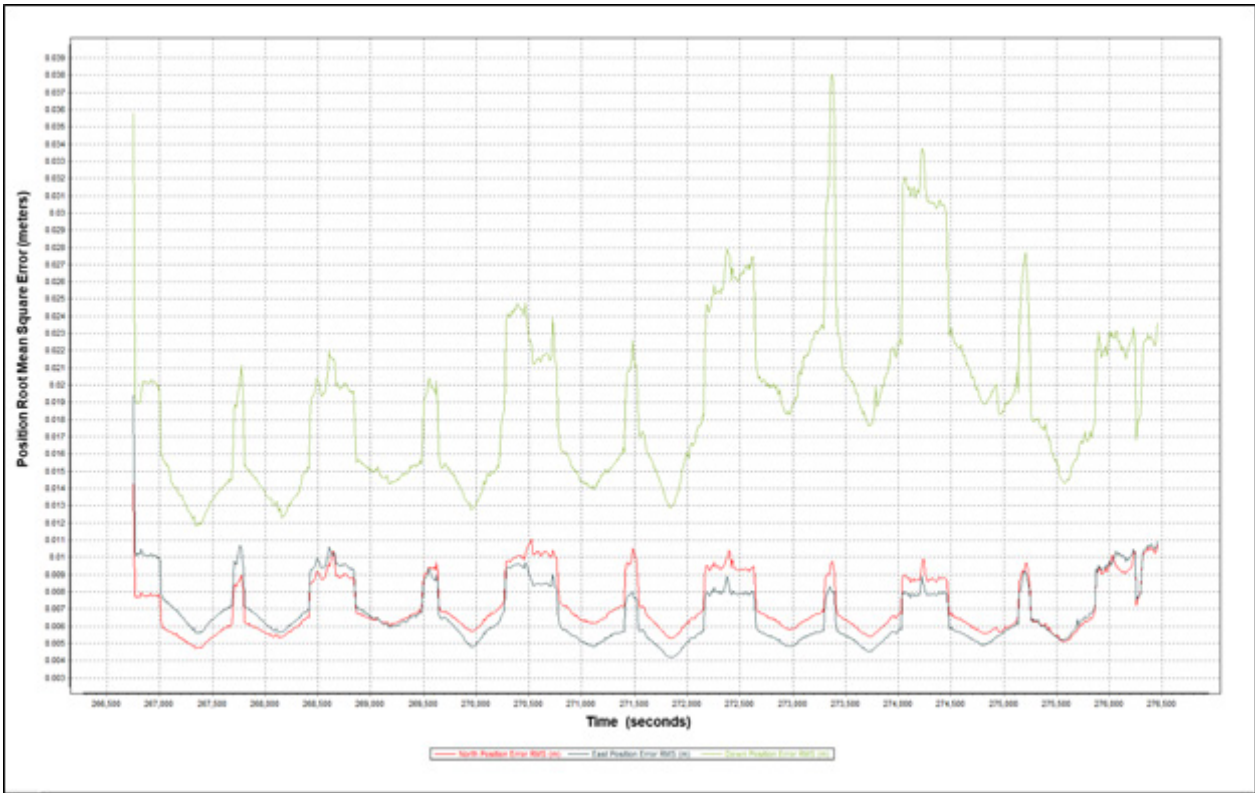


Figure 14. Smoothed Performance Metric Parameters of a Balili Flight 1549P

The time of flight was from 266500 seconds to 276500 seconds, which corresponds to morning of June 23, 2014. 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 14 shows that the North position RMSE peaks at 1.10 centimeters, the East position RMSE peaks at 1.10 centimeters, and the Down position RMSE peaks at 3.80 centimeters, which are within the prescribed accuracies described in the methodology.

Figure 15. Solution Status Parameters of Balili Flight 1549P

The Solution Statusparameters of flight 1549P, one of the Balili flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 15.The graphs indicate that the number of satellites during the acquisition did not go down to 6. Majority of the time, the number of satellites tracked was between 6 and 9. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode stayed at the value of 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 Balili flights is shown in Figure 16.

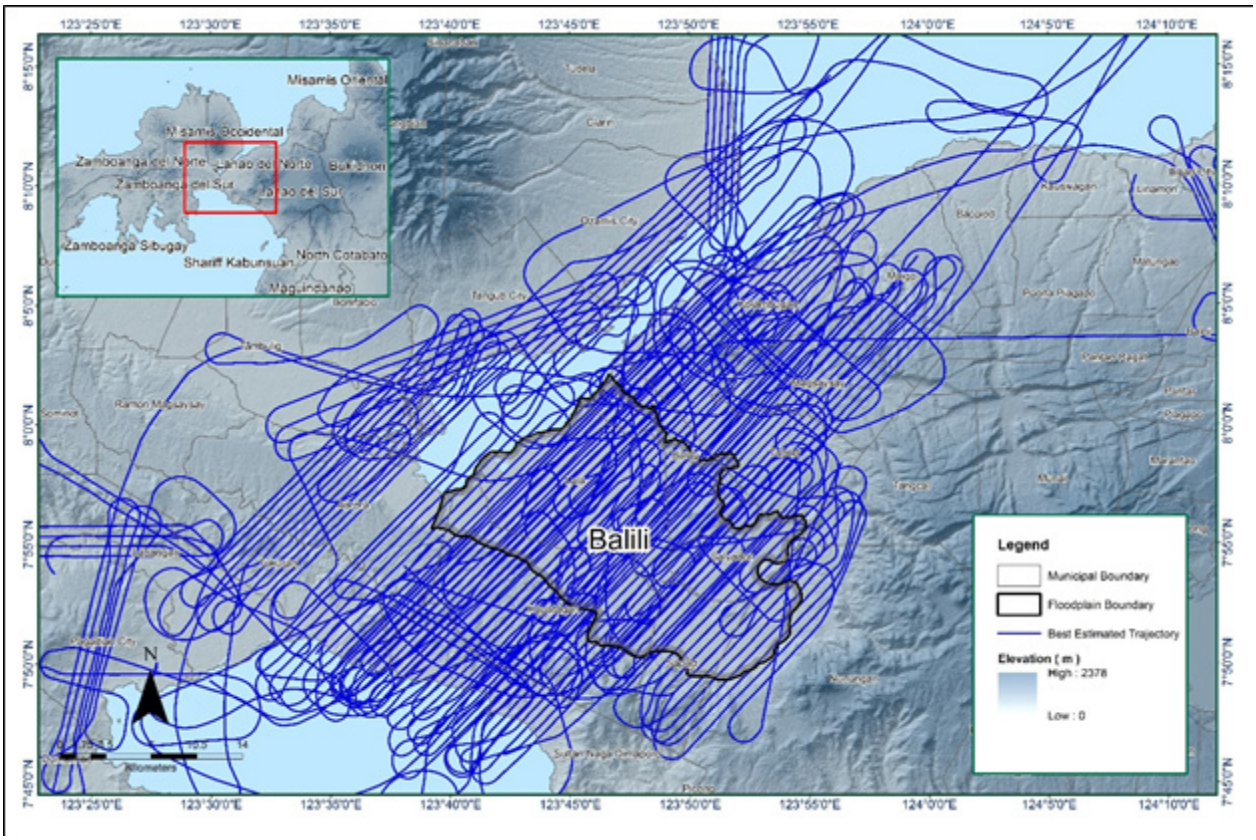


Figure 13. The Best Estimated Trajectory of the LiDAR missions conducted over the Balili floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 140 flight lines, with each flight line containing two channels, since the Pegasus system contain two channels. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Balili Floodplain are given in Table 15.

Table 15. Self-Calibration Results values for Balili flights

Parameter	Acceptable Value	Value
Boresight Correction stdev (<0.001degrees)	0.000335	0.000218
IMU Attitude Correction Roll and Pitch Corrections stdev (<0.001degrees)	0.001464	0.000903
GPS Position Z-correction stdev (<0.01meters)	0.0198	0.0027

The optimum accuracy was obtained for all Balili flights based on the computed standard deviations of the corrections of the orientation parameters. Standard deviation values for individual blocks are available in ANNEX 8.

3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data on top of a SAR Elevation Data over Balili Floodplain is shown in Figure 17. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

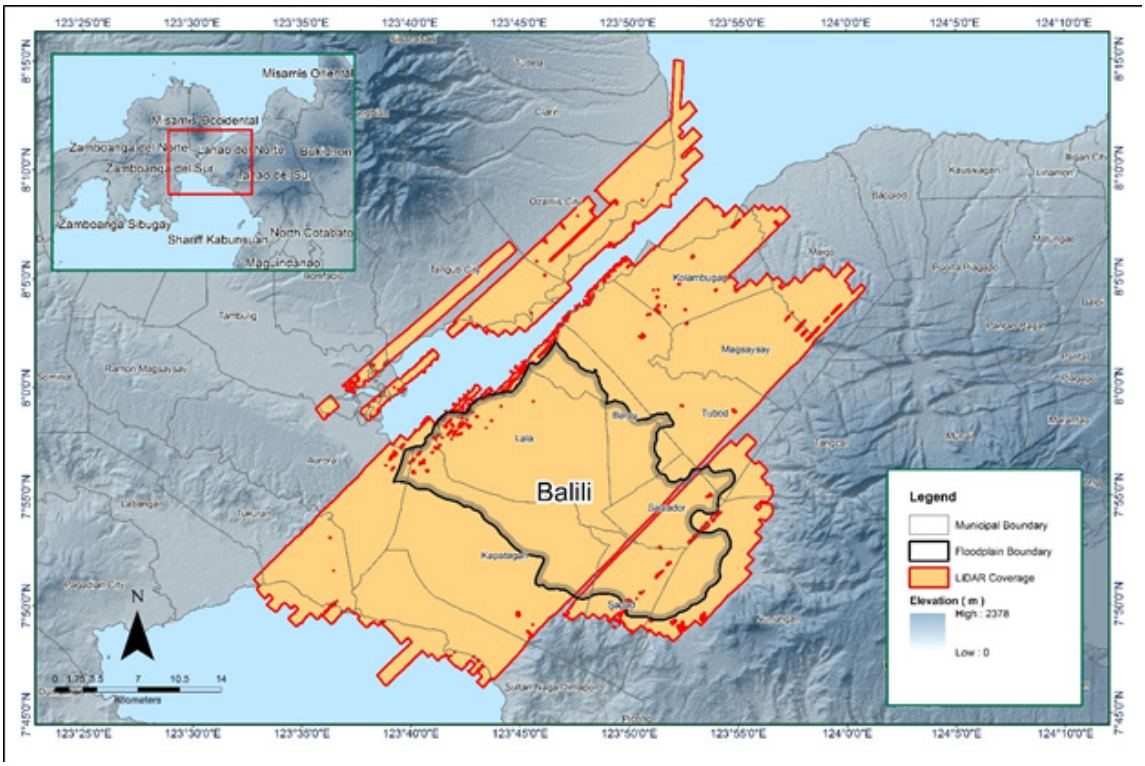


Figure 17. Boundary of the processed LiDAR data over Balili Floodplain

The total area covered by the Balili missions is 1,737.29 sq.km that is comprised of thirteen (13) flight acquisitions grouped and merged into twelve (12) blocks as shown in Table 16.

Table 16. List of LiDAR blocks for Balili Floodplain

LiDAR Blocks	Flight Numbers	Area (sq. km)
Pagadian_Blk76J	23088P	37.95
Pagadian_Blk76K	23084P	182.99
Pagadian_Blk76K_additional	23104P	53.29
Pagadian_Blk76M	23128P	71.78
Pagadian_Blk76N	23088P	136.47
Pagadian_Blk76N_additional	23104P	60.44
Pagadian_Blk76N_supplement	23104P	5.3
NorthernMindanao_Blk71_ extension	1665P	138.3
	1673P	
	1677P	
NorthernMindanao_Blk71E	1689P	194.58
NorthernMindanao_Blk71F	1565P	500.1
	1549P	
	1685P	
NorthernMindanao_Blk71G	1613P	282.38
Dipolog_reflight_Blk76M	23602P	73.71
Total		**1,737.29 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 18. Since the Pegasus system employ two channels, an average value of 2 (blue) for areas is expected where there is limited overlap, and a value of 3 (yellow) or more (red) for areas with three or more overlapping flight lines.

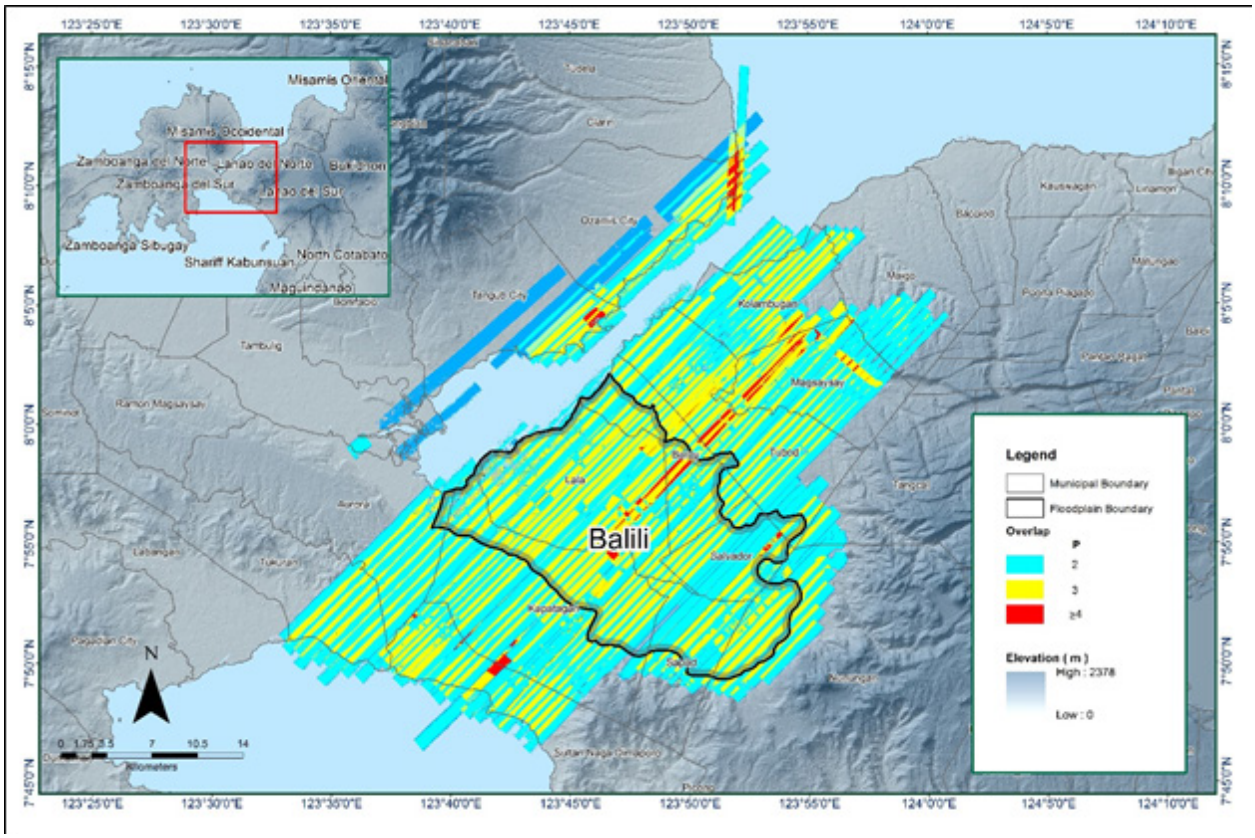


Figure 18. Image of data overlap for Balili Floodplain

The overlap statistics per block for the Balili 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 51.56% and 27.83%, respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion, is shown in Figure 19. It was determined that all LiDAR data for Balili Floodplain satisfy the point density requirement, and the average density for the entire survey area is 3.43 points per square meter.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the two (2) points per square meter criterion is shown in Figure 16. As seen in the figure below, it was determined that all LiDAR data for the Balili Floodplain Survey satisfy the point density requirement, as the average density for the entire survey area is 3.62 points per square meter.

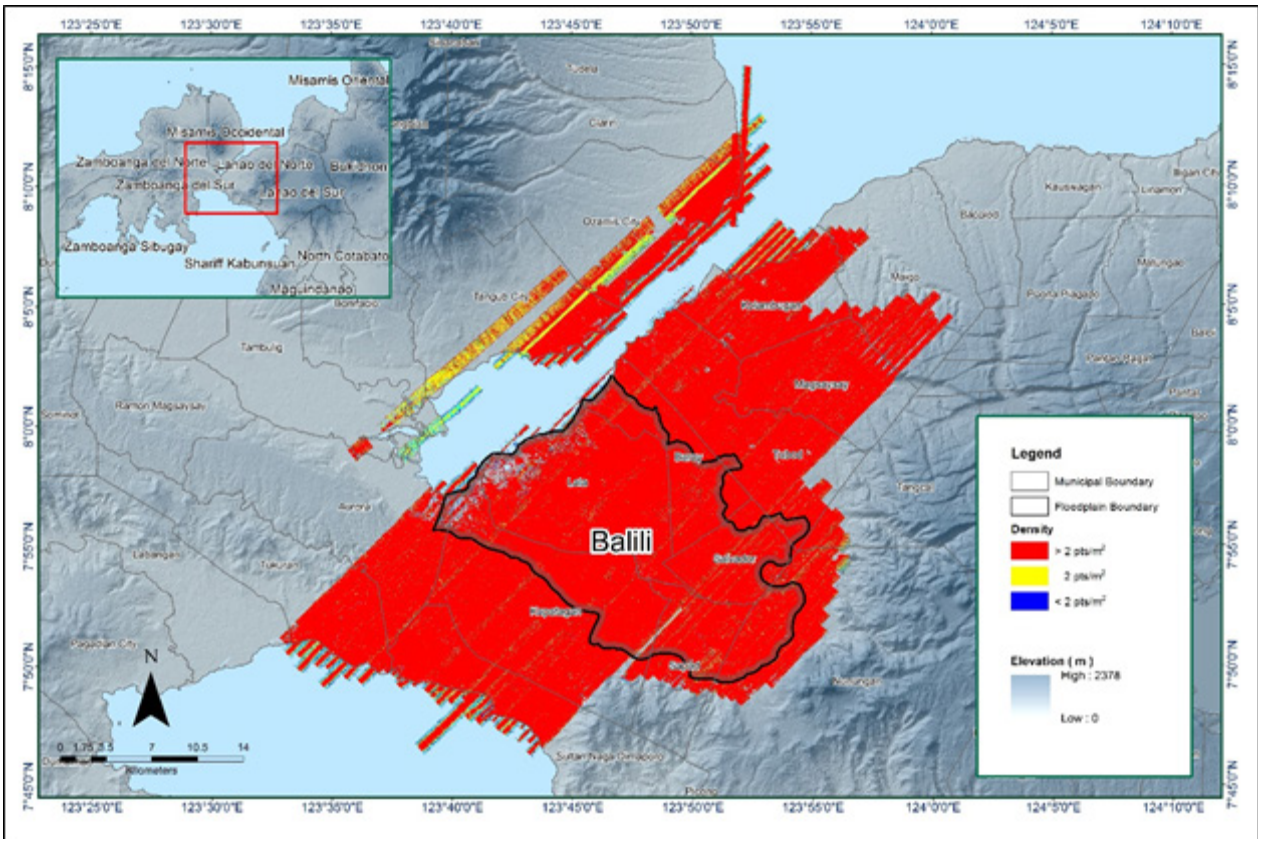


Figure 19. Pulse density map of merged LiDAR data for Balili Floodplain

The elevation difference between overlaps of adjacent flight lines is shown in Figure 20. The default color range is from blue to red. The 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.

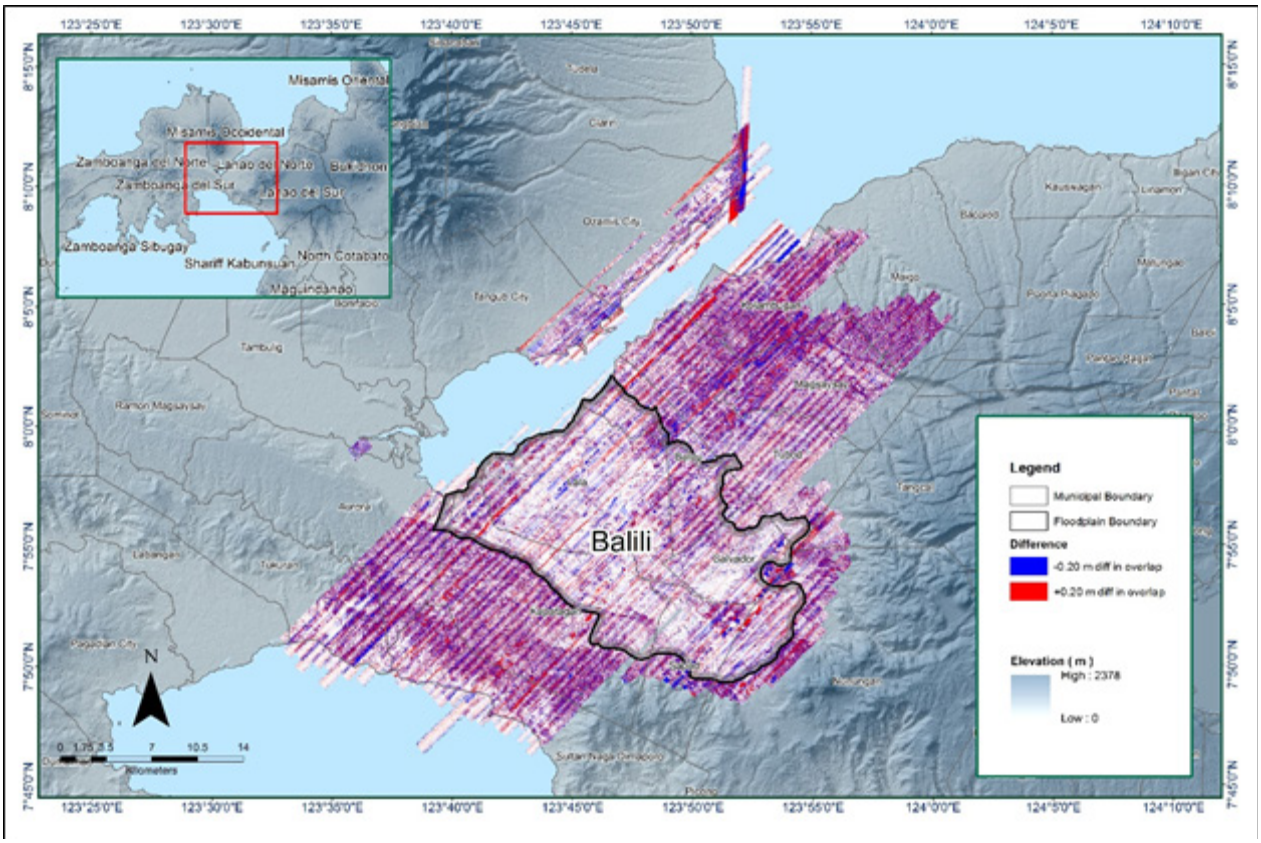


Figure 20. Elevation difference map between flight lines for Balili Floodplain

A screen capture of the processed LAS data from a Balili flight 1549P loaded in QT Modeler is shown in Figure 21. 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. No reprocessing was done for this LiDAR dataset.

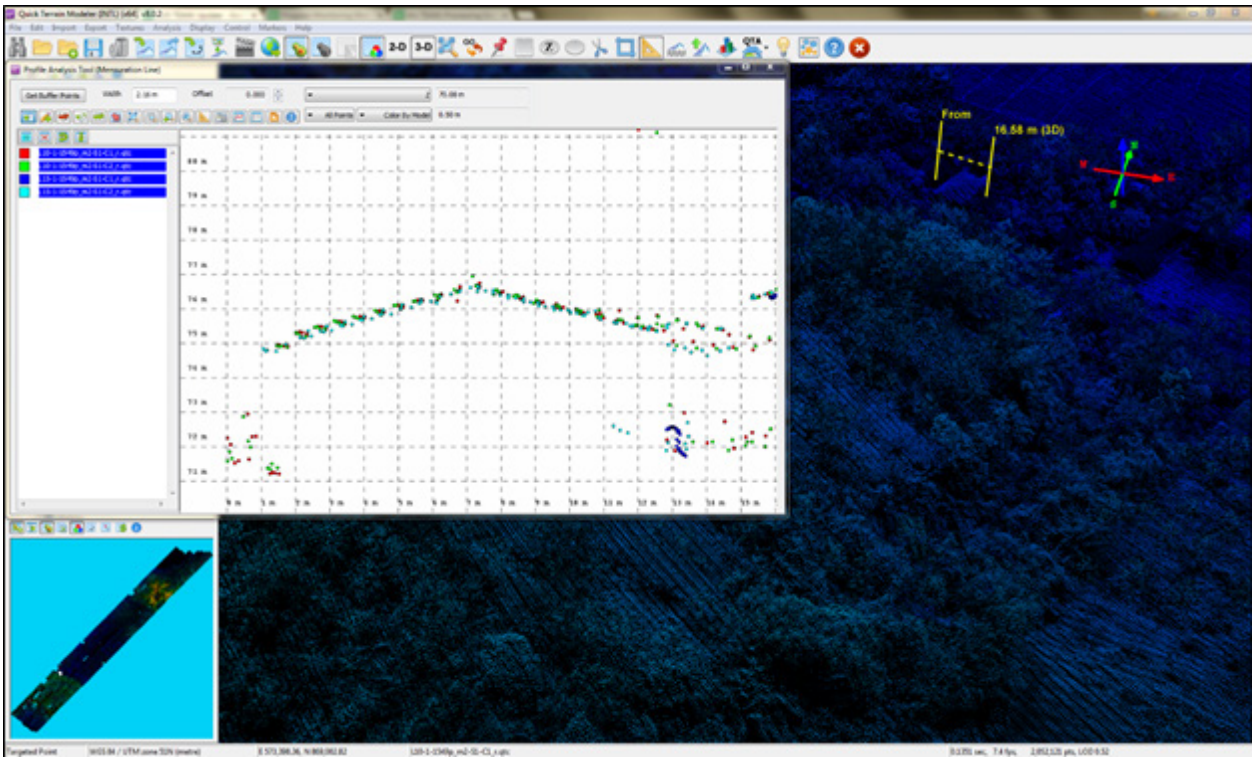


Figure 21. Quality checking for a Balili flight 1549P using the Profile Tool of QT Modeler

3.6 LiDAR Point Cloud Classification and Rasterization

Table 17. Balili classification results in TerraScan

Pertinent Class	Total Number of Points
Ground	1,808,617,897
Low Vegetation	1,572,153,754
Medium Vegetation	1,928,469,461
High Vegetation	2,983,548,273
Building	68,699,481

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Balili Floodplain is shown in Figure 22. A total of 2,428 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 17. The point cloud has a maximum and minimum height of 868.76 meters and 62.15 meters, respectively.

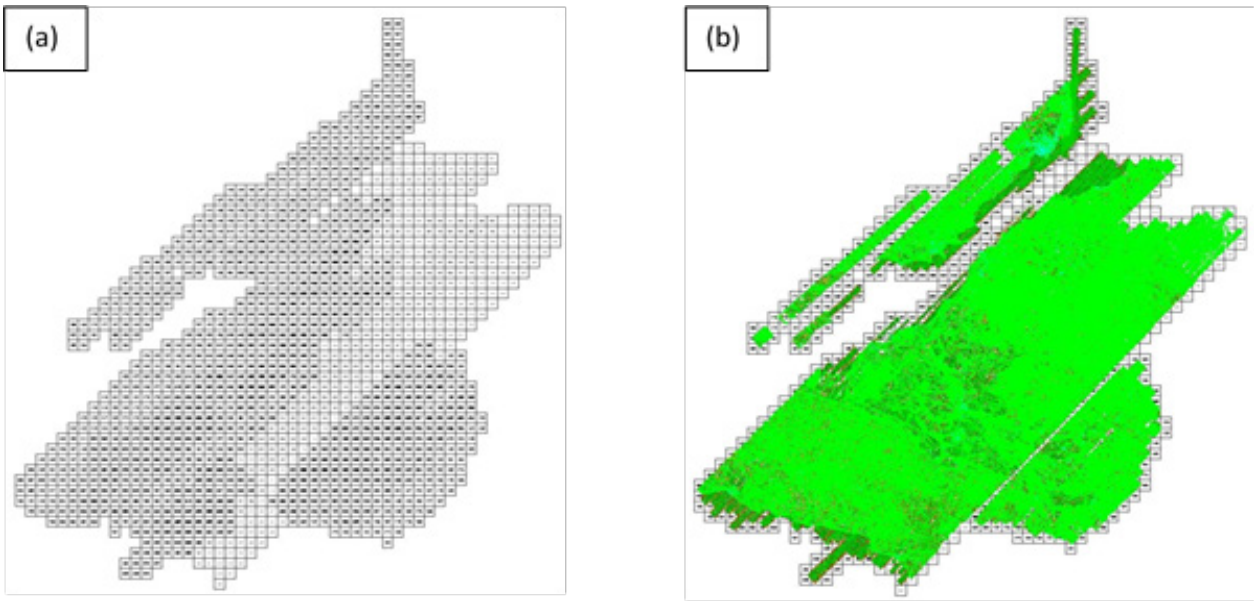


Figure 22. Tiles for Balili Floodplain (a) and classification results (b) in TerraScan

An isometric view of an area before and after running the classification routines is shown in Figure 23. 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.

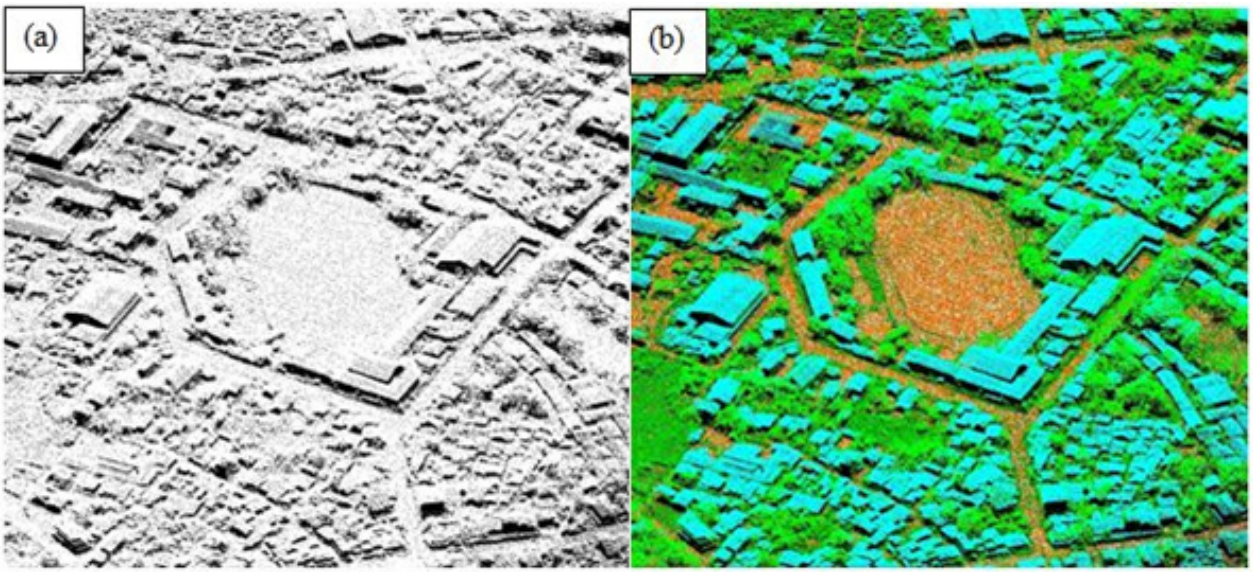


Figure 23. Point cloud before (a) and after (b) classification

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

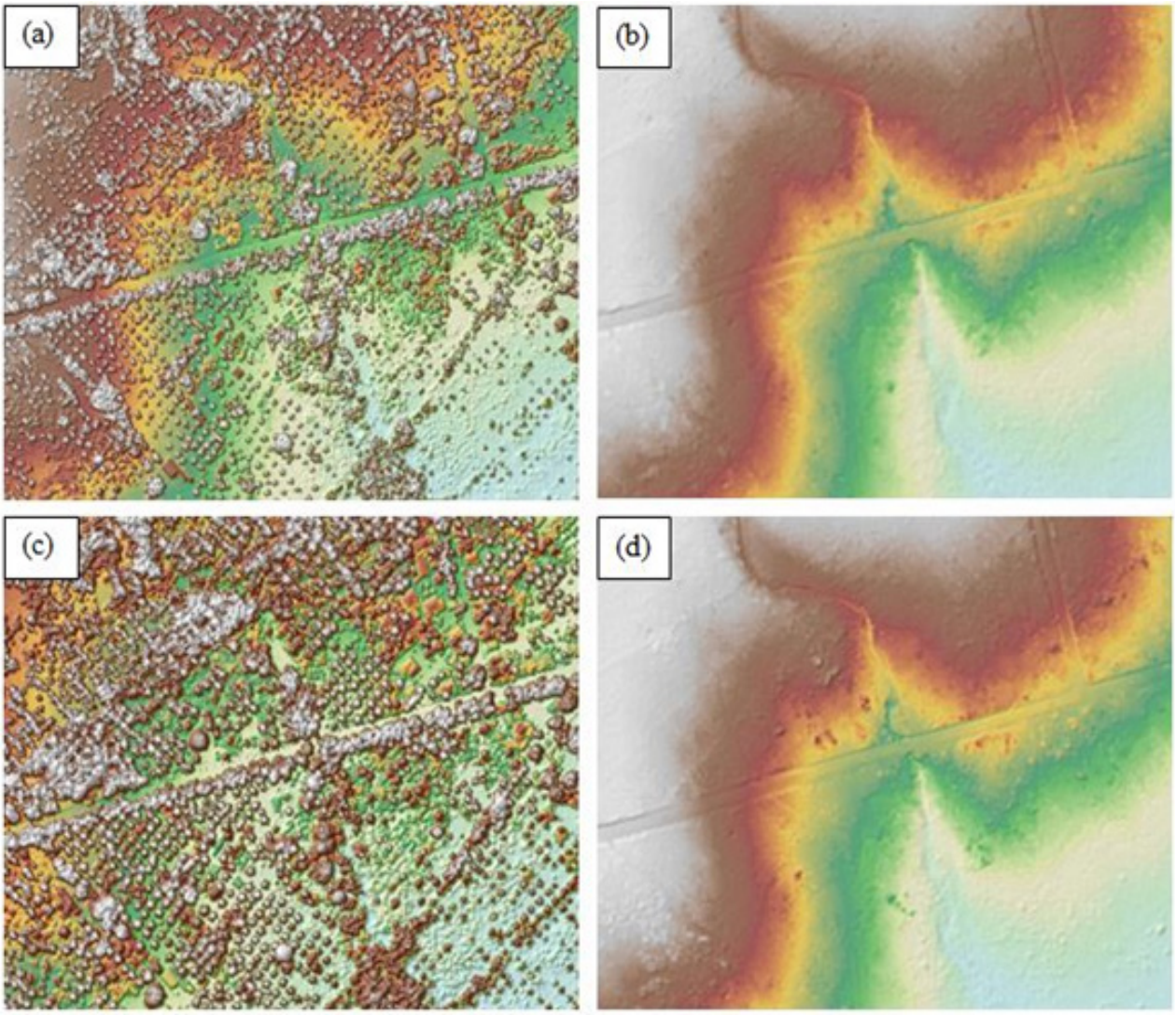


Figure 24. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Balili Floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 1,759 1km by 1km tiles area covered by Balili Floodplain is shown in Figure 25. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Balili Floodplain attained a total of 910.28 sq.km in orthophotogaph coverage, comprised of 3,374 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 26.

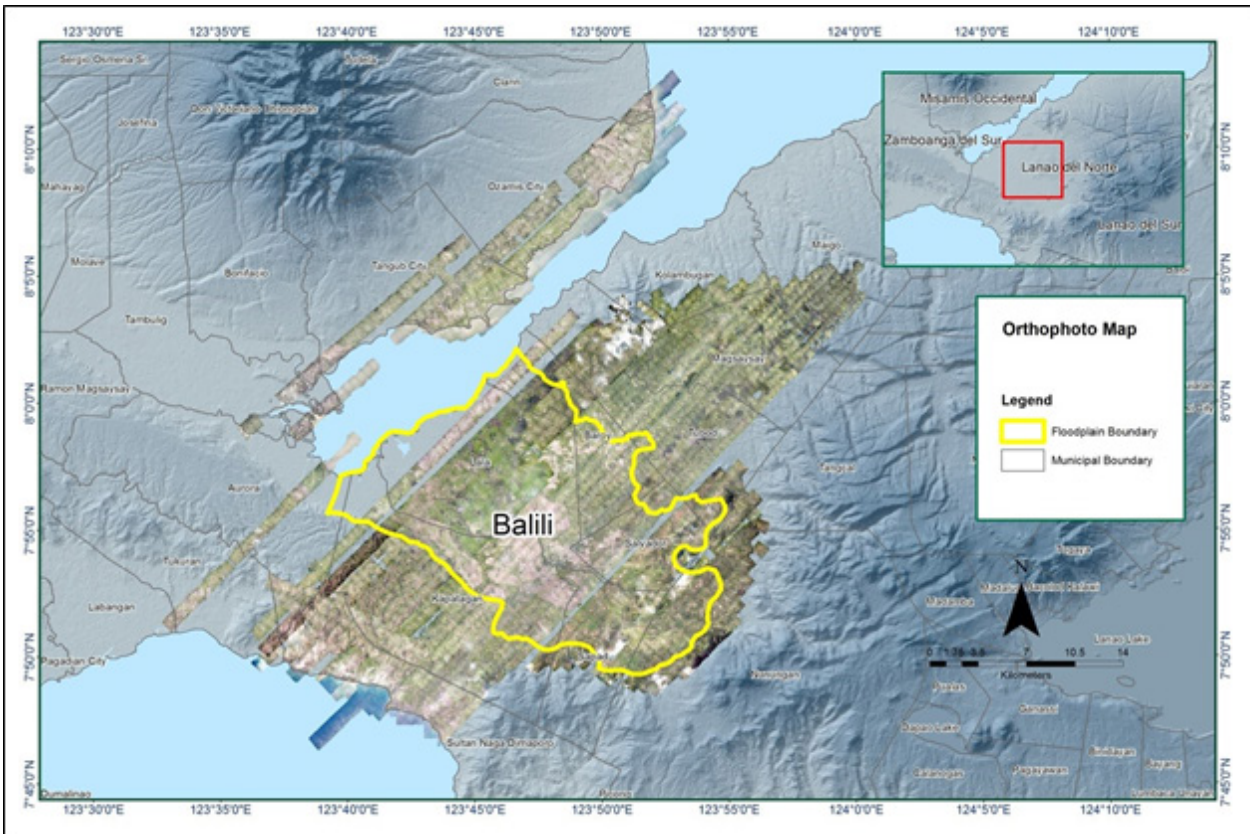


Figure 25. Balili Floodplain with available orthophotographs

Figure 26. Sample orthophotograph tiles for the Balili Floodplain.

3.8 DEM Editing and Hydro-Correction

Twelve (12) mission blocks were processed for Balili Floodplain. These blocks are composed of Dipolog_ reflight, Pagadian, and NorthernMindanao blocks with a total area of 1,737.29 sq. km. Table 18 shows the name and corresponding area of each block in square kilometers.

Table 18. LiDAR blocks with its corresponding area

LiDAR Blocks	Area (sq.km)
Pagadian_Blk76J	37.95
Pagadian_Blk76K	182.99
Pagadian_Blk76K_additional	53.29
Pagadian_Blk76M	71.78
Pagadian_Blk76N	136.47
Pagadian_Blk76N_additional	60.44
Pagadian_Blk76N_supplement	5.3
NorthernMindanao_Blk71_extension	138.3
NorthernMindanao_Blk71E	194.58
NorthernMindanao_Blk71F	500.1
NorthernMindanao_Blk71G	282.38
Dipolog_reflight_Blk76M	73.714
TOTAL	1,737.29 sq.km

Portions of DTM before and after manual editing are shown in Figure 27. The bridge (Figure 27a) is also considered to be an impedance to the flow of water along the river and has to be removed (Figure 27b) in order to hydrologically correct the river. The paddy field (Figure 27c) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 27d) to allow the correct flow of water.

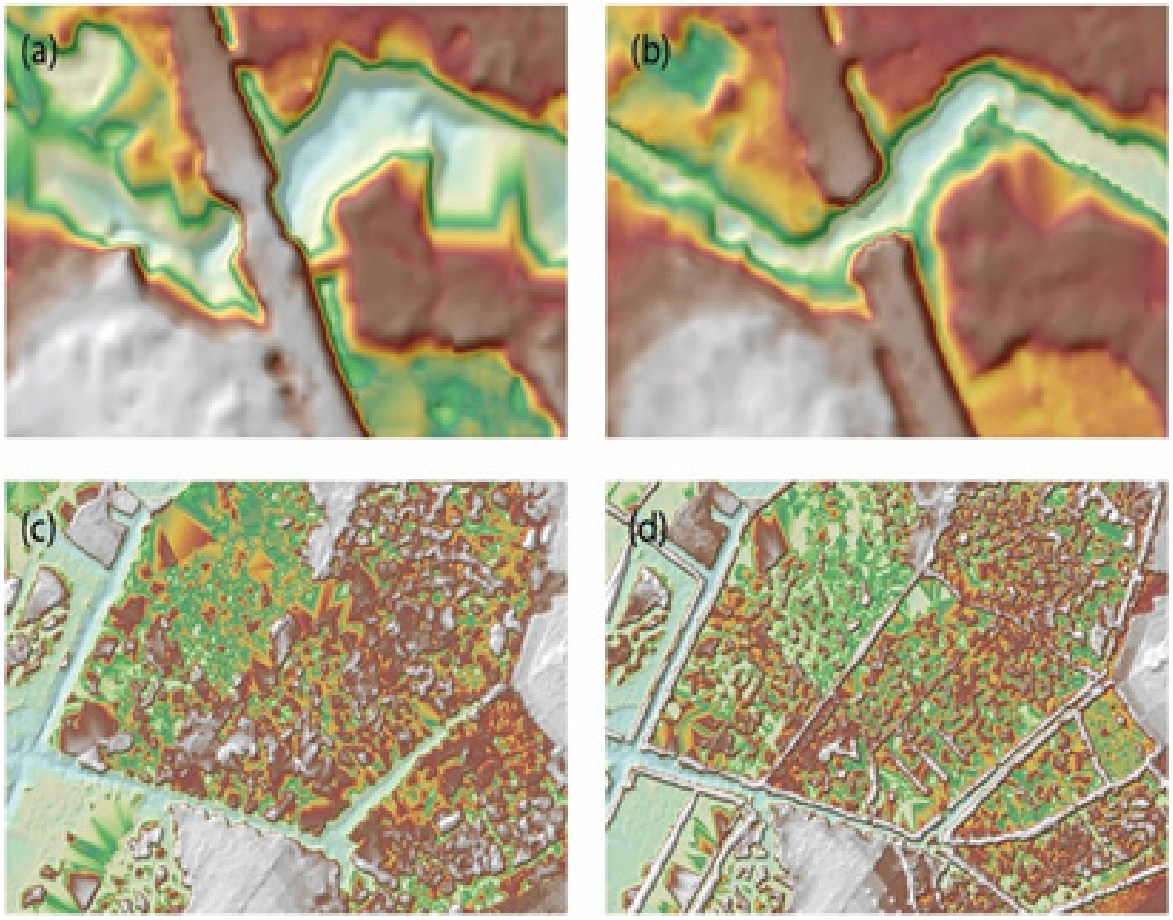


Figure 27. Portions in the DTM of Balili Floodplain—a bridge before (a) and after (b) manual editing; a paddy field before (c) and after (d) data retrieval

3.9 Mosaicking of Blocks

NorthernMindanao_Blk71F was used as the reference block at the start of mosaicking because it comprises the largest area among the missions blocks. Table 19 shows the shift values applied to each LiDAR block during mosaicking.

Table 19. Shift Values of each LiDAR block of Balili Floodplain

Mission Blocks	Shift Values (meters)		
	x	y	z
Pagadian_Blk76J	-0.20	0.40	0.00
Pagadian_Blk76K	0.00	0.00	0.00
Pagadian_Blk76K_additional	0.00	0.00	0.00
Pagadian_Blk76M	0.00	0.00	0.00
Pagadian_Blk76N	0.00	0.00	0.00
Pagadian_Blk76N_additional	0.75	0.50	-0.45
Pagadian_Blk76N_supplement	0.05	0.05	-0.45
NorthernMindanao_Blk71_extension	0.00	0.00	0.00
NorthernMindanao_Blk71E	0.00	0.00	-0.30
NorthernMindanao_Blk71F	0.00	0.00	0.00
NorthernMindanao_Blk71G	0.00	0.00	0.00
Dipolog_reflight_Blk76M	0.70	-0.60	-0.42

Mosaicked LiDAR DTM for Balili Floodplain is shown in Figure 28. It can be seen that the entire Balili Floodplain is 99.76% covered by LiDAR data.

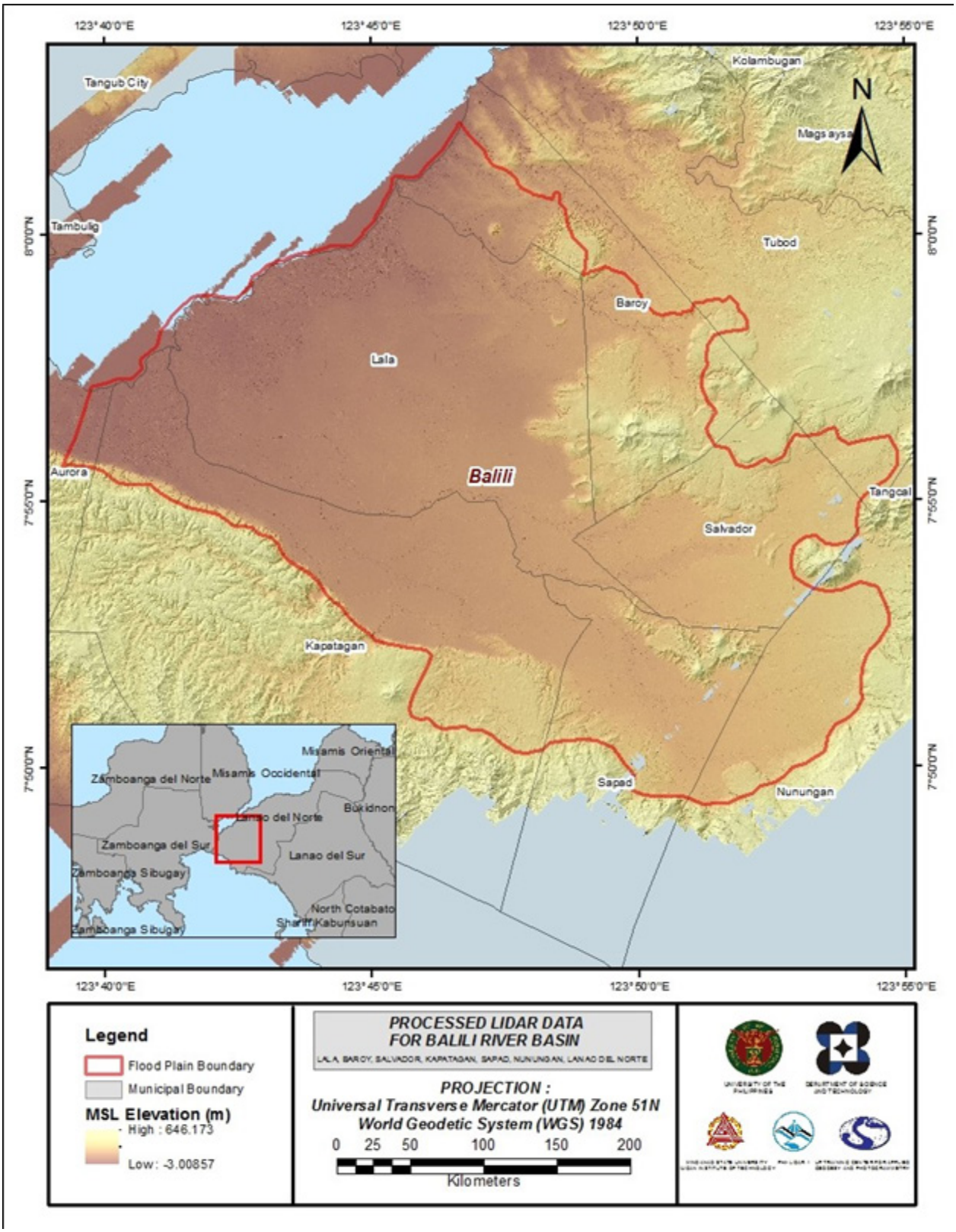


Figure 28. Map of Processed LiDAR Data for Balili Floodplain

3.10 Calibration and Validation of Mosaicked LiDAR Digital Elevation Model

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Balili to collect points with which the LiDAR dataset is validated is shown in Figure 29. A total of 2,003 survey points were used for calibration and validation of Balili LiDAR data. Random selection of 80% of the survey points, resulting in 1,602 points, was used for calibration. A good correlation between the uncalibrated mosaicked LiDAR elevation values and the ground survey elevation values is shown in Figure 30. 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 elevation values is 2.27 meters with a standard deviation of 0.08 meters. Calibration of Balili LiDAR data was done by adding the height difference value, 2.27 meters, to Balili mosaicked LiDAR data. Table 20 shows the statistical values of the compared elevation values between LiDAR data and calibration data.

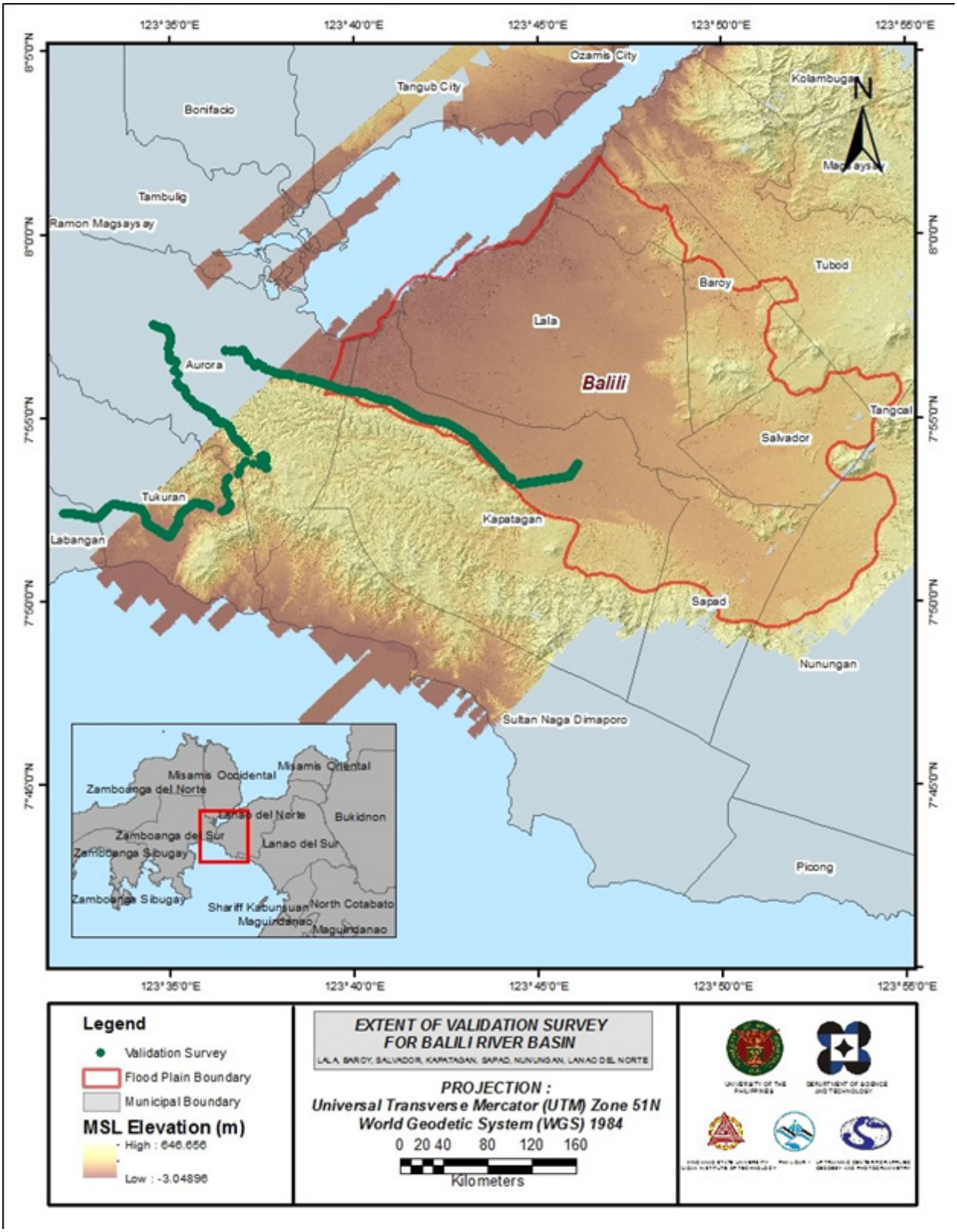


Figure 29. Map of Balili Floodplain with validation survey points in green

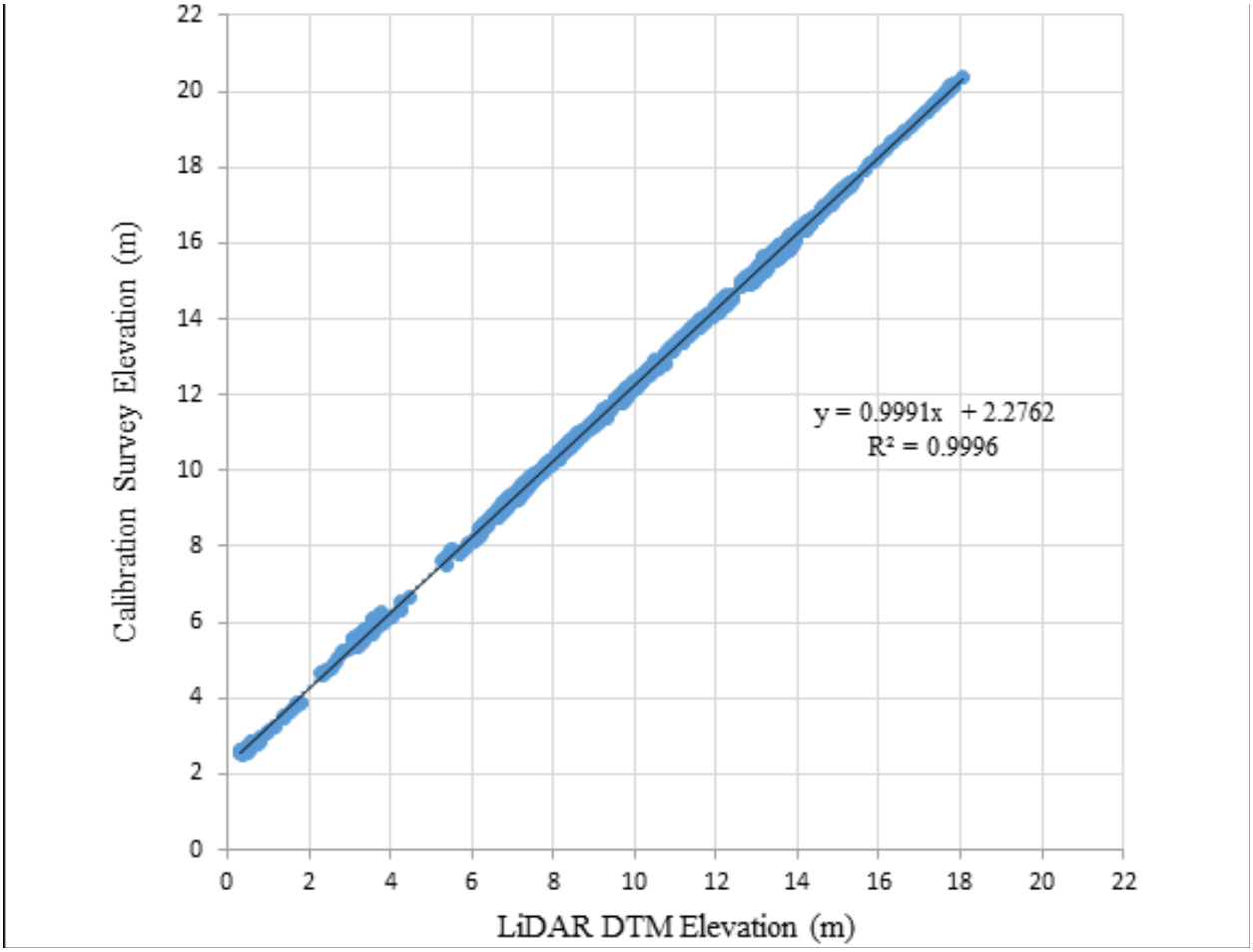


Figure 30. Correlation plot between calibration survey points and LiDAR data

Table 20. Calibration Statistical Measures

Calibration Statistical Measures	Value (meters)
Height Difference	2.27
Standard Deviation	0.08
Average	2.27
Minimum	2.06
Maximum	2.52

The remaining 20% of the total survey points, resulting in 1,110 points, were used for the validation of calibrated Balili 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 31. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.22 meters with a standard deviation of 0.21 meters, as shown in Table 21.

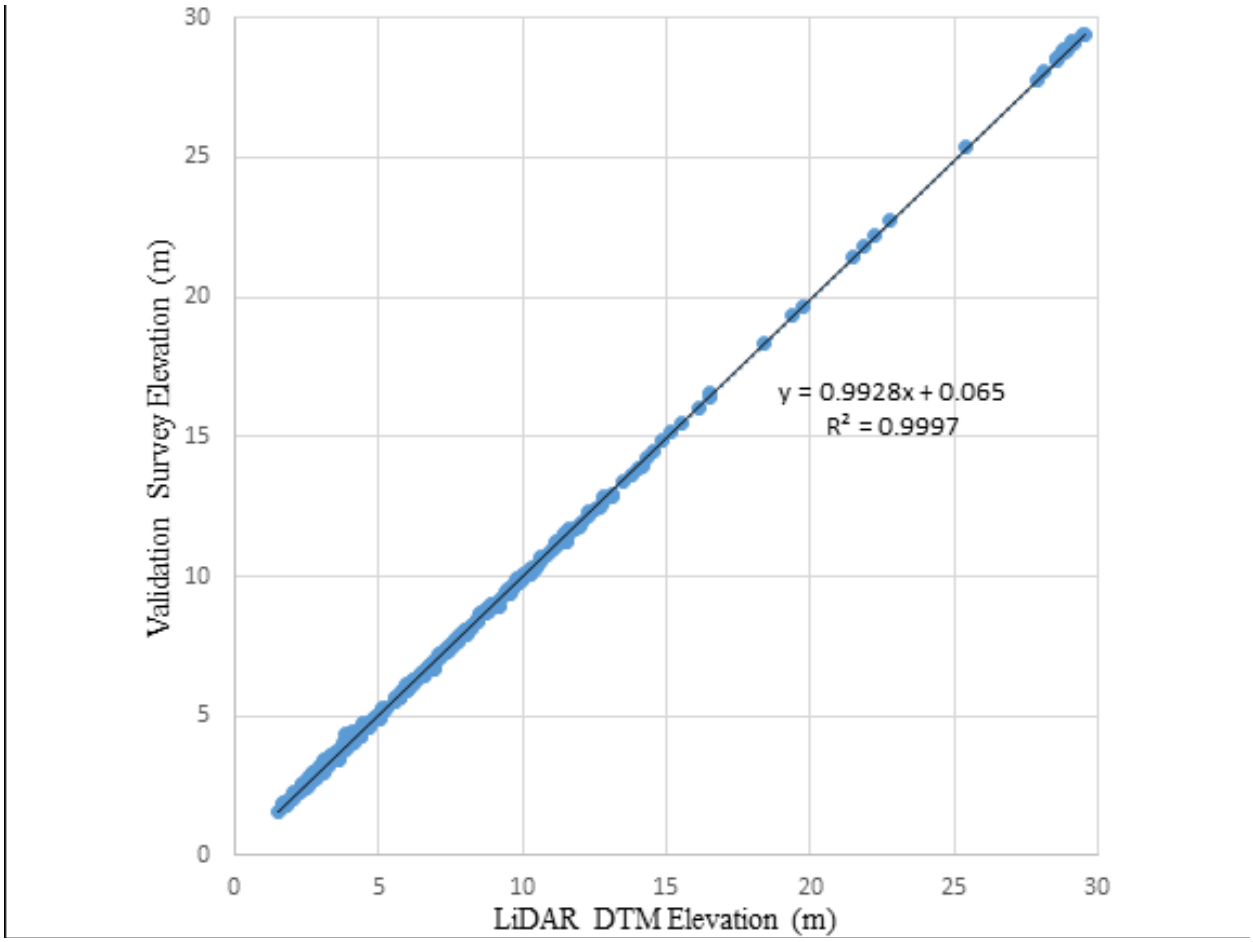


Figure 31. Correlation plot between validation survey points and LiDAR data

Table 21. Validation Statistical Measures

Validation Statistical Measures	Value (meters)
RMSE	0.22
Standard Deviation	0.21
Average	0.09
Minimum	-0.33
Maximum	0.50

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, only cross-section data was available for Balili with 1,113 bathymetric survey points. The resulting raster surface produced was done by Kernel interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.53meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Balili integrated with the processed LiDAR DEM is shown in Figure 32.

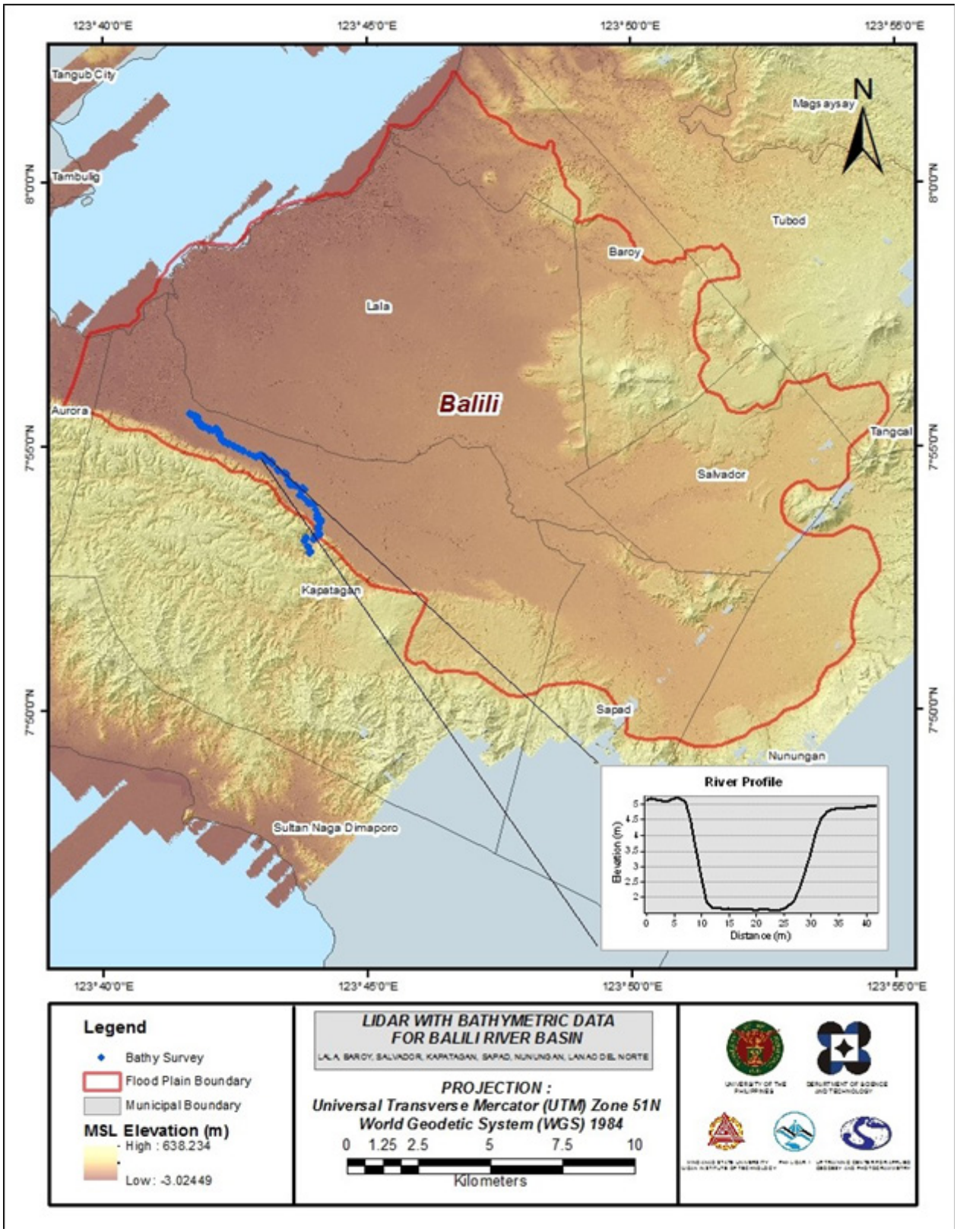


Figure 32. Map of Balili Floodplain with bathymetric survey points shown in blue

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 200m buffer zone. Mosaicked LiDAR DEM with 1m 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

Balili Floodplain, including its 200m buffer, has a total area of 367.13sq.km. For this area, a total of 12.00 sq.km, corresponding to a total of 2,495 building features, is considered for QC. Figure 33 shows the QC blocks for Balili Floodplain

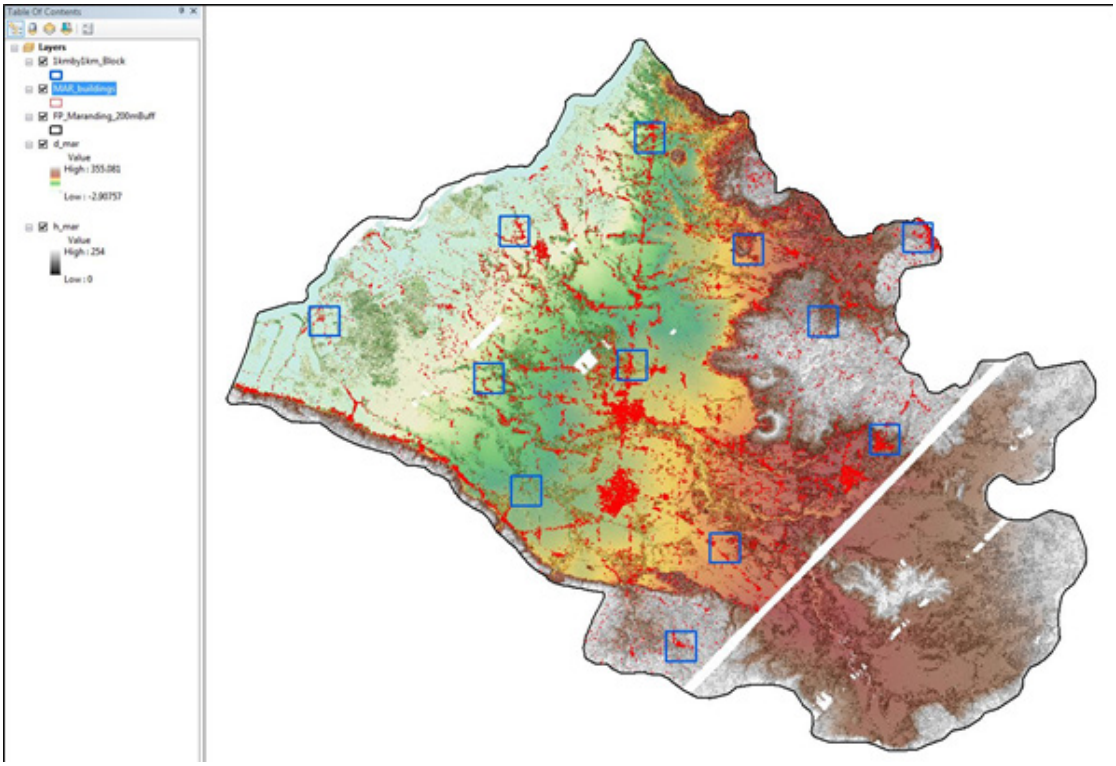


Figure 33. Blocks (in blue) of Balili building features that were subjected to QC.

Quality checking of Balili building features resulted in the ratings shown in Table 22.

Table 22. Quality Checking Ratings for Balili Building Features

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Balili	89.11	99.65	83.06	PASSED

3.12.2 Height Extraction

Height extraction was done for 53,418 building features in Balili Floodplain. Of these building features, 1,621 were filtered out after height extraction, resulting in 51,797 buildings with height attributes. The lowest building height is at 2.00m, while the highest building is at 20.37m.

3.12.3 Feature Attribution

Balili Floodplain is shared by six (6) municipalities namely municipality of Lala, municipality of Baroy, municipality of Salvador, municipality of Kapatagan, municipality of Sapad, and municipality of Nunungan. The building attribution on the municipalities of Lala, Baroy, Salvador, Kapatagan, Sapad, and Nunungan was done with the Google Earth approach. In Google Earth approach, aid from Purok representatives were sought for participatory mapping over the Google Earth software. The attributions of road, bridge, and water body features were done using NAMRIA maps, municipal and city records, and participatory mapping of municipals and cities.

Table 23 summarizes the number of building features per type. On the other hand, Table 24 shows the total length of each road type, while Table 25 shows the number of water features extracted per type.

Table 23. Building features that were extracted for the Balili Floodplain.

Facility Type	No. of Features
Residential	49,219
School	700
Market	23
Agricultural/Agro-Industrial Facilities	365
Medical Institutions	84
Barangay Hall	87
Military Institution	38
Sports Center/Gymnasium/Covered Court	34
Telecommunication Facilities	3
Transport Terminal	4
Warehouse	167
Power Plant/Substation	1
NGO/CSO Offices	3
Police Station	5
Water Supply/Sewerage	7
Religious Institutions	298
Bank	6
Factory	2
Gas Station	13
Fire Station	3
Other Government Offices	308
Other Commercial Establishments	427
Total	51,797

Table 24. Total Length of Extracted Roads for Balili Floodplain

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Balili	303.26	89.29	44.19	71.69	0.00	508.43

Table 25. Number of Extracted Water Bodies for Balili Floodplain

Floodplain	Water Body Type					Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Balili	39	0	0	3	231	273

A total of 105 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 34 shows the Digital Surface Model (DSM) of Balili Floodplain overlaid with its ground features.

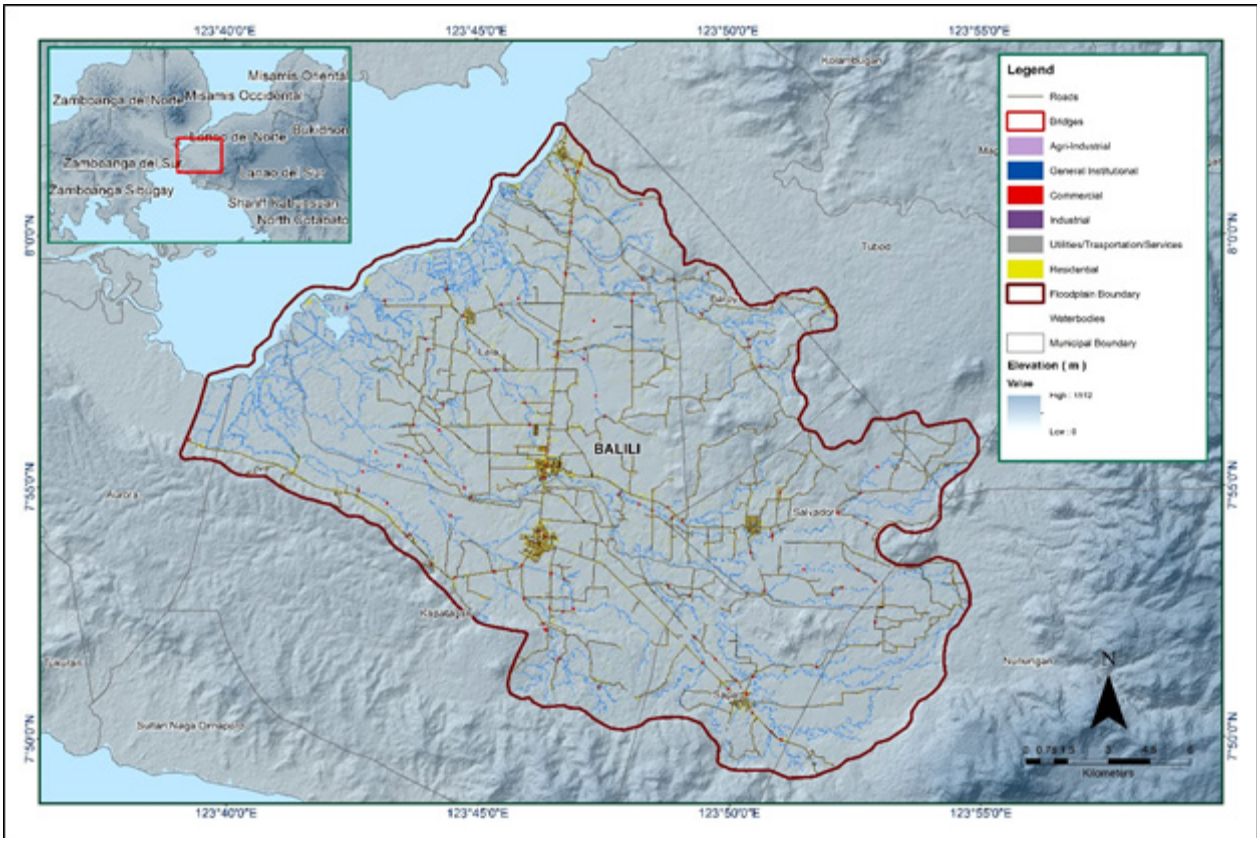


Figure 34. Extracted features for Balili Floodplain.

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

Engr. Louie P. Balicanta, Engr. Joemarie S. Caballero, Ms. Patrizcia Mae. P. dela Cruz, Engr. Kristine Ailene B. Borromeo

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

AB Surveying and Development (ABSD) conducted a field survey in Balili River on March 21, 2016 and May 11–13, 2016 with the following scope: reconnaissance; control survey; and cross-section and as-built survey at Balili Bridge in Brgy. Sta. Cruz, Municipality of Kapatagan, Lanao del Norte. Random checking points for the contractor's cross-section and bathymetry data were gathered by DVBC on August 19, 2016 using a Trimble® SPS 882 GNSS PPK survey technique. In addition to this, validation points acquisition survey was conducted covering the Balili River Basin area. The entire survey extent is illustrated in Figure 35.

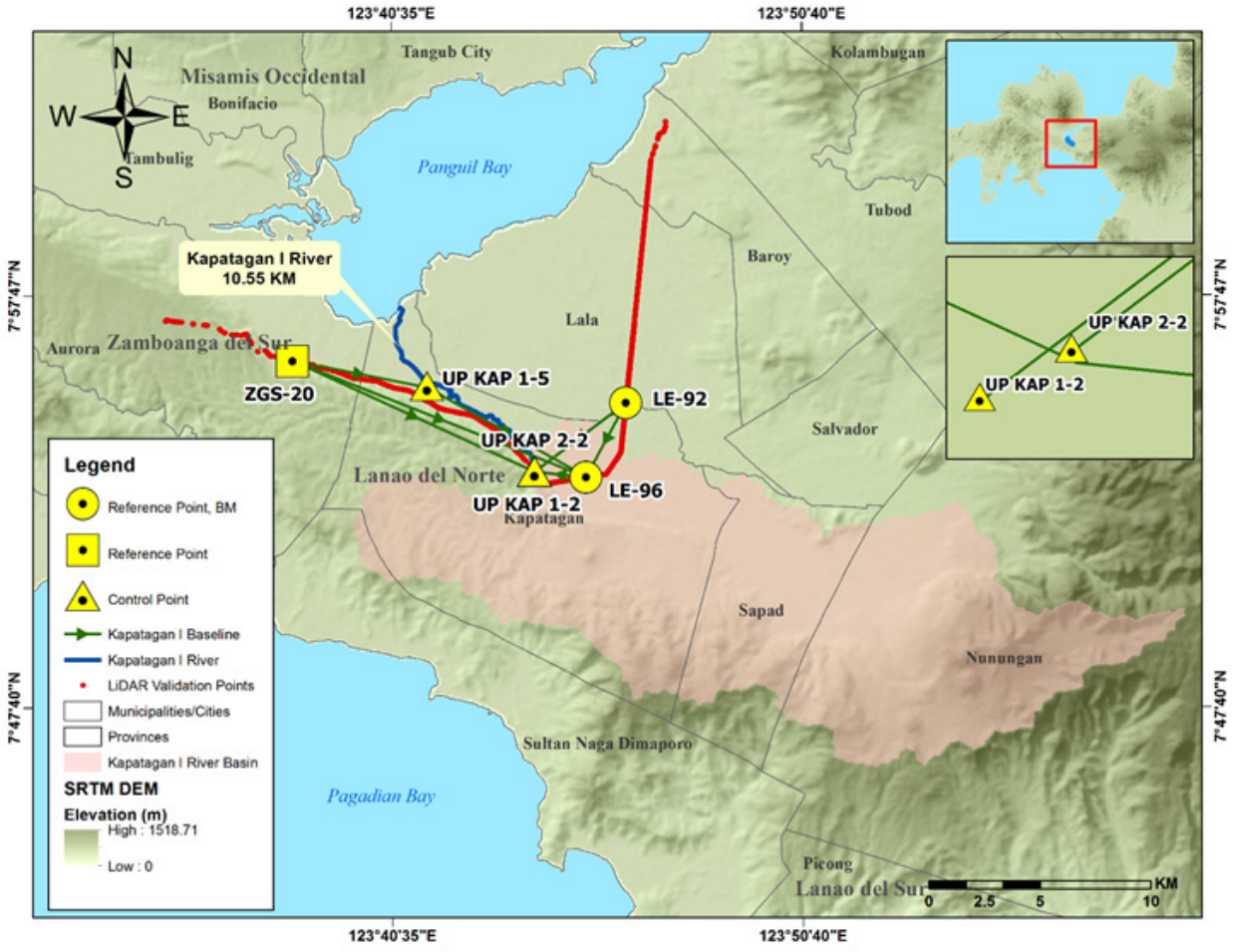


Figure 35. Extent of the bathymetric survey (in blue) in Balili River and the LiDAR data validation survey (in red)

4.2 Control Survey

The GNSS network used for Balili River is composed of four (4) loops established on August 8 and November 2, 2016 occupying the following reference points: ZGS-20, a second-order GCP, in Brgy. Anonang, Municipality of Aurora, Zamboanga del Sur; LE-92, a first-order BM, in Brgy. Maranding, Municipality of Lala, Lanao del Norte; and LE-96, a first-order BM, in Brgy. Poblacion, Municipality of Kapatagan, Lanao del Norte.

Three (3) control points established in the area were also occupied: UP_KAP 1-2, located near the approach of Balili Bridge in Brgy. Sta. Cruz, Municipality of Kapatagan, Province of Lanao del Norte; UP_KAP 1-5, located within a basketball court in Brgy. Lapinig, Municipality of Kapatagan, Province of Lanao del Norte; and UP_KAP 2-2, located near the approach of Butadon Bridge in Brgy. Sta. Cruz, Municipality of Kapatagan, Province of Lanao del Norte.

The summary of reference and control points and its location is summarized in Table 26 while GNSS network established is illustrated in Figure 36.

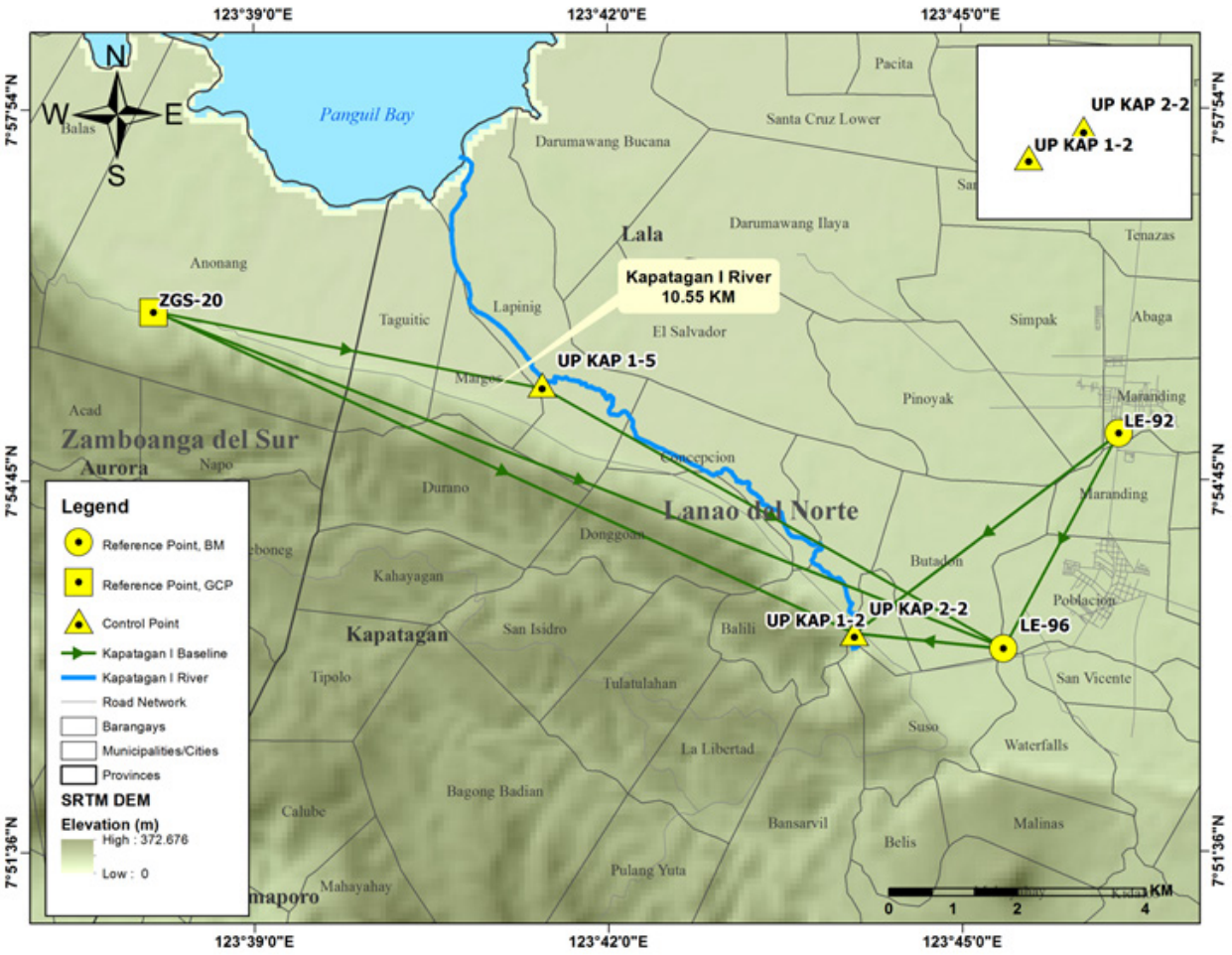


Figure 36. GNSS Network established in the Balili River Survey

Table 26. List of reference and control points used during the survey in Balili River (Source: NAMRIA, UP TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (Meter)	Elevation in MSL (Meter)	Date Established
ZGS-20	2nd order, GCP	7°56'10.67208"N	123°38'09.10220"E	95.136	26.596	2005
LE-92	1st order, BM	7°55'08.47442"N	123°46'19.89121"E	89.406	20.730	2007
LE-96	1st order, BM	7°53'19.07415"N	123°45'21.01225" E	85.854	17.153	2007
UP_KAP 1-2	Established	7°53'27.09042"N	123°44'05.15906"E	87.865	19.212	05-11-16
UP_KAP 1-5	Established	7°55'33.70206"N	123°41'26.70374"E	70.334	1.798	05-11-16
UP_KAP 2-2	Established	7°53'27.09071"N	123°44'05.15960"E	87.673	19.021	05-11-16

The GNSS set-ups on recovered reference points and established control points in Balili River are shown from Figure 37 to Figure 42.

Figure 37. GNSS receiver set-up, Trimble®SPS 882 at ZGS-20, located on the side of the National Highway from Zamboanga del Sur going to Lanao del Norte in Brgy. Anonang, Municipality of Aurora, Zamboanga del Sur

Figure 38. GNSS receiver set-up, Trimble®SPS 985, at LE-96, located at the approach of Butadon Bridge in Brgy. Poblacion, Municipality of Kapatagan, Lanao del Norte

Figure 39. GNSS receiver set-up, Trimble®SPS 882, at LE-96, located at the approach of Butadon Bridge in Brgy. Poblacion, Municipality of Kapatagan, Lanao del Norte

Figure 40. GNSS receiver set-up, Hi-Target®V30, at UP_KAP 1-5, located in a basketball court in Brgy. Lapinig, Municipality of Kapatagan, Lanao del Norte

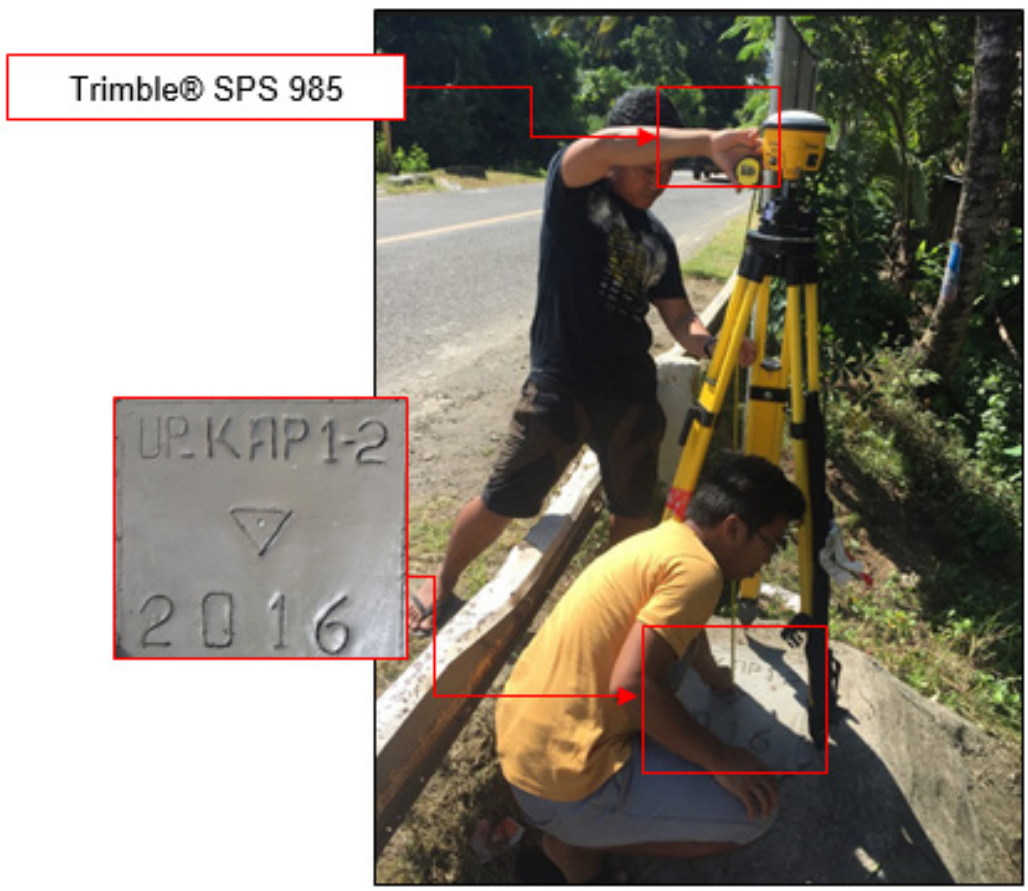


Figure 41. GNSS receiver set-up, Trimble®SPS 985, at UP_KAP 1-2, located near the approach of Balili Bridge in Brgy. Sta. Cruz, Municipality of Kapatagan, Lanao del Norte

Figure 42. GNSS receiver set-up, Trimble®SPS 882, at UP-KAP 2-2,located near the approach of Butadon Bridge in Brgy. Sta. Cruz, Municipality of Kapatagan, Lanao del Norte

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 was 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 Balili River Basin is summarized in Table 27 generated by TBC software.

Table 27. Baseline Processing Report for Balili River Static Survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
LE-92 --- UP KAP 1-2	8-18-2016	Fixed	0.005	0.024	232°57'38"	5170.225	-1.528
UP KAP 1-5 --- LE-96	8-18-2016	Fixed	0.006	0.029	119°57'00"	8283.207	15.481
LE-96 --- UP KAP 2-2	8-18-2016	Fixed	0.007	0.048	276°03'08”	2336.448	1.831
LE-96 --- UP KAP 1-2	8-18-2016	Fixed	0.014	0.072	276°03'09”	2336.467	1.877
LE-92 --- LE-96	8-18-2016	Fixed	0.012	0.055	208°13'12"	3814.139	-3.443
UP KAP 1-5 --- ZGS-20	8-18-2016	Fixed	0.003	0.019	100°37'31"	6157.763	-24.818
UP KAP 2-2 --- ZGS-20	8-18-2016	Fixed	0.005	0.029	114°44'01"	12007.875	-7.467
ZGS-20 --- LE-96	8-18-2016	Fixed	0.007	0.045	111°43'07"	14240.741	-9.312
LE-96 --- ZGS-20	8-18-2016	Fixed	0.007	0.051	111°43'07"	14240.722	-9.327

As shown in Table 27, a total of nine (9) baselines were processed with coordinate and ellipsoidal height values of ZGS-20 and LE-92 held fixed. All of them passed the required accuracy.

4.4 Network Adjustment

After the baseline processing procedure, the network adjustment is performed using the TBC software. 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 for each control point; or in equation form:

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

where:

xe is the Easting Error,
ye is the Northing Error, and
ze is the Elevation Error

See the Network Adjustment Report shown from Table 28 to Table 30 for the complete details. Refer to ANNEX 1 for the computation for the accuracy of ABSD.

The six (6) control points, ZGS-20, LE-92, LE-96, UP_KAP-1-2, UP_KAP-1-5, UP_KAP-2-2 were occupied and observed simultaneously to form a GNSS loop. The coordinates and ellipsoidal heights of ZGS-20 and LE-92 were held fixed during the processing of the control points as presented in Table 28. Through this reference point, the coordinates and ellipsoidal height of the unknown control points were computed.

Table 28. Control Point Constraints

Point ID	**Type**	**East σ (Meter)**	**North σ (Meter)**	**Height σ (Meter)**	**Elevation σ (Meter)**
LE-92	Global	Fixed	Fixed	Fixed	
ZGS-20	Global	Fixed	Fixed	Fixed	
Fixed = 0.000001(Meter)					

Table 29. Adjusted Grid Coordinated

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
ZGS-20	570083.672	?	877309.182	?	26.596	?	LLh
LE-92	585114.134	?	875424.503	?	20.730	?	LLh
LE-96	583317.383	0.019	872061.376	0.019	17.153	0.059	
UP KAP 1-2	580994.200	0.012	872303.417	0.011	19.212	0.068	
UP KAP 1-5	576135.647	0.011	876183.473	0.010	1.798	0.051	
UP KAP 2-2	580994.217	0.019	872303.426	0.019	19.021	0.077	

The results of the computation for accuracy are as follows:

ZGS-20
horizontal accuracy = Fixed
vertical accuracy = Fixed

LE-92
horizontal accuracy = Fixed
vertical accuracy = Fixed

LE-96
horizontal accuracy = $\sqrt{((1.9)^2 + (1.9)^2}$
= $\sqrt{}$ (3.61+ 3.61)
= 7.22< 20 cm
vertical accuracy = 5.9< 10 cm

UP KAP 1-2
horizontal accuracy = $\sqrt{((1.2)^2 + (1.1)^2}$
= $\sqrt{}$ (1.44 + 1.21)
= 2.65< 20 cm
vertical accuracy = 6.8< 10 cm

Following the given formula, the horizontal and vertical accuracy result of the six (6) occupied control points are within the required precision.

Table 30. Adjusted geodetic coordinates for control points used in the Balili River Flood Plain validation.

Point ID	Latitude	Longitude	Ellipsoid	Height	Constraint
LE-92	7°55'08.47442"N	123°46'19.89121"E	89.406	?	LLh
LE-96	7°53'19.07415"N	123°45'21.01225"E	85.854	0.059	
UP KAP 1-2	7°56'10.67208"N	123°38'09.10220"E	87.865	0.068	
UP KAP 1-5	7°53'27.09042"N	123°44'05.15906"E	70.334	0.051	
UP KAP 2-2	7°55'33.70206"N	123°41'26.70374"E	87.673	0.077	
ZGS-20	7°53'27.09071"N	123°44'05.15960"E	95.136	?	LLh

Table 31. Reference and control points used and its location (Source: NAMRIA, UP TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	BM Ortho (m)
LE-92	2nd Order, GCP	7°55'08.47442"N	123°46'19.89121"E	95.136	877309.182	570083.672	26.596
LE-96	1st Order, BM	7°53'19.07415"N	123°45'21.01225"E	89.406	875424.503	585114.134	20.730
ZGS-20	2nd Order, GCP	7°56'10.67208"N	123°38'09.10220"E	87.673	872303.426	580994.217	19.021
UP KAP 1-2	Established	7°53'27.09042"N	123°44'05.15906"E	85.854	872061.376	583317.383	17.153
UP KAP 1-5	Established	7°55'33.70206"N	123°41'26.70374"E	87.865	872303.417	580994.200	19.212
UP_KAP 2-2	Established	7°53'27.09071"N	123°44'05.15960"E	70.334	876183.473	576135.647	1.798

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

Cross-section and as-built surveys were conducted on May 11, 2016 by ABSD at the upstream side of Balili Bridge in Brgy. Sta. Cruz, Municipality of Kapatagan, Lanao del Sur as shown in Figure 43. Nikon®Total Station was utilized for this survey as shown in Figure 44.

Figure 43. Upstream/downstream side of Balili Bridge

Figure 44. As-built survey of Balili Bridge

The cross-sectional line of Balili Bridge is about 124.283 m with thirty-one(31) cross-sectional points using the control points UP_KAP 1-1 and UP_KAP 1-2 as the GNSS base stations. The cross-section location map, diagram, and the bridge data form are shown in Figure 45 and Figure 46.

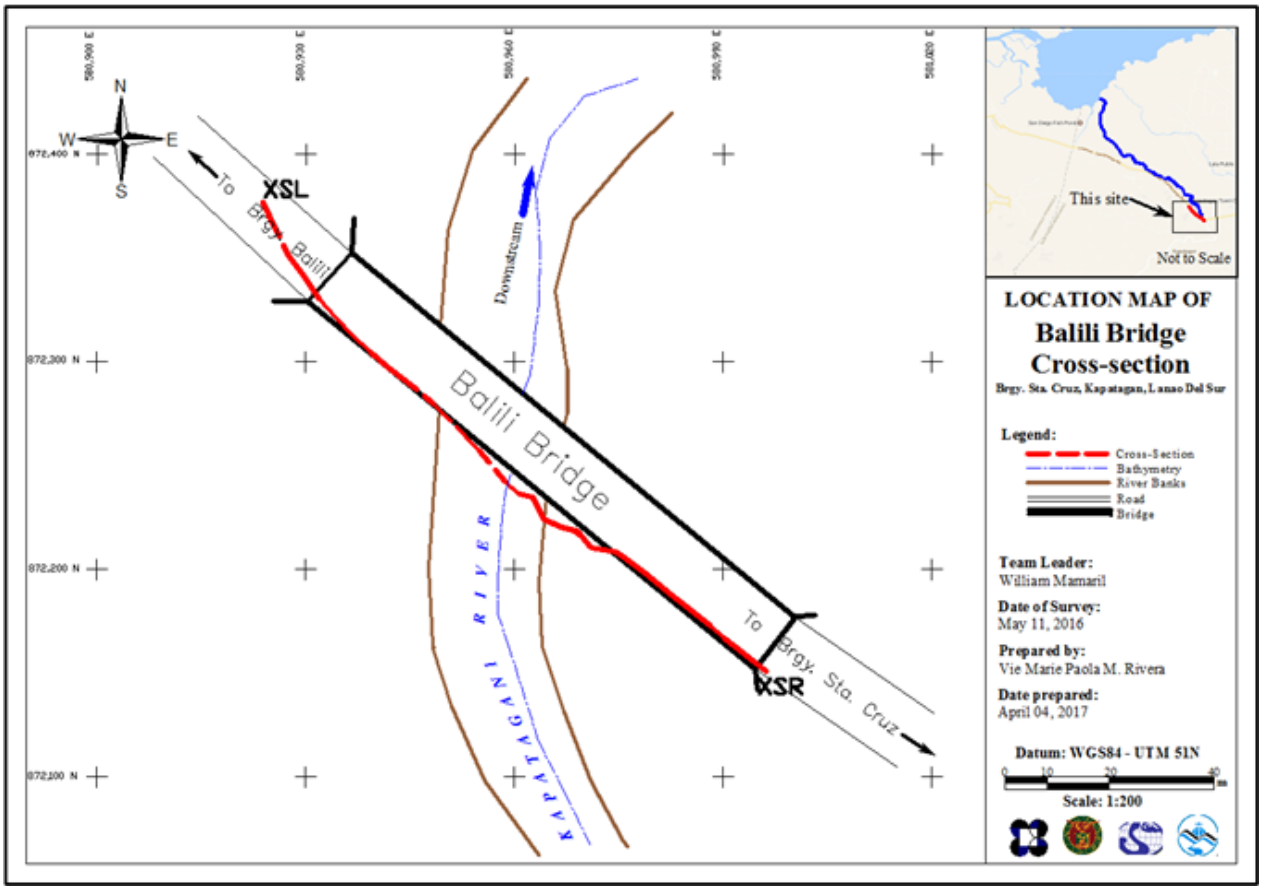


Figure 45. Balili Bridge cross-section location map

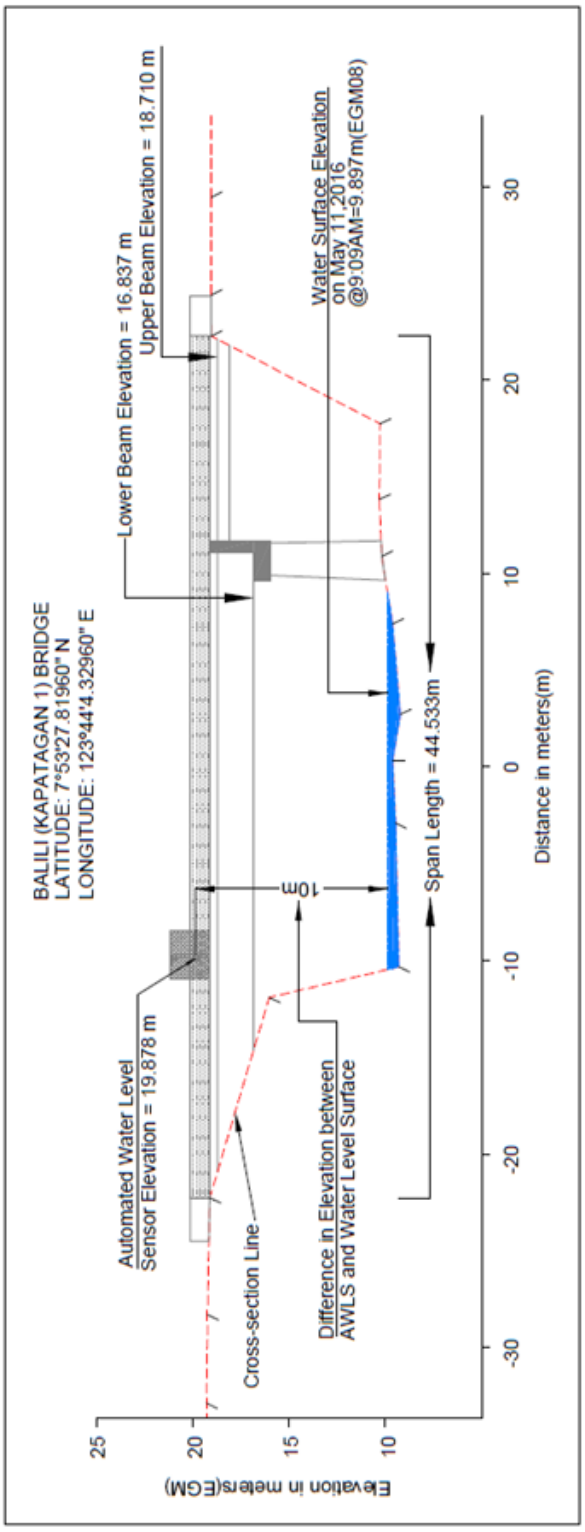


Figure 46. Balili Bridge cross-section diagram

Bridge Data Form

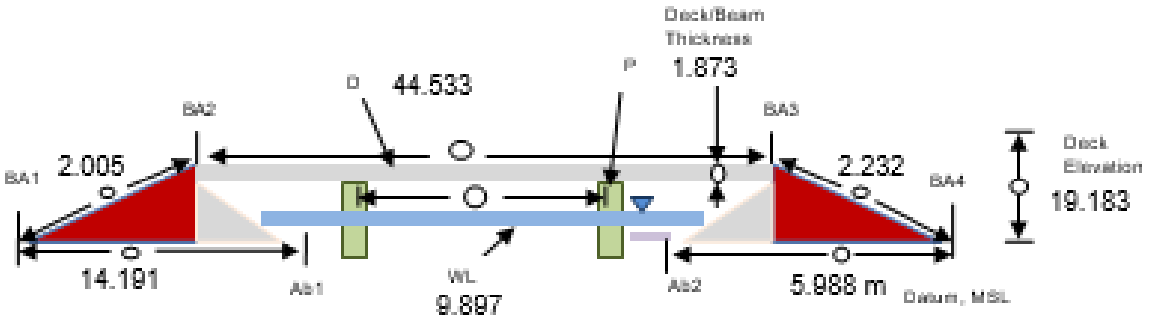
Bridge Name: BALILI BRIDGE

River Name: KAPATAGAN 1 RIVER
Location (Brgy, City, Region): Brgy. Sta. Cruz, Kapatagan, Lanao del Sur

Survey Team: William Magnaril, Jerby, Ote
Date and Time: May 11, 2016; 9:09 A.M.

Flow Condition: low ✔ normal high

Weather Condition: ✔ fair rainy



Legend:
BA = Bridge Approach
P = Pier
Ab = Abutment
D = Deck
WL = Water Level/Surface
MSL = Mean Sea Level
◯ = Measurement Value

Line Segment	Measurement (m)	Remarks
1. BA1-BA2	2.005 m	
2. BA2-BA3	44.533 m	
3. BA3-BA4	2.232 m	
4. BA1-Ab1	14.191 m	
5. Ab2-BA4	5.988 m	
6. Deck/beam thickness	1.873 m	
7. Deck elevation	19.183 m	

Note: Observer should be facing downstream

Figure 47. Balili Bridge Data Sheet

Water surface elevation of Balili River was determined by a Horizon® Total Station on May 11, 2016 at 9:09 A.M. at Balili Bridge area with a value of 9.897 m in EGM08 as shown in Figure 45. This was translated into marking on the bridge's pier as shown in Figure 48. The marking will serve as reference for flow data gathering and depth gauge deployment of the partner HEI responsible for Balili River, Mindanao State University – Iligan Institute of Technology.

Figure 48. Water-level markings on Balili Bridge

4.6 Validation Points Acquisition Survey

Validation points acquisition survey was conducted by DVBC from August 19-20, 2016 using a survey grade GNSS Rover receiver, Trimble® SPS 882, mounted on a range pole which was attached on the side of the vehicle as shown in Figure 49. It was secured with cable ties and ropes to ensure that it was horizontally and vertically balanced. The antenna height was 2.400 m and measured from the ground up to the bottom of the quick release of the GNSS Rover receiver. The PPK technique utilized for the conduct of the survey was set to continuous topo mode with UP_KAP 2-2 and LE-96 occupied as the GNSS base station in the conduct of the survey.

Figure 49. Validation points acquisition survey set-up for Balili River

The survey started from Brgy. Balili, Municipality of Kapatagan, Lanao del Norte going southwest along the national highway and ended in Brgy. Poblacion, Municipality of Aurora, Zamboanga del Sur on August 19, 2016 and from Brgy, Sta. Cruz, Municipality of Kapatagan, Lanao del Norte going northeast along the national highway and ended in Brgy. Sagadan, Municipality of Tubod, Lanao del Norte. A total of 5,192 points were gathered with an approximate length of 38.360 km using UP_KAP 2-2 and LE-96 as GNSS base stations for the entire extent of validation points acquisition survey as illustrated in the map in Figure 50.

Figure 50. Validation points acquisition covering the Balili River Basin Area

4.7 River Bathymetric Survey

Bathymetric survey was executed on May 21, 2016 using a Hi-Target® echo sounder as illustrated in Figure 51. The survey started downstream in Brgy. Lapinig, Municipality of Kapatagan with coordinates 7° 57' 31.34209"N, 123° 40' 42.90492"E and ended upstream in Brgy. Lapinig, Municipality of Kapatagan, Lanao del Norte with coordinates 7° 55' 36.75568"N, 123° 41' 27.01860"E.

Figure 51. Bathymetric survey of ABSD at Balili River using Hi-Target® echo sounder

Manual bathymetric survey was executed on May 21, 2016 using a Nikon® Total Station as illustrated in Figure 52. The survey started downstream in Brgy. Lapinig, Municipality of Kapatagan with coordinates 7° 55' 37.17333"N, 123° 41' 38.46804"E and ended upstream in Brgy. Suso, Municipality of Kapatagan, Lanao del Norte with coordinates 7° 52' 59.74343"N, 123° 43' 55.76124"E. The control points UP_KAP 1-5 and UP_KAP 1-6 were used as GNSS base station all throughout the entire survey.

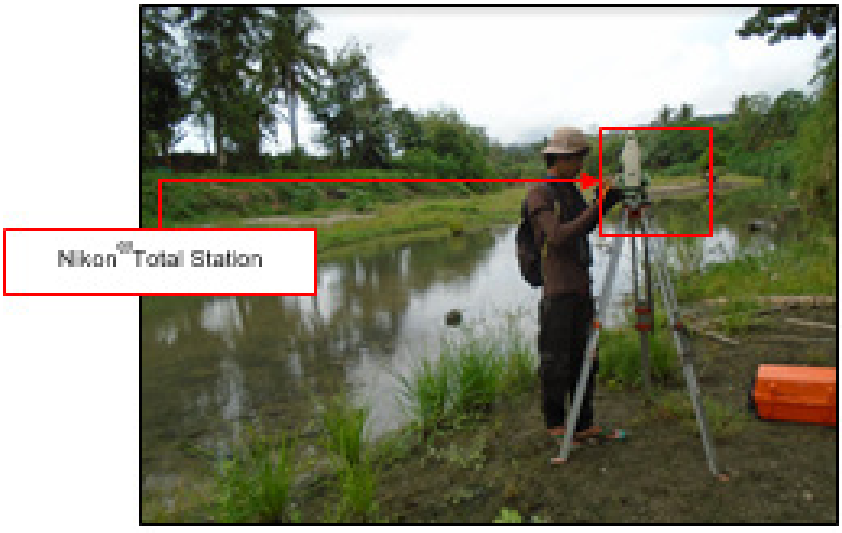


Figure 52. Manual bathymetric survey of ABSD at Balili River using NIkon®Total Station

Gathering of random points for the checking of ABSD's bathymetric data was performed by DVBC on August 19, 2016 using a Trimble® SPS 882 GNSS PPK survey technique. A map showing the DVBC bathymetric checking points is shown in Figure 54.

Linear square correlation (R2) and RMSE analysis were performed on the two (2) datasets. The linear square coefficient range is determined to ensure that the submitted data of the contractor is within the accuracy standard of the project which is ±20 cm and ±10 cm for horizontal and vertical, respectively. The R2 value must be within 0.85 to 1. An R2 approaching 1 signifies a strong correlation between the vertical (elevation values) of the two datasets. A computed R2 value of 0.999 was obtained by comparing the data of the contractor and DVBC; signifying a strong correlation between the two (2) datasets.

In addition to the Linear Square correlation, Root Mean Square (RMSE) analysis was also performed in order to assess the difference in elevation between the DVBC checking points and the contractor's.The RMSE value should only have a maximum radial distance of 5 m and the difference in elevation within the radius of 5 meters should not be beyond 0.50 m. For the bathymetric data, a computed value of 0.220 was acquired. The computed R2 and RMSE values are within the accuracy requirement of the program.

Figure 53. Gathering of random bathymetric points along Balili River

The bathymetric survey for Balili River gathered a total of 3,836 points covering an approximate of 13.410 km of the river traversing Brgy. of Lapinig, Concepcion, Balili, Sta. Cruz, and Suso in the Municipality of Kapatagan, Lanao del Norte. A CAD drawing was also produced to illustrate the riverbed profile of Ulot River. As shown in Figure 55, the highest and lowest elevation has a 25-m difference. The highest elevation observed was 31m above MSL located in Brgy. Sta. Cruz, Balili, Lanao del Norte while the lowest was -6m below MSL located in Brgy. Taguitic, Kapatagan, Lanao del Norte.

Figure 54. Bathymetric survey of Balili River

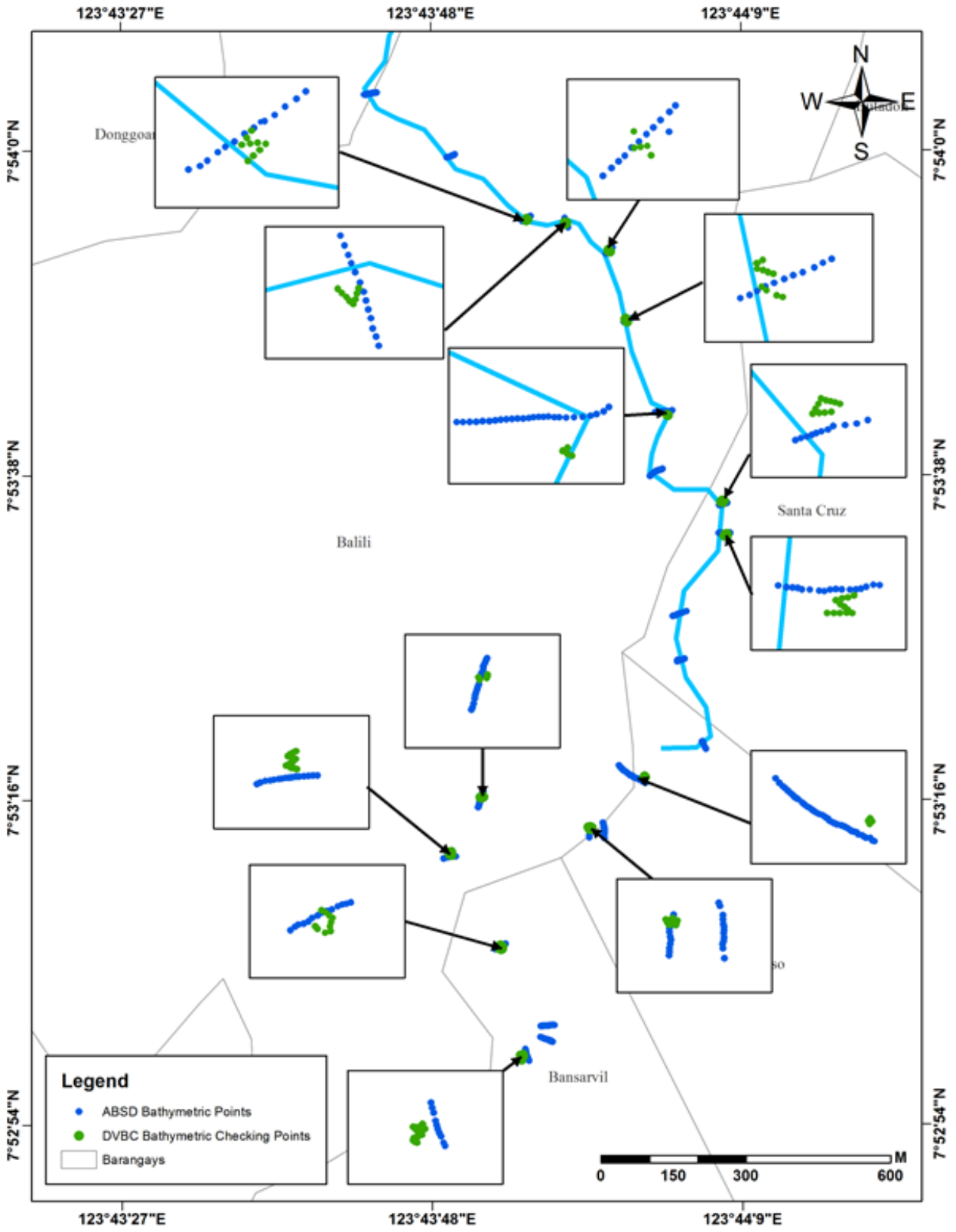
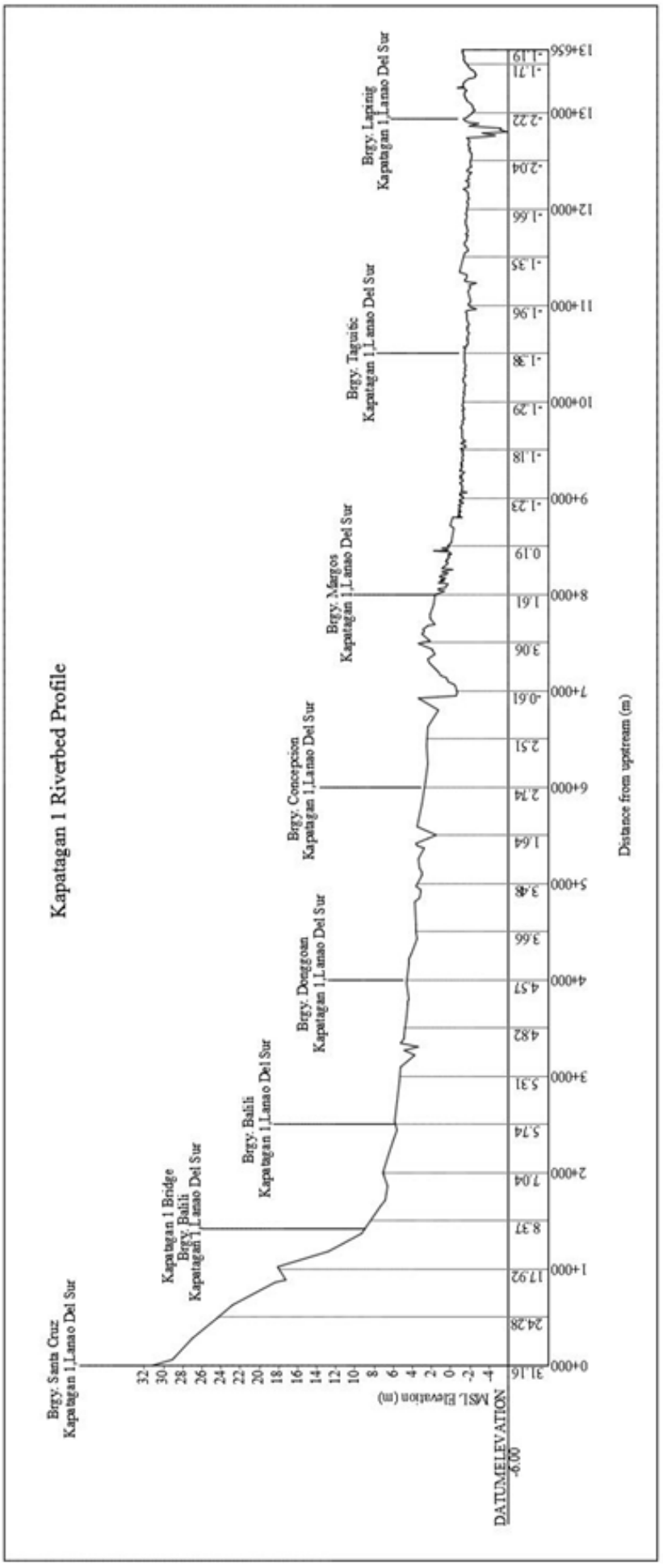


Figure 55. Quality checking points gathered along Balili River by DVBC



Balili Riverbed Profile

CHAPTER 5: FLOOD MODELING AND MAPPING

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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

Rainfall, water level, and flow in a certain period of time, which may affect the hydrologic cycle of the Balili River Basin were monitored, collected, and analyzed.

5.1.2 Precipitation

Precipitation data was taken from the Portable Rain Gauge (PRG) installed upstream by the Data Validation Component (DVC) of MSU-IIT. The PRG was specifically installed in the Municipality of Kapatagan at Brgy. Kahayagan with the coordinates of 7°55'4.37"N latitude and 123°40'45.23"E longitude. The location of the rain gauge is shown in Figure 57.

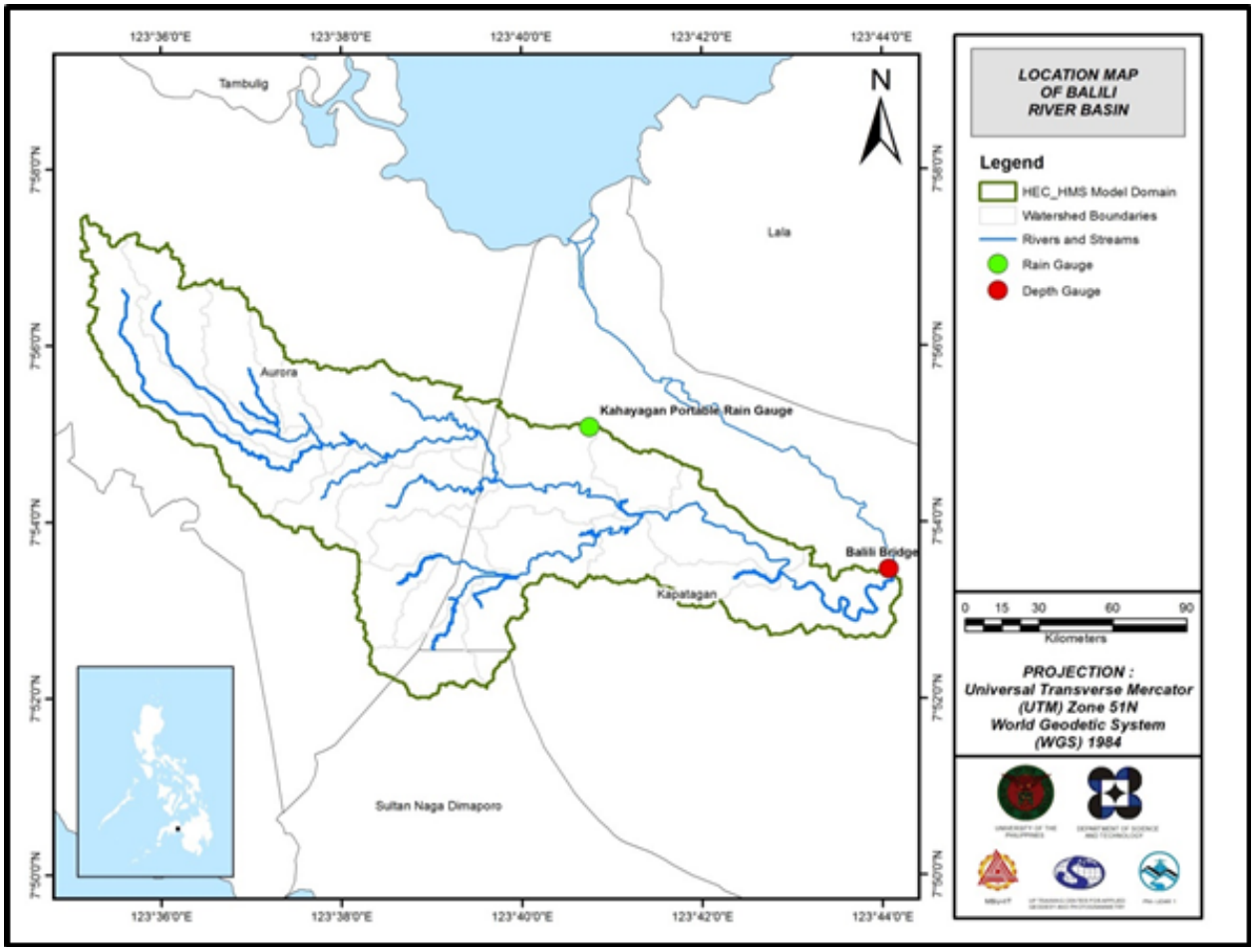


Figure 57. The location map of Balili HEC-HMS model used for calibration

5.1.3 Rating Curves and River Outflow

HQ curve analysis is important in determining the equation to be used in establishing Q values with R-Squared values closer to 1. A trendline is more accurate if the R-Squared value is closer or at 1. For Balili, base flow hydrometry was used.

Figure 59 shows the highest R-Squared value of 0.9973 compared to the graphs using the original Q. In this case, Q boxed values with Q at bank-full were plotted versus the stage.

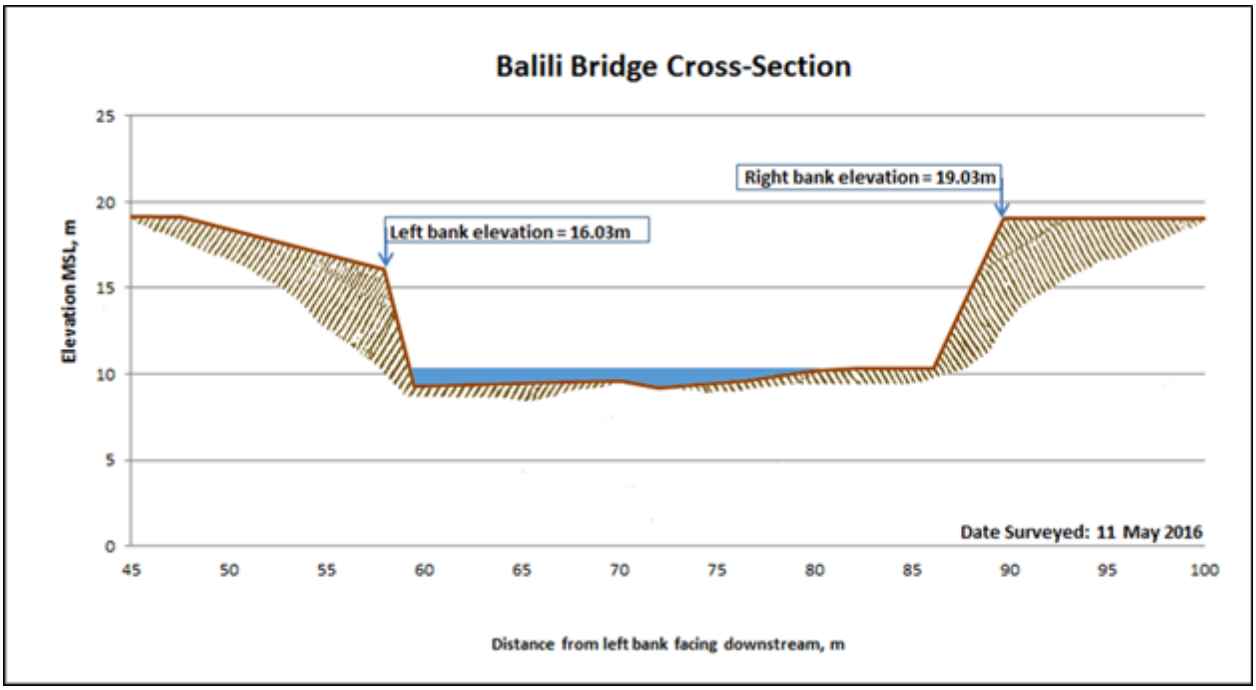


Figure 58. Cross-section plot of Balili Bridge

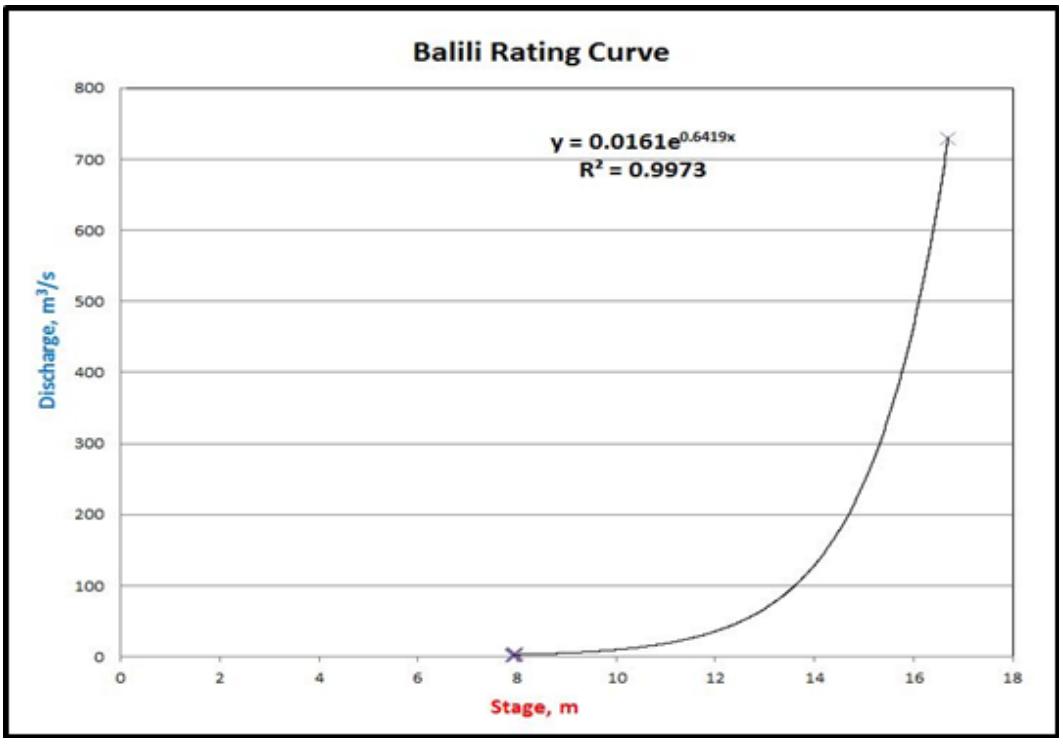


Figure 59. Rating curve at Balili Bridge

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

The total rainfall taken from the PRG at Brgy. Kahayagan was 46.20 mm. It peaked to 12 mm on 12 October 2016 14:20. The lag time between the peak rainfall and discharge is 3 hours.

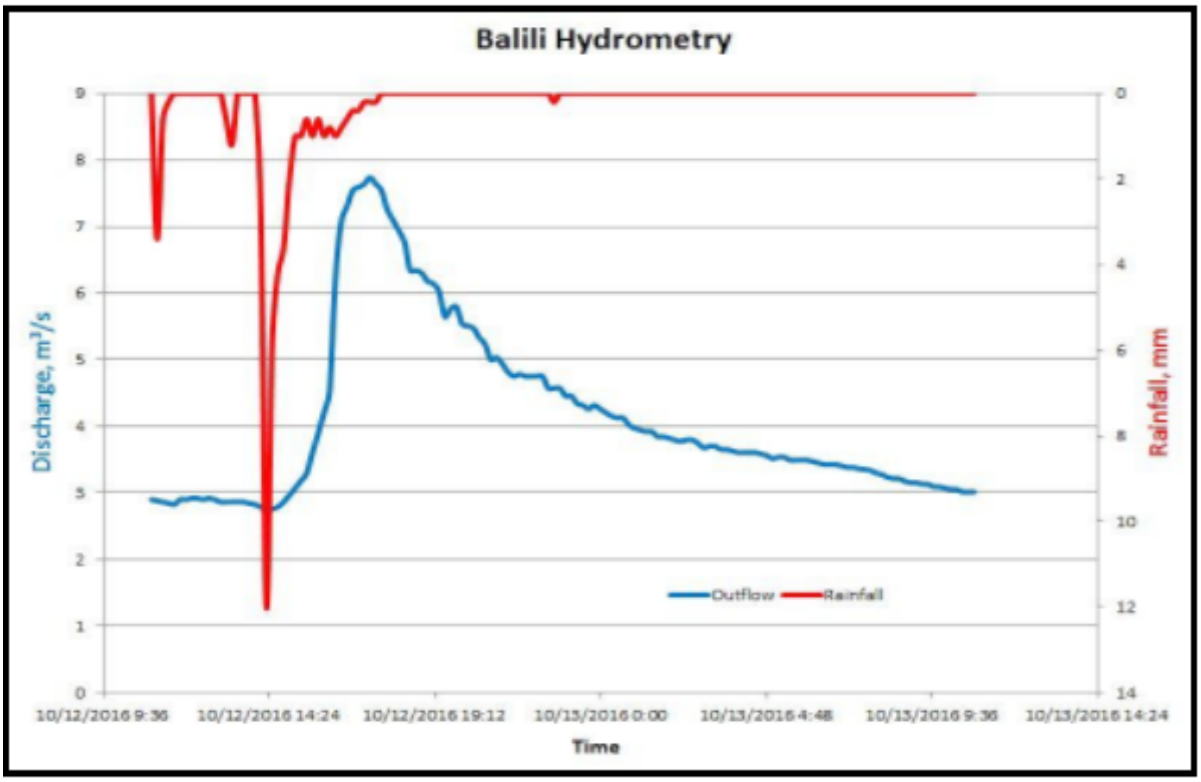


Figure 60. Rainfall and outflow data at Balili Bridge used for modeling

5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Dipolog Rain Gauge. The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and re-arranging the value in such a way certain peak value will be attained at a certain time. This station chosen based on its proximity to the Balili watershed. The extreme values for this watershed were computed based on a 51-year record.

Table 32. RIDF values for Dipolog 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	19.7	30.9	38.7	53.8	73.6	85.5	105.7	120.3	136.2
5	25.9	39.6	50.1	72.6	99.7	117.3	140.9	158.3	178.5
10	30	45.4	57.6	85.1	117	138.3	164.3	183.4	206.5
15	32.3	48.6	61.8	92.1	126.8	150.2	177.4	197.6	222.4
20	34	50.9	64.8	97.1	133.6	158.5	186.6	207.6	233.4
25	35.2	52.7	67.1	100.9	138.9	164.9	193.7	215.2	242
50	39	58.1	74.1	112.5	155.1	184.6	215.6	238.8	268.3
100	42.9	63.4	81.1	124.1	171.2	204.2	237.3	262.1	294.4

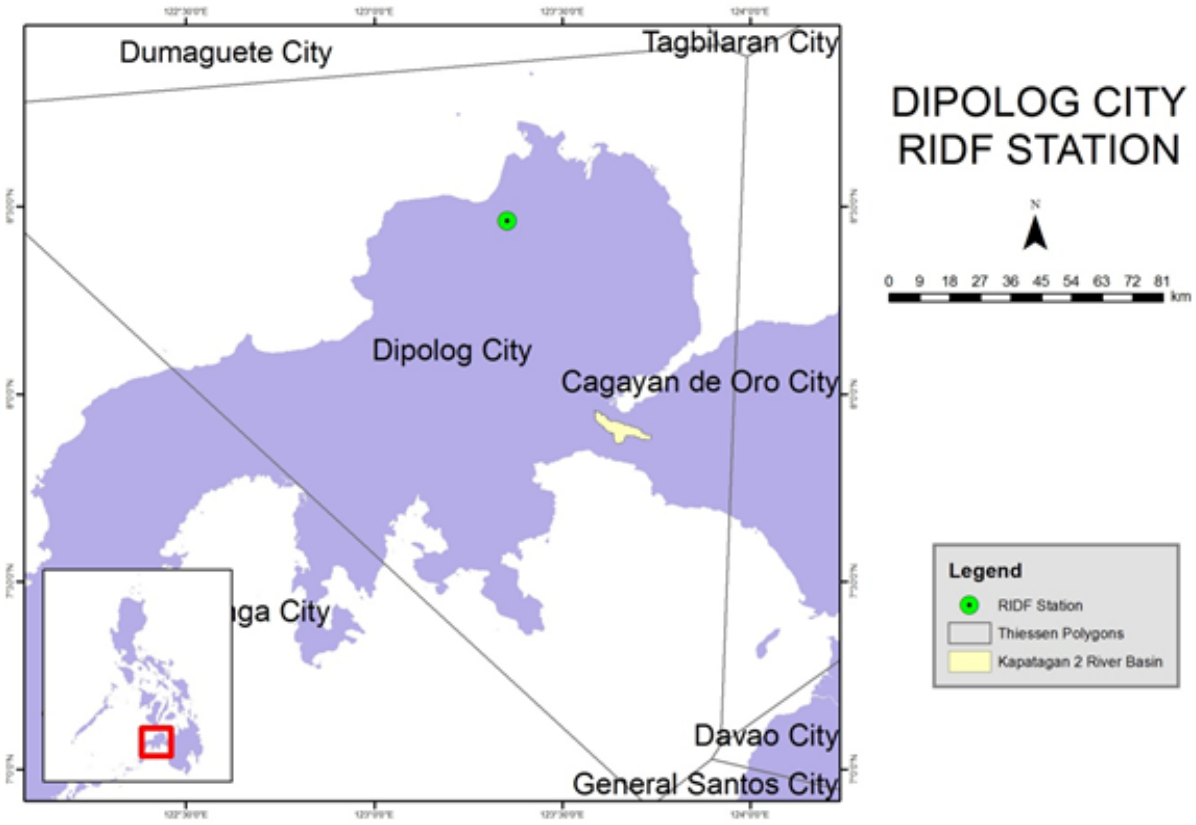


Figure 61. Location of Dipolog RIDF station relative to Balili (Balili 2) River Basin

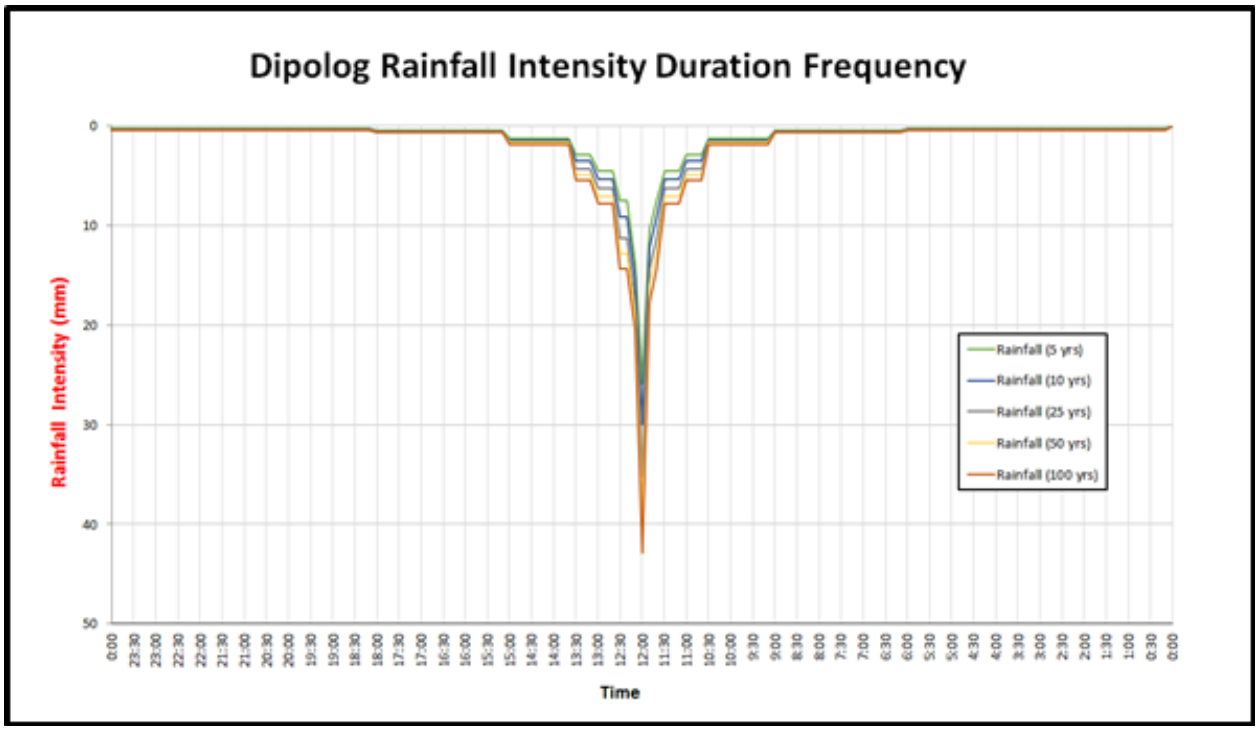


Figure 62. Synthetic storm generated for a 24-hr period rainfall for various return periods

5.3 HMS Model

The soil dataset was taken from the Bureau of Soils and Water Management (BSWM) under the Department of Agriculture. The soil dataset (Figure 63) of the Balili River basin was used as one of the factors for the estimation of the CN parameter.

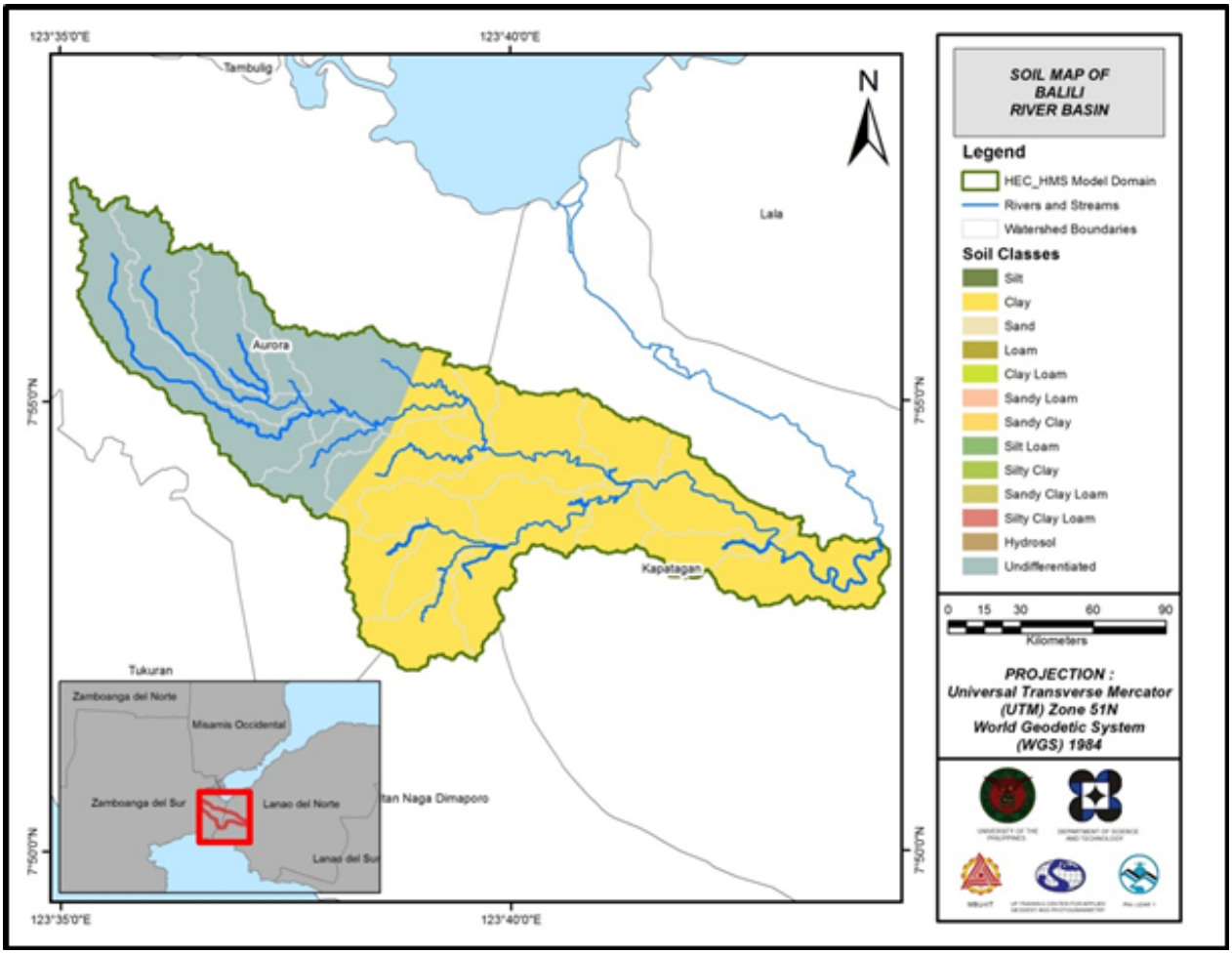


Figure 63. Soil map of Balili River Basin

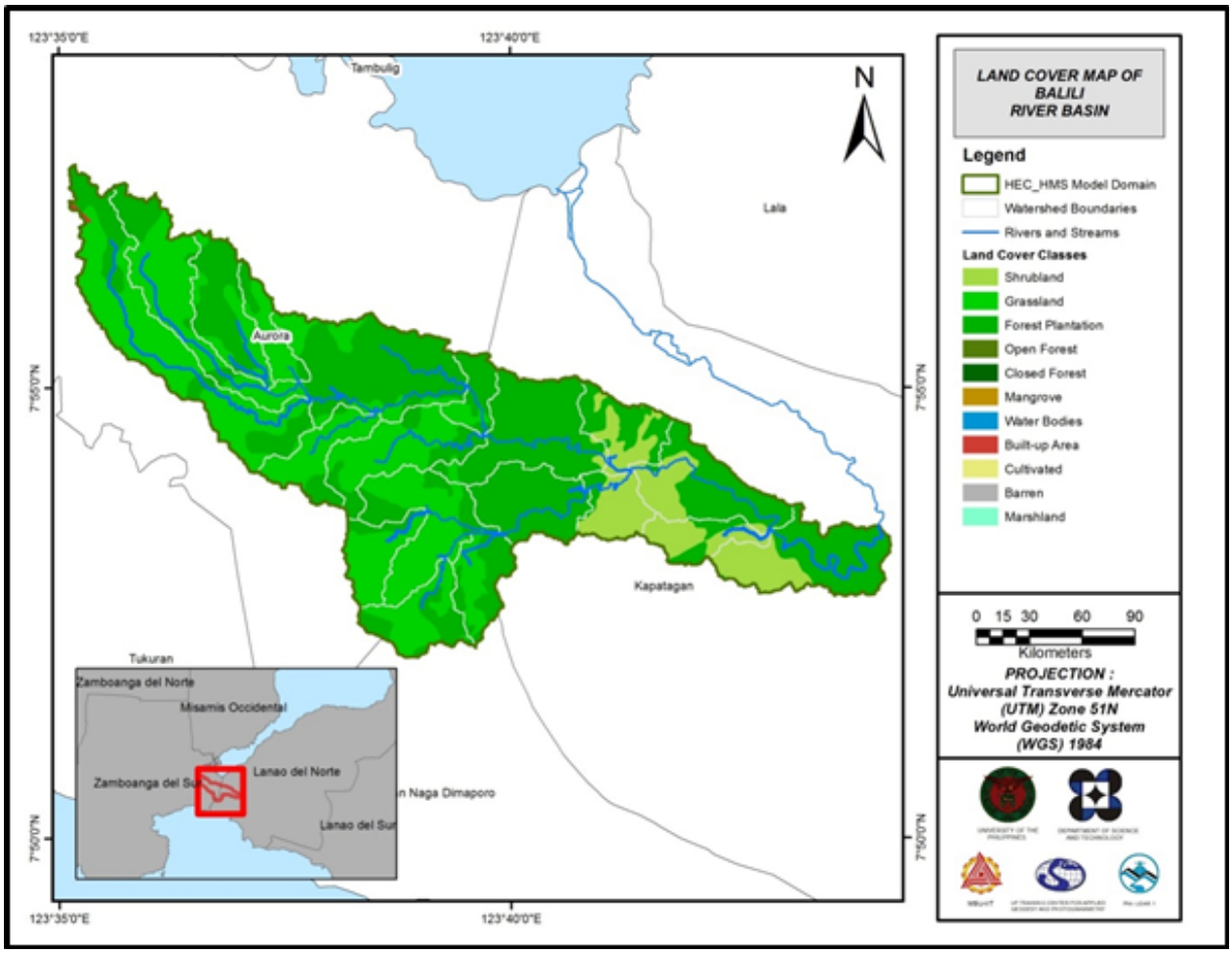


Figure 64. Land cover map of Balili River Basin (Source: NAMRIA)

Using the SAR-based DEM, the Balili Basin was delineated and further subdivided into subbasins. The model consists of 18 subbasins, 17 reaches, and 17 junctions. The main outlet is located at Balili Bridge, Brgy. Balili, Balili, Lanao del Norte. This basin model is illustrated in Figure 65. Finally, it was calibrated using hydrological data derived from the depth gauge and flow meter deployed at Balili Bridge.

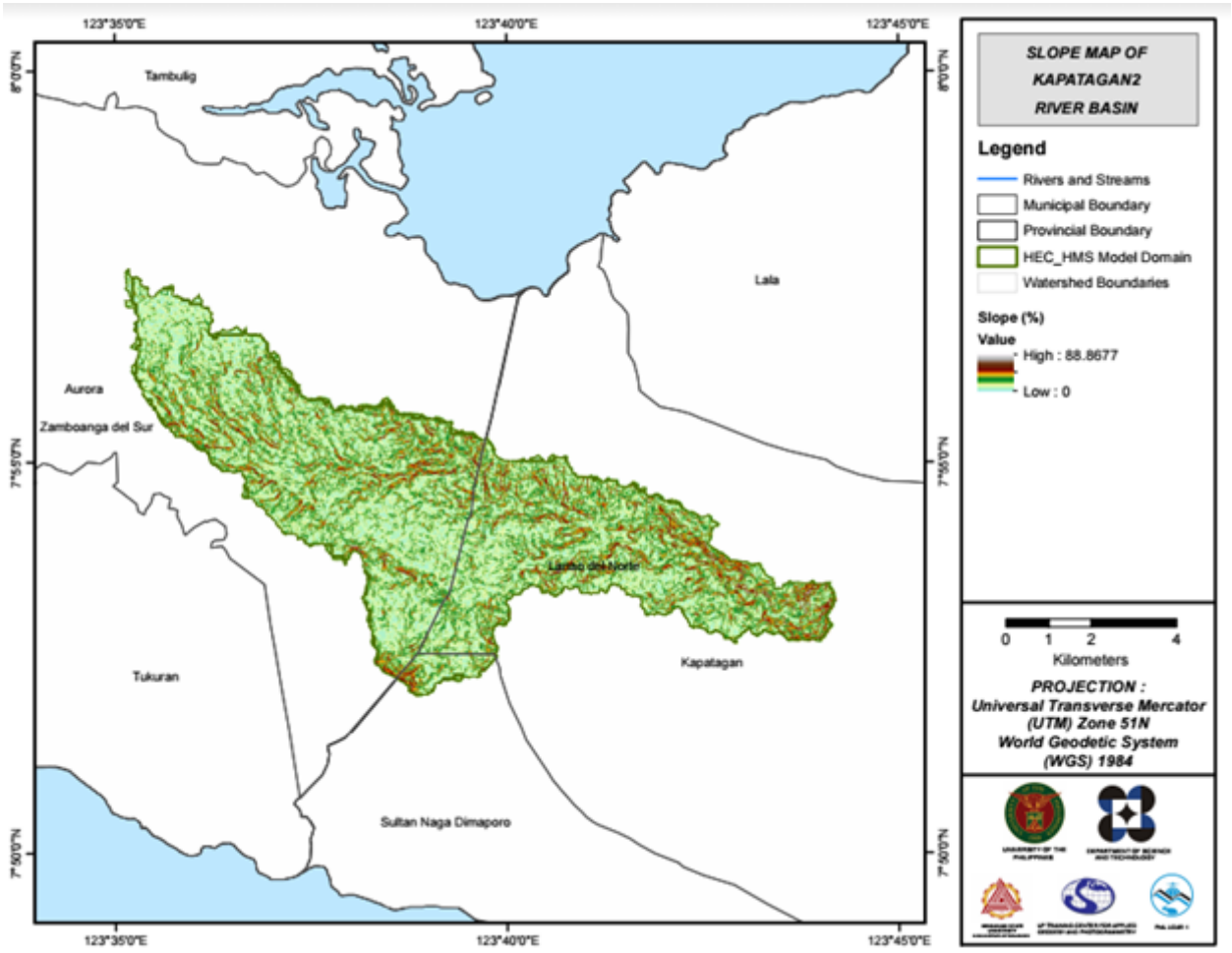


Figure 65. Slope map of Balili River Basin

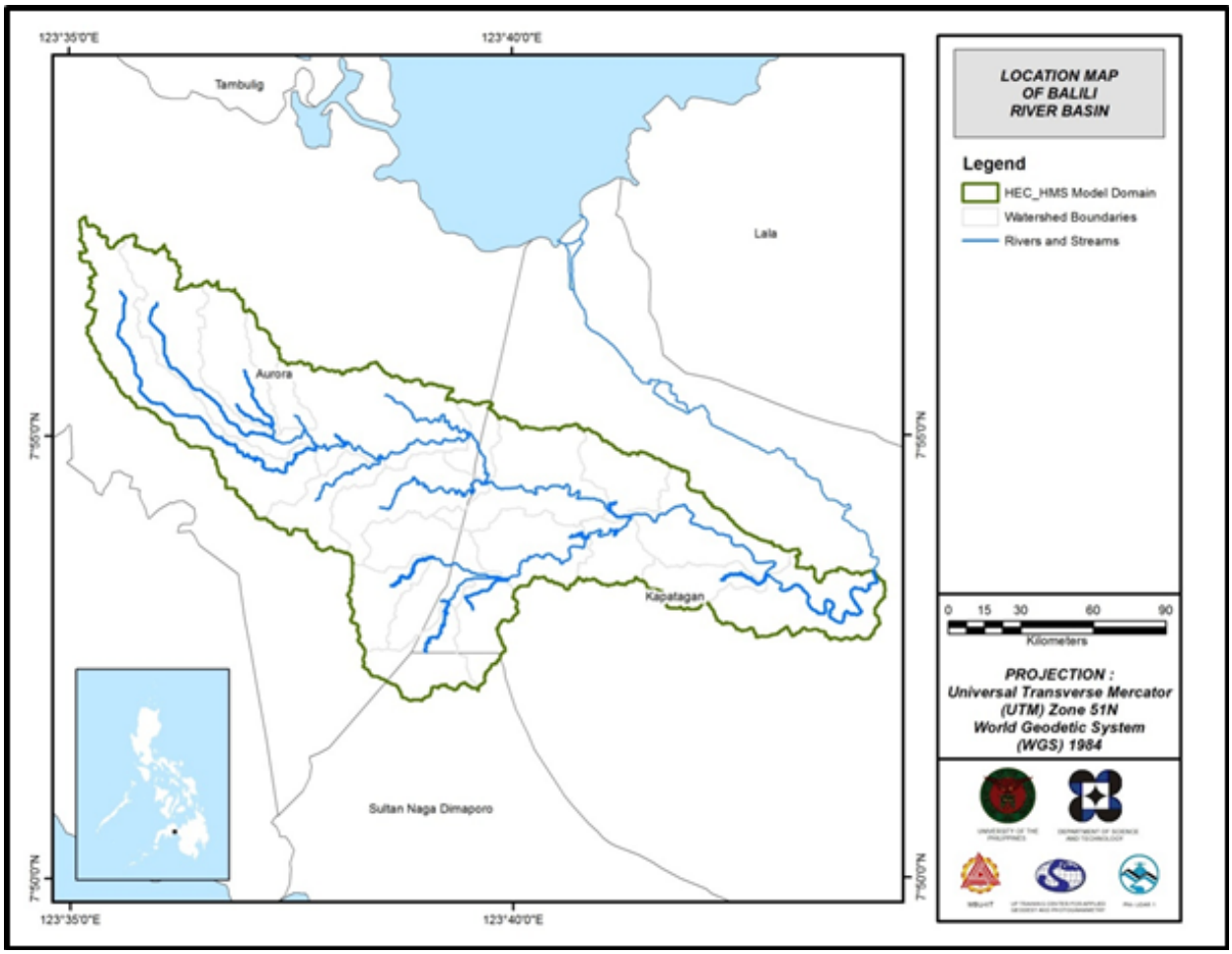


Figure 66. Stream delineation map of the Balili River Basin

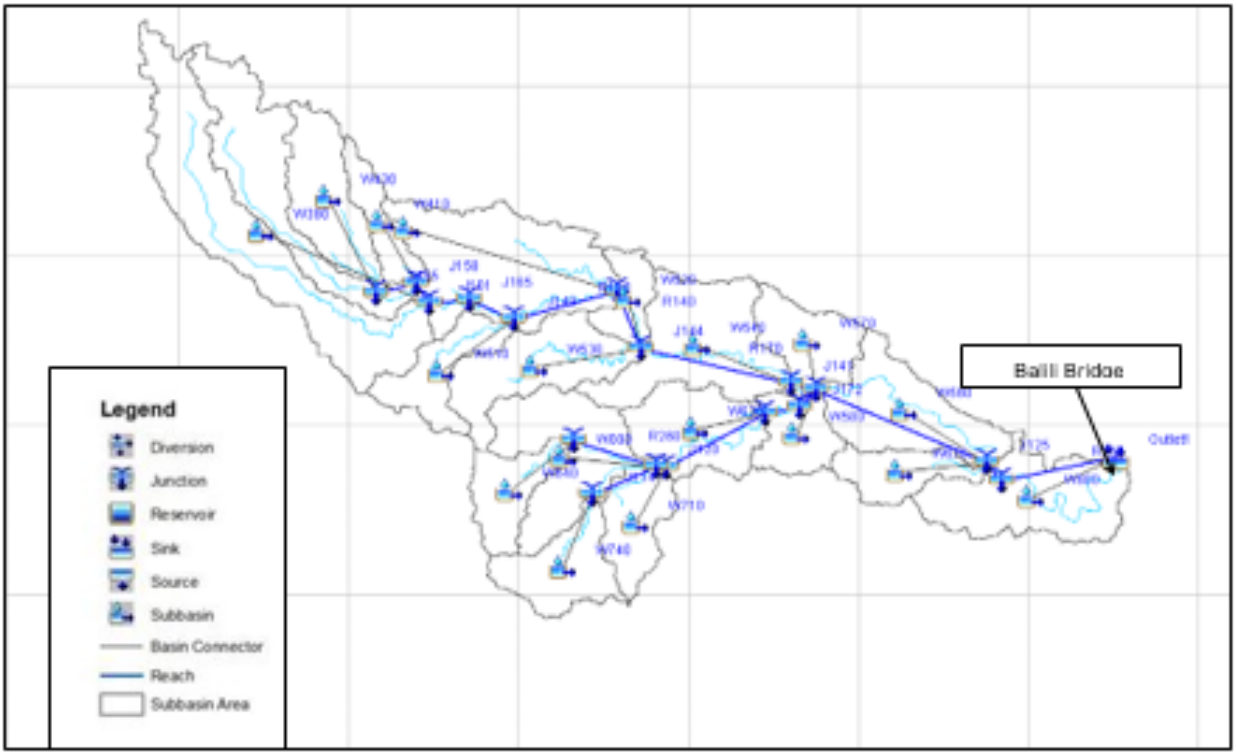


Figure 67. The Balili Hydrologic Model generated in HEC-GeoHMS

5.4 Cross-section Data

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

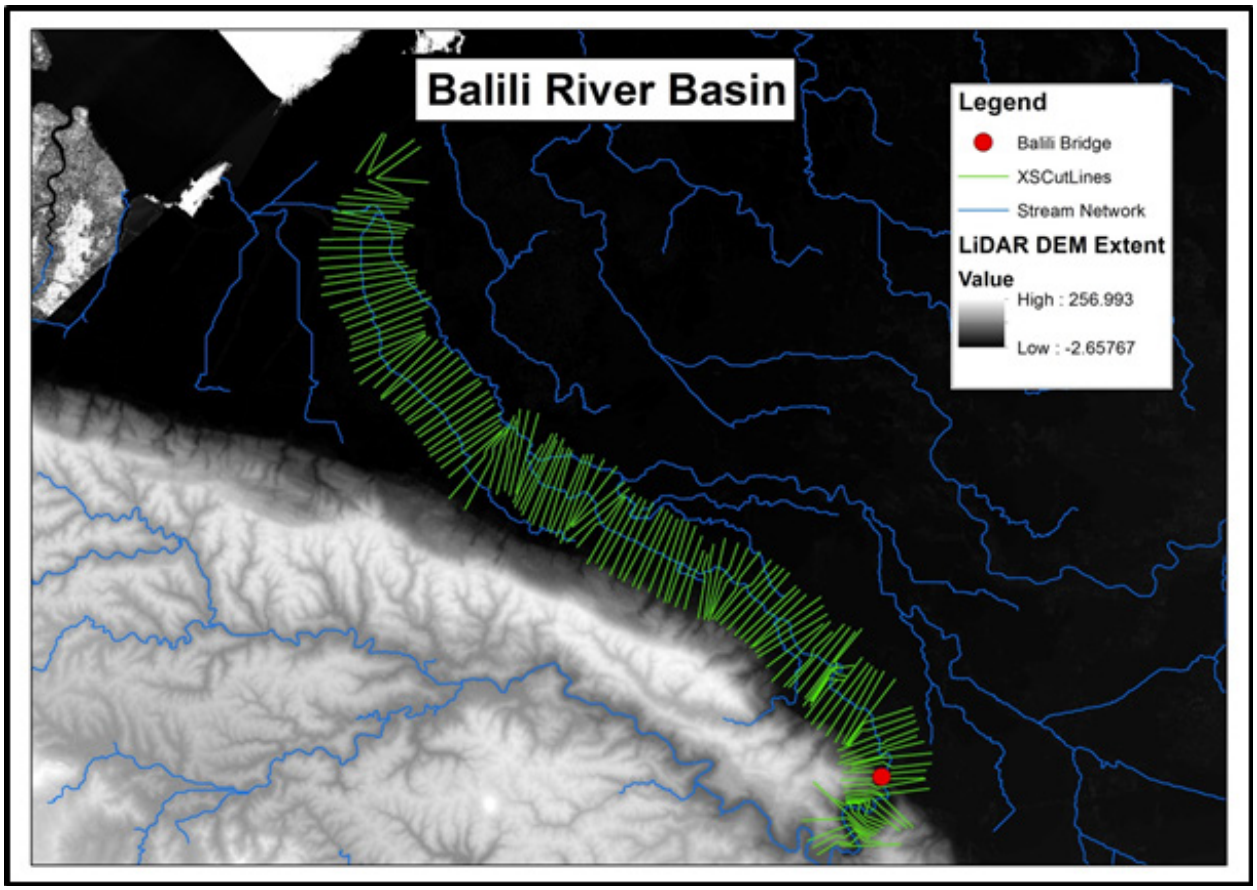


Figure 68. River cross-section of Balili River generated through Arcmap HEC GeoRAS tool

5.5 Flo 2D Model

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

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

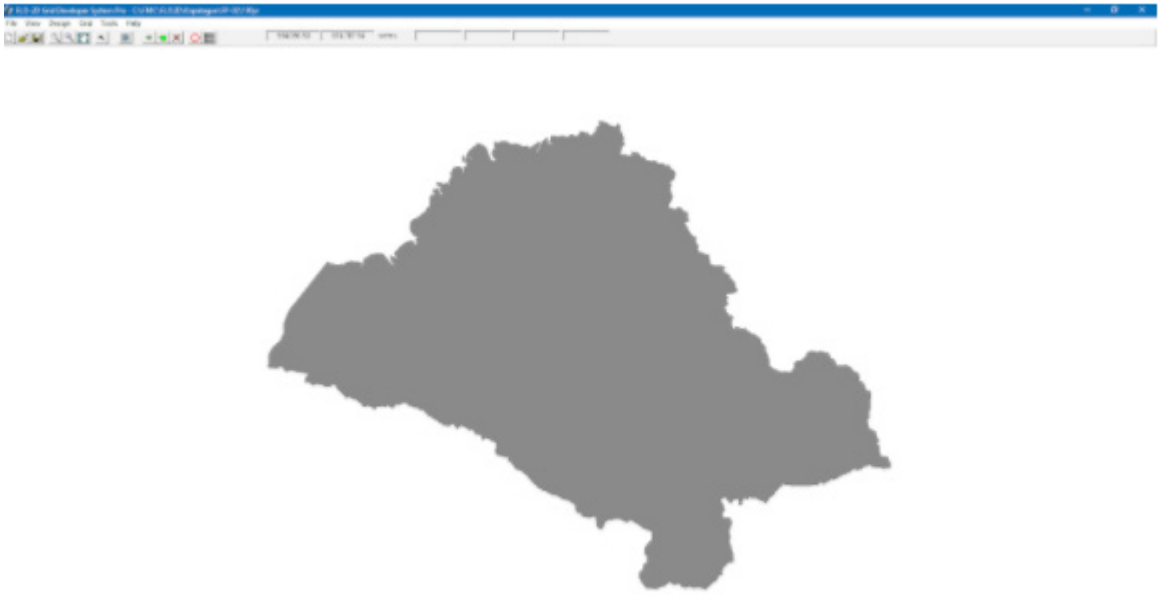


Figure 68. A screenshot of the river sub-catchment with the computational area to be modeled in FLO-2D Grid Developer System Pro (FLO-2D GDS Pro)

5.6 Results of HMS Calibration

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

Enumerated in Table 33 are the adjusted ranges of values of the parameters used in calibrating the model.

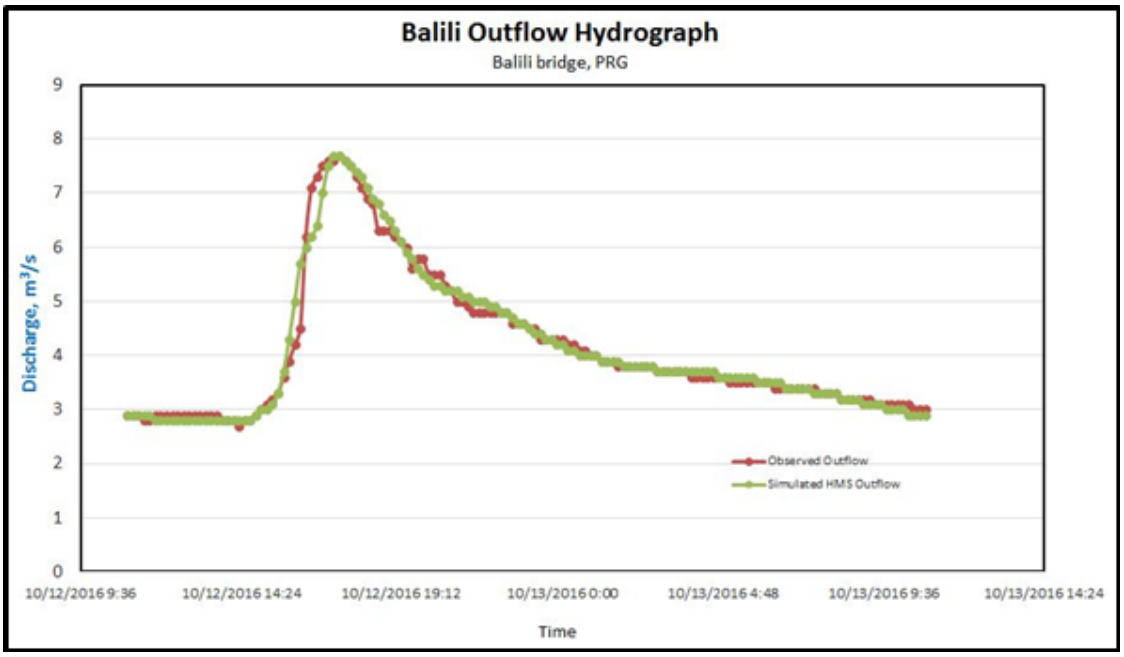


Figure 69. Outflow Hydrograph of Balili Bridge generated in HEC-HMS model compared with observed outflow

Table 33. Range of calibrated values for the Balili River Basin

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	13 - 31
			Curve Number	39 - 81
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	6 - 19
			Storage Coefficient (hr)	0.7 - 17
	Baseflow	Recession	Recession Constant	0.2 - 0.4
			Ratio to Peak	0.08 - 1
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.04

Initial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as initial abstraction decreases. The range of values from 13mm to 31mm means that there is average amount of infiltration or rainfall interception by vegetation per subbasin.

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The minimum value of 39 for this specific watershed goes to the lower side of the advisable curve number for Philippine watersheds depending on the soil and land cover of the area.

Time of concentration and storage coefficient are the travel time and index of temporary storage of runoff in a watershed. The range of calibrated values from 0.7 to 19 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 0.2 to 0.4 indicates that the basin is likely to quickly go back to its original discharge. Ratio to peak of 0.08 to 1 indicates a diverse reaction of receding limb in accordance with the subbasins.

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

Table 34. Summary of the Efficiency Test of Balili HMS Model

Accuracy measure	Value
RMSE	0.20
r2	0.9973
NSE	0.98
PBIAS	-0.08
RSR	0.15

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 0.20 (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 0.9973.

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 0.98.

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 -0.08.

The Observation Standard Deviation Ratio (RSR) is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.15.

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 70) shows the Balili outflow using the Dipolog 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 PAGASA data. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

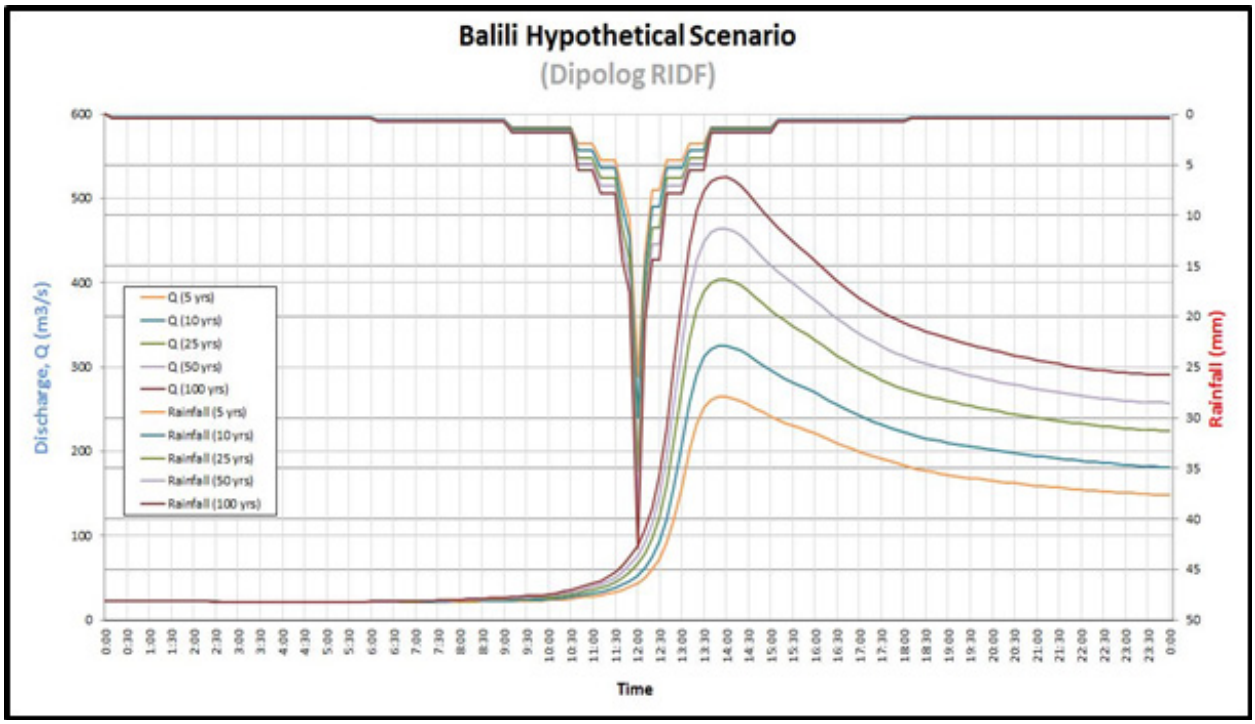


Figure 70. Outflow hydrograph at Balili Station generated using Dipolog RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow, and time to peak of the Balili discharge using the Dipolog RIDF in five different return periods is shown in Table 35.

Table 32. The peak values of the Balili HEC-HMS Model outflow using the Dipolog RIDF.

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m 3/s)	Time to Peak
5-Year	178.32	25.9	264.6	13 hours, 50 minutes
10-Year	206.37	30	325	13 hours, 50 minutes
25-Year	241.91	35.2	404.1	14 hours
50-Year	268.14	39	464.3	14 hours
100-Year	294.55	42.9	525.4	14 hours

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 was used in determining the flooded areas within the model. The simulated model was an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. The sample generated map of Balili River using the calibrated HMS base flow is shown in Figure 71.

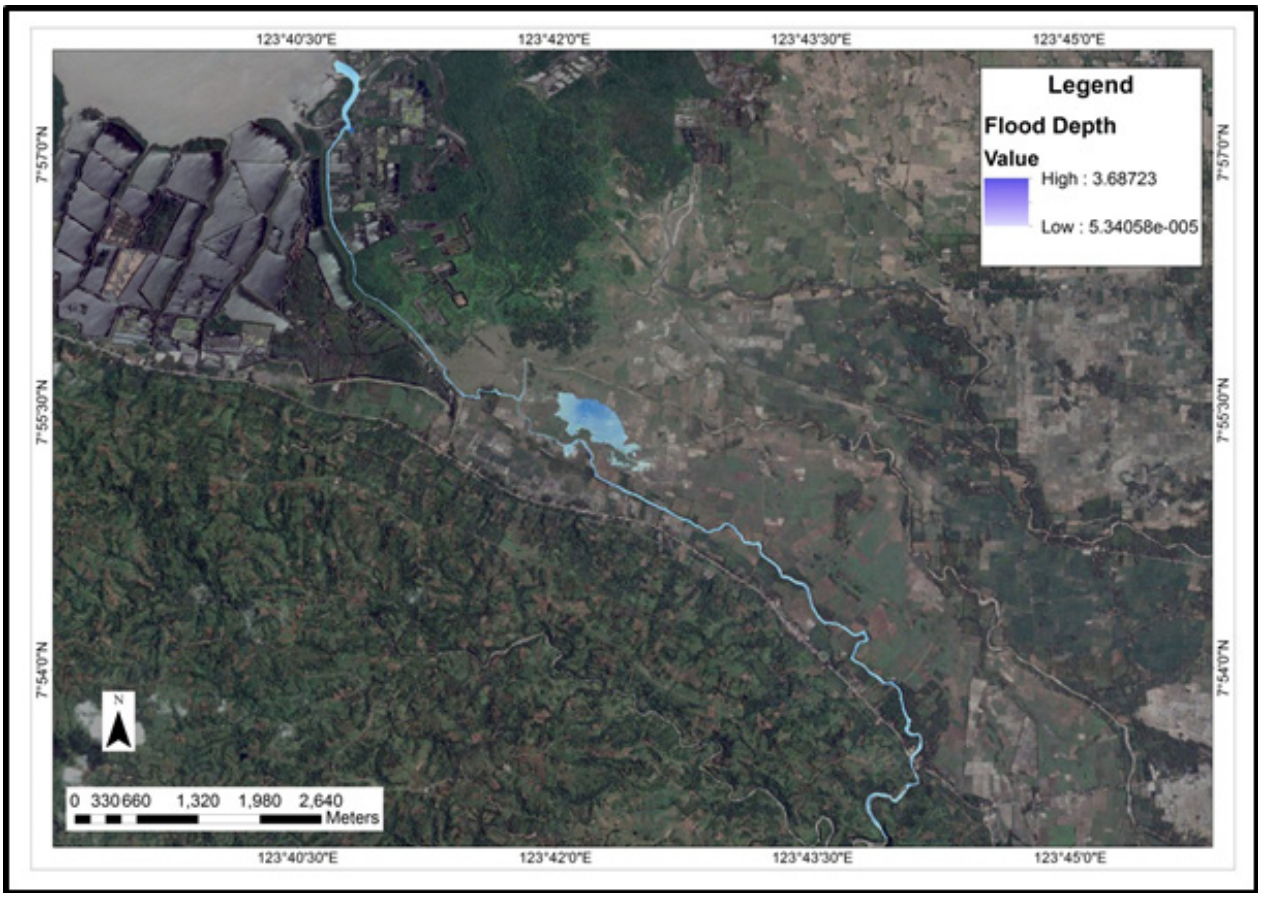


Figure 71. Sample output of Balili RAS Model

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 72 to Figure 77 show the 100-, 25-, and 5-year rain return scenarios of the Balili Floodplain. The floodplain, with an area of 218.63 sq.km., covers seven municipalities namely Baroy, Kapatagan, Lala, Salvador, Sapad, Tubod, and Aurora. Table 36 shows the percentage of area affected by flooding per municipality.

Table 36. Municipalities affected in Balili Floodplain

Municipality	Total Area	Area Flooded	% Flooded
Baroy	62.08	61.56	99%
Kapatagan	184.77	65.46	35%
Lala	125.18	124.31	99%
Salvador	46.46	12.02	26%
Sapad	65.13	3.39	5%
Tubod	121.95	17.64	14%
Aurora	162.23	4.92	3%

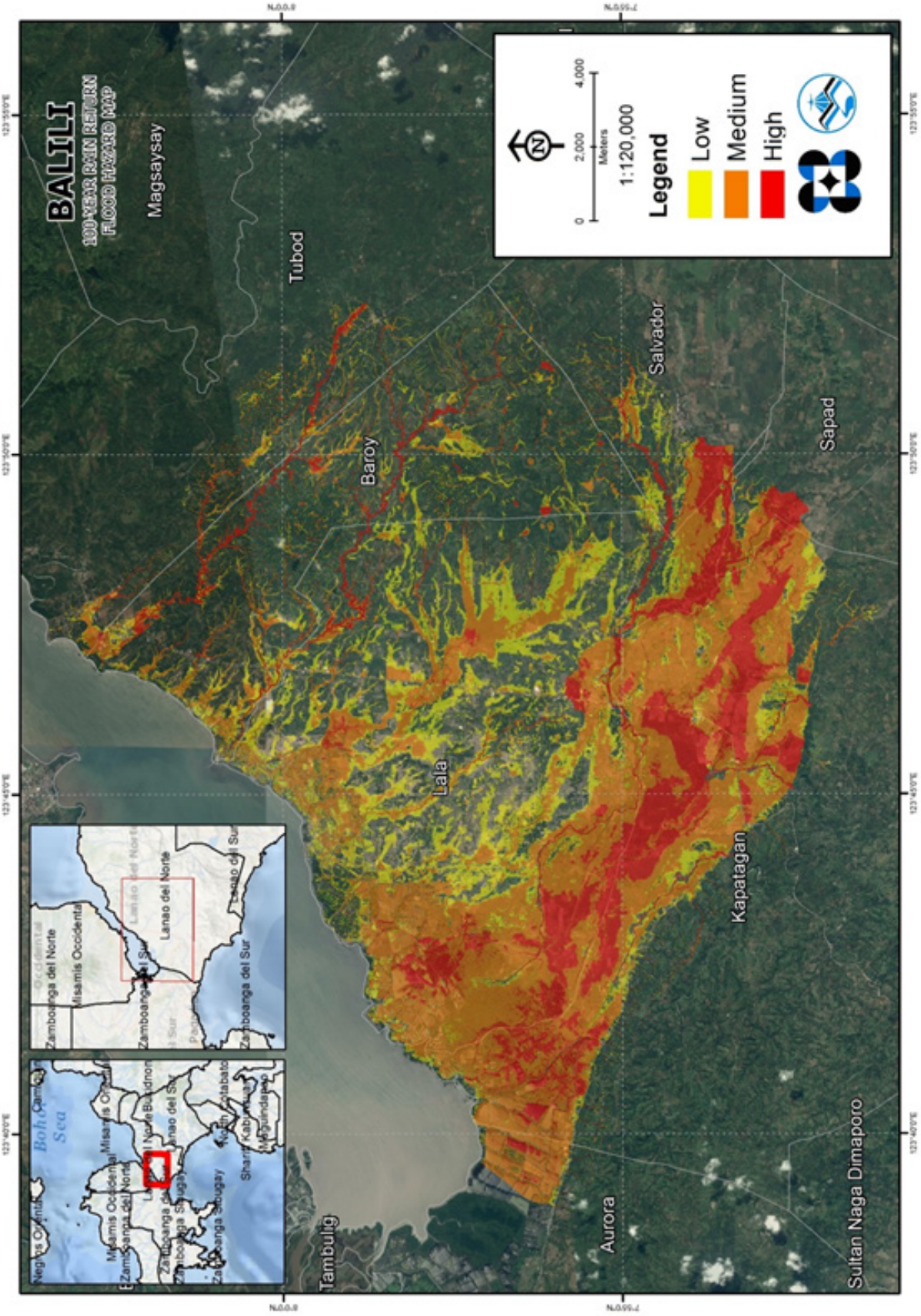


Figure 72. 100-year rain return flood hazard map for Balili Floodplain overlaid in Google Earth imagery

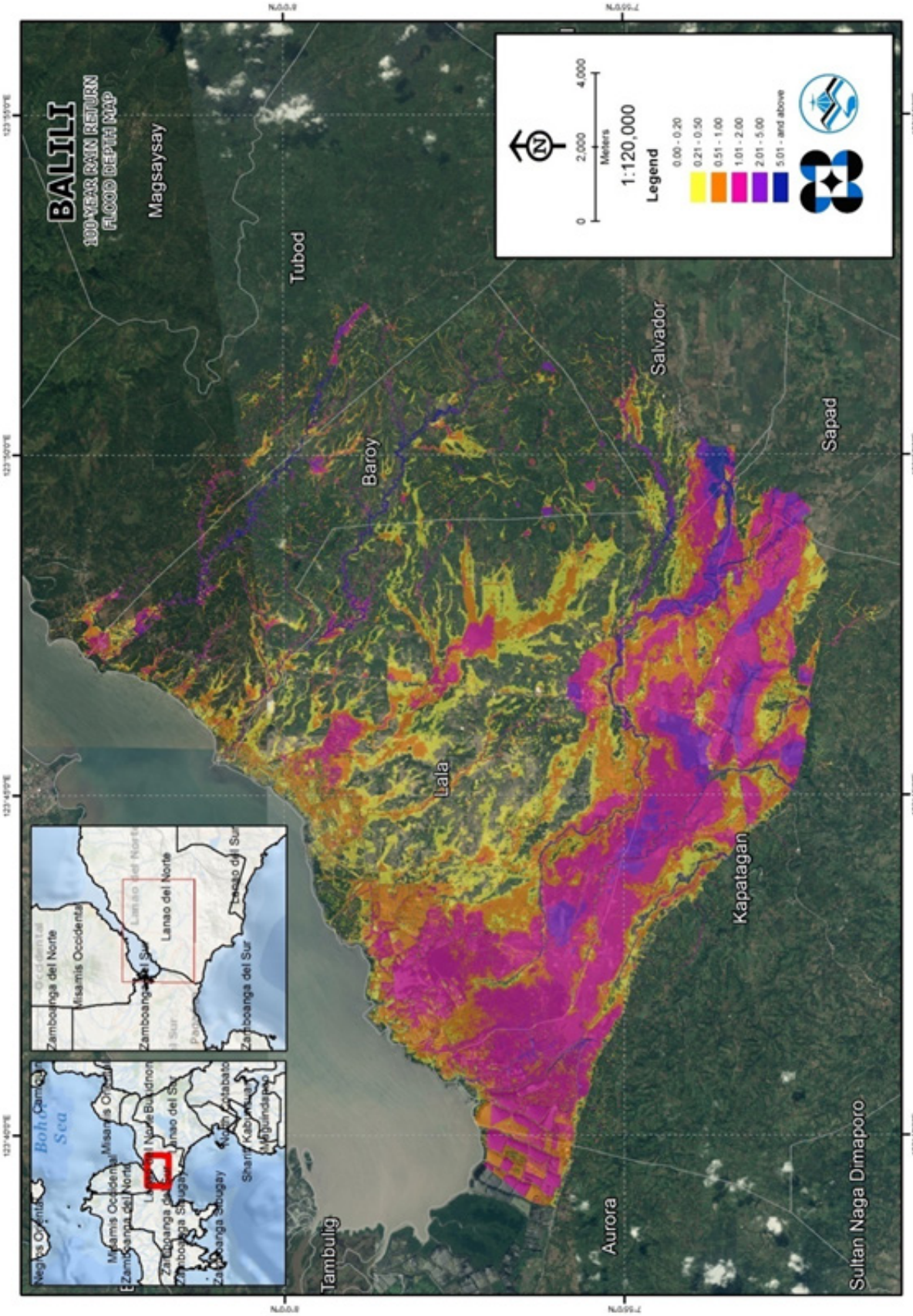


Figure 73. 100-year rain return flood depth map for Balili Floodplain overlaid in Google Earth imagery

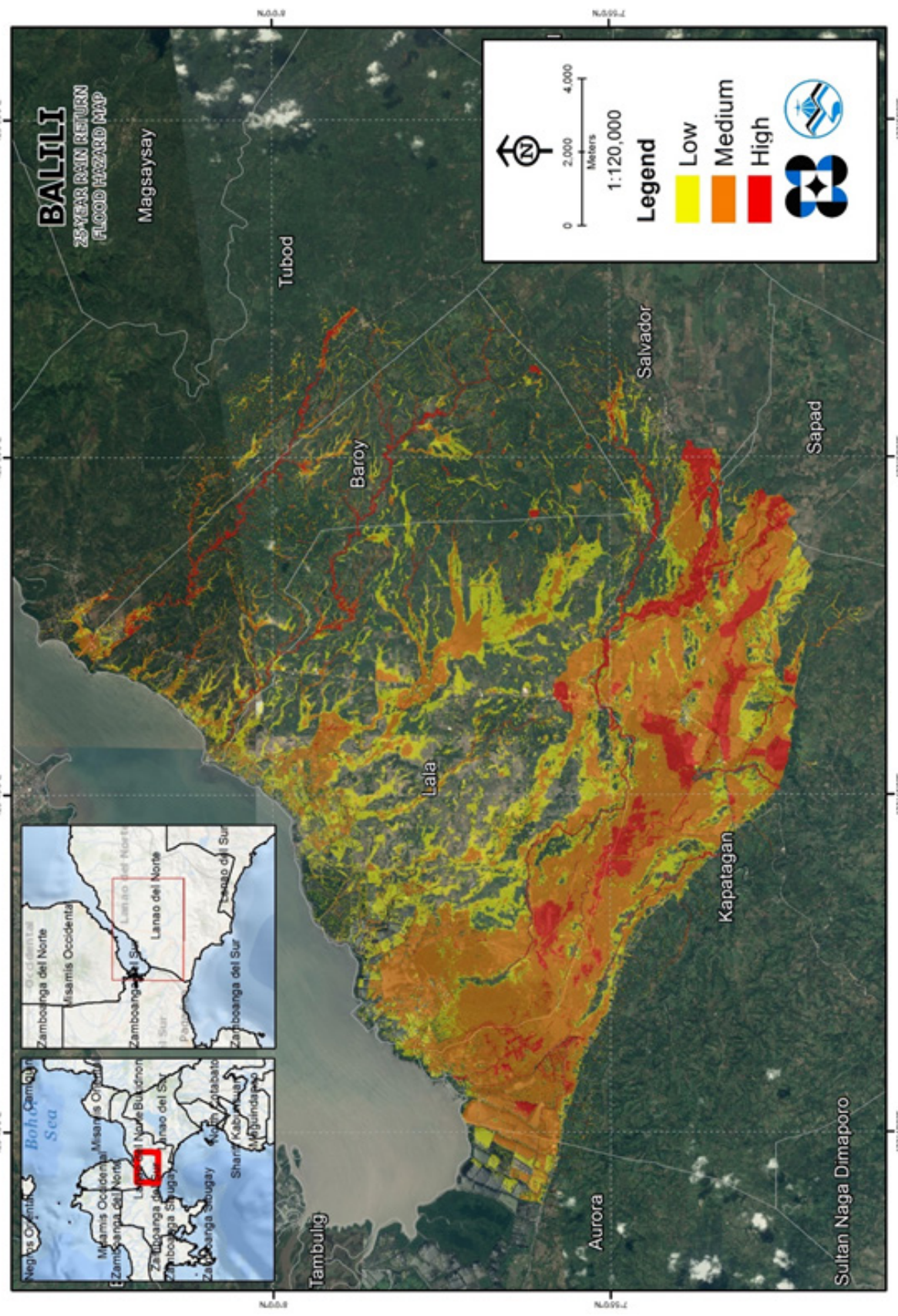


Figure 74. 25-year rain return flood hazard map for Balili Floodplain overlaid in Google Earth imagery

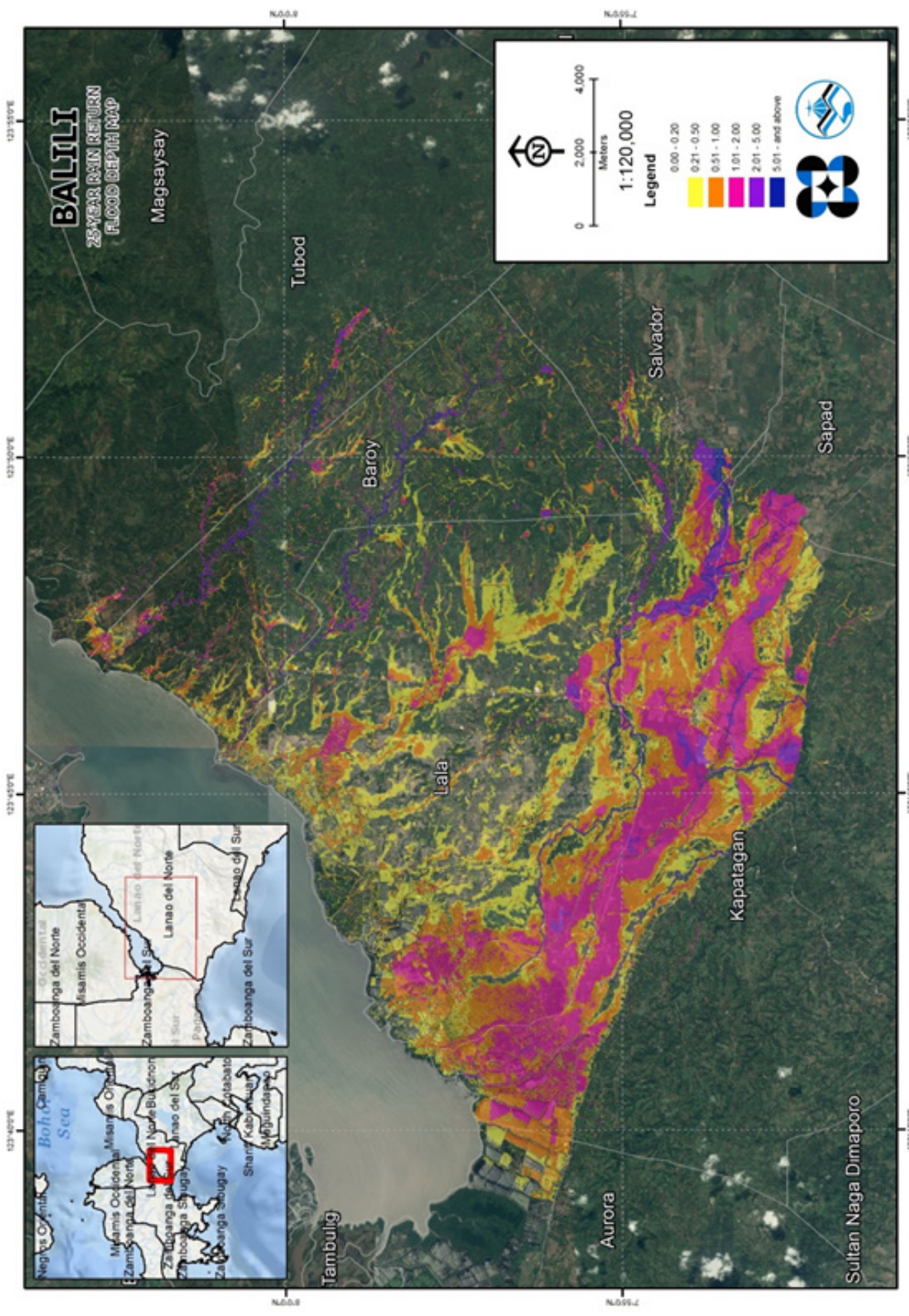


Figure 75. 25-year rain return flood depth map for Balili Floodplain overlaid in Google Earth imagery

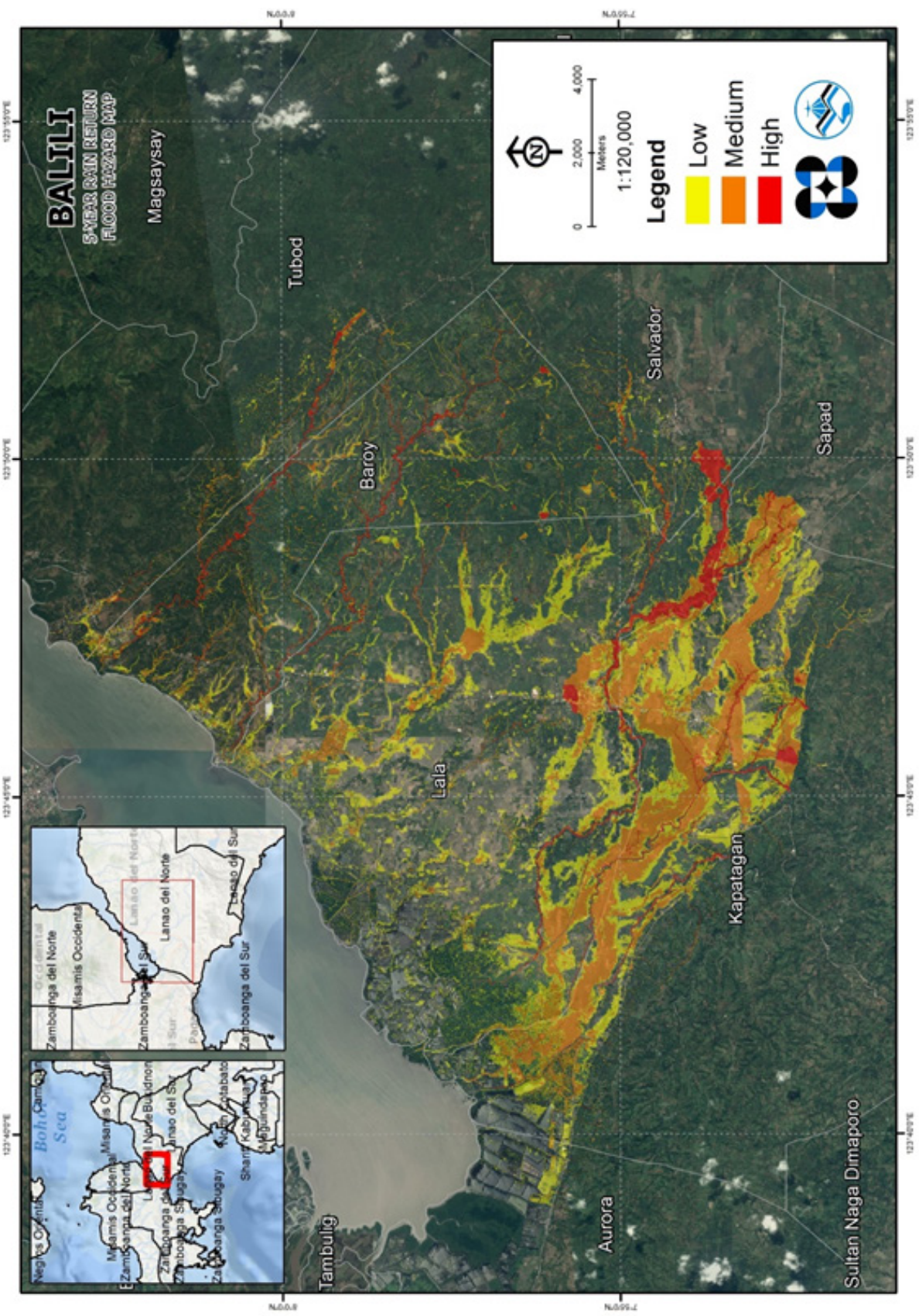


Figure 76. 5-year rain return flood hazard map for Balili Floodplain overlaid in Google Earth imagery

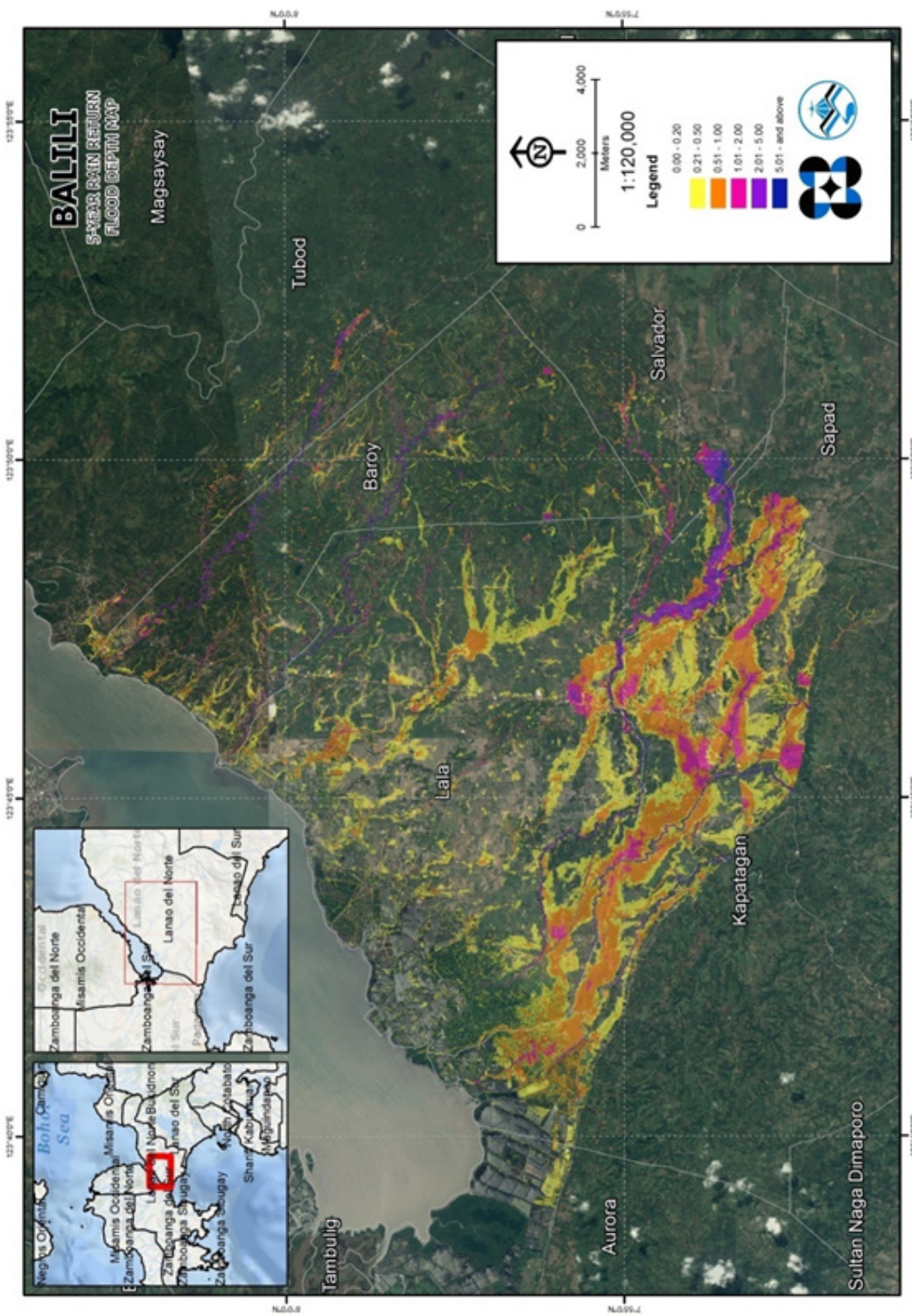


Figure 77. 5-year rain return flood depth map for Balili Floodplain overlaid in Google Earth imagery

5.10 Inventory of Areas Exposed to Flooding

Affected barangays in Balili River Basin, grouped by municipality, are listed below. For the said basin, seven municipalities consisting of 93 barangays are expected to experience flooding when subjected to 5-, 25-, and 100-year rainfall return period.

For the 5-year return period, 2.61% of the municipality of Aurora with an area of 162.225 sq.km. will experience flood levels of less 0.20 meters; 0.37% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.04%, 0.005%, and 0.002% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 37 are the affected areas in square kilometres by flood depth per barangay.

Table 37. Affected areas in Aurora, Zamboanga del Sur during 5-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Aurora
		Anonang
Affected Area (sq. km.)	0.03-0.20	4.23225
	0.21-0.50	0.607248
	0.51-1.00	0.0698
	1.01-2.00	0.0088
	2.01-5.00	0.0035
	> 5.00	0

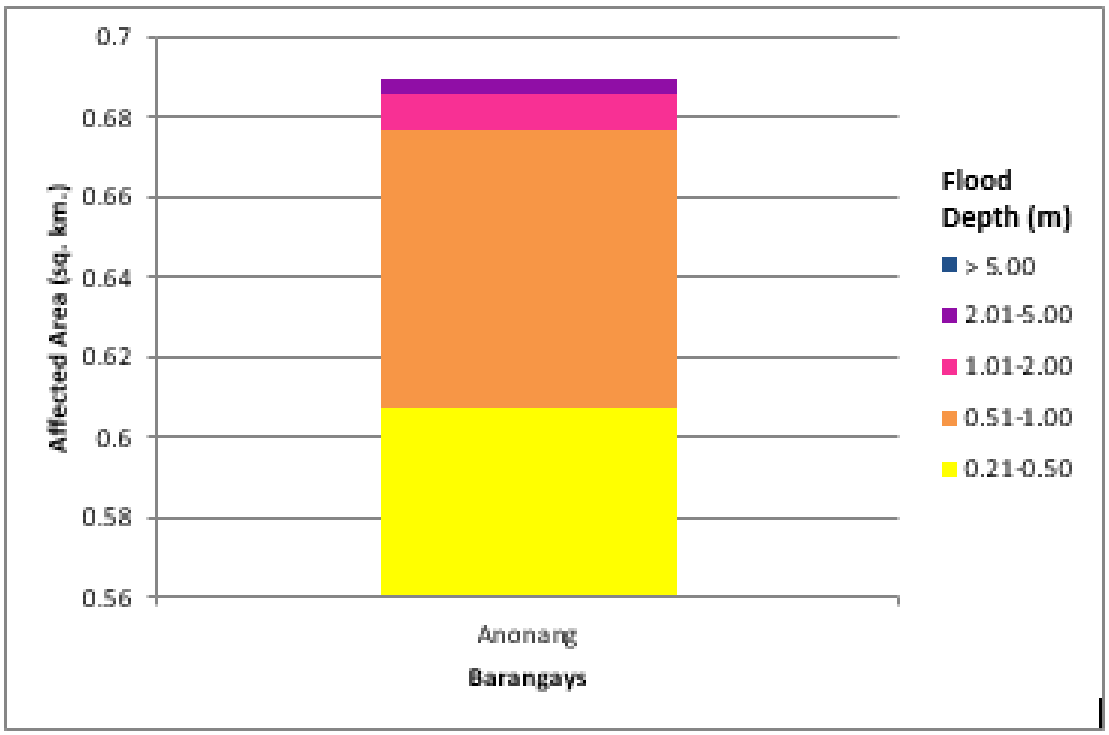


Figure 78. Affected areas in Aurora, Zamboanga del Sur during 5-year rainfall return period

For the municipality of Baroy, with an area of 32.08 sq. km., 87.96% will experience flood levels of less 0.20 meters; 5.63% of the area will experience flood levels of 0.21 to 0.50 meters; while 2.48%, 1.53%, 1.24%, and 0.42% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 38 are the affected areas in square kilometres by flood depth per barangay.

Table 38. Affected areas in Baroy, Lanao del Norte during 5-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Baroy										
		Andil	Bagong Dawis	Baroy Daku	Bato	Cabasagan	Dalama	Libertad	Limwag	Lindongan	Maliwanag	Manan-Ao
Affected Area (sq. km.)	0.03-0.20	4.40468	1.94386	0.950785	1.92576	2.69146	1.97162	1.45446	1.33433	2.5115	3.25986	1.91386
	0.21-0.50	0.154252	0.145173	0.197693	0.061336	0.088566	0.172662	0.248171	0.055754	0.169224	0.200007	0.133319
	0.51-1.00	0.124492	0.052227	0.075216	0.02992	0.027664	0.029435	0.054178	0.016812	0.082561	0.077854	0.048418
	1.01-2.00	0.102096	0.03623	0.01099	0.021333	0.013003	0.011984	0.0177	0.022	0.030489	0.063523	0.016632
	2.01-5.00	0.094202	0.032305	0.002	0.01061	0.005211	0.009427	0.011501	0.043624	0.0075	0.095362	0.006679
	> 5.00	0.037019	0.012545	0	0.0008	0.0002	0.001	0.000437	0.017503	0	0.058796	0

BUTADON-BALILI BASIN		Affected Barangays in Baroy											
		Pange	Pindolonan	Poblacion	Princesa	Rawan Point	Riverside	Sagadan	Sagadan Upper	Salong	San Juan	Tinubdan	Village
Affected Area (sq. km.)	0.03-0.20	1.93279	2.43917	1.20102	3.96815	2.40521	5.30325	1.68662	1.25265	3.77664	0.394761	4.46677	1.4217
	0.21-0.50	0.134309	0.13491	0.038619	0.129314	0.410837	0.196525	0.090365	0.181929	0.164645	0.047308	0.280242	0.059178
	0.51-1.00	0.056199	0.048979	0.033058	0.088016	0.095156	0.108863	0.069916	0.092541	0.073617	0.027344	0.160266	0.064989
	1.01-2.00	0.036621	0.032805	0.014573	0.105909	0.0371	0.099474	0.060861	0.027224	0.053561	0.005941	0.090185	0.04159
	2.01-5.00	0.0152	0.023764	0.002525	0.109157	0.050339	0.096868	0.053807	0.01805	0.003547	0.000356	0.067026	0.013
	> 5.00	0	0	0.022378	0.037951	0.01269	0.01943	0.0074	0	0	0	0.031794	0

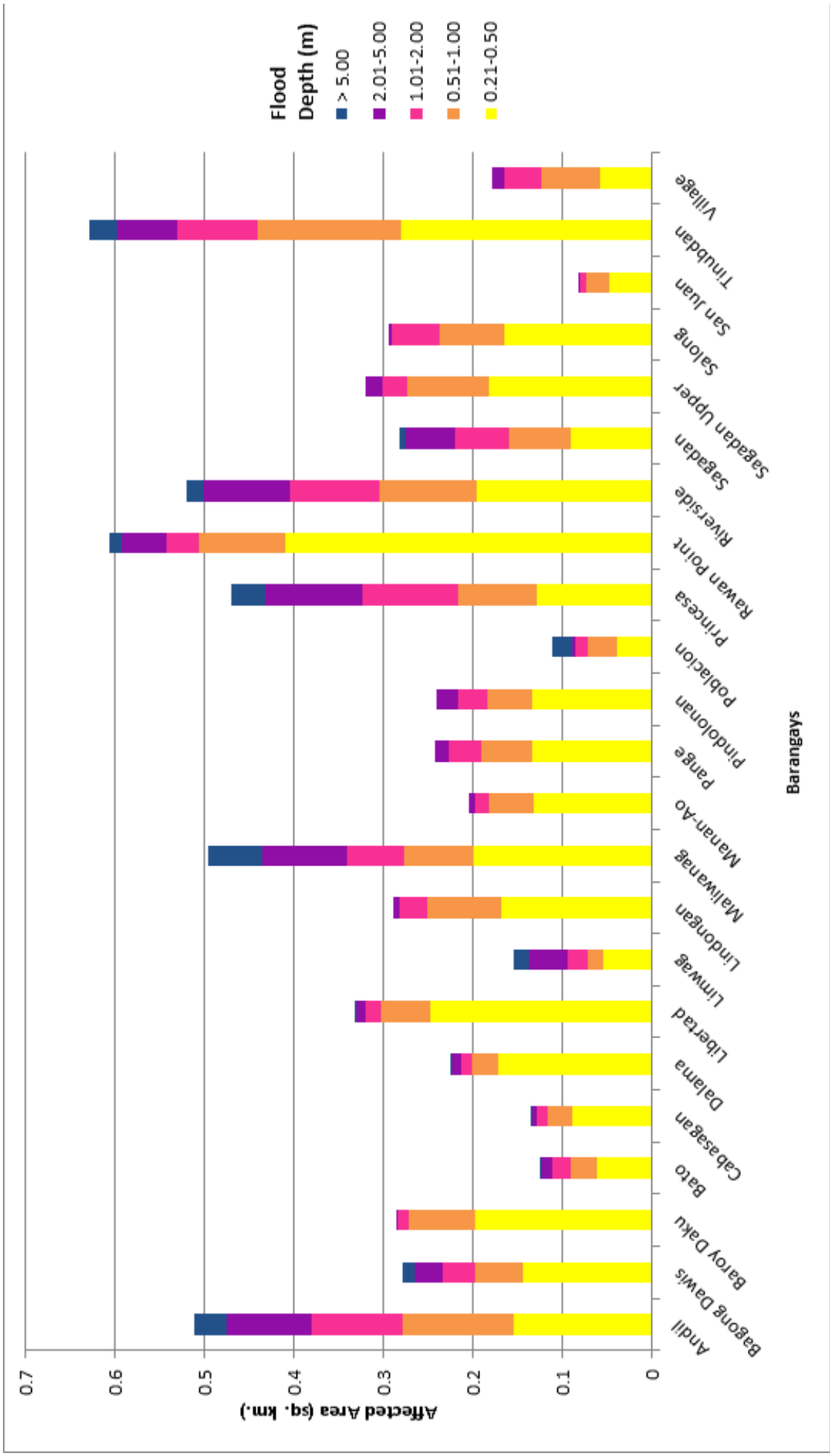


Figure 79. Affected areas in Baroy, Lanao del Norte during 5-year rainfall return period

For the Municipality of Kapatagan, with an area of 184.77 sq. km., 18.13% will experience flood levels of less 0.20 meters; 7.13% of the area will experience flood levels of 0.21 to 0.50 meters; while 6.20%, 1.37%, 0.31%, and 0.19% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 39 are the affected areas in square kilometres by flood depth per barangay.

Table 39. Affected areas in Kapatagan, Lanao del Norte during 5-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Balili											
		Bagong Silang	Balili	Bansarvil	Buenavista	Butadon	Cathedral Falls	Concepcion	Curvada	De Asis	Donggoan	Durano	Lapinig
Affected Area (sq. km.)	0.03-0.20	2.60197	2.30471	0.118836	1.33323	2.11904	1.03709	1.17152	0.689962	0.896606	3.53207	0.848083	3.6352
	0.21-0.50	1.57844	0.776544	0.0022	0.081905	1.49508	0.493558	1.16122	0.222296	0.955294	0.177508	0.010343	1.63532
	0.51-1.00	1.35935	0.828453	0.000193	0.024211	1.62124	0.256007	1.2326	0.275394	0.344252	0.142344	0.003087	1.88021
	1.01-2.00	0.568179	0.210979	0.0003	0.011576	0.16262	0.109467	0.059343	0.143599	0.02297	0.031429	0.00205	0.276532
	2.01-5.00	0.088038	0.068907	0	0.002393	0.07269	0.028248	0.071894	0.029391	0.024308	0.017228	0.000407	0.063171
	> 5.00	0.007475	0.043339	0	0.0001	0.067442	0.047745	0.038302	0.004784	0	0.0004	0	0.0002

BUTADON-BALILI BASIN		Affected Barangays in Balili											
		Malinas	Maranding	Margos	Poblacion	San Vicente	Santa Cruz	Santo Tomas	Suso	Taguitic	Tiacongan	Tulatulahan	Waterfalls
Affected Area (sq. km.)	0.03-0.20	0.336109	0.520039	1.40354	1.20102	0.540308	0.588903	0.229926	1.77454	3.74068	1.84231	0.053399	0.977286
	0.21-0.50	0.011628	0.650482	0.538427	0.038619	0.610971	0.369175	0.508256	0.588259	0.597039	0.187115	0	0.482734
	0.51-1.00	0.0041	1.01617	0.423782	0.033058	0.317403	0.034517	0.773081	0.207899	0.09892	0.05543	0	0.52229
	1.01-2.00	0.0002	0.336504	0.020483	0.014573	0.114874	0.003572	0.014817	0.018772	0.019797	0.020596	0	0.367235
	2.01-5.00	0	0.007241	0.003067	0.002525	0.003803	0.005429	0.013185	0.018343	0.003009	0.001307	0	0.040052
	> 5.00	0	0.020464	0.0001	0.022378	0	0.016578	0.000738	0.039113	0	0	0	0.03907

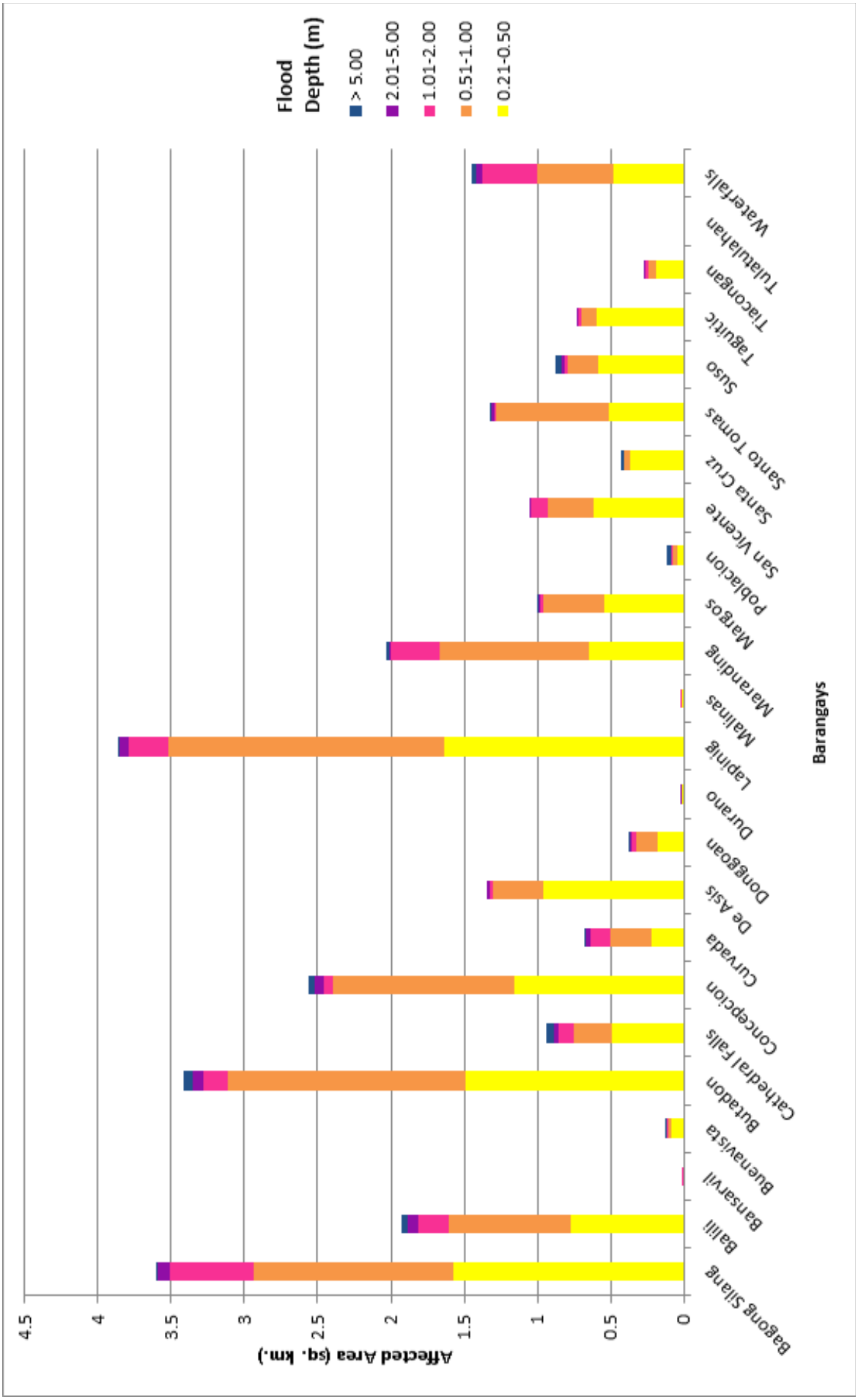


Figure 80. Affected areas in Kapatagan, Lanao del Norte during 5-year rainfall return period

For the municipality of Lala, with an area of 125.18 sq. km., 75.73% will experience flood levels of less 0.20 meters; 15.03% of the area will experience flood levels of 0.21 to 0.50 meters; while 5.57%, 1.43%, 1.31%, and 0.31% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 40 are the affected areas in square kilometres by flood depth per barangay.

Table 40. Affected areas in Lala, Lanao del Norte during 5-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Lala										
		Abaga	Andil	Cabasagan	Camalan	Darumawang Bucana	Darumawang Ilaya	El Salvador	Gumagamot	Lala Proper	Lanipao	Magpatao
Affected Area (sq. km.)	0.03-0.20	2.0051	4.40468	2.69146	2.90129	6.93797	8.40903	3.17868	2.66599	1.19515	1.54169	2.87387
	0.21-0.50	0.186849	0.154252	0.088566	0.703452	1.00461	1.45679	2.33241	0.468779	0.210934	0.311796	0.436569
	0.51-1.00	0.015355	0.124492	0.027664	0.241062	0.123578	0.217805	2.32056	0.129615	0.035978	0.082912	0.293539
	1.01-2.00	0.051482	0.102096	0.013003	0.008301	0.013001	0.025511	0.325324	0.0002	0.013891	0.0012	0.044382
	2.01-5.00	0.010081	0.094202	0.005211	0	0.0008	0.031236	0.165029	0	0	0	0.0022
	> 5.00	0	0.037019	0.0002	0	0	0.007404	0	0	0	0	0

BUTADON-BALILI BASIN		Affected Barangays in Lala										
		Maranding	Matampay Bucana	Matampay Ilaya	Pacita	Pendolonan	Pinoyak	Raw-An	Rebe	San Isidro Lower	San Isidro Upper	San Manuel
Affected Area (sq. km.)	0.03-0.20	0.520039	2.71572	1.36805	1.79739	4.80623	4.0972	1.37038	6.13423	3.89005	3.67033	3.55357
	0.21-0.50	0.650482	0.332162	0.225889	0.24538	1.03546	1.82841	0.104887	1.37439	0.421712	0.275114	0.641432
	0.51-1.00	1.01617	0.0265	0.039035	0.012931	0.081635	0.274938	0.003494	0.473929	0.048709	0.059496	0.188141
	1.01-2.00	0.336504	0	0.004135	0.0001	0.024116	0.03779	0.001578	0.321071	0.036361	0.05442	0.130907
	2.01-5.00	0.007241	0	0	0	0.0109	0.063902	0.000004	0.752258	0.000302	0.046517	0.373071
	> 5.00	0.020464	0	0	0	0.0001	0.100346	0	0.046175	0	0.031908	0.088457

BUTADON-BALILI BASIN		Affected Barangays in Lala				
		Santa Cruz Lower	Santa Cruz Upper	Simpak	Tenazas	Tuna-An
Affected Area (sq. km.)	0.03-0.20	5.08506	7.26576	5.33245	2.21415	2.16931
	0.21-0.50	0.69255	1.31312	1.3278	0.223156	0.771991
	0.51-1.00	0.08145	0.480047	0.376883	0.037169	0.15593
	1.01-2.00	0.003875	0.138883	0.071756	0.008628	0.02317
	2.01-5.00	0	0.060266	0.02115	0	0.001
	> 5.00	0	0.0411	0.018035	0	0

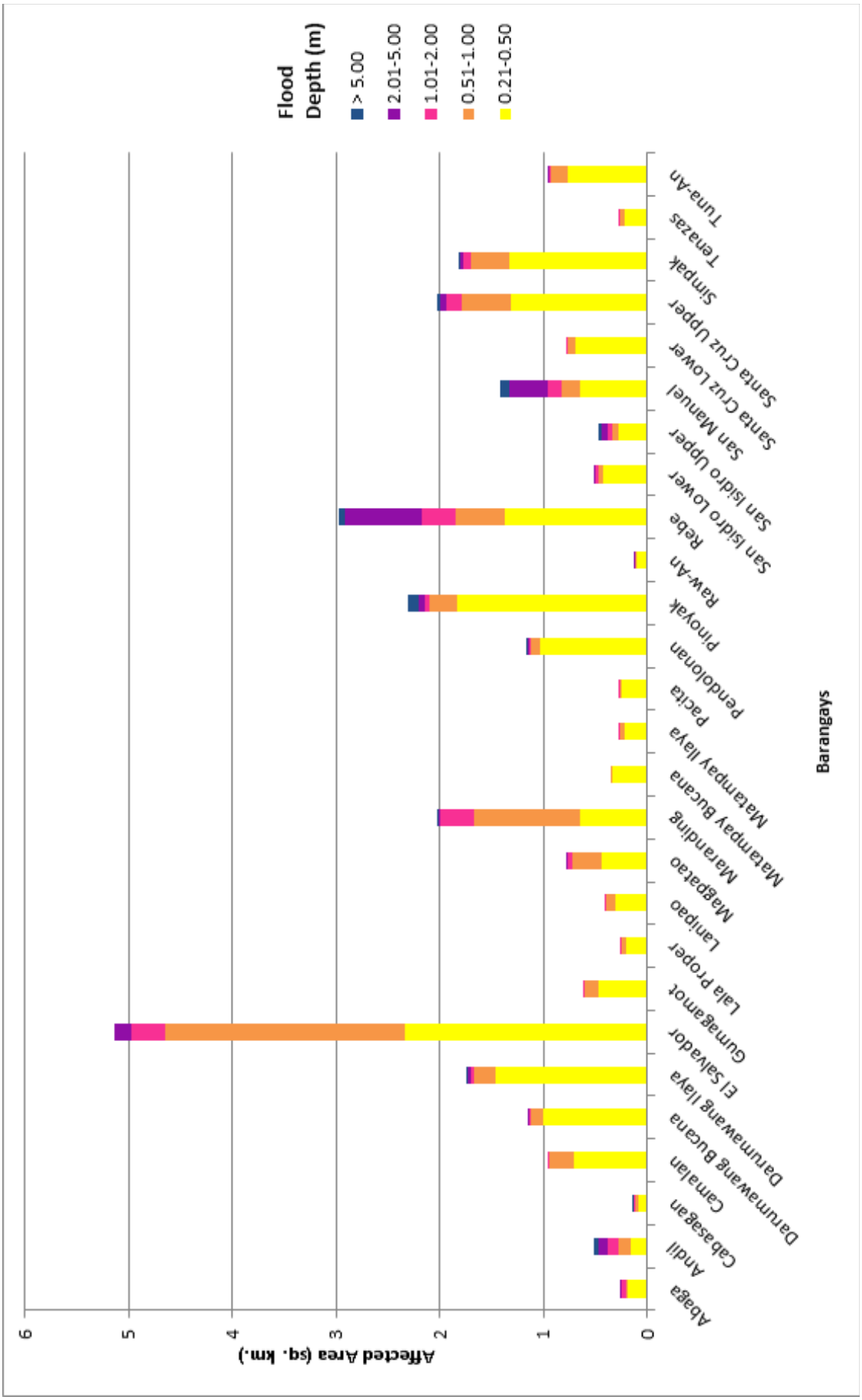


Figure 81. Affected areas in Lala, Lanao del Norte during 5-year rainfall return period

For the municipality of Salvador, with an area of 46.46 sq. km., 23.52% will experience flood levels of less 0.20 meters; 1.73% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.78%, 0.88%, 1.03%, and 0.39% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 41 are the affected areas in square kilometres by flood depth per barangay.

Table 41. Affected areas in Salvador, Lanao del Norte during 5-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Salvador										
		Camp III	**Camp III**	Curva-Miagao	Inasagan	Mabatao	Padianan	Pagayawan	Panaliwad-On	Panganta-pan	Poblacion	**Sudlon**
Affected Area (sq. km.)	**0.03-0.20**	3.10936	3.10936	1.25679	1.20012	1.49208	0.155442	0.037194	1.20721	0.007839	1.20102	1.26288
	0.21-0.50	0.218019	0.218019	0.165668	0.09619	0.048934	0.011049	0.002311	0.13714	0.0013	0.038619	0.084626
	0.51-1.00	0.110866	0.110866	0.065867	0.010089	0.027589	0.000158	0.0002	0.062408	0	0.033058	0.051633
	1.01-2.00	0.084129	0.084129	0.111241	0.0041	0.012341	0.000748	0.0001	0.117307	0	0.014573	0.062226
	2.01-5.00	0.026609	0.026609	0.014868	0.0003	0.0008	0.000549	0	0.39703	0	0.002525	0.035005
	> 5.00	0.0004	0.0004	0	0	0	0	0	0.160243	0	0.022378	0

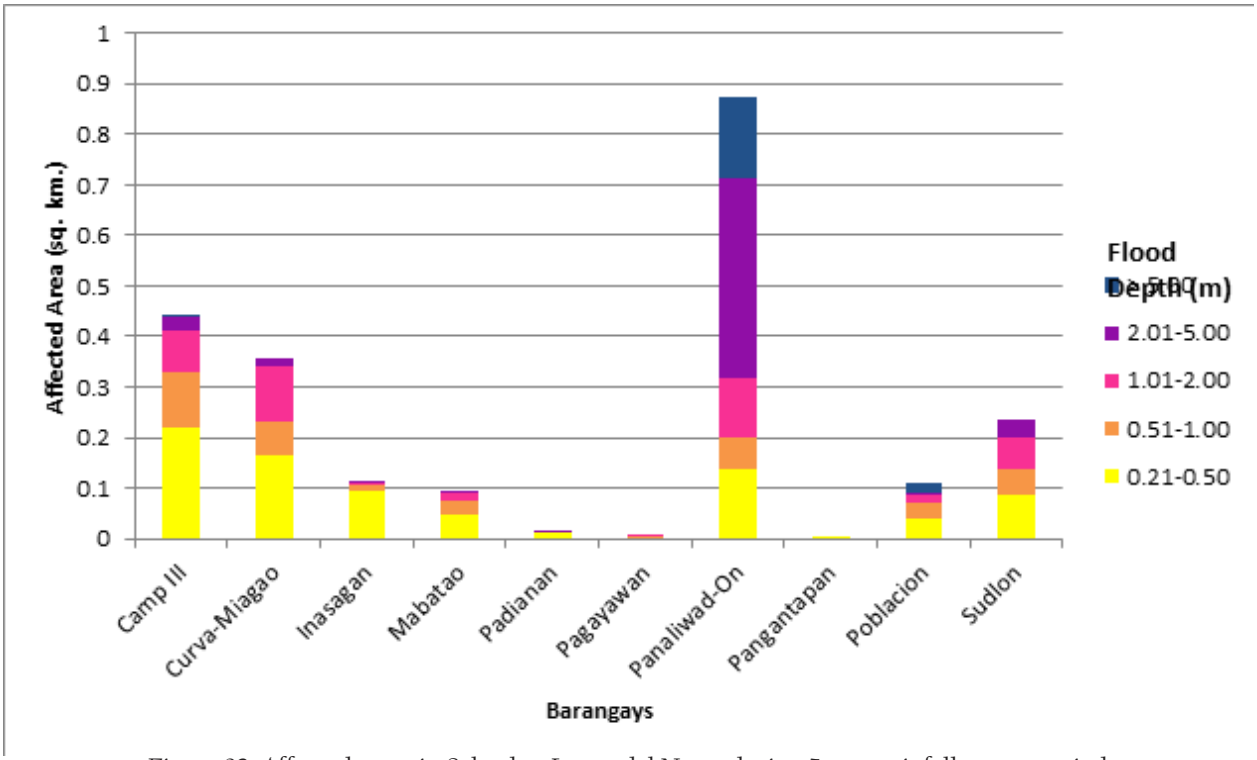


Figure 82. Affected areas in Salvador, Lanao del Norte during 5-year rainfall return period

For the municipality of Sapad, with an area of 65.13 sq. km., 2.15% will experience flood levels of less 0.20 meters; 0.89% of the area will experience flood levels of 0.21 to 0.50 meters; while 1.41%, 0.46%, 0.20%, and 0.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 42 are the affected areas in square kilometres by flood depth per barangay.

Table 42. Affected areas in Sapad, Lanao del Norte during 5-year rainfall return

BUTADON-BALILI BASIN		**Affected Barangays in Sapad**			
		Mabugnao	**Mapurog**	Pancilan	Panoloon
Affected Area (sq. km.)	**0.03-0.20**	0.586253	0.754582	0.008044	0.053034
	0.21-0.50	0.075851	0.385404	0.03873	0.079508
	0.51-1.00	0.097786	0.444446	0.272681	0.10131
	1.01-2.00	0.12516	0.094381	0.049688	0.031
	2.01-5.00	0.010804	0.090596	0.023474	0.005251
	> 5.00	0.014868	0.050502	0	0

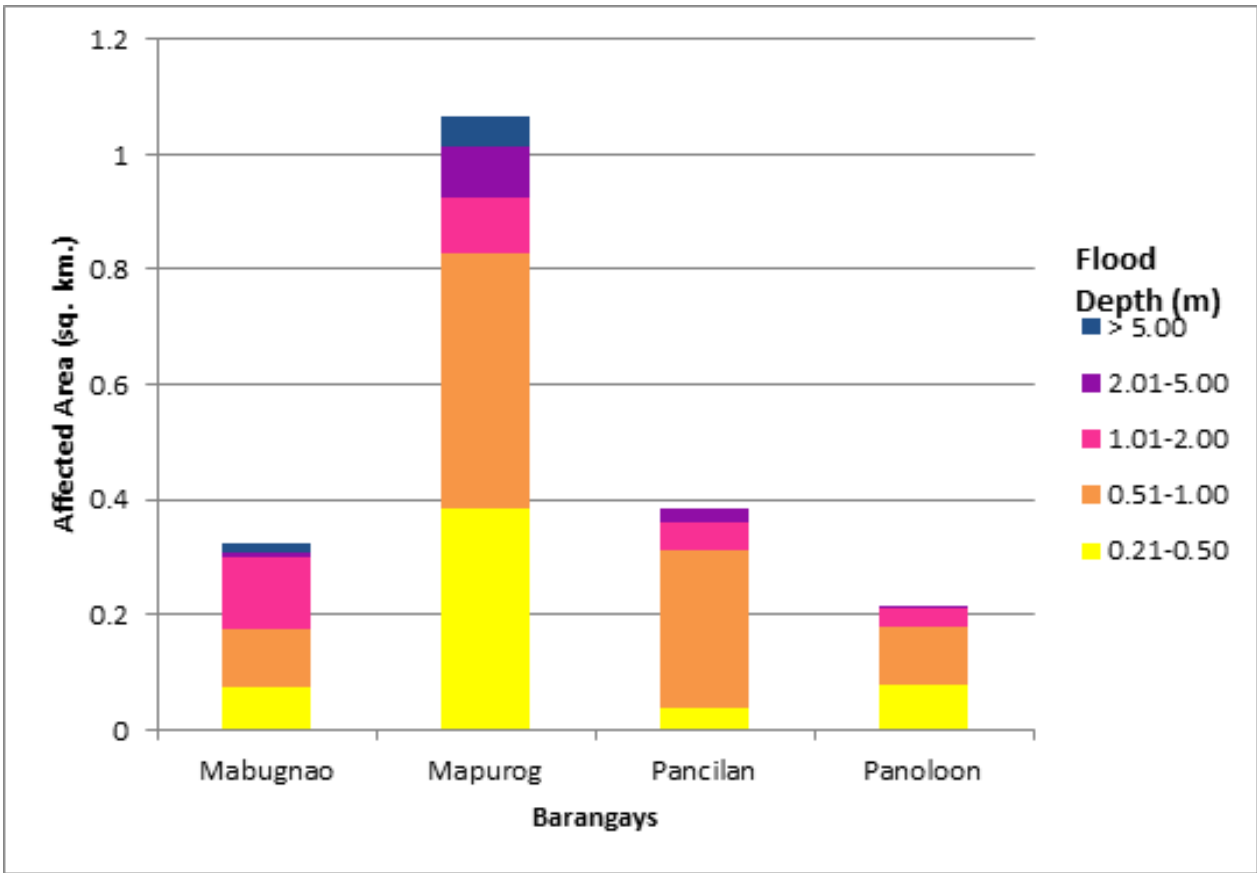


Table 42. Affected areas in Sapad, Lanao del Norte during 5-year rainfall return

For the municipality of Tubod, with an area of 121.95 sq. km., 12.74% will experience flood levels of less 0.20 meters; 067% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.46%, 0.29%, 0.15%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 43 are the affected areas in square kilometres by flood depth per barangay.

Table 43. Affected areas in Tubod, Lanao del Norte during 5-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Tubod									
		Bulod	**Candis**	Licapao	Malingao	Patudan	Pinpin	Poblacion	Pualas	San Antonio	Santo Niño
Affected Area (sq. km.)	**0.03-0.20**	0.271384	0.356899	2.89185	2.85429	1.06672	2.16465	1.20102	0.807976	1.50183	2.41784
	0.21-0.50	0.009286	0.010703	0.152622	0.174308	0.062407	0.087068	0.038619	0.039422	0.039382	0.203027
	0.51-1.00	0.007394	0.000988	0.095427	0.120329	0.030826	0.060027	0.033058	0.041976	0.065638	0.10149
	1.01-2.00	0.001638	0.000547	0.080673	0.075749	0.026712	0.036004	0.014573	0.025979	0.047821	0.048812
	2.01-5.00	0	0	0.0502	0.070755	0.011752	0.022404	0.002525	0.001363	0.023092	0.003495
	> 5.00	0	0	0	0.007285	0	0.016734	0.022378	0	0	0

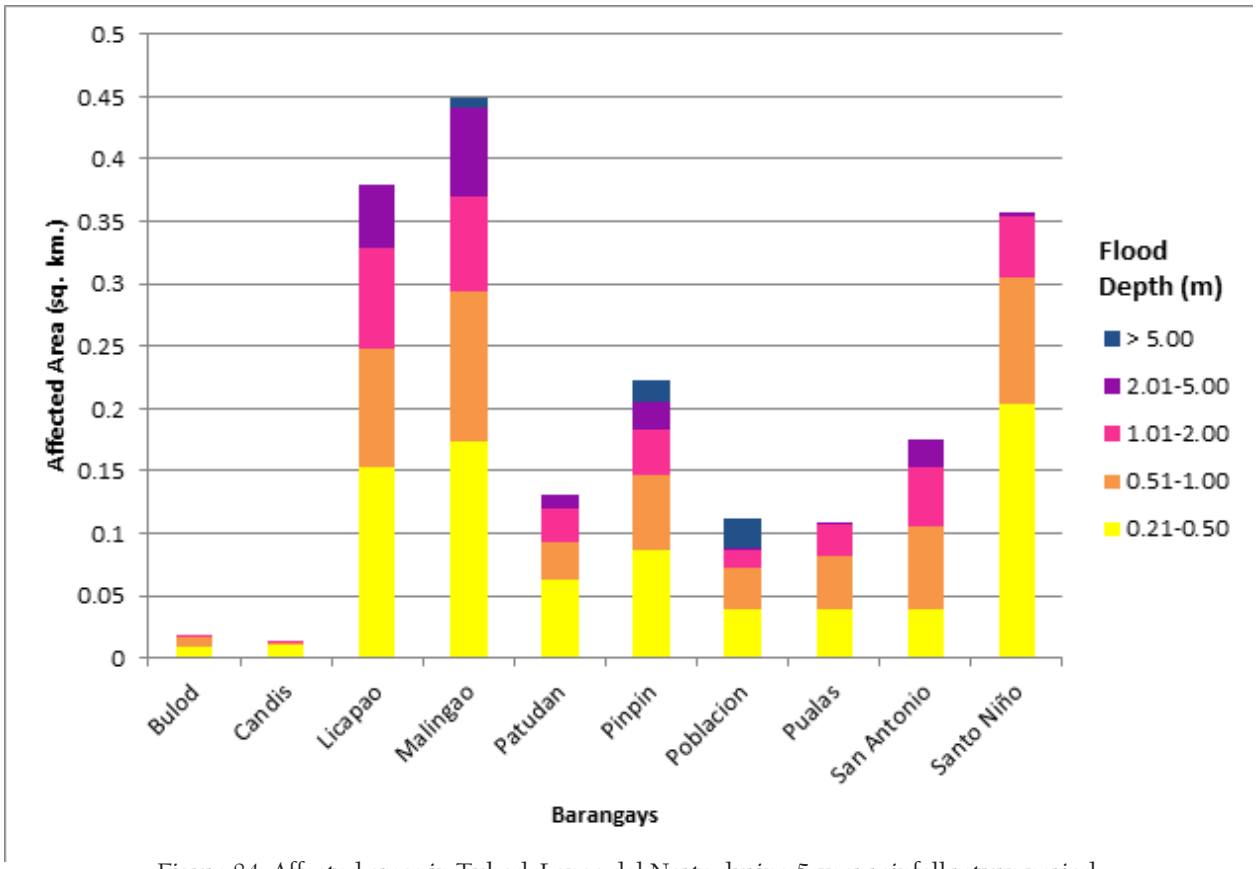


Figure 84. Affected areas in Tubod, Lanao del Norte during 5-year rainfall return period

For the 25-year return period, 2.61% of the municipality of Aurora with an area of 162.225 sq. km. will experience flood levels of less 0.20 meters; 1.72% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.59%, 067%, 0.04%, and 0.00006% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 44 are the affected areas in square kilometres by flood depth per barangay.

Table 44. Affected areas in Aurora, Zamboanga del Sur during 25-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Aurora
		Anonang
Affected Area (sq. km.)	0.03-0.20	
	0.21-0.50	2.78664
	0.51-1.00	0.965115
	1.01-2.00	1.09455
	2.01-5.00	0.070194
	> 5.00	0.005
		0.0001

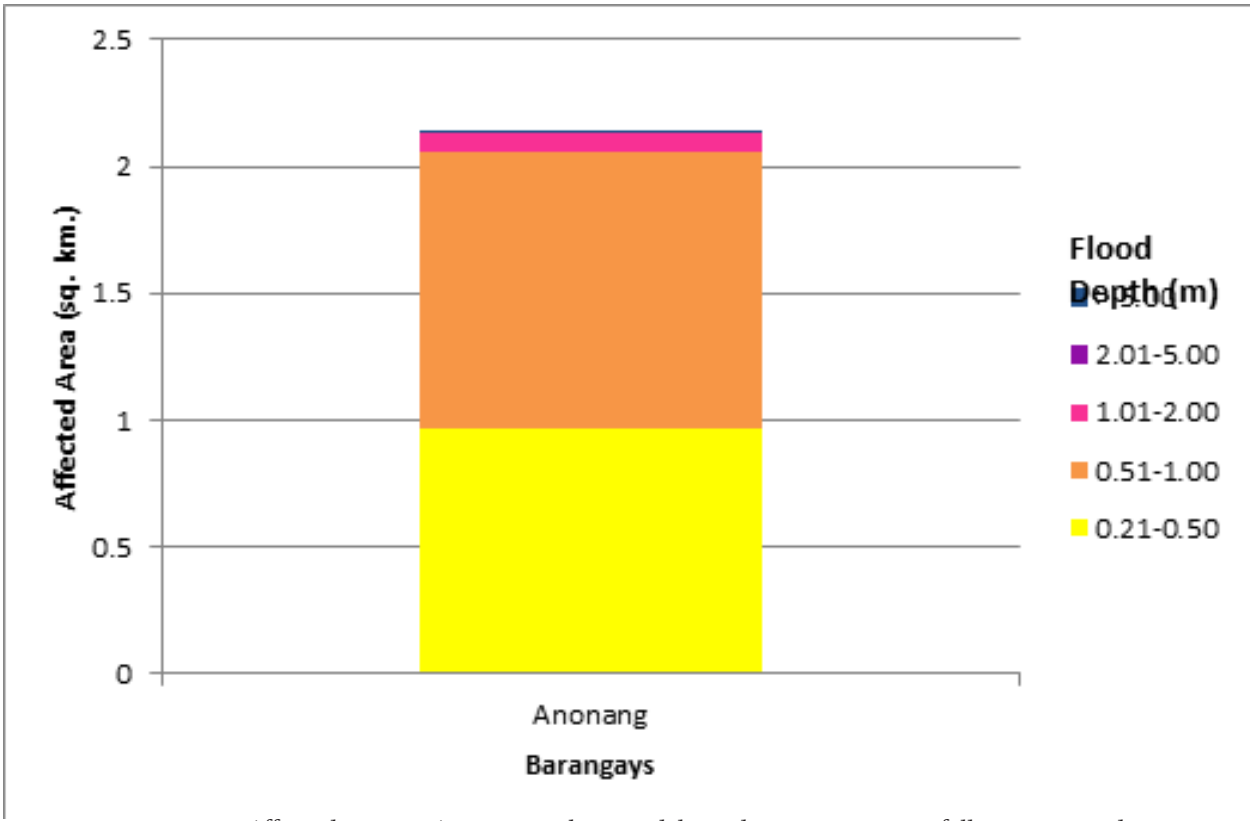


Figure 85. Affected areas in Aurora, Zamboanga del Sur during 25-year rainfall return period

For the municipality of Baroy, with an area of 32.08 sq. km., 82.85% will experience flood levels of less 0.20 meters; 7.63% of the area will experience flood levels of 0.21 to 0.50 meters; while 3.90%, 2.20%, 1.88%, and 0.86% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 45 are the affected areas in square kilometres by flood depth per barangay.

Table 45. Affected areas in Baroy, Lanao del Norte during 25-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Baroy										
		Andil	Bagong Dawis	Baroy Daku	Bato	Cabasagan	Dalama	Libertad	Limwag	Lindongan	Maliwanag	Manan-Ao
Affected Area (sq. km.)	0.03-0.20	4.26304	1.74382	0.831675	1.88203	2.62849	1.84807	1.22822	1.27297	2.40505	3.12666	1.80999
	0.21-0.50	0.182034	0.228371	0.224754	0.083227	0.127871	0.256325	0.36965	0.096025	0.197411	0.231464	0.199088
	0.51-1.00	0.131119	0.119307	0.148235	0.039758	0.036853	0.063819	0.13796	0.016355	0.132536	0.11072	0.064725
	1.01-2.00	0.124713	0.066959	0.028861	0.022638	0.023911	0.016984	0.032997	0.021021	0.046998	0.060243	0.035432
	2.01-5.00	0.14161	0.046133	0.003159	0.020911	0.009515	0.010627	0.014923	0.041812	0.020379	0.120213	0.010179
	> 5.00	0.074219	0.018344	0	0.0012	0.0006	0.0032	0.00269	0.041839	0	0.106096	0

BUTADON-BALILI BASIN		Affected Barangays in Baroy											
		Pange	Pindolonan	Poblacion	Princesa	Rawan Point	Riverside	Sagadan	Sagadan Upper	Salong	San Juan	Tinubdan	Village
Affected Area (sq. km.)	0.03-0.20	1.81	2.31629	1.18229	3.78414	1.89596	5.15615	1.53219	1.06921	3.68098	0.358449	4.23231	1.38177
	0.21-0.50	0.193487	0.218661	0.041469	0.150333	0.719264	0.249782	0.123475	0.207234	0.196755	0.062116	0.320094	0.061013
	0.51-1.00	0.092827	0.05664	0.036404	0.114746	0.274015	0.135016	0.098983	0.181649	0.099709	0.037702	0.226332	0.065006
	1.01-2.00	0.050907	0.043515	0.025036	0.120811	0.058567	0.091108	0.102442	0.093021	0.052795	0.016985	0.164768	0.067629
	2.01-5.00	0.027894	0.045385	0.004596	0.191985	0.050541	0.138301	0.081409	0.02128	0.042368	0.000456	0.096285	0.025041
	> 5.00	0	0	0.043139	0.076481	0.024887	0.054049	0.030471	0	0	0	0.056497	0

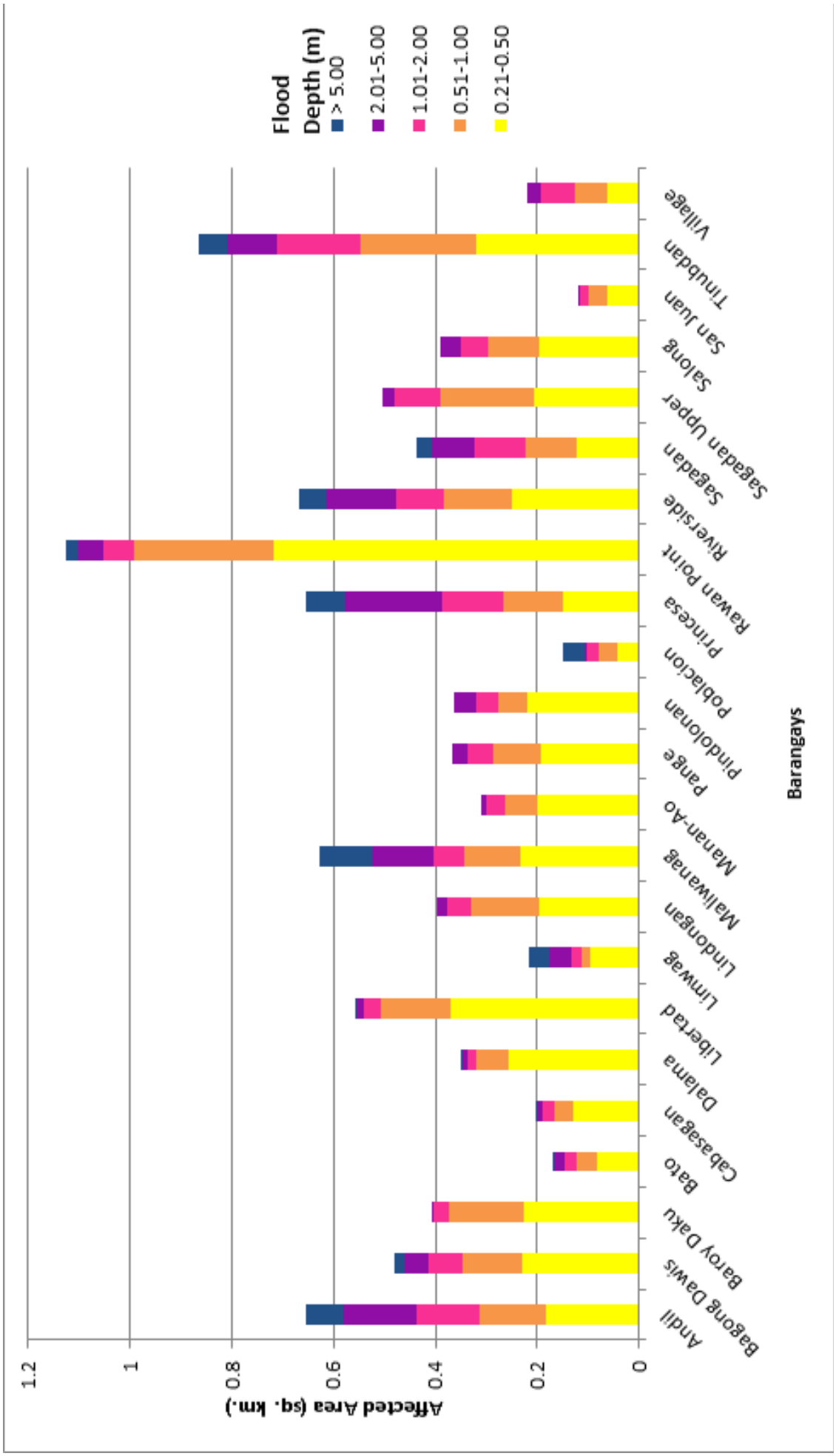


Figure 86. Affected areas in Baroy, Lanao del Norte during 25-year rainfall return period

For the Municipality of Kapatagan, with an area of 184.77 sq. km., 10.59% will experience flood levels of less 0.20 meters; 4.61% of the area will experience flood levels of 0.21 to 0.50 meters; while 8.58%, 8.59%, 0.73%, and 0.25% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 46 are the affected areas in square kilometres by flood depth per barangay.

Table 46. Affected areas in Kapatagan, Lanao del Norte during 25-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Balili											
		Bagong Silang	Balili	Bansarvil	Buenavista	Butadon	Cathedral Falls	Concepcion	Curvada	De Asis	Donggoan	Durano	Lapinig
Affected Area (sq. km.)	0.03-0.20	0.681206	1.38073	0.116857	1.28105	0.355727	0.776085	0.593858	0.111076	0.293725	3.40794	0.84211	1.37571
	0.21-0.50	1.47474	0.661879	0.003679	0.114161	0.679924	0.527673	0.686736	0.301007	0.525989	0.223136	0.013222	0.669498
	0.51-1.00	1.83158	0.777461	0.000648	0.035619	1.8505	0.380526	0.938203	0.437303	1.1486	0.190196	0.004581	2.30493
	1.01-2.00	1.86187	1.21334	0.000145	0.018588	2.48049	0.173599	1.39888	0.4612	0.255916	0.050335	0.00295	2.99481
	2.01-5.00	0.330236	0.131874	0.0002	0.003793	0.0905	0.065814	0.075886	0.041989	0.024024	0.028275	0.001	0.145178
	> 5.00	0.023814	0.067653	0	0.0002	0.088688	0.048417	0.041308	0.012852	0.003181	0.001094	0.000107	0.000493

BUTADON-BALILI BASIN		Affected Barangays in Balili											
		Malinas	Maranding	Margos	Poblacion	San Vicente	Santa Cruz	Santo Tomas	Suso	Taguitic	Tiacongan	Tulatulahan	Waterfalls
Affected Area (sq. km.)	0.03-0.20	0.330121	0.157747	0.856354	1.18229	0.138445	0.349874	0.095462	1.42163	1.4019	1.68229	0.053299	0.674534
	0.21-0.50	0.015292	0.2945	0.168328	0.041469	0.425059	0.20504	0.255489	0.444515	0.270848	0.27739	0.0001	0.2334
	0.51-1.00	0.005623	0.923331	0.383526	0.036404	0.420876	0.41574	0.991873	0.514602	1.63655	0.106461	0	0.523665
	1.01-2.00	0.001	1.14239	0.967025	0.025036	0.579768	0.024119	0.182983	0.208504	1.14404	0.038314	0	0.651371
	2.01-5.00	0	0.011412	0.014067	0.004596	0.023212	0.005785	0.015658	0.02142	0.006109	0.002307	0	0.30369
	> 5.00	0	0.021522	0.0001	0.043139	0	0.017616	0.000837	0.040442	0	0	0	0.042632

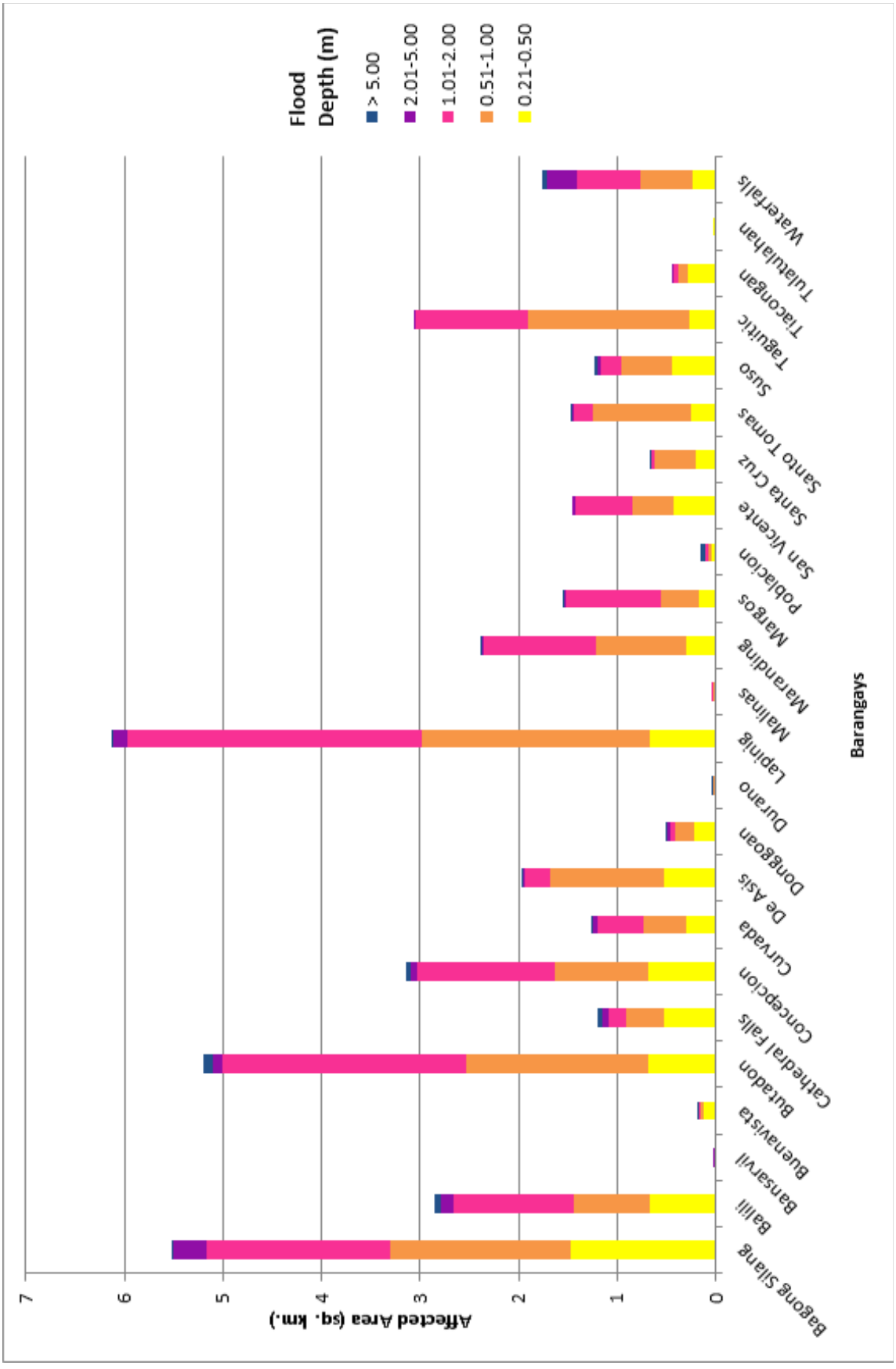


Figure 87. Affected areas in Kapatagan, Lanao del Norte during 25-year rainfall return period

For the municipality of Lala, with an area of 125.18 sq. km., 52.28% will experience flood levels of less 0.20 meters; 21.17% of the area will experience flood levels of 0.21 to 0.50 meters; while 14.95%, 8.74%, 1.79%, and 0.50% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 47 are the affected areas in square kilometres by flood depth per barangay.

Table 47. Affected areas in Lala, Lanao del Norte during 5-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Lala										
		Abaga	Andil	Cabasagan	Camalan	Darumawang Bucana	Darumawang Ilaya	El Salvador	Gumagamot	Lala Proper	Lanipao	Magpatao
Affected Area (sq. km.)	0.03-0.20	Abaga	Andil	Cabasagan	Camalan		Darumawang	El Salvador		Lala	Lanipao	Magpatao
	0.21-0.50	1.79083	4.26304	2.62849	1.5455	1.56072	4.26274	0.357566	2.19321	0.925401	1.16686	2.29348
	0.51-1.00	0.379307	0.182034	0.127871	1.16126	1.45496	3.05202	0.764308	0.730402	0.404857	0.536653	0.664225
	1.01-2.00	0.033972	0.131119	0.036853	0.947524	3.34876	2.09976	2.51342	0.326966	0.100367	0.178755	0.415824
	2.01-5.00	0.028599	0.124713	0.023911	0.199816	1.71353	0.691198	4.34052	0.019361	0.024133	0.055322	0.271817
	> 5.00	0.036262	0.14161	0.009515	0	0.002	0.031857	0.345345	0	0.0012	0	0.005217

BUTADON-BALILI BASIN		Affected Barangays in Lala										
		Maranding	Matampay Bucana	Matampay Ilaya	Pacita	Pendolonan	Pinoyak	Raw-An	Rebe	San Isidro Lower	San Isidro Upper	San Manuel
Affected Area (sq. km.)	0.03-0.20	Maranding	Matampay	Matampay	1.39871	3.98747	2.14318	1.23857	4.68903	3.24877	3.31729	2.30358
	0.21-0.50	0.157747	2.31232	0.954579	0.597407	1.57621	1.89517	0.220345	2.12674	0.895633	0.535997	0.876542
	0.51-1.00	0.2945	0.633382	0.555049	0.060082	0.340032	1.93157	0.021766	0.860422	0.206709	0.104144	0.697306
	1.01-2.00	0.923331	0.129876	0.121904	0.0011	0.041726	0.245252	0.003094	0.441274	0.035082	0.058576	0.511527
	2.01-5.00	1.14239	0.0001	0.00808	0	0.0128	0.077634	0.000083	0.867052	0.016402	0.079487	0.425045
	> 5.00	0.011412	0	0	0	0.0002	0.109788	0.000004	0.122116	0	0.044984	0.162469

BUTADON-BALILI BASIN		Affected Barangays in Lala				
		Santa Cruz Lower	Santa Cruz Upper	Simpak	Tenazas	Tuna-An
Affected Area (sq. km.)	0.03-0.20	3.07068	5.95593	4.32616	1.87531	1.47933
	0.21-0.50	1.73794	1.65553	1.88535	0.481954	1.07092
	0.51-1.00	0.726034	1.1036	0.762366	0.094939	0.491201
	1.01-2.00	0.332391	0.395766	0.125255	0.030508	0.078759
	2.01-5.00	0	0.139605	0.041248	0.0004	0.0012
	> 5.00	0	0.054174	0.018735	0	0

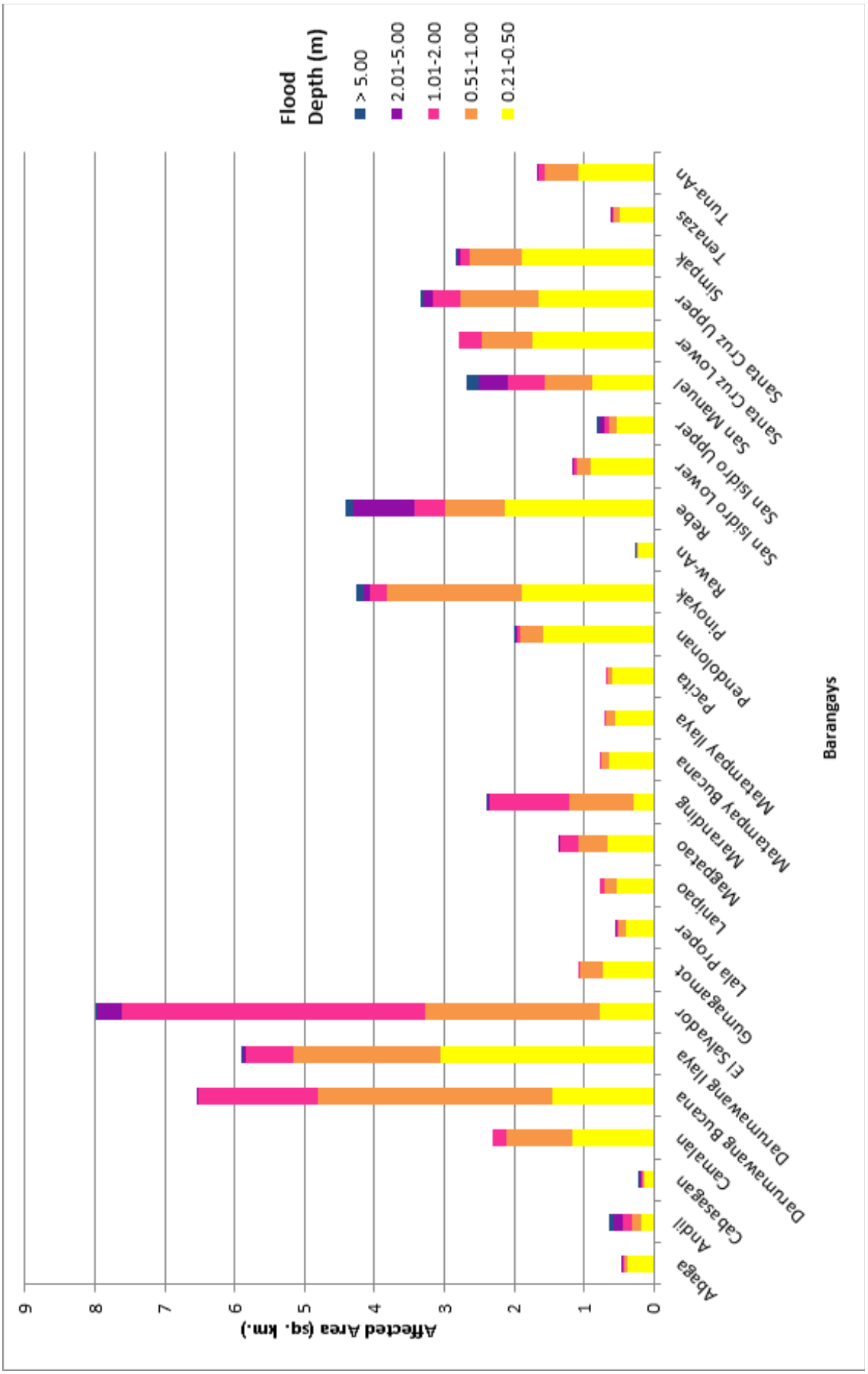


Figure 88. Affected areas in Lala, Lanao del Norte during 25-year rainfall return period

For the municipality of Salvador, with an area of 46.46 sq. km., 23.52% will experience flood levels of less 0.20 meters; 1.73% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.78%, 0.88%, 1.03%, and 0.39% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 48 are the affected areas in square kilometres by flood depth per barangay.

Table 48. Affected areas in Salvador, Lanao del Norte during 25-year rainfall return

BUTADON-BALILI BASIN		Affected Barangays in Salvador										
		Camp III	**Camp III**	Curva-Miagao	Inasagan	Mabatao	Padianan	Pagayawan	Panaliwad-On	Panganta-pan	Poblacion	**Sudlon**
Affected Area (sq. km.)	**0.03-0.20**	2.87042	0.890981	1.04467	1.45989	0.145715	0.035369	0.659671	0.006209	1.18229	1.12408	1.26288
	0.21-0.50	0.321941	0.355637	0.238856	0.06436	0.020508	0.003836	0.19082	0.00293	0.041469	0.145573	0.084626
	0.51-1.00	0.198428	0.123323	0.01952	0.035866	0.000369	0.0005	0.223969	0	0.036404	0.078048	0.051633
	1.01-2.00	0.110469	0.090474	0.007049	0.019869	0.000664	0	0.288435	0	0.025036	0.072404	0.062226
	2.01-5.00	0.047327	0.154019	0.0007	0.002657	0.00069	0.0001	0.455195	0	0.004596	0.076271	0.035005
	> 5.00	0.0008	0	0	0	0	0	0.263248	0	0.043139	0	0

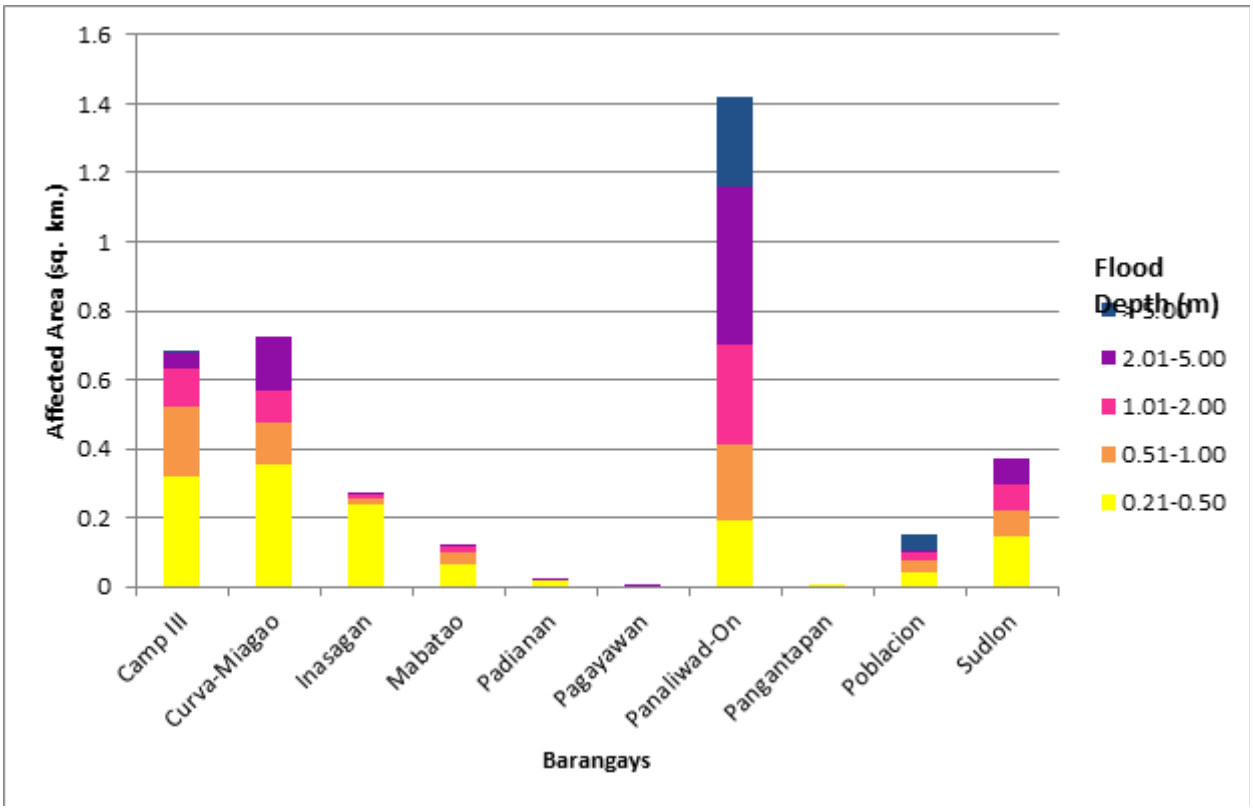


Figure 89. Affected areas in Salvador, Lanao del Norte during 25-year rainfall return period

For the municipality of Sapad, with an area of 65.13 sq. km., 2.15% will experience flood levels of less 0.20 meters; 0.89% of the area will experience flood levels of 0.21 to 0.50 meters; while 1.41%, 0.46%, 0.20%, and 0.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 49 are the affected areas in square kilometres by flood depth per barangay.

Table 49. Affected areas in Sapad, Lanao del Norte during 25-year rainfall return period

BUTADON-BALILI BASIN		**Affected Barangays in Sapad**			
		Mabugnao	**Mapurog**	Pancilan	Panoloon
Affected Area (sq. km.)	**0.03-0.20**	0.541182	0.389401	0	0.00968
	0.21-0.50	0.075331	0.245422	0.0003	0.02064
	0.51-1.00	0.062149	0.520633	0.013828	0.0497
	1.01-2.00	0.186013	0.470577	0.336615	0.178137
	2.01-5.00	0.030179	0.137181	0.041874	0.011947
	> 5.00	0.015868	0.056696	0	0

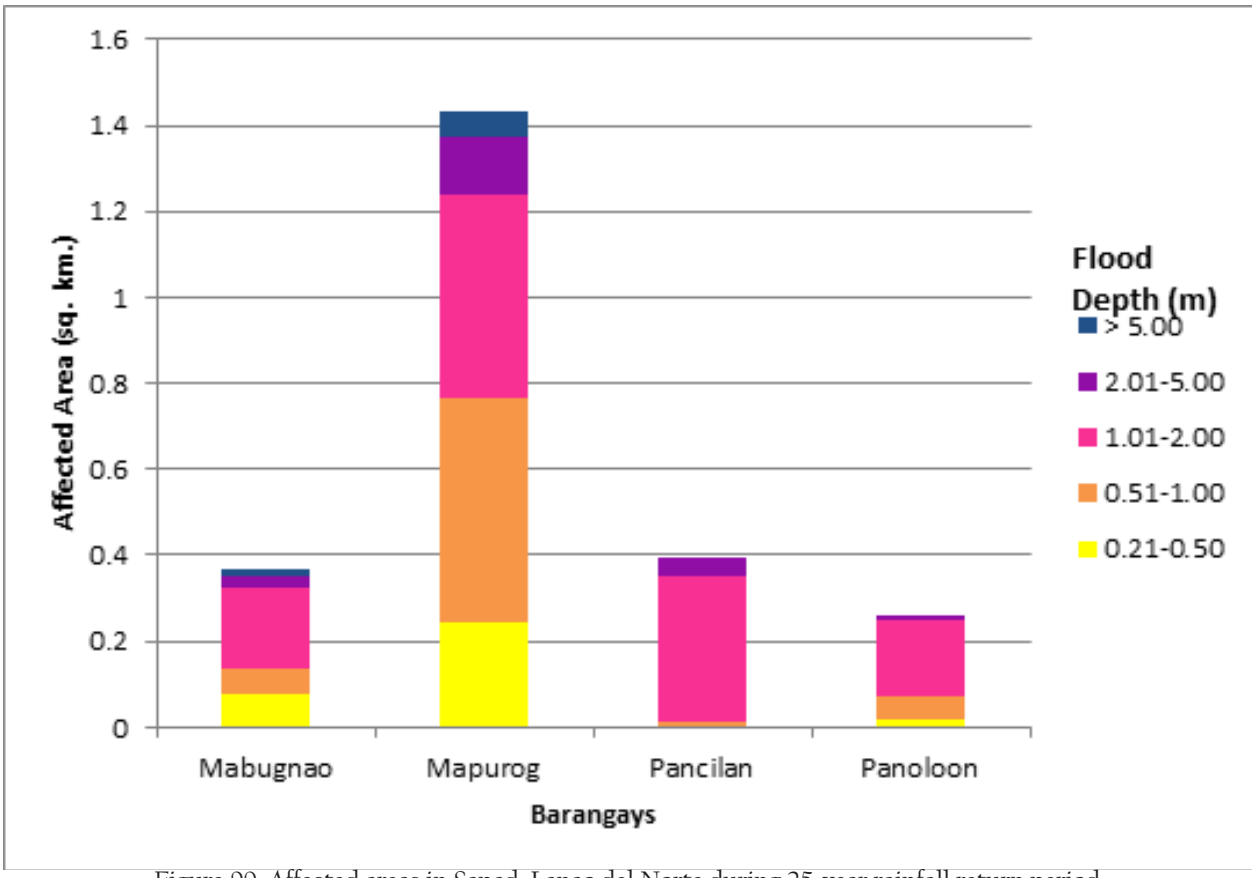


Figure 90. Affected areas in Sapad, Lanao del Norte during 25-year rainfall return period

For the municipality of Tubod, with an area of 121.95 sq. km., 12.74% will experience flood levels of less 0.20 meters; 067% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.46%, 0.29%, 0.15%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 50 are the affected areas in square kilometres by flood depth per barangay.

Table 50. Affected areas in Tubod, Lanao del Norte during 25-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Tubod									
		Bulod	**Candis**	Licapao	Malingao	Patudan	Pinpin	Poblacion	Pualas	San Antonio	Santo Niño
Affected Area (sq. km.)	**0.03-0.20**	0.265069	0.351044	2.77308	2.72772	1.01946	2.08268	1.18229	0.781151	1.46984	2.25839
	0.21-0.50	0.007408	0.015558	0.17407	0.191031	0.056251	0.108491	0.041469	0.031737	0.034409	0.238741
	0.51-1.00	0.010925	0.001788	0.119079	0.143898	0.050041	0.08056	0.036404	0.045292	0.051592	0.167833
	1.01-2.00	0.0063	0.000747	0.12037	0.107287	0.041645	0.058239	0.025036	0.05002	0.084113	0.091735
	2.01-5.00	0	0	0.084175	0.07968	0.031024	0.02639	0.004596	0.008515	0.037809	0.01796
	> 5.00	0	0	0	0.053096	0	0.030533	0.043139	0	0	0

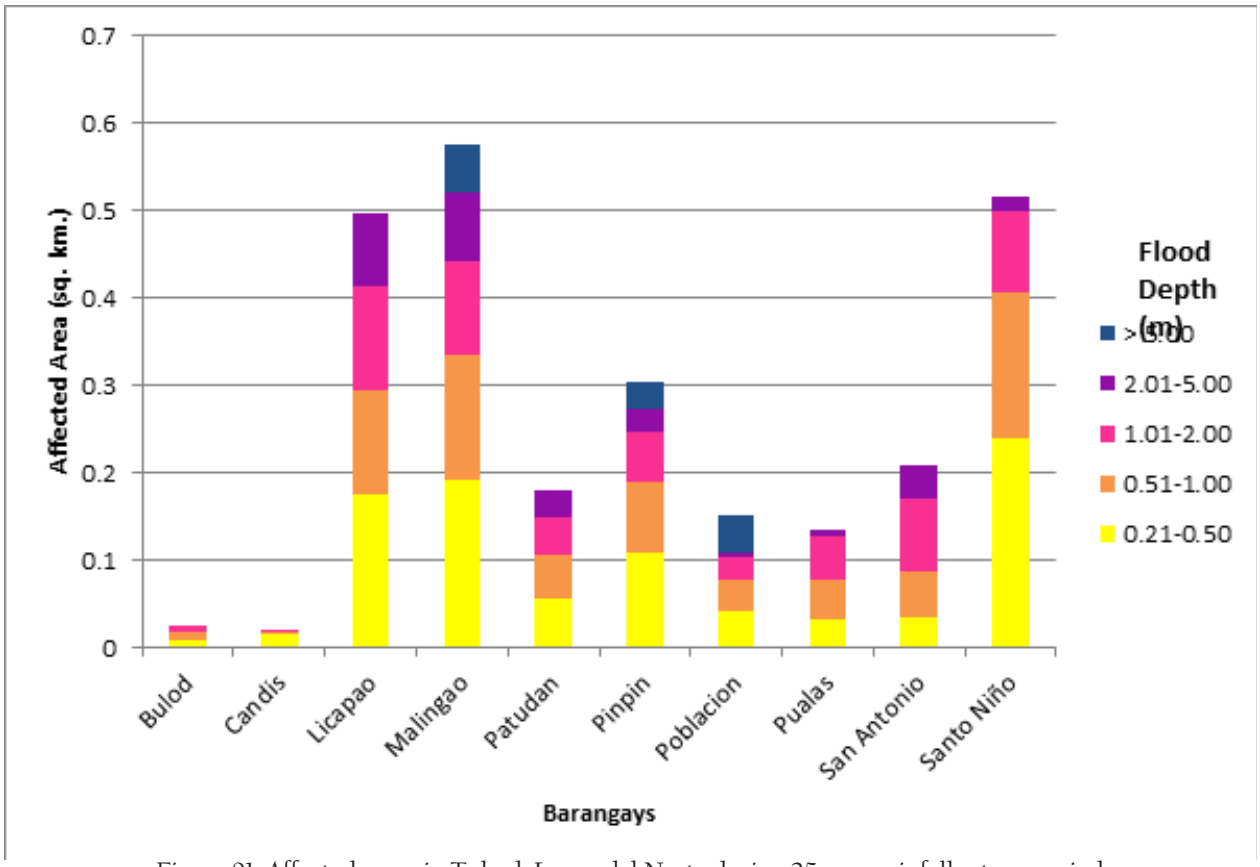


Figure 91. Affected areas in Tubod, Lanao del Norte during 25-year rainfall return period

Table 51. Affected areas in Aurora, Zamboanga del Sur during 100-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Aurora
		Anonang
Affected Area (sq. km.)	0.03-0.20	1.74136
	0.21-0.50	0.244848
	0.51-1.00	1.28596
	1.01-2.00	1.64243
	2.01-5.00	0.0069
	> 5.00	0.0001

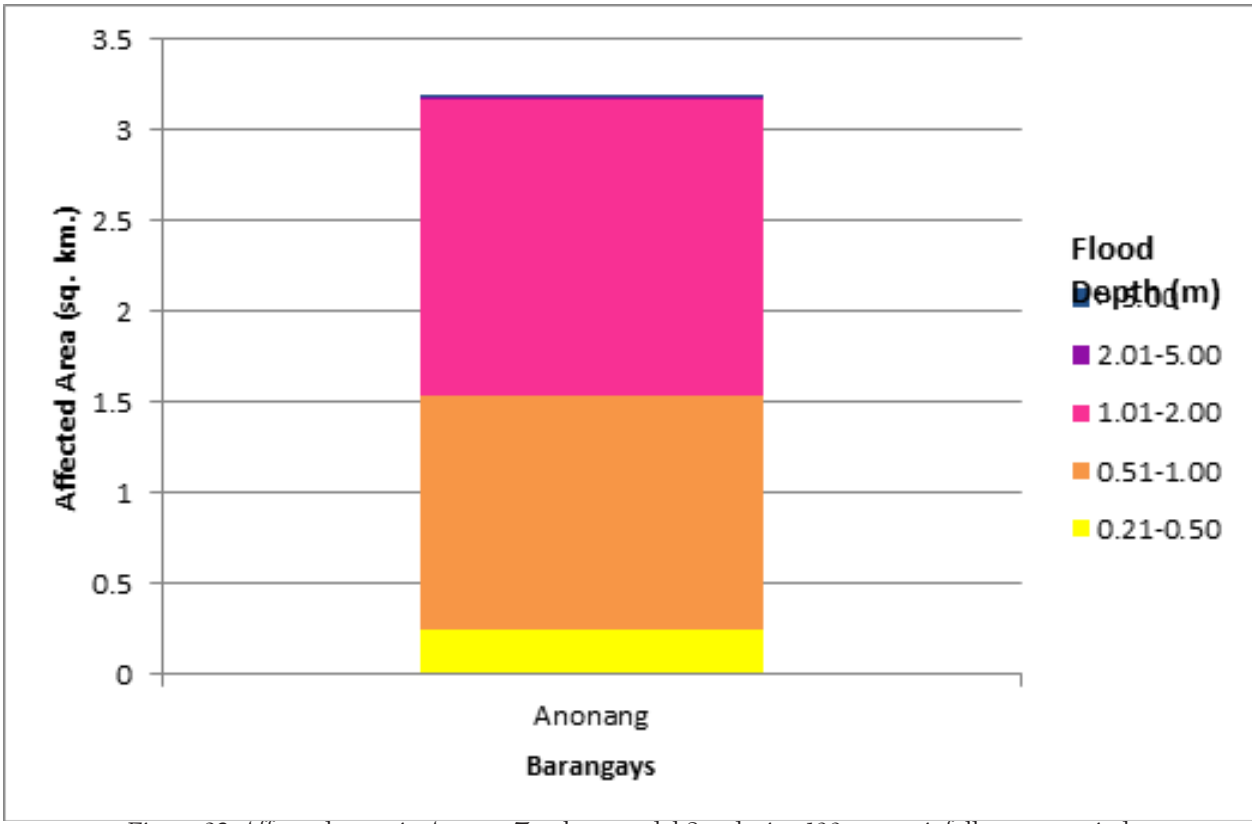


Figure 92. Affected areas in Aurora, Zamboanga del Sur during 100-year rainfall return period

For the municipality of Baroy, with an area of 32.08 sq. km., 79.47% will experience flood levels of less 0.20 meters; 8.49% of the area will experience flood levels of 0.21 to 0.50 meters; while 5.09%, 2.92%, 2.16%, and 1.24% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 52 are the affected areas in square kilometres by flood depth per barangay.

Table 52. Affected areas in Baroy, Lanao del Norte during 100-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Baroy										
		Andil	Bagong Dawis	Baroy Daku	Bato	Cabasagan	Dalama	Libertad	Limwag	Lindongan	Maliwanag	Manan-Ao
Affected Area (sq. km.)	0.03-0.20	4.1699	1.568	0.771113	1.83972	2.57914	1.77467	1.1196	1.22999	2.34039	3.04292	1.73139
	0.21-0.50	0.207506	0.288336	0.223375	0.106927	0.159096	0.293875	0.391821	0.116123	0.218244	0.242051	0.246042
	0.51-1.00	0.140753	0.195344	0.192101	0.047805	0.042558	0.09347	0.19456	0.024153	0.110536	0.145642	0.083173
	1.01-2.00	0.138584	0.099803	0.046137	0.029303	0.031431	0.021816	0.058074	0.021061	0.107534	0.065459	0.046281
	2.01-5.00	0.148306	0.052666	0.003959	0.024405	0.014015	0.011995	0.017771	0.037782	0.025972	0.108467	0.013111
	> 5.00	0.111688	0.021111	0	0.0016	0.0017	0.0039	0.004619	0.060917	0	0.150858	0.0001

BUTADON-BALILI BASIN		Affected Barangays in Baroy											
		Pange	Pindolonan	Poblacion	Princesa	Rawan Point	Riverside	Sagadan	Sagadan Upper	Salong	San Juan	Tinubdan	Village
Affected Area (sq. km.)	0.03-0.20	1.70504	2.23233	1.17049	3.6443	1.57667	5.05135	1.41586	0.994706	3.61781	0.333341	4.07544	1.3546
	0.21-0.50	0.243969	0.270396	0.04118	0.175112	0.734279	0.284249	0.156986	0.202867	0.213166	0.07636	0.318038	0.061653
	0.51-1.00	0.124488	0.072231	0.038491	0.139784	0.546323	0.155906	0.120933	0.20289	0.115928	0.040918	0.266236	0.065231
	1.01-2.00	0.064894	0.046893	0.032336	0.142245	0.093033	0.104776	0.130509	0.145416	0.067684	0.024535	0.213938	0.080469
	2.01-5.00	0.036492	0.059185	0.007295	0.225778	0.052841	0.125438	0.106807	0.026515	0.058374	0.000556	0.143673	0.038506
	> 5.00	0.000233	0.0001	0.054745	0.111277	0.026987	0.102694	0.037875	0	0	0	0.078956	0

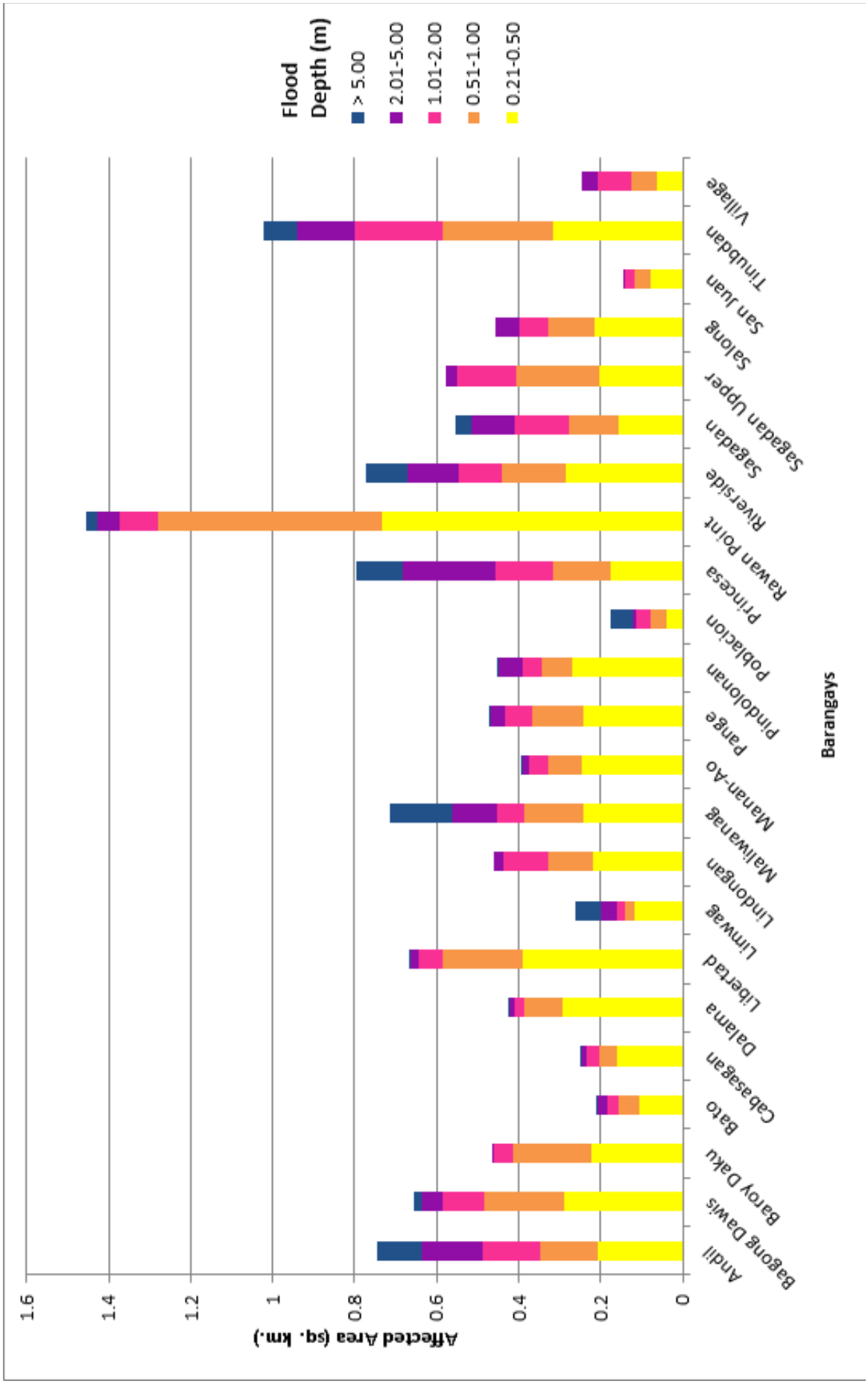


Figure 93. Affected areas in Baroy, Lanao del Norte during 100-year rainfall return period

For the Municipality of Kapatagan, with an area of 184.77 sq. km., 9.16% will experience flood levels of less 0.20 meters; 3.07% of the area will experience flood levels of 0.21 to 0.50 meters; while 6.84%, 12.01%, 2.00%, and 0.28% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 53 are the affected areas in square kilometres by flood depth per barangay.

Table 53. Affected areas in Kapatagan, Lanao del Norte during 100-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Balili											
		Bagong Silang	Balili	Bansarvil	Buenavista	Butadon	Cathedral Falls	Concepcion	Curvada	De Asis	Donggoan	Durano	Lapinig
Affected Area (sq. km.)	0.03-0.20	0.177695	1.17159	0.115609	1.24916	0.149141	0.70308	0.36793	0.03487	0.113671	3.33205	0.837806	1.05979
	0.21-0.50	0.718437	0.518964	0.004527	0.127006	0.239611	0.457581	0.559387	0.128743	0.339498	0.259939	0.015079	0.434852
	0.51-1.00	1.89178	0.656465	0.001048	0.048561	1.08274	0.455058	0.771606	0.510097	1.14222	0.206763	0.005995	1.35551
	1.01-2.00	2.53346	1.2674	0.000145	0.023088	3.44668	0.201414	1.90272	0.501248	0.624311	0.066116	0.003483	4.26509
	2.01-5.00	0.844673	0.534266	0.0002	0.005293	0.534962	0.106061	0.085513	0.17717	0.023167	0.034517	0.0015	0.374893
	> 5.00	0.037404	0.084246	0	0.0003	0.093582	0.04892	0.047708	0.013299	0.007859	0.001594	0.000107	0.000493

BUTADON-BALILI BASIN		Affected Barangays in Balili											
		Malinas	Maranding	Margos	Poblacion	San Vicente	Santa Cruz	Santo Tomas	Suso	Taguitic	Tiacongan	Tulatulahan	Waterfalls
Affected Area (sq. km.)	0.03-0.20	0.327051	0.06549	0.756131	1.17049	0.079536	0.27354	0.065845	1.34642	1.28998	1.58707	0.053299	0.601919
	0.21-0.50	0.016063	0.157067	0.127838	0.04118	0.249539	0.166409	0.148655	0.351515	0.219939	0.221516	0.0001	0.166361
	0.51-1.00	0.007223	0.618916	0.235121	0.038491	0.315664	0.328403	0.763823	0.509847	0.972827	0.217067	0	0.493836
	1.01-2.00	0.0017	1.44263	1.16636	0.032336	0.795752	0.225622	0.546114	0.381208	1.95929	0.076465	0	0.719918
	2.01-5.00	0	0.243789	0.103846	0.007295	0.146459	0.005501	0.017627	0.022298	0.017406	0.004646	0	0.403994
	> 5.00	0	0.023008	0.0001	0.054745	0.00041	0.0187	0.00084	0.041365	0	0	0	0.044028

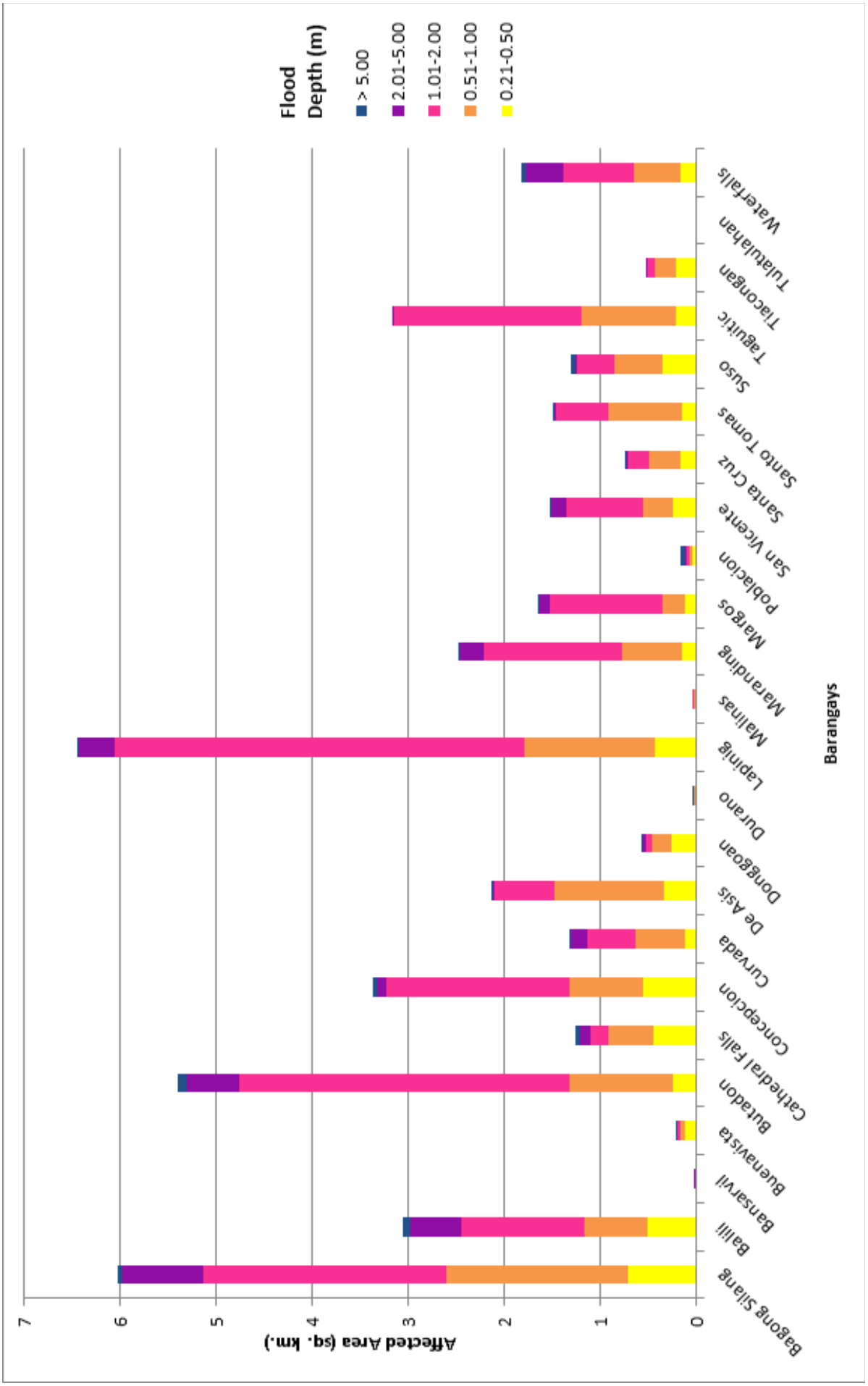


Figure 94. Affected areas in Kapatagan, Lanao del Norte during 100-year rainfall return period

For the municipality of Lala, with an area of 125.18 sq. km., 41.94% will experience flood levels of less 0.20 meters; 19.66% of the area will experience flood levels of 0.21 to 0.50 meters; while 18.02%, 16.32%, 2.83%, 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 Table 54 are the affected areas in square kilometres by flood depth per barangay.

Table 54. Affected areas in Lala, Lanao del Norte during 5-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Lala										
		Abaga	Andil	Cabasagan	Camalan	Darumawang Bucana	Darumawang Ilaya	El Salvador	Gumagamot	Lala Proper	Lanipao	Magpatao
Affected Area (sq. km.)	0.03-0.20	1.62361	4.1699	2.57914	1.13091	0.54081	2.4194	0.060992	1.85725	0.772655	0.932328	2.00569
	0.21-0.50	0.520495	0.207506	0.159096	0.873563	0.664719	2.8758	0.196089	0.896586	0.457586	0.662325	0.661436
	0.51-1.00	0.058657	0.140753	0.042558	1.4193	2.52536	2.6127	1.26632	0.438446	0.185458	0.204185	0.525129
	1.01-2.00	0.020341	0.138584	0.031431	0.428048	4.31332	2.18611	5.64087	0.078854	0.037659	0.138756	0.441832
	2.01-5.00	0.045861	0.148306	0.014015	0.00228	0.03575	0.040058	1.14008	0	0.0026	0	0.016476
	> 5.00	0	0.111688	0.0017	0	0	0.013704	0.017641	0	0	0	0

BUTADON-BALILI BASIN		Affected Barangays in Lala										
		Maranding	Matampay Bucana	Matampay Ilaya	Pacita	Pendolonan	Pinoyak	Raw-An	Rebe	San Isidro Lower	San Isidro Upper	San Manuel
Affected Area (sq. km.)	0.03-0.20	0.06549	1.76257	0.619675	1.19337	3.68474	1.13767	1.10252	3.72604	2.70838	3.09034	1.92167
	0.21-0.50	0.157067	0.806143	0.489372	0.696716	1.47869	0.965526	0.310549	2.41588	1.23719	0.691314	0.779179
	0.51-1.00	0.618916	0.44025	0.493868	0.163236	0.72698	2.56115	0.067479	1.34833	0.398999	0.149797	0.739669
	1.01-2.00	1.44263	0.075965	0.03941	0.004212	0.050728	1.53624	0.00384	0.538904	0.037025	0.060693	0.834135
	2.01-5.00	0.243789	0	0	0	0.0171	0.082202	0.000245	0.920395	0.023102	0.094496	0.447942
	> 5.00	0.023008	0	0	0	0.0002	0.119802	0.000004	0.162316	0	0.054251	0.254082

BUTADON-BALILI BASIN		Affected Barangays in Lala				
		Santa Cruz Lower	Santa Cruz Upper	Simpak	Tenazas	Tuna-An
Affected Area (sq. km.)	0.03-0.20	1.69206	5.19777	3.75823	1.62438	1.12107
	0.21-0.50	0.931505	1.83862	2.03709	0.620767	0.984099
	0.51-1.00	1.96329	1.38619	1.11295	0.175264	0.798465
	1.01-2.00	1.27893	0.630253	0.17744	0.061898	0.205435
	2.01-5.00	0.003856	0.193204	0.05855	0.0008	0.012331
	> 5.00	0	0.060474	0.019635	0	0

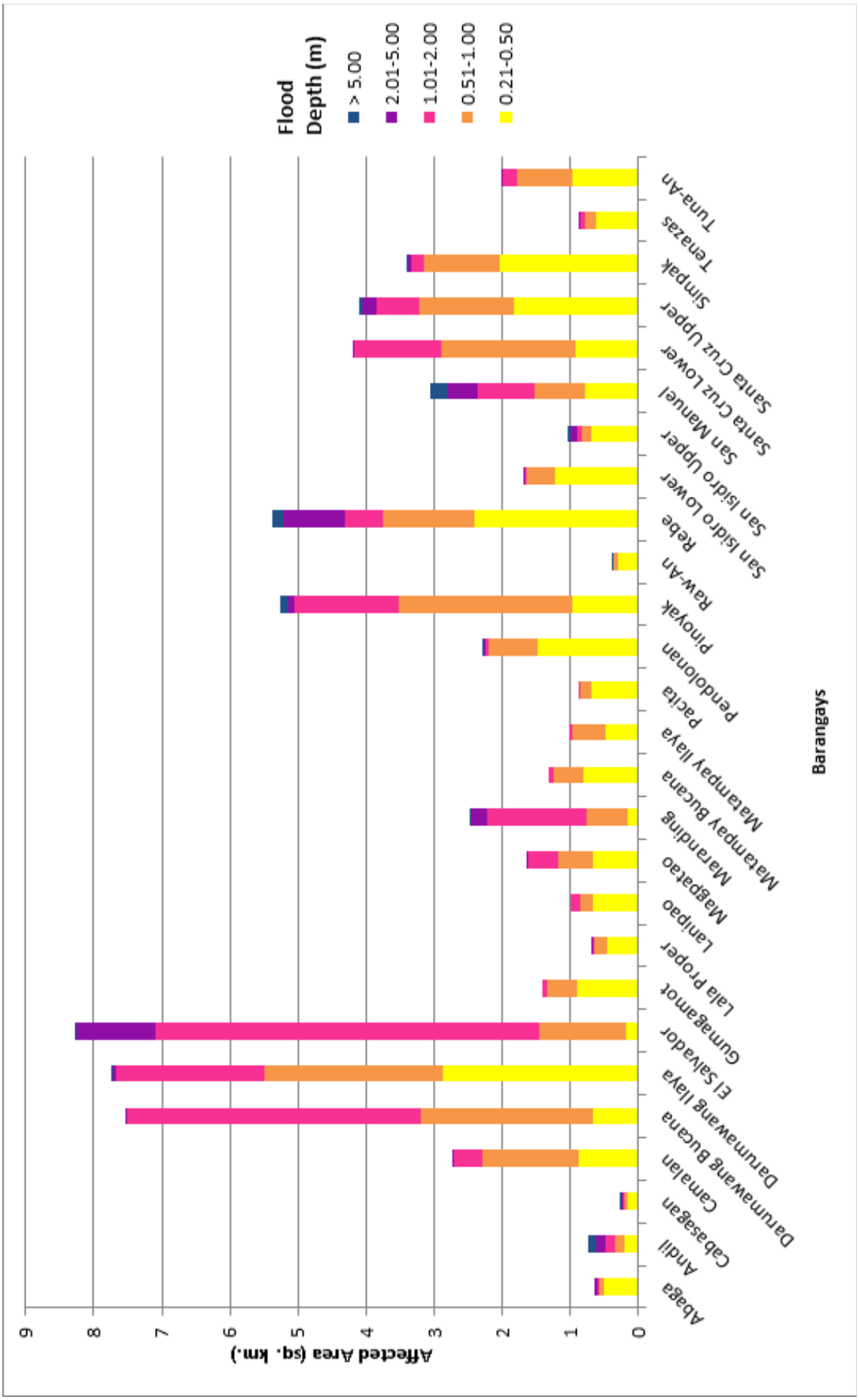


Figure 95. Affected areas in Lala, Lanao del Norte during 100-year rainfall return period

For the municipality of Salvador, with an area of 46.46 sq. km., 18.28% will experience flood levels of less 0.20 meters; 3.27% of the area will experience flood levels of 0.21 to 0.50 meters; while 2.03%, 1.97%, 1.52%, and 1.33% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 55 are the affected areas in square kilometres by flood depth per barangay.

Table 55. Affected areas in Salvador, Lanao del Norte during 100-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Salvador										
		Camp III	**Camp III**	Curva-Miagao	Inasagan	Mabatao	Padianan	Pagayawan	Panaliwad-On	Panganta-pan	Poblacion	**Sudlon**
Affected Area (sq. km.)	**0.03-0.20**	2.75792	0.66442	0.93799	1.44091	0.140007	0.033801	0.315921	0.000275	1.17049	1.03217	1.26288
	0.21-0.50	0.337176	0.396702	0.319958	0.071357	0.026095	0.005004	0.149166	0.00067	0.04118	0.170098	0.084626
	0.51-1.00	0.256625	0.184033	0.041751	0.040846	0.00039	0.0008	0.256164	0.007664	0.038491	0.117403	0.051633
	1.01-2.00	0.134534	0.141723	0.009999	0.024696	0.000565	0.0001	0.499169	0.00053	0.032336	0.070893	0.062226
	2.01-5.00	0.062127	0.182405	0.0011	0.004841	0.00089	0.0001	0.341783	0	0.007295	0.105807	0.035005
	> 5.00	0.001	0.04515	0	0	0	0	0.519136	0	0.054745	0	0

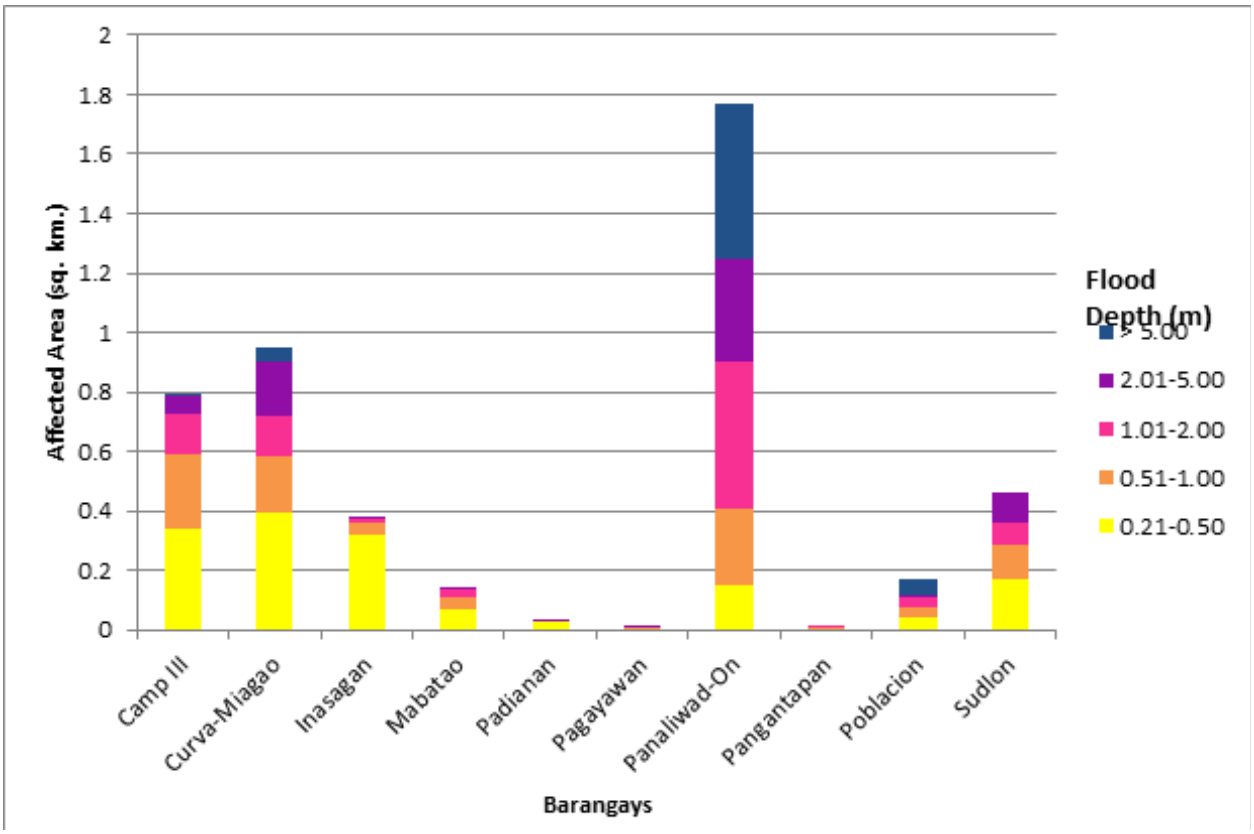


Figure 96. Affected areas in Salvador, Lanao del Norte during 100-year rainfall return period

For the municipality of Sapad, with an area of 65.13 sq. km., 1.23% will experience flood levels of less 0.20 meters; 0.34% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.81%, 1.83%, 0.88%, and 0.13% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 56 are the affected areas in square kilometres by flood depth per barangay.

Table 56. Affected areas in Sapad, Lanao del Norte during 100-year rainfall return period

BUTADON-BALILI BASIN		**Affected Barangays in Sapad**			
		Mabugnao	**Mapurog**	Pancilan	Panoloon
Affected Area (sq. km.)	**0.03-0.20**	0.513932	0.282155	0	0.004028
	0.21-0.50	0.078871	0.13696	0	0.005142
	0.51-1.00	0.066993	0.425635	0.000384	0.034355
	1.01-2.00	0.172747	0.722034	0.192054	0.104129
	2.01-5.00	0.061812	0.191911	0.19588	0.122449
	> 5.00	0.016368	0.061216	0.0043	0

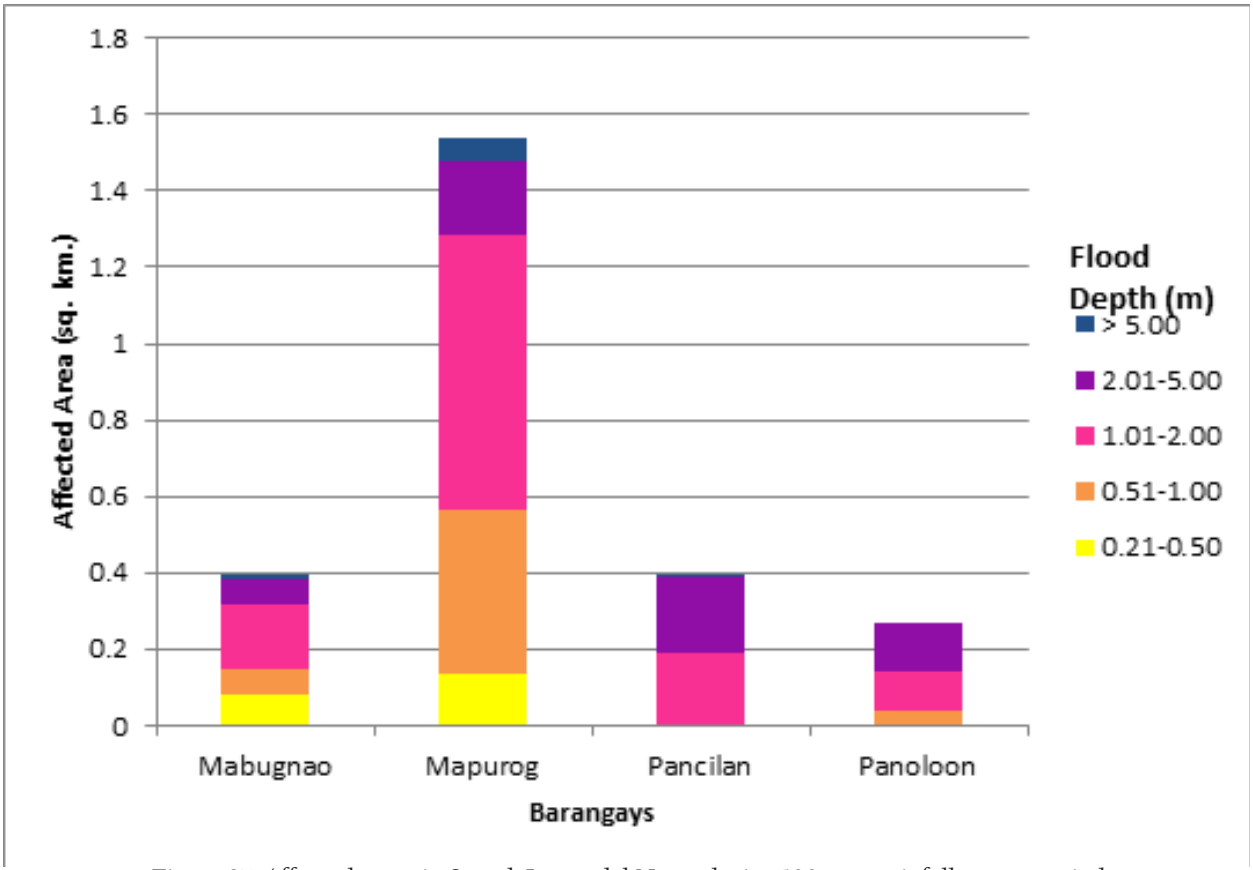


Figure 97. Affected areas in Sapad, Lanao del Norte during 100-year rainfall return period

For the municipality of Tubod, with an area of 121.95 sq. km., 11.84% will experience flood levels of less 0.20 meters; 0.82% of the area will experience flood levels of 0.21 to 0.50 meters; while 0.66%, 0.59%, 0.32%, and 0.15% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 57 are the affected areas in square kilometres by flood depth per barangay.

Table 57. Affected areas in Tubod, Lanao del Norte during 25-year rainfall return period

BUTADON-BALILI BASIN		Affected Barangays in Tubod									
		Bulod	**Candis**	Licapao	Malingao	Patudan	Pinpin	Poblacion	Pualas	San Antonio	Santo Niño
Affected Area (sq. km.)	**0.03-0.20**	0.261262	0.345767	2.69663	2.64028	0.991715	1.95965	1.17049	0.766122	1.45168	2.15577
	0.21-0.50	0.008352	0.019623	0.196496	0.209508	0.055078	0.157235	0.04118	0.030981	0.037499	0.243176
	0.51-1.00	0.010755	0.002811	0.122056	0.161114	0.055505	0.114205	0.038491	0.039692	0.043694	0.214537
	1.01-2.00	0.009333	0.000936	0.130131	0.131926	0.046327	0.084266	0.032336	0.064537	0.093955	0.124455
	2.01-5.00	0	0	0.124854	0.074095	0.049696	0.034042	0.007295	0.015384	0.050934	0.03672
	> 5.00	0	0	0.0006	0.085796	0.0001	0.037492	0.054745	0	0	0

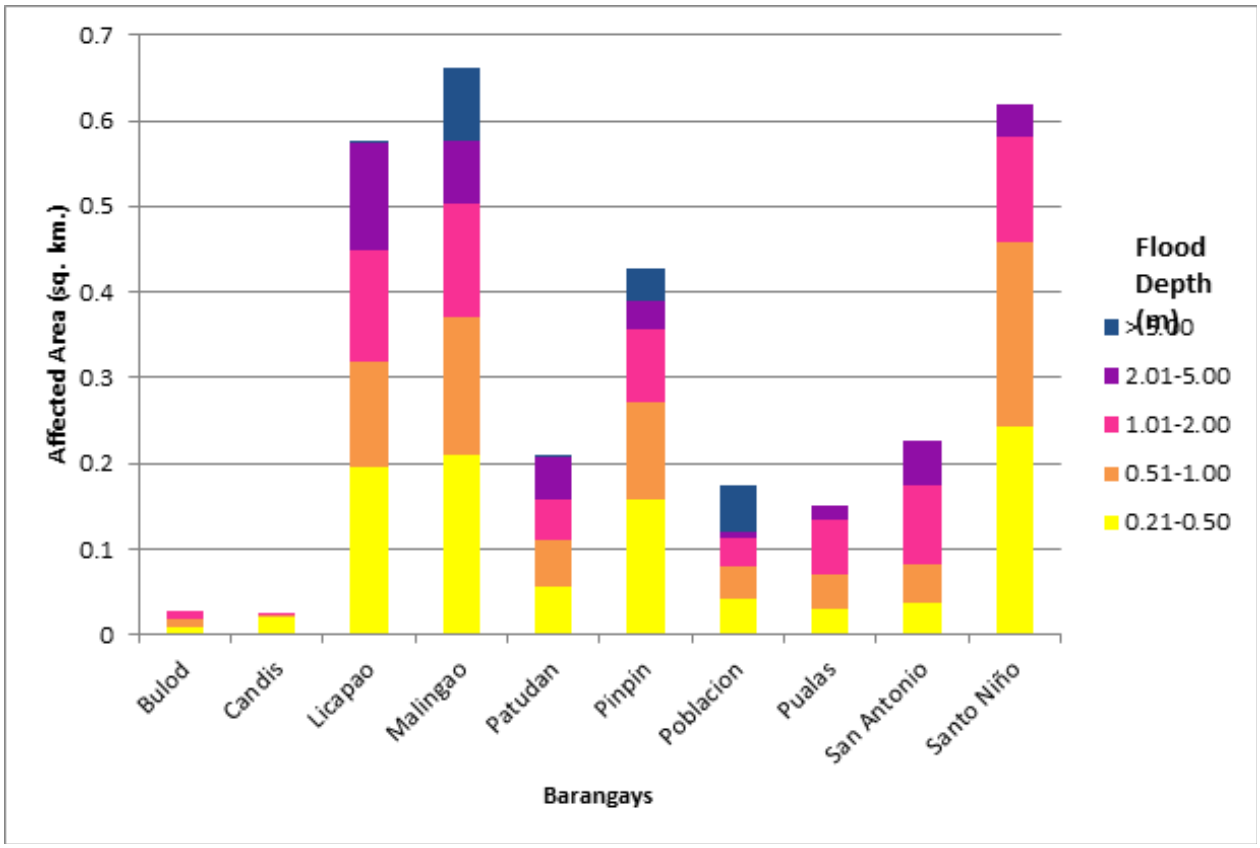


Figure 98. Affected areas in Tubod, Lanao del Norte during 100-year rainfall return period

Among the barangays in the municipality of Aurora, only Anonang is projected to have the percentage of area that will experience flood levels at 3.03%.

Among the barangays in the municipality of Baroy, Riverside is projected to have the highest percentage of area that will experience flood levels at 9.38%. Meanwhile, Tinubdan posted the second highest percentage of area that may be affected by flood depths at 8.21%.

Among the barangays in the Municipality of Kapatagan, Lapinig is projected to have the highest percentage of area that will experience flood levels at 4.05%. Meanwhile, Bagong Silang posted the second highest percentage of area that may be affected by flood depths at 3.36%.

Among the barangays in the municipality of Lala, Darumawang Ilaya is projected to have the highest percentage of area that will experience flood levels at 8.11%. Meanwhile, Santa Cruz Upper posted the second highest percentage of area that may be affected by flood depths at 7.43%.

Among the barangays in the municipality of Salvador, Camp III is projected to have the highest percentage of area that will experience flood levels at 7.64%. Meanwhile, Panaliwad-On posted the second highest percentage of area that may be affected by flood depths at 4.48%.

Among the barangays in the municipality of Sapad, Mapurog is projected to have the highest percentage of area that will experience flood levels at 2.79%. Meanwhile, Mabugnao posted the second highest percentage of area that may be affected by flood depths at 1.40%.

Among the barangays in the municipality of Tubod, Malingao is projected to have the highest percentage of area that will experience flood levels at 2.71%. Meanwhile, Licapao posted the second highest percentage of area that may be affected by flood depths at 2.68%.

Moreover, the generated flood hazard maps for the Balili Floodplain were used to assess the vulnerability of the educational and medical institutions in the floodplain. Using the flood depth units of PAGASA for hazard maps—"low", "medium", and "high"—the affected institutions were given their individual assessment for each flood hazard scenario (5 yr, 25 yr, and 100 yr).

Table 58. Area covered by each warning level with respect to the rainfall scenario

Warning Level	Area Covered in sq. km.		
	5 year	25 year	100 year
Low	41.80	45.72	40.45
Medium	29.72	67.10	76.74
High	7.25	17.83	33.95

Of the 393 identified education institutions in Balili Floodplain, 66 schools were assessed to be exposed to low-level flooding during a 5-year scenario while 61 schools were assessed to be exposed to medium-level flooding and 1 school was assessed to be exposed to high-level flooding in the same scenario. In the 25-year scenario, 86 schools were assessed to be exposed to low-level flooding while 108 schools were assessed to be exposed to medium-level flooding and 7 schools were assessed to be exposed to high-level flooding in the same scenario. For the 100-year scenario, 65 schools were assessed for low-level flooding and 118 schools for medium-level flooding. In the same scenario, 28 schools were assessed to be exposed to high-level flooding. See ANNEX 12 for a detailed enumeration of schools inside Balili Floodplain.

Of the 72 identified medical institutions in Balili Floodplain, 14 were assessed to be exposed to low-level flooding during a 5-year scenario while 10 were assessed to be exposed to medium-level flooding and 1 was assessed to be exposed to high-level flooding in the same scenario. In the 25-year scenario, 11 were assessed to be exposed to low-level flooding while 19 were assessed to be exposed to medium-level flooding and 2 were assessed to be exposed to high-level flooding. For the 100-year scenario, 16 schools were assessed for low-level flooding and 21 for medium-level flooding. In the same scenario, 4 were assessed to be exposed to high-level flooding. See ANNEX 13 for a detailed enumeration of medical institutions inside Balili Floodplain.

5.11 Flood Validation

In order to check and validate the extent of flooding in different river systems, there is a need to perform validation survey work. Field personnel 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 can be done through a local DRRM office to obtain maps or situation reports about the past flooding events or interview some residents with knowledge of or have had experienced flooding in a particular area.

After which, the actual data from the field 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 117 points randomly selected all over the Balili floodplain. It has an RMSE value of 1.51.

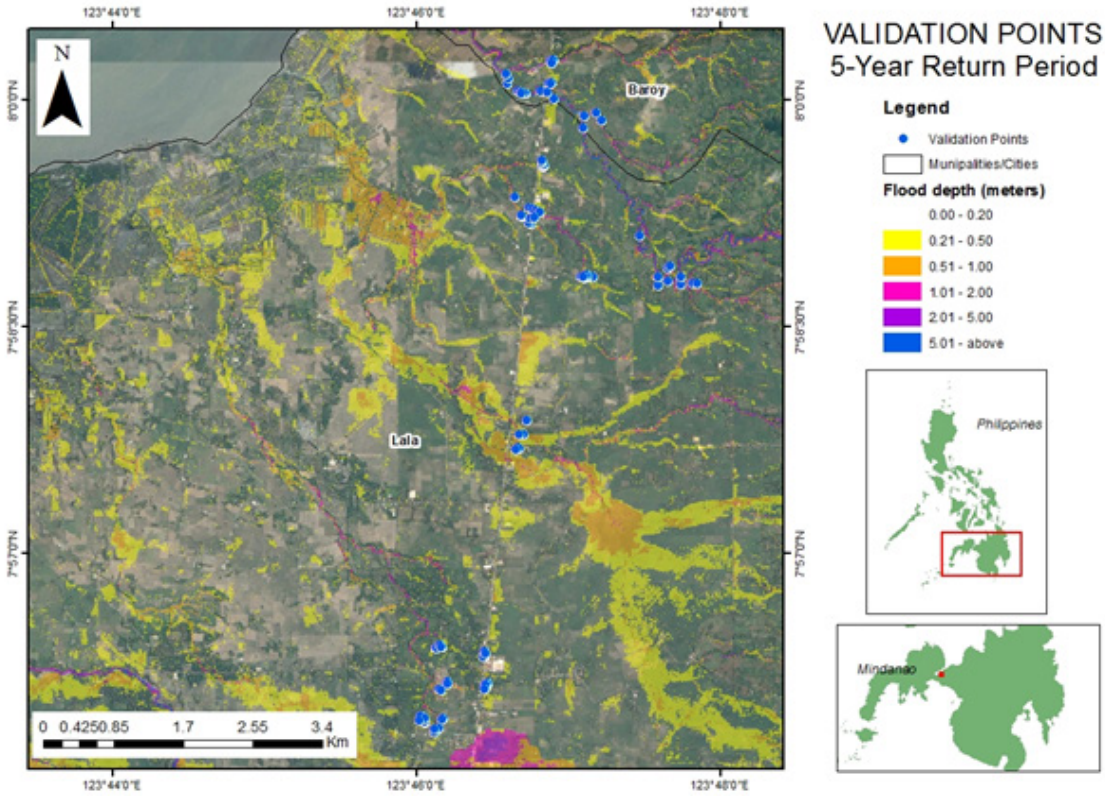


Figure 99. Validation points for 5-year Flood Depth Map of Balili Floodplain

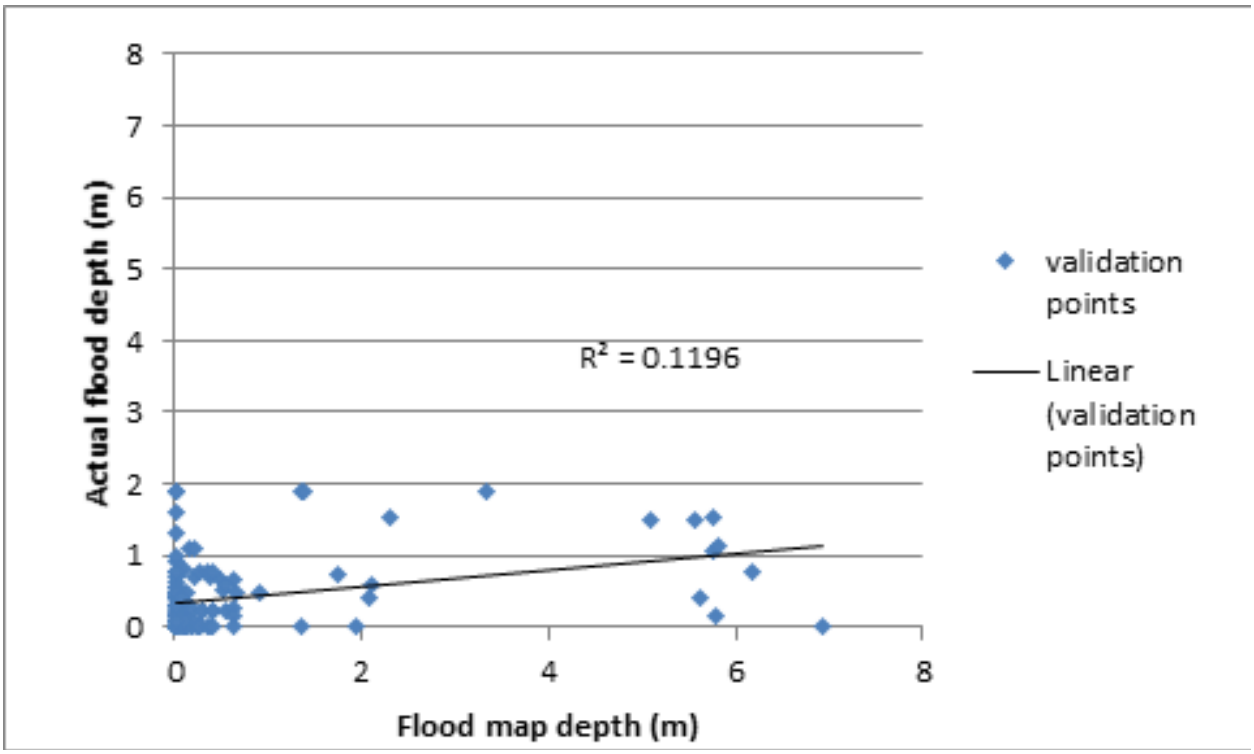


Figure 100. Flood map depth vs actual flood depth

Table 53. Actual flood vs simulated flood depth at differnent levels in the Balili River Basin.

BUTADON-BALILI 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	38	7	2	2	0	2	51
	0.21-0.50	20	4	4	0	1	1	30
	0.51-1.00	9	6	3	1	1	1	21
	1.01-2.00	6	0	0	2	2	5	15
	2.01-5.00	0	0	0	0	0	0	0
	> 5.00		0	0	0	0	0	0
Total		73	17	9	5	4	9	117

The overall accuracy generated by the flood model is estimated at 40.17%, with 47 points correctly matching the actual flood depths. In addition, there were 40 points estimated one level above and below the correct flood depths while there were 17 points and 13 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 29 points were overestimated while a total of 41 points were underestimated in the modelled flood depths of Balili.

Table 60. Summary of Accuracy Assessment in Balili

	No. of Points	%
Correct	47	40.17
Overestimated	29	24.79
Underestimated	41	35.04
Total	117	100

REFERENCES

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

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

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

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

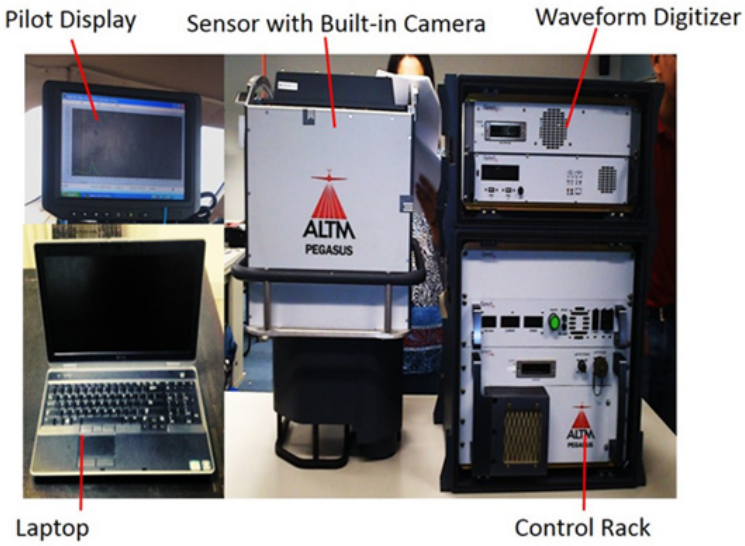
Sarmiento C., Paringit E.C., et al. 2014. DREAM Data Acquisition Component Manual. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

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

ANNEXES

ANNEX 1. Technical Specifications of the LIDAR Sensors used in the Balili Floodplain Survey

1. PEGASUS SENSOR



Parameter	Specification
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. D-8900 Aerial Digital Camera

Parameter	Specification
Camera Head	
Sensor type	60 Mpix full frame CCD, RGB
Sensor format (H x V)	8, 984 x 6, 732 pixels
Pixel size	6µm x 6 µm
Frame rate	1 frame/2 sec.
FMC	Electro-mechanical, driven by piezo technology (patented)
Shutter	Electro-mechanical iris mechanism 1/125 to 1/500++ sec. f-stops: 5.6, 8, 11, 16
Lenses	50 mm/70 mm/120 mm/210 mm
Filter	Color and near-infrared removable filters
Dimensions (H x W x D)	200 x 150 x 120 mm (70 mm lens)
Weight	~4.5 kg (70 mm lens)
Controller Unit	
Computer	Mini-ITX RoHS-compliant small-form-factor embedded
computers with AMD TurionTM 64 X2 CPU	5 MP interline camera (standard); 60 MP full frame (optional)
4 GB RAM, 4 GB flash disk local storage	12-bit Optech IWD-2 Intelligent Waveform Digitizer (optional)
IEEE 1394 Firewire interface	Sensor:250 x 430 x 320 mm; 30 kg;
Removable storage unit	~500 GB solid state drives, 8,000 images
Power consumption	~8 A, 168 W
Dimensions	2U full rack; 88 x 448 x 493 mm
Weight	~15 kg
Image Pre-Processing Software	
Capture One	Radiometric control and format conversion, TIFF or JPEG
Image output	8,984 x 6,732 pixels

ANNEX 2. NAMRIA Certification of Reference Points Used in the LIDAR Survey

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

October 30, 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: **ZAMBOANGA DEL NORTE**
Station Name: **ZGN-138**
Order: **2nd**

Island: **MINDANAO**
Municipality: **KATIPUNAN**
Barangay:
MSL Elevation:

PRS92 Coordinates

Latitude: **8° 30' 40.65974"** Longitude: **123° 18' 14.44217"** Ellipsoidal Hgt: **6.71500 m.**

WGS84 Coordinates

Latitude: **8° 30' 36.94779"** Longitude: **123° 18' 19.85548"** Ellipsoidal Hgt: **70.92500 m.**

PTM / PRS92 Coordinates

Northing: **941106.14 m.** Easting: **533471.036 m.** Zone: **4**

UTM / PRS92 Coordinates

Northing: **940,776.74** Easting: **533,459.32** Zone: **51**

Location Description

The station is marked by an 4" copper nail with its head flushed at the center of an cement putty on a concrete open canal with inscription " ZGN-138, 2009 NAMRIA".Located at brgy. Taga katipunan zamboanga del norte. The monument is situated inside taga central school 10 meters from the main gate going north west 6 meters from the flag pole going south east.

Requesting Party: **PHIL-LIDAR I**
Purpose: **Reference**
OR Number: **8075910 I**
T.N.: **2014-2584**

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

9910302014134012

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

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

July 11, 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: **ZAMBOANGA DEL SUR**
Station Name: **ZGS-88**
Order: **2nd**

Island: **MINDANAO**
Municipality: **AURORA**
Barangay: **SAN JOSE**
MSL Elevation:

PRS92 Coordinates

Latitude: **7° 57' 13.25316"** Longitude: **123° 34' 56.50093"** Ellipsoidal Hgt: **258.34500 m.**

WGS84 Coordinates

Latitude: **7° 57' 9.71271"** Longitude: **123° 35' 1.96243"** Ellipsoidal Hgt: **324.37300 m.**

PTM / PRS92 Coordinates

Northing: **879474.685 m.** Easting: **564207.26 m.** Zone: **4**

UTM / PRS92 Coordinates

Northing: **879,166.85** Easting: **564,184.79** Zone: **51**

Location Description

ZGS-88
Is located on the S end of the W wedge-shaped island in Purok Saray, Brgy. San Jose, Aurora. It is about 500 m. N of the municipal hall, 30 m. W of the Seaoil Gasoline Station and 5 m. E of the W side of the road. Mark is the head of a 3 in. copper nail embedded and centered on a 27 cm. x 26 cm. x cement putty, with inscriptions "ZGS-88 2005 NAMRIA LEP IX".

Requesting Party: **UP TCAGP / Engr. Christopher Cruz**
Pupose: **Reference**
OR Number: **8796507 A**
T.N.: **2014-1601**

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

9907112014150154

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

February 10, 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: **ZAMBOANGA DEL SUR**
Station Name: **ZGS-16**
Order: **2nd**
Island: **MINDANAO**
Municipality: **TUKURAN**
Barangay: **BACLAY**
MSL Elevation:

PRS92 Coordinates

Latitude:	**7° 52' 32.53106"**	Longitude:	**123° 36' 23.39905"**	Ellipsoidal Hgt:	**18.17800 m.**

WGS84 Coordinates

Latitude:	**7° 52' 29.01321"**	Longitude:	**123° 36' 28.86762"**	Ellipsoidal Hgt:	**84.42000 m.**

PTM / PRS92 Coordinates

Northing:	**870854.959 m.**	Easting:	**566881.259 m.**	Zone:	**4**

UTM / PRS92 Coordinates

Northing:	**870,550.15**	Easting:	**566,857.85**	Zone:	**51**

Location Description

ZGS-16
Is located at Purok Nangka, Brgy. Baclay. It is situated 1 m. NE of Km. Post # 1644 and about 50 m. SW of the chapel, approx. 3 km. from the road junction leading to Aurora town. Mark is the head of a 3 in. concrete nail embedded and centered on a 30 cm. x 30 cm. x 58 cm. concrete monument, with inscriptions "ZGS-16 2005 NAMRIA/LEP-IX".

Requesting Party: **UP DREAM**
Purpose: **Reference**
OR Number: **8089774 I**
T.N.: **2016-0334**

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

9902102014122213

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

February 10, 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: **ZAMBOANGA DEL SUR**
Station Name: **ZGS-17**
Order: **2nd**
Island: **MINDANAO**
Barangay: **BACLAY**
Municipality: **TUKURAN**
MSL Elevation:

PRS92 Coordinates

Latitude:	**7° 52' 42.71658"**	Longitude:	**123° 36' 29.22049"**	Ellipsoidal Hgt:	**29.68400 m.**

WGS84 Coordinates

Latitude:	**7° 52' 39.19813"**	Longitude:	**123° 36' 34.68878"**	Ellipsoidal Hgt:	**95.92400 m.**

PTM / PRS92 Coordinates

Northing:	**871168.108 m.**	Easting:	**567059.131 m.**	Zone:	**4**

UTM / PRS92 Coordinates

Northing:	**870,863.18**	Easting:	**567,035.66**	Zone:	**51**

Location Description

ZGS-17
Is located at Purok Kasoy, Brgy. Baclay, Tukuran. It is situated on the slope of a cultivated hill. It is about 100 m. NW of UCCP chapel and about 200 m. NNE of the roman catholic chapel. Mark is the head of a 4 in. copper nail embedded and centered on a 30 cm. x 30 cm. x 38 cm., with inscriptions "ZGS-17 2005 NAMRIA/LEP-IX".

Requesting Party: **UP DREAM**
Purpose: **Reference**
OR Number: **8089774 I**
T.N.: **2016-0333**

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

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

December 01, 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: **MISAMIS OCCIDENTAL**
Station Name: **MSW-5**
Order: **2nd**
Island: **MINDANAO** Barangay: **POBLACION**
Municipality: **SAPANG DALAGA** MSL Elevation:

PRS92 Coordinates

Latitude:	8° 32' 35.68185"	Longitude:	123° 33' 56.01853"	Ellipsoidal Hgt:	113.48100 m.

WGS84 Coordinates

Latitude:	8° 32' 31.98501"	Longitude:	123° 34' 1.42685"	Ellipsoidal Hgt:	178.27400 m.

PTM / PRS92 Coordinates

Northing:	944671.948 m.	Easting:	562262.537 m.	Zone:	4

UTM / PRS92 Coordinates

Northing:	944,341.30	Easting:	562,240.75	Zone:	51

Location Description

MSW-5
From Dipolog City, travel along the Nat'l. Highway going to Calamba until reaching Sapang Dalaga Proper. Station is located inside Sapang Dalaga Mun. Hall compound, beside the fence near the basketball court. It is about 50 m. from the DAR office and 100 m. from the mun. hall. Mark is the head of a 4 in. copper nail embedded on a 30 cm. x 30 cm. concrete block, with inscriptions "MSW-5 2007 NAMRIA".

Requesting Party: **PHIL-LIDAR 1**
Purpose: **Reference**
OR Number: **FREE ISSUE**
T.N.: **2016-2168**

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

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

October 30, 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: **ZAMBOANGA DEL NORTE**
Station Name: **ZN-53**

Island: **Mindanao**	Municipality: **KATIPUNAN**	Barangay: **DAANGLUNGSOD**
Elevation: **10.0561 +/- 0.00 m.**	Order: **1st Order**	Datum: **Mean Sea Level**
Latitude:	Longitude:	

Location Description

ZN-53
Along Dipolog Liloy National Road. The station is located at the compound of Taga Central School, near the flagpole and about 50 meters northwest of the centerline of the road. Mark is the head of a 4" copper nail set on a dsrilled hole and cemented flushed on top of 15cm x 15cm cement putty with inscription " ZN-53 2008 NAMRIA".

Requesting Party: **PHIL-LIDAR I**
Purpose: **Reference**
OR Number: **8075910 I**
T.N.: **2014-2589**

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

9910302014134448

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

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

June 24, 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: **LANAO DEL NORTE**
Station Name: **LAN-2**
Order: **1st**

Island: **MINDANAO**
Municipality: **LALA**
Barangay: **PINOYAK**

PRS92 Coordinates

Latitude:	**7° 54' 46.07859"**	Longitude:	**123° 46' 0.85333"**	Ellipsoidal Hgt:	**17.35400 m.**

WGS84 Coordinates

Latitude:	**7° 54' 42.56546"**	Longitude:	**123° 46' 6.31720"**	Ellipsoidal Hgt:	**83.92120 m.**

PTM Coordinates

Northing:	**875110.149 m.**	Easting:	**364025.74 m.**	Zone:	**5**

UTM Coordinates

Northing:	**874,680.35**	Easting:	**584,533.45**	Zone:	**51**

Location Description

LAN-2
From Iligan City, travel southwest along the National highway for 74.5 kilometers to the municipality of Lala. Travel farther along the national highway for 1.4 kilometers up to Maranding junction. Thence from the junction travel southeast along the national highway for another 1.3 kilometers to a dirt road going to Pinoyak barangay proper. Turn right on the dirt road and national highway intersection and continue travelling westward for 400 meters up to the irrigation canal. Station is located on top of the concrete irrigation canal water gate. Station mark is 0.15 m x 0.01 m in diameter brass rod, with cross cut on top, set in a drill hole on top of the concrete irrigation canal water gate; centered in cement patty and inscribed on top with the station name. All reference marks are 0.15 m x 0.01 m in diameter brass rod, with cross cut on top, set in drill holes on top of the concrete irrigation canal water gate; centered in cement patty and inscribed with the reference mark numbers and arrow pointing to the station.

Requesting Party: **Engr. Cruz**
Pupose: **Reference**
OR Number: **8796376 A**
T.N.: **2014-1441**

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

9906242014111658

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

December 09, 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: **ZAMBOANGA DEL NORTE**
Station Name: **ZN-123**

Island: **Mindanao**	Municipality: **SINDANGAN**	Barangay: **GOLEO**
Elevation: **13.1013 +/- 0.00 m.**	Order: **1st Order**	Datum: **Mean Sea Level**
Latitude:	Longitude:	

Location Description

BM ZN-123 is in the Province of Zamboanga Del Norte, Town of Sindangan, Brgy. Goleo, along the Dipolog-Sindangan National Road. The station is located west-northwest of Sindangan Bridge at KM. 1921 + 182 and about 4 meters northwest of the centerline of the road.

Mark is the head of a 4" copper nail set on a drilled hole and cemented flushed on the top of 15cm x 15cm cement putty with inscription "BM ZN-123,2009,NAMRIA".

Requesting Party: **Christopher Cruz**
Purpose: **Reference**
OR Number: **8077396 I**
T.N.: **2014-2985**

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

9912092014105708

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

CIP/4701/12/09/814

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

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

1. ZN-53

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
zgn 138 — zn 53 am (B1)	zgn 138	zn 53 am	Fixed	0.001	0.002	344°25'59"	12.263	0.357
zgn 138 — zn 53 pm (B2)	zgn 138	zn 53 pm	Fixed	0.003	0.004	344°25'44"	12.270	0.372

Acceptance Summary

Processed	Passed	Flag	Fail
2	2	0	0

Vector Components (Mark to Mark)

From:	zgn 138				
Grid		Local		Global	
Easting	533459.321 m	Latitude	N8°30'40.65974"	Latitude	N8°30'36.94779"
Northing	940776.736 m	Longitude	E123°18'14.44217"	Longitude	E123°18'19.85548"
Elevation	5.484 m	Height	6.715 m	Height	70.925 m

To:	zn 53 am				
Grid		Local		Global	
Easting	533456.022 m	Latitude	N8°30'41.04428"	Latitude	N8°30'37.33230"
Northing	940788.542 m	Longitude	E123°18'14.33457"	Longitude	E123°18'19.74787"
Elevation	5.842 m	Height	7.072 m	Height	71.282 m

Vector					
ΔEasting	-3.299 m	NS Fwd Azimuth	344°25'59"	ΔX	3.517 m
ΔNorthing	11.806 m	Ellipsoid Dist.	12.263 m	ΔY	0.641 m
ΔElevation	0.358 m	ΔHeight	0.357 m	ΔZ	11.736 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'09"	σ ΔX	0.001 m
σ ΔNorthing	0.000 m	σ Ellipsoid Dist.	0.000 m	σ ΔY	0.001 m
σ ΔElevation	0.001 m	σ ΔHeight	0.001 m	σ ΔZ	0.000 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000005629		
Y	-0.0000004033	0.0000010310	
Z	-0.0000000776	0.0000001462	0.0000001693

2. LE-50

Project Information		Coordinate System	
Name:		Name:	UTM
Size:		Datum:	WGS 1984
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	Occupation Start Time	Occupation Stop Time	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	ΔX (Meter)	ΔY (Meter)	ΔZ (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	Δ Height (Meter)	Processing Start Time	Processing Stop Time	Satellite Available
LE50 --- LAN2 (B1)	LAN2	LE50	6/20/2014 10:05:34 AM	6/20/2014 2:59:59 PM	Fixed	0.012	0.024	-15846.890	-15348.670	27636.104	37°51'51"	35361.439	-10.469	6/20/2014 10:05:34 AM	6/20/2014 2:59:59 PM	GPS: 15 GLONASS: 13 Galileo: 0 QZSS: 0

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

Vector Components (Mark to Mark)

From:	LAN2				
Grid		Local		Global	
Easting	584699.973 m	Latitude	N7°54'42.56546"	Latitude	N7°54'42.56546"
Northing	874628.035 m	Longitude	E123°46'06.31720"	Longitude	E123°46'06.31720"
Elevation	15.242 m	Height	83.921 m	Height	83.921 m

To:	LE50				
Grid		Local		Global	
Easting	606345.902 m	Latitude	N8°09'51.11024"	Latitude	N8°09'51.11024"
Northing	902577.426 m	Longitude	E123°57'55.36634"	Longitude	E123°57'55.36634"
Elevation	4.394 m	Height	73.452 m	Height	73.452 m

Vector					
ΔEasting	21645.929 m	NS Fwd Azimuth	37°51'51"	ΔX	-15847.070 m
ΔNorthing	27949.392 m	Ellipsoid Dist.	35361.439 m	ΔY	-15348.392 m
ΔElevation	-10.847 m	ΔHeight	-10.469 m	ΔZ	27636.144 m

3. LE-76

Vector Components (Mark to Mark)

From:	LE-50				
Grid		Local		Global	
Easting	606180.417 m	Latitude	N8°09'54.67217"	Latitude	N8°09'51.11024"
Northing	902629.434 m	Longitude	E123°57'49.92699"	Longitude	E123°57'55.36634"
Elevation	4.394 m	Height	6.900 m	Height	73.452 m

To:	LE-76				
Grid		Local		Global	
Easting	588530.790 m	Latitude	N8°03'05.36825"	Latitude	N8°03'01.82183"
Northing	890021.013 m	Longitude	E123°48'12.37307"	Longitude	E123°48'17.82405"
Elevation	7.017 m	Height	9.335 m	Height	75.717 m

Vector					
ΔEasting	-17649.627 m	NS Fwd Azimuth	234°35'42"	ΔX	13688.683 m
ΔNorthing	-12608.421 m	Ellipsoid Dist.	21696.715 m	ΔY	11332.042 m
ΔElevation	2.623 m	ΔHeight	2.435 m	ΔZ	-12447.993 m

Standard Errors

Vector errors:					
σ ΔEasting	0.021 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.024 m
σ ΔNorthing	0.006 m	σ Ellipsoid Dist.	0.015 m	σ ΔY	0.034 m
σ ΔElevation	0.036 m	σ ΔHeight	0.036 m	σ ΔZ	0.009 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0005606089		
Y	-0.0003223999	0.0011623638	
Z	-0.0000556148	0.0002703935	0.0000791896

4. ZS-198

Vector Components (Mark to Mark)

From:	ZGS-1				
Grid		Local		Global	
Easting	553699.482 m	Latitude	N8°04'26.98335"	Latitude	N8°04'23.40249"
Northing	892472.300 m	Longitude	E123°29'14.53868"	Longitude	E123°29'19.99013"
Elevation	20.051 m	Height	22.611 m	Height	88.163 m

To:	ZS-188A				
Grid		Local		Global	
Easting	553627.634 m	Latitude	N8°03'56.69408"	Latitude	N8°03'53.11537"
Northing	891542.089 m	Longitude	E123°29'12.15500"	Longitude	E123°29'17.60722"
Elevation	17.277 m	Height	19.832 m	Height	85.400 m

Vector					
ΔEasting	-71.848 m	NS Fwd Azimuth	184°29'06"	ΔX	-9.705 m
ΔNorthing	-930.211 m	Ellipsoid Dist.	933.322 m	ΔY	146.900 m
ΔElevation	-2.773 m	ΔHeight	-2.778 m	ΔZ	-921.644 m

Standard Errors

Vector errors:					
σ ΔEasting	0.004 m	σ NS fwd Azimuth	0°00'01"	σ ΔX	0.001 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.005 m
σ ΔElevation	0.004 m	σ ΔHeight	0.004 m	σ ΔZ	0.001 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000013603		
Y	0.0000026352	0.0000296273	
Z	0.0000004069	0.0000057486	0.0000013978

ANNEX 4. 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 SARMIENTO	UP-TCAGP
Survey Supervisor	Data Component Project Leader – I	ENGR. LOUIE P. BALICANTA	UP-TCAGP
	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP-TCAGP
		LOVELY GRACIA ACUÑA	UP-TCAGP
	Supervising Science Research Specialist (Supervising SRS)	LOVELYN ASUNCION	UP-TCAGP

FIELD TEAM

LiDAR Operation	Senior Science Research Specialist (SSRS)	ENGR. GEROME HIPOLITO	UP-TCAGP
		PAULINE JOANNE ARCEO	UP-TCAGP
	Research Associate (RA)	MA. VERLINA TONGA	UP-TCAGP
		JONALYN GONZALES	UP-TCAGP
		ENGR. RENAN PUNTO	UP-TCAGP
		ENGR. IRO NIEL ROXAS	UP-TCAGP
		JERIEL PAUL ALAMBAN, GEOL.	UP-TCAGP
		ENGR. KENNETH QUISADO	UP-TCAGP
		ENGR. GRACE SINADJAN	UP-TCAGP
		JONATHAN ALMALVEZ	UP-TCAGP
		ENG. GEF SORIANO	UP-TCAGP
		FRANK NICOLAS ILEJAY	UP-TCAGP
Ground Survey, Data Download and Transfer	Research Associate (RA)	JASMIN DOMINGO	UP-TCAGP
		MERLIN FERNANDO	UP-TCAGP
LiDAR Operation	Airborne Security	SSG. JAYCO MANZANO	PHILIPPINE AIR FORCE (PAF)
		SSG. GERONIMO BALICOW III	PAF
		SSG. LEEJAY PUNZALAN	PAF
	Pilot	CAPT. BRYAN DONGUINES	ASIAN AEROSPACE CORPORATION (AAC)
		CAPT. SHERWIN CESAR ALFONSO	AAC
		CAPT. ERNESTO SAYSAY JR.	AAC
		CAPT. ANTON DAYO	AAC

ANNEX 5. Data Transfer Sheet for Balili Floodplain

DATA TRANSFER SHEET
06/10/2014(Northern Mindanao) ongoing

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	
5/22/2014	1497P	1BLK67B142A	PEGASUS	1.8	1342	8.61	201	31.8	221	19.1	NA	5.19	1KB	1KB	49	NA	Z:\Airborne_Raw\1497P
5/23/2014	1501P	1BLK67C143A	PEGASUS	3	1221	14.1	271	77.3	539	29.5	NA	7.61	1KB	1KB	59/56	NA	Z:\Airborne_Raw\1501P
5/24/2014	1505P	1BLK67BC144A	PEGASUS	2.25	759	10	212	46.7	340	21.8	NA	7.68	1KB	1KB	97	NA	Z:\Airborne_Raw\1505P
5/25/2014	1509P	1RDXE145A	PEGASUS	2.4	338	11.2	254	NA 31.6 22	31.6/22 NA	26.2	NA	4.96	1KB	1KB	50/43	NA	Z:\Airborne_Raw\1509P
5/27/2014	1517P	1RXE147A	PEGASUS	2.74	1497	12	235	NA	NA	27.7	NA	9.7	1KB	1KB	78/72	NA	Z:\Airborne_Raw\1517P
5/28/2014	1521P	1RXC148A	PEGASUS	2.39	490	12	252	NA	NA	28	NA	5.54	1KB	1KB	52	NA	Z:\Airborne_Raw\1521P

Received from
Name C. SOLAMILLO
Position PA
Signature

Received by
Name JOIDA PRIETO
Position SSS
Signature 6/10/2014

DATA TRANSFER SHEET
06/20/2014(Northern Mindanao)

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	
29-May-14	1525P	1RXB149A	PEGASUS	1.6	457	9.27	265	na	na	26.5	NA	9.83	1KB	1KB	40	NA	Z:\Airborne_Raw\1525P
31-May-14	1533P	1BLK67151A	PEGASUS	3.32	270	14.4	224	43.2	428	33.3	NA	8.87	1KB	1KB	47/38	NA	Z:\Airborne_Raw\1533P
2-Jun-14	1541P	1BLK71B153A	PEGASUS	4	242	0	285	19.7	139	39	674MB	12.6	1KB	1KB	47/45/40/34	NA	Z:\Airborne_Raw\1541P
3-Jun-14	1545P	1BLK71C154A	PEGASUS	4.13	2259	13	253	69.7	533	40.1	272MB	9.95	1KB	1KB	141	NA	Z:\Airborne_Raw\1545P
4-Jun-14	1549P	1BLK71D155A	PEGASUS	3.48	150	14.3	264	NA	NA	34.6	NA	11.2	1KB	1KB	54/50/45	NA	Z:\Airborne_Raw\1549P
7-Jun-14	1561P	1RXE158A	PEGASUS	NA	44	NA	187	NA	NA	22	NA	8.1	1KB	1KB	71	NA	Z:\Airborne_Raw\1561P
8-Jun-14	1565P	1BLK71B159A	PEGASUS	NA	16	5.35	168	22.1	163	13.3	NA	7.75	1KB	1KB	36	NA	Z:\Airborne_Raw\1565P

Received from
Name C. SOLAMILLO
Position PA
Signature

Received by
Name JOIDA F. PRIETO
Position SSS
Signature 6/23/2014

DATA TRANSFER SHEET
08/05/2014(Northern Mindanao - ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	SHP	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	
7/3/2014	1665P	1BLK71ES184A	Pegasus	606	93	4.69	94.5	169	NA	NA	6.77	NA	6.94	1KB	1KB	35	NA	Z:\Airborne_Raw
7/5/2014	1673P	1BLK71ES186A	Pegasus	1.05	379	7.58	335	190	22.4	167	12.5	27.8	5.09	1KB	1KB	92/84	NA	Z:\Airborne_Raw
7/6/2014	1677P	1BLK71S187A	Pegasus	695	68	5.33	188	141	11.2	86	7.79	NA	4.94	1KB	1KB	130	NA	Z:\Airborne_Raw
7/8/2014	1685P	1BLK71S189A	Pegasus	2.31	515	11	578	242	37	288	22.4	47.4	4.39	1KB	1KB	184	NA	Z:\Airborne_Raw
7/8/2014	1687P	1BLK71S189B	Pegasus	749	79	4.81	176	136	NA	NA	7.47	NA	4.39	1KB	1KB	NA	NA	Z:\Airborne_Raw
7/9/2014	1689P	1BLK71S190A	Pegasus	2.56	156	12.6	740	257	NA	NA	27.1	NA	3.68	1KB	1KB	196/207	NA	Z:\Airborne_Raw
7/10/2014	1693P	1RXES191A	Pegasus	1.78	551	8.11	448	175	NA	NA	16.9	NA	4.08	1KB	1KB	53	NA	Z:\Airborne_Raw

Received from

Name TIN ANDAYA
Position RA
Signature

Received by

Name JOIDA F. PRIETO
Position SSRS
Signature 8/6/14

DATA TRANSFER SHEET
07/28/2014(Northern Mindanao - ready)

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	
6/8/2014	1565P	1BLK71B159A	Pegasus	NA	16	6.93	168	NA	NA	13.3	NA	7.75	1KB	1KB	36	NA	Z:\Airborne_Raw
6/9/2014	1569P	1BLKRXE160A	Pegasus	4.16	832	16.5	290	8.86	62	38.5	NA	10	1KB	1KB	85	NA	Z:\Airborne_Raw
6/16/2014	1597P	1BLKRXE167A	Pegasus	2.18	332	10.5	237	NA	NA	21.3	NA	7.52	1KB	1KB	68	NA	Z:\Airborne_Raw
6/19/2014	1609P	1RXS170A	Pegasus	2.16	526	11.2	259	45.3	309	22.1	NA	7.07	1KB	1KB	77/76	NA	Z:\Airborne_Raw
6/20/2014	1613P	1BLK71G171A	Pegasus	3.44	177	13.7	258	67.3	437	33.2	NA	5.92	1KB	1KB	46	NA	Z:\Airborne_Raw
6/23/2014	1625P	1BLK67BC174A	Pegasus	3.09	1112	11.7	212	60.3	415	29.4	86.6	4.97	1KB	1KB	52/56	NA	Z:\Airborne_Raw
6/24/2014	1629P	1BLKRXES175A	Pegasus	2.79	370	10.7	187	36.3	268	26.1	NA	4.45	1KB	1KB	73	NA	Z:\Airborne_Raw
6/27/2014	1641P	1BLK68A178A	Pegasus	2.94	1995	12.6	268	57.4	398	28.9	57.2	7.7	1KB	1KB	65/65/60/58	NA	Z:\Airborne_Raw
6/27/2014	1643P	1BLK67ABS178S	Pegasus	532	95	4.33	119	NA	NA	5.65	NA	7.7	1KB	1KB	48	NA	Z:\Airborne_Raw
6/28/2014	1645P	1BLK71C179A	Pegasus	2.84	NA	11.4	242	51.8	375	27.4	NA	6.25	1KB	1KB	59/68	NA	Z:\Airborne_Raw

Received from

Name TIN ANDAYA
Position RA
Signature

Received by

Name JOIDA PRIETO
Position SSRS
Signature 7/28/14

DATA TRANSFER SHEET

PAGADIAN 3/7/16

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	
02/20/2016	23116P	1BLK76NO051A	Pegasus	2.29 GB	NA	11.9 MB	294 MB	NA	NA	24.4 GB	0 B	63.8 MB	2KB	2KB	148/252/232	NA	Z:\DAC\RAW DATA
02/21/2016	23120P	1BLK69O052A	Pegasus	2.6 GB	NA	12 MB	298 MB	22.5 GB	NA	25.9 GB	0 B	59.6 MB	2KB	1KB	580/100/91/82	NA	Z:\DAC\RAW DATA
02/22/2016	23124P	1BLK89AB053A	Pegasus	1.89 GB	NA	11.4 MB	270 MB	NA	NA	21.1 GB	0 B	3.12 MB	1KB	NA	125/108/96/87/78/76	NA	Z:\DAC\RAW DATA
02/23/2016	23128P	1BLK70B054A	Pegasus	2.22 GB	NA	12.8 MB	273 MB	311 MB	NA	23.3	0 B	44.4 MB	1KB	NA	92/90/80/73	NA	Z:\DAC\RAW DATA
02/24/2016	23132P	1BLK73A055A	Pegasus	10.3 MB	NA	12.5 MB	266 MB	NA	NA	24.4 GB	0 B	49.7 MB	2KB	1KB	84/84/72/76/57	NA	Z:\DAC\RAW DATA
02/26/2016	23140P	1BLK73BS057A	Pegasus	2.47 GB	NA	13.5 MB	305 MB	NA	NA	26.5 GB	0 B	65.9 MB	2KB	1KB	85/83	NA	Z:\DAC\RAW DATA

Received from

Name R. PUNSTO

Position RA

Signature

Received by

Name AC BONGAT

Position SSP I

Signature 3/10/16

16-17

DATA TRANSFER SHEET

PAGADIAN 2/29/16

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	
2016-02-17	23104P	1BLK76DLM48A	Pegasus	1.81 GB	NA	10.09 MB	287.01 MB	25.87 GB	193.97 KB	18.3 GB	0 B	116.78 MB	133 B	1.08 KB	0 B	NA	Z:\DAC\RAW DATA\23104 P
2016-02-16	23100P	1BLK76G047A	Pegasus	2.83 GB	NA	12.33 MB	285.96 MB	38 GB	297.52 KB	27.31 GB	0 B	103.23 MB	132 B	341B	0 B	NA	Z:\DAC\RAW DATA\23100 P
2016-02-15	23096P	1BLK76NO46A	Pegasus	665.91 MB	NA	4.64 MB	164.2 MB	9.7 GB	82.64 KB	7.07 GB	0 B	90.32 MB	133 B	603 B	0 B	NA	Z:\DAC\RAW DATA\23096 P
2016-02-14	23092P	1BLK76IG045A	Pegasus	2.19 GB	NA	10.66 MB	203.46 MB	28.87 GB	230.75 KB	22.33 GB	0 B	110.72 MB	132 B	279 B	0 B	NA	Z:\DAC\RAW DATA\23092 P
2016-02-13	23088P	1BLK76IILM044A	Pegasus	2.48 GB	NA	11.64 MB	283.62 MB	35.45 GB	263.38 KB	24.65 GB	0 B	101.29 MB	133 B	889 B	0 B	NA	Z:\DAC\RAW DATA\23088 P
2016-02-12	23084P	1BLK76KJLM043A	Pegasus	3.01 GB	NA	13.36 MB	276.9 MB	44.56 GB	332.83 KB	29.36 GB	0 B	129.73 MB	133 B	362 B	0 B	NA	Z:\DAC\RAW DATA\23084 P

Received from

Name R. PUNTO

Position RA

Signature

Received by

Name AC Borgat

Position SSRS

Signature 3/1/16

16-16

DATA TRANSFER SHEET
DIPOLOG 12/8/2016

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
November 28, 2016	23590P	1BLK73DE F333A	PEGASUS	1.56	NA	7.69	203	32.6	296	16.6	NA	42.3	1KB	1KB	1.19	NA	Z:\DAC\RAW DATA
November 30, 2016	23598P	1BLK76A3 35A	PEGASUS	600	NA	6.93	239	NA	NA	7.85	NA	48.2	1KB	1KB	2.14	NA	Z:\DAC\RAW DATA
December 01, 2016	23602P	1BLK76AB 336A	PEGASUS	1.56	NA	9.08	287	NA	NA	16.5	NA	53.9	1KB	1KB	2.14	NA	Z:\DAC\RAW DATA

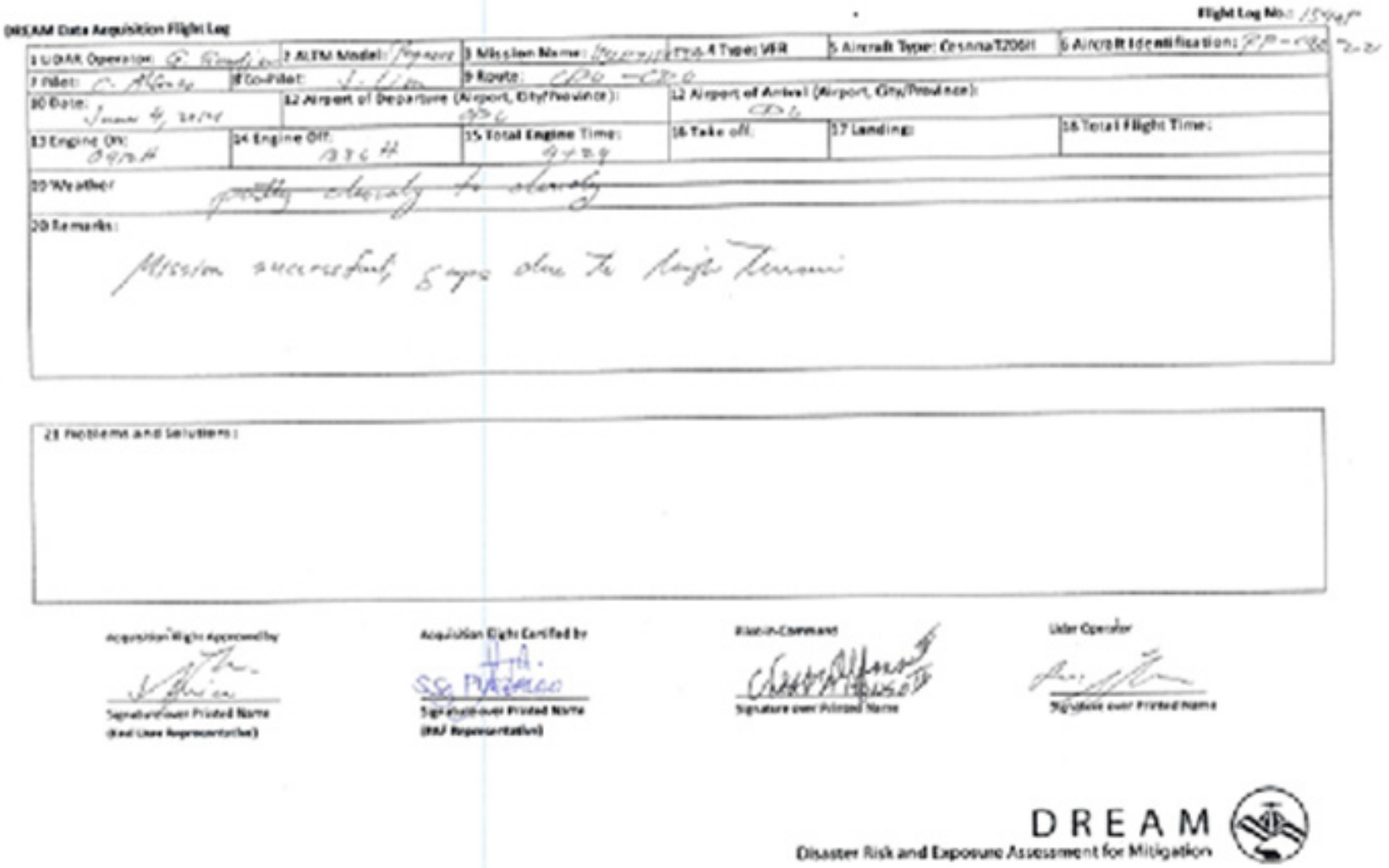
Received from

Name R. PUNTO
Position RA
Signature

Received by

Name MC Borgit
Position SSKS
Signature 12/8/16

ANNEX 6. Flight logs for the flight missions



DREAM Data Acquisition Flight Log

Flight Log No.: 15945

1 LiDAR Operator:	2 ALTM Model:	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification:
7 Pilot:	8 Co-Pilot:	9 Route:			
10 Date:	11 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine ON:	14 Engine Off:	15 Total Engine Time:	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather:					
20 Remarks:					

21 Problems and Solutions:

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

DREAM
Disaster Risk and Exposure Assessment for Mitigation

DREAM Data Acquisition Flight Log

Flight Log No.: 1525P

1 LiDAR Operator: G. Sinadjan	2 ALTM Model: Pegasus	3 Mission Name: [illegible]	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Lim	9 Route: CDO - CDO			
10 Date: June 8, 2014	12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO		
13 Engine On: 0804H	14 Engine Off: 1059H	15 Total Engine Time: 2+55	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: cloudy					

20 Remarks:

Data acquired but aborted mission due to heavy build up

21 Problems and Solutions:

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

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

Pilot-in-Command: Signature over Printed Name

Lidar Operator: Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

DREAM Data Acquisition Flight Log

Flight Log No.: 16

1 UDAS Operator: G. Sinfuego	2 ALTM Model: Pegasus	3 Mission Name: BALILI 02	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C8032
7 Pilot: C. Abuca	8 Co-Pilot: J. Lim	9 Route: CRO - CRO			
10 Date: June 22, 2014	11 Airport of Departure (Airport, City/Province): CRO	12 Airport of Arrival (Airport, City/Province): CRO			
13 Engine On: 10:04A	14 Engine Off: 1:16 PM	15 Total Engine Time: 3+12	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: cloudy					

20 Remarks:

Please manually move line out due to high tension

21 Problems and Solutions:

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

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log No.: 1689P

DREAM Data Acquisition Flight Log

1 LIDAR Operator: Rovic	2 ALTM Model: Peg	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9032
7 Pilot: C. Alfonso	8 Co-Pilot: J. Lim	9 Route: CBO			
10 Date: July 9, 2014	11 Airport of Departure (Airport, City/Province): CBO		12 Airport of Arrival (Airport, City/Province): CBO		
13 Engine On: 1135H	14 Engine Off: 1552H	15 Total Engine Time: 4+17	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Cloudy					

20 Remarks:

Mission successful at 1200m flying height

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
(Technical Representative)

Acquisition Flight Certified by

W. PLATILAN

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

Signature over Printed Name

Lidar Operator

Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log No.: 1693P

DREAM Data Acquisition Flight Log

1 LiDAR Operator: J. Alviar	2 ALTM Model: Peg	3 Mission Name: 1RXE190B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Ligas	9 Route: CDO			
10 Date: July 10, 2014	12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO		
13 Engine On: 0916H	14 Engine Off: 1227H	15 Total Engine Time: 3+11	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					

20 Remarks:

filled gaps in RXE; started at 1200m then 1400m over RXE ext.

21 Problems and Solutions:

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

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

Pilot-in-Command: C. Alfonso II — Signature over Printed Name

Lidar Operator: Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

DREAM Data Acquisition Flight Log

Flight Log No.: 1677

1 LiDAR Operator: G. Sinadjan	2 ALTM Model: Peg	3 Mission Name: BUK7151STA	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 Co-Pilot: J Lim	9 Route: CDO			
10 Date: July 6, 2014	12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO		
13 Engine On: 1021H	14 Engine Off: 1256H	15 Total Engine Time: 2+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	very cloudy				
20 Remarks: Heavy build up over all remaining survey areas; surveyed supplementary lines to BLK 71ext					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	W PANGALAN Signature over Printed Name (PAF Representative)	Cesar Alfonso III Signature over Printed Name	G. SINADJAN Signature over Printed Name

DREAM Data Acquisition Flight Log

Flight Log No.: 1677

1 LiDAR Operator: G Sinadjan	2 ALTM Model: Pcg	3 Mission Name: DUK7151BTA	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 Co-Pilot: J Lim	9 Route: CDO			
10 Date: July 6, 2017	12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO		
13 Engine On: 1021H	14 Engine Off: 1256H	15 Total Engine Time: 2+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	very cloudy				
20 Remarks: Heavy build up over all remaining survey areas; surveyed supplementary lines to BLK 71ext					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-In-Command	Lidar Operator
Signature over Printed Name (End User Representative)	W PANTALAN Signature over Printed Name (PAF Representative)	Cesar Alfonso III Signature over Printed Name	G. SINADJAN Signature over Printed Name

DREAM Data Acquisition Flight Log

Flight Log No.: 6857

1 LiDAR Operator: I. Roxas	2 ALTM Model: Peg	3 Mission Name: BLK71SB7A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RPC9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Lim	9 Route: CDO			
10 Date: July 8, 2014	12 Airport of Departure (Airport, City/Province): CDO		12 Airport of Arrival (Airport, City/Province): CDO		
13 Engine On: 0958H	14 Engine Off: 1403H	15 Total Engine Time: 4+5	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	cloudy				
20 Remarks: Surveyed BLK 71F at 1200m.					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
J. Alviar	W PUNZALAN	Cesar Alfonso III	I. Roxas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 2308AP

1 LiDAR Operator: I. Borras	2 ALTM Model: Peg	3 Mission Name: [redacted]	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9132
7 Pilot: C. Alfonso III	8 Co-Pilot: J. Jeciel	9 Route: Pagadian - Pagadian			
10 Date: 12 Feb 16	12 Airport of Departure (Airport, City/Province): Pagadian		12 Airport of Arrival (Airport, City/Province): Pagadian		
13 Engine On: 0715 H	14 Engine Off: 1132H	15 Total Engine Time: 4+17	16 Take off: 0730H	17 Landing: 1127 H	18 Total Flight Time: 4+07
19 Weather	Partly Cloudy				

20 Flight Classification

20.a Billable	20.b Non Billable	20.c Others
✓ Acquisition Flight	○ Aircraft Test Flight	○ LiDAR System Maintenance
○ Ferry Flight	○ AAC Admin Flight	○ Aircraft Maintenance
○ System Test Flight	○ Others: _____	○ Phil-LiDAR Admin Activities
○ Calibration Flight		

21 Remarks: Surveyed BLK 76 C, J, K and L.

22 Problems and Solutions

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LiDAR Operator	Aircraft Mechanic/ LiDAR Technician
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

PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 23088P

1 LiDAR Operator: J. Almolyez	2 ALTM Model: Pegasus	3 Mission Name: BLK76ILM0914A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9122
7 Pilot: C. Alfonso III	8 Co-Pilot: J. Secral	9 Route:			
10 Date: 13 Feb 16	12 Airport of Departure (Airport, City/Province): Pagadian		12 Airport of Arrival (Airport, City/Province): Pagadian		
13 Engine On: 0720 H	14 Engine Off: 1143H	15 Total Engine Time: 4+23	16 Take off: 0725H	17 Landing: 1135H	18 Total Flight Time: 4HS
19 Weather: Cloudy					

20 Flight Classification

20.a Billable	20.b Non Billable	20.c Others
☑ Acquisition Flight	○ Aircraft Test Flight	○ LiDAR System Maintenance
○ Ferry Flight	○ AAC Admin Flight	○ Aircraft Maintenance
○ System Test Flight	○ Others: _____	○ Phil-LiDAR Admin Activities
○ Calibration Flight		

21 Remarks: Surveyed BLK 76 I, L and M- With voids due to clouds.

22 Problems and Solutions

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LiDAR Operator	Aircraft Mechanic/ LiDAR Technician
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	N/A Signature over Printed Name

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 231 0QP

1 LiDAR Operator: J. Alma Ruz	2 ALTM Model: Pegasus	3 Mission Name: BLK76DKLM 04FEB16	Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification: PAL9122
7 Pilot: C. Alfonso III	8 Co-Pilot: J. Jocel	9 Route:			
10 Date: 17 Feb 16	12 Airport of Departure (Airport, City/Province): Pagadian	12 Airport of Arrival (Airport, City/Province): Pagadian			
13 Engine On: 0805 H	14 Engine Off: 1240H	15 Total Engine Time: 4+35	16 Take off: 0810H	17 Landing: 1235 H	18 Total Flight Time: 4+25
19 Weather: Partly Cloudy					

20 Flight Classification

20.a Billable	20.b Non Billable	20.c Others
✓ Acquisition Flight	○ Aircraft Test Flight	○ LiDAR System Maintenance
○ Ferry Flight	○ AAC Admin Flight	○ Aircraft Maintenance
○ System Test Flight	○ Others: _____	○ Phil-LiDAR Admin Activities
○ Calibration Flight		

21 Remarks: Surveyed voids over BLK 76 D, K, L and M

22 Problems and Solutions

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LiDAR Operator	Aircraft Mechanic/ LiDAR Technician
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
		C. Alfonso III		N/A

PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.:

1 LIDAR Operator: K. Quisado	2 ALTM Model: Pegasus	3 Mission Name:	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RPC9122
7 Pilot: C. Alfonso	8 Co-Pilot: J. Jecie	9 Route:			
10 Date: 2/23/2016	12 Airport of Departure (Airport, City/Province): Pagadian, Zamboanga del Sur		12 Airport of Arrival (Airport, City/Province): Pagadian, Zamboanga del Sur		
13 Engine On: 7:30	14 Engine Off: 11:47	15 Total Engine Time: 4:17	16 Take off: 7:35	17 Landing: 11:42	18 Total Flight Time: 4:07
19 Weather: Partly Cloudy					

20 Flight Classification

20.a Billable	20.b Non Billable	20.c Others
✓ Acquisition Flight	○ Aircraft Test Flight	○ LiDAR System Maintenance
○ Ferry Flight	○ AAC Admin Flight	○ Aircraft Maintenance
○ System Test Flight	○ Others: _____	○ Phil-LIDAR Admin Activities
○ Calibration Flight		

21 Remarks: Successful flight

22 Problems and Solutions

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-In-Command	LIDAR Operator	Aircraft Mechanic/ LIDAR Technician
Signature over Printed Name (End User Representative)	LEE JAY EL PUNGAYAN Signature over Printed Name (PAF Representative)	C. ALFONSO III Signature over Printed Name	Ian Quisado, Kenneth Quisado Signature over Printed Name	NA Signature over Printed Name

Phil-LIDAR 1 Data Acquisition Flight Log

Flight Log No.:

1 LIDAR Operator: RJ ARCEO	2 AI DH Model: PEGASUS	3 Mission Name:	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification: 9122
7 Pilot: A DAVID	8 Co-Pilot: E CAYSAY JR	9 Route:			
10 Date: 12/9/2016	12 Airport of Departure (Airport, City/Province): DIPOLOG	12 Airport of Arrival (Airport, City/Province): DIPOLOG			
13 Engine On: 0839H	14 Engine Off: 1314H	15 Total Engine Time: 4+35	16 Take off: 0844H	17 Landing: 1309H	18 Total Flight Time: 4+25
19 Weather CLOUDY					

20 Flight Classification

20.a Billable	20.b Non Billable	20.c Others
● Acquisition Flight	○ Aircraft Test Flight	○ LIDAR System Maintenance
○ Ferry Flight	○ AAC Admin Flight	○ Aircraft Maintenance
○ System Test Flight	○ Others:	○ Phil-LIDAR Admin Activities
○ Calibration Flight		

21 Remarks

COMPLETED BLK 76A AND BLK 71A OVER KUNAMPENG AND KABATAGAN.

22 Problems and Solutions

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LIDAR Operator	Aircraft Mechanic/ LIDAR Technician
RJ ARCEO	GERARDO ZALICOS JR	ANTON DAVID	RJ ARCEO	
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

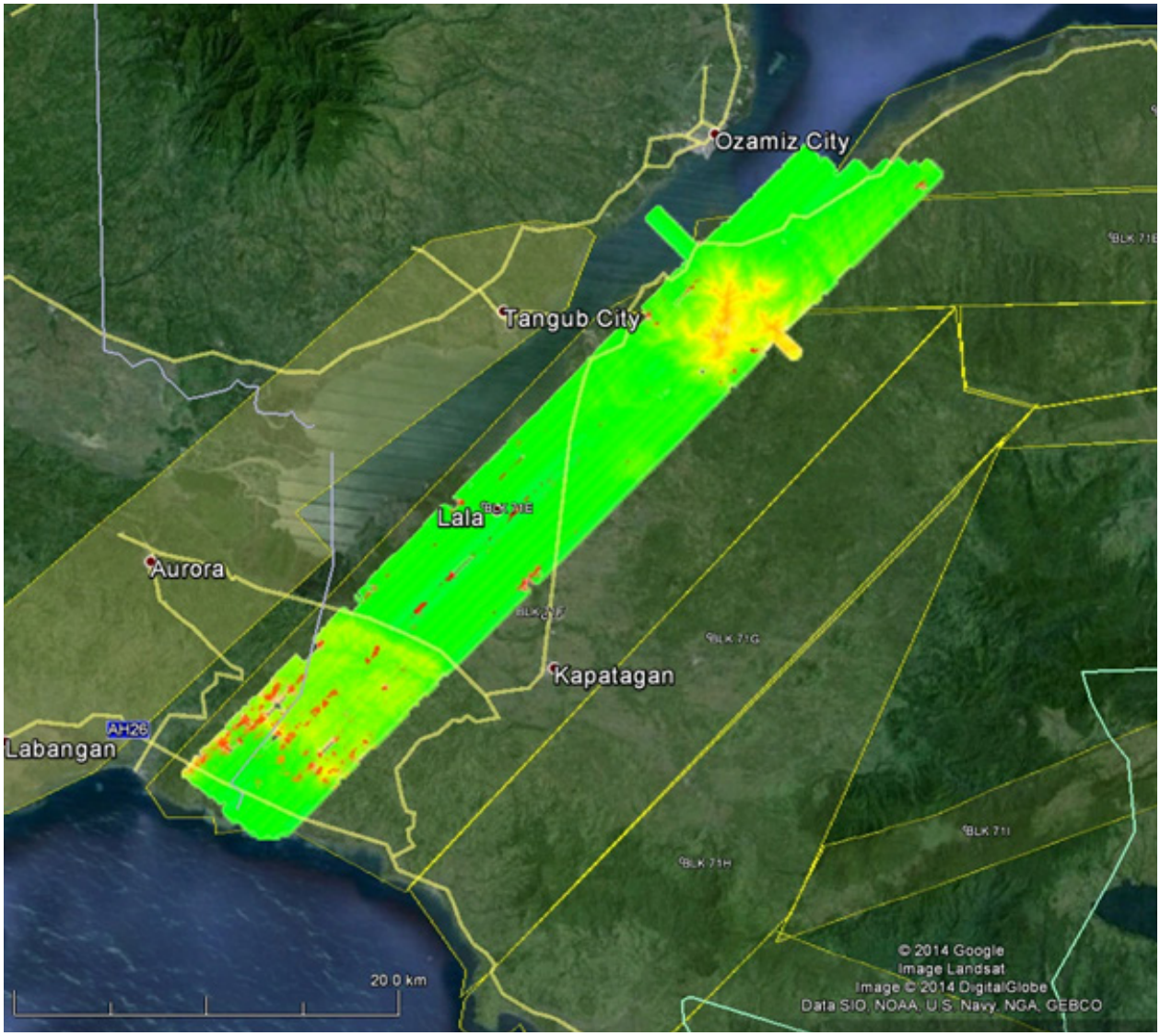
ANNEX 7. Flight status reports

Northern Mindanao
(June 4-July9, 2014; February 12-23, 2016; December 1, 2016)

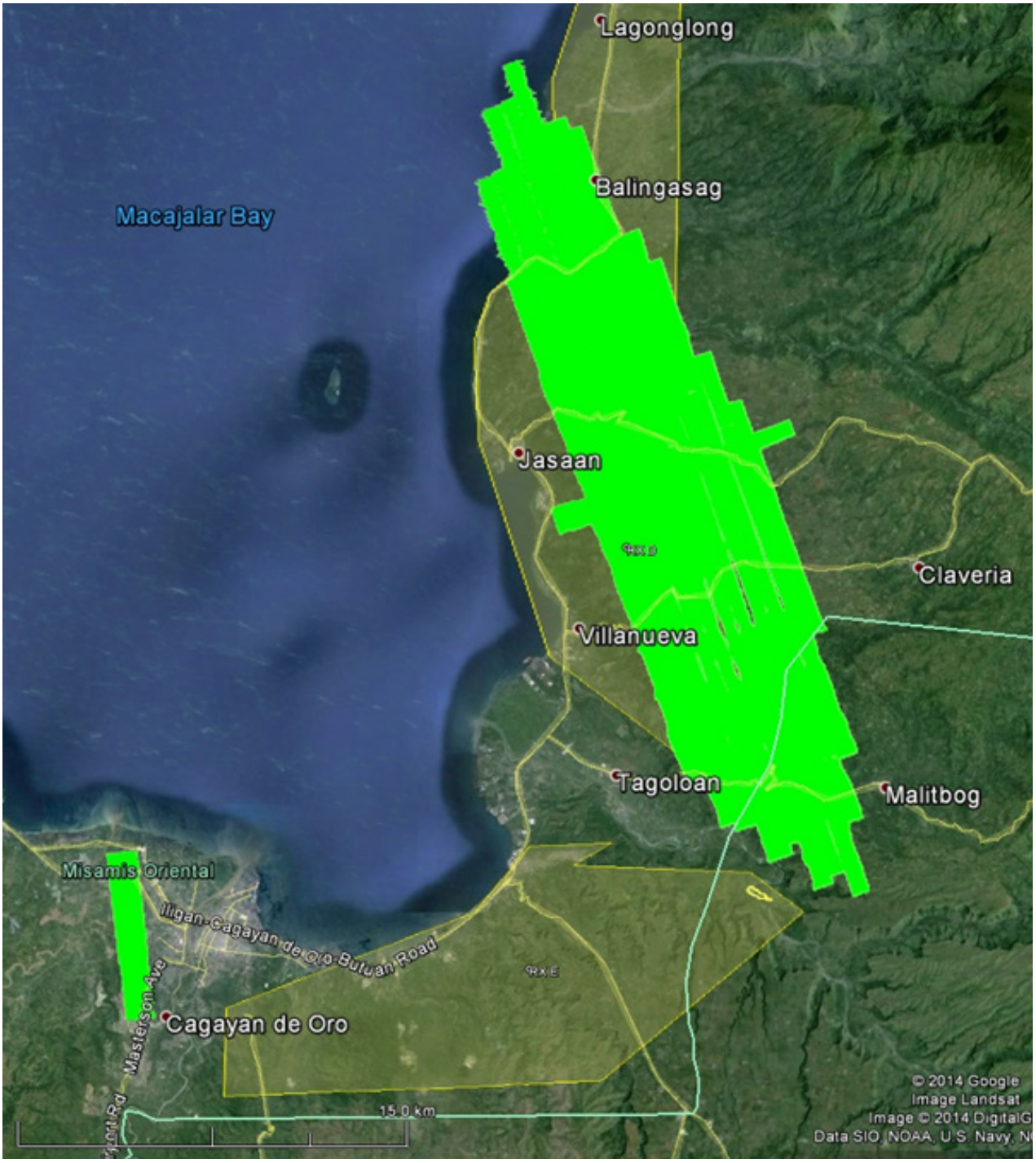
FLIGHT NO.	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1549P	BLK 71E	1BLK 71D155A	G. Sinadjan	June 4, 2014	Surveyed BLK 71E with gaps due to clouds; to be renamed to 1BLK71E155A
1565P	BLK 71F	1BLK71B159A	G. Sinadjan	June 8, 2014	Surveyed half of BLK 71F with gaps due to clouds; to be renamed 1BLK71F159A
1613P	BLK 71G	1BLK71G171A	G. Sinadjan	June 20, 2014	Mission successful; some lines cut due to high terrain
1665P	BLK 71 ext	1BLK71ES184A	J. Alviar	July 3, 2014	Heavy build up closing is over Lanao and Pagadian areas; searched for open areas and surveyed Ozamis City instead
1673P	BLK 71 ext	1BLK71ES186A	I.Roxas	July 5, 2014	Attempted to survey Lanao and Pagadian but transferred to Tangub and Ozamis due to heavy build up in the previous areas
1677P	BLK 71 ext	1BLK71S187A	G. Sinadjan	July 6, 2014	Heavy build over all remaining survey areas; surveyed supplementary lines to BLK 71ext
1685P	BLK 71F	1BLK71S189A	I.Roxas	July 8, 2014	Surveyed BLK 71F at 1200m
1689P	BLK 71E and BLK 71ABCs	1BLK71S190A	I.Roxas	July 9, 2014	Surveyed BLK 71E and the gaps in BLK 71ABC
23084P	BLK C,D,E,H,J,K,L	1BLK76JKLCs043A	I.Roxas	February 12, 2016	Finished BLK76C,J,K. Please also process tie lines as production data, using the intersecting line as tie line for BLK76D,E,H as they cover parts of FP
23088P	BLK I,L,M	1BLK76ILM044A	J. Almalvez	February 13, 2016	Cloudy over L & M. Pegasus problem encountered so no tie lines over I; please use 23078's and 23092's tie line
23104P	BLKD,L,M	1BLK76DLM048A	J. Almalvez	February 17, 2016	Cloudy on BLK76M so no tie line, please use 23088's tie line; also cloudy in BLK76L
23128P	BLK70B, 71A	1BLK70B054A	K. Quisado	February 23, 2016	Encountered Lost Channel A error several times; Surveyed blks
23602P	KUMALARANG, BALILI BLK 76A, 71A	1BLK76AB336A	P. Arceo	December 1, 2016	Compoleted Kumalarang floodplain and voids over Balili Floodplain

SWATH PER FLIGHT MISSION

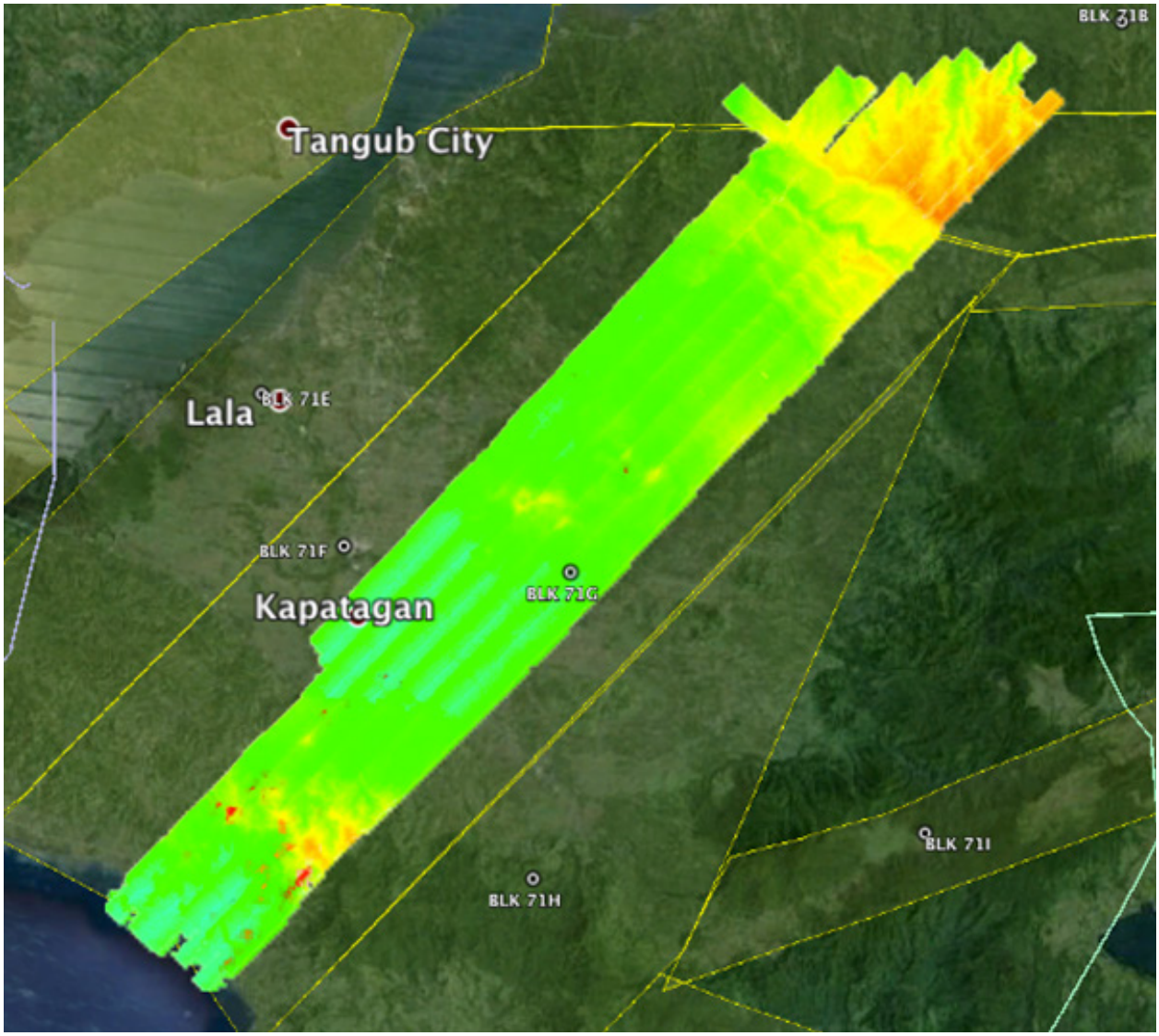
Flight No. : 1549P
Area: BLK 71E
Mission Name: 1BLK71D155A
Parameters: Altitude: 800m; Scan Frequency: 30; Scan Angle: 50



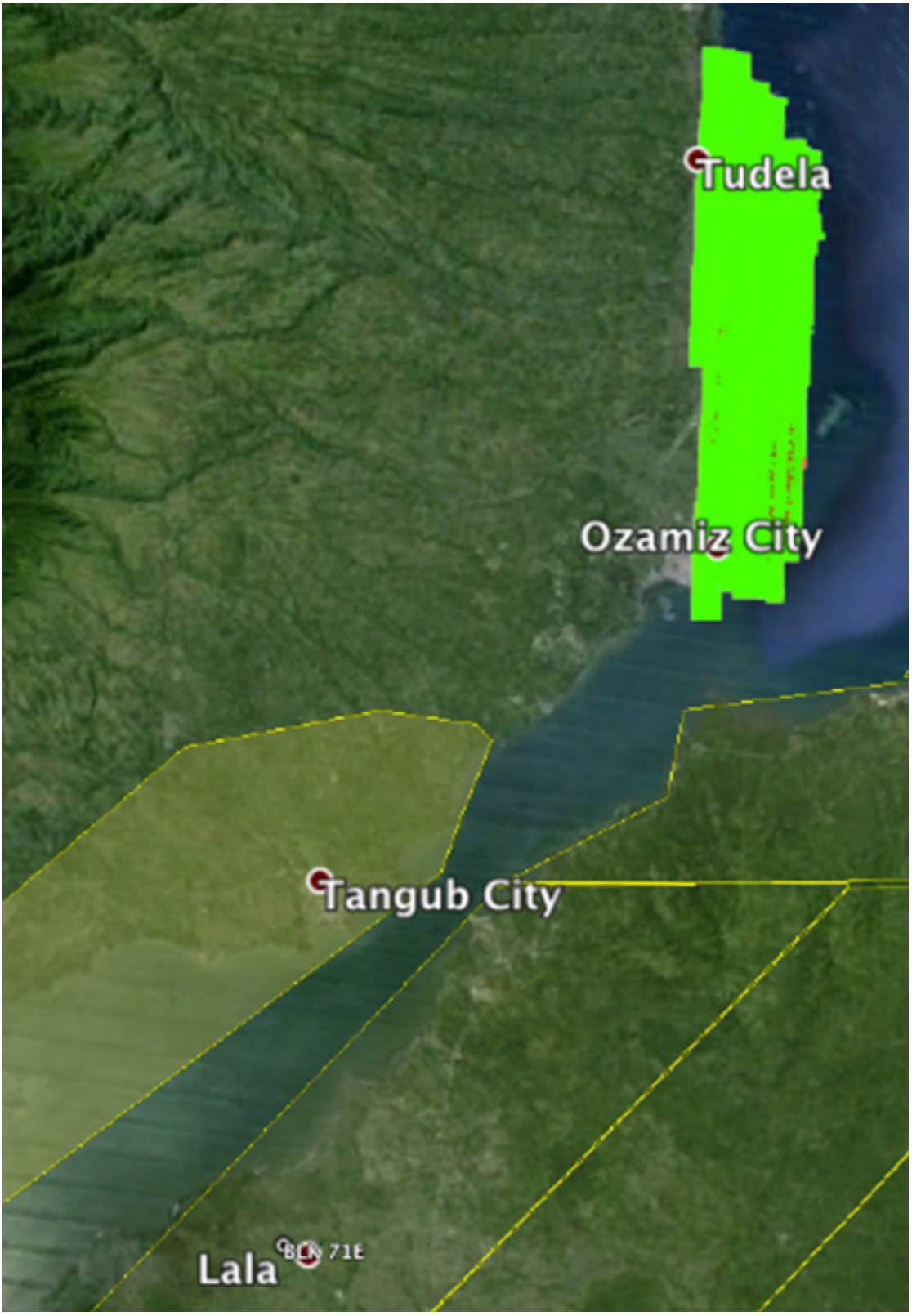
Flight No. : 1613P
Area: BLK 71G
Mission Name: 1BLK71G171A
Parameters: Altitude: 900m; Scan Frequency: 30; Scan Angle: 50



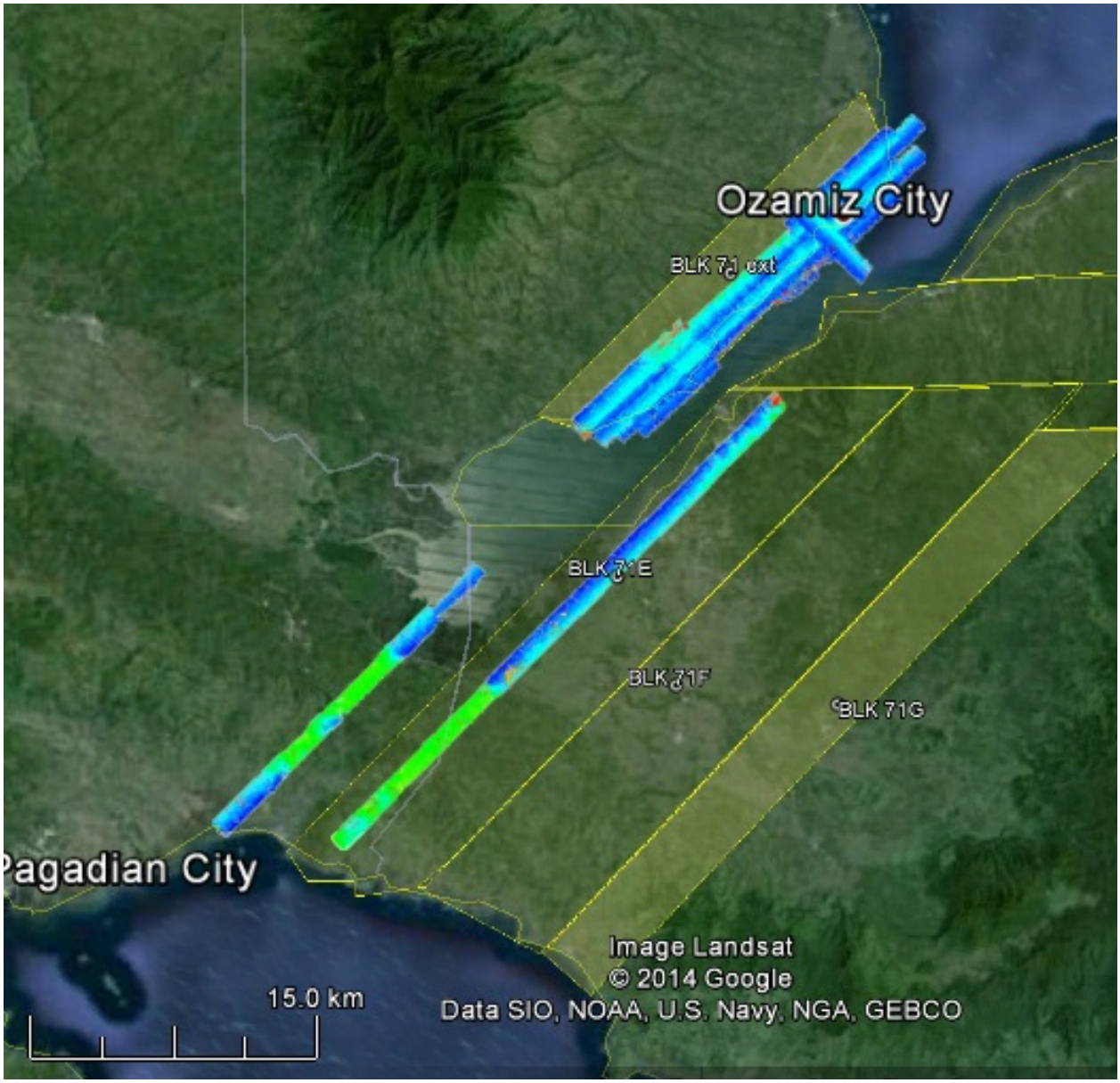
Flight No. : 1613P
Area: BLK 71G
Mission Name: 1BLK71G171A
Parameters: Altitude: 900m; Scan Frequency: 30; Scan Angle: 50



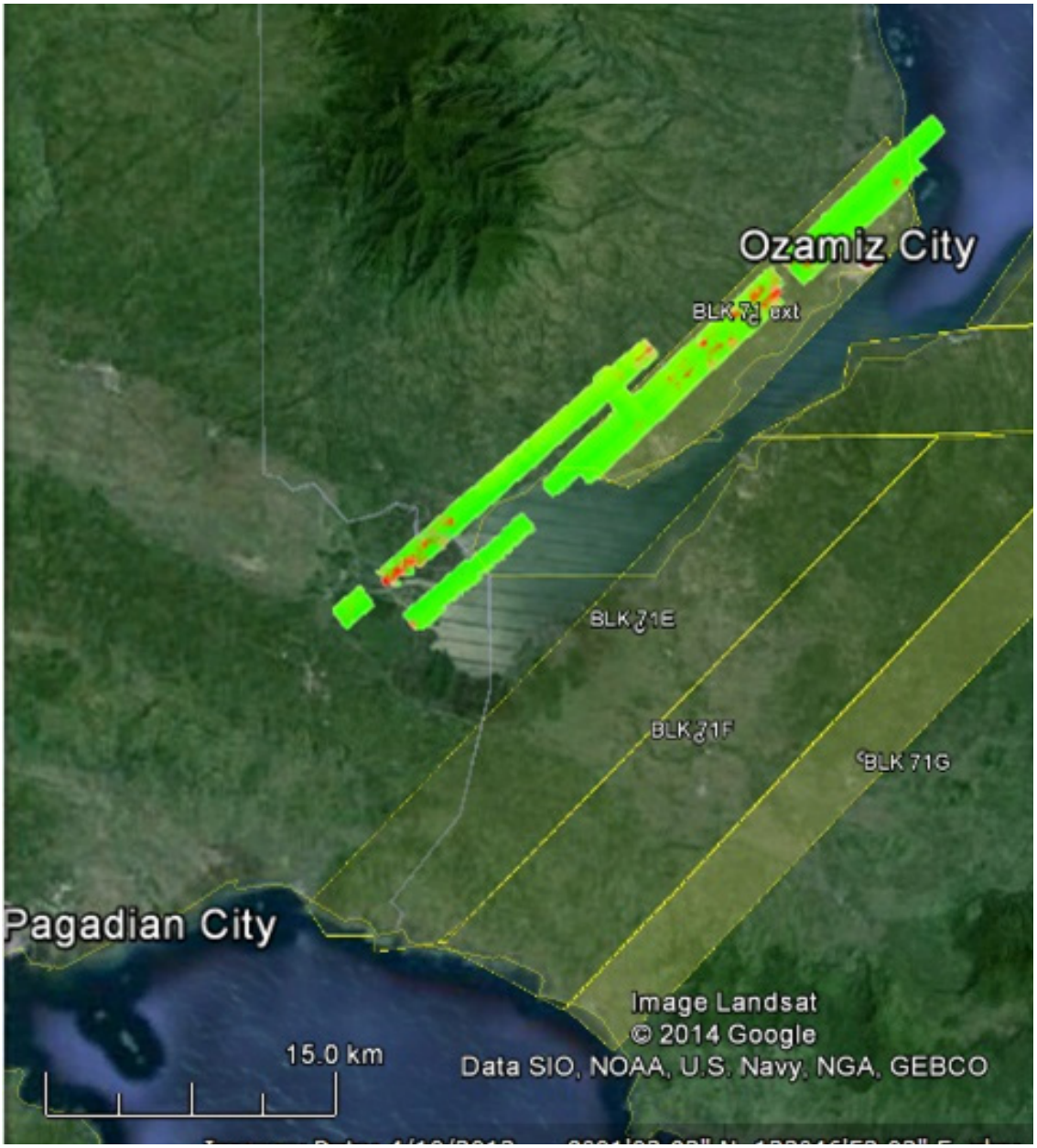
Flight No. : 1665P
Area: BLK 71Es
Mission Name: 1BLK71ES184A
Parameters: Altitude: 1100m; Scan Frequency: 30; Scan Angle: 50



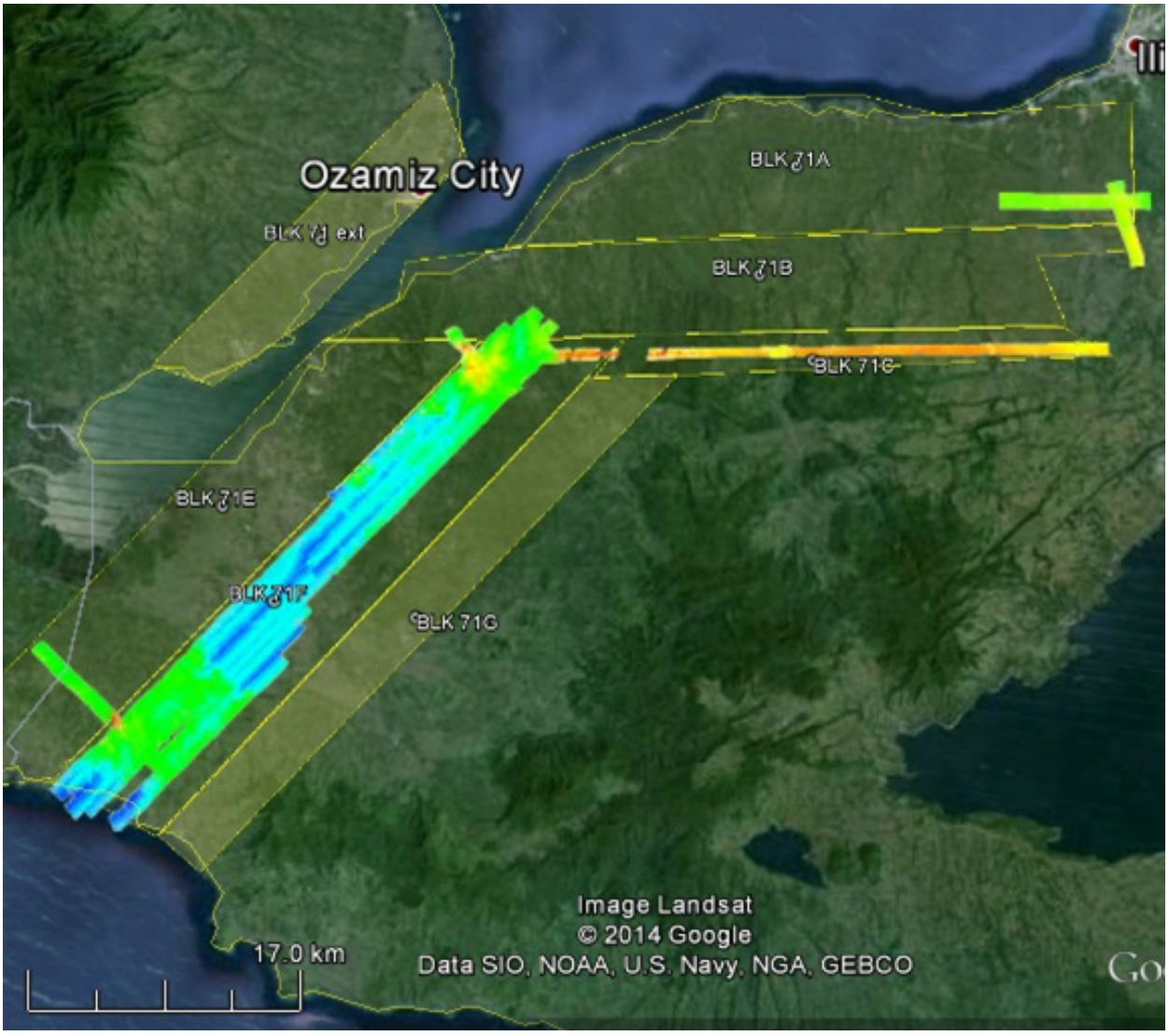
Flight No. : 1673P
Area: BLK 71 ext
Mission Name: 1BLK71ES186A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50



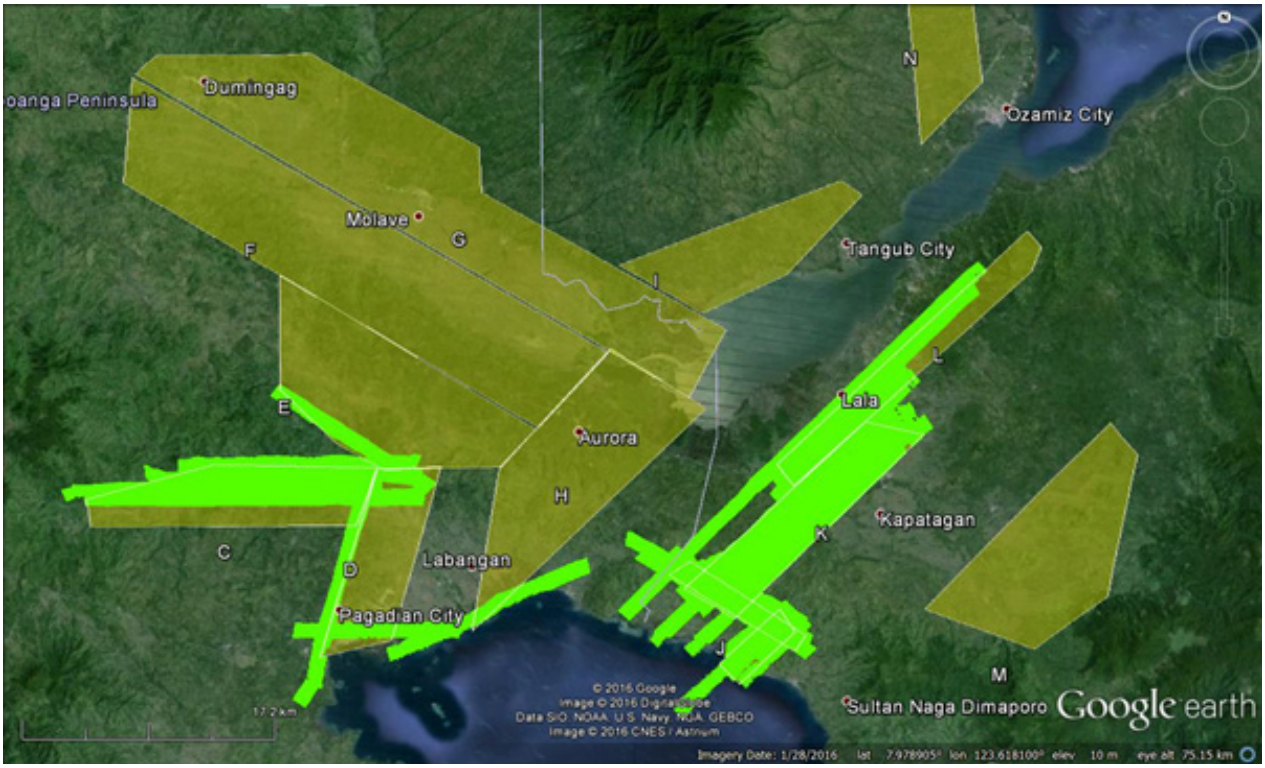
Flight No. : 1677P
Area: BLK 71 ext
Mission Name: 1BLK71S187A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50



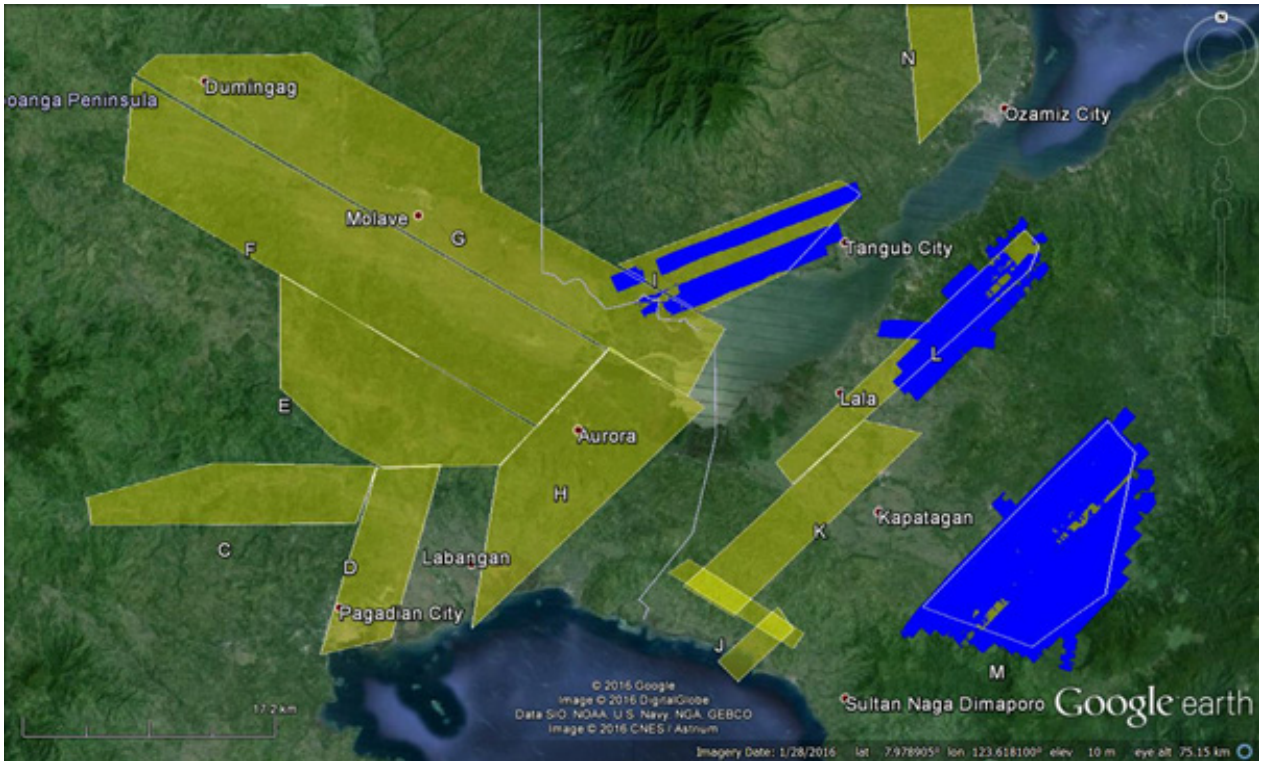
Flight No. : 1685P
Area: BLK 71F
Mission Name: 1BLK71S189A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50



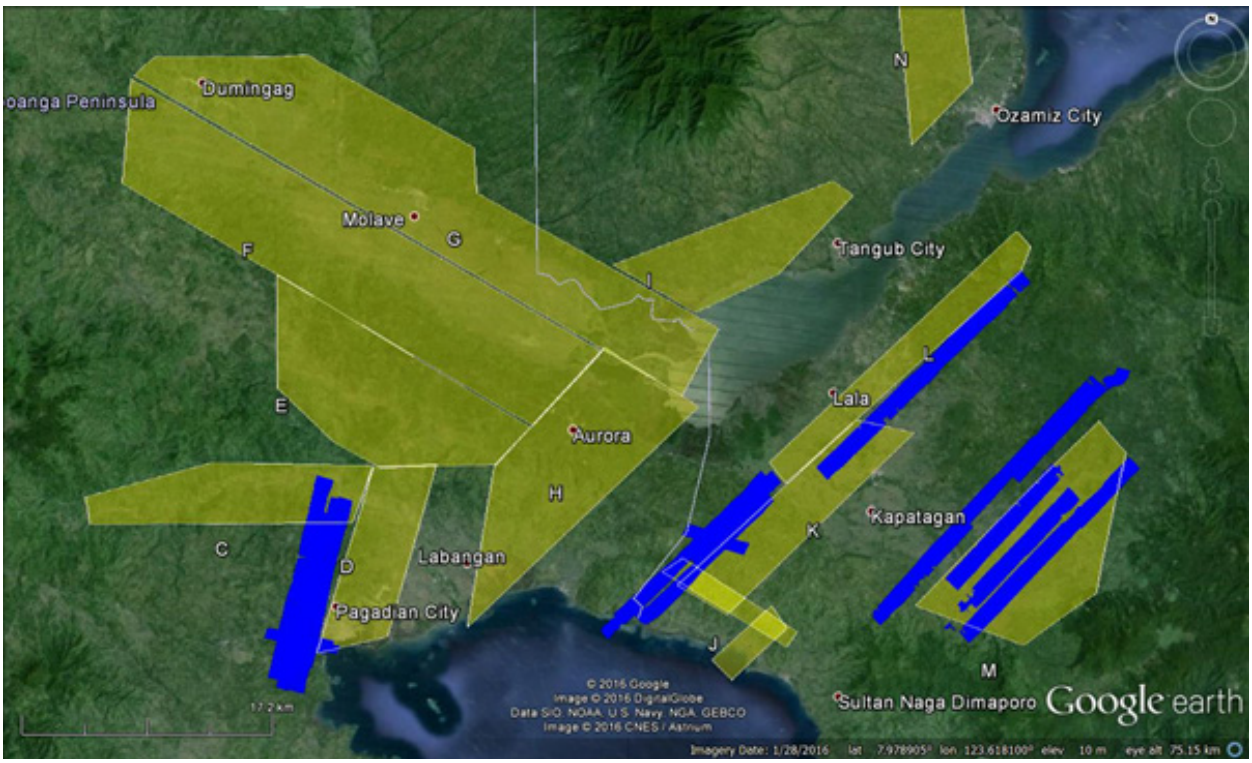
Flight No. : 23084P
Area: BLK C,D,E,H,J,K,L
Mission Name: 1BLK76JKLCs043A
Parameters: Altitude: 1100m; Scan Frequency: 30; Scan Angle: 50



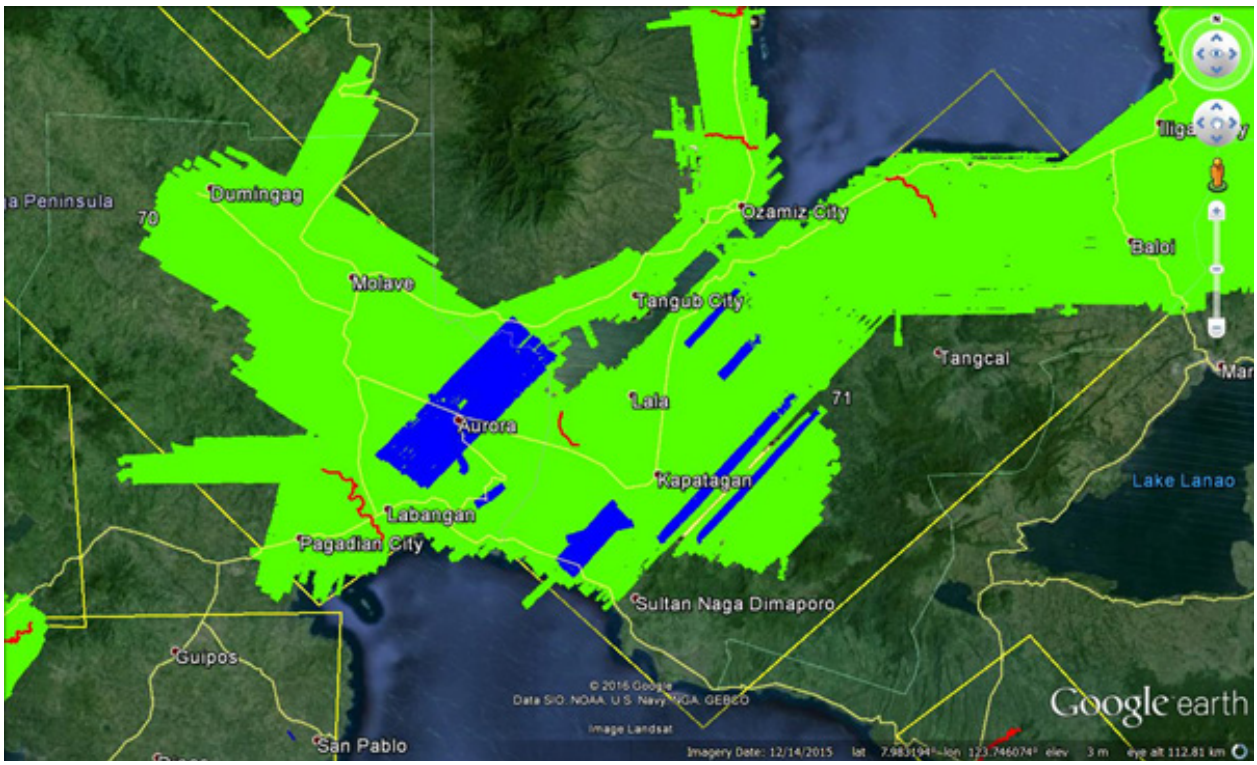
Flight No. : 23088P
Area: BLK I,L,M
Mission Name: 1BLK76ILM044A
Parameters: Altitude: 1000-1200m; Scan Frequency: 30; Scan Angle: 50



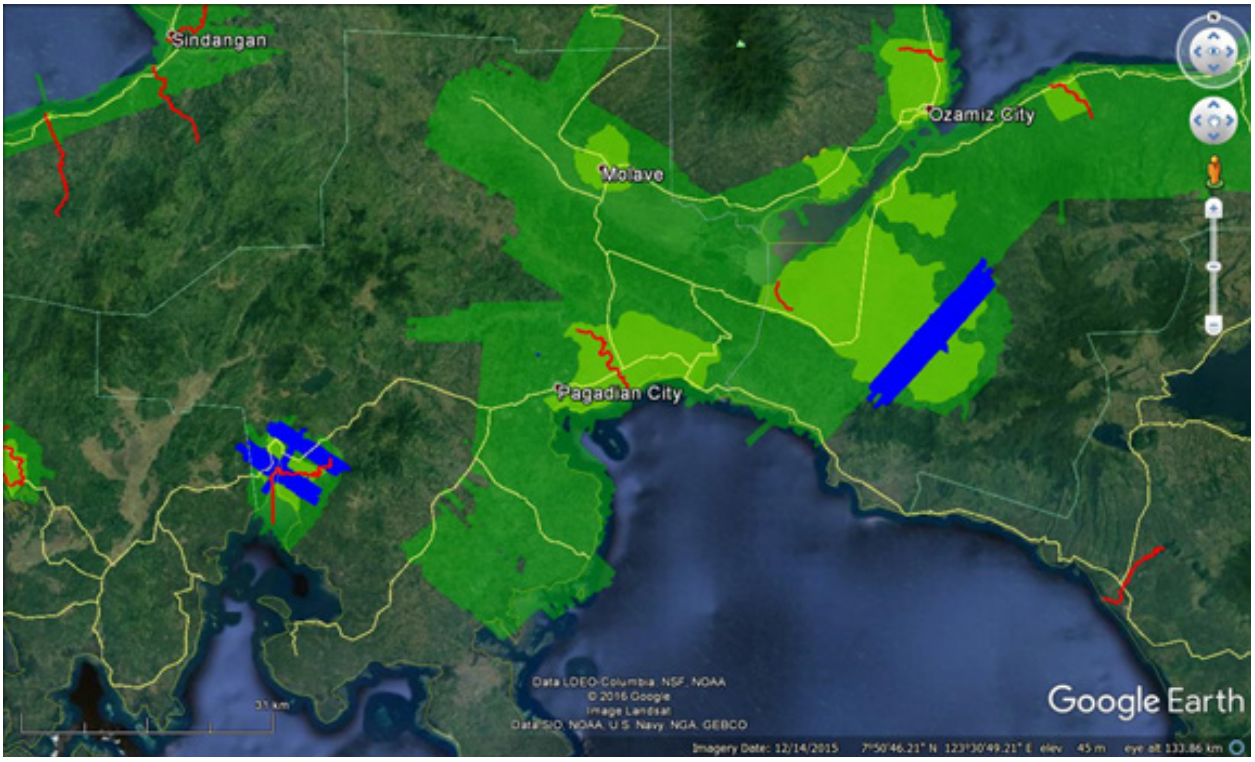
Flight No. : 23104P
Area: BLK D,L,M
Mission Name: 1BLK76DLM048A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50



Flight No. : 23128P
Area: BLK 70B, 71A
Mission Name: 1BLK70B054A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

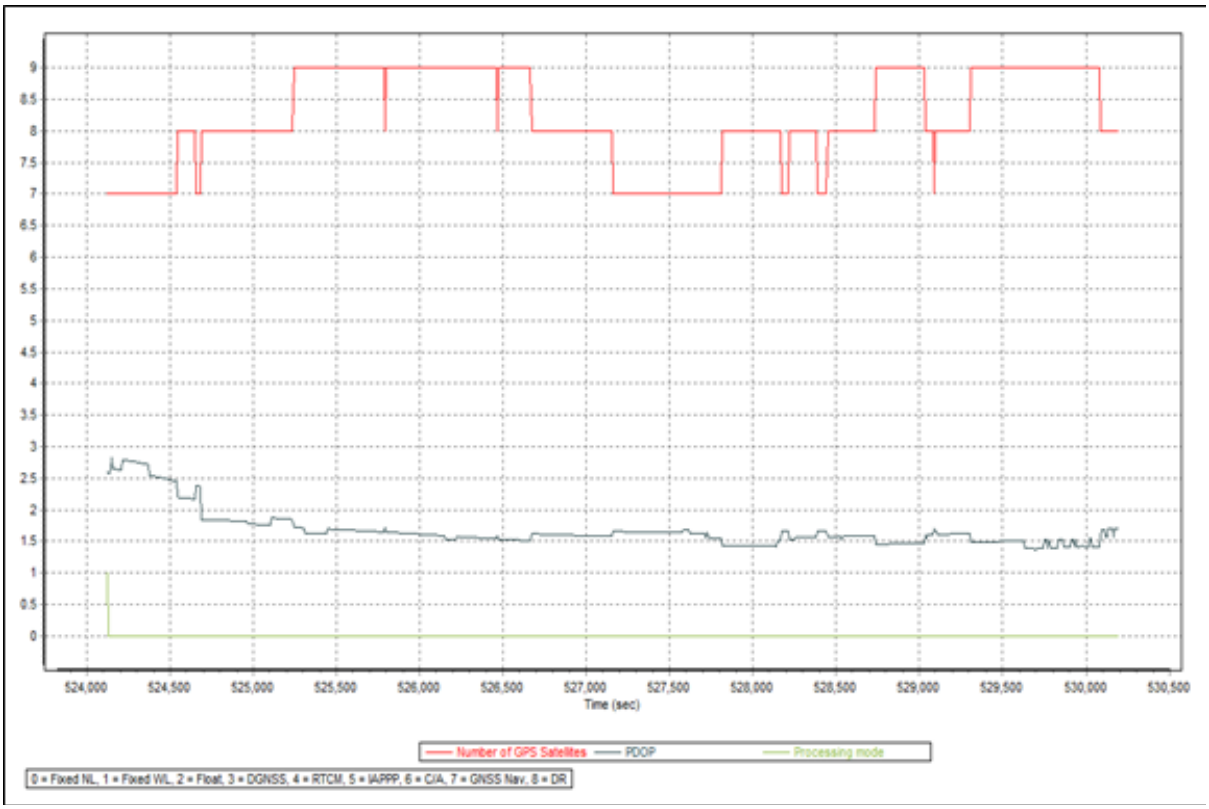


Flight No. : 23602P
Area: KUMALARANG AND BALILI
Mission Name: 1BLK76AB336A
Parameters: Altitude: 1200m; Scan Frequency: 30; Scan Angle: 50

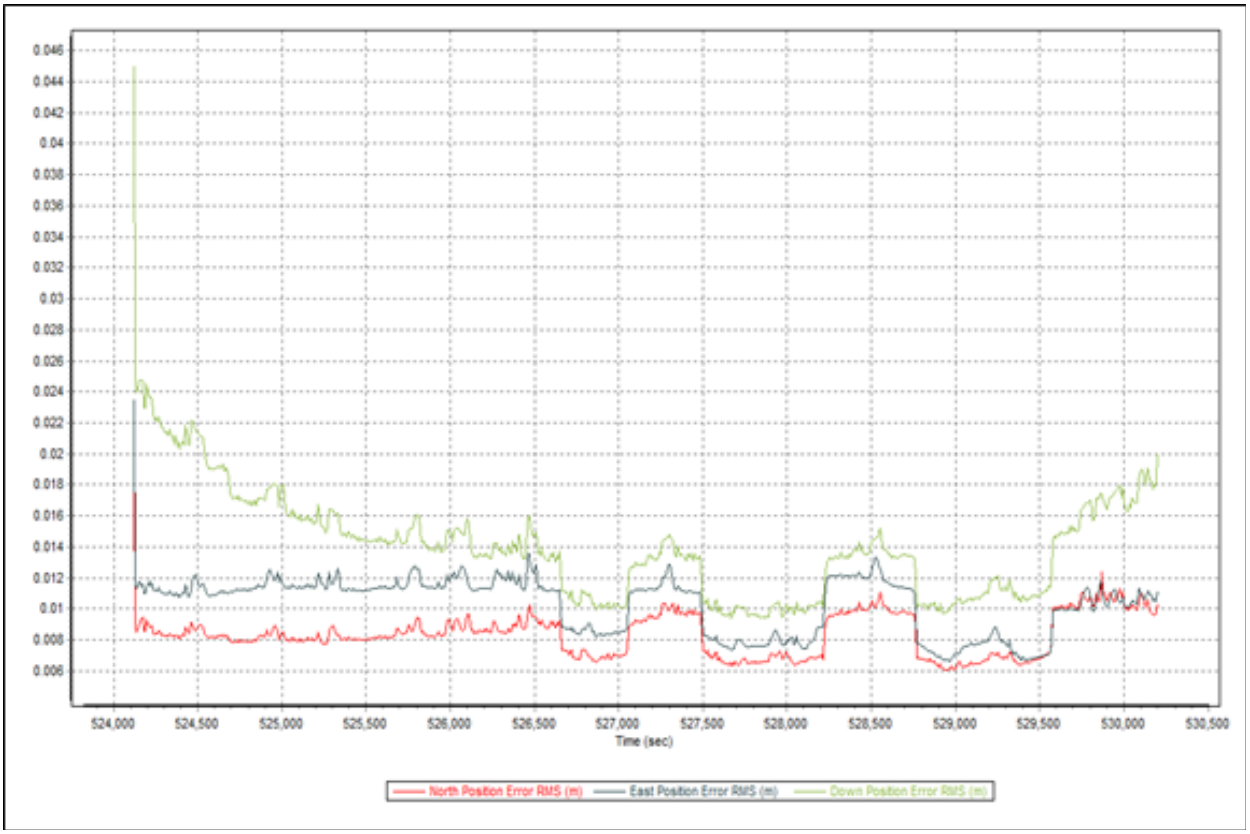


ANNEX 8. Mission Summary Reports

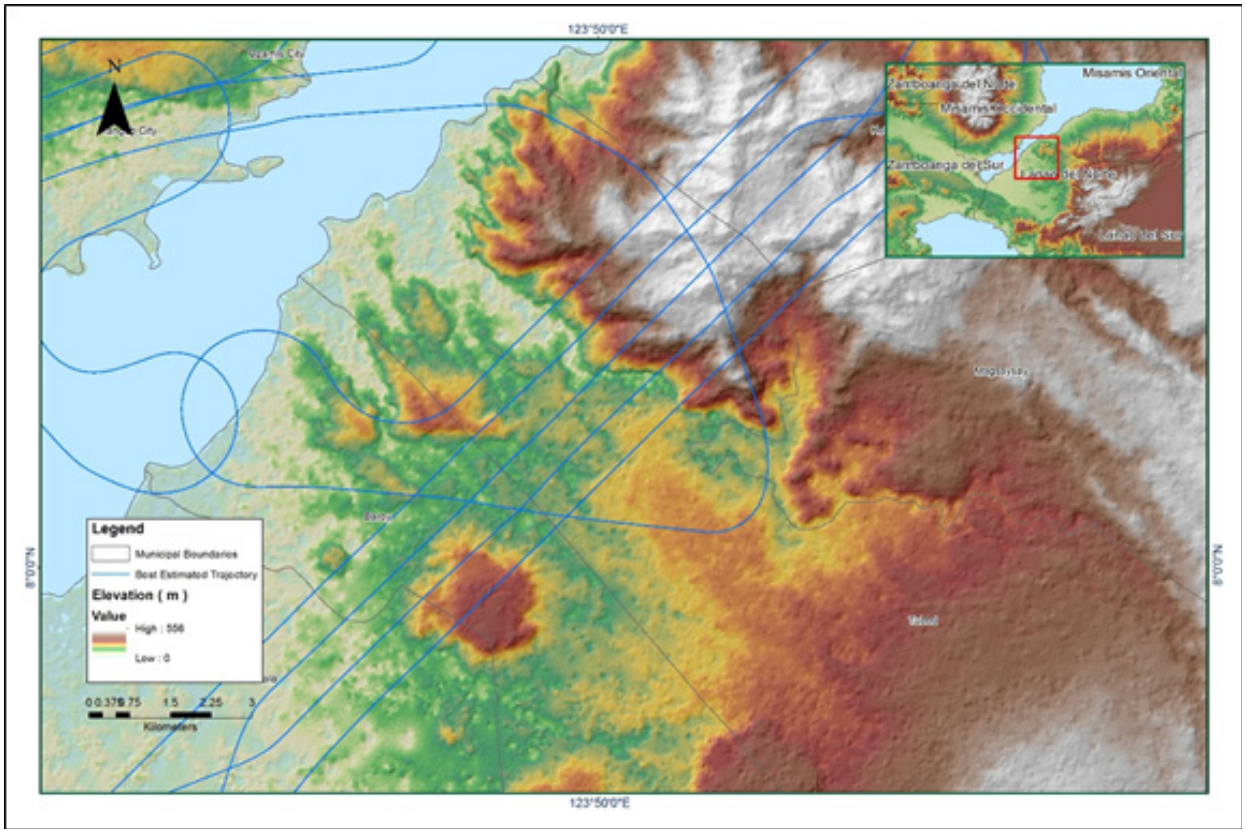
Flight Area	Pagadian
Mission Name	76J
Inclusive Flights	23088P
Range data size	24.65
POS data size	283.62
Base data size	101.29
Image	n/a
Transfer date	March 01, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.3
RMSE for East Position (<4.0 cm)	1.4
RMSE for Down Position (<8.0 cm)	2.5
Boresight correction stdev (<0.001deg)	0.000281
IMU attitude correction stdev (<0.001deg)	0.000180
GPS position stdev (<0.01m)	0.0014
Minimum % overlap (>25)	27.90
Ave point cloud density per sq.m. (>2.0)	3.23
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	72
Maximum Height	698.51 m
Minimum Height	68.61 m
Classification (# of points)	
Ground	34,165,050
Low vegetation	19,594,241
Medium vegetation	28,178,750
High vegetation	95,242,866
Building	801,190
Orthophoto	Yes
Processed by	Engr. Regis Guhiting, Engr. Jovelle Canlas, Engr. Krisha Marie Bautista



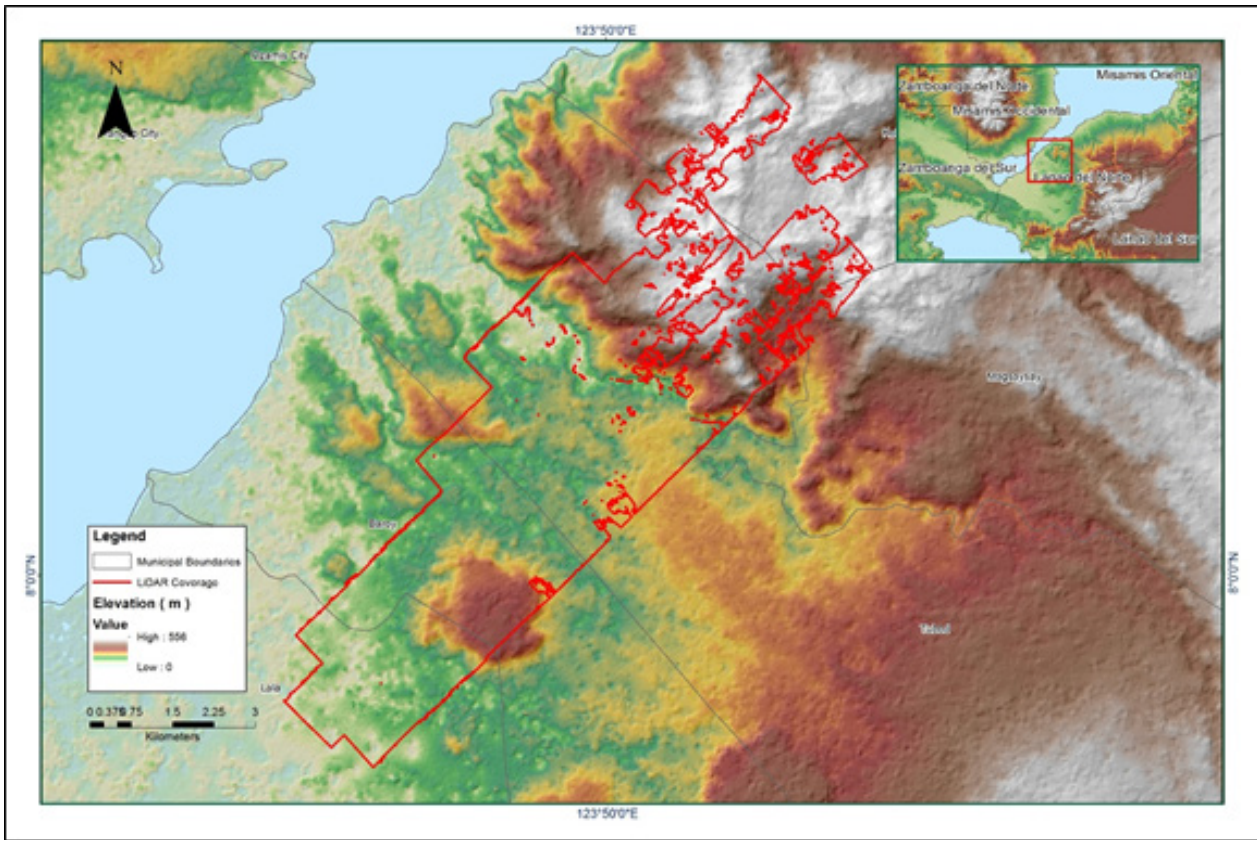
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

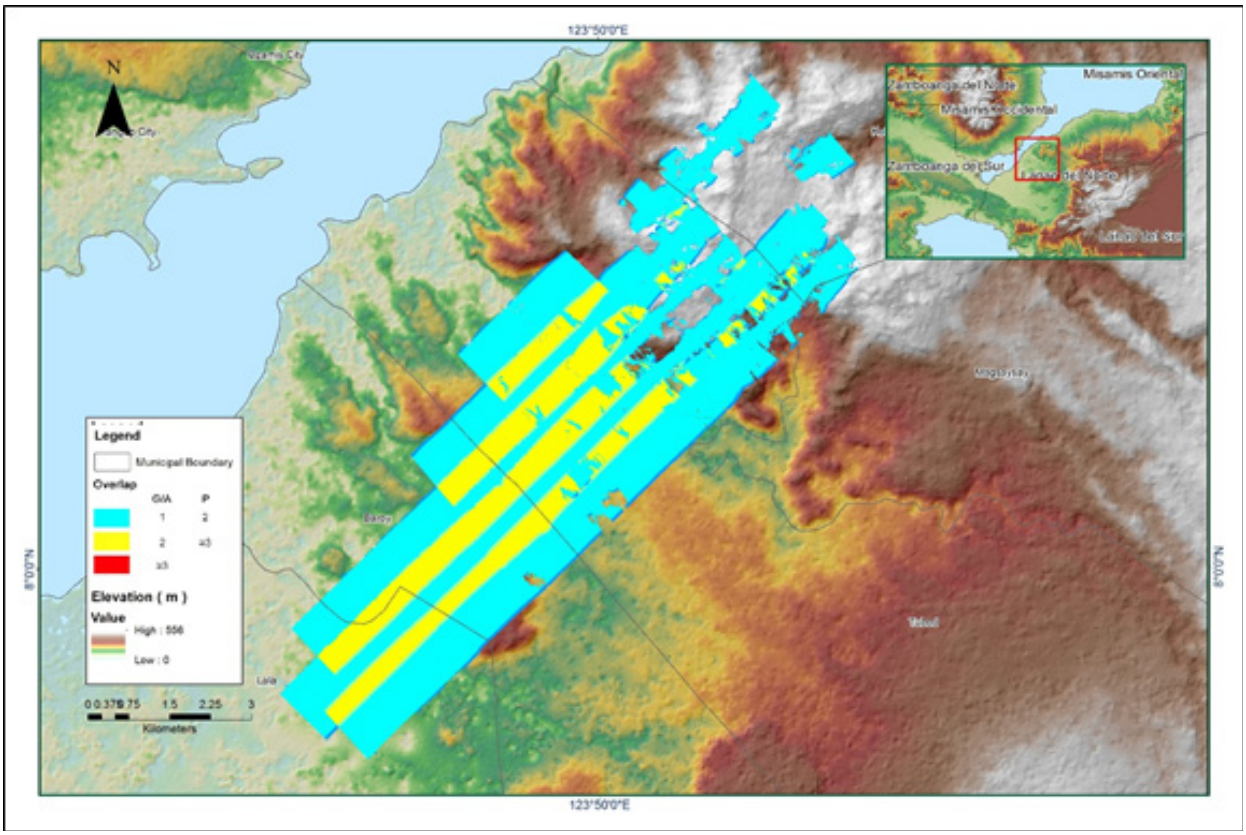
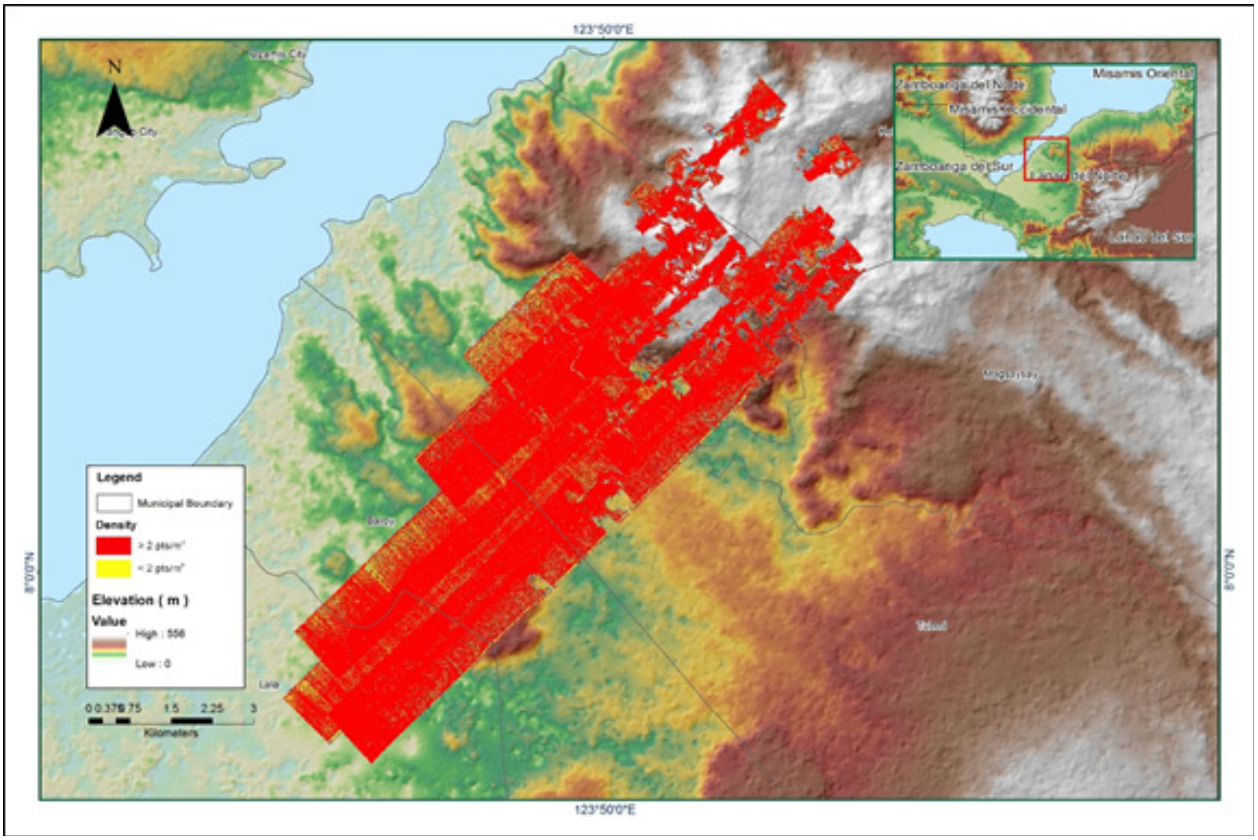
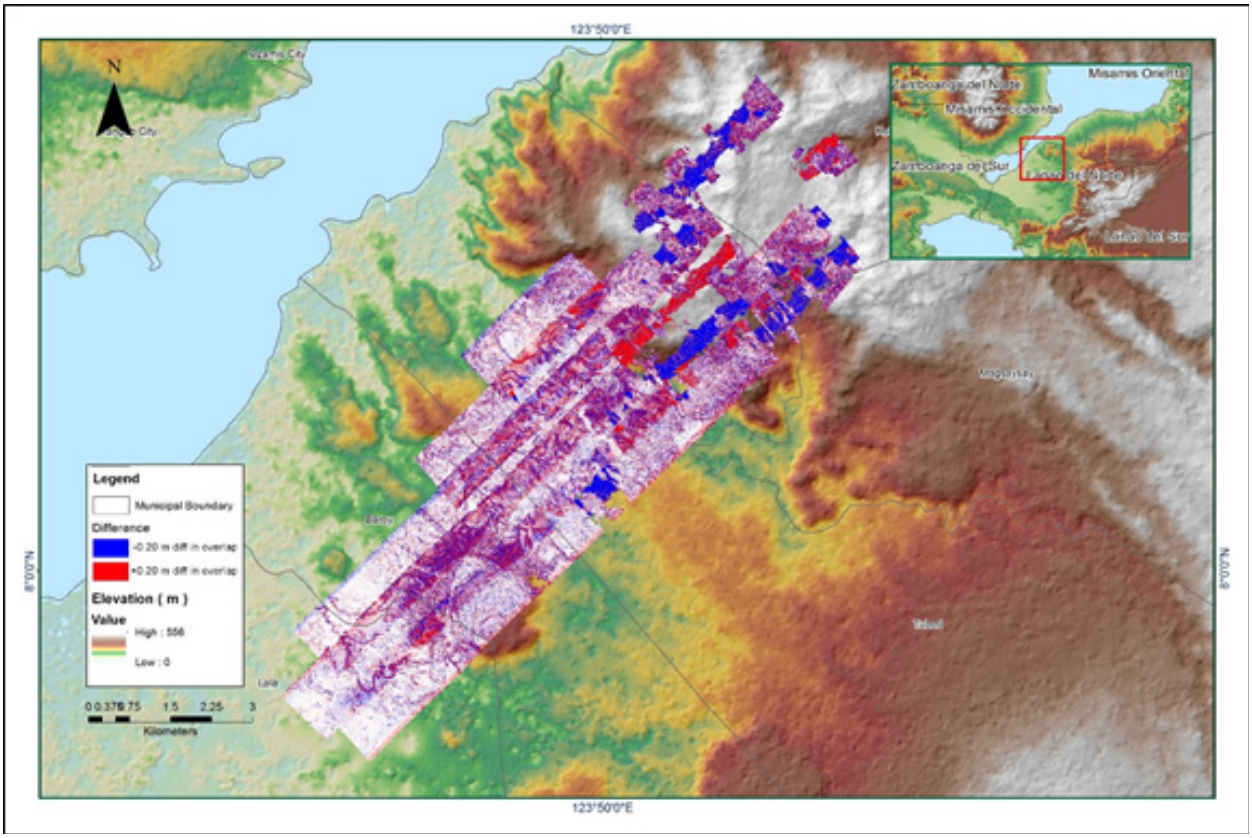


Image of Data Overlap

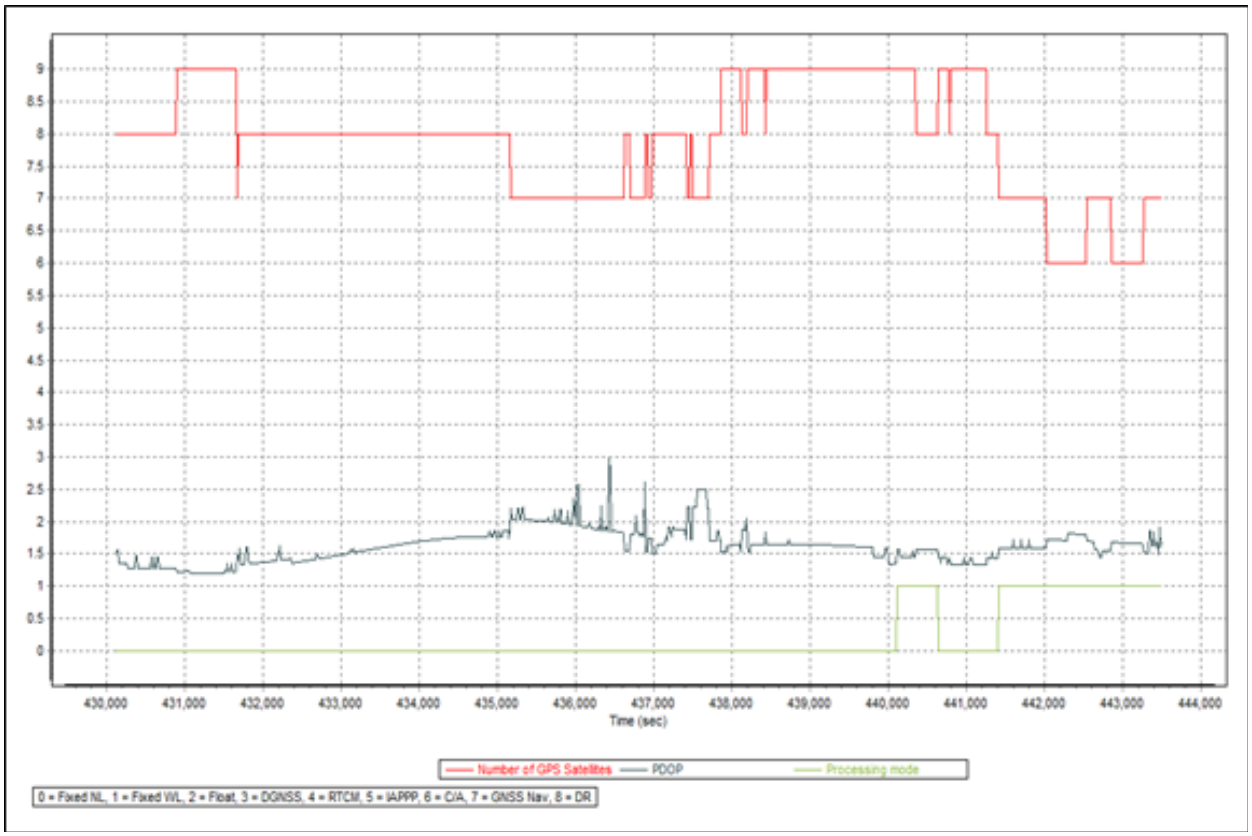


Density map of merged LiDAR data

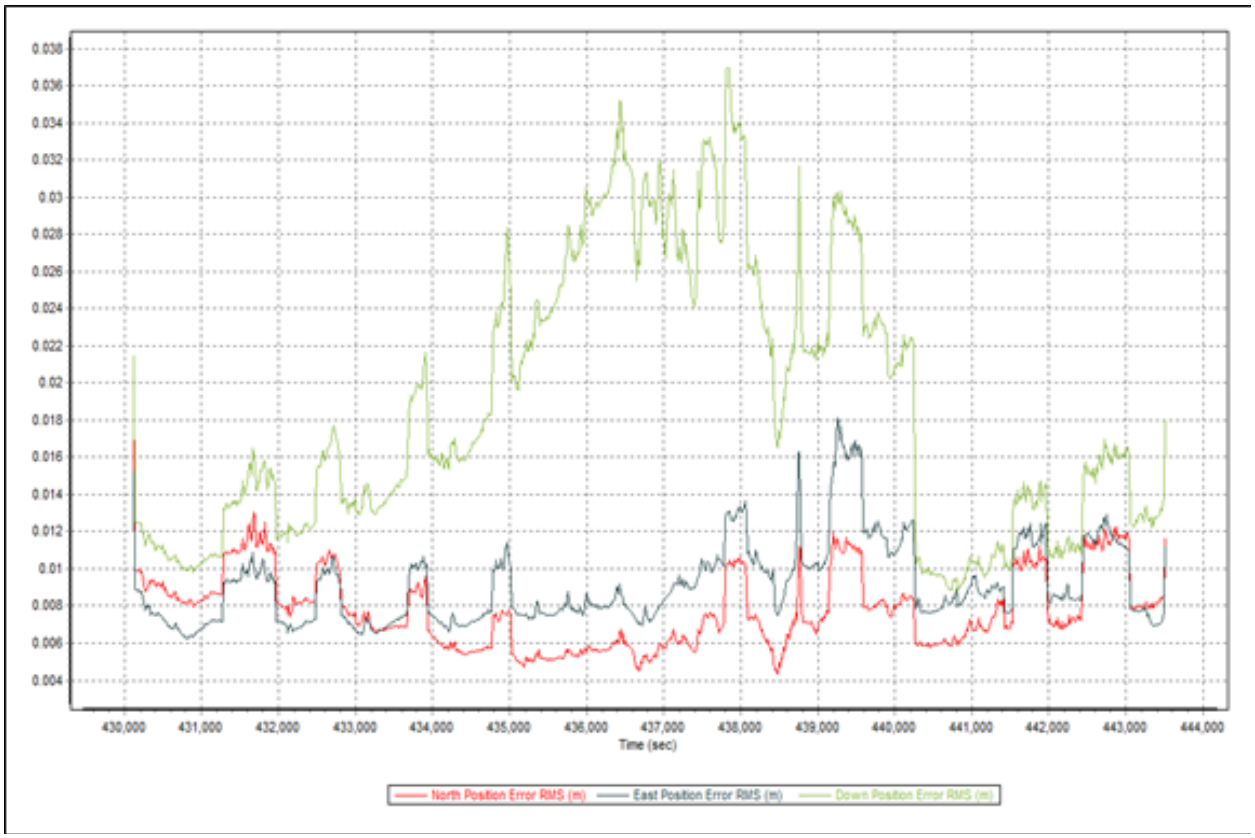


Elevation difference between flight lines

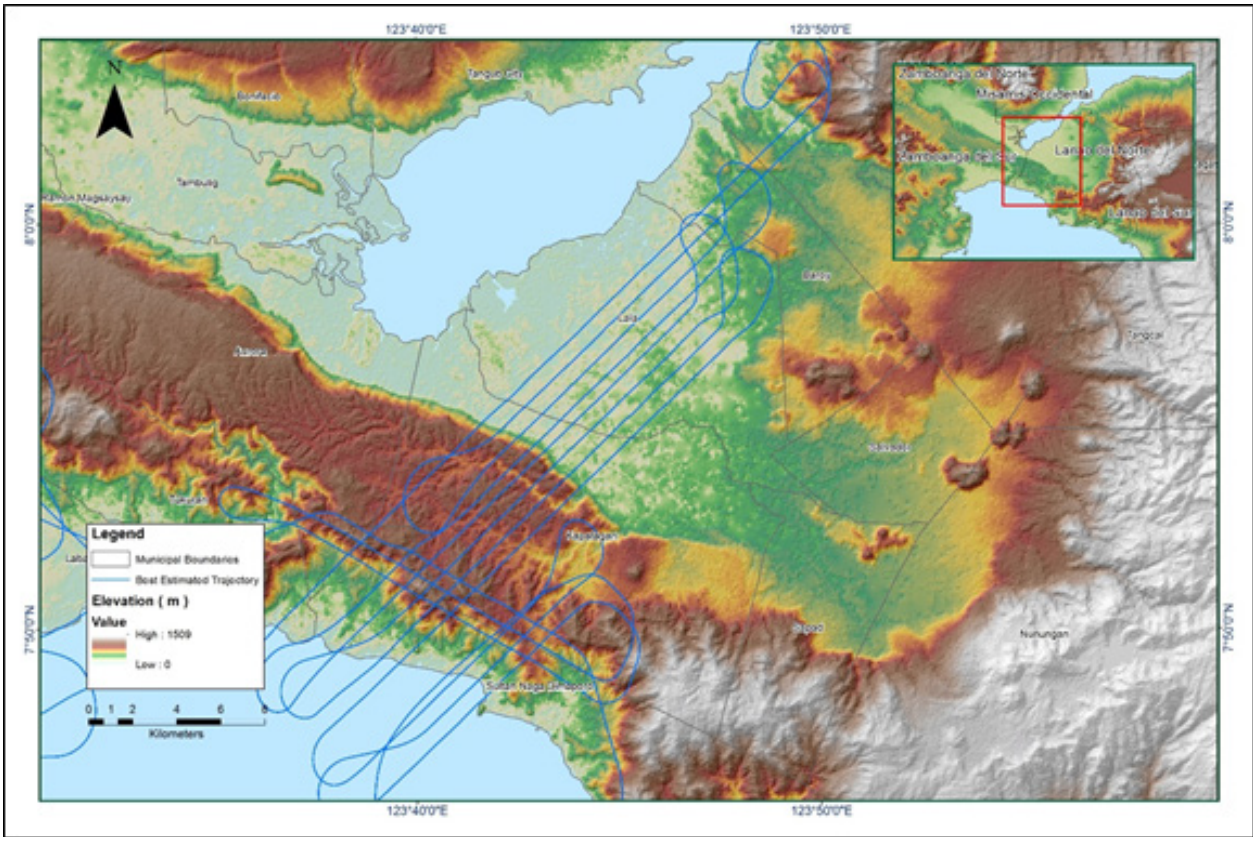
Flight Area	Pagadian
Mission Name	76K
Inclusive Flights	23084P
Range data size	29.36
POS data size	276.9
Base data size	129.73
Image	n/a
Transfer date	March 01, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.3
RMSE for East Position (<4.0 cm)	1.8
RMSE for Down Position (<8.0 cm)	3.7
Boresight correction stdev (<0.001deg)	0.000134
IMU attitude correction stdev (<0.001deg)	0.000524
GPS position stdev (<0.01m)	0.0064
Minimum % overlap (>25)	39.61
Ave point cloud density per sq.m. (>2.0)	3.19
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	280
Maximum Height	475.01 m
Minimum Height	62.15 m
Classification (# of points)	
Ground	263,061,671
Low vegetation	186,080,376
Medium vegetation	173,663,045
High vegetation	1,062,882,246
Building	4,176,141
Orthophoto	Yes
Processed by	Engr. Kenneth Solidum, Engr. Justine Francisco, Maria Tamsyn Malabanan



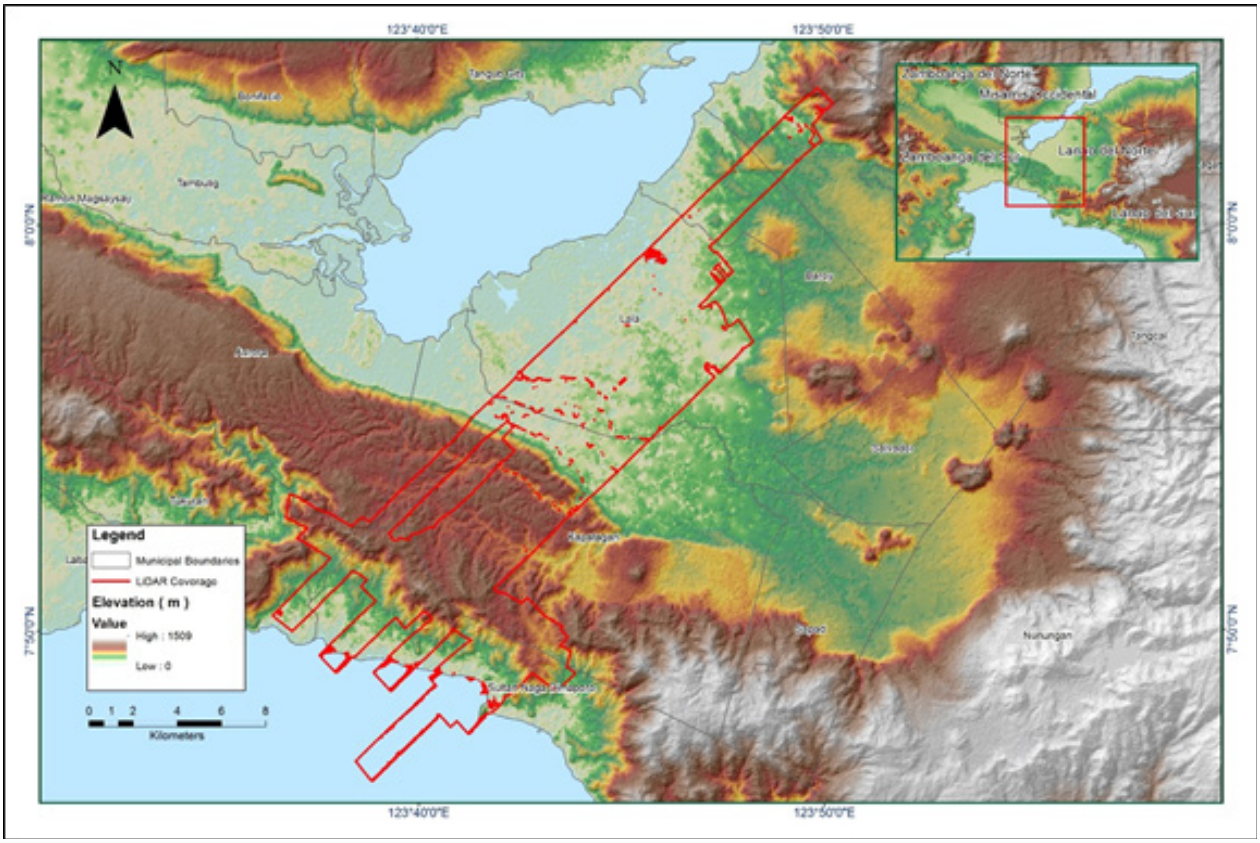
Solution Status Parameters



Smoothed Performance Metrics Parameters



Best Estimated Trajectory



Coverage of LiDAR data

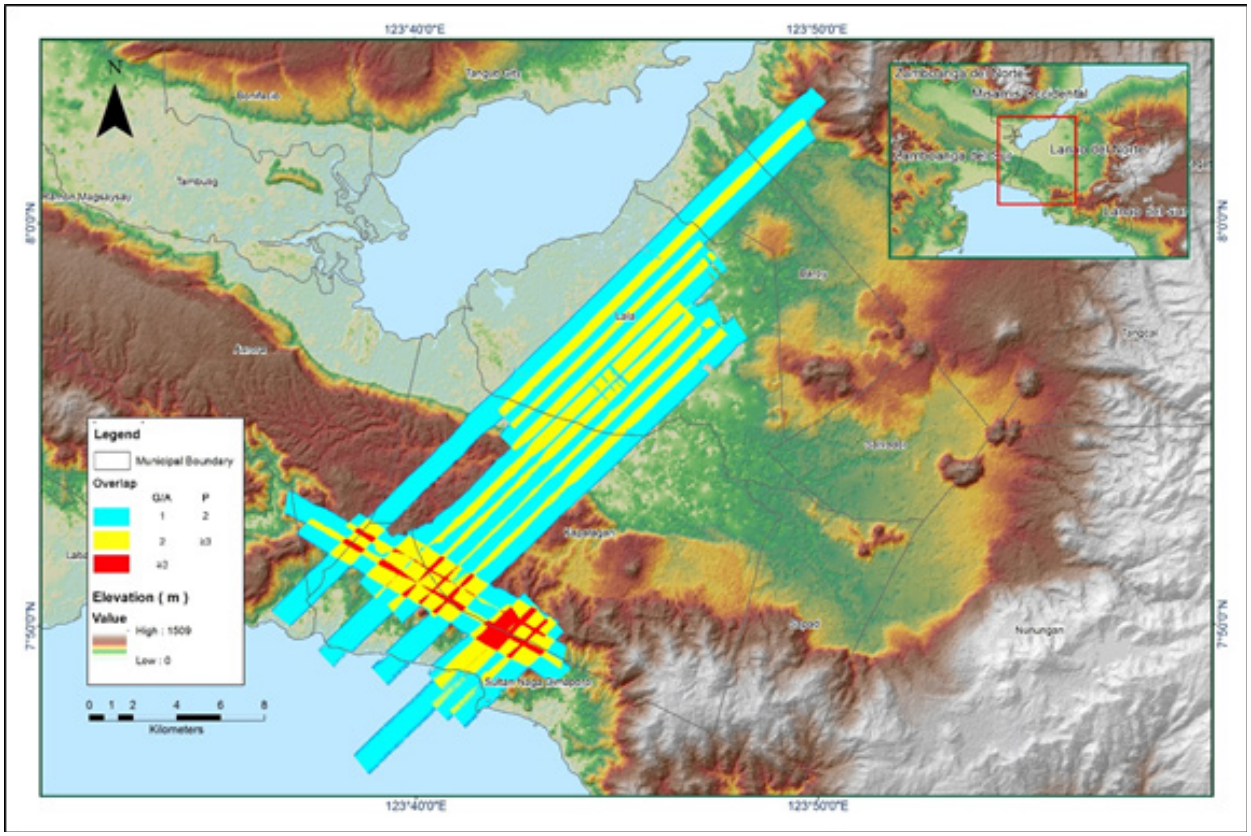
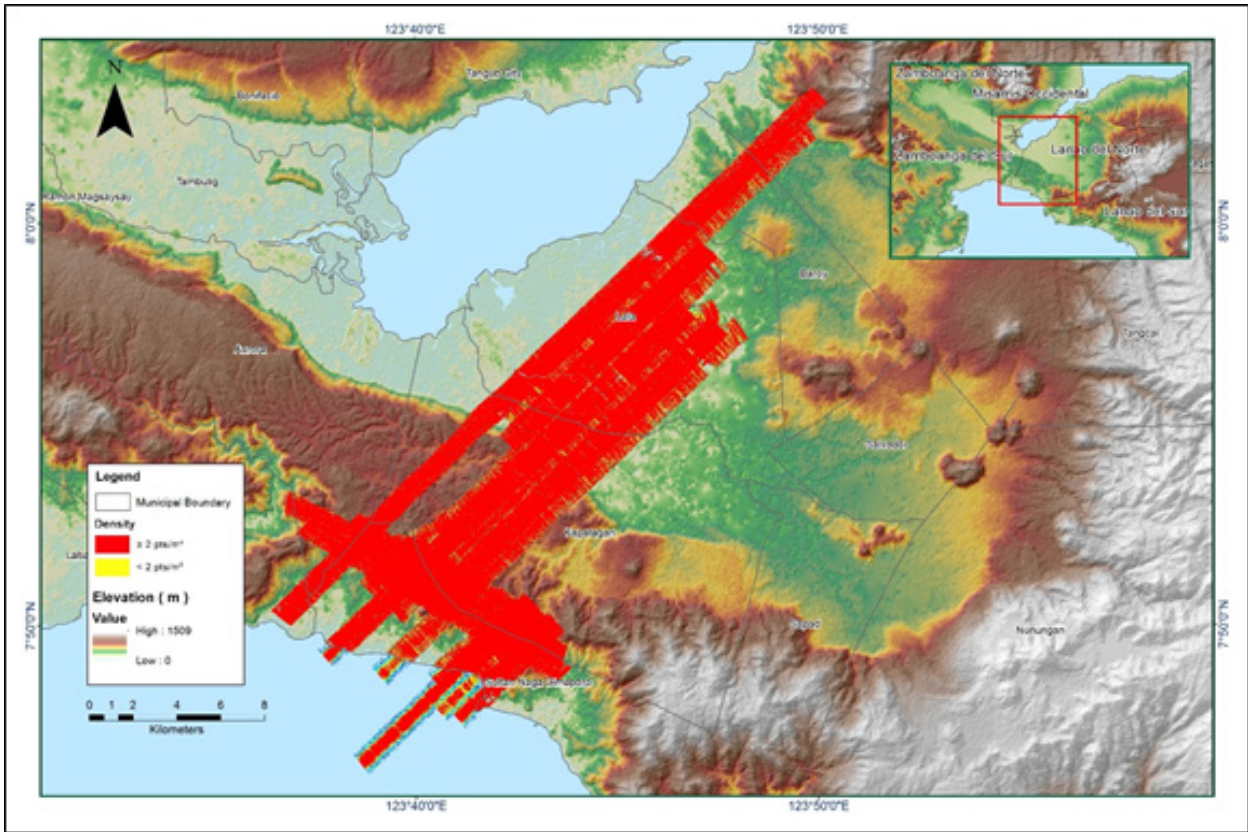
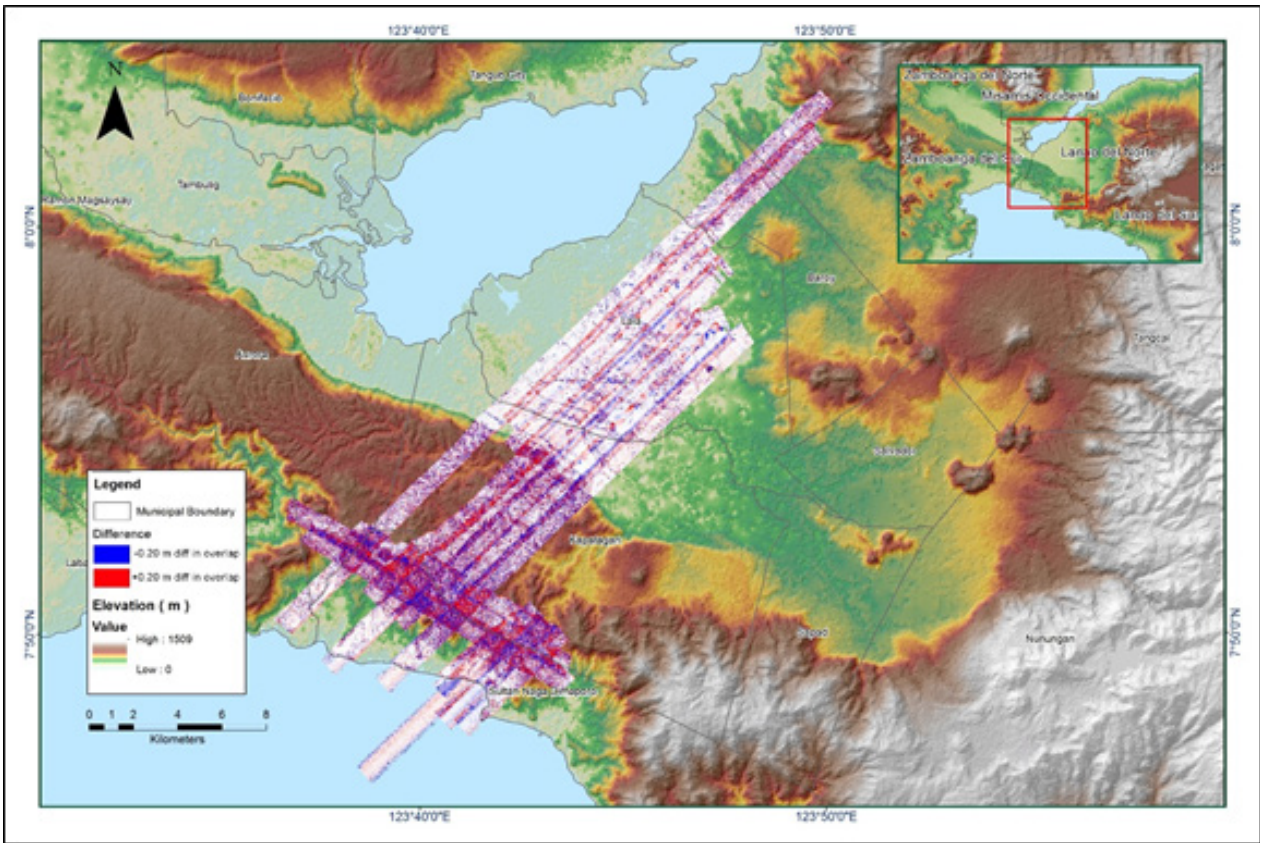


Image of Data Overlap

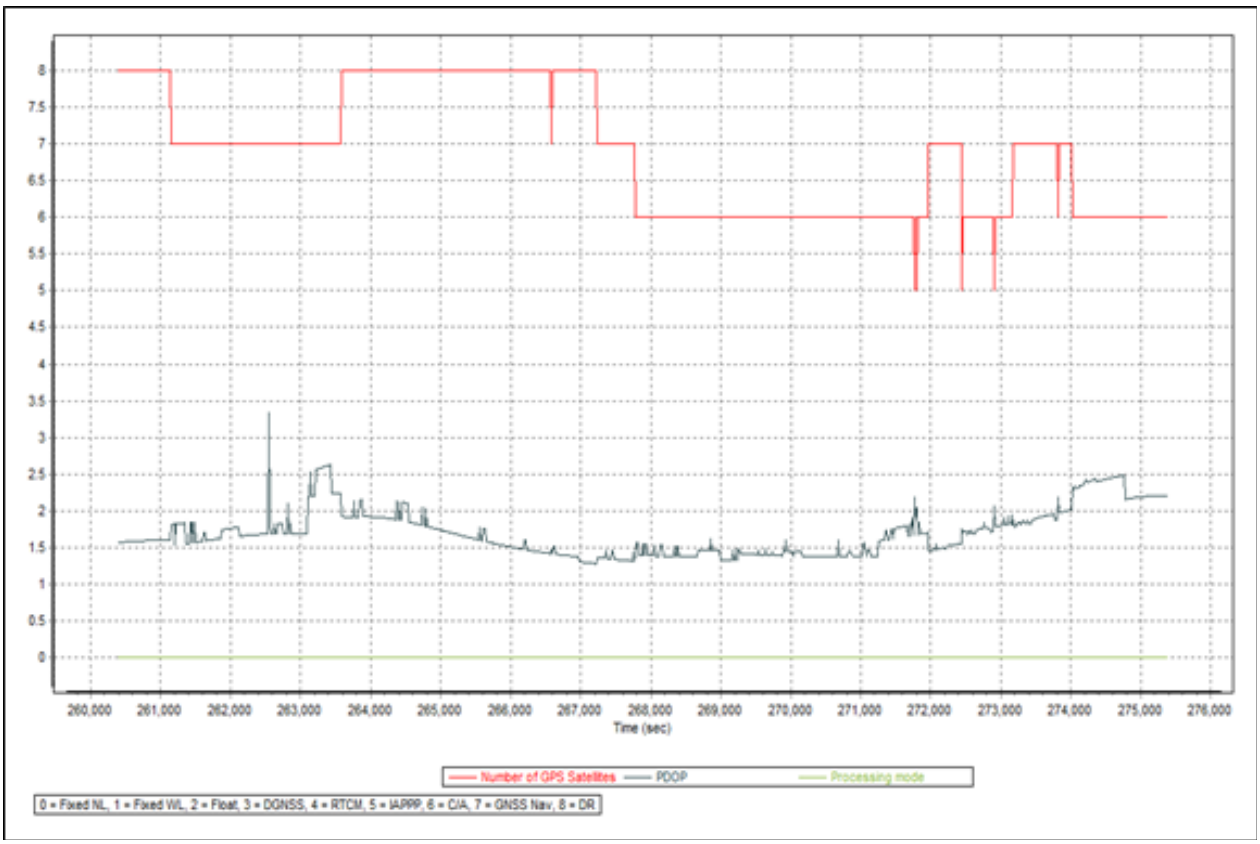


Density map of merged LiDAR data

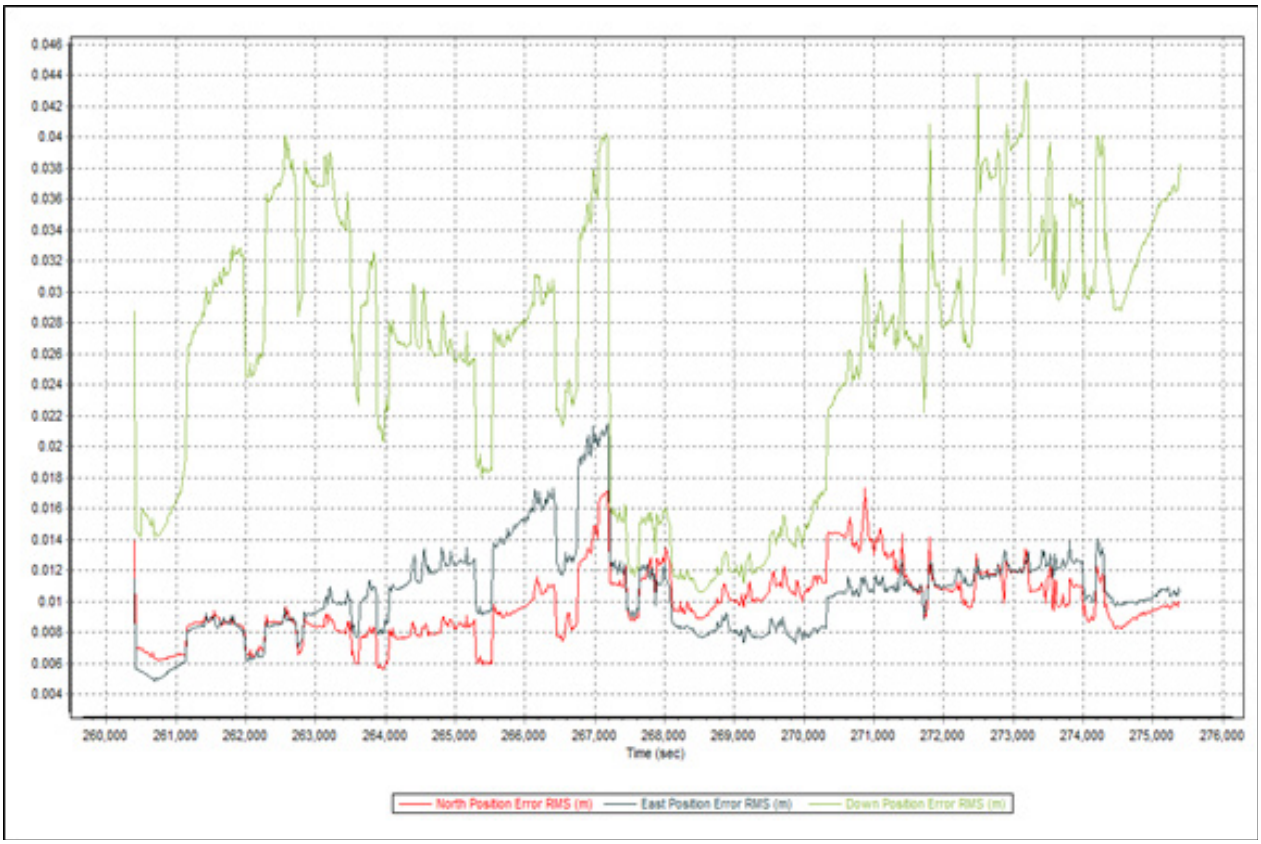


Elevation difference between flight lines

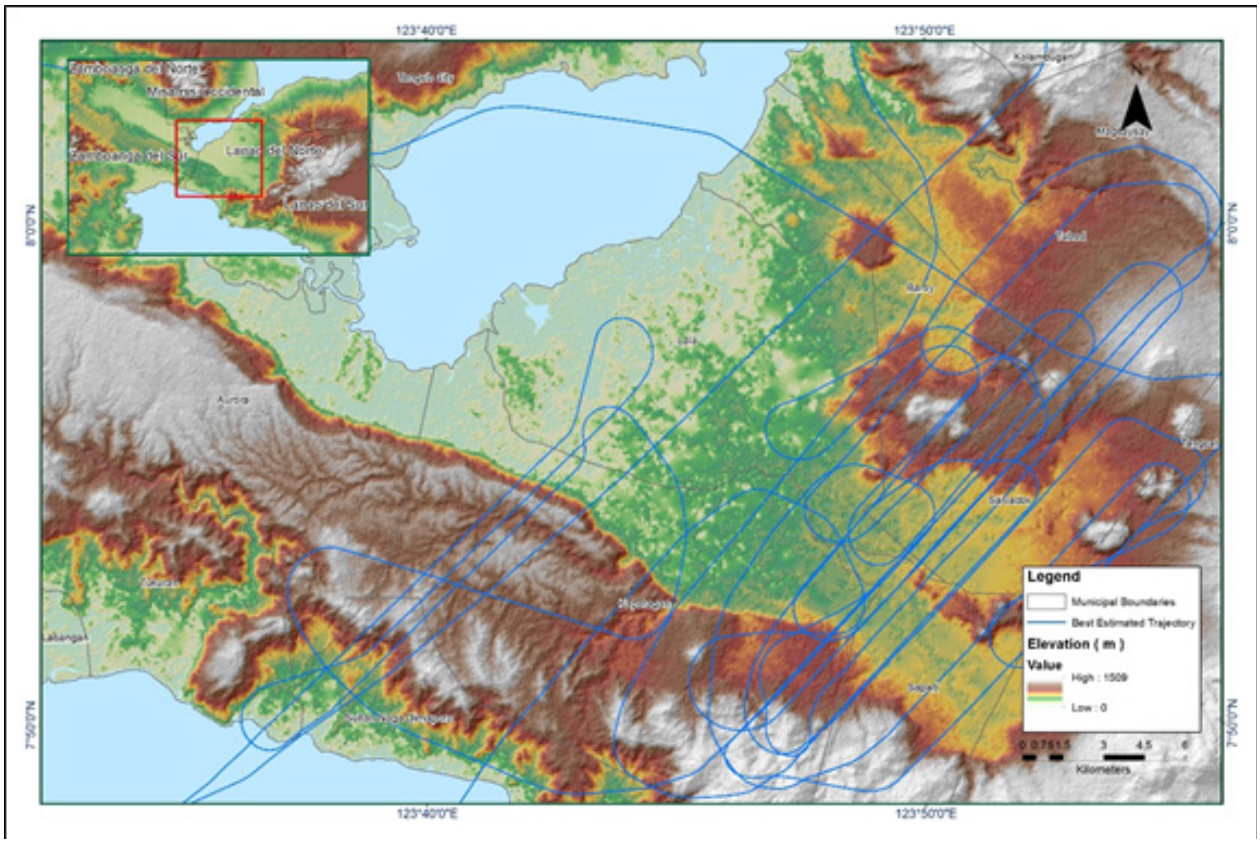
Flight Area	Pagadian
Mission Name	76K_Additional
Inclusive Flights	23104P
Range data size	14.6
POS data size	202
Base data size	60.7
Image	n/a
Transfer date	March 16, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.8
RMSE for East Position (<4.0 cm)	2.2
RMSE for Down Position (<8.0 cm)	4.4
Boresight correction stdev (<0.001deg)	0.000102
IMU attitude correction stdev (<0.001deg)	N/A
GPS position stdev (<0.01m)	0.0014
Minimum % overlap (>25)	9.58
Ave point cloud density per sq.m. (>2.0)	2.85
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	105
Maximum Height	416.26 m
Minimum Height	68.45 m
Classification (# of points)	
Ground	64,960,783
Low vegetation	36,364,032
Medium vegetation	44,325,454
High vegetation	121,969,533
Building	1,432,563
Orthophoto	Yes
Processed by	Engr. Don Matthew Banatin, Engr. Melanie Hingpit, Engr. Karl Adrian Vergara



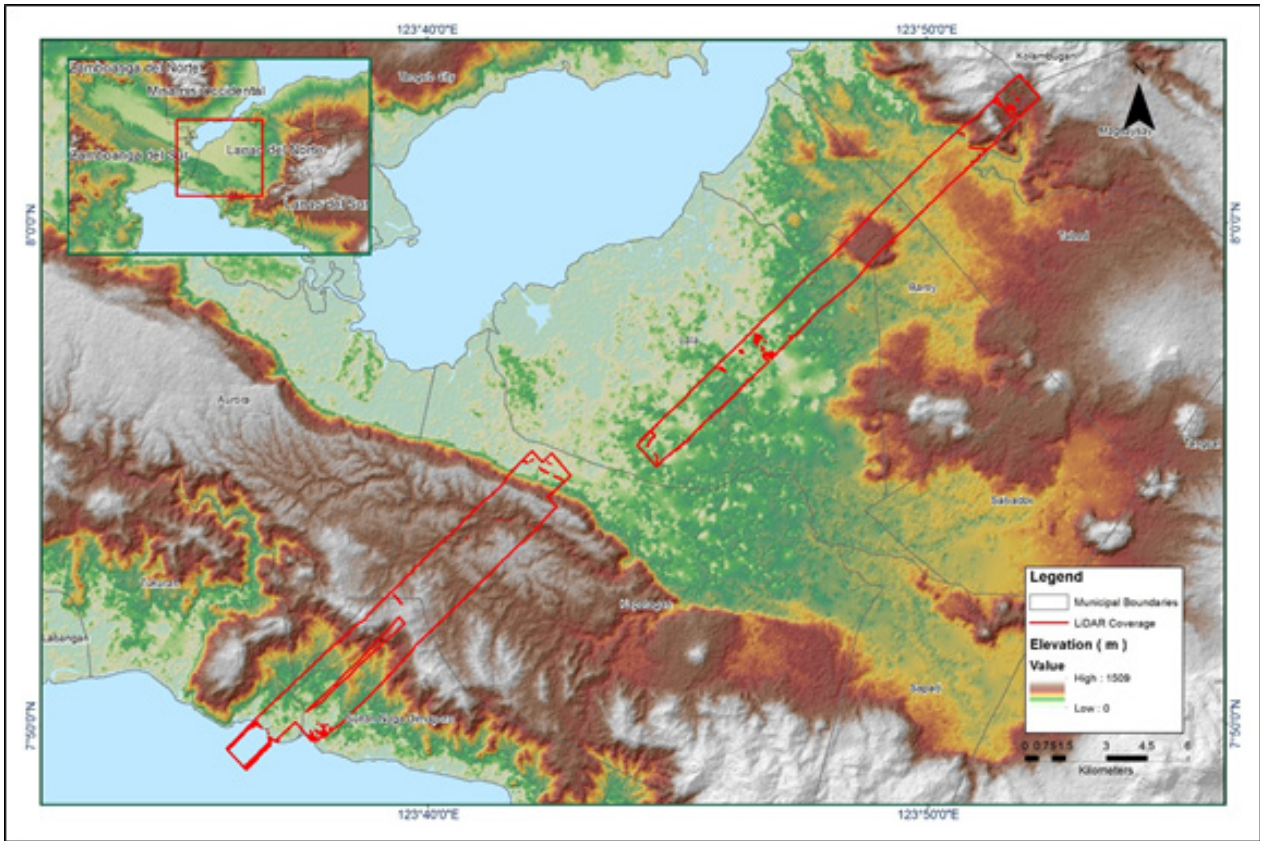
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

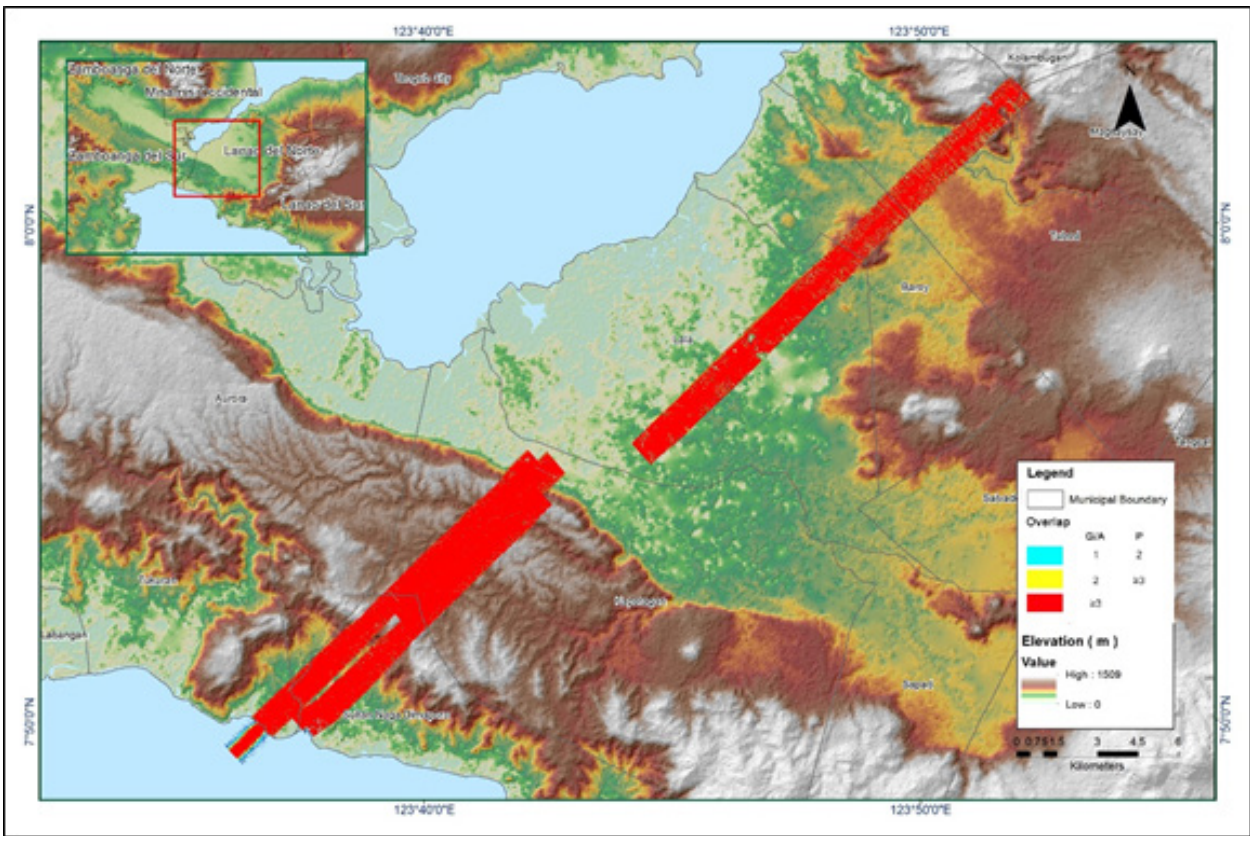
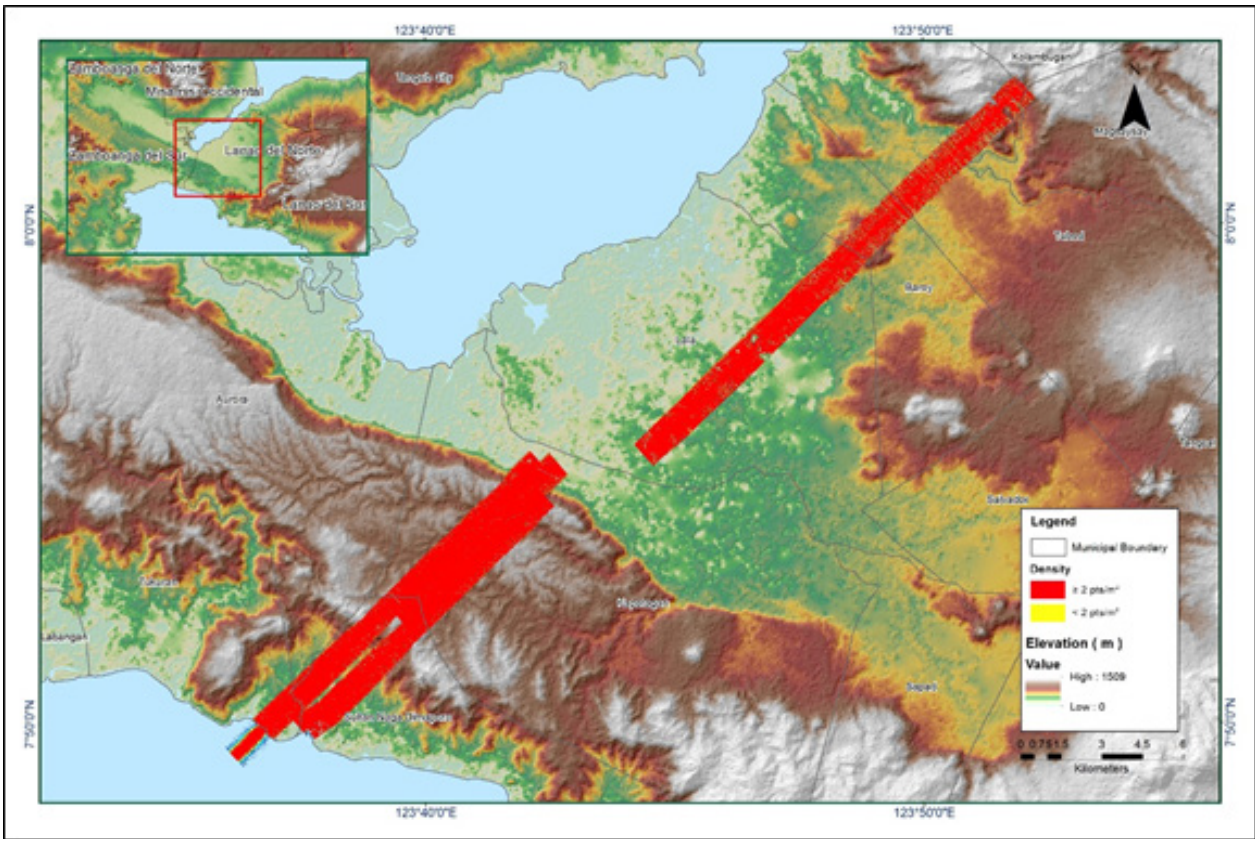
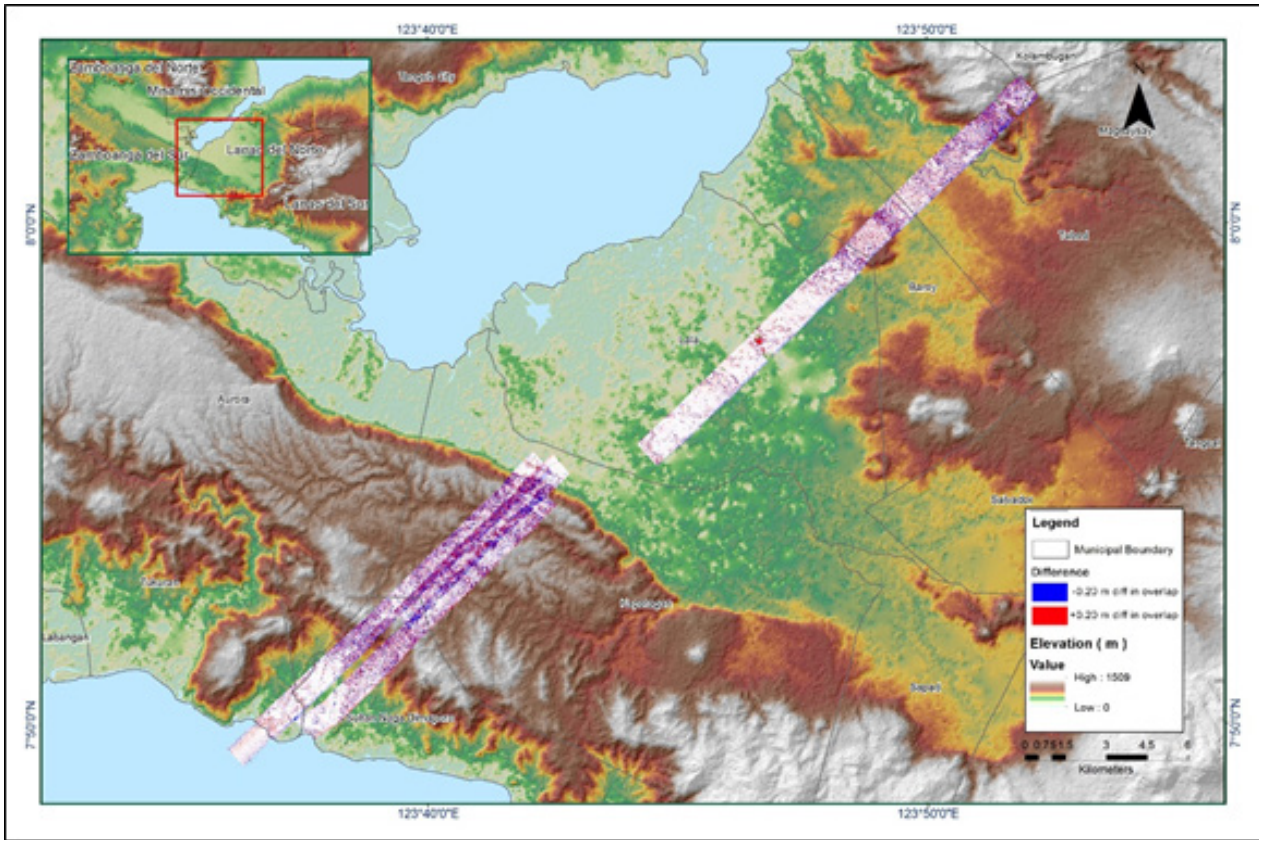


Image of Data Overlap

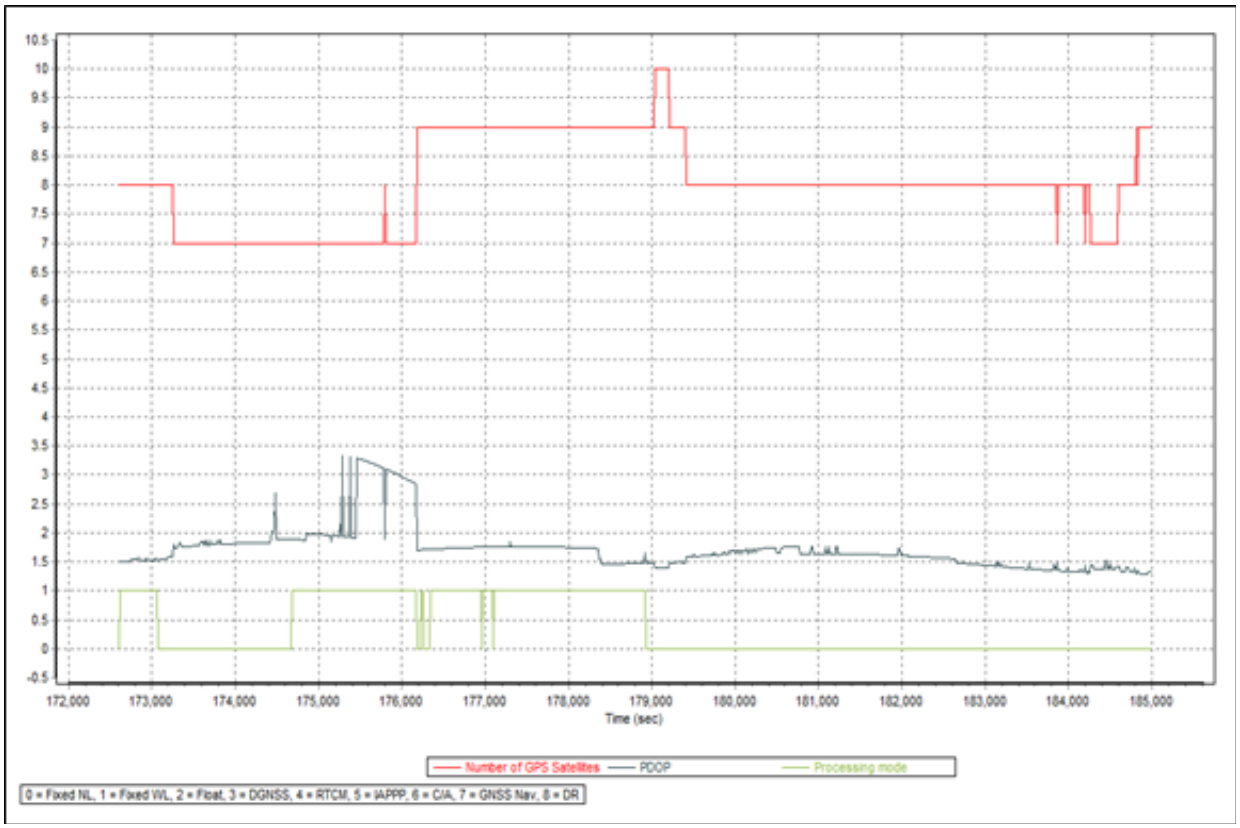


Density map of merged LiDAR data

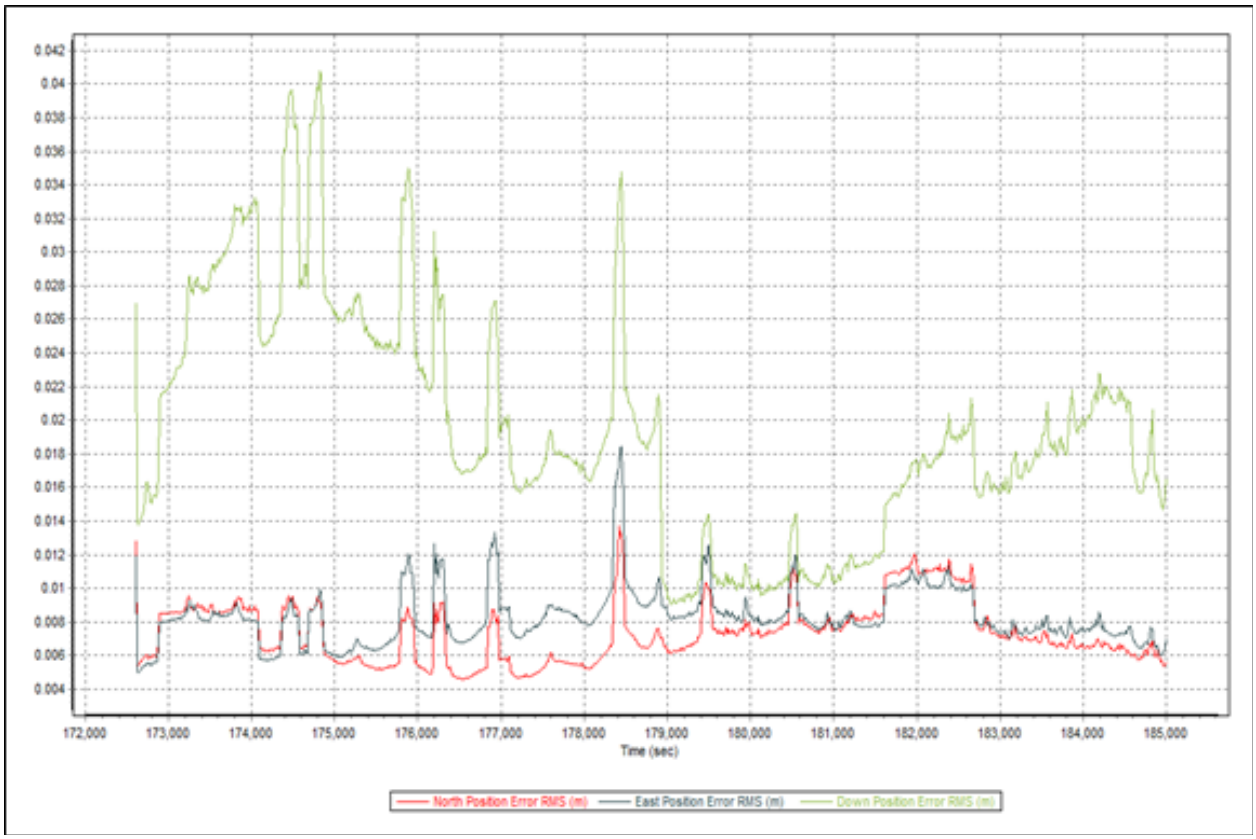


Elevation difference between flight lines

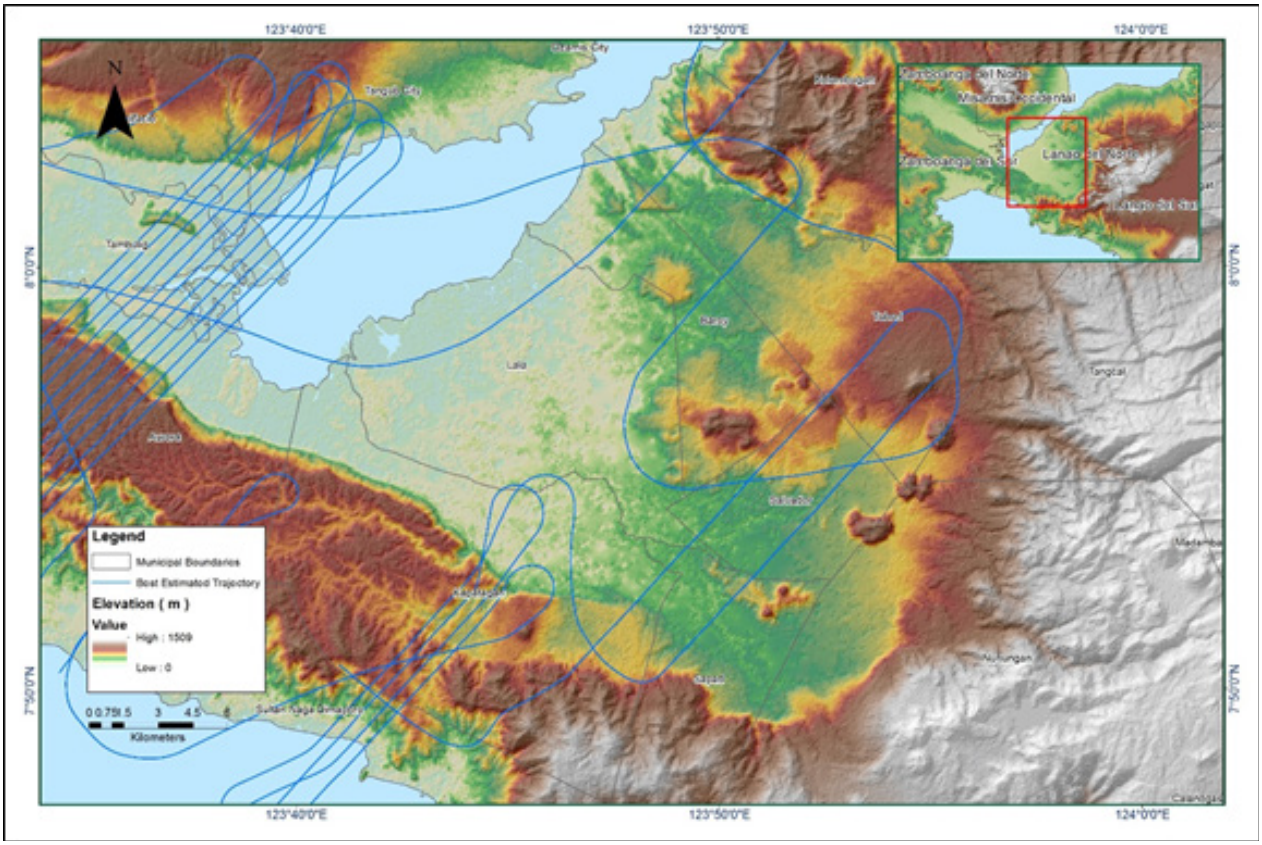
Flight Area	Pagadian
Mission Name	76M
Inclusive Flights	23128P
Range data size	23.30 GB
POS data size	273 MB
Base data size	311 MB
Image	n/a
Transfer date	March 10, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.4
RMSE for East Position (<4.0 cm)	1.9
RMSE for Down Position (<8.0 cm)	4.1
Boresight correction stdev (<0.001deg)	0.000128
IMU attitude correction stdev (<0.001deg)	0.000139
GPS position stdev (<0.01m)	0.0122
Minimum % overlap (>25)	14.01
Ave point cloud density per sq.m. (>2.0)	3.32
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	173
Maximum Height	503.88 m
Minimum Height	67.66 m
Classification (# of points)	
Ground	100,531,253
Low vegetation	60,833,381
Medium vegetation	70,336,602
High vegetation	177,937,163
Building	1,895,317
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Aljon Rei Araneta, Maria Tamsyn Malabanan



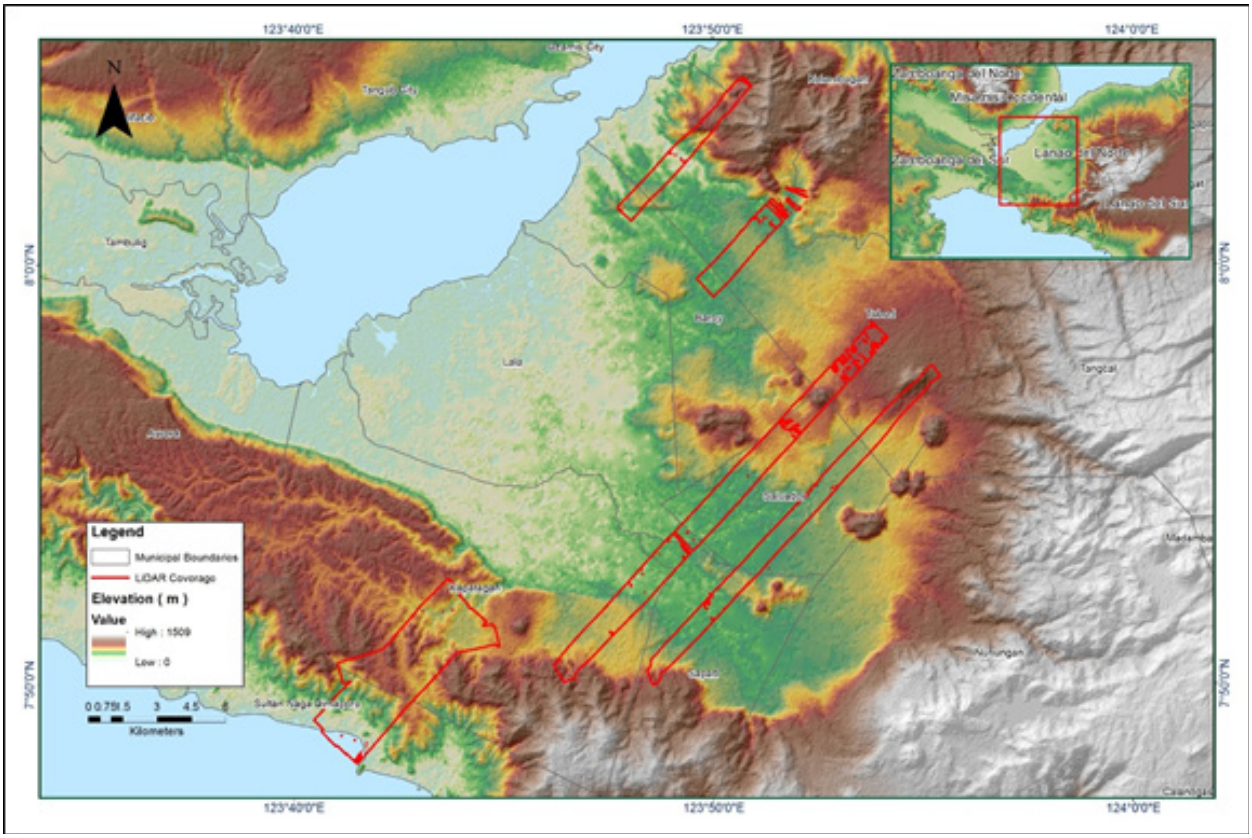
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

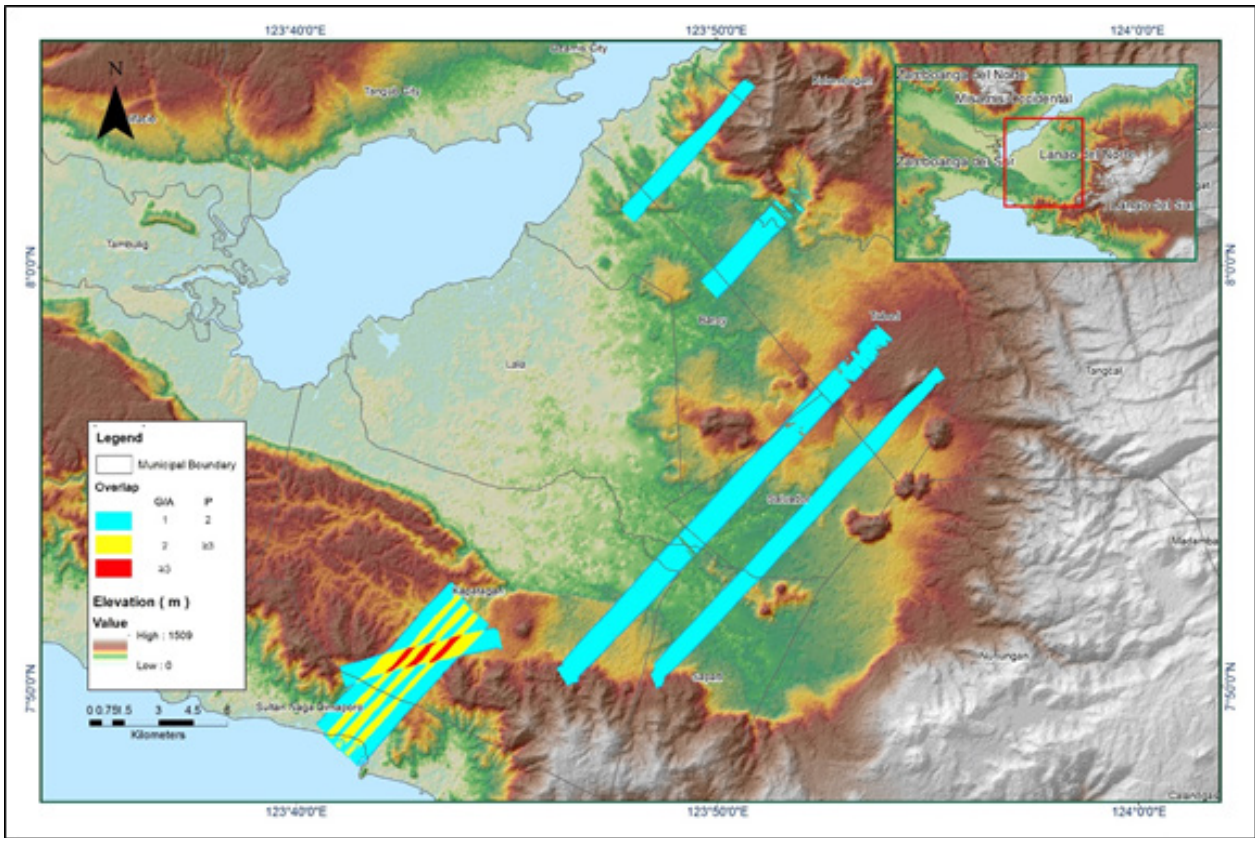
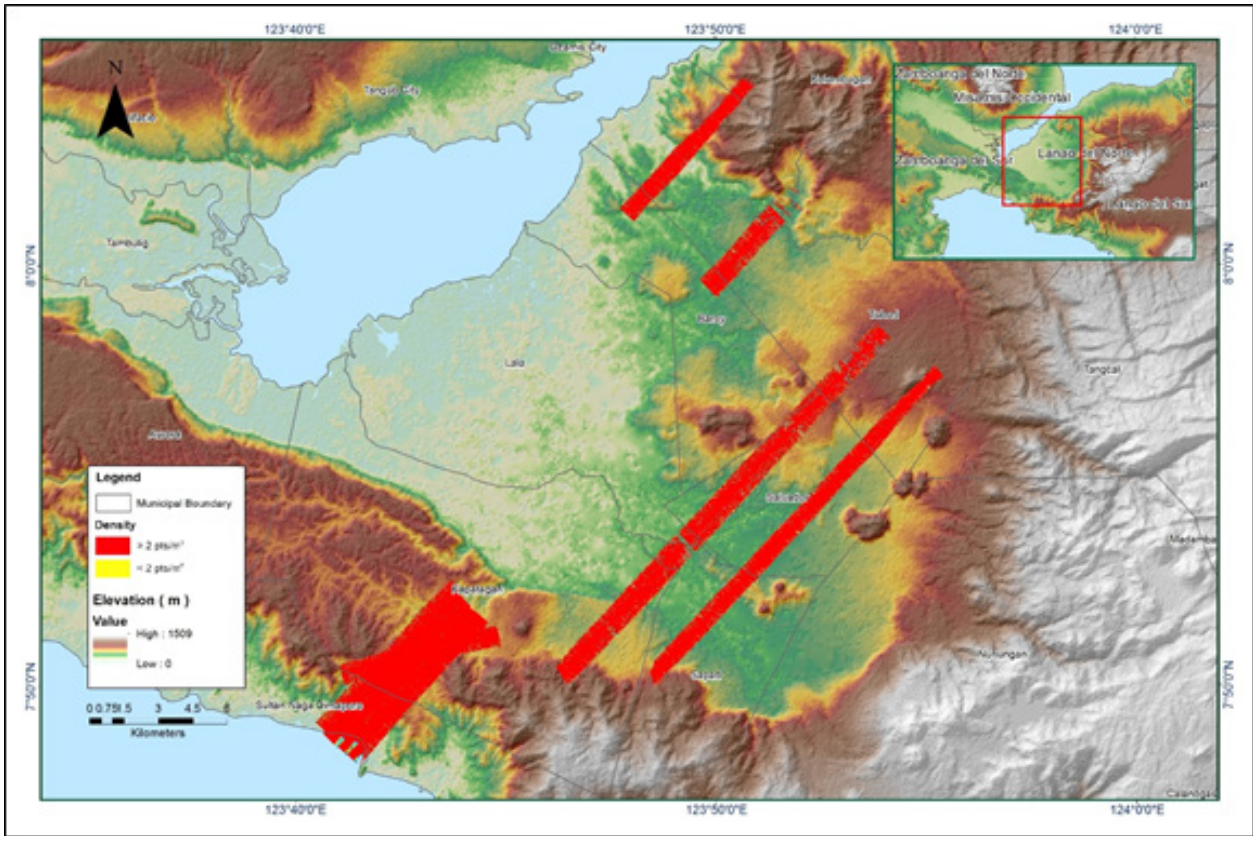
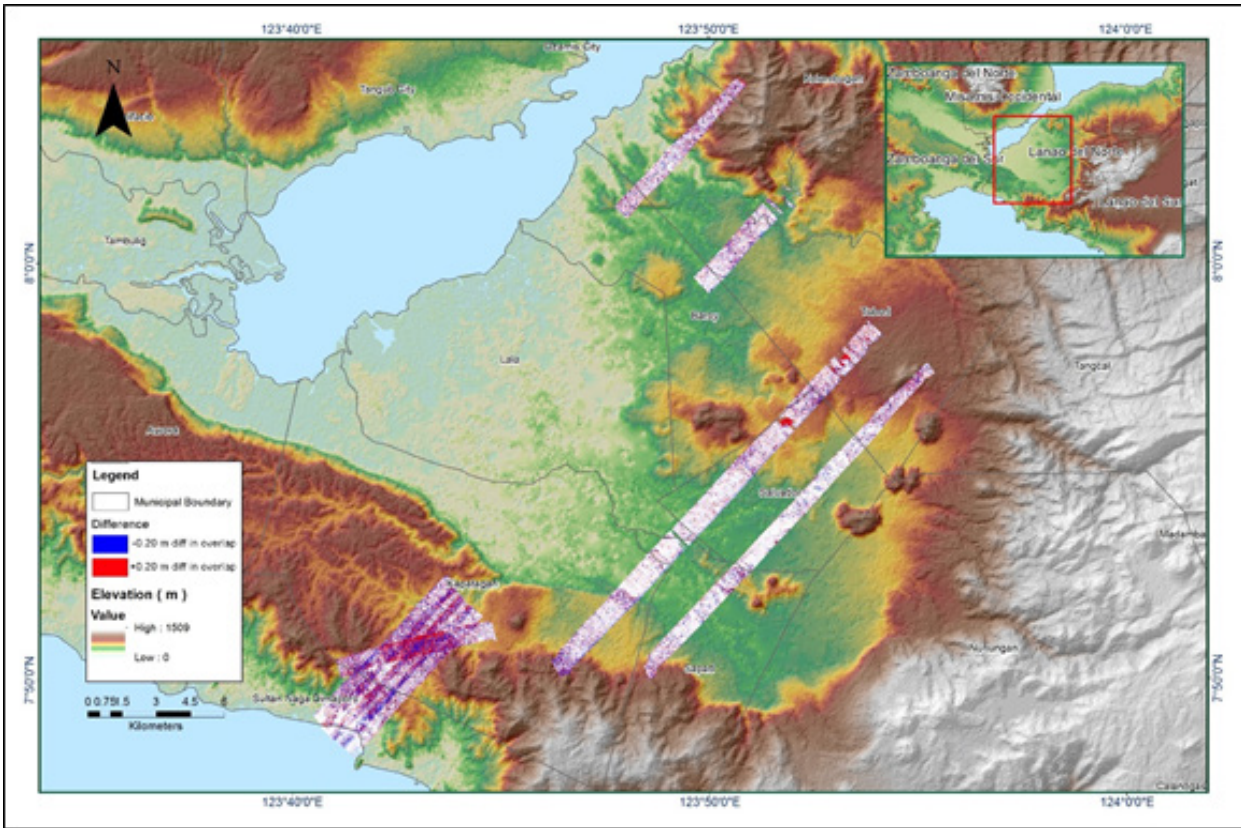


Image of Data Overlap

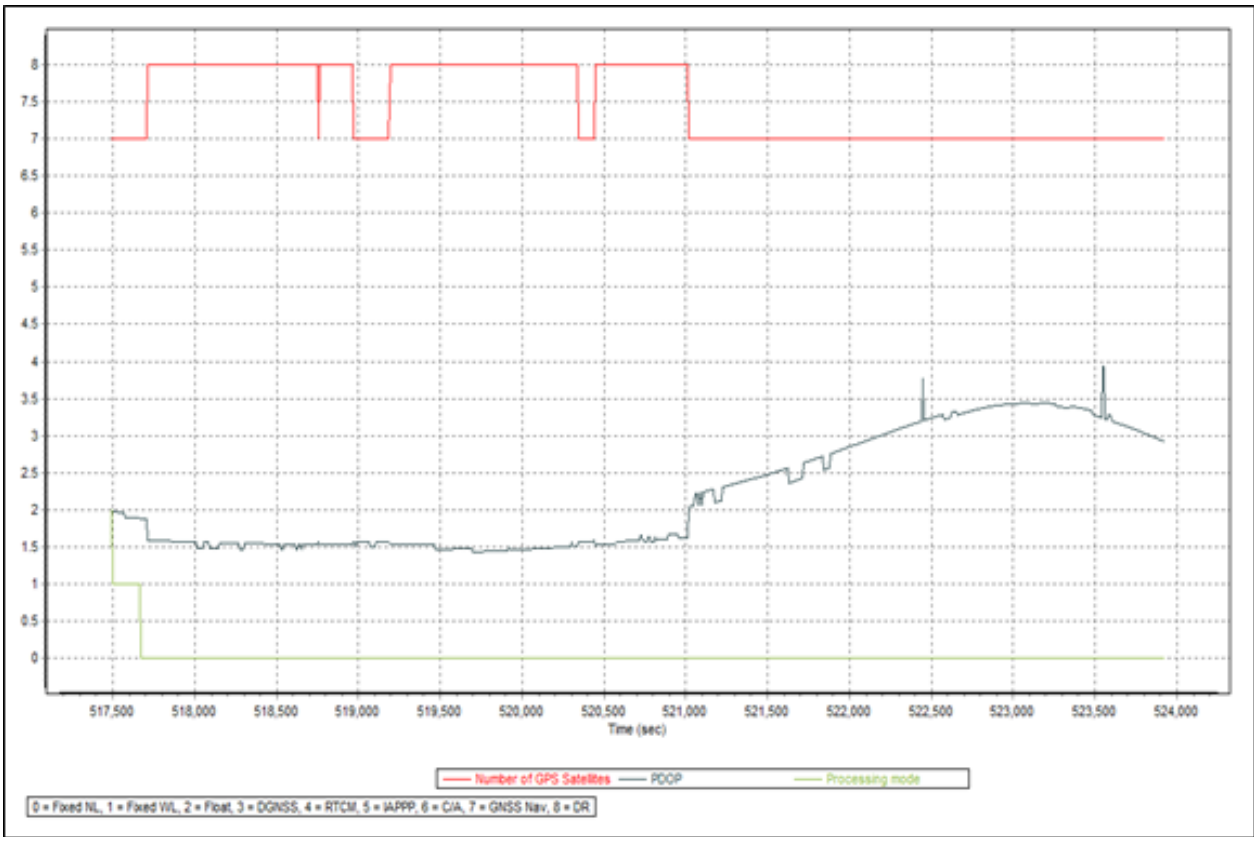


Density map of merged LiDAR data

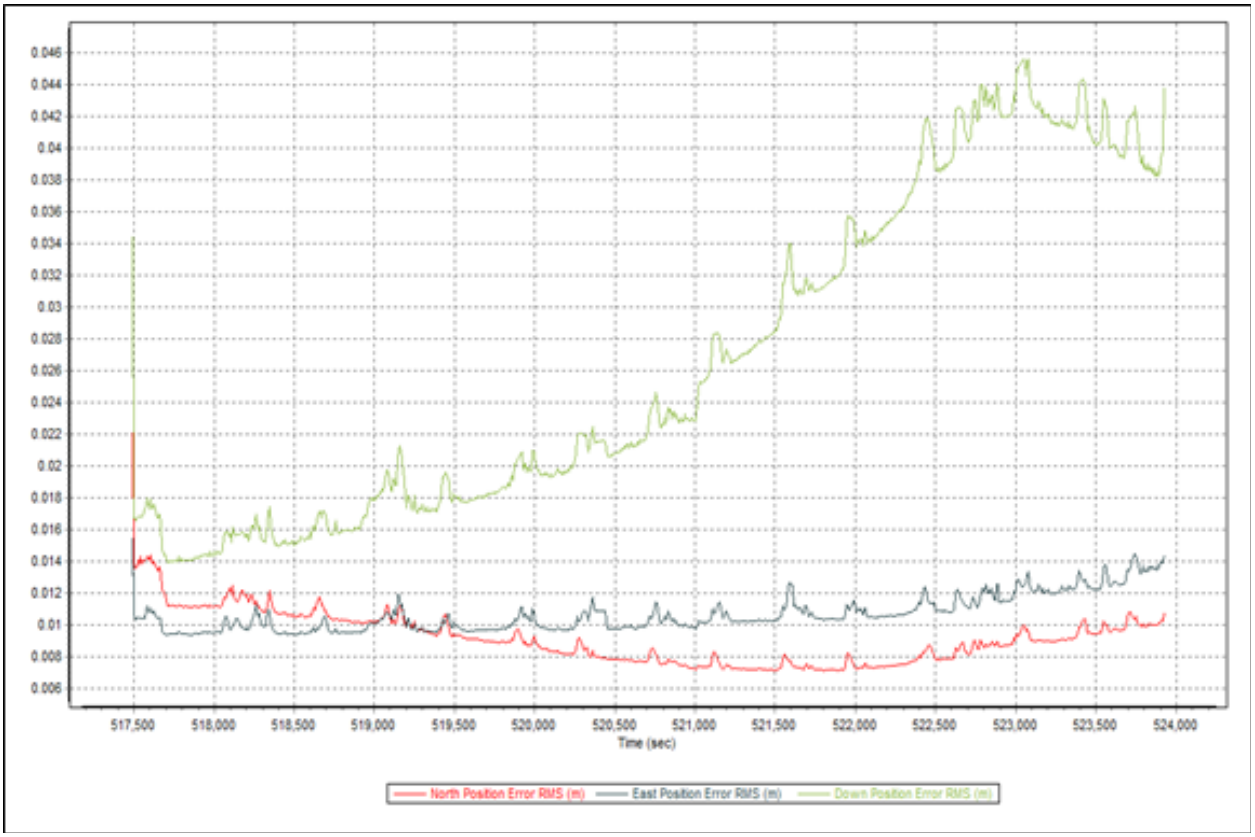


Elevation difference between flight lines

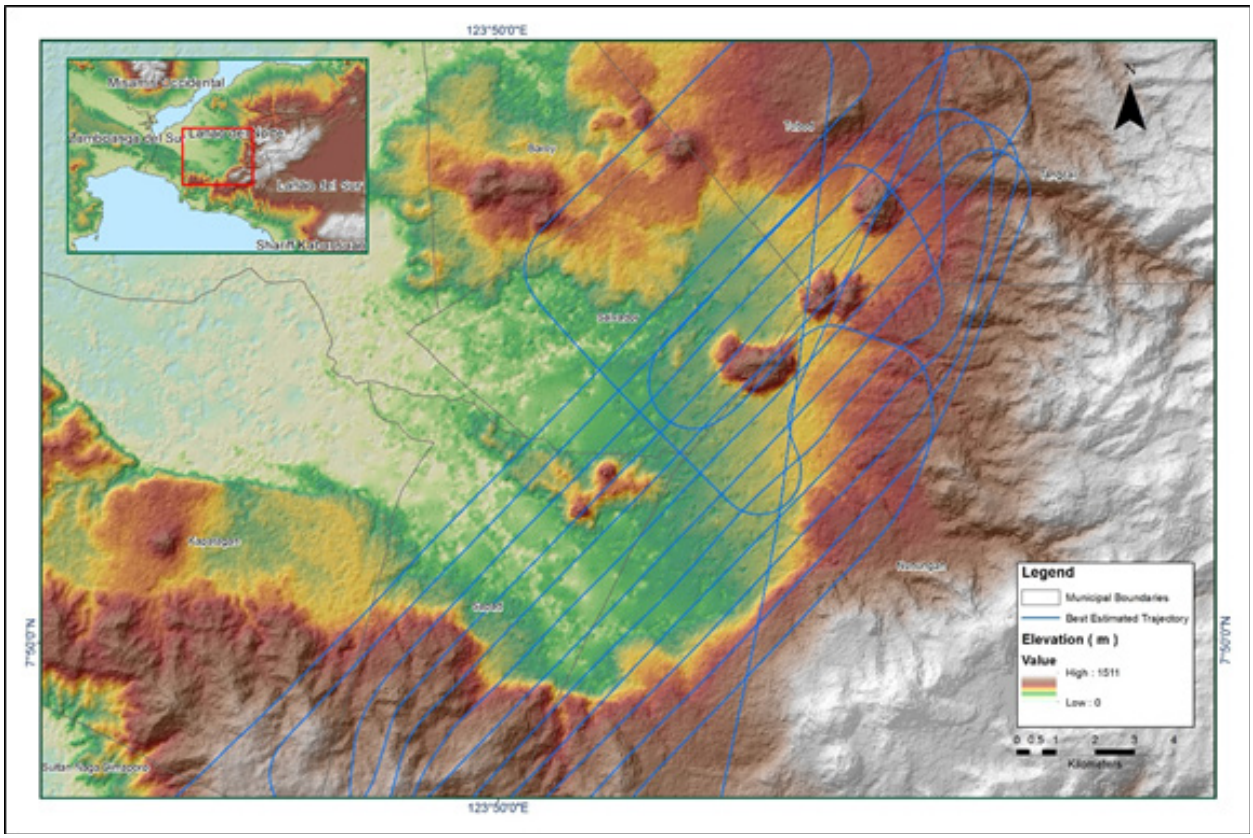
Flight Area	Pagadian
Mission Name	76N
Inclusive Flights	23088P
Range data size	24.65
POS data size	283.62
Base data size	101.29
Image	n/a
Transfer date	March 01, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.5
RMSE for East Position (<4.0 cm)	1.5
RMSE for Down Position (<8.0 cm)	4.6
Boresight correction stdev (<0.001deg)	0.000274
IMU attitude correction stdev (<0.001deg)	0.001049
GPS position stdev (<0.01m)	0.0073
Minimum % overlap (>25)	41.91
Ave point cloud density per sq.m. (>2.0)	2.98
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	189
Maximum Height	726.06 m
Minimum Height	92.16 m
Classification (# of points)	
Ground	140,736,400
Low vegetation	124,627,028
Medium vegetation	126,549,841
High vegetation	285,028,320
Building	4,597,452
Orthophoto	Yes
Processed by	Engr. Analyn Naldo, Engr. Merven Matthew Natino, Marie Denise Bueno



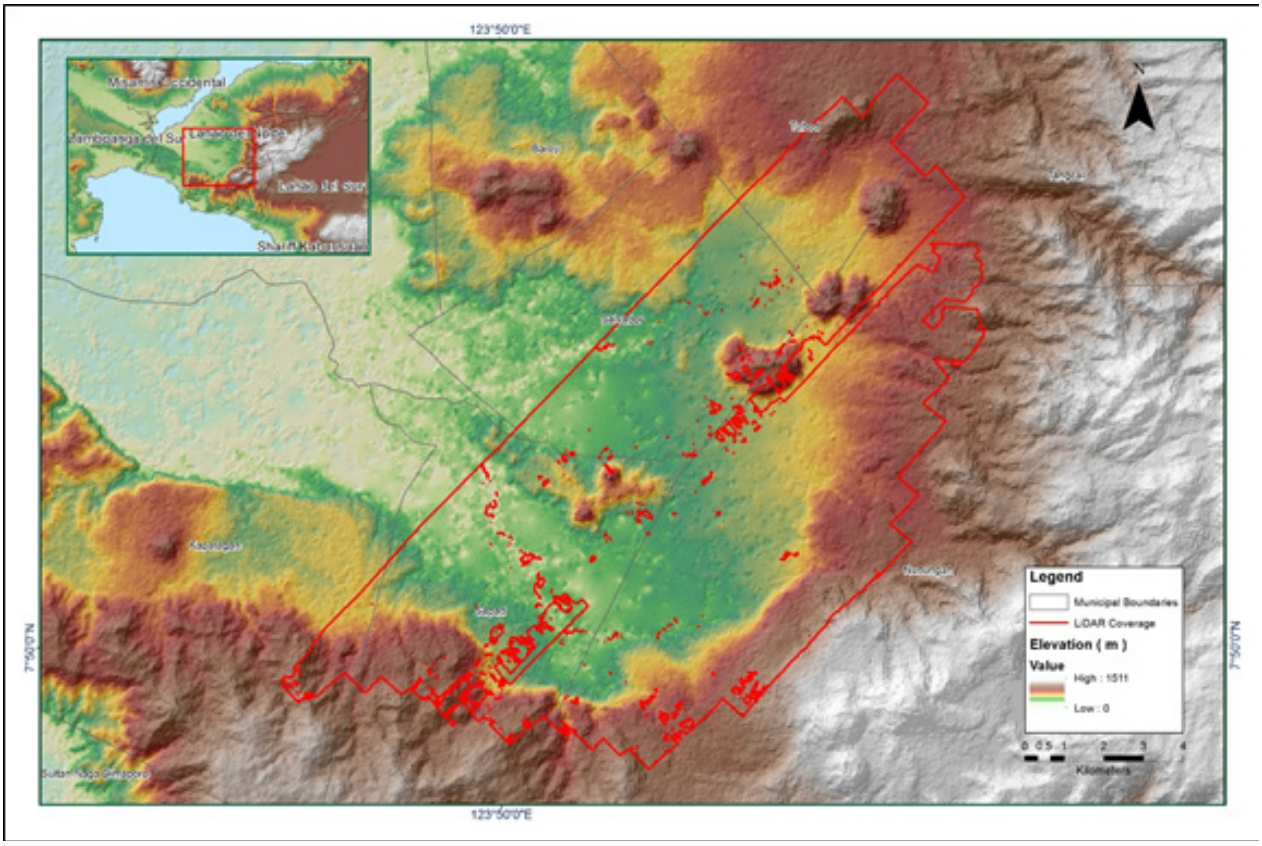
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

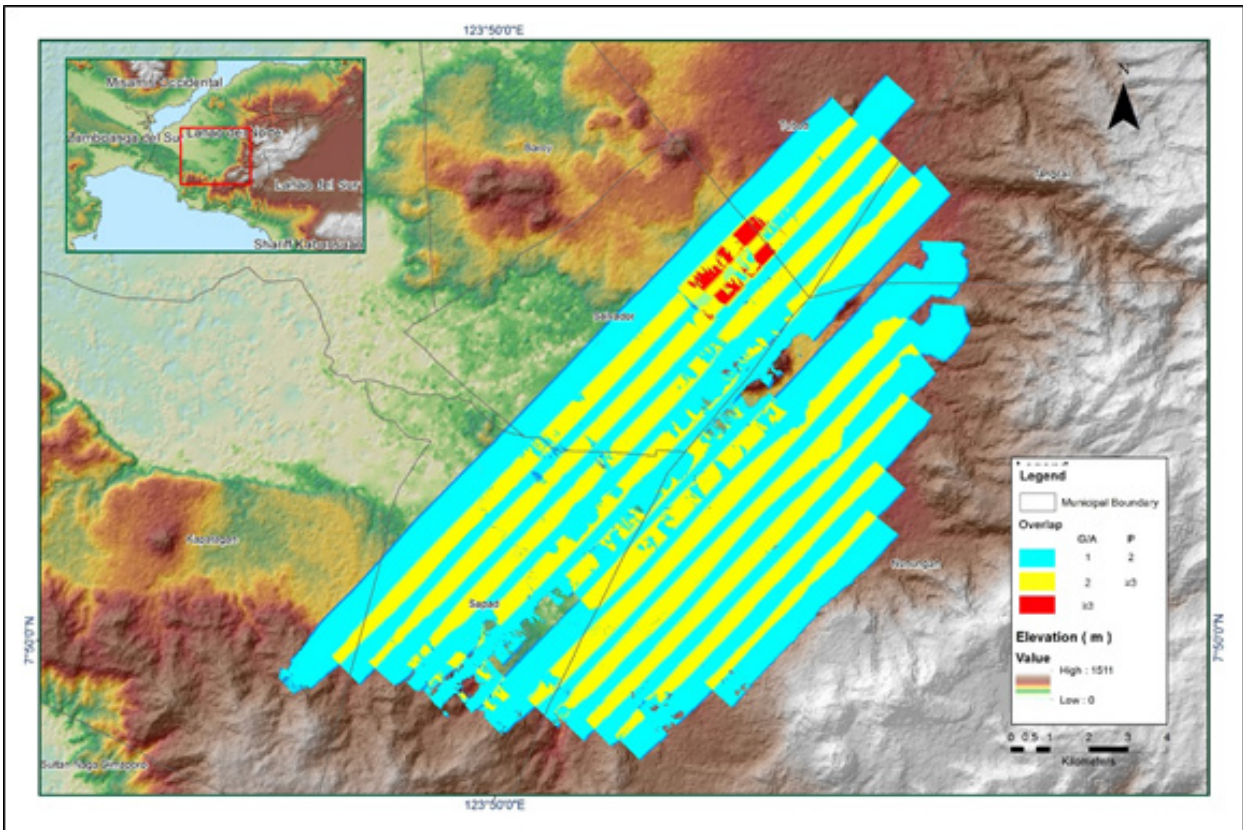
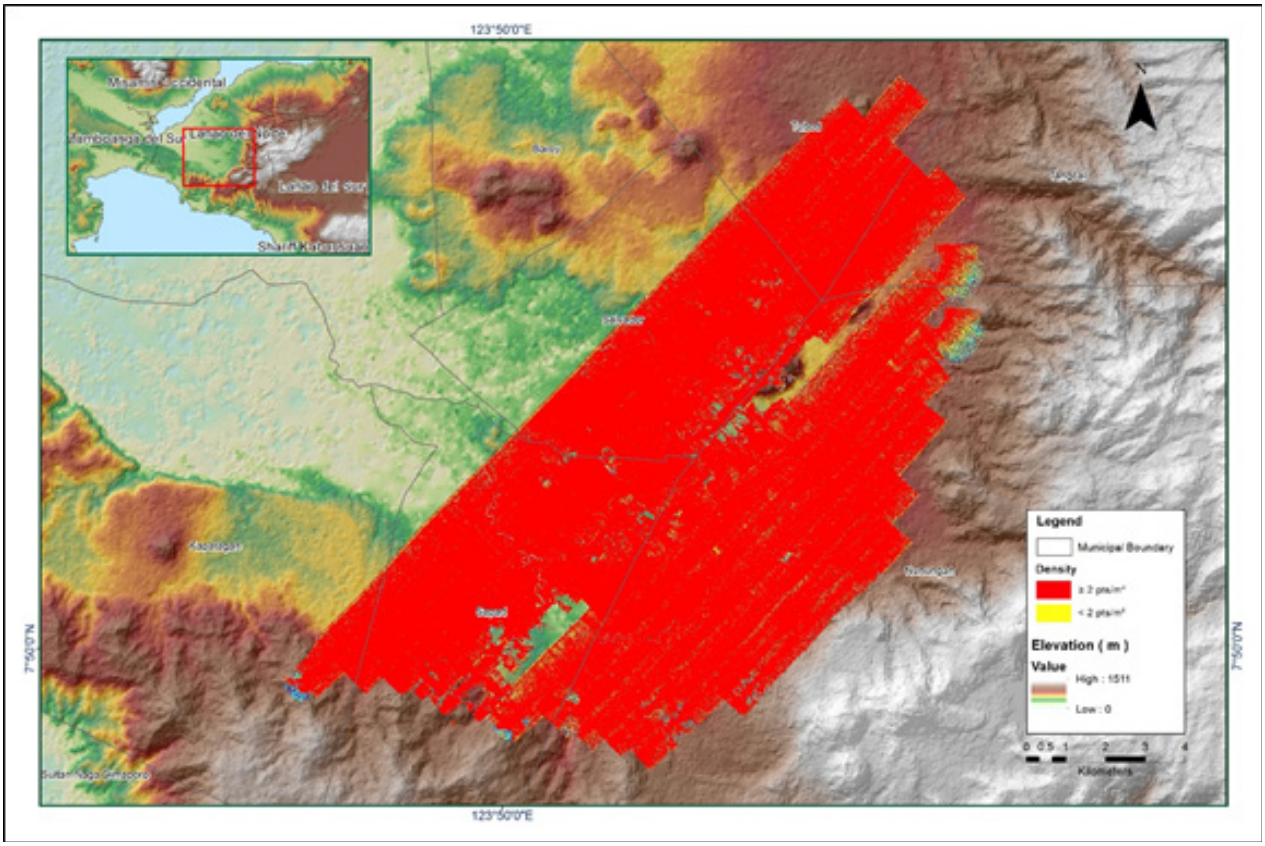
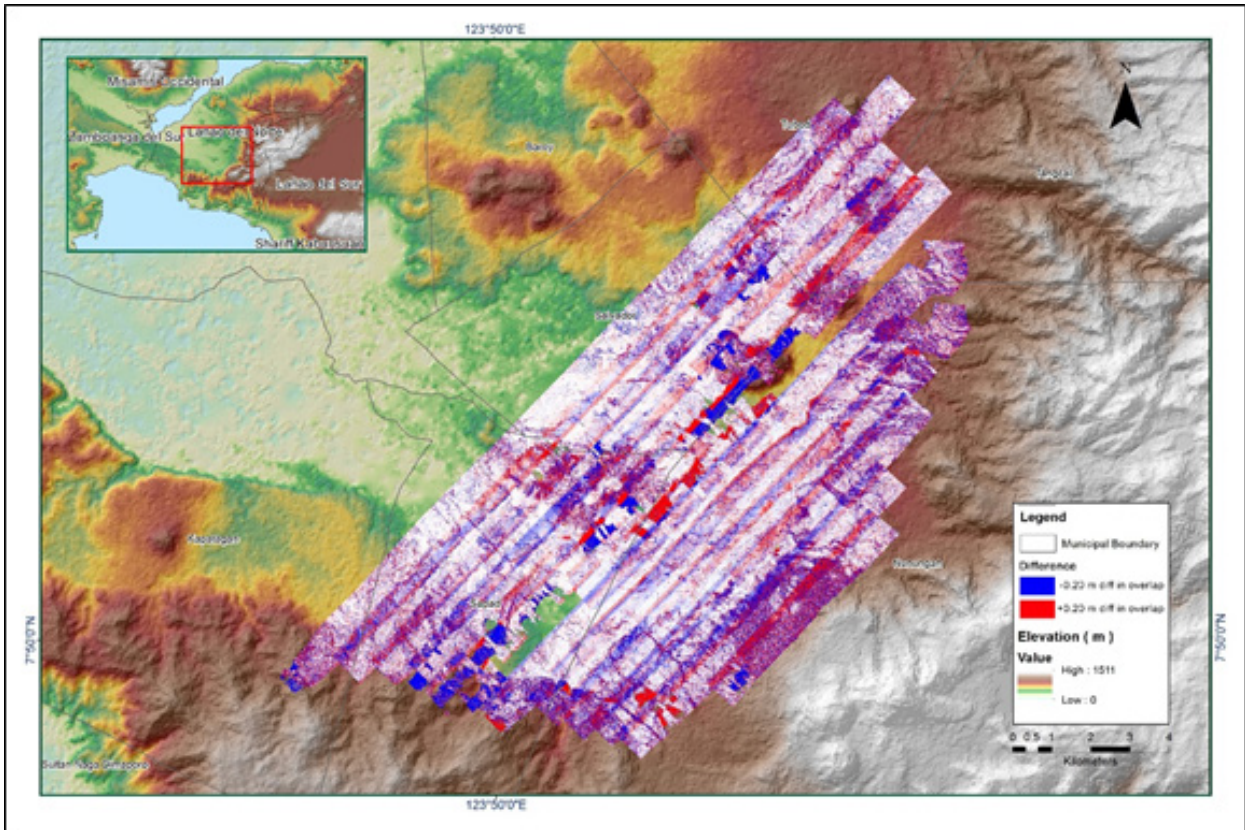


Image of Data Overlap

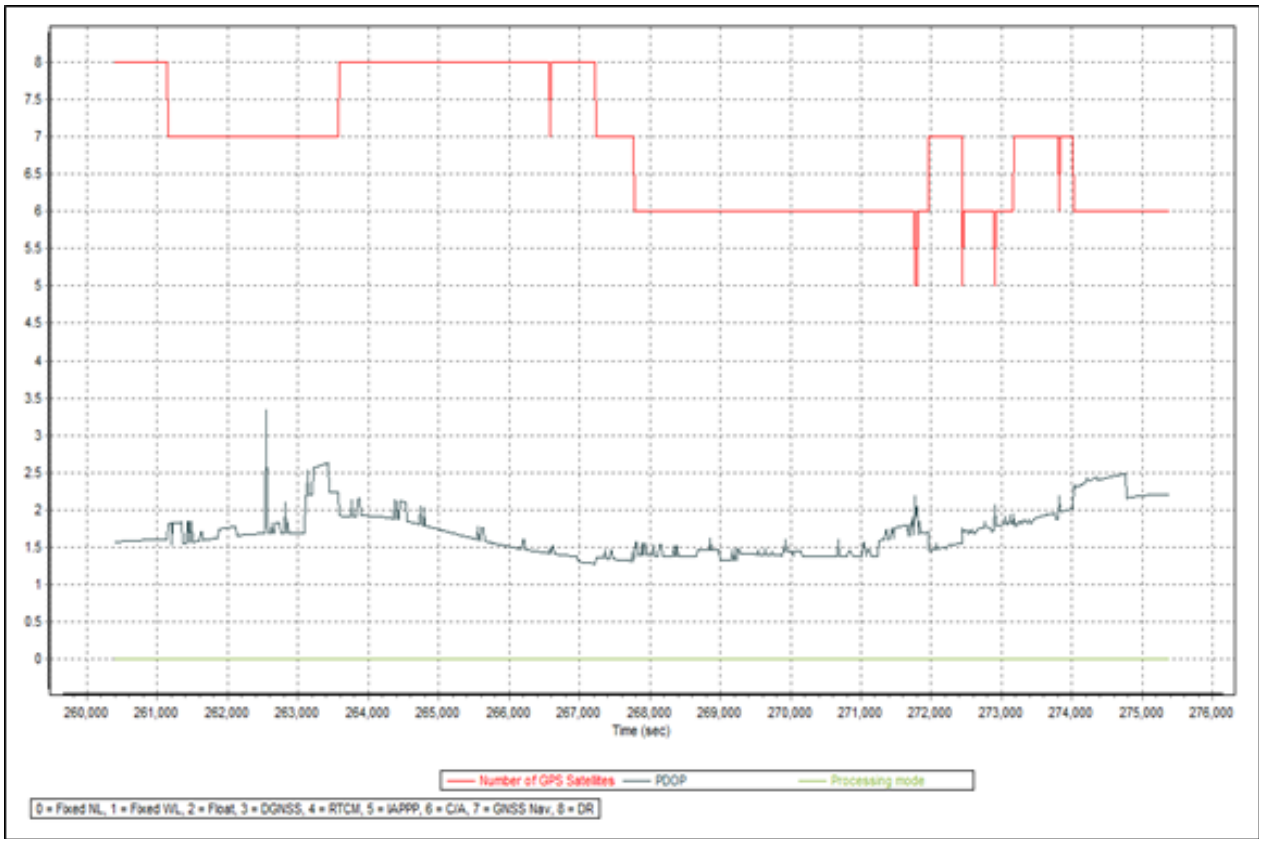


Density map of merged LiDAR data

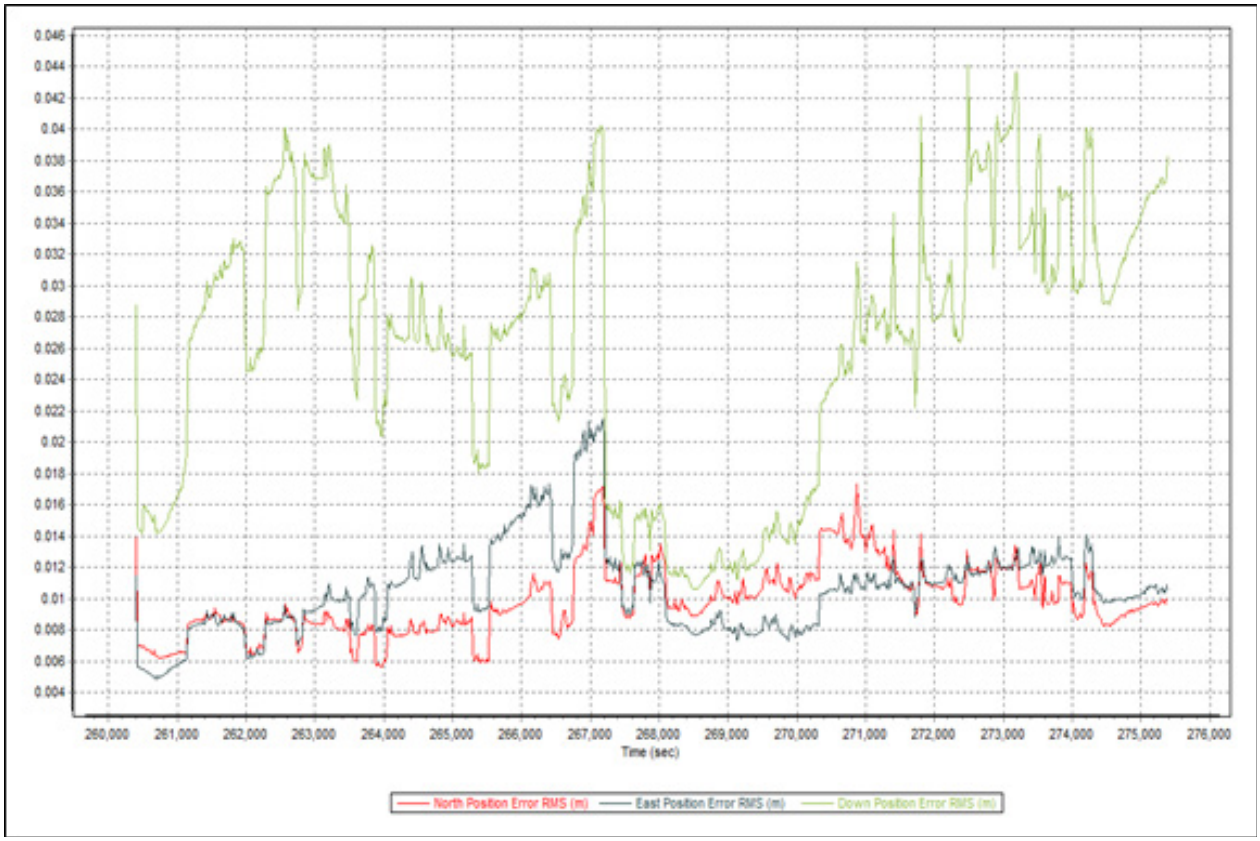


Elevation difference between flight lines

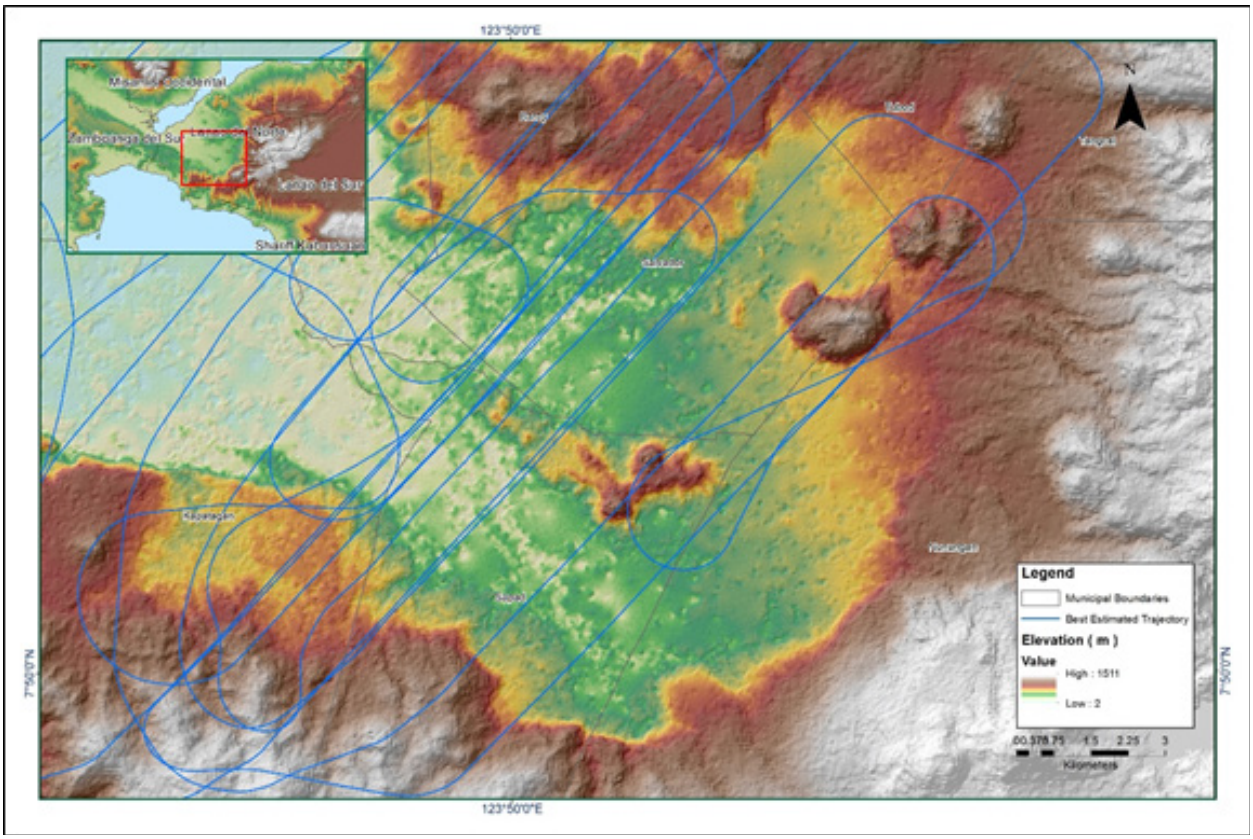
Flight Area	Pagadian
Mission Name	76N_Additional
Inclusive Flights	23104P
Range data size	18.3
POS data size	287.01
Base data size	116.78
Image	n/a
Transfer date	March 01, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.7
RMSE for East Position (<4.0 cm)	2.2
RMSE for Down Position (<8.0 cm)	4.2
Boresight correction stdev (<0.001deg)	N/A
IMU attitude correction stdev (<0.001deg)	N/A
GPS position stdev (<0.01m)	N/A
Minimum % overlap (>25)	10.37
Ave point cloud density per sq.m. (>2.0)	2.38
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	124
Maximum Height	436.04 m
Minimum Height	90.14 m
Classification (# of points)	
Ground	56,765,012
Low vegetation	52,157,492
Medium vegetation	41,240,260
High vegetation	93,342,982
Building	1,335,125
Orthophoto	Yes
Processed by	Engr. Don Matthew Banatin, Engr. Merven Matthew Natino, Jovy Narisma



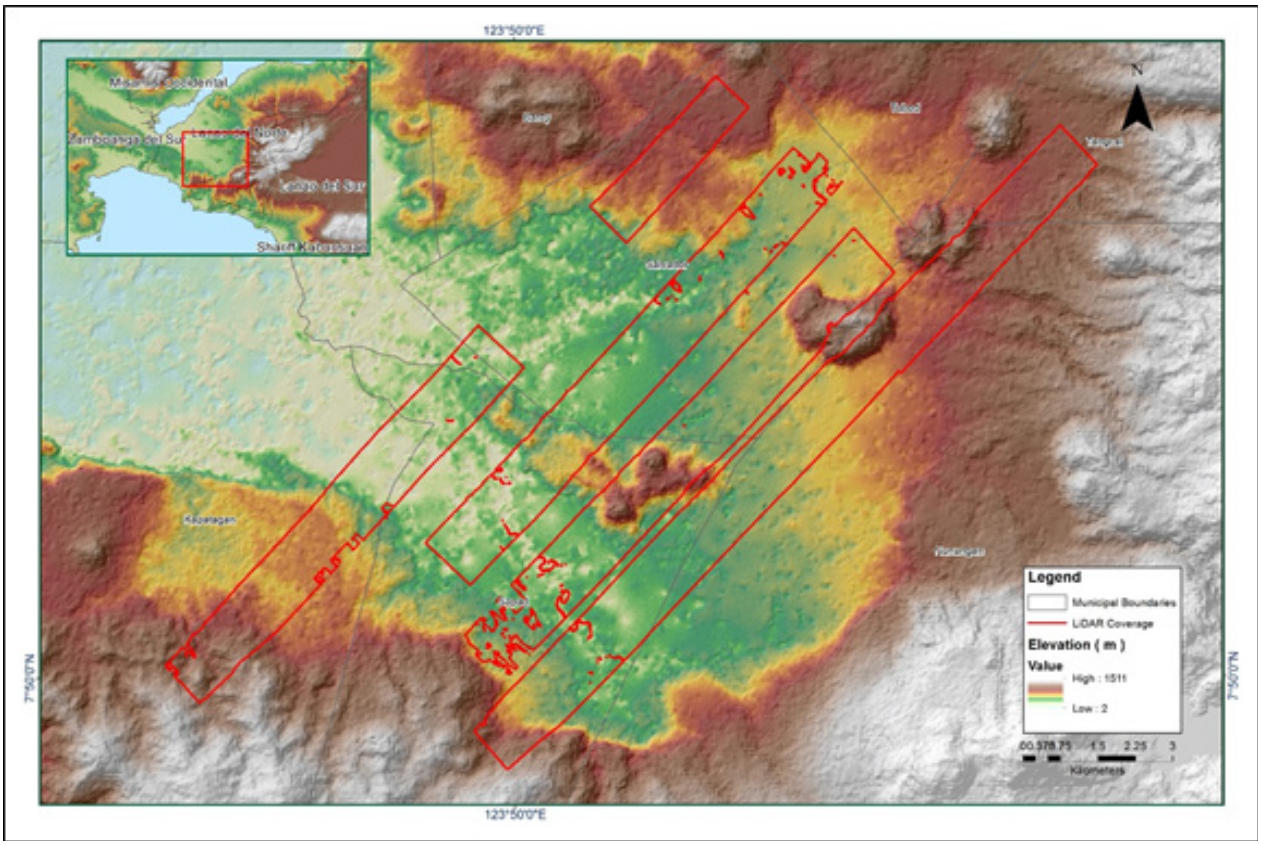
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

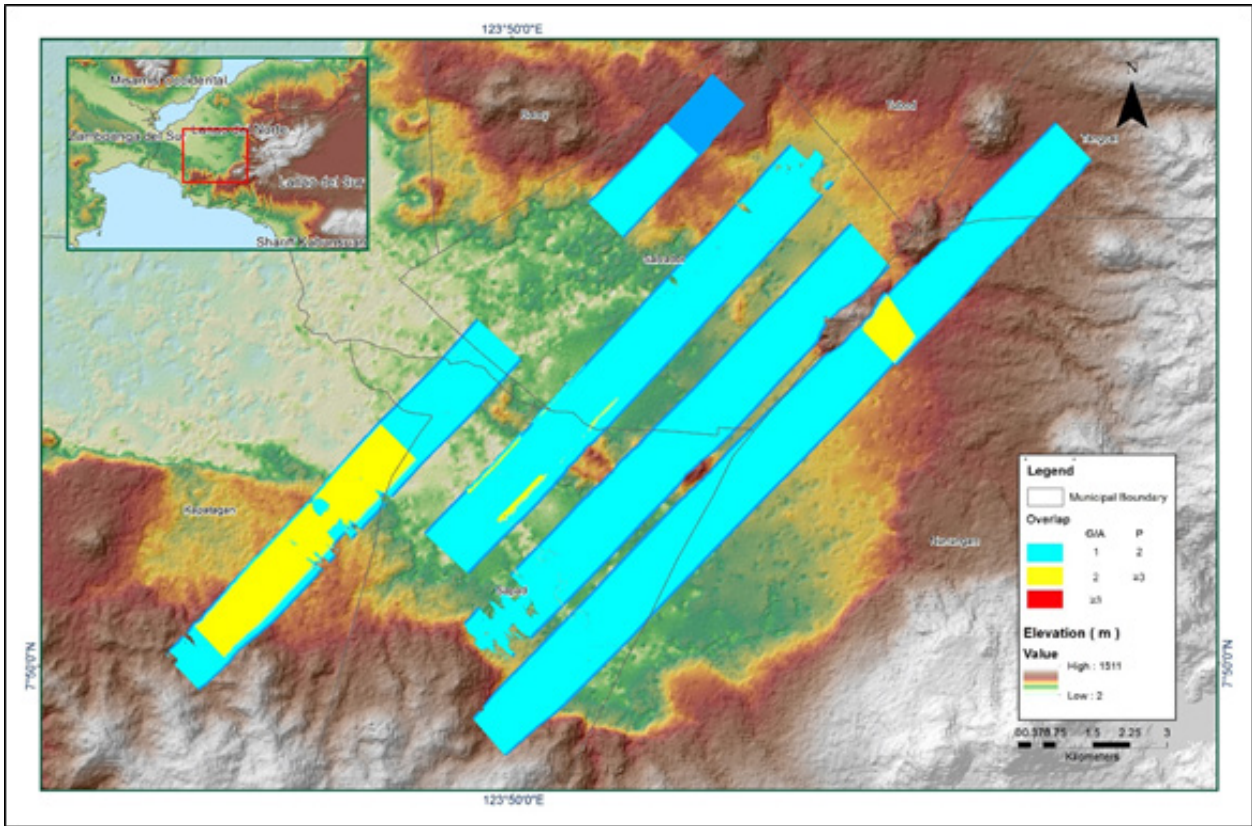
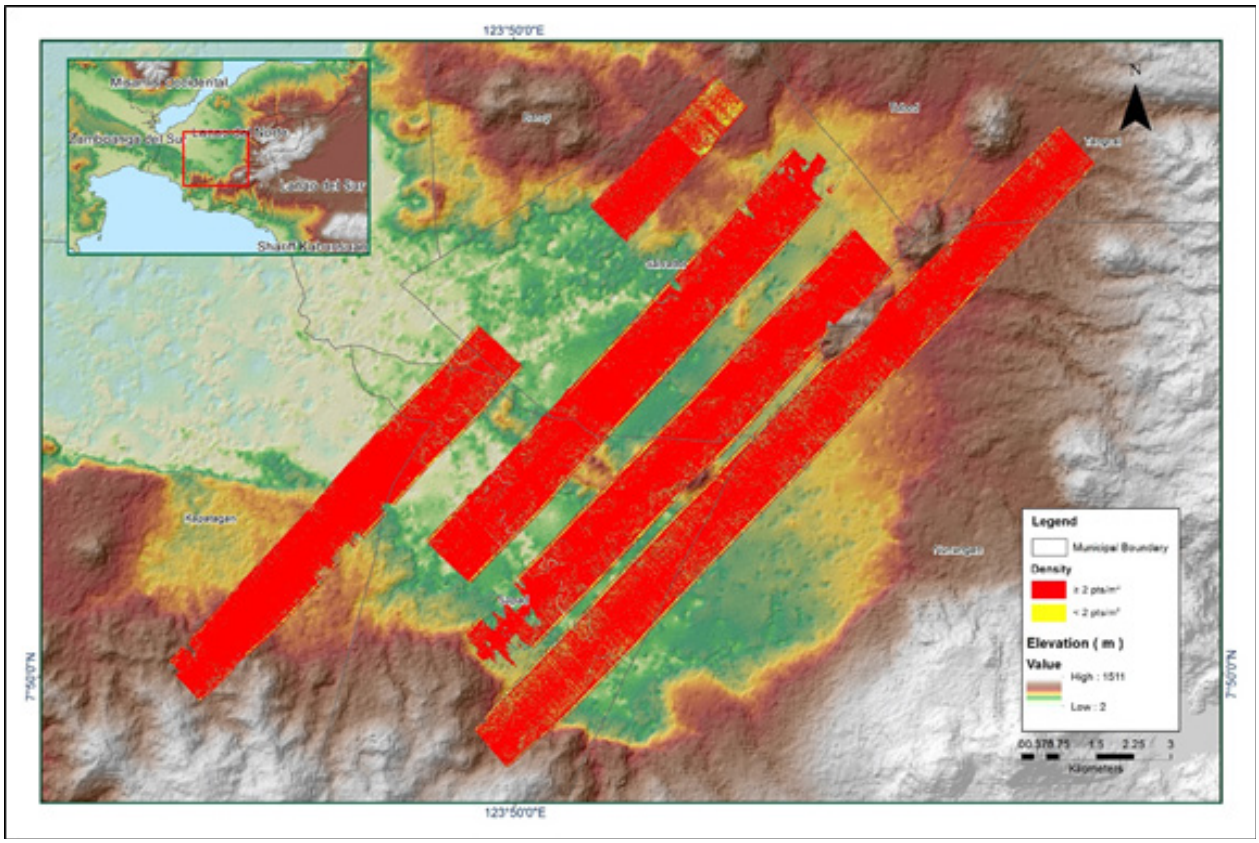
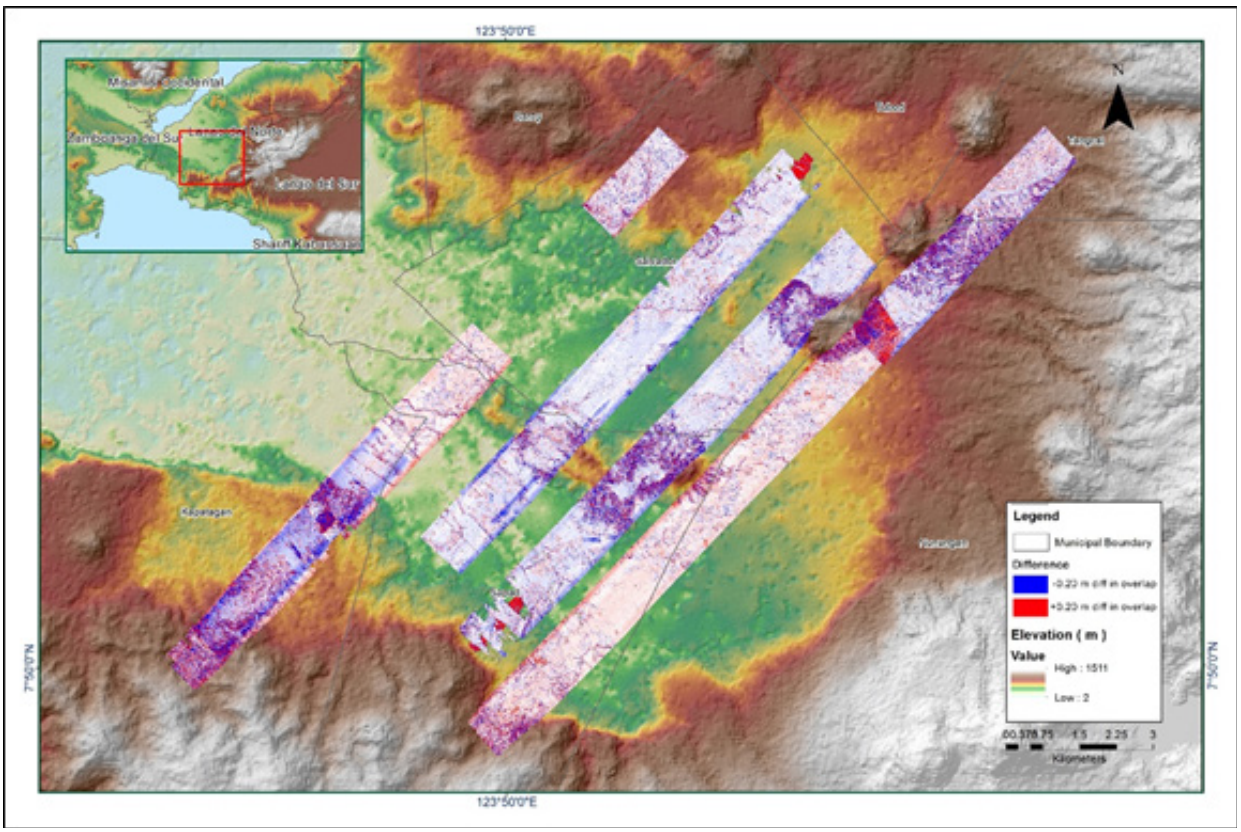


Image of Data Overlap

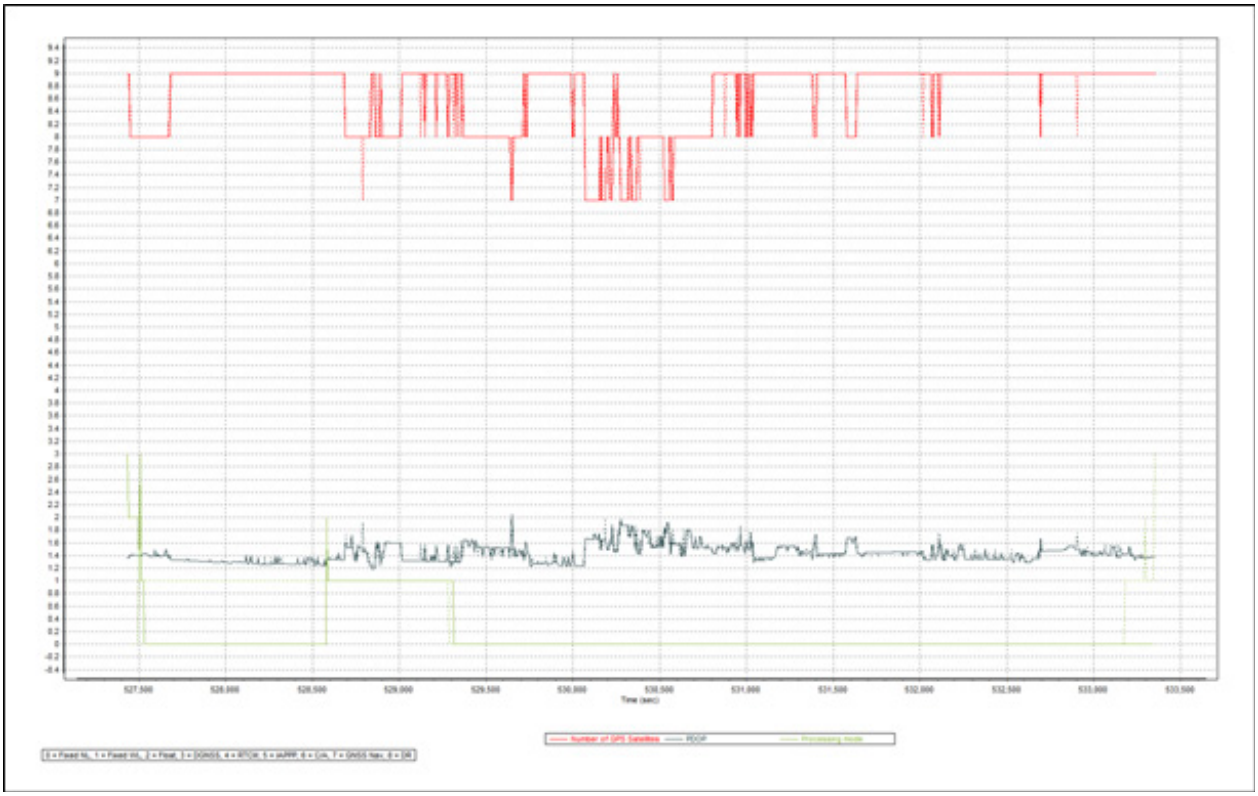


Density map of merged LiDAR data

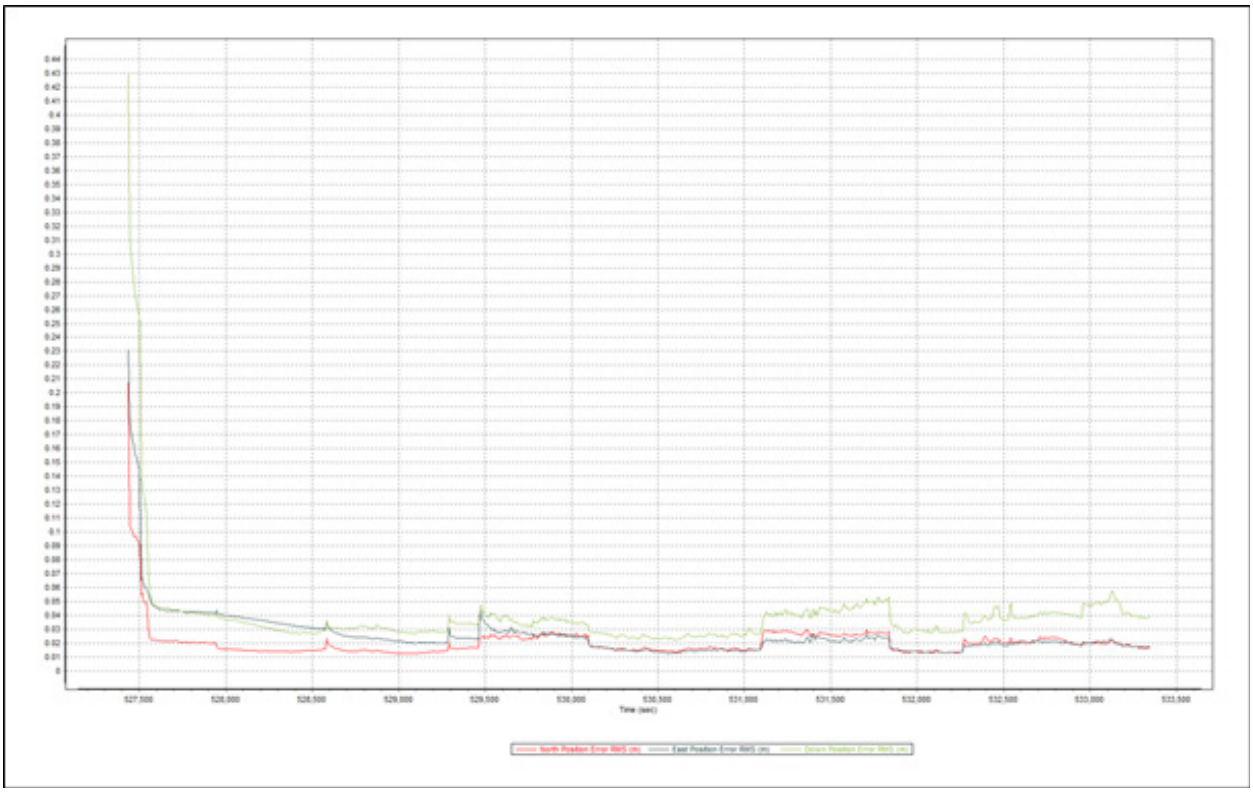


Elevation difference between flight lines

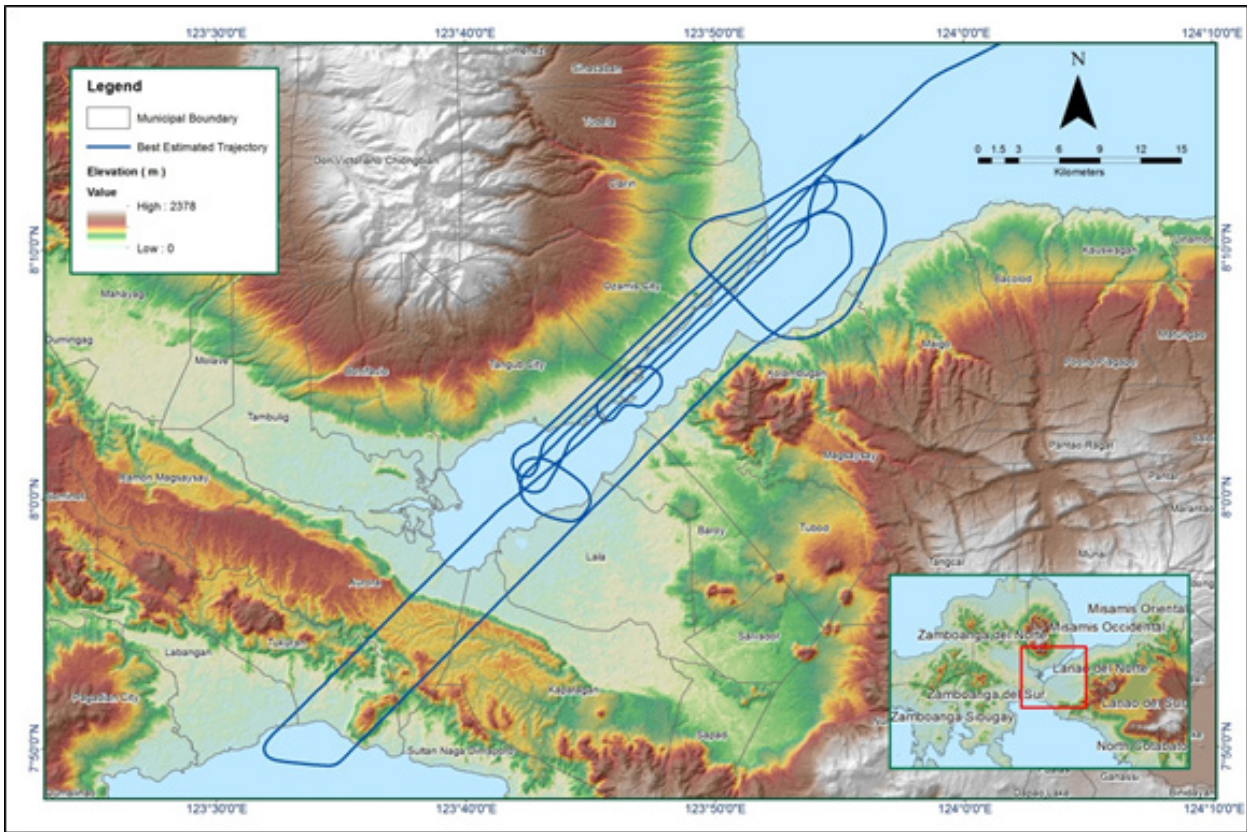
Flight Area	Northern Mindanao
Mission Name	Blk71Extension
Inclusive Flights	1665P, 1673P, 1677P
Range data size	27.06 GB
POS	500 MB
Image	33.6 GB
Transfer date	August 6, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.0
RMSE for East Position (<4.0 cm)	4.0
RMSE for Down Position (<8.0 cm)	5.0
Boresight correction stdev (<0.001deg)	0.000243
IMU attitude correction stdev (<0.001deg)	0.001298
GPS position stdev (<0.01m)	0.0076
Minimum % overlap (>25)	27.83%
Ave point cloud density per sq.m. (>2.0)	2.41
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	243
Maximum Height	868.76 m
Minimum Height	63.2 m
Classification (# of points)	
Ground	107,907,148
Low vegetation	96,229,157
Medium vegetation	96,176,102
High vegetation	80,601,347
Building	17,253,174
Orthophoto	Yes
Processed by	Engr. Analyn Naldo, Engr. Edgardo Gubatanga Jr., Engr. Elainne Lopez
Processed by	Engr. Analyn Naldo, Engr. Merven Matthew Natino, Engr. Elainne Lopez



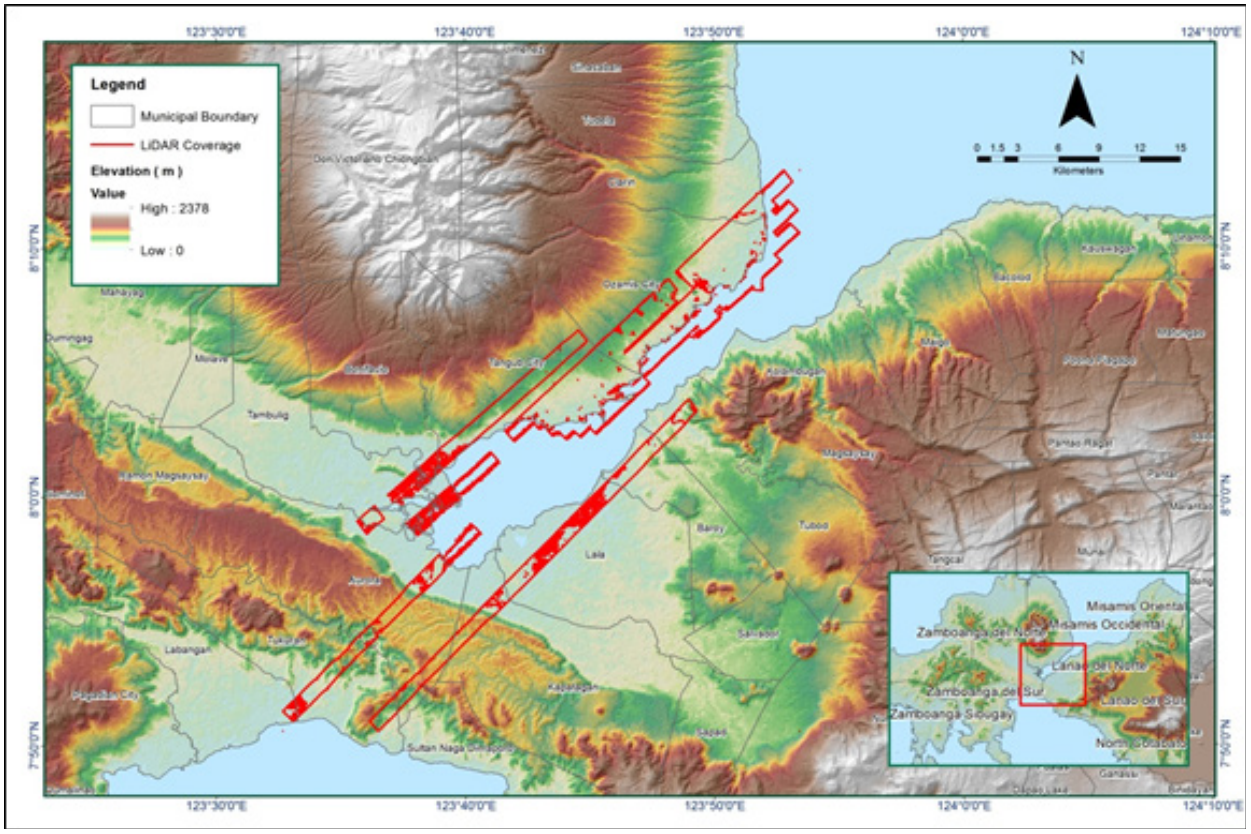
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

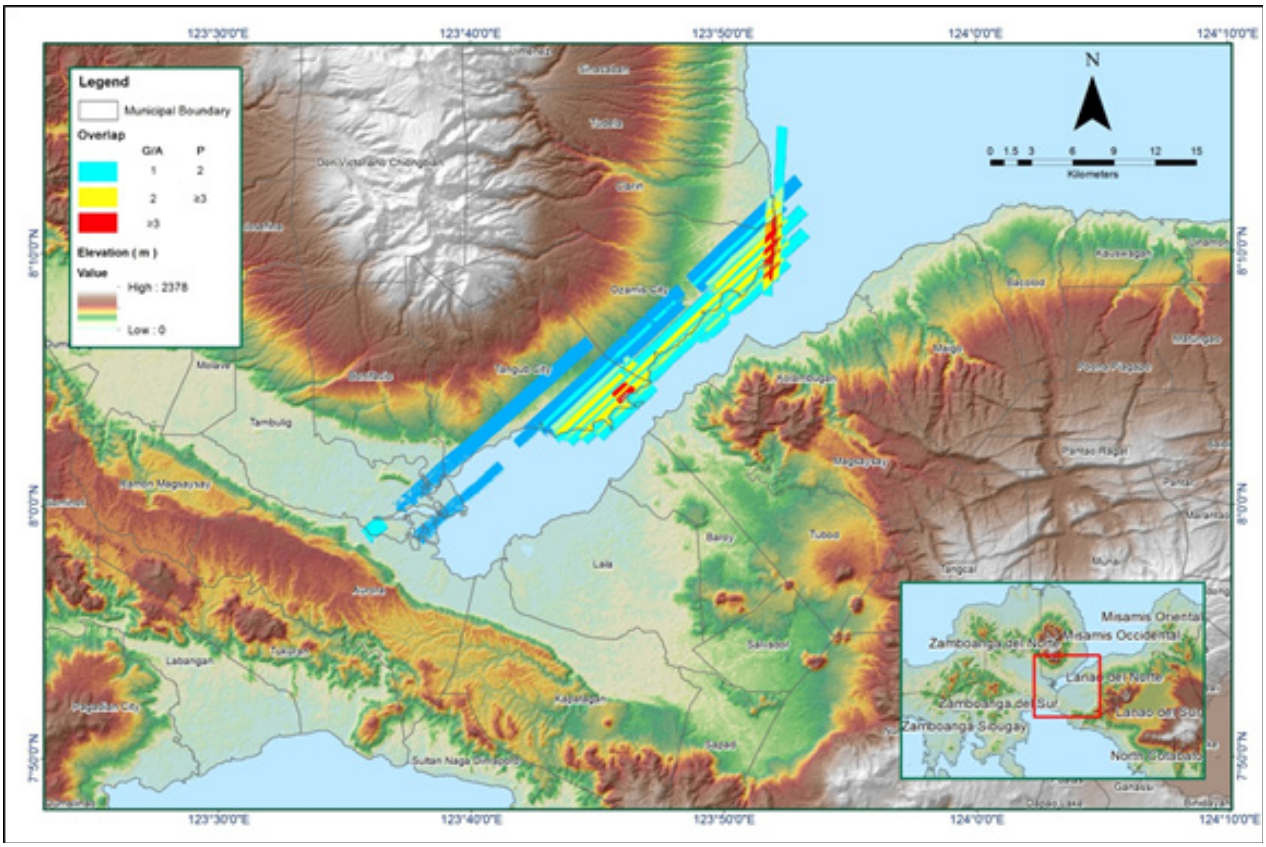
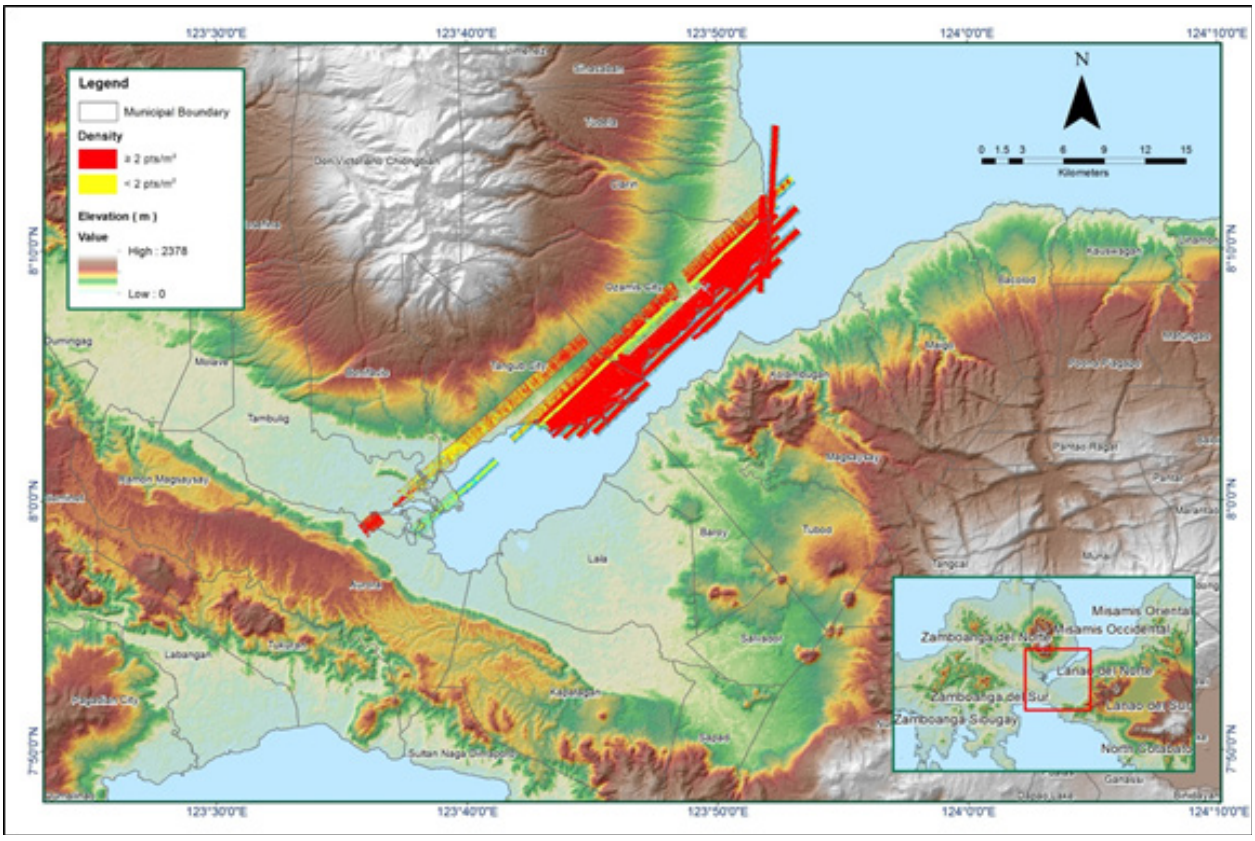
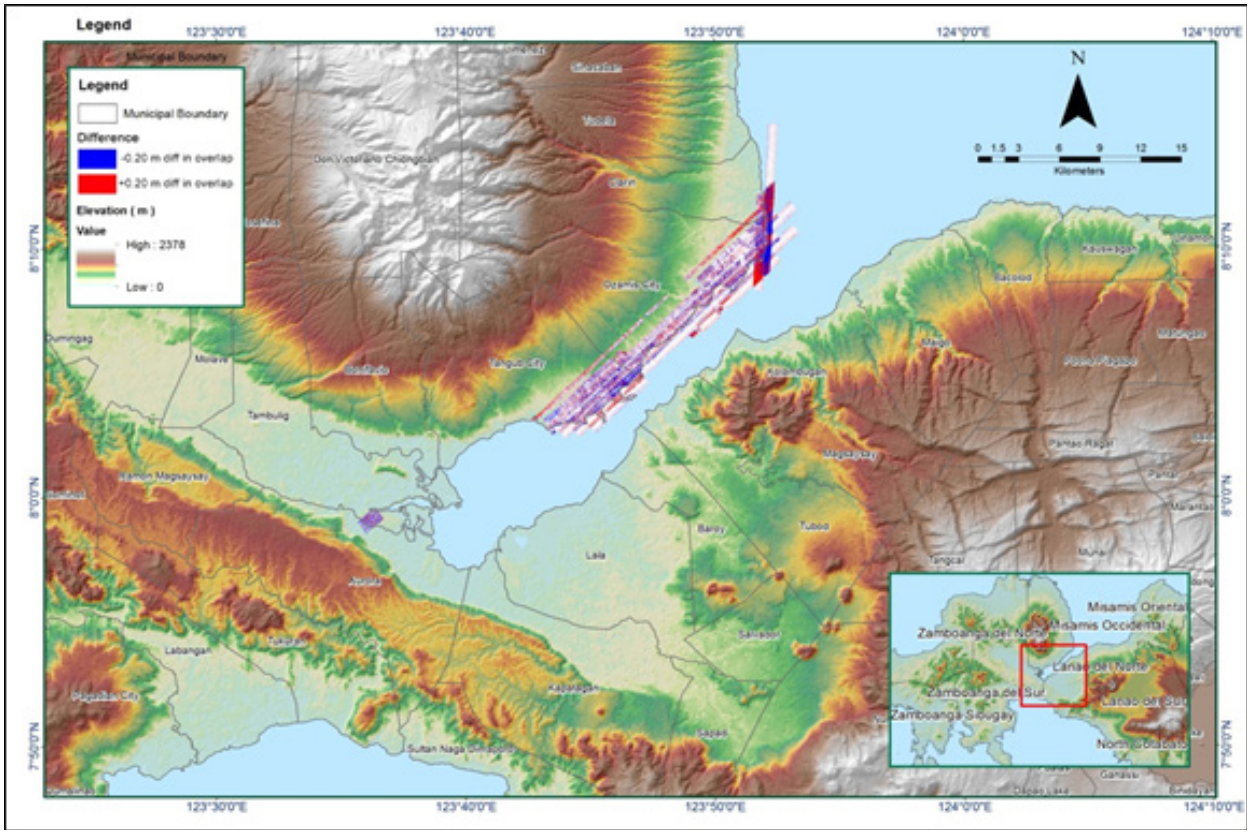


Image of Data Overlap

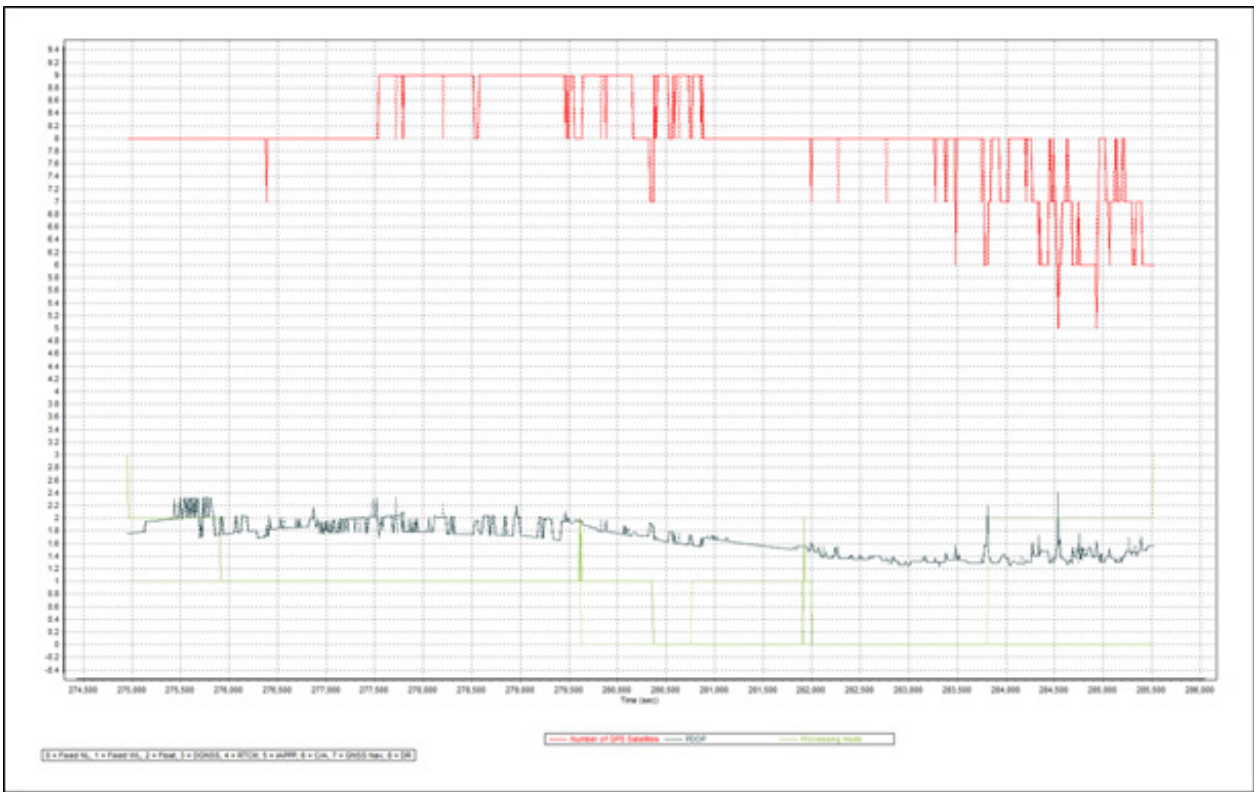


Density map of merged LiDAR data

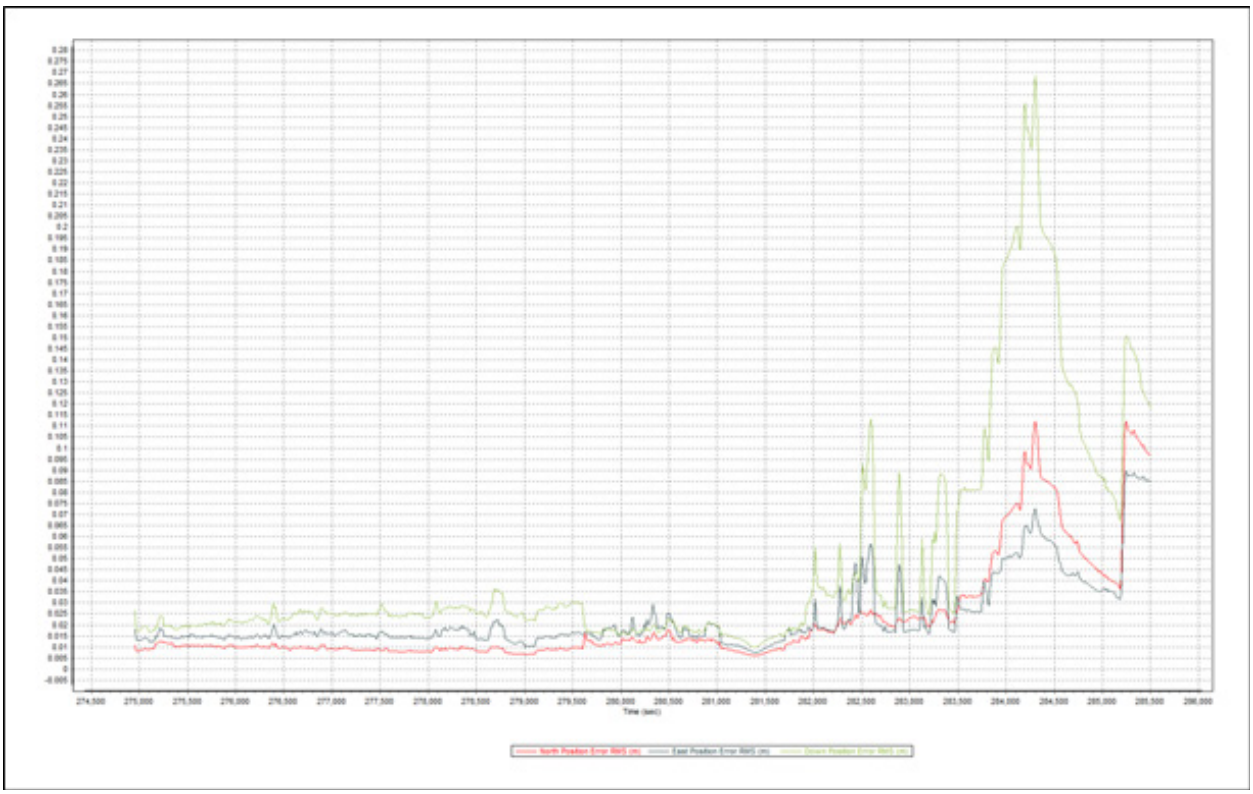


Elevation difference between flight lines

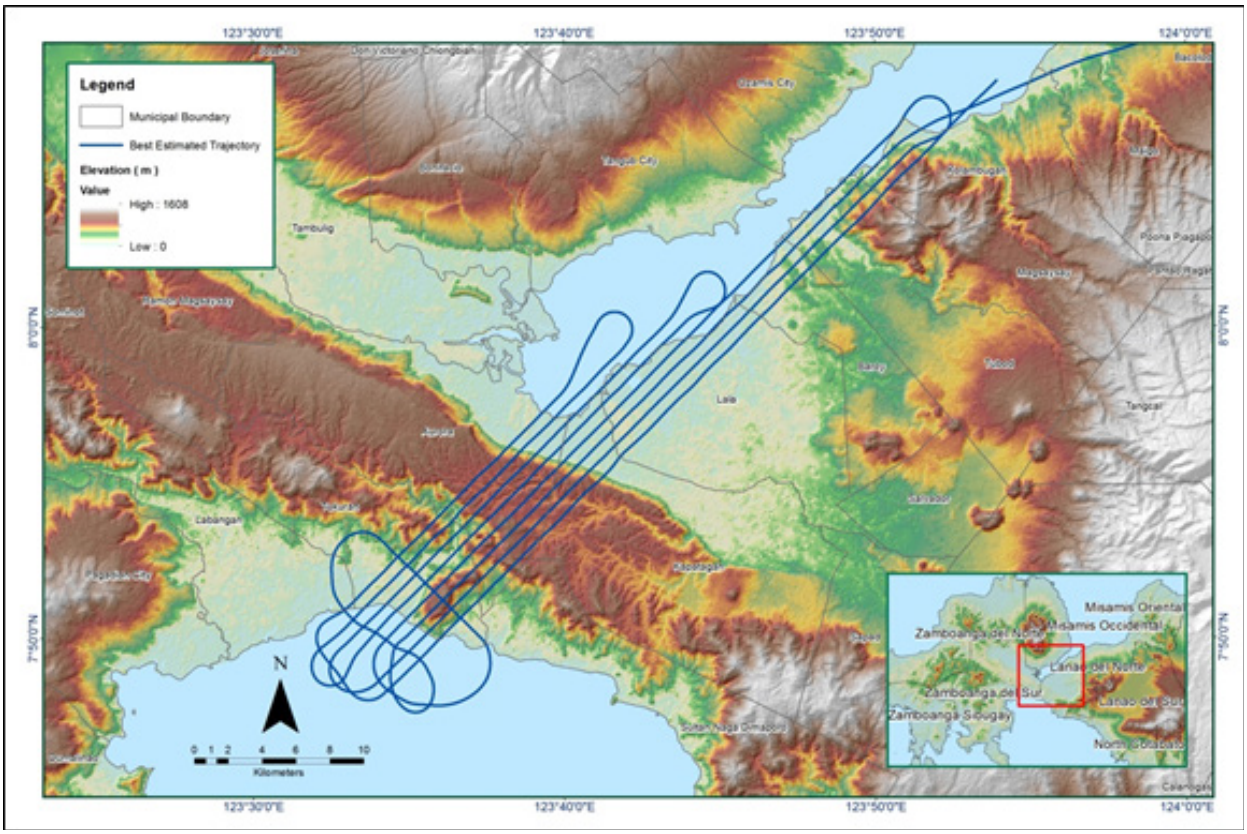
Flight Area	Northern Mindanao
Mission Name	Blk71E
Inclusive Flights	1689P
Range data size	27.1 GB
POS	257 MB
Image	n/a
Transfer date	August 6, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.5
RMSE for East Position (<4.0 cm)	5.5
RMSE for Down Position (<8.0 cm)	10
Boresight correction stdev (<0.001deg)	0.000536
IMU attitude correction stdev (<0.001deg)	0.001171
GPS position stdev (<0.01m)	0.0079
Minimum % overlap (>25)	35.35%
Ave point cloud density per sq.m. (>2.0)	2.79
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	253
Maximum Height	476.79
Minimum Height	66.37
Classification (# of points)	
Ground	157,189,225
Low vegetation	118,155,426
Medium vegetation	187,516,392
High vegetation	168,342,412
Building	7,092,549
Orthophoto	NO
Processed by	Engr. Carlyn Ann Ibañez, Engr. Melanie Hingpit, Engr. John Dill Macapagal



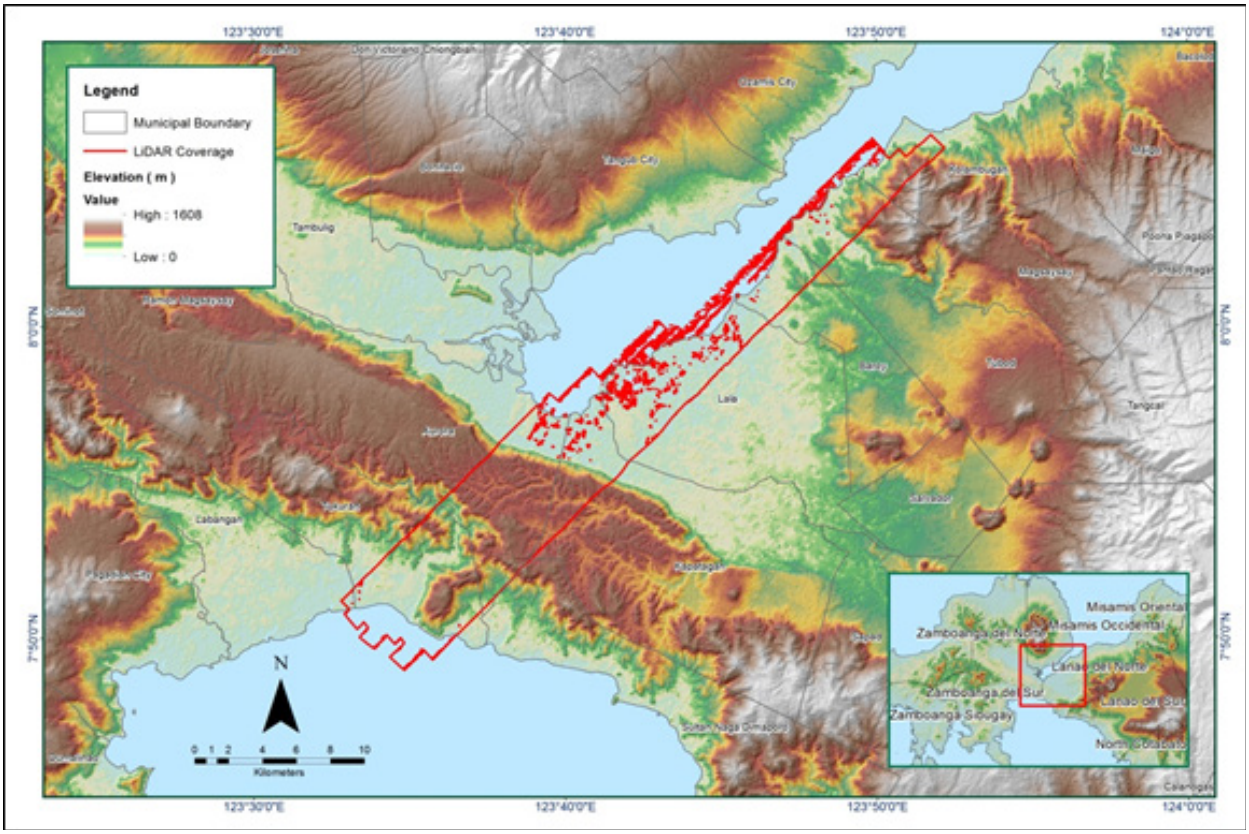
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

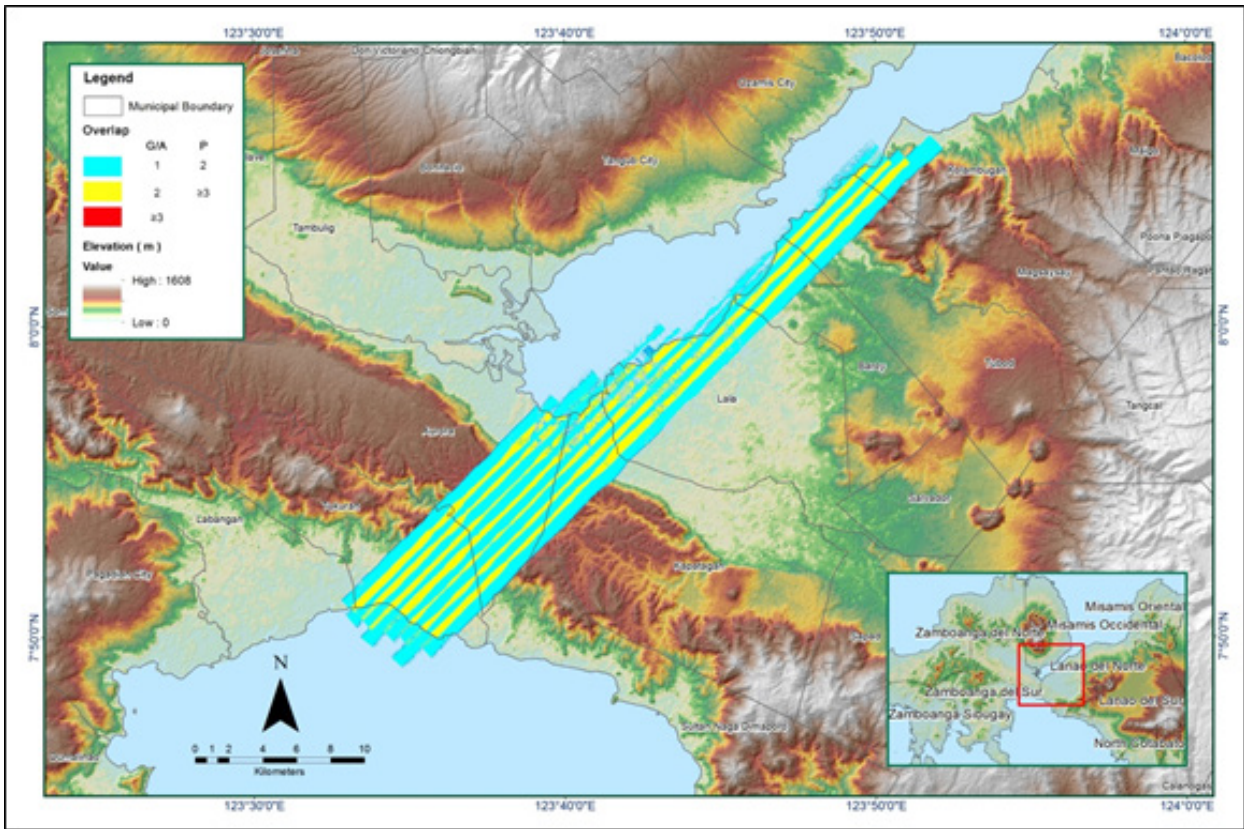
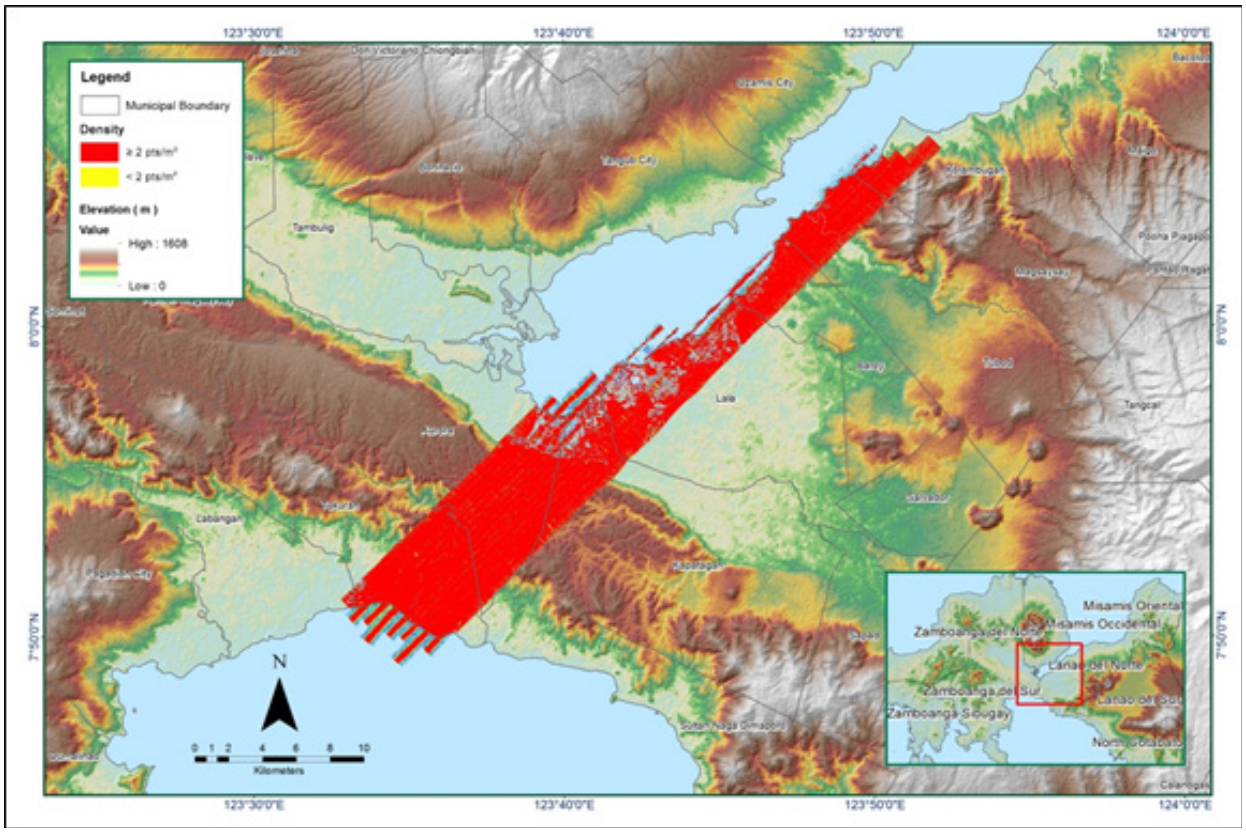
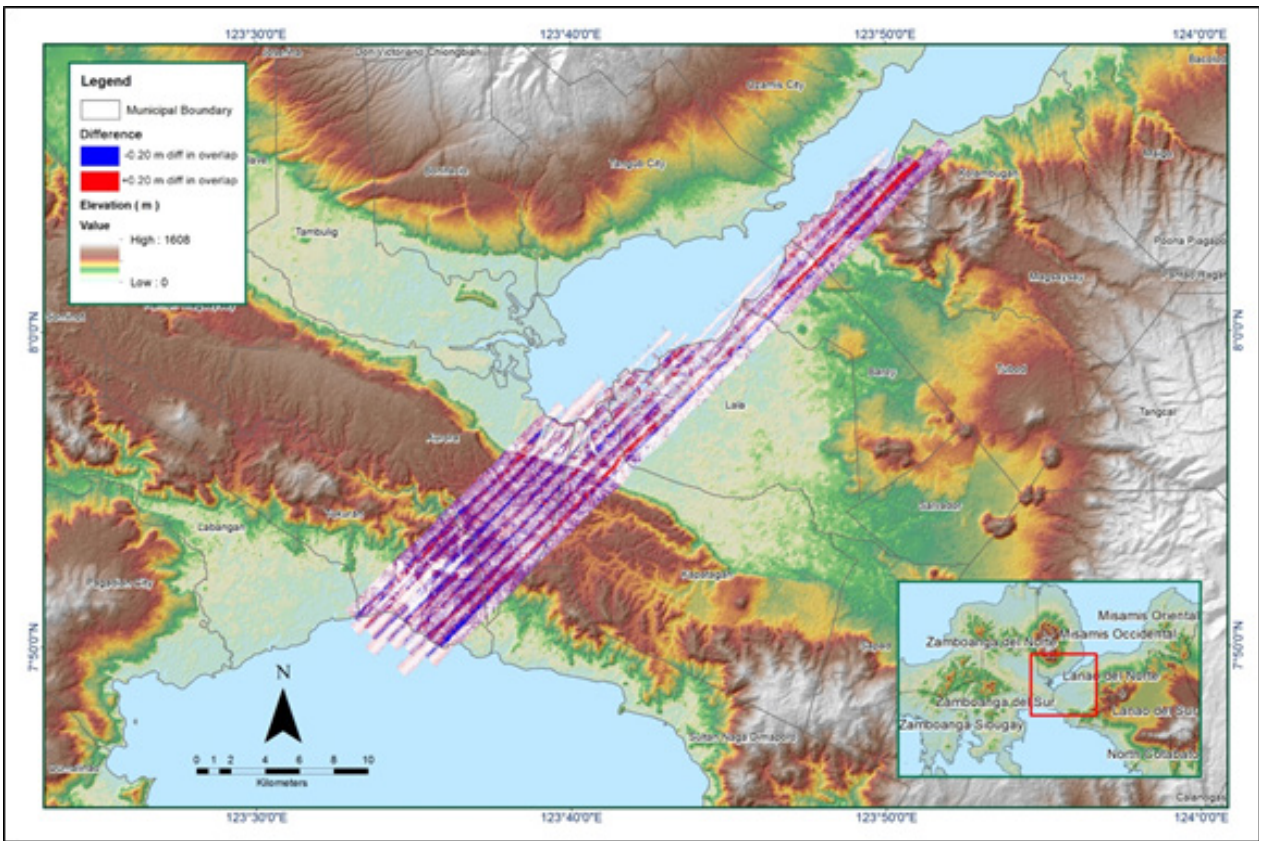


Image of Data Overlap

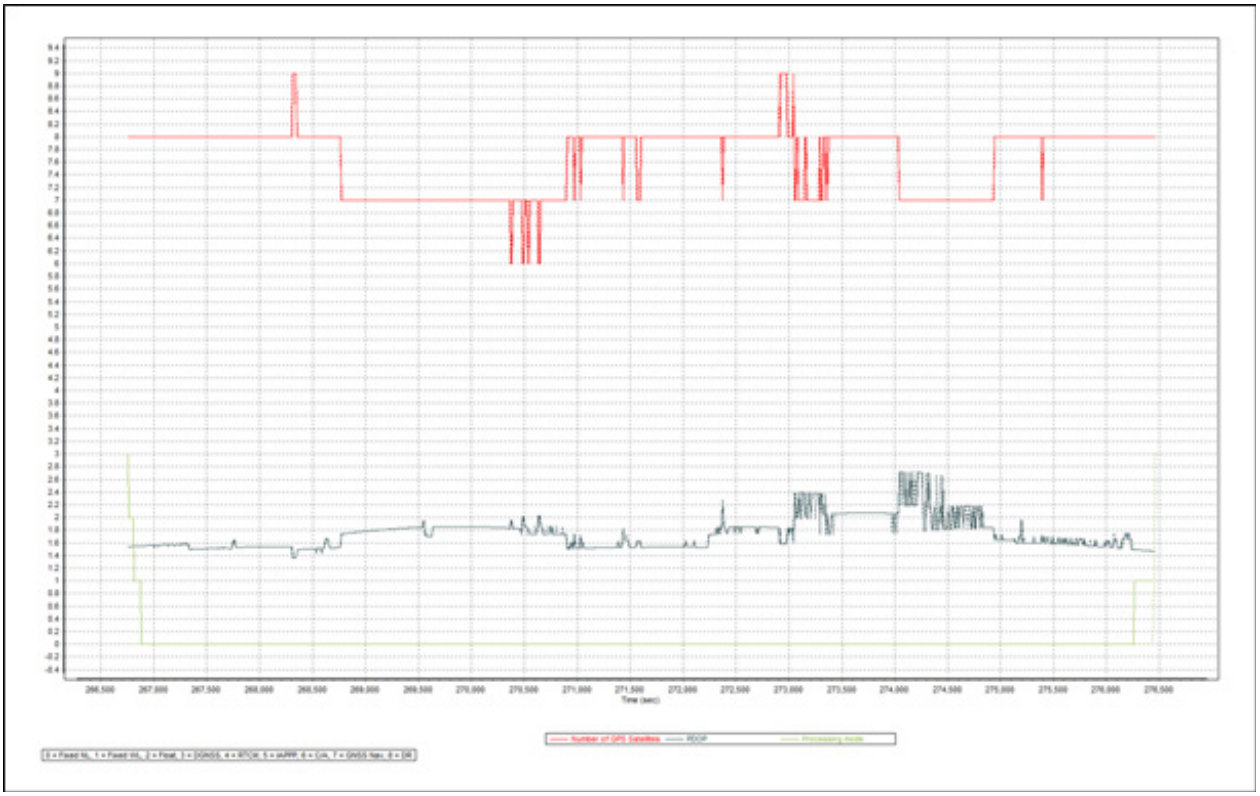


Density map of merged LiDAR data

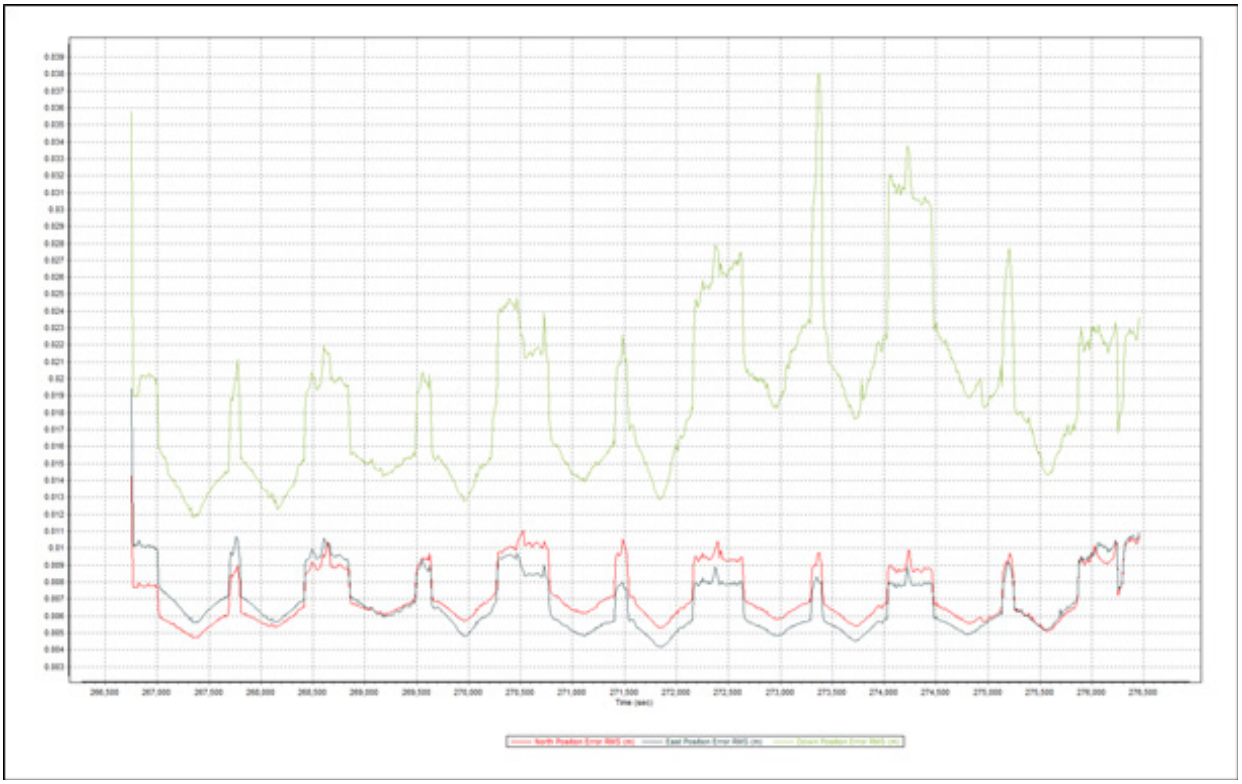


Elevation difference between flight lines

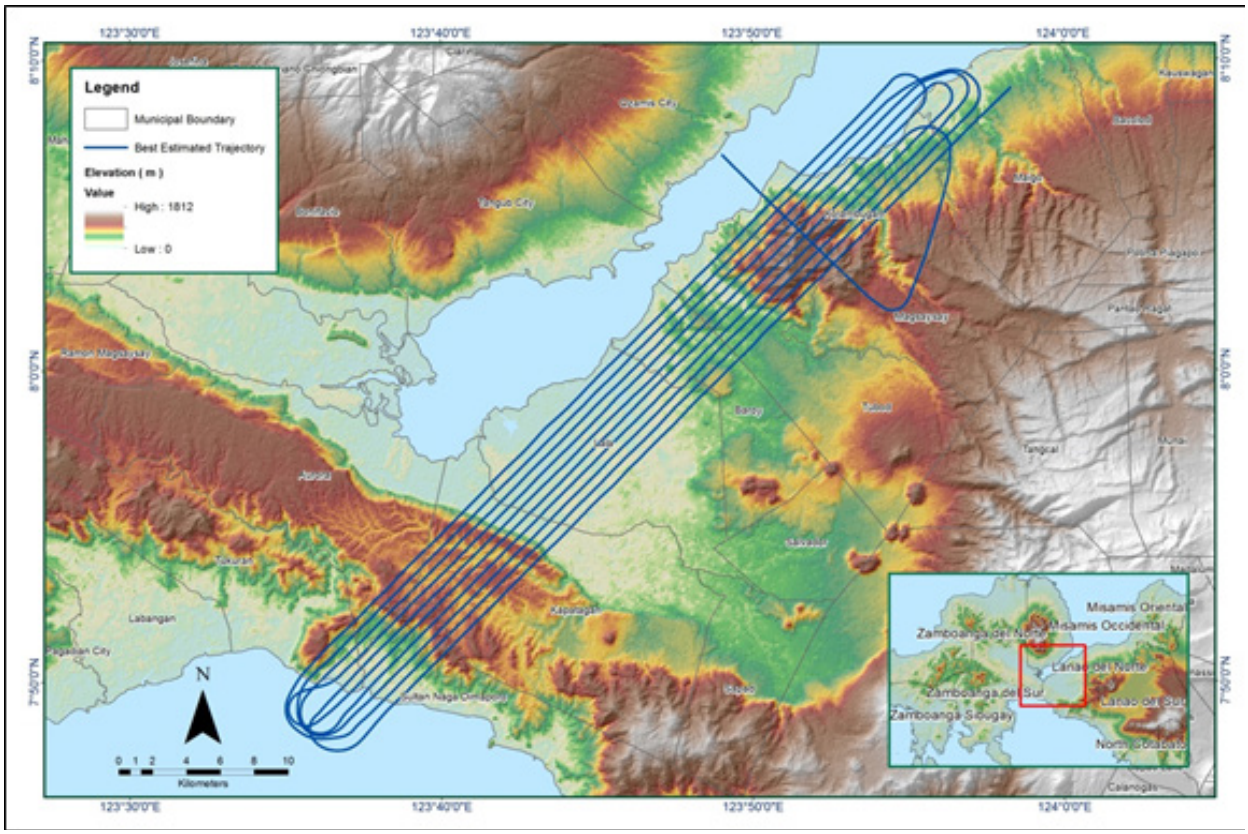
Flight Area	Northern Mindanao
Mission Name	Blk71F
Inclusive Flights	1565P, 1549P, 1685P
Range data size	70.3 GB
POS	674 MB
Image	59.1 GB
Transfer date	June 23, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.1
RMSE for East Position (<4.0 cm)	1.1
RMSE for Down Position (<8.0 cm)	3.8
Boresight correction stdev (<0.001deg)	0.000471
IMU attitude correction stdev (<0.001deg)	0.004323
GPS position stdev (<0.01m)	0.0198
Minimum % overlap (>25)	51.56%
Ave point cloud density per sq.m. (>2.0)	4.06
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	614
Maximum Height	685.55
Minimum Height	64.65
Classification (# of points)	
Ground	591,908,481
Low vegetation	609,869,904
Medium vegetation	757,441,192
High vegetation	606,070,790
Building	21,867,436
Orthophoto	Yes
Processed by	Engr. Jennifer Saguran, Engr. Carlyn Ann Ibañez, Engr. Christy Lubiano, Engr. John Dill Macapagal



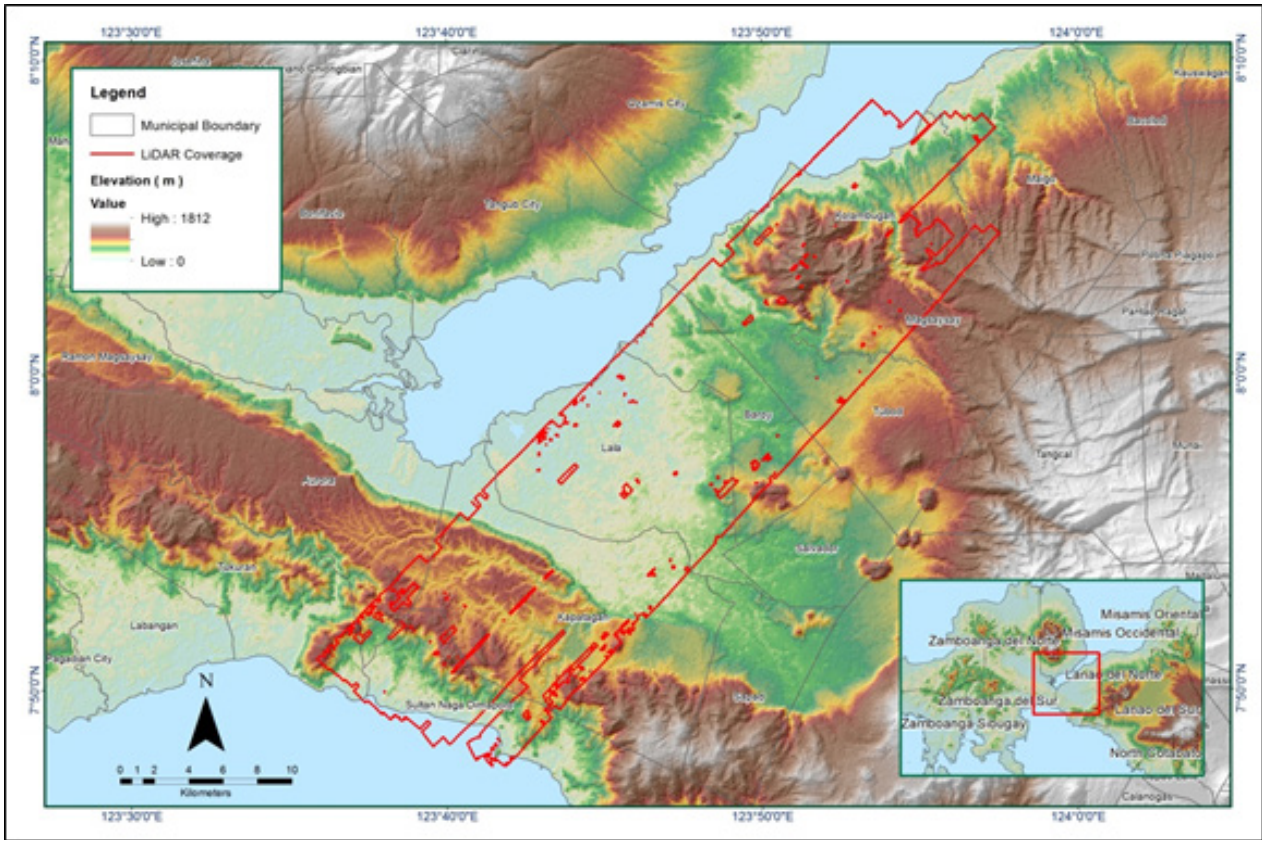
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

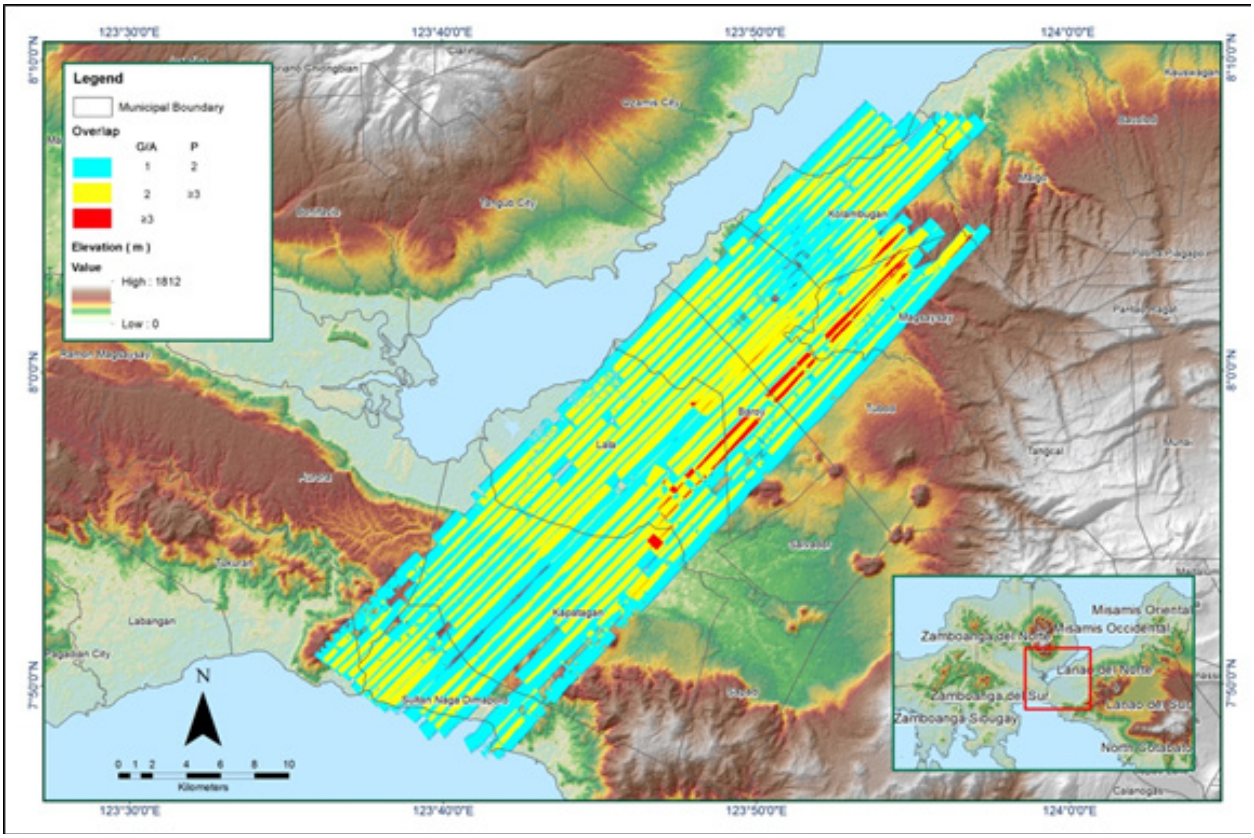
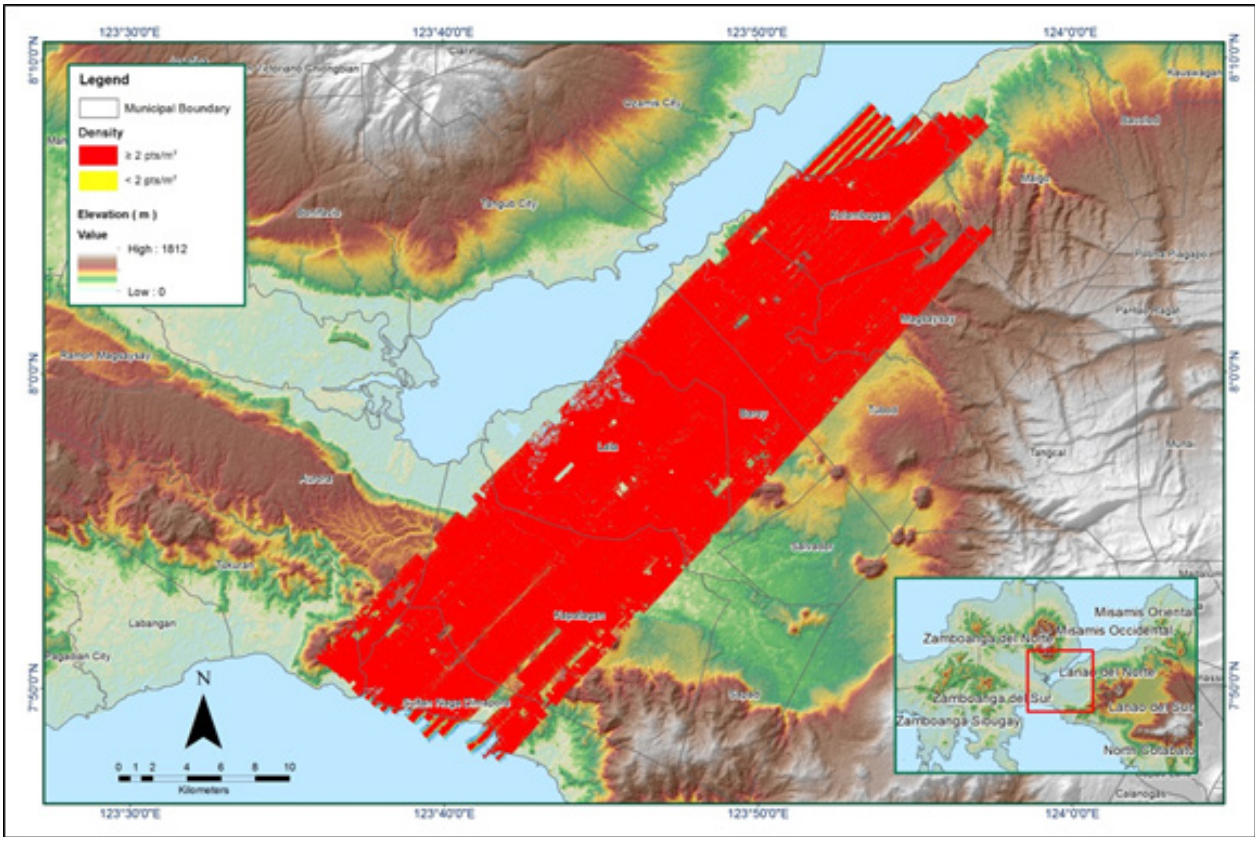
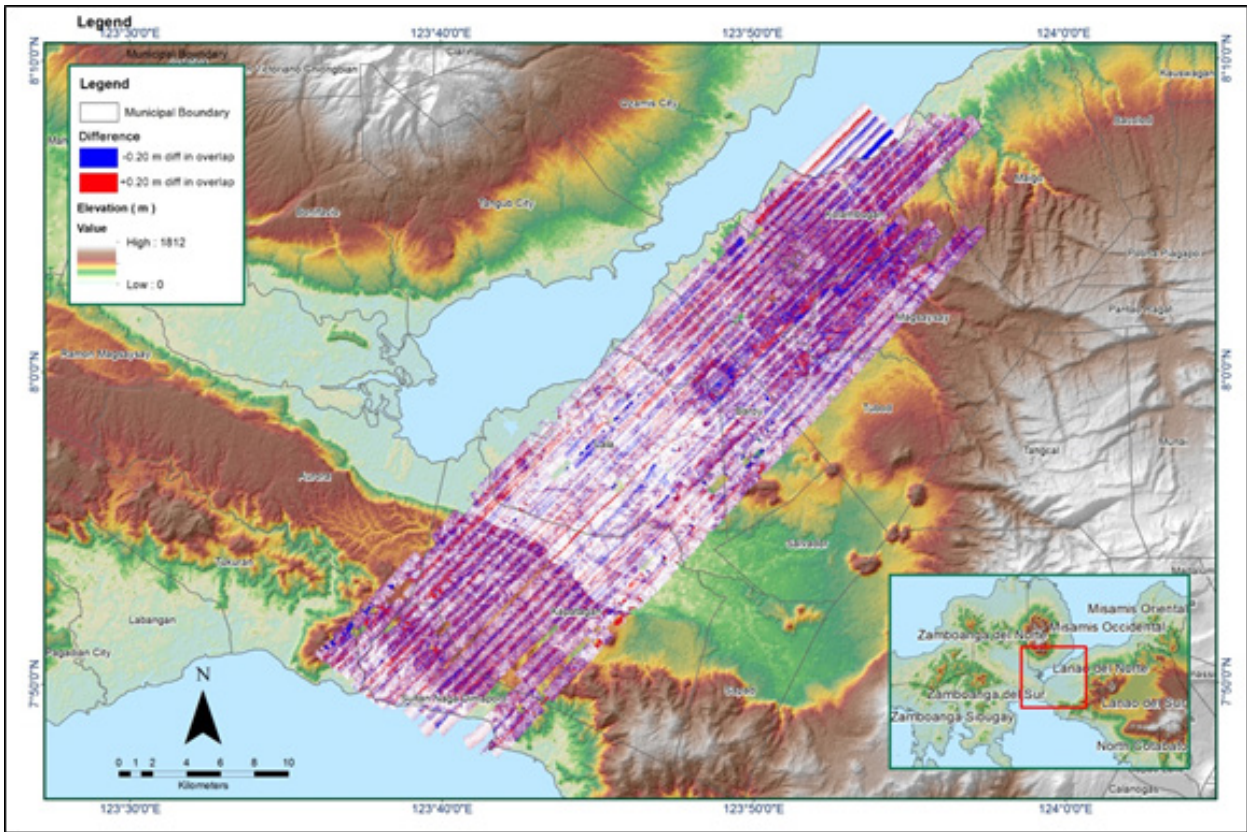


Image of Data Overlap

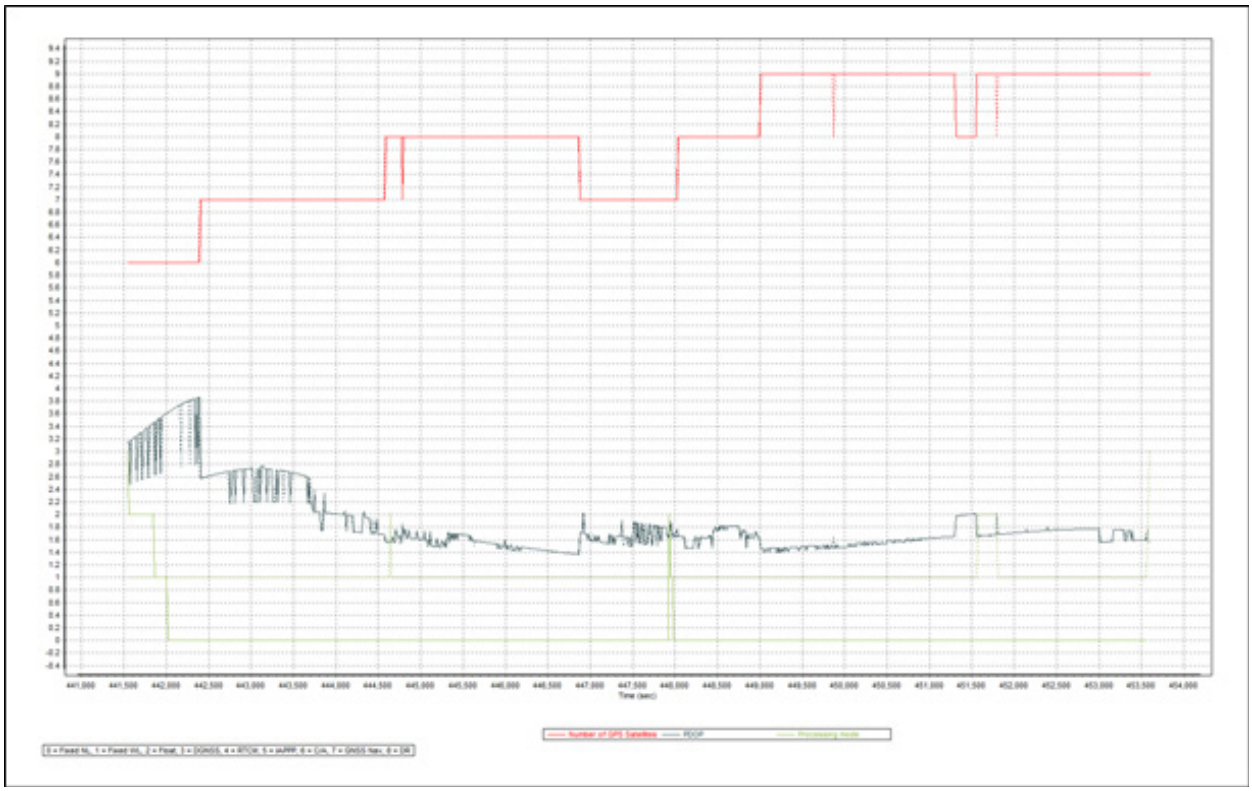


Density map of merged LiDAR data

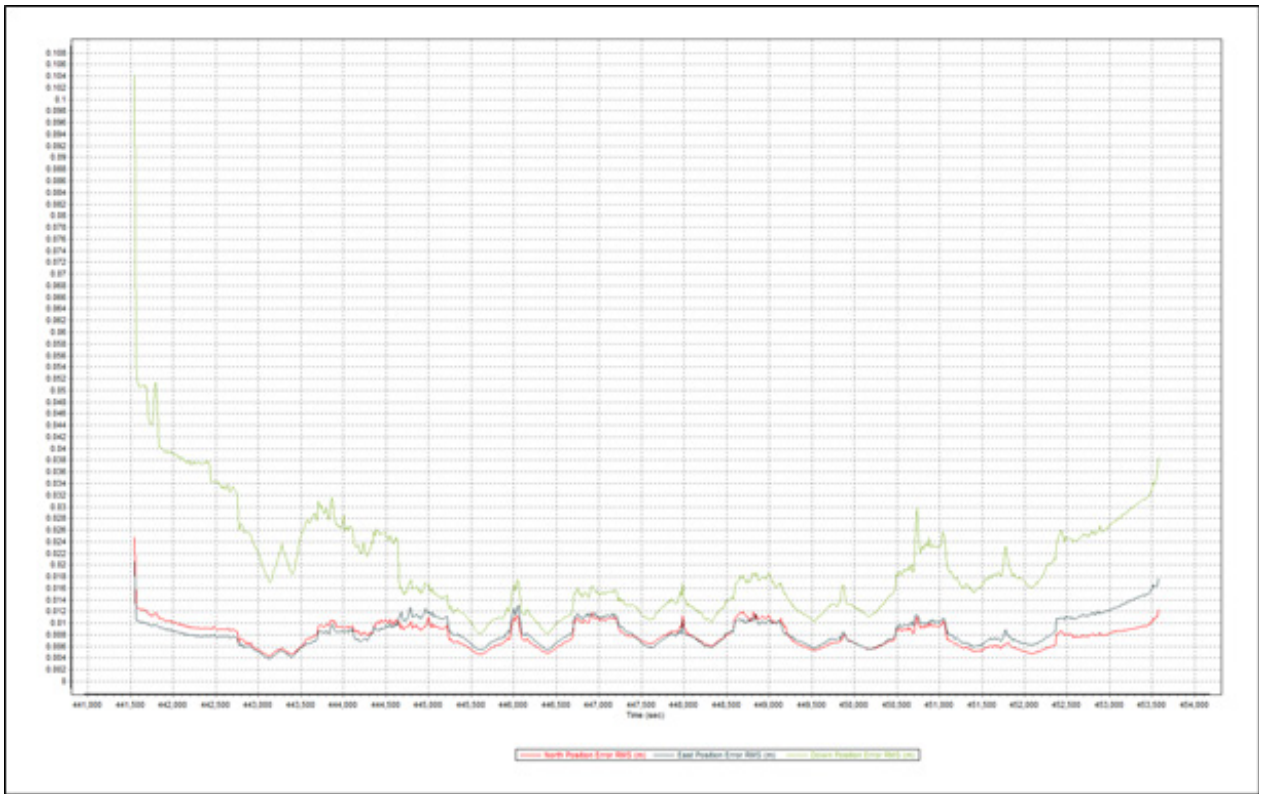


Elevation difference between flight lines

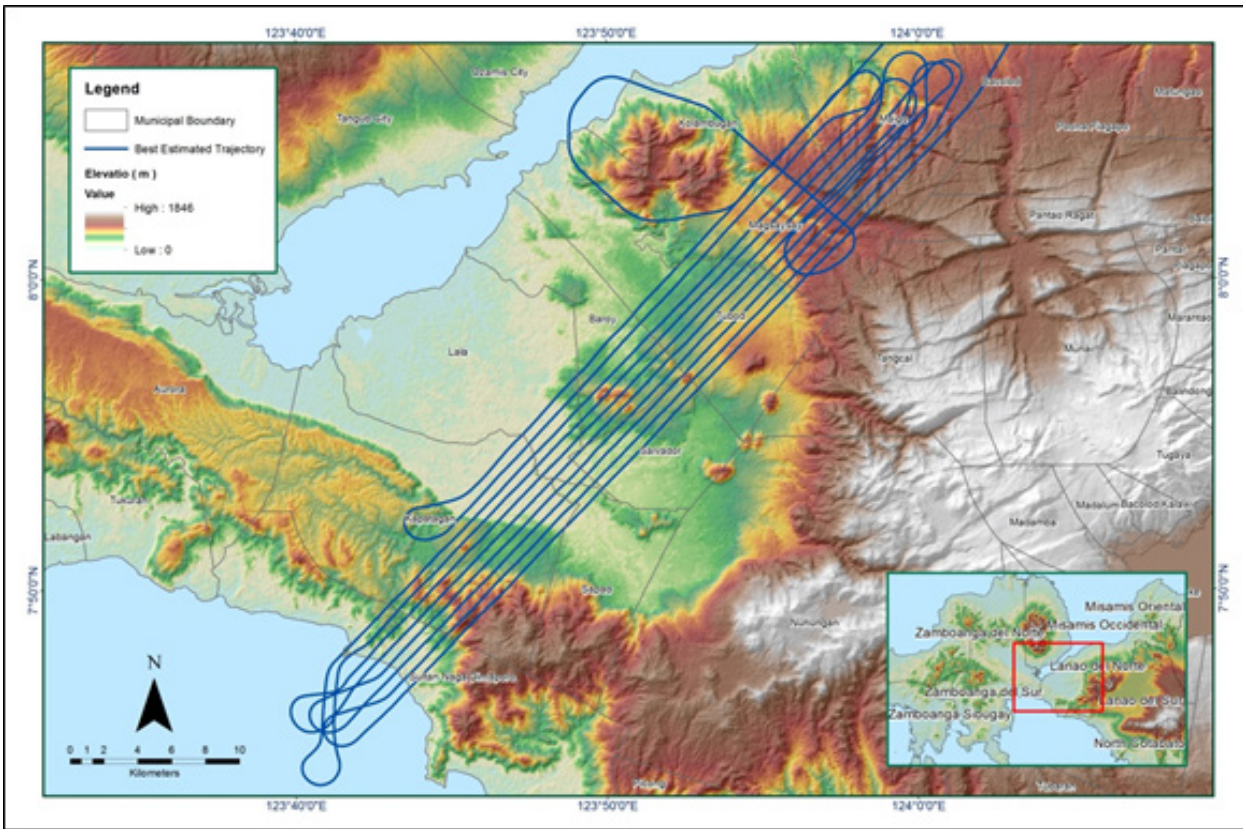
Flight Area	Northern Mindanao
Mission Name	Blk71G
Inclusive Flights	1613P
Range data size	33.2 GB
POS	258 MB
Image	67.3 GB
Transfer date	August 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.2
RMSE for East Position (<4.0 cm)	1.3
RMSE for Down Position (<8.0 cm)	3.0
Boresight correction stdev (<0.001deg)	0.000236
IMU attitude correction stdev (<0.001deg)	0.000781
GPS position stdev (<0.01m)	0.0018
Minimum % overlap (>25)	36.24%
Ave point cloud density per sq.m. (>2.0)	6.63
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	362
Maximum Height	766.63 m
Minimum Height	62.51 m
Classification (# of points)	
Ground	286,954,240
Low vegetation	266,488,104
Medium vegetation	404,520,939
High vegetation	376,191,706
Building	8,947,468
Orthophoto	YES
	Yes
Processed by	Engr. Don Matthew Banatin, Engr. Merven Matthew Natino, Jovy Narisma



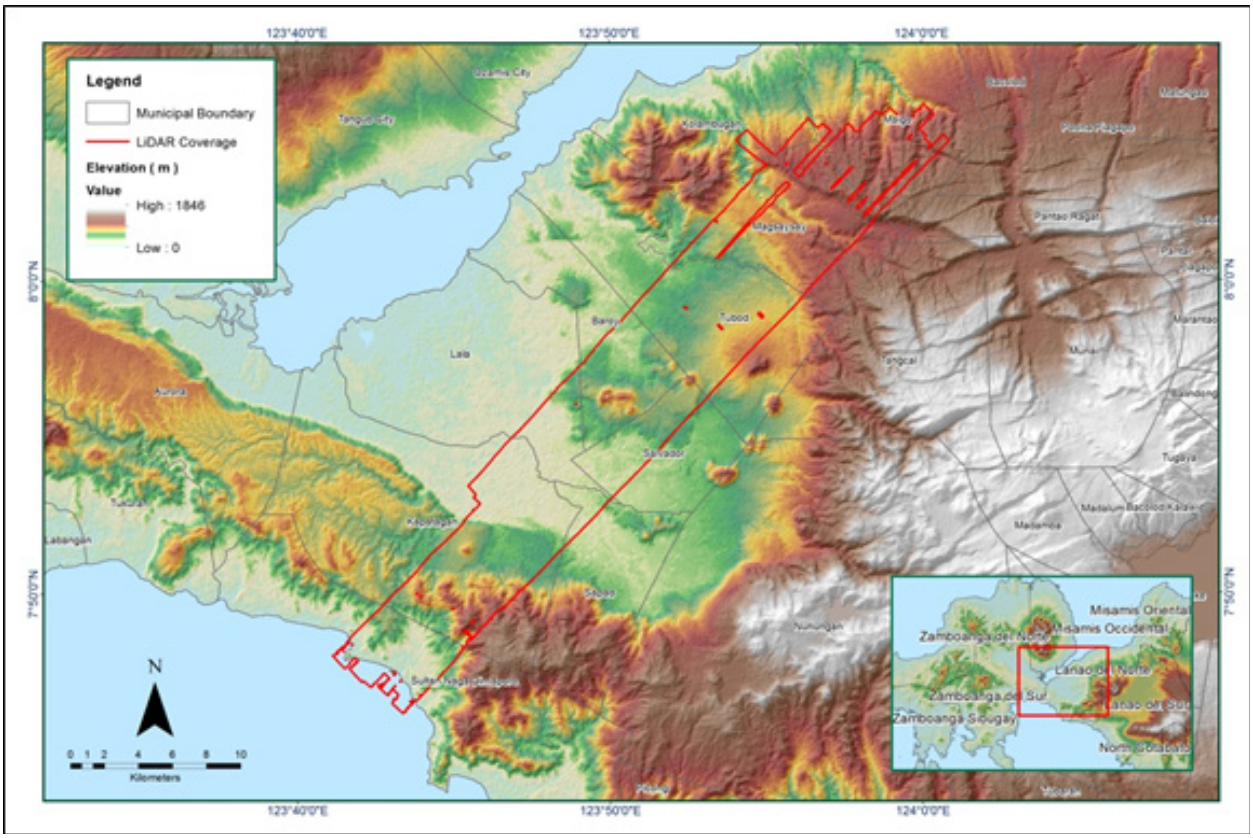
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

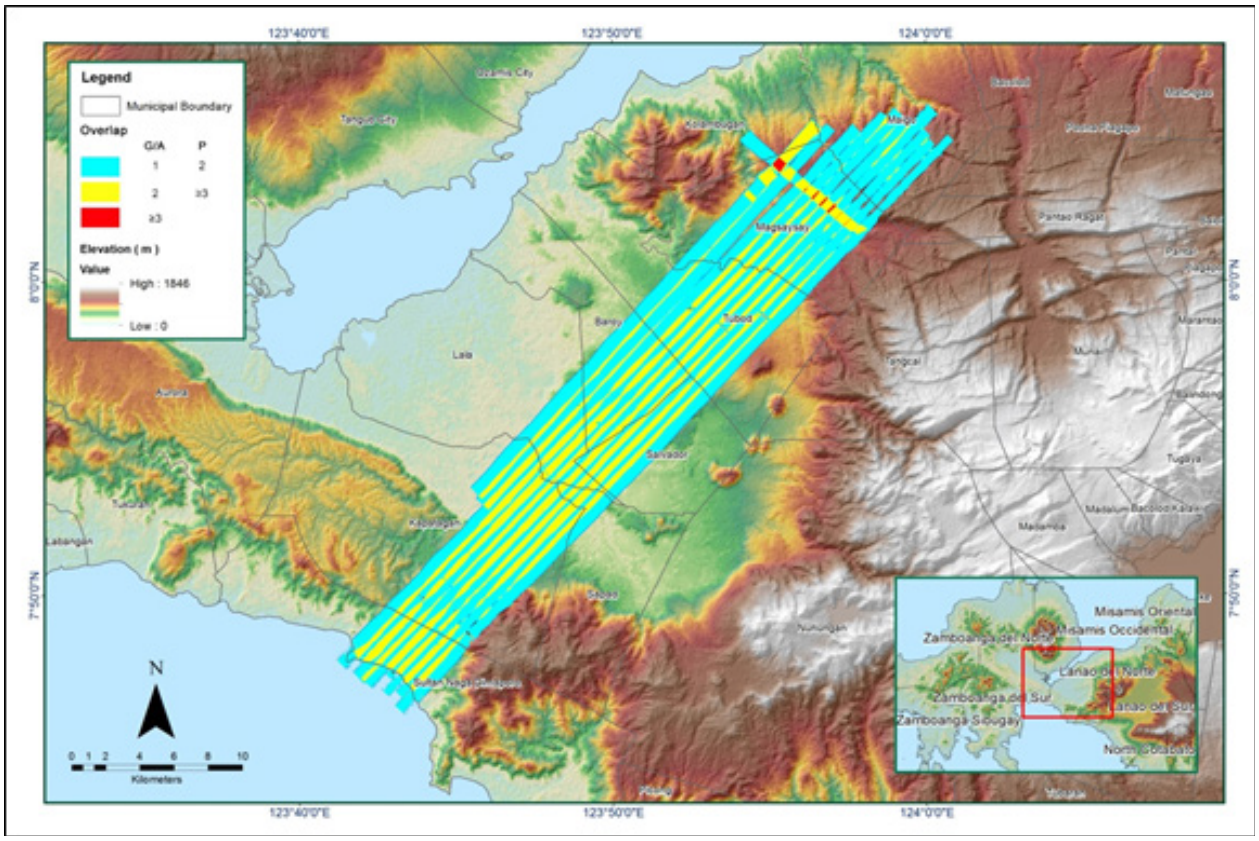
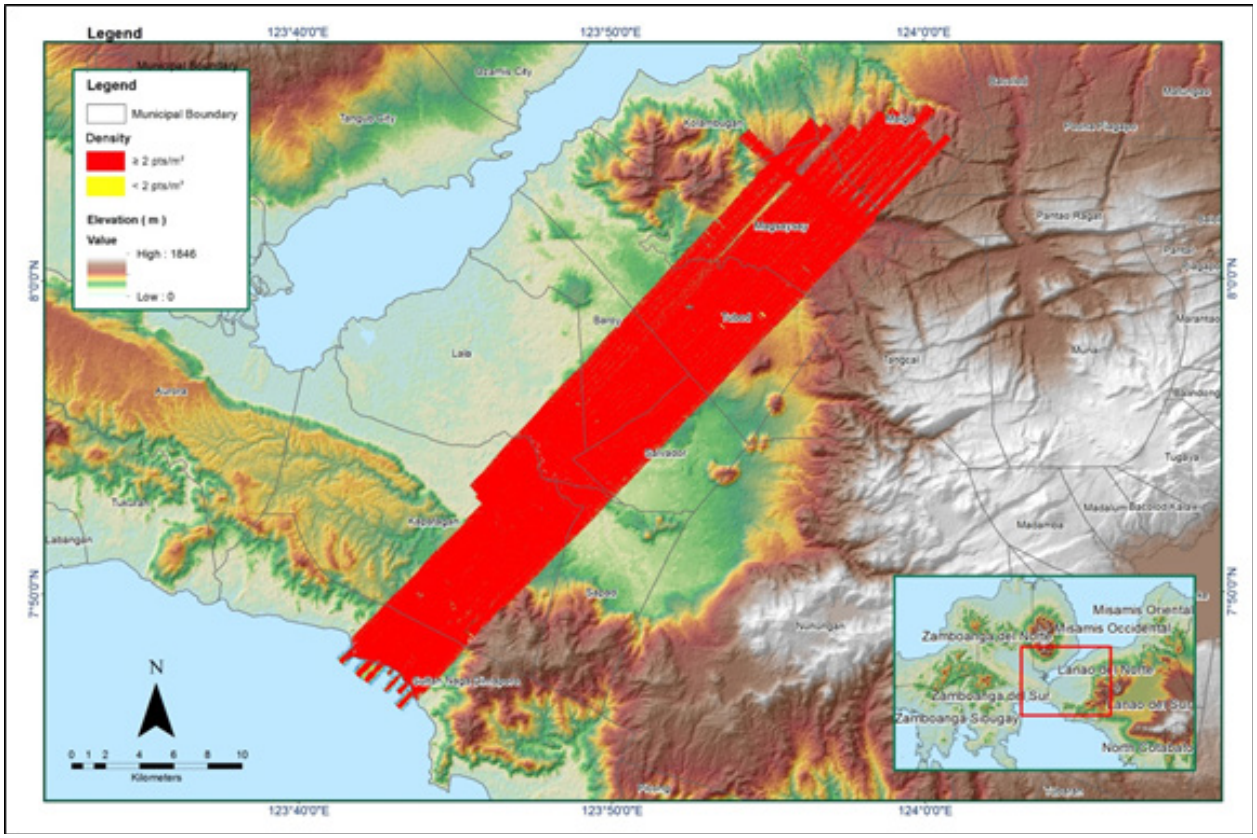
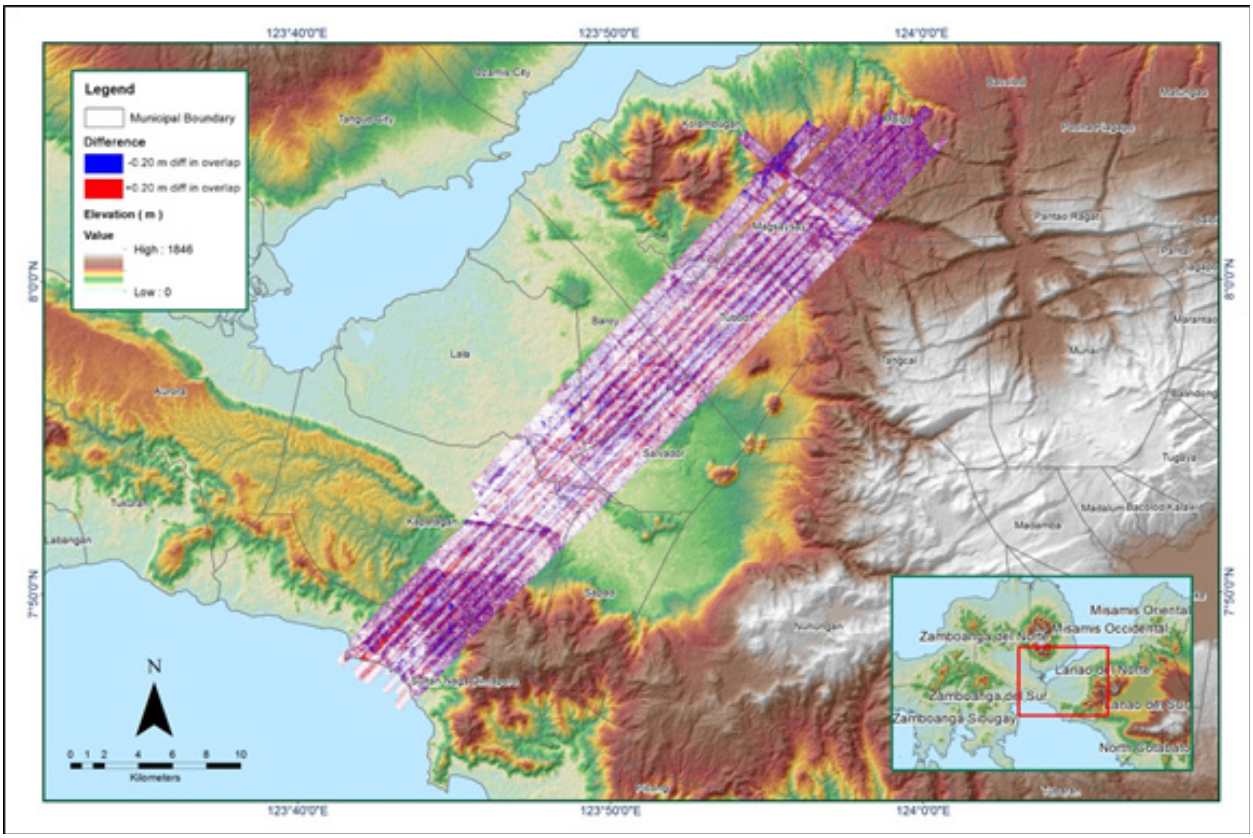


Image of Data Overlap

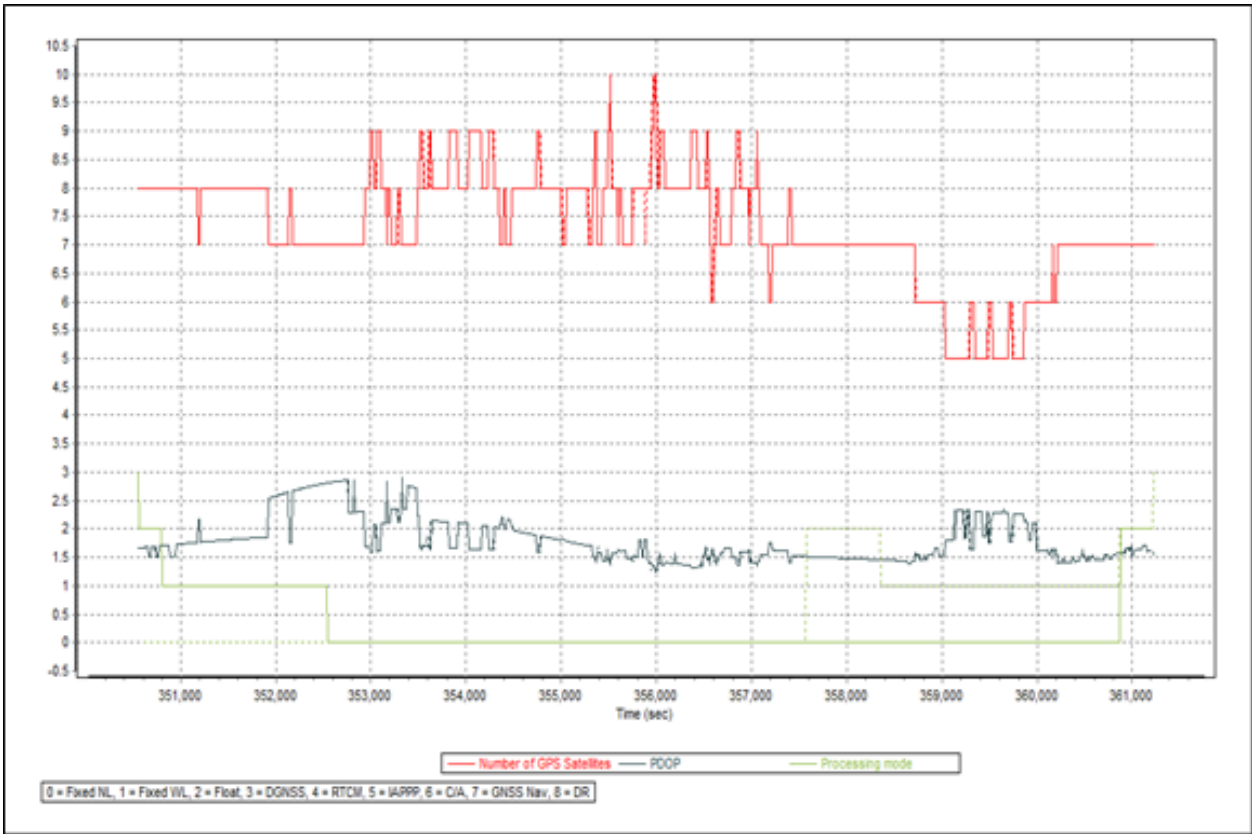


Density map of merged LiDAR data

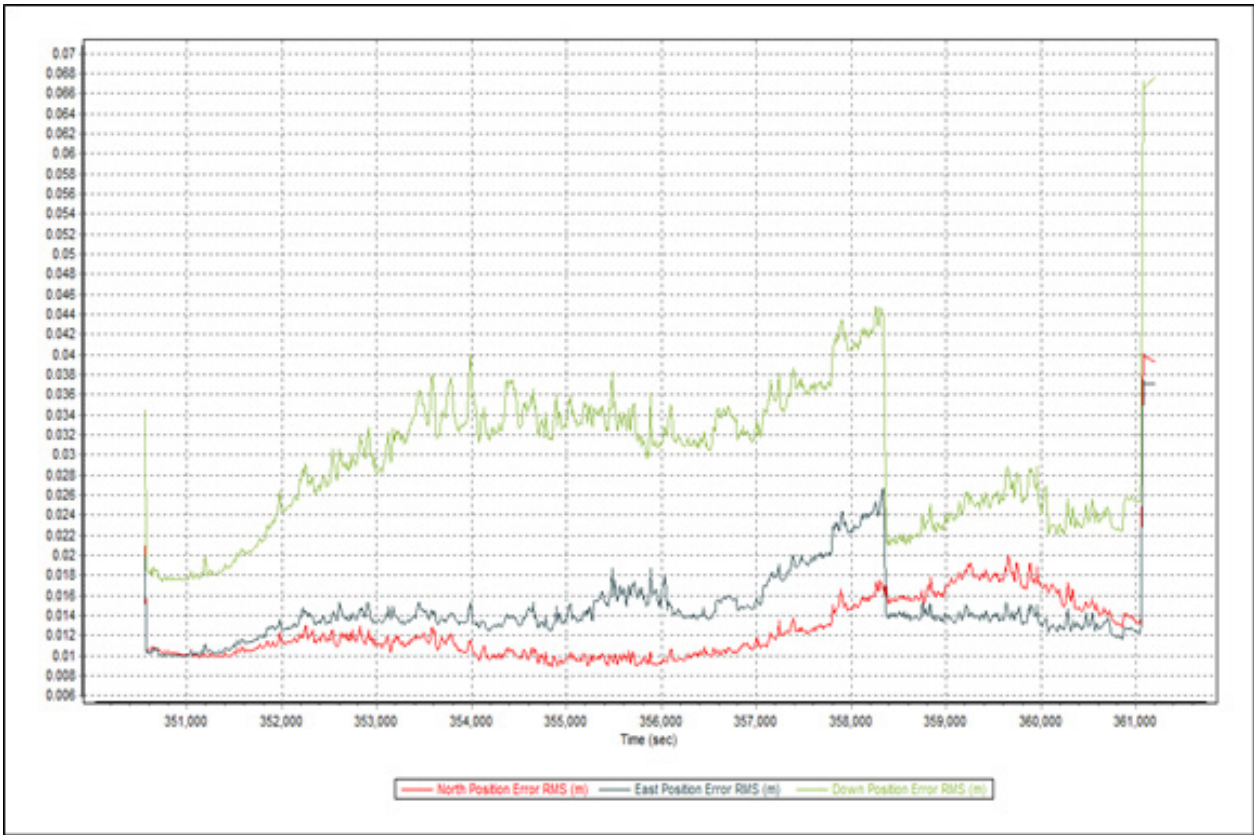


Elevation difference between flight lines

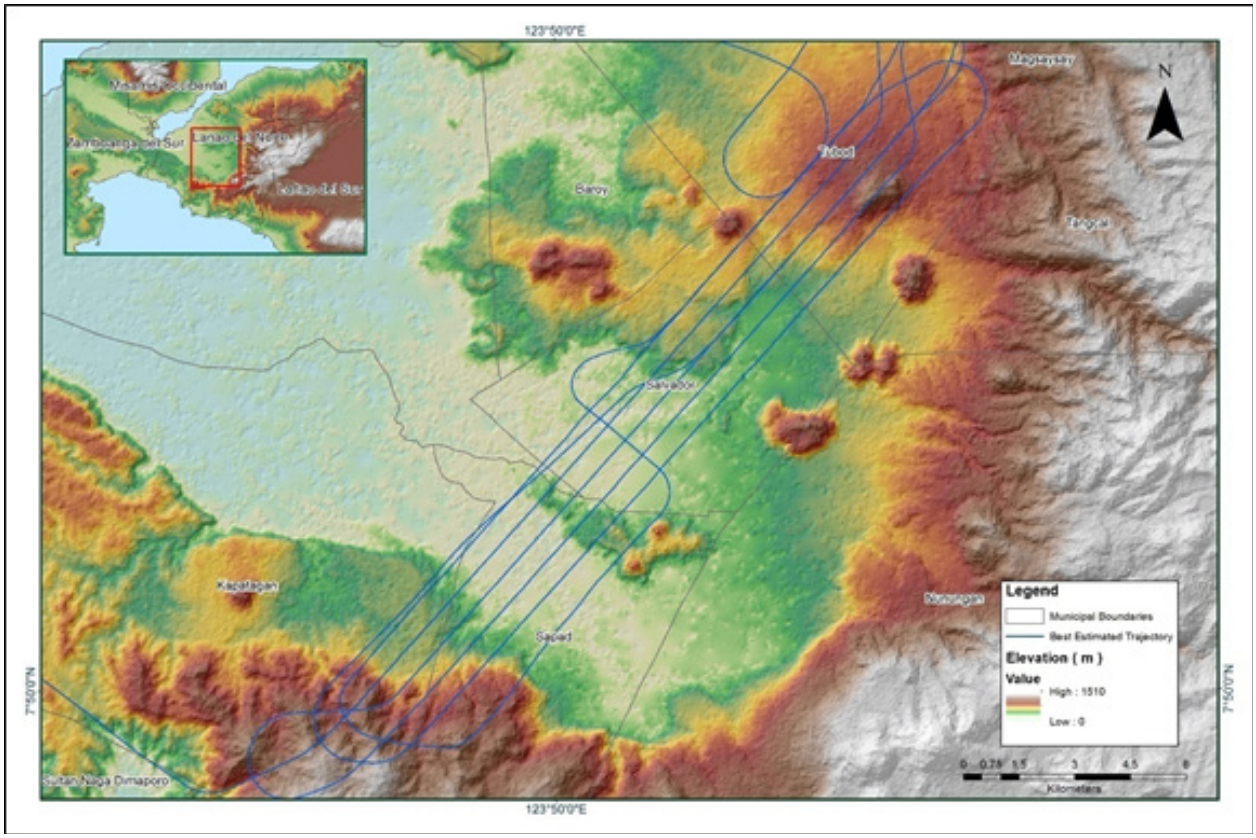
Flight Area	Dipolog Reflights
Mission Name	Blk76M
Inclusive Flights	23602P
Range data size	16.5 GB
POS data size	287 MB
Base data size	53.7 MB
Image	n/a
Transfer date	December 6, 2016
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.005
RMSE for East Position (<4.0 cm)	2.665
RMSE for Down Position (<8.0 cm)	4.473
Boresight correction stdev (<0.001deg)	0.001490
IMU attitude correction stdev (<0.001deg)	0.001292
GPS position stdev (<0.01m)	0.0194
Minimum % overlap (>25)	42.48 %
Ave point cloud density per sq.m. (>2.0)	3.50
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	108
Maximum Height	745.53 m
Minimum Height	91.32 m
Classification (# of points)	
Ground	77,707,647
Low vegetation	71,425,986
Medium vegetation	116,978,079
High vegetation	217,831,248
Building	2,673,553
Orthophoto	No
Processed by	Engr. Irish Cortez, Engr. Erica Erin Elazegui, Engr. Monalyne Rabino



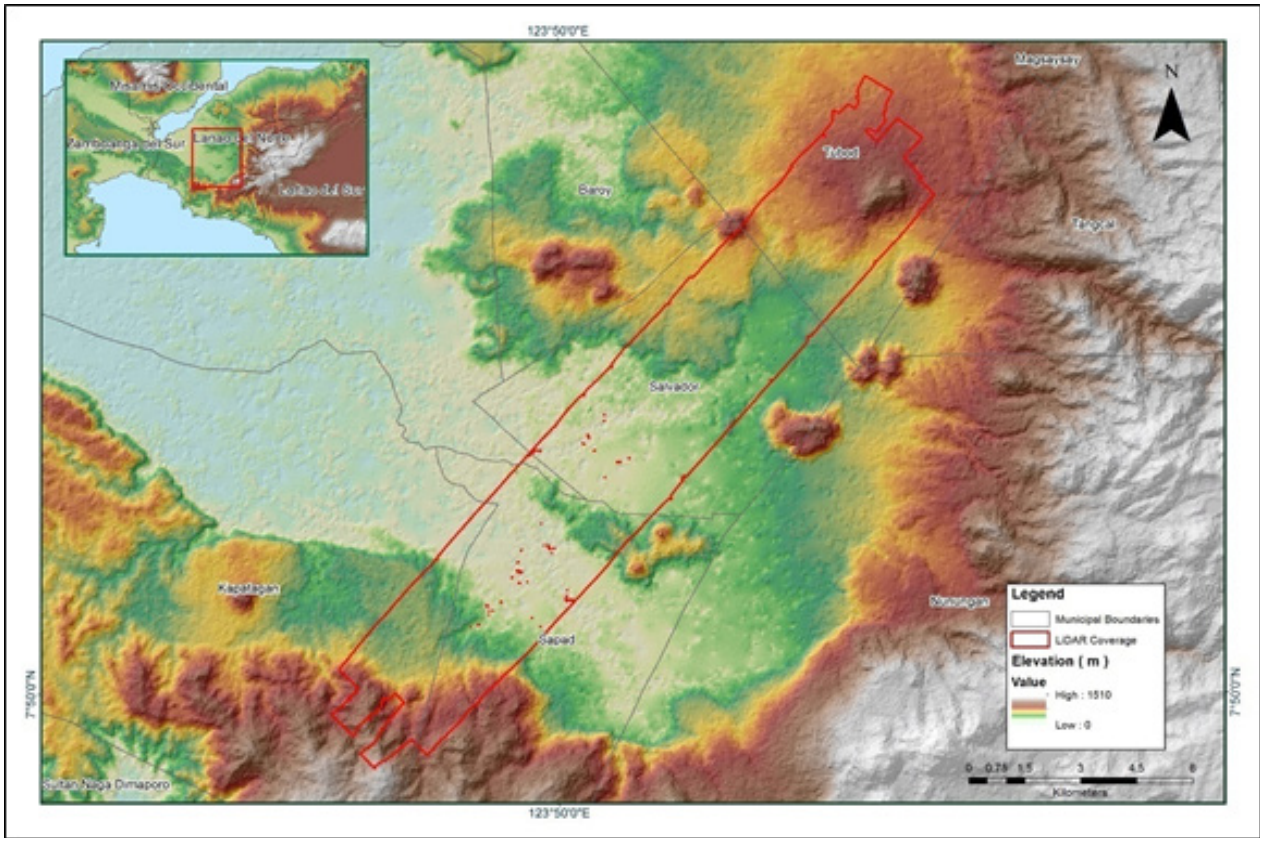
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

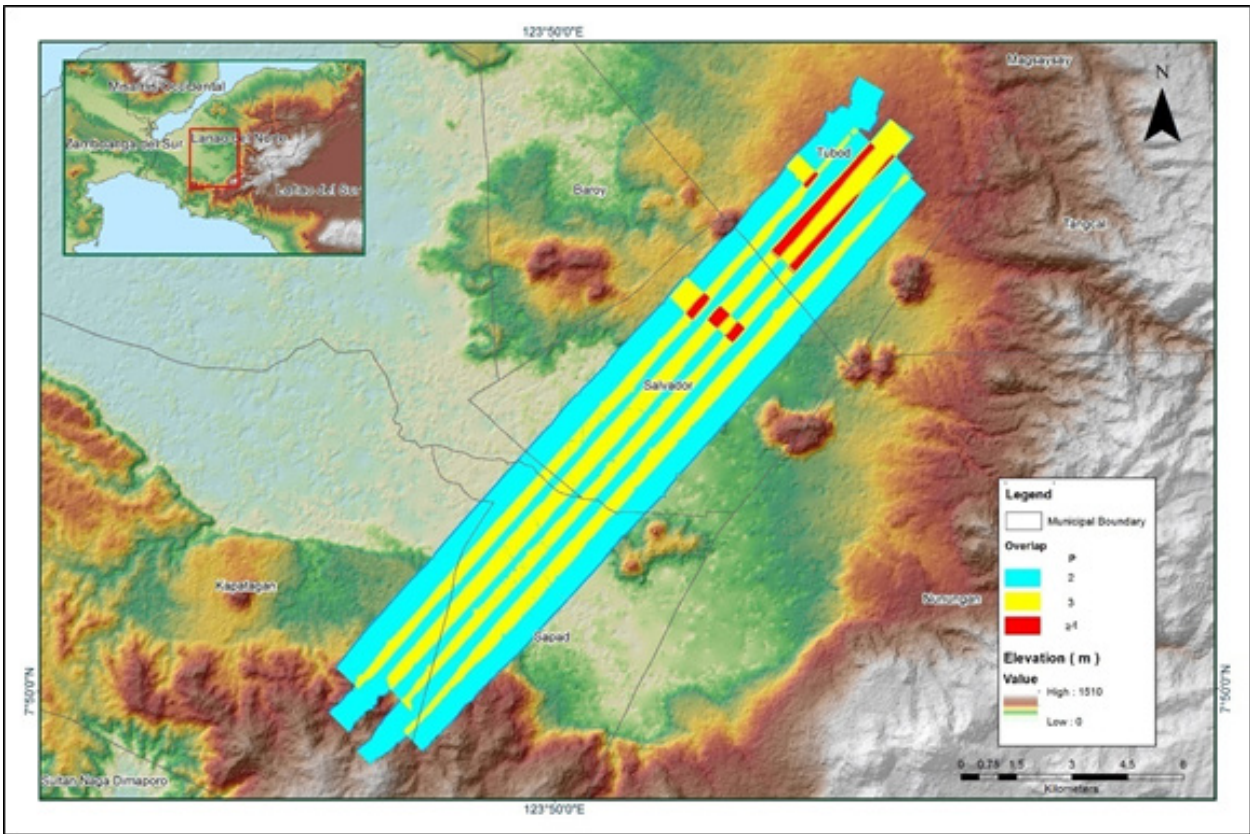
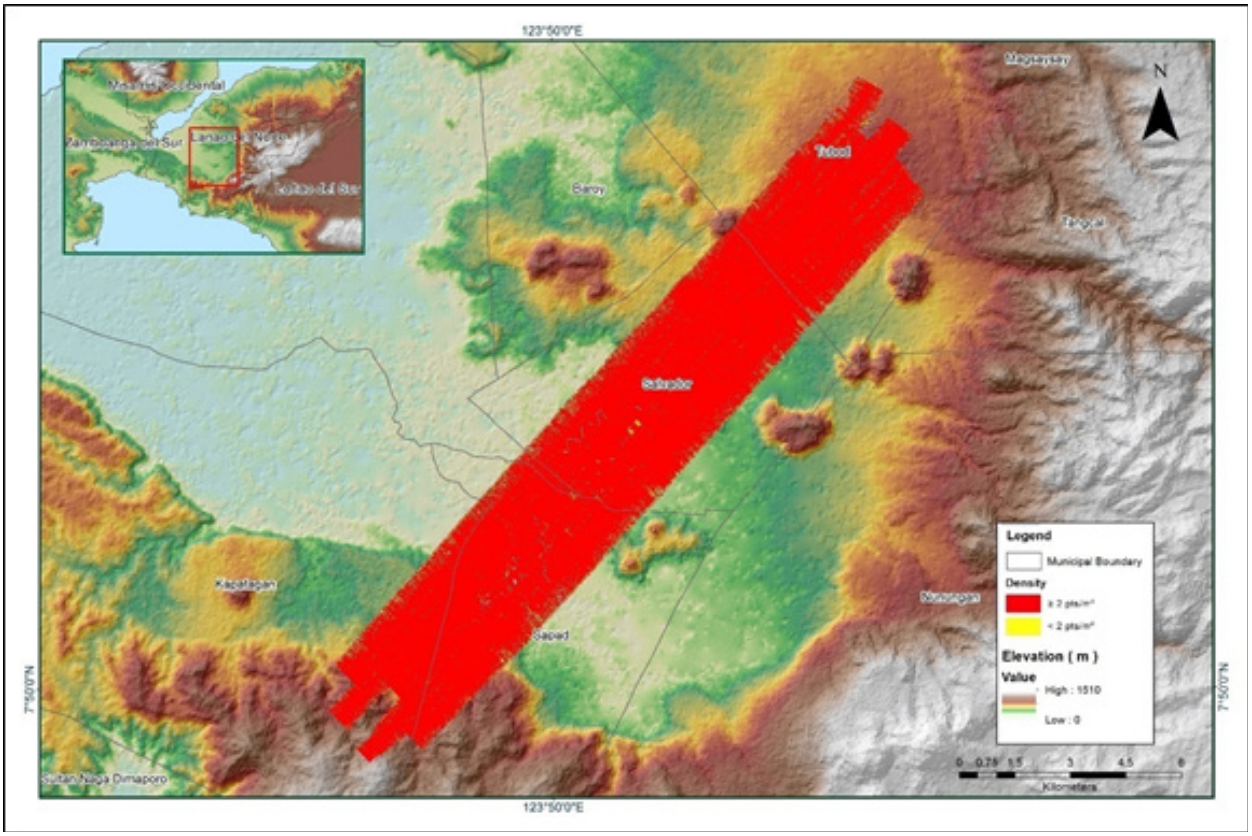
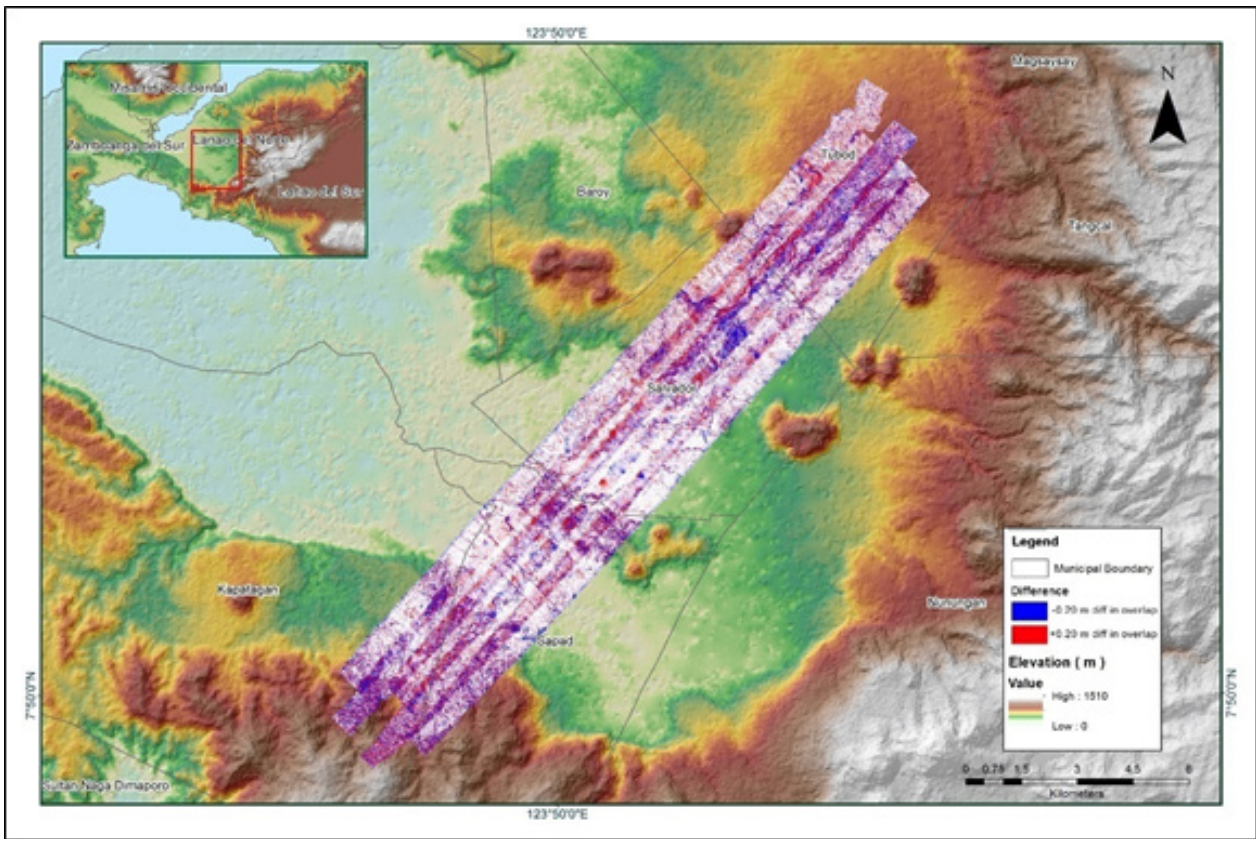


Image of Data Overlap

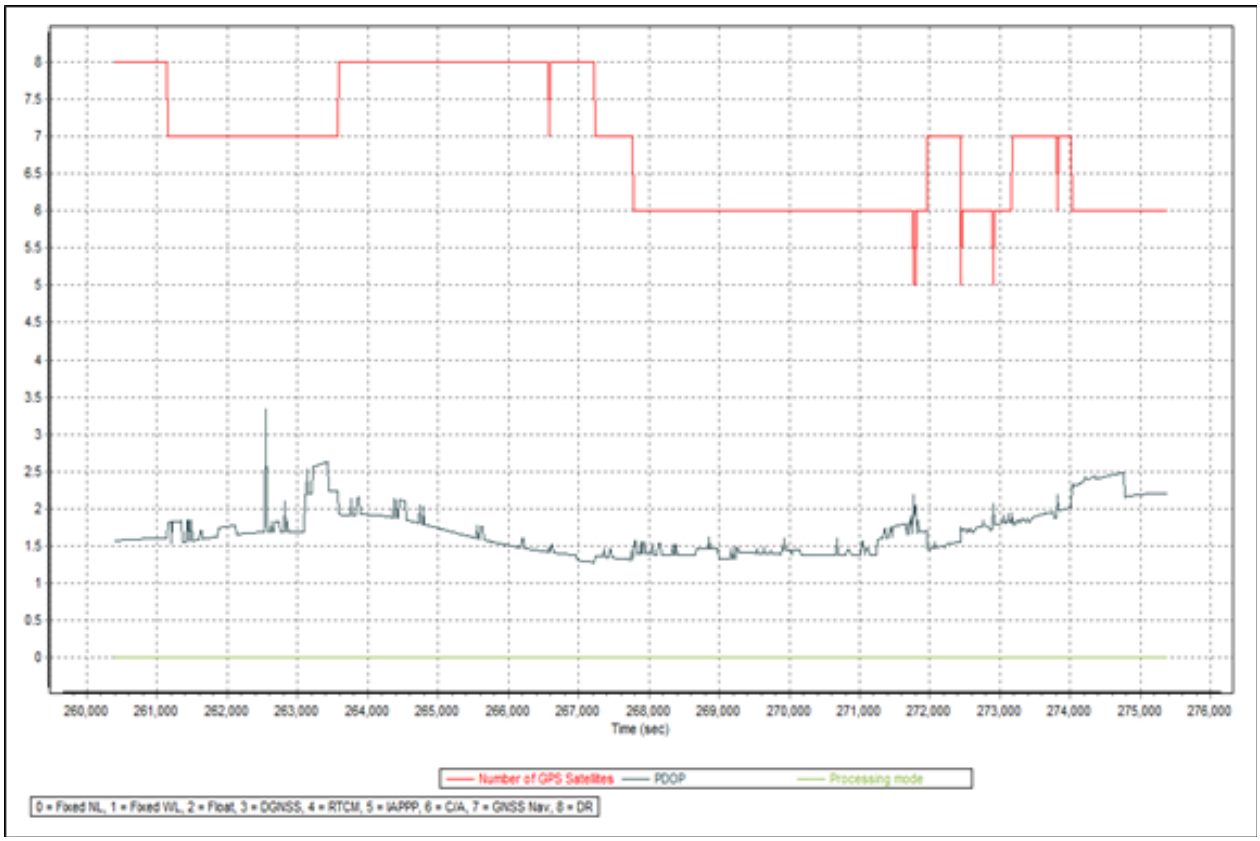


Density map of merged LiDAR data

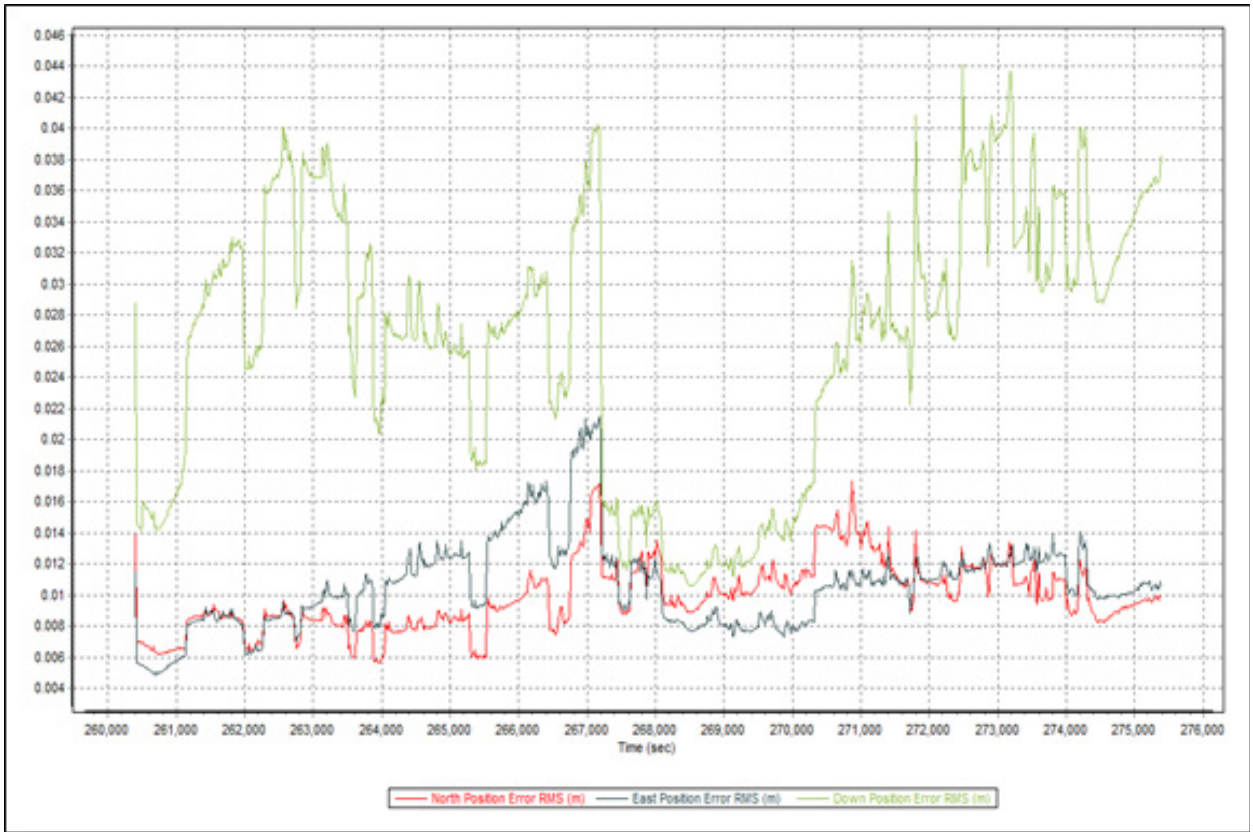


Elevation difference between flight lines

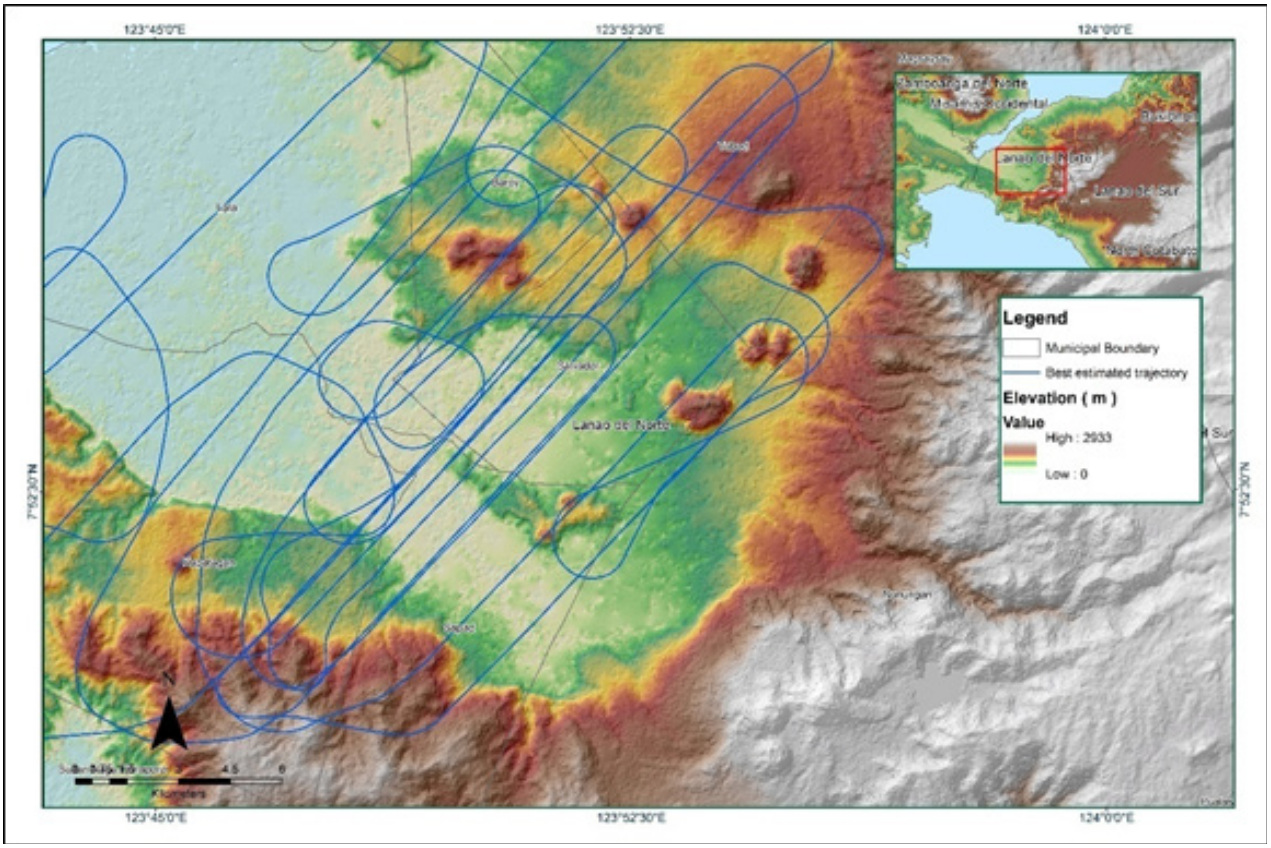
Flight Area	Pagadian
Mission Name	Blk76N_Supplement
Inclusive Flights	23104P
Range data size	18.3 GB
POS data size	287.01 MB
Base data size	116.78 MB
Image	25.87 GB
Transfer date	March 1, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.7
RMSE for East Position (<4.0 cm)	2.2
RMSE for Down Position (<8.0 cm)	4.2
Boresight correction stdev (<0.001deg)	0.000502
IMU attitude correction stdev (<0.001deg)	0.001509
GPS position stdev (<0.01m)	0.0017
Minimum % overlap (>25)	14.43
Ave point cloud density per sq.m. (>2.0)	2.64
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	13
Maximum Height	368.25
Minimum Height	93.58
Classification (# of points)	
Ground	4,438,634
Low vegetation	1,755,258
Medium vegetation	1,534,601
High vegetation	4,444,966
Building	34,342
Orthophoto	Yes
Processed by	Engr. Don Matthew Banatin, Engr. Justine Francisco, Engr. Gladys Mae Apat



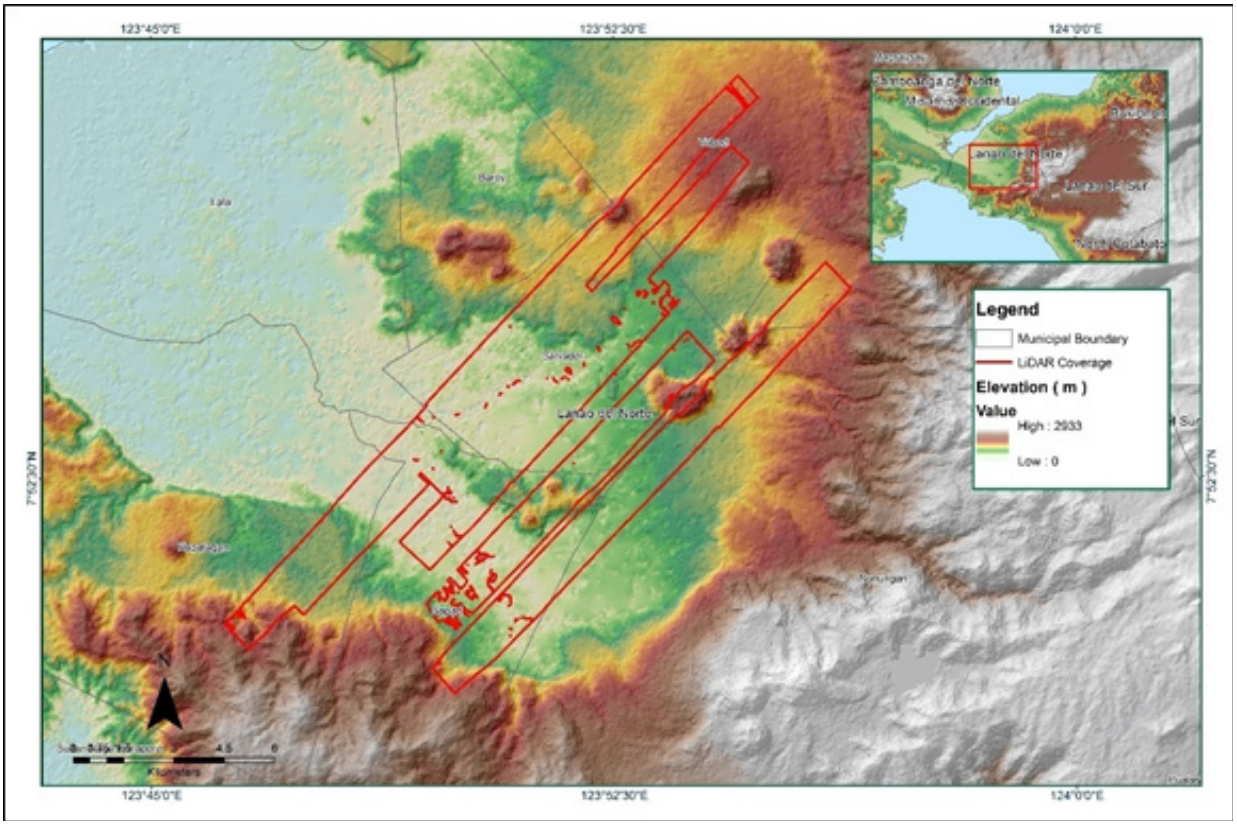
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

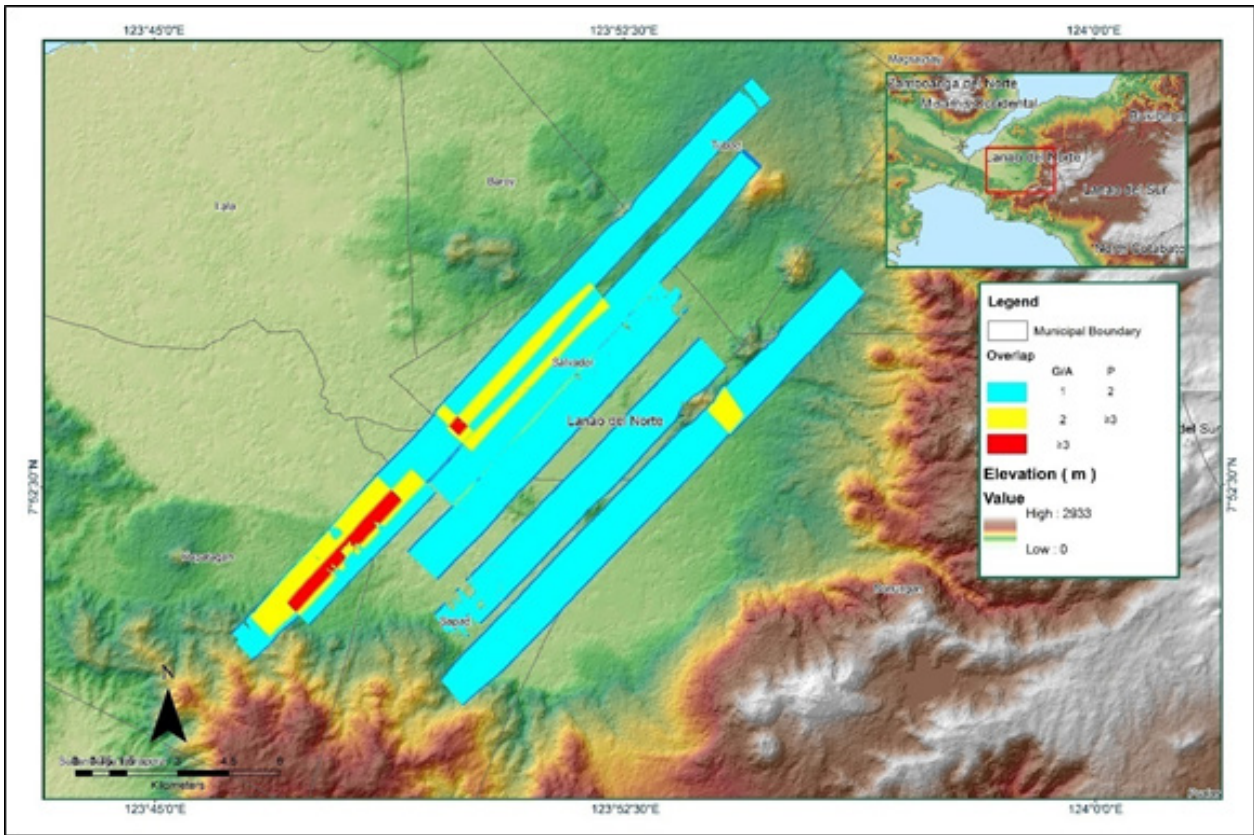
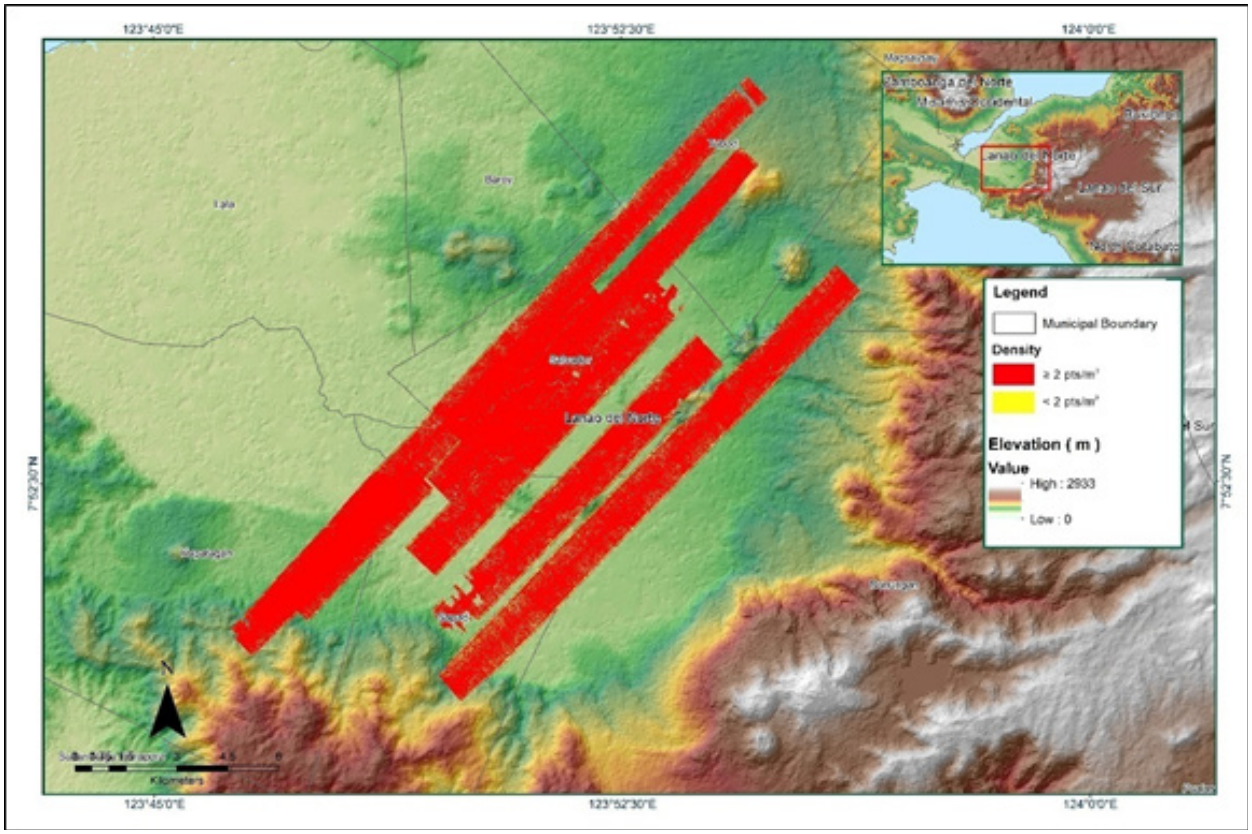
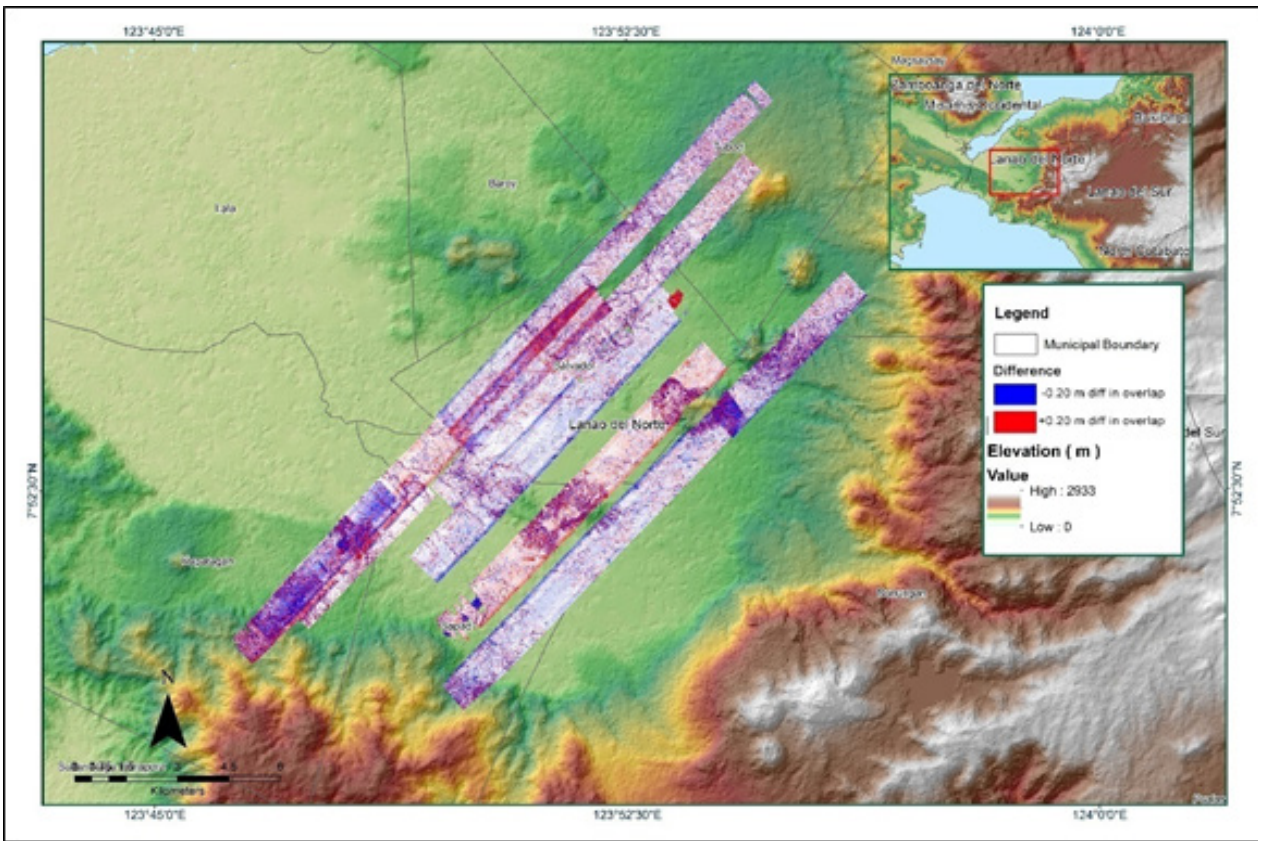


Image of Data Overlap



Density map of merged LiDAR data



Elevation difference between flight lines

ANNEX 9. Basili 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
W380	14.861	54.821	0	10.956	17.161	Discharge	0.34905	0.2925	Ratio to Peak	0.45
W410	22.271	54.926	0	10.87	5.2306	Discharge	0.0624926	0.19453	Ratio to Peak	0.56288
W430	30.051	55.424	0	6.2015	4.4773	Discharge	0.14128	0.28593	Ratio to Peak	0.63787
W470	17.632	61.653	0	18.939	13.652	Discharge	0.49898	0.13078	Ratio to Peak	0.45
W510	30.933	56.448	0	7.9208	5.7183	Discharge	0.0968188	0.1988	Ratio to Peak	0.93391
W520	15.091	75.996	0	1.233	1.8236	Discharge	0.0563880	0.13298	Ratio to Peak	0.126
W530	25.229	68.245	0	14.38	4.635	Discharge	0.16404	0.19942	Ratio to Peak	1
W540	16.113	47.731	0	12.885	6.2107	Discharge	0.22111	0.1954	Ratio to Peak	0.40677
W560	12.702	73.296	0	0.83399	2.1197	Discharge	0.17728	0.19923	Ratio to Peak	0.27763
W570	18.7	64.9	0	0.30261	1.7355	Discharge	0.10364	0.19947	Ratio to Peak	
W580	13.825	65.987	0	0.18359	0.69631	Discharge	0.0791453	0.19937	Ratio to Peak	0.18231
W630	15.887	44.293	0	18.101	4.0259	Discharge	0.14479	0.19943	Ratio to Peak	0.28236
W640	29.717	81.093	0	1.7484	2.86	Discharge	0.0879821	0.43771	Ratio to Peak	0.27246
W670	17.79	80.036	0	0.42766	1.0673	Discharge	0.0781045	0.19849	Ratio to Peak	
W680	13.199	73.495	0	0.65455	12.764	Discharge	0.20171	0.19937	Ratio to Peak	0.41966
W690	20.585	39.31	0	5.2462	6.0288	Discharge	0.19086	0.19849	Ratio to Peak	0.18824
W710	27.387	53.019	0	1.7111	1.9169	Discharge	0.0926106	0.19849	Ratio to Peak	0.41003
W740	12.892	49.912	0	1.6632	4.1429	Discharge	0.11373	0.29767	Ratio to Peak	0.28591

ANNEX 10. Balili 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	924.97	0.0021559	0.040	Trapezoid	8.816	1
R110	Automatic Fixed Interval	2311.4	0.0035353	0.040	Trapezoid	9.32	1
R120	Automatic Fixed Interval	1139.5	0.0020861	0.040	Trapezoid	11.09	1
R140	Automatic Fixed Interval	1463.7	0.0019643	0.040	Trapezoid	12.672	1
R170	Automatic Fixed Interval	3664.6	.0007217389191504974	0.040	Trapezoid	11.736	1
R190	Automatic Fixed Interval	490.42	0.0171794	0.040	Trapezoid	11.876	1
R200	Automatic Fixed Interval	500.42	0.0071852	0.040	Trapezoid	7.334	1
R220	Automatic Fixed Interval	1043.3	0.0025472	0.040	Trapezoid	10.136	1
R250	Automatic Fixed Interval	4694.2	0.0038027	0.040	Trapezoid	18.622	1
R260	Automatic Fixed Interval	1623.0	0.0022718	0.040	Trapezoid	6.5925	1
R270	Automatic Fixed Interval	168.28	0.0277707	0.040	Trapezoid	8.41	1
R280	Automatic Fixed Interval	2837.6	0.0051239	0.040	Trapezoid	8.356	1
R310	Automatic Fixed Interval	523.55	0.0081022	0.040	Trapezoid	19.236	1
R330	Automatic Fixed Interval	1356.7	0.0024456	0.040	Trapezoid	5.6067	1
R360	Automatic Fixed Interval	4955.1	0.0166752	0.040	Trapezoid	30.422	1
R70	Automatic Fixed Interval	922.55	0.0059499	0.040	Trapezoid	7.876	1
R90	Automatic Fixed Interval	488.70	0.0067411	0.040	Trapezoid	7.772	1

ANNEX 11. Balili Field Validation Points

Point Number	Validation Coordinates (in WGS84)		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
1	7.981514	123.794207	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
2	7.981691	123.794444	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
3	7.988185	123.778945	0.03	0.55	-0.52	Typhoon Lando / Oct. 12-22, 2015	5-Year
4	7.992743	123.780535	0.03	0.40	-0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
5	7.992821	123.780438	0.03	0.40	-0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
6	7.980504	123.785704	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
7	7.980538	123.785841	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
8	7.980555	123.785979	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
9	7.980754	123.785458	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
10	7.992839	123.780658	0.03	0.62	-0.59	Typhoon Lando / Oct. 12-22, 2015	5-Year
11	7.980768	123.785349	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
12	7.986539	123.779016	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
13	7.986316	123.779231	0.03	0.70	-0.67	Typhoon Lando / Oct. 12-22, 2015	5-Year
14	7.964649	123.778707	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
15	7.964705	123.778708	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
16	7.935516	123.774080	0.03	0.23	-0.2	Typhoon Lando / Oct. 12-22, 2015	5-Year
17	7.938687	123.773976	0.03	0.15	-0.12	Typhoon Lando / Oct. 12-22, 2015	5-Year
18	7.939533	123.768720	0.03	0.10	-0.07	Typhoon Lando / Oct. 12-22, 2015	5-Year
19	7.939532	123.768876	0.03	0.10	-0.07	Typhoon Lando / Oct. 12-22, 2015	5-Year
20	7.980594	123.785456	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
21	7.992973	123.780689	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
22	7.998681	123.786342	0.03	0.20	-0.17	Typhoon Lando / Oct. 12-22, 2015	5-Year
23	7.979651	123.795676	0.03	1.90	-1.87	Typhoon Lando / Oct. 12-22, 2015	5-Year
24	8.001841	123.776630	0.03	0.46	-0.43	Typhoon Lando / Oct. 12-22, 2015	5-Year

Point Number	Validation Coordinates (in WGS84)		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
25	7.986442	123.779019	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
26	7.987221	123.778188	0.03	0.17	-0.14	Typhoon Lando / Oct. 12-22, 2015	5-Year
27	7.938662	123.774095	0.03	0.15	-0.12	Typhoon Lando / Oct. 12-22, 2015	5-Year
28	7.993127	123.780453	0.03	0.40	-0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
29	7.932016	123.767185	0.04	0.17	-0.13	Typhoon Lando / Oct. 12-22, 2015	5-Year
30	7.987876	123.779290	0.03	0.09	-0.06	Typhoon Lando / Oct. 12-22, 2015	5-Year
31	7.931320	123.767503	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
32	7.988000	123.779309	0.03	0.55	-0.52	Typhoon Lando / Oct. 12-22, 2015	5-Year
33	7.935873	123.770076	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
34	7.938848	123.774109	0.04	0.15	-0.11	Typhoon Lando / Oct. 12-22, 2015	5-Year
35	7.938566	123.773949	0.05	0.15	-0.1	Typhoon Lando / Oct. 12-22, 2015	5-Year
36	7.935001	123.769311	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
37	7.932096	123.767065	0.09	0.10	-0.01	Typhoon Lando / Oct. 12-22, 2015	5-Year
38	7.931829	123.769548	0.06	0.00	0.06	Typhoon Lando / Oct. 12-22, 2015	5-Year
39	7.986930	123.779105	0.03	0.92	-0.89	Typhoon Lando / Oct. 12-22, 2015	5-Year
40	7.931425	123.767514	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
41	7.987375	123.778212	0.03	0.17	-0.14	Typhoon Lando / Oct. 12-22, 2015	5-Year
42	7.980544	123.784704	0.03	0.40	-0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
43	7.939183	123.774124	0.13	0.17	-0.04	Typhoon Lando / Oct. 12-22, 2015	5-Year
44	7.939014	123.774196	0.14	0.30	-0.16	Typhoon Lando / Oct. 12-22, 2015	5-Year
45	7.930260	123.768649	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
46	7.935010	123.769158	0.17	0.00	0.17	Typhoon Lando / Oct. 12-22, 2015	5-Year
47	7.993366	123.780460	0.03	0.98	-0.95	Typhoon Lando / Oct. 12-22, 2015	5-Year
48	7.979634	123.793113	0.03	1.60	-1.57	Typhoon Lando / Oct. 12-22, 2015	5-Year
49	7.996981	123.784958	0.03	0.00	0.03	Typhoon Lando / Oct. 12-22, 2015	5-Year
50	7.987914	123.779655	0.10	0.50	-0.4	Typhoon Lando / Oct. 12-22, 2015	5-Year

Point Number	Validation Coordinates (in WGS84)		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
51	7.935659	123.769877	0.13	0.00	0.13	Typhoon Lando / Oct. 12-22, 2015	5-Year
52	7.931861	123.767512	0.17	0.00	0.17	Typhoon Lando / Oct. 12-22, 2015	5-Year
53	7.939637	123.769425	0.09	0.39	-0.3	Typhoon Lando / Oct. 12-22, 2015	5-Year
54	7.939741	123.769304	0.09	0.00	0.09	Typhoon Lando / Oct. 12-22, 2015	5-Year
55	7.935179	123.774188	0.18	0.26	-0.08	Typhoon Lando / Oct. 12-22, 2015	5-Year
56	7.939873	123.769270	0.11	0.00	0.11	Typhoon Lando / Oct. 12-22, 2015	5-Year
57	7.935655	123.770007	0.14	0.00	0.14	Typhoon Lando / Oct. 12-22, 2015	5-Year
58	7.930678	123.769031	0.13	0.00	0.13	Typhoon Lando / Oct. 12-22, 2015	5-Year
59	7.931603	123.766996	0.27	0.00	0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
60	7.934922	123.769301	0.19	0.00	0.19	Typhoon Lando / Oct. 12-22, 2015	5-Year
61	7.935779	123.774412	0.23	0.00	0.23	Typhoon Lando / Oct. 12-22, 2015	5-Year
62	7.939654	123.769303	0.21	0.10	0.11	Typhoon Lando / Oct. 12-22, 2015	5-Year
63	8.000130	123.781743	0.03	0.77	-0.74	Typhoon Lando / Oct. 12-22, 2015	5-Year
64	8.004384	123.781422	0.03	0.47	-0.44	Typhoon Lando / Oct. 12-22, 2015	5-Year
65	7.987845	123.779666	0.12	0.50	-0.38	Typhoon Lando / Oct. 12-22, 2015	5-Year
66	7.935589	123.774291	0.29	0.23	0.06	Typhoon Lando / Oct. 12-22, 2015	5-Year
67	7.930747	123.769059	0.26	0.00	0.26	Typhoon Lando / Oct. 12-22, 2015	5-Year
68	7.935669	123.774413	0.30	0.23	0.07	Typhoon Lando / Oct. 12-22, 2015	5-Year
69	8.004526	123.781697	0.09	0.09	0	Typhoon Lando / Oct. 12-22, 2015	5-Year
70	7.987685	123.780079	0.22	0.72	-0.5	Typhoon Lando / Oct. 12-22, 2015	5-Year
71	7.931765	123.769431	0.36	0.00	0.36	Typhoon Lando / Oct. 12-22, 2015	5-Year
72	7.935619	123.774513	0.42	0.23	0.19	Typhoon Lando / Oct. 12-22, 2015	5-Year
73	7.935541	123.774396	0.42	0.23	0.19	Typhoon Lando / Oct. 12-22, 2015	5-Year
74	8.001823	123.781163	0.11	0.80	-0.69	Typhoon Lando / Oct. 12-22, 2015	5-Year
75	7.935156	123.774110	0.51	0.51	0	Typhoon Lando / Oct. 12-22, 2015	5-Year
76	7.980502	123.793189	0.03	0.50	-0.47	Typhoon Lando / Oct. 12-22, 2015	5-Year

Point Number	Validation Coordinates (in WGS84)		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
77	8.001977	123.781444	0.15	1.10	-0.95	Typhoon Lando / Oct. 12-22, 2015	5-Year
78	7.989308	123.777450	0.03	0.30	-0.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
79	7.989308	123.777450	0.03	0.10	-0.07	Typhoon Lando / Oct. 12-22, 2015	5-Year
80	7.935554	123.774184	0.55	0.23	0.32	Typhoon Lando / Oct. 12-22, 2015	5-Year
81	7.987678	123.780216	0.37	0.70	-0.33	Typhoon Lando / Oct. 12-22, 2015	5-Year
82	8.001891	123.781368	0.20	1.10	-0.9	Typhoon Lando / Oct. 12-22, 2015	5-Year
83	7.935045	123.774146	0.63	0.26	0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
84	7.980517	123.785039	0.48	0.65	-0.17	Typhoon Lando / Oct. 12-22, 2015	5-Year
85	8.004312	123.781313	0.03	0.78	-0.75	Typhoon Lando / Oct. 12-22, 2015	5-Year
86	7.987061	123.779624	0.63	0.15	0.48	Typhoon Lando / Oct. 12-22, 2015	5-Year
87	8.004427	123.781601	0.07	0.41	-0.34	Typhoon Lando / Oct. 12-22, 2015	5-Year
88	7.980478	123.785081	0.64	0.65	-0.01	Typhoon Lando / Oct. 12-22, 2015	5-Year
89	7.980526	123.785126	0.64	0.00	0.64	Typhoon Lando / Oct. 12-22, 2015	5-Year
90	7.980548	123.784899	0.67	0.50	0.17	Typhoon Lando / Oct. 12-22, 2015	5-Year
91	7.961692	123.777837	0.27	0.79	-0.52	Typhoon Lando / Oct. 12-22, 2015	5-Year
92	7.961655	123.777889	0.34	0.79	-0.45	Typhoon Lando / Oct. 12-22, 2015	5-Year
93	7.961480	123.777559	0.42	0.79	-0.37	Typhoon Lando / Oct. 12-22, 2015	5-Year
94	7.963154	123.778349	0.54	0.58	-0.04	Typhoon Lando / Oct. 12-22, 2015	5-Year
95	8.001065	123.780271	0.03	1.30	-1.27	Typhoon Lando / Oct. 12-22, 2015	5-Year
96	7.930322	123.768669	1.35	0.00	1.35	Typhoon Lando / Oct. 12-22, 2015	5-Year
97	7.963125	123.777910	0.90	0.50	0.4	Typhoon Lando / Oct. 12-22, 2015	5-Year
98	7.979766	123.797006	0.03	1.90	-1.87	Typhoon Lando / Oct. 12-22, 2015	5-Year
99	7.997823	123.786970	0.38	0.00	0.38	Typhoon Lando / Oct. 12-22, 2015	5-Year
100	7.930692	123.768669	1.95	0.00	1.95	Typhoon Lando / Oct. 12-22, 2015	5-Year

Point Number	Validation Coordinates (in WGS84)		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return
	Lat	Long					
101	7.998250	123.785045	0.40	0.00	0.4	Typhoon Lando / Oct. 12-22, 2015	5-Year
102	8.004088	123.781440	2.11	0.60	1.51	Typhoon Lando / Oct. 12-22, 2015	5-Year
103	8.001012	123.777848	1.75	0.73	1.02	Typhoon Lando / Oct. 12-22, 2015	5-Year
104	7.979806	123.797487	1.34	1.90	-0.56	Typhoon Lando / Oct. 12-22, 2015	5-Year
105	7.980514	123.795708	1.37	1.90	-0.53	Typhoon Lando / Oct. 12-22, 2015	5-Year
106	8.000880	123.778092	2.09	0.40	1.69	Typhoon Lando / Oct. 12-22, 2015	5-Year
107	8.000870	123.781029	2.31	1.52	0.79	Typhoon Lando / Oct. 12-22, 2015	5-Year
108	7.980019	123.794219	3.33	1.90	1.43	Typhoon Lando / Oct. 12-22, 2015	5-Year
109	8.002403	123.776674	5.10	1.51	3.59	Typhoon Lando / Oct. 12-22, 2015	5-Year
110	8.000846	123.778118	5.61	0.40	5.21	Typhoon Lando / Oct. 12-22, 2015	5-Year
111	8.002970	123.776507	5.77	1.06	4.71	Typhoon Lando / Oct. 12-22, 2015	5-Year
112	8.000736	123.778621	5.56	1.50	4.06	Typhoon Lando / Oct. 12-22, 2015	5-Year
113	8.000801	123.778297	5.77	1.54	4.23	Typhoon Lando / Oct. 12-22, 2015	5-Year
114	8.000747	123.778686	5.81	1.13	4.68	Typhoon Lando / Oct. 12-22, 2015	5-Year
115	8.000762	123.778461	5.78	0.15	5.63	Typhoon Lando / Oct. 12-22, 2015	5-Year
116	8.000830	123.778207	6.17	0.77	5.4	Typhoon Lando / Oct. 12-22, 2015	5-Year
117	7.985071	123.791123	6.94	0.00	6.94	Typhoon Lando / Oct. 12-22, 2015	5-Year

ANNEX 12. Educational Institutions Affected by flooding in Balili Flood Plain

LANAO DEL NORTE				
BAROY				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
Day Care	Andil			
Daycare Center	Andil			
Estevan Elementary School	Andil			
Grade High and 4	Andil			
Grade 5 and 6	Andil			
Pre-school and Grade Low	Andil			
Bagong Dawis Elementary School	Bagong Dawis			
Bag.ong Dawis Elementary School (Pre-school)	Bagong Dawis			
Daycare Center	Bagong Dawis			Low
Faculty Office	Bagong Dawis			
Grade Low	Bagong Dawis	Low	Low	Medium
Grade Medium	Bagong Dawis	Low	Low	Medium
Grade High	Bagong Dawis		Low	Medium
Grade 5 and 6	Bagong Dawis			
Kindergarten	Bagong Dawis		Low	Medium
Lanao Norte Nat'l High School	Baroy Daku			
Baroy Central Elem. School	Baroy Daku			
daycare	Baroy Daku			
Daycare	Baroy Daku			
Day Care Center	Bato			
Day Care Center	Cabasagan			
Non-functional School	Cabasagan	Low	Medium	Medium
Pendulonan Primary School	Cabasagan			
Daycare	Dalama			
canteen	Libertad			
Central elementary	Libertad	Low	Low	Low

LANAO DEL NORTE				
BAROY				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Computer Room	Libertad	Low	Medium	Medium
Diosdado Yap HIgh School	Libertad	Low	Low	Low
Primary School	Limwag			
Day Care Center	Lindongan			
Daycare	Manan-Ao			
Manan ao Elem	Manan-Ao			
Manan ao Elem Schhol	Manan-Ao			
Manan ao Elem School	Manan-Ao			
Sario de roda elementary school (grade Low)	Pange			
Sario de roda elementary school (grade 4 and High)	Pange			
HE Building	Pindolonan			
Lindongan Elem. School	Pindolonan			
Principal's Office	Pindolonan			
School Canteen	Pindolonan			
Baroy Central Elem. School	Poblacion			
District Office	Poblacion			
Lanao School of Science and Technology	Poblacion			
Principal's Office	Poblacion			
School Canteen	Poblacion			
Sto Nino Academy	Poblacion			
Day Care Center	Princesa			
Princessa Elem. School	Princesa			
Compter Center/ Pre School	Rawan Point			
Grade Low-High-4	Rawan Point			
Grade 6	Rawan Point	Low	Medium	Medium
Multi-purpose Hall	Rawan Point			
Raw-an Point Elem. School	Rawan Point			
Mediumnd Yr	Riverside			

LANAO DEL NORTE				
BAROY				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
Diosdado Yap HIgh School	Riverside	Medium	Medium	Medium
Sr High	Riverside		Low	Low
Temporary Rooms	Riverside			
Baroy Central Elem. School	San Juan			
Elementary School	San Juan			
Primary School	San Juan			
UCCP Pre-School	San Juan			
Daycare	Tinubdan			
Maliwanag Elem School	Tinubdan			
Lanao Norte Nat'l High School	Village			

LANAO DEL NORTE				
KAPATAGAN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Computer Room	Bagong Silang	Low	Medium	Medium
Day Care Center	Bagong Silang	Low	Medium	Medium
Grade Medium	Bagong Silang	Low	Medium	Medium
Grade 4	Bagong Silang	Low	Medium	Medium
Kinder	Bagong Silang	Low	Medium	Medium
Principal's Office	Bagong Silang		Low	Medium
School Canteen	Bagong Silang	Low	Medium	Medium
Daycare Center Tiacongan	Bagong Silang		Medium	Medium
Day Care Center	Balili		Medium	Medium
Grade 4	Balili		Medium	Medium
Grade 5-6	Balili		Medium	Medium
Grade 6	Balili		Medium	Medium
Pinoyak Elem. School	Balili		Medium	Medium
Principal's Office	Balili		Medium	Medium
Stage	Balili		Medium	Medium
Grade Low	Cathedral Falls			
Kitchen	Cathedral Falls			
Anacurita Elem School	Cathedral Falls	Medium	Medium	Medium
Anacurita Elem.	Cathedral Falls	Medium	Medium	Medium
Day Care	Cathedral Falls			
Day Care Center	Cathedral Falls	Low	Low	Medium
Grade High and gade 4	Cathedral Falls			
Grade 5 B	Cathedral Falls			
Grade 6 A	Cathedral Falls			
Preschool	Cathedral Falls			
Day Care	Concepcion	Medium	Medium	High
Grade High	Concepcion	Low	Medium	Medium
Grade 4	Concepcion	Low	Medium	Medium
Grade 5&6	Concepcion	Low	Medium	Medium

LANAO DEL NORTE				
KAPATAGAN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Principals Office	Concepcion	Low	Medium	Medium
Daycare Center	Concepcion		Low	Low
Emiliano Dizon Elem School	Concepcion	Medium	Medium	High
Curvada Elem	Curvada		Low	Medium
Kindergarten	De Asis	Medium	Medium	Medium
SCHOOL Stage	De Asis	Medium	Medium	Medium
Daycare	De Asis		Low	Low
Adventist School	Donggoan			
Balili Day Care Center	Donggoan			
Grade Low	Donggoan		Low	Medium
Grade Low&4	Donggoan		Low	Medium
Grade Medium	Donggoan	Low	Medium	Medium
Grade High	Donggoan	Low	Medium	Medium
HE Building	Donggoan		Low	Medium
Kinder Low	Donggoan		Low	Low
Learning Center	Donggoan			
Old Buildng	Donggoan			
Donggoan Elem School	Donggoan			
Daycare center	Lapinig	High	High	High
placida mequiabas national high school	Lapinig	Medium	Medium	High
Placida Mequiabas National High School	Lapinig			
Dishwashing Area	Maranding	Medium	Medium	Medium
School of Born Again Church	Maranding	Medium	Medium	Medium
Stage	Maranding	Medium	Medium	Medium
Waiting Shed	Maranding	Medium	Medium	Medium
Paradero Day Care	Maranding	Medium	Medium	Medium
Daycare Center	Margos			
Sixto Magnanoy Sr. Central School	Margos		Low	Low
Abandoned	Poblacion	Low	Medium	High

LANAO DEL NORTE				
KAPATAGAN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Abandoned Day Care	Poblacion	Medium	Medium	High
Canteen	Poblacion	Low	Medium	Medium
District Office	Poblacion	Medium	Medium	Medium
Grade Low Classroom	Poblacion	Low	Medium	Medium
Grade High Classroom	Poblacion	Low	Medium	Medium
Grade 5 Classroom	Poblacion	Low	Medium	Medium
grade 6	Poblacion	Medium	Medium	High
Grade 6 Classroom	Poblacion		Medium	Medium
HE Classroom	Poblacion	Low	Medium	Medium
San Vicente Elem. School	Poblacion	Low	Medium	High
School Room	Poblacion	Low	Medium	High
Technical School	Poblacion	Low	Medium	Medium
Daycare	Poblacion	Medium	Medium	High
Daycare Center	Poblacion		Low	Medium
reading center(purok)	Poblacion	Low	Medium	Medium
Day Care Center	Santo Tomas	Low	Low	Medium
Grade Low	Santo Tomas	Medium	Medium	Medium
Grade 4 Room	Santo Tomas	Medium	Medium	Medium
Grade 6 Room	Santo Tomas		Low	Low
Kindergarten	Santo Tomas			
Balili Elementary	Suso	Low	Medium	Medium
Daycare	Suso			
Daycare Center	Suso	Medium	Medium	Medium
Anacurita Elem.	Waterfalls	Medium	Medium	Medium
Daycare Center	Waterfalls	Medium	Medium	Medium
Itans Learning Center	Waterfalls	Low	Low	Medium

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Abaga Central Elementary School	Abaga			Low
Classroom	Abaga			Low
CR & Hand Washing	Abaga	Medium	Medium	Medium
Day Care Center Low	Abaga			
DU Tenazas Memorial Elem. School	Abaga		Low	Low
Function Hall	Abaga		Low	Low
Grade Low-High	Abaga			
Grade 4	Abaga		Low	Low
Grade 5	Abaga			
Grade 6 & Kinder	Abaga		Low	Low
Hand Washing Area	Abaga	Low	Medium	Medium
Maranding Christian School KLow-KMedium rooms	Abaga			
MCS Gym	Abaga			
MCS Office	Abaga			
MCS Old Buildings	Abaga			
Principal's Office	Abaga	Low	Medium	Medium
School Canteen	Abaga		Low	Low
School Multipurpose Hall	Abaga	Low	Low	Low
Science Room	Abaga			
Sario de roda elementary school (grade Low)	Andil			
Sario de roda elementary school (grade 4 and High)	Andil			
Sario de roda elementary school stage	Andil			
Daycare center	Andil			
Sario de roda elementary school (grade 5 and 6)	Andil			Low
Daycare Center	Cabasagan			
Francisco Bolante Memorial School (Pre-School to grade 6)	Cabasagan			
Purok 4-B Daycare Center	Cabasagan			

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Purok 6 Daycare Center	Cabasagan			
Camalan Primary School	Camalan			
Grade High-4	Camalan			
Day Care Center	Darumawang Bucana			
School Bldg	Darumawang Bucana			
School C.R.	Darumawang Bucana			
C.R.	Darumawang Ilaya			
Day Care	Darumawang Ilaya			
Grade Low	Darumawang Ilaya		Low	Low
Grade 4	Darumawang Ilaya		Low	Low
Grade 5	Darumawang Ilaya	Low	Low	Low
Grade 6	Darumawang Ilaya		Low	Low
Guidance Office	Darumawang Ilaya			
Lutuanan	Darumawang Ilaya			
Office and SchoolDormitory	Darumawang Ilaya			
Principal's Office	Darumawang Ilaya		Low	Low
School Canteen	Darumawang Ilaya			
Simpak Adventist Institute of Technology	Darumawang Ilaya			
Social hall	Darumawang Ilaya			
Vocational Bldg	Darumawang Ilaya		Low	Low
Vocational Bldg. Medium	Darumawang Ilaya			
Library	Darumawang Ilaya			
El Salvador Elem. School	El Salvador		Medium	Medium
Grade 4	El Salvador		Medium	Medium

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Grade 4	El Salvador		Medium	Medium
Grade 4-5-6	El Salvador		Medium	Medium
Principal's Office	El Salvador		Low	Medium
Stage	El Salvador		Medium	Medium
Grade Low-6	Gumagamot	Low	Low	Medium
Panadtaran Elem. School	Gumagamot		Low	Low
LALA Elem School Proper	Lala Proper	Low	Low	Medium
Daycare	Lanipao			
LALA North District School	Lanipao			
Classroom	Magpatao			
Computer Center	Magpatao			
Grade Low-Medium-High	Magpatao			
Grade 6	Magpatao			
HE Room	Magpatao			
Magpatao Elem	Magpatao			
Prk Medium Day Care Center	Magpatao			
School Stage	Magpatao			
Stage	Magpatao			
Daycare center	Magpatao			
Magpatao Elementary School	Magpatao			
Bible Baptist School	Maranding	Medium	Medium	Medium
Calssroom LowMedium	Maranding	Medium	High	High
Canteen	Maranding	Medium	Medium	Medium
Classroom	Maranding	Medium	Medium	Medium
Classroom LowLow	Maranding	Medium	Medium	High
Classroom 4	Maranding	Medium	Medium	Medium
Classroom 5	Maranding	Medium	High	High
Classroom 6	Maranding	Medium	Medium	High
Classroom 7	Maranding	Medium	Medium	High

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Classroom 8	Maranding	Medium	Medium	High
Classroom 9	Maranding	Medium	Medium	High
ClassroomLow	Maranding	Medium	High	High
ClassroomMedium	Maranding	Medium	High	High
Faculty Room	Maranding	Medium	Medium	High
Grade Medium	Maranding	Medium	Medium	Medium
grade High	Maranding	Medium	High	High
Grade 4	Maranding	Medium	Medium	Medium
Grade 5	Maranding	Medium	Medium	Medium
Guard House	Maranding	Medium	Medium	High
Lanao Norte-Learning Resource Center	Maranding	Medium	Medium	Medium
LNHS Gym	Maranding	Medium	High	High
LNHS Principal's Office	Maranding	Medium	Medium	High
Mini Canteen	Maranding	Medium	Medium	High
NCMC Building	Maranding	Low	Low	Medium
NCMC Collge Department	Maranding	Low	Low	Medium
NCMC Elementary Department	Maranding	Low	Medium	Medium
NCMC Gym	Maranding		Low	Low
NCMC HRM Department	Maranding	Medium	Medium	Medium
Preschool	Maranding	Medium	Medium	Medium
Principal's Office	Maranding		Low	Low
Prk. Rambutan Day Care Center	Maranding		Low	Medium
PTA Office	Maranding	Medium	Medium	Medium
School Clinic	Maranding	Medium	Medium	Medium
Social Hall	Maranding	Medium	Medium	Medium
Stage	Maranding	Medium	Medium	Medium
Grade Low	Maranding	Medium	Medium	Medium
Day Care Center Old	Matampay Bucana			
Matampay Bucana Elem. School	Matampay Bucana		Low	Medium

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
San Roque Chapel	Matampay Bucana			
Classrooms Low	Pacita			
Classrooms Medium	Pacita			
Day Care Center	Pacita			
Doggoan Elementary School	Pacita			
Grade Low-Medium	Pacita			
Grade High	Pacita			
Grade 4-5	Pacita			
Grade 6	Pacita			
Matampay Ilaya Elem. School	Pacita			
Prk Medium Day Care Center	Pacita	Low	Low	Low
School Clinic	Pacita			
Stage	Pacita			
Day Care Center Medium	Pendolonan		Low	Low
Comfort Room	Pendolonan			
Day Care Center	Pendolonan			
Generoso Lapasaran Memorial School Canteen	Pendolonan			
Grade Low	Pendolonan			
Grade 6	Pendolonan			
Pre-school and Faculty Office	Pendolonan			
School Library	Pendolonan			
Cabrera Day Care Center	Pinoyak	Low	Low	Low
Saavedra Day Care Center	Pinoyak			Low
FM Posadas Elementary School	Raw-An		Low	Medium
Classroom Low	Raw-An	Low	Low	Medium
Classroom Medium	Raw-An	Low	Low	Medium
Economics building	Raw-An		Low	Medium
Grade 5 and 6	Raw-An	Low	Medium	Medium
Kindergarten	Raw-An		Low	Medium

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
School Canteen	Raw-An		Low	Medium
Pedro B. Liwanag Memorial Elem	Rebe			
Antonio Lim Sr. Elem School	San Isidro Lower			
Brgy. Sta. Cruz Lower Elem. School	San Isidro Lower			
Day Care	San Isidro Lower			Low
daycare	San Isidro Lower			
Grade Low	San Isidro Lower			
Grade Low-Medium-4	San Isidro Lower			
Grade High	San Isidro Lower			
Grade 5-6	San Isidro Lower			
HE Room	San Isidro Lower			
Pre-School	San Isidro Lower			
Canteen	San Isidro Upper			
Computer Laboratory	San Isidro Upper	Low	Low	Low
Daycare Center	San Isidro Upper			
Grade Low	San Isidro Upper			
Pre-school and faculty room	San Isidro Upper			
San Isidro Elementary School(grade Medium-6)	San Isidro Upper			
Stage	San Isidro Upper			
Daycare	San Manuel	Medium	Medium	Medium
San Manuel Elem	San Manuel			
Daycare	Santa Cruz Lower			
Daycare	Santa Cruz Upper		Medium	Medium
Auditorium	Simpak		Low	Low
Grade Low	Simpak		Low	Low
Grade Medium	Simpak		Low	Low
Grade High	Simpak	Low	Low	Medium
Grade 4	Simpak	Medium	Medium	Medium
Grade 5	Simpak	Low	Medium	Medium

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Kindergarten	Simpak	Low	Medium	Medium
Principal's Office	Simpak	Low	Medium	Medium
Saavedra Elementary School	Simpak	Low	Low	Medium
School C.R.	Simpak			
School Canteen	Simpak	Low	Medium	Medium
School Clinic	Simpak		Low	Low
School Guard House	Simpak		Low	Low
School Old Canteen	Simpak		Low	Low
Stage	Simpak		Low	Low
Vermi Culture Center	Simpak		Low	Low
D.U. Tenzasas Elem	Tenazas			
D.u.Tenazasas Elem	Tenazas			
Daycare	Tenazas			
Montesory	Tenazas			Low
BFAR Dorm Low	Tuna-An			
BFAR Dorm Medium	Tuna-An	Low	Low	Medium
Day Care Center	Tuna-An			
Dorm High	Tuna-An	Medium	Medium	Medium
Dorm 4	Tuna-An			
Dorm 5	Tuna-An	Medium	Medium	Medium
Grade Low-4	Tuna-An			
Grade 5-6	Tuna-An			
Library	Tuna-An			
Tunaan Elem. School Stage	Tuna-An			

LANAO DEL NORTE				
SAVADOR				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Daycare Center	Camp III		Low	Medium
Grade Low - High	Camp III		Low	Low
Grade Medium and 5	Camp III			
Grade 5	Camp III			Low
Grade 6	Camp III	Low	Low	Low
School Booth	Camp III			
School Stage	Camp III			
Sudlon Elementary School	Camp III		Low	Low
Abandoned School	Curva-Miagao		Low	Low
Classroom	Curva-Miagao	Low	Medium	High
Curva-Miagao Elem. School	Curva-Miagao		Medium	Medium
Day Care Center	Curva-Miagao			
School Waiting Shed	Curva-Miagao	Low	Medium	High
Stage	Curva-Miagao		Medium	High
San Manuel Elem	Curva-Miagao			
Classroom	Inasagan	Low	Low	Low
Classroom Medium	Inasagan			
Classroom High	Inasagan			
Day Care Center	Inasagan		Low	Low
Day Care Center Kalahi	Inasagan			
Former Canteen	Inasagan		Low	Low
Grade Medium	Inasagan			
Grade 4	Inasagan	Low	Low	Low
Grade 5-6	Inasagan		Low	Low
Grade 6	Inasagan			
Kinder	Inasagan	Medium	Medium	Medium
School Bldg.	Inasagan			
Stock Room	Inasagan	Low	Low	Low
Social Hall	Inasagan			
Day Care Center	Mabatao			

LANAO DEL NORTE				
TUBOD				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Day Care Center Medium	Licapao			
Lanao Norte Provincial Science and Technology High School	Licapao			Low
Licapao Elem. School	Licapao			
LNPSTHS School Bldg	Licapao			
Malingao Central School	Licapao			
School Bldg.	Licapao		Low	Low
School Stage	Licapao			

LANAO DEL NORTE				
AURORA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Canteen	Anonang		Low	Low
Comfort Room	Anonang	Low	Low	Low
Computer Room	Anonang			
Grade Higha	Anonang		Low	Low
Grade 4	Anonang	Medium	Medium	Medium
Grade 5	Anonang	Low	Low	Low
Margos Elementary School	Anonang	Low	Medium	Medium
Principal's Office	Anonang			
School Health Center	Anonang			Low
School Waiting Shed	Anonang	Low	Low	Low
Social Hall	Anonang	Low	Low	Medium
grade 6	Anonang		Low	Low
HE room	Anonang	Medium	Medium	Medium
School Waiting Shed	Anonang		Low	Low

ANNEX 13. Health Institutions affected by flooding in Balili Floodplain

LANAO DEL NORTE				
BAROY				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
Health Center	Andil			
Health Care Center	Bagong Dawis			
Health Center	Bagong Dawis			Low
Health Center	Cabasagan			
Health center	Dalama			
Health Center	Libertad			
Health Center	Limwag			
Health Center	Lindongan			
OB Gyne Clinic	Poblacion			
Pharmacy	Poblacion			
Health Center	Princesa			
Temporary Health Center	Salong			Low

LANAO DEL NORTE				
KAPATAGAN				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
Clinic	Bagong Silang	Low	Medium	Medium
Polipog Health Center	Balili	Low	Medium	Medium
Health Center	Cathedral Falls	Medium	Medium	Medium
Health Center	De Asis		Low	Low
Balili Health Center Extension	Donggoan			
Health Center	Donggoan	Low	Low	Low
Health Center	Maranding	Medium	High	High
Provincial Hospital	Maranding	Low	Low	Medium
Provincial Hospital	Maranding			Low
Balili Provincial Hospital	Poblacion	Low	Medium	Medium
Mercury	Poblacion	Low	Medium	Medium

LANAO DEL NORTE				
KAPATAGAN				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
RightMeds Pharmacy	Poblacion			Low
Delbert Jon's Hospital	Poblacion		Medium	Medium
Dr. Gatchalian Hospital (OLD)	Poblacion	Medium	Medium	High
Municipal Health Office	Poblacion		Medium	High
Old Health Center	Santo Tomas			
Sto Tomas Health Center	Santo Tomas	Medium	Medium	Medium
Clinic	Waterfalls	Low	Medium	Medium

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Health Center	Abaga			
School Clinic	Abaga			Low
Health center	Andil			
Health Center	Cabasagan			
Brgy. Health Center	Darumawang Bucana			Low
Health Center	Darumawang Ilaya			
Health Center	El Salvador			Low
Health Center	Lala Proper		Low	Low
Vet Clinic	Lanipao	Low	Low	Low
Prk Medium Health Center	Magpatao			
Health Center	Magpatao			
AFC AMY Pharmacy	Maranding	Medium	Medium	Medium
Asintesta Medical Clinic	Maranding	High	High	High
Barangay Health Station	Maranding	Medium	Medium	Medium
Bontilao Country Hospital	Maranding	Medium	Medium	Medium
Gozo Community Hospital	Maranding	Low	Medium	Medium

LANAO DEL NORTE				
LALA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Maranding Community Hospital	Maranding			Low
Mendoza Macayan Optical Clinic	Maranding	Medium	Medium	Medium
Mercury Drug	Maranding	Medium	Medium	Medium
NCMC Lying In	Maranding	Low	Low	Medium
The Generics Pharmacy	Maranding	Low	Medium	Medium
Bulaclac Pharmacy	Maranding	Medium	Medium	Medium
Barangay Health Center	Matampay Bucana			
Health Center	Pacita			
Pacita Health Center	Pacita			Low
Health Center	Pendolonan			
Health Center	Rebe			
Health Center	San Isidro Lower			
Health Center	San Isidro Upper			
Health Center	San Manuel	Low	Low	Low
Health Center	Santa Cruz Upper		Low	Medium
Lanipao Health Center	Santa Cruz Upper		Low	Medium
Health Center	Simpak			
Health Center	Tuna-An			

LANAO DEL NORTE				
SALVADOR				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Barangay Health Center	Camp III			
Health Center	Curva-Miagao			
Barangay Health Center	Inasagan	Low	Low	Low
Health Center	Inasagan	Low	Medium	Medium
Health Center	Panaliwad-On			
Old Rural Health Center	Poblacion		Low	Low

LANAO DEL NORTE				
SALVADOR				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
Margos Health Center	Anonang			