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

LiDAR Surveys and Flood Mapping of Aklan River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
University of the Philippines Cebu

APRIL 2017

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

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

E.C. Paringit and J.R. Sinogaya (eds.) (2017), LiDAR Surveys and Flood Mapping of Aklan River, Quezon City: University of the Philippines Training Center on Applied Geodesy and Photogrammetry-266pp

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National Library of the Philippines
ISBN: 978-621-430-095-2

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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
UTM	Universal Transverse Mercator
WGS	World Geodetic System

CHAPTER 1: OVERVIEW OF THE PROGRAM AND AKLAN RIVER

Enrico C. Paringit, Dr. Eng. and Jonnifer Sinogaya, PhD.

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, supported by the Department of Science and Technology (DOST) Grant-in-Aid (GiA) Program. The program was primarily aimed at acquiring a national elevation and resource dataset at sufficient resolution to produce information necessary to support the different phases of disaster management. Particularly, it targeted to operationalize the development of flood hazard models that would produce updated and detailed flood hazard maps for the major river systems in the country.

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

The implementing partner university for the Phil-LiDAR 1 Program is the University of the Philippines Cebu (UPC). UPC 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 twenty-two (22) river basins in the Western Visayas Region. The university is located in Cebu City in the province of Cebu.

1.2 Overview of the Aklan River Basin

Aklan River Basin is located in the province of Aklan located at the north of Panay Island. The Aklan River Basin covers major portions of the Municipalities of Banga, Libacao, and Madalag and covers minor portions of the Municipalities of Tapaz, Jamindan, Malinao, and Culasi. The floodplain is 100% covered with LiDAR data which compromises 14 blocks. The LiDAR data was calibrated then mosaicked with an RMSE of -0.43 and then bathy burned. The bathy survey conducted reached a total length of 2.89 km starting from Tigbawan, Madalag up to the river mouth with 12965 points surveyed. There are 51111 buildings, 628.12 km roads, 1237 waterbodies and 77 bridges digitized based from the LiDAR data. Feature Extraction Attribution was conducted and among the building features, 47782 of them are Residential, 1010 are schools and 78 are Medical Institutions.

The flood hazard map produced covers the 65.50 km2, 71.52 km2, 73.81 km2 for the 5-year, 25-year, and 100 year rainfall return period in Banga which affects 3 barangays as well as in Kalibo which affects 16 barangays, in Lezo which affects 9 barangays, in Makato which affects 1 barangay, in New Washington which affects 7 barangays and in Numancia which affects 17 barangays. A flood depth validation was conducted using 190 randomly generated points which is spread throughout the 6 ranges namely 0m-0.2m, 0.21m-0.5m, 0.51m-1m, 1.01m-2m, 2.10m-5m, 5m+ depth using the 25-yr rainfall flood depth map. It yielded a 0.786 m RMSE.

A rating curve was developed at Guadalupe-Madalag Bridge, Madalag, Aklan, which shows the relationship between the observed water levels at Guadalupe-Madalag Bridge and outflow of the watershed at this location. This rating curve equation, expressed as Q = 66.291e0.5476x, was used to compute the river outflow at Guadalupe-Madalag Bridge for the calibration of the HEC-HMS model. The resulting outflow was used to simulate the flooded areas using HEC-RAS. The simulated model will be an integral part in determining the real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website.

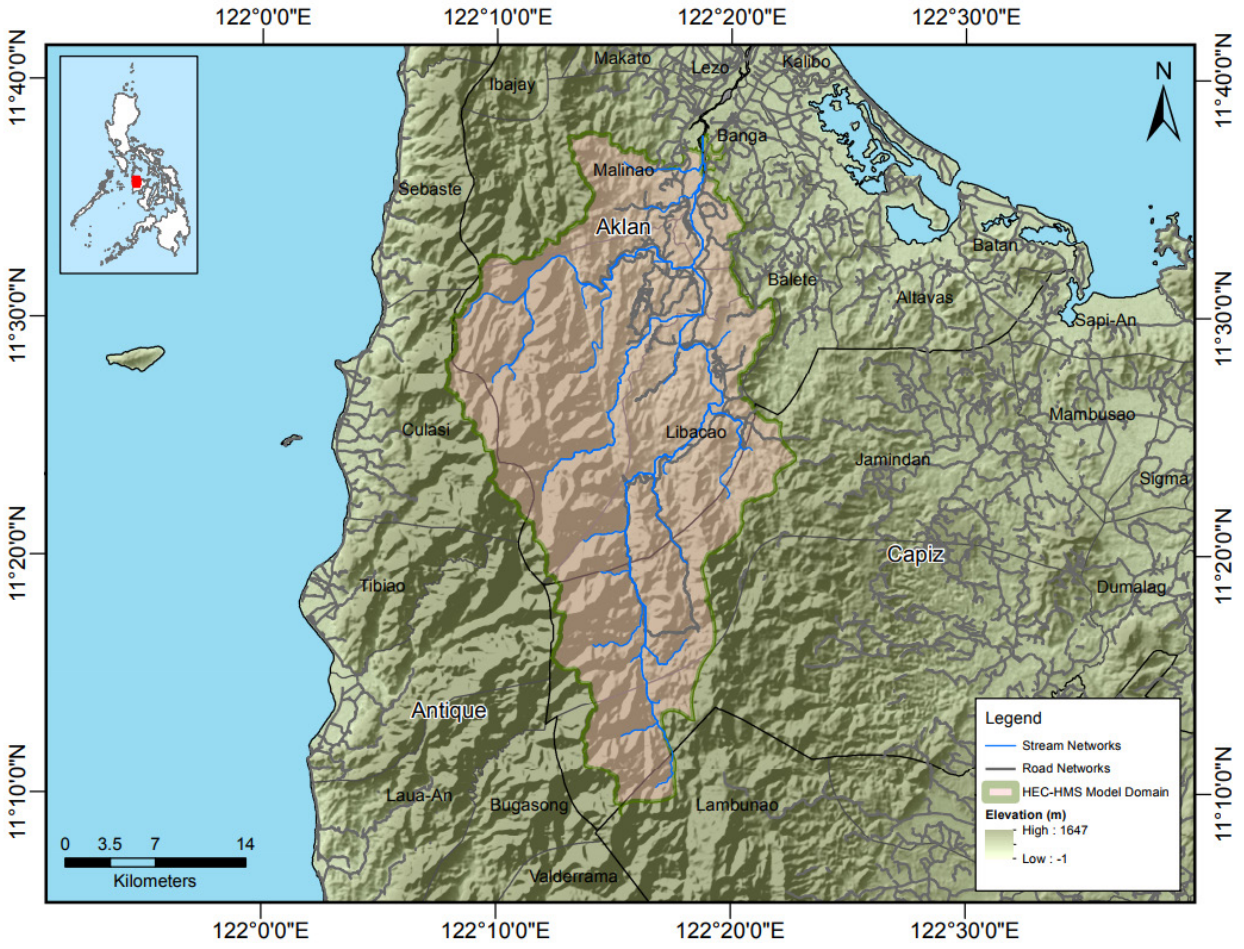

Figure 1. Location map of Aklan River Basin (in brown)

Based on the DENR River Basin Control Office (RBCO, 2015), the Aklan River Basin has a drainage area of 852 km2 and an estimated annual run-off of 353 MCM.

Its main stem, Aklan river is one of the 22 river systems in the Western Visayas region.. The river was named after the Province of Aklan. Quarrying activities is the primary source of livelihoods of communities along the river according to the local government and upon verification during the field survey execution. There are thirty-nine (39) barangays within the immediate vicinity of the river with a total population of 75,846 based on the 2010 NSO Census. Last December 30, 2012, province of Aklan has been placed under a state of calamity due to flooding brought by Tropical Storm “Quinta”.

CHAPTER 2: LIDAR ACQUISITION IN AKLAN FLOODPLAIN

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

2.1. Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Aklan Floodplain in Aklan. Each flight mission has an average of 21 lines that run for at most four and a half (4.5) hours including take-off, landing and turning time. The parameter used in the LiDAR systems for acquisition is found in Table 1 and 2. Figure 2 shows the flight plans for Aklan Floodplain.

Table 1. Flight planning parameters for Aquarius LiDAR system

Block Name	Flying Height (AGL)	Overlap (%)	Field of View	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency	Average Speed	Average Turn Time (Minutes)
BLK38F	600	30	36	50	40	130	5
BLK38G	600	30	36	50	40	130	5
BLK38H	600	30/50	36	50	40	130	5
BLK38I	600	30/50	36	50	40	130	5
BLK38J	600	40	50	50	40	130	5
BLK38K	600	40/50	36/50	50	40	130	5
BLK38L	600	40	50	50	40	130	5
BLK38M	600	40	50	50	40	130	5
BLK38N	600	40	50	50	40	130	5
BLK38KS	600	40	50	50	40	130	5

Table 2. Flight planning parameters for Gemini LiDAR system

Block Name	Flying Height (AGL)	Overlap (%)	Field of View	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency	Average Speed	Average Turn Time (Minutes)
BLK38A	800	25	50	125	40	130	5
BLK38B	800	25	50	125	40	130	5
BLK38C	800	30	40	125	50	130	5
BLK38D	600/800/ 1000	30	30/50	100/125/142	40/50	130	5
BLK38E	800/ 1000	30	40/50	100/125	50	130	5
BLK38F	800	25	50	125	40	130	5
BLK38G	800	30	50	125	50	130	5
BLK38I	800	30	50	125	50	130	5
BLK38J	800	30	50	125	50	130	5

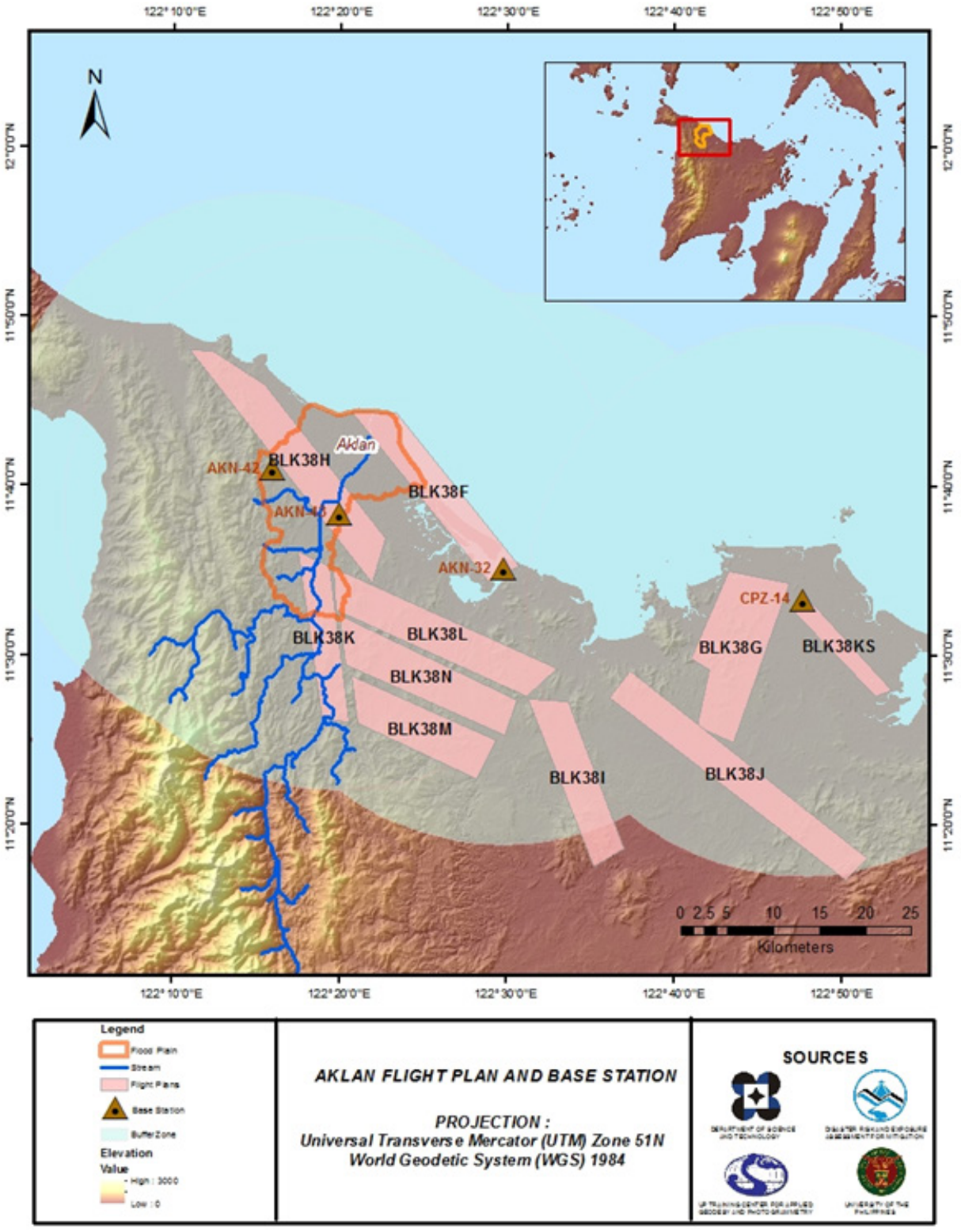

Figure 2. Flight plan for Aquarius LiDAR System and base stations used for Aklan Floodplain.

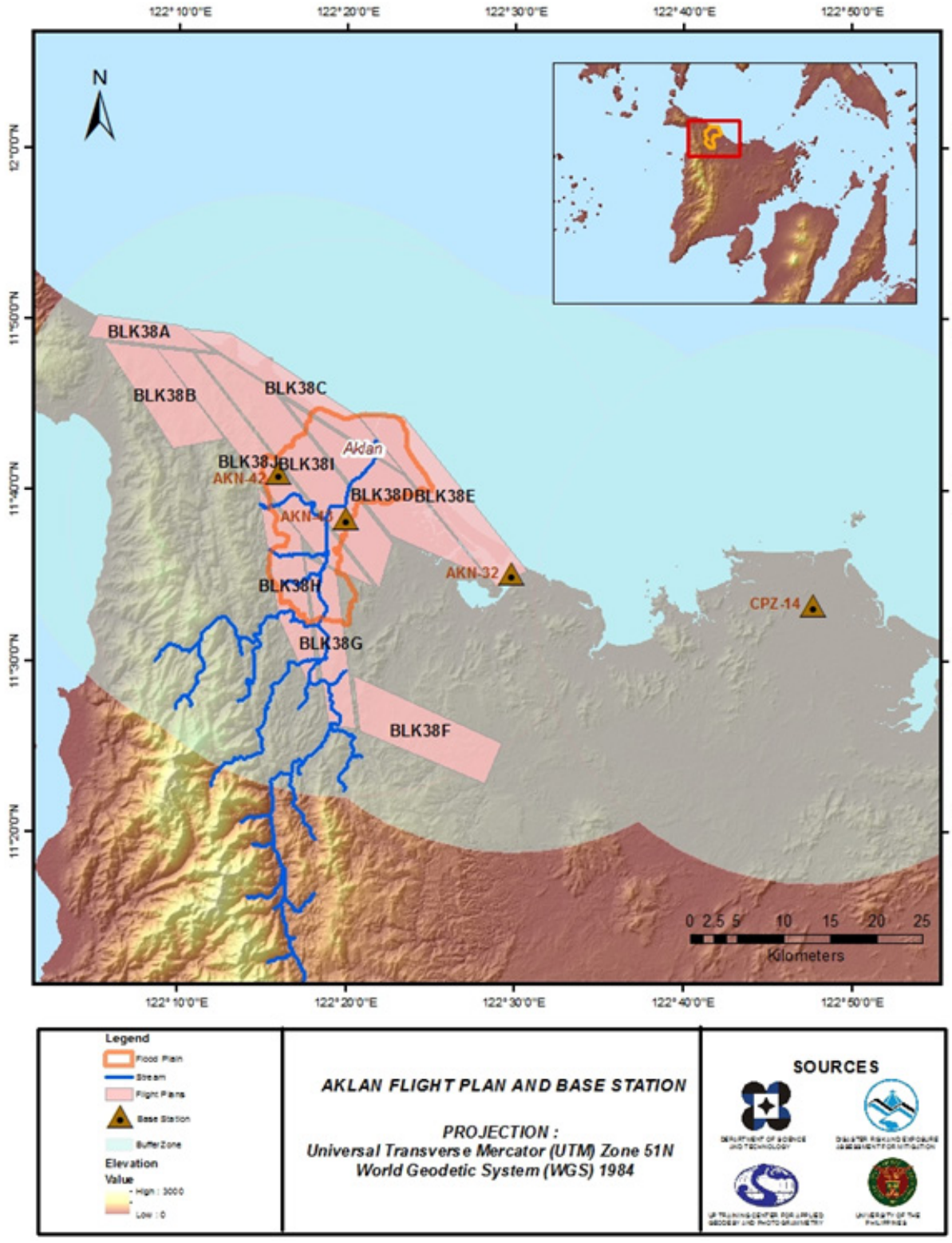

Figure 3. Flight plan for Gemini LiDAR System and base stations used for Aklan Floodplain.

2.2. Ground Base Station

The project team was able to recover four (4) NAMRIA reference points: AKN-43, AKN-42, AKN-32, and CPZ-14 with second (2nd) order accuracy, and (1) one Established point AKN-EST with second (2nd) order accuracy. The certification for the NAMRIA reference points and benchmarks are found in Annex 2. These were used as base stations during flight operations for the entire duration of the survey (March 15-22, 2014, and September 18-30, 2015). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 985, TRIMBLE SPS 852 and TOPCON GR-5. Flight plans and location of base stations used during the aerial LiDAR acquisition in Aklan floodplain are shown in Figure 2 and Figure 3.

Figure 4 to Figure 8 show the recovered NAMRIA reference points within the area. Table 3 to Table 7 show the details about the following NAMRIA reference stations and established points, while8 shows the list of all ground control points occupied during the acquisition with the corresponding dates of utilization.

Figure 4. GPS set-up over AKN-43 located on the concrete sidewalk in front of the municipal hall of Banga, Aklan, and NAMRIA reference point AKN-43 (b) as recovered by the field team.

Table 3. Details of the recovered NAMRIA horizontal control point ZGN-138 used as base station for the LiDAR Acquisition.

Station Name	AKN-43	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	11o 38’ 27.12194” North 122o 19’ 53.01891” East 17.74900 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	427093.296 meters 1287298.051 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	11o 38’ 22.52687” North 122o 19’ 58.16083” East 72.44500 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	427118.81 meters 1286847.47 meters

Figure 5. GPS set up over AKN-42 at the open court in Barangay Libang, Makato, Aklan (a) and NAMRIA reference point AKN-42 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA benchmark NS-61 used as base station for the LiDAR Acquisition.

Station Name	**AKN-42**	
Order of Accuracy	**2nd**	
Relative Error (horizontal positioning)	**1 in 50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	11o 41' 4.84235" North 122o 15' 49.78166" East 17.77900 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	419737.946 meters 1292162.5 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	11o 41' 0.23066" North 122o 15' 54.92018" East 72.20000 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	419766.04 meters 1291710.22 meters

Figure 6. GPS set up over AKN-32 located at the centerpoint of Batan Multi-purpose Sports Center, (a) and NAMRIA reference point AKN-32 (b) as recovered by the field team.

Table 5. Details of the recovered NAMRIA benchmark AKN-32 used as base station for the LiDAR Acquisition.

Station Name	**AKN-32**	
Order of Accuracy	**2nd**	
Relative Error (horizontal positioning)	**1 in 50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	11o 35' 14.35956" North 122o 29' 42.04171" East 3.89400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	444924.599 meters 1281338.493 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	11o 35' 9.79172" North 122o 29' 47.18726" East 59.12600 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	444943.88 meters 1280890.00 meters

(a)

(b)

Figure 7. GPS set up over CPZ-14 located at the centerpoint of Batan Multi-purpose Sports Center, (a) and NAMRIA reference point CPZ-14 (b) as recovered by the field team

Table 6. Details of the established horizontal reference point CPZ-14 used as base station for the LiDAR Acquisition.

Station Name	**CPZ-14**	
Order of Accuracy	**2nd**	
Relative Error (horizontal positioning)	**1 in 50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	11°33'24.51899" North 122° 47'34.41876" East 4.91900 meters
Grid Coordinates, Philippine Transverse Mercator Zone 4 (PTM Zone 5 PRS 92)	Easting Northing	477410.249 meters 1277923.165 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	11°33' 19.98412" North 122° 47' 39.56494" East 60.96000 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	477418.16 meters 1277475.87 meters

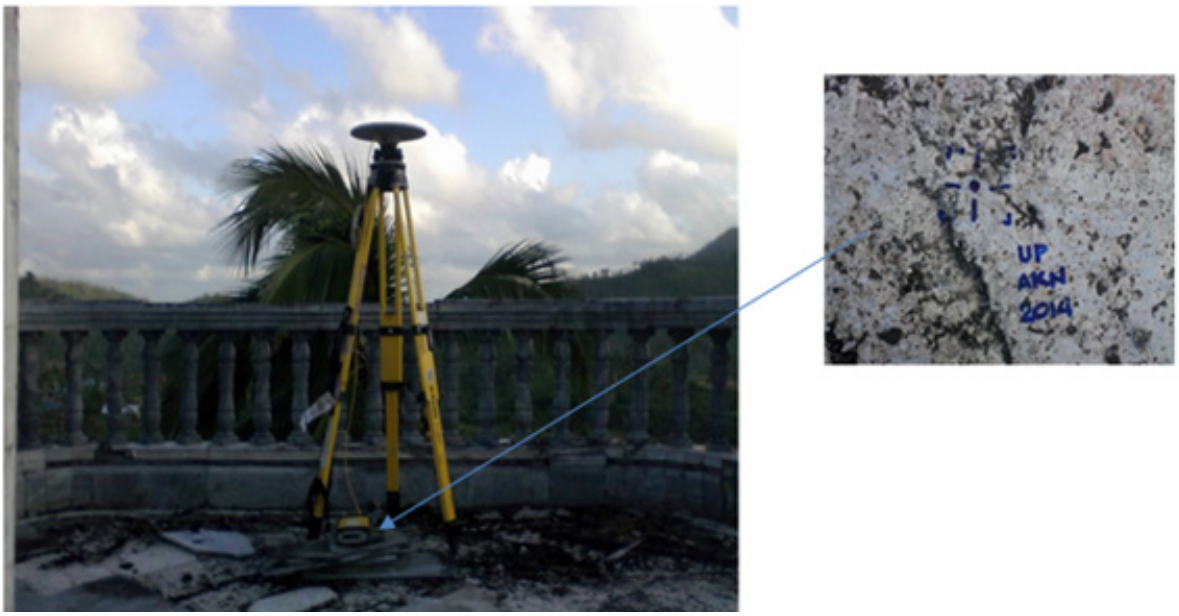

Figure 8. GPS set up over AKN-EST located at the rooftop of an abandoned building in Altavas, Aklan, (a) and point AKN-EST (b) as established by the field team

Table 7. Details of the established horizontal reference point AKN-EST used as base station for the LiDAR Acquisition.

Station Name	**AKN-EST**	
Order of Accuracy (benchmark)	**2nd**	
Elevation (horizontal positioning)	**1 in 50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	11o 30' 4.06"North 122o 28' 37.44"East 52.85 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	224679.042 meters 1272965.306 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	11o 29' 59.42372"North 122o 28' 47.18726"East 108.253 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	443101.888 meters 1271299.528 meters

Table 8. Ground control points used during LiDAR data acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
March 8, 2014	1186A	3BLK38067A	AKN-32, AKN-EST
March 9, 2014	1190A	3BLK38N068A	AKN-32, AKN-EST
March 9, 2014	1192A	3BLK38M068B	AKN-32, AKN-EST
March 10, 2014	1194A	3BLK38J069A	AKN-32
March 10, 2014	1196A	3BLK38KS069B	AKN-32
March 14, 2014	1210A	3BLK38FS073A	AKN-43, AKN 42
March 14, 2014	1212A	3BLK38FS073B	AKN-43, AKN 42
March 15, 2014	1214A	3BLK38G074A	AKN-43, AKN 42
March 17, 2014	1222A	3BLK38I076A	AKN-43, AKN 42
March 17, 2014	1224A	3BLK38FS076B	AKN-43, AKN 42
March 19, 2014	1230A	3BLK3HIS078A	AKN-43, AKN 42
March 19, 2014	1232A	3BLK38G078B	AKN-43, AKN 42
March 12, 2014	1238A	3BLK38GS080A	AKN-43, AKN 42
March 21, 2014	1240A	3BLK38HS080B	AKN-43, AKN 42
September 18, 2015	2742G	2BLK38D261A	AKN-43, AKN 42
September 19, 2015	2746G	2BLK38ADSE262A	AKN-43, AKN 42
September 24, 2015	2766G	2BLK38C267A	AKN-43, AKN 42
September 24, 2015	2768G	2BLKG267B	AKN-43, AKN 42
September 25, 2015	2770G	2BLK38BDVES268A	AKN-43, AKN 42, AKN-32
September 25, 2015	2772G	2BLK38GS268B	AKN-43, AKN 42
September 26, 2015	2774G	2BLK38ES269A	AKN-43, AKN 42, AKN-32
September 30, 2015	2790G	2BLK38BSF273A	AKN-43, AKN 42, AKN-32, CPZ-14
September 30, 2015	2792G	2BLK38IJ273B	AKN-43, AKN 42, AKN-32, CPZ-14

2.3 Flight Missions

Twenty-three (23) missions were conducted to complete LiDAR data acquisition in Aklan Floodplain, for a total of eighty four hours and twenty (84+20) minutes of flying time for RP-C9322 and RP-C9022. All missions were acquired using the Gemini and Aquarius LiDAR systems. Table 8 and Table 9 show the actual coverage and flying hours per mission and the actual parameters used during the LiDAR data acquisition, respectively.

Table 9. Flight missions for LiDAR data acquisition in Aklan 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
8-Mar-14	1186A	101.25	199.67	29.25	170.42	4	4	35
9-Mar-14	1190A	79	137.87	0	137.87	171	3	59
9-Mar-14	1192A	88.78	130.8	1.75	129.05	1007	3	17
10-Mar-14	1194A	108.82	144.55	0	144.55	1432	4	17
10-Mar-14	1196A	53.99	32.98	15.83	17.15	273	2	41
14-Mar-14	1210A	139.31	136.74	29.34	107.4	-	3	35
14-Mar-14	1212A	139.31	160.02	37.56	122.46	-	2	53
15-Mar-14	1214A	139.3	198.29	1.14	197.15	-	2	29
17-Mar-14	1222A	85.02	107.89	38.50	69.39	1369	4	29
17-Mar-14	1224A	84.17	174.98	43.94	131.04	716	2	23
19-Mar-14	1230A	114.34	232.32	75.26	157.06	1459	4	23
19-Mar-14	1232A	83.78	75.45	0	75.45	-	3	5
12-Mar-14	1238A	112.01	84.75	15.34	69.41	-	4	47
21-Mar-14	1240A	114.34	70.09	3.93	66.16	-	2	41
18-Sep-15	2742G	138.91	121.57	1.16	120.41	-	3	53
19-Sep-15	2746G	142.57	170.8	18.14	152.66	1056	4	6
24-Sep-15	2766G	112.3	162.23	0	162.23	-	4	5
24-Sep-15	2768G	101.25	141.1	9.78	131.32	577	3	17
25-Sep-15	2770G	230.37	198.77	18.55	180.22	898	4	23
25-Sep-15	2772G	109.27	315.47	12.1	303.37	618	3	11
26-Sep-15	2774G	84.17	243.94	47.97	195.97	750	4	17
30-Sep-15	2790G	140.57	157.9	46.52	111.38	953	4	23
30-Sep-15	2792G	180	181.90	0	181.90	602	3	11
TOTAL		2682.83	3580.08	446.06	3134.02	11885	84	20

Table 10. Actual parameters used during LiDAR data acquisition.

Date Surveyed	Flight Number	Mission Name	Ground Control Points
March 8, 2014	1186A	3BLK38067A	AKN-32, AKN-EST
March 9, 2014	1190A	3BLK38N068A	AKN-32, AKN-EST
March 9, 2014	1192A	3BLK38M068B	AKN-32, AKN-EST
March 10, 2014	1194A	3BLK38J069A	AKN-32
March 10, 2014	1196A	3BLK38KS069B	AKN-32
March 14, 2014	1210A	3BLK38FS073A	AKN-43, AKN 42
March 14, 2014	1212A	3BLK38FS073B	AKN-43, AKN 42
March 15, 2014	1214A	3BLK38G074A	AKN-43, AKN 42
March 17, 2014	1222A	3BLK38I076A	AKN-43, AKN 42
March 17, 2014	1224A	3BLK38FS076B	AKN-43, AKN 42
March 19, 2014	1230A	3BLK3HIS078A	AKN-43, AKN 42
March 19, 2014	1232A	3BLK38G078B	AKN-43, AKN 42
March 12, 2014	1238A	3BLK38GS080A	AKN-43, AKN 42
March 21, 2014	1240A	3BLK38HS080B	AKN-43, AKN 42
September 18, 2015	2742G	2BLK38D261A	AKN-43, AKN 42
September 19, 2015	2746G	2BLK38ADSE262A	AKN-43, AKN 42
September 24, 2015	2766G	2BLK38C267A	AKN-43, AKN 42
September 24, 2015	2768G	2BLKG267B	AKN-43, AKN 42
September 25, 2015	2770G	2BLK38BDVES268A	AKN-43, AKN 42, AKN-32
September 25, 2015	2772G	2BLK38GS268B	AKN-43, AKN 42
September 26, 2015	2774G	2BLK38ES269A	AKN-43, AKN 42, AKN-32
September 30, 2015	2790G	2BLK38BSF273A	AKN-43, AKN 42, AKN-32, CPZ-14
September 30, 2015	2792G	2BLK38IJ273B	AKN-43, AKN 42, AKN-32, CPZ-14

2.4 Survey Coverage

Aklan floodplain is located in the province of Aklan. Municipalities of Balete, Banga, Kalibo, Lezo, Madalag, Makato, Malinao, New Washington and Numancia were mostly covered by the survey. The list of municipalities surveyed, with at least one (1) square kilometer coverage, is shown in Table 11. The actual coverage of the LiDAR acquisition for Aklan Floodplain is presented in Figure 9.

Table 11. List of municipalities and cities surveyed during Aklan Floodplain LiDAR survey.

Province	Municipality/City	Area of Municipality/City (km2)	Total Area Surveyed (km2)	Percentage of Area Surveyed
Aklan	Altavas	105.30	105.24	100%
	Balete	108.40	108.40	100%
	Banga	66.10	66.10	100%
	Batan	80.55	68.02	84%
	Ibajay	132.35	96.15	73%
	Kalibo	34.09	34.09	100%
	Lezo	20.24	20.24	100%
	Libacao	173.15	56.15	32%
	Madalag	291.29	33.58	12%
	Makato	63.68	58.81	92%
	Malinao	220.46	78.59	36%
	Nabas	83.38	20.99	25%
	New Washington	48.08	48.08	100%
	Numancia	23.62	23.62	100%
	Tangalan	63.43	53.38	84%
Antique	Pandan	153.32	35.30	23%
Capiz	Cuartero	108.18	21.13	20%
	Dao	67.76	23.79	35%
	Dumalag	96.97	13.48	14%
	Dumarao	228.45	6.47	3%
	Ivisan	53.84	21.52	40%
	Jamindan	500.16	182.91	37%
	Ma-Ayon	192.60	22.89	12%
	Mambusao	103.26	43.39	42%
	Panay	129.87	17.35	13%
	Panitan	88.95	11.14	13%
	Pontevedra	95.28	16.99	18%
	Roxas City	99.65	64.84	65%
	Sapi-An	67.40	11.45	17%
	Sigma	103.89	44.72	43%
Total		3603.7	1408.81	39.09

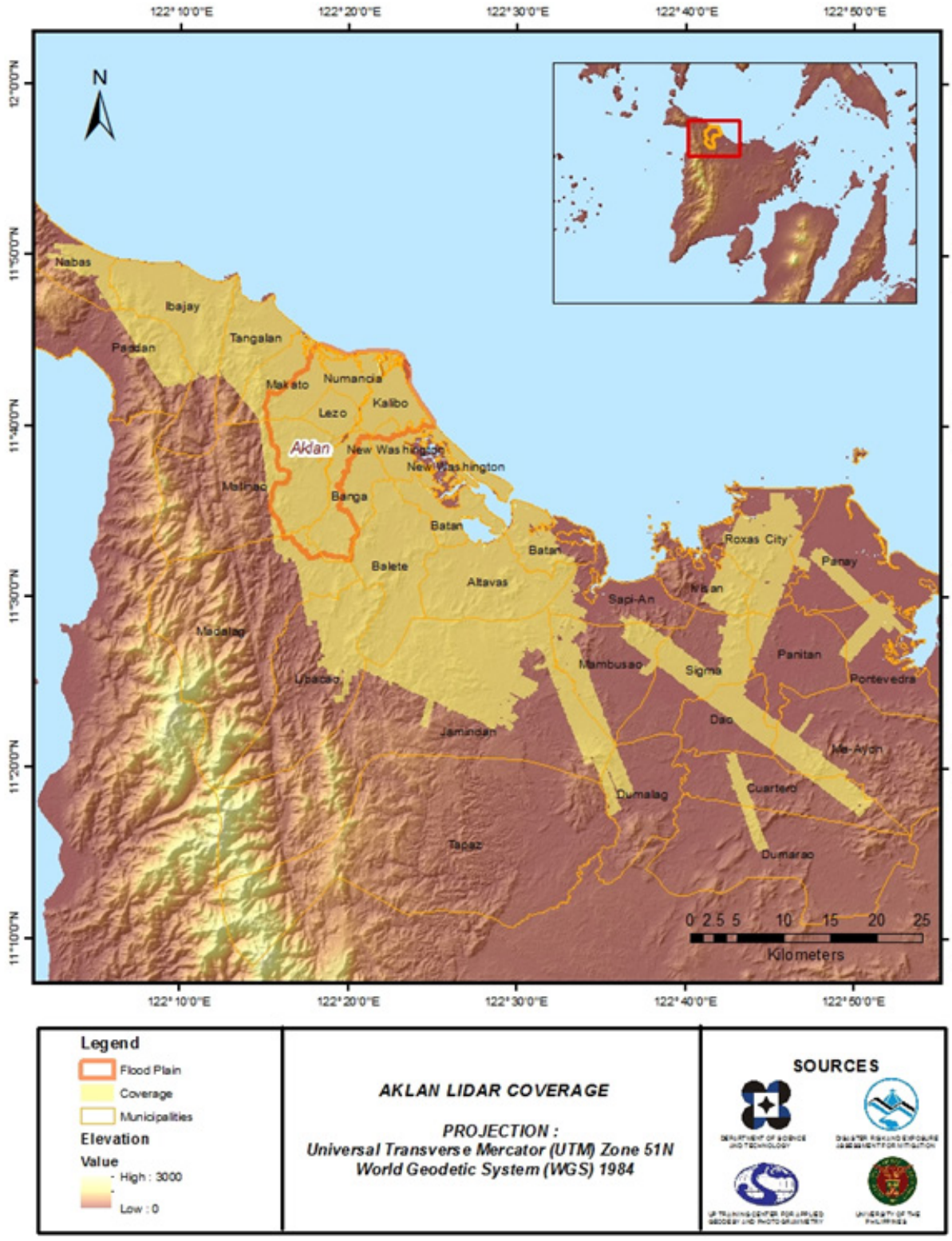

Figure 9. Actual LiDAR survey coverage for Aklan Floodplain.

CHAPTER 3: LIDAR DATA PROCESSING OF THE AKLAN 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 LiDAR Data Pre-Processing

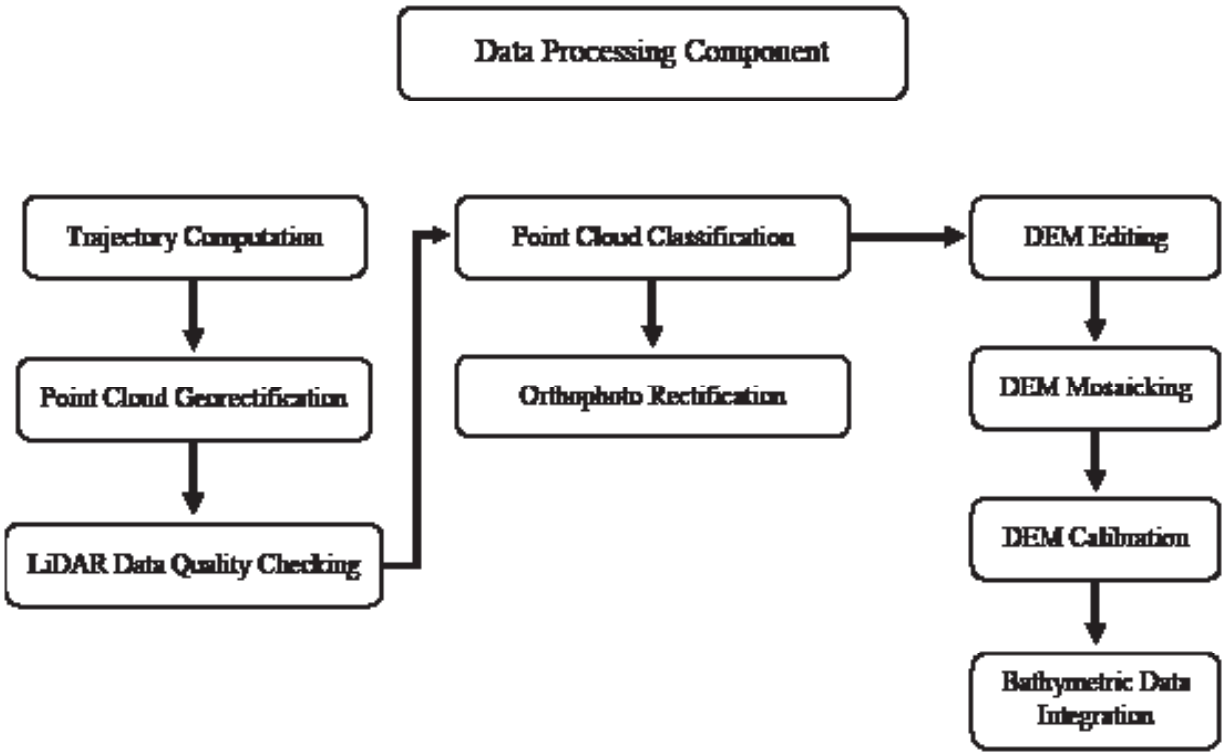

Figure 10. Schematic Diagram for Data Pre-Processing Component

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

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

These processes are summarized in the flowchart shown in Figure 10.

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Aklan floodplain can be found in Annex A-5. Data Transfer Sheets. Missions flown during the first survey conducted on March 2014 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Aquarius system while missions acquired during the second survey on September 2016 were flown using the Gemini system over Madalag, Aklan. The Data Acquisition Component (DAC) transferred a total of 352.76 Gigabytes of Range data, 4.42 Gigabytes of POS data, and 795.74 Megabytes of GPS base station data and 720.59 Gigabytes of raw image data to the data server on April 22, 2014 for the first survey and September 22, 2015 for the second survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Aklan was fully transferred on October 5, 2015 as indicated on the Data Transfer Sheets for Aklan floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 1232A, one of the Aklan flights, which is the North, East, and Down position RMSE values are shown in Figure 11. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell on March 19, 2014 00:00AM. The y-axis is the RMSE value for that particular position.

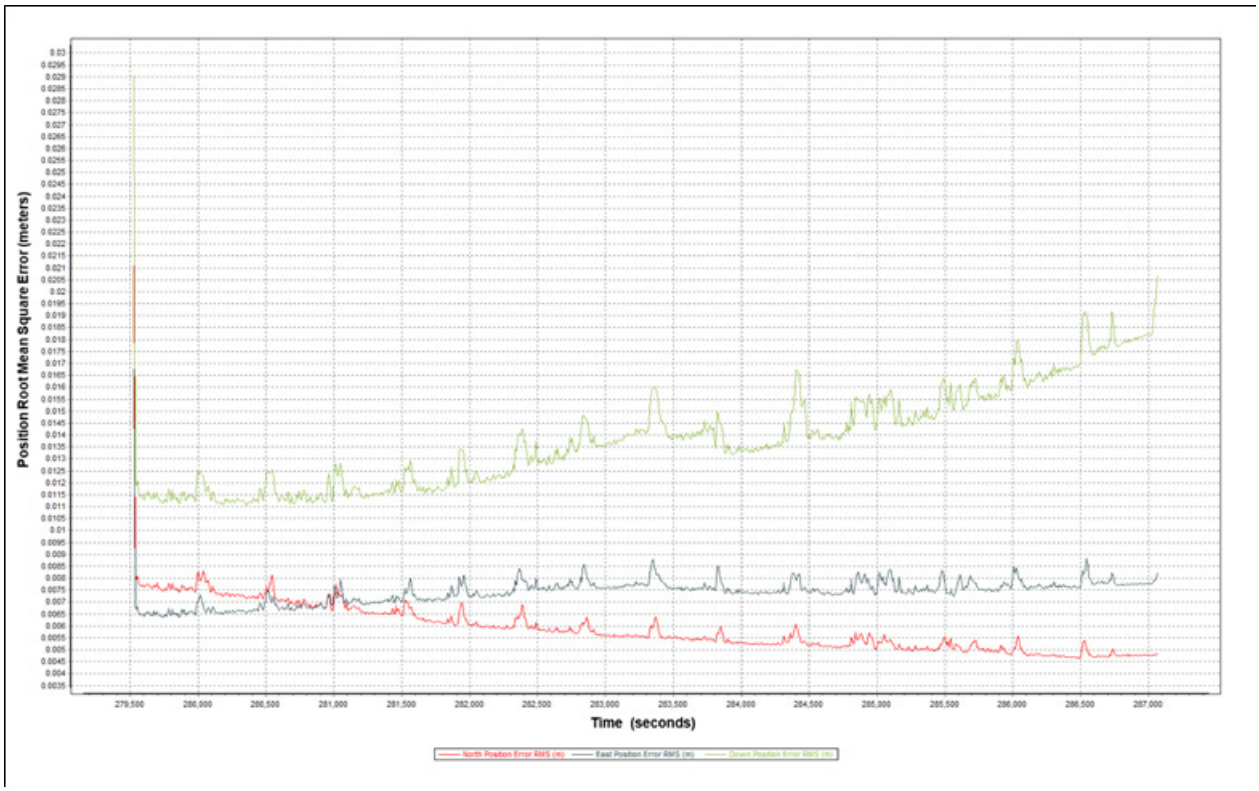

Figure 11. Smoothed Performance Metrics of Aklan Flight 1232A.

The time of flight was from 279500 seconds to 287000 seconds, which corresponds to afternoon of March 19, 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 minimize 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 11 shows that the North position RMSE peaks at 0.085 centimeters, the East position RMSE peaks at 0.09 centimeters, and the Down position RMSE peaks at 1.90 centimeters, which are within the prescribed accuracies described in the methodology.

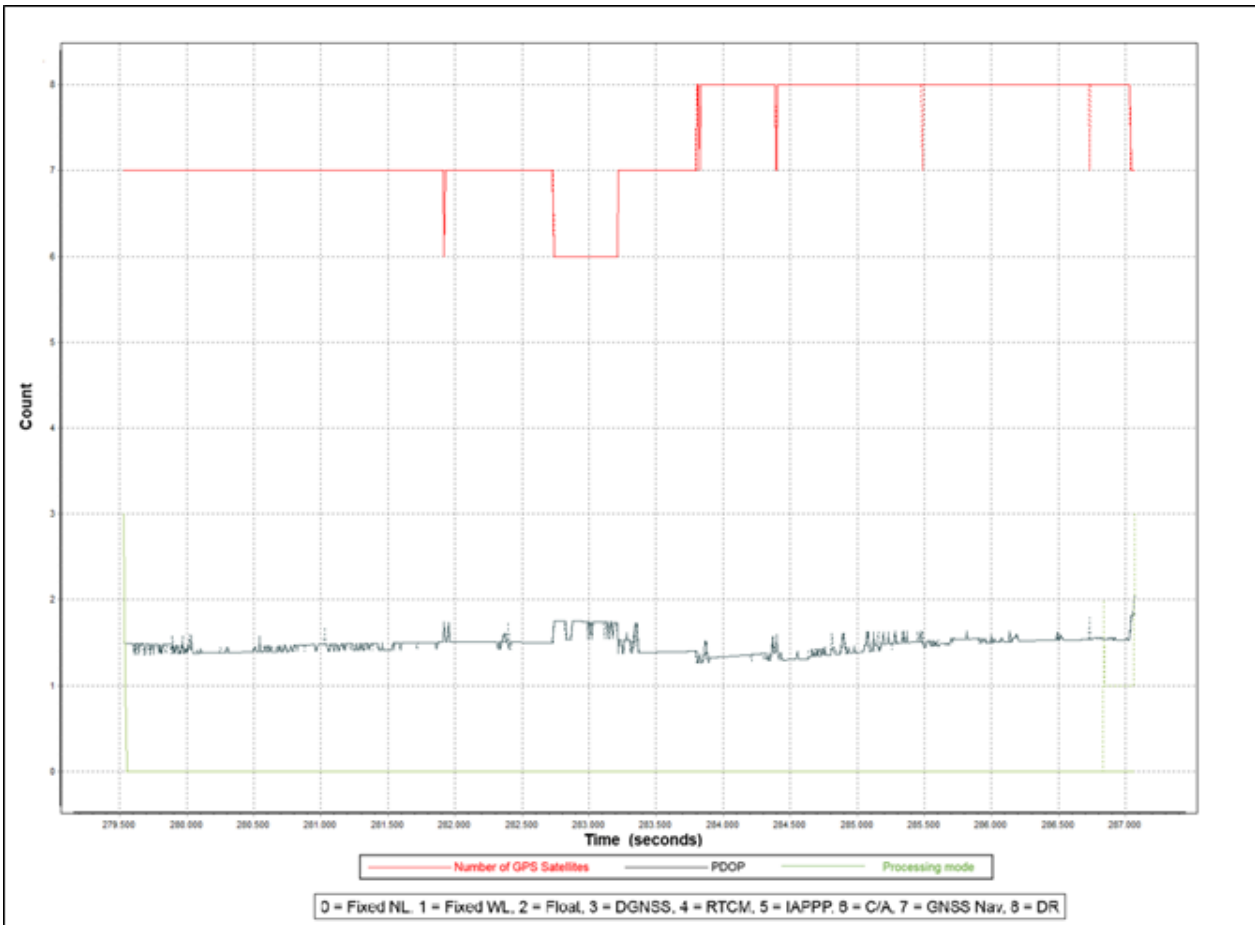

Figure 12. Solution Status Parameters of Aklan Flight 1232A.

The Solution Status parameters of flight 1232A, one of the Aklan flights, which are the number of GPS satellites, Positional Dilution of Precision, and the GPS processing mode used are shown in Figure 12. The graphs indicate that majority of 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 10. 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 and 2 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 Aklan flights is shown in Figure 13.

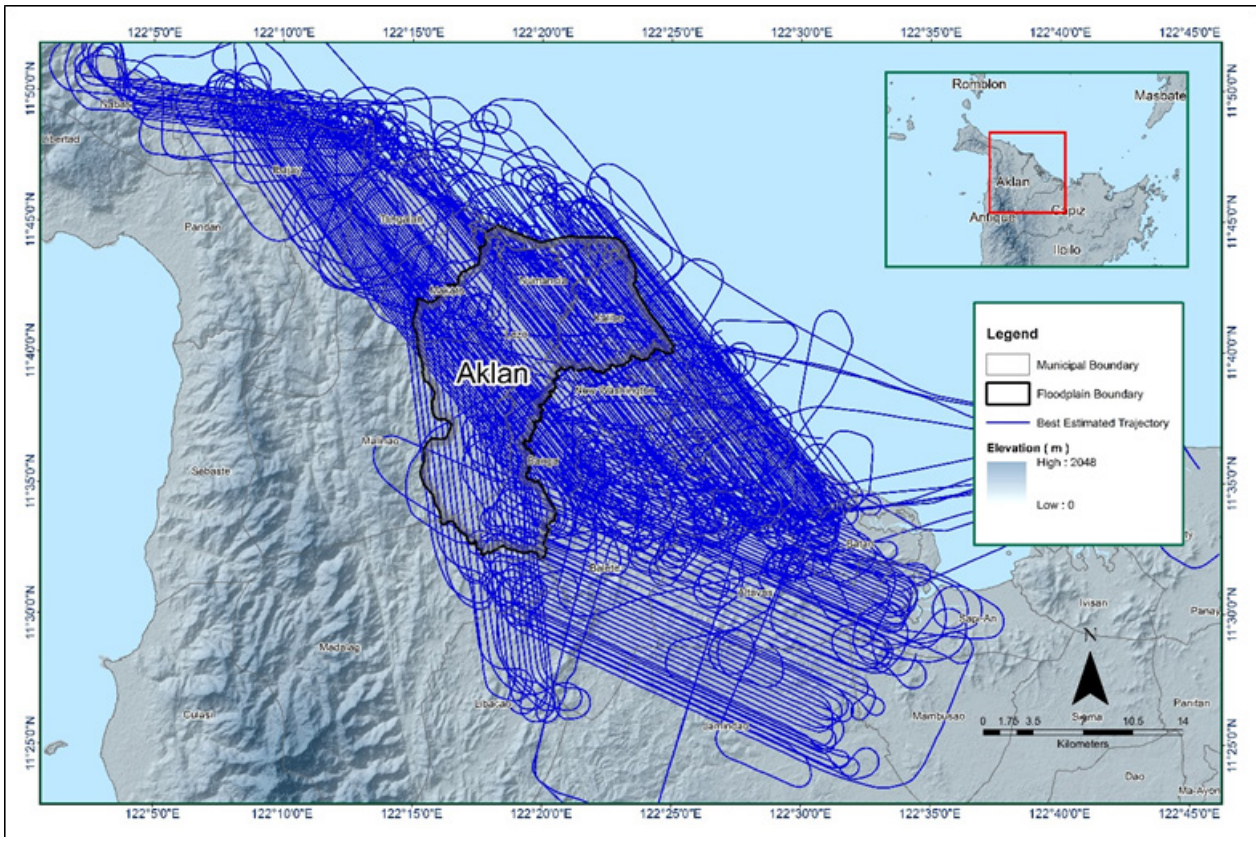

Figure 13. Best Estimated Trajectory for Aklan Floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 298 flight lines, with each flight line containing one channel, since the Aquarius system contains one channel only. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Aklan floodplain are given in Table 12.

Table 12. Self-Calibration Results values for Aklan flights.

Parameter	Acceptable Value	Value
Boresight Correction stdev	(<0.001degrees)	0.000315
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.000989
GPS Position Z-correction stdev	(<0.01meters)	0.0076

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

3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data on top of a SAR Elevation Data over Aklan Floodplain is shown in Figure 14. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

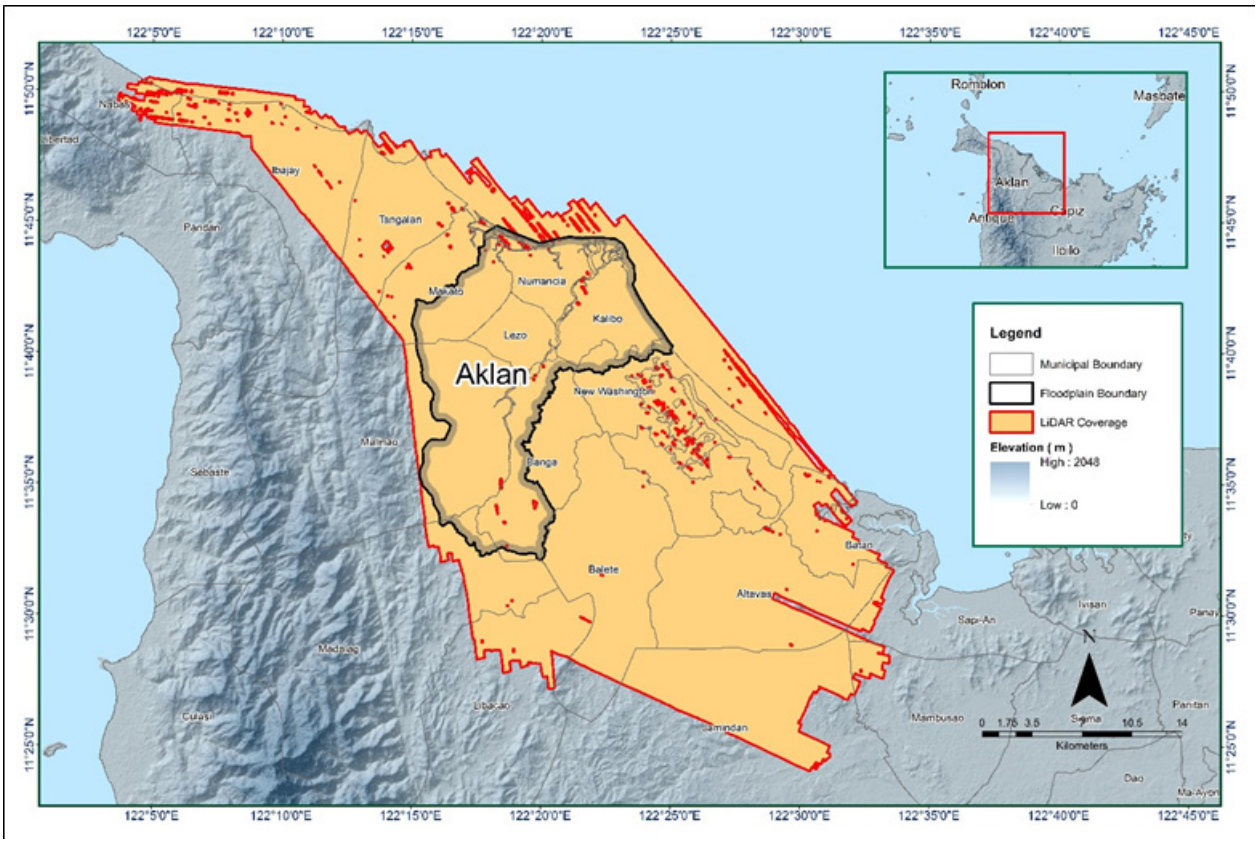

Figure 14. Boundary of the processed LiDAR data over Aklan Floodplain

The total area covered by the Aklan missions is 1,635.81 sq.km that is comprised of nineteen (19) flight acquisitions grouped and merged into fourteen (14) blocks as shown in Table 13.

Table 13. List of LiDAR blocks for Aklan Floodplain.

LiDAR Blocks	Flight Numbers	Area (sq. km)
Aklan_Blk38F	1210A	88.80
	1212A	
	1224A	
Aklan_Blk38G	1232A	141.61
	1238A	
	1214A	
Aklan_Blk38G_additional	1232A	17.61
Aklan_Blk38H	1230A	106.09
Aklan_Blk38I	1222A	90.37
Aklan_Blk38J	1194A	128.90
Aklan_Blk38N	1192A	121.00
Capiz_Aklan_Blk38C	2766G	145.80
Capiz_Aklan_Blk38D	2742G	217.24
	2746G	
	2770G	
Capiz_Aklan_Blk38E_supplement	2770G	94.67
	2746G	
	2774G	
Capiz_Aklan_Blk38E	2270G	223.00
	2746G	
	2774G	
Capiz_Aklan_Blk38F	2790G	48.65
Capiz_Aklan_Blk38G	2768G	158.70
	2772G	
Capiz_Aklan_Blk38I	2792G	53.48
TOTAL		**1635.81 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 15. Since the Gemini and Aquarius systems both employ one channel, we would expect an average value of 1 (blue) for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines.

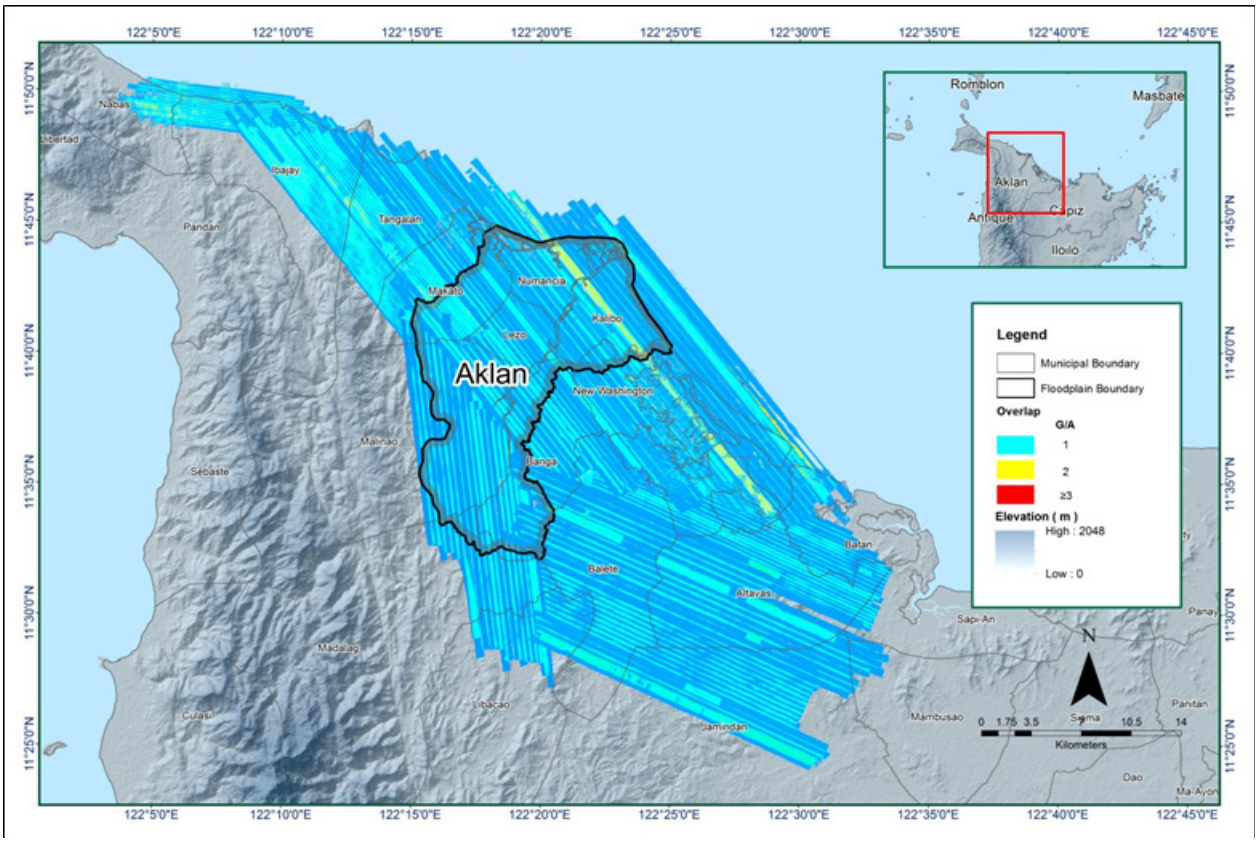

Figure 15. Image of data overlap for Aklan Floodplain.

The overlap statistics per block for the Aklan floodplain can be found in Annex 8. Mission Summary Reports. It should be noted that one pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 26.83% and 68.71% 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 16. It was determined that all LiDAR data for Aklan floodplain satisfy the point density requirement, and the average density for the entire survey area is 3.69 points per square meter.

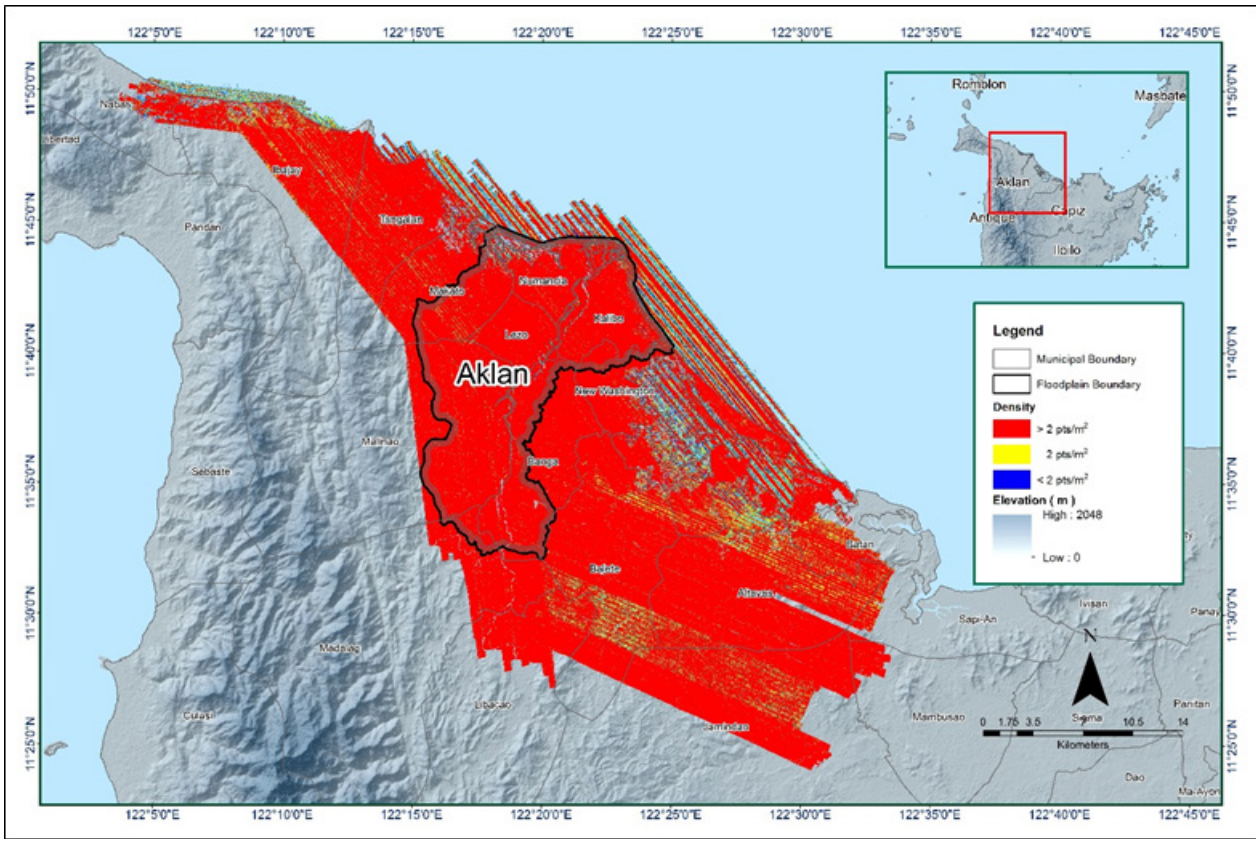

Figure 16. Pulse density map of merged LiDAR data for Aklan Floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 17. The default color range is from blue to red, where bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20m relative to elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20 m 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.

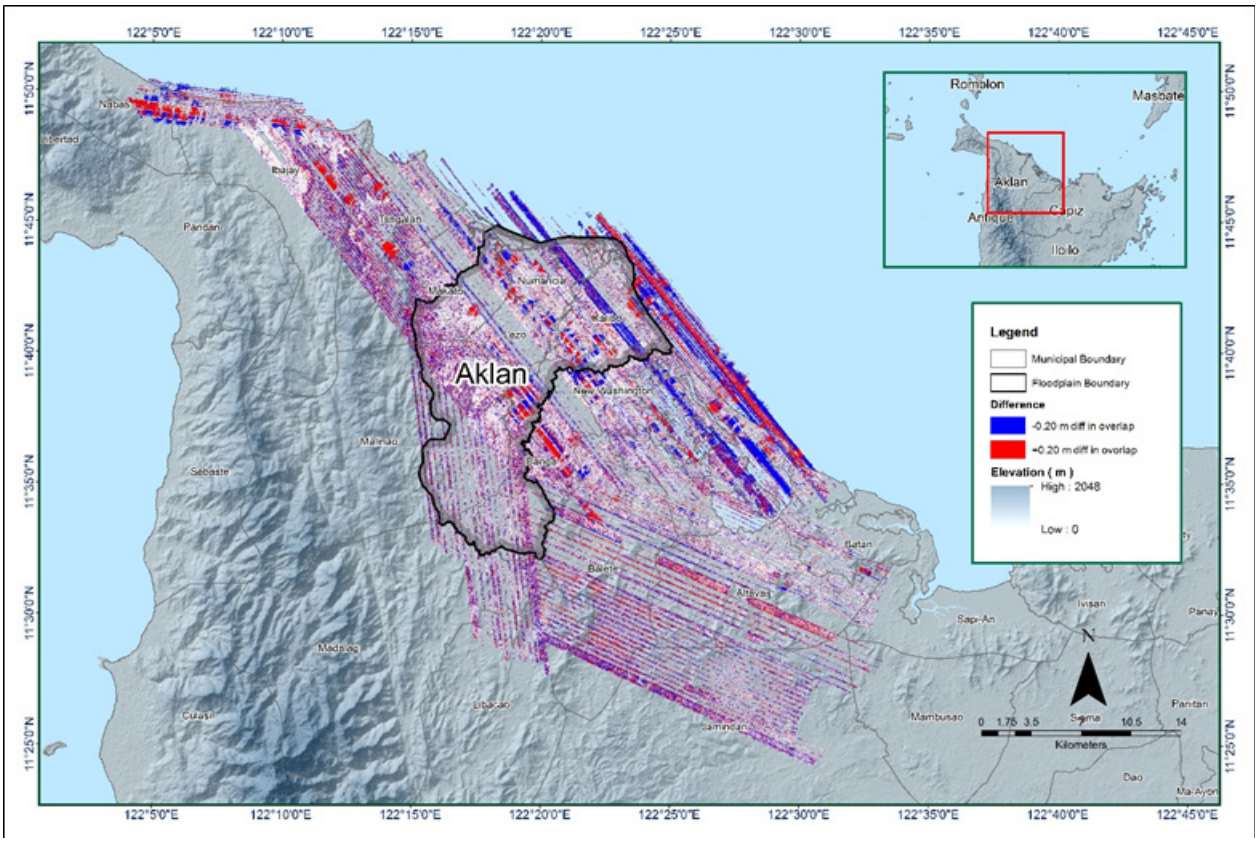

Figure 17. Elevation difference map between flight lines for Aklan Floodplain.

A screen capture of the processed LAS data from an Aklan flight 1232A loaded in QT Modeler is shown in Figure 18. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

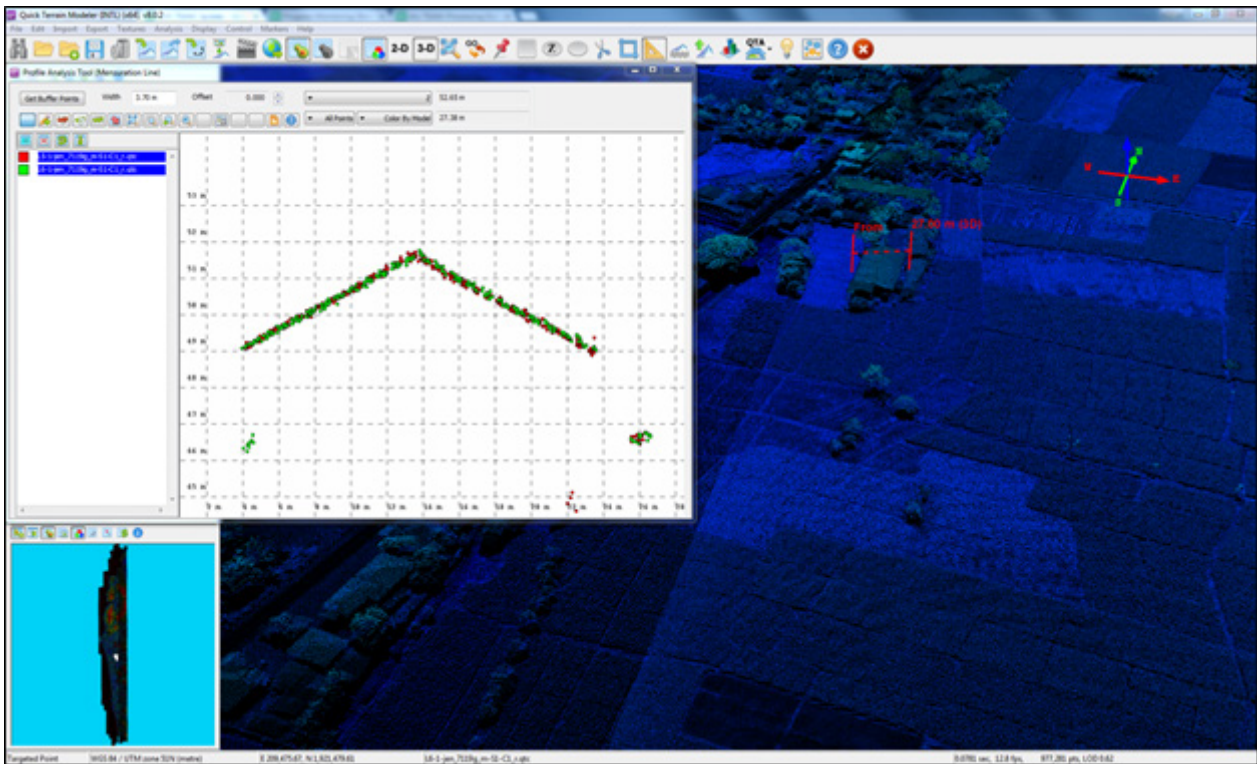

Figure 18. Quality checking for an Aklan flight 1232A using the Profile Tool of QT Modeler.

3.6 LiDAR Point Cloud Classification and Rasterization

Table 14. Aklan classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	834,148,364
Low Vegetation	1,039,040,852
Medium Vegetation	2,727,547,695
High Vegetation	1,920,635,609
Building	59,783,400

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Aklan floodplain is shown in Figure 19. A total of 2098 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 14. The point cloud has a maximum and minimum height of 903.42 meters and 4.71 meters respectively.

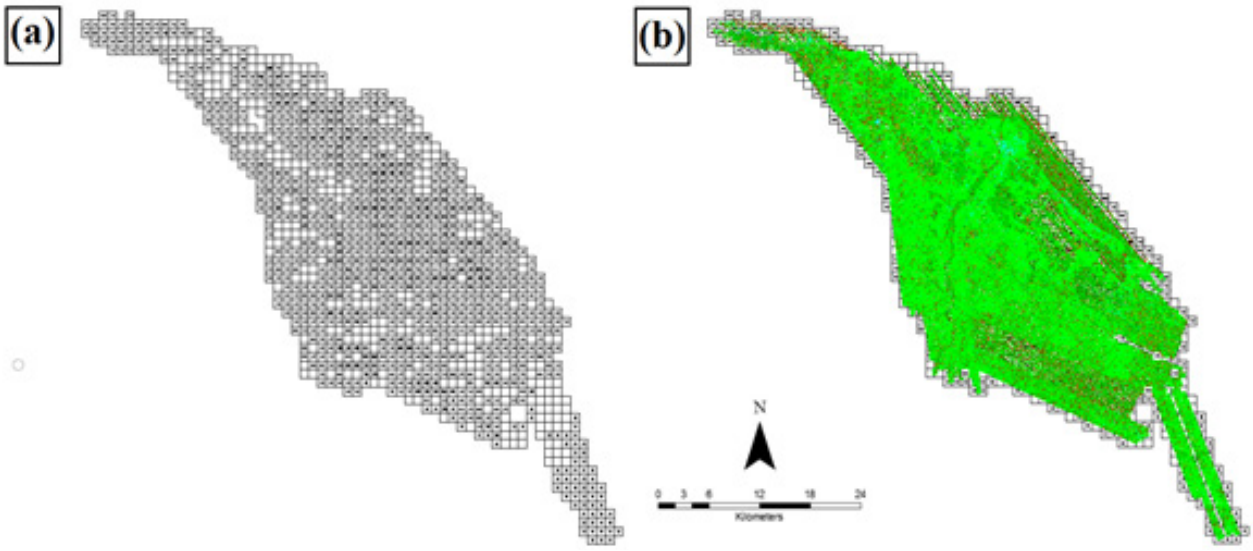

Figure 19. Tiles for Aklan Floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 20. 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.

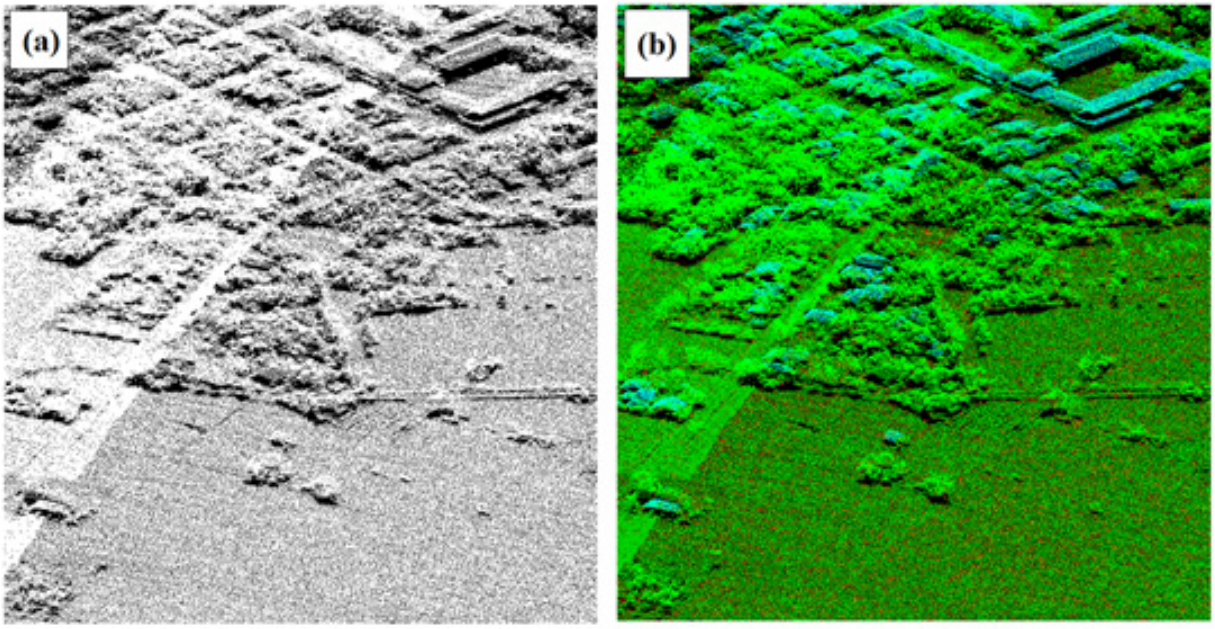

Figure 20. Point cloud before (a) and after (b) classification.

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

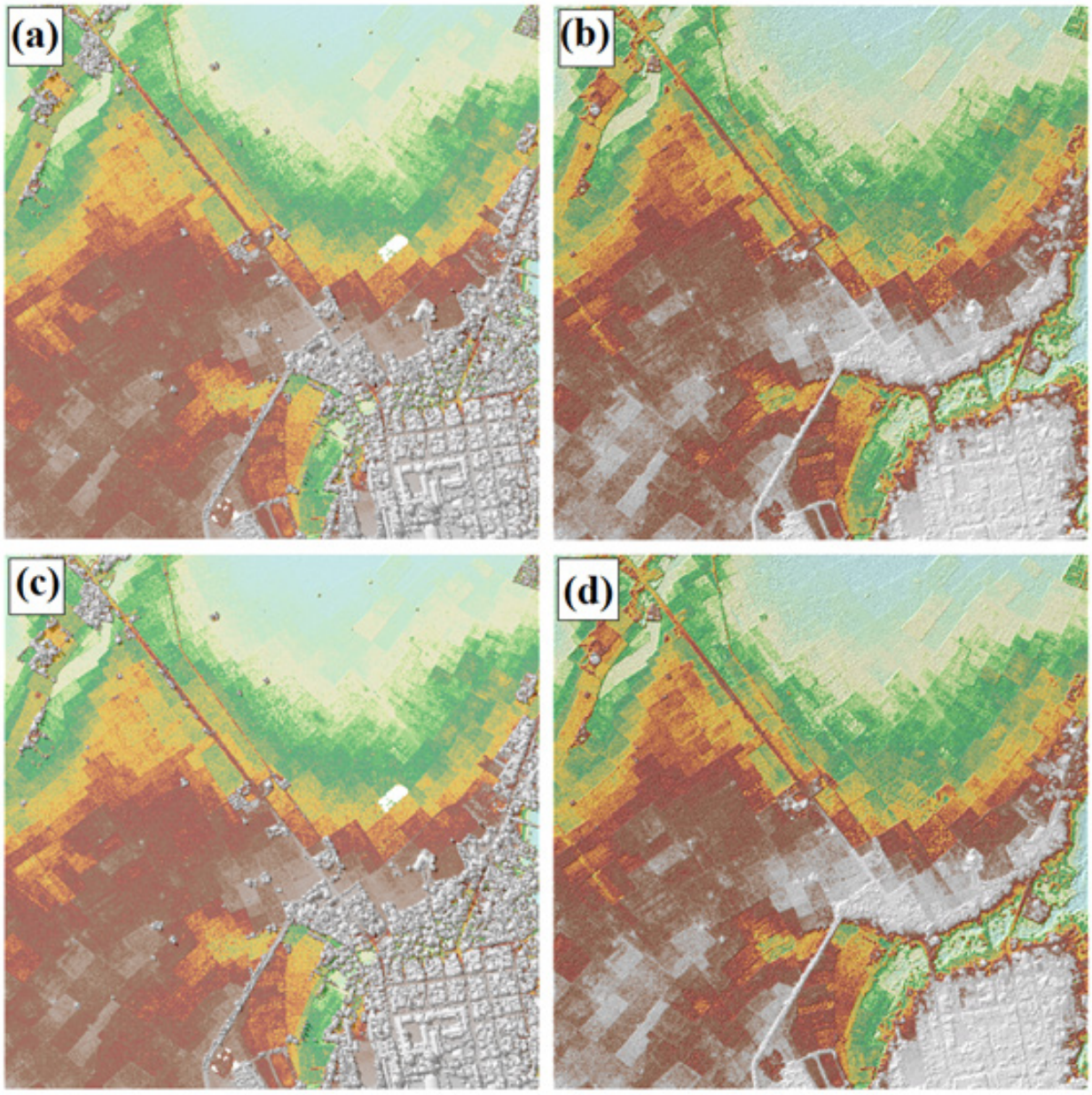

Figure 21. The Production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Aklan Floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 1,877 1km by 1km tiles area covered by Aklan floodplain is shown in Figure 22. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Aklan floodplain has a total of 881.90 sq.km orthophotogaph coverage comprised of 11,457 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 23.

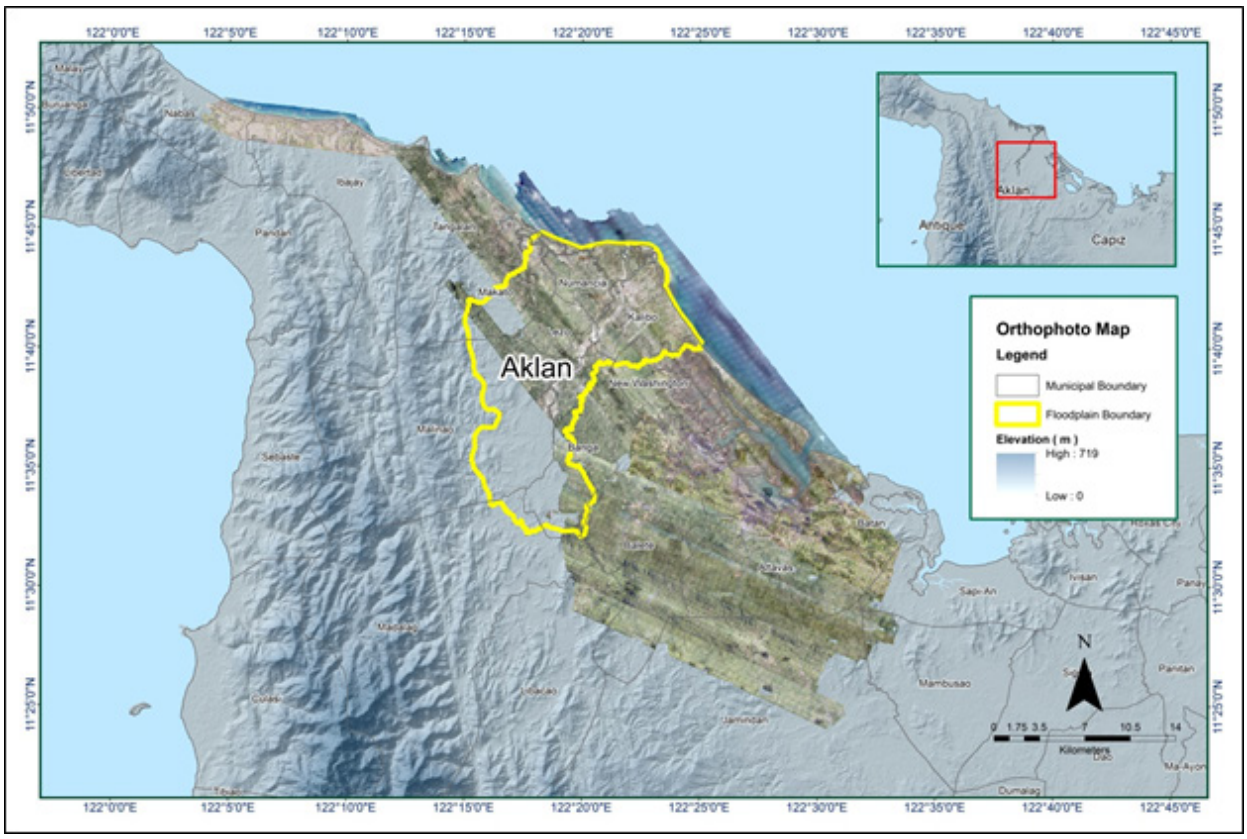

Figure 22. Aklan Floodplain with available orthophotographs.

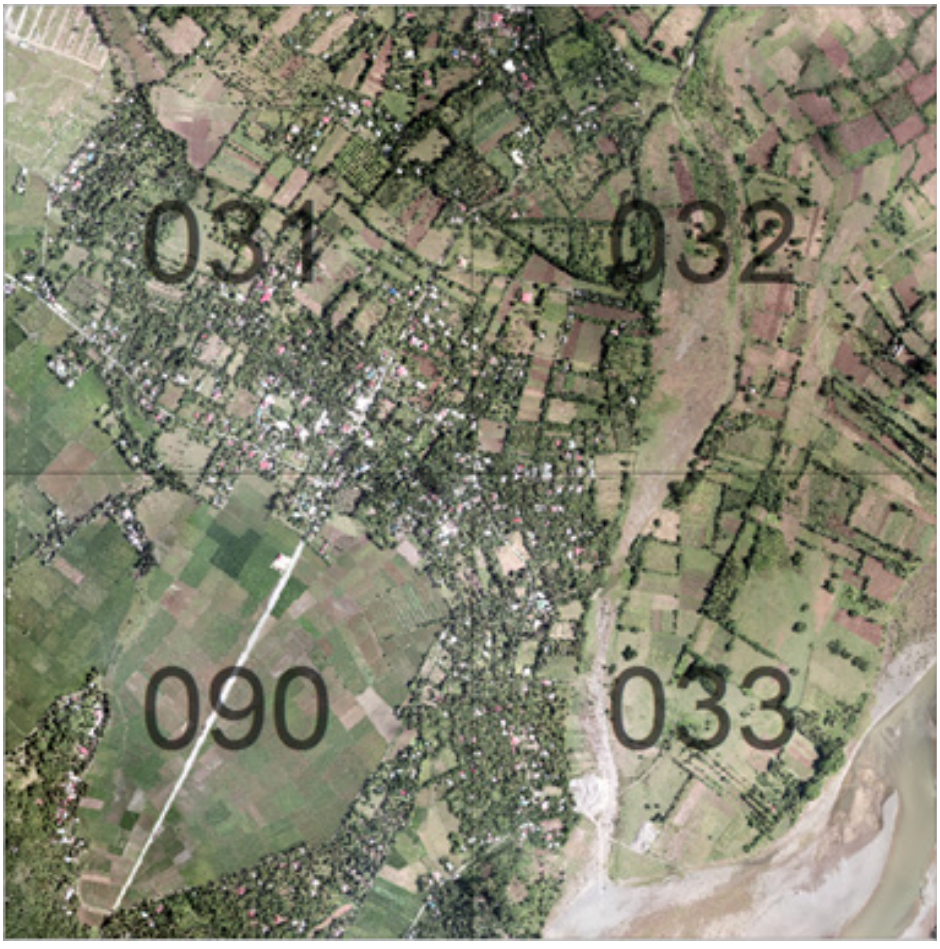

Figure 23. Sample orthophotograph tiles for Aklan Floodplain.

3.8 DEM Editing and Hydro-Correction

Fourteen (14) mission blocks were processed for Aklan flood plain. These blocks are composed of Aklan and Capiz_Aklan blocks with a total area of 1,635.81 square kilometers. Table 15 shows the name and corresponding area of each block in square kilometers.

Table 15. LiDAR blocks with its corresponding area.

LiDAR Blocks	Area (sq.km)
Aklan_Blk38F	88.8
Aklan_Blk38G	141.61
Aklan_Blk38G_additional	16.70
Aklan_Blk38H	106.10
Aklan_Blk38I	90.37
Aklan_Blk38J	128.90
Aklan_Blk38N	121.00
Capiz_Aklan_Blk38C	145.80
Capiz_Aklan_Blk38D	217.70
Capiz_Aklan_Blk38E_supplement	95.00
Capiz_Aklan_Blk38E	223.00
Capiz_Aklan_Blk38F	48.65
Capiz_Aklan_Blk38G	158.70
Capiz_Aklan_Blk38I	53.48
TOTAL	**1,635.81 sq. km**

Portions of DTM before and after manual editing are shown in Figure 24. It shows that the paddy field (Figure 24a) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 24b). The bridges (Figure 24c) would be an impedance to the flow of water along the river and have to be removed (Figure 24d) in order to hydrologically correct the river.

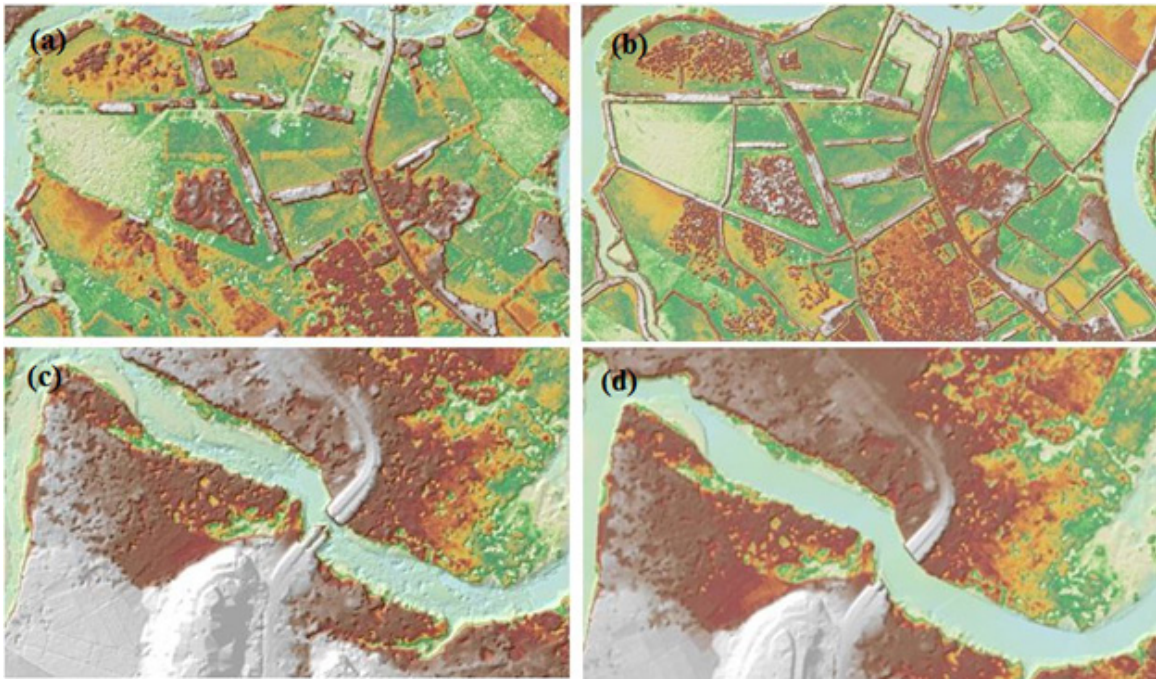

Figure 24. Portions in the DTM of Aklan Floodplain – a paddy field before (a) and after (b) data retrieval; bridges before (c) and after (d) manual editing

3.9 Mosaicking of Blocks

Capiz_Aklan_Blkl38D was used as the reference block at the start of mosaicking because it was referred to a base station with an acceptable order of accuracy. Table 16 shows the area of each LiDAR block and the shift values applied during mosaicking.

Mosaicked LiDAR DTM for Aklan floodplain is shown in Figure 25. It can be seen that the entire Aklan floodplain is 100% covered by LiDAR data.

Table 16. Shift Values of each LiDAR Block of Aklan Floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
Aklan_Blk38F	-0.48	0.22	-0.04
Aklan_Blk38G	-0.48	0.22	-0.06
Aklan_Blk38G_additional	-0.48	0.22	0.07
Aklan_Blk38H	-0.48	0.22	-0.09
Aklan_Blk38I	-0.65	0.22	-0.12
Aklan_Blk38J (upper block)	-0.48	0.22	0.14
Aklan_Blk38J (lower block)	-0.48	0.22	-0.20
Aklan_Blk38N	-0.16	0.44	-0.33
Capiz_Aklan_Blk38C	-0.48	0.22	-0.48
Capiz_Aklan_Blk38D	-0.48	0.22	-0.59
Capiz_Aklan_Blk38E_ supplement (right block)	0.37	0.22	-0.34
Capiz_Aklan_Blk38E_ supplement (left block)	-0.48	0.22	-0.60
Capiz_Aklan_Blk38E	-0.48	0.22	-0.53
Capiz_Aklan_Blk38F	-0.49	0.22	-1.10
Capiz_Aklan_Blk38G	-0.48	0.22	-1.11
Capiz_Aklan_Blk38I	-0.78	-0.07	-1.95

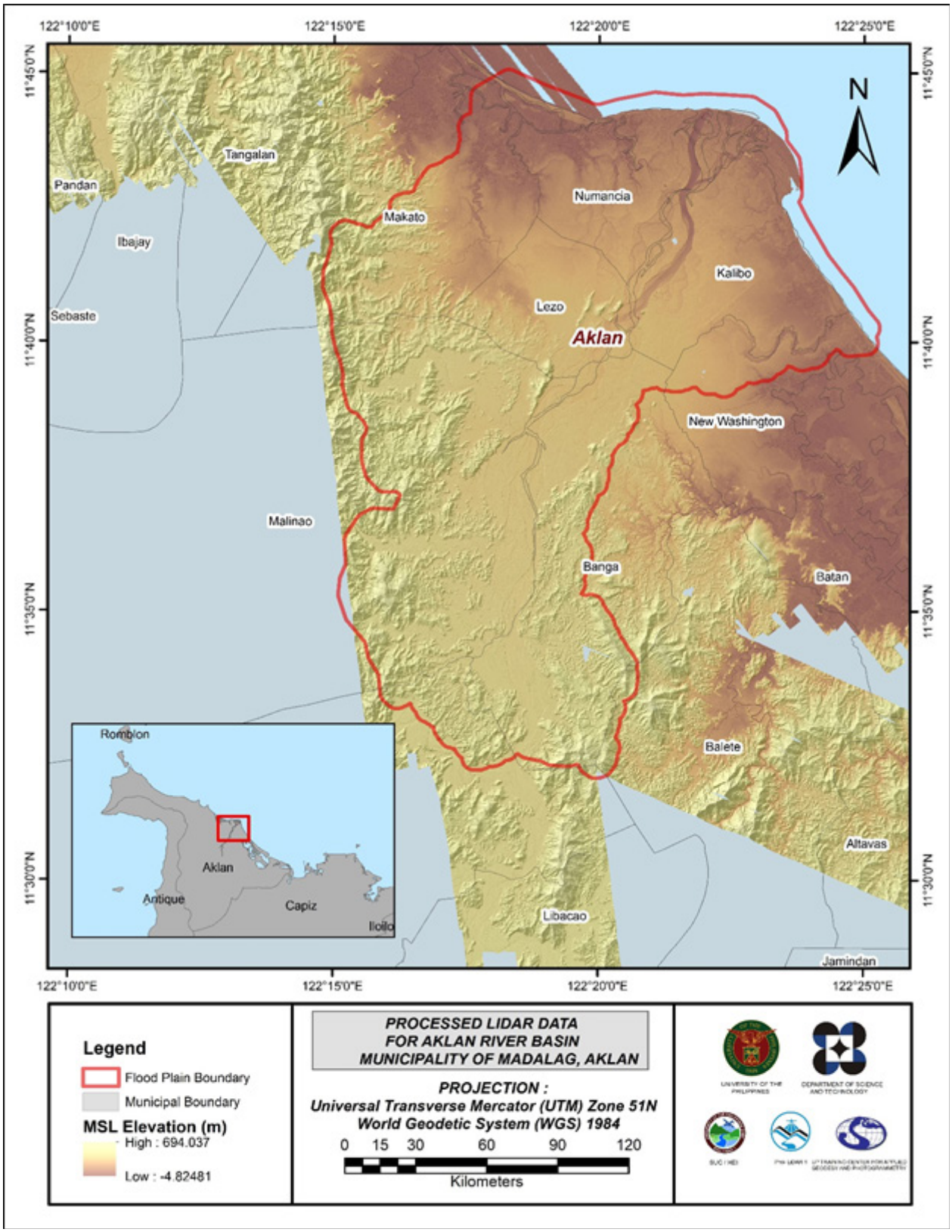

Figure 25. Map of Processed LiDAR Data for Aklan Floodplain.

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 Aklan to collect points with which the LiDAR dataset is validated is shown in Figure 25. A total of 3,836 points were gathered for the Aklan floodplain. However, the point dataset was not used for the calibration of the LiDAR data for Aklan because during the mosaicking process, each LiDAR block was referred to the calibrated Jalaur DEM. Therefore, the mosaicked DEM of Aklan can already be considered as a calibrated DEM.

A good correlation between the uncalibrated Jalaur LiDAR DTM and ground survey elevation values is shown in Figure 26. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration points is 1.71 meters with a standard deviation of 0.17 meters. Calibration of Jalaur LiDAR data was done by subtracting the height difference value, 1.71 meters, to Jalaur mosaicked LiDAR data. Table 17 shows the statistical values of the compared elevation values between Jalaur LiDAR data and calibration data. These values were also applicable to the Aklan DEM.

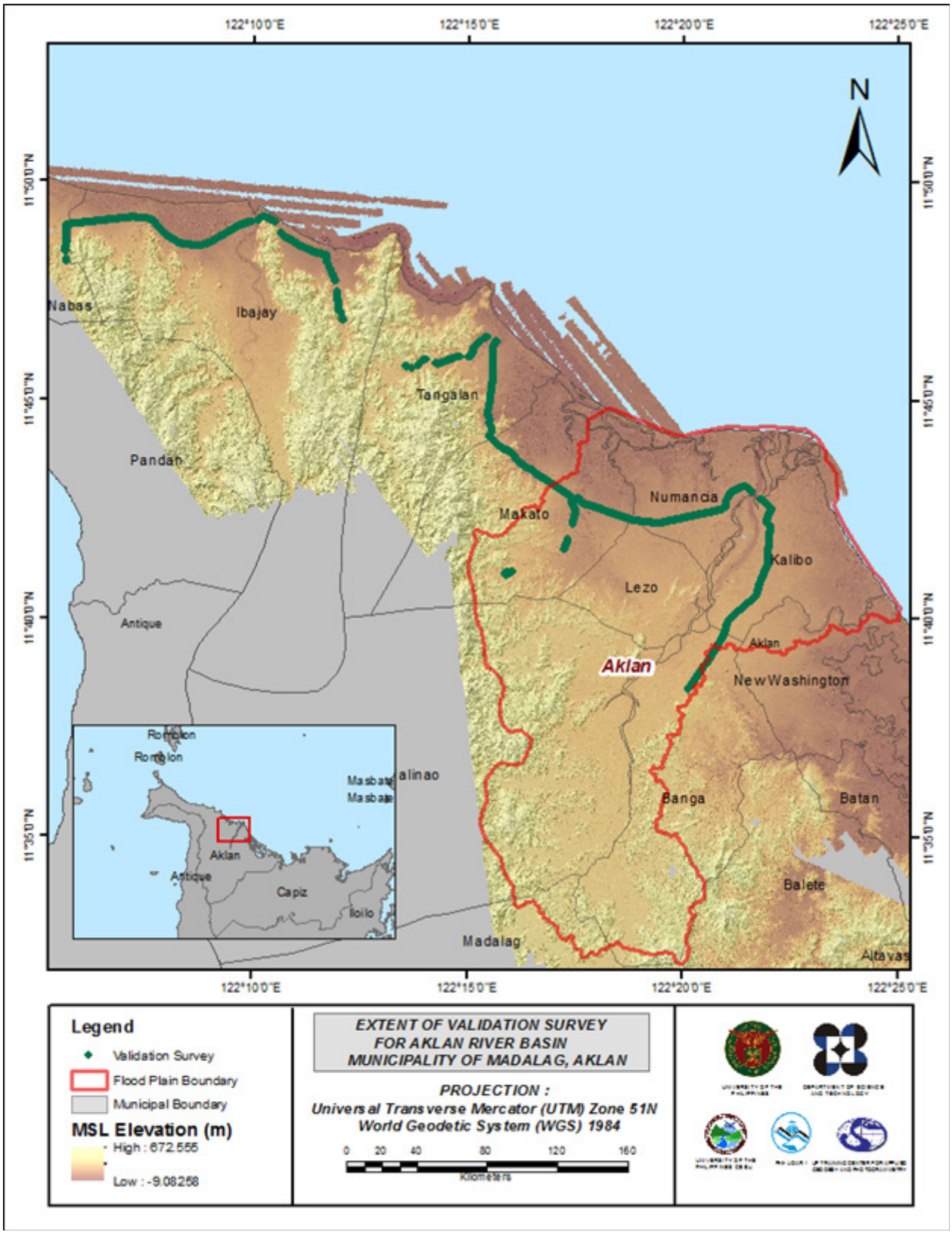

Figure 26. Map of Aklan Floodplain with validation survey points in green.

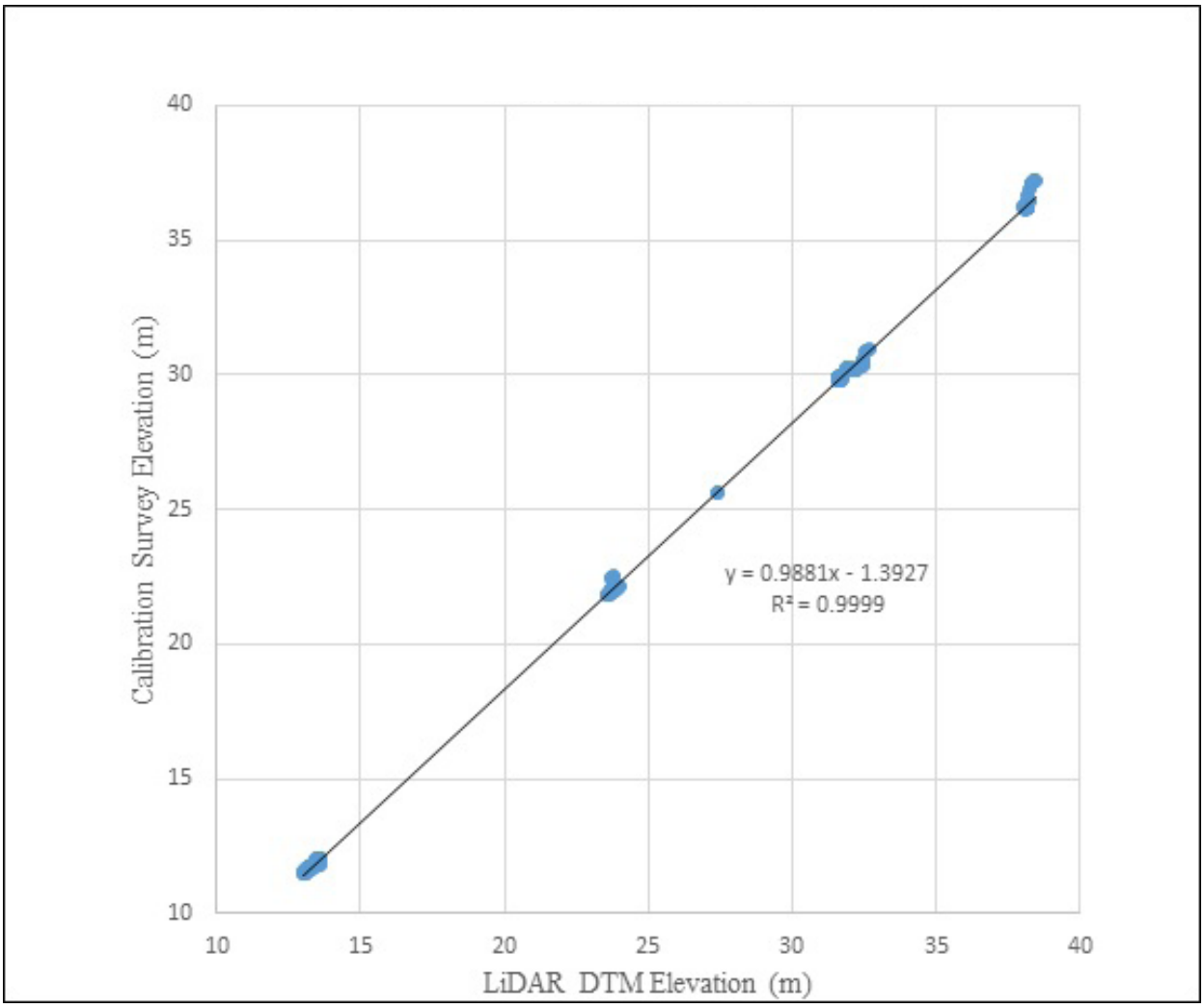

Figure 27. Correlation plot between calibration survey points and LiDAR data.

Table 17. Calibration Statistical Measures.

Calibration Statistical Measures	Value (meters)
Height Difference	1.71
Standard Deviation	0.17
Average	-1.70
Minimum	-2.13
Maximum	-1.16

A total of 3,836 survey points that are within the Aklan flood plain were used for the validation of the calibrated Aklan 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 28. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.15 meters with a standard deviation of 0.12 meters, as shown in Table 18.

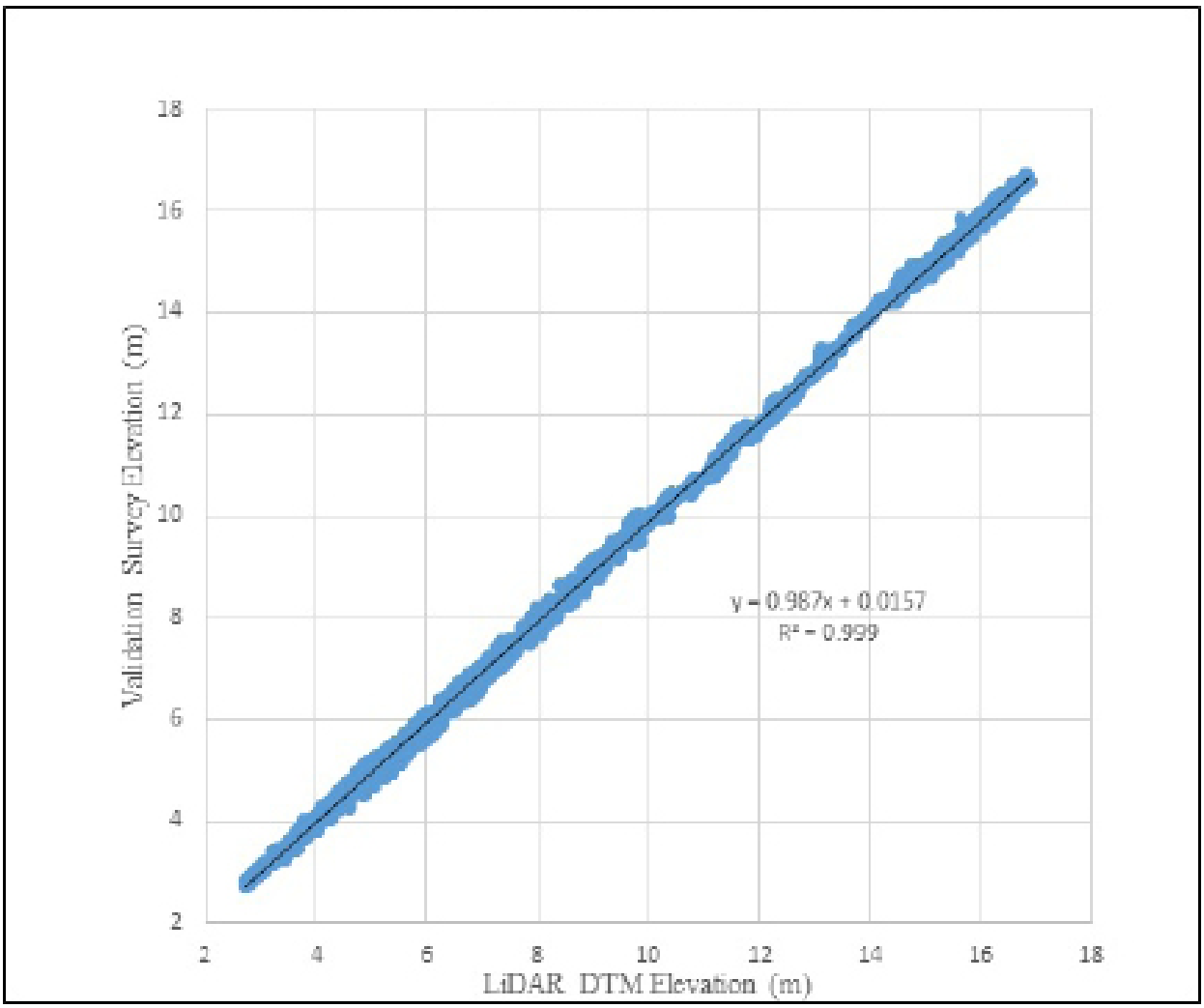

Figure 28. Correlation plot between validation survey points and LiDAR data.

Table 18. Validation Statistical Measures.

Validation Statistical Measures	Value (meters)
RMSE	0.15
Standard Deviation	0.12
Average	0.08
Minimum	-0.27
Maximum	0.40

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, a total of 40873 bathymetric survey points in centerline and zigzag was used for Aklan. The resulting raster surface produced was done by Inverse Distance Weighted (IDW) interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.28 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Aklan integrated with the processed LiDAR DEM is shown in Figure 29.

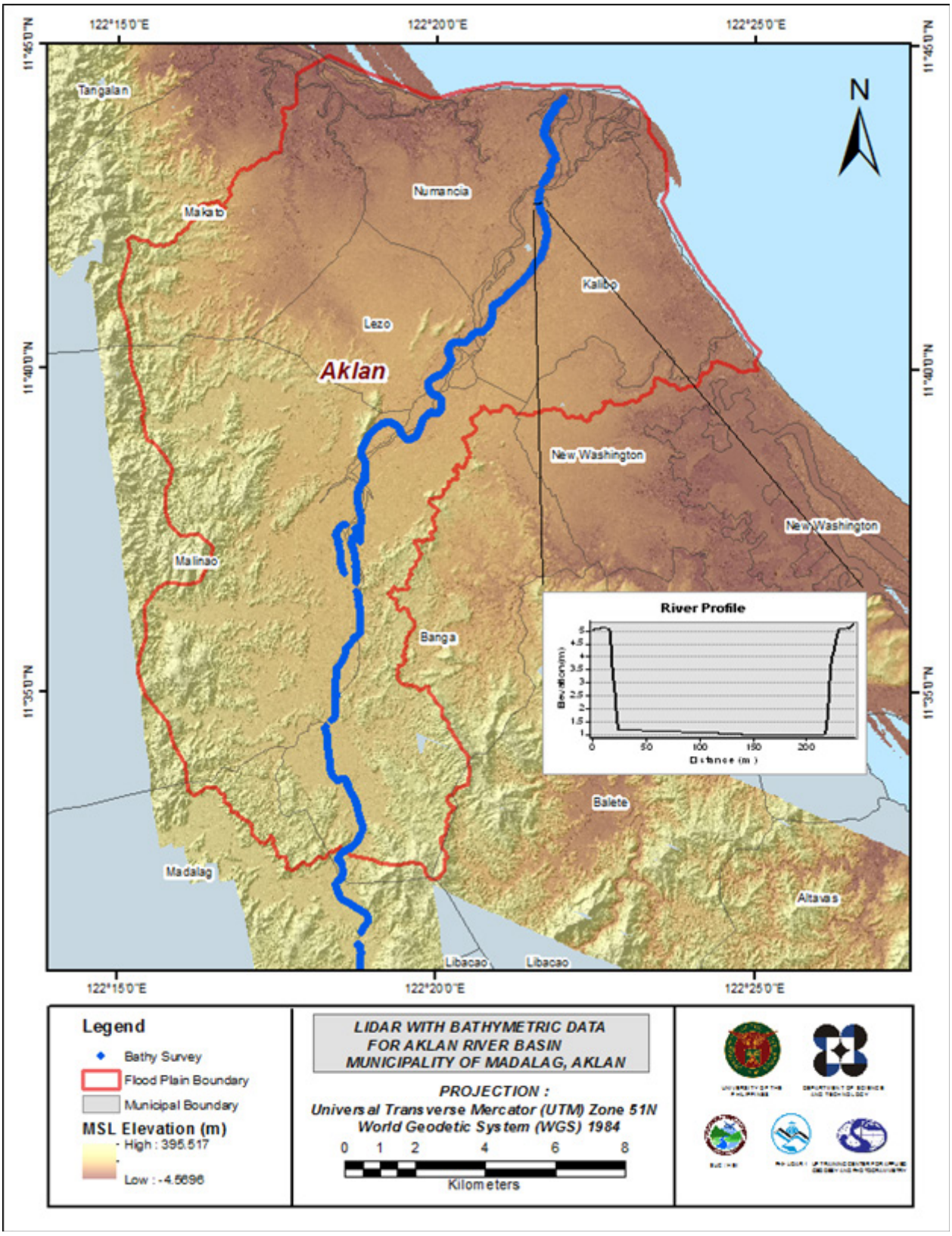

Figure 29. Map of Aklan Floodplain with bathymetric survey points shown in blue.

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

3.12.1 Quality Checking of Digitized Features' Boundary

Aklan floodplain, including its 200 m buffer, has a total area of 244.58 sq km. For this area, a total of 7.0 sq km, corresponding to a total of 1880 building features, are considered for QC. Figure 30 shows the QC blocks for Aklan floodplain.

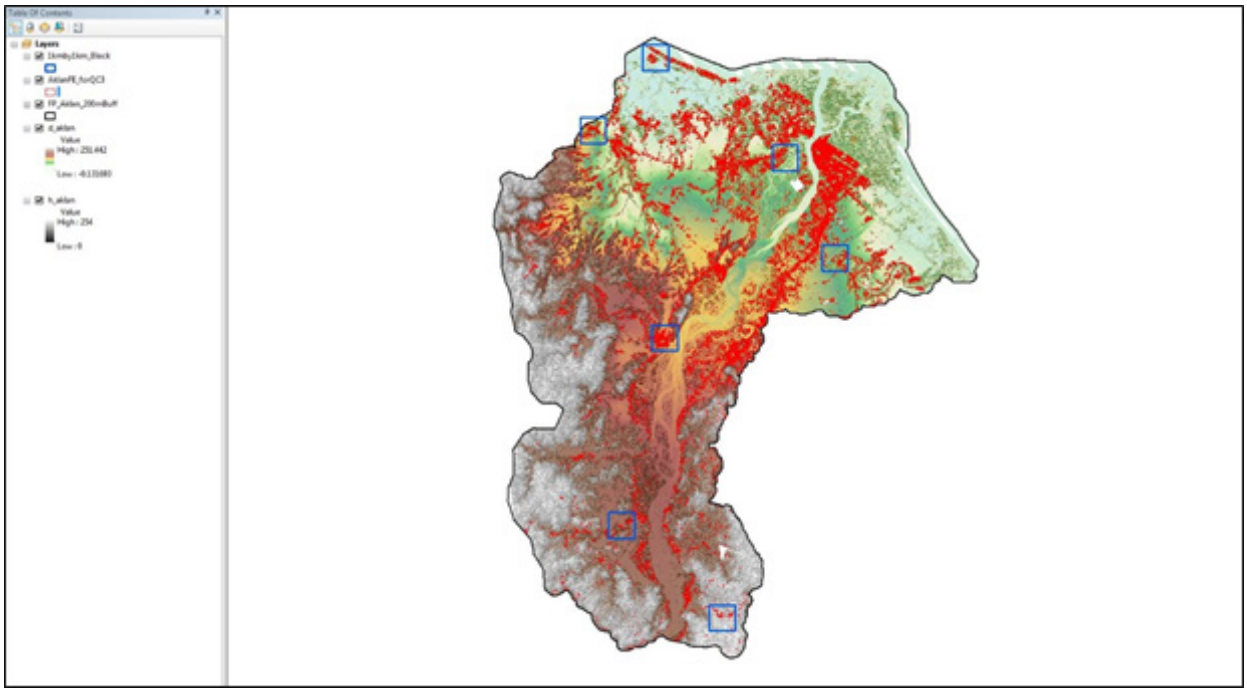

Figure 30. QC blocks for Aklan building features.

Quality checking of Aklan building features resulted in the ratings shown in Table 19.

Table 19. Quality checking ratings for Aklan building features

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Aklan	99.21	100.00	96.60	PASSED

3.12.2 Height Extraction

Height extraction was done for 62,672 building features in Aklan floodplain. Of these building features, 11,561 was filtered out after height extraction, resulting to 51,111 buildings with height attributes. The lowest building height is at 2.0 m, while the highest building is at 14.42 m.

3.12.3 Feature Attribution

The feature attribution survey was conducted through a participatory community-based mapping in coordination with the Local Government Units of the Municipality/City. The research associates of Phil-LiDAR 1 team visited local barangay units and interviewed local key personnel and officials who possessed expert knowledge of their local environments to identify and map out features.

Maps were displayed on a laptop and were presented to the interviewees for identification. The displayed map include the orthophotographs, Digital Surface Models, existing landmarks, and extracted feature shapefiles. Physical surveys of the barangay were also done by the Phil-LiDAR 1 team every after interview for validation. The number of days by which the survey was conducted was dependent on the number of features and number of barangays included in the flood plain of the river basin.

Table 20 summarizes the number of building features per type. On the other hand, Table 21 shows the total length of each road type, while Table 22 shows the number of water features extracted per type.

Table 20. Number of building features extracted for Aklan Floodplain.

Facility Type	No. of Features
Residential	47782
School	1010
Market	56
Agricultural/Agro-Industrial Facilities	84
Medical Institutions	78
Barangay Hall	82
Military Institution	2
Sports Center/Gymnasium/Covered Court	41
Telecommunication Facilities	20
Transport Terminal	27
Warehouse	70
Power Plant/Substation	21
NGO/CSO Offices	22
Police Station	19
Water Supply/Sewerage	13
Religious Institutions	235
Bank	16
Factory	18
Gas Station	47
Fire Station	3
Other Government Offices	168
Other Commercial Establishments	1205
Others	91
Total	**51111**

Table 21. Total length of extracted roads for Aklan Floodplain.

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Aklan	424.87	40.52	80.24	33.93	48.56	628.12

Table 22. Number of extracted water bodies for Aklan Floodplain.

Floodplain	Water Body Type						Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	Others	
Aklan	48	0	0	0	1189	0	1237

A total of 77 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 31 shows the Digital Surface Model (DSM) of Aklan floodplain overlaid with its ground features.

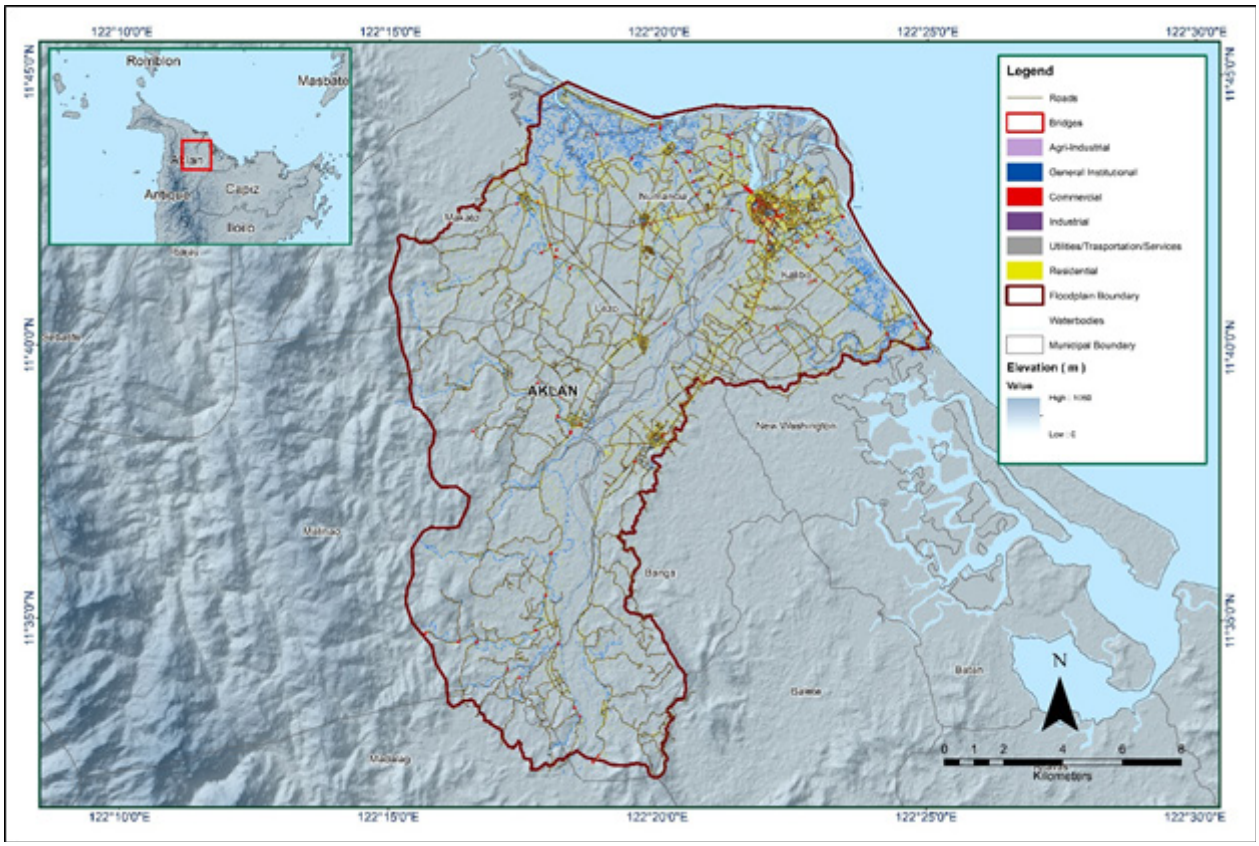

Figure 31. Extracted features for Aklan Floodplain.

CHAPTER 4: DATA VALIDATION SURVEY AND MEASUREMENTS IN THE AKLAN RIVER BASIN

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

4.1 Summary of Activities

The Data Validation and Bathymetry Component (DVBC) conducted survey in Aklan River on October 29-November 7, 2015 with the objective of conducting the following activities: cross-section, bridge as-built and water level marking in MSL of Guadalupe Bridge; gathering of validation point along the concrete roads within the Aklan River Basin; and 30.1 km bathymetry survey from the Municipality of Madalag to the Municipality of Numancia. The entire extent of the Aklan river basin survey is shown in Figure 32.

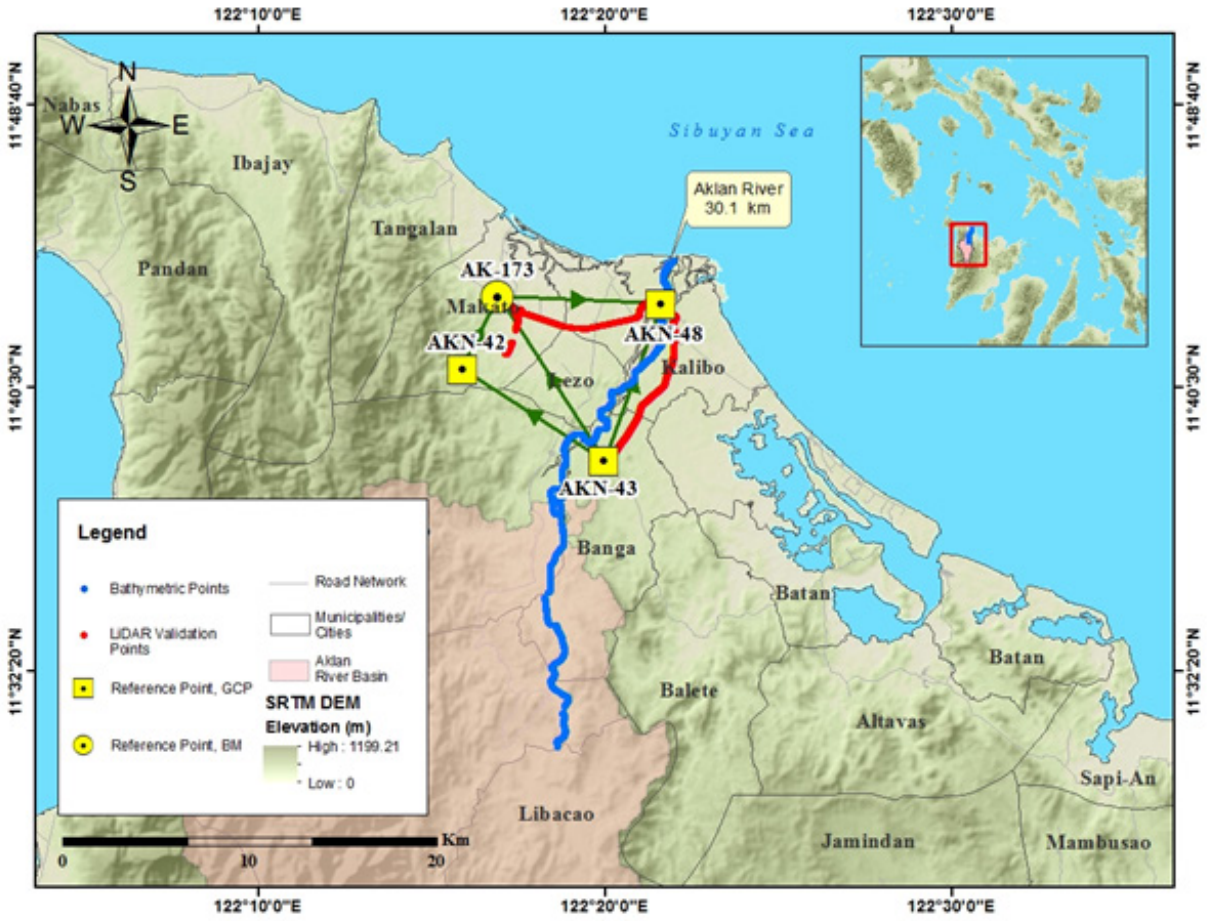


Figure 32. Aklan River Survey Extent

4.2 Control Survey

The GNSS network survey used in Aklan river survey was composed of two loops established on November 1, 2015 occupying the following reference points: AKN-43, in Brgy. Poblacion, Municipality of Banga; and AK-173 in Brgy. Dumga in the Municipality of Makato.

Two NAMRIA established control points namely: AKN-42 in Brgy. Libang, Municipality of Makato; and AKN-48, a second order GCP located in Brgy. Poblacion, Municipality of Kalibo; were also occupied to use as marker during the survey.

The summary of reference and control points and its location is shown in Figure 33 and Table 23.

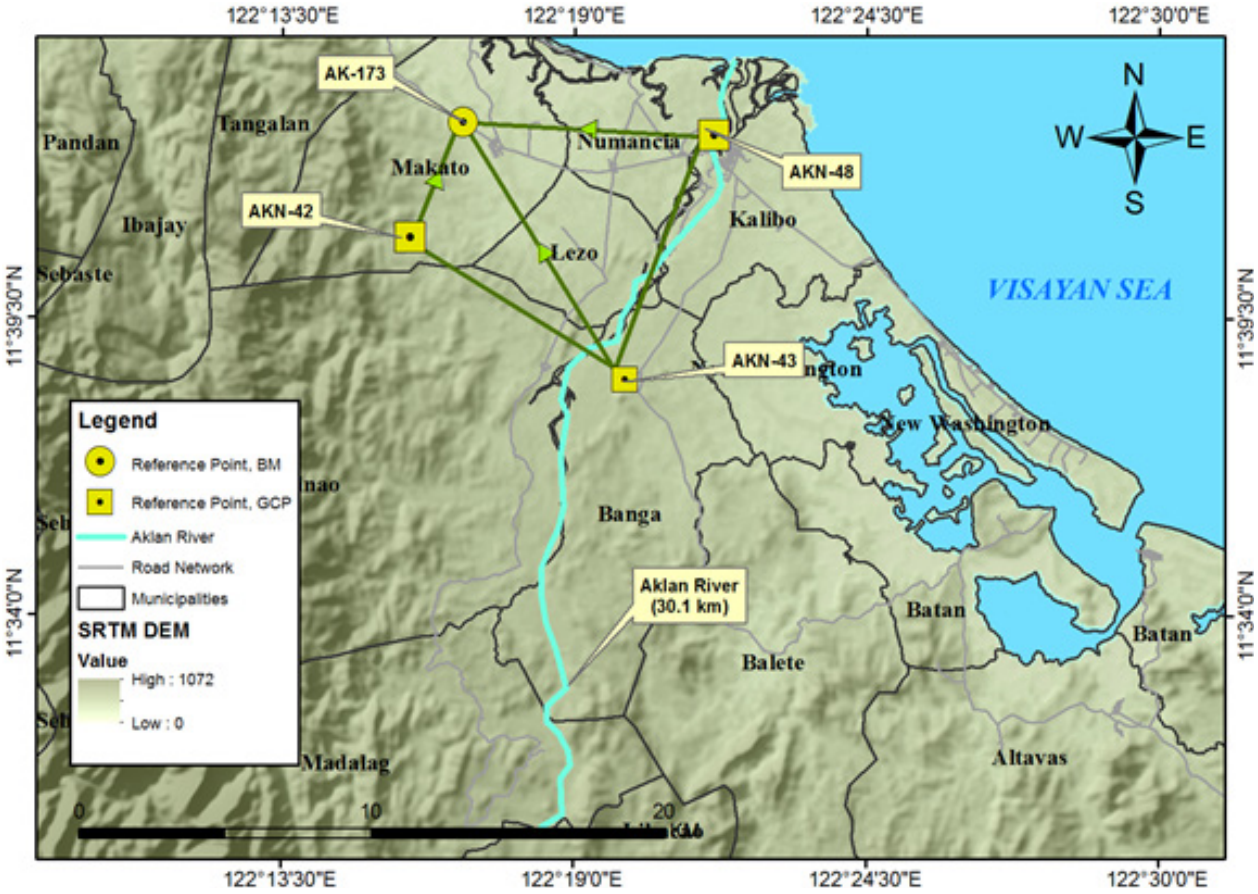


Figure 33. GNSS Network of Aklan Field Survey

Table 23. List of Reference and Control Points used in Aklan River survey
(Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (Meter)	Elevation in MSL (Meter)	Date Established
AKN-43	2nd Order, GCP	11°38'22.52687"	122°19'58.16083"	72.296	-	2007
AK-173	1st Order, BM	-	-	66.084	10.516	2007
AKN-42	Used as Marker	-	-	-	-	2007
AKN-48	Used as Marker	-	-	-	-	2007

The GNSS receiver set up and established control points in Aklan survey are shown in Figure 34 to Figure 37.

Figure 34. Trimble® SPS 852 GNSS receiver base station at AKN-43 infront of Banga Municipal Hall, Brgy. Poblacoin, Municipality of Banga

Figure 35. Trimble® SPS 882 GNSS receiver setup at AK-173, Dumga Bridge, Brgy. Dumga, Municipality of Makato

Figure 36. Trimble® SPS 882 GNSS receiver setup at AKN-42 inside a basketball court in Brgy. Libang, Municipality of Makato

Figure 37. Trimble® SPS 985 GNSS receiver occupation at AKN-48 in Kalibo Bridge, Brgy. Poblacion, Municipality of Kalibo

4.3 Baseline Processing

GNSS Baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within +/- 20 cm and +/- 10 cm requirement, respectively. In case where one or more baselines did not meet all of these criteria, masking is performed. Masking is done by removing/masking portions of these baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, resurvey is initiated. Baseline processing result of control points in Aklan River Basin is summarized in Table 24 generated by TBC software.

Table 24. Baseline Processing Report for Aklan River Basin Static Survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	Height (Meter)
AKN-43 --- AKN-48	11-1-2015	Fixed	0.003	0.017	200°00'42"	8870.089	9.527
AK-173 --- AKN-48	11-1-2015	Fixed	0.003	0.017	272°44'45"	8610.027	3.313
AKN-43 --- AK-173	11-1-2015	Fixed	0.003	0.018	327°31'49"	10367.060	-6.198
AKN-43 --- AKN-42	11-1-2015	Fixed	0.003	0.018	303°20'32"	8818.103	-0.135
AKN-42 --- AK-173	11-1-2015	Fixed	0.004	0.025	204°46'47"	4295.495	6.081

A shown in Table 24, a total of five baselines were processed with reference elevation of point AK-173 and coordinates of AKN-43 held fixed. All of them passed the required accuracy.

4.4 Network Adjustment

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

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

Where:

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

for each reference point. See the Network Adjustment Report in Table 25 to Table 28 for complete details.

The four (4) control points, AKN-43, AKN-42, AK-173, and AKN-48 were occupied and observed simultaneously to form a GNSS loop. Coordinates of point AKN-43 and elevation value of AK-173 were held fixed during the processing of the control points as presented in Table C-3. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 25. Control Point Constraints

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
AK-173	Global				Fixed
AKN-43	Global	Fixed	Fixed	Fixed	
Fixed = 0.000001(Meter)					

The list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 26. The fixed control point AK-173 and AKN-43, has no values for standard elevation and coordinates error, respectively.

Table 26. Adjusted Grid Coordinates

Point ID	Easting	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
AK-173	421731.966	0.003	1295542.888	0.003	10.516	?	e
AK-42	419922.257	0.003	1291648.742	0.003	16.382	0.023	
AK-43	427275.083	?	1286786.229	?	16.246	0.018	LL
AK-48	430328.301	0.003	1295111.093	0.003	7.126	0.019	

The network is fixed at reference point AK-173 and AKN-43 for elevation and coordinate values, respectively.

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

a. AKN – 43
Horizontal accuracy = fixed
Vertical accuracy = 1.8 < 10 cm

b. AK-173
Horizontal accuracy = $((0.3)^2 + (0.3)^2$
= √(0.9 + 0.9+)
= 1.34 cm < 20 cm
Vertical accuracy = fixed

c. AKN - 42
horizontal accuracy = $\sqrt{((0.3)^2 + (0.3)^2}$
= √(0.9 + 0.9+)
= 1.34 cm < 20 cm
vertical accuracy = 2.3 < 10 cm

d. AKN - 48
horizontal accuracy = $\sqrt{((0.3)^2 + (0.3)^2}$
= √(0.9+ 0.9)
= 1.34 cm < 20 cm
vertical accuracy = 1.9 < 10 cm

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

Table 27. Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
AK-173	N11°43'07.15414"	E122°16'54.36766"	66.084	?	e
AK-42	N11°41'00.23163"	E122°15'54.92080"	72.161	0.023	
AK-43	N11°38'22.52687"	E122°19'58.16083"	72.296	0.018	LL
AK-48	N11°42'53.77055"	E122°21'38.37206"	62.769	0.019	

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 27. Based on the result of the computation, the equation is satisfied; hence, the required accuracy for the program was met.

The summary of reference and control points used is indicated in Table 28.

Table 28. Reference and control points and its location (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoidal Height (m)	Northing	Easting	MSL Elevation (m)
AKN-43	2nd Order GCP	11°38'22.52687"	122°19'58.16083"	72.296	1286786.229	427275.083	16.246
AK-173	1st Order BM	11°43'07.15414"	122°16'54.36766"	66.084	1295542.888	421731.966	10.516
AKN-42	UP Established	11°41'00.23163"	122°15'54.92080"	72.161	1291648.742	419922.257	16.382
AKN-48	UP Established	11°42'53.77055"	122°21'38.37206"	62.769	1295111.093	430328.301	7.126

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

Cross section and as-built survey were conducted on November 2, 2015 at the downstream side of Guadalupe Bridge located in Brgy. Poblacion, Municipality of Madalag. using a Trimble® SPS 882 in GNSS PPK survey technique as shown in Figure 38.

Figure 38. AWLS elevation acquisition at Guadalupe Bridge, Brgy. Poblacion, Municipality of Madalag

The cross-sectional line of Guadalupe bridge has an estimated lenghth of 220 m with a total of 90 points acquired using AKN-43 as the GNSS base station. The location map, cross section diagram, and the bridge data form are shown in Figure 39 to Figure 41, respectively.

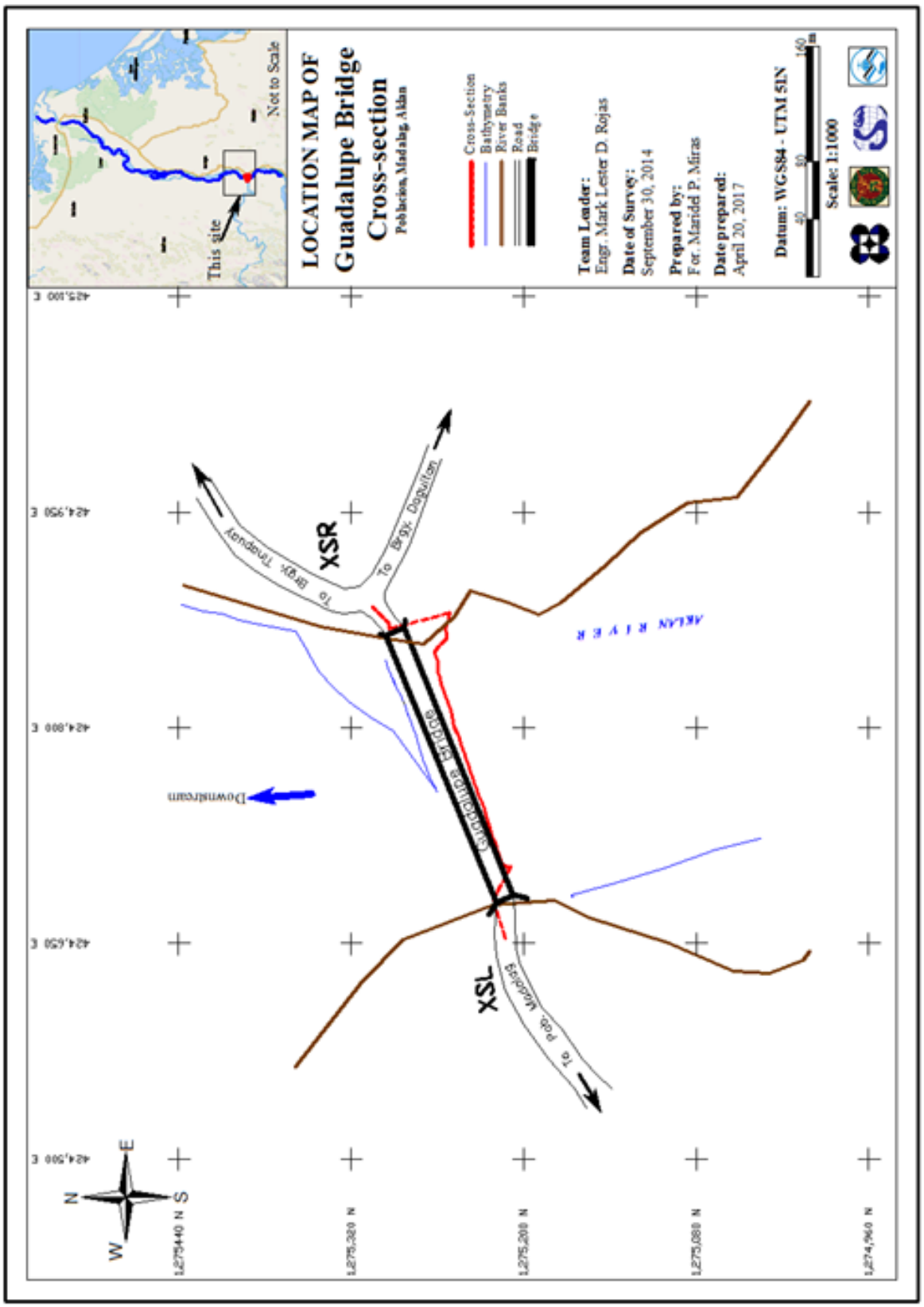


Figure 39. Guadalupe Bridge cross-section location map

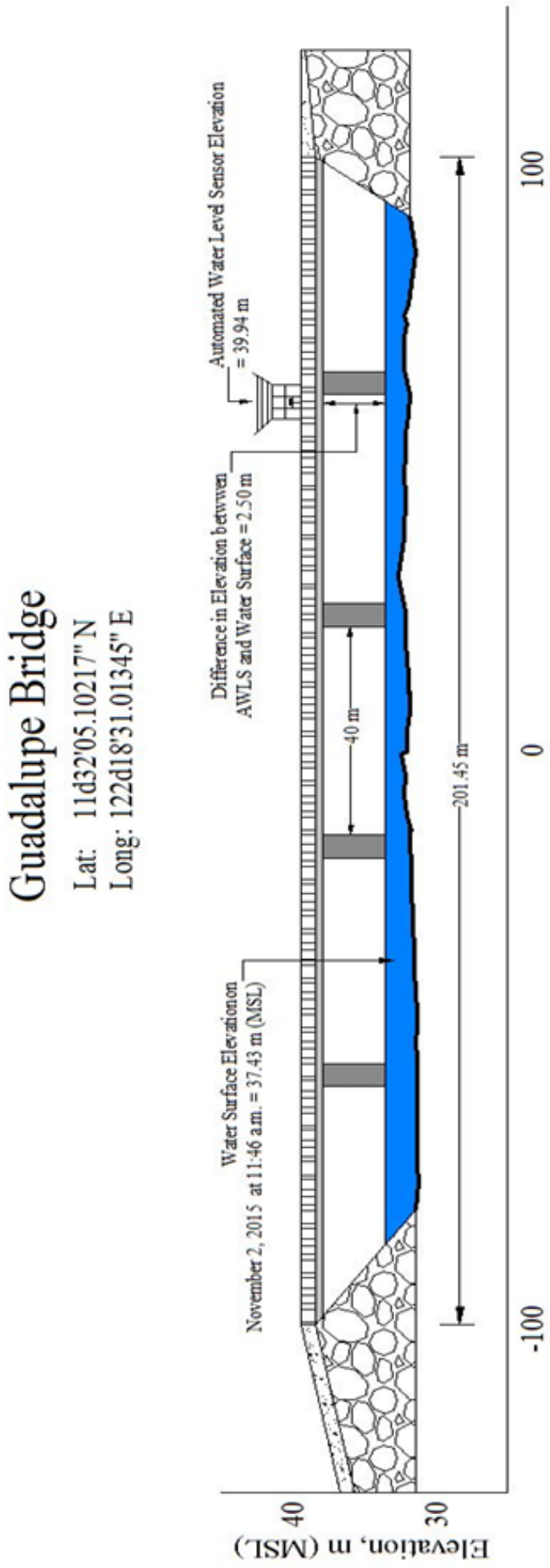


Figure 40. Guadalupe Bridge cross-section diagram

Bridge Data Form

Bridge Name: Guadalupe Bridge **Date:** November 4, 2015

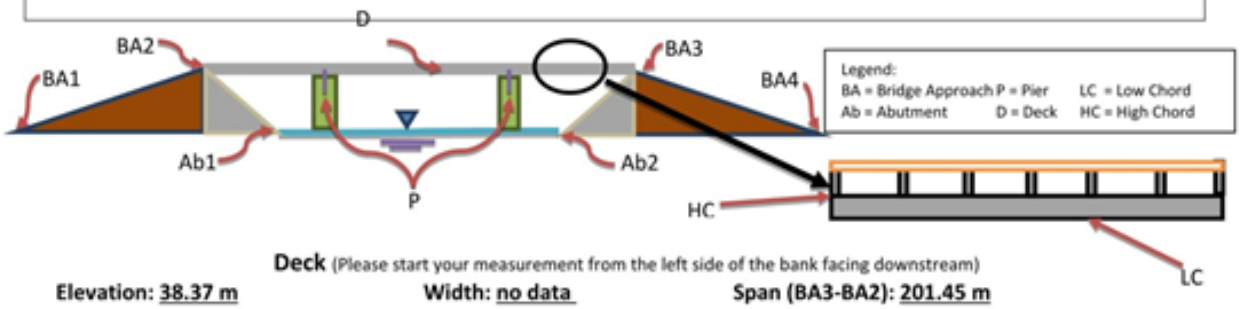
River Name: AKLAN RIVER **Time:** 11:40 a.m.

Location (Brgy, City,Region): Brgy. Poblacion, Madalag, Aklan

Survey Team: Michael Labrador, Erlan Mendoza, Romalyn Boada, Herbert Taniza

Flow condition: low normal high **Weather Condition:** fair rainy

Latitude: 11d32'04.46182"N **Longitude:** 122d18'28.69987"E



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

Elevation: 38.37 m **Width:** no data **Span (BA3-BA2):** 201.45 m

	Station	High Chord Elevation	Low Chord Elevation
1			
2			
3			

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	10.57	BA3	354.60	9.04
BA2	56.47	9.18	BA4	388.95	9.32

Abutment: Is the abutment sloping? Yes No; If yes, fill in the following information:

	Station (Distance from BA1)	Elevation
Ab1		
Ab2	230.23	31.11

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

Shape: Circular **Number of Piers:** Ten (10) **Height of column footing:** n/a

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	72.04	38.81	
Pier 2	111.47	38.70	
Pier 3	151.39	38.83	
Pier 4	191.43	38.75	

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

Figure 41. Guadalupe Bridge Data Form

The water surface elevation of Aklan River in Guadalupe Bridge was acquired using PPK survey technique on November 2, 2015 at 11:46 a.m. The resulting water surface elevation data at Guadalupe Bridge is 37.435 m above MSL. This was translated into a marking on the bridge's pier to serve as a reference for flow data gathering and depth gauge deployment of UP Cebu PHIL-LIDAR 1. The marked water level marking for Guadalupe Bridge is shown in Figure 42.

Figure 42. Water level gauge at one of the pier of Guadalupe Bridge, Brgy. Poblacion, Municipality of Madalag

4.6 Validation Points Acquisition Survey

Validation Points Acquisition Survey was conducted on November 1, 2015 using a survey-grade GNSS Rover receiver mounted on a pole which was attached to the front of vehicle as shown in Figure 43. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height is 2.532 m measured from the ground up to the bottom of notch of the GNSS Rover receiver. The survey was conducted using PPK technique on a continuous topo mode and by setting up a base station on AKN-43 in Brgy. Poblacion, Banga which is shown in Figure 42. The ground validation survey covered the major roads running along Aklan West Road and Iloilo-Antique Road from Brgy. Solido, Nagas City to Brgy. Aliputos, Numancia City, Aklan.

Figure 43. Validation points acquisition survey set-up

The Validation Point Acquisition Survey for the Aklan River Basin traversed the Municipalities of Banga, Kalibo, Numancia, and Makato. The gathered validation points was taken across the LiDAR flight strips in the survey area. A total of 4,039 validation points with an approximate length of 21.74 km was accomplished as illustrated in Figure 44.

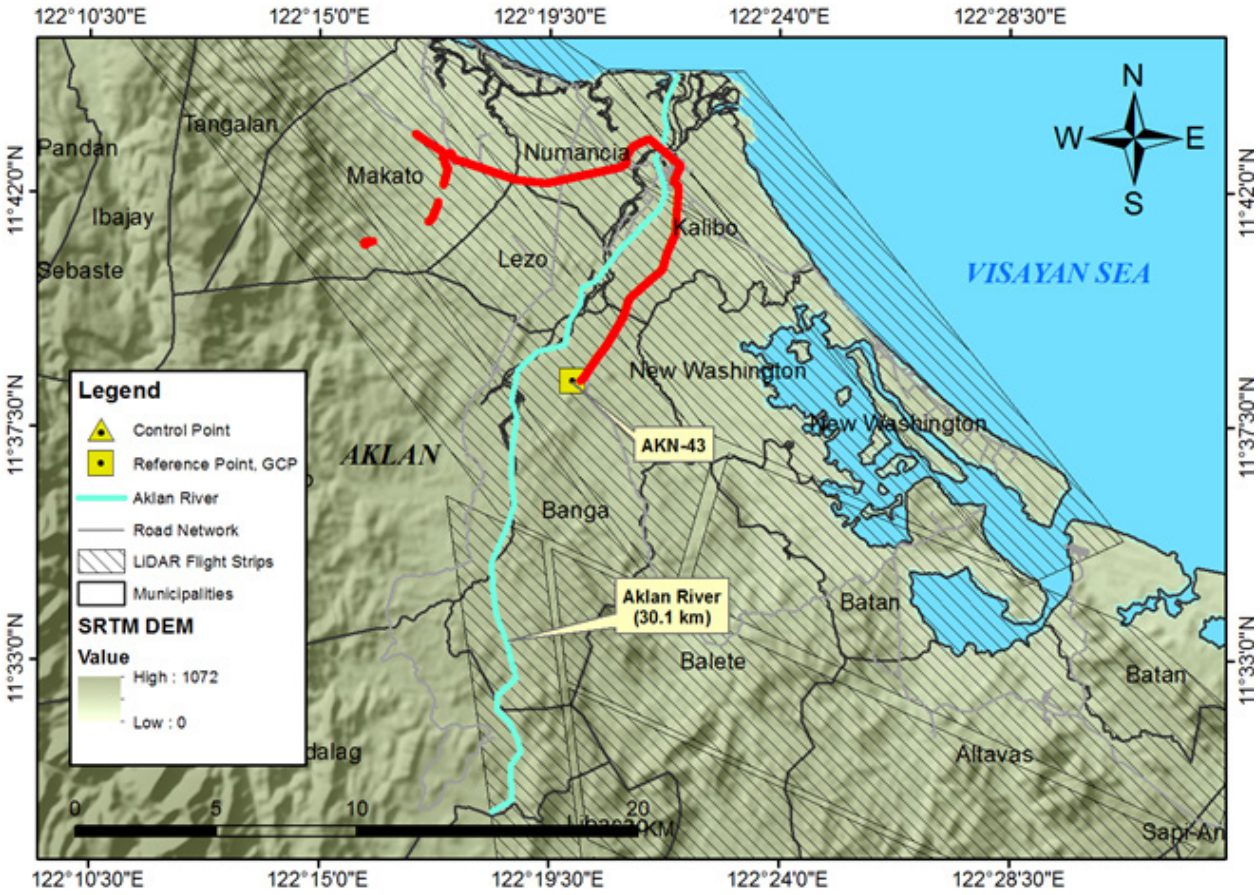


Figure 44. Validation Point Acquisition Survey for Aklan River

4.7 Bathymetric Survey

Bathymetric survey was conducted from November 3, 2015 using Trimble® SPS 882 in GNSS PPK survey technique and an Ohmex™ single beam echo sounder attached to a boat as shown in Figure 45. The survey started in the middle part of the river in Brgy. Cupang, Municipality of Malinao with coordinates 11°38'14.61781" 122°18'53.19268" an ended at the mouth of the river in Brgy. Pusiw, Municipality of Numancia with coordinates 11°44'10.95240" 122°22'00.21093".

Figure 45. OHMEX™ single beam echosounder set up on a boat for Aklan River bathymetric survey

Manual bathymetric survey was conducted for shallow portions of the river by traversing it by foot using a Trimble® SPS 882 Rover mounted on a pole implementing GNSS PPK survey technique as shown in Figure 46. The survey started from the upstream part of the river in Brgy. Tigbawan, Municipality of Madalag with coordinates 11°30'07.26843" 122°18'38.10019", and ended at the starting point of the bathymetric survey using boat. The control point AKN-43 was used as the GNSS base station all throughout the bathymetric survey.

Figure 46. Manual bathymetry survey of DVBC's personnel with the help of a local hire

An estimated length of 30.10 km with 3,020 points were acquired in the bathymetric survey as shown in Figure 47.

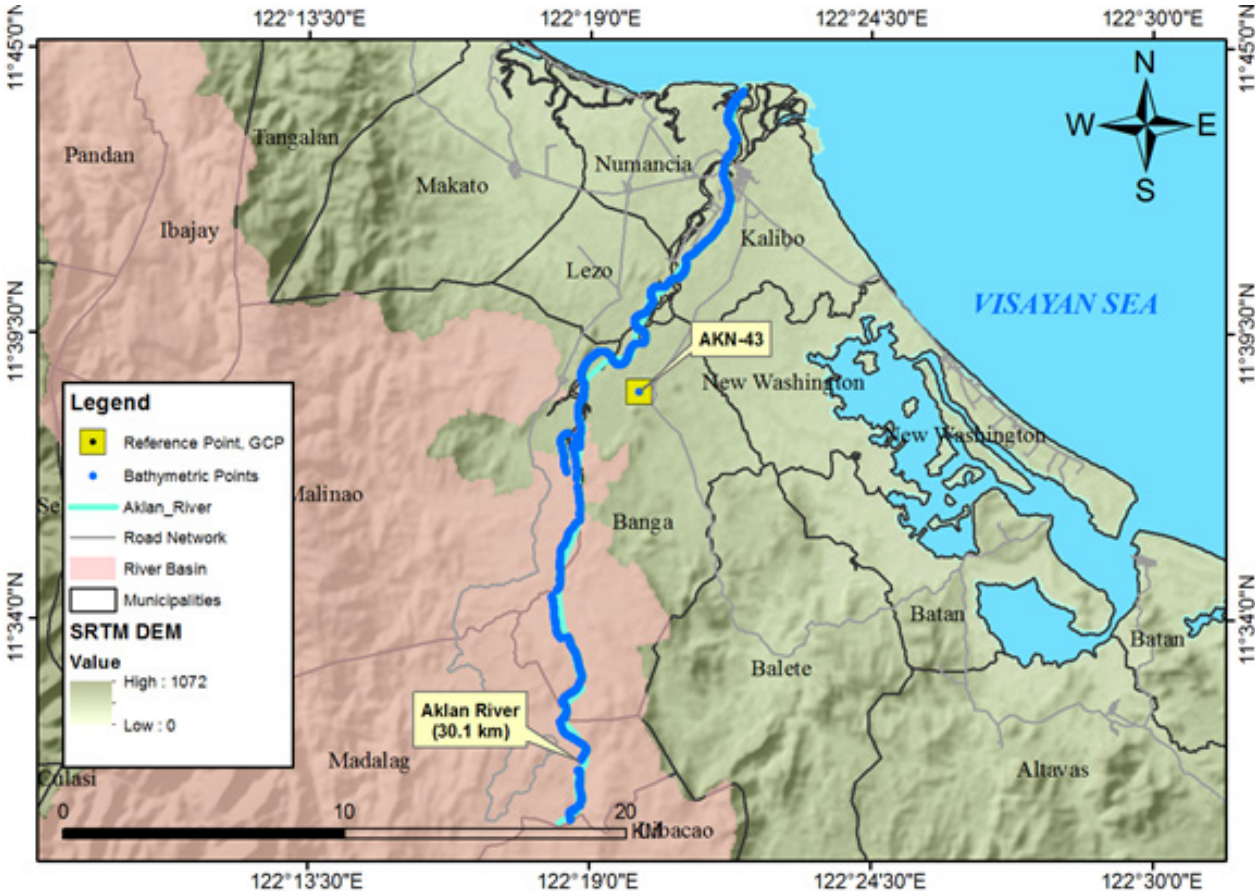


Figure 47. Bathymetric points gathered in Aklan River

A CAD drawing was also produced to illustrate the Aklan riverbed profile. As shown in Figure 48 to Figure 50, there is a difference of about 8.5 meters between the starting point in Brgy. Tigbawan, Municipality of Madalag and at Guadalupe Bridge in Brgy. Daguitan, Municipality of Banga. From Guadalupe Bridge to Brgy. Rosario, Municipality of Malinao, there is a change of elevation of about 9.4 meters. Going downstream, difference of about 32.1 meters, 37.1 meters and 39.6 meters were observed from the starting point for the Municipalities of Lezo, Kalibo and Numancia, respectively. A sudden drop in elevation is observed within Brgy. Mina in the Municipality of Lezo. This is most probably due to the numerous quarry sites present in the area. Additionally, the deepest portion or the lowest elevation recorded is about 1.9 meters below MSLwhich is located in Brgy. Pusiw, Numancia.

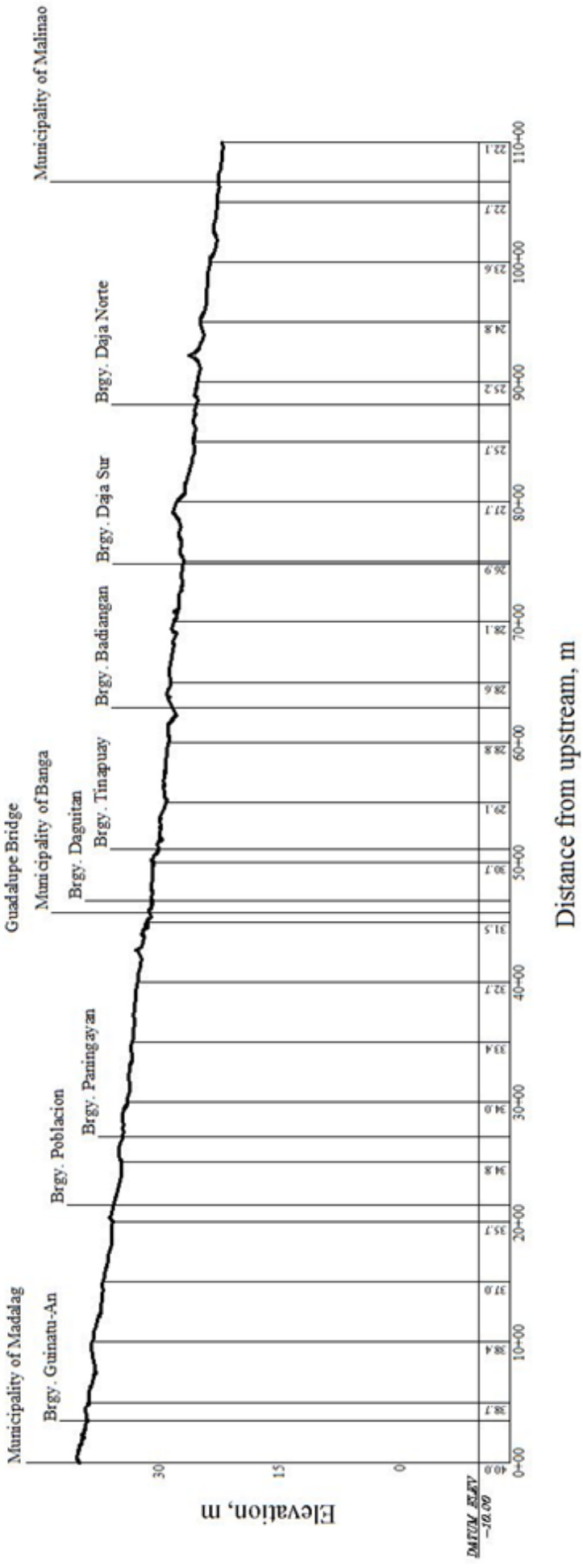


Figure 48. Aklan centreline riverbed profile (Upstream)

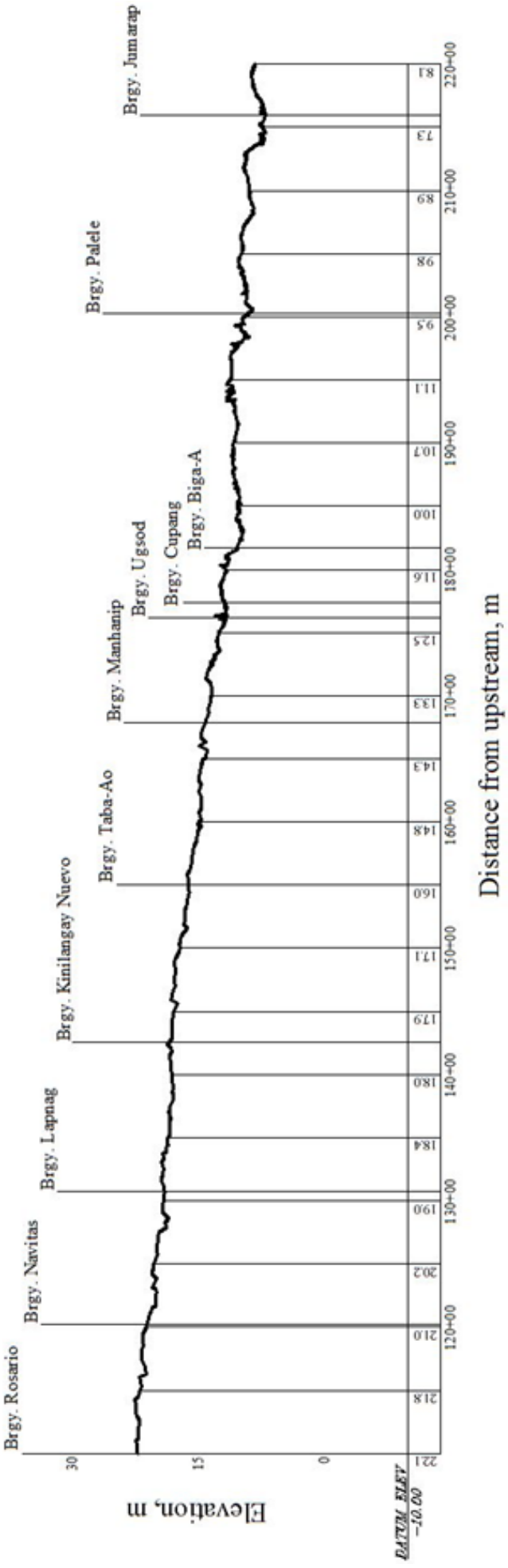


Figure 49. Aklan centreline riverbed profile (Middle)

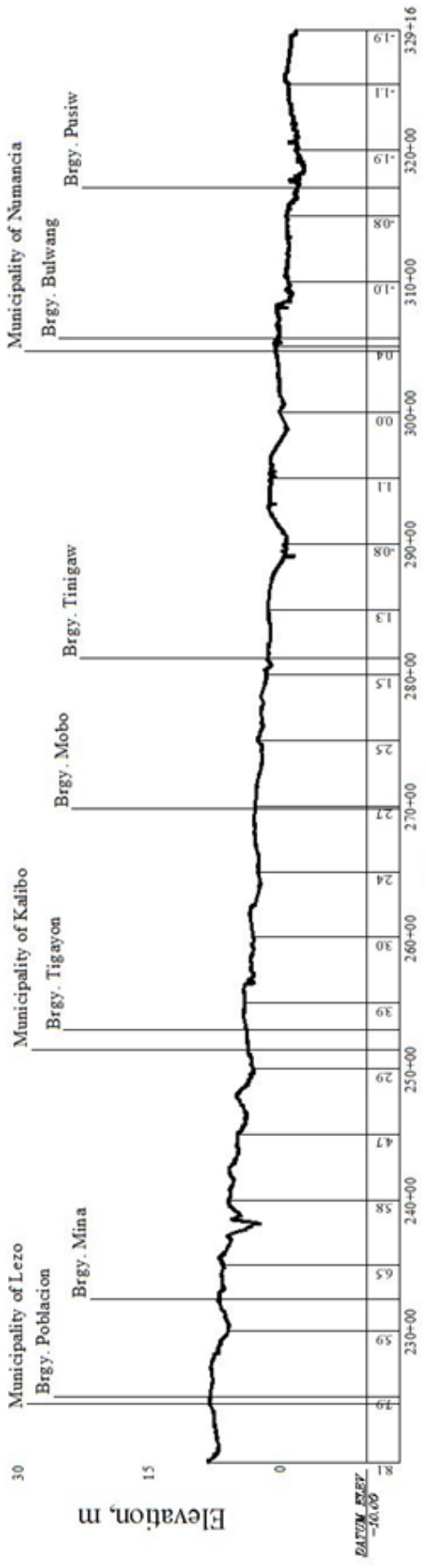


Figure 50. Aklan centreline riverbed profile (Downstream)

CHAPTER 5: FLOOD MODELING AND MAPPING

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

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

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

5.1.2 Precipitation

Precipitation data was taken from an automatic rain gauge (ARG) deployed by the UP Cebu Flood Modeling Component (FMC) team. The ARG was installed at Brgy. Mamba, Madalag, Aklan (Figure 51). The precipitation data collection started from July 20, 2016 from 12:00 AM to 11:50 PM with a recording interval of 5 minutes.

The total precipitation for this event in Brgy Mamba ARG was 41.95 mm with a peak rainfall of 4 mm. on July 20, 2016 at 10:05 in the morning. The lag time between the peak rainfall and discharge is 6 hours and 25 minutes.

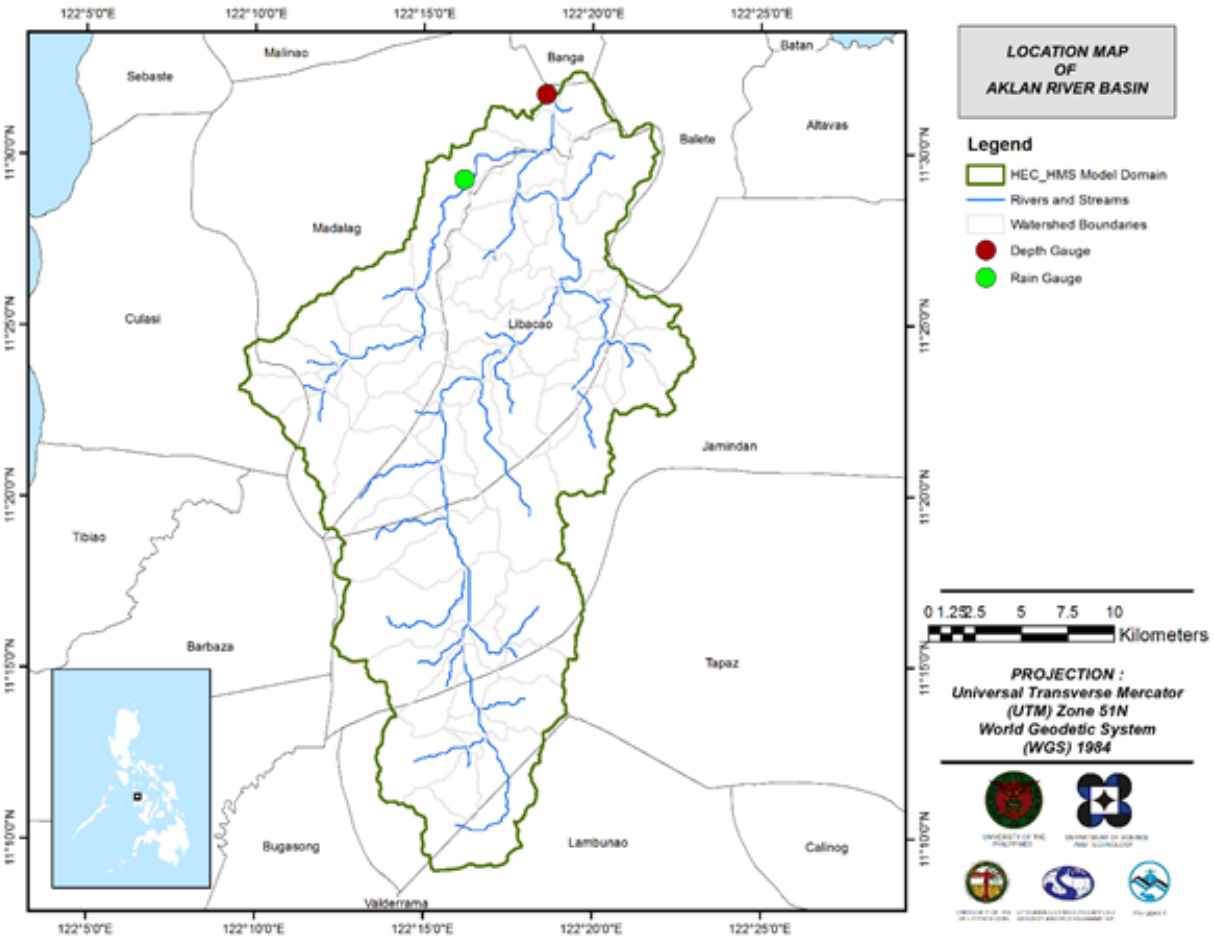


Figure 51. The location map of Aklan HEC-HMS model used for calibration

5.1.3 Rating Curves and River Outflow

A rating curve was computed using the prevailing cross-section (Figure 52) at Guadalupe-Madalag Bridge, Madalag, Aklan (11° 31' 47.47"N, 122° 18' 35.7"E). It gives the relationship between the observed water levels at Guadalupe Bridge and outflow of the watershed at this location.

For Guadalupe Bridge, the rating curve is expressed as Q = 66.291e0.5476x [see y formula] as shown in Figure 53.

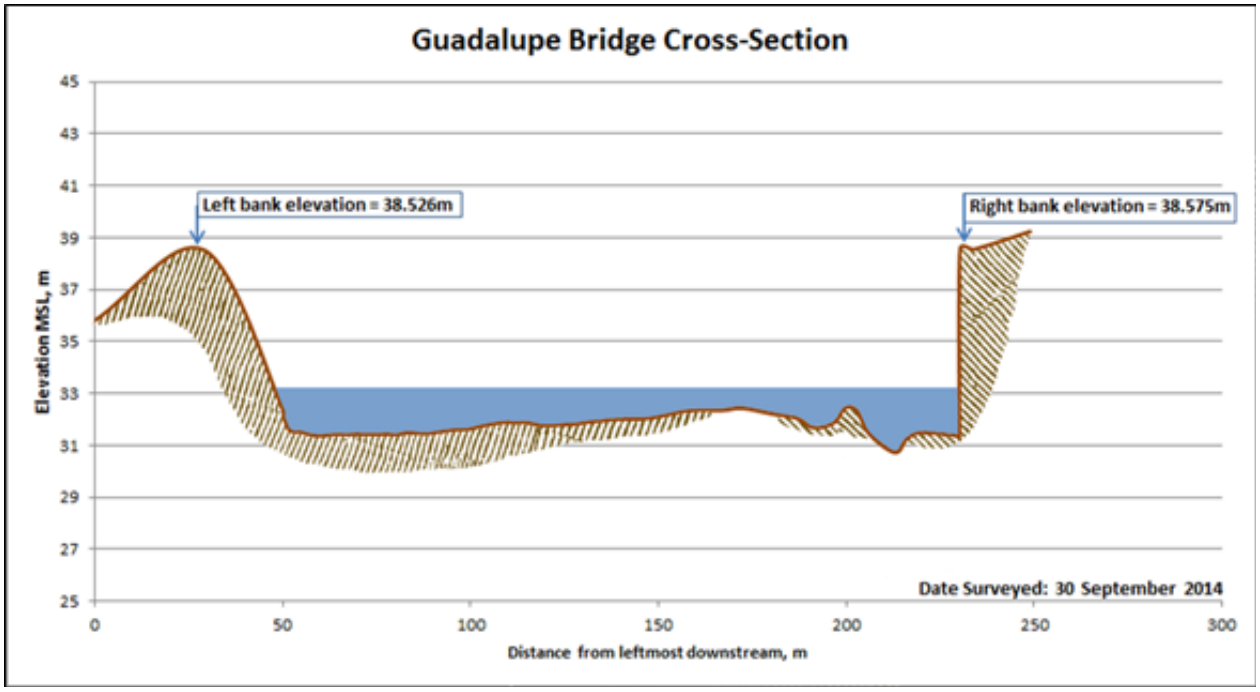


Figure 52. Cross-Section Plot of Guadalupe Bridge

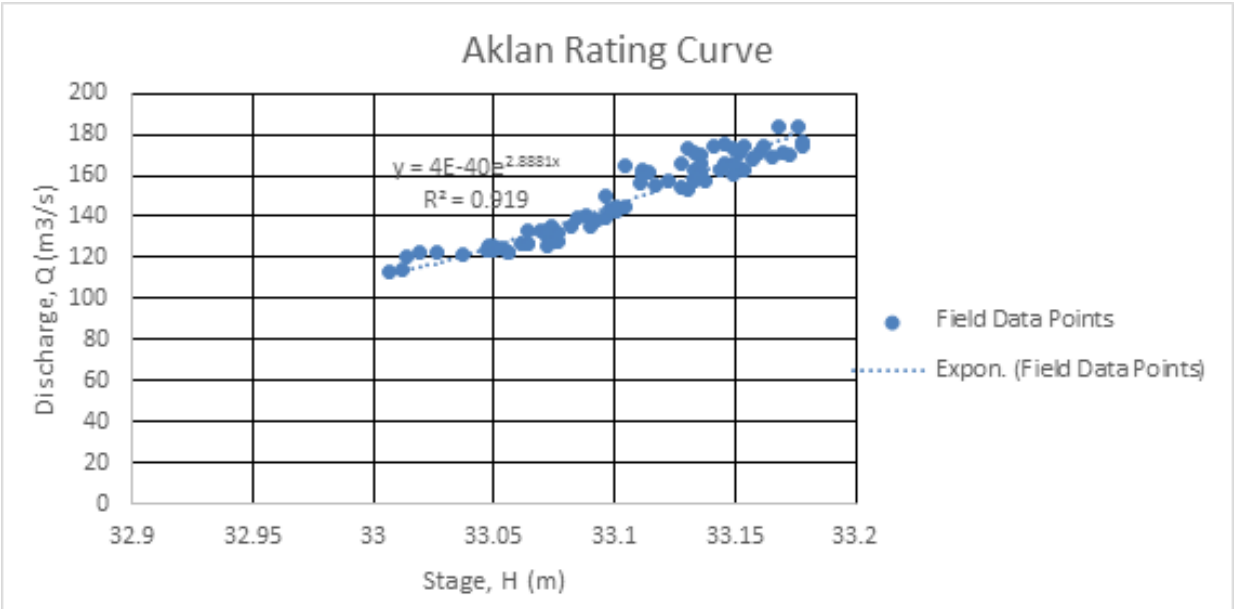


Figure 53. Rating Curve at Guadalupe-Madalag Bridge, Madalag, Aklan

This rating curve equation was used to compute the river outflow at Guadalupe Bridge for the calibration of the HEC-HMS model shown in Figure 54. The total rainfall for this event is 41.95mm and the peak discharge is 183.6m3/s at 4:30 PM, July 20, 2017.

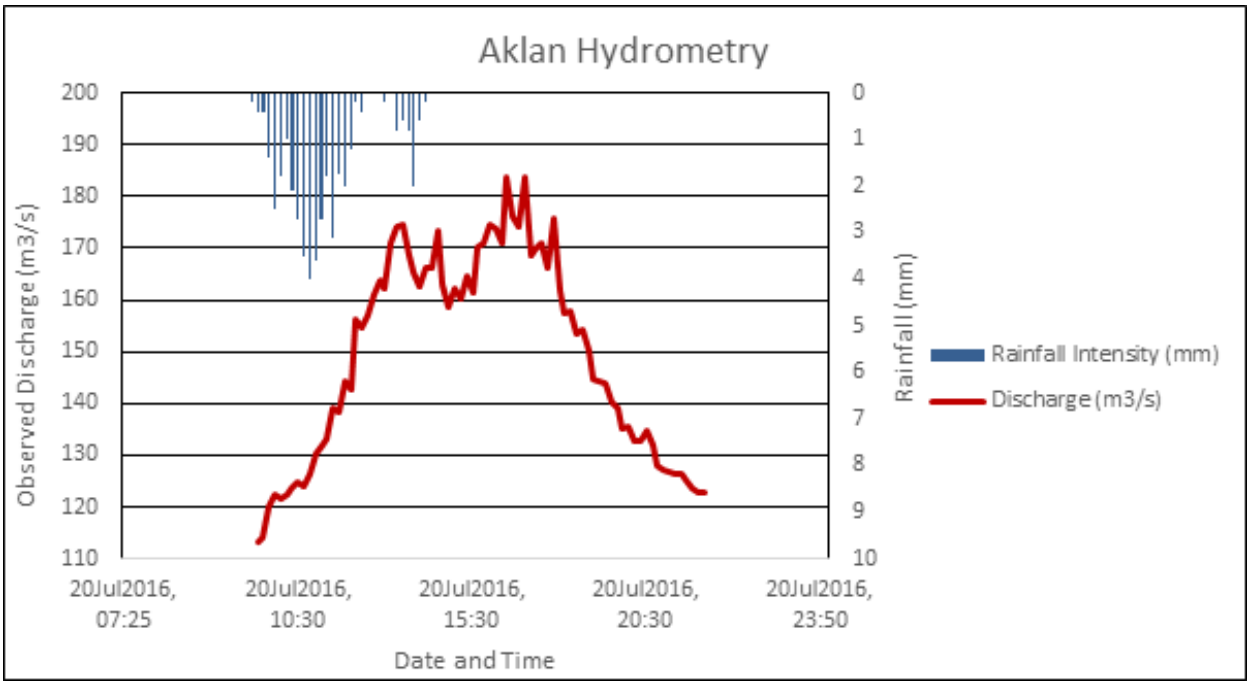


Figure 54. Rainfall and outflow data at Aklan used for modeling

5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Roxas 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 was chosen based on its proximity to the Aklan watershed. The extreme values for this watershed were computed based on a 59-year record.

Table 29. RIDF values for Roxas 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
5	26.6	40.5	51.3	72.1	98	115.5	142.8	165.9	186.2
10	31.3	47.8	60.7	86.2	118	139.4	172.3	200.1	224.6
25	37.4	57	72.5	104	143.1	169.6	209.7	243.4	273
50	41.8	63.8	81.3	117.2	161.8	192	237.4	275.4	308.9
100	46.2	70.5	90	130.2	180.3	214.2	264.9	307.2	344.6

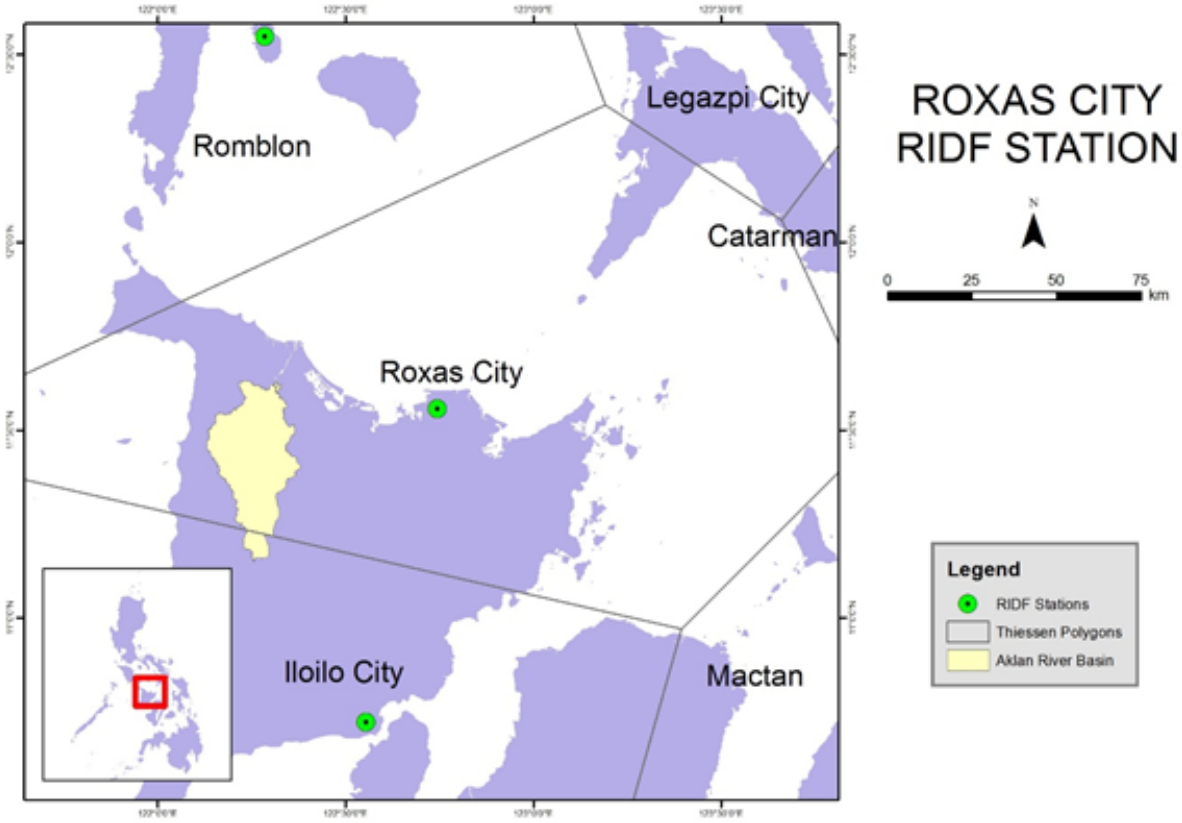


Figure 55. Location of Roxas RIDF station relative to Aklan River Basin

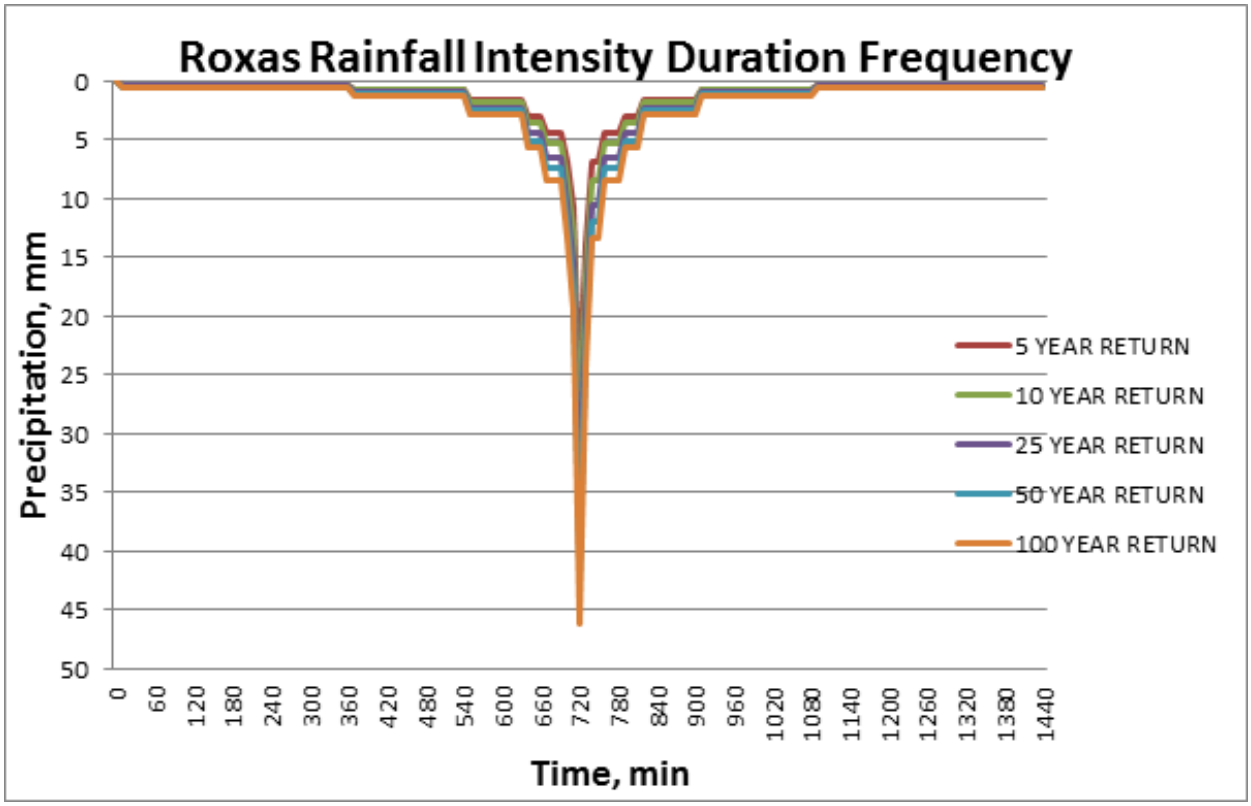


Figure 56. Synthetic storm generated for a 24-hr period rainfall for various return periods

5.3 HMS Model

The soil dataset was generated in 2004 by the Bureau of Soil and Water Management (BSWM); this is under the Department of Agriculture. The land cover dataset is from the National Mapping and Resource Information Authority (NAMRIA). The soil and land cover of the Aklan River Basin are shown in Figures 57 and 58, respectively.

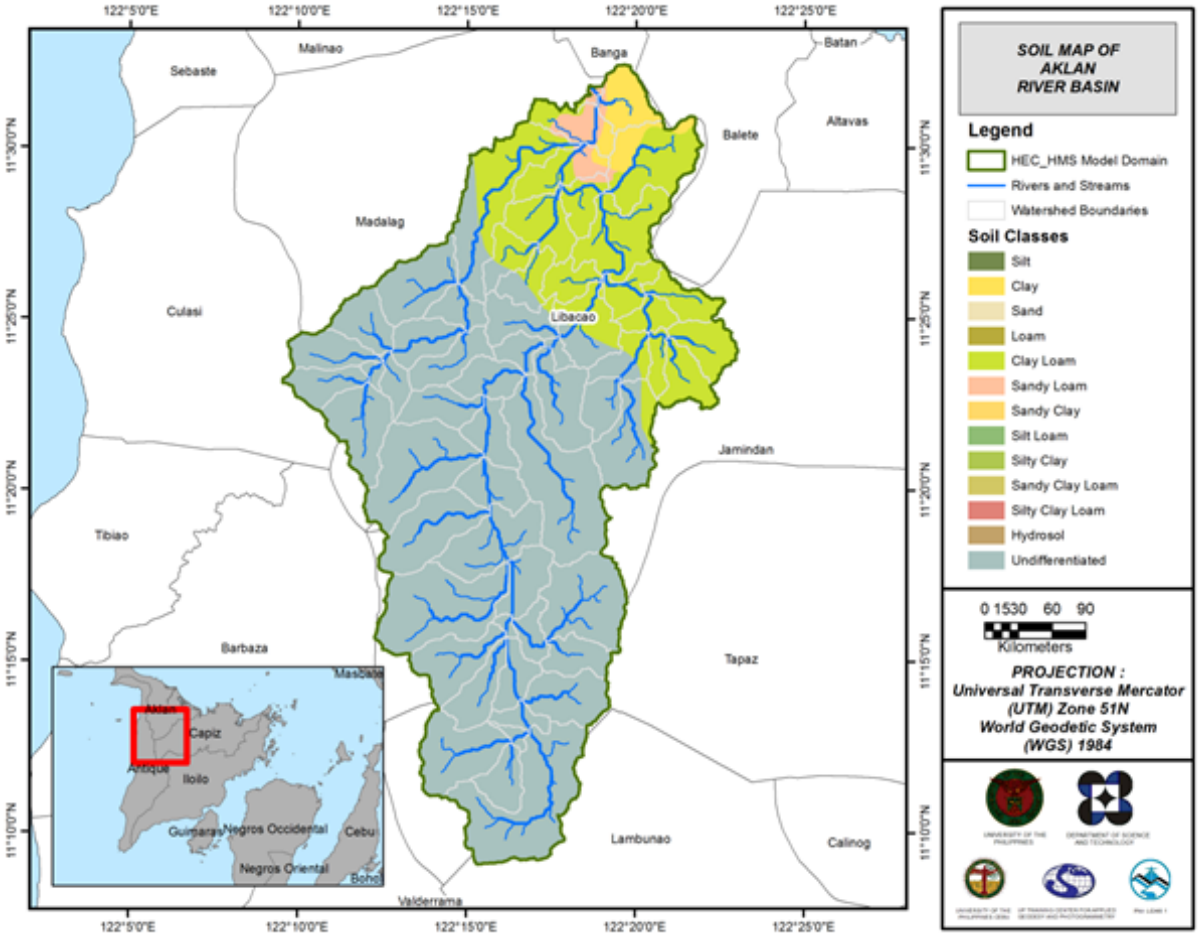


Figure 57. The soil map of the Aklan River Basin

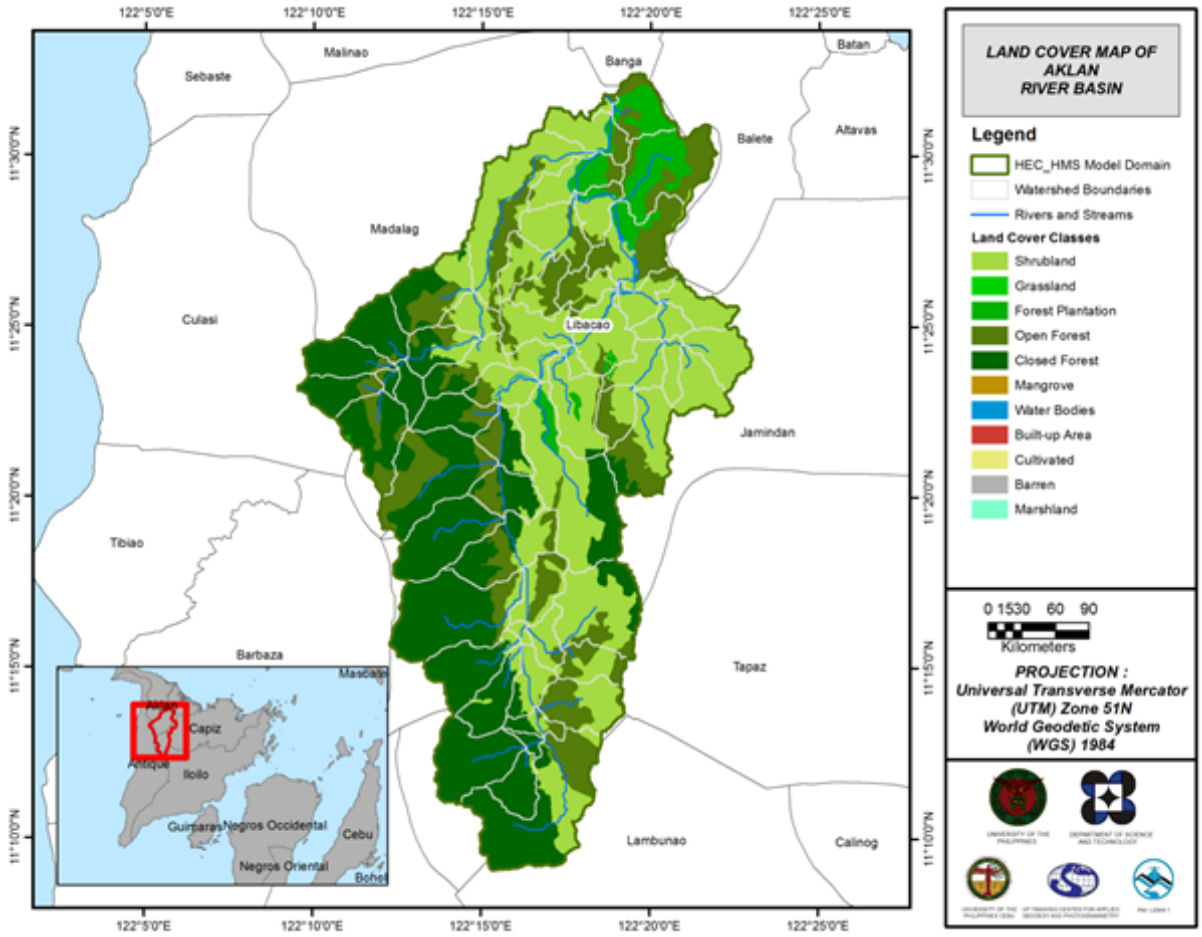


Figure 58. The land cover map of the Aklan River Basin

For Aklan, four (4) soil classes were identified. These are sandy loam, clay, clay loam, and undifferentiated soil. Moreover, four (4) land cover classes were identified. These are open and closed forest, shrubland, and forest plantation.

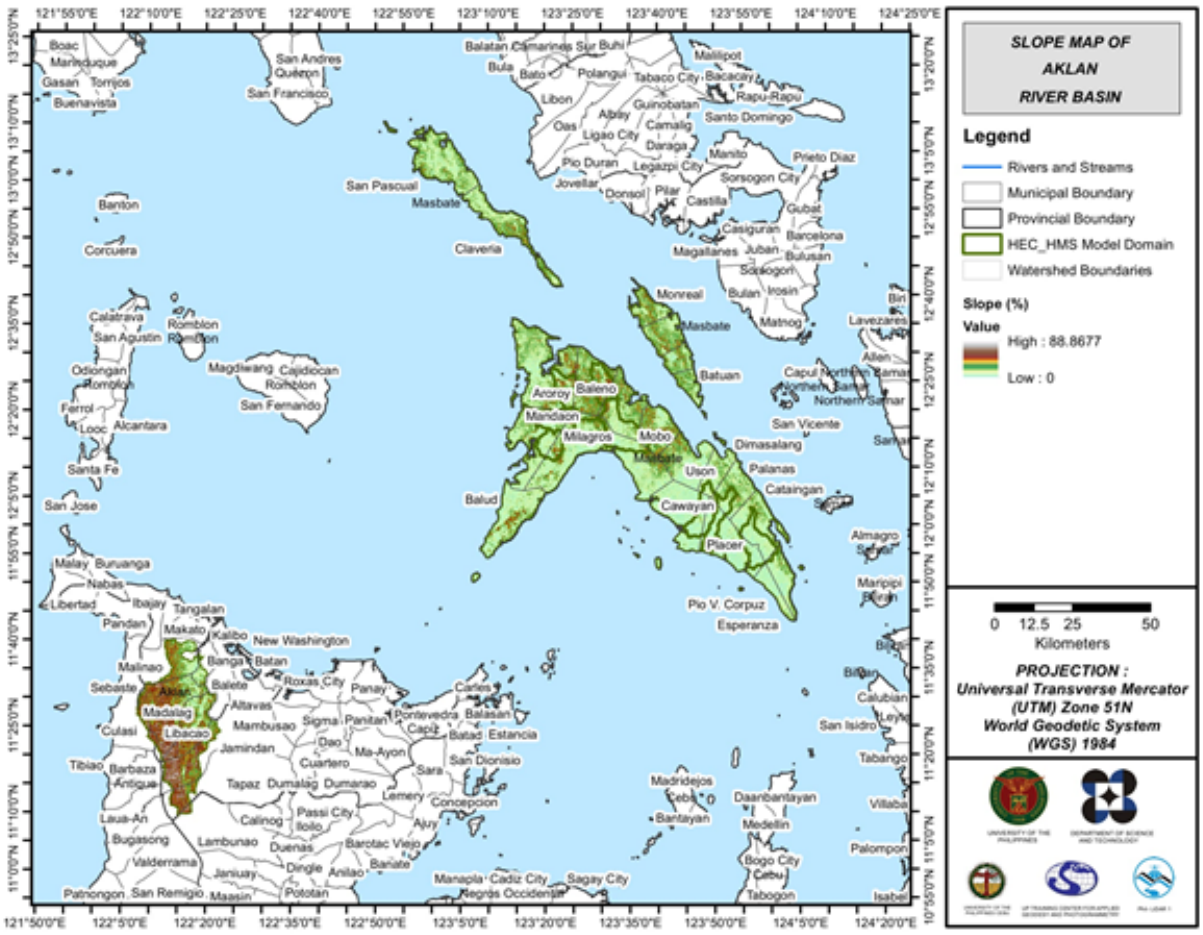


Figure 59. Slope map of Aklan River Basin

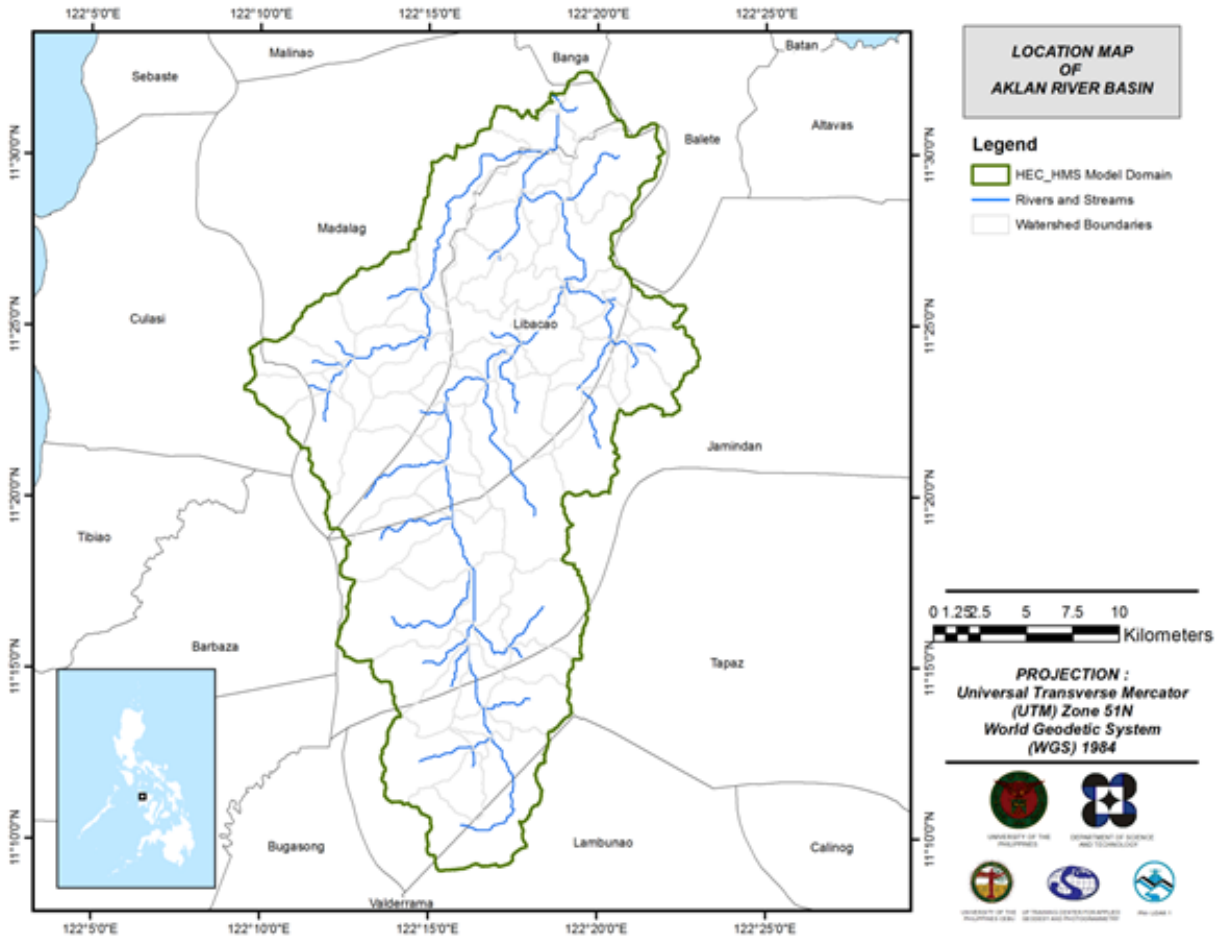


Figure 60. Stream delineation map of Aklan River Basin

Using the SAR-based DEM, the Aklan basin was delineated and further subdivided into subbasins. The model consists of 61 sub basins, 30 reaches, and 30 as shown in Figure 60. The main outlet is at Guadalupe Bridge.

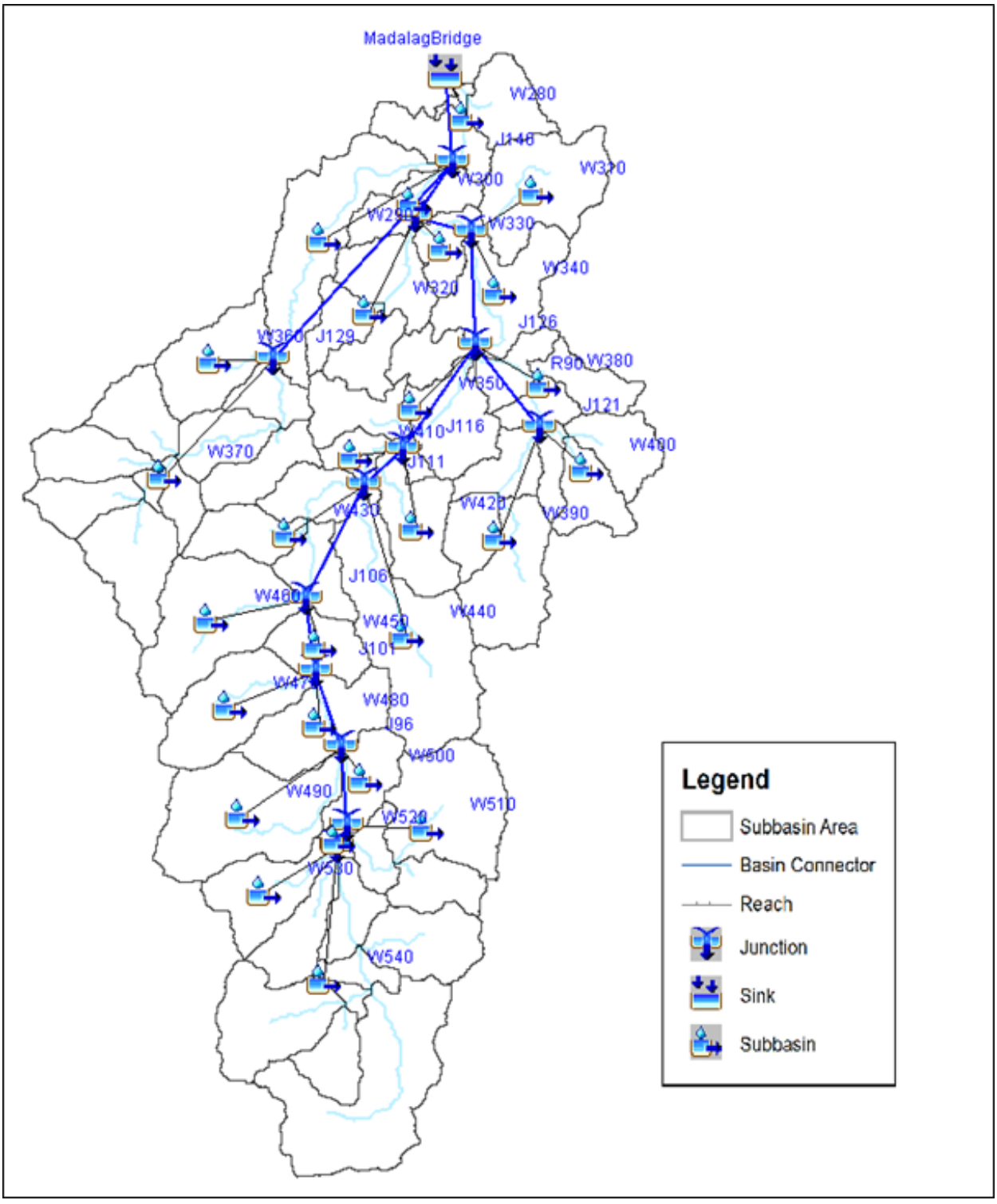


Figure 61. The Aklan Hydrologic Model generated in HEC-GeoHMS

5.4 Cross-section Data

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

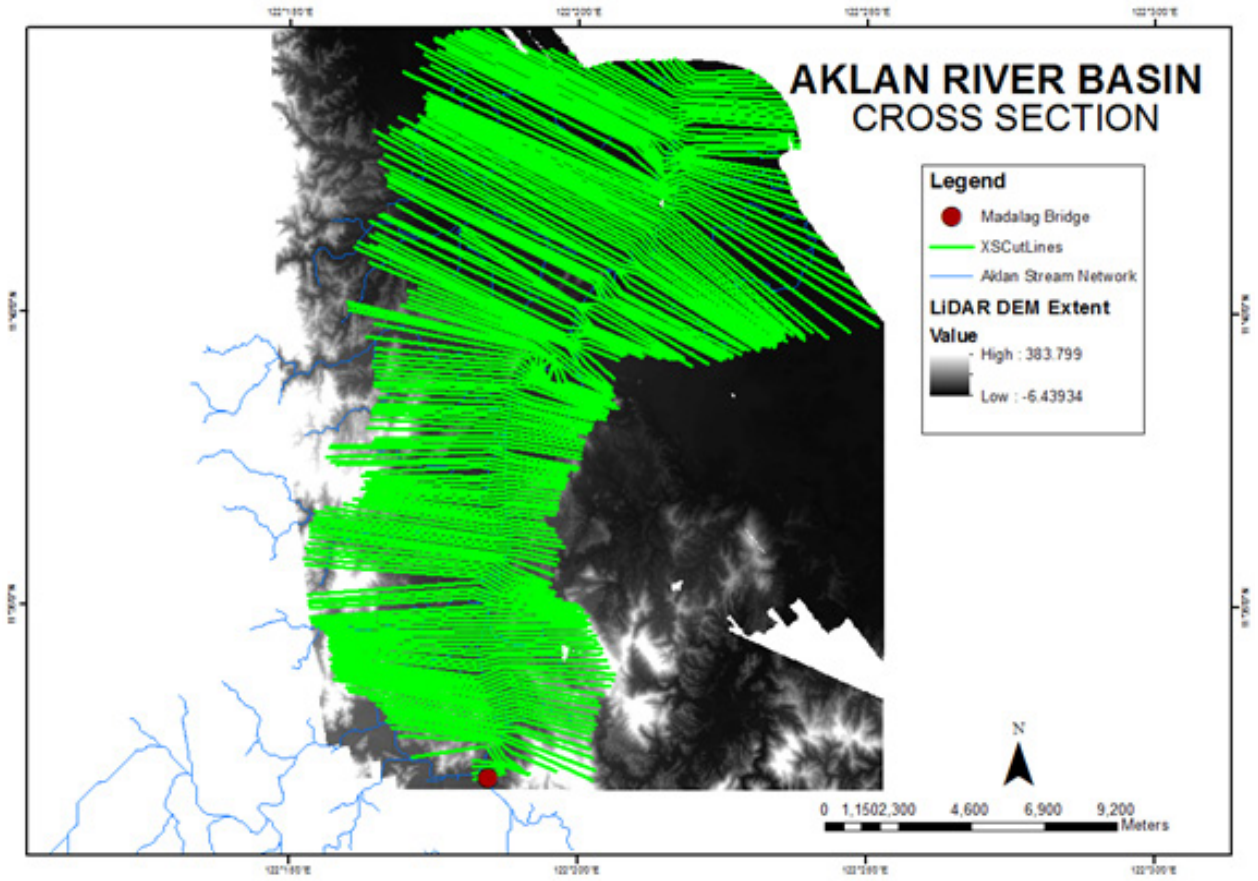


Figure 62. River cross-section of Aklan River generated through Arcmap HEC GeoRAS tool

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

Figure 63. Screenshot of subcatchment with the computational area to be modeled in FLO-2D Grid Developer System Pro (FLO-2D GDS Pro)

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 160.85840 hours. After the simulation, FLO-2D Mapper Pro is used to transform the simulation results into spatial data that shows flood hazard levels, as well as the extent and inundation of the flood. Assigning the appropriate flood depth and velocity values for Low, Medium, and High creates the following food hazard map. Most of the default values given by FLO-2D Mapper Pro are used, except for those in the Low hazard level. For this particular level, the minimum h (Maximum depth) is set at 0.2 m while the minimum vh (Product of maximum velocity (v) times maximum depth (h)) is set at 0 m2/s.

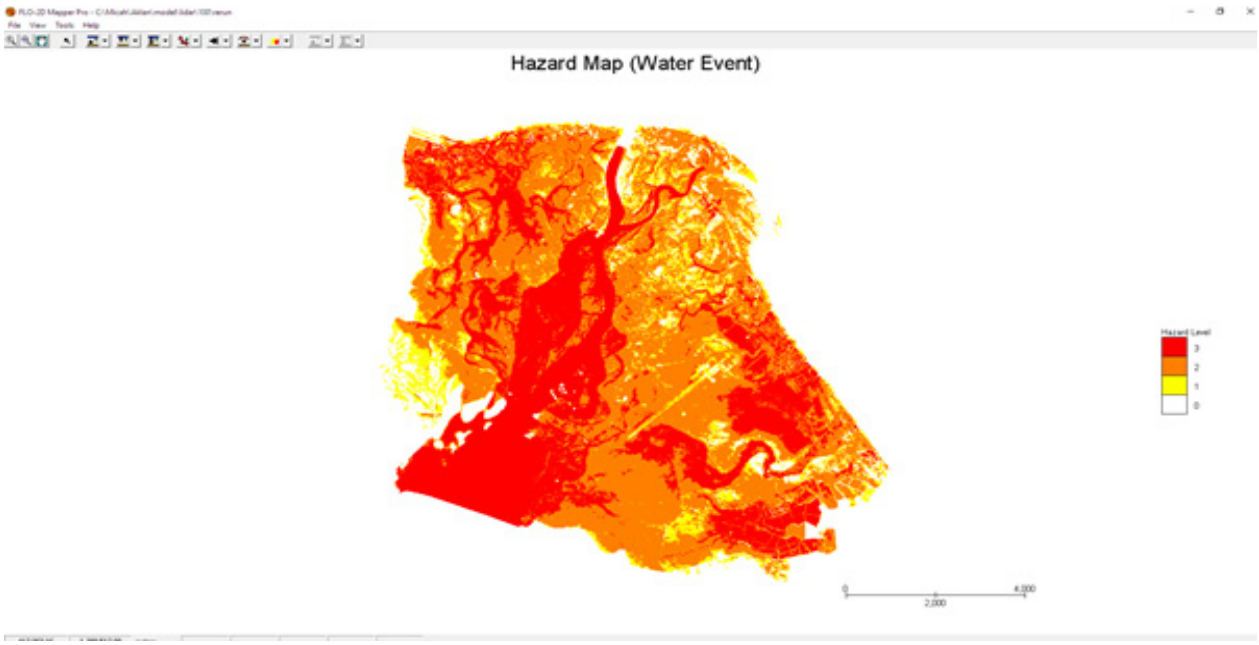


Figure 64. Generated 100-year rain return hazard map from FLO-2D Mapper

The creation of a flood hazard map from the model also automatically creates a flow depth map depicting the maximum amount of inundation for every grid element. The legend used by default in Flo-2D Mapper is not a good representation of the range of flood inundation values, so a different legend is used for the layout. In this particular model, the inundated parts cover a maximum land area of 87 293 400.00 m2.

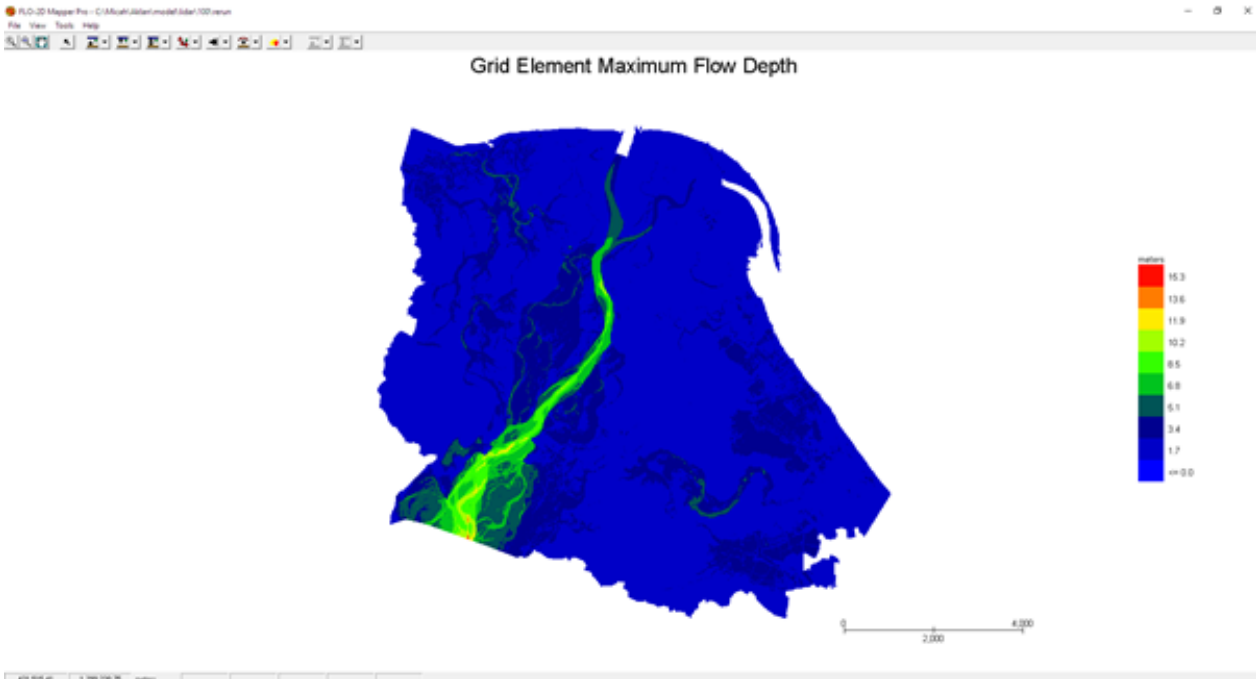


Figure 65. Generated 100-year rain return flow depth map from FLO-2D Mapper

There is a total of 272 752 612.97 m3 of water entering the model. Of this amount, 32 327 358.90 m3 is due to rainfall while 240 425 254.07 m3 is inflow from other areas outside the model. 23 027 724.00 m3 of this water is lost to infiltration and interception, while 74 953 956.17 m3 is stored by the flood plain. The rest, amounting up to 174 770 933.71 m3, is outflow.

5.6 Results of HMS Calibration

After calibrating the Aklan HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 66 shows the comparison between the two discharge data.

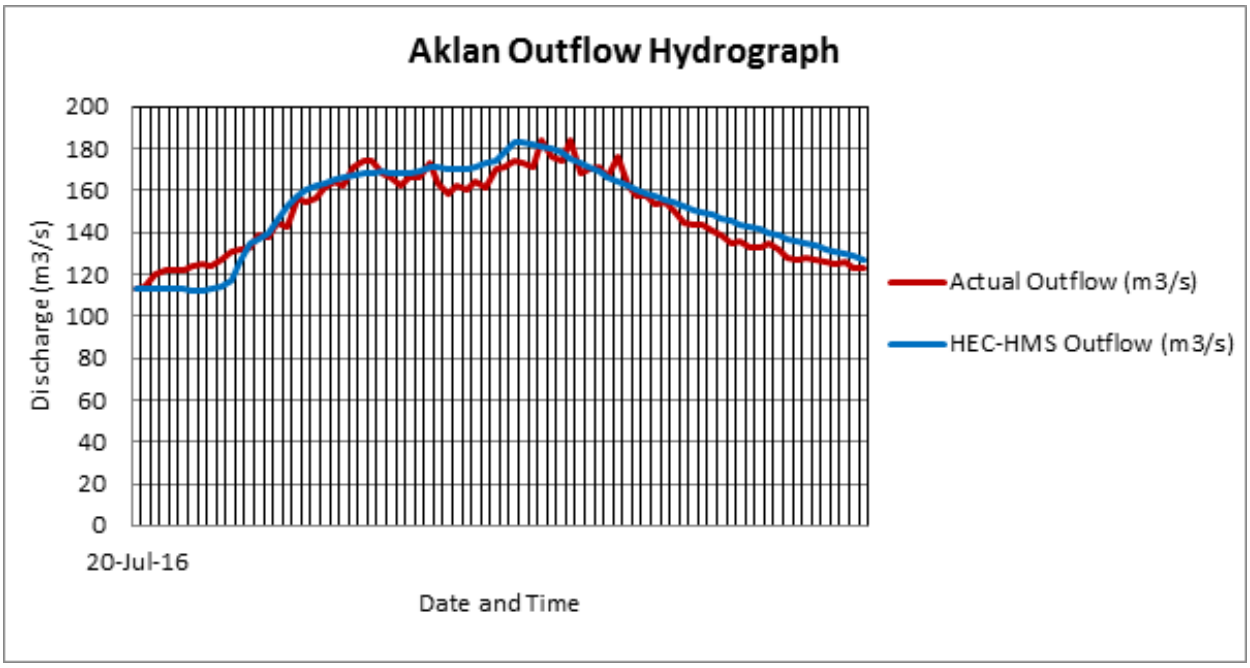


Figure 66. Outflow Hydrograph of Aklan produced by the HEC-HMS model compared with observed outflow

Enumerated in Table 30 are the adjusted ranges of values of the parameters used in calibrating the model.

Table 30. Range of Calibrated Values for Aklan

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	3-14
			Curve Number	50-85
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.06-0.39
			Storage Coefficient (hr)	1.09-6.24
	Baseflow	Recession	Recession Constant	0.09
			Ratio to Peak	0.5
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 3 mm to 14 mm means that there is minimal to average amount of infiltration or rainfall interception by vegetation.

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range of 50-85 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area (M. Horritt, personal communication, 2012). For Aklan, the basin mostly consists of grasslands, closed and open areas, and the soil consists of clay, clay loam, sandy loam, and undifferentiated lands.

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 0.06 hours to 6.24 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 0.09 indicates that the basin is unlikely to quickly go back to its original discharge and instead, will be higher. Ratio to peak of 0.5 indicates a gradual receding limb of the outflow hydrograph.

Manning's roughness coefficient of 0.04 corresponds to the common roughness of Philippine watersheds. Aklan river basin is determined to be cultivated with mature field crops (Brunner, 2010).

Table 31. Summary of the Efficiency Test of Aklan HMS Model

Accuracy Measure	Value
RMS Error	6.8229
r2	0.9544
NSE	0.8799
RSR	0.3466
PBIAS	-1.4088

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 6.82 (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 0.9543.

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 0.88.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -1.4088.

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 0.3465.

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 13) shows the Aklan outflow using the Iloilo Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAG-ASA) data. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods. from 186.2m3 in a 5-year return period to 344.6m3 for a 100-year return period.

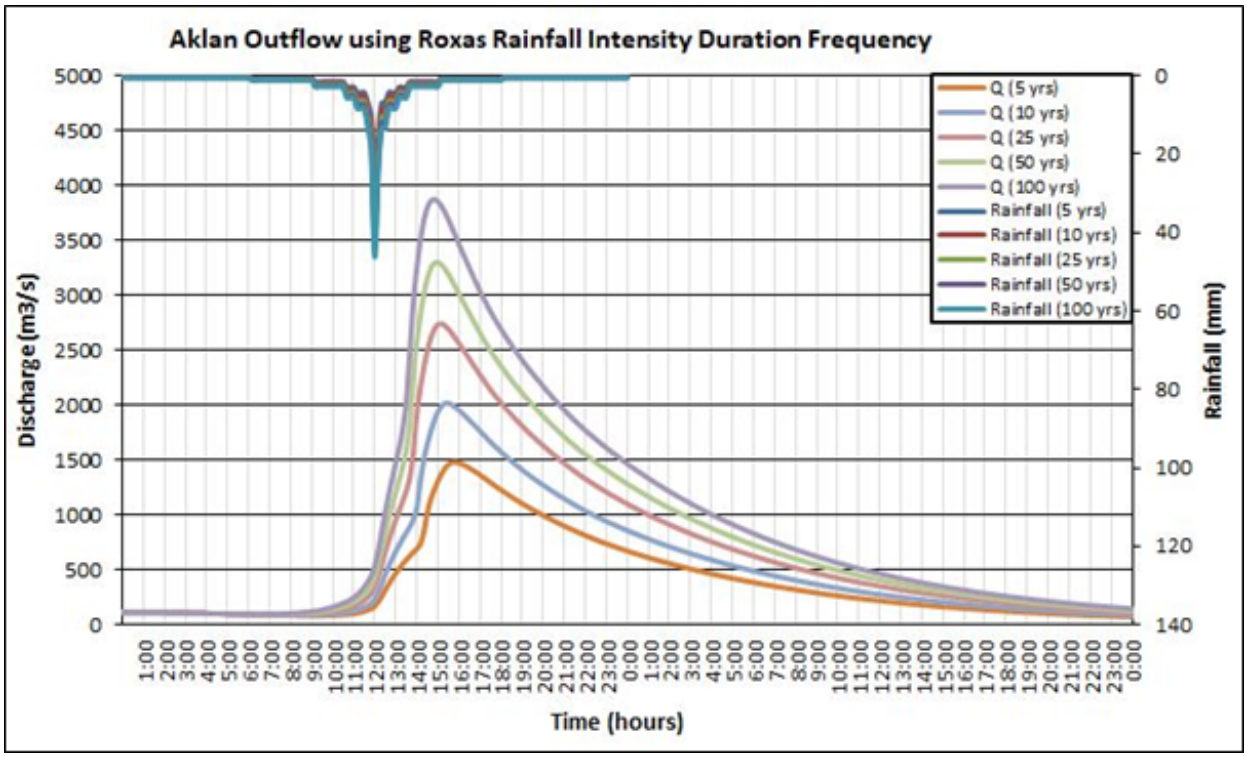


Figure 67. Outflow hydrograph at Aklan Station generated using Iloilo RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Aklan discharge using the Iloilo Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 32.

Table 32. Peak values of the Aklan HEC-HMS Model outflow using the Iloilo RIDF

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m 3/s)	Time to Peak
5-Year	186.2	26.6	1480.2	3 hours, 50 minutes
10-Year	224.6	31.3	2016.9	3 hours, 30 minutes
25-Year	273	37.4	2741.1	3 hours, 10 minutes
50-Year	308.9	41.8	3298.4	3 hours
100-Year	344.6	46.2	3872.9	2 hours, 50 minutes

5.7.2 Discharge data using Dr. Horritts's recommended hydrologic method

The river discharges entering the floodplain are shown in Figure 67 to . and the peak values are summarized in Table 33.

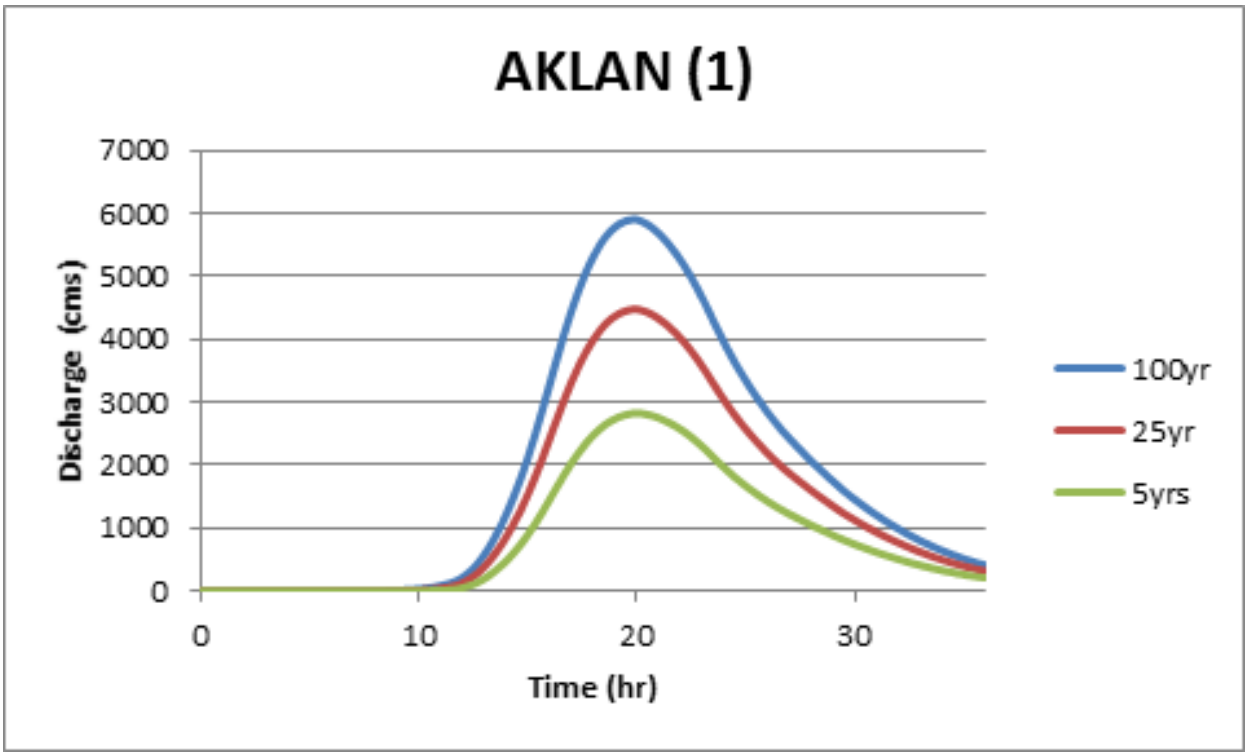


Figure 68. Aklan river (1) generated discharge using 5-, 25-, and 100-year Roxas rainfall intensity-duration-frequency (RIDF) in HEC-HMS

Table 33. Summary of Aklan river (1) discharge generated in HEC-HMS

RIDF Period	Peak discharge (cms)	Time-to-peak
100-Year	5902.6	19 hours, 50 minutes
25-Year	4476.4	20 hours
5-Year	2826.8	20 hours

Table 34. Validation of river discharge estimates

Discharge Point	QMED(SCS), cms	QBANKFUL, cms	QMED(SPEC), cms	VALIDATION	
				Bankful Discharge	Specific Discharge
Aklan (1)	2487.584	1958.430	815.610	Pass	Fail

The HEC-HMS river discharge estimates were able to satisfy the conditions for validation using the bankful method but did not satisfy the conditions for validation using specific discharge methods and will need further recalculation. The passing values are based on theory but are supported using other discharge computation methods so they were good to use for flood modeling. These values will need further investigation for the purpose of validation. It is therefore recommended to obtain actual values of the river discharges for higher-accuracy modeling.

5.8 River Analysis Model Simulation

The HEC-RAS Flood Model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. The sample generated map of Aklan River using the calibrated HMS event flow is shown in Figure 68.

Figure 69. Sample output of Aklan RAS Model

5.9 Flood Hazard and Flow Depth Map

The resulting hazard and flow depth maps have a 10m resolution. Figure 69 to Figure 74 show the 5-, 25-, and 100-year rain return scenarios of the Aklan floodplain. The floodplain, with an area of 86.92 sq.km., covers six municipalities namely, Banga, Kalibo, Lezo, Makato, New Washington, and Numancia.

Table 35. Municipalities affected in the Aklan Floodplain

City / Municipality	Total Area	Area Flooded	% Flooded
Banga	64.47	2.28	3.53
Kalibo	40.15	33.73	84.01
Lezo	19.81	9.72	49.03
Makato	60.25	0.051	0.085
New Washington	55.12	14.7	26.67
Numancia	24.15	19.64	81.34

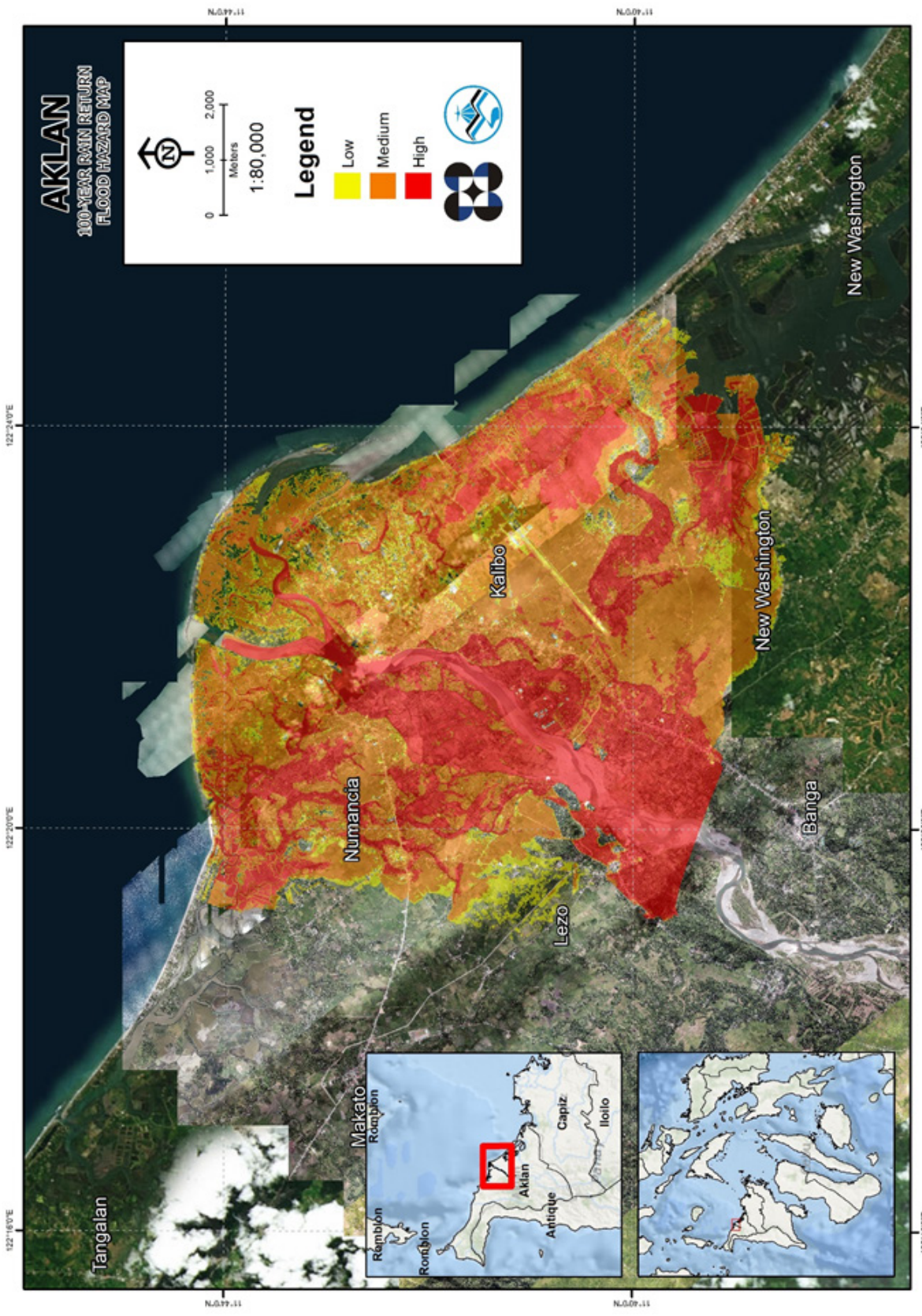


Figure 70. 100-year Flood Hazard Map for Aklan Floodplain overlaid on Google Earth imagery

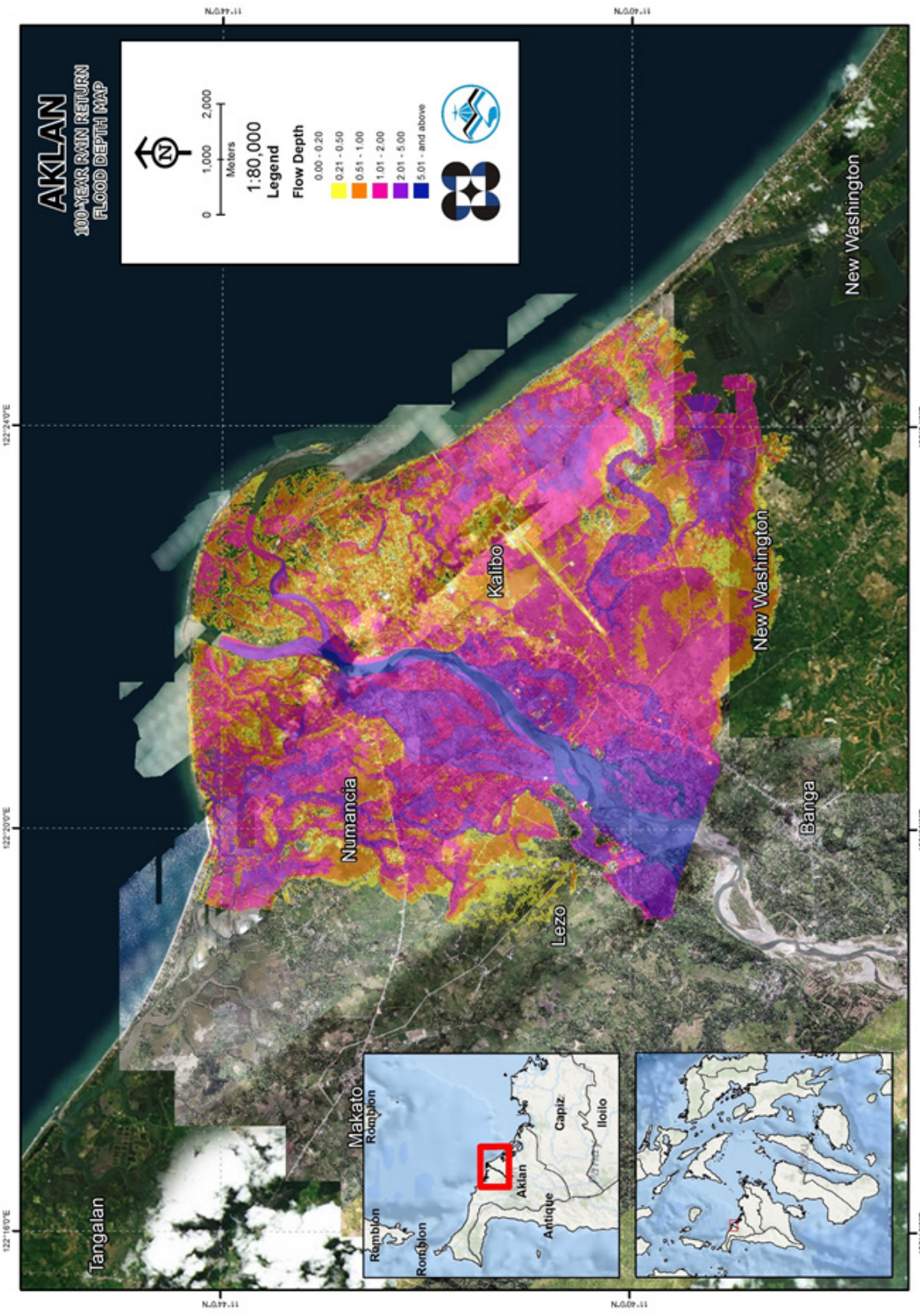


Figure 71. 100-year Flow Depth Map for Aklan Floodplain overlaid on Google Earth imagery

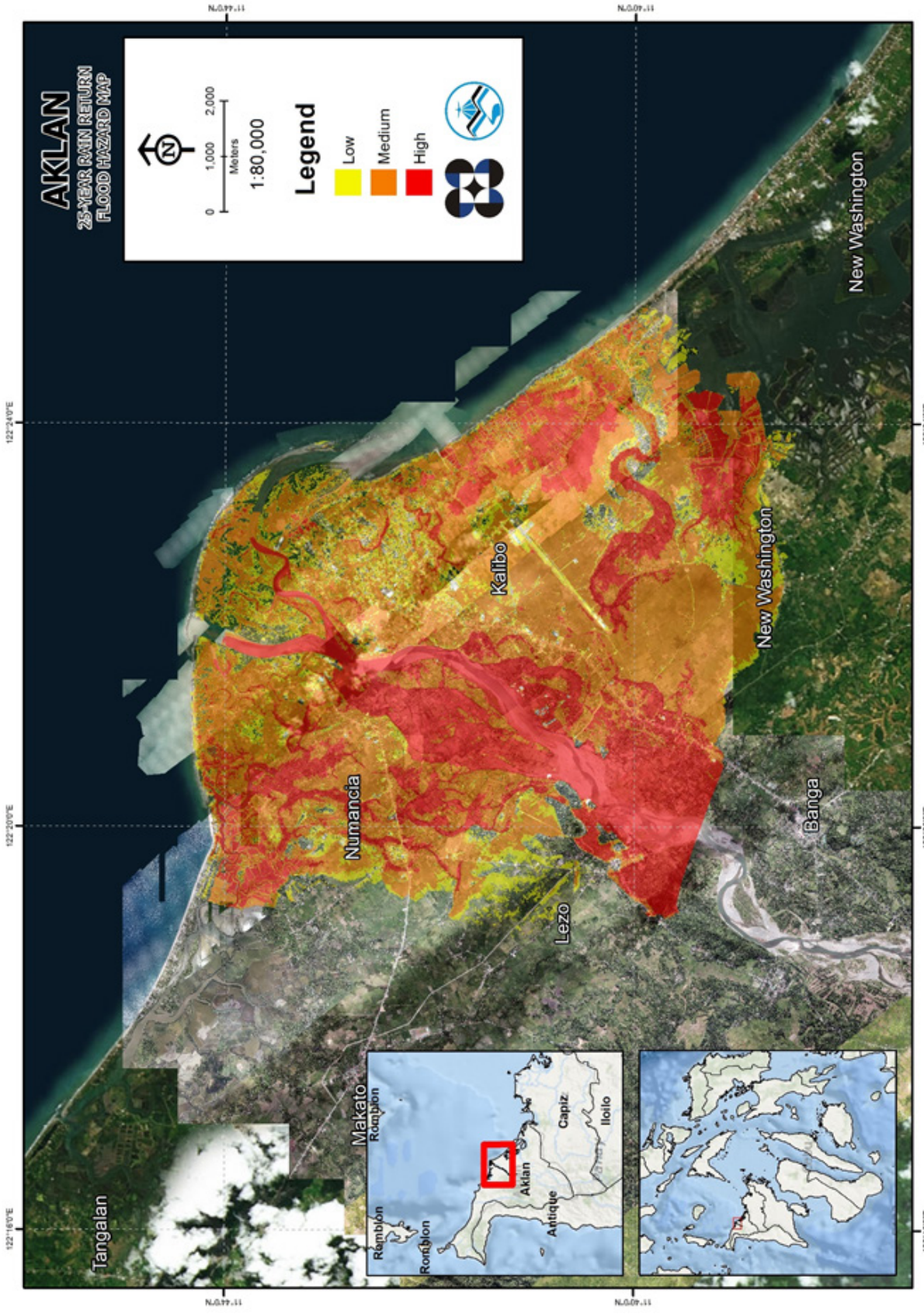


Figure 72. 25-year Flood Hazard Map for Aklan Floodplain overlaid on Google Earth imagery

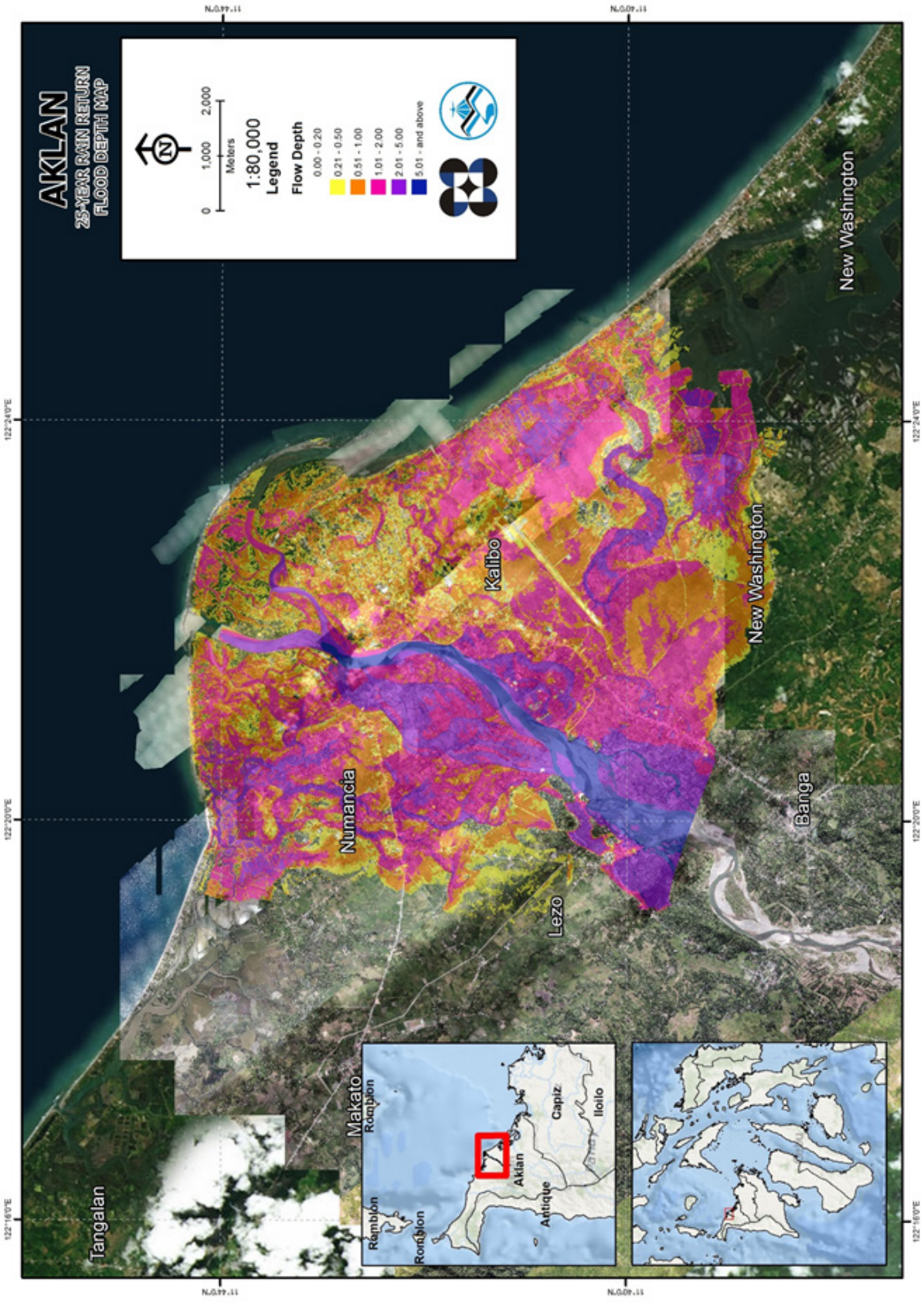


Figure 73. 25-year Flow Depth Map for Aklan Floodplain overlaid on Google Earth imagery

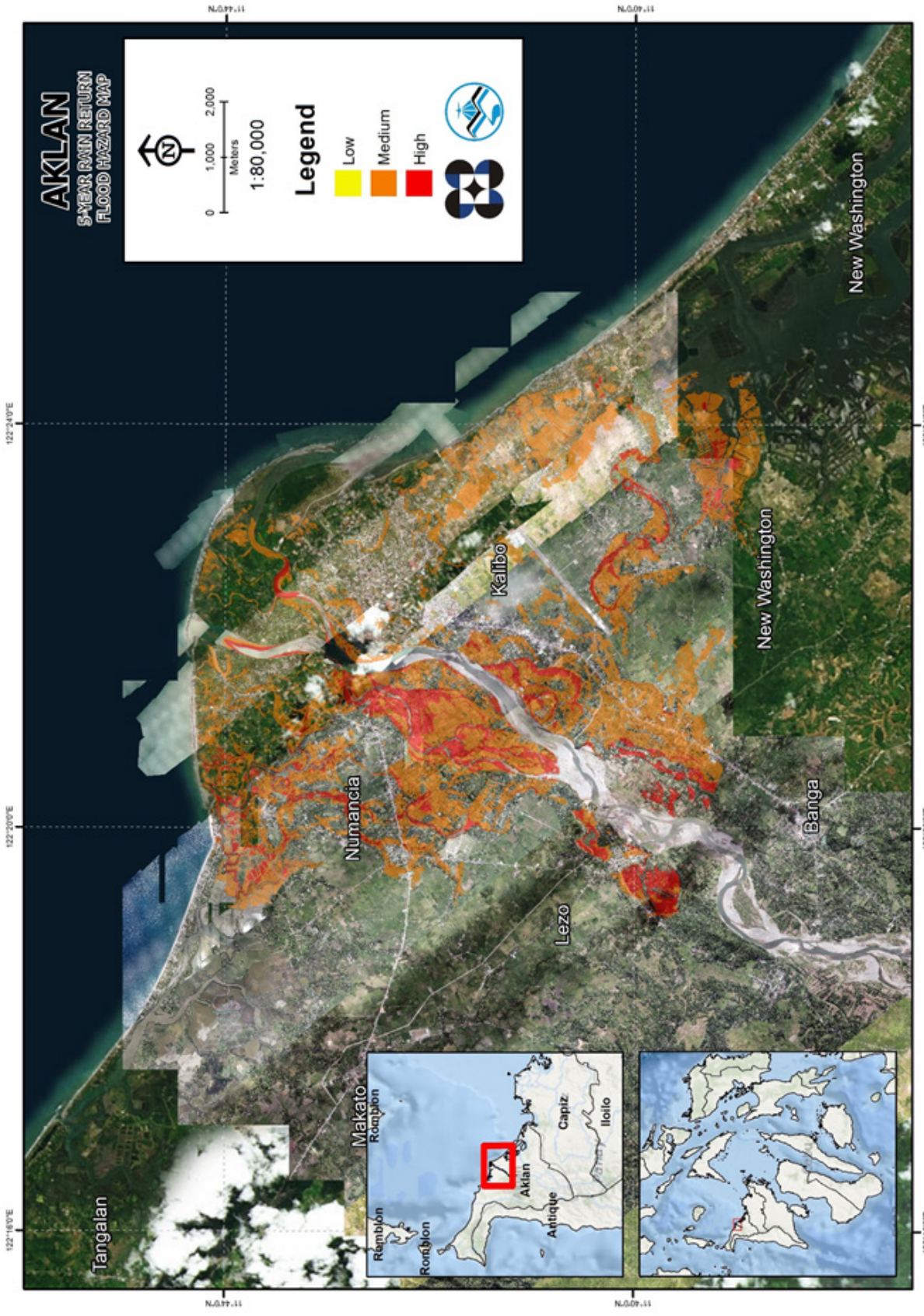


Figure 74. 5-year Flood Hazard Map for Aklan Floodplain overlaid on Google Earth imagery

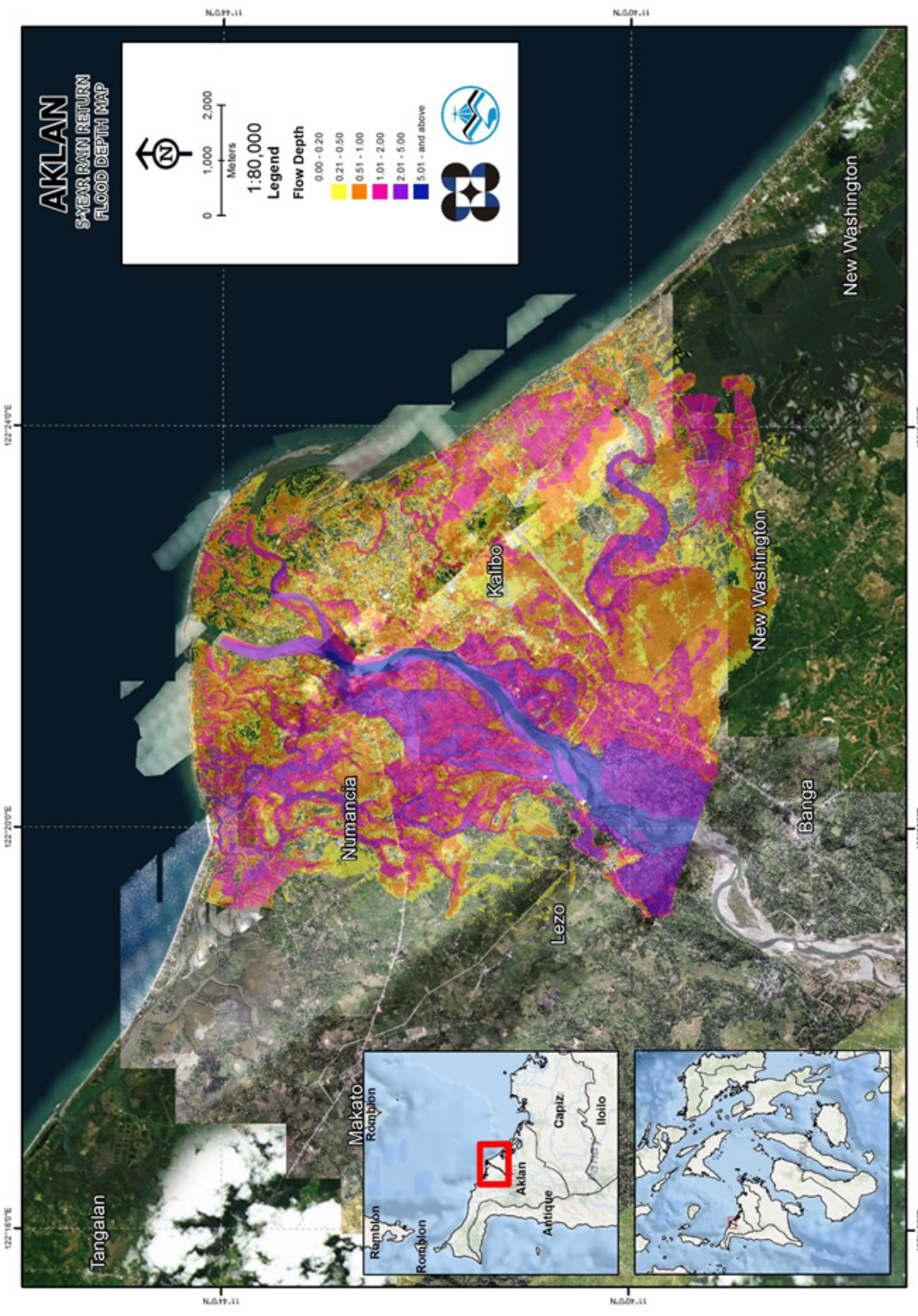


Figure 75. 5-year Flood Depth Map for Aklan Floodplain overlaid on Google Earth imagery

5.10 Inventory of Areas Exposed to Flooding

Affected barangays in the Aklan river basin, grouped by municipality, are listed below. For the said basin, six municipalities consisting of 53 barangays are expected to experience flooding when subjected to 5-yr rainfall return period.

For the 5-year return period, 0.017% of the municipality of Banga with an area of 64.47 sq. km. will experience flood levels of less 0.1 meters. 0.1% of the area will experience flood levels of 0.21 to 0.50 meters while 0.7%, 1.19%, 1.32%, and 0.21% 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 36 are the affected areas in square kilometres by flood depth per barangay.

Table 36. Affected Areas in Banga, Aklan during 5-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Banga (in sq. km.)		
	Jumarap	Linabuan Sur	Palale
0.03-0.20	0.000054	0.011	0
0.21-0.50	0.00066	0.062	0
0.51-1.00	0.006	0.44	0
1.01-2.00	0.024	0.75	0
2.01-5.00	0.35	0.49	0.0061
> 5.00	0.041	0.0061	0.088

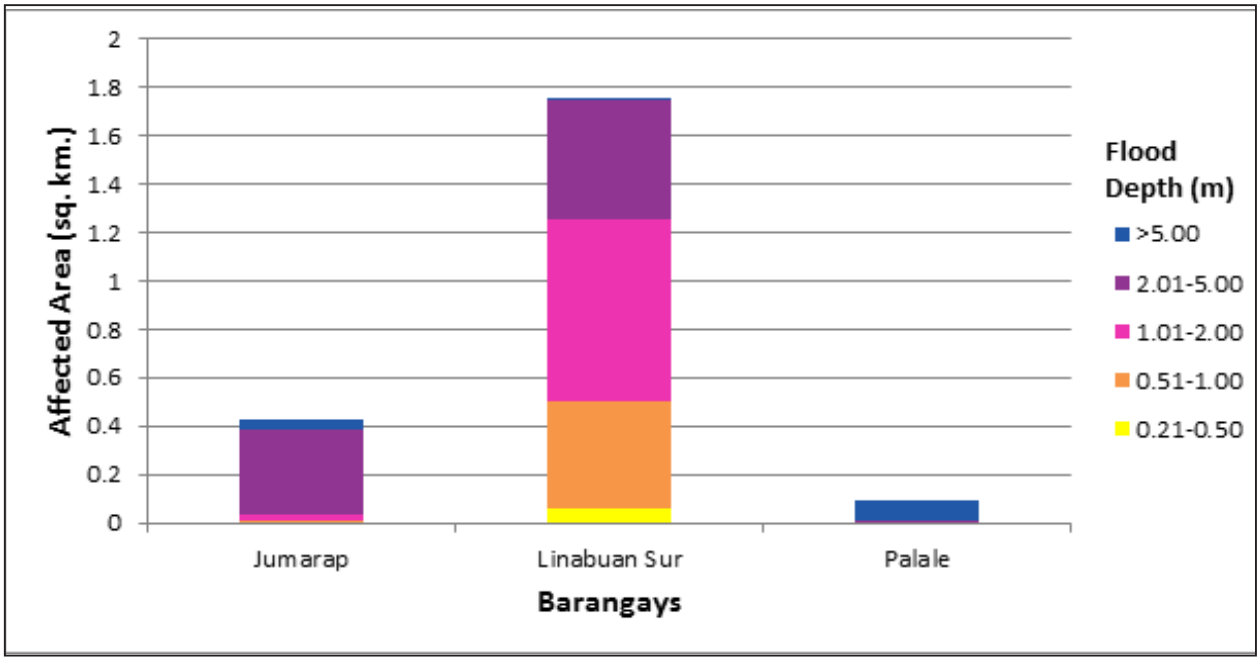


Figure 76. Affected Areas in Banga, Aklan during 5-Year Rainfall Return Period

For the municipality of Kalibo, with an area of 40.15 sq. km., 12.84% will experience flood levels of less 0.20 meters. 17.02% of the area will experience flood levels of 0.21 to 0.50 meters while 25.14%, 21%, 5.2%, and 2.79% 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 37 are the affected areas in square kilometres by flood depth per barangay.

Table 37. Affected Areas in Kalibo, Aklan during 5-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Kalibo (in sq. km.)							
	Andagaw	Bachaw Norte	Bachaw Sur	Briones	Buswang New	Buswang Old	Caano	Estancia
0.03-0.20	0.8	0.4	0.25	0.26	0.49	0.46	0.23	0.3
0.21-0.50	0.95	0.38	0.32	0.19	0.58	0.34	0.28	0.9
0.51-1.00	0.6	0.44	0.44	0.29	0.4	0.36	0.72	1.39
1.01-2.00	0.19	0.2	0.3	0.17	0.065	0.14	0.32	0.4
2.01-5.00	0.0053	0.0045	0.13	0.018	0.0001	0.0022	0.0034	0.0067
> 5.00	0	0	0	0	0	0	0	0.00032

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Kalibo (in sq. km.)							
	Linabuan Norte	Mabilo	Mobo	Nalook	Poblacion	Pook	Tigayon	Tinigaw
0.03-0.20	0.025	0.33	0.013	0.6	0.1	0.72	0.15	0.018
0.21-0.50	0.021	0.24	0.024	1.07	0.19	1	0.29	0.052
0.51-1.00	0.42	0.53	0.34	0.76	0.38	1.44	1.43	0.16
1.01-2.00	1.02	1.1	1.08	0.21	0.14	0.99	1.68	0.44
2.01-5.00	0.35	0.012	0.68	0.092	0.00064	0.0063	0.6	0.16
> 5.00	0.029	0	0.56	0	0	0	0.41	0.12

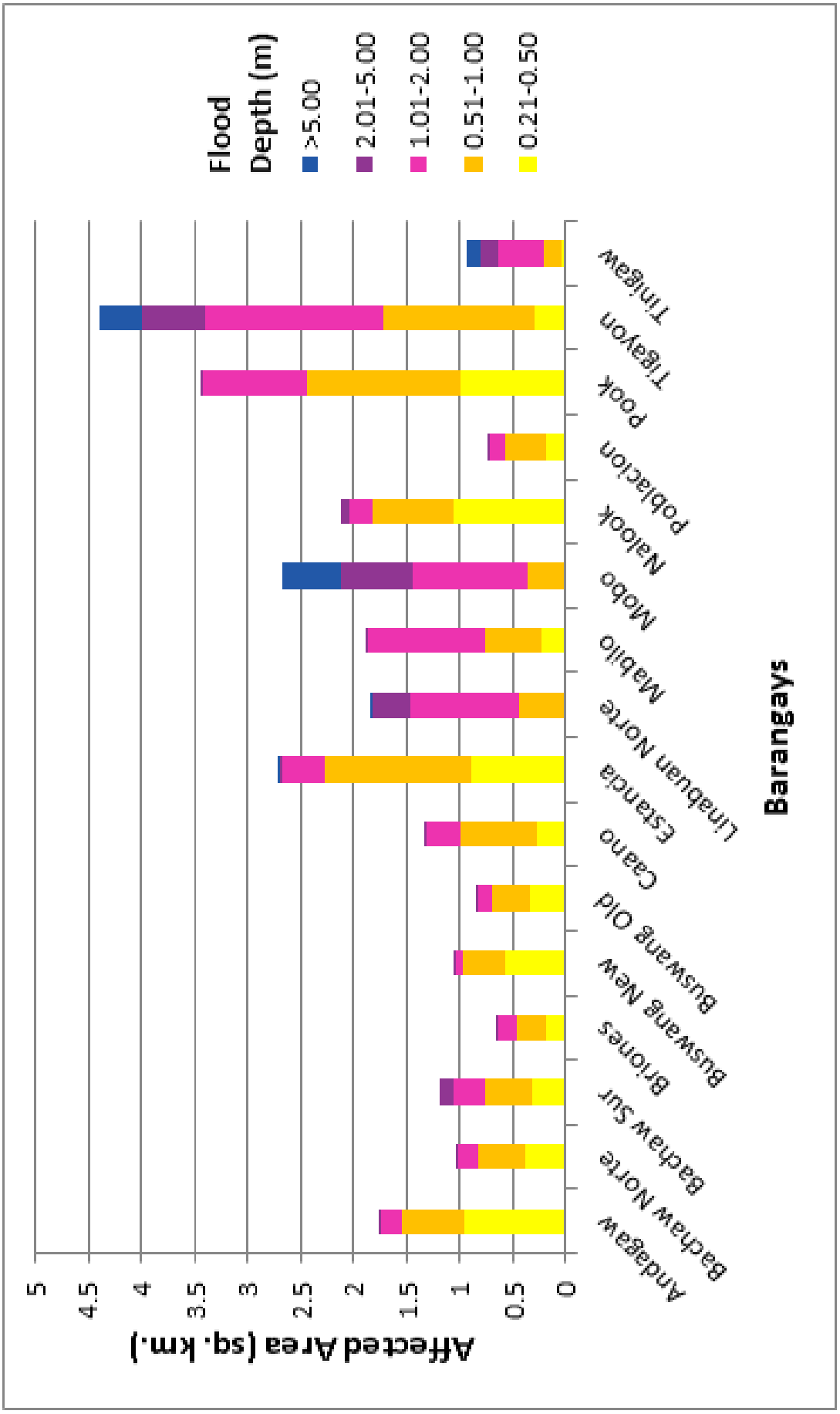


Figure 77. Affected Areas in Kalibo, Aklan during 5-Year Rainfall Return Period

For the municipality of Lezo, with an area of 19.81 sq. km., 13.52% will experience flood levels of less 0.20 meters. 11.41% of the area will experience flood levels of 0.21 to 0.50 meters while 5.15%, 3.9%, 9.83%, and 5.2% 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 Lezo, Aklan during 5-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Lezo (in sq. km.)								
	Bagto	Bugasongan	Carugdog	Cogon	Ibao	Mina	Poblacion	Santa Cruz	Santa Cruz Bigaa
0.03-0.20	0.59	0.46	0	0.49	0.15	0.44	0.33	0.15	0.064
0.21-0.50	0.16	0.36	1.17	0.18	0.27	0.038	0.055	0.015	0.0079
0.51-1.00	0.11	0.22	0.19	0.092	0.21	0.06	0.084	0.031	0.023
1.01-2.00	0.0083	0.088	0.0092	0.032	0.27	0.13	0.096	0.081	0.062
2.01-5.00	0.021	0.041	0	0.0003	0.058	0.84	0.19	0.53	0.26
> 5.00	0	0	0	0	0	0.63	0.35	0.048	0.0027

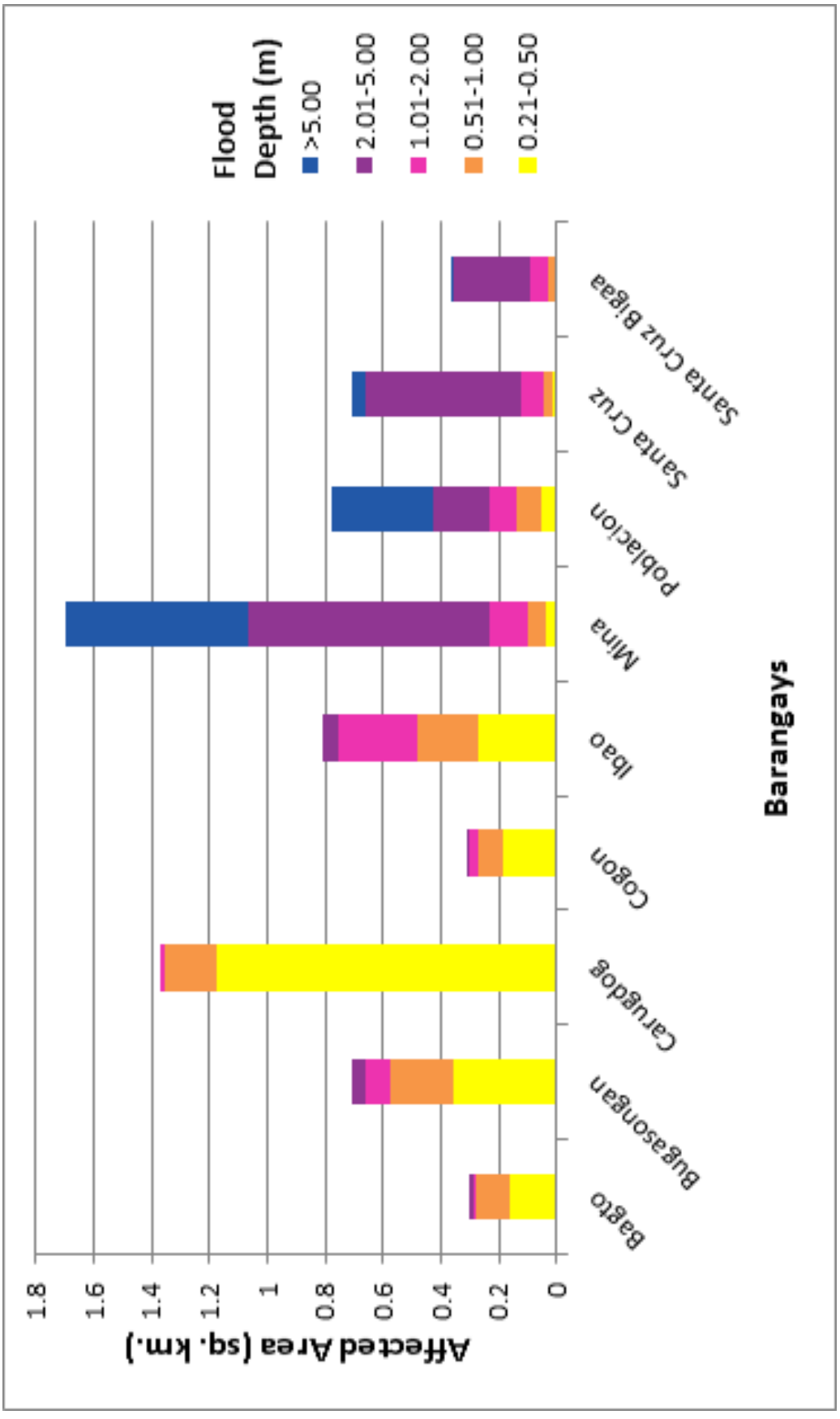


Figure 78. Affected Areas in Lezo, Aklan during 5-Year Rainfall Return Period

For the municipality of Makato, with an area of 60.25 sq. km., 03% will experience flood levels of less 0.20 meters. 0.018% of the area will experience flood levels of 0.21 to 0.50 meters while 0.008% of the area will experience flood depths of 0.51 to 1 meter. Listed in Table 39 are the affected areas in square kilometres by flood depth per barangay.

Table 39. Affected Areas in Makato, Aklan during 5-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Makato (in sq. km.)
	Alibagon
0.03-0.20	0.018
0.21-0.50	0.011
0.51-1.00	0.018
1.01-2.00	0.0049
2.01-5.00	0
> 5.00	0

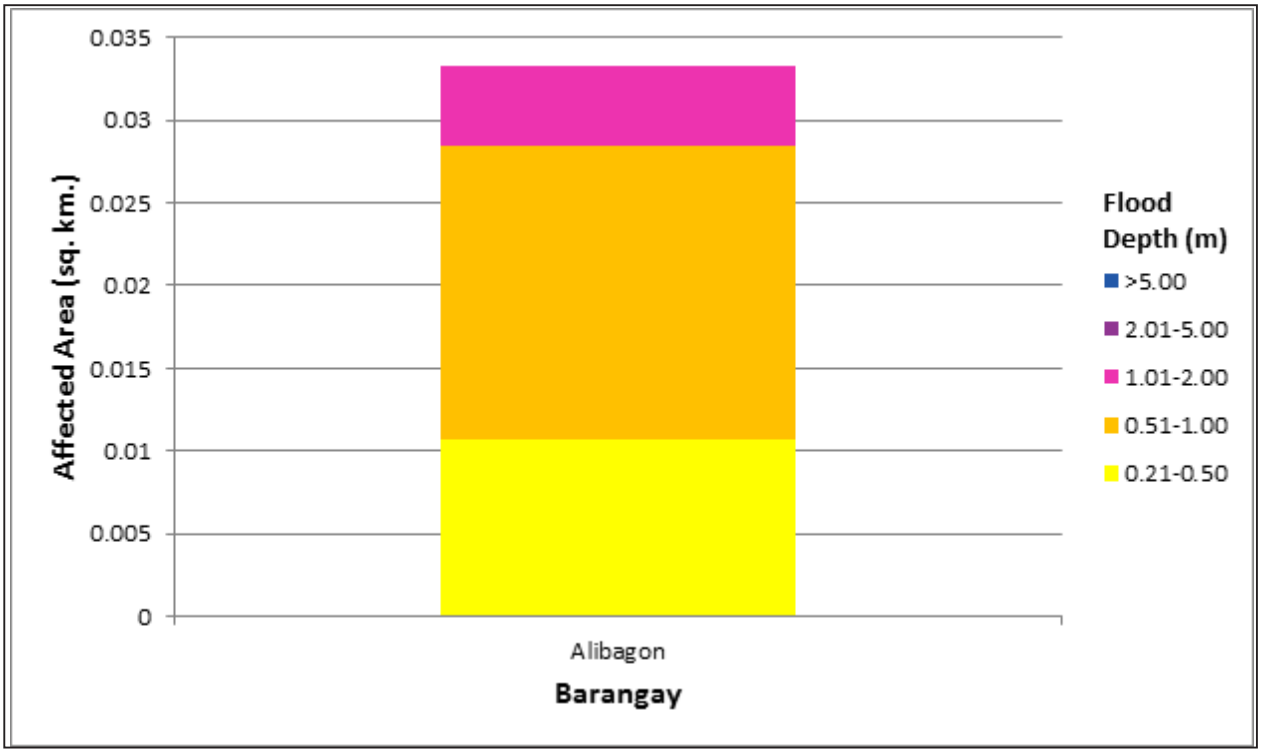


Figure 79. Affected Areas in Makato, Aklan during 5-Year Rainfall Return Period

For the municipality of New Washington, with an area of 55.12 sq. km., 5.61% will experience flood levels of less 0.20 meters. 5.51% of the area will experience flood levels of 0.21 to 0.50 meters while 9.6%, 4.7%, and 1.23% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 40 are the affected areas in square kilometres by flood depth per barangay.

Table 40. Affected Areas in New Washington, Aklan during 5-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in New Washington (in sq. km.)						
	Guinbaliwan	Jalas	Lawa-An	Mabilo	Mataphao	Puis	Tambak
0.03-0.20	0.69	0.47	0.006	1.04	0.21	0.19	0.5
0.21-0.50	0.47	0.6	0.00055	0.65	0.48	0.61	0.23
0.51-1.00	0.48	0.26	0	0.94	1.12	2.26	0.23
1.01-2.00	0.35	0.11	0	0.81	0.22	1.05	0.058
2.01-5.00	0.053	0.12	0	0.25	0	0.25	0.0098
> 5.00	0	0	0	0	0	0	0

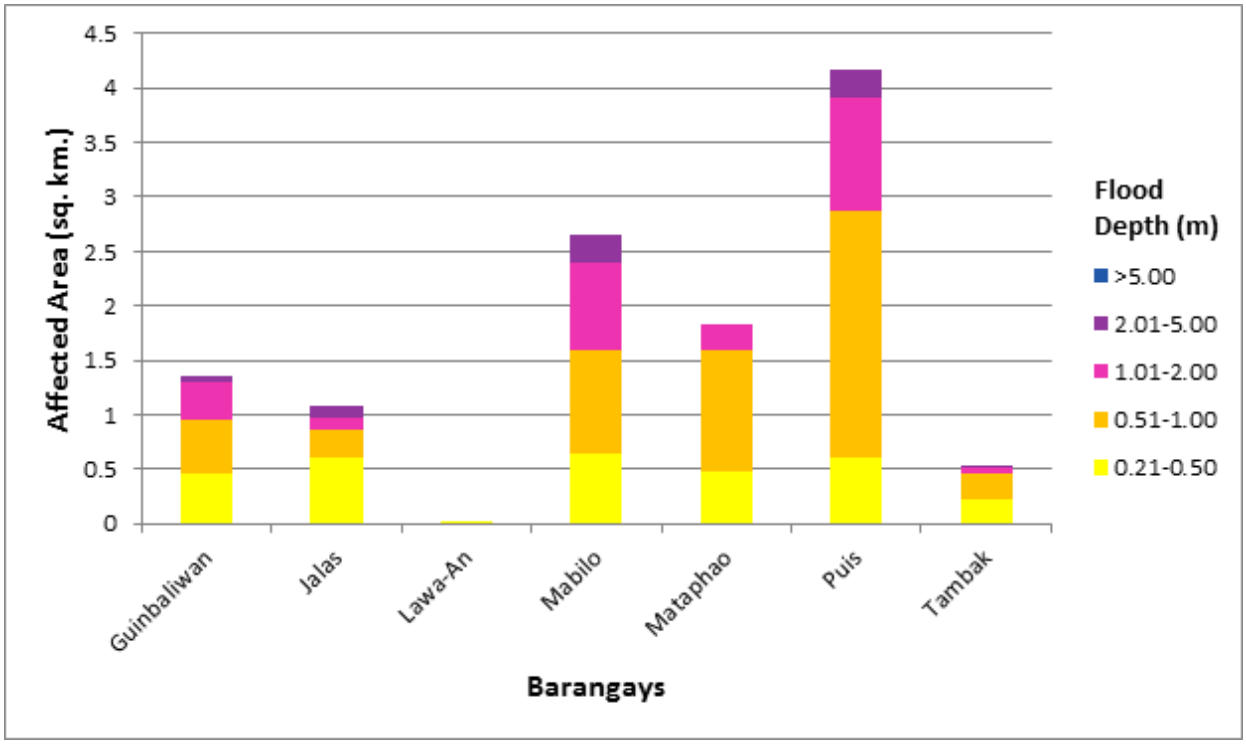


Figure 80. Affected Areas inNew Washington, Aklan during 5-Year Rainfall Return Period

For the municipality of Numancia, with an area of 24.15 sq. km., 10.39% will experience flood levels of less 0.20 meters. 12.43% of the area will experience flood levels of 0.21 to 0.50 meters while 23.45%, 23.77%, 11.12%, and 0.17% 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 41are the affected areas in square kilometres by flood depth per barangay.

Table 41. Affected Areas in Numancia, Aklan during 5-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Numancia (in sq. km.)								
	Albasan	Aliputos	Badio	Bubog	Bulwang	Camanci Norte	Camanci Sur	Dongon East	Dongon West
0.03-0.20	0.13	0.053	0.34	0.019	0.079	0.26	0.17	0.49	0.12
0.21-0.50	0.15	0.18	0.32	0.063	0.11	0.29	0.4	0.2	0.057
0.51-1.00	0.36	0.63	0.35	0.45	0.14	0.83	0.72	0.18	0.062
1.01-2.00	0.61	1.58	0.36	0.55	0.1	0.58	0.3	0.35	0.0065
2.01-5.00	0.4	0.77	0.13	0.21	0.25	0.079	0.027	0.048	0
> 5.00	0	0.0004	0	0	0.039	0	0	0	0

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Numancia (in sq. km.)							
	Joyao-Joyao	Laguinbanua East	Laguinbanua West	Marianos	Navitas	Poblacion	Pusiw	Tabangka
0.03-0.20	0.012	0.077	0.021	0.024	0.25	0.18	0.25	0.04
0.21-0.50	0.04	0.24	0.11	0.046	0.059	0.43	0.16	0.14
0.51-1.00	0.16	0.63	0.34	0.16	0.079	0.2	0.18	0.18
1.01-2.00	0.15	0.37	0.057	0.16	0.082	0.32	0.08	0.089
2.01-5.00	0.077	0.32	0.0043	0.12	0.0087	0.036	0.22	0.0015
> 5.00	0	0.0014	0	0	0	0	0	0

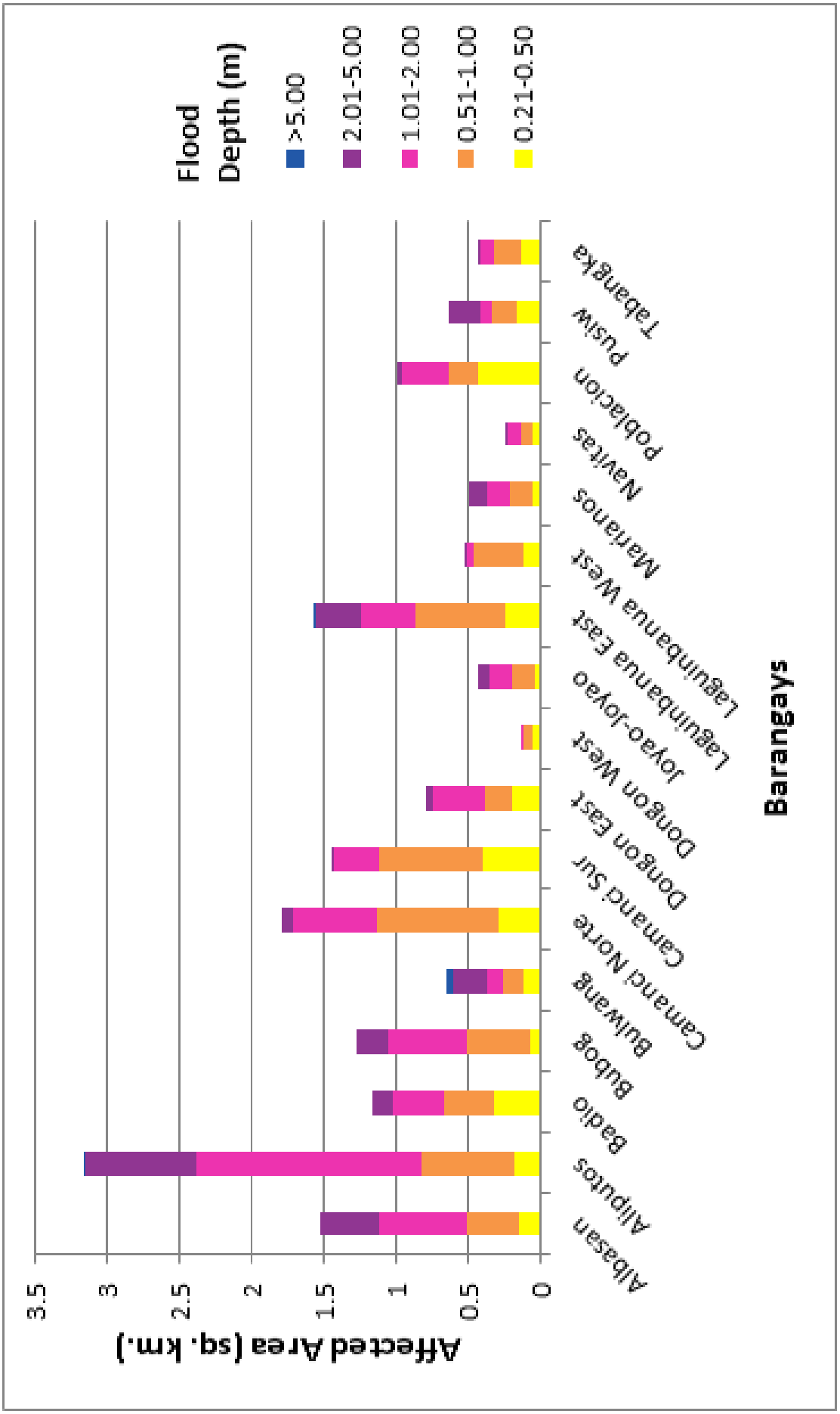


Figure 81. Affected Areas in Numancia, Aklan during 5-Year Rainfall Return Period

For the 25-year return period, 0.004% of the municipality of Banga with an area of 64.47 sq. km. will experience flood levels of less 0.1 meters. 0.018% of the area will experience flood levels of 0.21 to 0.50 meters while 0.27%, 1.41%, 1.55%, and 0.29% 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 Banga, Aklan during 25-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Banga (in sq. km.)		
	Jumarap	Linabuan Sur	Palale
0.03-0.20	0	0.0024	0
0.21-0.50	0	0.011	0
0.51-1.00	0.00015	0.17	0
1.01-2.00	0.023	0.88	0
2.01-5.00	0.34	0.65	0.005
> 5.00	0.061	0.039	0.09

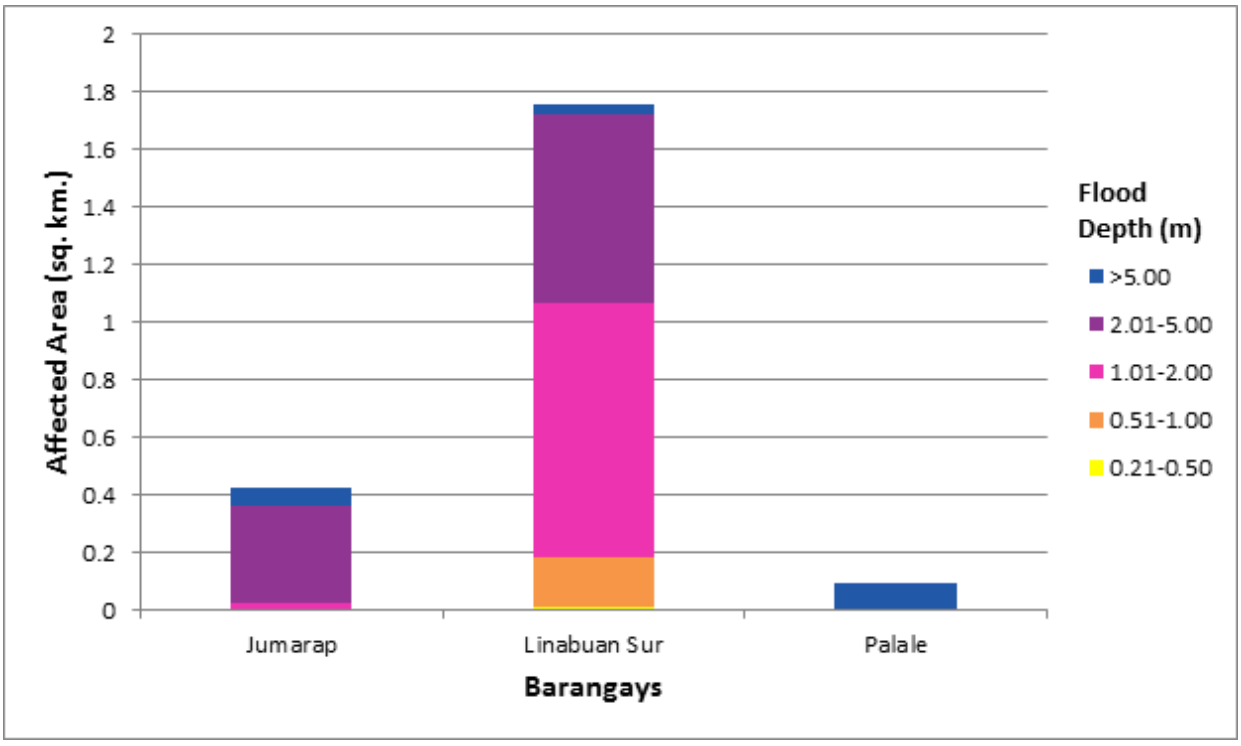


Figure 82. Affected Areas in Banga, Aklan during 25-Year Rainfall Return Period

For the municipality of Kalibo, with an area of 40.15 sq. km., 6.34% will experience flood levels of less 0.20 meters. 11.09% of the area will experience flood levels of 0.21 to 0.50 meters while 24.33%, 30.43%, 8.76%, and 3.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 43 are the affected areas in square kilometres by flood depth per barangay.

Table 43. Affected Areas in Kalibo, Aklan during 25-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Kalibo (in sq. km.)							
	Andagaw	Bachaw Norte	Bachaw Sur	Briones	Buswang New	Buswang Old	Caano	Estancia
0.03-0.20	0.36	0.29	0.17	0.14	0.27	0.32	0.038	0.11
0.21-0.50	0.88	0.36	0.29	0.11	0.52	0.33	0.067	0.44
0.51-1.00	0.97	0.5	0.48	0.17	0.62	0.44	0.3	1.54
1.01-2.00	0.32	0.28	0.36	0.48	0.13	0.21	1.04	0.9
2.01-5.00	0.021	0.0054	0.14	0.026	0.001	0.0055	0.1	0.0071
> 5.00	0	0	0	0	0	0	0	0.00032

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Kalibo (in sq. km.)							
	Linabuan Norte	Mabilo	Mobo	Nalook	Poblacion	Pook	Tigayon	Tinigaw
0.03-0.20	0.02	0.11	0.0071	0.23	0.062	0.34	0.075	0.0061
0.21-0.50	0.0051	0.14	0.014	0.43	0.14	0.61	0.11	0.021
0.51-1.00	0.085	0.35	0.14	1.36	0.38	1.49	0.82	0.13
1.01-2.00	1.26	1.02	1.13	0.58	0.24	1.63	2.24	0.42
2.01-5.00	0.45	0.6	0.81	0.14	0.0041	0.095	0.86	0.24
> 5.00	0.052	0	0.6	0	0	0	0.45	0.13

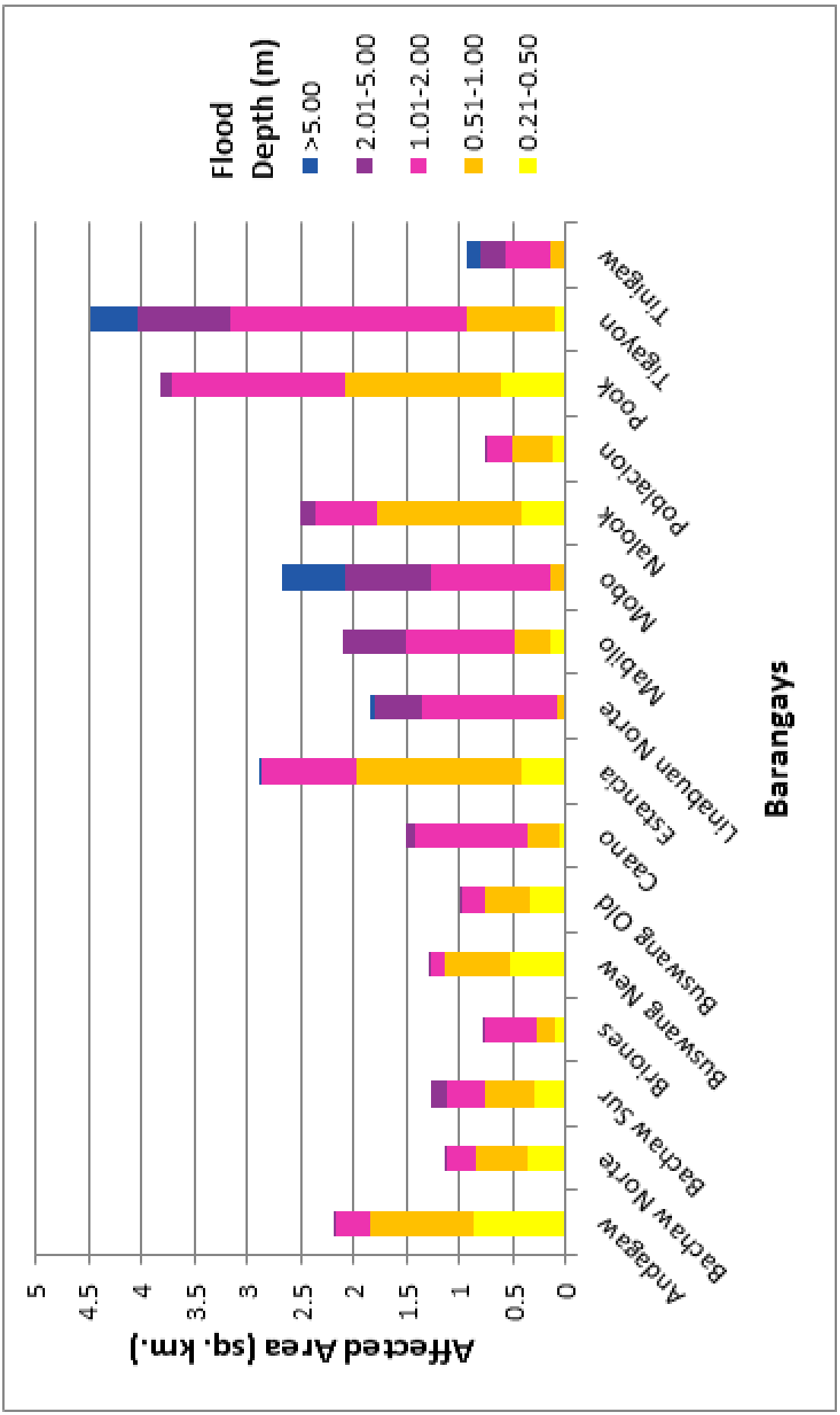


Figure 83. Affected Areas in Kalibo, Aklan during 25-Year Rainfall Return Period

For the municipality of Lezo, with an area of 19.81 sq. km., 13.52% will experience flood levels of less 0.20 meters. 11.41% of the area will experience flood levels of 0.21 to 0.50 meters while 5.15%, 3.9%, 9.83%, and 5.2% 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 Lezo, Aklan during 25-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Lezo (in sq. km.)								
	Bagto	Bugasongan	Carugdog	Cogon	Ibao	Mina	Poblacion	Santa Cruz	Santa Cruz Bigaa
0.03-0.20	0.49	0.19	1	0.32	0.043	0.39	0.26	0.14	0.057
0.21-0.50	0.19	0.34	0.35	0.29	0.13	0.039	0.043	0.014	0.0027
0.51-1.00	0.11	0.42	0.016	0.12	0.34	0.054	0.054	0.011	0.0079
1.01-2.00	0.071	0.16	0	0.067	0.36	0.13	0.14	0.061	0.038
2.01-5.00	0.026	0.061	0	0.0052	0.089	0.79	0.19	0.51	0.31
> 5.00	0	0	0	0	0.0004	0.74	0.41	0.12	0.011

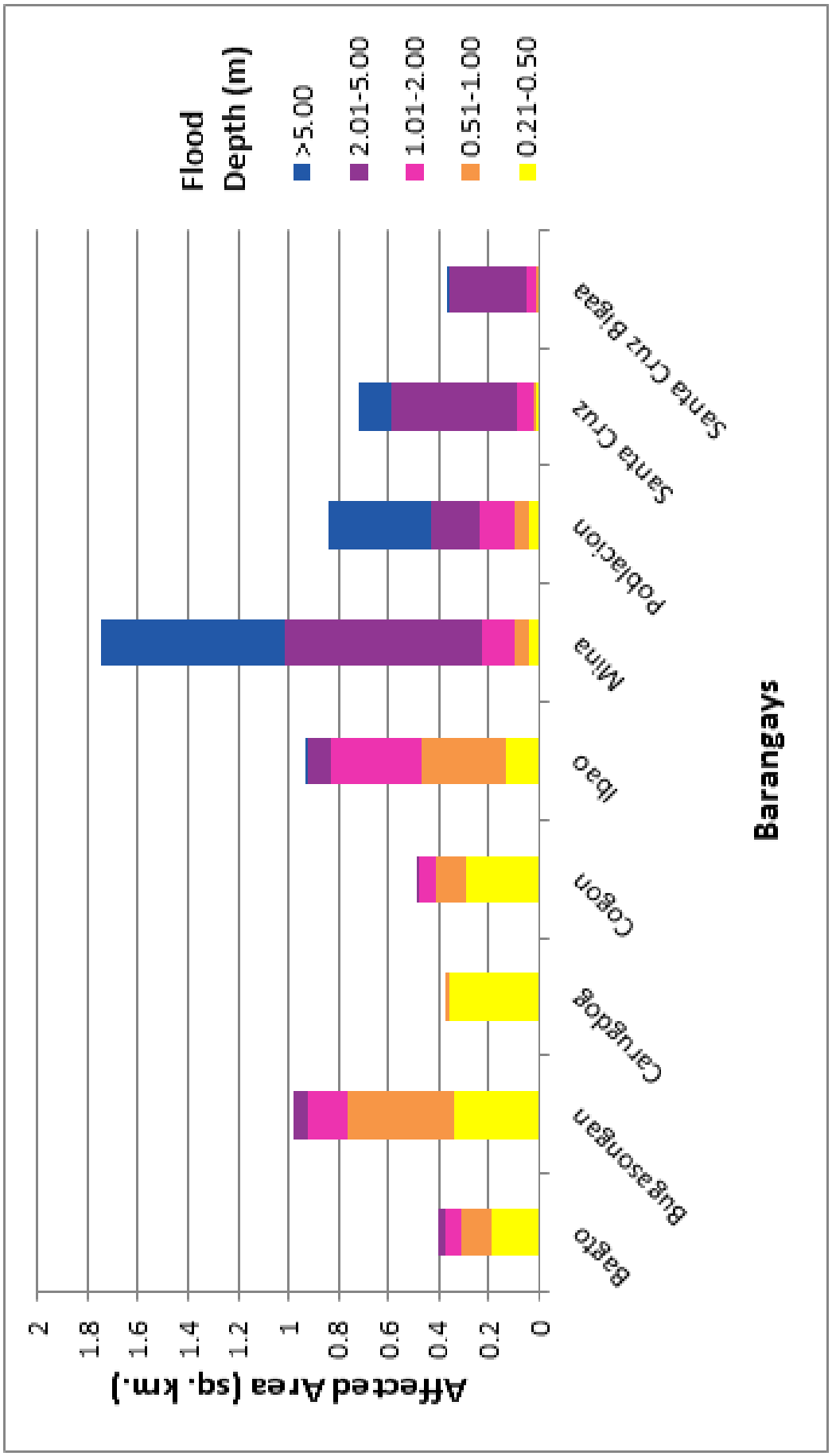


Figure 84. Affected Areas in Lezo, Aklan during 25-Year Rainfall Return Period

For the municipality of Makato, with an area of 60.25 sq. km., 0.024% will experience flood levels of less 0.20 meters. 0.009% of the area will experience flood levels of 0.21 to 0.50 meters while 0.03%, 0.02%, and 0.00007% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 45 are the affected areas in square kilometres by flood depth per barangay.

Table 45. Affected Areas in Makato, Aklan during 25-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Makato (in sq. km.)
	Alibagon
0.03-0.20	0.014
0.21-0.50	0.0054
0.51-1.00	0.02
1.01-2.00	0.012
2.01-5.00	0.000043
> 5.00	0

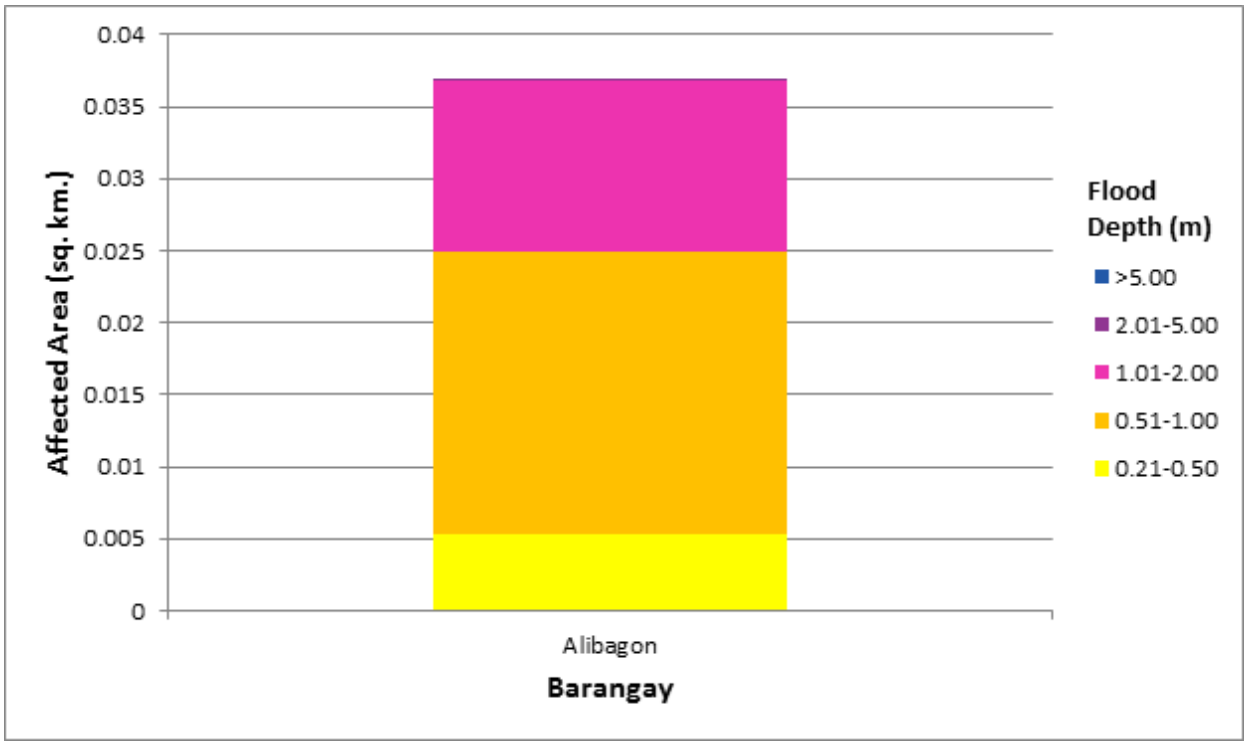


Figure 85. Affected Areas in Makato, Aklan during 25-Year Rainfall Return Period

For the municipality of New Washington, with an area of 55.12 sq. km., 2.94% will experience flood levels of less 0.20 meters. 3.75% of the area will experience flood levels of 0.21 to 0.50 meters while 9.33%, 8.46%, and 2.19% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 46 are the affected areas in square kilometres by flood depth per barangay.

Table 46. Affected Areas in New Washington, Aklan during 25-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in New Washington (in sq. km.)						
	Guinbali-wan	Jalas	Lawa-An	Mabilo	Mataphao	Puis	Tambak
0.03-0.20	0.47	0.12	0.0027	0.58	0.13	0.042	0.28
0.21-0.50	0.28	0.52	0.0027	0.55	0.27	0.25	0.17
0.51-1.00	0.58	0.56	0.0011	1.02	0.97	1.7	0.31
1.01-2.00	0.55	0.18	0	1.05	0.67	1.97	0.24
2.01-5.00	0.15	0.17	0	0.48	0	0.38	0.018
> 5.00	0	0	0	0	0	0	0

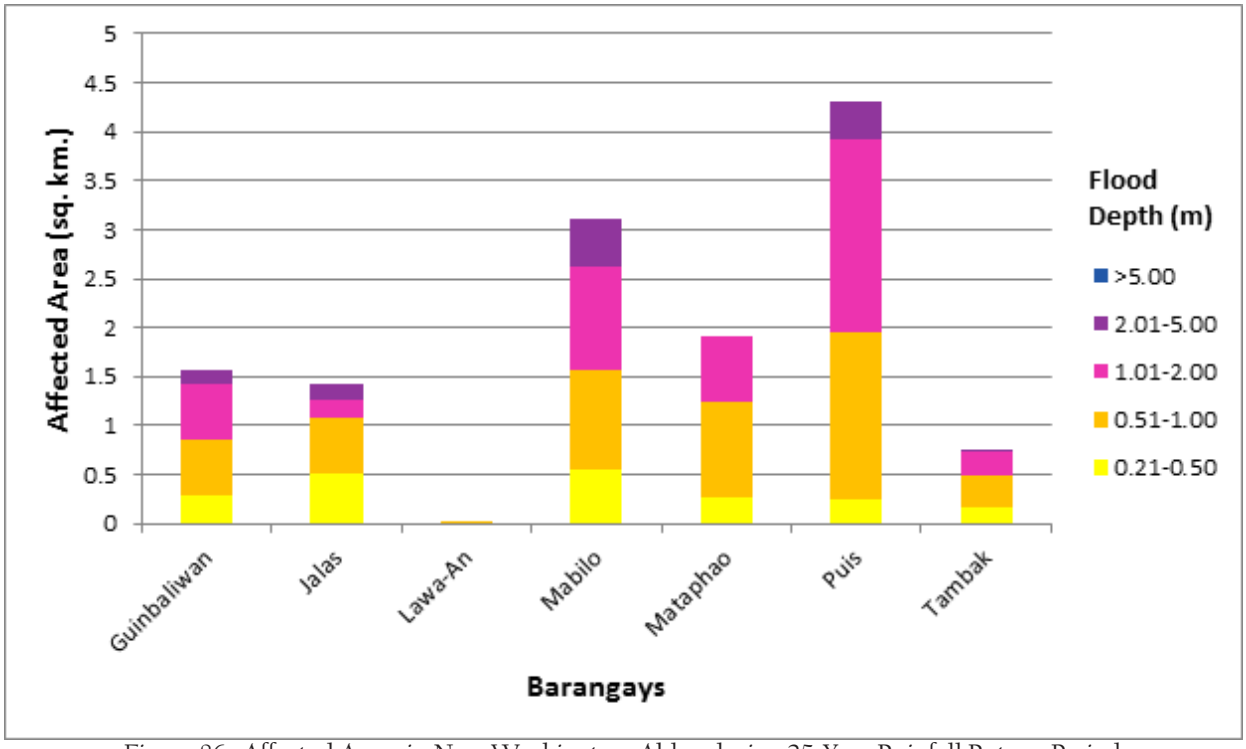


Figure 86. Affected Areas in New Washington, Aklan during 25-Year Rainfall Return Period

For the municipality of Numancia, with an area of 24.15 sq. km., 6.38% will experience flood levels of less 0.20 meters. 8.46% of the area will experience flood levels of 0.21 to 0.50 meters while 22.35%, 29.24%, 14.68%, and 0.23% 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 Numancia, Aklan during 25-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Numancia (in sq. km.)								
	Albasan	Aliputos	Badio	Bubog	Bulwang	Camanci Norte	Camanci Sur	Dongon East	Dongon West
0.03-0.20	0.066	0.0099	0.17	0.0079	0.053	0.19	0.065	0.37	0.088
0.21-0.50	0.092	0.088	0.27	0.017	0.097	0.22	0.28	0.15	0.063
0.51-1.00	0.3	0.41	0.43	0.25	0.16	0.71	0.75	0.21	0.083
1.01-2.00	0.65	1.64	0.46	0.71	0.12	0.81	0.48	0.39	0.01
2.01-5.00	0.54	1.06	0.18	0.3	0.24	0.12	0.038	0.14	0
> 5.00	0	0.0014	0	0.0007	0.051	0	0	0	0

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Numancia (in sq. km.)							
	Joyao-Joyao	Laguinbanua East	Laguinbanua West	Marianos	Navitas	Poblacion	Pusiw	Tabangka
0.03-0.20	0.0077	0.027	0.0075	0.0095	0.22	0.057	0.19	0.011
0.21-0.50	0.013	0.12	0.041	0.023	0.062	0.26	0.17	0.072
0.51-1.00	0.12	0.6	0.37	0.11	0.072	0.42	0.2	0.2
1.01-2.00	0.21	0.52	0.11	0.22	0.12	0.36	0.1	0.16
2.01-5.00	0.092	0.36	0.0077	0.15	0.012	0.075	0.22	0.0052
> 5.00	0	0.0024	0	0	0	0	0.00018	0

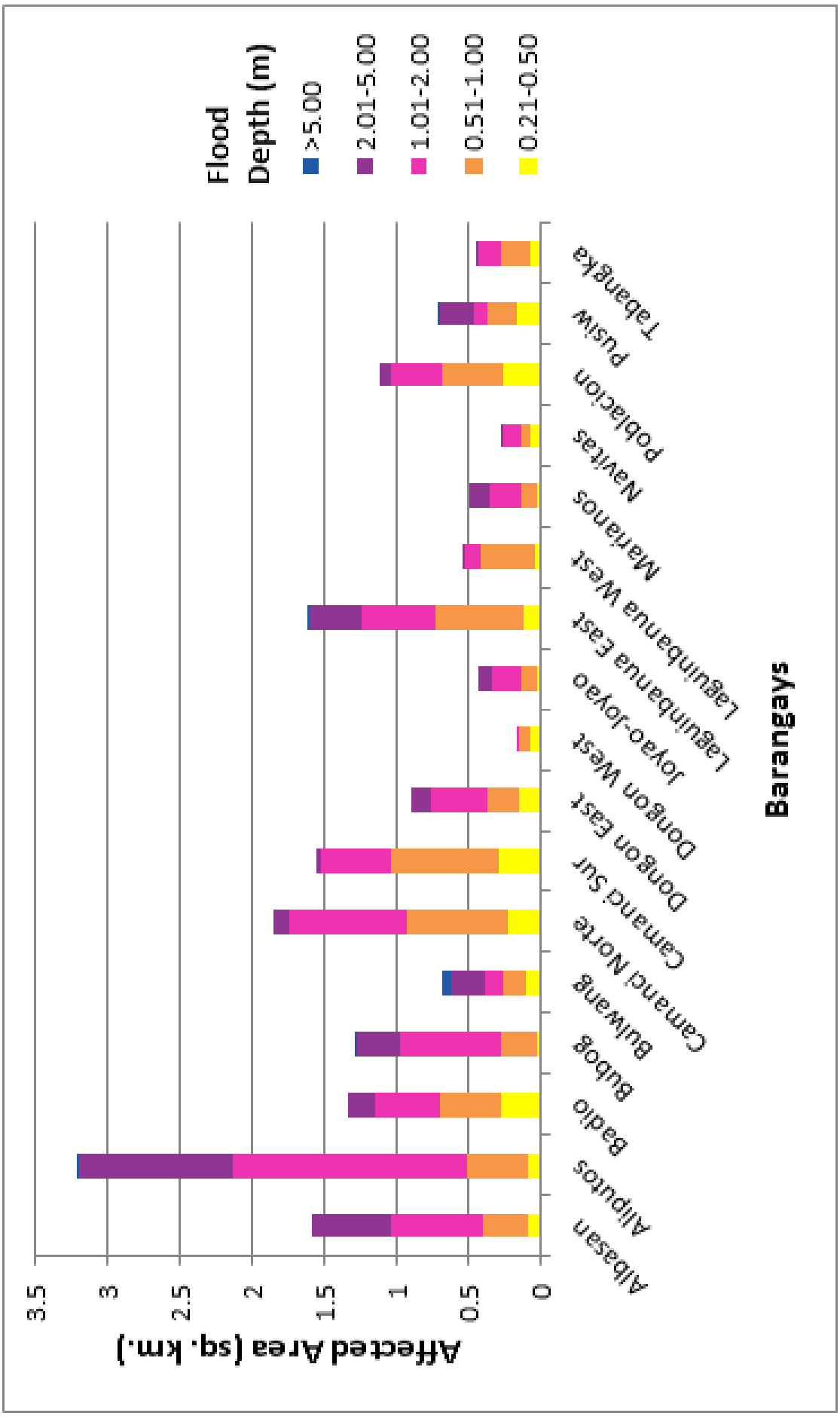


Figure 87. Affected Areas in Numancia, Aklan during 25-Year Rainfall Return Period

For the 100-year return period, 0.0002% of the municipality of Banga with an area of 64.47 sq. km. will experience flood levels of less 0.1 meters. 0.01% of the area will experience flood levels of 0.21 to 0.50 meters while 0.12%, 1.19%, 1.74%, and 0.5% 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 Banga, Aklan during 100-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Area of affected barangays in Banga (in sq. km.)		
	Jumarap	Linabuan Sur	Palale
0.03-0.20	0	0.0001	0
0.21-0.50	0	0.0068	0
0.51-1.00	0	0.08	0
1.01-2.00	0.0045	0.76	0
2.01-5.00	0.28	0.84	0.0038
> 5.00	0.15	0.086	0.092

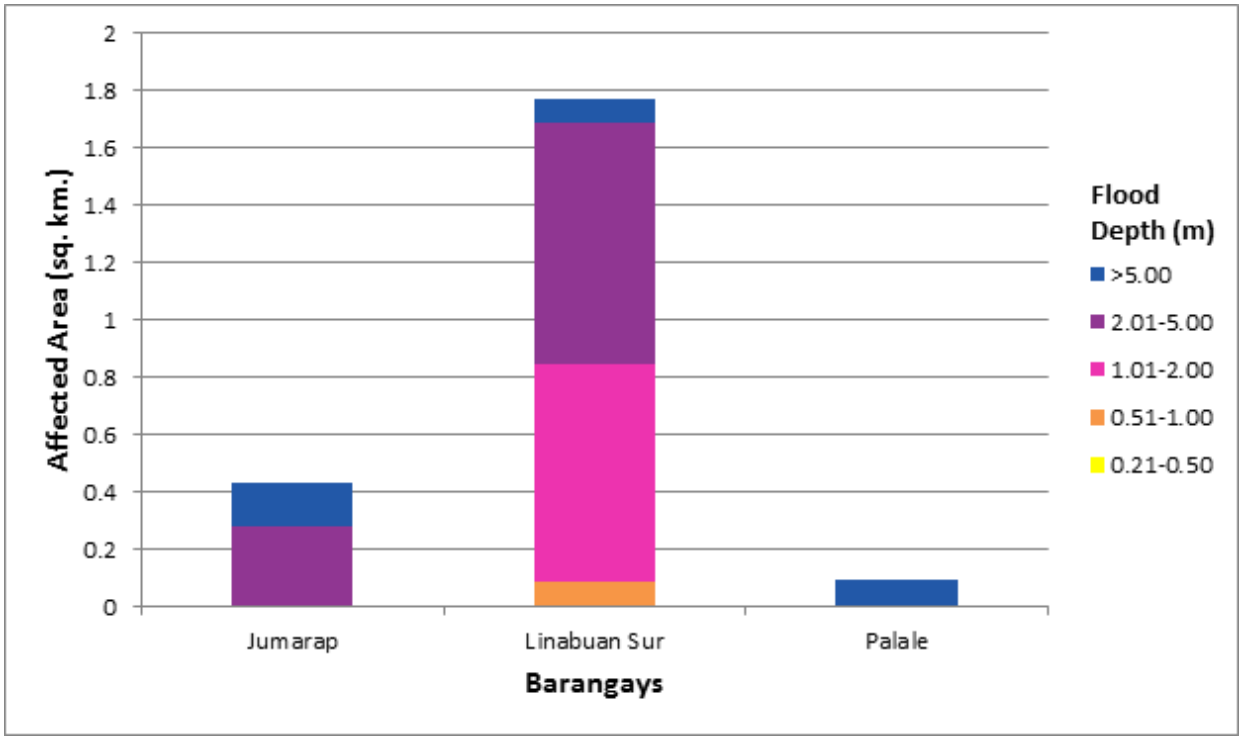


Figure 88. Affected Areas in Banga, Aklan during 100-Year Rainfall Return Period

For the municipality of Kalibo, with an area of 40.15 sq. km., 6.34% will experience flood levels of less 0.20 meters. 11.09% of the area will experience flood levels of 0.21 to 0.50 meters while 24.33%, 30.43%, 8.76%, and 3.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 43 are the affected areas in square kilometres by flood depth per barangay.

Table 49. Affected Areas in Kalibo, Aklan during 100-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Kalibo (in sq. km.)							
	Andagaw	Bachaw Norte	Bachaw Sur	Briones	Buswang New	Buswang Old	Caano	Estancia
0.03-0.20	0.22	0.24	0.13	0.099	0.17	0.24	0.014	0.067
0.21-0.50	0.65	0.31	0.25	0.078	0.43	0.3	0.032	0.24
0.51-1.00	1.21	0.55	0.51	0.15	0.75	0.47	0.14	1.47
1.01-2.00	0.42	0.34	0.4	0.53	0.19	0.27	0.94	1.21
2.01-5.00	0.047	0.0065	0.16	0.063	0.0062	0.018	0.43	0.0083
> 5.00	0	0	0	0	0	0	0	0.00032

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Kalibo (in sq. km.)							
	Linabuan Norte	Mabilo	Mobo	Nalook	Poblacion	Pook	Tigayon	Tinigaw
0.03-0.20	0.018	0.077	0.0052	0.12	0.044	0.2	0.059	0.0039
0.21-0.50	0.0026	0.1	0.0092	0.31	0.11	0.43	0.051	0.0099
0.51-1.00	0.019	0.28	0.066	0.98	0.36	1.26	0.43	0.092
1.01-2.00	1.1	0.83	1.07	1.15	0.3	1.96	2.42	0.39
2.01-5.00	0.65	0.93	0.92	0.17	0.0068	0.32	1.12	0.31
> 5.00	0.079	0	0.62	0	0	0	0.47	0.14

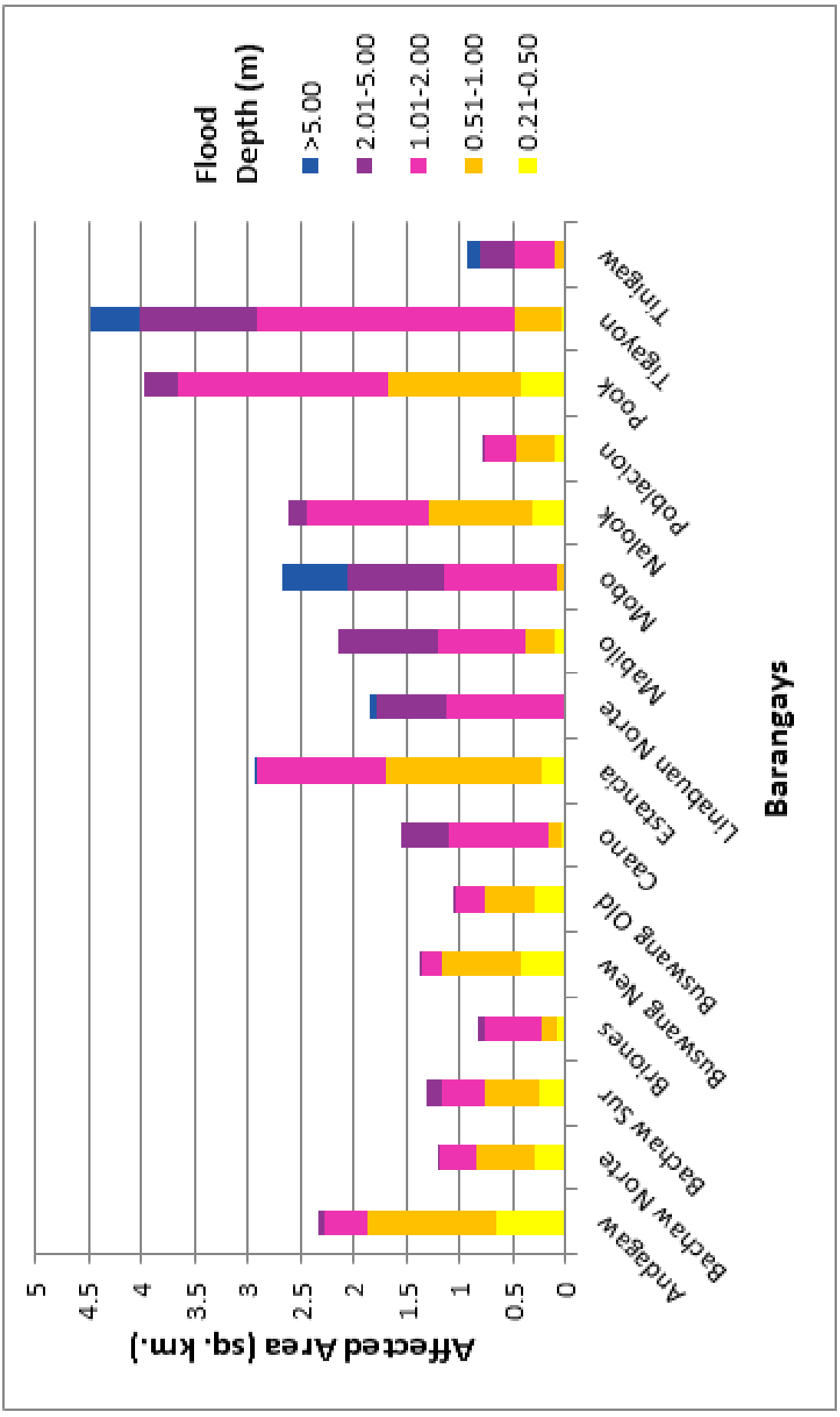


Figure 89. Affected Areas in Kalibo, Aklan during 100-Year Rainfall Return Period

For the municipality of Lezo, with an area of 19.81 sq. km., 11.91% will experience flood levels of less 0.20 meters. 7.29% of the area will experience flood levels of 0.21 to 0.50 meters while 6.32%, 6.29%, 9.68%, and 7.8% 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 Lezo, Aklan during 100-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Lezo (in sq. km.)								
	Bagto	Bugasongan	Carugdog	Cogon	Ibao	Mina	Poblacion	Santa Cruz	Santa Cruz Bigaa
0.03-0.20	0.42	0.073	0.82	0.22	0.023	0.37	0.24	0.15	0.058
0.21-0.50	0.23	0.24	0.53	0.32	0.042	0.02	0.04	0.019	0.0022
0.51-1.00	0.087	0.52	0.025	0.17	0.34	0.065	0.042	0.0037	0.0056
1.01-2.00	0.13	0.26	0	0.1	0.43	0.12	0.13	0.05	0.033
2.01-5.00	0.03	0.075	0	0.007	0.13	0.67	0.23	0.47	0.31
> 5.00	0	0	0	0	0.0029	0.9	0.44	0.19	0.022

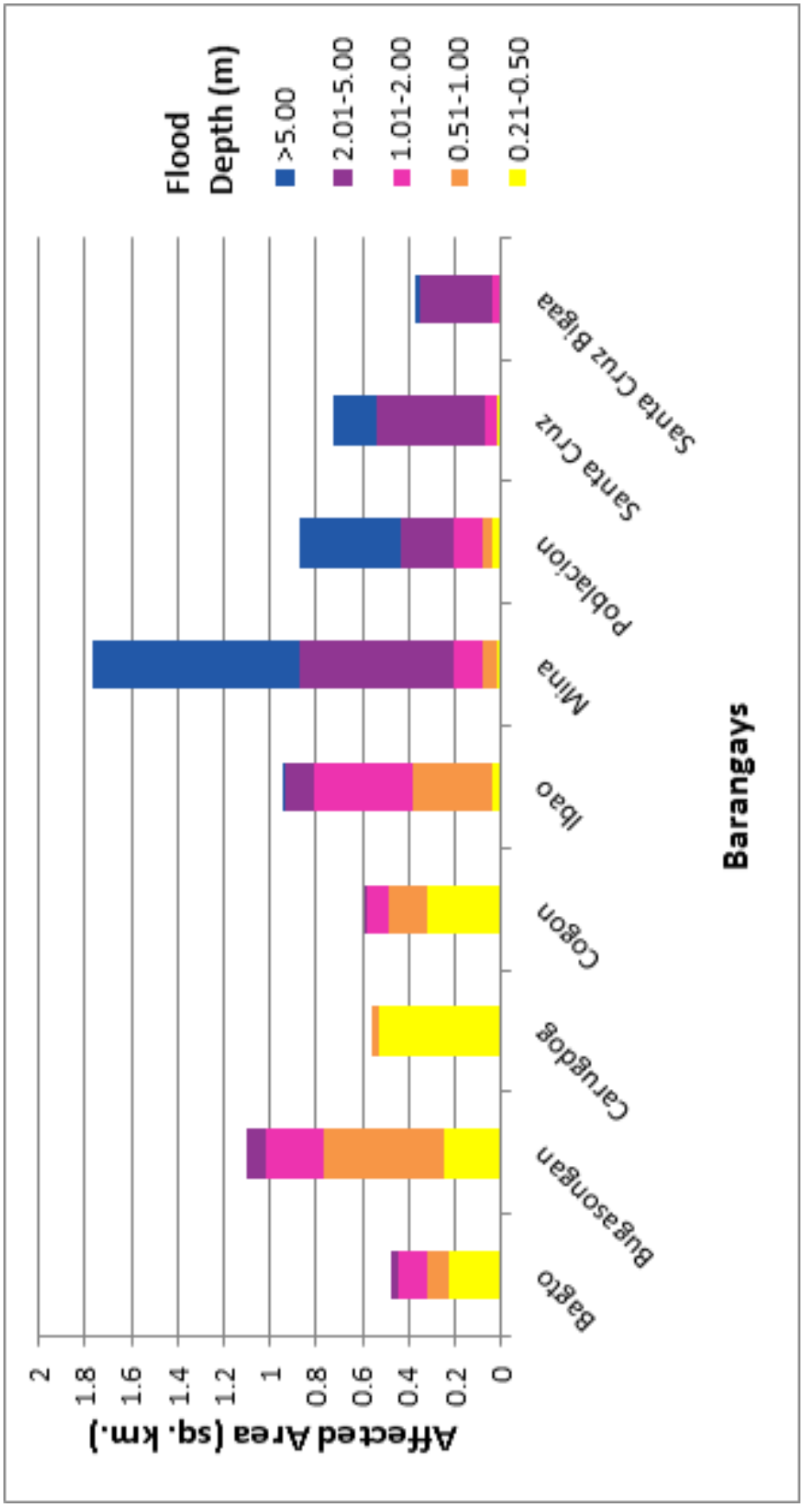


Figure 90. Affected Areas in Lezo, Aklan during 100-Year Rainfall Return Period

For the municipality of Makato, with an area of 60.25 sq. km., 0.024% will experience flood levels of less 0.20 meters. 0.009% of the area will experience flood levels of 0.21 to 0.50 meters while 0.03%, 0.02%, and 0.00007% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 45 are the affected areas in square kilometres by flood depth per barangay.

Table 51. Affected Areas in Makato, Aklan during 100-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Makato (in sq. km.)
	Alibagon
0.03-0.20	0.015
0.21-0.50	0.0053
0.51-1.00	0.016
1.01-2.00	0.018
2.01-5.00	0.00033
> 5.00	0

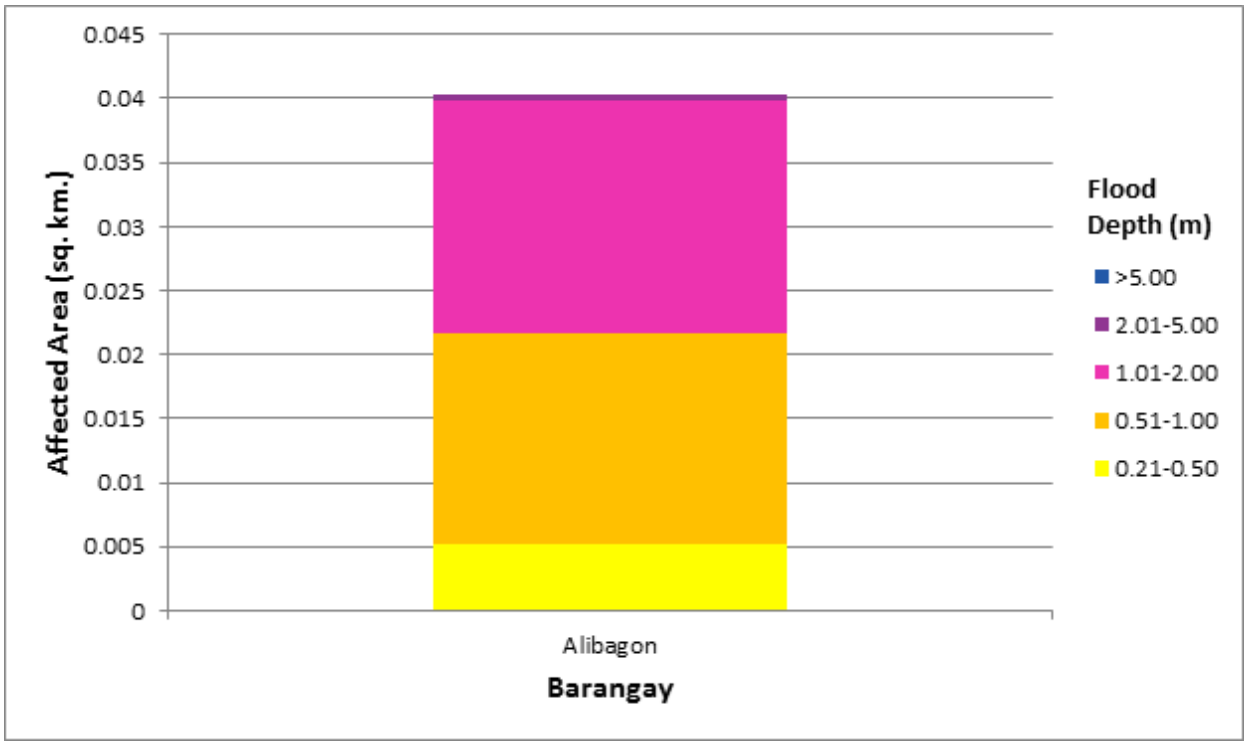


Figure 91. Affected Areas in Makato, Aklan during 100-Year Rainfall Return Period

For the municipality of New Washington, with an area of 55.12 sq. km., 2.30% will experience flood levels of less 0.20 meters. 2.71% of the area will experience flood levels of 0.21 to 0.50 meters while 8.18%, 10.81%, and 2.82% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and 2.01 to 5 meters, respectively. Listed in Table 52 are the affected areas in square kilometres by flood depth per barangay.

Table 52. Affected Areas in New Washington, Aklan during 100-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in New Washington (in sq. km.)						
	Guinbaliwan	Jalas	Lawa-An	Mabilo	Mataphao	Puis	Tambak
0.03-0.20	0.043	0.0021	0.43	0.11	0.014	0.25	0.28
0.21-0.50	0.32	0.0027	0.42	0.19	0.18	0.15	0.17
0.51-1.00	0.73	0.0026	0.99	0.85	1.05	0.31	0.31
1.01-2.00	0.25	0	1.28	0.91	2.6	0.3	0.24
2.01-5.00	0.2	0	0.58	0	0.51	0.025	0.018
> 5.00	0	0	0	0	0	0	0

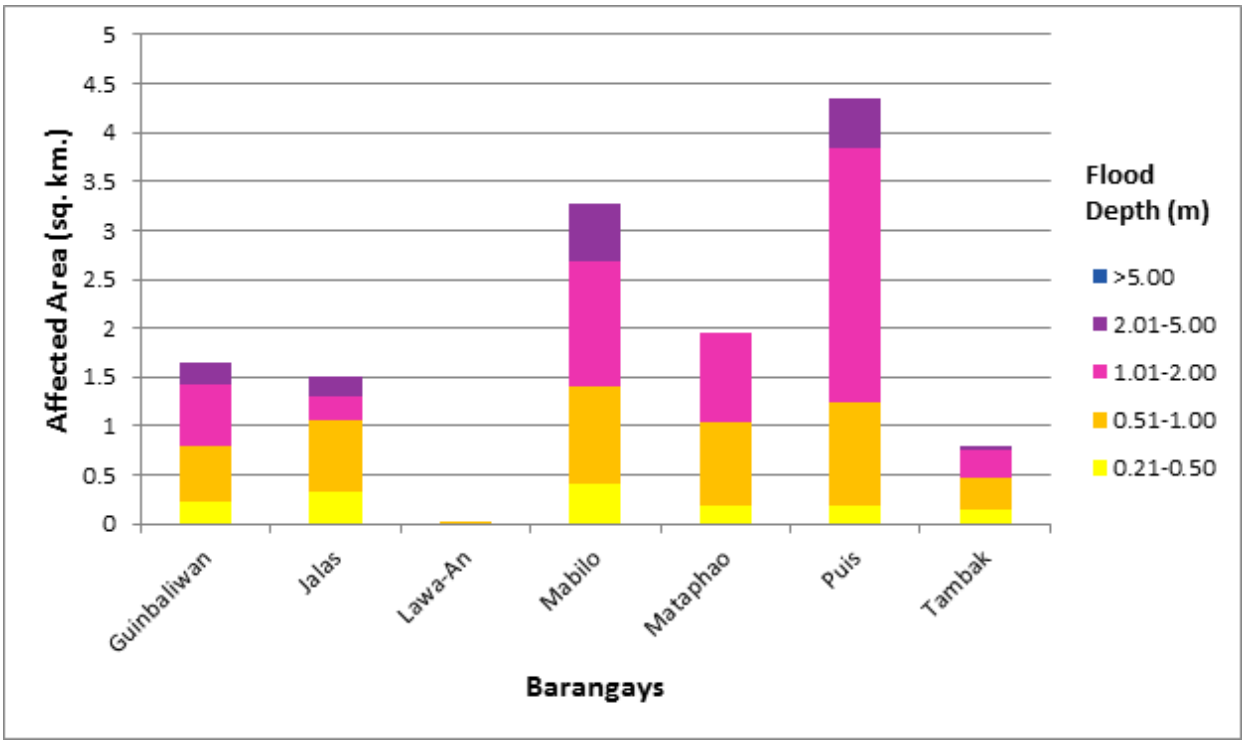


Figure 92. Affected Areas in New Washington, Aklan during 100-Year Rainfall Return Period

For the municipality of Numancia, with an area of 24.15 sq. km., 4.98% will experience flood levels of less 0.20 meters. 6.04% of the area will experience flood levels of 0.21 to 0.50 meters while 20.17%, 32.86%, 17.19%, and 0.3% 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 Numancia, Aklan during 100-Year Rainfall Return Period

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Numancia (in sq. km.)								
	Albasan	Aliputos	Badio	Bubog	Bulwang	Camanci Norte	Camanci Sur	Dongon East	Dongon West
0.03-0.20	0.042	0.0042	0.1	0.0046	0.041	0.15	0.031	0.32	0.077
0.21-0.50	0.062	0.043	0.21	0.0088	0.071	0.18	0.17	0.13	0.074
0.51-1.00	0.25	0.28	0.46	0.12	0.18	0.6	0.74	0.2	0.086
1.01-2.00	0.68	1.59	0.53	0.79	0.13	0.97	0.63	0.42	0.019
2.01-5.00	0.62	1.29	0.21	0.36	0.24	0.15	0.046	0.21	0
> 5.00	0	0.0026	0	0.0047	0.061	0	0	0	0

Affected area (sq.km.) by flood depth (in m.)	Affected Barangays in Numancia (in sq. km.)							
	Joyao-Joyao	Laguinbanua East	Laguinbanua West	Marianos	Navitas	Poblacion	Pusiw	Tabangka
0.03-0.20	0.0054	0.016	0.004	0.0066	0.21	0.031	0.15	0.0093
0.21-0.50	0.0077	0.063	0.023	0.012	0.068	0.13	0.17	0.037
0.51-1.00	0.087	0.49	0.33	0.077	0.054	0.52	0.21	0.19
1.01-2.00	0.24	0.67	0.17	0.25	0.15	0.38	0.13	0.21
2.01-5.00	0.099	0.39	0.012	0.17	0.016	0.11	0.23	0.0086
> 5.00	0	0.0034	0	0	0	0	0.002	0

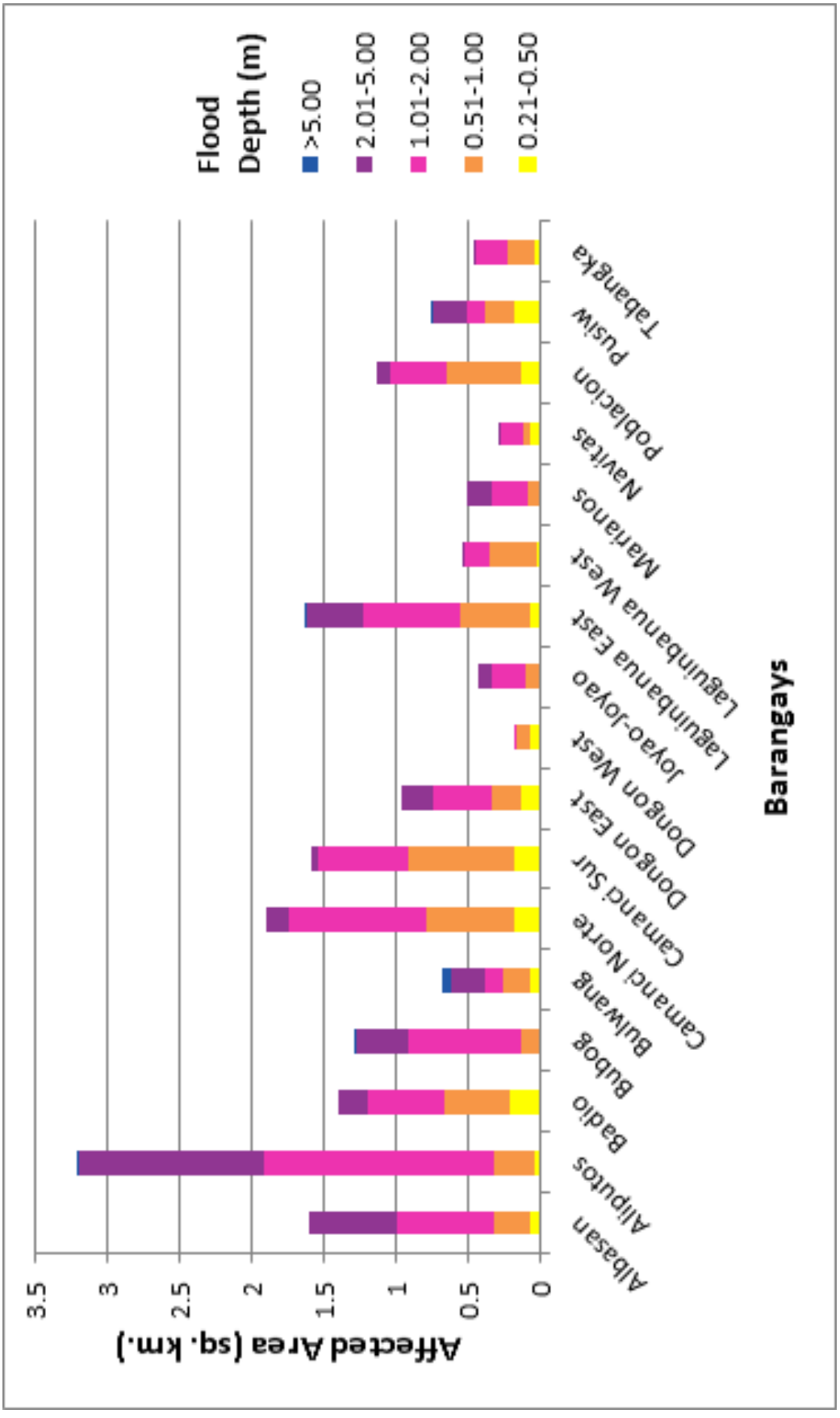


Figure 93. Affected Areas in Numancia, Aklan during 100-Year Rainfall Return Period

Among the barangays in the municipality of Banga, Linabuan Sur is projected to have the highest percentage of area that will experience flood levels at 2.73%. Meanwhile, Jumarap posted the second highest percentage of area that may be affected by flood depths at 0.66%.

Among the barangays in the municipality of Kalibo, Tigayon is projected to have the highest percentage of area that will experience flood levels at 11.35%. Meanwhile, Pook posted the second highest percentage of area that may be affected by flood depths at 10.36%.

Among the barangays in the municipality of Lezo, Mina is projected to have the highest percentage of area that will experience flood levels at 10.79%. Meanwhile, Carugdog posted the second highest percentage of area that may be affected by flood depths at 6.90%.

Among the barangays in the municipality of Makato, Alibangon is projected to have the highest percentage of area that will experience flood levels at 0.05%.

Among the barangays in the municipality of New Washington, Puis is projected to have the highest percentage of area that will experience flood levels at 7.91%. Meanwhile, Mabilo posted the second highest percentage of area that may be affected by flood depths at 6.68%.

Among the barangays in the municipality of Numancia, Aliputos is projected to have the highest percentage of area that will experience flood levels at 13.29%. Meanwhile, Albasan posted the second highest percentage of area that may be affected by flood depths at 6.84%.

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

Table 54. 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	15.14	10.89	8.58
Medium	36.64	40.42	40.00
High	18.61	25.50	30.81
TOTAL	**70.39**	**76.81**	**79.39**

Of the 116 identified education institutions in the Aklan Floodplain, 33 schools were assessed to be exposed to the Low level flooding during a 5 year scenario while 65 schools were assessed to be exposed to medium level flooding in the same scenario. In the 25 year scenario, 21 schools were assessed to be exposed to the Low level flooding, while 78 schools were assessed to be exposed to medium level flooding and 9 schools were assessed to be exposed to high level flooding. For the 100 year scenario, 15 schools were assessed for Low level flooding and 82 schools for Medium level flooding. In the same scenario, 11 schools were assessed to be exposed to High level flooding. The educational institutions exposed to flooding in the Aklan floodplain are found in Annex 12.

Thirty-eight (38) health institutions were identified in the Aklan Floodplain, 11 were assessed to be exposed to the Low level flooding during a 5 year scenario, while 14 were assessed to be exposed to medium level flooding and 1 was assessed to be exposed to the high level flooding scenario. In the 25 year scenario, 7 were assessed to be exposed to the Low level flooding, while 25 were assessed to be exposed to medium level flooding and 1 was assessed to be exposed to high level flooding. . For the 100 year scenario, 5 were assessed for Low level flooding and 26 for Medium level flooding. In the same scenario, 4 were assessed to be exposed to High level flooding. The health institutions exposed to flooding in the Aklan floodplain are found in Annex 13.

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 are identified for validation.

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

After which, the actual data from the field will be compared to the simulated data to assess the accuracy of the Flood Depth Maps produced and to improve on what is needed. The points in the flood map versus its corresponding validation depths are shown in Figure 93.

The flood validation data were obtained on November 18, 2016. The flood validation consists of 188 points randomly selected all over the Aklan floodplain. Comparing it with the flood depth map of the nearest storm event, the map has an RMSE value of 1.38m. Figure 94 shows a contingency matrix of the comparison.

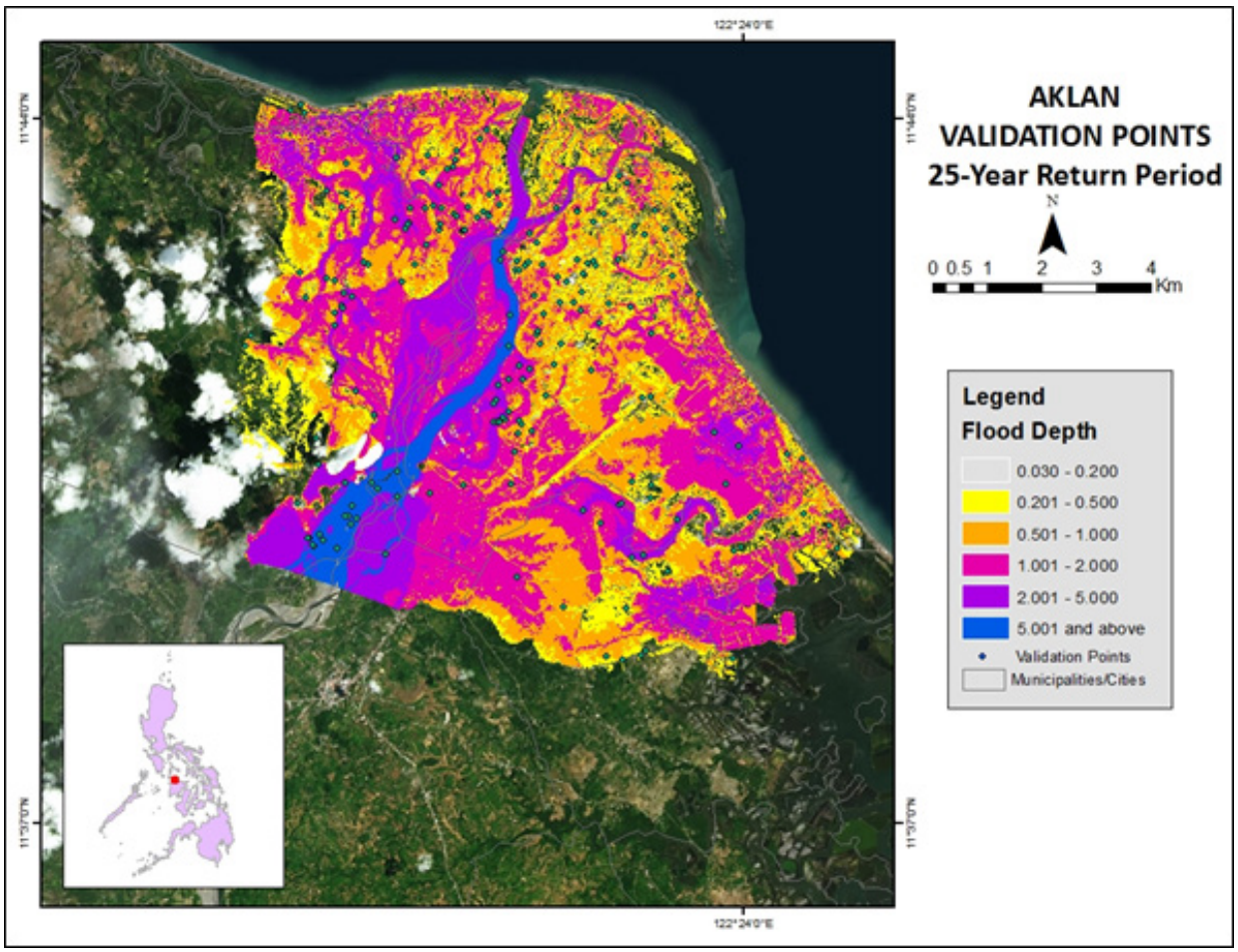


Figure 94. Validation points for 25-year Flood Depth Map of Aklan Floodplain

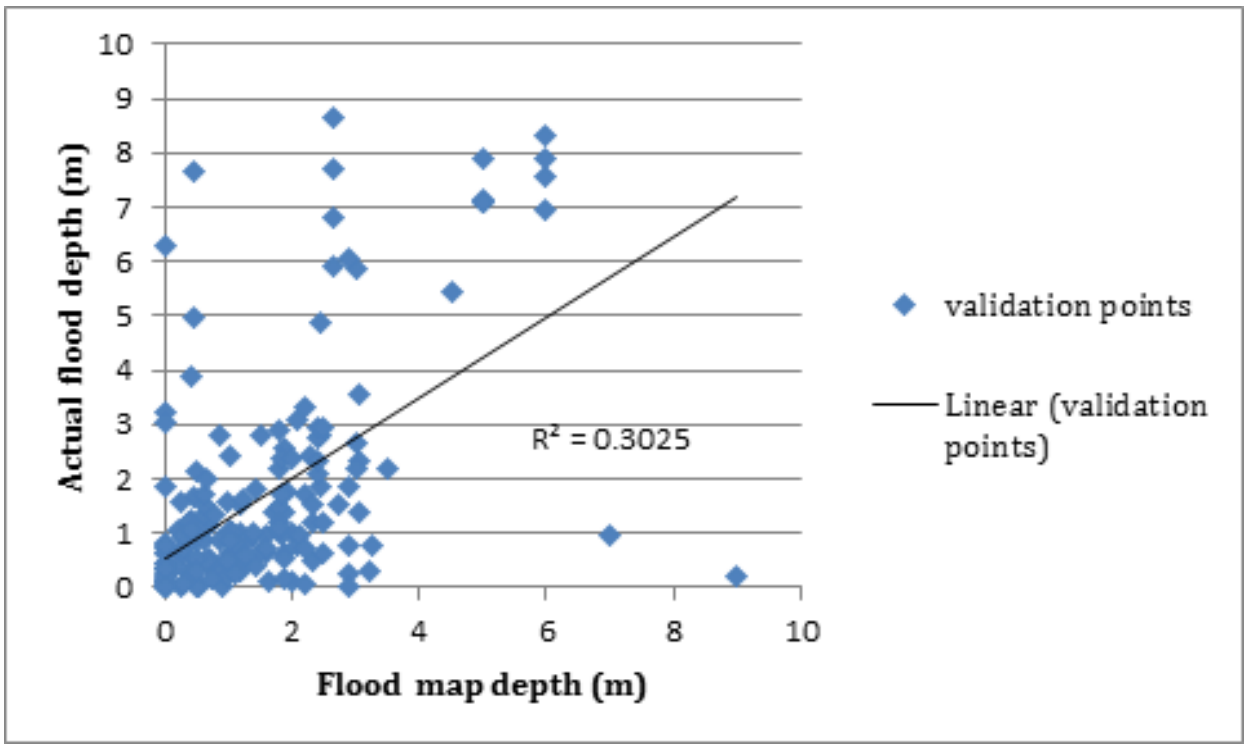


Figure 95. Flood map depth vs actual flood depth

Table 55. Actual Flood Depth vs Simulated Flood Depth in at different levels in the Aklan River Basin.

Actual Flood Depth (m)	Modeled Flood Depth (m)						
	0-0.20	0.21-0.50	0.51-1.00	1.01-2.00	2.01-5.00	> 5.00	Total
0-0.20	11	10	5	2	2	1	31
0.21-0.50	4	4	8	5	3	1	25
0.51-1.00	3	7	7	7	2	0	26
1.01-2.00	4	6	16	14	7	0	47
2.01-5.00	11	3	6	9	15	11	55
> 5.00	1	0	1	0	0	4	6
Total	34	30	43	37	29	17	190

The overall accuracy generated by the flood model is estimated at 28.95%, with 55 points correctly matching the actual flood depths. In addition, there were 85 points estimated one level above and below the correct flood depths while there were 106 points and 141 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 64 points were overestimated while a total of 71 points were underestimated in the modelled flood depths of Aklan. Table 56 depicts the summary of the Accuracy Assessment in the Aklan River Basin Survey.

Table 56. Summary of Accuracy Assessment in the Aklan River Basin Survey

	No. of Points	%
Correct	55	28.95
Overestimated	64	33.68
Underestimated	71	37.37
Total	190	100

REFERENCES

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

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

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

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

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

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

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

ANNEXES

Annex 1. Optech Technical Specification

AQUARIUS SENSOR

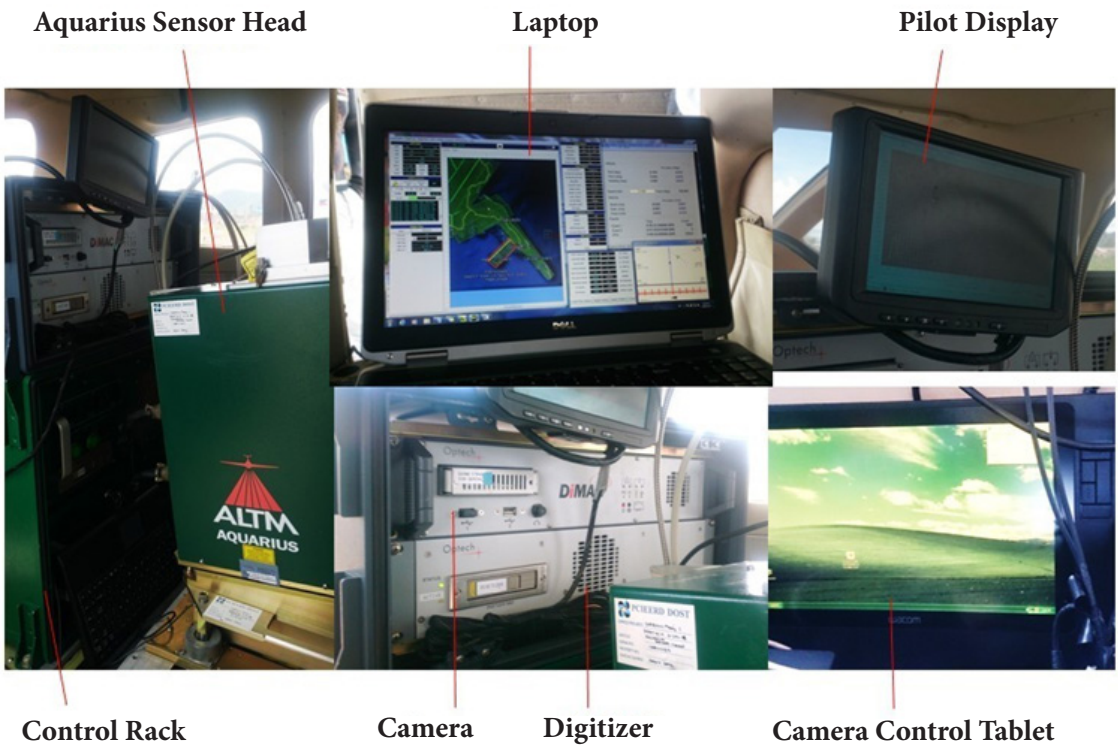


Figure A-1.1. The Aquarius Sensor

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

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

GEMINI SENSOR

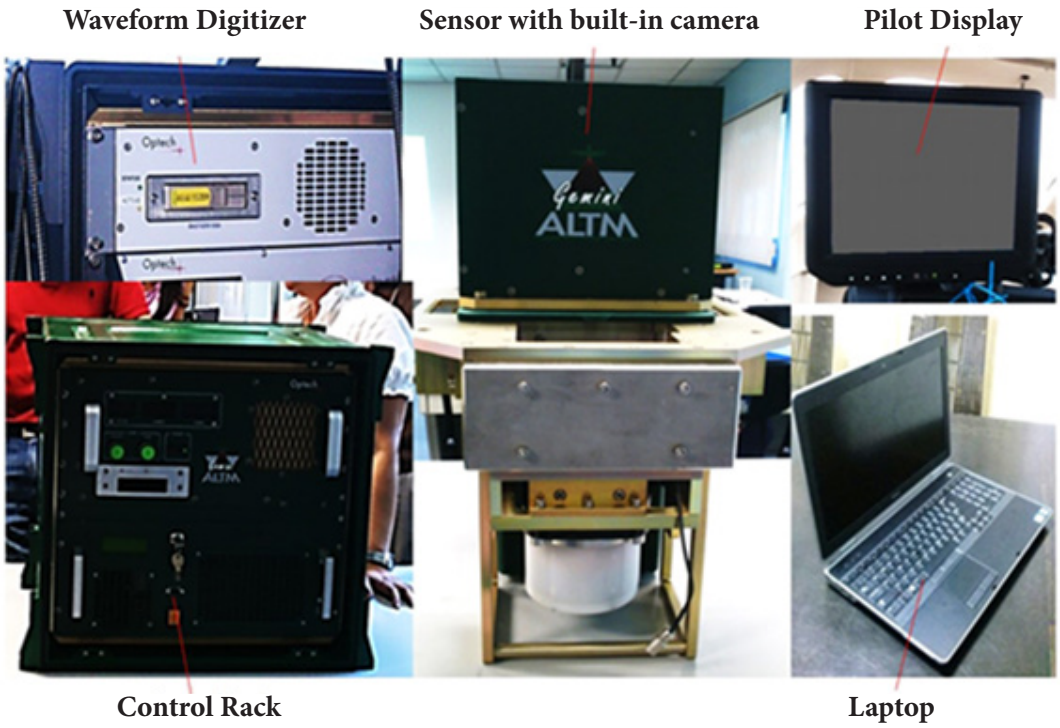


Figure A-1.2. The Gemini Sensor

Table A-1.2. Parameters and Specification of the Gemini Sensor

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

Annex 2. NAMRIA Certificates of Reference Points Used

1. AKN-43

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

March 25, 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: **AKLAN**
Station Name: **AKN-43**
Order: **2nd**

Island: **VISAYAS**
Municipality: **BANGA**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude: **11° 38' 27.12194"** Longitude: **122° 19' 53.01891"** Ellipsoidal Hgt: **17.74900 m.**

WGS84 Coordinates

Latitude: **11° 38' 22.52687"** Longitude: **122° 19' 58.16083"** Ellipsoidal Hgt: **72.44500 m.**

PTM Coordinates

Northing: **1287298.051 m.** Easting: **427093.296 m.** Zone: **4**

UTM Coordinates

Northing: **1,286,847.47** Easting: **427,118.81** Zone: **51**

Location Description

AKN-43
From Kalibo, travel S to the Mun. of Banga. Station is located on the concrete sidewalk in front of the mun. hall in line with the flagpole, about 20 m. SW of Rosal St. and 7 m. from Sampaguita St. Mark is the head of a 4 in. copper nail centered on a 25 cm. x 25 cm. cement putty, with inscriptions "AKN-43 2007 NAMRIA".

Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8795829 A**
T.N.: **2014-654**

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

9903252014114601

CIP/4701/12/09/814

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.1. AKN-43

2. AKN-42

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

March 25, 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: **AKLAN**
Station Name: **AKN-42**
Order: **2nd**

Island: **VISAYAS**
Municipality: **MAKATO**
Barangay: **LIBANG**

PRS92 Coordinates

Latitude: **11° 41' 4.84235"** Longitude: **122° 15' 49.78166"** Ellipsoidal Hgt: **17.77900 m.**

WGS84 Coordinates

Latitude: **11° 41' 0.23066"** Longitude: **122° 15' 54.92018"** Ellipsoidal Hgt: **72.20000 m.**

PTM Coordinates

Northing: **1292162.5 m.** Easting: **419737.946 m.** Zone: **4**

UTM Coordinates

Northing: **1,291,710.22** Easting: **419,766.04** Zone: **51**

Location Description

AKN-42

From Kalibo, travel NW to the Mun. of Makato. From the town proper, travel for about 5.6 km. to Brgy. Libang. Station is located at Brgy. Libang Multi-Purpose Center, beside the basketball court about 14 m. and 5 m. from the road, respectively.

Mark is the head of a 4 in. copper nail centered on a 30 cm. x 30 cm. cement putty, with inscriptions "AKN-42 2007 NAMRIA".

Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8795829 A**
T.N.: **2014-650**

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

9903252014114424

CIP/4701/12/09/834

NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
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Figure A-2.2. AKN-42

3. AKN-32

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

March 25, 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: **AKLAN**
Station Name: **AKN-46 (AKN-32)**
Order: **2nd**

Island: **VISAYAS**
Municipality: **BATAN**
Barangay: **POBLACION**

PRS92 Coordinates

Latitude: **11° 35' 14.35956"** Longitude: **122° 29' 42.04171"** Ellipsoidal Hgt: **3.89400 m.**

WGS84 Coordinates

Latitude: **11° 35' 9.79172"** Longitude: **122° 29' 47.18726"** Ellipsoidal Hgt: **59.12600 m.**

PTM Coordinates

Northing: **1281338.493 m.** Easting: **444924.599 m.** Zone: **4**

UTM Coordinates

Northing: **1,280,890.00** Easting: **444,943.88** Zone: **51**

Location Description

AKN-46 (AKN-32, 2000)

Is located at the Mun. of Batan, at the center point of Batan Multi-Purpose Sports Center, SW portion of the tennis court.

Mark is the head of a 4 in. copper nail centered on a 7 in. x 7 in. cement putty, with inscriptions "AKN-32 2000 NAMRIA".

Requesting Party: **UP DREAM**
Pupose: **Reference**
OR Number: **8795829 A**
T.N.: **2014-658**

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

9903252014114732

CIP/4701/12/09/814

NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
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Figure A-2.3. AKN-32

4. CPZ-14

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

April 26, 2013

CERTIFICATION

To whom it may concern:

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

Province: **CAPIZ**
Station Name: **CPZ-14**
Order: **2nd**

Island: **VISAYAS**
Municipality: **PANAY**
Barangay: **POBLACION ILAWOD**

PRS92 Coordinates

Latitude: **11° 33' 24.51899"** Longitude: **122° 47' 34.41876"** Ellipsoidal Hgt: **4.91900 m.**

WGS84 Coordinates

Latitude: **11° 33' 19.98412"** Longitude: **122° 47' 39.56494"** Ellipsoidal Hgt: **60.96000 m.**

PTM Coordinates

Northing: **1277923.165 m.** Easting: **477410.249 m.** Zone: **4**

UTM Coordinates

Northing: **1,277,475.87** Easting: **477,418.16** Zone: **51**

Location Description

CPZ-14
From Roxas City, travel E to the Mun. of Panay. Then proceed directly to the town plaza, where the station is located. Station is located at Panay Park, about 30 m. from the chuch and about 30 m. from the nat'l. road. Mark is the head of a 4 in. copper nail set flushed on top of a 30 cm. x 30 cm. concrete monument protruding 20 cm. above the ground, with inscriptions "CPZ-14 2007 NAMRIA".

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3943584 B**
T.N.: **2013-0364**

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

.9904262013163425

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

Figure A-2.4. CPZ-14

Annex 3. Baseline Processing Report of Reference Points Used

Vector Components (Mark to Mark)

From:	AKN-46 (AKN-32)				
Grid		Local		Global	
Easting	444943.877 m	Latitude	N11°35'14.35957"	Latitude	N11°35'09.79172"
Northing	1280890.002 m	Longitude	E122°29'42.04171"	Longitude	E122°29'47.18726"
Elevation	2.579 m	Height	3.894 m	Height	59.126 m

To:	AKN-ESTABLISHED				
Grid		Local		Global	
Easting	442945.322 m	Latitude	N11°30'03.97140"	Latitude	N11°29'59.42349"
Northing	1271360.155 m	Longitude	E122°28'36.62615"	Longitude	E122°28'41.77934"
Elevation	51.417 m	Height	52.842 m	Height	108.242 m

Vector					
ΔEasting	-1998.555 m	NS Fwd Azimuth	191°44'35"	ΔX	620.925 m
ΔNorthing	-9529.848 m	Ellipsoid Dist.	9740.674 m	ΔY	2714.840 m
ΔElevation	48.839 m	ΔHeight	48.948 m	ΔZ	-9334.230 m

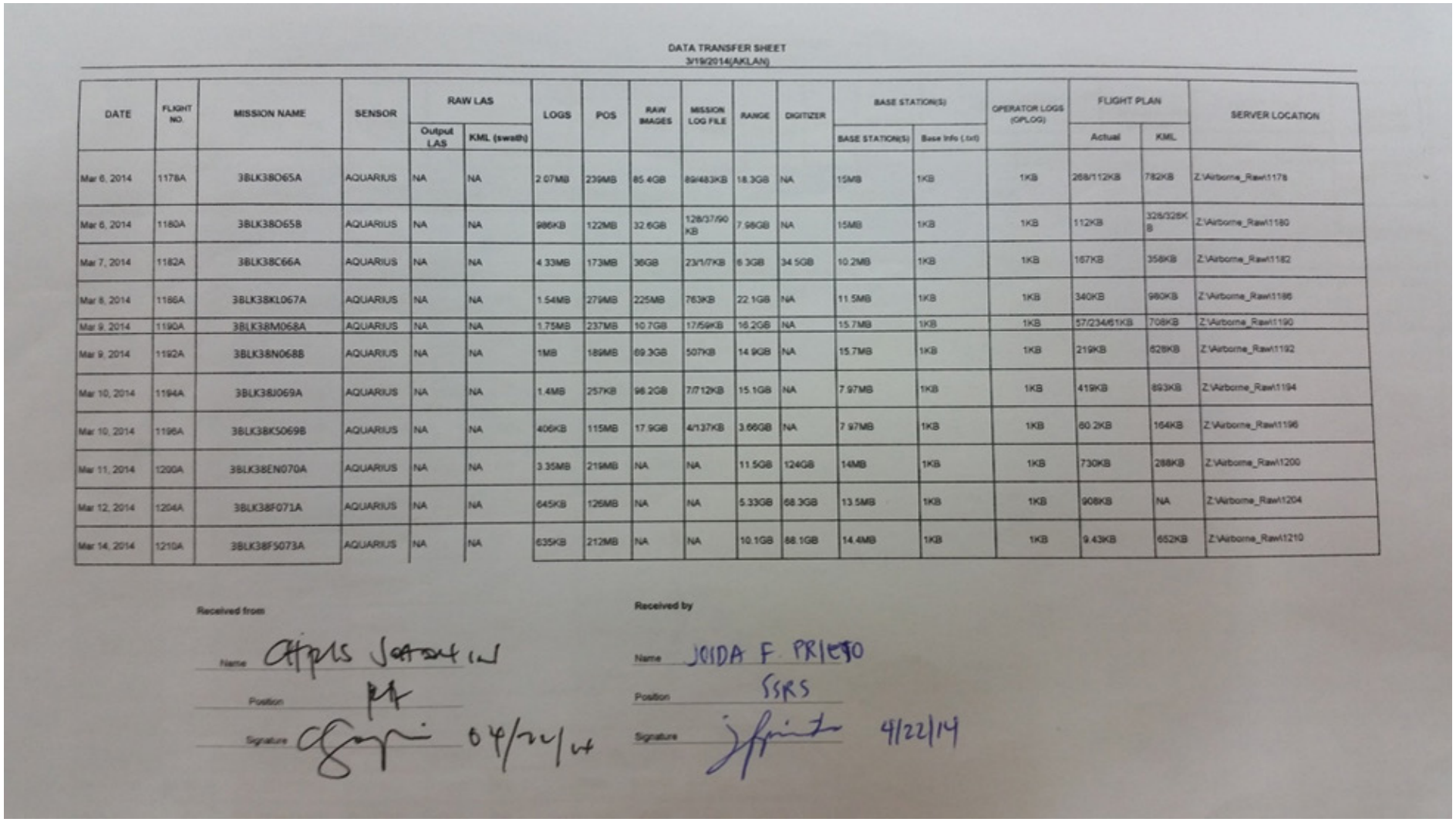
Figure A-3.1 Baseline Processing Report - A

Annex 4. The LiDAR Survey Team

Table A-4.1. 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. LOUIE P. BALICANTA	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP-TCAGP
	Supervising Science Research Specialist (Supervising SRS)	LOVELY GRACIA ACUNA	UP TCAGP
		LOVELYN ASUNCION	UP TCAGP
FIELD TEAM			
LiDAR Operation	Senior Science Research Specialist (SSRS)	JULIE PEARL MARS	UP-TCAGP
		PAULINE JOANNE ARCEO	UP-TCAGP
	Research Associate (RA)	PATRICIA ALCANTARA	UP-TCAGP
		DAN CHRISTOFFER ALDOVINO	
		JONATHAN ALMALVEZ	
		MARY CATHERINE ELIZABETH BALIGUAS	
Ground Survey, Data Download and Transfer	RA	JERIEL PAUL ALAMBAN	UP-TCAGP
		REGINA AEDRIENNE FELISMINO	UP-TCAGP
LiDAR Operation	Airborne Security	SSG. DAVE GUMBAN	PHILIPPINE AIR FORCE (PAF)
		SSG. JAYCO MANZANO	
	Pilot	CAPT. ALBERT LIM	ASIAN AEROSPACE CORPORATION (AAC)
		CAPT. JERICO JECIEL	AAC
		CAPT. JEPH ALAJAR	AAC
		CAPT. JACKSON JAVIER	AAC

Annex 5. Data Transfer Sheet for Aklan Floodplain Flights



DATA TRANSFER SHEET
3/19/2014(AKLAN)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS	RAW IMAGES	MISSION LOG FILE	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
Mar 6, 2014	1178A	3BLK38O65A	AQUARIUS	NA	NA	2.07MB	239MB	85.4GB	89/483KB	18.3GB	NA	15MB	1KB	1KB	268/112KB	782KB	Z:\Airborne_Raw\1178
Mar 6, 2014	1180A	3BLK38O65B	AQUARIUS	NA	NA	986KB	122MB	32.6GB	128/37/90 KB	7.98GB	NA	15MB	1KB	1KB	112KB	328/325KB	Z:\Airborne_Raw\1180
Mar 7, 2014	1182A	3BLK38C66A	AQUARIUS	NA	NA	4.33MB	173MB	36GB	23/1/7KB	6.3GB	34.5GB	10.2MB	1KB	1KB	167KB	358KB	Z:\Airborne_Raw\1182
Mar 8, 2014	1186A	3BLK38KL067A	AQUARIUS	NA	NA	1.54MB	279MB	225MB	763KB	22.1GB	NA	11.5MB	1KB	1KB	340KB	980KB	Z:\Airborne_Raw\1186
Mar 9, 2014	1190A	3BLK38M068A	AQUARIUS	NA	NA	1.75MB	237MB	10.7GB	17/59KB	16.2GB	NA	15.7MB	1KB	1KB	57/234/61KB	708KB	Z:\Airborne_Raw\1190
Mar 9, 2014	1192A	3BLK38N068B	AQUARIUS	NA	NA	1MB	189MB	69.3GB	507KB	14.9GB	NA	15.7MB	1KB	1KB	219KB	628KB	Z:\Airborne_Raw\1192
Mar 10, 2014	1194A	3BLK38J069A	AQUARIUS	NA	NA	1.4MB	257KB	98.2GB	7/712KB	15.1GB	NA	7.97MB	1KB	1KB	419KB	693KB	Z:\Airborne_Raw\1194
Mar 10, 2014	1196A	3BLK38K5069B	AQUARIUS	NA	NA	406KB	115MB	17.9GB	4/137KB	3.66GB	NA	7.97MB	1KB	1KB	60.2KB	164KB	Z:\Airborne_Raw\1196
Mar 11, 2014	1200A	3BLK38EN070A	AQUARIUS	NA	NA	3.35MB	219MB	NA	NA	11.5GB	124GB	14MB	1KB	1KB	730KB	288KB	Z:\Airborne_Raw\1200
Mar 12, 2014	1204A	3BLK38F071A	AQUARIUS	NA	NA	645KB	126MB	NA	NA	5.33GB	68.3GB	13.5MB	1KB	1KB	908KB	NA	Z:\Airborne_Raw\1204
Mar 14, 2014	1210A	3BLK38F5073A	AQUARIUS	NA	NA	635KB	212MB	NA	NA	10.1GB	68.1GB	14.4MB	1KB	1KB	9.43KB	652KB	Z:\Airborne_Raw\1210

Received from

Name

Position

Signature 04/22/14

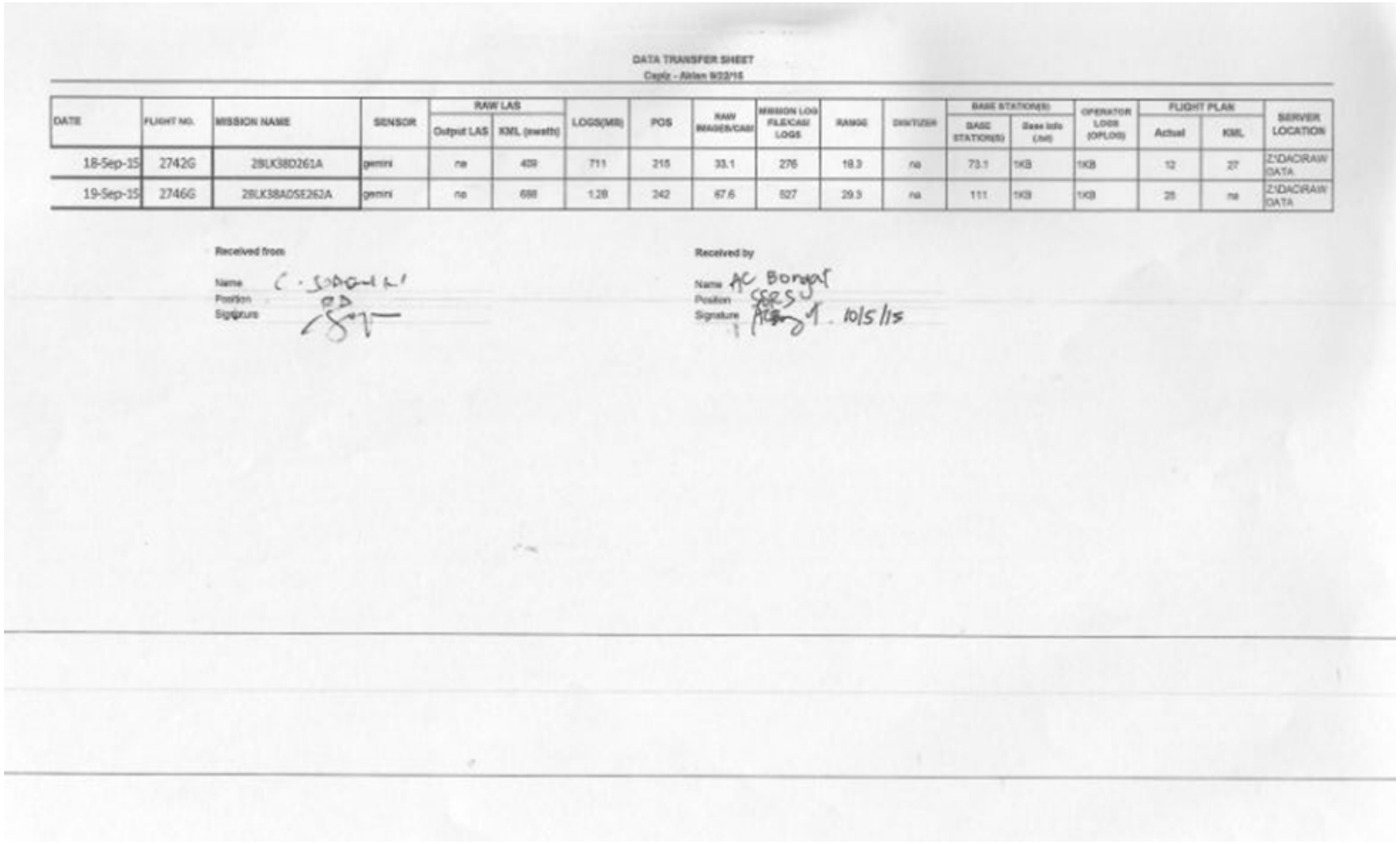
Received by

Name JOIDA F. PRIETO

Position SSRS

Signature 4/22/14

Figure A-5.1. Data Transfer Sheet for Aklan Floodplain - A



DATA TRANSFER SHEET

Copy - Aklan 9/22/15

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CAM	MISSION LOG FILE/CAM 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	
18-Sep-15	2742G	28LK38D261A	gemini	na	409	711	215	33.1	276	18.3	na	73.1	1KB	1KB	12	27	Z:\DAC\RAW DATA
19-Sep-15	2746G	28LK38ADSE262A	gemini	na	688	1.28	242	67.6	527	29.3	na	111	1KB	1KB	25	na	Z:\DAC\RAW DATA

Received from

Name C. SOLOMON

Position PD

Signature

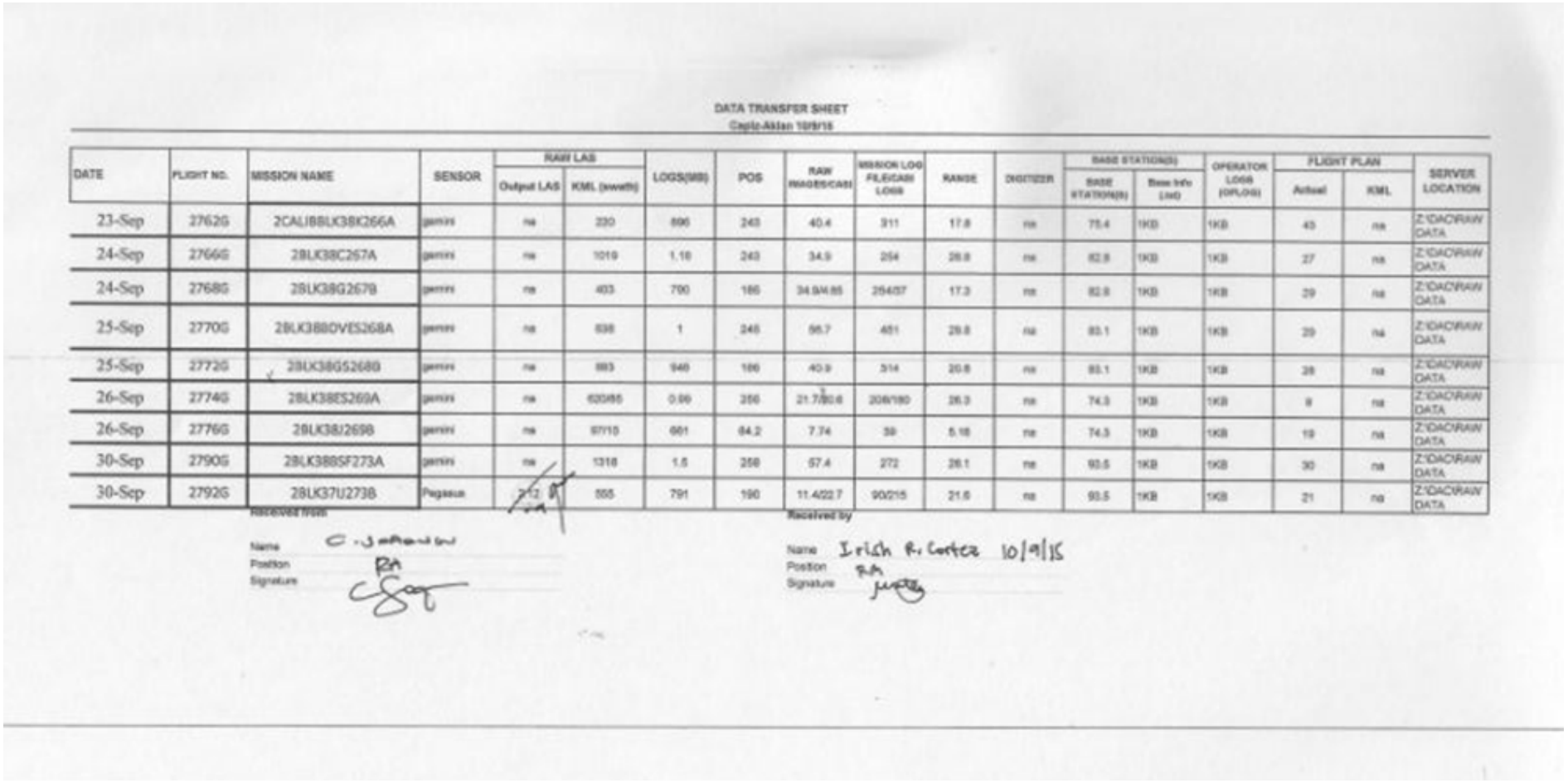
Received by

Name AC Bongat

Position SSRSJ

Signature 10/5/15

Figure A-5.2. Data Transfer Sheet for Aklan Floodplain - B



DATA TRANSFER SHEET

Cagayan-Aklan 10/9/15

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CAM	MISSION LOG FILE/CAM 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	
23-Sep	2762G	2CALIBBLK38K266A	gemini	na	220	896	243	40.4	311	17.8	na	75.4	1KB	1KB	43	na	Z:\DAC\RAW DATA
24-Sep	2766G	2BLK38C267A	gemini	na	1019	1.18	243	34.9	264	28.8	na	82.8	1KB	1KB	27	na	Z:\DAC\RAW DATA
24-Sep	2768G	2BLK38G267B	gemini	na	403	700	186	34.9/4.85	254/57	17.3	na	82.8	1KB	1KB	29	na	Z:\DAC\RAW DATA
25-Sep	2770G	2BLK38BOVES268A	gemini	na	838	1	246	56.7	451	29.8	na	83.1	1KB	1KB	29	na	Z:\DAC\RAW DATA
25-Sep	2772G	2BLK38GS268B	gemini	na	883	946	186	40.9	314	20.8	na	83.1	1KB	1KB	28	na	Z:\DAC\RAW DATA
26-Sep	2774G	2BLK38ES269A	gemini	na	620/85	0.99	256	21.7/80.6	208/180	26.3	na	74.3	1KB	1KB	9	na	Z:\DAC\RAW DATA
26-Sep	2776G	2BLK38J269B	gemini	na	97/15	661	84.2	7.74	59	5.16	na	74.3	1KB	1KB	19	na	Z:\DAC\RAW DATA
30-Sep	2790G	2BLK38BSF273A	gemini	na	1318	1.5	256	57.4	272	28.1	na	93.5	1KB	1KB	30	na	Z:\DAC\RAW DATA
30-Sep	2792G	2BLK37U273B	Pegasus	212	555	791	190	11.4/22.7	90/215	21.6	na	93.5	1KB	1KB	21	na	Z:\DAC\RAW DATA

Received from

Name C. J. [illegible]

Position RA

Signature

Received by

Name Irish R. Cortez 10/9/15

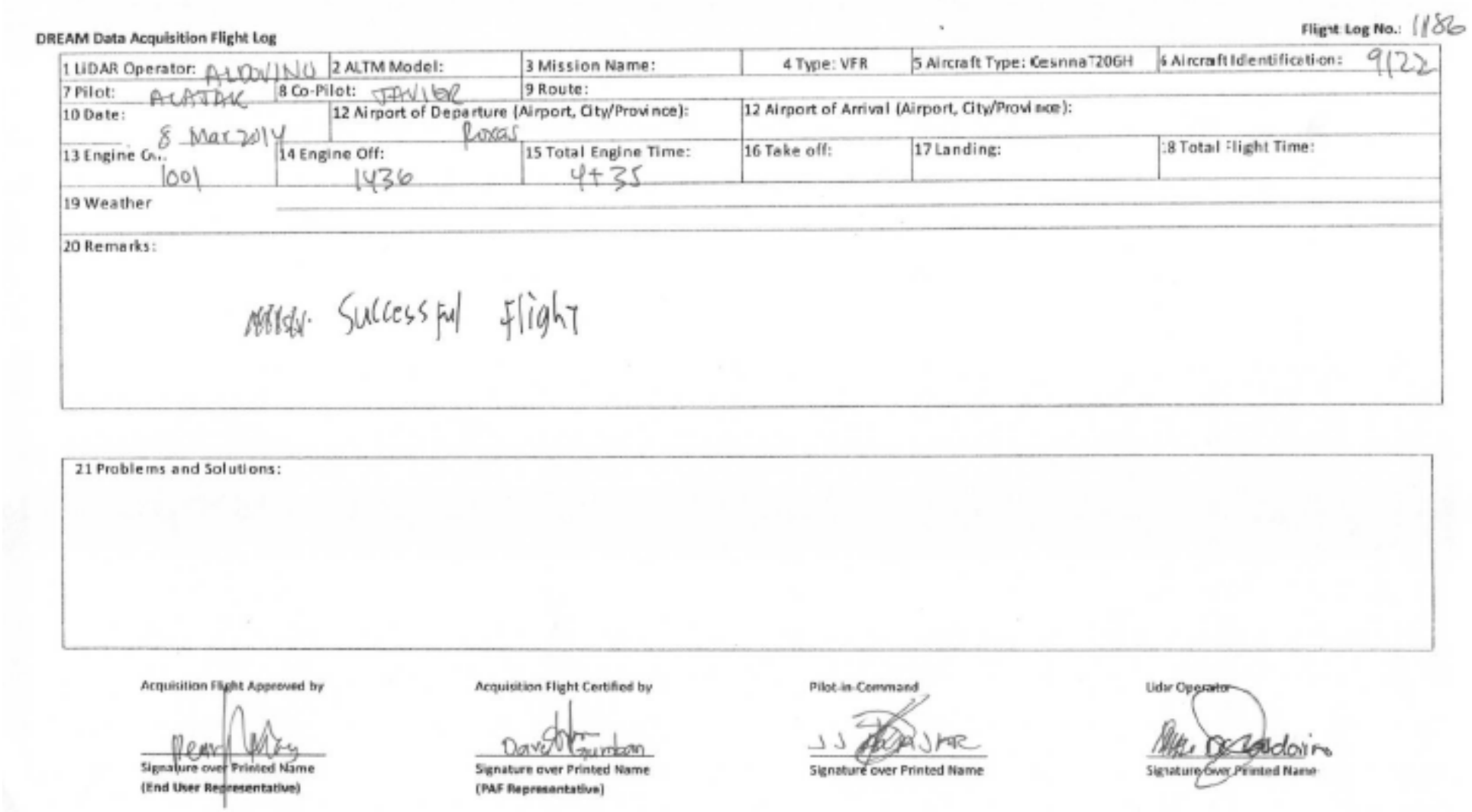
Position RA

Signature

Figure A-5.3. Data Transfer Sheet for Aklan Floodplain - C

Annex 6. Flight Logs

1. Flight log for 1186A mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1186

1 LiDAR Operator: ALDOVINO	2 ALTM Model:	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: ALASTAIR	8 Co-Pilot: JAVIER	9 Route:			
10 Date: 8 Mar 2014	12 Airport of Departure (Airport, City/Province): Roxas	12 Airport of Arrival (Airport, City/Province):			
13 Engine On: 1001	14 Engine Off: 1436	15 Total Engine Time: 4+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: Successful Flight					
21 Problems and Solutions:					

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

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Figure A-6.1. Flight Log for Mission 1186A

2. Flight log for 1190A mission

DREAM Data Acquisition Flight Log — Flight Log No.: 1190

1 LiDAR Operator: P-MAPS	2 ALTM Model: AQUA	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 4122
7 Pilot: [illegible]	8 Co-Pilot: [illegible]	9 Route:			
10 Date: 9 March 2014	12 Airport of Departure (Airport, City/Province): Roxas	12 Airport of Arrival (Airport, City/Province):			
13 Engine On: 818	14 Engine Off: 1217	15 Total Engine Time: 3+59	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: Successful flight					
21 Problems and Solutions:					

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

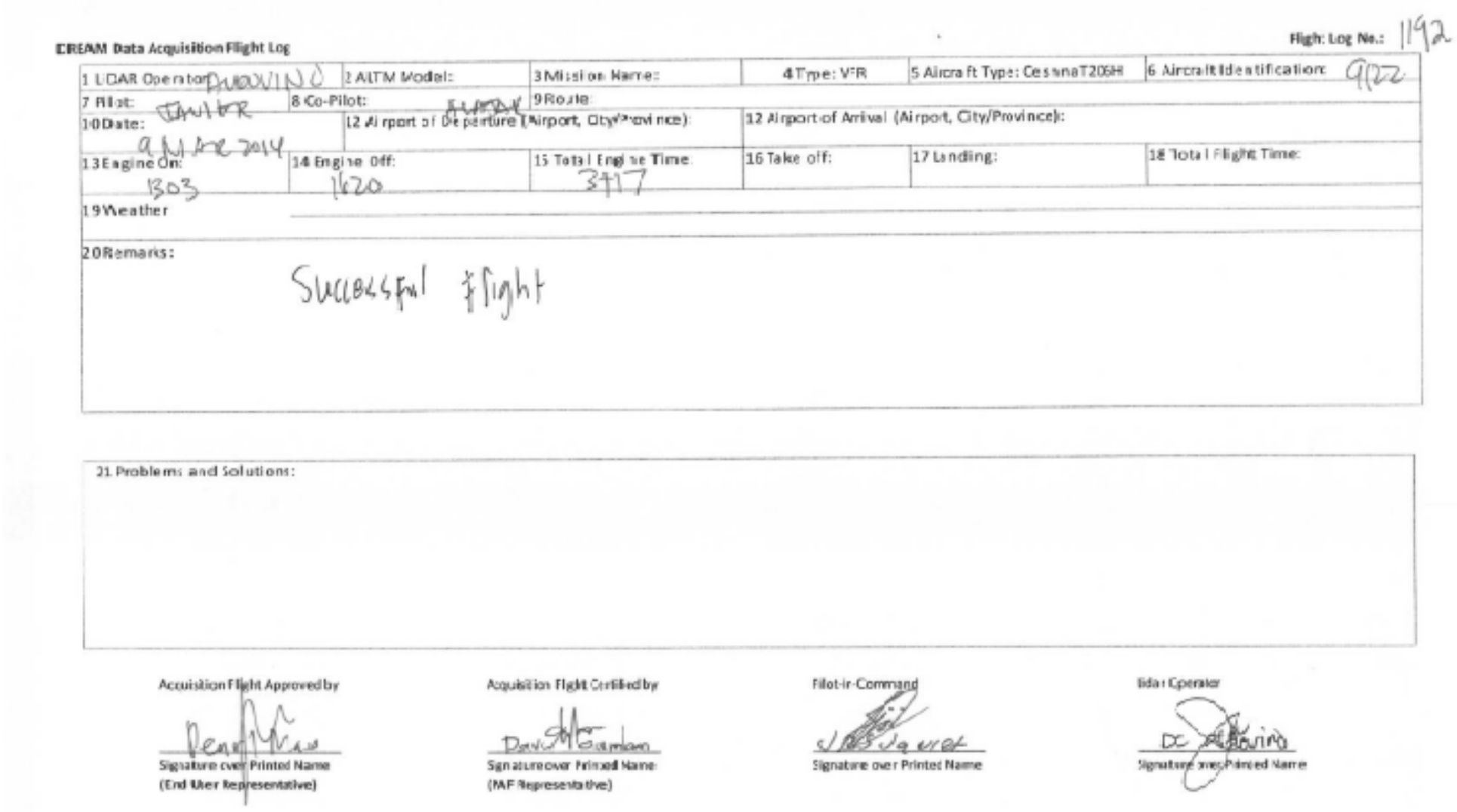
Acquisition Flight Certified by
Signature over Printed Name
(PAF Representative)

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Figure A-6.2. Flight Log for Mission 1190A

3. Flight log for 1192A mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1192

1 LiDAR Operator: PHILVINCO	2 ALTM Model:	3 Mission Name:	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification: 9122
7 Pilot: JAMTOR	8 Co-Pilot:	9 Route:			
10 Date: 9 JUNE 2014	11 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1303	14 Engine Off: 1620	15 Total Engine Time: 3.17	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks: Successful flight					
21 Problems and Solutions:					

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

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

Pilot-in-Command
Signature over Printed Name

lidar Operator
Signature over Printed Name

Figure A-6.3. Flight Log for Mission 1192A

4. Flight log for 1194A mission

DREAM Data Acquisition Flight Log — Flight Log No.: 1194

1 DAR Operator: Aboitiz NCO	2 ALTM Model: Aero	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9172
7 Pilot: JAYSON	8 Co-Pilot: CHRISTIAN	9 Route :			
10 Date : 10 Mar 2014	11 Airport of Departure (Airport, City/Province): Roxas	12 Airport of Arrival (Airport, City/Province):			
13 Engine On.: 0617	14 Engine Off: 1234	15 Total Engine Time: 4+17	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					
20 Remarks : Successful Flight					
21 Problems and Solutions:					

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

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Figure A-6.4. Flight Log for Mission 1194A

5. Flight log for 1196A mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1196

1 LiDAR Operator: Pat Macatara	2 ALTM Model: Aquarius	3 Mission Name: [illegible]	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification: 9122
7 Pilot: Javier	8 Co-Pilot: Alajar	9 Route:			
10 Date: Mar 10, 2014	12 Airport of Departure (Airport, City/Province): Roxas		12 Airport of Arrival (Airport, City/Province): Roxas		
13 Engine On: 135	14 Engine Off: 416	15 Total Engine Time: 2+41	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Windy					

20 Remarks:

shutter wont open, range missing
camera hanged, restart camera

Finished 5 lines

21 Problems and Solutions:

range missing, restart system
camera hanged, restart sy

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

Figure A-6.5. Flight Log for Mission 1196A

6. Flight log for 1210A mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1210

1 LiDAR Operator: Rear, Mac	2 ALTM Model: ATOVA	3 Mission Name: [illegible]	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification: 9122
7 Pilot: [illegible]	8 Co-Pilot: [illegible]	9 Route:			
10 Date: 14 March 2014	12 Airport of Departure (Airport, City/Province): Roxas City	12 Airport of Arrival (Airport, City/Province):			
13 Engine On: 850	14 Engine Off: 1225	15 Total Engine Time: 3+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					
20 Remarks: Success FM flight					
21 Problems and Solutions:					

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

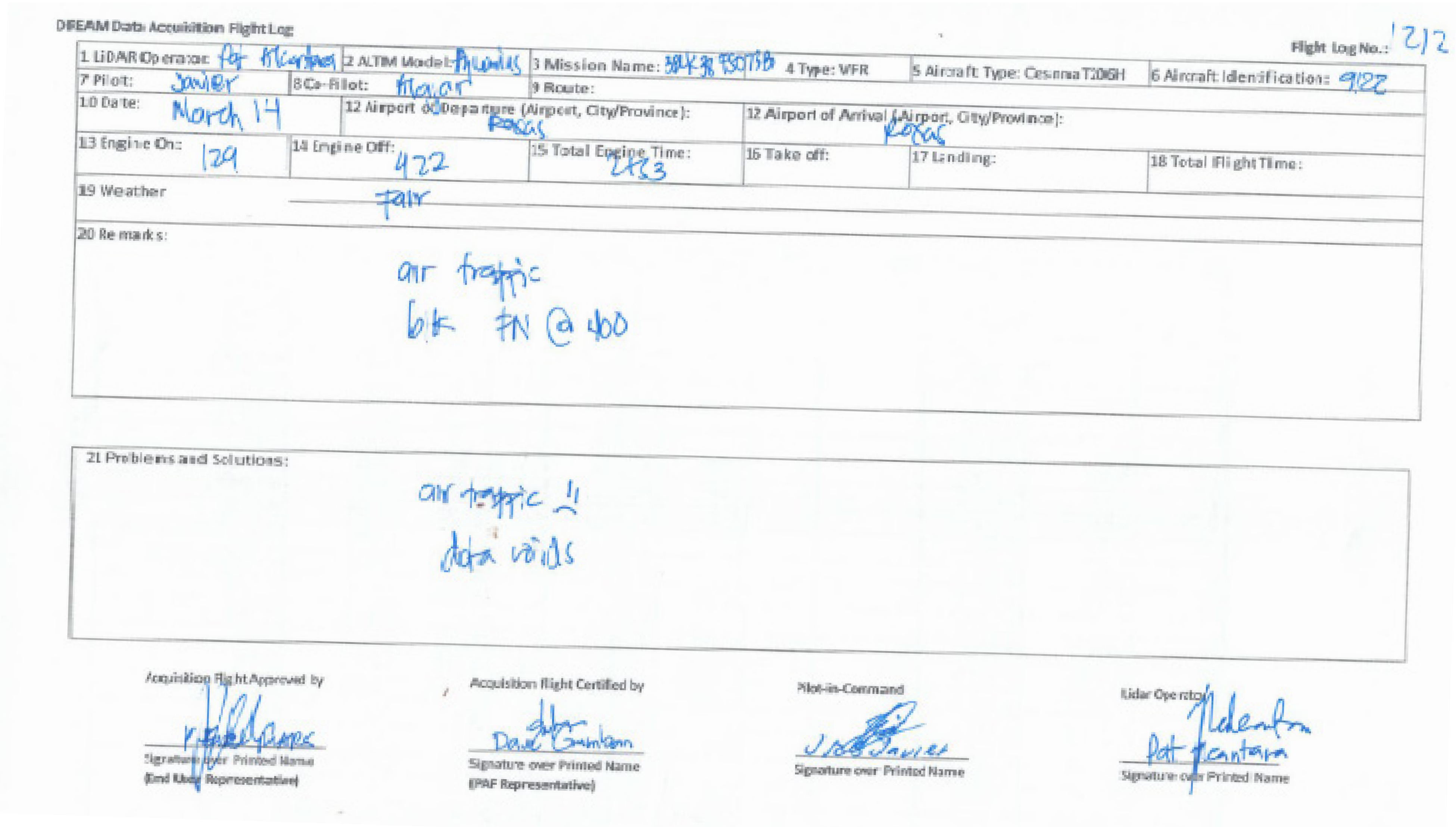
Acquisition Flight Certified by
Signature over Printed Name
(PAF Representative)

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Figure A-6.6. Flight Log for Mission 1210A

7. Flight log for 1212A mission


DREAM Data Acquisition Flight Log

Flight Log No.: 1212

1 LiDAR Operator: Pat Alcantara	2 ALTM Model: Pegasus	3 Mission Name: 3BLK38B50173B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: Javier	8 Co-Pilot: Mayor	9 Route:			
10 Date: March 14	12 Airport of Departure (Airport, City/Province): Roxas		12 Airport of Arrival (Airport, City/Province): Roxas		
13 Engine On: 129	14 Engine Off: 422	15 Total Engine Time: 2+53	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: fair					

20 Remarks:

air traffic

6.1k FN @ 400

21 Problems and Solutions:

air traffic !!

data voids

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

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

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

Lidar Operator — Pat Alcantara — Signature over Printed Name

Figure A-6.7. Flight Log for Mission 1212A

8. Flight log for 1214A mission

DREAM Data Acquisition Flight Log Flight Log No.: 1214

1 LiDAR Operator: Pat Mcantara	2 ALTM Model: Aquarius	3 Mission Name: 30KX6074A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: Javier	8 Co-Pilot: Mayar	9 Route:			
10 Date: Mar 15	12 Airport of Departure (Airport, City/Province): Roxas	12 Airport of Arrival (Airport, City/Province): Roxas			
13 Engine On: 1148	14 Engine Off: 1550 1617	15 Total Engine Time: 2+	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Rainy, low clouds					
20 Remarks: Mission Aborted, Full of data voids, changed area 3x Bad weather — low clouds, rain					
21 Problems and Solutions: Camera empty status, no photos; restart camera					

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

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

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

Figure A-6.8. Flight Log for Mission 1214A

9. Flight log for 1222A mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1222

1 LiDAR Operator: D-Mars	2 ALTM Model: Aerial	3 Mission Name: [illegible]	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: Javier	8 Co-Pilot: Major	9 Route:			
10 Date: 7 Mar 2014	11 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0840	14 Engine Off: 1309	15 Total Engine Time: 4.29	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					
20 Remarks: Successful flight					
21 Problems and Solutions:					

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

Figure A-6.9. Flight Log for Mission 1222A

10. Flight log for 1224A mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1224

1 LiDAR Operator: [illegible]	2 ALTM Model: [illegible]	3 Mission Name: [illegible]	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: [illegible]	8 Co-Pilot: [illegible]	9 Route:			
10 Date: March 17	11 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1350	14 Engine Off: 16:13	15 Total Engine Time: 2+23	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: FAIR					
20 Remarks: SUCCESSFUL flight					

21 Problems and Solutions:

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

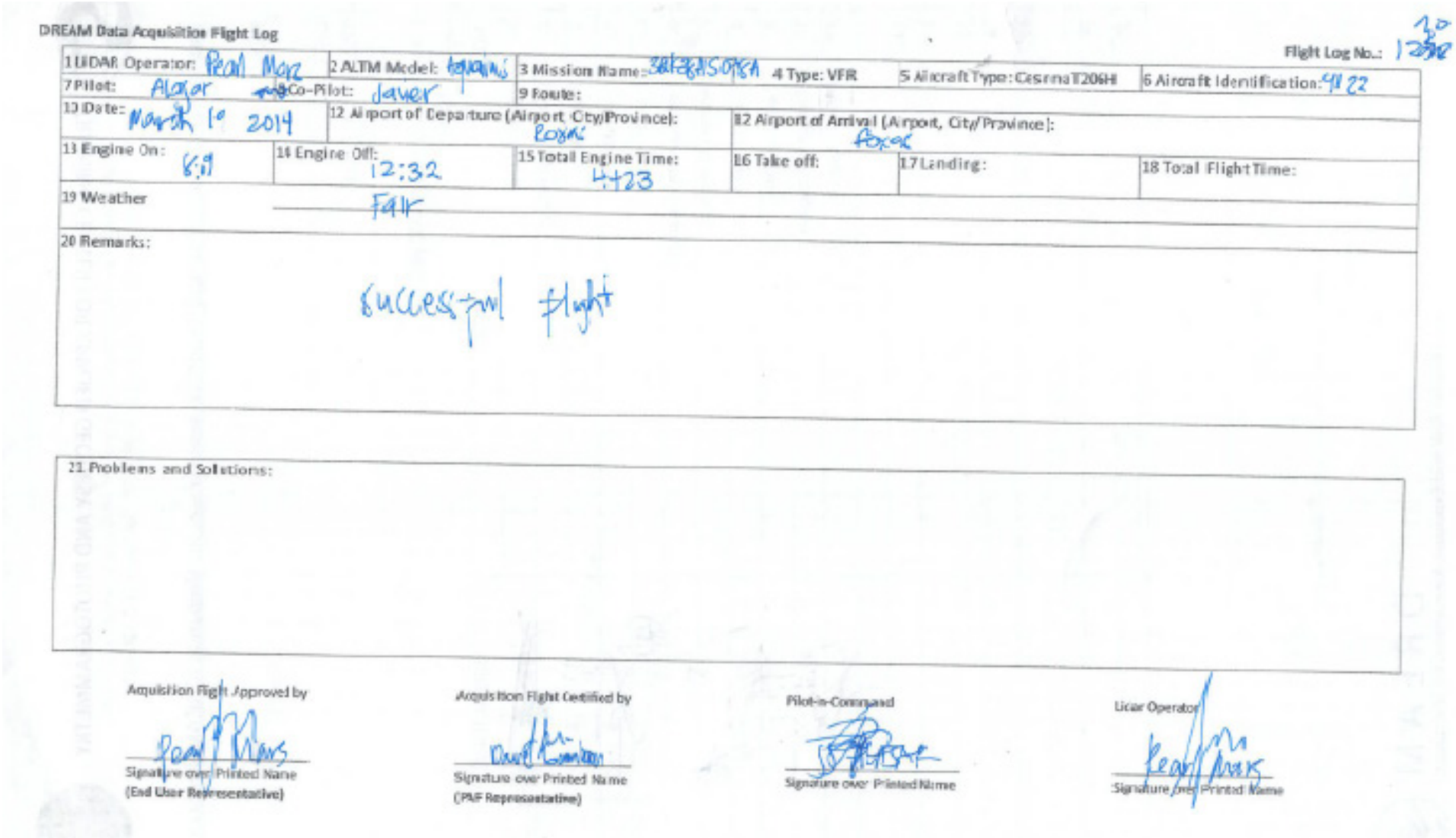
Acquisition Flight Certified by
Signature over Printed Name
(NAF Representative)

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Figure A-6.10. Flight Log for Mission 1224A

11. Flight log for 1230A mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1230A

1 LiDAR Operator: Pearl Mae	2 ALTM Model: [illegible]	3 Mission Name: 3AKLAN01A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 4122
7 Pilot: Alajar	8 Co-Pilot: Javier	9 Route:			
10 Date: March 10 2014	11 Airport of Departure (Airport, City/Province): Boracay		12 Airport of Arrival (Airport, City/Province): Boracay		
13 Engine On: 8:9	14 Engine Off: 12:32	15 Total Engine Time: 4+23	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					
20 Remarks: Successful flight					
21 Problems and Solutions:					

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

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Figure A-6.11. Flight Log for Mission 1230A

12. Flight log for 1232A mission

DREAM Data Acquisition Flight Log — Flight Log No.: 1232A

1 LiDAR Operator: DC Pidoyno	2 ALTM Model: Aquarius	3 Mission Name: [illegible]	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: Algar	8 Co-Pilot: Javier	9 Route:			
10 Date: Mar 19 2014	12 Airport of Departure (Airport, City/Province): Boxas	12 Airport of Arrival (Airport, City/Province): Boxas			
13 Engine On: 1:13	14 Engine Off: 4:18	15 Total Engine Time: 3+5	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					
20 Remarks: successful flight					

21 Problems and Solutions:

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

Figure A-6.12. Flight Log for Mission 1232A

13. Flight log for 1238A mission

DREAM Data Acquisition Flight Log — Flight Log No.: 1238

1 LiDAR Operator: P. Mars	2 ALTM Model: Aquarius	3 Mission Name: 3BLK38B080A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: Alajar	8 Co-Pilot: Javier	9 Route:			
10 Date: 21 Mar 2014	12 Airport of Departure (Airport, City/Province): Roxas	12 Airport of Arrival (Airport, City/Province): Roxas			
13 Engine On: 7:40	14 Engine Off: 12:27	15 Total Engine Time: 4+47	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					
20 Remarks: successful flight					

21 Problems and Solutions:

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

Figure A-6.13. Flight Log for Mission 1238A

14. Flight log for 1240A mission

DREAM Data Acquisition Flight Log — **Flight Log No.:** 1240

1 LIDAR Operator: DC ALCOVIND	2 ALTM Model: AQUA	3 Mission Name: 3BLK38B0790	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: C9122
7 Pilot: J. JAVIER	8 Co-Pilot: J. ALCASAR	9 Route: AKLAN			
10 Date: MAR. 21, 2014	12 Airport of Departure (Airport, City/Province): AKLAN		12 Airport of Arrival (Airport, City/Province): AKLAN		
13 Engine On: 1302	14 Engine Off: 1543	15 Total Engine Time: 2+41	16 Take off:	17 Landing:	18 Total Flight Time: 2+33
19 Weather					
20 Remarks: SUCCESSFUL FLIGHT					

21 Problems and Solutions:

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

Figure A-6.14. Flight Log for Mission 1240A

15. Flight log for 2742G mission

Data Acquisition Flight Log — **Flight Log No.:** 2742G

1 LiDAR Operator: MCE BALIGWAS & PJ ARCEO	2 ALTM Model: GEMINI	3 Mission Name: 30LK380261A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: A. LIM	8 Co-Pilot: D. CABUDOL	9 Route:			
10 Date: Sept. 18, 2015	12 Airport of Departure (Airport, City/Province): RDXAS	12 Airport of Arrival (Airport, City/Province):			
13 Engine On: 0917	14 Engine Off: 1003	15 Total Engine Time: 3.53	16 Take off:	17 Landing:	18 Total Flight Time:
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 380

22 Problems and Solutions

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

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

Figure A-6.15. Flight Log for Mission 2742G

16. Flight log for 2746G mission

Data Acquisition Flight Log — **Flight Log No.:** 2746G

1 LiDAR Operator: MCE BALICIAS RJ ARCEO	2 ALTM Model: GEMINI	3 Mission Name: 28LK38A05E2JAA	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: A. LIM	8 Co-Pilot: D. CABUDOL	9 Route:			
10 Date: Sept. 19, 2015	12 Airport of Departure (Airport, City/Province): ROXAS	12 Airport of Arrival (Airport, City/Province):			
13 Engine On: 1129	14 Engine Off: 1535	15 Total Engine Time: 04 + 06	16 Take off:	17 Landing:	18 Total Flight Time:
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 BLK38A & BLK38E and voids over BLK38D.

22 Problems and Solutions

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator	Aircraft Mechanic/ Technician
LOVELYN B. AGUNOD	MC TOYCO MONTEMAYOR PAF		MCE BALICIAS	
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.16. Flight Log for Mission 2746G

17. Flight log for 2766G mission

Data Acquisition Flight Log

Flight Log No.: 2766

1 LiDAR Operator: MCE BALIGVAS	2 ALTM Model: GEM	3 Mission Name: 28BK39C207A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: A. LIM	8 Co-Pilot: J. JECIEL	9 Route:			
10 Date: 24 SEPT 15	12 Airport of Departure (Airport, City/Province):	12 Airport of Arrival (Airport, City/Province):			
13 Engine On: 0950	14 Engine Off: 0955	15 Total Engine Time: 4705	16 Take off:	17 Landing:	18 Total Flight Time:
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 39C

22 Problems and Solutions

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

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

Figure A-6.17. Flight Log for Mission 2766G

18. Flight log for 2768G mission

Data Acquisition Flight Log

Flight Log No.: 2768G

1 LiDAR Operator: RAY FELICIANO	2 ALTM Model: GEMINI	3 Mission Name: BLK38G2768	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: A. LIM	8 Co-Pilot: J. JEGEL	9 Route: ROXAS – ROXAS			
10 Date: 24 SEPT 15	12 Airport of Departure (Airport, City/Province): ROXAS		12 Airport of Arrival (Airport, City/Province): ROXAS		
13 Engine On: 1242	14 Engine Off: 1559	15 Total Engine Time: 3+17	16 Take off: 1247	17 Landing: 1554	18 Total Flight Time: 3+07
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 Mairtenance
○ System Test Flight	○ Others: _____	○ Phil-LiDAR Admin Activities
○ Calibration Flight		

21 Remarks: Surveyed 8 lines over BLK38G with voids

22 Problems and Solutions

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator	Aircraft Mechanic/ Technician
LOVELYN ASUNCION	[illegible] PAF	A. LIM	RAY FELICIANO	___
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.18. Flight Log for Mission 2768G

19. Flight log for 2770G mission

Data Acquisition Flight Log

Flight Log No.: 2770G

1 LiDAR Operator: RNG PELISMINO	2 ALTM Model: GEM	3 Mission Name: 28LK38OVES 2684	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: A. LIM	8 Co-Pilot: J. JECIEL	9 Route:			
10 Date: 25 SEPT 19	12 Airport of Departure (Airport, City/Province): ILOILO	12 Airport of Arrival (Airport, City/Province):			
13 Engine On: 0555	14 Engine Off: 1018	15 Total Engine Time: 4+23	16 Take off:	17 Landing:	18 Total Flight Time:
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

Covered voids over BLK38D & 2 lines over BLK38E

22 Problems and Solutions

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

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

Figure A-6.19. Flight Log for Mission 2770G

20. Flight log for 2772G mission

Data Acquisition Flight Log

Flight Log No.: 2772G

1 LIDAR Operator: MCE BALIGUAS	2 ALTM Model: GEM	3 Mission Name: 28LK386G	2688 4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 922
7 Pilot: A. LIM	8 Co-Pilot: J. JECIEL	9 Route: ROXAS – ROXAS			
10 Date: 25 SEPT 15	12 Airport of Departure (Airport, City/Province): ROXAS	12 Airport of Arrival (Airport, City/Province): ROXAS			
13 Engine On: 1244	14 Engine Off: 1555	15 Total Engine Time: 3+11	16 Take off: 1249	17 Landing: 1650	18 Total Flight Time: 3+01
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 28LK386G

22 Problems and Solutions

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

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

Figure A-6.20. Flight Log for Mission 2772G

21. Flight log for 2774G mission

Data Acquisition Flight Log

Flight Log No.: 2774G

1 LiDAR Operator: L. ASUNCION JR. / J. ALMALUEZ	2 ALTM Model: GEM	3 Mission Name: 2BLK39ES269A	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification: 9122
7 Pilot: A. LIM	8 Co-Pilot: J. JECIEL	9 Route: ROXAS - ROXAS			
10 Date: 26 SEPT 15	12 Airport of Departure (Airport, City/Province): ROXAS	12 Airport of Arrival (Airport, City/Province): ROXAS			
13 Engine On: 0607	14 Engine Off: 1024	15 Total Engine Time: 4+17	16 Take off: 0612	17 Landing: 1019	18 Total Flight Time: 4+07
19 Weather: PAIK					

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 39E

22 Problems and Solutions

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

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

Figure A-6.21. Flight Log for Mission 2774G

22. Flight log for 2790G mission

Data Acquisition Flight Log

Flight Log No.: 2790G

1 LiDAR Operator: PAG FOLGARINO	2 ALTM Model: GEMI	3 Mission Name: 2BLK3BOVES 2484	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: A. LIM	8 Co-Pilot: J. JECIEL	9 Route:			
10 Date: 25 SEPT 19	12 Airport of Departure (Airport, City/Province): LOKAS	12 Airport of Arrival (Airport, City/Province):			
13 Engine On: 0755	14 Engine Off: 1018	15 Total Engine Time: 4+23	16 Take off:	17 Landing:	18 Total Flight Time:
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: Covered wide over BLK3GD 2 & 3 lines each BLK3GE

22 Problems and Solutions

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

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

Figure A-6.22. Flight Log for Mission 2790G

23. Flight log for 2792G mission

Data Acquisition Flight Log

Flight Log No.: 29926

1 LiDAR Operator: MCE BALUYAS	2 ALTM Model: GEM	3 Mission Name: BLK38 RJ 2788	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: A. LIM	8 Co-Pilot: J. ESCALE	9 Route:			
10 Date: 30 SEPT 13	12 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1249	14 Engine Off: 1600	15 Total Engine Time: 03/11	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Hazy					

20 Flight Classification

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

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

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

21 Remarks: Completed BLK38J 2 surveyed 7 lines over BLK38I

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-In-Command	Lidar Operator	Aircraft Mechanic/ Technician
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	MCE BALUYAS Signature over Printed Name	Signature over Printed Name

Figure A-6.23. Flight Log for Mission 2792G

Annex 7. Flight Status Reports

FLIGHT STATUS REPORT
AKLAN AND CAPIZ-AKLAN REFLIGHTS
(March 15-22, 2014, and September 18-30, 2015)

Table A-7.1. Flight Status Report

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1186A	BLK 38 K AND BLK 38L	3BLK38KL067A	DC ALDOVINO	8 MAR 14	
1190A	BLK 38M	3BLK38M068A	PEARL MARS	9 MAR 14	Mission completed
1192A	BLK 38N	3BLK38N068B	DC ALDOVINO	9 MAR 14	Successful
1194A	BLK 38J	3BLK38J069A	DC ALDOVINO	10 MAR 14	Mission completed
1196A	BLK 38KS	3BLK38KS069B	PAT ALCANTARA	10 MAR 14	Finished 5 lines. Missing Range Data Pop Up. Performed in-air realignment
1210A	BLK 38F	3BLK38FS073A	PEARL MARS	14 MAR 14	Many lines covered half-way due to heavy air traffic over Kalibo Aerodrome
1212A	BLK 38F	3BLK38FS073B	PAT ALCANTARA	14 MAR 14	Supplementary to 1210A. Covered half block of 38F
1214A	BLK 38G, 38H, 38I	3BLK38G074A	PAT ALCANTARA	15 MAR 14	Strips of BLK 38G, H, I. Mission aborted duet to low cloud ceiling and precipitation in the survey area
1222A	BLK 38I	3BLK38I076A	PEARL MARS	17 MAR 14	Successful
1224A	BLK 38F	3BLK38FS076B	DC ALDOVINO	17 MAR 14	Supplementary of BLK 38F
1230A	BLK 38H, BLK 38I	3BLK38HIS078A	PEARL MARS	19 MAR 14	Supplement block of BLK 38I and covered half of BLK 38H
1232A	BLK 38G	3BLK38G078B	DC ALDOVINO	19 MAR 14	Completed 15 lines odf BLK 38G

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1238A	BLK 38G	3BLK38GS080A	PEARL MARS	21 MAR 14	Completed BLK 38R and completed BLK 38G. Experienced heavy air traffic in Kalibo airport
1240A	BLK 38H	3BLK38HS080B	DC ALDOVINO	21 MAR 14	Supplementary to BLK 38H
2742G	BLK38D	2BLK38D261A	MCE BALIGUAS & PJ ARCEO	SEPT. 18, 2015	Covered several lines of BLK38D. 3 lines wherein the beam divergence became wide and roll compensation was off. Presence of data gap. No digitizer. Partly cloudy and strong winds.
2746G	BLKs38 A, D, & E	2BLK38ADSE262A	MCE BALIGUAS & PJ ARCEO	SEPT. 19, 2015	Continuation of BLK38D, covered BLK38A and few lines from BLK38E. 2 lines wherein beam divergence became wide and roll compensation was off. No digitizer. Partly cloudy
2766G	BLK38C	2BLK38C267A	MCE BALIGUAS	SEPT. 24, 2015	Completed BLK38C. Cloudy in high terrain, hazy and strong gust of winds. Getting dark images from the camera. No digitizer
2768G	BLK38G	2BLK38G267B	RA FELISMINO	SEPT. 24, 2015	Unfinished mission, shutting off of laser due to eye safety.
2770G	BLKs38 B, D & E	2BLK38BDVES268A	RA FELISMINO	SEPT. 25, 2015	Completed BLK38 A, covered voids on D and 3 lines of E. No digitizer
2772G	BLK38G	2BLK38GS268B	MCE BALIGUAS	SEPT. 25, 2015	Supplementary flight for BLK38G, camera not triggering when the laser is firing at the start of the line. No digitizer
2774G	BLK38E	2BLK38ES269A	LR ASUNCION & JM ALMALVEZ	SEPT. 26, 2015	Completed BLK38E, captured images through camera time trigger in some lines. Repeat two lines because of bad swath produced. No digitizer
2790G	BLKs38 B & F	2BLK38BSF273A	RA FELISMINO	SEPT. 30, 2015	Completed BLK38B and few lines of BLK38F.Changed of altitudes because of clouds and high terrain
2792G	BLKs38 I & J	2BLK37IJ273B	MCE BALIGUAS & LR ASUNCION	SEPT. 30, 2015	Completed BLK38I and covered several lines of BLK38J. No images on the first line, restarted the camera. No digitizer.

LAS/SWATH BOUNDARIES PER MISSION FLIGHT

Flight No. : 1186A
Area: BLK 38 K AND BLK 38L
Mission Name: 3BLK38KL067A
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 25

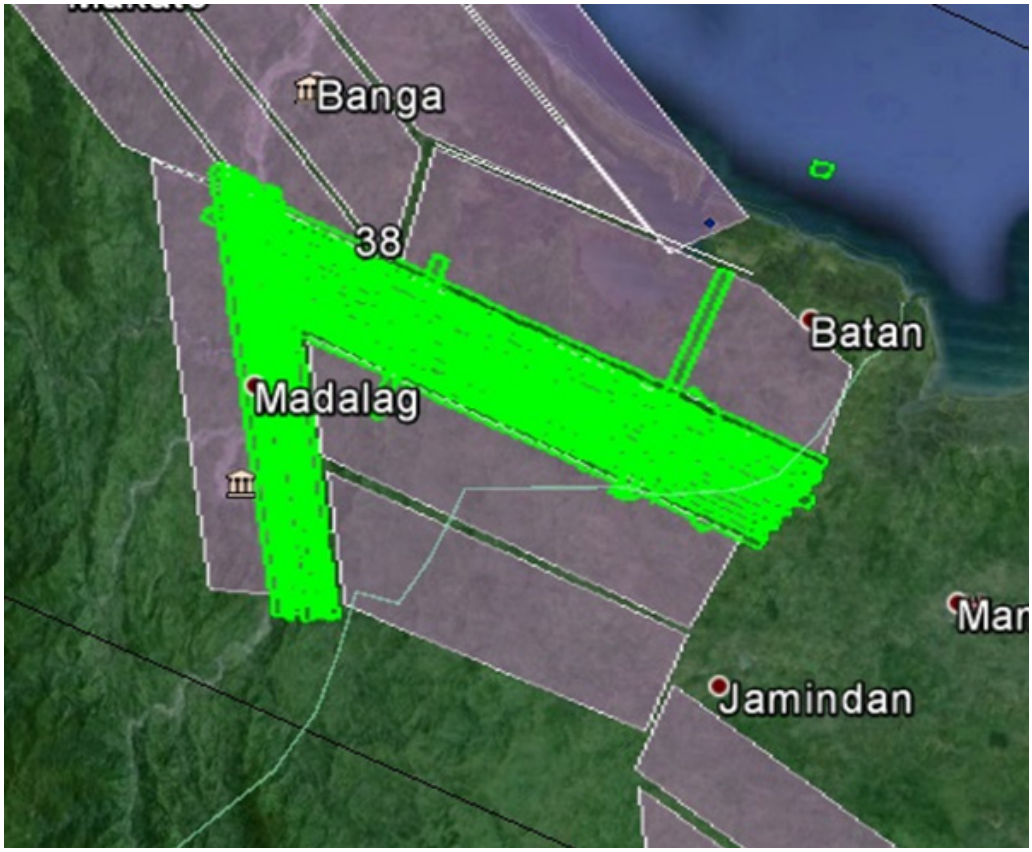


Figure A-7.1. Swath for Flight No. 1186A

Flight No. : 1190A
Area: BLK 38M
Mission Name: 3BLK38M068A
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 25

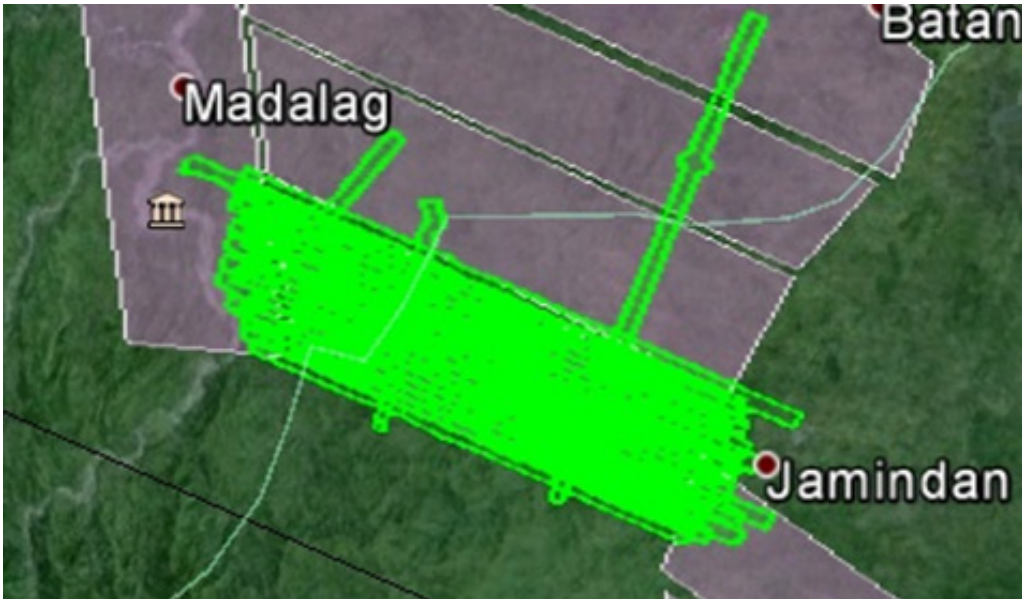


Figure A-7.2. Swath for Flight No. 1190A

Flight No. : 1192A
Area: BLK 38N
Mission Name: 3BLK38N068B
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 25

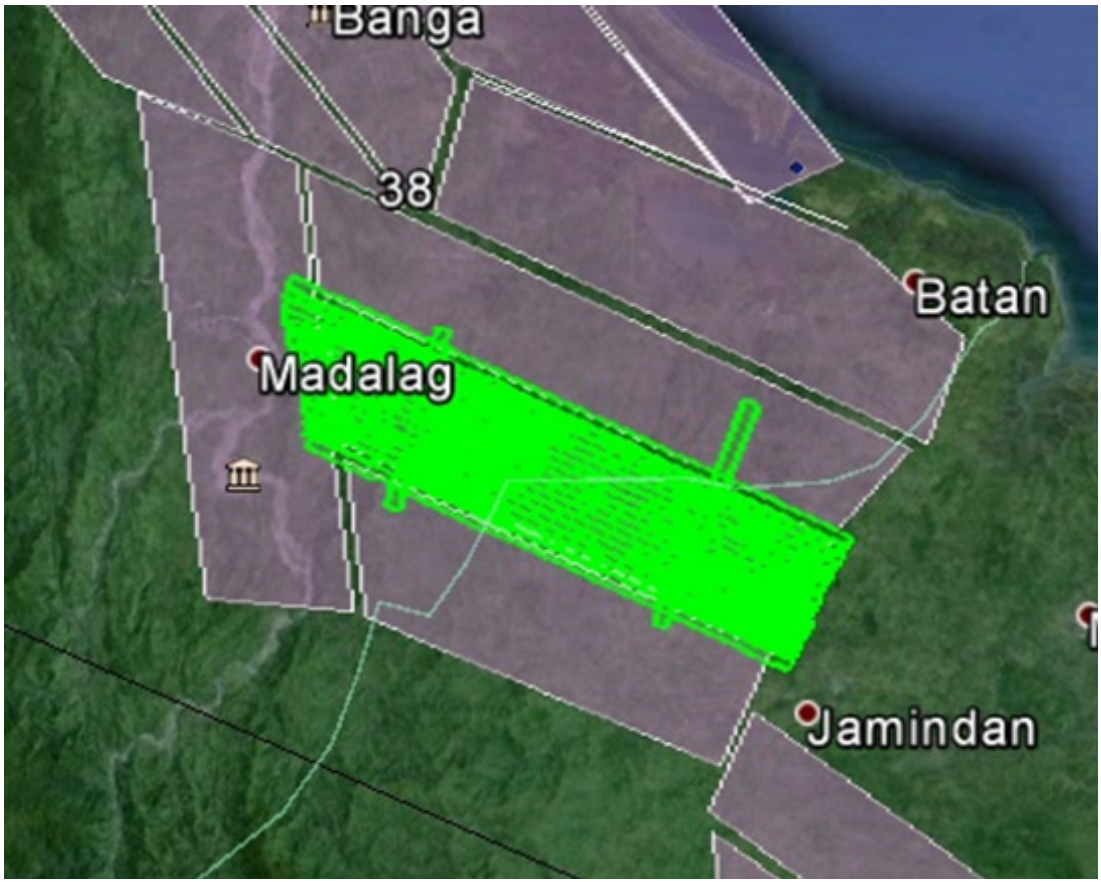


Figure A-7.3. Swath for Flight No. 1192A

Flight No. : 1194A
Area: BLK 38J
Mission Name: 3BLK38J069A
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 25; Overlap: 40

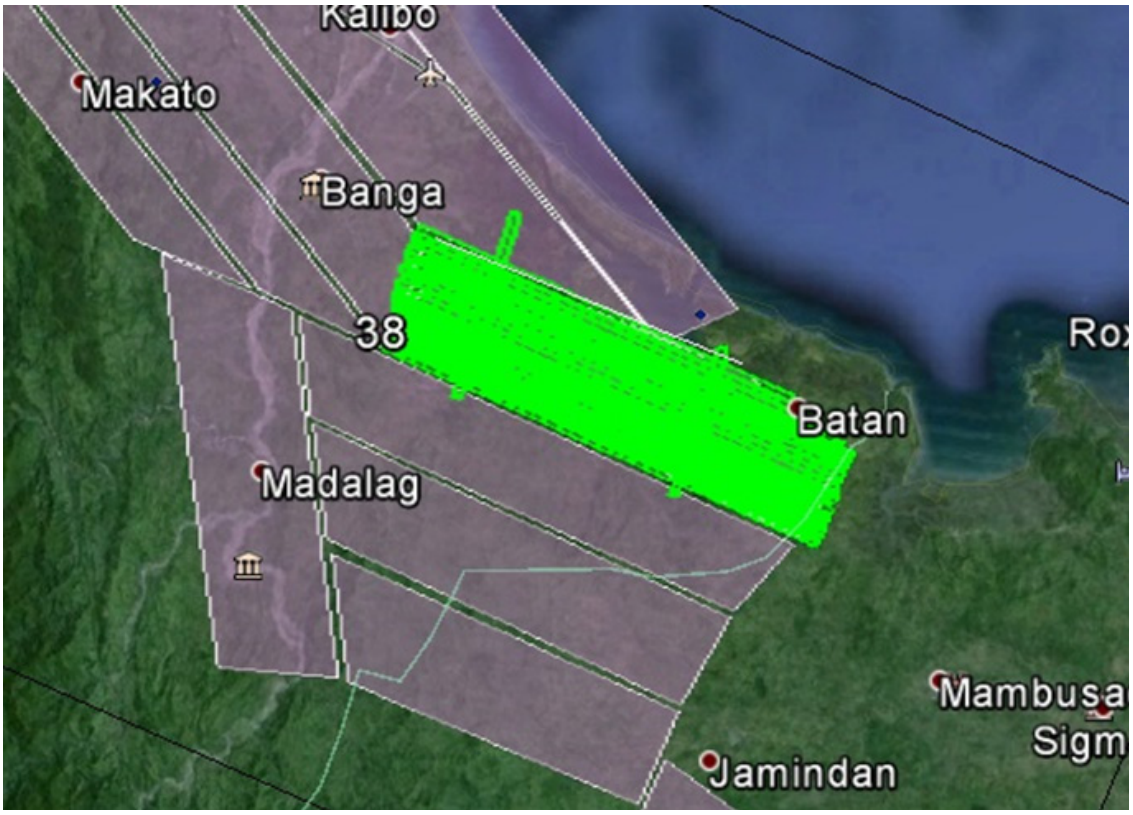


Figure A-7.4. Swath for Flight No. 1194A

Flight No. : 1196A
Area: BLK 38K
Mission Name: 3BLK38KS069B
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 25

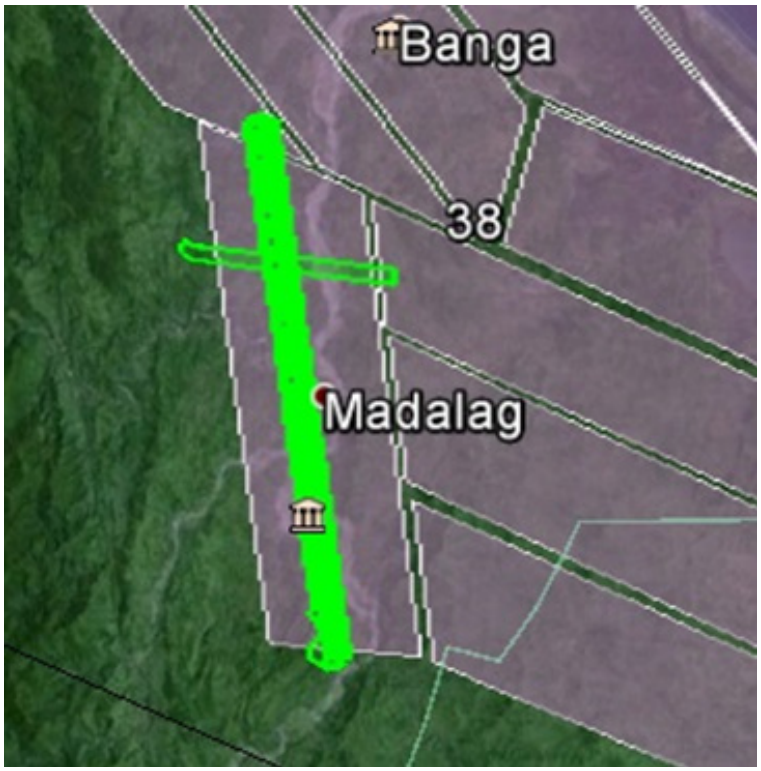


Figure A-7.5. Swath for Flight No. 1196A

Flight No. : 1210A
Area: BLK 38F
Mission Name: 3BLK38FS073A
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 18; Overlap: 30%

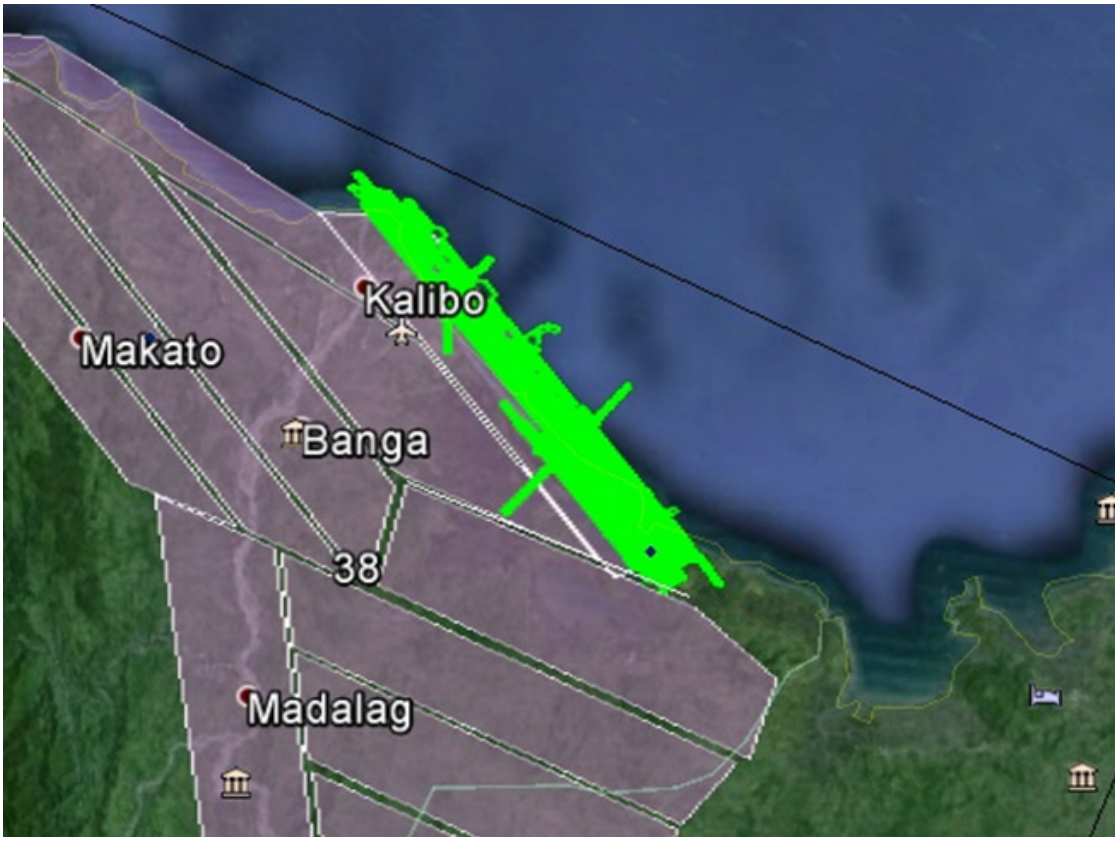


Figure A-7.6. Swath for Flight No. 1210A

Flight No. : 1212A
Area: BLK 38F
Mission Name: 3BLK38FS073B
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 18; Overlap: 30%

Figure A-7.7. Swath for Flight No. 1212A

Flight No. : 1214A
Area: BLK 38G, H, I
Mission Name: 3BLK38G074A
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 18; Overlap: 30%

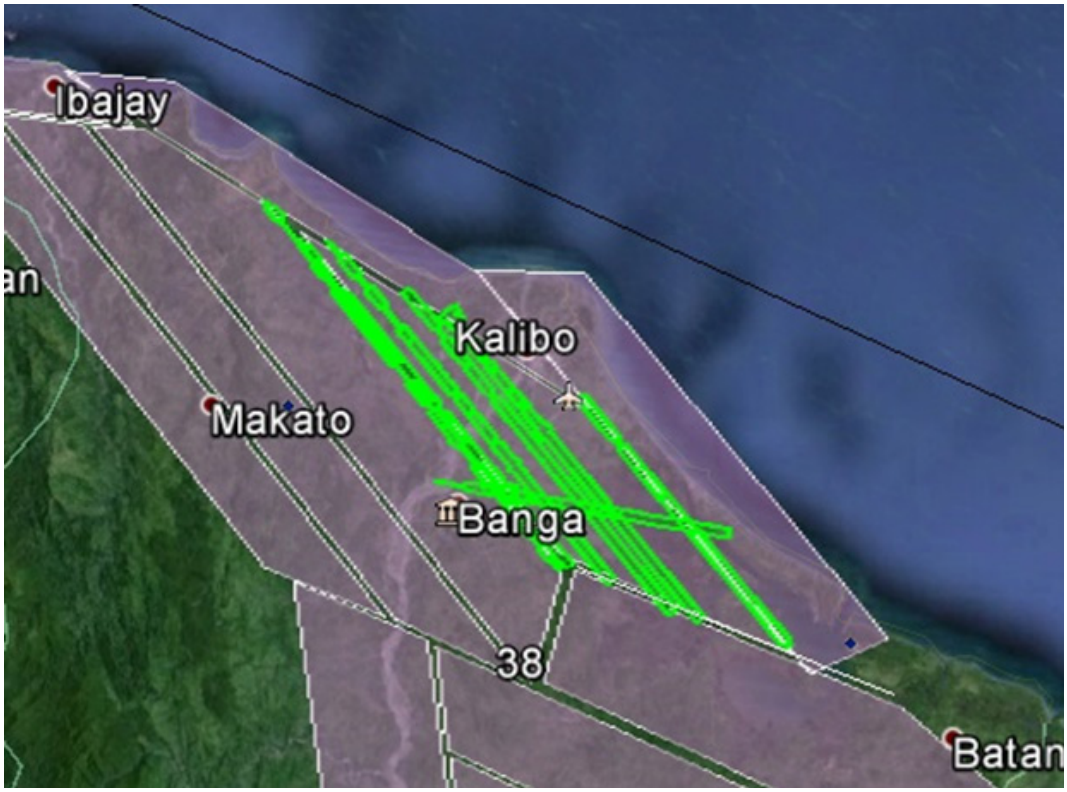


Figure A-7.8. Swath for Flight No. 1214A

Flight No. : 1222A
Area: BLK 38I
Mission Name: 3BLK38I076A
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 18; Overlap: 30%

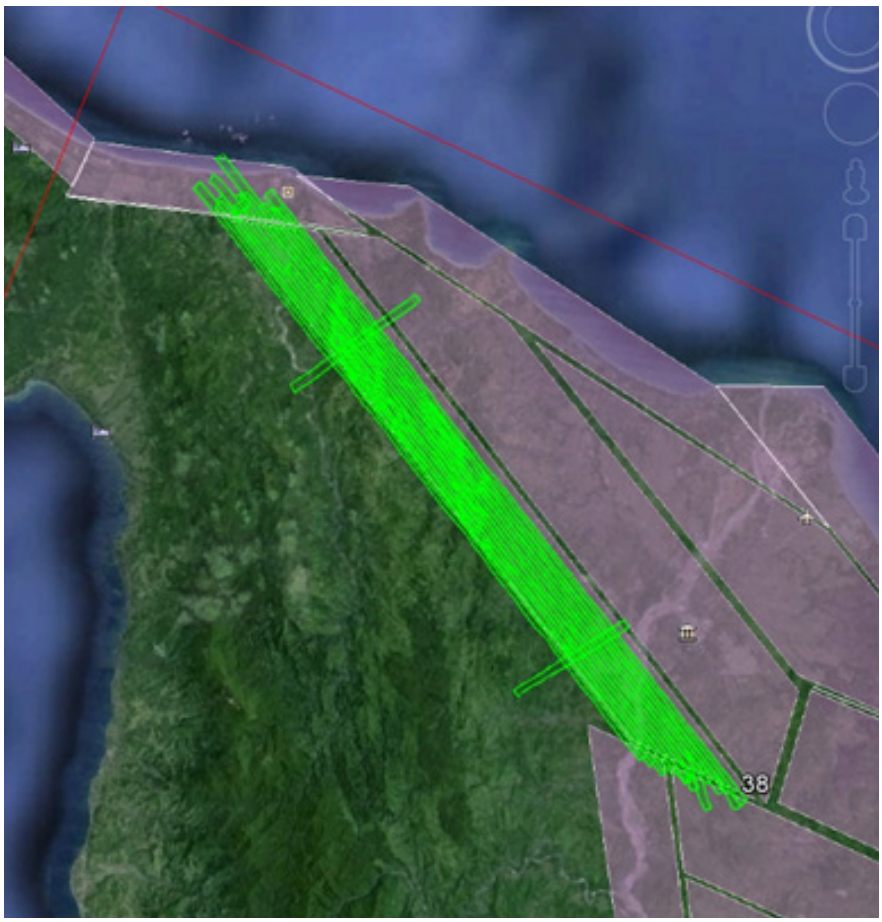


Figure A-7.9. Swath for Flight No. 1222A

Flight No. : 1224A
Area: BLK 38F
Mission Name: 3BLKFS076B
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 18; Overlap: 30%

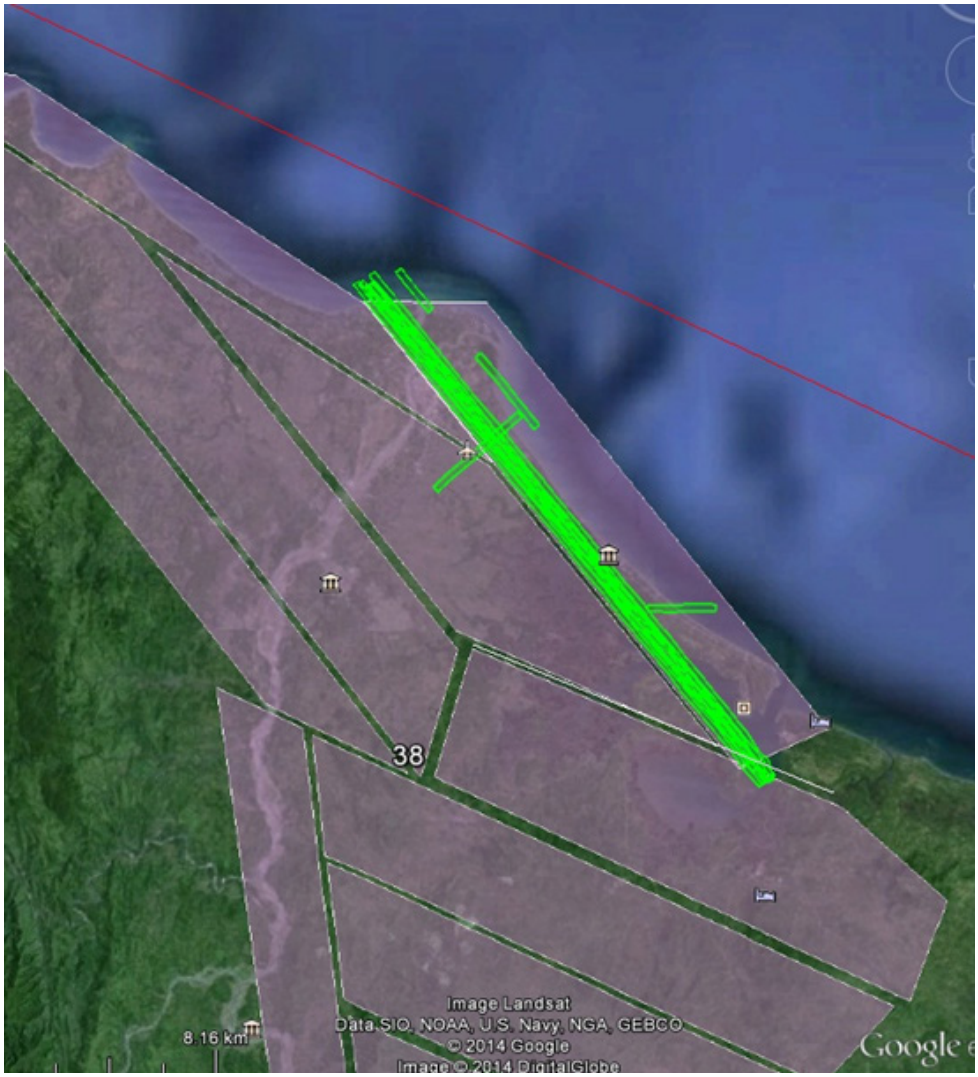


Figure A-7.10. Swath for Flight No. 1224A

Flight No. : 1230A
Area: BLK 38H, BLK 38I
Mission Name: 3BLK38HIS078A
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 18; Overlap: 50%

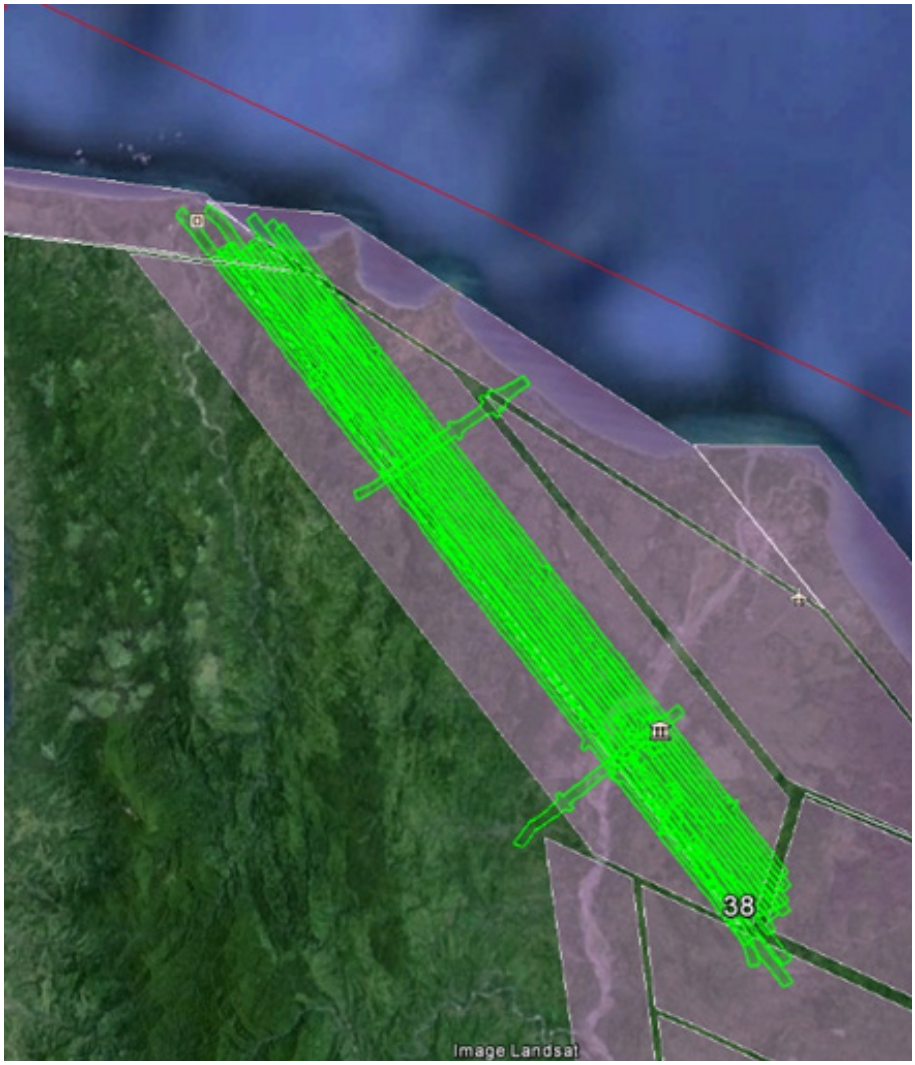


Figure A-7.11. Swath for Flight No. 1230A

Flight No. : 1232A
Area: BLK 38G
Mission Name: 3BLK38G078B
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 18; Overlap: 30%

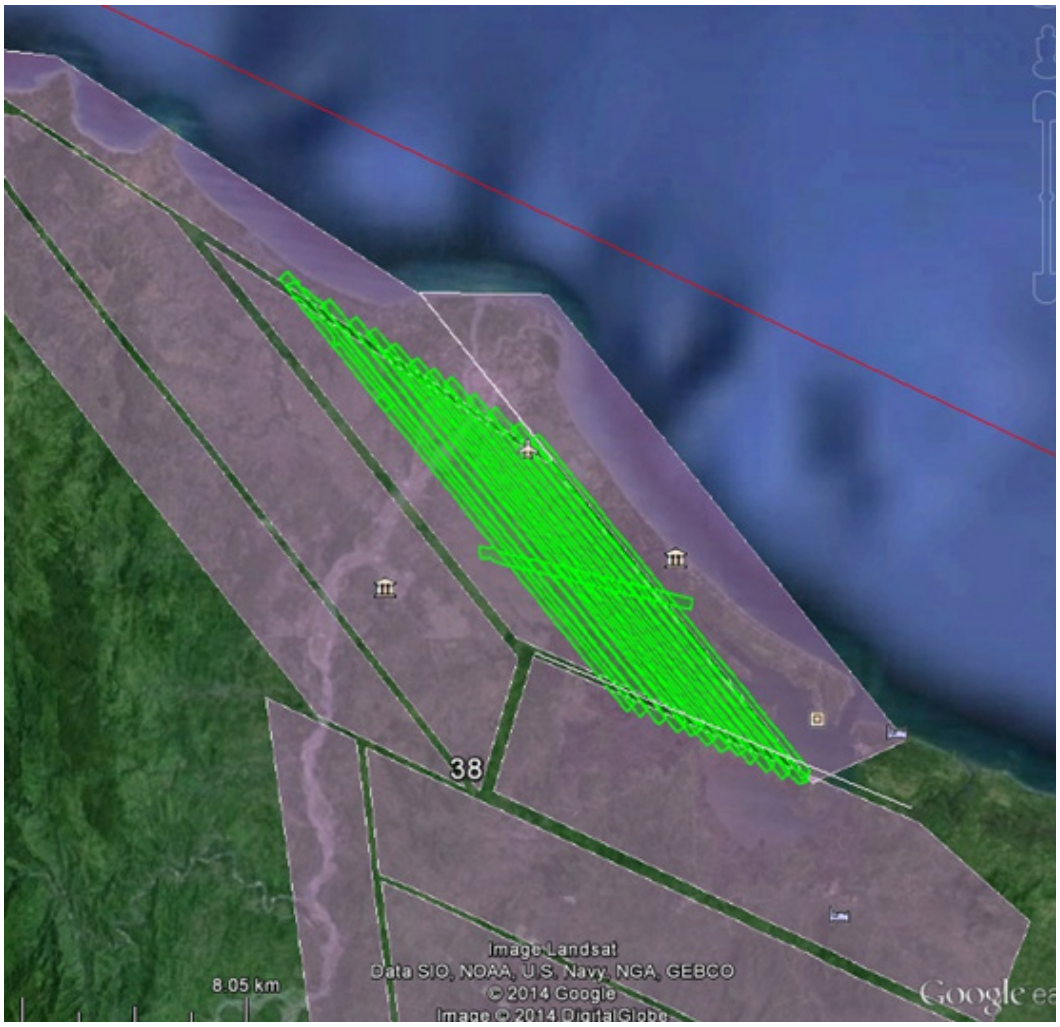


Figure A-7.12. Swath for Flight No. 1232A

Flight No. : 1238A
Area: BLK 38G
Mission Name: 3BLK38GS080A
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 18; Overlap: 30%

Figure A-7.13. Swath for Flight No. 1238A

Flight No. : 1240A
Area: BLK 38F
Mission Name: 3BLK38HS080B
Parameters: Alt: 600m; Scan Fz: 40; Scan ange: 18; Overlap: 30%

Figure A-7.14. Swath for Flight No. 1240A

Flight No. :	2742G
Area:	BLK38D
Mission Name:	2BLK38D261A
Parameters:	Alt: 1000m; Scan Fz: 50; Scan angLe: 15; Overlap: 30%, PRF:100 Alt: 800m; Scan Fz: 40; Scan angLe: 25; Overlap: 30%, PRF:142 Alt: 600m; Scan Fz: 40; Scan angLe: 25; Overlap: 30%, PRF:125
Area surveyed:	113.23 sq km.

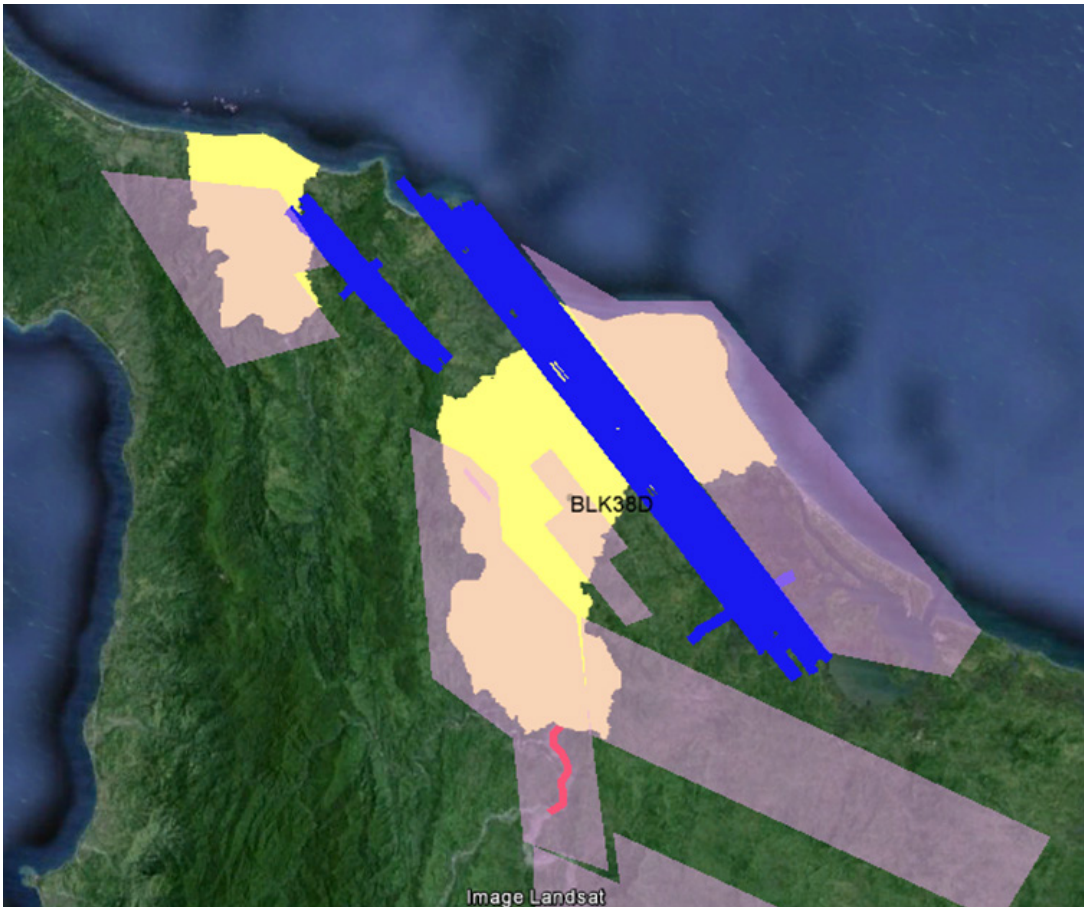


Figure A-7.15. Swath for Flight No. 2742G

Flight No. :	2746G
Area:	BLKs38 A, D & E
Mission Name:	2BLK38ADSE262A
Parameters:	For BLK38E: Alt: 800m; Scan Fz: 50; Scan angle: 20; Overlap: 30% For BLK38D: Alt: 800 & 600m; Scan Fz: 50; Scan angle: 20; Overlap: 30%
Area surveyed:	164.92 sq km.

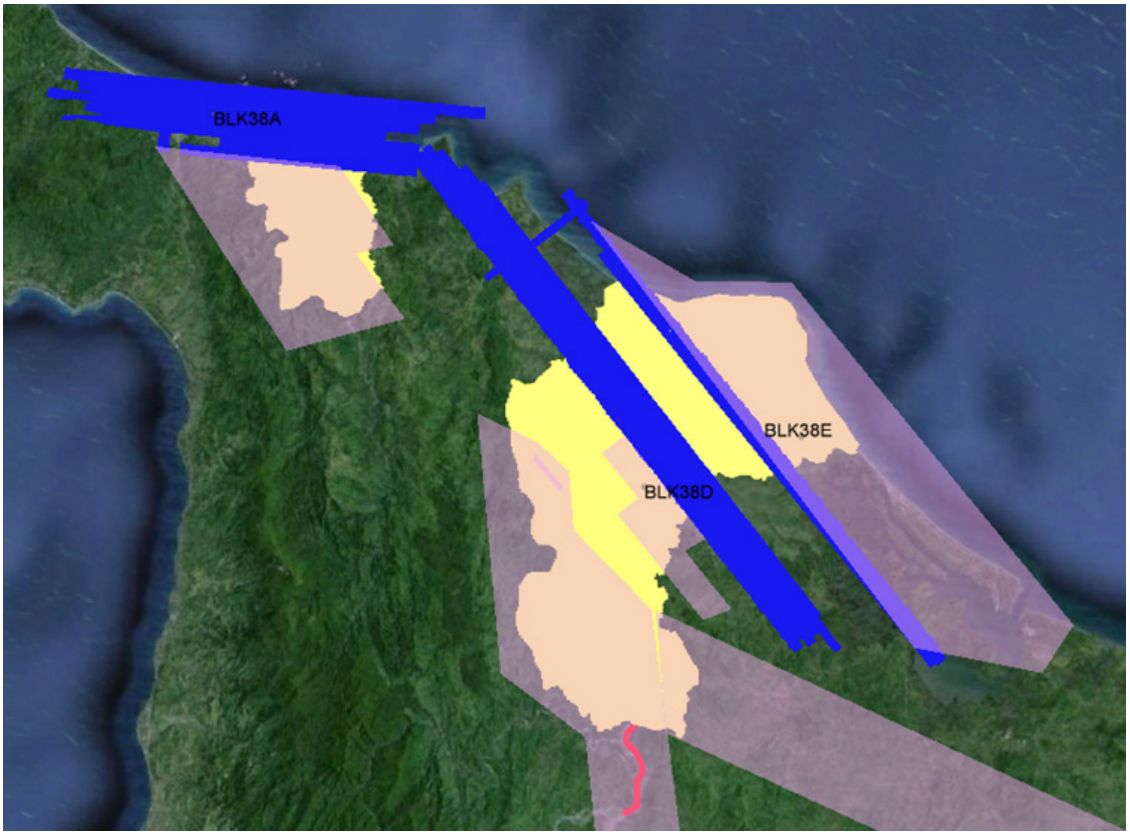


Figure A-7.16. Swath for Flight No. 2746G

Flight No. : 2766G
Area: BLK38C
Mission Name: 2BLK38C267A
Parameters: Alt: 800m; Scan Fz: 50; Scan angle: 20; PRF: 125
Area surveyed: 148.14 sq km.

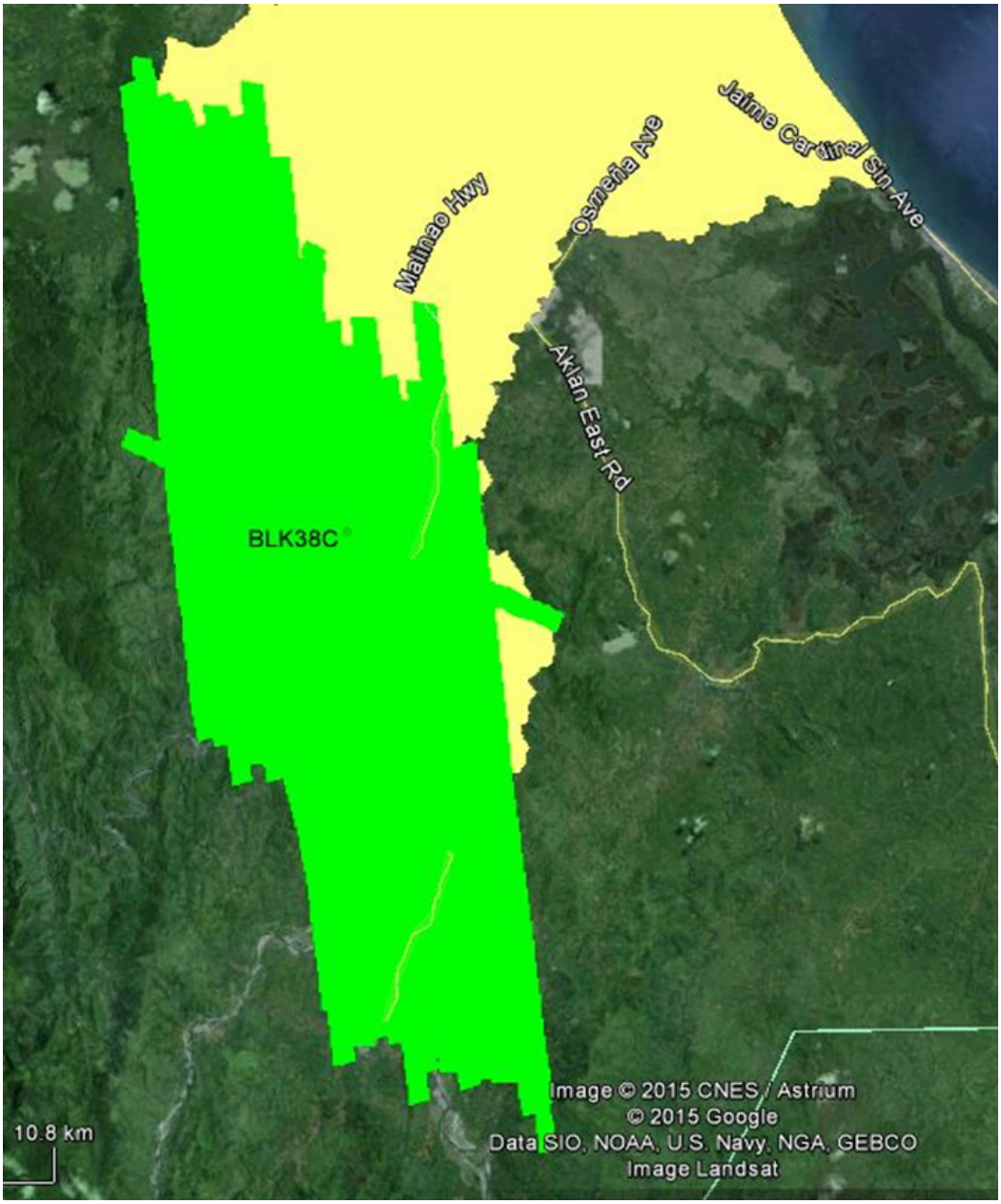


Figure A-7.17. Swath for Flight No. 2766G

Flight No. : 2768G
Area: BLK38G
Mission Name: 2BLK38G267B
Parameters: Alt: 800m; Scan Fz: 50; Scan angle: 20; PRF: 125
Area surveyed: 99.38 sq km.

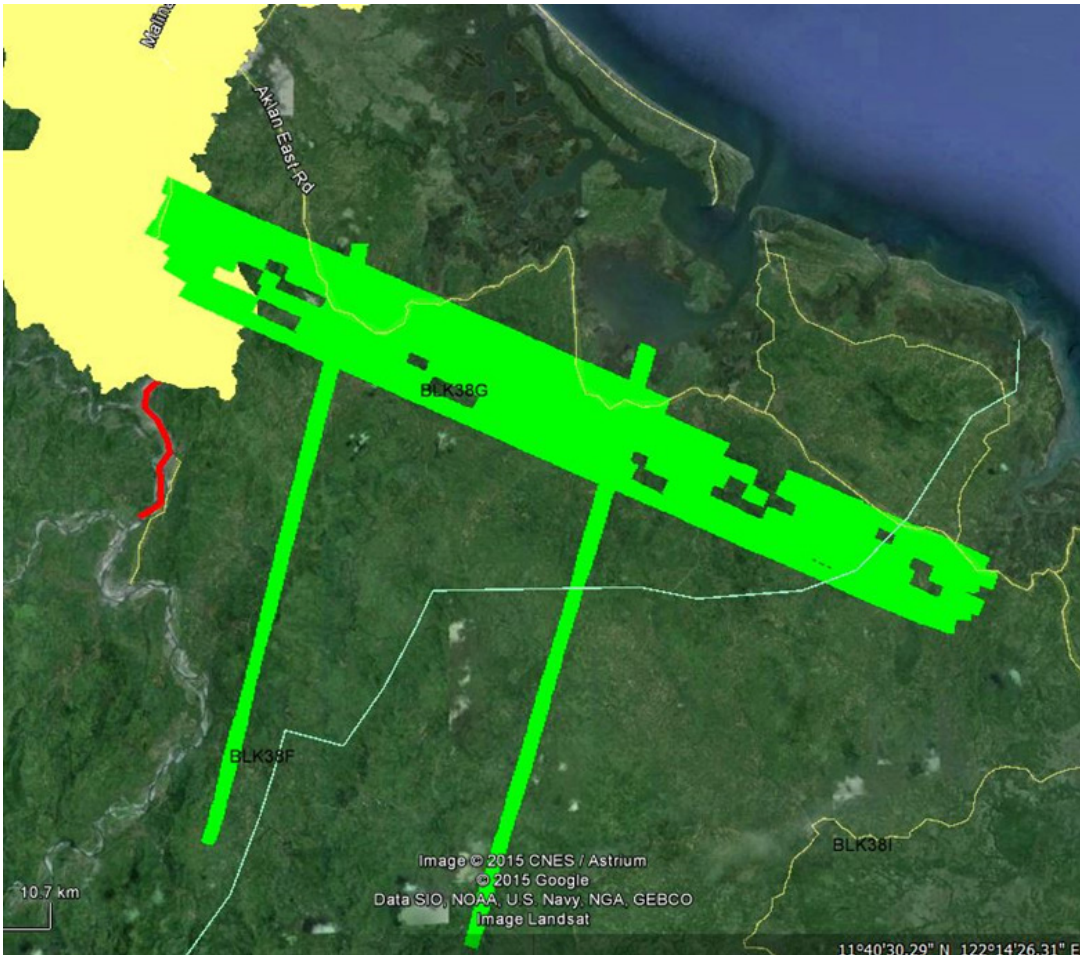


Figure A-7.18. Swath for Flight No. 2768G

Flight No. : 2770G
Area: BLKs38 B, D & E
Mission Name: 2BLK38BDVES268A
Parameters: Alt: 800m; Scan Fz: 50; Scan angle: 20; PRF: 125
Area surveyed: 188.62 sq km.

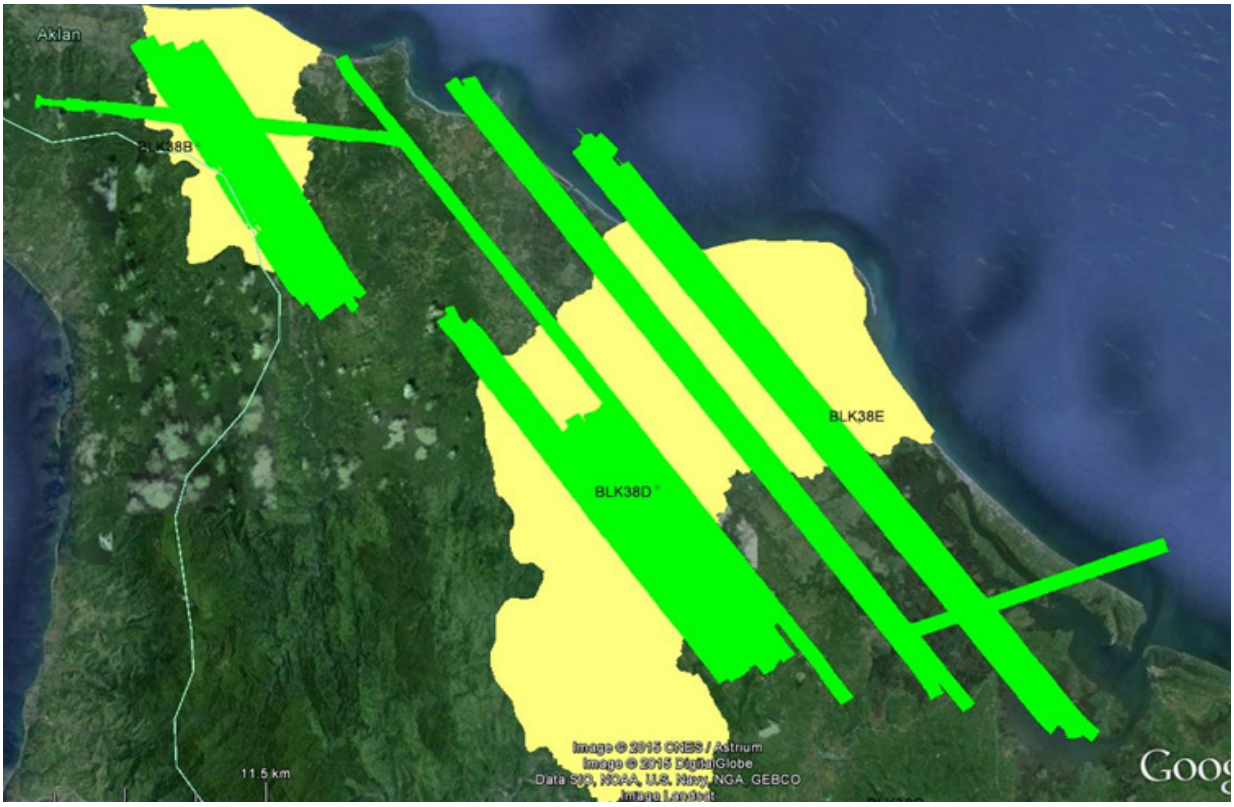


Figure A-7.19. Swath for Flight No. 2770G

Flight No. : 2772G
Area: BLK38G
Mission Name: 2BLK38GS268B
Parameters: Alt: 800m; Scan Fz: 50; Scan angle: 20; PRF: 125
Area surveyed: 131.52 sq km.

Figure A-7.20. Swath for Flight No. 2772G

Flight No. : 2774G
Area: BLK38E
Mission Name: 2BLK38ES269A
Parameters: Alt: 800 & 1000m; Scan Fz: 50; Scan angle: 20 & 15; PRF: 125 & 100
Area surveyed: 167.63 sq km.

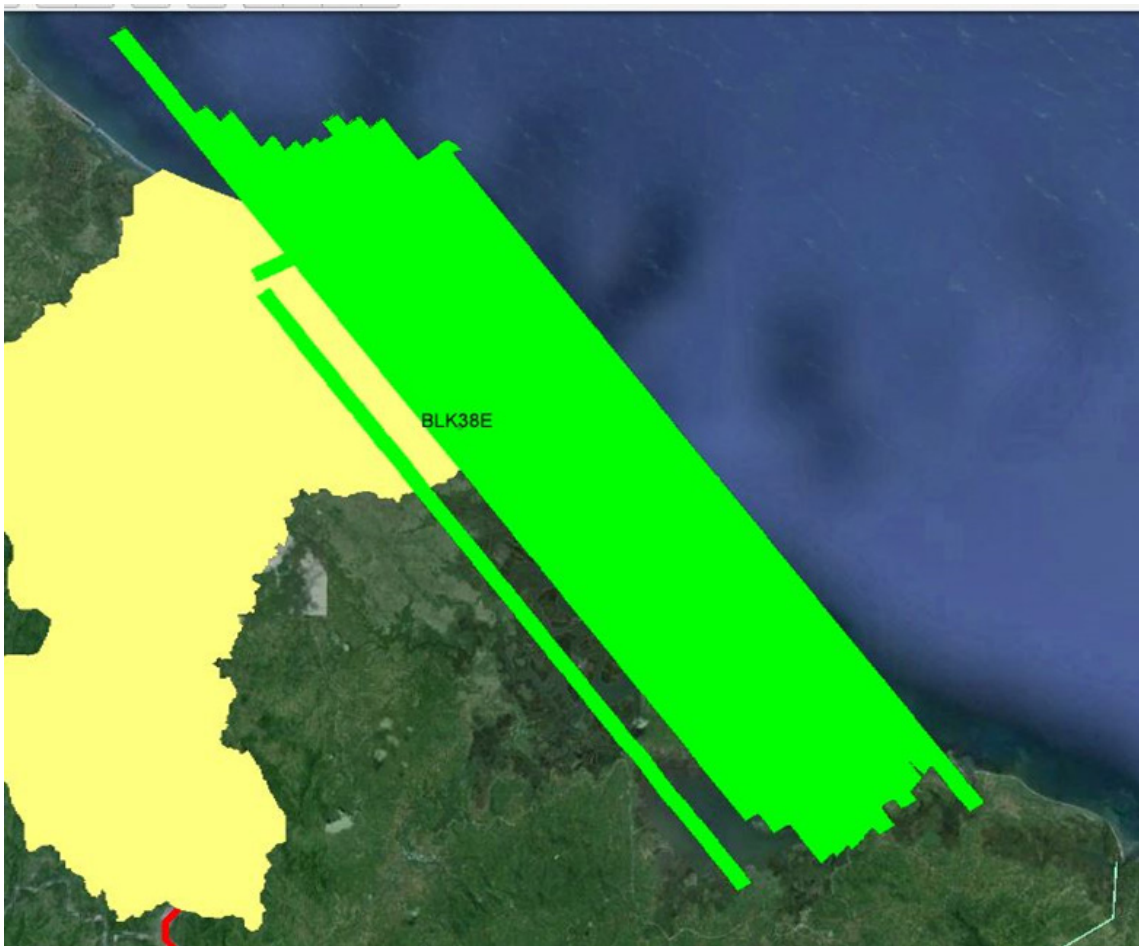


Figure A-7.21. Swath for Flight No. 2774G

Flight No. : 2790G
Area: BLKs38 B & F
Mission Name: 2BLK38BSF273A
Parameters: Alt: 800m; Scan Fz: 50; Scan angle: 20; PRF: 125
Area surveyed: 153.45 sq km.

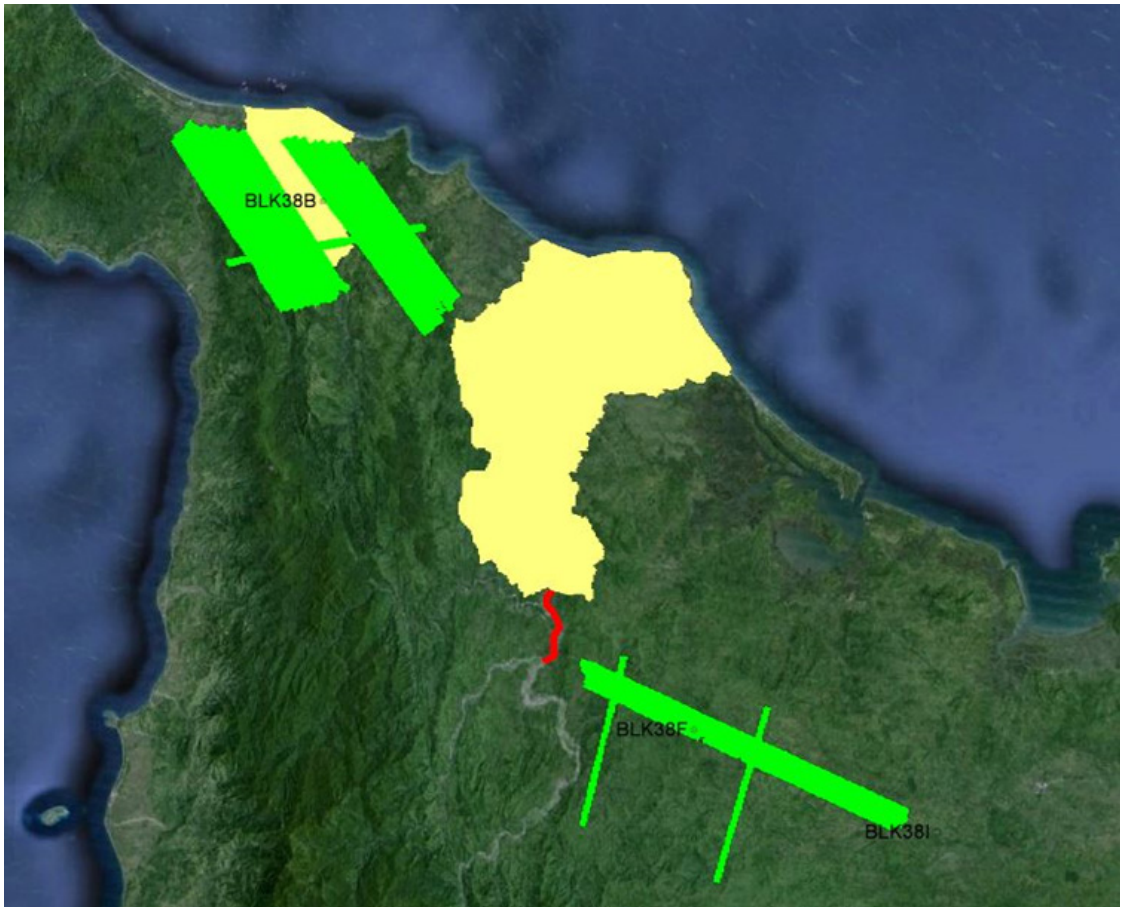


Figure A-7.22. Swath for Flight No. 2790G

Flight No. : 2792G
Area: BLKs38 I & J
Mission Name: 2BLK38IJ273B
Parameters: Alt: 800m; Scan Fz: 50; Scan angle: 20; PRF: 125
Area surveyed: 128.96 sq km.

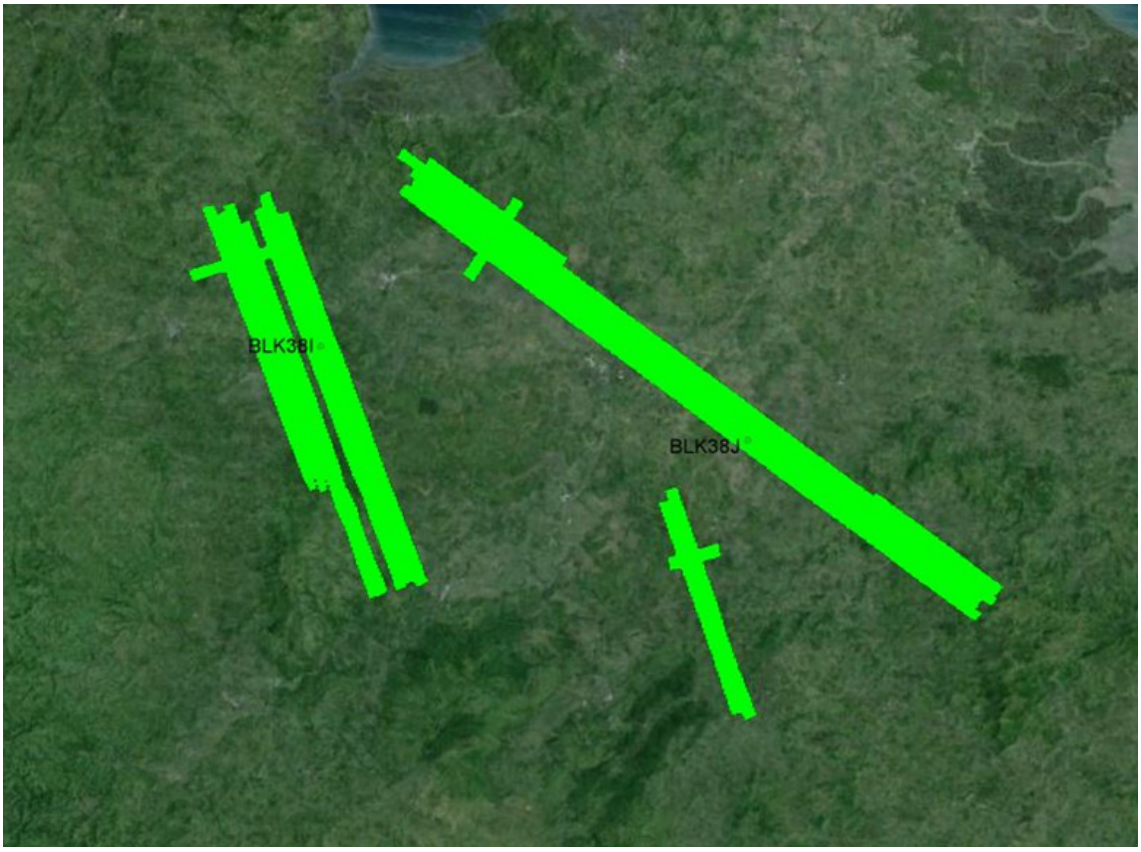


Figure A-7.23. Swath for Flight No. 2792G

Annex 8. Mission Summary Reports

Table A-8.1. Mission Summary Report for Mission Blk38G

Flight Area	Aklan
Mission Name	Blk38G
Inclusive Flights	1232A, 1238A, 1214A
Mission Name	3BLK38GS080A
Range data size	29.6 GB
POS	599 MB
Base data size	49.8 MB
Image	77.5 GB
Transfer date	April 2, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.45
RMSE for East Position (<4.0 cm)	3.0
RMSE for Down Position (<8.0 cm)	9.5
Boresight correction stdev (<0.001deg)	0.000422
IMU attitude correction stdev (<0.001deg)	0.0873
GPS position stdev (<0.01m)	0.0419
Minimum % overlap (>25)	48.38%
Ave point cloud density per sq.m. (>2.0)	3.26
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	124
Maximum Height	473.98m
Minimum Height	65.86m
Classification (# of points)	
Ground	65,523,912
Low vegetation	112,670,061
Medium vegetation	125,580,846
High vegetation	52,818,739
Building	10,632,013
Orthophoto	Yes
Processed By	Engr. Kenneth Solidum, Engr. Mark Joshua Salvacion, Engr. Elainne Lopez

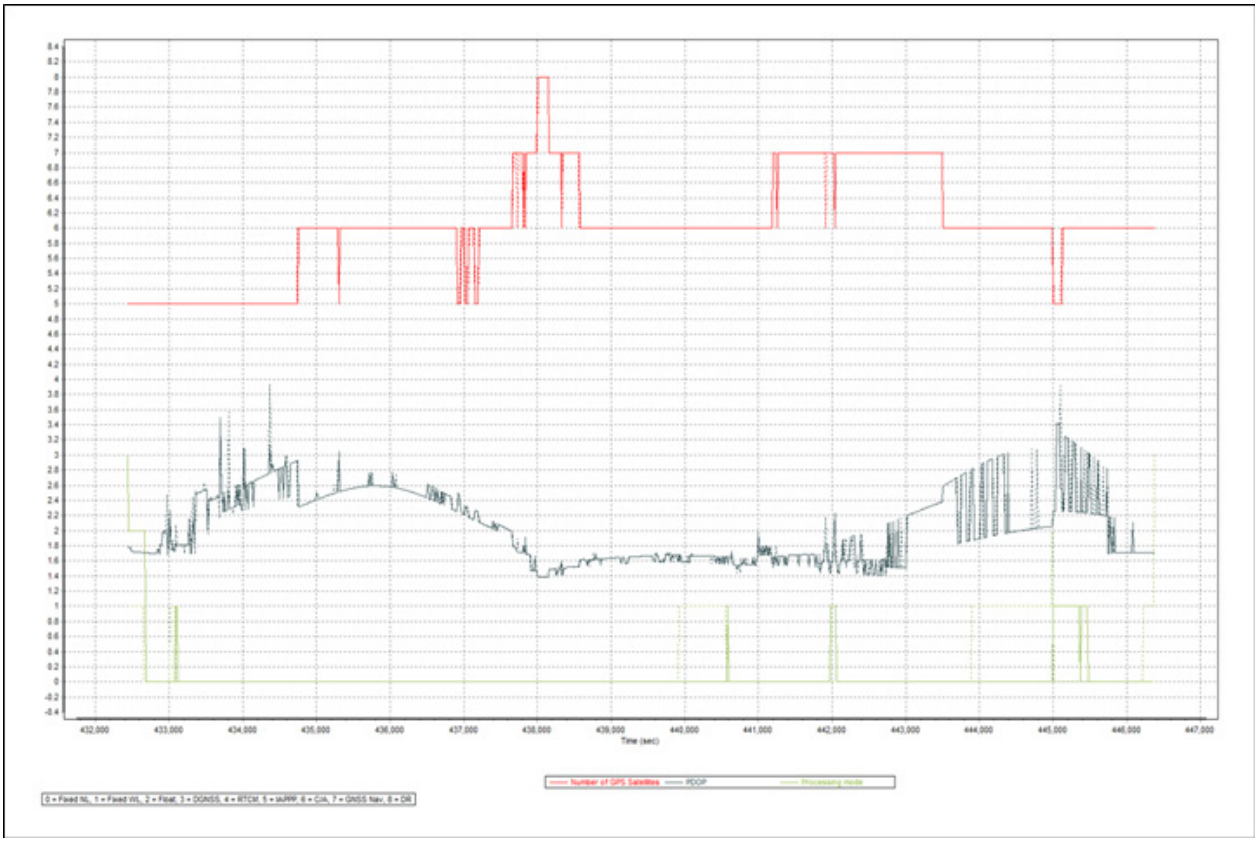


Figure A-8.1. Solution Status

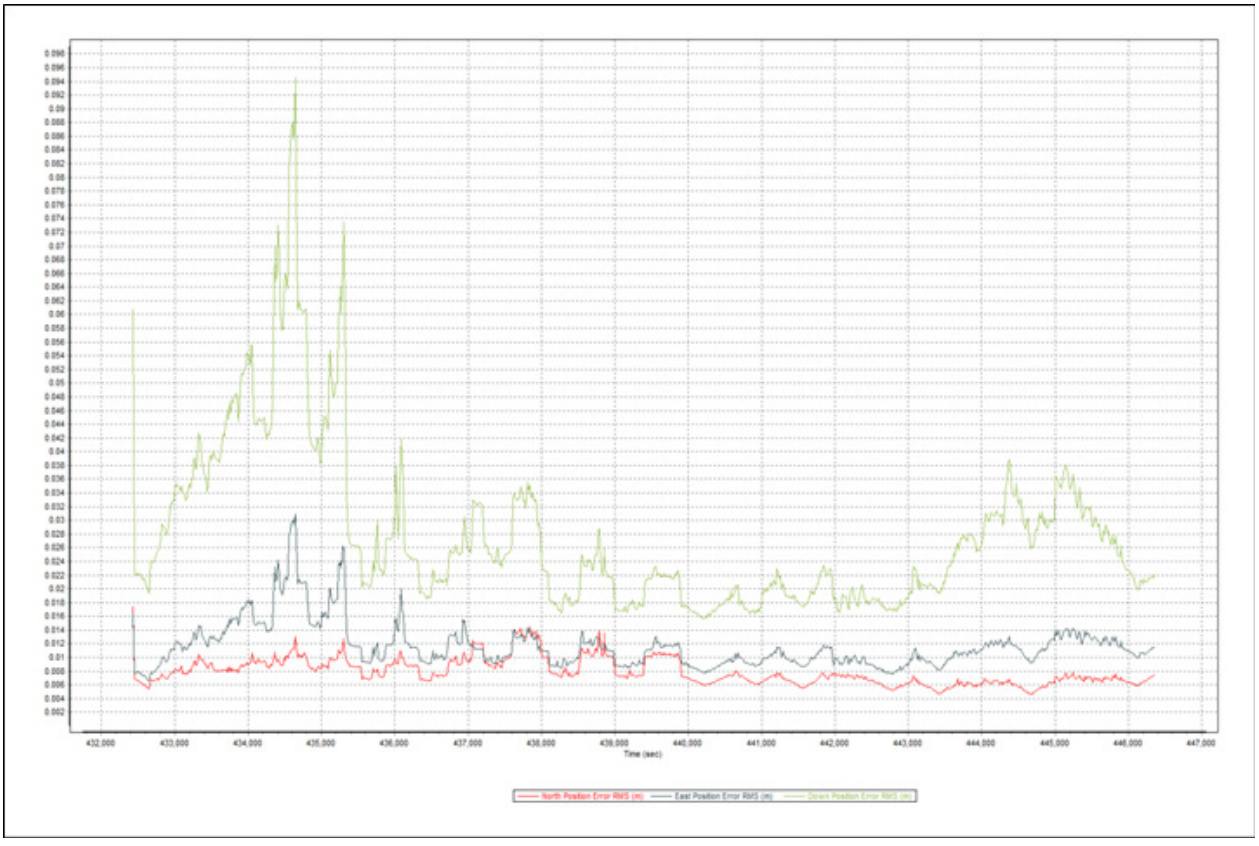


Figure A-8.2. Smoothed Performance Metric Parameters

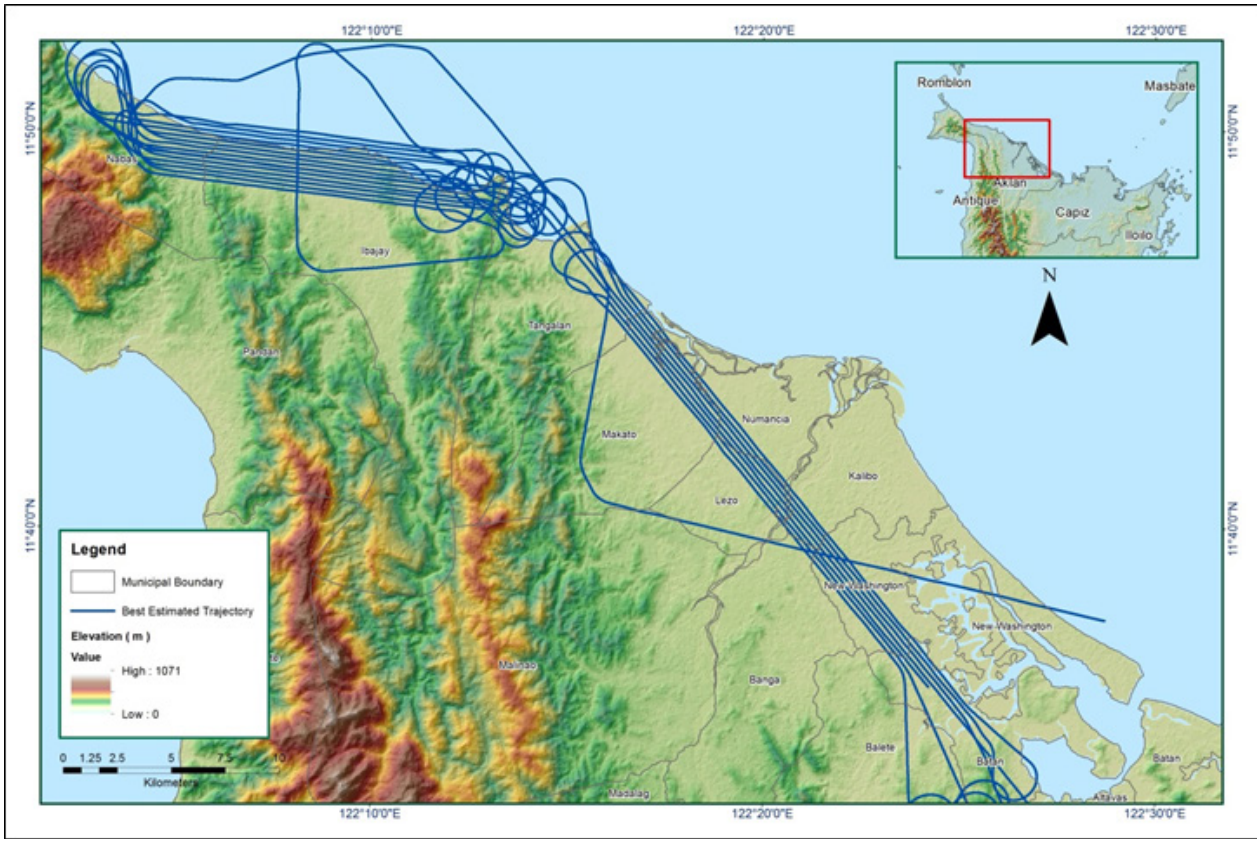


Figure A-8.3. Best Estimated Trajectory

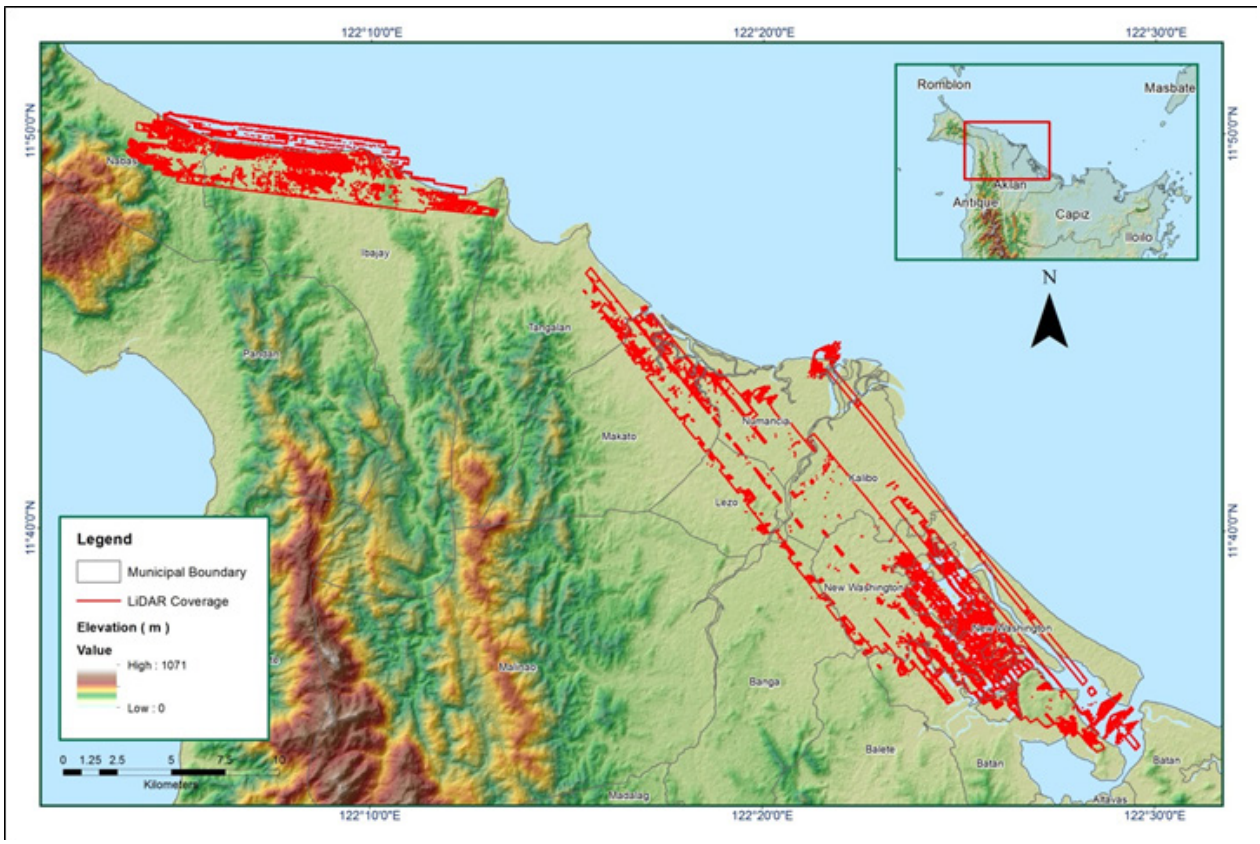


Figure A-8.4. Coverage of LiDAR data

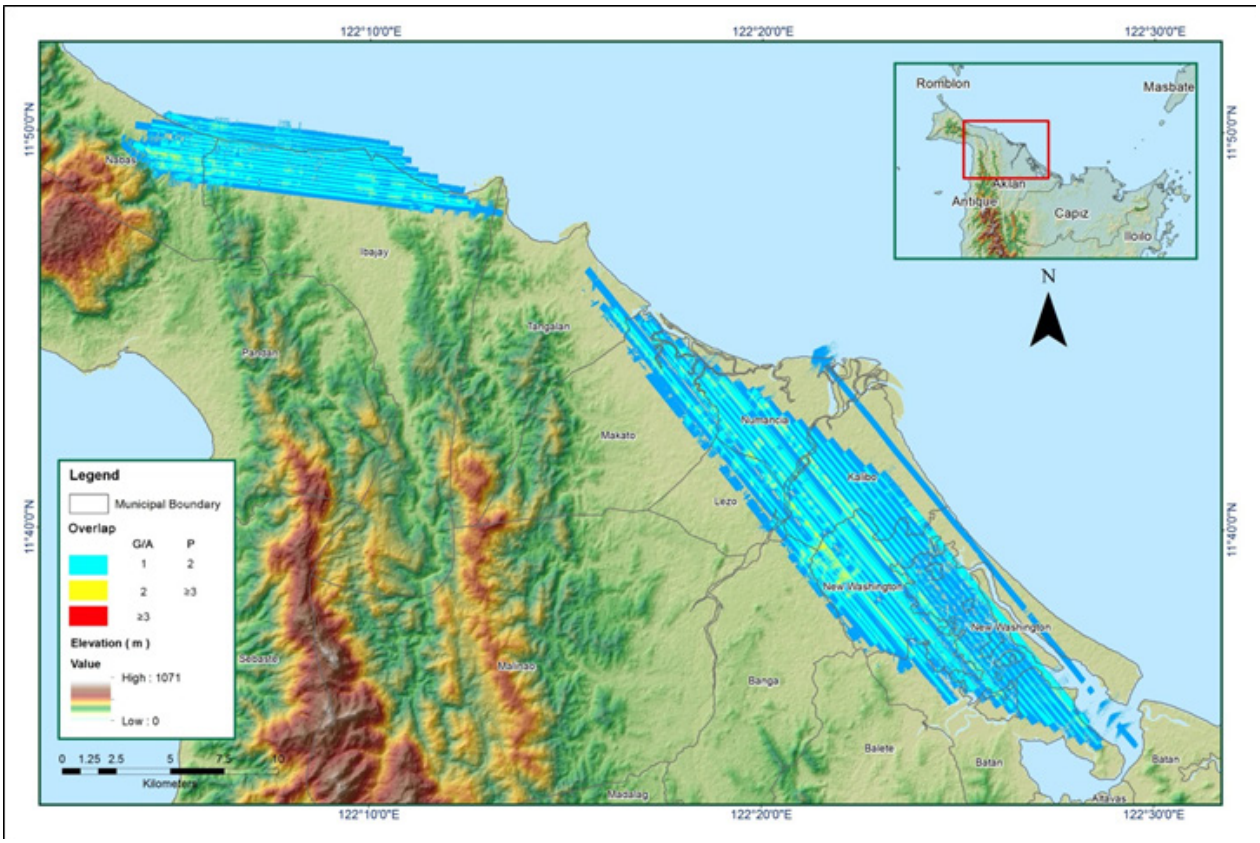


Figure A-8.5. Image of data overlap

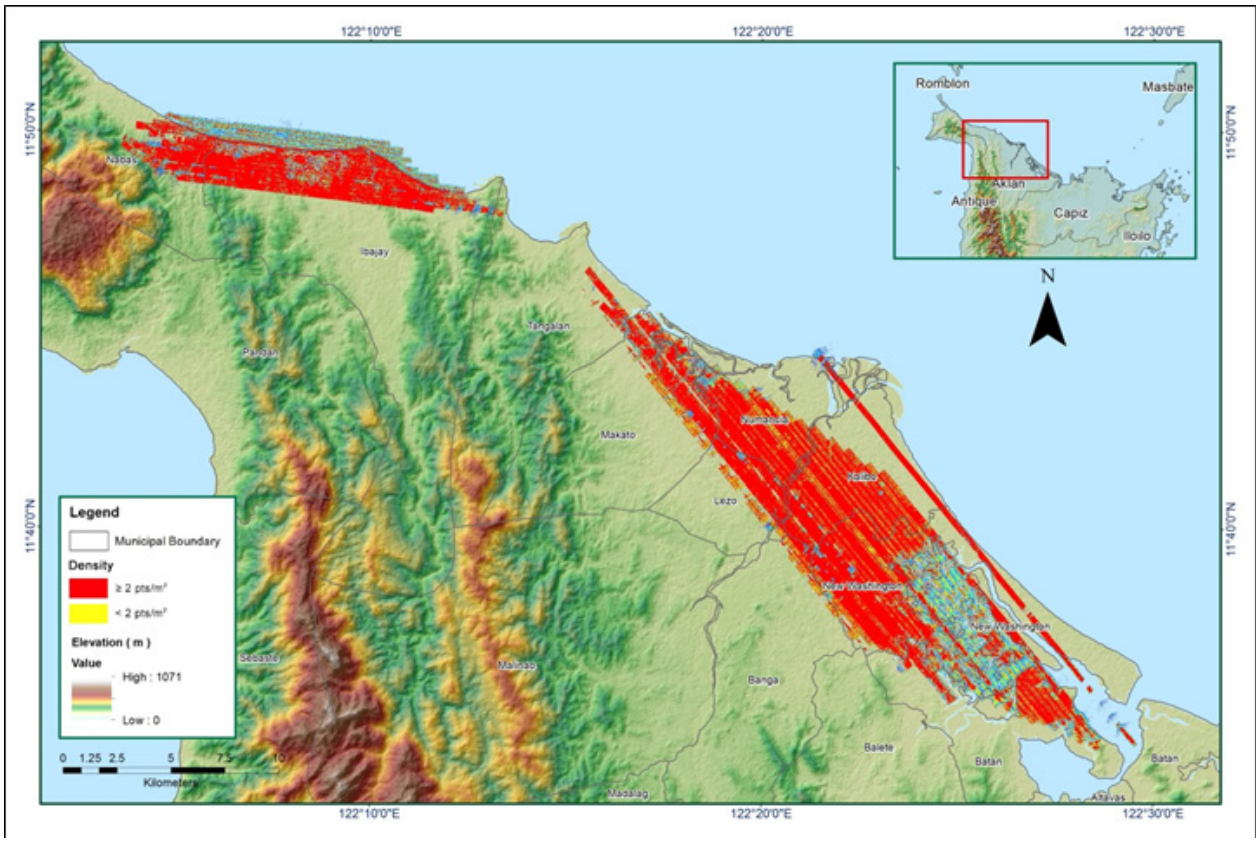


Figure A-8.6. Density map of merged LiDAR data

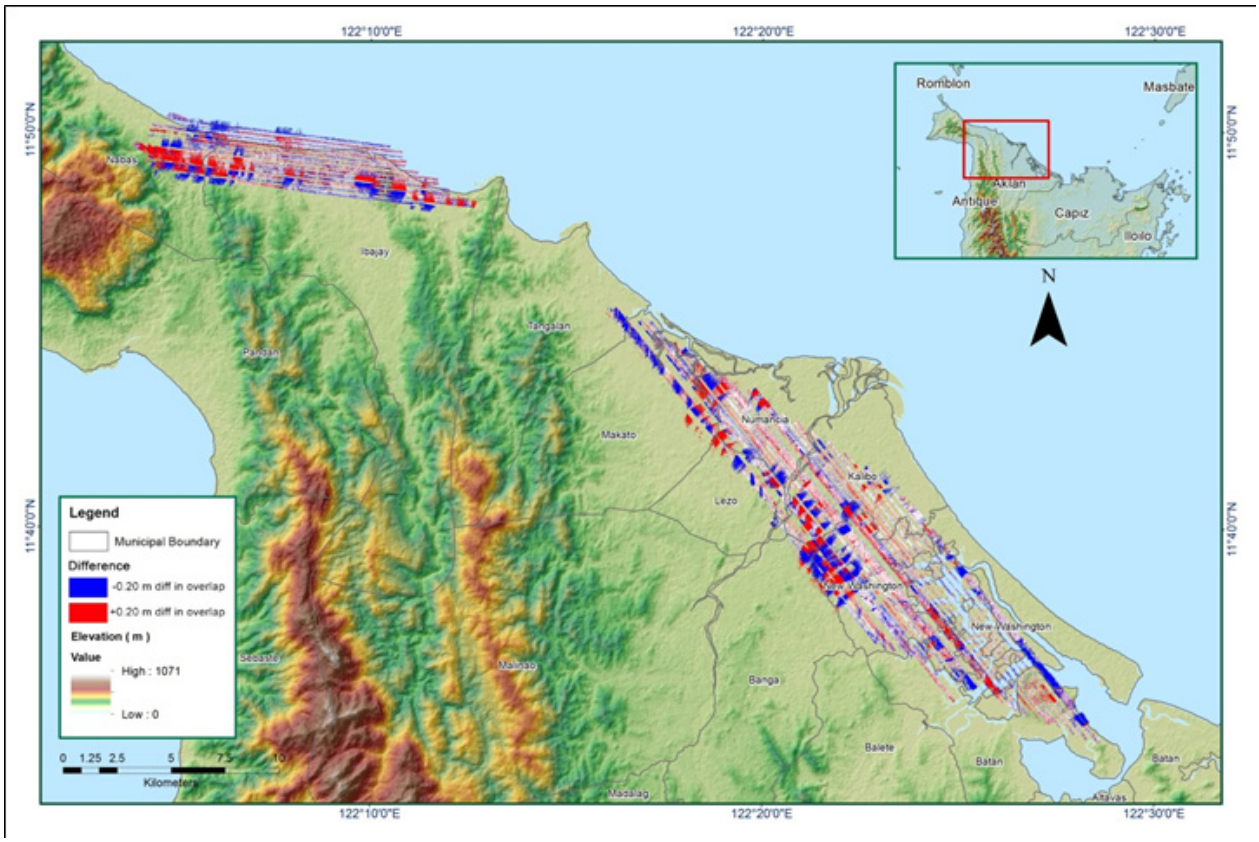


Figure A-8.7. Elevation difference between flight lines

Table A-8.2. Mission Summary Report for Mission Blk38G_additional

Flight Area	Aklan
Mission Name	Blk38G_additional
Inclusive Flights	1232A
Mission Name	3BLK38GS080A
Range data size	8.34 GB
POS	177 MB
Base data size	17 MB
Image	48.8 GB
Transfer date	April 2, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	0.8
RMSE for East Position (<4.0 cm)	0.85
RMSE for Down Position (<8.0 cm)	2.0
Boresight correction stdev (<0.001deg)	0.000422
IMU attitude correction stdev (<0.001deg)	0.0873
GPS position stdev (<0.01m)	0.0419
Minimum % overlap (>25)	19.94%
Ave point cloud density per sq.m. (>2.0)	2.20
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	47
Maximum Height	134.62 m
Minimum Height	54.28 m
Classification (# of points)	
Ground	8,055,404
Low vegetation	8,343,333
Medium vegetation	6,562,457
High vegetation	2,670,706
Building	796,451
Orthophoto	Yes
Processed By	Engr. Kenneth Solidum, Engr. Chelou Prado, Engr. Roa Shelmar Redo

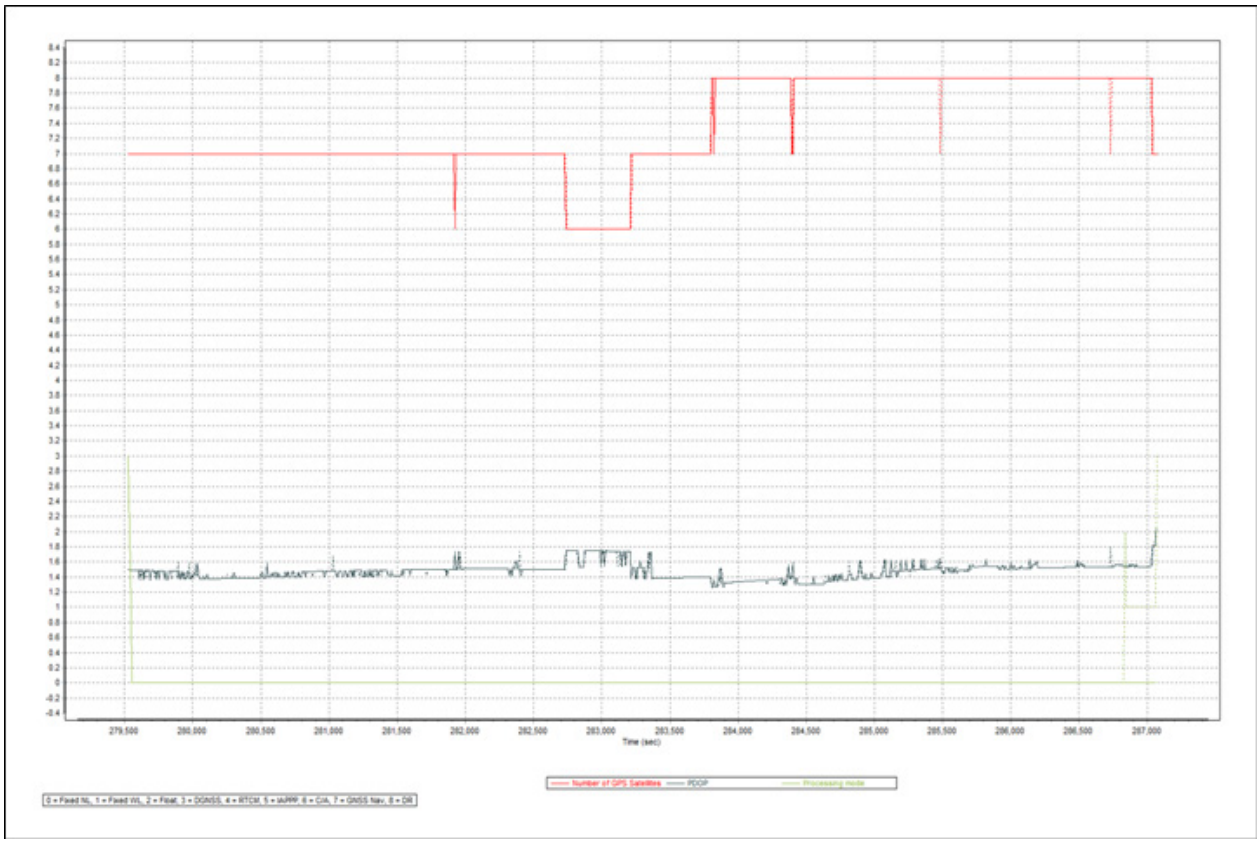


Figure A-8.8. Solution Status

Figure A-8.9. Smoothed Performance Metric Parameters

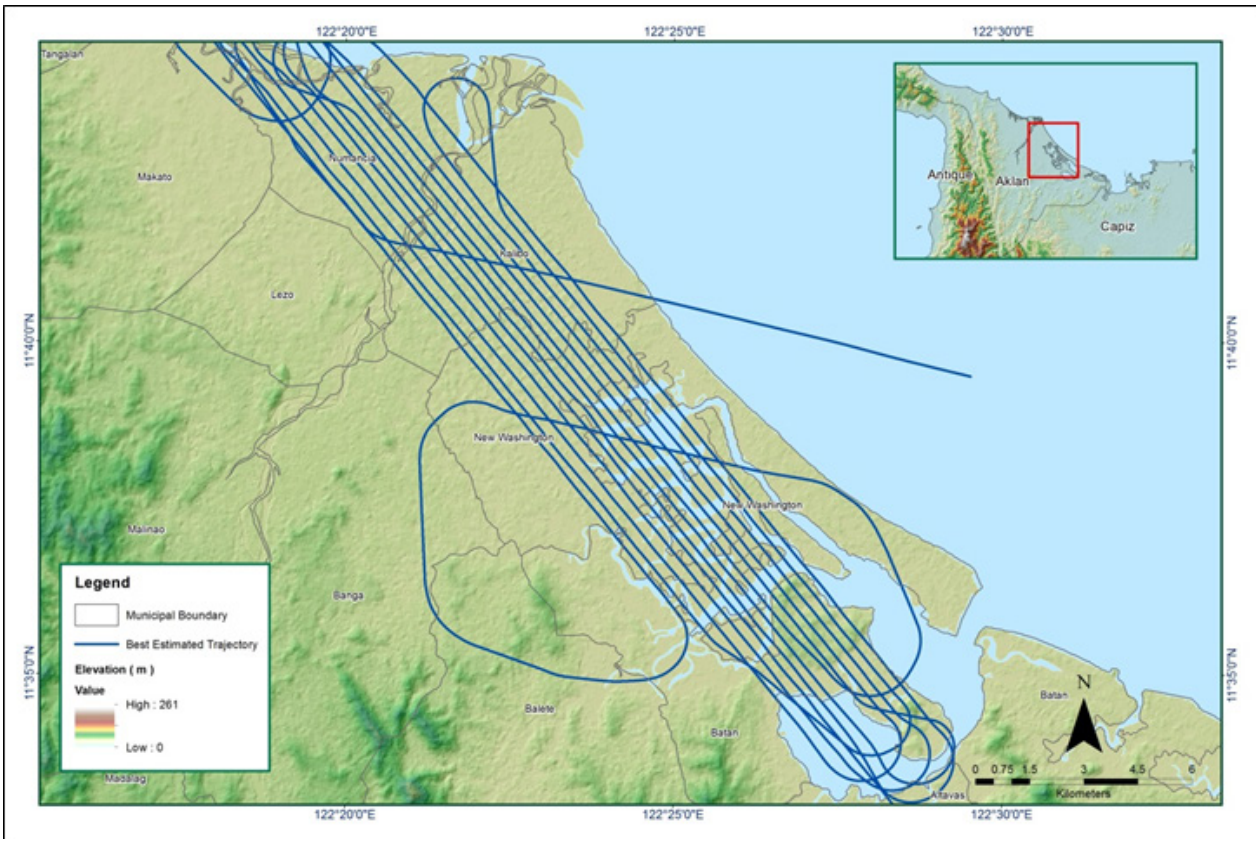


Figure A-8.10. Best Estimated Trajectory

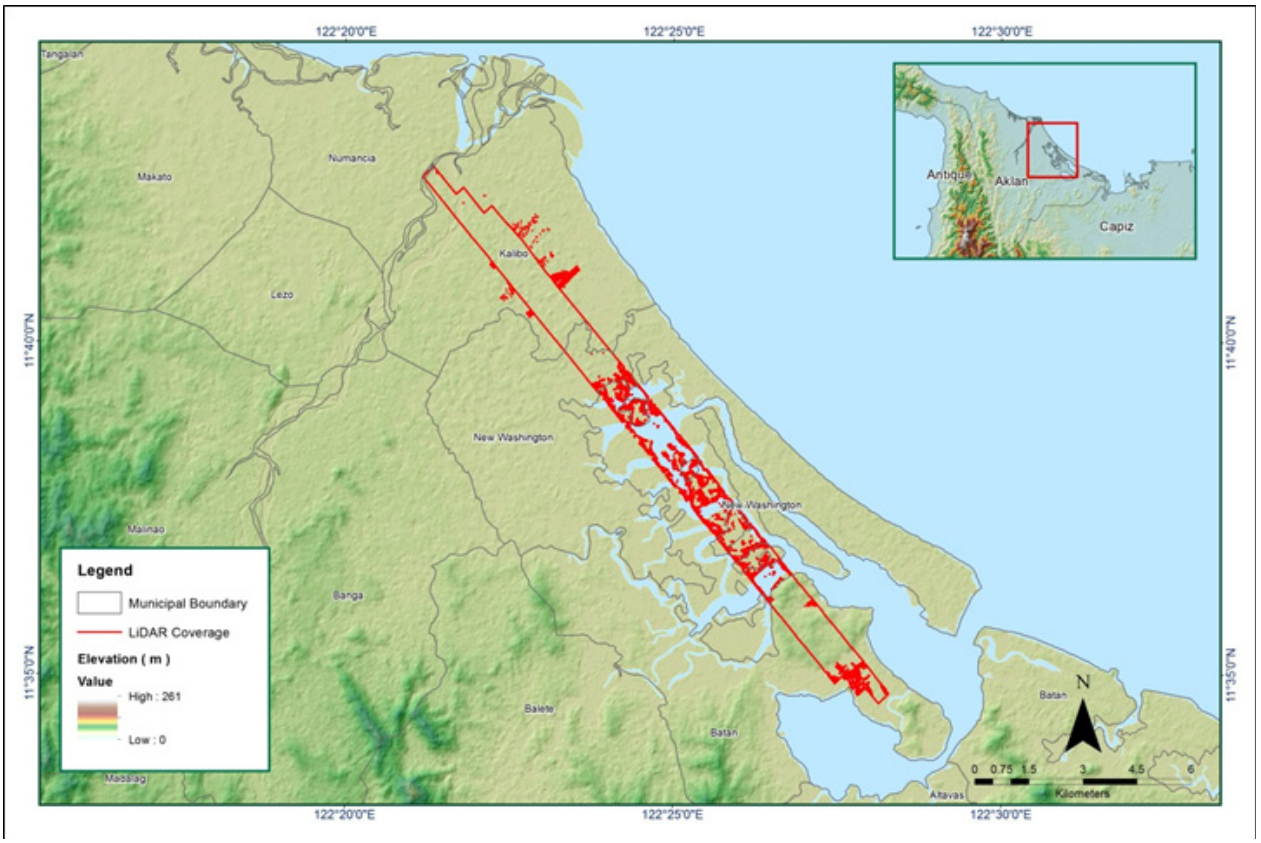


Figure A-8.11. Coverage of LiDAR data

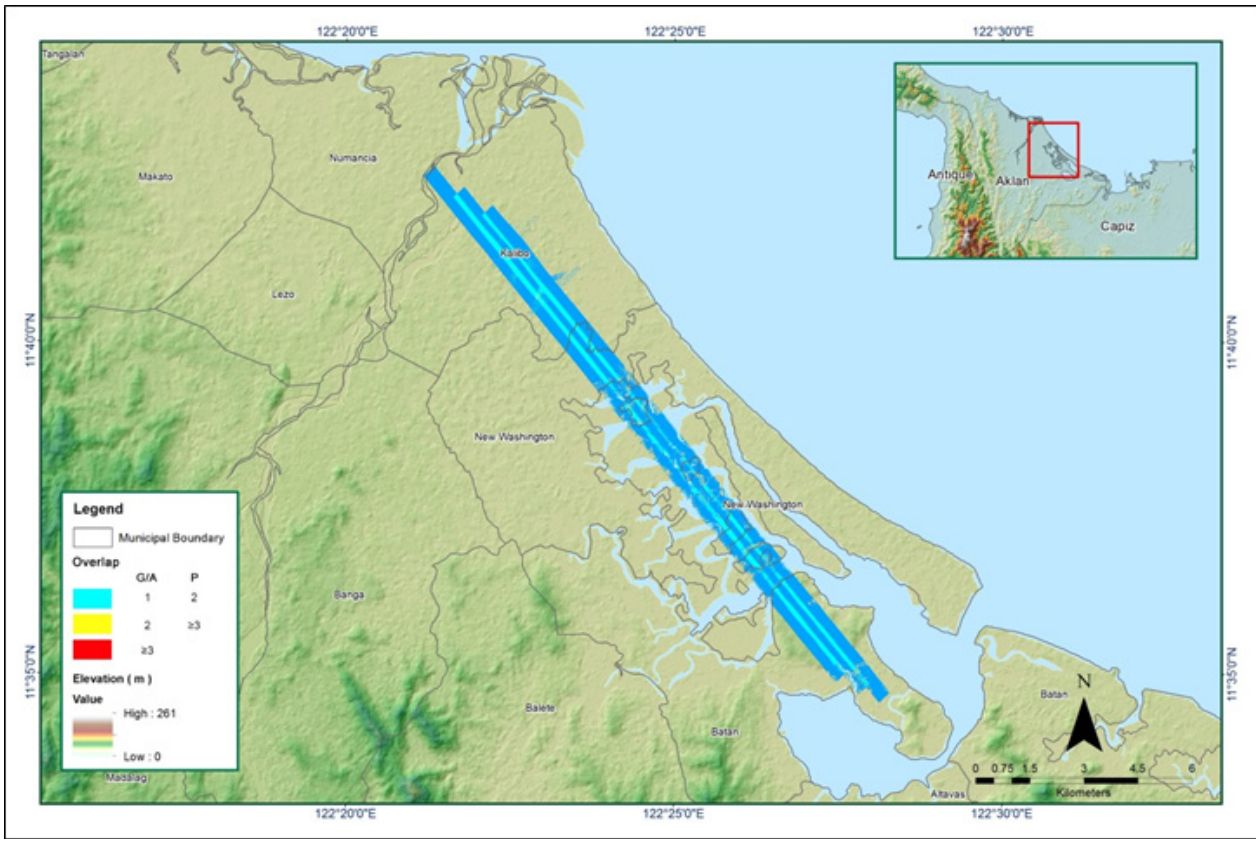


Figure A-8.12. Image of data overlap

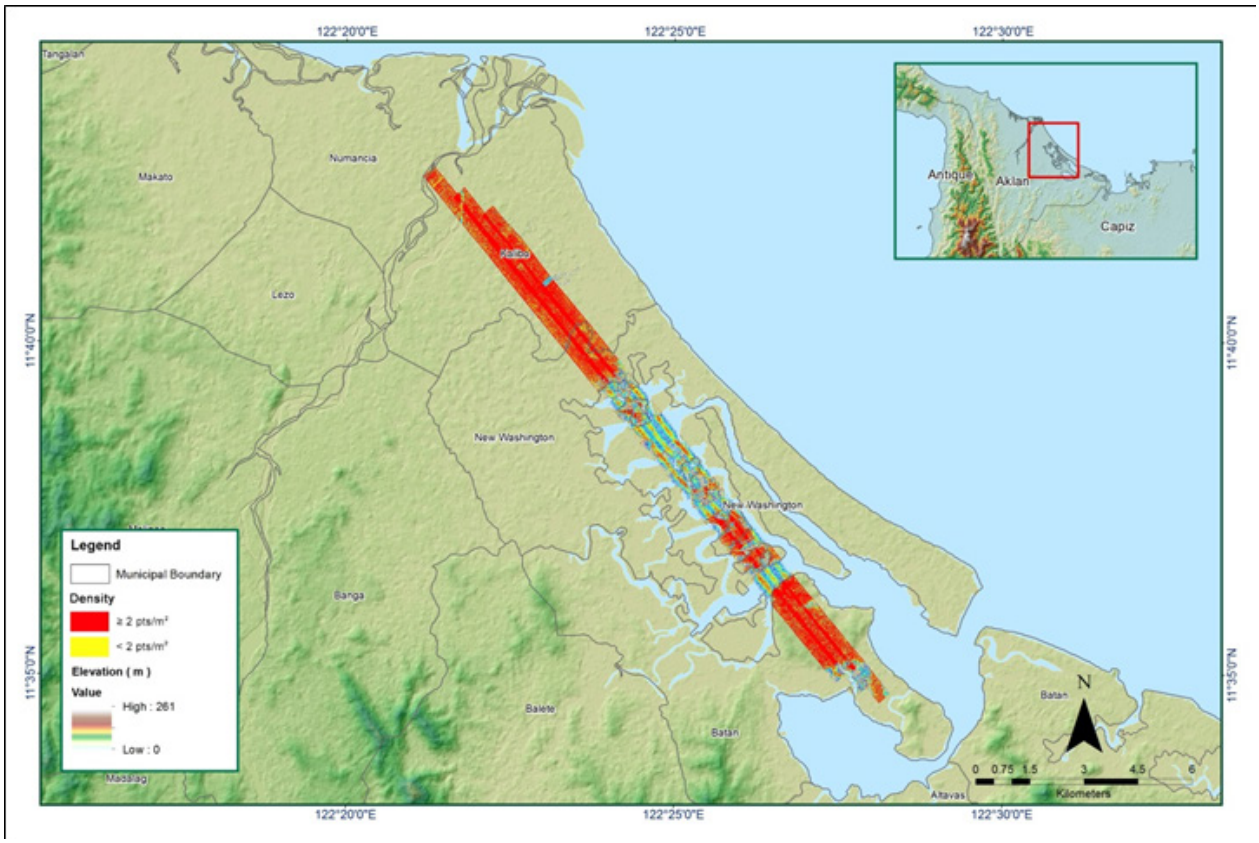


Figure A-8.13. Density map of merged LiDAR data

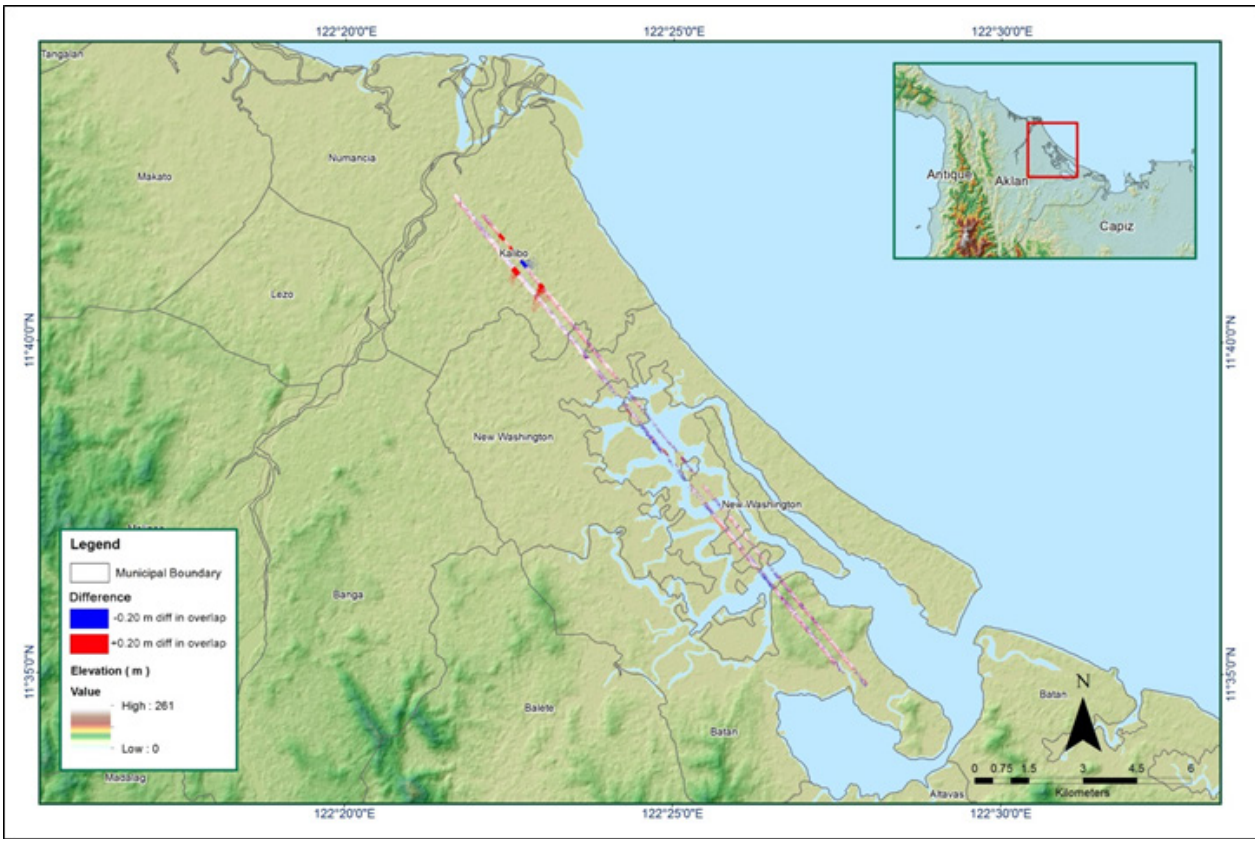


Figure A-8.14. Elevation difference between flight lines

Table A-8.3. Mission Summary Report for Mission Blk38H

Flight Area	Aklan
Mission Name	Blk38H
Inclusive Flights	1230A, 1240A
Mission Name	3BLK38HIS078A
Range data size	22.93 GB
POS	405 MB
Image	536 GB
Transfer date	April 2, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.1
RMSE for East Position (<4.0 cm)	1.2
RMSE for Down Position (<8.0 cm)	3.5
Boresight correction stdev (<0.001deg)	0.000327
IMU attitude correction stdev (<0.001deg)	0.000854
GPS position stdev (<0.01m)	0.0095
Minimum % overlap (>25)	68.05%
Ave point cloud density per sq.m. (>2.0)	3.80
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	182
Maximum Height	424.79 m
Minimum Height	52.37 m
Classification (# of points)	
Ground	145,519,463
Low vegetation	165,819,430
Medium vegetation	187,679,061
High vegetation	178,946,950
Building	8,616,434
Orthophoto	Yes
Processed by	Engr. Jennifer Saguran, Engr. Charmaine Cruz, Engr. Gladys Mae Apat

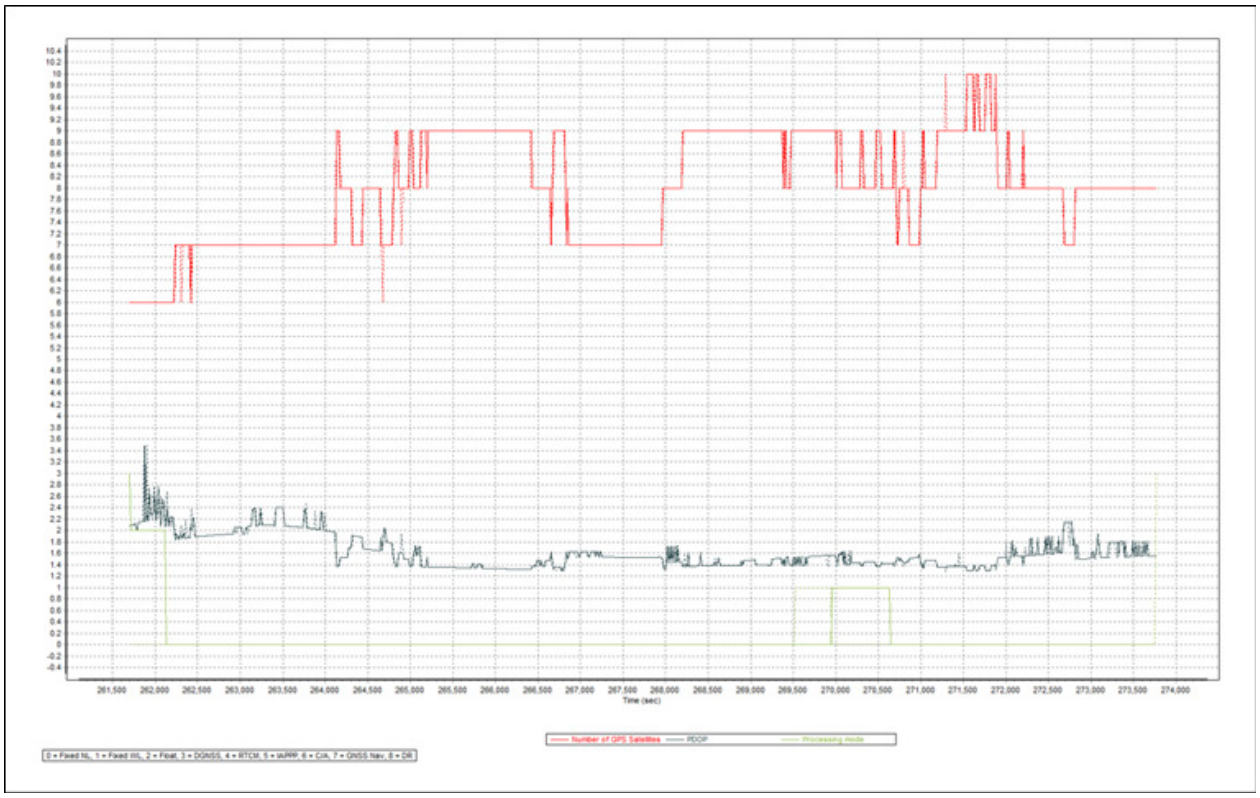


Figure A-8.15. Solution Status

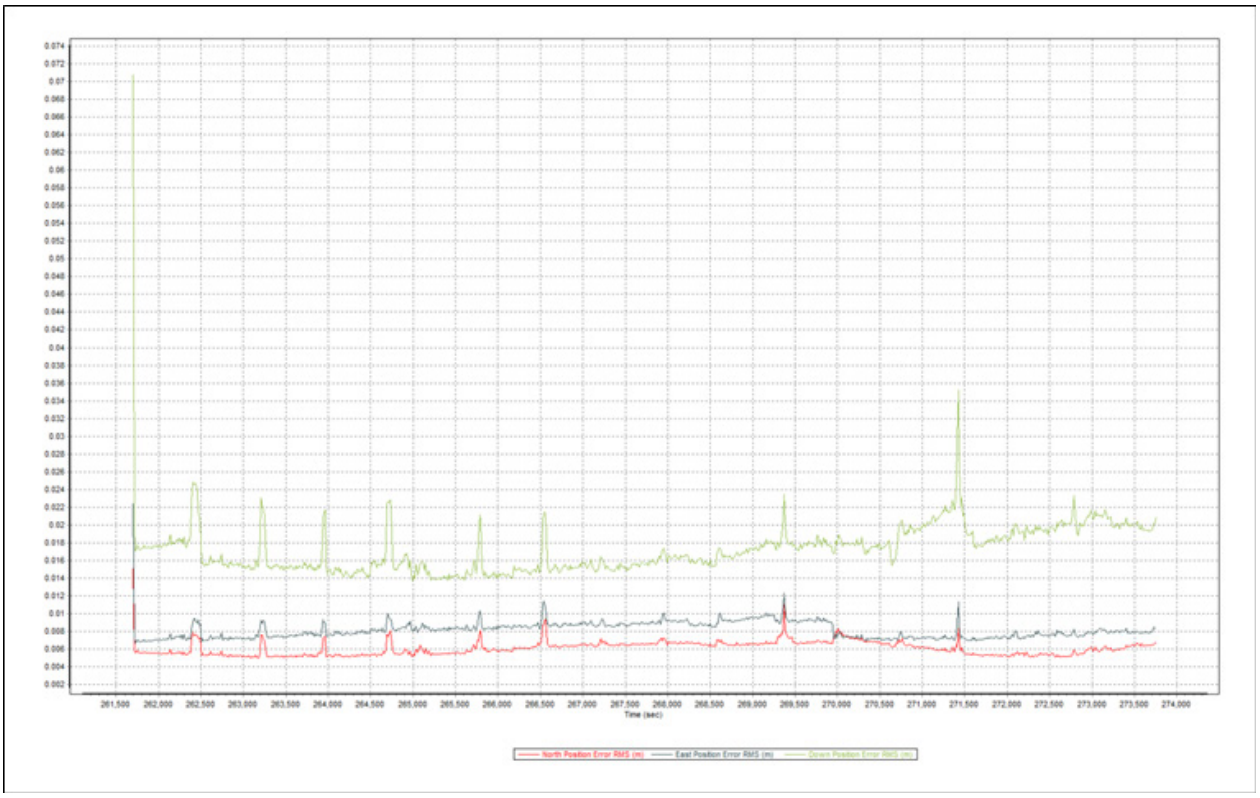


Figure A-8.16. Smoothed Performance Metric Parameters

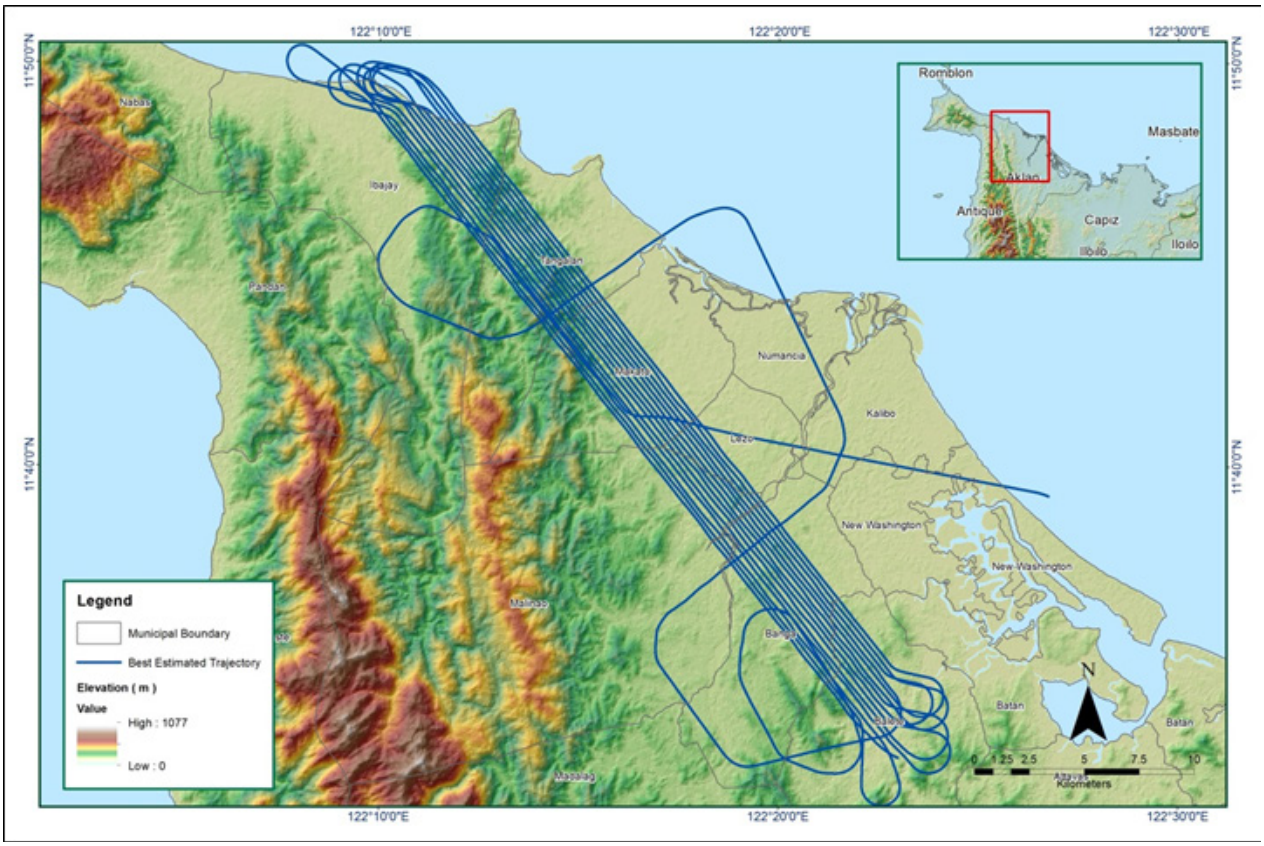


Figure A-8.17. Best Estimated Trajectory

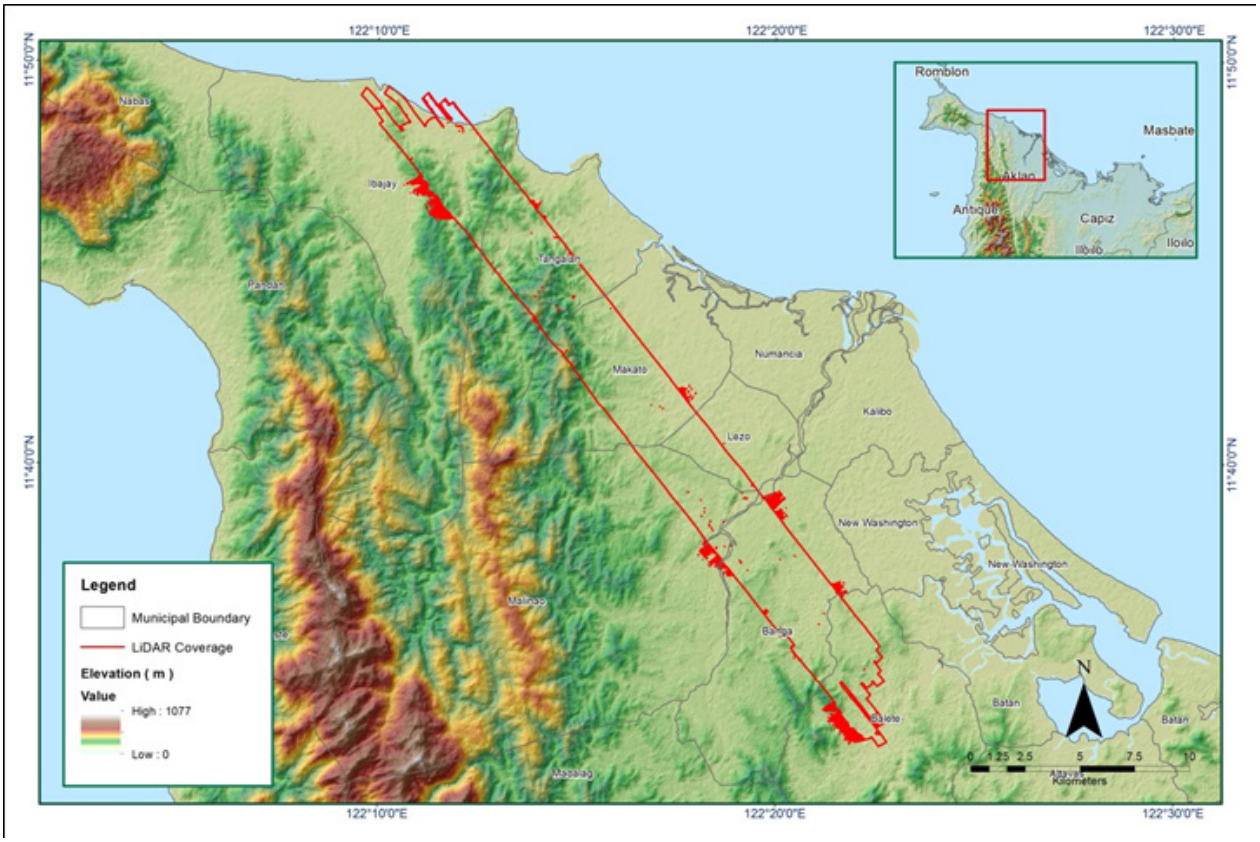


Figure A-8.18. Coverage of LiDAR data

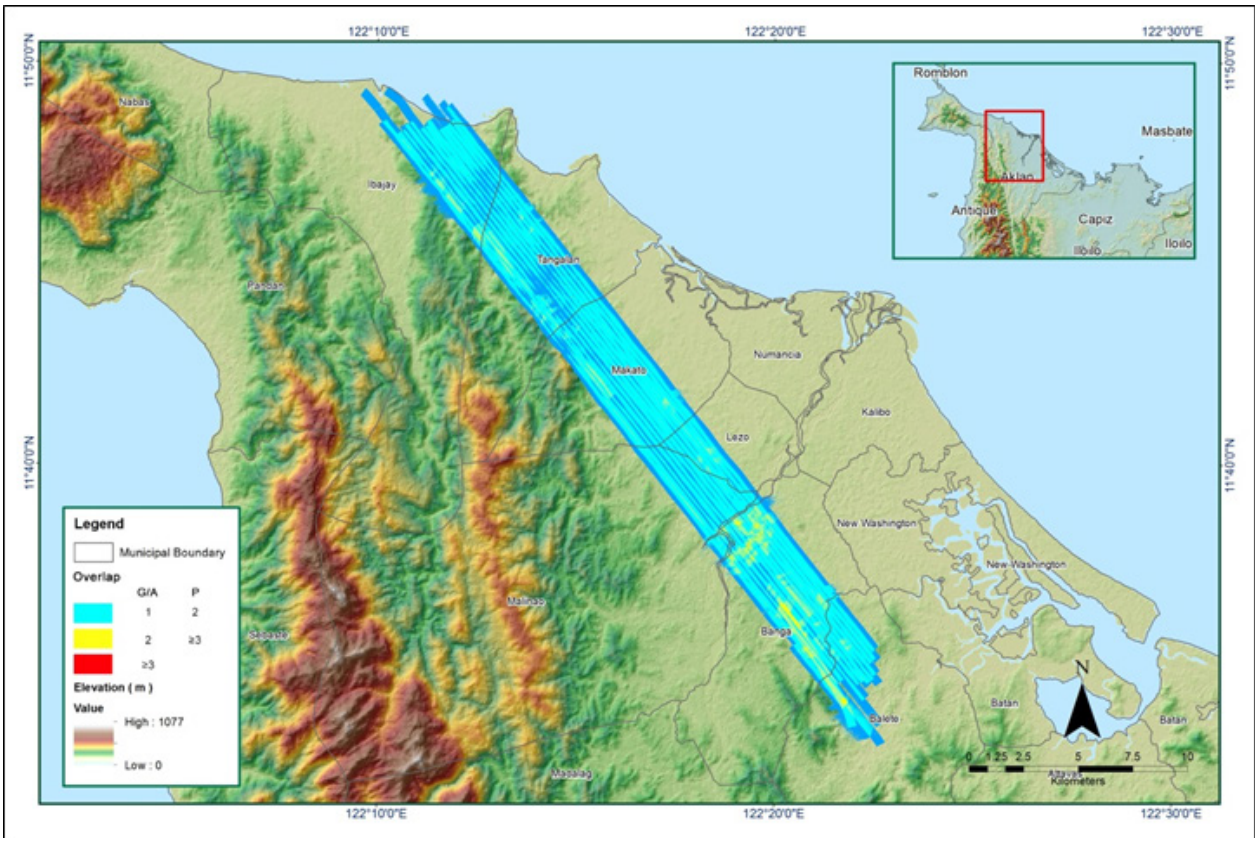


Figure A-8.19. Image of data overlap

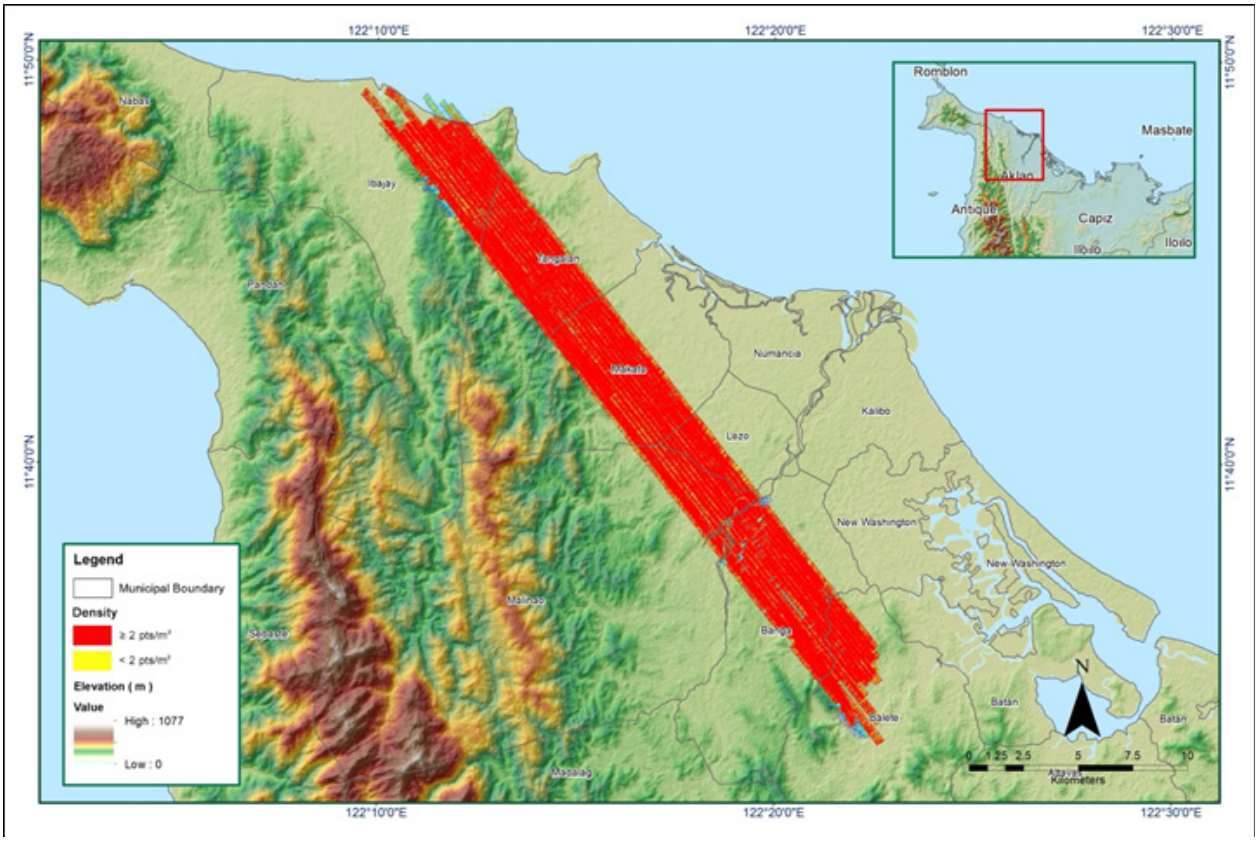


Figure A-8.20. Density map of merged LiDAR data

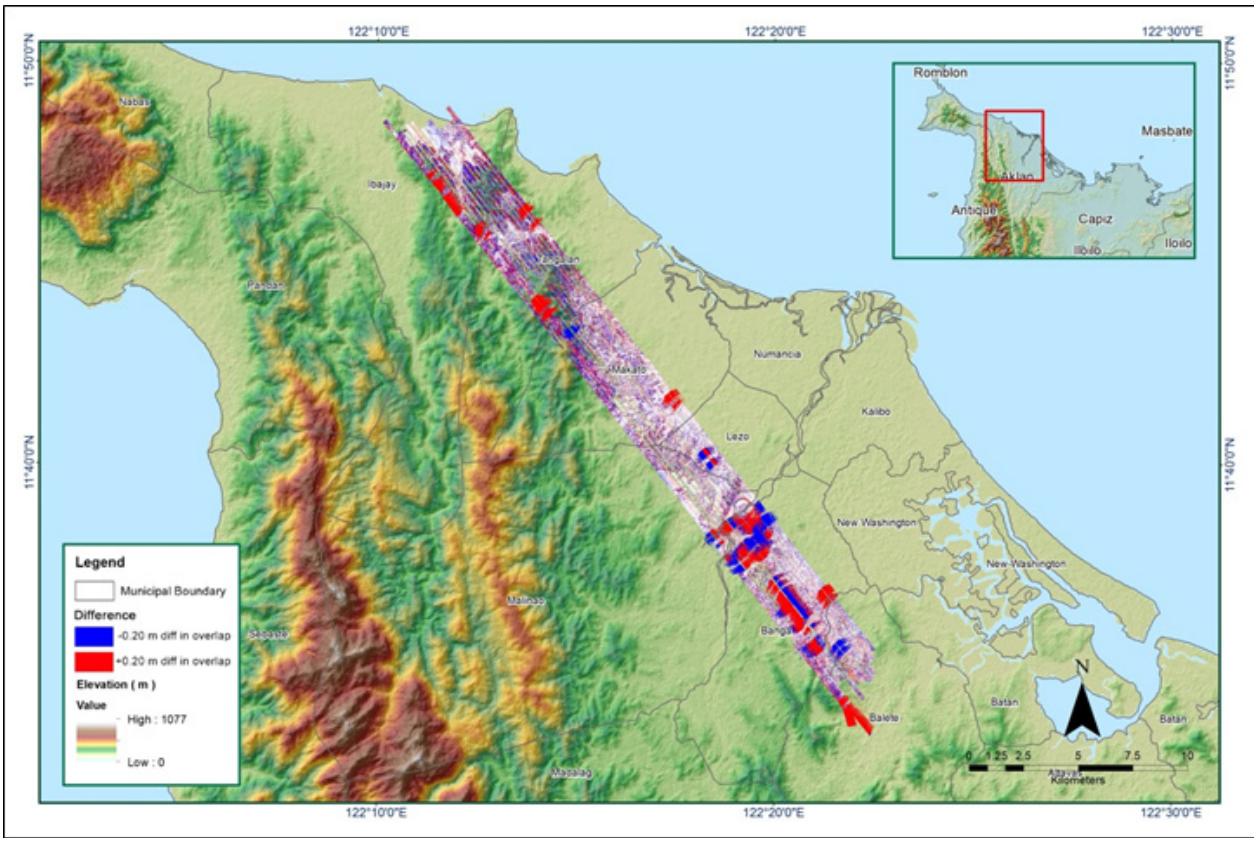


Figure A-8.21. Elevation difference between flight lines

Table A-8.4. Mission Summary Report for Mission Blk38N

Flight Area	Aklan
Mission Name	Blk38N
Inclusive Flights	1192A
Mission Name	3BLK38M068B
Range data size	14.9 GB
POS	189 MB
Base data size	15.7 MB
Image	69.3 GB
Transfer date	April 22, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.1
RMSE for East Position (<4.0 cm)	1.7
RMSE for Down Position (<8.0 cm)	3.0
Boresight correction stdev (<0.001deg)	0.000745
IMU attitude correction stdev (<0.001deg)	0.699159
GPS position stdev (<0.01m)	0.0394
Minimum % overlap (>25)	35.24%
Ave point cloud density per sq.m. (>2.0)	2.77
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	158
Maximum Height	580.79 m
Minimum Height	60.49 m
Classification (# of points)	
Ground	45119614
Low vegetation	30636165
Medium vegetation	149692011
High vegetation	25112119
Building	340269
Orthophoto	Yes
Processed by	Victoria Rejuso, Engr. Merven Matthew Natino, Ailyn Biñas

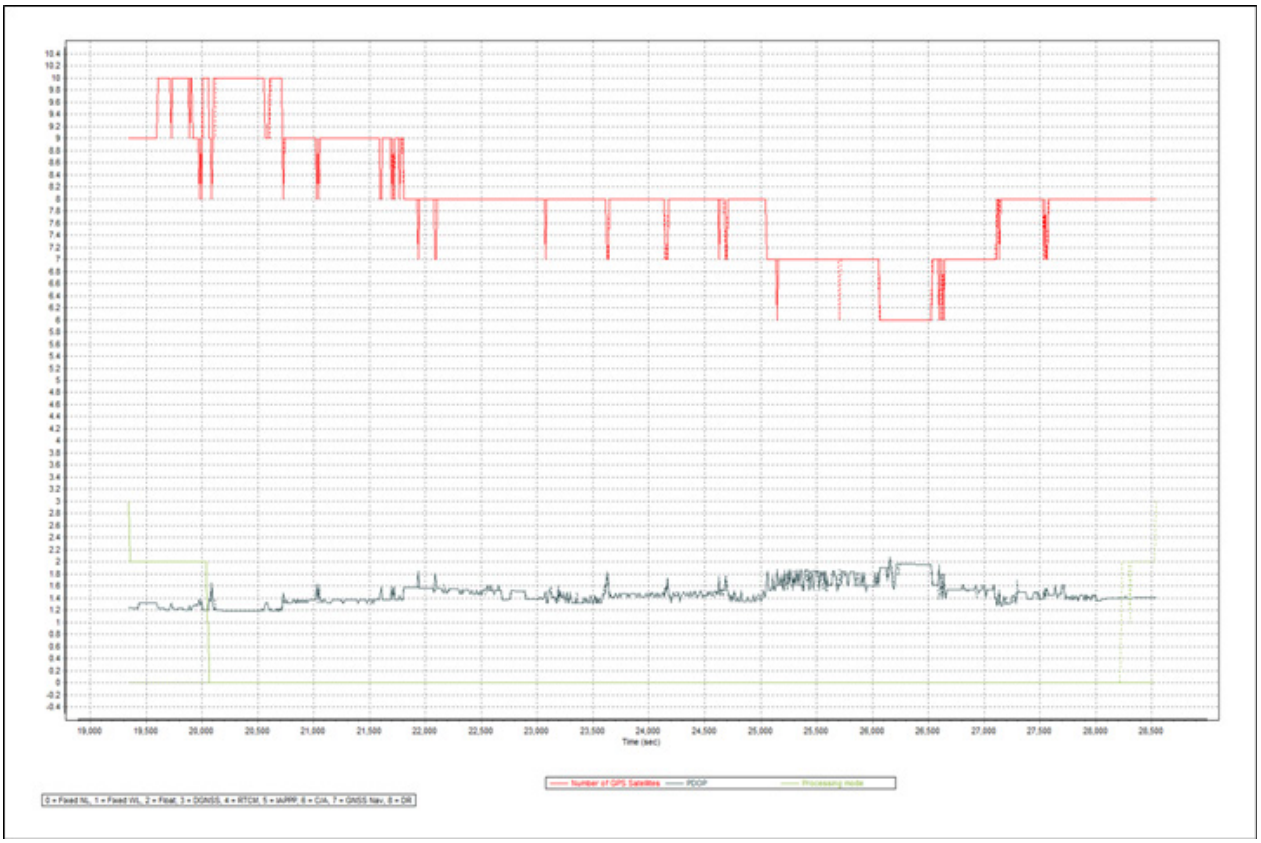


Figure A-8.22. Solution Status

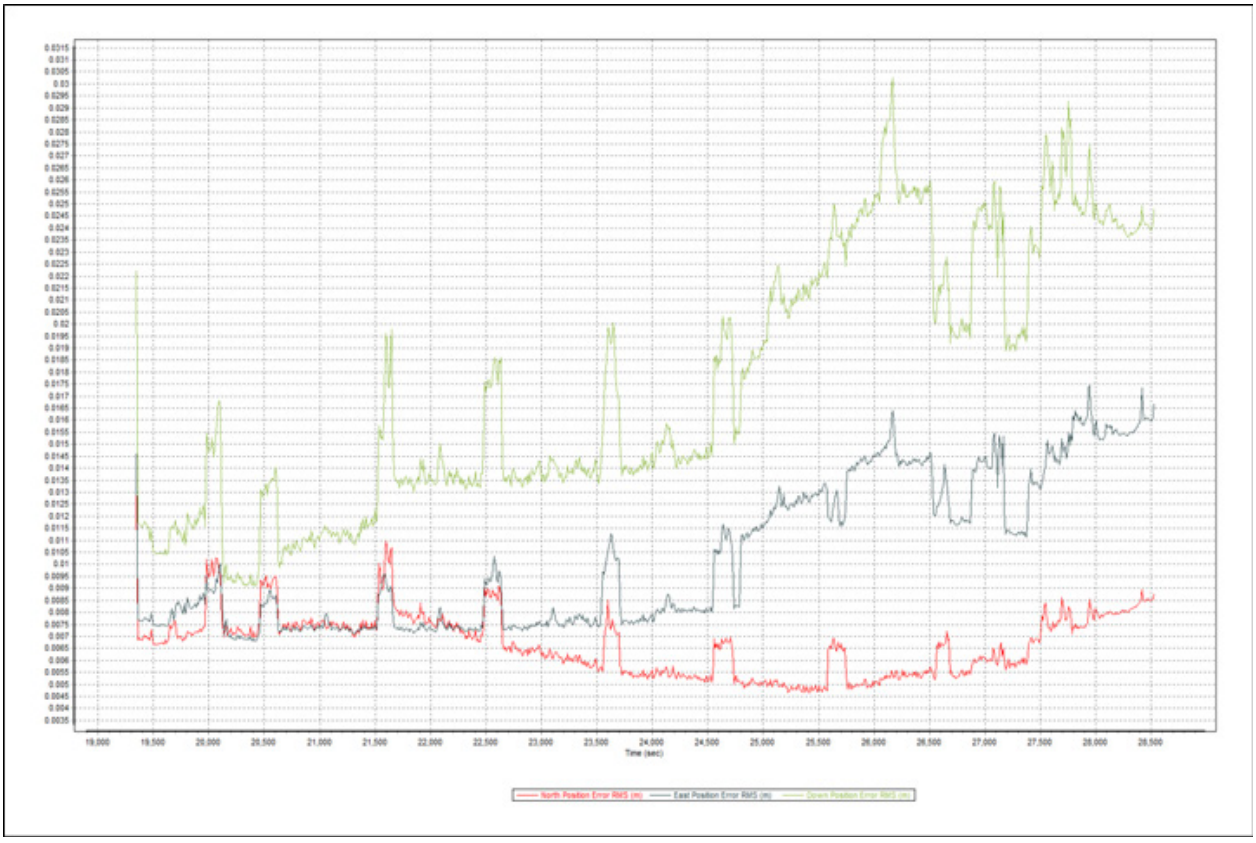


Figure A-8.23. Smoothed Performance Metric Parameters

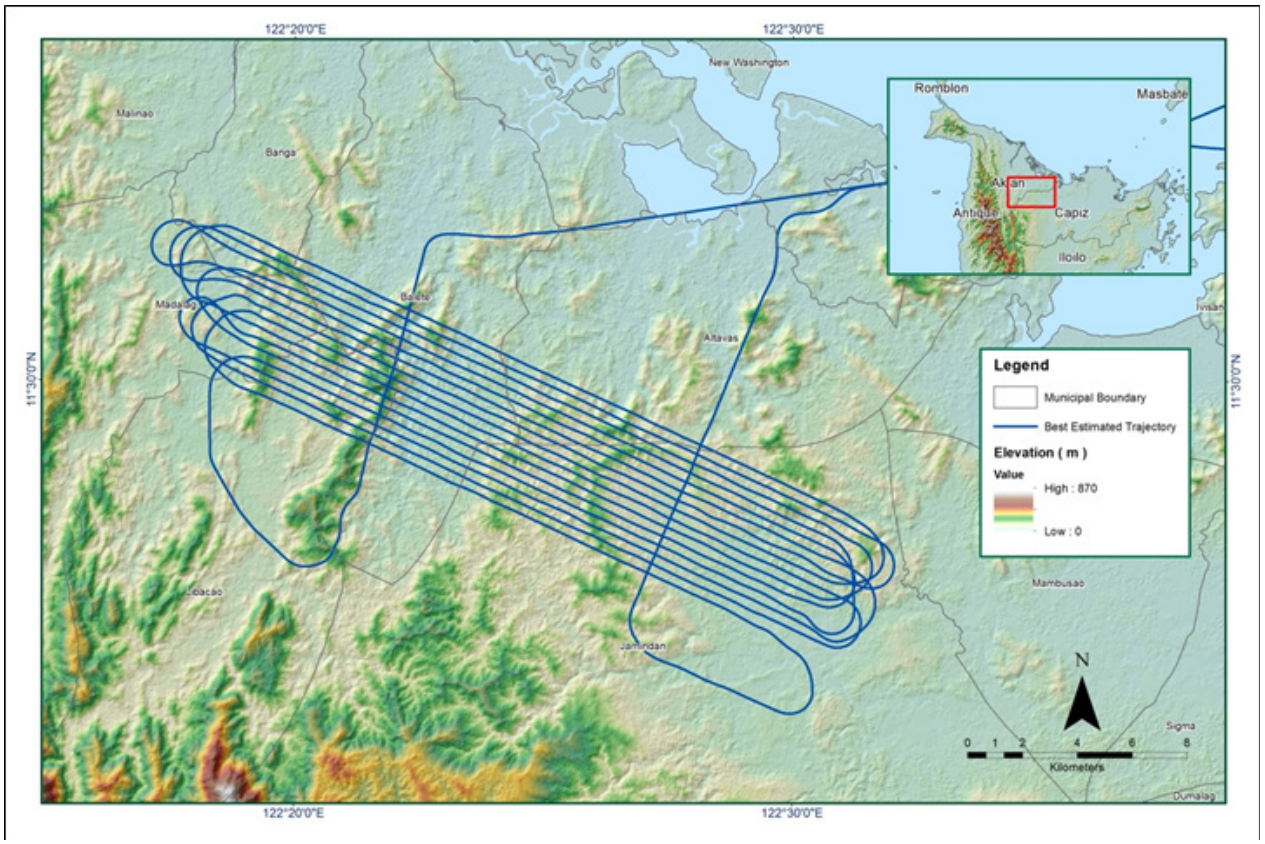


Figure A-8.24. Best Estimated Trajectory

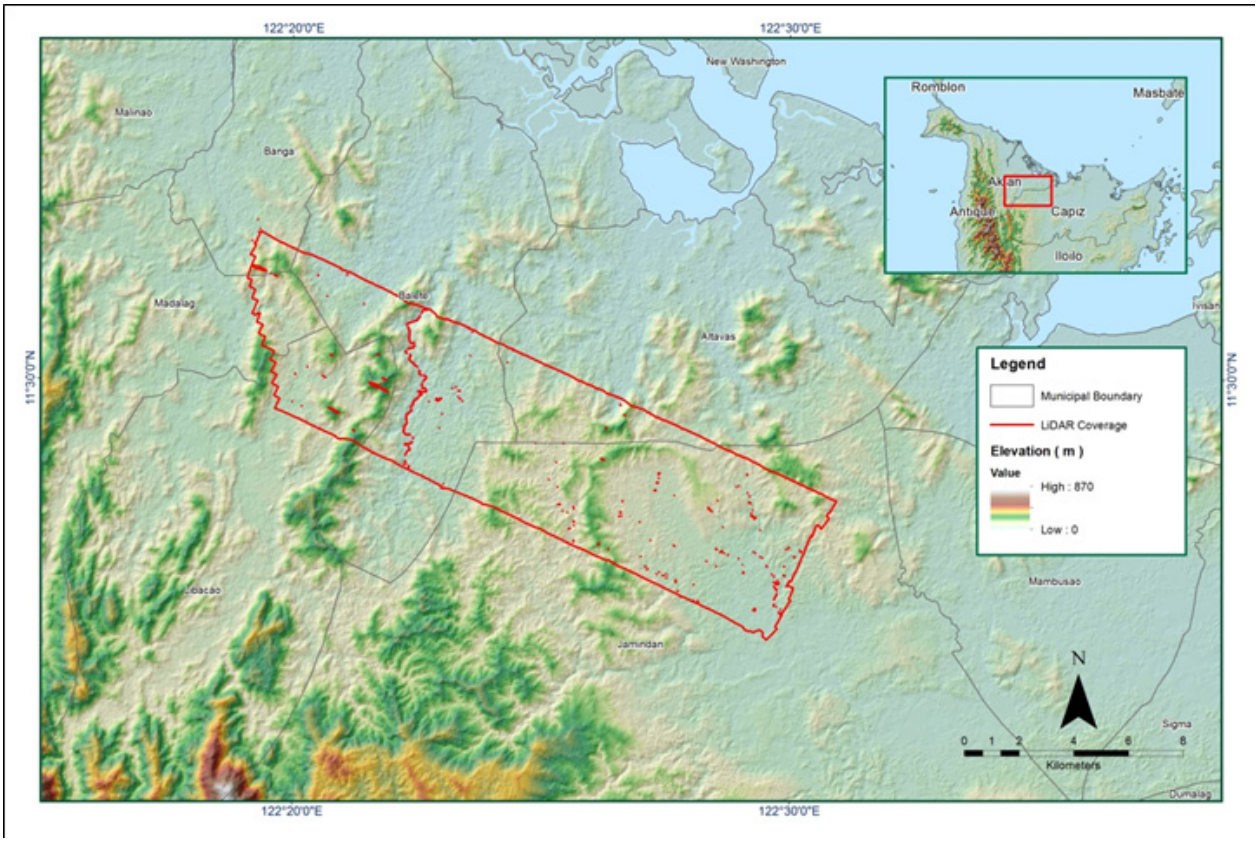


Figure A-8.25. Coverage of LiDAR data

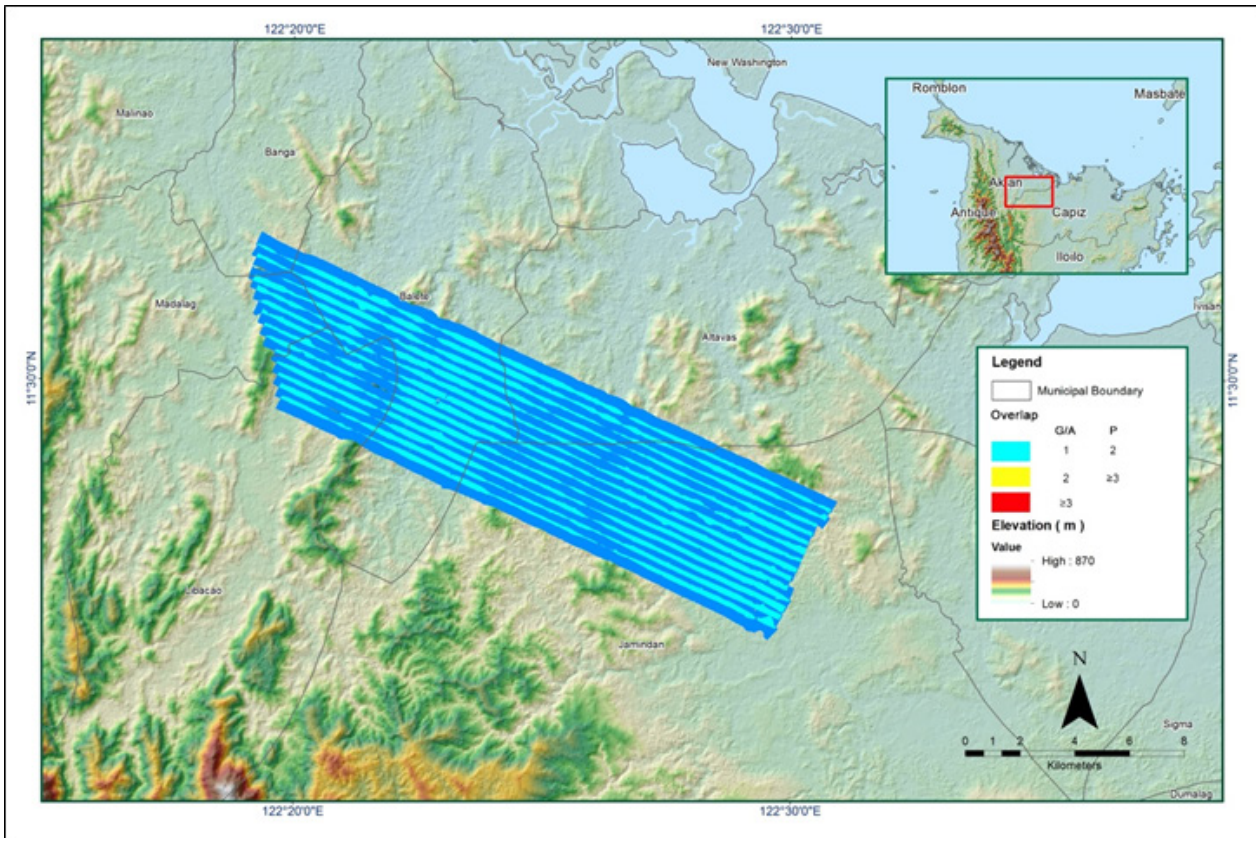


Figure A-8.26. Image of data overlap

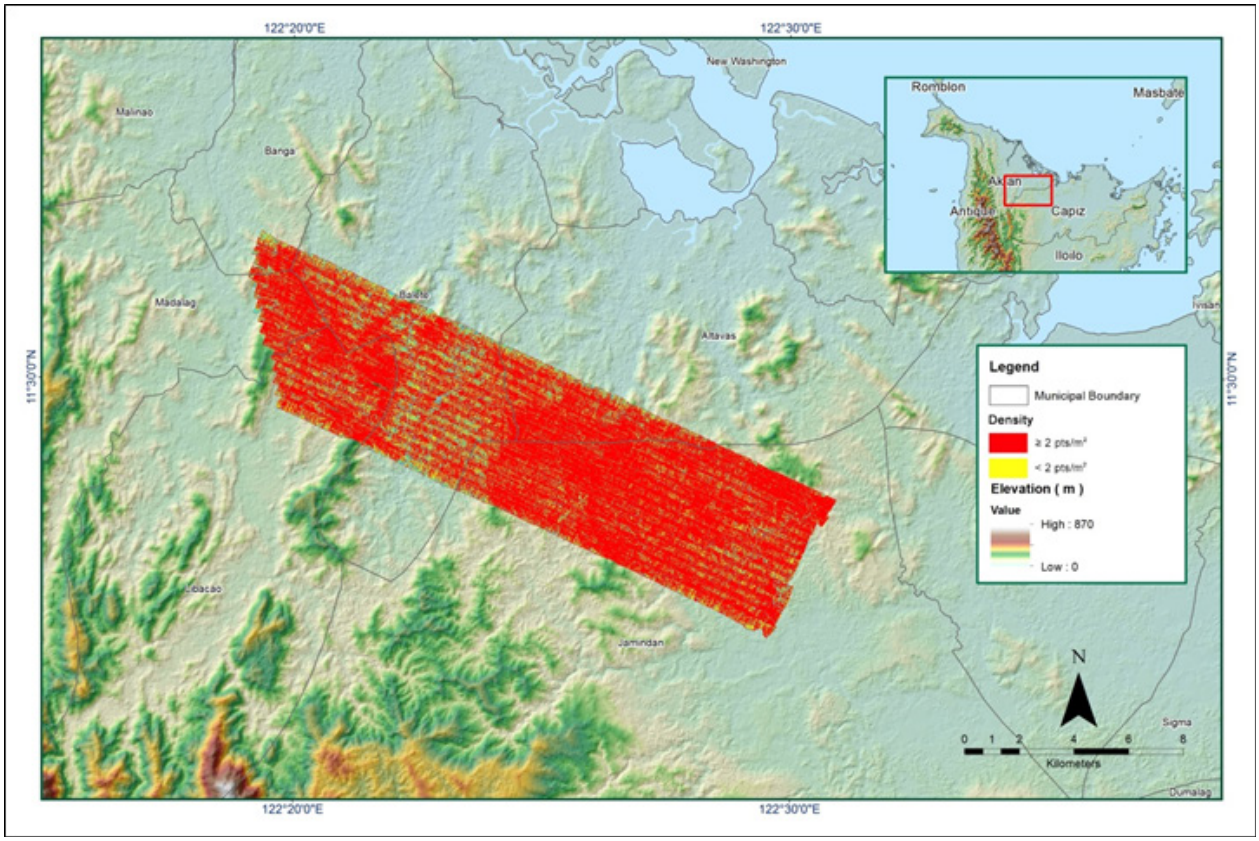


Figure A-8.27. Density map of merged LiDAR data

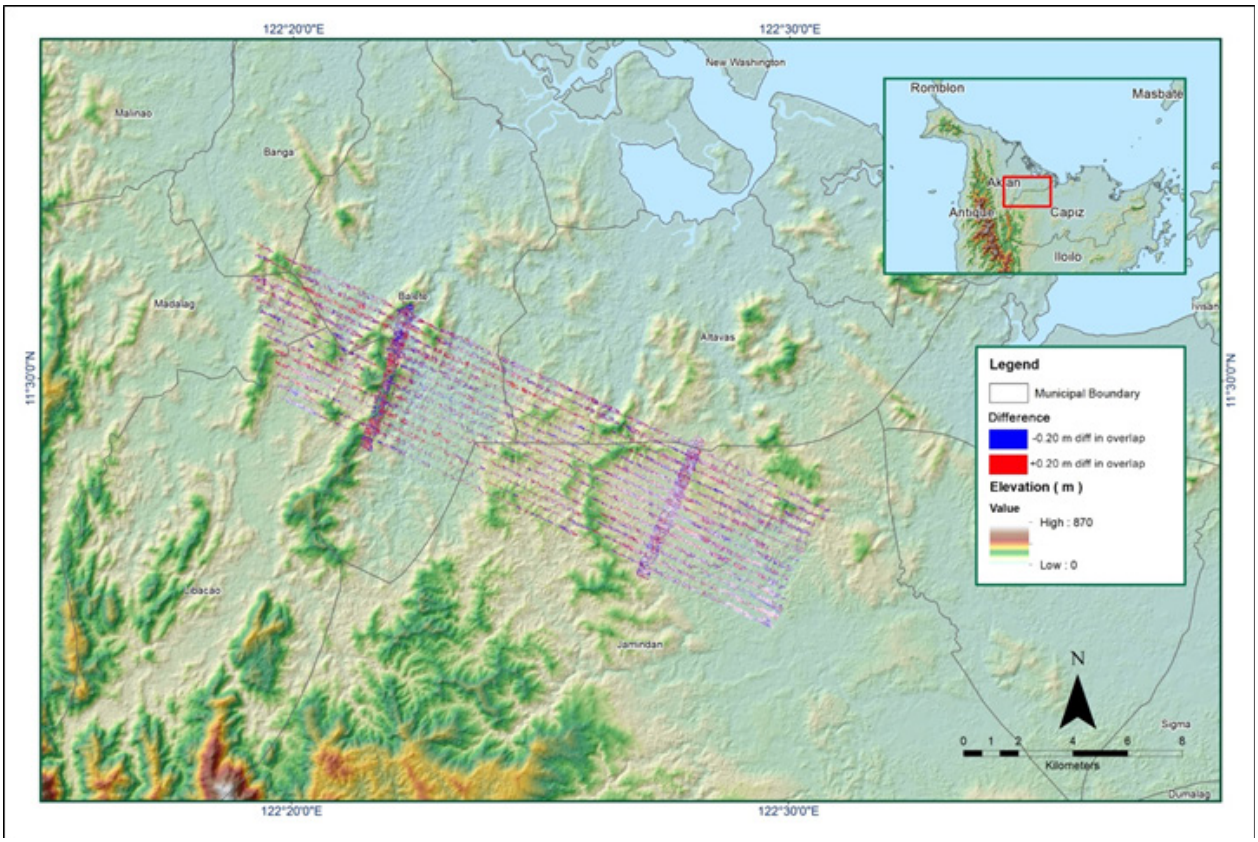


Figure A-8.28. Elevation difference between flight lines

Table A-8.5. Mission Summary Report for Mission Blk38F

Flight Area	Aklan
Mission Name	Blk38F
Inclusive Flights	1210A,1212A, 1224A
Mission Name	3BLK38FS073A
Range data size	10.1 GB
POS	212 MB
Base data size	14.4 MB
Image	n/a
Transfer date	April 22, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.8
RMSE for East Position (<4.0 cm)	1.8
RMSE for Down Position (<8.0 cm)	4.5
Boresight correction stdev (<0.001deg)	0.000585
IMU attitude correction stdev (<0.001deg)	18.358539
GPS position stdev (<0.01m)	0.0037
Minimum % overlap (>25)	59.20%
Ave point cloud density per sq.m. (>2.0)	4.04
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	145
Maximum Height	159.60 m
Minimum Height	44.66 m
Classification (# of points)	
Ground	46,608,155
Low vegetation	62,424,760
Medium vegetation	134,430,834
High vegetation	27,020,290
Building	5,921,882
Orthophoto	Yes
Processed by	Engr. Angelo Carlo Bongat, Engr. Chelou Prado, Ryan James Nicholai Dizon

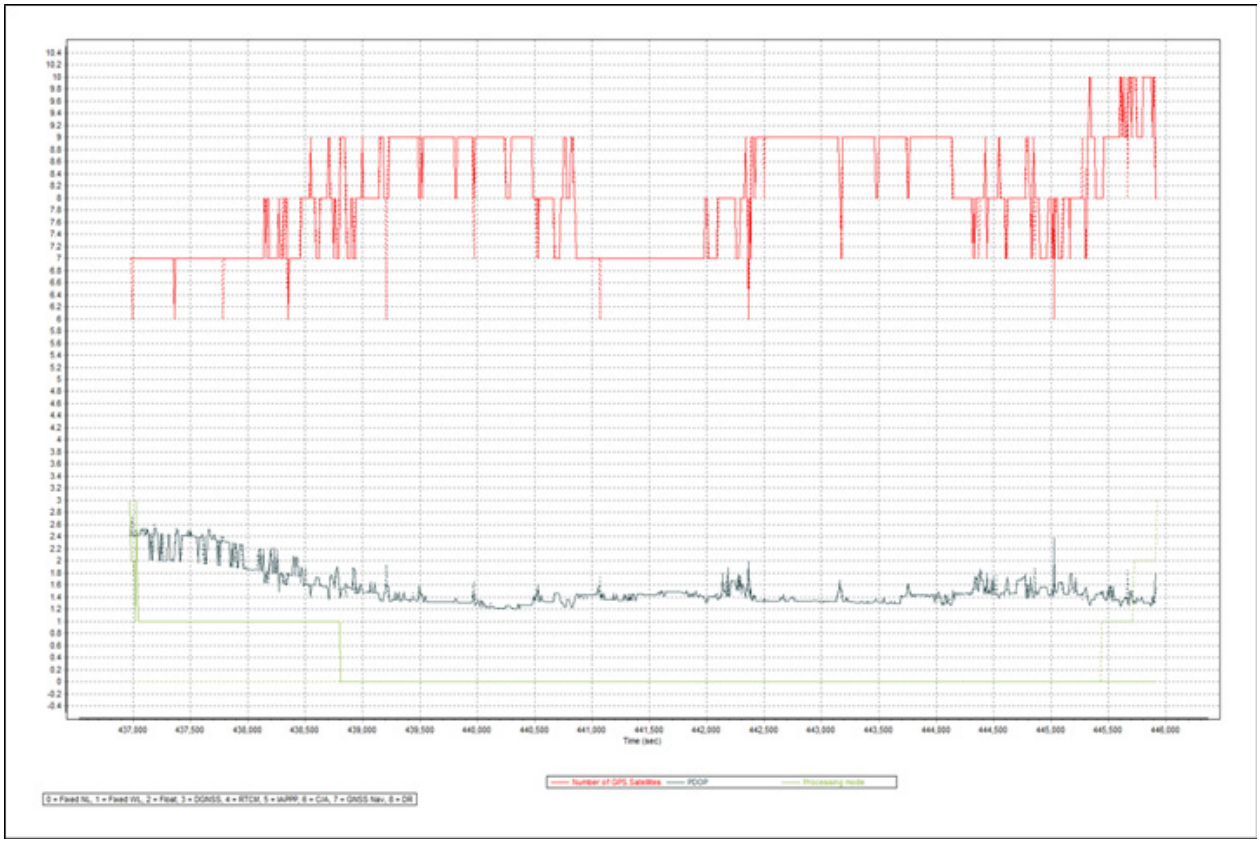


Figure A-8.29. Solution Status

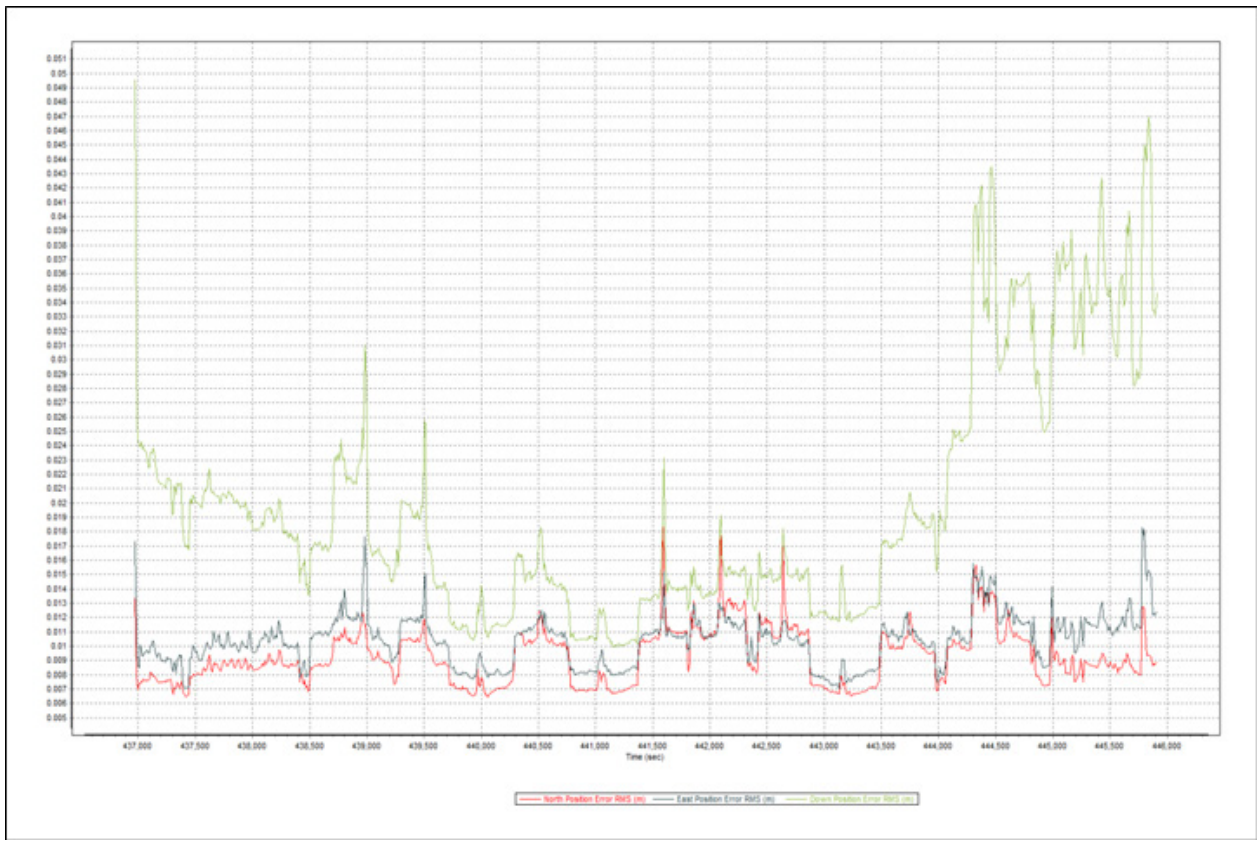


Figure A-8.30. Smoothed Performance Metric Parameters

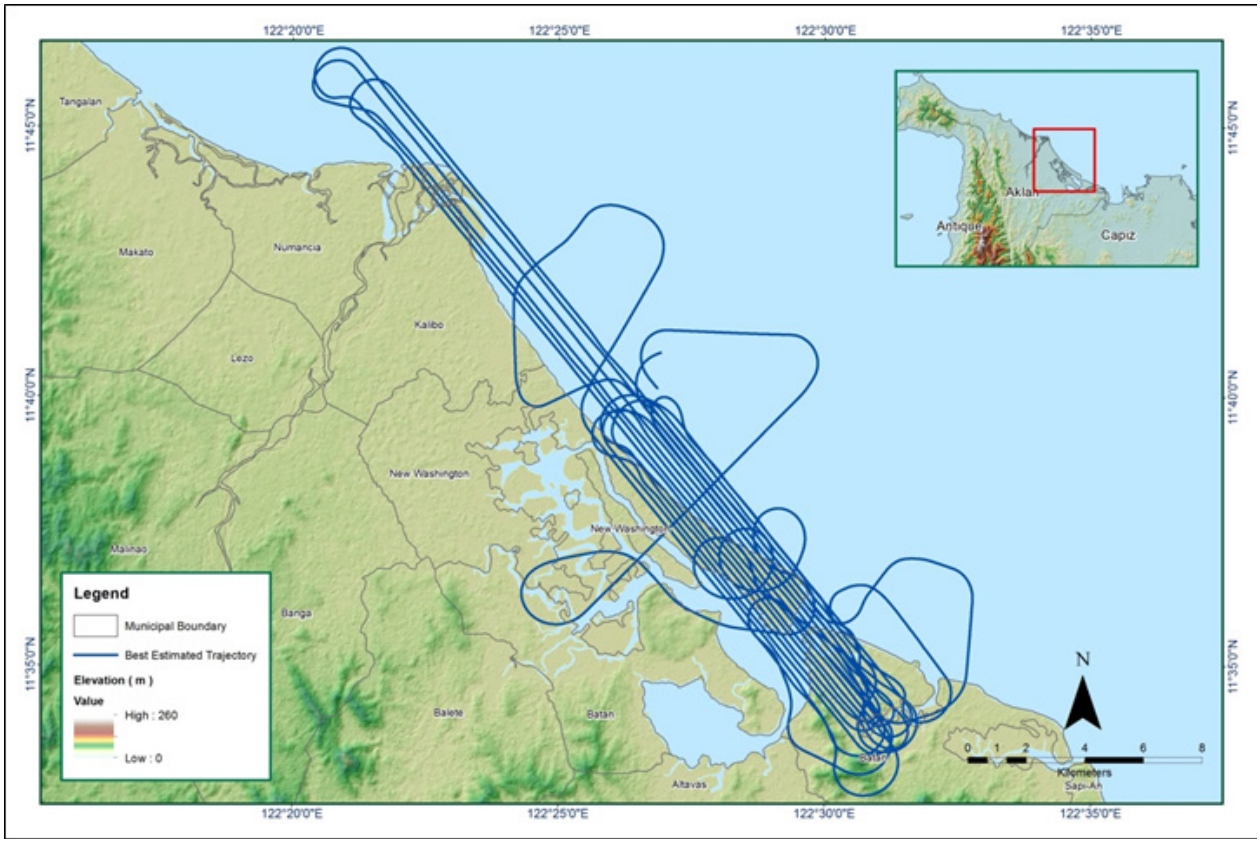


Figure A-8.31. Best Estimated Trajectory

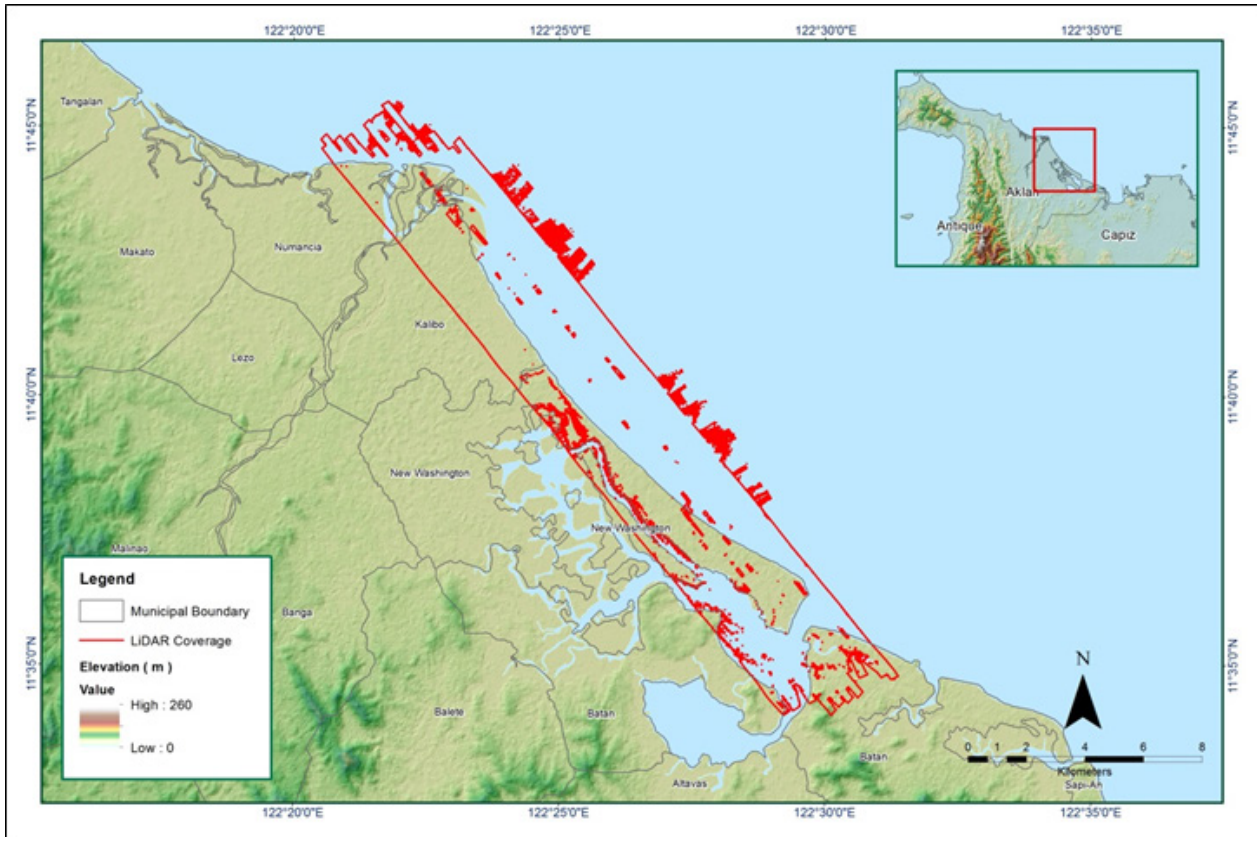


Figure A-8.32. Coverage of LiDAR data

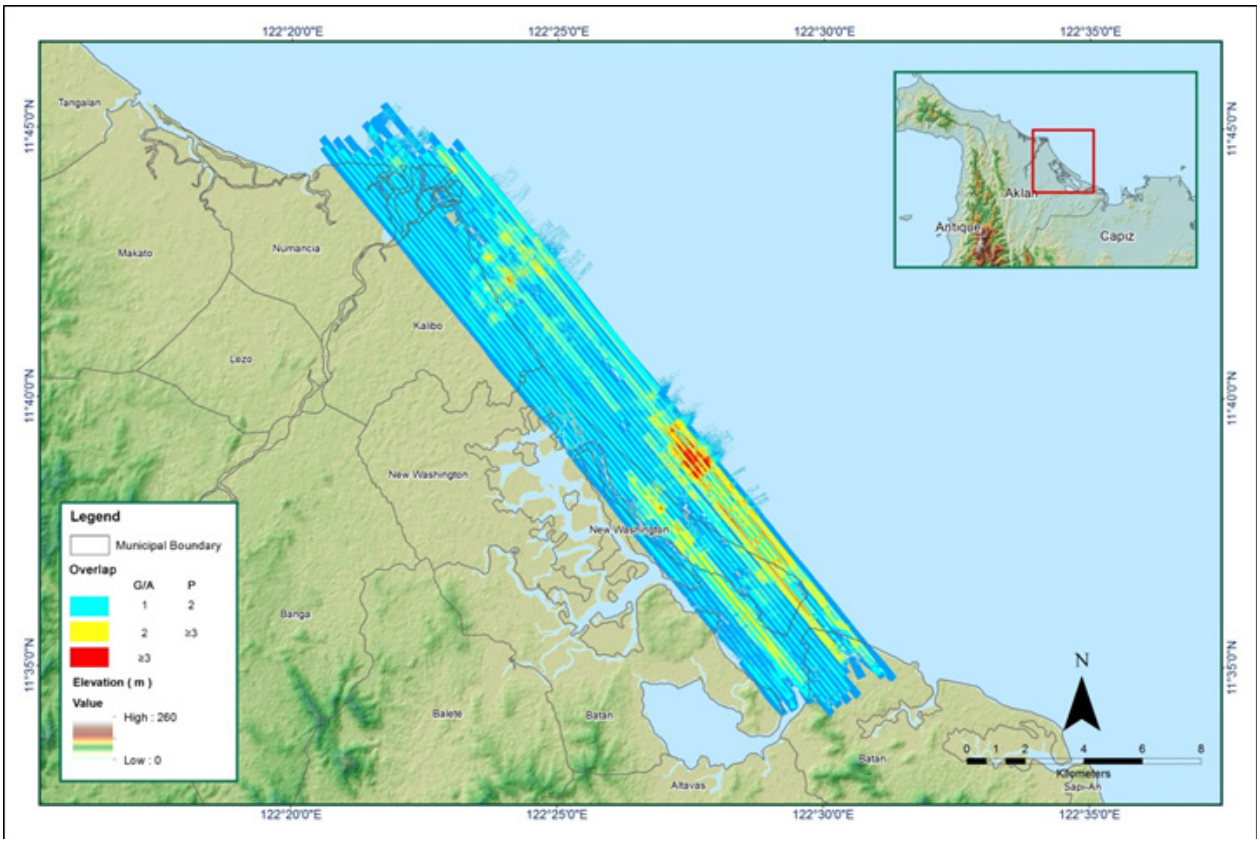


Figure A-8.33. Image of data overlap

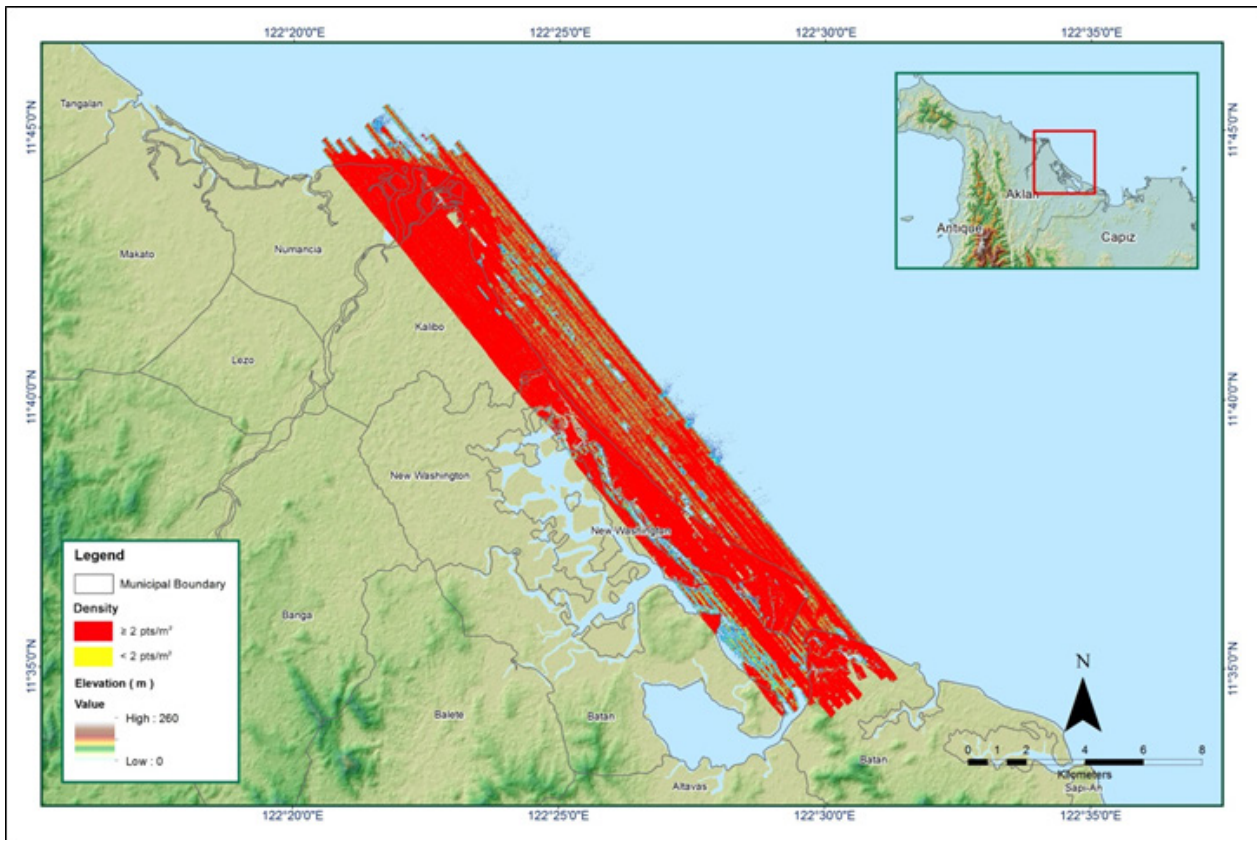


Figure A-8.34. Density map of merged LiDAR data

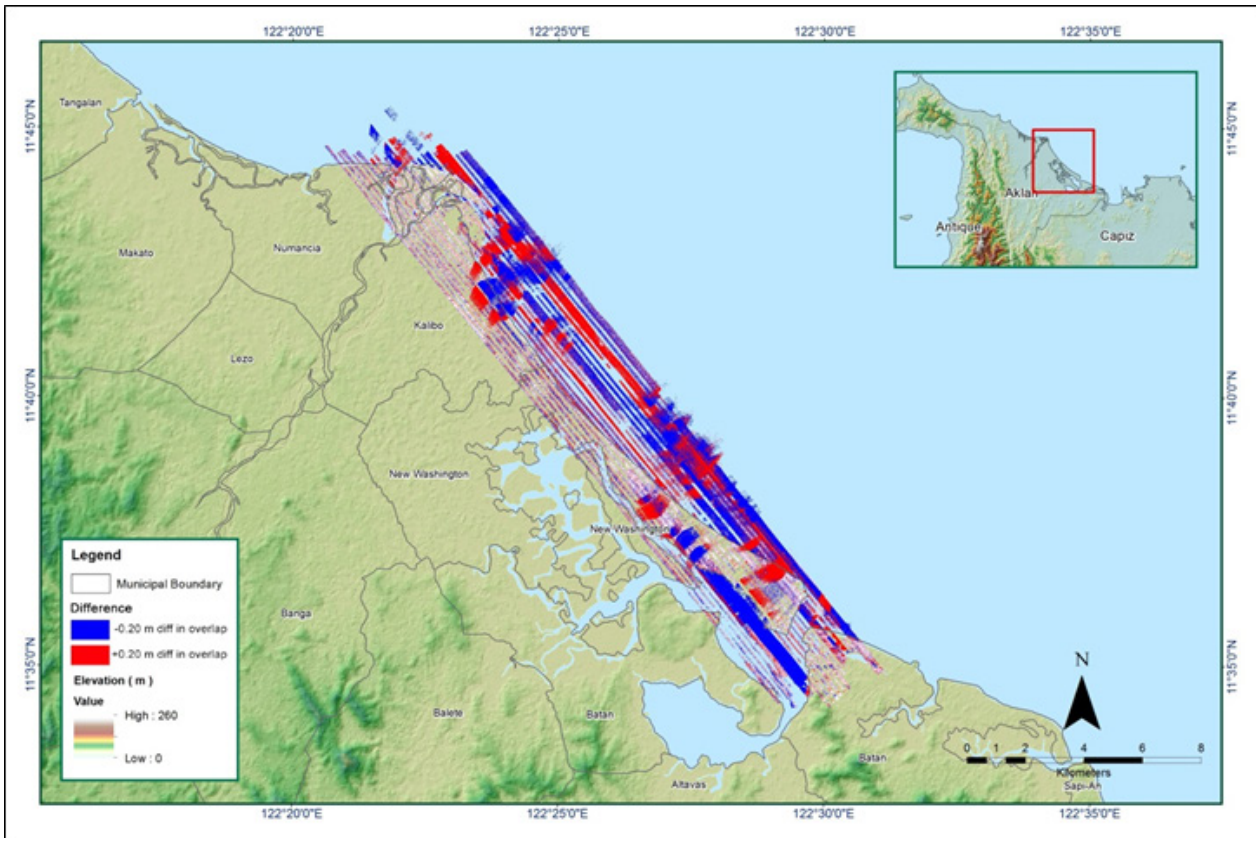


Figure A-8.35. Elevation difference between flight lines

Table A-8.6. Mission Summary Report for Mission Blk38J

Flight Area	Aklan
Mission Name	Blk38J
Inclusive Flights	1194A
Mission Name	3BLK38J069A
Range data size	15.1 GB
POS	257 MB
Base data size	7.97 MB
Image	98.2 GB
Transfer date	April 22, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.2
RMSE for East Position (<4.0 cm)	1.1
RMSE for Down Position (<8.0 cm)	3.0
Boresight correction stdev (<0.001deg)	0.000315
IMU attitude correction stdev (<0.001deg)	0.078676
GPS position stdev (<0.01m)	0.0351
Minimum % overlap (>25)	40.81%
Ave point cloud density per sq.m. (>2.0)	2.93
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	168
Maximum Height	389.57 m
Minimum Height	46.2 m
Classification (# of points)	
Ground	113518291
Low vegetation	229229294
Medium vegetation	321507947
High vegetation	117183209
Building	9796385
Orthophoto	Yes
Processed by	Engr. Jennifer Saguran, Engr. Chelou Prado, Engr. Jeffrey Delica

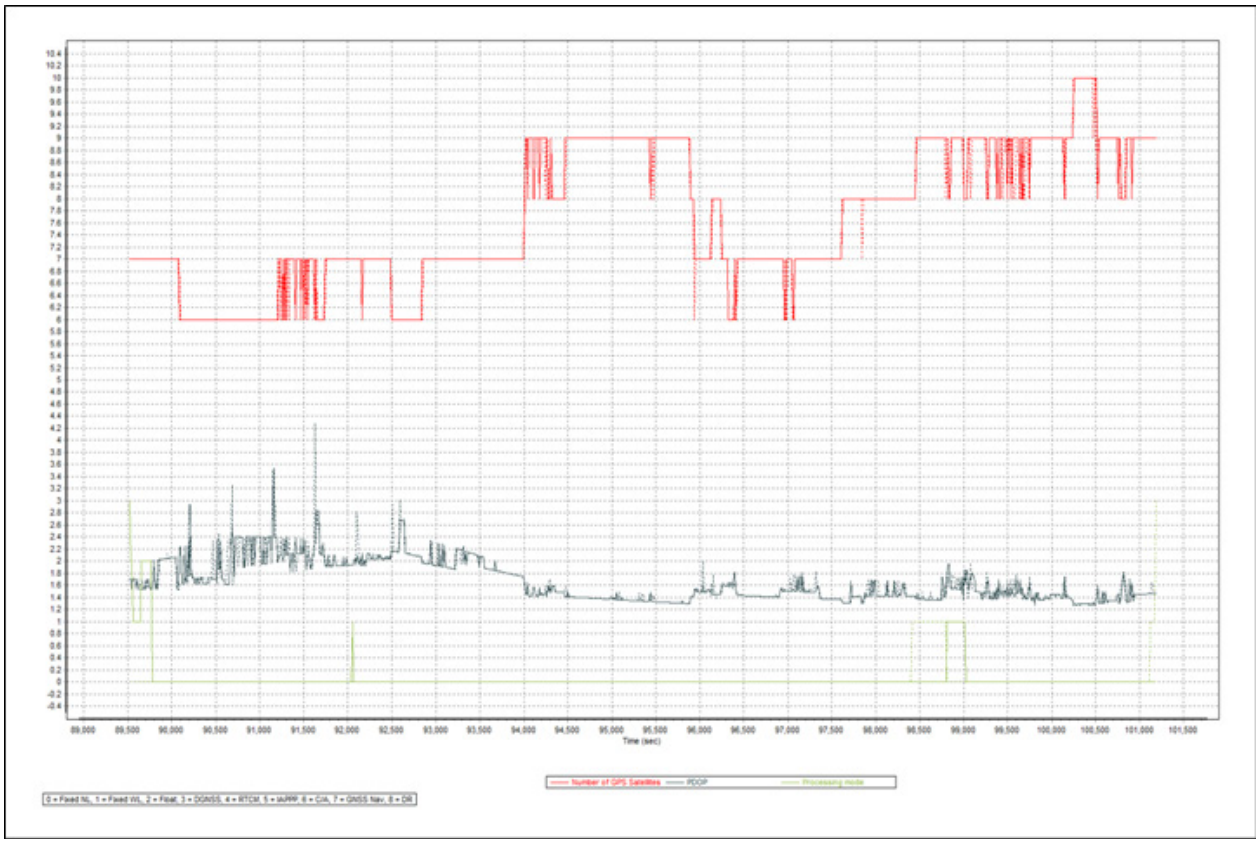


Figure A-8.36. Solution Status

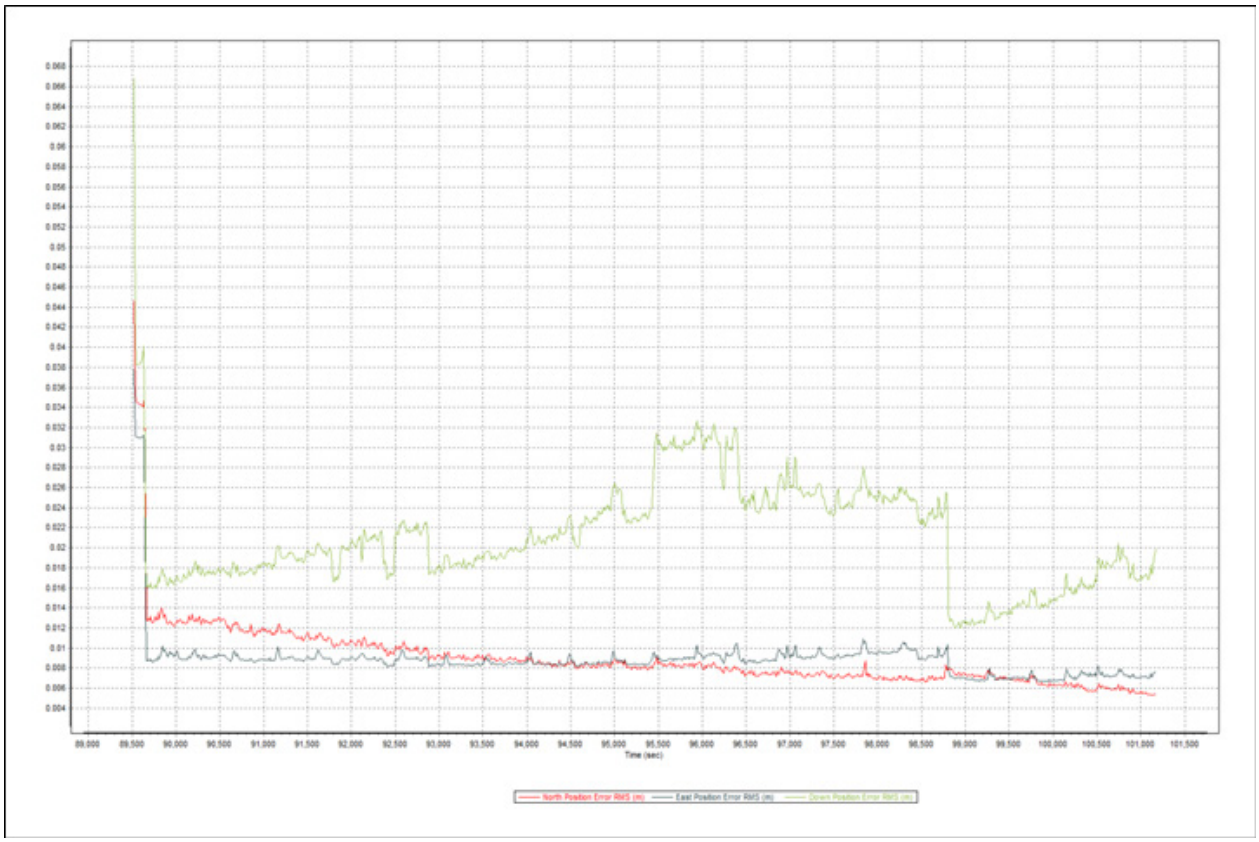


Figure A-8.37. Smoothed Performance Metric Parameters

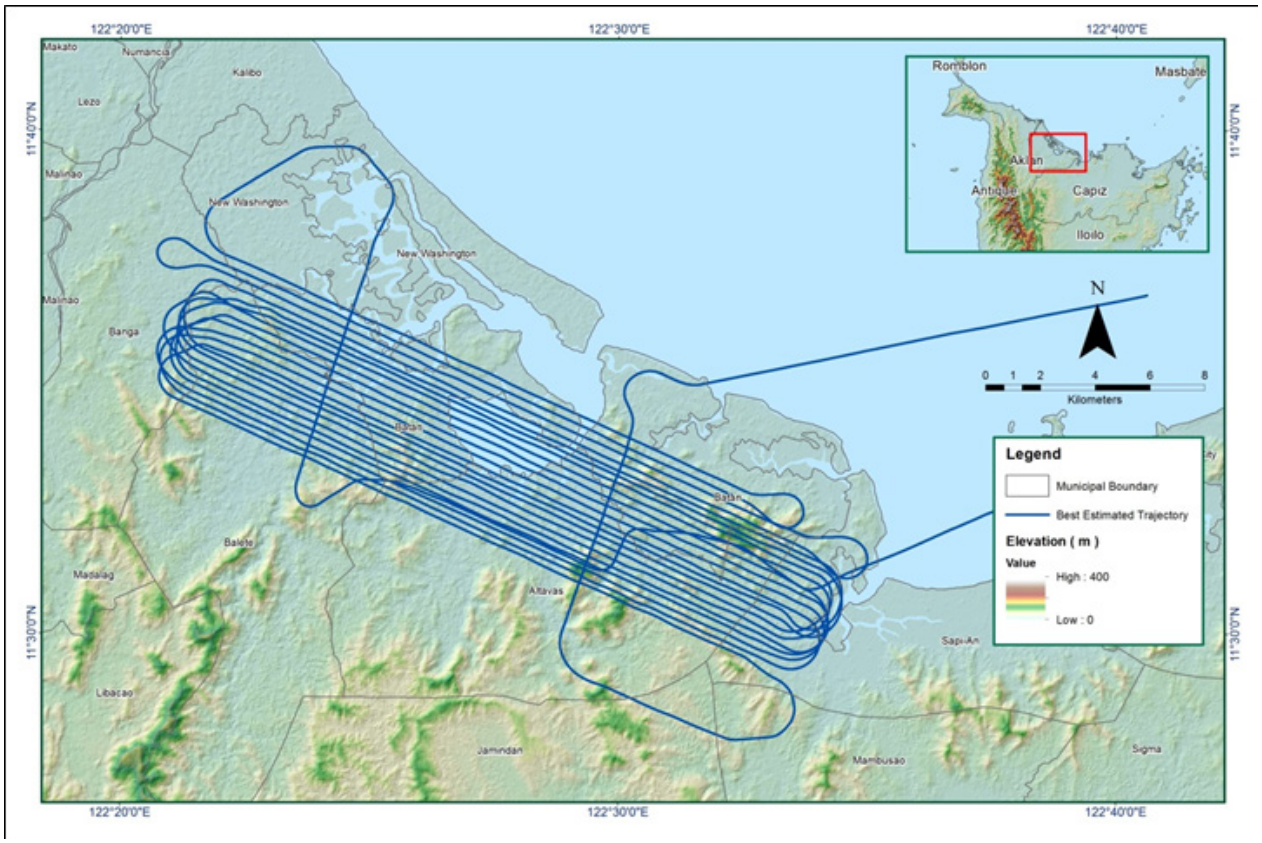


Figure A-8.38. Best Estimated Trajectory

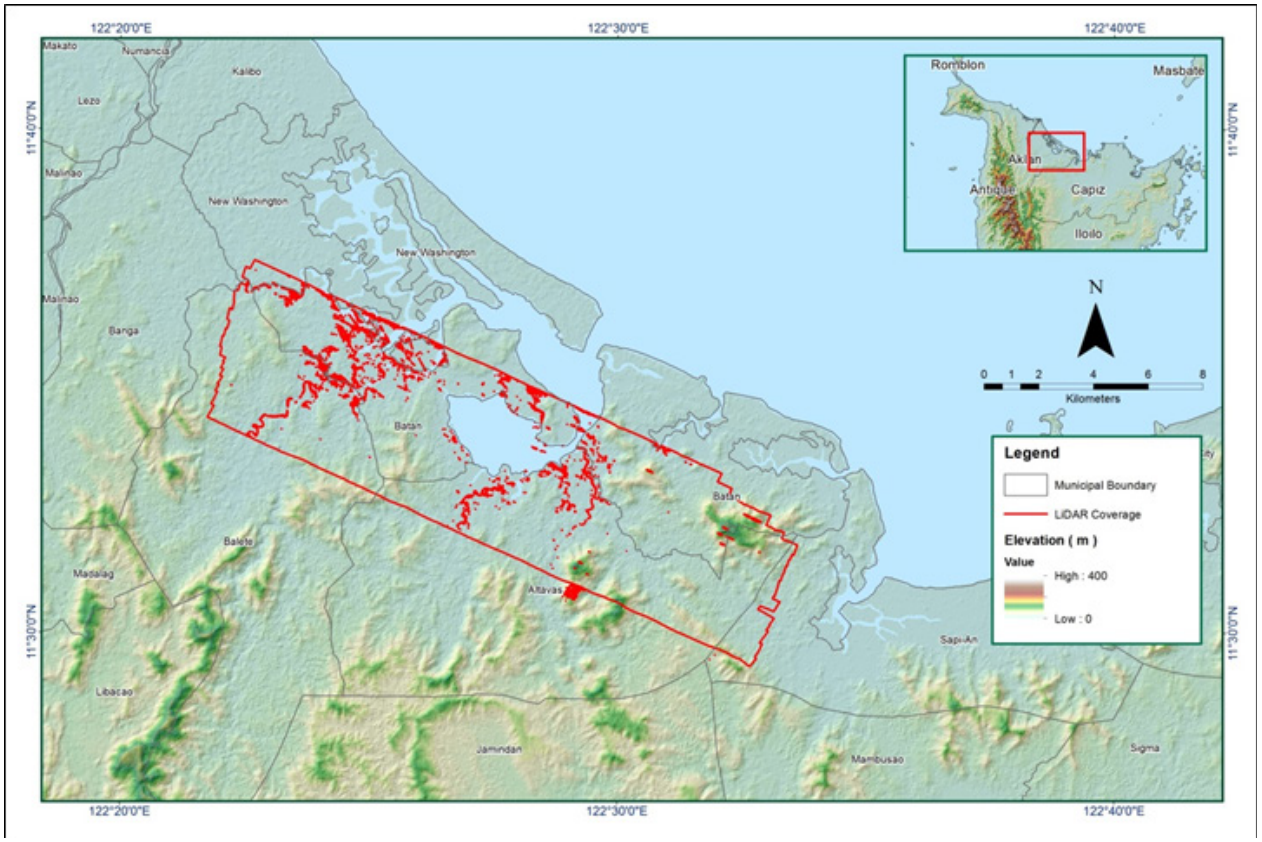


Figure A-8.39. Coverage of LiDAR data

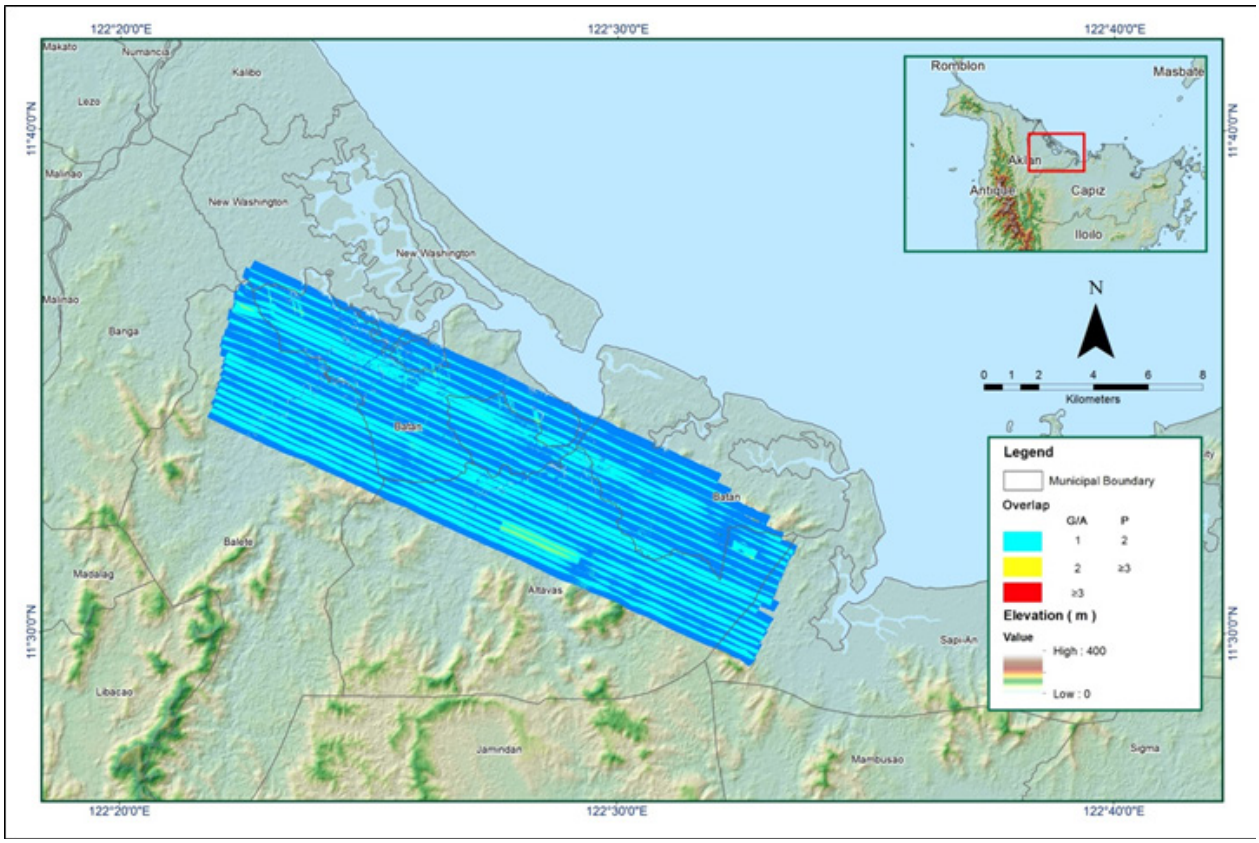


Figure A-8.40. Image of data overlap

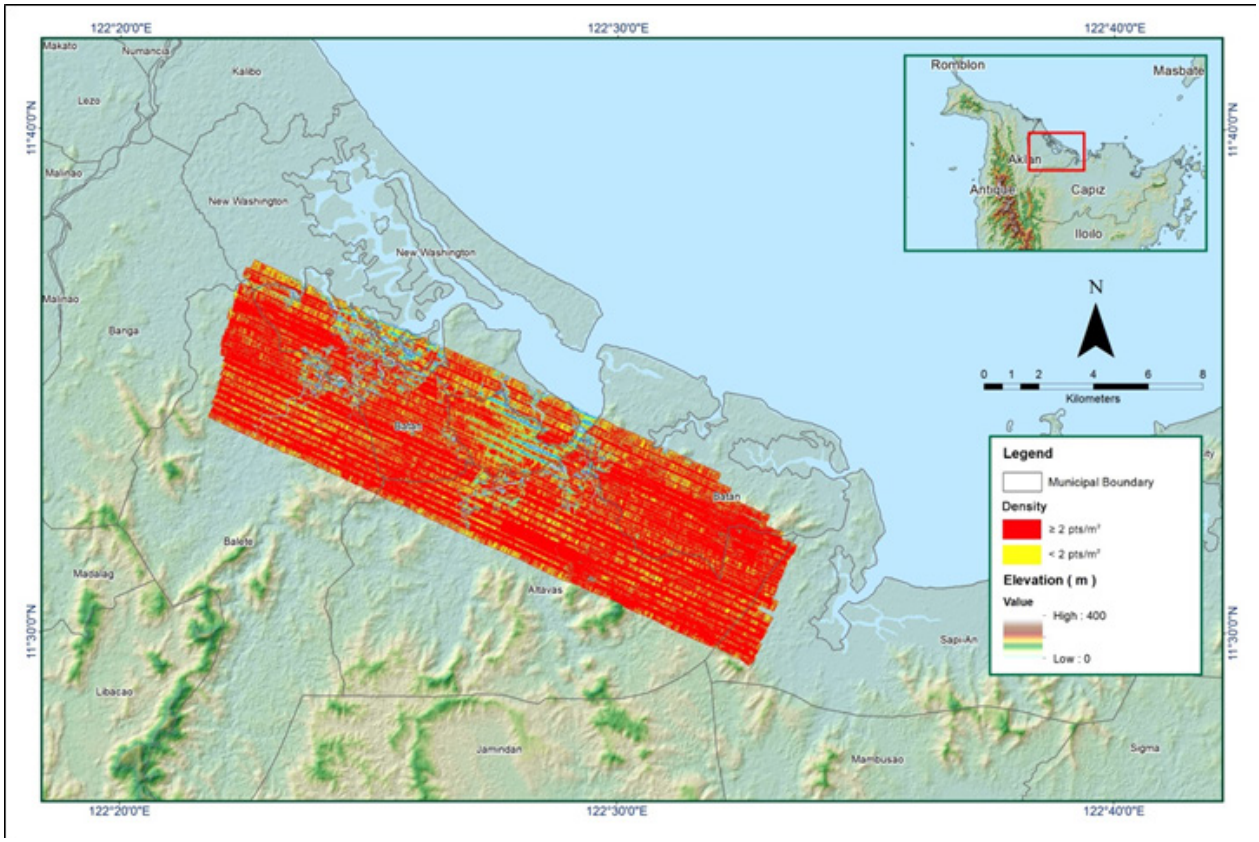


Figure A-8.41. Density map of merged LiDAR data

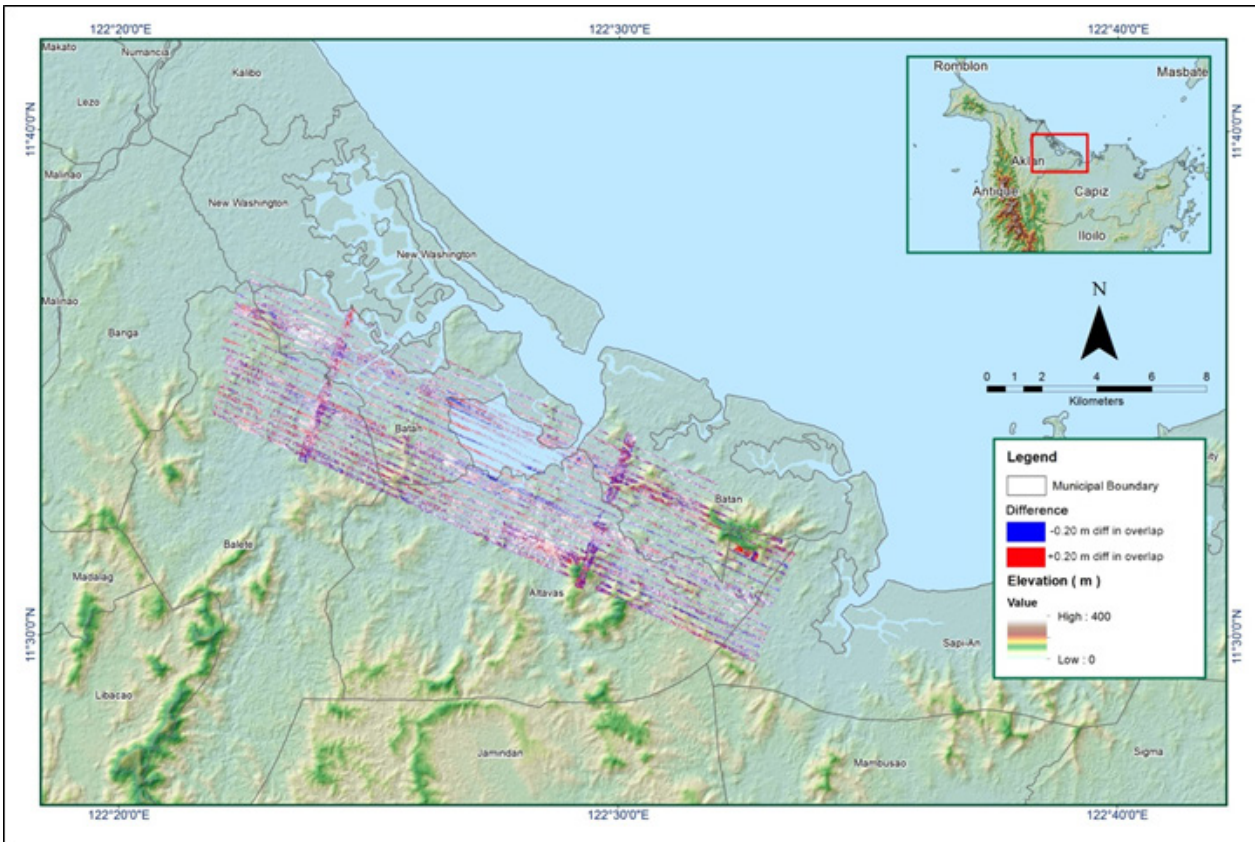


Figure A-8.42. Elevation difference between flight lines

Table A-8.7. Mission Summary Report for Mission Blk38I

Flight Area	Aklan
Mission Name	Blk38I
Inclusive Flights	1222A
Mission Name	3BLK38G076A
Range data size	38.93 GB
POS	675 MB
Base data size	
Image	222.4 GB
Transfer date	April 2, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.4
RMSE for East Position (<4.0 cm)	1.7
RMSE for Down Position (<8.0 cm)	4.5
Boresight correction stdev (<0.001deg)	0.000406
IMU attitude correction stdev (<0.001deg)	0.001186
GPS position stdev (<0.01m)	0.0109
Minimum % overlap (>25)	68.71%
Ave point cloud density per sq.m. (>2.0)	4.33
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	146
Maximum Height	469.21 m
Minimum Height	53.63 m
Classification (# of points)	
Ground	54457974
Low vegetation	65789993
Medium vegetation	89582887
High vegetation	107260595
Building	3036380
Orthophoto	Yes
Processed by	Engr. Jennifer Saguran, Engr. Melanie Hingpit, John Dill Macapagal

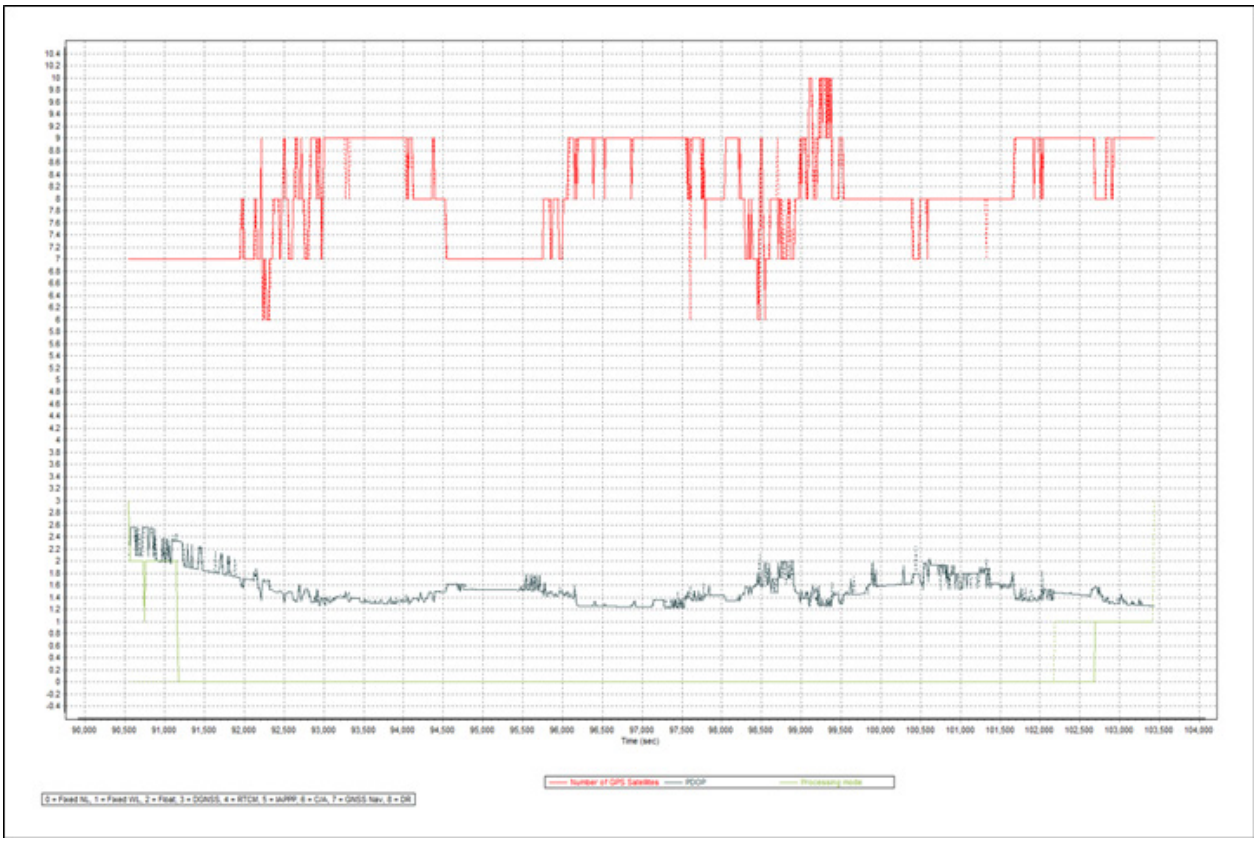


Figure A-8.43. Solution Status

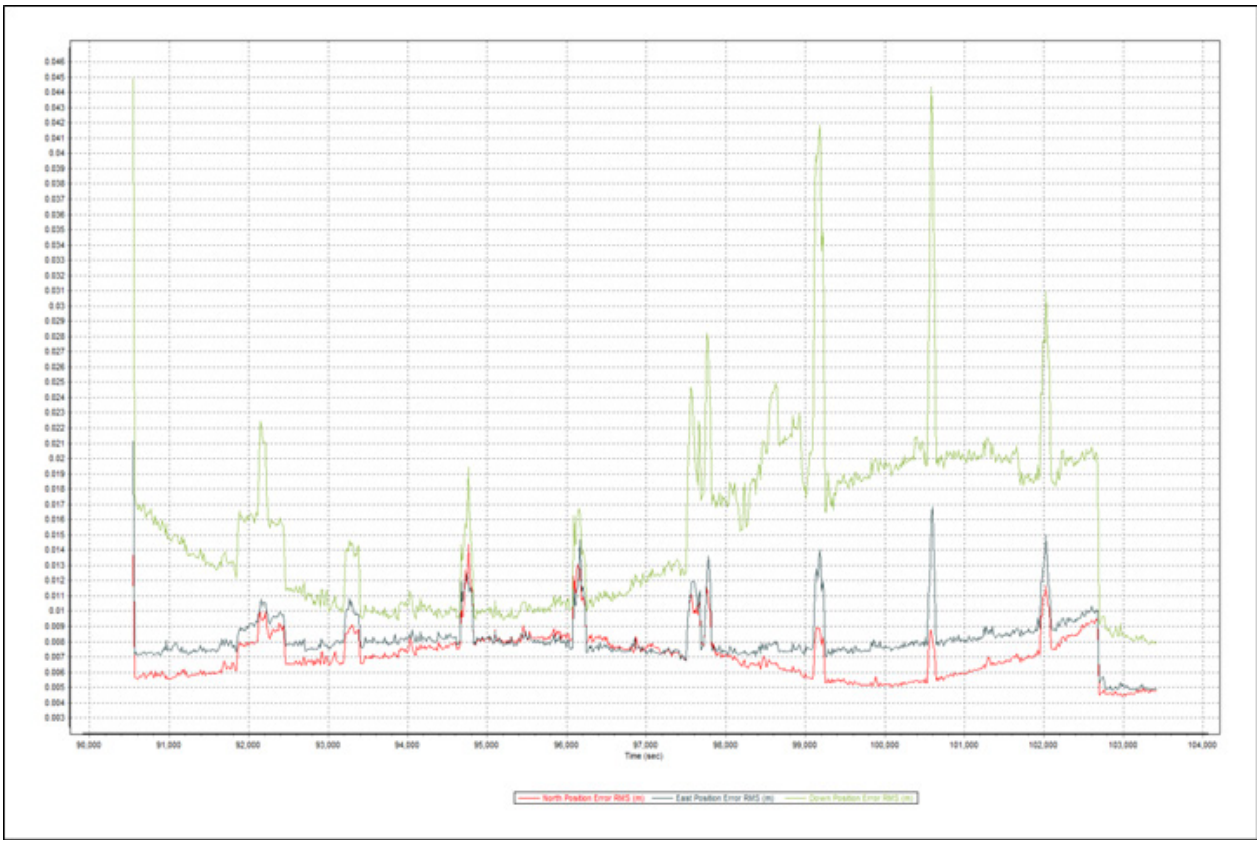


Figure A-8.44. Smoothed Performance Metric Parameters

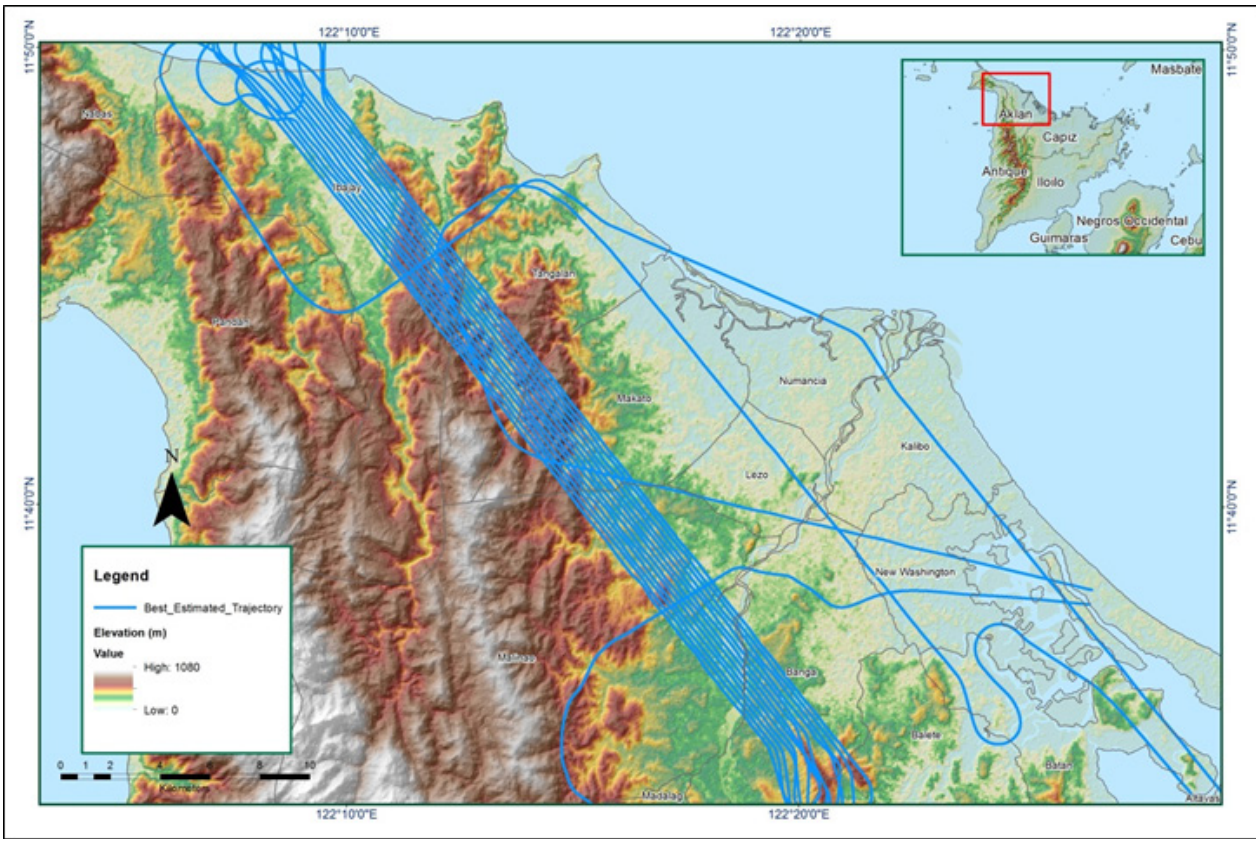


Figure A-8.45. Best Estimated Trajectory

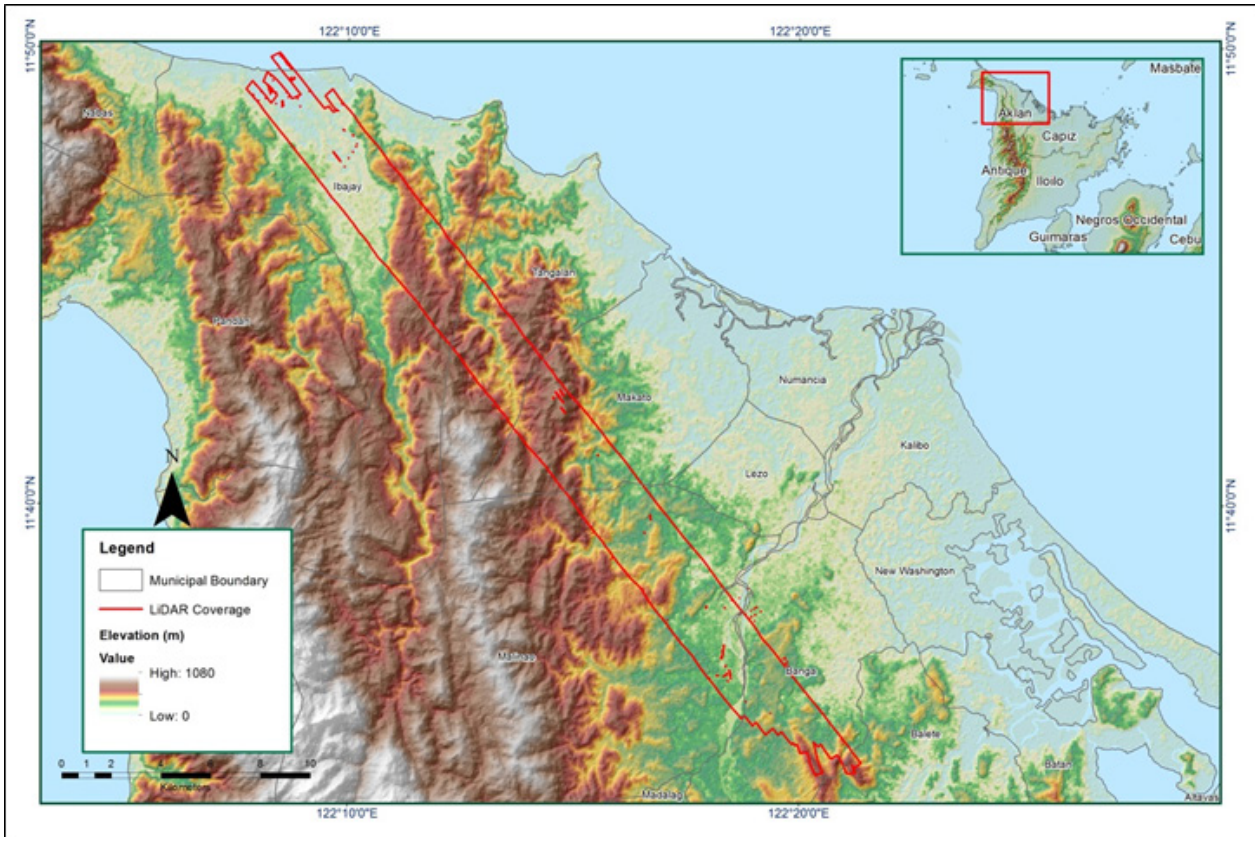


Figure A-8.46. Coverage of LiDAR data

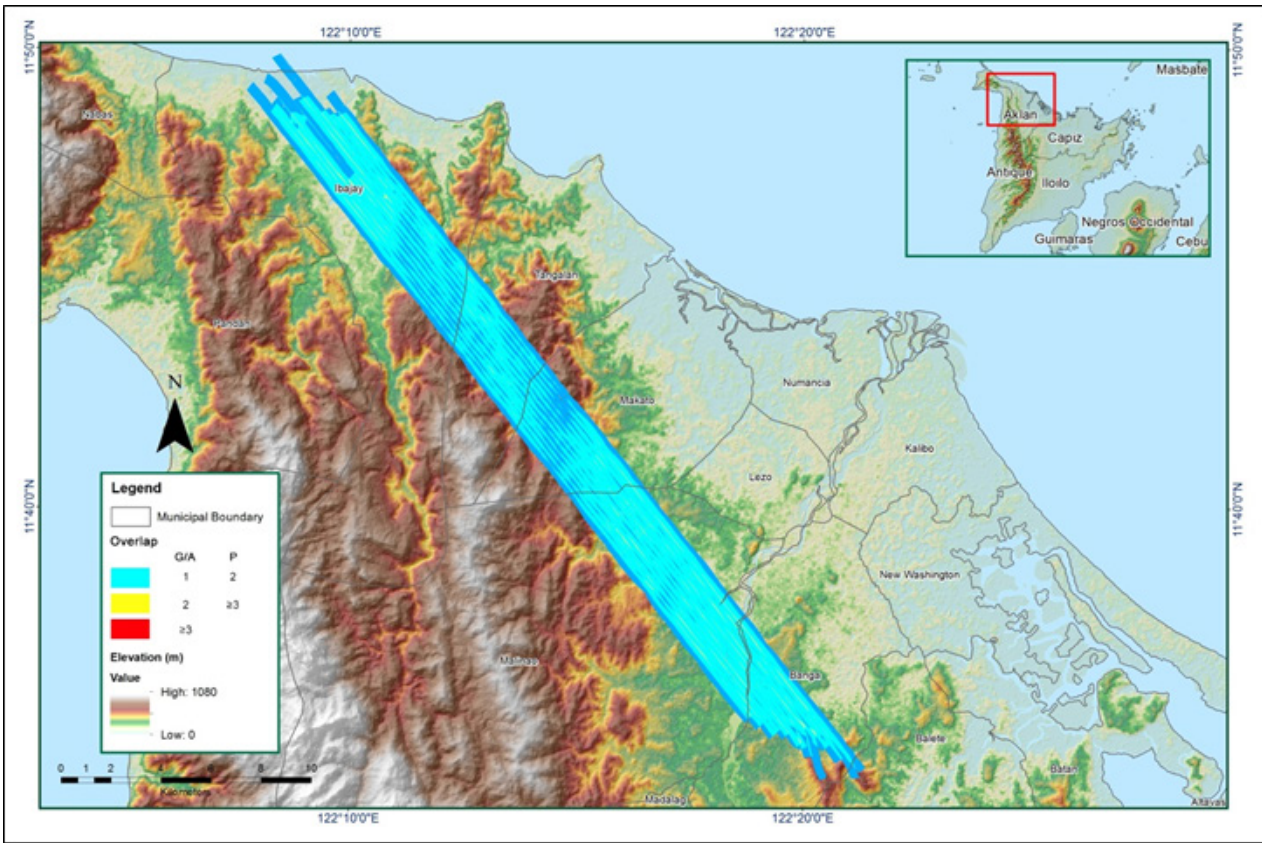


Figure A-8.47. Image of data overlap

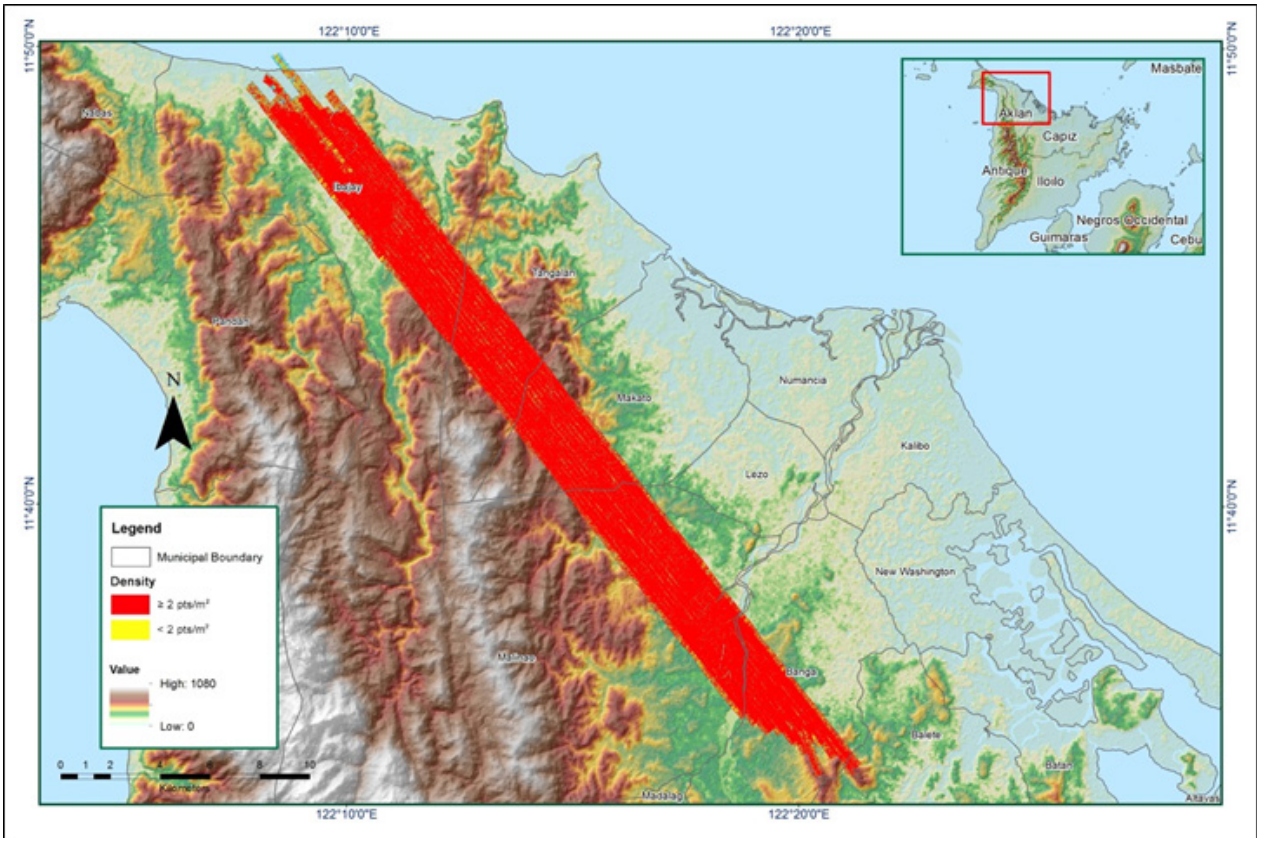


Figure A-8.48. Density map of merged LiDAR data

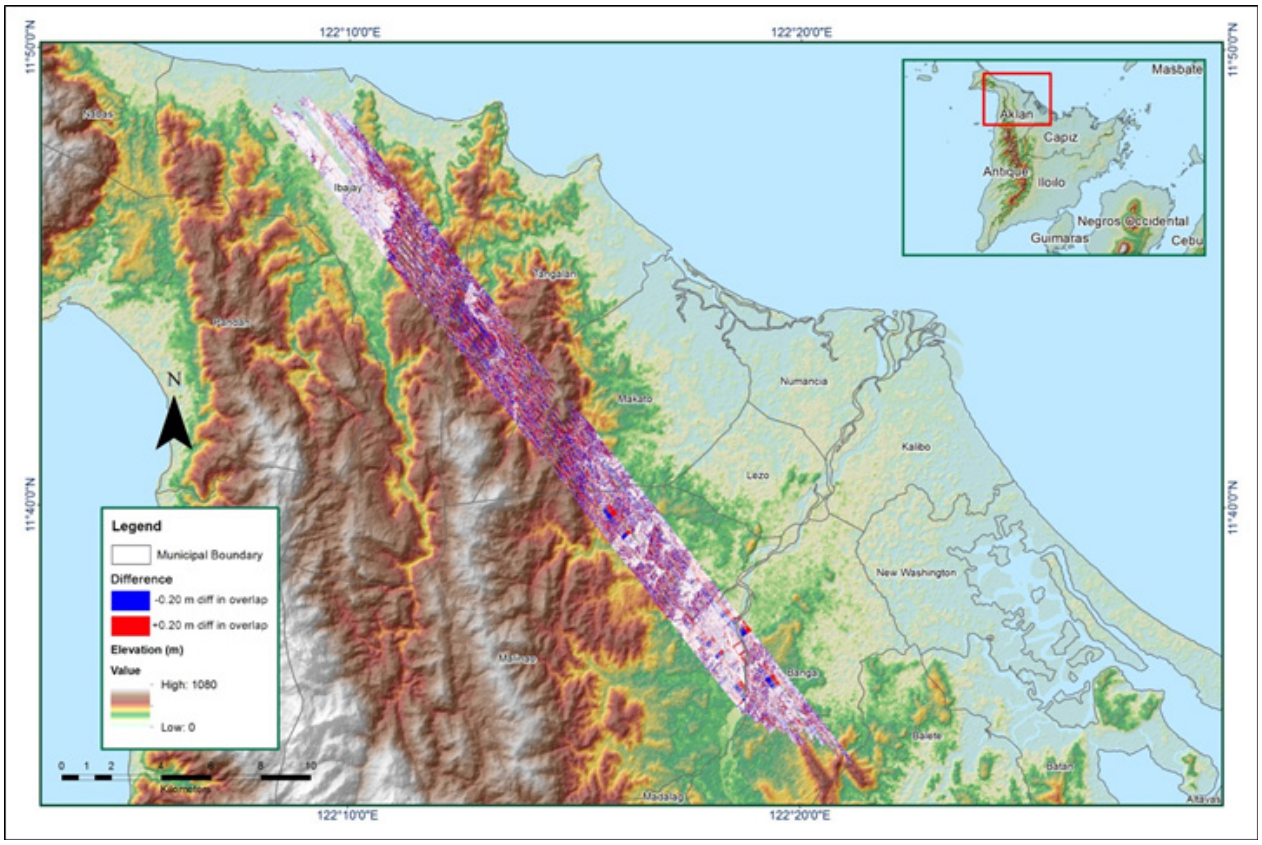


Figure A-8.49. Elevation difference between flight lines

Table A-8.8. Mission Summary Report for Mission Blk38C

Flight Area	Capiz_Aklan
Mission Name	Blk38C
Inclusive Flights	2766G
Range data size	28.8GB
POS	243MB
Base data size	82.8 MB
Image	34.9MB
Transfer date	October 9, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.23
RMSE for East Position (<4.0 cm)	1.62
RMSE for Down Position (<8.0 cm)	2.71
Boresight correction stdev (<0.001deg)	0.002175
IMU attitude correction stdev (<0.001deg)	0.007149
GPS position stdev (<0.01m)	0.0022
Minimum % overlap (>25)	35.31
Ave point cloud density per sq.m. (>2.0)	5.81
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	190
Maximum Height	903.42 m
Minimum Height	61.91 m
Classification (# of points)	
Ground	80,815
Low vegetation	53,226,449
Medium vegetation	308,349,339
High vegetation	382,849,454
Building	1,320,671
Orthophoto	No
Processed by	Engr. Irish Cortez, Engr. Melanie Hingpit, Engr. Krisha Marie Bautista

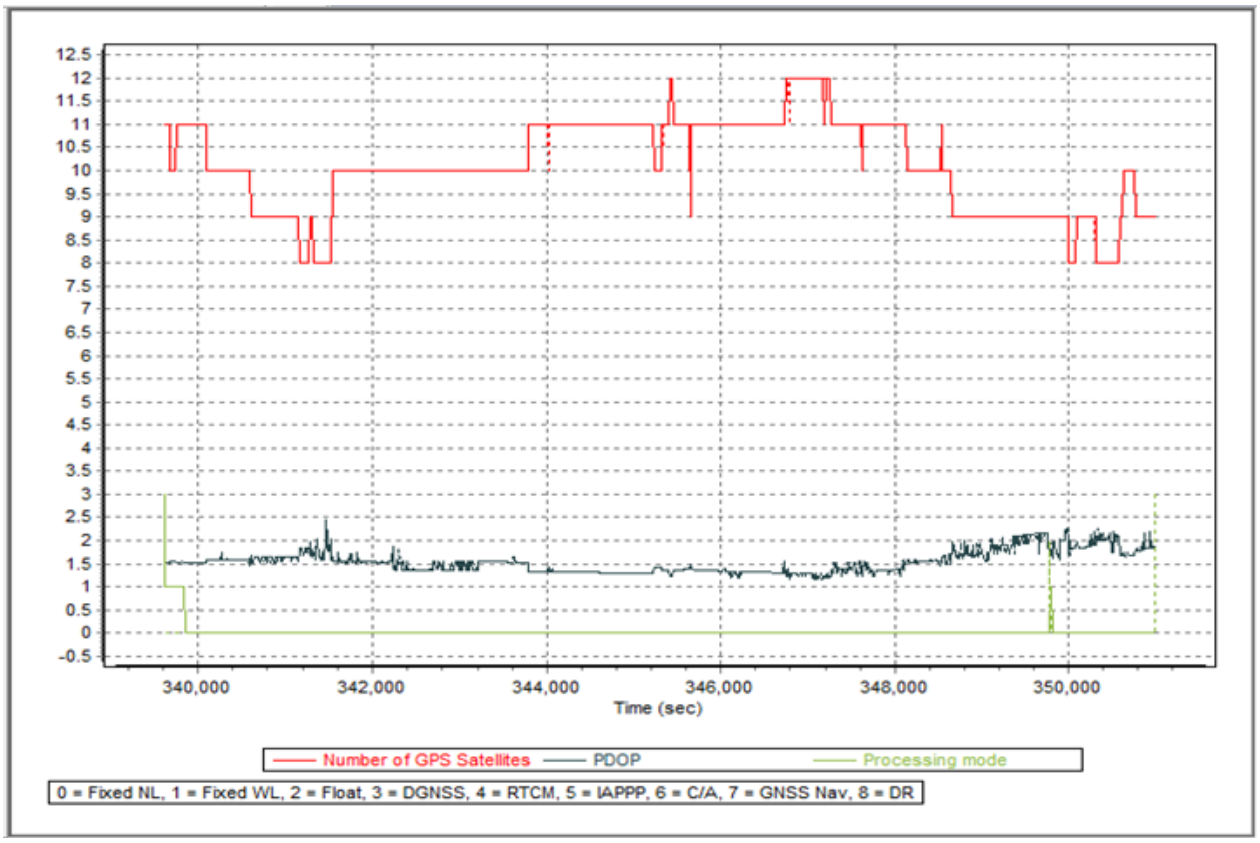


Figure A-8.50. Solution Status

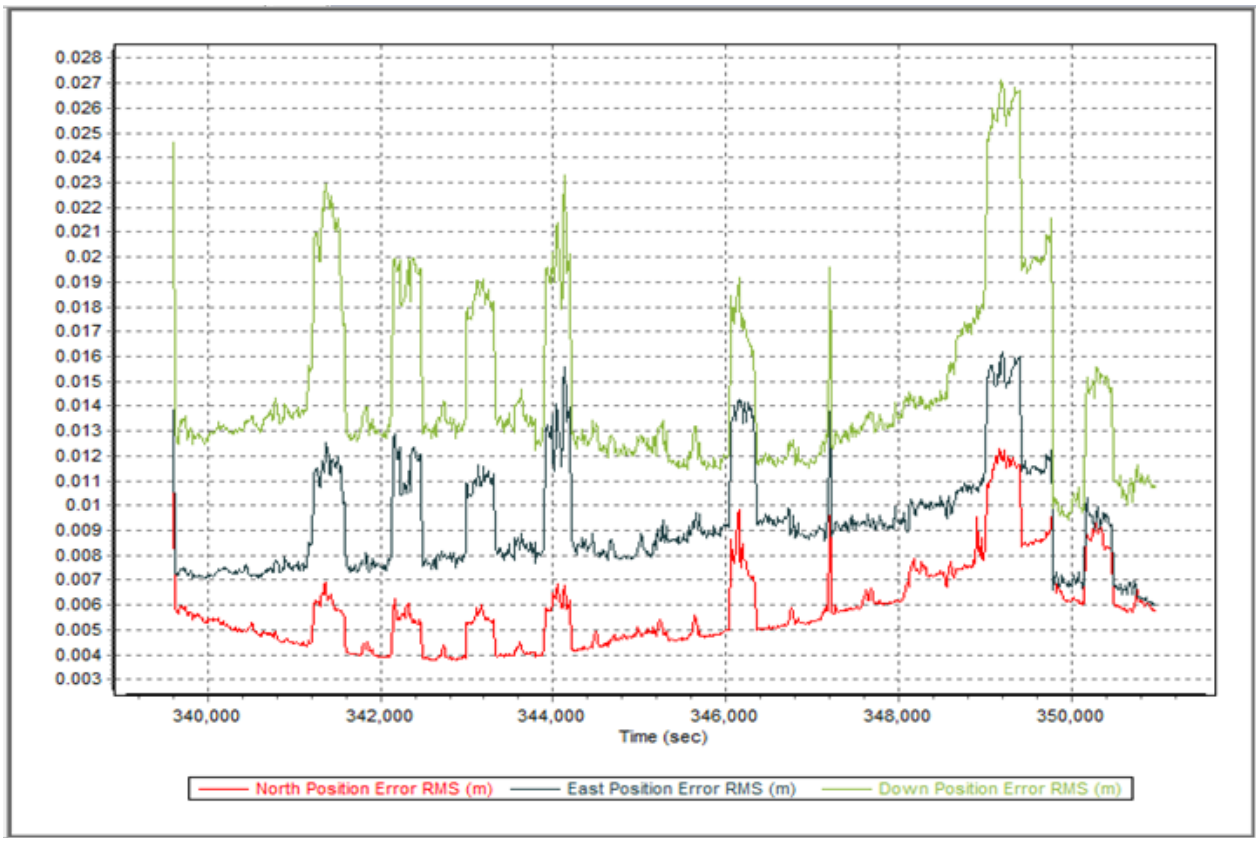


Figure A-8.51. Smoothed Performance Metric Parameters

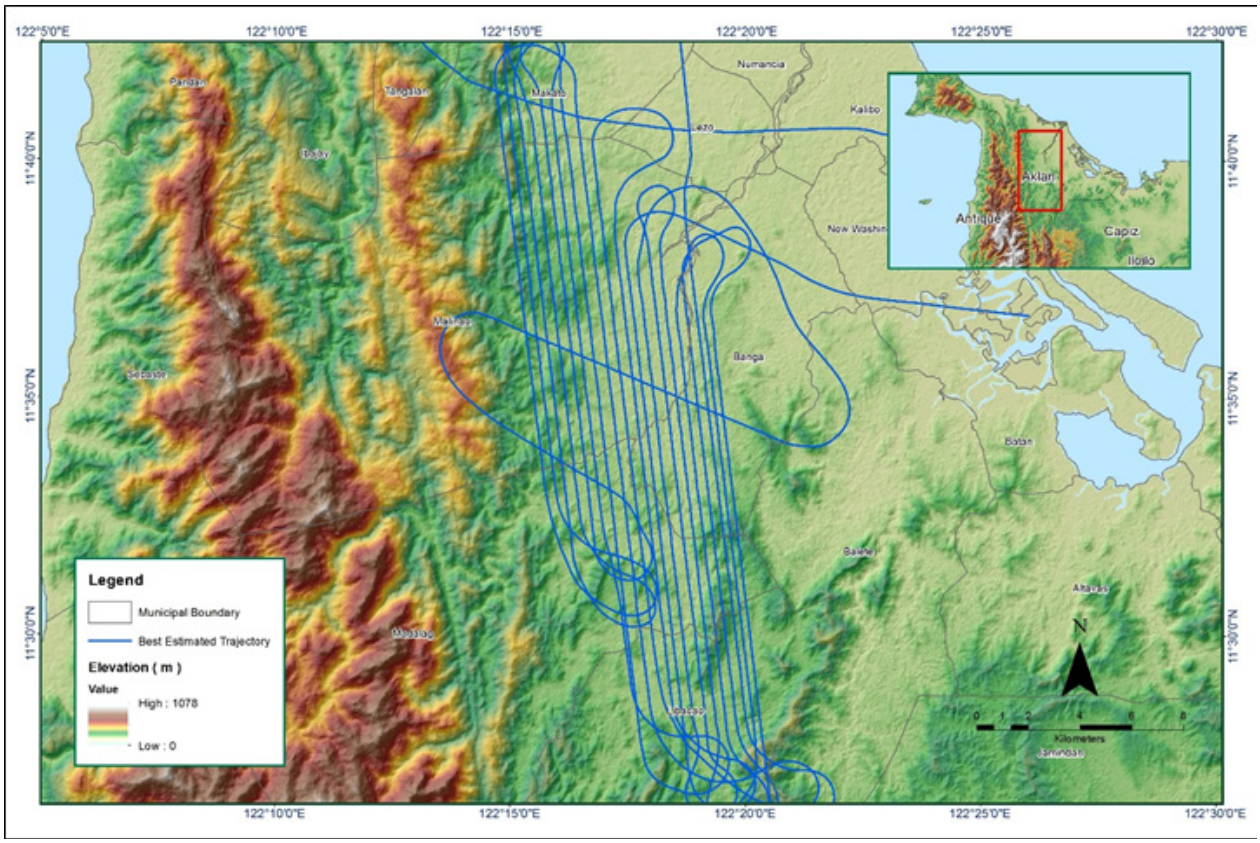


Figure A-8.52. Best Estimated Trajectory

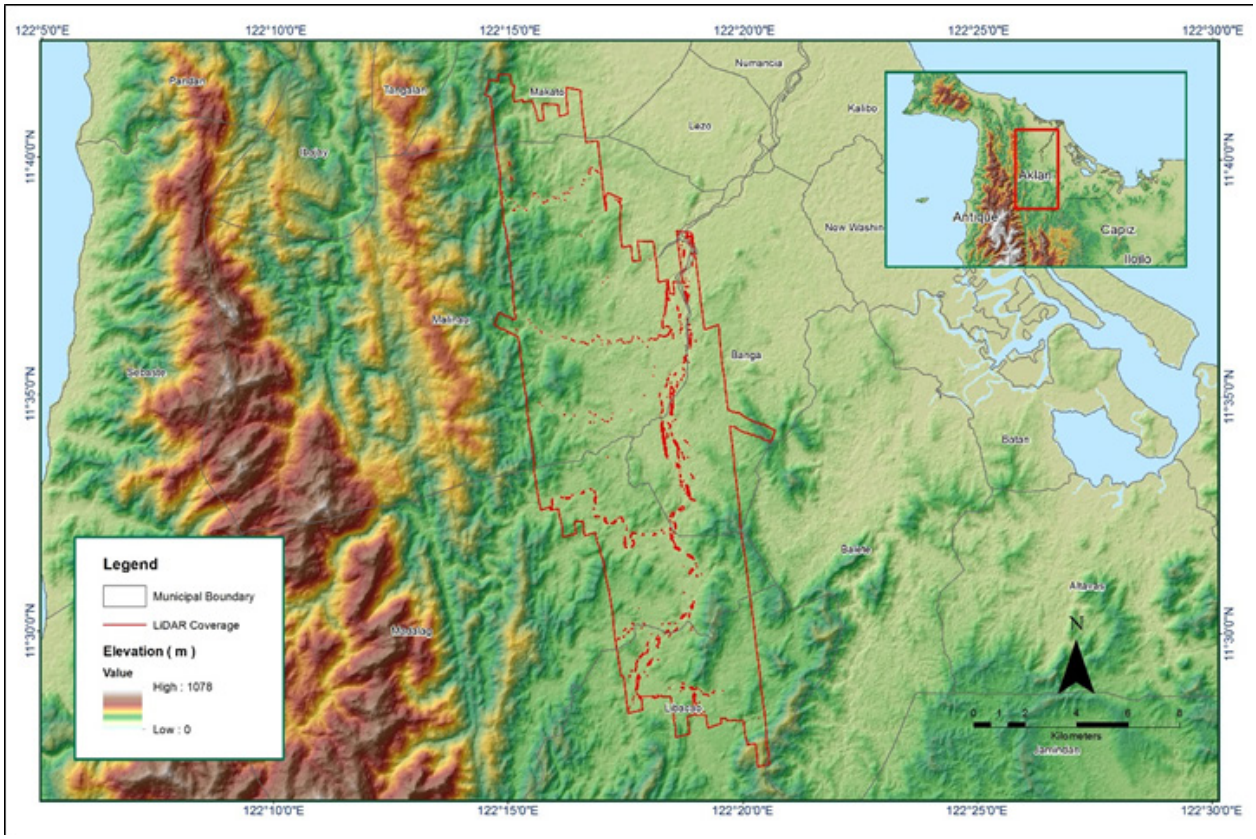


Figure A-8.53. Coverage of LiDAR data

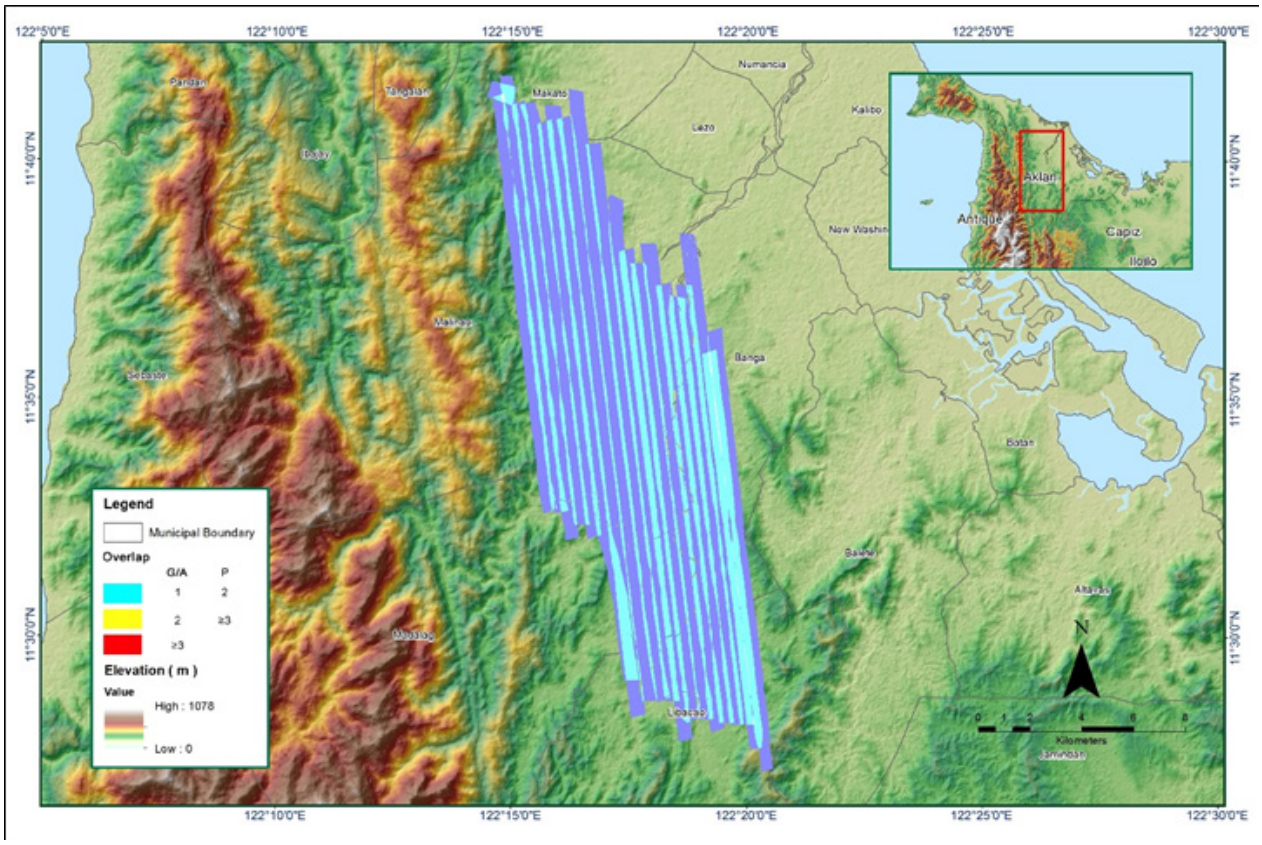


Figure A-8.54. Image of data overlap

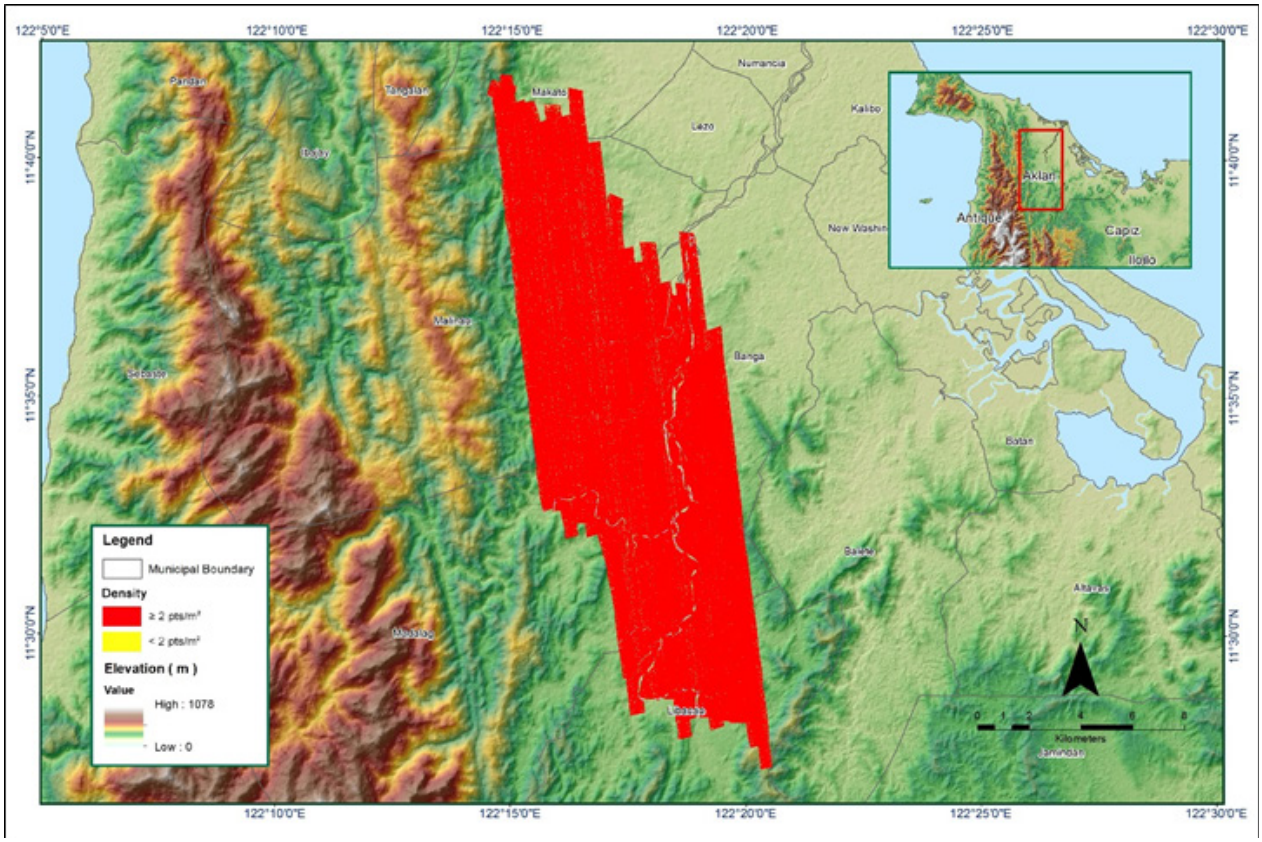


Figure A-8.55. Density map of merged LiDAR data

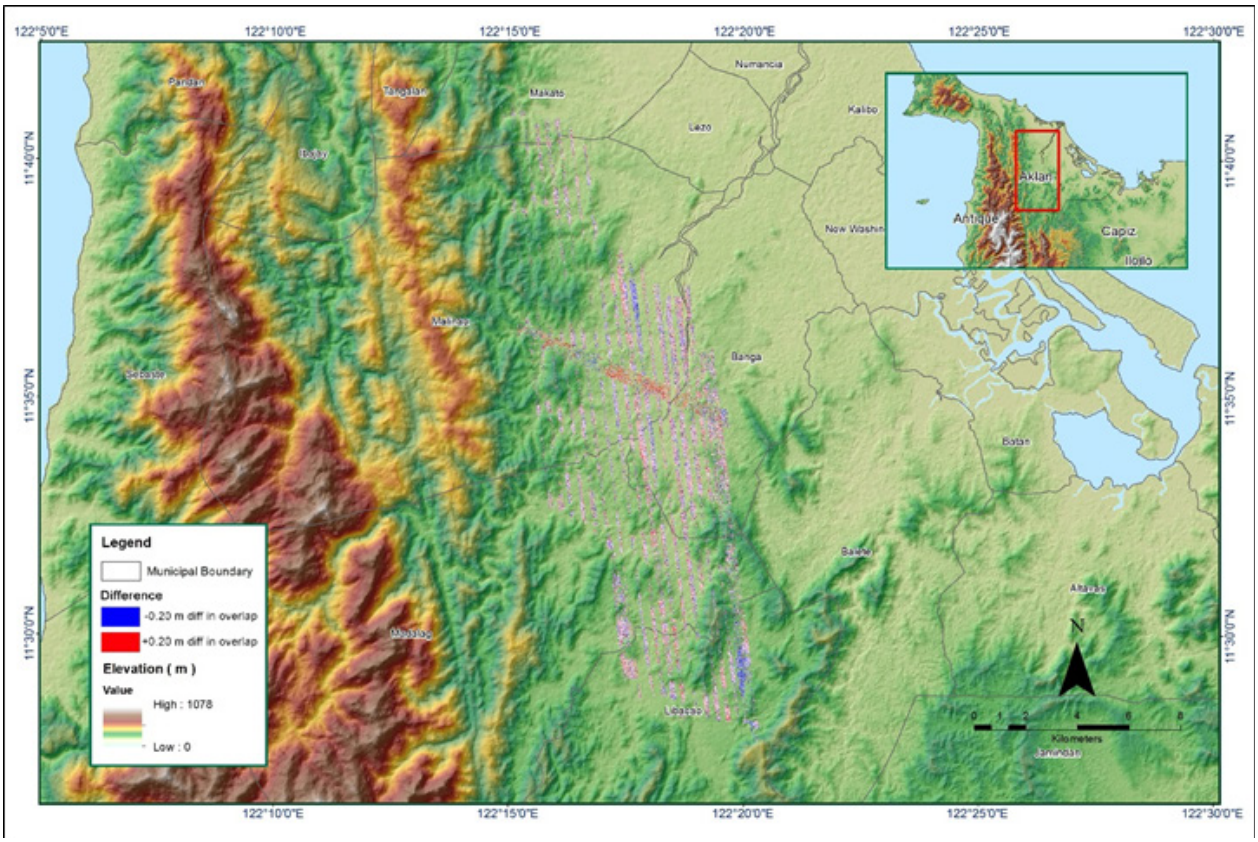


Figure A-8.56. Elevation difference between flight lines

Table A-8.9. Mission Summary Report for Mission Blk38D

Flight Area	Capiz_Aklan
Mission Name	Blk38D
Inclusive Flights	2742G, 2746G, 2770G
Range data size	77.4 GB
POS	702 MB
Base data size	267.2 MB
Image	157.4 MB
Transfer date	October 9, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.17
RMSE for East Position (<4.0 cm)	1.67
RMSE for Down Position (<8.0 cm)	2.24
Boresight correction stdev (<0.001deg)	0.001859
IMU attitude correction stdev (<0.001deg)	0.005610
GPS position stdev (<0.01m)	0.0021
Minimum % overlap (>25)	30.61
Ave point cloud density per sq.m. (>2.0)	4.97
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	296
Maximum Height	881.84 m
Minimum Height	48.68 m
Classification (# of points)	
Ground	83,846,065
Low vegetation	113,989,662
Medium vegetation	438,553,266
High vegetation	345,315,045
Building	7,474,300
Orthophoto	Yes
Processed by	Engr. Sheila-Maye Santillan, Engr. Justine Francisco, Alex John Escobido

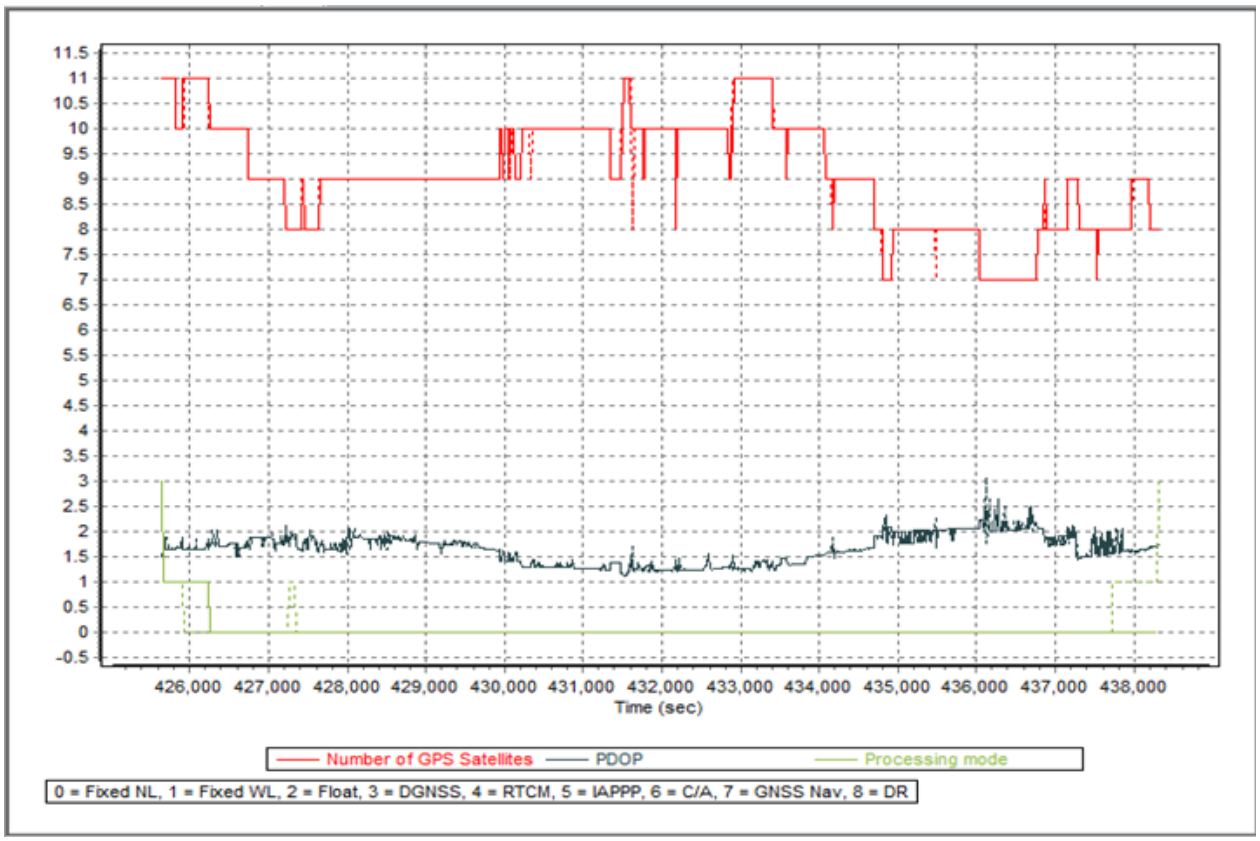


Figure A-8.57. Solution Status

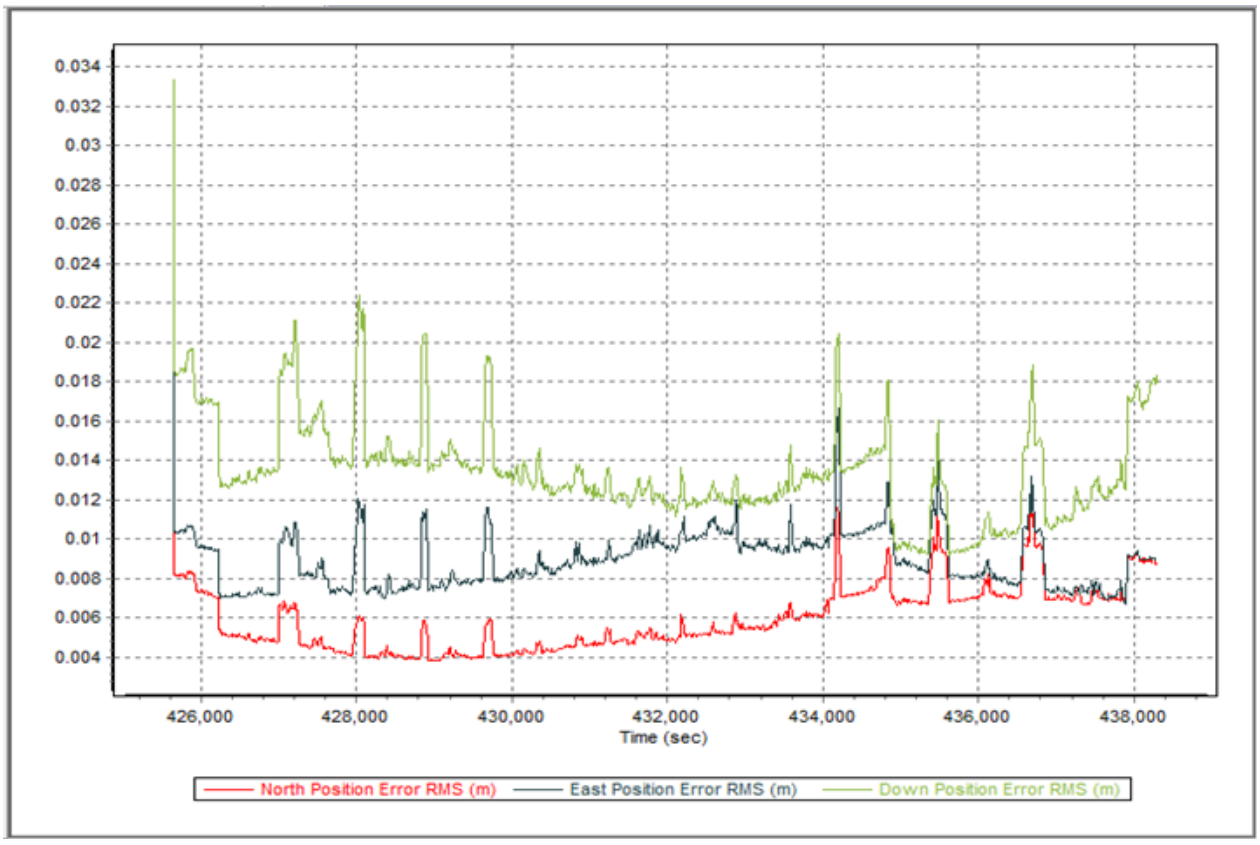


Figure A-8.58. Smoothed Performance Metric Parameters

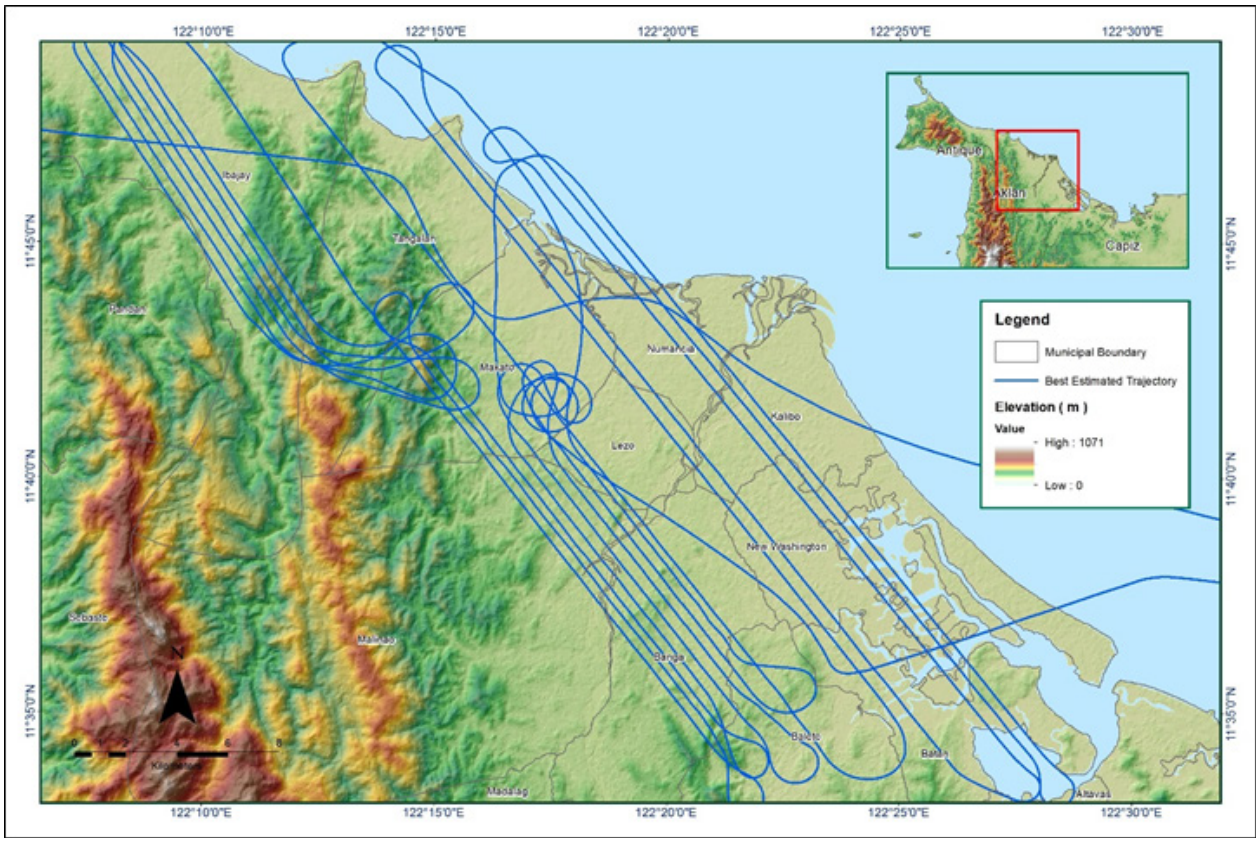


Figure A-8.59. Best Estimated Trajectory

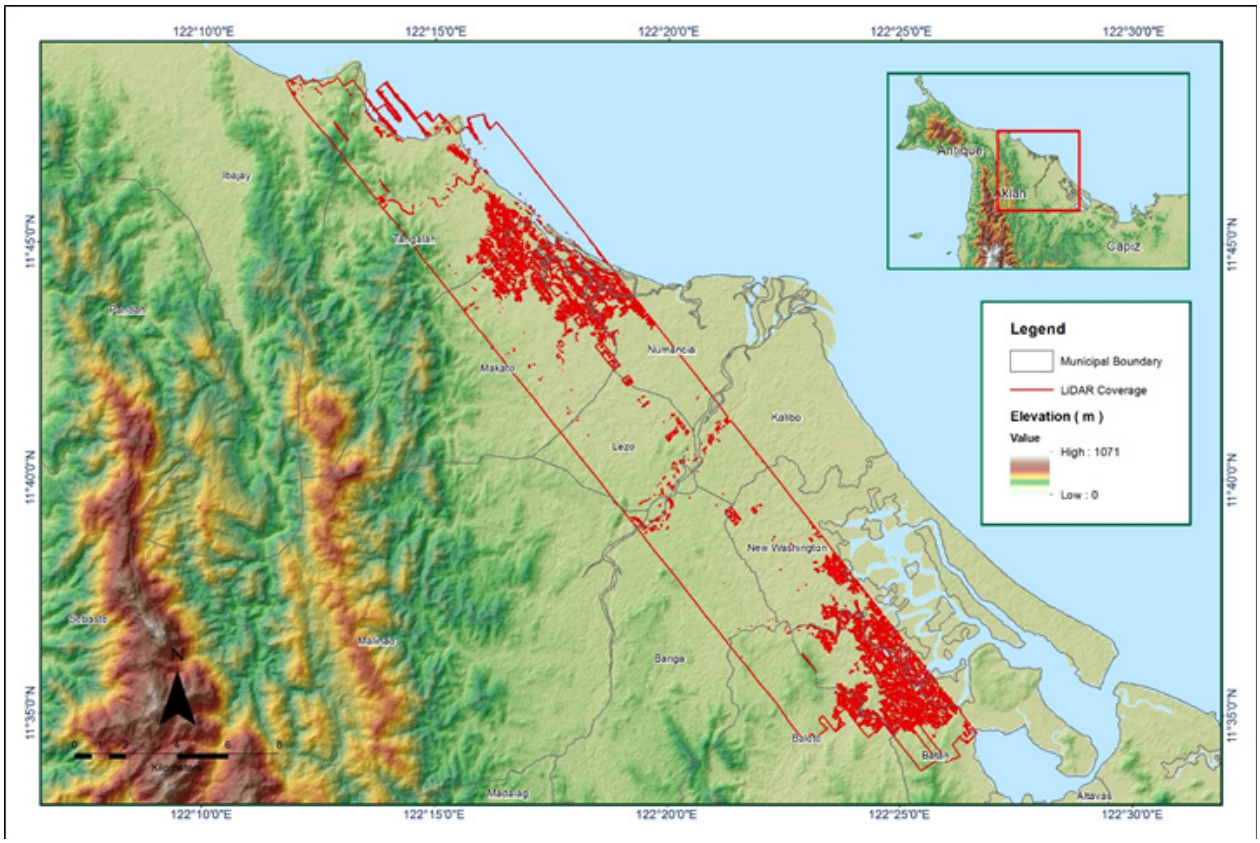


Figure A-8.60. Coverage of LiDAR data

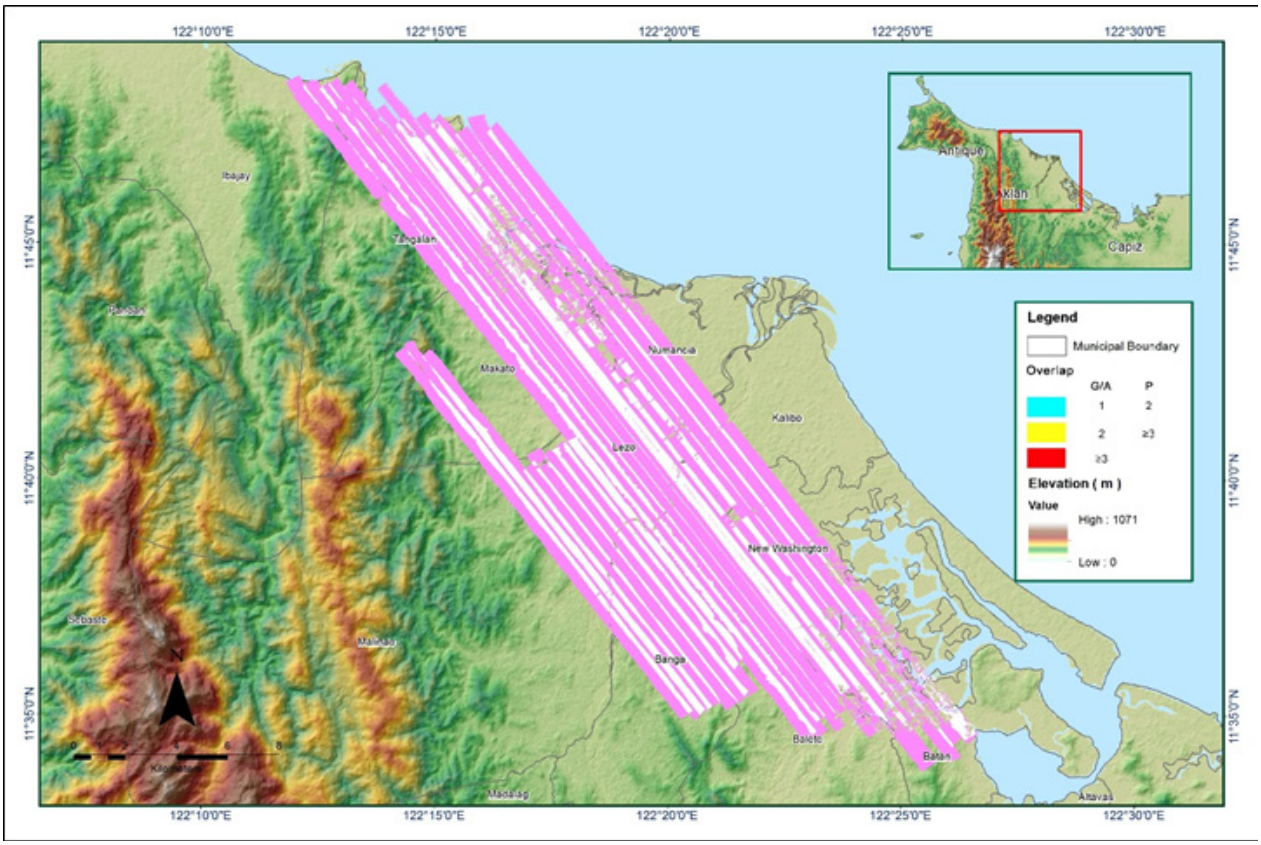


Figure A-8.61. Image of data overlap

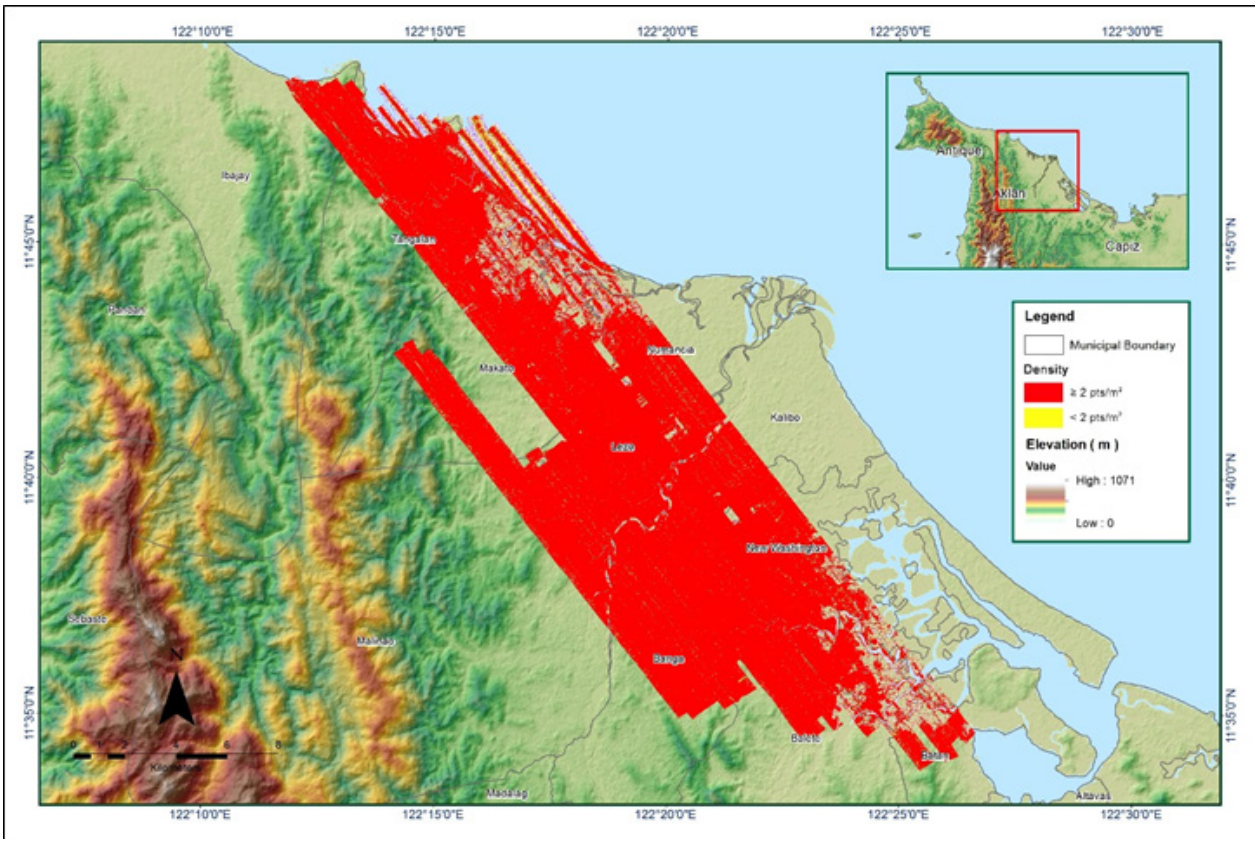


Figure A-8.62. Density map of merged LiDAR data

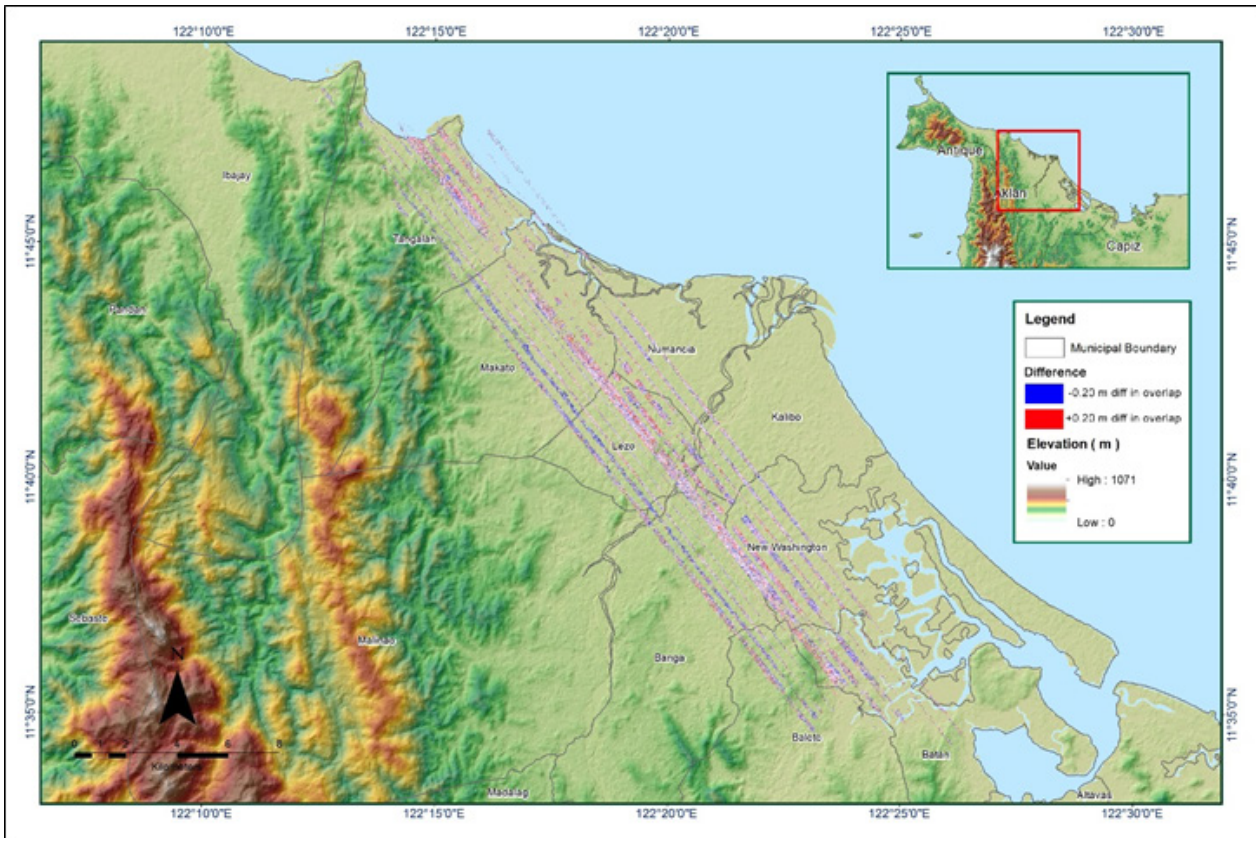


Figure A-8.63. Elevation difference between flight lines

Table A-8.10. Mission Summary Report for Mission Blk38E_supplement

Flight Area	Capiz, Aklan
Mission Name	Blk38E_supplement
Inclusive Flights	2746G, 2770G
Range data size	59.1 GB
POS	487 MB
Base data size	194.1 MB
Image	124.3 GB
Transfer date	October 9, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.13
RMSE for East Position (<4.0 cm)	1.53
RMSE for Down Position (<8.0 cm)	2.10
Boresight correction stdev (<0.001deg)	0.000423
IMU attitude correction stdev (<0.001deg)	0.000933
GPS position stdev (<0.01m)	0.0029
Minimum % overlap (>25)	18.76
Ave point cloud density per sq.m. (>2.0)	3.85
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	184
Maximum Height	874.11 m
Minimum Height	47.67 m
Classification (# of points)	
Ground	28,446,693
Low vegetation	33,154,263
Medium vegetation	148,126,342
High vegetation	78,509,732
Building	2,022,190
Orthophoto	Yes
Processed by	Engr. Regis Guhiting, Aljon Rie Araneta, Alex John Escobido

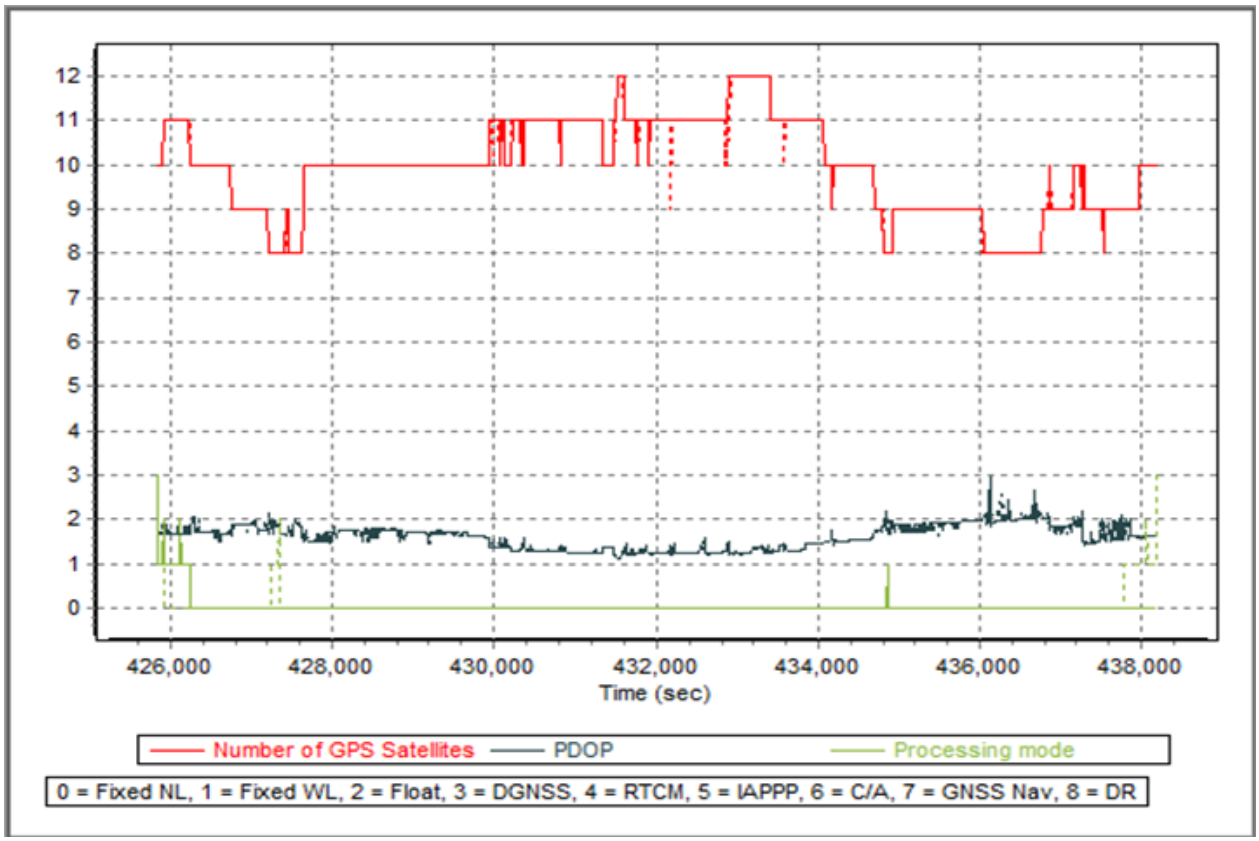


Figure A-8.64. Solution Status

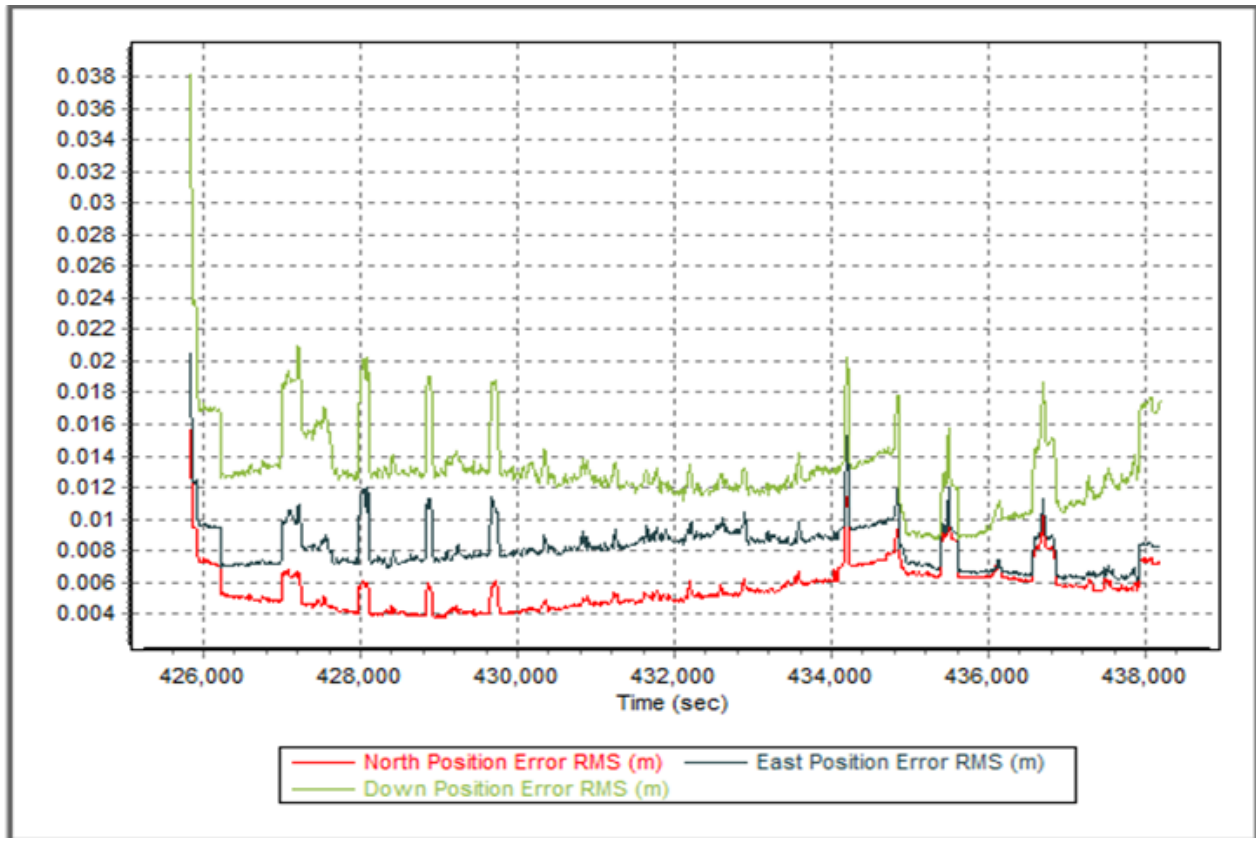


Figure A-8.65. Smoothed Performance Metric Parameters

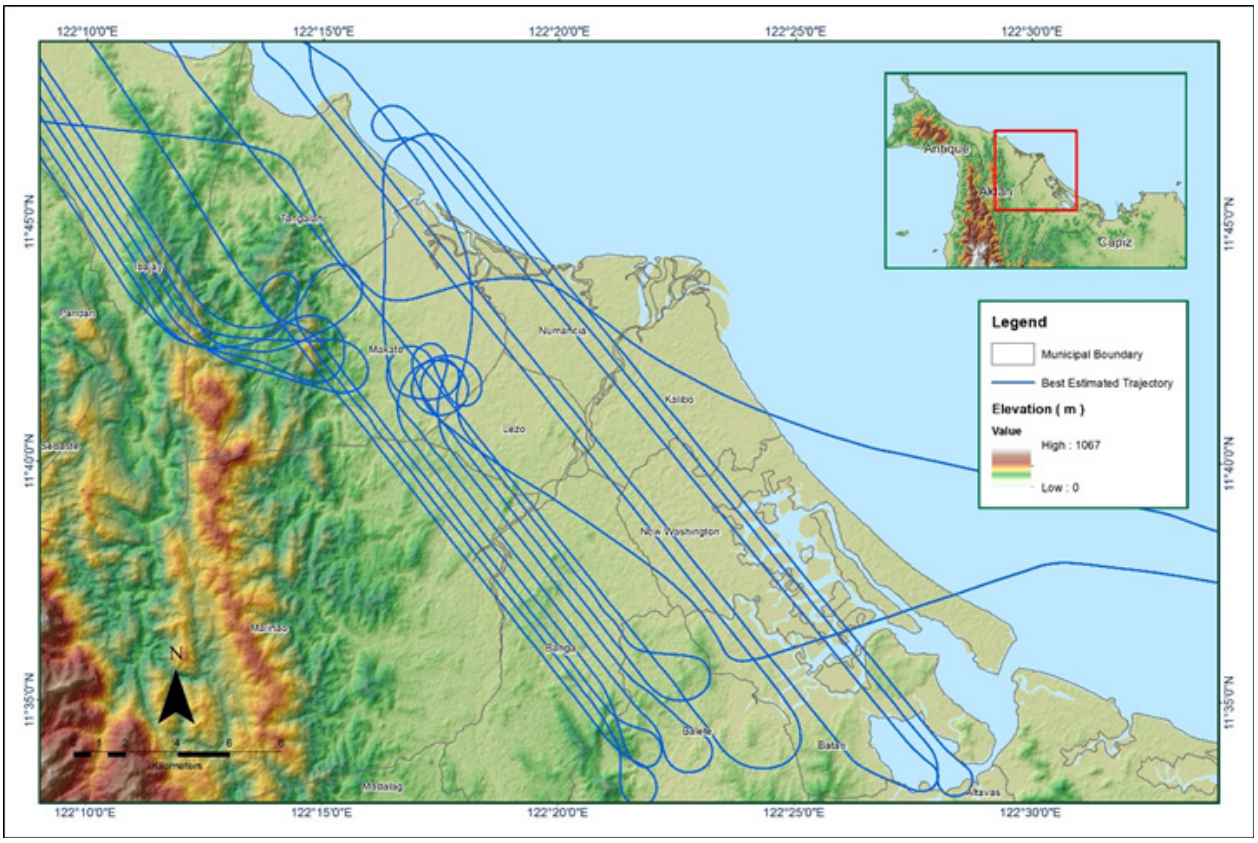


Figure A-8.66. Best Estimated Trajectory

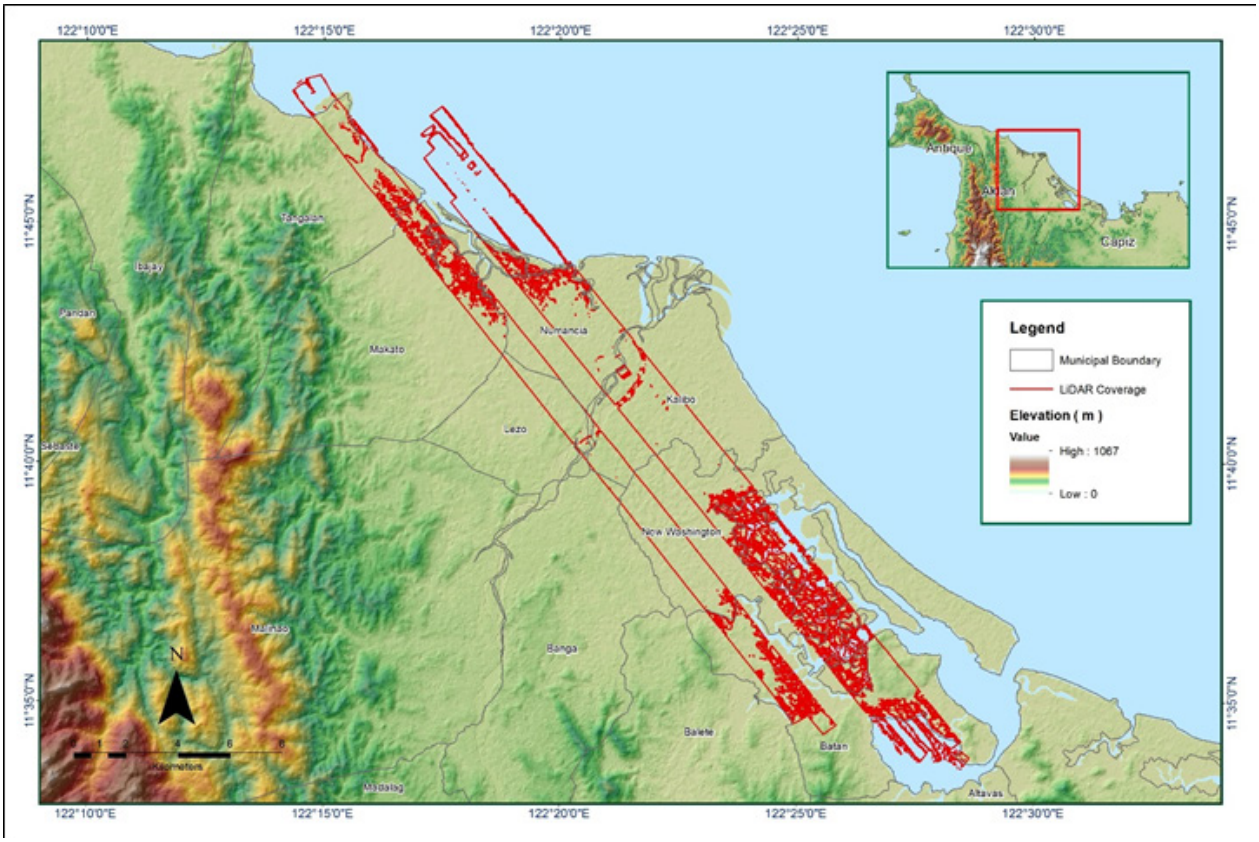


Figure A-8.67. Coverage of LiDAR data

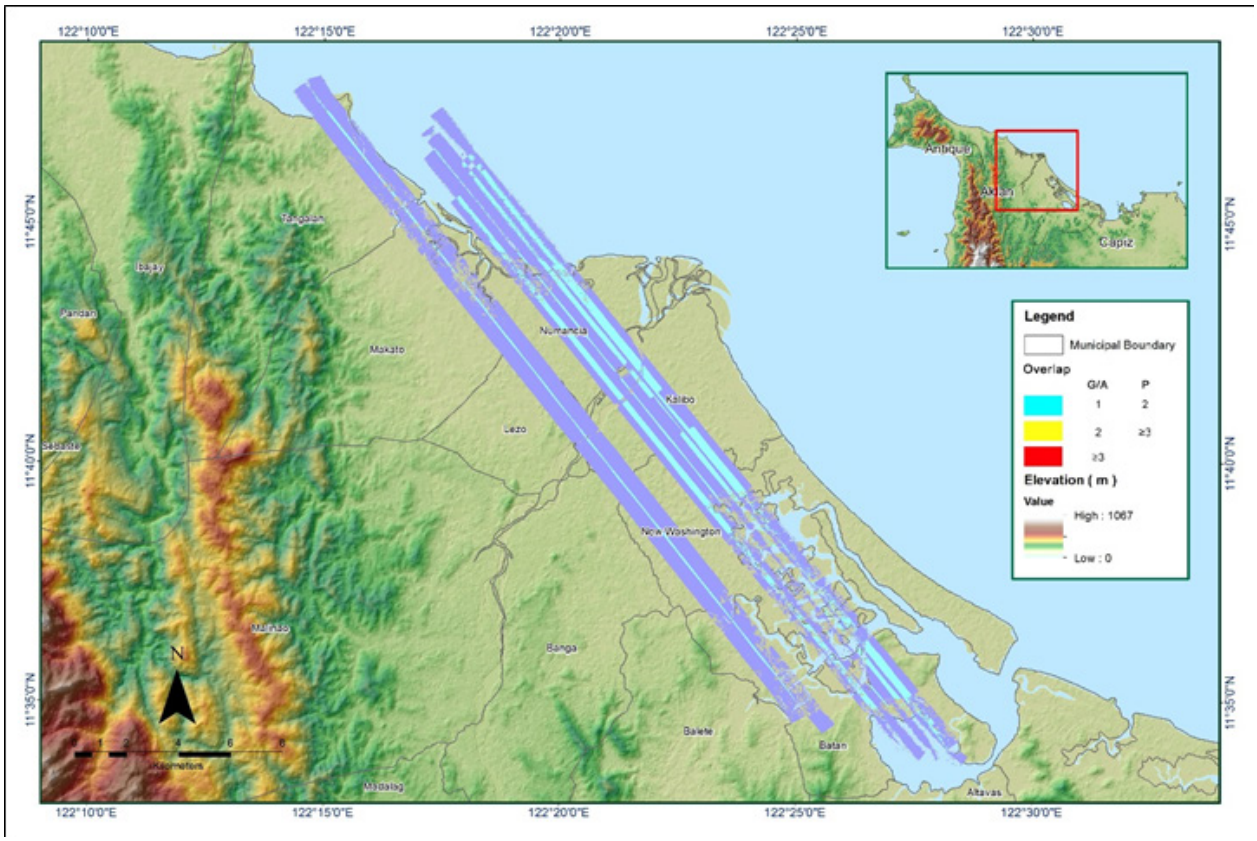


Figure A-8.68. Image of data overlap

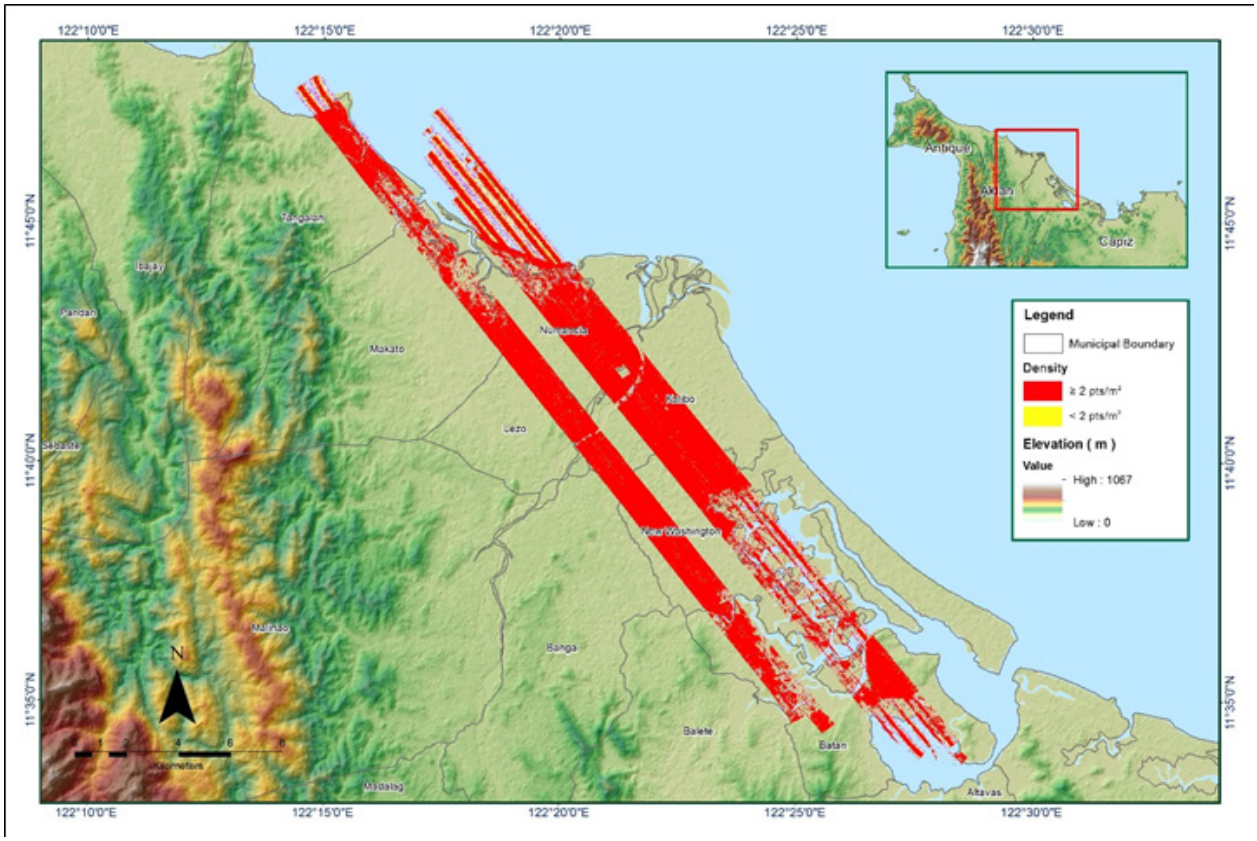


Figure A-8.69. Density map of merged LiDAR data

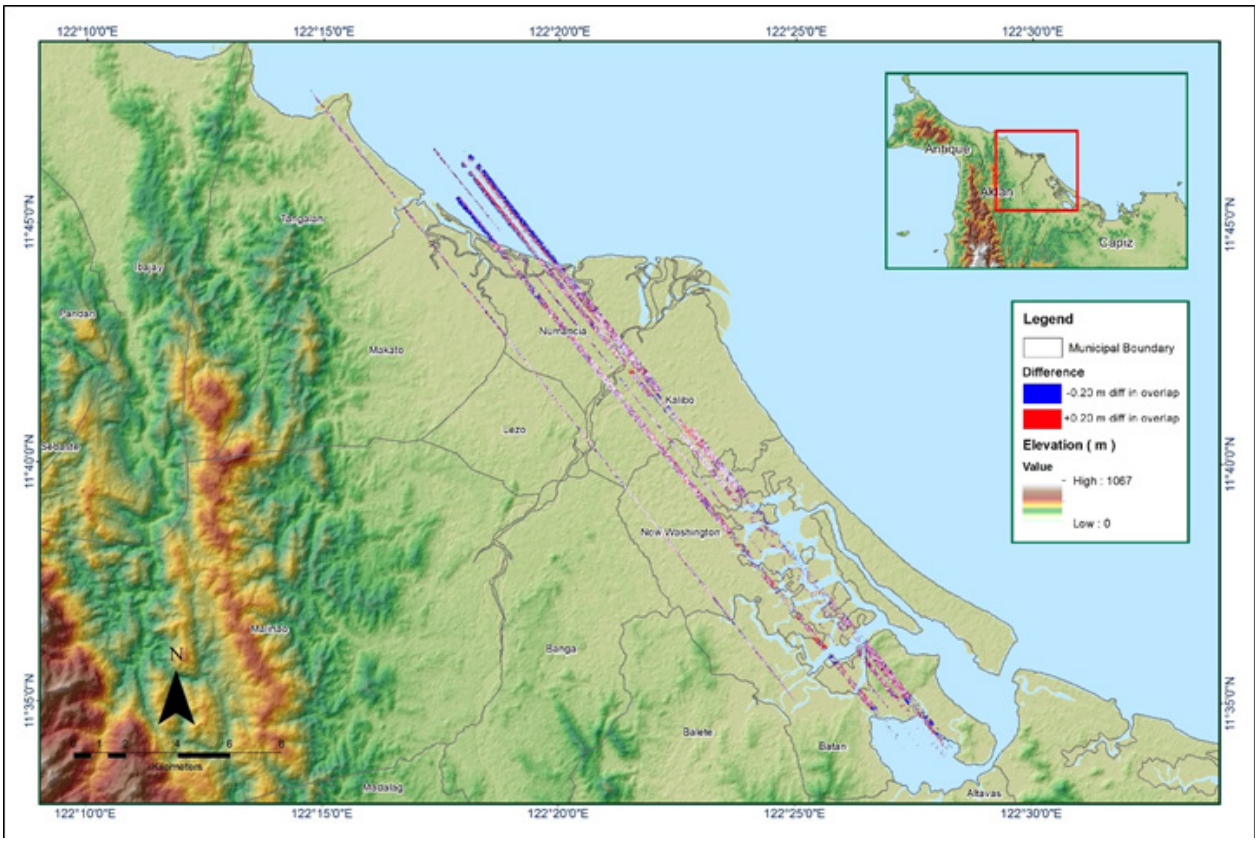


Figure A-8.70. Elevation difference between flight lines

Table A-8.11. Mission Summary Report for Mission Blk38E

Flight Area	Capiz_Aklan
Mission Name	Blk38E
Inclusive Flights	2746G, 2770G, 2774G
Range data size	85.4 GB
POS	742 MB
Base data size	268.4 MB
Image	146 MB
Transfer date	October 9, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.51
RMSE for East Position (<4.0 cm)	1.44
RMSE for Down Position (<8.0 cm)	2.66
Boresight correction stdev (<0.001deg)	0.000423
IMU attitude correction stdev (<0.001deg)	0.000933
GPS position stdev (<0.01m)	0.0029
Minimum % overlap (>25)	9.53
Ave point cloud density per sq.m. (>2.0)	2.56
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	99
Maximum Height	121.95
Minimum Height	54.17
Classification (# of points)	
Ground	28,671,750
Low vegetation	24,294,506
Medium vegetation	79,135,070
High vegetation	46,202,617
Building	2,357,775
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Merven Matthew Natino, Maria Tamsyn Malabanan,

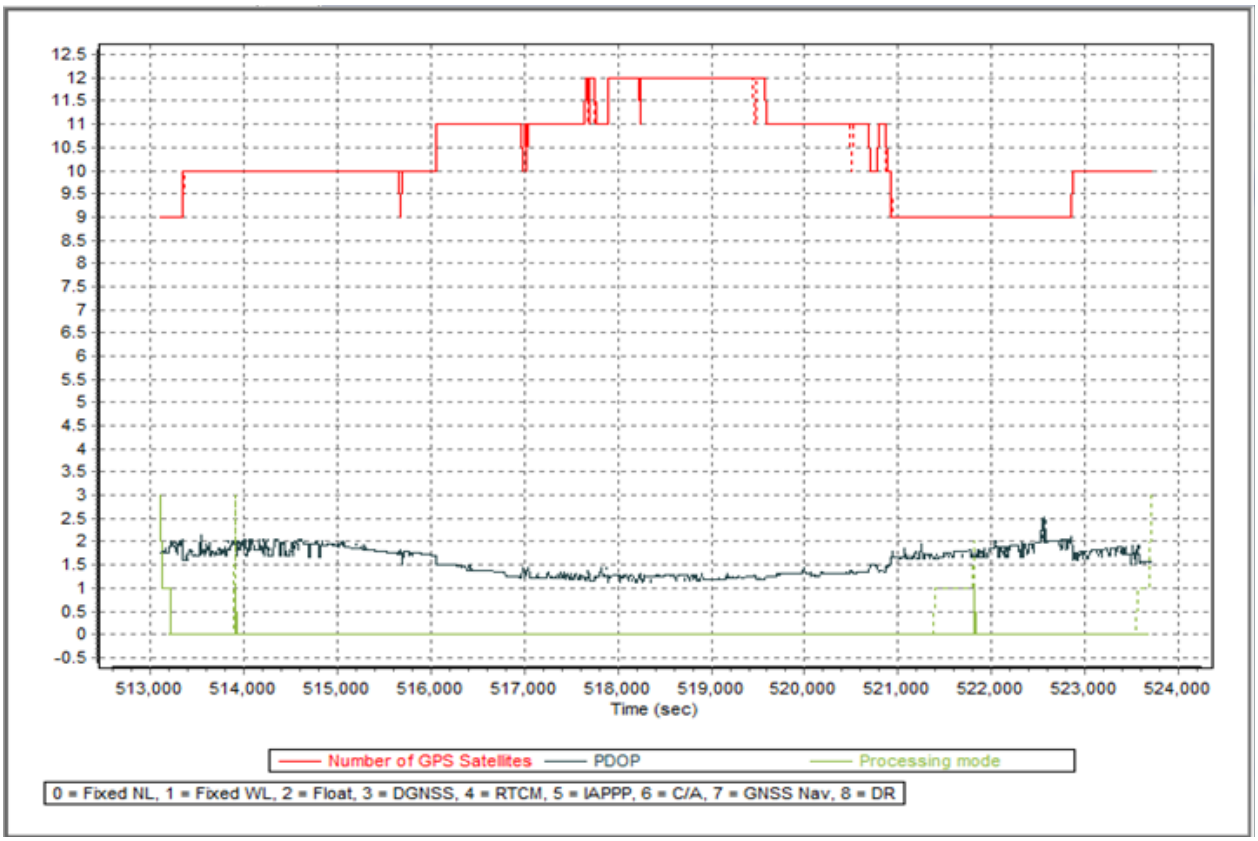


Figure A-8.71. Solution Status

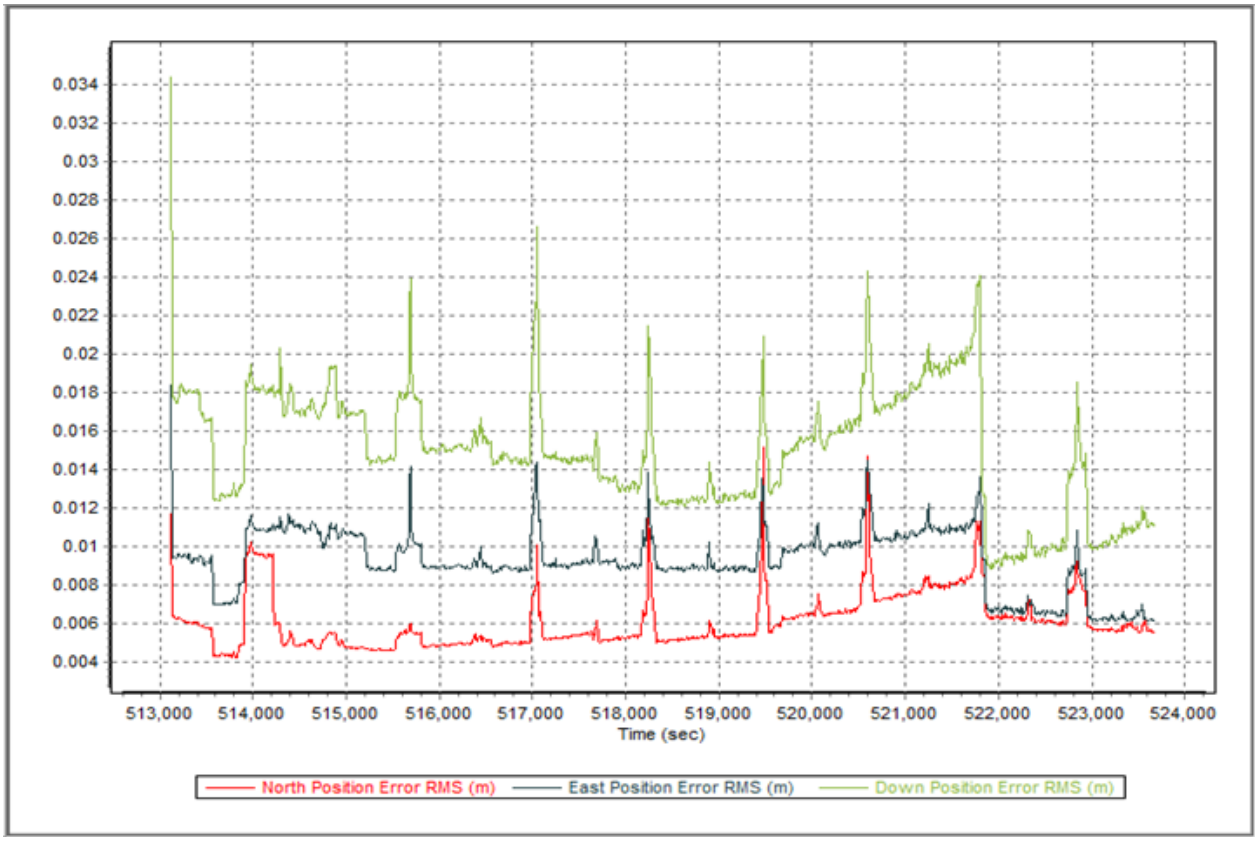


Figure A-8.72. Smoothed Performance Metric Parameters

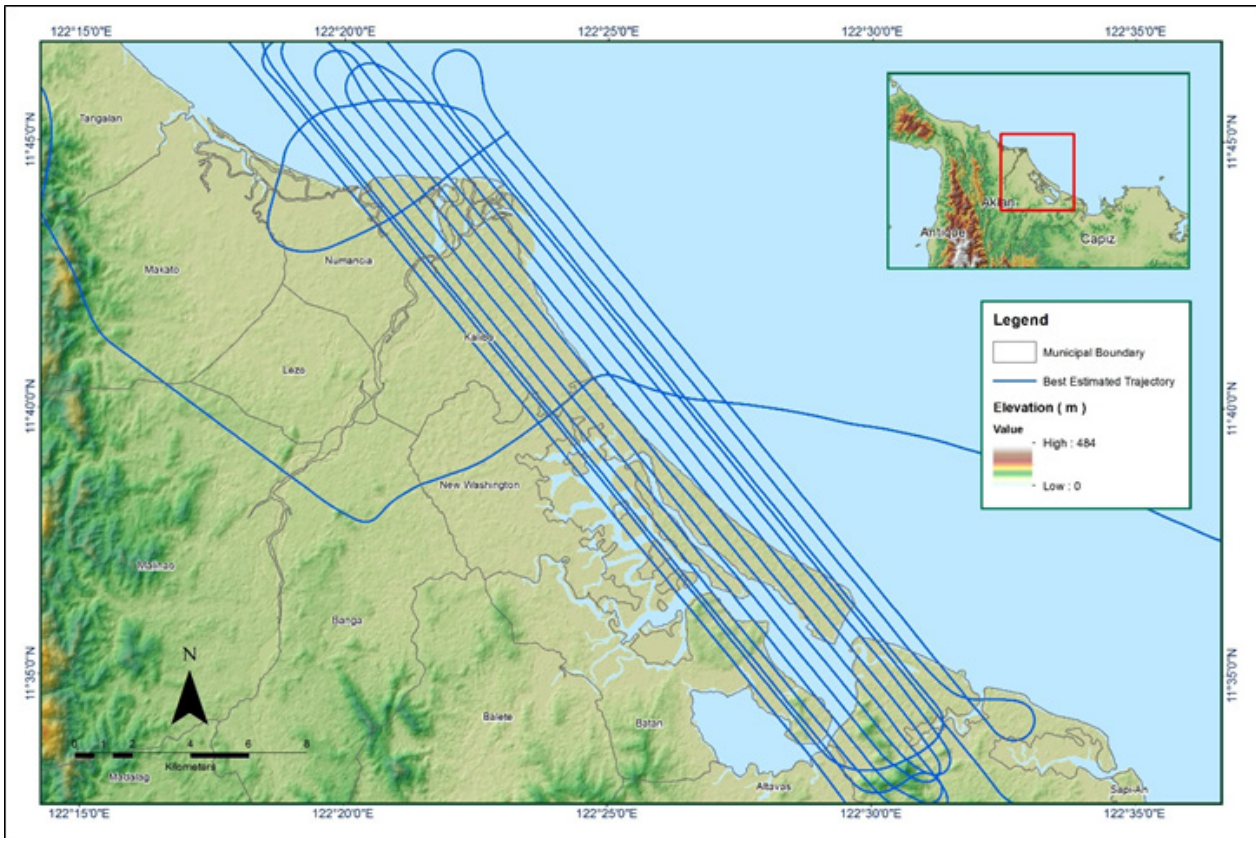


Figure A-8.73. Best Estimated Trajectory

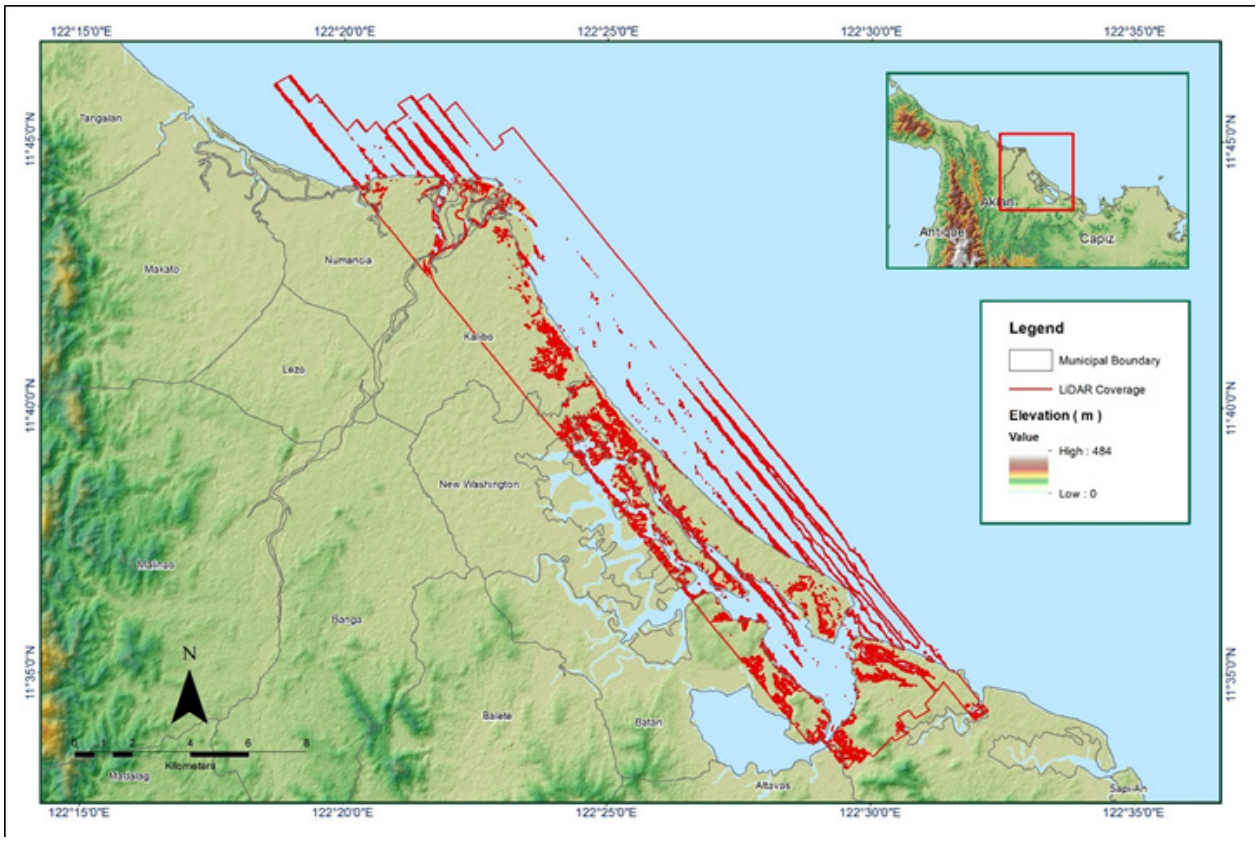


Figure A-8.74. Coverage of LiDAR data

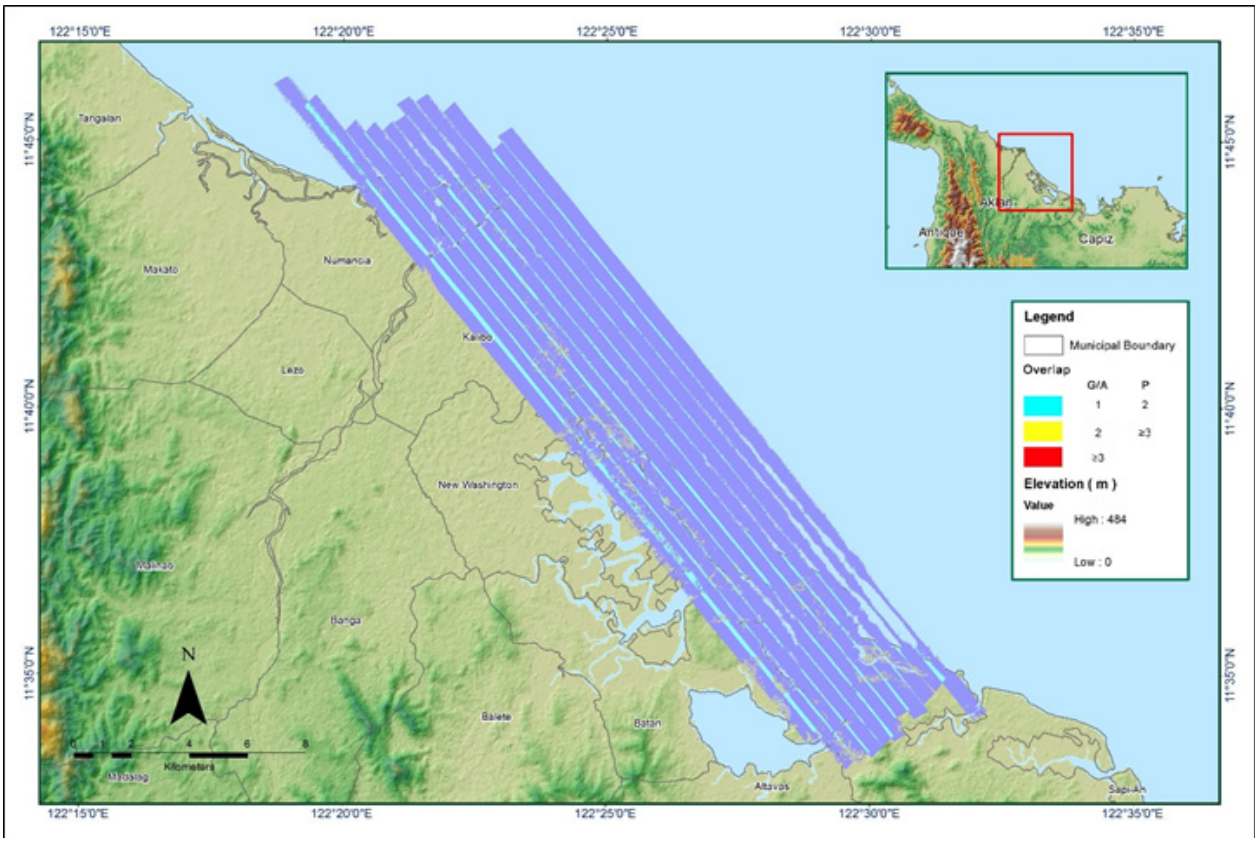


Figure A-8.75. Image of data overlap

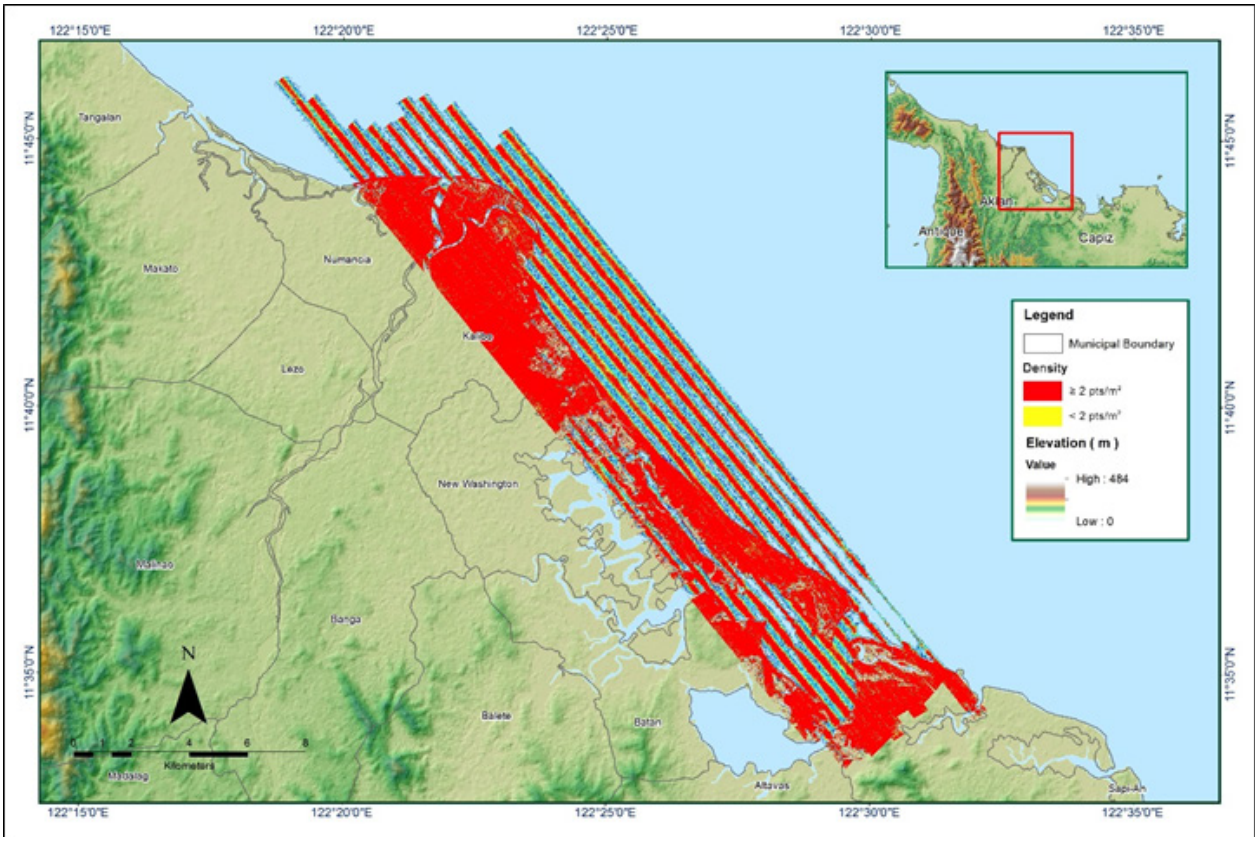


Figure A-8.76. Density map of merged LiDAR data

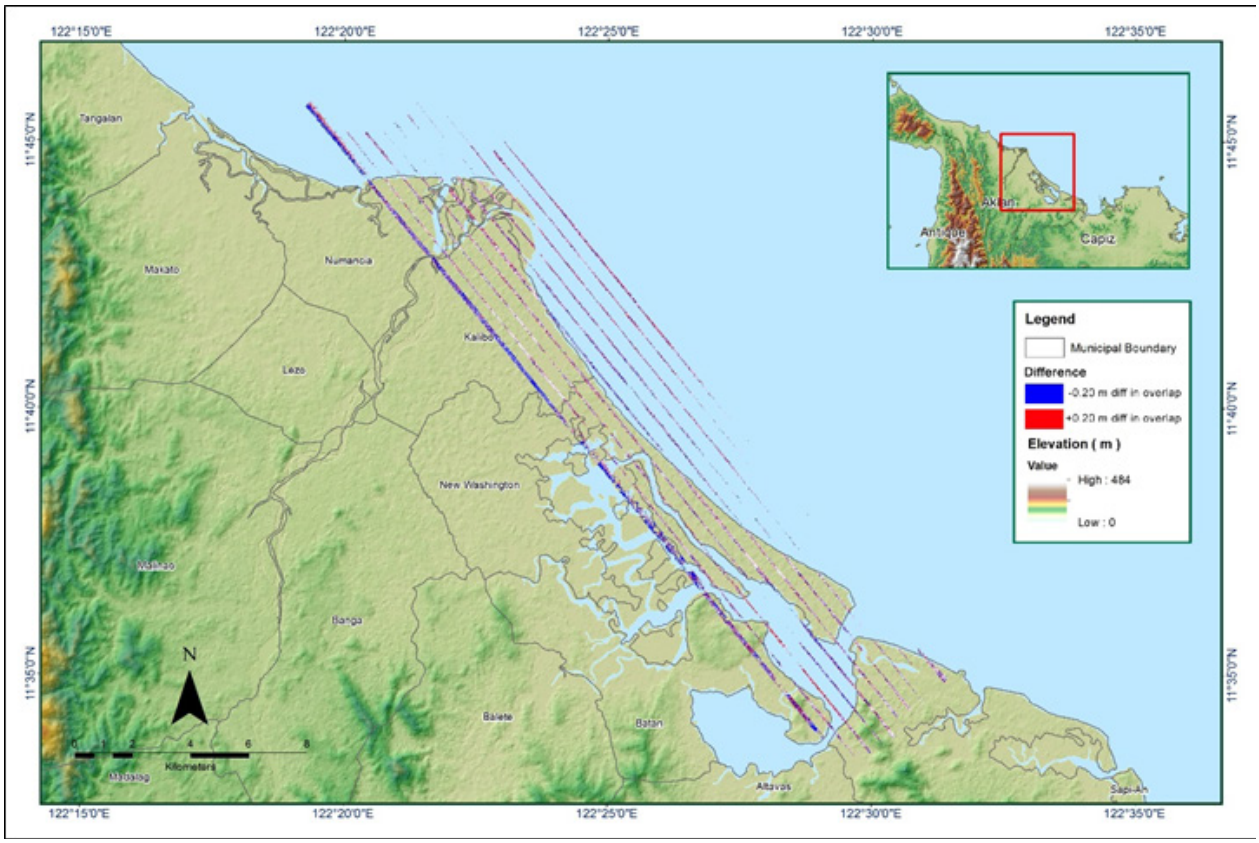


Figure A-8.77. Elevation difference between flight lines

Table A-8.12. Mission Summary Report for Mission Blk38G

Flight Area	Capiz_Aklan
Mission Name	Blk38G
Inclusive Flights	2768G, 2772G
Range data size	37.9 GB
POS	371 MB
Base data size	165.9 MB
Image	75.8 MB
Transfer date	October 9, 2015
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)	1.90
RMSE for East Position (<4.0 cm)	1.54
RMSE for Down Position (<8.0 cm)	4.62
Boresight correction stdev (<0.001deg)	NA
IMU attitude correction stdev (<0.001deg)	NA
GPS position stdev (<0.01m)	NA
Minimum % overlap (>25)	24.63
Ave point cloud density per sq.m. (>2.0)	4.97
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	213
Maximum Height	900.62 m
Minimum Height	52.35 m
Classification (# of points)	
Ground	90,030,964
Low vegetation	49,798,910
Medium vegetation	325,134,162
High vegetation	252,978,885
Building	667,556
Orthophoto	Yes
Processed by	Engr. Regis Guhiting, Aljon Rie Araneta, Engr. Melissa Fernandez

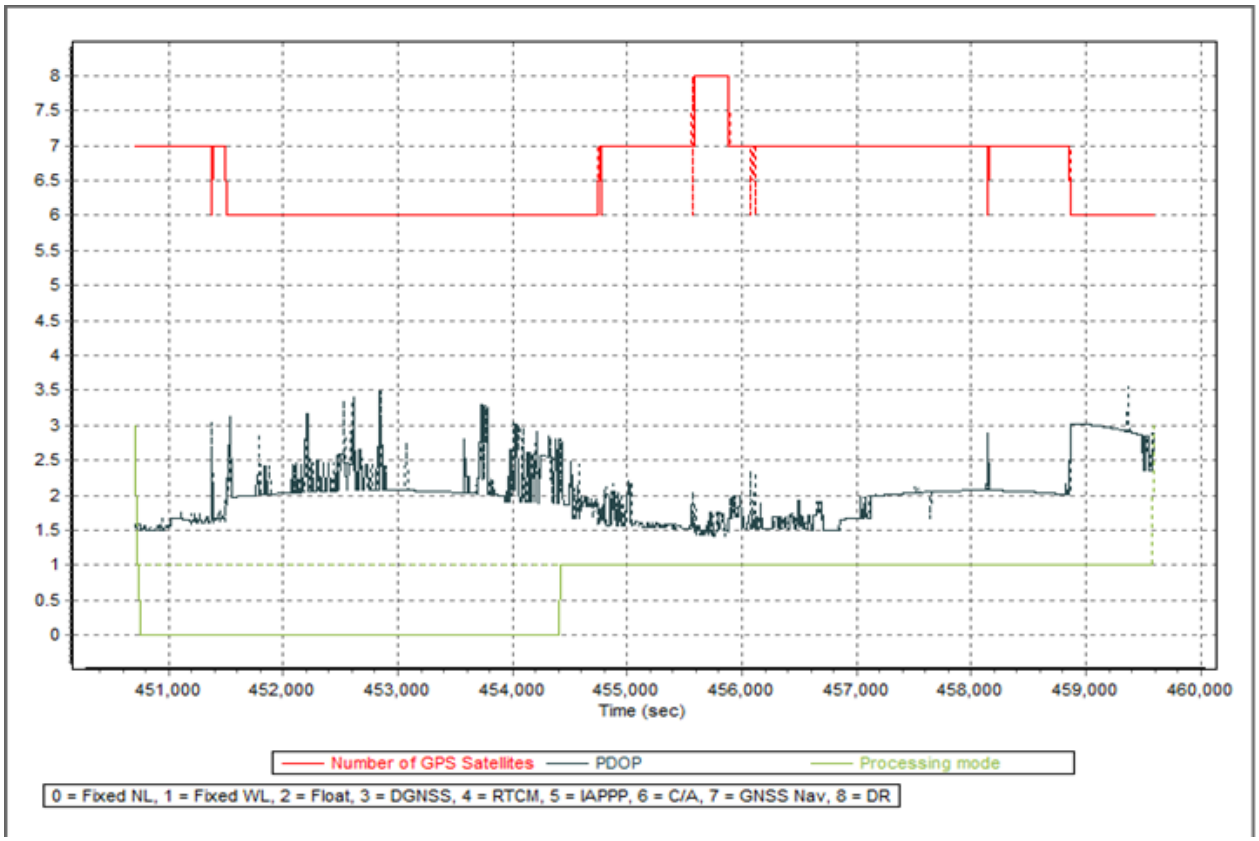


Figure A-8.78. Solution Status

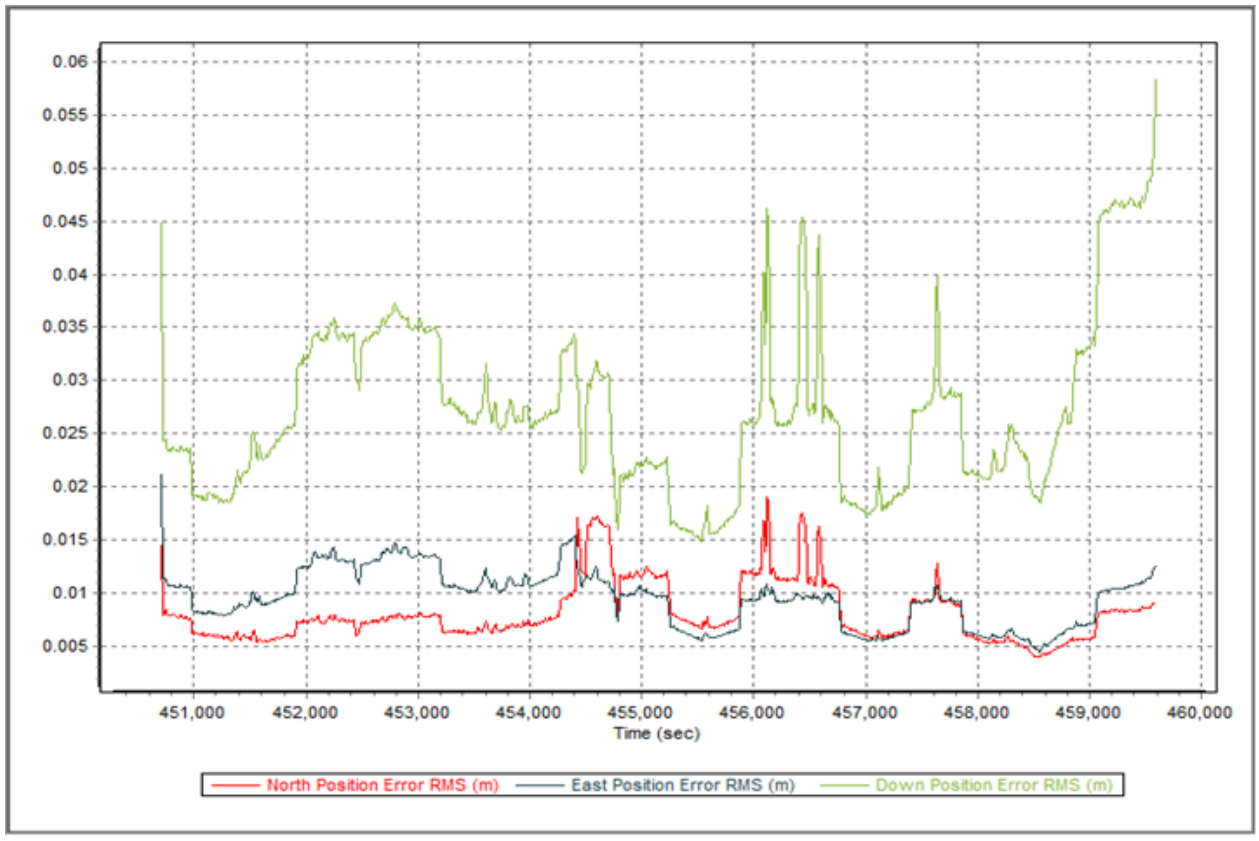


Figure A-8.79. Smoothed Performance Metric Parameters

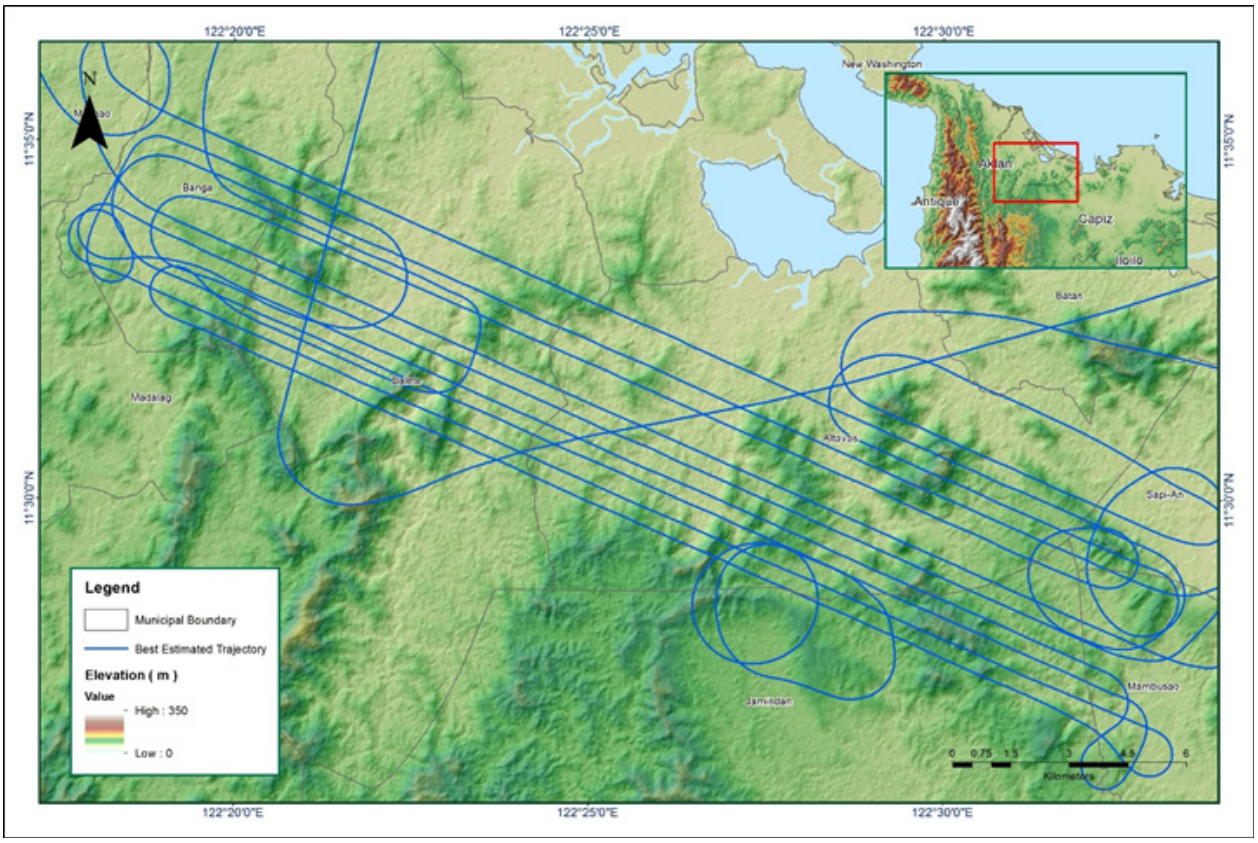


Figure A-8.80. Best Estimated Trajectory

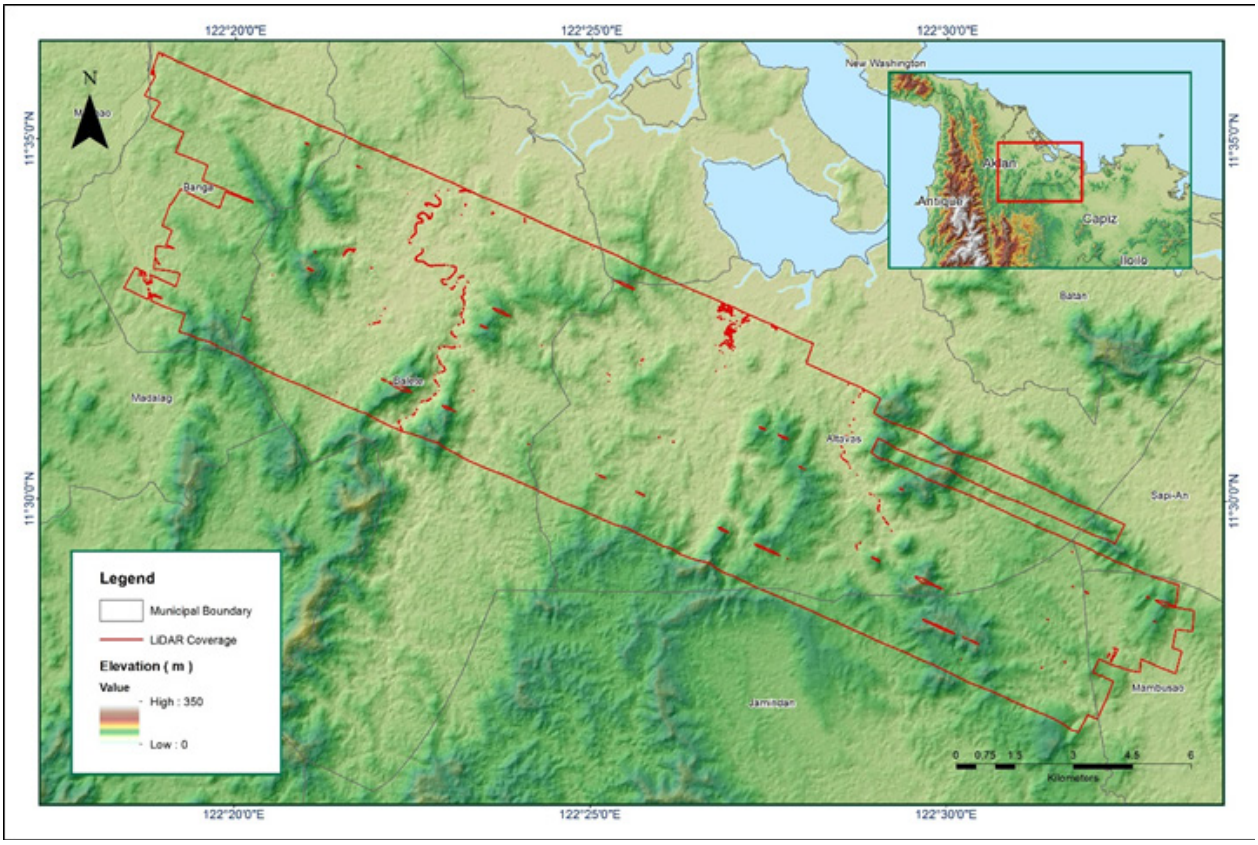


Figure A-8.81. Coverage of LiDAR data

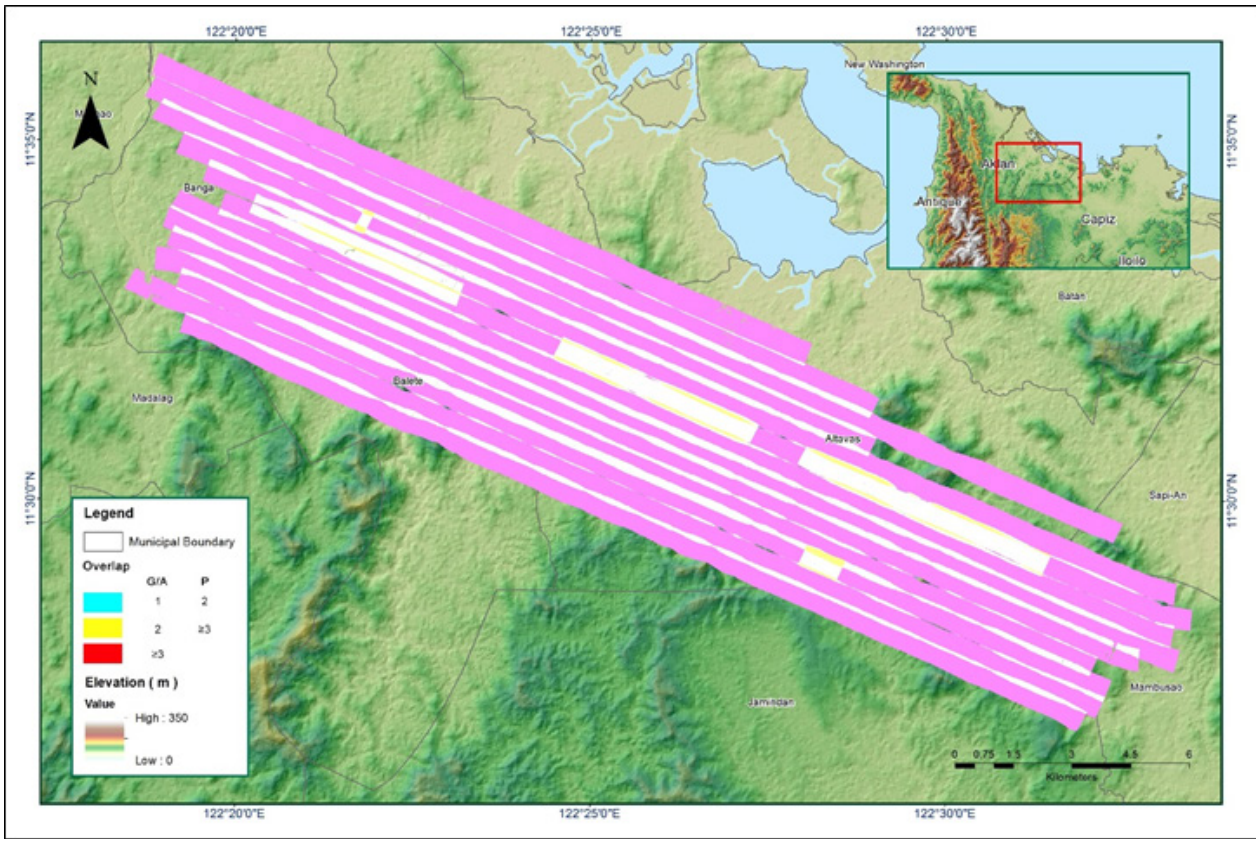


Figure A-8.82. Image of data overlap

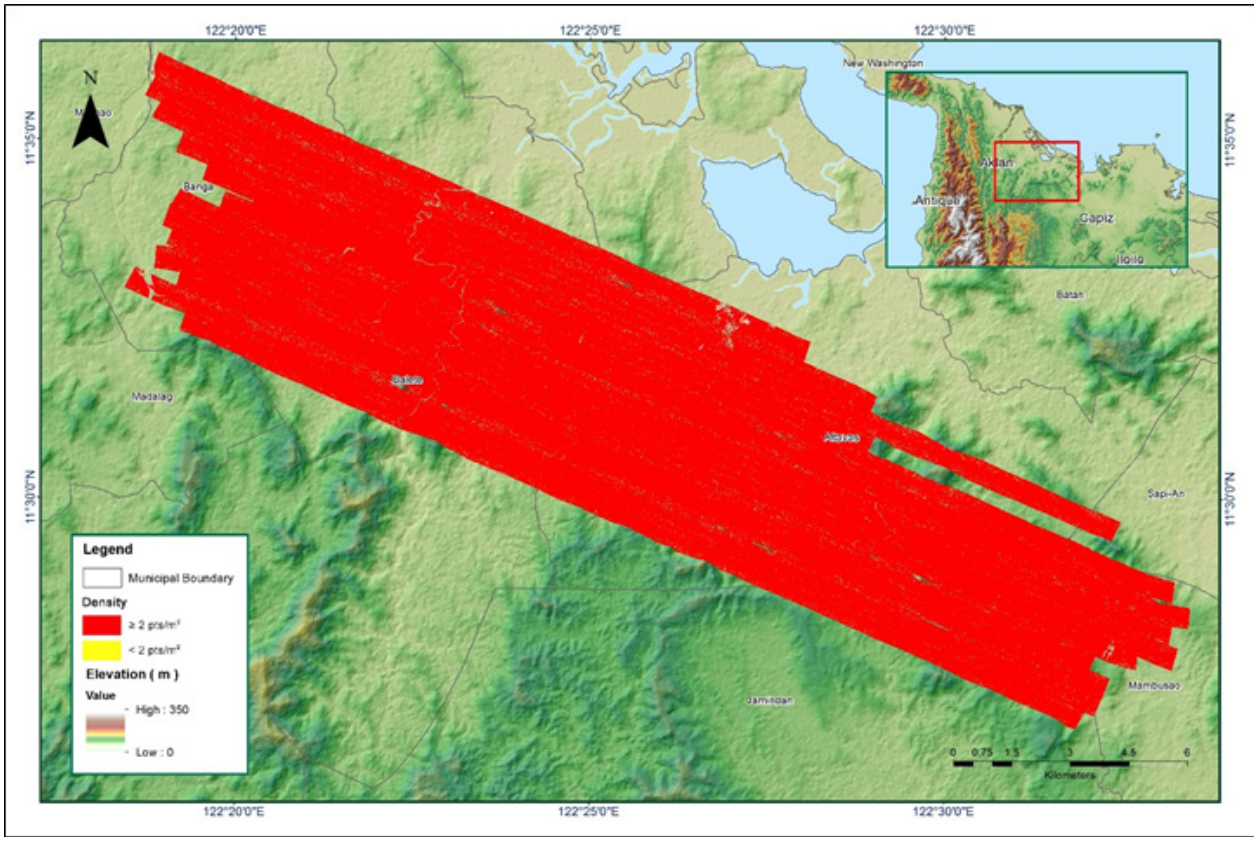


Figure A-8.83. Density map of merged LiDAR data

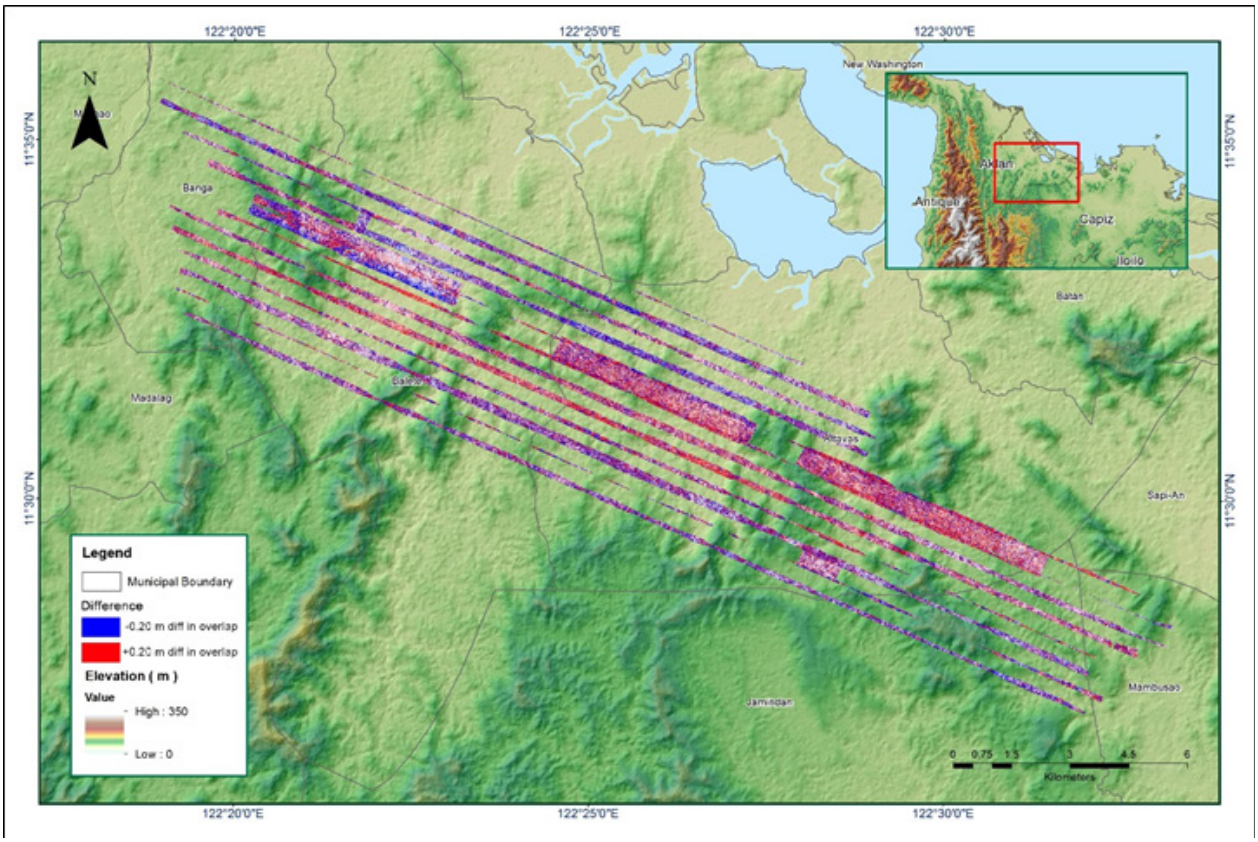


Figure A-8.84. Elevation difference between flight lines

Table A-8.13. Mission Summary Report for Mission Blk38F

Flight Area	Capiz_Aklan
Mission Name	Blk38F
Inclusive Flights	2790G
Range data size	28.1 GB
POS	258 MB
Base data size	93.5 MB
Image	57.4 MB
Transfer date	October 9, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.06
RMSE for East Position (<4.0 cm)	1.16
RMSE for Down Position (<8.0 cm)	2.93
Boresight correction stdev (<0.001deg)	0.000529
IMU attitude correction stdev (<0.001deg)	0.000773
GPS position stdev (<0.01m)	0.0015
Minimum % overlap (>25)	36.03
Ave point cloud density per sq.m. (>2.0)	5.55
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	82
Maximum Height	382.01 m
Minimum Height	68.43 m
Classification (# of points)	
Ground	29,590,492
Low vegetation	20,271,346
Medium vegetation	116,293,552
High vegetation	93,856,437
Building	785,353
Orthophoto	Yes
Processed by	Engr. Regis Guhiting, Aljon Rie Araneta, Maria Tamsyn Malabanan,

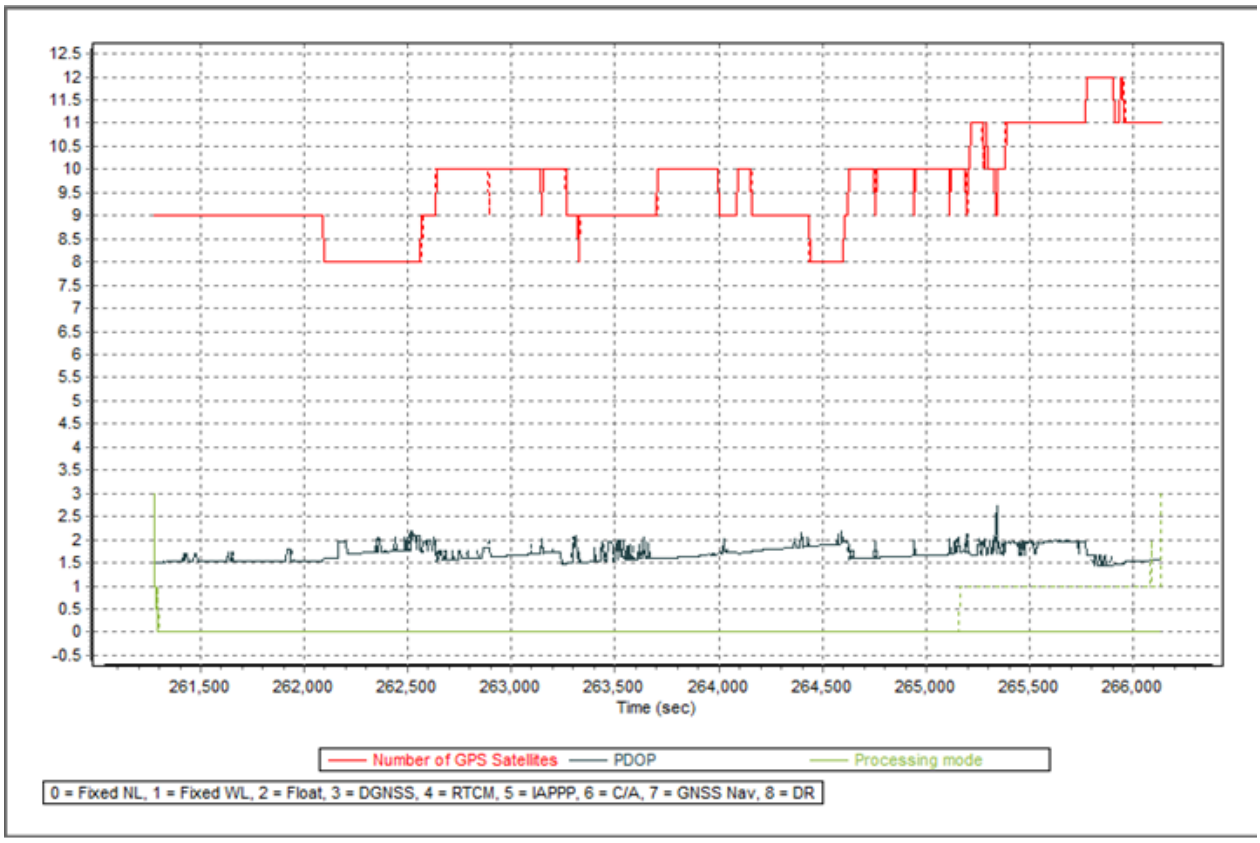


Figure A-8.85. Solution Status

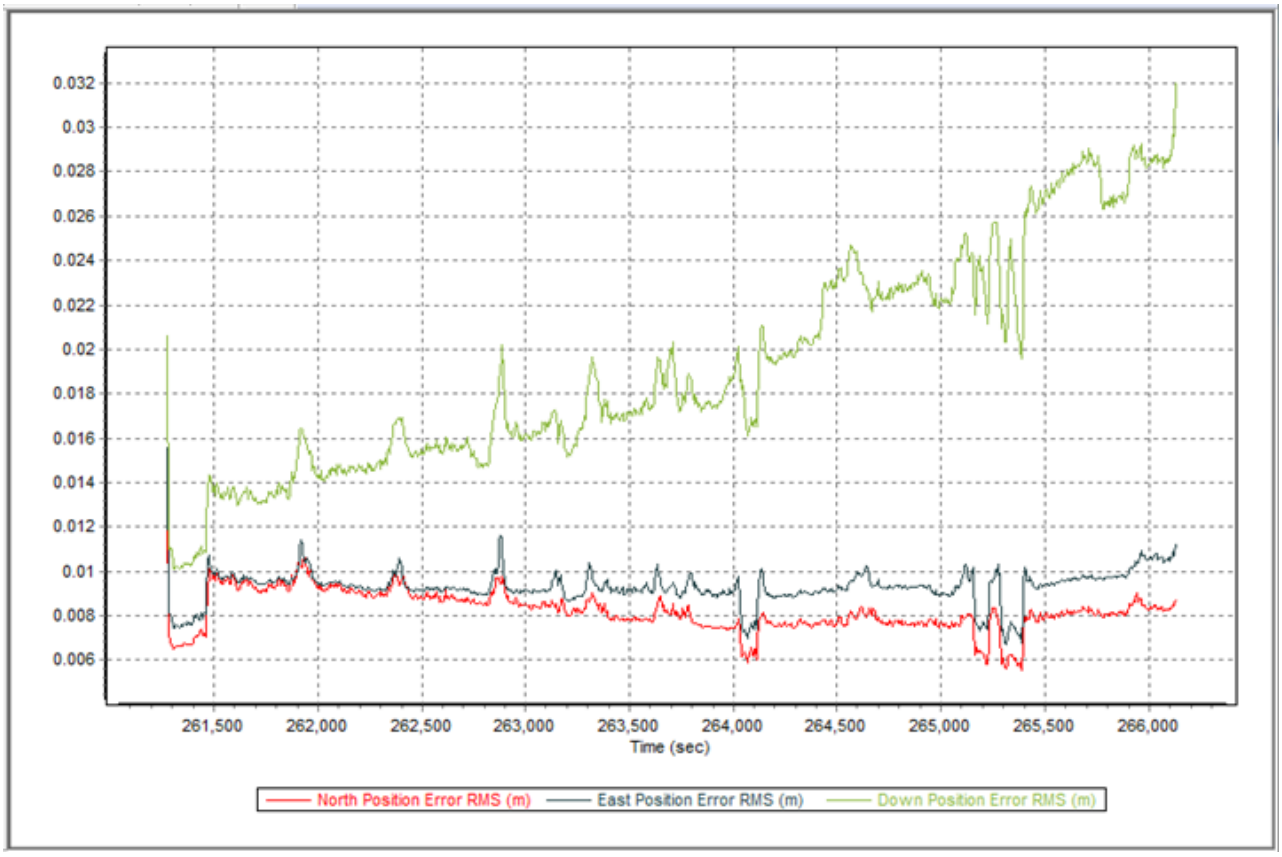


Figure A-8.86. Smoothed Performance Metric Parameters

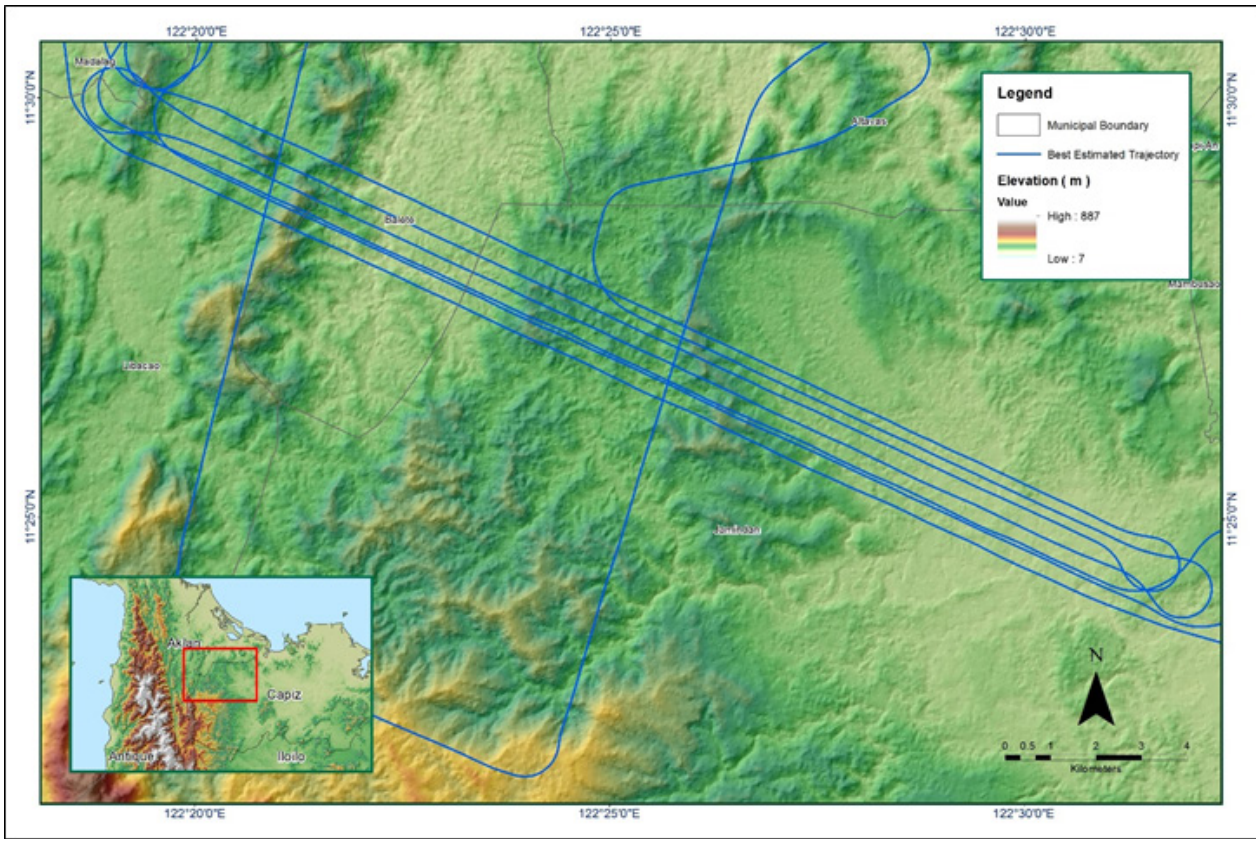


Figure A-8.87. Best Estimated Trajectory

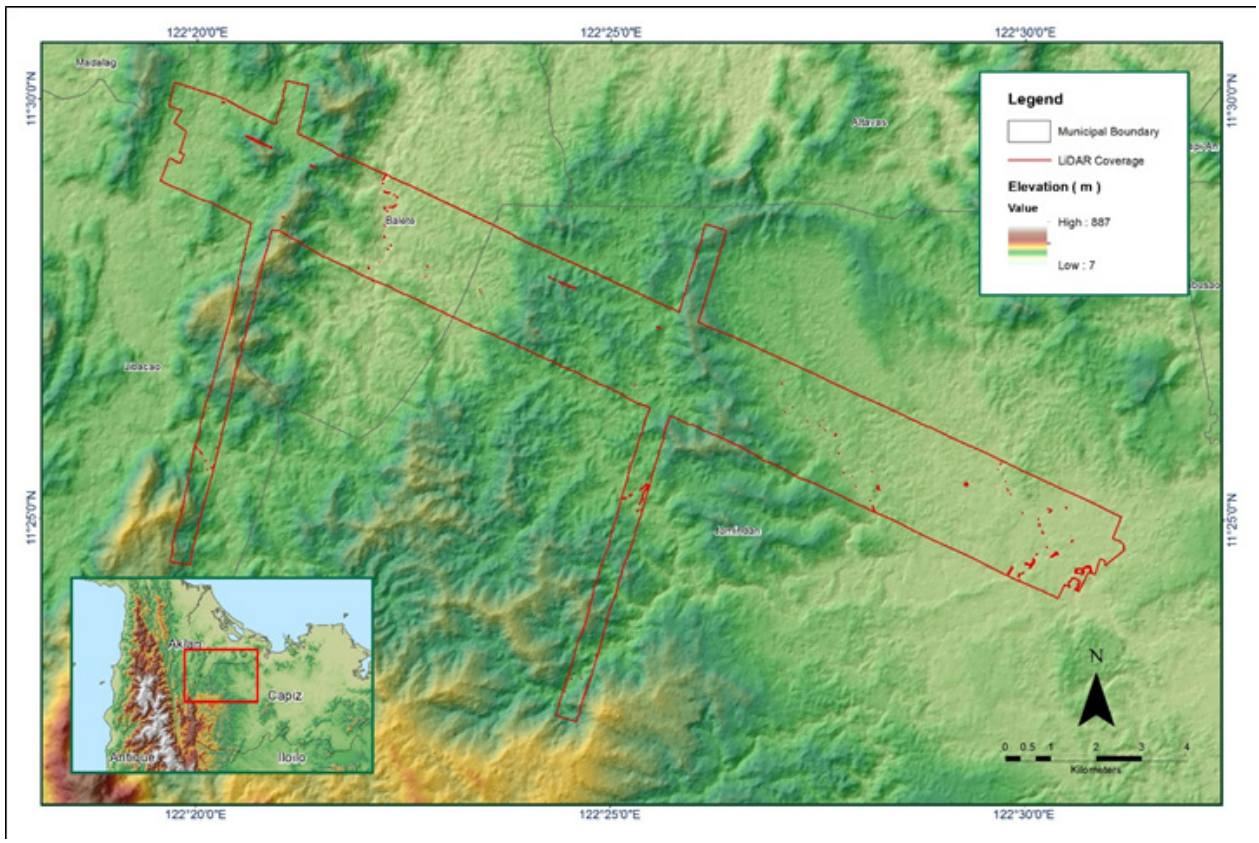


Figure A-8.88. Coverage of LiDAR data

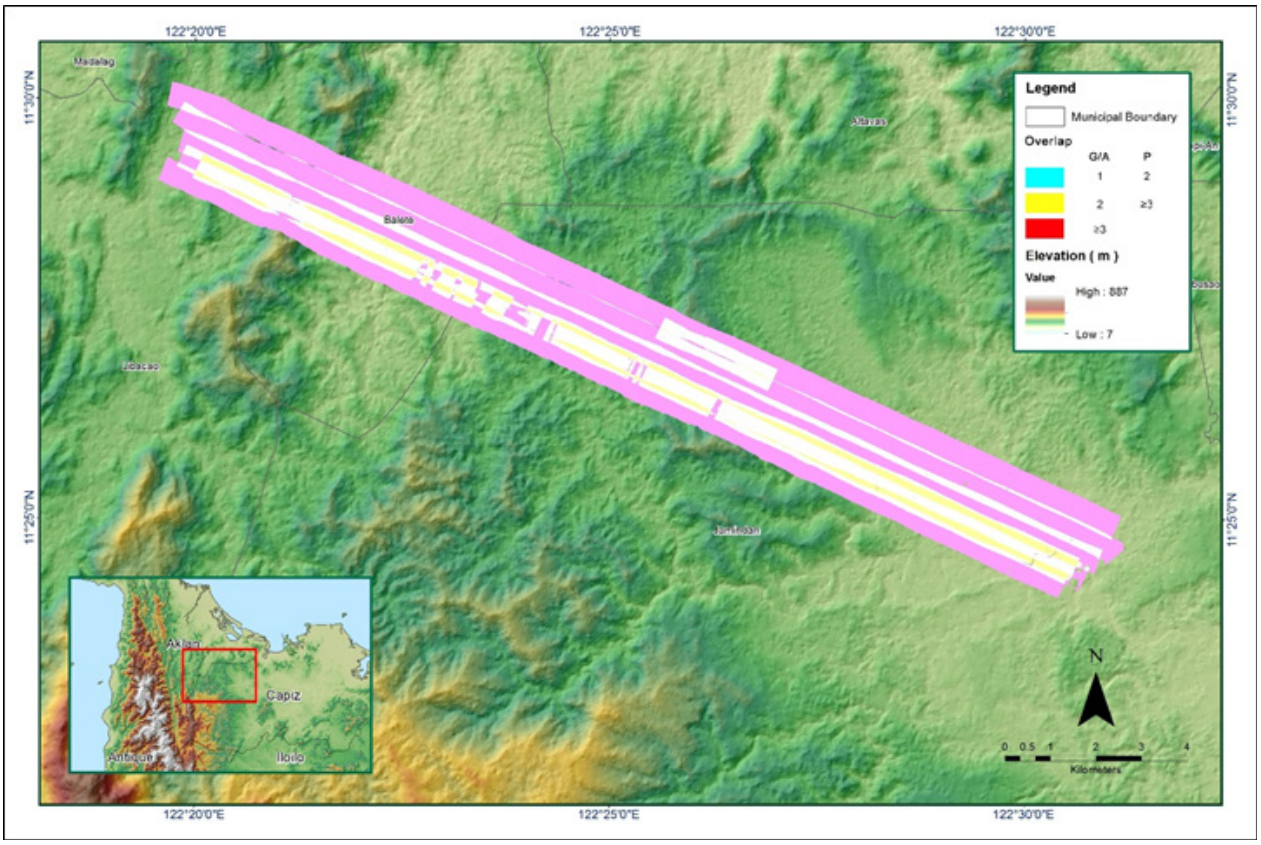


Figure A-8.89. Image of data overlap

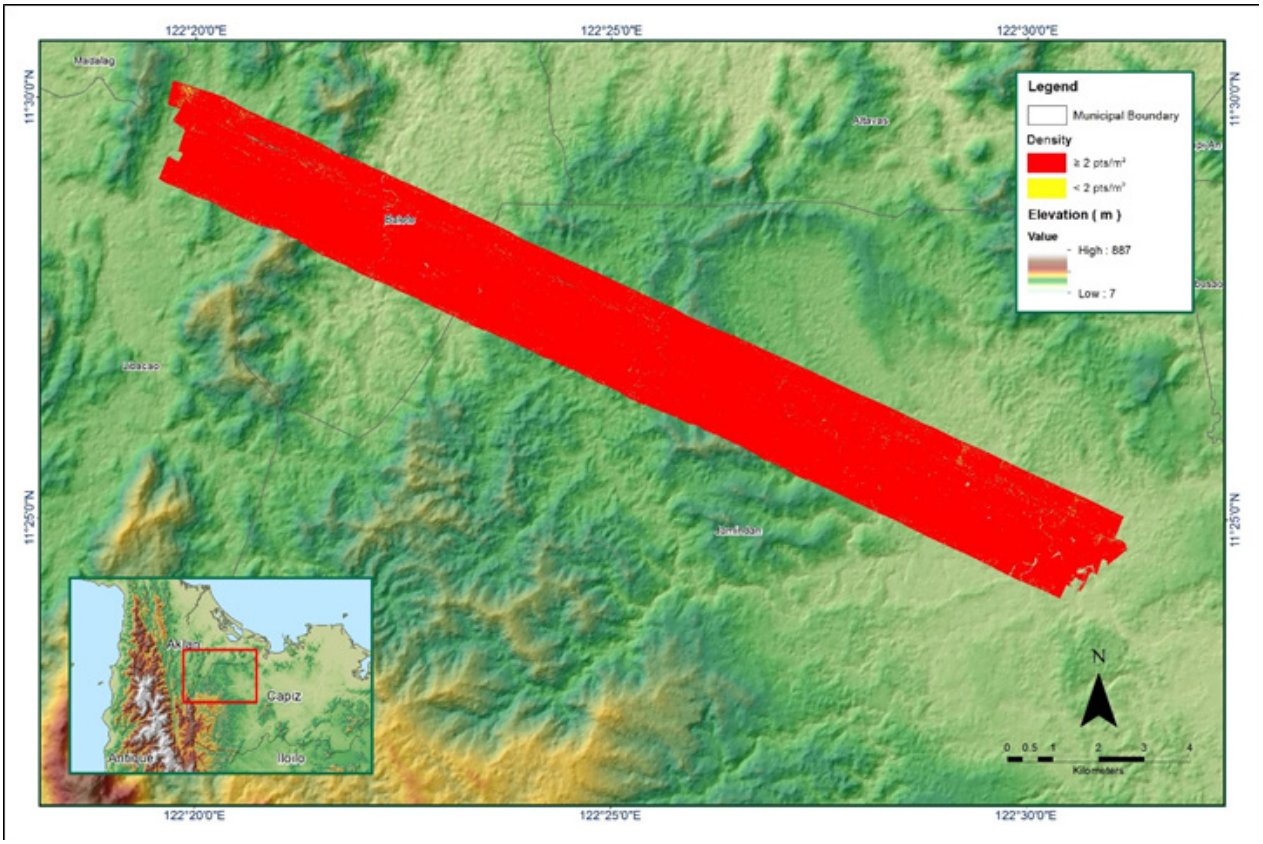


Figure A-8.90. Density map of merged LiDAR data

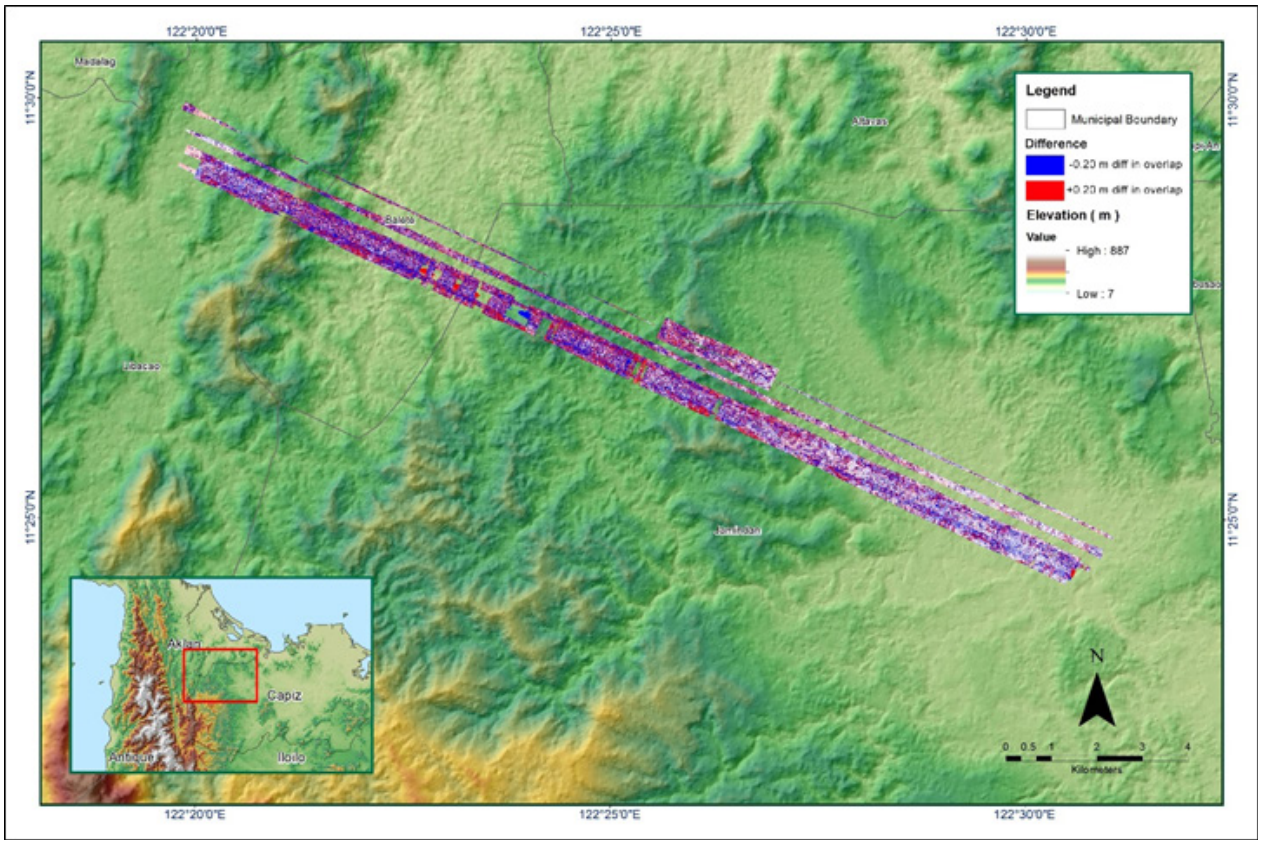


Figure A-8.91. Elevation difference between flight lines

Table A-8.14. Mission Summary Report for Mission Blk38I

Flight Area	Capiz_Aklan
Mission Name	Blk38I
Inclusive Flights	2792G
Range data size	21.6 GB
POS	190 MB
Image	11.4 MB
Transfer date	Ocotber 9, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.46
RMSE for East Position (<4.0 cm)	1.27
RMSE for Down Position (<8.0 cm)	4.79
Boresight correction stdev (<0.001deg)	0.001495
IMU attitude correction stdev (<0.001deg)	0.003061
GPS position stdev (<0.01m)	0.0086
Minimum % overlap (>25)	21.45
Ave point cloud density per sq.m. (>2.0)	4.95
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	88
Maximum Height	460.75 m
Minimum Height	67.83 m
Classification (# of points)	
Ground	25,280,265
Low vegetation	27,311,346
Medium vegetation	128,406,936
High vegetation	101,781,716
Building	376,099
Orthophoto	Yes
Processed by	Engr. Analyn Naldo, Engr. Chelou Prado, Engr. Harmond Santos

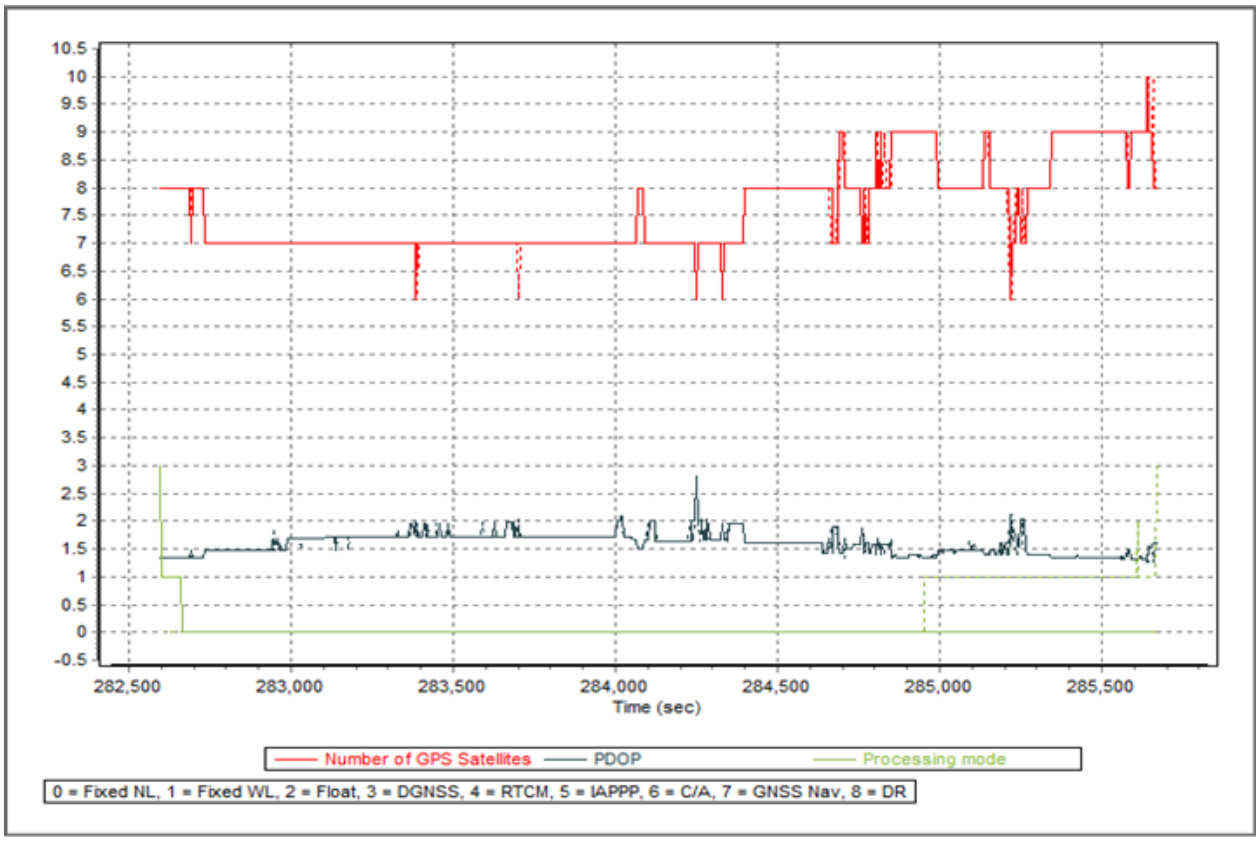


Figure A-8.92. Solution Status

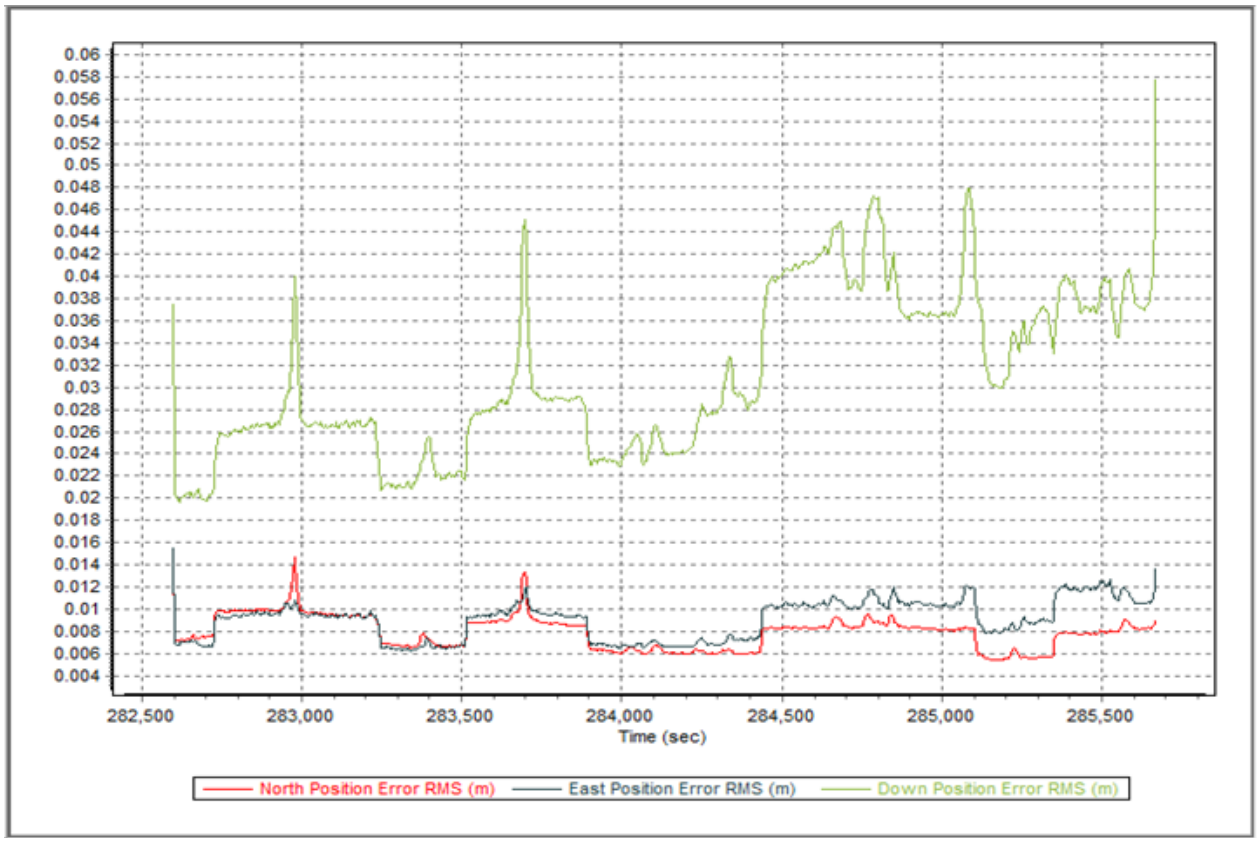


Figure A-8.93. Smoothed Performance Metric Parameters

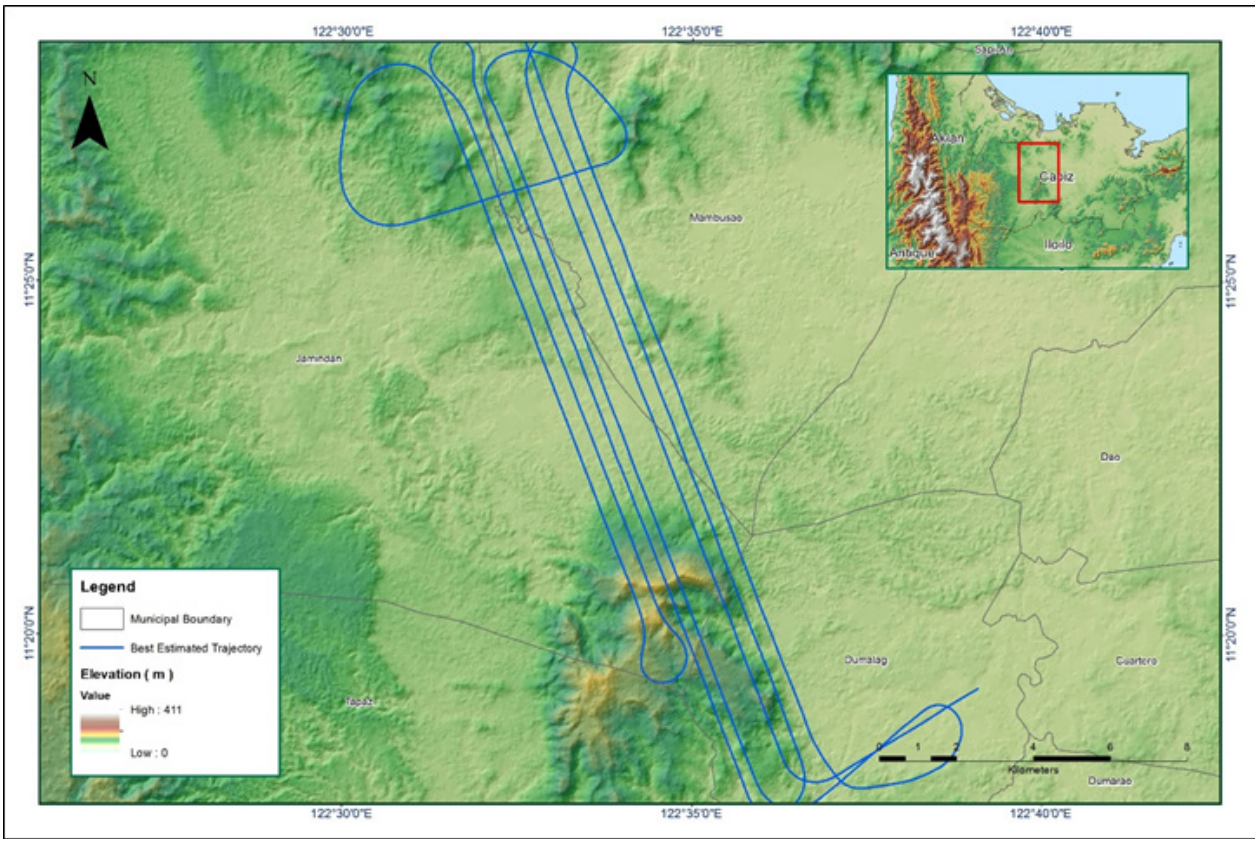


Figure A-8.94. Best Estimated Trajectory

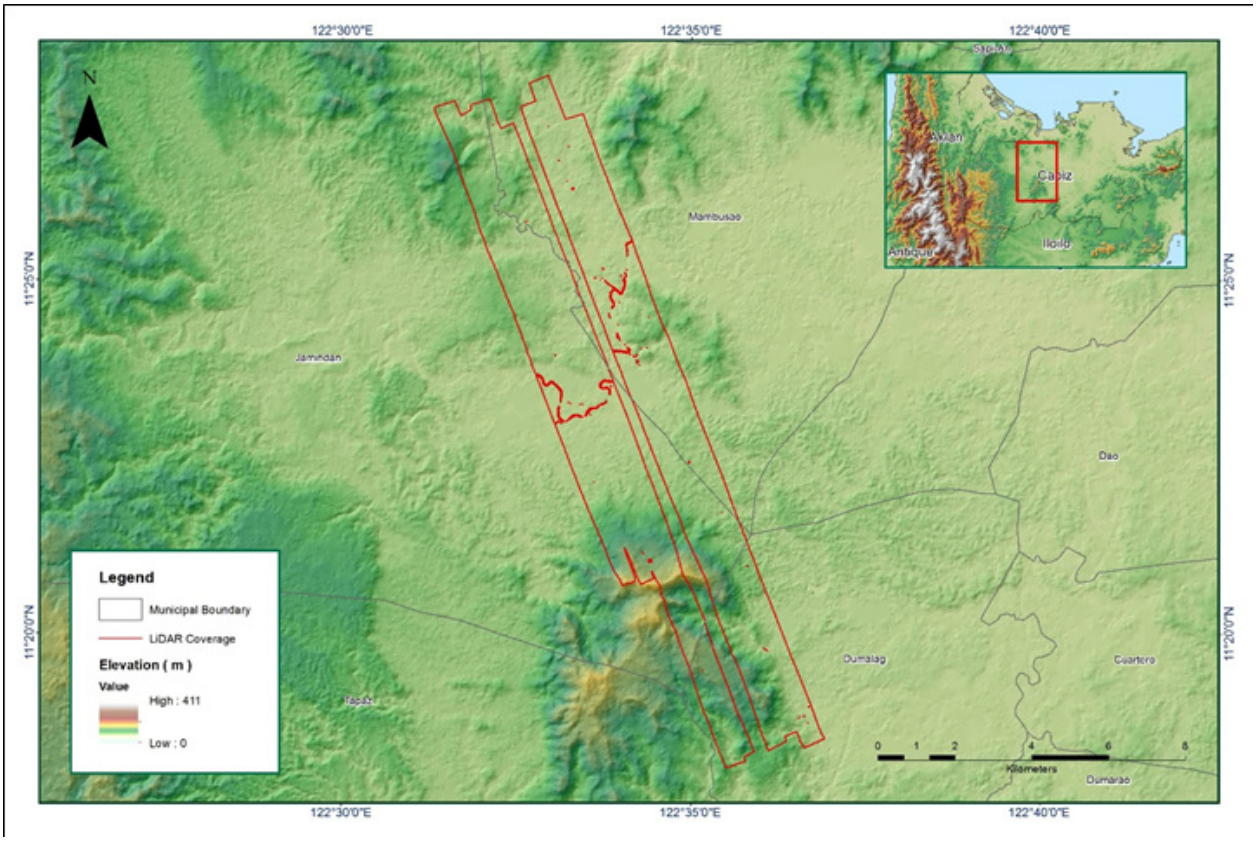


Figure A-8.95. Coverage of LiDAR data

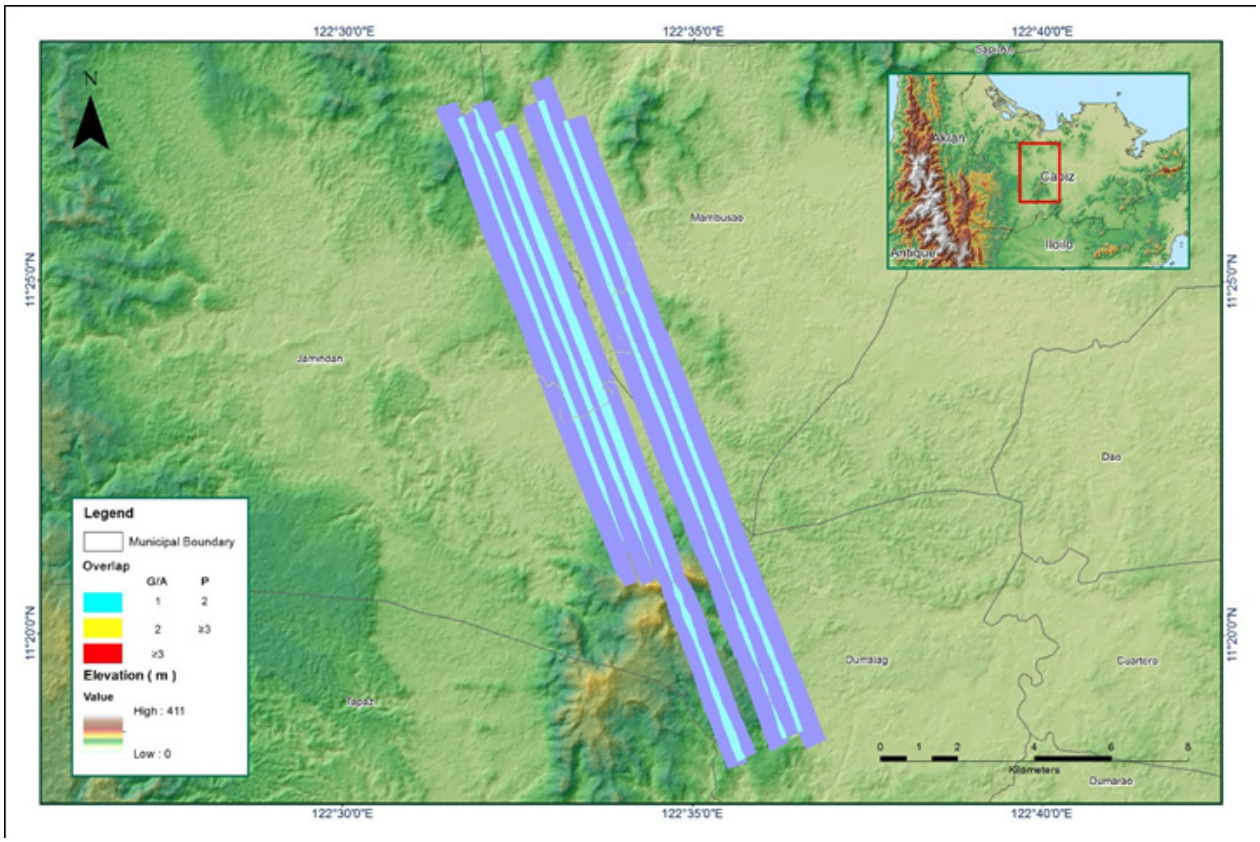


Figure A-8.96. Image of data overlap

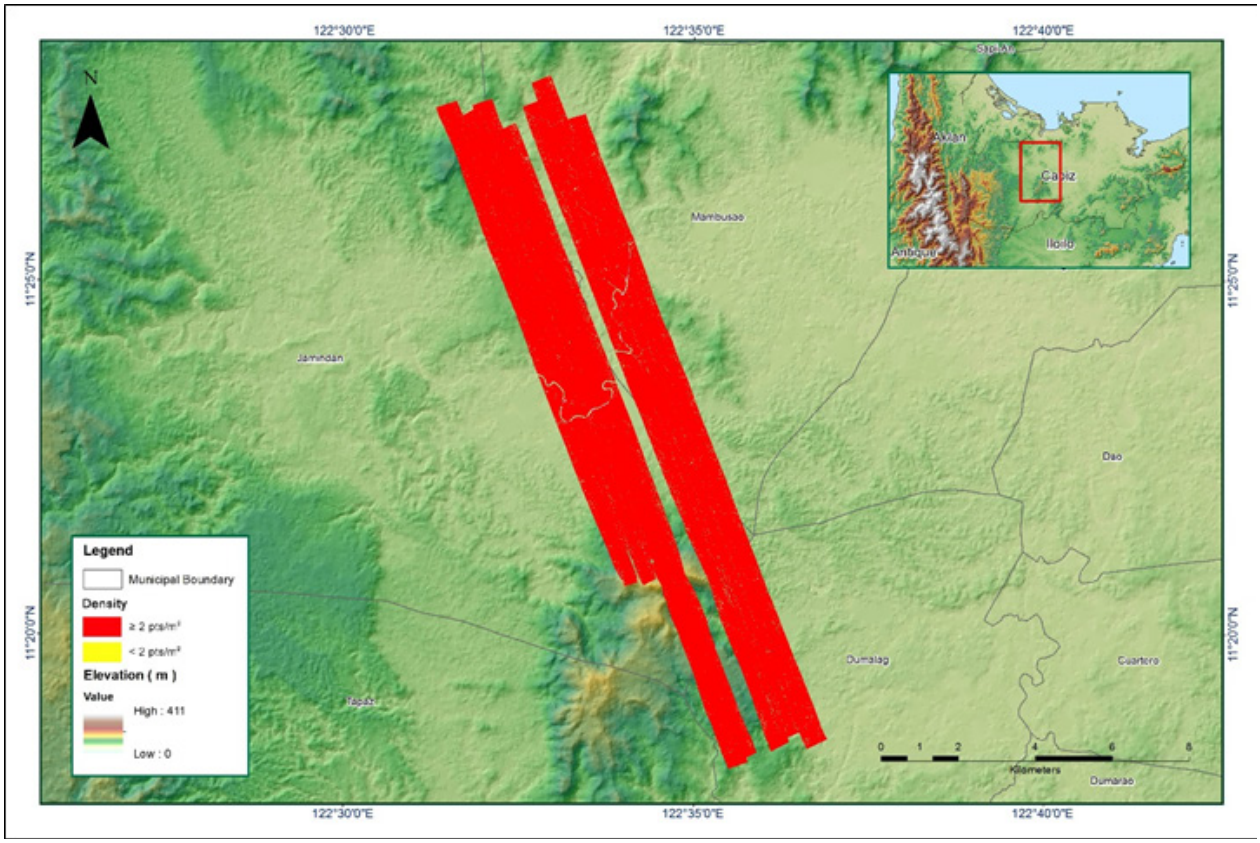


Figure A-8.97. Density map of merged LiDAR data

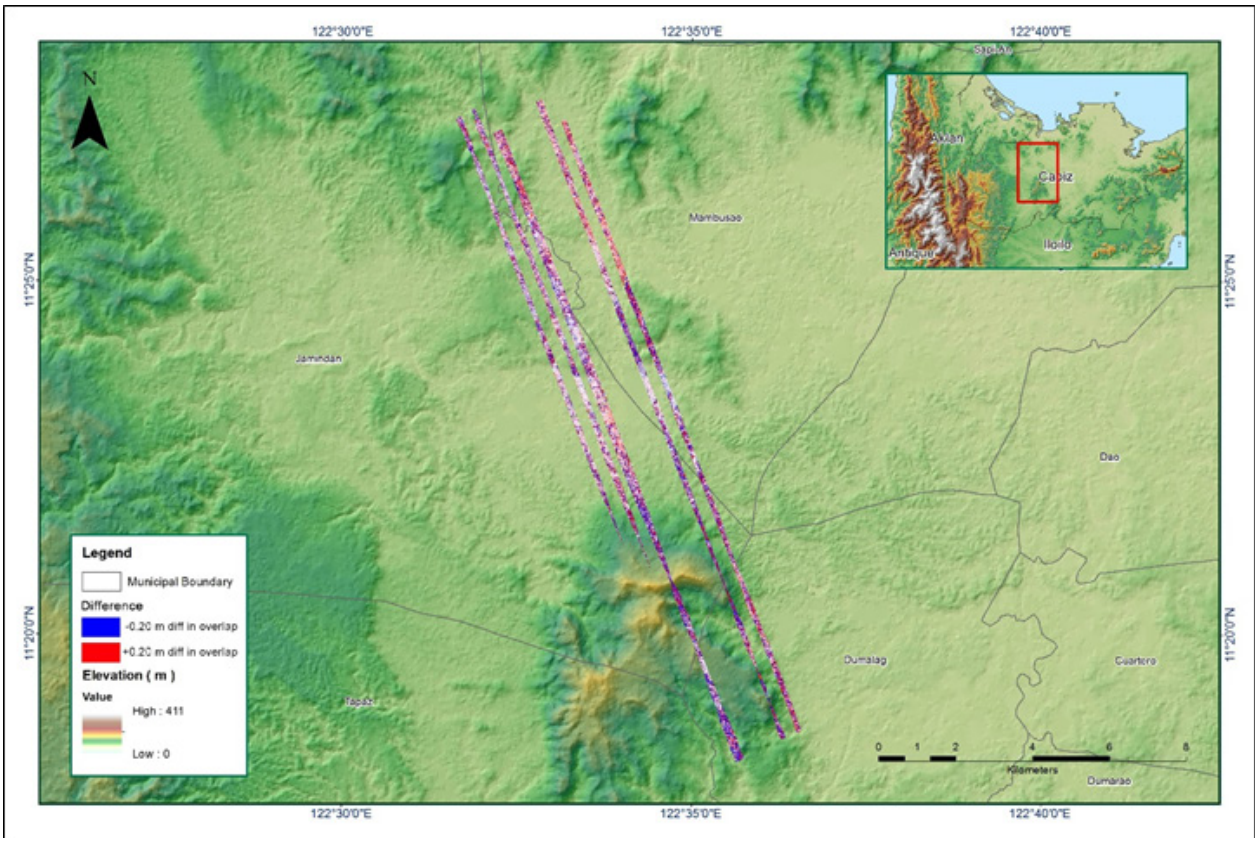


Figure A-8.98. Elevation difference between flight lines

Annex 9. Aklan Model Basin Parameters

Table A-9.1. Aklan 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
W280	7.4029	66.3338	0	0.270555	4.4155	Discharge	4.0565	0.09	Ratio to Peak	0.5
W290	6.8321	68.2721	0	0.382325	6.2395	Discharge	5.3813	0.09	Ratio to Peak	0.5
W300	6.1357	70.796	0	0.16477	2.68905	Discharge	1.9391	0.09	Ratio to Peak	0.5
W310	3.0011	84.9303	0	0.134115	2.18875	Discharge	3.6092	0.09	Ratio to Peak	0.5
W320	5.3548	73.8581	0	0.20299	3.3128	Discharge	4.6947	0.09	Ratio to Peak	0.5
W330	4.556	77.2779	0	0.106935	1.7452	Discharge	1.2743	0.09	Ratio to Peak	0.5
W340	3.3586	83.04	0	0.158485	2.5865	Discharge	3.5053	0.09	Ratio to Peak	0.5
W350	7.2924	66.7	0	0.269945	4.4055	Discharge	5.8401	0.09	Ratio to Peak	0.5
W360	10.543	57.3731	0	0.103265	1.68525	Discharge	2.8903	0.09	Ratio to Peak	0.5
W370	10.499	57.4812	0	0.32574	5.316	Discharge	13.531	0.09	Ratio to Peak	0.5
W380	4.4853	77.595	0	0.17607	2.87345	Discharge	3.3535	0.09	Ratio to Peak	0.5
W390	9.4458	60.2144	0	0.198655	3.242	Discharge	5.5593	0.09	Ratio to Peak	0.5
W400	4.6973	76.65	0	0.103245	1.68495	Discharge	3.2533	0.09	Ratio to Peak	0.5
W410	12.538	52.8381	0	0.12385	2.0212	Discharge	0.85536	0.09	Ratio to Peak	0.5
W420	12.874	52.142	0	0.172695	2.8184	Discharge	2.6755	0.09	Ratio to Peak	0.5

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
W430	10.382	57.771	0	0.16767	2.73635	Discharge	4.7464	0.09	Ratio to Peak	0.5
W440	12.107	53.7558	0	0.30431	4.96635	Discharge	6.5808	0.09	Ratio to Peak	0.5
W450	9.7785	59.3229	0	0.10066	1.6428	Discharge	1.7369	0.09	Ratio to Peak	0.5
W460	9.5159	60.0243	0	0.13331	2.1756	Discharge	4.958	0.09	Ratio to Peak	0.5
W470	10.355	57.8403	0	0.13024	2.12555	Discharge	3.4812	0.09	Ratio to Peak	0.5
W480	10.643	57.1274	0	0.128525	2.0975	Discharge	3.2511	0.09	Ratio to Peak	0.5
W490	10.184	58.2729	0	0.17575	2.86825	Discharge	5.5158	0.09	Ratio to Peak	0.5
W500	11.126	55.9692	0	0.090615	1.47885	Discharge	1.7289	0.09	Ratio to Peak	0.5
W510	12.17	53.6183	0	0.239805	3.9136	Discharge	5.6361	0.09	Ratio to Peak	0.5
W520	13.523	50.8515	0	0.0671	1.0951	Discharge	0.22314	0.09	Ratio to Peak	0.5
W530	10.432	57.6471	0	0.10751	1.7546	Discharge	2.5211	0.09	Ratio to Peak	0.5
W540	10.694	57.002	0	0.252835	4.1263	Discharge	10.323	0.09	Ratio to Peak	0.5

Annex 10. Aklan Model Reach Parameters

Table A-10.1. Aklan Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R10	Automatic Fixed Interval	4375.8	0.0111267	0.04	Trapezoid	199	1
R20	Automatic Fixed Interval	2782.6	0.0001952	0.04	Trapezoid	199	1
R40	Automatic Fixed Interval	2946.8	0.0019267	0.04	Trapezoid	199	1
R60	Automatic Fixed Interval	6218.3	0.0036355	0.04	Trapezoid	199	1
R70	Automatic Fixed Interval	13626	0.0048222	0.04	Trapezoid	199	1
R90	Automatic Fixed Interval	5702.3	0.0011059	0.04	Trapezoid	199	1
R110	Automatic Fixed Interval	5486.5	0.0022875	0.04	Trapezoid	199	1
R120	Automatic Fixed Interval	2789.7	0.0056411	0.04	Trapezoid	199	1
R160	Automatic Fixed Interval	6938.3	0.0082476	0.04	Trapezoid	199	1
R190	Automatic Fixed Interval	2954.7	0.0137997	0.04	Trapezoid	199	1
R210	Automatic Fixed Interval	3438.4	0.0016869	0.04	Trapezoid	199	1
R220	Automatic Fixed Interval	3105.3	0.0121304	0.04	Trapezoid	199	1
R240	Automatic Fixed Interval	974.97	0.0018016	0.04	Trapezoid	199	1

Annex 11. Aklan Field Validation

Table A-11.1. Aklan Field Validation

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/ Date	Rain Return / Scenario
	Lat	Long					
1	11.71302681	122.3661523	0.652999997	1.2	0.299	Frank	100-Year
2	11.65854294	122.3876018	0.363999993	0.0762	0.083	Frank	100-Year
3	11.70917955	122.3758106	0.379000008	0.48	0.010	Frank	100-Year
4	11.6762311	122.3302733	0.037999999	0	0.001	Frank	100-Year
5	11.71771401	122.3772261	0.31099999	3.2	8.346	Frank	100-Year
6	11.70947236	122.3745037	0.298999995	0.8	0.251	Frank	100-Year
7	11.70770967	122.3740095	0.456999987	0.94	0.233	Frank	100-Year
8	11.70905914	122.364171	0.135000005	1.63	2.235	Frank	100-Year
9	11.71836859	122.3727763	0.623000026	1.2	0.333	Frank	100-Year
10	11.64459918	122.3833535	0.029999999	0.9144	0.782	Yolanda	5-Year
11	11.66973854	122.3268198	0.030999999	0	0.001		
12	11.72749082	122.3483079	0.400999993	1.09	0.475	Frank	100-Year
13	11.70986235	122.3755103	0.246999994	0.36	0.013	Frank	100-Year
14	11.69958397	122.3764273	0.476000011	2.32	3.400	Frank	100-Year
15	11.73575338	122.3274665	0.486999989	1.2192	0.536	Frank	100-Year
16	11.67069487	122.3848901	0.048	0	0.002		
17	11.70842748	122.3626398	0.100000001	2	3.610	Frank	100-Year
18	11.71425151	122.3839294	0.488999993	0.5	0.000	Frank	100-Year
19	11.66733514	122.4011443	0.331	0	0.110		
20	11.66243698	122.3996322	0.029999999	0	0.001		
22	11.64377382	122.380309	0.333000004	0	0.111		
25	11.71816394	122.3573602	0.246000007	2.9	7.044	Frank	100-Year
27	11.67270049	122.3849771	0.029999999	0.254	0.050	Yolanda	5-Year
28	11.70831313	122.3632159	0.193000004	0.4	0.043	Yolanda	5-Year
29	11.71525063	122.3872623	0.046999998	2.2	4.635	Frank	100-Year
31	11.69753804	122.3192858	0.029999999	0	0.001	Yolanda	5-Year
32	11.65264813	122.3704763	0.924000025	0.4826	0.195	Frank	100-Year
33	11.64531658	122.3840751	0.112999998	0	0.013		
34	11.73488561	122.3258477	0.421000004	0.83	0.167	Yolanda	5-Year
35	11.64405675	122.3982588	0.029999999	0	0.001		
36	11.66184604	122.398523	0.181999996	0	0.033		
39	11.68058825	122.3299737	0.030999999	0.55	0.269	Frank	100-Year
40	11.71831959	122.3855382	0.029999999	0.5	0.221	Frank	100-Year
41	11.70991487	122.3629758	0.555000007	0.7	0.021	Frank	100-Year
42	11.72450787	122.347391	0.644999981	1.04	0.156	Frank	100-Year
43	11.71010237	122.372815	0.620999992	1.6	0.958	Frank	100-Year
44	11.70125672	122.3330217	1.041000009	1.01	0.001	Frank	100-Year
45	11.72608192	122.3349412	0.499000013	0.54	0.002	Frank	100-Year
47	11.7022515	122.3816426	0.564999998	0.3	0.070	Frank	100-Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/ Date	Rain Return / Scenario
	Lat	Long					
48	11.71634715	122.375548	0.029999999	2.9	8.237	Frank	100-Year
49	11.70924367	122.3671395	1.077000022	0.2	0.769	Frank	100-Year
50	11.69617838	122.3700988	0.546000004	1	0.206	Frank	100-Year
51	11.70642762	122.3711126	0.837000012	1.28	0.196	Frank	100-Year
52	11.68735022	122.3847262	0.382999986	0.1778	0.042	Yolanda	5-Year
55	11.71496266	122.3502307	0.632000029	1.9	1.608	Frank	100-Year
56	11.72124548	122.3597382	0.272000015	0	0.074	Marce	5-Year
57	11.70927113	122.3384952	0.289000005	1.21	0.848	Frank	100-Year
58	11.70278797	122.3779225	0.307000011	1.1	0.629	Frank	100-Year
59	11.70474228	122.3735572	0.312999994	0.9	0.345	Frank	100-Year
60	11.73448904	122.3281332	0.029999999	0	0.001	Yolanda	5-Year
61	11.69270294	122.3689132	0.474999994	0.65	0.031	Yolanda	5-Year
62	11.71553886	122.382098	0.187000006	1.9	2.934	Frank	100-Year
64	11.7038915	122.3281459	0.633000016	0	0.401	Yolanda	5-Year
65	11.70717474	122.3696711	0.957000017	1.4	0.196	Frank	100-Year
66	11.70965238	122.3647856	0.460000008	0	0.212	Frank	100-Year
67	11.70742878	122.3884561	0.229000002	1	0.594	Frank	100-Year
68	11.66808092	122.4098905	0.093999997	0	0.009		
69	11.72110056	122.3348395	0.414000005	1.44	1.053	Frank	100-Year
72	11.70796587	122.3272017	0.54400003	0.52	0.001	Frank	100-Year
74	11.72294994	122.3810331	0.248999998	1.1	0.724	Frank	100-Year
75	11.69791844	122.3850154	0.887000024	0.5	0.150	Frank	100-Year
76	11.64444737	122.3775811	0.324999988	0.4826	0.025	Undang	5-Year
77	11.69590164	122.3182566	0.150000006	0.73	0.336	Yolanda	5-Year
78	11.65235529	122.3807823	0.711000025	0.3048	0.165	Frank	100-Year
79	11.70444962	122.3929046	0.086000003	0.3	0.046	Yolanda	5-Year
80	11.67704374	122.4098115	0.958999991	7	36.494	Frank	100-Year
81	11.7177407	122.358102	0.792999983	2.9	4.439	Frank	100-Year
82	11.71818049	122.3727991	0	1.6	2.560	Yolanda	5-Year
83	11.67798871	122.4073004	1.133999944	0.7112	0.179	Frank	100-Year
84	11.71780239	122.3526344	0.958999991	1.59	0.398	Quinta	5-Year
85	11.68289683	122.3637077	1.236999989	0.4	0.701	Frank	100-Year
87	11.68133169	122.363008	0.938000023	1	0.004	Frank	100-Year
88	11.68498366	122.3616673	1.513000011	1.2	0.098	Frank	100-Year
89	11.71885848	122.3548353	1.014000058	2.01	0.992	Frank	100-Year
90	11.70171388	122.3734329	1.712000012	2.19	0.228	Frank	100-Year
91	11.70778755	122.3736814	0.677999973	1.512	0.696	Frank	100-Year
92	11.72091541	122.3583877	0.331	0	0.110	Marce	5-Year
93	11.71871641	122.3477637	1.212000012	2.33	1.250	Frank	100-Year
94	11.70311555	122.3723166	0.592000008	1.26	0.446	Frank	100-Year
95	11.70926989	122.3460731	0.787999988	3.25	6.061	Frank	100-Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/ Date	Rain Return / Scenario
	Lat	Long					
96	11.69613314	122.3666725	0.783999979	2.1	1.732	Frank	100-Year
97	11.73003126	122.3567297	0.966000021	1.86	0.799	Frank	100-Year
98	11.6728981	122.3619963	0.962000012	0.3048	0.432	Frank	100-Year
99	11.68752574	122.3675929	0.514999986	1	0.235	Yolanda	5-Year
101	11.70312371	122.3699608	0.428000003	0	0.183		
102	11.70660288	122.3329935	0.991999984	1.17	0.032	Frank	100-Year
105	11.68726367	122.3833979	0.912999988	0.3048	0.370	Frank	100-Year
106	11.71885497	122.3342177	0.953000009	2.1336	1.394	Frank	100-Year
107	11.71917484	122.3599618	0.624000013	0	0.389	Marce	5-Year
108	11.70654103	122.3439892	0.805999994	0	0.650	Yolanda	5-Year
109	11.67827903	122.3625929	1.220000029	0.37	0.723	Frank	100-Year
110	11.72410027	122.379714	1.585000038	1	0.342	Frank	100-Year
112	11.67337199	122.3817425	0.203999996	0	0.042		
113	11.66228062	122.4154283	0.330000013	0	0.109		
115	11.69183474	122.3751162	1.008000016	1.0668	0.003	Frank	100-Year
116	11.71859872	122.3694414	0.876999974	0.4	0.228	Nina	5-Year
121	11.6681263	122.4021277	0.029999999	0	0.001		
122	11.69765243	122.3660623	1.396999955	1.7	0.092	Frank	100-Year
123	11.72664798	122.3528729	0.879000008	0.6096	0.073	Quinta	5-Year
124	11.66640487	122.3765576	0.75	0	0.563		
125	11.70108349	122.3673355	1.00999999	1.4	0.152	Frank	100-Year
126	11.68351708	122.3633191	1.041000009	0.6	0.194	Frank	100-Year
127	11.66947517	122.3797611	1.695000052	0.4572	1.532	Frank	100-Year
128	11.72249223	122.3502184	1.532999992	2.72	1.409	Frank	100-Year
129	11.71600006	122.3503838	1.366999984	1.9	0.284	Frank	100-Year
130	11.7101072	122.3794297	0.816999972	1.1	0.080	Frank	100-Year
131	11.71718944	122.3563351	0.632000029	2.49	3.452	Frank	100-Year
132	11.6982422	122.3664033	1.476999998	1.8	0.104	Frank	100-Year
133	11.70424161	122.3656773	1.050999999	1.8	0.561	Frank	100-Year
134	11.71670369	122.3428853	1.220999956	1.78	0.312	Frank	100-Year
135	11.72546392	122.3524355	1.32099998	0.6096	0.506	Quinta	5-Year
136	11.69196264	122.3649481	2.177999973	3.5	1.748	Frank	100-Year
137	11.71254497	122.3480141	1.090999961	1.8	0.503	Frank	100-Year
138	11.70456207	122.3345426	1.850999951	2.46	0.371	Frank	100-Year
139	11.67146751	122.3485269	1.621000051	1.2446	0.142	Frank	100-Year
140	11.69026937	122.3614854	1.333999991	0.8	0.285	Yolanda	5-Year
143	11.66976607	122.3800915	1.508000016	0.6096	0.807	Frank	100-Year
144	11.71446862	122.3650029	0.745000005	2.2	2.117	Frank	100-Year
145	11.71868026	122.3453117	1.541000009	2.34	0.638	Frank	100-Year
146	11.72811048	122.3529618	0.558000028	1.88	1.748	Quinta	5-Year
147	11.68844711	122.3364364	1.187000036	2.47	1.646	Frank	100-Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/ Date	Rain Return / Scenario
	Lat	Long					
148	11.71739071	122.3530413	0.72299999	1.59	0.752	Quinta	5-Year
149	11.68437206	122.3394573	1.751000047	1.93	0.032	Frank	100-Year
151	11.68177063	122.3654184	0.875	0.85	0.001	Frank	100-Year
152	11.67271191	122.3541494	0.799000025	0	0.638		
156	11.67302458	122.3972902	0.850000024	1.0414	0.037	Yolanda	5-Year
158	11.73154818	122.357996	1.735000014	1.86	0.016	Frank	100-Year
159	11.65760563	122.3629941	0.967000008	0.3048	0.439	Undang	5-Year
160	11.66082294	122.3817434	3.865999937	0.4064	11.969		
161	11.70249138	122.3340557	2.311000109	3.048	0.543	Frank	100-Year
162	11.68694557	122.3594585	2.558000088	1.9	0.433	Frank	100-Year
163	11.71610959	122.3452796	2.822000027	0.88	3.771	Frank	100-Year
164	11.70409476	122.3357832	2.811000109	2.46	0.123	Frank	100-Year
165	11.68314029	122.3590825	2.736999989	2.4	0.114	Frank	100-Year
166	11.69037607	122.3638503	2.210999966	1.8	0.169	Frank	100-Year
167	11.68328245	122.35964	3.315999985	2.2	1.245	Frank	100-Year
168	11.69250347	122.3632556	2.426000118	2.3	0.016	Frank	100-Year
169	11.7190419	122.3492643	2.08100009	2.39	0.095	Frank	100-Year
170	11.70711703	122.3317404	1.046000004	0.4	0.417	Frank	100-Year
171	11.68628444	122.3591644	2.911999941	1.8	1.237	Frank	100-Year
172	11.72156194	122.3316802	1.815000057	1.45	0.133	Frank	100-Year
173	11.66118259	122.3837065	3.226999998	0	10.414		
174	11.70205312	122.3343695	3.562000036	3.048	0.264	Frank	100-Year
177	11.72511024	122.3514567	1.736999989	0.6096	1.271	Quinta	5-Year
179	11.71593158	122.344933	2.940000057	2.4	0.292	Frank	100-Year
180	11.71516459	122.3446275	2.322000027	2.4	0.006	Frank	100-Year
181	11.68352397	122.3610133	1.388000011	3.05	2.762	Frank	100-Year
182	11.68398543	122.3606814	2.651000023	3	0.122	Frank	100-Year
183	11.68316008	122.3601194	3.094000101	2.1	0.988	Frank	100-Year
184	11.71866269	122.3505037	1.578999996	0.25	1.766	Marce	5-Year
185	11.71738283	122.3583184	1.855999947	2.9	1.090	Frank	100-Year
186	11.7097618	122.3376869	2.404000044	1.01	1.943	Frank	100-Year
189	11.68928141	122.3597797	2.957000017	2.5	0.209	Frank	100-Year
191	11.72696843	122.3431167	2.377000093	1.8288	0.301	Frank	100-Year

Annex 12. Educational Institutions Affected in Aklan Floodplain

Table A-12.1. Educational Institutions in Kalibo, Aklan Affected by Flooding in the Aklan Floodplain

AKLAN				
KALIBO				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Andagaw	Aklan Catholic College	Medium	Medium	Medium
Andagaw	Aklan Inter Faith Academy	Low	Medium	Medium
Andagaw	Aklan Learning Center	Medium	Medium	Medium
Andagaw	Aklan National High School For Arts and Trades	Low	Medium	Medium
Andagaw	Aklan Polytechnic College	Medium	Medium	Medium
Andagaw	Aklan State University College of Industrial Technology	Low	Medium	Medium
Andagaw	Andagaw Elementary School	Low	Low	Medium
Andagaw	Day Care Center	Medium	Medium	Medium
Andagaw	Infant Jesus Academy	Low	Low	Medium
Andagaw	Marian High Kalibo Foundation Inc.	Low	Medium	Medium
Andagaw	Quix! Mart	Medium	Medium	Medium
Andagaw	RRM Technical Institute, Inc.		Low	Low
Andagaw	St. Anne Montessori School Kalibo, Aklan. Inc.	Medium	Medium	Medium
Andagaw	Villa Salvacin Child Development Center I.II	Low	Medium	Medium
Andagaw	Wadeford School		Low	Low
Bachaw Norte	Bachaw Norte Elementary School	Medium	Medium	Medium
Bachaw Norte	Pigado Day Care Center	Medium	Medium	Medium
Bachaw Sur	Bachaw Sur Day Care Center	Medium	Medium	Medium
Bachaw Sur	New Day Care Center	Low	Low	Medium
Bachaw Sur	StarGlow Private School			
Briones	Briones Elementary School			
Buswang New	Aklan Catholic College	Medium	Medium	Medium
Buswang New	Care Kids Learning PlayHouse			
Buswang New	New Buswang Elementary School	Low	Low	Low
Buswang Old	Old Buswang Bachao Sur Elementary School	Medium	Medium	Medium
Buswang Old	Old Buswang Day Care Center			
Buswang Old	Regional Science High School	Low	Low	Medium
Buswang Old	Saint Gabriel College			
Caano	Caano Day Care Center	Low	Medium	Medium
Caano	Caano Elementary School		Medium	Medium
Estancia	Aklan Polytechnic College	Medium	Medium	Medium
Estancia	Brilliant Sucerity Training Academy	Medium	Medium	Medium
Estancia	Central Panal College of Science and Technology Inc	Medium	Medium	Medium
Estancia	Estancia Elementary School	Medium	Medium	Medium
Estancia	Garcia College of Technology	Medium	Medium	Medium
Estancia	Garcia College of Technology - Annex Building	Medium	Medium	Medium

AKLAN				
KALIBO				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Estancia	Garcia College of Technology Inc	Medium	Medium	Medium
Estancia	Infant Jesus Academy	Low	Medium	Medium
Estancia	Infant Jesus School	Medium	Medium	Medium
Estancia	Maranata Christian Academy	Low	Low	Medium
Estancia	North Western Visayan College	Medium	Medium	Medium
Estancia	North Western Visayan College - College of Criminal Justice Education	Medium	Medium	Medium
Estancia	North Western Visayas College		Low	Low
Estancia	Quix! Mart	Medium	Medium	Medium
Estancia	St. Dominic School of Kalibo	Medium	Medium	Medium
Estancia	STI College - Kalibo		Low	Low
Linabuan Norte	Barangay Linabuan Norte Day Care Center	Medium	High	High
Linabuan Norte	Linabuan Norte Elementary School - Linabuan National High School	Medium	High	High
Mabilo	General F. Castiilo Memorial School	Medium	Medium	High
Mabilo	Mabilo Day Care Center	Low	Medium	Medium
Mobo	Barangay Mobo Day Care Center	Medium	Medium	Medium
Mobo	Mobo Elementary School	Medium	Medium	Medium
Mobo	St. Gabriel College	Low	Medium	Medium
Mobo	St. Gabriel English School	Medium	Medium	Medium
Nalook	Nalook Elementary School	Low	Medium	Medium
Poblacion	After-School Tutorial Services	Medium	Medium	Medium
Poblacion	Aklan Catholic College	Low	Low	Low
Poblacion	Bliss Day Care Center	Medium	Medium	Medium
Poblacion	Day Care Center Oyo Torong	Medium	Medium	Medium
Poblacion	Dela Cruz Institute of Business & Industry	Medium	Medium	Medium
Poblacion	Kalibo Elementary School	Medium	Medium	High
Poblacion	Kalibo Institute	Medium	Medium	Medium
Poblacion	Kalibo Integrated Special Education Center	Medium	Medium	Medium
Poblacion	Kalibo Pilot Elementary School	Medium	Medium	Medium
Poblacion	Kalibo SunYatsen School	Medium	Medium	Medium
Poblacion	Office of the District Supervisor	Medium	Medium	Medium
Poblacion	Panay Teechnological Collage	Medium	Medium	Medium
Poblacion	Rebesencio Bldg. II (Kidzcare Children's Learning Center, Otto)	Low	Low	Low
Poblacion	The Holy Nursery and Kindergarten School	Medium	Medium	Medium
Pook	Pook Day Care center	Low	Low	Low
Pook	Pook Elementary School	Low	Medium	Medium
Pook	Verde Grande Culinary School	Medium	Medium	Medium
Tigayon	Barangay Tigayon Day Care Center	Medium	Medium	Medium
Tigayon	Mother Nature School	Medium	Medium	Medium

AKLAN				
KALIBO				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Tigayon	TESDA Security School	Medium	Medium	Medium
Tigayon	Tigayon Elementary School	Medium	Medium	Medium
Tinigaw	Estancia Elementary School	Medium	Medium	Medium
Tinigaw	Tinigaw Elementary School	Medium	High	High

Table A-12.2. Educational Institutions in Lezo, Aklan Affected by Flooding in the Aklan Floodplain

AKLAN				
LEZO				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Bugasongan Barangay Hall	Bugasongan		Low	Low
Bugasongan Elementary School	Bugasongan		Medium	Medium
Barangay Poblacion Day Care Center	Poblacion	Medium	High	High
Lezo Integrated School	Poblacion	Low	Medium	Medium
Lezo Technical College	Poblacion	Medium	High	High

Table A-12.3. Educational Institutions in New Washington, Aklan Affected by Flooding in the Aklan Floodplain

AKLAN				
NEW WASHINGTON				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Barangay Mabilo Day Care Center	Mabilo	Low	Low	Low
Mabilo Elementary School	Mabilo	Low	Low	Medium
Prudence Learning Center	Mabilo	Medium	Medium	Medium
Puis Elementary School	Puis	Medium	Medium	Medium
Aklan Polytechnic College Maritime Training Center	Tambak	Medium	Medium	Medium

Table A-12.4. Educational Institutions in Numancia, Aklan Affected by Flooding in the Aklan Floodplain

AKLAN				
NUMANCIA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Albasan Elementary School	Albasan	Medium	Medium	Medium
Numancia National School of Fisheries	Albasan	High	High	High
Aliputos Elementary School	Aliputos	Medium	Medium	Medium
Badio Elementary School	Badio	Low	Medium	Medium
Barangay Badio Day Care Center	Badio		Low	Low

AKLAN				
NUMANCIA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Bubog Elementary School	Bubog	Medium	Medium	Medium
Bubog Elementary School Stage	Bubog	Medium	High	High
Bulwang Elementary School	Bulwang	Medium	Medium	Medium
Camanci Norte Barangay Day Care Center	Camanci Norte	Medium	Medium	Medium
Camanci Norte Elementary School	Camanci Norte	Medium	Medium	Medium
Payben's Resort	Camanci Norte	Medium	Medium	Medium
Camanci Sur Barangay Day Care Center	Camanci Sur	Low	Medium	Medium
Camanci Sur Elementary School	Camanci Sur	Low	Medium	Medium
Irao Institute	Camanci Sur	Medium	Medium	Medium
Laguinbanua East Day Care Center	Laguinbanua East	Low	Medium	Medium
Laguinbanua Elementary School	Laguinbanua East	Medium	Medium	Medium
Adolphus International Technical Institute Driving School	Laguinbanua West	High	High	High
Carillo Culinary Arts and Skills Development Center INC.	Laguinbanua West	Low	Low	Low
Laguinbanua West Day Care Center	Laguinbanua West	Low	Medium	Medium
Navitas Barangay Day Care Center	Navitas			
Navitas Elementary School	Navitas			
MADYAAS Institute	Poblacion			
Numancia Integrated School	Poblacion	Medium	Medium	Medium
Poblacion Day Care	Poblacion	Medium	High	High
St. Joseph Formation Center	Poblacion	Low	Low	Low
St. Joseph parochial Learning Center	Poblacion	Low	Medium	Medium
Sto. Nino Seminary	Poblacion	Low	Low	Low

Annex 13. Health Institutions Affected in Aklan Floodplain

Table A-13.1. Health Institutions in Banga, Aklan Affected by Flooding in the Aklan Floodplain

AKLAN				
BANGA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Veterinary Hospital	Linabuan Sur	High	High	High

Table A-13.2. Health Institutions in Kalibo, Aklan Affected by Flooding in the Aklan Floodplain

AKLAN				
KALIBO				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Aklan Animal Rescue and Rehabilitaion Center	Andagaw			Low
Aklan Cooperative Mission Hospital	Andagaw		Low	Low
Rebadulla Animal Clinic	Andagaw	Medium	Medium	Medium
Caano Barangay Health Center	Caano		Low	Medium
Ismael Medical Clinic	Estancia	Low	Medium	Medium
Panay Health Care	Estancia			
Rebadulla Animal Clinic	Estancia	Medium	Medium	Medium
Barangay Mobo Hleath Center	Mobo	Medium	Medium	Medium
Salazar Medical X-Ray and Ultrasound Clinic	Mobo	Medium	Medium	Medium
St. Jude Hospital	Mobo			Low
Nalook Health Center	Nalook		Low	Medium
Bautista Nutrition Center	Poblacion	Low	Medium	Medium
Children's Clinic , Tambong Medical Clinic, Ibarreta Jayme Pediatrician	Poblacion			
Kalibo Rural Health Center	Poblacion		Low	Low
Ma. Eden C. Sealog, M.D. General Physicians	Poblacion	Medium	Medium	High
Municipal Health Office	Poblacion		Low	Low
Reyes-EQuina Ortho-Dental Care Clinic	Poblacion	Medium	Medium	Medium
Saint Martha's Walk-In Medical Clinic	Poblacion	Low	Medium	Medium
Saratiosa Bldg. (Medicus Diagnostic Center)	Poblacion	Medium	Medium	Medium
St. Gabriel Medical Center	Poblacion	Low	Medium	Medium
Tayco Medical Clinic & Drugstore	Poblacion	Low	Low	Medium
Tirazona-Gomez Dental Clinic	Poblacion	Medium	Medium	Medium
Torres-Oliva Bldg. (Medway Polyclinic)	Poblacion	Low	Medium	Medium
UGC Clinics & Laboratories	Poblacion	Medium	Medium	Medium
Barangay Tigayon Health Center	Tigayon	Low	Medium	Medium

Table A-13.3. Health Institutions in Lezo, Aklan Affected by Flooding in the Aklan Floodplain

AKLAN				
LEZO				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Barangay Ibao Health Center	Ibao	Medium	Medium	Medium
Lezo Birthing Facility	Poblacion	Low	Medium	High
Lezo Municipal Health Office	Poblacion	Medium	Medium	High

Table A-13.4. Health Institutions in New Washington, Aklan Affected by Flooding in the Aklan Floodplain

AKLAN				
NEW WASHINGTON				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Barangay Outpost, Health Center	Puis	Low	Medium	Medium

Table A-13.5. Health Institutions in Numancia, Aklan Affected by Flooding in the Aklan Floodplain

AKLAN				
NUMANCIA				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Barangay Bubog Health Center	Bubog	Medium	Medium	Medium
Bulwang Healh Center	Bulwang	Low	Low	Medium
Camanci Sur Barangay Health Center	Camanci Sur	Medium	Medium	Medium
Nutrition & Health Center	Laguinbanua East	Medium	Medium	Medium
Nutrition Center	Laguinbanua West	Medium	Medium	Medium
Navitas Barangay Health Center	Navitas			
Municipal Nutrition Center	Poblacion	Medium	Medium	Medium
Poblacin Health Center	Poblacion	Low	Medium	Medium

Annex 14. UPC Phil-LiDAR 1 Team Composition

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