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

LiDAR Surveys and Flood Mapping of Hinatuan River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
Caraga State University

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Asian Aerospace Corporation
Ab	abutment
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
AWLS	Automated Water Level Sensor
BA	Bridge Approach
BM	benchmark
CAD	Computer-Aided Design
CN	Curve Number
CSRS	Chief Science Research Specialist
CSU	Caraga State University
DA	Department of Agriculture
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
NAM-RIA	National Mapping and Resource Information Authority
NSO	National Statistics Office
NSTC	Northern Subtropical Convergence
PAF	Philippine Air Force
PAGA-SA	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
RBCO	River Basin Control Office
RIDF	Rainfall-Intensity-Duration-Frequency
RMSE	Root Mean Square Error
SAR	Synthetic Aperture Radar
SCS	Soil Conservation Service
SRTM	Shuttle Radar Topography Mission
SRS	Science Research Specialist
SSG	Special Service Group
TBC	Thermal Barrier Coatings
UP-TCAGP	University of the Philippines – Training Center for Applied Geodesy and Photogrammetry
UTM	Universal Transverse Mercator
WGS	World Geodetic System

CHAPTER 1: OVERVIEW OF THE PROGRAM AND HINATUAN RIVER

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Arthur A. Amora

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

Also, the program was aimed at producing an up-to-date and detailed national elevation dataset suitable for 1:5,000 scale mapping, with 50 cm and 20 cm horizontal and vertical accuracies, respectively. These accuracies were achieved through the use of the state-of-the-art Light Detection and Ranging (LiDAR) airborne technology procured by the project through DOST. The methods applied in this report are thoroughly described in a separate publication entitled "Flood Mapping of Rivers in the Philippines Using Airborne LiDAR: Methods" (Paringit, et. al., 2017), available separately.

The implementing partner university for the Phil-LiDAR 1 Program is the Caraga State University (CSU). CSU 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 twelve (12) river basins in the Caraga Region. The university is located in Butuan City in the province of Agusan del Norte.

1.2 Overview of the Hinatuan River Basin

The Hinatuan River Basin covers the Municipalities of Hinatuan and Tagbina in the province of Surigao del Sur, and the Municipality of Rosario in the province of Agusan del Sur. The Department of Environment and Natural Resources (DENR) River Basin Control Office (RBCO) identified the basin to have a drainage area of 344 km^2 and an estimated 688 million cubic meter (MCM) annual run-off (RBCO, 2015).

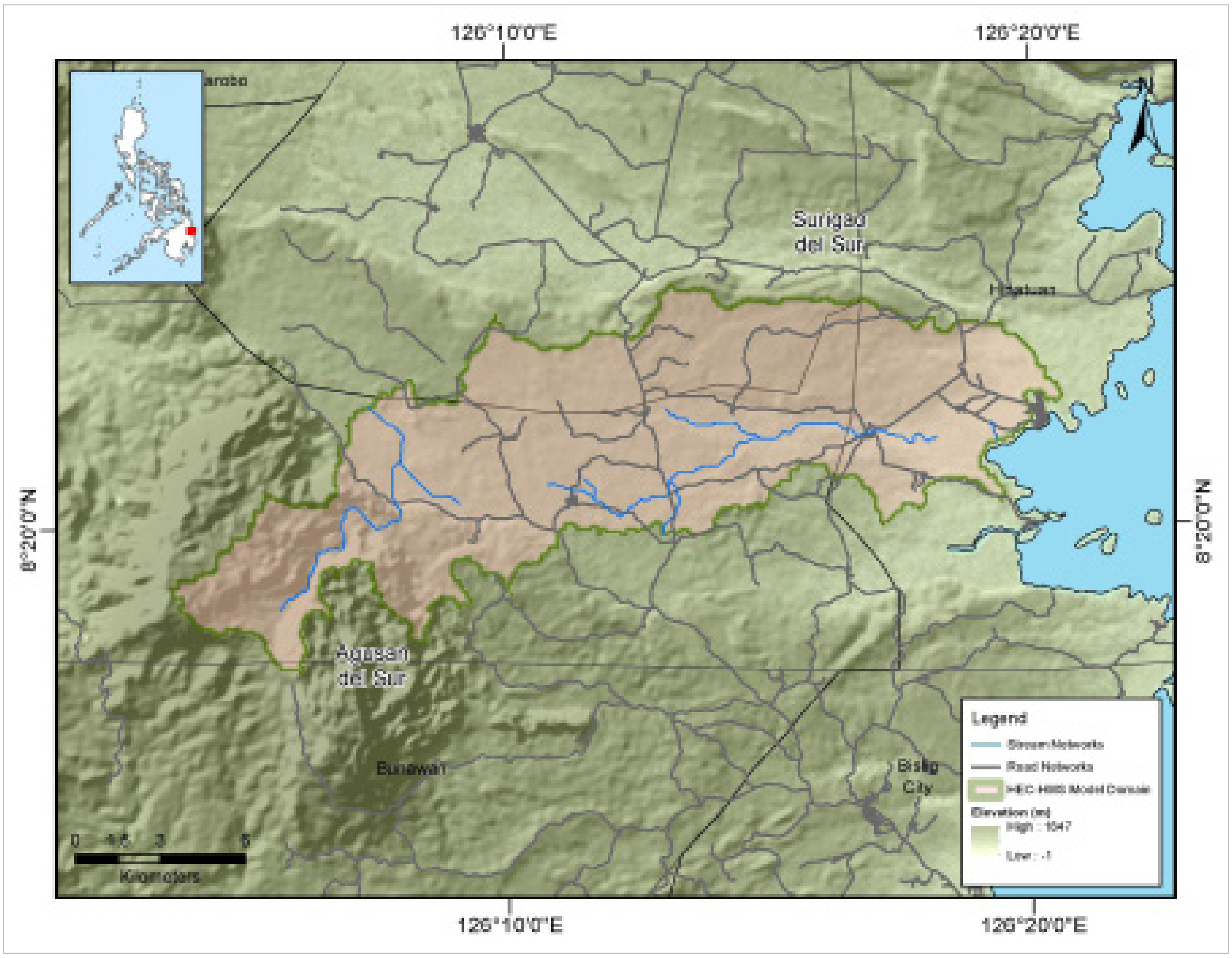

Figure 1. Location map of the Hinatuan River Basin (in brown)

The Hinatuan River Basin is located in the eastern portion of the Island of Mindanao, Philippines. It lies generally at 126002' to 126018' east longitude and 8023' to 8033' north latitude. It includes a major part of the Municipalities of Tagbina, Hinatuan and Barobo and small area of Lianga in Surigao del Sur, and of the Municipalities of San Francisco and Rosario in Agusan del Sur. The basin covers an area of approximately 417 square kilometers, and is about 25 kilometers long from north to south and averages about 33 kilometers in width from east to west.

The Hinatuan River is the principal drainageway of the basin and is divided into two outlets in which the junction of the two outlets is located at the boundary of Barangay Bitoon, Barangay Tiwi and Barangay Dugmanon in the Municipality of Hinatuan, Surigao del Sur and approximately 1.2 kilometers southeast of Dugmanon Bridge. From the junction, the first drainageway drains through Barangay Tiwi and the second drainageway pass through the municipal proper of Hinatuan, Surigao del Sur. It has one tributary river which can be traced at Barangay Bitoon, Hinatuan, Surigao del Sur, located at the southeast portion of the basin, and meets the Hinatuan River at a junction between the boundary of Barangay Bitoon and Barangay Tiwi, Hinatuan, Surigao del Sur and approximately 2 kilometers southeast of Dugmanon bridge. From this junction, Hinatuan River flows towards Hinatuan Bay at a distance of approximately 3.5 kilometers. At this portion, the river channel is wide and is navigable by motor boats.

tThe basin's highest point is at 452 meters above mean sea level situated along the mountain ridges of Barangay Tambis, Municipality of Barobo, Surigao del Sur . The most abundant soil type in the basin based on maps published by the Department of Agriculture is clay loam which accounts for 97% of the basin's

The climate of the basin is Type II which is characterized by no dry season but with a very pronounced precipitation period generally during November to January. The seasonal precipitation distribution, which is similar to that of the nearby Agusan River Basin, is caused primarily by the three main seasonal winds that pass through it. The northeast monsoon passes during the period from October to January, the trade wind with an east to southeast direction from February to April, and the southwest monsoon for the rest of the year .

CHAPTER 2: LIDAR DATA ACQUISITION OF THE HINATUAN 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

To initiate the LiDAR acquisition survey of the Hinatuan Floodplain, the Data Acquisition Component (DAC) created flight plans within the delineated priority area for the Hinatuan floodplain in Surigao del Sur. These missions were planned for fourteen (14) lines, and ran for at most four and a half (4.5) hours including take-off, landing and turning time. The Aquarius LiDAR system was used for the survey (See ANNEX 1 for the sensor specifications). The flight planning parameters for the LiDAR system are found in . shows the flight plan for the Hinatuan floodplain survey.

Table 1. Flight planning parameters for Aquarius LiDAR system

Block Name	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (KHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK65H	600	40	36	50	45	120	5
BLK66E	500,600	30	36	50	45	120	5
BLK66G	500,600	30	36	50	45	120	5
BLK66K	500	45	40	50	40	120	5
BLK66L	600	40,45	36	50	45	120	5
BLK66M	600	40	36	50	45	120	5
BLK66N	600	40	36	50	45	120	5
BLK66O	600	40	36	50	45	120	5
BLK66P	600	40	36	50	45	120	5
BLK66Q	600	40	36	50	45	120	5
BLK66R	500,600	40	36	50	45	120	5
BLK66S	600	40	36	50	45	120	5
BLK66T	600	40,45	36	50	45	120	5

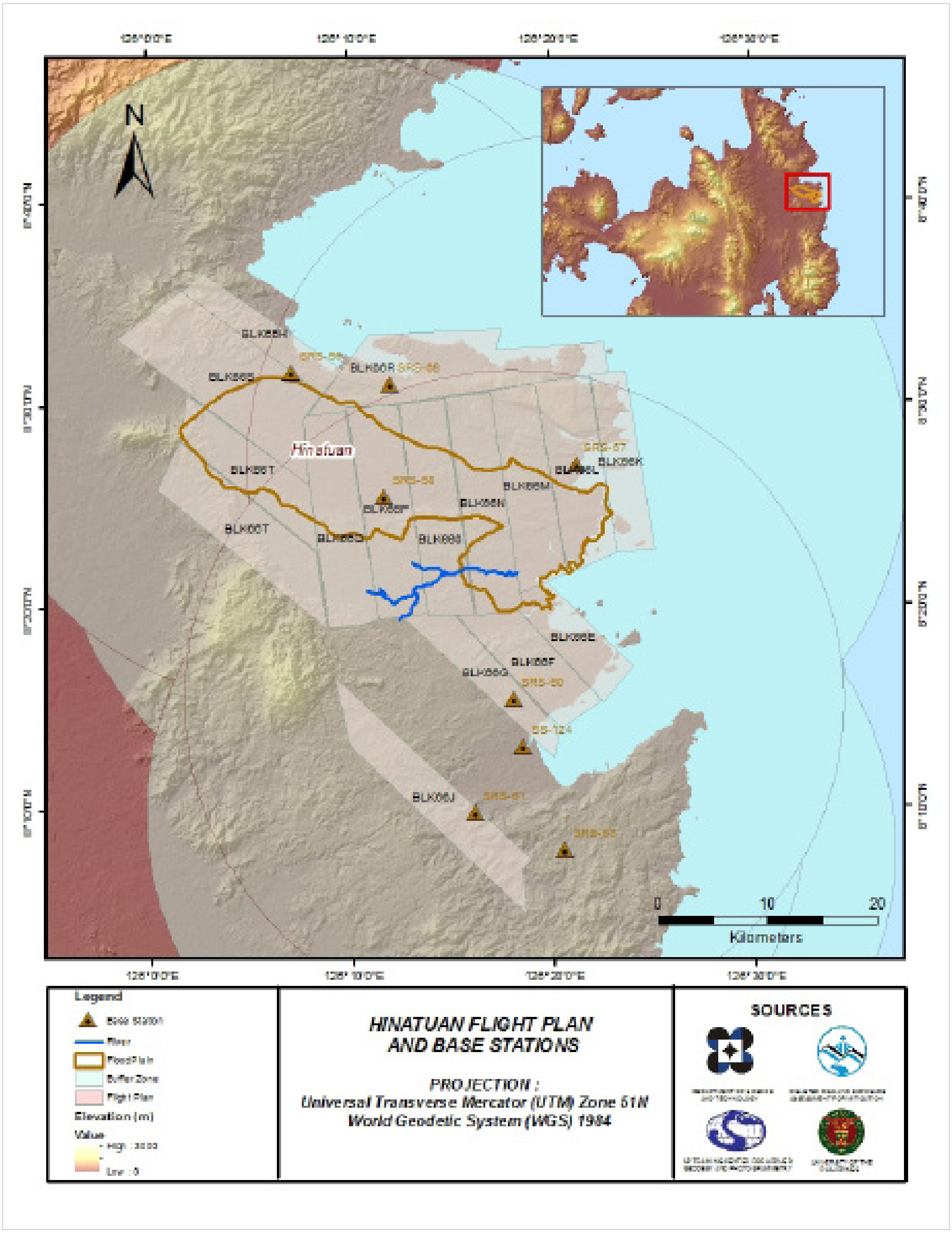

Figure 2. Flight plans and base stations used to cover the Hinatuan floodplain survey.

2.2 Ground Base Stations

The field team for this undertaking was able to recover eight (8) NAMRIA horizontal ground control points: SRS-53, SRS-56, SRS-57, SRS-58, SRS-60, SRS-61, SRS-63, and SRS-68, which are all of second (2nd) order accuracy. Two (2) NAMRIA benchmarks were recovered: SS-124 and SS-201, which are both of first (1st) order accuracy. These benchmarks were used as vertical reference points, and were also established as ground control points. The certifications for the NAMRIA reference points and benchmarks are found in ANNEX 2, while the baseline processing reports for the established control points are presented in ANNEX 3. These were used as base stations during flight operations for the entire duration of the survey, held on July 4-August 1, 2014 and August 3-September 5, 2014. The Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852 and SPS 985. Flight plans and location of base stations used during the aerial LiDAR acquisition in Hinatuan floodplain are shown in Figure 2. The composition of the project team is found in ANNEX 4.

Figure 3 to Figure 12 exhibit the recovered NAMRIA reference points within the area. Table 2 to Table 11 indicate the details about the following NAMRIA control stations and established points, while Table 12 lists all ground control points occupied during the acquisition with the corresponding dates of utilization.

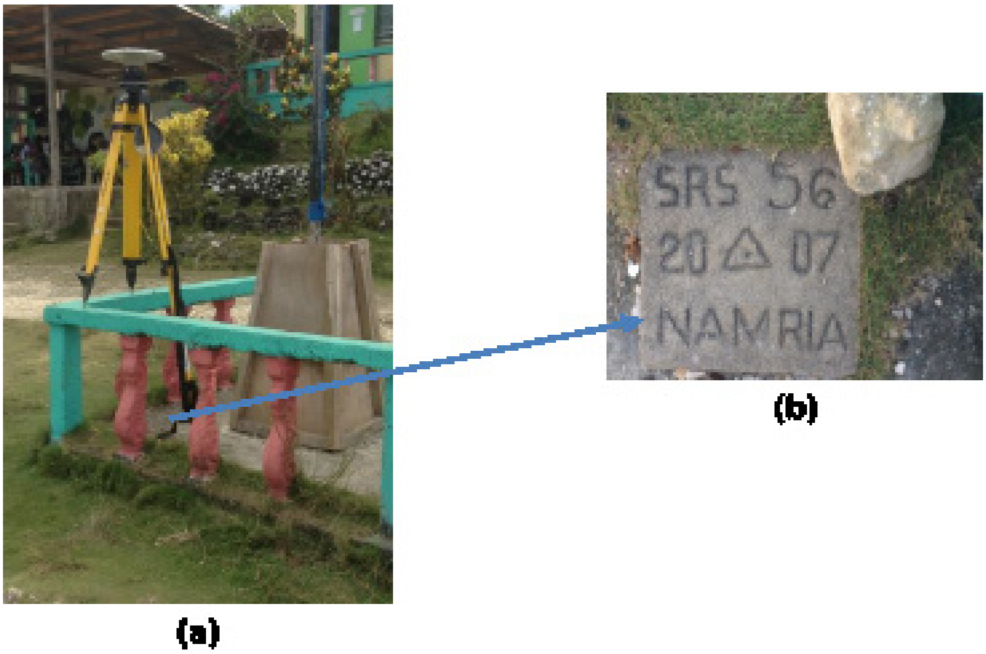

Figure 3. GPS set-up over SRS-56 recovered on the east side of the ground corner of the flagpole of Barobo Town Site Elementary School in Barangay Poblacion, Barobo, Surigao Del Sur (a) and NAMRIA reference point SRS-56 (b) as recovered by the field team.

Table 2. Details of the recovered NAMRIA horizontal control point SRS-56 used as base station for the LiDAR acquisition.

Station Name	**SRS-56**	
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	8° 31’ 39.52861” North 126° 7’ 4.08061” East 36.22400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	623069.127 meters 943079.391 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8° 31’ 36.06400” North 126° 7’ 9.46645” East 107.36300 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	182673.15 meters 943755.61 meters

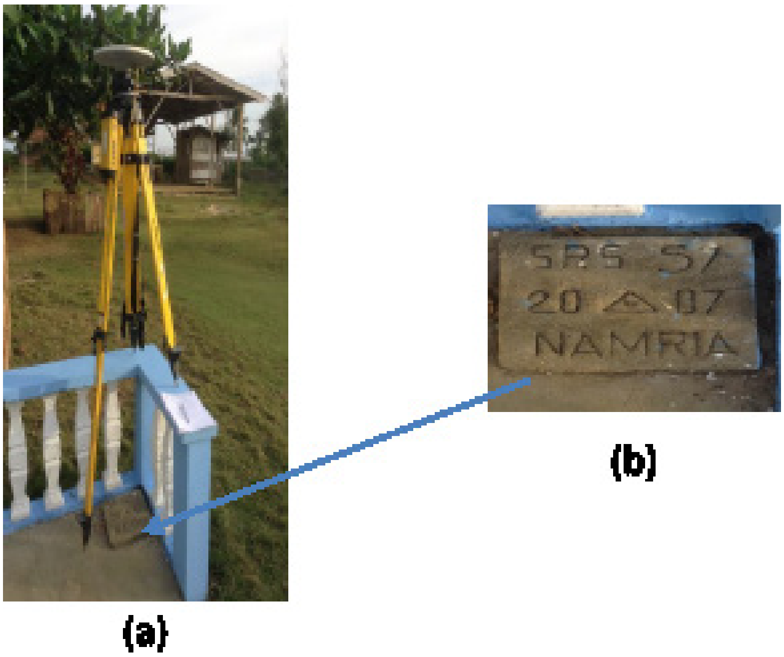

Figure 4. GPS set-up over SRS-57 located on the concrete ground corner of the flagpole of Talisay Elementary School in Brgy. Talisay , Hinatuan (a) and NAMRIA reference point SRS-57 (b) as recovered by the field team.

Table 3. Details of the recovered NAMRIA horizontal control point SRS-57 used as base station for the LiDAR acquisition.

Station Name	**SRS-57**	
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	8° 27’ 1.69252” North 126° 21’ 8.66908” East 26.14400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	648933.286 meters 934625.002 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8° 26’ 58.26936” North 126° 21’ 14.05931” East 98.02200 meters

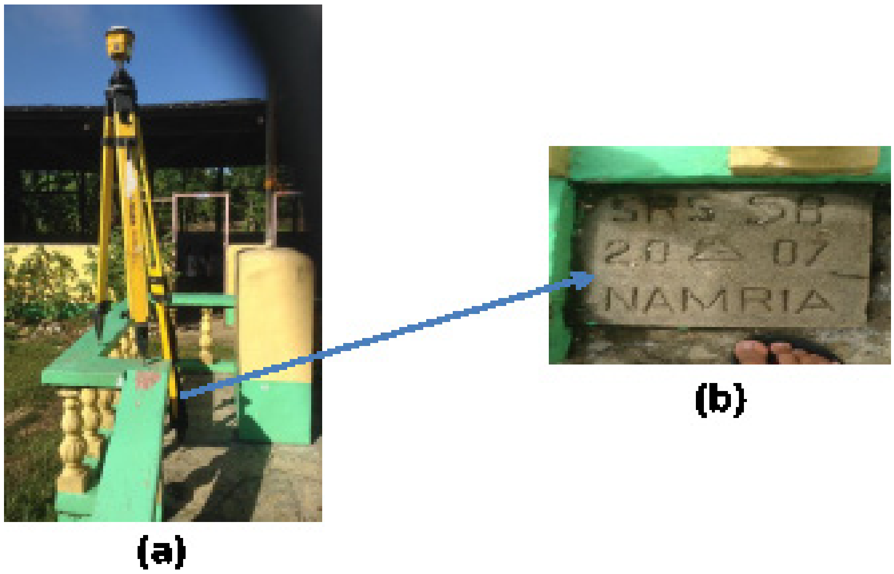

Figure 5. GPS set-up over SRS-58 recovered on the concrete ground of the flagpole of Maglambing Elementary School in Brgy. Maglambing, Tagbina, Surigao Del Sur (a) and NAMRIA reference point SRS-58 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point SRS-58 used as base station for the LiDAR acquisition.

Station Name	**SRS-58**	
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	8° 25' 30.89446" North 126° 11' 37.55708" East 10.93400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	631468.821 meters 931778.214 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8° 25' 27.46381" North 126° 11' 42.95134" East 82.47300 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	190961.53 meters 932360.98 meters

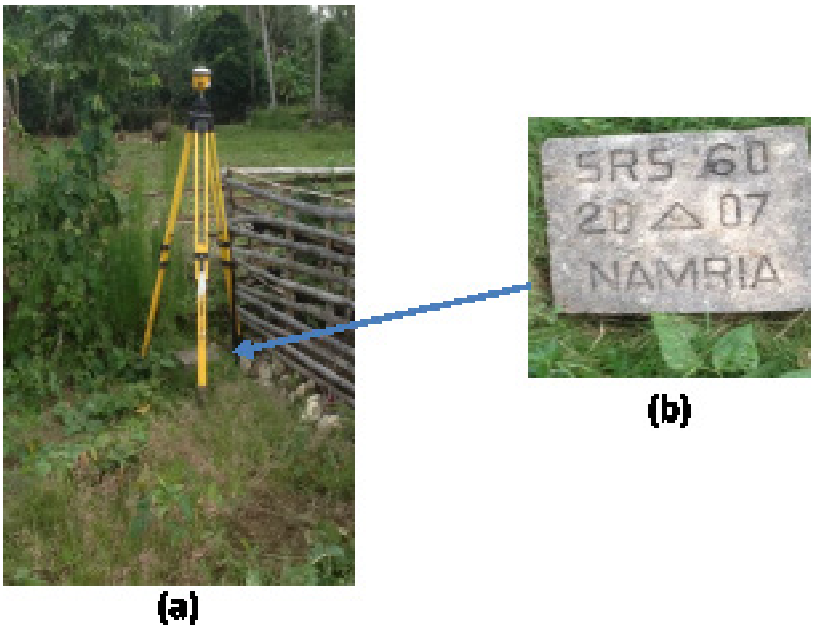

Figure 6. GPS set-up over SRS-60 as recovered inside Brgy. Sta Cruz health center, on the corner near the bamboo fence (a) NAMRIA reference point SRS-60 (b) as recovered by the field team.

Table 5. Details of the recovered NAMRIA horizontal control point SRS-60 used as base station for the LiDAR acquisition.

Station Name	SRS-60	
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	8° 15' 26.63928" North 126° 17' 56.66192" East 83.08300 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	643129.132 meters 913248.992 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8°15' 23.26276" North 126° 18' 2.07013" East 155.22600 meters

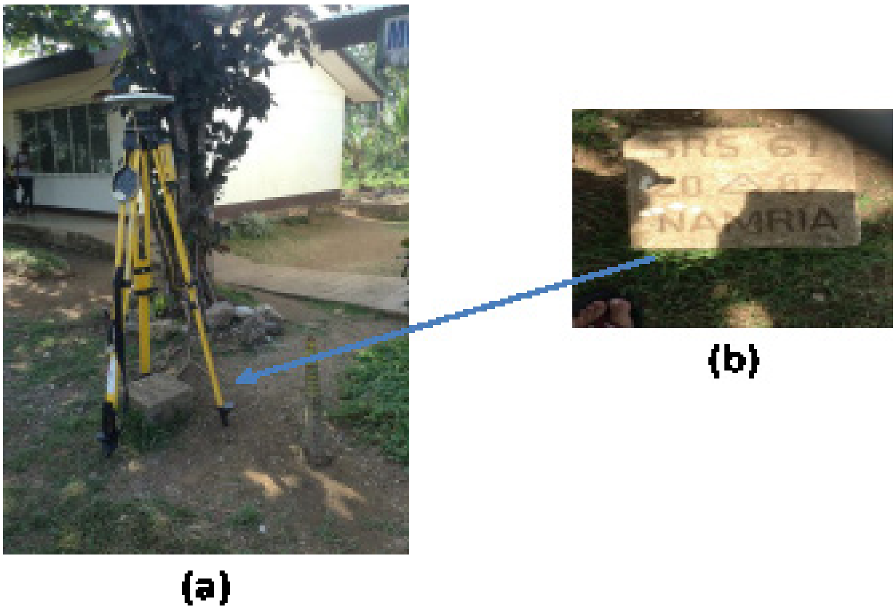

Figure 7. GPS set-up over SRS-61 as recovered on the open field about 100m away from the flagpole of Mone National High School in Brgy. Mone, Bislig, Surigao Del Sur (a) and NAMRIA reference point SRS-61 (b) as recovered by the field team.

Table 6. Details of the recovered NAMRIA horizontal control point SRS-61 used as base station for the LiDAR acquisition.

Station Name	**SRS-61**	
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	8° 9' 52.82479" North 126° 16' 5.42126" East 2.46400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	639590.647 meters 902980.994 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8° 9' 49.47002" North 126° 16' 5.42126" East 74.71500meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	198797.23 meters 903466.77 meters

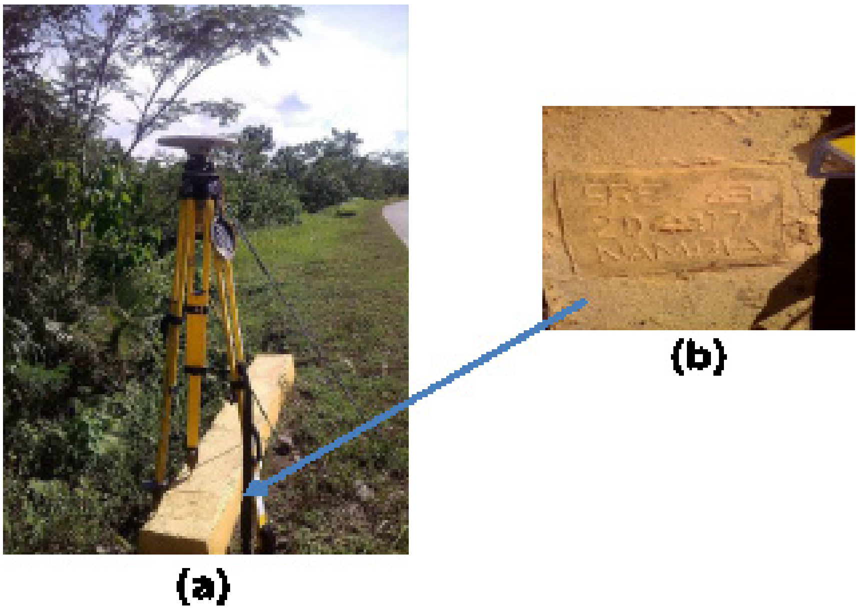

Figure 8. GPS set-up over SRS-63 located 4 kms to the junction of the road of San Antonio in Brgy. Sitio Pagmam-am, Bislig, Surigao Del Sur (a) and NAMRIA reference point SRS-63 (b) as recovered by the field team.

Table 7. Details of the recovered NAMRIA horizontal control point SRS-63 used as base station for the LiDAR acquisition.

Station Name	SRS-63	
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	8° 8' 0.61702" North 126° 20' 25.46527" East 89.36100 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	647729.756 meters 899559.567 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8° 7' 57.27724" North 126° 20' 30.88421" East 161.85800 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	206906.01 meters 899963.22 meters

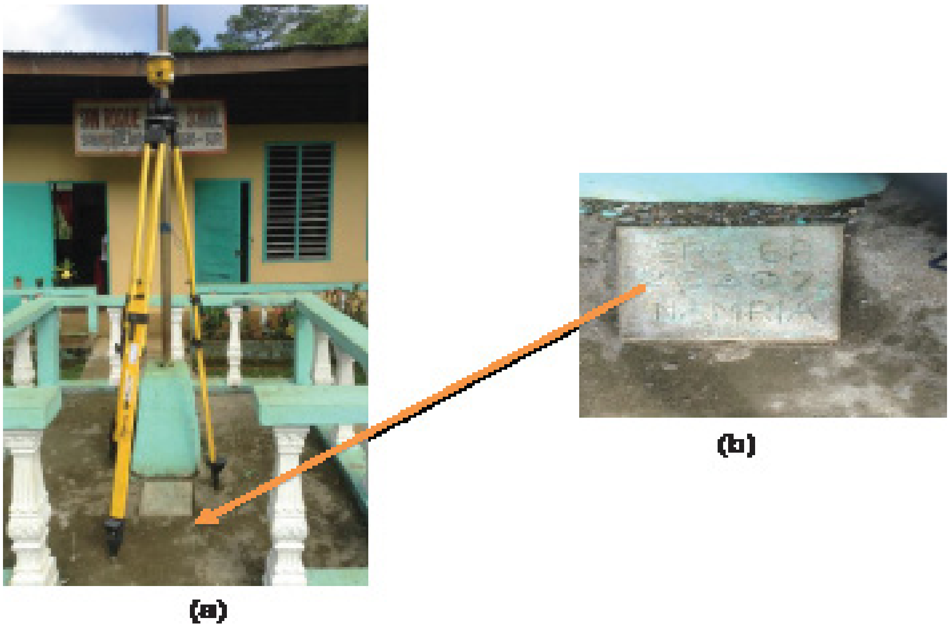

Figure 9. GPS set-up over SRS-68 located in front of the concrete foundation of flagpole of San Roque Elementary School in Brgy. San Roque, Barobo, Surigao Del Sur (a) and NAMRIA reference point SRS-68 (b) as recovered by the field team.

Table 8. Details of the recovered NAMRIA horizontal control point SRS-68 used as base station for the LiDAR Acquisition.

Station Name	**SRS-68**	
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	8° 31’ 4.13752” North 126° 11’ 54.80630” East 144.36800 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	631965.017 meters 942018.662 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8° 31’ 0.68280” North 126° 12’ 0.19207” East 215.72700 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	191563.45 meters 942602.08 meters

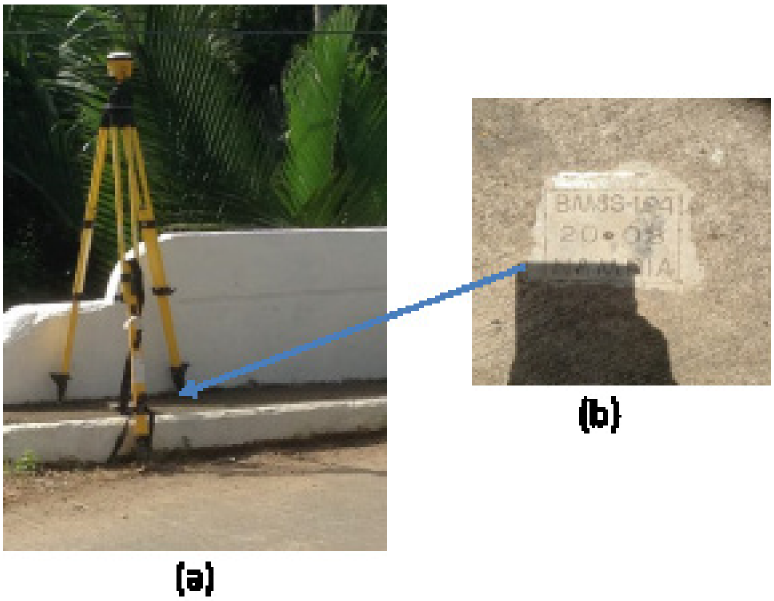

Figure 10. GPS set-up over SS-124 located at the second approach of Bislig bridge in Bislig, Surigao Del Sur (a) and NAMRIA reference point SS-124 (b) as recovered by the field team.

Table 9. Details of the recovered NAMRIA vertical control point SS-124 used as base station for the LiDAR acquisition with established coordinates.

Station Name	SS-124	
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	8°13’07.07644” North 126°18’24.14659” East 3.637 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	864399.325 meters 909915.188 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8°13’03.71089” North 126°18’29.55827” East 80.77 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	1085282.295meters 911895.258meters

Figure 11. GPS Set-up over BMSS-201

Table 10. Details of the recovered NAMRIA benchmark BMSS-201 used as base station for the LiDAR acquisition.

Station Name	BMSS-201	
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	8°46'03.02195" 126°14'07.03352" 72.180 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	856009.096 meters 970681.752 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8°46'03.02195" 126°14'07.03352" 72.180 meter3

(a)

Figure 12. GPS Set-up over SRS-53

Table 11. Details of the recovered NAMRIA horizontal control point SRS-53 used as base station for the LiDAR acquisition.

Station Name	SRS-53	
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	8° 44' 37.87784" 126° 13' 16.64511" -1.34900 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	414316.026 meters 966899.682 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	8° 44' 34.36515" North 126° 13' 22.01039" East 69.59300 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	194250.44 meters 967600.49 meters

Table 12. Ground control points used during LiDAR data acquisition.

Date Surveyed	Flight Number	Mission Name	Ground Control Points
21-JUL-14	1728A	3BLK65H202B	SRS-53 and SS-201
22-JUL-14	1730A	3BLK65HS203A	SRS-53 and SS-201
4-Aug-14	1782A	3BLK66F216A	SRS-60 and SS-124
5-Aug-14	1788A	3BLK66EGS217B	SRS-60 and SS-124
6-Aug-14	1790A	3BLK66M218A	SRS-57 and SRS-60
7-Aug-14	1794A	3BLK66LMS219A	SRS-57 and SRS-60
7-Aug-14	1796A	3BLK66LSJS219B	SRS-57 and SRS-60
8-Aug-14	1798A	3BLK66N220A	SRS-57 and SRS-60
8-Aug-14	1800A	3BLK66O220B	SRS-57 and SRS-60
9-Aug-14	1804A	3BLK66OSP221B	SRS-57 and SRS-60
11-Aug-14	1810A	3BLK66PSQ223A	SRS-57 and SRS-60
11-Aug-14	1812A	3BLK66QS223B	SRS-57 and SRS-60
12-Aug-14	1814A	3BLK66KR224A	SRS-56 and SRS-57
12-Aug-14	1816A	3BLK66RS224B	SRS-56 and SRS-57
14-Aug-14	1822A	3BLK66S226A	SRS-56 and SRS-57
18-Aug-14	1838A	3BLK66SS230A	SRS-56 and SRS-68
19-Aug-14	1842A	3BLK66T231A	SRS-56 and SRS-68
5-Sep-14	1912A	3BLK66RS248B	SRS-56, SRS-58, SRS-61 and SRS-63
7-Sep-14	1918A	3BLK66RS250A	SRS-56 and SRS-58

2.3 Flight Missions

A total of nineteen (19) flight missions were conducted to complete the LiDAR data acquisition in the Hinatuan floodplain, for a total of seventy-two hours and twenty-three minutes (72+23) of flying time for RP-C9122. All missions were acquired using the Aquarius LiDAR system. Table 13 shows the total area of actual coverage for each mission, and the corresponding flying hours per mission. Table 14 presents the actual parameters used during the LiDAR data acquisition. ANNEX 6 shows the flight logs for the missions.

Table 13. Flight missions for LiDAR data acquisition in Hinatuan floodplain.

Date Surveyed	Flight Number	Flight Plan Area (km^2)	Surveyed Area (km^2)	Area Surveyed within the Floodplain (km^2)	Area Surveyed outside the Floodplain (km^2)	No. of Images (Frames)	Flying Hours	
							Hr	Min
21-JUL-14	1728A	46.40	27.57	0.47	350.75	216	2	53
22-JUL-14	1730A	46.40	50.79	4.99	346.23	652	3	35
4-Aug-14	1782A	57.37	85.47	5.53	345.69	870	3	53
5-Aug-14	1788A	94.33	101.46	17.08	334.14	884	3	53
6-Aug-14	1790A	83.09	97.77	51.09	300.13	902	4	17
7-Aug-14	1794A	165.32	124.02	51.63	299.59	664	4	23
7-Aug-14	1796A	169.34	155.12	20.93	330.29	1031	3	53
8-Aug-14	1798A	83.67	113.43	51.97	299.25	1089	4	5
8-Aug-14	1800A	80.88	74.67	22.65	328.57	652	3	5
9-Aug-14	1804A	168.51	93.40	31.42	319.80	911	4	23
11-Aug-14	1810A	172.53	140.33	72.08	279.14	237	4	23
11-Aug-14	1812A	84.90	67.55	35.49	315.73	570	2	41
12-Aug-14	1814A	175.94	100.77	2.16	349.06	1073	4	23
12-Aug-14	1816A	122.09	79.52	NA	NA	0	3	5
14-Aug-14	1822A	131.10	87.15	26.63	324.59	112	3	53
18-Aug-14	1838A	131.10	109.42	52.66	298.56	1001	4	11
19-Aug-14	1842A	85.10	186.05	97.71	253.51	848	4	23
5-Sep-14	1912A	122.09	52.33	2.45	348.77	294	2	41
7-Sep-14	1918A	122.09	74.09	1.96	349.26	0	4	23
TOTAL		**2142.25**	**1820.91**	**548.9**	**5773.06**	**12006**	**72**	**23**

Table 14. Actual parameters used during LiDAR data acquisition

Flight Number	Flying Height (m AGL)	Overlap (%)	FOV (θ)	PRF (KHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
1728A	600	40	36	50	45	120	5
1730A	600	40	36	50	45	120	5
1782A	600	30	36	50	45	120	5
1788A	500,600	30	36	50	45	120	5
1790A	600	40	36	50	45	120	5
1794A	600	40	36	50	45	120	5
1796A	600	45	36	50	45	120	5
1798A	600	40	36	50	45	120	5
1800A	600	40	36	50	45	120	5
1804A	600	40	36	50	45	120	5
1810A	600	40	36	50	45	120	5
1812A	600	40	36	50	45	120	5
1814A	500	45	40	50	40	120	5
1816A	500	25	40	50	50	120	5
1822A	600	35,60	36	50	45	120	5
1838A	600	40	36	50	45	120	5
1842A	600	40,45	36	50	45	120	5
1912A	600	40	36	50	45	120	5
1918A	500,600	40	36	50	45	120	5

2.4 Survey Coverage

This certain LiDAR acquisition survey covered the Hinatuan floodplain (See ANNEX 7 for the flight status reports). The Hinatuan floodplain is located in the province of Surigao del Sur and Agusan del Sur with majority of the floodplain situated within the municipality of Tagbina and Hinatuan. The Municipalities of Hinatuan, Barobo and Tagbina are mostly covered by the survey. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 15. The actual coverage of the LiDAR acquisition for the Hinatuan floodplain is presented in Figure 13.

Table 15. List of municipalities and cities surveyed during the Hinatuan floodplain LiDAR survey.

Province	Municipality/City	Area of Municipality/ City (km^2)	Total Area Surveyed (km^2)	Percentage of Area Surveyed
Agusan del Sur	Rosario	452.81	108.13	23.88%
	San Francisco	451.66	58.16	12.88%
	Trento	515.17	37.18	7.22%
	Bunawan	608.49	14.5	2.38%
Surigao del Sur	Hinatuan	238.31	236.08	99.06%
	Barobo	194.07	191.93	98.89%
	Tagbina	294.29	280.22	95.22%
	Lianga	141.51	26.02	18.39%
	Bislig City	269.88	37.23	13.8%
TOTAL		**3,166.19**	**989.45**	**31.25%**

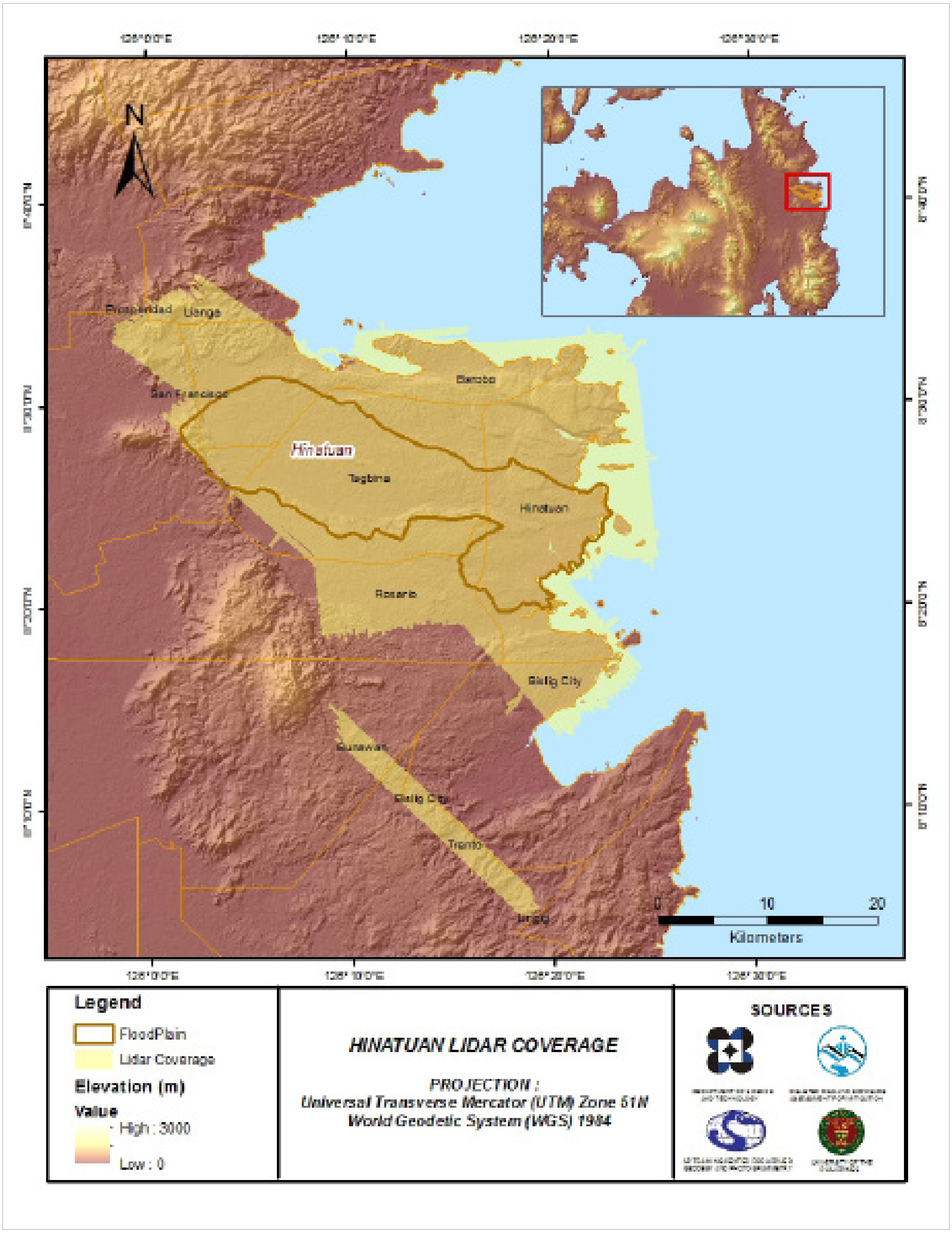

Figure 13. Actual LiDAR survey coverage for Hinatuan floodplain.

CHAPTER 3: LIDAR DATA PROCESSING OF THE HINATUAN FLOODPLAIN

Engr. Ma. Rosario Concepcion O. Ang, Engr. John Louie D. Fabila, Engr. Sarah Jane D. Samalburo, Engr. Joida F. Prieto, Engr. Elainne R. Lopez, Engr. Jovelle Anjeanette S. Canlas, Engr. Irish R. Cortez, Jovy Anne S. Narisma , Engr. Jommer M. Medina, and Myra Laika C. Estur

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

3.1 Overview of the LIDAR Data Pre-Processing

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

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

These processes are summarized in the diagram shown in Figure 14.

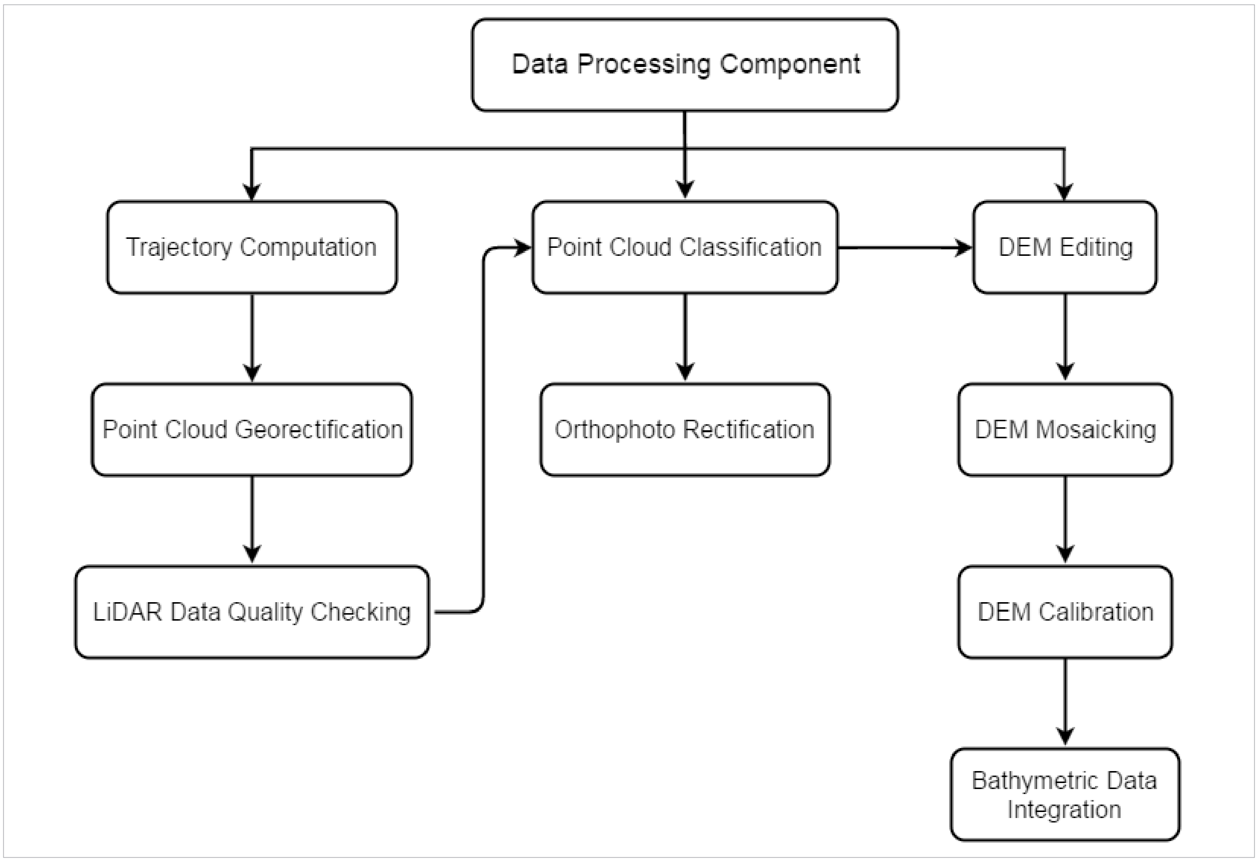

Figure 14. Schematic Diagram for Data Pre-Processing Component

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for the Hinatuan floodplain can be found in ANNEX 5. Missions flown during the survey conducted in July 2014 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Aquarius system over Surigao del Sur. The DAC transferred a total of 184.34 Gigabytes of Range data, 4.085 Gigabytes of POS data, 294 Megabytes of GPS base station data, and 790.15 Gigabytes of raw image data to the data server on September 9, 2014. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Hinatuan was fully transferred on October 1, 2014, as indicated on the Data Transfer Sheets for the Hinatuan floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metric parameters of the computed trajectory for flight 1838A, one of the Hinatuan flights, which are the North, East, and Down position RMSE values, are illustrated in Figure 15. 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 fell on August 18, 2014 00:00AM on that week. The y-axis is the RMSE value for that particular position.

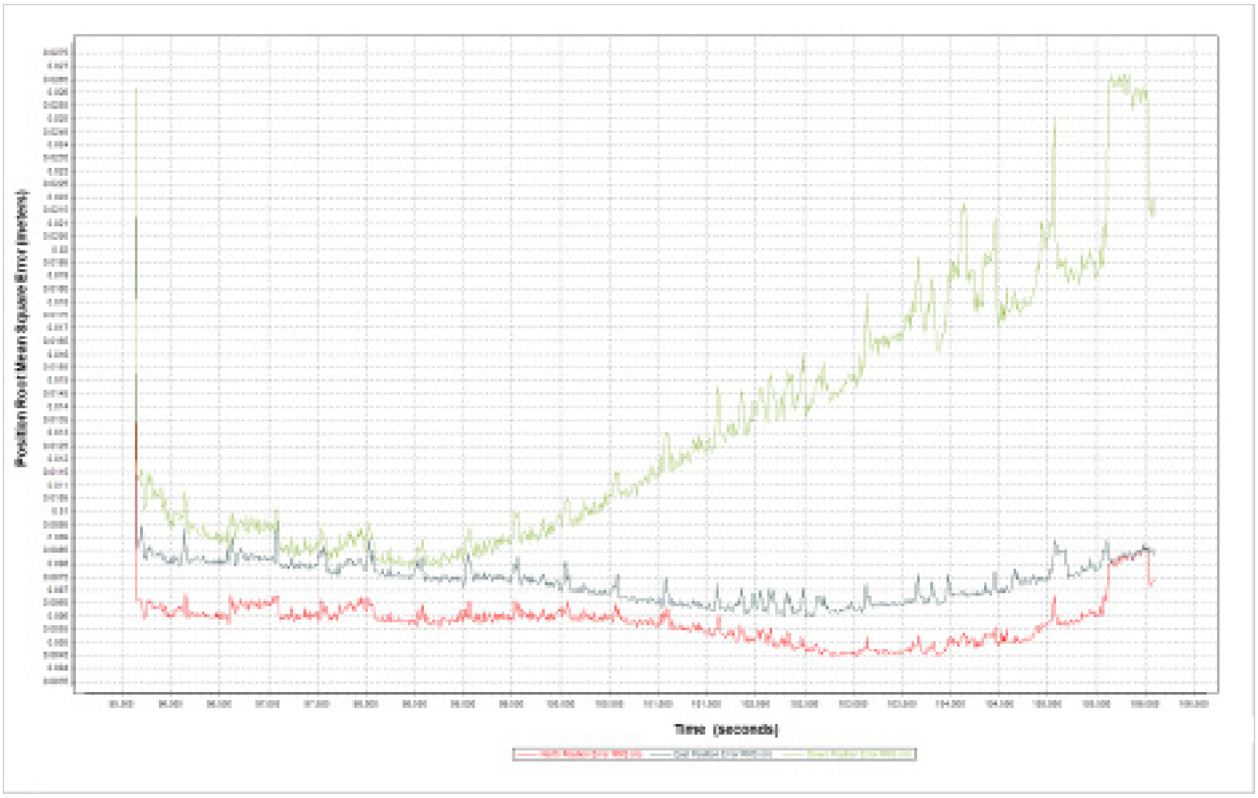

Figure 15. Smoothed Performance Metric Parameters of a Hinatuan Flight 1838A.

The time of flight was from 95600 seconds to 106100 seconds, which corresponds to the morning of August 18, 2014. The initial spike reflected on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system was starting to compute for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values corresponds to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 15 shows that the North position RMSE peaks at 0.85 centimeters, the East position RMSE peaks at 0.95 centimeters, and the Down position RMSE peaks at 2.65 centimeters, which are within the prescribed accuracies described in the methodology.

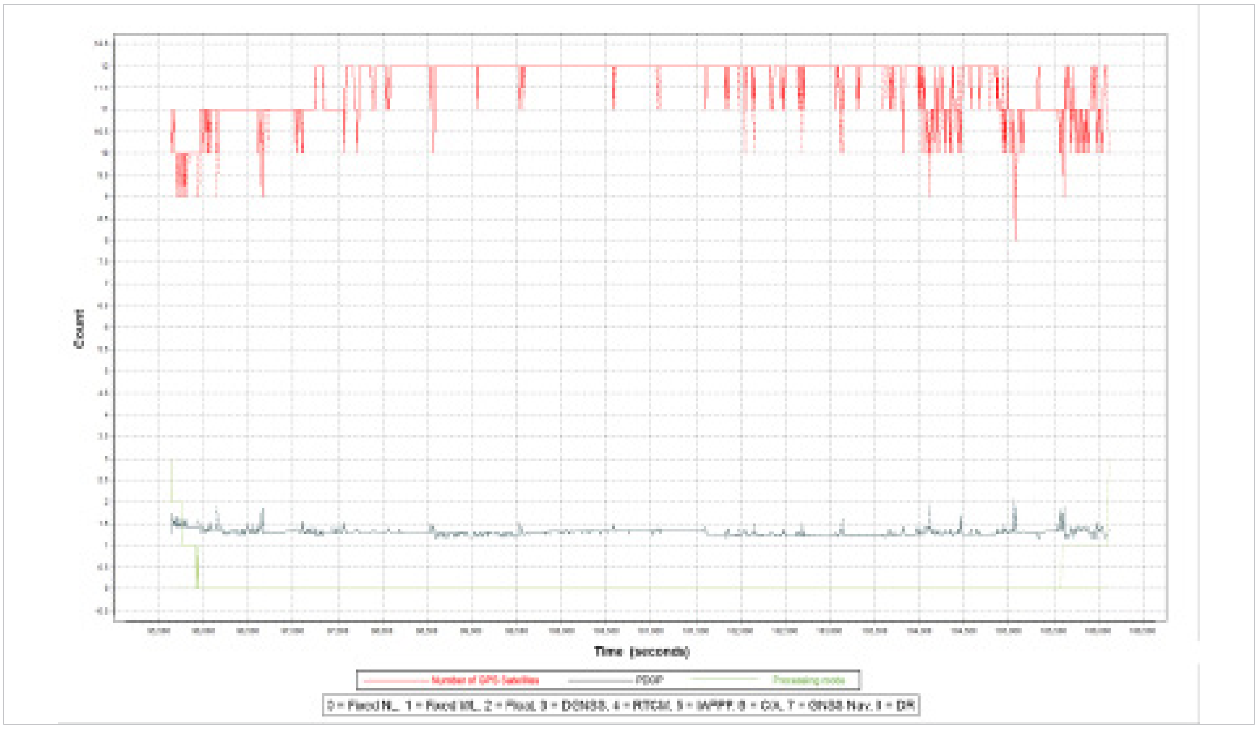

Figure 16. Solution Status Parameters of Hinatuan Flight 1838A.

The Solution Status parameters of flight 1838A, one of the Hinatuan flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are presented in Figure 16. The graphs indicate that the number of satellites during the acquisition did not go down to six (6). Majority of the time, the number of satellites tracked was between eight (8) and twelve (12). The PDOP value did not go above the value of three (3), which indicates optimal GPS geometry. The processing mode stayed at the value of zero (0) for majority of the survey, with some peaks up to three (3), attributed to the turns performed by the aircraft. The value of zero (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 Hinatuan flights is shown in Figure 17.

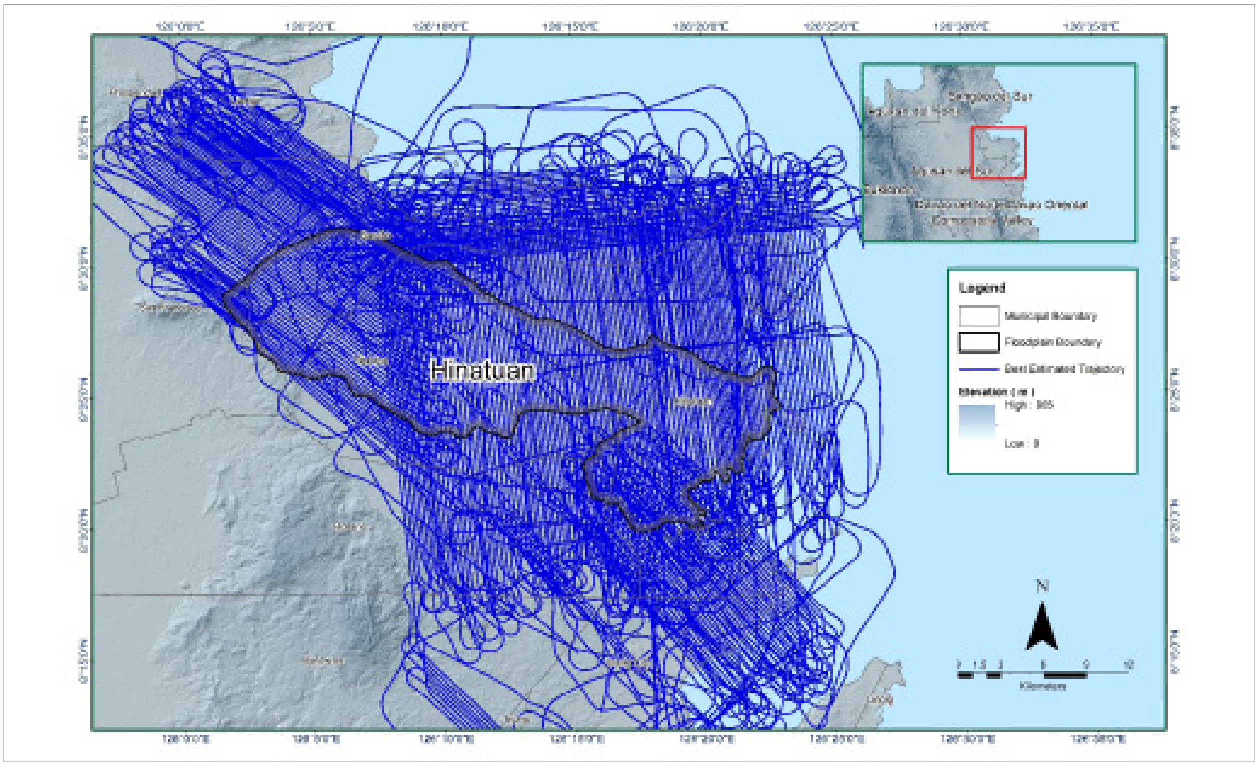

Figure 17. Best estimated trajectory conducted over the Hinatuan floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 346 flight lines, with each flight line containing one (1) channel, since the Aquarius system contains only one (1) channel. The summary of the self-calibration results obtained from LiDAR processing in the LiDAR Mapping Suite (LMS) software for all flights over the Hinatuan floodplain are given in Table 16.

Table 16. Self-Calibration Results values for Hinatuan flights.

Parameter	Acceptable Value
Boresight Correction stdev (<0.001degrees)	0.000688
IMU Attitude Correction Roll and Pitch Corrections stdev (<0.001degrees)	0.000917
GPS Position Z-correction stdev (<0.01meters)	0.0079

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

3.5 LiDAR Data Quality Checking

The boundaries of the processed LiDAR data on top of a SAR Elevation Data over the Hinatuan floodplain is illustrated in Figure 18. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

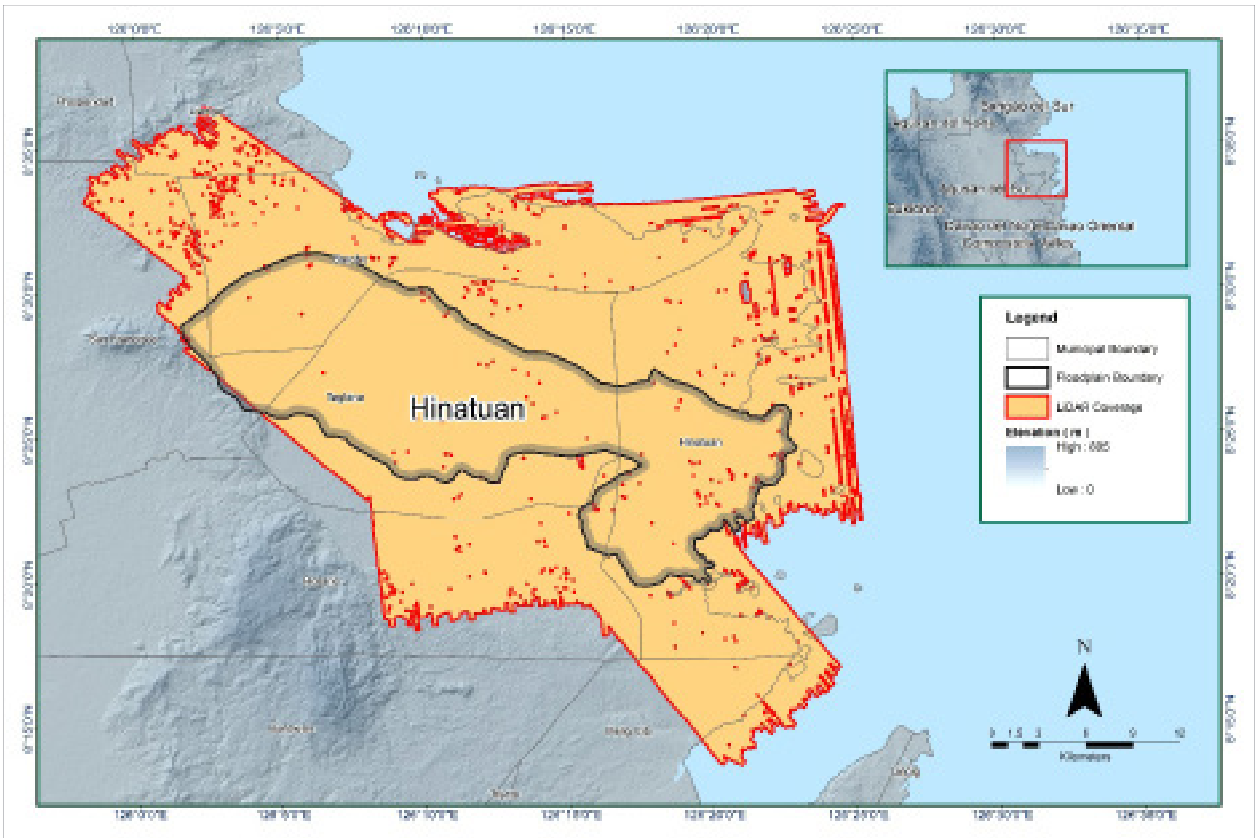

Figure 18. Boundaries of the processed LiDAR data over the Hinatuan Floodplain

The total area covered by the Hinatuan missions is 1,257.76 sq.km, comprised of nineteen (19) flight acquisitions grouped and merged into fifteen (15) blocks, as indicated in Table 17.

Table 17. List of LiDAR blocks for Hinatuan floodplain.

LiDAR Blocks	Flight Numbers	Area (sq. km)
SurigaodelSur_Blk65H	1728A	56.06
	1730A	
SurigaodelSur_Blk66E	1788A	68.25
SurigaodelSur_Blk66L	1794A	92.05
	1796A	
SurigaodelSur_Blk66M	1790A	88.21
	1794A	
SurigaodelSur_Blk66N	1798A	97.26
SurigaodelSur_Blk66O	1800A	58.01
SurigaodelSur_Blk66P	1804A	79.03
SurigaodelSur_Blk66Q	1810A	171.96
	1812A	
SurigaodelSur_Blk66R_ Supplement	1912A	53.94
	1918A	
SurigaodelSur_Blk66R	1814A	75.15
	1816A	
SurigaodelSur_Blk66T	1842A	68.75
SurigaodelSur_Blk66S	1838A	152.82
	1822A	
SurigaodelSur_Blk66T_Additional	1918A	68.67
SurigaodelSur_Blk66K	1814A	60.33
SurigaodelSur_Blk66F	1782A	67.27
TOTAL		**1,257.76 sq.km**

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location is presented in Figure 19. Since the Aquarius system employs only one (1) channel, it is expected to have 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.

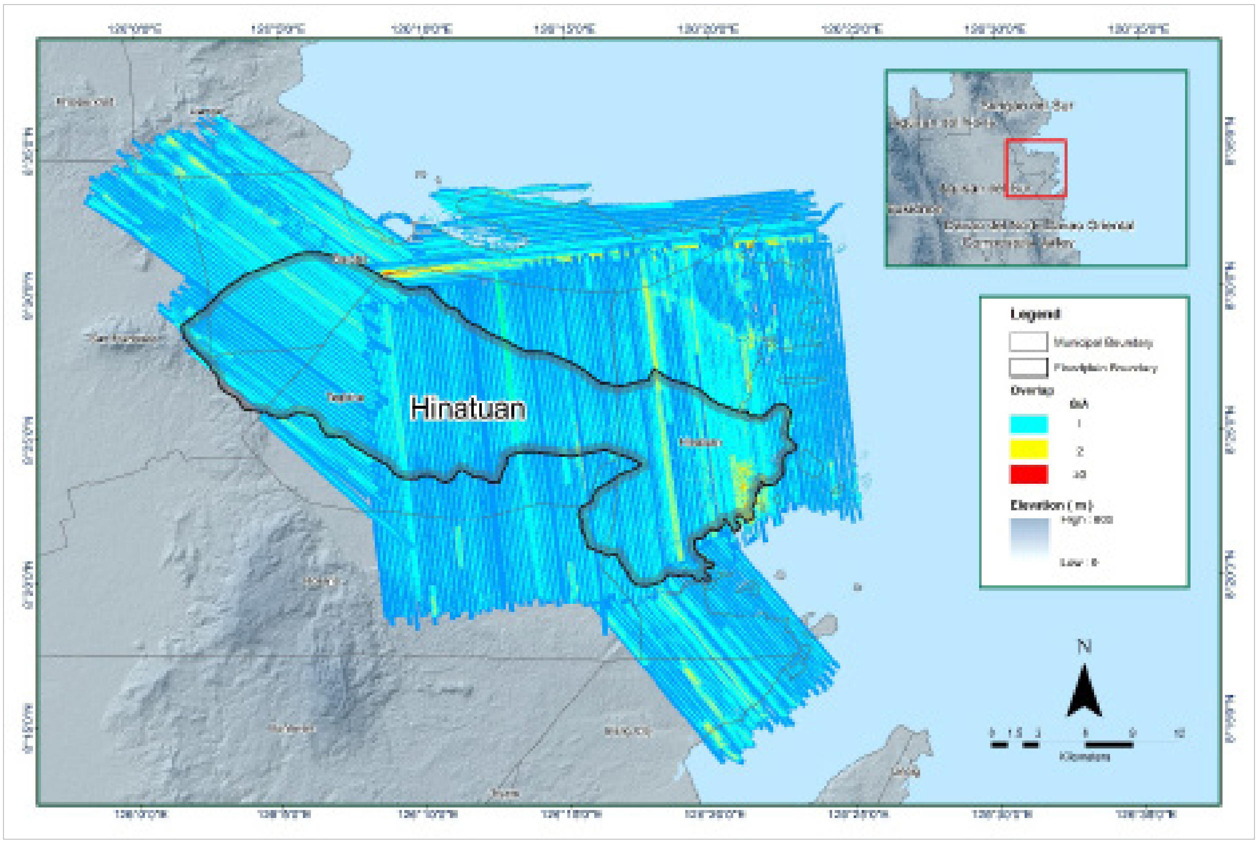

Figure 19. Image of data overlap for Hinatuan floodplain.

The overlap statistics per block for the Hinatuan floodplain can be found in ANNEX 8. 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 31.54% and 61.86%, respectively, which satisfy 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 exhibited in Figure 20. It was determined that all LiDAR data for the Hinatuan floodplain satisfy the point density requirement, and that the average density for the entire survey area is 3.487 points per square meter.

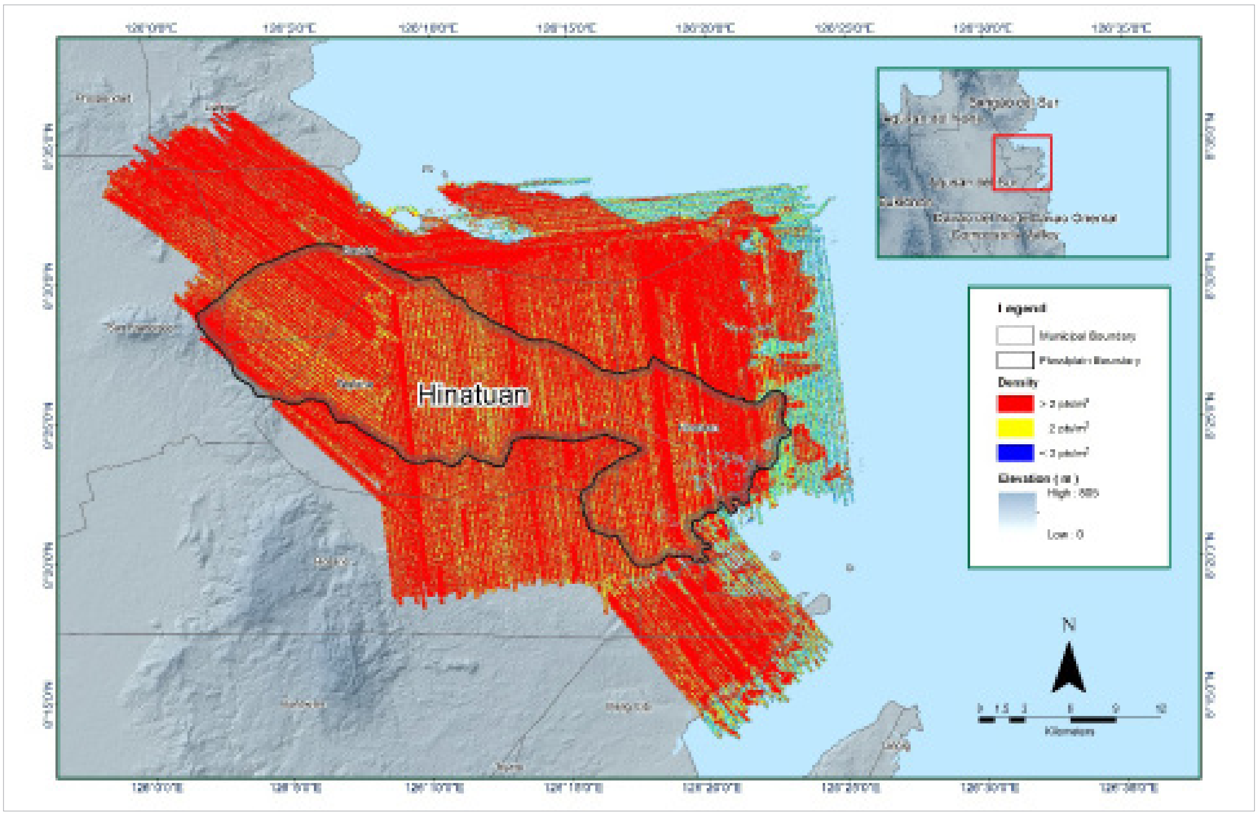

Figure 20. Pulse density map of merged LiDAR data for Hinatuan floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 21. The default color range is from blue to red, where bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20m relative to elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m relative to elevations of its adjacent flight line. Areas with bright red or bright blue were investigated further using the Quick Terrain Modeler software.

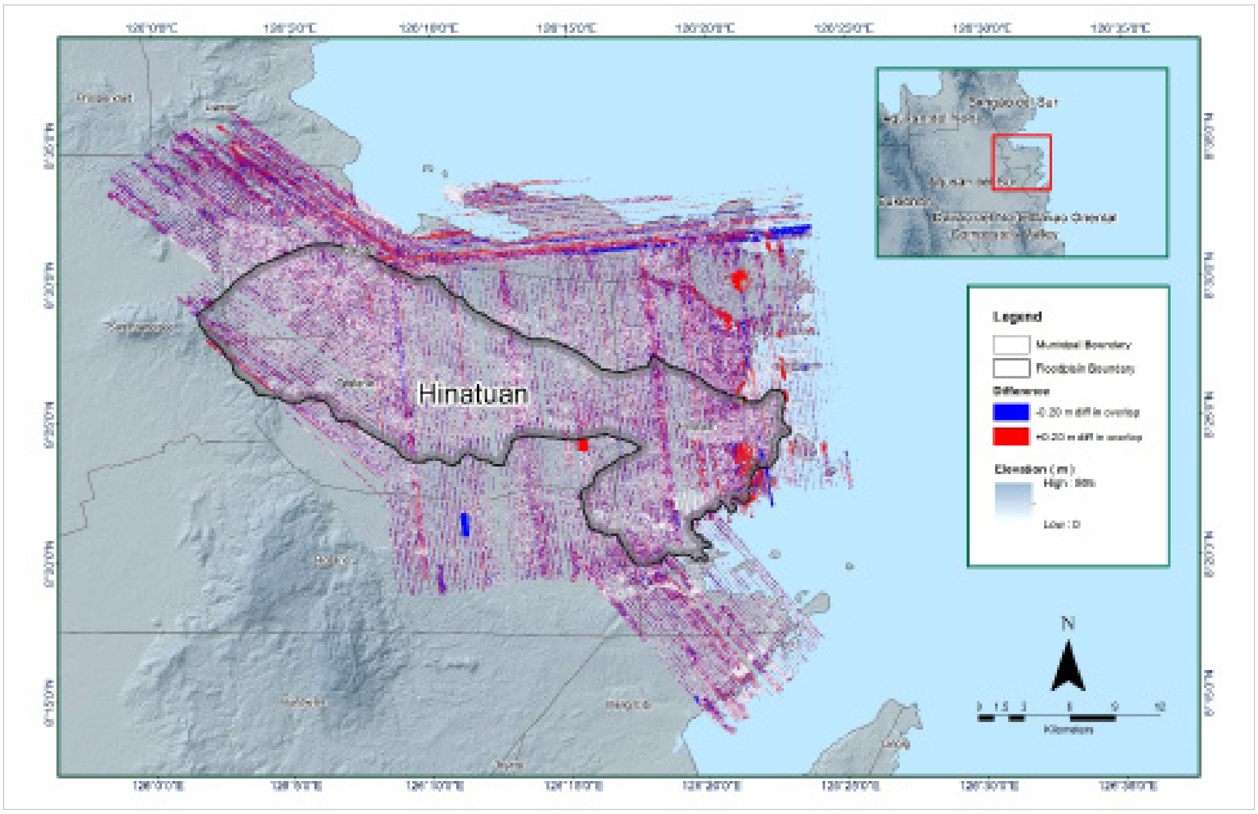

Figure 21. Elevation difference map between flight lines for Hinatuan floodplain.

A screen capture of the processed LAS data from a Hinatuan flight 1838A loaded in the QT Modeler is shown in Figure 22. The upper left image shows the elevations of the points from two (2) 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 became satisfactory. No reprocessing was done for this LiDAR dataset.

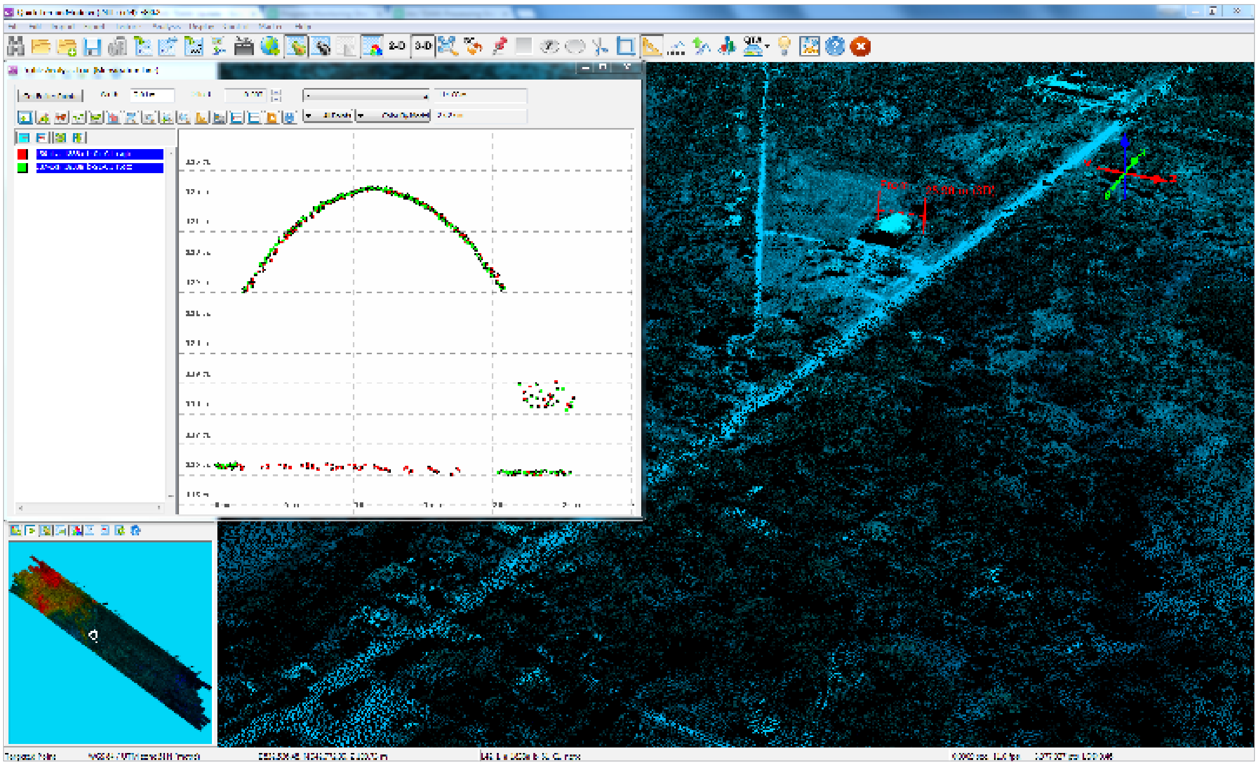

Figure 22. Quality checking for a Hinatuan flight 1838A using the Profile Tool of QT Modeler.

3.6 LiDAR Point Cloud Classification and Rasterization

Table 18. Hinatuan classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	502,659,499
Low Vegetation	485,453,408
Medium Vegetation	1,237,061,289
High Vegetation	1,672,936,800
Building	69,136,577

The tile system that the TerraScan employed for the LiDAR data and the final classification image for a block in the Hinatuan floodplain is illustrated in Figure 23. A total of 1,812 1km by 1km tiles were produced. The number of points classified to the pertinent categories is indicated in Table 18. The point cloud has a maximum and minimum height of 623.93 meters and 41.45 meters, respectively

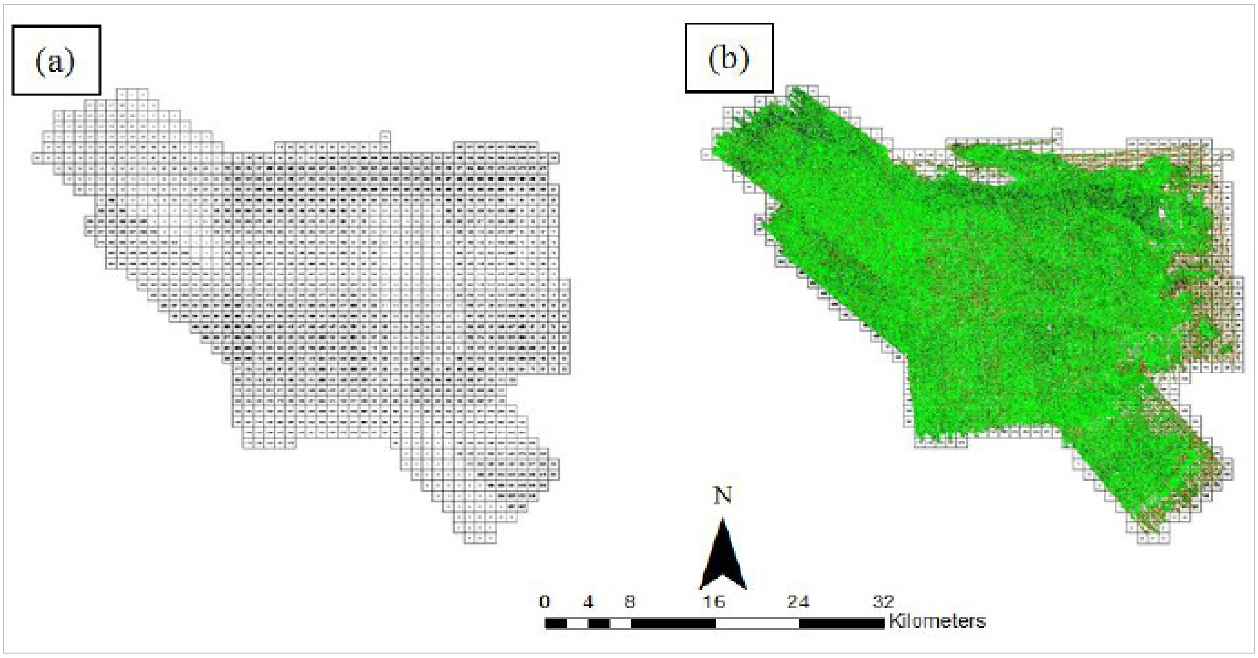

Figure 23. Tiles for Hinatuan floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 24. 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.

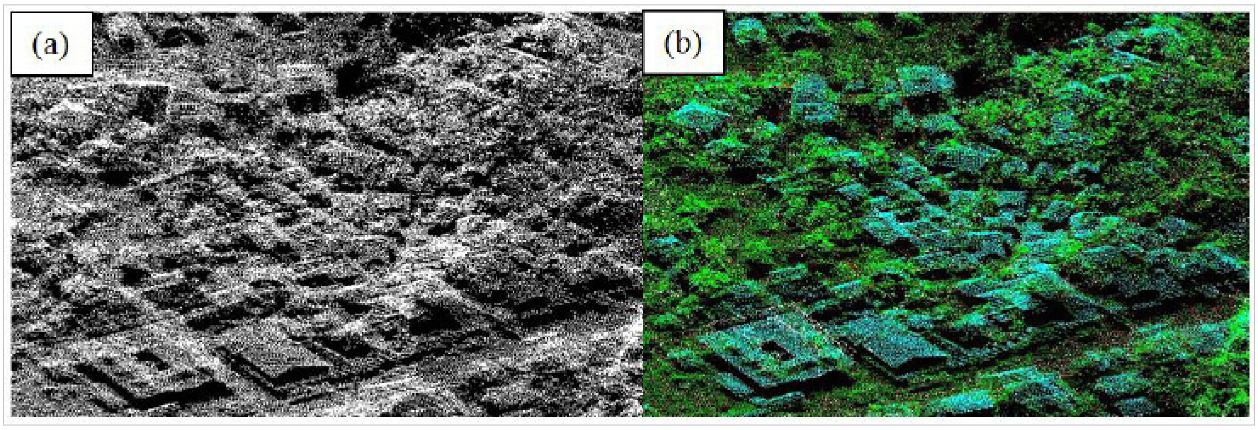

Figure 24. Point cloud before (a) and after (b) classification.

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 presented in Figure 25. It shows that DTMs are the representation of the bare earth, while the DSMs reflect all features present, such as buildings and vegetation.

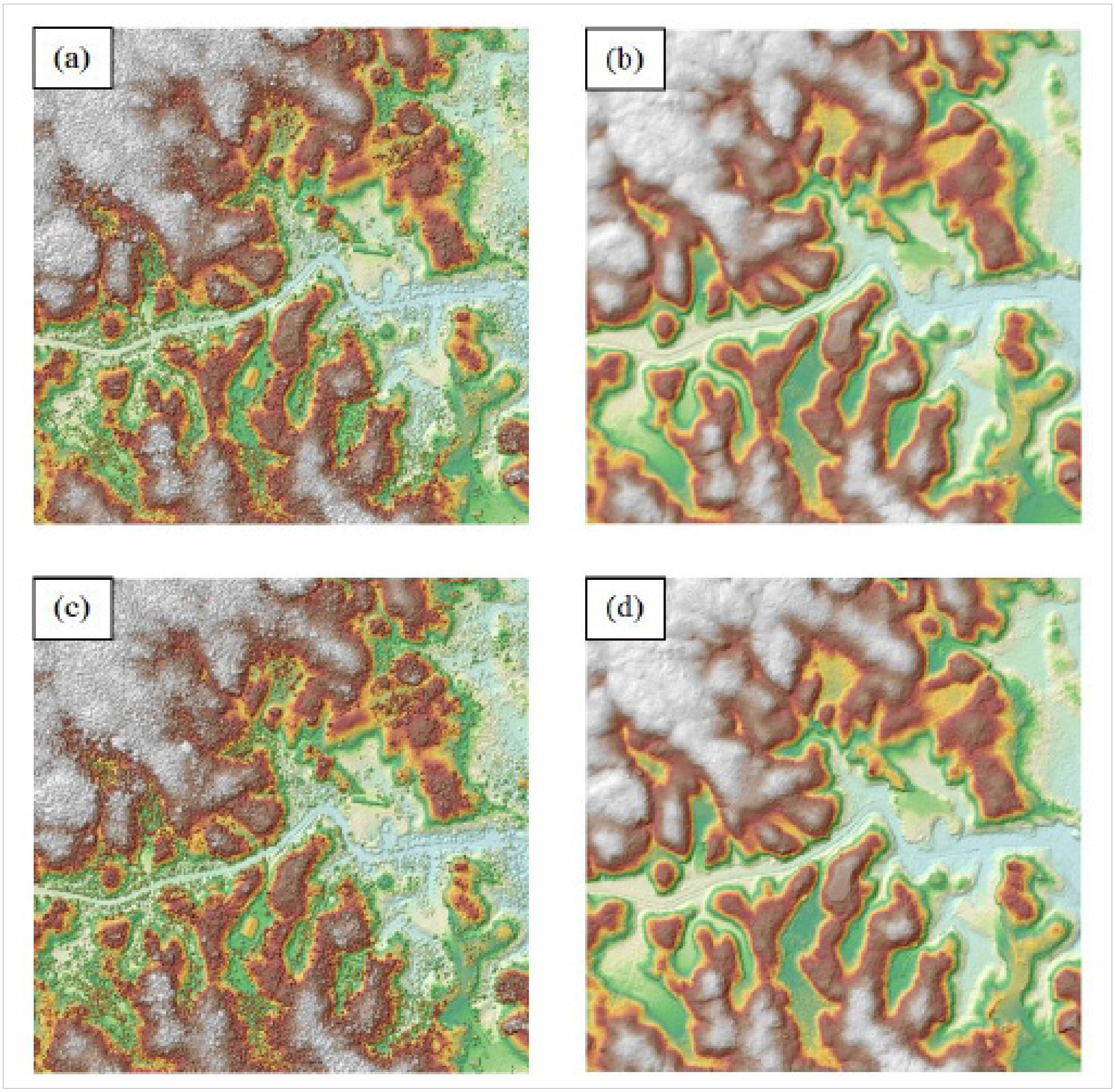

Figure 25. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Hinatuan floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 1,383 1km by 1km tiles area covered by the Hinatuan floodplain is shown in Figure 26. After employing tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seam lines where photos overlap. The Hinatuan floodplain survey attained a total of 833.86 sq. km. in orthophotogaphic coverage, comprised of 10,653 images. Zoomed in versions of sample orthophotographs named in reference to their tile numbers are provided in Figure 27.

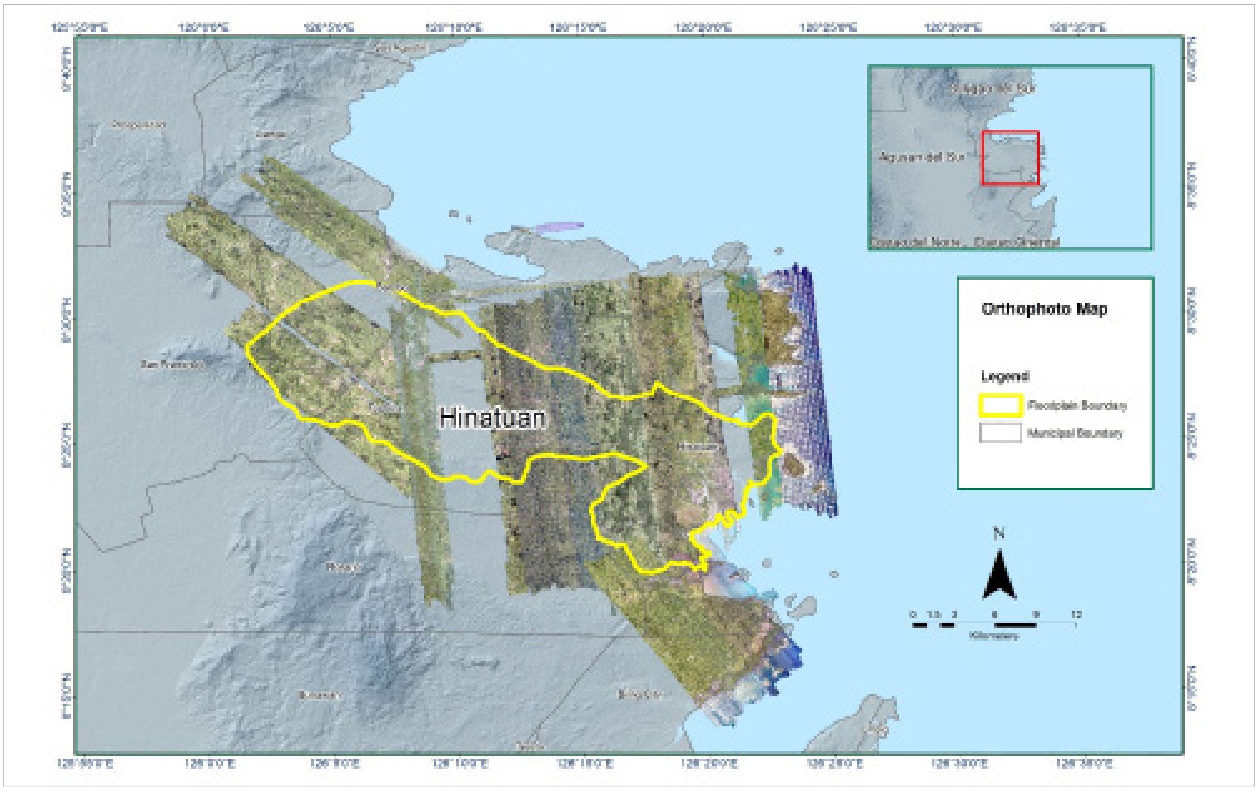

Figure 26. Hinatuan floodplain with available orthophotographs.

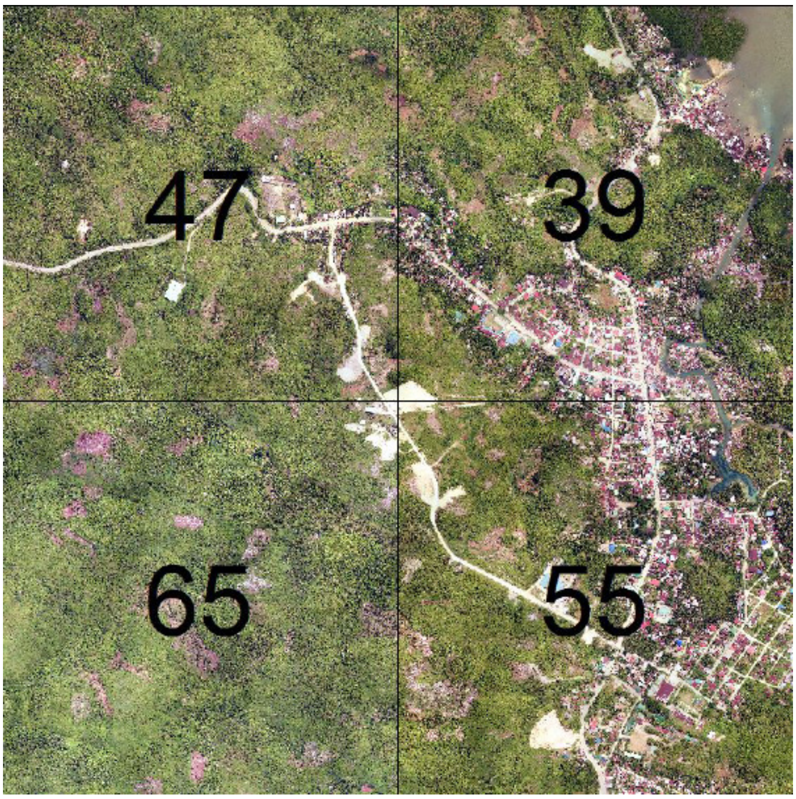

Figure 26. Hinatuan floodplain with available orthophotographs.

3.8 DEM Editing and Hydro-Correction

Fifteen (15) mission blocks were processed for the Hinatuan flood plain. These are composed of SurigaodelSur blocks, with a total area of 1,257.76 square kilometers. Table 19 indicates the name and corresponding area of each block, in square kilometers.

Table 19. LiDAR blocks with its corresponding area.

LiDAR Blocks	Area (sq.km)
SurigaodelSur_Blk65H	56.06
SurigaodelSur_Blk66E	68.25
SurigaodelSur_Blk66L	92.05
SurigaodelSur_Blk66M	88.21
SurigaodelSur_Blk66N	97.26
SurigaodelSur_Blk66O	58.01
SurigaodelSur_Blk66P	79.03
SurigaodelSur_Blk66Q	171.96
SurigaodelSur_Blk66R_ Supplement	53.94
SurigaodelSur_Blk66R	75.15
SurigaodelSur_Blk66T	68.75
SurigaodelSur_Blk66S	152.82
SurigaodelSur_Blk66T_ Additional	68.67
SurigaodelSur_Blk66K	60.33
SurigaodelSur_Blk66F	67.27
TOTAL	**1,257.76 sq.km**

Portions of DTM before and after manual editing are shown in Figure 28. Hilly portions (Figure 28a) were misclassified and removed during the classification process, and had to be retrieved to complete the surface (Figure 28b) to allow for the correct flow of water. The bridge (Figure 28c) was also considered to be an impedance to the flow of water along the river, and had to be removed (Figure 28d) in order to hydrologically correct the river.

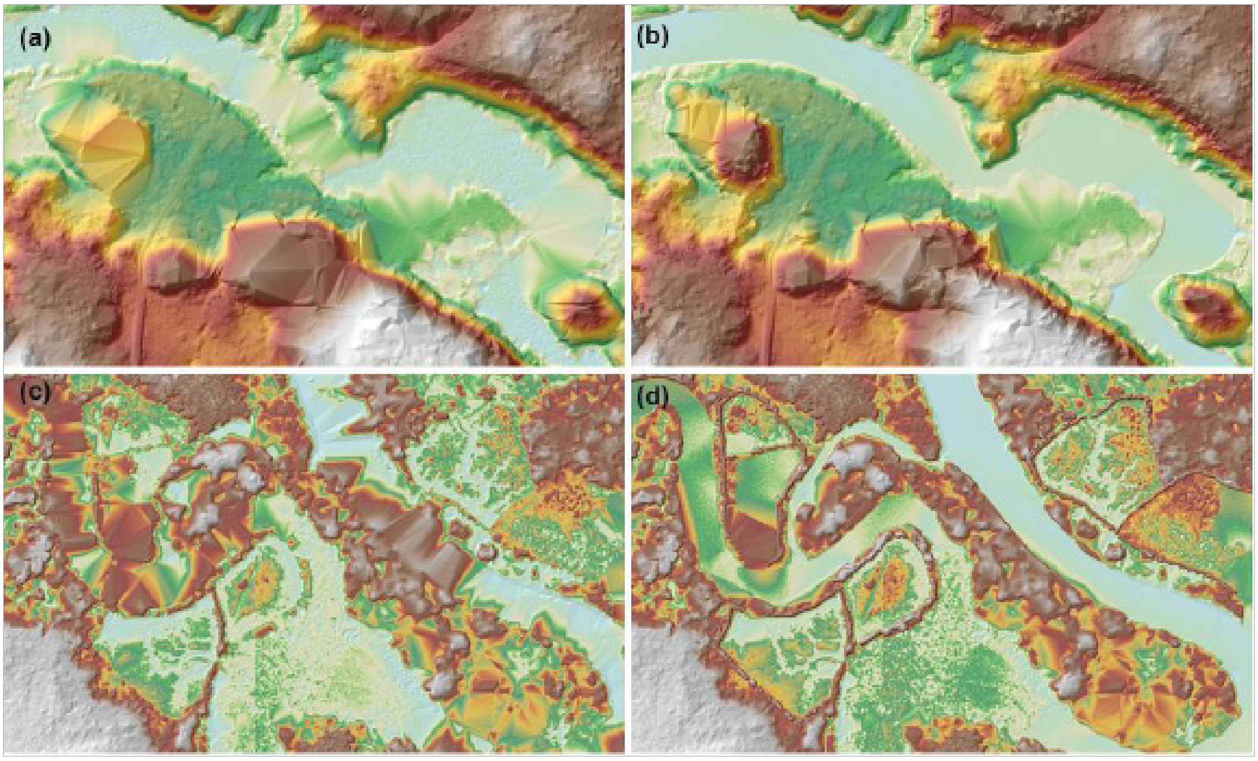

Figure 28. Portions in the DTM of Hinatuan floodplain – hilly portions before (a) and after (b) data retrieval; and a bridge before (c) and after (d) manual editing.

3.9 Mosaicking of Blocks

SurigaodelSur_Blk66M was used as the reference block at the start of mosaicking, as this block contains national highway where the validation surveys traversed. Table 20 provides the area of each LiDAR block and the shift values applied during mosaicking.

Mosaicked LiDAR DTM for the Hinatuan floodplain is shown in Figure 29. It can be seen that the entire Hinatuan floodplain is 99.62% covered by LiDAR data.

Table 20. Shift Values of each LiDAR Block of the Hinatuan floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
SurigaodelSur_Blk65H	0.00	0.00	1.48
SurigaodelSur_Blk66E	0.00	0.00	0.59
SurigaodelSur_Blk66L	0.00	0.00	-0.17
SurigaodelSur_Blk66N	0.00	0.00	0.20
SurigaodelSur_Blk66O	0.00	0.00	0.04
SurigaodelSur_Blk66P	0.00	0.00	-0.18
SurigaodelSur_Blk66Q	0.00	0.00	-0.29
SurigaodelSur_Blk66R_Supplement	0.00	0.00	-0.30
SurigaodelSur_Blk66R	3.00	0.00	0.30
SurigaodelSur_Blk66T	0.00	0.00	0.08
SurigaodelSur_Blk66S	0.00	0.00	0.06
SurigaodelSur_Blk66T_Additional	0.00	0.00	0.08
SurigaodelSur_Blk66K	0.00	0.00	-0.18
SurigaodelSur_Blk66F	0.00	0.00	0.42

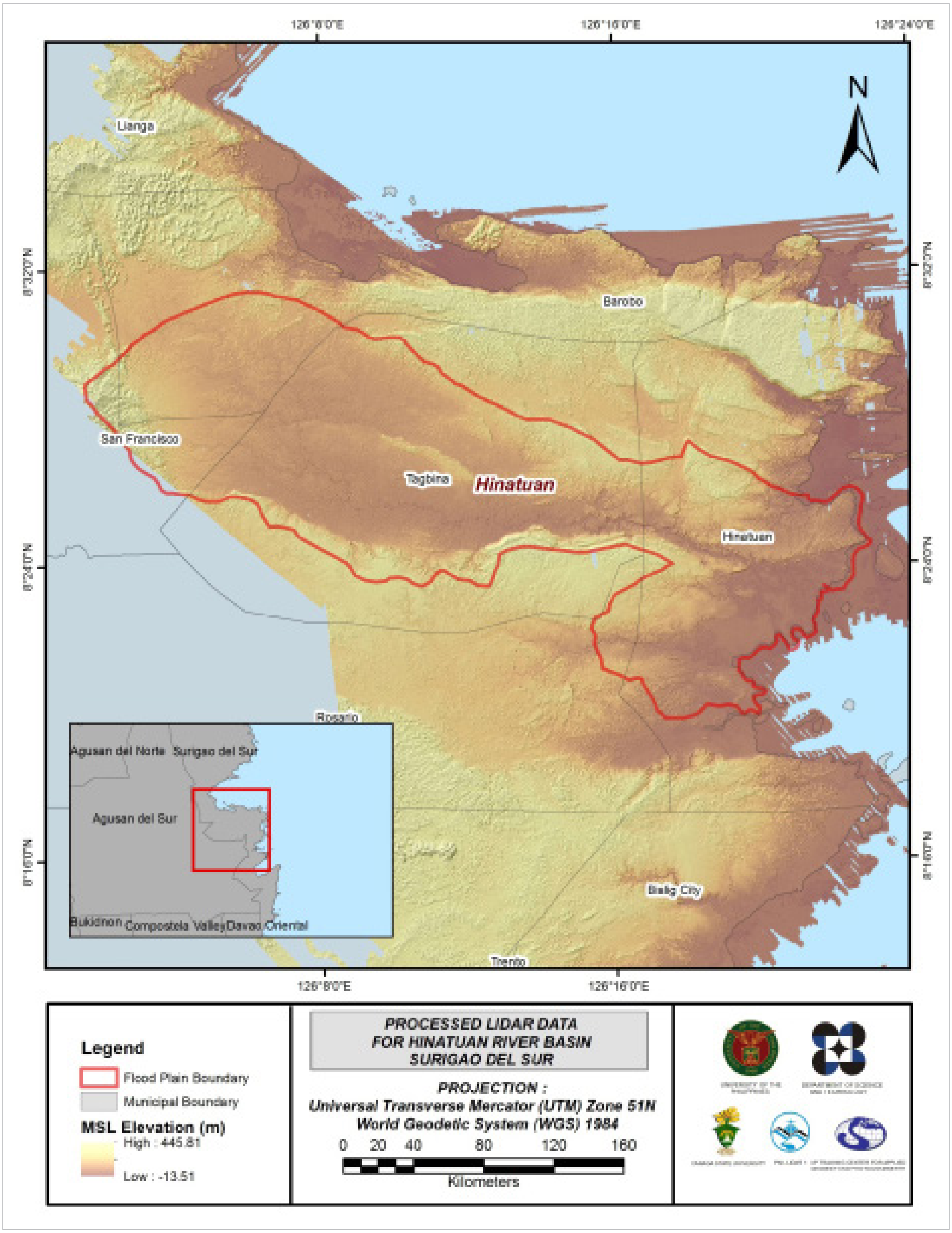

Figure 29. Map of Processed LiDAR Data for the Hinatuan floodplain.

3.10 Calibration and Validation of Mosaicked LiDAR DEM

To undertake the data validation of the Mosaicked LiDAR DEMs, the Data Validation and Bathymetry Component (DVBC) conducted a validation survey along the Hinatuan floodplain. The extent of the validation survey done by the DVBC in Hinatuan to collect points with which the LiDAR dataset was validated is presented in Figure 30, with the validation survey points highlighted in green. A total of 6,051 survey points were used for calibration and validation of the Hinatuan LiDAR data. Random selection of 80% of the survey points, resulting in 4,841 points, was used for calibration. A good correlation between the uncalibrated mosaicked LiDAR elevation values and the ground survey elevation values is reflected in Figure 31. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data, and to obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration elevation values is 0.32 meters, with a standard deviation of 0.17 meters. Calibration of the Hinatuan LiDAR data was performed by adding the height difference value, 0.32 meters, to the Hinatuan mosaicked LiDAR data. Table 21 enumerates the statistical values of the compared elevation values between the LiDAR data and the calibration data.

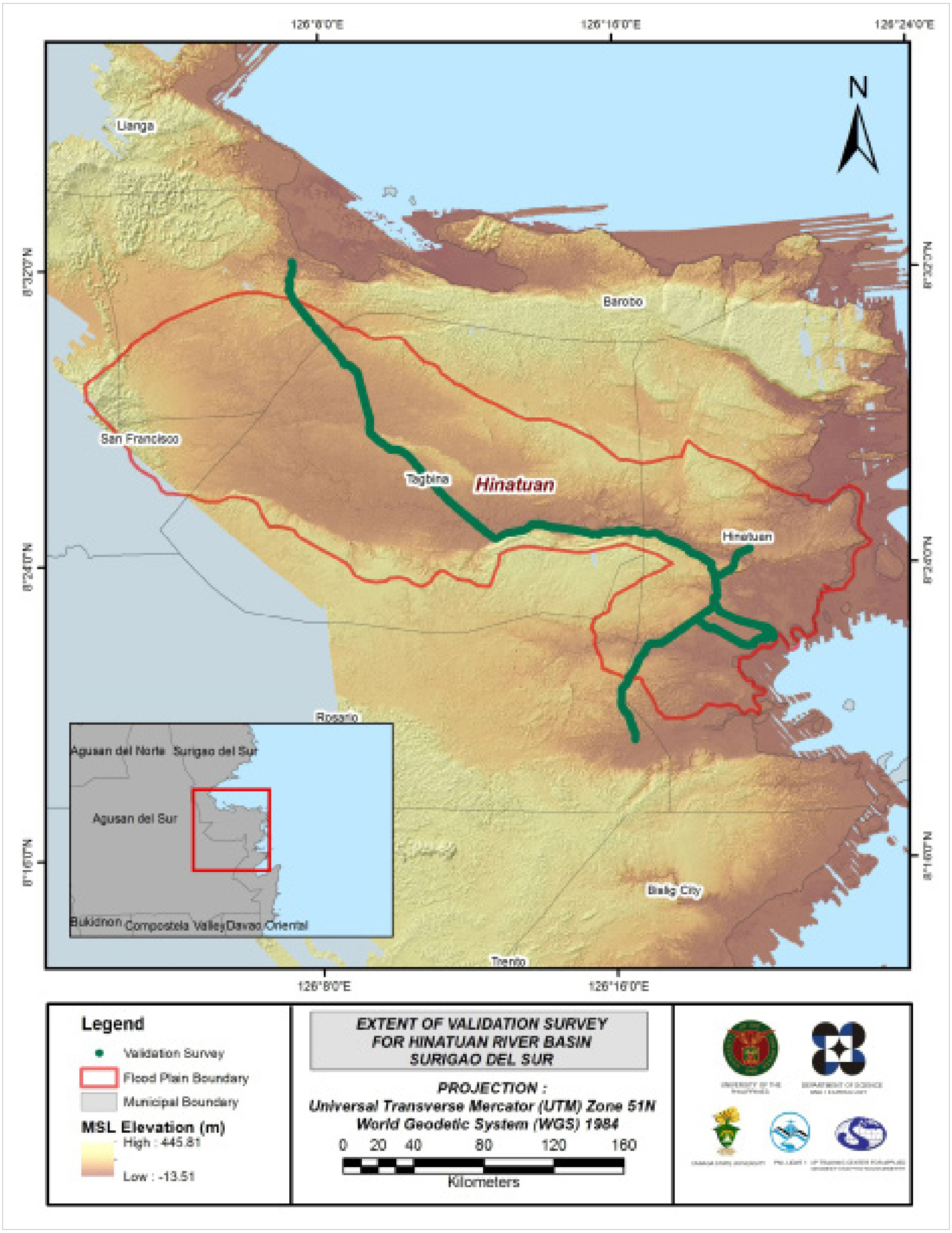

Figure 30. Map of the Hinatuan floodplain, with validation survey points in green.

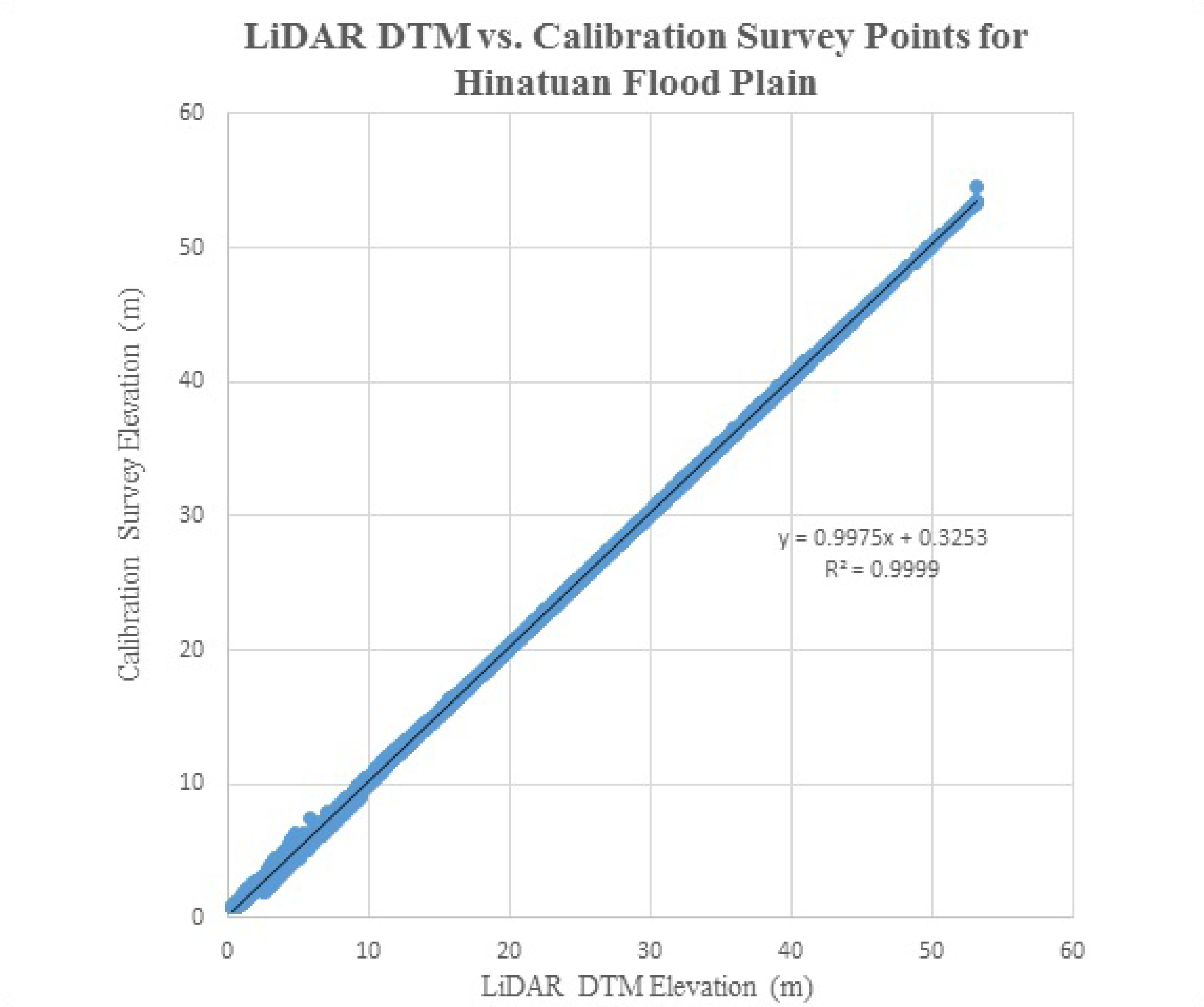

Figure 31. Correlation plot between calibration survey points and LiDAR data.

Table 21. Calibration Statistical Measures.

Calibration Statistical Measures	Value (meters)
Height Difference	0.32
Standard Deviation	0.17
Average	0.28
Minimum	-0.06
Maximum	0.61

The remaining 20% of the total survey points, resulting in 1,210 points, was used for the validation of calibrated Hinatuan 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 32. The computed RMSE between the calibrated LiDAR DTM and the validation elevation values is 0.16 meters, with a standard deviation of 0.16 meters, as presented in Table 22.

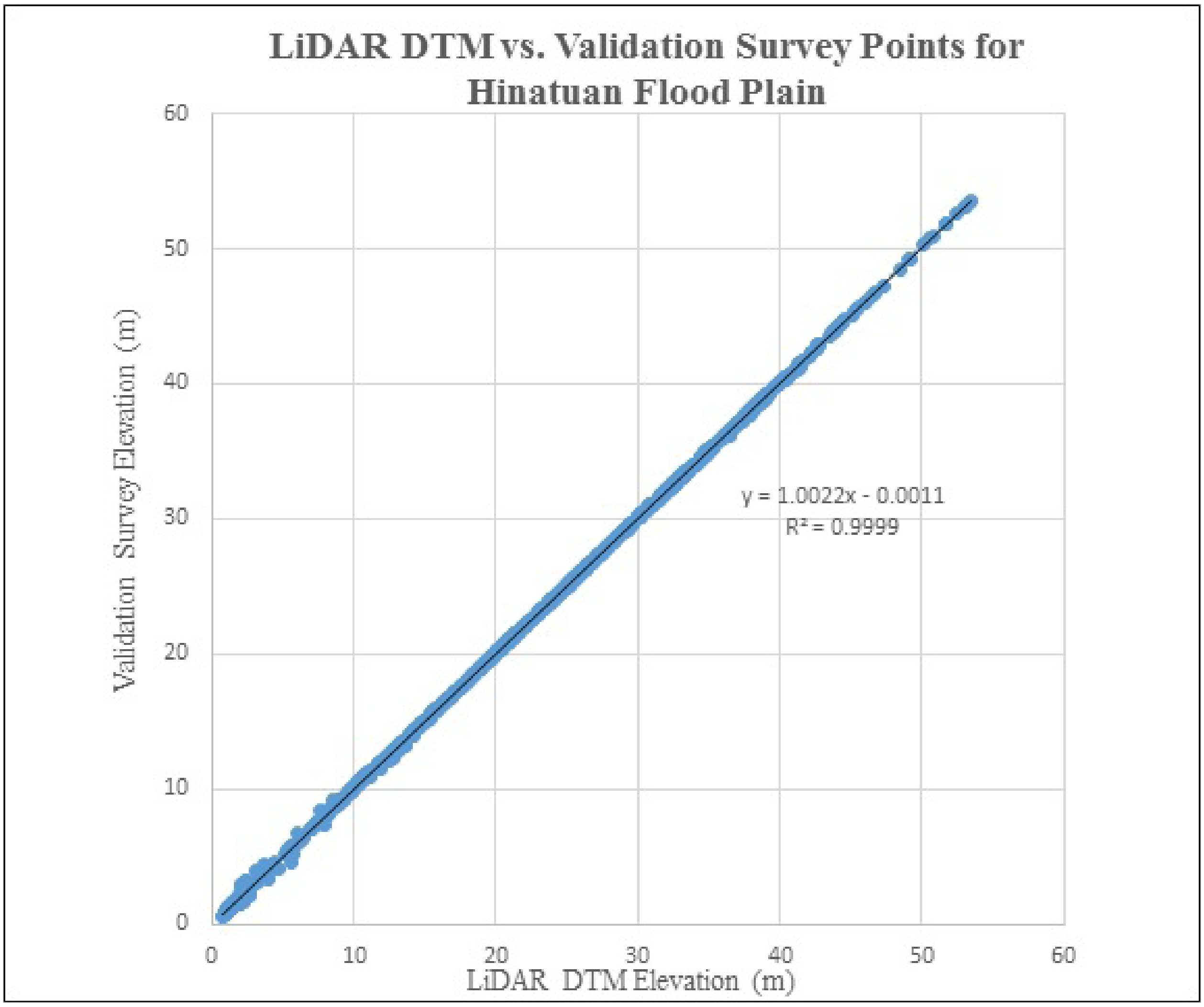

Figure 32. Correlation plot between validation survey points and LiDAR data.

Table 22. Validation Statistical Measures.

Calibration Statistical Measures	Value (meters)
Height Difference	0.16
Standard Deviation	0.16
Average	-0.04
Minimum	-0.35
Maximum	0.27

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, centerline and zigzag data were available for Hinatuan, with 11,738 bathymetric survey points. The resulting raster surface produced was done by employing the Kernel Interpolation with Barriers interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.10 meters. The extent of the bathymetric survey executed by the DVBC in Hinatuan, integrated with the processed LiDAR DEM, is illustrated in Figure 33.

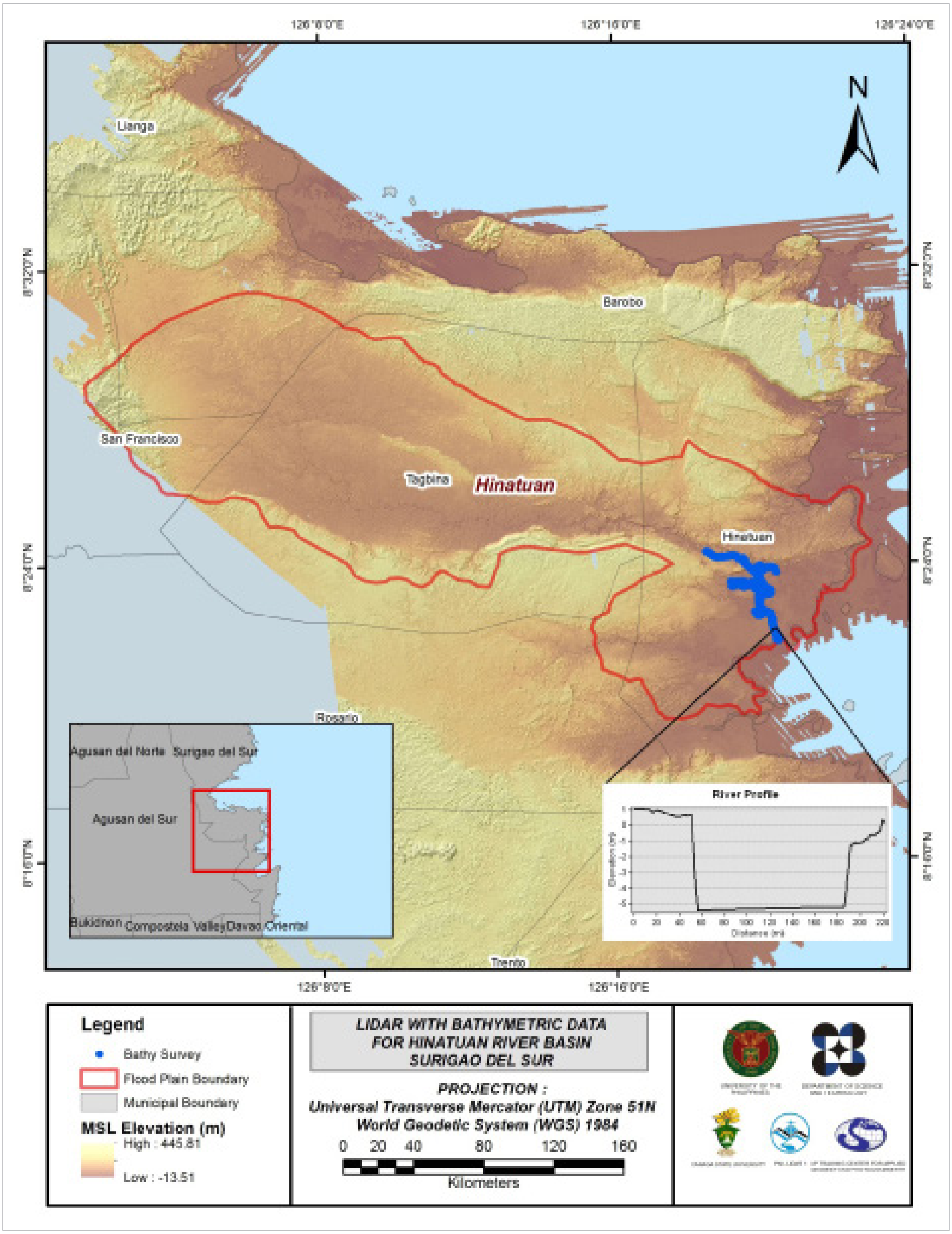

Figure 33. Map of the Hinatuan Floodplain with bathymetric survey points shown in blue.

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 a 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, comprised of main thoroughfares such as highways and municipal and barangay roads, are 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

The Hinatuan floodplain, including its 200-m buffer zone, has a total area of 374.94 sq. km. For this area, a total of 12.0 sq. km., corresponding to a total of 6,149 building features, were considered for quality checking (QC). Figure 34 shows the QC blocks for the Hinatuan floodplain.

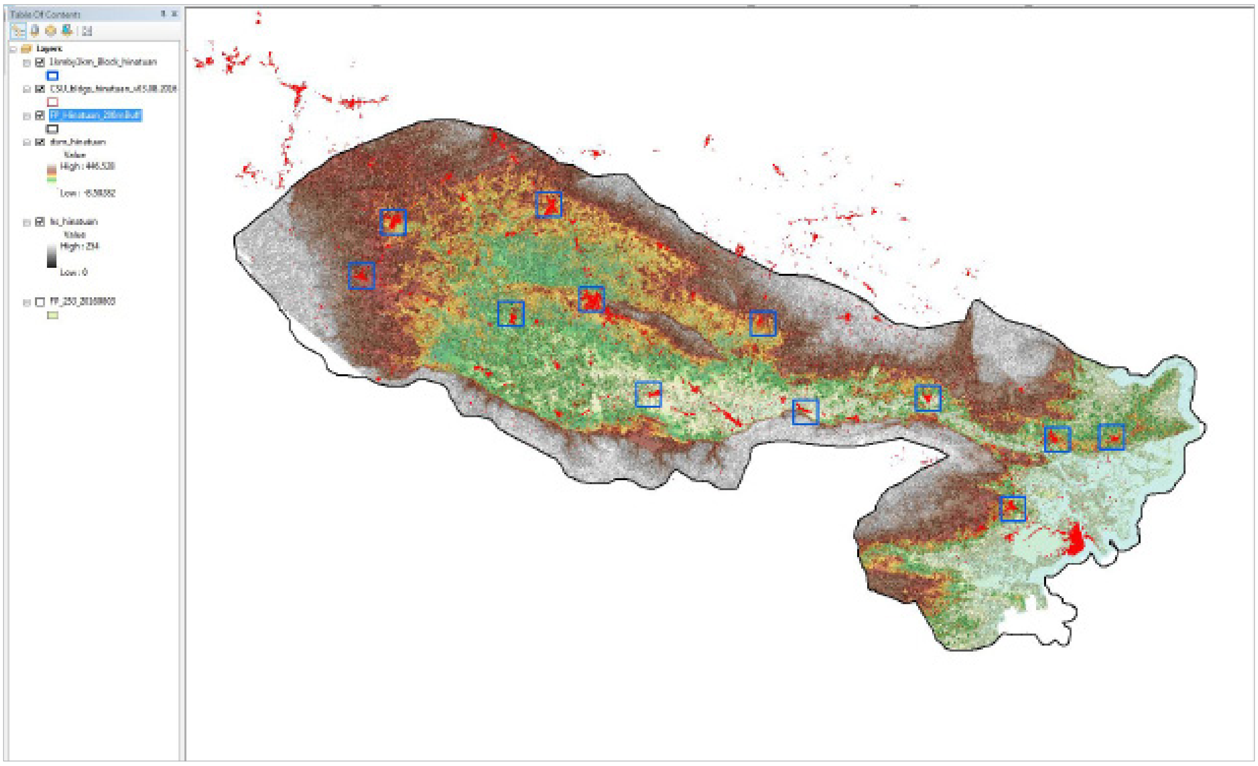

Figure 34. Blocks (in blue) of Hinatuan building features that were subjected to QC.

Quality checking of Hinatuan building features resulted in the ratings given in Table 23.

Table 23. Quality Checking Ratings for Hinatuan Building Features.

Floodplain	Completeness	Correctness	Quality	Remarks
Hinatuan	95.39	99.56	80.37	PASSED

3.12.2 Height Extraction

Height extraction was done for 17,180 building features in the Hinatuan floodplain. Of these building features, 1,295 buildings were filtered out after height extraction, resulting in 15,885 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 5.87 meters.

3.12.3 Feature Attribution

Field surveys, familiarity with the area, and free online web maps like Wikimapia (http://wikimapia.org/) and Google Maps (https://www.google.com/maps), were used to gather information, such as the names and types of the features within the river basin.

Table 24 summarizes the number of building features per type. Table 25 shows the total length of each road type, while Table 26 indicates the number of water features extracted per type.

Table 24. Building Features Extracted for the Hinatuan Floodplain.

Facility Type	No. of Features
Residential	15,697
School	164
Market	1
Agricultural/Agro-Industrial Facilities	0
Medical Institutions	8
Barangay Hall	0
Military Institution	0
Sports Center/Gymnasium/Covered Court	9
Telecommunication Facilities	0
Transport Terminal	1
Warehouse	0
Power Plant/Substation	0
NGO/CSO Offices	0
Police Station	0
Water Supply/Sewerage	0
Religious Institutions	1
Bank	1
Factory	0
Gas Station	0
Fire Station	1
Other Government Offices	2
Other Commercial Establishments	0
Total	**15,885**

Table 25. Total Length of Extracted Roads for the Hinatuan Floodplain.

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/ Municipal Road	Provincial Road	National Road	Others	
Hinatuan	319.44	18.06	198.45	67.22	36.52	**639.69**

Table 26. Number of Extracted Water Bodies for the Hinatuan Floodplain.

Floodplain	Water Body Type					Total
	Rivers/ Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Hinatuan	7	0	0	0	278	**285**

A total of sixty-five (65) 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 comprised the flood hazard exposure database for the floodplain. This completes the feature extraction phase of the project.

Figure 35 illustrates the Digital Surface Model (DSM) of the Hinatuan floodplain overlaid with its ground features

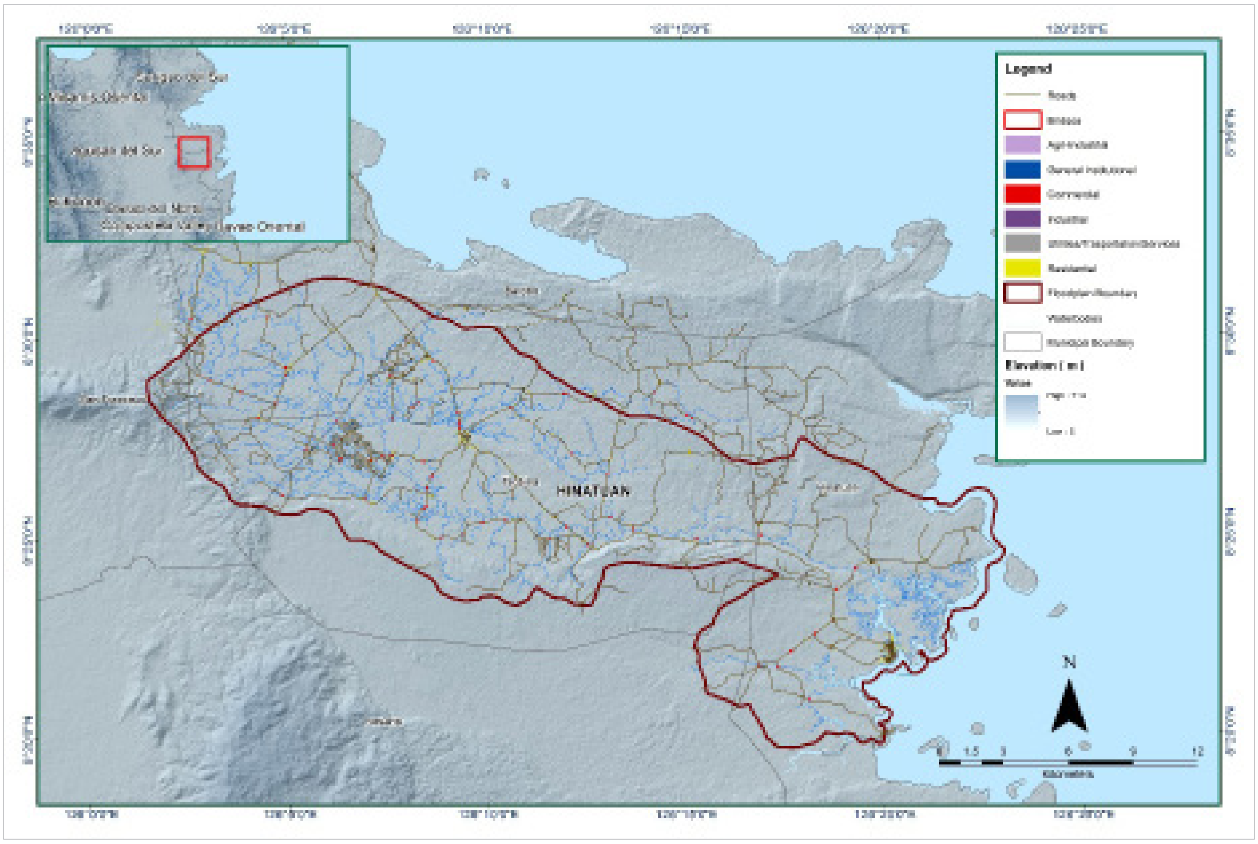

Figure 35. Extracted features for the Hinatuan floodplain.

CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE HINATUAN 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 DVBC conducted field surveys in the Hinatuan River on August 24 – September 7, 2015. The scope of work was comprised of: (i.) reconnaissance; (ii.) control point survey; (iii.) validation points acquisition of about 262.899 km. covering the Hinatuan River Basin area; and (iv.) bathymetric survey from the river's upstream in Barangay Tagbobonga in the Municipality of Hinatuan to the mouth of the river located in Barangay Benigno Aquino in the same Municipality, with an estimated length of 12.451 km using Ohmex™ single beam echo sounder and Trimble® SPS 882 GNSS PPK survey technique. A re-survey in the Hinatuan River was conducted on May 19 – 22, 2016 for the cross-section survey at the Hinatuan Bridge and the bathymetric surveys, to reconcile inconsistencies found in the elevation of the bathymetric and cross-section data.

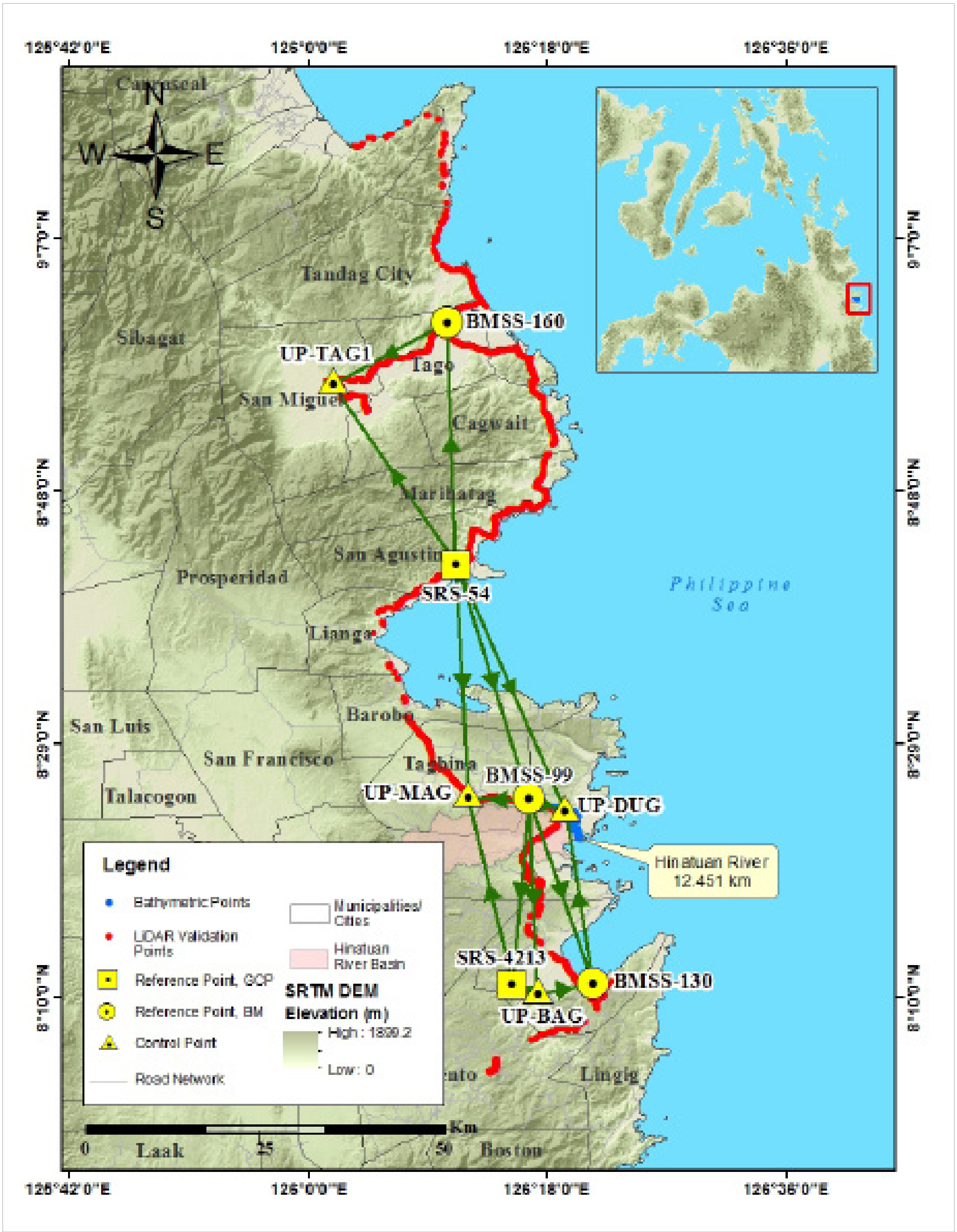


Figure 36. Extent of the bathymetric survey (in blue) in the Hinatuan River and the LiDAR data validation survey (in red)

4.2 Control Survey

The GNSS network used for the Hinatuan River Basin is composed of seven (7) loops established on August 24, and September 5-6, 2015. The network occupies the following reference points: (i.) BMSS-130, a first-order BM located in Barangay Mangagoy in Bislig City; (ii.) BMSS-160, a first-order BM located in Barangay Gamut in the Municipality of Tago; (iii.) BMSS-99, a first-order BM located in Barangay Pocto in the Municipality of Hinatuan; and (iv.) SRS-54, a second-order GCP located in Barangay Gata in the Municipality of San Agustin ().

A NAMRIA control point, SRS-4213 located in Barangay Burboanan in Bislig City, was also occupied and used as a marker along with four (4) other control points that were established in the area: (i.) UP-BAG located in Barangay Mone in Bislig City; (ii.) UP-DUG located in Barangay Dugmanon in the Municipality of Hinatuan; (iii.) UP-MAG located in Barangay Maglambing in the Municipality of Tagbina; and (iv.) UP-TAG1 located in Barangay Poblacion in the Municipality of San Miguel.

A summary of the reference and control points and their corresponding locations is provided in [ ], while the GNSS network established is illustrated in [ ].

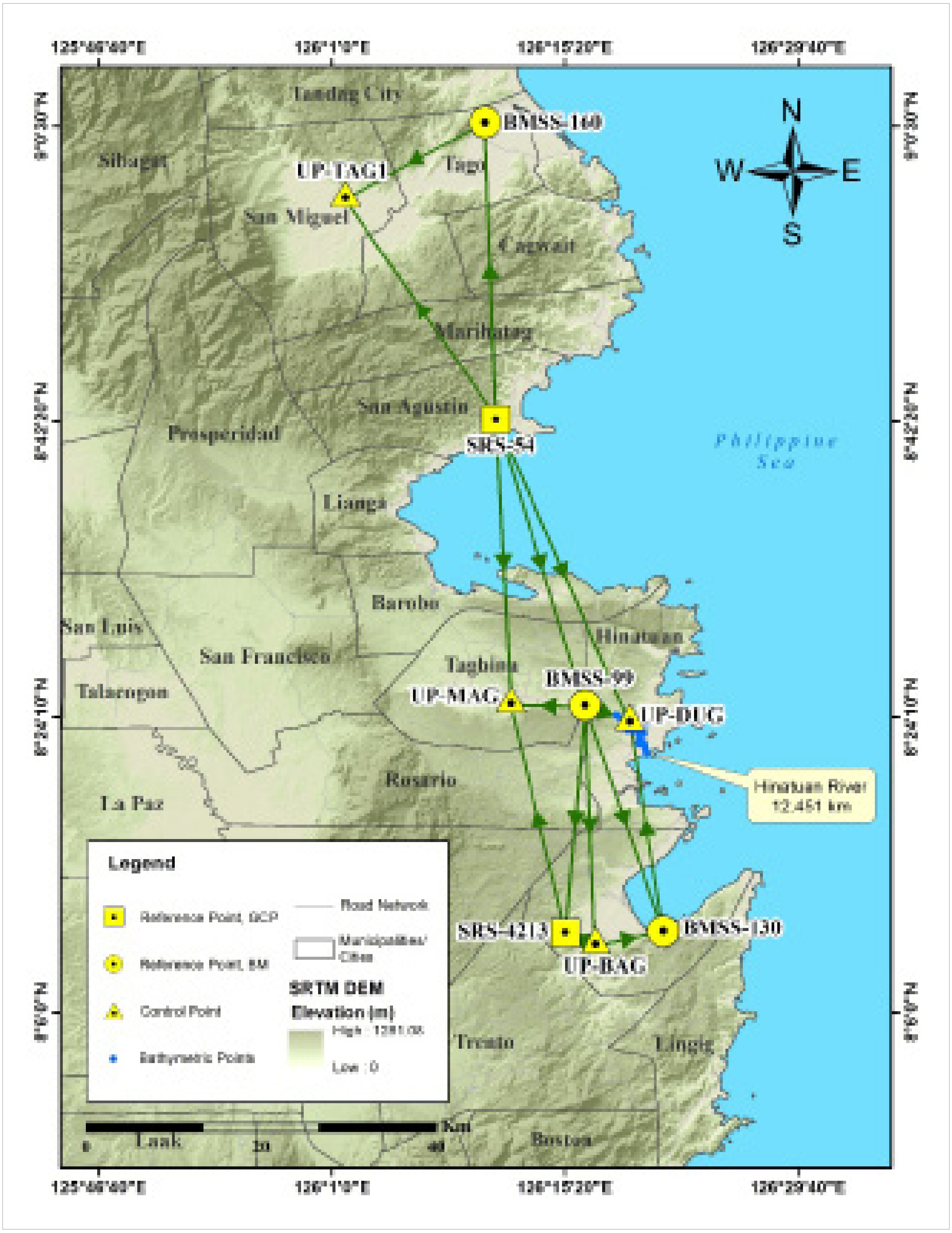


Figure 37. GNSS Network covering the Hinatuan River

Table 27. List of reference and control points occupied for Hinatuan River Survey

Control Point	Order of Accuracy	Geographic Coordinates (WGS UTM Zone 52N)				
		Latitude	Longitude	Ellipsoid Height (m)	Elevation (MSL) (m)	Date of Establishment
BMSS-130	1st order, BM	-	-	73.968	5.237	2008
BMSS-160	1st order, BM	-	-	75.213	7.065	2009
BMSS-99	1st order, BM	-	-	98.351	29.841	2008
SRS-54	2nd order, GCP	8˚42'29.12518" N	126˚11'07.08070" E	72.007	-	2007
SRS-4213	Used as Marker	-	-	-	-	2012
UP-BAG	UP Established	-	-	-	-	Sep 5, 2015
UP-DUG	UP Established	-	-	-	-	Sep 6, 2015
UP-MAG	UP Established	-	-	-	-	Sep 6, 2015
UP-TAG1	UP Established	-	-	-	-	Aug 27, 2015

The GNSS set-ups on the recovered reference points and established control points in the Hinatuan River are depicted in to :

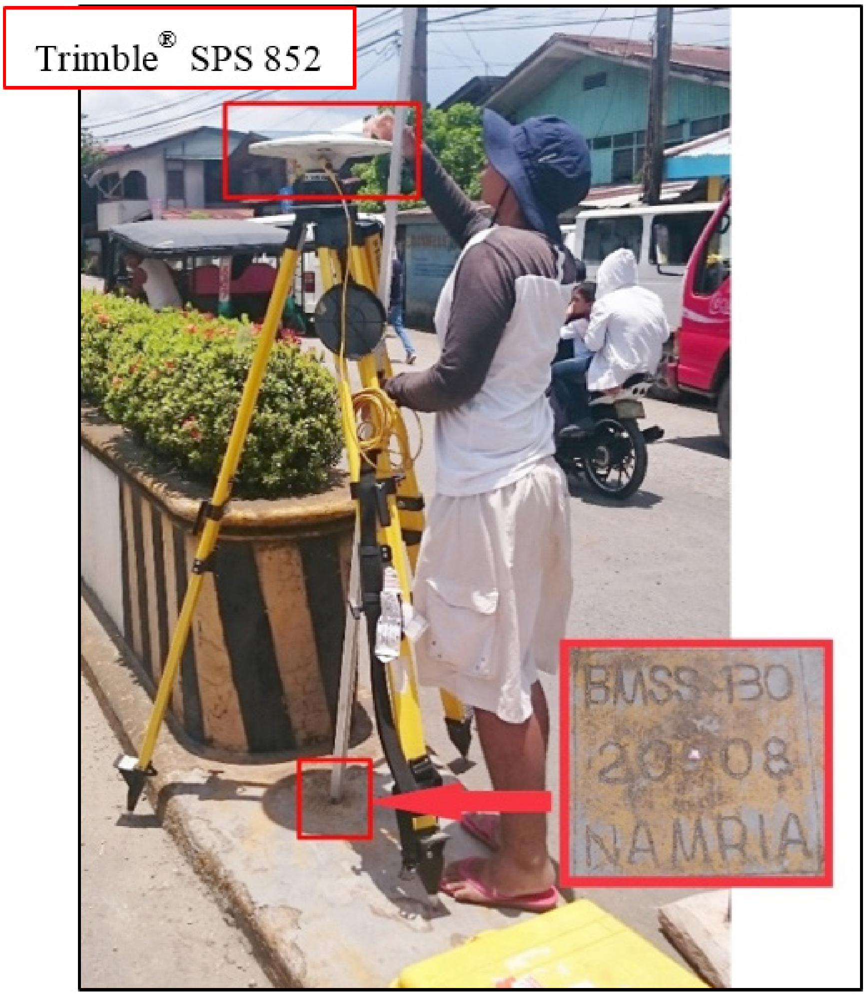


Figure 38. GNSS base set-up, Trimble® SPS 852, at BMSS-130 located on one end of a concrete barrier along Surigao-Davao Coastal Road in Barangay Mangagoy, Bislig City, Surigao del Sur

Figure 39. GNSS base set-up, Trimble® SPS 852, at BMSS-160, located at Pamuksukan Bridge in Barangay Gamut, Tago, Surigao del Sur

Figure 40. GNSS receiver set-up, Trimble® SPS 882, at BMSS-99 located inside the Mahayhay Primary School in the Municipality of Hinatuan, Surigao del Sur

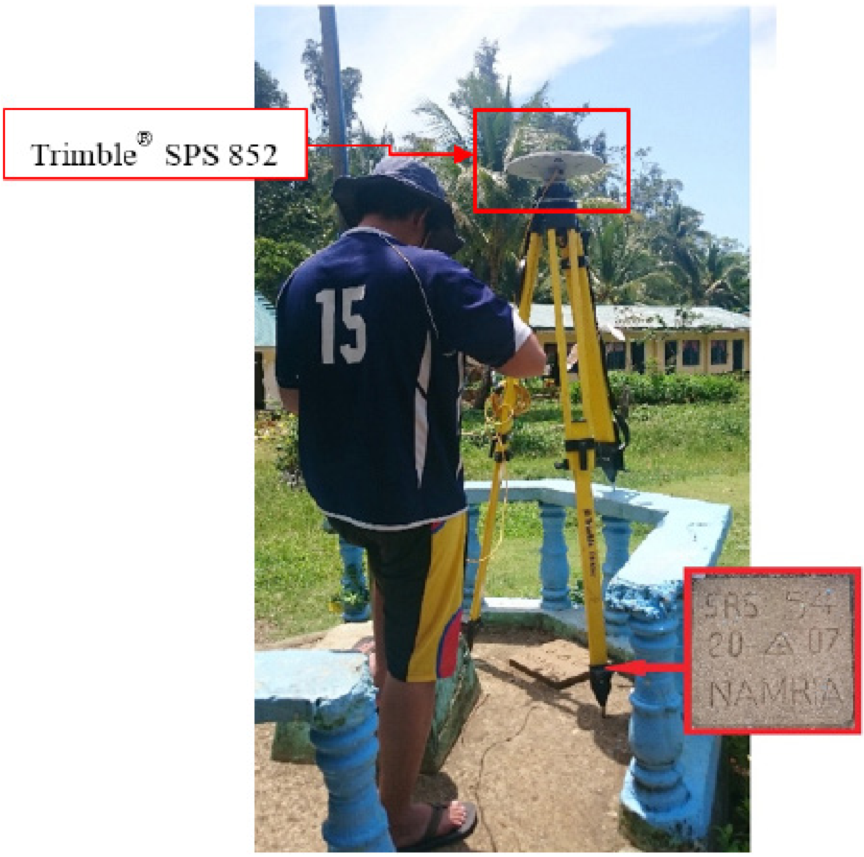


Figure 41. GNSS receiver set-up, Trimble® SPS 853, at SRS-54 near the flag pole of the Gata Integrated School in San Agustin, Surigao del Sur

Figure 42. GNSS receiver set-up, Trimble® SPS 882, at BMSS-4213 located near the Burboanan Bridge in Barangay Burboanan, Bislig City, Surigao del Sur

Figure 43. GNSS base set-up, Trimble® SPS 852, at UP-BAG, located near the Bagnan Bridge in Barangay Mone, Bislig City, Surigao del Sur

Figure 44. GNSS receiver set-up, Trimble® SPS 882, at UP-DUG, located near the Hinatuan Bridge in the Municipality of Hinatuan, Surigao del Sur

Figure 45. GNSS base set-up, Trimble® SPS 985, at UP-MAG, located at the Maglambing Bridge along Surigao-Davao Coastal Road in Barangay Maglambing in the Municipality of Tagbina, Surigao del Sur

Figure 46. GNSS base set-up, Trimble® SPS 882, at UP-TAG1, located at the Tago-San Miguel Bridge, Municipality of San Miguel, Surigao del Sur

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 cases where one or more baselines did not meet all of these criteria, masking was performed. Masking is the removal of 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, a re-survey is initiated. Baseline processing results of control points in the Hinatuan River Basin generated by the TBC software is summarized in .

Table 28. Baseline Processing Report for the Hinatuan River Basin Static Survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	Δ Height (m)
SRS-4213— UP-MAG	09-06-2015	Fixed	0.006	0.028	346°54'31"	27101.111	10.348
UP-BAG — SRS-4213	09-05-2015	Fixed	0.003	0.016	283°45'49"	3553.032	0.870
SS-99 — SS-130	09-06-2015	Fixed	0.004	0.025	160°56'32"	27048.109	-24.369
UP-BAG — SS-130	09-05-2015	Fixed	0.007	0.030	82°31'19"	7687.540	2.595
SS-99 — UP-BAG	09-06-2015	Fixed	0.005	0.028	177°23'35"	26593.869	-26.916
SS-99 — SRS-4213	09-06-2015	Fixed	0.008	0.030	184°58'49"	25818.568	-26.099
SS-130 — UP-DUG	09-06-2015	Fixed	0.004	0.026	351°04'11"	24555.772	-1.865
SS-99 — UP-DUG	09-06-2015	Fixed	0.005	0.017	104°37'16"	5182.796	-26.175
SS-160 — SRS-54	08-27-2015	Fixed	0.009	0.042	357°50'28"	33687.727	3.259
SS-99 — UP-MAG	09-06-2015	Fixed	0.006	0.020	274°36'46"	8405.733	-15.761
UP-TAG1 — SRS-54	08-27-2015	Fixed	0.005	0.037	326°20'38"	30763.333	13.888
UP-DUG — BMSS-99	09-06-2015	Fixed	0.003	0.019	284°37'40"	5182.793	26.194
SS-99 — UP-MAG	09-06-2015	Fixed	0.005	0.023	274°36'46"	8405.736	-15.773
SS-99 — SRS-54	09-06-2015	Fixed	0.011	0.031	162°48'46"	33945.127	26.544
SRS-54 — UP-MAG	09-06-2015	Fixed	0.014	0.058	177°01'20"	31798.307	10.764
UP-DUG — SRS-54	09-06-2015	Fixed	0.005	0.025	155°57'50"	36939.414	0.268
SS-160 — UP-TAG1	08-27-2015	Fixed	0.008	0.017	242°57'01"	17718.093	10.680

As shown in a total of seventeen (17) baselines were processed with reference point SRS-54 held fixed for coordinate value; and BMSS-130, BMSS-160, and, BMSS-99 held fixed for elevation values. All of the baselines satisfied the required accuracy.

4.4 Network Adjustment

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

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

Where:

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

The nine (9) control points, SRS-54, SS-130, SS-160, SS-99, SRS-4213, UP-BAG, UP-DUG, UP-MAG, and UP-TAG1, were occupied and observed simultaneously to form a GNSS loop. Coordinates of SRS-54 and elevation values of SS-130 and SS-160 were held fixed during the processing of the control points, as presented in . Through these reference points, the coordinates and elevation of the unknown control points were computed.

Table 29. Control Point Constraints

Point ID	Type	North (Meter)	East (Meter)	Height (Meter)	Elevation (Meter)
BMSS-130	Grid				Fixed
BMSS-160	Grid				Fixed
BMSS-99	Grid				Fixed
SRS-54	Global	Fixed	Fixed		
Fixed = 0.000001(Meter)					

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

Table 30. Adjusted grid coordinates

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
BMSS-130	869923.595	0.025	906149.656	0.019	5.237	?	e
BMSS-160	848999.411	0.009	997745.370	0.008	7.065	?	e
BMSS-99	860869.543	0.023	931673.348	0.017	29.782	0.069	
SRS-4213	858838.293	0.024	905903.658	0.019	2.959	0.088	
SRS-54	850558.697	?	964056.168	?	3.335	0.072	LL
UP-BAG	862300.278	0.025	905085.566	0.019	2.211	0.083	
UP-DUG	865901.481	0.023	930405.547	0.017	4.035	0.075	
UP-MAG	852475.815	0.023	932279.823	0.018	13.509	0.085	
UP-TAG1	833273.403	0.007	989543.115	0.007	16.502	0.064	

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

a. SRS-54

Horizontal Accuracy = Fixed
Vertical Accuracy = 7.2 cm < 10 cm

b. SS-130

Horizontal Accuracy = $\sqrt{(2.50)^2 + (1.90)^2}$
= $\sqrt{6.25 + 3.61}$
= 3.14 cm < 10 cm
Vertical Accuracy = Fixed

c. SS-160

Horizontal Accuracy = $\sqrt{(0.9)^2 + (0.8)^2}$
= $\sqrt{0.81 + 0.64}$
= 1.20 cm < 10 cm
Vertical Accuracy = Fixed

d. SS-99

Horizontal Accuracy = $\sqrt{(2.30)^2 + (1.70)^2}$
= $\sqrt{5.29 + 2.89}$
= 2.86 cm < 20 cm
Vertical Accuracy = 6.90 cm < 10 cm

e. SRS-4213

Horizontal Accuracy = $\sqrt{(2.40)^2 + (1.90)^2}$
= $\sqrt{5.76 + 3.61}$
= 3.06 cm < 20 cm
Vertical Accuracy = 8.80 cm < 10 cm

f. UP-BAG

Horizontal Accuracy = $\sqrt{(2.50)^2 + (1.90)^2}$
= $\sqrt{6.25 + 3.61}$
= 3.14 cm < 20 cm
Vertical Accuracy = 8.30 cm < 10 cm

g. UP-DUG

Horizontal Accuracy = $\sqrt{(2.30)^2 + (1.70)^2}$
= $\sqrt{5.29 + 2.89}$
= 2.86 cm < 20 cm
Vertical Accuracy = 7.50 cm < 10 cm

h. UP-MAG

Horizontal Accuracy = $\sqrt{(2.30)^2 + (1.80)^2}$
= $\sqrt{5.29 + 3.24}$
= 2.92 cm < 20 cm
Vertical Accuracy = 8.50 cm < 10 cm

i. UP-TAG1

Horizontal Accuracy = $\sqrt{(0.70)^2 + (0.70)^2}$
= $\sqrt{0.49 + 0.49}$
= 0.99 cm < 20 cm
Vertical Accuracy = 6.40 cm < 10 cm

Following the given formula, the horizontal and vertical accuracy results of the two (2) occupied control points are within the required accuracy of the project.

Table 31. Adjusted geodetic coordinates

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
BMSS-130	N8°11'01.30897"	E126°21'23.49960"	73.969	?	e
BMSS-160	N9°00'44.86640"	E126°10'25.53097"	75.213	?	e
BMSS-99	N8°24'53.51089"	E126°16'34.96716"	98.292	0.069	
SRS-4213	N8°10'56.27507"	E126°15'21.74124"	72.265	0.088	
SRS-54	N8°42'29.12518"	E126°11'07.08070"	71.864	0.072	LL
UP-BAG	N8°10'28.76338"	E126°17'14.48487"	71.388	0.083	
UP-DUG	N8°24'10.91693"	E126°19'18.89585"	72.120	0.075	
UP-MAG	N8°25'15.48835"	E126°12'01.07825"	82.582	0.085	
UP-TAG1	N8°56'22.49905"	E126°01'48.98421"	85.877	0.064	

The corresponding geodetic coordinates of the observed points are within the required accuracy, as shown in

Based on the results of the computation, the accuracy conditions are satisfied; hence, the required accuracy for the program was met.

The computed coordinates of the reference and control points utilized in the Hinatuan River GNSS Static Survey are indicated in .

Table 32. Reference and control points used and their corresponding locations (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoid Height (m)	Northing (m)	Easting (m)	BM Ortho (m)
SRS-54	2nd Order, GCP	8°42'29.12518"	126°11'07.08070"	71.864	964056.168	850558.697	3.335
SS-130	1st Order, BM	8°11'01.30897"	126°21'23.49960"	73.969	906149.656	869923.595	5.237
SS-160	1st Order, BM	9°00'44.86640"	126°10'25.53097"	75.213	997745.370	848999.411	7.065
SS-99	Used as Marker	8°24'53.51089"	126°16'34.96716"	98.292	931673.348	860869.543	29.782
SRS-4213	Used as Marker	8°10'56.27507"	126°15'21.74124"	72.265	905903.658	858838.293	2.959
UP-BAG	UP Established	8°10'28.76338"	126°17'14.48487"	71.388	905085.566	862300.278	2.211
UP-DUG	UP Established	8°24'10.91693"	126°19'18.89585"	72.120	930405.547	865901.481	4.035
UP-MAG	UP Established	8°25'15.48835"	126°12'01.07825"	82.582	932279.823	852475.815	13.509
UP-TAG1	UP Established	8°56'22.49905"	126°01'48.98421"	85.877	989543.115	833273.403	16.502

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

Cross-section and bridge as-built surveys were conducted on May 21, 2016 at the downstream side of the Hinatuan Bridge located in Barangay Pagtigni-An, Municipality of Hinatuan, Surigao del Sur. as shown in . A Trimble® SPS 882 GNSS PPK survey technique and Ohmex™ single beam echo sounder was utilized for this survey.

Figure 47. Hinatuan Bridge facing downstream

The length of the cross-sectional line surveyed in the Hinatuan Bridge is about 92.86 m., with 157 cross-sectional points using the control point BMSS-99 as the GNSS base station. The location map, cross-section diagram, and bridge as-built form are shown in Figure 48,

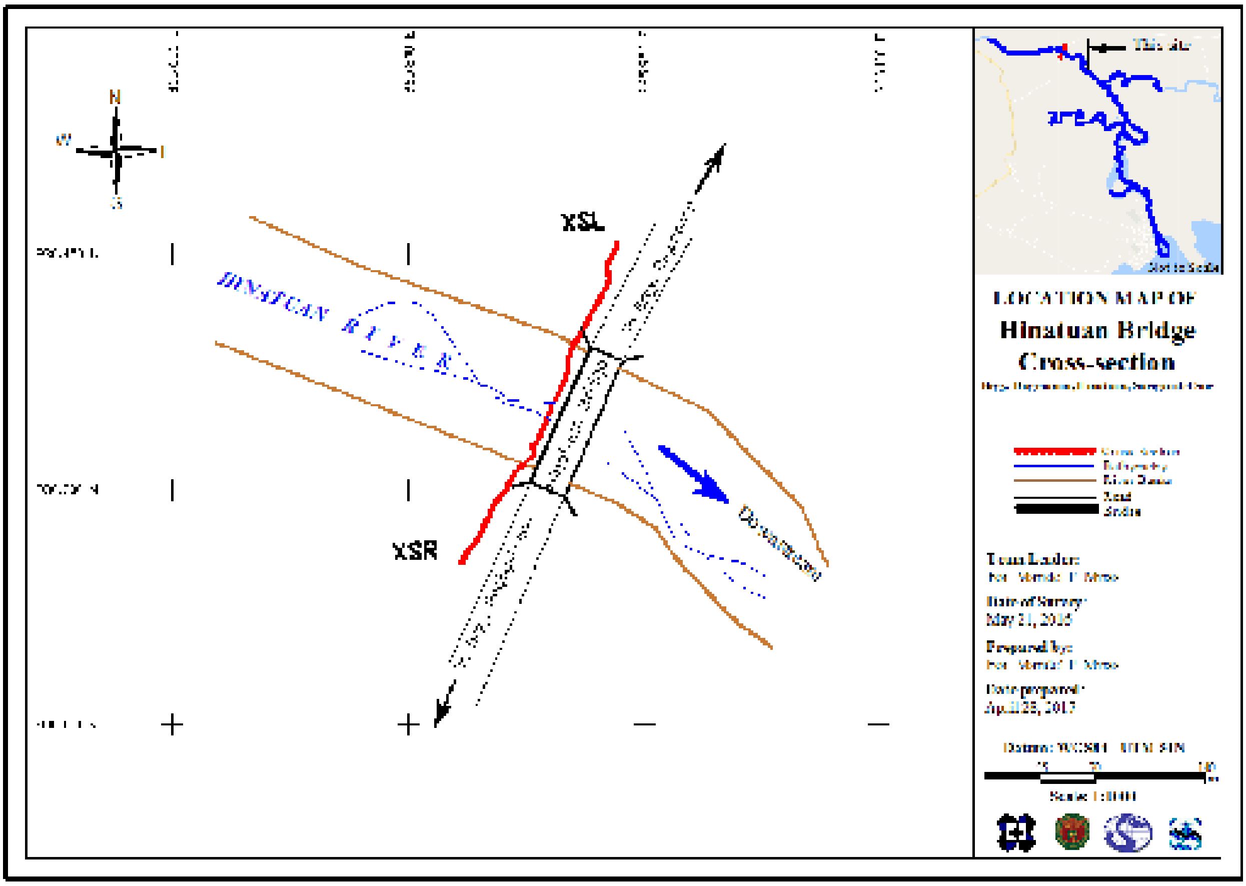


Figure 48. Hinatuan bridge cross-section location map

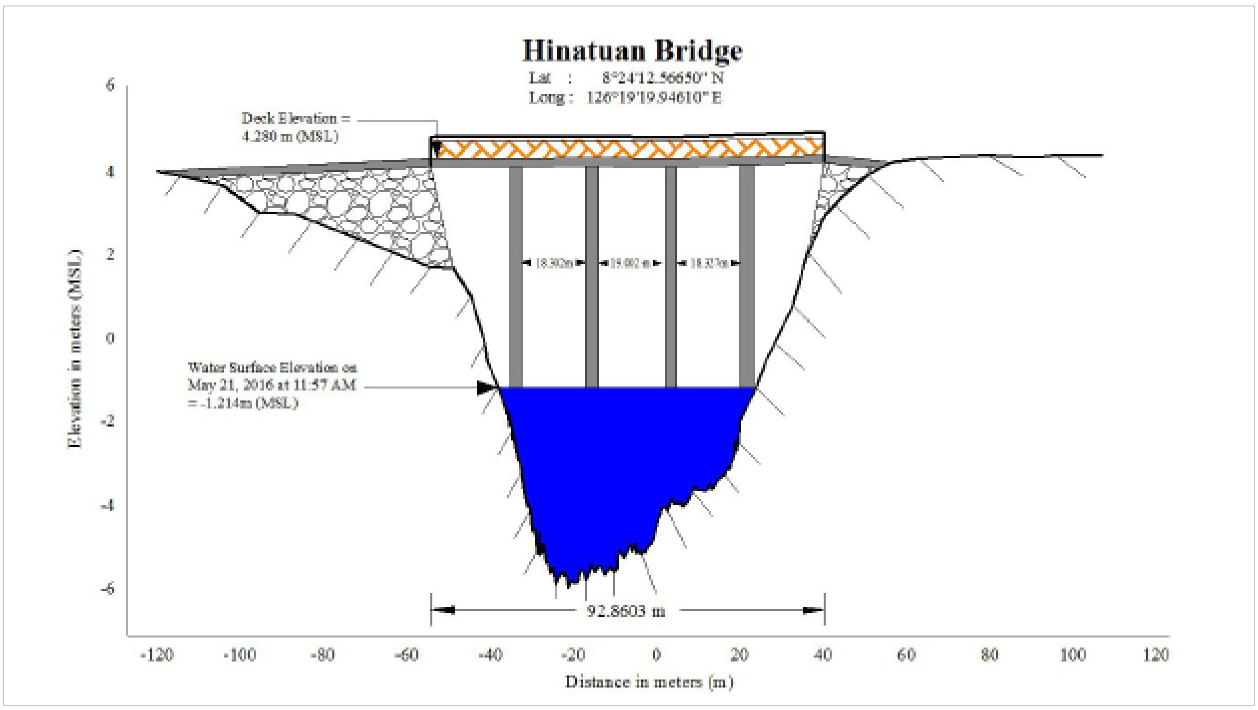


Figure 49. Hinatuan Bridge cross-section diagram

Bridge Data Form

Bridge Name: Hinatuan Bridge — Date: May 21, 2016

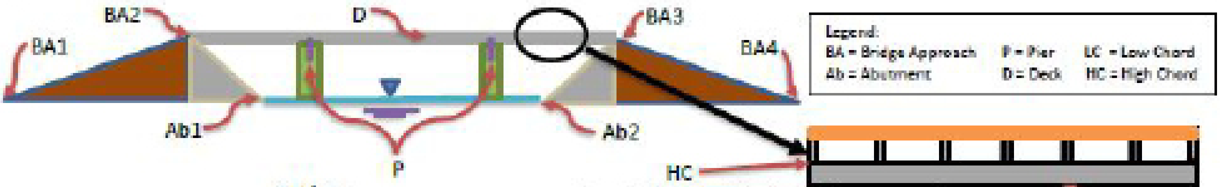
River Name: Hinatuan River — Time: 11:57 AM

Location (Brgy, City, Region): Brgy. Pagtigni-an, Municipality of Hinatuan, Surigao del Sur

Survey Team: Maridel Miras, Caren Joy Ordona, Cibyl Atacador

Flow condition: average — Weather Condition: fair

Latitude: 8°24'12.56650" N — Longitude: 126°19'19.94610" E



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

Elevation: 4.280 m — Width: — Span (BA3-BA2): 92.860 m

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

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	3.983 m	BA3	160.090	4.374 m
BA2	67.229 m	4.280 m	BA4	226.909 m	4.366 m

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

	Station (Distance from BA1)	Elevation
Ab1	NA	NA

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

Shape: round — Number of Piers: 4 — Height of column footing: Not available

	Station (Distance from BA1)	Elevation	Pier Diameter
Pier 1	86.086 m	4.284 m	1 m
Pier 2	104.388 m	4.298 m	1 m
Pier 3	123.391 m	4.272 m	1 m
Pier 4	141.718 m	4.324 m	1 m

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

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure 50. Bridge as-built form of Trinidad Bridge

Water surface elevation of the Hinatuan River at the Hinatuan Bridge was determined using Trimble® SPS 882 GNSS PPK survey technique on May 21, 2016 at 11:57 AM, with a value of -1.214 m. This was translated into markings on the wall under the bridge using the same technique. The marking served as reference for flow data gathering and depth gauge deployment of CSU.

4.6 Validation Points Acquisition Survey

The validation points acquisition survey was conducted on August 25, 26, and 31, 2015 and September 1 and 3, 2015. The survey was performed using a survey-grade GNSS Rover receiver, Trimble® SPS 885, mounted in front of a vehicle, as shown in Figure 51.

It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height was 2.404 m., measured from the ground up to the bottom of notch of the GNSS Rover receiver. The PPK technique utilized for the conduct of the survey was set to continuous topo mode, with SRS-54, BMSS-130, BMSS-160, BMSS-99, and UP-TAG1 occupied as the GNSS base stations.

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

The survey commenced in Barangay Caras-An in the Municipality of Tago, heading east until reaching Barangay Victoria in the same municipality. The survey continued the following day, and was executed until September 3, 2015. The continuation of the survey started in Barangay Gamut in the Municipality of Tago, and traversed fourteen (14) municipalities southward, ending in Barangay Santa Maria in the Municipality of Tagbina. A total of 27,310 points were gathered, with an approximate length of 262.899 km., using SRS-54, BMSS-130, BMSS-160, BMSS-99, and UP-TAG1 as the GNSS base stations for the entire validation points acquisition survey. This is illustrated in the map in Figure 52.

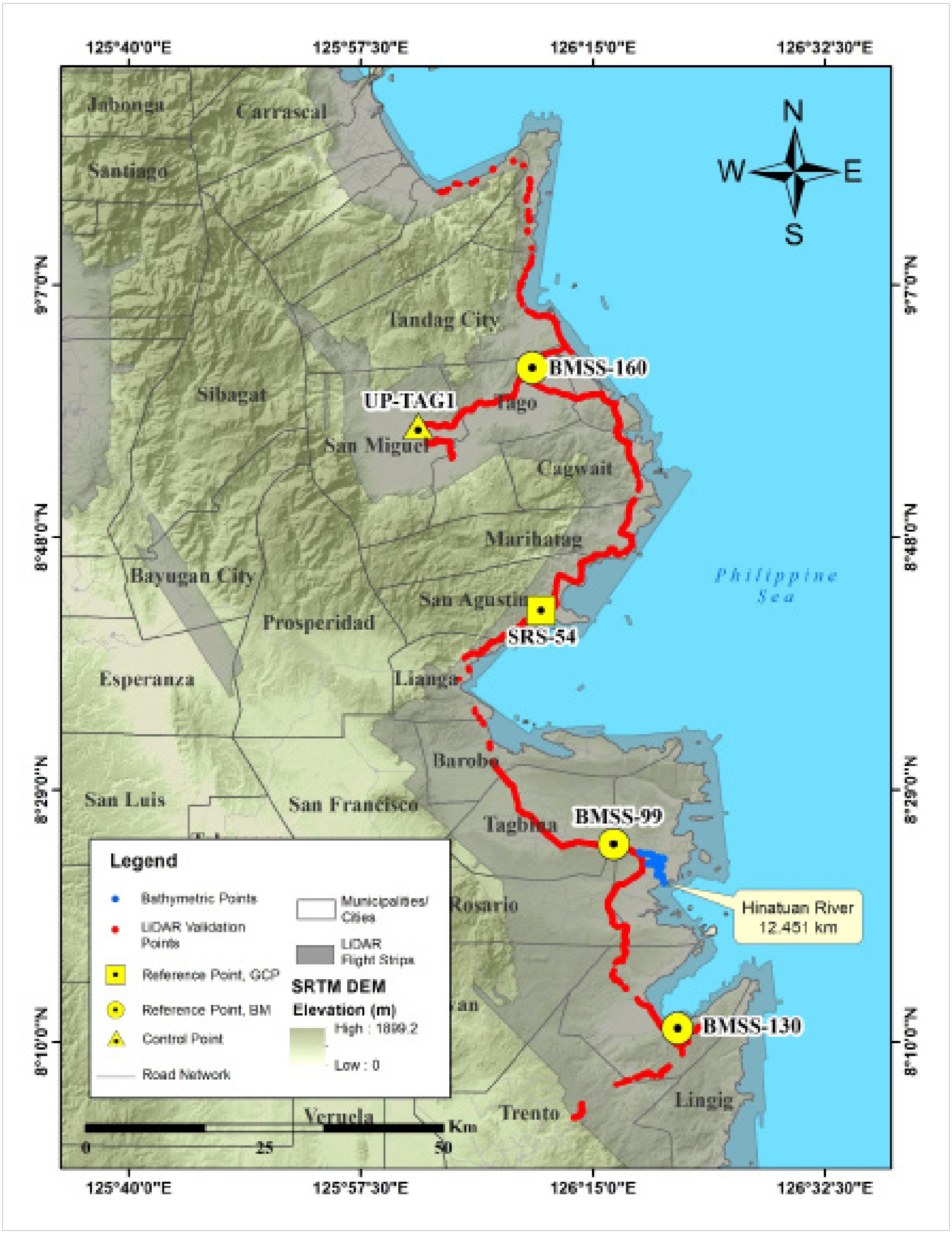


Figure 52. Extent of the LiDAR ground validation survey of the Hinatuan River Basin

4.7 Bathymetric Survey

A manual bathymetric survey was executed on September 3, 2015 using an Ohmex™ single beam echo sounder, and Trimble® SPS 885 in GNSS PPK survey technique in continuous topo mode, as illustrated in [ ]. The survey started in Barangay Tagbobonga in the Municipality of Hinatuan, with grid coordinates 930590.658 northing and 864386.545 easting; and ended at the downstream side of the river in Barangay Zone II in the same municipality, with grid coordinates 926166.228 northing and 867986.298 easting. The control point BMSS-99 was used as the GNSS base station all throughout the survey. A re-survey for the bathymetry data of the Hinatuan River was conducted on May 19 – 22, 2016 to reconcile discrepancies found in the elevation of the previously surveyed data.

Figure 53. Bathymetry set-up using OHMEX™ single beam echo sounder in Hinatuan River

The bathymetric survey for the Hinatuan River gathered a total of 10,901 points, covering 12.451 km. of the river, traversing five (5) barangays in the Municipality of Hinatuan. A CAD drawing was also produced to illustrate the riverbed profile of the Hinatuan River. As shown in [ ], [ ], and, [ ], the highest and lowest elevation had a 62.678-m. difference. The highest elevation observed was 68.349 m. above MSL, located in Barangay Tagbobonga in the Municipality of Hinatuan. The lowest elevation was -5.671 m. below MSL, located in Barangay Zone II in the same Municipality. The survey for the remaining 3 km. downstream of the river was curtailed because the LiDAR DEM data of its riverbed was already available.

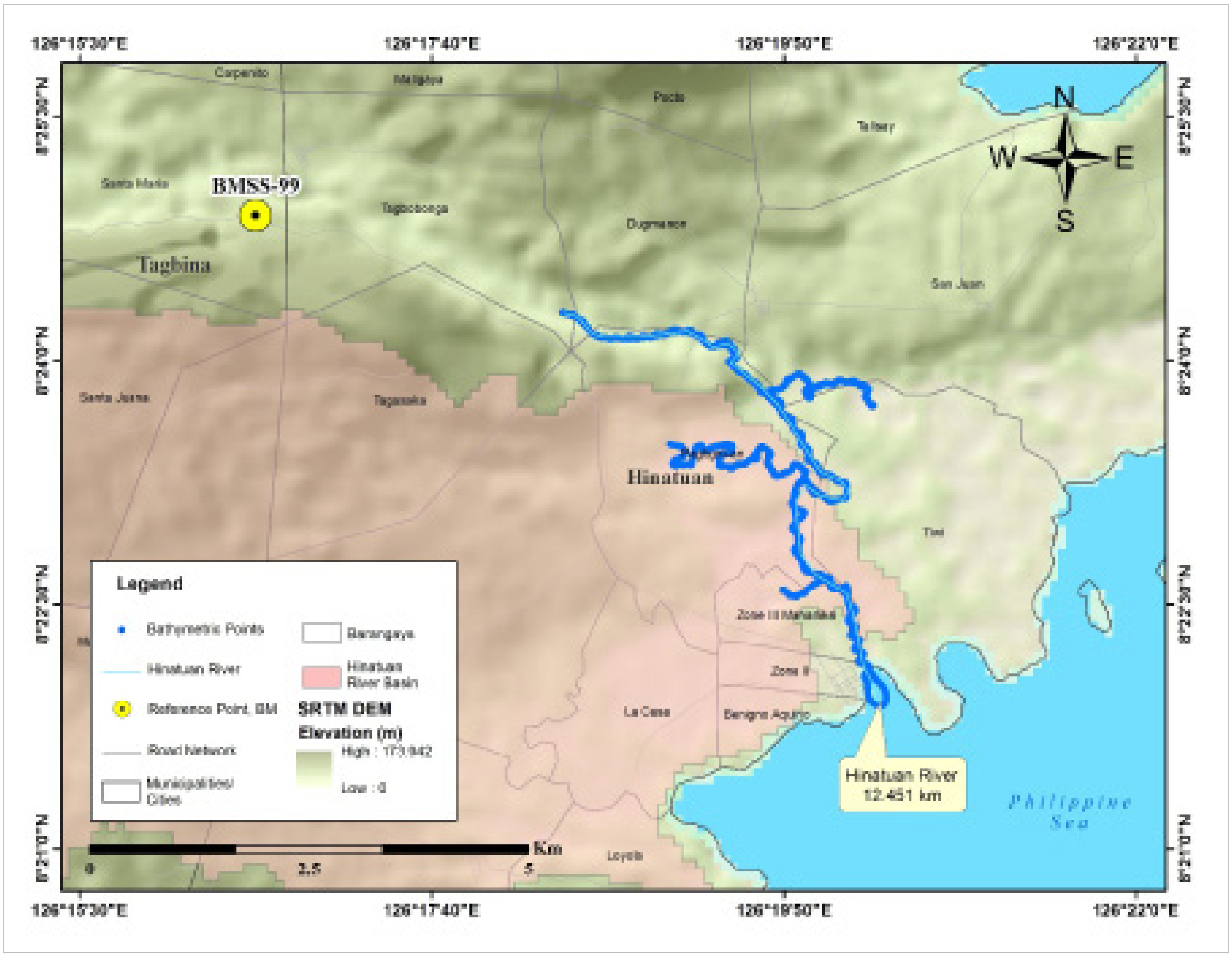


Figure 54. Extent of the bathymetric survey of the Hinatuan River

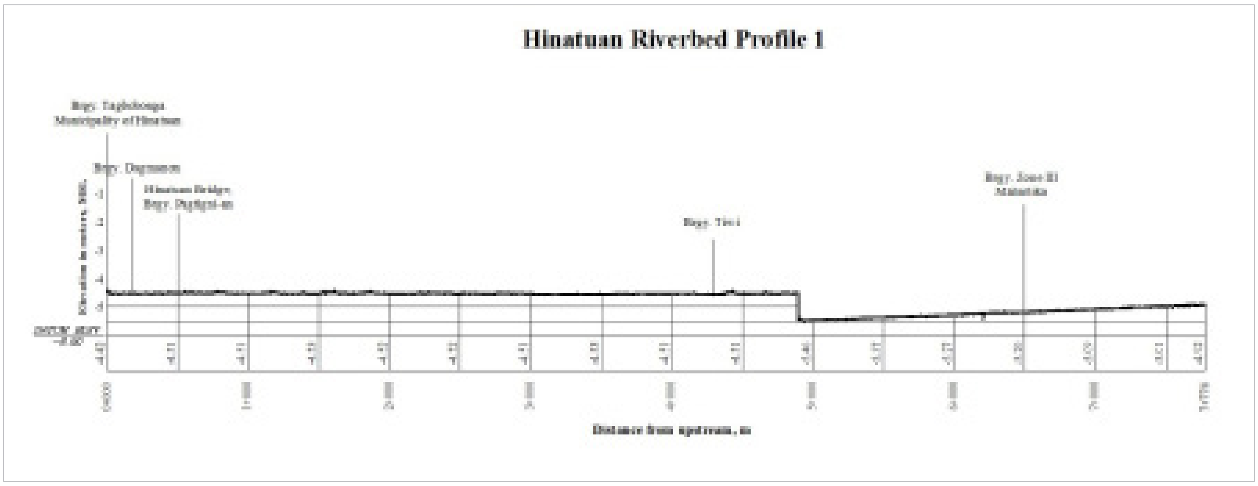


Figure 55. Hinatuan Riverbed Profile 1

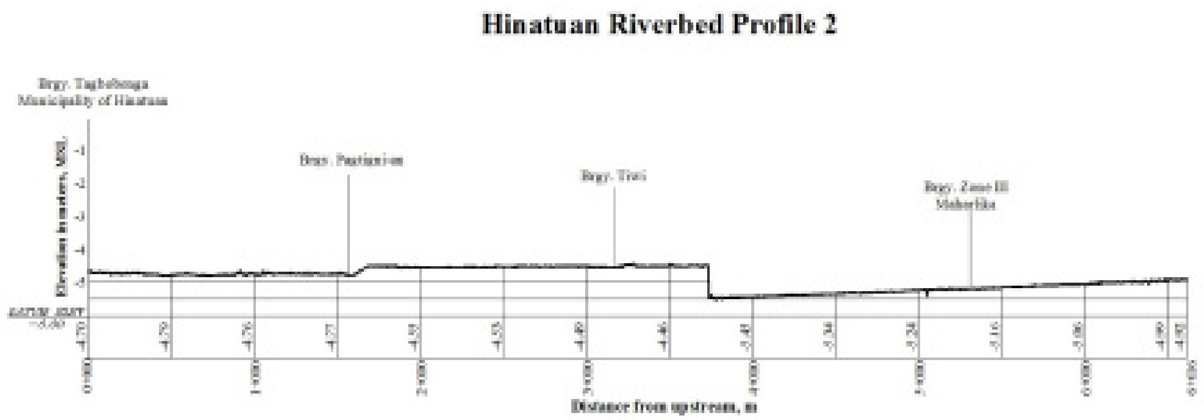


Figure 56. Hinatuan Riverbed Profile 2

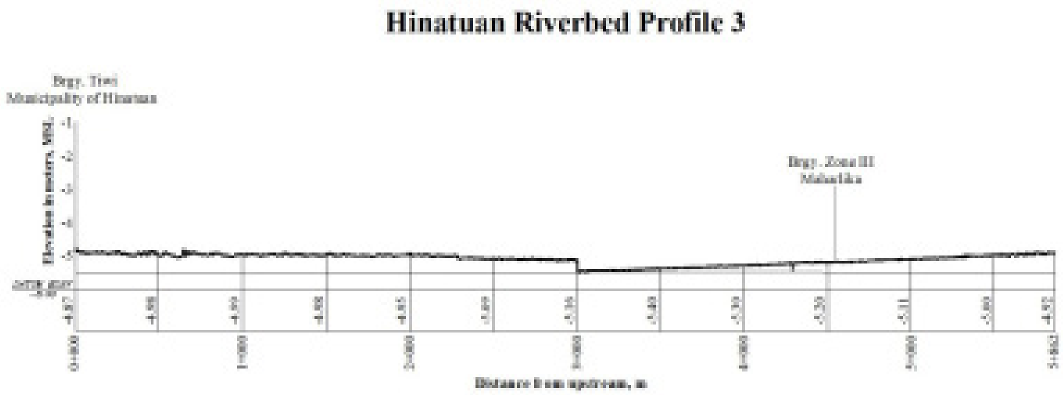


Figure 57. Hinatuan Riverbed Profile 3

CHAPTER 5: FLOOD MODELING AND MAPPING

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

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

5.1 Data Used for Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

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

5.1.2 Precipitation

Precipitation data was taken from one (1) rain gauge installed by the CSU Phil-LiDAR 1 Team. This rain gauge was temporarily installed in the Municipal Hall of Tagbina from November 5, 2015 at 09:40 hrs. to November 19, 2015 at 12:00 hrs. The location of this rain gauge is presented in Figure 58.

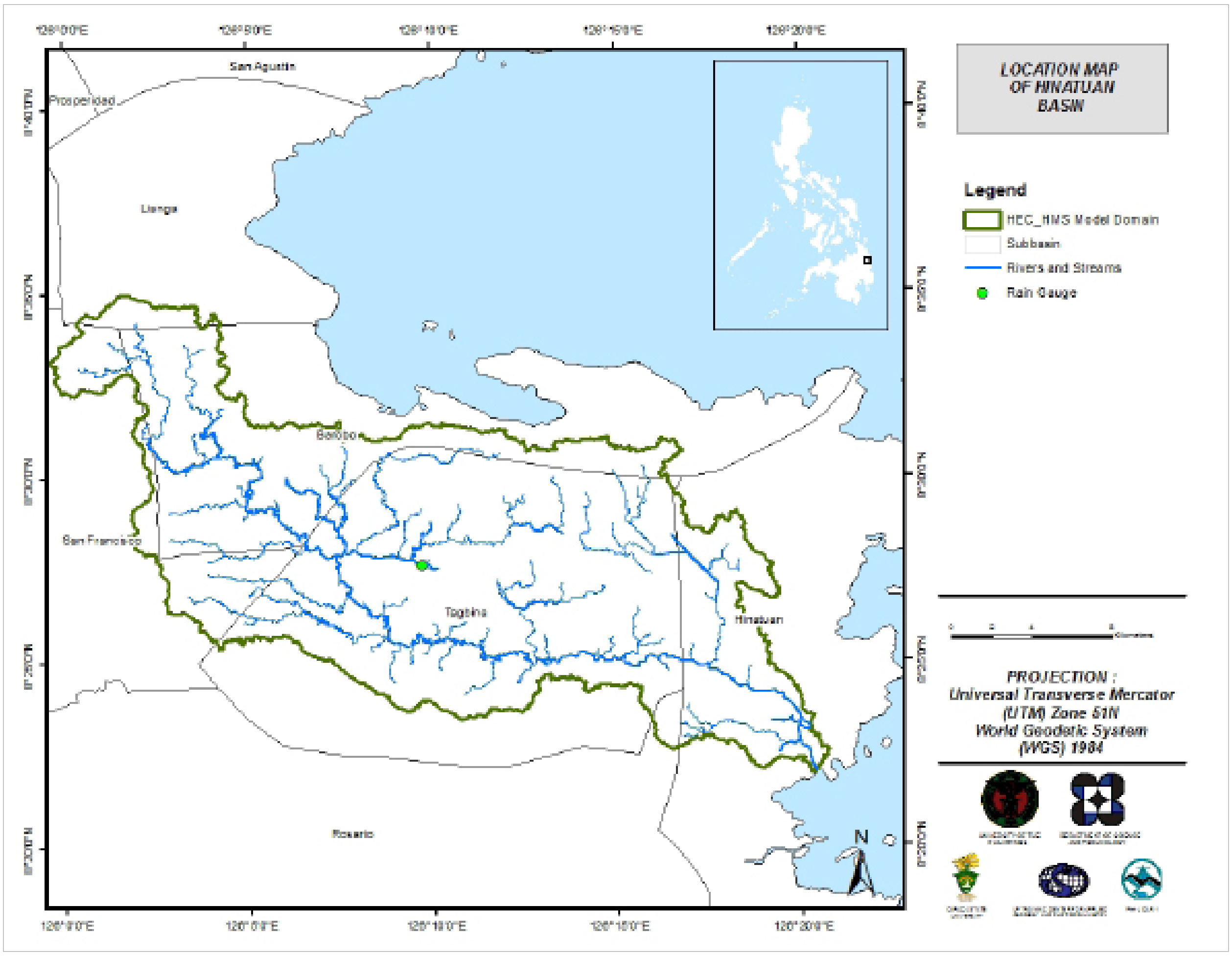


Figure 58. Location map of the rain gauge at the Hinatuan HEC-HMS model.

Total rain recorded from the Tagbina rain gauge from November 17, 2015 at 00:00 hrs. to November 18, 2015 at 10:00 hrs. is 96.4 mm. It peaked at 14.8 mm. on November 17, 2015 at 09:30 hrs. The lag time between the peak rainfall and the resulting peak discharge at the Maglambing Bridge is 9 hours, as reflected in Figure 59.

5.1.3 Rating Curves and River Outflow

A rating curve was computed at the Maglambing Bridge in the Municipality of Tagbina, Surigao del Sur (8°25'15.01"N, 126°12'2.30"E) to establish the relationship between the observed water levels (H) from the Maglambing Bridge and the outflow (Q) of the watershed at this location.

For the Maglambing Bridge, the rating curve is expressed as Q = 23.756H2 – 19.142H + 10.067, as shown in Figure 60.

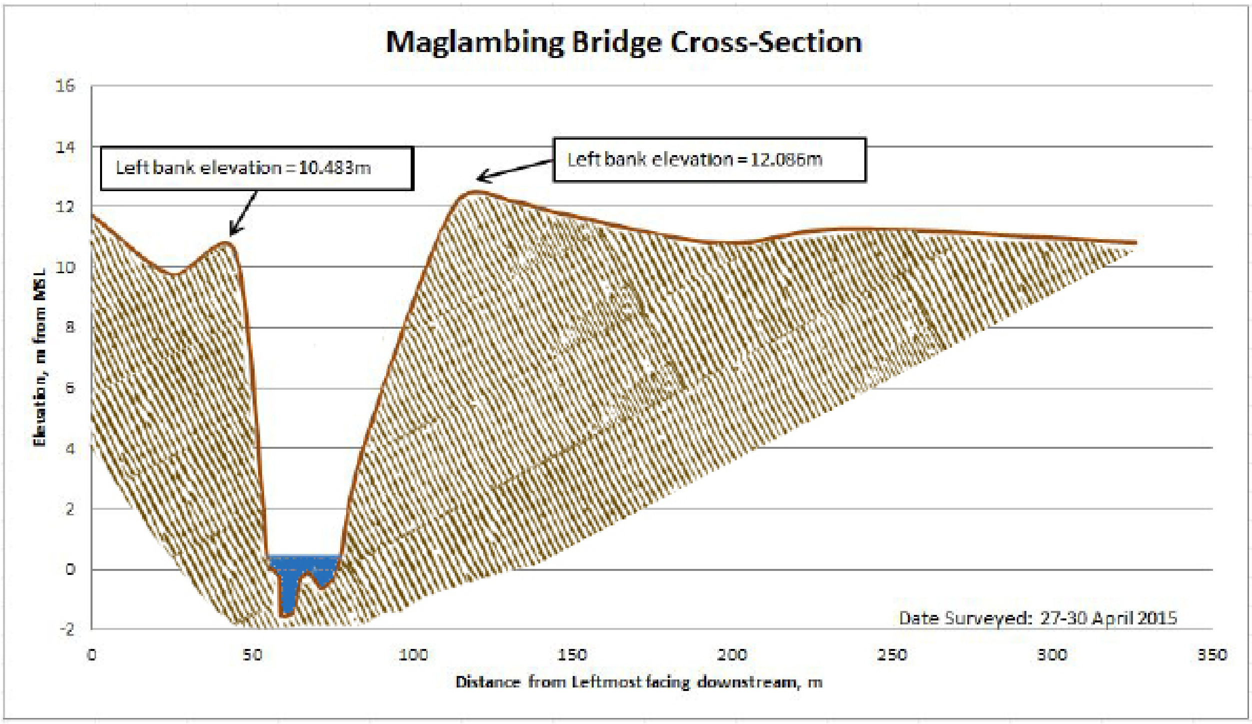


Figure 59. Cross-section plot of the Hinatuan Bridge

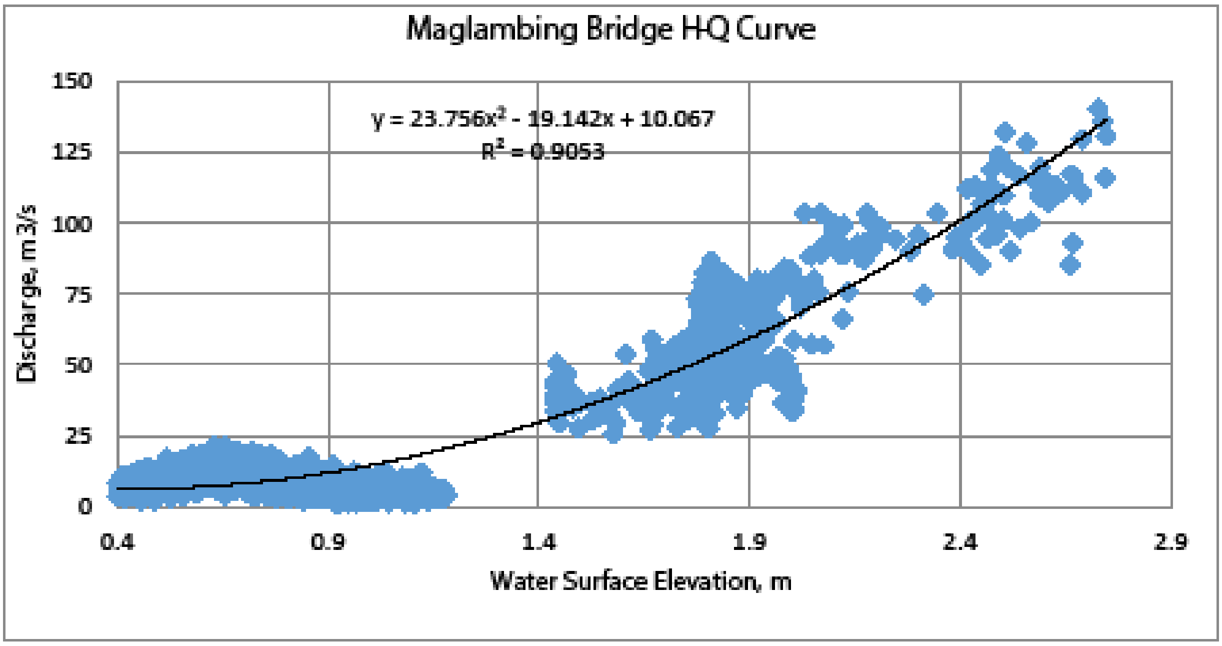


Figure 60. Rating curve at the Maglambing Bridge, Tagbina, Surigao del Sur

The measured river outflow at the Maglambing Bridge (Figure 61) was utilized for the calibration of the HEC-HMS model. The peak discharge was at 263.21 cubic meters per second (cms) on November 18, 2015 at 07:10 hrs.

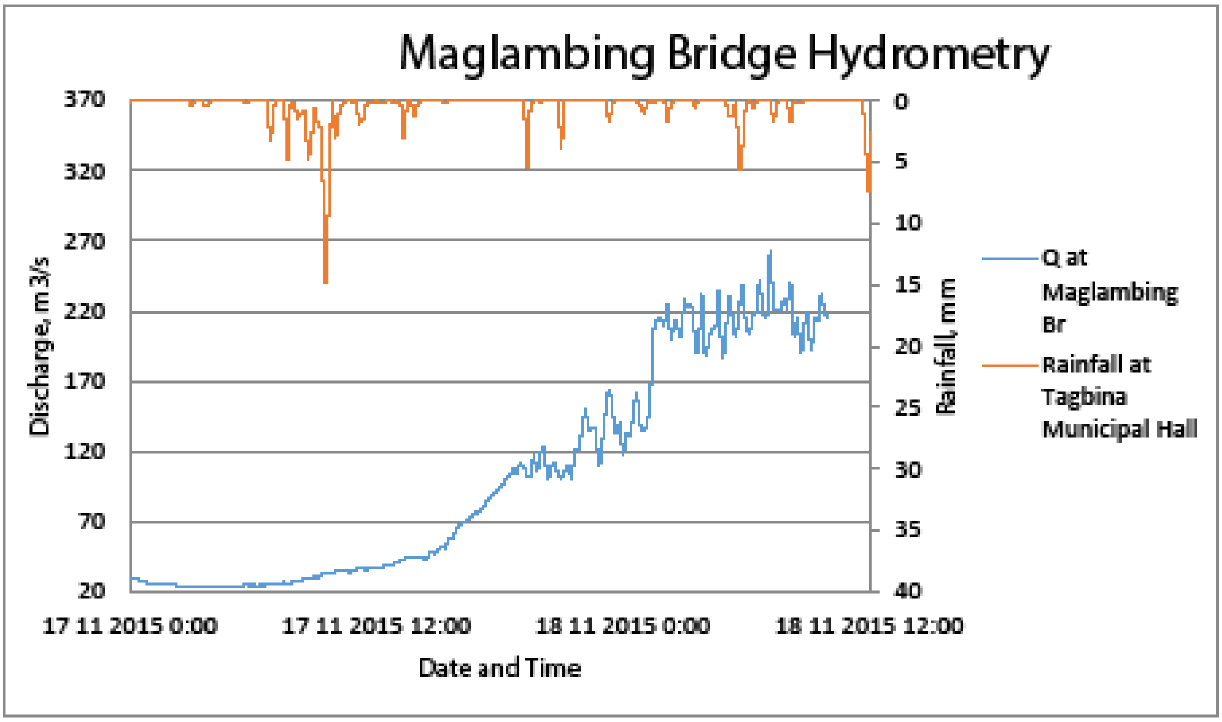


Figure 61. Rainfall at the Tagbina Municipal Hall and outflow data at the Maglambing Bridge used for modeling.

5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed the Rainfall Intensity Duration Frequency (RIDF) values for the Butuan Rain Gauge. This station was selected based on its proximity to the Hinatuan watershed (Figure 62). The extreme values (Table 33) for this watershed were computed based on a 21-year record.

Table 33. Computed extreme values (in mm) of precipitation at the Hinatuan River Basin, based on average RIDF data of the Hinatuan station.

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	15.9	31.9	35.9	82.8	116.9	141.9	190.6	230.6	276.5
10	18.5	36.9	41.7	96.6	137.5	167.2	228.9	274.4	326.5
25	21.7	43.3	49	114.2	163.5	199.1	277.3	329.8	389.7
50	24.1	48.1	54.4	127.2	182.8	222.8	313.2	370.9	436.6
100	26.4	52.8	59.8	140.1	202	246.3	348.8	411.7	483.1

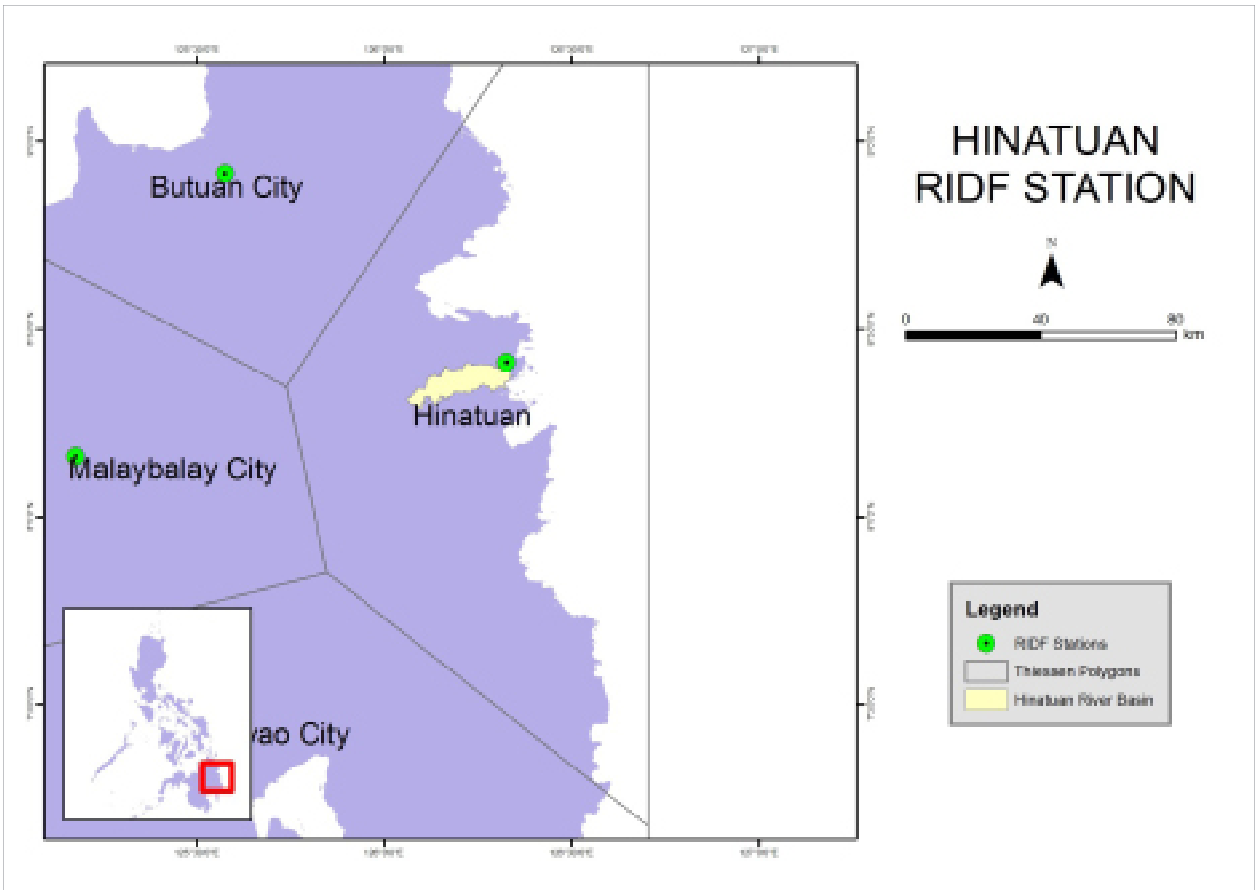


Figure 62. Location map of the Hinatuan RIDF Station

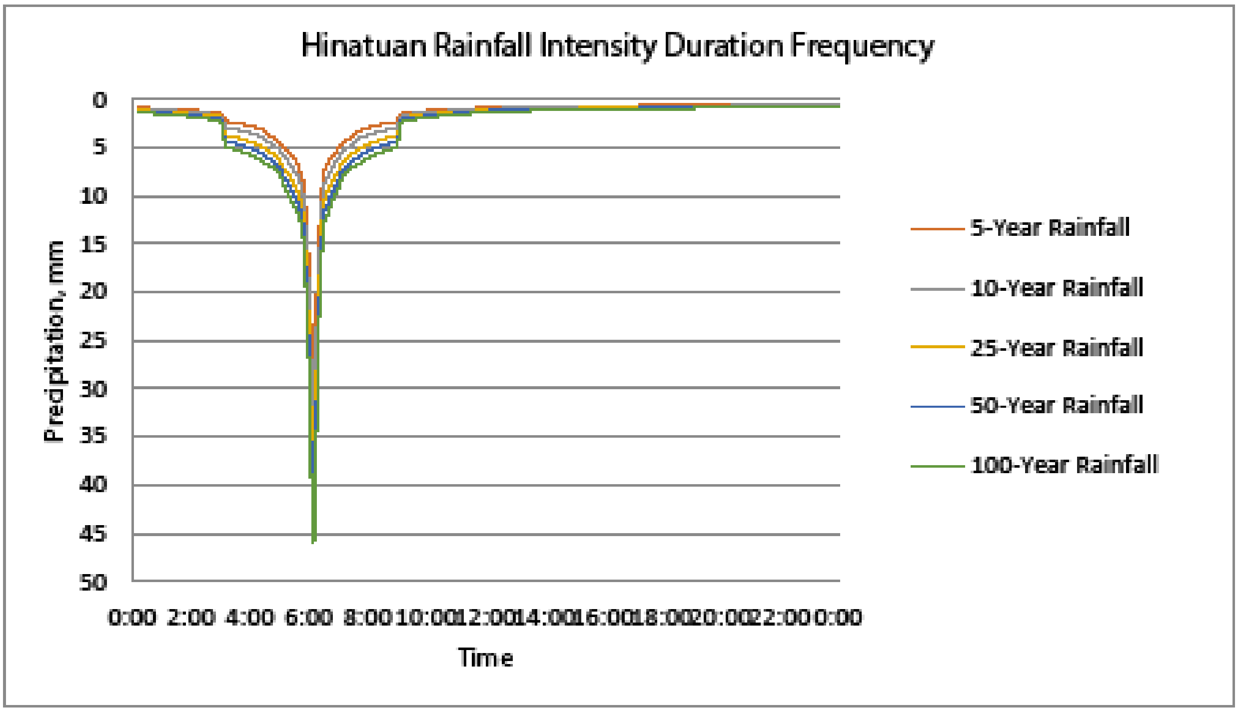


Figure 63. Synthetic storm generated for a 24-hr period rainfall for various return periods

5.3 HMS Model

The soil shapefile was taken from the Bureau of Soils and Water Management (BSWM) under the Department of Agriculture (DA). The land cover dataset is from the National Mapping and Resource information Authority (NAMRIA). These soil datasets were taken before 2004. The soil map and land cover map of the Hinatuan River Basin are presented in Figure 64 and Figure 65, respectively.

Figure 64. The soil map of the Hinatuan River Basin (Source: DA)

Figure 65. The land cover map of the Hinatuan River Basin (Source: NAMRIA).

[Insert text on soil classes and land cover classes here.]

Figure 66. Slope map of the Hinatuan River Basin

Figure 67. Stream delineation map of the Hinatuan River Basin

Using the SAR-based DEM, the Hinatuan basin was delineated and further subdivided into sub basins. The Hinatuan basin model consists of one hundred seventy-two (172) sub basins, eighty-seven (87) reaches, and eighty-eight (88) junctions. This basin model is illustrated in Figure 68. See ANNEX 10 for the Hinatuan Model Reach Parameters. The sub basins were identified based on the delineation using the 10-meter SAR DEM and the resampled 10-meter LiDAR DTM. Precipitation was taken from the DOST rain gauges. The basin was calibrated using data gathered through hydrological measurement at the Maglambing Bridge, as shown Figure 68.

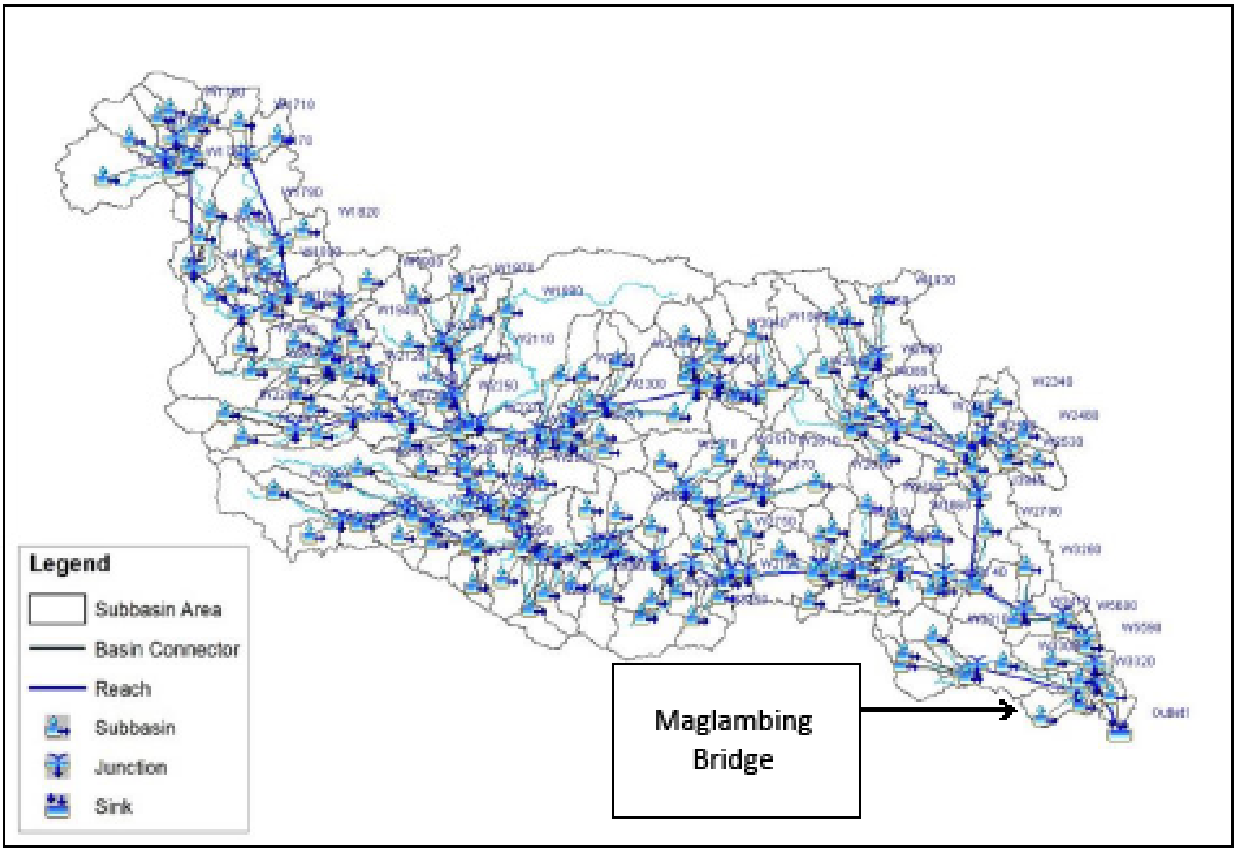


Figure 68. Hinatuan River Basin model generated using HEC-HMS.

5.4 Cross-section Data

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

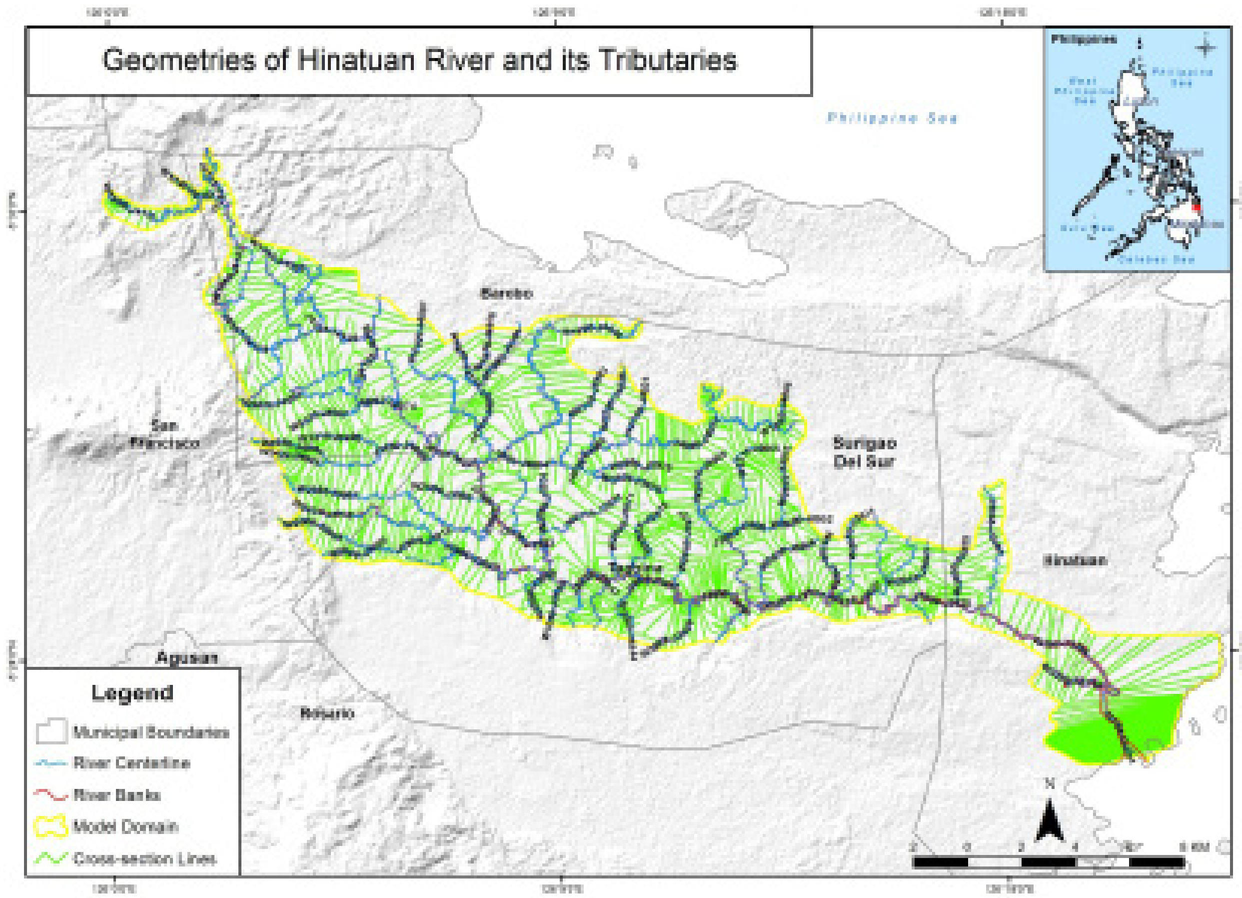


Figure 69. Created geometries of Hinatuan HEC RAS model.

5.5 Flo 2D Model

[Insert text for Flo 2D Model section here.]

Figure 70. Screenshot of subcatchment with computational area to be modeled in

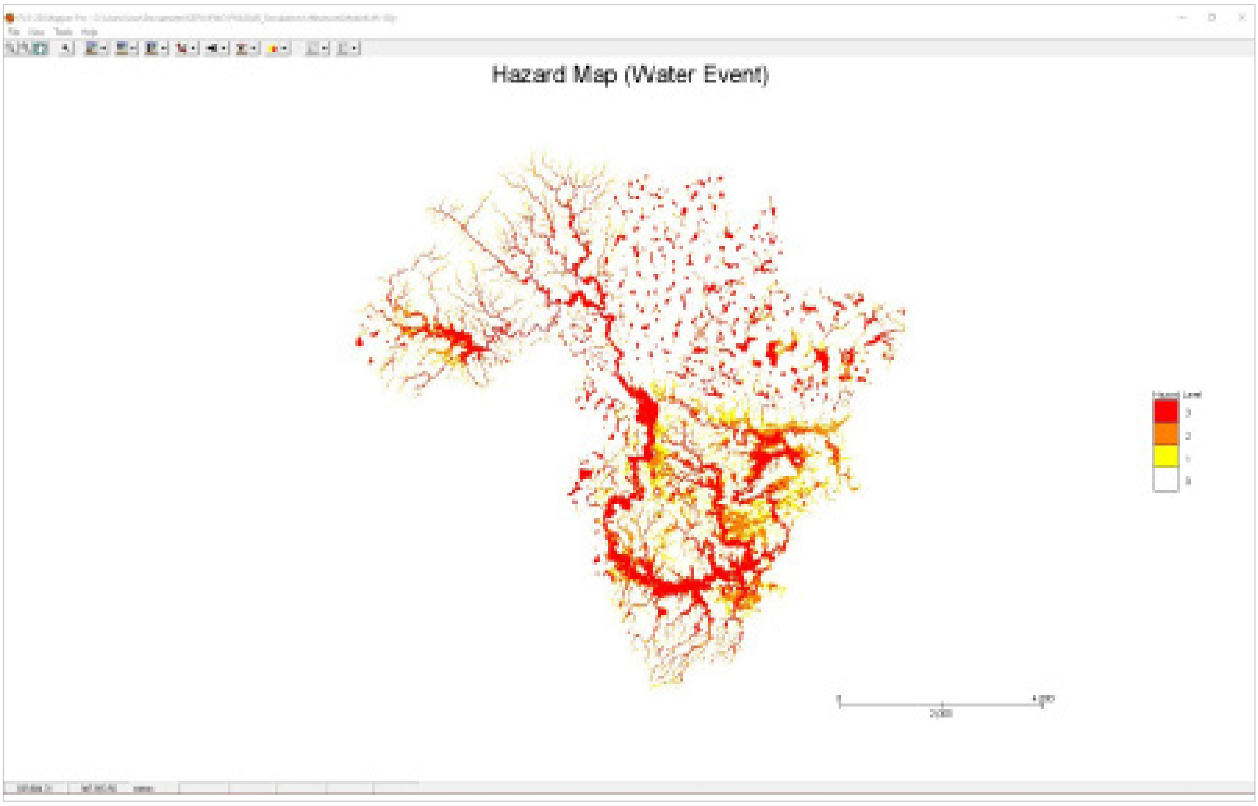


Figure 71. Generated 100-year rain return hazard map from FLO-2D Mapper

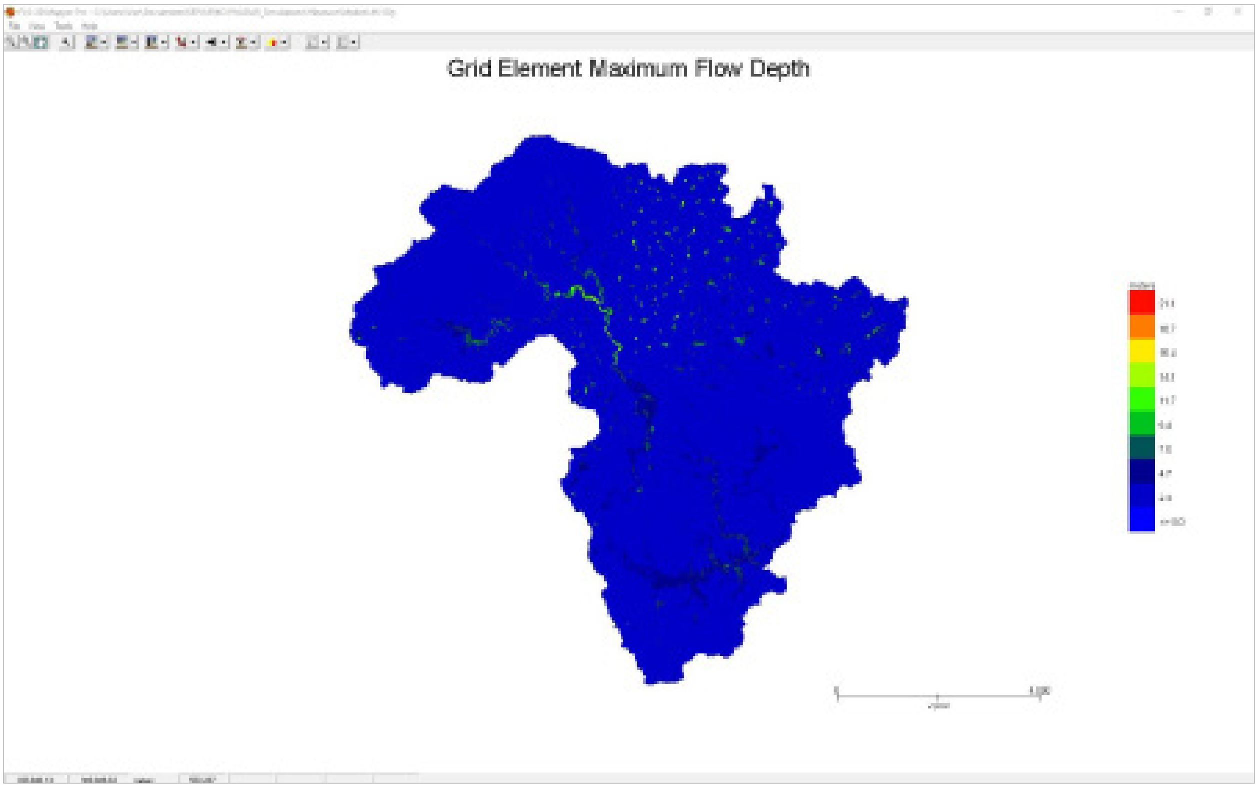


Figure 72. Generated 100-year rain return flow depth map from FLO-2D Mapper

5.6 Results of HMS Calibration

After calibrating the Hinatuan HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 73 shows the comparison between the two discharge data. The Hinatuan Model Basin Parameters are presented in ANNEX 9.

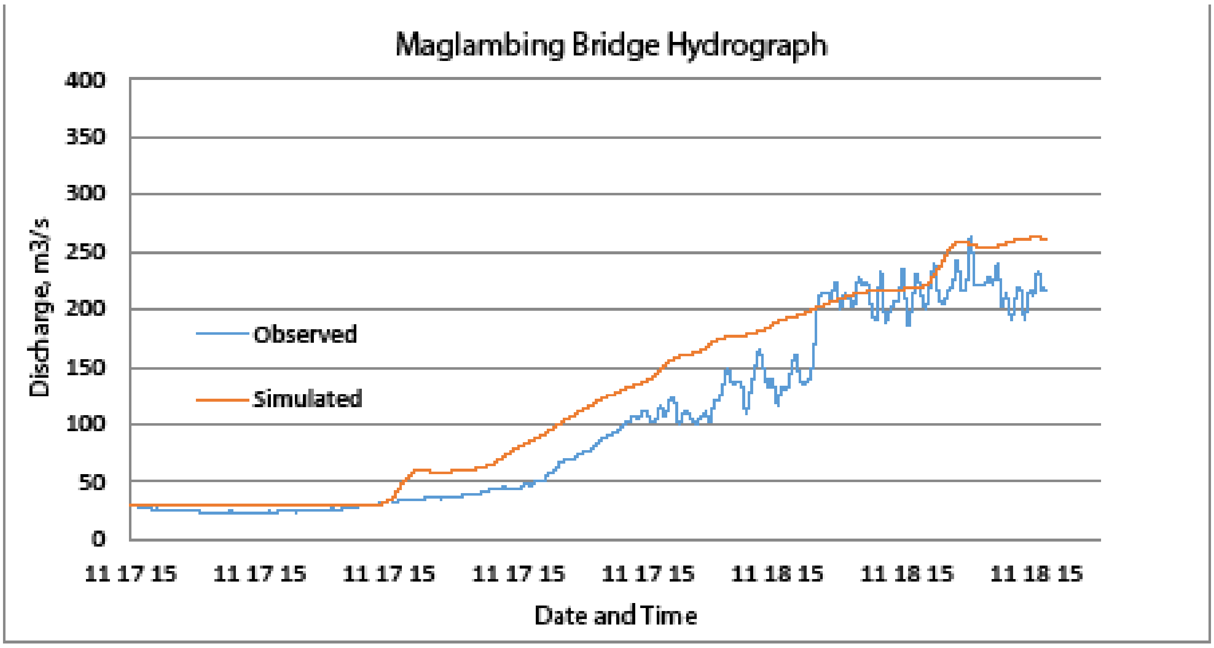


Figure 73. Outflow Hydrograph of the Maglambing Bridge produced by the HEC-HMS model, compared with observed outflow.

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 30.3 m^3/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 is measured at 0.9427.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model, with 1 being the optimal value. The model attained an efficiency coefficient of 0.84.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate a bias towards over-prediction. The optimal value is 0. In the model, the PBIAS is -22.17.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error units of the values are quantified. The model attained an RSR value of 0.40.

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

r^2	0.9427
NSE	0.84
PBIAS	-22.17
RSR	0.40

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 in Figure 74 shows the Hinatuan outflow using the Hinatuan Rainfall Intensity-Duration-Frequency curves (RIDF) in five (5) different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the PAGASA data. The simulation results reveal a significant increase in outflow magnitude as the rainfall intensity increases, for a range of durations and return periods.

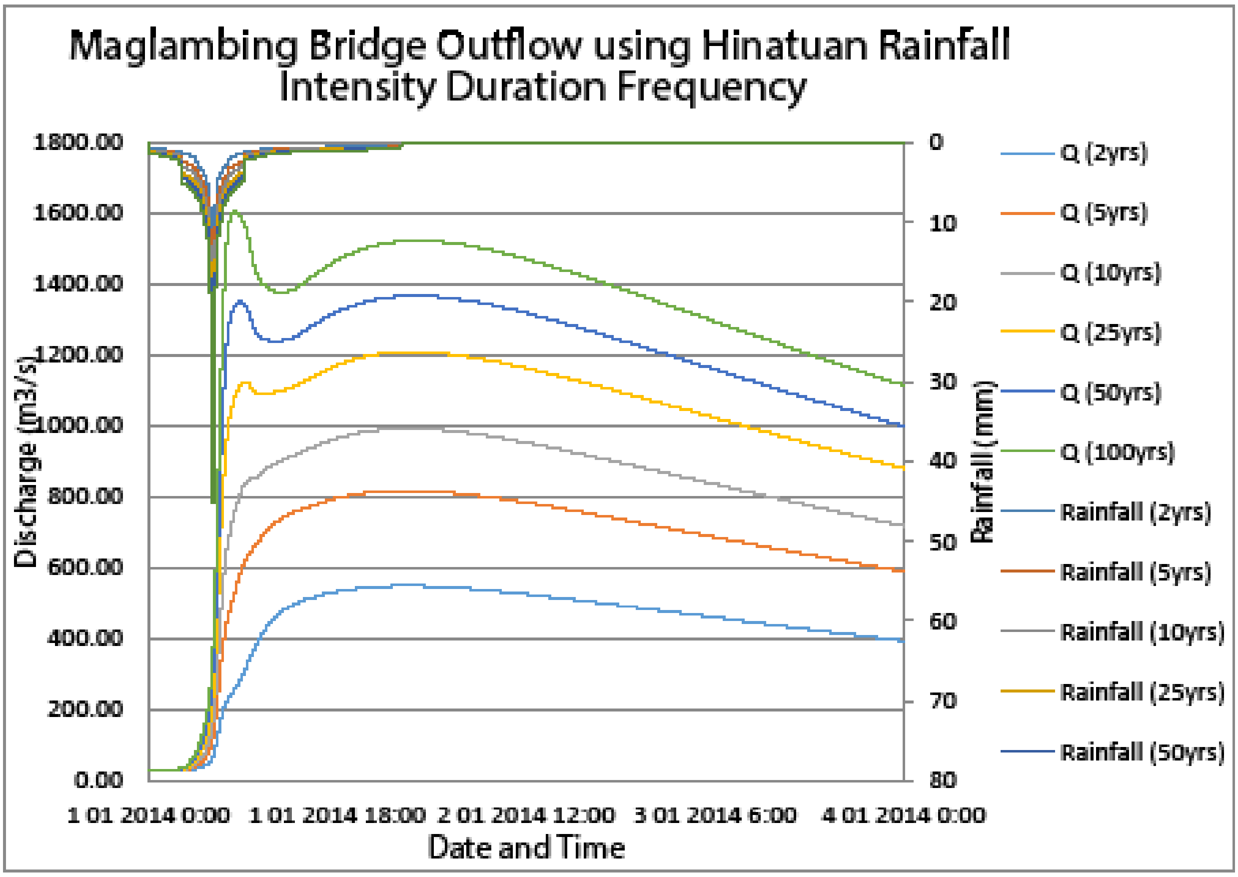


Figure 74. Outflow hydrograph at the Hinatuan Station

Table 35. Peak values of the Hinatuan HEC-HMS Model at Maglambing Bridge outflow using the Hinatuan RIDF.

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m^3/s)	Time to Peak
2-Year	200.24	20.59	550.12	18 hours and 40 minutes
5-Year	275.46	27.14	818.54	18 hours and 30 minutes
10-Year	325.27	31.54	992.68	18 hours and 40 minutes
25-Year	388.23	37.05	1,209.58	19 hours and 10 minutes
50-Year	434.95	41.13	1,367.64	19 hours and 20 minutes
100-Year	481.27	45.18	1,604.29	2 hours and 10 minutes

5.8 River Analysis (RAS) Model Simulation

The HEC-RAS Flood Model produces 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 the extent of real-time flood inundation of the river, after it has been automated and uploaded on the DREAM website. The sample generated map of the Hinatuan River during the Agaton typhoon event, simulated using the calibrated HMS, is shown in Figure 75.

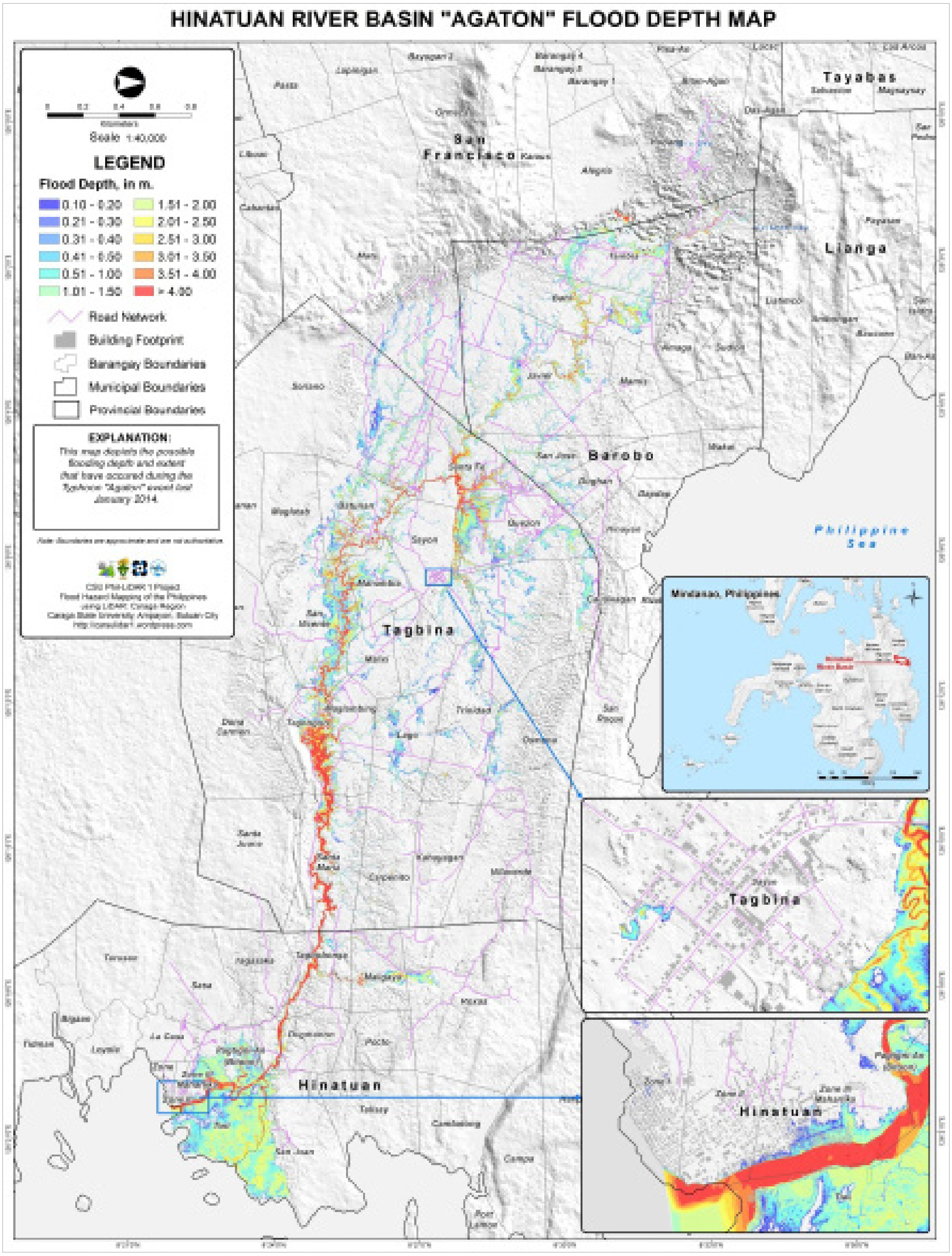


Figure 75. Flood depth and extent at Hinatuan River basin during typhoon "Agaton"

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. The 5-, 25-, and 100-year rain return scenarios of the Hinatuan floodplain are shown in Figures 76 to 81. The floodplain covers three (3) municipalities, namely the Municipalities of Hinatuan and Tagbina in the province of Surigao del Sur, and the Municipality of Rosario in the province of Agusan del Sur. Table 36 shows the percentage of area affected by flooding per municipality.

Table 36. Municipalities affected in the Hinatuan floodplain

Province	Municipality	Total Area	Area Flooded	% Flooded

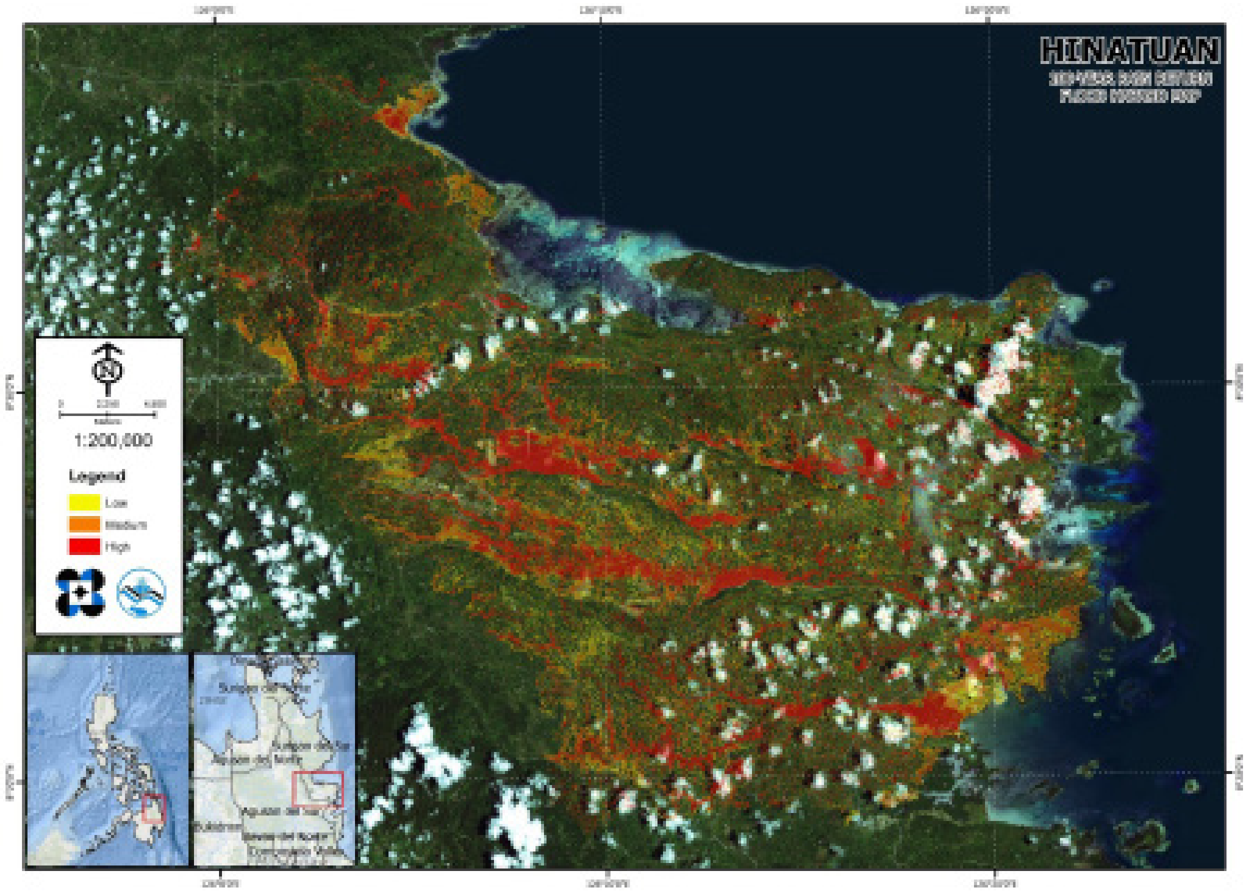


Figure 76. 100-year Flood Hazard Map for the Hinatuan floodplain

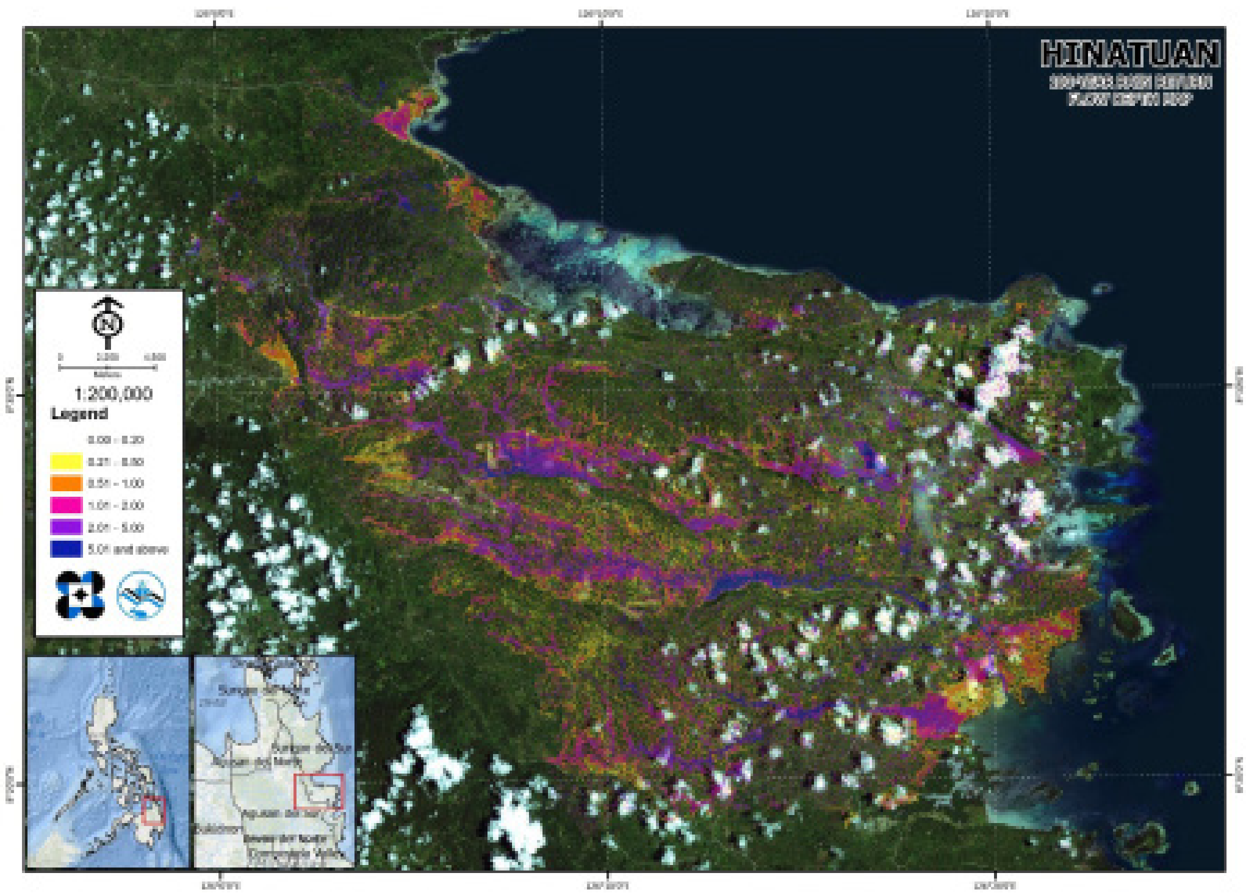


Figure 77. 100-year Flow Depth Map for the Hinatuan floodplain

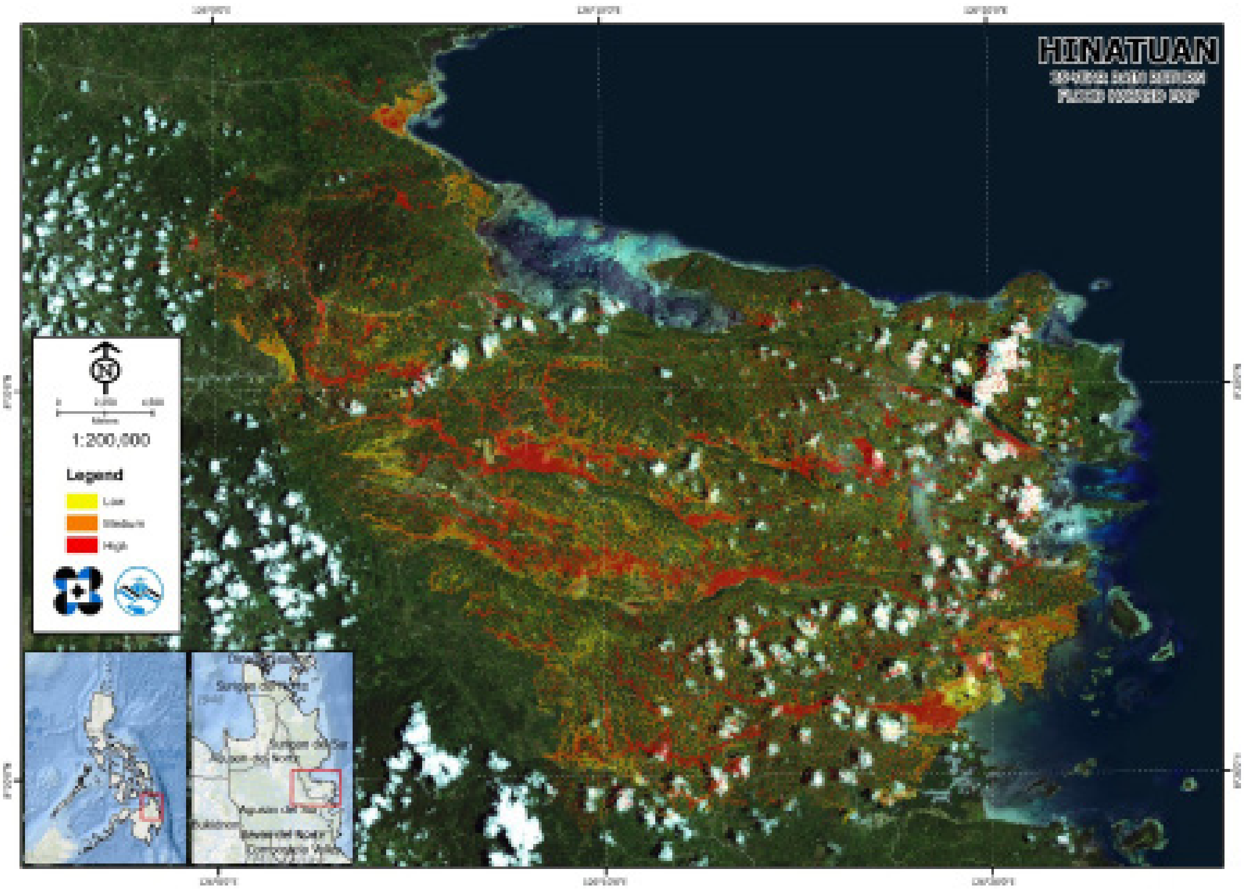


Figure 78. 25-year Flood Hazard Map for the Hinatuan floodplain

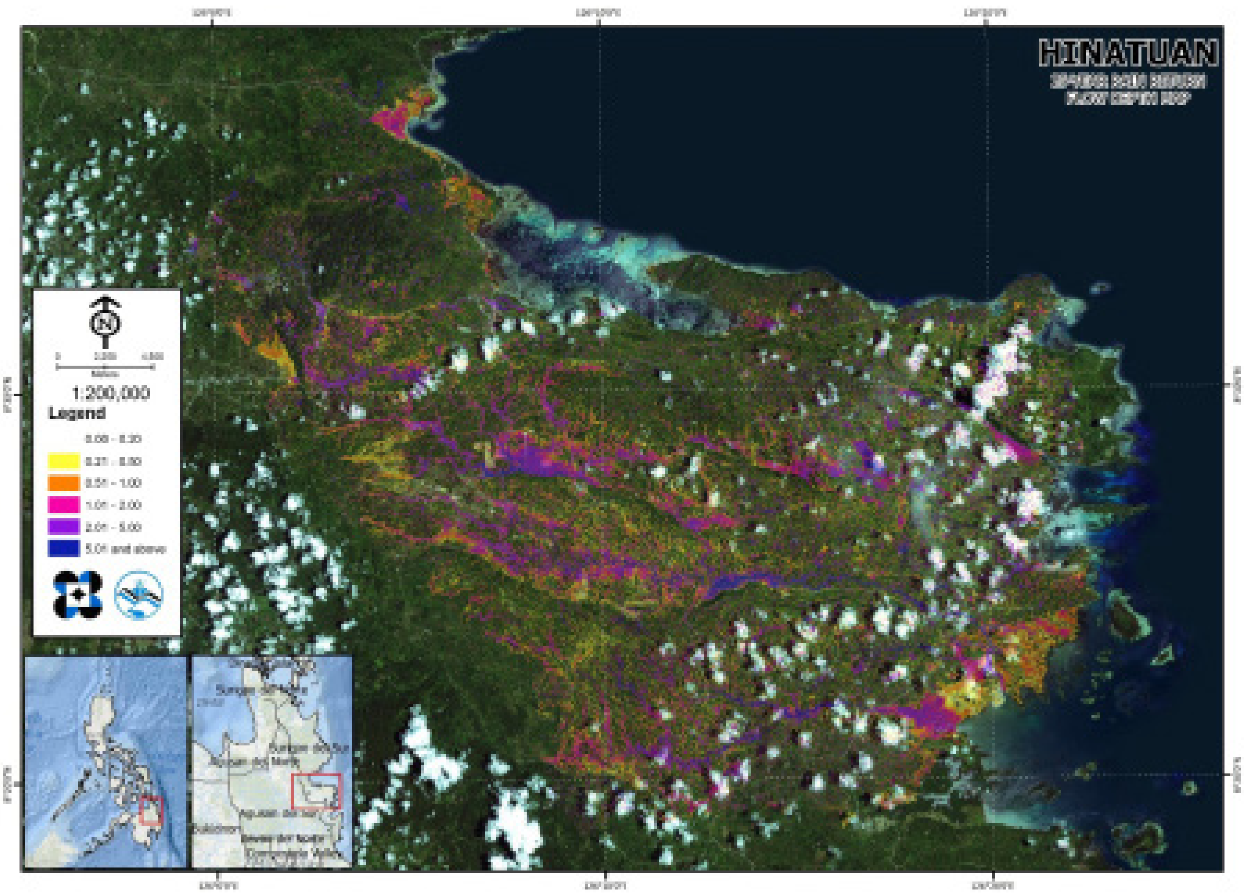


Figure 79. 25-year Flow Depth Map for the Hinatuan floodplain

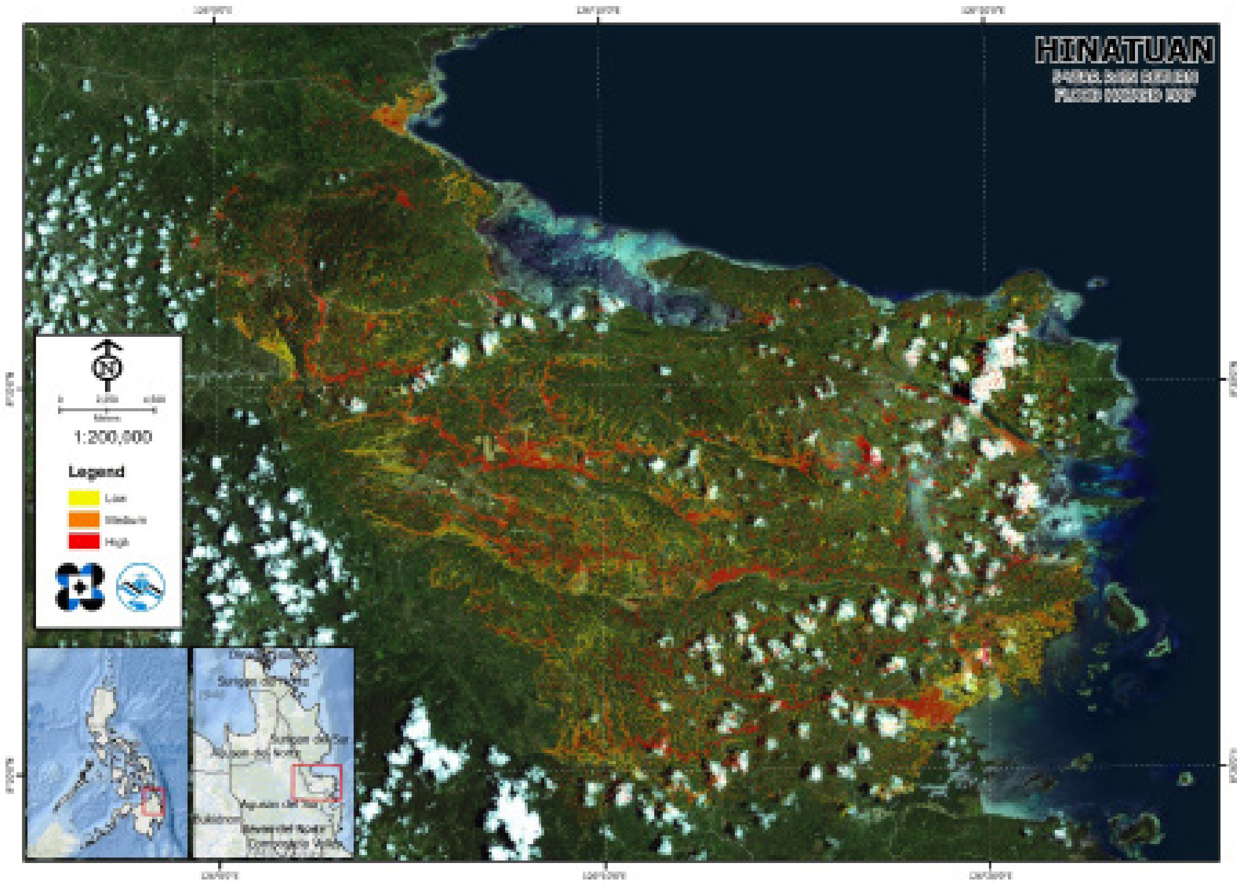


Figure 80. 5-year Flood Hazard Map for the Hinatuan floodplain

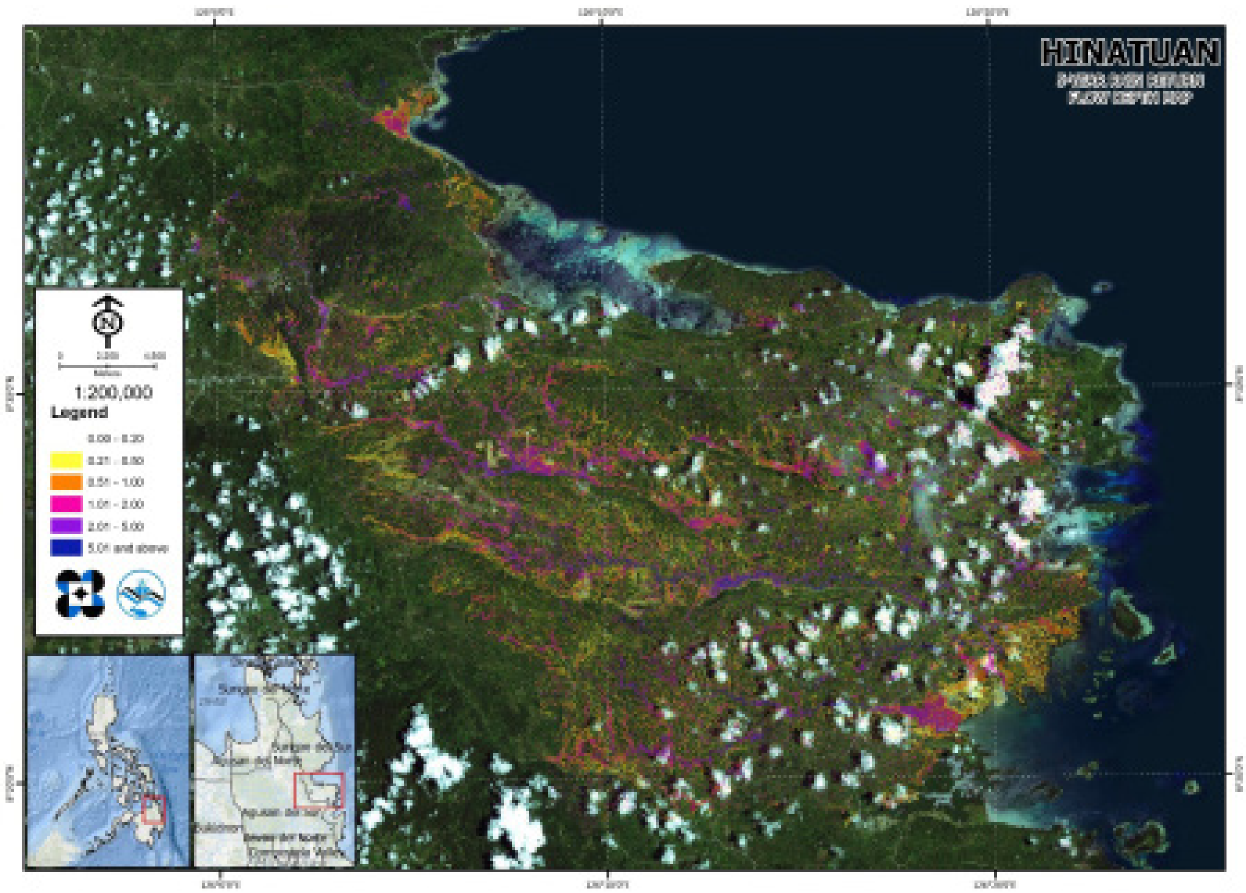


Figure 81. 5-year Flow Depth Map for the Hinatuan floodplain

5.10 Inventory of Areas Exposed to Flooding

Insert text and data on Inventory of Exposed/Affected Areas section here.

Table 37. Affected areas in Hinatuan, Surigao del Sur during a 5-year Rainfall Return

Affected Area (sq. km.) by flood depth (in m.)							
0.03-0.20							
0.21-0.50							
0.51-1.00							
1.01-2.00							
2.01-5.00							
> 5.00							

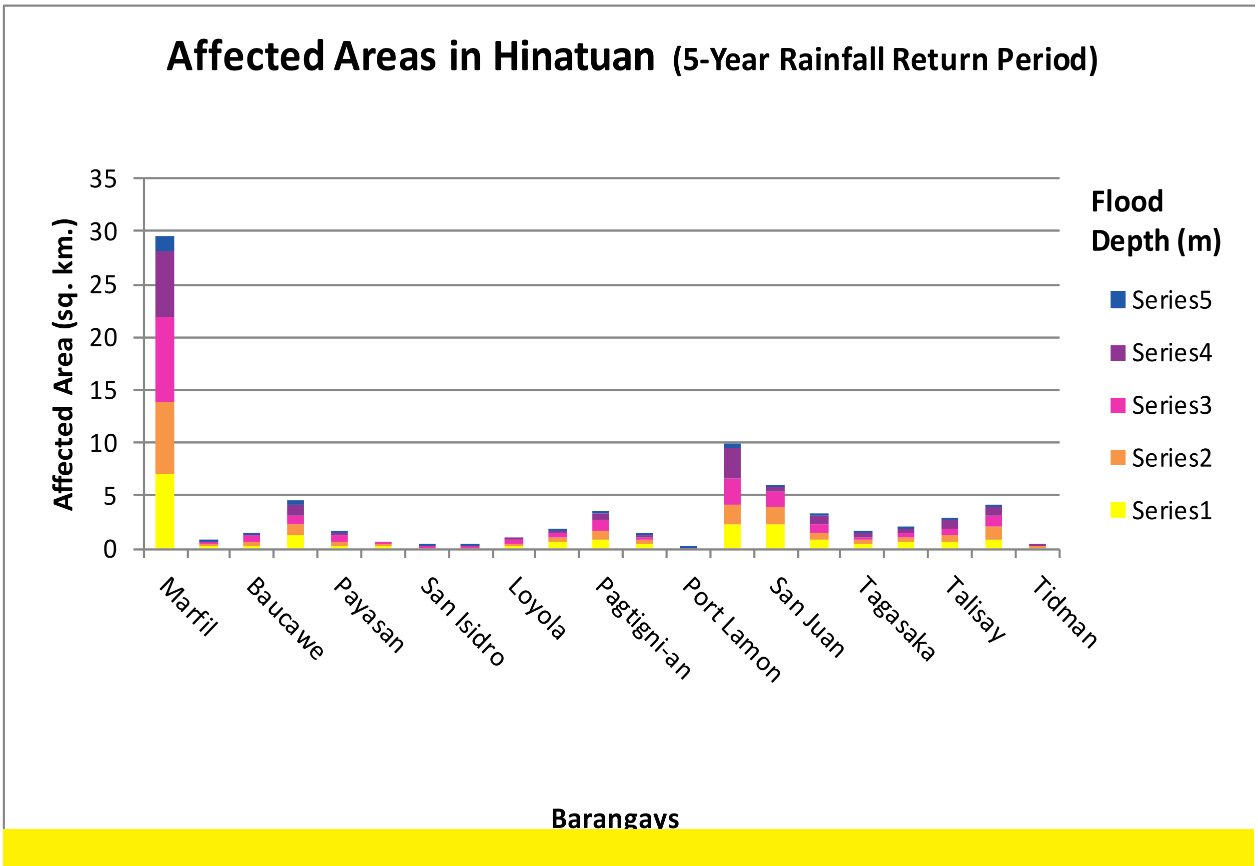


Figure 82. Affected areas in Hinatuan, Surigao del Sur during a 5-year Rainfall Return Period

[Insert text here.]

Table 38. Affected areas in Tagbina, Surigao del Sur during a 5-year Rainfall Return Period

Affected area (sq. km.) By flood depth (in m.)	
0-0.20	
0.21-0.50	
0.51-1.00	
1.01-2.00	
2.01-5.00	
> 5.00	

Figure 83. Affected areas in Tagbina, Surigao del Sur during a 5-year Rainfall Return Period

[Insert text here.]

Table 39. Affected areas in Rosario, Agusan del Sur during a 5-year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)							
0.03-0.20							
0.21-0.50							
0.51-1.00							
1.01-2.00							
2.01-5.00							
> 5.00							

Figure 84. Affected areas in Rosario, Agusan del Sur during a 5-year Rainfall Return Period

[Insert text here.]

Table 40. Affected areas in Hinatuan, Surigao del Sur during a 25-year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)							
0.03-0.20							
0.21-0.50							
0.51-1.00							
1.01-2.00							
2.01-5.00							
> 5.00							

Figure 85. Affected areas in Hinatuan, Surigao del Sur during a 25-year Rainfall Return Period

[Insert text here.]

Table 41. Affected areas in Tagbina, Surigao del Sur during a 25-year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)							
0.03-0.20							
0.21-0.50							
0.51-1.00							
1.01-2.00							
2.01-5.00							
> 5.00							

Figure 86. Affected areas in Tagbina, Surigao del Sur during a 25-year Rainfall Return Period

[Insert text here.]

Table 42. Affected areas in Rosario, Agusan del Sur during a 25-year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)							
0.03-0.20							
0.21-0.50							
0.51-1.00							
1.01-2.00							
2.01-5.00							
> 5.00							

Figure 87. Affected areas in Rosario, Agusan del Sur during a 25-year Rainfall Return Period

[Insert text here.]

Table 43. Affected areas in Hinatuan, Surigao del Sur during a 100-year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)							
0.03-0.20							
0.21-0.50							
0.51-1.00							
1.01-2.00							
2.01-5.00							
> 5.00							

Figure 88. Affected areas in Hinatuan, Surigao del Sur during a 100-year Rainfall Return Period

[Insert text here.]

Table 44. Affected areas in Tagbina, Surigao del Sur during a 100-year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)							
0.03-0.20							
0.21-0.50							
0.51-1.00							
1.01-2.00							
2.01-5.00							
> 5.00							

Figure 89. Affected areas in Tagbina, Surigao del Sur during a 100-year Rainfall Return Period

[Insert text here.]

Table 45. Affected areas in Rosario, Agusan del Sur during a 100-year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)							
0.03-0.20							
0.21-0.50							
0.51-1.00							
1.01-2.00							
2.01-5.00							
> 5.00							

Figure 90. Affected areas in Rosario, Agusan del Sur during a 100-year Rainfall Return Period

[Insert text on summary of data per municipality here.]

The generated flood hazard maps for the Hinatuan Floodplain were also used to assess the vulnerability of the educational and medical institutions in the floodplain. Using the flood depth units of PAGASA for hazard maps – "Low", "Medium", and "High" – the exposed institutions were given their individual assessment for each flood hazard scenario (5-year, 25-year, and 100-year). ANNEX 12 and ANNEX 13 present the educational and health institutions exposed to flooding, respectively.

Table 46. 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	69.17	69.97	69.70
Medium	85.29	94.82	98.95
High	58.85	91.58	114.22

[Insert text on educational and medical institutions here.]

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 occurrences in the respective areas within the major river systems in the Philippines.

From the flood depth maps produced by the Phil-LiDAR 1 Program, multiple points representing the different flood depths for different scenarios were identified for validation.

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

After which, the actual data from the field were compared against the simulated data to assess the accuracy of the flood depth maps produced, and to improve on the results of the flood map. The points in the flood map versus the corresponding validation depths are illustrated in Figure 92.

The flood validation consists of 738 points randomly selected all over the Hinatuan floodplain. Comparing it with the flood depth map of the nearest storm event, it has an RMSE value of 0.99m. Table 47__ shows the contingency matrix of the comparison. The Hinatuan validation points are found in ANNEX 11.

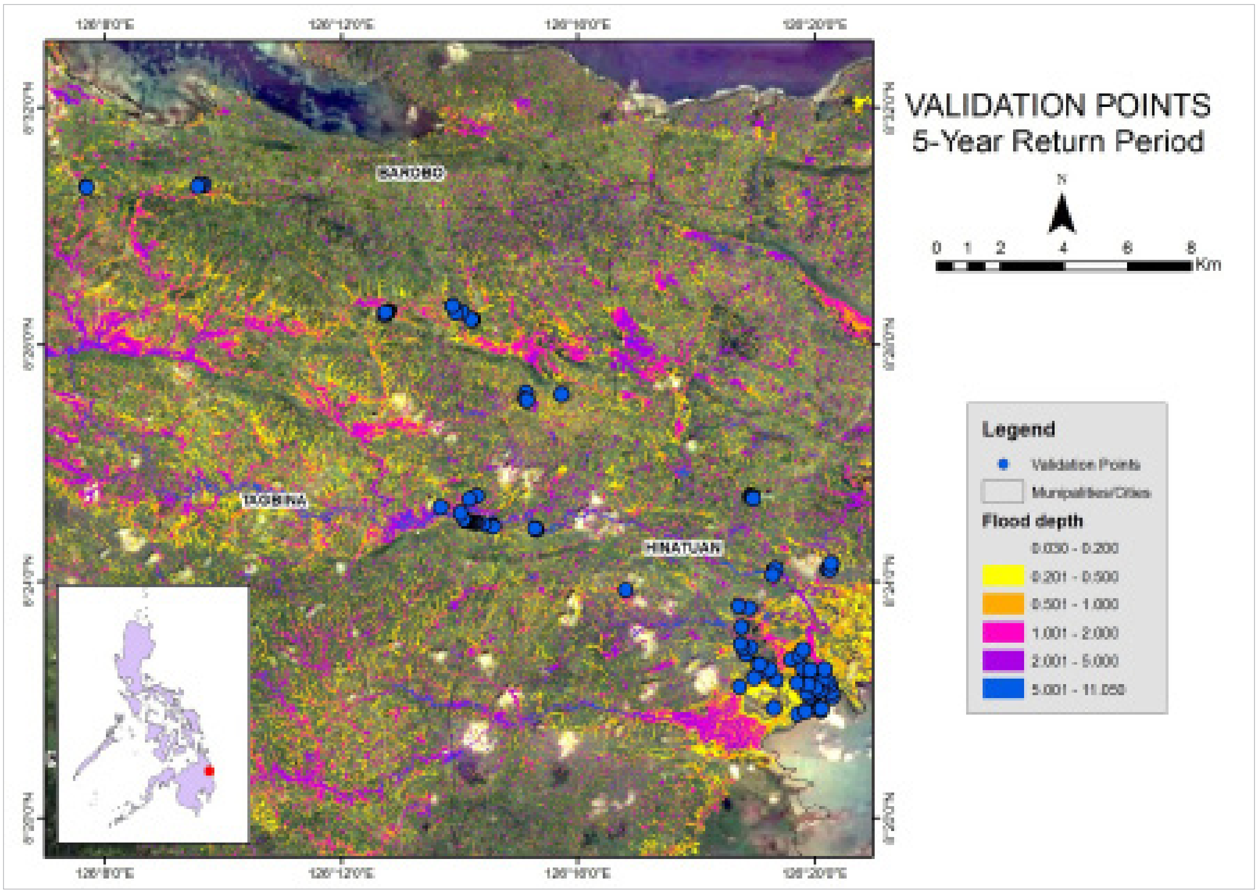


Figure 91. Flood Validation Points of Hinatuan River Basin

Figure 92. Flood map depth vs. actual flood depth

Table 47. Actual flood vs. simulated flood depth at different levels in the Hinatuan River Basin

HINATUAN RIVER BASIN		MODELED FLOOD DEPTH (m)						
		0-0.20	0.21-0.50	0.51-1.00	1.01-2.00	2.01-5.00	> 5.00	Total
Actual Flood Depth (m)	0-0.20							
	0.21-0.50							
	0.51-1.00							
	1.01-2.00							
	2.01-5.00							
	> 5.00							
	Total							

[Insert text on overall accuracy summary here.]

Table 48. Summary of the Accuracy Assessment in the Hinatuan River Basin Survey

	No. of Points	%
Correct	53	29.44
Overestimated	122	67.78
Underestimated	5	2.78
Total	**180**	**100**

REFERENCES

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

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

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

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

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

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

ANNEX

ANNEX 1. Technical Specifications of the Aquarius LiDAR Sensor used in the Hinatuan Floodplain Survey

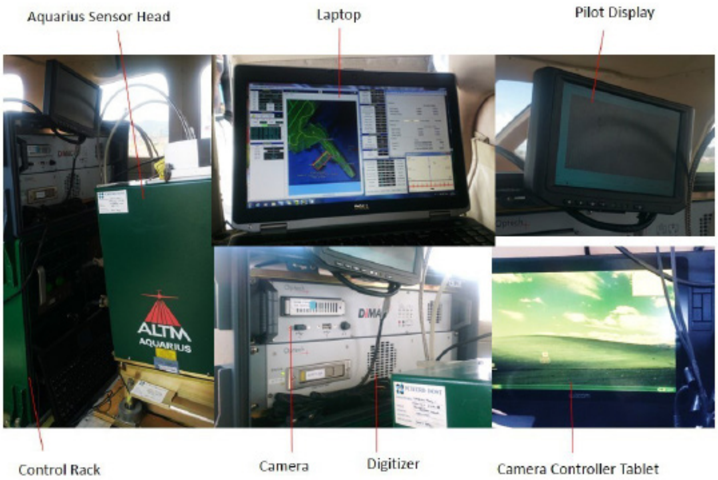


Figure A-1.1. Aquarius LiDAR Sensor

Table A-1.1. Aquarius LiDAR Sensor Specifications

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
Dimensions and weight	Sensor: 260 mm (w) x 190 mm (l) x 570 mm (h); 23 kg Control rack: 650 mm (w) x 590 mm (l) x 530 mm (h); 53 kg
Operating temperature	-10˚C to +35˚C (with insulating jacket)
Relative humidity	0-95% no-condensing

ANNEX 2. NAMRIA Certification of Reference Points used in the LiDAR Survey

1. SRS-53

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

July 11, 2014

CERTIFICATION

To whom it may concern:

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

Province: **SURIGAO DEL SUR**
Station Name: **SRS-53**
Order: **2nd**

Island: **MINDANAO**		Barangay: **POBLACION**
Municipality: **SAN AGUSTIN**		MSL Elevation:
	PRS92 Coordinates	
Latitude: **8° 44' 37.87784"**	Longitude: **126° 13' 16.64511"**	Ellipsoidal Hgt: **-1.34900 m.**
	WGS84 Coordinates	
Latitude: **8° 44' 34.36515"**	Longitude: **126° 13' 22.01039"**	Ellipsoidal Hgt: **69.59300 m.**
	PTM / PRS92 Coordinates	
Northing: **966899.682 m.**	Easting: **414316.026 m.**	Zone: **5**
	UTM / PRS92 Coordinates	
Northing: **967,600.49**	Easting: **194,250.44**	Zone: **52**

Location Description

SRS-53
From Tandag City travel for 68 km south to municipality of San Agustin; then turn left on the national road about 70 m leading to San Agustin school. Station is located inside the compound of San Agustin Central Elementary School; 82 m from stage on the NE corner of the flagpole. Mark is the head of a 3: copper nail set at the center of cement block embedded on the ground with inscriptions SRS-53 2007 NAMRIA.

Requesting Party: **UP TCAGP / Engr. Christopher Cruz**
Pupose: **Reference**
OR Number: **8796507 A**
T.N.: **2014-1593**

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Director, Mapping And Geodesy Branch

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Figure A-2.1. SRS-53

2. SRS-56

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

August 15, 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: **SURIGAO DEL SUR**
Station Name: **SRS-56**
Order: **2nd**

Island: **MINDANAO**		Barangay: **POBLACION**
Municipality: **BAROBO**		MSL Elevation:
	PRS92 Coordinates	
Latitude: **8° 31' 39.52861"**	Longitude: **126° 7' 4.08061"**	Ellipsoidal Hgt: **36.22400 m.**
	WGS84 Coordinates	
Latitude: **8° 31' 36.06400"**	Longitude: **126° 7' 9.46645"**	Ellipsoidal Hgt: **107.36300 m.**
	PTM / PRS92 Coordinates	
Northing: **943079.391 m.**	Easting: **623069.127 m.**	Zone: **5**
	UTM / PRS92 Coordinates	
Northing: **943,755.61**	Easting: **182,673.15**	Zone: **52**

Location Description

SRS-56
From Barobo town proper 1.5 km south to the Barobo town site elementary school along the national road. Station is located on the east ground corner of the flagpole and 20 m from the school rooms. Mark is the head of a 3" copper nail set at the center of cement block embedded on the ground with inscriptions SRS-56 2007 NAMRIA.

Requesting Party: **Engr. Cristopher Cruz**
Purpose: **Reference**
OR Number: **8798719 A**
T.N.: **2014-1852**

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

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Figure A-2.1. SRS-53

3. SRS-57

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

August 08, 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: **SURIGAO DEL SUR**
Station Name: **SRS-57**
Order: **2nd**

Island: **MINDANAO**		Barangay: **TALISAY**
Municipality: **HINATUAN**		MSL Elevation:
	PRS92 Coordinates	
Latitude: **8° 27' 1.69252"**	Longitude: **126° 21' 8.66908"**	Ellipsoidal Hgt: **26.14400 m.**
	WGS84 Coordinates	
Latitude: **8° 26' 58.26936"**	Longitude: **126° 21' 14.05931"**	Ellipsoidal Hgt: **98.02200 m.**
	PTM / PRS92 Coordinates	
Northing: **934625.022 m.**	Easting: **648933.286 m.**	Zone: **5**
	UTM / PRS92 Coordinates	
Northing:	Easting:	Zone:

Location Description

SRS-57
From Hinatuan town proper travel to junction of Bislig for 25 km, 9 km north side to Brgy. Talisay. The station is inside the Talisay Elementary School; on the concrete ground corner of the flagpole; 35 m NW from the main gate. Mark is the head of a 3" copper nail set at the center of cement block embedded on the ground with inscriptions SRS-57 2007 NAMRIA.

Requesting Party: **ENGR. CHRISTOPHER CRUZ**
Pupose: **Reference**
OR Number: **8799670 A**
T.N.: **2014-1782**

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Director, Mapping And Geodesy Branch

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Figure A-2.3. SRS-57

4. SRS-58

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

August 29, 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: **SURIGAO DEL SUR**
Station Name: **SRS-58**
Order: **2nd**

Island: **MINDANAO**		Barangay: **MAGLAMBING**			
Municipality: **TAGBINA**		MSL Elevation:			
		PRS92 Coordinates			
Latitude:	**8° 25' 30.89446"**	Longitude:	**126° 11' 37.55708"**	Ellipsoidal Hgt:	**10.93400 m.**
		WGS84 Coordinates			
Latitude:	**8° 25' 27.46381"**	Longitude:	**126° 11' 42.95134"**	Ellipsoidal Hgt:	**82.47300 m.**
		PTM / PRS92 Coordinates			
Northing:	**931778.214 m.**	Easting:	**631468.821 m.**	Zone:	**5**
		UTM / PRS92 Coordinates			
Northing:	**932,360.98**	Easting:	**190,961.53**	Zone:	**52**

Location Description

SRS-58
From Tagbina town proper travel for 4 km to Brgy. Maglambing Elementary School along the national road. The station is located inside Maglambing Elementary School; on the concrete ground SE corner of the flagpole; 72 m SW from the main gate. Mark is the head of a 3" copper nail set at the center of a cement block embedded on the ground with inscriptions SRS-58 2007 NAMRIA.

Requesting Party: **ENGR. CHRISTOPHER CRUZ**
Purpose: **Reference**
OR Number: **8799780 A**
T.N.: **2014-1897**

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Director, Mapping And Geodesy Branch

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Figure A-2.4. SRS-58

5. SRS-60

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

August 08, 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: **SURIGAO DEL SUR**
Station Name: **SRS-60**
Order: **2nd**

Island: **MINDANAO**		Barangay: **STA. CRUZ**
Municipality: **BISLIG**		MSL Elevation:
	PRS92 Coordinates	
Latitude: **8° 18' 26.83928"**	Longitude: **126° 17' 56.66192"**	Ellipsoidal Hgt: **83.08300 m.**
	WGS84 Coordinates	
Latitude: **8° 18' 23.26276"**	Longitude: **126° 18' 2.07013"**	Ellipsoidal Hgt: **155.22600 m.**
	PTM / PRS92 Coordinates	
Northing: **913248.992 m.**	Easting: **643129.132 m.**	Zone: **5**
	UTM / PRS92 Coordinates	
Northing:	Easting:	Zone:

Location Description

SRS-60
From barangay hall 100 m SE to Brgy. Health Center, the station is located inside the barangay health center compound, on the SW ground corner near the bamboo fence. Mark is the head of a 3" copper nail set at the center of cement block embedded on the ground with inscriptions SRS-60 2007 NAMRIA.

Requesting Party:	**ENGR. CHRISTOPHER CRUZ**
Pupose:	**Reference**
OR Number:	**8799670 A**
T.N.:	**2014-1784**

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

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Figure A-2.5. SRS-60

6. SRS-61

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

August 15, 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: **SURIGAO DEL SUR**
Station Name: **SRS-61**
Order: **2nd**

Island: **MINDANAO**		Barangay: **MONE**
Municipality: **BISLIG**		MSL Elevation:
	PRS92 Coordinates	
Latitude: **8° 9' 52.82479"**	Longitude: **126° 16' 0.00425"**	Ellipsoidal Hgt: **2.46400 m.**
	WGS84 Coordinates	
Latitude: **8° 9' 49.47002"**	Longitude: **126° 16' 5.42126"**	Ellipsoidal Hgt: **74.71500 m.**
	PTM / PRS92 Coordinates	
Northing: **902980.994 m.**	Easting: **639590.647 m.**	Zone: **5**
	UTM / PRS92 Coordinates	
Northing: **903,466.77**	Easting: **198,797.23**	Zone: **52**

Location Description

SRS-61
From Bislig City proper for 12 km to Brgy. Mone; the station is located inside Mone National Highschool compound on the open field about 100 m away from the flagpole and 300 m from the center of the road. Mark is the head of a 3" copper nail set at the center of cement block embedded on the ground with inscriptions SRS-61 2007 NAMRIA.

Requesting Party: **Engr. Cristopher Cruz**
Pupose: **Reference**
OR Number: **8799719 A**
T.N.: **2014-1851**

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

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Figure A-2.6. SRS-61

7. SRS-63

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

September 05, 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: **SURIGAO DEL SUR**		
	Station Name: **SRS-63**		
	Order: **2nd**		
Island: **MINDANAO**	Barangay: **SITIO PAGMAM-AN**		
Municipality: **BISLIG**	MSL Elevation:		
	PRS92 Coordinates		
Latitude: **8° 8' 0.61702"**	Longitude: **126° 20' 25.46527"**	Ellipsoidal Hgt:	**89.36100 m.**
	WGS84 Coordinates		
Latitude: **8° 7' 57.27724"**	Longitude: **126° 20' 30.88421"**	Ellipsoidal Hgt:	**161.85800 m.**
	PTM / PRS92 Coordinates		
Northing: **899559.567 m.**	Easting: **647729.756 m.**	Zone:	**5**
	UTM / PRS92 Coordinates		
Northing: **899,963.22**	Easting: **206,906.01**	Zone:	**52**

Location Description

SRS-63
From Bislig junction landmark travel towards Brgy. Pagmam-an distance of 4 kms to the junction road of San Antonio southeast side. The location of the monument is in the head of RCP (Along the national highway). Mark is the head of a 3" copper nail set at the center of cement block embedded on the ground with inscriptions SRS-63 2007 NAMRIA.

Requesting Party: **ENGR. CHRISTOPHER CRUZ**
Purpose: **Reference**
OR Number: **8075532 A**
T.N.: **2014-1942**

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Director, Mapping And Geodesy Branch

9909952014124537

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Figure A-2.7. SRS-63

8. SRS-68

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

August 29, 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: **SURIGAO DEL SUR**
Station Name: **SRS-68**
Order: **2nd**

Island: **MINDANAO**	Barangay: **SAN ROQUE**		
Municipality: **BAROBO**	MSL Elevation:		

PRS92 Coordinates

Latitude: **8° 31' 4.13752"**	Longitude: **126° 11' 54.80630"**	Ellipsoidal Hgt: **144.36800 m.**

WGS84 Coordinates

Latitude: **8° 31' 0.68280"**	Longitude: **126° 12' 0.19207"**	Ellipsoidal Hgt: **216.72700 m.**

PTM / PRS92 Coordinates

Northing: **942018.662 m.**	Easting: **631965.017 m.**	Zone: **5**

UTM / PRS92 Coordinates

Northing: **942,602.08**	Easting: **191,563.45**	Zone: **52**

Location Description

SRS-68
From Barobo town proper travel south towards Brgy. Dughan crossing in a distance of 2.5 km then turn left and travel a distance of 9.2 km towards San Roque Elementary School. The location of SRS-68 is inside San Roque Elementary School left side from the road. From San Roque Elementary School main gate, distance of 47 m SW side is the location of SRS-68 monument at the concrete foundation of the flagpole. Mark is the head of a 3" copper nail set at the center of cement block embedded on the ground with inscriptions SRS-68 2007 NAMRIA.

Requesting Party: **ENGR. CHRISTOPHER CRUZ**
Purpose: **Reference**
OR Number: **8799780 A**
T.N.: **2014-1899**

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Figure A-2.8. SRS-68

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

1. SS-124

Table A-3.1. SS-124

Vector Components (Mark to Mark)

From:	SRS-60				
Grid		**Local**		**Global**	
Easting	863521.635 m	**Latitude**	N8°15'26.63926"	**Latitude**	N8°15'23.26276"
Northing	914200.696 m	**Longitude**	E126°17'56.66192"	**Longitude**	E126°18'02.07013"
Elevation	86.358 m	**Height**	83.083 m	**Height**	155.226 m

To:	BMSS-124				
Grid		**Local**		**Global**	
Easting	864399.330 m	**Latitude**	N8°13'07.07643"	**Latitude**	N8°13'03.71088"
Northing	909915.188 m	**Longitude**	E126°18'34.14670"	**Longitude**	E126°18'20.55843"
Elevation	7.131 m	**Height**	3.821 m	**Height**	76.062 m

Vector					
ΔEasting	877.695 m	**NS Fwd Azimuth**	168°53'56"	**ΔX**	-895.278 m
ΔNorthing	-4285.508 m	**Ellipsoid Dist.**	4369.046 m	**ΔY**	-68.246 m
ΔElevation	-79.227 m	**ΔHeight**	-79.262 m	**ΔZ**	-4254.421 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	**σ NS fwd Azimuth**	0°00'00"	**σ ΔX**	0.005 m
σ ΔNorthing	0.002 m	**σ Ellipsoid Dist.**	0.002 m	**σ ΔY**	0.006 m
σ ΔElevation	0.006 m	**σ ΔHeight**	0.006 m	**σ ΔZ**	0.002 m

Aposteriori Covariance Matrix (Meter²)

	X	**Y**	**Z**
X	0.0000292083		
Y	-0.0000323684	0.0000417973	
Z	-0.0000075535	0.0000094738	0.0000049392

Occupations

	From	**To**
Point ID:	SRS-60	BMSS-124
Data file:	C:\Users\Windows User\Documents \Business Center - HCE\Unnamed (3)\SRS60 (Modular) 8-3-14 [1.685m].T02	C:\Users\Windows User\Documents \Business Center - HCE\Unnamed (3)\BMSS124 (Rover) 8-3-14 [1.768m].T02
Receiver type:	SPS852	SPS985
Receiver serial number:	5203K81512	5245F15374
Antenna type:	Zephyr Geodetic 2	SPS985 Internal
Antenna serial number:	--------	--------
Antenna height (measured):	1.685 m	1.768 m
Antenna method:	Bottom of notch	Antenna Phase Center

Tracking Summary

2. SS-201

Table A-3.2. SS-201

Vector Components (Mark to Mark)

From:	SRS53				
Grid		Local		Global	
Easting	854654.870 m	Latitude	N8°44'34.36515"	Latitude	N8°44'34.36515"
Northing	967943.120 m	Longitude	E126°13'22.01030"	Longitude	E126°13'22.01030"
Elevation	3.274 m	Height	69.583 m	Height	69.583 m

To:	BMSS201				
Grid		Local		Global	
Easting	856009.096 m	Latitude	N8°46'03.02195"	Latitude	N8°46'03.02195"
Northing	970681.752 m	Longitude	E126°14'07.03352"	Longitude	E126°14'07.03352"
Elevation	6.020 m	Height	72.180 m	Height	72.180 m

Vector					
ΔEasting	1354.226 m	NS Fwd Azimuth	26°48'11"	ΔX	-666.534 m
ΔNorthing	2738.632 m	Ellipsoid Dist.	3051.618 m	ΔY	-1145.673 m
ΔElevation	2.746 m	ΔHeight	2.597 m	ΔZ	2692.420 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.004 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.005 m
σ ΔElevation	0.006 m	σ ΔHeight	0.006 m	σ ΔZ	0.002 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000139315		
Y	-0.0000161276	0.0000265278	
Z	-0.0000041845	0.0000058211	0.0000027778

Occupations

	From	To
Point ID:	SRS53	BMSS201
Data file:	C:\Users\DAC\Documents\Business Center - HCE\Unnamed(1)\SRS53 (Modular) 7-16-14 [1.775m].T02	C:\Users\DAC\Documents\Business Center - HCE\Unnamed(1)\BMSS201 (Rover0 7-16-14 [1.755m].T02
Receiver type:	SPS852	SPS985
Receiver serial number:	5203K81512	5245F15374
Antenna type:	Zephyr Geodetic 2	SPS985 Internal
Antenna serial number:	--------	--------
Antenna height (measured):	1.775 m	1.755 m
Antenna method:	Bottom of notch	Bottom of antenna mount

Tracking Summary

ANNEX 4. The LiDAR Survey Team Composition

Table A-4.1. LiDAR Survey Team Composition

<table>
<tr><th>Data Acquisition Component Sub-Team</th><th>Designation</th><th>Name</th><th>Agency / Affiliation</th></tr>
<tr><td>PHIL-LIDAR 1</td><td>Program Leader</td><td>ENRICO C. PARINGIT, D.ENG</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="2">Data Acquisition Component Leader</td><td rowspan="2">Data Component Project Leader – I</td><td>ENGR. CZAR JAKIRI SARMIENTO</td><td rowspan="2">UP-TCAGP</td></tr>
<tr><td>ENGR. LOUIE P. BALICANTA</td></tr>
<tr><td rowspan="3">Survey Supervisor</td><td>Chief Science Research Specialist (CSRS)</td><td>ENGR. CHRISTOPHER CRUZ</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="2">Supervising Science Research Specialist (Supervising SRS)</td><td>LOVELY GRACIA ACUÑA</td><td>UP-TCAGP</td></tr>
<tr><td>ENGR. LOVELYN ASUNCION</td><td>UP-TCAGP</td></tr>
<tr><td colspan="4">FIELD TEAM</td></tr>
<tr><td rowspan="2">LiDAR Operation</td><td rowspan="2">Research Associate (RA)</td><td>MARY CATHERINE ELIZABETH BALIGUAS</td><td>UP-TCAGP</td></tr>
<tr><td>MA. REMEDIOS VILLANUEVA</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="2">Ground Survey, Data Download and Transfer</td><td rowspan="2">RA</td><td>JERIEL PAUL ALAMBAN, GEOL</td><td>UP-TCAGP</td></tr>
<tr><td>DAN CHRISTOFFER ALDOVINO</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="4">LiDAR Operation</td><td>Airborne Security</td><td>TSG. MICHAEL BERONILLA</td><td>Philippine Air Force (PAF)</td></tr>
<tr><td rowspan="3">Pilot</td><td>CAPT. JEFFREY JEREMY ALAJAR</td><td>Asian Aerospace Corporation (AAC)</td></tr>
<tr><td>CAPT. NEIL ACHILLES AGAWIN</td><td>AAC</td></tr>
<tr><td>CAPT. ANGELO GARCHITORENA</td><td>AAC</td></tr>
</table>

ANNEX 5. Data Transfer Sheets for the Hinatuan Floodplain Flights

DATA TRANSFER SHEET

SURIGAO DEL SUR (08/26/2014)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS (MB)	RAW IMAGES / CASI	MISSION LOG FILE / CASI LOGS	RANGE (KB)	DIGITIZER (KB)	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION/S	BASE INFO (.txt)		ACTUAL	KML	
11-Aug-14	1810	3BLK66PSC223A	Aquarius	N/A	3.08 MB	1.46 MB	269	15.9 GB	649 KB	12.7	13.3	18.5	1 KB	1 KB	561	22.5 KB	\\Aquinas.las.dream.upd.edu.ph\RAWDATA
14-Aug-14	1822	1BLK66GS226A	Aquarius	N/A	499 KB	840 KB	218	6.94 GB	365 KB	10.2	N/A	11.7	1 KB	1 KB	210	22 KB	\\Aquinas.las.dream.upd.edu.ph\RAWDATA

RECEIVED FROM:

NAME: C. Joaquin

POSITION: RA

SIGNATURE:

RECEIVED BY:

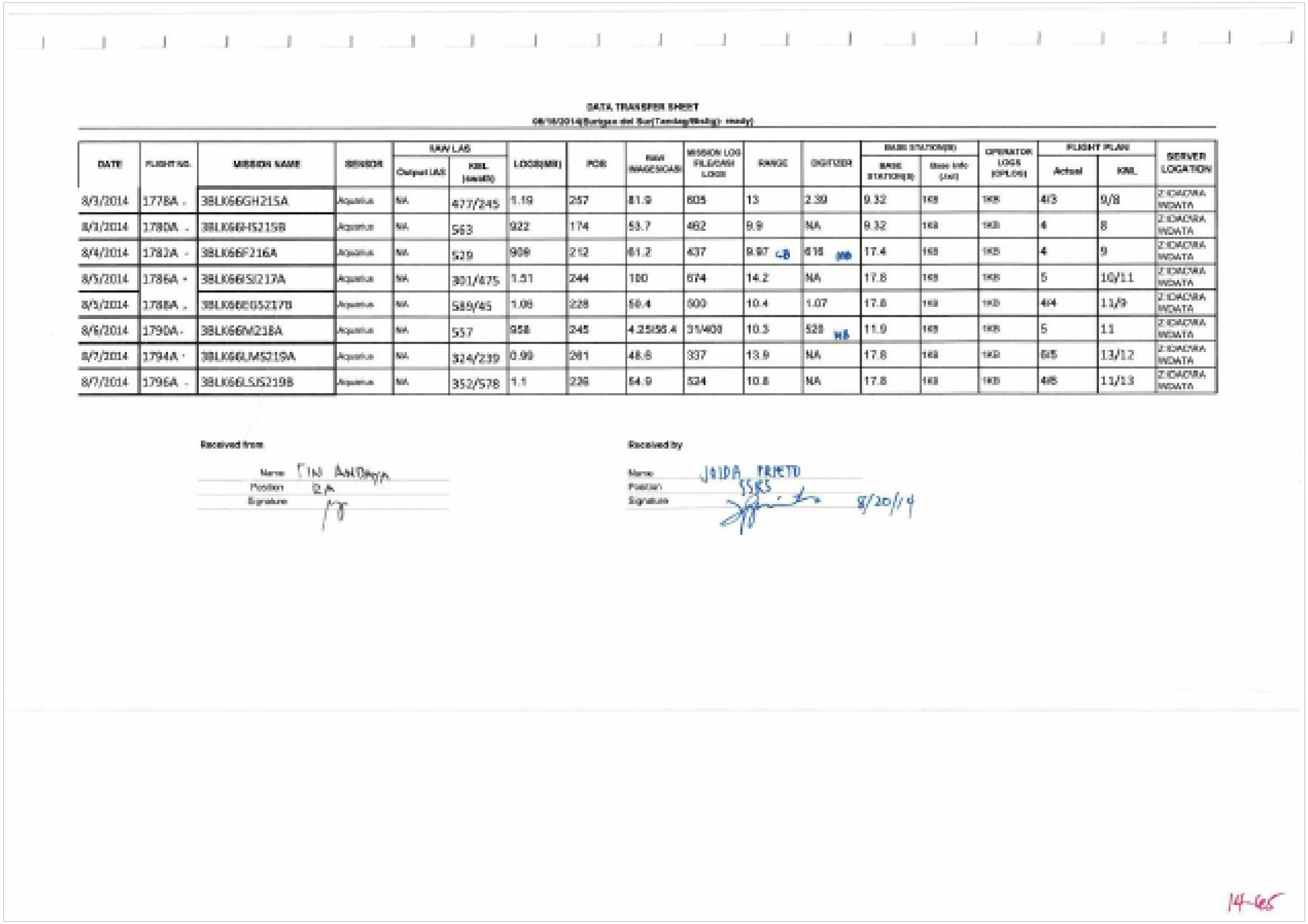
NAME: JOIDA PRIETO

POSITION: SRS

SIGNATURE:

DATE: 8/26/2014

Figure A-5.1. Transfer Sheet for Hinatuan Floodplain – A



DATA TRANSFER SHEET
08/18/2014(Surigao del Sur(Tandag/Madrid): ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
8/3/2014	1778A	3BLK66GH215A	Aquarius	NA	477/245	1.19	257	81.9	605	13	2.39	9.32	1KB	1KB	4/3	9/8	Z:\DAC\RAW DATA
8/3/2014	1780A	3BLK66HS215B	Aquarius	NA	563	922	174	53.7	462	9.9	NA	9.32	1KB	1KB	4	8	Z:\DAC\RAW DATA
8/4/2014	1782A	3BLK66F216A	Aquarius	NA	529	909	212	61.2	437	9.97 GB	616 MB	17.4	1KB	1KB	4	9	Z:\DAC\RAW DATA
8/5/2014	1786A	3BLK66IS217A	Aquarius	NA	301/475	1.51	244	100	674	14.2	NA	17.8	1KB	1KB	5	10/11	Z:\DAC\RAW DATA
8/5/2014	1788A	3BLK66EGS217B	Aquarius	NA	589/45	1.06	228	59.4	600	10.4	1.07	17.8	1KB	1KB	4/4	11/9	Z:\DAC\RAW DATA
8/6/2014	1790A	3BLK66M218A	Aquarius	NA	557	958	245	4.25/56.4	31/400	10.3	528 MB	11.9	1KB	1KB	5	11	Z:\DAC\RAW DATA
8/7/2014	1794A	3BLK66LMS219A	Aquarius	NA	324/239	0.99	261	48.6	337	13.9	NA	17.8	1KB	1KB	6/5	13/12	Z:\DAC\RAW DATA
8/7/2014	1796A	3BLK66LSJS219B	Aquarius	NA	352/578	1.1	226	64.9	524	10.8	NA	17.8	1KB	1KB	4/6	11/13	Z:\DAC\RAW DATA

Received from

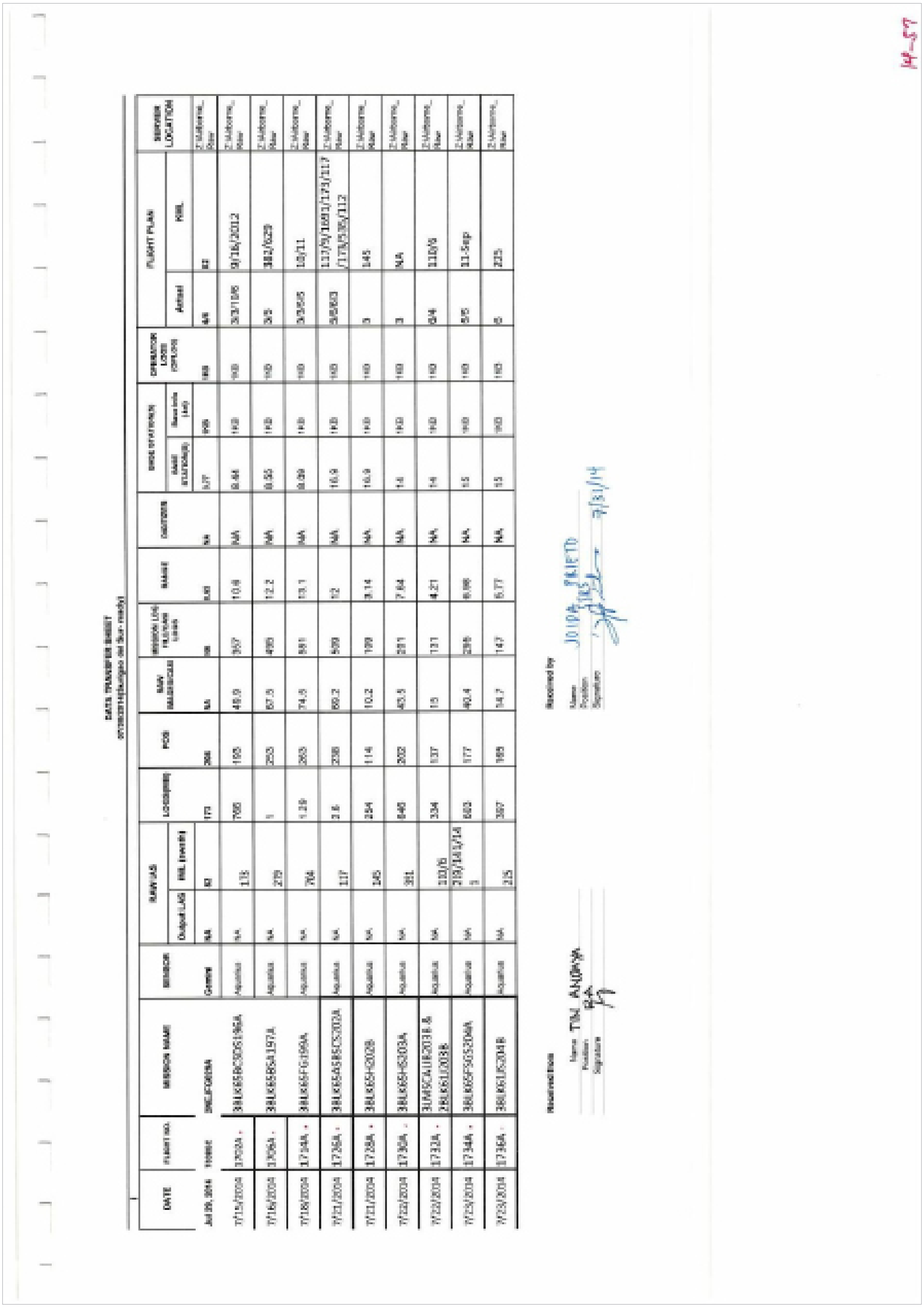
Name: Tin Andaya
Position: RA
Signature:

Received by

Name: JAIDA PRIETO
Position: SSRS
Signature: 8/20/14

14-66

Figure A-5.2. Transfer Sheet for Hinatuan Floodplain – B



DATA TRANSFER SHEET
07/28/2014(Surigao del Sur- ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
Jul 29, 2014	[illegible]	[illegible]	Gemini	NA	82	173	[illegible]	NA	[illegible]	[illegible]	NA	[illegible]	[illegible]	[illegible]	4/4	82	Z:\Airborne_Raw
7/15/2014	1702A	3BLK65BCSDS196A	Aquarius	NA	135	768	193	48.9	357	10.6	NA	8.44	1KB	1KB	3/3/10/6	9/16/2012	Z:\Airborne_Raw
7/16/2014	1706A	3BLK65BSA197A	Aquarius	NA	279	1	253	67.5	495	12.2	NA	8.55	1KB	1KB	3/5	382/629	Z:\Airborne_Raw
7/18/2014	1714A	3BLK65FG199A	Aquarius	NA	764	1.29	263	74.5	551	13.1	NA	9.09	1KB	1KB	3/3/5/5	10/11	Z:\Airborne_Raw
7/21/2014	1726A	3BLK65AS8SCS202A	Aquarius	NA	117	2.6	238	69.2	509	12	NA	16.9	1KB	1KB	5/5/6/3	117/9/1681/171/117/178/535/112	Z:\Airborne_Raw
7/21/2014	1728A	3BLK65H202B	Aquarius	NA	145	254	114	10.2	109	3.14	NA	16.9	1KB	1KB	3	145	Z:\Airborne_Raw
7/22/2014	1730A	3BLK65HS203A	Aquarius	NA	381	846	202	45.5	201	7.64	NA	14	1KB	1KB	3	NA	Z:\Airborne_Raw
7/22/2014	1732A	3UMSCAUB203B & 2BLK61J203B	Aquarius	NA	110/6	334	137	15	131	4.21	NA	14	1KB	1KB	6/4	110/6	Z:\Airborne_Raw
7/23/2014	1734A	3BLK65FSGS204A	Aquarius	NA	219/141/141	603	177	40.4	295	6.98	NA	15	1KB	1KB	5/5	11-Sep	Z:\Airborne_Raw
7/23/2014	1736A	3BLK61JS204B	Aquarius	NA	225	397	165	14.7	147	5.77	NA	15	1KB	1KB	6	225	Z:\Airborne_Raw

Received from

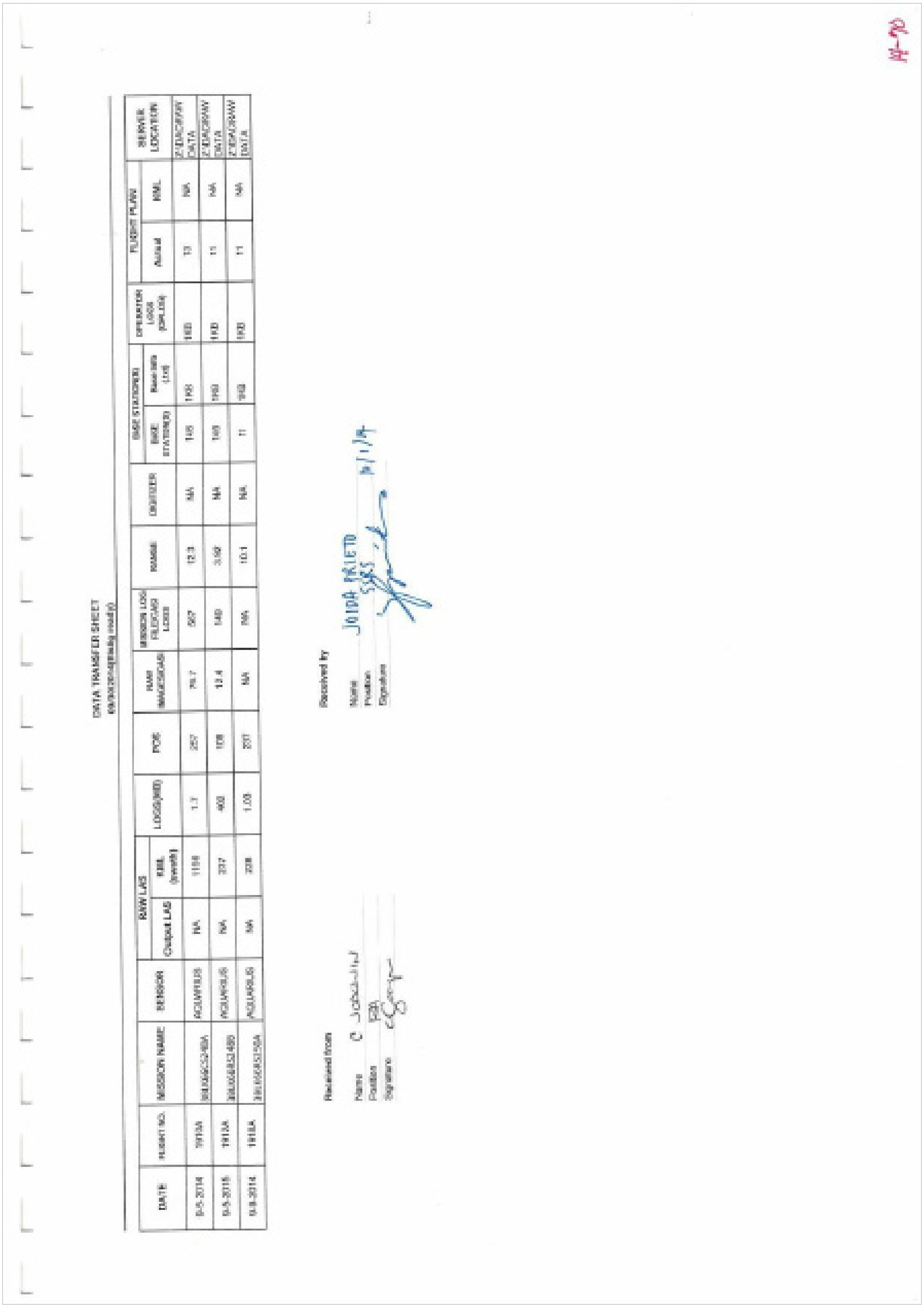
Name TIN ANDAYA
Position RA
Signature

Received by

Name JOIDA PRIETO
Position SRS
Signature 7/31/14

H-57

Figure A-5.3. Transfer Sheet for Hinatuan Floodplain – C



DATA TRANSFER SHEET
09/30/2014(Billing ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
9-5-2014	1910A	3BLK68CS248A	AQUARIUS	NA	1158	1.7	257	79.7	567	12.3	NA	145	1KB	1KB	13	NA	Z:\DAC\RAW DATA
9-5-2015	1912A	3BLK68BS248B	AQUARIUS	NA	237	402	108	13.4	140	3.92	NA	149	1KB	1KB	11	NA	Z:\DAC\RAW DATA
9-8-2014	1918A	3BLK68BS250A	AQUARIUS	NA	228	1.03	237	NA	NA	10.1	NA	11	1KB	1KB	11	NA	Z:\DAC\RAW DATA

Received from

Name: C [illegible]
Position: FSA
Signature:

Received by

Name: JOIDA PRIETO
Position: SSRS
Signature:
10/1/14

Figure A-5.4. Transfer Sheet for Hinatuan Floodplain – D

DATA TRANSFER SHEET
08/29/2014(Surigao del Sur(Tandag/Bislig)- ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
7/25/2014	1740A	[illegible]	Aquarius	NA	260	721	258	34.1	260	8.78	NA	5.53	1KB	1KB	5/14	37	Z:\AIRBORNE_RAW
7/27/2014	1750A	[illegible]	Aquarius	NA	260	385	144	29	96	4.23	NA	15	1KB	1KB	4	197	Z:\DAC\RAWDATA
7/27/2014	1752A	[illegible]	Aquarius	NA	263	332	130	5.41	46	3.35	NA	15	1KB	1KB	5/4	13	Z:\DAC\RAWDATA
7/29/2014	1758A	3BLK81FCHKMSN210A	Aquarius	NA	156/271/250	1.01	271	15.7	0	12.7	NA	8.78	1KB	1KB	8/7/8	5/17	Z:\DAC\RAWDATA
8/4/2014	1784A	3BLK88H211B	Aquarius	NA	ll	2.65	191	41/17.9	218/186	10.7	NA	17.4	1KB	1KB	4/4	5/5	Z:\DAC\RAWDATA
8/8/2014	1798A	3BLK88N220A	Aquarius	NA	141	1.03	256	75.7	389	11.4	522	15.5	1KB	1KB	6	6	Z:\DAC\RAWDATA
8/8/2014	1800A	3BLK88O220B	Aquarius	NA	181	645	162	42.2	329	7.27	944	15.6	1KB	1KB	5	11	Z:\DAC\RAWDATA
8/9/2014	1804A	3BLK88OSP221B	Aquarius	NA	266/275	888	231	58.9	485	10.1	NA	14.1	1KB	1KB	6/6	11/12	Z:\DAC\RAWDATA
8/11/2014	1812A	3BLK88G222B	Aquarius	NA	188	593	143	28.9	237	8.85	NA	18.3	1KB	1KB	6	33	Z:\DAC\RAWDATA
8/12/2014	1814A	3BLK88RF224A	Aquarius	NA	52/W71	1	287	87.1	386	10.3	459	16.9	1KB	1KB	6/7	12/13	Z:\DAC\RAWDATA
8/13/2014	1816A	3BLK88SE224B	Aquarius	NA	212	457	189	NA	NA	8.21	NA	16.9	1KB	1KB	6	13	Z:\DAC\RAWDATA
8/13/2014	1818A	3BLK88D225A	Aquarius	NA	382	644	257	32.1	156	10.3	NA	5.12	1KB	1KB	7	15	Z:\DAC\RAWDATA
8/17/2014	1834A	3BLK88AS8229A	Aquarius	NA	170	405	175	NA	NA	7.71	NA	16.5	1KB	1KB	6	NA	Z:\DAC\RAWDATA
8/17/2014	1836A	3BLK88D5229B	Aquarius	NA	430	686	176	30.7	180	8.01	NA	18.5	1KB	1KB	7	6	Z:\DAC\RAWDATA

Received from
Name KRISTINE ANDAYA
Position RA
Signature

Received by
Name JOIDA PRIETO
Position SSRS
Signature 9/1/14

14-69

Figure A-5.5. Transfer Sheet for Hinatuan Floodplain – E

DATA TRANSFER SHEET

08/13/2014(Surigao del Sur(Tandag/Bislig) - ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS Output LAS	RAW LAS KML (swath)	LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S) BASE STATION (S)	BASE STATION(S) Base Info (.txt)	OPERATOR LOGS (OPLOG)	FLIGHT PLAN Actual	FLIGHT PLAN KML	SERVER LOCATION
8/5/2014	1788A	3BLK66EGS217B	Aquarius	NA	588/45	1.06	228	60.4	600	10.4	1.07	17.8	1KB	1KB	4/4	11/9	Z:\DAC\RAWDATA
8/6/2014	1790A	3BLK66M218A	Aquarius	NA	557	958	245	4.25/56.4	31/400	10.3	520	11.9	1KB	1KB	5	11	Z:\DAC\RAWDATA
8/7/2014	1794A	3BLK66LMS219A	Aquarius	NA	324/239	0.99	291	48.6	337	13.9	NA	17.8	1KB	1KB	6/5	13/12	Z:\DAC\RAWDATA
8/7/2014	1796A	3BLK66LSJS219B	Aquarius	NA	352/578	1.1	226	54.9	524	10.8	NA	17.8	1KB	1KB	4/6	11/13	Z:\DAC\RAWDATA
8/18/2014	1838A	3BLK66SS230A	Aquarius	NA	646	1.4	245	45.8/21.3	1/343/129	12	NA	11.3	1KB	1KB	4/8	13/25	Z:\DAC\RAWDATA
8/19/2014	1842A	3BLK66T231A	Aquarius	NA	505	1.6	272	56.6	428	9.83	NA	9.7	1KB	1KB	7	16	Z:\DAC\RAWDATA
8/21/2014	1850A	3BLK66VW233A	Aquarius	NA	196/667	1.42	260	97.4	739	15.2	NA	10.6	1KB	1KB	4/9/6	8	Z:\DAC\RAWDATA
8/22/2014	1854A	3BLK66BWS234A	Aquarius	NA	45/395	872	248	45.5	352	8.36	NA	9.63	1KB	1KB	6/7	6/14	Z:\DAC\RAWDATA
8/26/2014	1870A	3BLK66ASB238A	Aquarius	NA	306/715	1.43	287	105	760	18.1	NA	10.5	1KB	1KB	4/5/6/5	8/9	Z:\DAC\RAWDATA

Received from

Name: TIN ANDAYA

Position: RA

Signature

Received by

Name: JUDA PRIETO 9/5/17

Position: SSRS

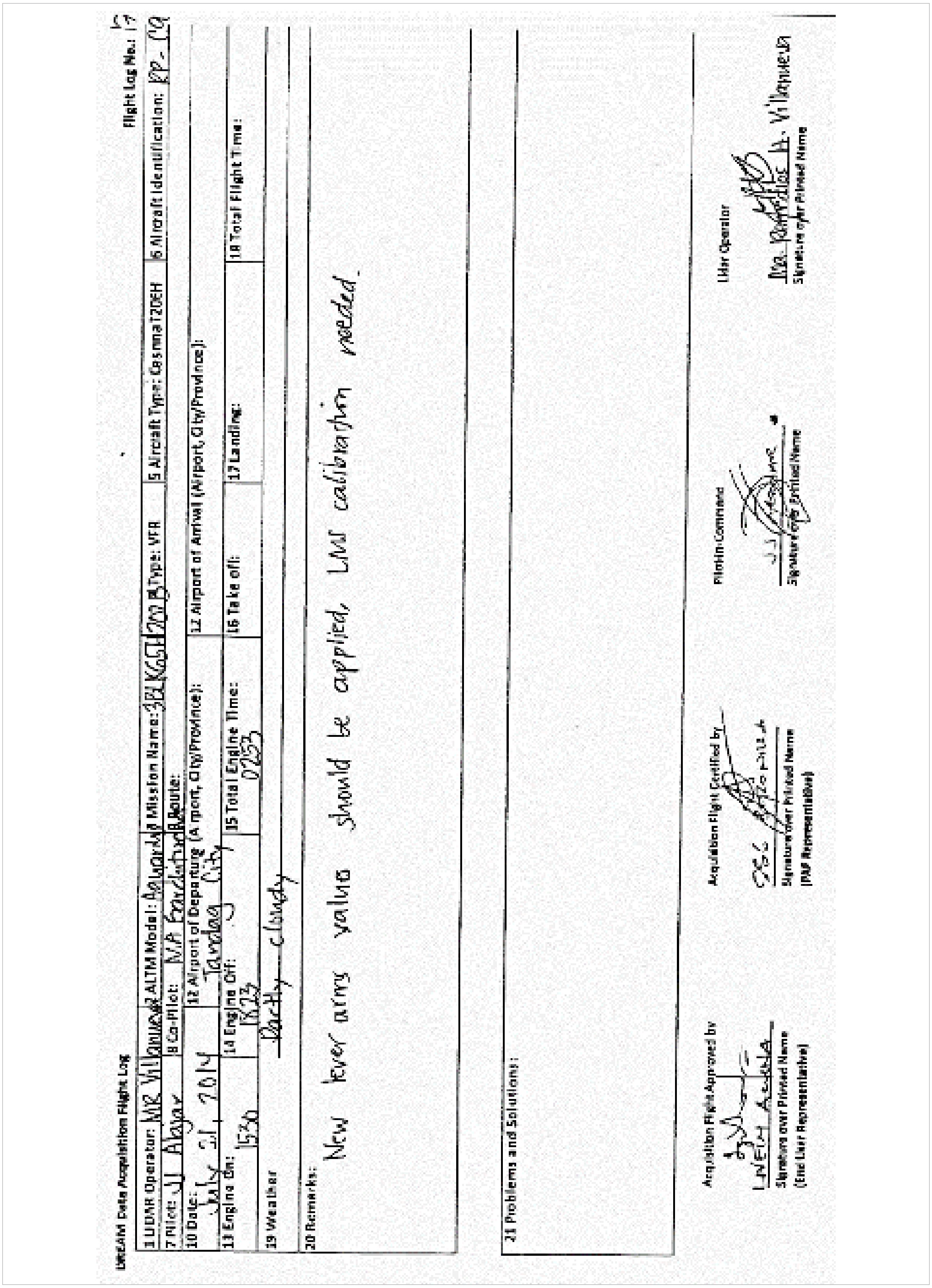
Signature

14-63

Figure A-5.6. Transfer Sheet for Hinatuan Floodplain – F

ANNEX 6. Flight Logs for the Flight Missions

1. Flight Log for 3BLK65H202B Mission


DREAM Data Acquisition Flight Log

Flight Log No.: 17

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK65H202B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9
7 Pilot: JJ Alajar	8 Co-Pilot: NA Bardaje	9 Route:			
10 Date: July 21, 2014	12 Airport of Departure (Airport, City/Province): Tandag City	12 Airport of Arrival (Airport, City/Province):			
13 Engine On: 1530	14 Engine Off: 1823	15 Total Engine Time: 0253	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks: New lever arms value should be applied, LMS calibration needed.

21 Problems and Solutions:

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

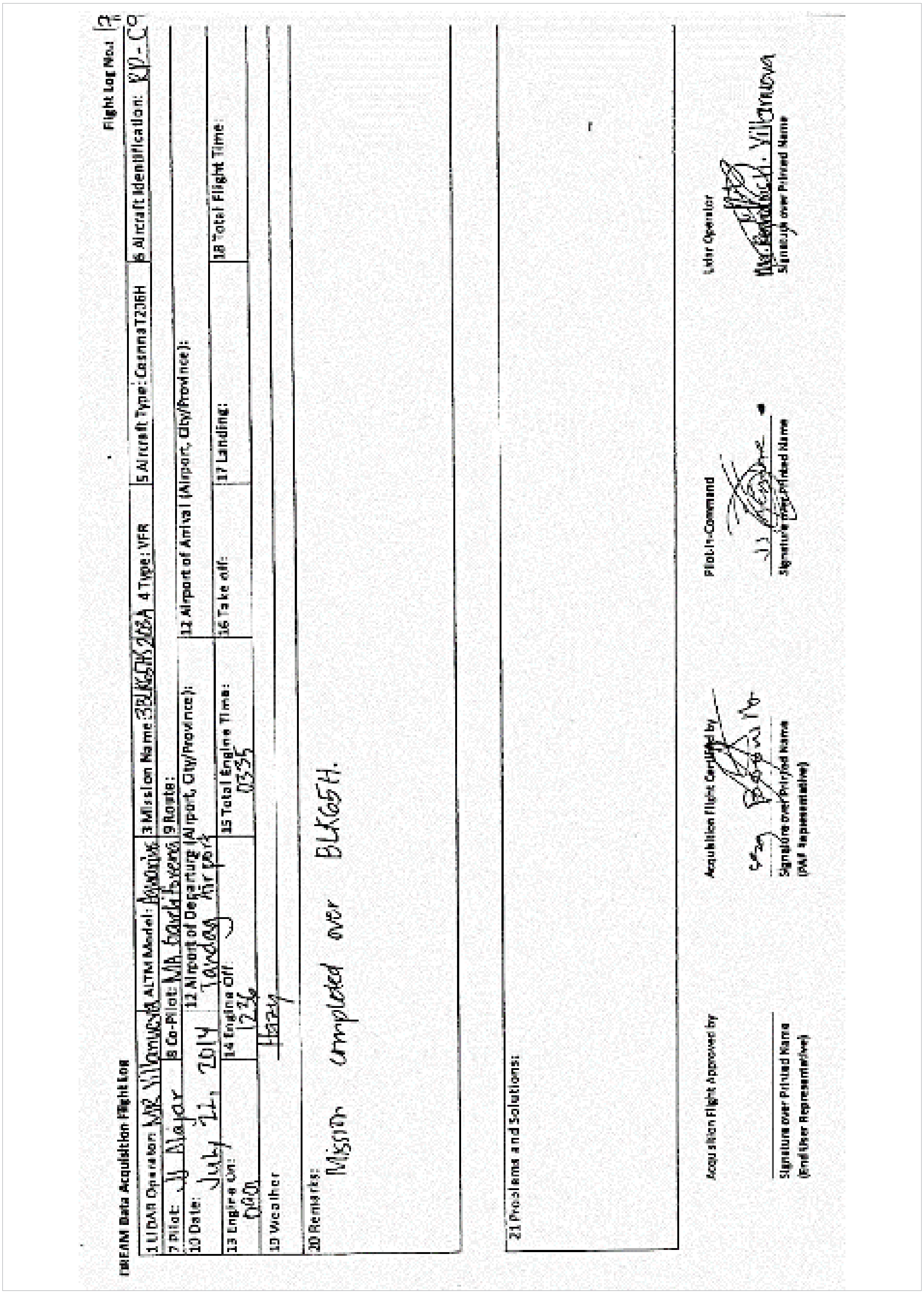
Acquisition Flight Certified by: Signature over Printed Name (PAF Representative)

Pilot-in-Command: JJ Alajar — Signature over Printed Name

Lidar Operator: Ma. Remedios B. Villanueva — Signature over Printed Name

Figure A-6.1. Flight Log for Mission 3BLK65H202B

2. Flight Log for 3BLK65H203A Mission



DREAM Data Acquisition Flight Log — Flight Log No.: 13

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK65H203A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9
7 Pilot: JJ Alajar	8 Co-Pilot: MA Bautista	9 Route:			
10 Date: July 22, 2014	12 Airport of Departure (Airport, City/Province): Tandag Airport		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0900	14 Engine Off: 1235	15 Total Engine Time: 0335	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Hazy					

20 Remarks: Mission completed over BLK65H.

21 Problems and Solutions:

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

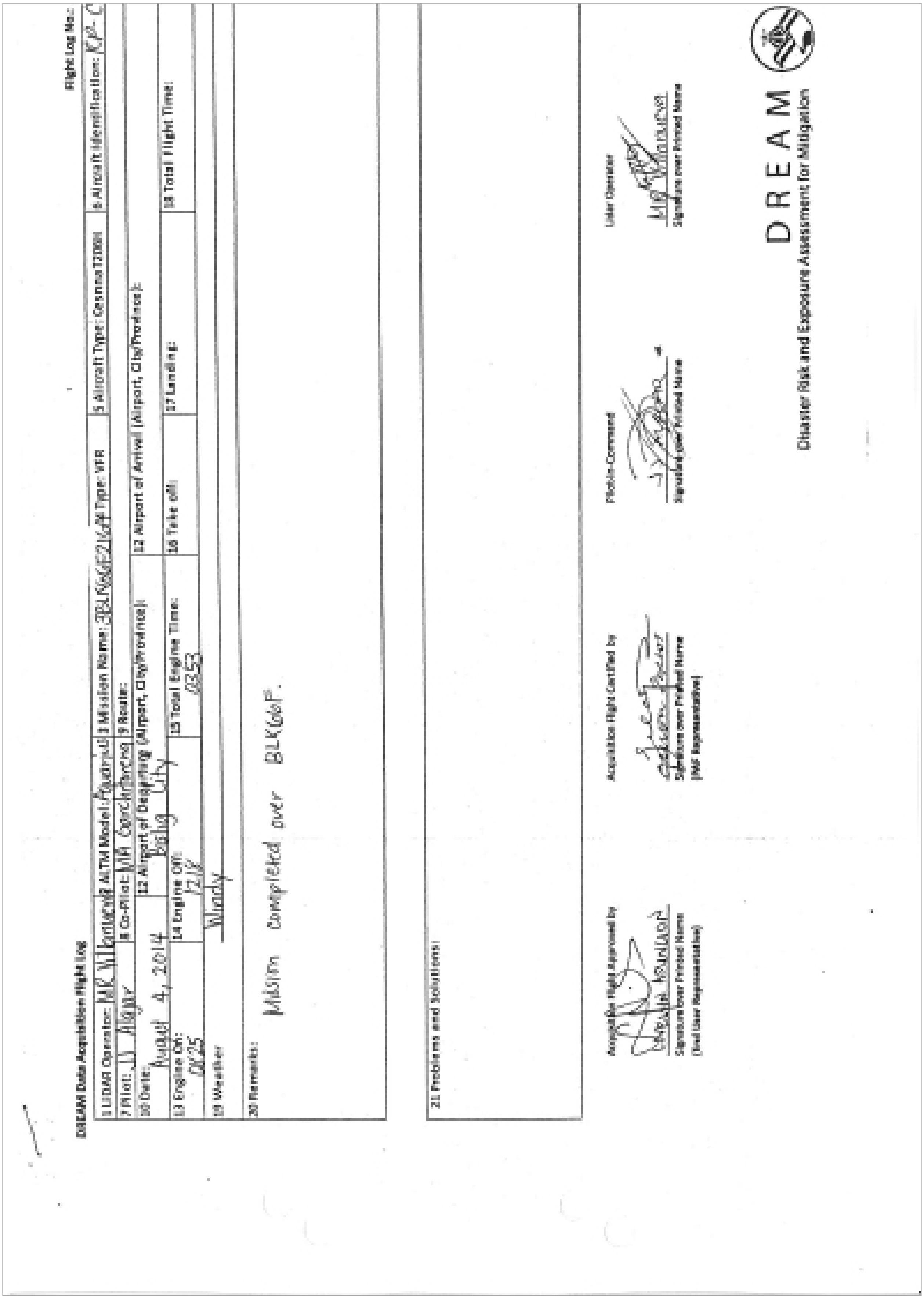
Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

Figure A-6.2. Flight Log for Mission 3BLK65H203A

3. Flight Log for 3BLK66F216A Mission



DREAM Data Acquisition Flight Log

Flight Log No.:

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Pegasus	3 Mission Name: 3BLK66F216A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C[illegible]
7 Pilot: JJ Alajar	8 Co-Pilot: MA [illegible]	9 Route:			
10 Date: August 4, 2014	12 Airport of Departure (Airport, City/Province): Butuan City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0825	14 Engine Off: 1218	15 Total Engine Time: 0353	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Windy					

20 Remarks:

Mission completed over BLK66F.

21 Problems and Solutions:

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

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

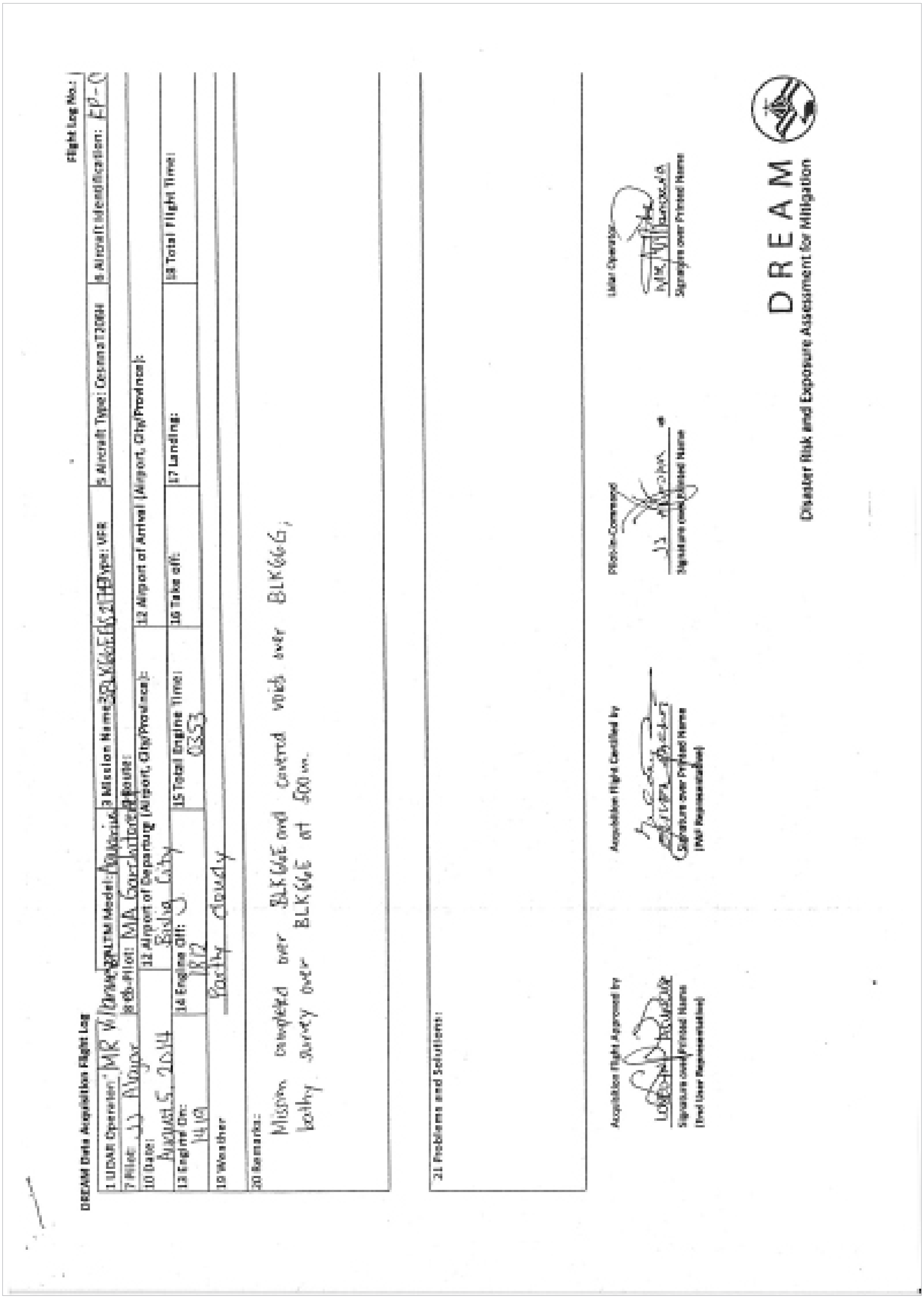
Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.3. Flight Log for Mission 3BLK66F216A

4. Flight Log for 3BLK66EGS217B Mission


DREAM Data Acquisition Flight Log

Flight Log No.: EP-

1 LiDAR Operator: MR Villanueva	2 ALTM Model: Pegasus	3 Mission Name: 3BLK66EGS217B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification:
7 Pilot: JJ Mayor	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 5, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1410	14 Engine Off: 1812	15 Total Engine Time: 0353	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks:

Mission completed over BLK66E and covered void over BLK66G; bathy survey over BLK66E at 500 m.

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)

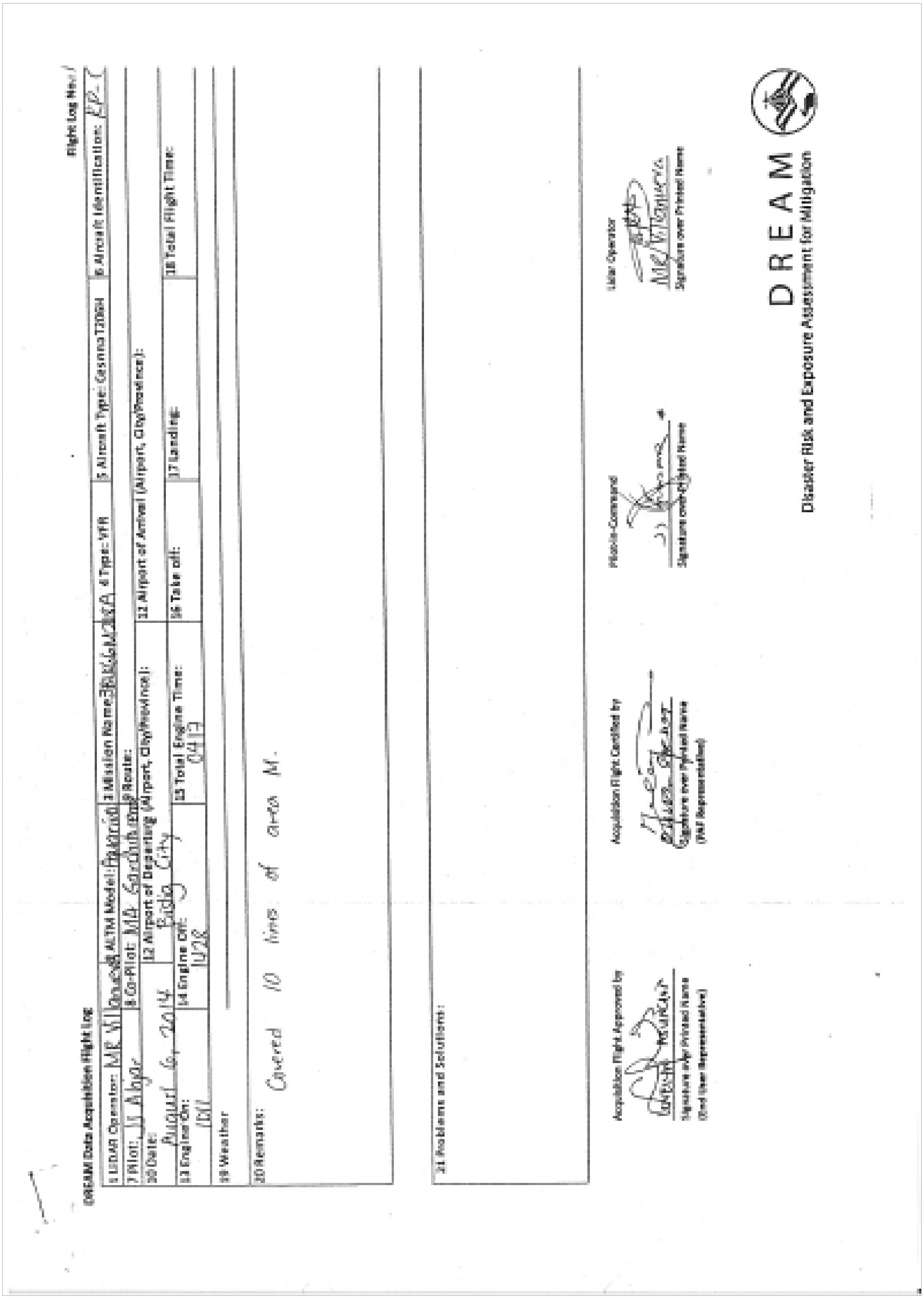
Pilot-in-Command — JJ Mayor — Signature over Printed Name

Lidar Operator — MR Villanueva — Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.4. Flight Log for Mission 3BLK66EGS217B

5. Flight Log for 3BLK66M218A Mission



DREAM Data Acquisition Flight Log

Flight Log No.:

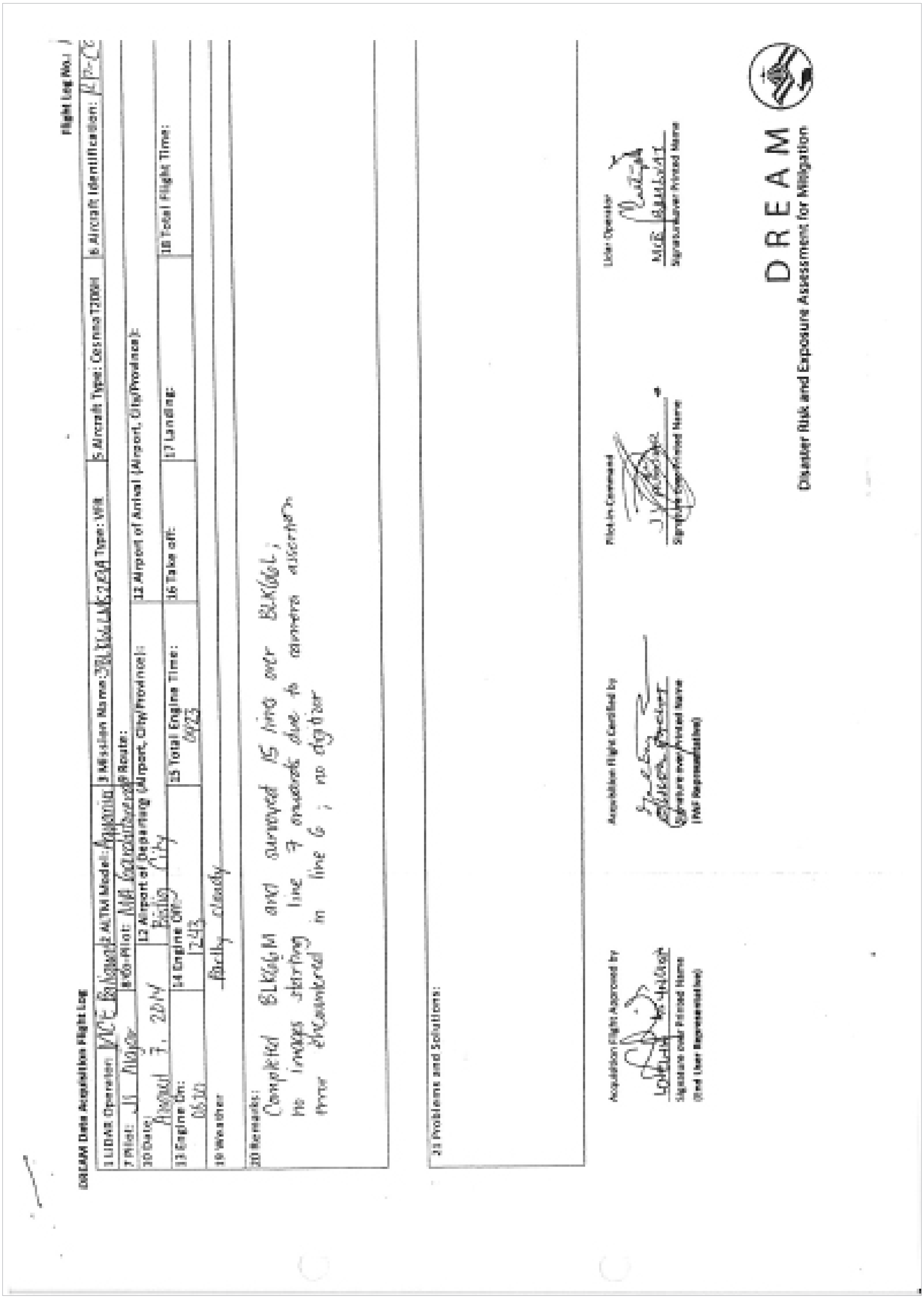
1 LIDAR Operator: MR Villanueva
2 ALTM Model: Pegasus
3 Mission Name: 3BLK66M218A
4 Type: VFR
5 Aircraft Type: Cessna T206H
6 Aircraft Identification: RP-C
7 Pilot: JJ Alviar
8 Co-Pilot: MB Sandoval
9 Route:
10 Date: August 6, 2014
12 Airport of Departure (Airport, City/Province): Bislig City
12 Airport of Arrival (Airport, City/Province):
13 Engine On: 1011
14 Engine Off: 1428
15 Total Engine Time: 0417
16 Take off:
17 Landing:
18 Total Flight Time:
19 Weather
20 Remarks: Covered 10 lines of area M.
21 Problems and Solutions:

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

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.5. Flight Log for Mission 3BLK66M218A

6. Flight Log for 3BLK66LMS219A Mission


DREAM Data Acquisition Flight Log

Flight Log No.:

1 LIDAR Operator: MCE Balquiedra | 2 ALTM Model: Pegasus | 3 Mission Name: 3BLK66LMS219A | 4 Type: VFR | 5 Aircraft Type: Cessna T206H | 6 Aircraft Identification:

7 Pilot: JL Mayor | 8 Co-Pilot: | 9 Route:

10 Date: August 7, 2014 | 12 Airport of Departure (Airport, City/Province): Iloilo City | 12 Airport of Arrival (Airport, City/Province):

13 Engine On: | 14 Engine Off: | 15 Total Engine Time: | 16 Take off: | 17 Landing: | 18 Total Flight Time:

19 Weather: Partly cloudy

20 Remarks: Completed BLK66M and surveyed 15 lines over BLK66L; no images starting line 7 onwards due to camera assertion error encountered in line 6; no digitizer

21 Problems and Solutions:

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

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

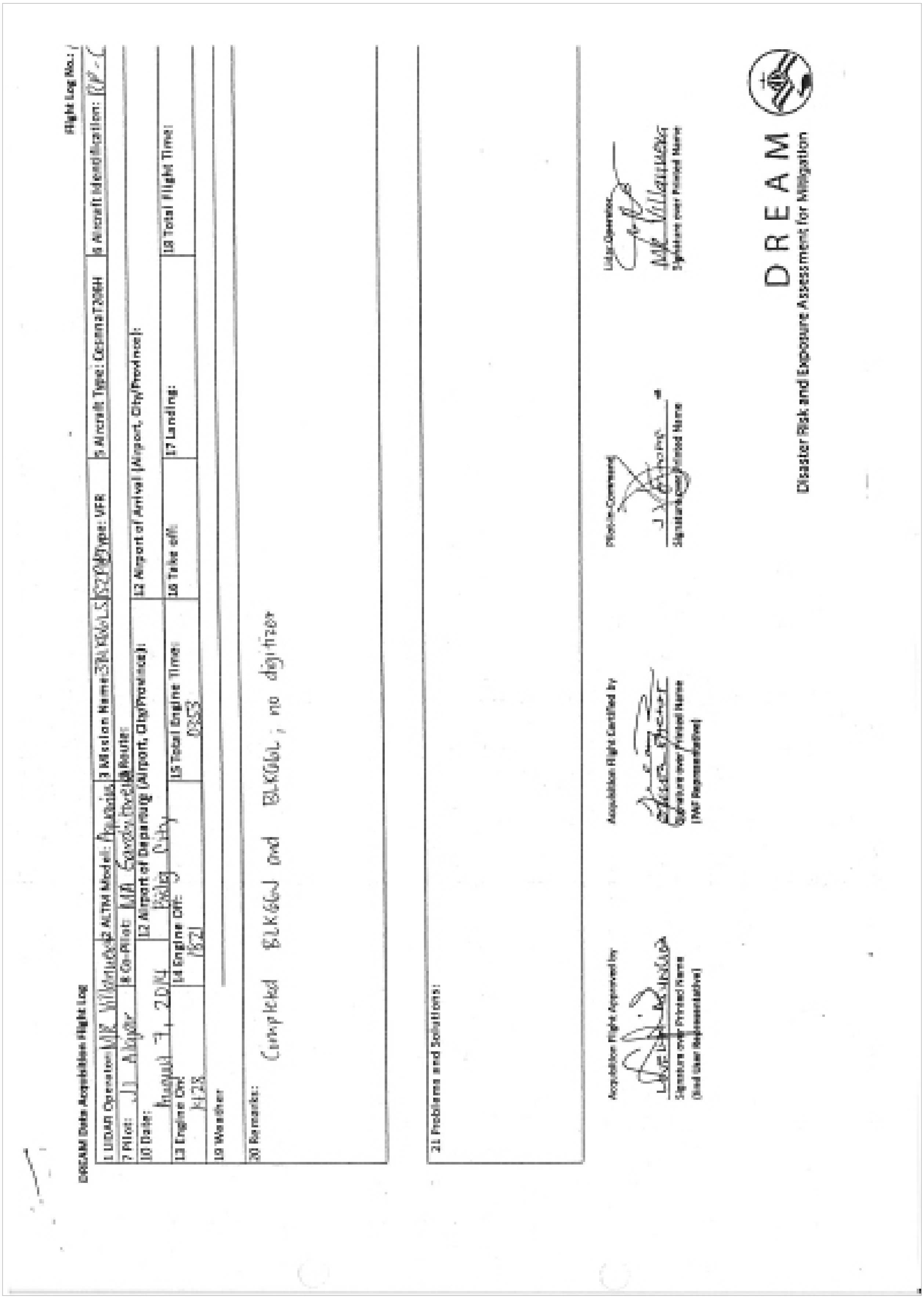
Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.6. Flight Log for Mission 3BLK66LMS219A

7. Flight Log for 3BLK66LSJS219B Mission



DREAM Data Acquisition Flight Log

Flight Log No.:

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66LSJS219B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C
7 Pilot: JJ Alviar	8 Co-Pilot: MA Sandoval	9 Route:			
10 Date: August 7, 2014	12 Airport of Departure (Airport, City/Province): Butuan City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1428	14 Engine Off: 1821	15 Total Engine Time: 0353	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

Completed BLK66J and BLK66L; no digitizer

21 Problems and Solutions:

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

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

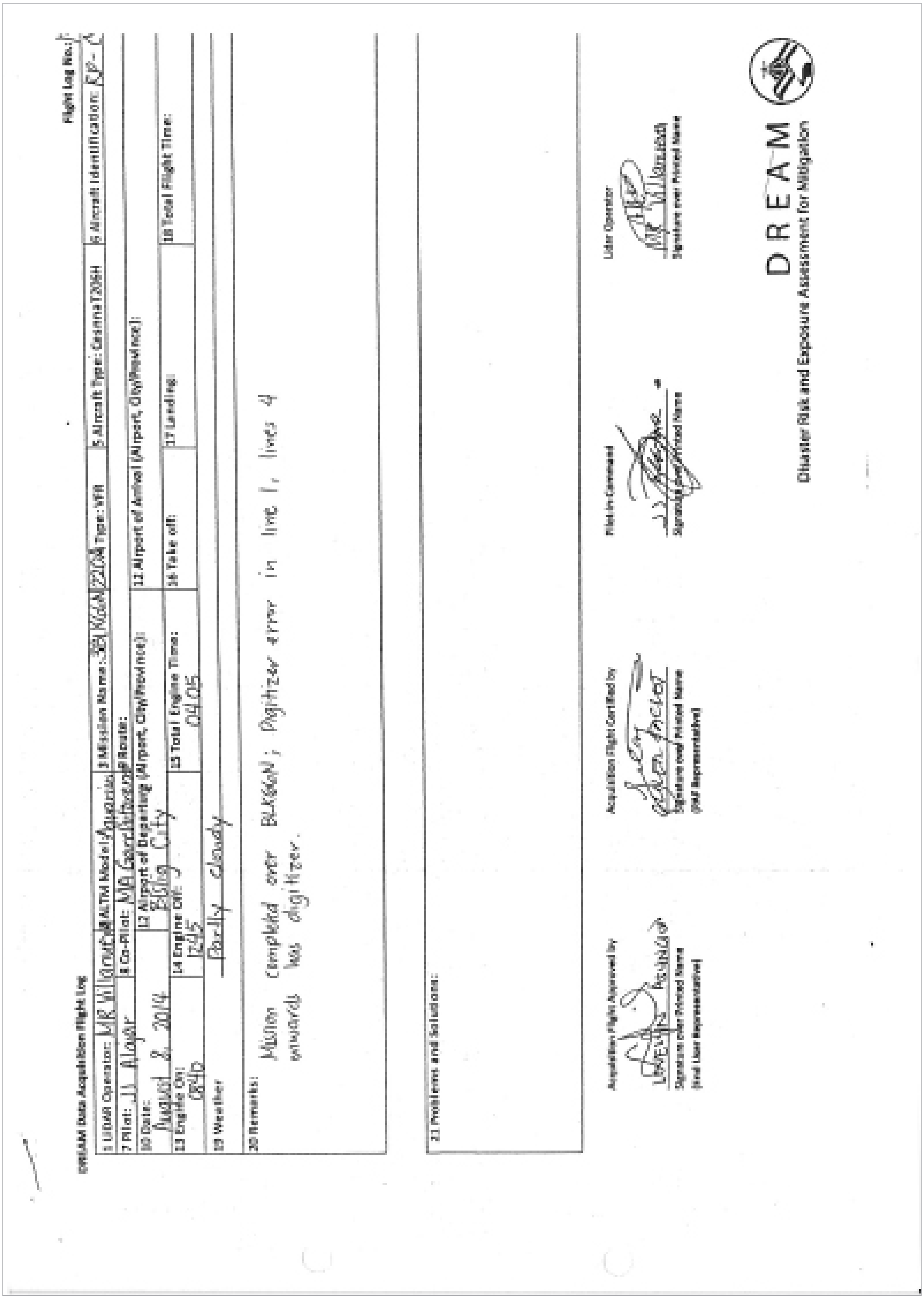
Pilot-in-Command: J Alviar — Signature over Printed Name

Lidar Operator: MR Villanueva — Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.7. Flight Log for Mission 3BLK66LSJS219B

8. Flight Log for 3BLK66N220A Mission


DREAM Data Acquisition Flight Log

Flight Log No.: [illegible]

1 LiDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66N220A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C[illegible]
7 Pilot: JJ Alagar	8 Co-Pilot: [illegible]	9 Route:			
10 Date: August 8, 2014	12 Airport of Departing (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0840	14 Engine Off: 1245	15 Total Engine Time: 0405	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks:

Mission completed over BLK66N; Digitizer error in line 1, lines 4 onwards was digitizer.

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)

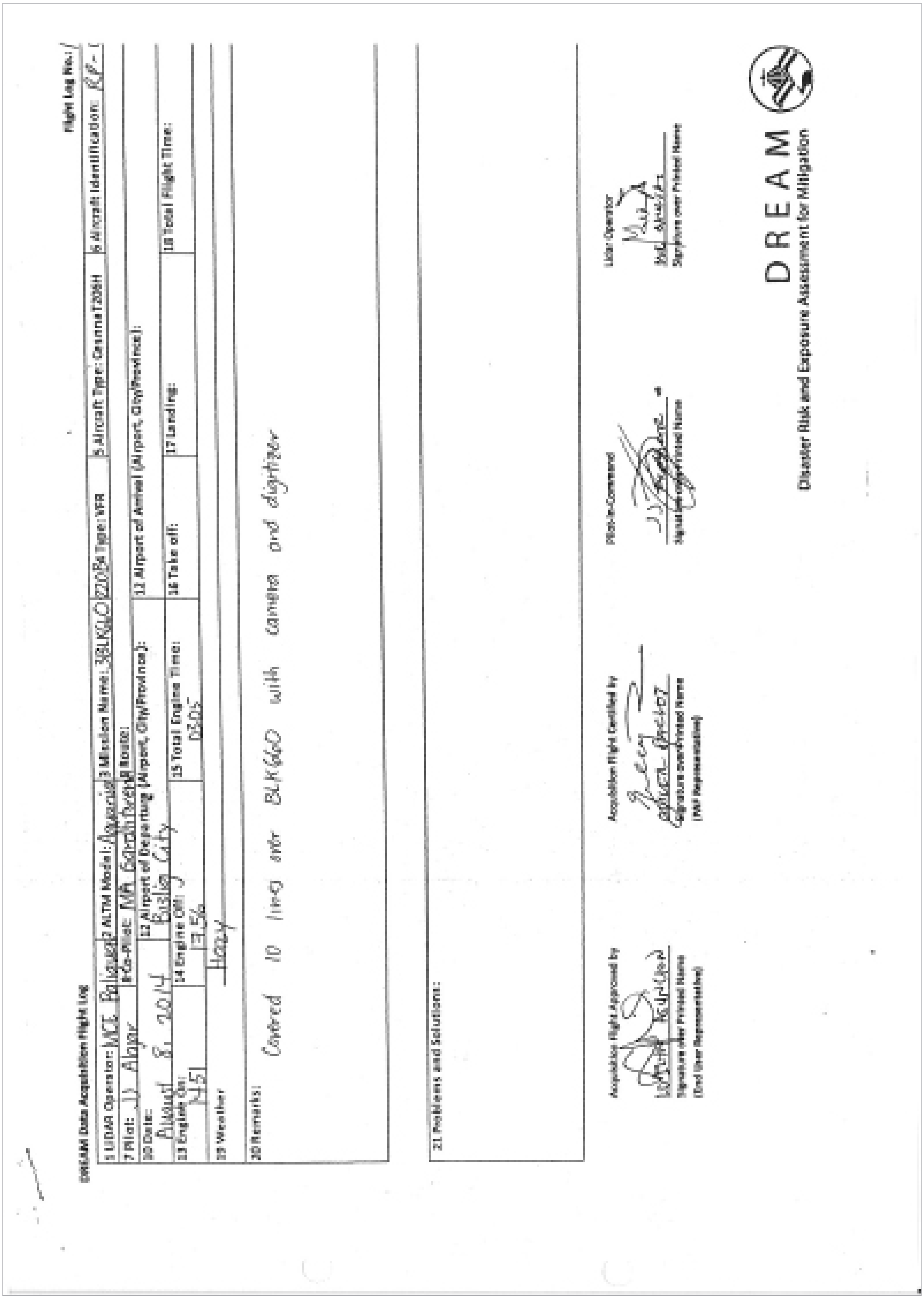
Pilot-in-Command — Signature over Printed Name

Lidar Operator — MR Villanueva — Signature over Printed Name

DREAM Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.8. Flight Log for Mission 3BLK66N220A

9. Flight Log for 3BLK66O220B Mission



DREAM Data Acquisition Flight Log

Flight Log No.:

1 LIDAR Operator: MCE Balicanta	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66O220B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garabiles	9 Route:			
10 Date: August 8, 2014	12 Airport of Departure (Airport, City/Province): Butuan City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1451	14 Engine Off: 1756	15 Total Engine Time: 0305	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Hazy					

20 Remarks:

Covered 10 lines over BLK66O with camera and digitizer

21 Problems and Solutions:

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

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

Pilot-in-Command — Signature over Printed Name

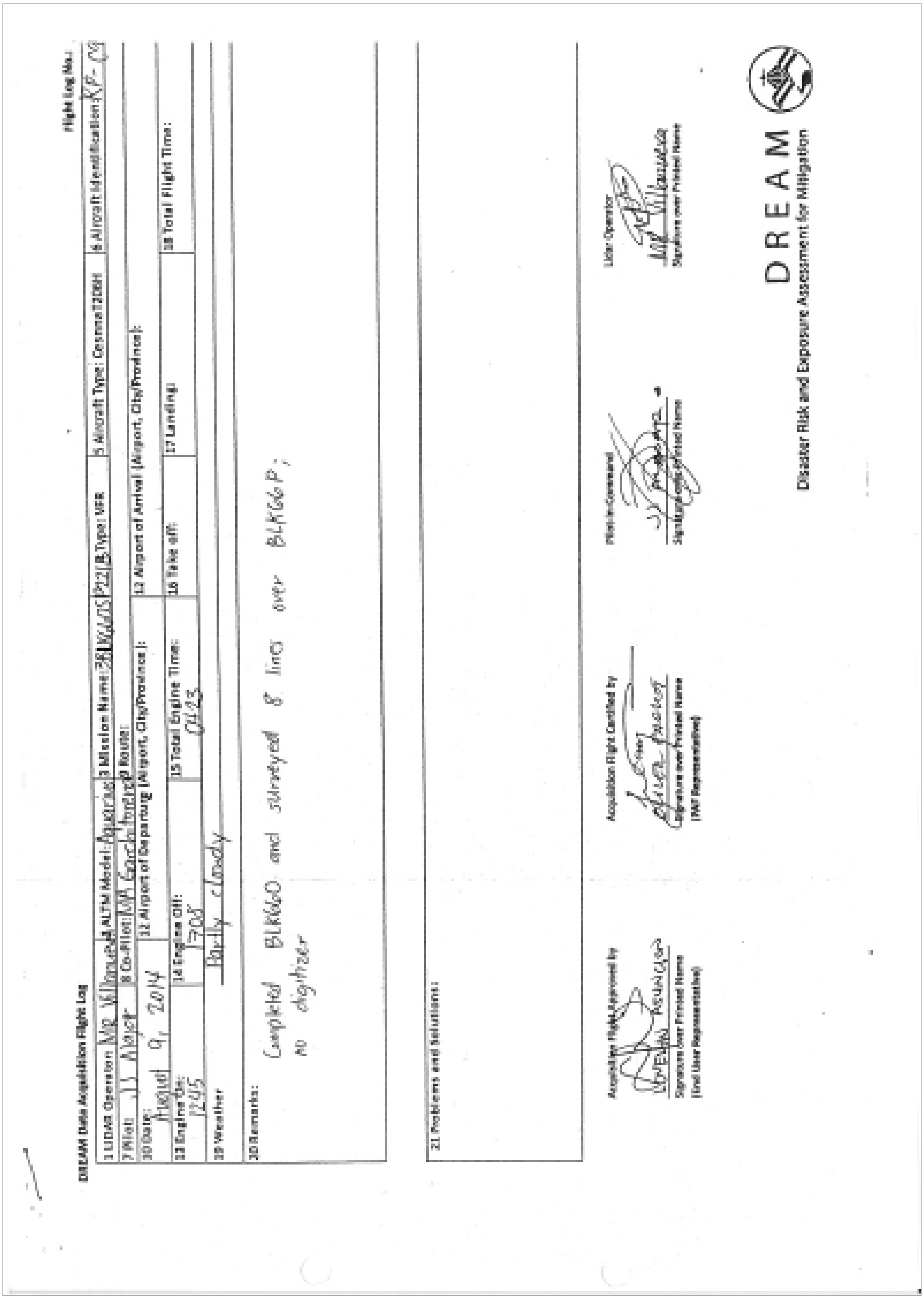
Lidar Operator — Signature over Printed Name

DREAM

Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.9. Flight Log for Mission 3BLK66O220B

10. Flight Log for 3BLK66OSP221B Mission



DREAM Data Acquisition Flight Log

Flight Log No.:

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66OSP221B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9
7 Pilot: JJ Alviar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 9, 2014	12 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1245	14 Engine Off: 1708	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks:

Completed BLK66O and surveyed 8 lines over BLK66P; no digitizer

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)

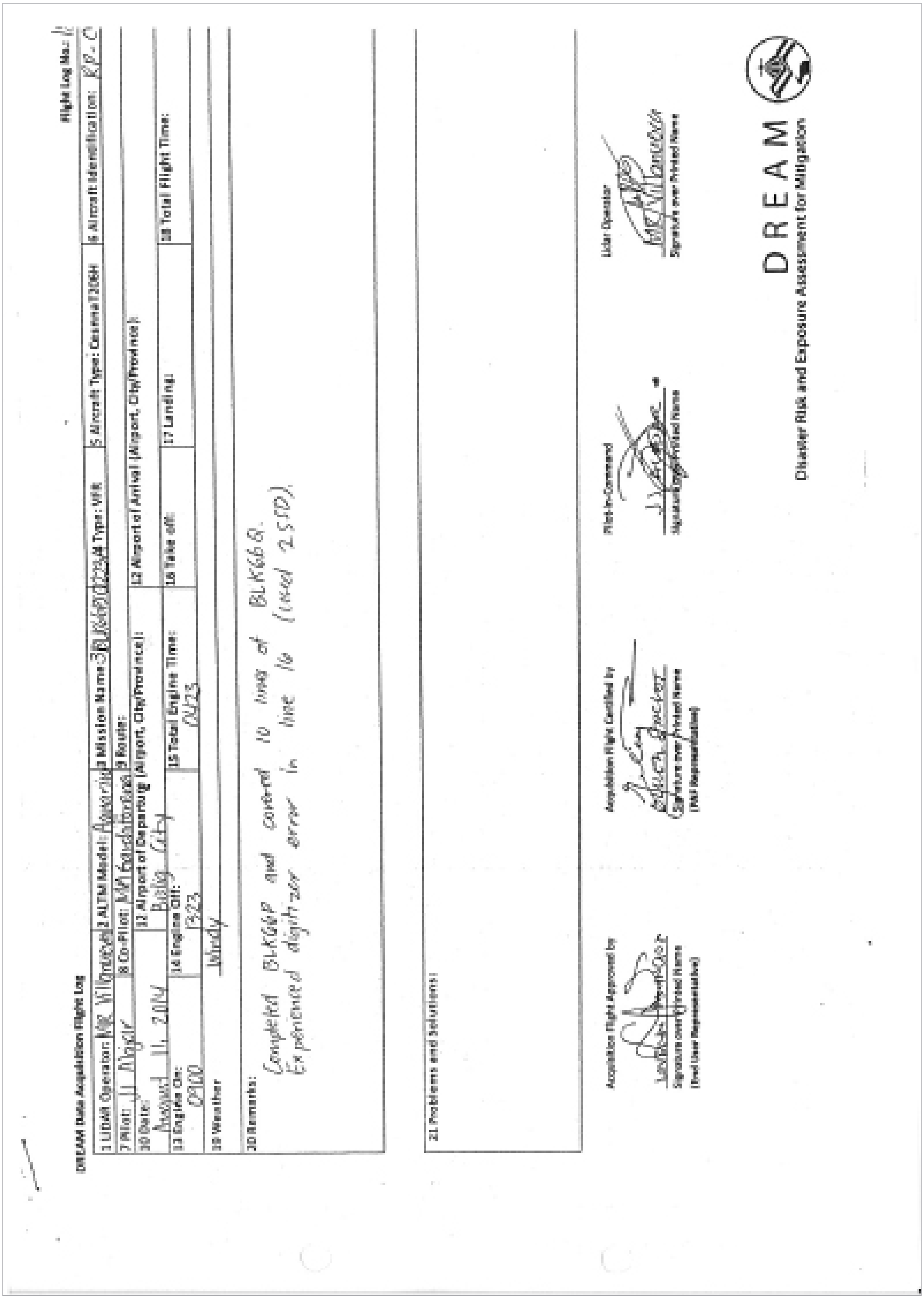
Pilot-in-Command — JJ Alviar — Signature over Printed Name

Lidar Operator — MR Villanueva — Signature over Printed Name

DREAM — Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.10. Flight Log for Mission 3BLK66OSP221B

11. Flight Log for 3BLK66PSQ223A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 11

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66PSQ223A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C
7 Pilot: JJ Major	8 Co-Pilot: MA Gaudiatorena	9 Route:			
10 Date: August 11, 2014	12 Airport of Departure (Airport, City/Province): Butig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0900	14 Engine Off: 1323	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Windy					

20 Remarks:

Completed BLK66P and covered 10 lines of BLK66Q. Experienced digitizer error in line 16 (used 2550).

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: JJ Major, Signature over Printed Name

Lidar Operator: MR Villanueva, Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.11. Flight Log for Mission 3BLK66PSQ223A

12. Flight Log for 3BLK66QS223B Mission

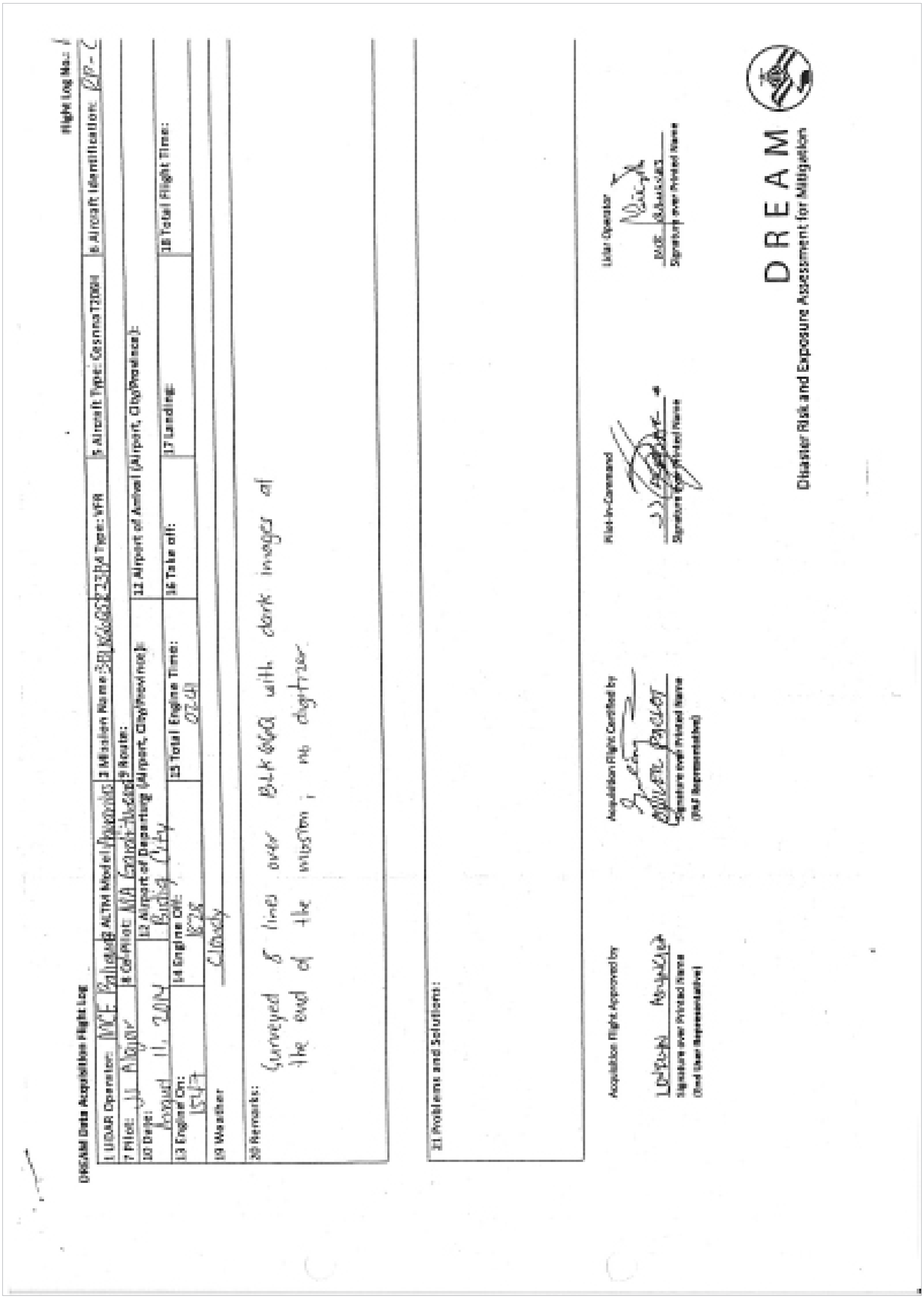
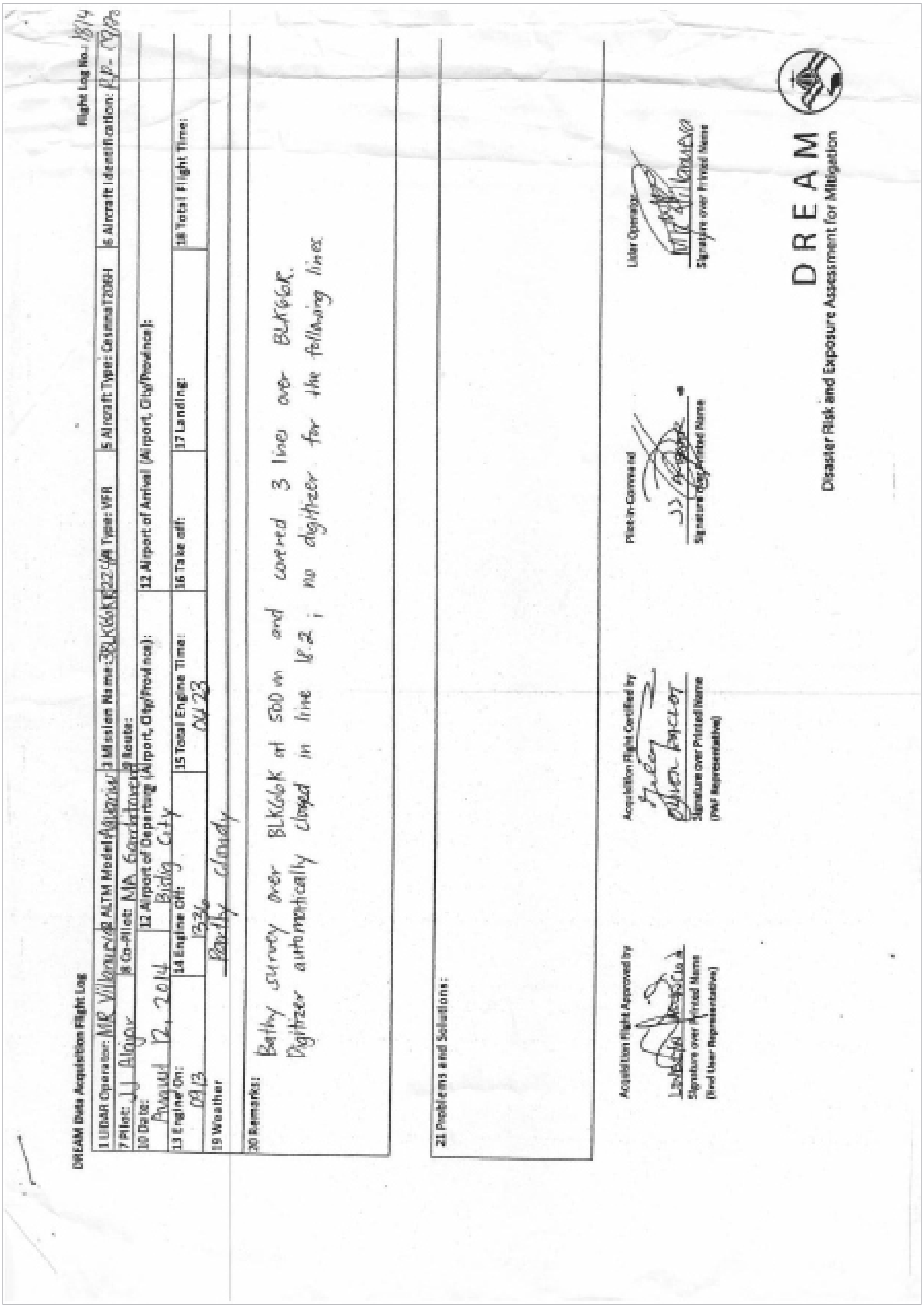


Figure A-6.12. Flight Log for Mission 3BLK66QS223B

13. Flight Log for 3BLK66KR224A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1814

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66KR224A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9022
7 Pilot: JJ Alajar	8 Co-Pilot: MA Gandatorn	9 Route:			
10 Date: August 12, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0913	14 Engine Off: 1336	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Partly cloudy				

20 Remarks:

Bathy survey over BLK66K at 500 m and covered 3 lines over BLK66R. Digitizer automatically closed in line 18.2; no digitizer for the following lines.

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)

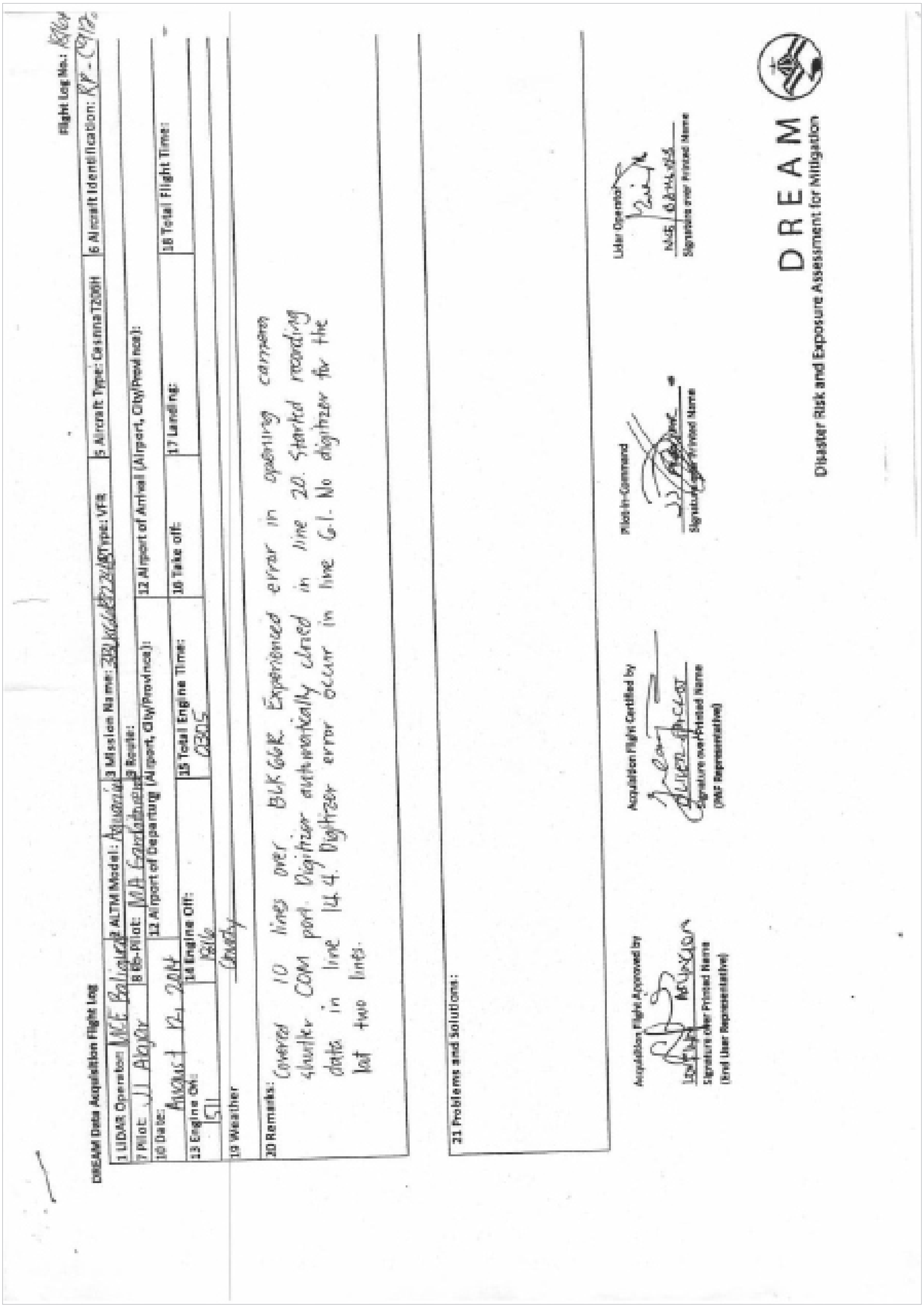
Pilot-in-Command: JJ Alajar, Signature over Printed Name

Lidar Operator: MR Villanueva, Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.13. Flight Log for Mission 3BLK66KR224A

14. Flight Log for 3BLK66RS224B Mission


DREAM Data Acquisition Flight Log

Flight Log No.:

1 LIDAR Operator:	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66RS224B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: JJ Alajar	8 Co-Pilot:	9 Route:			
10 Date: August 12, 2014	12 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1511	14 Engine Off: 1816	15 Total Engine Time: 0305	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Cloudy					

20 Remarks: Covered 10 lines over BLK 66R. Experienced error in opening camera shutter, COM port. Digitizer automatically closed in line 20. Started recording data in line 14.4. Digitizer error occur in line 6.1. No digitizer for the last two lines.

21 Problems and Solutions:

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

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

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

DREAM Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.14. Flight Log for Mission 3BLK66RS224B

15. Flight Log for 3BLK66S226A Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 182

1 LIDAR Operator: MCE Balicanta	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66S226A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: JI Alajar	8 Co-Pilot: MA [illegible]	9 Route:			
10 Date: August 14, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		11 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0925	14 Engine Off: 1318	15 Total Engine Time: 0353	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Cloudy					

20 Remarks:

Covered 13 lines over BLK66 with voids due to high terrain; no digitizer, with camera.

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)

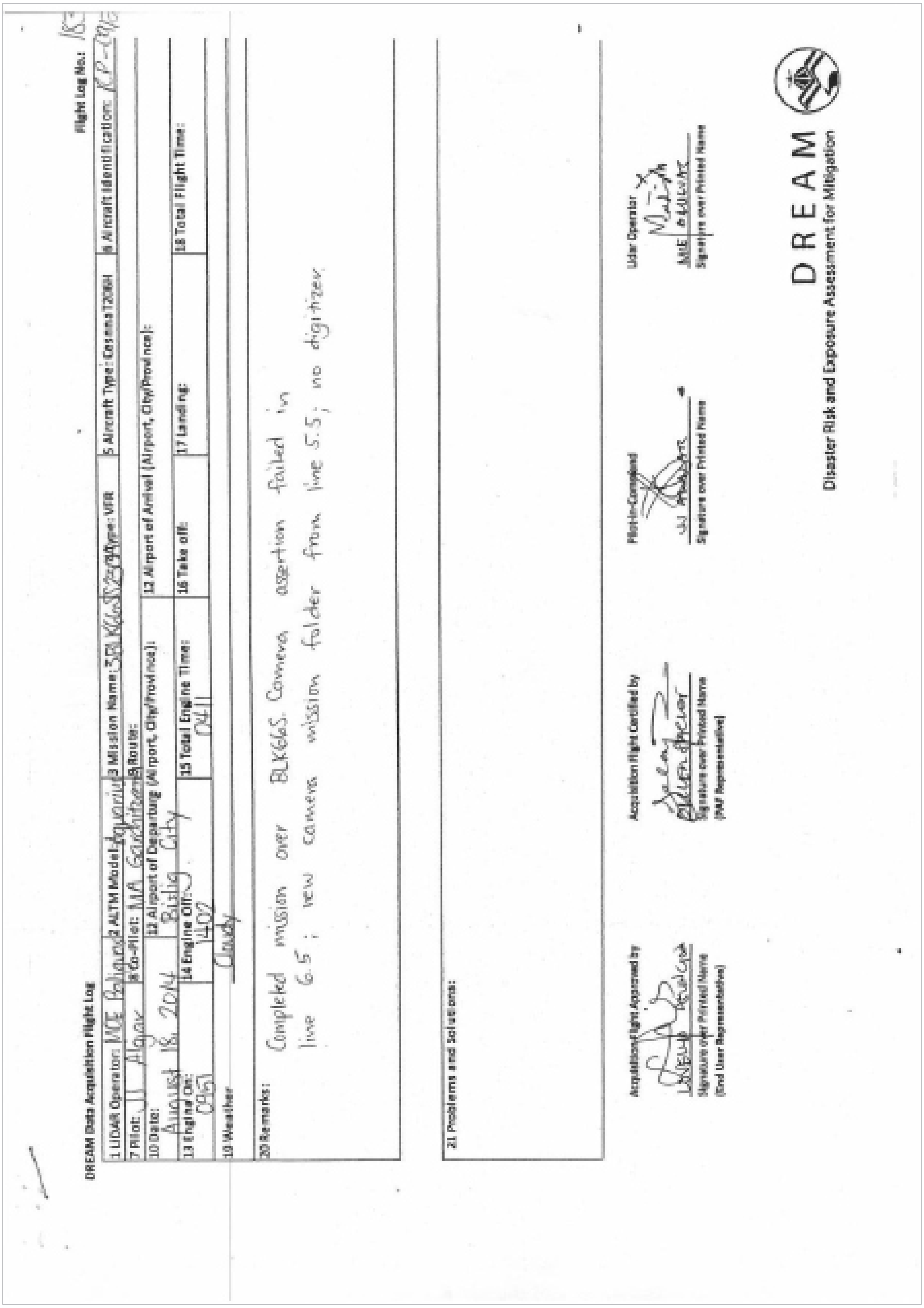
Pilot-in-Command — Signature over Printed Name

Lidar Operator — MCE Balicanta — Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.15. Flight Log for Mission 3BLK66S226A

16. Flight Log for 3BLK66SS230A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: [illegible]

1 LIDAR Operator: MCE Baliguas	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66SS230A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: JJ Alagar	8 Co-Pilot: MA Gaoilitan	9 Route:			
10 Date: August 18, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0951	14 Engine Off: 1402	15 Total Engine Time: 04+11	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Cloudy					

20 Remarks:

Completed mission over BLK66S. Camera assertion failed in line 6.5; new camera mission folder from line 5.5; no digitizer

21 Problems and Solutions:

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

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

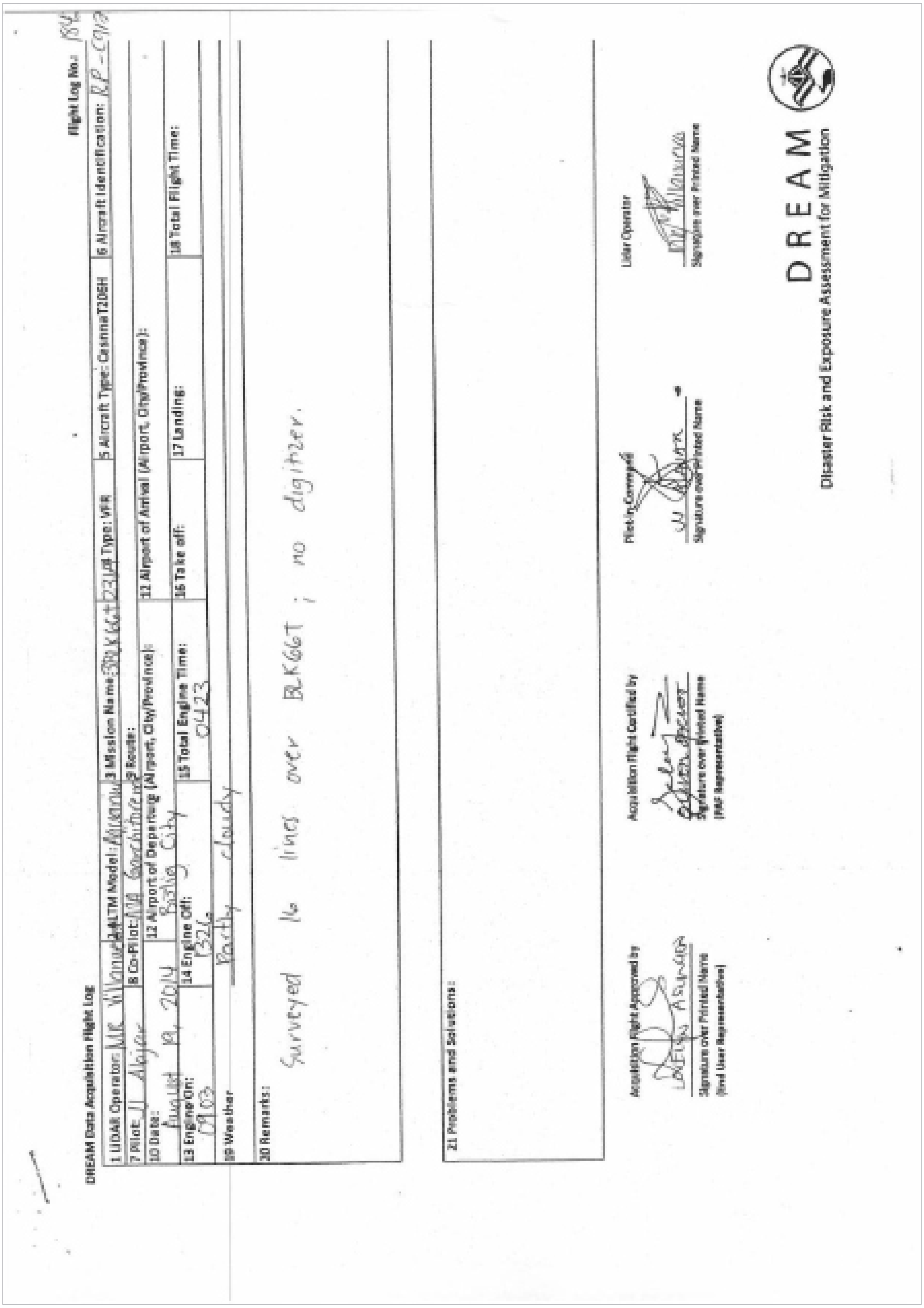
Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

DREAM — Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.16. Flight Log for Mission 3BLK66SS230A

17. Flight Log for 3BLK66T231A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 134

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66T231A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: JJ Alajar	8 Co-Pilot: NA Ranchirrere	9 Route:			
10 Date: August 19, 2014	12 Airport of Departure (Airport, City/Province): Butuan City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0903	14 Engine Off: 1326	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks:

Surveyed 16 lines over BLK66T ; no digitizer.

21 Problems and Solutions:

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

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

Pilot-in-Command: Signature over Printed Name

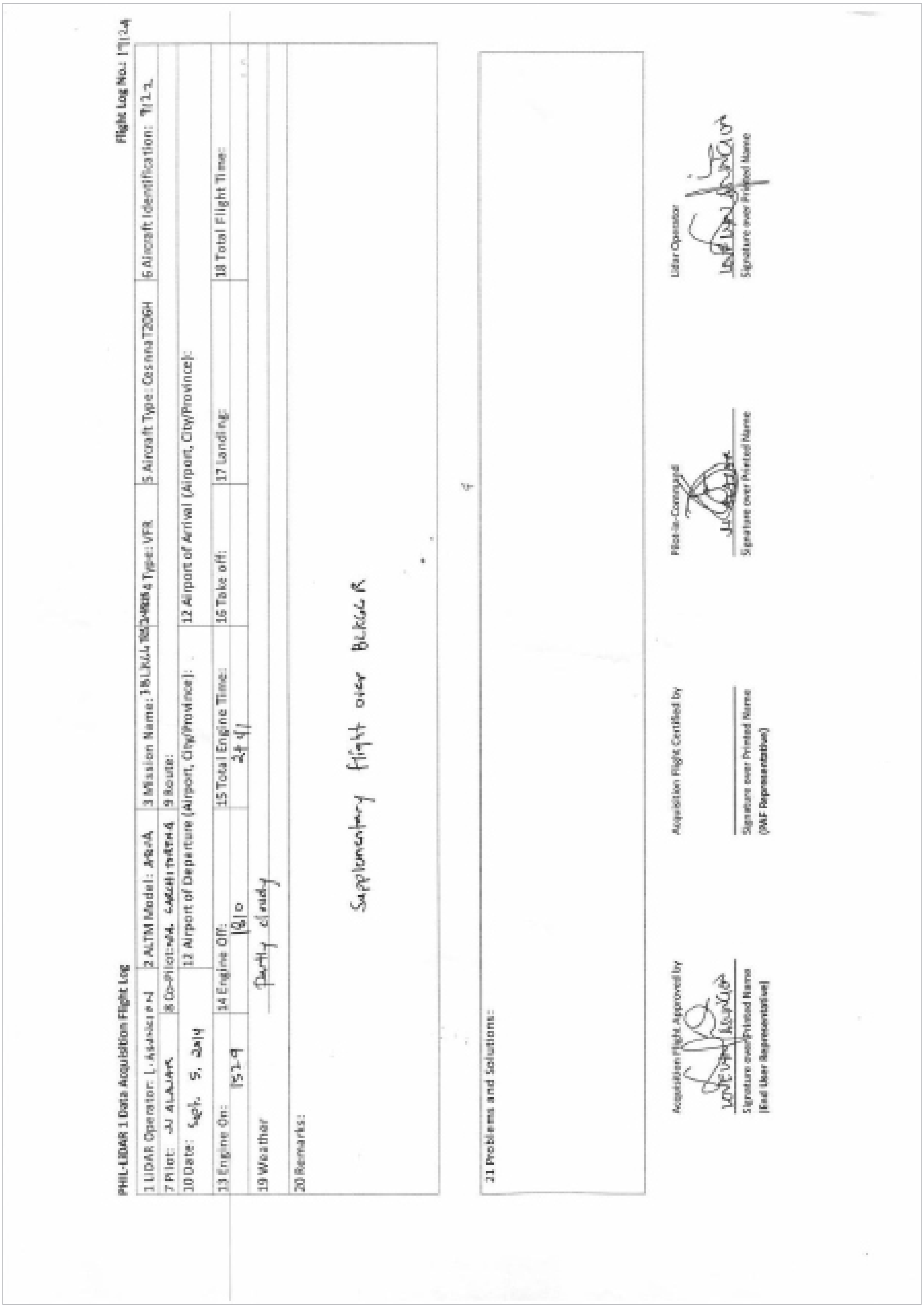
Lidar Operator: Signature over Printed Name

DREAM

Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.17. Flight Log for Mission 3BLK66T231A

18. Flight Log for 3BLK66RS248B Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7124

1 LIDAR Operator: L. ASUNCION	2 ALTM Model: AQUA	3 Mission Name: 3BLK66RS248B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: JJ ALAJAR	8 Co-Pilot: [illegible]	9 Route:			
10 Date: Sept. 5, 2014	11 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1529	14 Engine Off: 1810	15 Total Engine Time: 2+41	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks:

Supplementary flight over BLK66R

21 Problems and Solutions:

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

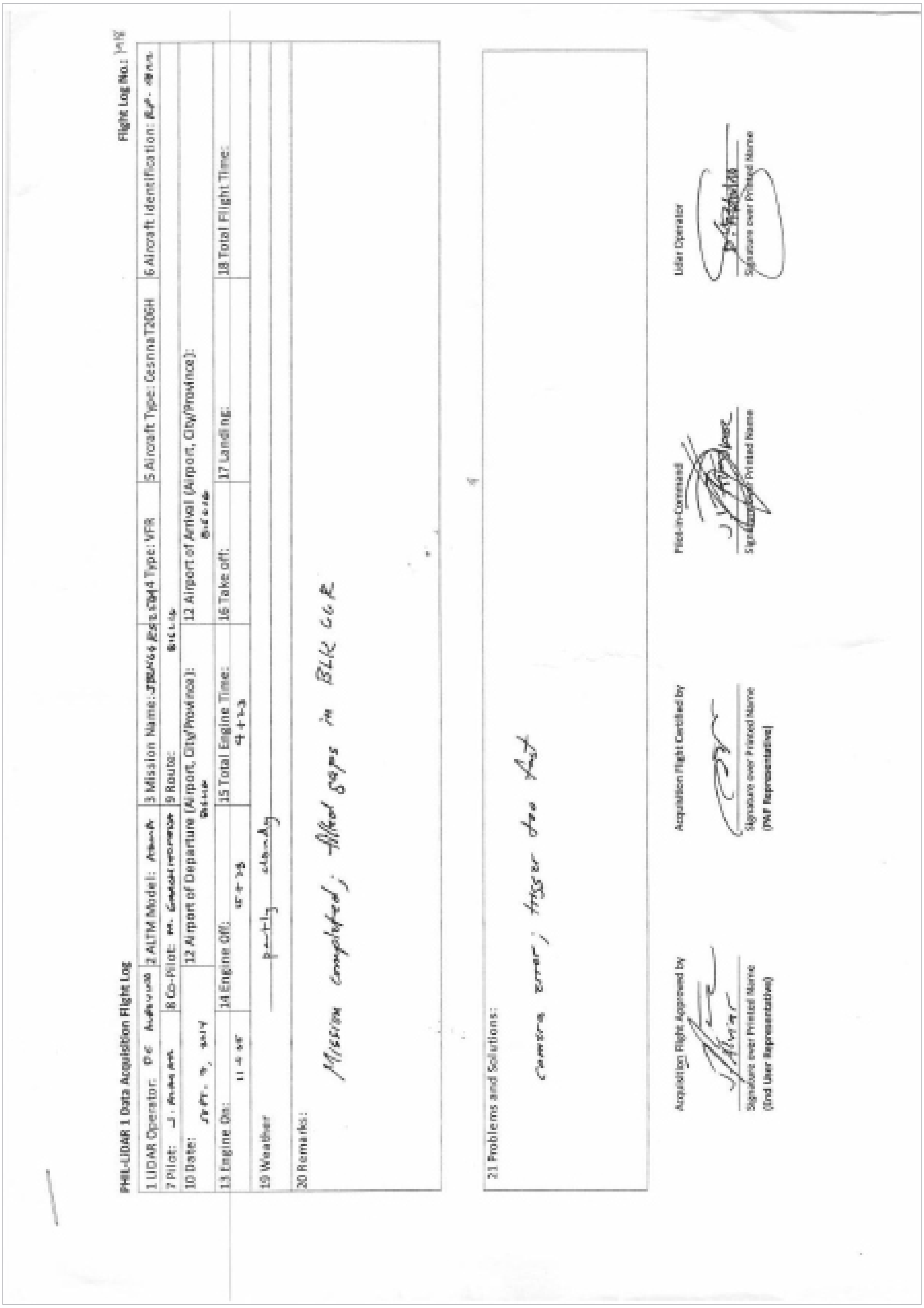
Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

Figure A-6.18. Flight Log for Mission 3BLK66RS248B

19. Flight Log for 3BLK66RS250A Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 1418

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

19 Weather partly cloudy

20 Remarks:

Mission completed; filled gaps in BLK 66R

21 Problems and Solutions:

camera error; trigger too fast

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-6.19. Flight Log for Mission 3BLK66RS250A

ANNEX 7. Flight Status Reports

FLIGHT STATUS REPORT
TANDAG, SURIGAO DEL SUR
July 4-August 1, 2014

Table A-7.1. Flight Status Report – A

Flight No	Area	Mission	Operator	Date Flown	Remarks
1728	BLK65H	MR VILLANUEVA	3BLK65H202B	21 JULY 14	New Lever Arms values should be applied, LMS calibration needed
1730	BLK65H	MR VILLANUEVA	3BLK65HS203A	22 JULY 14	Mission completed over BLK65H

FLIGHT STATUS REPORT
BISLIG, SURIGAO DEL SUR
August 3-September 5, 2014

Table A-7.2. Flight Status Report – B

Flight No	Area	Mission	Operator	Date Flown	Remarks
1782A	BLK66F	3BLK66F216A	MR. VILLANUEVA	04-Aug-14	Mission completed.
1788A	BLK66E & BLK66G	3BLK66EGS217B	MCE BALIGUAS	05-Aug-14	Completed area G and E. (Bathy survey on area E @ 500m.
1790A	BLK66M	3BLK66M218A	MR. VILLANUEVA	06-Aug-14	Covered 10 lines of area M.
1794A	BLK66L & BLK66M	3BLK66LMS219A	MCE BALIGUAS	07-Aug-14	Completed area M 15 lines of area L. No images starting line 7 onwards due to camera assertion error encountered in line 6.
1796A	BLK66L & BLK66J	3BLK66LSJS219B	MR. VILLANUEVA	07-Aug-14	Completed area L and J.
1798A	BLK66N	3BLK66N220A	MR. VILLANUEVA	08-Aug-14	Mission completed. Digitizer error in line 1, lines 4 onwards have digitizer.
1800A	BLK66O	3BLK66O220B	MCE BALIGUAS	08-Aug-14	Covered 10 lines. (with camera and digitizer)
1804A	BLK66O & BLK66P	3BLK66OSP221B	MR. VILLANUEVA	09-Aug-14	Completed area O and covered 8 lines of area P.

Flight No	Area	Mission	Operator	Date Flown	Remarks
1810A	BLK66P & BLK66Q	3BLK66PSQ223A	MR. VILLANUEVA	11-Aug-14	Completed area P. Covered 10 lines of area Q. Experienced digitizer error in line 16. Replaced digitizer SSD (used 2 digitizer's SSD for this mission)
1812A	BLK66Q	3BLK66QS223B	MCE BALIGUAS	11-Aug-14	Completed area Q. No digitizer data
1814A	BLK66K & BLK66R	3BLK66KR224A	MR. VILLANUEVA	12-Aug-14	Completed area K. Covered 2 lines of area R.
1816A	BLK66R	3BLK66RS224B	MCE BALIGUAS	12-Aug-14	Supplementary flight for area R. Encountered errors in ALTM, Digitizer and camera. No images for this flight
1822A	BLK66S	3BLK66S226A	MCE BALIGUAS	14-Aug-14	Unfinished mission. Camera hanged in line 30. No digitizer for this flight.
1838A	BLK66S	3BLK66SS230A	MCE BALIGUAS	18-Aug-14	Completed area S. Covered two lines of area T.
1842A	BLK66T	3BLK66T231A	MR. VILLANUEVA	19-Aug-14	Covered 17 lines, No digitizer for this mission
1912A	BLK66R	3BLK66RS248B	L. ASUNCION	5-Sep-14	Covered 5 strips of area R (supplementary flight). Lost connection with pilot display, lots of dark images due to time of acquisition. No digitizer
1918A	BLK66R	3BLK66RS250A	DC. ALDOVINO	7-Sep-14	Completed area R and 3 lines of area T, including tie line

SWATH PER FLIGHT MISSION

1. Swath Coverage of Mission 3BLK65H202B

Flight No.:	1728
Area:	BLK65H
Mission Name:	3BLK65H202B
Parameters:	
Alt:	600
Scan Freq:	40 kHz
Scan Angle:	25 deg
Total Area Surveyed:	16.44 sq. km

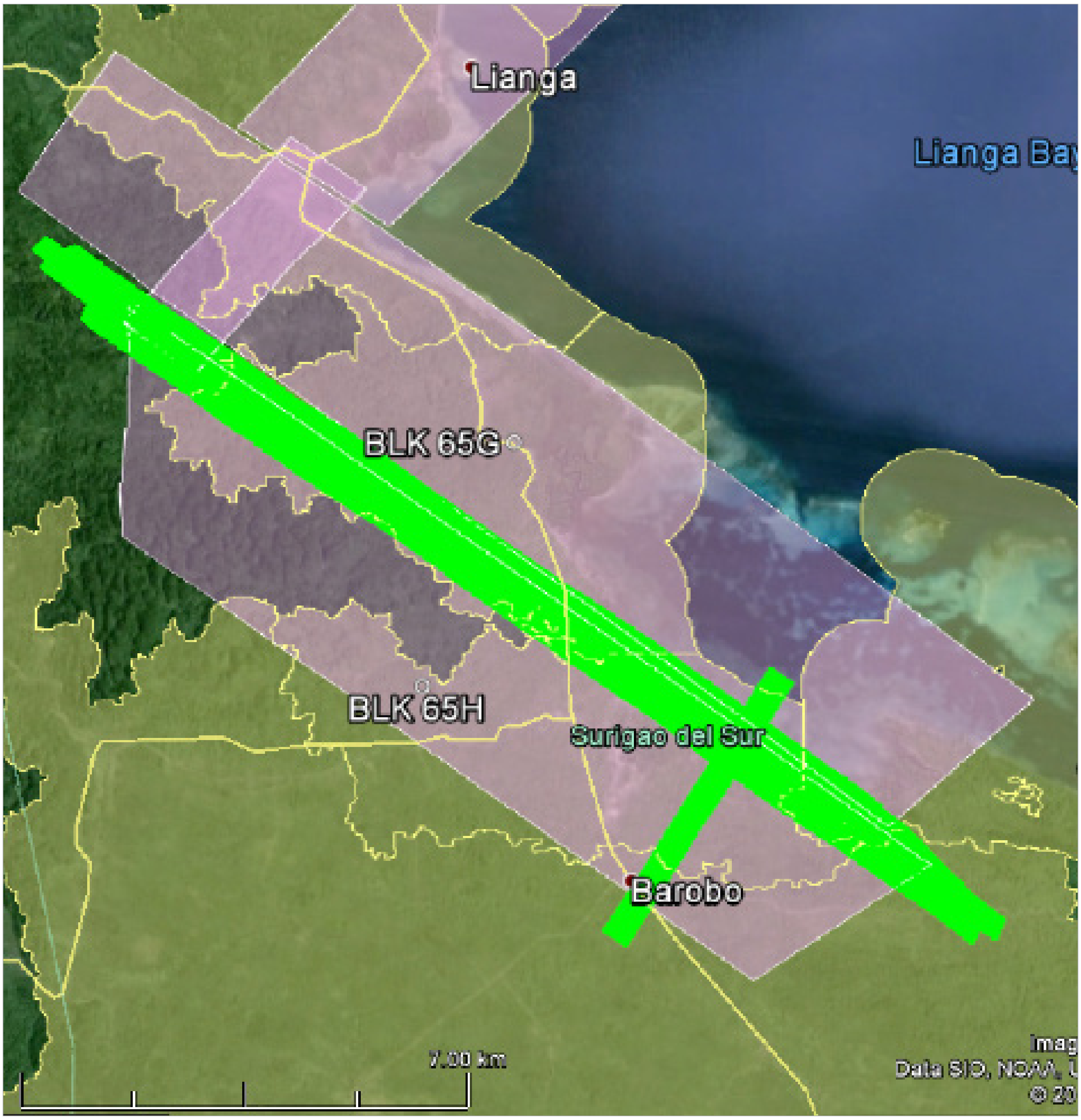


Figure A-7.1. Swath for Flight No. 1728

2. Swath Coverage of Mission 3BLK65HS203A

Flight No. :	1730
Area:	BLK65H
Mission Name:	3BLK65HS203A
Parameters:	
Alt:	600
Scan Freq:	40 kHz
Scan Angle:	25 deg
Total Area Surveyed:	42.4 sq. km

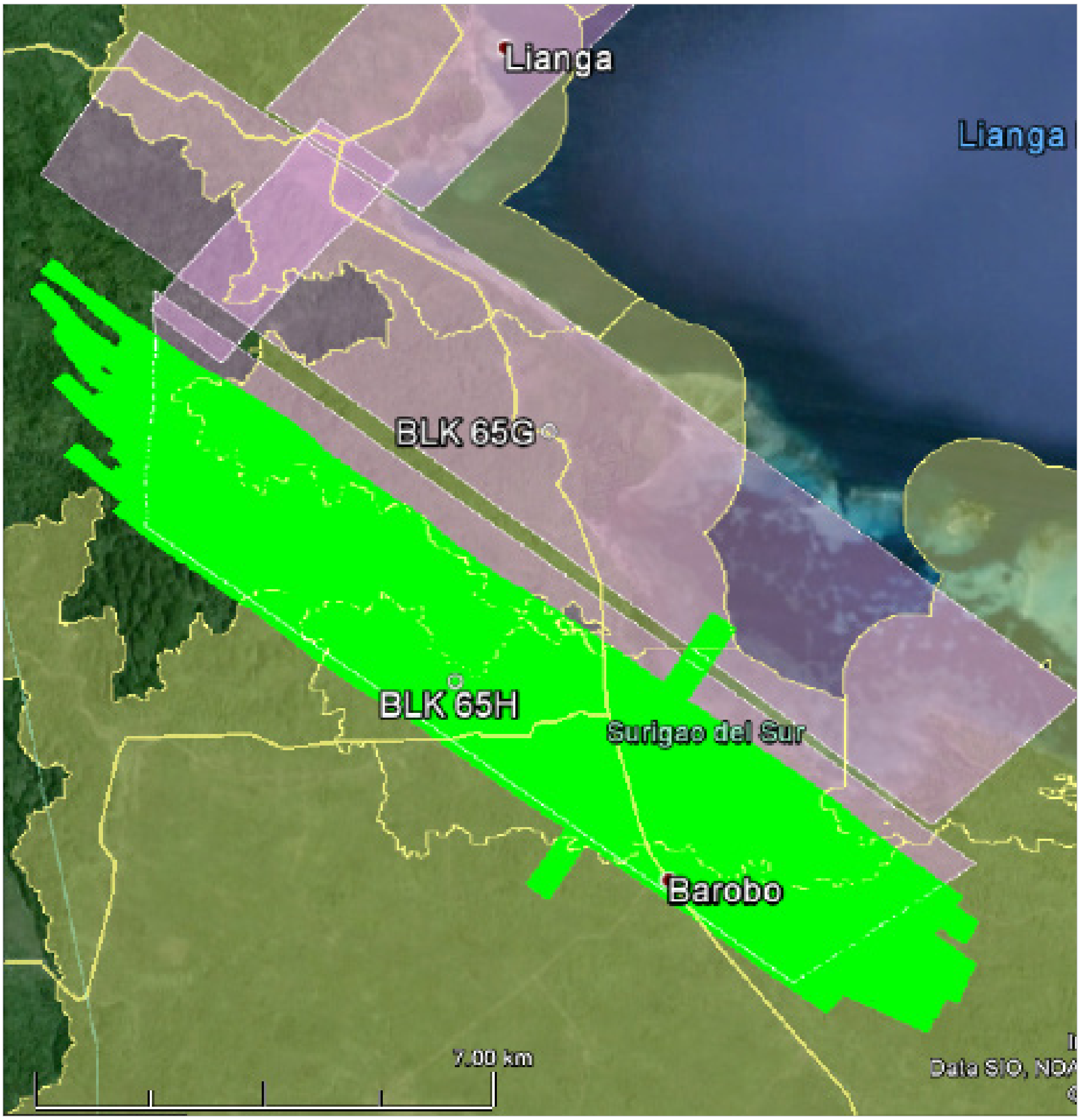


Figure A-7.2. Swath for Flight No. 1730

3. Swath Coverage of Mission 3BLK66F216A

FLIGHT LOG NO.	1782A
AREA:	BLK66F
MISSION NAME:	3BLK66F216A
SWATH AREA:	61.16 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

Figure A-7.3. Swath for Flight No. 1782A

4. Swath Coverage of Mission 3BLK66EGS217B

FLIGHT LOG NO.	1788A
AREA:	BLK66E & BLK66G
MISSION NAME:	3BLK66EGS217B
SWATH AREA:	80.67 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

Figure A-7.4. Swath for Flight No. 1788A

5. Swath Coverage of Mission 3BLK66M218A

FLIGHT LOG NO.	1790A
AREA:	BLK66M
MISSION NAME:	3BLK66M218A
SWATH AREA:	66.92 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

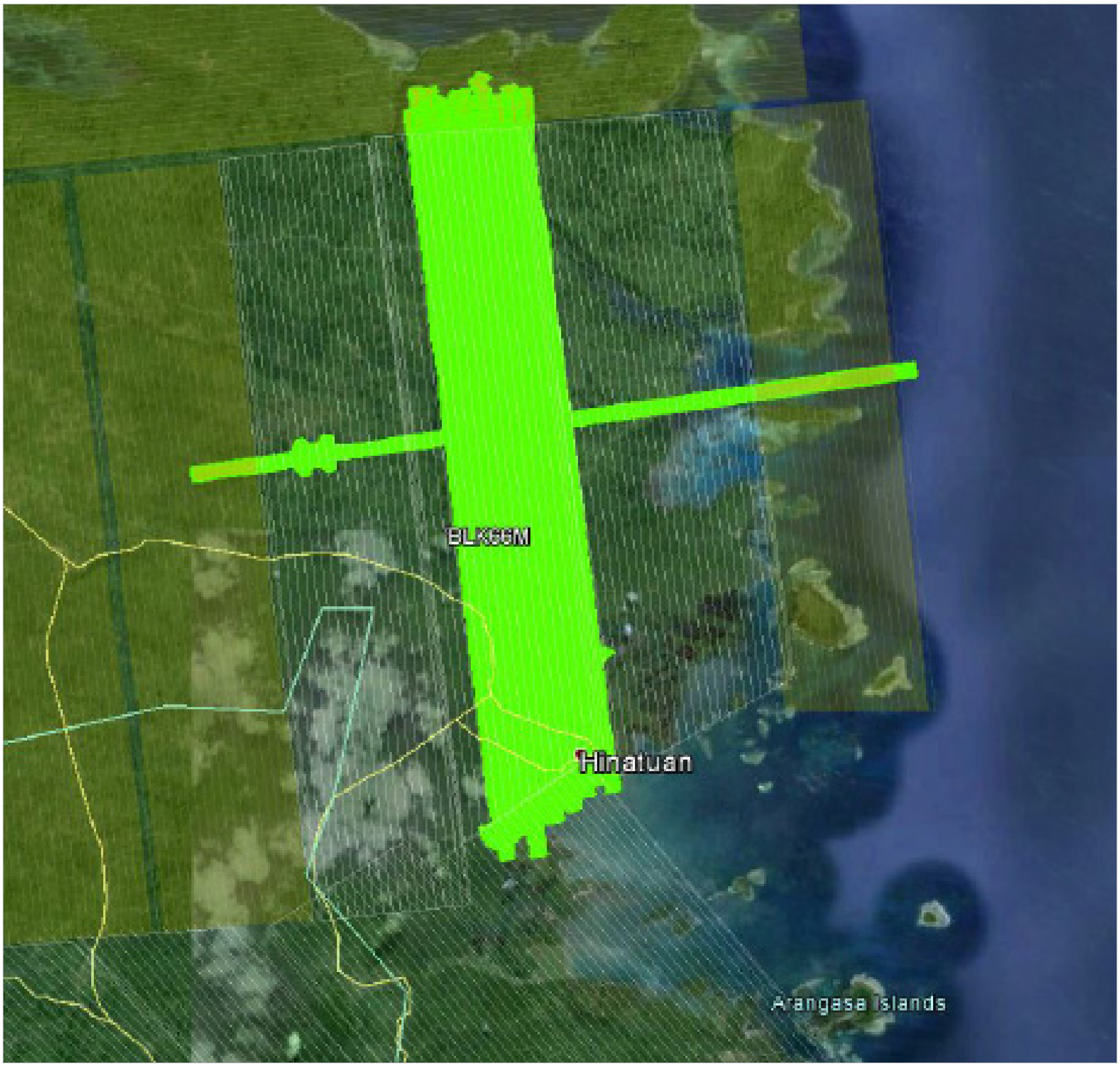


Figure A-7.5. Swath for Flight No. 1790A

6. Swath Coverage of Mission 3BLK66LMS219A

FLIGHT LOG NO.	1794A
AREA:	BLK66L & BLK66M
MISSION NAME:	3BLK66LMS219A
SWATH AREA:	97.54 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

Figure A-7.6. Swath for Flight No. 1794A

7. Swath Coverage of Mission 3BLK66LSJS219B

FLIGHT LOG NO.	1796A
AREA:	BLK66L & BLK66J
MISSION NAME:	3BLK66LSJS219B
SWATH AREA:	93.57 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

Figure A-7.7. Swath for Flight No. 1796A

8. Swath Coverage of Mission 3BLK66N220A

FLIGHT LOG NO.	1798A
AREA:	BLK66N
MISSION NAME:	3BLK66N220A
SWATH AREA:	98.21 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

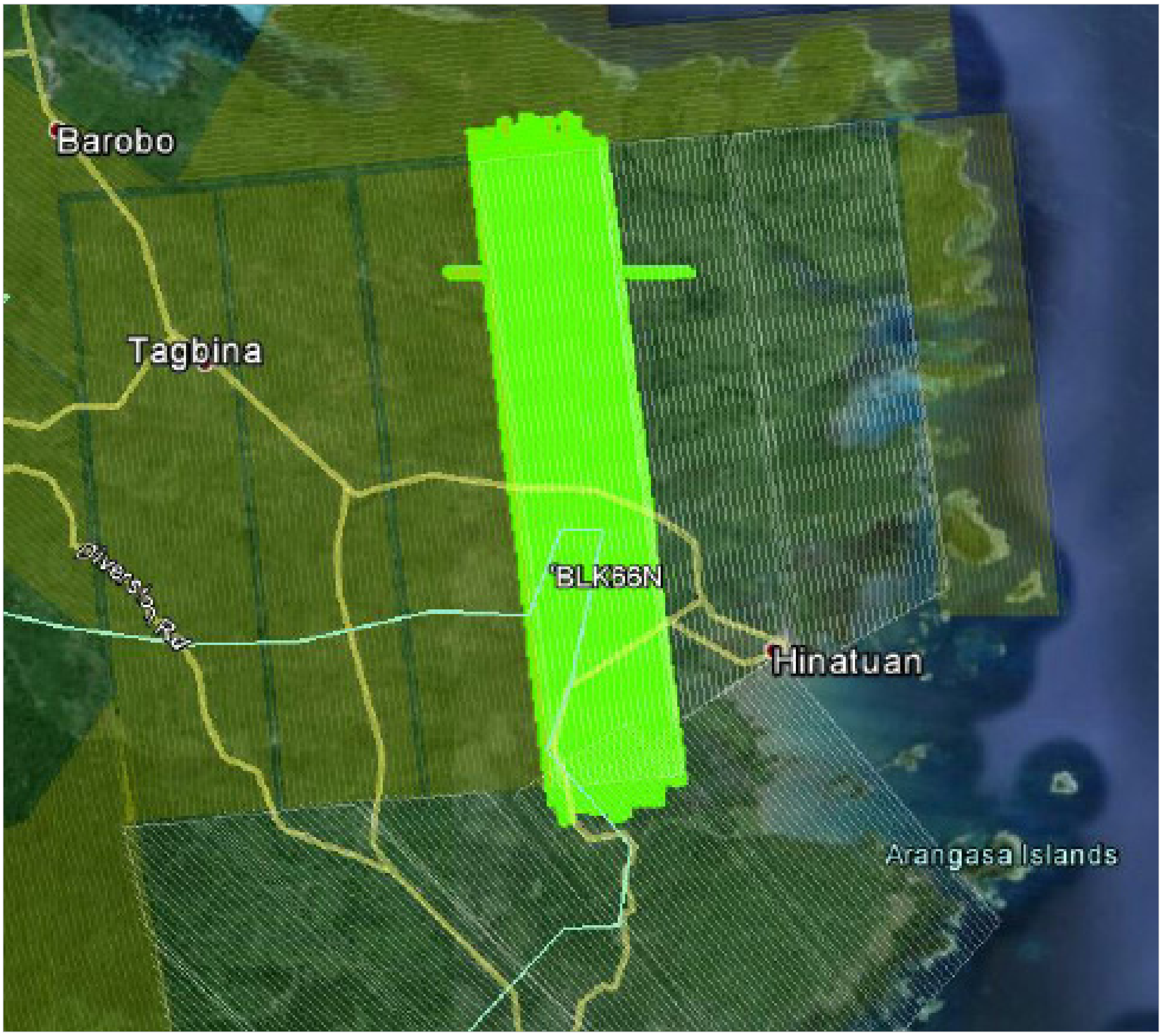


Figure A-7.8. Swath for Flight No. 1798A

9. Swath Coverage of Mission 3BLK66O220B

FLIGHT LOG NO.	1800A
AREA:	BLK66O
MISSION NAME:	3BLK66O220B
SWATH AREA:	57.42 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

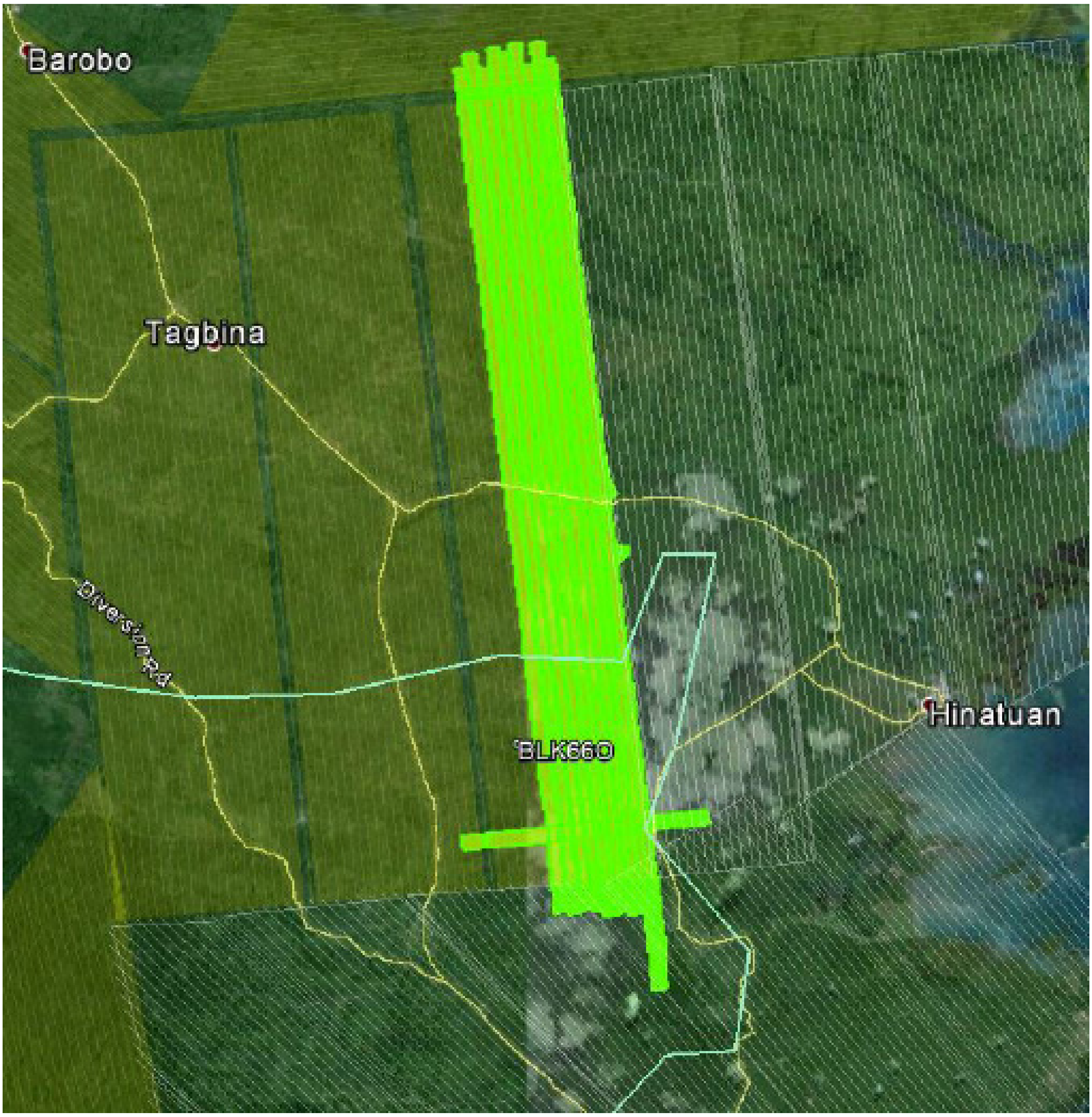


Figure A-7.9. Swath for Flight No. 1800A

10. Swath Coverage of Mission 3BLK66OSP221B

FLIGHT LOG NO.	1804A
AREA:	BLK66O & BLK66P
MISSION NAME:	3BLK66OSP221B
SWATH AREA:	79.06 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

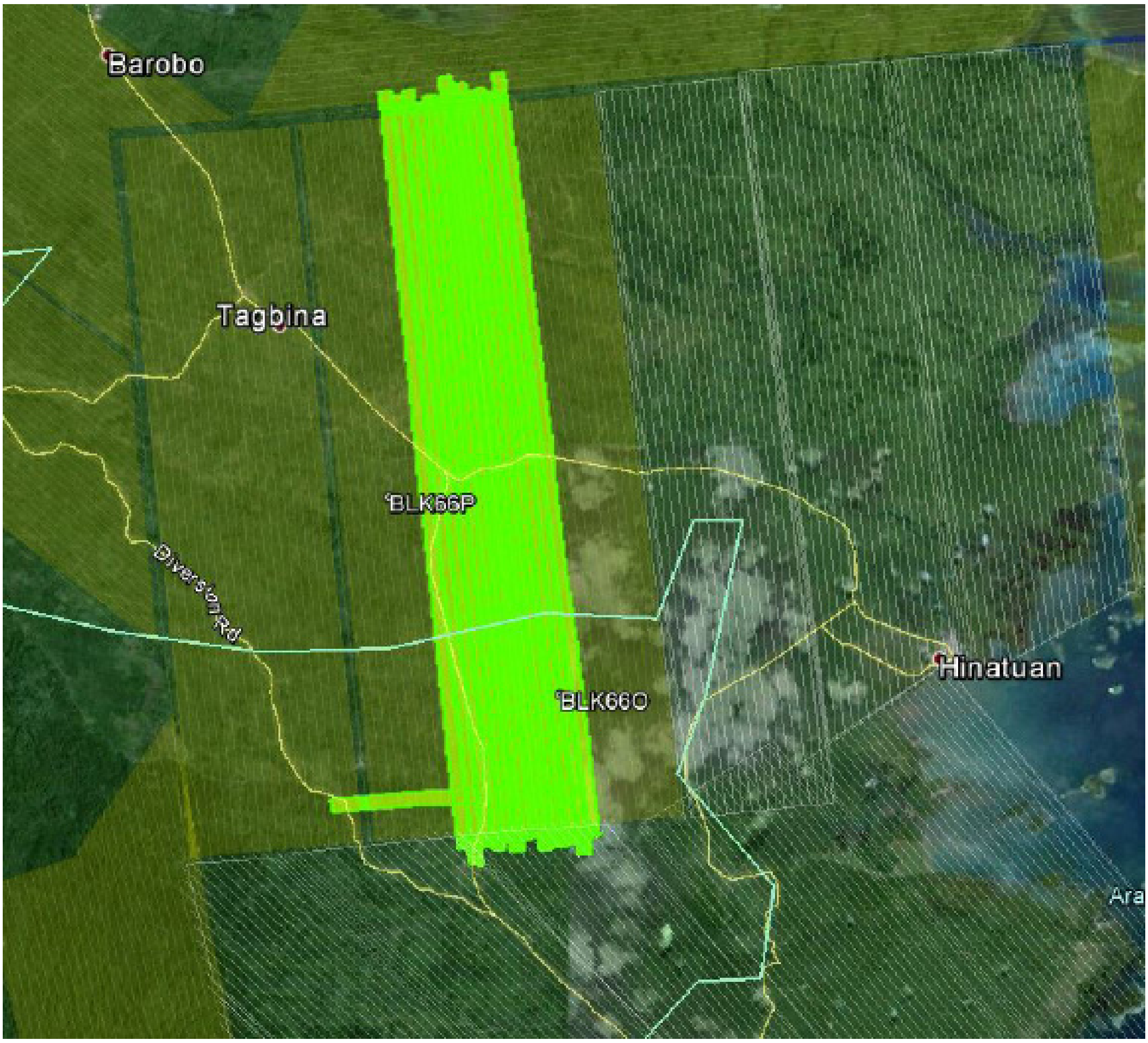


Figure A-7.10. Swath for Flight No. 1804A

11. Swath Coverage of Mission 3BLK66PSQ223A

FLIGHT LOG NO.	1810A
AREA:	BLK66P & BLK66Q
MISSION NAME:	3BLK66PSQ223A
SWATH AREA:	120.93 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

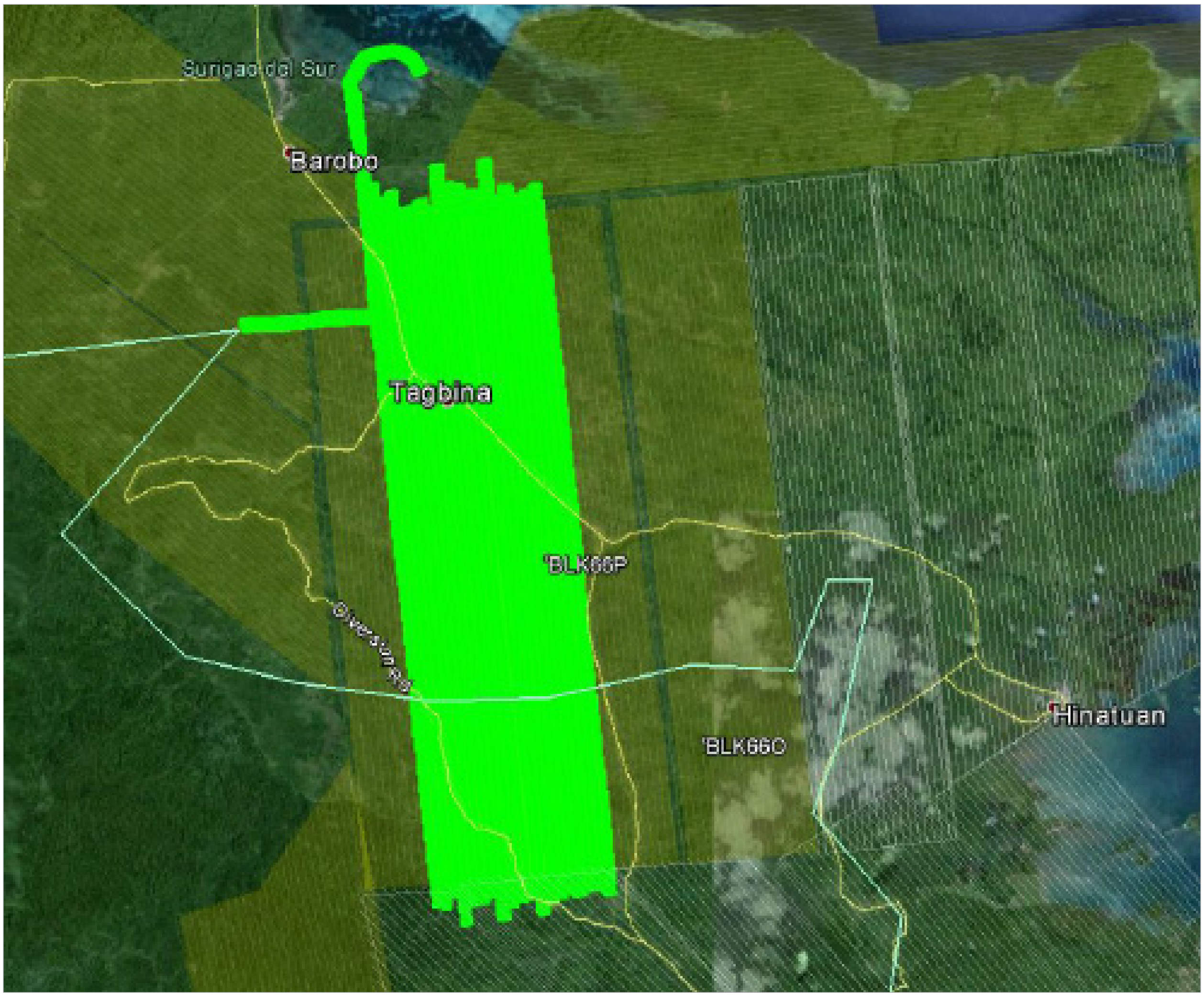


Figure A-7.11. Swath for Flight No. 1810A

12. Swath Coverage of Mission 3BLK66QS223B

FLIGHT LOG NO.	1812A
AREA:	BLK66Q
MISSION NAME:	3BLK66QS223B
SWATH AREA:	54.42 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

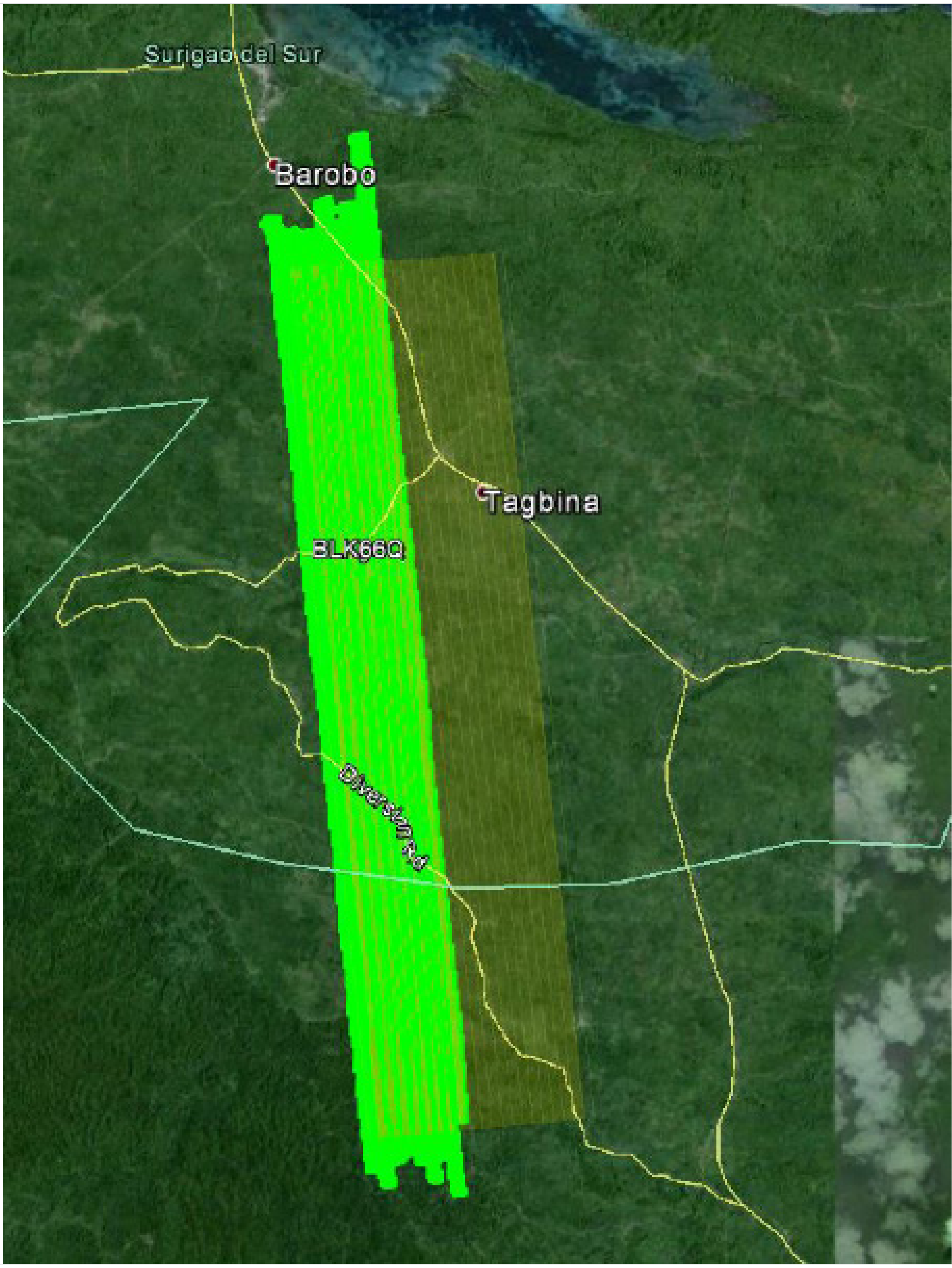


Figure A-7.12. Swath for Flight No. 1812A

13. Swath Coverage of Mission 3BLK66KR224A

FLIGHT LOG NO.	1814A		
AREA:	BLK66K and BLK66R		
MISSION NAME:	3BLK66KR224A		
SWATH AREA:	78.23 sq.km		
PARAMETERS:	Alt: 500 m	Scan Freq: 40 kHz	Scan Angle: 25 deg
SURVEY COVERAGE:			

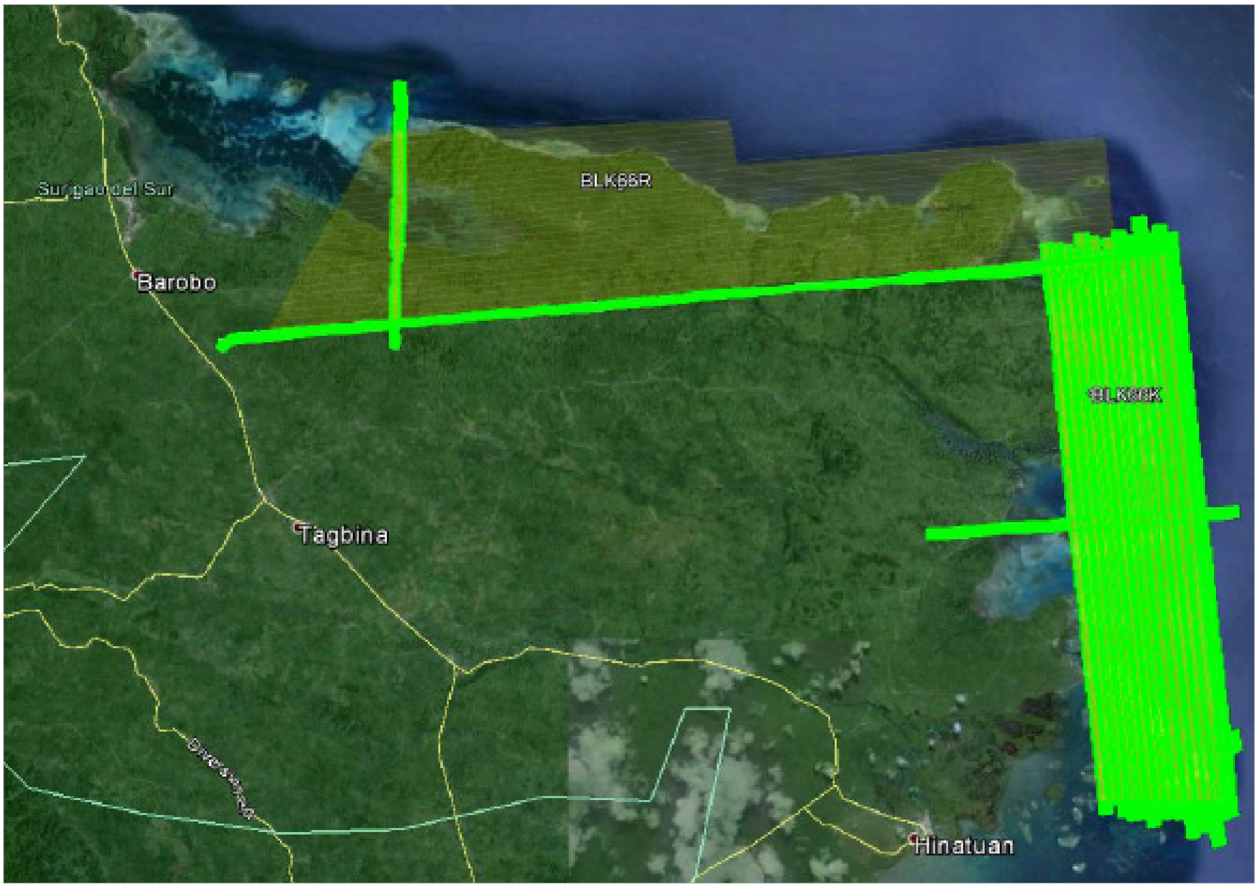


Figure A-7.13. Swath for Flight No. 1814A

14. Swath Coverage of Mission 3BLK66RS224B

FLIGHT LOG NO.	1816A		
AREA:	BLK66R		
MISSION NAME:	3BLK66RS224B		
SWATH AREA:	77.70 sq.km		
PARAMETERS:	Alt: 500 m	Scan Freq: 40 kHz	Scan Angle: 25 deg
SURVEY COVERAGE:			

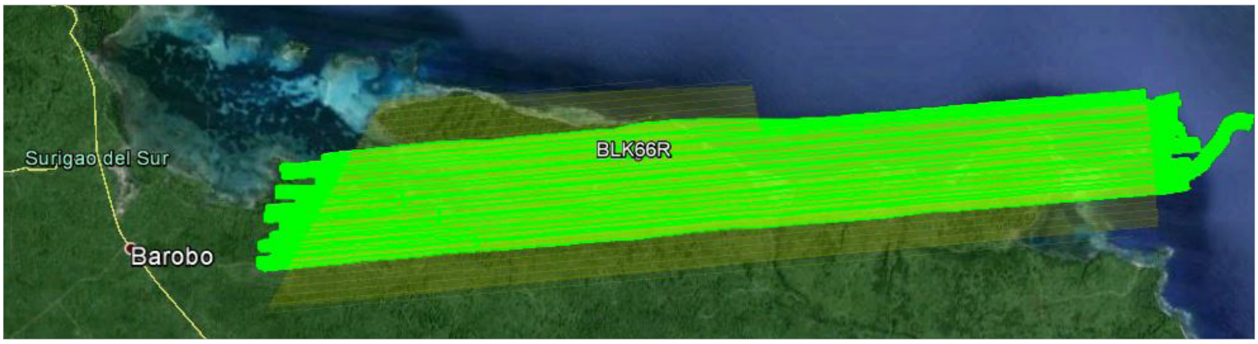


Figure A-7.14. Swath for Flight No. 1816A

15. Swath Coverage of Mission 3BLK66S226A

FLIGHT LOG NO.	1822A
AREA:	BLK66S
MISSION NAME:	3BLK66S226A
SWATH AREA:	67.28 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

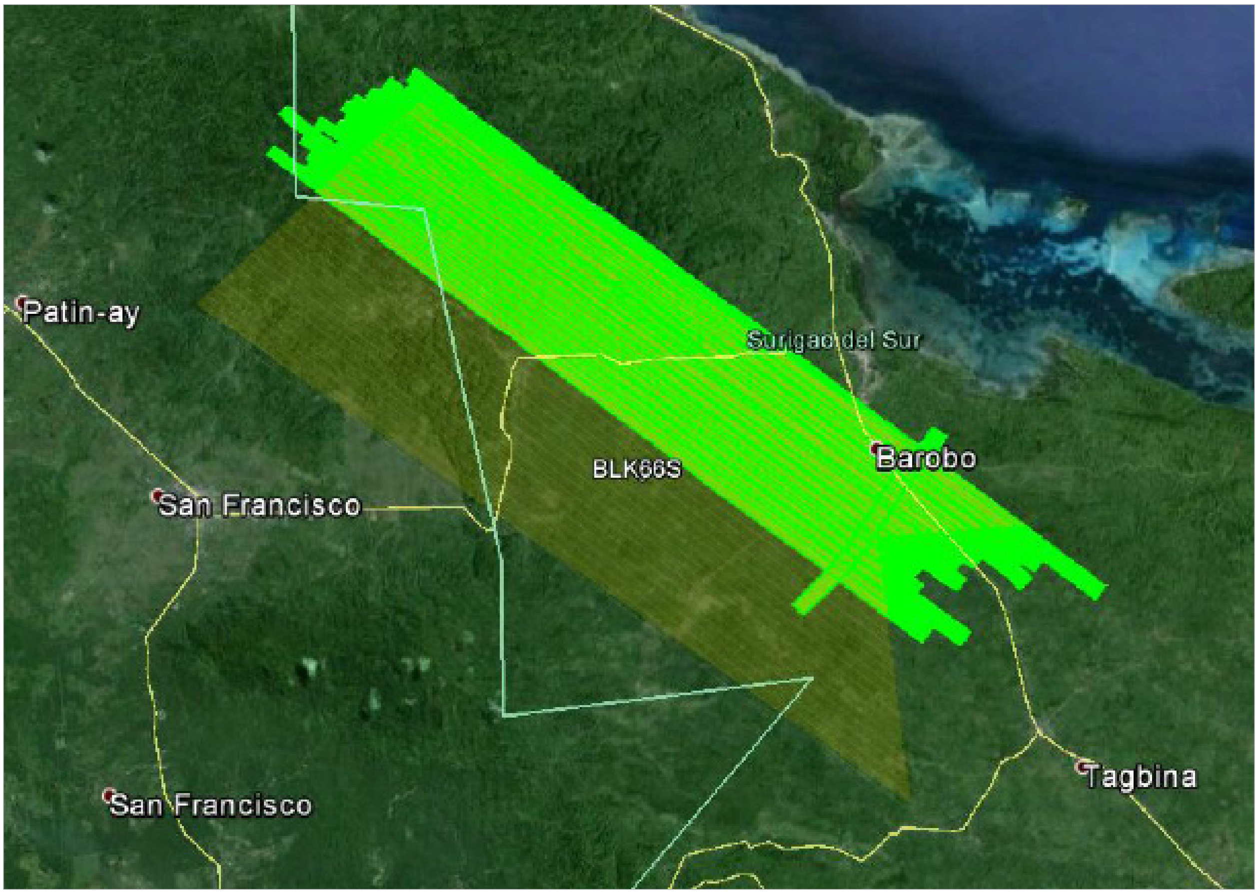


Figure A-7.15. Swath for Flight No. 1822A

16. Swath Coverage of Mission 3BLK66S230A

FLIGHT LOG NO.	1838A
AREA:	BLK66S
MISSION NAME:	3BLK66S230A
SWATH AREA:	92.05 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

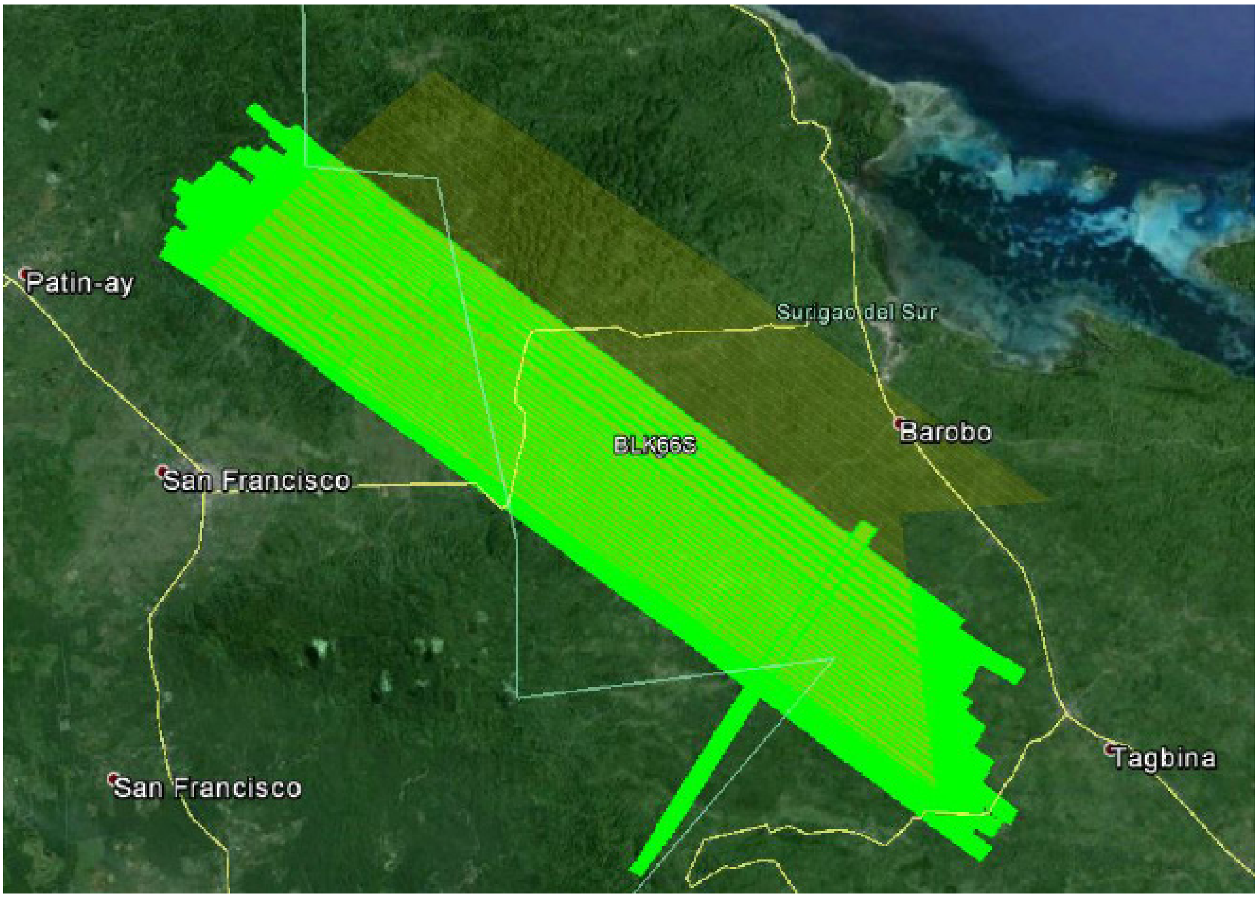


Figure A-7.16. Swath for Flight No. 1838A

17. Swath Coverage of Mission 3BLK66T231A

FLIGHT LOG NO.	1842A
AREA:	BLK66T
MISSION NAME:	3BLK66T231A
SWATH AREA:	72.08 sq.km
PARAMETERS:	
Alt:	600 m
Scan Freq:	40 kHz
Scan Angle:	25 deg
SURVEY COVERAGE:	

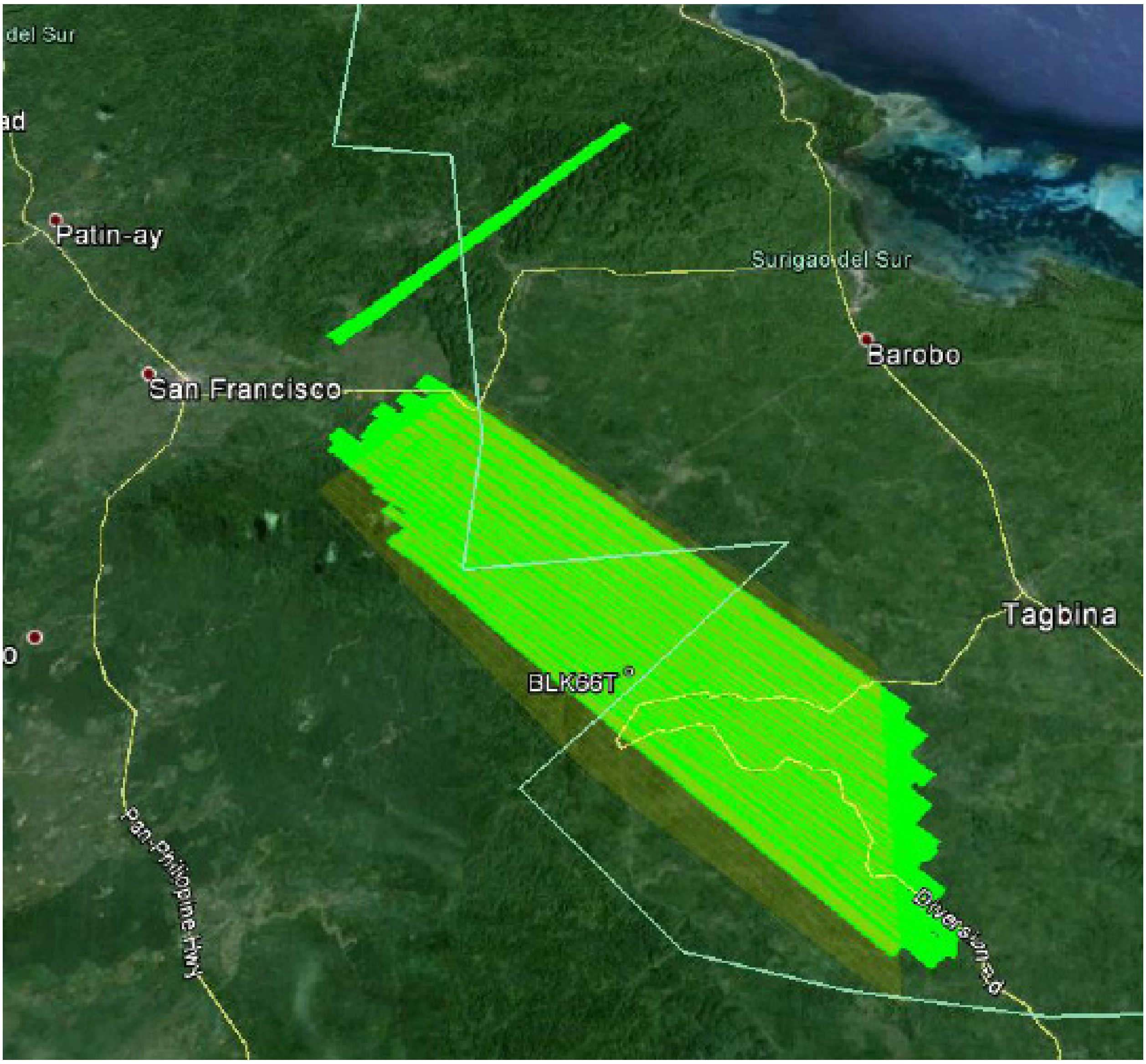


Figure A-7.17. Swath for Flight No. 1842A

18. Swath Coverage of Mission 3BLK66RS248B

FLIGHT LOG NO.	1912A		
AREA:	BLK66R		
MISSION NAME:	3BLK66RS248B		
SWATH AREA:	30.76 sq.km		
PARAMETERS:	Alt: 600 m	Scan Freq: 40 kHz	Scan Angle: 25 deg
SURVEY COVERAGE:			

Figure A-7.18. Swath for Flight No. 1912A

19. Swath Coverage of Mission 3BLK66RS250A

FLIGHT LOG NO.	1918A		
AREA:	BLK66R and BLK66T		
MISSION NAME:	3BLK66RS250A		
SWATH AREA:	67.16 sq.km		
PARAMETERS:	Alt: 600 m	Scan Freq: 40 kHz	Scan Angle: 25 deg
SURVEY COVERAGE:			

Figure A-7.19. Swath for Flight No. 1918A

ANNEX 8. Mission Summary Reports

Table A-8.1. Mission Summary Report for Block 65H

Flight Area	Tandag (Surigao Del Sur)
Mission Name	Block 65H
Inclusive Flights	1728A & 1730A
Range data size	10.78 GB
Base data size	30.9
POS	316MB
Image	53.70 MB
Transfer date	July 31, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	2.00
RMSE for East Position (<4.0 cm)	2.40
RMSE for Down Position (<8.0 cm)	4.40
Boresight correction stdev (<0.001deg)	0.000351
IMU attitude correction stdev (<0.001deg)	0.001633
GPS position stdev (<0.01m)	0.0026
Minimum % overlap (>25)	64.56
Ave point cloud density per sq.m. (>2.0)	5.06
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	86
Maximum Height	472.22 m
Minimum Height	63.46 m
Classification (# of points)	
Ground	18,252,647
Low vegetation	15,792,279
Medium vegetation	57,465,702
High vegetation	126,247,586
Building	2,737,223
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Antonio Chua, Jr., Engr. Ma. Ailyn Olanda

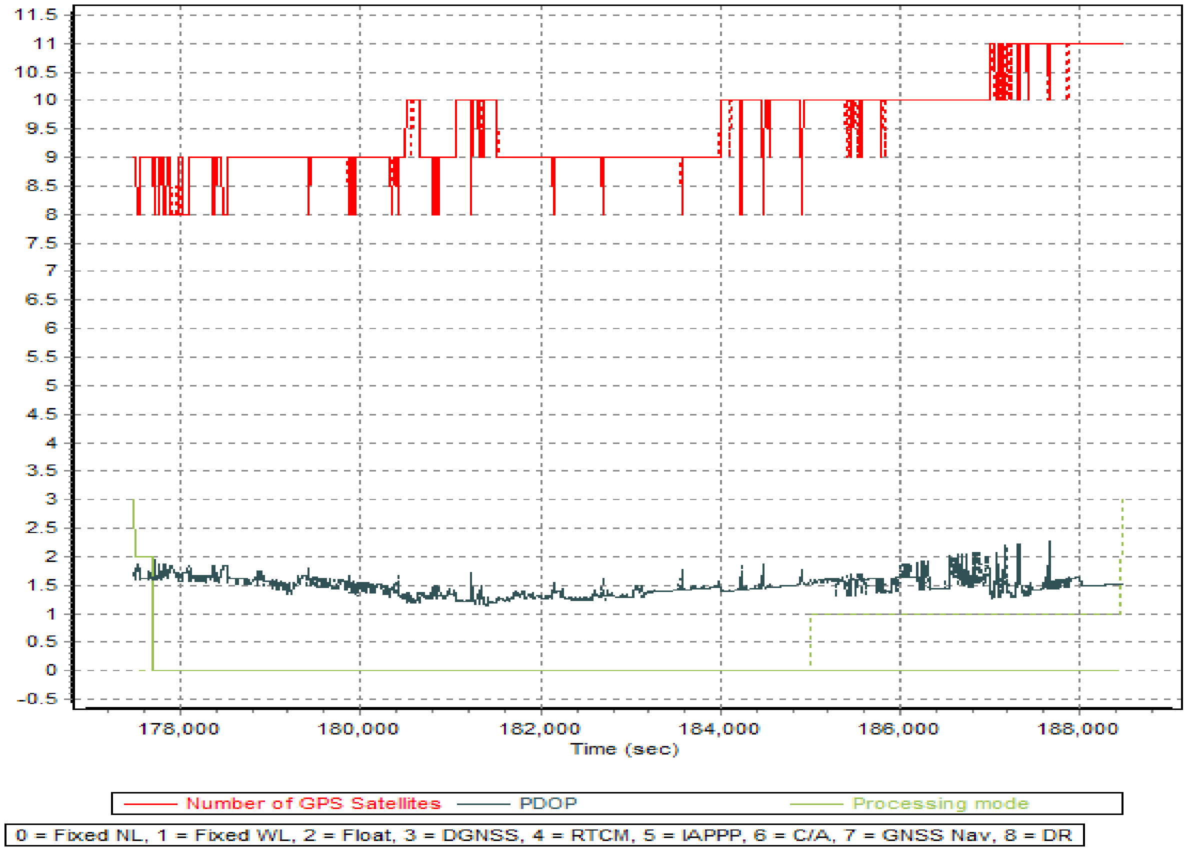


Figure A-8.1 Solution Status

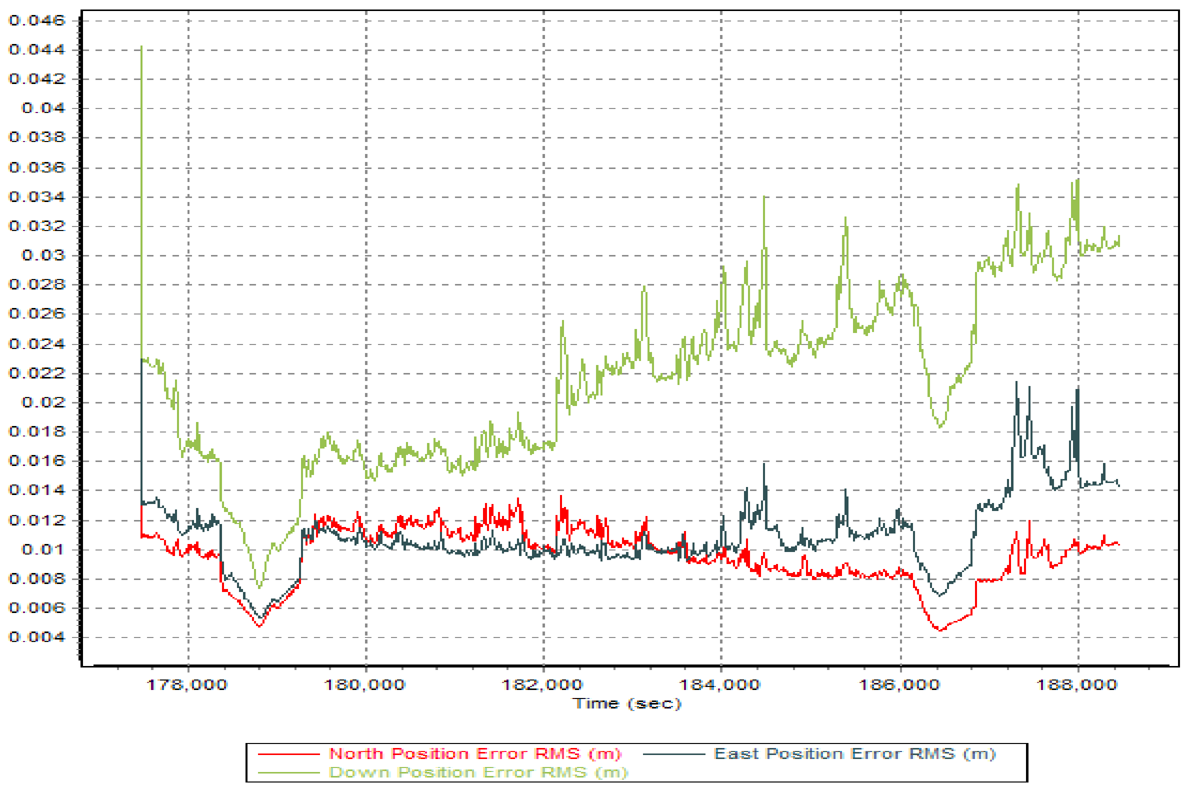


Figure A-8.2 Smoothed Performance Metric Parameters

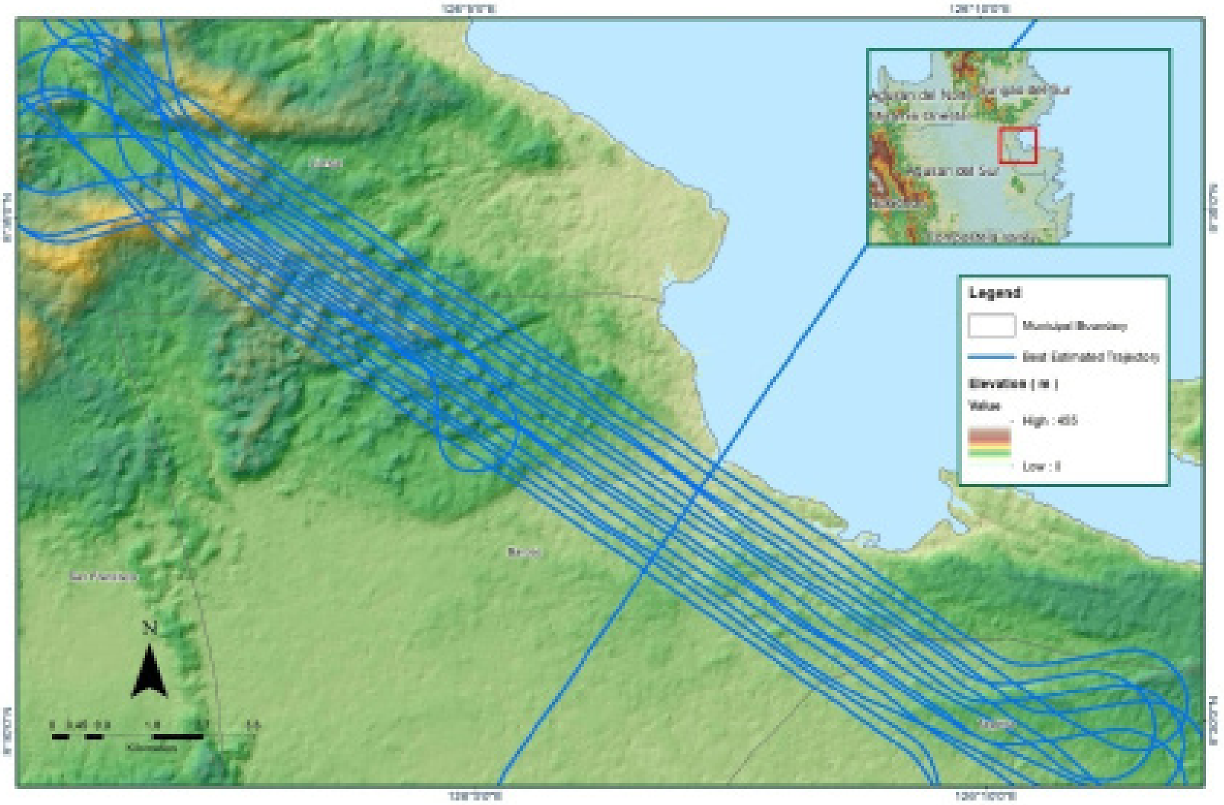


Figure A-8.3 Best Estimated Trajectory

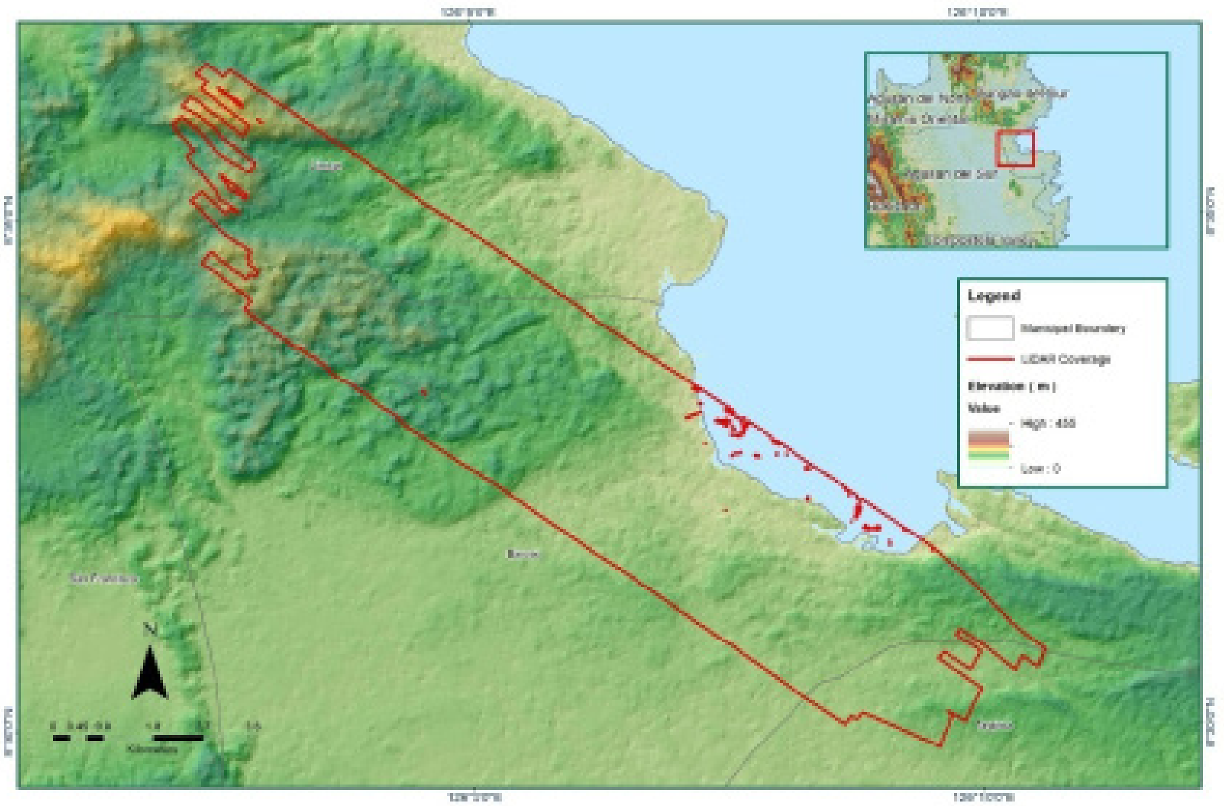


Figure A-8.4 Coverage of LiDAR data

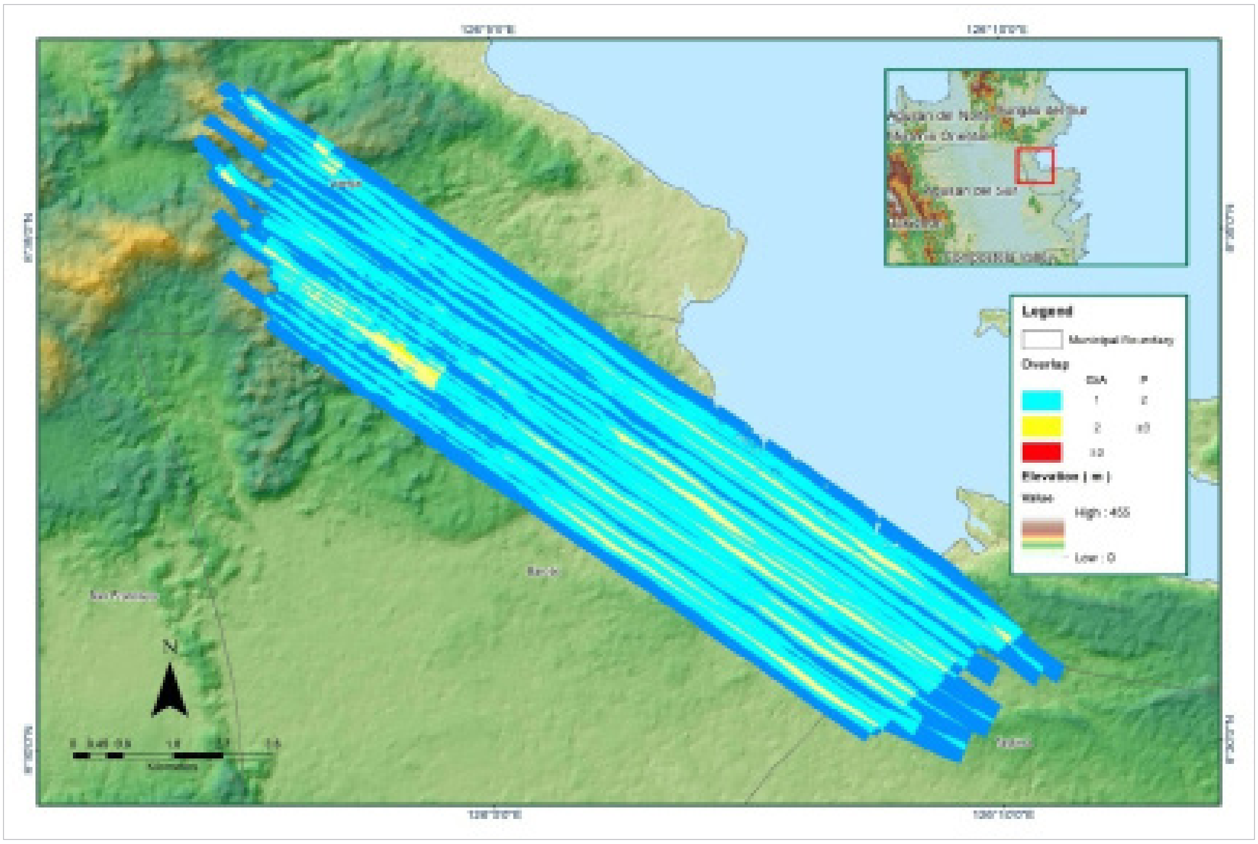


Figure A-8.5 Image of data overlap

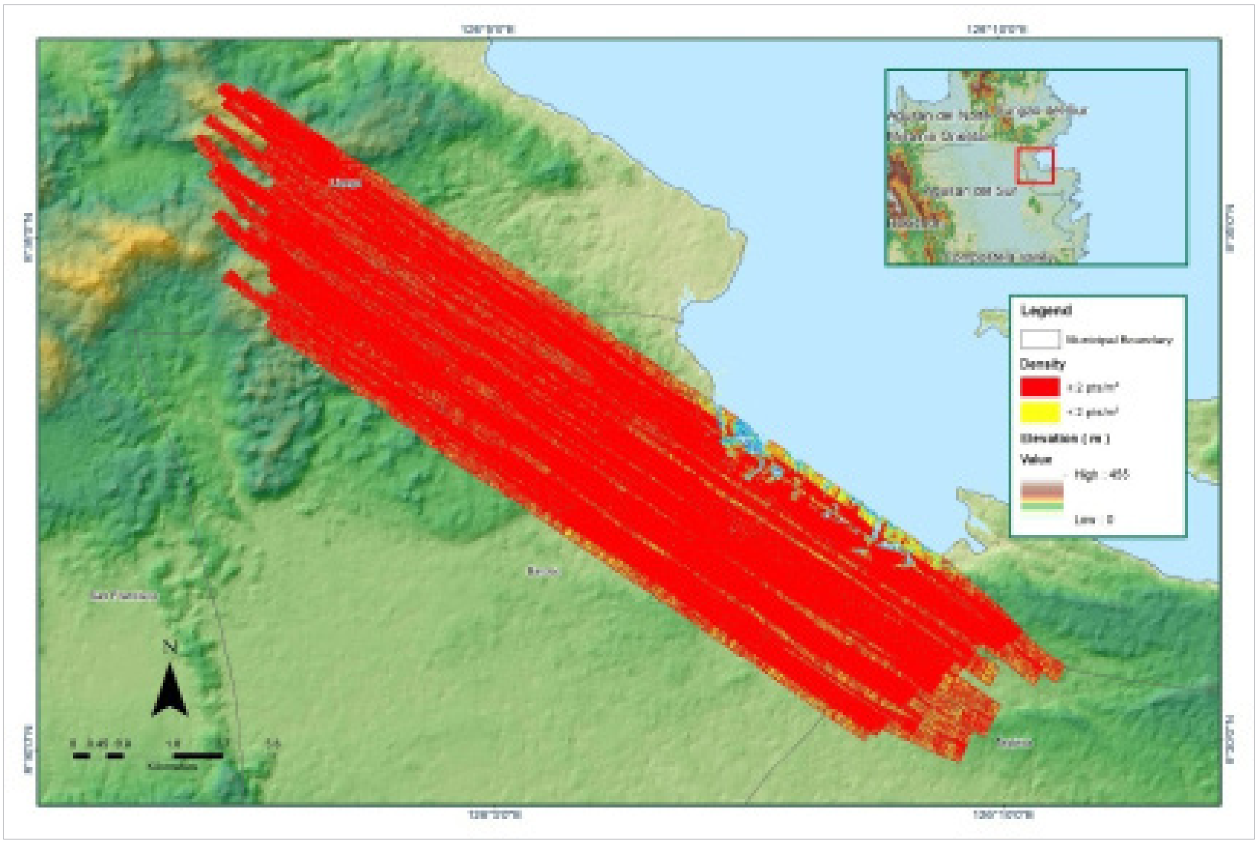


Figure A-8.6 Density map of merged LiDAR data

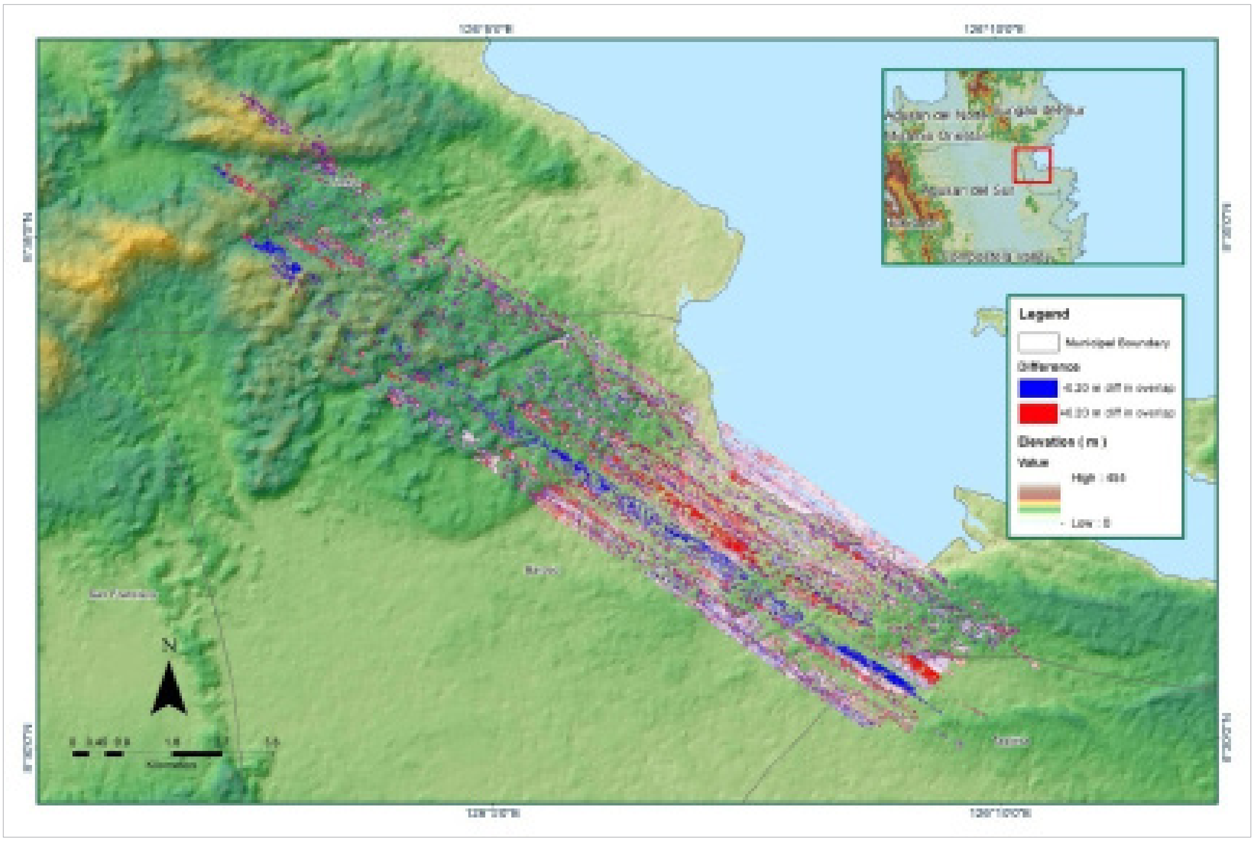


Figure A-8.7 Elevation difference between flight lines

Table A-8.2. Mission Summary Report for Block 66S

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66S
Inclusive Flights	1822A& 1838A
Range data size	22.20 GB
Base data size	11.3 MB
POS	463 MB
Image	28.24 MB
Transfer date	September 5, 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)	1.65
RMSE for East Position (<4.0 cm)	2.50
RMSE for Down Position (<8.0 cm)	3.50
Boresight correction stdev (<0.001deg)	0.000362
IMU attitude correction stdev (<0.001deg)	0.001529
GPS position stdev (<0.01m)	0.0067
Minimum % overlap (>25)	54.19
Ave point cloud density per sq.m. (>2.0)	3.89
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	205
Maximum Height	557.58 m
Minimum Height	76.09 m
Classification (# of points)	
Ground	66,474,079
Low vegetation	103,217,374
Medium vegetation	274,979,920
High vegetation	442,114,136
Building	39,534,564
Orthophoto	Yes
Processed by	Engr. Carlyn Ann Ibanez, Engr. Mark Joshua Salvacion, Engr. Melissa Fernandez

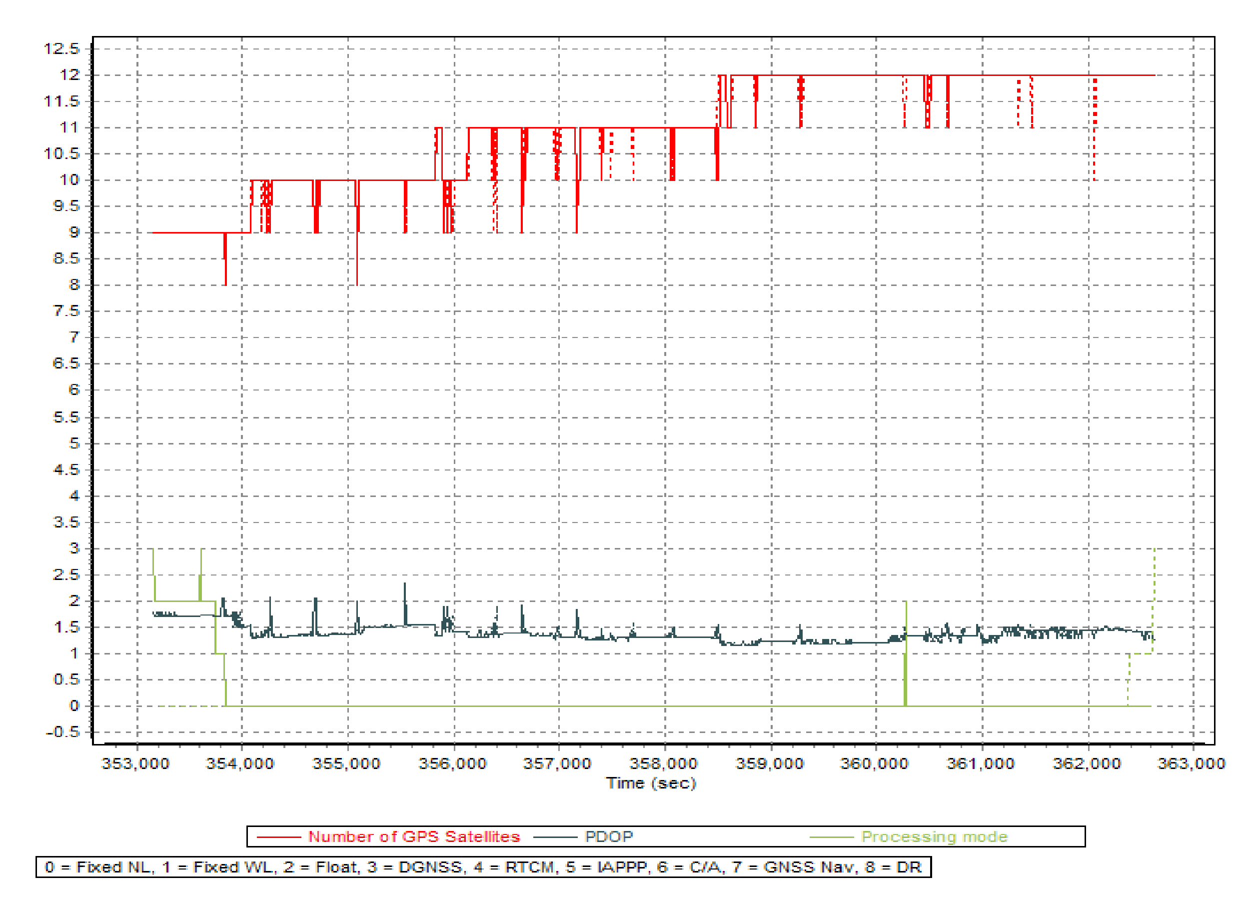


Figure A-8.8. Solution Status

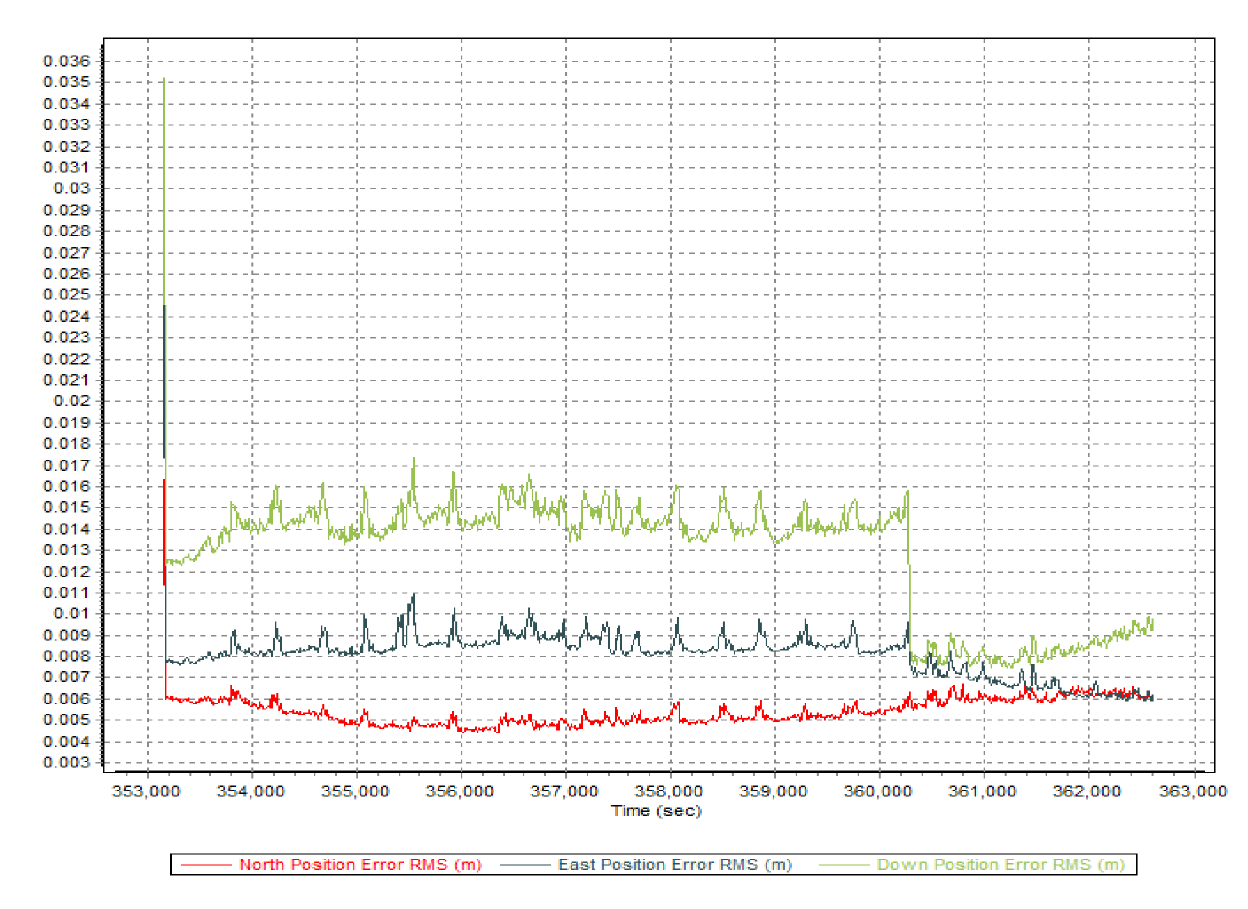
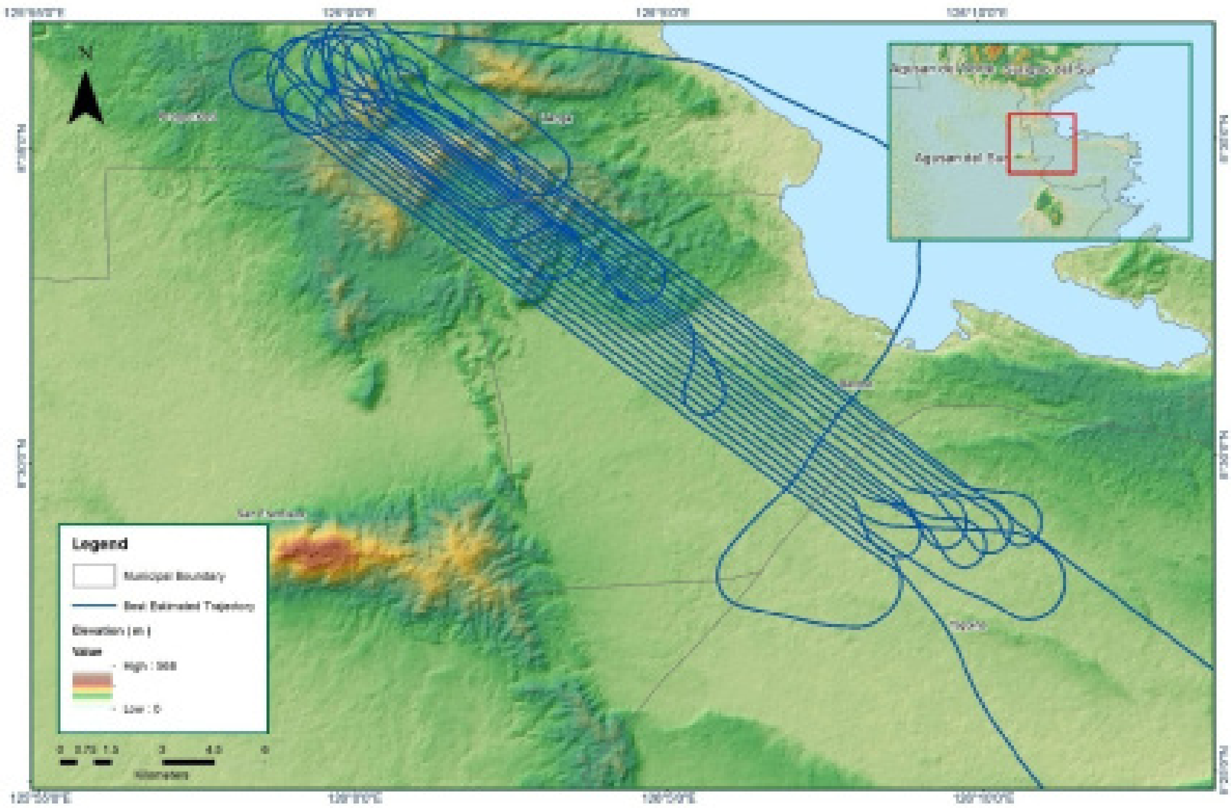


Figure A-8.9. Smoothed Performance Metric Parameters



FigureA-8.10. Best Estimated Trajectory

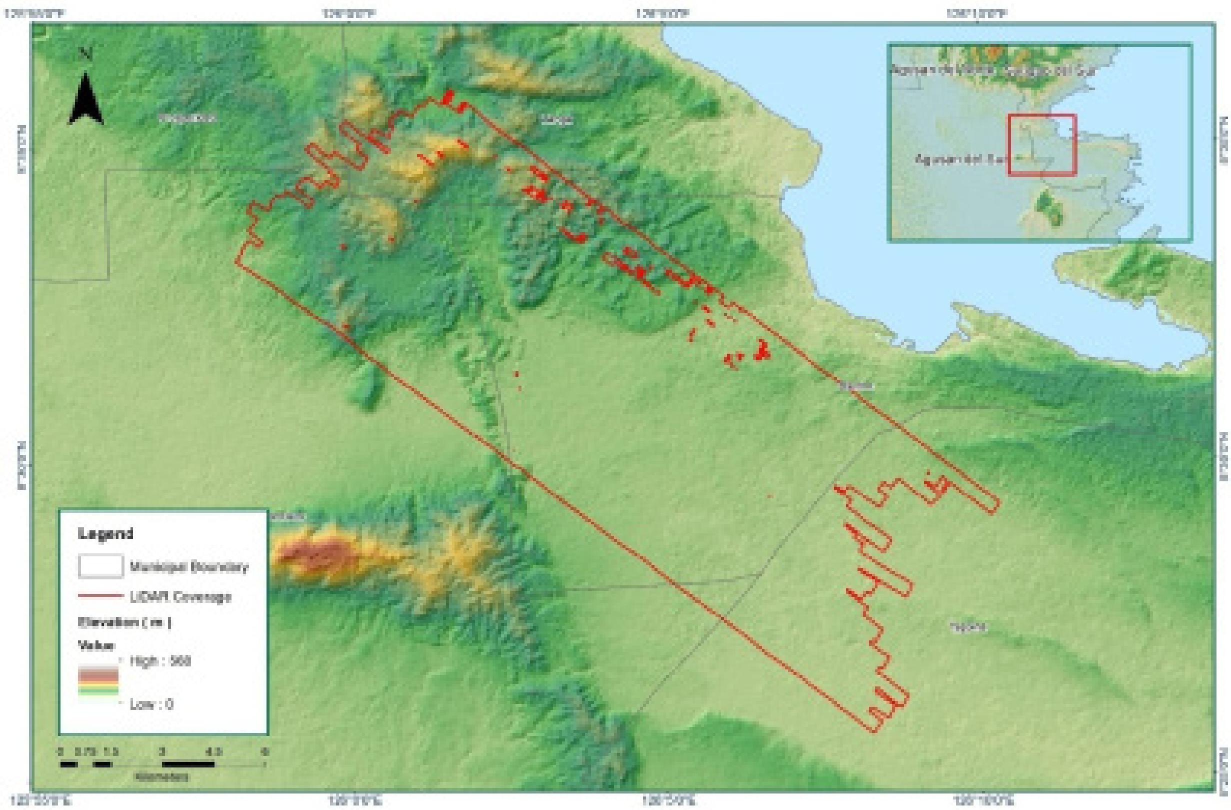


Figure A-8.11. Coverage of LiDAR data

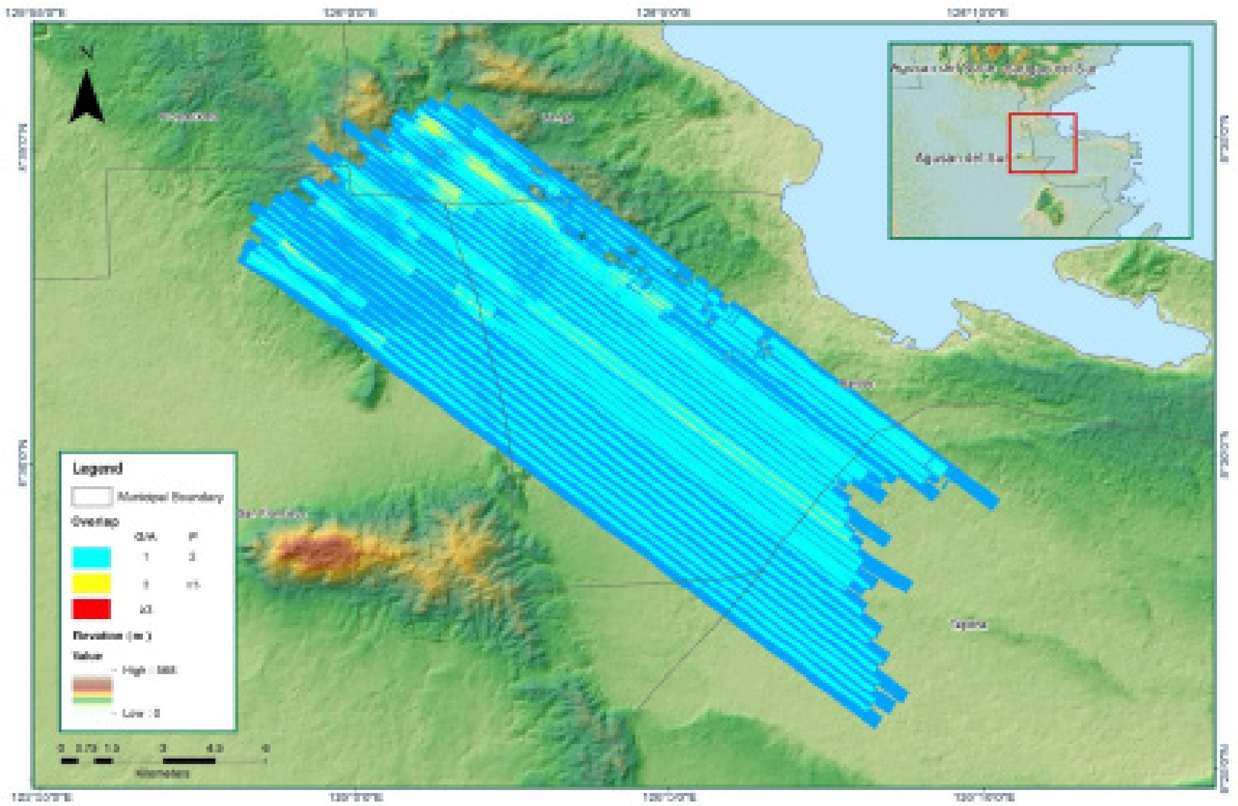


Figure A-8.12. Image of data overlap

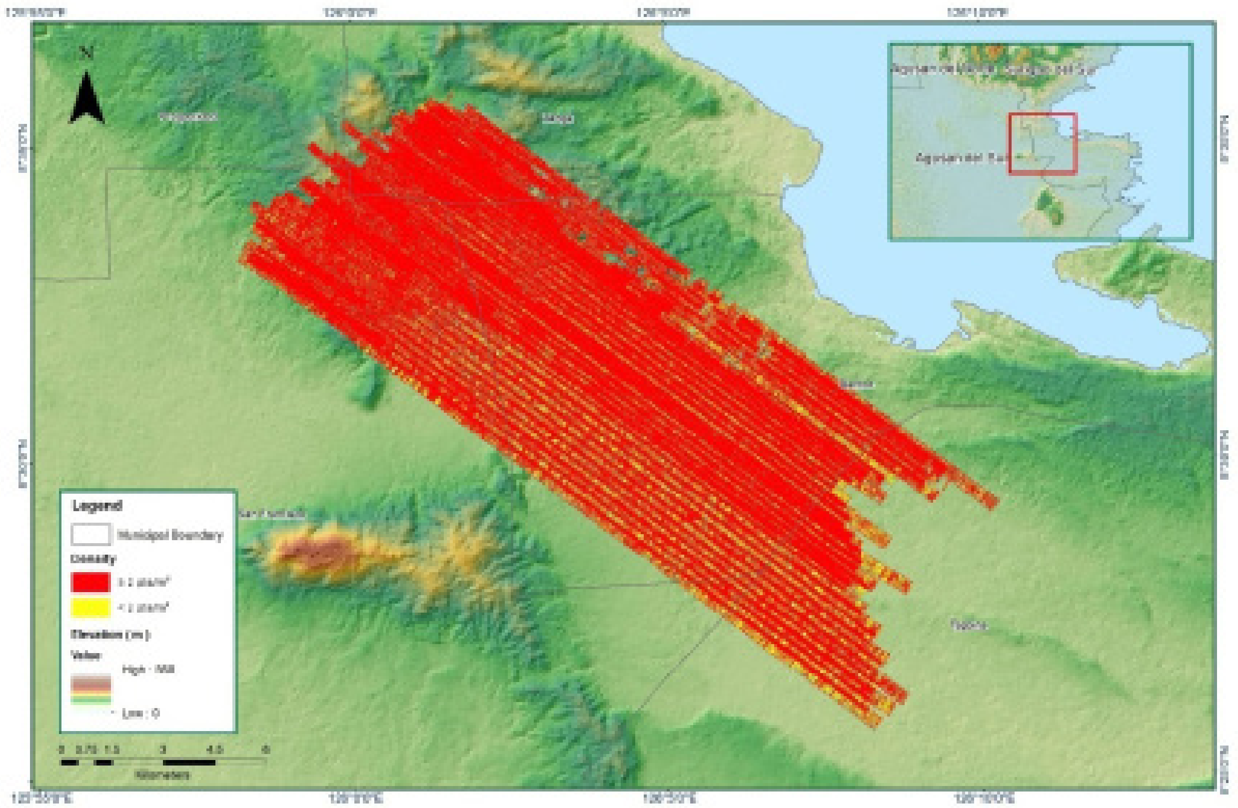


Figure A-8.13. Density map of merged LiDAR data

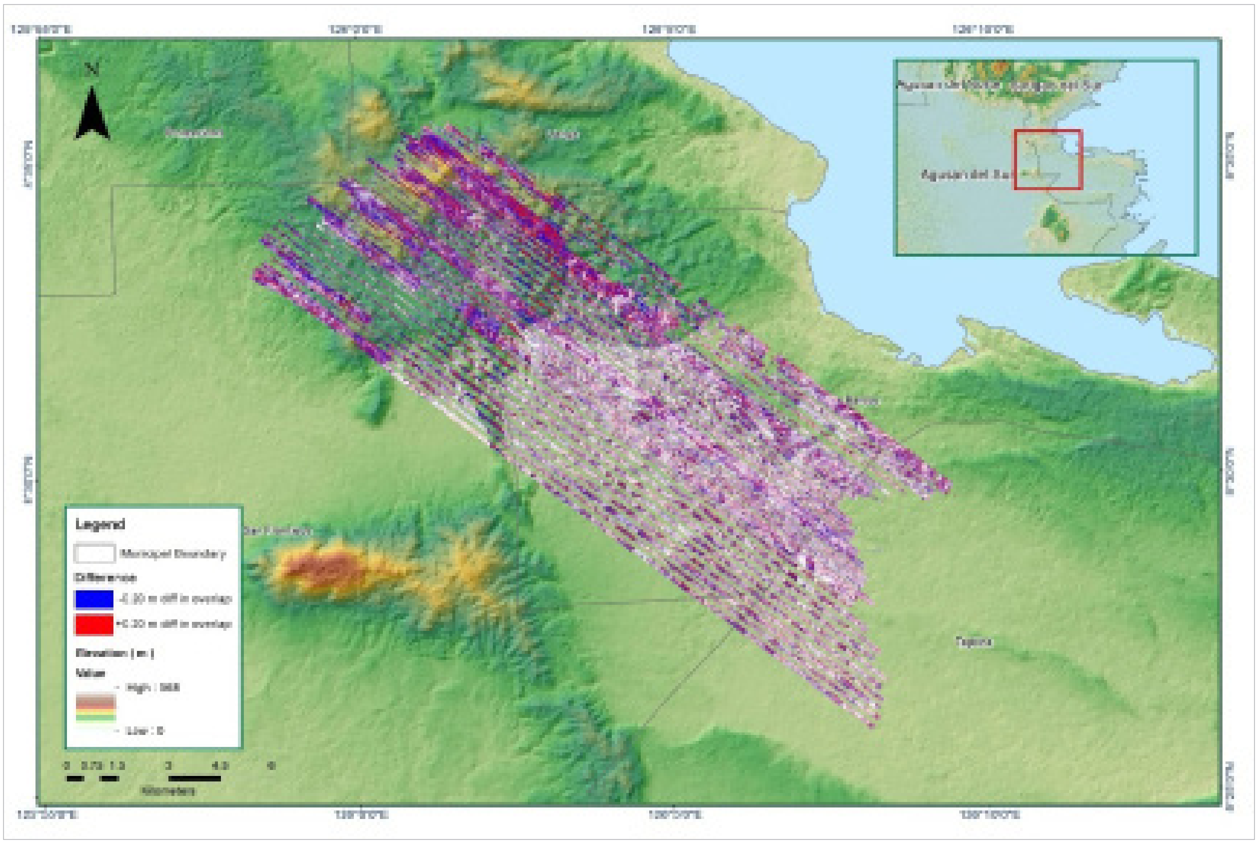


Figure A-8.14. Elevation difference between flight lines

Table A-8.3. Mission Summary Report for Block 66T

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66T
Inclusive Flights	1842A
Range data size	9.83 GB
Base data size	9.7 MB
POS	272MB
Image	56.60MB
Transfer date	September 5, 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)	2.50
RMSE for East Position (<4.0 cm)	2.60
RMSE for Down Position (<8.0 cm)	3.80
Boresight correction stdev (<0.001deg)	0.000825
IMU attitude correction stdev (<0.001deg)	0.000218
GPS position stdev (<0.01m)	0.0405
Minimum % overlap (>25)	40.38
Ave point cloud density per sq.m. (>2.0)	3.51
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	102
Maximum Height	526.47 m
Minimum Height	78.26 m
Classification (# of points)	
Ground	23,052,590
Low vegetation	19,884,665
Medium vegetation	60,690,591
High vegetation	90,773,998
Building	2,919,908
Orthophoto	Yes
Processed by	Engr. Carlyn Ann Ibañez, Engr. Harmond Santos, Engr. Jeffrey Delica

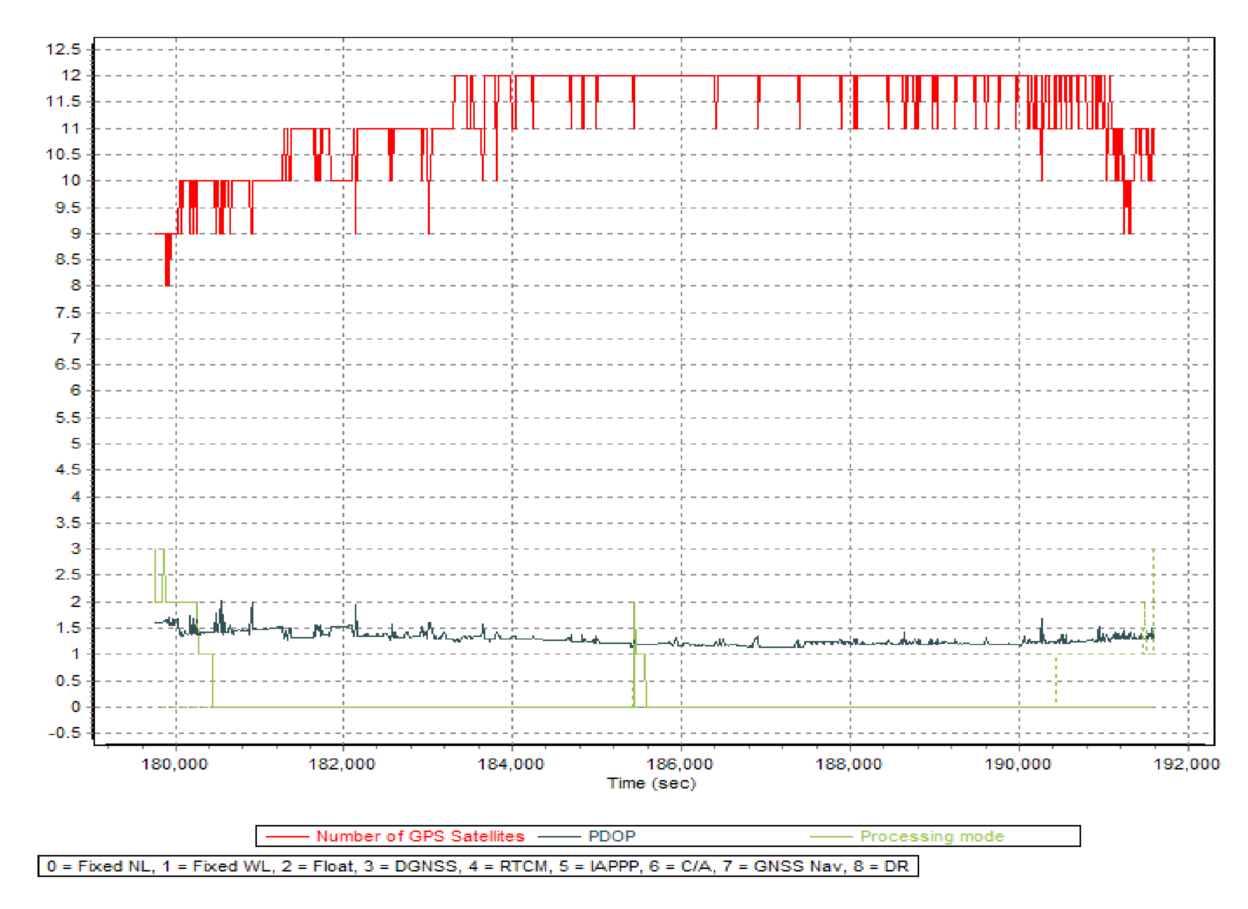


Figure A-8.15. Solution Status

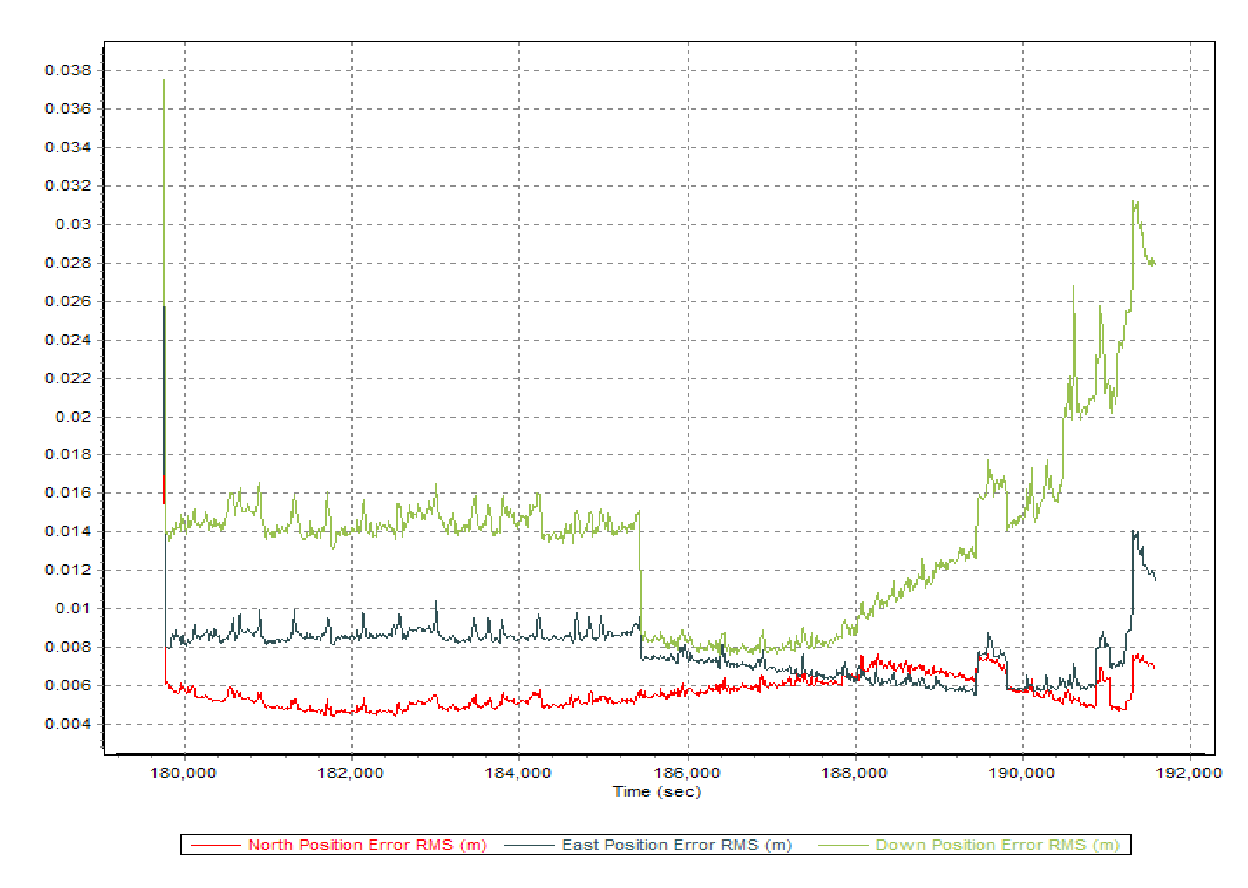


Figure A-8.16. Smoothed Performance Metric Parameters

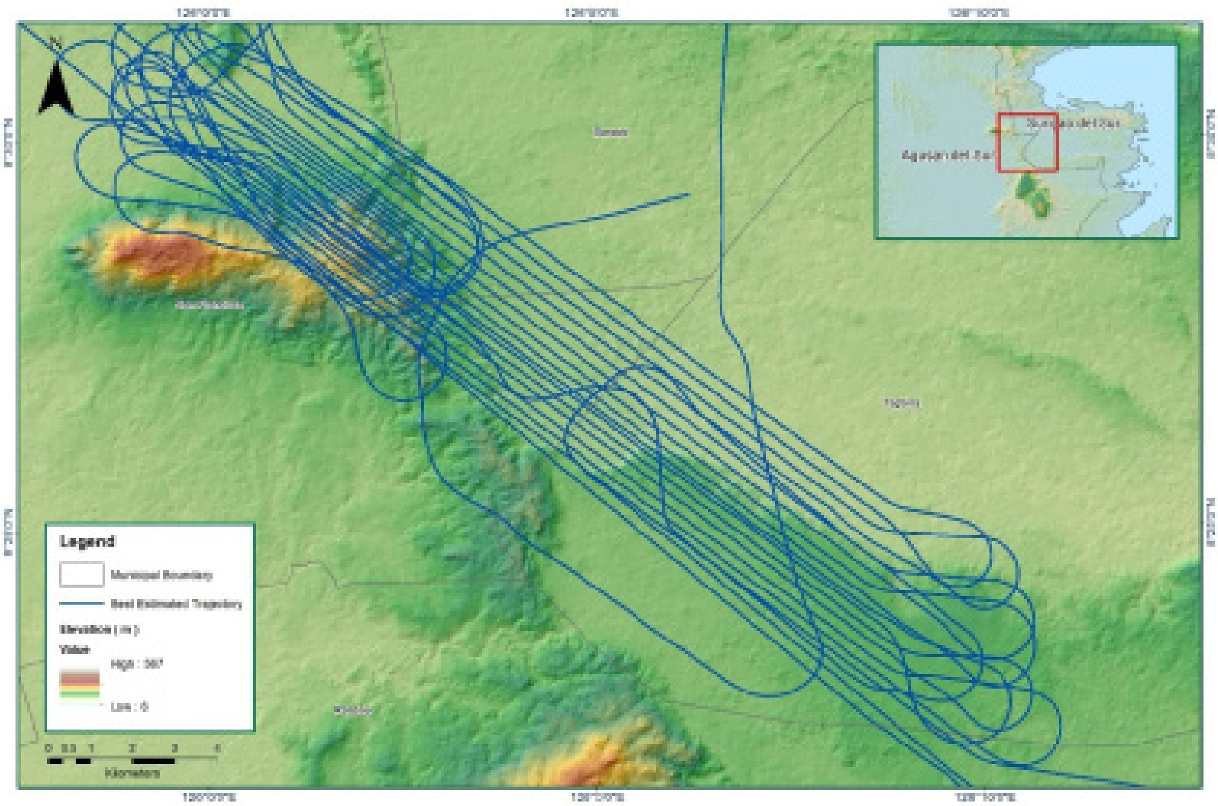


Figure A-8.17. Best Estimated Trajectory

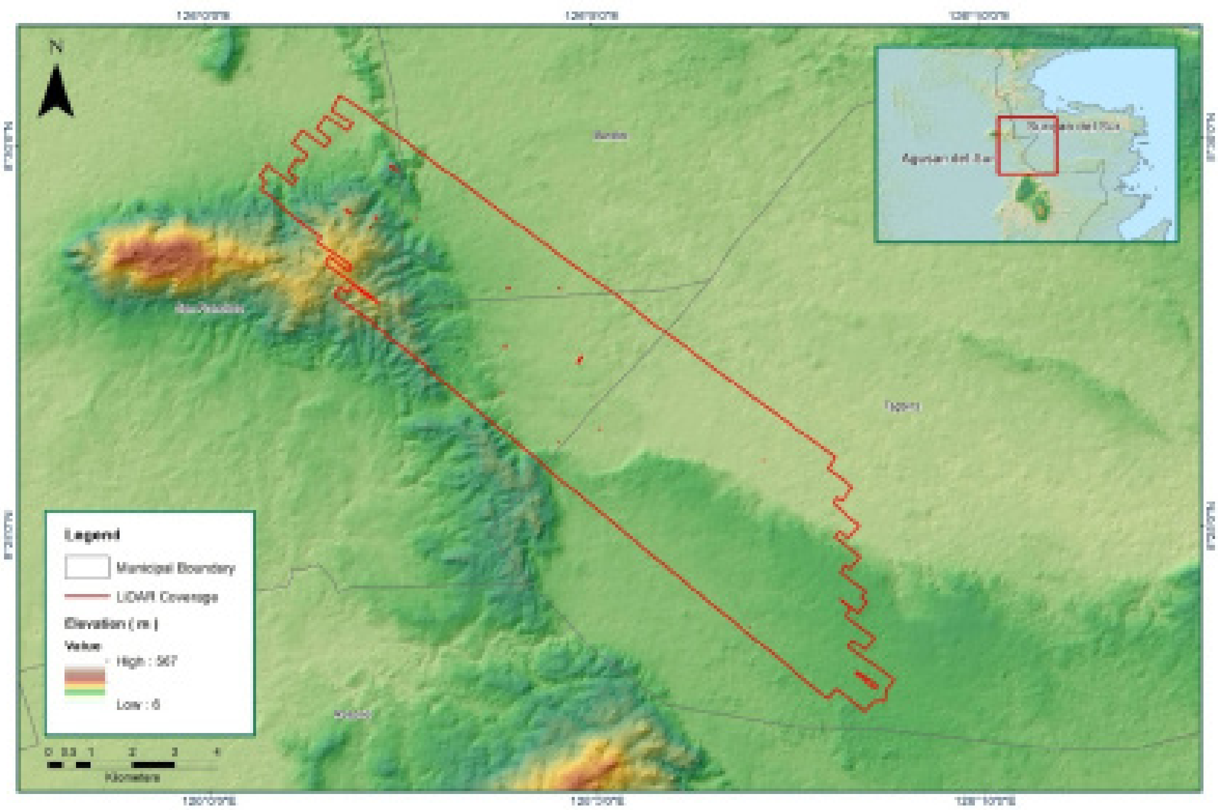


Figure A-8.18. Coverage of LiDAR data

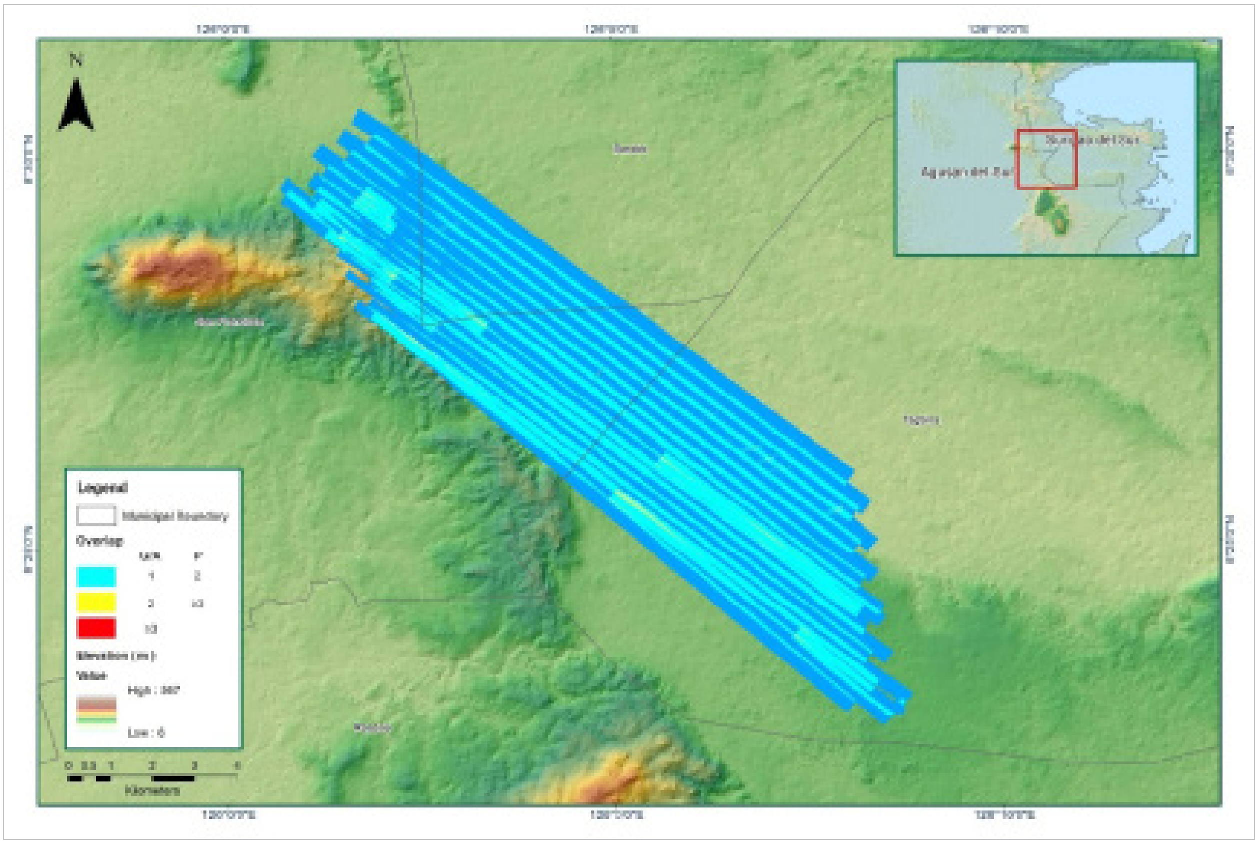


Figure A-8.19. Image of data overlap

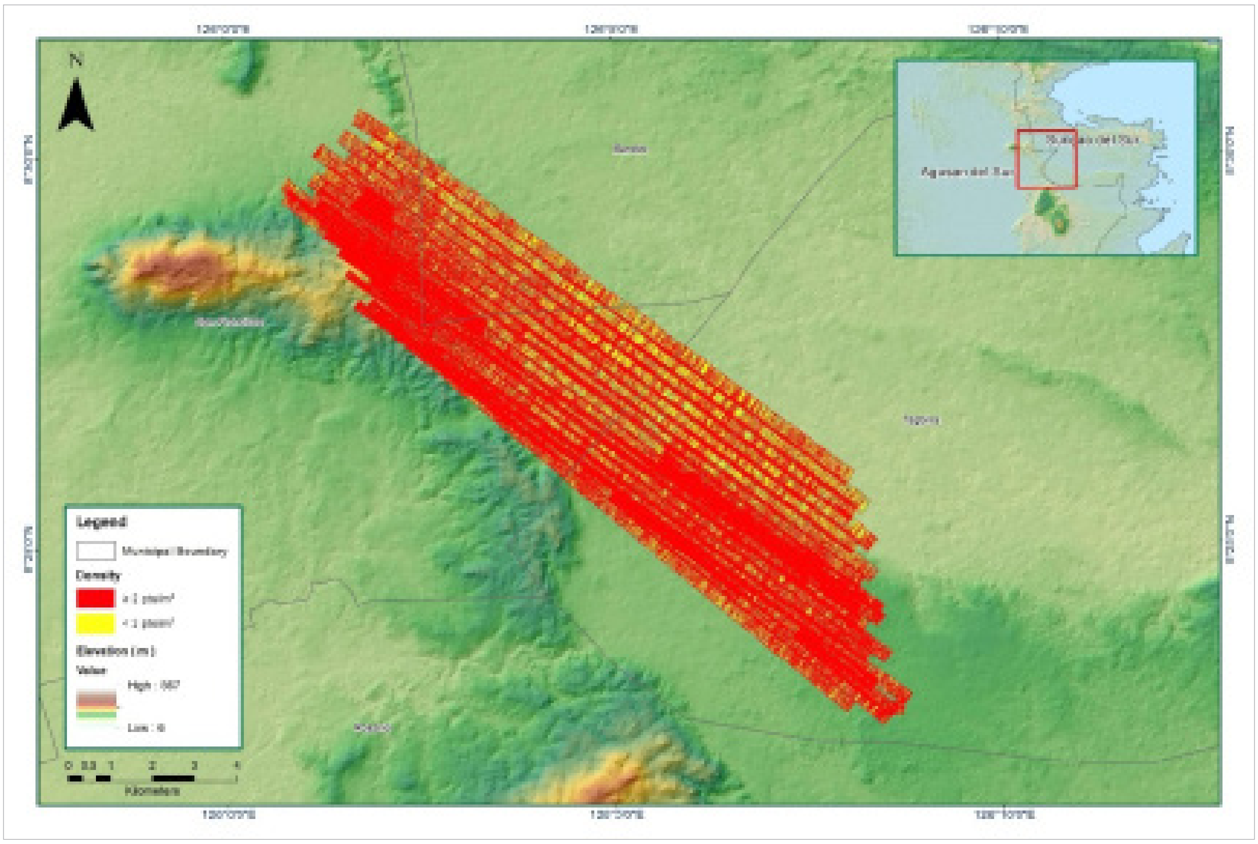


Figure A-8.20. Density map of merged LiDAR data

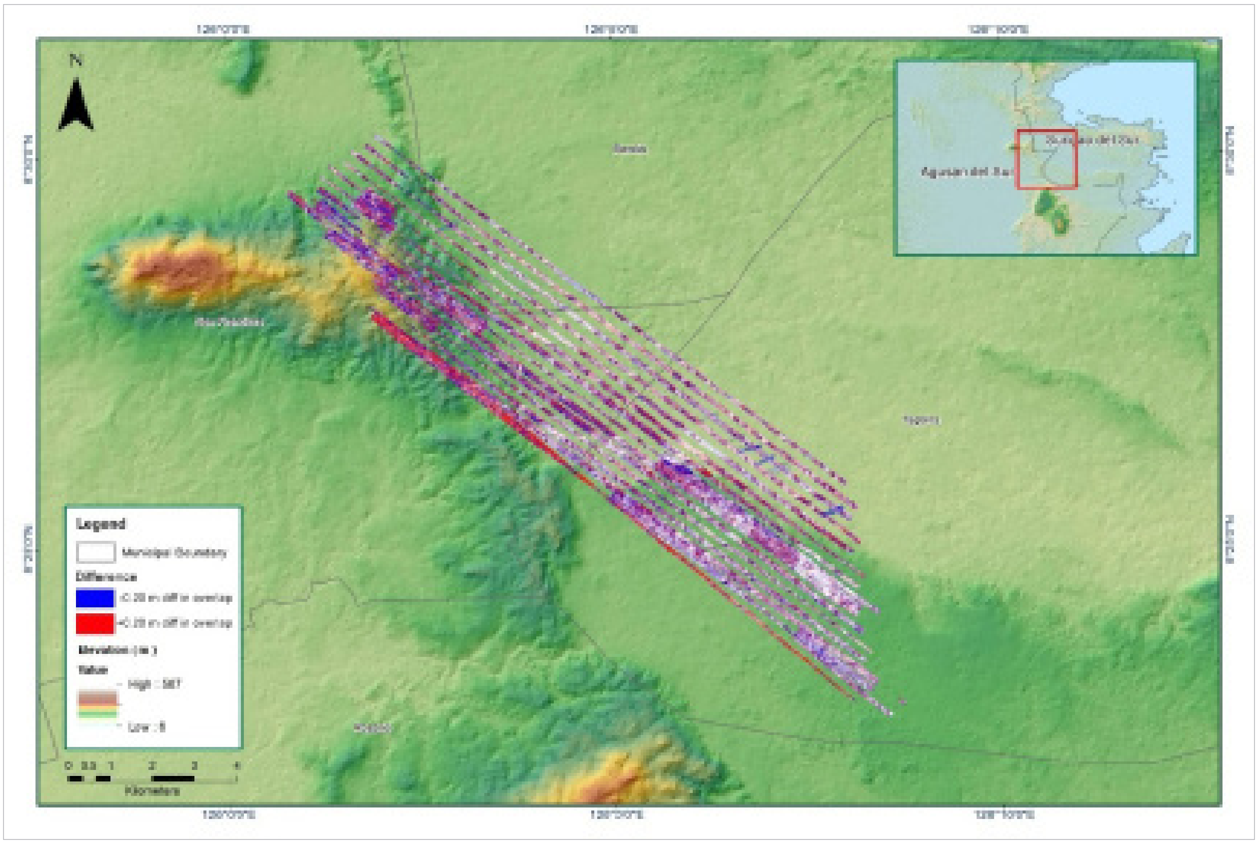


Figure A-8.21. Elevation difference between flight lines

Table A-8.4. Mission Summary Report for Block 66T_additional

Flight Area	Bislig
Mission Name	Blk 66T_additional
Inclusive Flights	1918A
Range data size	10.1 GB
POS	237 MB
Base data size	11 MB
Image	NA
Transfer date	September 9, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.26
RMSE for East Position (<4.0 cm)	1.33
RMSE for Down Position (<8.0 cm)	2.82
Boresight correction stdev (<0.001deg)	0.000910
IMU attitude correction stdev (<0.001deg)	0.013831
GPS position stdev (<0.01m)	0.0114
Minimum % overlap (>25)	19.04
Ave point cloud density per sq.m. (>2.0)	3.25
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	27
Maximum Height	276.2 m
Minimum Height	123.6 m
Classification (# of points)	
Ground	4805449
Low vegetation	2646714
Medium vegetation	6504120
High vegetation	13858118
Building	945252
Orthophoto	No
Processed by	Engr. Analyn Naldo, Engr. Chelou Prado, Engr. Karl Adrian Vergara

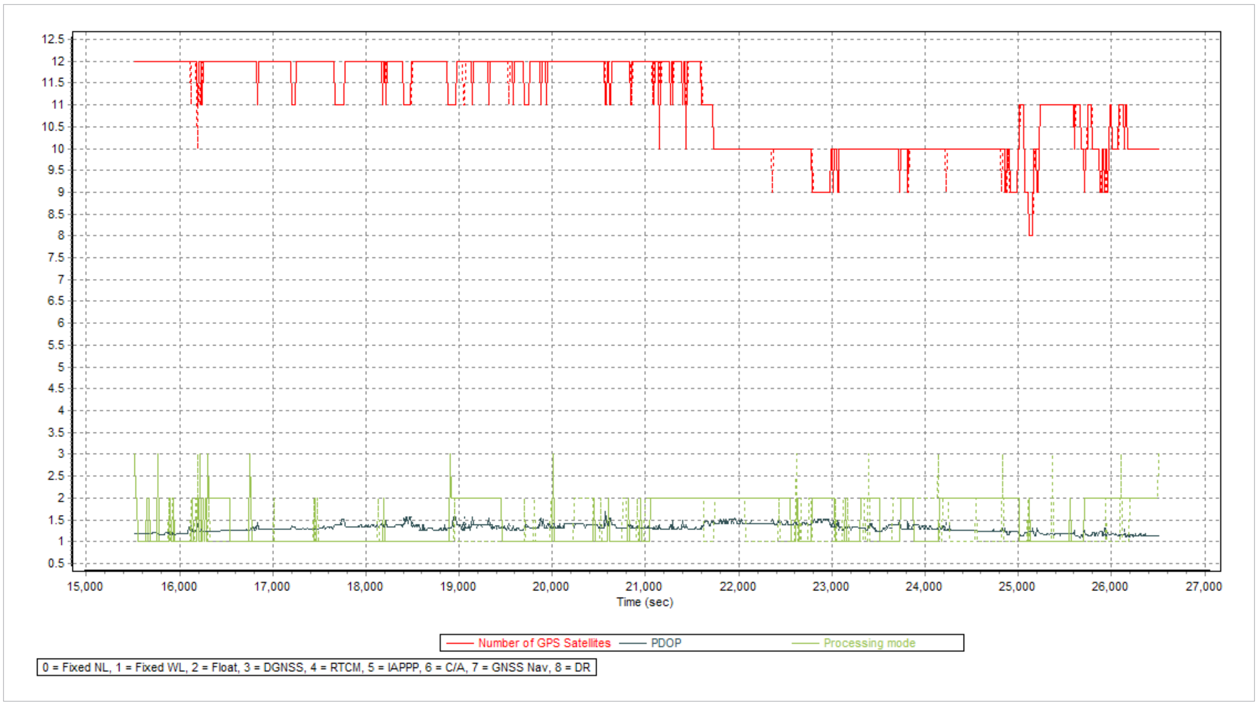


Figure A-8.22. Solution Status

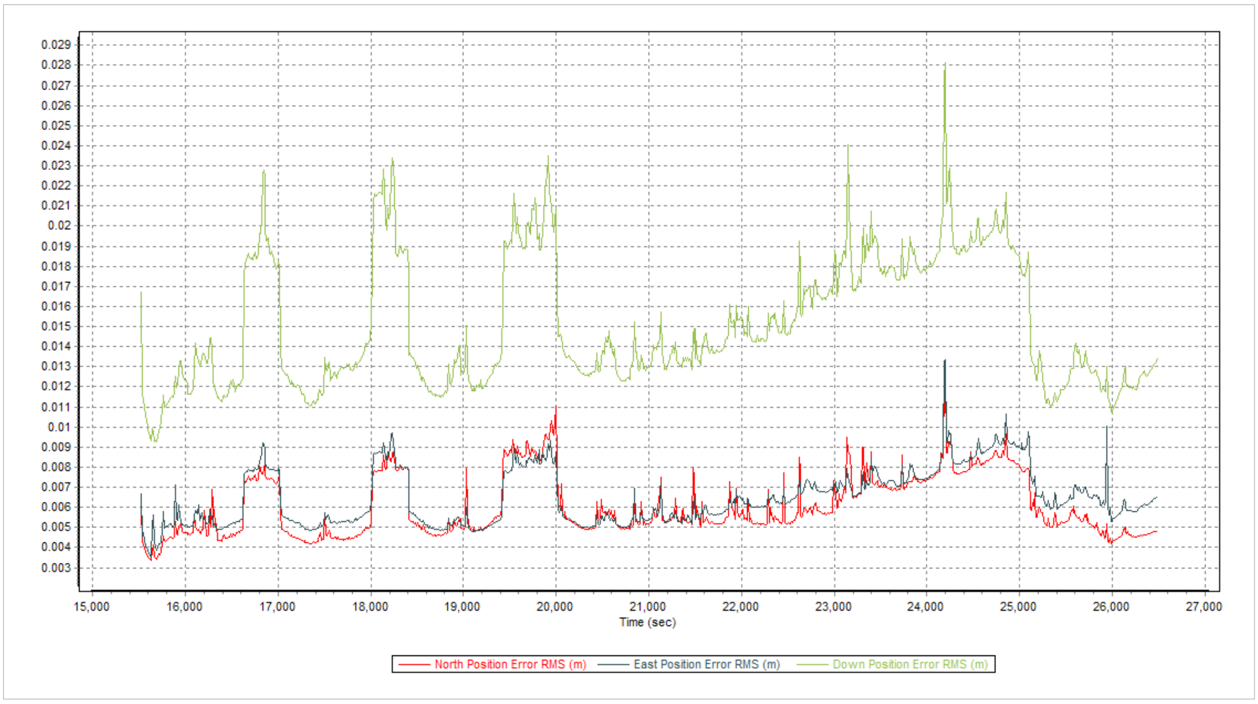


Figure A-8.23. Smoothed Performance Metric Parameters

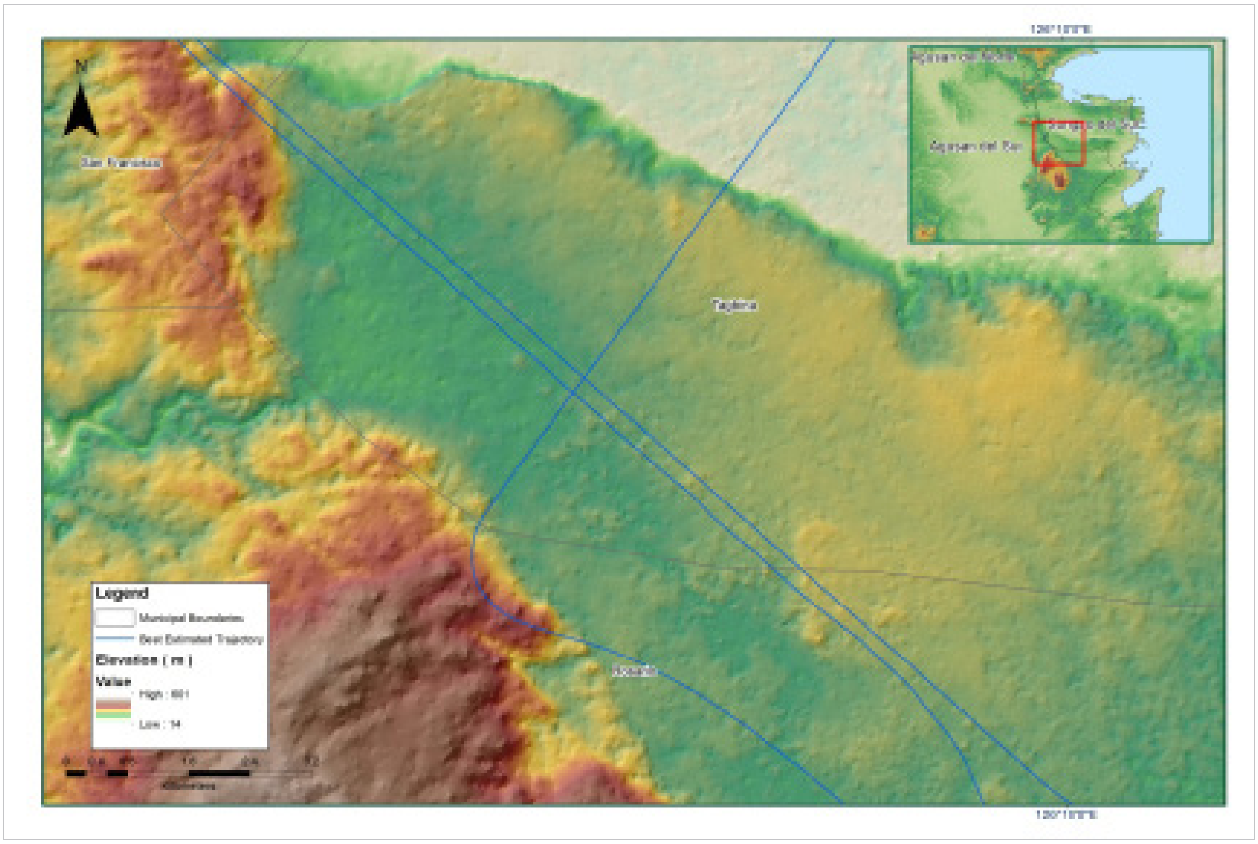


Figure A-8.24. Best Estimated Trajectory

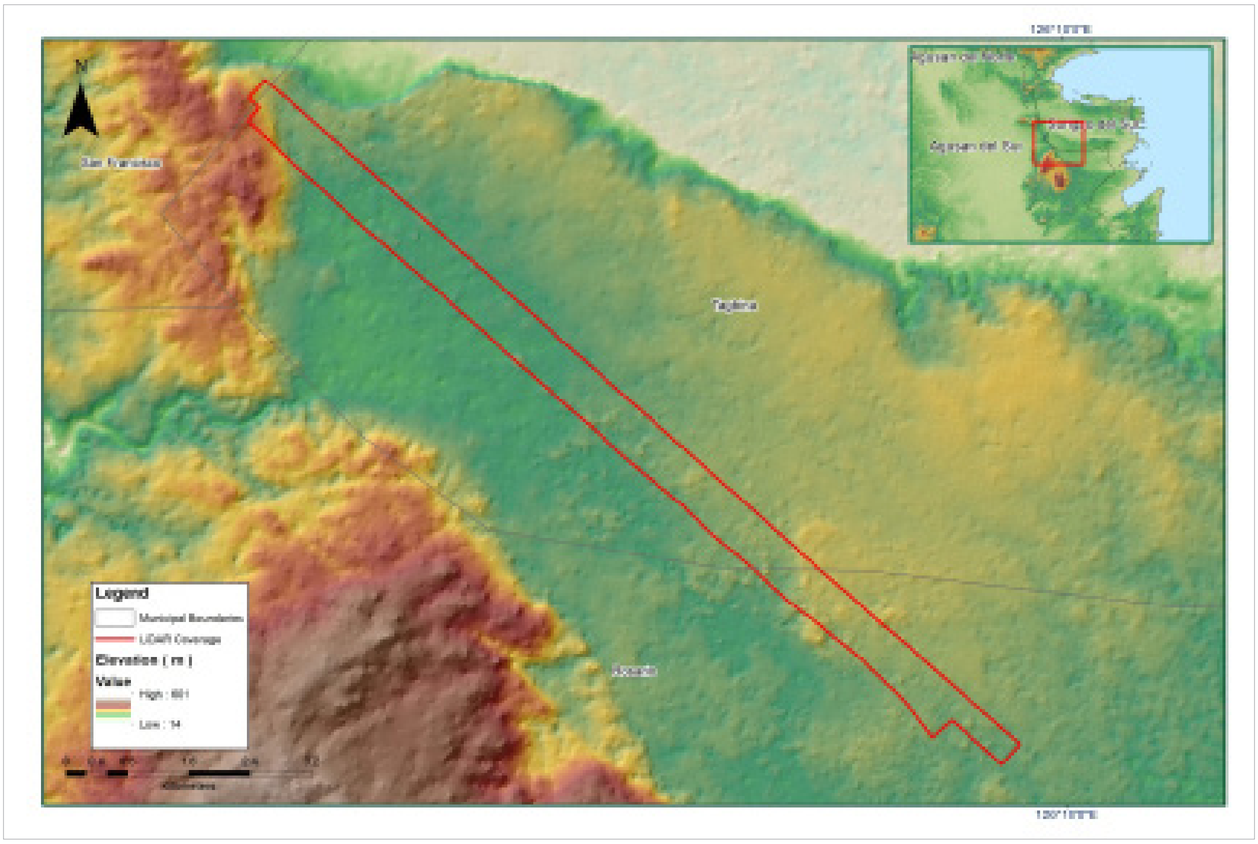


Figure A-8.25. Coverage of LiDAR data

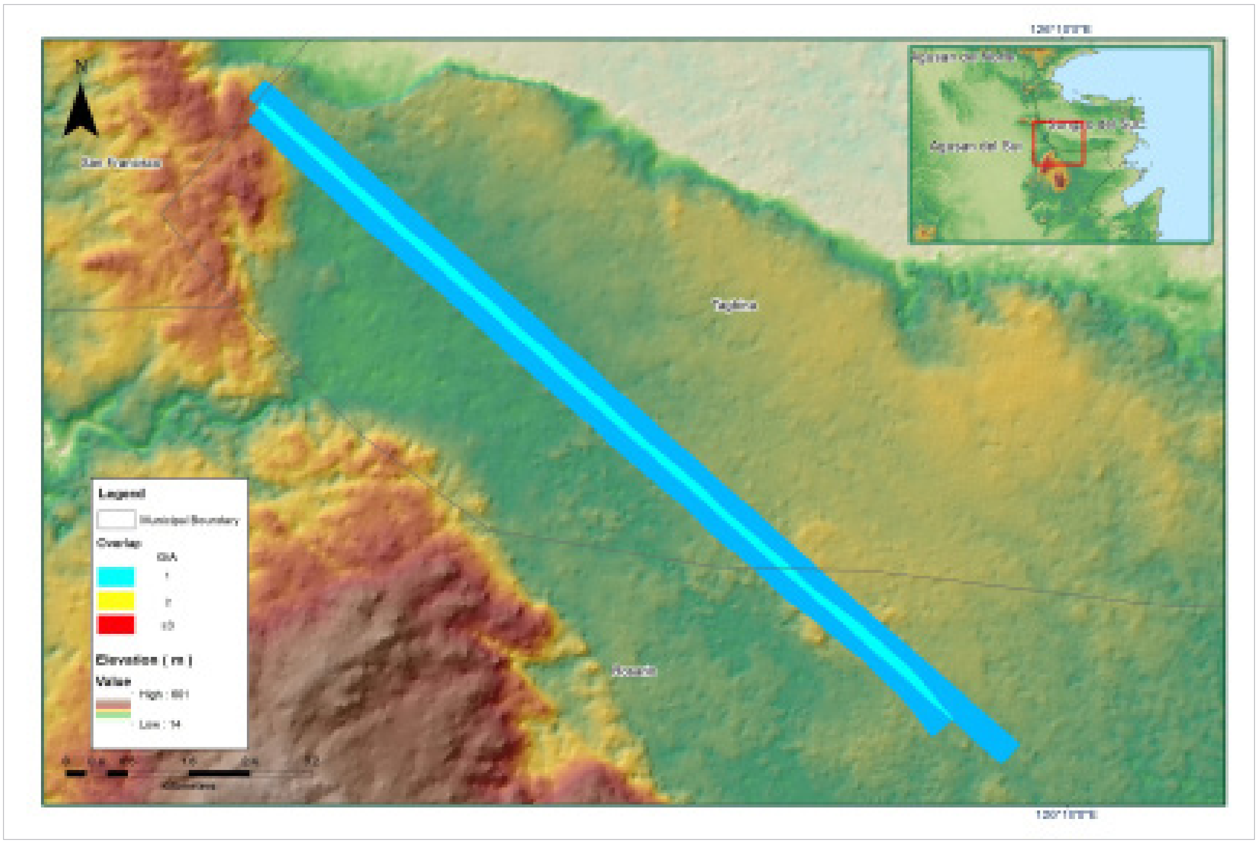


Figure A-8.26. Image of data overlap

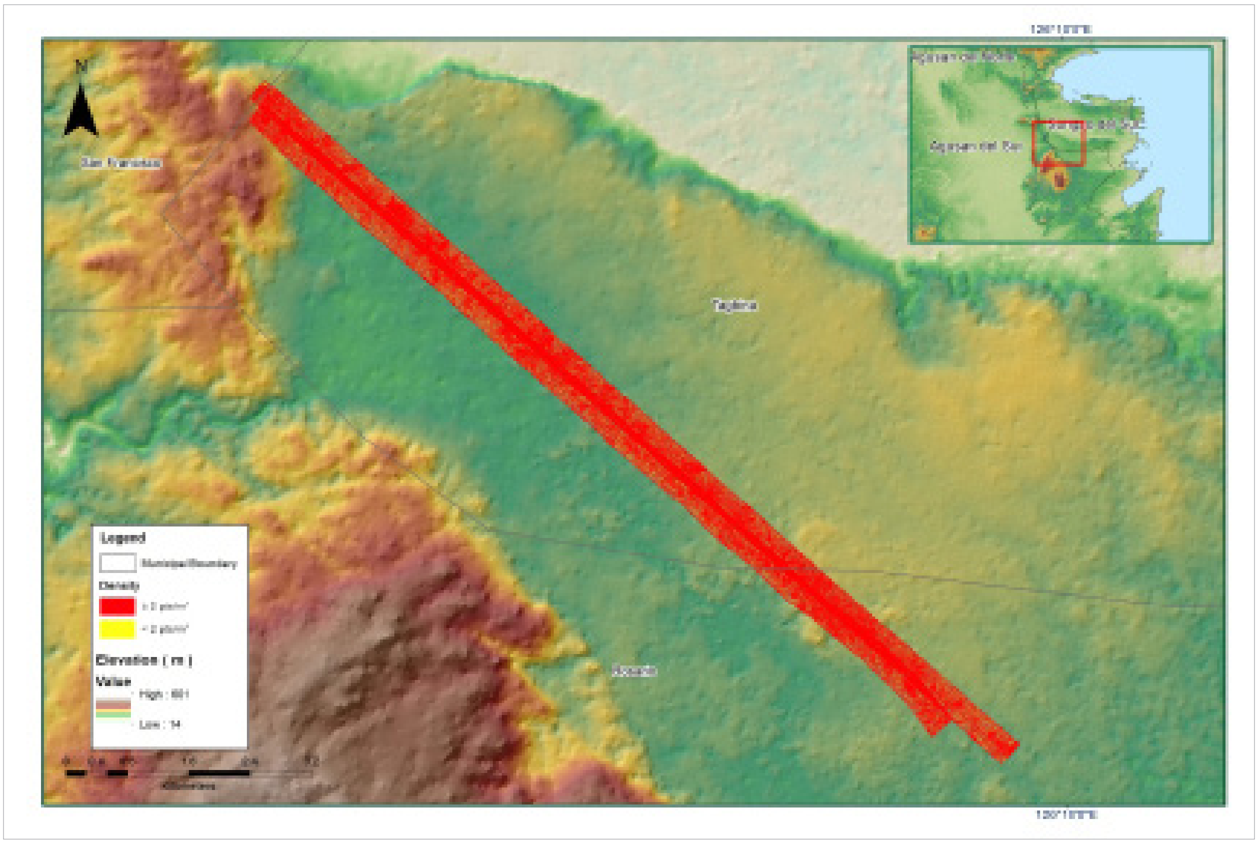


Figure A-8.27. Density map of merged LiDAR data

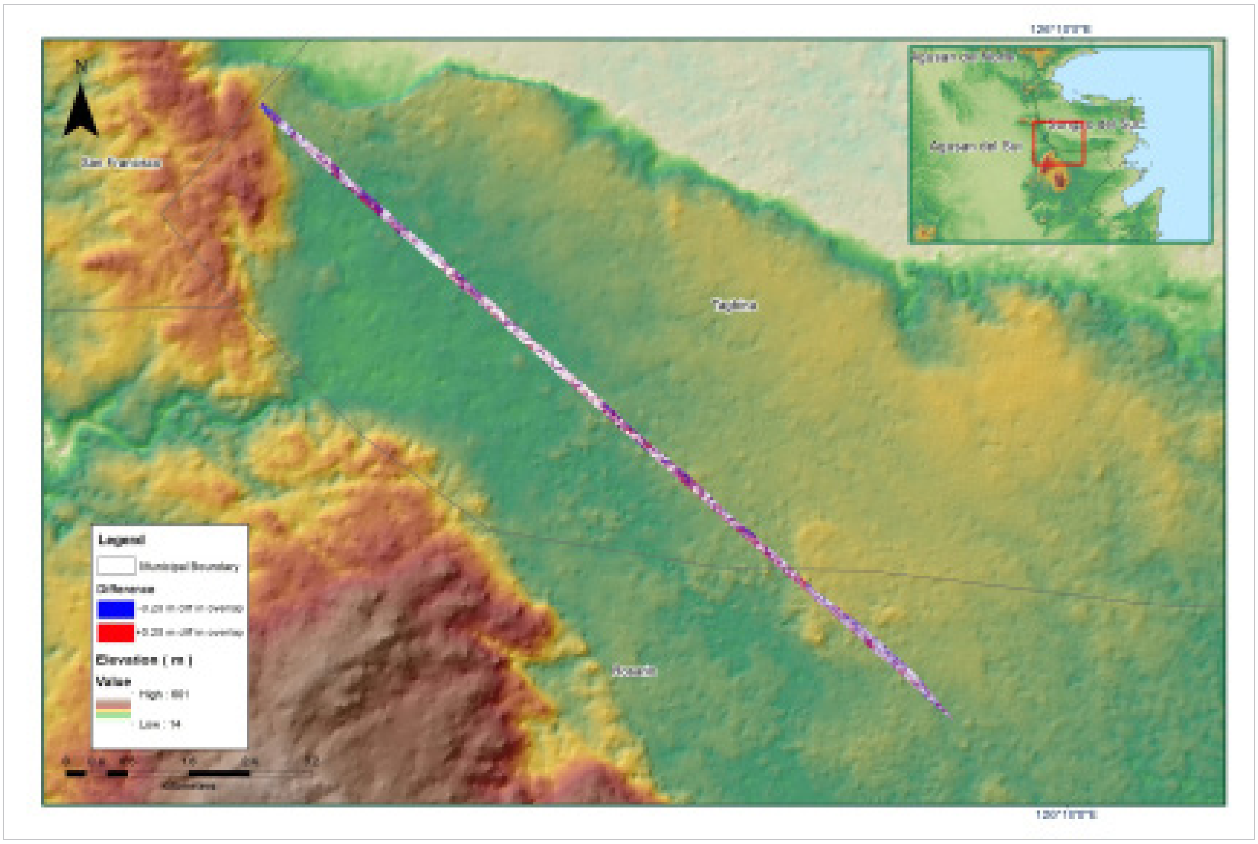


Figure A-8.28. Elevation difference between flight lines

Table A-8.5. Mission Summary Report for Block 66R

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66R
Inclusive Flights	1814A & 1816A
Range data size	19.51 GB
Base data size	33.8 MB
POS	426MB
Image	87.10 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	1.15
RMSE for East Position (<4.0 cm)	1.80
RMSE for Down Position (<8.0 cm)	2.25
Boresight correction stdev (<0.001deg)	0.000763
IMU attitude correction stdev (<0.001deg)	0.002617
GPS position stdev (<0.01m)	0.0183
Minimum % overlap (>25)	31.54
Ave point cloud density per sq.m. (>2.0)	2.82
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	112
Maximum Height	304.32 m
Minimum Height	46.59 m
Classification (# of points)	
Ground	25,905,739
Low vegetation	18,936,577
Medium vegetation	46,995,263
High vegetation	60,296,697
Building	997,107
Orthophoto	No
Processed by	Engr. Jommer Medina, Engr. Harmond Santos, Engr. Roa Shalemar Redo

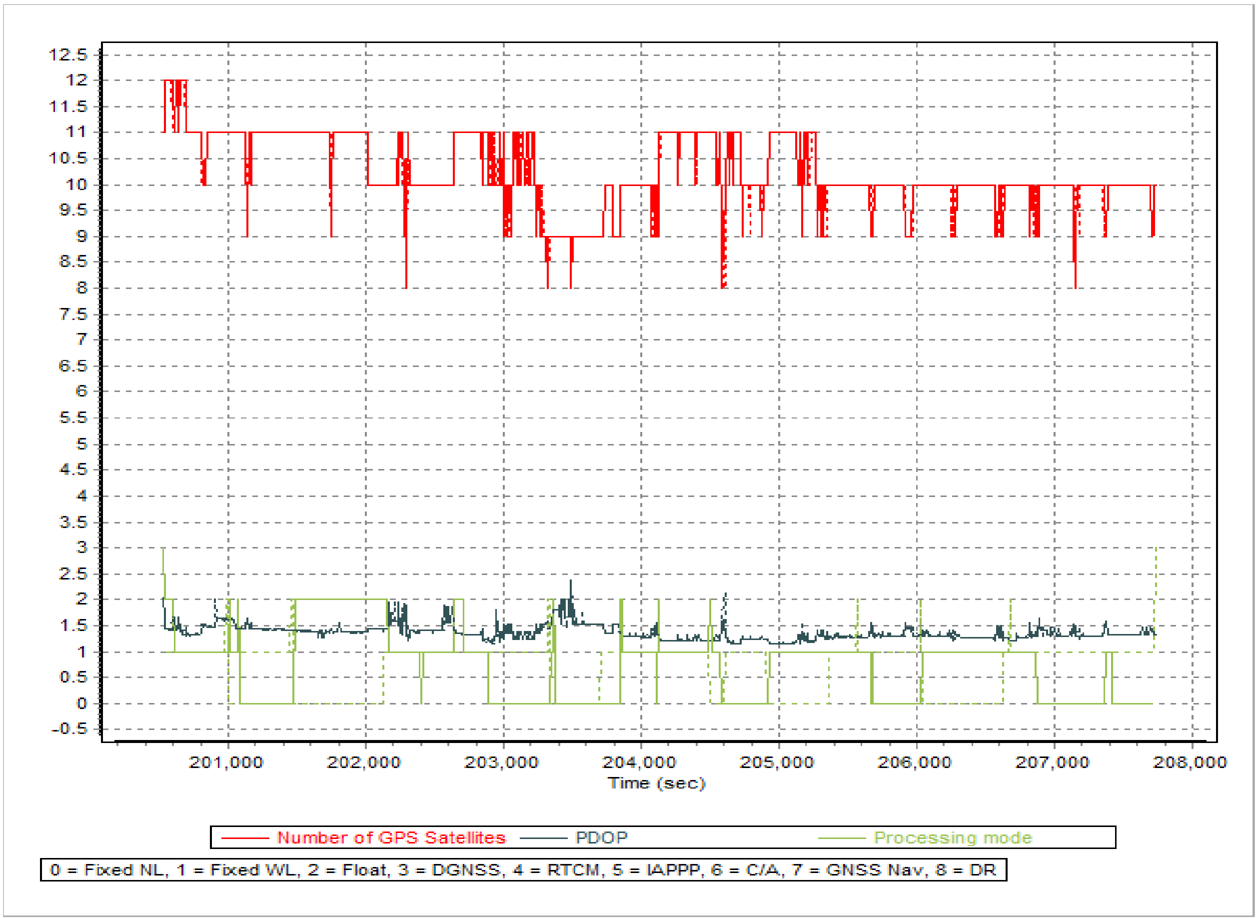


Figure A-8.29.1 Solution Status

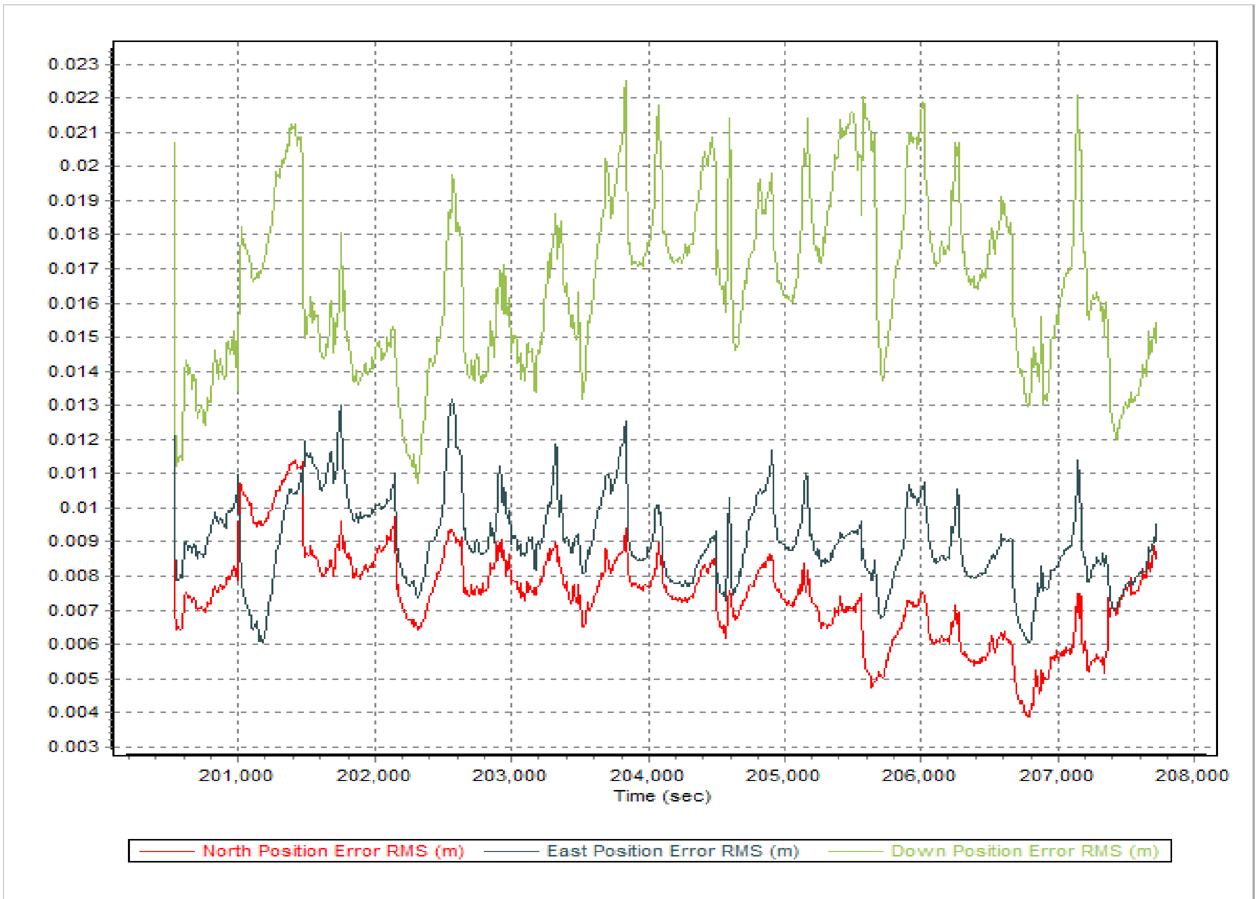


Figure A-8.30. Smoothed Performance Metric Parameters

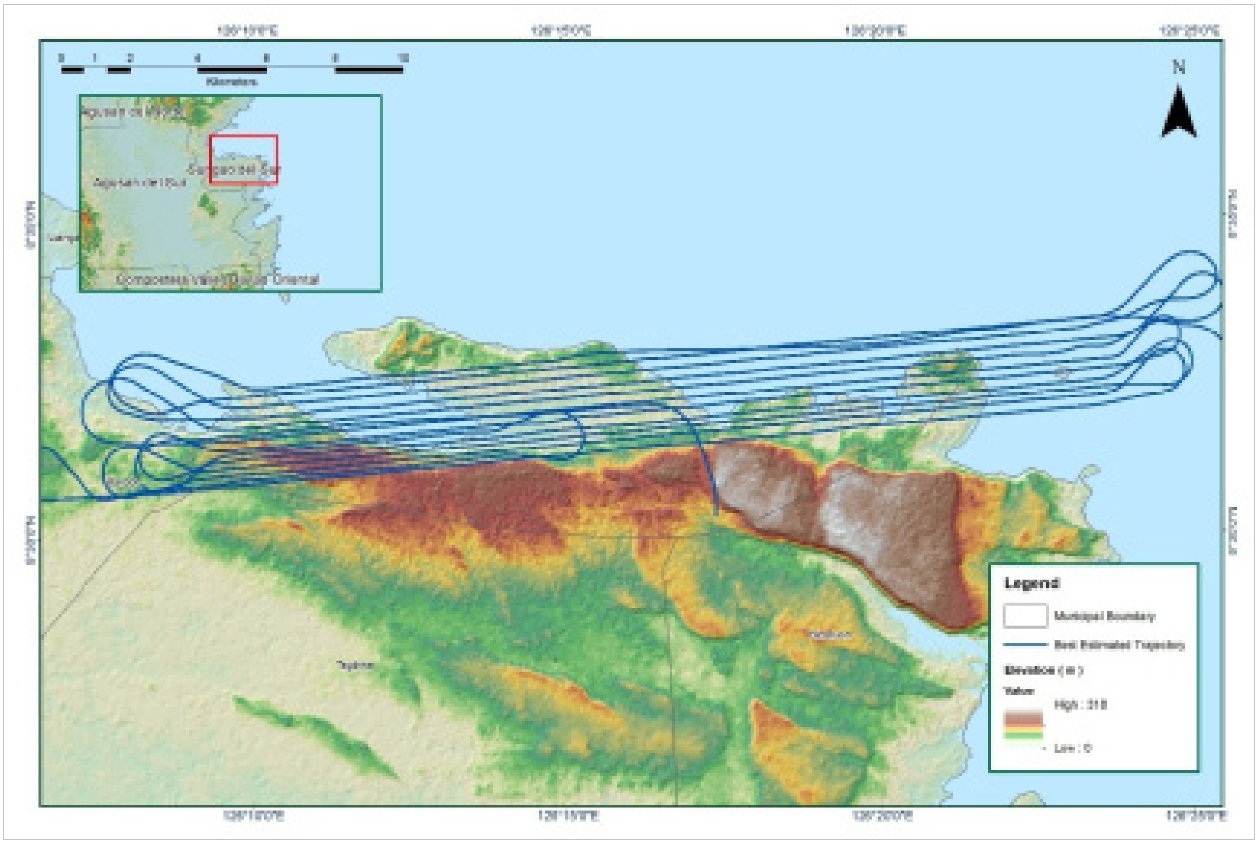
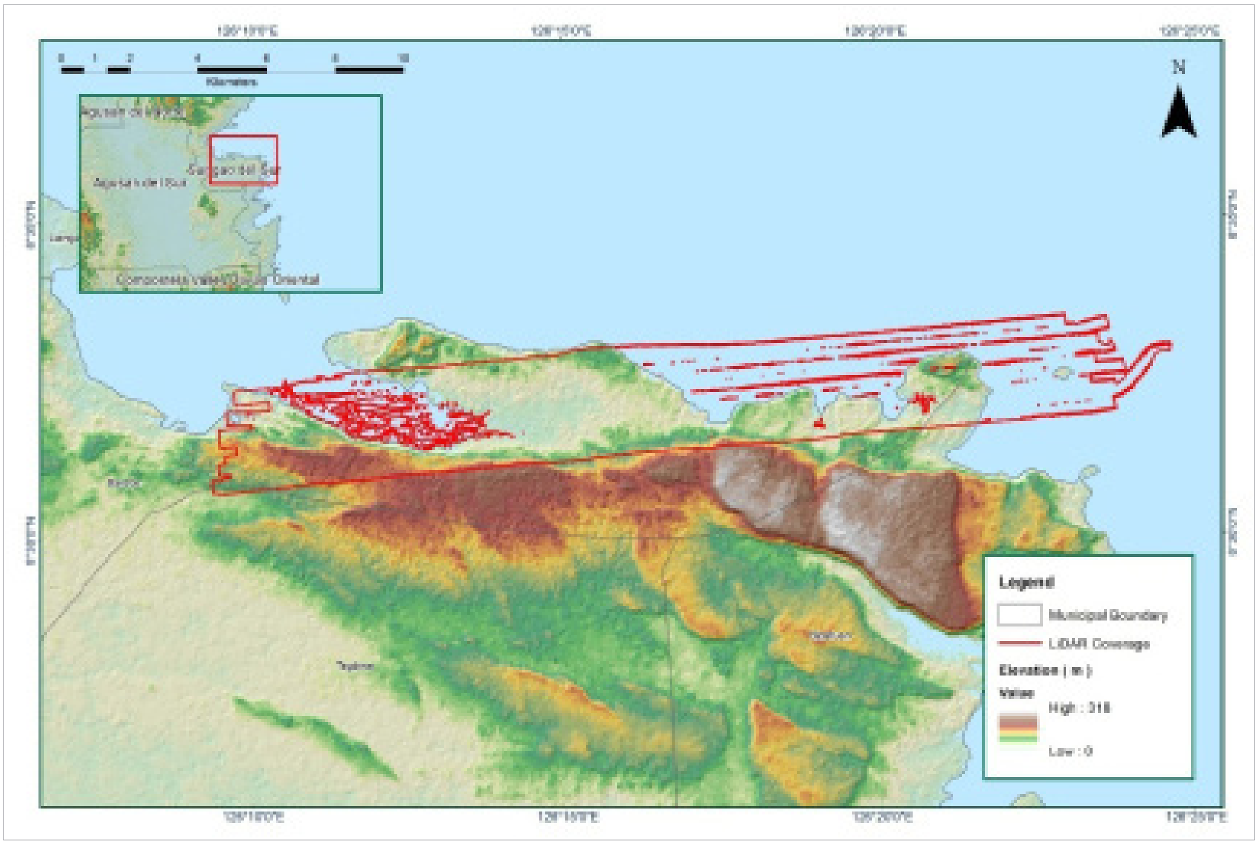


Figure A-8.31. Best Estimated Trajectory



FigureA-8.32. Coverage of LiDAR data

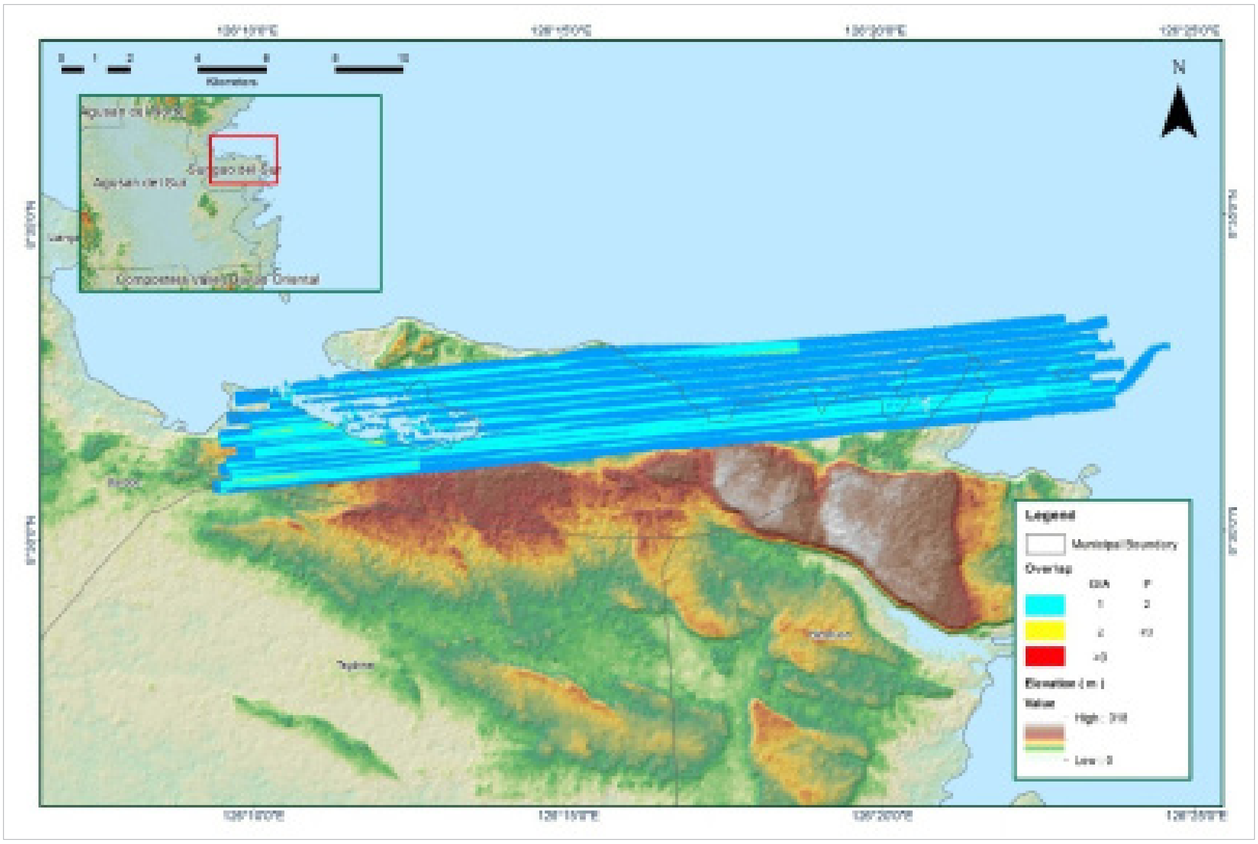


Figure A-8.33. Image of data overlap

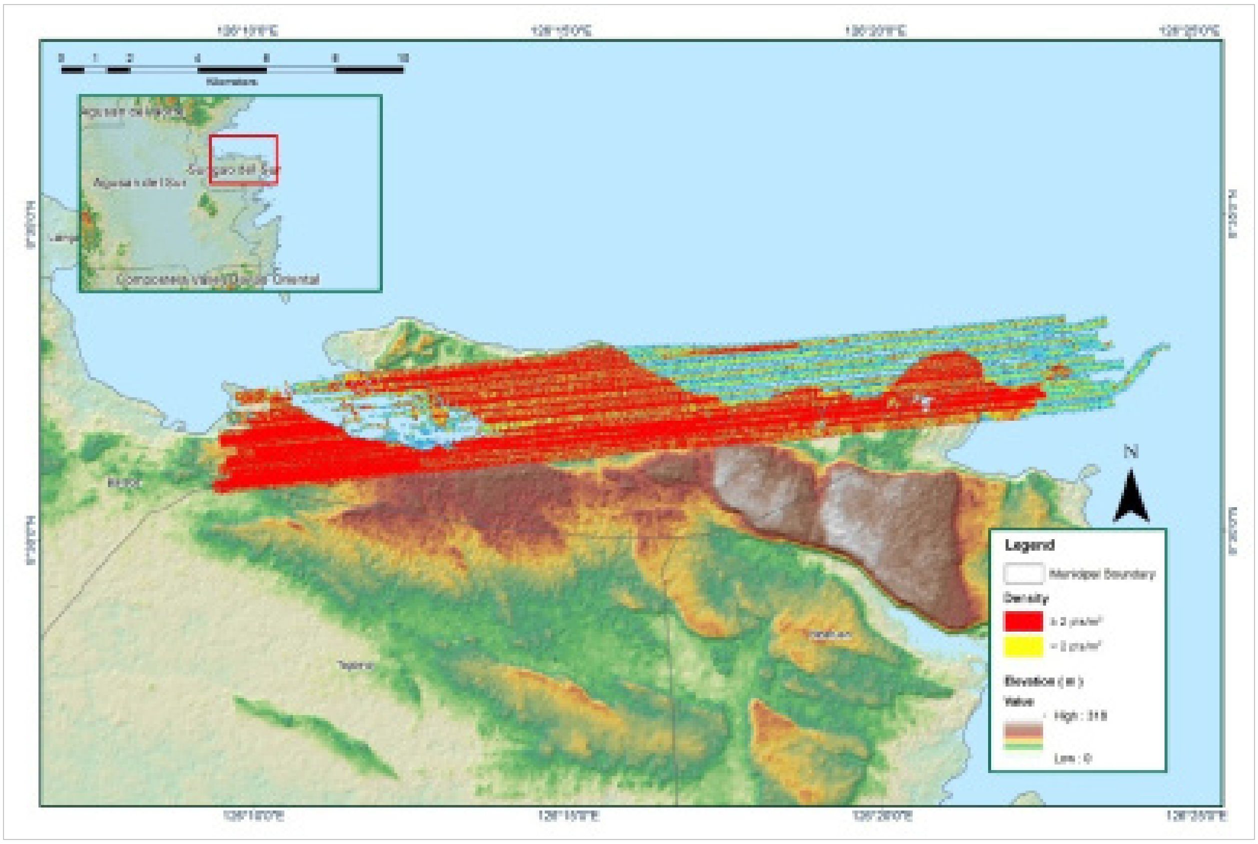


Figure A-8.34. Density map of merged LiDAR data

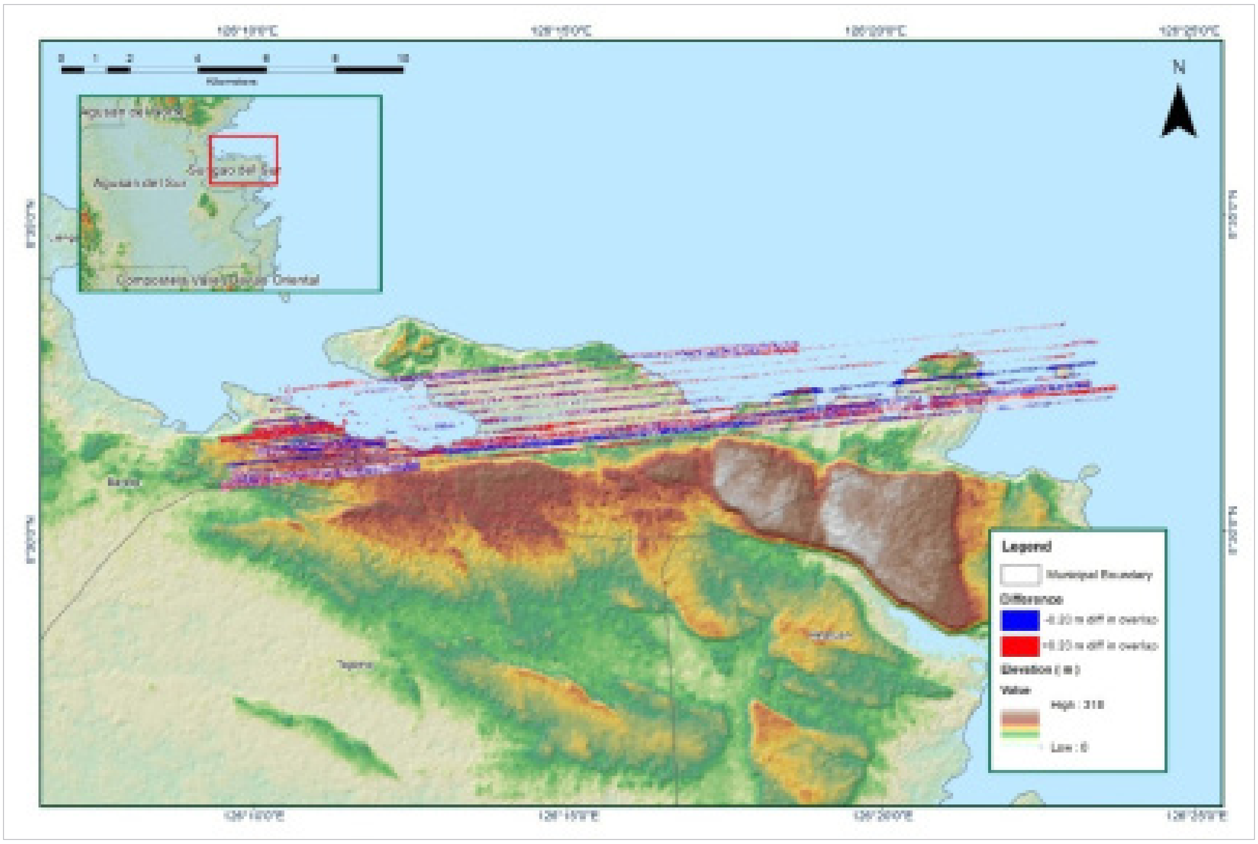


Figure A-8.35. Elevation difference between flight lines

Table A-8.6. Mission Summary Report for Block 66R Supplement

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66R Supplement
Inclusive Flights	1912A & 1918A
Range data size	14.02 GB
Base data size	25.6 MB
POS	345MB
Image	12.40 MB
Transfer date	October 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	1.25
RMSE for East Position (<4.0 cm)	1.35
RMSE for Down Position (<8.0 cm)	2.80
Boresight correction stdev (<0.001deg)	0.000910
IMU attitude correction stdev (<0.001deg)	0.020623
GPS position stdev (<0.01m)	0.0354
Minimum % overlap (>25)	58.75
Ave point cloud density per sq.m. (>2.0)	5.04
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	106
Maximum Height	639.27 m
Minimum Height	53.59 m
Classification (# of points)	
Ground	21,328,714
Low vegetation	21,170,667
Medium vegetation	75,475,480
High vegetation	75,869,990
Building	1,152,661
Orthophoto	Yes
Processed by	Engr. Analyn Naldo, Engr. Antonio Chua, Jr., Engr. Melissa Fernandez

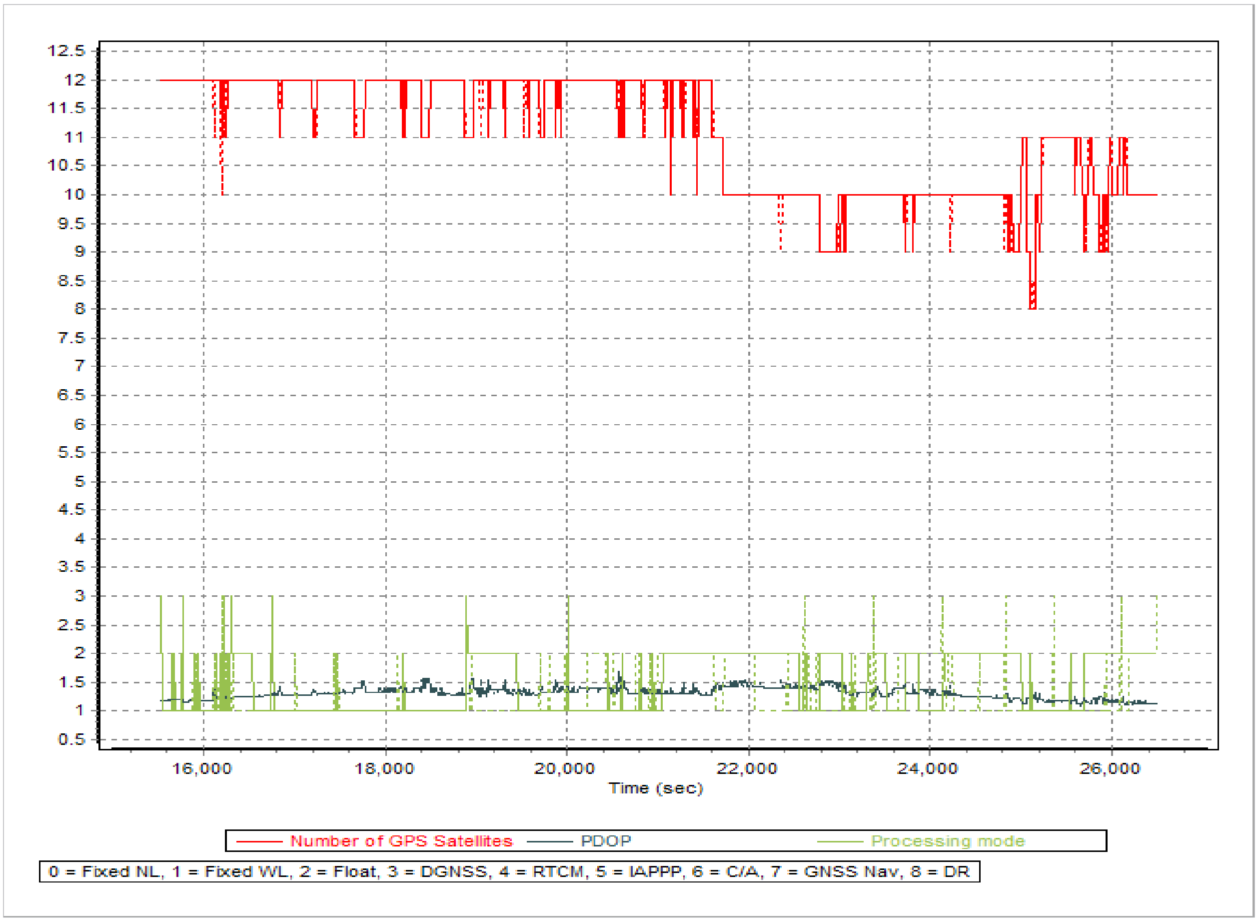


Figure A-8.36. Solution Status

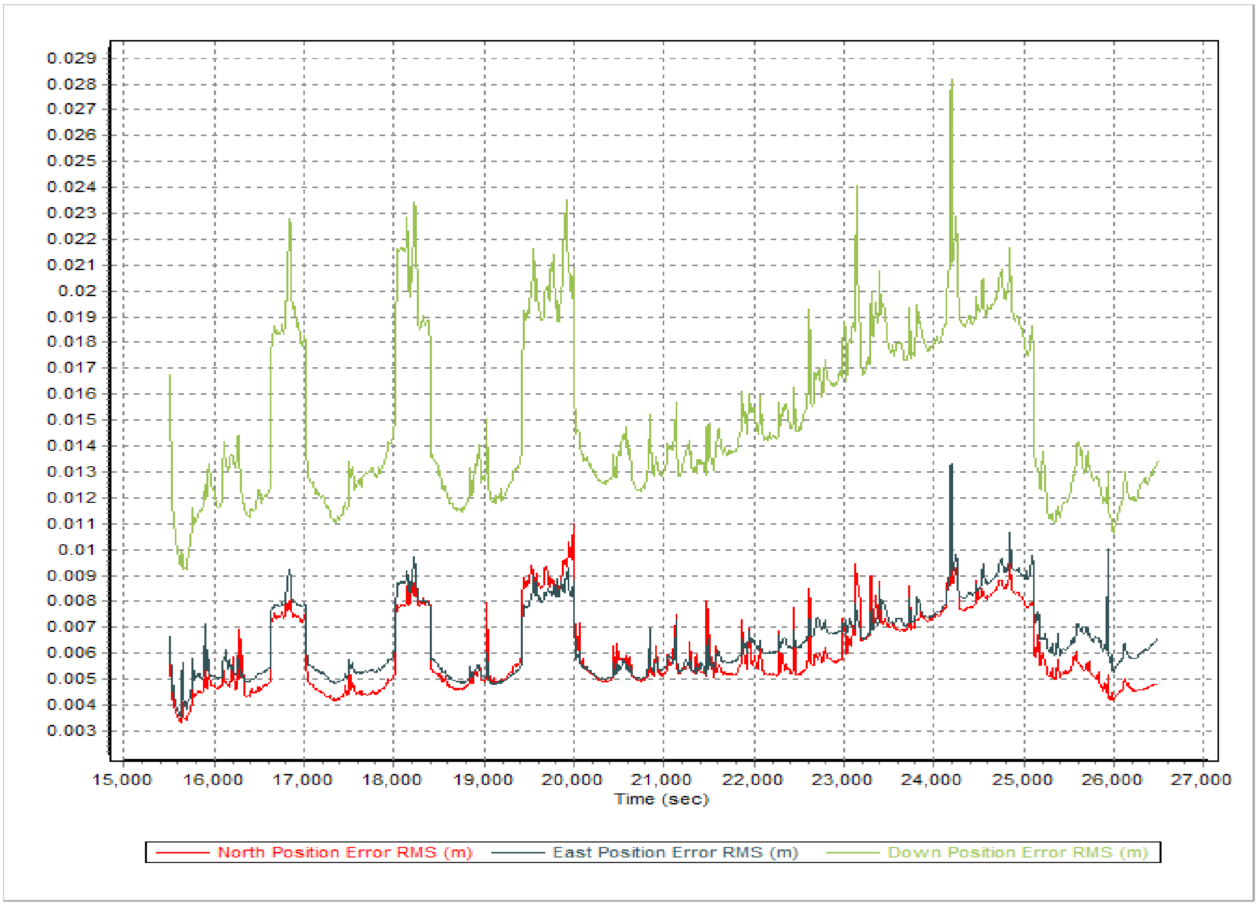


Figure A-8.37. Smoothed Performance Metric Parameters

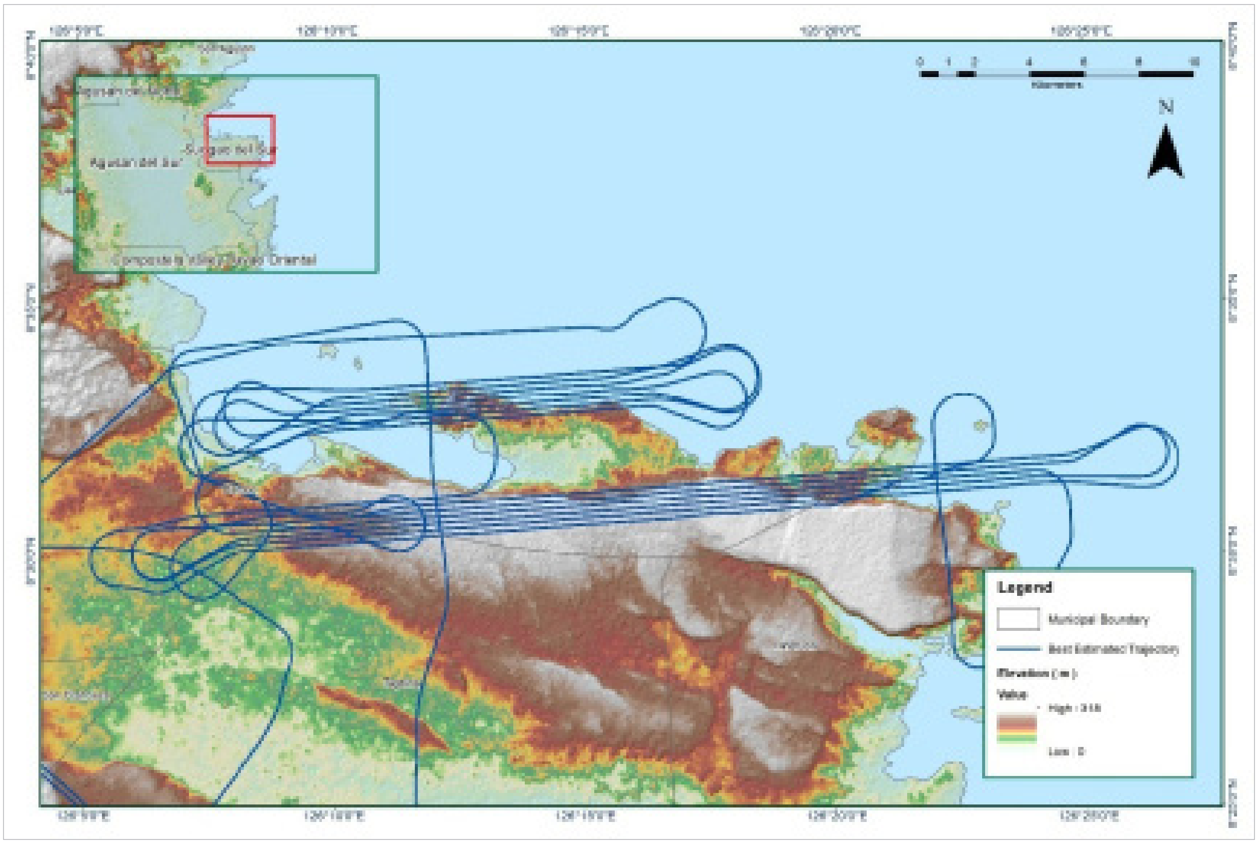


Figure A-8.38. Best Estimated Trajectory

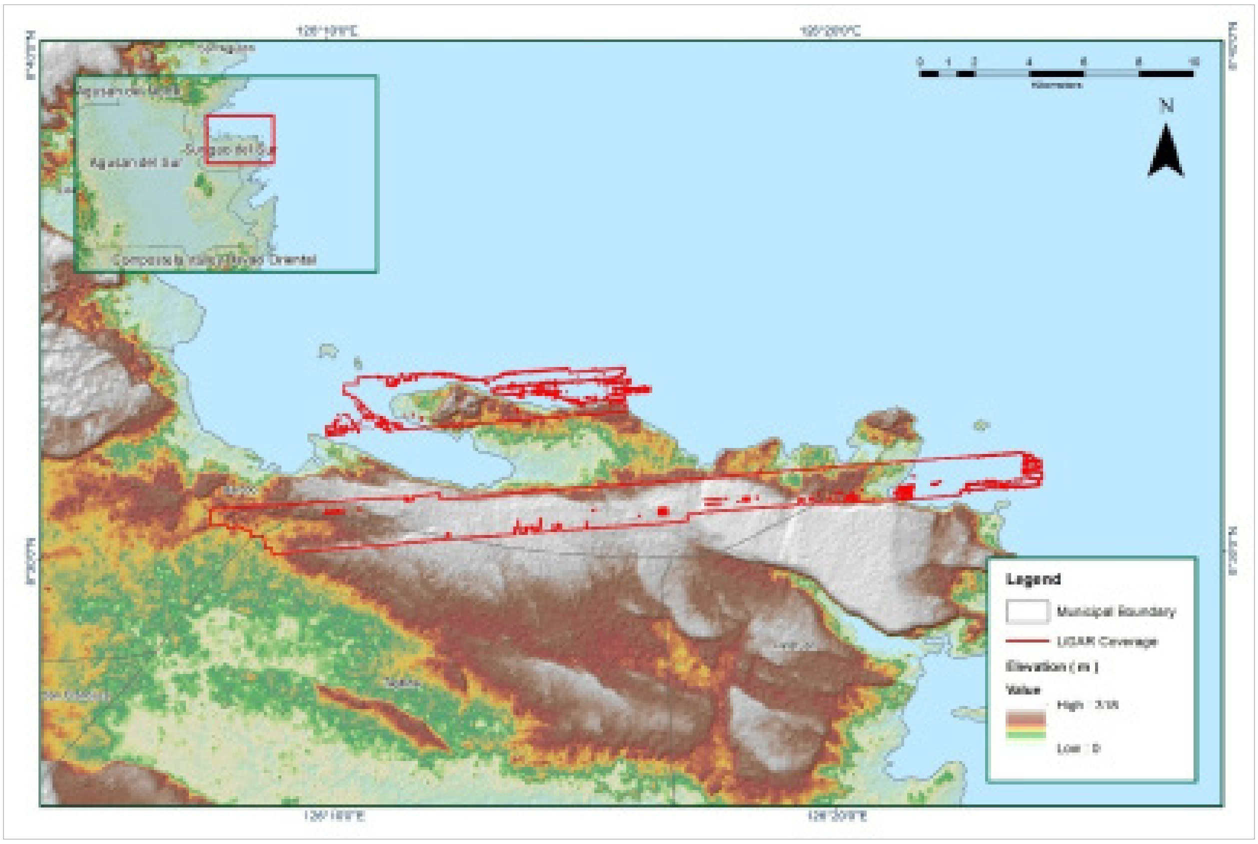


Figure A-8.39. Coverage of LiDAR data

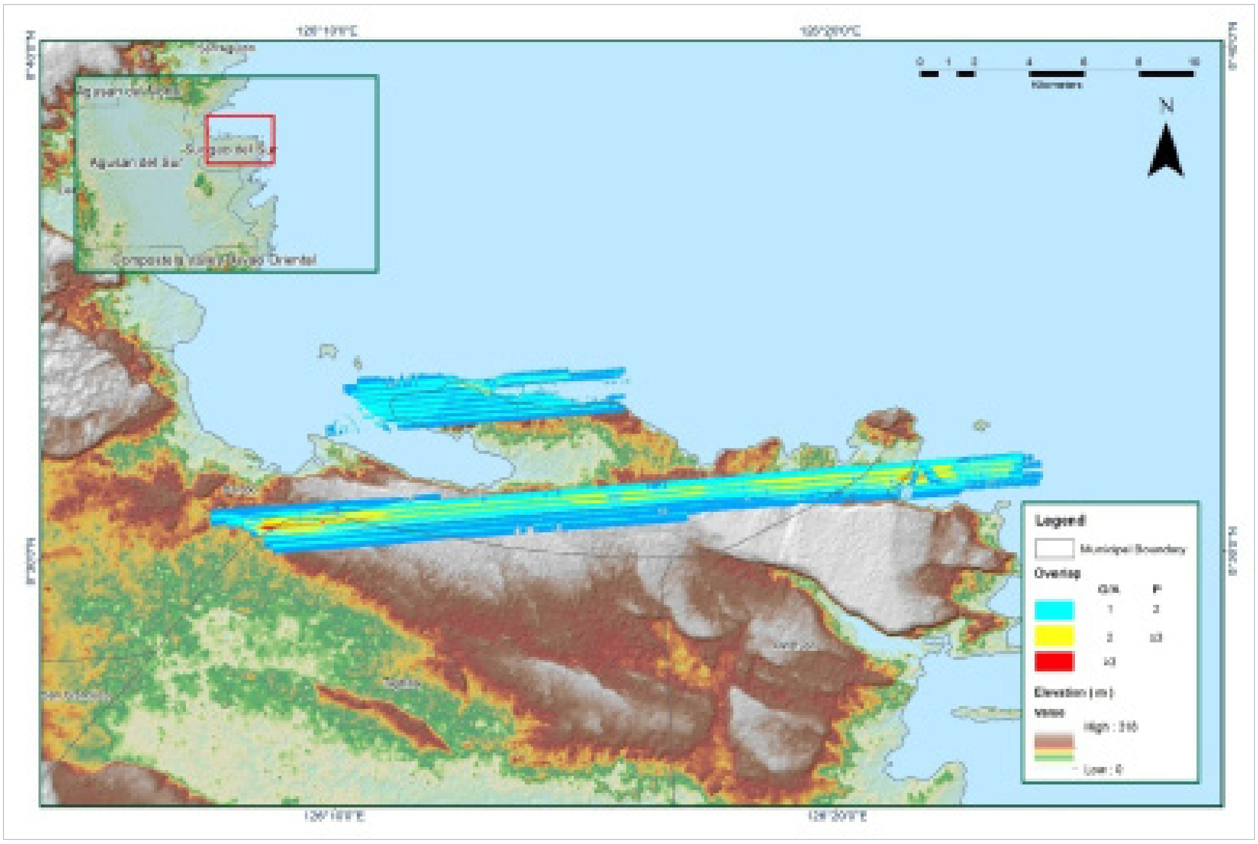


Figure A-8.40. Image of data overlap

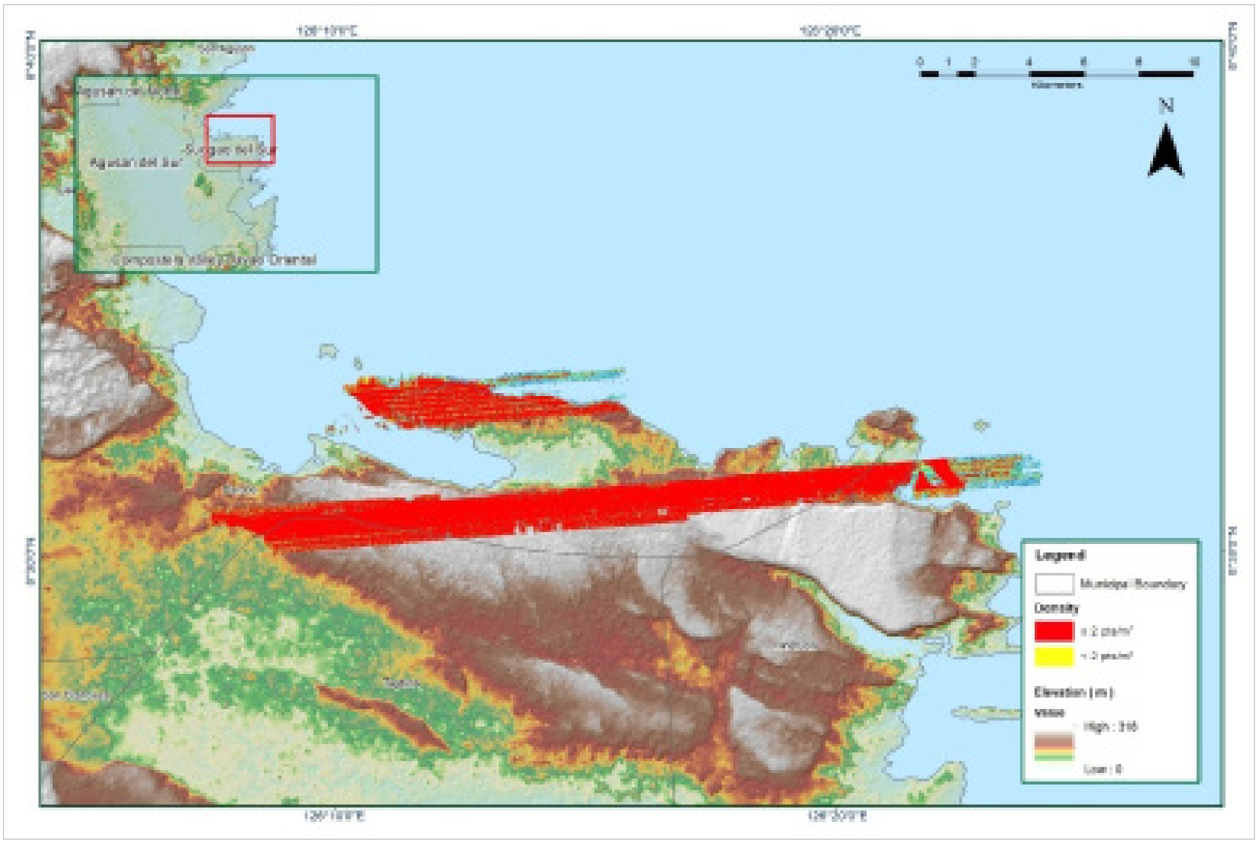


Figure A-8.41. Density map of merged LiDAR data

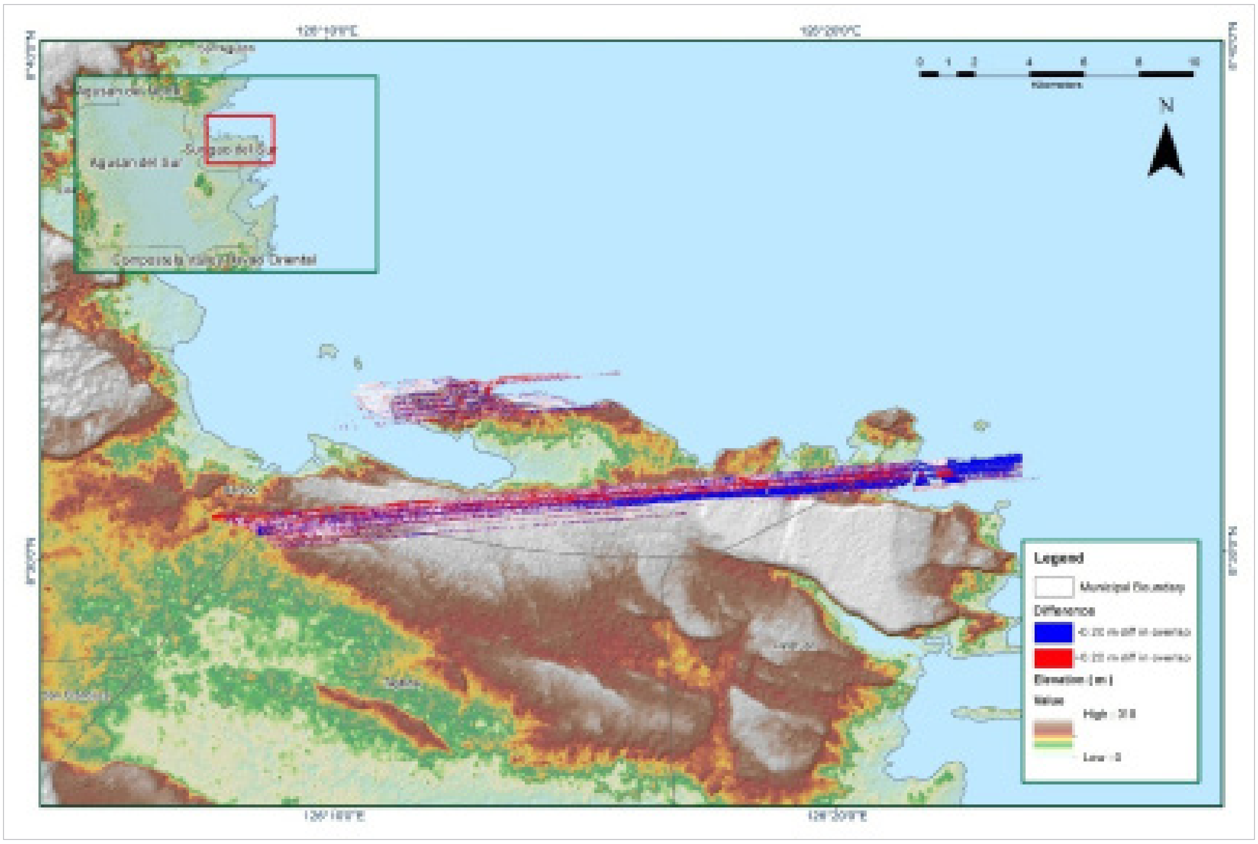


Figure A-8.42. Elevation difference between flight lines

Table A-8.7. Mission Summary Report for Block 66K

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66K
Inclusive Flights	1814A
Range data size	10.30 GB
Base data size	16.9 MB
POS	257MB
Image	87.10 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	1.70
RMSE for East Position (<4.0 cm)	2.10
RMSE for Down Position (<8.0 cm)	4.44
Boresight correction stdev (<0.001deg)	0.000729
IMU attitude correction stdev (<0.001deg)	0.009434
GPS position stdev (<0.01m)	0.0173
Minimum % overlap (>25)	23.61
Ave point cloud density per sq.m. (>2.0)	2.02
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	98
Maximum Height	243.50 m
Minimum Height	40.87 m
Classification (# of points)	
Ground	24,490,004
Low vegetation	22,208,110
Medium vegetation	19,708,876
High vegetation	19,515,747
Building	887,645
Orthophoto	Yes
Processed by	John Dill Macapagal, Engr. Harmond Santos, Engr. Jommer Medina

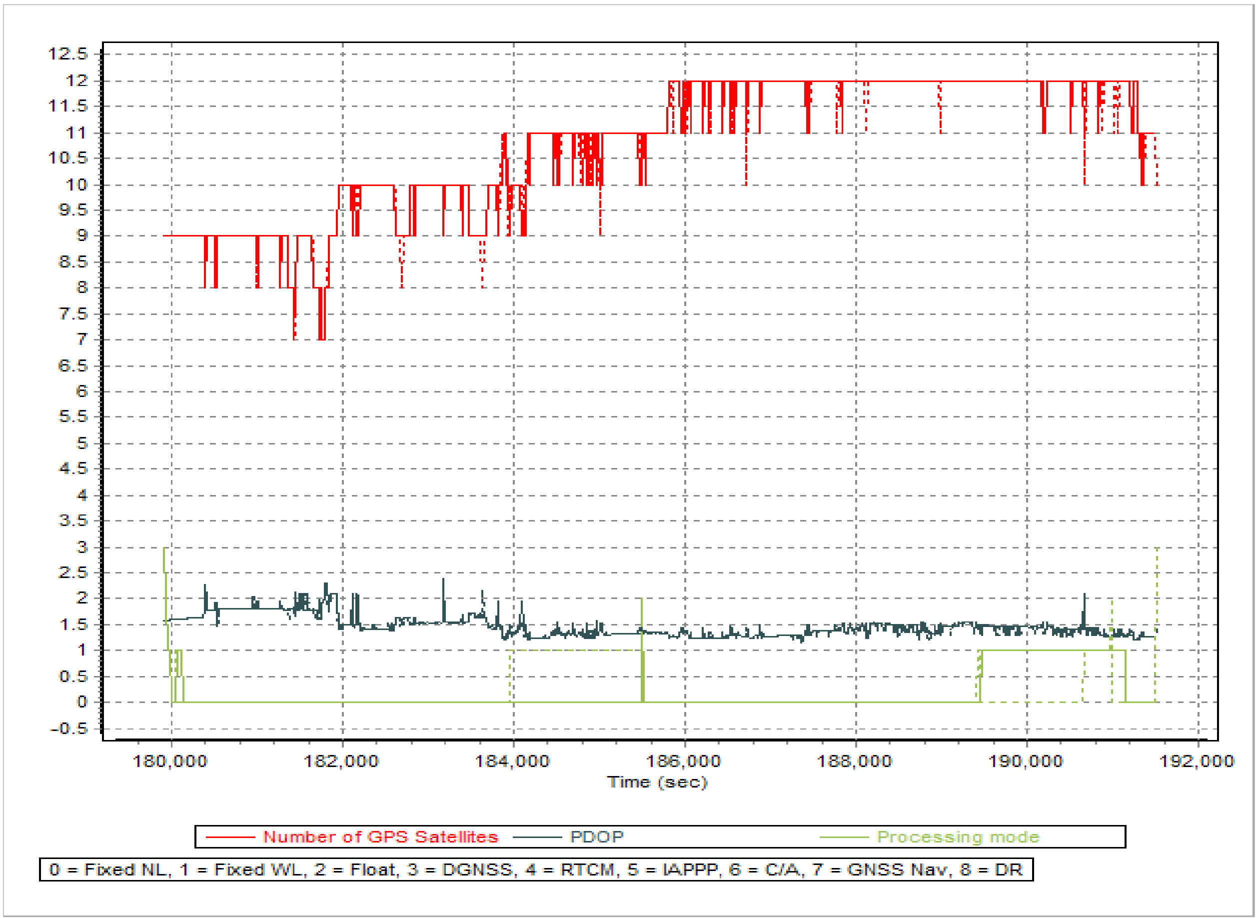


Figure A-8.43. Solution Status

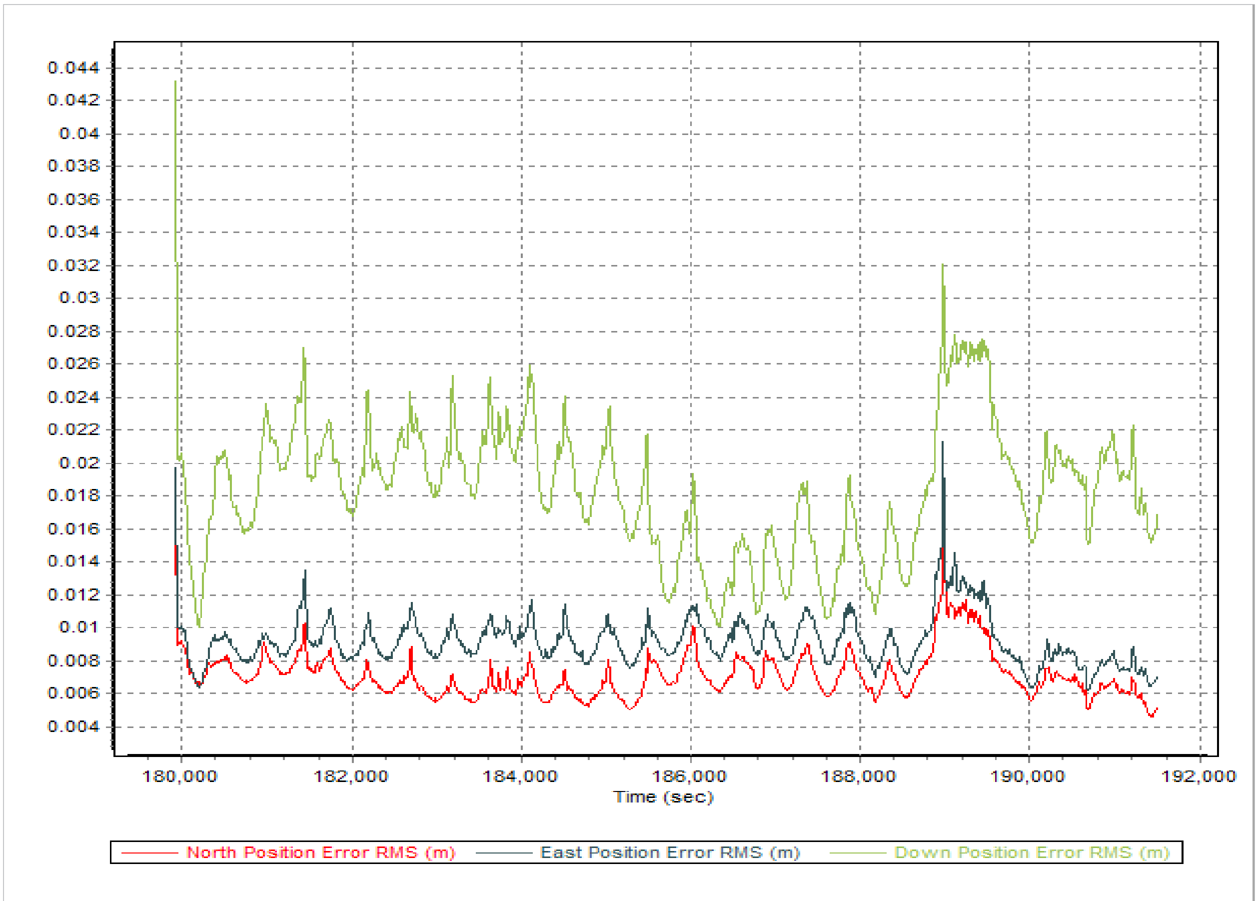


Figure A-8.44. Smoothed Performance Metric Parameters

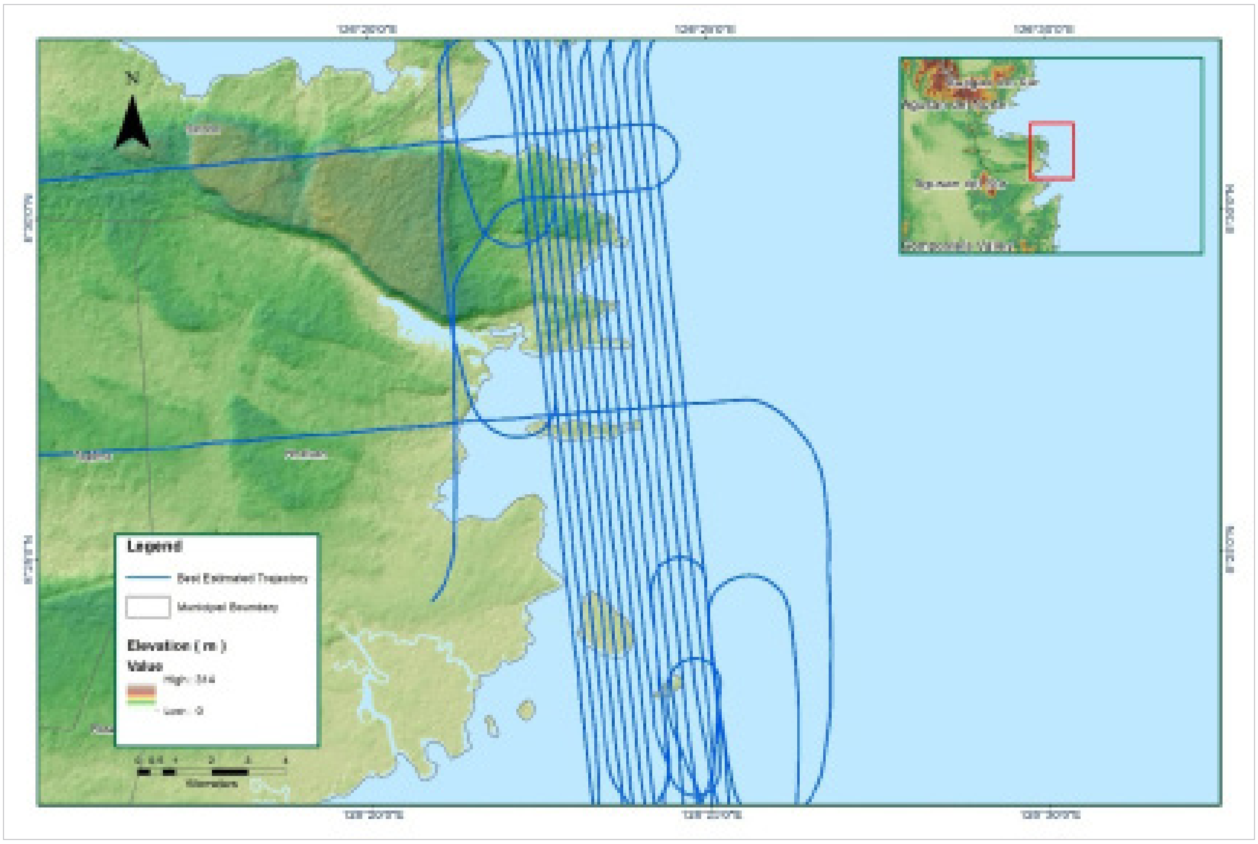


Figure A-8.45. Best Estimated Trajectory

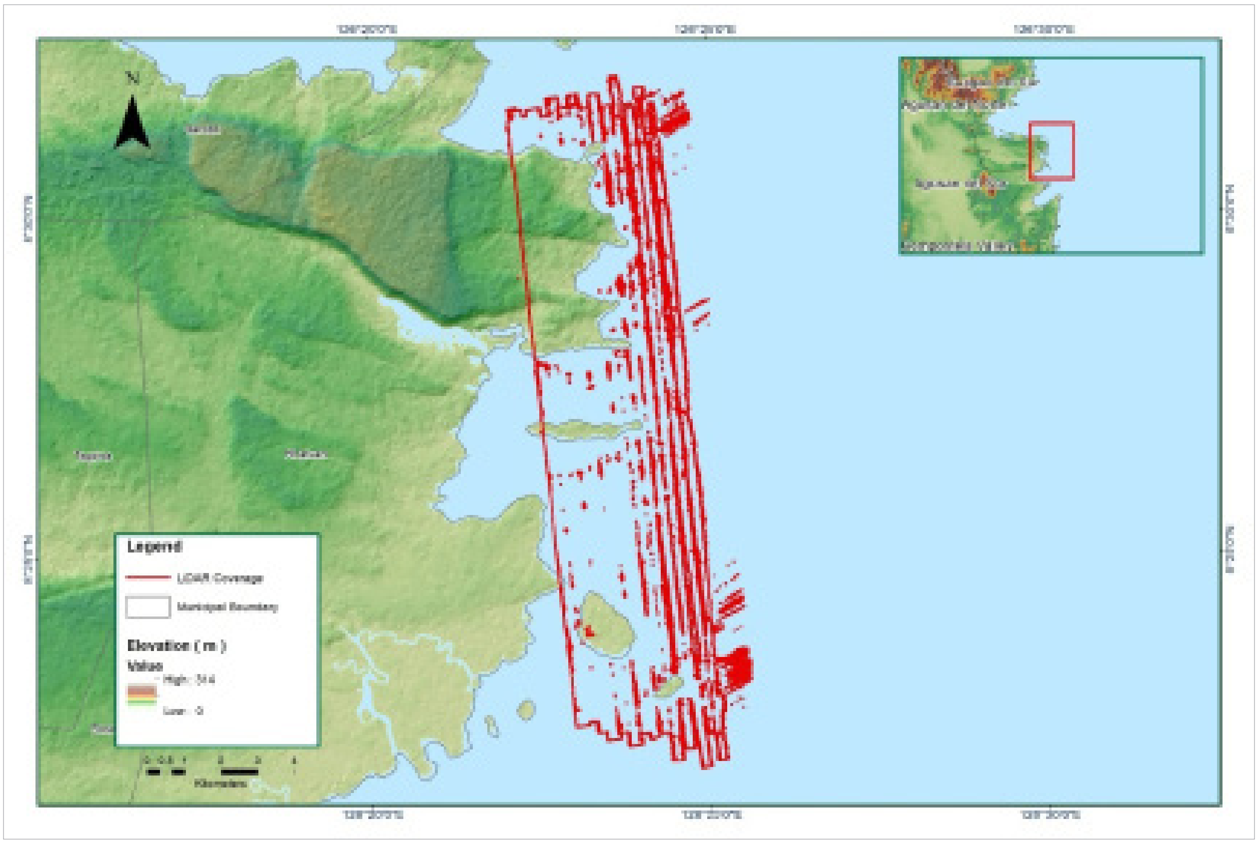


Figure A-8.46. Coverage of LiDAR data

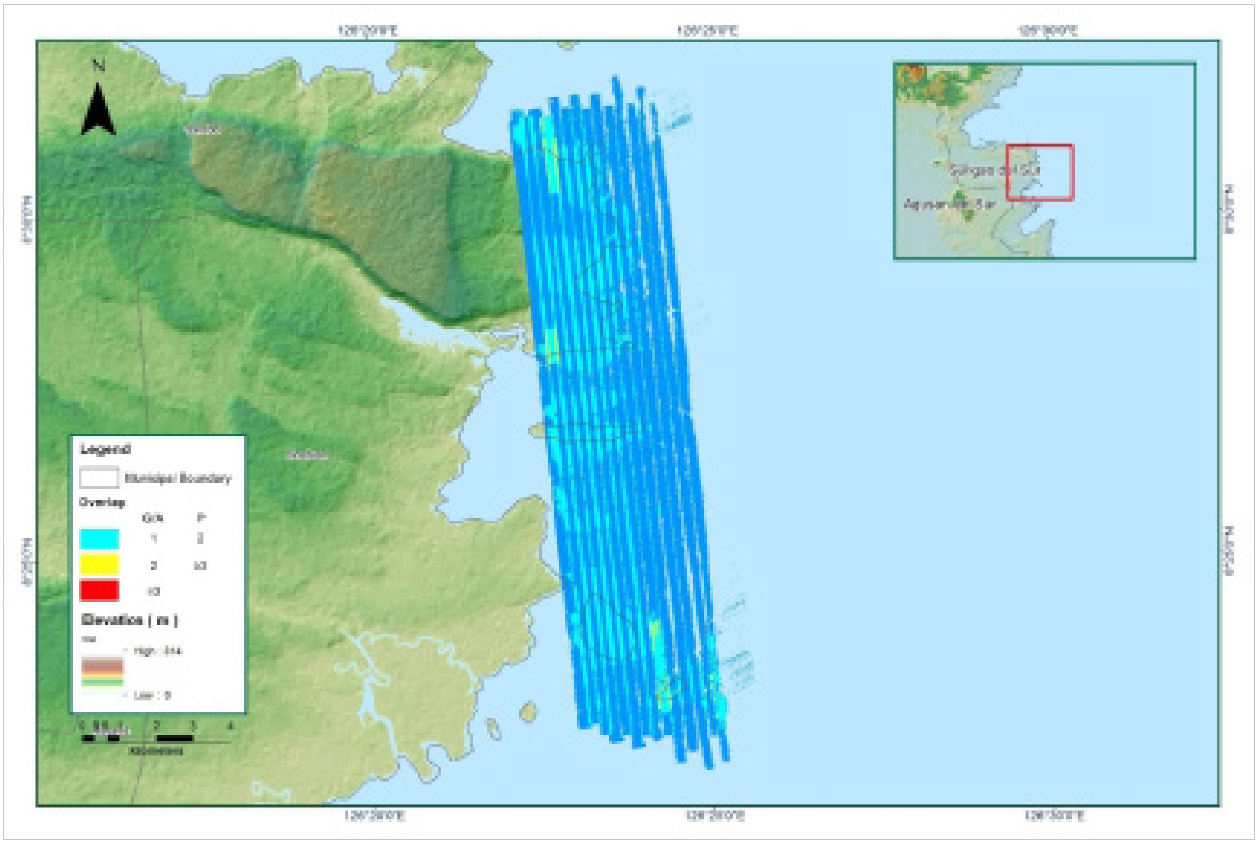


Figure A-8.47. Image of data overlap

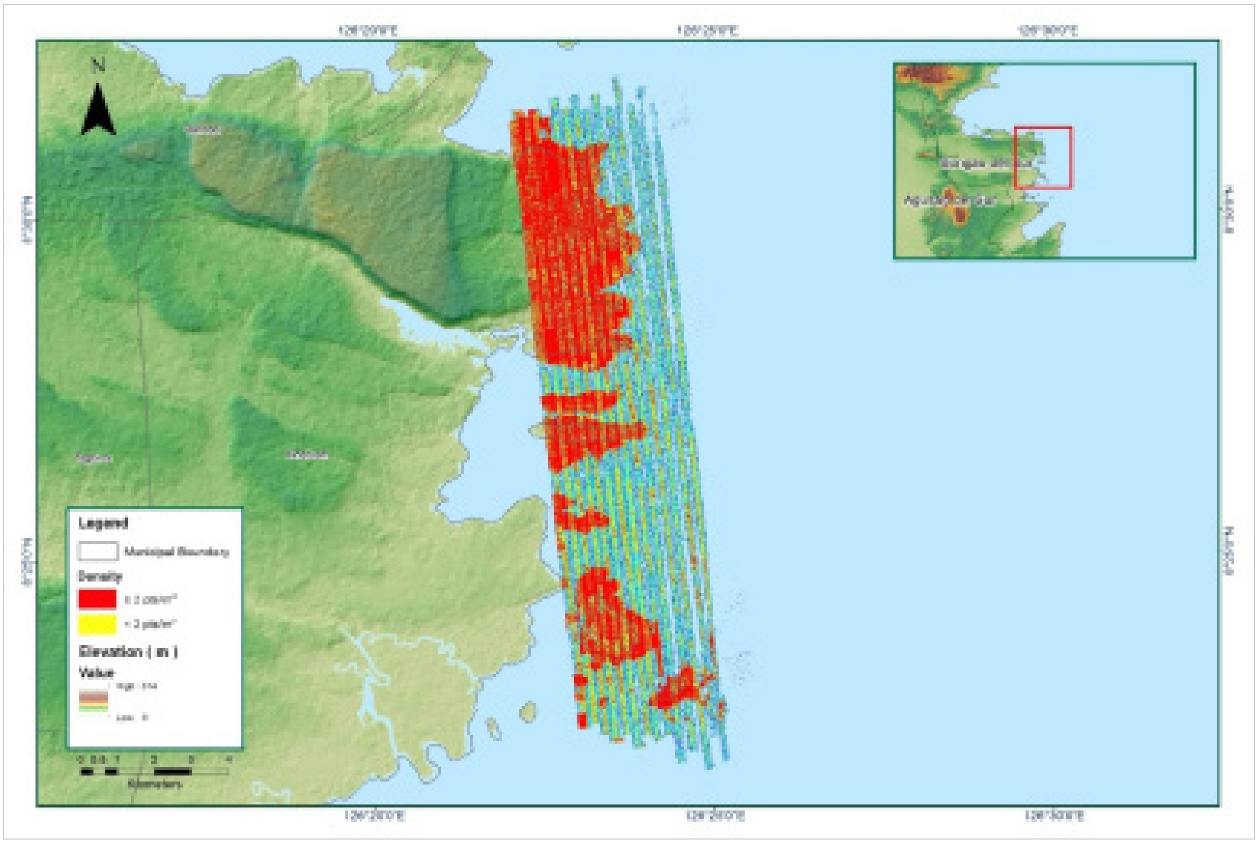


Figure A-8.48. Density map of merged LiDAR data

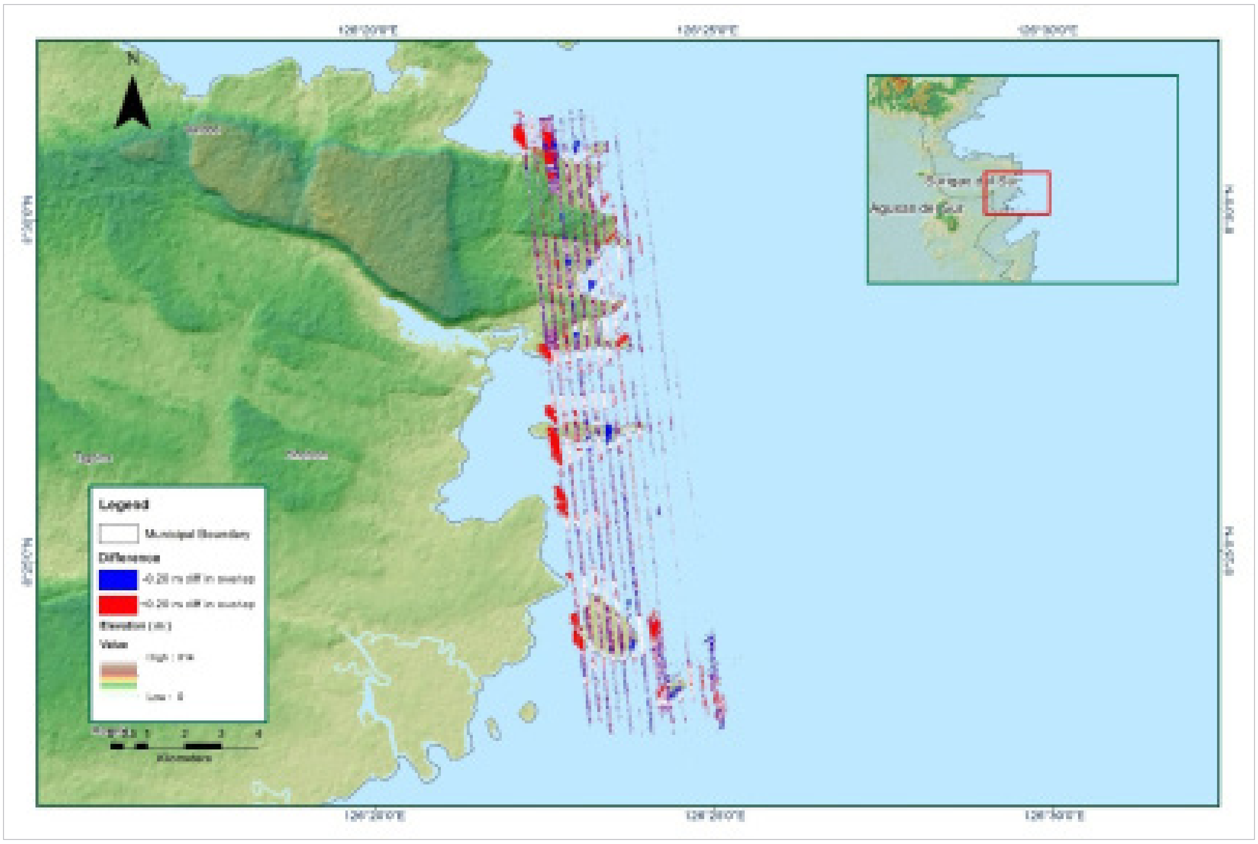


Figure A-8.49. Elevation difference between flight lines

Table A-8.8. Mission Summary Report for Block 66L

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66L
Inclusive Flights	1794A & 1796A
Range data size	24.70 GB
Base data size	35.6 MB
POS	487MB
Image	103.50 MB
Transfer date	August 20, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	2.50
RMSE for East Position (<4.0 cm)	2.00
RMSE for Down Position (<8.0 cm)	3.50
Boresight correction stdev (<0.001deg)	0.000372
IMU attitude correction stdev (<0.001deg)	0.023350
GPS position stdev (<0.01m)	0.0035
Minimum % overlap (>25)	61.86
Ave point cloud density per sq.m. (>2.0)	3.59
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	130
Maximum Height	389.27 m
Minimum Height	55.09 m
Classification (# of points)	
Ground	34,789,627
Low vegetation	34,708,740
Medium vegetation	78,857,422
High vegetation	97,514,753
Building	2,581,879
Orthophoto	Yes
Processed by	Engr. Angelo Carlo Bongat, Engr. Edgardo Gubatanga Jr., Jovy Narisma

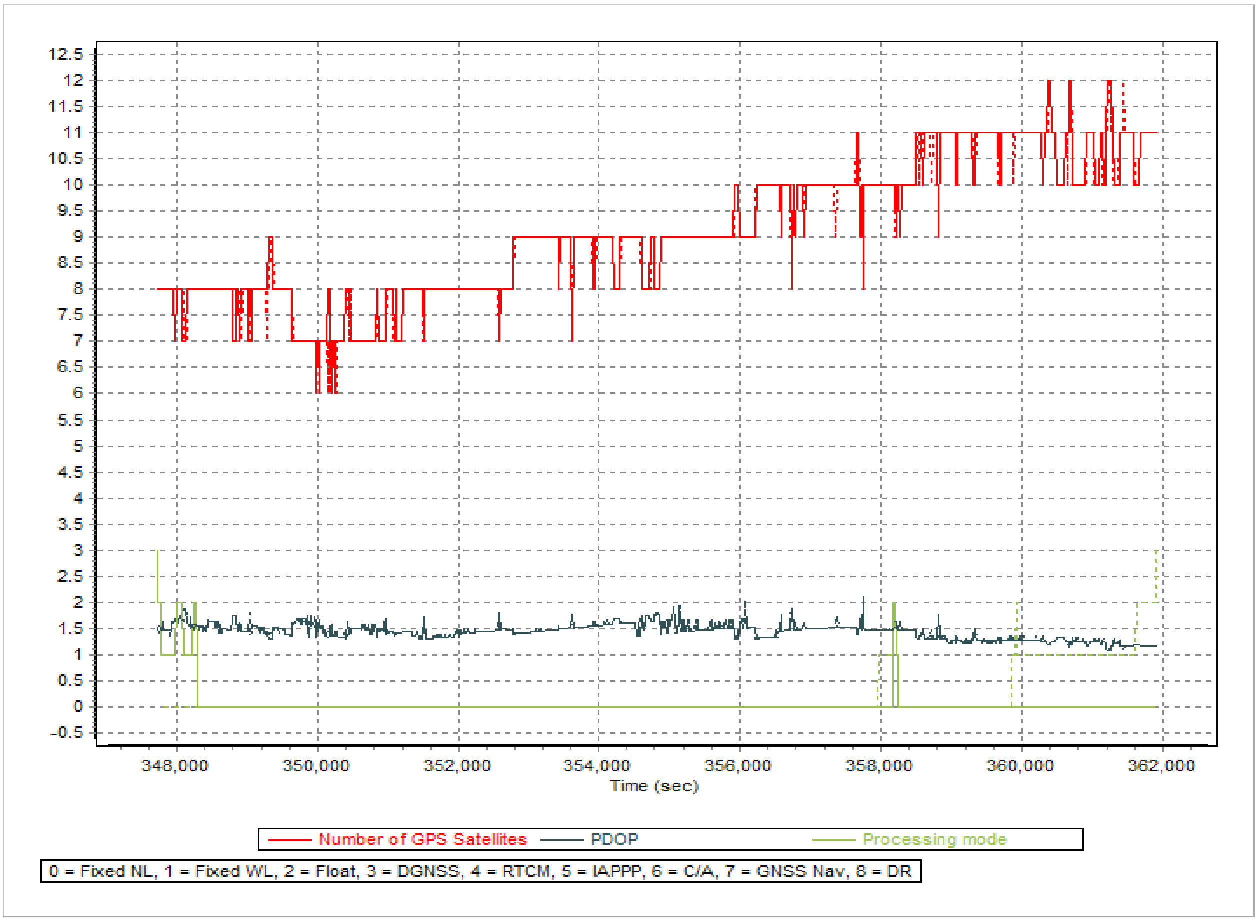


Figure A-8.50. Solution Status

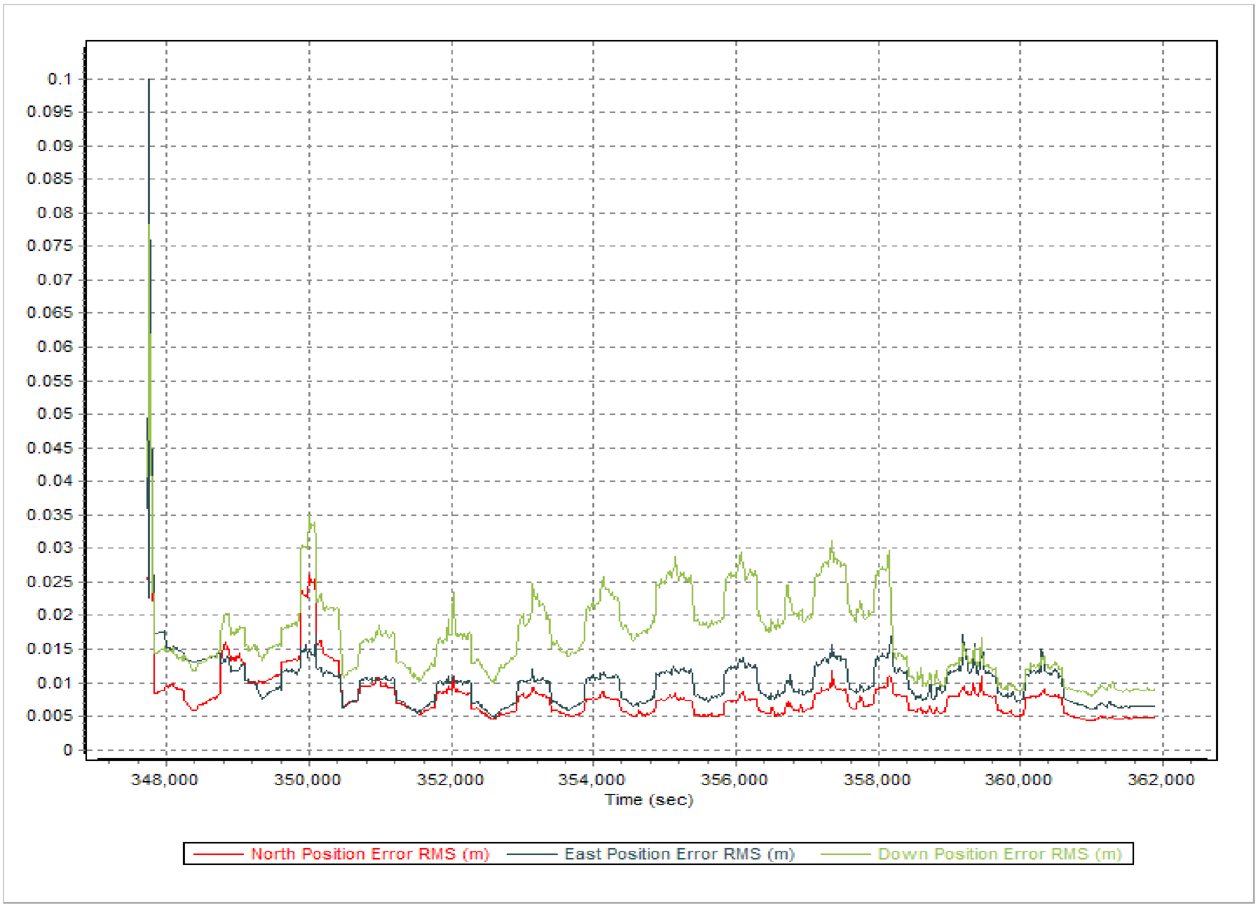


Figure A-8.51. Smoothed Performance Metric Parameters

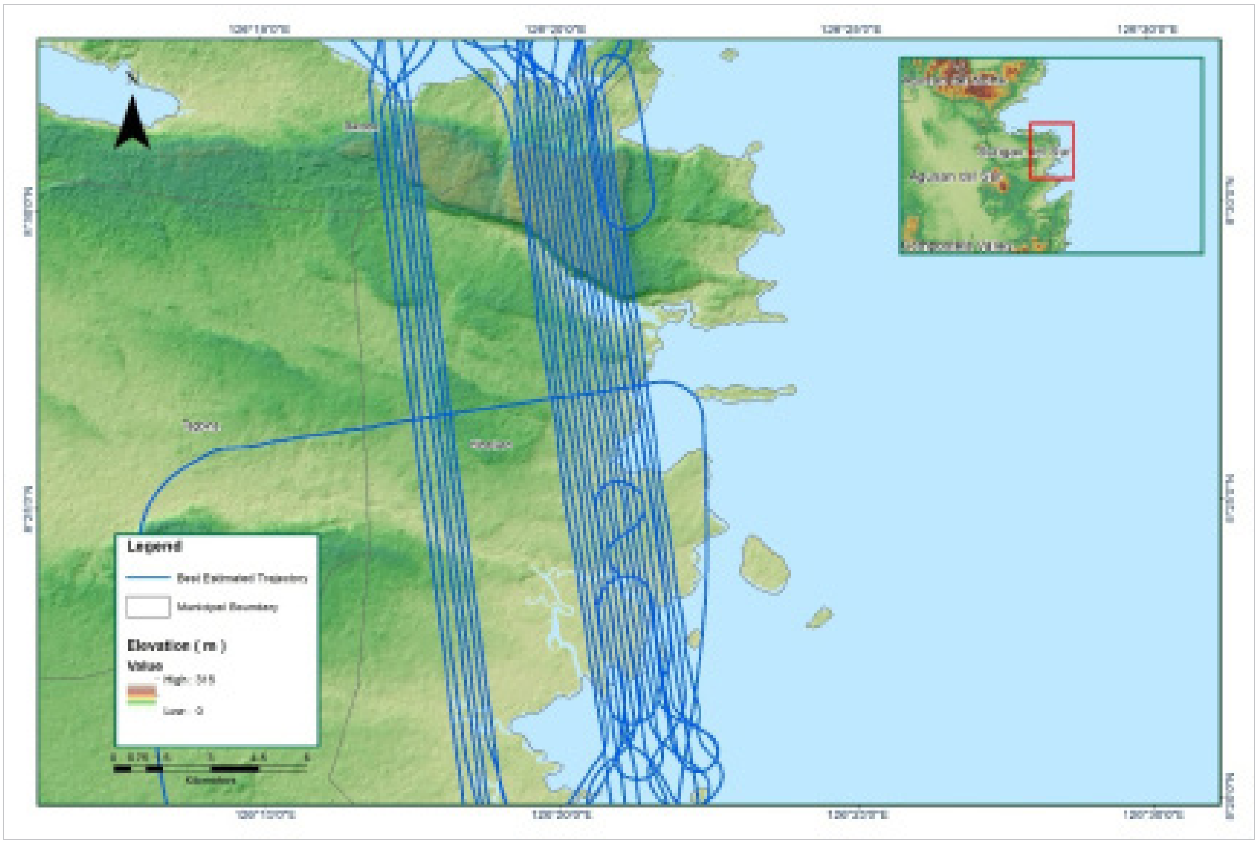


Figure A-8.52. Best Estimated Trajectory

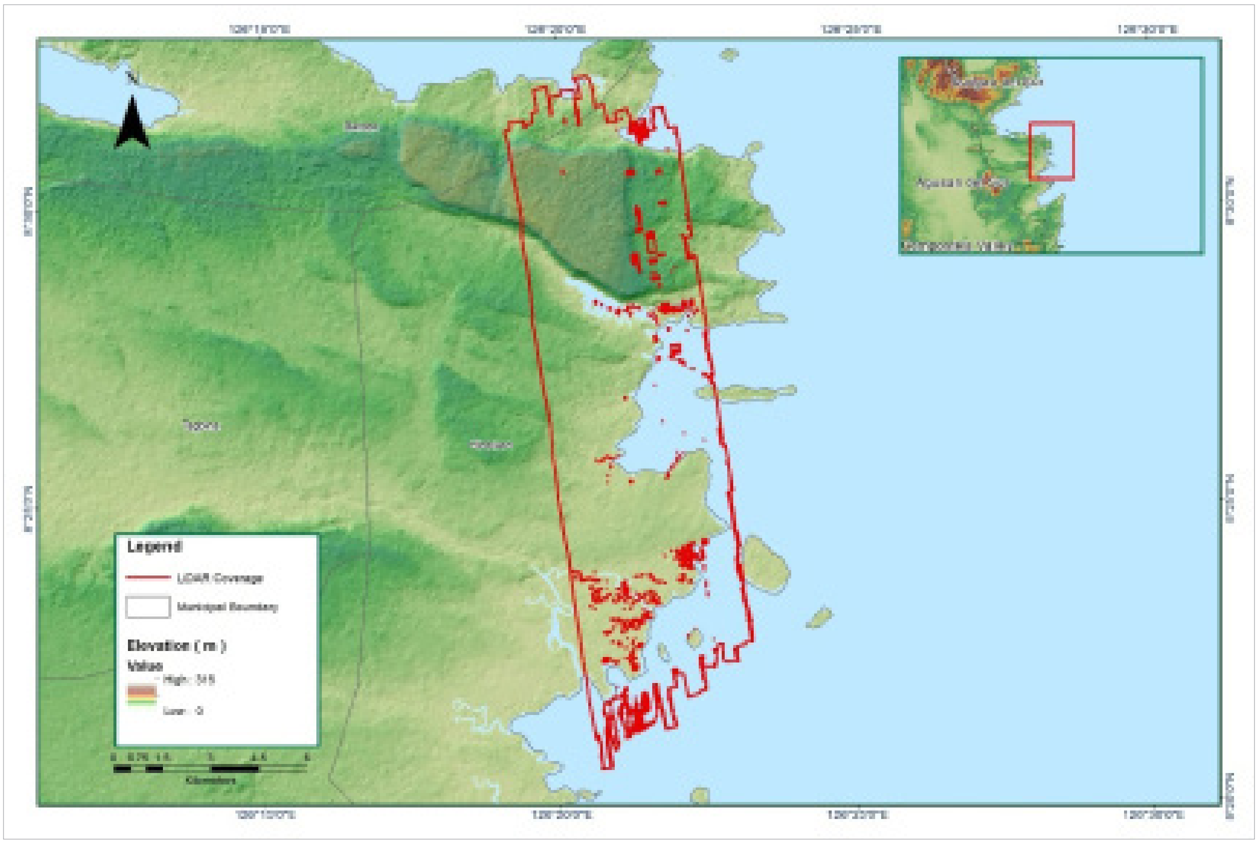


Figure A-8.53. Coverage of LiDAR data

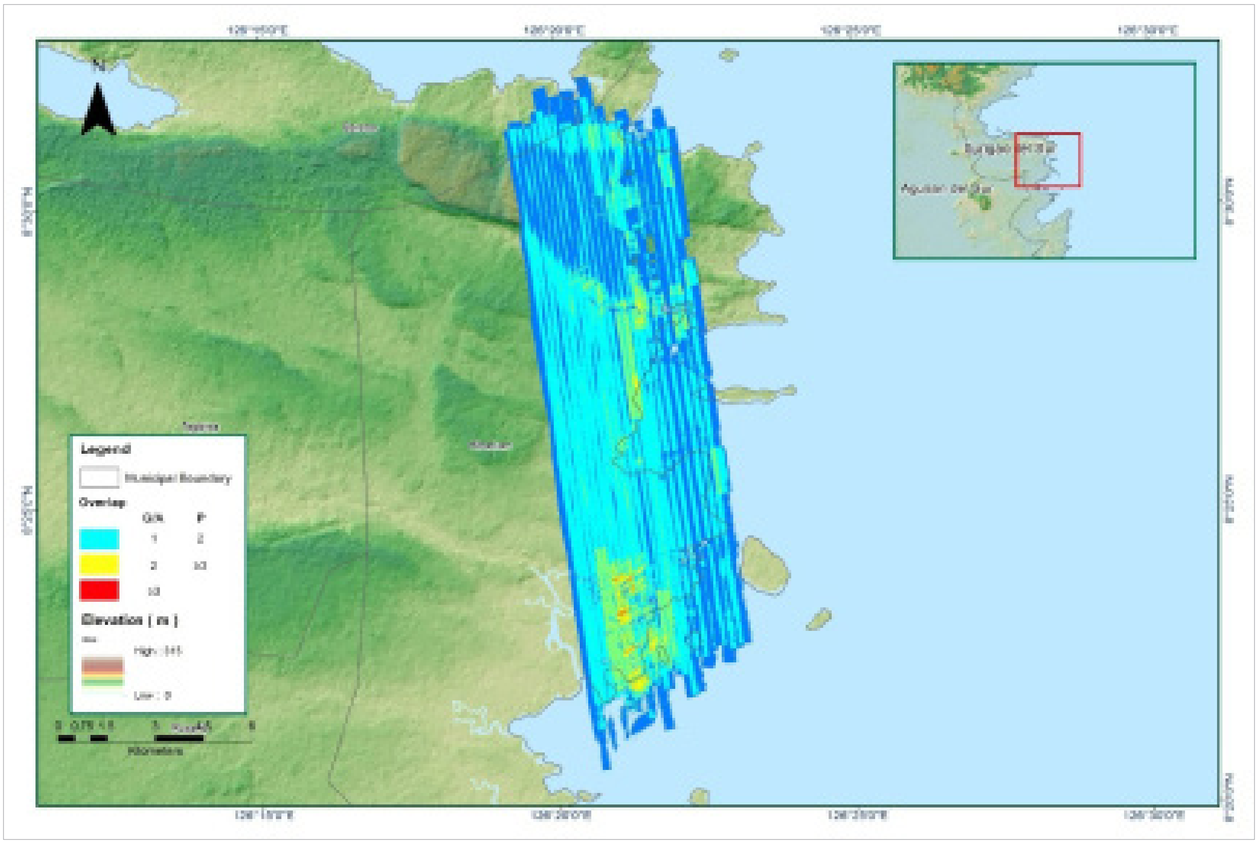


Figure A-8.54. Image of data overlap

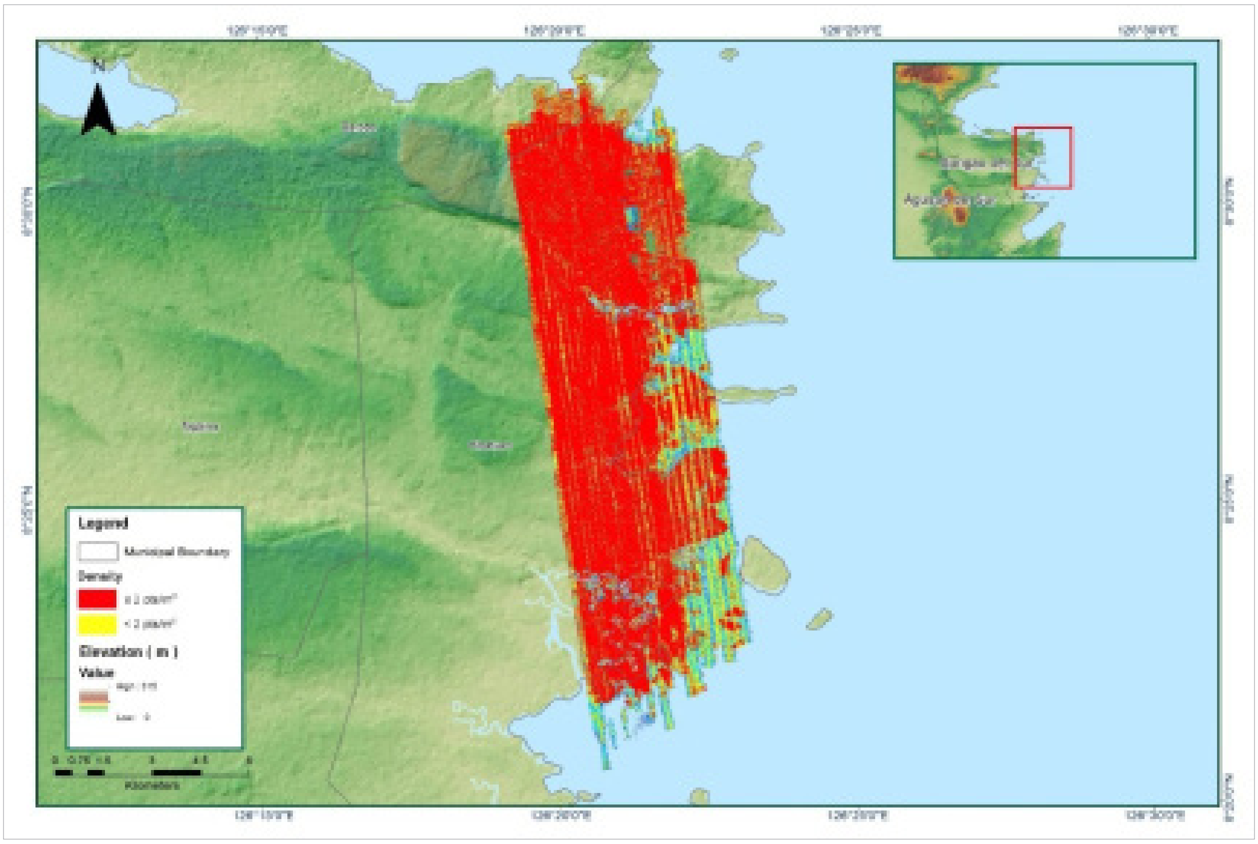


Figure A-8.55. Density map of merged LiDAR data

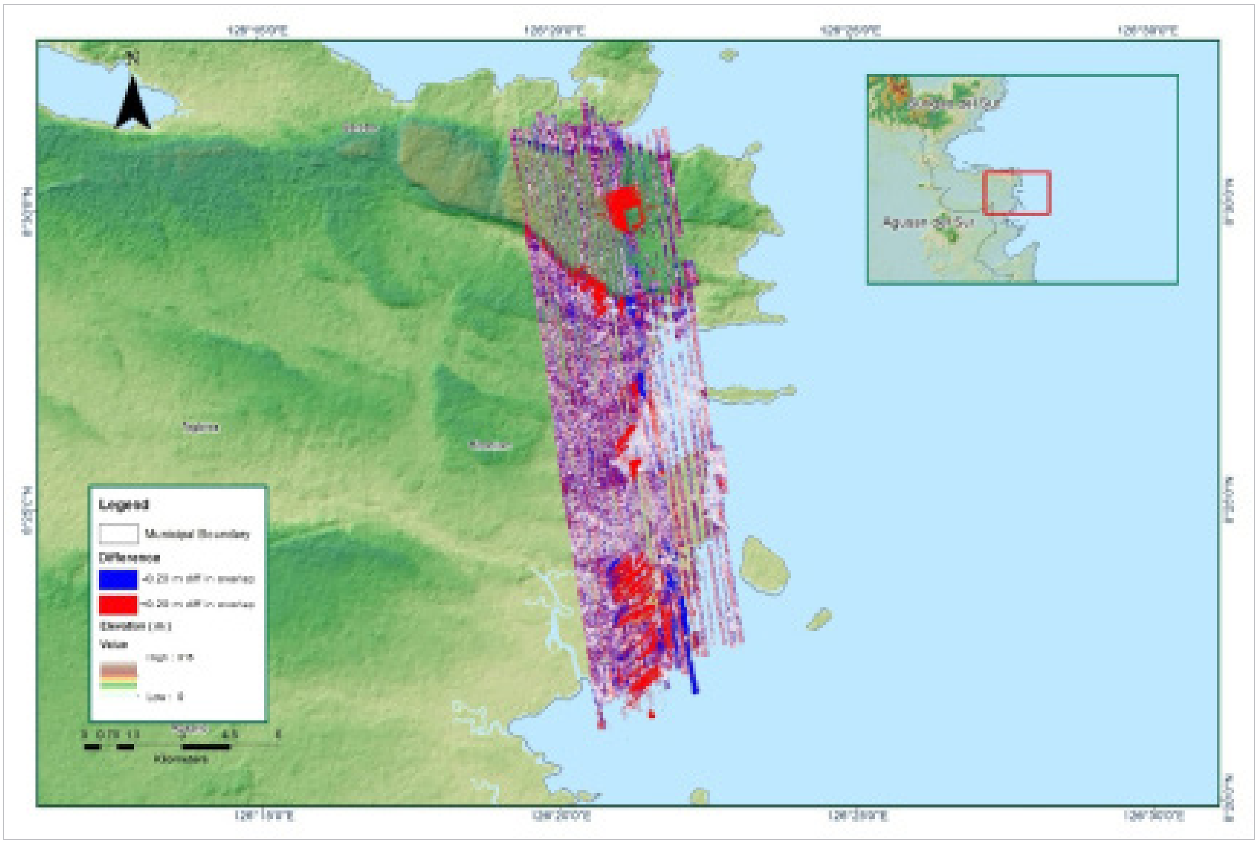


Figure A-8.56. Elevation difference between flight lines

Table A-8.9. Mission Summary Report for Block 66M

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66M
Inclusive Flights	1790A & 1794A
Range data size	24.20 GB
Base data size	39.7 MB
POS	506 MB
Image	105 MB
Transfer date	August 20, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	1.70
RMSE for East Position (<4.0 cm)	3.80
RMSE for Down Position (<8.0 cm)	7.80
Boresight correction stdev (<0.001deg)	0.000324
IMU attitude correction stdev (<0.001deg)	0.001414
GPS position stdev (<0.01m)	0.0026
Minimum % overlap (>25)	60.90
Ave point cloud density per sq.m. (>2.0)	4.06
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	119
Maximum Height	388.75 m
Minimum Height	64.97 m
Classification (# of points)	
Ground	36,632,278
Low vegetation	35,477,482
Medium vegetation	108,204,209
High vegetation	110,238,280
Building	3,249,782
Orthophoto	Yes
Processed by	Engr. Angelo Carlo Bongat, Engr. Melanie Hingpit, Engr. Ma. Ailyn Olanda

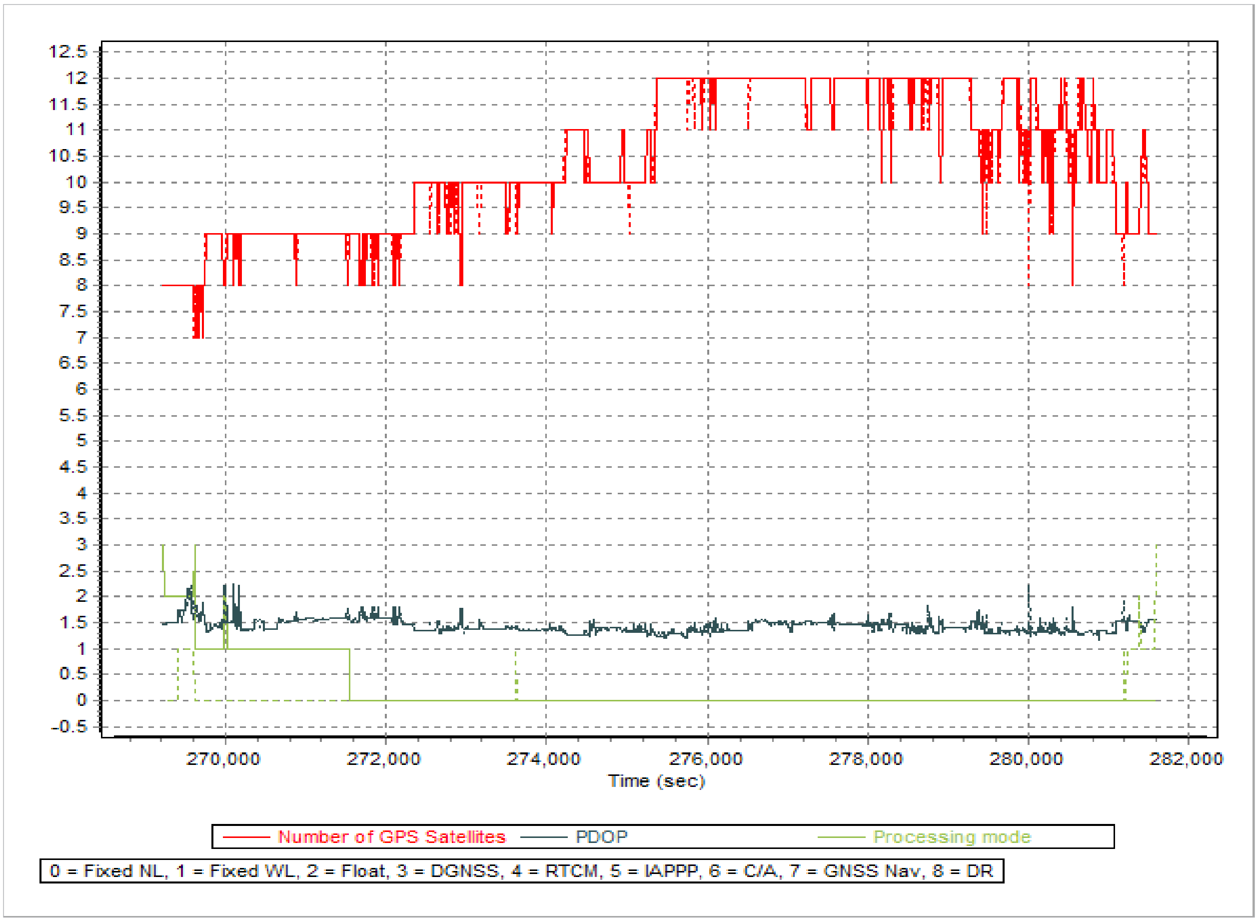


Figure A-8.57. Solution Status

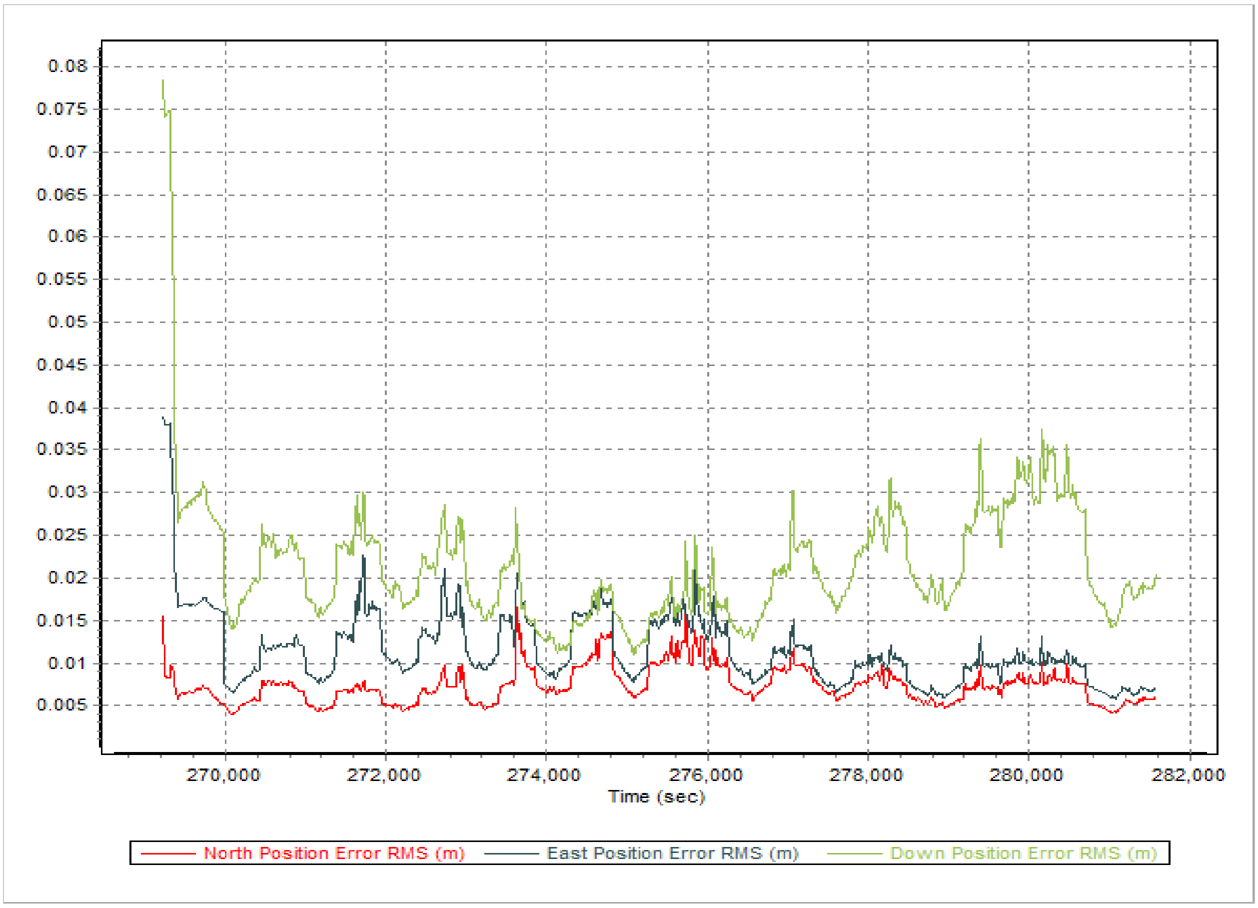
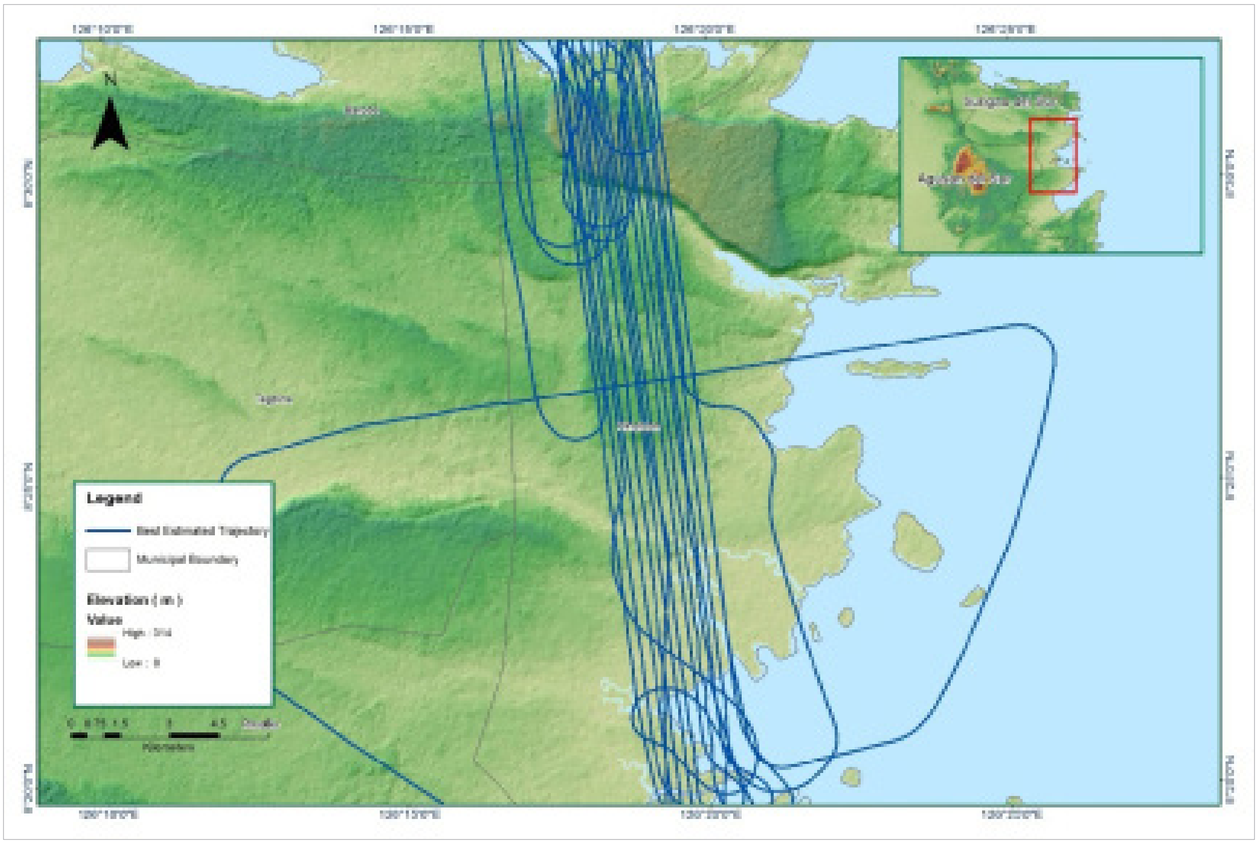


Figure A-8.58. Smoothed Performance Metric Parameters



FigureA-8.59, Best Estimated Trajectory

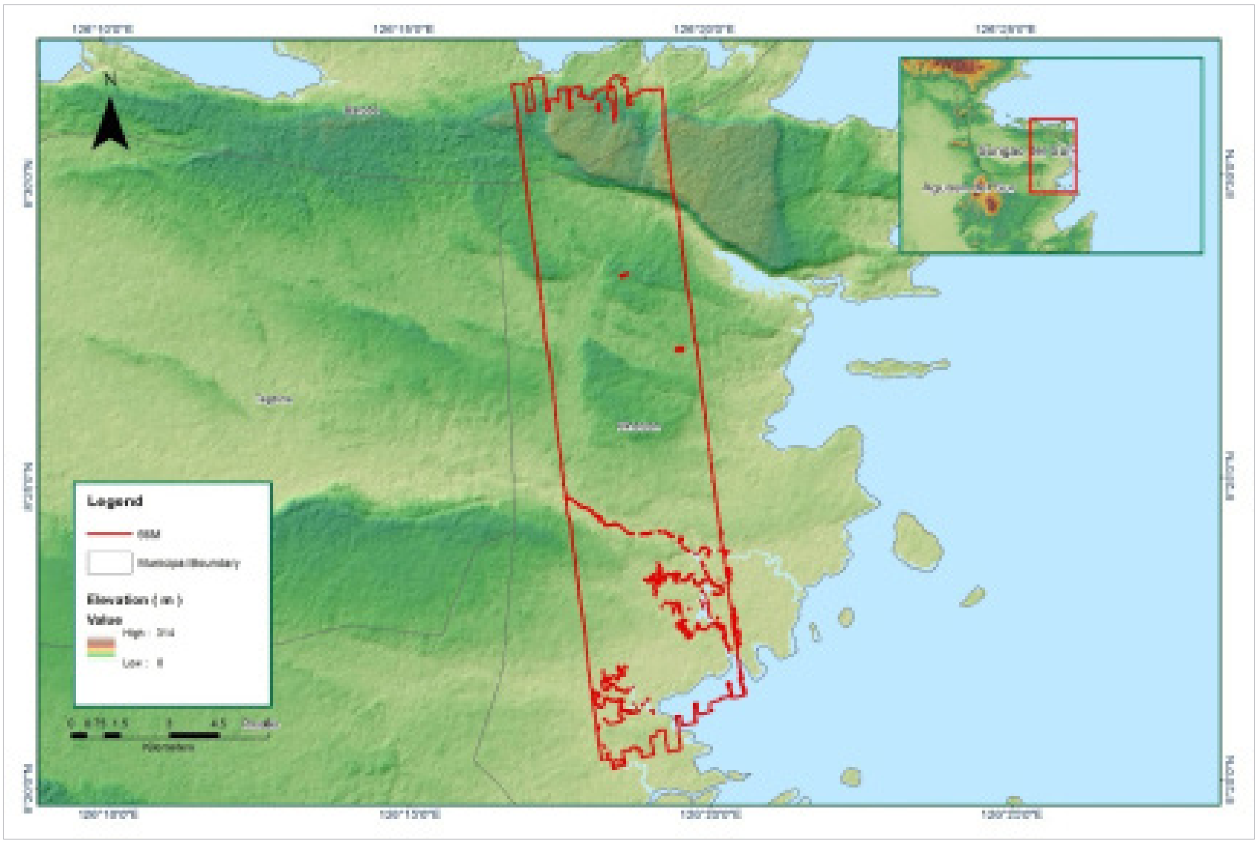


Figure A-8.60. Coverage of LiDAR data

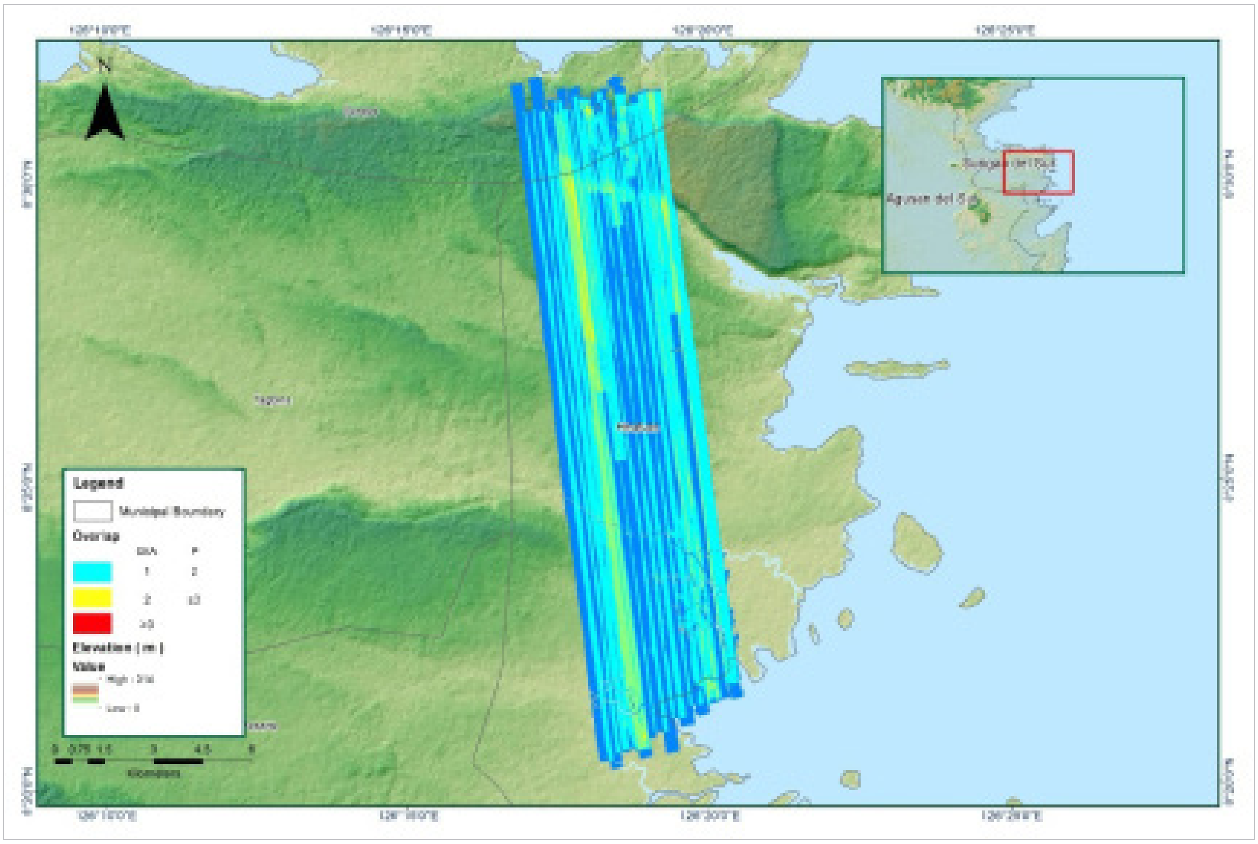


Figure A-8.61. Image of data overlap

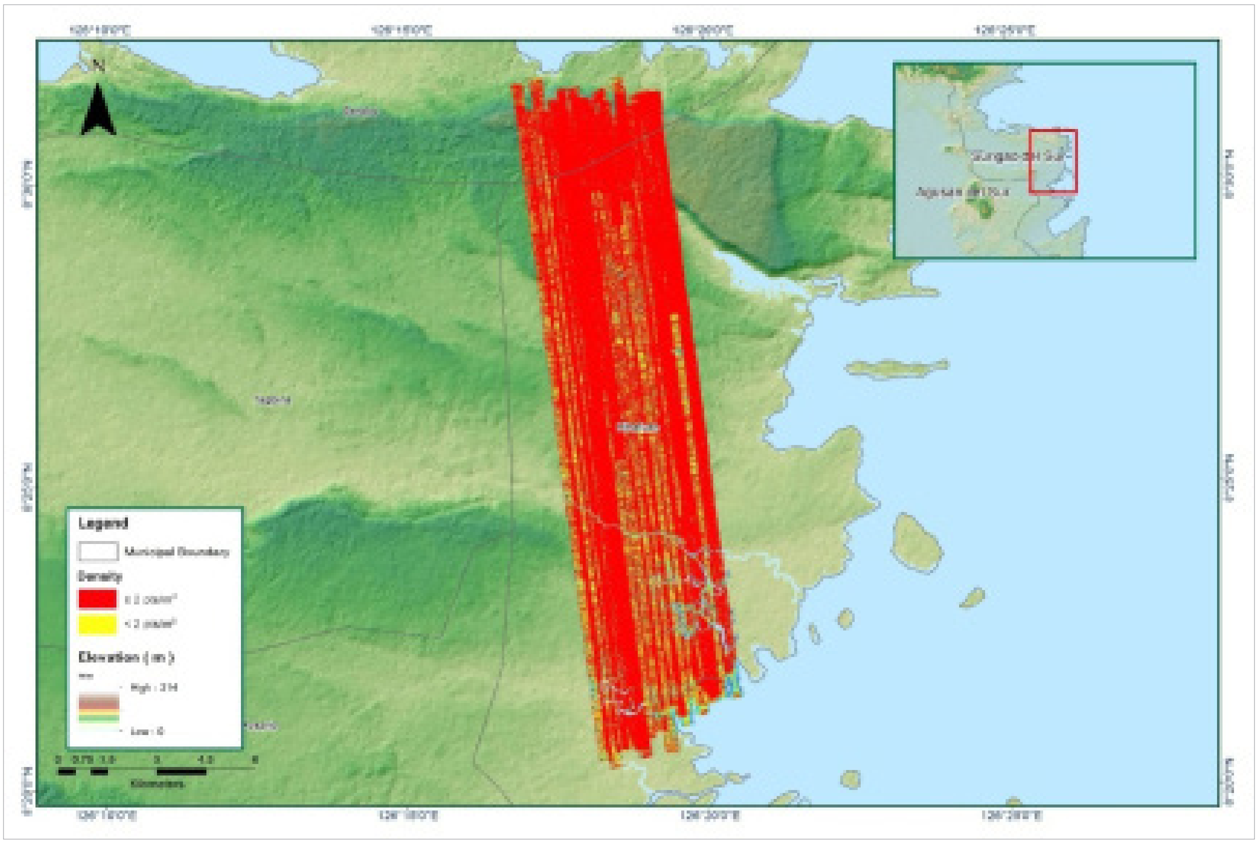


Figure A-8.62. Density map of merged LiDAR data

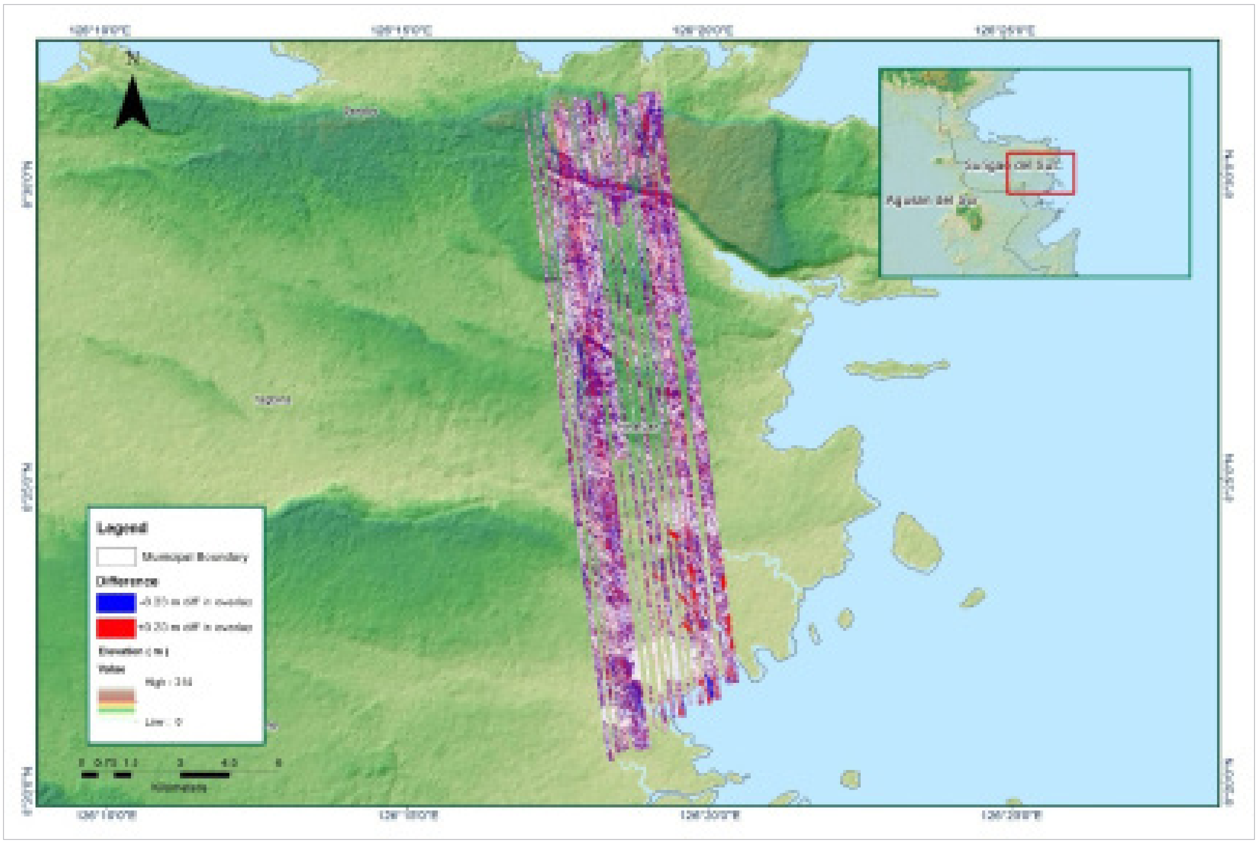


Figure A-8.63. Elevation difference between flight lines

Table A-8.10. Mission Summary Report for Block 66N

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66N
Inclusive Flights	1798A
Range data size	11.40 GB
Base data size	15.5 MB
POS	235MB
Image	75.70 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	1.35
RMSE for East Position (<4.0 cm)	1.45
RMSE for Down Position (<8.0 cm)	3.00
Boresight correction stdev (<0.001deg)	0.000441
IMU attitude correction stdev (<0.001deg)	0.001028
GPS position stdev (<0.01m)	0.0084
Minimum % overlap (>25)	41.26
Ave point cloud density per sq.m. (>2.0)	3.20
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	129
Maximum Height	321.46 m
Minimum Height	64.97 m
Classification (# of points)	
Ground	37,204,281
Low vegetation	29,885,270
Medium vegetation	89,706,603
High vegetation	99,956,048
Building	1,613,522
Orthophoto	Yes
Processed by	John Dill Macapagal, Engr. Christy Lubiano, Engr. Jommer Medina

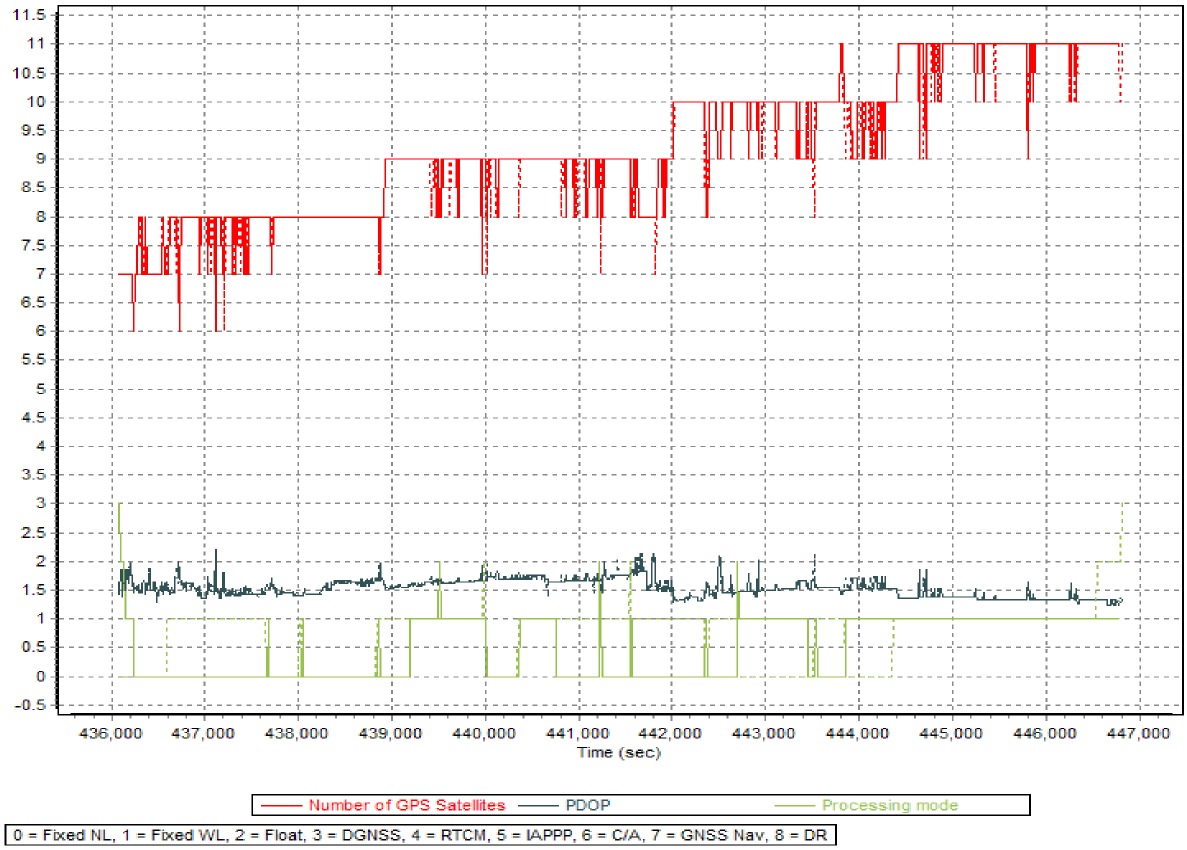


Figure A-8.64. Solution Status

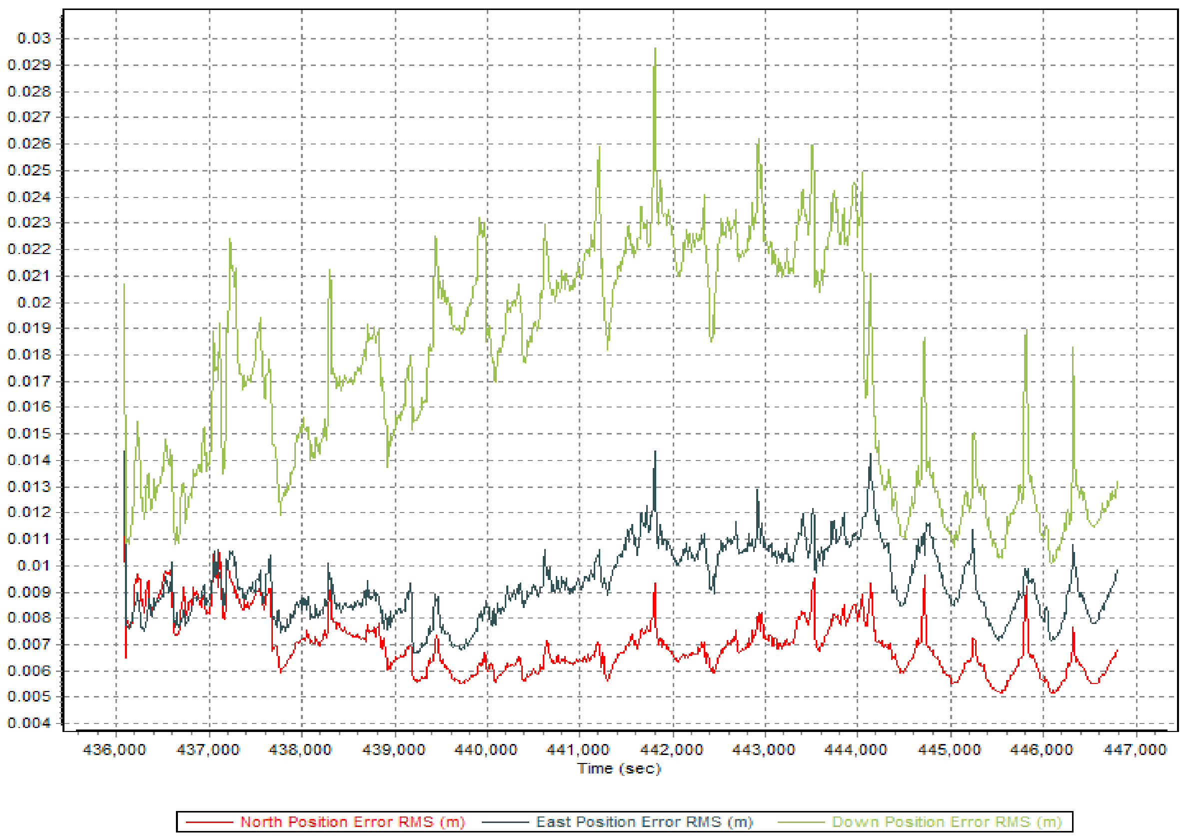
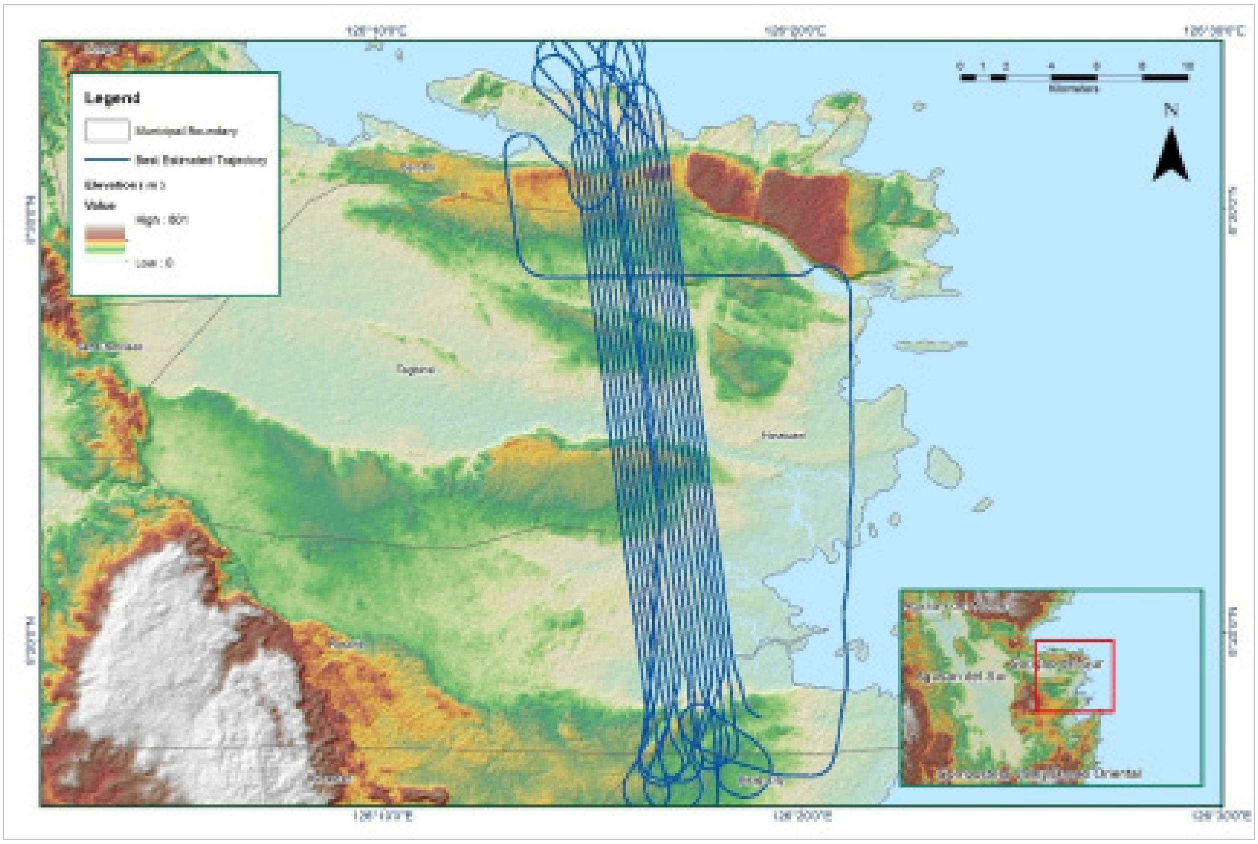


Figure A-8.65, Smoothed Performance Metric Parameters



FigureA-8.66. Best Estimated Trajectory

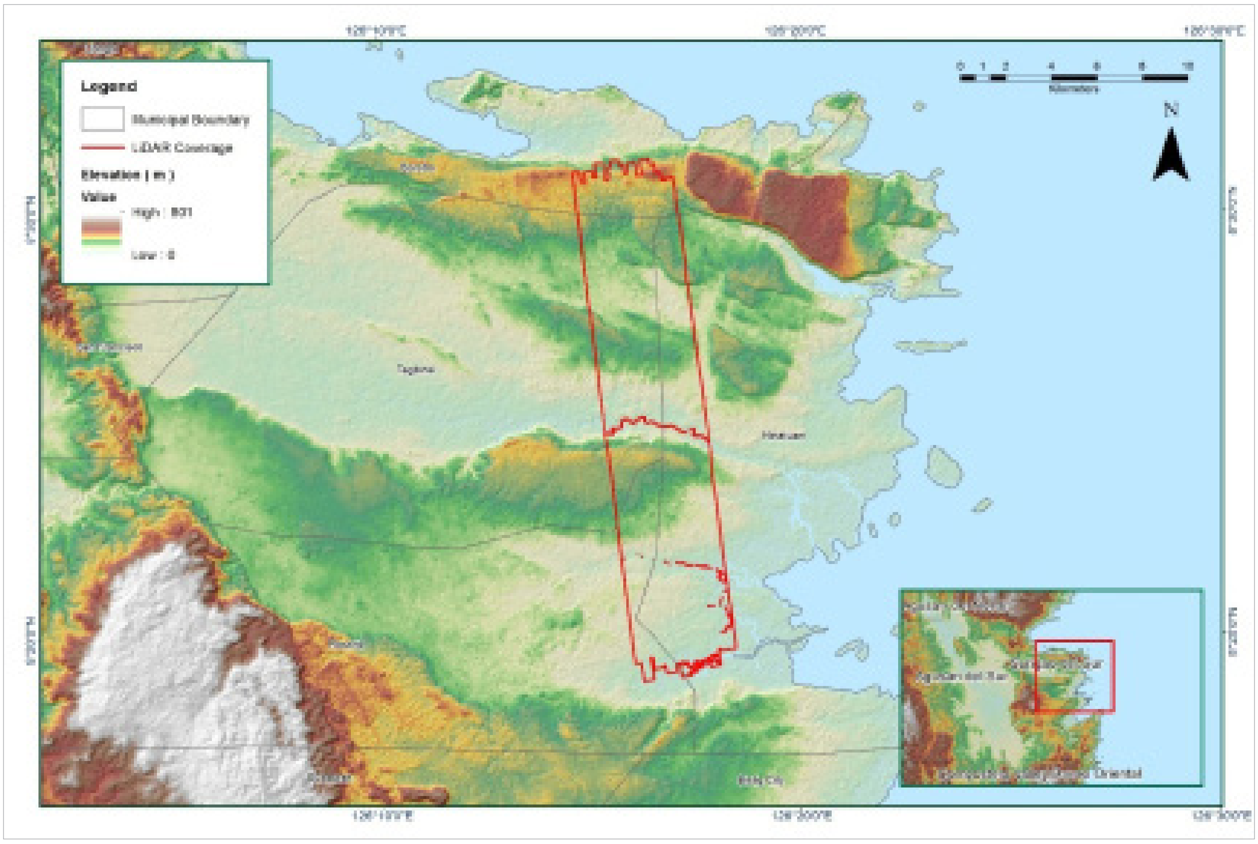


Figure A-8.67. Coverage of LiDAR data

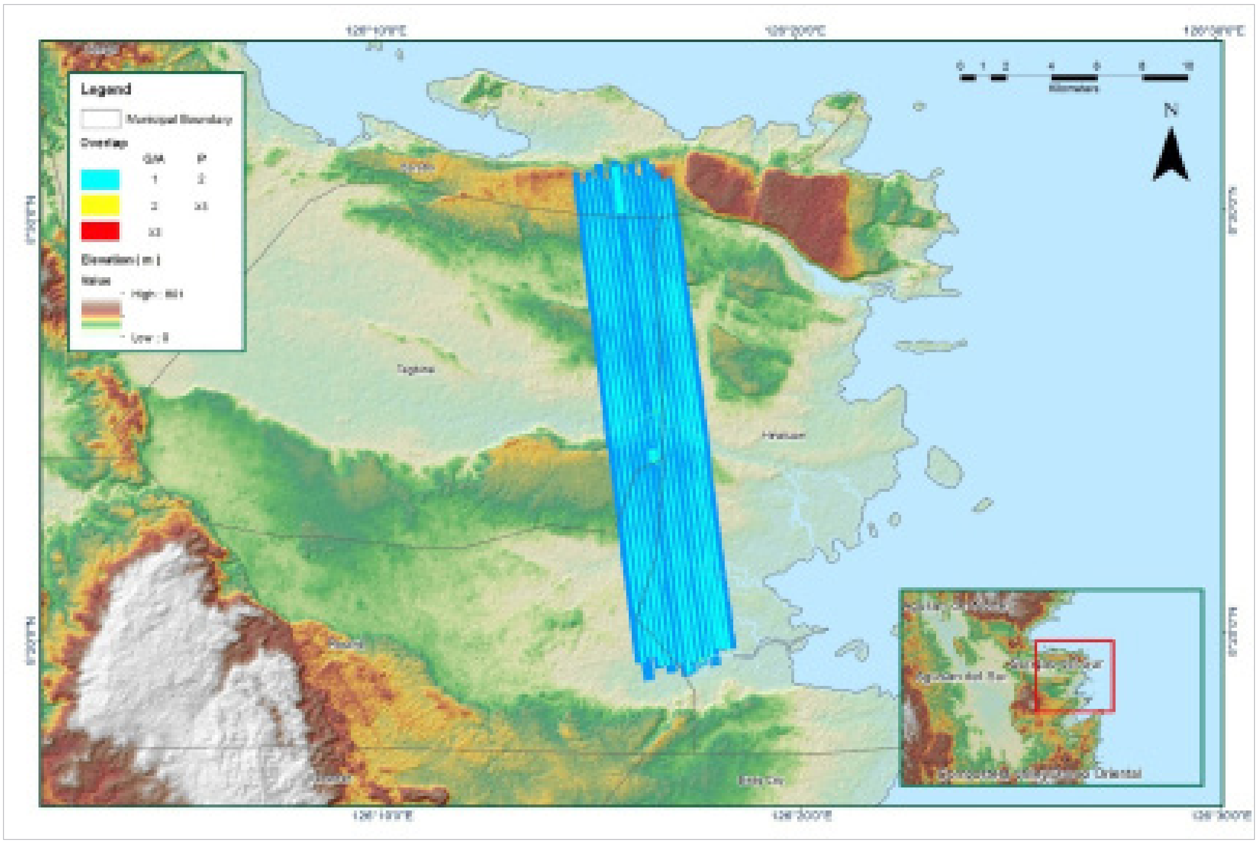


Figure A-8.68. Image of data overlap

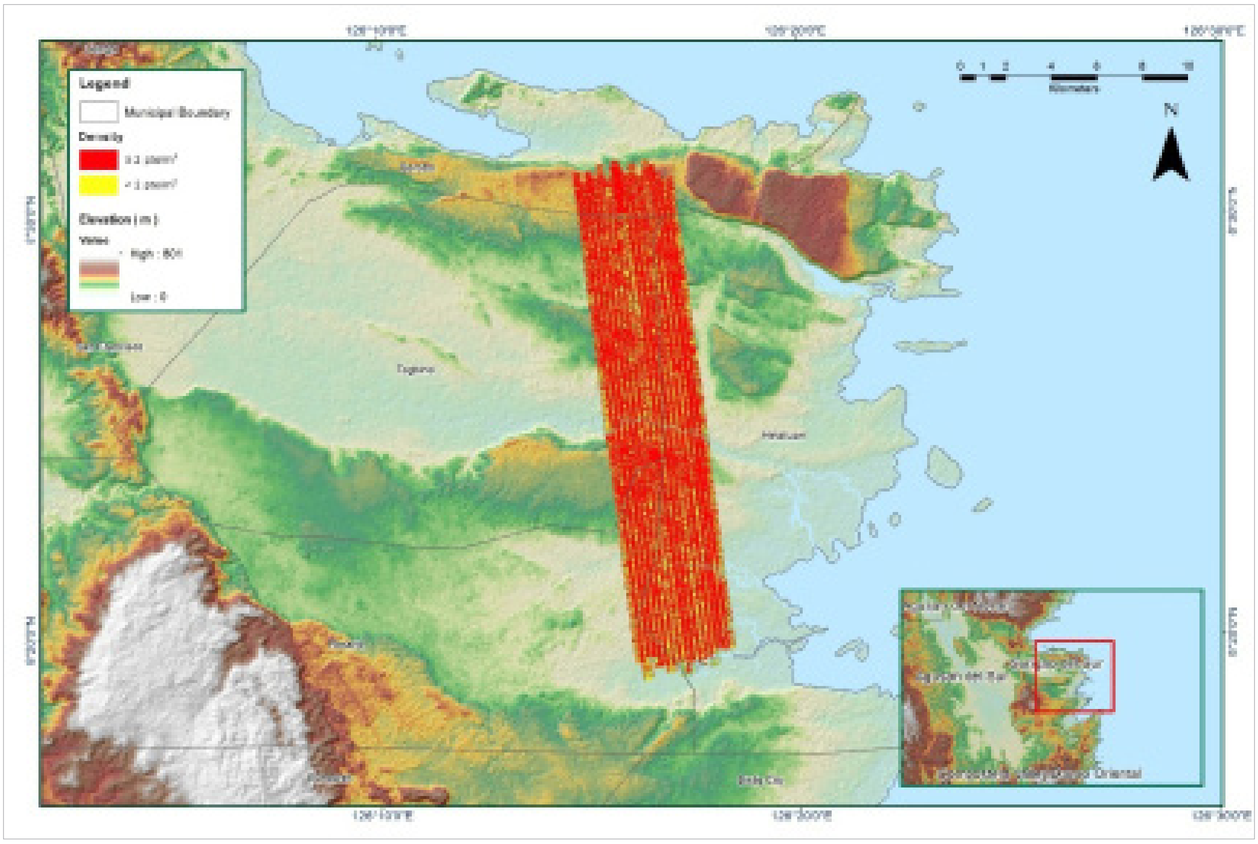


Figure A-8.69. Density map of merged LiDAR data

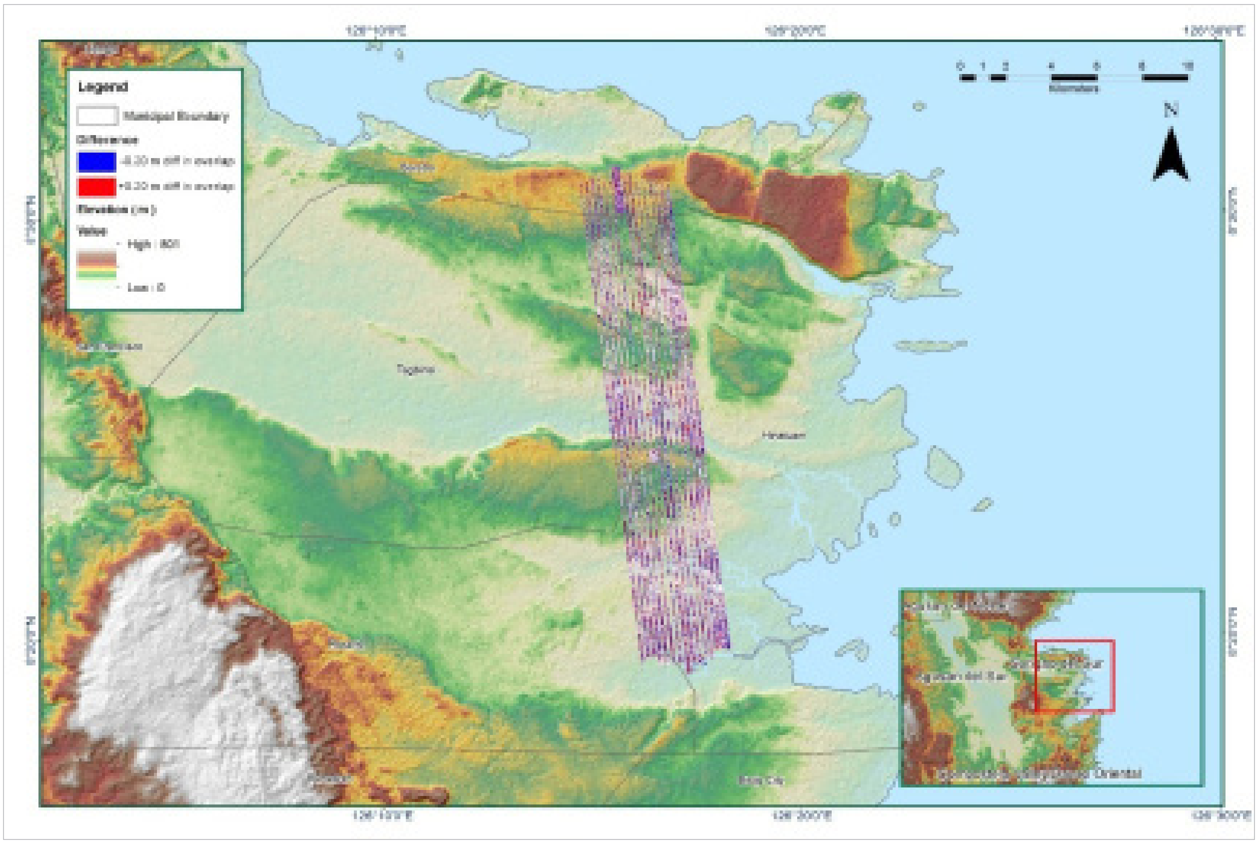


Figure A-8.70. Elevation difference between flight lines

Table A-8.11. Mission Summary Report for Block 66O

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66O
Inclusive Flights	1800A
Range data size	7.27 GB
Base data size	15.5 MB
POS	162MB
Image	42.20 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	1.95
RMSE for East Position (<4.0 cm)	2.30
RMSE for Down Position (<8.0 cm)	3.00
Boresight correction stdev (<0.001deg)	0.000476
IMU attitude correction stdev (<0.001deg)	0.005288
GPS position stdev (<0.01m)	0.0133
Minimum % overlap (>25)	35.75
Ave point cloud density per sq.m. (>2.0)	3.26
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	90
Maximum Height	305.06 m
Minimum Height	66.10 m
Classification (# of points)	
Ground	23,097,136
Low vegetation	18,464,590
Medium vegetation	53,273,982
High vegetation	61,443,070
Building	1,536,374
Orthophoto	Yes
Processed by	Engr. Jommer Medina, Engr. Christy Lubiano, Engr. Melissa Fernandez

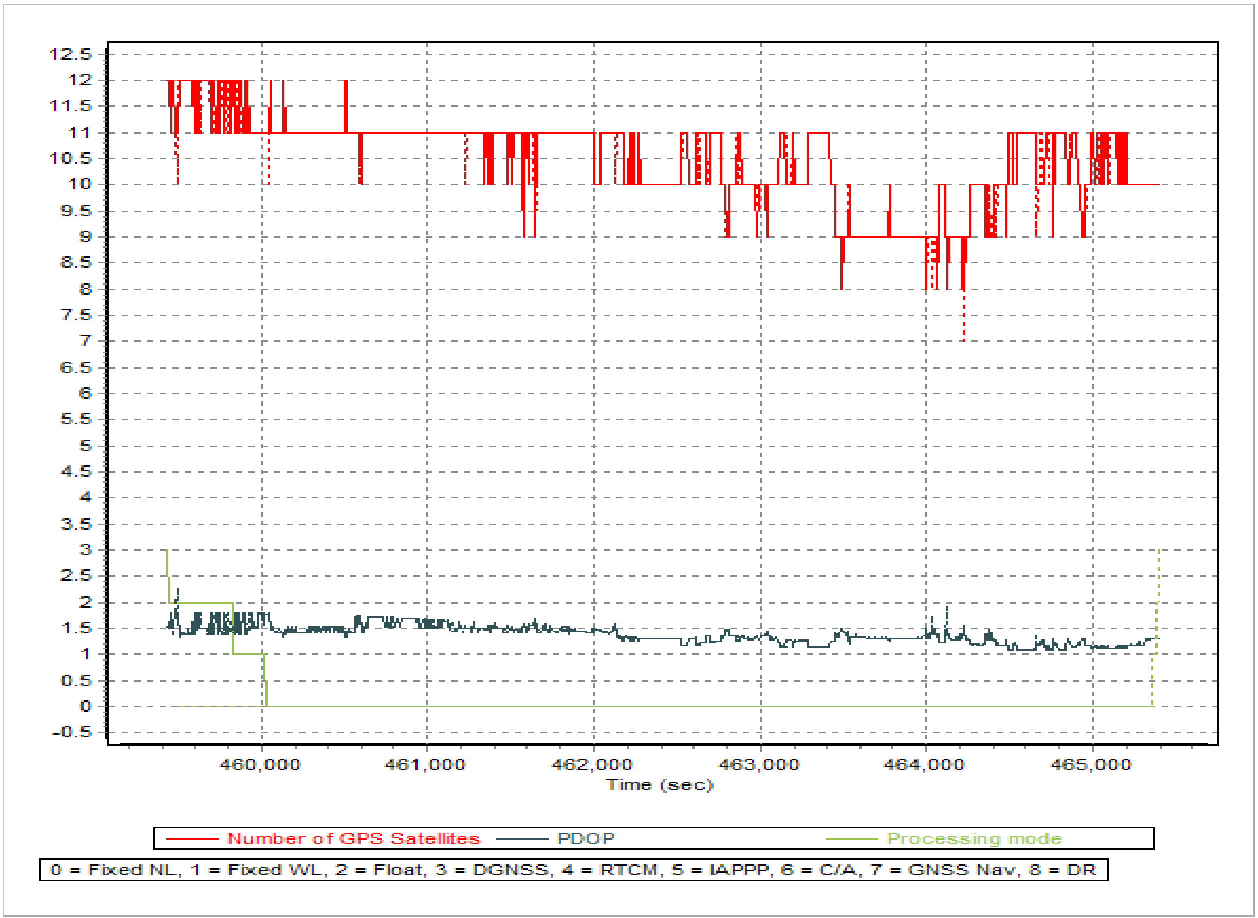


Figure A-8.71. Solution Status

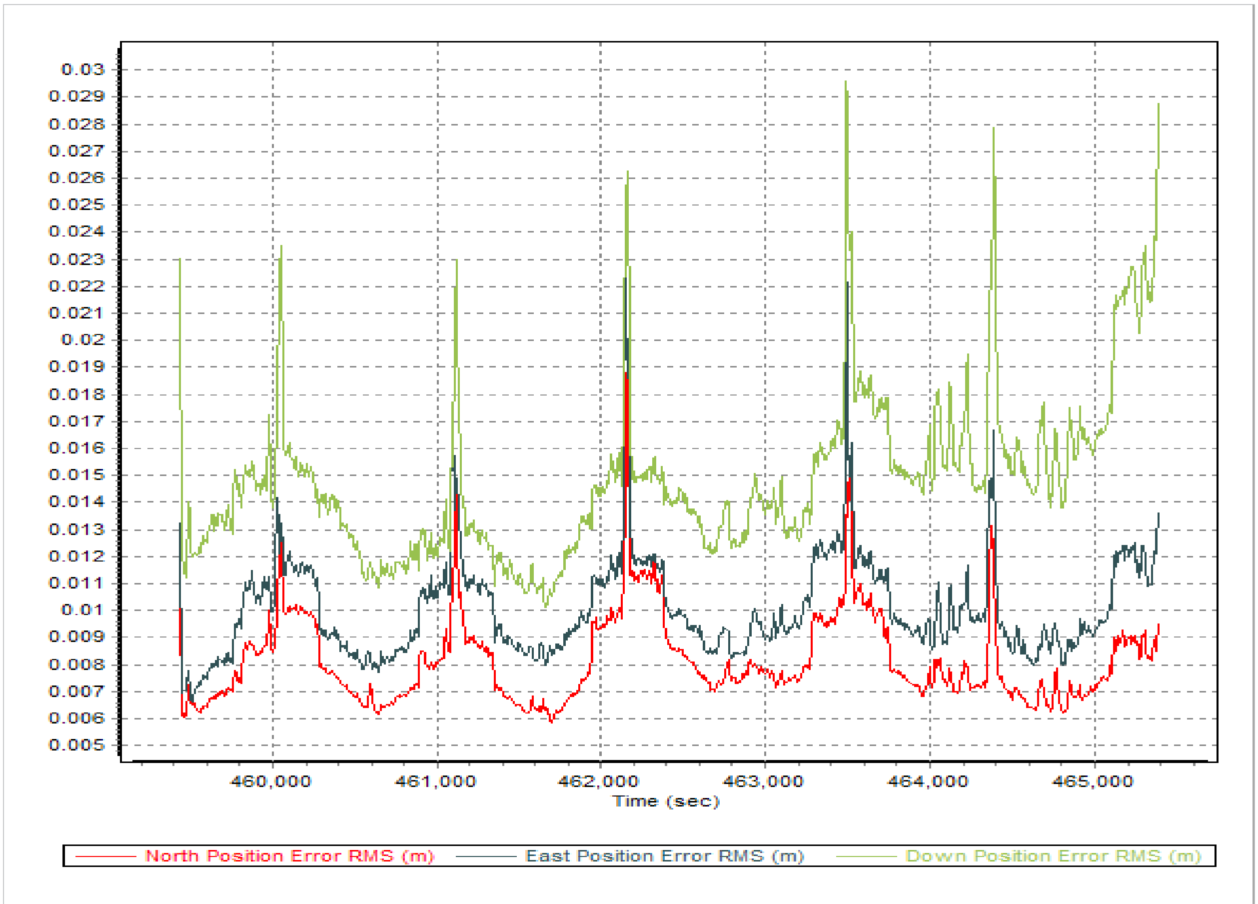
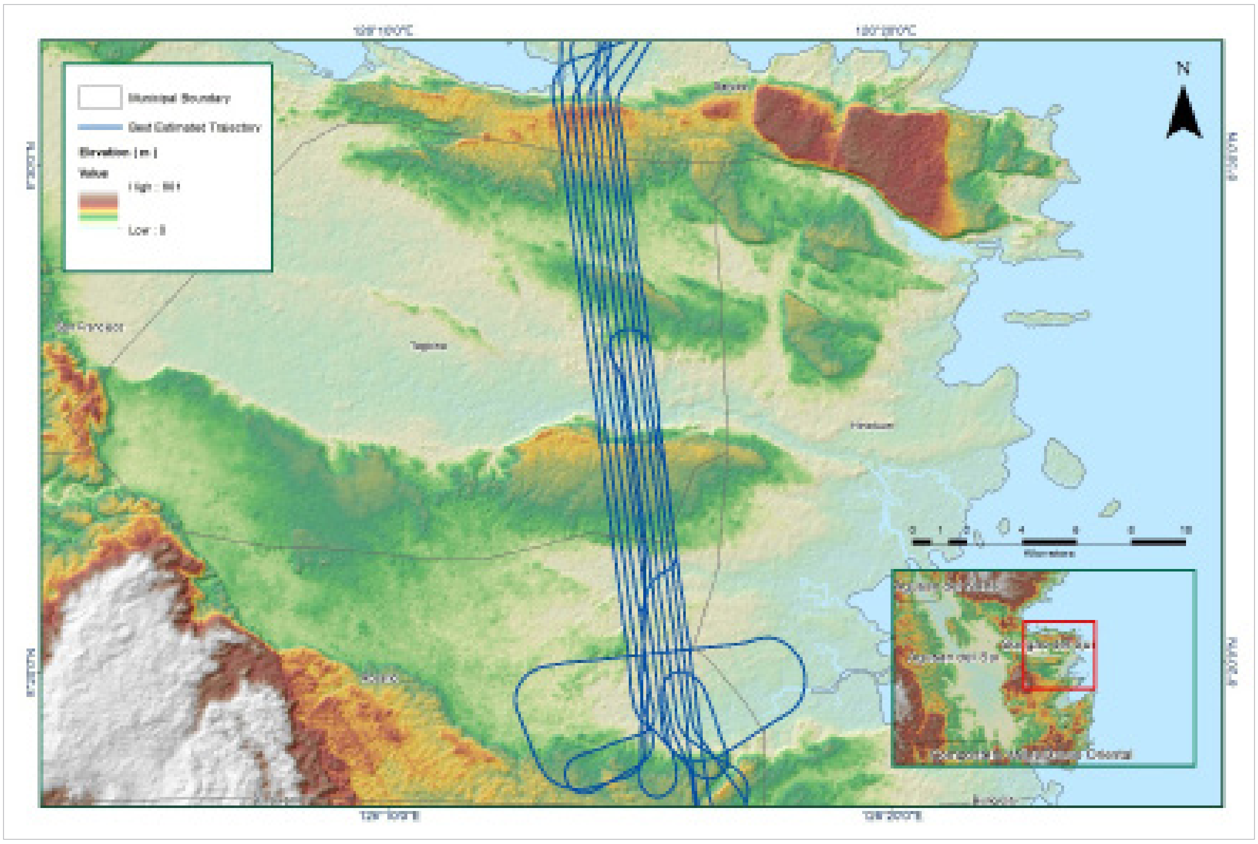


Figure A-8.72. Smoothed Performance Metric Parameters



FigureA-8.73. Best Estimated Trajectory

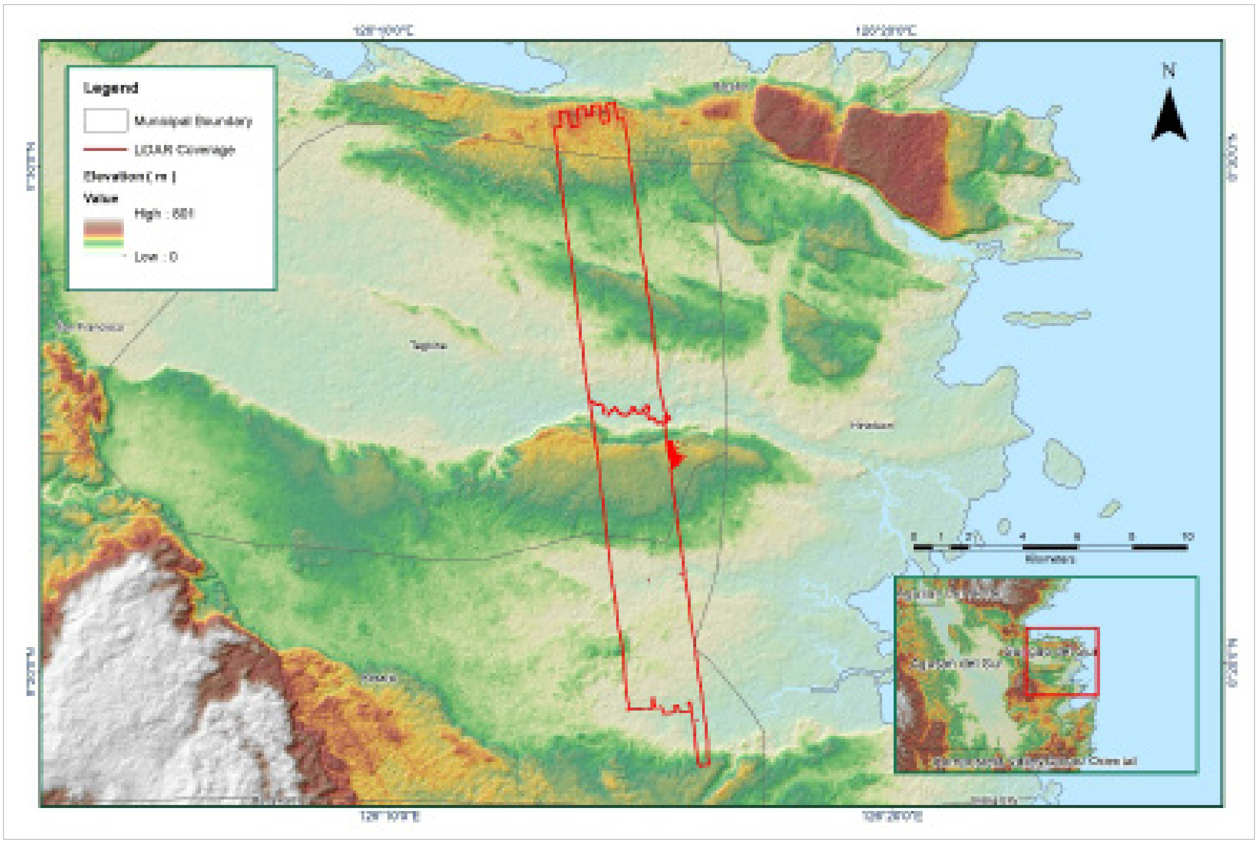


Figure A-8.74. Coverage of LiDAR data

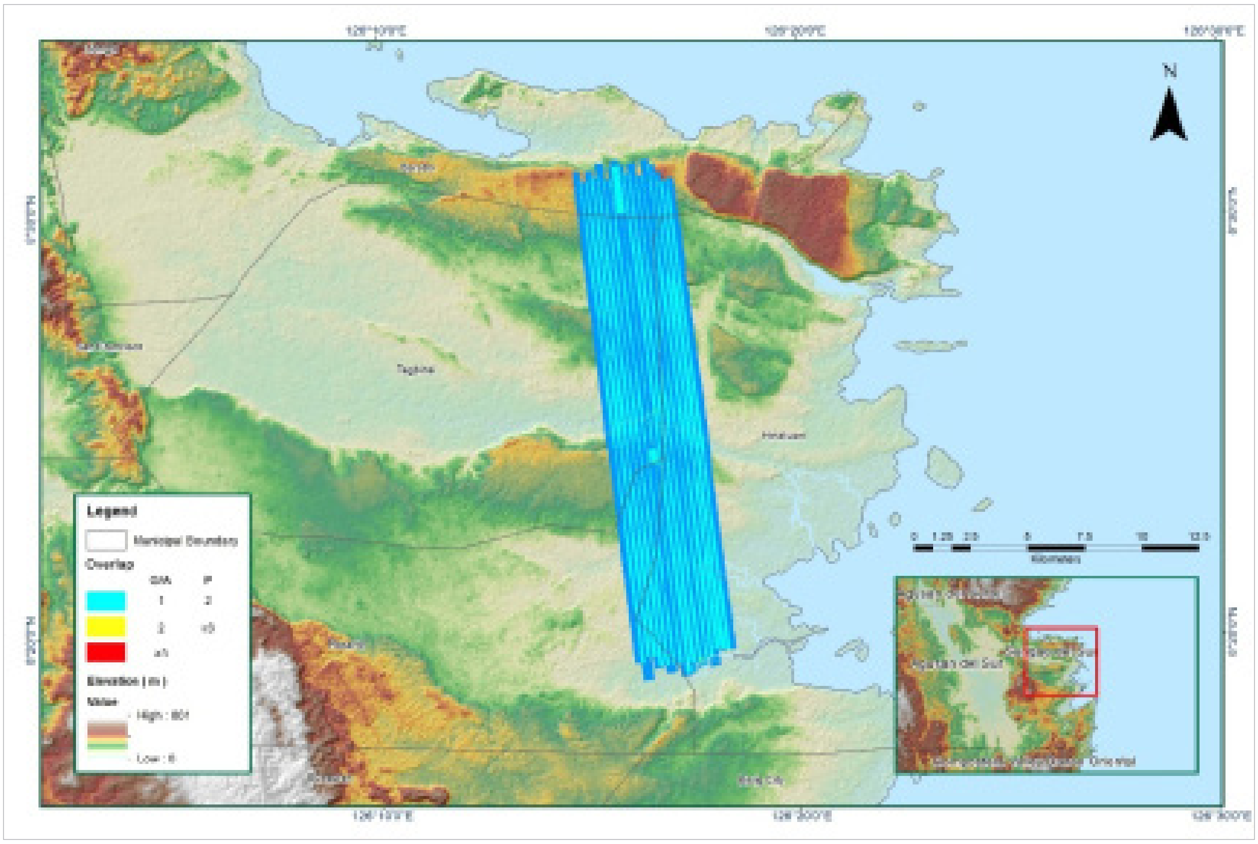


Figure A-8.75. Image of data overlap

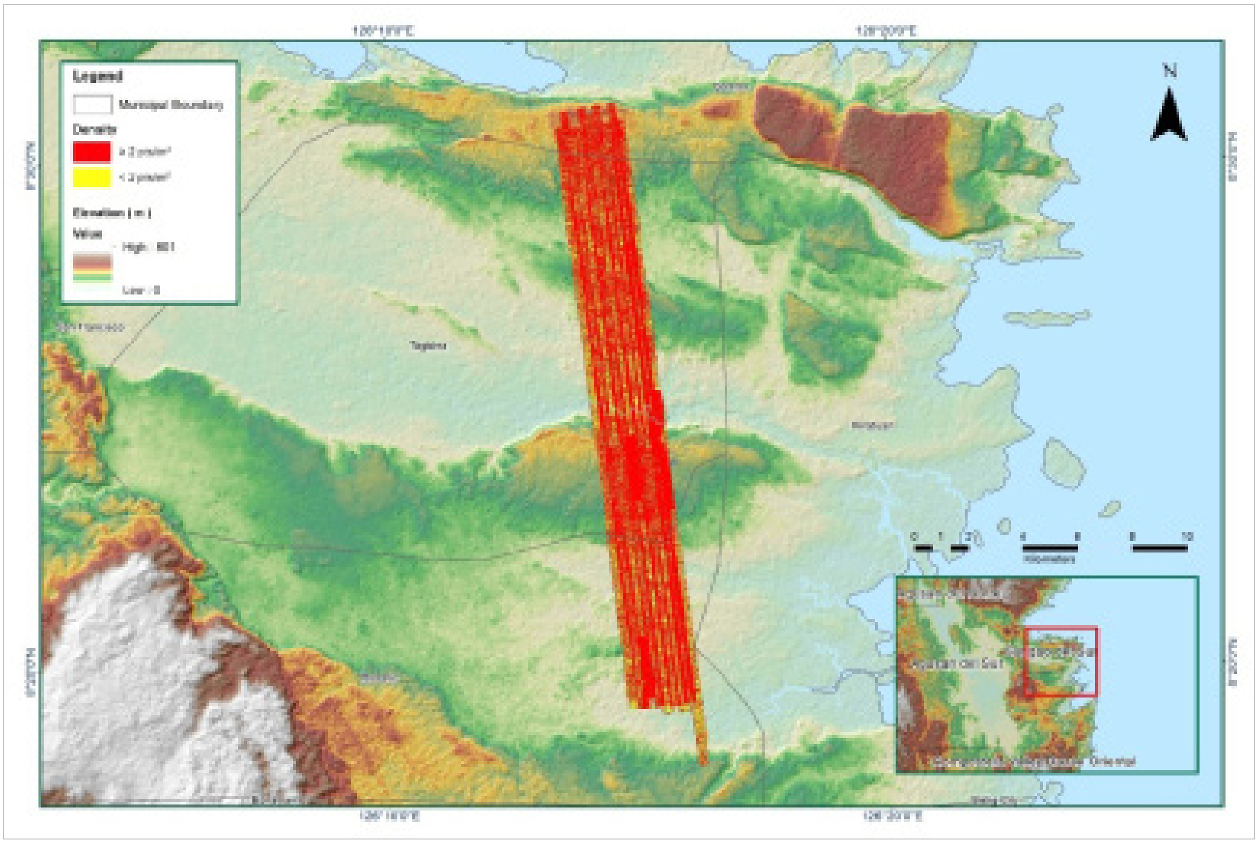


Figure A-8.76. Density map of merged LiDAR data

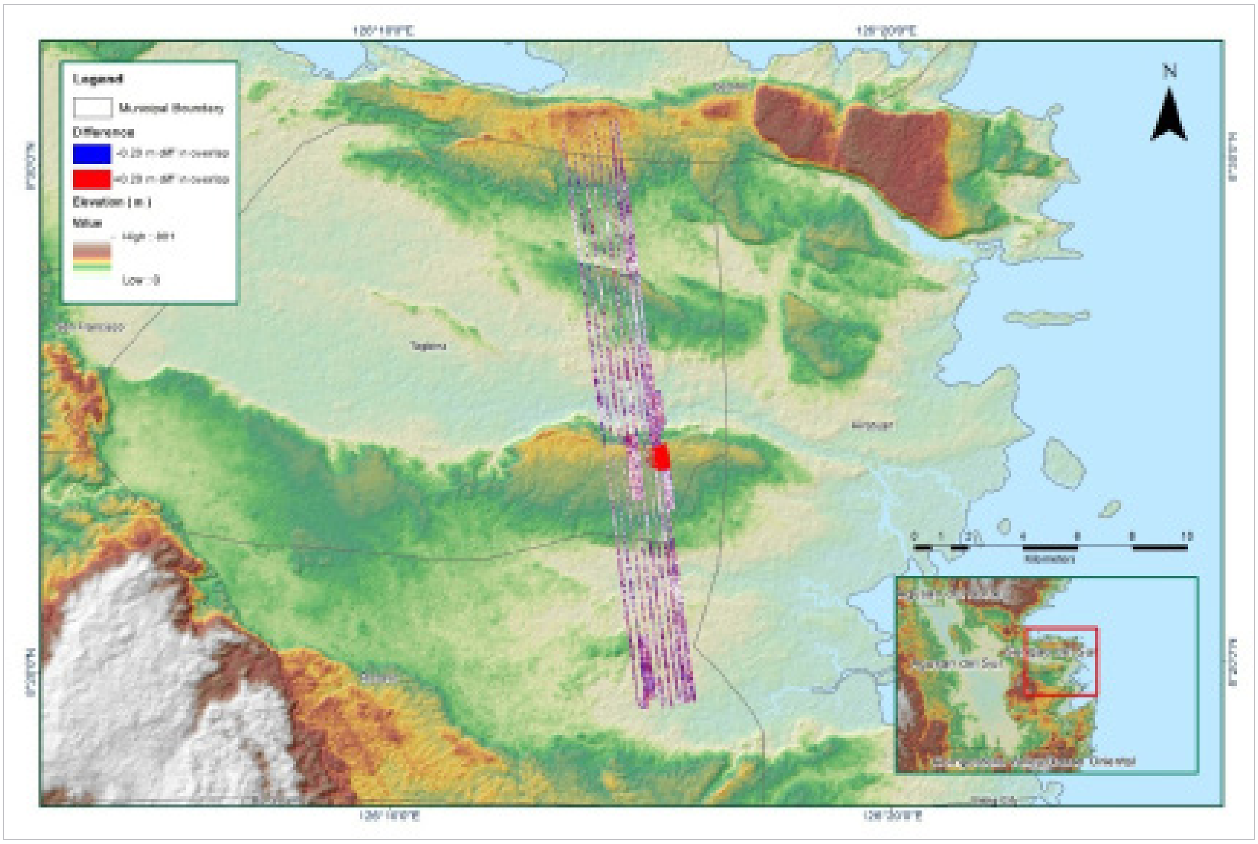


Figure A-8.77. Elevation difference between flight lines

Table A-8.12. Mission Summary Report for Block 66P

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66P
Inclusive Flights	1804A
Range data size	10.10 GB
Base data size	14.1 MB
POS	231MB
Image	58.90 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	2.80
RMSE for East Position (<4.0 cm)	2.80
RMSE for Down Position (<8.0 cm)	5.00
Boresight correction stdev (<0.001deg)	0.000554
IMU attitude correction stdev (<0.001deg)	0.001883
GPS position stdev (<0.01m)	0.0096
Minimum % overlap (>25)	41.21
Ave point cloud density per sq.m. (>2.0)	3.23
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	111
Maximum Height	336.50 m
Minimum Height	66.34 m
Classification (# of points)	
Ground	30,361,440
Low vegetation	29,980,607
Medium vegetation	65,876,694
High vegetation	81,259,951
Building	1,474,870
Orthophoto	Yes
Processed by	Engr. Jommer Medina, Engr. Harmond Santos, John Dill Macapagal

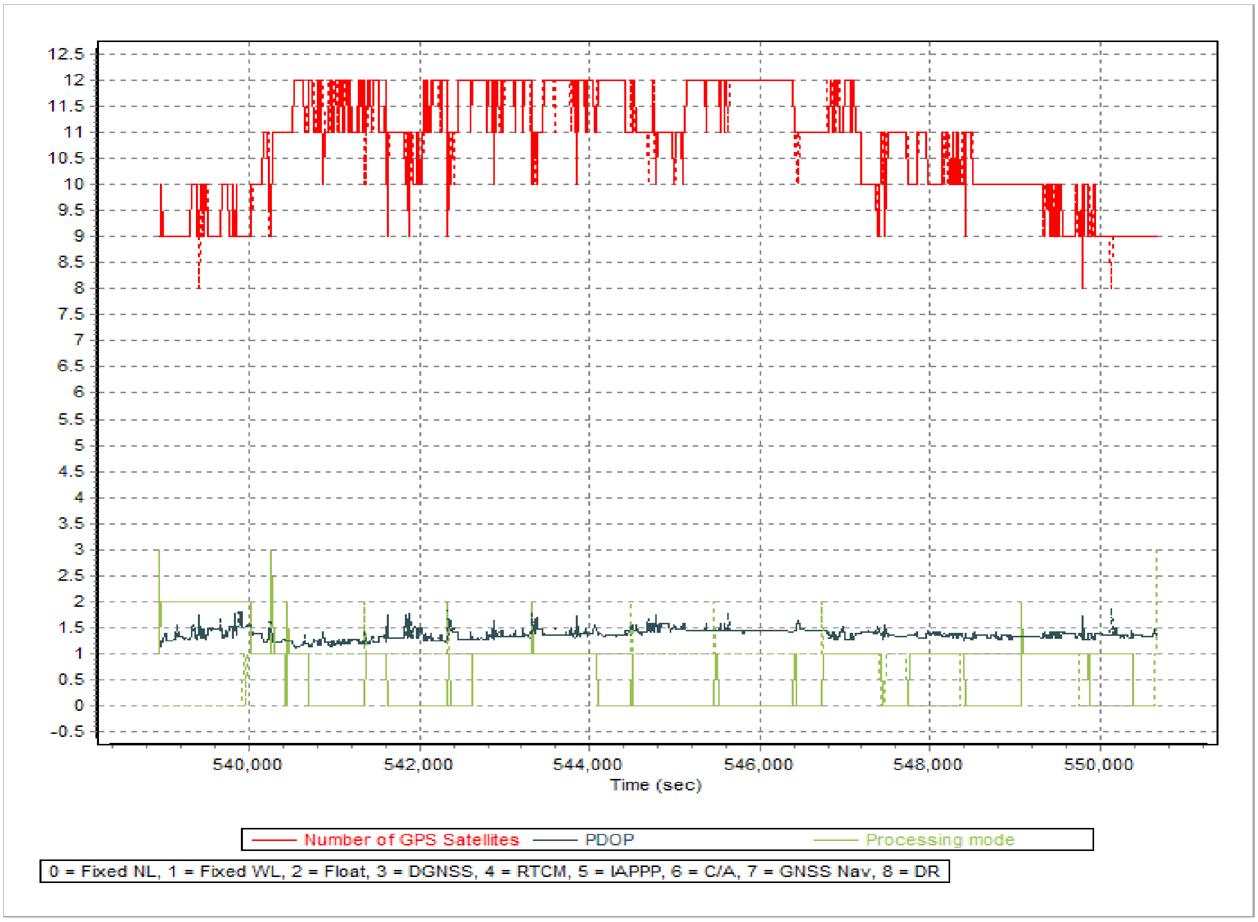


Figure A-8.78. Solution Status

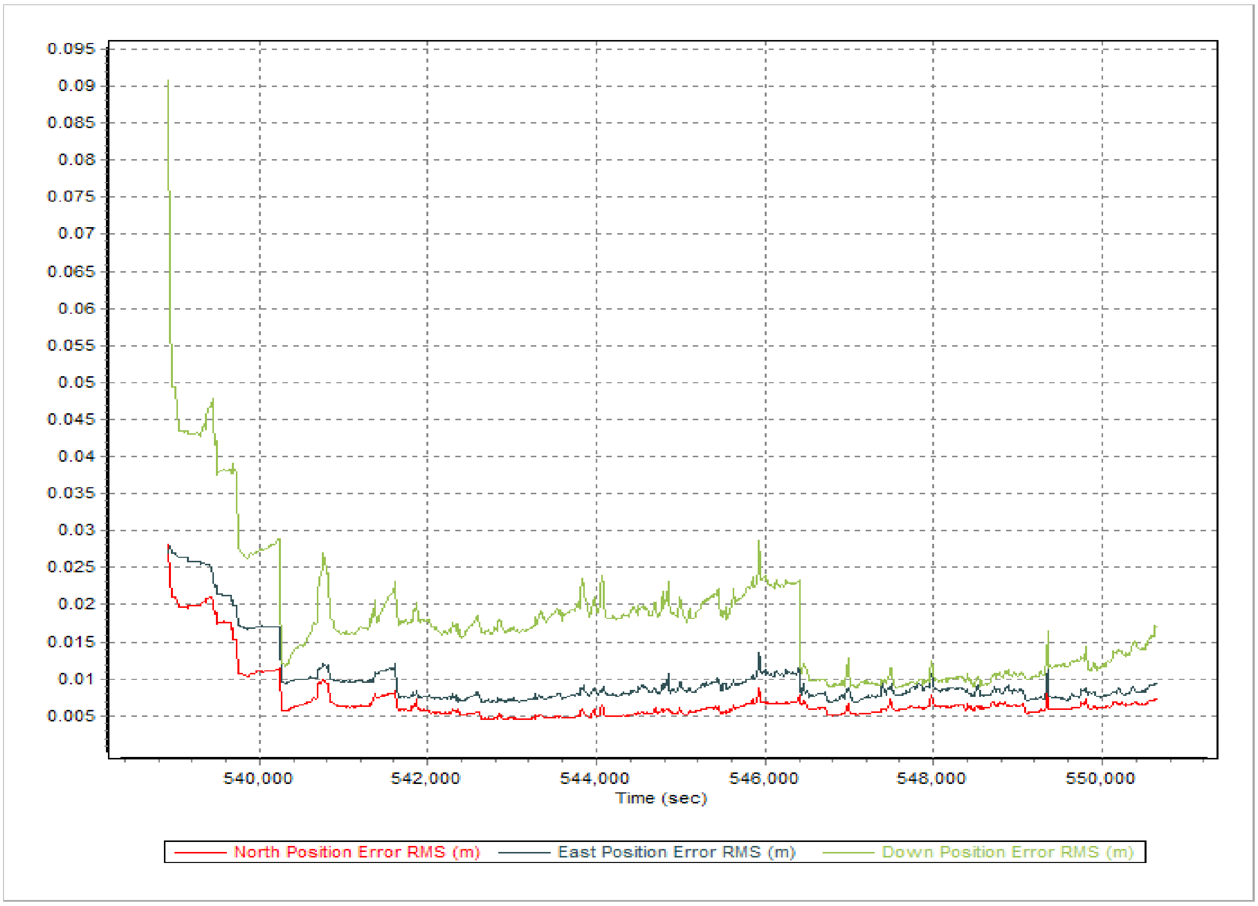


Figure A-8.79. Smoothed Performance Metric Parameters

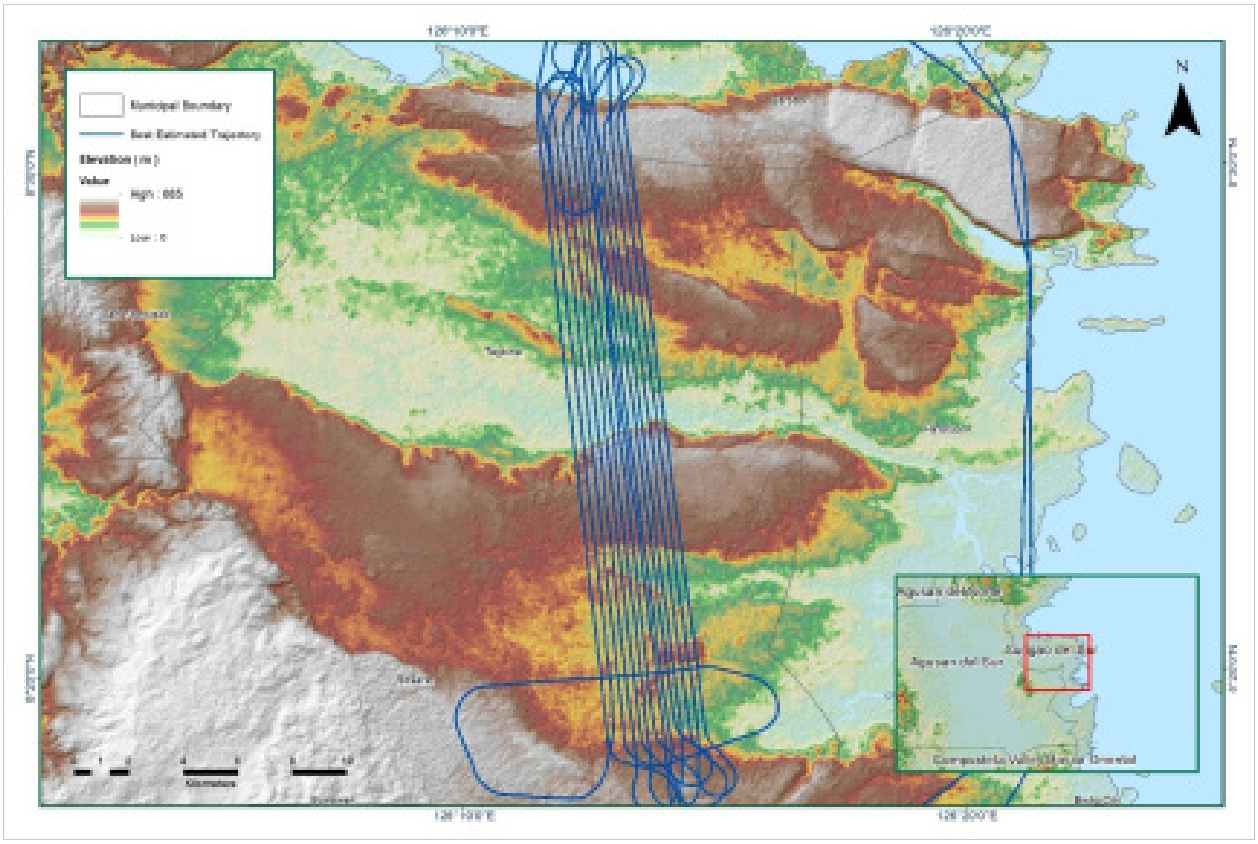


Figure A-8.80. Best Estimated Trajectory

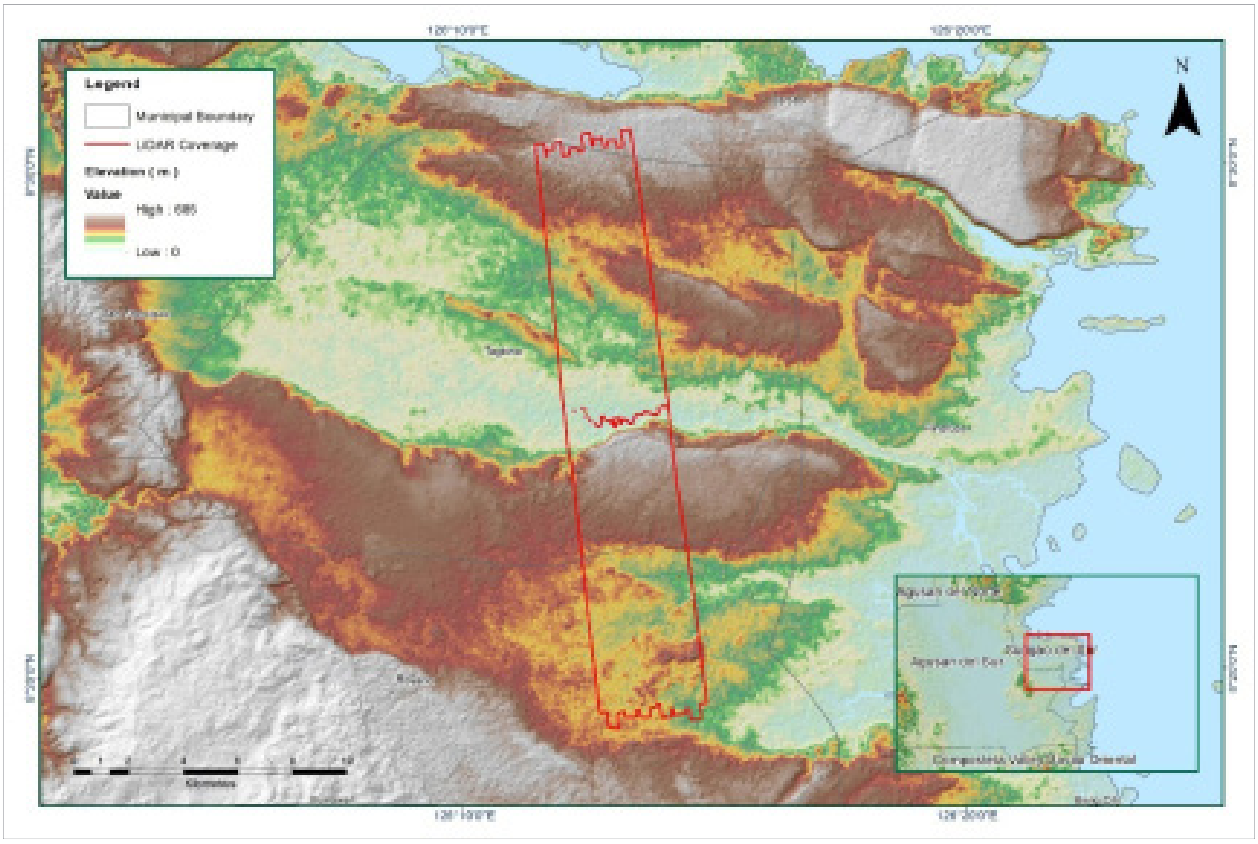


Figure A-8.81. Coverage of LiDAR data

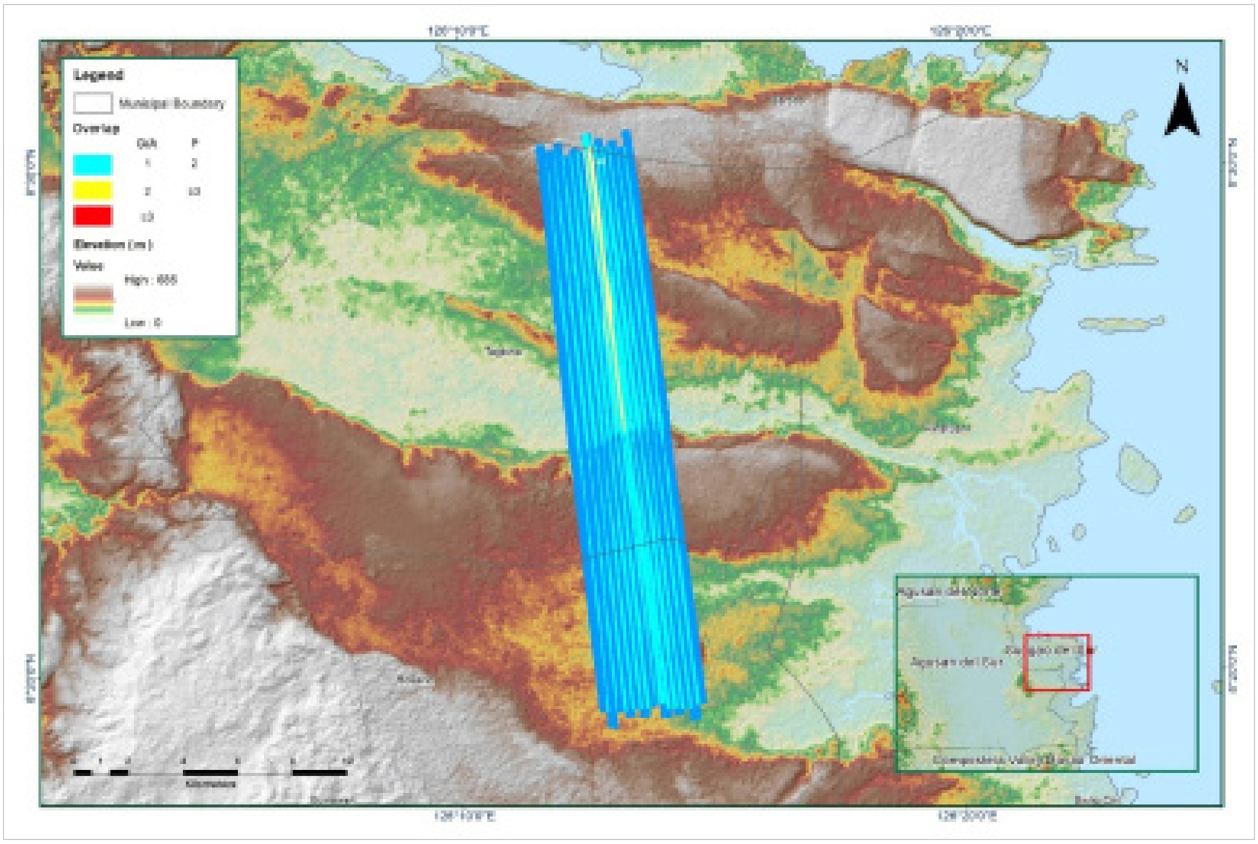


Figure A-8.82. Image of data overlap

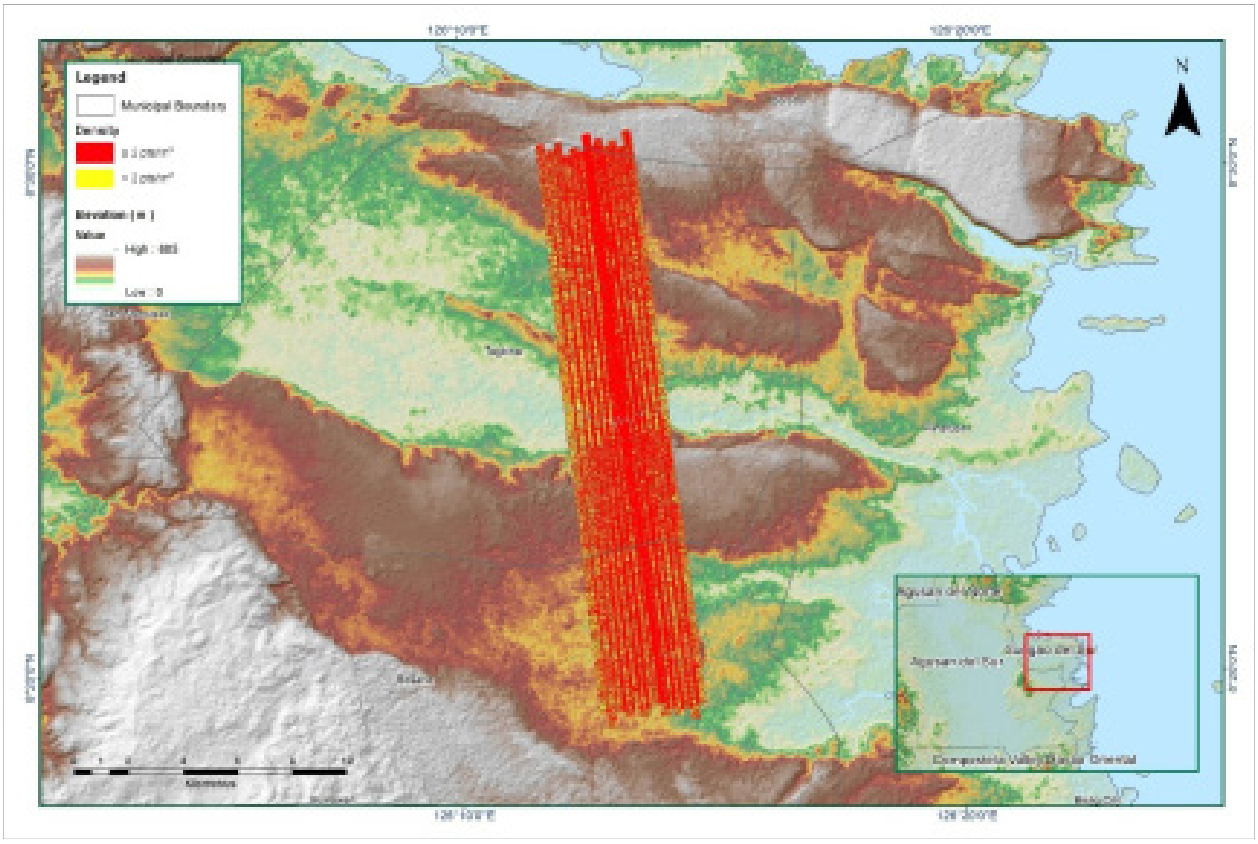


Figure A-8.83. Density map of merged LiDAR data

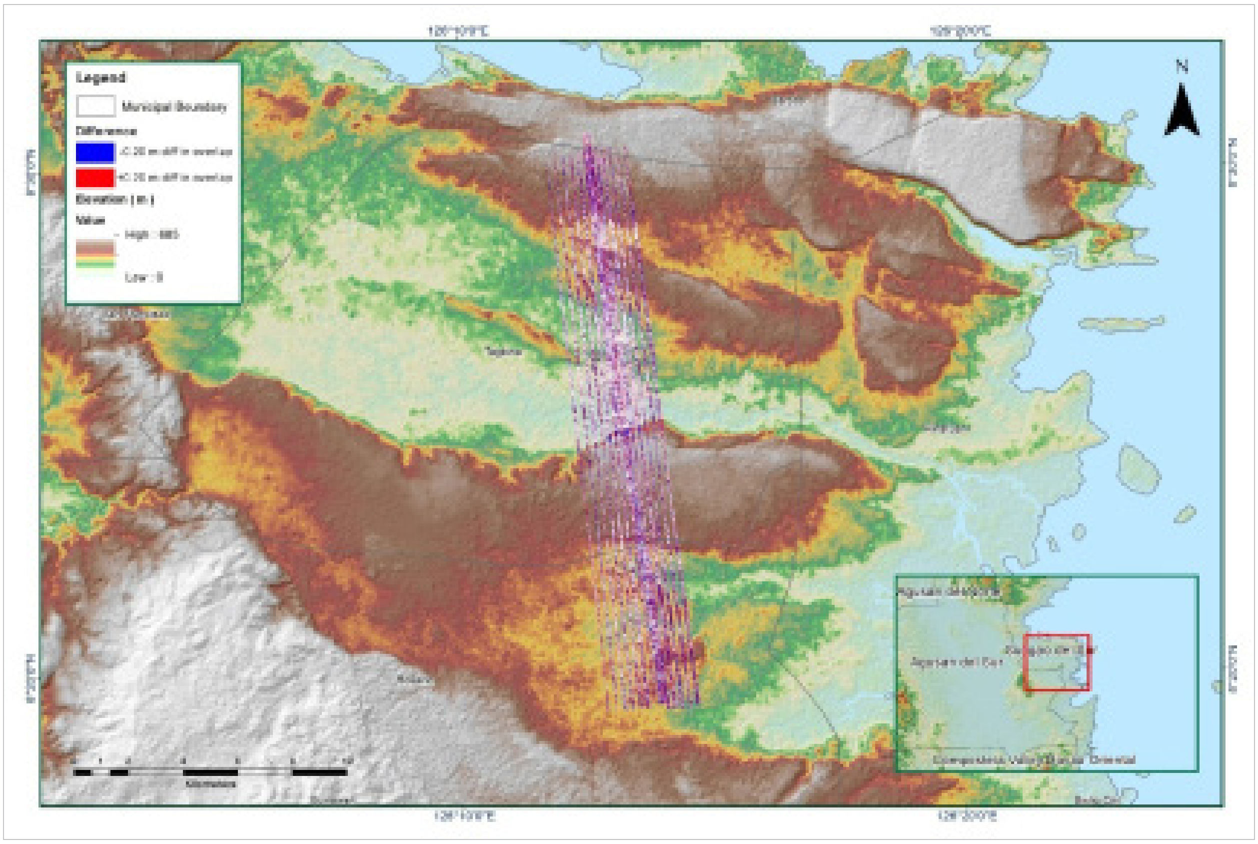


Figure A-8.84. Elevation difference between flight lines

Table A-8.13. Mission Summary Report for Block 66Q

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66Q
Inclusive Flights	1810A& 1812A
Range data size	20.36 GB
Base data size	18.3 MB
POS	412MB
Image	44.80 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	2.60
RMSE for East Position (<4.0 cm)	3.60
RMSE for Down Position (<8.0 cm)	4.44
Boresight correction stdev (<0.001deg)	0.000688
IMU attitude correction stdev (<0.001deg)	0.001361
GPS position stdev (<0.01m)	0.0079
Minimum % overlap (>25)	39.42
Ave point cloud density per sq.m. (>2.0)	3.11
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	221
Maximum Height	361.24 m
Minimum Height	61.51 m
Classification (# of points)	
Ground	63,637,588
Low vegetation	59,205,087
Medium vegetation	139,975,963
High vegetation	174,850,836
Building	2,941,636
Orthophoto	Yes
Processed by	Engr. Jommer Medina, Engr. Edgardo Gubatanga Jr., John Dill Macapagal

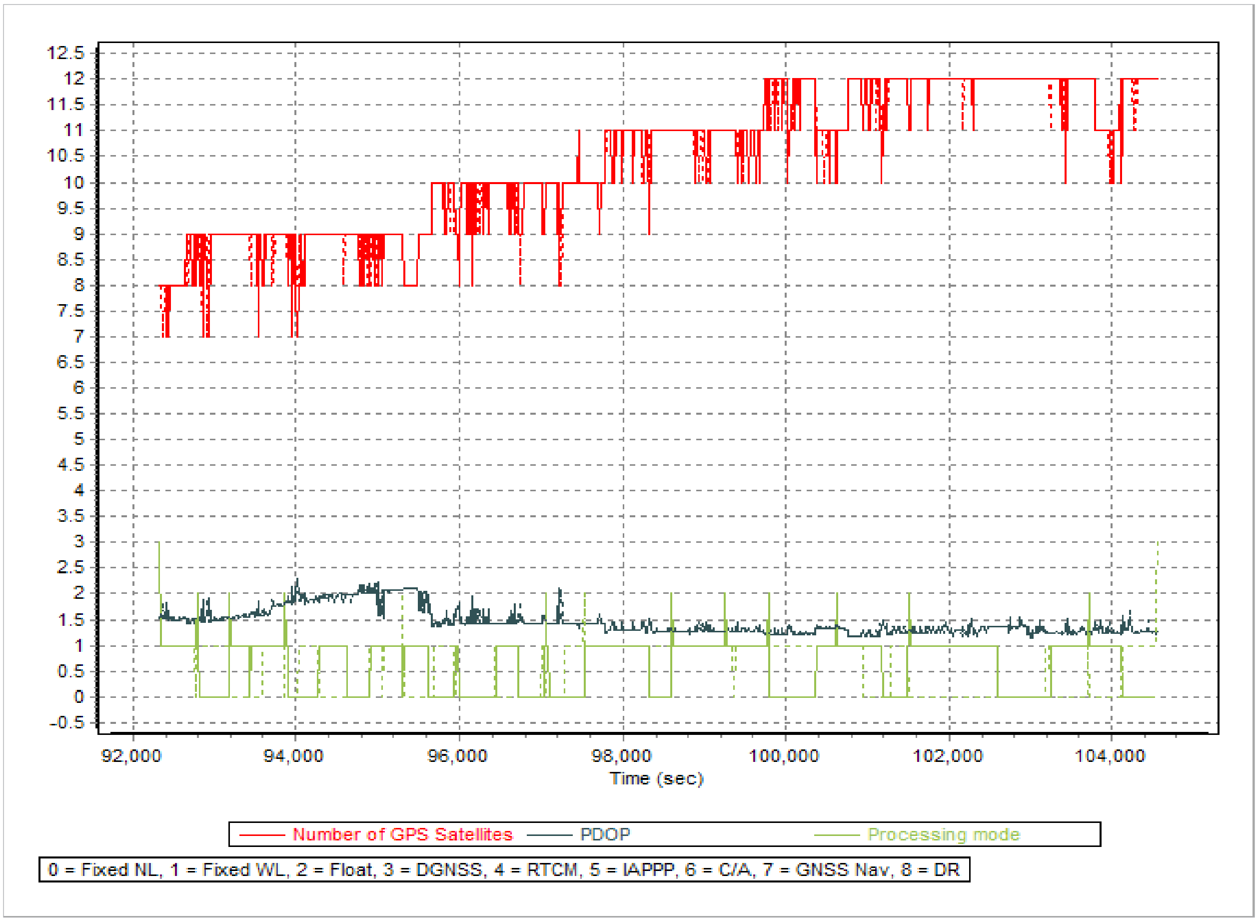


Figure A-8.85. Solution Status

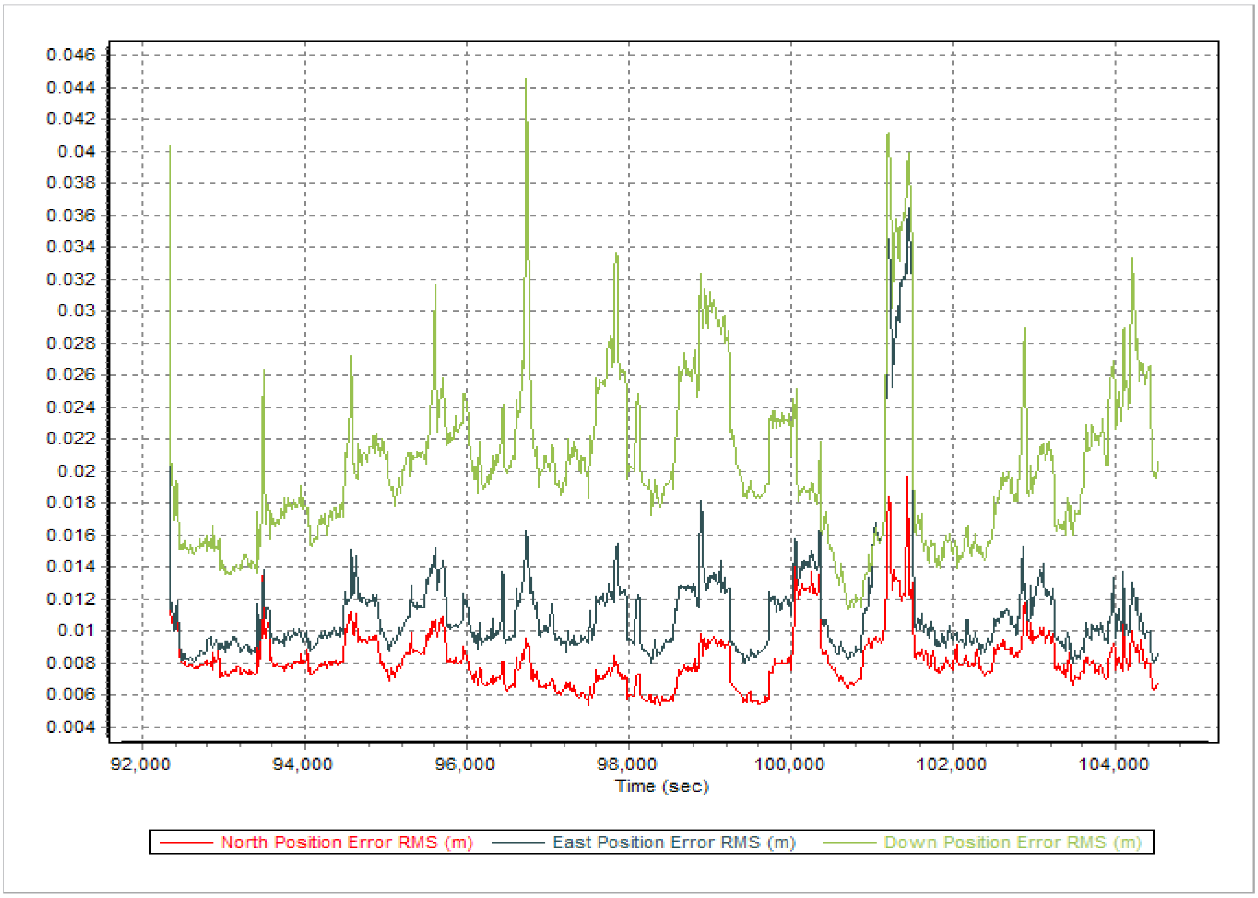


Figure A-8.86. Smoothed Performance Metric Parameters

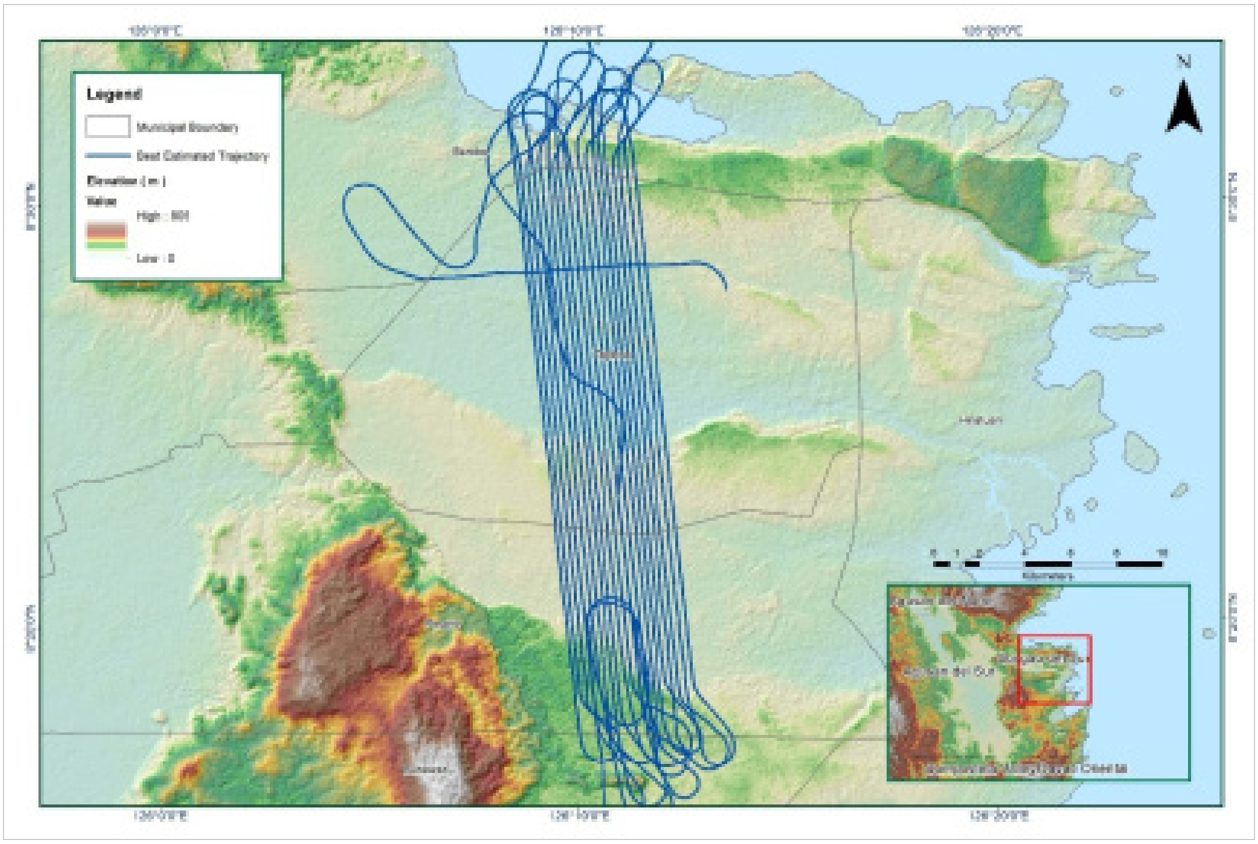


Figure A-8.87. Best Estimated Trajectory

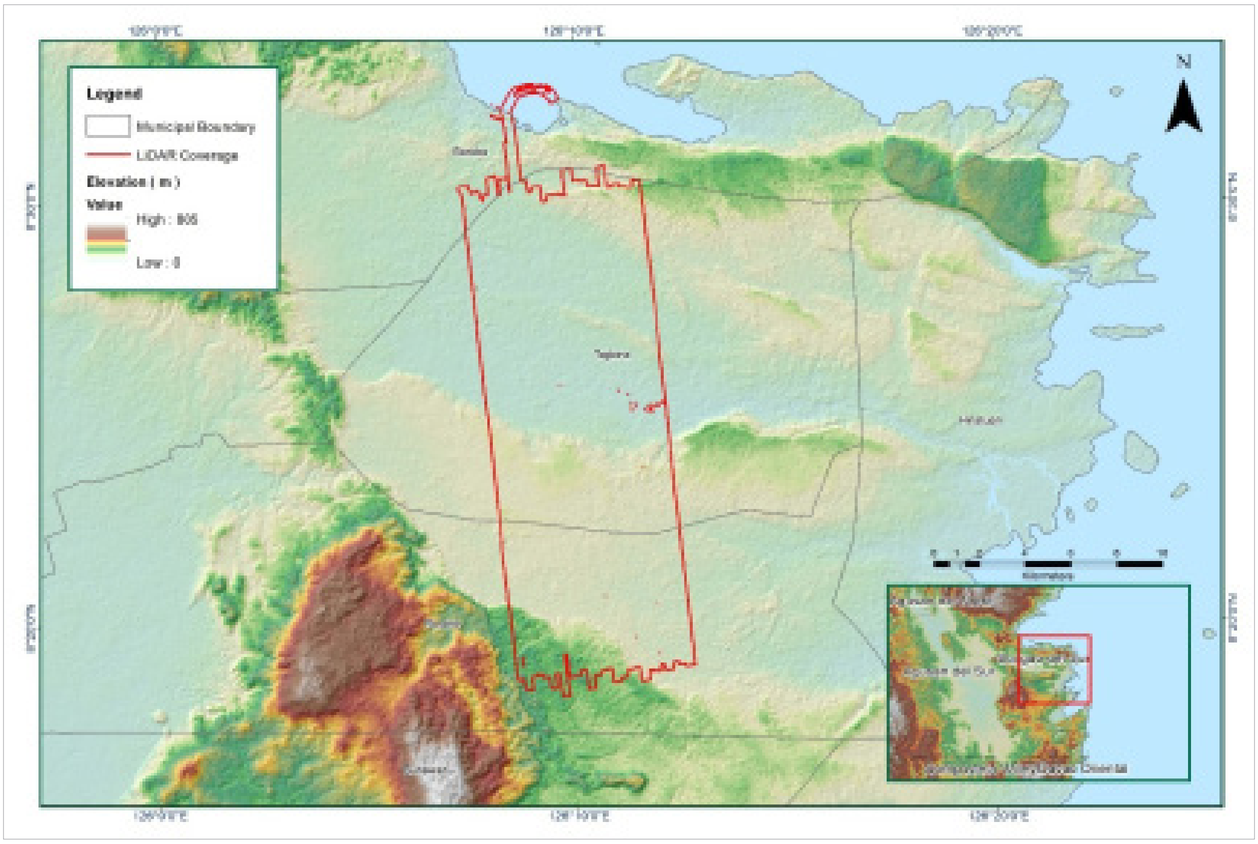


Figure A-8.88. Coverage of LiDAR data

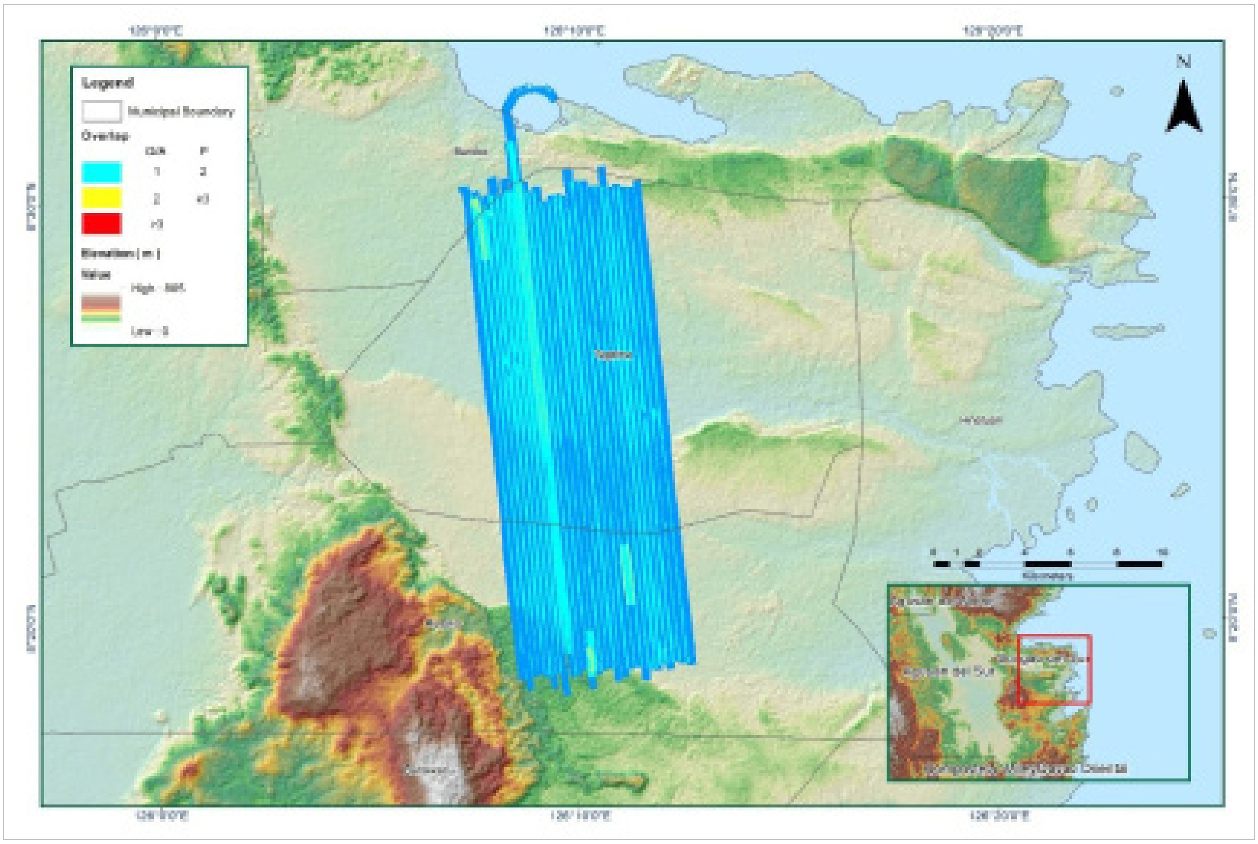


Figure A-8.89. Image of data overlap

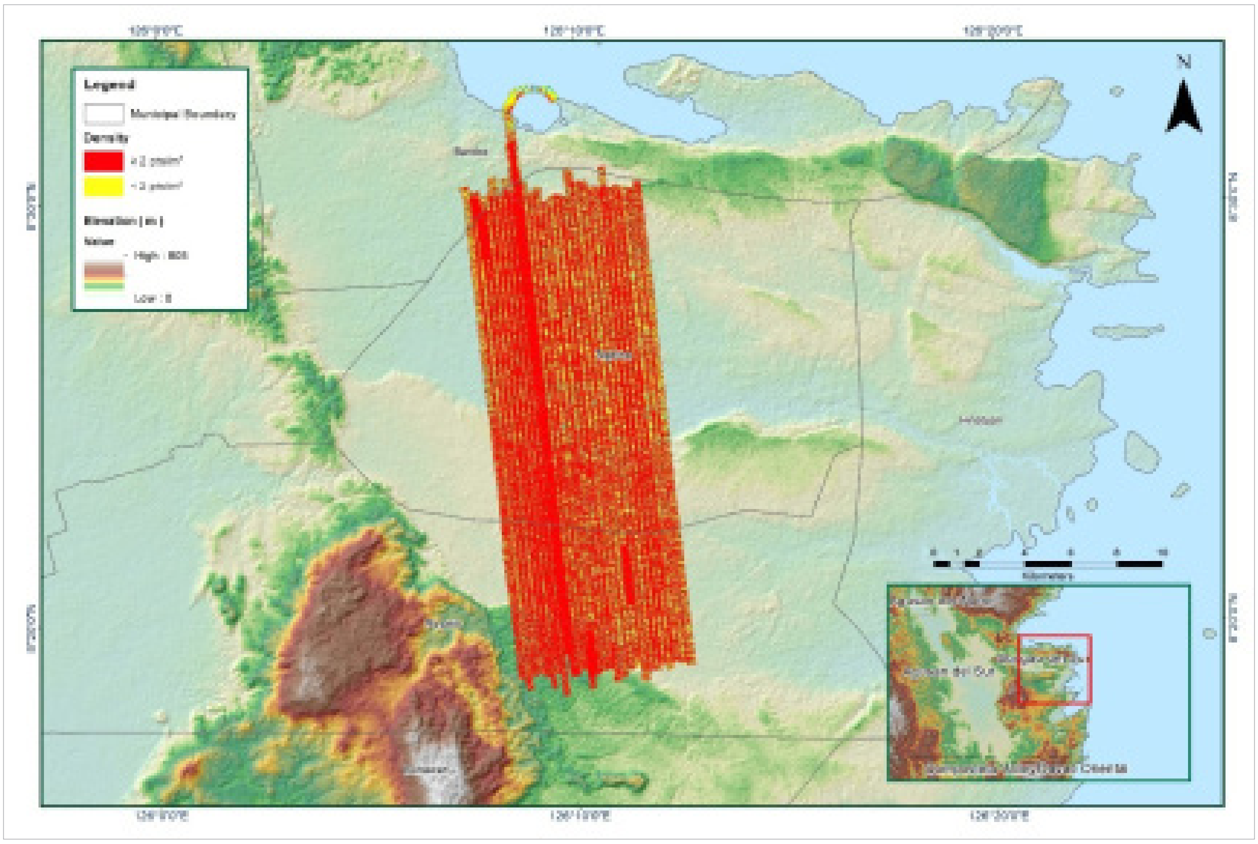


Figure A-8.90. Density map of merged LiDAR data

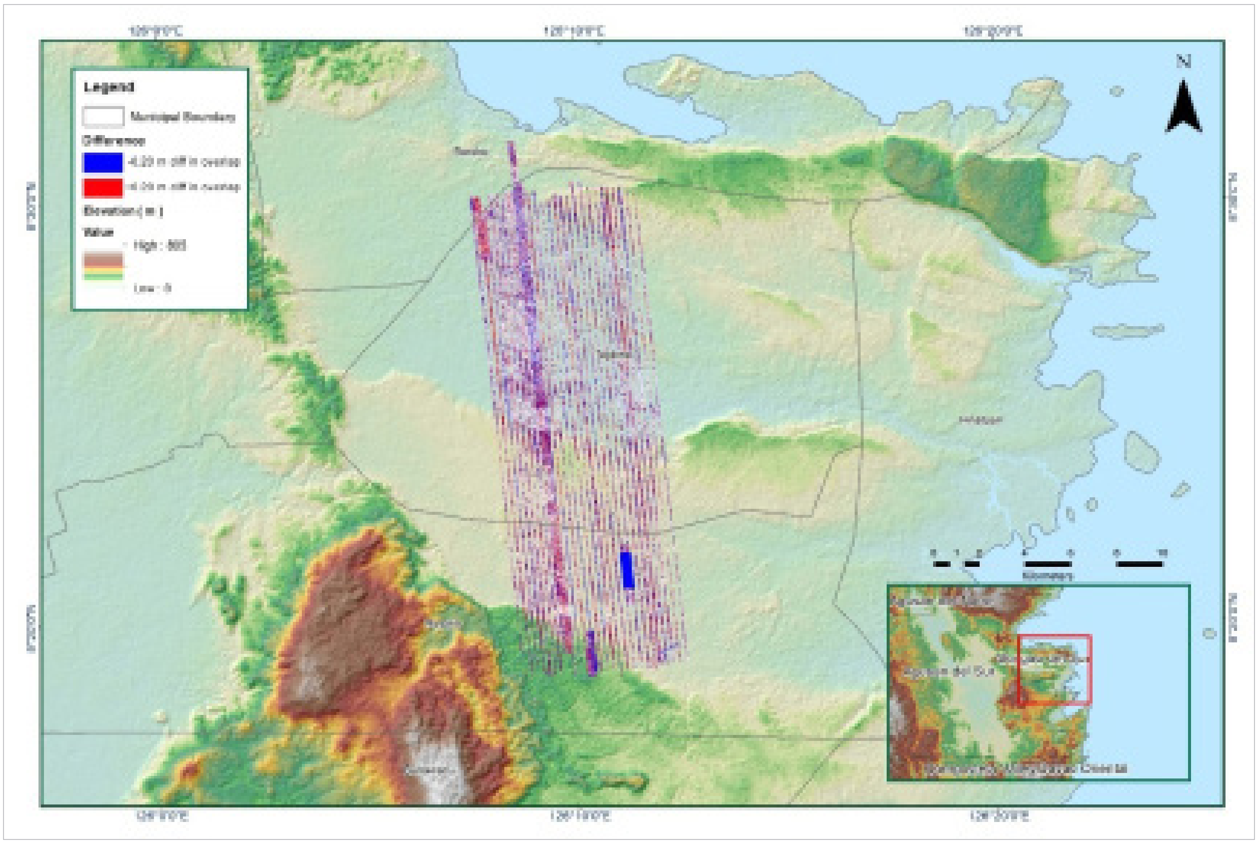


Figure A-8.91. Elevation difference between flight lines

Table A-8.14. Mission Summary Report for Block 66E

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66E
Inclusive Flights	1788A
Range data size	10.40 GB
Base data size	17.8 MB
POS	228 MB
Image	50.40 MB
Transfer date	August 20, 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)	1.60
RMSE for East Position (<4.0 cm)	1.08
RMSE for Down Position (<8.0 cm)	3.80
Boresight correction stdev (<0.001deg)	0.001353
IMU attitude correction stdev (<0.001deg)	0.003331
GPS position stdev (<0.01m)	0.0032
Minimum % overlap (>25)	33.98
Ave point cloud density per sq.m. (>2.0)	2.85
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	103
Maximum Height	174.22 m
Minimum Height	52.25 m
Classification (# of points)	
Ground	30229246
Low vegetation	31059866
Medium vegetation	49036578
High vegetation	47086168
Building	1361570
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Aljon Rie Araneta, Jovy Narisma

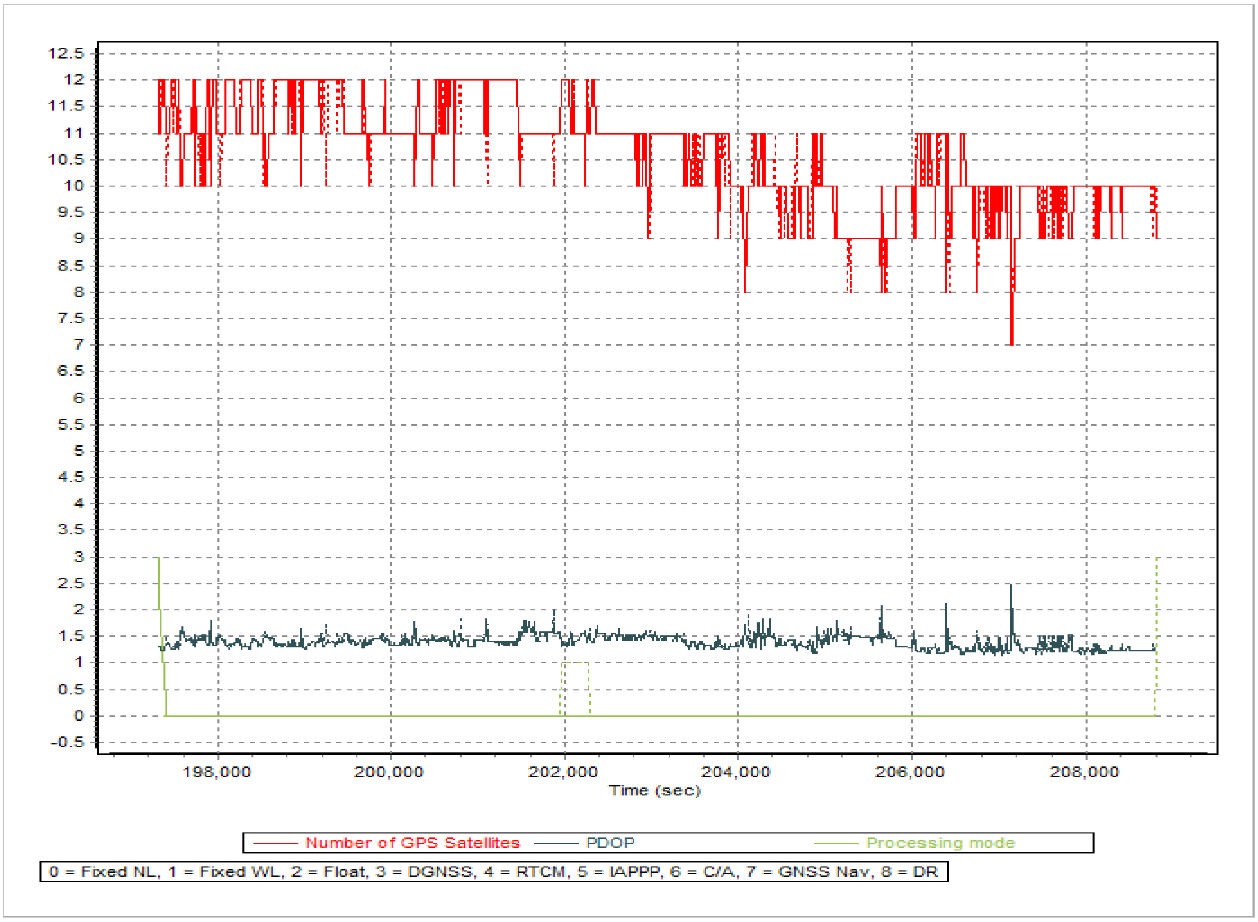


Figure A-8.92. Solution Status

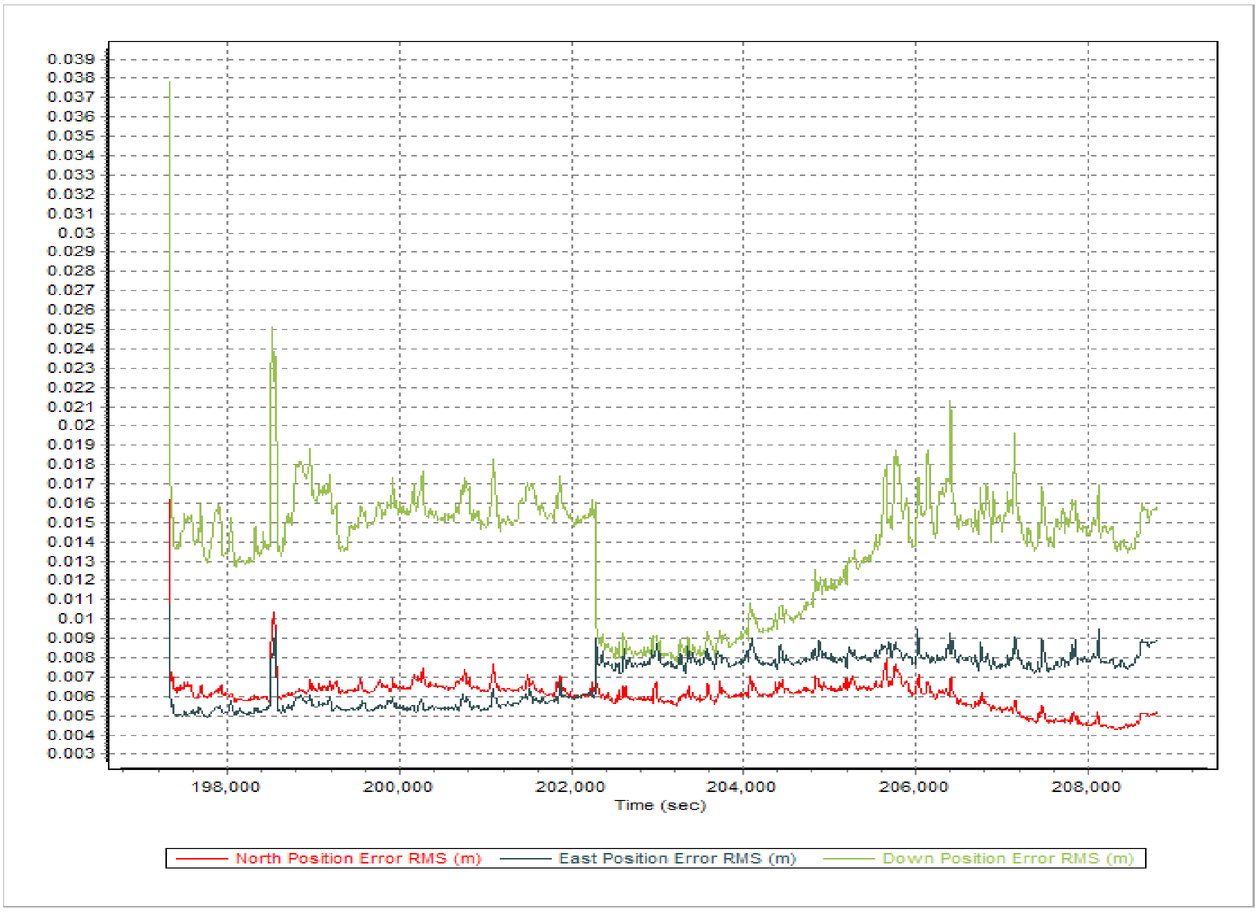


Figure A-8.93. Smoothed Performance Metric Parameters

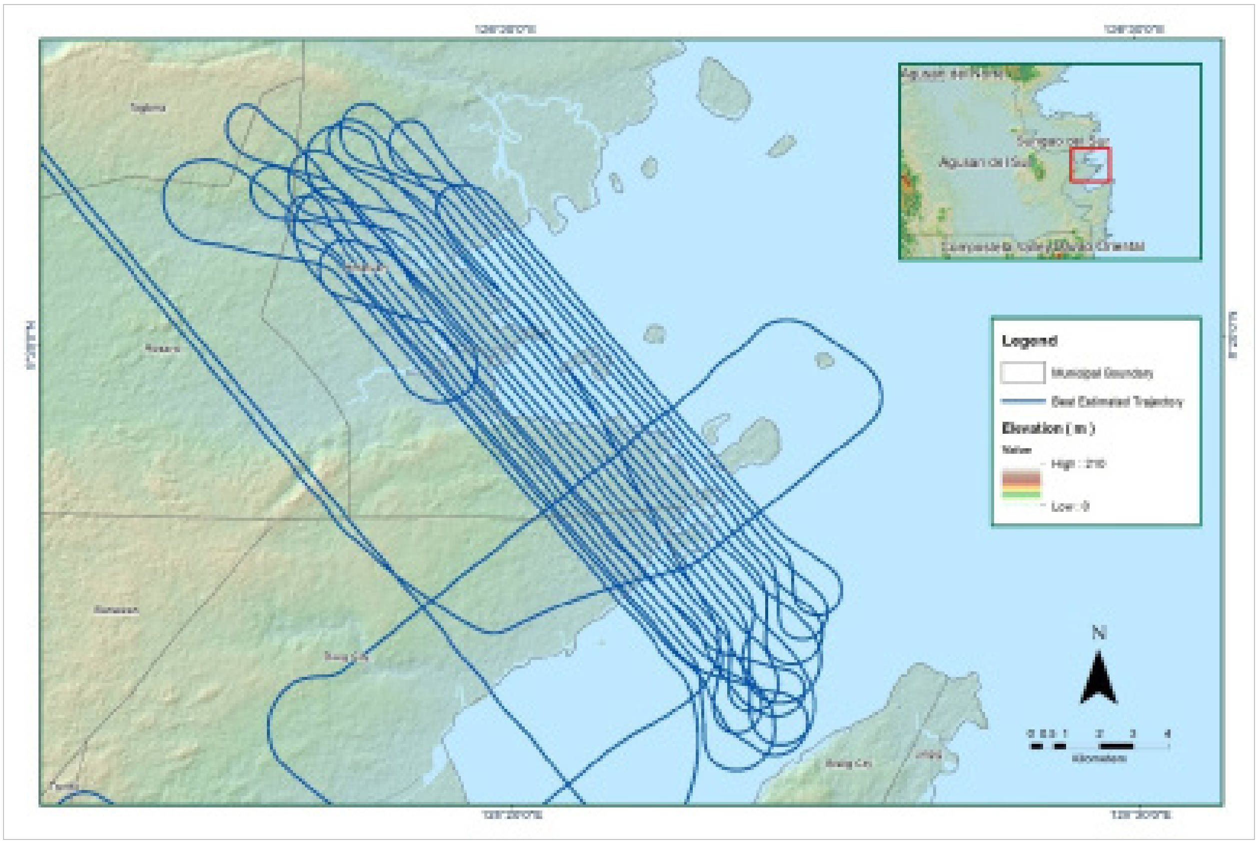


Figure A-8.94. Best Estimated Trajectory

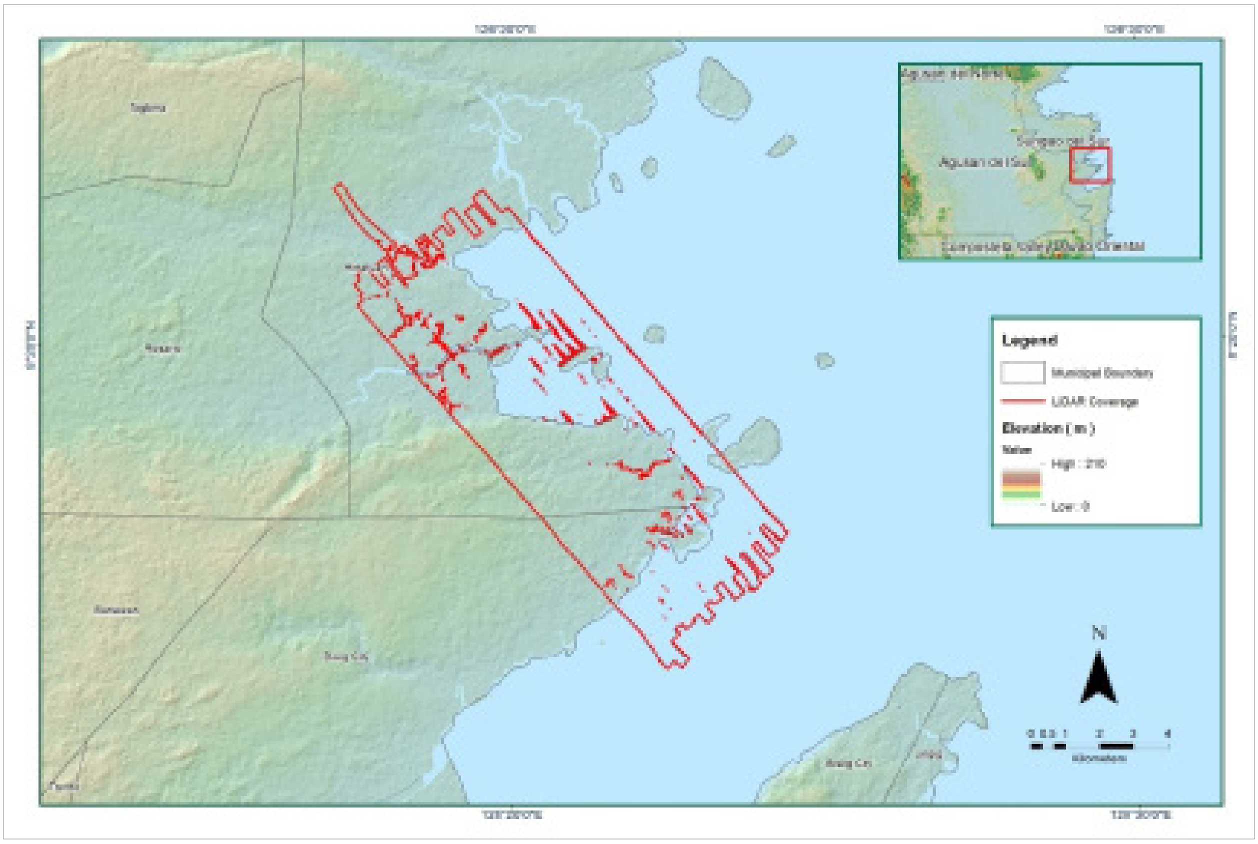


Figure A-8.95 Coverage of LiDAR data

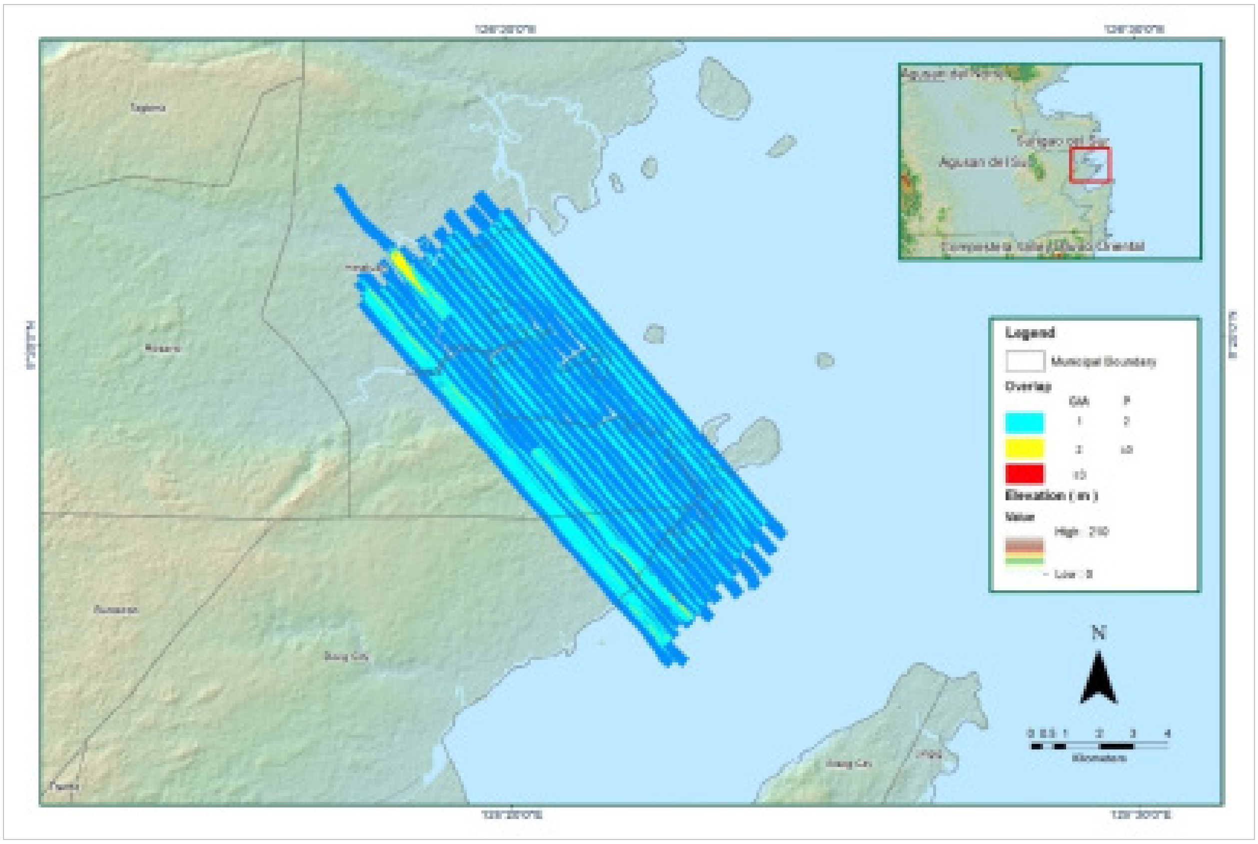


Figure A-8.96. Image of data overlap

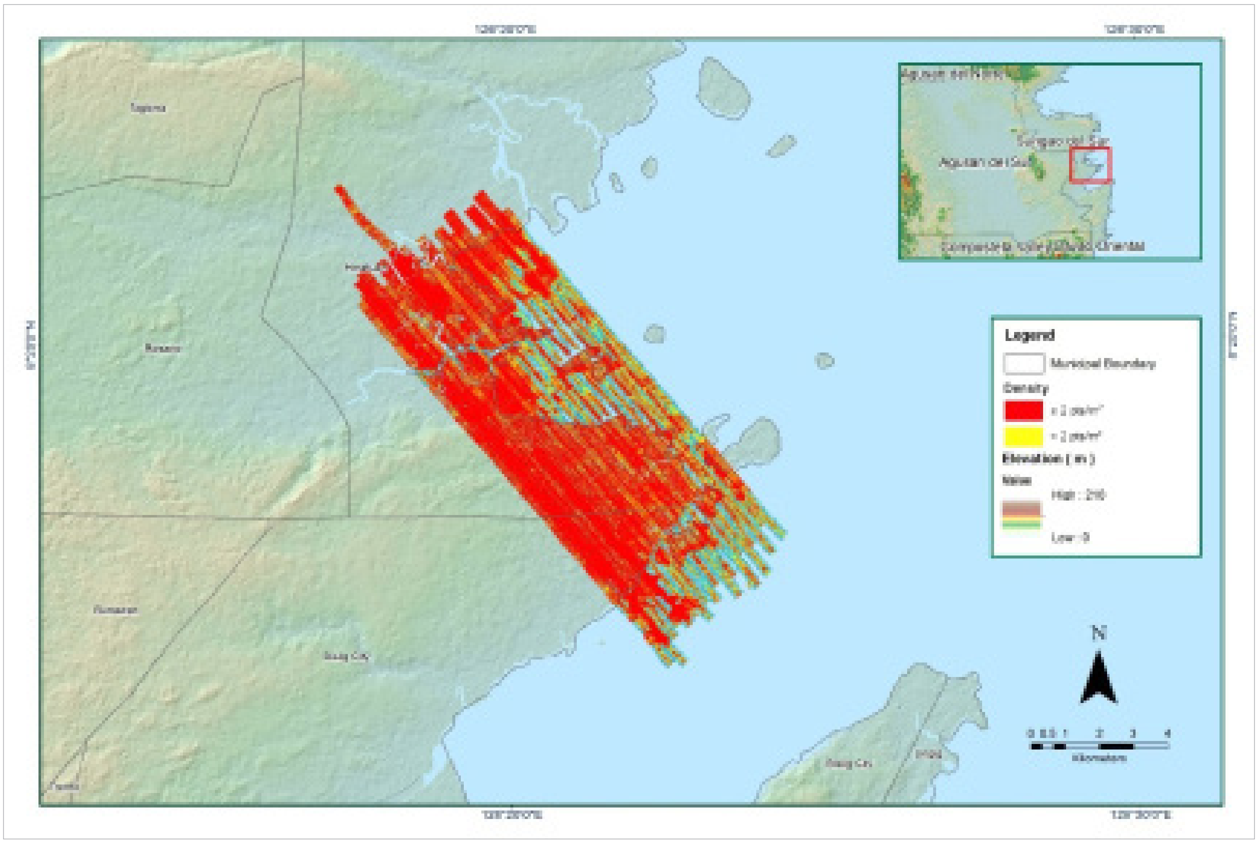


Figure A-8.97. Density map of merged LiDAR data

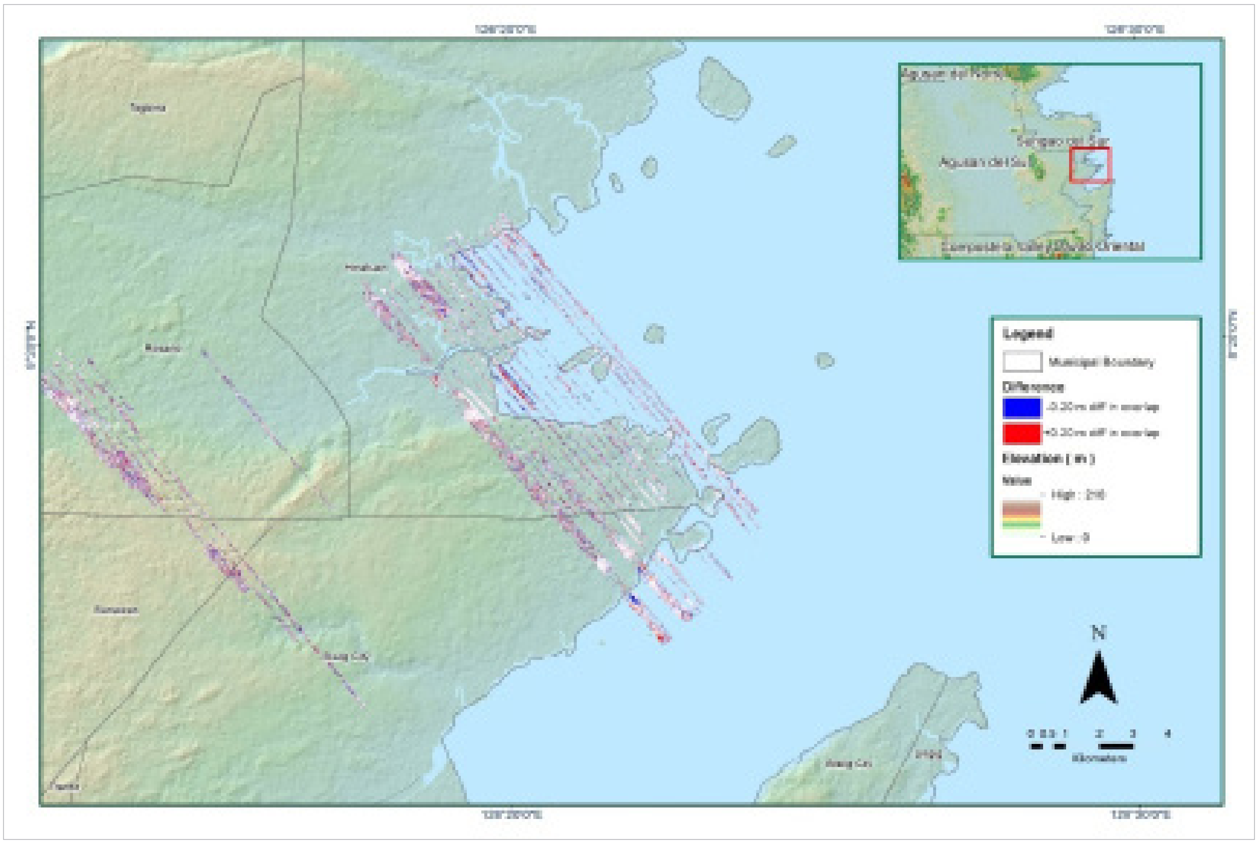


Figure A-8.98. Elevation difference between flight lines

Table A-8.15. Mission Summary Report for Block 66F

Flight Area	Bislig (Surigao Del Sur)
Mission Name	Block 66F
Inclusive Flights	1782A
Range data size	9.97 GB
Base data size	17.4 MB
POS	212 MB
Image	61.20 MB
Transfer date	August 20, 2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	No
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	2.50
RMSE for East Position (<4.0 cm)	2.22
RMSE for Down Position (<8.0 cm)	2.70
Boresight correction stdev (<0.001deg)	0.000443
IMU attitude correction stdev (<0.001deg)	0.001218
GPS position stdev (<0.01m)	0.0099
Minimum % overlap (>25)	54.81
Ave point cloud density per sq.m. (>2.0)	3.41
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	99
Maximum Height	265.6 m
Minimum Height	58.82 m
Classification (# of points)	
Ground	25561773
Low vegetation	24740503
Medium vegetation	54919507
High vegetation	77633766
Building	1970252
Orthophoto	Yes
Processed by	Engr. Carlyn Ann Ibañez, Engr. Mark Joshua Salvacion, Engr. Jeffrey Delica

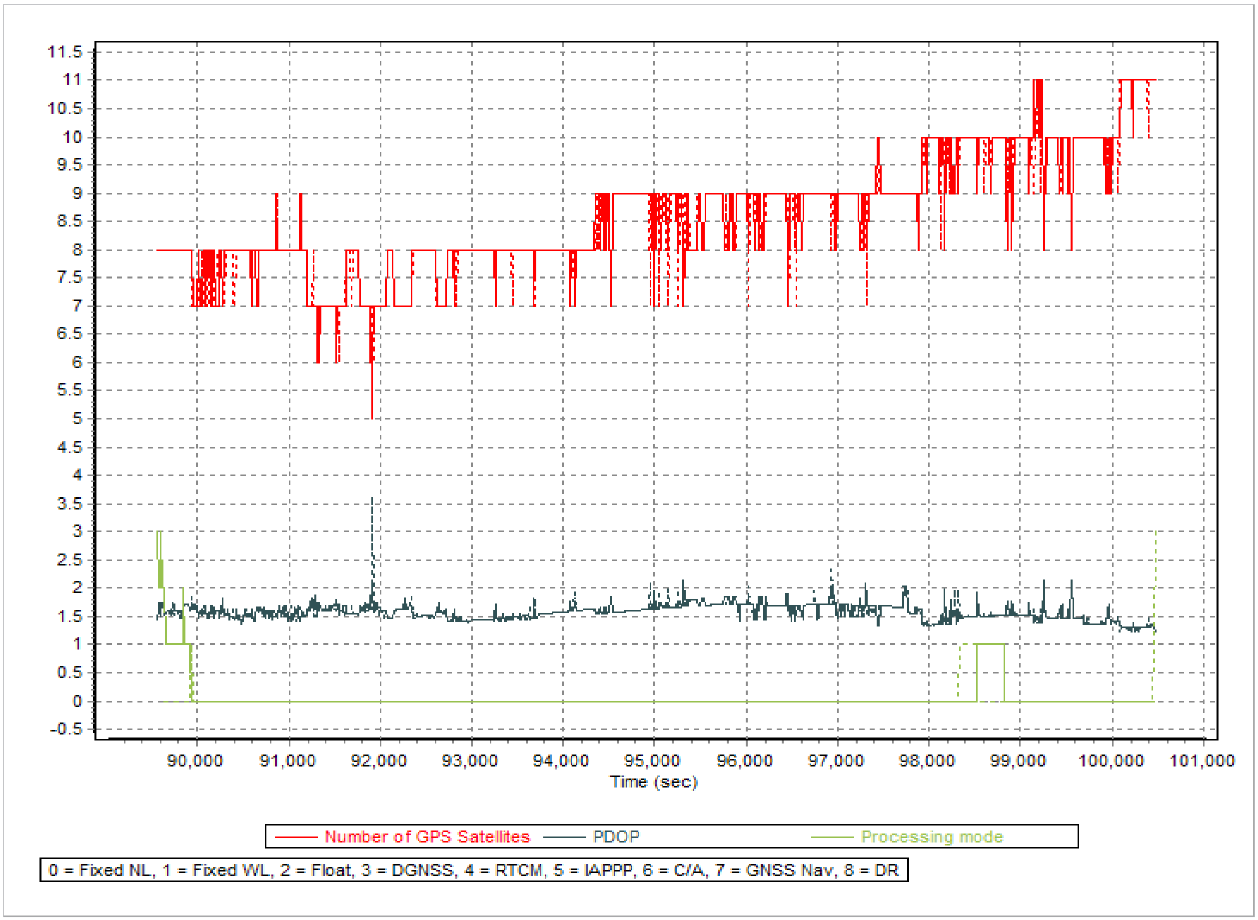


Figure A-8.99. Solution Status

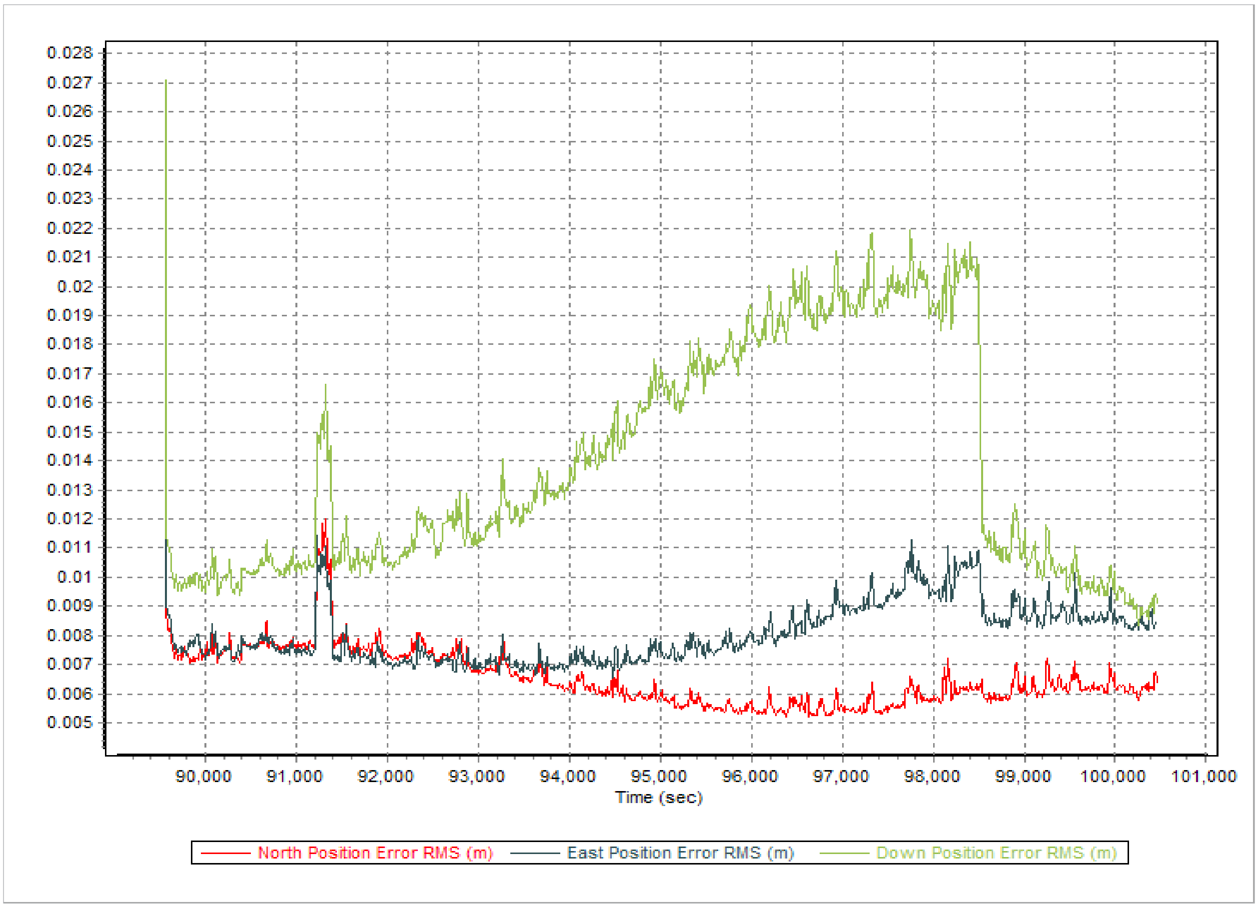


Figure A-8.100. Smoothed Performance Metric Parameters

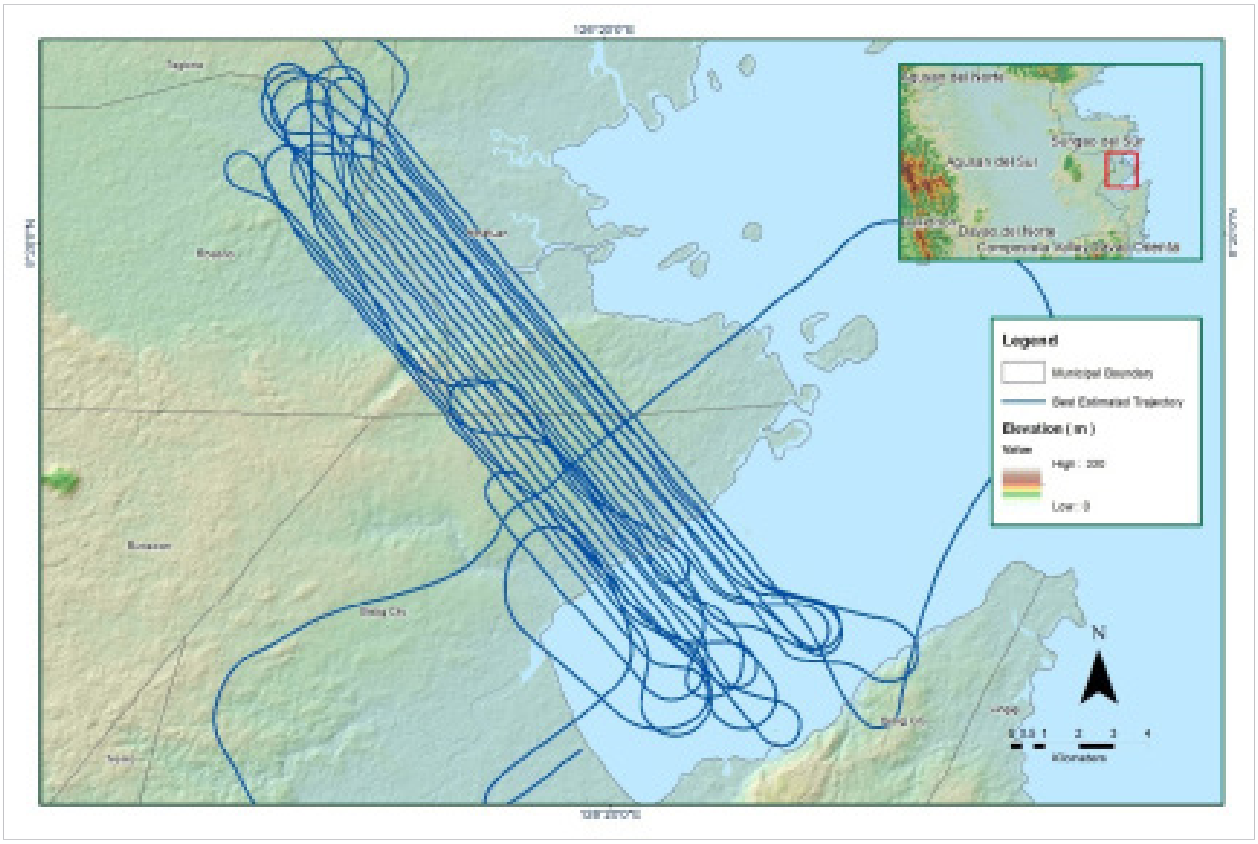


Figure A-8.101. Best Estimated Trajectory

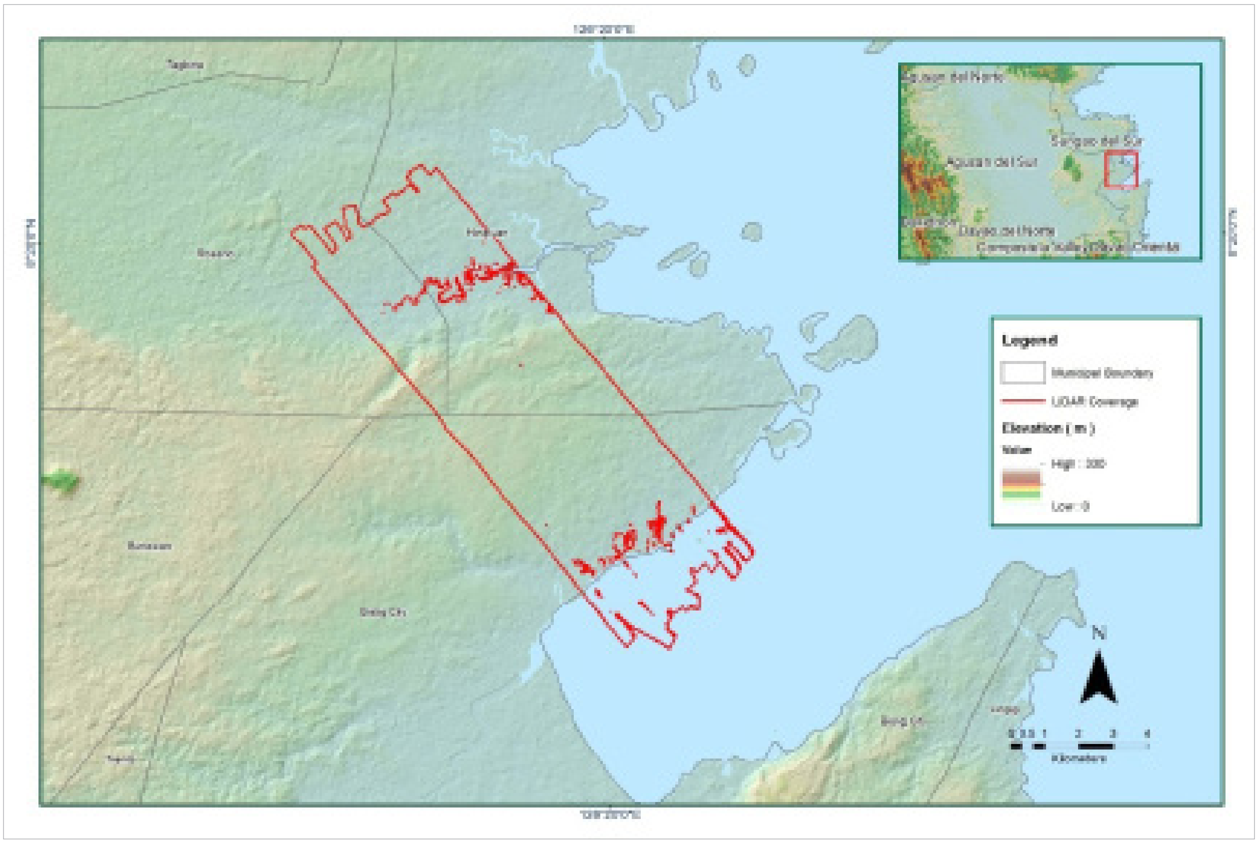


Figure A-8.102. Coverage of LiDAR data

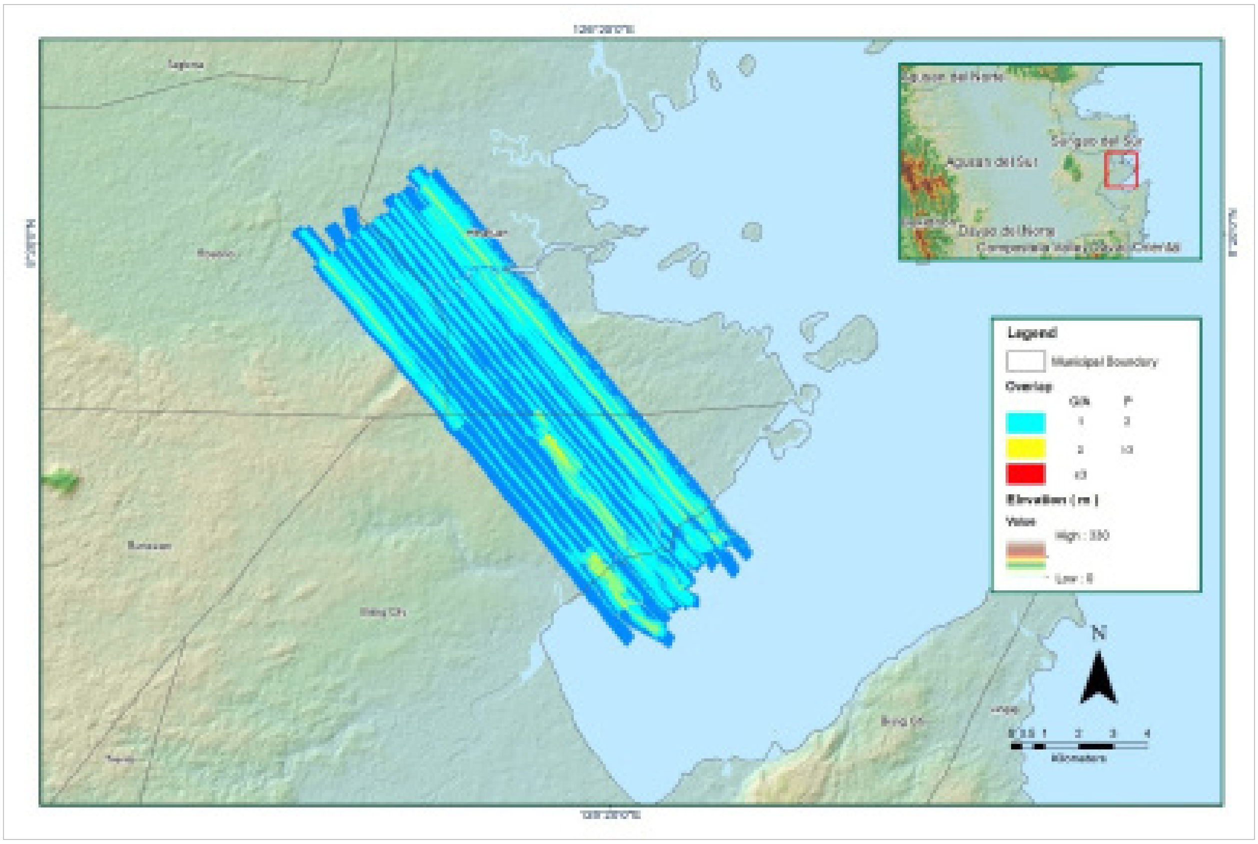


Figure A-8.103. Image of data overlap

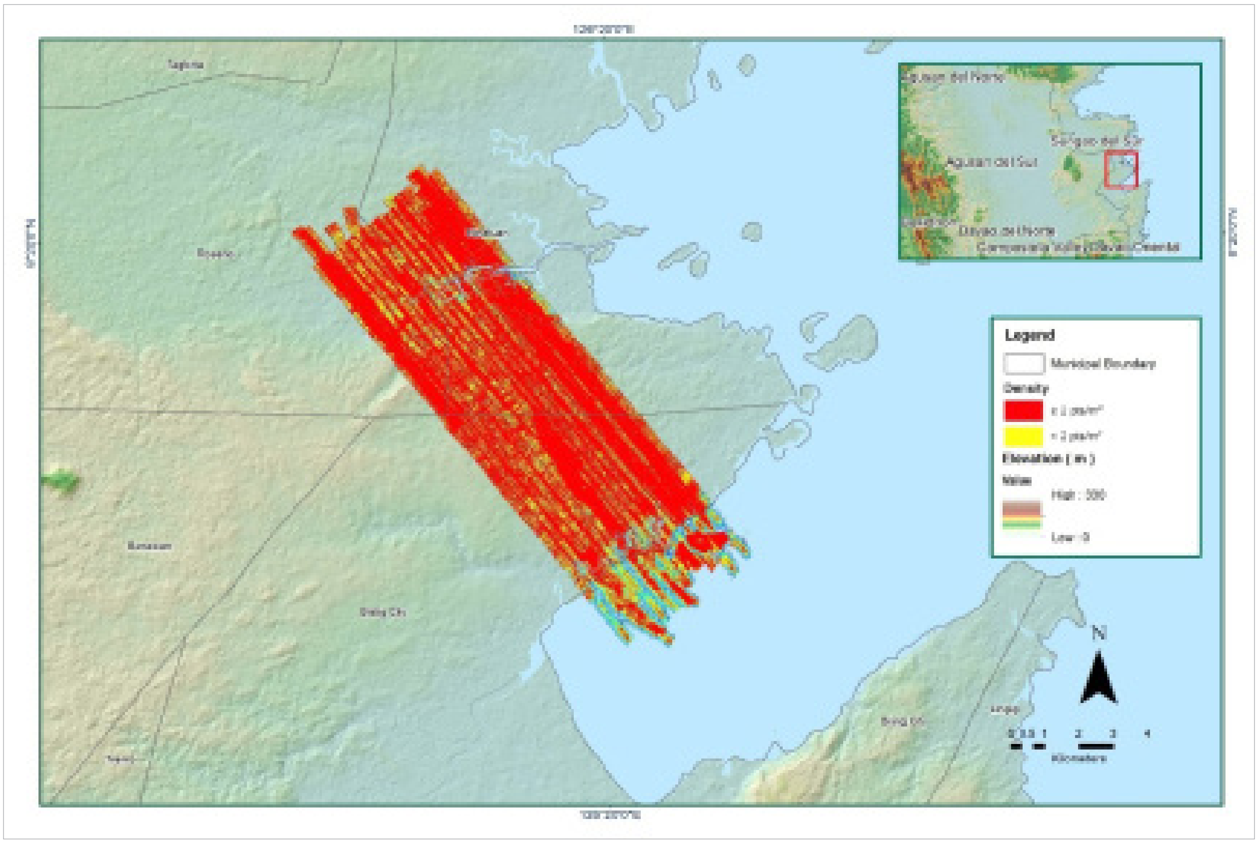


Figure A-8.104. Density map of merged LiDAR data

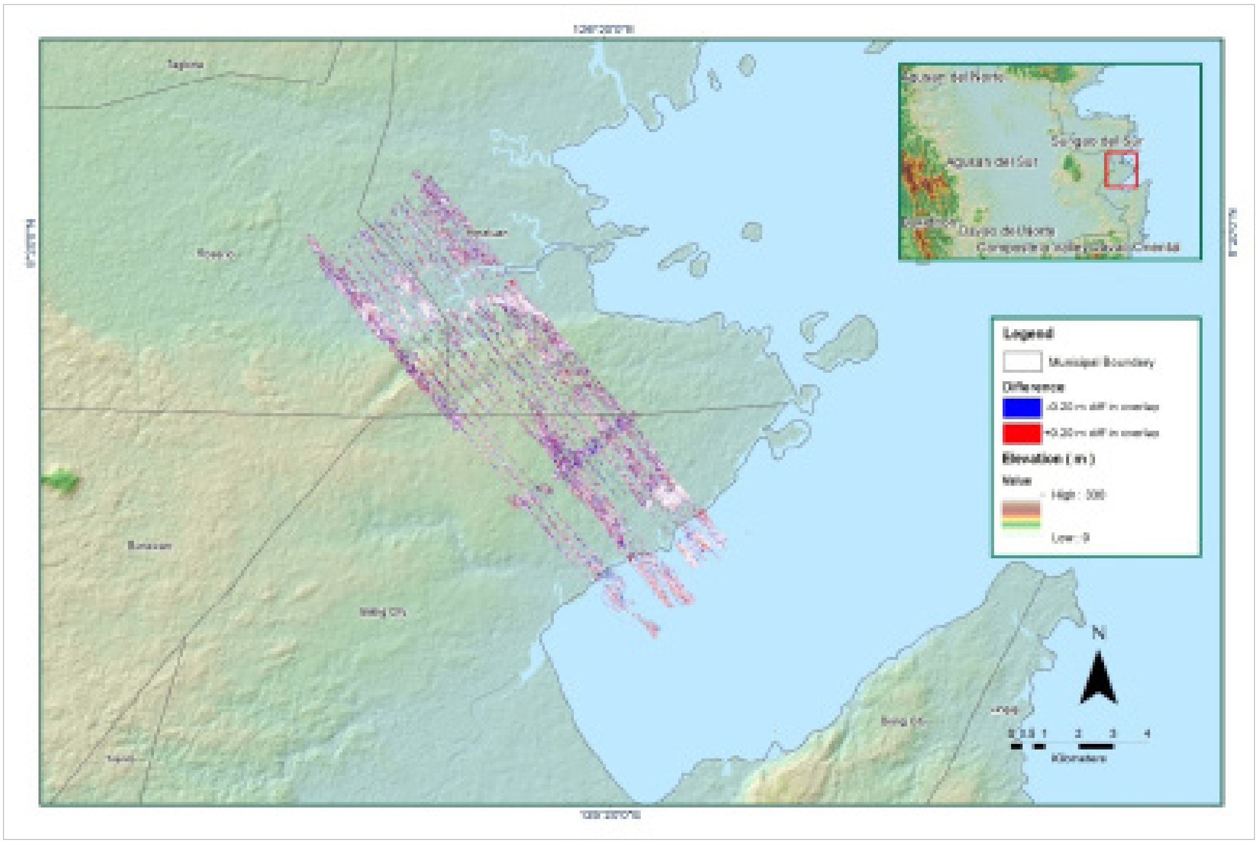


Figure A-8.105. Elevation difference between flight lines

ANNEX 9. Hinatuan Model Basin Parameters

Table A-9.1. Hinatuan Model Basin Parameters

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (m^3/s)	Recession Constant	Threshold Type	Ratio to Peak
W1800	10.65	76.95	2.00	61.17	Discharge	0.8429	0.8	Ratio to Peak	0.25
W1740	10.23	77.90	0.00	29.39	Discharge	0.3574	0.8	Ratio to Peak	0.25
W1700	9.40	76.95	0.00	26.16	Discharge	0.2910	0.8	Ratio to Peak	0.25
W1720	9.52	81.70	0.00	25.68	Discharge	0.1803	0.8	Ratio to Peak	0.25
W1770	10.11	74.10	0.00	20.04	Discharge	0.2850	0.8	Ratio to Peak	0.25
W1730	9.95	78.85	0.00	22.31	Discharge	0.1278	0.8	Ratio to Peak	0.25
W1760	9.00	75.05	0.00	19.86	Discharge	0.0970	0.8	Ratio to Peak	0.25
W1780	9.73	74.10	0.00	5.81	Discharge	0.0070	0.8	Ratio to Peak	0.25
W1810	9.00	78.85	0.00	43.43	Discharge	0.3450	0.8	Ratio to Peak	0.25
W1840	9.77	77.90	0.00	28.21	Discharge	0.2629	0.8	Ratio to Peak	0.25
W1860	8.99	77.90	0.00	41.30	Discharge	0.4925	0.8	Ratio to Peak	0.25
W1960	8.37	78.85	0.00	35.47	Discharge	0.1705	0.8	Ratio to Peak	0.25
W1910	8.59	77.90	0.00	72.16	Discharge	0.3334	0.8	Ratio to Peak	0.25
W1850	8.36	76.00	0.00	74.15	Discharge	0.2605	0.8	Ratio to Peak	0.25
W1710	10.06	83.60	0.00	16.73	Discharge	0.2702	0.8	Ratio to Peak	0.25
W1750	9.98	77.90	0.00	16.87	Discharge	0.2424	0.8	Ratio to Peak	0.25
W1790	8.93	78.85	0.00	45.03	Discharge	0.8175	0.8	Ratio to Peak	0.25
W1820	8.94	78.85	0.00	46.15	Discharge	0.2705	0.8	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (m^3/s)	Recession Constant	Threshold Type	Ratio to Peak
W1830	8.36	77.90	0.00	73.58	Discharge	0.2652	0.8	Ratio to Peak	0.25
W1890	8.36	78.85	0.00	36.70	Discharge	0.0825	0.8	Ratio to Peak	0.25
W1900	8.73	78.85	0.00	37.32	Discharge	0.3538	0.8	Ratio to Peak	0.25
W1920	8.41	78.85	0.00	55.45	Discharge	0.3426	0.8	Ratio to Peak	0.25
W2010	8.36	77.90	0.00	65.63	Discharge	0.2492	0.8	Ratio to Peak	0.25
W1940	8.61	78.85	0.00	51.44	Discharge	0.1880	0.8	Ratio to Peak	0.25
W2070	9.49	76.95	0.00	68.06	Discharge	0.6774	0.8	Ratio to Peak	0.25
W2060	6.60	77.90	0.00	13.72	Discharge	0.0226	0.8	Ratio to Peak	0.25
W2170	5.44	81.70	0.00	73.12	Discharge	0.2108	0.8	Ratio to Peak	0.25
W2160	7.46	79.80	0.00	57.27	Discharge	0.0988	0.8	Ratio to Peak	0.25
W2140	9.41	78.85	0.00	47.52	Discharge	0.2287	0.8	Ratio to Peak	0.25
W2120	8.10	78.85	0.00	53.88	Discharge	0.1869	0.8	Ratio to Peak	0.25
W2280	10.00	78.85	0.00	37.96	Discharge	0.3383	0.8	Ratio to Peak	0.25
W2430	9.22	74.10	0.00	34.48	Discharge	0.2845	0.8	Ratio to Peak	0.25
W2450	7.00	76.95	0.00	75.86	Discharge	0.2580	0.8	Ratio to Peak	0.25
W2310	7.59	77.90	0.00	63.87	Discharge	0.1775	0.8	Ratio to Peak	0.25
W2290	8.36	77.90	0.00	49.46	Discharge	0.2739	0.8	Ratio to Peak	0.25
W2240	8.78	77.90	0.00	62.42	Discharge	0.2544	0.8	Ratio to Peak	0.25
W1980	10.14	77.90	0.00	48.83	Discharge	0.5181	0.8	Ratio to Peak	0.25
W2260	7.90	76.95	0.00	37.78	Discharge	0.2152	0.8	Ratio to Peak	0.25
W2210	7.65	78.85	0.00	41.22	Discharge	0.2275	0.8	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (m^3/s)	Recession Constant	Threshold Type	Ratio to Peak
W2180	8.05	79.80	0.00	30.63	Discharge	0.1670	0.8	Ratio to Peak	0.25
W2090	10.93	78.85	0.00	29.40	Discharge	0.3219	0.8	Ratio to Peak	0.25
W2050	10.52	79.80	0.00	35.42	Discharge	0.2379	0.8	Ratio to Peak	0.25
W2200	7.44	76.95	0.00	22.97	Discharge	0.0825	0.8	Ratio to Peak	0.25
W2150	7.67	79.80	0.00	18.26	Discharge	0.0475	0.8	Ratio to Peak	0.25
W2320	8.18	78.85	0.00	87.42	Discharge	0.8301	0.8	Ratio to Peak	0.25
W2100	8.51	77.90	0.00	42.56	Discharge	0.2909	0.8	Ratio to Peak	0.25
W2220	8.72	78.85	0.00	59.16	Discharge	0.3440	0.8	Ratio to Peak	0.25
W2300	7.87	78.85	0.00	48.19	Discharge	0.1107	0.8	Ratio to Peak	0.25
W2520	10.36	73.15	0.00	51.25	Discharge	0.2544	0.8	Ratio to Peak	0.25
W2500	10.10	73.15	0.00	55.65	Discharge	0.1763	0.8	Ratio to Peak	0.25
W2350	8.15	75.05	0.00	34.33	Discharge	0.0786	0.8	Ratio to Peak	0.25
W2490	7.08	75.05	8.36	25.72	Discharge	0.0448	0.8	Ratio to Peak	0.25
W2130	9.33	78.85	0.00	80.00	Discharge	0.4245	0.8	Ratio to Peak	0.25
W2460	9.05	74.10	14.18	35.02	Discharge	0.0790	0.8	Ratio to Peak	0.25
W1880	9.88	79.80	0.00	163.17	Discharge	2.5819	0.8	Ratio to Peak	0.25
W2420	9.87	73.15	0.00	55.53	Discharge	0.2533	0.8	Ratio to Peak	0.25
W1870	8.64	77.90	0.00	57.97	Discharge	0.4505	0.8	Ratio to Peak	0.25
W1970	9.76	78.85	0.00	56.26	Discharge	0.3244	0.8	Ratio to Peak	0.25
W1990	8.36	79.80	0.00	54.66	Discharge	0.2717	0.8	Ratio to Peak	0.25
W2030	8.36	77.90	0.00	25.40	Discharge	0.0373	0.8	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (m^3/s)	Recession Constant	Threshold Type	Ratio to Peak
W2020	8.91	77.90	0.00	100.03	Discharge	0.7941	0.8	Ratio to Peak	0.25
W2110	8.36	80.75	0.00	80.88	Discharge	0.3028	0.8	Ratio to Peak	0.25
W2250	8.41	73.15	0.00	51.85	Discharge	0.1445	0.8	Ratio to Peak	0.25
W2370	10.59	73.15	0.00	16.39	Discharge	0.0201	0.8	Ratio to Peak	0.25
W2410	8.50	73.15	0.00	53.37	Discharge	0.2617	0.8	Ratio to Peak	0.25
W2390	8.53	77.90	0.00	14.74	Discharge	0.0206	0.8	Ratio to Peak	0.25
W2590	9.76	74.10	0.00	54.16	Discharge	0.1707	0.8	Ratio to Peak	0.25
W2440	9.95	73.15	0.00	44.13	Discharge	0.1695	0.8	Ratio to Peak	0.25
W2560	8.81	73.15	0.00	146.59	Discharge	1.0821	0.8	Ratio to Peak	0.25
W2600	10.97	75.05	0.00	36.83	Discharge	0.0711	0.8	Ratio to Peak	0.25
W2690	11.32	78.85	0.00	71.34	Discharge	0.2188	0.8	Ratio to Peak	0.25
W2640	11.18	73.15	0.00	24.54	Discharge	0.0654	0.8	Ratio to Peak	0.25
W2710	7.89	73.15	0.17	66.93	Discharge	0.3739	0.8	Ratio to Peak	0.25
W2680	9.71	76.00	0.00	70.56	Discharge	0.1973	0.8	Ratio to Peak	0.25
W2730	11.38	76.95	0.00	37.56	Discharge	0.0553	0.8	Ratio to Peak	0.25
W2740	10.78	75.05	0.00	13.17	Discharge	0.0138	0.8	Ratio to Peak	0.25
W2660	10.24	74.10	0.00	58.51	Discharge	0.6862	0.8	Ratio to Peak	0.25
W2800	11.15	77.90	0.00	35.23	Discharge	0.2199	0.8	Ratio to Peak	0.25
W2630	8.90	76.95	0.00	107.30	Discharge	0.5543	0.8	Ratio to Peak	0.25
W2760	11.24	77.90	0.00	59.50	Discharge	0.1993	0.8	Ratio to Peak	0.25
W2810	9.42	76.95	0.00	33.50	Discharge	0.2096	0.8	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (m^3/s)	Recession Constant	Threshold Type	Ratio to Peak
W2770	10.13	77.90	0.00	47.21	Discharge	0.0627	0.8	Ratio to Peak	0.25
W2830	10.65	77.90	0.00	62.95	Discharge	0.1952	0.8	Ratio to Peak	0.25
W2880	10.21	76.95	0.00	39.90	Discharge	0.1748	0.8	Ratio to Peak	0.25
W3000	9.02	74.10	0.00	34.05	Discharge	0.1952	0.8	Ratio to Peak	0.25
W2900	11.38	79.80	0.00	21.12	Discharge	0.0207	0.8	Ratio to Peak	0.25
W2890	11.02	76.00	0.00	62.22	Discharge	0.2413	0.8	Ratio to Peak	0.25
W2790	11.07	77.90	0.00	38.17	Discharge	0.0851	0.8	Ratio to Peak	0.25
W2980	9.29	78.85	0.00	61.92	Discharge	0.3382	0.8	Ratio to Peak	0.25
W2920	11.38	75.05	0.00	5.86	Discharge	0.0024	0.8	Ratio to Peak	0.25
W3040	10.08	78.85	0.00	61.66	Discharge	0.2934	0.8	Ratio to Peak	0.25
W3020	11.38	78.85	0.00	26.85	Discharge	0.0439	0.8	Ratio to Peak	0.25
W3080	10.46	78.85	0.00	53.05	Discharge	0.2154	0.8	Ratio to Peak	0.25
W3070	11.38	77.90	0.00	16.74	Discharge	0.0208	0.8	Ratio to Peak	0.25
W2870	9.17	75.05	0.00	64.64	Discharge	0.3079	0.8	Ratio to Peak	0.25
W3050	10.82	75.05	0.00	49.16	Discharge	0.2285	0.8	Ratio to Peak	0.25
W2840	8.88	76.00	0.00	62.58	Discharge	0.3437	0.8	Ratio to Peak	0.25
W2960	11.38	77.90	0.00	13.09	Discharge	0.0130	0.8	Ratio to Peak	0.25
W2820	10.88	77.90	0.00	74.58	Discharge	0.3617	0.8	Ratio to Peak	0.25
W2940	11.38	78.85	0.00	12.39	Discharge	0.0143	0.8	Ratio to Peak	0.25
W3060	11.28	76.95	0.00	72.10	Discharge	0.3950	0.8	Ratio to Peak	0.25
W2970	9.97	77.90	0.00	19.08	Discharge	0.0302	0.8	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (m^3/s)	Recession Constant	Threshold Type	Ratio to Peak
W2850	8.45	77.90	0.00	56.09	Discharge	0.3033	0.8	Ratio to Peak	0.25
W3010	9.87	74.10	0.00	54.38	Discharge	0.1558	0.8	Ratio to Peak	0.25
W3200	11.38	77.90	0.00	56.98	Discharge	0.4493	0.8	Ratio to Peak	0.25
W3090	11.06	80.75	0.00	61.15	Discharge	0.2766	0.8	Ratio to Peak	0.25
W3460	10.30	75.05	0.00	50.44	Discharge	0.2937	0.8	Ratio to Peak	0.25
W3450	9.40	78.85	0.00	57.49	Discharge	0.2674	0.8	Ratio to Peak	0.25
W3250	11.38	76.95	0.00	40.29	Discharge	0.2574	0.8	Ratio to Peak	0.25
W2510	7.83	75.05	0.00	72.79	Discharge	0.4862	0.8	Ratio to Peak	0.25
W2570	8.62	76.95	0.00	49.35	Discharge	0.4058	0.8	Ratio to Peak	0.25
W2620	7.71	73.15	0.00	50.09	Discharge	0.5821	0.8	Ratio to Peak	0.25
W2610	8.33	76.00	0.00	31.33	Discharge	0.2867	0.8	Ratio to Peak	0.25
W2670	7.79	73.15	0.00	68.77	Discharge	0.3563	0.8	Ratio to Peak	0.25
W2720	7.78	74.10	0.00	28.20	Discharge	0.1067	0.8	Ratio to Peak	0.25
W2750	9.08	76.00	0.00	52.96	Discharge	0.2584	0.8	Ratio to Peak	0.25
W3190	11.38	77.90	0.00	11.63	Discharge	0.0111	0.8	Ratio to Peak	0.25
W2930	8.43	75.05	0.00	58.57	Discharge	0.2849	0.8	Ratio to Peak	0.25
W3210	11.12	76.95	0.00	27.88	Discharge	0.1530	0.8	Ratio to Peak	0.25
W2910	7.56	77.90	0.00	44.44	Discharge	0.2471	0.8	Ratio to Peak	0.25
W3100	7.90	76.95	0.00	40.12	Discharge	0.1838	0.8	Ratio to Peak	0.25
W3110	9.10	75.05	0.00	37.88	Discharge	0.6227	0.8	Ratio to Peak	0.25
W3170	7.50	76.00	0.00	2.94	Discharge	0.0008	0.8	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (m^3/s)	Recession Constant	Threshold Type	Ratio to Peak
W3220	7.27	77.90	0.00	18.72	Discharge	0.1662	0.8	Ratio to Peak	0.25
W3180	6.55	77.90	0.00	6.16	Discharge	0.0099	0.8	Ratio to Peak	0.25
W2780	7.31	74.10	0.00	40.65	Discharge	0.4587	0.8	Ratio to Peak	0.25
W2860	7.26	76.00	0.00	31.58	Discharge	0.1976	0.8	Ratio to Peak	0.25
W2950	7.59	76.95	0.00	42.25	Discharge	0.2429	0.8	Ratio to Peak	0.25
W2990	8.07	79.80	0.00	5.83	Discharge	0.0019	0.8	Ratio to Peak	0.25
W3130	8.03	76.00	0.00	18.49	Discharge	0.1014	0.8	Ratio to Peak	0.25
W3150	6.76	83.60	0.00	15.83	Discharge	0.0514	0.8	Ratio to Peak	0.25
W3230	8.18	77.90	0.00	28.78	Discharge	0.2342	0.8	Ratio to Peak	0.25
W3160	8.09	80.75	0.00	27.42	Discharge	0.1931	0.8	Ratio to Peak	0.25
W3030	8.13	78.85	0.00	41.86	Discharge	0.4099	0.8	Ratio to Peak	0.25
W3140	8.98	79.80	0.00	23.34	Discharge	0.1677	0.8	Ratio to Peak	0.25
W2040	8.54	77.90	0.00	70.67	Discharge	0.8796	0.8	Ratio to Peak	0.25
W2380	7.46	76.00	0.00	41.80	Discharge	0.2621	0.8	Ratio to Peak	0.25
W2190	8.10	79.80	0.00	44.43	Discharge	0.4022	0.8	Ratio to Peak	0.25
W2360	8.14	74.10	0.00	16.90	Discharge	0.0127	0.8	Ratio to Peak	0.25
W1930	8.28	78.85	0.00	36.27	Discharge	0.5407	0.8	Ratio to Peak	0.25
W2000	8.24	76.95	0.00	29.97	Discharge	0.2053	0.8	Ratio to Peak	0.25
W1950	8.99	78.85	0.00	48.02	Discharge	0.4678	0.8	Ratio to Peak	0.25
W2080	7.38	77.90	0.00	21.27	Discharge	0.1008	0.8	Ratio to Peak	0.25
W2330	8.18	73.15	0.00	45.77	Discharge	0.1767	0.8	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (m^3/s)	Recession Constant	Threshold Type	Ratio to Peak
W2230	7.64	74.10	0.00	33.52	Discharge	0.1257	0.8	Ratio to Peak	0.25
W2270	7.89	78.85	0.00	44.96	Discharge	0.5564	0.8	Ratio to Peak	0.25
W2400	7.96	75.05	0.00	39.79	Discharge	0.3521	0.8	Ratio to Peak	0.25
W2480	7.96	73.15	0.00	26.58	Discharge	0.1982	0.8	Ratio to Peak	0.25
W2540	7.74	74.10	0.00	30.67	Discharge	0.1682	0.8	Ratio to Peak	0.25
W2340	7.79	76.00	0.00	29.17	Discharge	0.2241	0.8	Ratio to Peak	0.25
W2530	8.32	76.95	0.00	22.94	Discharge	0.1167	0.8	Ratio to Peak	0.25
W2470	7.73	76.95	0.00	34.73	Discharge	0.1635	0.8	Ratio to Peak	0.25
W2550	8.07	74.10	0.00	10.04	Discharge	0.0017	0.8	Ratio to Peak	0.25
W2650	7.35	75.05	0.00	40.39	Discharge	0.2044	0.8	Ratio to Peak	0.25
W2580	8.46	75.05	0.00	27.83	Discharge	0.1460	0.8	Ratio to Peak	0.25
W2700	8.17	73.15	0.00	50.27	Discharge	0.6758	0.8	Ratio to Peak	0.25
W3240	9.47	76.95	0.00	23.45	Discharge	0.1459	0.8	Ratio to Peak	0.25
W3270	8.73	75.05	0.00	34.64	Discharge	0.4297	0.8	Ratio to Peak	0.25
W3260	8.15	75.05	0.00	36.18	Discharge	0.3283	0.8	Ratio to Peak	0.25
W3410	7.67	76.00	0.00	33.70	Discharge	0.3419	0.8	Ratio to Peak	0.25
W5600	7.79	74.10	0.00	21.48	Discharge	0.0921	0.8	Ratio to Peak	0.25
W3290	9.36	77.90	0.00	56.46	Discharge	0.3212	0.8	Ratio to Peak	0.25
W5590	8.49	77.90	0.00	53.27	Discharge	0.1587	0.8	Ratio to Peak	0.25
W3350	11.07	76.95	0.00	67.68	Discharge	0.2822	0.8	Ratio to Peak	0.25
W3340	10.63	76.00	0.00	58.64	Discharge	0.2345	0.8	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (m^3/s)	Recession Constant	Threshold Type	Ratio to Peak
W3310	10.21	76.95	0.00	51.90	Discharge	0.2993	0.8	Ratio to Peak	0.25
W3330	8.51	76.95	0.00	9.79	Discharge	0.0211	0.8	Ratio to Peak	0.25
W3300	8.38	77.90	0.00	64.26	Discharge	0.6713	0.8	Ratio to Peak	0.25
W3380	7.98	76.00	0.00	62.85	Discharge	0.2270	0.8	Ratio to Peak	0.25
W3370	7.05	75.05	0.00	55.92	Discharge	0.0737	0.8	Ratio to Peak	0.25
W3320	5.77	76.00	0.00	26.70	Discharge	0.0633	0.8	Ratio to Peak	0.25
W3360	9.18	75.05	0.01	88.87	Discharge	0.1984	0.8	Ratio to Peak	0.25

ANNEX 10. Hinatuan Model Reach Parameters

Table A-10.1. Hinatuan Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R80	Automatic Fixed Interval	1424.00	0.006610	0.15	Rectangle	27.31
R30	Automatic Fixed Interval	1237.10	0.009450	0.15	Rectangle	23.25
R90	Automatic Fixed Interval	446.27	0.014464	0.15	Rectangle	22.77
R140	Automatic Fixed Interval	6740.70	0.004432	0.15	Rectangle	24.82
R210	Automatic Fixed Interval	4405.30	0.001505	0.15	Rectangle	15.00
R200	Automatic Fixed Interval	2597.60	0.000990	0.15	Rectangle	15.87
R170	Automatic Fixed Interval	825.69	0.002049	0.15	Rectangle	17.00
R110	Automatic Fixed Interval	6748.10	0.009247	0.15	Rectangle	17.00
R150	Automatic Fixed Interval	5362.30	0.001213	0.15	Rectangle	12.88
R190	Automatic Fixed Interval	3860.90	0.000564	0.15	Rectangle	22.93
R250	Automatic Fixed Interval	3288.80	0.000736	0.15	Rectangle	26.05
R310	Automatic Fixed Interval	757.70	0.000023	0.15	Rectangle	23.36
R340	Automatic Fixed Interval	353.85	0.002014	0.15	Rectangle	22.48
R370	Automatic Fixed Interval	3539.90	0.001577	0.15	Rectangle	24.56
R550	Automatic Fixed Interval	3788.90	0.001269	0.15	Rectangle	28.60
R700	Automatic Fixed Interval	3918.20	0.004423	0.15	Rectangle	14.12
R620	Automatic Fixed Interval	3875.50	0.002366	0.15	Rectangle	22.36
R690	Automatic Fixed Interval	2616.60	0.001369	0.15	Rectangle	24.00
R470	Automatic Fixed Interval	2988.10	0.001591	0.15	Rectangle	13.29
R430	Automatic Fixed Interval	1220.50	0.000513	0.15	Rectangle	13.64
R420	Automatic Fixed Interval	1273.70	0.006661	0.15	Rectangle	8.55
R510	Automatic Fixed Interval	6284.40	0.004965	0.15	Rectangle	21.67
R530	Automatic Fixed Interval	2349.70	0.002336	0.15	Rectangle	23.65
R710	Automatic Fixed Interval	2166.20	0.000023	0.15	Rectangle	24.04
R750	Automatic Fixed Interval	923.97	0.001695	0.15	Rectangle	8.55
R720	Automatic Fixed Interval	798.41	0.001591	0.15	Rectangle	29.49
R670	Automatic Fixed Interval	2792.80	0.001347	0.15	Rectangle	33.04
R610	Automatic Fixed Interval	685.98	0.000190	0.15	Rectangle	29.29

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R280	Automatic Fixed Interval	1135.70	0.000679	0.15	Rectangle	22.10
R450	Automatic Fixed Interval	3605.80	0.001783	0.15	Rectangle	20.56
R570	Automatic Fixed Interval	1809.20	0.001613	0.15	Rectangle	18.05
R650	Automatic Fixed Interval	551.13	0.001923	0.15	Rectangle	47.15
R850	Automatic Fixed Interval	1805.40	0.001293	0.15	Rectangle	34.59
R870	Automatic Fixed Interval	1440.50	0.001378	0.15	Rectangle	37.24
R940	Automatic Fixed Interval	1053.00	0.000060	0.15	Rectangle	34.10
R1030	Automatic Fixed Interval	2089.20	0.000791	0.15	Rectangle	32.95
R1020	Automatic Fixed Interval	488.70	0.006748	0.15	Rectangle	36.45
R1110	Automatic Fixed Interval	2451.10	0.000957	0.15	Rectangle	35.70
R1060	Automatic Fixed Interval	4113.70	0.003297	0.15	Rectangle	12.68
R1050	Automatic Fixed Interval	1980.40	0.000525	0.15	Rectangle	14.16
R1090	Automatic Fixed Interval	2544.20	0.000186	0.15	Rectangle	17.11
R1180	Automatic Fixed Interval	544.56	0.004760	0.15	Rectangle	30.90
R1190	Automatic Fixed Interval	2730.50	0.002813	0.15	Rectangle	37.33
R1140	Automatic Fixed Interval	106.57	0.000023	0.15	Rectangle	27.08
R1210	Automatic Fixed Interval	652.84	0.000810	0.15	Rectangle	45.26
R1270	Automatic Fixed Interval	731.84	0.000023	0.15	Rectangle	36.48
R1260	Automatic Fixed Interval	2901.50	0.000731	0.15	Rectangle	41.59
R1240	Automatic Fixed Interval	718.70	0.000187	0.15	Rectangle	48.93
R1150	Automatic Fixed Interval	660.12	0.001204	0.15	Rectangle	40.62
R1220	Automatic Fixed Interval	701.13	0.001143	0.15	Rectangle	36.70
R1280	Automatic Fixed Interval	2076.90	0.000238	0.15	Rectangle	44.28
R1370	Automatic Fixed Interval	1668.50	0.000365	0.15	Rectangle	48.72
R3470	Automatic Fixed Interval	1636.80	0.000558	0.15	Rectangle	43.68
R1450	Automatic Fixed Interval	2291.40	0.000023	0.15	Rectangle	60.05
R1470	Automatic Fixed Interval	514.56	0.003575	0.15	Rectangle	52.08
R980	Automatic Fixed Interval	1575.40	0.000948	0.15	Rectangle	18.99
R990	Automatic Fixed Interval	3337.50	0.001854	0.15	Rectangle	15.23
R1360	Automatic Fixed Interval	3873.70	0.005783	0.15	Rectangle	34.31

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R1480	Automatic Fixed Interval	1230.20	0.000674	0.15	Rectangle	58.53
R1440	Automatic Fixed Interval	3748.90	0.000023	0.15	Rectangle	56.27
R1350	Automatic Fixed Interval	96.57	0.029113	0.15	Rectangle	40.51
R1410	Automatic Fixed Interval	412.84	0.000023	0.15	Rectangle	55.01
R1420	Automatic Fixed Interval	1197.10	0.000986	0.15	Rectangle	65.11
R1230	Automatic Fixed Interval	144.85	0.000635	0.15	Rectangle	26.09
R1320	Automatic Fixed Interval	1514.40	0.005616	0.15	Rectangle	96.56
R1510	Automatic Fixed Interval	2852.10	0.000366	0.15	Rectangle	64.61
R1400	Automatic Fixed Interval	1897.10	0.000023	0.15	Rectangle	69.38
R1490	Automatic Fixed Interval	1226.40	0.000023	0.15	Rectangle	65.21
R580	Automatic Fixed Interval	444.56	0.007322	0.15	Rectangle	21.63
R590	Automatic Fixed Interval	2322.50	0.002291	0.15	Rectangle	24.23
R410	Automatic Fixed Interval	1854.40	0.005737	0.15	Rectangle	8.55
R600	Automatic Fixed Interval	2799.50	0.003970	0.15	Rectangle	8.55
R800	Automatic Fixed Interval	2990.50	0.000023	0.15	Rectangle	25.93
R830	Automatic Fixed Interval	28.28	0.000023	0.15	Rectangle	8.55
R770	Automatic Fixed Interval	1228.40	0.002501	0.15	Rectangle	8.55
R840	Automatic Fixed Interval	1097.40	0.000023	0.15	Rectangle	8.55
R930	Automatic Fixed Interval	2065.80	0.002060	0.15	Rectangle	8.55
R1500	Automatic Fixed Interval	4547.60	0.010366	0.15	Rectangle	27.06
R1570	Automatic Fixed Interval	2442.80	0.000360	0.15	Rectangle	55.50
R3420	Automatic Fixed Interval	1567.40	0.000023	0.15	Rectangle	80.14
R5610	Automatic Fixed Interval	1330.70	0.000606	0.15	Rectangle	78.31
R1610	Automatic Fixed Interval	2160.10	0.000023	0.15	Rectangle	78.32
R1650	Automatic Fixed Interval	692.13	0.000304	0.15	Rectangle	176.71
R1630	Automatic Fixed Interval	666.98	0.014944	0.15	Rectangle	31.83
R1660	Automatic Fixed Interval	5013.90	0.007058	0.15	Rectangle	48.95
R1670	Automatic Fixed Interval	936.40	0.000586	0.15	Rectangle	188.01
R1690	Automatic Fixed Interval	2051.20	0.000023	0.15	Rectangle	159.47

ANNEX 11. Hinatuan Field Validation Points

Table A-11.1. Hinatuan Field Validation Points

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
1	8.364539	126.3334	0.03	0.3	0.000	Agaton	5-year
2	8.363677	126.3313	0.04	0.12	0.080	Agaton	5-year
3	8.364121	126.3317	0.04	0	-0.040	Agaton	5-year
4	8.364417	126.332	0.03	0	-0.030	Agaton	5-year
5	8.364786	126.3324	0.09	0.17	0.080	Agaton	5-year
6	8.365023	126.3335	0.17	0.35	0.180	Agaton	5-year
7	8.364571	126.3346	0.09	0.18	0.090	Agaton	5-year
8	8.364146	126.3349	0.29	0.3	0.010	Agaton	5-year
9	8.363566	126.3351	0.28	0	-0.280	Agaton	5-year
10	8.364212	126.3353	0.22	0.3	0.080	Agaton	5-year
11	8.367463	126.3383	0.06	0	-0.060	Agaton	5-year
12	8.368847	126.3381	0.18	0	-0.180	Agaton	5-year
13	8.370949	126.3376	0.89	0	-0.890	Agaton	5-year
14	8.371968	126.3371	0.26	0.6	0.340	Agaton	5-year
15	8.374103	126.3341	0.03	0	-0.030	Agaton	5-year
16	8.372097	126.3358	0.26	0.04	-0.220	Agaton	5-year
17	8.36911	126.335	0.3	0	-0.300	Agaton	5-year
18	8.36852	126.3313	0.58	0.13	-0.450	Agaton	5-year
19	8.370251	126.3337	0.25	0	-0.250	Agaton	5-year
20	8.371115	126.3317	0.16	0	-0.160	Agaton	5-year
21	8.371596	126.3285	0.24	0	-0.240	Agaton	5-year
22	8.33727	126.3262	0	0.26	0.260	Agaton	5-year
23	8.403148	126.3219	0.07	0	-0.070	Agaton	5-year
24	8.403607	126.3223	0.1	0	-0.100	Agaton	5-year
25	8.403639	126.3371	0.03	0	-0.030	Agaton	5-year
26	8.40357	126.3377	0.03	0	-0.030	Agaton	5-year
27	8.405224	126.338	0.03	0	-0.030	Agaton	5-year
28	8.424132	126.3153	0.04	0	-0.040	Agaton	5-year
29	8.423925	126.3158	0.08	0	-0.080	Agaton	5-year
30	8.423474	126.3161	0.07	0	-0.070	Agaton	5-year
31	8.372463	126.3223	0.39	0	-0.390	Agaton	5-year
32	8.374583	126.32	0.1	0.03	-0.070	Agaton	5-year
33	8.372868	126.3163	0.14	0	-0.140	Agaton	5-year
34	8.370529	126.3121	0.38	0	-0.380	Agaton	5-year
35	8.368819	126.3129	0.05	0.95	0.900	Agaton	5-year
36	8.364254	126.3218	0.21	0	-0.210	Agaton	5-year
37	8.362636	126.3286	0.08	0	-0.080	Agaton	5-year
38	8.363346	126.3309	0.05	0.63	0.580	Agaton	5-year
39	8.356979	126.2674	0.03	0	-0.030	Agaton	5-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
40	8.354631	126.2664	0.03	0	-0.030	Agaton	5-year
41	8.342638	126.3183	0	0	0.000	Agaton	5-year
42	8.342571	126.3186	0	0	0.000	Agaton	5-year
43	8.341745	126.3227	0	0	0.000	Agaton	5-year
44	8.319812	126.2725	0.03	0	-0.030	Agaton	5-year
45	8.319149	126.2741	0.03	0	-0.030	Agaton	5-year
46	8.317695	126.275	0	0.5	0.500	Agaton	5-year
47	8.369597	126.2621	0.03	0	-0.030	Agaton	5-year
48	8.36957	126.2535	0.05	0	-0.050	Agaton	5-year
49	8.369569	126.2532	0.07	0	-0.070	Agaton	5-year
50	8.36998	126.2496	0.77	0	-0.770	Agaton	5-year
51	8.38972	126.2433	0.03	0	-0.030	Agaton	5-year
52	8.389895	126.2433	0.11	0	-0.110	Agaton	5-year
53	8.391496	126.2438	0.03	0	-0.030	Agaton	5-year
54	8.391556	126.2439	0.04	0	-0.040	Agaton	5-year
55	8.397622	126.2801	1.27	0.1	-1.170	Agaton	5-year
56	8.414518	126.255	0.56	0	-0.560	Agaton	5-year
57	8.415118	126.2548	0.03	0.8	0.770	Agaton	5-year
58	8.414912	126.2546	0.03	0	-0.030	Agaton	5-year
59	8.368886	126.2953	0.03	0	-0.030	Agaton	5-year
60	8.370474	126.2972	0.03	0	-0.030	Agaton	5-year
61	8.452739	126.262	0.03	0	-0.030	Agaton	5-year
62	8.453302	126.252	0.44	0	-0.440	Agaton	5-year
63	8.451396	126.2518	1.38	0	-1.380	Agaton	5-year
64	8.4511	126.2524	0.14	0	-0.140	Agaton	5-year
65	8.473721	126.2371	0.07	0	-0.070	Agaton	5-year
66	8.473735	126.2366	0.07	0	-0.070	Agaton	5-year
67	8.476041	126.234	0.32	0	-0.320	Agaton	5-year
68	8.475748	126.2321	0.22	0.3	0.080	Agaton	5-year
69	8.47775	126.2313	0.05	0	-0.050	Agaton	5-year
70	8.475527	126.2121	1.53	0.74	-0.790	Agaton	5-year
71	8.511474	126.1279	0.03	0	-0.030	Agaton	5-year
72	8.475066	126.2123	0.54	0	-0.540	Agaton	5-year
73	8.511795	126.1608	0.03	0	-0.030	Agaton	5-year
74	8.511896	126.1611	0.04	0	-0.040	Agaton	5-year
75	8.512077	126.1601	0.06	0	-0.060	Agaton	5-year
76	8.511159	126.1282	0.03	0.2	0.170	Agaton	5-year
77	8.511479	126.1595	0.06	0	-0.060	Agaton	5-year
78	8.420978	126.228	0.03	0	-0.030	Agaton	5-year
79	8.424191	126.2382	0.06	0	-0.060	Agaton	5-year
80	8.4239	126.3236	0.03	0	-0.030	Agaton	5-year
81	8.423263	126.236	0.04	0	-0.040	Agaton	5-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
82	8.476264	126.2133	0.83	0.52	-0.310	Agaton	5-year
83	8.475941	126.213	1.69	0	-1.690	Agaton	5-year
84	8.475948	126.2127	2.02	0.64	-1.380	Agaton	5-year
85	8.475824	126.2124	1.86	0.5	-1.360	Agaton	5-year
86	8.416066	126.2407	1.97	1.8	-0.170	Agaton	5-year
87	8.375506	126.3303	0.04	0	-0.040	Agaton	5-year
88	8.375374	126.3362	0.09	0.24	0.150	Agaton	5-year
89	8.375166	126.3322	0.18	0	-0.180	Agaton	5-year
90	8.378	126.3266	0.68	0	-0.680	Agaton	5-year
91	8.3792	126.329	0.07	0	-0.070	Agaton	5-year
92	8.3807	126.3303	0.46	0	-0.460	Agaton	5-year
93	8.375356	126.3208	0.17	0.1	-0.070	Agaton	5-year
94	8.376764	126.3178	0.22	0	-0.220	Agaton	5-year
95	8.376673	126.3179	0.64	0.31	-0.330	Agaton	5-year
96	8.379569	126.3141	0.12	0	-0.120	Agaton	5-year
97	8.381568	126.3153	0.38	0	-0.380	Agaton	5-year
98	8.381155	126.3131	0.03	0	-0.030	Agaton	5-year
99	8.402029	126.3216	0.03	0	-0.030	Agaton	5-year
100	8.39249	126.3149	0.03	0	-0.030	Agaton	5-year
101	8.393097	126.3119	0.28	0	-0.280	Agaton	5-year
102	8.387198	126.3128	0.03	0.21	0.180	Agaton	5-year
103	8.382337	126.3125	0.06	0	-0.060	Agaton	5-year
104	8.341477	126.2551	0.03	0	-0.030	Agaton	5-year
105	8.41505	126.2548	0.03	0	-0.030	Agaton	5-year
106	8.414923	126.2546	0.03	0	-0.030	Agaton	5-year
107	8.415988	126.2426	0.03	0	-0.030	Agaton	5-year
108	8.415434	126.2428	0.3	0	-0.300	Agaton	5-year
109	8.416207	126.2401	3.12	1.61	-1.510	Agaton	5-year
110	8.416566	126.2382	0.12	0.2	0.080	Agaton	5-year
111	8.416423	126.238	0.25	1.79	1.540	Agaton	5-year
112	8.416705	126.2373	0.03	0	-0.030	Agaton	5-year
113	8.416603	126.237	0.53	0	-0.530	Agaton	5-year
114	8.416725	126.237	0.04	0	-0.040	Agaton	5-year
115	8.416807	126.2364	0.41	0	-0.410	Agaton	5-year
116	8.416973	126.2362	0.21	0	-0.210	Agaton	5-year
117	8.41709	126.2356	0.08	0.24	0.160	Agaton	5-year
118	8.417012	126.2353	0.6	0	-0.600	Agaton	5-year
119	8.417221	126.2349	0.09	0.26	0.170	Agaton	5-year
120	8.41754	126.2351	0.2	0.2	0.000	Agaton	5-year
121	8.417375	126.2348	0.03	0	-0.030	Agaton	5-year
122	8.41769	126.2345	0.06	0	-0.060	Agaton	5-year
123	8.41937	126.2335	2.49	1.5	-0.990	Agaton	5-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
124	8.364539	126.3334	0.03	0.3	0.270	Seniang	5-year
125	8.363677	126.3313	0.04	0.12	0.080	Seniang	5-year
126	8.364121	126.3317	0.04	0	-0.040	Seniang	5-year
127	8.364417	126.332	0.03	0	-0.030	Seniang	5-year
128	8.364786	126.3324	0.09	0.17	0.080	Seniang	5-year
129	8.365023	126.3335	0.17	0.35	0.180	Seniang	5-year
130	8.364571	126.3346	0.09	0.18	0.090	Seniang	5-year
131	8.364146	126.3349	0.29	0.3	0.010	Seniang	5-year
132	8.363566	126.3351	0.28	0	-0.280	Seniang	5-year
133	8.364212	126.3353	0.22	0.3	0.080	Seniang	5-year
134	8.367463	126.3383	0.06	0	-0.060	Seniang	5-year
135	8.368847	126.3381	0.18	0	-0.180	Seniang	5-year
136	8.370949	126.3376	0.89	0	-0.890	Seniang	5-year
137	8.371968	126.3371	0.26	0.6	0.340	Seniang	5-year
138	8.374103	126.3341	0.03	0	-0.030	Seniang	5-year
139	8.372097	126.3358	0.26	0.04	-0.220	Seniang	5-year
140	8.36911	126.335	0.3	0	-0.300	Seniang	5-year
141	8.36852	126.3313	0.58	0.13	-0.450	Seniang	5-year
142	8.370251	126.3337	0.25	0	-0.250	Seniang	5-year
143	8.371115	126.3317	0.16	0	-0.160	Seniang	5-year
144	8.371596	126.3285	0.24	0	-0.240	Seniang	5-year
145	8.33727	126.3262	0	0.26	0.260	Seniang	5-year
146	8.403148	126.3219	0.07	0	-0.070	Seniang	5-year
147	8.403607	126.3223	0.1	0	-0.100	Seniang	5-year
148	8.403639	126.3371	0.03	0	-0.030	Seniang	5-year
149	8.40357	126.3377	0.03	0	-0.030	Seniang	5-year
150	8.405224	126.338	0.03	0	-0.030	Seniang	5-year
151	8.424132	126.3153	0.04	0	-0.040	Seniang	5-year
152	8.423925	126.3158	0.08	0	-0.080	Seniang	5-year
153	8.423474	126.3161	0.07	0	-0.070	Seniang	5-year
154	8.372463	126.3223	0.39	0	-0.390	Seniang	5-year
155	8.374583	126.32	0.1	0.03	-0.070	Seniang	5-year
156	8.372868	126.3163	0.14	0	-0.140	Seniang	5-year
157	8.370529	126.3121	0.38	0	-0.380	Seniang	5-year
158	8.368819	126.3129	0.05	0.95	0.900	Seniang	5-year
159	8.364254	126.3218	0.21	0	-0.210	Seniang	5-year
160	8.362636	126.3286	0.08	0	-0.080	Seniang	5-year
161	8.363346	126.3309	0.05	0.63	0.580	Seniang	5-year
162	8.356979	126.2674	0.03	0	-0.030	Seniang	5-year
163	8.354631	126.2664	0.03	0	-0.030	Seniang	5-year
164	8.342638	126.3183	0	0	0.000	Seniang	5-year
165	8.342571	126.3186	0	0	0.000	Seniang	5-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
166	8.341745	126.3227	0	0	0.000	Seniang	5-year
167	8.319812	126.2725	0.03	0	-0.030	Seniang	5-year
168	8.319149	126.2741	0.03	0	-0.030	Seniang	5-year
169	8.317695	126.275	0	0.5	0.500	Seniang	5-year
170	8.369597	126.2621	0.03	0	-0.030	Seniang	5-year
171	8.36957	126.2535	0.05	0	-0.050	Seniang	5-year
172	8.369569	126.2532	0.07	0	-0.070	Seniang	5-year
173	8.36998	126.2496	0.77	0	-0.770	Seniang	5-year
174	8.38972	126.2433	0.03	0	-0.030	Seniang	5-year
175	8.389895	126.2433	0.11	0	-0.110	Seniang	5-year
176	8.391496	126.2438	0.03	0	-0.030	Seniang	5-year
177	8.391556	126.2439	0.04	0	-0.040	Seniang	5-year
178	8.397622	126.2801	1.27	0.1	-1.170	Seniang	5-year
179	8.414518	126.255	0.56	0	-0.560	Seniang	5-year
180	8.415118	126.2548	0.03	0.8	0.770	Seniang	5-year
181	8.414912	126.2546	0.03	0	-0.030	Seniang	5-year
182	8.368886	126.2953	0.03	0	-0.030	Seniang	5-year
183	8.370474	126.2972	0.03	0	-0.030	Seniang	5-year
184	8.452739	126.262	0.03	0	-0.030	Seniang	5-year
185	8.453302	126.252	0.44	0	-0.440	Seniang	5-year
186	8.451396	126.2518	1.38	0	-1.380	Seniang	5-year
187	8.4511	126.2524	0.14	0	-0.140	Seniang	5-year
188	8.473721	126.2371	0.07	0	-0.070	Seniang	5-year
189	8.473735	126.2366	0.07	0	-0.070	Seniang	5-year
190	8.476041	126.234	0.32	0	-0.320	Seniang	5-year
191	8.475748	126.2321	0.22	0.3	0.080	Seniang	5-year
192	8.47775	126.2313	0.05	0	-0.050	Seniang	5-year
193	8.475527	126.2121	1.53	0.74	-0.790	Seniang	5-year
194	8.511474	126.1279	0.03	0	-0.030	Seniang	5-year
195	8.475066	126.2123	0.54	0	-0.540	Seniang	5-year
196	8.511795	126.1608	0.03	0	-0.030	Seniang	5-year
197	8.511896	126.1611	0.04	0	-0.040	Seniang	5-year
198	8.512077	126.1601	0.06	0	-0.060	Seniang	5-year
199	8.511159	126.1282	0.03	0.2	0.170	Seniang	5-year
200	8.511479	126.1595	0.06	0	-0.060	Seniang	5-year
201	8.420978	126.228	0.03	0	-0.030	Seniang	5-year
202	8.424191	126.2382	0.06	0	-0.060	Seniang	5-year
203	8.4239	126.3236	0.03	0	-0.030	Seniang	5-year
204	8.423263	126.236	0.04	0	-0.040	Seniang	5-year
205	8.476264	126.2133	0.83	0.52	-0.310	Seniang	5-year
206	8.475941	126.213	1.69	0	-1.690	Seniang	5-year
207	8.475948	126.2127	2.02	0.64	-1.380	Seniang	5-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
208	8.475824	126.2124	1.86	0.5	-1.360	Seniang	5-year
209	8.416066	126.2407	1.97	1.8	-0.170	Seniang	5-year
210	8.375506	126.3303	0.04	0	-0.040	Seniang	5-year
211	8.375374	126.3362	0.09	0.24	0.150	Seniang	5-year
212	8.375166	126.3322	0.18	0	-0.180	Seniang	5-year
213	8.378	126.3266	0.68	0	-0.680	Seniang	5-year
214	8.3792	126.329	0.07	0	-0.070	Seniang	5-year
215	8.3807	126.3303	0.46	0	-0.460	Seniang	5-year
216	8.375356	126.3208	0.17	0.1	-0.070	Seniang	5-year
217	8.376764	126.3178	0.22	0	-0.220	Seniang	5-year
218	8.376673	126.3179	0.64	0.31	-0.330	Seniang	5-year
219	8.379569	126.3141	0.12	0	-0.120	Seniang	5-year
220	8.381568	126.3153	0.38	0	-0.380	Seniang	5-year
221	8.381155	126.3131	0.03	0	-0.030	Seniang	5-year
222	8.402029	126.3216	0.03	0	-0.030	Seniang	5-year
223	8.39249	126.3149	0.03	0	-0.030	Seniang	5-year
224	8.393097	126.3119	0.28	0	-0.280	Seniang	5-year
225	8.387198	126.3128	0.03	0.21	0.180	Seniang	5-year
226	8.382337	126.3125	0.06	0	-0.060	Seniang	5-year
227	8.341477	126.2551	0.03	0	-0.030	Seniang	5-year
228	8.41505	126.2548	0.03	0	-0.030	Seniang	5-year
229	8.414923	126.2546	0.03	0	-0.030	Seniang	5-year
230	8.415988	126.2426	0.03	0	-0.030	Seniang	5-year
231	8.415434	126.2428	0.3	0	-0.300	Seniang	5-year
232	8.416207	126.2401	3.12	1.61	-1.510	Seniang	5-year
233	8.416566	126.2382	0.12	0.2	0.080	Seniang	5-year
234	8.416423	126.238	0.25	1.79	1.540	Seniang	5-year
235	8.416705	126.2373	0.03	0	-0.030	Seniang	5-year
236	8.416603	126.237	0.53	0	-0.530	Seniang	5-year
237	8.416725	126.237	0.04	0	-0.040	Seniang	5-year
238	8.416807	126.2364	0.41	0	-0.410	Seniang	5-year
239	8.416973	126.2362	0.21	0	-0.210	Seniang	5-year
240	8.41709	126.2356	0.08	0.24	0.160	Seniang	5-year
241	8.417012	126.2353	0.6	0	-0.600	Seniang	5-year
242	8.417221	126.2349	0.09	0.26	0.170	Seniang	5-year
243	8.41754	126.2351	0.2	0.2	0.000	Seniang	5-year
244	8.417375	126.2348	0.03	0	-0.030	Seniang	5-year
245	8.41769	126.2345	0.06	0	-0.060	Seniang	5-year
246	8.41937	126.2335	2.49	1.5	-0.990	Seniang	5-year
247	8.364539	126.3334	0.03	0.3	0.270	Agaton	25-year
248	8.363677	126.3313	0.06	0.12	0.060	Agaton	25-year
249	8.364121	126.3317	0.06	0	-0.060	Agaton	25-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
250	8.364417	126.332	0.03	0	-0.030	Agaton	25-year
251	8.364786	126.3324	0.09	0.17	0.080	Agaton	25-year
252	8.365023	126.3335	0.24	0.35	0.110	Agaton	25-year
253	8.364571	126.3346	0.14	0.18	0.040	Agaton	25-year
254	8.364146	126.3349	0.33	0.3	-0.030	Agaton	25-year
255	8.363566	126.3351	0.31	0	-0.310	Agaton	25-year
256	8.364212	126.3353	0.26	0.3	0.040	Agaton	25-year
257	8.367463	126.3383	0.09	0	-0.090	Agaton	25-year
258	8.368847	126.3381	0.22	0	-0.220	Agaton	25-year
259	8.370949	126.3376	1.37	0	-1.370	Agaton	25-year
260	8.371968	126.3371	0.3	0.6	0.300	Agaton	25-year
261	8.374103	126.3341	0.03	0	-0.030	Agaton	25-year
262	8.372097	126.3358	0.32	0.04	-0.280	Agaton	25-year
263	8.36911	126.335	0.36	0	-0.360	Agaton	25-year
264	8.36852	126.3313	0.67	0.13	-0.540	Agaton	25-year
265	8.370251	126.3337	0.32	0	-0.320	Agaton	25-year
266	8.371115	126.3317	0.21	0	-0.210	Agaton	25-year
267	8.371596	126.3285	0.38	0	-0.380	Agaton	25-year
268	8.33727	126.3262	0	0.26	0.260	Agaton	25-year
269	8.403148	126.3219	0.16	0	-0.160	Agaton	25-year
270	8.403607	126.3223	0.15	0	-0.150	Agaton	25-year
271	8.403639	126.3371	0.03	0	-0.030	Agaton	25-year
272	8.40357	126.3377	0.03	0	-0.030	Agaton	25-year
273	8.405224	126.338	0.03	0	-0.030	Agaton	25-year
274	8.424132	126.3153	0.05	0	-0.050	Agaton	25-year
275	8.423925	126.3158	0.09	0	-0.090	Agaton	25-year
276	8.423474	126.3161	0.08	0	-0.080	Agaton	25-year
277	8.372463	126.3223	0.49	0	-0.490	Agaton	25-year
278	8.374583	126.32	0.21	0.03	-0.180	Agaton	25-year
279	8.372868	126.3163	0.19	0	-0.190	Agaton	25-year
280	8.370529	126.3121	0.47	0	-0.470	Agaton	25-year
281	8.368819	126.3129	0.34	0.95	0.610	Agaton	25-year
282	8.364254	126.3218	0.29	0	-0.290	Agaton	25-year
283	8.362636	126.3286	0.1	0	-0.100	Agaton	25-year
284	8.363346	126.3309	0.1	0.63	0.530	Agaton	25-year
285	8.356979	126.2674	0.05	0	-0.050	Agaton	25-year
286	8.354631	126.2664	0.03	0	-0.030	Agaton	25-year
287	8.342638	126.3183	0	0	0.000	Agaton	25-year
288	8.342571	126.3186	0	0	0.000	Agaton	25-year
289	8.341745	126.3227	0	0	0.000	Agaton	25-year
290	8.319812	126.2725	0.03	0	-0.030	Agaton	25-year
291	8.319149	126.2741	0.03	0	-0.030	Agaton	25-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
292	8.317695	126.275	0	0.5	0.500	Agaton	25-year
293	8.369597	126.2621	0.03	0	-0.030	Agaton	25-year
294	8.36957	126.2535	0.06	0	-0.060	Agaton	25-year
295	8.369569	126.2532	0.08	0	-0.080	Agaton	25-year
296	8.36998	126.2496	1.23	0	-1.230	Agaton	25-year
297	8.38972	126.2433	0.03	0	-0.030	Agaton	25-year
298	8.389895	126.2433	0.13	0	-0.130	Agaton	25-year
299	8.391496	126.2438	0.04	0	-0.040	Agaton	25-year
300	8.391556	126.2439	0.05	0	-0.050	Agaton	25-year
301	8.397622	126.2801	1.7	0.1	-1.600	Agaton	25-year
302	8.414518	126.255	0.67	0	-0.670	Agaton	25-year
303	8.415118	126.2548	1.69	0.8	-0.890	Agaton	25-year
304	8.414912	126.2546	0.03	0	-0.030	Agaton	25-year
305	8.368886	126.2953	0.03	0	-0.030	Agaton	25-year
306	8.370474	126.2972	0.03	0	-0.030	Agaton	25-year
307	8.452739	126.262	0.03	0	-0.030	Agaton	25-year
308	8.453302	126.252	0.53	0	-0.530	Agaton	25-year
309	8.451396	126.2518	1.48	0	-1.480	Agaton	25-year
310	8.4511	126.2524	0.19	0	-0.190	Agaton	25-year
311	8.473721	126.2371	0.08	0	-0.080	Agaton	25-year
312	8.473735	126.2366	0.07	0	-0.070	Agaton	25-year
313	8.476041	126.234	0.39	0	-0.390	Agaton	25-year
314	8.475748	126.2321	0.28	0.3	0.020	Agaton	25-year
315	8.47775	126.2313	0.06	0	-0.060	Agaton	25-year
316	8.475527	126.2121	2.28	0.74	-1.540	Agaton	25-year
317	8.511474	126.1279	0.04	0	-0.040	Agaton	25-year
318	8.475066	126.2123	1.3	0	-1.300	Agaton	25-year
319	8.511795	126.1608	0.03	0	-0.030	Agaton	25-year
320	8.511896	126.1611	0.05	0	-0.050	Agaton	25-year
321	8.512077	126.1601	0.07	0	-0.070	Agaton	25-year
322	8.511159	126.1282	0.03	0.2	0.170	Agaton	25-year
323	8.511479	126.1595	0.1	0	-0.100	Agaton	25-year
324	8.420978	126.228	0.03	0	-0.030	Agaton	25-year
325	8.424191	126.2382	0.14	0	-0.140	Agaton	25-year
326	8.4239	126.3236	0.03	0	-0.030	Agaton	25-year
327	8.423263	126.236	0.05	0	-0.050	Agaton	25-year
328	8.476264	126.2133	1.61	0.52	-1.090	Agaton	25-year
329	8.475941	126.213	2.47	0	-2.470	Agaton	25-year
330	8.475948	126.2127	2.79	0.64	-2.150	Agaton	25-year
331	8.475824	126.2124	2.63	0.5	-2.130	Agaton	25-year
332	8.416066	126.2407	4.44	1.8	-2.640	Agaton	25-year
333	8.375506	126.3303	0.05	0	-0.050	Agaton	25-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
334	8.375374	126.3362	0.09	0.24	0.150	Agaton	25-year
335	8.375166	126.3322	0.19	0	-0.190	Agaton	25-year
336	8.378	126.3266	1.08	0	-1.080	Agaton	25-year
337	8.3792	126.329	0.51	0	-0.510	Agaton	25-year
338	8.3807	126.3303	1.5	0	-1.500	Agaton	25-year
339	8.375356	126.3208	0.24	0.1	-0.140	Agaton	25-year
340	8.376764	126.3178	0.36	0	-0.360	Agaton	25-year
341	8.376673	126.3179	0.77	0.31	-0.460	Agaton	25-year
342	8.379569	126.3141	0.15	0	-0.150	Agaton	25-year
343	8.381568	126.3153	0.39	0	-0.390	Agaton	25-year
344	8.381155	126.3131	0.03	0	-0.030	Agaton	25-year
345	8.402029	126.3216	0.03	0	-0.030	Agaton	25-year
346	8.39249	126.3149	0.03	0	-0.030	Agaton	25-year
347	8.393097	126.3119	0.35	0	-0.350	Agaton	25-year
348	8.387198	126.3128	0.04	0.21	0.170	Agaton	25-year
349	8.382337	126.3125	0.07	0	-0.070	Agaton	25-year
350	8.341477	126.2551	0.03	0	-0.030	Agaton	25-year
351	8.41505	126.2548	1.39	0	-1.390	Agaton	25-year
352	8.414923	126.2546	0.03	0	-0.030	Agaton	25-year
353	8.415988	126.2426	0.3	0	-0.300	Agaton	25-year
354	8.415434	126.2428	1.7	0	-1.700	Agaton	25-year
355	8.416207	126.2401	5.61	1.61	-4.000	Agaton	25-year
356	8.416566	126.2382	2.56	0.2	-2.360	Agaton	25-year
357	8.416423	126.238	2.74	1.79	-0.950	Agaton	25-year
358	8.416705	126.2373	0.73	0	-0.730	Agaton	25-year
359	8.416603	126.237	0.61	0	-0.610	Agaton	25-year
360	8.416725	126.237	0.34	0	-0.340	Agaton	25-year
361	8.416807	126.2364	0.5	0	-0.500	Agaton	25-year
362	8.416973	126.2362	0.28	0	-0.280	Agaton	25-year
363	8.41709	126.2356	0.14	0.24	0.100	Agaton	25-year
364	8.417012	126.2353	0.7	0	-0.700	Agaton	25-year
365	8.417221	126.2349	0.13	0.26	0.130	Agaton	25-year
366	8.41754	126.2351	0.75	0.2	-0.550	Agaton	25-year
367	8.417375	126.2348	0.04	0	-0.040	Agaton	25-year
368	8.41769	126.2345	0.08	0	-0.080	Agaton	25-year
369	8.41937	126.2335	4.87	1.5	-3.370	Agaton	25-year
370	8.364539	126.3334	0.03	0.3	0.27	Seniang	25-year
371	8.363677	126.3313	0.06	0.12	0.06	Seniang	25-year
372	8.364121	126.3317	0.06	0	-0.06	Seniang	25-year
373	8.364417	126.332	0.03	0	-0.03	Seniang	25-year
374	8.364786	126.3324	0.09	0.17	0.08	Seniang	25-year
375	8.365023	126.3335	0.24	0.35	0.11	Seniang	25-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
376	8.364571	126.3346	0.14	0.18	0.04	Seniang	25-year
377	8.364146	126.3349	0.33	0.3	-0.03	Seniang	25-year
378	8.363566	126.3351	0.31	0	-0.31	Seniang	25-year
379	8.364212	126.3353	0.26	0.3	0.04	Seniang	25-year
380	8.367463	126.3383	0.09	0	-0.09	Seniang	25-year
381	8.368847	126.3381	0.22	0	-0.22	Seniang	25-year
382	8.370949	126.3376	1.37	0	-1.37	Seniang	25-year
383	8.371968	126.3371	0.3	0.6	0.3	Seniang	25-year
384	8.374103	126.3341	0.03	0	-0.03	Seniang	25-year
385	8.372097	126.3358	0.32	0.04	-0.28	Seniang	25-year
386	8.36911	126.335	0.36	0	-0.36	Seniang	25-year
387	8.36852	126.3313	0.67	0.13	-0.54	Seniang	25-year
388	8.370251	126.3337	0.32	0	-0.32	Seniang	25-year
389	8.371115	126.3317	0.21	0	-0.21	Seniang	25-year
390	8.371596	126.3285	0.38	0	-0.38	Seniang	25-year
391	8.33727	126.3262	0	0.26	0.26	Seniang	25-year
392	8.403148	126.3219	0.16	0	-0.16	Seniang	25-year
393	8.403607	126.3223	0.15	0	-0.15	Seniang	25-year
394	8.403639	126.3371	0.03	0	-0.03	Seniang	25-year
395	8.40357	126.3377	0.03	0	-0.03	Seniang	25-year
396	8.405224	126.338	0.03	0	-0.03	Seniang	25-year
397	8.424132	126.3153	0.05	0	-0.05	Seniang	25-year
398	8.423925	126.3158	0.09	0	-0.09	Seniang	25-year
399	8.423474	126.3161	0.08	0	-0.08	Seniang	25-year
400	8.372463	126.3223	0.49	0	-0.49	Seniang	25-year
401	8.374583	126.32	0.21	0.03	-0.18	Seniang	25-year
402	8.372868	126.3163	0.19	0	-0.19	Seniang	25-year
403	8.370529	126.3121	0.47	0	-0.47	Seniang	25-year
404	8.368819	126.3129	0.34	0.95	0.61	Seniang	25-year
405	8.364254	126.3218	0.29	0	-0.29	Seniang	25-year
406	8.362636	126.3286	0.1	0	-0.1	Seniang	25-year
407	8.363346	126.3309	0.1	0.63	0.53	Seniang	25-year
408	8.356979	126.2674	0.05	0	-0.05	Seniang	25-year
409	8.354631	126.2664	0.03	0	-0.03	Seniang	25-year
410	8.342638	126.3183	0	0	0	Seniang	25-year
411	8.342571	126.3186	0	0	0	Seniang	25-year
412	8.341745	126.3227	0	0	0	Seniang	25-year
413	8.319812	126.2725	0.03	0	-0.03	Seniang	25-year
414	8.319149	126.2741	0.03	0	-0.03	Seniang	25-year
415	8.317695	126.275	0	0.5	0.5	Seniang	25-year
416	8.369597	126.2621	0.03	0	-0.03	Seniang	25-year
417	8.36957	126.2535	0.06	0	-0.06	Seniang	25-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
418	8.369569	126.2532	0.08	0	-0.08	Seniang	25-year
419	8.36998	126.2496	1.23	0	-1.23	Seniang	25-year
420	8.38972	126.2433	0.03	0	-0.03	Seniang	25-year
421	8.389895	126.2433	0.13	0	-0.13	Seniang	25-year
422	8.391496	126.2438	0.04	0	-0.04	Seniang	25-year
423	8.391556	126.2439	0.05	0	-0.05	Seniang	25-year
424	8.397622	126.2801	1.7	0.1	-1.6	Seniang	25-year
425	8.414518	126.255	0.67	0	-0.67	Seniang	25-year
426	8.415118	126.2548	1.69	0.8	-0.89	Seniang	25-year
427	8.414912	126.2546	0.03	0	-0.03	Seniang	25-year
428	8.368886	126.2953	0.03	0	-0.03	Seniang	25-year
429	8.370474	126.2972	0.03	0	-0.03	Seniang	25-year
430	8.452739	126.262	0.03	0	-0.03	Seniang	25-year
431	8.453302	126.252	0.53	0	-0.53	Seniang	25-year
432	8.451396	126.2518	1.48	0	-1.48	Seniang	25-year
433	8.4511	126.2524	0.19	0	-0.19	Seniang	25-year
434	8.473721	126.2371	0.08	0	-0.08	Seniang	25-year
435	8.473735	126.2366	0.07	0	-0.07	Seniang	25-year
436	8.476041	126.234	0.39	0	-0.39	Seniang	25-year
437	8.475748	126.2321	0.28	0.3	0.02	Seniang	25-year
438	8.47775	126.2313	0.06	0	-0.06	Seniang	25-year
439	8.475527	126.2121	2.28	0.74	-1.54	Seniang	25-year
440	8.511474	126.1279	0.04	0	-0.04	Seniang	25-year
441	8.475066	126.2123	1.3	0	-1.3	Seniang	25-year
442	8.511795	126.1608	0.03	0	-0.03	Seniang	25-year
443	8.511896	126.1611	0.05	0	-0.05	Seniang	25-year
444	8.512077	126.1601	0.07	0	-0.07	Seniang	25-year
445	8.511159	126.1282	0.03	0.2	0.17	Seniang	25-year
446	8.511479	126.1595	0.1	0	-0.1	Seniang	25-year
447	8.420978	126.228	0.03	0	-0.03	Seniang	25-year
448	8.424191	126.2382	0.14	0	-0.14	Seniang	25-year
449	8.4239	126.3236	0.03	0	-0.03	Seniang	25-year
450	8.423263	126.236	0.05	0	-0.05	Seniang	25-year
451	8.476264	126.2133	1.61	0.52	-1.09	Seniang	25-year
452	8.475941	126.213	2.47	0	-2.47	Seniang	25-year
453	8.475948	126.2127	2.79	0.64	-2.15	Seniang	25-year
454	8.475824	126.2124	2.63	0.5	-2.13	Seniang	25-year
455	8.416066	126.2407	4.44	1.8	-2.64	Seniang	25-year
456	8.375506	126.3303	0.05	0	-0.05	Seniang	25-year
457	8.375374	126.3362	0.09	0.24	0.15	Seniang	25-year
458	8.375166	126.3322	0.19	0	-0.19	Seniang	25-year
459	8.378	126.3266	1.08	0	-1.08	Seniang	25-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
460	8.3792	126.329	0.51	0	-0.51	Seniang	25-year
461	8.3807	126.3303	1.5	0	-1.5	Seniang	25-year
462	8.375356	126.3208	0.24	0.1	-0.14	Seniang	25-year
463	8.376764	126.3178	0.36	0	-0.36	Seniang	25-year
464	8.376673	126.3179	0.77	0.31	-0.46	Seniang	25-year
465	8.379569	126.3141	0.15	0	-0.15	Seniang	25-year
466	8.381568	126.3153	0.39	0	-0.39	Seniang	25-year
467	8.381155	126.3131	0.03	0	-0.03	Seniang	25-year
468	8.402029	126.3216	0.03	0	-0.03	Seniang	25-year
469	8.39249	126.3149	0.03	0	-0.03	Seniang	25-year
470	8.393097	126.3119	0.35	0	-0.35	Seniang	25-year
471	8.387198	126.3128	0.04	0.21	0.17	Seniang	25-year
472	8.382337	126.3125	0.07	0	-0.07	Seniang	25-year
473	8.341477	126.2551	0.03	0	-0.03	Seniang	25-year
474	8.41505	126.2548	1.39	0	-1.39	Seniang	25-year
475	8.414923	126.2546	0.03	0	-0.03	Seniang	25-year
476	8.415988	126.2426	0.3	0	-0.3	Seniang	25-year
477	8.415434	126.2428	1.7	0	-1.7	Seniang	25-year
478	8.416207	126.2401	5.61	1.61	-4	Seniang	25-year
479	8.416566	126.2382	2.56	0.2	-2.36	Seniang	25-year
480	8.416423	126.238	2.74	1.79	-0.95	Seniang	25-year
481	8.416705	126.2373	0.73	0	-0.73	Seniang	25-year
482	8.416603	126.237	0.61	0	-0.61	Seniang	25-year
483	8.416725	126.237	0.34	0	-0.34	Seniang	25-year
484	8.416807	126.2364	0.5	0	-0.5	Seniang	25-year
485	8.416973	126.2362	0.28	0	-0.28	Seniang	25-year
486	8.41709	126.2356	0.14	0.24	0.1	Seniang	25-year
487	8.417012	126.2353	0.7	0	-0.7	Seniang	25-year
488	8.417221	126.2349	0.13	0.26	0.13	Seniang	25-year
489	8.41754	126.2351	0.75	0.2	-0.55	Seniang	25-year
490	8.417375	126.2348	0.04	0	-0.04	Seniang	25-year
491	8.41769	126.2345	0.08	0	-0.08	Seniang	25-year
492	8.41937	126.2335	4.87	1.5	-3.37	Seniang	25-year
493	8.364539	126.3334	0.03	0.3	0.27	Agaton	100-year
494	8.363677	126.3313	0.07	0.12	0.05	Agaton	100-year
495	8.364121	126.3317	0.07	0	-0.07	Agaton	100-year
496	8.364417	126.332	0.03	0	-0.03	Agaton	100-year
497	8.364786	126.3324	0.09	0.17	0.08	Agaton	100-year
498	8.365023	126.3335	0.28	0.35	0.07	Agaton	100-year
499	8.364571	126.3346	0.18	0.18	0	Agaton	100-year
500	8.364146	126.3349	0.36	0.3	-0.06	Agaton	100-year
501	8.363566	126.3351	0.33	0	-0.33	Agaton	100-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
502	8.364212	126.3353	0.29	0.3	0.01	Agaton	100-year
503	8.367463	126.3383	0.1	0	-0.1	Agaton	100-year
504	8.368847	126.3381	0.29	0	-0.29	Agaton	100-year
505	8.370949	126.3376	1.7	0	-1.7	Agaton	100-year
506	8.371968	126.3371	0.33	0.6	0.27	Agaton	100-year
507	8.374103	126.3341	0.03	0	-0.03	Agaton	100-year
508	8.372097	126.3358	0.35	0.04	-0.31	Agaton	100-year
509	8.36911	126.335	0.4	0	-0.4	Agaton	100-year
510	8.36852	126.3313	0.74	0.13	-0.61	Agaton	100-year
511	8.370251	126.3337	0.37	0	-0.37	Agaton	100-year
512	8.371115	126.3317	0.24	0	-0.24	Agaton	100-year
513	8.371596	126.3285	0.49	0	-0.49	Agaton	100-year
514	8.33727	126.3262	0	0.26	0.26	Agaton	100-year
515	8.403148	126.3219	1.42	0	-1.42	Agaton	100-year
516	8.403607	126.3223	0.42	0	-0.42	Agaton	100-year
517	8.403639	126.3371	0.03	0	-0.03	Agaton	100-year
518	8.40357	126.3377	0.04	0	-0.04	Agaton	100-year
519	8.405224	126.338	0.03	0	-0.03	Agaton	100-year
520	8.424132	126.3153	0.06	0	-0.06	Agaton	100-year
521	8.423925	126.3158	0.1	0	-0.1	Agaton	100-year
522	8.423474	126.3161	0.1	0	-0.1	Agaton	100-year
523	8.372463	126.3223	0.55	0	-0.55	Agaton	100-year
524	8.374583	126.32	0.27	0.03	-0.24	Agaton	100-year
525	8.372868	126.3163	0.21	0	-0.21	Agaton	100-year
526	8.370529	126.3121	0.55	0	-0.55	Agaton	100-year
527	8.368819	126.3129	0.59	0.95	0.36	Agaton	100-year
528	8.364254	126.3218	0.39	0	-0.39	Agaton	100-year
529	8.362636	126.3286	0.12	0	-0.12	Agaton	100-year
530	8.363346	126.3309	0.14	0.63	0.49	Agaton	100-year
531	8.356979	126.2674	0.06	0	-0.06	Agaton	100-year
532	8.354631	126.2664	0.03	0	-0.03	Agaton	100-year
533	8.342638	126.3183	0	0	0	Agaton	100-year
534	8.342571	126.3186	0	0	0	Agaton	100-year
535	8.341745	126.3227	0	0	0	Agaton	100-year
536	8.319812	126.2725	0.03	0	-0.03	Agaton	100-year
537	8.319149	126.2741	0.03	0	-0.03	Agaton	100-year
538	8.317695	126.275	0	0.5	0.5	Agaton	100-year
539	8.369597	126.2621	0.04	0	-0.04	Agaton	100-year
540	8.36957	126.2535	0.06	0	-0.06	Agaton	100-year
541	8.369569	126.2532	0.08	0	-0.08	Agaton	100-year
542	8.36998	126.2496	1.58	0	-1.58	Agaton	100-year
543	8.38972	126.2433	0.03	0	-0.03	Agaton	100-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
544	8.389895	126.2433	0.15	0	-0.15	Agaton	100-year
545	8.391496	126.2438	0.05	0	-0.05	Agaton	100-year
546	8.391556	126.2439	0.06	0	-0.06	Agaton	100-year
547	8.397622	126.2801	1.99	0.1	-1.89	Agaton	100-year
548	8.414518	126.255	0.73	0	-0.73	Agaton	100-year
549	8.415118	126.2548	3.34	0.8	-2.54	Agaton	100-year
550	8.414912	126.2546	0.03	0	-0.03	Agaton	100-year
551	8.368886	126.2953	0.03	0	-0.03	Agaton	100-year
552	8.370474	126.2972	0.03	0	-0.03	Agaton	100-year
553	8.452739	126.262	0.03	0	-0.03	Agaton	100-year
554	8.453302	126.252	0.58	0	-0.58	Agaton	100-year
555	8.451396	126.2518	1.54	0	-1.54	Agaton	100-year
556	8.4511	126.2524	0.26	0	-0.26	Agaton	100-year
557	8.473721	126.2371	0.09	0	-0.09	Agaton	100-year
558	8.473735	126.2366	0.07	0	-0.07	Agaton	100-year
559	8.476041	126.234	0.44	0	-0.44	Agaton	100-year
560	8.475748	126.2321	0.32	0.3	-0.02	Agaton	100-year
561	8.47775	126.2313	0.06	0	-0.06	Agaton	100-year
562	8.475527	126.2121	2.81	0.74	-2.07	Agaton	100-year
563	8.511474	126.1279	0.22	0	-0.22	Agaton	100-year
564	8.475066	126.2123	1.83	0	-1.83	Agaton	100-year
565	8.511795	126.1608	0.03	0	-0.03	Agaton	100-year
566	8.511896	126.1611	0.05	0	-0.05	Agaton	100-year
567	8.512077	126.1601	0.09	0	-0.09	Agaton	100-year
568	8.511159	126.1282	0.29	0.2	-0.09	Agaton	100-year
569	8.511479	126.1595	0.41	0	-0.41	Agaton	100-year
570	8.420978	126.228	0.03	0	-0.03	Agaton	100-year
571	8.424191	126.2382	0.22	0	-0.22	Agaton	100-year
572	8.4239	126.3236	0.03	0	-0.03	Agaton	100-year
573	8.423263	126.236	0.5	0	-0.5	Agaton	100-year
574	8.476264	126.2133	2.15	0.52	-1.63	Agaton	100-year
575	8.475941	126.213	3	0	-3	Agaton	100-year
576	8.475948	126.2127	3.31	0.64	-2.67	Agaton	100-year
577	8.475824	126.2124	3.15	0.5	-2.65	Agaton	100-year
578	8.416066	126.2407	6.39	1.8	-4.59	Agaton	100-year
579	8.375506	126.3303	0.05	0	-0.05	Agaton	100-year
580	8.375374	126.3362	0.1	0.24	0.14	Agaton	100-year
581	8.375166	126.3322	0.2	0	-0.2	Agaton	100-year
582	8.378	126.3266	1.26	0	-1.26	Agaton	100-year
583	8.3792	126.329	0.7	0	-0.7	Agaton	100-year
584	8.3807	126.3303	2.28	0	-2.28	Agaton	100-year
585	8.375356	126.3208	0.28	0.1	-0.18	Agaton	100-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
586	8.376764	126.3178	0.45	0	-0.45	Agaton	100-year
587	8.376673	126.3179	0.87	0.31	-0.56	Agaton	100-year
588	8.379569	126.3141	0.17	0	-0.17	Agaton	100-year
589	8.381568	126.3153	0.4	0	-0.4	Agaton	100-year
590	8.381155	126.3131	0.03	0	-0.03	Agaton	100-year
591	8.402029	126.3216	0.03	0	-0.03	Agaton	100-year
592	8.39249	126.3149	0.03	0	-0.03	Agaton	100-year
593	8.393097	126.3119	0.39	0	-0.39	Agaton	100-year
594	8.387198	126.3128	0.04	0.21	0.17	Agaton	100-year
595	8.382337	126.3125	0.07	0	-0.07	Agaton	100-year
596	8.341477	126.2551	0.03	0	-0.03	Agaton	100-year
597	8.41505	126.2548	3.03	0	-3.03	Agaton	100-year
598	8.414923	126.2546	0.03	0	-0.03	Agaton	100-year
599	8.415988	126.2426	2.14	0	-2.14	Agaton	100-year
600	8.415434	126.2428	3.54	0	-3.54	Agaton	100-year
601	8.416207	126.2401	7.57	1.61	-5.96	Agaton	100-year
602	8.416566	126.2382	4.54	0.2	-4.34	Agaton	100-year
603	8.416423	126.238	4.72	1.79	-2.93	Agaton	100-year
604	8.416705	126.2373	2.73	0	-2.73	Agaton	100-year
605	8.416603	126.237	2.55	0	-2.55	Agaton	100-year
606	8.416725	126.237	2.35	0	-2.35	Agaton	100-year
607	8.416807	126.2364	1.59	0	-1.59	Agaton	100-year
608	8.416973	126.2362	1.17	0	-1.17	Agaton	100-year
609	8.41709	126.2356	1.27	0.24	-1.03	Agaton	100-year
610	8.417012	126.2353	0.75	0	-0.75	Agaton	100-year
611	8.417221	126.2349	0.18	0.26	0.08	Agaton	100-year
612	8.41754	126.2351	2.7	0.2	-2.5	Agaton	100-year
613	8.417375	126.2348	0.06	0	-0.06	Agaton	100-year
614	8.41769	126.2345	0.72	0	-0.72	Agaton	100-year
615	8.41937	126.2335	6.88	1.5	-5.38	Agaton	100-year
616	8.364539	126.3334	0.03	0.3	0.27	Seniang	100-year
617	8.363677	126.3313	0.07	0.12	0.05	Seniang	100-year
618	8.364121	126.3317	0.07	0	-0.07	Seniang	100-year
619	8.364417	126.332	0.03	0	-0.03	Seniang	100-year
620	8.364786	126.3324	0.09	0.17	0.08	Seniang	100-year
621	8.365023	126.3335	0.28	0.35	0.07	Seniang	100-year
622	8.364571	126.3346	0.18	0.18	0	Seniang	100-year
623	8.364146	126.3349	0.36	0.3	-0.06	Seniang	100-year
624	8.363566	126.3351	0.33	0	-0.33	Seniang	100-year
625	8.364212	126.3353	0.29	0.3	0.01	Seniang	100-year
626	8.367463	126.3383	0.1	0	-0.1	Seniang	100-year
627	8.368847	126.3381	0.29	0	-0.29	Seniang	100-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
628	8.370949	126.3376	1.7	0	-1.7	Seniang	100-year
629	8.371968	126.3371	0.33	0.6	0.27	Seniang	100-year
630	8.374103	126.3341	0.03	0	-0.03	Seniang	100-year
631	8.372097	126.3358	0.35	0.04	-0.31	Seniang	100-year
632	8.36911	126.335	0.4	0	-0.4	Seniang	100-year
633	8.36852	126.3313	0.74	0.13	-0.61	Seniang	100-year
634	8.370251	126.3337	0.37	0	-0.37	Seniang	100-year
635	8.371115	126.3317	0.24	0	-0.24	Seniang	100-year
636	8.371596	126.3285	0.49	0	-0.49	Seniang	100-year
637	8.33727	126.3262	0	0.26	0.26	Seniang	100-year
638	8.403148	126.3219	1.42	0	-1.42	Seniang	100-year
639	8.403607	126.3223	0.42	0	-0.42	Seniang	100-year
640	8.403639	126.3371	0.03	0	-0.03	Seniang	100-year
641	8.40357	126.3377	0.04	0	-0.04	Seniang	100-year
642	8.405224	126.338	0.03	0	-0.03	Seniang	100-year
643	8.424132	126.3153	0.06	0	-0.06	Seniang	100-year
644	8.423925	126.3158	0.1	0	-0.1	Seniang	100-year
645	8.423474	126.3161	0.1	0	-0.1	Seniang	100-year
646	8.372463	126.3223	0.55	0	-0.55	Seniang	100-year
647	8.374583	126.32	0.27	0.03	-0.24	Seniang	100-year
648	8.372868	126.3163	0.21	0	-0.21	Seniang	100-year
649	8.370529	126.3121	0.55	0	-0.55	Seniang	100-year
650	8.368819	126.3129	0.59	0.95	0.36	Seniang	100-year
651	8.364254	126.3218	0.39	0	-0.39	Seniang	100-year
652	8.362636	126.3286	0.12	0	-0.12	Seniang	100-year
653	8.363346	126.3309	0.14	0.63	0.49	Seniang	100-year
654	8.356979	126.2674	0.06	0	-0.06	Seniang	100-year
655	8.354631	126.2664	0.03	0	-0.03	Seniang	100-year
656	8.342638	126.3183	0	0	0	Seniang	100-year
657	8.342571	126.3186	0	0	0	Seniang	100-year
658	8.341745	126.3227	0	0	0	Seniang	100-year
659	8.319812	126.2725	0.03	0	-0.03	Seniang	100-year
660	8.319149	126.2741	0.03	0	-0.03	Seniang	100-year
661	8.317695	126.275	0	0.5	0.5	Seniang	100-year
662	8.369597	126.2621	0.04	0	-0.04	Seniang	100-year
663	8.36957	126.2535	0.06	0	-0.06	Seniang	100-year
664	8.369569	126.2532	0.08	0	-0.08	Seniang	100-year
665	8.36998	126.2496	1.58	0	-1.58	Seniang	100-year
666	8.38972	126.2433	0.03	0	-0.03	Seniang	100-year
667	8.389895	126.2433	0.15	0	-0.15	Seniang	100-year
668	8.391496	126.2438	0.05	0	-0.05	Seniang	100-year
669	8.391556	126.2439	0.06	0	-0.06	Seniang	100-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
670	8.397622	126.2801	1.99	0.1	-1.89	Seniang	100-year
671	8.414518	126.255	0.73	0	-0.73	Seniang	100-year
672	8.415118	126.2548	3.34	0.8	-2.54	Seniang	100-year
673	8.414912	126.2546	0.03	0	-0.03	Seniang	100-year
674	8.368886	126.2953	0.03	0	-0.03	Seniang	100-year
675	8.370474	126.2972	0.03	0	-0.03	Seniang	100-year
676	8.452739	126.262	0.03	0	-0.03	Seniang	100-year
677	8.453302	126.252	0.58	0	-0.58	Seniang	100-year
678	8.451396	126.2518	1.54	0	-1.54	Seniang	100-year
679	8.4511	126.2524	0.26	0	-0.26	Seniang	100-year
680	8.473721	126.2371	0.09	0	-0.09	Seniang	100-year
681	8.473735	126.2366	0.07	0	-0.07	Seniang	100-year
682	8.476041	126.234	0.44	0	-0.44	Seniang	100-year
683	8.475748	126.2321	0.32	0.3	-0.02	Seniang	100-year
684	8.47775	126.2313	0.06	0	-0.06	Seniang	100-year
685	8.475527	126.2121	2.81	0.74	-2.07	Seniang	100-year
686	8.511474	126.1279	0.22	0	-0.22	Seniang	100-year
687	8.475066	126.2123	1.83	0	-1.83	Seniang	100-year
688	8.511795	126.1608	0.03	0	-0.03	Seniang	100-year
689	8.511896	126.1611	0.05	0	-0.05	Seniang	100-year
690	8.512077	126.1601	0.09	0	-0.09	Seniang	100-year
691	8.511159	126.1282	0.29	0.2	-0.09	Seniang	100-year
692	8.511479	126.1595	0.41	0	-0.41	Seniang	100-year
693	8.420978	126.228	0.03	0	-0.03	Seniang	100-year
694	8.424191	126.2382	0.22	0	-0.22	Seniang	100-year
695	8.4239	126.3236	0.03	0	-0.03	Seniang	100-year
696	8.423263	126.236	0.5	0	-0.5	Seniang	100-year
697	8.476264	126.2133	2.15	0.52	-1.63	Seniang	100-year
698	8.475941	126.213	3	0	-3	Seniang	100-year
699	8.475948	126.2127	3.31	0.64	-2.67	Seniang	100-year
700	8.475824	126.2124	3.15	0.5	-2.65	Seniang	100-year
701	8.416066	126.2407	6.39	1.8	-4.59	Seniang	100-year
702	8.375506	126.3303	0.05	0	-0.05	Seniang	100-year
703	8.375374	126.3362	0.1	0.24	0.14	Seniang	100-year
704	8.375166	126.3322	0.2	0	-0.2	Seniang	100-year
705	8.378	126.3266	1.26	0	-1.26	Seniang	100-year
706	8.3792	126.329	0.7	0	-0.7	Seniang	100-year
707	8.3807	126.3303	2.28	0	-2.28	Seniang	100-year
708	8.375356	126.3208	0.28	0.1	-0.18	Seniang	100-year
709	8.376764	126.3178	0.45	0	-0.45	Seniang	100-year
710	8.376673	126.3179	0.87	0.31	-0.56	Seniang	100-year
711	8.379569	126.3141	0.17	0	-0.17	Seniang	100-year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error (m)	Event/Date	Rain Return/ Scenario
	Lat	Long					
712	8.381568	126.3153	0.4	0	-0.4	Seniang	100-year
713	8.381155	126.3131	0.03	0	-0.03	Seniang	100-year
714	8.402029	126.3216	0.03	0	-0.03	Seniang	100-year
715	8.39249	126.3149	0.03	0	-0.03	Seniang	100-year
716	8.393097	126.3119	0.39	0	-0.39	Seniang	100-year
717	8.387198	126.3128	0.04	0.21	0.17	Seniang	100-year
718	8.382337	126.3125	0.07	0	-0.07	Seniang	100-year
719	8.341477	126.2551	0.03	0	-0.03	Seniang	100-year
720	8.41505	126.2548	3.03	0	-3.03	Seniang	100-year
721	8.414923	126.2546	0.03	0	-0.03	Seniang	100-year
722	8.415988	126.2426	2.14	0	-2.14	Seniang	100-year
723	8.415434	126.2428	3.54	0	-3.54	Seniang	100-year
724	8.416207	126.2401	7.57	1.61	-5.96	Seniang	100-year
725	8.416566	126.2382	4.54	0.2	-4.34	Seniang	100-year
726	8.416423	126.238	4.72	1.79	-2.93	Seniang	100-year
727	8.416705	126.2373	2.73	0	-2.73	Seniang	100-year
728	8.416603	126.237	2.55	0	-2.55	Seniang	100-year
729	8.416725	126.237	2.35	0	-2.35	Seniang	100-year
730	8.416807	126.2364	1.59	0	-1.59	Seniang	100-year
731	8.416973	126.2362	1.17	0	-1.17	Seniang	100-year
732	8.41709	126.2356	1.27	0.24	-1.03	Seniang	100-year
733	8.417012	126.2353	0.75	0	-0.75	Seniang	100-year
734	8.417221	126.2349	0.18	0.26	0.08	Seniang	100-year
735	8.41754	126.2351	2.7	0.2	-2.5	Seniang	100-year
736	8.417375	126.2348	0.06	0	-0.06	Seniang	100-year
737	8.41769	126.2345	0.72	0	-0.72	Seniang	100-year
738	8.41937	126.2335	6.88	1.5	-5.38	Seniang	100-year

ANNEX 12. Educational Institutions Affected by Flooding in Hinatuan Floodplain

Table A-12.1. Educational Institutions Affected by Flooding in Hinatuan Floodplin

Surigao del Sur				
Barobo				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Amaga Elementary School	Bahi	1	2	2
Dinuyan Elementary School	Cambagang	0	0	0
Sinai Elementary School	Cambagang	3	3	3
Dughan Elementary School	Dughan	0	0	0
Nuevo Paraiso Elementary School	Gamut	0	0	0
Guinhalinan Elementary School	Javier	1	1	1
Javier Elementary School	Javier	0	0	0
Javier National High School	Javier	2	3	3
San Jose Elementary School	San Jose	0	0	0
San Roque Elementary School	San Roque	2	2	3
Bahi Elementary School	Tambis	0	0	0
Tambis Elementary School	Tambis	0	0	1
Tambis National High School	Tambis	0	0	0

Surigao del Sur				
Hinatuan				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Dugmanon Elementary School	Dugmanon	0	0	0
Sasa Elementary School	Dugmanon	0	0	1
Bitoon Elementary School	La Casa	1	2	2
Dugmanon Elementary School	Pagtigni-an	0	0	0
Tiwi Elementary School	San Juan	0	0	0
Pocto Elementary School	San Juan	0	0	0
Tabok Elementary School	Tagbobonga	2	2	2
Father Urios Academy	Tiwi	0	0	1
Hinatuan Day Care Center	Zone II	0	0	0
Hinatuan South Central Elementary School	Zone II	0	0	0
Hinatuan Southern College	Zone II	0	0	0
Hinatuan National Comprehensive High School	Zone II	1	1	1
Hinatuan North Central Elementary School	Zone III Maharlika	1	1	1

Surigao del Sur				
Liangan				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Jose U. Cortes Elementary School	Liatimco			
	Zone III Maharlika	0	0	1

Surigao del Sur				
Tagbina				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Manambia Elementary School	Batunan	0	2	2
Kahayagan National High School	Carpenito	0	0	0
Kahayagan Elementary School	Kahayagan	1	1	1
Kahayagan National High School	Kahayagan	0	0	0
Mabuhay Elementary School	Kahayagan	0	0	0
Lago Elementary School	Lago	0	1	1
Maglambing Integrated School	Maglambing	2	0	0
Causwagan Elementary School	Magsaysay	0	1	1
Magsaysay Elementary School	Magsaysay	0	0	0
Katipunan Elementary School	Manambia	0	0	0
Surigao del Sur State University	Manambia	0	2	2
Surigao del Sur State University	Poblacion	1	2	2
Trinidad Elementary School	Poblacion	1	0	0
Quezon Elementary School	Quezon	0	3	3
Malixi Elementary School	San Vicente		2	2
Sta. Fe Elementary School	Santa Fe		0	1
Mahayahay Primary School	Santa Maria		0	0
Roxas National High School	Santa Maria		0	0
Tuburan Primary School	Santa Maria		3	3
Sayon Elementary School	Sayon		0	0
Surigao del Sur State University	Sayon		0	0
Tagbina Central Elementary School	Sayon		0	0
Tagbina National High School	Sayon		0	0
Batonan Elementary School	Soriano		2	3
Soriano Elementary School	Soriano		0	0
Carpenito Elementary School	Tagongon		2	3
Tagongon Elementary School	Tagongon		0	2
Osme Ea Integrated School	Trinidad		0	0
Quary I Integrated School	Villaverde		3	3
Villaverde Elementary School	Villaverde		0	0

ANNEX 13. Medical Institutions Affected by Flooding in Hinatuan Floodplain

Table A-13.1. Medical Institutions Affected by Flooding in Hinatuan Floodplain

Surigao del Sur				
Liangan				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Hinatuan District Hospital	Benigno Aquino	0	0	0
Hinatuan District Hospital	Zone II	0	0	0
Hinatuan Municipal Health Center	Zone II	1	1	1