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

LiDAR Surveys and Flood Mapping of Malinao Inlet River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
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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
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DOST	Department of Science and Technology
DPPC	Data Pre-Processing Component
DREAM	Disaster Risk and Exposure Assessment for Mitigation [Program]
DRRM	Disaster Risk Reduction and Management
DSM	Digital Surface Model
DTM	Digital Terrain Model
DVBC	Data Validation and Bathymetry Component
FMC	Flood Modeling Component
FOV	Field of View
GiA	Grants-in-Aid
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HC	High Chord
IDW	Inverse Distance Weighted [interpolation method]
IMU	Inertial Measurement Unit
kts	knots
LAS	LiDAR Data Exchange File format
LC	Low Chord
LGU	local government unit
LiDAR	Light Detection and Ranging
LMS	LiDAR Mapping Suite
m AGL	meters Above Ground Level
MMS	Mobile Mapping Suite
MSL	mean sea level
NSTC	Northern Subtropical Convergence
PAF	Philippine Air Force
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PDOP	Positional Dilution of Precision
PPK	Post-Processed Kinematic [technique]
PRF	Pulse Repetition Frequency
PTM	Philippine Transverse Mercator
QC	Quality Check
QT	Quick Terrain [Modeler]
RA	Research Associate
RIDF	Rainfall-Intensity-Duration-Frequency
RMSE	Root Mean Square Error
SAR	Synthetic Aperture Radar
SCS	Soil Conservation Service
SRTM	Shuttle Radar Topography Mission
SRS	Science Research Specialist
SSG	Special Service Group
TBC	Thermal Barrier Coatings
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 MALINAO INLET RIVER

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1.1 Background of the Phil-LiDAR 1 Program

The University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) launched a research program entitled "Nationwide Hazard Mapping using LiDAR in 2014" or Phil-LiDAR 1, supported by the Department of Science and Technology (DOST) Granst-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 Riveres 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 11 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 Malinao Inlet River Basin

The Malinao Inlet River Basin is located in the northernmost portion of the Island of Mindanao, Philippines. It lies at 125034' to 125038' east longitude and 10014' to 10019' north latitude. It includes a major part of Libjo and Tubajon municipalities and small areas of Loreto municipality of Dinagat Islands. The basin covers an area of approximately 344 square kilometers, and is about 17 kilometers long and averages about 14 kilometers in width. kilometers, and is about 17 kilometers long and averages about 29 kilometers in width.

The Malinao River is the principal drainageway of the basin. It originates in the Barangay of Malinao and traverses the entire length of the basin in a northeasterly direction and drains to Municipality of Tubajon and Loreto, Dinagat Islands which faces the Pacific Ocean. It has two tributaries whose origins can be traced from the northeast and southwest portions of the basin. The Diaz River in the northeast and Everan River in the southwest portion of the basin are the tributaries that meet the Malinao River at a junction near Barangay Malinao, Municipality of Tubajon and Loreto, Dinagat Islands. The river channel is wide and is navigable by motor boats up to about 20 kilometers.

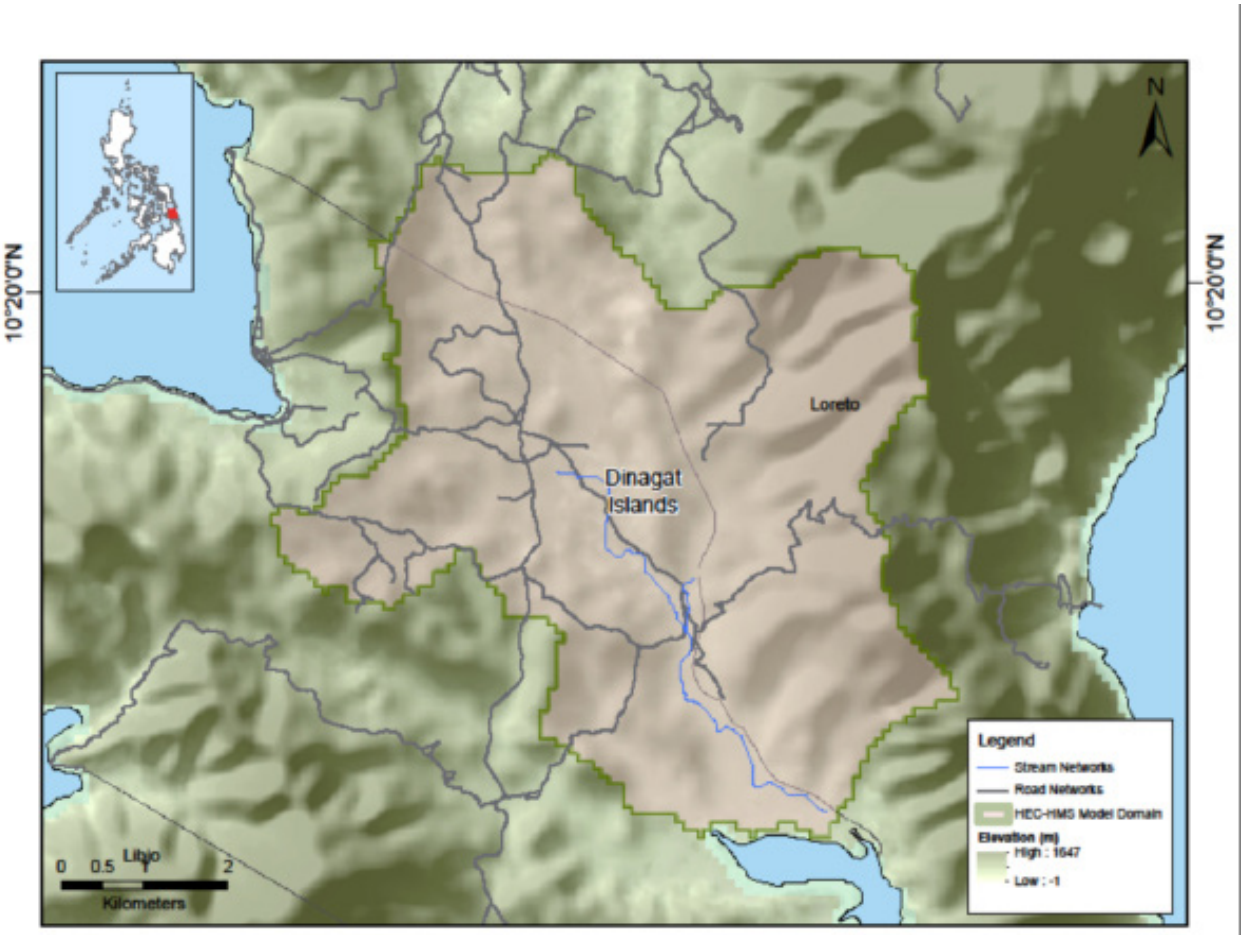

Figure 1. Map of Malinao Inlet River Basin (in brown)

The climate on the basin is classified as tropical according to Köppen and Geiger classification – in which even in the driest month rainfall may still occur. It is typically wet throughout the year and rainfall is both heavy and frequent.

The basin's highest point is at 780 meters above mean sea level situated along the mountain ridges of Barangay Bayanihan, Municipality of Libjo, Dinagat Islands . The most abundant soil type in the basin based on maps published by the Department of Agriculture is loam which accounts for 51% of the basin's land area. The basin is mostly covered by open canopy forests and brush land leaving the built-up areas only covering less than 1% of the basin.

The province of Dinagat Islands, where Malinao River Basin is located, consists of the eponymous Dinagat Island and surrounding islands and islets known for its caves, resorts and beaches. As of the 2015 estimate, the province has a population of 127,152 with a density of 120 inhabitants per square kilometer. Old settlers of the province are called "Lumad" and residents of the Dinagat Islands are called "Dinagatnon". The Dinagat Islands is predominantly a Cebuano-speaking province. However, towns facing the Surigao del Norte are Surigaonon-speaking, particularly the municipalities of Dinagat and Cagdianao due to their proximity to the province of Surigao del Norte. Influences of the Cebuano and Boholano languages with a Tausug accent can be also traced[Dinagat Islands. (2017, July 02). Retrieved July 03, 2017, from https://en.wikipedia.org/wiki/Dinagat_Islands].

The Dinagat Islands is one of the most environmentally-significant provinces in the Philippines, where endemism of fauna is unique in its region. The province is highly forested and is considered as a Key Biodiversity Area by Haribon Foundtion Department of Environment and Natural Resources because of its unique fauna and flora, along with its lush rainforest which are classified as primary forests which have never been fully obliterated since pre-colonial times[Dinagat Islands. (2017, July 02). Retrieved July 03, 2017, from https://en.wikipedia.org/wiki/Dinagat_Islands].

The Malinao Inlet River Basin is one of the affected basins during the onslaught of Tropical Storm "Basyang" in January 2014 to the extent that a 'state of calamity' was declared by the City government. It can be recalled that "Basyang" was the second Tropical Cyclone that affected the country. "Basyang" was already a Tropical Depression with maximum sustained wind of 55 kilometers per hour near the center when it entered the Philippine Area of Responsibility (PAR) in the afternoon of 30 January 2014 and moved West in a faster pace at 30 kilometers per hour[http://www.ndrrmc.gov.ph/attachments/article/2792/FINAL_REPORT_re_Effects_of_Tropical_Storm_BASYANG_(Kajiki)_30JAN_-_01FEB_2014.pdf]. The occurrence of "Basyang" and the continuous rain and strong winds that it brought along has caused flooding not only the municipalities within the Malinao River Basin but also in other localities in Mindanao.

CHAPTER 2: LIDAR DATA ACQUISITION OF THE MALINAO INLET FLOODPLAIN

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

2.1 Flight Plans

To initiate the LiDAR acquisition survey of the Malinao Inlet floodplain, the Data Acquisition Component (DAC) created flight plans within the delineated priority area for Malinao Inlet Floodplain in Dinagat Island. These flight missions were planned for 12 lines and ran for at most four and a half hours including take-off, landing and turning time. The flight planning parameters for the LiDAR system are outlined in Table 1. Figure 2 shows the flight plan for Malinao Inlet floodplain survey.

Table 1. Flight planning parameters for the Aquarius LiDAR system.

Block Name	Flying Height (m AGL)	Overlap (%)	Field of view (ø)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK59A	600	30	18	50	45	130	5
BLK59B	600	30	18	50	45	130	5
BLK59C	600	30	18	50	45	130	5
BLK59D	600	30	18	50	45	130	5
BLK59E	600	30	18	50	45	130	5
BLK59F	600	30	18	50	45	130	5

[1] The explanation of the parameters used are in the volume “LiDAR Surveys and Flood Mapping in the Philippines: Methods.”

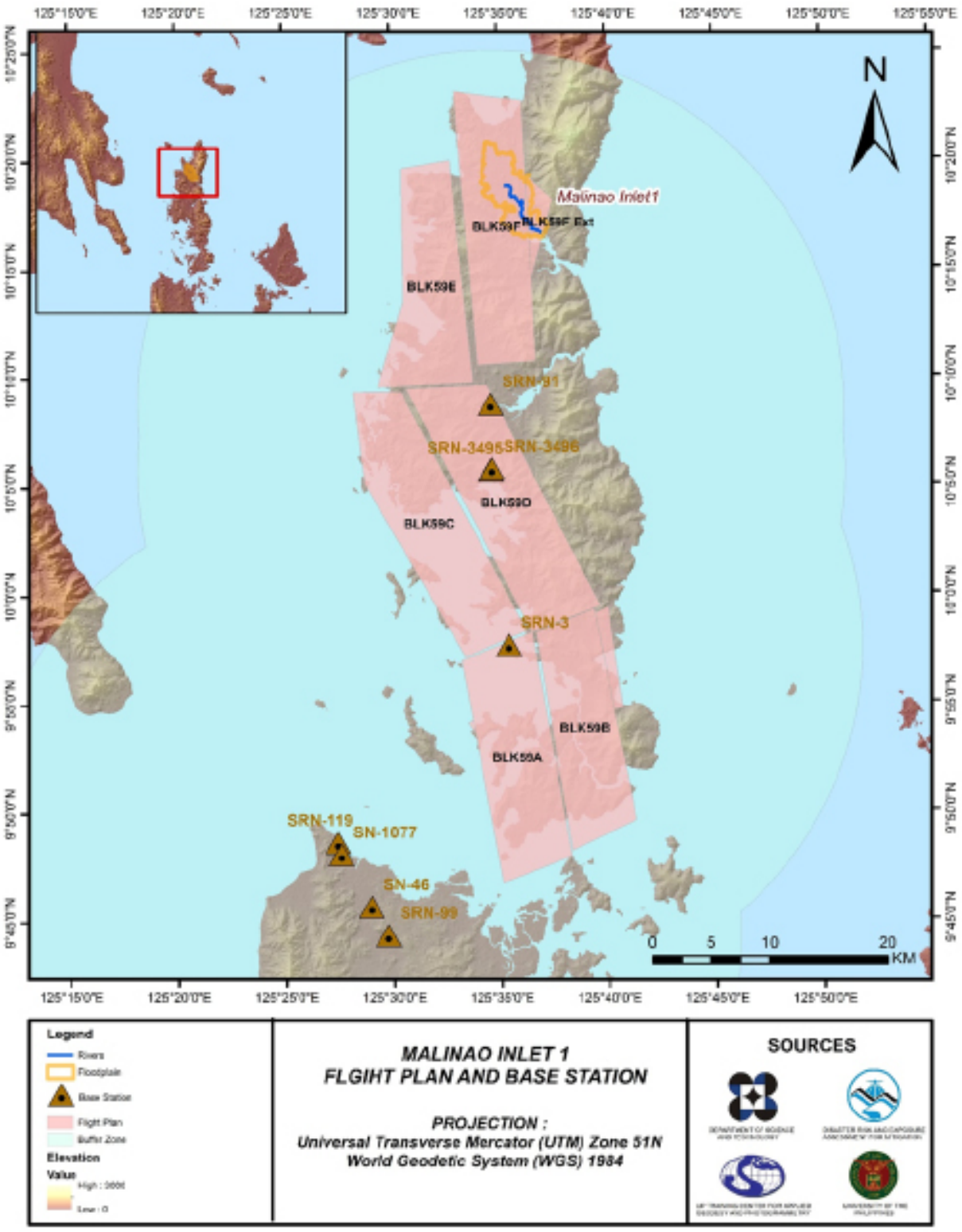

Figure 2. Flight Plan and base stations used for the Malinao Inlet Floodplain survey using Aquarius sensor.

2.2 Ground Base Stations

The field team was able to recover two (8) NAMRIA ground control points: SRN-3, which is of first (1st) order accuracy, SRN-199, SRN-91, and SRN-99, which are of second (2nd) order accuracy, SRN-3495 and SRN-3496, which are of fourth (4th) order accuracy, and two (2) NAMRIA benchmarks, SN-1077 and SN-46.

The certifications for the base stations are found in Annex 2 while the baseline processing reports for the established control points are found in Annex 3. These were used as base stations during flight operations for the entire duration of the survey from September 11 – 28, 2014; October 11 – 20, 2014; and May 14 - 17, 2016. Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 882, SPS852, and SPS985. Flight plans and location of base stations used during the aerial LiDAR acquisition in Malinao Inlet floodplain are shown in Figure 2.

The succeeding sections depict the sets of reference points, control stations and established points, and the ground control points for the entire Malinao Inlet Floodplain LiDAR Survey. Figure 3 shows the recovered NAMRIA reference points and established point within the area of the floodplain, while Table 2 to Table 9 presents the details of the recovered NAMRIA horizontal control points.

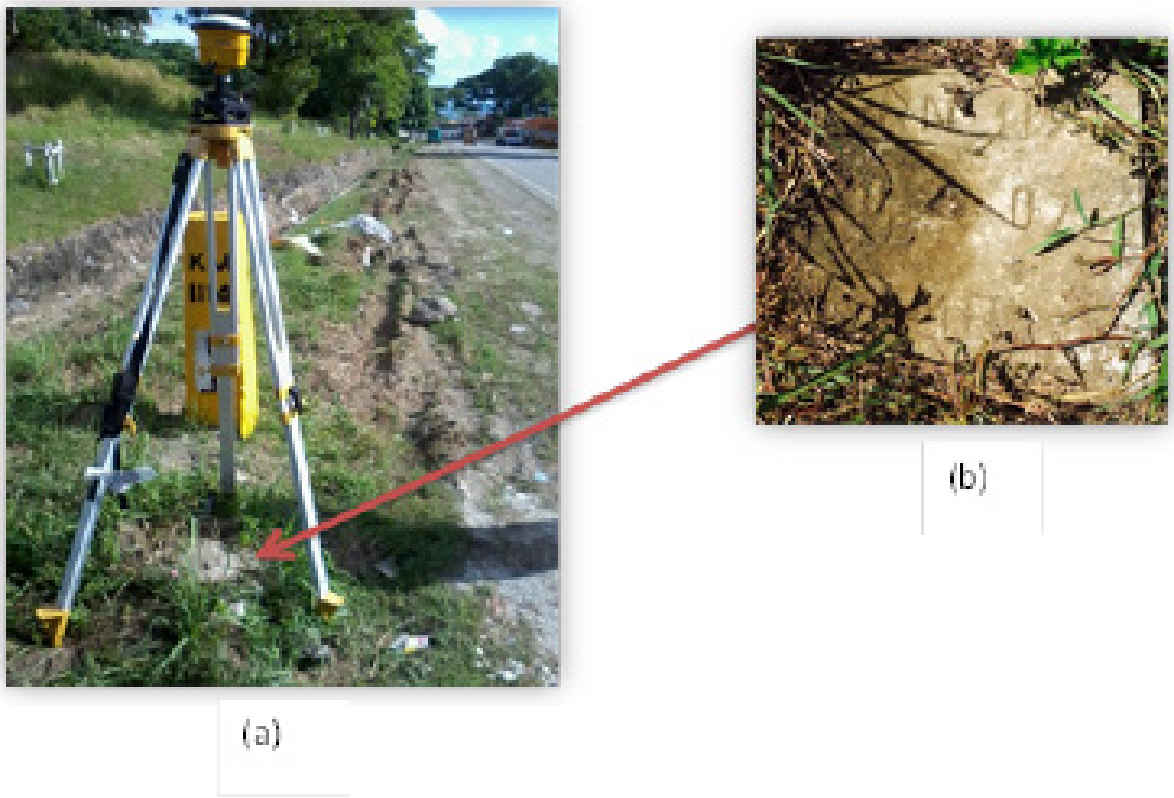

Figure 3. GPS set-up over SRN-119 Kilometer Post 1114 along the National Highway at Surigao City, Surigao Del Norte (a) and NAMRIA reference point SRN-119 (b) as recovered by the field team

Table 2. Details of the recovered NAMRIA horizontal control point SRN-119 used as base station for the LiDAR acquisition.

Station Name	**SRN-119**	
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	9° 48’ 39.52825” North 125° 27’ 19.47825” East 26.179 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	549958.116 meters 1084859.315 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9° 48’ 35.66803” North 125° 27’ 24.75607” East 92.905 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	769495.998 meters 1085380.264 meters

Table 3. Details of the recovered NAMRIA horizontal reference point CGY-87 used as base station for the LiDAR acquisition.

Station Name	**BMSN-1077**	
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	9° 48' 6.91949" North 125° 27' 28.92849" East 4.502 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	769632.898 meters 1084429.454 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9° 48' 3.06184" North 125° 27' 34.20710" East 71.255 meters

Table 4. Details of the recovered NAMRIA horizontal control point SRN-3495 used as base station for the LiDAR acquisition.

Station Name	**CGY-110**	
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	10° 05' 45.35035" North 125° 34' 31.64667" East 152.484 meters
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 5 PRS 92)	Easting Northing	782268.608 meters 1117061.565 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	10° 05' 41.42677" North 125° 34' 36.89786" East 218.856 meters

Table 5. Details of the recovered NAMRIA horizontal control point SRN-3496 used as base station for the LiDAR acquisition.

Station Name	**SRN-3496**	
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	10° 05' 49.75545" North 125° 34' 35.51936" East 148.416 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	782385.516 meters 1117197.907 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	10° 05' 45.83165" North 125° 34' 40.77044" East 214.789 meters

Table 6. Details of the recovered NAMRIA Benchmark SN-46 with processed coordinates used as base station for the LiDAR acquisition.

Station Name	**SN-46**	
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	9° 45' 41.79368" North 125° 28' 52.27552" East 6.010 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	772206.879 meters 1079987.356 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9° 45' 37.94854" North 125° 28' 57.55750" East 72.910 meters

Table 7. Details of the recovered NAMRIA horizontal control point SRN-3 used as base station for the LiDAR acquisition.

Station Name	**SRN-3496**	
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	9° 57' 43.04816" North 125° 35' 19.65373" East 21.451 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	564560.974 meters 1101580.223 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9° 57' 39.16040" North 125° 35' 24.91678" East 88.16300 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	783847.82 meters 1102247.18 meters

Table 8. Details of the recovered NAMRIA horizontal control point SRN-91 used as base station for the LiDAR acquisition.

Station Name	**SN-46**	
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	10° 8' 49.06477" North 125° 34' 33.14033" East 31.801 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	563108.305 meters 1122039.462 meters
Geographic Coordinates, World Geodetic System 1984	Latitude Longitude Ellipsoidal Height	10° 8' 45.12793" North 125° 34' 38.38708" East 98.058 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	782269.46 meters 1122709.27 meters

Table 9. Details of the recovered NAMRIA horizontal control point SRN-99 used as base station for the LiDAR acquisition.

Station Name	**SRN-99**	
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	9° 44' 22.95065" North 125° 29' 38.38093" East 11.848 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	554202.388 meters 1076982.803 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9° 44' 19.11233" North 125° 29' 43.66472" East 78.829 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	773630.64 meters 1077574.28 meters

Table 10. Ground control points that were used during the LiDAR data acquisition.

Date Surveyed	Flight Number	Mission Name	Ground Control Points
September 11, 2014	1934A	3BLK59A254A	SRN-119, BMSN-1077
September 11, 2014	1936A	3BLK59B254B	SRN-119, BMSN-1077
September 14, 2014	1946A	3BLK59BS257A	SRN-119
September 15, 2014	1950A	3BLK59D258A	SRN-119
September 19, 2014	1966A	3BLK59C262A	SRN-119
September 19, 2014	1968A	3BLK59DS262B	SRN-119
September 23, 2014	1982A	3BLK59DS266A	SRN-3
September 23, 2014	1986A	3BLK59E267A	SRN-3496, SRN-3
September 23, 2014	1988A	3BLK59ES267B	SRN-3496, SRN-3
September 27, 2014	1998A	3BLK59F270A	SRN-3496, SRN-3495
September 28, 2014	2002A	3BLK59FDS271A	SRN-3496, SRN-3495
October 11, 2014	2054A	3BLK59DS284A	SRN-3496, SRN-3495
October 12, 2014	2060A	3BLK59S285B	SRN-3496, SRN-3495
October 18, 2014	2082A	3BLK59S291A	SRN-3496, SRN-3495
October 20, 2014	2090A	3BLK59DS293A	SRN-3496, SRN-3495
May 14, 2016	8493AC	3DNGB135A	SRN-46, SRN-99
May 16, 2016	8497AC	3DNGABSC137A	SRN-91, SRN-91A
May 17, 2016	8499AC	3DNGDE138A	SRN-46, SRN-99

2.3 Flight Missions

A total of eighteen (18) missions were conducted to complete the LiDAR data acquisition in Malinao Inlet floodplain, for a total of thirty hours and thirty four minutes (30+34) of flying time for[Check total flying hours] RP-C9122 (See Annex 6). All missions were acquired using the Aquarius system. As shown below, the total area of actual coverage per mission and the corresponding flying hours are depicted in Table 11, while the actual parameters used during the LiDAR data acquisition are presented in Table 12.

Table 11. Flight missions for LiDAR data acquisition in Malinao Inlet floodplain.

Date Surveyed	Flight No.	Flight Plan Area (km2)	Surveyed Area (km2)	Area Surveyed within the Floodplain (km2)	Area Surveyed Outside the Floodplain (km2)	No. of Images (Frames)	Flying Hours	
							Hr	Min
September 11, 2014	1934A	120.40	143.58	-	143.58	232	4	23
September 11, 2014	1936A	102.27	58.89	-	58.89	626	3	11
September 14, 2014	1946A	102.27	126.34	-	126.34	1413	2	59
September 15, 2014	1950A	138.90	87.44	-	87.44	46	3	35
September 19, 2014	1966A	136.40	99.36	-	99.36	2482	3	35
September 19, 2014	1968A	136.40	52.88	-	52.88	223	2	29
September 23, 2014	1982A	136.40	57.18	-	57.18	3	2	35
September 24, 2014	1986A	102.70	111.50	-	111.50	10	3	41
September 24, 2014	1988A	102.70	95.80	-	95.80	992	3	29
September 27, 2014	1998A	224.80	350.37	20.54	329.83	42	4	23
September 28, 2014	2002A	122.10	85.07	2.25	82.81	2	4	17
October 11, 2014	2054A	102.70	42.18	-	42.18	2	4	23
October 12, 2014	2060A	23.01	13.57	-	13.57	NA	2	19
October 18, 2014	2082A	23.01	10.02	-	10.02	948	3	0
October 20, 2014	2090A	138.40	38.46	-	38.46	4	2	35
May 14, 2016	8493AC	17.70	13.56	-	13.56	1	1	35
May 16, 2016	8497AC	23.01	61.94	12.01	49.93	12	3	59
May 17, 2016	8499AC	34.47	59.14	-	59.14	2	3	53
TOTAL	1787.64	1507.28	34.8	462.57	1013	30	34	

Table 12. Actual parameters used during LiDAR data acquisition.

Flight Number	Flying Height (m AGL)	Overlap (%)	FOV (θ)	PRF (khz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
1934A	600	30	18	50	45	130	5
1936A	600	30	18	50	45	130	5
1946A	600	30	18	50	45	130	5
1950A	600	30	18	50	45	130	5
1966A	600	30	18	50	45	130	5
1968A	600	30	18	50	45	130	5
1982A	600	30	18	50	45	130	5
1986A	600	30	18	50	45	130	5
1988A	600	30	18	50	45	130	5
1998A	600	30	18	50	45	130	5
2002A	600	30	18	50	45	130	5
2054A	600	30	18	50	45	130	5
2060A	600	30	18	50	45	130	5
2082A	600	30	18	50	45	130	5
2090A	600	30	18	50	45	130	5
8493AC	500	30	18	50	45	130	5
8497AC	500	30	18	50	45	130	5
8499AC	500	30	18	50	45	130	5

2.4 Survey Coverage

This certain LiDAR acquisition survey covered the Malinao Inlet floodplain (See Annex 7). It is located in the province of Dinagat Island with majority of the floodplain situated within the municipality of Manilao Inlet 1 City. The municipalitiy of Dinagat is partially covered by the survey. The list of municipalities and cities surveyed with at least one (1) square kilometer coverage is shown in Table 13, Figure 4 on the other hand, shows the actual coverage of the LiDAR acquisition for the Malinao Inlet floodplain.

Table 13. Area of Coverage of the LiDAR Data Acquisition in Malinao Inlet floodplain.

Province	Municipality/ City	Area of Municipality/City (km2)	Total Area Surveyed (km2)	Percentage of Area Surveyed
Dinagat Island	Dinagat	12.98	12.63	97%
	San Jose	29.33	28.16	96%
	Basilisa	71.20	64.37	90%
	Libjo	205.11	179.88	88%
	Tubajon	85.88	73.81	86%
	Cagdianao	236.24	69.16	29%
	Loreto	168.86	37.08	22%
Surigao del Norte	Surigao City	240.67	78.50	33%
Total		**1,050.27**	**543.59**	**51.76%**

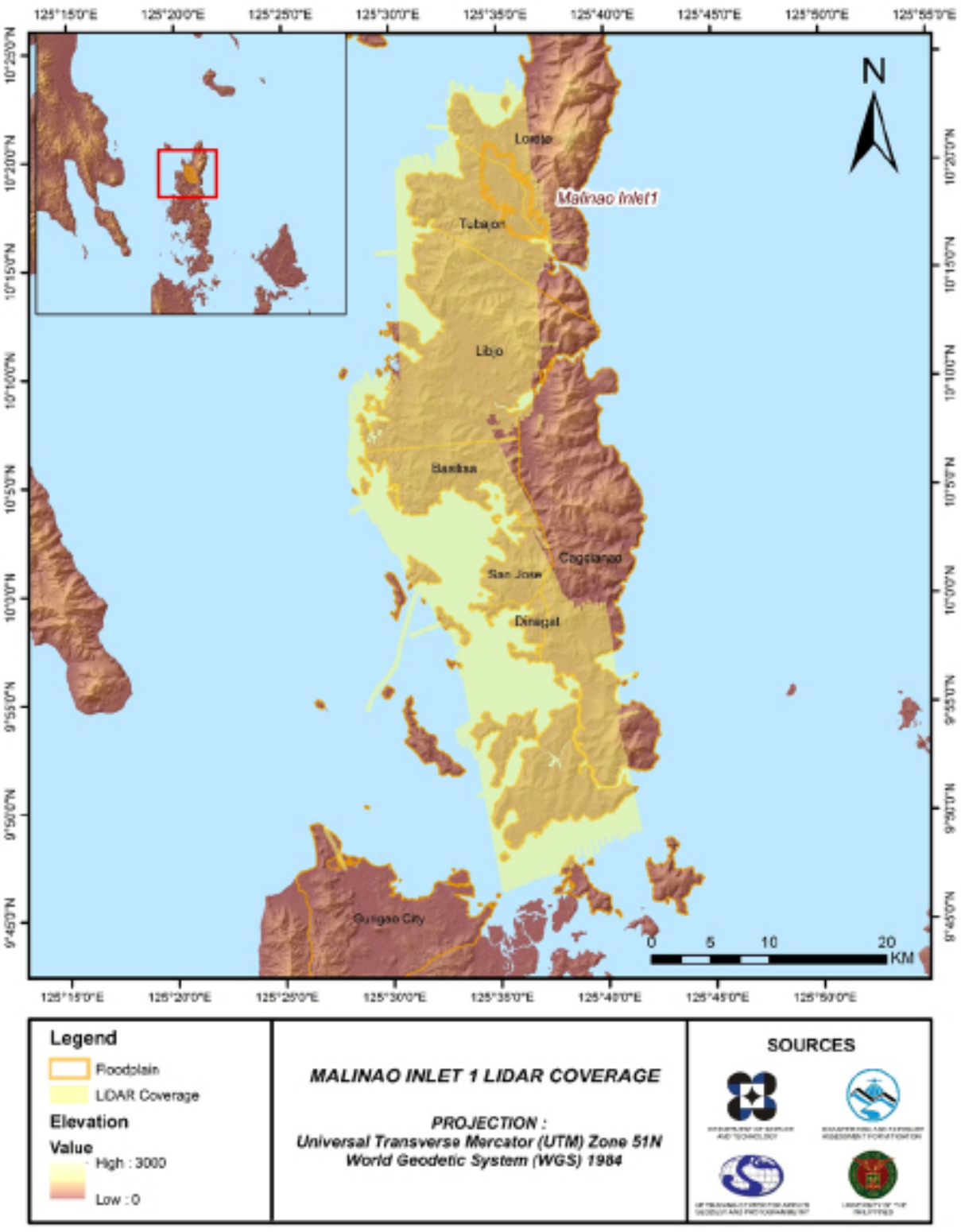

Figure 4. Actual LiDAR survey coverage for Malinao Inlet floodplain.

CHAPTER 3: LIDAR DATA PROCESSING OF THE MALINAO INLET FLOODPLAIN

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

3.1 Overview of the LiDAR Data Pre-Processing

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

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

These processes are summarized in the flowchart shown in Figure 5.

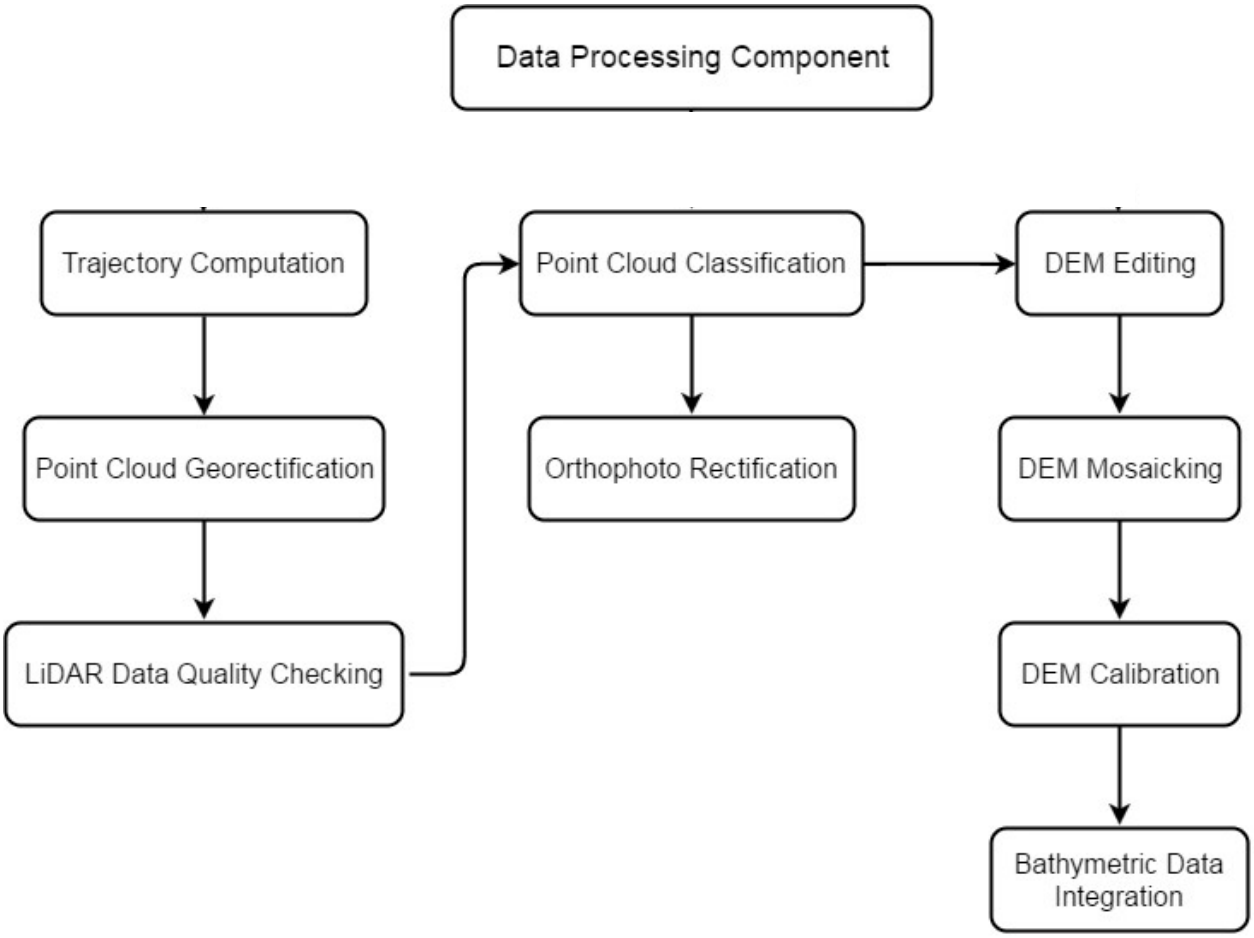

Figure 5. Schematic diagram for the data pre-processing.

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for the Malinao Inlet Floodplain can be found in Annex 5. Missions flown during the first survey conducted on September 2014 utilized the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Aquarius system over Dinagat Island.

The Data Acquisition Component (DAC) transferred a total of 129.31 Gigabytes of Range data, 2.71 Gigabytes of POS data, 235.51 Megabytes of GPS base station data, and 91.2 Gigabytes of raw image data to the data server on Octocer 31, 2014 for the survey, which was verified for accuracy and completeness by the DPPC. The whole dataset for the Malinao Inlet Floodplain was fully transferred on July 23, 2016, as indicated on the Data Transfer Sheets for the Malinao Inlet floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for Flight 1934A, one of the Malinao Inlet flights, which is the North, East, and Down position RMSE values are shown in Figure 6. The x-axis corresponds to the time of the flight, which was measured by the number of seconds from the midnight of the start of the GPS week, which fell on the date and time of September 11, 2014, 00:00AM. The y-axis, on the other hand, represents the RMSE value for that particular position.

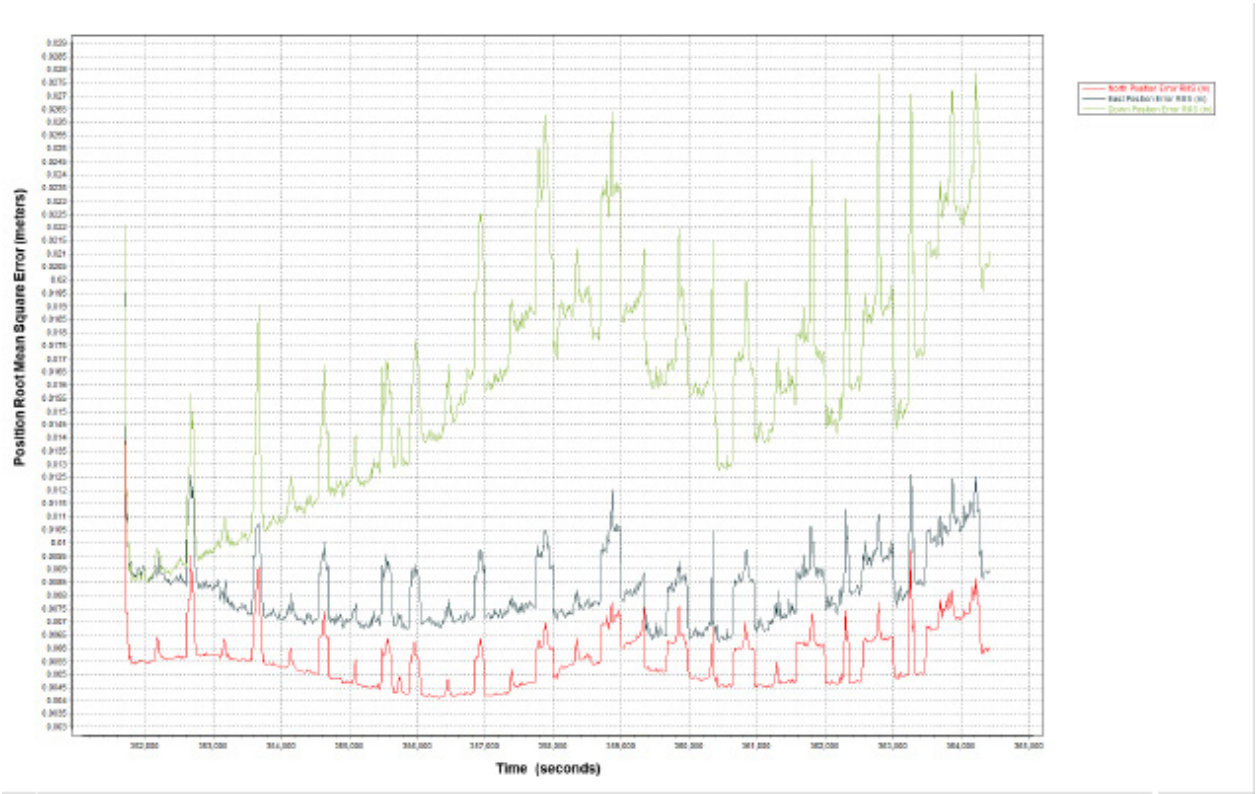

Figure 6. Smoothed Performance Metrics of Malinao Inlet Flight 1934A.

The time of flight was from 352000 seconds to 365000 seconds, which corresponds to morning of September 11,2014. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft.

Redundant measurements from the POS system quickly minimize the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 9 shows that the North position RMSE peaks at 1.9 centimeters, the East position RMSE peaks at 2.60 centimeters, and the Down position RMSE peaks at 5.40 centimeters, which are within the prescribed accuracies described in the methodology.

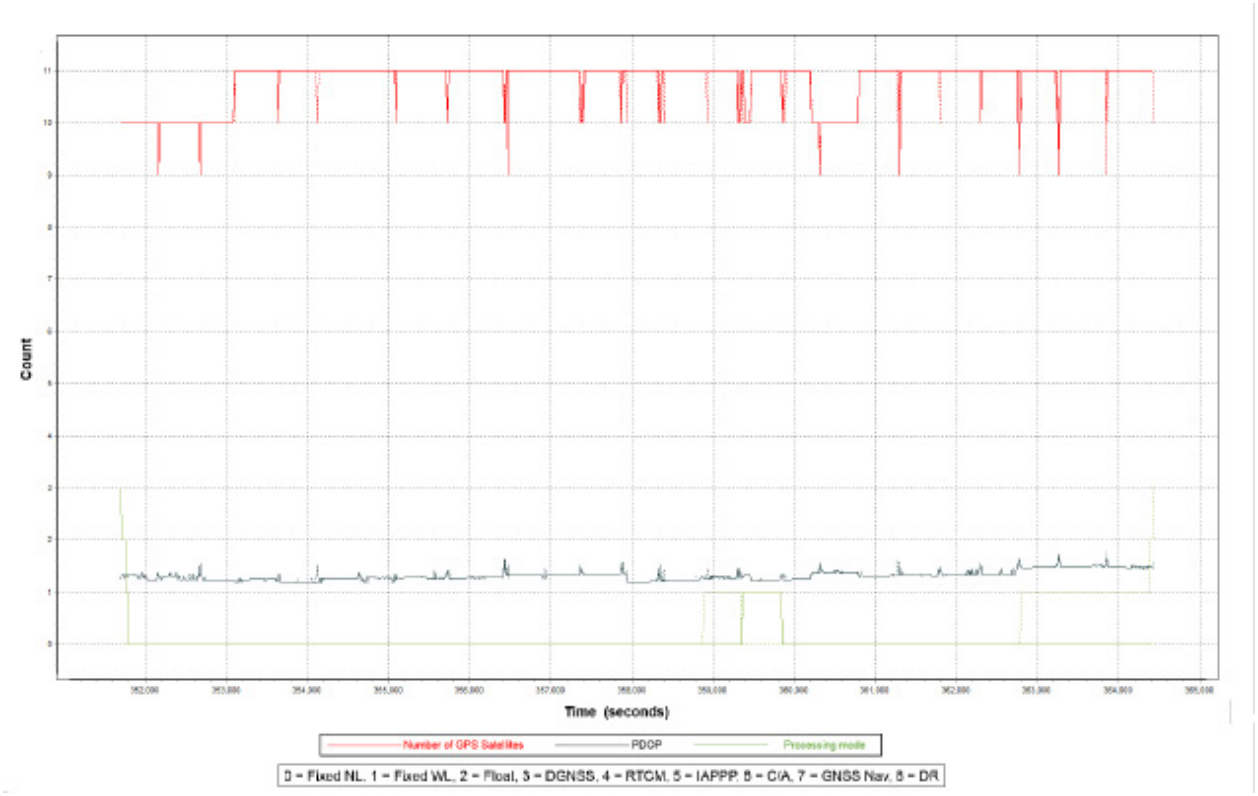

Figure 7. Solution Status Parameters of Malinao Inlet Flight 1934A.

The Solution Status parameters, which indicate the number of GPS satellites; Positional Dilution of Precision (PDOP); and the GPS processing mode used for Malinao Inlet Flight 1934A are shown in Figure 7. For the Solution Status parameters, the figure above signifies that the number of satellites utilized and tracked during the acquisition were between 9 and 11, not going lower than 8. Similarly, the PDOP value did not go above the value of 3, which indicates optimal GPS geometry. The processing mode also remained at 0 for the majority of the survey stayed at the value of 0. The value of 0 corresponds to a Fixed, Narrow-Lane Mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for the POSPAC MMS. Fundamentally, 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 Malinao Inlet flights is shown in Figure 8.

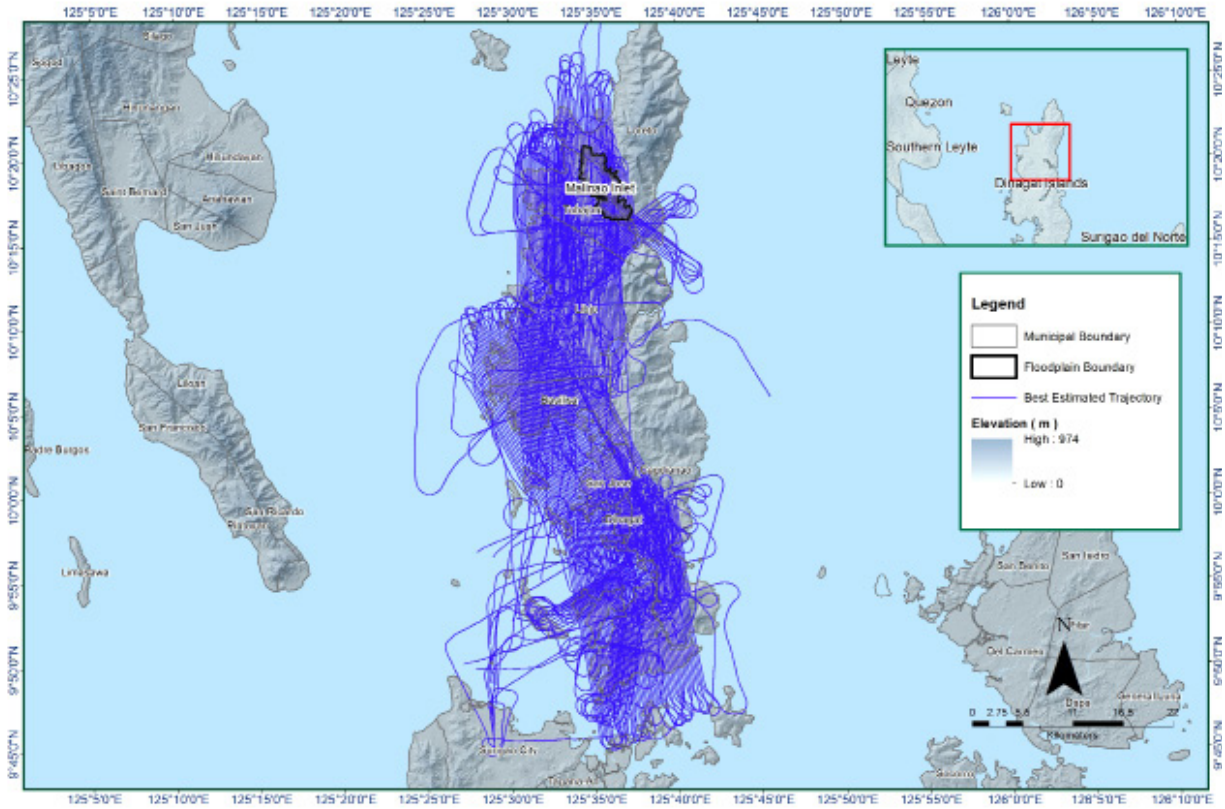

Figure 8. Best estimated trajectory of the LiDAR missions conducted over the Malinao Inlet Floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS contains 239 flight lines, with each flight line contains one channel, since the Aquarius system contains only one channel. The summary of the self-calibration results obtained from LiDAR processing in the LiDAR Mapping Suite (LMS) software for all flights over the Malinao Inlet floodplain are given in Table 14.

Table 14. Self-calibration results values for Malinao Inlet flights.

Parameter	Acceptable Value	Computed Value
Boresight Correction stdev	<0.001degrees	0.000218
IMU Attitude Correction Roll and Pitch Correction stdev	<0.001degrees	0.000903
GPS Position Z-correction stdev	<0.01meters	0.0027

The optimum accuracy values for all Malinao Inlet flights were also calculated, which are based on the computed standard deviations of the corrections of the orientation parameters. The standard deviation values for individual blocks are presented in the Mission Summary Reports (Annex 8).

3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data is shown in Figure 9. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

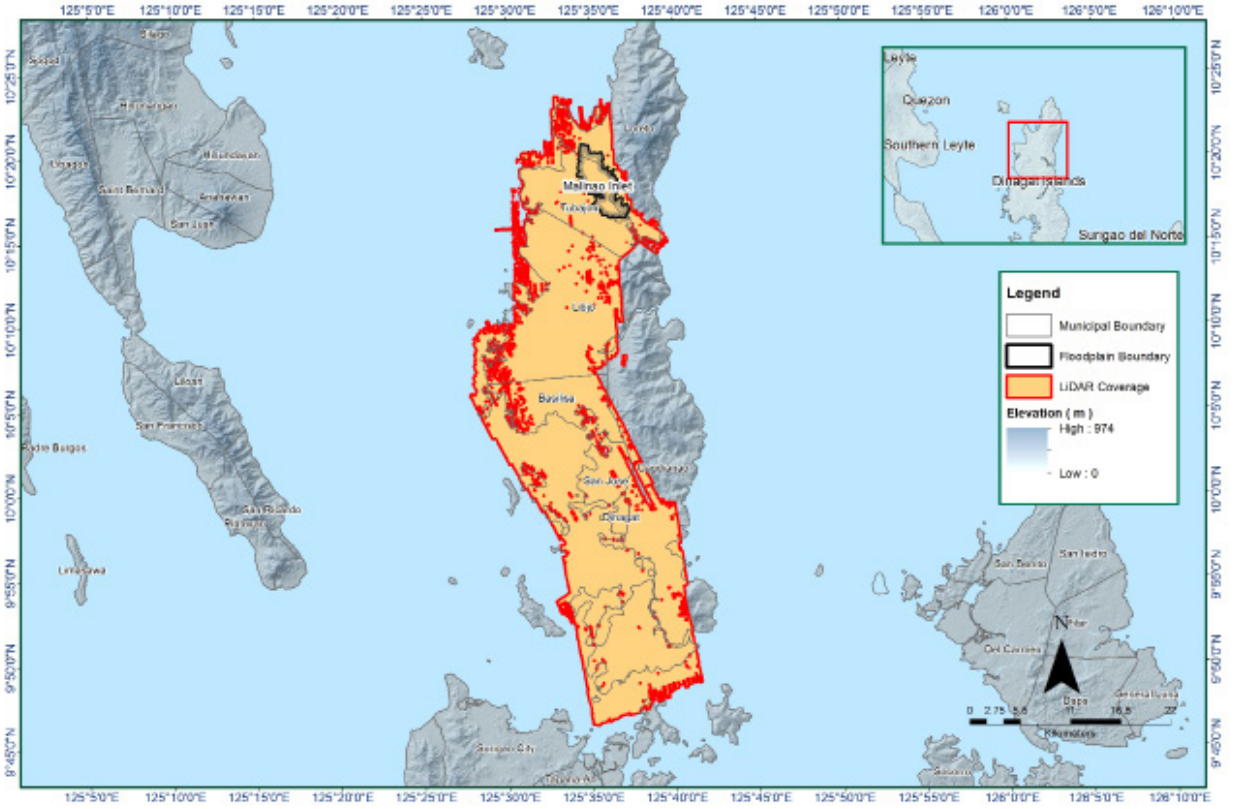

Figure 9. Boundaries of the processed LiDAR data on top of the SAR Elevation Data over the Malinao Inlet Floodplain.

A total area of 1,049.71 square kilometers (sq. kms.) were covered by the Malinao Inlet flight missions as a result of sixteen (16) flight acquisitions, which were grouped and merged into twelve (12) blocks accordingly, as portrayed in Table 15.

Table 15. List of LiDAR blocks for the Malinao Inlet floodplain.

LiDAR Blocks	Flight Numbers	Area (sq. km)
Siargao_Blk59A	1934A	132.81
Siargao_Blk59B	1936A	53.44
	1946A	
Siargao_Blk59B_supplement	1946A	68.57
Siargao_Blk59C	1966A	180.21
	1968A	
	1982A	
Siargao_Blk59D	1950A	114.11
	1968A	
	2090A	
Siargao_Blk59D_additional	2002A	20.50
Siargao_Blk59E	1986A	179.40
	1988A	
	2054A	
Siargao_Blk59F	1998A	178.19
	2002A	
	2060A	
	2082A	
Surigao_reflights_Blk59A	8499AC	22.86
Surigao_reflights_Blk59A_supplement	8499AC	31.25
Surigao_reflights_Blk59B	8493AC	34.58
	8497A	
Surigao_reflights_Blk59F	8497A	33.79
TOTAL		**1,049.71**

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location is shown in Figure 10. Since the Aquarius system employs one channel, we would expect an average value of 1 (blue) for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines.

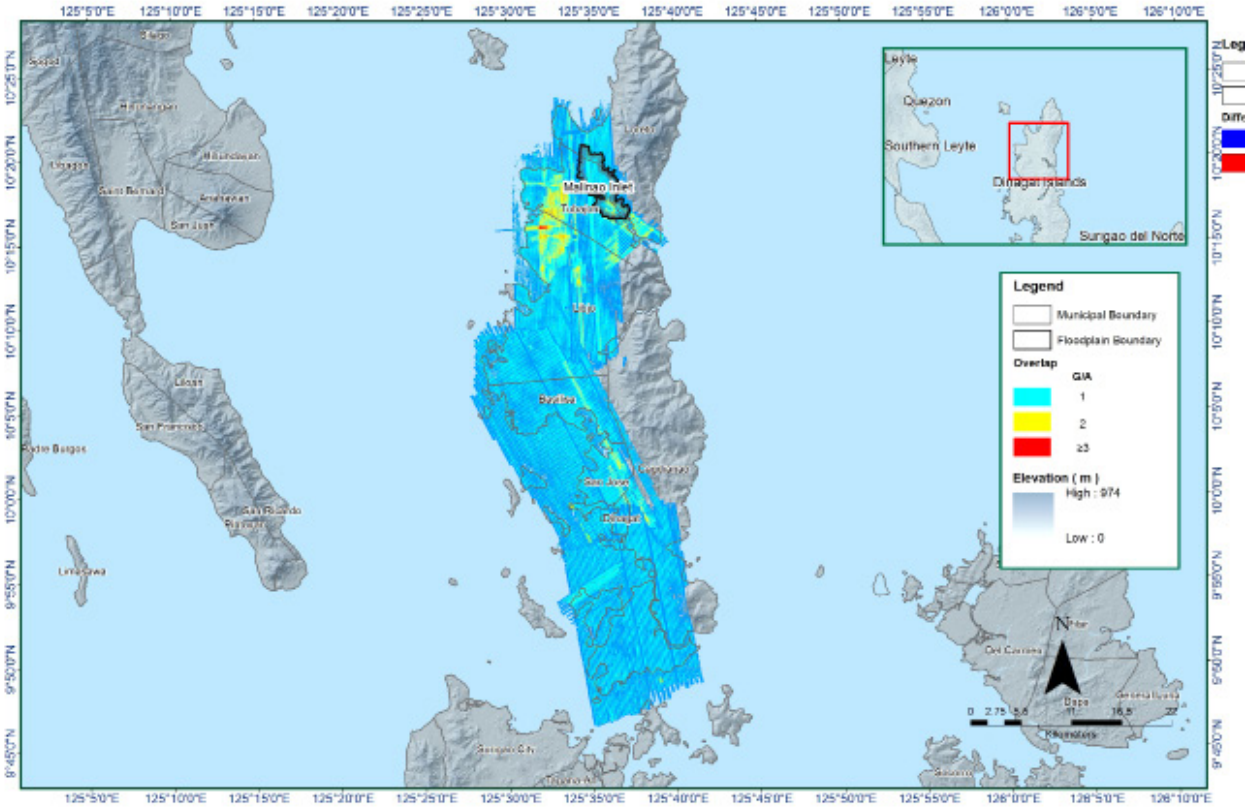

Figure 10. Image of data overlap for Malinao Inlet Floodplain.

The overlap statistics per block for the Malinao Inlet floodplain can be found in the Mission Summary Reports (Annex 8). One pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 30.20% and 52.10% respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the two (2) points per square meter criterion is shown in Figure 11. As seen in the figure below, it was determined that all LiDAR data for the Malinao Inlet Floodplain Survey satisfy the point density requirement, as the average density for the entire survey area is 3.19 points per square meter.

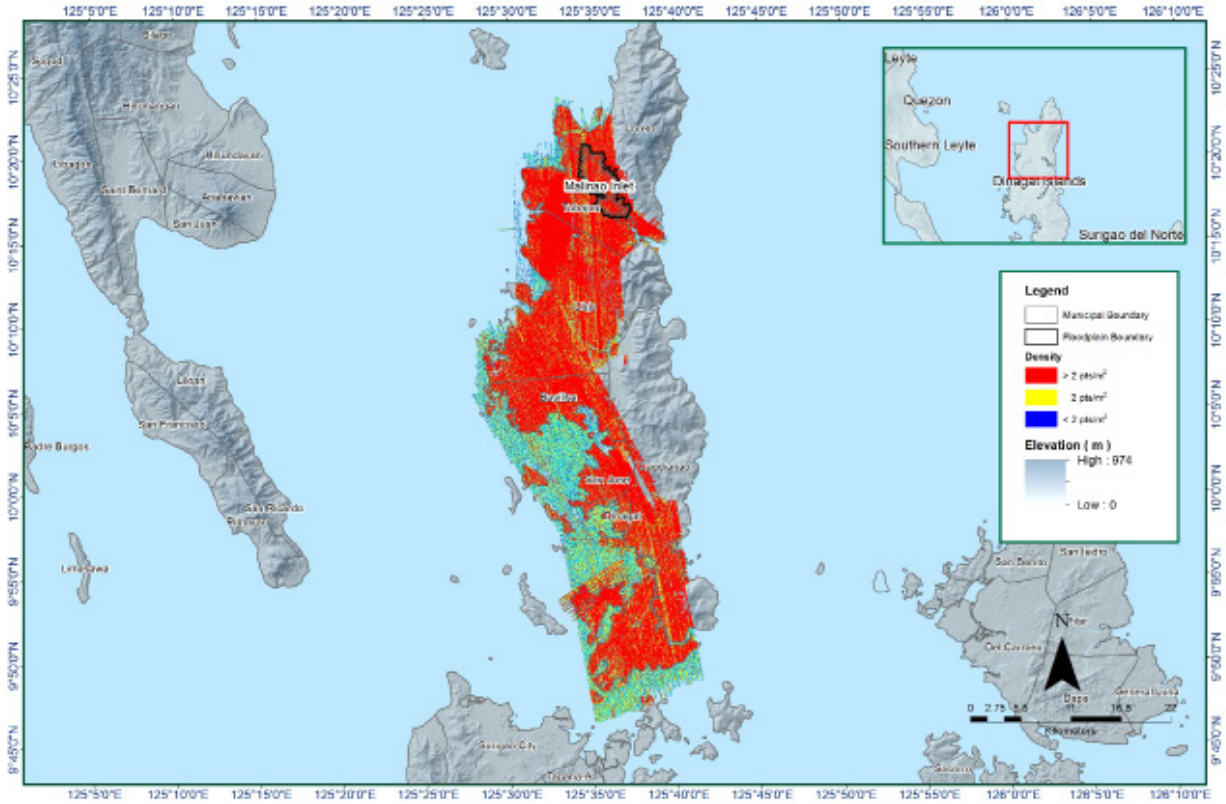

Figure 11. Pulse density map of the merged LiDAR data for Malinao Inlet Floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 12. The default color range is blue to red, where bright blue areas correspond to portions where elevations of a previous flight line are higher by more than 0.20m, as identified by its acquisition time; which is relative to the elevations of its adjacent flight line. Similarly, bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m, relative to the elevations of its adjacent flight line. Areas highlighted in bright red or bright blue necessitate further investigation using the Quick Terrain Modeler software.

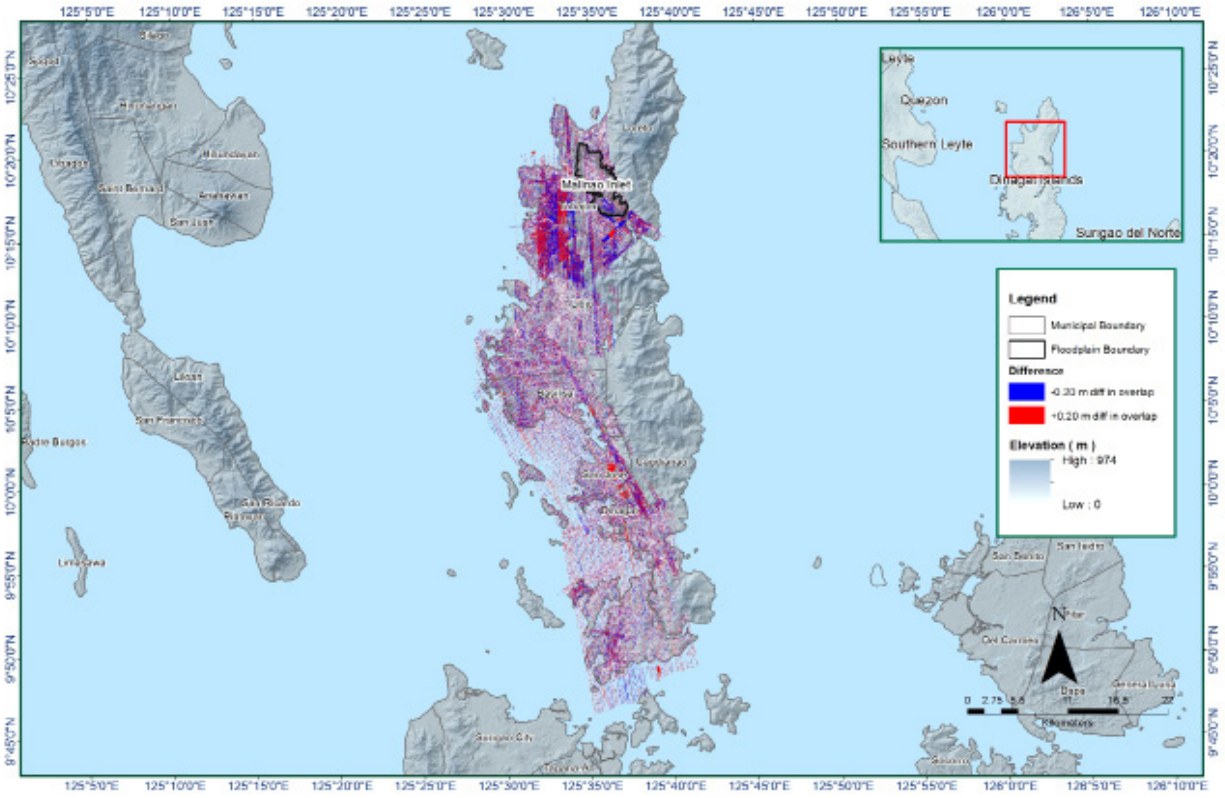

Figure 12. Elevation difference Map between flight lines for the Malinao Inlet Floodplain Survey.

A screen-capture of the processed LAS data from Malinao Inlet flight 1934A loaded in QT Modeler is shown in Figure 13. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data generated satisfactory results. No reprocessing was done for this LiDAR dataset.

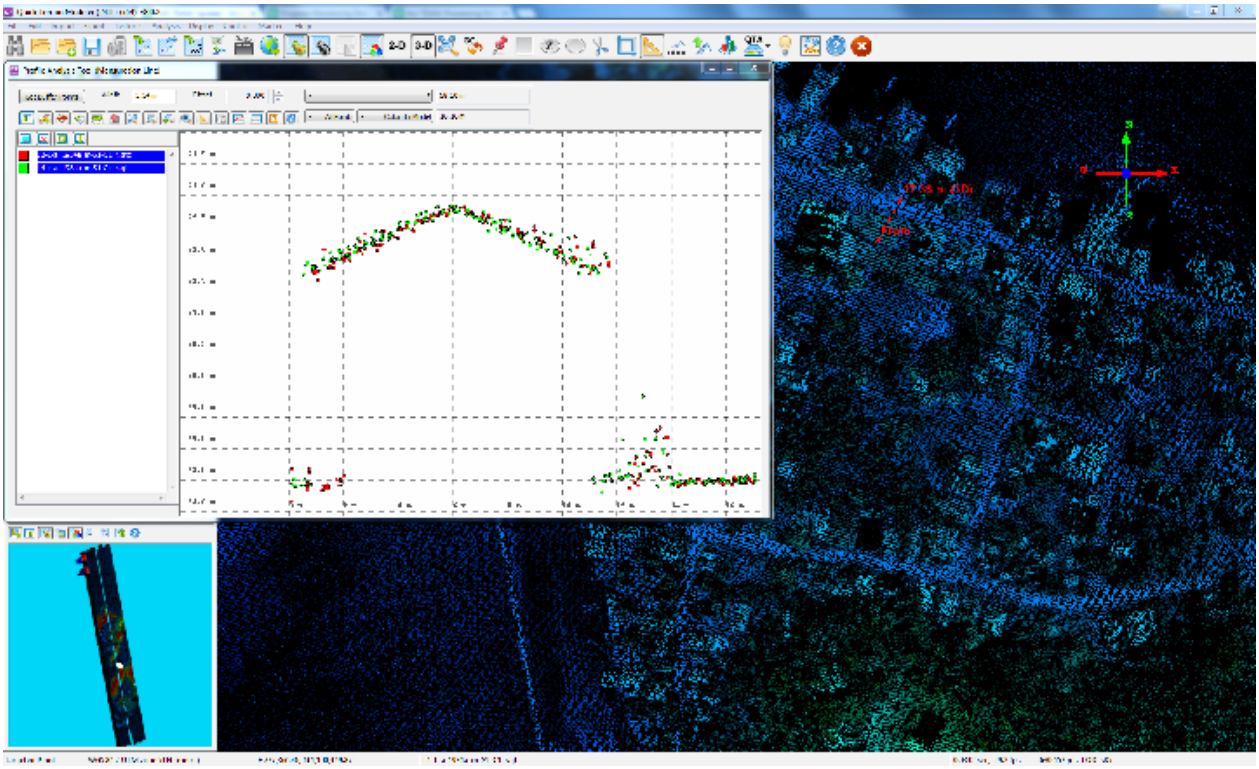

Figure 13. Quality checking for Malinao Inlte flight 1934A using the Profile Tool of QT Modeler.

3.6 LiDAR Point Cloud Classification and Rasterization

Table 16. Malinao Inlet classification results in TerraScan

Pertinent Class	Total Number of Points
Ground	391,985,219
Low Vegetation	290,035,785
Medium Vegetation	666,708,562
High Vegetation	769,494,650
Building	21,573,180

The tile system that TerraScan employed for the LiDAR data as well as the final classification image for a block of the Malinao Inlet floodplain is shown in Figure 14. A total of 1,361 tiles with 1 km. X 1 km. (one kilometer by one kilometer) size were produced. Correspondingly, Table 16 summarizes the number of points classified to the pertinent categories. The point cloud has a maximum and minimum height of 596.44 meters and 46.45 meters respectively.

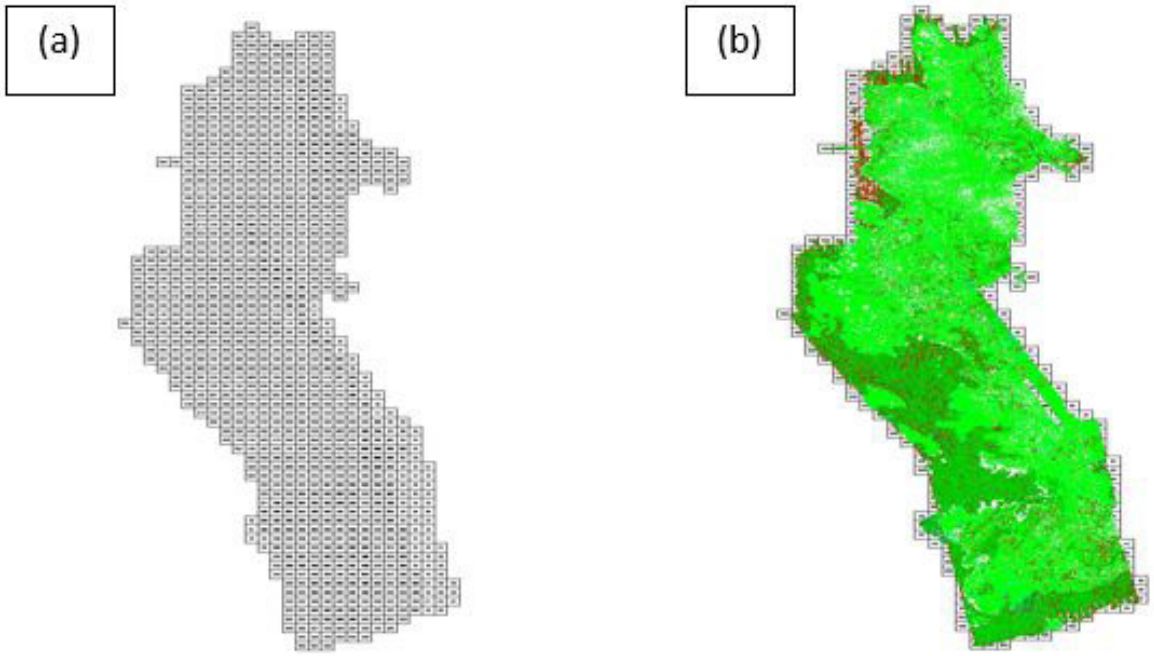

Figure 14. Tiles for Malinao Inlet Floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 15. The ground points are highlighted in orange, while the vegetation are in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below the canopy are classified correctly, due to the density of the LiDAR data.

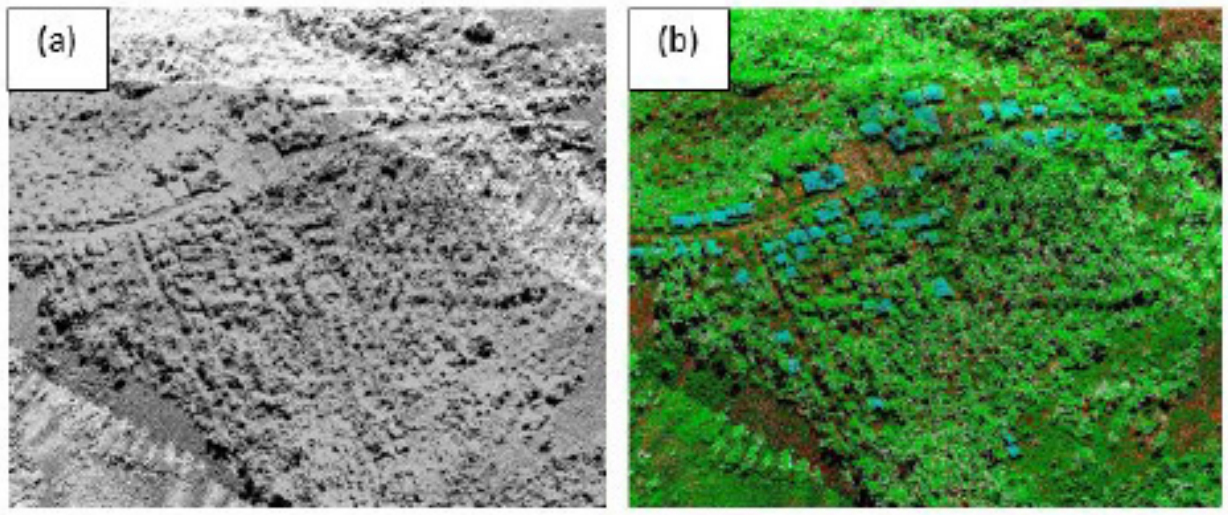

Figure 15. Point cloud before (a) and after (b) classification

The production of the last return (V_ASCII) and secondary (T_ ASCII) DTM as well as the first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 16. It shows that DTMs are the representation of the bare earth, while on the DSMs, all features are present, such as buildings and vegetation.

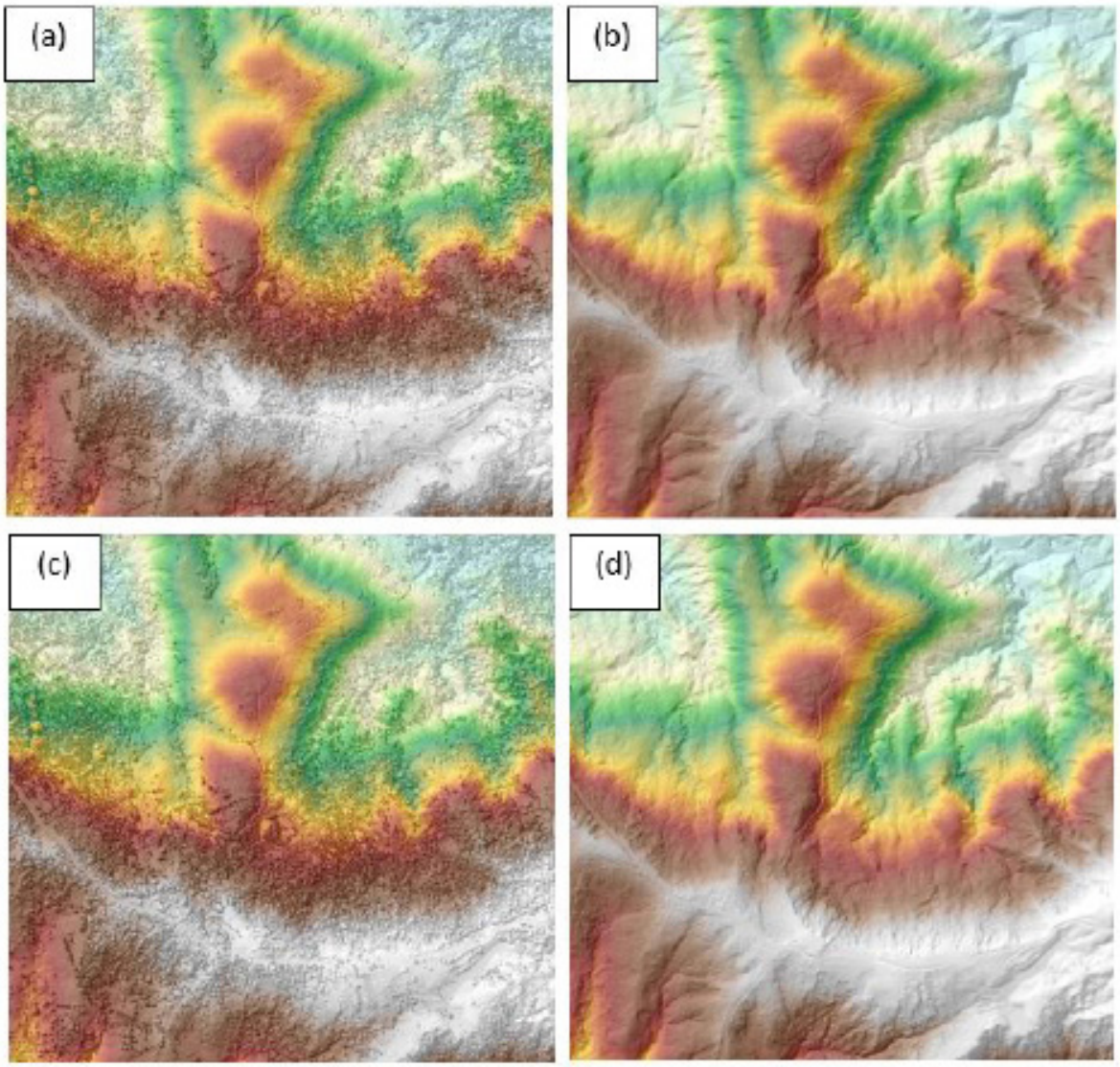

Figure 16. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Malinao Inlet Floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

There are no available orthophotographs for the Malinao Inlet floodplain.

3.8 DEM Editing and Hydro-Correction

Twelve (12) mission blocks were processed for the Malinao Inlet Floodplain Survey. These blocks are composed of Siargao and Surigao_reflights blocks with a total area of 1,049.71 square kilometers. Table 17 shows the name and corresponding area of each block in square kilometers.

Table 17. LiDAR blocks with its corresponding areas.

LiDAR Blocks	Area (sq.km)
Siargao_Blk59F	178.19
Siargao_Blk59E	179.40
Siargao_Blk59C	180.21
Siargao_Blk59D	114.11
Siargao_Blk59A	132.81
Siargao_Blk59B	53.44
Siargao_Blk59B_supplement	68.57
Siargao_Blk59D_additional	20.50
Surigao_reflights_Blk59F	33.79
Surigao_reflights_Blk59A	22.86
Surigao_reflights_Blk59A_supplement	31.25
Surigao_reflights_Blk59B	34.58
TOTAL	**1,049.71 sq.km**

Figure 17 shows portions of a DTM before and after manual editing. As evident in the figure, the hilly portion (Figure 17a) was misclassified and removed during the classification process. To complete the surface, the hilly portion (Figure 17b) was retrieved and reclassified through manual editing to allow the correct water flow. Likewise, the bridge (Figure 17c) has obstructed the flow of water along the river. To correct the river hydrologically, the bridge was removed through manual editing (Figure 17d).

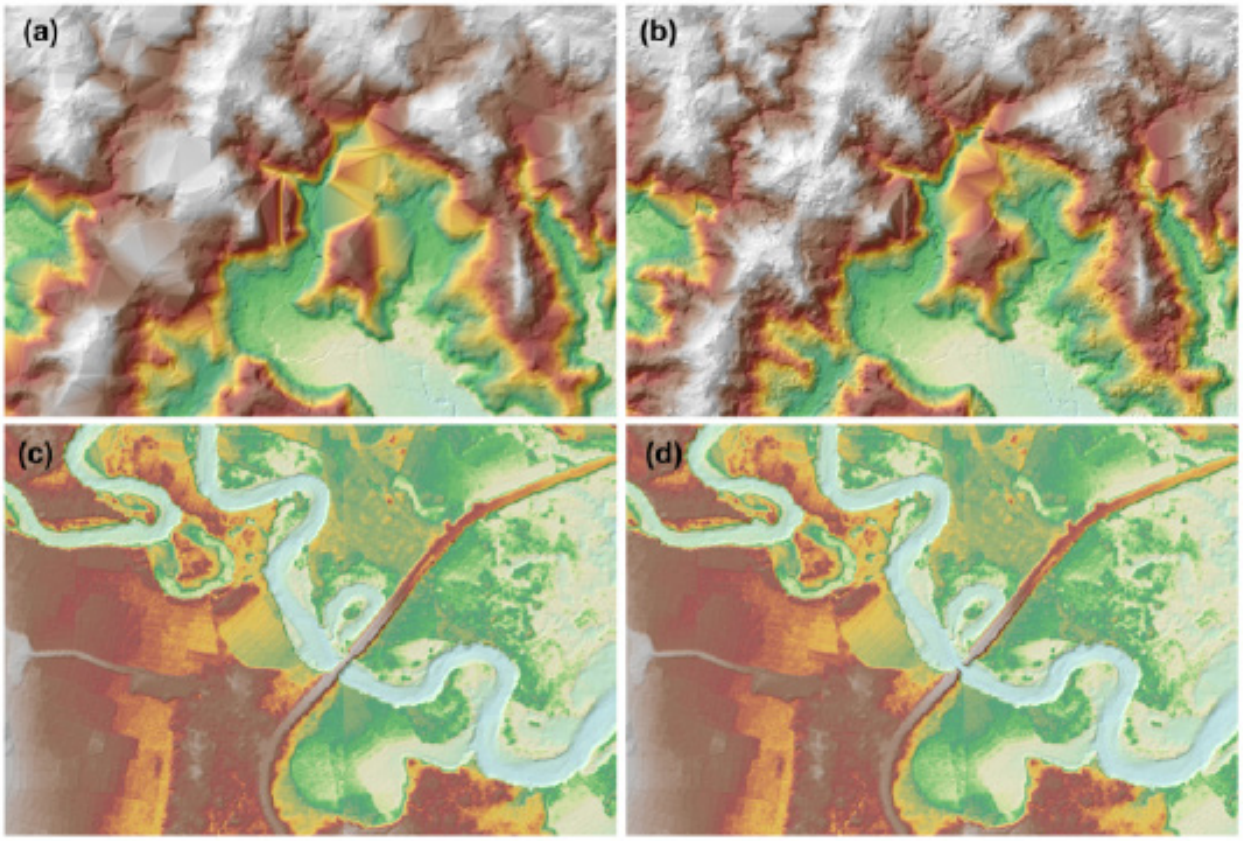

Figure 17. Portions in the DTM of the Malinao Inlet Floodplain – hilly portion before (a) and after (b) data retrieval; a bridge before (c) and after (d) manual editing.

3.9 Mosaicking of Blocks

Siargao_Blk59F was used as the reference block at the start of mosaicking because this block contained national highway in which the validation surveys passed through this road. Table 18 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Malinao Inlet Floodplain is shown in Figure 18. It can be seen that the entire Malinao Inlet floodplain is 99.92% covered by LiDAR data.

Table 18. Shift values of each LiDAR block of Malinao Inlet Floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
Siargao_Blk59E	0.00	0.00	0.56
Siargao_Blk59C	0.00	0.00	0.36
Siargao_Blk59D	0.00	0.00	0.31
Siargao_Blk59A	0.00	0.00	0.29
Siargao_Blk59B	0.00	0.00	0.43
Siargao_Blk59B_supplement	0.00	0.00	0.40
Siargao_Blk59D_additional	0.00	0.00	1.01
Surigao_reflights_Blk59F	0.00	0.00	0.25
Surigao_reflights_Blk59A	0.00	0.00	0.36
Surigao_reflights_Blk59A_supplement	0.00	0.00	0.20
Surigao_reflights_Blk59B	0.00	0.00	0.63

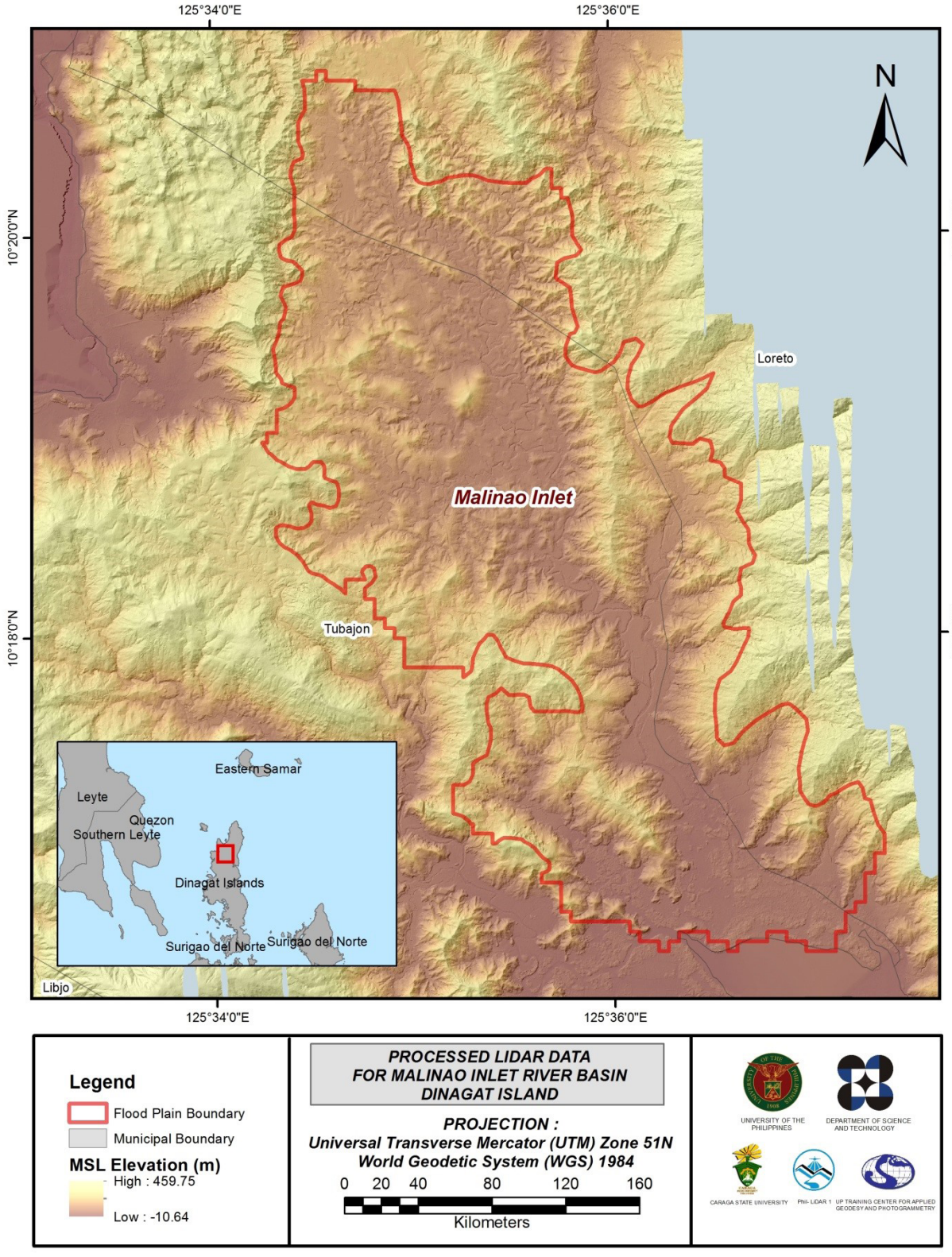

Figure 18. Map of processed LiDAR data for the Malinao Inlet Floodplain

3.10 Calibration and Validation of Mosaicked LiDAR Digital Elevation Model (DEM)

The extent of the validation survey done by the CSU's Field Survey Team (FST) in coordination with the Data Validation and Bathymetry Component (DVBC) in Malinao Inlet to collect points with which the LiDAR dataset is validated is shown in Figure 19, with the validation survey points highlighted in green. A total of 3,905 survey points were gathered for the Malinao Inlet floodplain. Random selection of 80% of the survey points, resulting to 3,124 points, was used for calibration.

A good correlation between the uncalibrated mosaicked LiDAR DTM and the ground survey elevation values is shown in Figure 20. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of the data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration points is 0.25 meters, with a standard deviation of 0.20 meters. The calibration of the Malinao Inlet LiDAR data was accomplished by adding the height difference value of 0.25 meters to the Malinao Inlet mosaicked LiDAR data. Table 19 shows the statistical values of the compared elevation values between the Malinao Inlet LiDAR data and the calibration data.

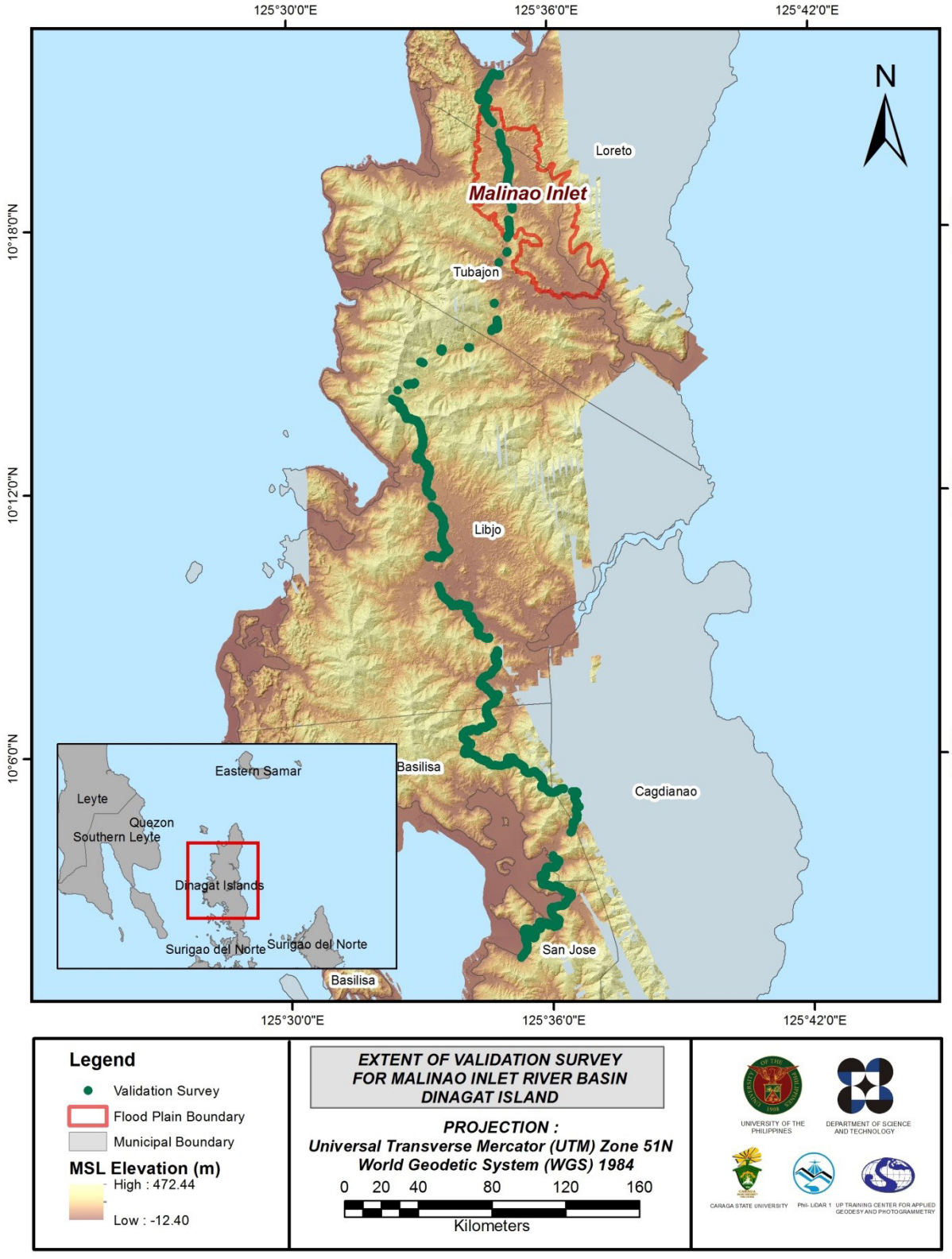

Figure 19. Map of Malinao Inlet Floodplain with validation survey points in green

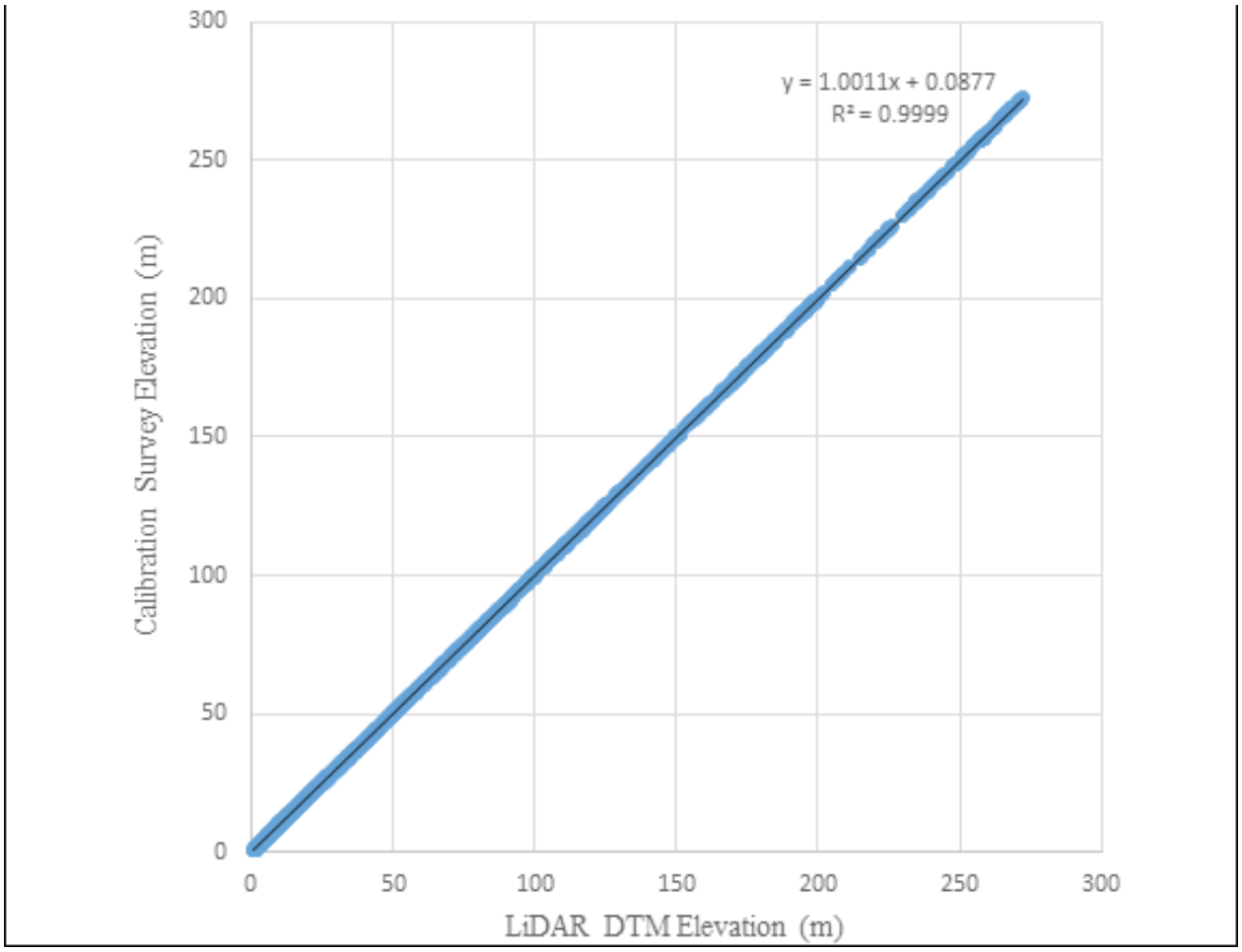

Figure 20. Correlation plot between calibration survey points and LiDAR data.

Table 19. Calibration Statistical Measures

Calibration Statistical Measures	Value (meters)
Height Difference	4.07
Standard Deviation	0.14
Average	-4.07
Minimum	-4.50
Maximum	-3.77

A total of 781 survey points lie within the Malinao Inlet Floodplain; all of which were used to validate the calibrated Malinao Inlet DTM. A good correlation between the calibrated mosaicked LiDAR elevation and the ground survey elevation values, which point toward the quality of the LiDAR DTM is shown in Figure 21. The computed RMSE value between the calibrated LiDAR DTM and the validation elevation values is at 0.22 meters with a standard deviation of 0.20 meters, as shown in Table 20.

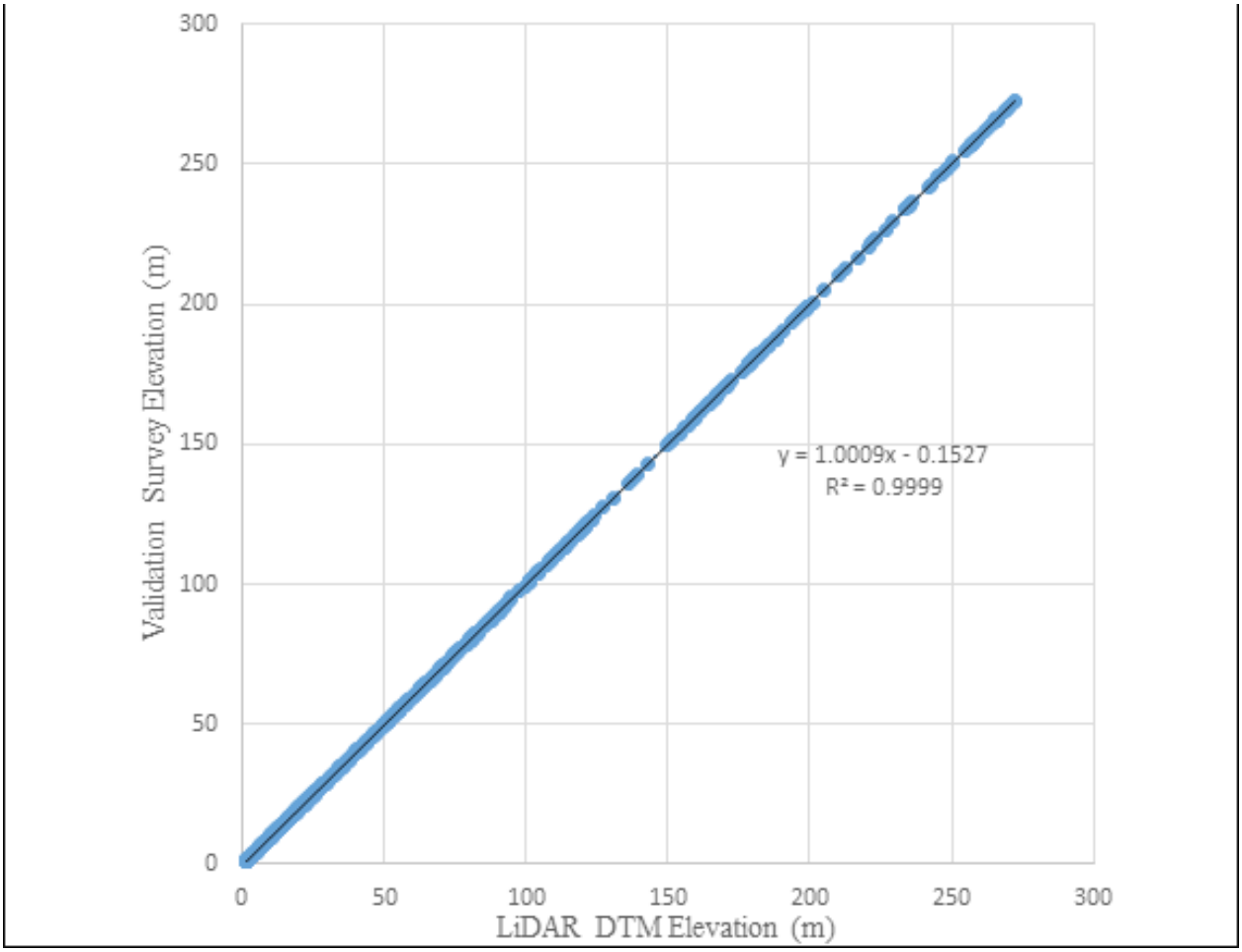

Figure 21. Correlation plot between the validation survey points and the LiDAR data.

Table 20. Validation Statistical Measures

Validation Statistical Measures	Value (meters)
RMSE	0.22
Standard Deviation	0.20
Average	-0.10
Minimum	-0.49
Maximum	0.30

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, centerline and zigzag data were available for Malinao Inlet with a total of 28,318 bathymetric survey points. The resulting raster surface produced was done by 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 0.47 meters. The extent of the bathymetric survey done by the CSU's Field Survey Team (FST) in coordination with Data Validation and Bathymetry Component (DVBC) in Malinao Inlet integrated with the processed LiDAR DEM is shown in Figure 22.

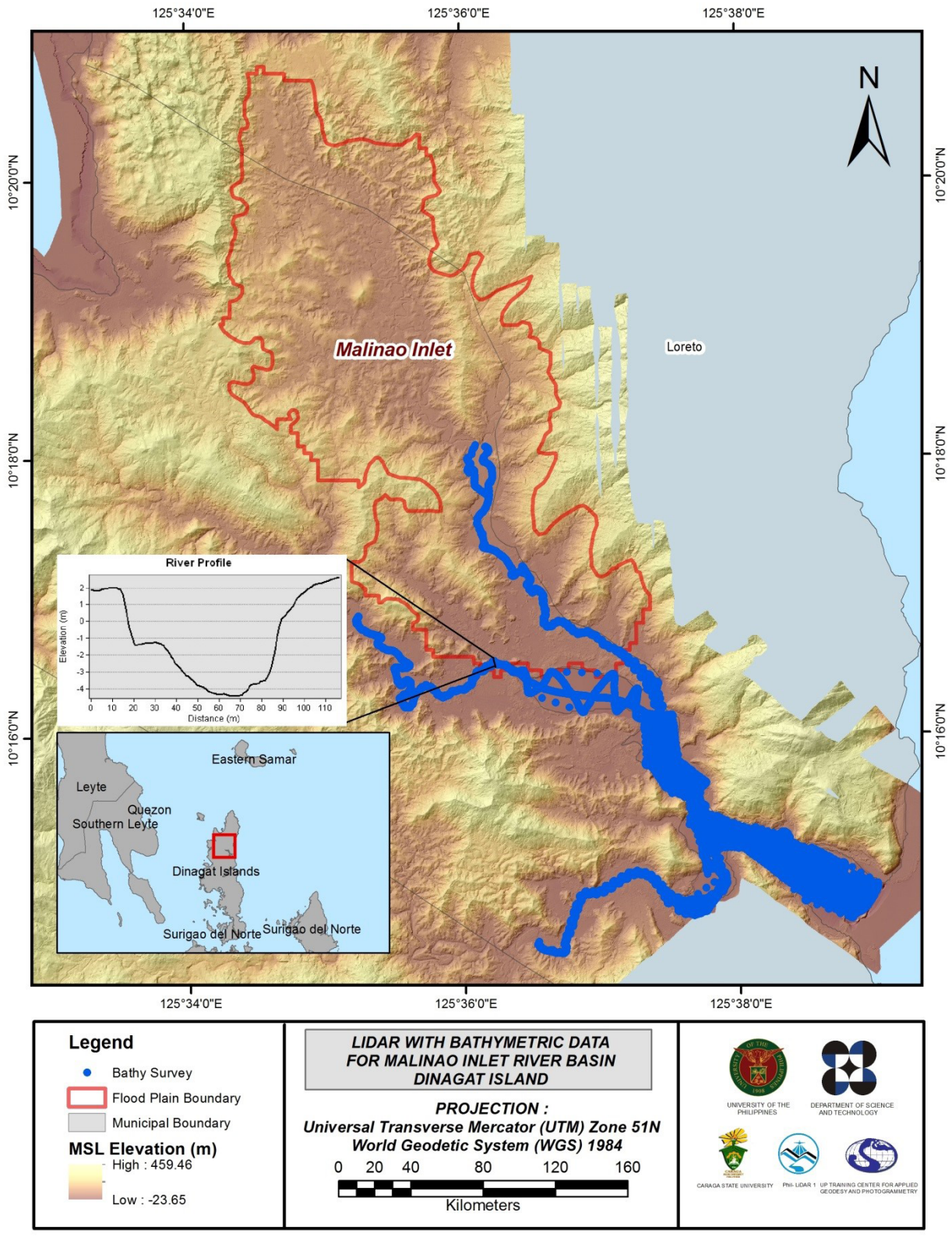

Figure 22. Map of Maliano Inlet Floodplain with bathymetric survey points in blue.

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

3.12.1 Quality Checking of Digitized Features' Boundary

Maliano Inlet floodplain, including its 200-m buffer, has a total area of 28.87 sq km. For this area, a total of 5.0 sq. km., corresponding to a total of 387 building features, were considered for QC.Figure 23 shows the QC blocks for the Maliano Inlet floodplain.

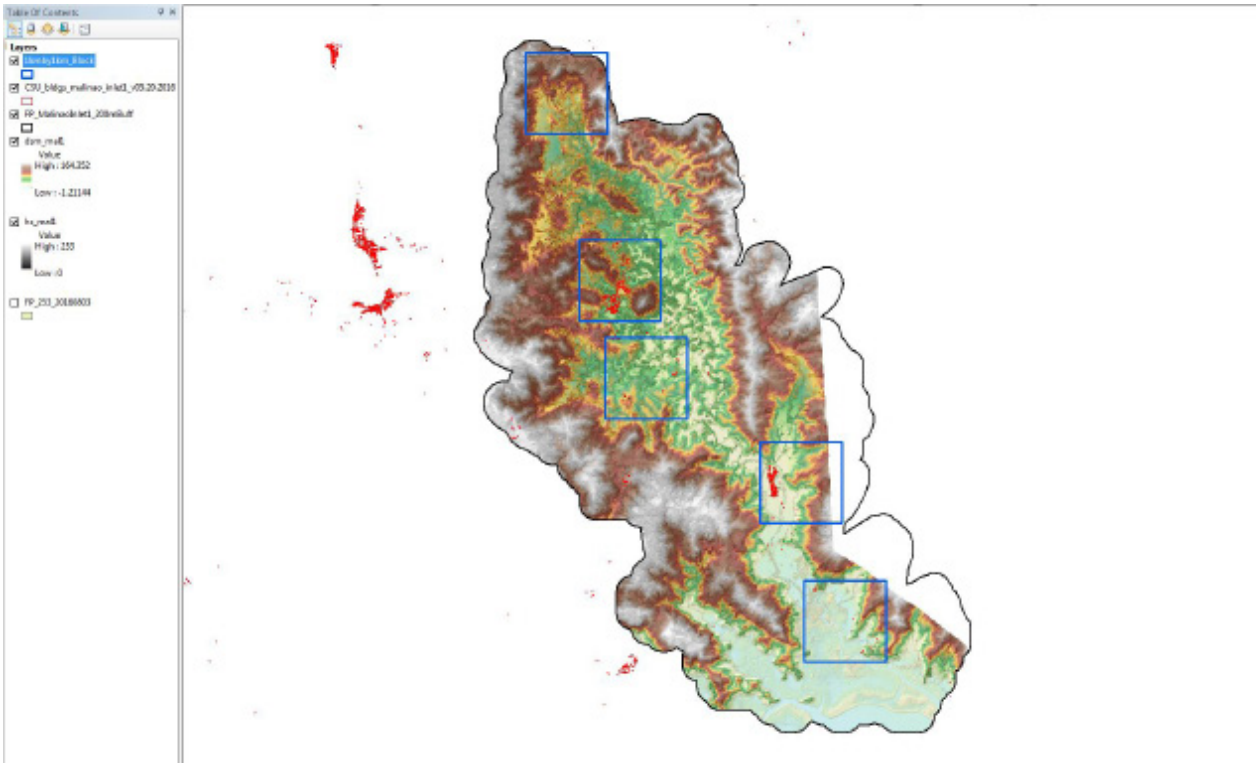

Figure 23. Blocks (in blue) of Malinao Inlet building features that were subjected to QC.

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

Table 21. Details of the quality checking ratings for the building features extracted for the Maliano Inlet River Basin

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Malinao Inlet	99.42	100.00	98.84	PASSED

3.12.2 Height Extraction

Height extraction was done for 3,332 building features in Malinao Inlet floodplain. Of these building features, 144 buildings were filtered out after height extraction, resulting to 3,188 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 5.72 meters.

3.12.3 Feature Attribution

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

Table 22 summarizes the number of building features per type, while Table 23 shows the total length of each road type. Table 24, on the other hand, shows the number of water features extracted per type.

Table 22. Building features extracted for Malinao Inlet Floodplain.

Facility Type	No. of Features
Residential	3,046
School	69
Market	6
Agricultural/Agro-Industrial Facilities	0
Medical Institutions	6
Barangay Hall	6
Military Institution	0
Sports Center/Gymnasium/Covered Court	9
Telecommunication Facilities	0
Transport Terminal	1
Warehouse	34
Power Plant/Substation	0
NGO/CSO Offices	0
Police Station	0
Water Supply/Sewerage	0
Religious Institutions	7
Bank	1
Factory	0
Gas Station	0
Fire Station	0
Other Government Offices	2
Other Commercial Establishments	1
Total	**3,188**

Table 23. Total length of extracted roads for Malinao Inlet Floodplain.

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Malinao Inlet	38.28	6.94	124.74	24.49	0.00	194.45

Table 24. Number of extracted water bodies for Malinao Inlet Floodplain.

Floodplain	Water Body Type					Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Malinao Inlet	13	0	0	0	0	13

A total of 43 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 given the complete required attributes. Respectively, all these output features comprise the flood hazard exposure database for the floodplain. The final quality checking completes the feature extraction phase of the project.

Figure 24 shows the completed Digital Surface Model (DSM) of the Malinao Inlet floodplain overlaid with its ground features.

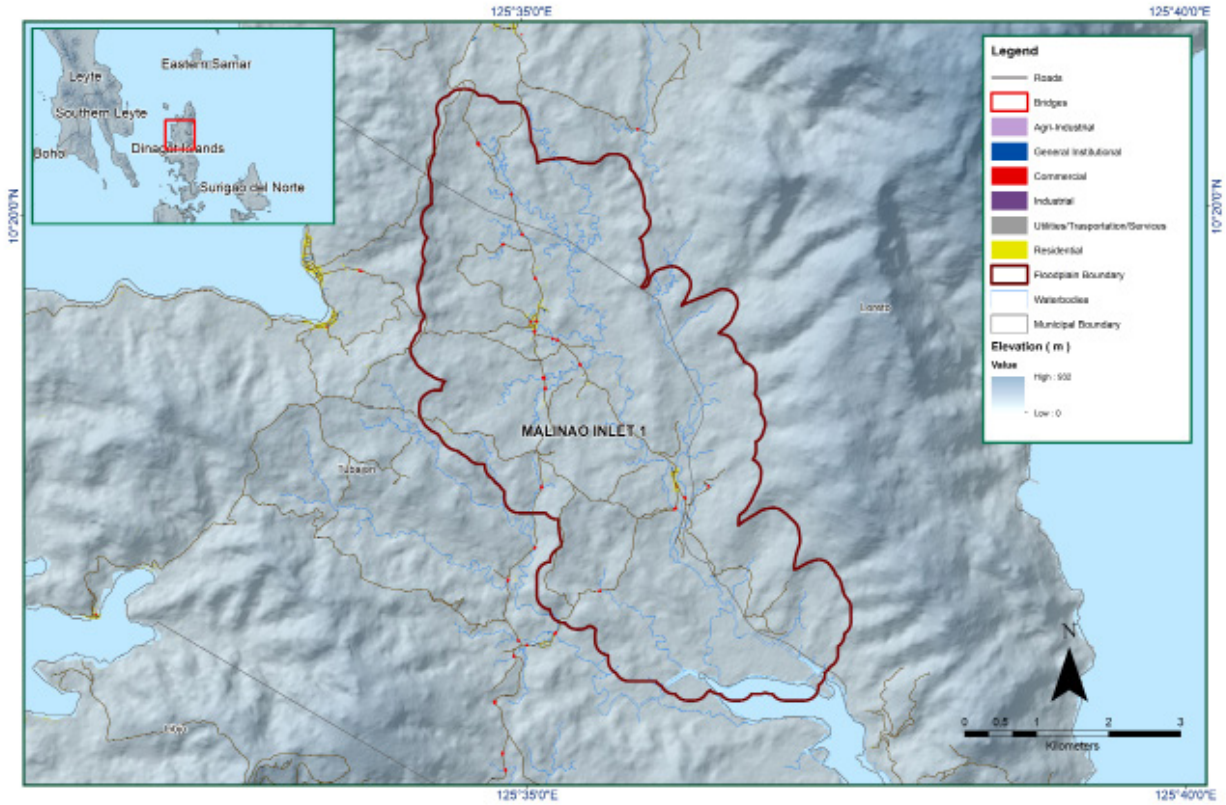

Figure 24. Extracted features of the Maliano Inlet Floodplain.

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

Engr. Louie P. Balicanta, Engr. Joemarie S. Caballero, Ms. Patrizcia Mae. P. dela Cruz, Engr. Kristine Ailene B. Borromeo,For. Dona Rina Patricia C. Tajora, Elaine Bennet Salvador, For. Rodel C. Alberto

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

4.1 Summary of Activities

The Data Validation and Bathymetry Component (DVBC) conducted a field survey in Malinao Inlet River on November 14 to 25, 2016 with the following scope of work: reconnaissance; control survey; cross-section survey of selected riverbed in Brgy. Malinao, Municipality of Tubajon; validation points acquisition of about 47.53 km covering the municipalities of Loreto, Tubajon, Libjo, Basilisa, and San Jose in the province of Dinagat Islands; and bathymetric survey from its two upstreams in Brgy. Diaz and Brgy. Navarro, in the Municipality of Tubajon, to the mouth of the river located in Brgy. Malinao, Municipality of Tubajon, with an approximate length of 20.993 km using Ohmex™ single beam echo sounder and Trimble® SPS 882 GNSS PPK survey technique as shown in Figure 25.

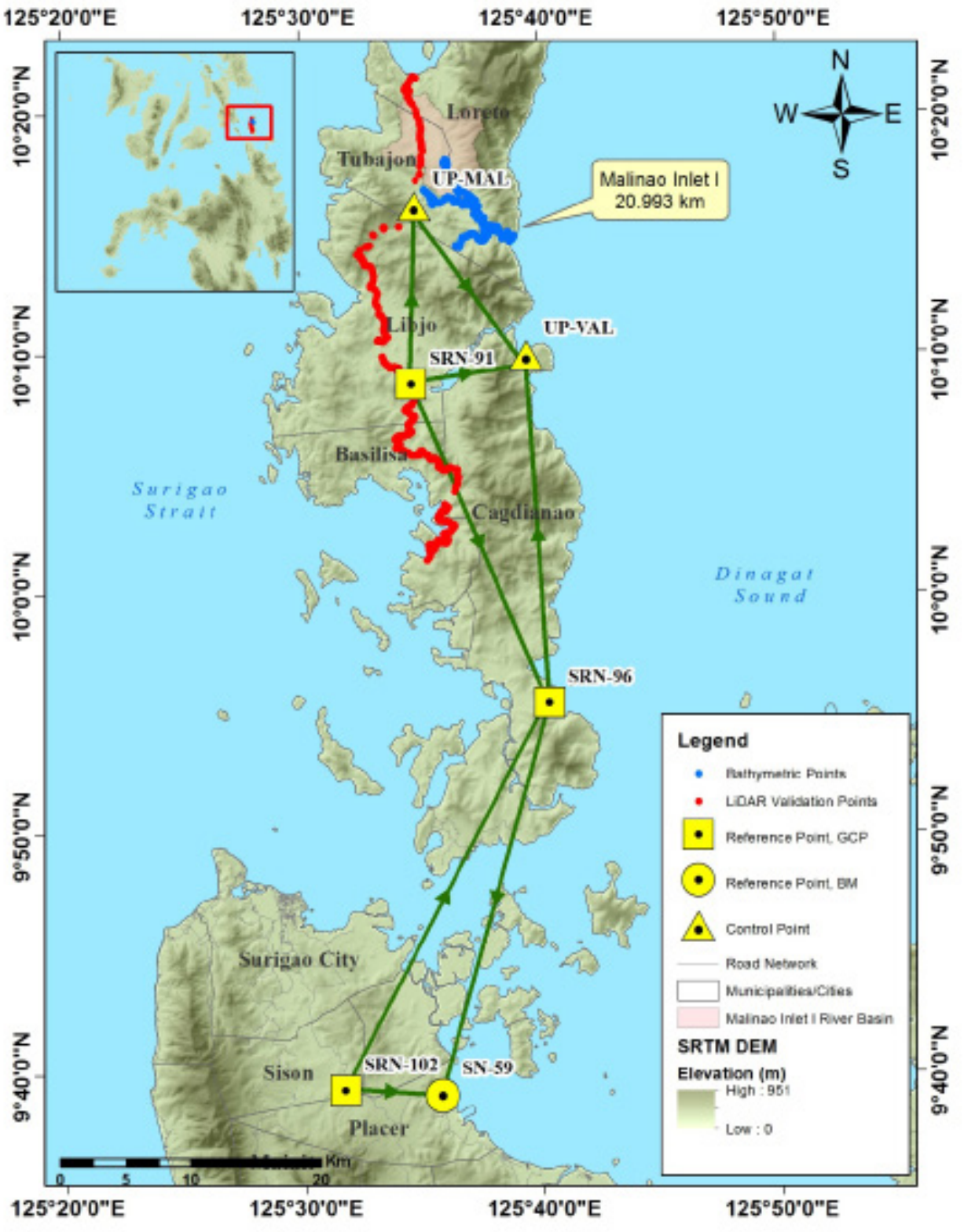

Figure 25. Extent of the bathymetric survey (in blue line) in Malinao Inlet River and the LiDAR data validation survey (in red).

4.2 Control Survey

The GNSS network used for Malinao Inlet River survey is composed of three (3) loop established on on November 15 and 17, 2016 occupying the following reference points SRN-91, a 2nd order GCP in Brgy. Llamer, Municipality of Libjo, Dinagat Islands; SRN-102, a 2nd order GCP in Brgy. Lower Patag, Municipality of Sison, Surigao Del Norte; and SN-59, a 1st order BM in Brgy. Magsaysay, Municipality of Placer, Also in Surigao Del Norte.

Two control points were established namely UP-MAL in Brgy. Malinao, Municipality of Tubajon; and UP-VAL in Brgy. Legaspi, Municipality of Cagdianao, both in Dinagat Islands. A NAMRIA established control point namely, SRN-96, in Brgy. Poblacion, Municipality of Cagdianao, Surigao Del Norte, was also occupied to use as marker for the survey.

Table 25 depicts the summary of reference and control points utilized, with their corresponding locations, while Figure 26 shows the GNSS network established in the Maliano Inlet River Survey.

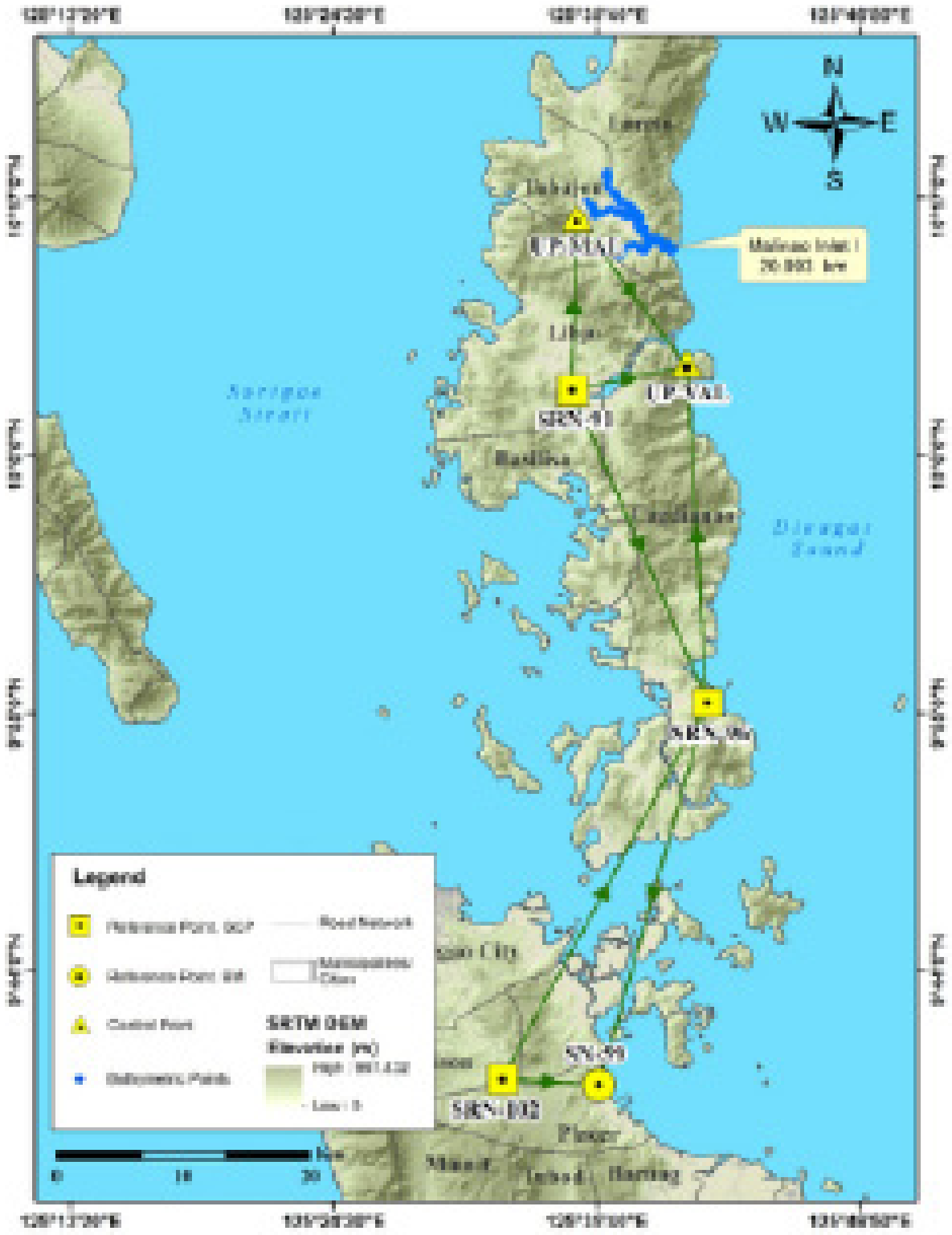

Figure 26. The GNSS Network established in the Malinao Inlet River Survey.

Table 25. References used and control points established in the Malinao Inlet River Survey (Source: NAMRIA, UP-TCAGP).

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (Meter)	Elevation in MSL (Meter)	Date Established
SRN-91	2nd Order, GCP	10°08'45.12793"	125°34'38.38708"	98.040	-	11-17-16
SRN-102	2nd Order, GCP	09°39'21.00341"	125°31'40.71501"	102.409	-	11-17-16
SN-59	1st Order , BM	-	-	73.433	18.716	11-15-16
SRN-96	Used as marker	-	-	69.372	-	11-17-16
UP-MAL	UP established	-	-	124.789	-	11-17-16
UP-VAL	UP Established	-	-	68.878	-	11-17-16

Figure 27 to Figure 31 depict the setup of the GNSS on recovered reference points and established control points in the Malinao Inlet River.

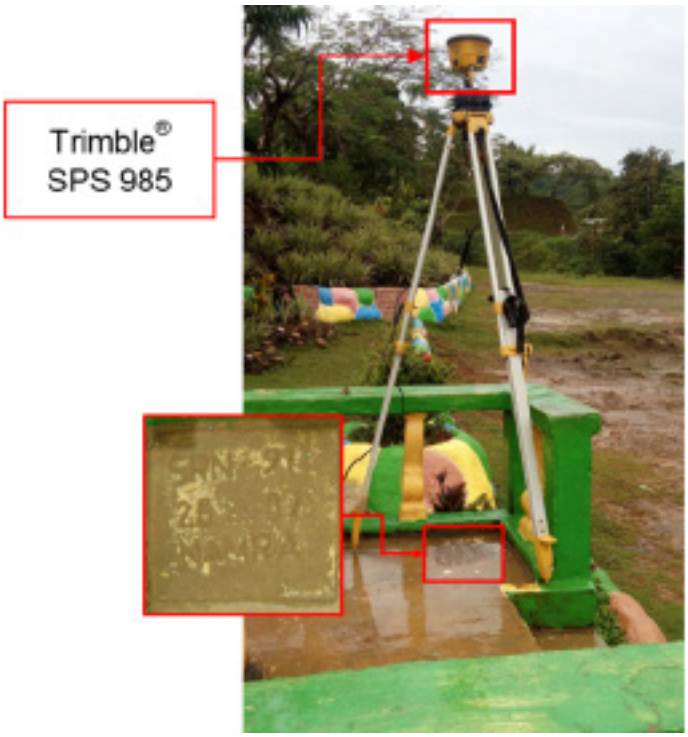

Figure 27. The GNSS base receiver setup, Trimble® SPS 985, at SRN-91, located in Brgy. Llamer, Municipality of Libjo, Dinagat Islands.

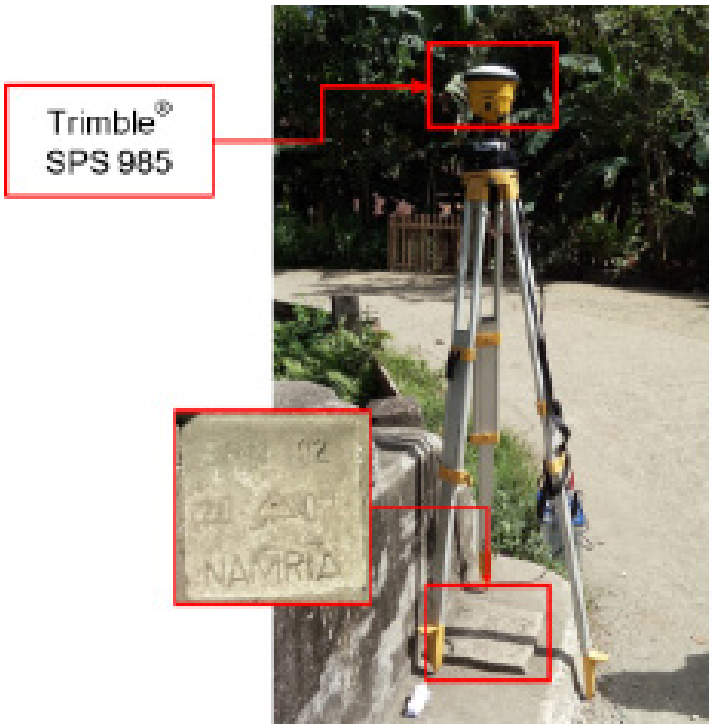

Figure 28. GNSS base receiver setup, Trimble® SPS 985, at SRN-102, located in Brgy. Lower Patag, Municipality of Sison, Surigao Del Norte.

Figure 29. GNSS base receiver setup, Trimble® SPS 882 at SN-59 in Brgy. Magsaysay, Municipality of Placer, Surigao Del Norte.

Figure 30. GNSS base receiver setup, Trimble® SPS 985, at SRN-96 in Brgy. Poblacion, Municipality of Cagdianao, Dinagat Islands.

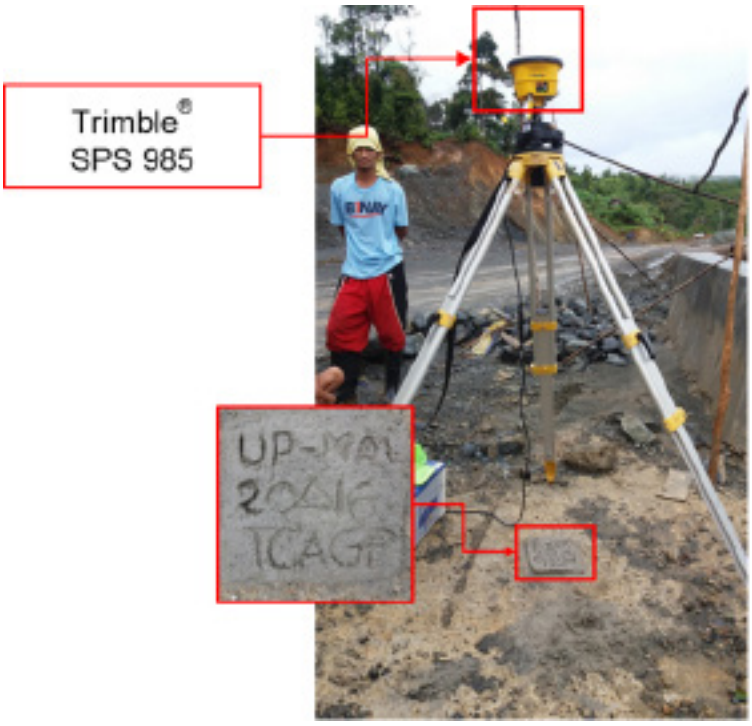

Figure 31. GNSS base receiver setup, Trimble® SPS 985, at UP-MAL in Brgy. Malinao, Municipality of Tubajon, Dinagat Islands.

4.3 Baseline Processing

The 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 or covering of portions of the baseline data using the same processing software. The data is then repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, a resurvey is initiated. Table 26 presents the baseline processing results of control points in the Maliano Inlet River Basin, as generated by the TBC software.

Table 26. The Baseline processing report for the Maliano Inlet River GNSS static observation survey.

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SRN-102 --- SRN-96	11-17-16	Fixed	0.0046	0.050	28°07'44"	33643.801	-33.067
SRN-96 --- SN-59	11-15-16	Fixed	0.003	0.027	195°38'26"	31284.720	4.046
SRN-91 --- SRN-96	11-17-16	Fixed	0.007	0.117	156°55'47"	26665.775	-28.724
SRN-91 --- SRN-96	11-17-16	Fixed	0.006	0.113		26665.778	-28.722
SRN-96 --- UP-VAL	11-17-16	Fixed	0.004	0.021	356°33'33"	26723.358	-0.495
UP-VAL --- SRN-96	11-17-16	Fixed	0.016	0.035	353°33'33"	26723.373	-0.495
SRN-102 --- SN-59	11-15-16	Fixed	0.004	0.036	93°32'12"	7454.354	-28.959
UP-MAL --- SRN-91	11-17-16	Fixed	0.003	0.011	1°22'34"	13630.649	26.750
SRN-91 --- UP-VAL	11-17-16	Fixed	0.004	0.016	76°22'43"	9093.475	-29.165
UP-MAL --- UP-VAL	11-17-16	Fixed	0.004	0.017	143°27'45"	14294.556	-55.908

As shown in Table 26, a total of ten (10) baselines were processed with the coordinates of SRN-91 and SRN-102, and the elevation value of reference points SN-59 held fixed; it is apparent that all baselines passed the required accuracy.

4.4 Network Adjustment

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

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

where:

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

For complete details, see the Network Adjustment Report shown in Table 27 toTable 29.

The six (6) control points: SRN-91, SRN-102, SN-59, SRN-96, UP-MAL and UP-VAL were occupied and observed simultaneously to form a GNSS loop. Coordinates of SRN-91 and SRN-102; and elevation value of SN-59; were held fixed during the processing of the control points as presented in Table 27. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 27. Constraints applied to the adjustment of the control points.

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
SN-59	Grid				Fixed
SRN-102	Global	Fixed	Fixed		
SRN-91	Global	Fixed	Fixed		
Fixed = 0.000001 (Meter)					

Likewise, the list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 28. The fixed control points has no values for grid and elevation errors.

Table 28. . Adjusted grid coordinates for the control points used in the Maliano Inlet River Floodplain survey.

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
SN-59	784874.613	0.006	1067982.775	0.005	5.127	?	e
SRN-102	777426.960	?	1068387.750	?	34.590	0.078	LL
SRN-91	782426.827	?	1122659.870	?	30.581	0.082	LL
SRN-96	793074.821	0.005	1098194.163	0.005	1.734	0.063	
UP-MAL	782645.625	0.006	1136296.759	0.005	57.808	0.083	
UP-VAL	791252.698	0.006	1124872.875	0.005	1.704	0.077	

The results of the computation for accuracy are as follows:

a.SRN-91
horizontal accuracy = Fixed
vertical accuracy = 8.2 < 10 cm

b.SRN-102
horizontal accuracy = Fixed
vertical accuracy = 7.8 < 10 cm

c.SN-59
horizontal accuracy = $\sqrt{((0.6)^2 + (0.5)^2}$
= $\sqrt{(0.36 + 0.25)}$
= 0.78 < 20 cm
vertical accuracy = Fixed

d.SRN-96
horizontal accuracy = $\sqrt{((0.5)^2 + (0.05)^2}$
= $\sqrt{(0.25 + 0.25)}$
= 0.71 < 20 cm
vertical accuracy = 6.3 < 10 cm

e.UP-MAL
horizontal accuracy = $\sqrt{((0.6)^2 + (0.5)^2}$
= $\sqrt{(0.36 + 0.25)}$
= 0.78 < 20 cm
vertical accuracy = 8.3 < 10 cm

f.UP-VAL
horizontal accuracy = $\sqrt{((0.6)^2 + (0.5)^2}$
= $\sqrt{(0.36 + 0.25)}$
= 0.78 < 20 cm
vertical accuracy = 7.7 < 10 cm

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

Table 29. Adjusted geodetic coordinates for control points used in the Maliano Inlet River Floodplain validation.

Point ID	Latitude	Longitude	Ellipsoid	Height	Constraint
SN-59	N9°39'06.01253"	E125°35'44.75626"	73.433	?	e
SRN-102	N9°39'21.00341"	E125°31'40.71501"	102.409	0.078	LL
SRN-91	N10°08'45.12793"	E125°34'38.38708"	98.040	0.082	LL
SRN-96	N9°55'26.58939"	E125°40'21.40761"	69.372	0.063	
UP-MAL	N10°16'08.63651"	E125°34'49.14548"	124.789	0.083	
UP-VAL	N10°09'54.79391"	E125°39'28.71991"	68.878	0.077	

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 29. 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 Maliano Inlet River GNSS Static Survey are seen in Table 30.

Table 30. The reference and control points utilized in the Maliano Inlet River Static Survey, with their corresponding locations (Source: NAMRIA, UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	BM Ortho (m)
SRN-91	2nd Order, GCP	10°08'45.12793"	125°34'38.38708"	98.040	1122659.870	782426.827	30.581
SRN-102	2nd Order, GCP	9°55'26.58939"	125°40'21.40761"	69.372	1098194.163	793074.821	1.734
SN-59	1st Order, BM	9°39'06.01253"	125°35'44.75626"	73.433	1067982.775	784874.613	5.127
SRN-91	Used as marker	9°39'21.00341"	125°31'40.71501"	102.409	1068387.750	777426.960	34.590
UP-MAL	UP Established	10°16'08.63651"	125°34'49.14548"	124.789	1136296.759	782645.625	57.808
UP-VAL	UP-Established	10°09'54.79391"	125°39'28.71991"	68.878	1124872.875	791252.698	1.704

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

The bridge cross-section and as-built surveys were conducted on November 18, 2016 in Brgy. Malinao, Municipality of Tubajo as shown in Table 29 using the GNSS receiver Trimble® SPS 985 in PPK survey technique.

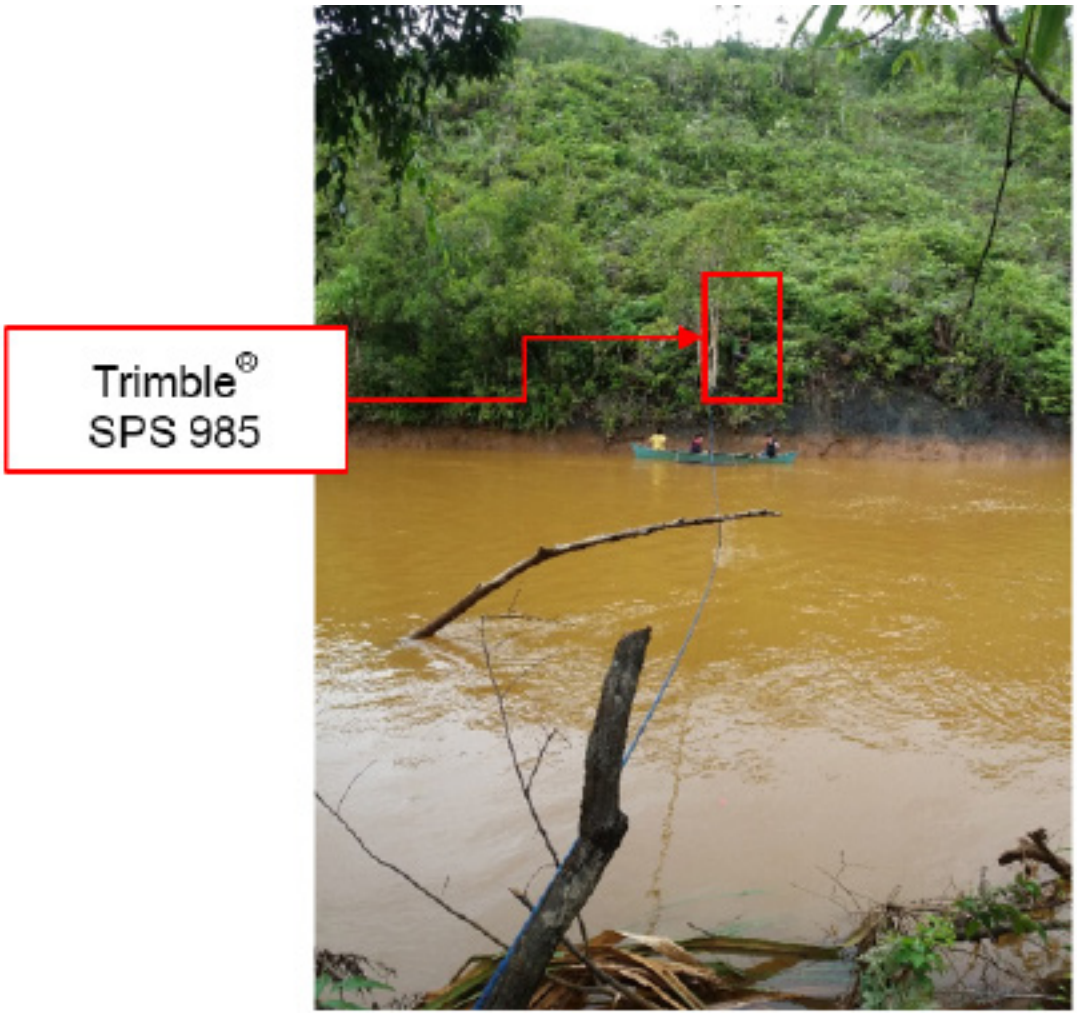

Figure 32. Cross-section survey of the depth gauge deployment site in Malinao Inlet River.

The cross-sectional line of Maliano Inlet Bridge is about 37 m with thirty-four (34) points acquired using the control point UP-MAL as GNSS base station. The location map and cross-section diagram are shown in Figure 33 and Figure 34.

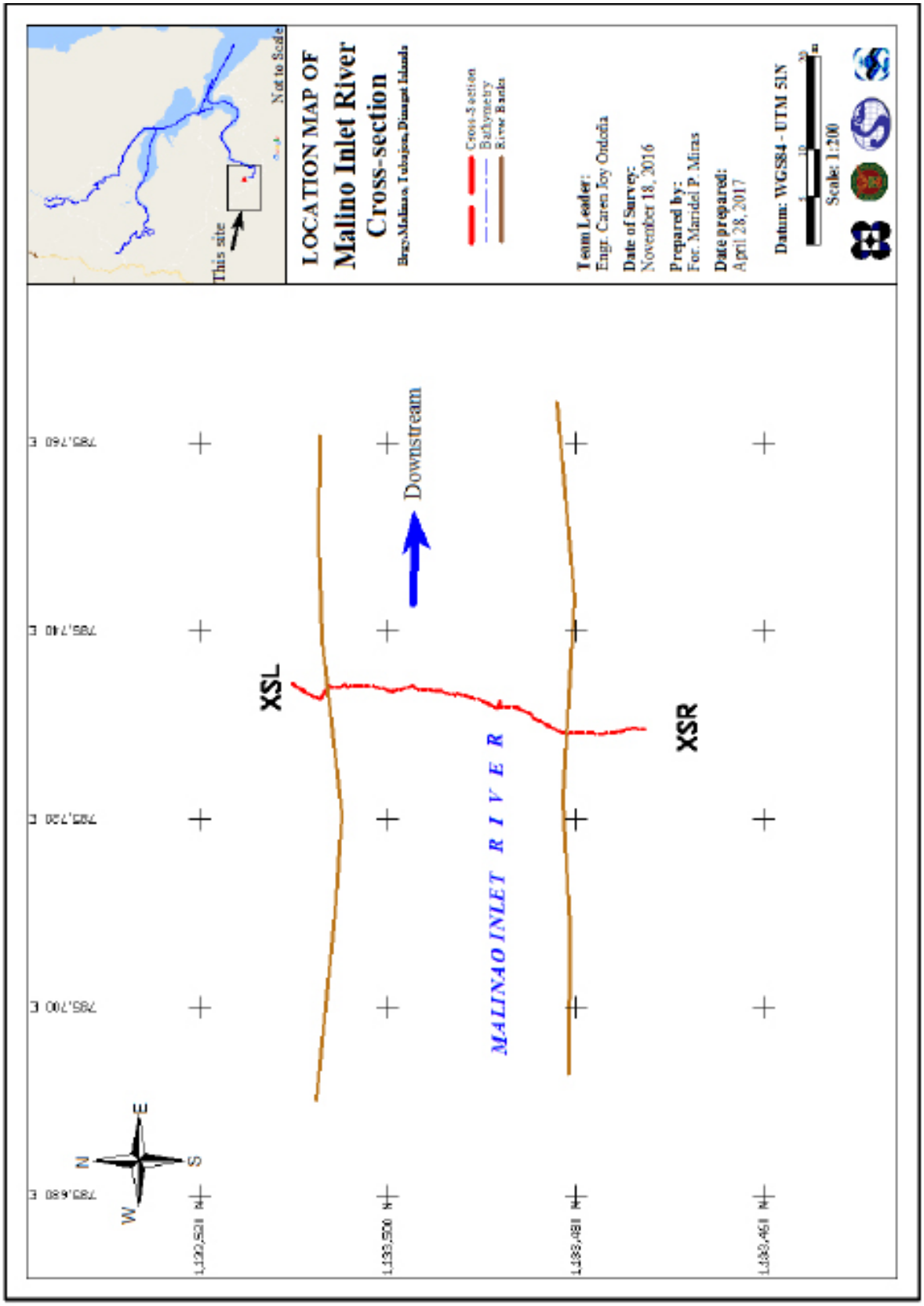

Figure 33. Location map of the Maliano Inlet cross-section survey.

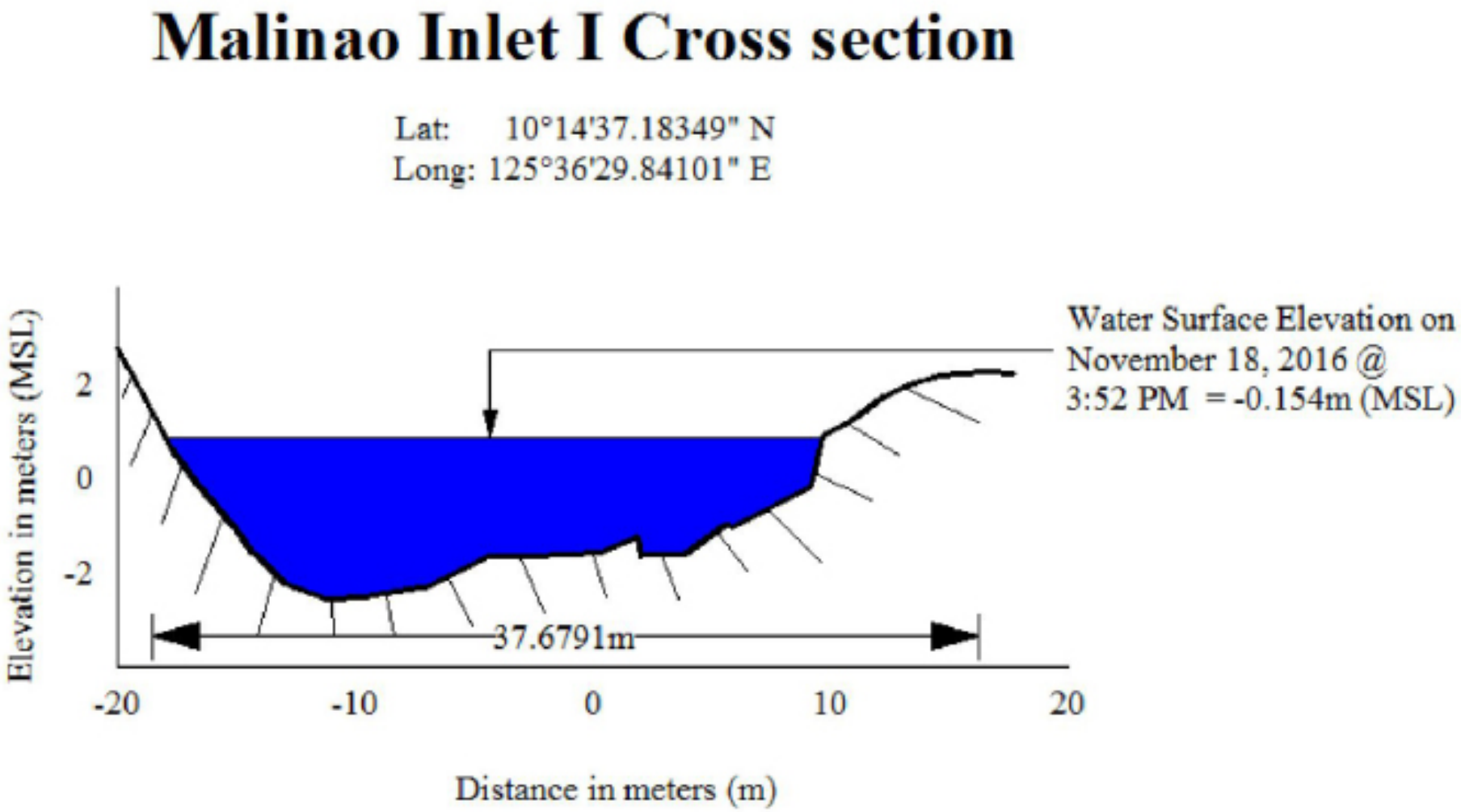

Figure 34. Cross-section diagram of Malinao Inlet1 River.

4.6 Validation Points Acquisition Survey

The validation points acquisition survey was conducted on November 22, 2016 using a survey GNSS rover receiver Trimble® SPS 882, mounted at the side of a vehicle as shown in Figure 35. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height was 2.371 m and 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 topographic mode with UP-MAL occupied as the GNSS base station in the conduct of the survey.

Figure 35. GNSS Receiver Trimble® SPS 882 installed on a vehicle for Ground Validation Survey

The survey started in Brgy. Poblacion, Municipality of San Enrique going south along national high way covering five (5) Municipalities in Dinagat Islands namely: Basilisa, Libjo, Loreto, San Jose at Tubajon. The ground validation line is approximately 48 km in length with 6,893 points, as shown in Figure 36.

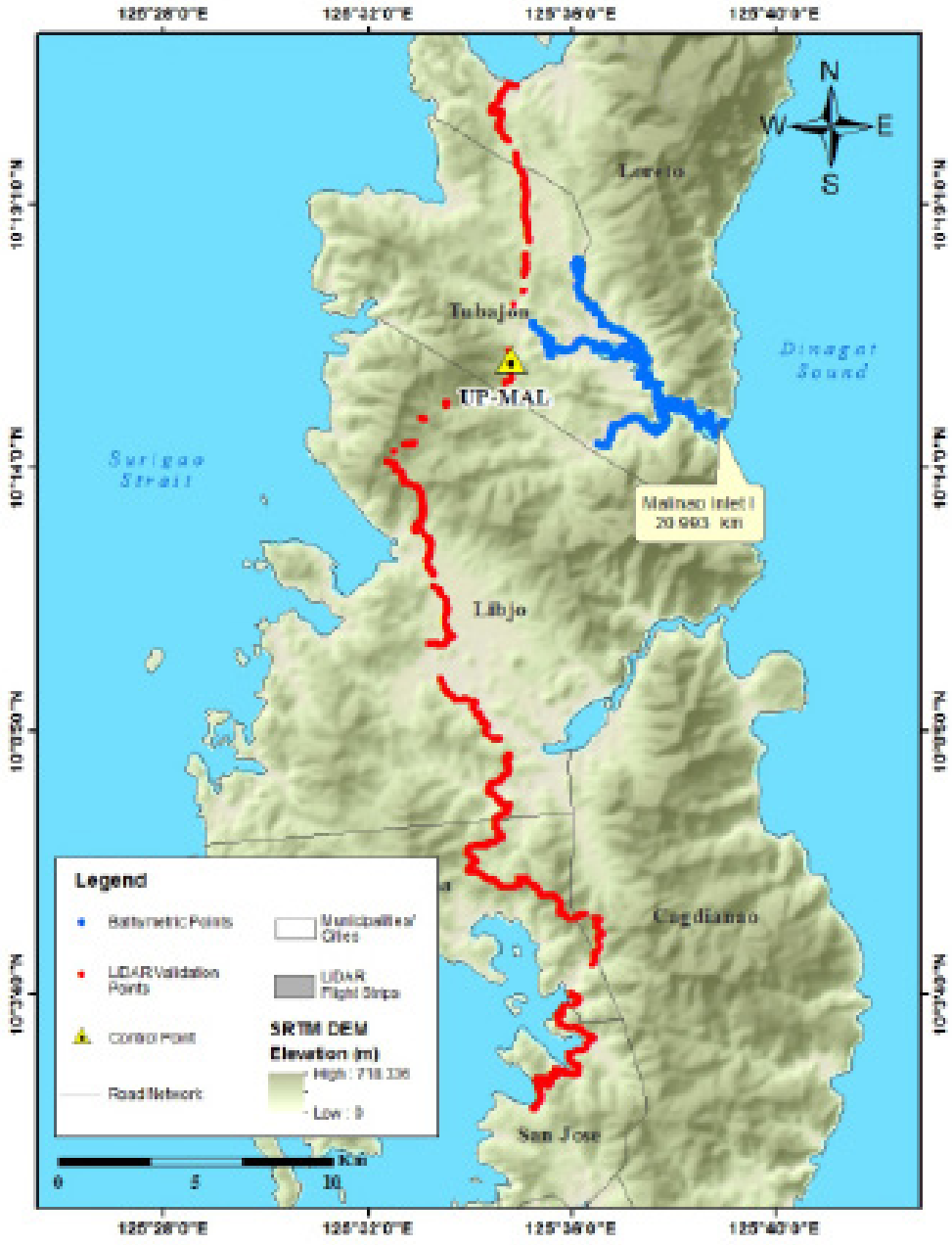

Figure 36. The extent of the LiDAR ground validation survey (in red) for Maliano Inlet River Basin

4.7 River Bathymetric Survey

On November 19 and 20, 2016 Trimble® SPS 985 in GNSS PPK survey technique in continuous topo mode as illustrated in Figure 37. The survey started at three different locations namely: Brgy. Diaz, with coordinates 10°17'12.54005"N, 125°36'25.98761"E; Brgy. Navarrro with coordinates 10°16'18.12179"N, 125°35'34.62153"E; and in Brgy. Malinao with coordinates 10°14'28.96038"N, 125°36'32.00462"E, all in Municipality of Tubajon. It all ended at the mouth of the river in Brgy. Malinao with coordinates 10°14'44.88231"N, 125°38'54.79475"E.

Figure 37. Set up of the bathymetric survey in Malinao Inlet River

Manual Bathymetric survey on the other hand was also executed on November 19 and 20, 2016 using Trimble® SPS 985 in GNSS PPK survey technique in continuous topo mode as shown in Figure 38. The survey started at three upstream areas - two in Brgy. Diaz with coordinates 10°18'04.53051"N, 125°36'10.04254"E, and 10°18'05.60578"N, 125°36'05.55763"E traversing down the river by foot and ended at the starting point of bathymetric survey using boat in Brgy. Diaz; and one with coordinates 10°16'51.81569"N, 125°35'14.05742"E which ended at the starting point of bathymetric survey using boat in Brgy. Navarro. The control point UP-MAL was used as GNSS base station all throughout the entire survey.

Figure 38. Manual bathymetric survey using a Trimble® SPS 985 in GNSS PPK survey technique in Malinao Inlet River

The bathymetric survey for Malinao Inlet River gathered a total of 29,678 points covering 20.993 km of the river traversing Barangays Diaz, Navarro and Malinao in Municipality of Tubajon in Dinagat Islands as shown in Figure 39. A CAD drawing was also produced to illustrate the riverbed profile of Binalbagan River. As shown in Figure 40 to Figure 43, the highest and lowest elevation has a 17-m difference. The highest elevation observed was 5.027 m above MSL located in Brgy. Diaz; while the lowest was -11.233 m below MSL located in Brgy. Malinao, both in Municipality of Tubajon. The survey extended the planned bathymetric lines to cover the major tributaries of the river which according to the SUC contributes to flooding in the area.

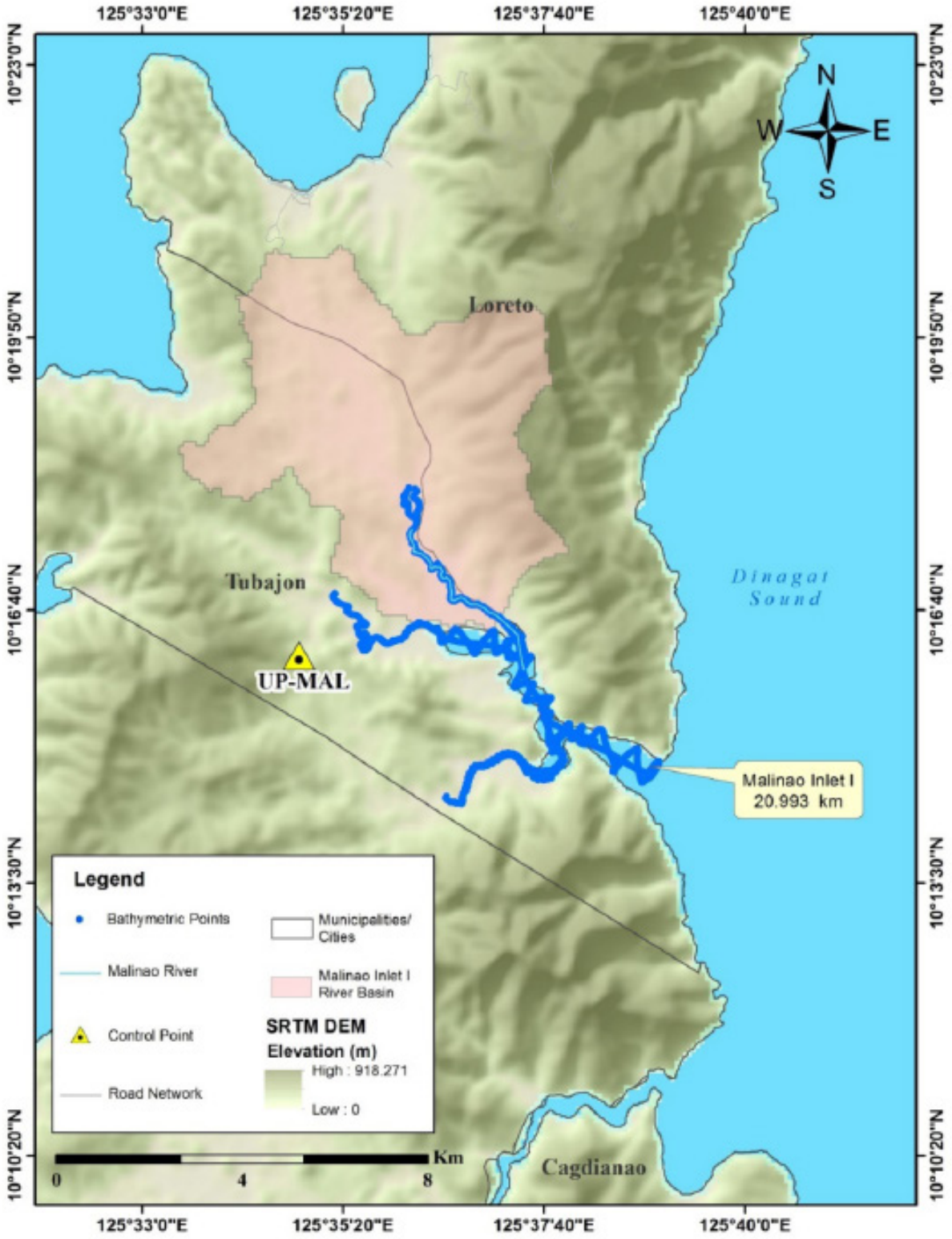

Figure 39. The extent of the Malinao Inlet River Bathymetry Survey and the LiDAR bathymetric data validation points.

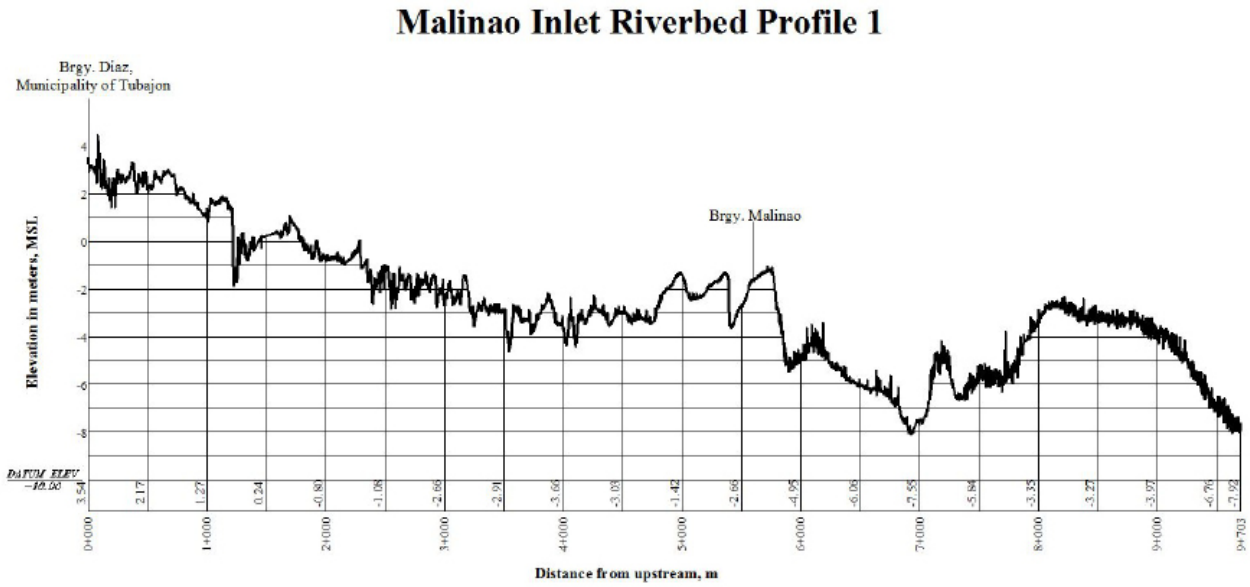

Figure 40. The Malinao Inlet River Bed Profile from Brgy. Diaz 1

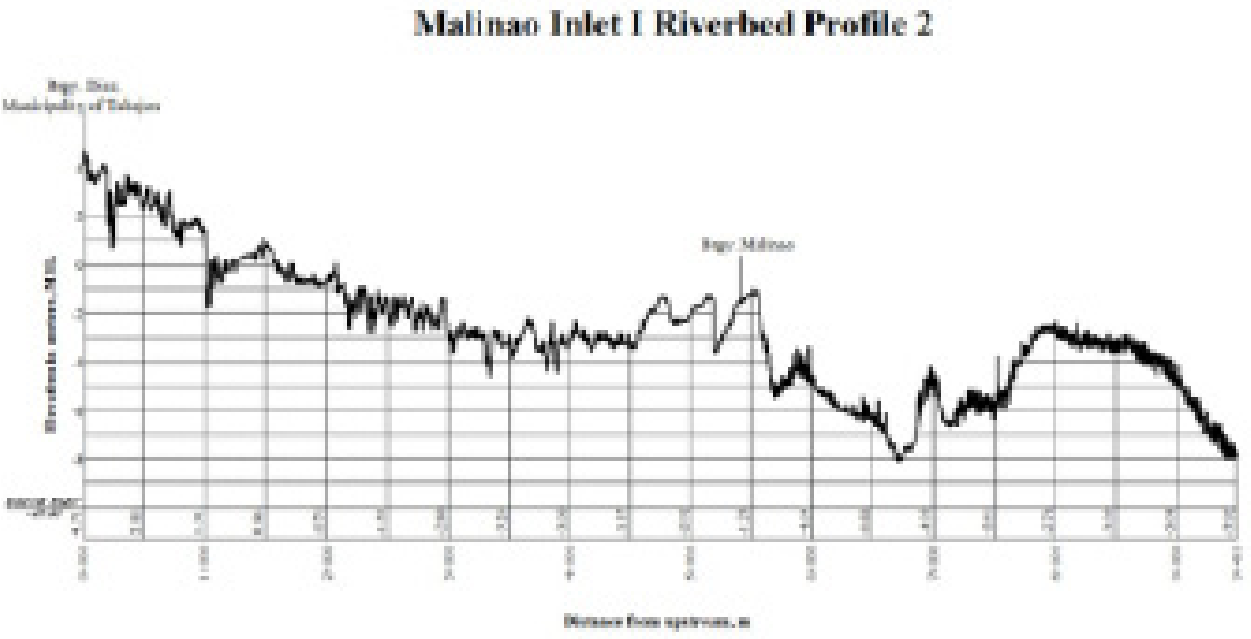

Figure 41. The Malinao Inlet River Bed Profile from Brgy. Diaz 2

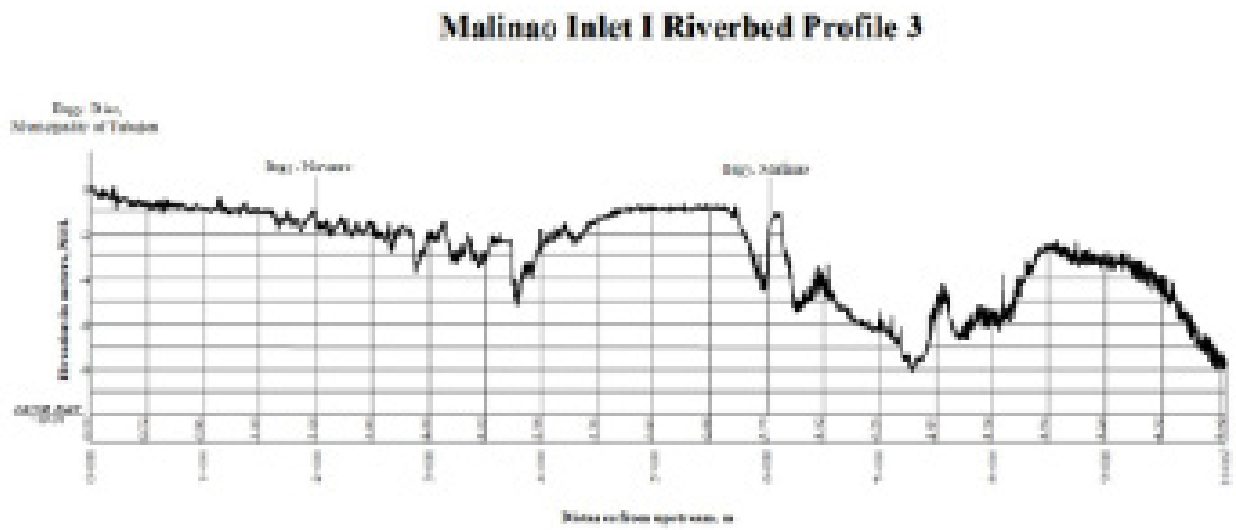

Figure 42. The Malinao Inlet River Bed Profile from Brgy. Diaz 3

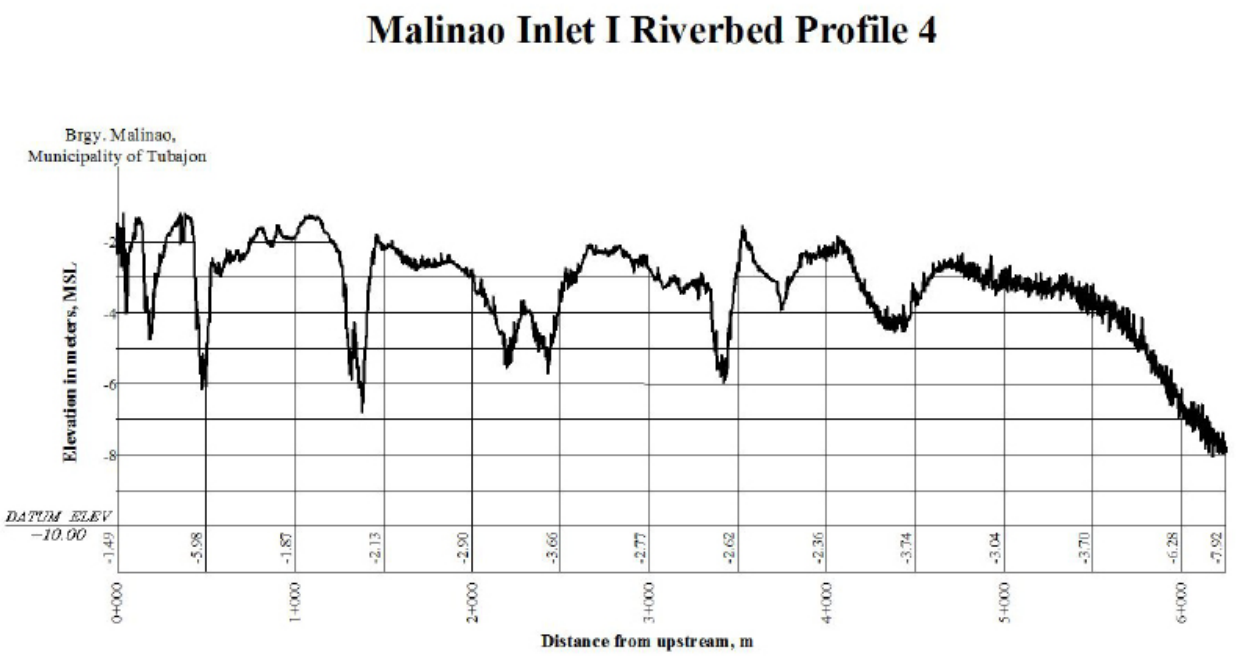

Figure 43. The Malinao Inlet River Bed Profile from from Brgy. Malinao

CHAPTER 5: FLOOD MODELING AND MAPPING

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

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

5.1 Data Used for Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

All components and data, such as rainfall, water level, and flow in a certain period of time, which may affect the hydrologic cycle of the Malinao Inlet River Basin were monitored, collected, and analyzed.

5.1.2 Precipitation

Precipitation data was taken from an automatic rain gauge (ARG) installed by the CSU Phil-LiDAR 1 as shown in Figure 44. The precipitation data collection started from October 05, 2016 08:00 to October 06, 2016 15:00.

The total precipitation for this event in the rain gauge that was temporarily installed in the Chapel of Brgy. Navarro, Tubajon, Dinagat Islands Brgy.Navarro was 32 mm. It has a peak rainfall of 5 mm. on October 05, 2016 14:00. The lag time between the peak rainfall and discharge at Envaran River is 3 hours, as shown in Figure 47.

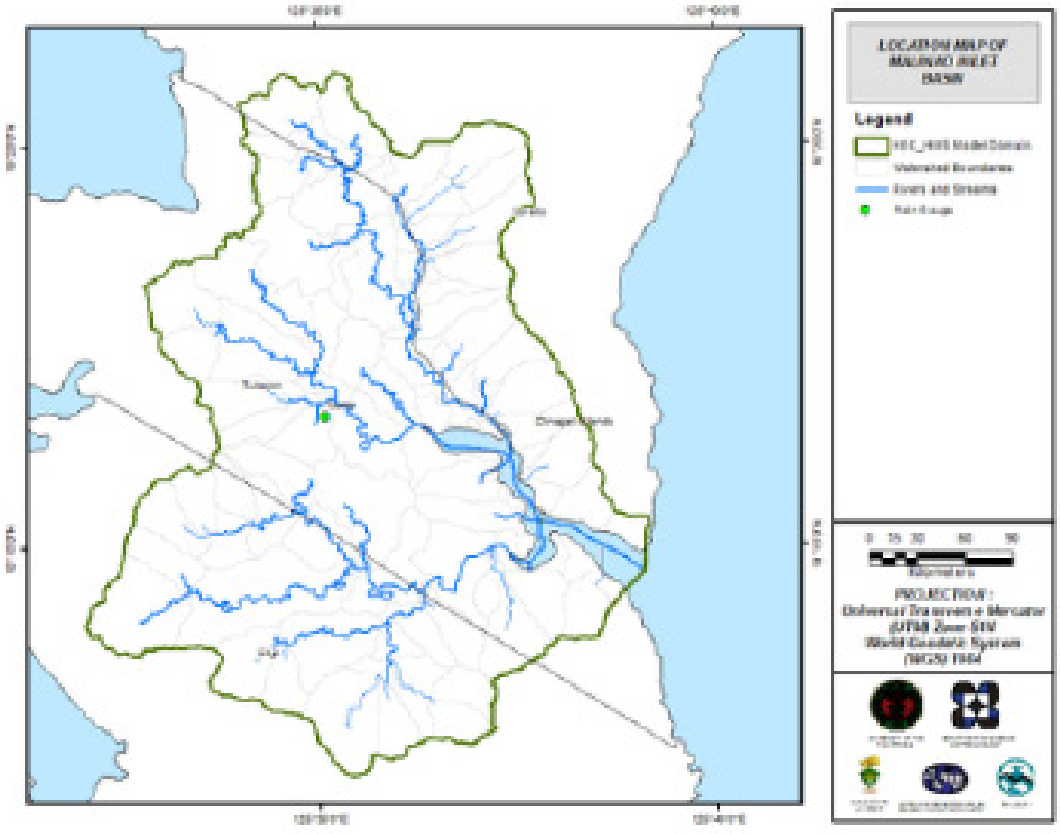

Figure 44. Location Map of the Malinao Inlet HEC-HMS model used for calibration

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Envaran River, Brgy. Malinao, Tubajon, Dinagat Islands (10°16'43.6"N, 125°35'7.81"E). It gives the relationship between the observed water levels from Envaran River and outflow of the watershed at this location.

For Envaran River, the rating curve is expressed as Q = 0.7202H2 +1.4016H + 1.1492 as shown in Figure 46.

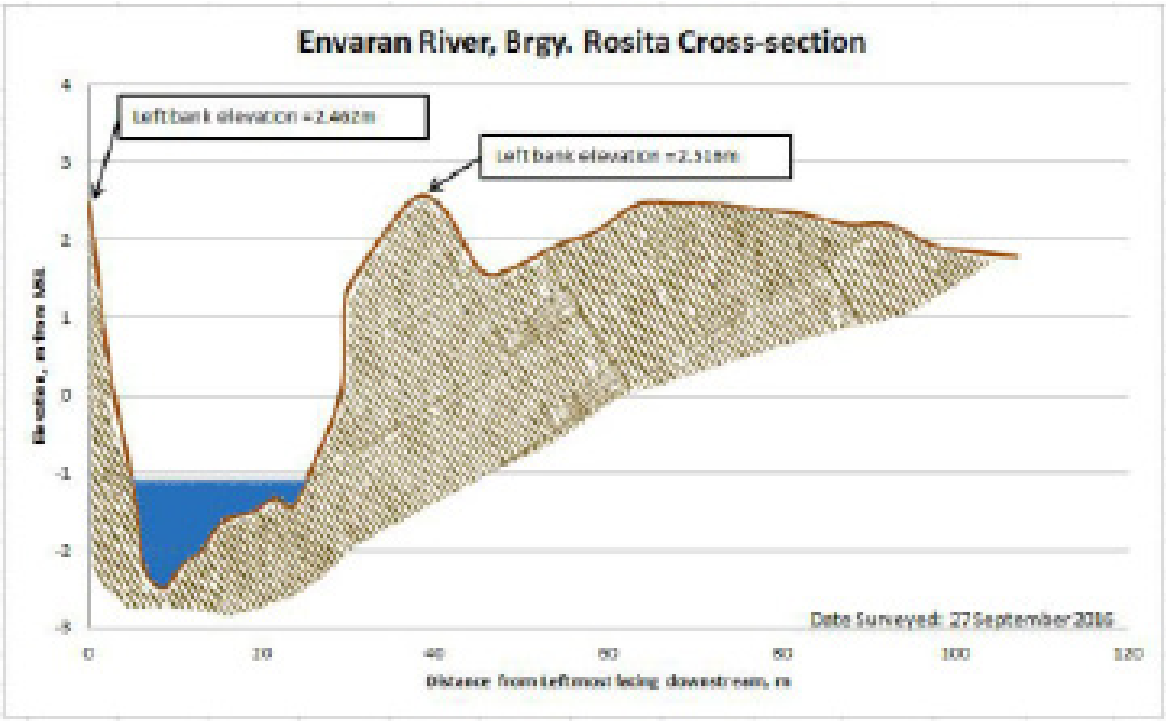

Figure 45. The cross-section plot of the Envaran River.

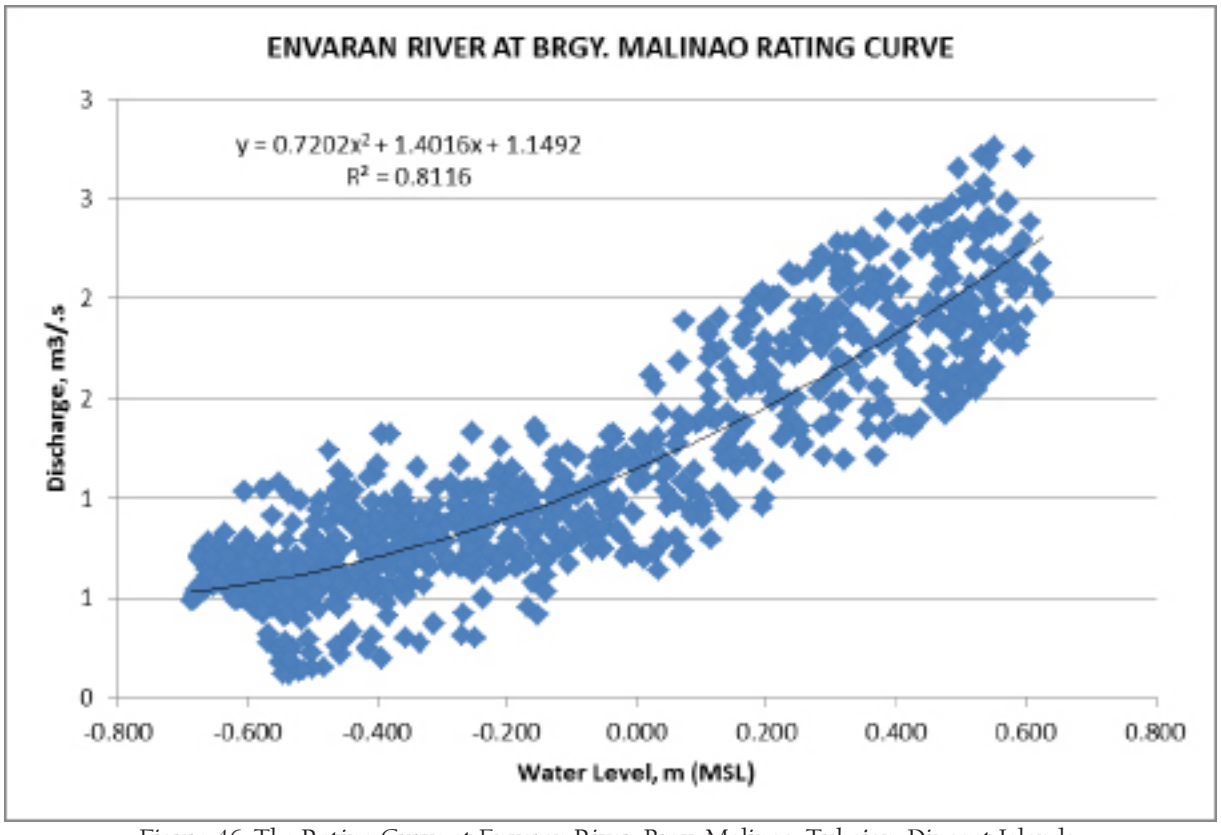

Figure 46. The Rating Curve at Envaran River, Brgy. Malinao, Tubajon, Dinagat Islands.

This rating curve equation was used to compute the river outflow at Evaran River for the calibration of the HEC-HMS model shown in Figure 45. The peak discharge is 8.55 cubic meter per second (cms) at 05:00 PM, October 05, 2016 (Figure 47).

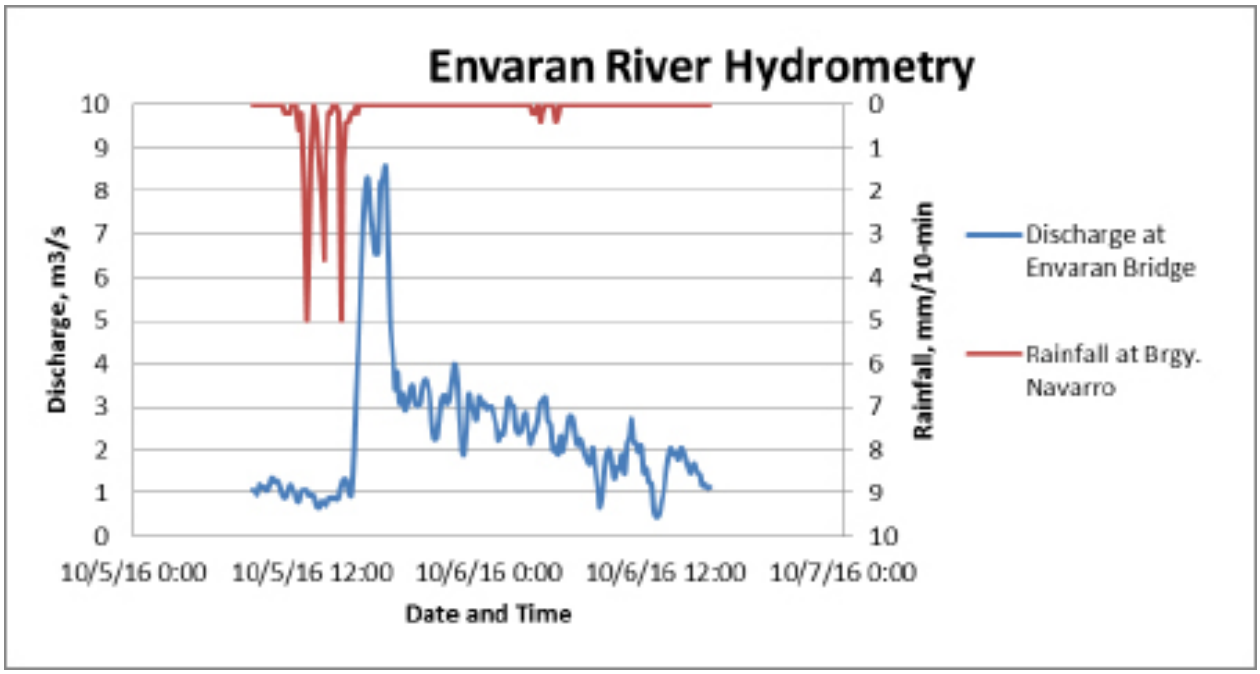

Figure 47. Rainfall at Brgy, Navarro chapel and outflow data at Evaran River used for modeling.

5.2 RIDF Station

PAGASA computed the Rainfall Intensity Duration Frequency (RIDF) values for the Surigao Rain Gauge (Table 31). The RIDF rainfall amount for 24 hours was converted into a synthetic storm by interpolating and re-arranging the values in such a way that certain peak values will be attained at a certain time (Figure 49). This station was selected based on its proximity to the Malinao Inlet watershed. The extreme values for this watershed were computed based on a 21-year record.

Table 31. RIDF values for the Malinao Inlet River Basin based on average RIDF data of Surigao Inlet, as computed by PAGASA

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION									
T (yrs)	**10 mins**	**20 mins**	**30 mins**	**1 hr**	**2 hrs**	**3 hrs**	**6 hrs**	**12 hrs**	**24 hrs**
2	11.3	22.5	26.4	59	81.8	97.1	128.7	157.4	188.7
5	17.2	34.34	39.7	88.3	125.8	150.9	199.2	246.3	286.5
10	21.1	42.3	48.6	107.7	155	186.5	245.8	305.1	351.2
15	23.4	46.7	53.5	118.6	171.4	206.6	272.1	338.3	387.7
20	24.9	49.8	57	126.3	182.9	220.6	290.5	361.6	413.3
25	26.1	52.2	59.7	132.2	191.8	231.4	304.7	379.5	433
50	29.8	59.6	68	150.3	219.1	264.8	348.4	434.6	493.7
100	33.5	66.9	76.2	168.3	246.2	297.9	391.8	489.4	553.9

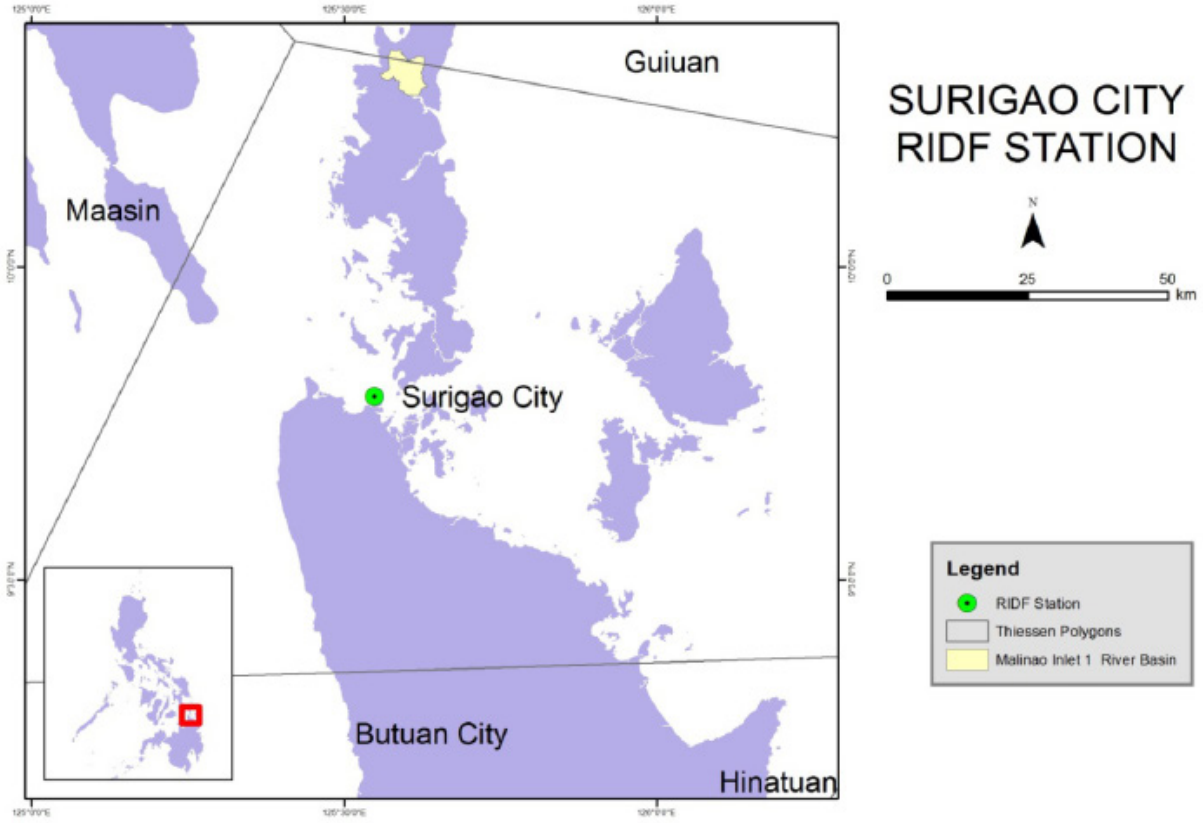

Figure 48. The location of the Surigao RIDF station relative to the Malinao Inlet River Basin.

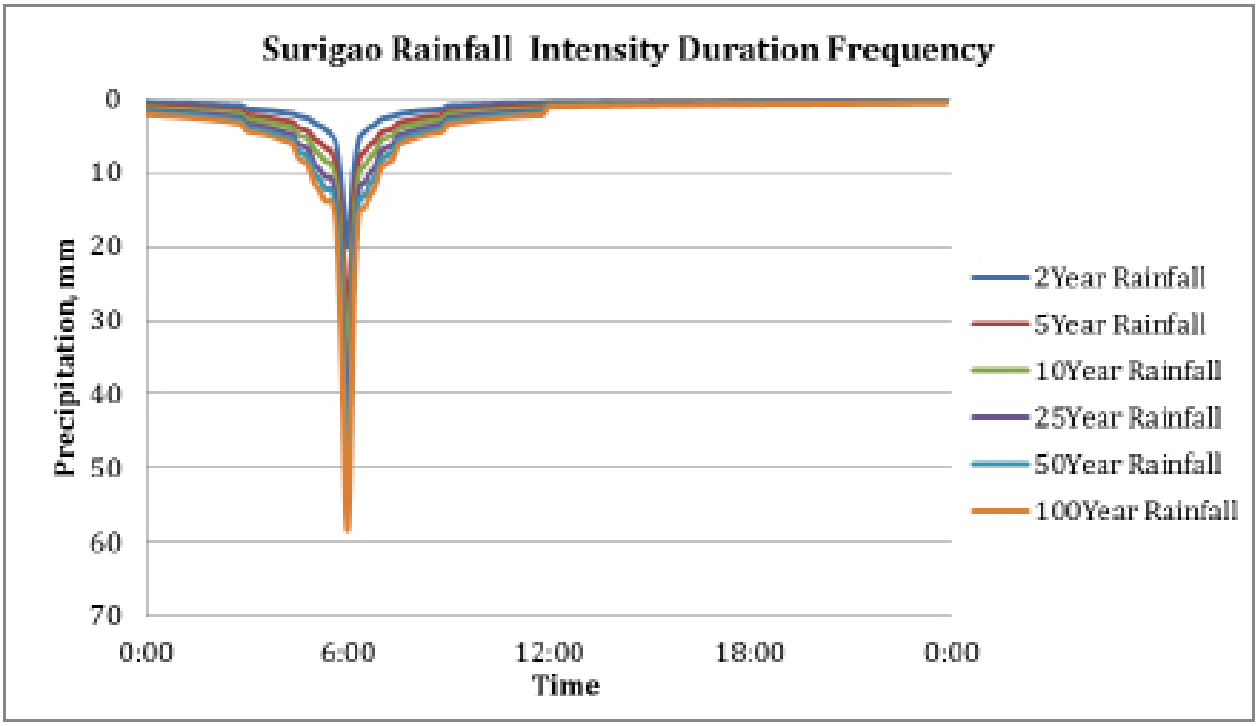

Figure 49. The synthetic storm generated for a 24-hour period rainfall for various return periods

5.3 HMS Model

These soil dataset was generated before 2004 by the Bureau of Soils and Water Management (BSWM). It is under the Department of Agriculture (DA). The land cover dataset is from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Malinao Inlet River Basin are shown in Figure 50 and Figure 51 respectively.

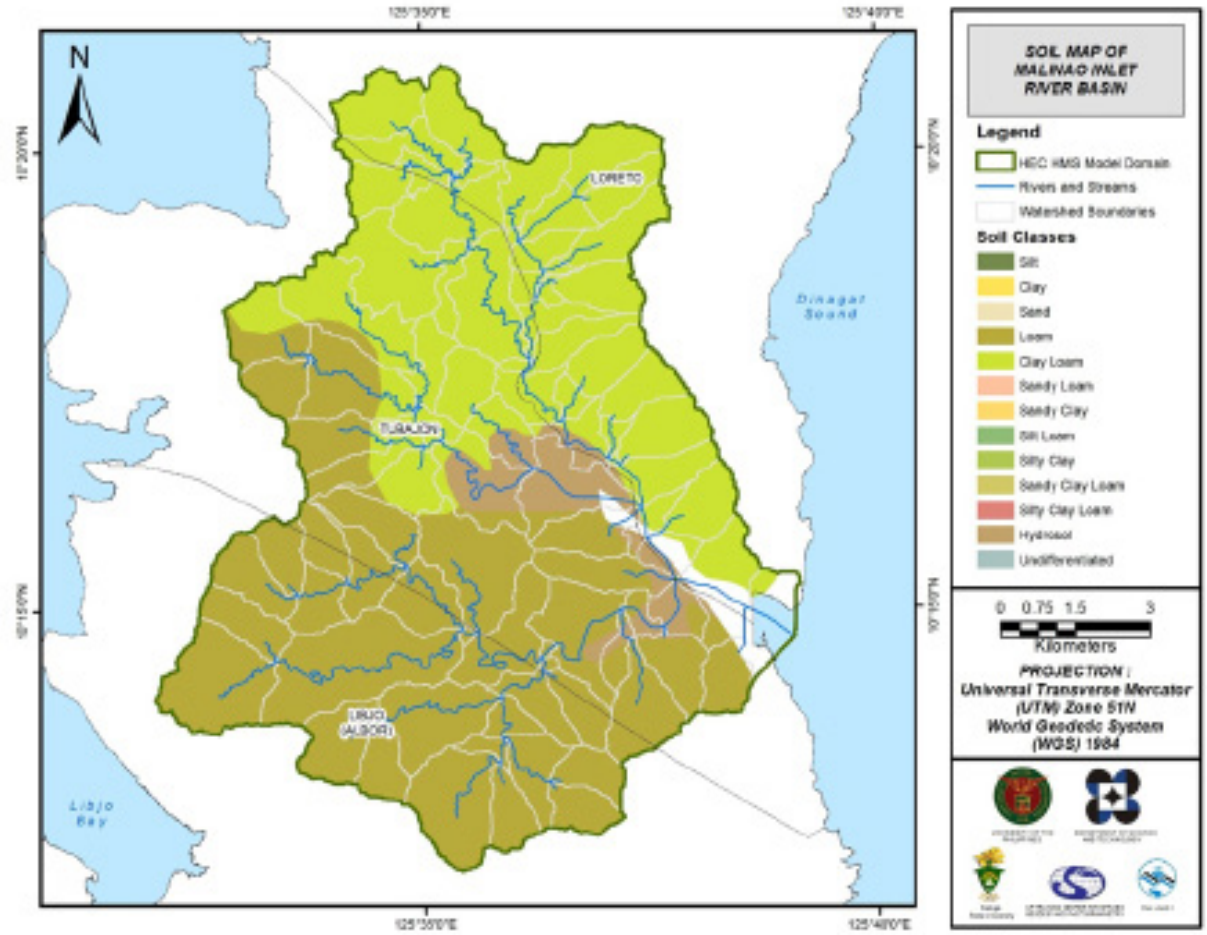

Figure 50. Soil Map of Maliano Inlet River Basin.

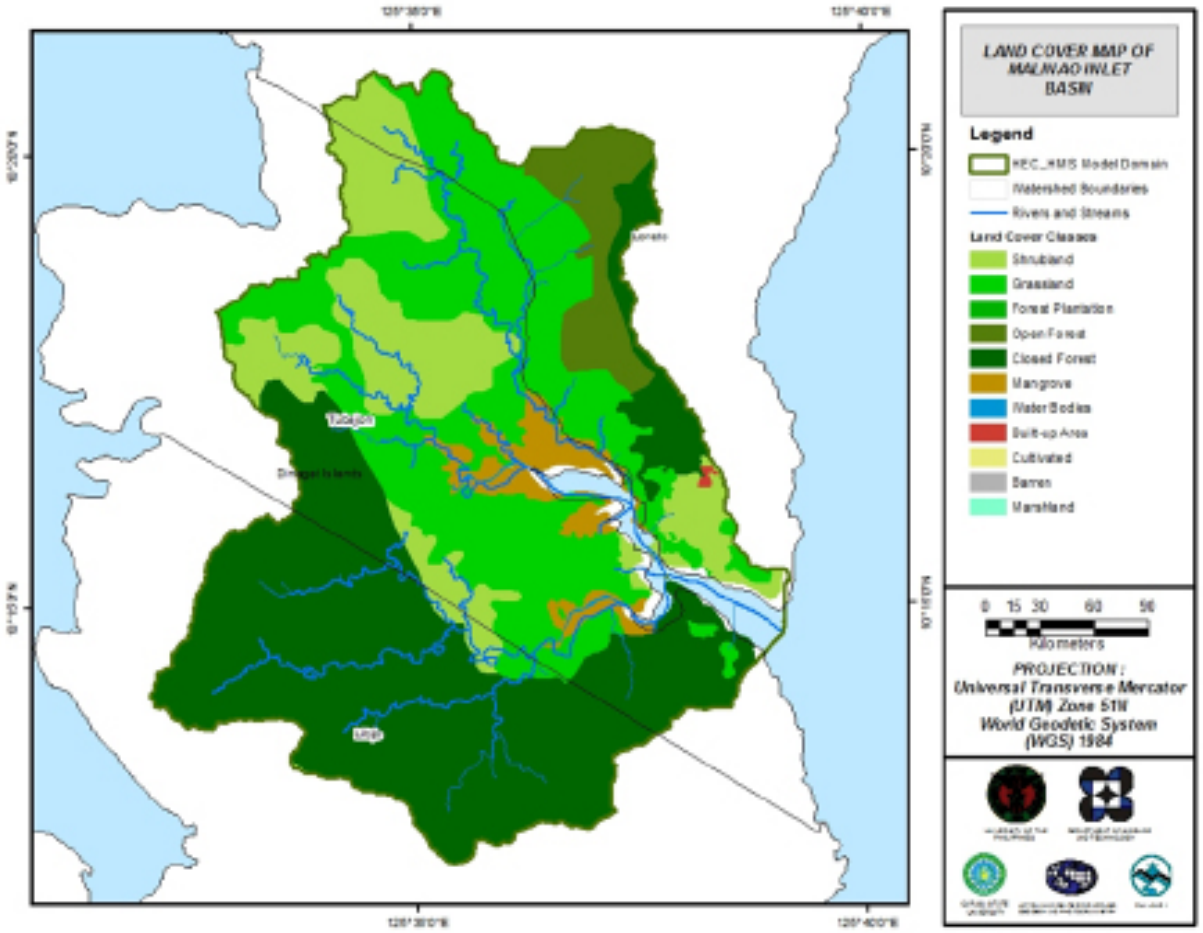

Figure 51. Land Cover Map of Malinao Inlet River Basin

For the Malinao Inlet River Basin, the three (3) types of soil identified were loam, hydrosol, and clay loam. Moreover, there were six (6) types of land cover identified. These are closed forest, open forest, grassland, shrubland, mangrove, and built-up area.

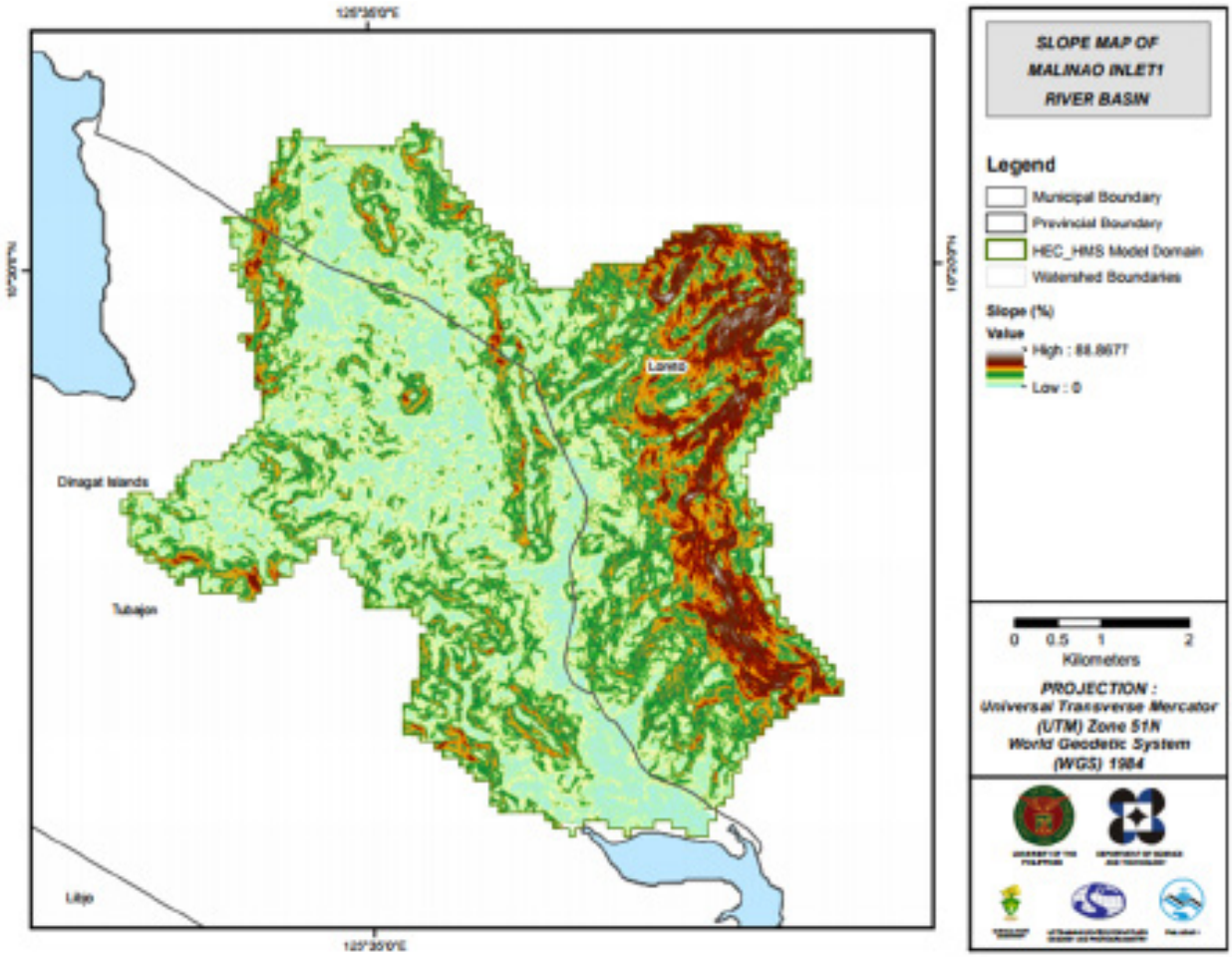

Figure 52. Slope Map of the Malinao Inlet River Basin.

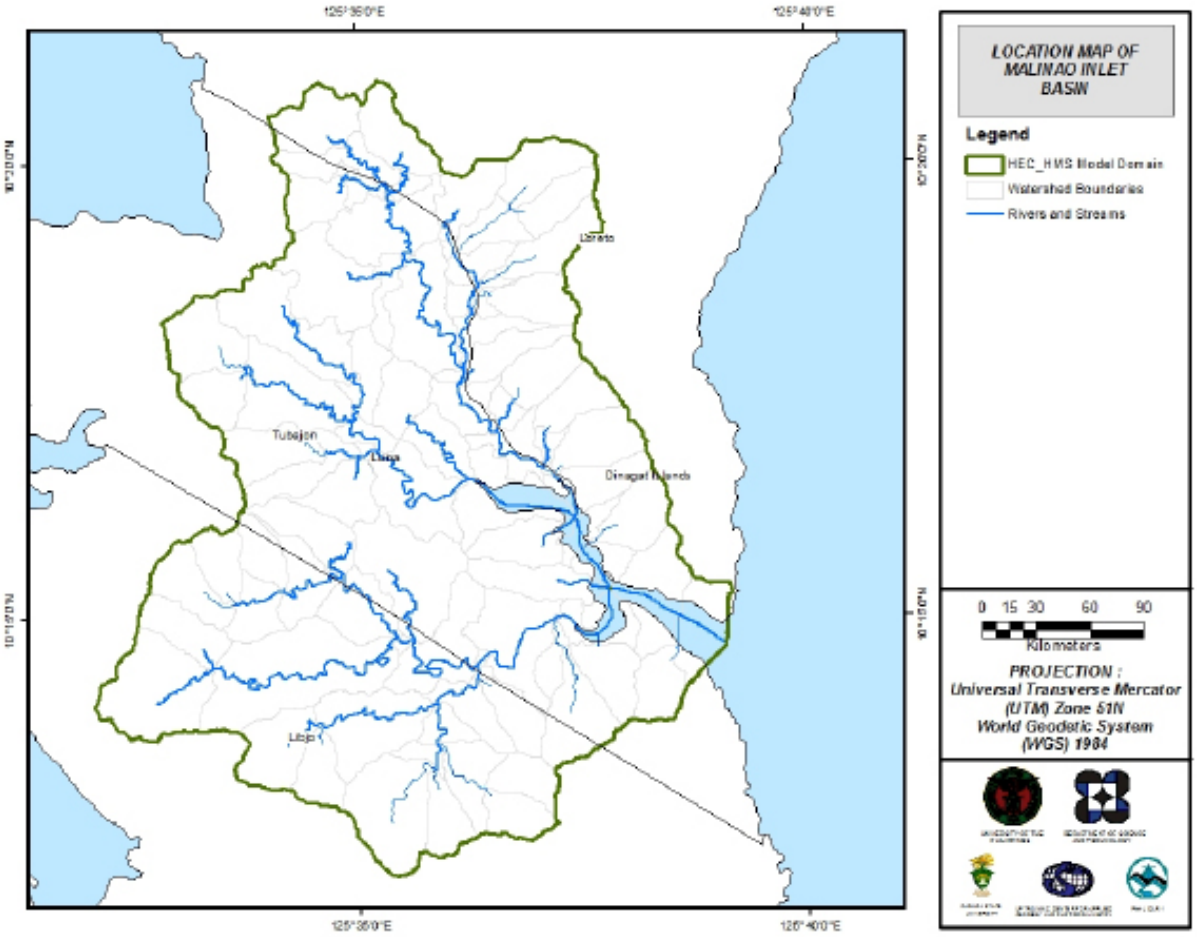

Figure 53. Stream Delineation Map of Maliano Inlet River Basin

Using the SAR-based DEM and the resampled 10 meter LiDAR DTM, the Malinao Inlet basin was delineated and further subdivided into subbasins. The model consists of 90 sub basins, 52 reaches, and 52 junctions as shown in Figure 54. The main outlet is at Malinao Inlet Bridge. Finally, it was calibrated using data gathered through hydrological measurement at Envaran River.

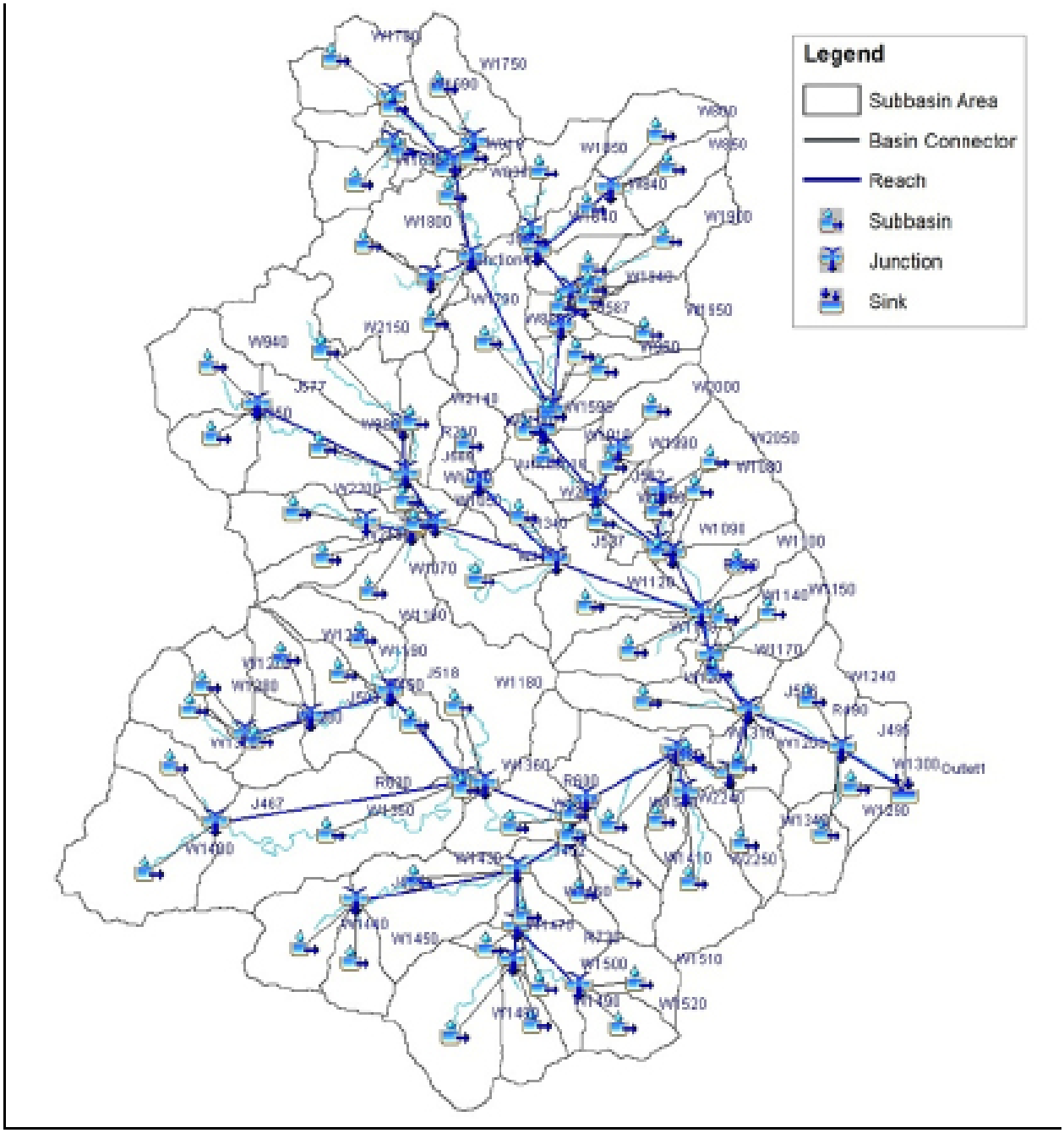

Figure 54. The Maliano Inlet River Basin model generated using HEC-HMS.

5.4 Cross-section Data

The riverbed cross-sections of the watershed were necessary in the HEC-RAS model setup. The cross-section data for the HEC-RAS model was derived from the LiDAR DEM data, which was defined using the Arc GeoRAS tool and was post-processed in ArcGIS (Figure 55).

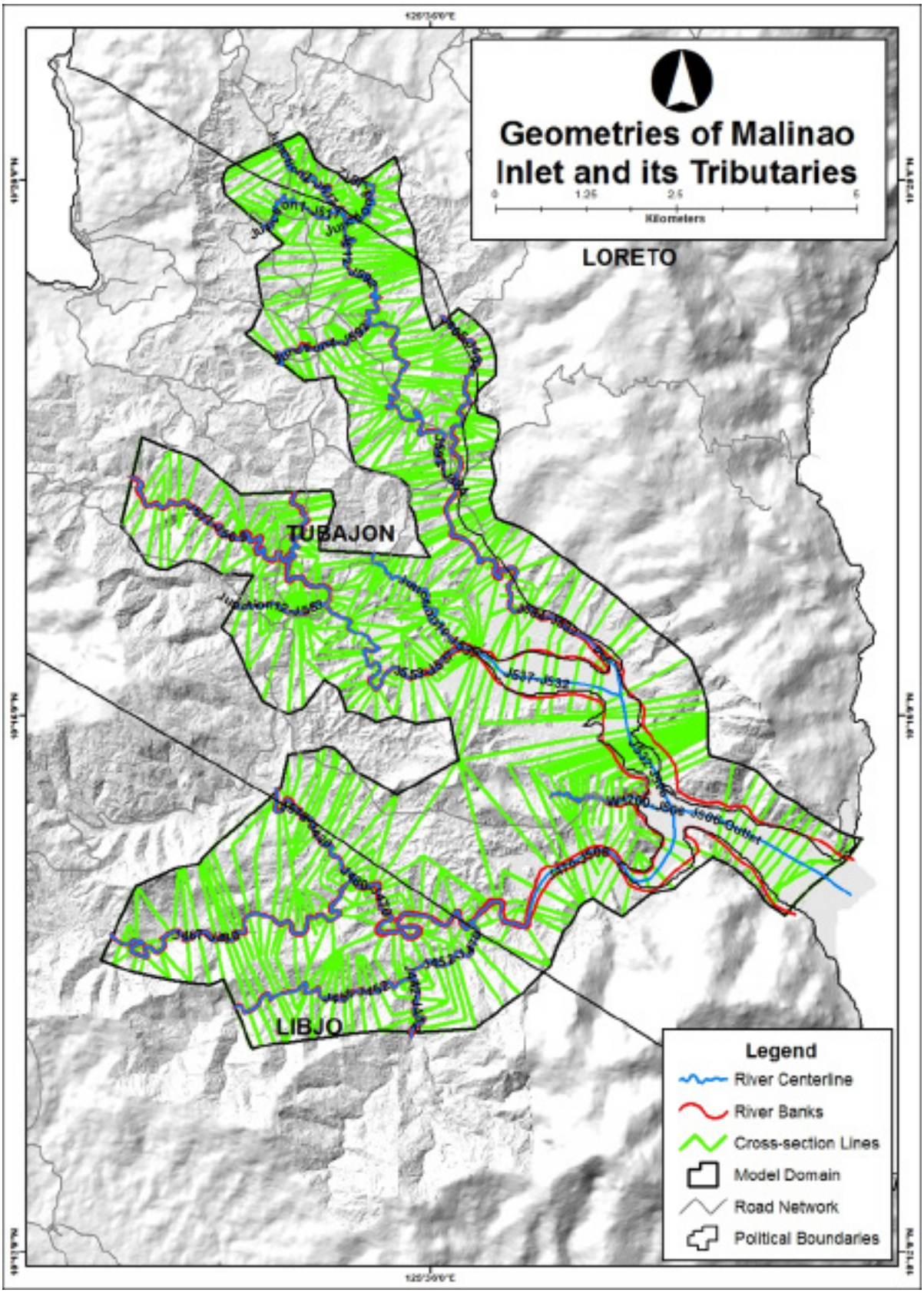

Figure 55. River cross-section of the Malinao Inlet River through the ArcMap HEC GeoRas tool

5.5 Flo 2D Model

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

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

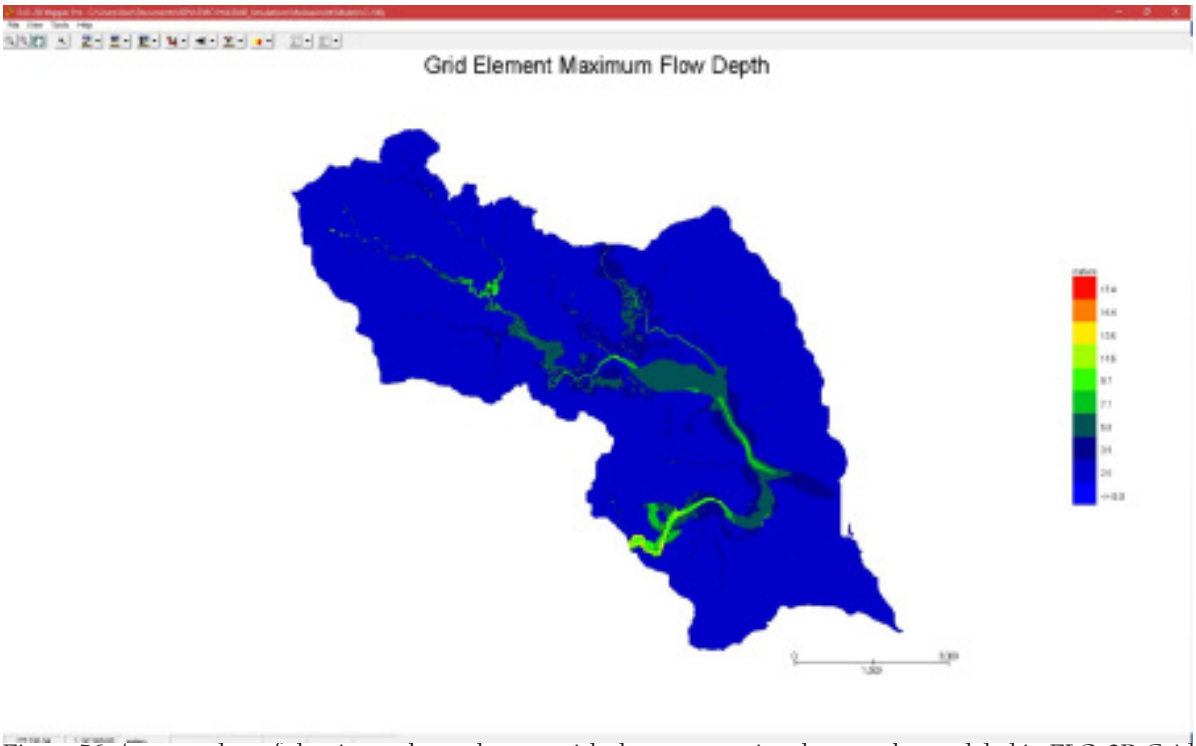

Figure 56. A screenshot of the river sub-catchment with the computational area to be modeled in FLO-2D Grid Developer System Pro (FLO-2D GDS Pro)

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 44.99207 hours. After the simulation, FLO-2D Mapper Pro is used to transform the simulation results into spatial data that shows flood hazard levels, as well as the extent and inundation of the flood. Assigning the appropriate flood depth and velocity values for Low, Medium, and High creates the following food hazard map. Most of the default values given by FLO-2D Mapper Pro are used, except for those in the Low hazard level. For this particular level, the minimum h (Maximum depth) is set at 0.2 m while the minimum vh (Product of maximum velocity (v) times maximum depth (h)) is set at 0 m2/s. The generated hazard maps for Maliano Inlet are in Figure 60, 62 and 64.

The creation of a flood hazard map from the model also automatically creates a flow depth map depicting the maximum amount of inundation for every grid element. The legend used by default in Flo-2D Mapper is not a good representation of the range of flood inundation values, so a different legend is used for the layout. In this particular model, the inundated parts cover a maximum land area of 42809000.00 m2. The generated flood depth maps for Malinao Inlet are in Figure 61, 63, and 65.

There is a total of 19900806.29 m3 of water entering the model. Of this amount, 19900806.29 m3 is due to rainfall while 0.00 m3 is inflow from other areas outside the model. 2623467.25 m3 of this water is lost to infiltration and interception, while 1994863.48 m3 is stored by the flood plain. The rest, amounting up to 15282471.59 m3, is outflow.

5.6 Results of HMS Calibration

After calibrating the Malinao Inlet HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 57 shows the comparison between the two discharge data.

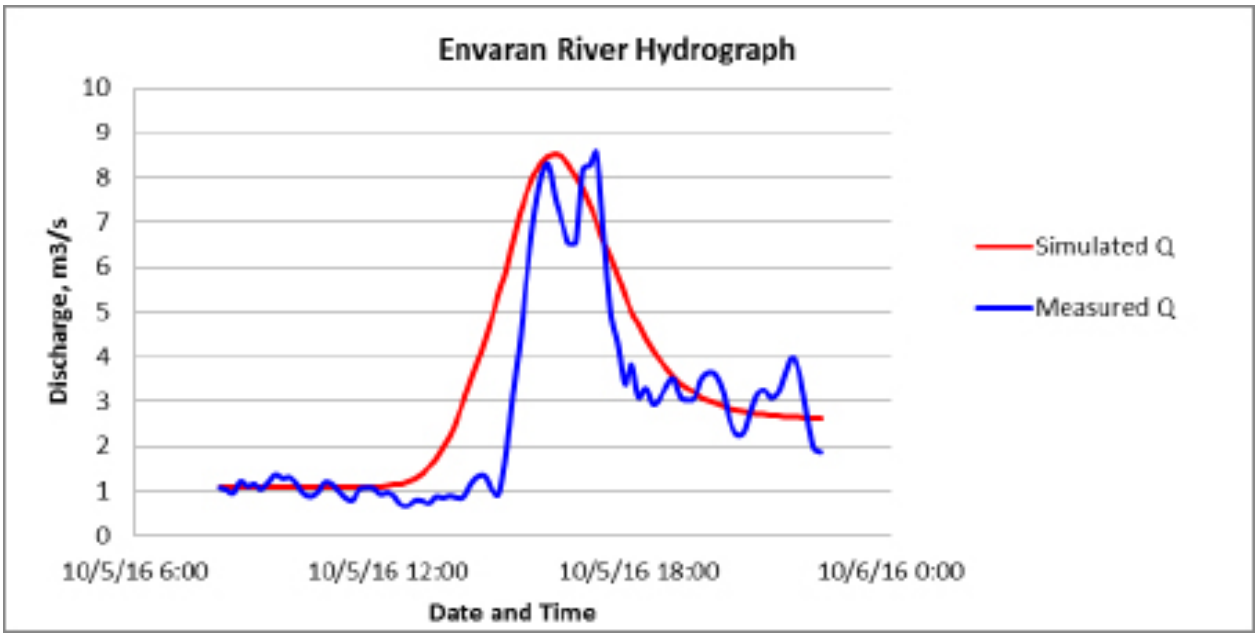

Figure 57. Outflow Hydrograph of Evaran River produced by the HEC-HMS model compared with observed outflow

Table 32 shows adjusted ranges of values of the parameters used in calibrating the model.

Table 32. Range of calibrated values for the Malinao Inlet River Basin.

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	0.21-8.31
			Curve Number	55-97.96
	Transform	SCS Unit Hydrograph	Time of Concentration (hr)	0-7.18
			Storage Coefficient (hr)	4.86-197.41
	Baseflow	Recession	Recession Constant	1
			Ratio to Peak	0.25
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.025

Initial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as initial abstraction decreases. The range of values from 0.21-8.31mm means that there is minimal to average amount of infiltration or rainfall interception by vegetation.

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range of 65 to 90 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area (M. Horritt, personal communication, 2012). For Maliano Inlet, the basin mostly consists of shrublands, forest plantations and urban area, and the soil consists of clay, loam, clay loam, and sandy loam.

Time of concentration and storage coefficient are the travel time and index of temporary storage of runoff in a watershed. The range of calibrated values from values 4.86-197.41 minutes determines the reaction time of the model with respect to the rainfall. The peak magnitude of the hydrograph also decreases when these parameters are increased.

Recession constant is the rate at which baseflow recedes between storm events and ratio to peak is the ratio of the baseflow discharge to the peak discharge. Recession constant of 1 indicates that the basin is unlikely to quickly go back to its original discharge and instead, will be higher. Ratio to peak of 0.025 indicates a steeper receding limb of the outflow hydrograph.

Manning's roughness coefficient of 0.025 corresponds to the common roughness in the Malinao Inlet watershed, which is determined to be cultivated with mature field crops (Brunner, 2010).

Table 33. Summary of the Efficiency Test of the Malinao Inlet HMS Model

Accuracy measure	Value
RMSE	1.3
r2	0.65
NSE	-20.97
PBIAS	0.59
RSR	0.32

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified at 1.3 m3/s.

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.7618.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.65.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -20.97.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.59.

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

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 58) shows the Malinao Inlet outflow using the Surigao Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) data. The simulation results reveal show increasing outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

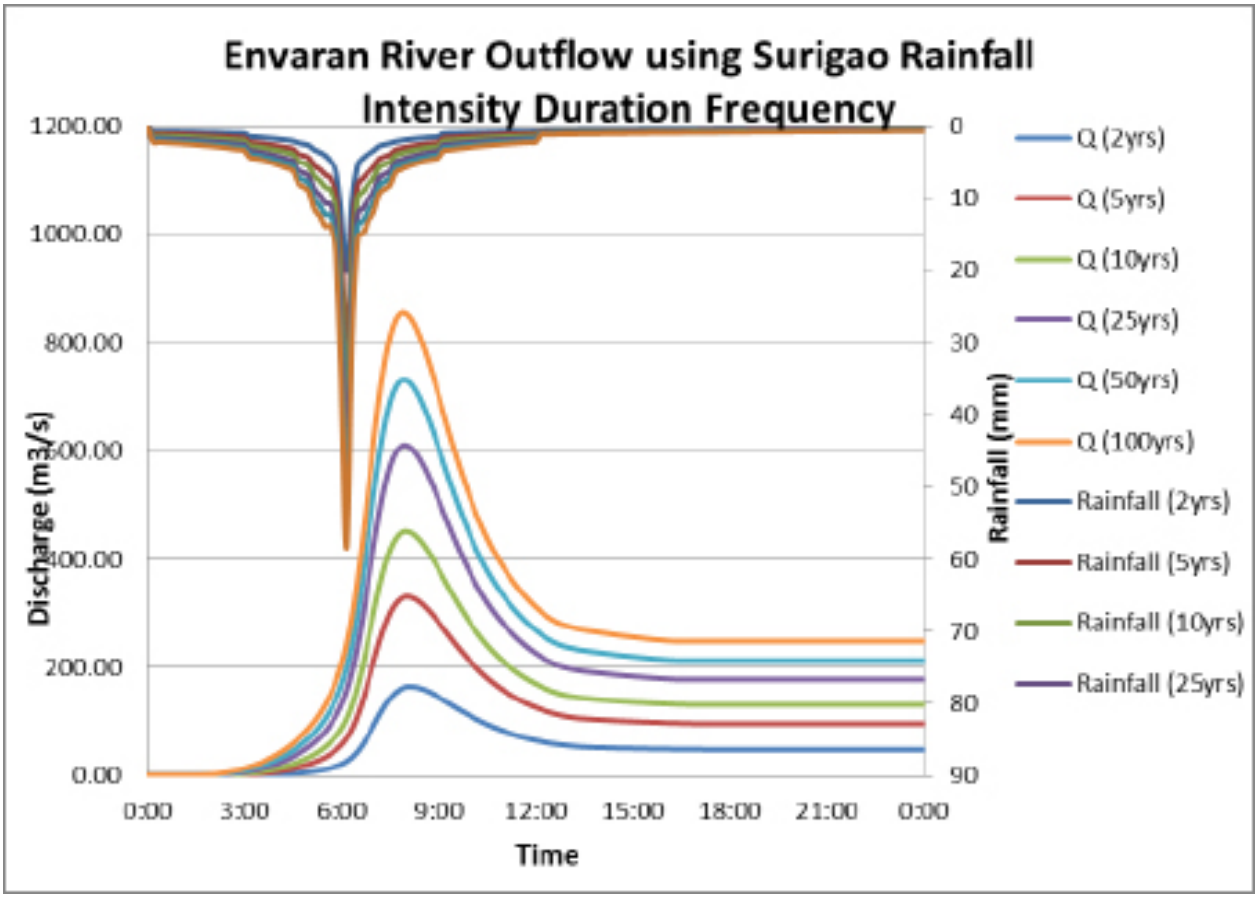

Figure 58. The Outflow hydrograph at the Malinao Inlet Station, generated using the Surigao RIDF simulated in HEC-HMS.

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

Table 34. The peak values of the Malinao Inlet HEC-HMS Model outflow using the Surigao RIDF.

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m 3/s)	Time to Peak
5-Year	186.24	30.33	331.15	2 hours and 0 minute
10-Year	350.89	37.15	451.71	2 hours and 0 minute
25-Year	432.61	45.70	610.69	2 hours and 0 minute
50-Year	493.26	52.09	731.51	2 hours and 0 minute
100-Year	533.40	58.41	853.97	1 hour and 50 minutes

5.8 River Analysis (RAS) Model Simulation

The HEC-RAS Flood Model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. Figure 67 shows a generated sample map of the Malinao Inlet River using the calibrated HMS base flow.

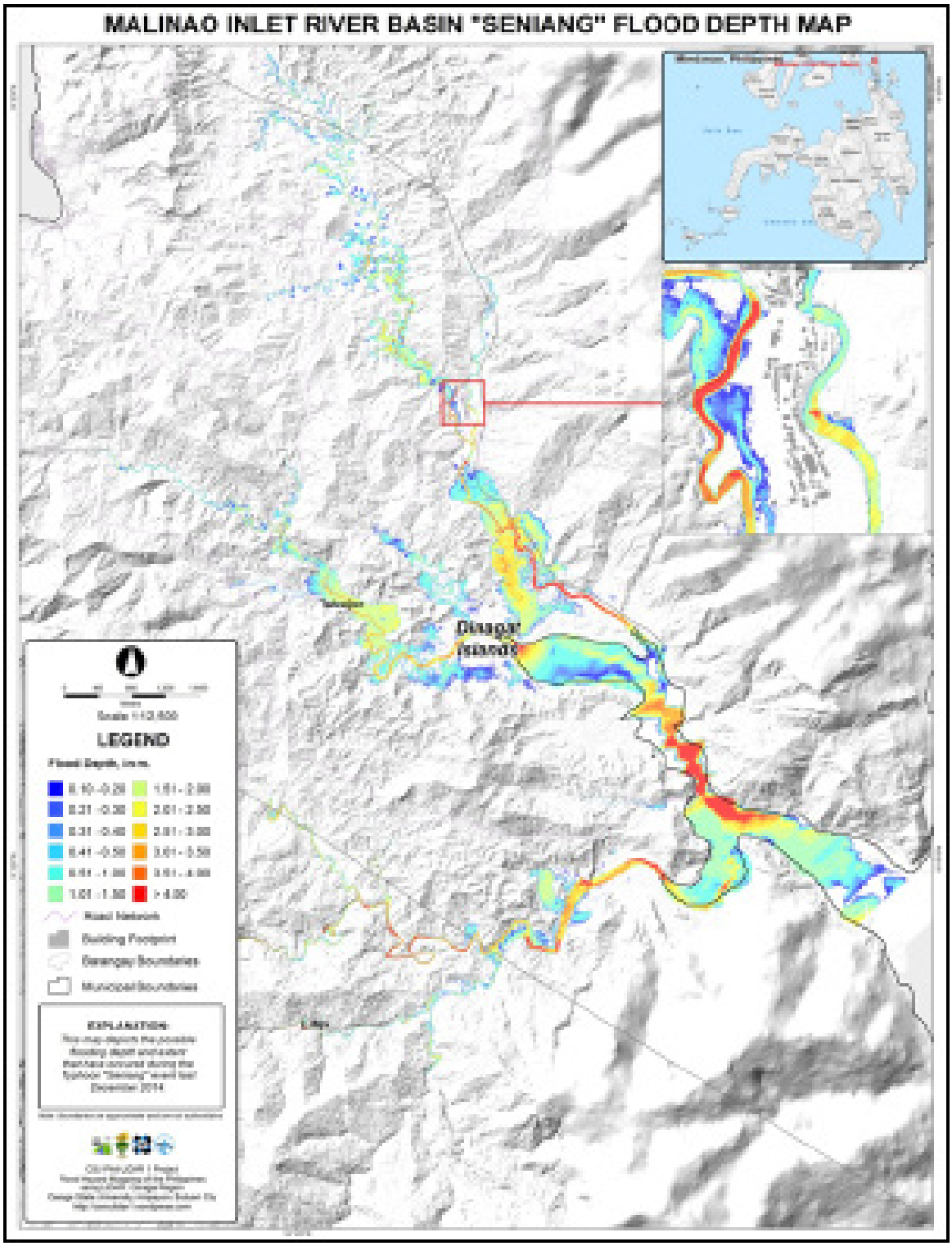

Figure 59. The sample output map of the Malinao Inlet RAS Model.

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps for the 5-, 25-, and 100-year rain return scenarios of the Malinao Inlet floodplain are shown in Figure 60 to Figure 65. The floodplain, with an area of 109.17 sq. km., covers three municipalites namel Libjo, Loreto and Tubajon. Table 35 shows the percentage of area affected by flooding per municipality.

Table 35. Municipalities affected in Malinao Inlet Floodplain.

Municipality	Total Area	Area Flooded	% Flooded
Libjo	205.11	33.41	16%
Loreto	168.86	21.46	13%
Tubajon	85.88	51.40	60%

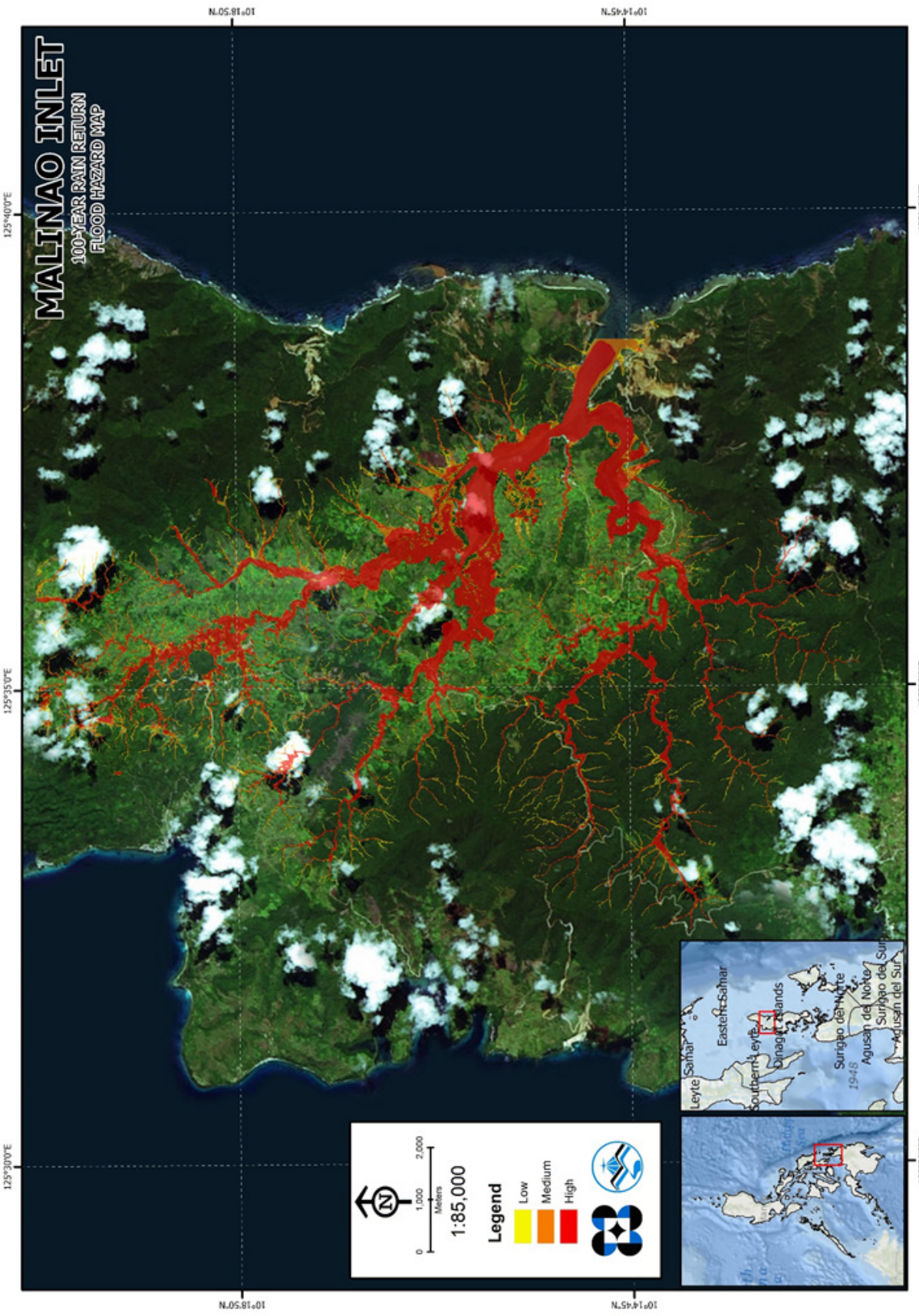

Figure 60. A 100-year Flood Hazard Map for Malinao Inlet Floodplain overlaid on Google Earth imagery.

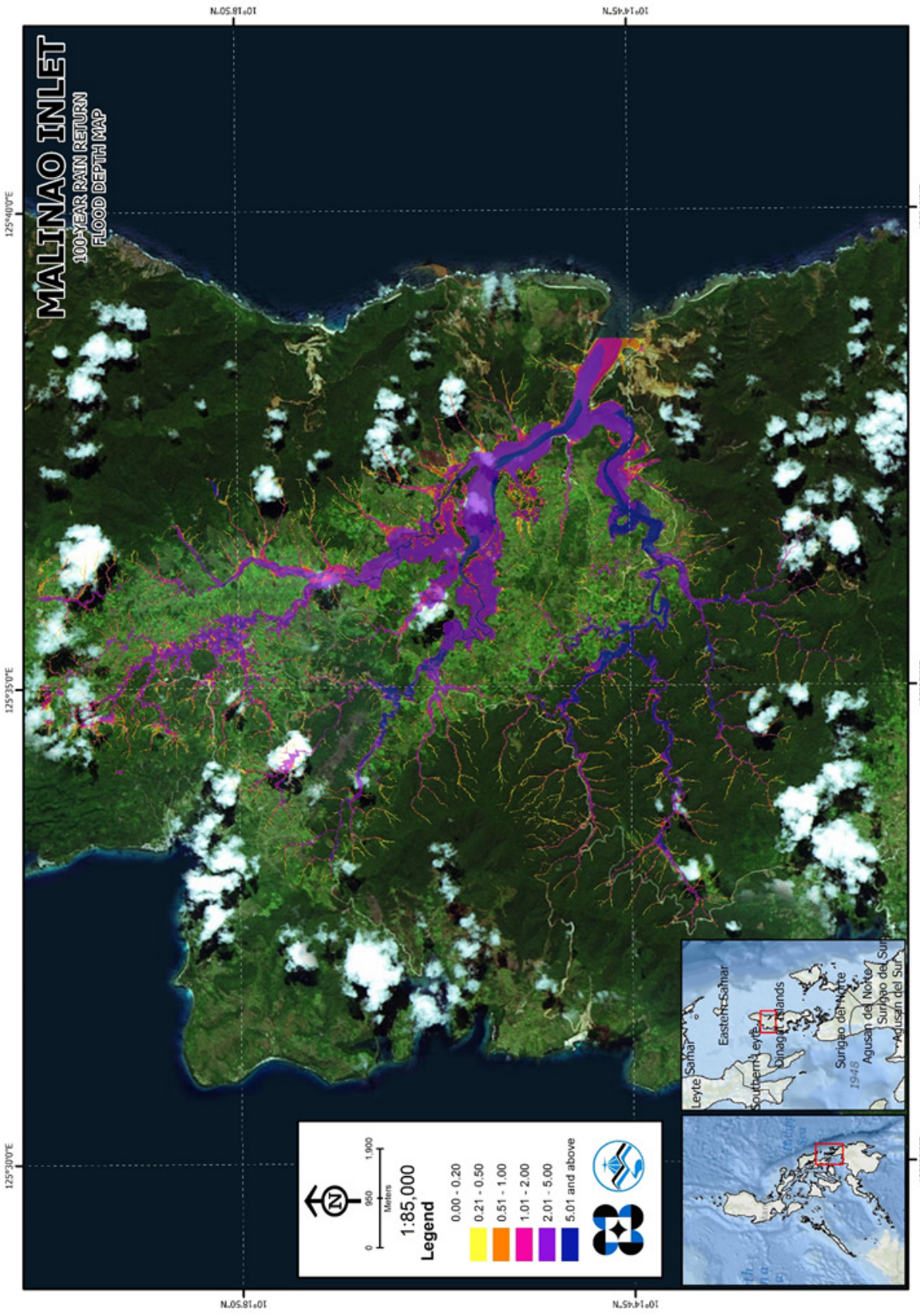

Figure 61. A 100-year Flow Depth Map for Malinao Inlet Floodplain overlaid on Google Earth imagery.

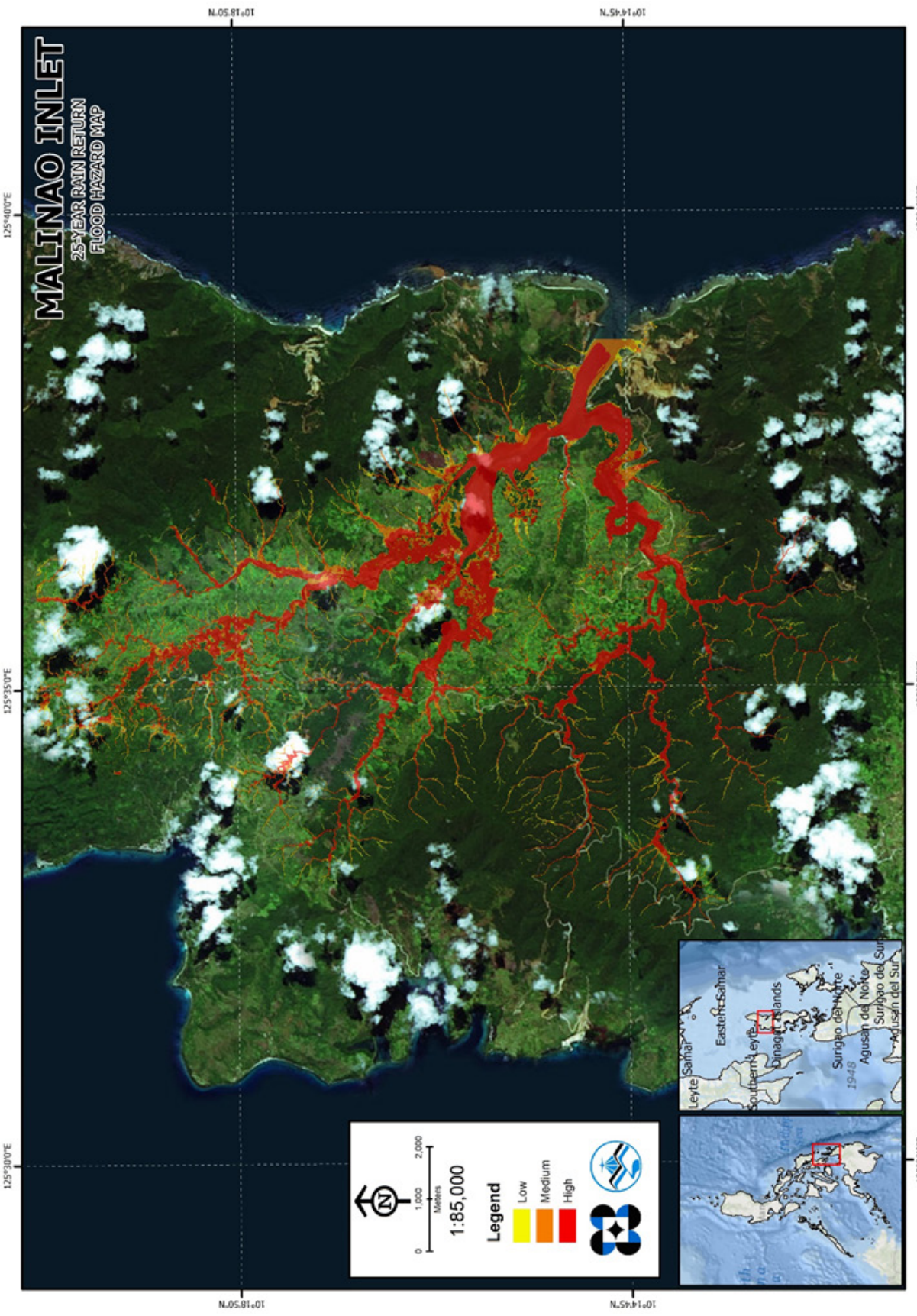

Figure 62. A 25-year Flood Hazard Map for Malinao Inlet Floodplain overlaid on Google Earth imagery.

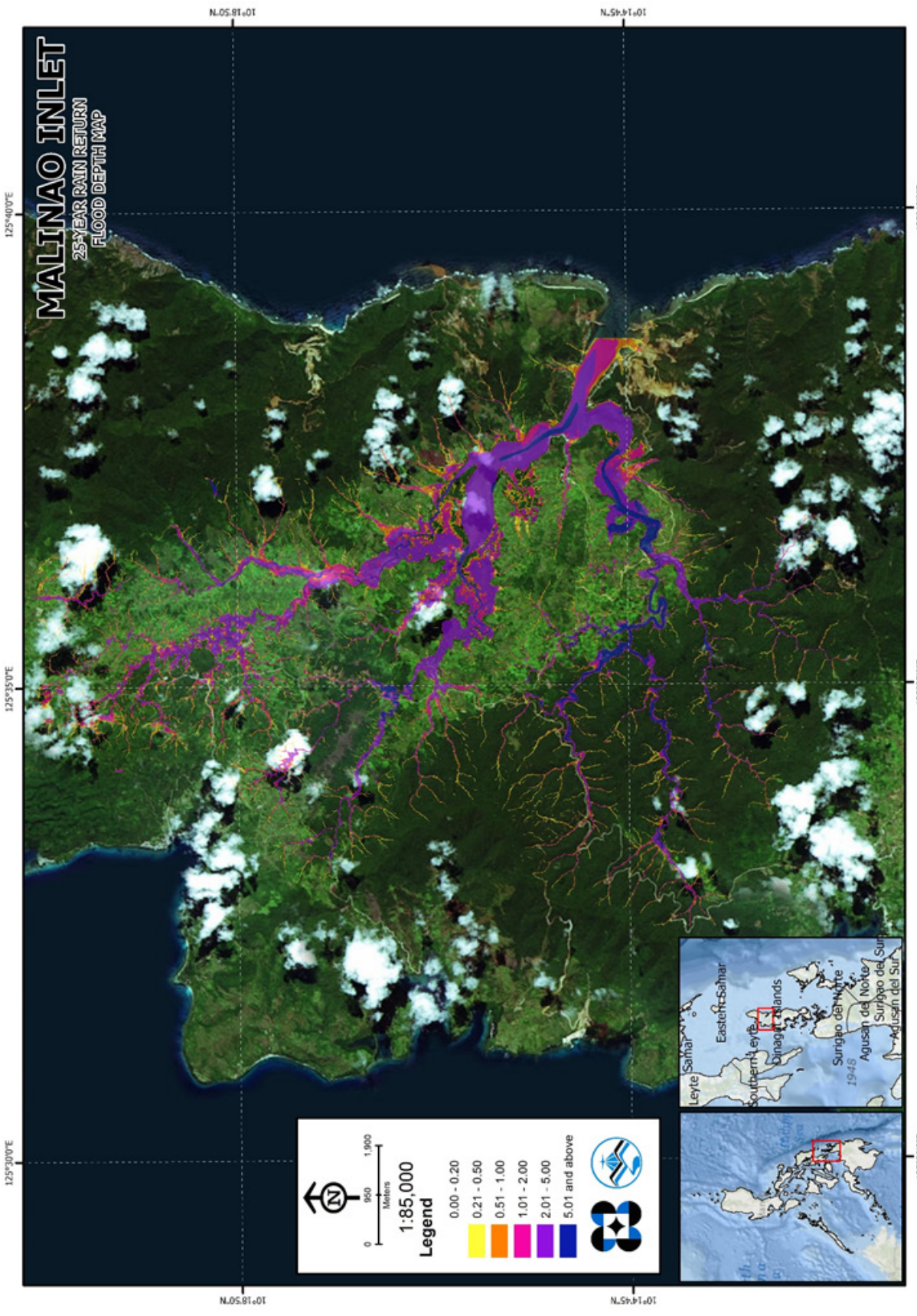

Figure 63. A 25-year Flow Depth Map for Malinao Inlet Floodplain overlaid on Google Earth imagery.

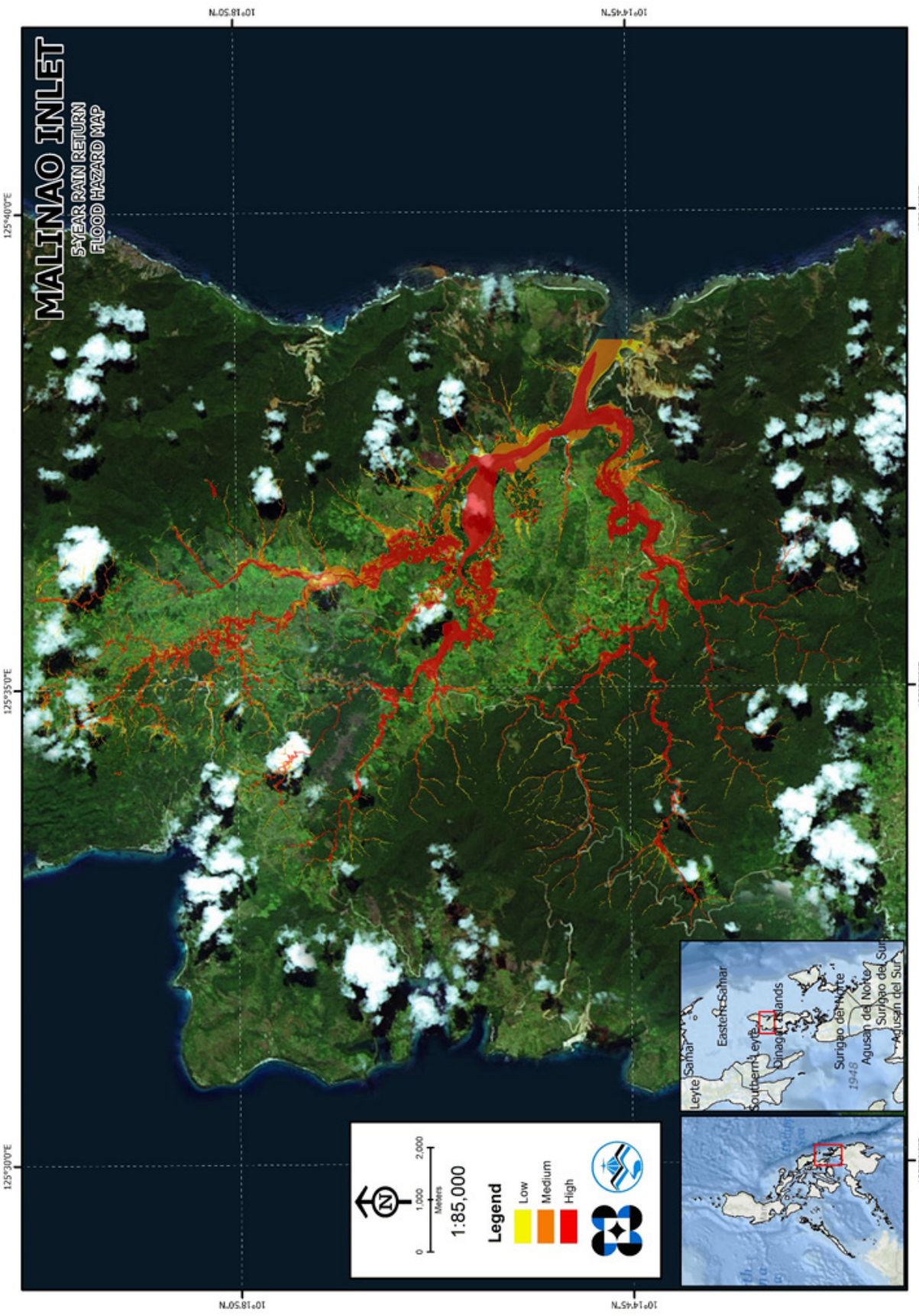

Figure 64. A 5-year Flood Hazard Map for Malinao Inlet Floodplain overlaid on Google Earth imagery.

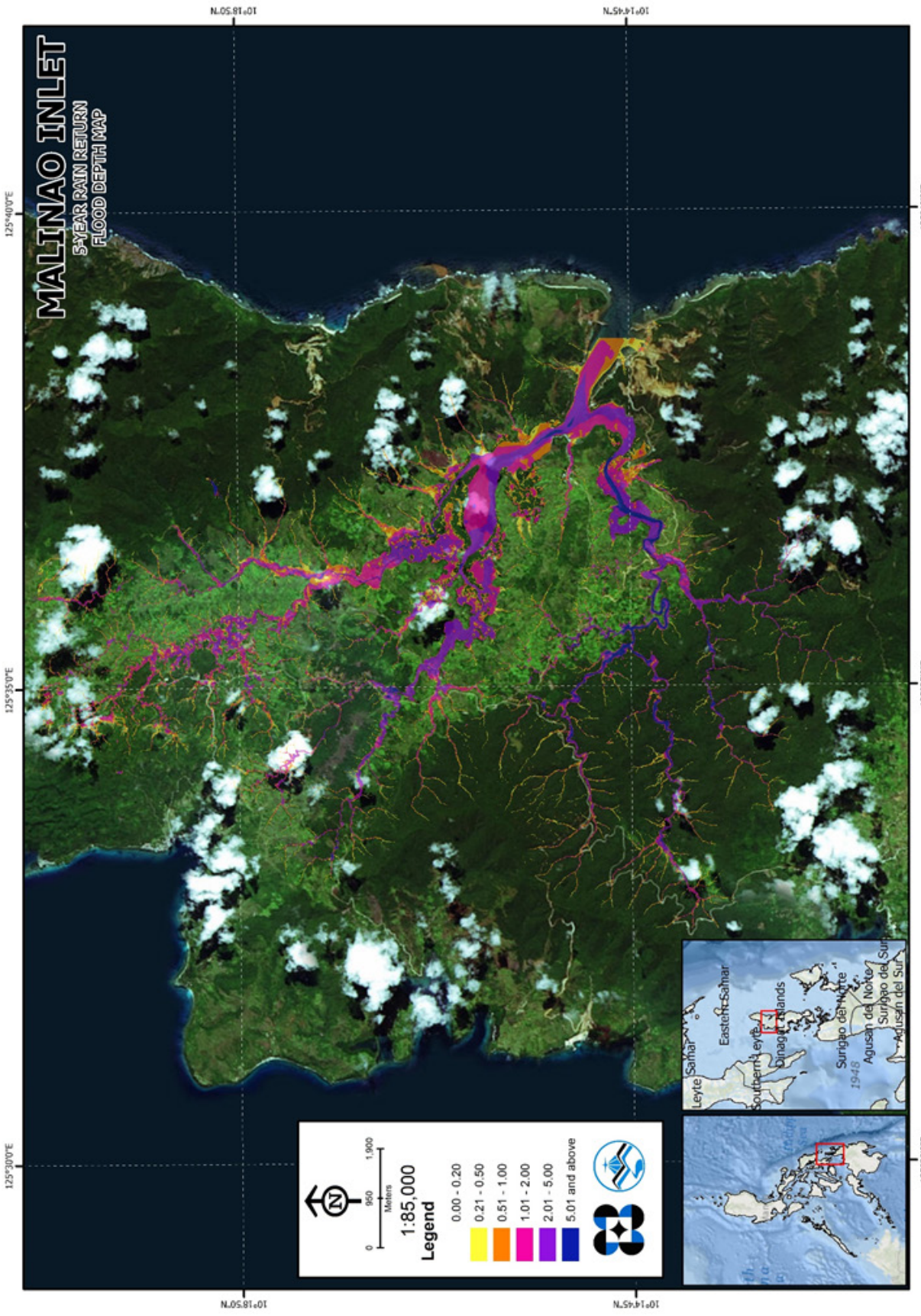

Figure 65. A 5-year Flood Depth Map for Malinao Inlet Floodplain overlaid on Google Earth imagery.

5.10 Inventory of Areas Exposed to Flooding

Listed below are the barangays affected by the Malinao Inlet River Basin, grouped accordingly by municipality. For the said basin, three (3) municipalities consisting of 15 barangays are expected to experience flooding when subjected to a 5-year rainfall return period.

For the 5-year return period, 0.00% of the municipality of Libjo with an area of 205.11 sq. km. will experience flood levels of less than 0.20 meters. 0.00% of the area will experience flood levels of 0.21 to 0.50 meters while 0.00%, 0.00%, 0.00%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the Table 36 are the affected areas in square kilometers by flood depth per barangay.

Table 36. Affected Areas in Municipality of Libjo, Dinagat Islands during 5-Year Rainfall Return Period.

Affected Area (in sq.km) by flood depth (in m.)	Affected Barangays in Libjo		
	Bayanihan	General Aguinaldo	San Antonio
0.03-0.20	8.38	21.09	1.1
0.21-0.50	0.17	0.54	0.025
0.51-1.00	0.11	0.38	0.023
1.01-2.00	0.11	0.41	0.021
2.01-5.00	0.12	0.6	0.004
> 5.00	0.0082	0.33	0

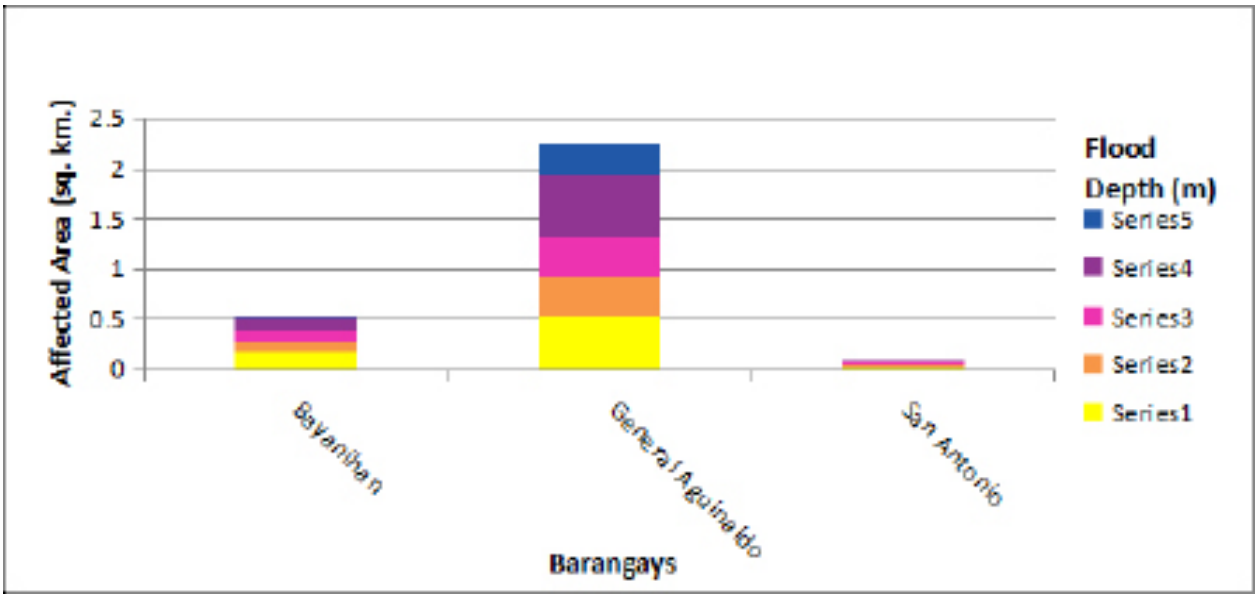

Figure 66. Affected Areas in Municipallity of Libjo, Dinagat Islands during 5-Year Rainfall Return Period.

For the 5-year return period, 0.00% of the municipality of Loreto with an area of 1298.02 sq. km. will experience flood levels of less than 0.20 meters. 0.00% of the area will experience flood levels of 0.21 to 0.50 meters while 0.00%, 0.00%, 0.00%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 37 are the affected areas in square kilometers by flood depth per barangay.

Table 37. Affected Areas in Municipality of Loreto, Dinagat Islands during 5-Year Rainfall Return Period.

Affected Area (in sq.km) by flood depth (in m.)	Affected Barangays in Loreto			
	Carmen	San Juan	Santa Cruz	Santiago
0.03-0.20	0.31	0.76	1.52	16.29
0.21-0.50	0.0079	0.071	0.065	0.69
0.51-1.00	0.0017	0.081	0.079	0.61
1.01-2.00	0.0011	0.07	0.12	0.53
2.01-5.00	0.000014	0.0048	0.034	0.2
> 5.00	0	0	0	0.014

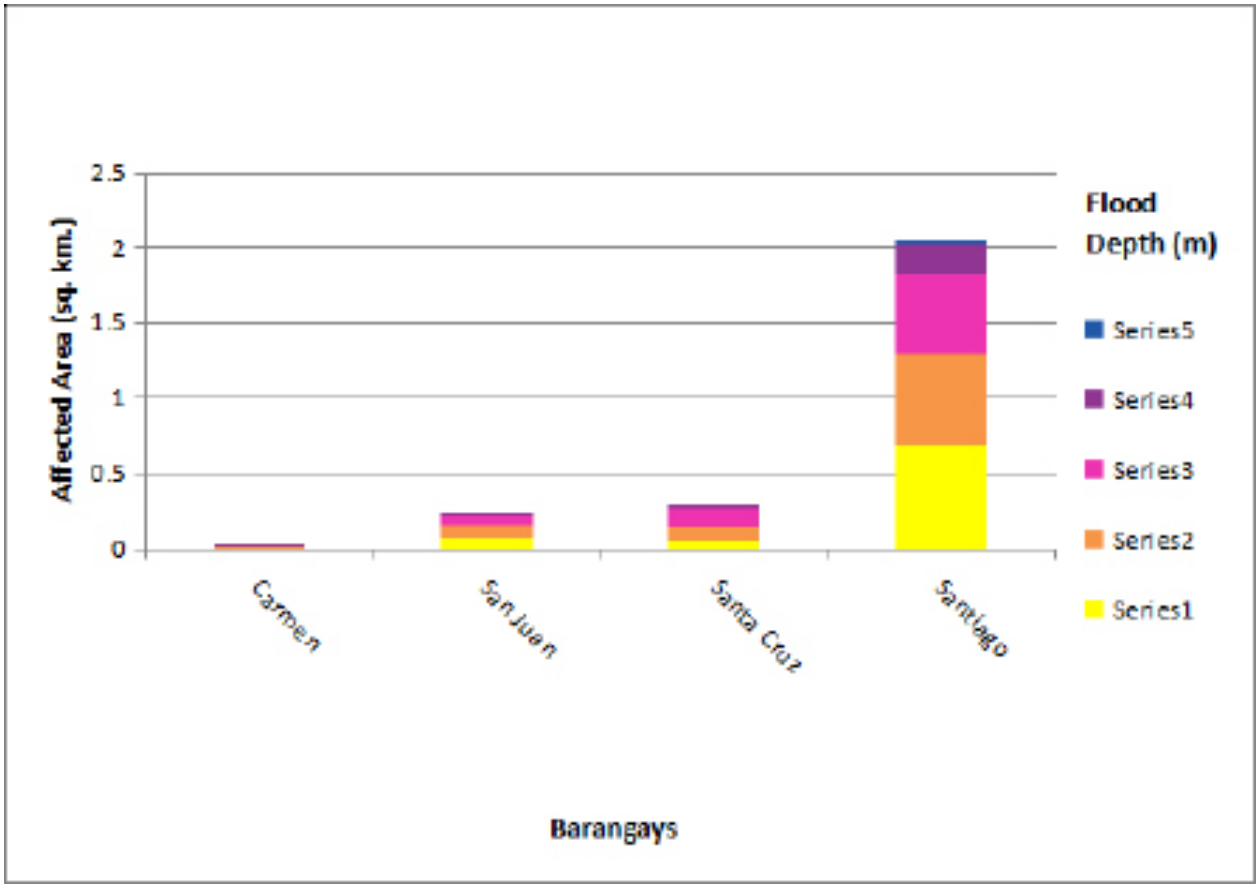

Figure 67. Affected Areas in Municipality of Loreto, Dinagat Islands during 5-Year Rainfall Return Period

For the 5-year return period, 0.00% of the municipality of Tubajon with an area of 85.88 sq. km. will experience flood levels of less than 0.20 meters. 0.00% of the area will experience flood levels of 0.21 to 0.50 meters while 0.00%, 0.00%, 0.00%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 38 are the affected areas in square kilometers by flood depth per barangay.

Table 38. Affected Areas in Municipality of Tubajon, Dinagat Islands during 5-Year Rainfall Return Period.

Affected Area (in sq.km) by flood depth (in m.)	Affected Barangays in Tubajon								
	Diaz	Imelda	Mabini	Malinao	Navarro	Roxas	San Roque	San Vicente	Santa Cruz
0.03-0.20	10.29	1	5.45	6.15	12.12	0.85	0.38	0.46	5.23
0.21-0.50	0.57	0.032	0.27	0.25	0.32	0.031	0.015	0.021	0.15
0.51-1.00	0.66	0.015	0.32	0.32	0.26	0.034	0.012	0.008	0.12
1.01-2.00	1.32	0.014	0.58	0.4	0.37	0.036	0.0036	0.0042	0.13
2.01-5.00	1.34	0.029	0.35	0.62	0.51	0.011	0	0.0002	0.087
> 5.00	0.047	0.013	0.00068	0.19	0.036	0	0	0	0.0073

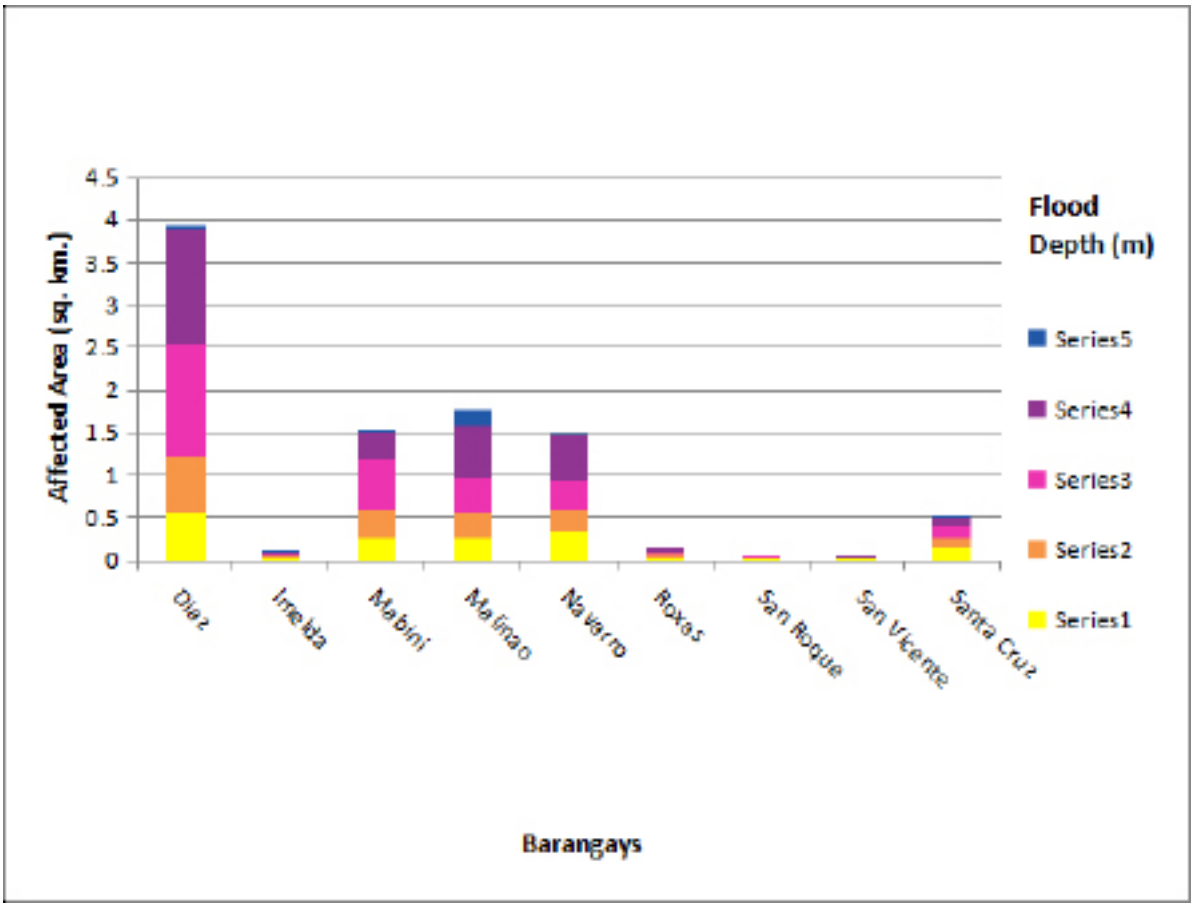

Figure 68. Affected Areas in Municipality of Tubajon, Dinagat Islands during 5-Year Rainfall Return Period.

For the 25-year return period, 14.65% of the municipality of Libjo with an area of 205.11 sq. km. will experience flood levels of less than 0.20 meters. 0.41% of the area will experience flood levels of 0.21 to 0.50 meters while 0.27%, 0.26%, 0.43%, and 0.26% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 39 are the affected areas in square kilometers by flood depth per barangay.

Table 39. Affected Areas in Municipality of Libjo, Dinagat Islands during 25-Year Rainfall Return Period.

Affected Area (in sq.km) by flood depth (in m.)	Affected Barangays in Libjo		
	Bayanihan	General Aguinaldo	San Antonio
0.03-0.20	8.29	20.67	1.08
0.21-0.50	0.19	0.62	0.028
0.51-1.00	0.12	0.41	0.022
1.01-2.00	0.11	0.4	0.026
2.01-5.00	0.15	0.73	0.008
> 5.00	0.023	0.52	0

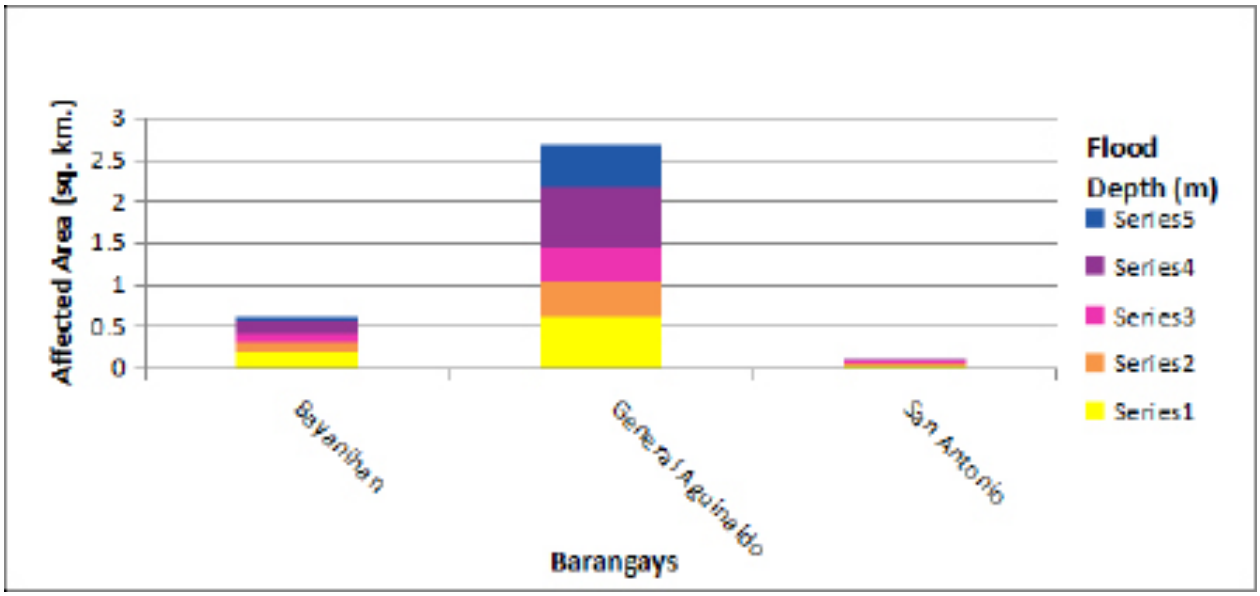

Figure 69. Affected Areas in Municipality of Libjo, Dinagat Islands during 25-Year Rainfall Return Period.

For the 25-year return period, 1.42% of the municipality of Loreto with an area of 1298.02 sq. km. will experience flood levels of less than 0.20 meters. 0.06% of the area will experience flood levels of 0.21 to 0.50 meters while 0.06%, 0.07%, 0.04%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 40 are the affected areas in square kilometers by flood depth per barangay.

Table 40. Affected Areas in Municipality of Loreto, Dinagat Islands during 25-Year Rainfall Return Period.

Affected Area (in sq.km) by flood depth (in m.)	Affected Barangays in Loreto			
	Carmen	San Juan	Santa Cruz	Santiago
0.03-0.20	0.3	0.72	1.47	15.9
0.21-0.50	0.011	0.065	0.067	0.7
0.51-1.00	0.0028	0.09	0.076	0.61
1.01-2.00	0.0016	0.094	0.12	0.66
2.01-5.00	0.00011	0.016	0.089	0.46
> 5.00	0	0	0.0001	0.021

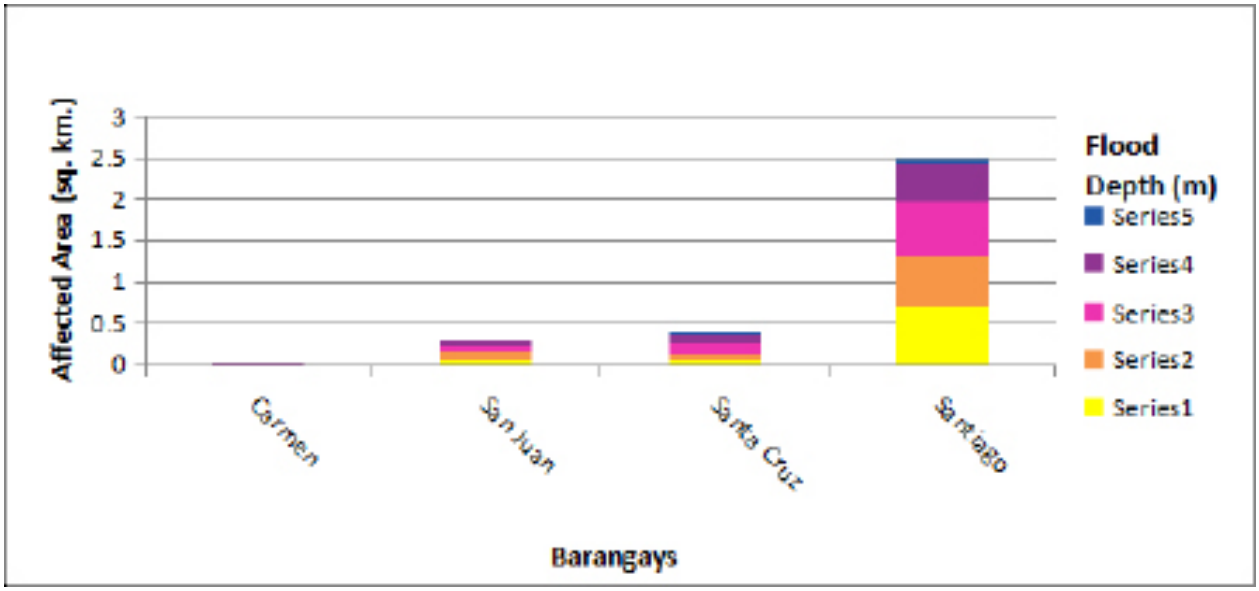

Figure 70. Affected Areas in Municipality of Loreto, Dinagat Islands during 25-Year Rainfall Return Period.

For the 25-year return period, 4035.00% of the municipality of Tubajon with an area of 85.88 sq. km. will experience flood levels of less than 0.20 meters. 162.90% of the area will experience flood levels of 0.21 to 0.50 meters while 157.00%, 263.39%, 445.44%, and 77.43% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 41 are the affected areas in square kilometers by flood depth per barangay.

Table 41. Affected Areas in Municipality of Tubajon, Dinagat Islands during 25-Year Rainfall Return Period.

Affected Area (in sq.km) by flood depth (in m.)	Affected Barangays in Tubajon								
	Diaz	Imelda	Mabini	Malinao	Navarro	Roxas	San Roque	San Vicente	Santa Cruz
0.03-0.20	9.63	0.97	5.19	5.92	11.86	0.83	0.37	0.45	5.13
0.21-0.50	0.46	0.038	0.27	0.25	0.37	0.034	0.018	0.019	0.17
0.51-1.00	0.57	0.018	0.3	0.24	0.26	0.034	0.014	0.014	0.12
1.01-2.00	1.18	0.012	0.5	0.4	0.34	0.039	0.0073	0.0056	0.15
2.01-5.00	2.2	0.035	0.71	0.69	0.65	0.029	0	0.0004	0.14
> 5.00	0.17	0.027	0.0053	0.43	0.13	0	0	0	0.012

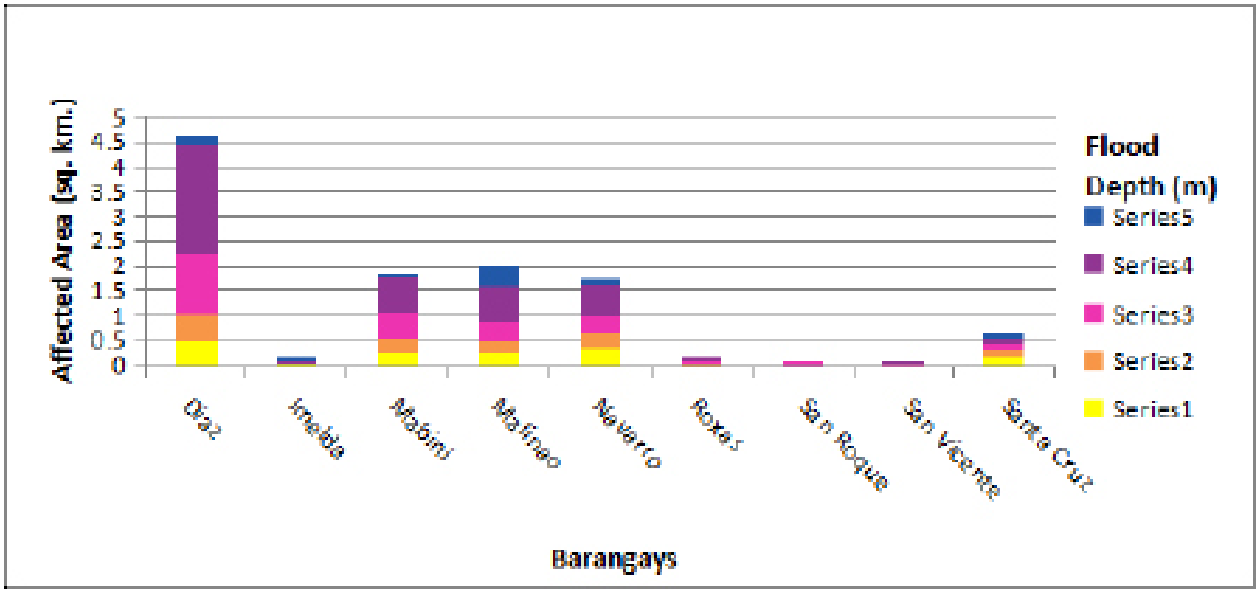

Figure 71. Affected Areas in Municipality of Tubajon, Dinagat Islands during 25-Year Rainfall Return Period.

For the 100-year return period, 14.47% of the municipality of Libjo with an area of 205.11 sq. km. will experience flood levels of less than 0.20 meters. 0.45% of the area will experience flood levels of 0.21 to 0.50 meters while 0.28%, 0.27%, 0.46%, and 0.36% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 42 are the affected areas in square kilometers by flood depth per barangay.

Table 42. Affected Areas in Municipality of Libjo, Dinagat Islands during 100-Year Rainfall Return Period.

Affected Area (in sq.km) by flood depth (in m.)	Affected Barangays in Libjo		
	Bayanihan	General Aguinaldo	San Antonio
0.03-0.20	8.22	20.37	1.08
0.21-0.50	0.22	0.68	0.029
0.51-1.00	0.13	0.43	0.023
1.01-2.00	0.11	0.42	0.027
2.01-5.00	0.16	0.77	0.012
> 5.00	0.048	0.69	0

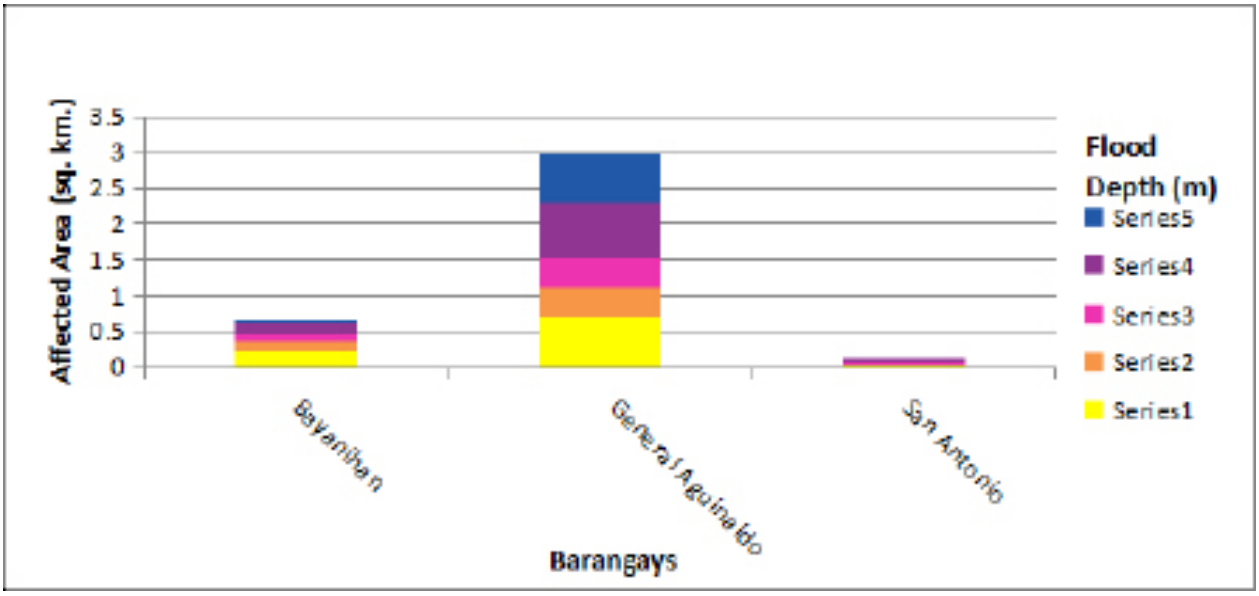

Figure 72. Affected Areas in Municipality of Libjo, Dinagat Islands during 100-Year Rainfall Return Period.

For the 100-year return period, 1.39% of the municipality of Loreto with an area of 1298.02 sq. km. will experience flood levels of less than 0.20 meters. 0.07% of the area will experience flood levels of 0.21 to 0.50 meters while 0.06%, 0.07%, 0.06%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 43 are the affected areas in square kilometers by flood depth per barangay.

Table 43. Affected Areas in Municipality of Loreto, Dinagat Islands during 100-Year Rainfall Return Period

Affected Area (in sq.km) by flood depth (in m.)	Affected Barangays in Loreto			
	Carmen	San Juan	Santa Cruz	Santiago
0.03-0.20	0.3	0.7	1.43	15.63
0.21-0.50	0.013	0.063	0.067	0.75
0.51-1.00	0.0041	0.086	0.075	0.6
1.01-2.00	0.0018	0.11	0.12	0.66
2.01-5.00	0.00021	0.032	0.12	0.67
> 5.00	0	0	0.0006	0.028

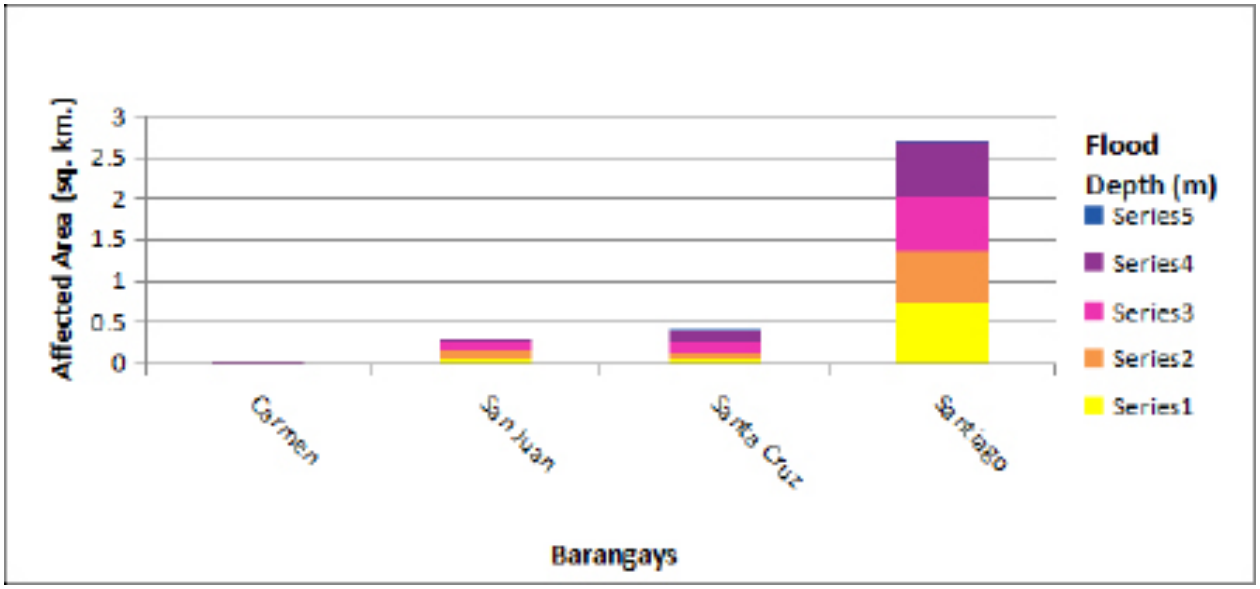

Figure 73. Affected Areas in Municipality of Loreto, Dinagat Islands during 100-Year Rainfall Return Period.

For the 100-year return period, 45.88% of the municipality of Tubajon with an area of 85.88 sq. km. will experience flood levels of less than 0.20 meters. 1.90% of the area will experience flood levels of 0.21 to 0.50 meters while 1.68%, 2.78%, 6.13%, and 1.49% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 44 are the affected areas in square kilometers by flood depth per barangay.

Table 44. Affected Areas in Municipality of Tubajon, Dinagat Islands during 100-Year Rainfall Return Period

Affected Area (in sq.km) by flood depth (in m.)	Affected Barangays in Tubajon								
	Diaz	Imelda	Mabini	Malinao	Navarro	Roxas	San Roque	San Vicente	Santa Cruz
0.03-0.20	9.28	0.95	5.03	5.76	11.68	0.82	0.37	0.44	5.07
0.21-0.50	0.41	0.043	0.26	0.25	0.41	0.037	0.019	0.023	0.18
0.51-1.00	0.42	0.019	0.3	0.24	0.27	0.033	0.015	0.017	0.13
1.01-2.00	1	0.012	0.48	0.36	0.33	0.042	0.01	0.006	0.15
2.01-5.00	2.78	0.032	0.87	0.72	0.65	0.038	0.0001	0.001	0.17
> 5.00	0.33	0.038	0.023	0.6	0.27	0	0	0	0.018

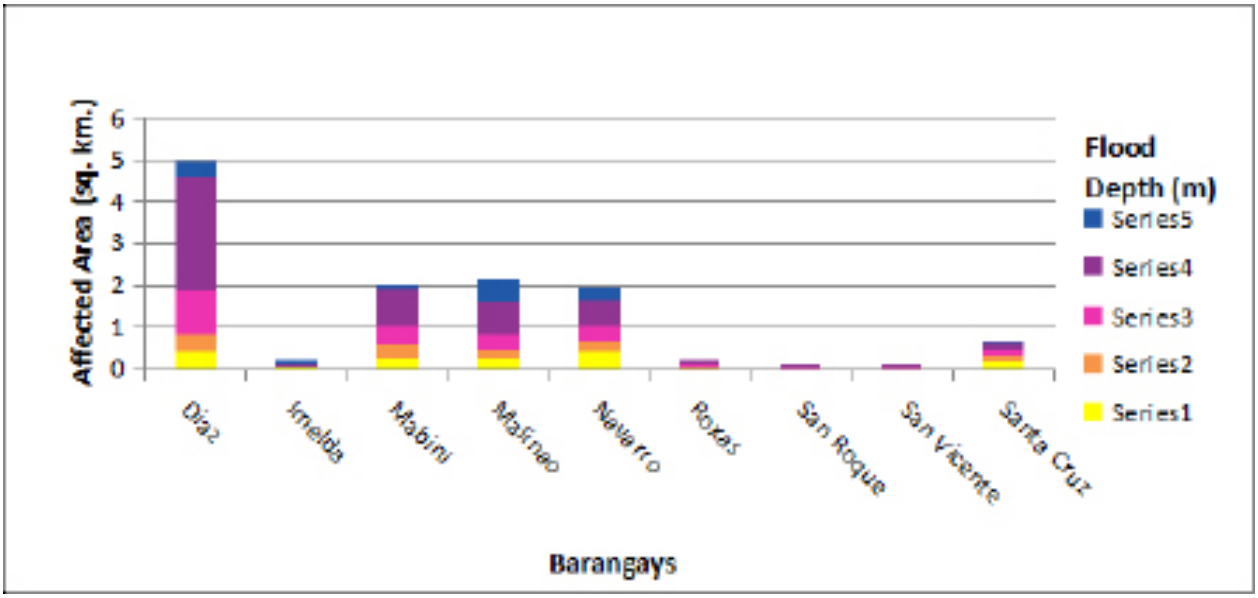

Figure 74. Affected Areas in Municipality of Tubajon, Dinagat Islands during 100-Year Rainfall Return Period.

Among the barangays in the municipality of Libjo, General Aguinaldois projected to have the highest percentage of area that will experience flood levels at 11%. Meanwhile, Bayanihan posted the second highest percentage of area that may be affected by flood depths at 4%.

Among the barangays in the municipality of Loreto, Santiago is projected to have the highest percentage of area that will experience flood levels at 1.41 %. Meanwhile, Santa Cruz posted the second highest percentage of area that may be affected by flood depths at 0.14%.

Among the barangays in the municipality of Tubajon, Diaz is projected to have the highest percentage of area that will experience flood levels at 17%. Meanwhile, Navarro posted the second highest percentage of area that may be affected by flood depths at 16%.

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

Table 45. 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	3.29	3.29	3.43
Medium	5.65	5.03	4.66
High	8.83	12.13	14.06
Total	17.77	20.45	22.15

Of the 4 identified educational institutions in Malinao Flood plain, one (1) school was found exposed to Medium-level flooding in the same scenario. One was under high flooding.

In the 25-year scenario, one (1) school was found exposed to Medium-level flooding in the same scenario. One was under high flooding.

For the 100-year scenario, two (2) schools were found exposed to High-level flooding in the same scenario. The educational institutions affected by flooding in the Malinao Inlet floodplain are found in Annex 12.

Meanwhile, there are no medical or health institutions affected by flooding in the Malinao Inlet floodplain.

5.11 Flood Validation

In order to check and validate the extent of flooding in different river systems, there is a need to perform validation survey work. Field personnel gathered secondary data regarding flood occurrence in the area within the major river system in the Philippines.

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

The validation personnel went to the specified points identified in a river basin and gathered data regarding the actual flood level in each location. Data gathering can be done through a local DRRM office to obtain maps or situation reports about the past flooding events or interview some residents with knowledge of or have had experienced flooding in a particular area. The flood validation data were obtained on September 29-30, 2016

After which, the actual data from the field were compared to the simulated data to assess the accuracy of the Flood Depth Maps produced and to improve on the results of the flood map. The points in the flood map versus its corresponding validation depths are shown in Figure 75.

The flood validation consisted of 235 points randomly selected all over the Malinao Inlet floodplain (Figure 76). Comparing it with the flood depth map of the nearest storm event, the map has an RMSE value of 0.40302m. Table 46 shows a contingency matrix of the comparison. The validation points are found in Annex 11.

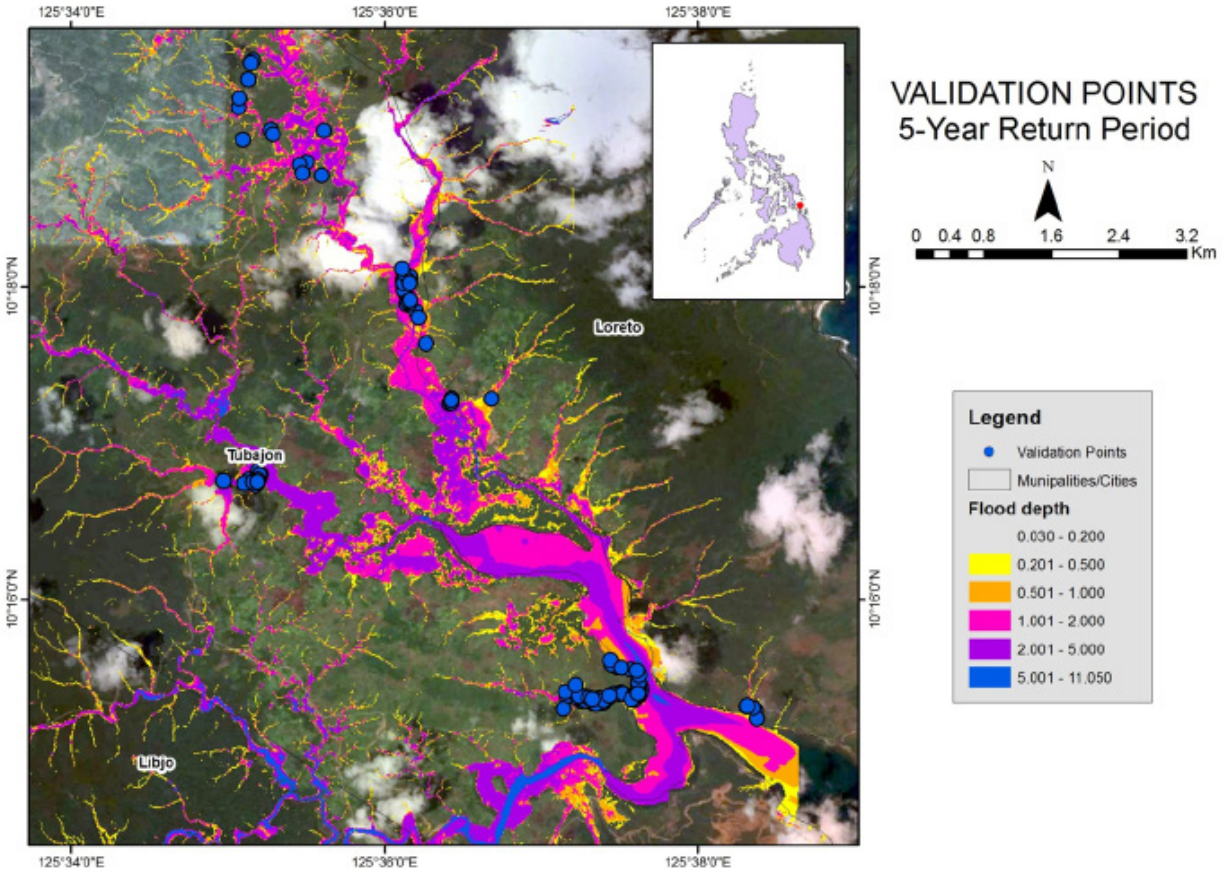

Figure 75. The Validation Points for a 5-year Flood Depth Map of the Malinao Inlet Floodplain.

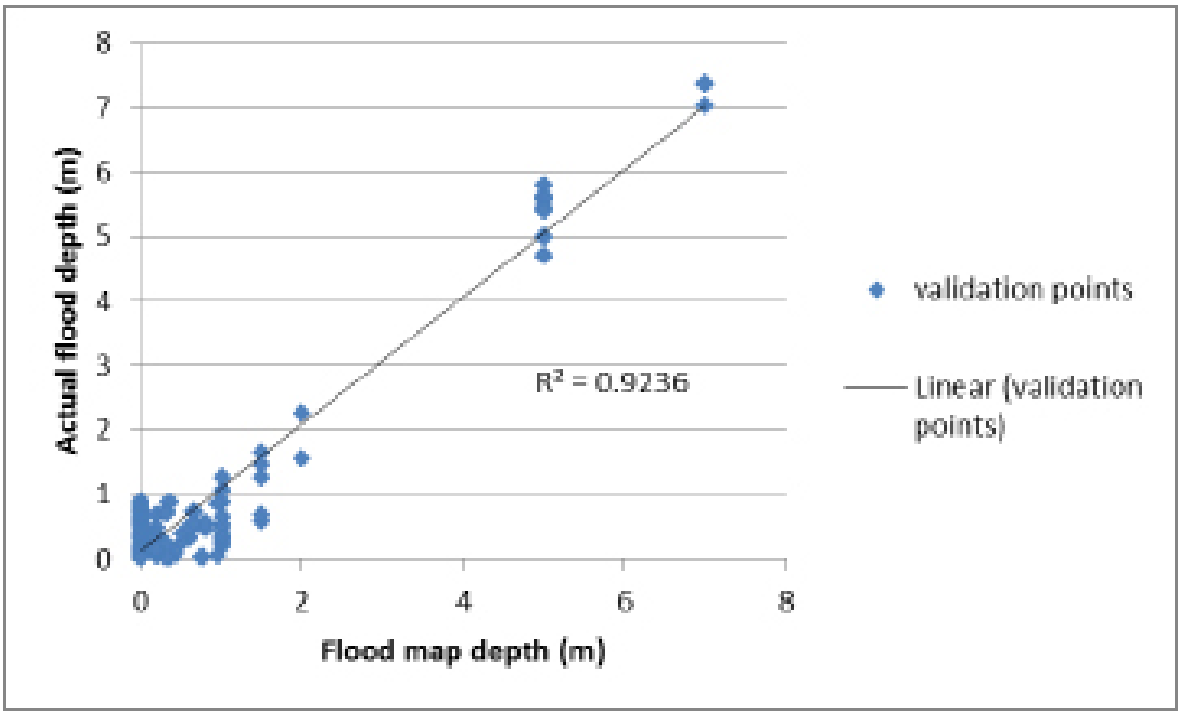

Figure 76. Flood map depth versus actual flood depth

Table 46. Actual Flood Depth versuss Simulated Flood Depth at different levels in the Malinao Inlet River Basin.

Actual Flood Depth (m)	Modeled Flood Depth (m)						
	0-0.20	0.21-0.50	0.51-1.00	1.01-2.00	2.01-5.00	> 5.00	Total
0-0.20	59	16	23	0	0	0	98
0.21-0.50	4	3	3	0	0	0	10
0.51-1.00	3	11	8	3	0	0	25
1.01-2.00	0	0	2	4	1	0	7
2.01-5.00	0	0	0	0	2	6	8
> 5.00	0	0	0	0	2	2	4
Total	66	30	36	7	5	8	152

On the whole, the overall accuracy generated by the flood model is estimated at 51.32%, with 78 points correctly matching the actual flood depths. In addition, there were 48 points estimated one level above and below the correct flood depths while there were 26 points estimated two levels above and below. A total of 52 points were overestimated while a total of 22 points were underestimated in the modelled flood depths of Himogaan-Tano. Table 41 depicts the summary of the Accuracy Assessment in the Himogaan-Hubo-Otieza River Basin Flood Depth Map.

Table 47. Summary of the Accuracy Assessment in the Malinao Inlet River Basin Survey.

	No. of Points	%
Correct	78	51.32
Overestimated	52	34.21
Underestimated	22	14.47
Total	152	100.00

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ANNEXES

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

1. AQUARIUS SENSOR

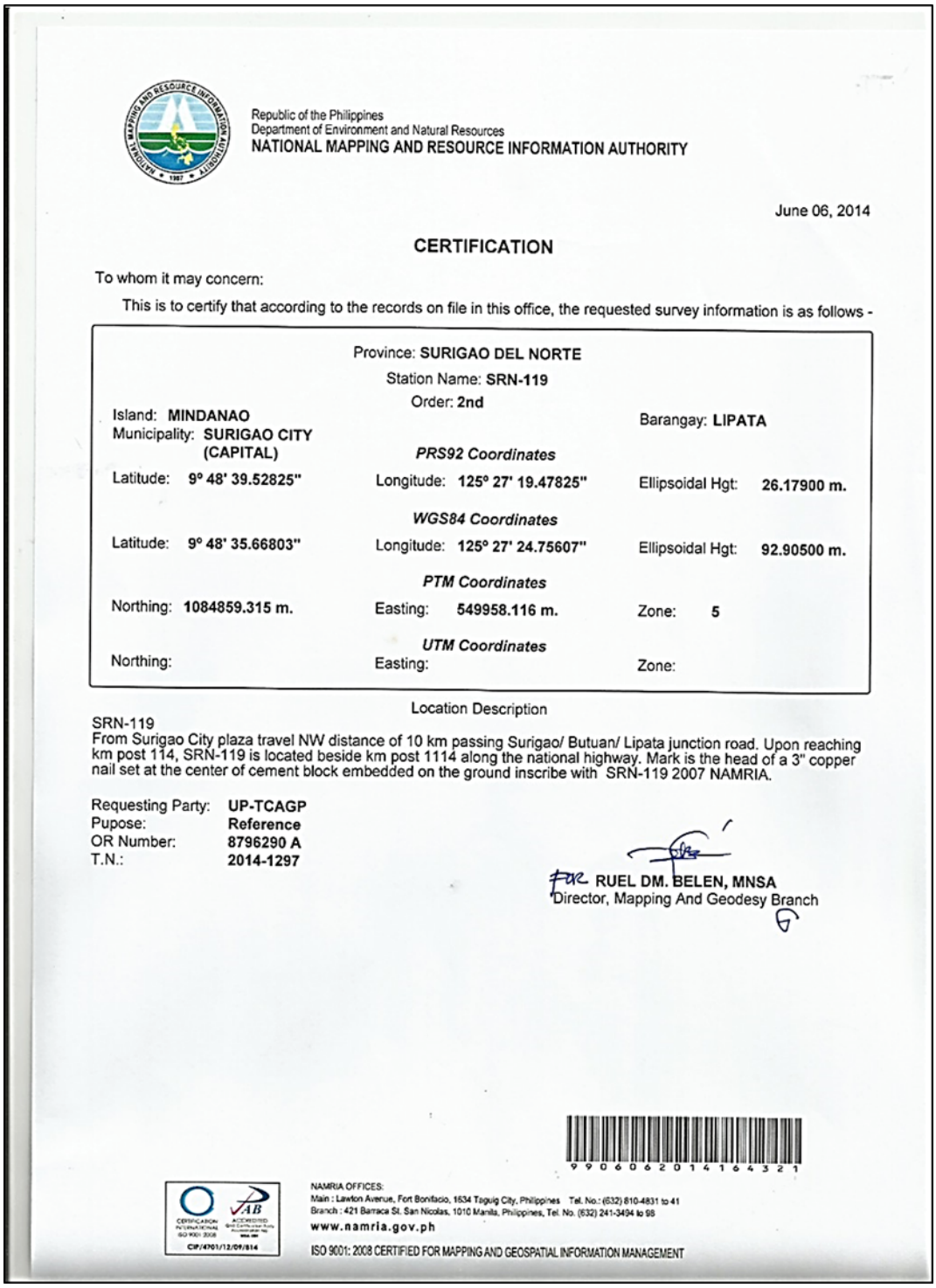
Figure A-1.1. Aquarius Sensor

Table A-1.1. Parameters and Specifications of Aquarius Sensor

Parameter	Specification
Operational altitude	300-600 m AGL
Laser pulse repetition rate	33, 50. 70 kHz
Scan rate	0-70 Hz
Scan half-angle	0 to ± 25 ˚
Laser footprint on water surface	30-60 cm
Depth range	0 to > 10 m (for k < 0.1/m)
Topographic mode	
Operational altitiude	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

Annex 2. NAMRIA Certificate of Reference Points Used in the LiDAR Survey

1. SRN-119



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

June 06, 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 NORTE**
Station Name: **SRN-119**
Order: **2nd**

Island: **MINDANAO**
Municipality: **SURIGAO CITY (CAPITAL)**
Barangay: **LIPATA**

PRS92 Coordinates

Latitude: **9° 48' 39.52825"** Longitude: **125° 27' 19.47825"** Ellipsoidal Hgt: **26.17900 m.**

WGS84 Coordinates

Latitude: **9° 48' 35.66803"** Longitude: **125° 27' 24.75607"** Ellipsoidal Hgt: **92.90500 m.**

PTM Coordinates

Northing: **1084859.315 m.** Easting: **549958.116 m.** Zone: **5**

UTM Coordinates

Northing: Easting: Zone:

Location Description

SRN-119
From Surigao City plaza travel NW distance of 10 km passing Surigao/ Butuan/ Lipata junction road. Upon reaching km post 114, SRN-119 is located beside km post 1114 along the national highway. Mark is the head of a 3" copper nail set at the center of cement block embedded on the ground inscribe with SRN-119 2007 NAMRIA.

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **8796290 A**
T.N.: **2014-1297**

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

9906062014164321

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

CIP/4701/12/09/814

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.1. SRN-119

2. SRN-3

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**
Municipality: **SAN AGUSTIN**
Barangay: **POBLACION**
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**

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

9907112014145921

CIP/4701/12/09/814

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www.namria.gov.ph
ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.2. SRN-3

3. SRN-91

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

May 17, 2016

CERTIFICATION

To whom it may concern:

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

Province: **SURIGAO DEL NORTE**
Station Name: **SRN-91**
Order: **2nd**
Island: **MINDANAO** Barangay: **LLAMERA**
Municipality: **LIBJO (ALBOR)** MSL Elevation:

PRS92 Coordinates

Latitude: **10° 8' 49.06477"** Longitude: **125° 34' 33.14033"** Ellipsoidal Hgt: **31.80100 m.**

WGS84 Coordinates

Latitude: **10° 8' 45.12793"** Longitude: **125° 34' 38.38708"** Ellipsoidal Hgt: **98.05800 m.**

PTM / PRS92 Coordinates

Northing: **1122039.462 m.** Easting: **563108.305 m.** Zone: **5**

UTM / PRS92 Coordinates

Northing: **1,122,709.27** Easting: **782,269.46** Zone: **51**

Location Description

SRN-91
From Surigao City pier no. 2 travel by pump boat to the pier of Basilisa for 2 hours, then travel by a motorcycle for one hour, 20 km to Brgy. Llamera municipality of Libjo, Island of Dinagat. Mark is the head of a 3" copper nail set at the center of cement block embedded on the ground with inscriptions SRN-91 2007 NAMRIA.

Requesting Party: **UP-DREAM**
Purpose: **Reference**
OR Number: **8090370 I**
T.N.: **2016-1112**

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

9905172016095909

CIP/4701/12/09/814

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www.namria.gov.ph
ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.3. SRN-91

4. SRN-99

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

May 17, 2016

CERTIFICATION

To whom it may concern:

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

Province: **SURIGAO DEL NORTE**
Station Name: **SRN-99**
Order: **2nd**

Island: **MINDANAO**
Municipality: **SURIGAO CITY (CAPITAL)**
Barangay: **BONIFACIO**
MSL Elevation:

PRS92 Coordinates

Latitude: **9° 44' 22.95065"** Longitude: **125° 29' 38.38093"** Ellipsoidal Hgt: **11.84800 m.**

WGS84 Coordinates

Latitude: **9° 44' 19.11233"** Longitude: **125° 29' 43.66472"** Ellipsoidal Hgt: **78.82900 m.**

PTM / PRS92 Coordinates

Northing: **1076982.803 m.** Easting: **554202.388 m.** Zone: **5**

UTM / PRS92 Coordinates

Northing: **1,077,574.28** Easting: **773,630.64** Zone: **51**

Location Description

SRN-99
The station is located inside Bonifacio Elementary School compound on the concrete ground beside a 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 SRN-99 2007 NAMRIA.

Requesting Party: **UP-DREAM**
Purpose: **Reference**
OR Number: **8090370 I**
T.N.: **2016-1111**

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

9905172016095849

CIP/4701/12/09/814

NAMRIA OFFICES:
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Figure A-2.4. SRN-99

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

1. BMSN-1077

Table A-3.1. BMSN-1077

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SRN119 --- BMSN1077 (B1)	SRN119	BMSN1077	Fixed	0.002	0.002	163°57'43"	1042.382	-21.677

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

Vector Components (Mark to Mark)

From:	SRN119				
Grid		Local		Global	
Easting	769337.455 m	Latitude	N9°48'39.52825"	Latitude	N9°48'35.66803"
Northing	1085429.633 m	Longitude	E125°27'19.47825"	Longitude	E125°27'24.75607"
Elevation	26.269 m	Height	26.179 m	Height	92.905 m

To:	BMSN1077				
Grid		Local		Global	
Easting	769632.898 m	Latitude	N9°48'06.91949"	Latitude	N9°48'03.06184"
Northing	1084429.454 m	Longitude	E125°27'28.92849"	Longitude	E125°27'34.20710"
Elevation	4.584 m	Height	4.502 m	Height	71.255 m

Vector					
ΔEasting	295.443 m	NS Fwd Azimuth	163°57'43"	ΔX	-321.190 m
ΔNorthing	-1000.179 m	Ellipsoid Dist.	1042.382 m	ΔY	-45.485 m
ΔElevation	-21.685 m	ΔHeight	-21.677 m	ΔZ	-990.859 m

Standard Errors

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

2. SRN-3495

Table A-3.2. SRN-3495

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SRN-3495 --- SRN-3 (B1)	SRN-3	SRN-3495	Fixed	0.003	0.010	354°21'59"	14889.511	131.033
SRN-3495 --- SRN-3 (B2)	SRN-3	SRN-3495	Fixed	0.003	0.010	354°21'59"	14889.518	131.061

Acceptance Summary

Processed	Passed	Flag	Fail
2	2	0	0

Vector Components (Mark to Mark)

From:	SRN-3				
Grid		Local		Global	
Easting	783847.824 m	Latitude	N9°57'43.04817"	Latitude	N9°57'39.16040"
Northing	1102247.180 m	Longitude	E125°35'19.65373"	Longitude	E125°35'24.91678"
Elevation	20.632 m	Height	21.451 m	Height	88.163 m

To:	SRN-3495				
Grid		Local		Global	
Easting	782268.608 m	Latitude	N10°05'45.35035"	Latitude	N10°05'41.42677"
Northing	1117061.565 m	Longitude	E125°34'31.64667"	Longitude	E125°34'36.89786"
Elevation	151.237 m	Height	152.484 m	Height	218.856 m

Vector					
ΔEasting	-1579.216 m	NS Fwd Azimuth	354°21'59"	ΔX	2615.761 m
ΔNorthing	14814.385 m	Ellipsoid Dist.	14889.511 m	ΔY	-1142.776 m
ΔElevation	130.605 m	ΔHeight	131.033 m	ΔZ	14614.105 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.003 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.005 m
σ ΔElevation	0.005 m	σ ΔHeight	0.005 m	σ ΔZ	0.001 m

3. SRN-3496

Table A-3.3. SRN-3496

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SRN3 --- SRN3496 (B1)	SRN3	SRN3496	Fixed	0.003	0.009	354°51'54"	15013.182	126.965

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

Vector Components (Mark to Mark)

From:	SRN3				
Grid		Local		Global	
Easting	783847.824 m	Latitude	N9°57'43.04817"	Latitude	N9°57'39.16040"
Northing	1102247.180 m	Longitude	E125°35'19.65373"	Longitude	E125°35'24.91678"
Elevation	20.632 m	Height	21.451 m	Height	88.163 m

To:	SRN3496				
Grid		Local		Global	
Easting	782385.516 m	Latitude	N10°05'49.75545"	Latitude	N10°05'45.83165"
Northing	1117197.907 m	Longitude	E125°34'35.51936"	Longitude	E125°34'40.77044"
Elevation	147.171 m	Height	148.416 m	Height	214.789 m

Vector					
ΔEasting	-1462.308 m	NS Fwd Azimuth	354°51'54"	ΔX	2535.994 m
ΔNorthing	14950.728 m	Ellipsoid Dist.	15013.182 m	ΔY	-1233.929 m
ΔElevation	126.539 m	ΔHeight	126.965 m	ΔZ	14746.639 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.003 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.004 m
σ ΔElevation	0.004 m	σ ΔHeight	0.004 m	σ ΔZ	0.001 m

4. SN-46

Table A-3.4. SN-46

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SRN-91 --- SRN-91A (B3)	SRN-91	SRN-91A	Fixed	0.001	0.002	98°42'29"	2.273	0.154
SRN-91 --- SRN-91A (B2)	SRN-91	SRN-91A	Fixed	0.001	0.003	98°42'35"	2.275	0.150
BMSN-106 --- SRN-106 (B5)	SRN-106	BMSN-106	Fixed	0.002	0.002	321°38'41"	659.752	1.558
SN-46 --- SRN-99 (B4)	SN-46	SRN-99	Fixed	0.026	0.137	149°46'09"	2796.818	5.434
SRN-116 --- BMSN-83 (B7)	SRN-116	BMSN-83	Fixed	0.003	0.016	166°39'47"	4243.865	10.203
BMSN-83 --- UPMAG-01 (B1)	BMSN-83	UPMAG-01	Fixed	0.001	0.002	250°39'29"	8.201	-0.428

Acceptance Summary

Processed	Passed	Flag	Fail
6	5	1	0

Vector Components (Mark to Mark)

From:	SN-46				
Grid		Local		Global	
Easting	772206.879 m	Latitude	N9°45'41.79368"	Latitude	N9°45'37.94854"
Northing	1079987.356 m	Longitude	E125°28'52.27552"	Longitude	E125°28'57.55750"
Elevation	5.970 m	Height	6.010 m	Height	72.910 m

To:	SRN-99				
Grid		Local		Global	
Easting	773633.477 m	Latitude	N9°44'23.13724"	Latitude	N9°44'19.29891"
Northing	1077580.038 m	Longitude	E125°29'38.47543"	Longitude	E125°29'43.75922"
Elevation	11.297 m	Height	11.444 m	Height	78.425 m

Vector					
ΔEasting	1426.598 m	NS Fwd Azimuth	149°46'09"	ΔX	-1387.291 m
ΔNorthing	-2407.318 m	Ellipsoid Dist.	2796.818 m	ΔY	-479.896 m
ΔElevation	5.328 m	ΔHeight	5.434 m	ΔZ	-2380.620 m

Standard Errors

Vector errors:					
σ ΔEasting	0.011 m	σ NS fwd Azimuth	0°00'01"	σ ΔX	0.034 m
σ ΔNorthing	0.006 m	σ Ellipsoid Dist.	0.007 m	σ ΔY	0.061 m
σ ΔElevation	0.070 m	σ ΔHeight	0.070 m	σ ΔZ	0.013 m

Annex 4. The LiDAR Survey Team Composition

Table A-4.1. The LiDAR Survey Team Composition

Data Acquisition Component Sub - team	Designation	Name	Agency / Affiliation
PHIL-LIDAR 1	Program Leader	ENRICO C. PARINGIT D. ENG	UP-TCAGP
Data Acquisition Component Leader	Data Component Project Leader –I	ENGR. CZAR JAKIRI S. SARMIENTO	UP TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP TCAGP
	Supervising Science Research Specialist (Supervising SRS)	LOVELY GRACIA ACUNA	UP TCAGP
		ENGR. LOVELYN ASUNCION	UP TCAGP
FIELD TEAM			
LiDAR Operation	Senior Science Research Specialist (SSRS)	JASMINE ALVIAR	UP TCAGP
	SSRS	PAULINE JOANNE ARCEO	UP TCAGP
	Research Associate (RA)	MARY CATHERINE ELIZABETH BALIGUAS	UP TCAGP
	RA	DAN CHRISTOFFER ALDOVINO	UP TCAGP
		ENGR. RENAN PUNTO	UP TCAGP
		ENGR. MILLIE SHANE REYES	UP TCAGP
		MARY CATHERINE ELIZABETH BALIGUAS	UP TCAGP
Ground Survey, Data download and transfer		KRISTINE JOY ANDAYA	UP TCAGP
		ENGR. GEF SORIANO	UP TCAGP
LiDAR Operation	Airborne Security	SSG. ERIC CACANINDIN	PHILIPPINE AIR FORCE (PAF)
		SSG. CHARISNA NAVARRO	PAF
	Pilot	CAPT. SHERWIN ALFONSO III	ASIAN AEROSPACE CORPORATION (AAC)
		CAPT. MARK GARCHTORENO	AAC
		CAPT. MARK LAWRENCE TANGONAN	AAC
		CAPT. RANDY LAGCO	AAC

Annex 5. Data Transfer Sheet for Malinao Inlet Floodplain

DATA TRANSFER SHEET
10/30/2014(Surigao-Dinagat)

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	
14-Sep	1946A	3BLK59BS257A	Aquarius	na	844	0.98	170	na	na	8.45	na	9.26	1KB	1KB	5/6	na	Z:\DAC\RAW DATA
15-Sep	1950A	3BLK59D258A	Aquarius	na	286	577	209	na	na	11.2	na	9.14	1KB	1KB	7	na	Z:\DAC\RAW DATA
19-Sep	1966A	3BLK59C262A	Aquarius	na	1167	2.14	214	na	na	12	na	10.3	1KB	1KB	10	na	Z:\DAC\RAW DATA
19-Sep	1968A	3BLK59D262B	Aquarius	na	231	1.99	137	na	na	6.56	na	10.3	1KB	1KB	10/7	na	Z:\DAC\RAW DATA
20-Sep	1970A	3BLK59S263A	Aquarius	na	341	2.98	153	na	na	6.25	na	9.05	1KB	1KB	11	na	Z:\DAC\RAW DATA
21-Sep	1974A	3BLK59S264A	Aquarius	na	204	867	182	na	na	8.2	na	13.4	1KB	1KB	8	na	Z:\DAC\RAW DATA
23-Sep	1982A	3BLK59DS266A	Aquarius	na	149	324	142	na	na	6.44	na	8.44	1KB	1KB	10	na	Z:\DAC\RAW DATA
24-Sep	1986A	3BLK59E267A	Aquarius	na	332	643	220	na	na	13.5	na	22.7	1KB	1KB	14.8	na	Z:\DAC\RAW DATA
24-Sep	1988A	3BLK59ES267B	Aquarius	na	630	0.98	186	na	na	11.6	na	22.7	1KB	1KB	7	na	Z:\DAC\RAW DATA
27-Sep	1998A	3BLK59F270A	Aquarius	na	537/119	1.3	278	na	na	15.7	na	12.4	1KB	1KB	12/18	na	Z:\DAC\RAW DATA
28-Sep	2002A	3BLK59FDS271A	Aquarius	na	226	619	207	na	na	11.7	na	9.74	1KB	1KB	10/18	na	Z:\DAC\RAW DATA
11-Oct	2054A	3BLK59S284A	Aquarius	na	na	466	212	na	na	6.7	na	8.54	1KB	1KB	10/20/21	na	Z:\DAC\RAW DATA
12-Oct	2060A	3BLK59FS285B	Aquarius	na	40	1.33	120	na	na	2.36	na	13.7	1KB	1KB	21/24	na	Z:\DAC\RAW DATA
18-Oct	2082A	3BLK59S291A	Aquarius	na	431	724	152	na	na	4.73	na	6.1	1KB	1KB	na	na	Z:\DAC\RAW DATA
20-Oct	2090A	3BLK59DS293A	Aquarius	na	89	240	117	na	na	5.04	na	5.43	1KB	1KB	11	na	Z:\DAC\RAW DATA
21-Oct	2094A	3BLK63R294A	Aquarius	na	193	691	205	na	na	8.75	na	10.4	1KB	1KB	5/6	na	Z:\DAC\RAW DATA
21-Oct	2096A	3BLK63R294B	Aquarius	na	405	875	190	na	na	8.84	na	9.64	1KB	1KB	5/6	na	Z:\DAC\RAW DATA
22-Oct	2098A	3BLK59S295A	Aquarius	na	na	329	106	na	na	2.48	na	8.9	1KB	1KB	15/23	na	Z:\DAC\RAW DATA

Received from

Name C. JOAQUIN
Position PA
Signature

Received by

Name JOIDA F. PRIETO
Position SUPSRS
Signature 10/31/2014

14-73

Figure A-5.1. Data Transfer Sheet for Malinao Inlet Floodplain - A

DATA TRANSFER SHEET
09/30/2014(Siargao 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-Sep	1928A	3BLK60A252B	AQUARIUS	NA	779	1.15	164	5.68	64	8.91	NA	13.5	1KB	1KB	5	NA	Z:\DAC\RAW DATA
10-Sep	1930A	3BLK60AS253A	AQUARIUS	NA	469	879	249	5.50/941mb	44/18/16/22	14.6	NA	14.4	1KB	1KB	9	NA	Z:\DAC\RAW DATA
10-Sep	1932A	3BLK60B253B	AQUARIUS	NA	792	1.44	179	1.27	117	6.57	NA	14.4	1KB	1KB	14/9	NA	Z:\DAC\RAW DATA
11-Sep	1934A	3BLK59A254A	AQUARIUS	NA	482	879	283	91.2	21	16.9	NA	16.8	1KB	1KB	5	NA	Z:\DAC\RAW DATA
11-Sep	1936A	3BLK59B254B	AQUARIUS	NA	377	726	132	NA	131	6.89	NA	16.8	1KB	1KB	5	NA	Z:\DAC\RAW DATA

Received from

Name C. JOAQUIN
Position PA
Signature

Received by

Name JOIDA PRIETO
Position SRS I
Signature 10/1/14

14-71

Figure A-5.2. Data Transfer Sheet for Malinao Inlet Floodplain - B

DATA TRANSFER SHEET
20/06/2016 SURIGAO DEL NORTE AND DINAGAT

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
5/8/2016	8481AC	3BLK59AB129A	AQUARIUS	NA	268	683	253	42.9	31.8/6.19	11.7	163	76.5	1KB	1KB	17/187	NA	Z:\DAC\RAWDATA
5/10/2016	8485AC	3BLK59BC131A	AQUARIUS	NA	250	659	231	39.8	92.4/181/0	10.6	183	74.9	1KB	1KB	15.3/170	42.9	Z:\DAC\RAWDATA
5/11/2016	8487AC	3BLK60AB132A	AQUARIUS	NA	311	1.01	270	77.2	199/120	13.5	147	125	1KB	1KB	16.3/219	NA	Z:\DAC\RAWDATA
5/11/2016	8488AC	3BLK60D132B	AQUARIUS	NA	108	1.01	144	30.1	199/120	5.13	76.8	125	1KB	1KB	13/75.2	NA	Z:\DAC\RAWDATA
5/12/2016	8489AC	3BLK60EF133A	AQUARIUS	NA	210	585	256	75.5	164/172	9.49	152	91.3	1KB	1KB	13/75.2	NA	Z:\DAC\RAWDATA
5/12/2016	8490AC	3BLK60CEsG133B	AQUARIUS	NA	318	948	146	23.2	164/172	5.19	NA	91.3	1KB	1KB	13	NA	Z:\DAC\RAWDATA
5/13/2016	8491AC	3CALIB134A & 3BLK59C134A	AQUARIUS	NA	156	734	190	37.6	384/554	7.13	113	91.6	1KB	1KB	14.1/107	NA	Z:\DAC\RAWDATA
5/13/2016	8492AC	3BLK60CS134B	AQUARIUS	NA	306	268	146	NA	NA	4.79	74.7	91.6	1KB	1KB	13/143	NA	Z:\DAC\RAWDATA
5/14/2016	8493AC	3DNGB135A	AQUARIUS	NA	43.6	156	74.8	12.9	64.9	2.24	13.5	28.4	1KB	1KB	4.38/29.4	NA	Z:\DAC\RAWDATA
5/16/2016	8497AC	3DNGABSC137A	AQUARIUS	NA	216	604	240	51.4	183	9.66	NA	75.7	1KB	1KB	6.87/144	NA	Z:\DAC\RAWDATA
5/17/2016	8499AC	3DNGE138A	AQUARIUS	NA	210	611	236	NA	NA	9.44	NA	3	1KB	1KB	4.59/145	14.5	Z:\DAC\RAWDATA
5/18/2016	8501AC	3BLK60AS139A	AQUARIUS	NA	59.6	173	113	11	76.2	3.09	NA	47.6	1KB	1KB	40.6	NA	Z:\DAC\RAWDATA

Name DARRYL M. AUSTRIA
Position R.A.
Signature

Name AC Bongat
Position SSRS
Signature 6/23/16

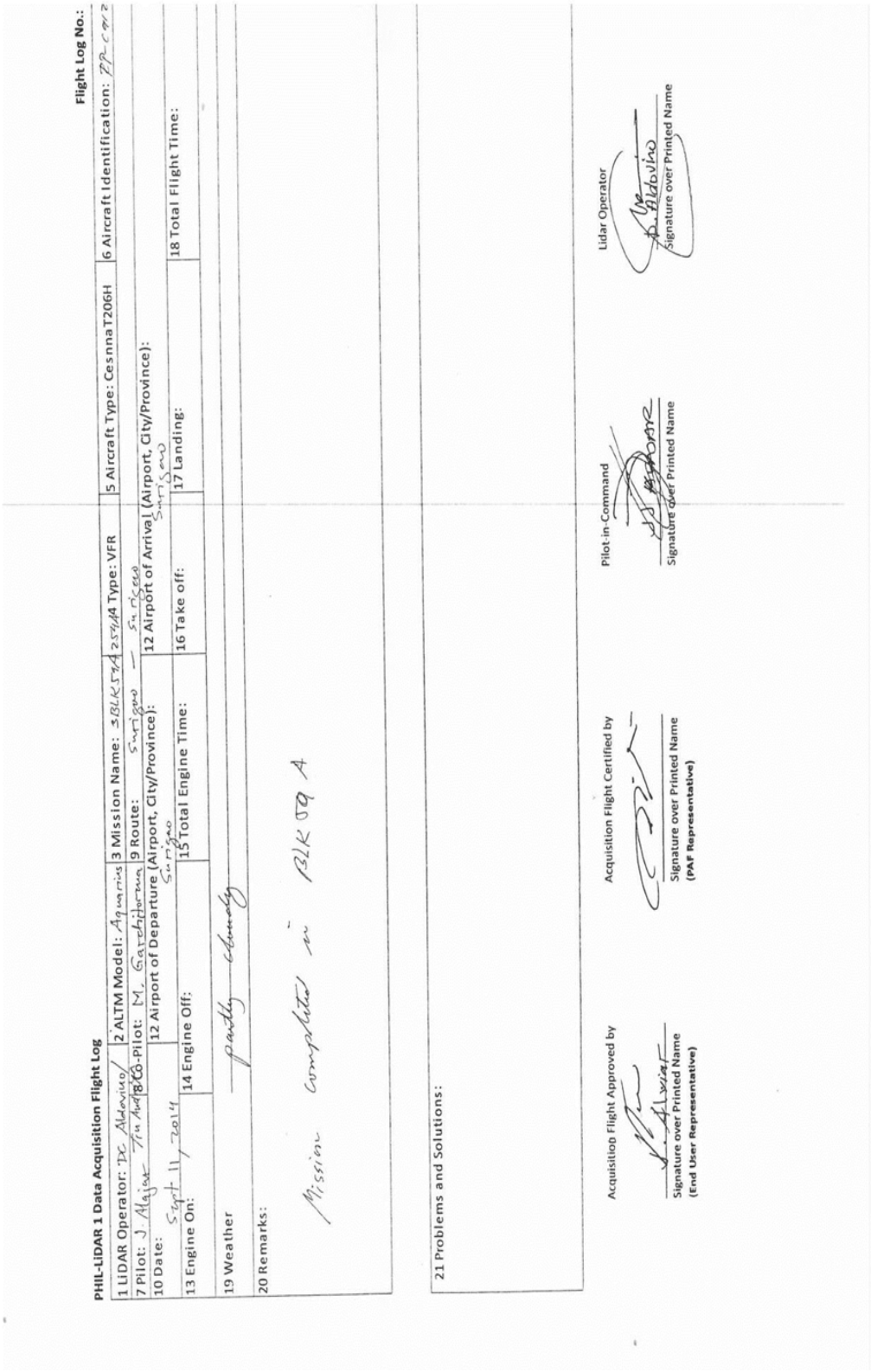
DH
- Sheila

16-38

Figure A-5.3. Data Transfer Sheet for Malinao Inlet Floodplain - C

Annex 6. Flight logs for the flight missions

1. Flight Log for 3BLK9A254A Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.:

1 LiDAR Operator: DC Alcovia	2 ALTM Model: Agusta	3 Mission Name: 3BLK9A254A Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C [illegible]
7 Pilot: J. Alajar / Tru Aud	8 Co-Pilot: M. Garchitorena	9 Route: Surigao — Siargao		
10 Date: Sept 11, 2014	12 Airport of Departure (Airport, City/Province): Surigao		12 Airport of Arrival (Airport, City/Province): Surigao	
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 in 3BLK9A

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

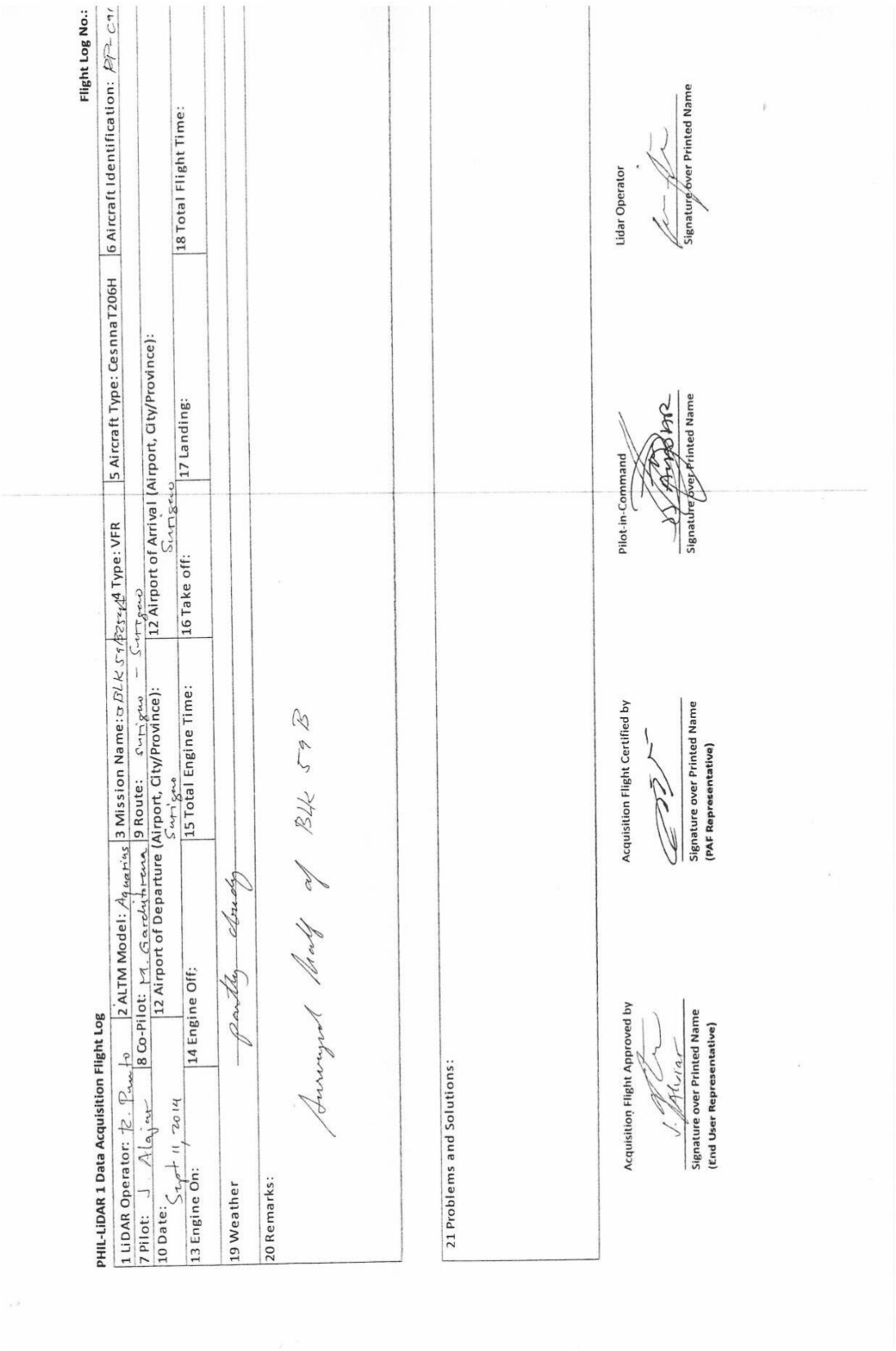
Signature over Printed Name

Lidar Operator

Signature over Printed Name

Figure A-6.1. Flight Log for Mission 3BLK9A254A

2. Flight Log for 3BLK59B254B Mission



PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.:

1 LiDAR Operator: R. Prieto	2 ALTM Model: Agustus	3 Mission Name: 3BLK59B254B Type: VFR	5 Aircraft Type: Cessna T206H / 6 Aircraft Identification: RP-C91
7 Pilot: J. Alajar	8 Co-Pilot: M. Garduntema	9 Route: Surigao – Surigao	
10 Date: Sept 11 2014	12 Airport of Departure (Airport, City/Province): Surigao	12 Airport of Arrival (Airport, City/Province): Surigao	
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:	January Mandy of Blk 59B		
21 Problems and Solutions:			

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

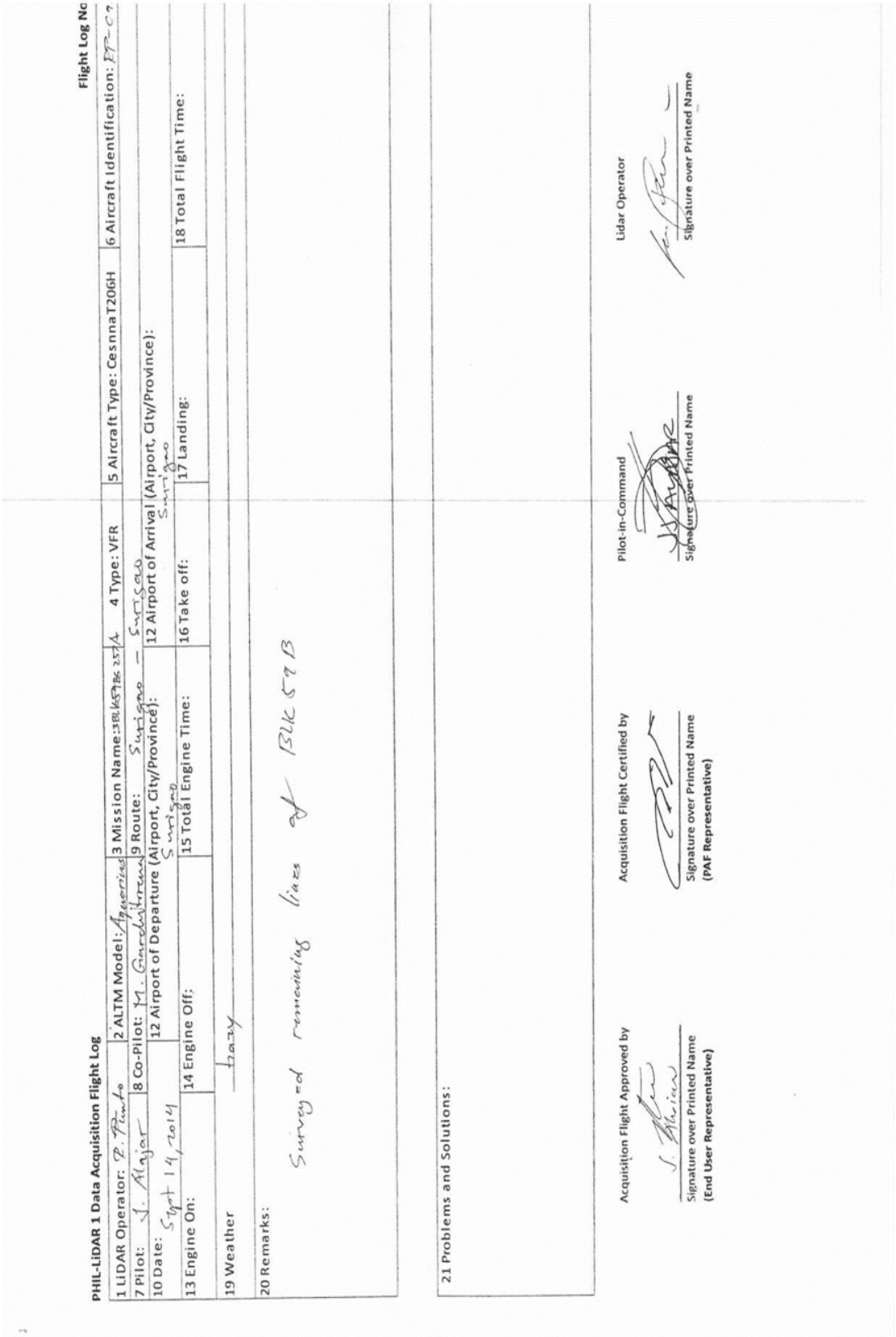
Acquisition Flight Certified by
Signature over Printed Name
(PAF Representative)

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Figure A-6.2. Flight Log for Mission 3BLK59B254B

3. Flight Log for 3BLK59BS257A Mission



PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No

1 LiDAR Operator: R. Pinto	2 ALTM Model: Aquarius	3 Mission Name: 3BLK59BS257A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C7
7 Pilot: J. Major	8 Co-Pilot: M. Garcelotrum	9 Route: Surigao – Surigao			
10 Date: Sept 19 2014	11 Airport of Departure (Airport, City/Province): Surigao		12 Airport of Arrival (Airport, City/Province): Surigao		
13 Engine On:	14 Engine Off:	15 Total Engine Time:	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Hazy					

20 Remarks:

Surveyed remaining lines of BLK 59B

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

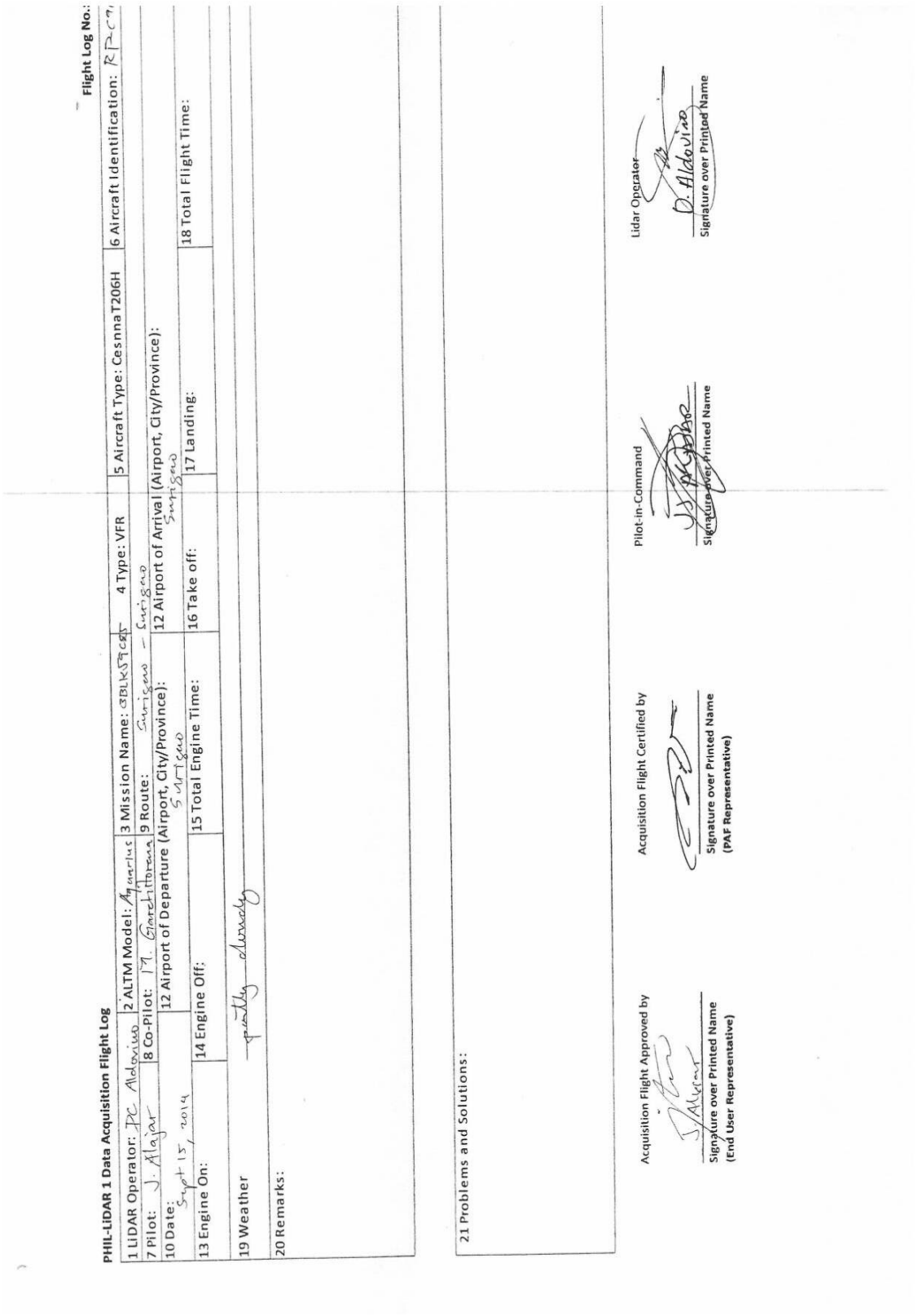
Signature over Printed Name

Lidar Operator

Signature over Printed Name

Figure A-6.3. Flight Log for Mission 3BLK59BS257A

4. Flight Log for 3BLK59D258A Mission



PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.:

1 LiDAR Operator: PC Aldovino	2 ALTM Model: Agarius	3 Mission Name: 3BLK59D258A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C7
7 Pilot: J. Alajar	8 Co-Pilot: M. Garcia	9 Route: Surigao – Surigao			
10 Date: Sept 15, 2019		12 Airport of Departure (Airport, City/Province): Surigao		12 Airport of Arrival (Airport, City/Province): Surigao	
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:

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

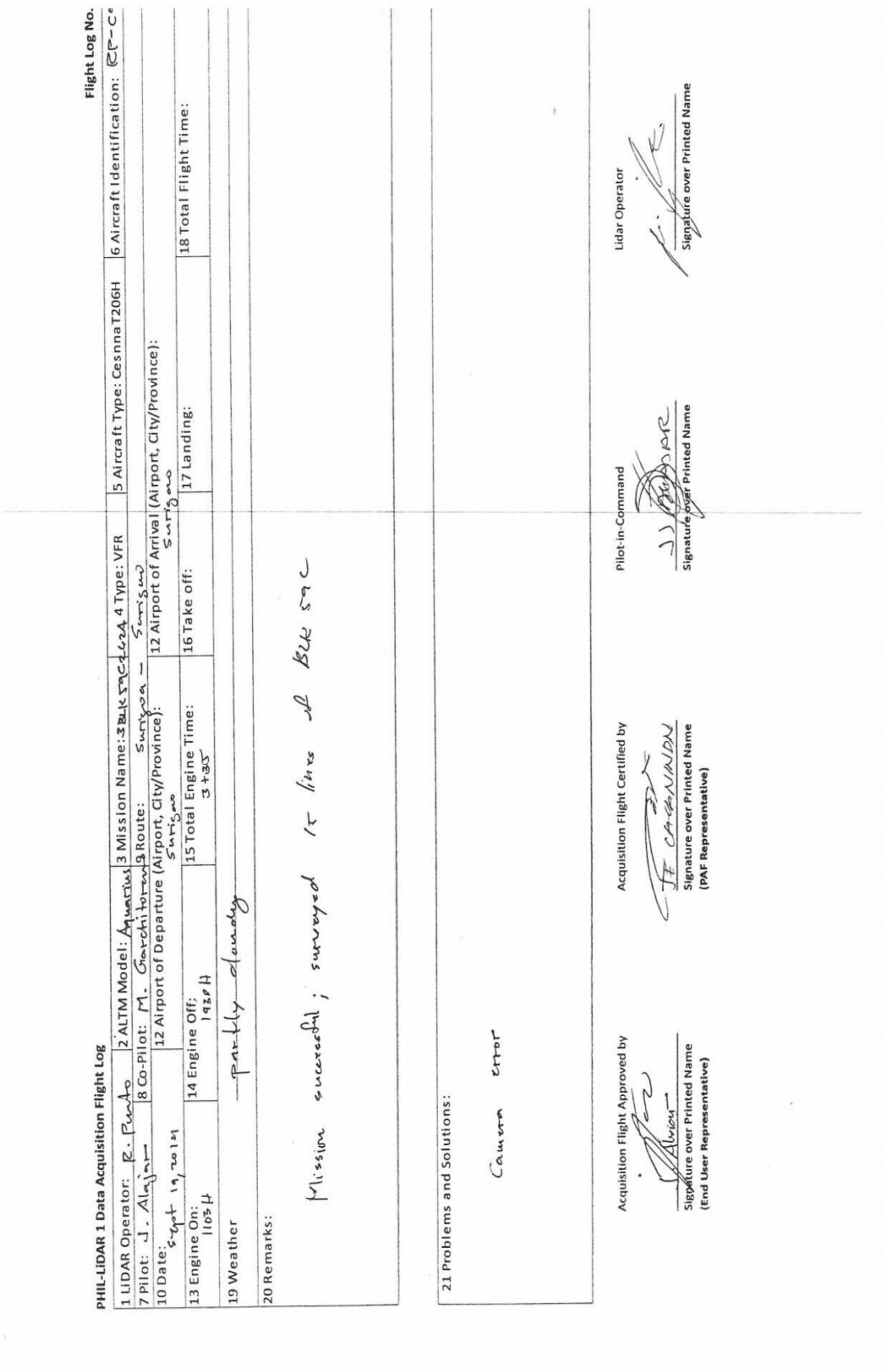
Lidar Operator

D. Aldovino

Signature over Printed Name

Figure A-6.4. Flight Log for Mission 3BLK59D258A

5. Flight Log for 3BLK59C262A Mission



PHIL-LiDAR 1 Data Acquisition Flight Log — **Flight Log No.**

1 LiDAR Operator: R. Prado	2 ALTM Model: Aquarius	3 Mission Name: 3BLK59C262A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C[illegible]
7 Pilot: J. Alejano	8 Co-Pilot: M. Gonzalez	9 Route: Surigao – Surigao			
10 Date: Sept 19, 2014	11 Airport of Departure (Airport, City/Province): Surigao		12 Airport of Arrival (Airport, City/Province): Surigao		
13 Engine On: 1105 H	14 Engine Off: 1930 H	15 Total Engine Time: 3+30	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather — Partly cloudy					

20 Remarks:

Mission successful; surveyed 12 lines of BLK 59C

21 Problems and Solutions:

Cause error

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

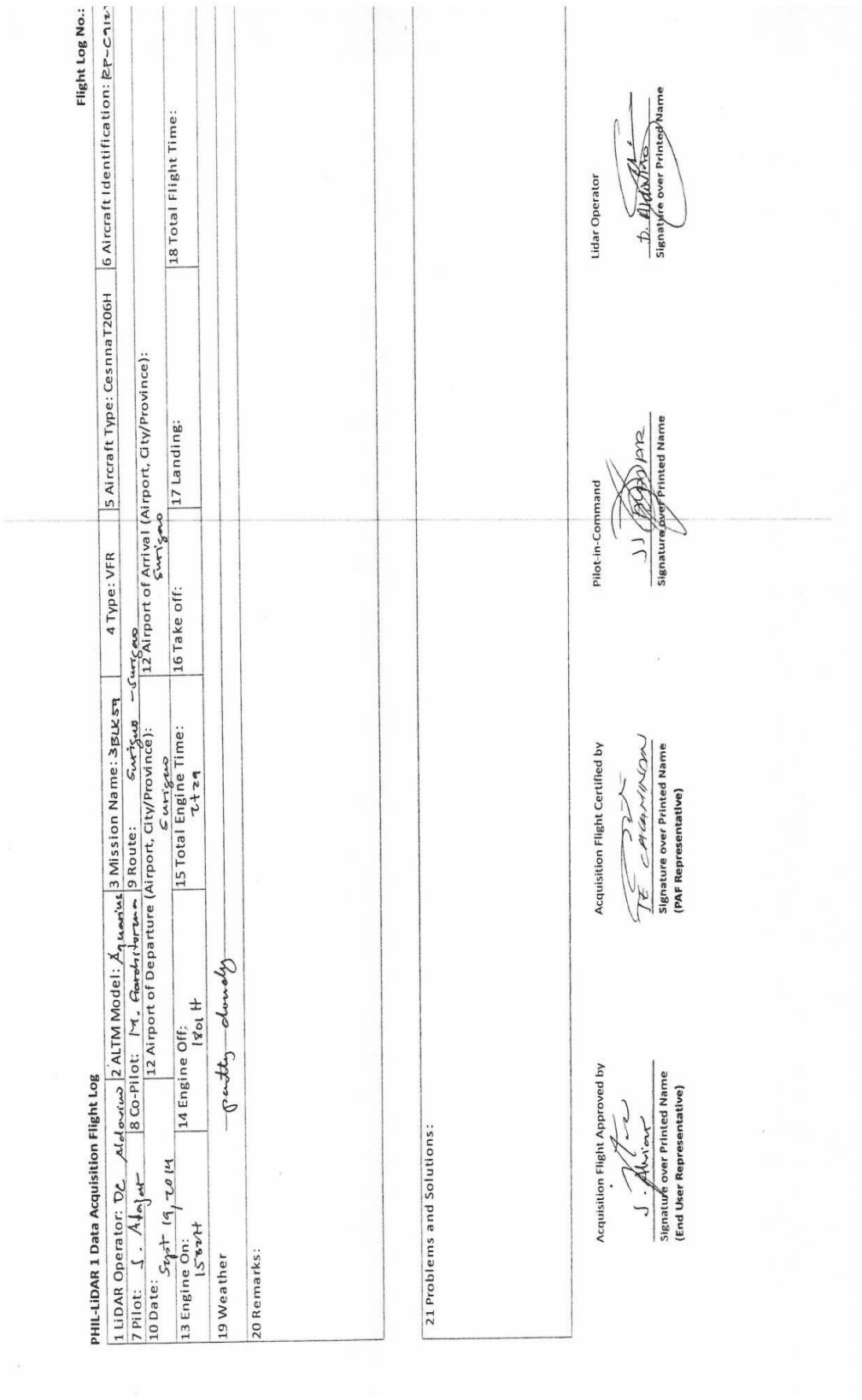
Signature over Printed Name

Lidar Operator

Signature over Printed Name

Figure A-6.5. Flight Log for Mission 3BLK59C262A

6. Flight Log for 3BLK59DS262B Mission



PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.:

1 LiDAR Operator: DE Alcantara	2 ALTM Model: Aquarius	3 Mission Name: 3BLK59	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C2126
7 Pilot: J. Alcantara	8 Co-Pilot: [illegible]	9 Route: Surigao – Surigao			
10 Date: Sept 19, 2014	11 Airport of Departure (Airport, City/Province): Surigao		12 Airport of Arrival (Airport, City/Province): Surigao		
13 Engine On: 1500H	14 Engine Off: 1801 H	15 Total Engine Time: 2.2.9	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather – Partly cloudy					
20 Remarks:					
21 Problems and Solutions:					

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

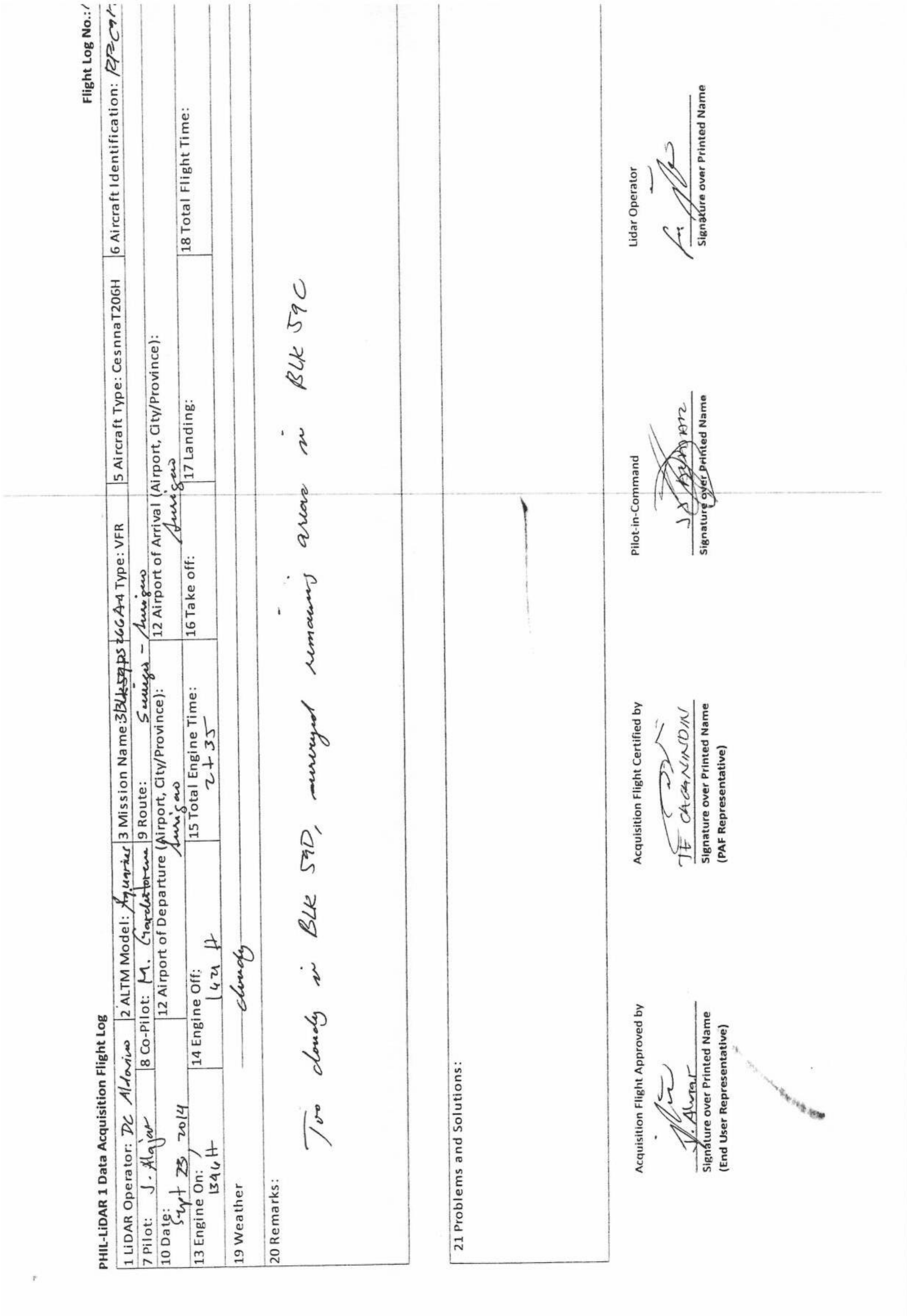
Acquisition Flight Certified by
[illegible]
Signature over Printed Name
(PAF Representative)

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

Lidar Operator
[illegible]
Signature over Printed Name

Figure A-6.6. Flight Log for Mission 3BLK59DS262B

7. Flight Log for 3BLK59DS266A Mission



Flight Log No.:

PHIL-LiDAR 1 Data Acquisition Flight Log

1 LiDAR Operator: DC Aldovino	2 ALTM Model: Aquarius	3 Mission Name: 3BLK59DS266A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9
7 Pilot: J. Alajar	8 Co-Pilot: M. Garcia	9 Route: Surigao - Surigao			
10 Date: Sept 23 2014	12 Airport of Departure (Airport, City/Province): Surigao		12 Airport of Arrival (Airport, City/Province): Surigao		
13 Engine On: 1346 H	14 Engine Off: 1421 H	15 Total Engine Time: 2+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: cloudy					

20 Remarks:

Too cloudy in BLK 59D, surveyed remaining areas in BLK 59C

21 Problems and Solutions:

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

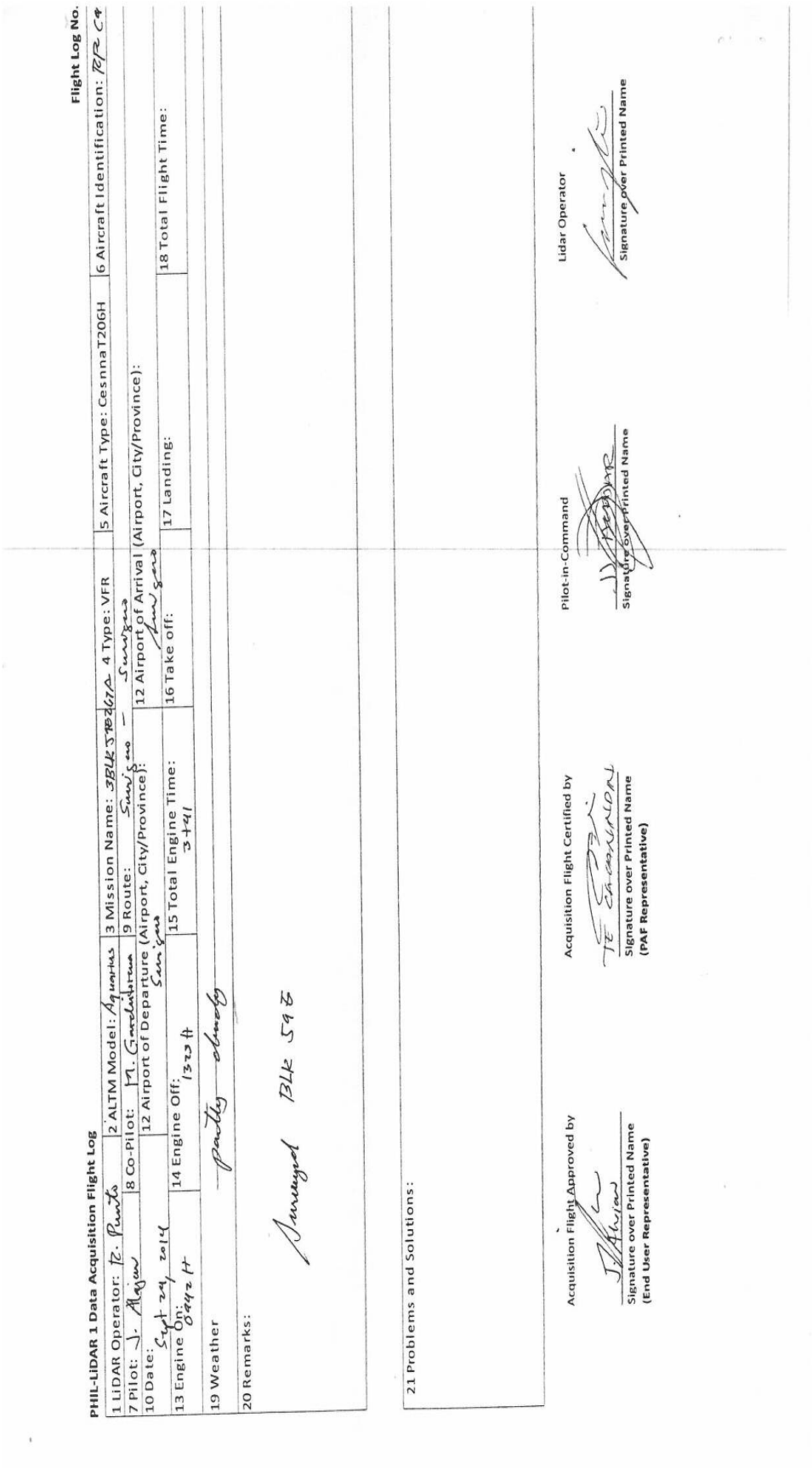
Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

Figure A-6.7. Flight Log for Mission 3BLK59DS266A

8. Flight Log for 3BLK59E267A Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.

1 LiDAR Operator: Pt. Punto	2 ALTM Model: Aquarius	3 Mission Name: 3BLK59E267A	4 Type: VFR	5 Aircraft Type: CessnaT206H	6 Aircraft Identification: RP-C4
7 Pilot: J. Magsu	8 Co-Pilot: M. Gaduluran	9 Route: Sanjose – Sanjose			
10 Date: Sept 29, 2014	11 Airport of Departure (Airport, City/Province): Sanjose		12 Airport of Arrival (Airport, City/Province): Sanjose		
13 Engine On: 0442 H	14 Engine Off: 1323 H	15 Total Engine Time: 3+41	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					
20 Remarks: Surveyed BLK 59 B					
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

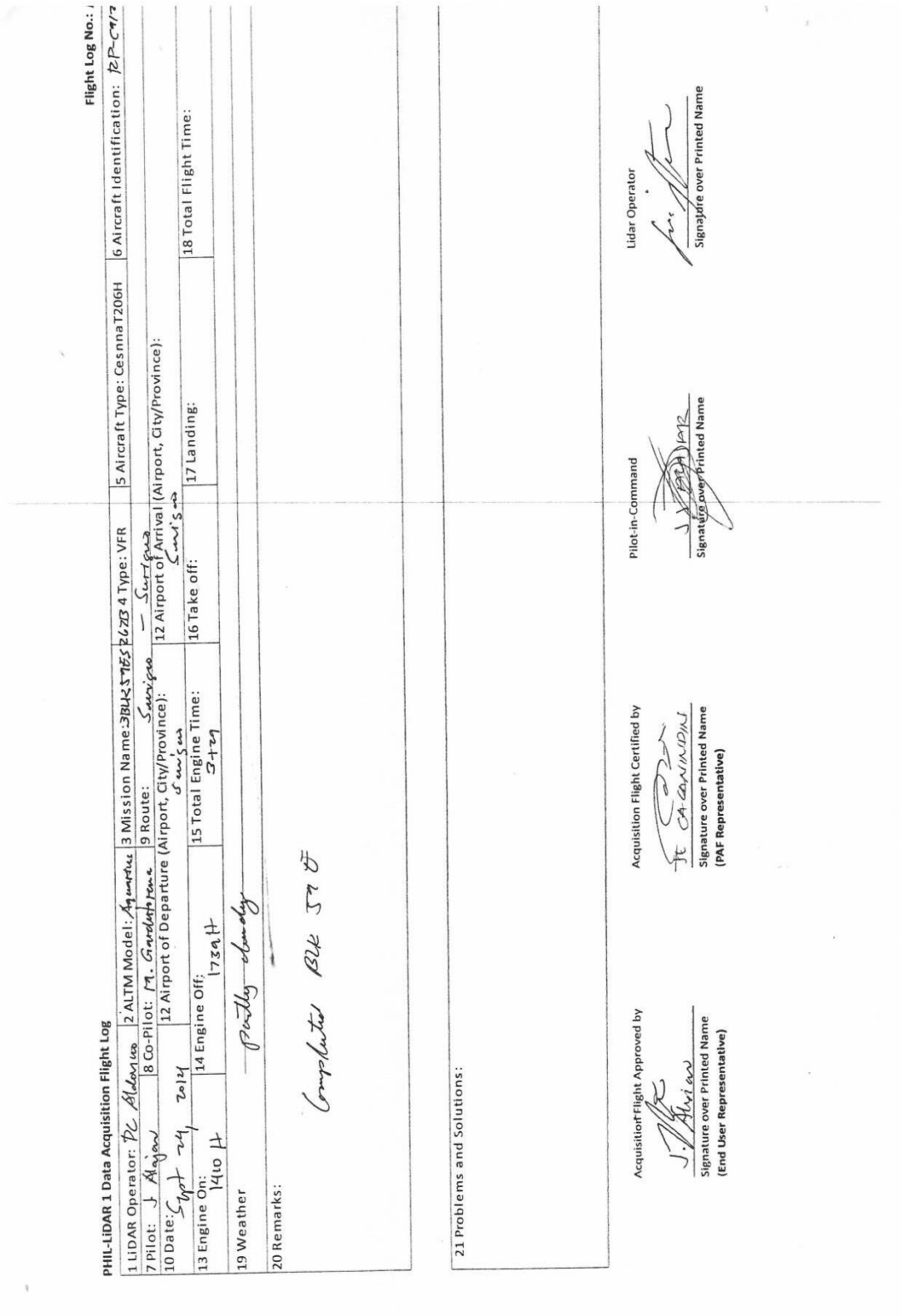
Signature over Printed Name

Lidar Operator

Signature over Printed Name

Figure A-6.8. Flight Log for Mission 3BLK59E267A

9. Flight Log for 3BLK59ES267B Mission



PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 1

1 LiDAR Operator: PL Alonzo	2 ALTM Model: Aquarius	3 Mission Name: 3BLK59ES267B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C917
7 Pilot: J. Alejo	8 Co-Pilot: M. Gradiptone	9 Route: Sanipaa – Surigao			
10 Date: Sept 24, 2014		12 Airport of Departure (Airport, City/Province): Sanipaa		12 Airport of Arrival (Airport, City/Province): Surigao	
13 Engine On: 1410 H	14 Engine Off: 1739 H	15 Total Engine Time: 3+29		16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Partly cloudy				

20 Remarks:

Completed BLK 59 ES

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Ft CA CANLUBANG

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

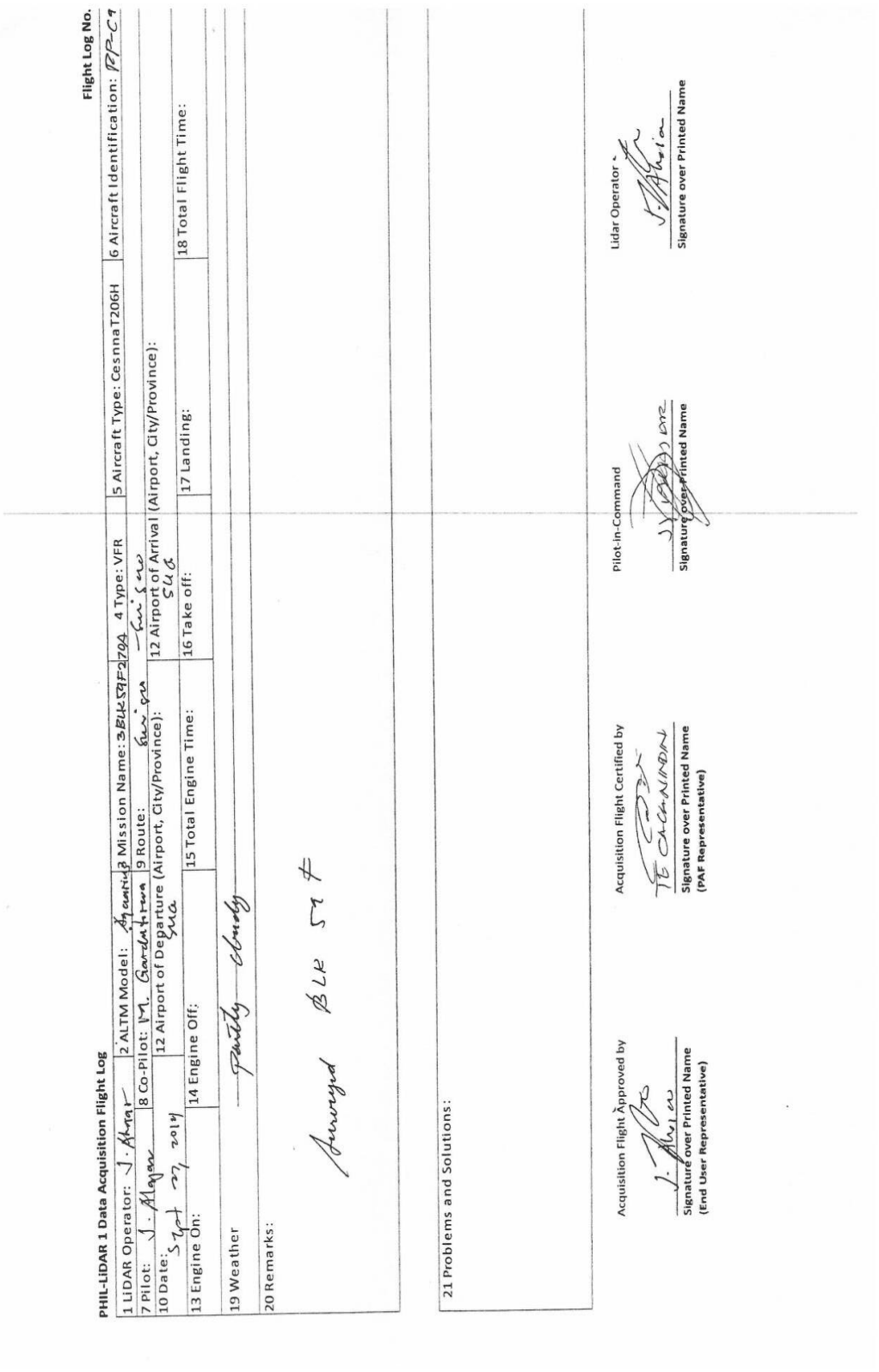
Signature over Printed Name

Lidar Operator

Signature over Printed Name

Figure A-6.9. Flight Log for Mission 3BLK59ES267B

10. Flight Log for 3BLK59F270A Mission



PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No. PPC-9

1 LiDAR Operator: J. Alajar	2 ALTM Model: Aquarius	3 Mission Name: 3BLK59F270A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9
7 Pilot: J. Alajar	8 Co-Pilot: M. Garduque	9 Route: Guimaras	10 Date: Sept 27, 2014	11 Airport of Departure (Airport, City/Province): Sta Ana	12 Airport of Arrival (Airport, City/Province): Sta Ana
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: Surveyed BLK 59F					
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-6.10. Flight Log for Mission 3BLK59F270A

11. Flight Log for 3BLK59FDS271A Mission

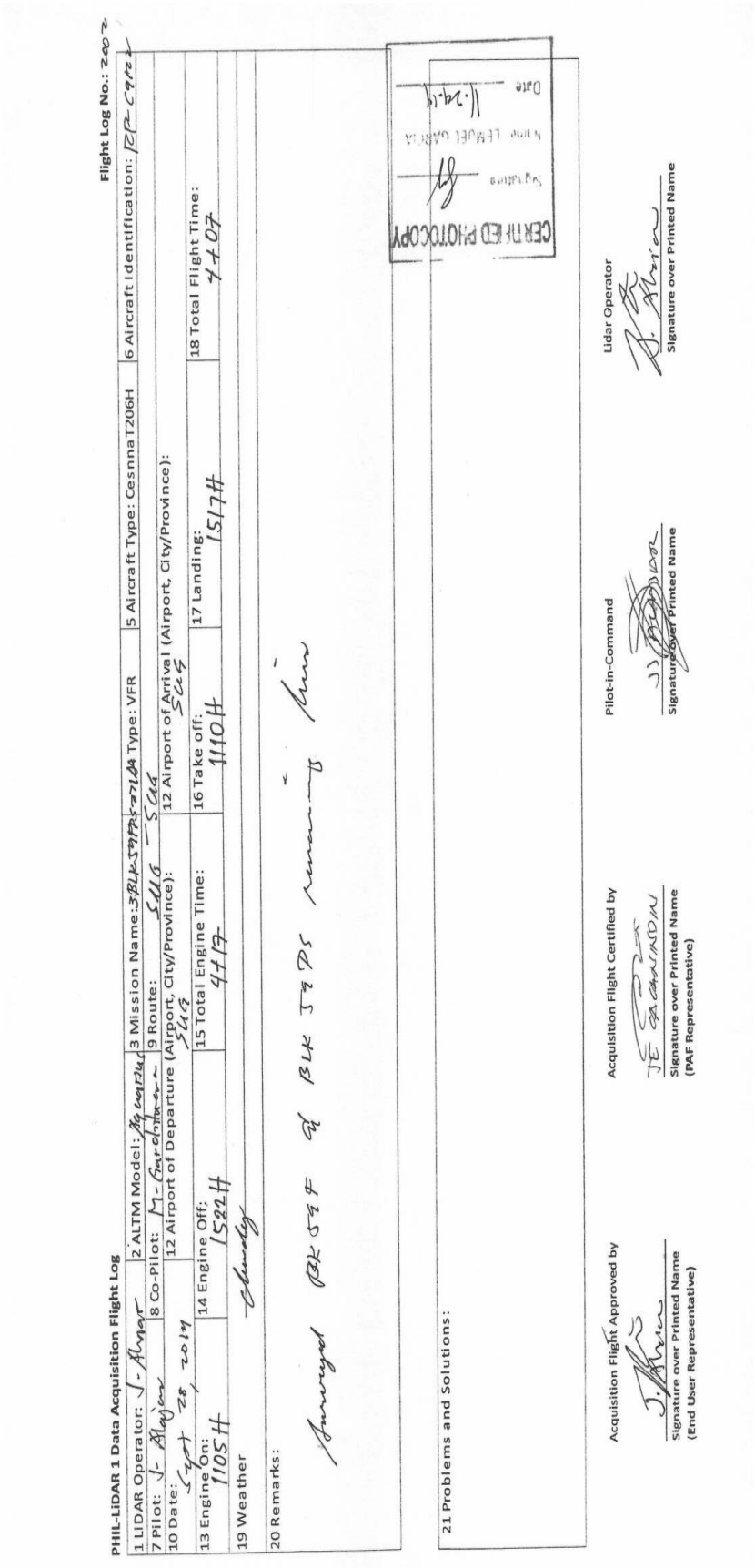
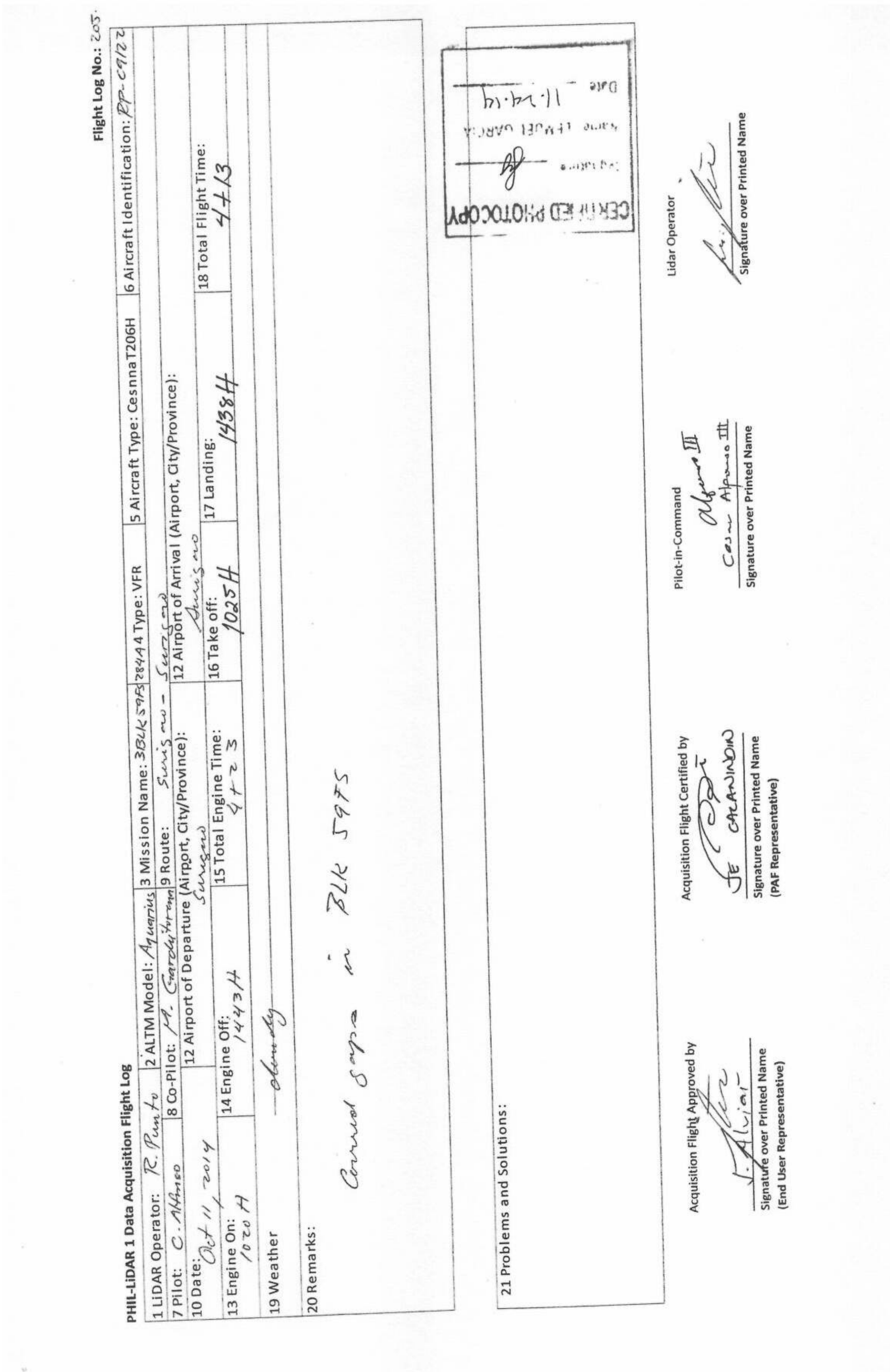


Figure A-6.11. Flight Log for Mission 3BLK59FDS271A

12. Flight Log for 3BLK59DS284A Mission



Flight Log No.: 205

PHIL-LiDAR 1 Data Acquisition Flight Log

1 LiDAR Operator: R. Punto	2 ALTM Model: Aquarius	3 Mission Name: 3BLK59FS284A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: C. Alfonso	8 Co-Pilot: M. Gardoltorena	9 Route: Surigao - Surigao			
10 Date: Oct 11, 2014	12 Airport of Departure (Airport, City/Province): Surigao		12 Airport of Arrival (Airport, City/Province): Surigao		
13 Engine On: 1020H	14 Engine Off: 1443H	15 Total Engine Time: 4+23	16 Take off: 1025H	17 Landing: 1438H	18 Total Flight Time: 4+13
19 Weather: cloudy					
20 Remarks: Covered gaps in BLK 59FS					

21 Problems and Solutions:

CERTIFIED PHOTOCOPY
Name: LEMUEL GARCIA
Date: 11.24.14

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

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

Pilot-in-Command: Cesar Alfonso III — Signature over Printed Name

Lidar Operator: — Signature over Printed Name

Figure A-6.12. Flight Log for Mission 3BLK59DS284A

13. Flight Log for 3BLK59S285B Mission

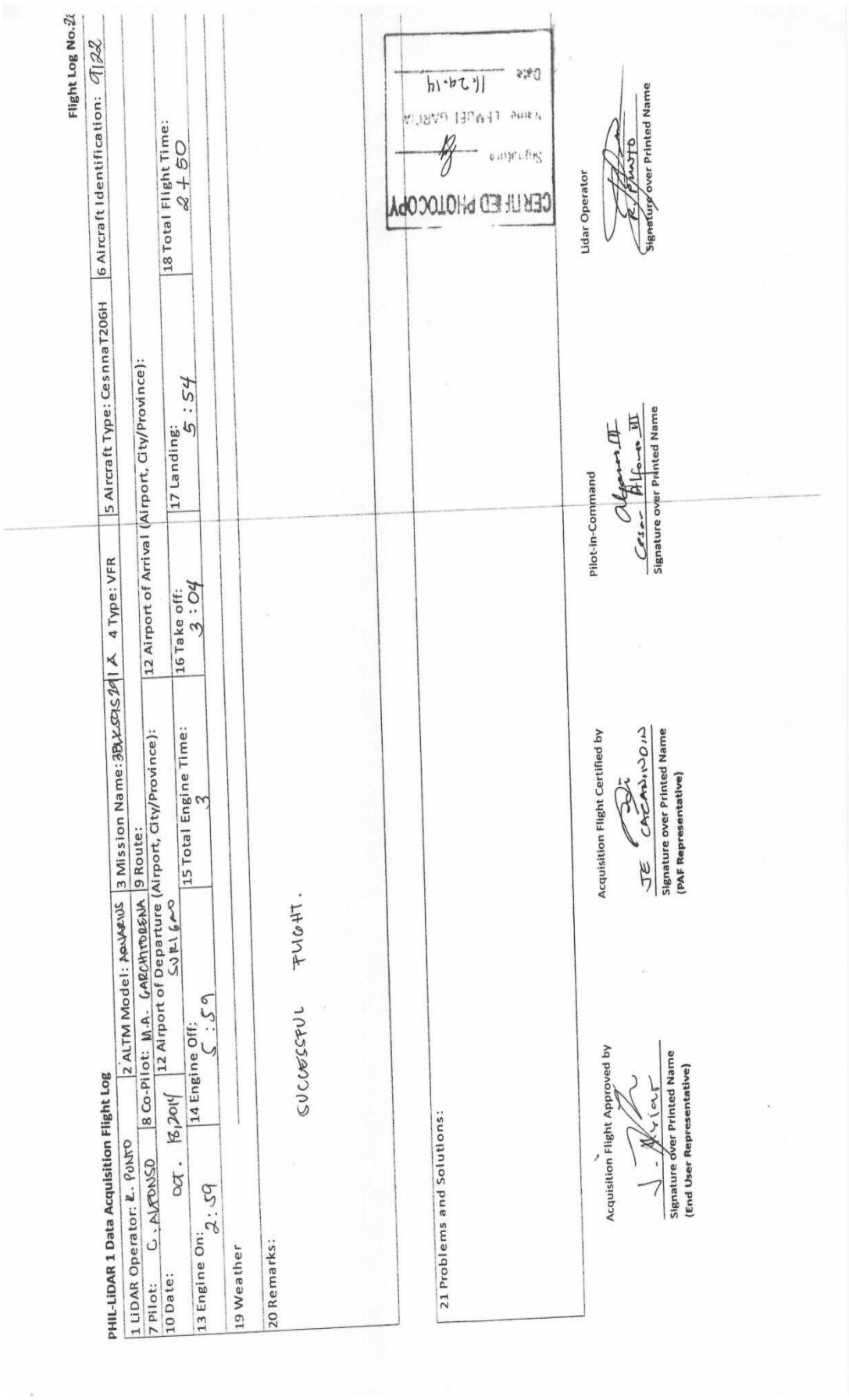
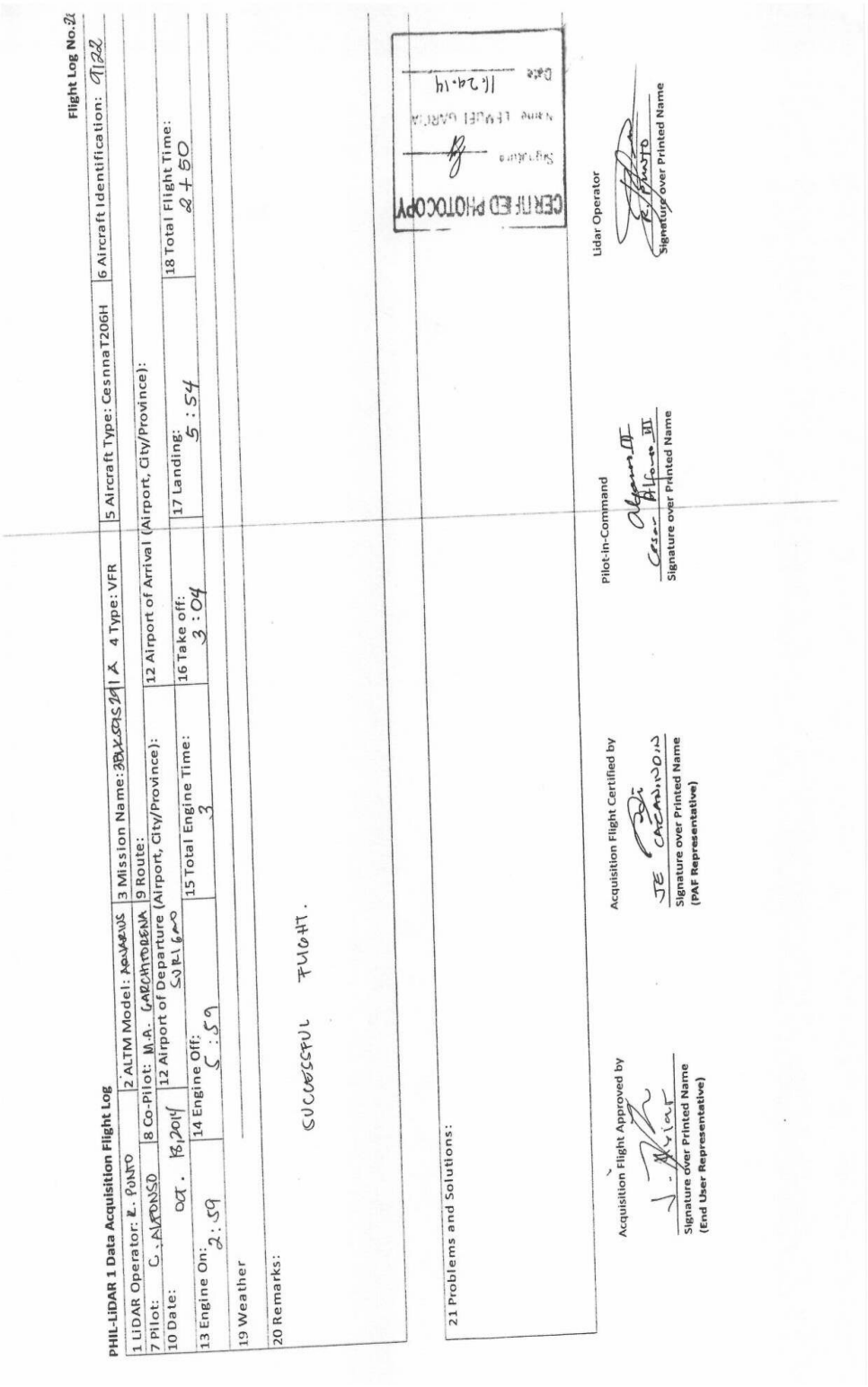


Figure A-6.13. Flight Log for Mission 3BLK59S285B

14. Flight Log for 3BLK59S291A Mission



PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.21

1 LiDAR Operator: E. PINTO	2 ALTM Model: [illegible]	3 Mission Name: 3BLK59S291A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: C. ALFONSO	8 Co-Pilot: M.A. CARCHITOBENA	9 Route:			
10 Date: OCT. 15, 2014	11 Airport of Departure (Airport, City/Province): SUBIC	12 Airport of Arrival (Airport, City/Province):			
13 Engine On: 2:59	14 Engine Off: 5:59	15 Total Engine Time: 3	16 Take off: 3:04	17 Landing: 5:54	18 Total Flight Time: 2+50

19 Weather

20 Remarks: SUCCESSFUL FLIGHT.

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

Pilot-In-Command

Signature over Printed Name

Lidar Operator

Signature over Printed Name

CERTIFIED PHOTOCOPY

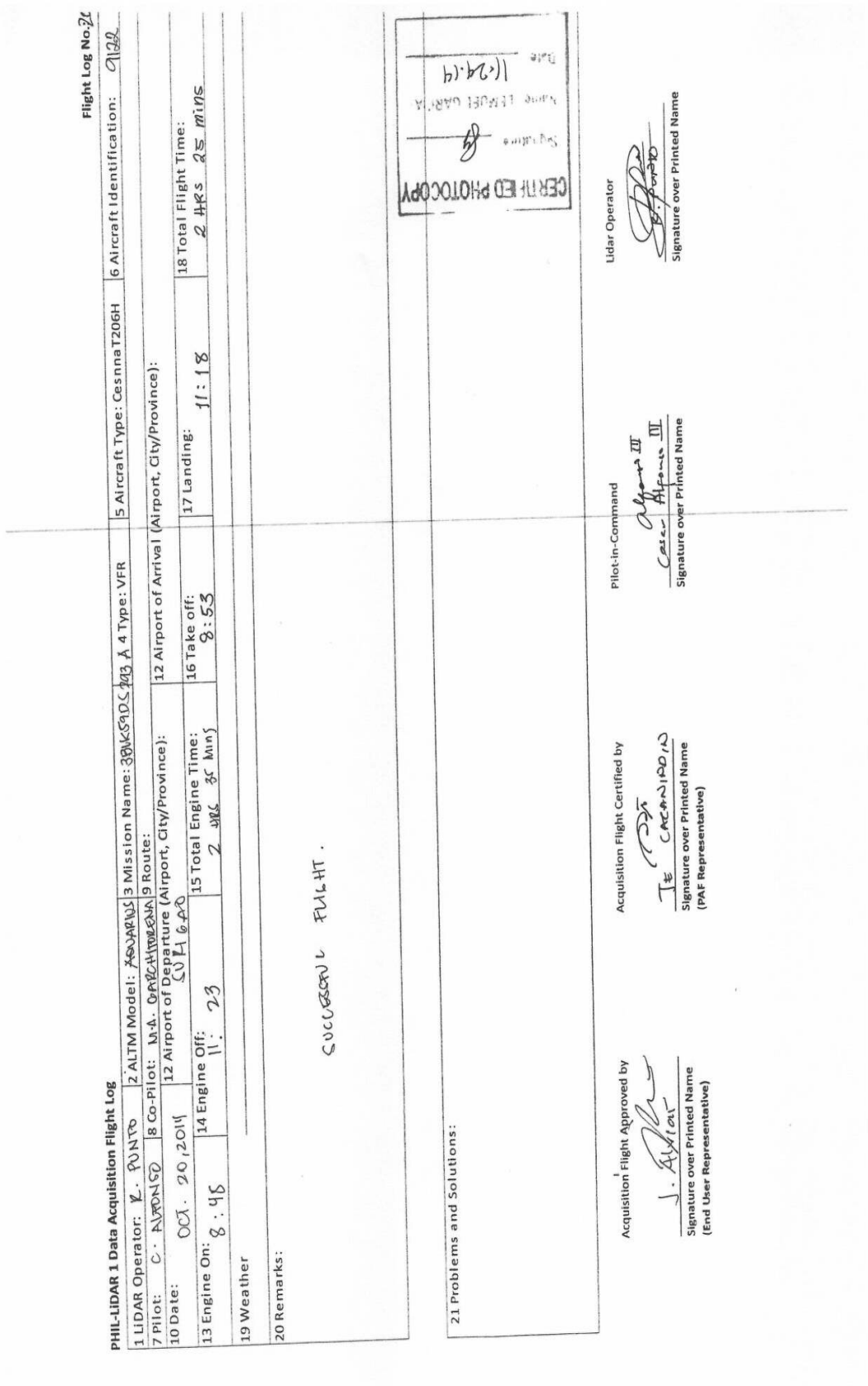
Name [illegible]

Sign [illegible]

Date 11.24.14

Figure A-6.14. Flight Log for Mission 3BLK59S291A

15. Flight Log for3BLK59DS293A Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No. 21

1 LiDAR Operator: R. PUNTO	2 ALTM Model: ~~RANGER~~	3 Mission Name: 3BLK59DS293A	4 Type: VFR
5 Aircraft Type: CessnnaT206H	6 Aircraft Identification: 9182		
7 Pilot: C. ALFONSO	8 Co-Pilot: M.A. ~~CARCHITORENA~~	9 Route:	
10 Date: OCT. 20, 2014	12 Airport of Departure (Airport, City/Province): CUH GAO	12 Airport of Arrival (Airport, City/Province):	
13 Engine On: 8:45	14 Engine Off: 11: 23	15 Total Engine Time: 2 HRS 38 Mins	16 Take off: 8:53
17 Landing: 11:18	18 Total Flight Time: 2 HRS 25 mins		

19 Weather

20 Remarks: SUCCESSFUL FLIGHT.

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name (End User Representative)

Acquisition Flight Certified by

Signature over Printed Name (PAF Representative)

Pilot-in-Command

Cesar Alfonso III

Signature over Printed Name

Lidar Operator

Signature over Printed Name

CERTIFIED PHOTOCOPY

Name [illegible]

Date 11.24.14

Figure A-6.15. Flight Log for Mission for3BLK59DS293A

. 16. Flight Log for 3DNGB135A Mission

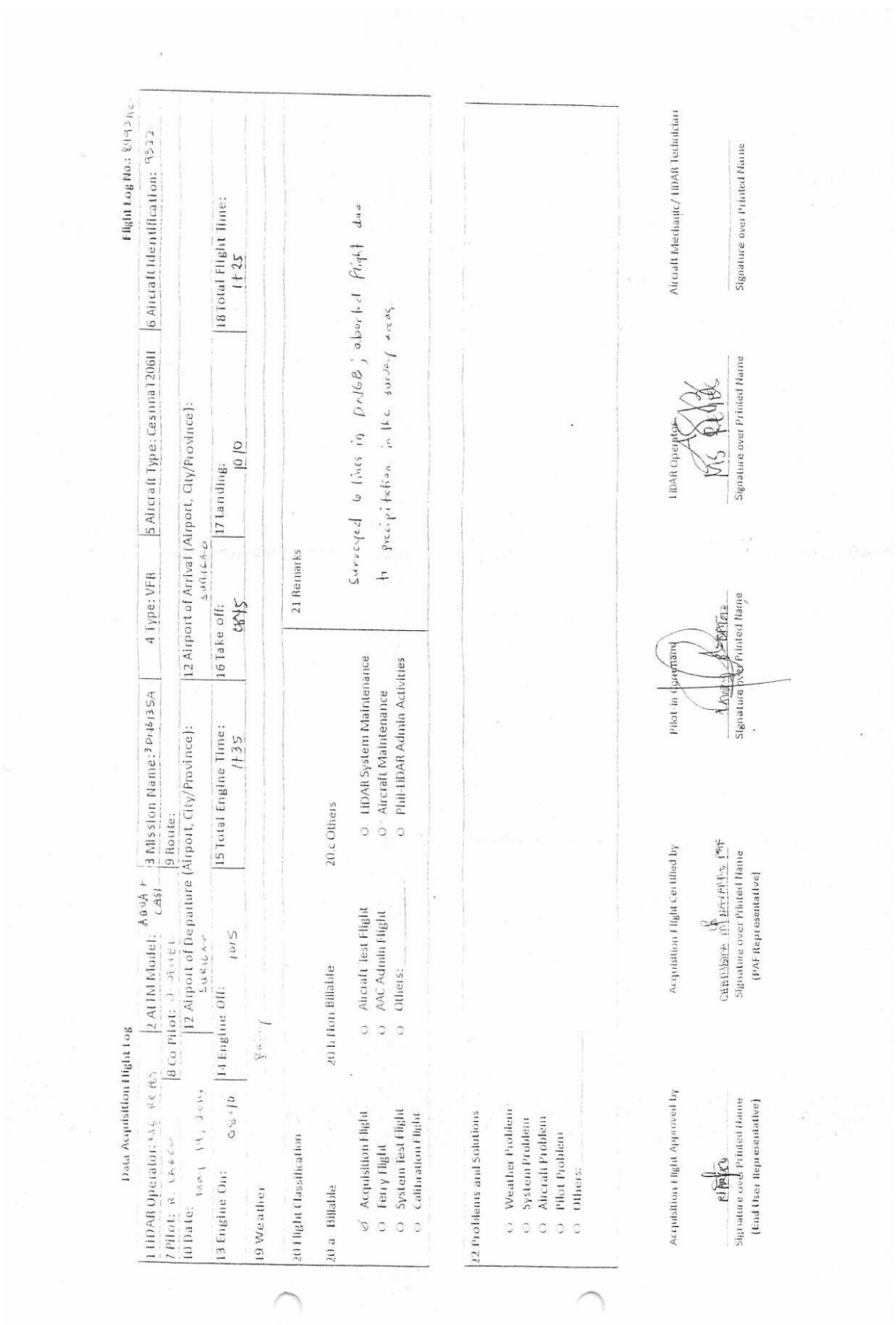
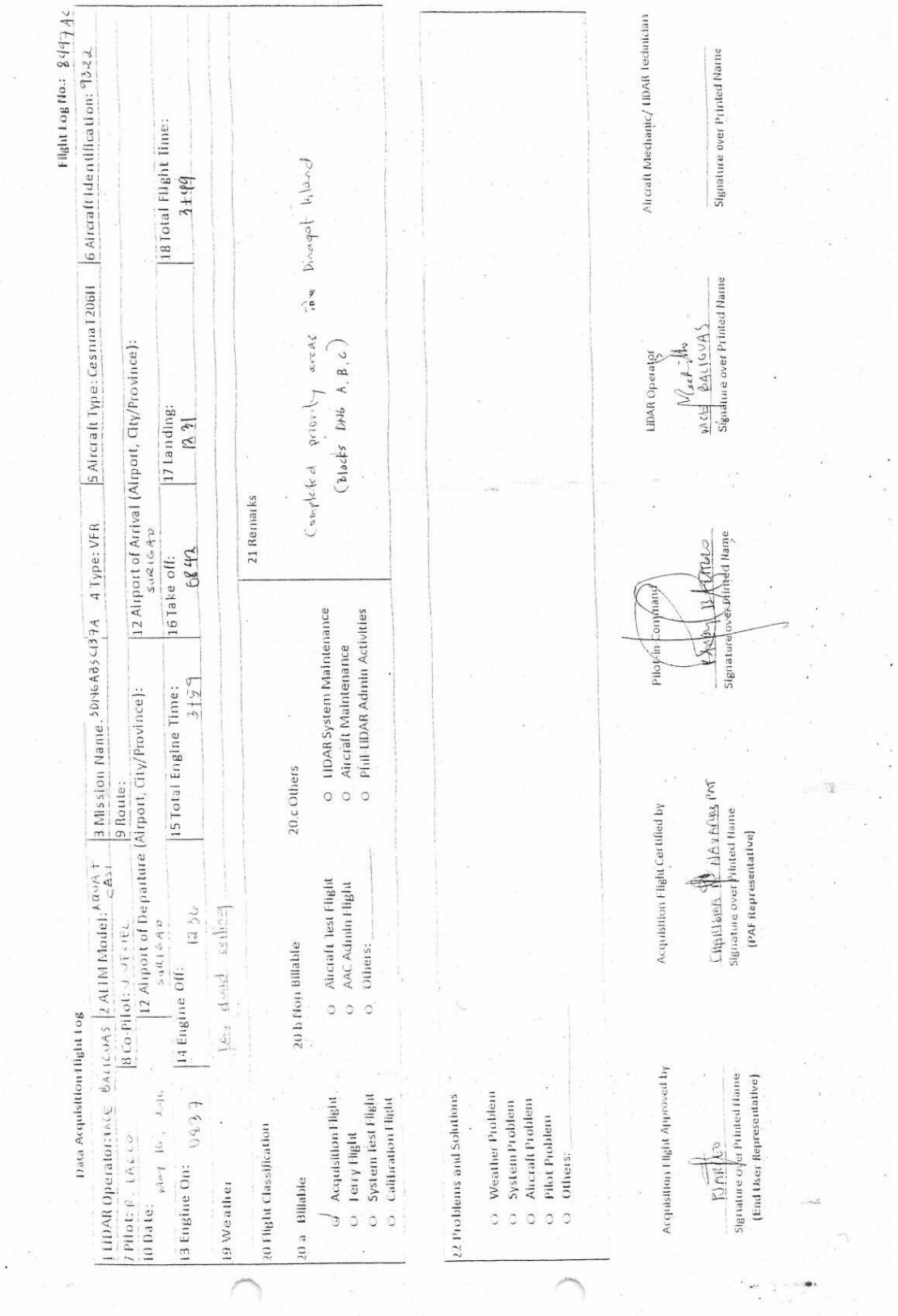


Figure A-6.16. Flight Log for Mission 3DNGB135A

17. Flight Log for 3DNGABSC137A Mission



Data Acquisition Flight Log

Flight Log No.: 8447AC

1 LIDAR Operator: BALICAS	2 AIM Model: AGUSTA 109A	3 Mission Name: 3DNGABSC137A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9322
7 Pilot: [illegible]	8 Co-Pilot: [illegible]	9 Route:			
10 Date: [illegible]	11 Airport of Departure (Airport, City/Province): SANGABAD	12 Airport of Arrival (Airport, City/Province): SANGABAD			
13 Engine On: 0937	14 Engine Off: 1236	15 Total Engine Time: 3+29	16 Take off: 0842	17 Landing: 1231	18 Total Flight Time: 3+49

19 Weather: [illegible]

20 Flight Classification

20 a Billable

- ✓ Acquisition Flight
- ○ Ferry Flight
- ○ System Test Flight
- ○ Calibration Flight

20 b Non Billable

- ○ Aircraft Test Flight
- ○ AAC Admin Flight
- ○ Others: _____

20 c Others

- ○ LIDAR System Maintenance
- ○ Aircraft Maintenance
- ○ Phil LIDAR Admin Activities

21 Remarks

Completed primary areas (Blocks DNG A, B, C) [illegible] Bacolod Island

22 Problems and Solutions

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

Acquisition Flight Approved by

[illegible]
Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

[illegible] LIDAR Expert
Signature over Printed Name
(PAF Representative)

Pilot in Command

[illegible]
Signature over Printed Name

LIDAR Operator

[illegible] BALICAS
Signature over Printed Name

Aircraft Mechanic/ LIDAR Technician

Signature over Printed Name

Figure A-6.17. Flight Log for Mission 3DNGABSC137A

. 18. Flight Log for 3DNGDE138A AMission

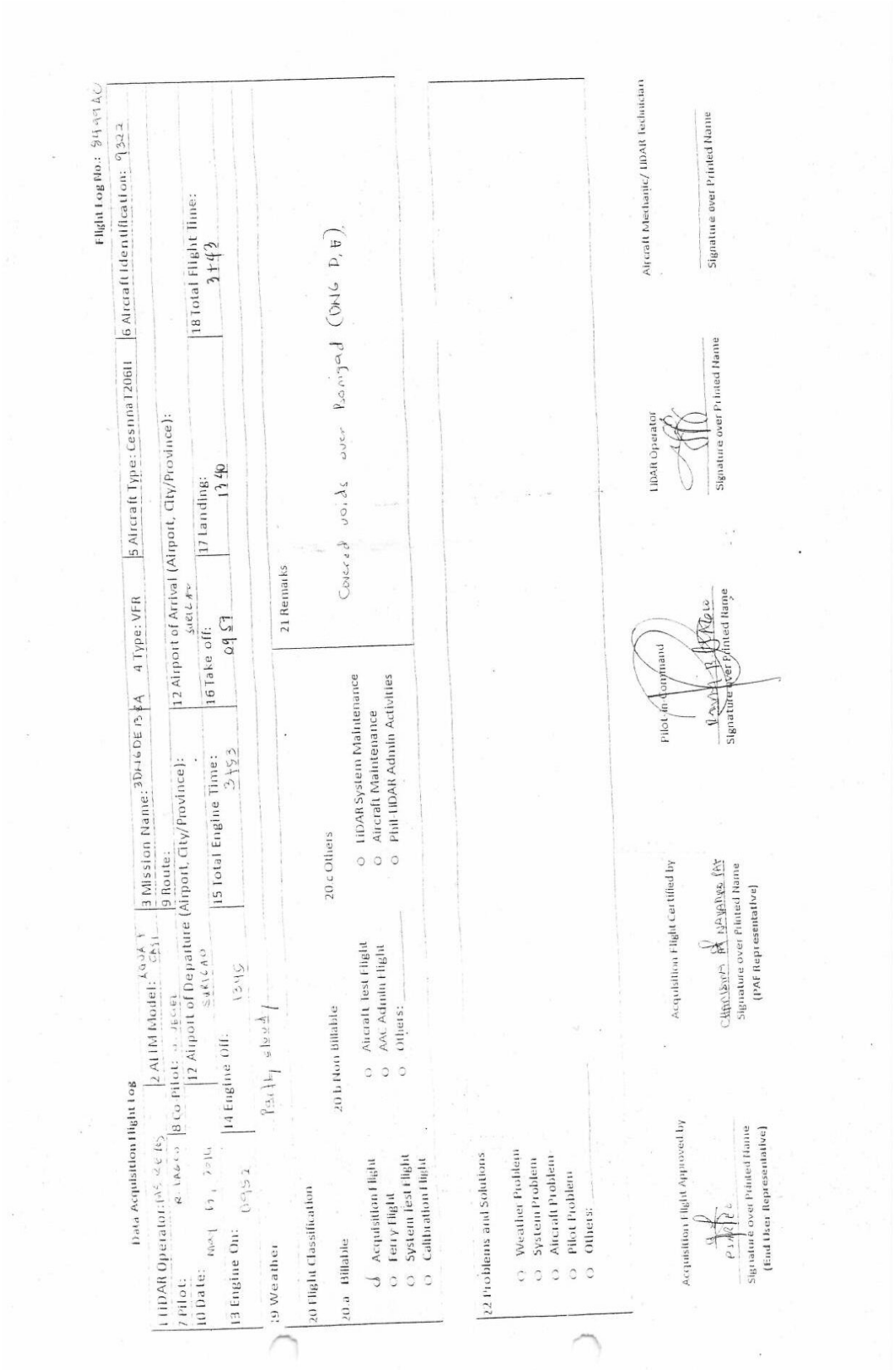


Figure A-6.18. Flight Log for Mission 3DNGDE138A

Annex 7. Flight Status Reports

Table A-7.1. Flight Status Report

Surigao – Dinagat					
(September 11 – 28, 2014; October 11 – 20, 2014; and May 14 - 17, 2016)					
FLIGHT NO	**AREA**	**MISSION**	**OPERATOR**	**DATE FLOWN**	**REMARKS**
1934A	BLK 59A	3BLK59A254A	DC Aldovino	11-Sep-14	Completed BLK 59A; camera error (overrun, black preview and captures)
1936A	BLK 59B	3BLK59B254B	R. Punto	11-Sep-14	Covered half of BLK 59B; camera error (overrun, black preview and captures)
1946A	BLK 59BS	3BLK59BS257A	R. Punto	14-Sep-14	Surveyed BLK 59BS
1950A	BLK 59D	3BLK59D258A	DC Aldovino	15-Sep-14	Surveyed BLK 59D
1966A	BLK 59C	3BLK59C262A	R. Punto	19-Sep-14	Surveyed BLK 59C
1968A	BLK 59D	3BLK59D262B	DC Aldvino	19-Sep-14	Surveyed BLK 59D
1982A	BLK 59DS	3BLK59DS266A	DC Aldovino	23-Sep-14	Surveyed BLK 59DS
1986A	BLK 59E	3BLK59E267A	R. Punto	24-Sep-14	Surveyed BLK 59E
1988A	BLK 59E	3BLK59ES267B	DC Aldovino	24-Sep-14	Completed BLK 59E
1998A	BLK 59F	3BLK59F270A	J. Alviar	27-Sep-14	Surveyed BLK 59F
2002A	BLK 59FD	3BLK59FDS271A	J. Alviar	28-Sep-14	Filled up gaps in BLK 59F and BLK 59D; too cloudy in BLK 59D; ALTM NAV stopped responding while laser was still firing
2054A	BLK 59EFS	3BLK59S284A	R. Punto	11-Oct-14	Filled up gaps in BLK 59EFS
2058A	BLK 59FS	3BLK59FS285B	R. Punto	12-Oct-14	Filled up gaps in BLK 59D
2082A	BLK 59F ext	3BLK59S291A	R. Punto	18-Oct-14	Surveyed valley area as extension of BLK 59F
2090A	BLK 59DS	3BLK59DS293A	J. Alviar	20-Oct-14	Surveyed remaining half of BLK 59D; some gaps left due to rainclouds in the area

8493	DINAGAT	3DNGB135A	MS REYES	14-May-16	SURVEYED 6 LINES IN DNGB; ABORTED FLIGHT DUE TO PRECIPITATION IN THE SURVEY AREAS
8497	DINAGAT	3DNGABSC137A	MCE BALIGU-AS	16-May-16	COMPLETED PRIORI-TY AREAS IN DINAGAT ISLAND
8499	DINAGAT	3DNGE138A	MS REYES	17-May-16	COVERED VOIDS OVER BANIGAD

SWATH PER FLIGHT MISSION

Flight No.: 1934A

Area: BLK 59A

Mission Name: 3BLK59A254A

Parameters: PRF 50 SF 45 SCA 18

SWATH

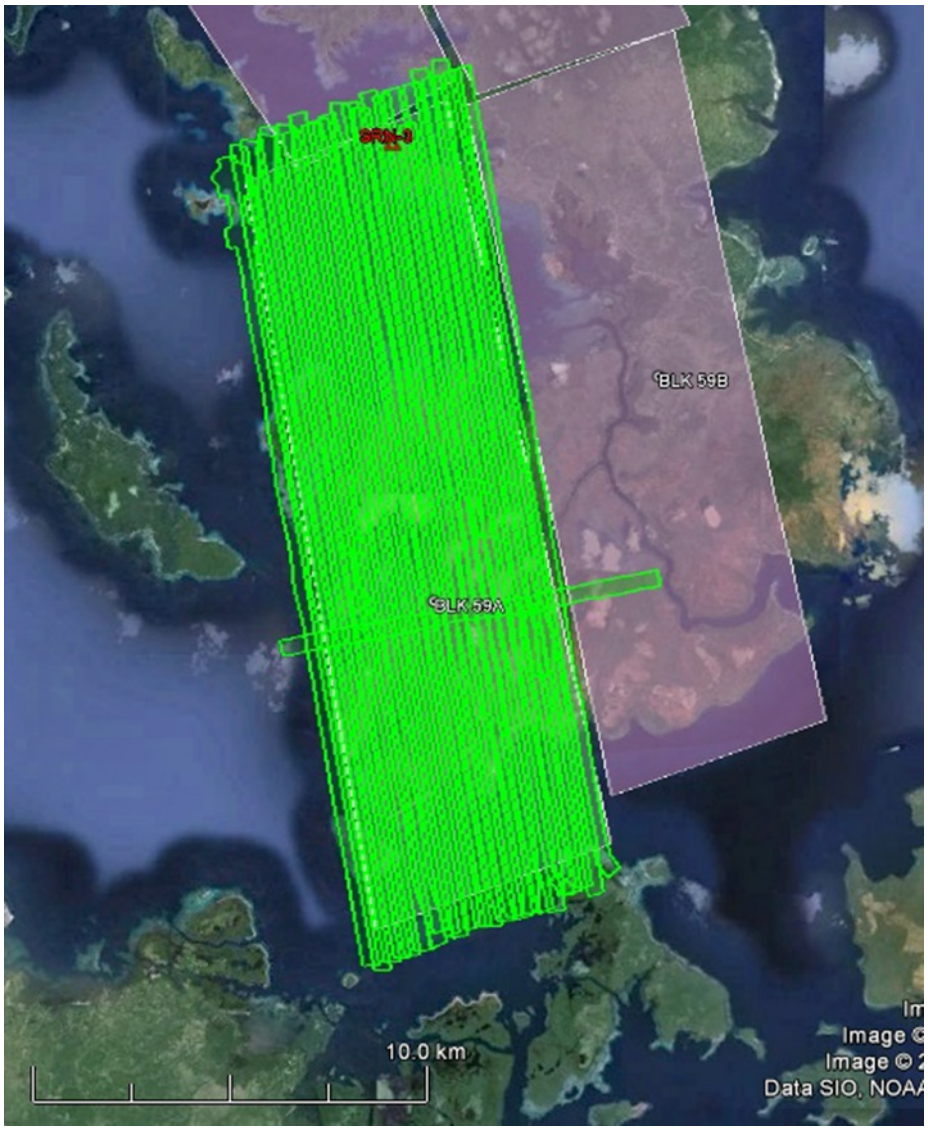


Figure A-7.1. Swath for Flight No. 1934A

Flight No.: 1936A

Area: BLK 59B

Mission Name: 3BLK59BS257A

Parameters: PRF 50 SF 45 SCA 18

SWATH

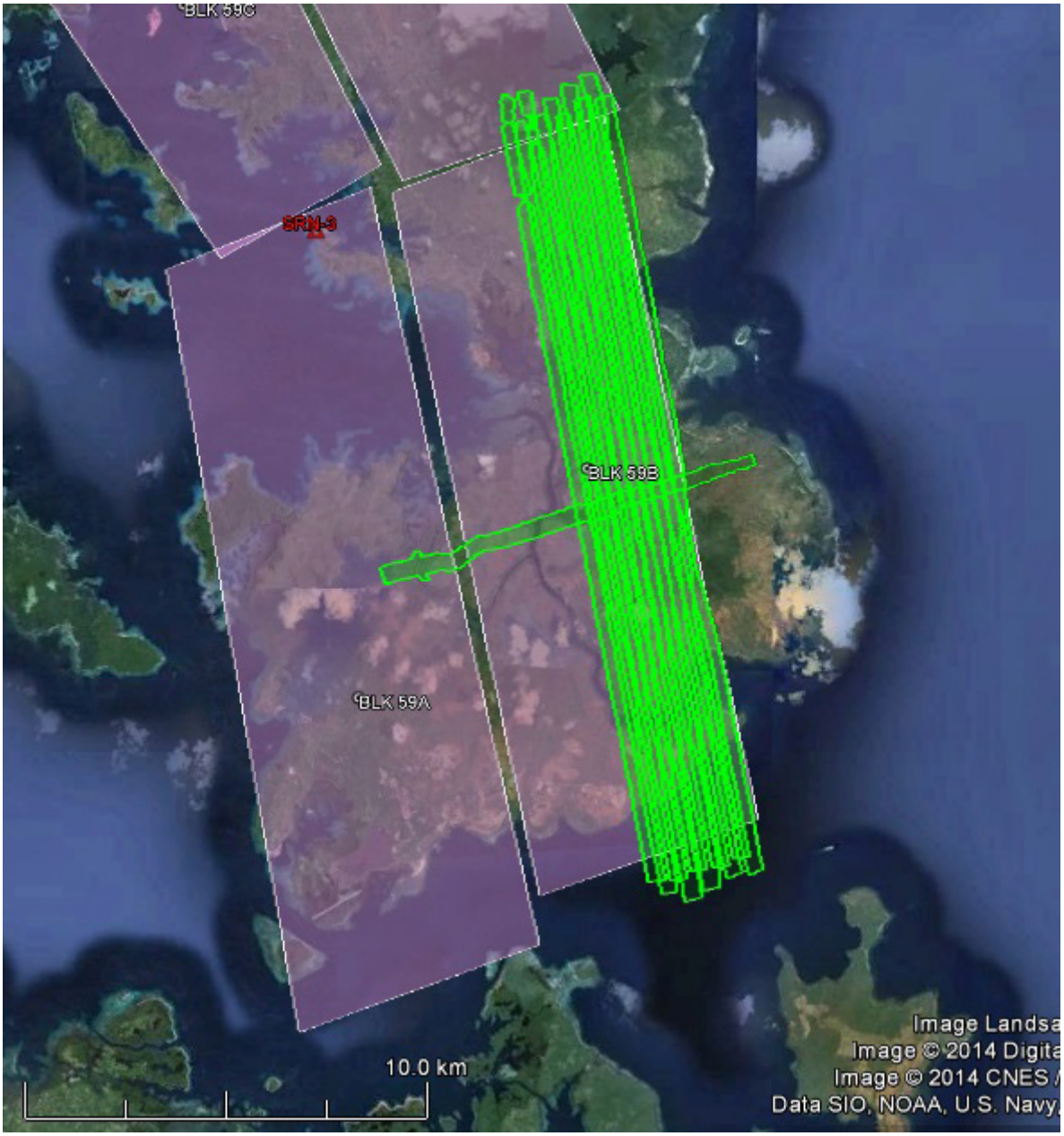


Figure A-7.2. Swath for Flight No. 1936A

Flight No.: 1946A

Area: BLK 59B

Mission Name: 3BLK59BS257A

Parameters: PRF 50 SF 45 SCA 18

LAS BOUNDARY

Figure A-7.3. Las for Flight No. 1946A

Flight No.: 1950A

Area: BLK 59D

Mission Name: 3BLK59D258A

Parameters: PRF 50 SF 45 SCA 18

LAS BOUNDARY

Figure A-7.4. Las for Flight No. 1950A

Flight No.: 1966A

Area: BLK 59C

Mission Name: 3BLK59C262A

Parameters: PRF 50 SF 45 SCA 18

LAS BOUNDARY

Figure A-7.5. Las for Flight No. 1966A

Flight No.: 1968A

Area: BLK 59C&DS

Mission Name: 3BLK59D262B

Parameters: PRF 50 SF 45 SCA 18

LAS BOUNDARY

Figure A-7.6. Las for Flight No. 1968A

Flight No.: 1982A

Area: BLK 59C

Mission Name: 3BLK59DS266A

Parameters: PRF 50 SF 45 SCA 18

LAS BOUNDARY

Figure A-7.7. Las for Flight No. 1982A

Flight No.: 1986A

Area: BLK 59F, BLK 59DS, BLK 59CS

Mission Name: 3BLK59E267A

Parameters: PRF 50 SF 45 SCA 18

LAS BOUNDARY

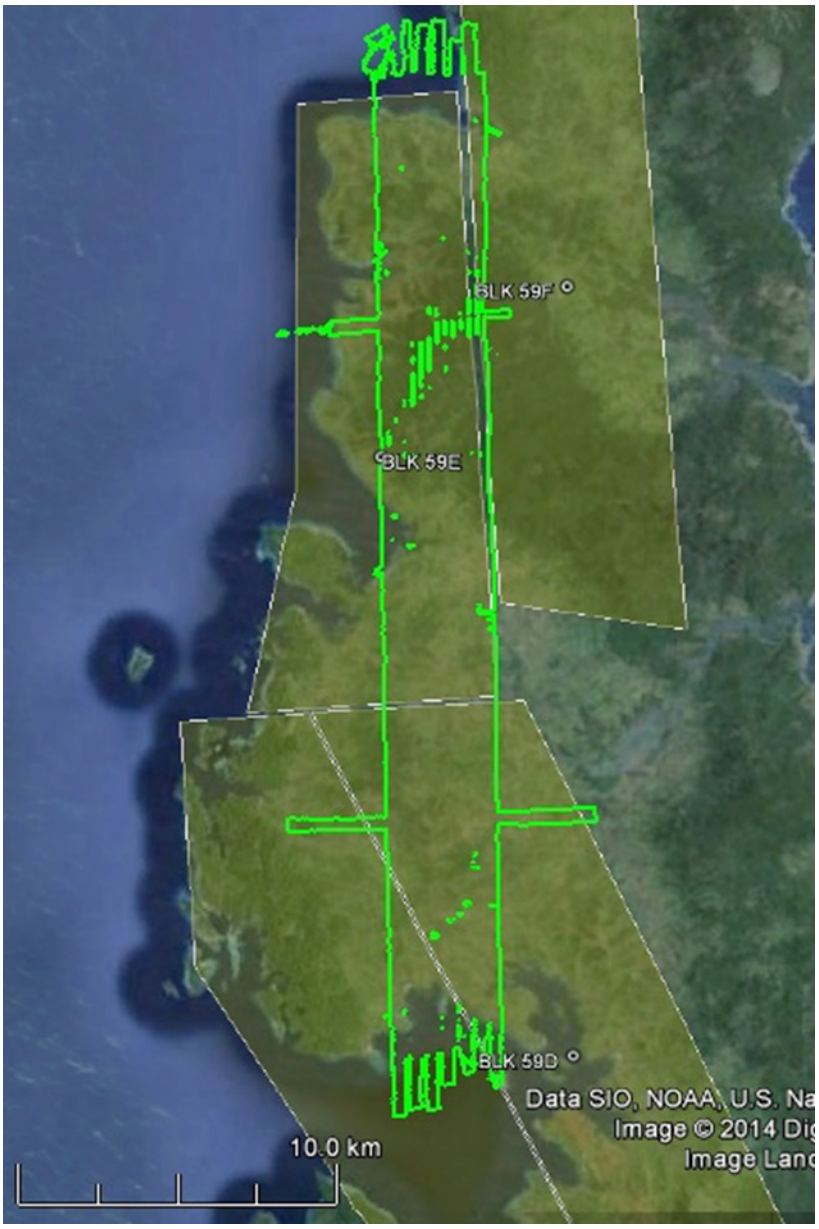


Figure A-7.8. Las for Flight No. 1986A

Flight No. : 1988A

Area: BLK 59E, BLK 59CS, BLK 59DS

Mission Name: 3BLK59ES267B

Parameters: PRF 50 SF 45 SCA 18

LAS BOUNDARY

Figure A-7.9.Las for Flight No. 1988A

Flight No. : 1998A

Area: BLK 59F

Mission Name: 3BLK59F270A

Parameters: PRF 50 SF 45 SCA 18

LAS BOUNDARY

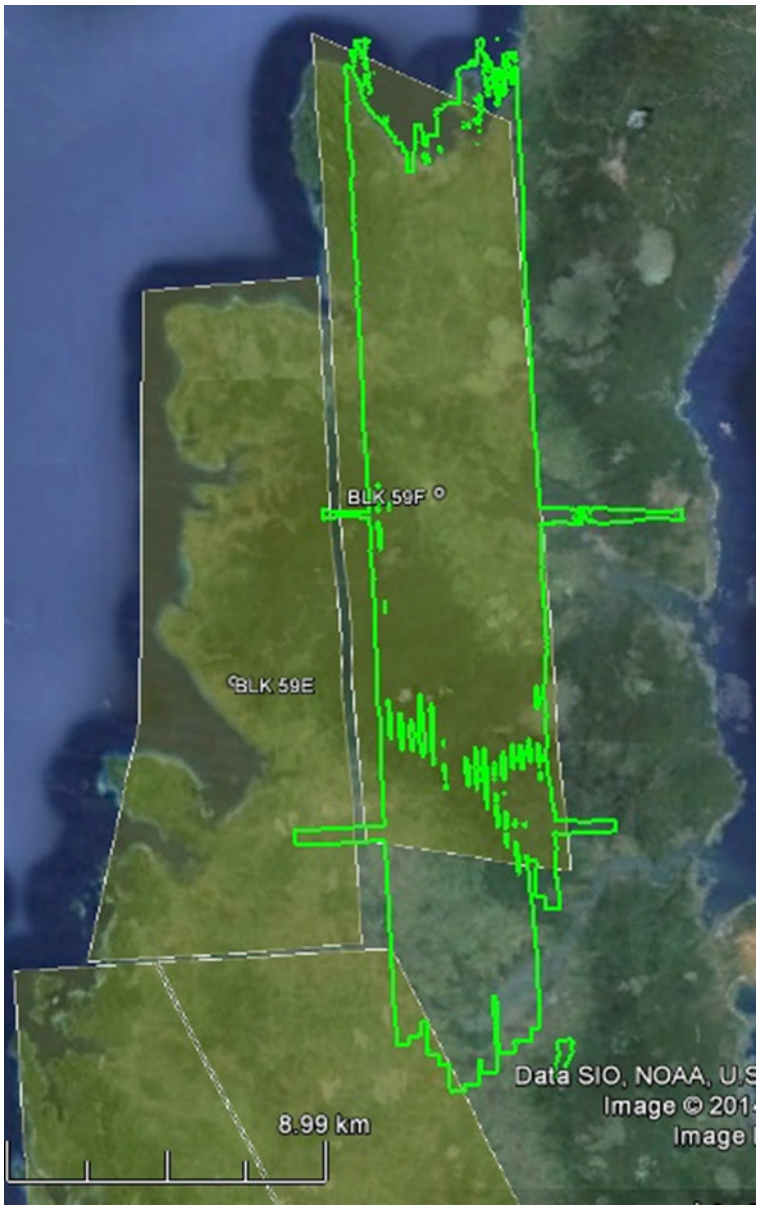


Figure A-7.10. Las for Flight No. 1998A

Flight No. : 2002A

Area: BLK 59F, BLK 59D

Mission Name: 3BLK59DFS271A

Parameters: PRF 50 SF 45 SCA 18

LAS BOUNDARY

Figure A-7.11. Las for Flight No. 2002A

Flight No. : 2054A

Area: BLK 59ES

Mission Name: 3BLK59S284A

Parameters: PRF 50 SF 45 SCA 18

SWATH

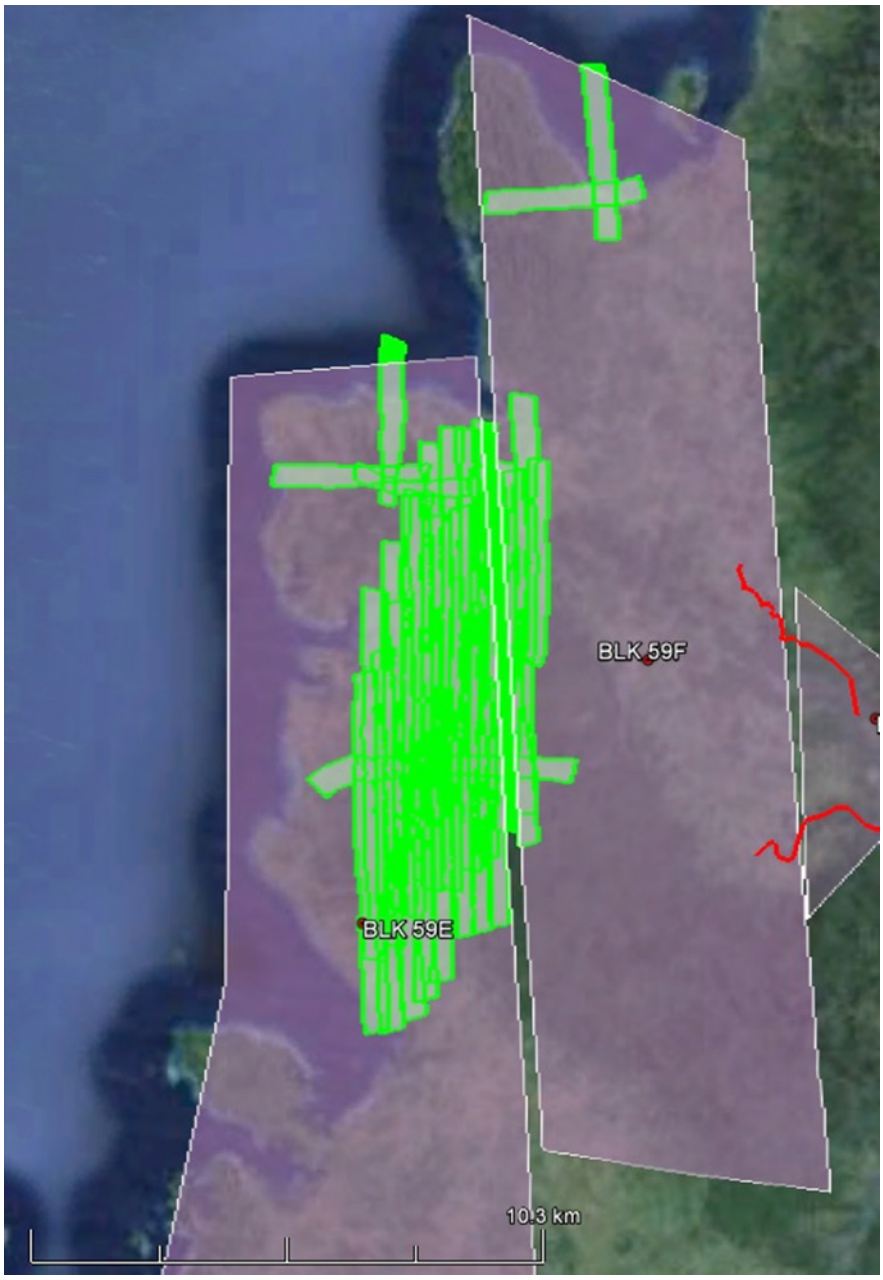


Figure A-7.12. Swath for Flight No. 2054A

Flight No. : 2060A

Area: BLK 59FS

Mission Name: 1BLK59FS285B

Parameters: PRF 50 SF 45 SCA 18

SWATH

Figure A-7.13. Swath for Flight No. 2060A

Flight No. : 2082A

Area: BLK 59F ext

Mission Name: 3BLK59S291A

Parameters: PRF 50 SF 45 SCA 18

SWATH

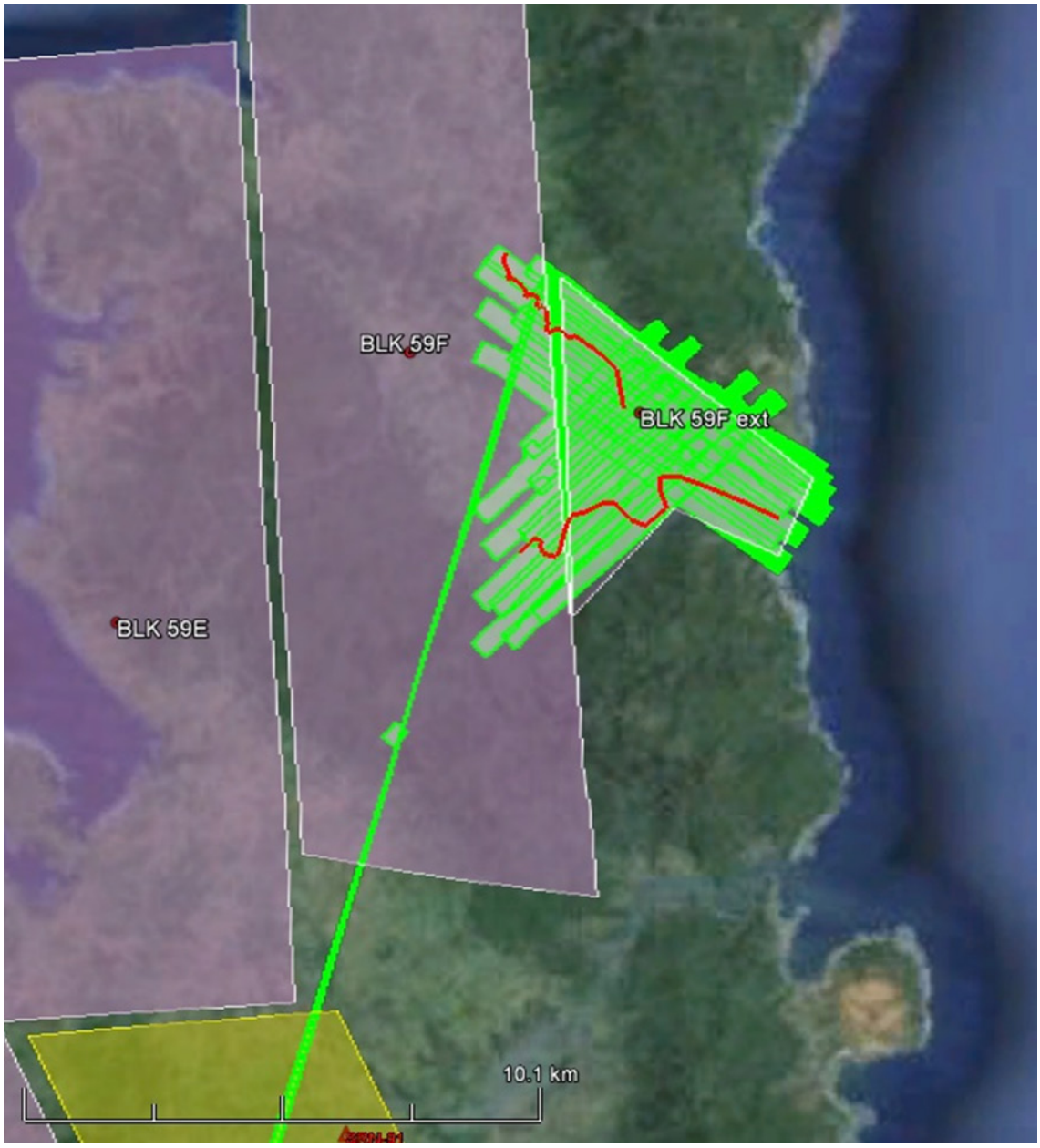


Figure A-7.14. Swath for Flight No. 2082A

Flight No. : 2090A

Area: BLK 59F ext

Mission Name: 3BLK59DS293A

Parameters: PRF 50 SF 45 SCA 18

SWATH

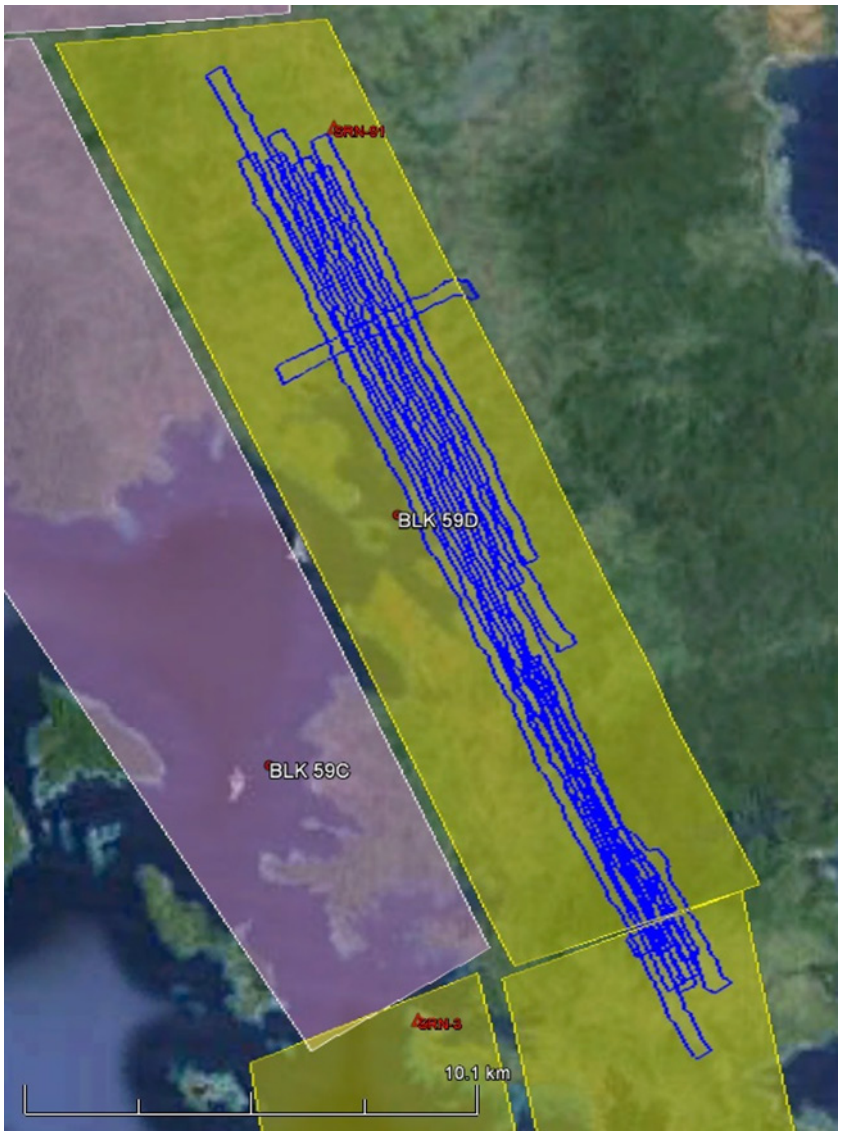


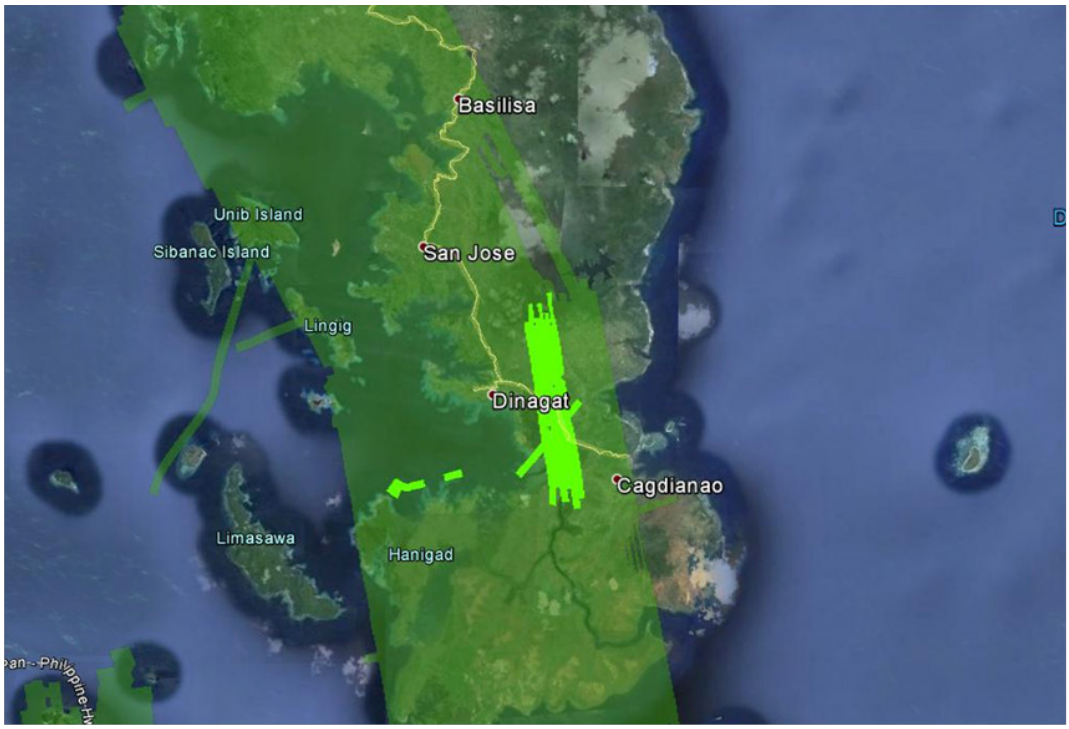
Figure A-7.15. Swath for Flight No. 2090A

Flight No. : 8493

Area: DINAGAT

Mission Name: 3DNGB135A

Parameters: ALT: 500 SCAN FREQ: 45 SCAN ANGLE: 18



START	STOP	LINE#	ALT	PRF	FREQ	ANGLE	MP	DIV	RC	MPM	HDG	Plan File
01:12:11.159	01:12:35.469	1	587	50	45.00	18.00	OFF	NAR	ON	OFF	351.00	dinagat.pln
01:12:47.549	01:13:06.999	1	585	50	45.00	18.00	OFF	NAR	ON	OFF	351.00	dinagat.pln
01:16:59.772	01:19:18.857	13	587	50	45.00	18.00	OFF	NAR	ON	OFF	171.00	dinagat.pln
01:21:54.746	01:24:13.605	12	589	50	45.00	18.00	OFF	NAR	ON	OFF	351.00	dinagat.pln
01:27:04.599	01:29:25.603	11	589	50	45.00	18.00	OFF	NAR	ON	OFF	351.00	dinagat.pln
01:27:04.599	01:29:25.603	11	589	50	45.00	18.00	OFF	NAR	ON	OFF	171.00	dinagat.pln
01:32:12.772	01:34:27.971	10	588	50	45.00	18.00	OFF	NAR	ON	OFF	171.00	dinagat.pln
01:37:24.77	01:39:54.884	9	586	50	45.00	18.00	OFF	NAR	ON	OFF	351.00	dinagat.pln
01:37:24.77	01:39:54.884	9	586	50	45.00	18.00	OFF	NAR	ON	OFF	171.00	dinagat.pln
01:42:45.823	01:45:12.772	8	590	50	45.00	18.00	OFF	NAR	ON	OFF	171.00	dinagat.pln
01:46:59.637	01:48:21.296	8	588	50	45.00	18.00	OFF	NAR	ON	OFF	171.00	dinagat.pln

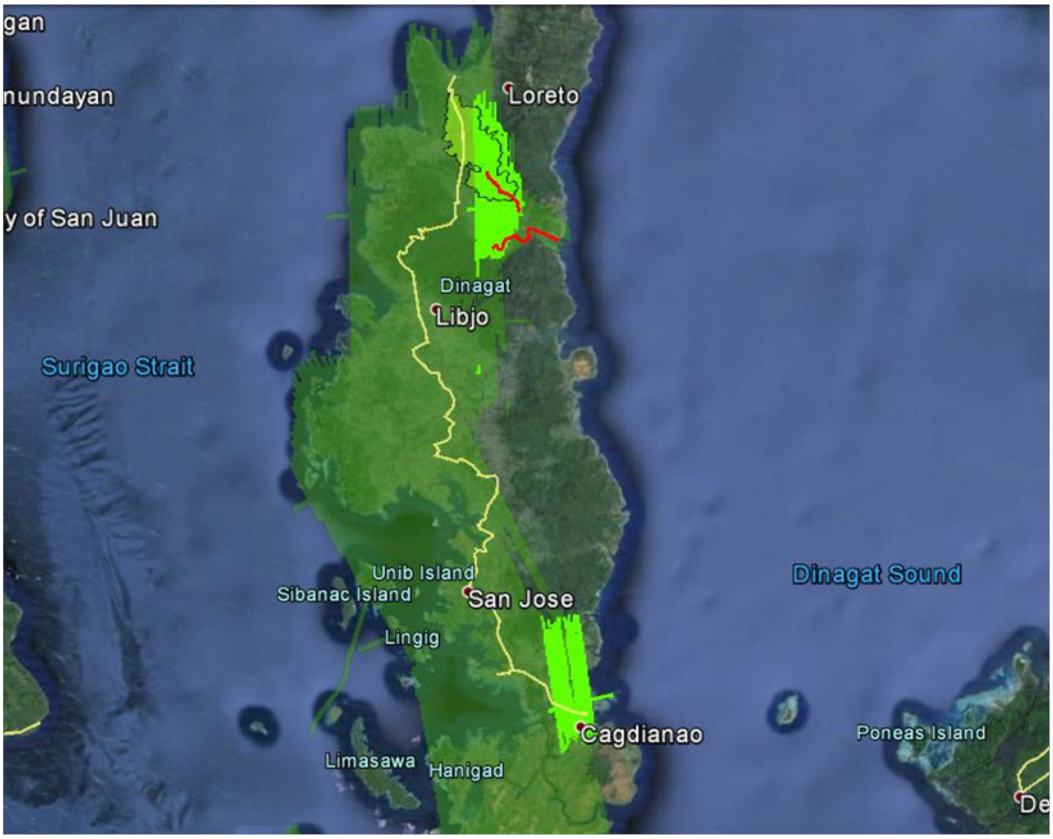
Figure A-7.16. Swath for Flight No. 8493

Flight No. : 8497

Area: DINAGAT

Mission Name: 3DNGABSC137A

Parameters: ALT: 500 SCAN FREQ: 45 SCAN ANGLE: 18



START	STOP	LINE#	ALT	PRF	FREQ	ANGLE	MP	DIV	RC	MPM	HDG	Plan File
01:08:30.839	01:08:46.499	27	587	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:10:33.418	01:14:20.841	27	585	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:10:33.418	01:14:20.841	27	585	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:10:33.418	01:14:20.841	27	585	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:10:33.418	01:14:20.841	27	585	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:16:57.02	01:20:20.364	28	585	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:16:57.02	01:20:20.364	28	585	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:24:36.307	01:27:53.191	29	585	50	45.00	18.00	OFF	NAR	ON	OFF	179.00	dinagat priority areas.pln
01:24:36.307	01:27:53.191	29	585	50	45.00	18.00	OFF	NAR	ON	OFF	179.00	dinagat priority areas.pln
01:24:36.307	01:27:53.191	29	585	50	45.00	18.00	OFF	NAR	ON	OFF	179.00	dinagat priority areas.pln
01:30:14.535	01:33:37.244	30	587	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:30:14.535	01:33:37.244	30	587	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:37:36.702	01:40:44.706	31	587	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:37:36.702	01:40:44.706	31	587	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:42:55.22	01:46:05.674	32	585	50	45.00	18.00	OFF	NAR	ON	OFF	179.00	dinagat priority areas.pln
01:49:44.303	01:52:39.732	32	584	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
01:55:02.281	01:58:13.53	33	584	50	45.00	18.00	OFF	NAR	ON	OFF	179.00	dinagat priority areas.pln
02:02:00.314	02:04:58.398	34	596	50	45.00	18.00	OFF	NAR	ON	OFF	179.00	dinagat priority areas.pln
02:02:00.314	02:04:58.398	34	597	50	45.00	18.00	OFF	NAR	ON	OFF	179.00	dinagat priority areas.pln
02:06:58.622	02:09:40.201	35	600	50	45.00	18.00	OFF	NAR	ON	OFF	179.00	dinagat priority areas.pln
02:12:22.54	02:14:56.484	36	587	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln
02:17:06.794	02:19:17.928	37	604	50	45.00	18.00	OFF	NAR	ON	OFF	359.00	dinagat priority areas.pln

Figure A-7.17. Swath for Flight No. 8497

Flight No. : 8499

Area: DINAGAT

Mission Name: 3DNGDE138A

Parameters: ALT: 500 SCAN FREQ: 45 SCAN ANGLE: 18

START	STOP	LINE#	ALT	PRF	FREQ	ANGLE	MP	DIV	RC	MPM	HDG	Plan File
02:13:04.198	02:15:21.882	1	595	50	45.00	18.00	OFF	NAR	ON	OFF	235.99	additional_dinagat.pln
02:17:59.071	02:20:06.216	2	593	50	45.00	18.00	OFF	NAR	ON	OFF	55.99	additional_dinagat.pln
02:22:50.04	02:25:32.509	3	596	50	45.00	18.00	OFF	NAR	ON	OFF	235.99	additional_dinagat.pln
02:22:50.04	02:25:32.509	3	597	50	45.00	18.00	OFF	NAR	ON	OFF	235.99	additional_dinagat.pln
02:22:50.04	02:25:32.509	3	598	50	45.00	18.00	OFF	NAR	ON	OFF	235.99	additional_dinagat.pln
02:22:50.04	02:25:32.509	3	599	50	45.00	18.00	OFF	NAR	ON	OFF	235.99	additional_dinagat.pln
02:27:45.938	02:29:53.832	4	593	50	45.00	18.00	OFF	NAR	ON	OFF	235.99	additional_dinagat.pln
02:32:42.366	02:35:00.496	5	592	50	45.00	18.00	OFF	NAR	ON	OFF	235.99	additional_dinagat.pln
02:37:41.915	02:39:38.014	6	592	50	45.00	18.00	OFF	NAR	ON	OFF	55.99	additional_dinagat.pln
02:42:29.943	02:44:58.303	7	591	50	45.00	18.00	OFF	NAR	ON	OFF	235.99	additional_dinagat.pln
02:42:29.943	02:44:58.303	7	590	50	45.00	18.00	OFF	NAR	ON	OFF	235.99	additional_dinagat.pln
02:47:21.077	02:49:24.806	6	591	50	45.00	18.00	OFF	NAR	ON	OFF	56.00	additional_dinagat.pln
02:52:28.785	02:54:47.725	7	591	50	45.00	18.00	OFF	NAR	ON	OFF	236.00	additional_dinagat.pln
02:57:24.414	02:59:27.243	8	590	50	45.00	18.00	OFF	NAR	ON	OFF	56.00	additional_dinagat.pln
03:02:12.918	03:04:28.017	9	592	50	45.00	18.00	OFF	NAR	ON	OFF	236.00	additional_dinagat.pln
03:07:09.611	03:09:12.581	10	591	50	45.00	18.00	OFF	NAR	ON	OFF	56.00	additional_dinagat.pln
03:12:00.325	03:14:13.944	11	591	50	45.00	18.00	OFF	NAR	ON	OFF	236.00	additional_dinagat.pln
03:16:56.038	03:18:54.003	12	591	50	45.00	18.00	OFF	NAR	ON	OFF	56.00	additional_dinagat.pln
03:21:47.132	03:23:57.071	13	591	50	45.00	18.00	OFF	NAR	ON	OFF	56.00	additional_dinagat.pln
03:25:49.721	03:27:16.32	13	593	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
03:29:51.305	03:32:06.079	14	591	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
03:34:55.298	03:37:16.298	15	594	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
03:34:55.298	03:37:16.298	15	593	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
03:39:57.242	03:42:09.551	16	590	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
03:44:58.165	03:47:16.925	16	590	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
03:50:00.894	03:52:16.268	17	590	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
03:55:11.948	03:57:41.017	18	588	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
04:00:34.181	04:02:51.74	19	587	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
04:00:34.181	04:02:51.74	19	587	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
04:05:25.21	04:07:47.689	20	586	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
04:10:38.018	04:12:57.203	21	585	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
04:15:48.582	04:17:58.431	22	586	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
04:20:17.356	04:22:36.185	23	582	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
04:25:08.869	04:27:31.749	24	585	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
04:29:56.983	04:32:15.667	25	583	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
04:34:44.927	04:37:11.496	26	575	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
04:34:44.927	04:37:11.496	26	576	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
04:34:44.927	04:37:11.496	26	577	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
04:39:43.105	04:42:10.045	27	582	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
04:44:30.984	04:46:16.158	27	584	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
04:49:26.473	04:51:42.017	18	577	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
04:54:17.241	04:55:22.101	19	578	50	45.00	18.00	OFF	NAR	ON	OFF	188.00	additional_dinagat.pln
04:59:04.24	05:00:29.3	21	579	50	45.00	18.00	OFF	NAR	ON	OFF	8.00	additional_dinagat.pln
05:05:35.363	05:06:44.603	30	576	50	45.00	18.00	OFF	NAR	ON	OFF	101.07	additional_dinagat.pln
05:09:24.137	05:10:31.217	30	580	50	45.00	18.00	OFF	NAR	ON	OFF	281.07	additional_dinagat.pln
05:13:01.016	05:14:13.361	30	584	50	45.00	18.00	OFF	NAR	ON	OFF	101.07	additional_dinagat.pln
05:17:35.245	05:18:41.555	29	580	50	45.00	18.00	OFF	NAR	ON	OFF	281.07	additional_dinagat.pln

Figure A-7.18. Swath for Flight No. 8499

Annex 8. Mission Summary Reports

Table A-8.1. Mission Summary Report for Mission Blk59F

Flight Area	Surigao City
Mission Name	Blk59F (Siargao)
Inclusive Flights	1998A, 2002A, 2060A & 2082A
Range data size	34.49 GB
Base data size	52.24 MB
POS	757 MB
Image	NA
Transfer date	October 31, 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)	1.90
RMSE for East Position (<4.0 cm)	2.60
RMSE for Down Position (<8.0 cm)	5.40
Boresight correction stdev (<0.001deg)	0.000599
IMU attitude correction stdev (<0.001deg)	0.026449
GPS position stdev (<0.01m)	0.0354
Minimum % overlap (>25)	49.39
Ave point cloud density per sq.m. (>2.0)	3.58
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	88
Maximum Height	491.32 m
Minimum Height	61.97 m
Classification (# of points)	
Ground	18,621,501
Low vegetation	14,653,423
Medium vegetation	38,755,029
High vegetation	94,542,606
Building	2,540,120
Orthophoto	No
Processed by	Engr. Analyn Naldo, Engr. Chelou Prado, Engr. Jeffrey Delica

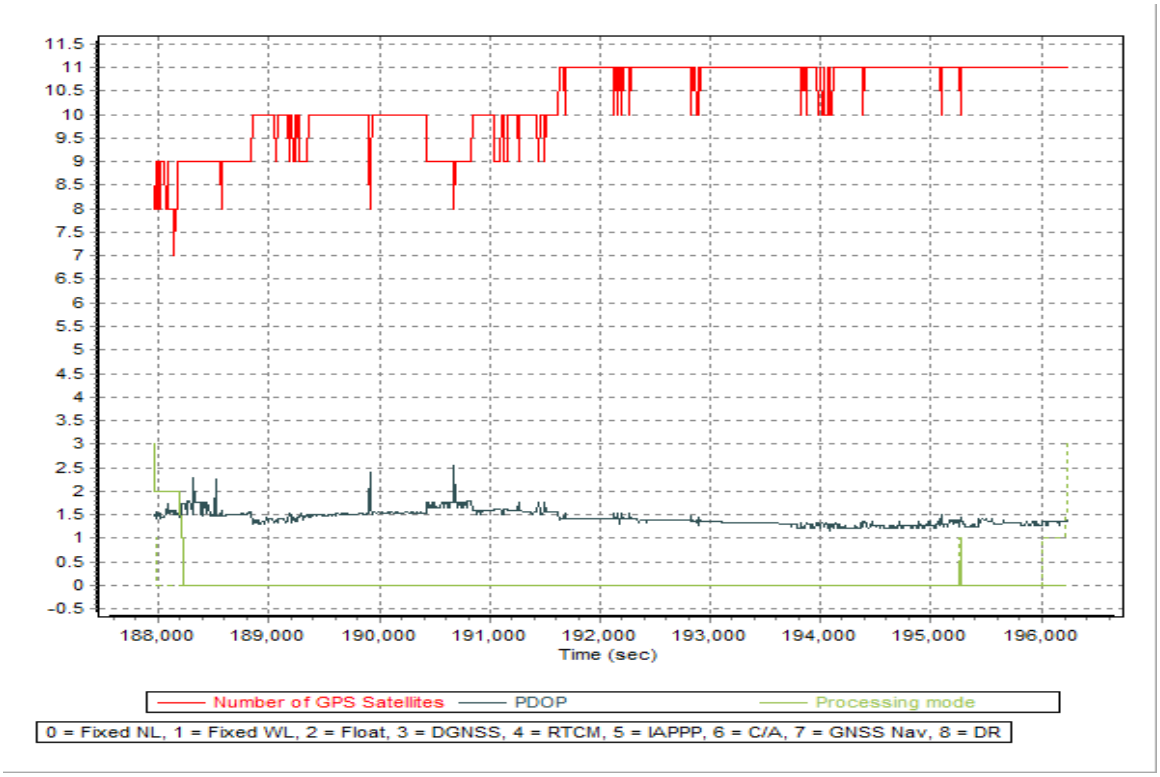


Figure A-8.1 Solution Status

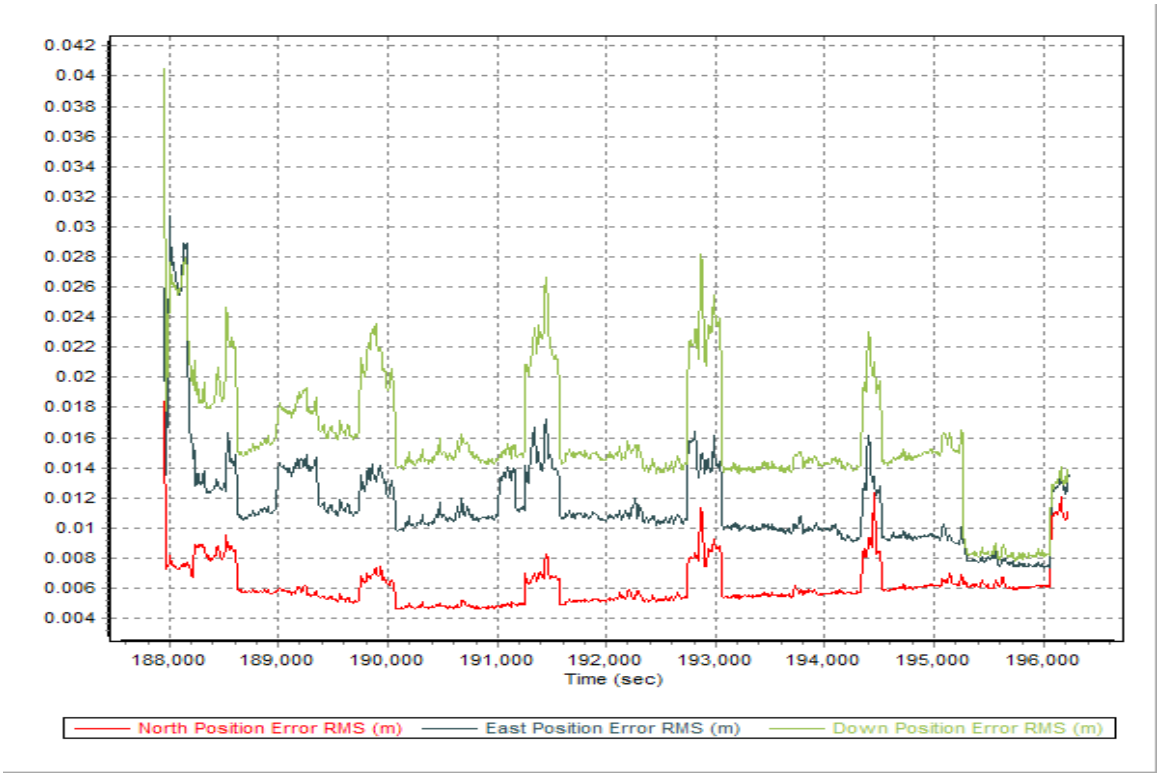


Figure A-8.2 Smoothed Performance Metric Parameters

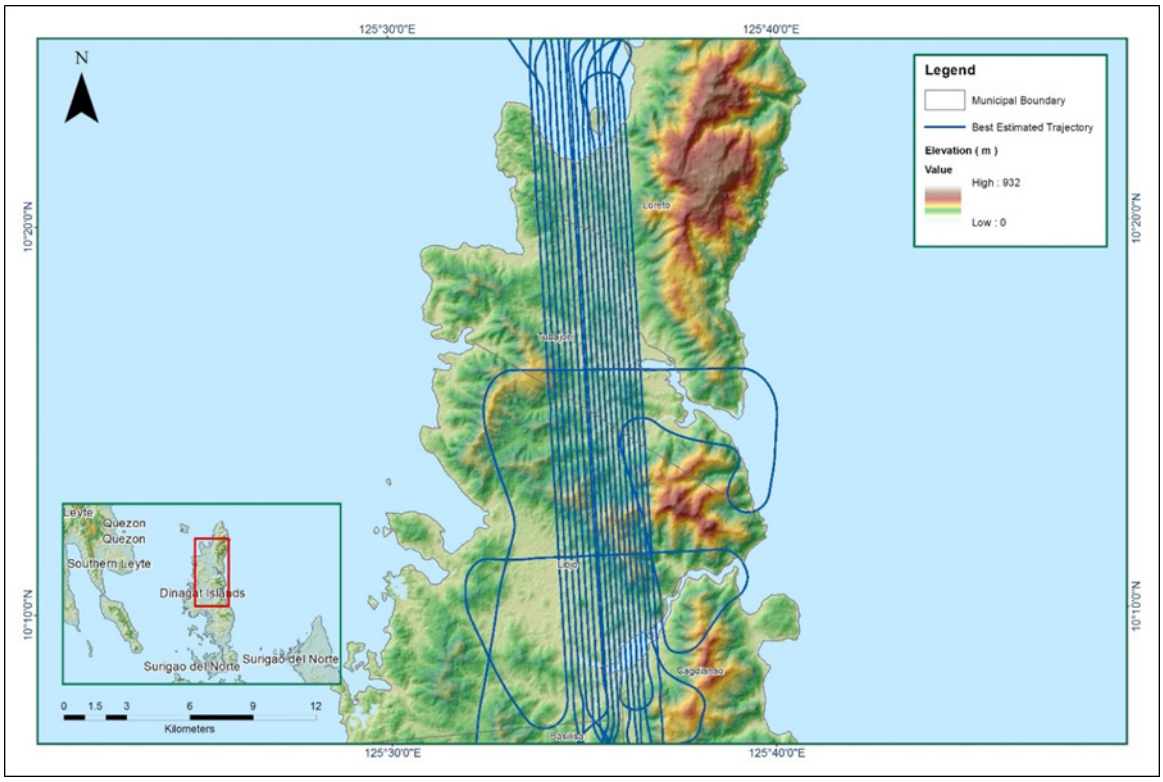


Figure A-8.3 Best Estimated Trajectory

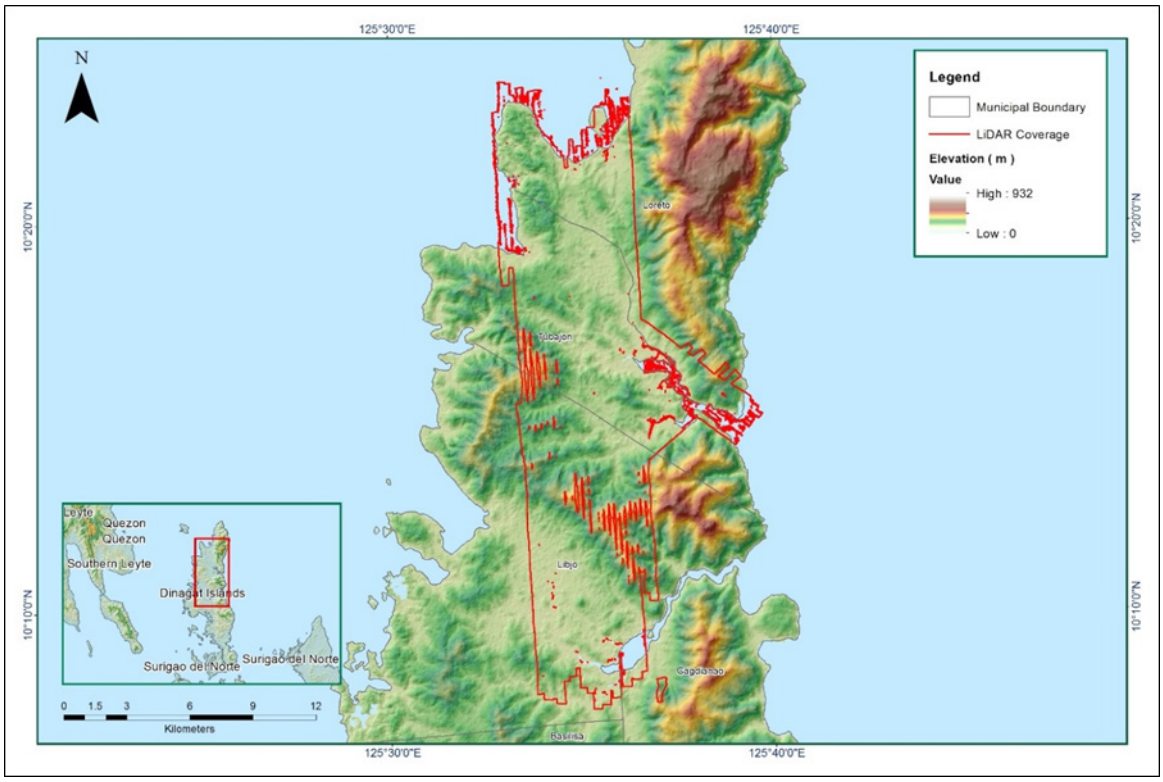


Figure A-8.4 Coverage of LiDAR data

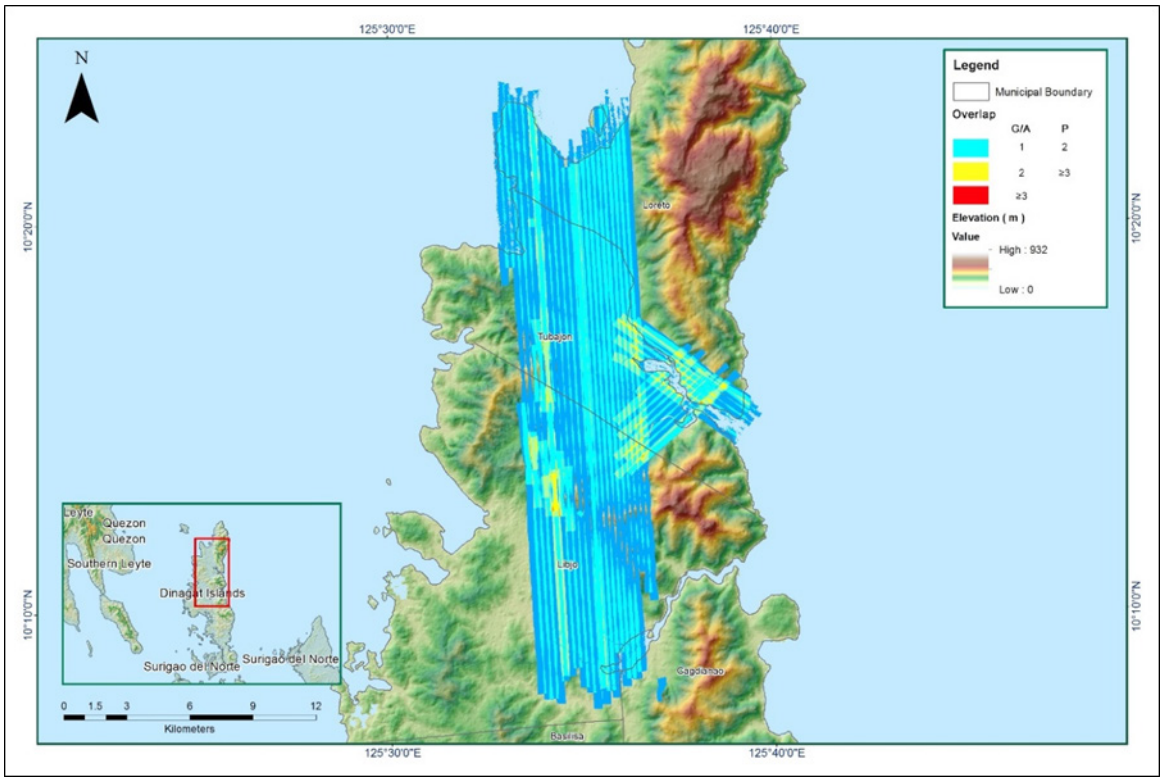


Figure A-8.5 Image of data overlap

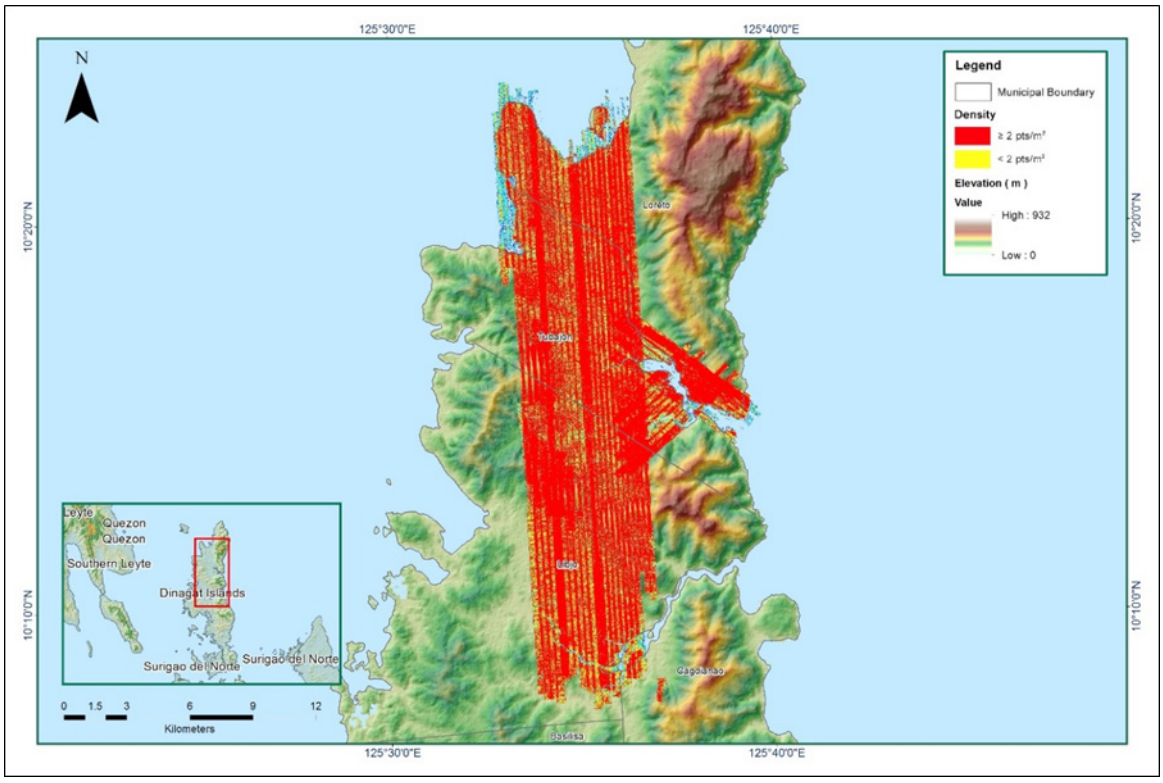


Figure A-8.6 Density map of merged LiDAR data

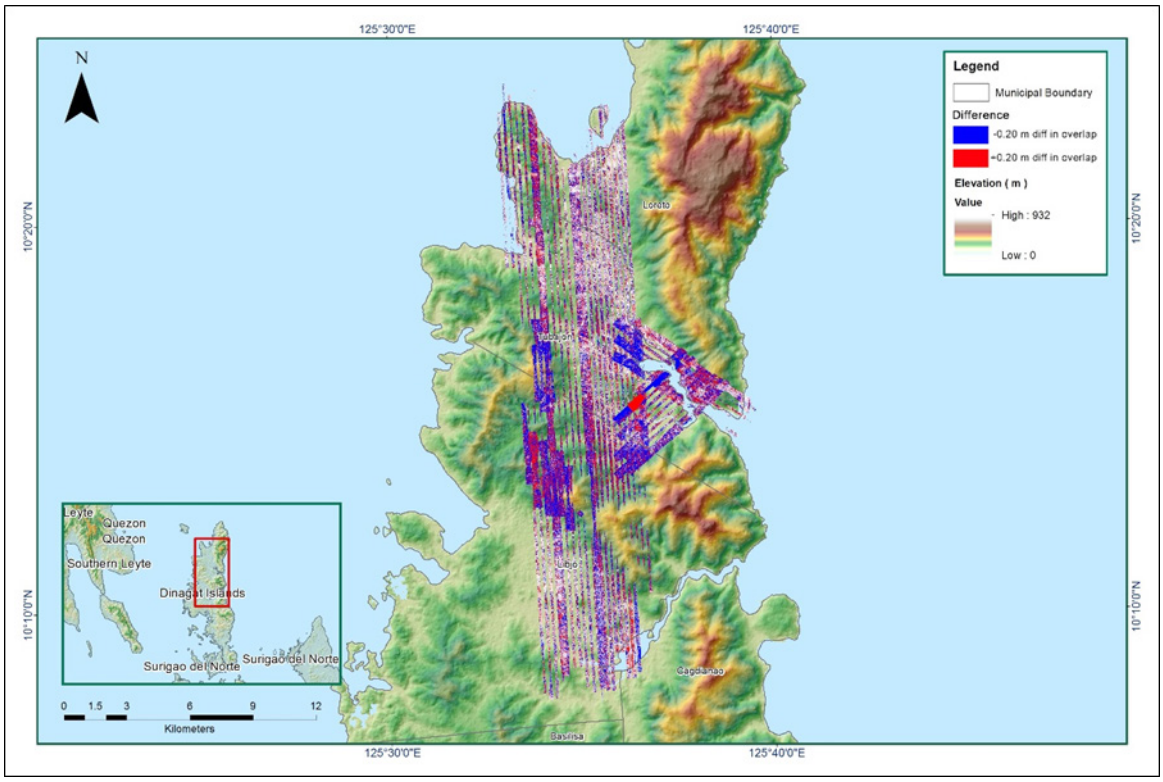


Figure A-8.7 Elevation difference between flight lines

Table A-8.2. Mission Summary Report for Mission Blk59E

Flight Area	**Surigao City**
Mission Name	Blk59E (Siargao)
Inclusive Flights	1986A, 1988A & 2054A
Range data size	31.80 GB
Base data size	53.94 MB
POS	618 MB
Image	NA
Transfer date	October 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)	1.11
RMSE for East Position (<4.0 cm)	1.50
RMSE for Down Position (<8.0 cm)	3.20
Boresight correction stdev (<0.001deg)	0.000238
IMU attitude correction stdev (<0.001deg)	0.003661
GPS position stdev (<0.01m)	0.0098
Minimum % overlap (>25)	52.10
Ave point cloud density per sq.m. (>2.0)	3.88
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	276
Maximum Height	538.01 m
Minimum Height	50.00 m
Classification (# of points)	
Ground	71,106,689
Low vegetation	64,042,937
Medium vegetation	178,736,152
High vegetation	251,642,390
Building	9,196,144
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Engr. Mark Joshua Salvacion, Engr. Elainne Lopez

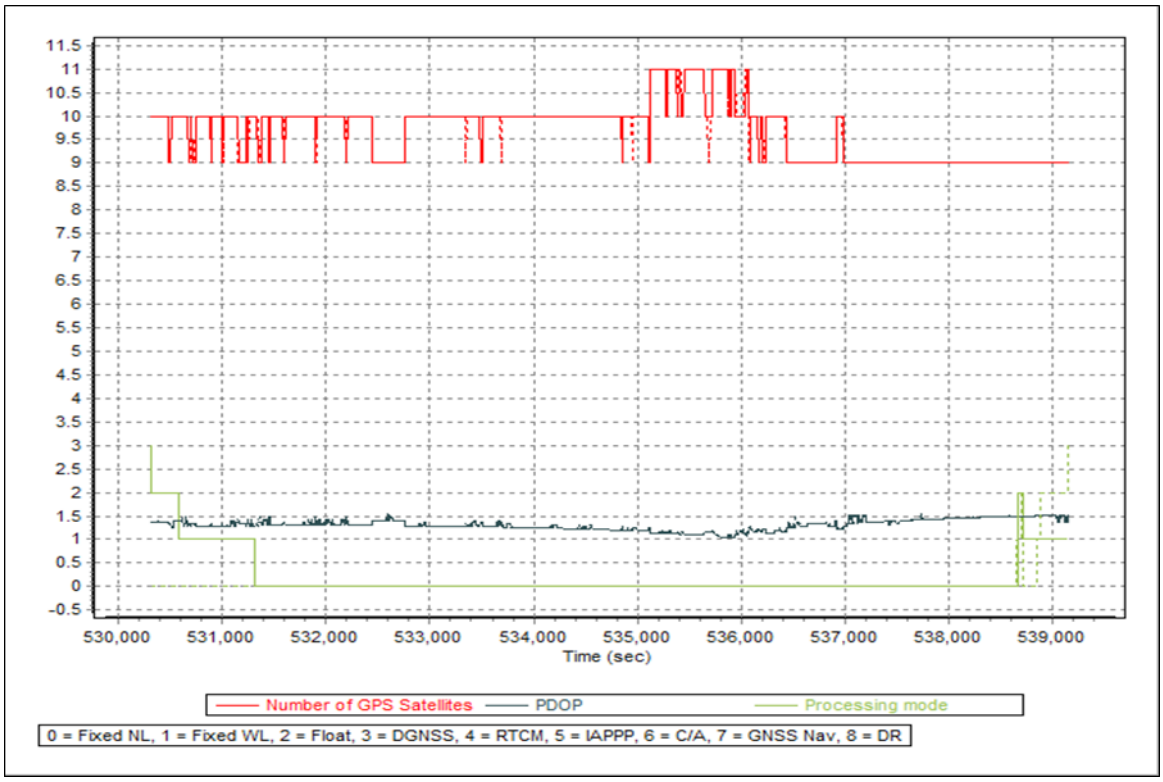


Figure A-8.8 Solution Status

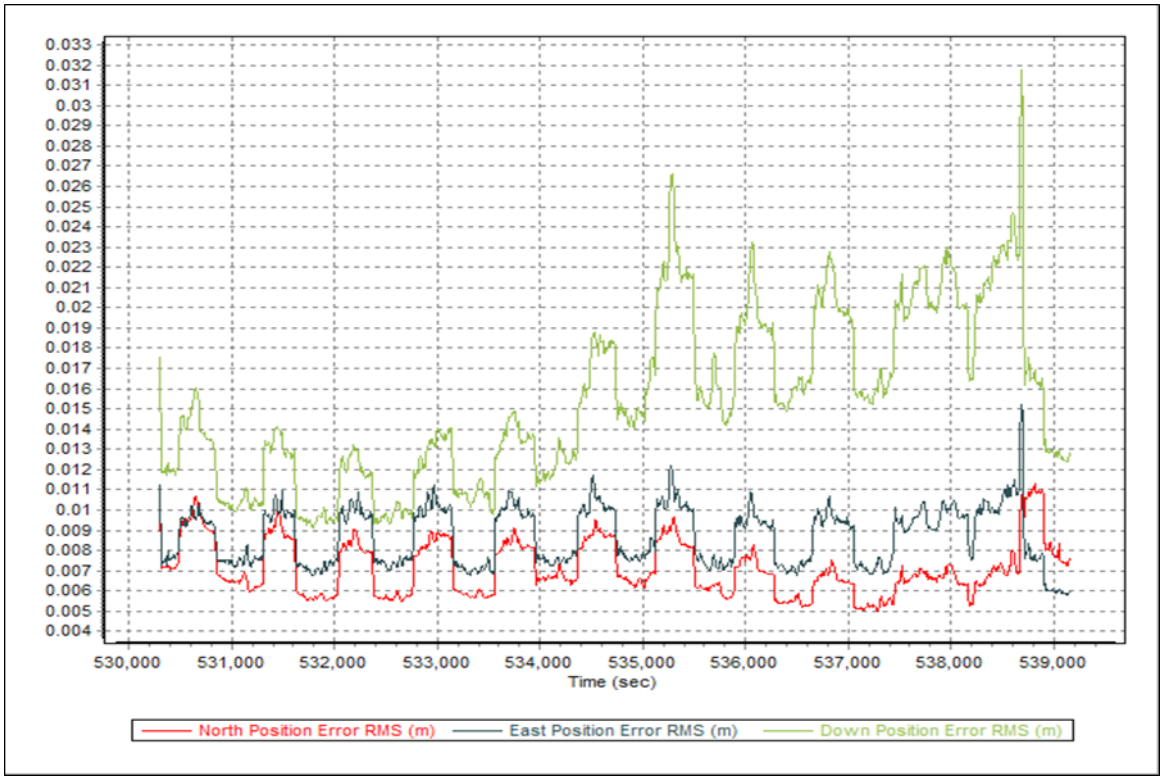


Figure A-8.9 Smoothed Performance Metric Parameters

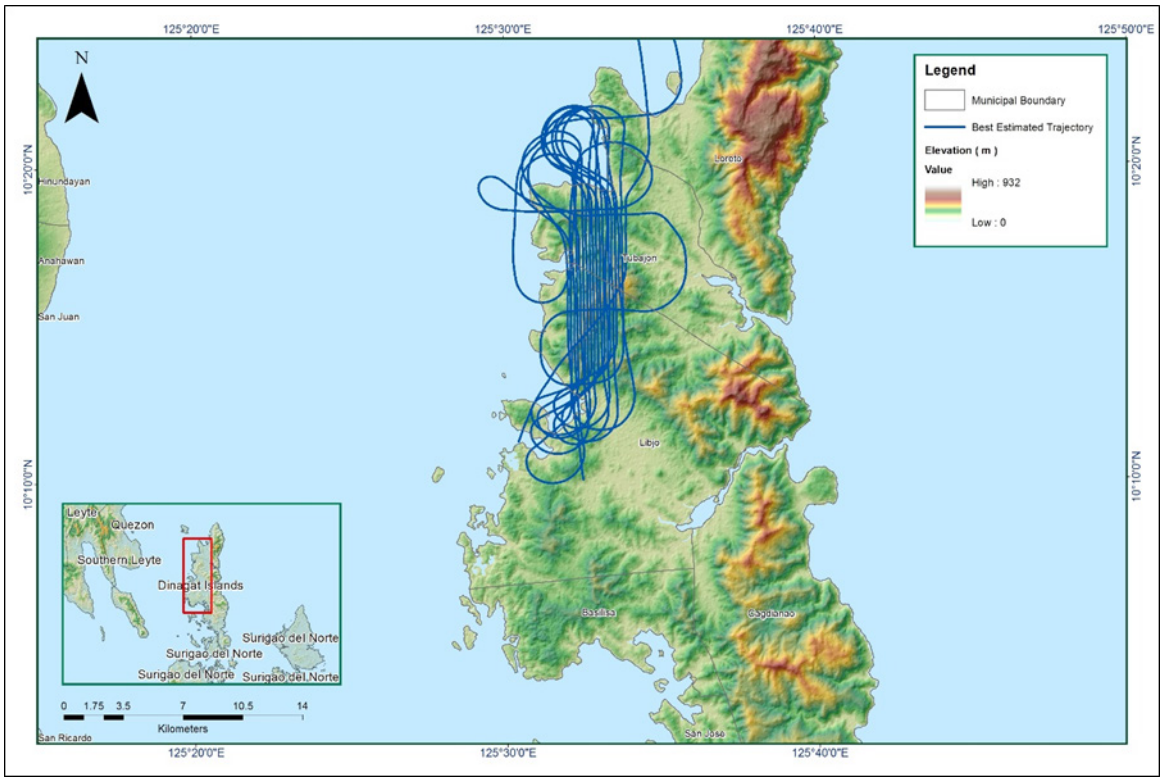


Figure A-8.10 Best Estimated Trajectory

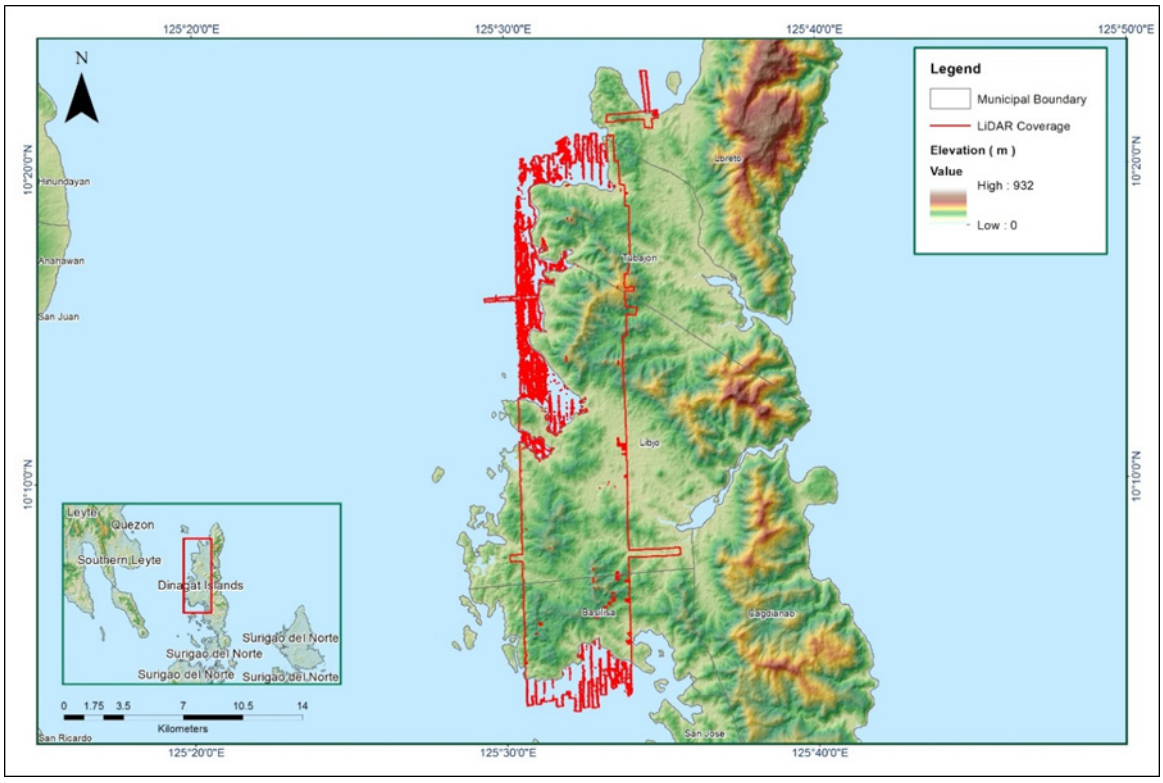


Figure A-8.11 Coverage of LiDAR data

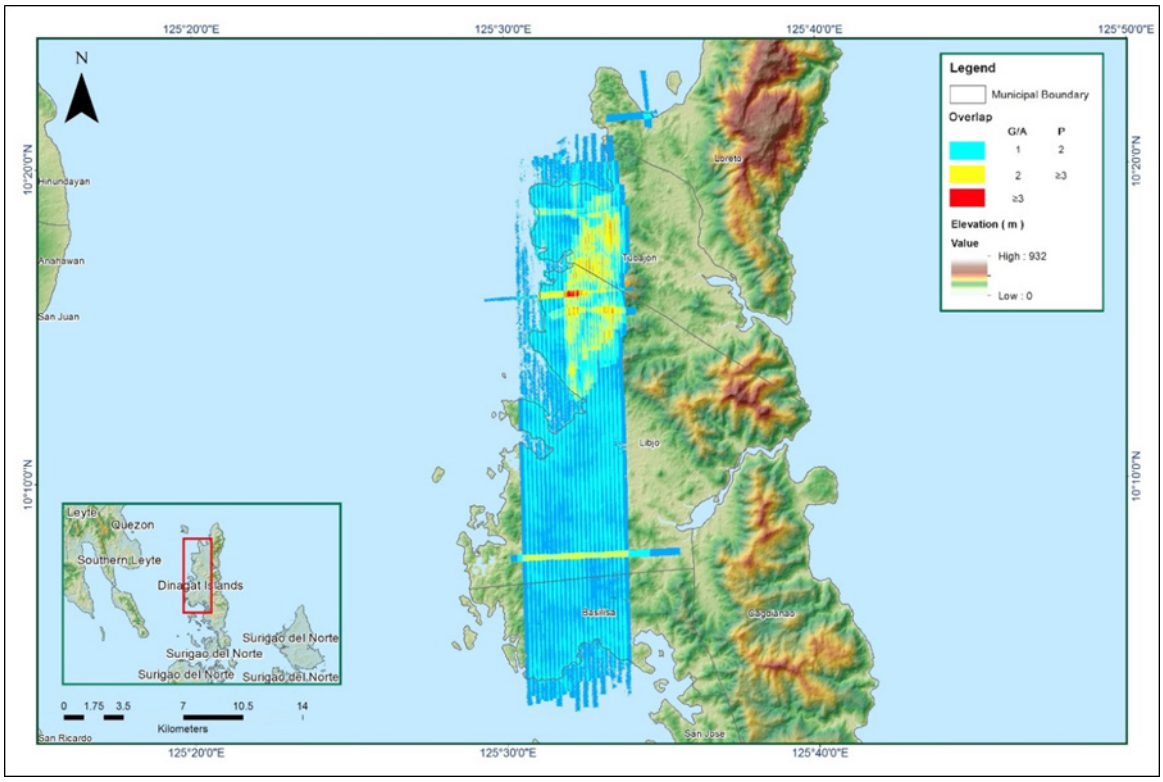


Figure A-8.12 Image of data overlap

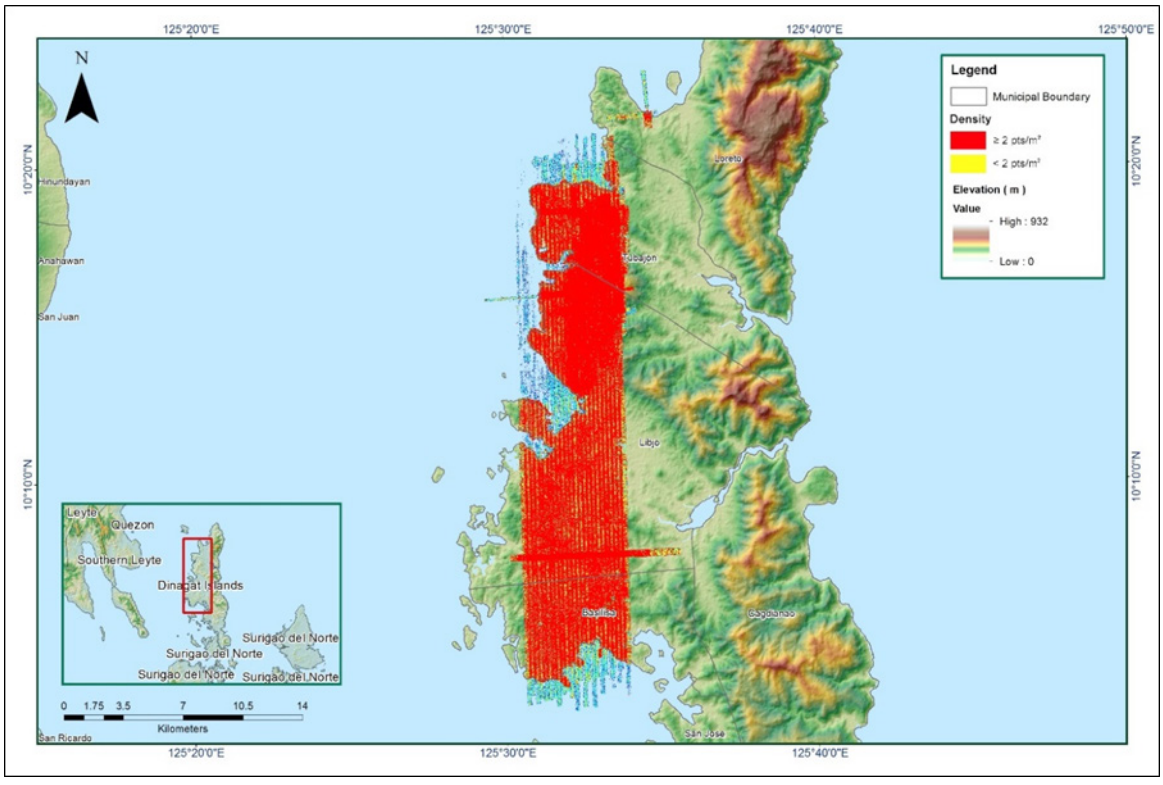


Figure A-8.13 Density map of merged LiDAR data

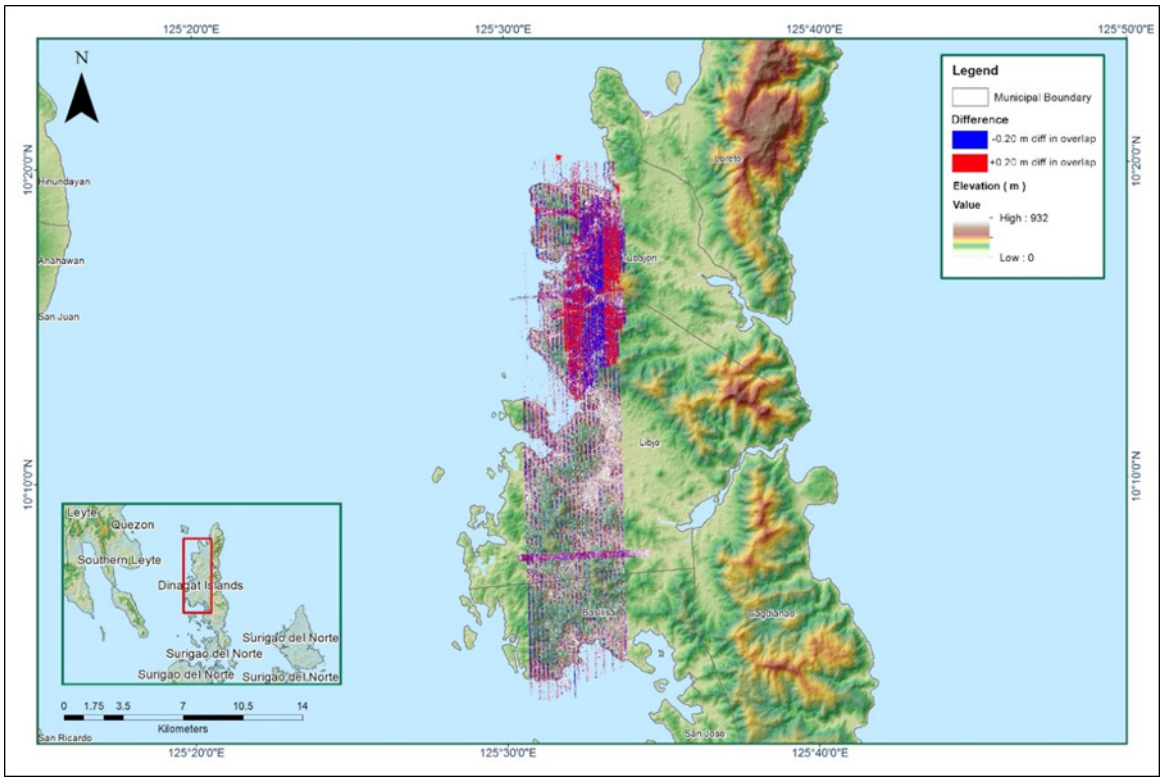


Figure A-8.14 Elevation difference between flight lines

Table A-8.3. Mission Summary Report for Mission Blk59D

Flight Area	**Surigao City**
Mission Name	Blk59D (Siargao)
Inclusive Flights	1950A, 1968A & 2090A
Range data size	22.80 GB
Base data size	24.87 MB
POS	463 MB
Image	NA
Transfer date	October 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)	2.50
RMSE for East Position (<4.0 cm)	2.30
RMSE for Down Position (<8.0 cm)	4.10
Boresight correction stdev (<0.001deg)	0.000306
IMU attitude correction stdev (<0.001deg)	0.001277
GPS position stdev (<0.01m)	0.0077
Minimum % overlap (>25)	50.26
Ave point cloud density per sq.m. (>2.0)	3.36
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	162
Maximum Height	490.27 m
Minimum Height	57.89 m
Classification (# of points)	
Ground	48,787,225
Low vegetation	39,198,579
Medium vegetation	119,905,035
High vegetation	102,741,726
Building	3,144,171
Orthophoto	No
Processed by	Engr. Carlyn Ann Ibañez, Engr. Jommer Medina, Aljon Rie Araneta,Engr. Elainne Lopez

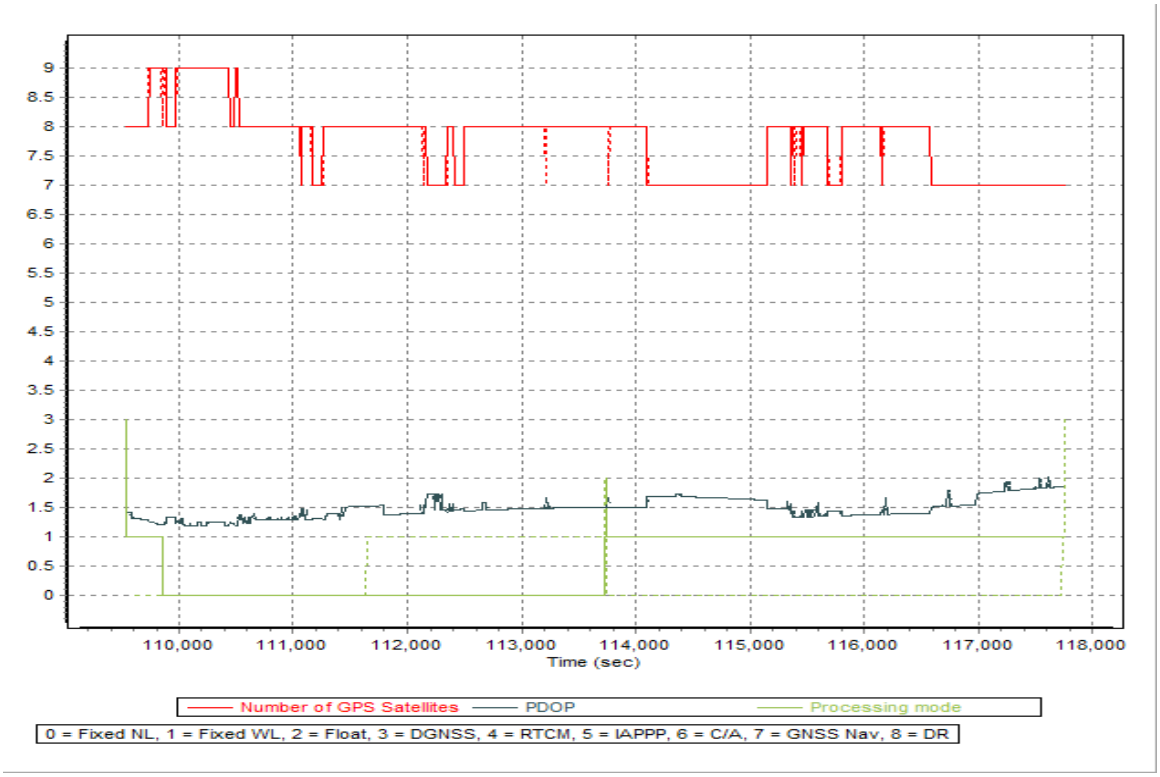


Figure A-8.15 Solution Status

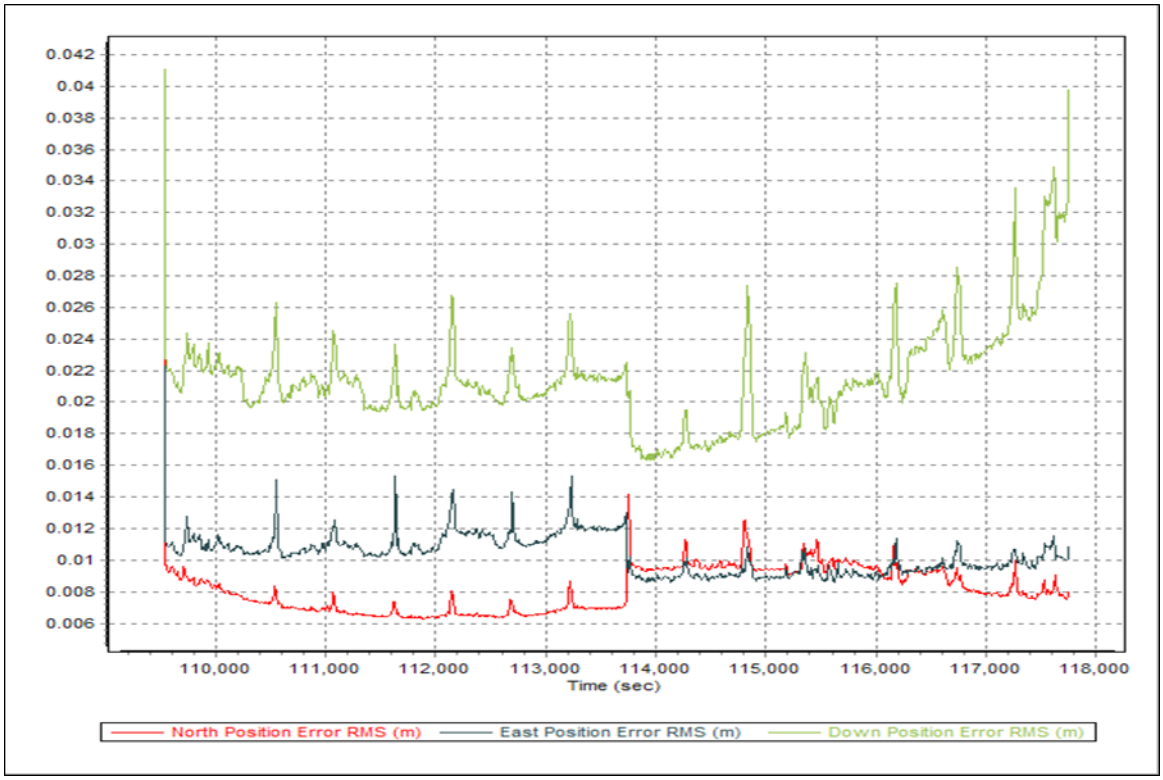


Figure A-8.16 Smoothed Performance Metric Parameters

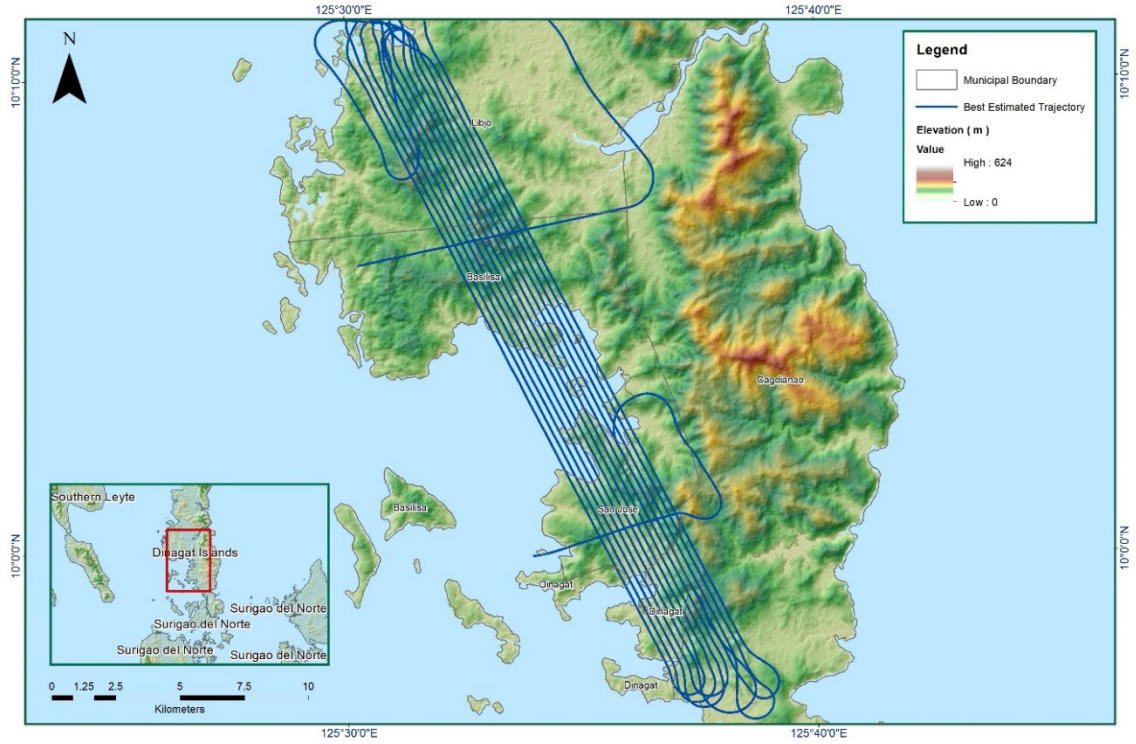


Figure A-8.17 Best Estimated Trajectory

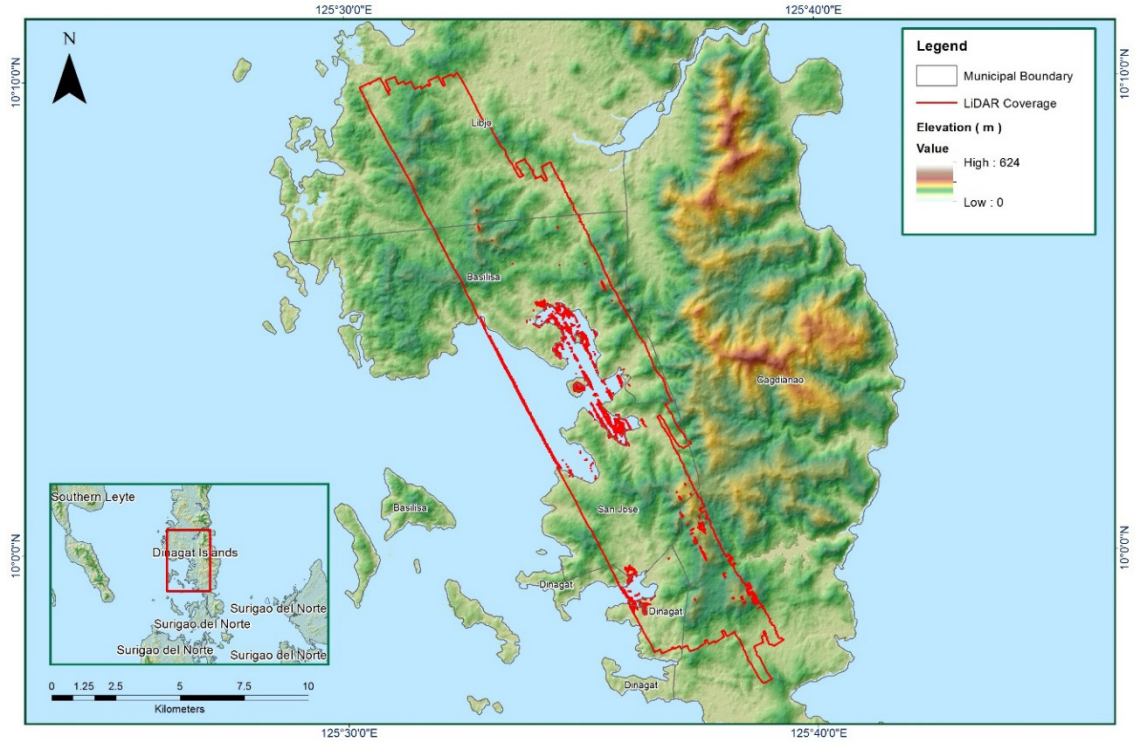


Figure A-8.18 Coverage of LiDAR data

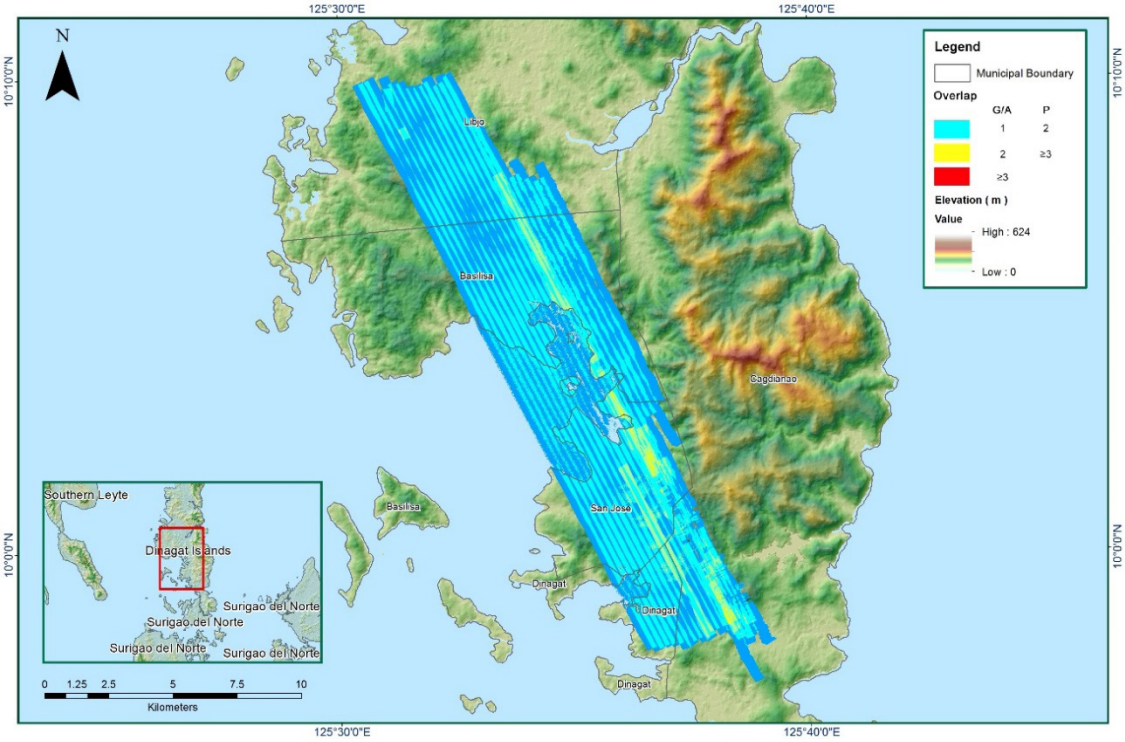


Figure A-8.19 Image of data overlap

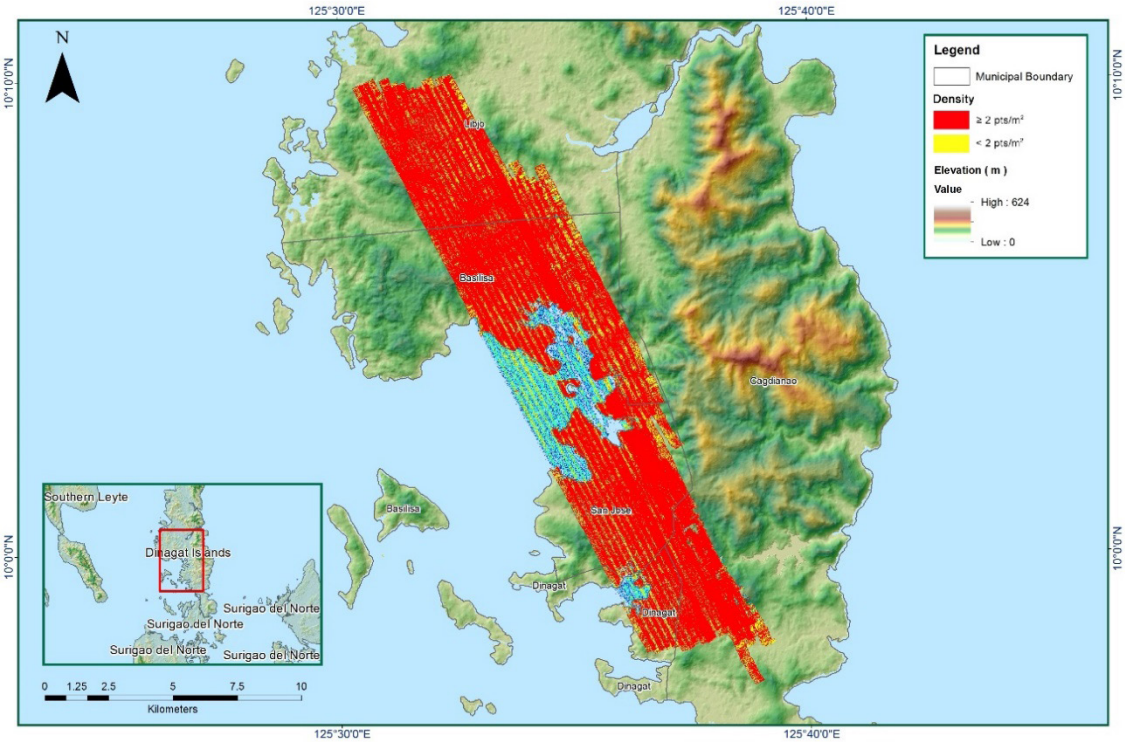


Figure A-8.20 Density map of merged LiDAR data

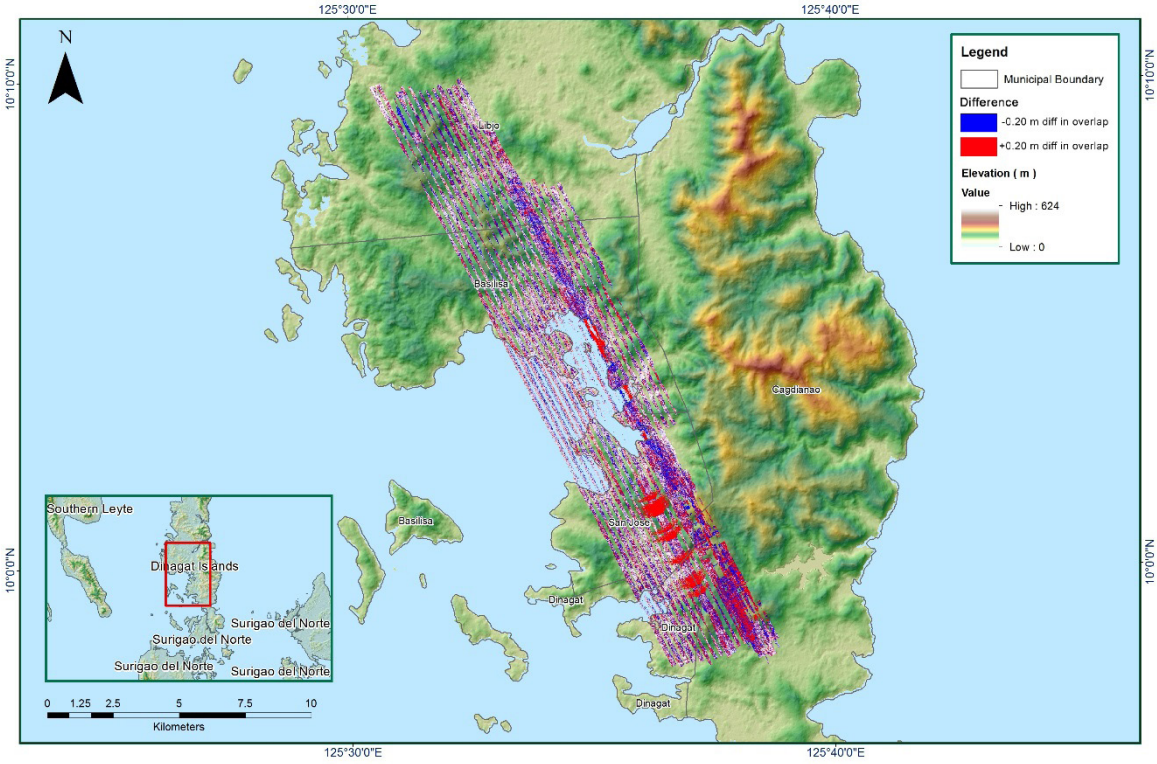


Figure A-8.21 Elevation difference between flight lines

Table A-8.4. Mission Summary Report for Mission Blk59D

Flight Area	**Surigao City**
Mission Name	Blk59D additional (Siargao)
Inclusive Flights	2002A
Range data size	11.7 GB
Base data size	9.74 MB
POS	207 MB
Image	na
Transfer date	October 31, 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)	2.531
RMSE for East Position (<4.0 cm)	2.548
RMSE for Down Position (<8.0 cm)	4.11
Boresight correction stdev (<0.001deg)	0.000599
IMU attitude correction stdev (<0.001deg)	0.246708
GPS position stdev (<0.01m)	0.0354
Minimum % overlap (>25)	14.63
Ave point cloud density per sq.m. (>2.0)	3.17
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	60
Maximum Height	507.04
Minimum Height	64.70
Classification (# of points)	
Ground	10,736,552
Low vegetation	3,776,076,
Medium vegetation	14,749,632
High vegetation	29,177,441
Building	203,630
Orthophoto	No
Processed by	Engr. Analyn Naldo, Engr. Edgardo Gubatanga Jr., Engr. Monalyne Rabino

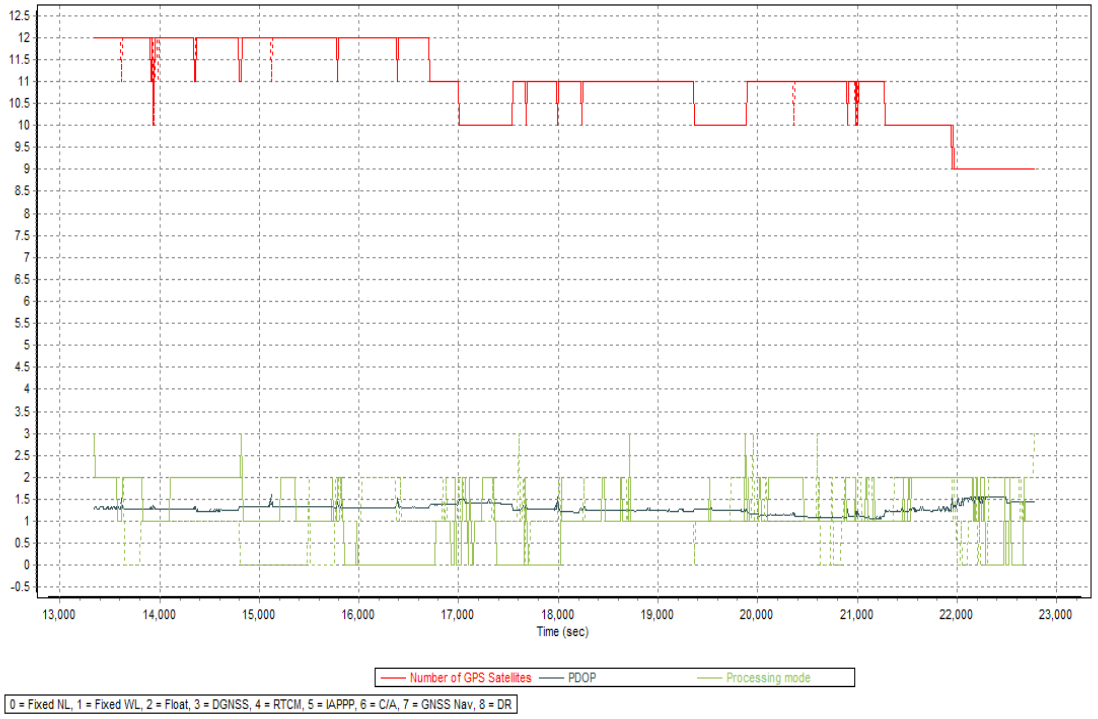


Figure A-8.22 Solution Status

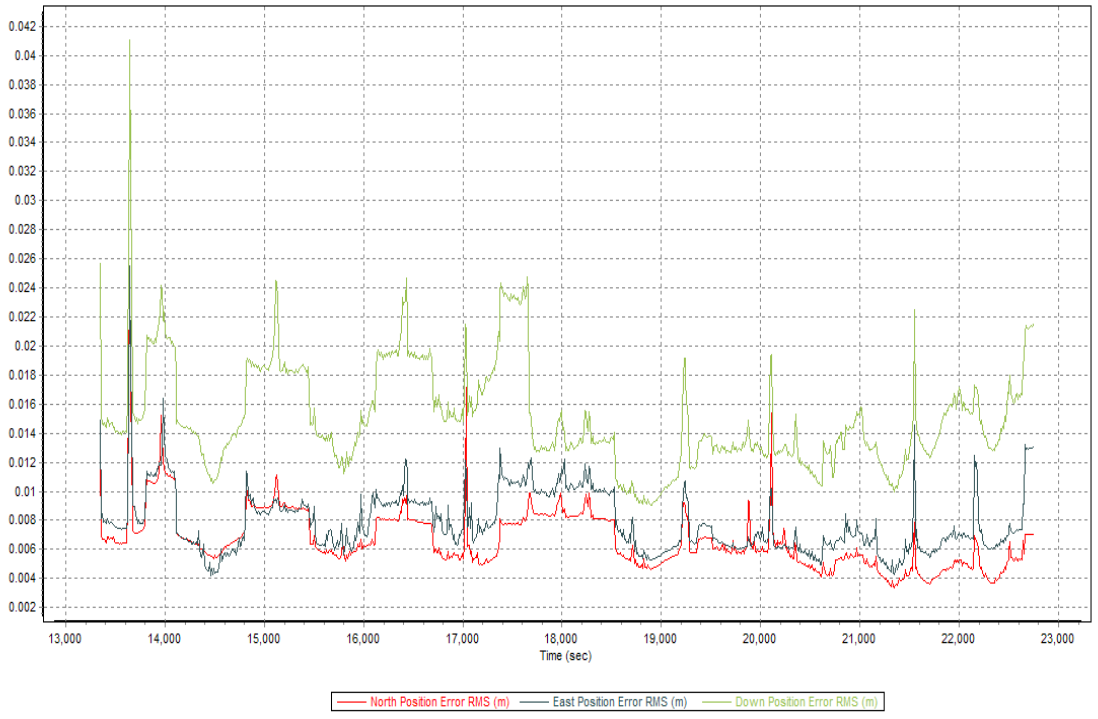


Figure A-8.23 Smoothed Performance Metric Parameters

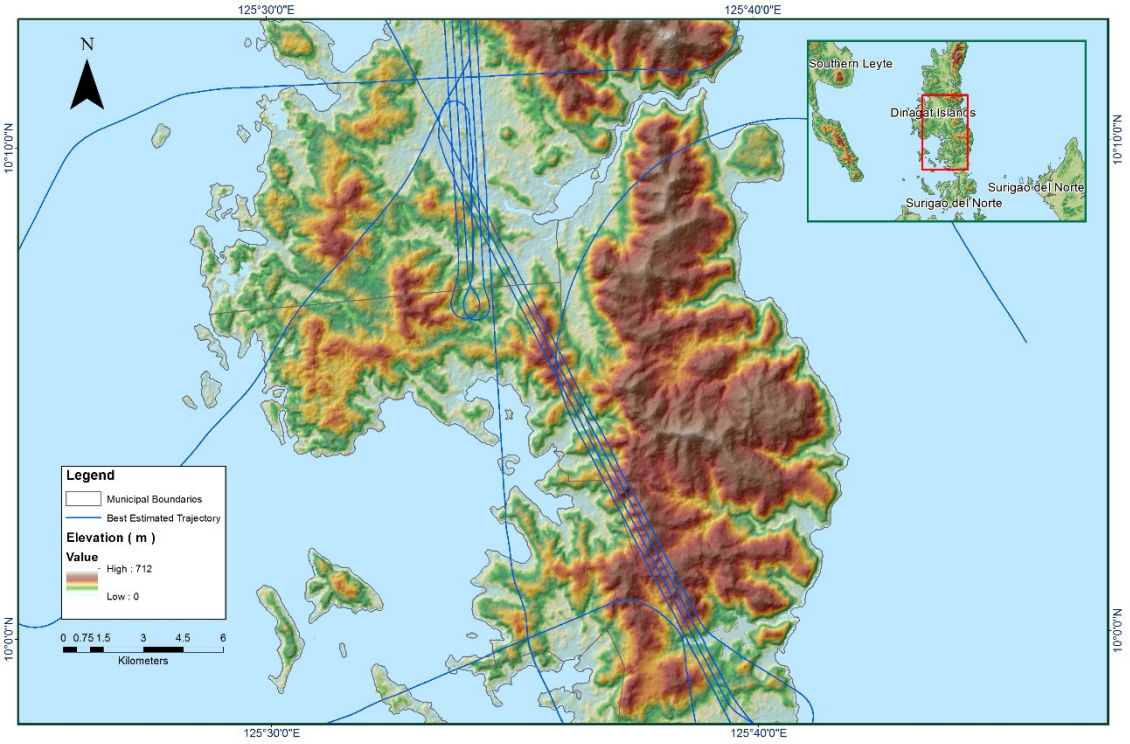


Figure A-8.24 Best Estimated Trajectory

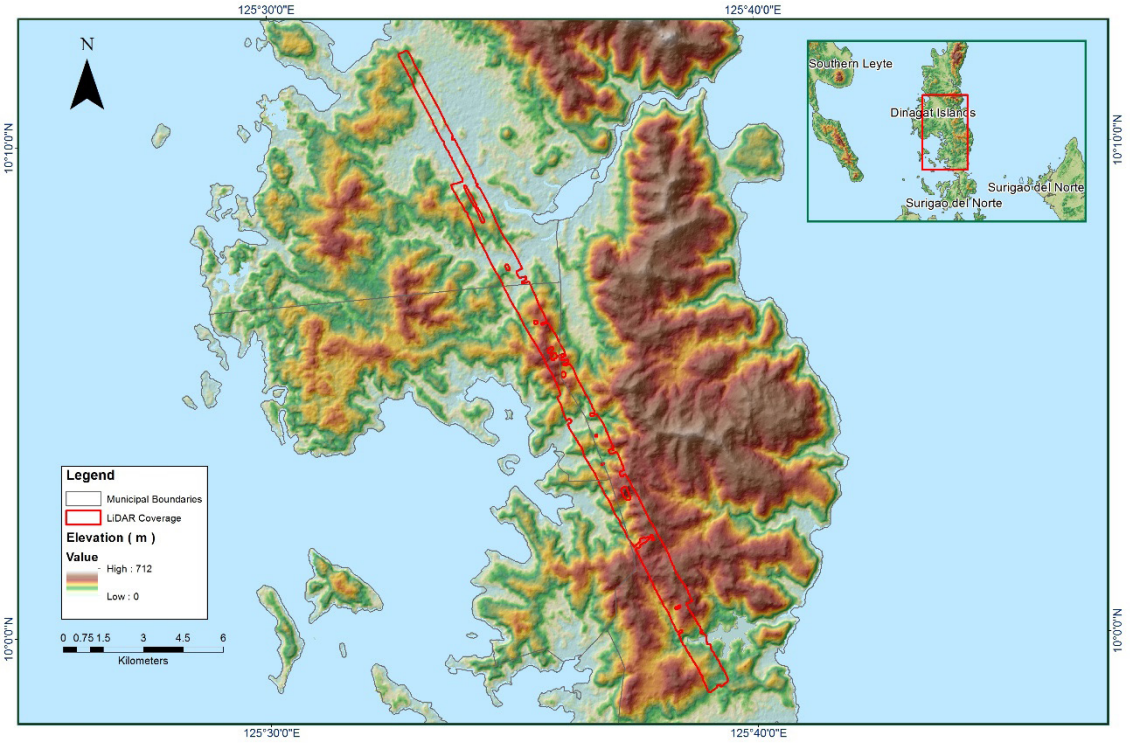


Figure A-8.25 Coverage of LiDAR data

Figure A-8.26 Image of data overlap

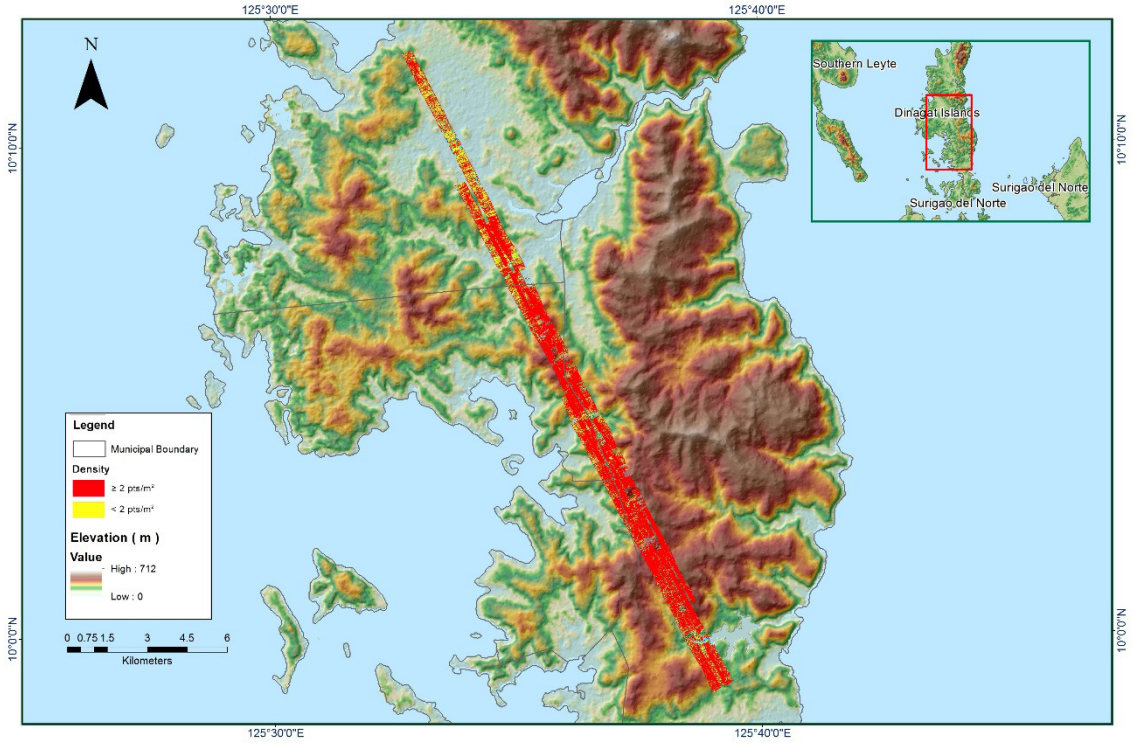


Figure A-8.27 Density map of merged LiDAR data

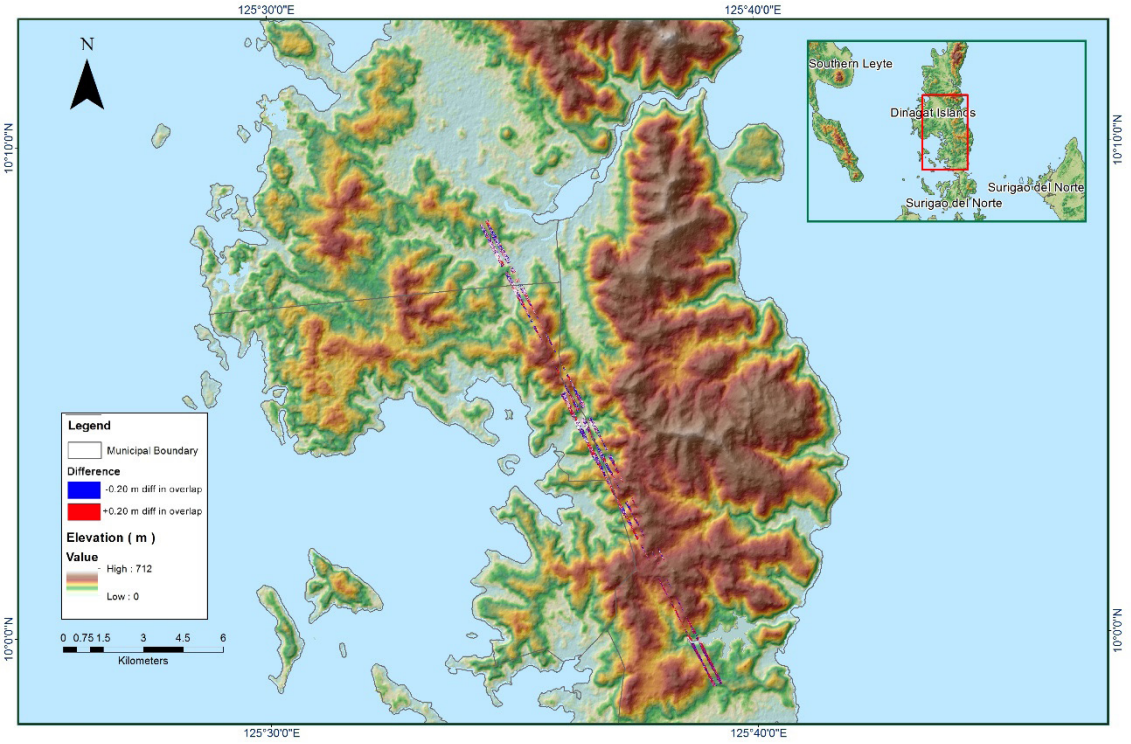


Figure A-8.28 Elevation difference between flight lines

Table A-8.5. Mission Summary Report for Mission Blk59C

Flight Area	**Surigao City**
Mission Name	Blk59C (Siargao)
Inclusive Flights	1966A, 1968A & 1982A
Range data size	25 GB
Base data size	29.04 MB
POS	493 MB
Image	NA
Transfer date	October 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)	1.45
RMSE for East Position (<4.0 cm)	2.03
RMSE for Down Position (<8.0 cm)	3.80
Boresight correction stdev (<0.001deg)	0.000357
IMU attitude correction stdev (<0.001deg)	0.002806
GPS position stdev (<0.01m)	0.0085
Minimum % overlap (>25)	36.33
Ave point cloud density per sq.m. (>2.0)	2.08
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	224
Maximum Height	362.54 m
Minimum Height	51.22 m
Classification (# of points)	
Ground	53,540,370
Low vegetation	36,928,678
Medium vegetation	57,330,979
High vegetation	103,202,311
Building	3,358,478
Orthophoto	No
Processed by	Engr. Jommer Medina, Engr. Edgardo Gubatanga Jr., Jovy Narisma

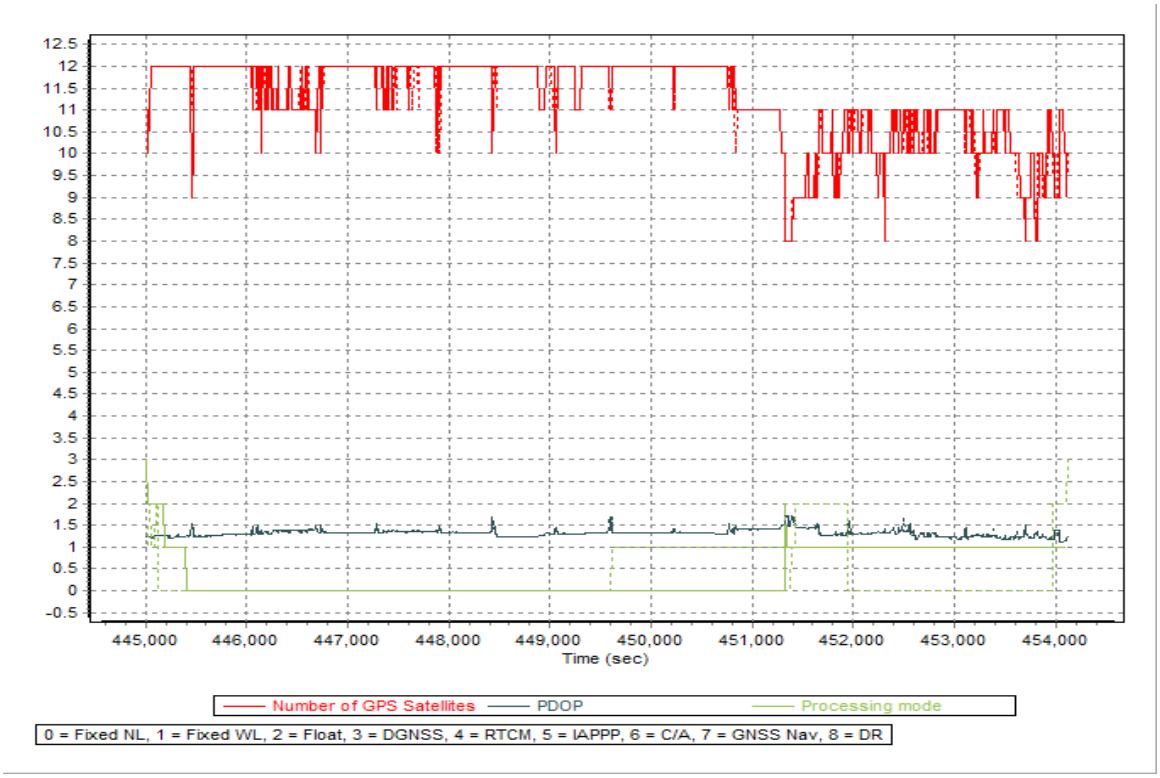


Figure A-8.29. Solution Status

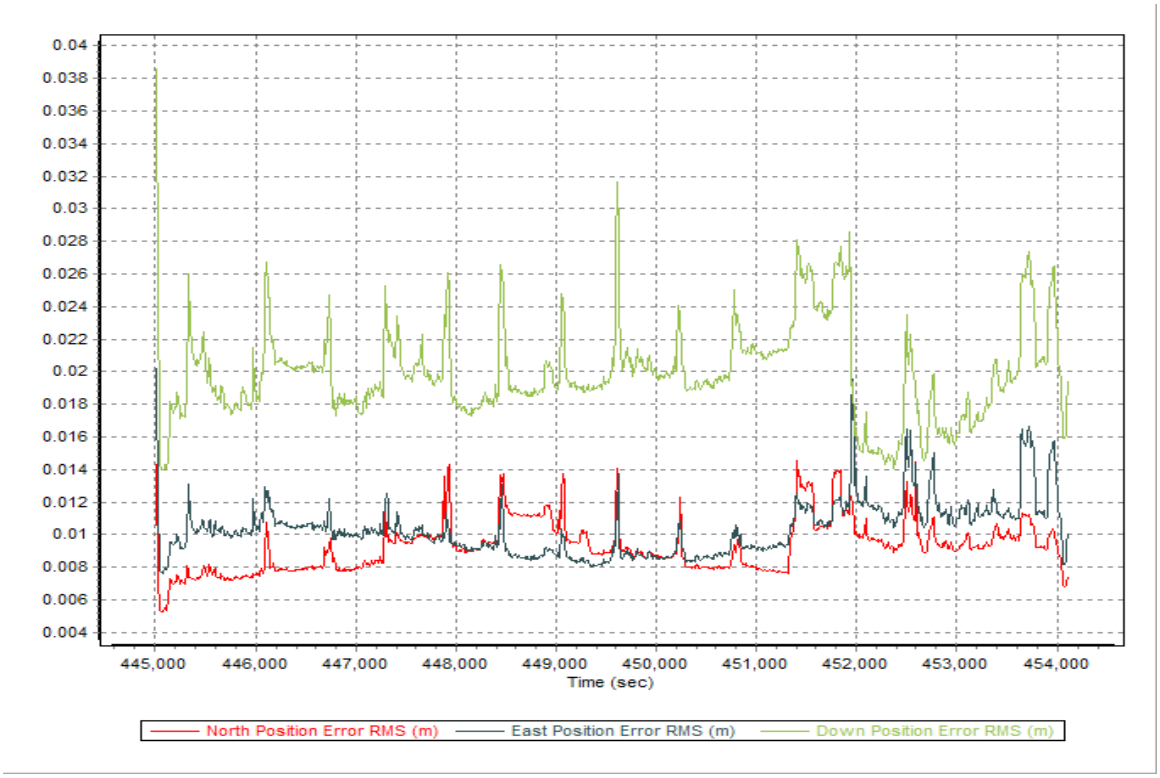


Figure A-8.30. Smoothed Performance Metric Parameters

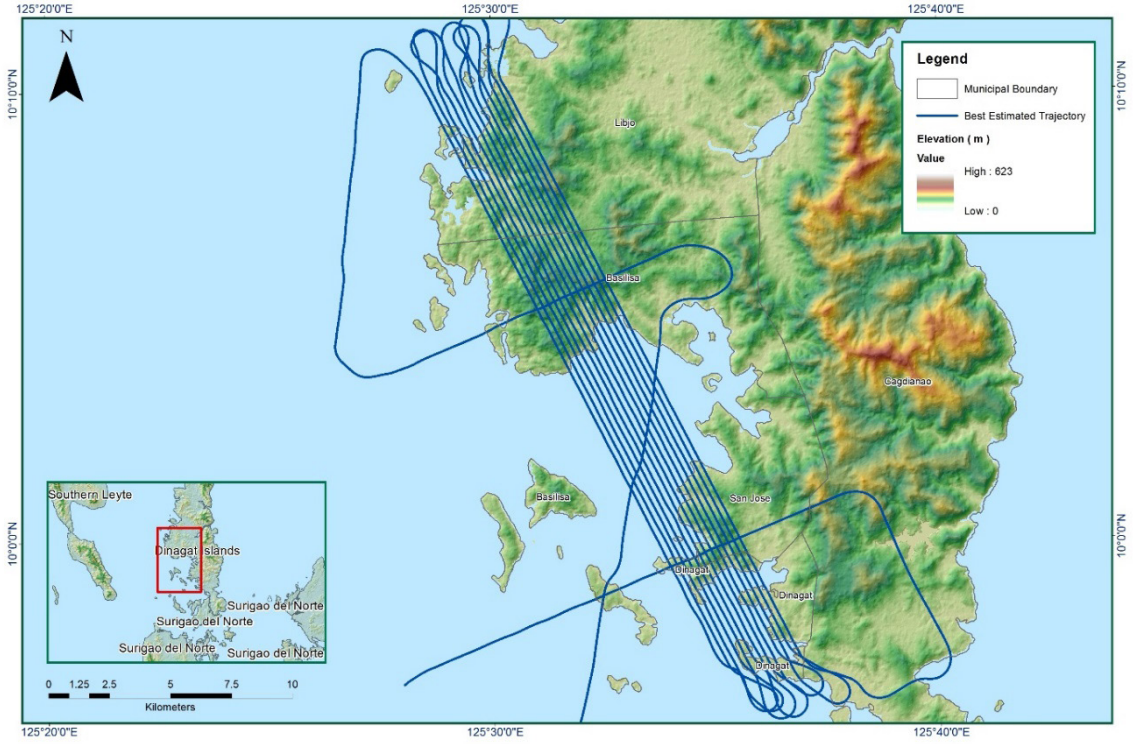


Figure A-8.31 Best Estimated Trajectory

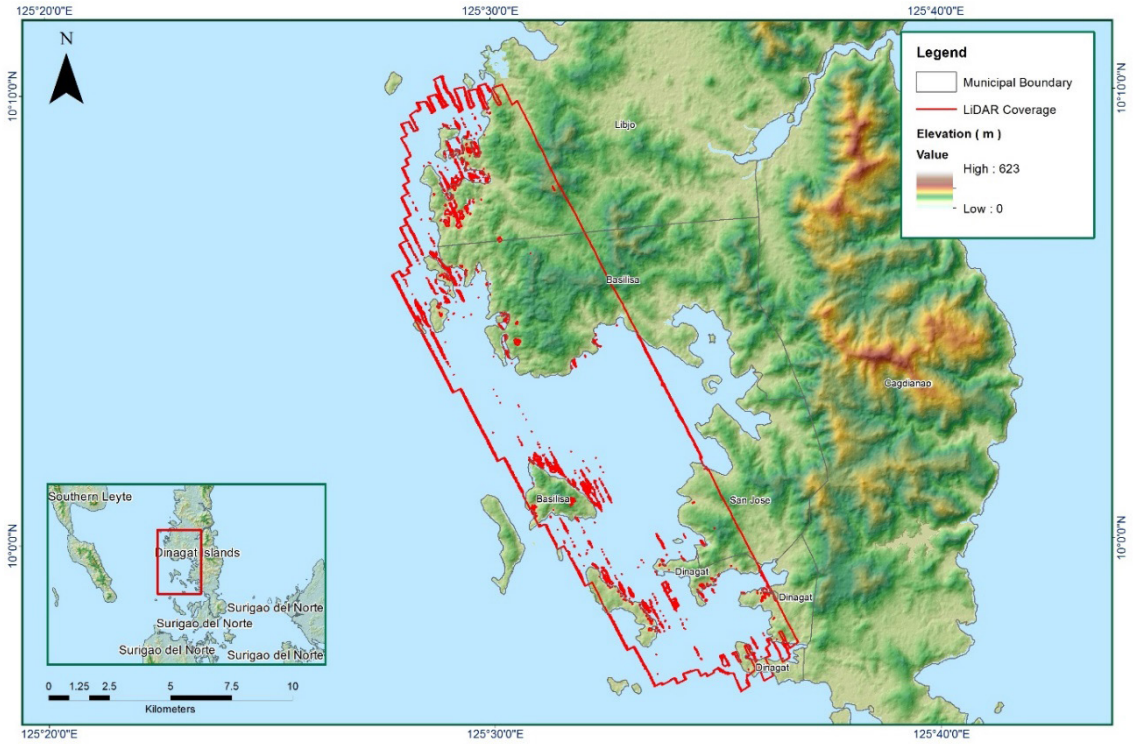


Figure A-8.32 Coverage of LiDAR data

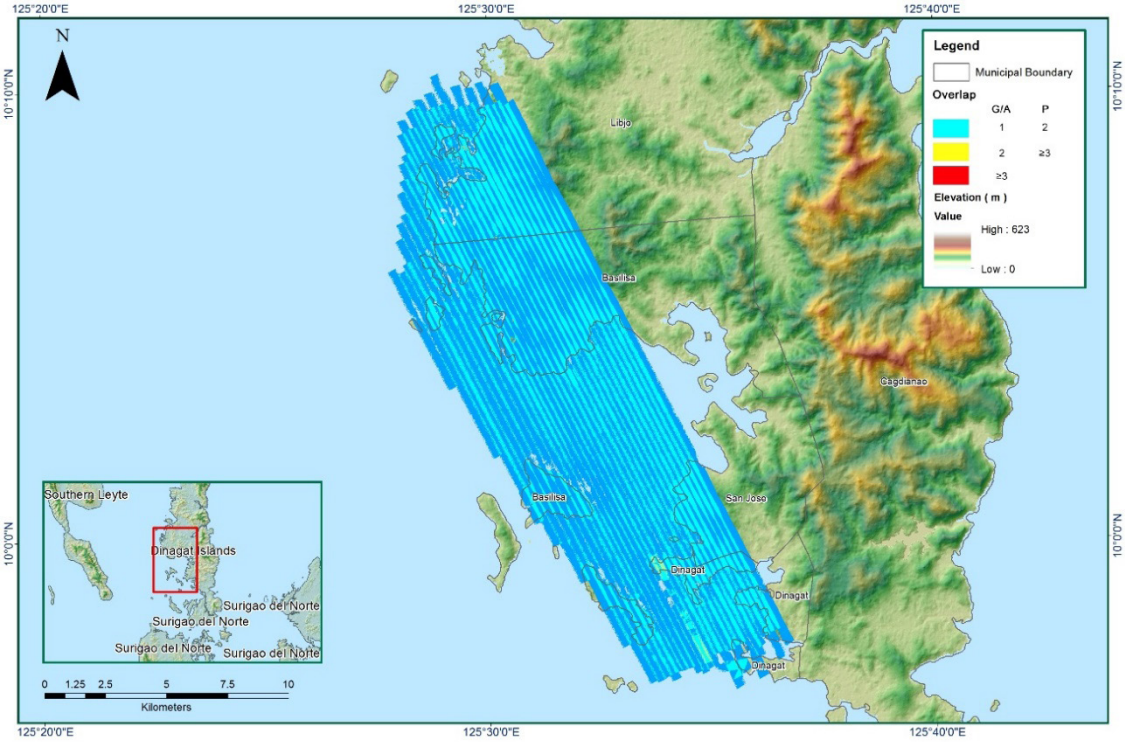


Figure A-8.33 Image of data overlap

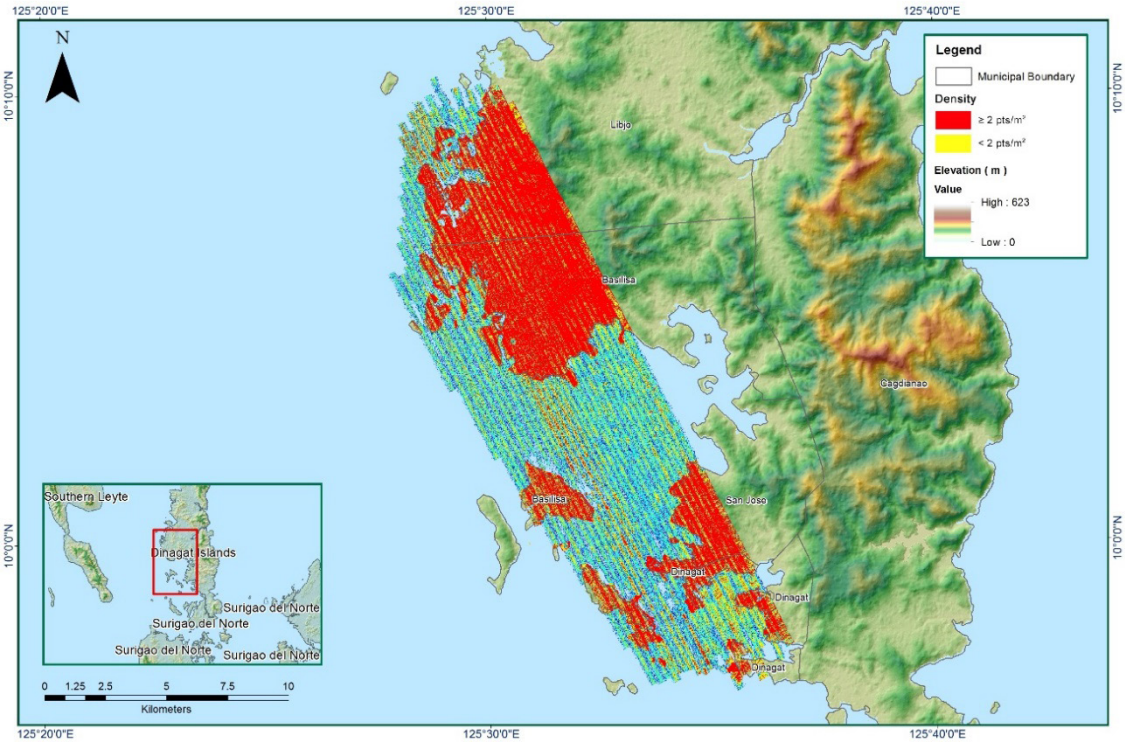


Figure A-8.34 Density Map of merged LiDAR data

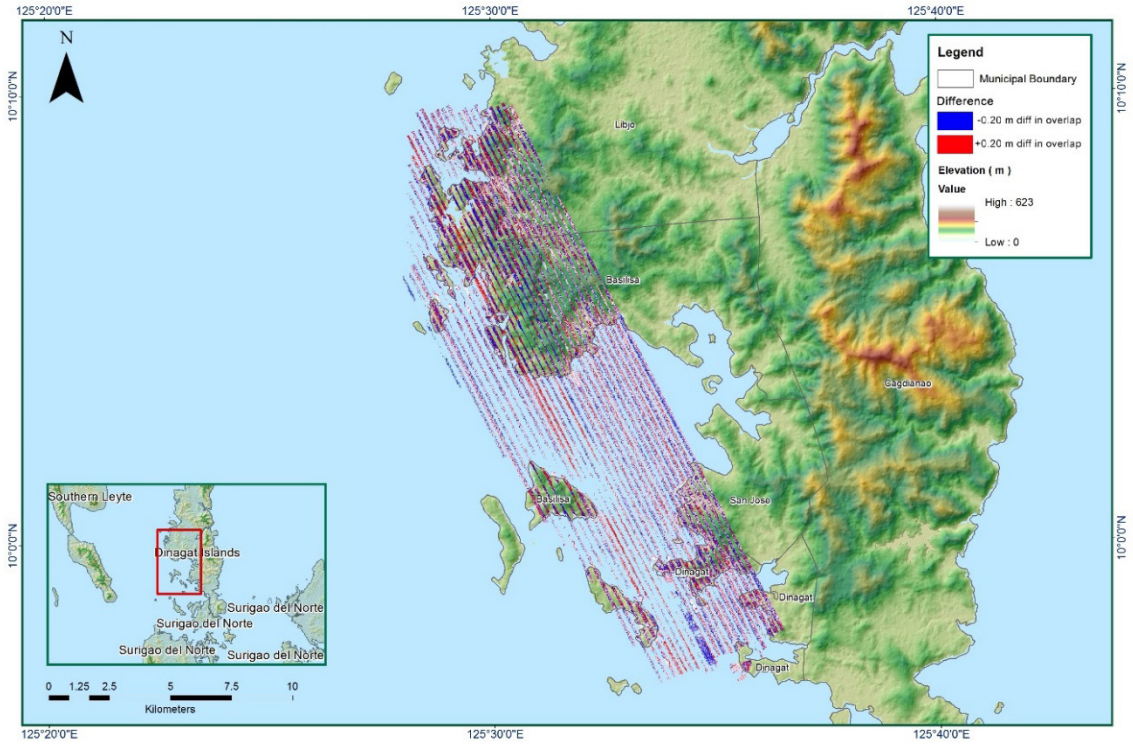


Figure A-8.35 Elevation Difference Between flight lines

Table A-8.6. Mission Summary Report for Mission Blk59B

Flight Area	**Surigao City**
Mission Name	Blk59B (Siargao)
Inclusive Flights	1936A
Range data size	6.89 GB
Base data size	16.8 MB
POS	132 MB
Image	NA
Transfer date	October 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)	1.65
RMSE for East Position (<4.0 cm)	1.80
RMSE for Down Position (<8.0 cm)	4.45
Boresight correction stdev (<0.001deg)	0.000213
IMU attitude correction stdev (<0.001deg)	0.000491
GPS position stdev (<0.01m)	0.0020
Minimum % overlap (>25)	30.20
Ave point cloud density per sq.m. (>2.0)	2.97
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	87
Maximum Height	594.16 m
Minimum Height	57.44 m
Classification (# of points)	
Ground	25,599,832
Low vegetation	20,578,793
Medium vegetation	41,589,897
High vegetation	35,974,699
Building	802,571
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Engr. Jommer Medina, Engr. Melanie Hingpit,Engr. Jeffrey Delica

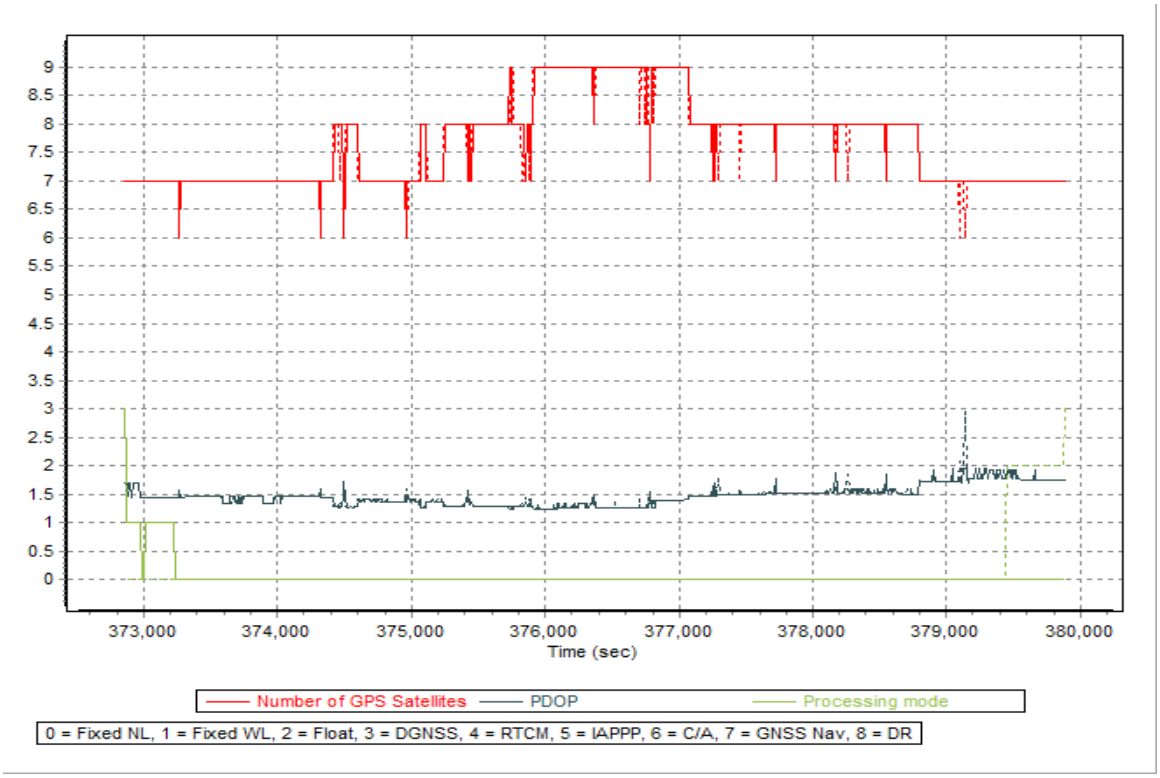


Figure A-8.36. Solution Status

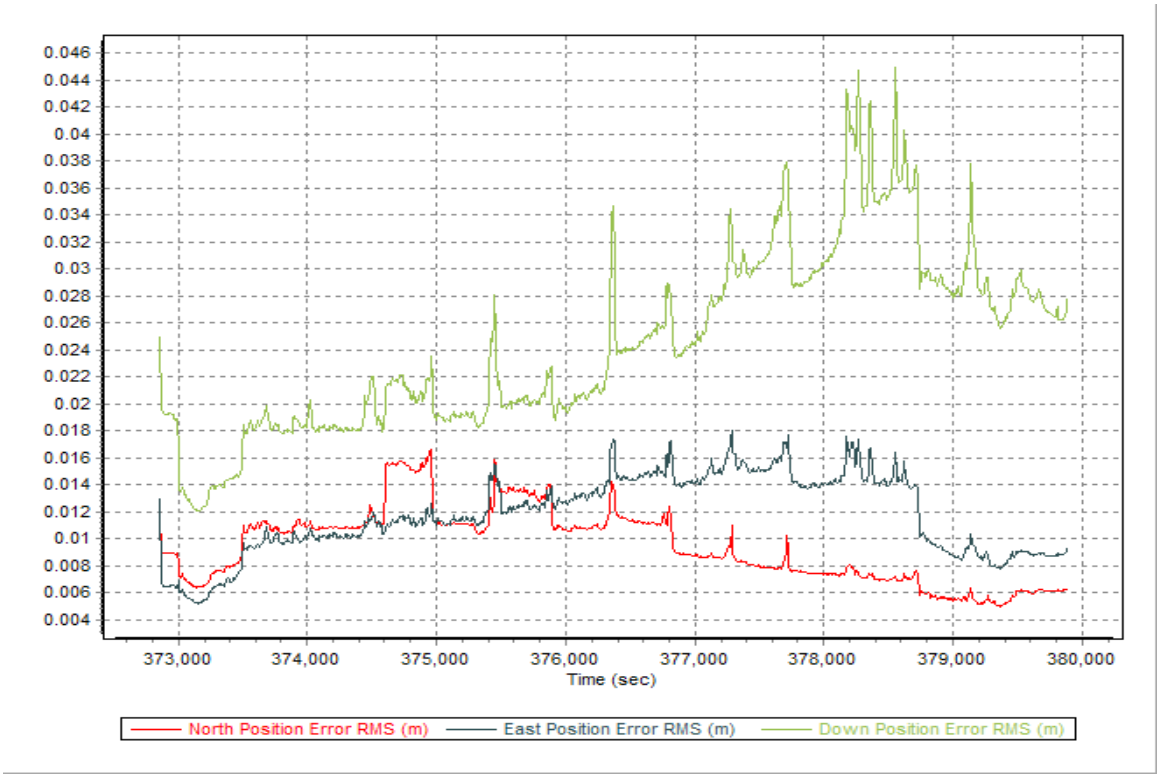


Figure A-8.37. Smoothed Performance Metric Parameters

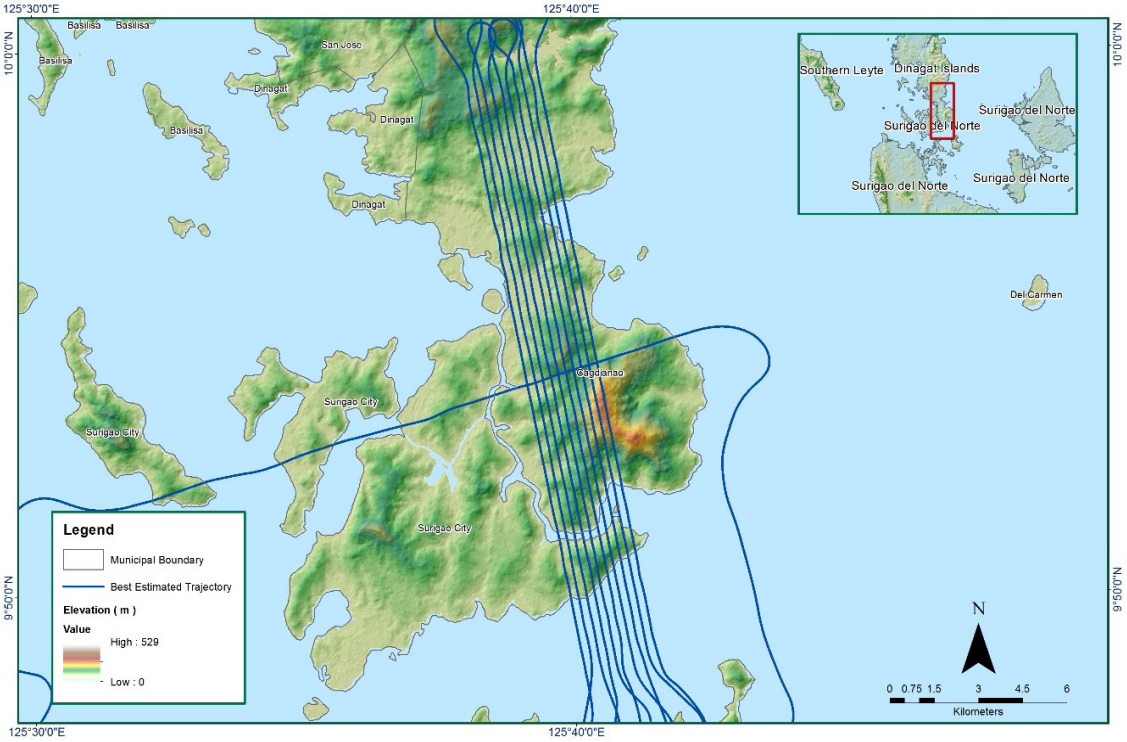


Figure A-8.38 Best Estimated Trajectory

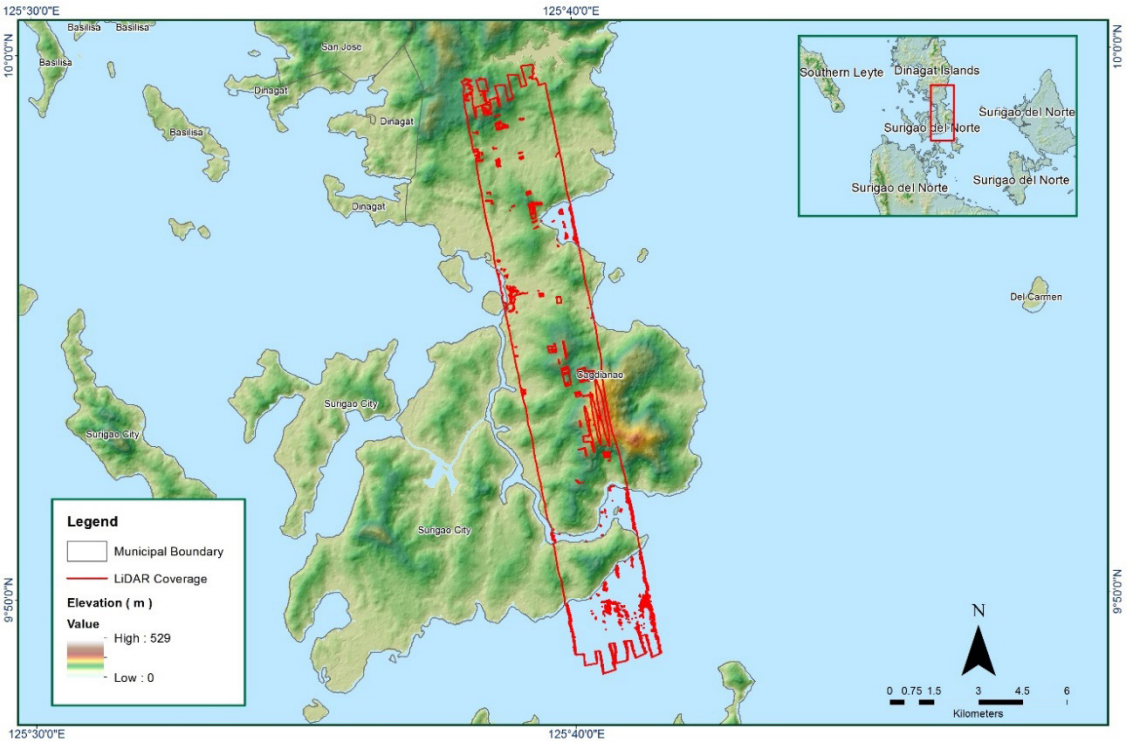


Figure A-8.39 Coverage of LiDAR data

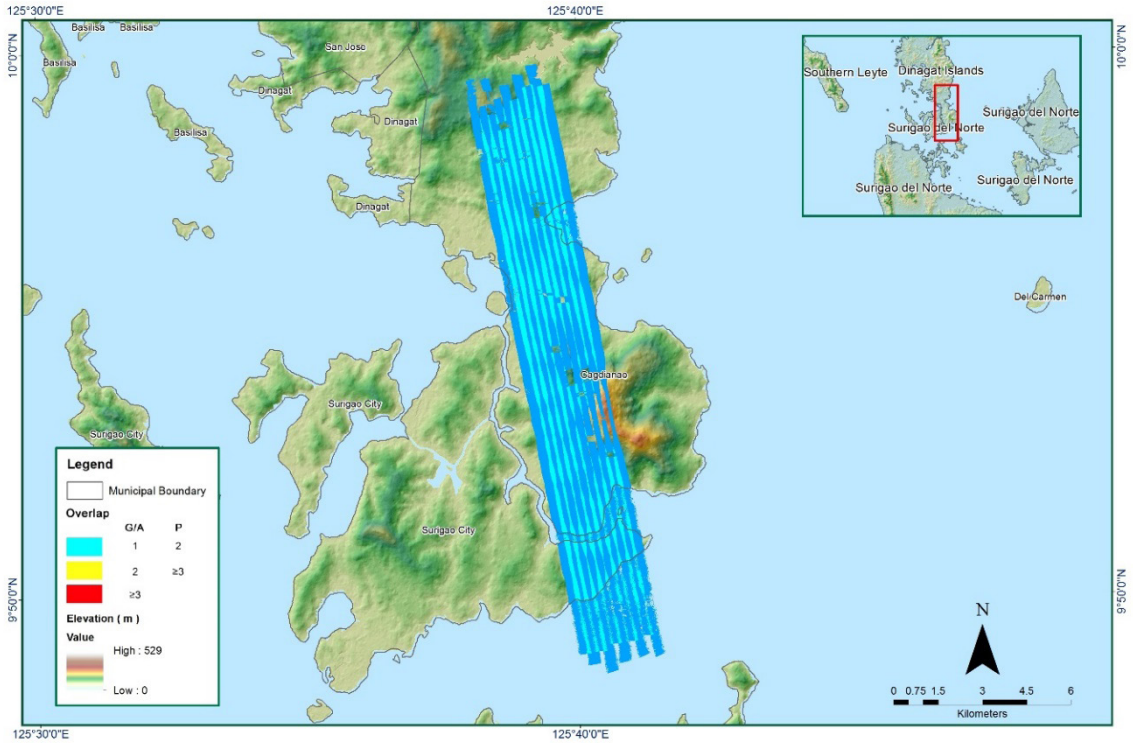


Figure A-8.40 Image of data overlap

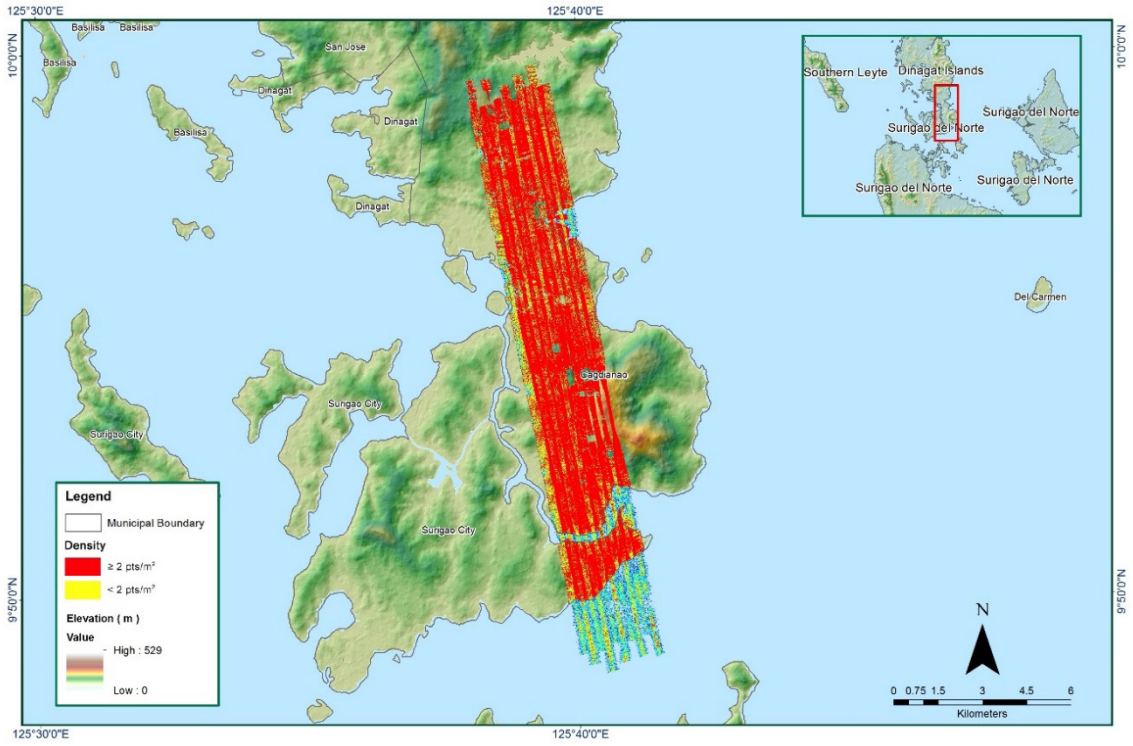


Figure A-8.41 Density Map of merged LiDAR data

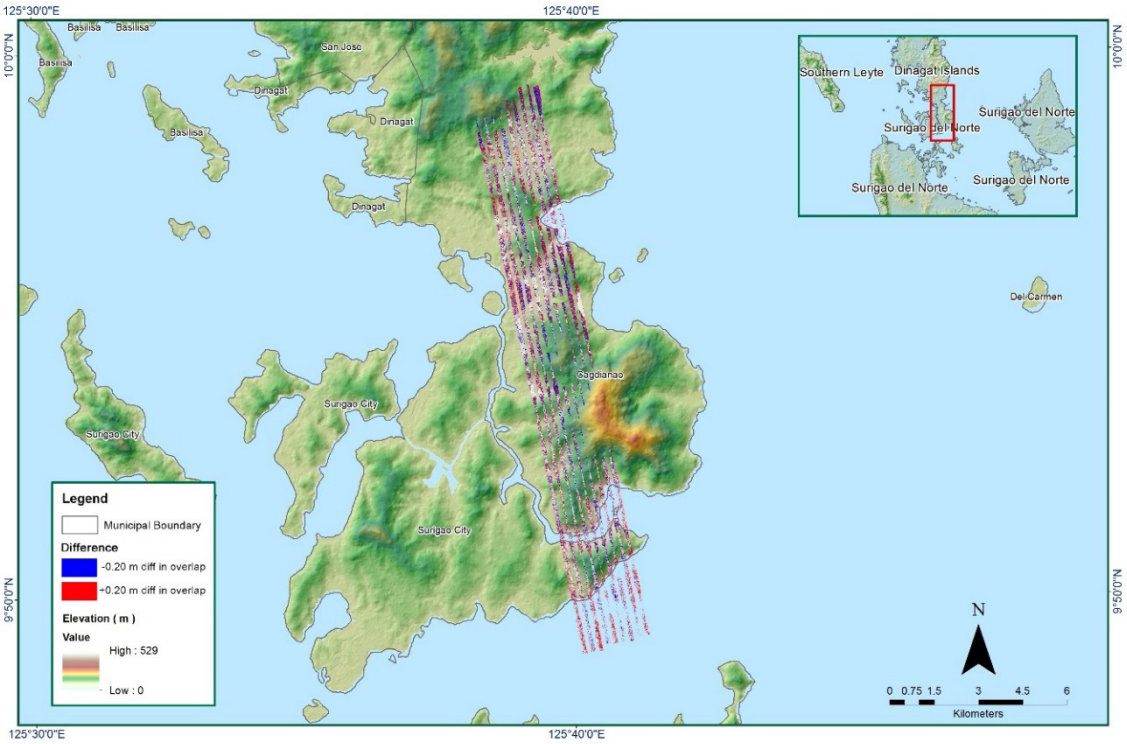


Figure A-8.42 Elevation Difference Between flight lines

Table A-8.7. Mission Summary Report for Mission Blk59B Supplement

Flight Area	**Surigao City**
Mission Name	Blk59B Supplement (Siargao)
Inclusive Flights	1946A
Range data size	8.45 GB
Base data size	9.26 MB
POS	170 MB
Image	NA
Transfer date	October 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)	1.55
RMSE for East Position (<4.0 cm)	2.90
RMSE for Down Position (<8.0 cm)	3.20
Boresight correction stdev (<0.001deg)	0.000746
IMU attitude correction stdev (<0.001deg)	0.017851
GPS position stdev (<0.01m)	0.0205
Minimum % overlap (>25)	37.27
Ave point cloud density per sq.m. (>2.0)	2.52
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	102
Maximum Height	369.58 m
Minimum Height	58.55 m
Classification (# of points)	
Ground	29,883,090
Low vegetation	23,948,141
Medium vegetation	51,568,425
High vegetation	29,714,220
Building	694,324
Orthophoto	No
Processed by	Engr. Carlyn Ann Ibañez, Engr. Jommer Medina, Engr. Christy Lubiano,Engr. Ma. Ailyn Olanda

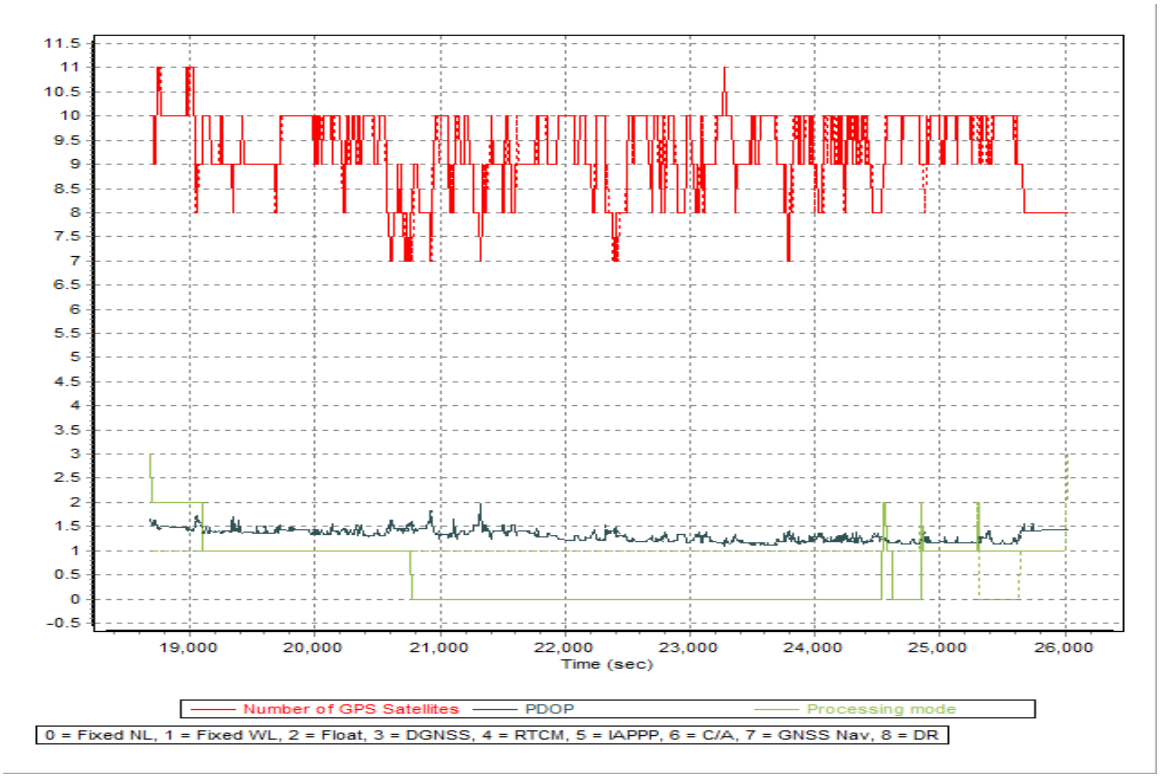


Figure A-8.43. Solution Status

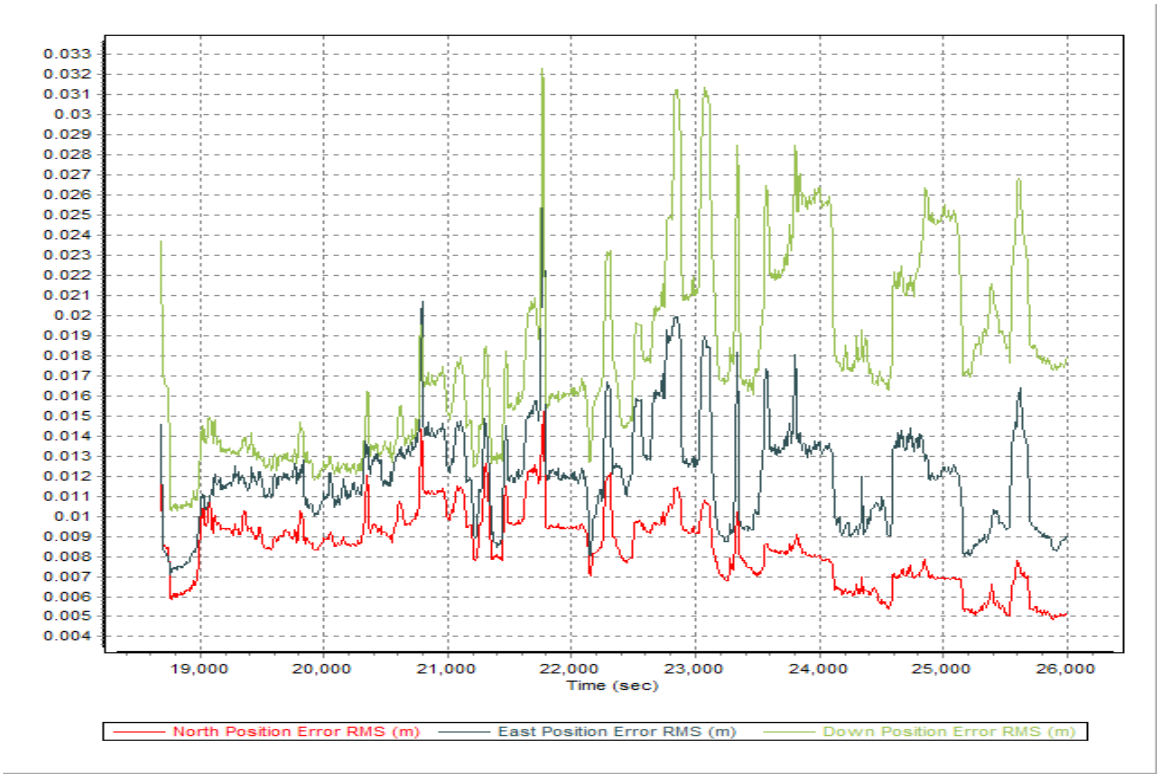


Figure A-8.44. Smoothed Performance Metric Parameters

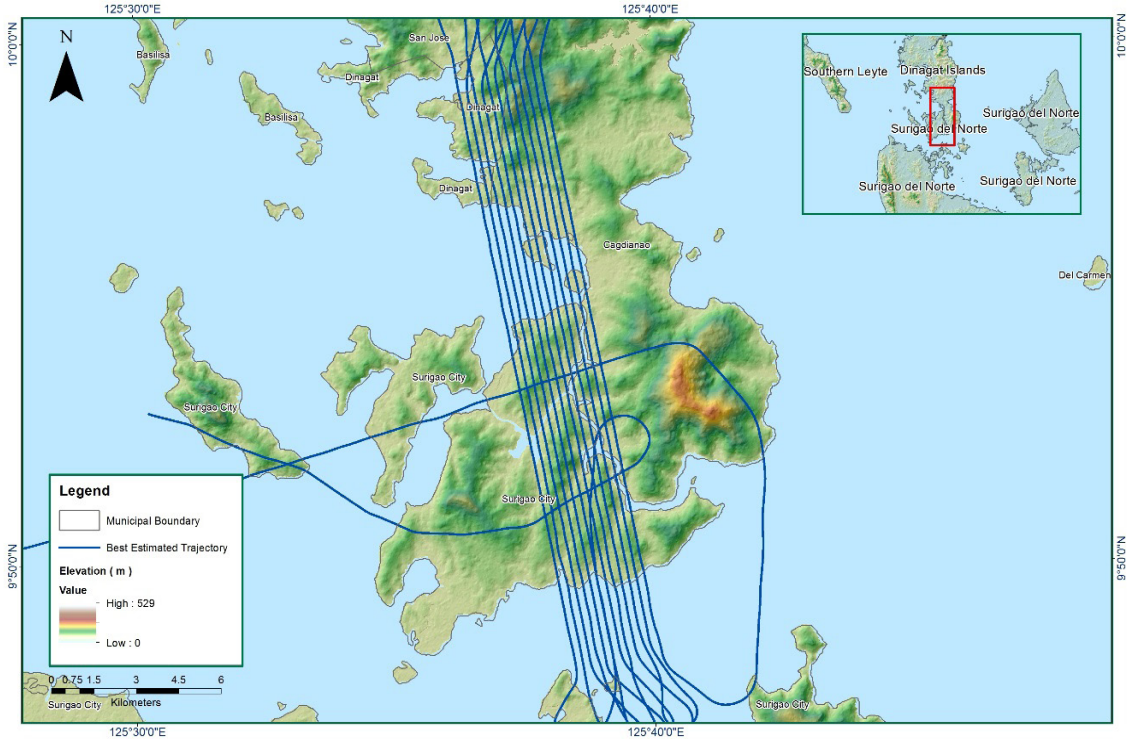


Figure A-8.45 Best Estimated Trajectory

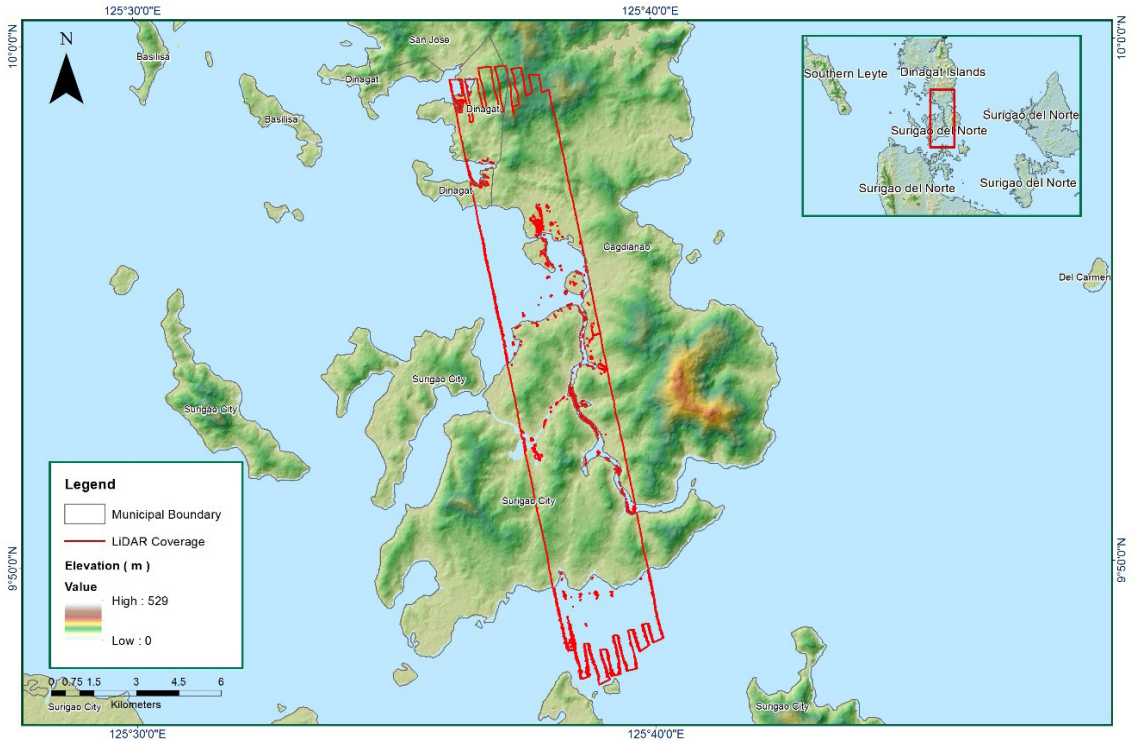


Figure A-8.46 Coverage of LiDAR data

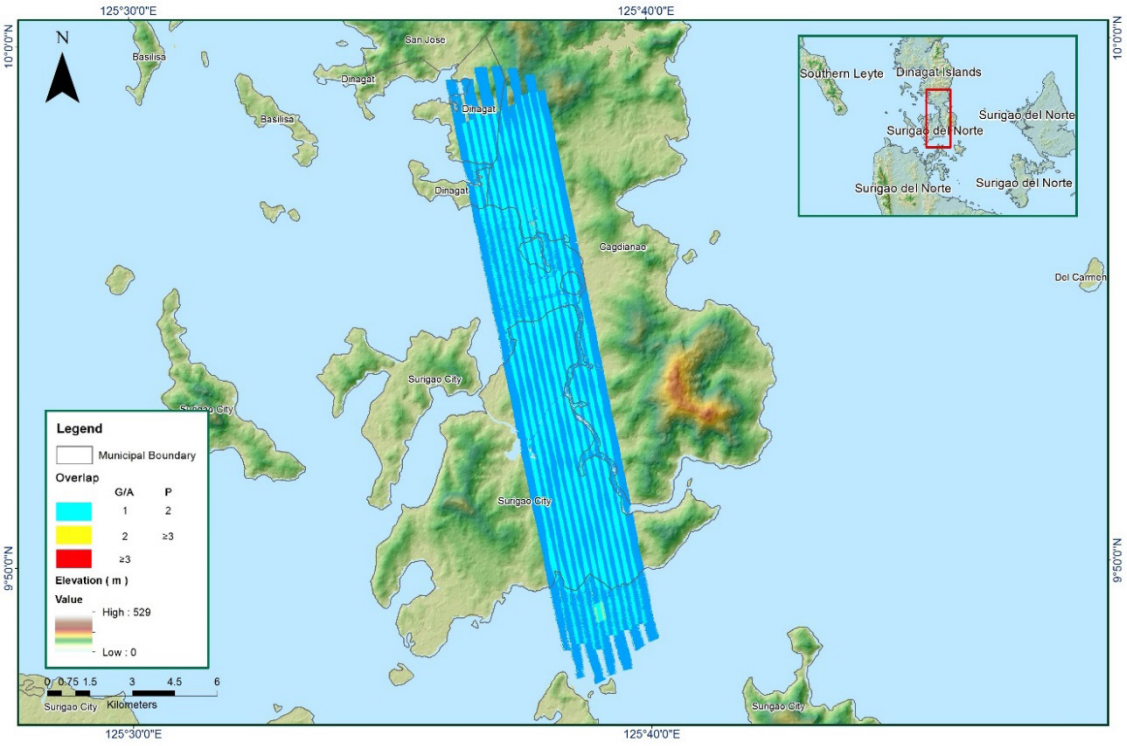


Figure A-8.47 Image of data overlap

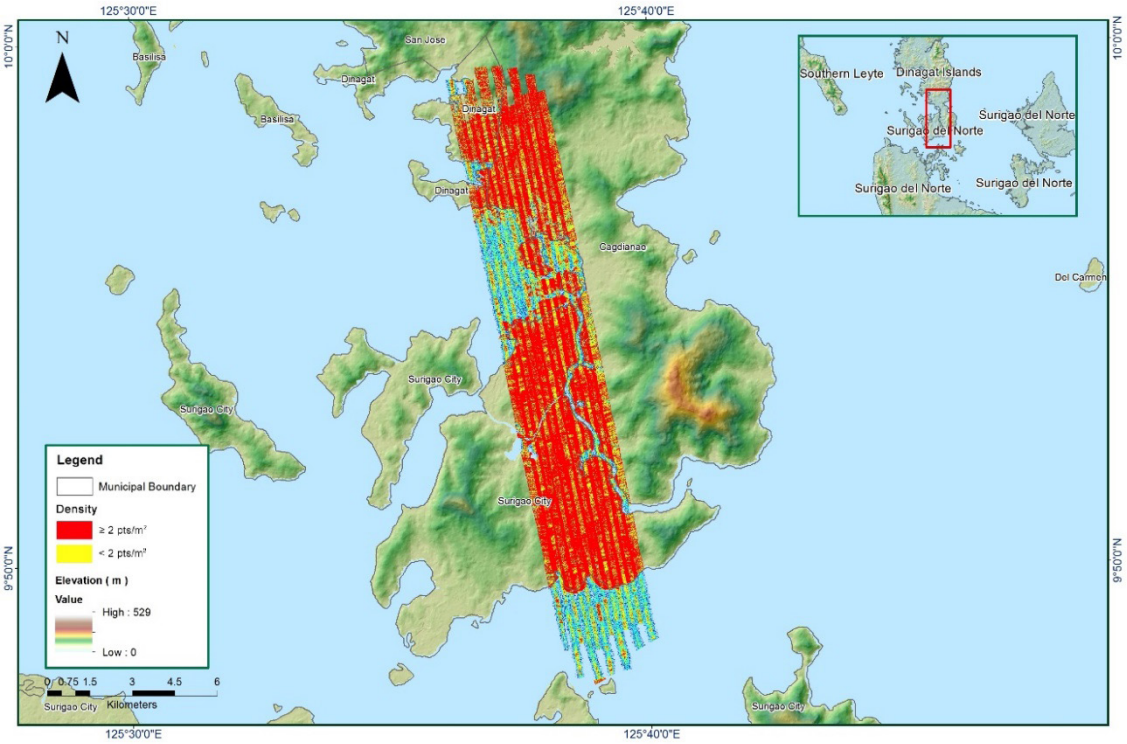


Figure A-8.48 Density Map of merged LiDAR data

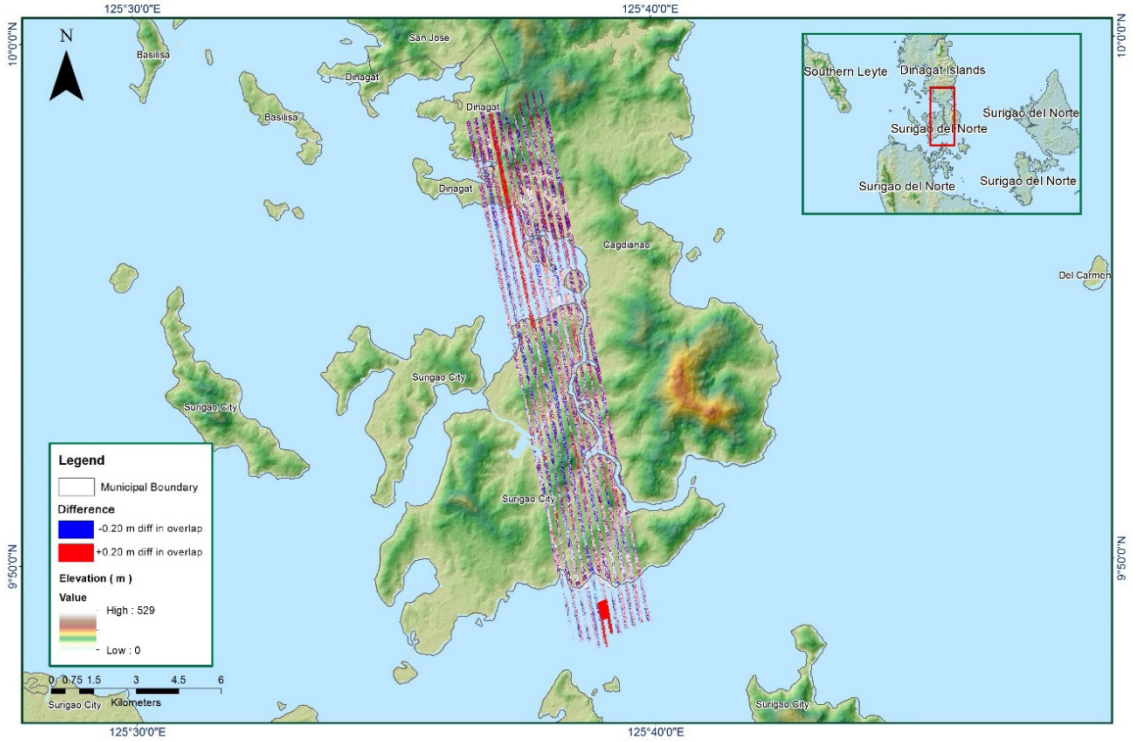


Figure A-8.49 Elevation Difference Between flight lines

Table A-8.8. Mission Summary Report for Mission Blk59A

Flight Area	**Surigao City**
Mission Name	Blk59A (Siargao)
Inclusive Flights	1934A
Range data size	16.90 GB
Base data size	16.8 MB
POS	283 MB
Image	91.20 MB
Transfer date	October 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)	1.40
RMSE for East Position (<4.0 cm)	2.15
RMSE for Down Position (<8.0 cm)	2.80
Boresight correction stdev (<0.001deg)	0.000562
IMU attitude correction stdev (<0.001deg)	0.002742
GPS position stdev (<0.01m)	0.0197
Minimum % overlap (>25)	39.05
Ave point cloud density per sq.m. (>2.0)	1.94
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	176
Maximum Height	396.96 m
Minimum Height	50.49 m
Classification (# of points)	
Ground	52,033,090
Low vegetation	39,252,921
Medium vegetation	56,834,101
High vegetation	39,803,985
Building	2,045,762
Orthophoto	No
Processed by	Engr. Carlyn Ann Ibañez, Engr. Harmond Santos, Ryan James Nicholai Dizon

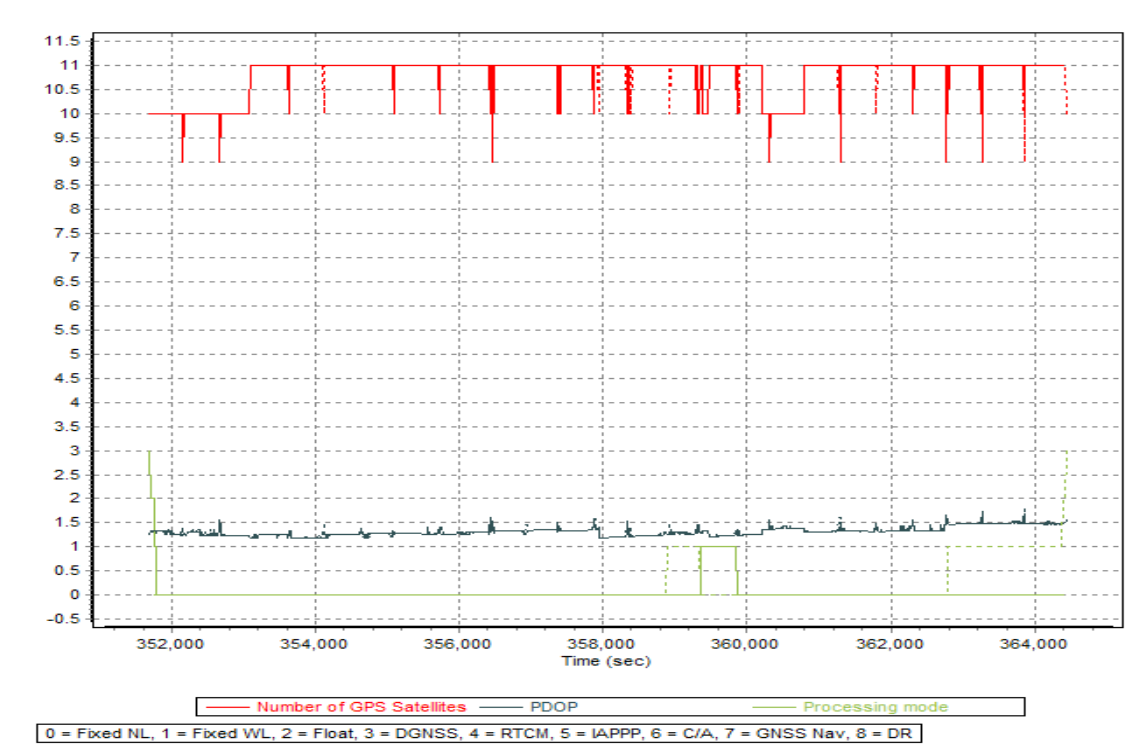


Figure A-8.50. Solution Status

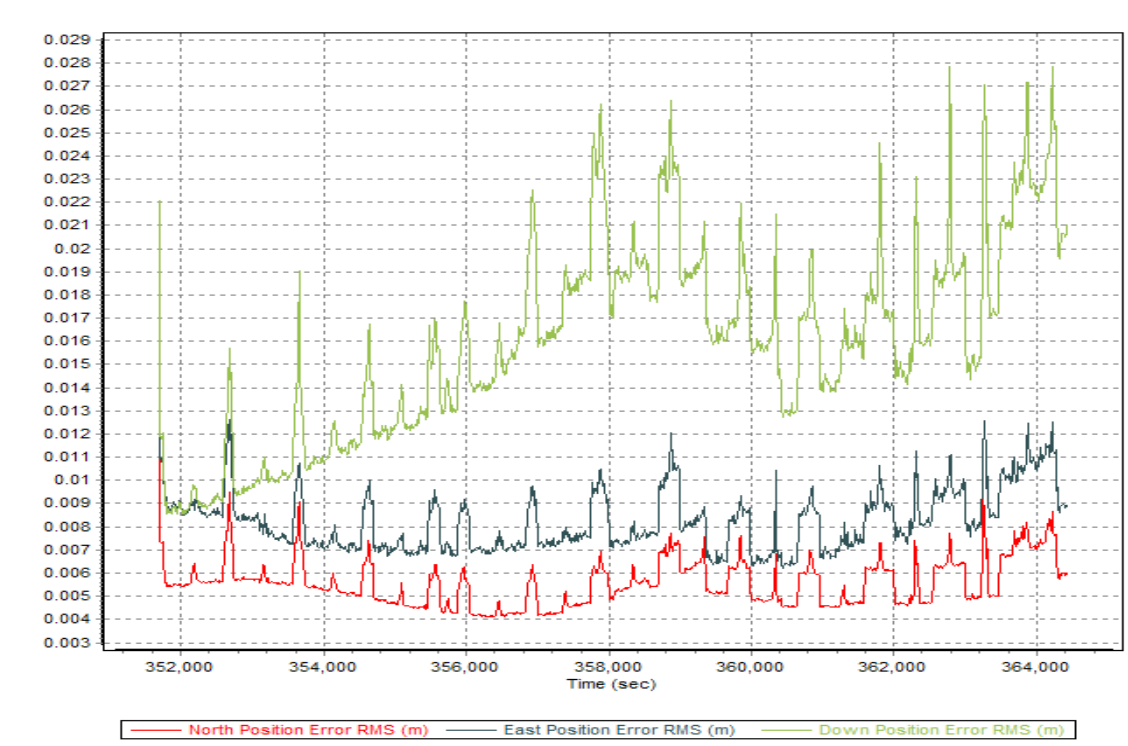


Figure A-8.51. Smoothed Performance Metric Parameters

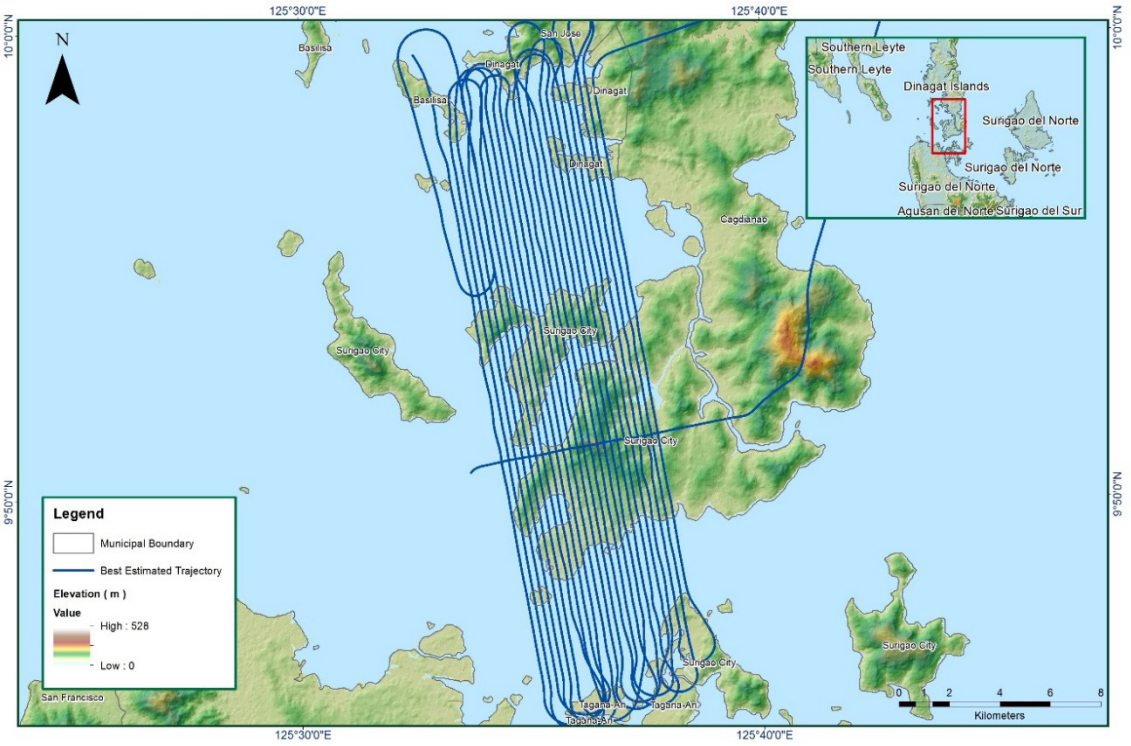


Figure A-8.52 Best Estimated Trajectory

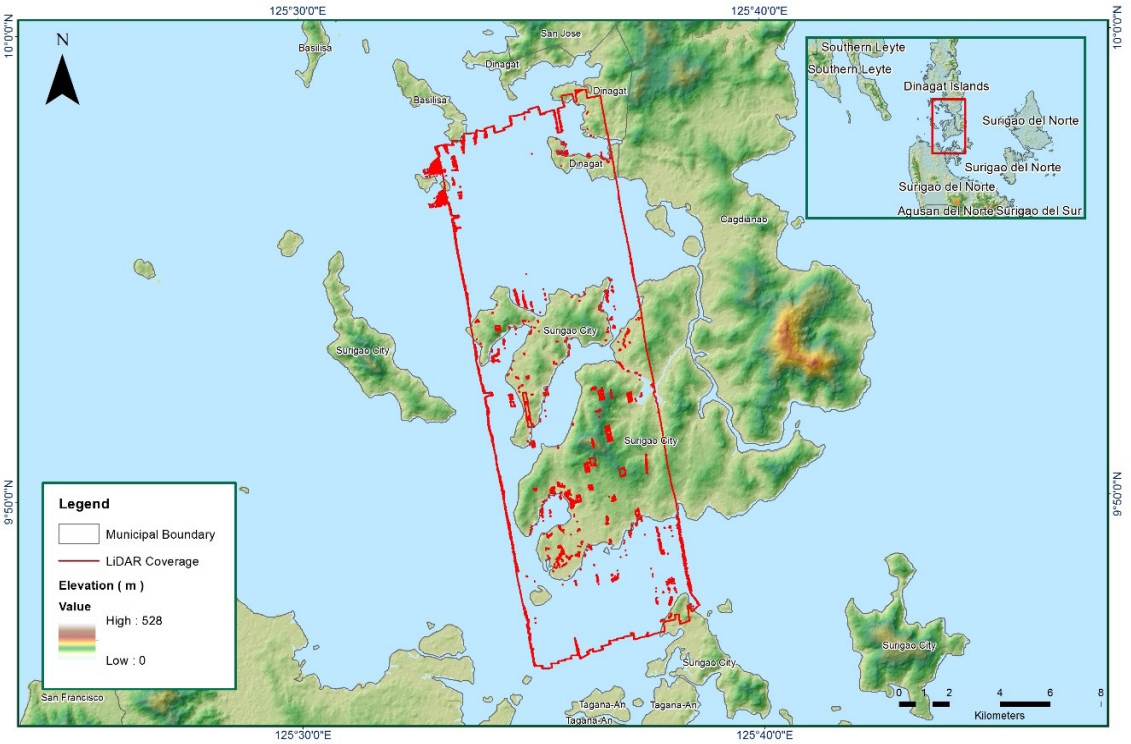


Figure A-8.53 Coverage of LiDAR data

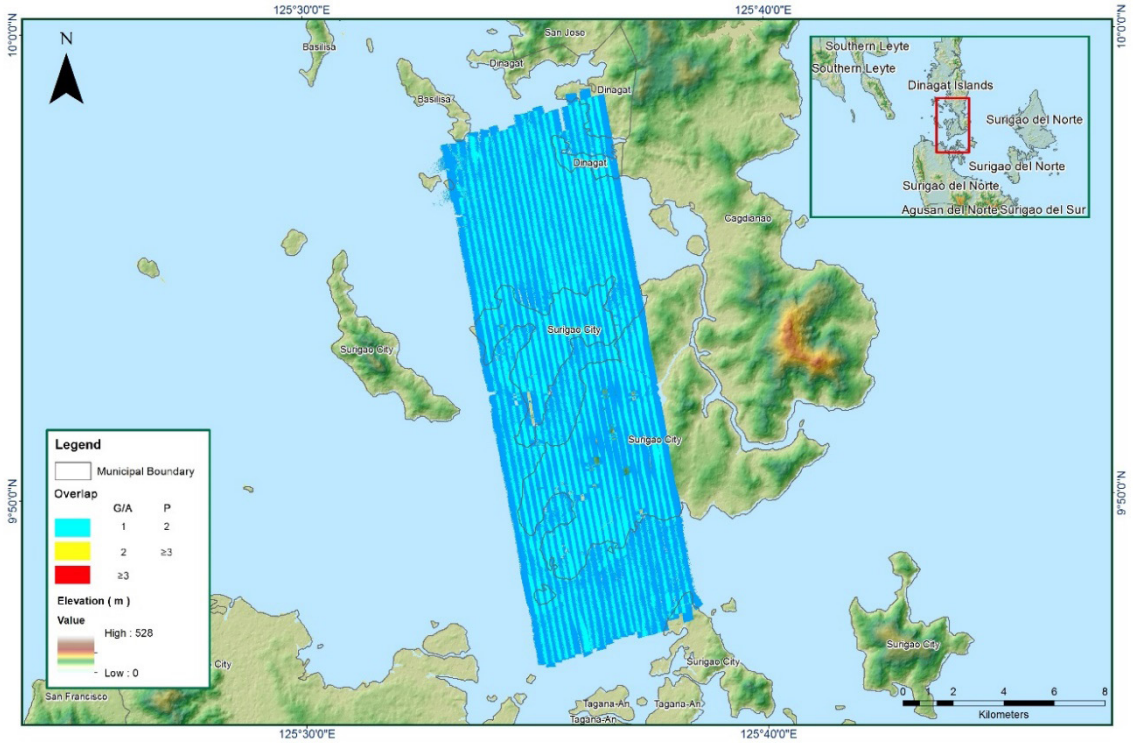


Figure A-8.54 Image of data overlap

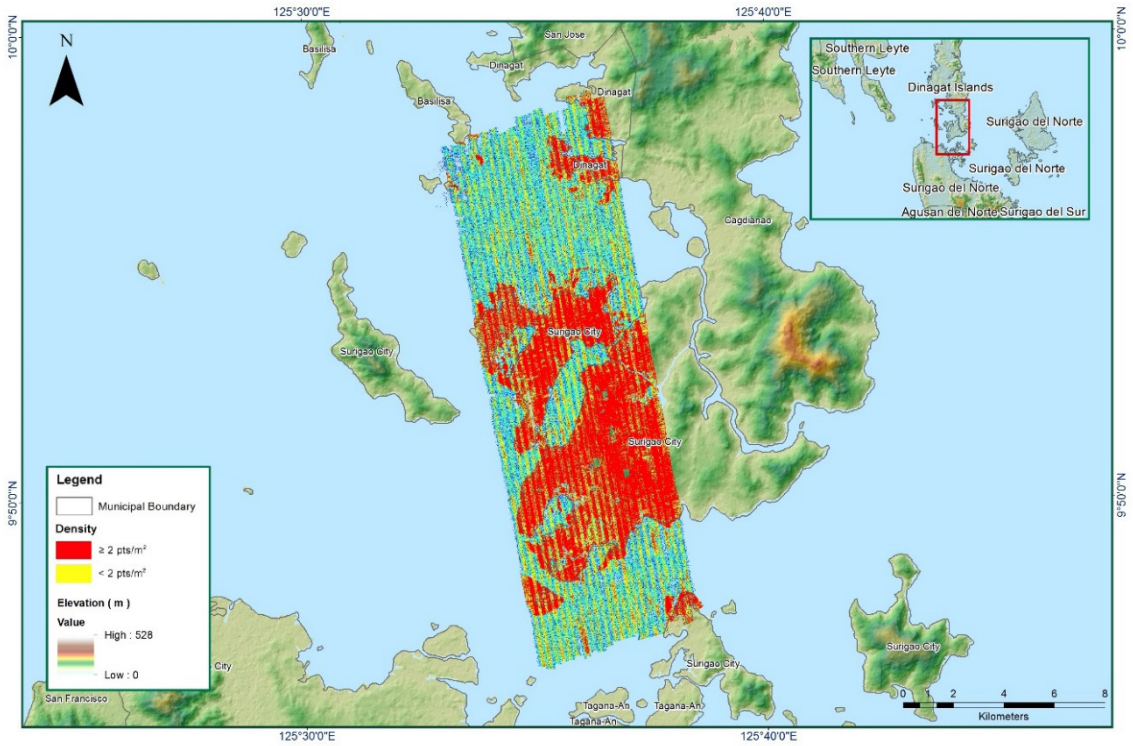


Figure A-8.55 Density Map of merged LiDAR data

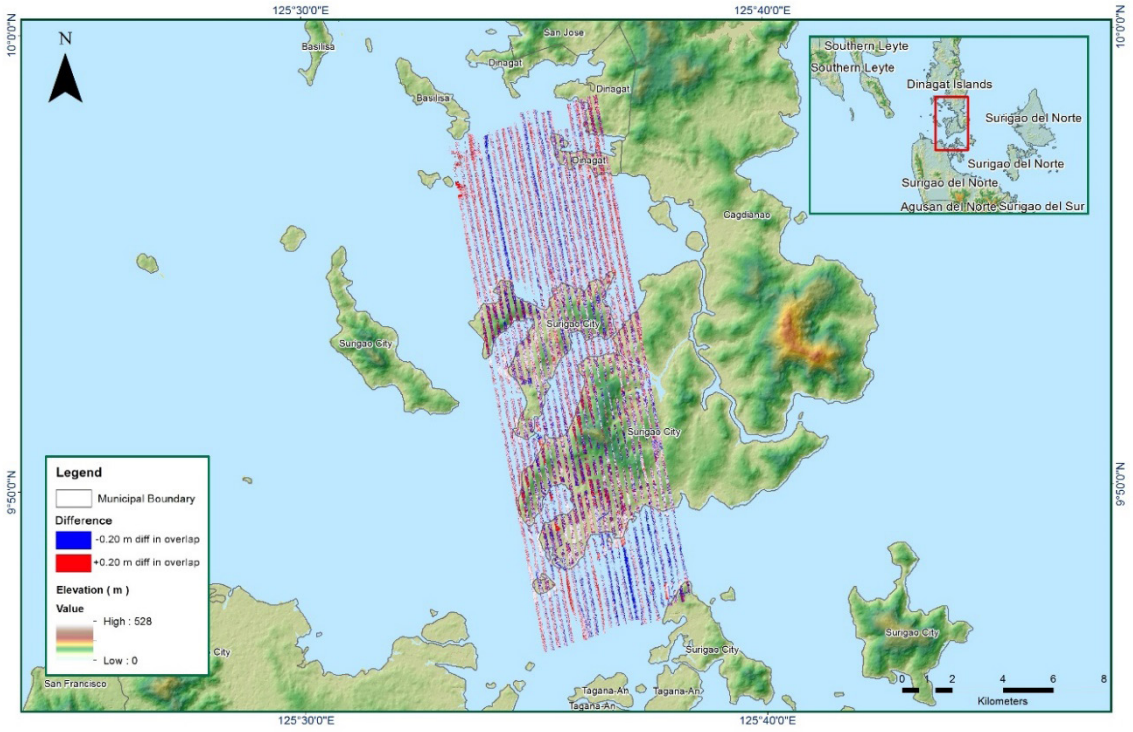


Figure A-8.56 Elevation Difference Between flight lines

Table A-8.9. Mission Summary Report for Mission Block 59F

Flight Area	Surigao Reflights
Mission Name	Block 59F
Inclusive Flights	8497AC
Range data size	9.66 GB
POS data size	240 MB
Base data size	75.7 MB
Image	51.4 GB
Transfer date	June 23, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.045
RMSE for East Position (<4.0 cm)	1.634
RMSE for Down Position (<8.0 cm)	2.540
Boresight correction stdev (<0.001deg)	0.000428
IMU attitude correction stdev (<0.001deg)	0.001525
GPS position stdev (<0.01m)	0.0095
Minimum % overlap (>25)	37.45
Ave point cloud density per sq.m. (>2.0)	3.98
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	55
Maximum Height	488.71 m
Minimum Height	64.92 m
Classification (# of points)	
Ground	15,242,615
Low vegetation	13,343,026
Medium vegetation	47,757,952
High vegetation	37,102,664
Building	1,091,014
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Ma. Joanne Balaga, Alex John Escobido

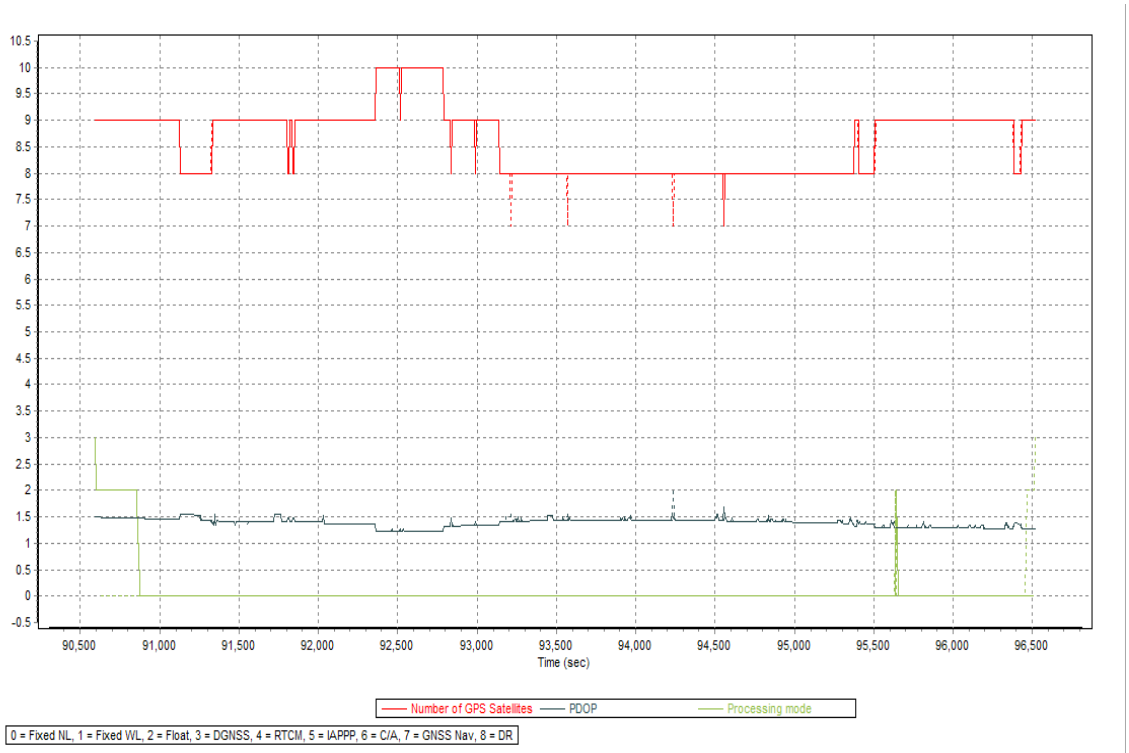


Figure A-8.57. Solution Status

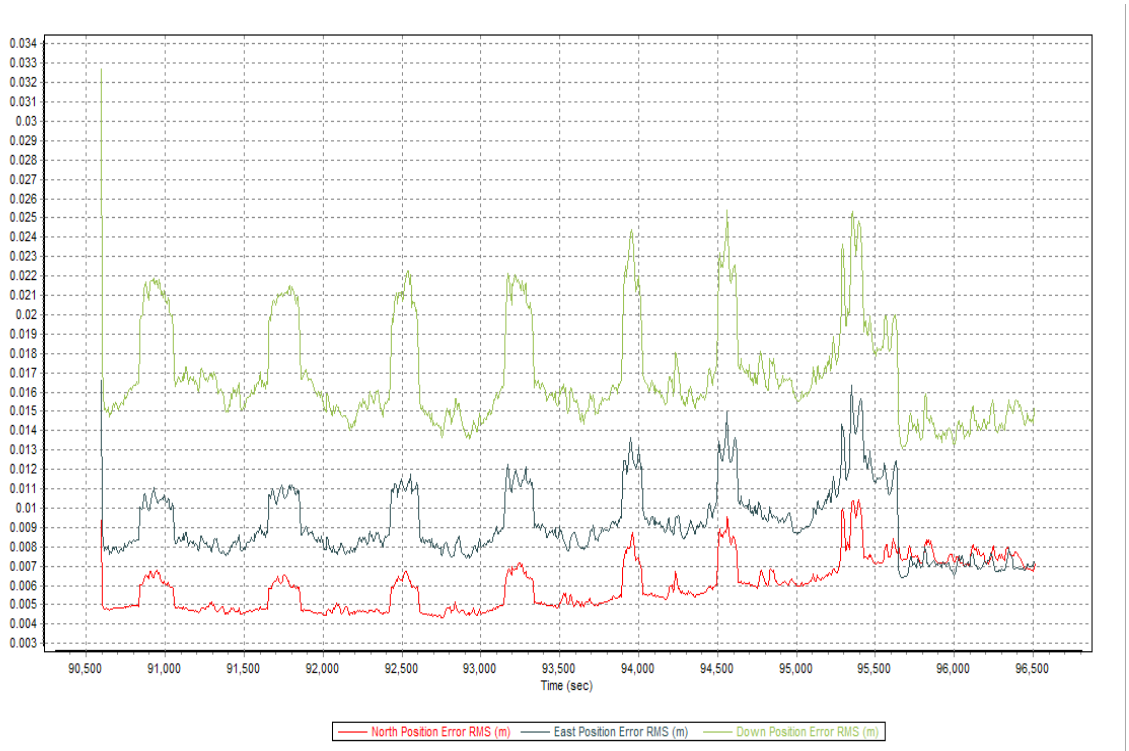


Figure A-8.58. Smoothed Performance Metric Parameters

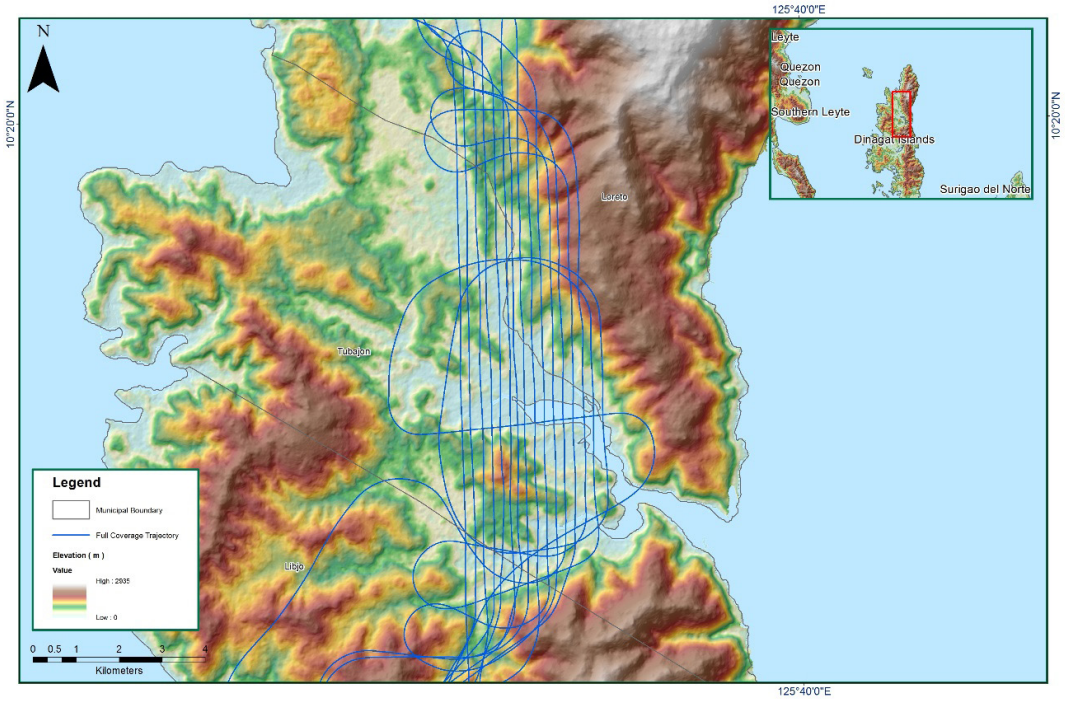


Figure A-8.59 Best Estimated Trajectory

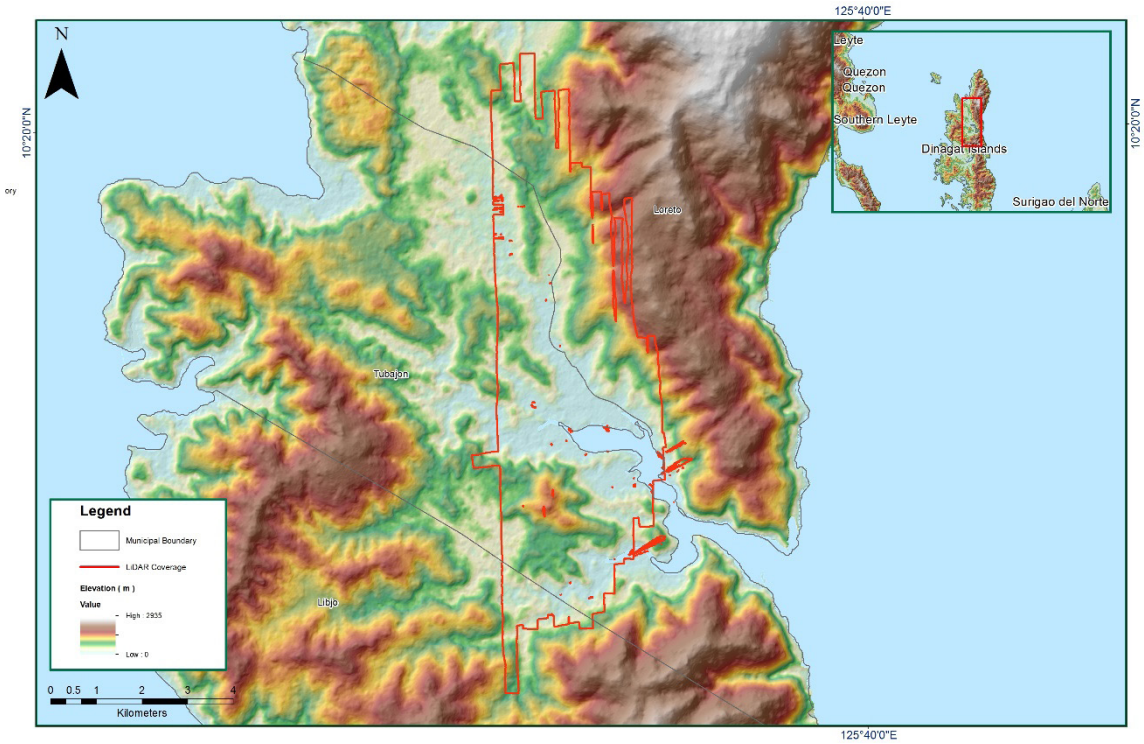


Figure A-8.60 Coverage of LiDAR data

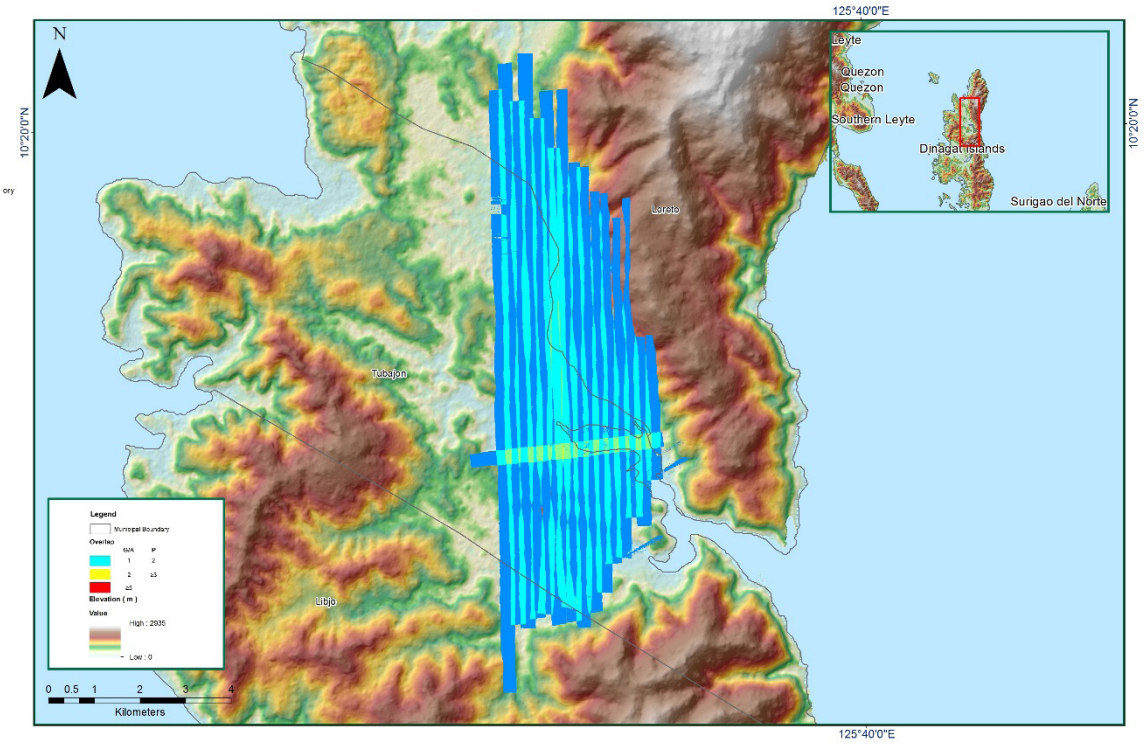


Figure A-8.61 Image of data overlap

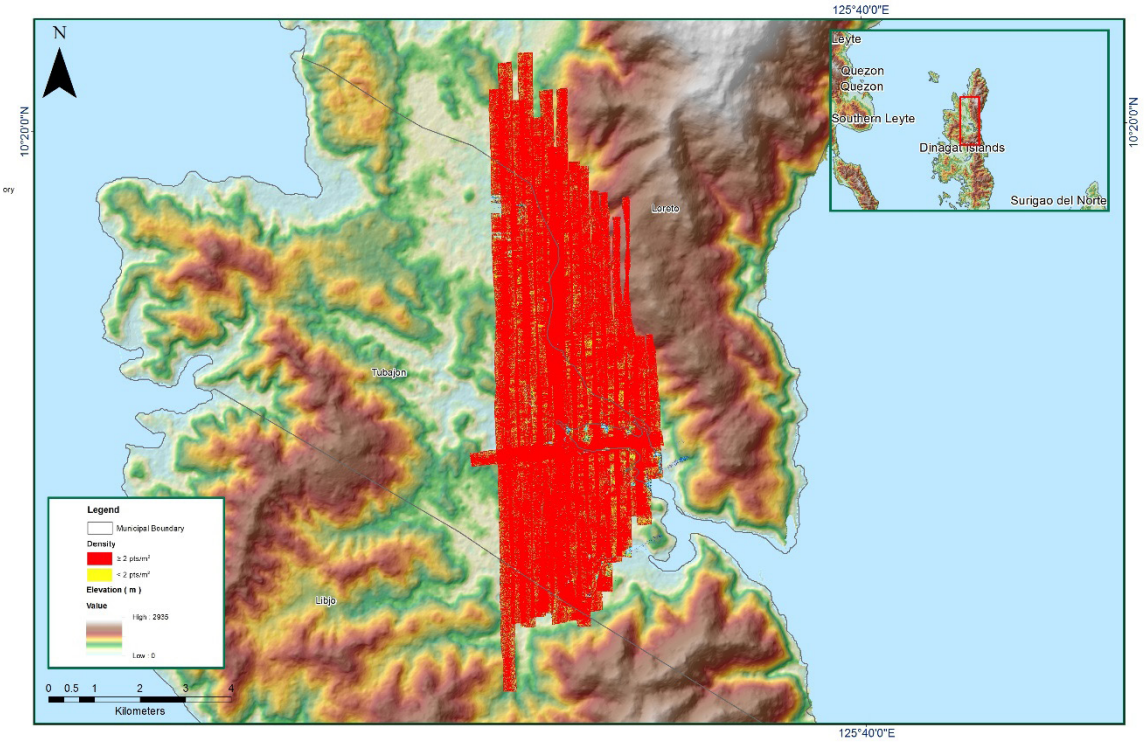


Figure A-8.62 Density Map of merged LiDAR data

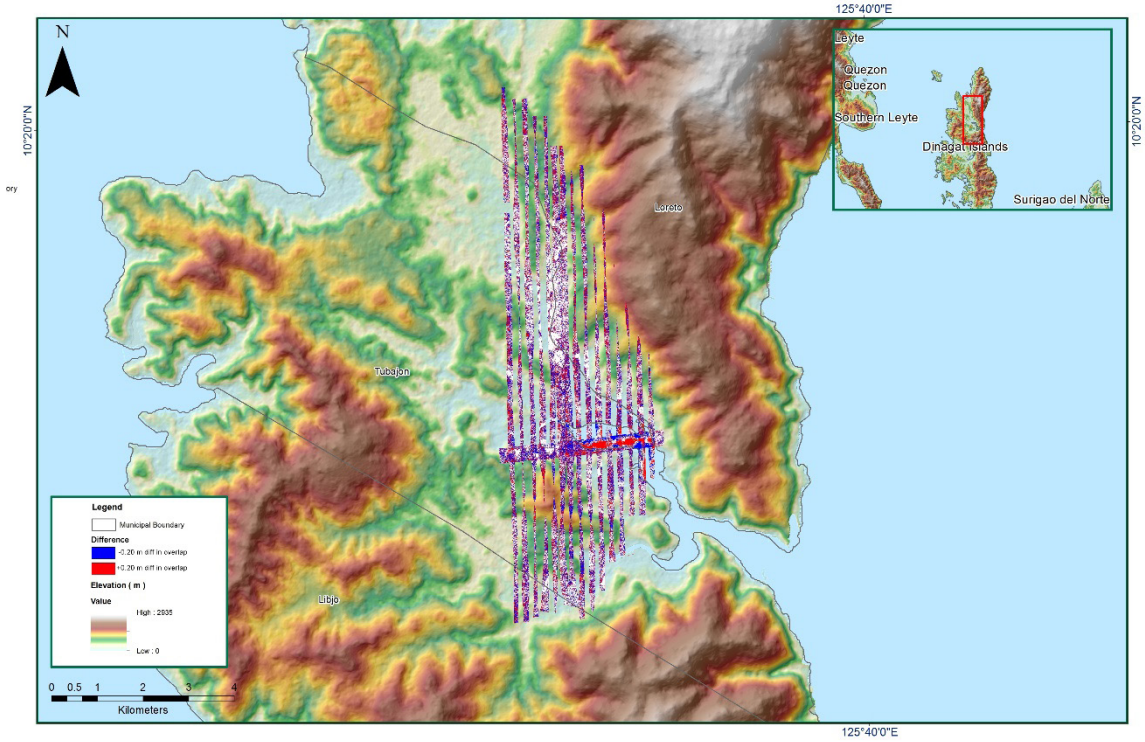


Figure A-8.63 Elevation Difference Between flight lines

Table A-8.10. Mission Summary Report for Mission Block 59B

Flight Area	Surigao Reflights
Mission Name	Block 59B
Inclusive Flights	8493AC
Range data size	2.24 GB
POS data size	74.8 MB
Base data size	28.4 MB
Image	12.9 GB
Transfer date	June 23, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	0.797
RMSE for East Position (<4.0 cm)	1.261
RMSE for Down Position (<8.0 cm)	2.695
Boresight correction stdev (<0.001deg)	0.000502
IMU attitude correction stdev (<0.001deg)	0.002310
GPS position stdev (<0.01m)	0.0024
Minimum % overlap (>25)	33.87
Ave point cloud density per sq.m. (>2.0)	4.22
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	56
Maximum Height	393.04 m
Minimum Height	-9.32 m
Classification (# of points)	
Ground	27,887,573
Low vegetation	14,978,781
Medium vegetation	32,800,643
High vegetation	51,855,194
Building	1,837,571
Orthophoto	No
Processed by	Engr. Sheila-Maye Santillan, Engr. Edgardo Gubatanga Jr., Engr. Monalyne Rabino

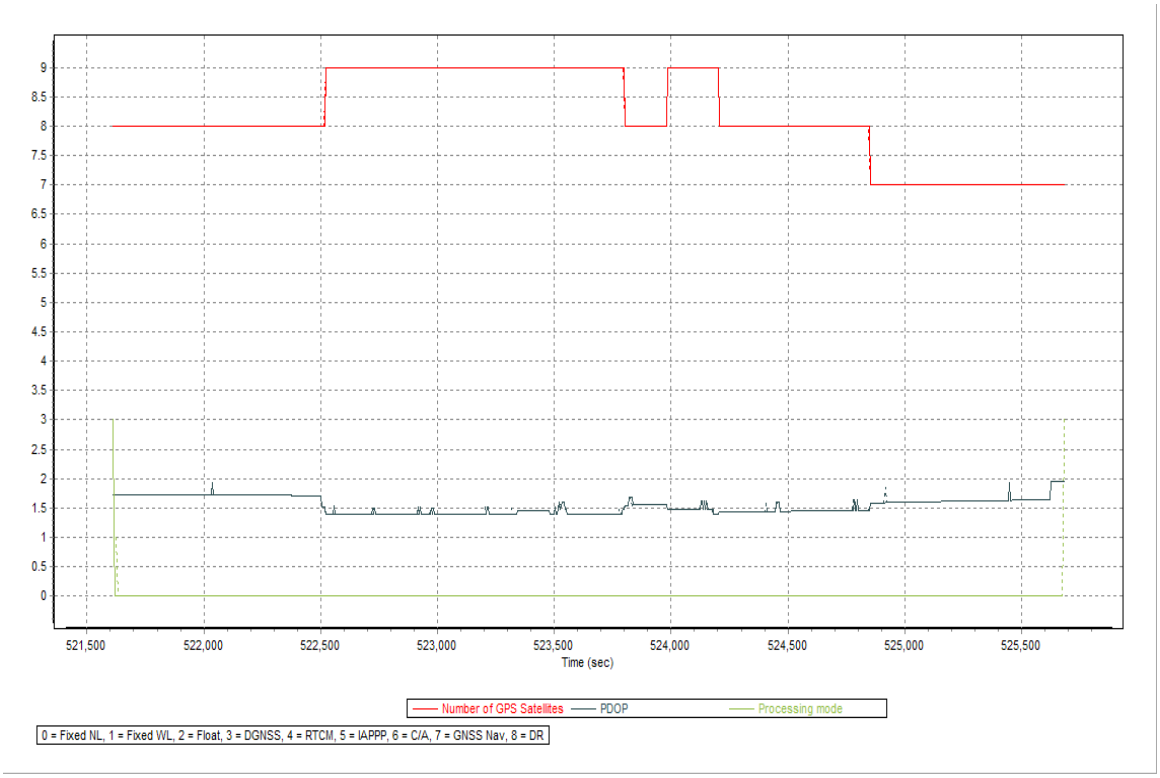


Figure A-8.64. Solution Status

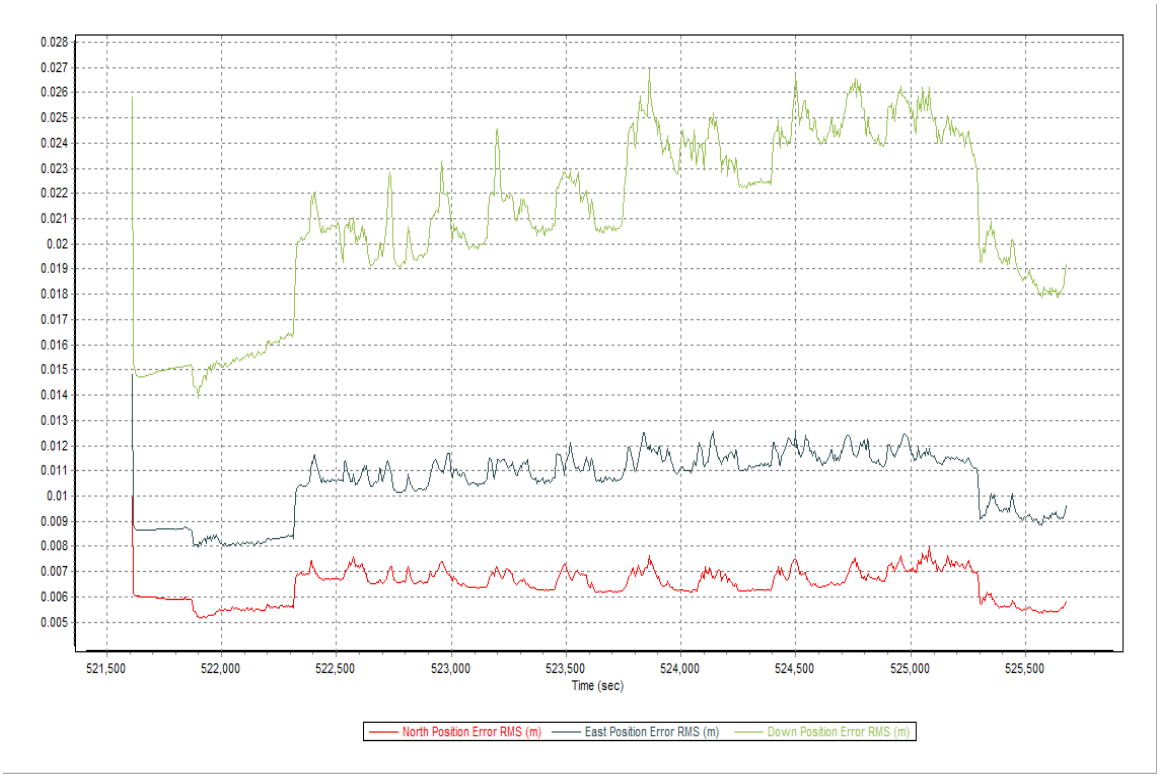


Figure A-8.65. Smoothed Performance Metric Parameters

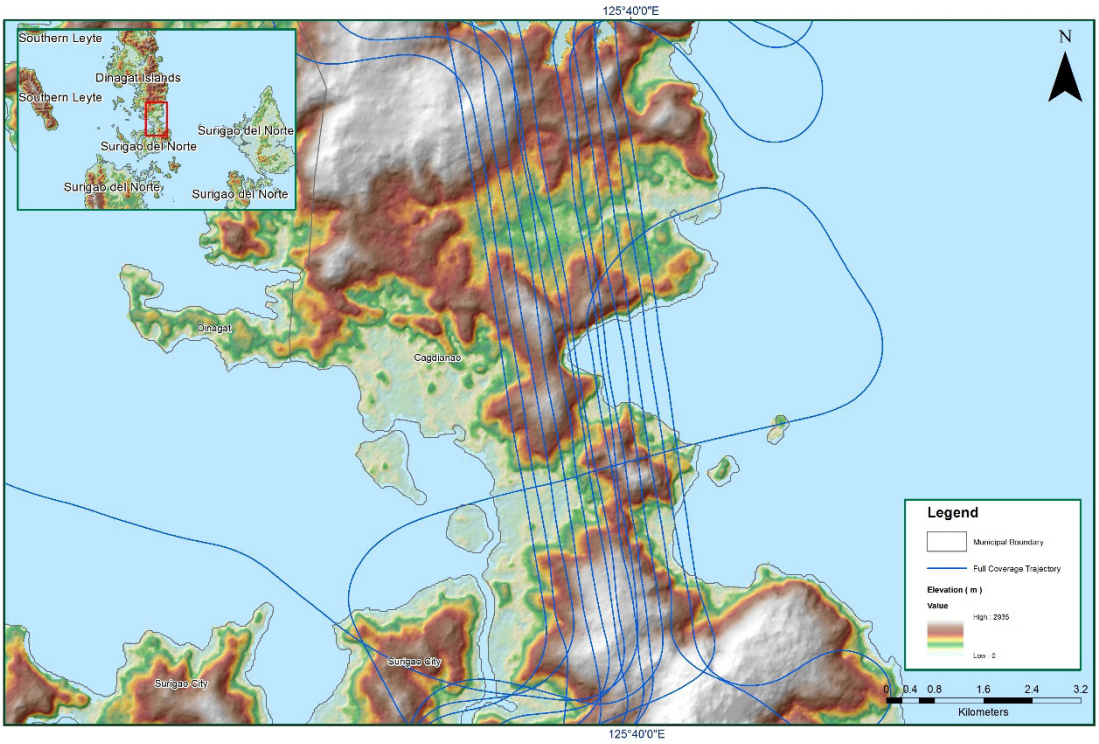


Figure A-8.66 Best Estimated Trajectory

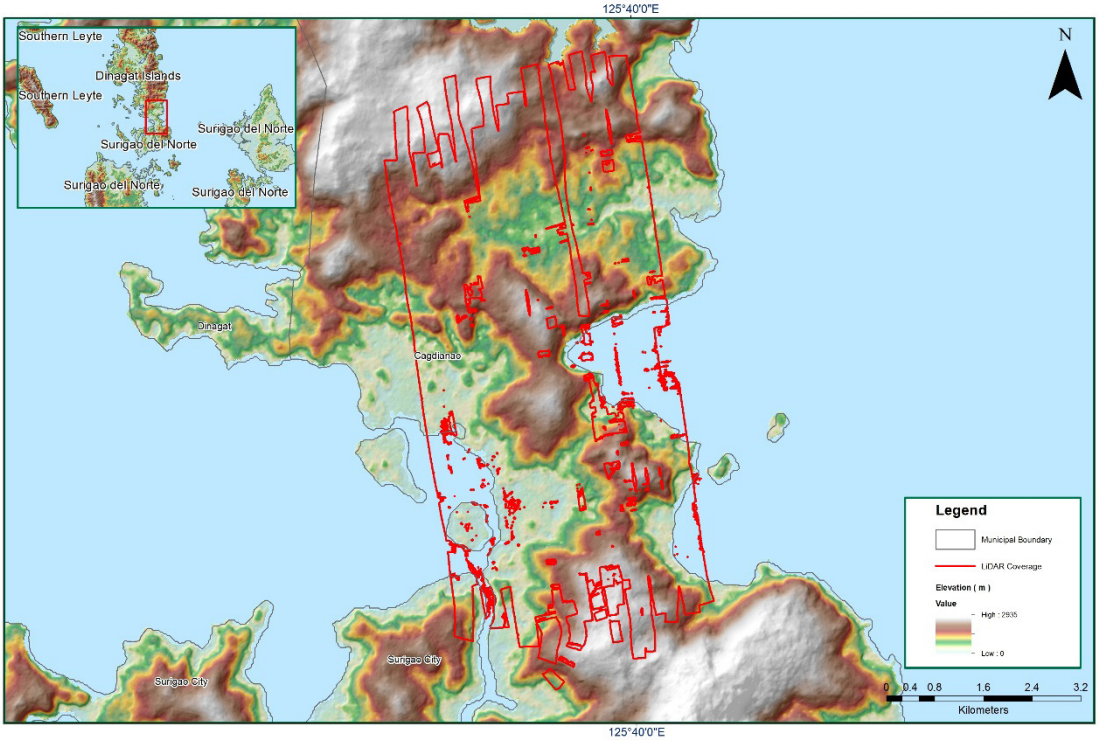


Figure A-8.67 Coverage of LiDAR data

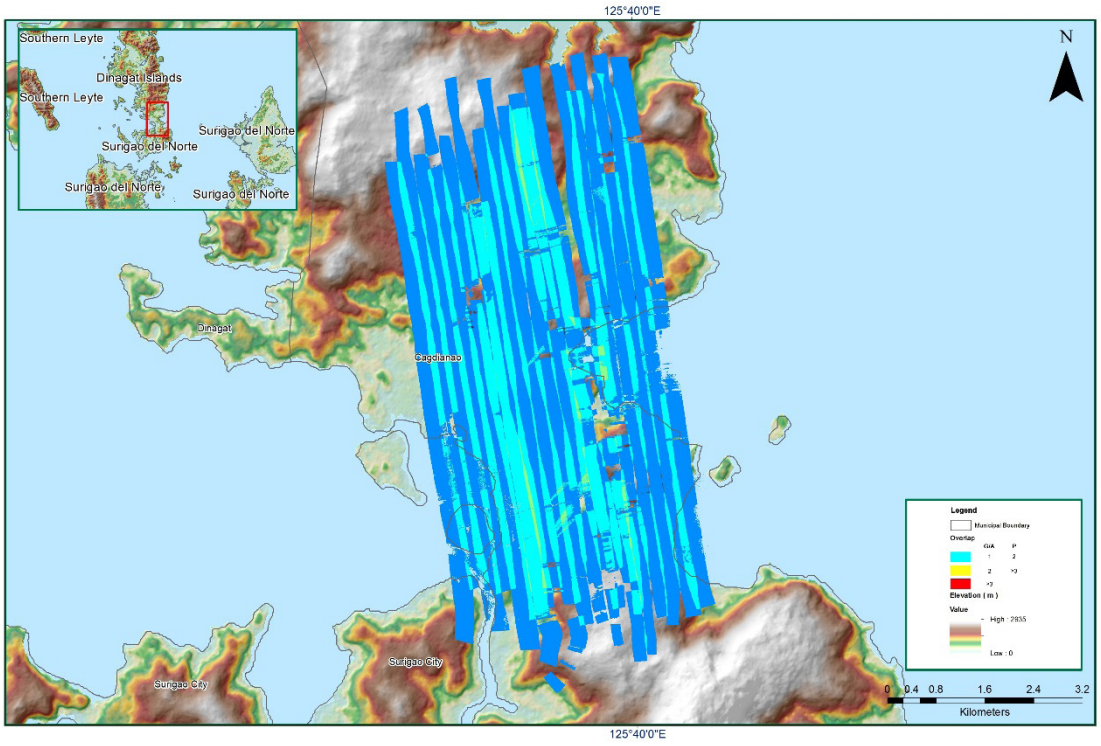


Figure A-8.68 Image of data overlap

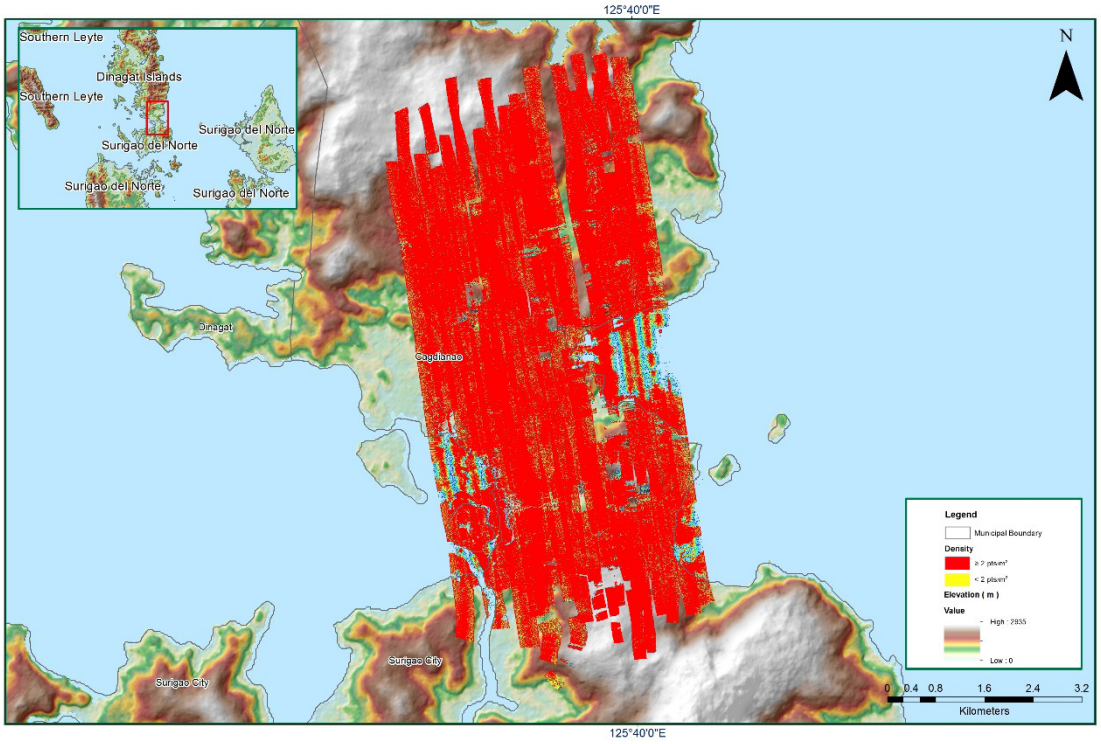


Figure A-8.69 Density Map of merged LiDAR data

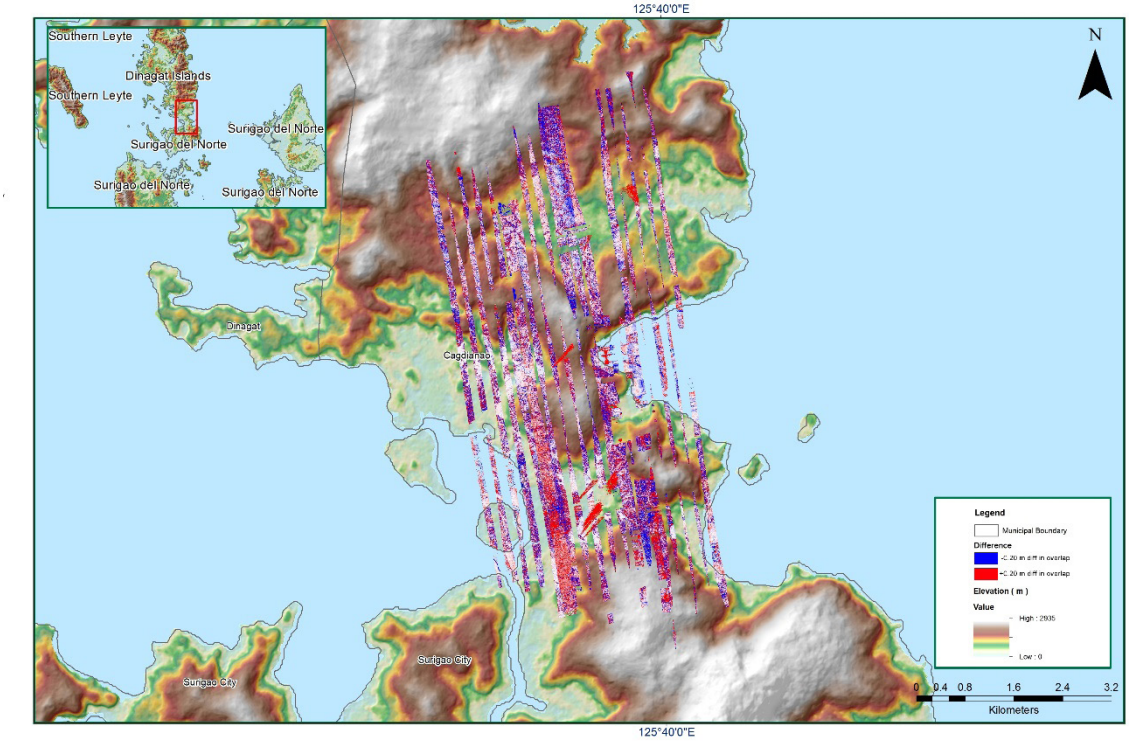


Figure A-8.70 Elevation Difference Between flight lines

Table A-8.11. Mission Summary Report for Mission Block 59A

Flight Area	Surigao Reflights
Mission Name	Block 59A
Inclusive Flights	8499AC
Range data size	9.44 GB
POS data size	236 MB
Base data size	3 MB
Image	n/a
Transfer date	June 23, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.252
RMSE for East Position (<4.0 cm)	1.080
RMSE for Down Position (<8.0 cm)	3.145
Boresight correction stdev (<0.001deg)	0.000532
IMU attitude correction stdev (<0.001deg)	0.004844
GPS position stdev (<0.01m)	0.0145
Minimum % overlap (>25)	45.86
Ave point cloud density per sq.m. (>2.0)	2.61
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	44
Maximum Height	246.16 m
Minimum Height	46.45 m
Classification (# of points)	
Ground	14,861,251
Low vegetation	11,587,871
Medium vegetation	9,917,938
High vegetation	13,417,530
Building	1,117,101
Orthophoto	No
Processed by	Engr. Kenneth Solidum, Erica Erin Elazegui, Karl Adrian Vergara

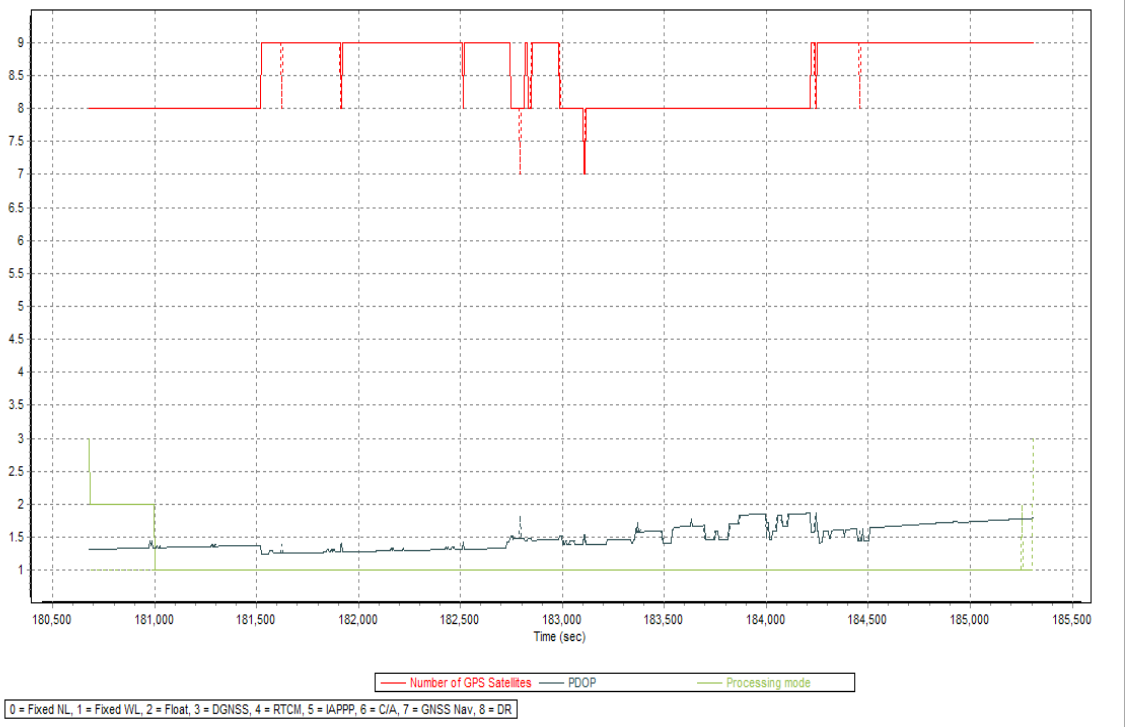


Figure A-8.71. Solution Status

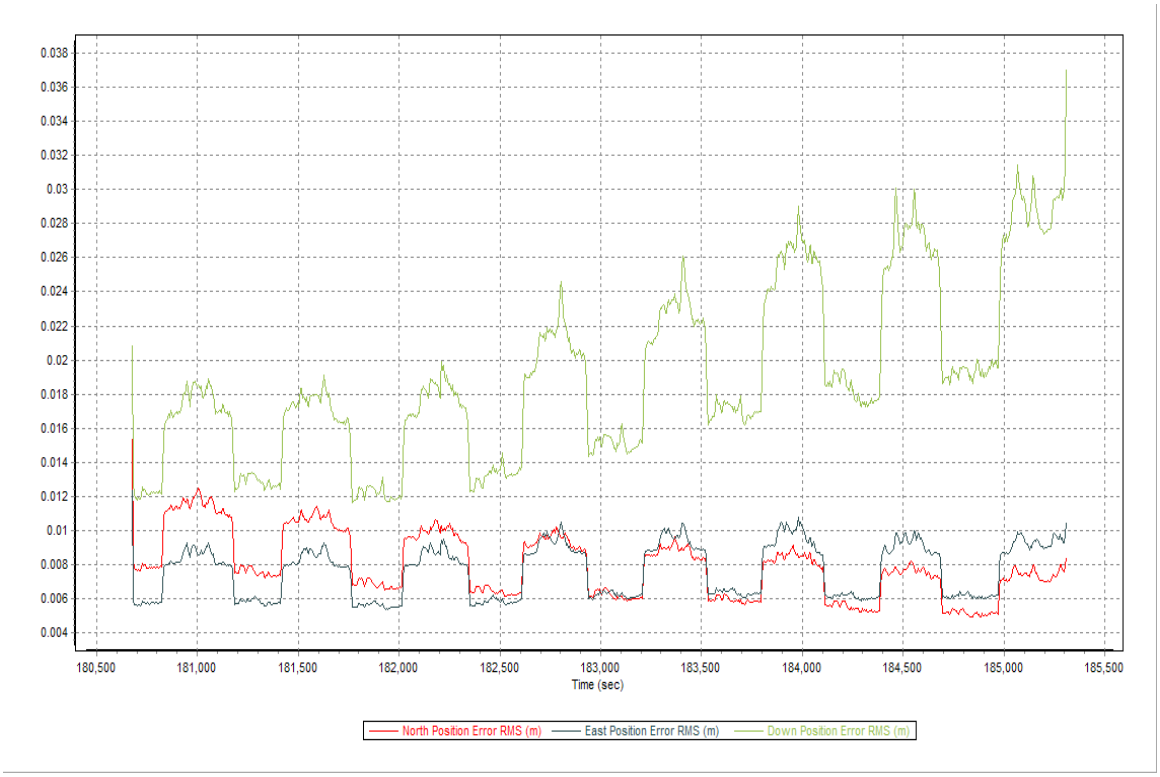


Figure A-8.72. Smoothed Performance Metric Parameters

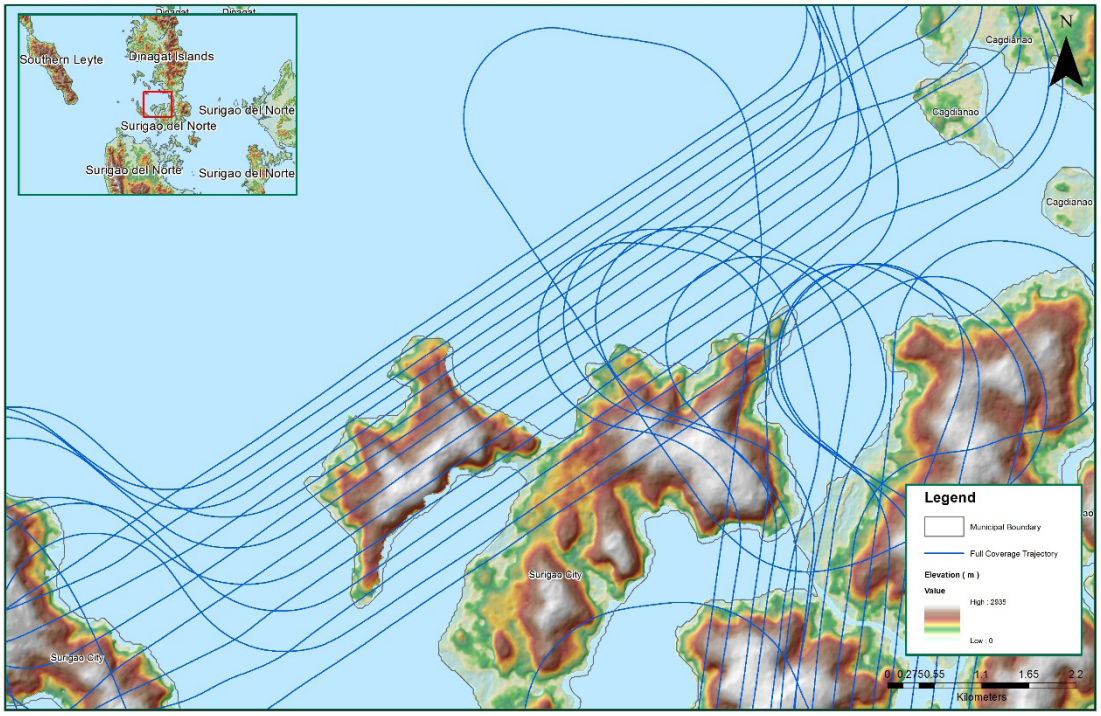


Figure A-8.73 Best Estimated Trajectory

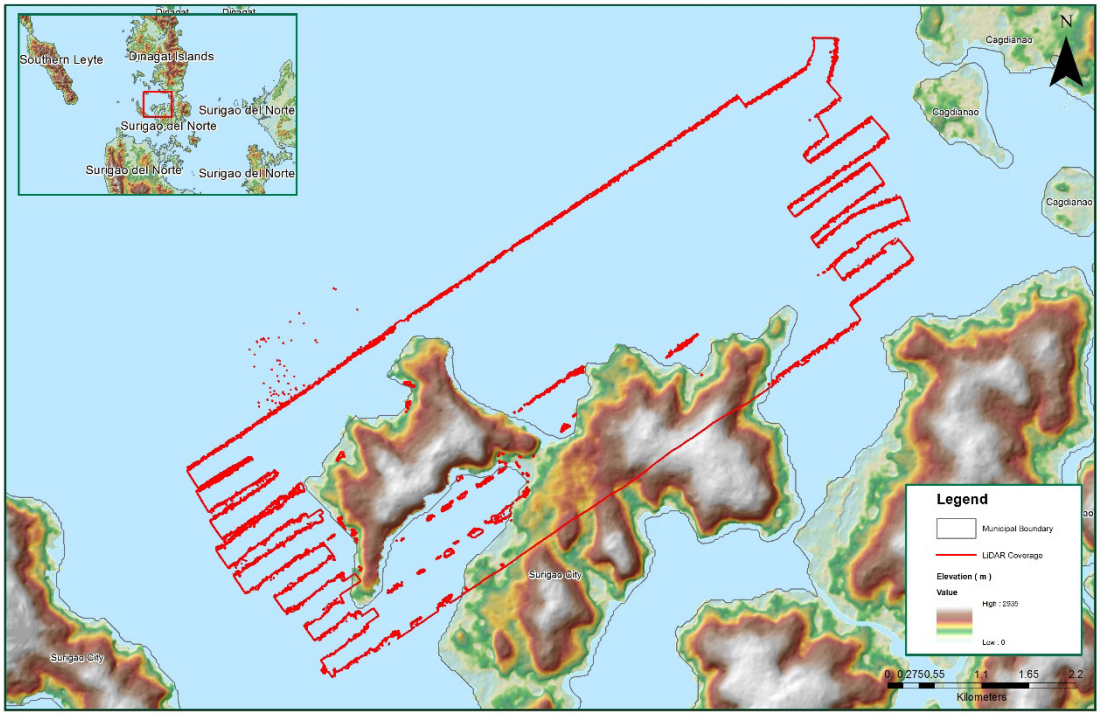


Figure A-8.74 Coverage of LiDAR data

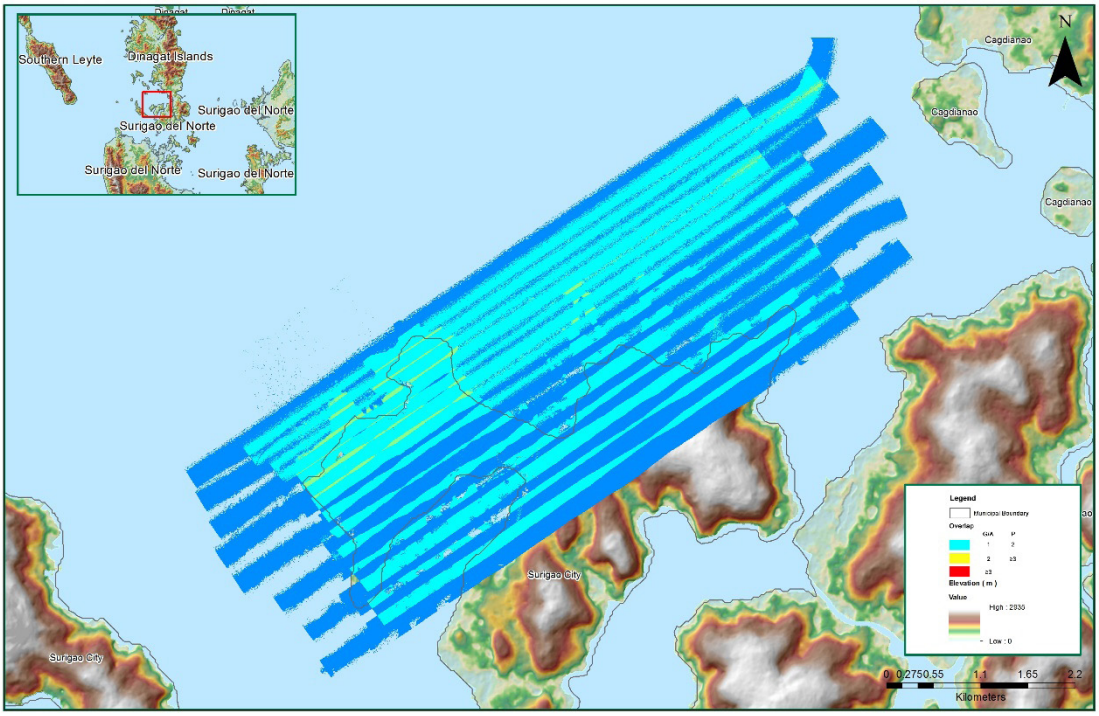


Figure A-8.75 Image of data overlap

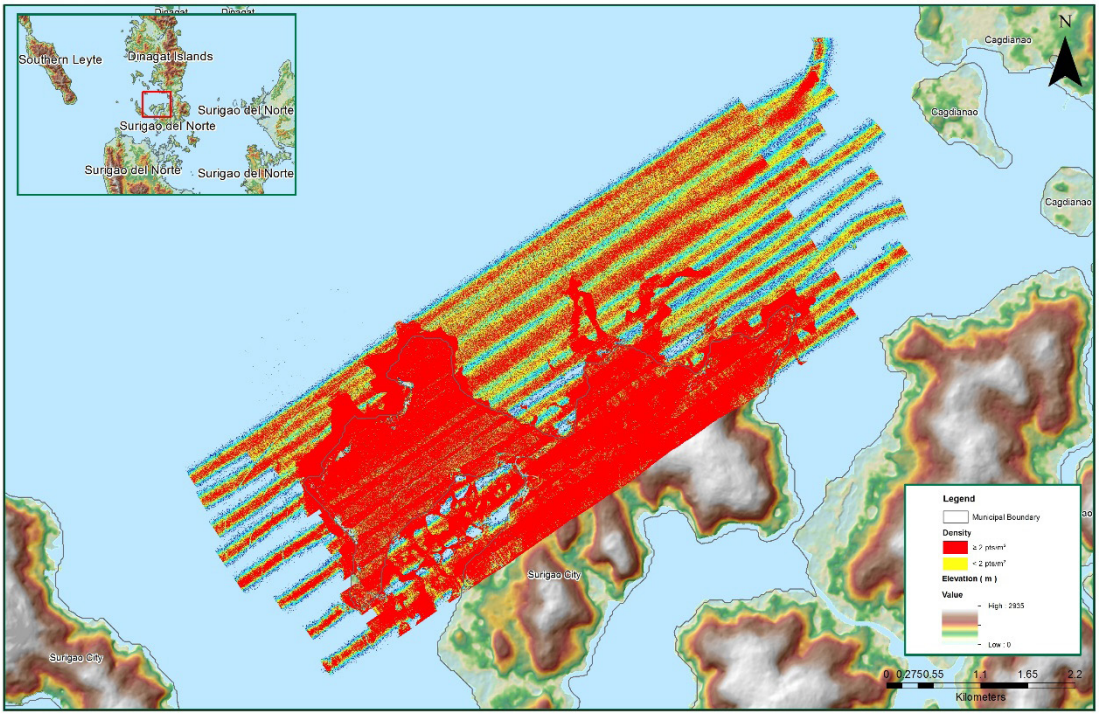


Figure A-8.76 Coverage of LiDAR data

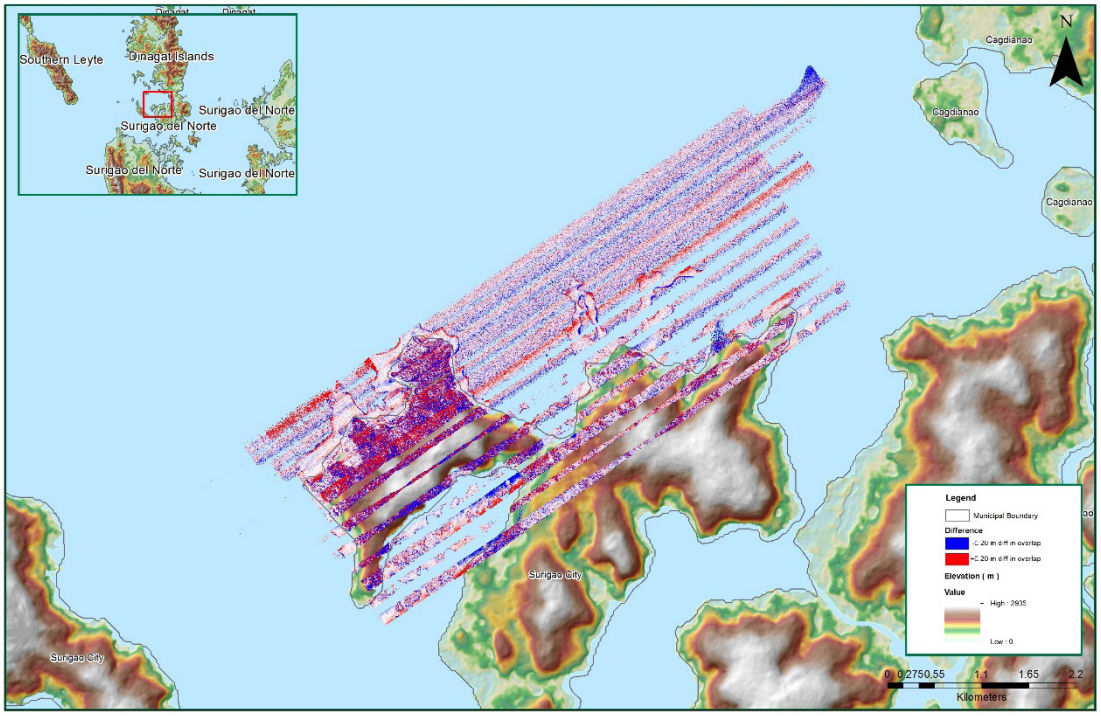


Figure A-8.77 Elevation Difference Between flight lines

Table A-8.12. Mission Summary Report for Mission Block 59A Supplement

Flight Area	**Surigao Reflights**
Mission Name	Block 59A Supplement
Inclusive Flights	8499AC
Range data size	9.44 GB
POS data size	236 MB
Base data size	3 MB
Image	n/a
Transfer date	June 23, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	0.978
RMSE for East Position (<4.0 cm)	1.062
RMSE for Down Position (<8.0 cm)	2.073
Boresight correction stdev (<0.001deg)	0.000532
IMU attitude correction stdev (<0.001deg)	0.004844
GPS position stdev (<0.01m)	0.0145
Minimum % overlap (>25)	41.57
Ave point cloud density per sq.m. (>2.0)	3.95
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	51
Maximum Height	523.86 m
Minimum Height	57.60 m
Classification (# of points)	
Ground	28,217,056
Low vegetation	15,092,740
Medium vegetation	28,774,965
High vegetation	38,152,863
Building	2,310,991
Orthophoto	No
Processed by	Engr. Kenneth Solidum, Erica Erin Elazegui, Alex John Escobido

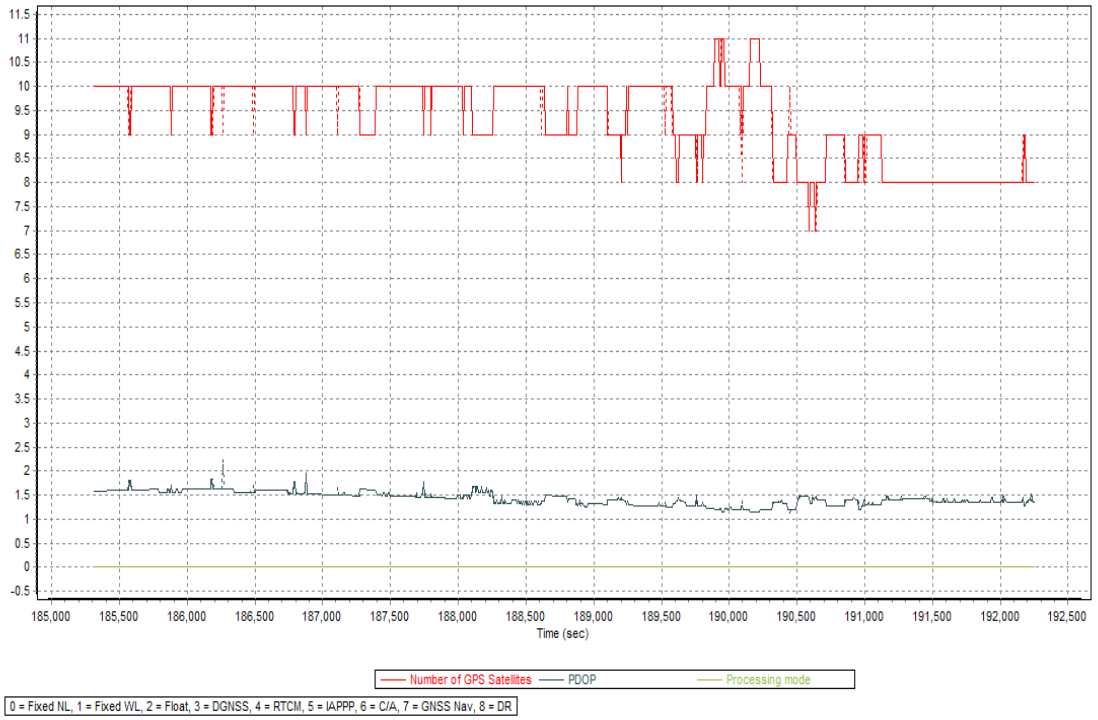


Figure A-8.78. Solution Status

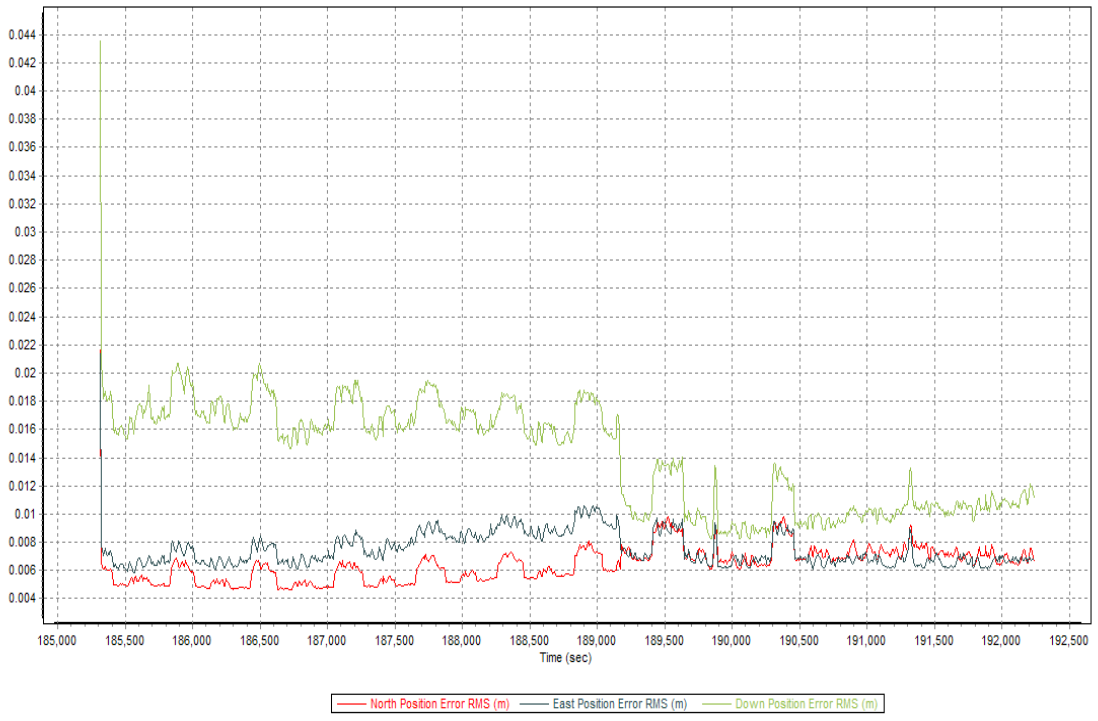


Figure A-8.79. Smoothed Performance Metric Parameters

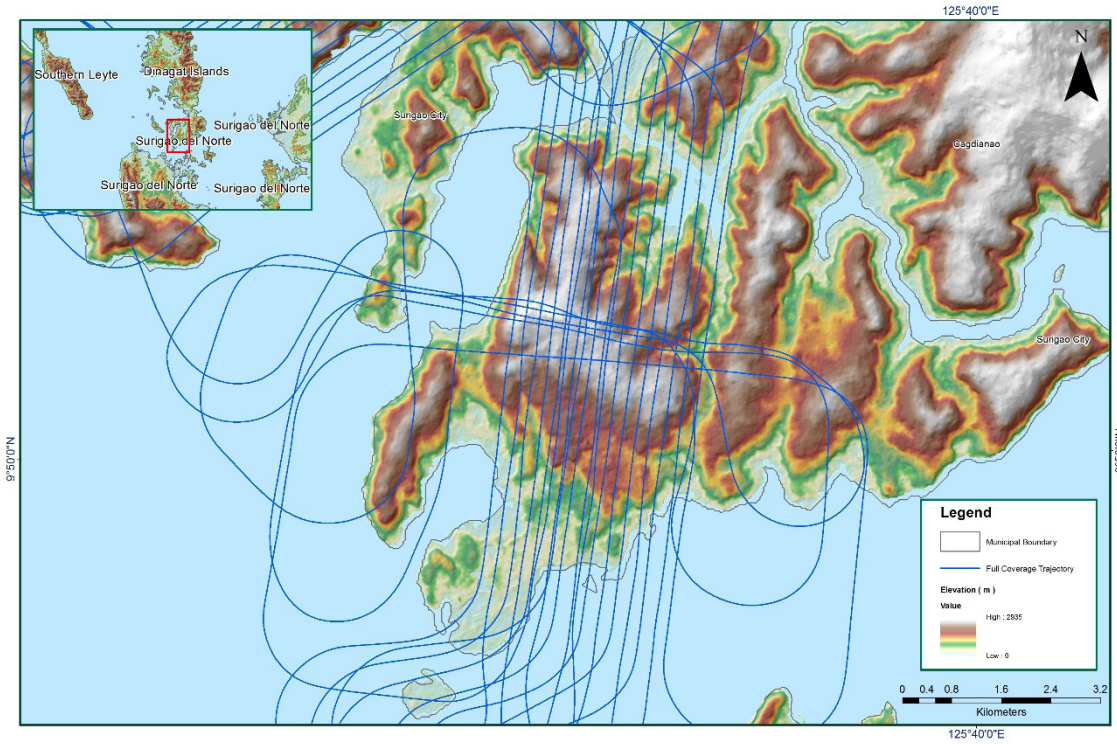


Figure A-8.80 Best Estimated Trajectory

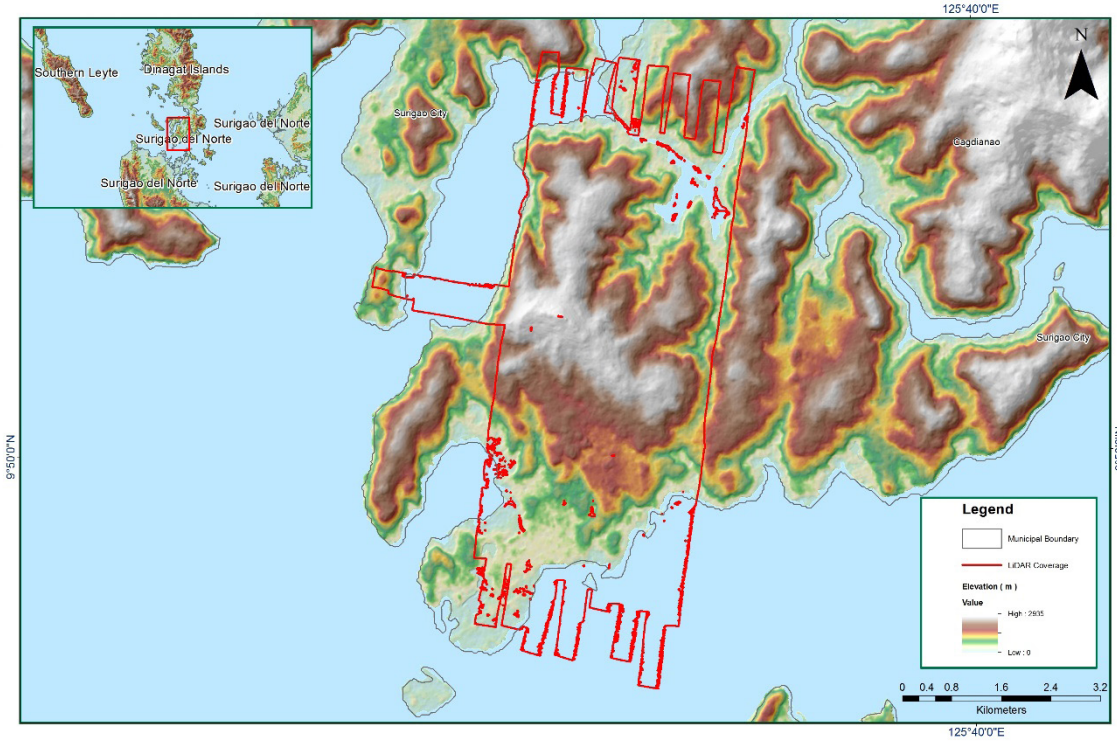


Figure A-8.81 Coverage of LiDAR data

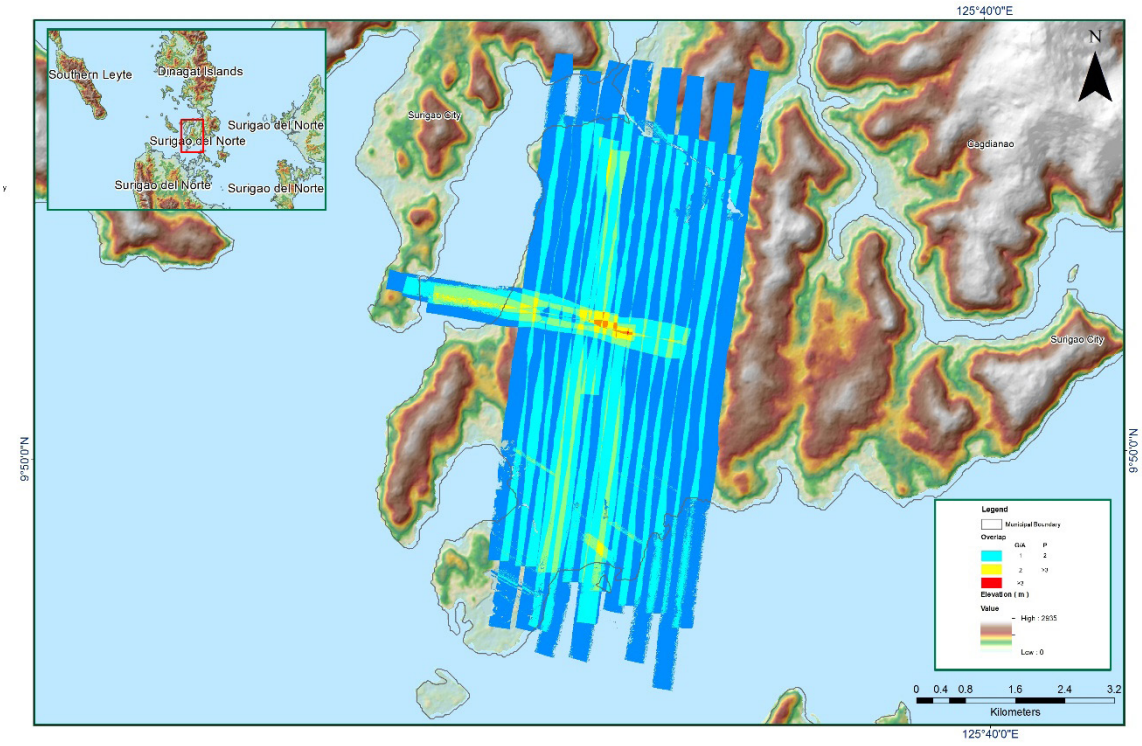


Figure A-8.82 Image of data overlap

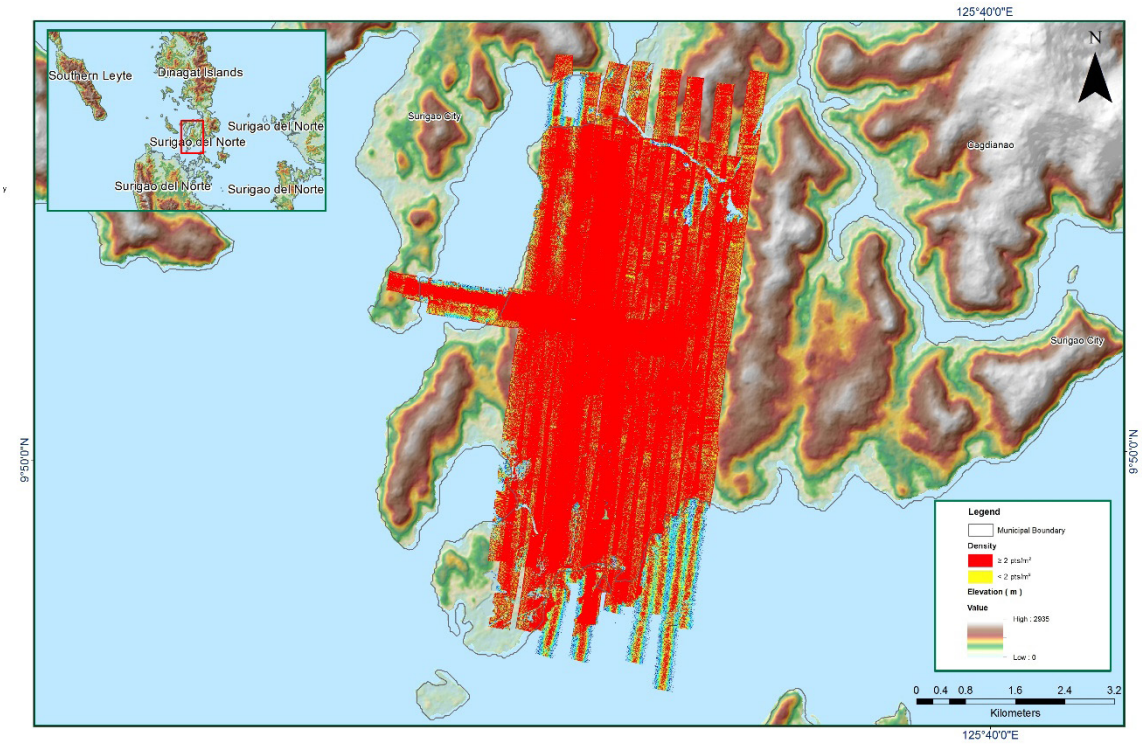


Figure A-8.83 Coverage of LiDAR data

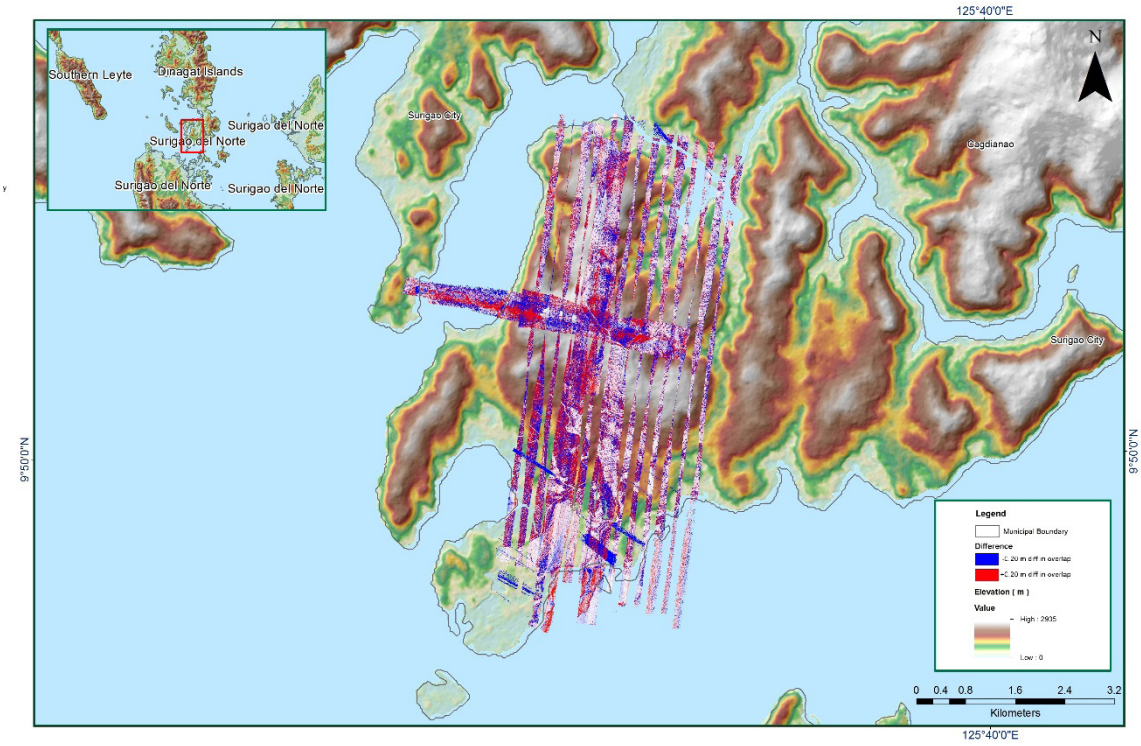


Figure A-8.84 Elevation Difference Between flight lines

Annex 9. Malinao Inlet Model Basin Parameters

Table A-9.1. Molinao Inlet Model Basin Parameters

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph Transform	Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W1010	2.26	81.824	0.0	54.526	Discharge	0.0287989	1	Ratio to Peak	0.25
W1030	2.09	82.906	0.0	28.164	Discharge	0.0125500	1	Ratio to Peak	0.25
W1050	2.14	82.606	0.0	17.9252	Discharge	0.0027380	1	Ratio to Peak	0.25
W1060	2.50	80.223	0.0	62.742	Discharge	0.0262003	1	Ratio to Peak	0.25
W1070	2.55	79.928	0.0	47.732	Discharge	0.0354572	1	Ratio to Peak	0.25
W1080	2.78	78.546	0.0	36.564	Discharge	0.0429842	1	Ratio to Peak	0.25
W1090	2.84	78.171	0.0	12.2358	Discharge	0.0010753	1	Ratio to Peak	0.25
W1100	2.34	81.300	0.0	41.632	Discharge	0.0358704	1	Ratio to Peak	0.25
W1110	2.62	79.492	0.0	75.378	Discharge	0.0629493	1	Ratio to Peak	0.25
W1120	1.68	85.814	0.0	78.672	Discharge	0.0619960	1	Ratio to Peak	0.25
W1130	4.19	70.809	0.0	82.604	Discharge	0.0381678	1	Ratio to Peak	0.25
W1140	1.71	85.619	0.0	36.966	Discharge	0.0156241	1	Ratio to Peak	0.25
W1150	2.76	78.612	7.1817	40.052	Discharge	0.0384367	1	Ratio to Peak	0.25
W1160	8.26	55.150	0.0	122.97	Discharge	0.0402935	1	Ratio to Peak	0.25
W1170	0.89	91.982	0.0	19.6216	Discharge	0.0194473	1	Ratio to Peak	0.25
W1180	5.56	64.642	0.0	117.554	Discharge	0.0881390	1	Ratio to Peak	0.25
W1190	8.31	55	0.0	102.412	Discharge	0.0362039	1	Ratio to Peak	0.25
W1200	4.11	71.189	0.0	70.652	Discharge	0.0403159	1	Ratio to Peak	0.25
W1210	8.22	55.283	0.0	113.626	Discharge	0.0412842	1	Ratio to Peak	0.25
W1220	8.31	55	0.0	69.178	Discharge	0.0254535	1	Ratio to Peak	0.25

W1240	1.68	85.793	0.0	32.872	Discharge	0.0601814	1	Ratio to Peak	0.25
W1250	2.54	80.008	0.0	34.966	Discharge	0.0227155	1	Ratio to Peak	0.25
W1260	8.31	55	0.0	62.658	Discharge	0.0284031	1	Ratio to Peak	0.25
W1270	8.31	55	0.0	66.58	Discharge	0.0287068	1	Ratio to Peak	0.25
W1280	8.31	55	0.0	63.822	Discharge	0.0380135	1	Ratio to Peak	0.25
W1290	6.82	59.824	0.0	58.26	Discharge	0.0317360	1	Ratio to Peak	0.25
W1300	0.21	97.960	0.0	17.757	Discharge	0.0429270	1	Ratio to Peak	0.25
W1310	2.99	77.256	0.0	38.446	Discharge	0.0118979	1	Ratio to Peak	0.25
W1340	7.86	56.367	0.0	57.316	Discharge	0.0364329	1	Ratio to Peak	0.25
W1350	8.31	55	0.0	197.412	Discharge	0.13793	1	Ratio to Peak	0.25
W1360	8.27		0.0	30.932	Discharge	0.0022302	1	Ratio to Peak	0.25
W1370	8.31	55	0.0	76.258	Discharge	0.0351759	1	Ratio to Peak	0.25
W1380	5.99	62.920	0.0	106.526	Discharge	0.0582972	1	Ratio to Peak	0.25
W1390	4.56	69	0.0	29.256	Discharge	0.0022128	1	Ratio to Peak	0.25
W1400	8.31	55.002	0.0	99.76	Discharge	0.0898266	1	Ratio to Peak	0.25
W1410	7.76	56.697	0.0	65.838	Discharge	0.0282612	1	Ratio to Peak	0.25
W1420	7.68	56.952	0.0	61.994	Discharge	0.0293241	1	Ratio to Peak	0.25
W1430	8.31	55	0.0	115.818	Discharge	0.0700880	1	Ratio to Peak	0.25
W1440	8.31	55.013	0.0	90.58	Discharge	0.0475965	1	Ratio to Peak	0.25
W1450	8.31	55	0.0	62.216	Discharge	0.0285450	1	Ratio to Peak	0.25
W1460	8.31	55	0.0	56.846	Discharge	0.0160796	1	Ratio to Peak	0.25
W1470	8.31	55	0.0	53.94	Discharge	0.0088836	1	Ratio to Peak	0.25
W1480	8.31	55	0.0	109	Discharge	0.0797831	1	Ratio to Peak	0.25
W1490	8.31	55	0.0	62.262	Discharge	0.0285649	1	Ratio to Peak	0.25
W1500	8.31	55	0.0	74.356	Discharge	0.0345014	1	Ratio to Peak	0.25
W1510	8.31	55	0.0	54.644	Discharge	0.0269495	1	Ratio to Peak	0.25
W1520	8.31	55	0.0	49.352	Discharge	0.0273602	1	Ratio to Peak	0.25
W1540	5.12	66.501	0.0	85.916	Discharge	0.0675741	1	Ratio to Peak	0.25

W1550	4.78	67.988	0.0	20.016	Discharge	0.0018942	1	Ratio to Peak	0.25
W1590	2.19	82.236	0.0	20.11	Discharge	0.0036739	1	Ratio to Peak	0.25
W1600	1.94	84	0.0	4.8588	Discharge	5.72493E-5	1	Ratio to Peak	0.25
W1640	2.83	78.239	0.0	51.974	Discharge	0.0111761	1	Ratio to Peak	0.25
W1650	3.03	77	0.0	55.39	Discharge	0.0279625	1	Ratio to Peak	0.25
W1690	2.68	79.099	0.0	83.762	Discharge	0.0323633	1	Ratio to Peak	0.25
W1700	2.86	78.016	0.0	59.412	Discharge	0.0452593	1	Ratio to Peak	0.25
W1740	1.94	84	0.0	30.932	Discharge	0.0065862	1	Ratio to Peak	0.25
W1750	1.94	84	0.0	62.172	Discharge	0.0428349	1	Ratio to Peak	0.25
W1790	2.09	82.912	0.0	61.164	Discharge	0.0179439	1	Ratio to Peak	0.25
W1800	2.31	81.485	0.0	65.588	Discharge	0.0715964	1	Ratio to Peak	0.25
W1840	1.94	84	0.0	13.373	Discharge	0.0022501	1	Ratio to Peak	0.25
W1850	2.18	82.354	0.0	52.668	Discharge	0.0355394	1	Ratio to Peak	0.25
W1890	1.94	84	0.0	19.5502	Discharge	0.003425	1	Ratio to Peak	0.25
W1900	2.68	79.144	0.0	42.31	Discharge	0.0381853	1	Ratio to Peak	0.25
W1940	1.94	84	0.0	33.63	Discharge	0.0057100	1	Ratio to Peak	0.25
W1950	2.46	80.539	0.0	35.012	Discharge	0.0351386	1	Ratio to Peak	0.25
W1990	1.94	83.966	0.0	28.39	Discharge	0.0107280	1	Ratio to Peak	0.25
W2000	2.48	80.404	0.0	30.018	Discharge	0.0360944	1	Ratio to Peak	0.25
W2040	2.00	83.568	0.0	27.928	Discharge	0.0073802	1	Ratio to Peak	0.25
W2050	2.54	79.991	0.0	30.742	Discharge	0.0321816	1	Ratio to Peak	0.25
W2090	2.26	81.776	0.0	54.144	Discharge	0.0311237	1	Ratio to Peak	0.25
W2100	2.85	78.067	0.0	38.496	Discharge	0.0329855	1	Ratio to Peak	0.25
W2140	3.01	77.168	0.0	57.448	Discharge	0.0277360	1	Ratio to Peak	0.25
W2150	2.83	78.195	0.0	90.612	Discharge	0.0796561	1	Ratio to Peak	0.25
W2190	4.74	68.194	0.0	69.278	Discharge	0.0335381	1	Ratio to Peak	0.25
W2200	7.04	59.056	0.0	76.416	Discharge	0.0412369	1	Ratio to Peak	0.25
W2240	5.61	64.432	0.0	61.488	Discharge	0.0149719	1	Ratio to Peak	0.25

W2250	8.29	55.073	0.0	75.684	Discharge	0.0532468	1	Ratio to Peak	0.25
W800	2.70	79	0.0	35.038	Discharge	0.0399202	1	Ratio to Peak	0.25
W810	1.94	84	0.0	9.2608	Discharge	.000311137	1	Ratio to Peak	0.25
W820	2.30	81.534	0.0	75.856	Discharge	0.0639947	1	Ratio to Peak	0.25
W840	2.03	83.362	0.0	38.24	Discharge	0.0240372	1	Ratio to Peak	0.25
W850	2.78	78.509	0.0	30.706	Discharge	0.0296327	1	Ratio to Peak	0.25
W860	1.94	84	0.0	28.46	Discharge	0.0190989	1	Ratio to Peak	0.25
W880	2.27	81.709	0.0	90.43	Discharge	0.0700457	1	Ratio to Peak	0.25
W900	1.94	84	0.0	23.596	Discharge	0.0095532	1	Ratio to Peak	0.25
W920	2.09	82.934	0.0	59.588	Discharge	0.0205799	1	Ratio to Peak	0.25
W940	4.51	69.235	0.0	64.116	Discharge	0.0492866	1	Ratio to Peak	0.25
W950	8.10	55.633	0.0	61.212	Discharge	0.0309370	1	Ratio to Peak	0.25
W960	2.30	81.522	0.0	51.586	Discharge	0.0296128	1	Ratio to Peak	0.25
W980	5.50	64.861	0.0	113.702	Discharge	0.0722137	1	Ratio to Peak	0.25

Annex 10. Malinao Inlet Model Reach Parameters

Table A-10.1. Maliano Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width (m)
R10	Automatic Fixed Interval	2030.4	0.0027615	0.025	Rectangle	4.8428294
R100	Automatic Fixed Interval	881.54	0.0034428	0.025	Rectangle	5.4010
R110	Automatic Fixed Interval	895.69	0.015412	0.025	Rectangle	3.8838
R120	Automatic Fixed Interval	403.85	0.0618291	0.025	Rectangle	4.54106
R130	Automatic Fixed Interval	675.27	0.0121594	0.025	Rectangle	3.8008
R140	Automatic Fixed Interval	627.70	0.0278765	0.025	Rectangle	5.1354371
R1560	Automatic Fixed Interval	365.27	0.001622	0.025	Rectangle	7.6166
R160	Automatic Fixed Interval	4396.9	0.0024071	0.025	Rectangle	5.9050
R1610	Automatic Fixed Interval	20.000	0.0025521	0.025	Rectangle	4.9952
R170	Automatic Fixed Interval	1645.1	0.007402	0.025	Rectangle	6.3074
R190	Automatic Fixed Interval	347.99	0.0113092	0.025	Rectangle	5.4523334
R20	Automatic Fixed Interval	160.71	0.0097873	0.025	Rectangle	4.7990
R210	Automatic Fixed Interval	1197.8	0.0149418	0.025	Rectangle	5.5102
R220	Automatic Fixed Interval	4036.2	0.0067295	0.025	Rectangle	6.6600
R230	Automatic Fixed Interval	916.69	0.0187713	0.025	Rectangle	2.0240180
R240	Automatic Fixed Interval	1697.5	0.001622	0.025	Rectangle	5.8078
R250	Automatic Fixed Interval	1438.1	0.0086498	0.025	Rectangle	4.8647189
R260	Automatic Fixed Interval	917.40	0.0178682	0.025	Rectangle	2.3603
R270	Automatic Fixed Interval	432.13	0.0075568	0.025	Rectangle	4.5685
R280	Automatic Fixed Interval	1537.8	0.001622	0.025	Rectangle	8.5092193
R290	Automatic Fixed Interval	936.69	0.0137012	0.025	Rectangle	1.6894
R30	Automatic Fixed Interval	869.12	0.0081766	0.025	Rectangle	4.1098537
R300	Automatic Fixed Interval	263.85	0.0384808	0.025	Rectangle	12.173
R330	Automatic Fixed Interval	2471.8	0.0063639	0.025	Rectangle	3.4915

R340	Automatic Fixed Interval	3831.7	0.0019187	0.025	Rectangle	6.1511
R350	Automatic Fixed Interval	2536.5	0.001622	0.025	Rectangle	97.6682384
R360	Automatic Fixed Interval	1106.4	0.001622	0.025	Rectangle	35.1145
R380	Automatic Fixed Interval	696.27	0.001622	0.025	Rectangle	178.41
R40	Automatic Fixed Interval	1215.4	0.0086338	0.025	Rectangle	4.1438
R420	Automatic Fixed Interval	1063.7	0.001622	0.025	Rectangle	104.1044616
R430	Automatic Fixed Interval	10.0000	0.001622	0.025	Rectangle	1.4811
R450	Automatic Fixed Interval	2095.5	0.0103151	0.025	Rectangle	7.7178
R470	Automatic Fixed Interval	1208.8	0.0257525	0.025	Rectangle	5.8247
R490	Automatic Fixed Interval	1652.0	0.001622	0.025	Rectangle	152.26
R500	Automatic Fixed Interval	1132.3	0.001622	0.025	Rectangle	116.62
R510	Automatic Fixed Interval	1043.3	0.001622	0.025	Rectangle	34.378
R520	Automatic Fixed Interval	2431.8	0.0090127	0.025	Rectangle	7.6122
R540	Automatic Fixed Interval	387.99	0.001622	0.025	Rectangle	5.2307
R550	Automatic Fixed Interval	1185.2	0.001622	0.025	Rectangle	283.72448
R580	Automatic Fixed Interval	2386.5	0.0039545	0.025	Rectangle	15.669
R600	Automatic Fixed Interval	3456.3	0.0053487	0.025	Rectangle	5.2427
R610	Automatic Fixed Interval	319.71	0.0205356	0.025	Rectangle	8.2190
R630	Automatic Fixed Interval	6996.0	0.0124293	0.025	Rectangle	11.845
R640	Automatic Fixed Interval	1385.4	0.0049927	0.025	Rectangle	6.0839753
R660	Automatic Fixed Interval	779.41	0.0312719	0.025	Rectangle	4.4705
R670	Automatic Fixed Interval	3470.9	0.0223729	0.025	Rectangle	7.3996
R690	Automatic Fixed Interval	1159.8	0.0225927	0.025	Rectangle	7.5157
R70	Automatic Fixed Interval	351.42	0.029137	0.025	Rectangle	2.4513
R710	Automatic Fixed Interval	668.70	0.0259683	0.025	Rectangle	9.4387
R730	Automatic Fixed Interval	1693.7	0.0457956	0.025	Rectangle	9.9552
R80	Automatic Fixed Interval	1565.5	0.0422314	0.025	Rectangle	4.3587634
R90	Automatic Fixed Interval	2548.7	0.001622	0.025	Rectangle	6.2556707

Annex 11. Malinao Inlet Field Validation Points

Table A-11.1. Malinao Inlet Field Validation Points

Point Number	Validation Coordinates		Model var (m)	Validation Points (m)	Error	Event/Date	Rain Return /Scenario
	Lat	Long					
1	10.25525	125.6385	0.34	1.7	1.36	Basyang	5-Year
2	10.25511	125.6393	0.21	0	-0.21	Basyang	5-Year
3	10.25515	125.6393	0.27	0	-0.27	Basyang	5-Year
4	10.25588	125.6209	1.22	0.56	-0.66	Basyang	5-Year
5	10.25624	125.6219	0.41	1.1	0.69	Basyang	5-Year
6	10.25573	125.623	0.6	0	-0.6	Basyang	5-Year
7	10.2557	125.6222	1.55	1.3	-0.25	Basyang	5-Year
8	10.25571	125.6229	1.05	0	-1.05	Basyang	5-Year
9	10.25571	125.6233	1.97	0.97	-1	Basyang	5-Year
10	10.25617	125.6238	2.19	1.21	-0.98	Basyang	5-Year
11	10.25616	125.6226	0.03	0.3	0.27	Basyang	5-Year
12	10.25603	125.6235	2.1	1	-1.1	Basyang	5-Year
13	10.25632	125.6217	1.19	0.71	-0.48	Basyang	5-Year
14	10.25622	125.6229	0.03	0.15	0.12	Basyang	5-Year
15	10.25612	125.623	0.03	0.8	0.77	Basyang	5-Year
16	10.2562	125.6232	0.03	0.9	0.87	Basyang	5-Year
17	10.2567	125.6244	0.04	0.5	0.46	Basyang	5-Year
18	10.25683	125.6251	0.03	1.2	1.17	Basyang	5-Year
19	10.25665	125.625	0.04	1.3	1.26	Basyang	5-Year
20	10.25636	125.626	0.03	0	-0.03	Basyang	5-Year
21	10.2566	125.6257	0.04	0	-0.04	Basyang	5-Year
22	10.25664	125.6255	0.03	1	0.97	Basyang	5-Year
23	10.25673	125.6254	0.04	0.31	0.27	Basyang	5-Year

24	10.25611	125.6264	0.03	0	-0.03	Basyang	5-Year
25	10.25648	125.6265	0.04	0.5	0.46	Basyang	5-Year
26	10.25644	125.6267	0.03	1.9	1.87	Basyang	5-Year
27	10.256	125.6266	0.93	1.25	0.32	Basyang	5-Year
28	10.25649	125.6271	0.3	2.2	1.9	Basyang	5-Year
29	10.25661	125.6269	0.03	0.4	0.37	Basyang	5-Year
30	10.25684	125.6273	0.03	0	-0.03	Basyang	5-Year
31	10.25704	125.6274	0.03	0	-0.03	Basyang	5-Year
32	10.25745	125.6273	0.03	0.5	0.47	Basyang	5-Year
33	10.25761	125.6271	0.06	0	-0.06	Basyang	5-Year
34	10.25768	125.627	0.06	0	-0.06	Basyang	5-Year
35	10.25791	125.627	0.04	0	-0.04	Basyang	5-Year
36	10.25862	125.6271	0.03	0.15	0.12	Basyang	5-Year
37	10.25929	125.6262	0.04	0.8	0.76	Basyang	5-Year
38	10.25948	125.6247	0.08	0	-0.08	Basyang	5-Year
39	10.25974	125.6242	0.04	0.7	0.66	Basyang	5-Year
40	10.26023	125.6241	0.32	1	0.68	Basyang	5-Year
41	10.30007	125.602	0.31	0	-0.31	Basyang	5-Year
42	10.30082	125.602	0.61	0	-0.61	Basyang	5-Year
43	10.29915	125.6023	0.69	0.47	-0.22	Basyang	5-Year
44	10.29945	125.6021	0.27	0	-0.27	Basyang	5-Year
45	10.29819	125.6023	0.67	0.28	-0.39	Basyang	5-Year
46	10.30123	125.6025	0.5	0	-0.5	Basyang	5-Year
47	10.29743	125.6033	0.49	0	-0.49	Basyang	5-Year
48	10.31677	125.5879	0.03	0	-0.03	Basyang	5-Year
49	10.28768	125.607	0.03	0	-0.03	Basyang	5-Year
50	10.28762	125.6069	0.03	0	-0.03	Basyang	5-Year
51	10.28763	125.6071	0.03	0	-0.03	Basyang	5-Year

52	10.29972	125.602	0.49	0.8	0.31	Basyang	5-Year
53	10.28814	125.6071	0.03	0	-0.03	Basyang	5-Year
54	10.31189	125.5933	0.03	0	-0.03	Basyang	5-Year
55	10.301	125.6028	1.62	0	-1.62	Basyang	5-Year
56	10.30114	125.6027	1.69	0	-1.69	Basyang	5-Year
57	10.3167	125.5935	0.66	1.08	0.42	Basyang	5-Year
58	10.31332	125.5917	0.03	0	-0.03	Basyang	5-Year
59	10.31307	125.5909	0.03	1.83	1.8	Basyang	5-Year
60	10.25563	125.6225	1.15	1.18	0.03	Basyang	5-Year
61	10.25636	125.6216	1.19	0.89	-0.3	Basyang	5-Year
62	10.25649	125.6205	1.35	0.4	-0.95	Basyang	5-Year
63	10.25668	125.6198	1.18	0.6	-0.58	Basyang	5-Year
64	10.25594	125.6233	2.16	1.14	-1.02	Basyang	5-Year
65	10.25616	125.621	2.08	1.5	-0.58	Basyang	5-Year
66	10.25617	125.6207	1.36	0.77	-0.59	Basyang	5-Year
67	10.25671	125.6203	0.41	0.28	-0.13	Basyang	5-Year
68	10.25639	125.6213	1.23	0	-1.23	Basyang	5-Year
69	10.27922	125.5852	0.64	0	-0.64	Basyang	5-Year
70	10.27916	125.5854	0.81	1.58	0.77	Basyang	5-Year
71	10.28046	125.5865	2.9	2.11	-0.79	Basyang	5-Year
72	10.28012	125.5867	1.93	2.59	0.66	Basyang	5-Year
73	10.27975	125.5867	2.87	2.45	-0.42	Basyang	5-Year
74	10.27947	125.5866	2.55	1.9	-0.65	Basyang	5-Year
75	10.2794	125.5854	1.88	1.57	-0.31	Basyang	5-Year
76	10.27946	125.5855	1.78	1.83	0.05	Basyang	5-Year
77	10.27956	125.5863	2.56	2.3	-0.26	Basyang	5-Year
78	10.28008	125.5868	1.93	2.65	0.72	Basyang	5-Year
79	10.28811	125.6114	0.91	0	-0.91	Basyang	5-Year

80	10.30062	125.602	0.63	0	-0.63	Basyang	5-Year
81	10.30044	125.602	0.47	0	-0.47	Basyang	5-Year
82	10.25613	125.6219	0.55	0.42	-0.13	Basyang	5-Year
83	10.25629	125.6204	0.03	0.96	0.93	Basyang	5-Year
84	10.27909	125.5851	0.03	0	-0.03	Basyang	5-Year
85	10.29826	125.6027	0.42	0	-0.42	Basyang	5-Year
86	10.2968	125.6036	0.83	0	-0.83	Basyang	5-Year
87	10.30062	125.6026	0.93	0	-0.93	Basyang	5-Year
88	10.27886	125.5863	0.03	0	-0.03	Basyang	5-Year
89	10.27916	125.5865	0.03	0	-0.03	Basyang	5-Year
90	10.30154	125.602	0.03	0	-0.03	Basyang	5-Year
91	10.302	125.6018	0.03	0	-0.03	Basyang	5-Year
92	10.32421	125.586	0.03	0	-0.03	Basyang	5-Year
93	10.32393	125.5857	0.03	0	-0.03	Basyang	5-Year
94	10.31916	125.5844	0.56	0	-0.56	Basyang	5-Year
95	10.32016	125.5845	0.49	0	-0.49	Basyang	5-Year
96	10.32214	125.5855	0.03	0	-0.03	Basyang	5-Year
97	10.31576	125.5849	0.03	0	-0.03	Basyang	5-Year
98	10.31214	125.5912	0.03	0	-0.03	Basyang	5-Year
99	10.28792	125.6071	0.03	0	-0.03	Basyang	5-Year
100	10.29399	125.6044	0.03	0	-0.03	Basyang	5-Year
101	10.25489	125.6396	0.24	0.68	0.44	Basyang	5-Year
102	10.25404	125.6396	0.03	0.9	0.87	Basyang	5-Year
103	10.25518	125.6393	0.22	0.1	-0.12	Basyang	5-Year
104	10.25539	125.6386	0.31	0.1	-0.21	Basyang	5-Year
105	10.25918	125.6269	0.03	0.96	0.93	Basyang	5-Year
106	10.30045	125.6027	1.61	0.43	-1.18	Basyang	5-Year
107	10.31634	125.5881	0.03	0	-0.03	Basyang	5-Year

108	10.25643	125.6194	0.09	0	-0.09	Basyang	5-Year
109	10.25674	125.6202	0.58	0.41	-0.17	Basyang	5-Year
110	10.25596	125.6215	0.03	0	-0.03	Basyang	5-Year
111	10.25686	125.6193	0.03	0	-0.03	Basyang	5-Year
112	10.27928	125.586	2.14	1.86	-0.28	Basyang	5-Year
113	10.29851	125.6025	0.41	0	-0.41	Basyang	5-Year
114	10.2561	125.6263	0.03	1.12	1.09	Basyang	5-Year
115	10.28001	125.5867	2.82	0	-2.82	Basyang	5-Year
116	10.25944	125.6252	0.98	0.3	-0.68	Basyang	5-Year
117	10.27946	125.5865	2.48	2.1	-0.38	Basyang	5-Year
118	10.27927	125.5865	0.29	0.54	0.25	Basyang	5-Year
119	10.25641	125.6207	1.5	1.29	-0.21	Basyang	5-Year
120	10.25626	125.6218	1.28	0.8	-0.48	Basyang	5-Year
121	10.25672	125.627	0.03	1.1	1.07	Basyang	5-Year
122	10.29863	125.6027	0.15	0	-0.15	Basyang	5-Year
123	10.25648	125.624	0.04	1.51	1.47	Basyang	5-Year
124	10.25605	125.6221	0.84	0.59	-0.25	Basyang	5-Year
125	10.27937	125.5828	1.85	0	-1.85	Basyang	5-Year
126	10.25764	125.6204	0.04	0	-0.04	Basyang	5-Year
127	10.25507	125.619	0.03	0	-0.03	Basyang	5-Year
128	10.25525	125.6385	0.47	1.7	1.23	Basyang	25-Year
129	10.25511	125.6393	0.28	0	-0.28	Basyang	25-Year
130	10.25515	125.6393	0.36	0	-0.36	Basyang	25-Year
131	10.25588	125.6209	1.75	0.56	-1.19	Basyang	25-Year
132	10.25624	125.6219	0.92	1.1	0.18	Basyang	25-Year
133	10.25573	125.623	1.01	0	-1.01	Basyang	25-Year
134	10.2557	125.6222	2	1.3	-0.7	Basyang	25-Year
135	10.25571	125.6229	1.45	0	-1.45	Basyang	25-Year

136	10.25571	125.6233	2.39	0.97	-1.42	Basyang	25-Year
137	10.25617	125.6238	2.53	1.21	-1.32	Basyang	25-Year
138	10.25616	125.6226	0.04	0.3	0.26	Basyang	25-Year
139	10.25603	125.6235	2.5	1	-1.5	Basyang	25-Year
140	10.25632	125.6217	1.7	0.71	-0.99	Basyang	25-Year
141	10.25622	125.6229	0.04	0.15	0.11	Basyang	25-Year
142	10.25612	125.623	0.03	0.8	0.77	Basyang	25-Year
143	10.2562	125.6232	0.04	0.9	0.86	Basyang	25-Year
144	10.2567	125.6244	0.04	0.5	0.46	Basyang	25-Year
145	10.25683	125.6251	0.04	1.2	1.16	Basyang	25-Year
146	10.25665	125.625	0.04	1.3	1.26	Basyang	25-Year
147	10.25636	125.626	0.03	0	-0.03	Basyang	25-Year
148	10.2566	125.6257	0.05	0	-0.05	Basyang	25-Year
149	10.25664	125.6255	0.03	1	0.97	Basyang	25-Year
150	10.25673	125.6254	0.04	0.31	0.27	Basyang	25-Year
151	10.25611	125.6264	0.03	0	-0.03	Basyang	25-Year
152	10.25648	125.6265	0.03	0.5	0.47	Basyang	25-Year
153	10.25644	125.6267	0.04	1.9	1.86	Basyang	25-Year
154	10.256	125.6266	2.04	1.25	-0.79	Basyang	25-Year
155	10.25649	125.6271	1.4	2.2	0.8	Basyang	25-Year
156	10.25661	125.6269	0.03	0.4	0.37	Basyang	25-Year
157	10.25684	125.6273	0.03	0	-0.03	Basyang	25-Year
158	10.25704	125.6274	0.03	0	-0.03	Basyang	25-Year
159	10.25745	125.6273	0.97	0.5	-0.47	Basyang	25-Year
160	10.25761	125.6271	0.07	0	-0.07	Basyang	25-Year
161	10.25768	125.627	0.07	0	-0.07	Basyang	25-Year
162	10.25791	125.627	0.04	0	-0.04	Basyang	25-Year
163	10.25862	125.6271	0.03	0.15	0.12	Basyang	25-Year

164	10.25929	125.6262	0.51	0.8	0.29	Basyang	25-Year
165	10.25948	125.6247	0.39	0	-0.39	Basyang	25-Year
166	10.25974	125.6242	0.05	0.7	0.65	Basyang	25-Year
167	10.26023	125.6241	1.59	1	-0.59	Basyang	25-Year
168	10.30007	125.602	0.92	0	-0.92	Basyang	25-Year
169	10.30082	125.602	1.17	0	-1.17	Basyang	25-Year
170	10.29915	125.6023	1.05	0.47	-0.58	Basyang	25-Year
171	10.29945	125.6021	0.71	0	-0.71	Basyang	25-Year
172	10.29819	125.6023	1.34	0.28	-1.06	Basyang	25-Year
173	10.30123	125.6025	1.07	0	-1.07	Basyang	25-Year
174	10.29743	125.6033	0.9	0	-0.9	Basyang	25-Year
175	10.31677	125.5879	0.03	0	-0.03	Basyang	25-Year
176	10.28768	125.607	0.03	0	-0.03	Basyang	25-Year
177	10.28762	125.6069	0.03	0	-0.03	Basyang	25-Year
178	10.28763	125.6071	0.03	0	-0.03	Basyang	25-Year
179	10.29972	125.602	1.09	0.8	-0.29	Basyang	25-Year
180	10.28814	125.6071	0.03	0	-0.03	Basyang	25-Year
181	10.31189	125.5933	0.03	0	-0.03	Basyang	25-Year
182	10.301	125.6028	2.2	0	-2.2	Basyang	25-Year
183	10.30114	125.6027	2.28	0	-2.28	Basyang	25-Year
184	10.3167	125.5935	1.58	1.08	-0.5	Basyang	25-Year
185	10.31332	125.5917	0.86	0	-0.86	Basyang	25-Year
186	10.31307	125.5909	0.04	1.83	1.79	Basyang	25-Year
187	10.25563	125.6225	1.56	1.18	-0.38	Basyang	25-Year
188	10.25636	125.6216	1.7	0.89	-0.81	Basyang	25-Year
189	10.25649	125.6205	1.88	0.4	-1.48	Basyang	25-Year
190	10.25668	125.6198	1.62	0.6	-1.02	Basyang	25-Year
191	10.25594	125.6233	2.57	1.14	-1.43	Basyang	25-Year

192	10.25616	125.621	2.61	1.5	-1.11	Basyang	25-Year
193	10.25617	125.6207	1.89	0.77	-1.12	Basyang	25-Year
194	10.25671	125.6203	0.91	0.28	-0.63	Basyang	25-Year
195	10.25639	125.6213	1.75	0	-1.75	Basyang	25-Year
196	10.27922	125.5852	1.96	0	-1.96	Basyang	25-Year
197	10.27916	125.5854	2.13	1.58	-0.55	Basyang	25-Year
198	10.28046	125.5865	4.29	2.11	-2.18	Basyang	25-Year
199	10.28012	125.5867	3.25	2.59	-0.66	Basyang	25-Year
200	10.27975	125.5867	4.19	2.45	-1.74	Basyang	25-Year
201	10.27947	125.5866	3.85	1.9	-1.95	Basyang	25-Year
202	10.2794	125.5854	3.2	1.57	-1.63	Basyang	25-Year
203	10.27946	125.5855	3.1	1.83	-1.27	Basyang	25-Year
204	10.27956	125.5863	3.88	2.3	-1.58	Basyang	25-Year
205	10.28008	125.5868	3.25	2.65	-0.6	Basyang	25-Year
206	10.28811	125.6114	1.18	0	-1.18	Basyang	25-Year
207	10.30062	125.602	1.24	0	-1.24	Basyang	25-Year
208	10.30044	125.602	1.07	0	-1.07	Basyang	25-Year
209	10.25613	125.6219	1.06	0.42	-0.64	Basyang	25-Year
210	10.25629	125.6204	0.47	0.96	0.49	Basyang	25-Year
211	10.27909	125.5851	0.03	0	-0.03	Basyang	25-Year
212	10.29826	125.6027	0.97	0	-0.97	Basyang	25-Year
213	10.2968	125.6036	1.3	0	-1.3	Basyang	25-Year
214	10.30062	125.6026	1.4	0	-1.4	Basyang	25-Year
215	10.27886	125.5863	0.03	0	-0.03	Basyang	25-Year
216	10.27916	125.5865	0.03	0	-0.03	Basyang	25-Year
217	10.30154	125.602	0.03	0	-0.03	Basyang	25-Year
218	10.302	125.6018	0.03	0	-0.03	Basyang	25-Year
219	10.32421	125.586	0.03	0	-0.03	Basyang	25-Year

220	10.32393	125.5857	0.03	0	-0.03	Basyang	25-Year
221	10.31916	125.5844	0.68	0	-0.68	Basyang	25-Year
222	10.32016	125.5845	0.65	0	-0.65	Basyang	25-Year
223	10.32214	125.5855	0.04	0	-0.04	Basyang	25-Year
224	10.31576	125.5849	0.03	0	-0.03	Basyang	25-Year
225	10.31214	125.5912	0.03	0	-0.03	Basyang	25-Year
226	10.28792	125.6071	0.03	0	-0.03	Basyang	25-Year
227	10.29399	125.6044	0.03	0	-0.03	Basyang	25-Year
228	10.25489	125.6396	0.29	0.68	0.39	Basyang	25-Year
229	10.25404	125.6396	0.03	0.9	0.87	Basyang	25-Year
230	10.25518	125.6393	0.3	0.1	-0.2	Basyang	25-Year
231	10.25539	125.6386	0.45	0.1	-0.35	Basyang	25-Year
232	10.25918	125.6269	0.23	0.96	0.73	Basyang	25-Year
233	10.30045	125.6027	2.1	0.43	-1.67	Basyang	25-Year
234	10.31634	125.5881	0.04	0	-0.04	Basyang	25-Year
235	10.25643	125.6194	0.37	0	-0.37	Basyang	25-Year
236	10.25674	125.6202	1.08	0.41	-0.67	Basyang	25-Year
237	10.25596	125.6215	0.03	0	-0.03	Basyang	25-Year
238	10.25686	125.6193	0.03	0	-0.03	Basyang	25-Year
239	10.27928	125.586	3.46	1.86	-1.6	Basyang	25-Year
240	10.29851	125.6025	1.05	0	-1.05	Basyang	25-Year
241	10.2561	125.6263	0.03	1.12	1.09	Basyang	25-Year
242	10.28001	125.5867	4.14	0	-4.14	Basyang	25-Year
243	10.25944	125.6252	2.24	0.3	-1.94	Basyang	25-Year
244	10.27946	125.5865	3.79	2.1	-1.69	Basyang	25-Year
245	10.27927	125.5865	1.6	0.54	-1.06	Basyang	25-Year
246	10.25641	125.6207	2.03	1.29	-0.74	Basyang	25-Year
247	10.25626	125.6218	1.8	0.8	-1	Basyang	25-Year

248	10.25672	125.627	0.03	1.1	1.07	Basyang	25-Year
249	10.29863	125.6027	0.55	0	-0.55	Basyang	25-Year
250	10.25648	125.624	0.04	1.51	1.47	Basyang	25-Year
251	10.25605	125.6221	1.31	0.59	-0.72	Basyang	25-Year
252	10.27937	125.5828	2.58	0	-2.58	Basyang	25-Year
253	10.25764	125.6204	0.06	0	-0.06	Basyang	25-Year
254	10.25507	125.619	0.03	0	-0.03	Basyang	25-Year
255	10.25525	125.6385	0.56	1.7	1.14	Basyang	100-Year
256	10.25511	125.6393	0.36	0	-0.36	Basyang	100-Year
257	10.25515	125.6393	0.44	0	-0.44	Basyang	100-Year
258	10.25588	125.6209	2.13	0.56	-1.57	Basyang	100-Year
259	10.25624	125.6219	1.28	1.1	-0.18	Basyang	100-Year
260	10.25573	125.623	1.27	0	-1.27	Basyang	100-Year
261	10.2557	125.6222	2.31	1.3	-1.01	Basyang	100-Year
262	10.25571	125.6229	1.72	0	-1.72	Basyang	100-Year
263	10.25571	125.6233	2.65	0.97	-1.68	Basyang	100-Year
264	10.25617	125.6238	2.75	1.21	-1.54	Basyang	100-Year
265	10.25616	125.6226	0.05	0.3	0.25	Basyang	100-Year
266	10.25603	125.6235	2.75	1	-1.75	Basyang	100-Year
267	10.25632	125.6217	2.08	0.71	-1.37	Basyang	100-Year
268	10.25622	125.6229	0.04	0.15	0.11	Basyang	100-Year
269	10.25612	125.623	0.04	0.8	0.76	Basyang	100-Year
270	10.2562	125.6232	0.05	0.9	0.85	Basyang	100-Year
271	10.2567	125.6244	0.05	0.5	0.45	Basyang	100-Year
272	10.25683	125.6251	0.04	1.2	1.16	Basyang	100-Year
273	10.25665	125.625	0.04	1.3	1.26	Basyang	100-Year
274	10.25636	125.626	0.03	0	-0.03	Basyang	100-Year
275	10.2566	125.6257	0.05	0	-0.05	Basyang	100-Year

276	10.25664	125.6255	0.04	1	0.96	Basyang	100-Year
277	10.25673	125.6254	0.04	0.31	0.27	Basyang	100-Year
278	10.25611	125.6264	0.03	0	-0.03	Basyang	100-Year
279	10.25648	125.6265	0.03	0.5	0.47	Basyang	100-Year
280	10.25644	125.6267	0.04	1.9	1.86	Basyang	100-Year
281	10.256	125.6266	2.78	1.25	-1.53	Basyang	100-Year
282	10.25649	125.6271	2.15	2.2	0.05	Basyang	100-Year
283	10.25661	125.6269	0.03	0.4	0.37	Basyang	100-Year
284	10.25684	125.6273	0.03	0	-0.03	Basyang	100-Year
285	10.25704	125.6274	0.03	0	-0.03	Basyang	100-Year
286	10.25745	125.6273	1.73	0.5	-1.23	Basyang	100-Year
287	10.25761	125.6271	0.15	0	-0.15	Basyang	100-Year
288	10.25768	125.627	0.15	0	-0.15	Basyang	100-Year
289	10.25791	125.627	0.05	0	-0.05	Basyang	100-Year
290	10.25862	125.6271	0.48	0.15	-0.33	Basyang	100-Year
291	10.25929	125.6262	1.31	0.8	-0.51	Basyang	100-Year
292	10.25948	125.6247	1.19	0	-1.19	Basyang	100-Year
293	10.25974	125.6242	0.06	0.7	0.64	Basyang	100-Year
294	10.26023	125.6241	2.39	1	-1.39	Basyang	100-Year
295	10.30007	125.602	1.43	0	-1.43	Basyang	100-Year
296	10.30082	125.602	1.64	0	-1.64	Basyang	100-Year
297	10.29915	125.6023	1.47	0.47	-1	Basyang	100-Year
298	10.29945	125.6021	1.16	0	-1.16	Basyang	100-Year
299	10.29819	125.6023	1.78	0.28	-1.5	Basyang	100-Year
300	10.30123	125.6025	1.44	0	-1.44	Basyang	100-Year
301	10.29743	125.6033	1.27	0	-1.27	Basyang	100-Year
302	10.31677	125.5879	0.03	0	-0.03	Basyang	100-Year
303	10.28768	125.607	0.03	0	-0.03	Basyang	100-Year

304	10.28762	125.6069	0.03	0	-0.03	Basyang	100-Year
305	10.28763	125.6071	0.03	0	-0.03	Basyang	100-Year
306	10.29972	125.602	1.59	0.8	-0.79	Basyang	100-Year
307	10.28814	125.6071	0.29	0	-0.29	Basyang	100-Year
308	10.31189	125.5933	0.03	0	-0.03	Basyang	100-Year
309	10.301	125.6028	2.59	0	-2.59	Basyang	100-Year
310	10.30114	125.6027	2.67	0	-2.67	Basyang	100-Year
311	10.3167	125.5935	2.18	1.08	-1.1	Basyang	100-Year
312	10.31332	125.5917	1.44	0	-1.44	Basyang	100-Year
313	10.31307	125.5909	0.04	1.83	1.79	Basyang	100-Year
314	10.25563	125.6225	1.85	1.18	-0.67	Basyang	100-Year
315	10.25636	125.6216	2.08	0.89	-1.19	Basyang	100-Year
316	10.25649	125.6205	2.27	0.4	-1.87	Basyang	100-Year
317	10.25668	125.6198	1.94	0.6	-1.34	Basyang	100-Year
318	10.25594	125.6233	2.82	1.14	-1.68	Basyang	100-Year
319	10.25616	125.621	3	1.5	-1.5	Basyang	100-Year
320	10.25617	125.6207	2.28	0.77	-1.51	Basyang	100-Year
321	10.25671	125.6203	1.28	0.28	-1	Basyang	100-Year
322	10.25639	125.6213	2.14	0	-2.14	Basyang	100-Year
323	10.27922	125.5852	2.83	0	-2.83	Basyang	100-Year
324	10.27916	125.5854	3	1.58	-1.42	Basyang	100-Year
325	10.28046	125.5865	5.13	2.11	-3.02	Basyang	100-Year
326	10.28012	125.5867	4.1	2.59	-1.51	Basyang	100-Year
327	10.27975	125.5867	5.02	2.45	-2.57	Basyang	100-Year
328	10.27947	125.5866	4.71	1.9	-2.81	Basyang	100-Year
329	10.2794	125.5854	4.08	1.57	-2.51	Basyang	100-Year
330	10.27946	125.5855	3.97	1.83	-2.14	Basyang	100-Year
331	10.27956	125.5863	4.73	2.3	-2.43	Basyang	100-Year

332	10.28008	125.5868	4.1	2.65	-1.45	Basyang	100-Year
333	10.28811	125.6114	1.4	0	-1.4	Basyang	100-Year
334	10.30062	125.602	1.73	0	-1.73	Basyang	100-Year
335	10.30044	125.602	1.56	0	-1.56	Basyang	100-Year
336	10.25613	125.6219	1.39	0.42	-0.97	Basyang	100-Year
337	10.25629	125.6204	0.87	0.96	0.09	Basyang	100-Year
338	10.27909	125.5851	0.54	0	-0.54	Basyang	100-Year
339	10.29826	125.6027	1.38	0	-1.38	Basyang	100-Year
340	10.2968	125.6036	1.68	0	-1.68	Basyang	100-Year
341	10.30062	125.6026	1.74	0	-1.74	Basyang	100-Year
342	10.27886	125.5863	0.03	0	-0.03	Basyang	100-Year
343	10.27916	125.5865	0.03	0	-0.03	Basyang	100-Year
344	10.30154	125.602	0.22	0	-0.22	Basyang	100-Year
345	10.302	125.6018	0.03	0	-0.03	Basyang	100-Year
346	10.32421	125.586	0.03	0	-0.03	Basyang	100-Year
347	10.32393	125.5857	0.04	0	-0.04	Basyang	100-Year
348	10.31916	125.5844	0.74	0	-0.74	Basyang	100-Year
349	10.32016	125.5845	0.73	0	-0.73	Basyang	100-Year
350	10.32214	125.5855	0.04	0	-0.04	Basyang	100-Year
351	10.31576	125.5849	0.03	0	-0.03	Basyang	100-Year
352	10.31214	125.5912	0.03	0	-0.03	Basyang	100-Year
353	10.28792	125.6071	0.03	0	-0.03	Basyang	100-Year
354	10.29399	125.6044	0.04	0	-0.04	Basyang	100-Year
355	10.25489	125.6396	0.34	0.68	0.34	Basyang	100-Year
356	10.25404	125.6396	0.03	0.9	0.87	Basyang	100-Year
357	10.25518	125.6393	0.37	0.1	-0.27	Basyang	100-Year
358	10.25539	125.6386	0.55	0.1	-0.45	Basyang	100-Year
359	10.25918	125.6269	1.05	0.96	-0.09	Basyang	100-Year

360	10.30045	125.6027	2.44	0.43	-2.01	Basyang	100-Year
361	10.31634	125.5881	0.05	0	-0.05	Basyang	100-Year
362	10.25643	125.6194	0.58	0	-0.58	Basyang	100-Year
363	10.25674	125.6202	1.43	0.41	-1.02	Basyang	100-Year
364	10.25596	125.6215	0.03	0	-0.03	Basyang	100-Year
365	10.25686	125.6193	0.03	0	-0.03	Basyang	100-Year
366	10.27928	125.586	4.32	1.86	-2.46	Basyang	100-Year
367	10.29851	125.6025	1.5	0	-1.5	Basyang	100-Year
368	10.2561	125.6263	0.03	1.12	1.09	Basyang	100-Year
369	10.28001	125.5867	4.99	0	-4.99	Basyang	100-Year
370	10.25944	125.6252	3.03	0.3	-2.73	Basyang	100-Year
371	10.27946	125.5865	4.64	2.1	-2.54	Basyang	100-Year
372	10.27927	125.5865	2.45	0.54	-1.91	Basyang	100-Year
373	10.25641	125.6207	2.42	1.29	-1.13	Basyang	100-Year
374	10.25626	125.6218	2.16	0.8	-1.36	Basyang	100-Year
375	10.25672	125.627	0.03	1.1	1.07	Basyang	100-Year
376	10.29863	125.6027	0.96	0	-0.96	Basyang	100-Year
377	10.25648	125.624	0.05	1.51	1.46	Basyang	100-Year
378	10.25605	125.6221	1.62	0.59	-1.03	Basyang	100-Year
379	10.27937	125.5828	3.07	0	-3.07	Basyang	100-Year
380	10.25764	125.6204	0.06	0	-0.06	Basyang	100-Year
381	10.25507	125.619	0.03	0	-0.03	Basyang	100-Year
382	10.25525	125.6385	0	0.34	-0.34	Seniang	5-year
383	10.25511	125.6393	0	0.21	-0.21	Seniang	5-year
384	10.25515	125.6393	0	0.27	-0.27	Seniang	5-year
385	10.25588	125.6209	0	1.22	-1.22	Seniang	5-year
386	10.25624	125.6219	0	0.41	-0.41	Seniang	5-year
387	10.25573	125.623	0	0.6	-0.6	Seniang	5-year

388	10.2557	125.6222	0	1.55	-1.55	Seniang	5-year
389	10.25571	125.6229	0	1.05	-1.05	Seniang	5-year
390	10.25571	125.6233	0	1.97	-1.97	Seniang	5-year
391	10.25617	125.6238	0	2.19	-2.19	Seniang	5-year
392	10.25616	125.6226	0	0.03	-0.03	Seniang	5-year
393	10.25603	125.6235	0	2.1	-2.1	Seniang	5-year
394	10.25632	125.6217	0	1.19	-1.19	Seniang	5-year
395	10.25622	125.6229	0	0.03	-0.03	Seniang	5-year
396	10.25612	125.623	0	0.03	-0.03	Seniang	5-year
397	10.2562	125.6232	0	0.03	-0.03	Seniang	5-year
398	10.2567	125.6244	0	0.04	-0.04	Seniang	5-year
399	10.25683	125.6251	0	0.03	-0.03	Seniang	5-year
400	10.25665	125.625	0	0.04	-0.04	Seniang	5-year
401	10.25636	125.626	0	0.03	-0.03	Seniang	5-year
402	10.2566	125.6257	0	0.04	-0.04	Seniang	5-year
403	10.25664	125.6255	0	0.03	-0.03	Seniang	5-year
404	10.25673	125.6254	0	0.04	-0.04	Seniang	5-year
405	10.25611	125.6264	0	0.03	-0.03	Seniang	5-year
406	10.25648	125.6265	0	0.04	-0.04	Seniang	5-year
407	10.25644	125.6267	0	0.03	-0.03	Seniang	5-year
408	10.256	125.6266	0	0.93	-0.93	Seniang	5-year
409	10.25649	125.6271	0	0.3	-0.3	Seniang	5-year
410	10.25661	125.6269	0	0.03	-0.03	Seniang	5-year
411	10.25684	125.6273	0	0.03	-0.03	Seniang	5-year
412	10.25704	125.6274	0	0.03	-0.03	Seniang	5-year
413	10.25745	125.6273	0	0.03	-0.03	Seniang	5-year
414	10.25761	125.6271	0	0.06	-0.06	Seniang	5-year
415	10.25768	125.627	0	0.06	-0.06	Seniang	5-year

416	10.25791	125.627	0	0.04	-0.04	Seniang	5-year
417	10.25862	125.6271	0	0.03	-0.03	Seniang	5-year
418	10.25929	125.6262	0	0.04	-0.04	Seniang	5-year
419	10.25948	125.6247	0	0.08	-0.08	Seniang	5-year
420	10.25974	125.6242	0	0.04	-0.04	Seniang	5-year
421	10.26023	125.6241	0	0.32	-0.32	Seniang	5-year
422	10.30007	125.602	0	0.31	-0.31	Seniang	5-year
423	10.30082	125.602	0	0.61	-0.61	Seniang	5-year
424	10.29915	125.6023	0	0.69	-0.69	Seniang	5-year
425	10.29945	125.6021	0.2	0.27	-0.07	Seniang	5-year
426	10.29819	125.6023	0	0.67	-0.67	Seniang	5-year
427	10.30123	125.6025	0	0.5	-0.5	Seniang	5-year
428	10.29743	125.6033	0	0.49	-0.49	Seniang	5-year
429	10.31677	125.5879	0	0.03	-0.03	Seniang	5-year
430	10.28768	125.607	0	0.03	-0.03	Seniang	5-year
431	10.28762	125.6069	0	0.03	-0.03	Seniang	5-year
432	10.28763	125.6071	0	0.03	-0.03	Seniang	5-year
433	10.29972	125.602	0	0.49	-0.49	Seniang	5-year
434	10.28814	125.6071	0	0.03	-0.03	Seniang	5-year
435	10.31189	125.5933	0	0.03	-0.03	Seniang	5-year
436	10.301	125.6028	0	1.62	-1.62	Seniang	5-year
437	10.30114	125.6027	0	1.69	-1.69	Seniang	5-year
438	10.3167	125.5935	0	0.66	-0.66	Seniang	5-year
439	10.31332	125.5917	0	0.03	-0.03	Seniang	5-year
440	10.31307	125.5909	0	0.03	-0.03	Seniang	5-year
441	10.25563	125.6225	0	1.15	-1.15	Seniang	5-year
442	10.25636	125.6216	0	1.19	-1.19	Seniang	5-year
443	10.25649	125.6205	0	1.35	-1.35	Seniang	5-year

444	10.25668	125.6198	0	1.18	-1.18	Seniang	5-year
445	10.25594	125.6233	0	2.16	-2.16	Seniang	5-year
446	10.25616	125.621	0	2.08	-2.08	Seniang	5-year
447	10.25617	125.6207	0.25	1.36	-1.11	Seniang	5-year
448	10.25671	125.6203	0	0.41	-0.41	Seniang	5-year
449	10.25639	125.6213	0	1.23	-1.23	Seniang	5-year
450	10.27922	125.5852	0	0.64	-0.64	Seniang	5-year
451	10.27916	125.5854	0	0.81	-0.81	Seniang	5-year
452	10.28046	125.5865	0	2.9	-2.9	Seniang	5-year
453	10.28012	125.5867	0	1.93	-1.93	Seniang	5-year
454	10.27975	125.5867	0	2.87	-2.87	Seniang	5-year
455	10.27947	125.5866	0	2.55	-2.55	Seniang	5-year
456	10.2794	125.5854	0	1.88	-1.88	Seniang	5-year
457	10.27946	125.5855	0	1.78	-1.78	Seniang	5-year
458	10.27956	125.5863	0	2.56	-2.56	Seniang	5-year
459	10.28008	125.5868	0	1.93	-1.93	Seniang	5-year
460	10.28811	125.6114	0.23	0.91	-0.68	Seniang	5-year
461	10.30062	125.602	0	0.63	-0.63	Seniang	5-year
462	10.30044	125.602	0	0.47	-0.47	Seniang	5-year
463	10.25613	125.6219	0	0.55	-0.55	Seniang	5-year
464	10.25629	125.6204	0	0.03	-0.03	Seniang	5-year
465	10.27909	125.5851	0	0.03	-0.03	Seniang	5-year
466	10.29826	125.6027	0	0.42	-0.42	Seniang	5-year
467	10.2968	125.6036	0	0.83	-0.83	Seniang	5-year
468	10.30062	125.6026	0	0.93	-0.93	Seniang	5-year
469	10.27886	125.5863	0	0.03	-0.03	Seniang	5-year
470	10.27916	125.5865	0	0.03	-0.03	Seniang	5-year
471	10.30154	125.602	0	0.03	-0.03	Seniang	5-year

472	10.302	125.6018	0	0.03	-0.03	Seniang	5-year
473	10.32421	125.586	0	0.03	-0.03	Seniang	5-year
474	10.32393	125.5857	0	0.03	-0.03	Seniang	5-year
475	10.31916	125.5844	0	0.56	-0.56	Seniang	5-year
476	10.32016	125.5845	0	0.49	-0.49	Seniang	5-year
477	10.32214	125.5855	0	0.03	-0.03	Seniang	5-year
478	10.31576	125.5849	0	0.03	-0.03	Seniang	5-year
479	10.31214	125.5912	0	0.03	-0.03	Seniang	5-year
480	10.28792	125.6071	0	0.03	-0.03	Seniang	5-year
481	10.29399	125.6044	0	0.03	-0.03	Seniang	5-year
482	10.25489	125.6396	0	0.24	-0.24	Seniang	5-year
483	10.25404	125.6396	0	0.03	-0.03	Seniang	5-year
484	10.25518	125.6393	0	0.22	-0.22	Seniang	5-year
485	10.25539	125.6386	0	0.31	-0.31	Seniang	5-year
486	10.25918	125.6269	0	0.03	-0.03	Seniang	5-year
487	10.30045	125.6027	0	1.61	-1.61	Seniang	5-year
488	10.31634	125.5881	0	0.03	-0.03	Seniang	5-year
489	10.25643	125.6194	0	0.09	-0.09	Seniang	5-year
490	10.25674	125.6202	0	0.58	-0.58	Seniang	5-year
491	10.25596	125.6215	0	0.03	-0.03	Seniang	5-year
492	10.25686	125.6193	0	0.03	-0.03	Seniang	5-year
493	10.27928	125.586	0	2.14	-2.14	Seniang	5-year
494	10.29851	125.6025	0	0.41	-0.41	Seniang	5-year
495	10.2561	125.6263	0	0.03	-0.03	Seniang	5-year
496	10.28001	125.5867	2.6	2.82	-0.22	Seniang	5-year
497	10.25944	125.6252	0	0.98	-0.98	Seniang	5-year
498	10.27946	125.5865	0	2.48	-2.48	Seniang	5-year
499	10.27927	125.5865	0	0.29	-0.29	Seniang	5-year

500	10.25641	125.6207	0.2	1.5	-1.3	Seniang	5-year
501	10.25626	125.6218	0	1.28	-1.28	Seniang	5-year
502	10.25672	125.627	0	0.03	-0.03	Seniang	5-year
503	10.29863	125.6027	0	0.15	-0.15	Seniang	5-year
504	10.25648	125.624	0	0.04	-0.04	Seniang	5-year
505	10.25605	125.6221	0	0.84	-0.84	Seniang	5-year
506	10.27937	125.5828	0.67	1.85	-1.18	Seniang	5-year
507	10.25764	125.6204	0	0.04	-0.04	Seniang	5-year
508	10.25507	125.619	0	0.03	-0.03	Seniang	5-year
509	10.25525	125.6385	0	0.47	-0.47	Seniang	25-year
510	10.25511	125.6393	0	0.28	-0.28	Seniang	25-year
511	10.25515	125.6393	0	0.36	-0.36	Seniang	25-year
512	10.25588	125.6209	0	1.75	-1.75	Seniang	25-year
513	10.25624	125.6219	0	0.92	-0.92	Seniang	25-year
514	10.25573	125.623	0	1.01	-1.01	Seniang	25-year
515	10.2557	125.6222	0	2	-2	Seniang	25-year
516	10.25571	125.6229	0	1.45	-1.45	Seniang	25-year
517	10.25571	125.6233	0	2.39	-2.39	Seniang	25-year
518	10.25617	125.6238	0	2.53	-2.53	Seniang	25-year
519	10.25616	125.6226	0	0.04	-0.04	Seniang	25-year
520	10.25603	125.6235	0	2.5	-2.5	Seniang	25-year
521	10.25632	125.6217	0	1.7	-1.7	Seniang	25-year
522	10.25622	125.6229	0	0.04	-0.04	Seniang	25-year
523	10.25612	125.623	0	0.03	-0.03	Seniang	25-year
524	10.2562	125.6232	0	0.04	-0.04	Seniang	25-year
525	10.2567	125.6244	0	0.04	-0.04	Seniang	25-year
526	10.25683	125.6251	0	0.04	-0.04	Seniang	25-year
527	10.25665	125.625	0	0.04	-0.04	Seniang	25-year

528	10.25636	125.626	0	0.03	-0.03	Seniang	25-year
529	10.2566	125.6257	0	0.05	-0.05	Seniang	25-year
530	10.25664	125.6255	0	0.03	-0.03	Seniang	25-year
531	10.25673	125.6254	0	0.04	-0.04	Seniang	25-year
532	10.25611	125.6264	0	0.03	-0.03	Seniang	25-year
533	10.25648	125.6265	0	0.03	-0.03	Seniang	25-year
534	10.25644	125.6267	0	0.04	-0.04	Seniang	25-year
535	10.256	125.6266	0	2.04	-2.04	Seniang	25-year
536	10.25649	125.6271	0	1.4	-1.4	Seniang	25-year
537	10.25661	125.6269	0	0.03	-0.03	Seniang	25-year
538	10.25684	125.6273	0	0.03	-0.03	Seniang	25-year
539	10.25704	125.6274	0	0.03	-0.03	Seniang	25-year
540	10.25745	125.6273	0	0.97	-0.97	Seniang	25-year
541	10.25761	125.6271	0	0.07	-0.07	Seniang	25-year
542	10.25768	125.627	0	0.07	-0.07	Seniang	25-year
543	10.25791	125.627	0	0.04	-0.04	Seniang	25-year
544	10.25862	125.6271	0	0.03	-0.03	Seniang	25-year
545	10.25929	125.6262	0	0.51	-0.51	Seniang	25-year
546	10.25948	125.6247	0	0.39	-0.39	Seniang	25-year
547	10.25974	125.6242	0	0.05	-0.05	Seniang	25-year
548	10.26023	125.6241	0	1.59	-1.59	Seniang	25-year
549	10.30007	125.602	0	0.92	-0.92	Seniang	25-year
550	10.30082	125.602	0	1.17	-1.17	Seniang	25-year
551	10.29915	125.6023	0	1.05	-1.05	Seniang	25-year
552	10.29945	125.6021	0.2	0.71	-0.51	Seniang	25-year
553	10.29819	125.6023	0	1.34	-1.34	Seniang	25-year
554	10.30123	125.6025	0	1.07	-1.07	Seniang	25-year
555	10.29743	125.6033	0	0.9	-0.9	Seniang	25-year

556	10.31677	125.5879	0	0.03	-0.03	Seniang	25-year
557	10.28768	125.607	0	0.03	-0.03	Seniang	25-year
558	10.28762	125.6069	0	0.03	-0.03	Seniang	25-year
559	10.28763	125.6071	0	0.03	-0.03	Seniang	25-year
560	10.29972	125.602	0	1.09	-1.09	Seniang	25-year
561	10.28814	125.6071	0	0.03	-0.03	Seniang	25-year
562	10.31189	125.5933	0	0.03	-0.03	Seniang	25-year
563	10.301	125.6028	0	2.2	-2.2	Seniang	25-year
564	10.30114	125.6027	0	2.28	-2.28	Seniang	25-year
565	10.3167	125.5935	0	1.58	-1.58	Seniang	25-year
566	10.31332	125.5917	0	0.86	-0.86	Seniang	25-year
567	10.31307	125.5909	0	0.04	-0.04	Seniang	25-year
568	10.25563	125.6225	0	1.56	-1.56	Seniang	25-year
569	10.25636	125.6216	0	1.7	-1.7	Seniang	25-year
570	10.25649	125.6205	0	1.88	-1.88	Seniang	25-year
571	10.25668	125.6198	0	1.62	-1.62	Seniang	25-year
572	10.25594	125.6233	0	2.57	-2.57	Seniang	25-year
573	10.25616	125.621	0	2.61	-2.61	Seniang	25-year
574	10.25617	125.6207	0.25	1.89	-1.64	Seniang	25-year
575	10.25671	125.6203	0	0.91	-0.91	Seniang	25-year
576	10.25639	125.6213	0	1.75	-1.75	Seniang	25-year
577	10.27922	125.5852	0	1.96	-1.96	Seniang	25-year
578	10.27916	125.5854	0	2.13	-2.13	Seniang	25-year
579	10.28046	125.5865	0	4.29	-4.29	Seniang	25-year
580	10.28012	125.5867	0	3.25	-3.25	Seniang	25-year
581	10.27975	125.5867	0	4.19	-4.19	Seniang	25-year
582	10.27947	125.5866	0	3.85	-3.85	Seniang	25-year
583	10.2794	125.5854	0	3.2	-3.2	Seniang	25-year

584	10.27946	125.5855	0	3.1	-3.1	Seniang	25-year
585	10.27956	125.5863	0	3.88	-3.88	Seniang	25-year
586	10.28008	125.5868	0	3.25	-3.25	Seniang	25-year
587	10.28811	125.6114	0.23	1.18	-0.95	Seniang	25-year
588	10.30062	125.602	0	1.24	-1.24	Seniang	25-year
589	10.30044	125.602	0	1.07	-1.07	Seniang	25-year
590	10.25613	125.6219	0	1.06	-1.06	Seniang	25-year
591	10.25629	125.6204	0	0.47	-0.47	Seniang	25-year
592	10.27909	125.5851	0	0.03	-0.03	Seniang	25-year
593	10.29826	125.6027	0	0.97	-0.97	Seniang	25-year
594	10.2968	125.6036	0	1.3	-1.3	Seniang	25-year
595	10.30062	125.6026	0	1.4	-1.4	Seniang	25-year
596	10.27886	125.5863	0	0.03	-0.03	Seniang	25-year
597	10.27916	125.5865	0	0.03	-0.03	Seniang	25-year
598	10.30154	125.602	0	0.03	-0.03	Seniang	25-year
599	10.302	125.6018	0	0.03	-0.03	Seniang	25-year
600	10.32421	125.586	0	0.03	-0.03	Seniang	25-year
601	10.32393	125.5857	0	0.03	-0.03	Seniang	25-year
602	10.31916	125.5844	0	0.68	-0.68	Seniang	25-year
603	10.32016	125.5845	0	0.65	-0.65	Seniang	25-year
604	10.32214	125.5855	0	0.04	-0.04	Seniang	25-year
605	10.31576	125.5849	0	0.03	-0.03	Seniang	25-year
606	10.31214	125.5912	0	0.03	-0.03	Seniang	25-year
607	10.28792	125.6071	0	0.03	-0.03	Seniang	25-year
608	10.29399	125.6044	0	0.03	-0.03	Seniang	25-year
609	10.25489	125.6396	0	0.29	-0.29	Seniang	25-year
610	10.25404	125.6396	0	0.03	-0.03	Seniang	25-year
611	10.25518	125.6393	0	0.3	-0.3	Seniang	25-year

612	10.25539	125.6386	0	0.45	-0.45	Seniang	25-year
613	10.25918	125.6269	0	0.23	-0.23	Seniang	25-year
614	10.30045	125.6027	0	2.1	-2.1	Seniang	25-year
615	10.31634	125.5881	0	0.04	-0.04	Seniang	25-year
616	10.25643	125.6194	0	0.37	-0.37	Seniang	25-year
617	10.25674	125.6202	0	1.08	-1.08	Seniang	25-year
618	10.25596	125.6215	0	0.03	-0.03	Seniang	25-year
619	10.25686	125.6193	0	0.03	-0.03	Seniang	25-year
620	10.27928	125.586	0	3.46	-3.46	Seniang	25-year
621	10.29851	125.6025	0	1.05	-1.05	Seniang	25-year
622	10.2561	125.6263	0	0.03	-0.03	Seniang	25-year
623	10.28001	125.5867	2.6	4.14	-1.54	Seniang	25-year
624	10.25944	125.6252	0	2.24	-2.24	Seniang	25-year
625	10.27946	125.5865	0	3.79	-3.79	Seniang	25-year
626	10.27927	125.5865	0	1.6	-1.6	Seniang	25-year
627	10.25641	125.6207	0.2	2.03	-1.83	Seniang	25-year
628	10.25626	125.6218	0	1.8	-1.8	Seniang	25-year
629	10.25672	125.627	0	0.03	-0.03	Seniang	25-year
630	10.29863	125.6027	0	0.55	-0.55	Seniang	25-year
631	10.25648	125.624	0	0.04	-0.04	Seniang	25-year
632	10.25605	125.6221	0	1.31	-1.31	Seniang	25-year
633	10.27937	125.5828	0.67	2.58	-1.91	Seniang	25-year
634	10.25764	125.6204	0	0.06	-0.06	Seniang	25-year
635	10.25507	125.619	0	0.03	-0.03	Seniang	25-year
636	10.25525	125.6385	0	0.56	-0.56	Seniang	100-year
637	10.25511	125.6393	0	0.36	-0.36	Seniang	100-year
638	10.25515	125.6393	0	0.44	-0.44	Seniang	100-year
639	10.25588	125.6209	0	2.13	-2.13	Seniang	100-year

640	10.25624	125.6219	0	1.28	-1.28	Seniang	100-year
641	10.25573	125.623	0	1.27	-1.27	Seniang	100-year
642	10.2557	125.6222	0	2.31	-2.31	Seniang	100-year
643	10.25571	125.6229	0	1.72	-1.72	Seniang	100-year
644	10.25571	125.6233	0	2.65	-2.65	Seniang	100-year
645	10.25617	125.6238	0	2.75	-2.75	Seniang	100-year
646	10.25616	125.6226	0	0.05	-0.05	Seniang	100-year
647	10.25603	125.6235	0	2.75	-2.75	Seniang	100-year
648	10.25632	125.6217	0	2.08	-2.08	Seniang	100-year
649	10.25622	125.6229	0	0.04	-0.04	Seniang	100-year
650	10.25612	125.623	0	0.04	-0.04	Seniang	100-year
651	10.2562	125.6232	0	0.05	-0.05	Seniang	100-year
652	10.2567	125.6244	0	0.05	-0.05	Seniang	100-year
653	10.25683	125.6251	0	0.04	-0.04	Seniang	100-year
654	10.25665	125.625	0	0.04	-0.04	Seniang	100-year
655	10.25636	125.626	0	0.03	-0.03	Seniang	100-year
656	10.2566	125.6257	0	0.05	-0.05	Seniang	100-year
657	10.25664	125.6255	0	0.04	-0.04	Seniang	100-year
658	10.25673	125.6254	0	0.04	-0.04	Seniang	100-year
659	10.25611	125.6264	0	0.03	-0.03	Seniang	100-year
660	10.25648	125.6265	0	0.03	-0.03	Seniang	100-year
661	10.25644	125.6267	0	0.04	-0.04	Seniang	100-year
662	10.256	125.6266	0	2.78	-2.78	Seniang	100-year
663	10.25649	125.6271	0	2.15	-2.15	Seniang	100-year
664	10.25661	125.6269	0	0.03	-0.03	Seniang	100-year
665	10.25684	125.6273	0	0.03	-0.03	Seniang	100-year
666	10.25704	125.6274	0	0.03	-0.03	Seniang	100-year
667	10.25745	125.6273	0	1.73	-1.73	Seniang	100-year

668	10.25761	125.6271	0	0.15	-0.15	Seniang	100-year
669	10.25768	125.627	0	0.15	-0.15	Seniang	100-year
670	10.25791	125.627	0	0.05	-0.05	Seniang	100-year
671	10.25862	125.6271	0	0.48	-0.48	Seniang	100-year
672	10.25929	125.6262	0	1.31	-1.31	Seniang	100-year
673	10.25948	125.6247	0	1.19	-1.19	Seniang	100-year
674	10.25974	125.6242	0	0.06	-0.06	Seniang	100-year
675	10.26023	125.6241	0	2.39	-2.39	Seniang	100-year
676	10.30007	125.602	0	1.43	-1.43	Seniang	100-year
677	10.30082	125.602	0	1.64	-1.64	Seniang	100-year
678	10.29915	125.6023	0	1.47	-1.47	Seniang	100-year
679	10.29945	125.6021	0.2	1.16	-0.96	Seniang	100-year
680	10.29819	125.6023	0	1.78	-1.78	Seniang	100-year
681	10.30123	125.6025	0	1.44	-1.44	Seniang	100-year
682	10.29743	125.6033	0	1.27	-1.27	Seniang	100-year
683	10.31677	125.5879	0	0.03	-0.03	Seniang	100-year
684	10.28768	125.607	0	0.03	-0.03	Seniang	100-year
685	10.28762	125.6069	0	0.03	-0.03	Seniang	100-year
686	10.28763	125.6071	0	0.03	-0.03	Seniang	100-year
687	10.29972	125.602	0	1.59	-1.59	Seniang	100-year
688	10.28814	125.6071	0	0.29	-0.29	Seniang	100-year
689	10.31189	125.5933	0	0.03	-0.03	Seniang	100-year
690	10.301	125.6028	0	2.59	-2.59	Seniang	100-year
691	10.30114	125.6027	0	2.67	-2.67	Seniang	100-year
692	10.3167	125.5935	0	2.18	-2.18	Seniang	100-year
693	10.31332	125.5917	0	1.44	-1.44	Seniang	100-year
694	10.31307	125.5909	0	0.04	-0.04	Seniang	100-year
695	10.25563	125.6225	0	1.85	-1.85	Seniang	100-year

696	10.25636	125.6216	0	2.08	-2.08	Seniang	100-year
697	10.25649	125.6205	0	2.27	-2.27	Seniang	100-year
698	10.25668	125.6198	0	1.94	-1.94	Seniang	100-year
699	10.25594	125.6233	0	2.82	-2.82	Seniang	100-year
700	10.25616	125.621	0	3	-3	Seniang	100-year
701	10.25617	125.6207	0.25	2.28	-2.03	Seniang	100-year
702	10.25671	125.6203	0	1.28	-1.28	Seniang	100-year
703	10.25639	125.6213	0	2.14	-2.14	Seniang	100-year
704	10.27922	125.5852	0	2.83	-2.83	Seniang	100-year
705	10.27916	125.5854	0	3	-3	Seniang	100-year
706	10.28046	125.5865	0	5.13	-5.13	Seniang	100-year
707	10.28012	125.5867	0	4.1	-4.1	Seniang	100-year
708	10.27975	125.5867	0	5.02	-5.02	Seniang	100-year
709	10.27947	125.5866	0	4.71	-4.71	Seniang	100-year
710	10.2794	125.5854	0	4.08	-4.08	Seniang	100-year
711	10.27946	125.5855	0	3.97	-3.97	Seniang	100-year
712	10.27956	125.5863	0	4.73	-4.73	Seniang	100-year
713	10.28008	125.5868	0	4.1	-4.1	Seniang	100-year
714	10.28811	125.6114	0.23	1.4	-1.17	Seniang	100-year
715	10.30062	125.602	0	1.73	-1.73	Seniang	100-year
716	10.30044	125.602	0	1.56	-1.56	Seniang	100-year
717	10.25613	125.6219	0	1.39	-1.39	Seniang	100-year
718	10.25629	125.6204	0	0.87	-0.87	Seniang	100-year
719	10.27909	125.5851	0	0.54	-0.54	Seniang	100-year
720	10.29826	125.6027	0	1.38	-1.38	Seniang	100-year
721	10.2968	125.6036	0	1.68	-1.68	Seniang	100-year
722	10.30062	125.6026	0	1.74	-1.74	Seniang	100-year
723	10.27886	125.5863	0	0.03	-0.03	Seniang	100-year

724	10.27916	125.5865	0	0.03	-0.03	Seniang	100-year
725	10.30154	125.602	0	0.22	-0.22	Seniang	100-year
726	10.302	125.6018	0	0.03	-0.03	Seniang	100-year
727	10.32421	125.586	0	0.03	-0.03	Seniang	100-year
728	10.32393	125.5857	0	0.04	-0.04	Seniang	100-year
729	10.31916	125.5844	0	0.74	-0.74	Seniang	100-year
730	10.32016	125.5845	0	0.73	-0.73	Seniang	100-year
731	10.32214	125.5855	0	0.04	-0.04	Seniang	100-year
732	10.31576	125.5849	0	0.03	-0.03	Seniang	100-year
733	10.31214	125.5912	0	0.03	-0.03	Seniang	100-year
734	10.28792	125.6071	0	0.03	-0.03	Seniang	100-year
735	10.29399	125.6044	0	0.04	-0.04	Seniang	100-year
736	10.25489	125.6396	0	0.34	-0.34	Seniang	100-year
737	10.25404	125.6396	0	0.03	-0.03	Seniang	100-year
738	10.25518	125.6393	0	0.37	-0.37	Seniang	100-year
739	10.25539	125.6386	0	0.55	-0.55	Seniang	100-year
740	10.25918	125.6269	0	1.05	-1.05	Seniang	100-year
741	10.30045	125.6027	0	2.44	-2.44	Seniang	100-year
742	10.31634	125.5881	0	0.05	-0.05	Seniang	100-year
743	10.25643	125.6194	0	0.58	-0.58	Seniang	100-year
744	10.25674	125.6202	0	1.43	-1.43	Seniang	100-year
745	10.25596	125.6215	0	0.03	-0.03	Seniang	100-year
746	10.25686	125.6193	0	0.03	-0.03	Seniang	100-year
747	10.27928	125.586	0	4.32	-4.32	Seniang	100-year
748	10.29851	125.6025	0	1.5	-1.5	Seniang	100-year
749	10.2561	125.6263	0	0.03	-0.03	Seniang	100-year
750	10.28001	125.5867	2.6	4.99	-2.39	Seniang	100-year
751	10.25944	125.6252	0	3.03	-3.03	Seniang	100-year

752	10.27946	125.5865	0	4.64	-4.64	Seniang	100-year
753	10.27927	125.5865	0	2.45	-2.45	Seniang	100-year
754	10.25641	125.6207	0.2	2.42	-2.22	Seniang	100-year
755	10.25626	125.6218	0	2.16	-2.16	Seniang	100-year
756	10.25672	125.627	0	0.03	-0.03	Seniang	100-year
757	10.29863	125.6027	0	0.96	-0.96	Seniang	100-year
758	10.25648	125.624	0	0.05	-0.05	Seniang	100-year
759	10.25605	125.6221	0	1.62	-1.62	Seniang	100-year
760	10.27937	125.5828	0.67	3.07	-2.4	Seniang	100-year
761	10.25764	125.6204	0	0.06	-0.06	Seniang	100-year
762	10.25507	125.619	0	0.03	-0.03	Seniang	100-year

Annex 12. Educational Institutions Affected by flooding in Malinao Inlet Floodplain

Table A-12.1. Educational Institutions in Tubajon, Caraga affected by flooding in Malinao Inlet Floodplain

Caraga				
Tubajon				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Mauro Diaz Elem	Diaz	Medium	Medium	High
Mabini Elementary	Mabini			
Malinao Elem	Malinao			
Navarro Elem	Navarro	High	High	High

Annex 13. Health Institutions Affected by flooding in Malinao Inlet Floodplain

There are no medical or health institutions affected by flooding in the Malinao Inlet Floodplain.