HAZARD MAPPING OF THE PHILIPPINES USING LIDAR (PHIL-LIDAR 1)

LiDAR Surveys and Flood Mapping of Bislig River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
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For questions/queries regarding this report, contact:

Engr. Meriam Makinano-Santillan
Project Leader, Phil-LiDAR 1 Program
CARAGA State University
Butuan City, Philippines 8600
mmsantillan@carsu.edu.ph

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

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Asian Aerospace Corporation
Ab	abutment
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
BA	Bridge Approach
BM	benchmark
CAD	Computer-Aided Design
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	Land Analysis System
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
NAMRIA	National Mapping and Resource Information Authority
NSTC	Northern Subtropical Convergence
PAF	Philippine Air Force
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PDOP	Positional Dilution of Precision
PPK	Post-Processed Kinematic [technique]
PRF	Pulse Repetition Frequency
PTM	Philippine Transverse Mercator
QC	Quality Check
QT	Quick Terrain [Modeler]
RA	Research Associate
RIDF	Rainfall Intensity Duration Frequency
RMSE	Root Mean Square Error
SAR	Synthetic Aperture Radar
SCS	Sun Canopy Sensor
SRTM	Shuttle Radar Topography Mission
SRS	Science Research Specialist
SSG	Special Service Group
TBC	Thermal Barrier Coatings
UPC	University of the Philippines Cebu
UP-TCAGP	University of the Philippines – Training Center for Applied Geodesy and Photogrammetry
UTM	Universal Transverse Mercator
WGS	World Geodetic System

CHAPTER 1: OVERVIEW OF THE PROGRAM AND BISLIG RIVER

Enrico C. Paringit, Dr. Eng., Engr. Meriam Makinano-Santillan, and Engr. Jojene Santillan

1.1 Background of the Phil-LIDAR 1 Program

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

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

The 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 13 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 Bislig River Basin

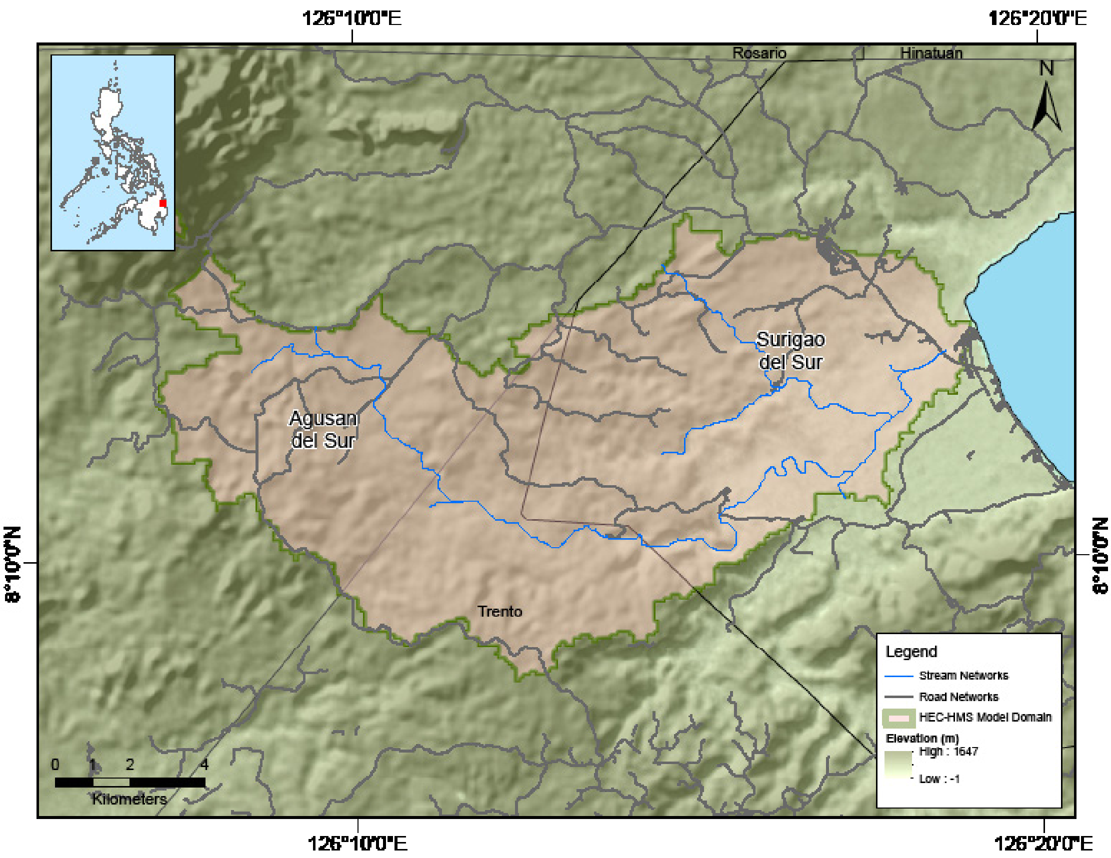


Figure 1. Map of Bislig River Basin

The Bislig River Basin is located in the eastern portion of the Island of Mindanao, Philippines. It lies generally between 126°06' to 126°23' east longitude and 8°00' to 8°20' north latitude. It includes a major part of Bislig City, Surigao del Sur, and small areas of Lingig, Hinatuan, and Tagbina municipalities of Surigao del

Sur; and of Trento, Bunawan, and Rosario municipalities of Agusan del Sur. The basin covers an area of approximately 516 square kilometers, and is about 35 kilometers long and averages about 30 kilometers in width.

The Bislig River is the principal drainage way of the basin. It has two major tributaries whose origins can be traced from the northwest and south portions of the basin. The northwestern and southern tributaries meet the Bislig River at a junction near Barangay Burboanan, Surigao del Sur. From this junction, Bislig River flows towards Bislig Bay at a distance of approximately 6.5 kilometers. At this portion, the river channel is wide and is navigable by motor boats.

The climate of the basin is Type II which is characterized by no dry season but with a very pronounced precipitation period generally during November to January. The seasonal precipitation distribution, which is similar to that of the nearby Agusan River Basin, is caused primarily by the three main seasonal winds that pass through it. The northeast monsoon passes during the period from October to January, the trade wind with an east to southeast direction from February to April, and the southwest monsoon for the rest of the year[1].

The basin's highest point is at738 meters above mean sea level situated along the mountain ridges of the Municipality of Rosario, Agusan del Sur. The most abundant soil type in the basin based on maps published by the Department of Agriculture was clay which accounts for 72% 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 1.0 % of the basin.

Built-up areas and communities in the basin are concentrated in Bislig City, particularly in Barangay Mangagoy, the downtown area often dubbed by its residents as "the little city within the city". Barangay Mangagoy is the largest barangay in the city in terms of population and land area, and is considered the center of trade and industry. As of the 2015 estimate, this barangay has a population of 32,464. Since Brgy. Poblacion is often referred by the locals simply as 'Bislig', Mangagoy on the other hand is often mistaken as a separate town though it is only just one out of the 24 barangays that comprises the entire City of Bislig[2]. The Bislig Bridge which plies the Surigao-Davao Coastal Road connects the city and other localities in the south to Hinatuan, Surigao del Sur in the north.

Based on Caraga Region 2015 Census of Population, Bislig City was ranked 3rd in the Top 10 Most Populous Cities/Municipalities in the Region with 94,535 people residing. The local language of the city is Cebuano although some residents used the *Kamayo* language. The city's socio-economic condition thrived by producing good quality agricultural and aquamarine products and becoming a leading eco-tourism destination in Southeastern Philippines. The people's main sources of living are fishing, corn cropping, logging and tourism. Bislig City Water District is providing the people, particularly in the urban areas, with clean water sourced from the basin's upstream watersheds. As for the folks in the rural area, they relish the unlimited flowing of fresh clean water from the basin's tropical forest. Covered by a diverse ecosystem, the city is preserving and nurturing their natural resources such as the mangrove areas, tropical rain forest and aquatic resources[3].

Bislig City is one of localities that was affected during the onslaught of Tropical Storm "Agaton" in January 2014 to the extent that a 'state of calamity' was declared by the City government. It can be recalled that "Agaton" was the first Tropical Storm that affected the country. It was a low pressure area and developed into a Tropical Depression 130 kilometer northeast of Guiian, Eastern Samar in the morning of 17 January 2014, and it moved westward slowly at 5 kilometers per hour closer to the provinces of Surigao del Norte and Surigao del Sur[4]. The slow movement of "Agaton" and the continuous rain and strong winds that it brought along has caused flooding and landslides not only in the Bislig City but also in other localities in Mindanao.

1 US Department of Interior, 1966. A Report on the Agusan River Basin, Mindanao, Philippines. Bureau of Reclamation, US Department of Interior.
2 https://en.wikipedia.org/wiki/Bislig
3 Ecosystems Research and Development Bureau-DENR, Bislig City
4 NDRRMC Update, Final Report, re: Effects of Tropical Depression "AGATON" http://ndrrmc.gov.ph/attachments/article/2783/FINAL_REPORT_re_Effects_of_Tropical_Depression_AGATON_17_-_20JAN2014.pdf

CHAPTER 2: LIDAR ACQUISITION IN BISLIG FLOODPLAIN

Engr. Louie P. Balicanta, Engr. Christopher Cruz, Lovely Gracia Acuña, Engr. Gerome Hipolito, Engr. Christopher L. Joaquin, Ms. Mary Catherine Elizabeth M. Baliguas

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

1.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Bislig floodplain in Surigao del Sur. These missions were planned for 17 lines and ran for at most four and a half (4.5) hours including take-off, landing and turning time. The flight planning parameters for the LiDAR system is found in Table 1. Figure 1 shows the flight plan for Bislig floodplain survey.

Table 1. Flight planning parameters for Aquarius LiDAR system.

Block Name	Flying Height (AGL)	Overlap	Field of View (θ)	Pulse Rate Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Around (Minutes)
BLK66A	500	30,40	36	50	45	130	5
BLK66B	550	30,40	36	50	45	130	5
	600	30,40	36	50	45	130	5
BLK66C	600	40	36	50	45	130	5
BLK66D	500	40,60	40	50	45	130	5
	600	40,60	40	50	45	130	5
BLK66G	600	30	50	50	40	130	5
BLK66H	600	30	36,50	50	40,45	130	5
BLK66I	600	30	36	50	45	130	5
BLK66J	600	30	36	50	45	130	5
BLK66L	600	45	36	50	45	130	5
BLK66U	600	40	36	50	45	130	5
BLK66V	600	30,40	36	50	45	130	5
BLK66W	550	30,40	36	50	45	130	5
	600	30,40	36	50	45	130	5

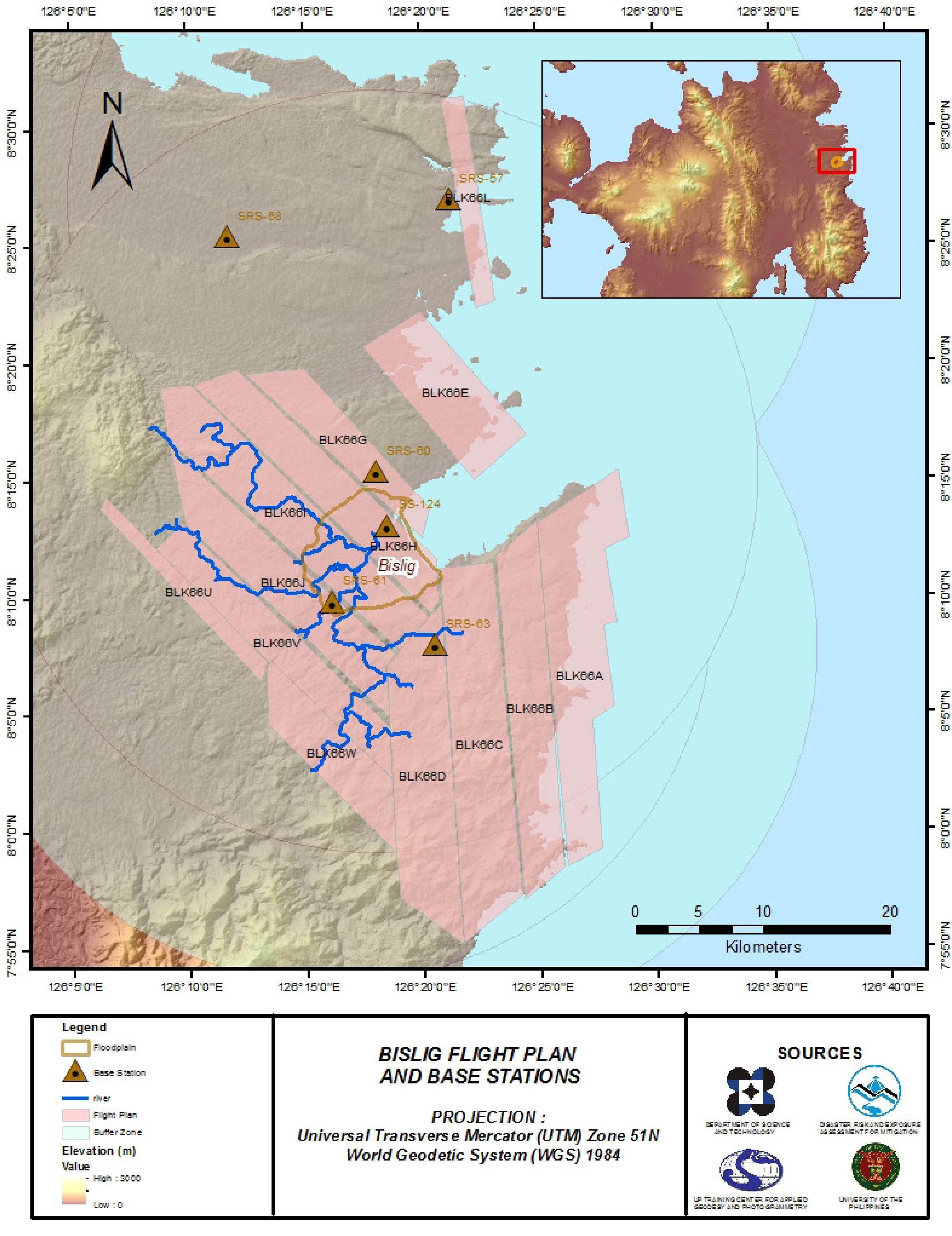
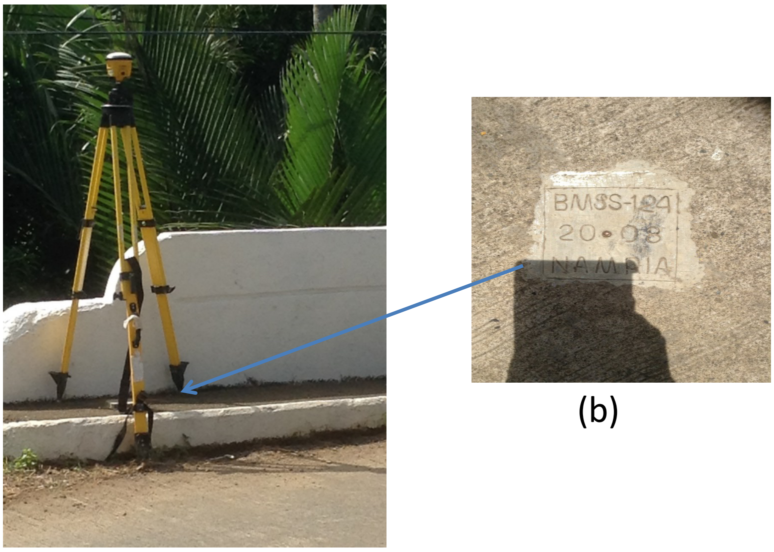


Figure 2. Flight plan and base stations used for Bislig floodplain

2.2 Ground Base Stations

The project team was able to recover six (6) NAMRIA ground control points:SRS-60, SRS-57, SRS-61, SRS-63, SRS-56 and SRS-58 which are of second (2nd) order accuracy and one (1) NAMRIA Benchmark SS-124. The benchmark was used as vertical reference point and was also established as ground control point. The certifications for the NAMRIA reference points are found inAnnex B and the baseline processing report for the established control pointis found inAnnex C. These were used as base stations during flight operations for the entire duration of the survey (August 3 - September 5, 2014). Base stations were observed using dual frequency GPS receivers, TRIMBLESPS 852, and SPS 985. Flight plans and location of base stations used during the aerial LiDAR acquisition in Bislig floodplain are shown in Figure 1.

Figure 3 to Figure 9 shows the recovered NAMRIA reference points within the area. In addition,Table 2to Table 8show the details about the following NAMRIA control stations and established point, while Table 9shows the list of all ground control points occupied during the acquisition with the corresponding dates of utilization.



(b)

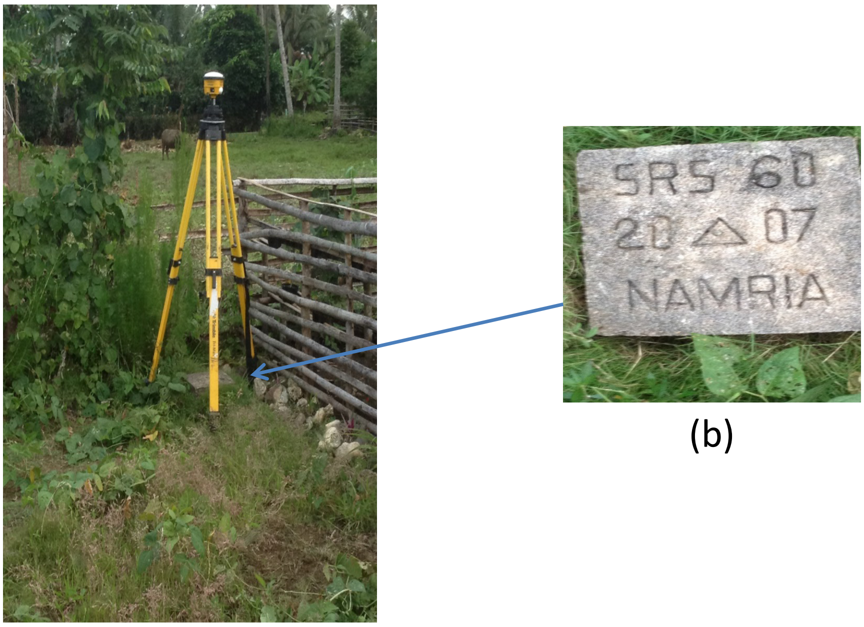
(a)

Figure 3. GPS set-up over SS-124located at the second approach of Bislig bridge in Bislig, Surigao Del Sur(a) and NAMRIA reference point SS-124(b) as recovered by the field team.

Table2. Details of the recovered NAMRIA benchmark point SS-124 with processed coordinatesused as base station for the LiDAR acquisition.

Station Name	SS-124	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8°13’07.07644” North
	Longitude	126°18’24.14659” East
	Ellipsoidal Height	3.637 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	864399.325 meters
	Northing	909915.188 meters

Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8°13'03.71089"North
	Longitude	126°18'29.55827"East
	Ellipsoidal Height	80.77 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	1085282.295meters
	Northing	911895.258meters

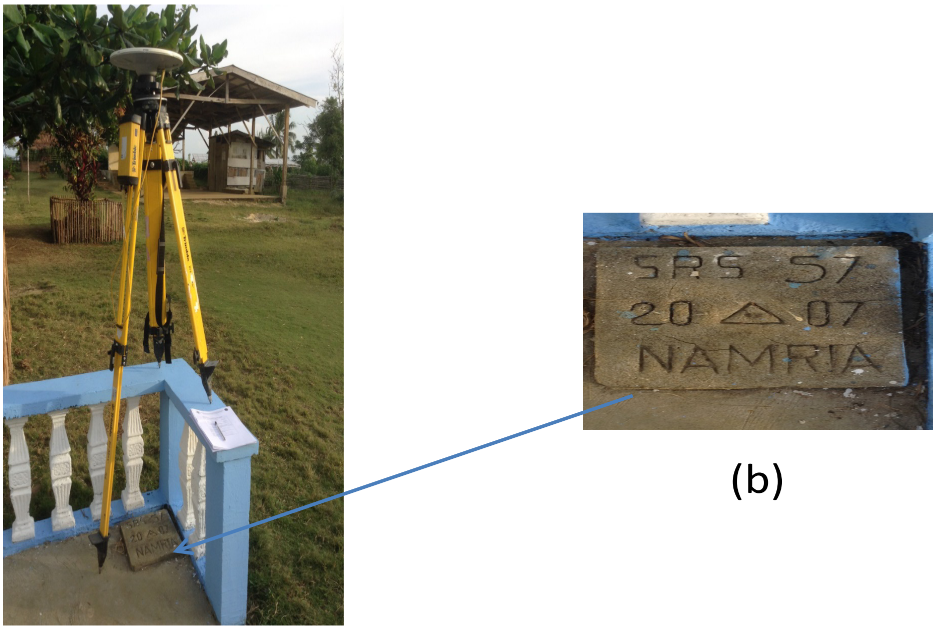


(a)

Figure 4. GPS set-up over SRS-60 as recovered inside Brgy. Sta Cruz health center, on the corner near the bamboo fence (a) NAMRIA reference point SRS-60 (b) as recovered by the field team.

Table 3. Details of the recovered NAMRIA horizontal control point SRS-60 used as base station for the LiDAR acquisition.

Station Name	SRS-60	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8° 15' 26.63928" North
	Longitude	126° 17' 56.66192" East
	Ellipsoidal Height	83.08300 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	643129.132 meters
	Northing	913248.992 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8°15' 23.26276" North
	Longitude	126° 18' 2.07013" East
	Ellipsoidal Height	155.22600meters



(b)

(a)

Figure 5. GPS set-up over SRS-57 locatedon the concrete ground corner of the flagpole of Talisay Elementary School in Brgy. Talisay , Hinatuan (a) and NAMRIA reference point SRS-57 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point SRS-57 used as base station for the LiDAR acquisition.

Station Name	SRS-57	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8° 27’ 1.69252” North
	Longitude	126° 21’ 8.66908” East
	Ellipsoidal Height	26.14400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	648933.286 meters
	Northing	934625.002 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8° 26’ 58.26936” North
	Longitude	126° 21’ 14.05931” East
	Ellipsoidal Height	98.02200meters

Figure 6. GPS set-up over SRS-61 as recovered on the open field about 100m away from the flagpole of Mone National High School in Brgy. Mone, Bislig, Surigao Del Sur (a) and NAMRIA reference point SRS-61 (b) as recovered by the field team.

Table 5. Details of the recovered NAMRIA horizontal control point SRS-61 used as base station for the LiDAR acquisition.

Station Name	SRS-61	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8° 9' 52.82479" North
	Longitude	126° 16' 5.42126" East
	Ellipsoidal Height	2.46400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	639590.647 meters
	Northing	902980.994 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8° 9' 49.47002" North
	Longitude	126° 16' 5.42126" East
	Ellipsoidal Height	74.71500meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	198797.23 meters
	Northing	903466.77 meters

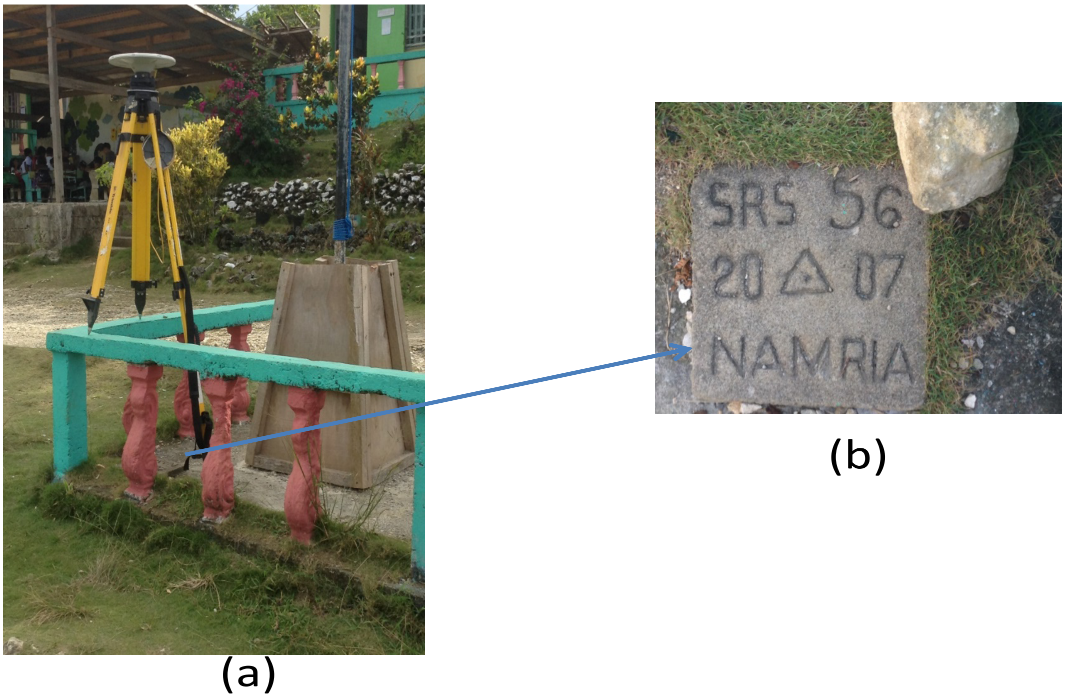
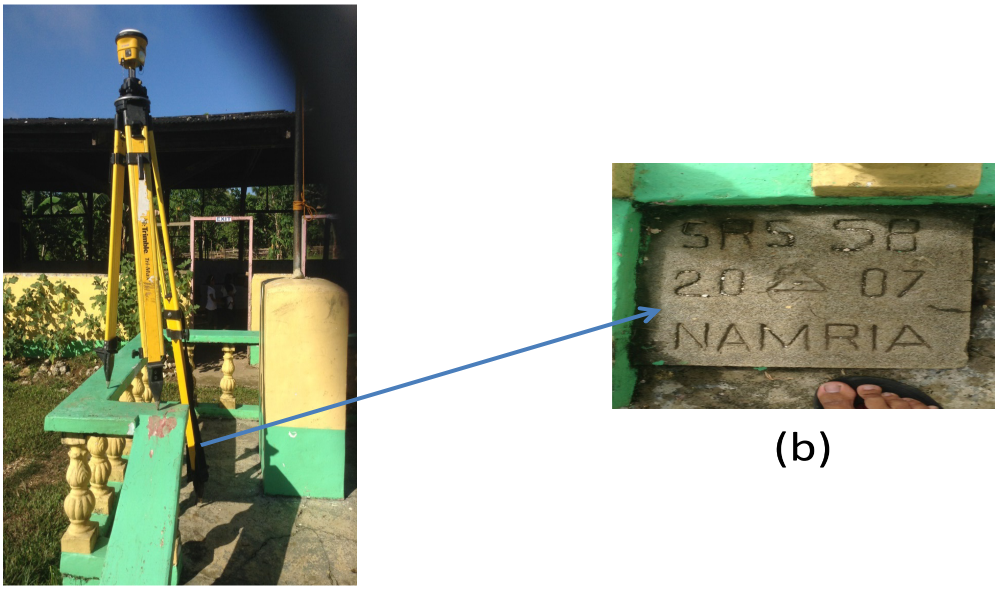


Figure 7. GPS set-up over SRS-56 recovered on the east side of the ground corner of the flagpole of Barobo Town Site Elementary School in Brgy. Poblacion, Barobo, Surigao Del Sur (a) and NAMRIA reference point SRS-56 (b) as recovered by the field team.

Table 6. Details of the recovered NAMRIA horizontal control point SRS-56 used as base station for the LiDAR acquisition.

Station Name	SRS-56	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8° 31’ 39.52861” North
	Longitude	126° 7’ 4.08061” East
	Ellipsoidal Height	36.22400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	623069.127 meters
	Northing	943079.391 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8° 31’ 36.06400” North
	Longitude	126° 7’ 9.46645” East
	Ellipsoidal Height	107.36300meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	182673.15 meters
	Northing	943755.61meters



(a) (b)

Figure 8. GPS set-up over SRS-58 recovered on the concrete ground of the flagpole of Maglambing Elementary School in Brgy. Maglambing, Tagbina, Surigao Del Sur (a) and NAMRIA reference point SRS-58 (b) as recovered by the field team.

Table 7. Details of the recovered NAMRIA horizontal control point SRS-58 used as base station for the LiDAR acquisition.

Station Name	SRS-58	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8° 25' 30.89446" North
	Longitude	126° 11' 37.55708" East
	Ellipsoidal Height	10.93400 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	631468.821 meters
	Northing	931778.214 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8° 25' 27.46381" North
	Longitude	126° 11' 42.95134" East
	Ellipsoidal Height	82.47300meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	190961.53meters
	Northing	932360.98meters

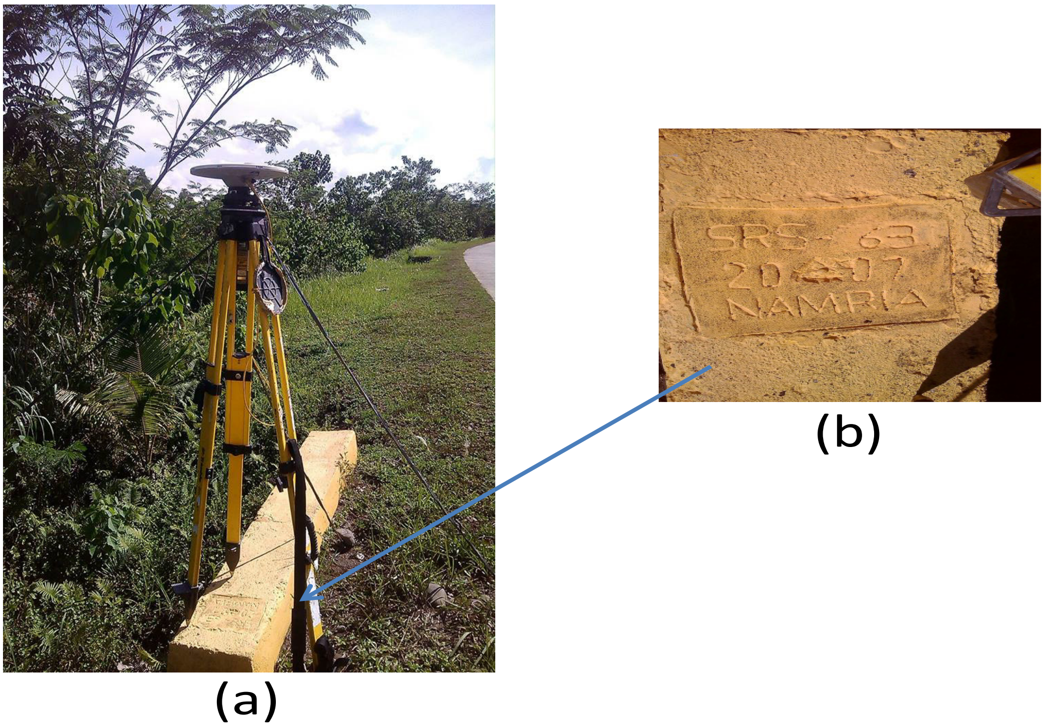


Figure 9. GPS set-up over SRS-63 located 4 kms to the junction of the road of San Antonio in Brgy. Sitio Pagmam-am, Bislig, Surigao Del Sur (a) and NAMRIA reference point SRS-63 (b) as recovered by the field team.

Table 8. Details of the recovered NAMRIA horizontal control point SRS-63 used as base station for the LiDAR acquisition.

Station Name	SRS-63	
Order of Accuracy	2^{nd}	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	8° 8' 0.61702" North
	Longitude	126° 20' 25.46527" East
	Ellipsoidal Height	89.36100 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	647729.756 meters
	Northing	899559.567 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	8° 7' 57.27724" North
	Longitude	126° 20' 30.88421" East
	Ellipsoidal Height	161.85800meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	206906.01 meters
	Northing	899963.22 meters

Table 9. Ground control points used during LiDAR data acquisition.

Date Surveyed	Flight Number	Mission Name	Ground Control Points
03-Aug-14	1778A	3BLK66GH215A	SS-124 andSRS-60
03-Aug-14	1780A	3BLK66HS215B	SS-124 andSRS-60
04-Aug-14	1784A	3BLK66HSI216B	SS-124 andSRS-60
05-Aug-14	1786A	3BLK66ISJ217A	SS-124 andSRS-60
05-Aug-14	1788A	3BLK66EGS217B	SS-124 AND SRS-60
07-Aug-14	1796A	3BLK66LSJS219B	SRS-57 andSRS-60
13-Aug-14	1818A	3BLK66D225A	SRS-60 andSRS-61
16-Aug-14	1830A	3BLK66A228A	SRS-60 andSRS-61
17-Aug-14	1834A	3BLK66AS229A	SRS-60 andSRS-61
17-Aug-14	1836A	3BLK66DS229B	SRS-60 andSRS-61
21-Aug-14	1850A	3BLK66VW233A	SRS-60 andSRS-61
22-Aug-14	1854A	3BLK66BWS234A	SRS-61 and SRS-63
26-Aug-14	1870A	3BLK66ASB238A	SRS-61 andSRS-63
2-Sep-14	1898A	3BLK66C245A	SRS-61 and SRS-63
5-Sep-14	1910A	3BLK66CSU248A	SRS-56, SRS-58, SRS-61 andSRS-63

2.3 Flight Missions

Fifteen (15) missions were conducted to complete the LiDAR Acquisition in Bislig floodplain for a total of fifty-nine hours and thirty-four minutes (59+34) of flying time for RP-C9122. All missions were acquired using the Aquarius LiDAR system. Table 10 shows the total area of actual coverage and the corresponding flying hours per mission while Table 11 presents the actual parameters used during the LiDAR data acquisition.

Table10. Flight missions for LiDAR data acquisition in Bislig floodplain.

Date Surveyed	Flight Number	Flight Plan Area (km²)	Surveyed Area (km²)	Area Surveyed within the Floodplain (km²)	Area Surveyed Outside the Floodplain (km²)	No. of Images (Frames)	Flying Hours	
							Hr	Min
3-Aug-14	1778A	82.889	102.32	19.09	83.23	1201	4	23
3-Aug-14	1780A	82	75.61	24.37	51.24	945	3	5
4-Aug-14	1784A	98.845	90.02	24.51	65.51	1918	3	17
5-Aug-14	1786A	98	112	15.47	96.53	865	4	17
5-Aug-14	1788	70	82.05	NA	95.58	884	3	53
07-Aug-14	1796A	79.152	95.58	NA	95.58	1029	3	53
13-Aug-14	1818A	94	60.56	NA	60.56	449	4	23
16-Aug-14	1830A	92	73.34	NA	73.34	83	4	23
17-Aug-14	1834A	97	128.16	NA	128.16	NA	3	23
17-Aug-14	1836A	94	65.32	NA	65.32	636	3	5
21-Aug-14	1850A	140	116.47	NA	116.47	1465	4	23
22-Aug-14	1854A	80.311	45.49	NA	45.49	697	4	23
26-Aug-14	1870A	118.516	147.98	NA	147.98	1506	4	23
2-Sep-14	1898A	132	131.84	NA	131.84	NA	4	23
5-Sep-14	1910A	114	96.36	NA	96.36	1107	4	23
TOTAL		1472.713	1423.1	83.44	1353.19	12785	59	34

Table11.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)
1778A	600	30	50	50	40	120	5
1780A	600	30	36	50	45	120	5
1784A	600	30	36	50	45	120	5
1786A	600	30	36	50	45	120	5
1788A	600	30	36	50	40,45	120	5
1796A	600	45	36	50	45	120	5
1818A	500,600	40,60	40	50	50	120	5
1830A	500	40	36	50	45	120	5
1834A	500	40	36	50	45	120	5
1836A	600	40,60	36	50	45	120	5
1850A	600	30,40	36	50	45	120	5
1854A	550,600	40	36	50	45	120	5
1870A	600	30,40	36	50	45	120	5
1898A	600	40	36	50	45	120	5
1910A	600	40	36	50	45	120	5

2.4 Survey Coverage

Bislig floodplain is located in the province of Surigao del Sur with majority of the floodplain situated within the city of Bislig. The municipality of Lingigis completely covered during the survey. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 12. The actual coverage of the LiDAR acquisition for Bislig floodplain is presented in Figure 10.

Table 12. List of municipalities and cities surveyed during Bislig floodplain LiDAR survey.

Province	Municipality/ City	Area of Municipality/ City (km^2)	Total Area Surveyed(km^2)	Percentage of Area Surveyed
Surigao del Sur	Lingig	227.04	227.04	100%
	Bislig	269.88	249.39	92%
	Hinatuan	238.31	52.89	22%
Agusan del Sur	Trento	515.17	197.46	38%
	Bunawan	608.49	112.57	18%
	Rosario	452.81	67	15%
Davao Oriental	Boston	392.62	37.27	9%

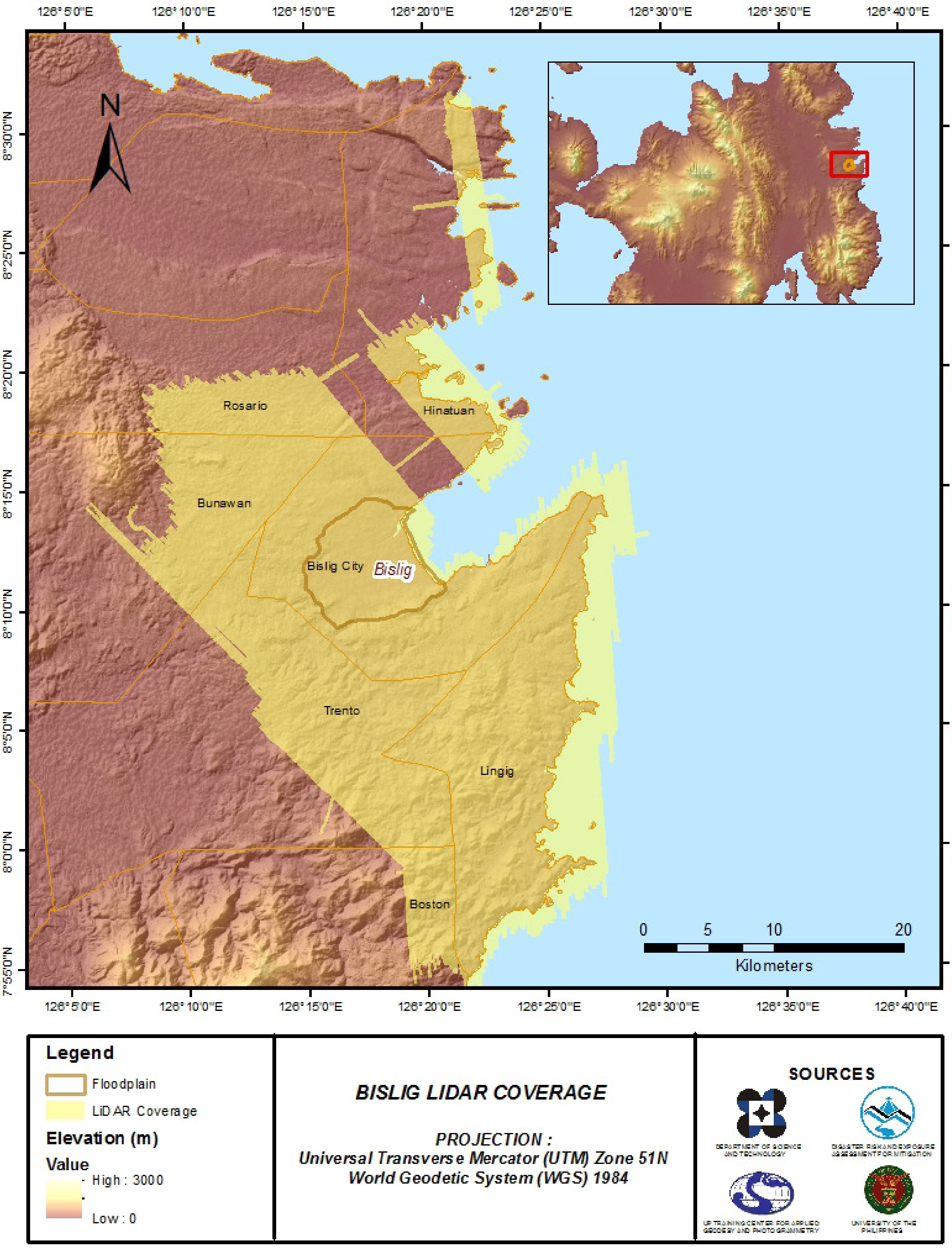


Figure 10. Actual LiDAR survey coveragefor Bislig floodplain.

CHAPTER 3: LIDAR DATA PROCESSING OF THE BISLIG FLOODPLAIN

Engr. Louie P. Balicanta, Engr. Joemarie S. Caballero, Ms. Patrizcia Mae. P. dela Cruz, Engr. Dexter T. Lozano, For. Dona Rina Patricia C. Tajora, Elaine Bennet Salvador, 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).]

3.1 Overview of the LiDAR Data Pre-Processing

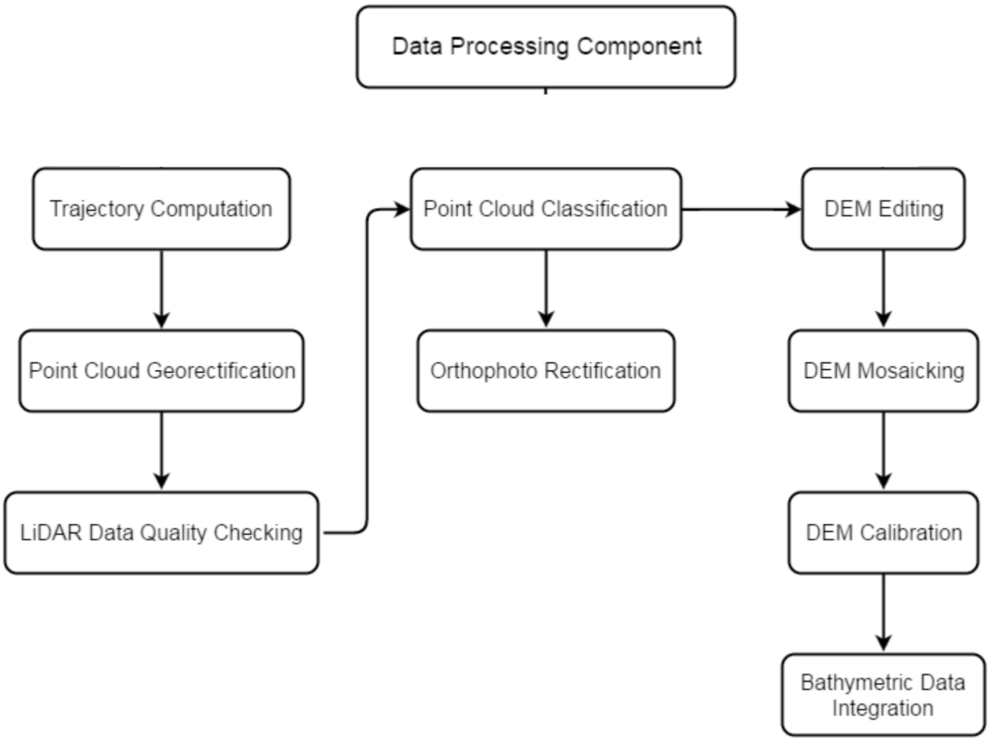


Figure 11. Schematic Diagram for Data Pre-Processing Component

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

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

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

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Bislig floodplain can be found in Annex A-5. Data Transfer Sheets. Missions flown during the first survey conducted on August 2014 used the Airborne LiDAR Terrain

Mapper (ALTM™ Optech Inc.) Aquarius system over Surigao del Sur. The Data Acquisition Component (DAC) transferred a total of 176.88 Gigabytes of Range data, 3.52 Gigabytes of POS data, 200.59 Megabytes of GPS base station data, and 774.6 Gigabytes of raw image data to the data server on September 9, 2014. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Bislig was fully transferred on December 9, 2014 as indicated on the Data Transfer Sheets for Bislig floodplain.

3.3 Trajectory Computation

The *Smoothed Performance Metric*parameters of the computed trajectory for flight 1870A, one of the Bisligflights, which is the North, East, and Down position RMSE values are shown in Figure 11. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell onFebruary 7, 2015 00:00 AM. The y-axis is the RMSE value for that particular position.

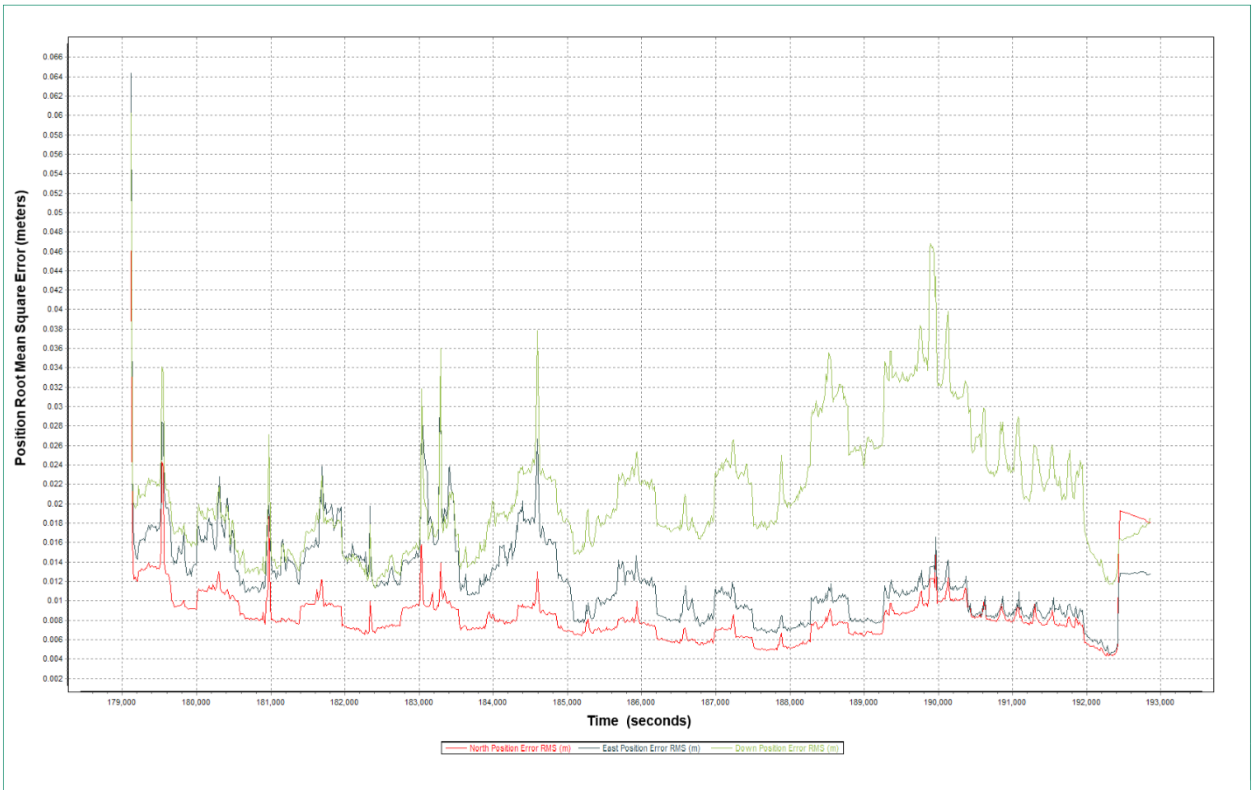


Figure 12. Smoothed Performance Metric Parameters of Bislig Flight 1870A

The time of flight was from 179000 seconds to 193000 seconds, which corresponds to morning of August 26, 2014.The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure B-2 shows that the North position RMSE peaks at 2.40 centimeters, the East position RMSE peaks at 2.80 centimeters, and the Down position RMSE peaks at 4.60 centimeters, which are within the prescribed accuracies described in the methodology.

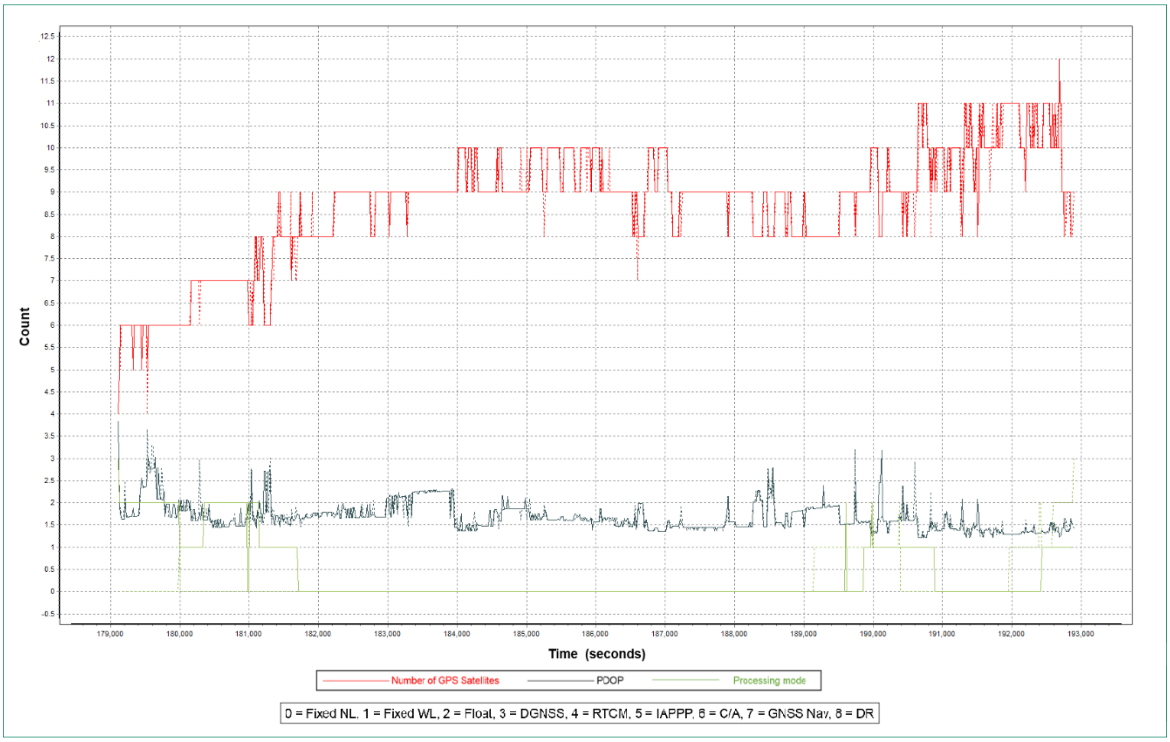


Figure 13. Solution Status Parameters of Bislig Flight 1870A.

The S*olution Status*parameters of flight 1870Aone of the Bisligflights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure B-3. The graphs indicate that the number of satellites during the acquisition did not go down to 4. Majority of the time, the number of satellites tracked was between 4 and 11. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode stayed at the value of 0 for majority of the survey with some peaks up to 1 attributed to the turns performed by the aircraft. The value of 0 corresponds to a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters adhered to the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Bislig flights is shown in Figure 13.

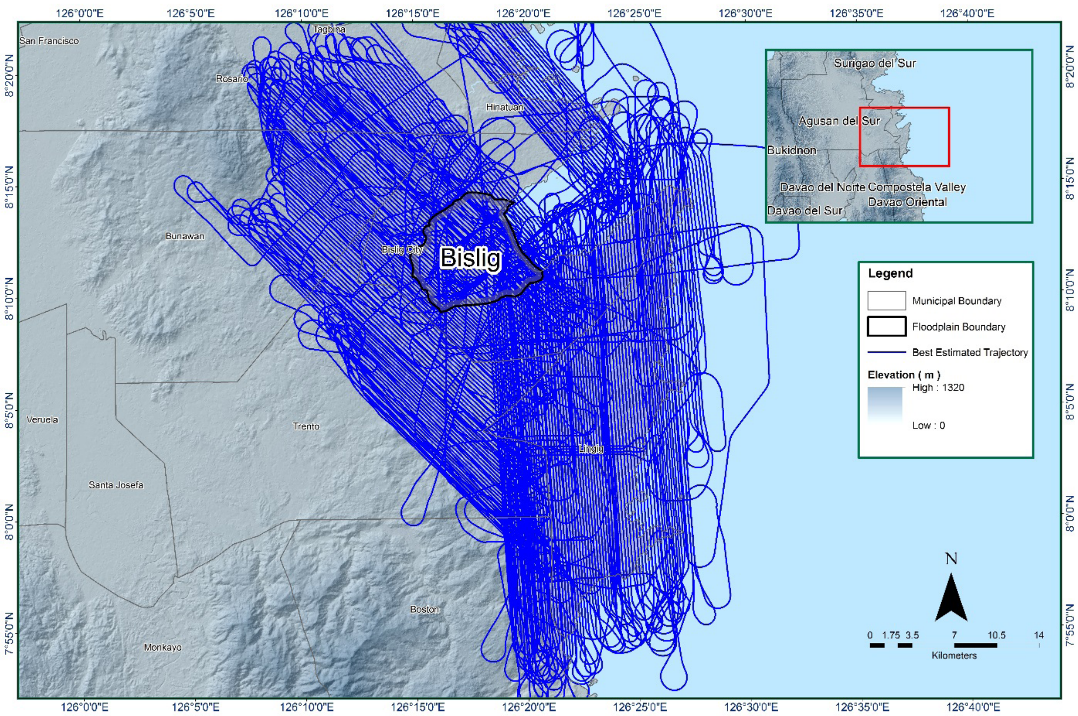


Figure 14. The best estimated trajectory of the LiDAR missions conducted over the Bislig floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 256flight lines, with each flight line containing one channel, since the Aquarius system contains one channel only. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Bislig floodplain are given in Table 13.

Table 13. Self-Calibration Results values for Bislig flights.

Parameter	Acceptable Value
Boresight Correction stdev(<0.001degrees)	0.000305
IMU Attitude Correction Roll and Pitch Corrections stdev(<0.001degrees)	0.001336
GPS Position Z-correction stdev(<0.01meters)	0.0022

The optimum accuracy is obtained for all Bislig flights based on the computed standard deviations of the corrections of the orientation parameters. Standard deviation values for individual blocks are available in the Annex B-1. Mission Summary Reports.

3.5 LiDAR Data Quality Checking

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

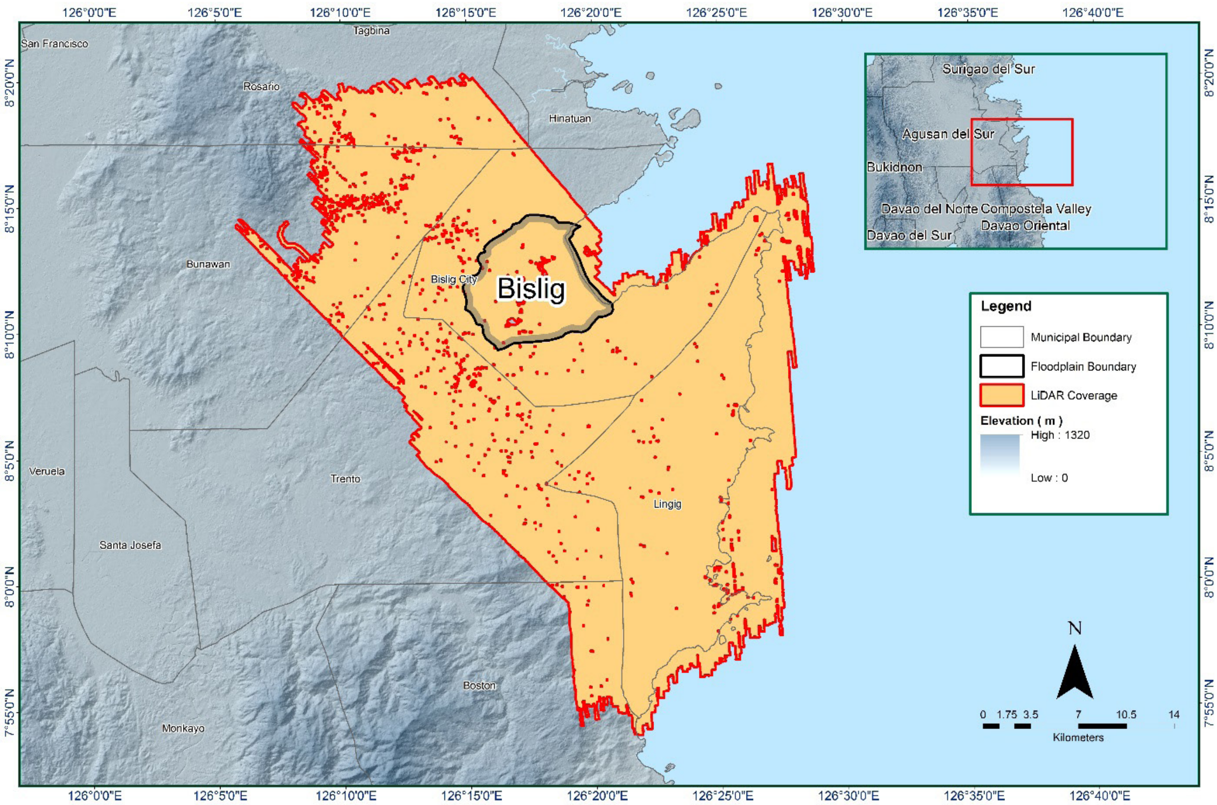


Figure 15. Boundary of the processed LiDAR data over Bislig Floodplain

The total area covered by the Bislig missions is 1148.08 sq.km that is comprised of fifteen (15) flight acquisitions grouped and merged into twelve (12) blocks as shown in Table 14.

Table 14. List of LiDAR blocks for Bislig floodplain.

LiDAR Blocks	Flight Numbers	Area (sq. km)
SurigaoDelSur_Blk66AB	1870A	239.58
	1830A	
	1834A	
	1854A	
SurigaoDelSur_Blk66C	1910A	89.05
SurigaoDelSur_Blk66C_supplement	1898A	127.62
SurigaoDelSur_Blk66D	1818A	73.54
	1836A	
SurigaoDelSur_Blk66D_additional	1836A	48.83
SurigaoDelSur_Blk66W	1854A	39.34
SurigaoDelSur_Blk66V	1850A	115.47
SurigaoDelSur_Blk66J	1786A	121.92
	1796A	
SurigaoDelSur_Blk66H	1778A	97.67
	1780A	
	1784A	
SurigaoDelSur_Blk66G	1778A	26.41
	1788A	
SurigaoDelSur_Blk66G_additional	1778A	47.85
SurigaoDelSur_Blk66I	1784A	118.60
	1786A	
TOTAL		**1145.88 sq.km**

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location is shown in Figure 15. Since the Aquarius system employs one channel only, 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.

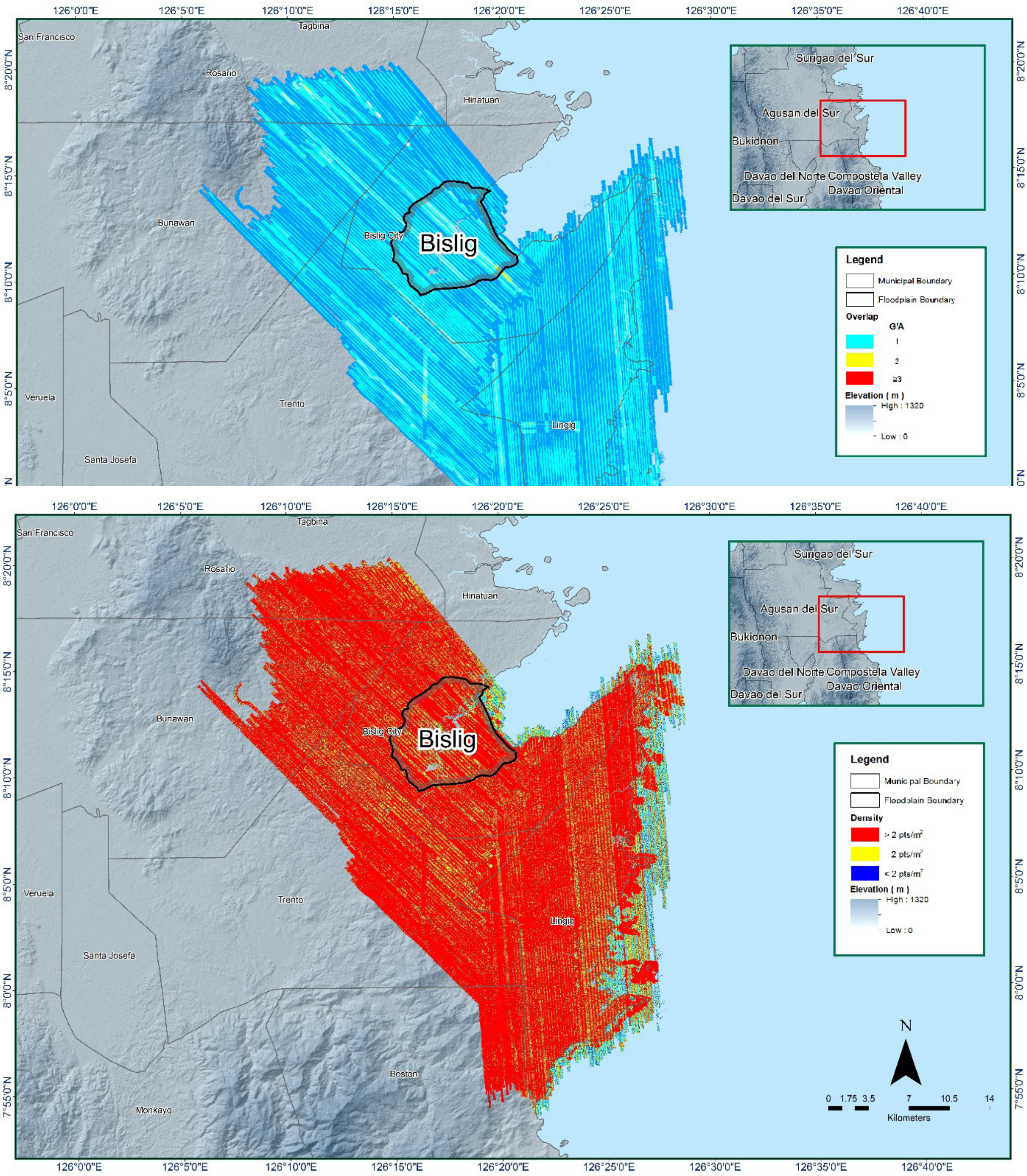


Figure 17. Pulse density map of merged LiDAR data for Bislig floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 17. The default color range is from blue to red, where bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time,are higher by more than 0.20m relative to elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m relative to elevations of its adjacent flight line. Areas with bright red or bright blue need to be investigated further using Quick Terrain Modeler software.

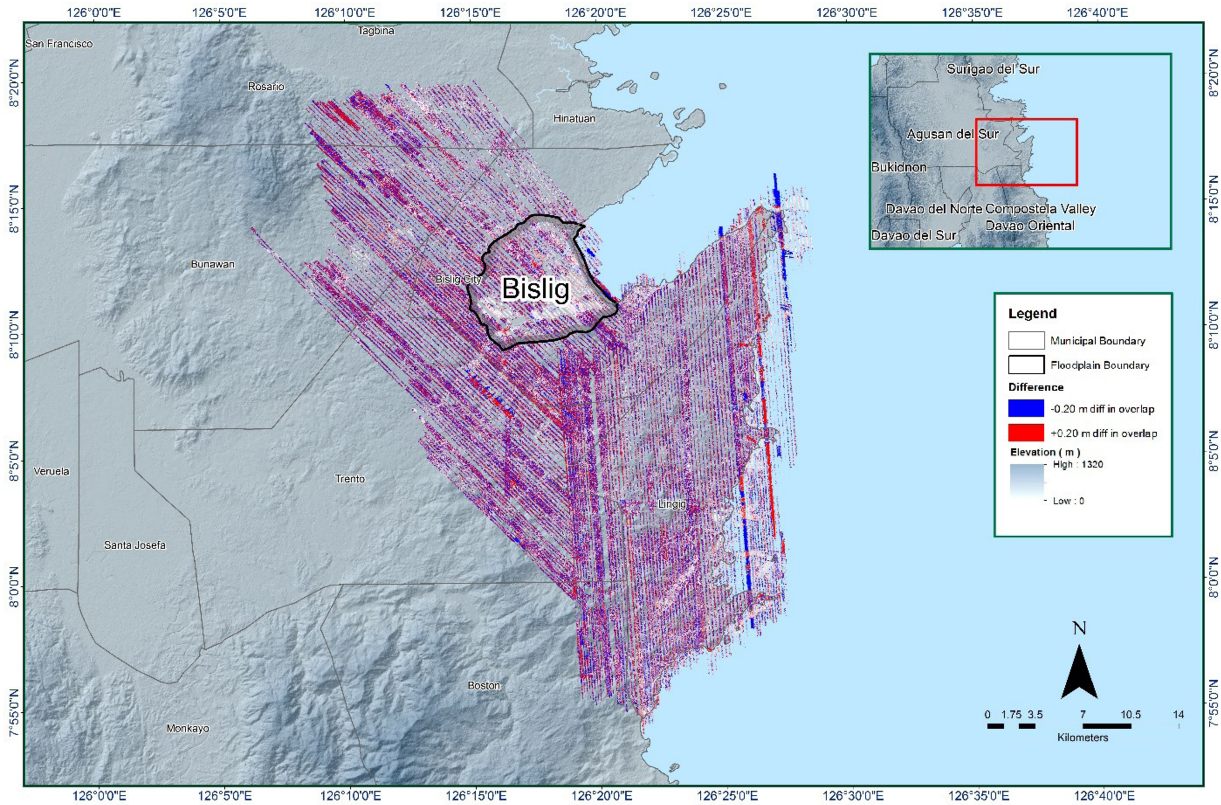


Figure 18. Elevation difference map between flight lines for Bislig floodplain.

A screen capture of the processed LAS data from a Bislig flight 1870A loaded in QT Modeler is shown in Figure 18. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed green line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

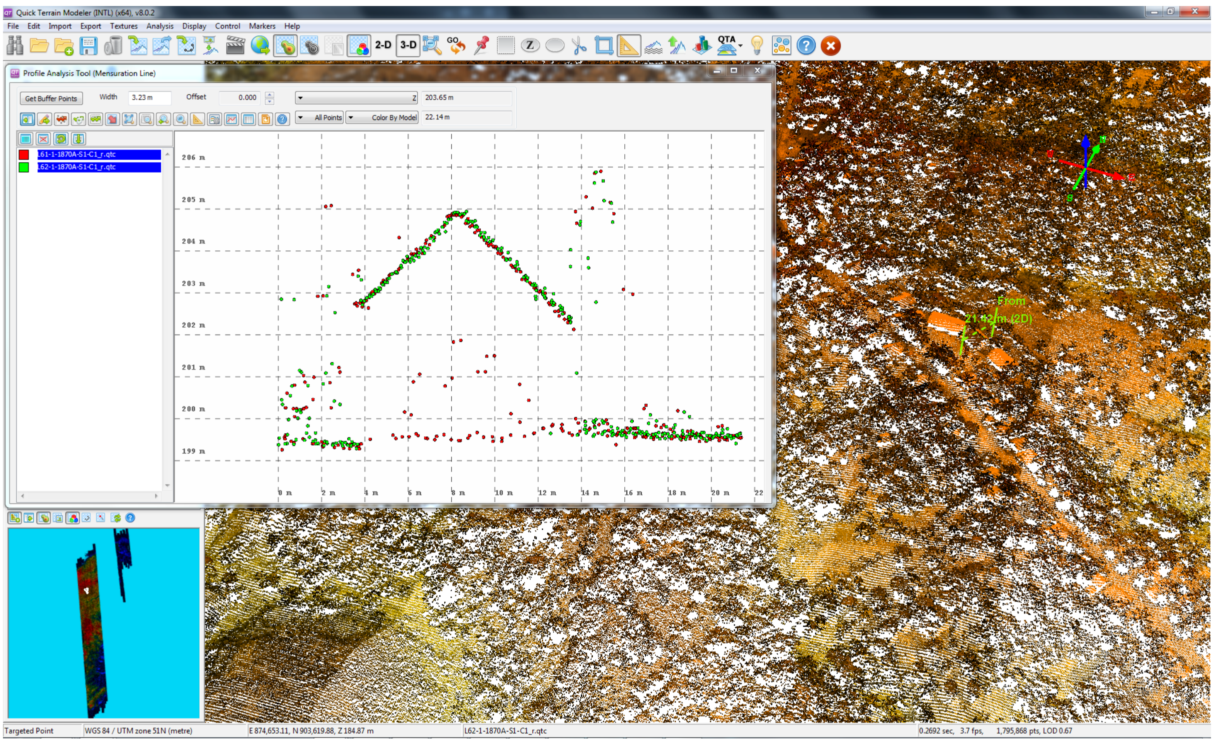


Figure 19. Quality checking for a Bislig flight 1870A using the Profile Tool of QT Modeler.

3.6 LiDAR Point Cloud Classification and Rasterization

Table 15. Bislig classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	349,364,436
Low Vegetation	288,932,927
Medium Vegetation	1,050,209,459
High Vegetation	1,765,023,021
Building	28,980,247

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Bislig floodplain is shown in Figure 19. A total of 1765 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 15. The point cloud has a maximum and minimum height of 630.35 meters and 46.6 meters respectively.

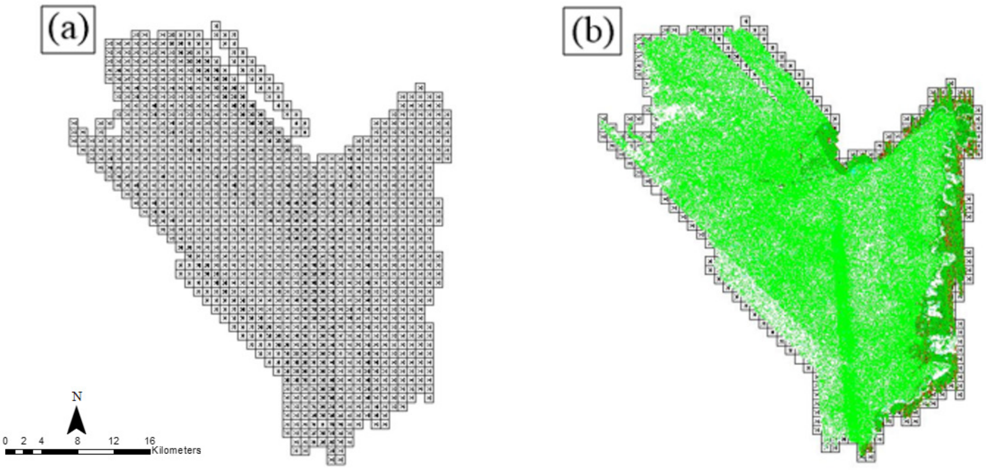


Figure 19. Tiles for Bislig floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 20. The ground points are in orange, the vegetation is in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below canopy are classified correctly, due to the density of the LiDAR data.

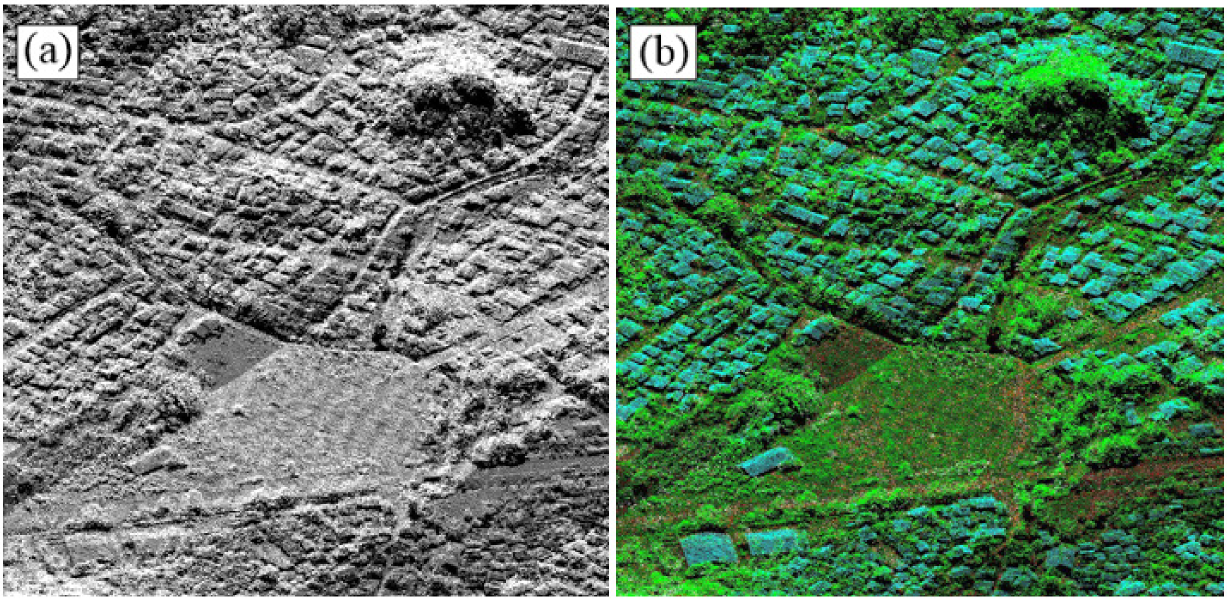


Figure 21. Point cloud before (a) and after (b) classification.

The production of last return (V_ASCII) and the secondary (T_ ASCII) DTM, first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 21. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

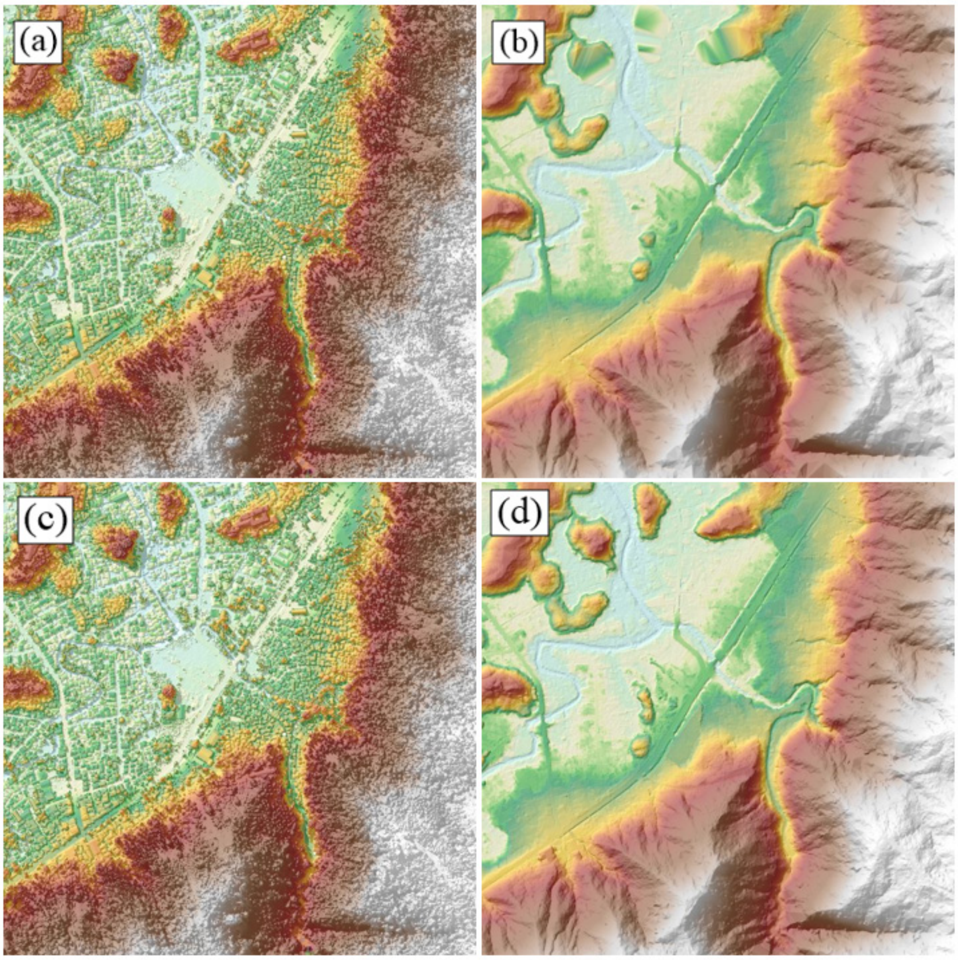


Figure 22. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Bislig floodplain

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 1,4681km by 1km tiles area covered by Bislig floodplain is shown in Figure 23. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Bislig floodplain survey attained a total of 823.2 sq. km in orthophotogaph coverage comprised of 11,848 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 23.

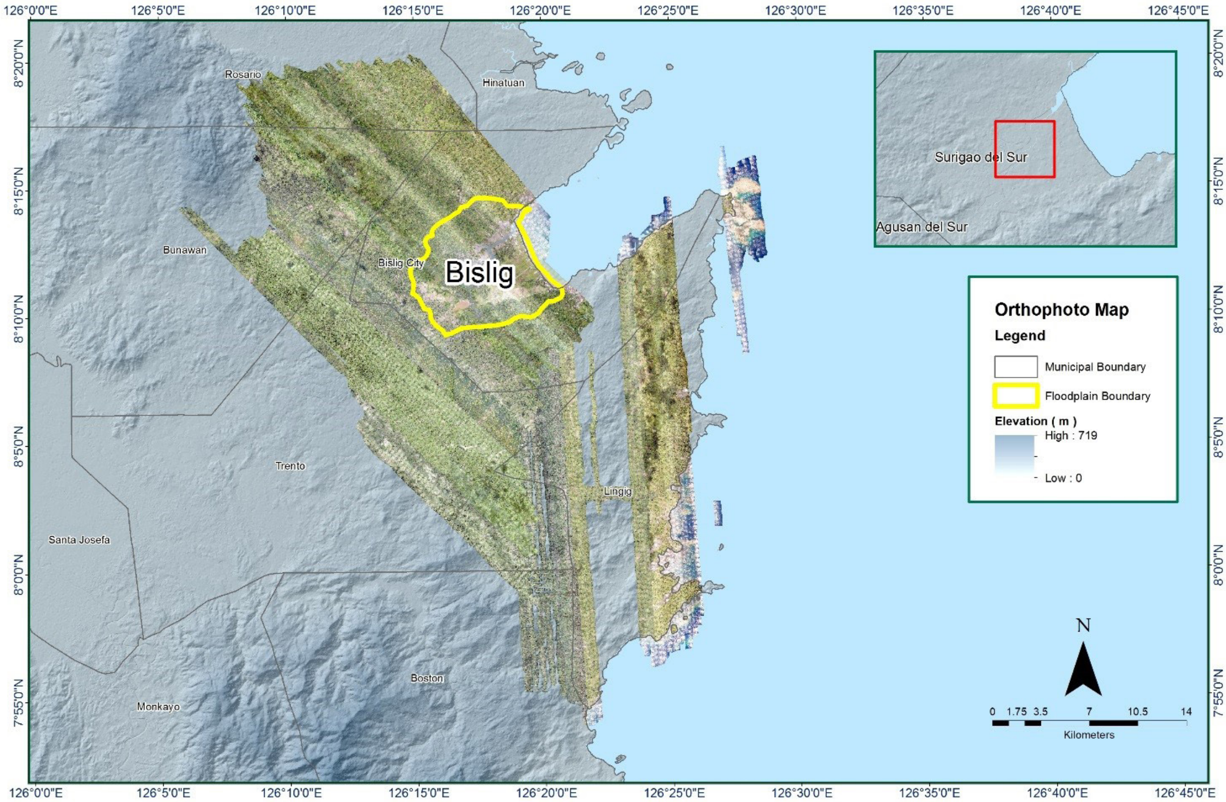


Figure 23. Bislig floodplain with available orthophotographs.

Figure 24. Sample orthophotograph tiles for Bislig floodplain

3.8 DEM Editing and Hydro-Correction

Fourteen (14) mission blocks were processed for Bislig flood plain. These blocks are composed of Surigao del Sur blocks with a total area of 1,281.40 square kilometers. Table 16 shows the name and corresponding area of each block in square kilometers.

Table 16. LiDAR blocks with its corresponding area.

LiDAR Blocks	Area (sq.km)
SurigaodelSur_Blk66H	97.67
SurigaodelSur_Blk66I	118.60
SurigaodelSur_Blk66J	121.92
SurigaodelSur_Blk66V	115.47
SurigaodelSur_Blk66W	39.34
SurigaodelSur_Blk66D	73.54
SurigaodelSur_Blk66D_Additional	48.83
SurigaodelSur_Blk66C	89.05
SurigaodelSur_Blk66C_Supplement	127.62
SurigaodelSur_Blk66G	26.41
SurigaodelSur_Blk66G_Additional	47.85
SurigaodelSur_Blk66AB	239.58
TOTAL	1,145.88 sq.km

Portions of DTM before and after manual editing are shown in Figure 24. Hilly portions (Figure 24a) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 24b) to allow the correct flow of water. The bridge (Figure 24c) is also considered to be an impedance to the flow of water along the river and has to be removed (Figure 24d) in order to hydrologically correct the river.

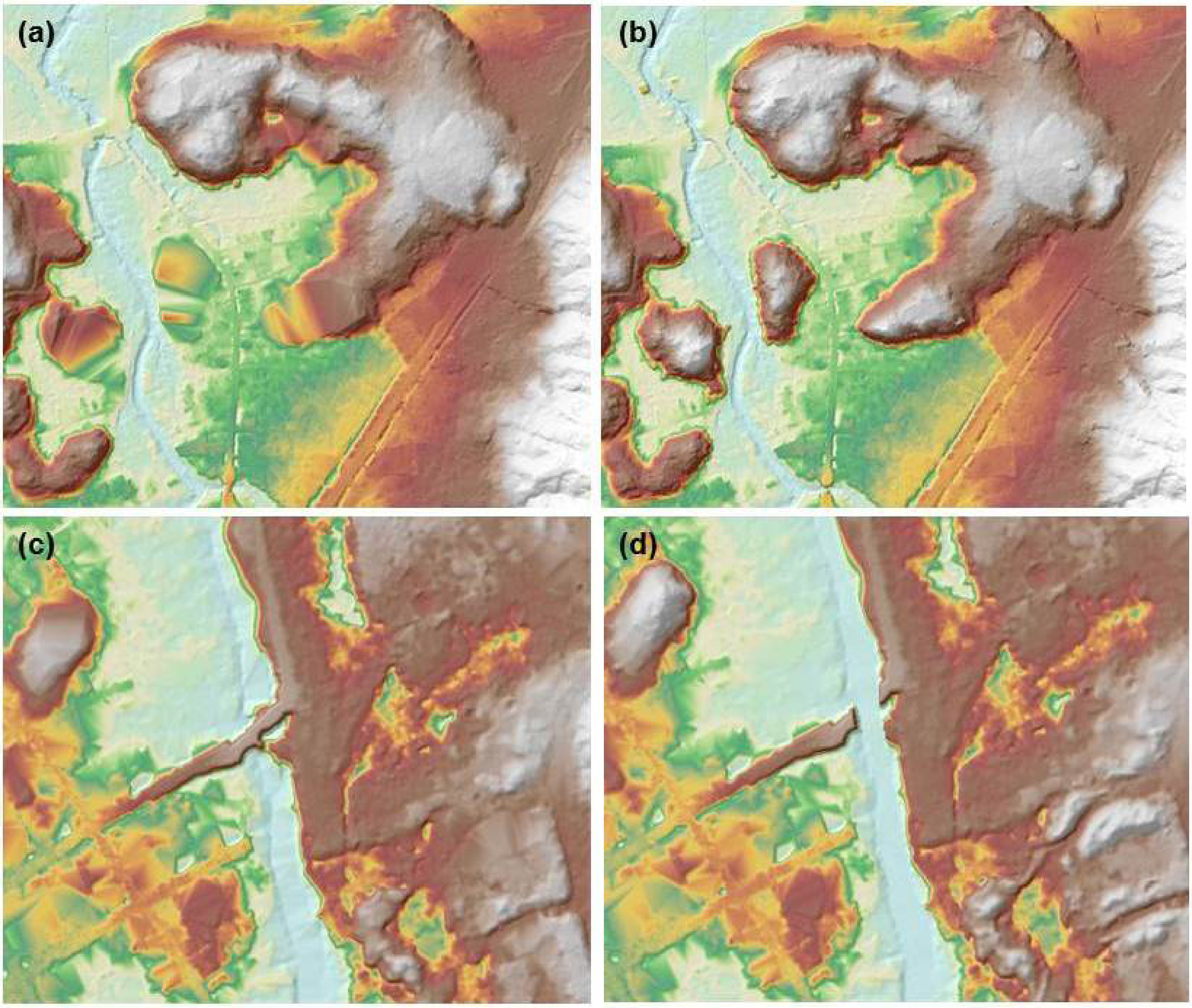


Figure 25. Portions in the DTM of Bislig floodplain – hilly portions before (a) and after (b) data retrieval; and a bridge before (c) and after (d) manual editing

3.9 Mosaicking of Blocks

SurigaodelSur_Blk66H 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.

Mosaicked LiDAR DTM for Bislig floodplain is shown in Figure B-16. It can be seen that the entire Bislig floodplain is 99.99% covered by LiDAR data.

Table 17. Shift Values of each LiDAR Block of Bislig floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
SurigaodelSur_Blk66I	0.00	0.00	0.20
SurigaodelSur_Blk66J	0.00	0.00	0.34
SurigaodelSur_Blk66V	0.00	0.00	0.75
SurigaodelSur_Blk66W	0.00	0.00	0.65
SurigaodelSur_Blk66D	0.00	0.00	0.12
SurigaodelSur_Blk66D_Additional	0.00	0.00	0.04
SurigaodelSur_Blk66C	0.00	0.00	0.69
SurigaodelSur_Blk66C_Supplement	0.00	0.00	0.73
SurigaodelSur_Blk66G	0.00	0.00	0.41
SurigaodelSur_Blk66G_Additional	0.00	0.00	0.40
SurigaodelSur_Blk66AB	0.00	0.00	0.66
SurigaodelSur_Blk66F	0.00	0.00	0.42
SurigaodelSur_Blk66E	0.00	0.00	0.59

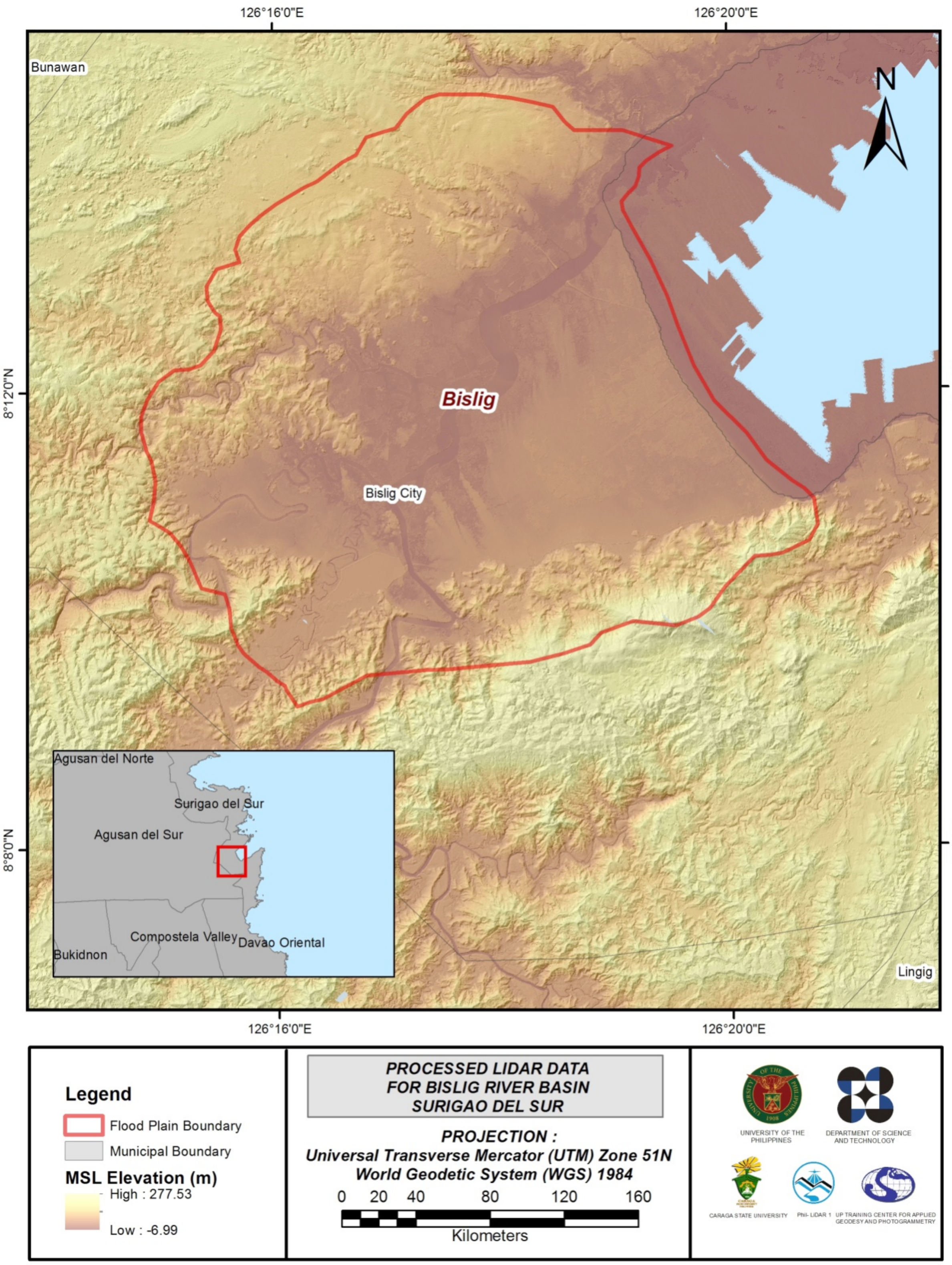


Figure 26. Map of Processed LiDAR Data for Bislig Flood Plain.

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

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Bislig to collect points with which the LiDAR dataset is validated is shown in Figure 26. A total of 3,702 survey points were used for calibration and validation of Bislig LiDAR data. Random selection of 80% of the survey points, resulting to 2,962 points, was used for calibration. A good correlation between the uncalibrated mosaicked LiDAR elevation values and the ground survey elevation values is shown in Figure 27. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration elevation values is 0.35 meters with a standard deviation of 0.16 meters. Calibration of Bislig LiDAR data was done by subtracting the height difference value, 0.35 meters, to Bislig mosaicked LiDAR data. Table 18 shows the statistical values of the compared elevation values between LiDAR data and calibration data.

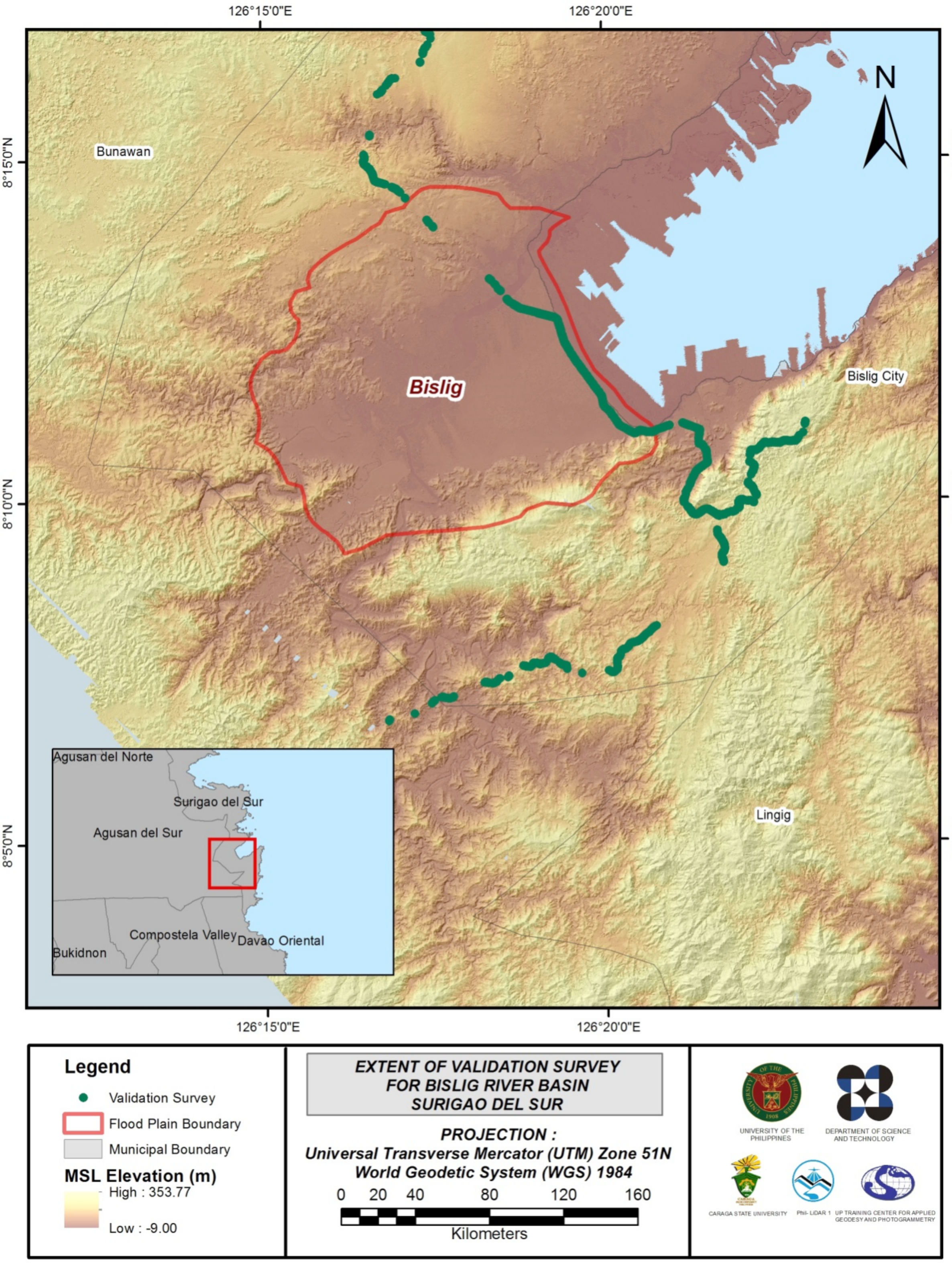


Figure 27. Map of Bislig Flood Plain with validation survey points in green.

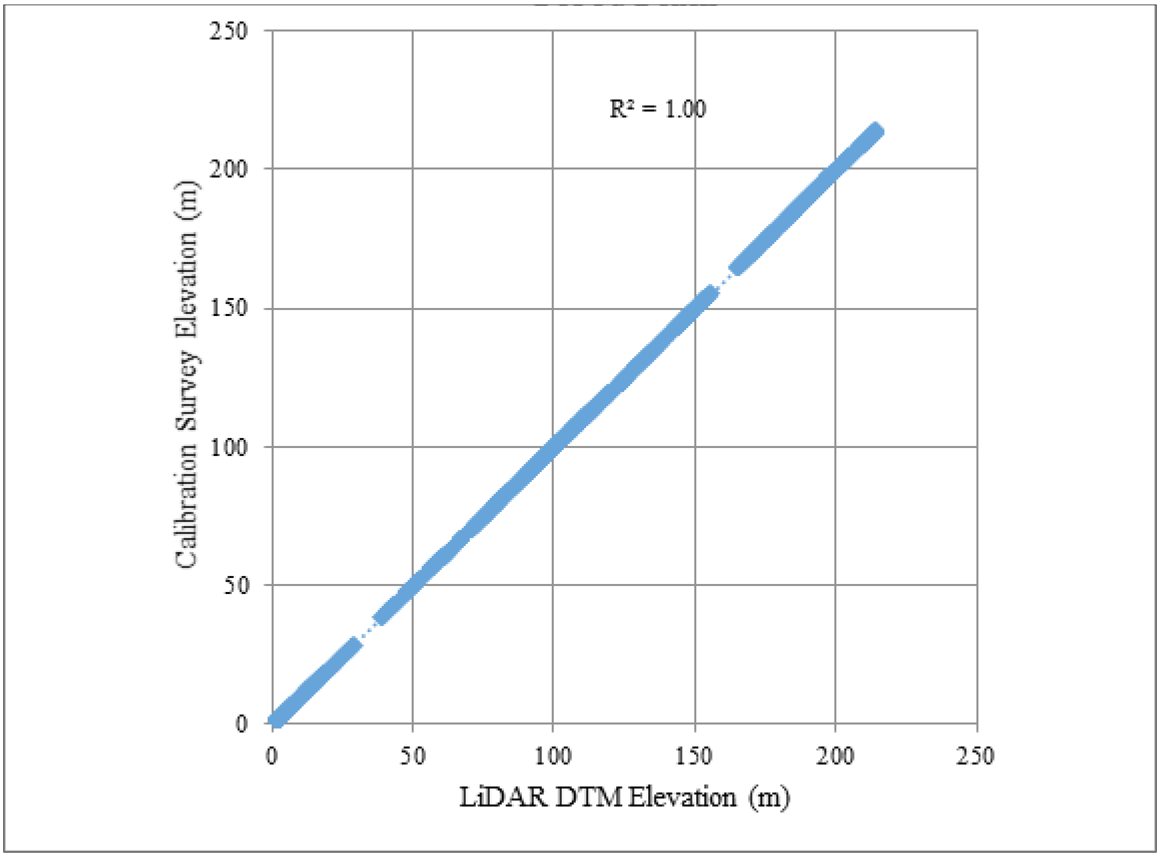


Figure 28. Correlation plot between calibration survey points and LiDAR data

Table 18. Calibration Statistical Measures.

Calibration Statistical Measures	Value (meters)
Height Difference	0.35
Standard Deviation	0.16
Average	-0.32
Minimum	-0.63
Maximum	0.00

The remaining 20% of the total survey points, resulting to 740 points, were used for the validation of calibrated Bislig DTM. A good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM is shown in Figure 28. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.15 meters with a standard deviation of 0.15 meters, as shown in Table 19.

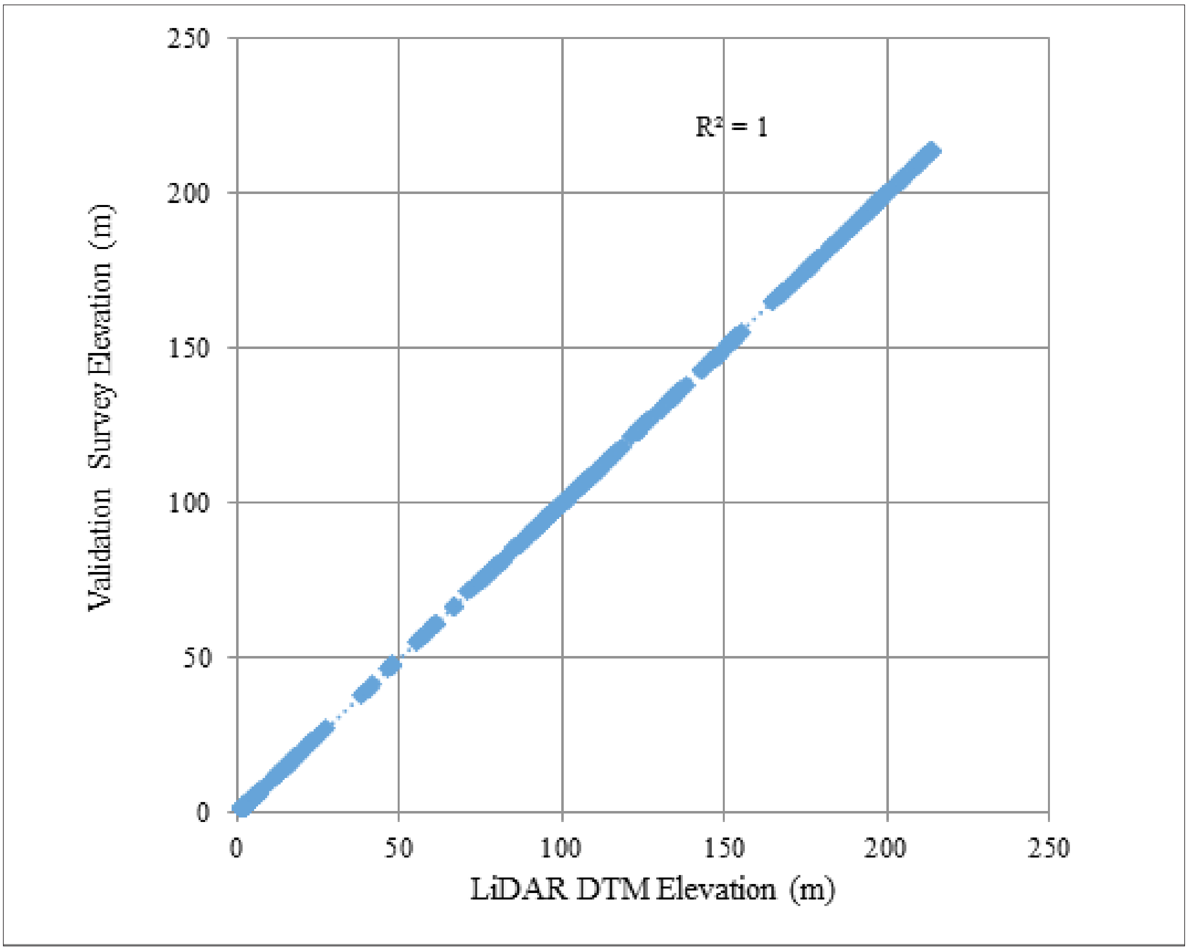


Figure 29. Correlation plot between validation survey points and LiDAR data

Table 19. Validation Statistical Measures.

Validation Statistical Measures	Value (meters)
RMSE	0.15
Standard Deviation	0.15
Average	0.03
Minimum	-0.27
Maximum	0.32

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, centerline and zigzag data were available for Bislig with 17,175 bathymetric survey points. The resulting raster surface produced was done by Kernel Interpolation with Barriers method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.56 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Bislig integrated with the processed LiDAR DEM is shown in Figure 30.

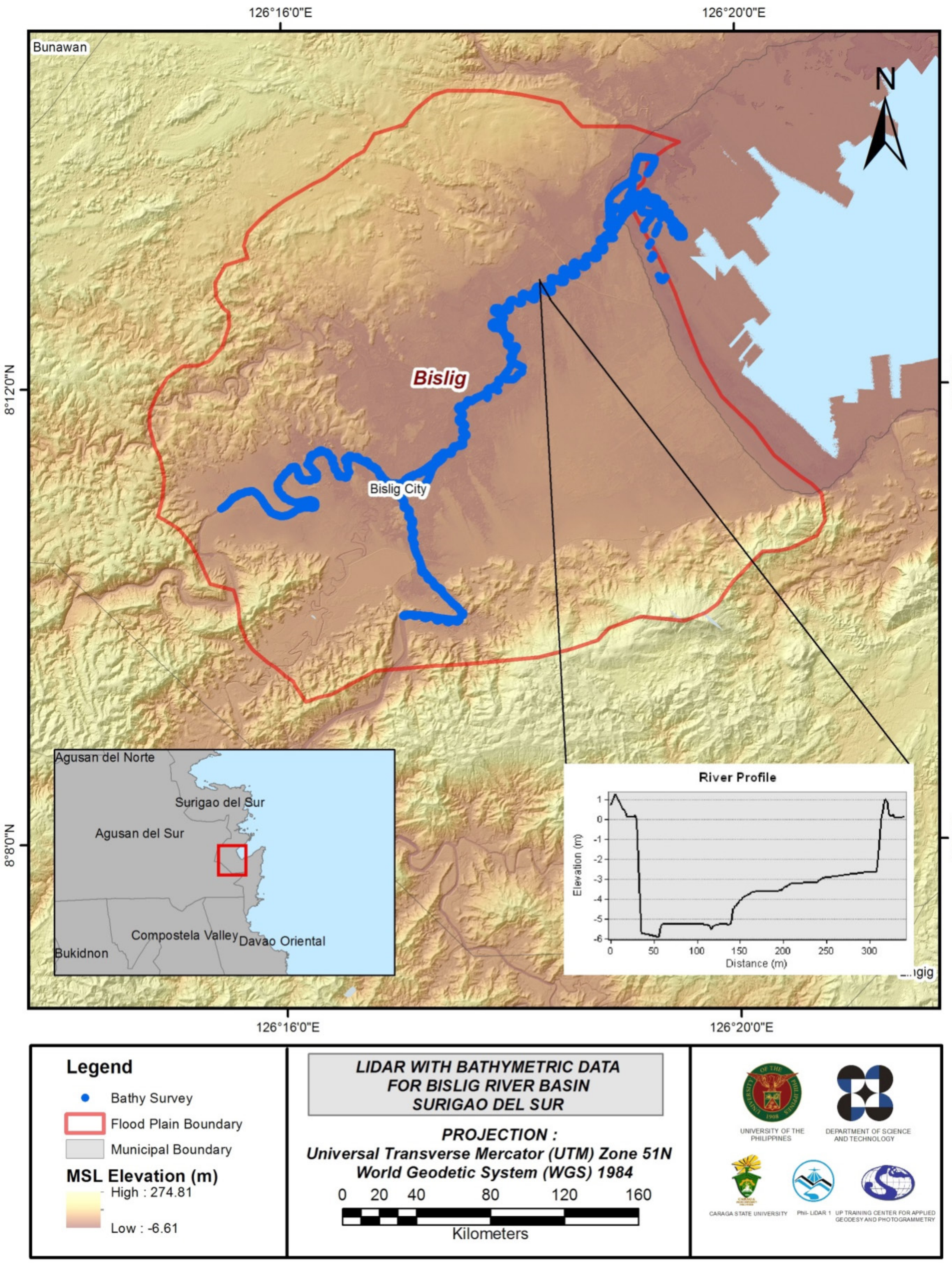


Figure 30. Map of Bislig Flood Plain with bathymetric survey points shown in blue.

3.12 Feature Extraction

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

3.12.1 Quality Checking of Digitized Features' Boundary

Bislig floodplain, including its 200 m buffer, has a total area of 76.88 sq km. For this area, a total of 5.0 sq km, corresponding to a total of 2182 building features, are considered for QC. Figure 30 shows the QC blocks for Bislig floodplain.

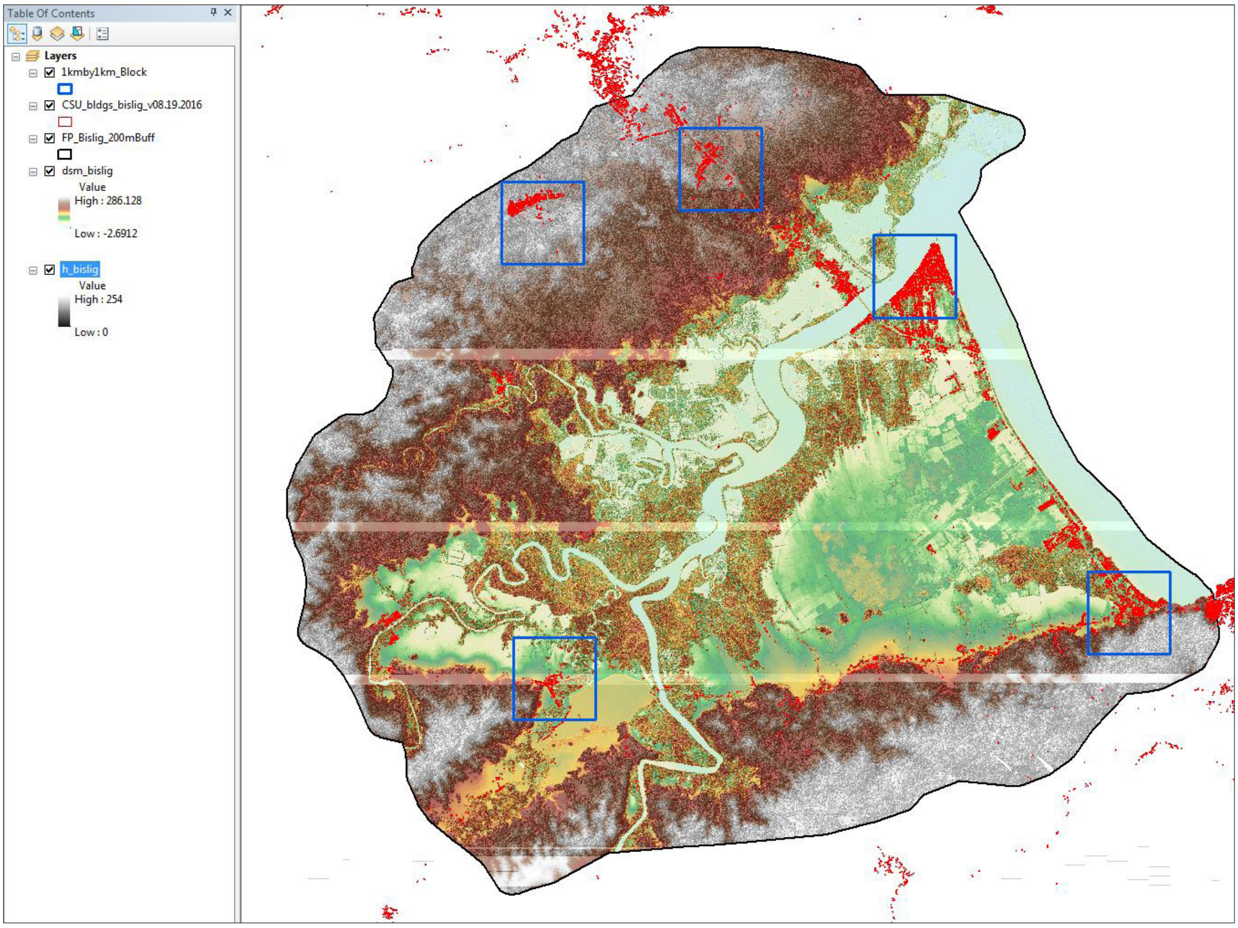


Figure 31. Blocks (in blue) of Bislig building features that were subjected to QC.

Quality checking of Bislig building features resulted in the ratings shown in Table 20.

Table 20. Quality Checking Ratings for Bislig Building Features.

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Bislig	99.68	99.95	90.15	PASSED

3.12.2 Height Extraction

Height extraction was done for 18,202 building features in Bislig floodplain. Of these building features, 751 buildings were filtered out after height extraction, resulting to 17,451 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 21.18m.

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

Table 21. Building Features Extracted for Bislig Floodplain.

Facility Type	No. of Features
Residential	16,878
School	258
Market	5
Agricultural/Agro-Industrial Facilities	4
Medical Institutions	15
Barangay Hall	4
Military Institution	0
Sports Center/Gymnasium/Covered Court	15
Telecommunication Facilities	0
Transport Terminal	6
Warehouse	0
Power Plant/Substation	7
NGO/CSO Offices	0
Police Station	3
Water Supply/Sewerage	0
Religious Institutions	21
Bank	4
Factory	187
Gas Station	5
Fire Station	0
Other Government Offices	21
Other Commercial Establishments	18
Total	**17,451**

Table 22. Total Length of Extracted Roads for Bislig Floodplain.

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Bislig	454.27	8.90	145.39	34.95	1.60	**645.11**

Table 23. Number of Extracted Water Bodies for Bislig Floodplain.

Floodplain	Water Body Type					Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Bislig	18	1	0	0	0	**19**

A total of 35 bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

3.12.4 Final Quality Checking of Extracted Features

All extracted ground features were completely given the required attributes. All these output features comprise the flood hazard exposure database for the floodplain. This completes the feature extraction phase of the project.

Figure 31 shows the Digital Surface Model (DSM) ofBislig floodplain overlaid with its ground features.

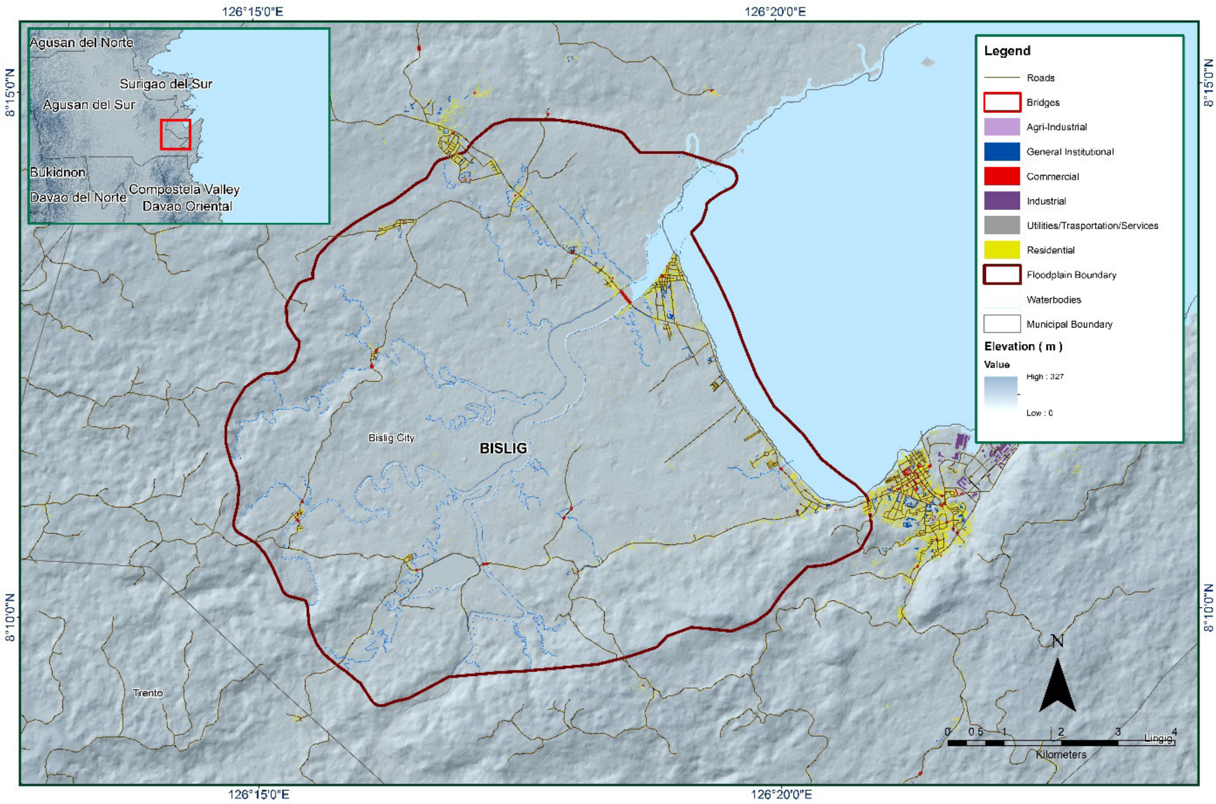


Figure 32. Extracted features for Bislig floodplain.

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

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

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

4.1 Summary of Activities

Bislig River Basin covers portions of the City of Bislig in the province of Surigao del Sur, and the Municipality of Bunawan and Trento in Agusan del Sur. According to DENR – RCBO,itcovers a drainage area of 381 km^2 and has an estimated annual run-off of 762 million cubic meters.

Its main stem, Bislig River, is part of the twelve (12) river systems in the CARAGA region. According to the 2015 national census of NSO, a total of 17,980locals are residing in the immediate vicinity of the river distributed among barangays Burboanan, Kahayag, Mone, Poblacion, San Fernando and San Isidro.The latest flooding event in Bislig River was last January 13, 2014, where hundreds of residents were evacuated due to flooding caused by a low-pressure area (http://interaksyon.com/article/52461/7000-flee-floods-in-caraga-region).

In line with this, the DVBC in partnership with the CSU conducted field survey in Bislig RiveronMay 4-8 and August 24 – September 7, 2015 with the following scope of work: reconnaissance; static survey for the establishment of a control point;cross-section and as-built survey of Burboanan Bridge in Brgy. Burbonan and Bagnan Bridge in Brgy. Mone, Bislig City, Surigao Del Sur; LiDAR Validation of about268 km; and bathymetric survey from Brgy. Mone down to the mouth of the river in Brgy. Poblacion, with an estimated length of 16.60 km using an OHMEX™ Single Beam Echo Sounder and GNSS PPK survey technique.

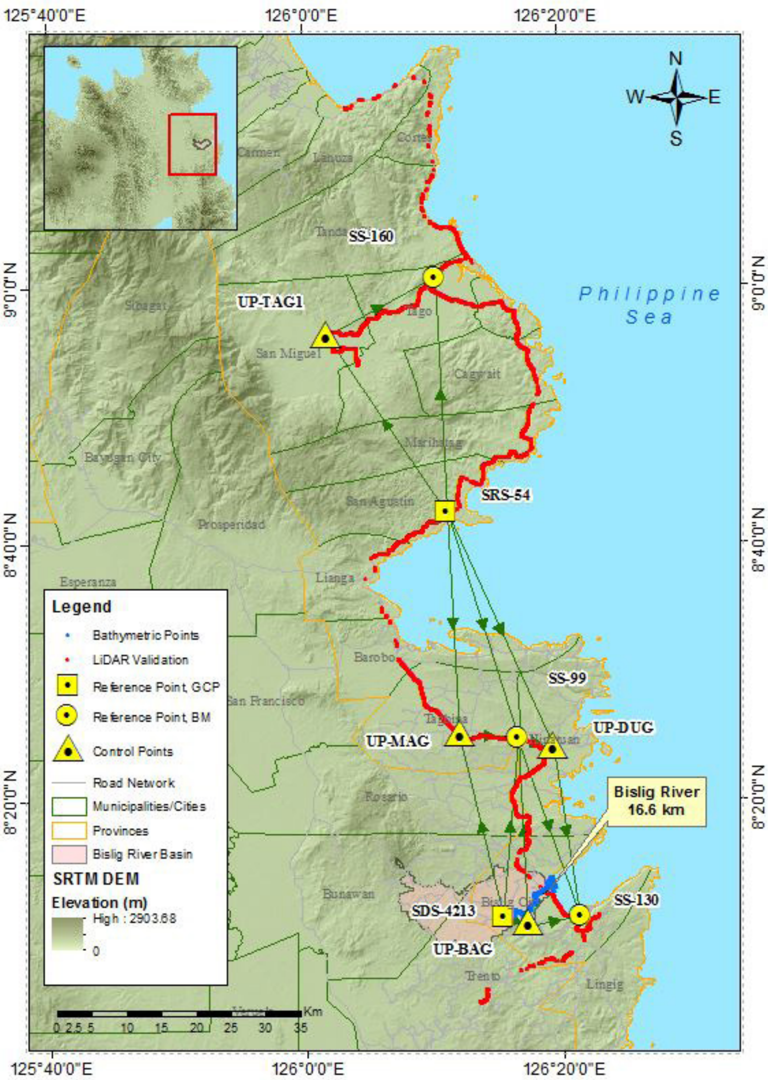


Figure 33. Extent of the bhathymetric survey (in blue line) in Bislig River and the LiDAR data validation survey (red).

4.2 Control Survey

The GNSS network used for Bislig River Basin is composed of seven (7) loops established on August 27, September 5 and 6, 2015 occupying the following reference points: SRS-54, a second order GCPin Brgy. Gata, Municipality of San Agustin; SS-130, a first order BM in Brgy. Mangagoy, Bislig City; and SS-160, a first order BM in Brgy. Gamut, Municipality of Tago, all in Surigao del Sur.

Four control points were established along the approach of bridges namely: UP-BAG, located at the approach of Bagnan Bridge in Brgy. Mone, Bislig City;UP-DUG, at Dugmanon Bridge in Brgy, Dugmanon, Municipality of Hinatuan; UP-MAG at Maglambing Bridge in Brgy. Maglambing,Municipality of Tagbina; and UP-TAG1 located at Tago-San Miguel Bridge, Municipality of San Miguel, all in Surigao del Sur. NAMRIA established control points namely SS-99, in Brgy. Mahayhay, Municipality of Hinatuan; and SS-4213, at Burboanan Bridge in Brgy. Burboanan, Bislig City were also occupied to use as marker during the survey.

The summary of references and control points and its location is summarized in in Table 24 while the GNSS network established is illustrated in Figure 33.

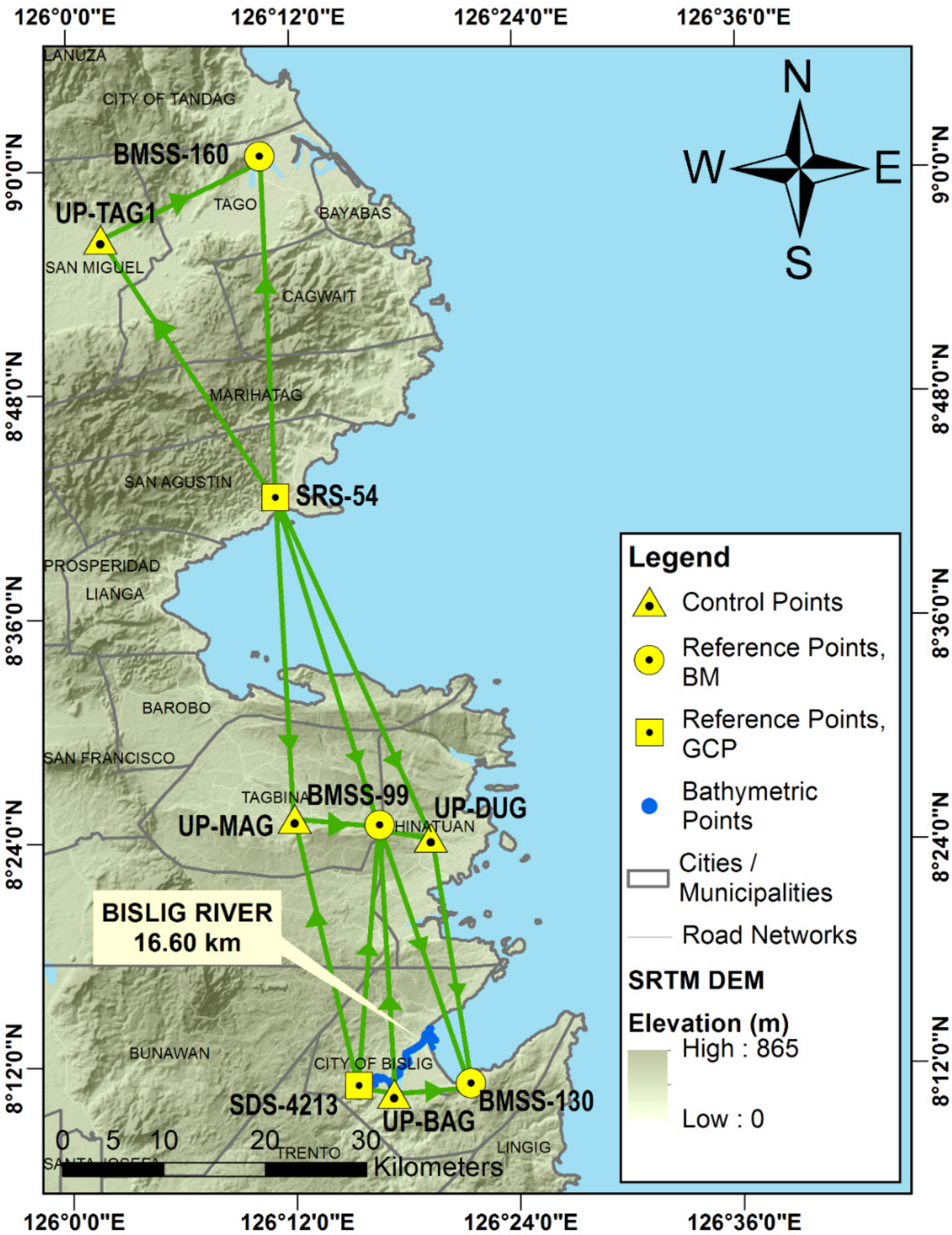


Figure 34. GNSS Network of Bislig River Field Survey

Table 24. List of References and Control Points used in Surigao del Sur survey. (Source: NAMRIA and UP-TCAGP)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoid Height (m)	Elevation in MSL (Meter)	Date Established
SRS-54	2nd order, GCP	8°42'29.12518"	126°11'07.08070"	71.938	3.335	2007
SS-130	1st order, BM	8°11'01.30897"	126°21'23.49960"	73.969	5.237	2008
SS-160	1st order, BM	9°00'44.86640"	126°10'25.53097"	75.213	7.065	2009

SS-99	Used as Marker	8°24’53.51089”	126°16’34.96716”	98.350	29.782	2008
SRS-4213	Used as Marker	8°10’56.27507”	126°15’21.74124”	72.222	2.959	2012
UP-BAG	UP Established	8°10’28.76338”	126°17’14.48487”	71.368	2.211	Sep 5, 2015
UP-DUG	UP Established	8°24’10.91693”	126°19’18.89585”	72.157	4.035	Sep 6, 2015
UP-MAG	UP Established	8°25’15.48835”	126°12’01.07825”	82.586	13.509	Sep 6, 2015
UP-TAG1	UP Established	8°56’22.49905”	126°01’48.98421”	85.888	16.502	Aug 27, 2015

The GNSS set ups made in the location of the reference and control points are exhibited in Figure 34-Figure 42:

Figure 35. Trimble® SPS 852 setup at SRS-54 near the flag pole of Gata Integrated School in San Agustin, Surigao del Sur

Figure 36. GNSS base set up, Trimble® SPS 852at BMSS-130 located on one end of a concrete barrier along Surigao-Davao Coastal Road in Brgy. Mangagoy, Bislig City, Surigao del Sur

Figure 37. GNSS base set up, Trimble® SPS 852 at BMSS-160, located at Pamuksukan Bridge in Brgy. Gamut, Tago, Surigao del Sur

Figure 38. GNSS receiver set up, Trimble® SPS 882at BMSS-99 located inside Mahayhay Primary School in the Municipality of Hinatuan, Surigao del Sur

Figure 39. GNSS receiver set up, Trimble® SPS 882 at BMSS-4213 located near Burboanan Bridge in Brgy. Burboanan, Bislig City, Surigao del Sur

Figure 40. GNSS base set up, Trimble® SPS 852 at UP-BAG , located near Bagnan Bridge in Brgy. Mone, Bislig City, Surigao del Sur

Figure 41. Trimble® SPS 882 setup at UP-DUG, located near Dugmanon Bridge in the Municipality of Hinatuan, Surigao del Sur

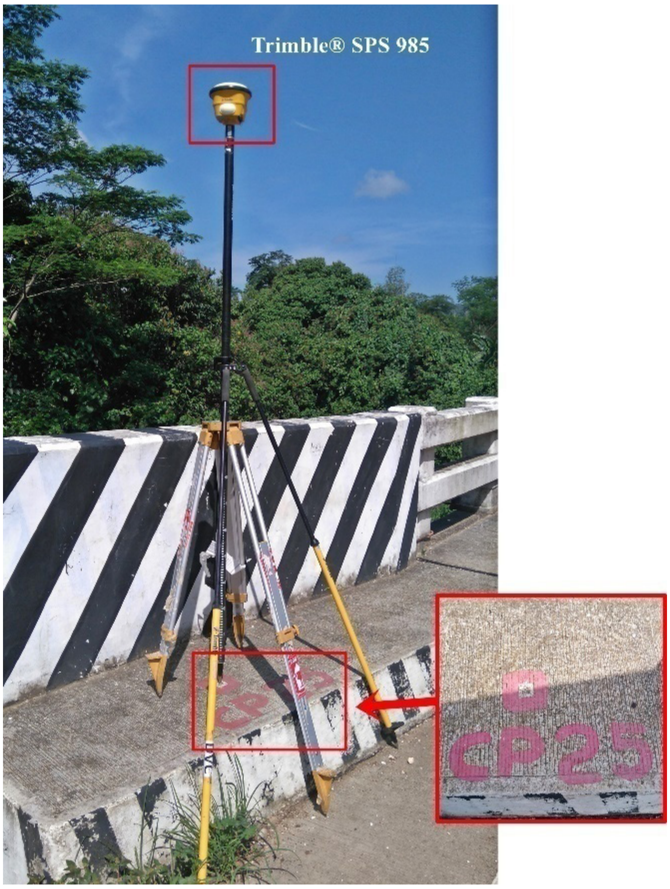


Figure 42. GNSS base set up, Trimble® SPS 985 at UP-MAG, located at Maglambing Bridge along Surigao-Davao Coastal Road in Brgy. Maglambing in the Municipality of Tagbina, Surigao del Sur

Figure 43. GNSS base set up, Trimble® SPS 882 at UP-TAG1, located at Tago-San Miguel Bridge, Municipality of San Miguel, Surigao del Sur

4.3 Baseline Processing

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

Table 25. Baseline Processing Report for Bislig river survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SRS-4213 --- UP-MAG	09-06-2015	Fixed	0.006	0.028	346°54’31”	27101.111	10.348
UP-BAG --- SRS-4213	09-05-2015	Fixed	0.003	0.016	283°45’49”	3553.032	0.870
SS-99 --- SS-130	09-06-2015	Fixed	0.004	0.025	160°56’32”	27048.109	-24.369
UP-BAG --- SS-130	09-05-2015	Fixed	0.007	0.030	82°31’19”	7687.540	2.595
SS-99 --- UP-BAG	09-06-2015	Fixed	0.005	0.028	177°23’35”	26593.869	-26.916
SS-99 --- SRS-4213	09-06-2015	Fixed	0.008	0.030	184°58’49”	25818.568	-26.099
SS-130 --- UP-DUG	09-06-2015	Fixed	0.004	0.026	351°04’11”	24555.772	-1.865
SS-99 --- UP-DUG	09-06-2015	Fixed	0.005	0.017	104°37’16”	5182.796	-26.175
SS-160 --- SRS-54	08-27-2015	Fixed	0.009	0.042	357°50’28”	33687.727	3.259

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
SS-99 --- UP-MAG	09-06-2015	Fixed	0.006	0.020	274°36'46"	8405.733	-15.761
UP-TAG1 --- SRS-54	08-27-2015	Fixed	0.005	0.037	326°20'38"	30763.333	13.888
UP-DUG --- BMSS-99	09-06-2015	Fixed	0.003	0.019	284°37'40"	5182.793	26.194
SS-99 --- UP-MAG	09-06-2015	Fixed	0.005	0.023	274°36'46"	8405.736	-15.773
SS-99 --- SRS-54	09-06-2015	Fixed	0.011	0.031	162°48'46"	33945.127	26.544
SRS-54 --- UP-MAG	09-06-2015	Fixed	0.014	0.058	177°01'20"	31798.307	10.764
UP-DUG --- SRS-54	09-06-2015	Fixed	0.005	0.025	155°57'50"	36939.414	0.268
SS-160 --- UP-TAG1	08-27-2015	Fixed	0.008	0.017	242°57'01"	17718.093	10.680

As shown in Table 25, a total of 17 baselines were processed and all of them passed the required accuracy set by the project.

4.4 Network Adjustment

After the baseline processing procedure, network adjustment is performed using TBC. Looking at the Adjusted Grid Coordinates Table C-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 20cm and z less than 10cm in equation from:

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

Where:

Xe is the Easting error,

Ye is the Northing error, and

Ze is the Elevation error

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

Table 26. Through these reference points, the corrdinates and elevation of the unknown control points were computed.

Table 26. Control Point Constraints

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

The list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 27. All fixed control points have no values for grid and elevation errors.

Table 27. Adjusted Grid Coordinates

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

With the mentioned equation, for horizontal and for the vertical; the computation for the accuracy are as follows:

SRS-54
horizontal accuracy = Fixed
Vertical accuracy = 7.2 cm < 10 cm

SS-130

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

SS-160

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

SS-99

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

SRS-4213

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

UP-BAG

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

UP-DUG

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

UP-MAG

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

UP-TAG1

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

Following the given formula and based on the results of the computations, the horizontal and vertical accuracy conditions of the project are satisfied.

Table 28.Adjusted Geodetic Coordinates

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

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 28. Based on the result of the computation, the equation is satisfied; hence, the required accuracy for the program was met.

The summary of reference and control points used is indicated in Table 29.

Table 29. Reference and control points used and its location (Source: NAMRIA, UP-TCAGP)

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

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

Cross-section and As-built survey was conducted on May 4 to 8 and September 6, 2015 at the downstream side of Bagnan Bridge in Brgy. Mone and Burboanan Bridges in Brgy. Burboanan, City of Bislig, Surigao del Sur using PPK technique using Trimble® SPS 882 GNSS PPK survey technique as shown in Figure 43.

Figure 44. As-built at (a) Bagnan Bridge (b) and Burboanan Bridge in Bislig City, Surigao del Sur

The cross-sectional line of Bagnan Bridge is about 258.30 m with eighty (80) cross-sectional points; and Burboanan Bridge is about147.39 m with sixty-two (62) cross-sectional points; using the control point SMR-3322 as the GNSS base station. The cross-section diagrams, planimetric maps, and the bridge data forms are shown in Figure 44 to Figure 49, respectively.

The water surface elevation of Bislig River was determined using a survey grade GNSS receiver Trimble® SPS 882 in PPK survey technique on September 2, 2015 at 1:07 PM with a value of 0.216 m (MSL) for Bagnan Bridge as shown in Figure 46; and on the same day at 11:50 AM with a value of 1.13 m (MSL) for Burboanan Bridge as shown in Figure 47.

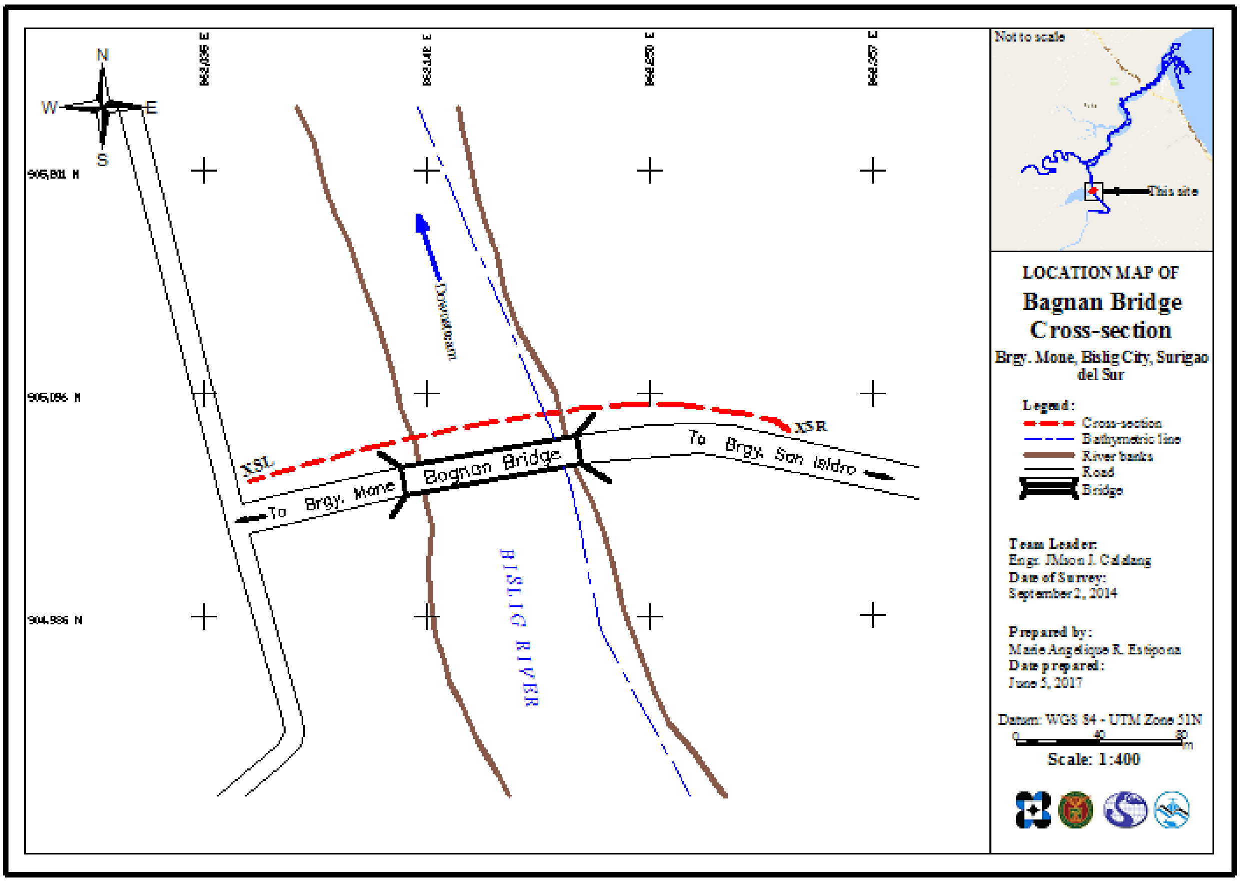


Figure 45. Location map of Bagnan bridge cross-section

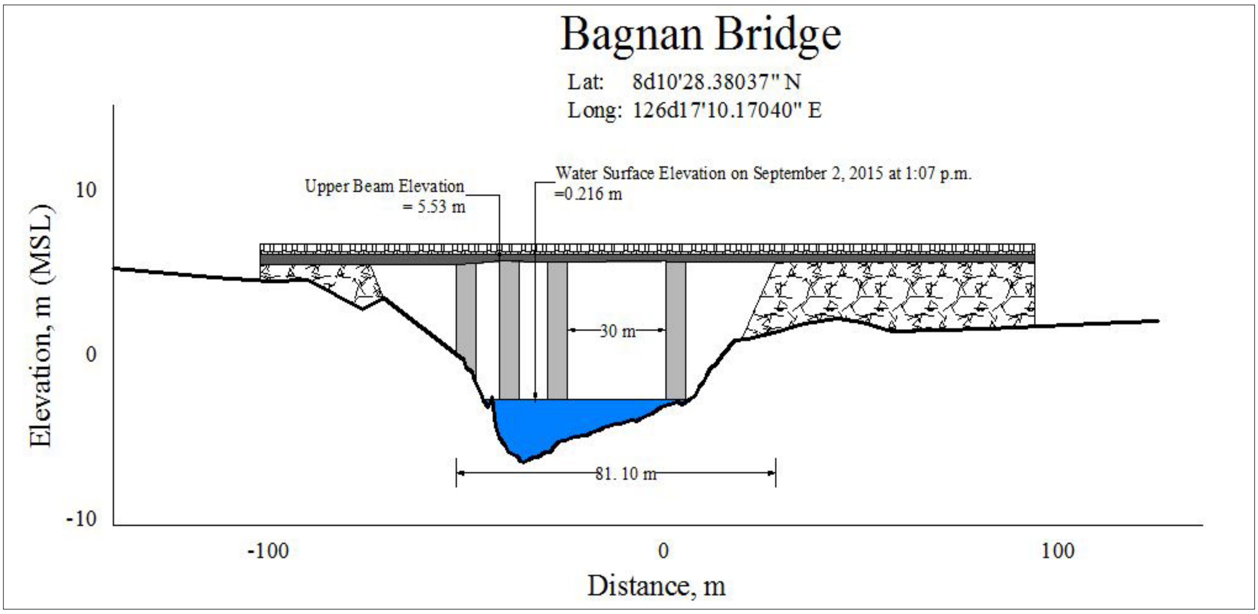


Figure 46. Bagnan bridge cross-section diagram

Bridge Data Form

Bridge Name: BAGNAN BRIDGE **Date:** September 2, 2015

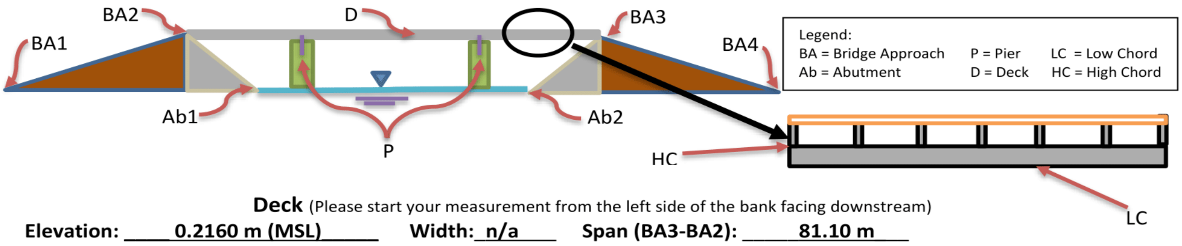
River Name: BISLIG RIVER **Time:** 1:07 pm

Location (Brgy, City, Region): Brgy. Mone, Bislig City, Surigao del Sur

Survey Team: DVBC/DVC Surigao del Sur Team Survey – Team JM

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

Latitude: 8°10'28.38037" N **Longitude:** 126°17'10.17040" E



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

Elevation: **0.2160 m (MSL)** **Width:** **n/a** **Span (BA3-BA2):** **81.10 m**

	Station	High Chord Elevation	Low Chord Elevation
1	**Pier 1**	5.528 m	
2	**Pier 2**	5.501 m	
3	**Pier 3**	5.535 m	
4	**Pier 4**	5.428 m	

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	4.759 m	**BA3**	121.874 m	5.369 m
BA2	40.793 m	5.521 m	**BA4**	168.275 m	3.359 m

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

	Station (Distance from BA1)	Elevation
Ab1	n/a	n/a
Ab2	n/a	n/a

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

Shape: ___ __ **Number of Piers:** 4 **Height of column footing:** _______________

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	54.299 m	5.528 m	
Pier 2	69.698 m	5.501 m	
Pier 3	84.841 m	5.535 m	
Pier 4	115.101 m	5.428 m	

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

Figure 47. Bagnan bridge data form

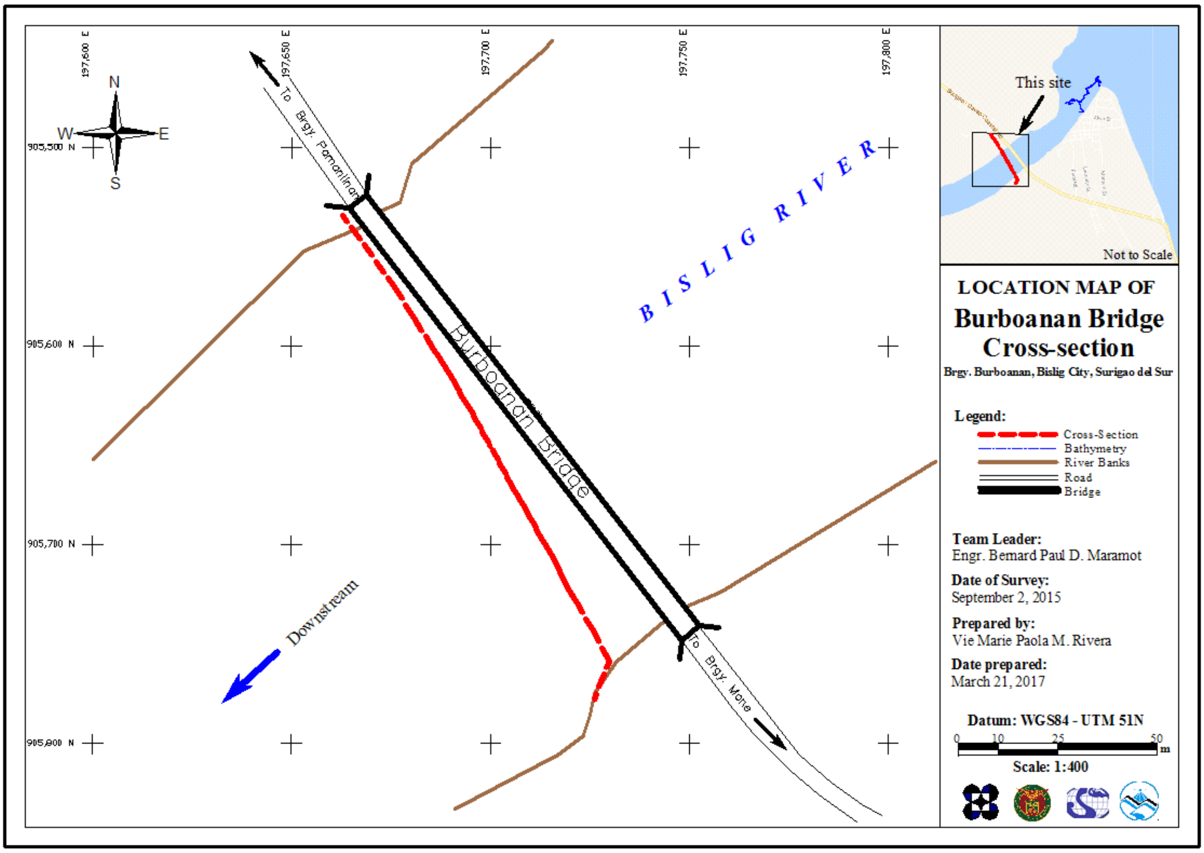


Figure 48. Location Map of Burboanan bridge cross-section

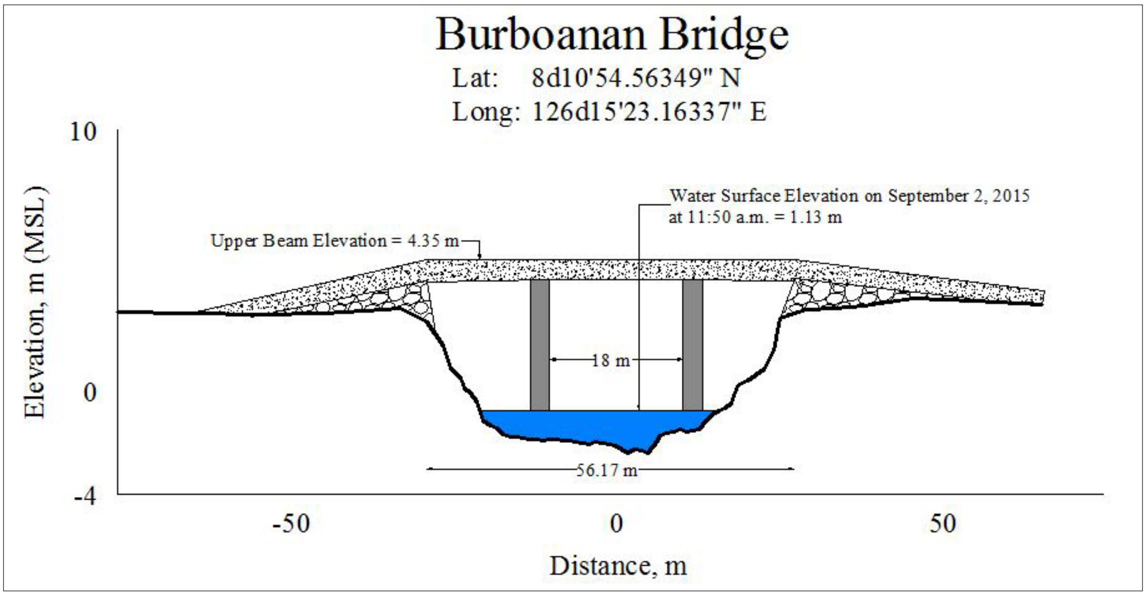


Figure 49. Burboanan bridge cross-section diagram

Bridge Data Form

Bridge Name: BURBOANAN BRIDGE **Date:** September 2, 2015

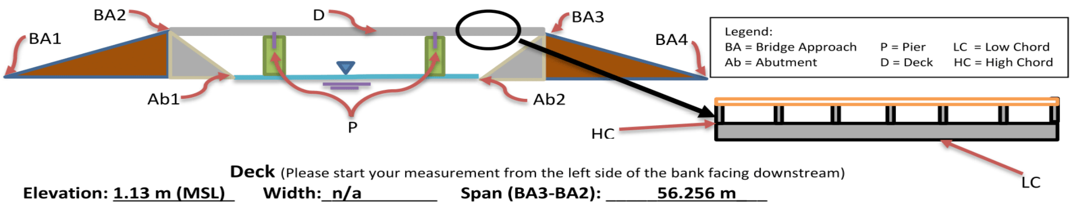
River Name: BISLIG RIVER **Time:** 11:50 am

Location (Brgy, City, Region): Brgy. Burboanan, Bislig City, Surigao del Sur

Survey Team: DVBC/DVC Surigao del Sur Team Survey – Team JM

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

Latitude: 8°10'54.56349" N **Longitude:** 126°15'23.16337" E



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

Elevation: 1.13 m (MSL) **Width:** n/a **Span (BA3-BA2):** 56.256 m

	Station	High Chord Elevation	Low Chord Elevation
1	Pier 1	4.347 m	
2	Pier 2	4.345 m	

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

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	0	2.929 m	BA3	83.325 m	4.26 m
BA2	27.109 m	4.267 m	BA4	110.418 m	3.615 m

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

	Station (Distance from BA1)	Elevation
Ab1	n/a	n/a
Ab2	n/a	n/a

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

Shape: ___ __ **Number of Piers:** 4 **Height of column footing:** _______________

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	46.464 m	4.347 m	
Pier 2	64.788 m	4.345 m	

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

Figure 50. Burboanan bridge data form

4.6 Validation Points Acquisition Survey

Validation points acquisition survey was conducted on August 25, 26, 31, September 1 & 3, 2015 using a survey grade GNSS rover receiverTrimble® SPS 882 mounted on a pole which was attached in front of a vehicle, as shown inFigure 50. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The height of instrument was measured and noted a 2.404-meter distance from the ground up to the bottom of notch. Points were gathered along major concrete roads with the aid of a vehicle which moved at a speed of 20-40 kph, cutting across the flight strips of the DAC with the aid of available topographic maps and Google Earth™ images.

Figure 51. Ground Validation setup: A Trimble® SPS 882, mounted in a 2-meter pole and attached in front of the vehicle

The survey covered Municipalities of Rosario and Trento in Agusan Del Sur andtwelve (12) municipalities in Surigao Del Sur namely: Barobo, Bayabas, Cagwait, Cortes, Hinatuan, Lanuza, Lianga, Marihatag, San Agustin, San Miguel, Tagbina and Tago including Bislig and Tandag City of Surigao Del Sur. The routestarted in Brgy. Zone 14, Municipality of Lanuza, Surigao Del Sur, going down through the National High Way and ended in Brgy. Santa Maria, Municipality of Trento, Agusan Del Sur, A total of 27,314 points were gathered with approximate length of 268 km using SS-130, SS-99, SS-160, SRS-54, and UP-TAG1 as GNSS base stations for the entire extent validation points acquisition survey as illustrated in the map in Figure 51.

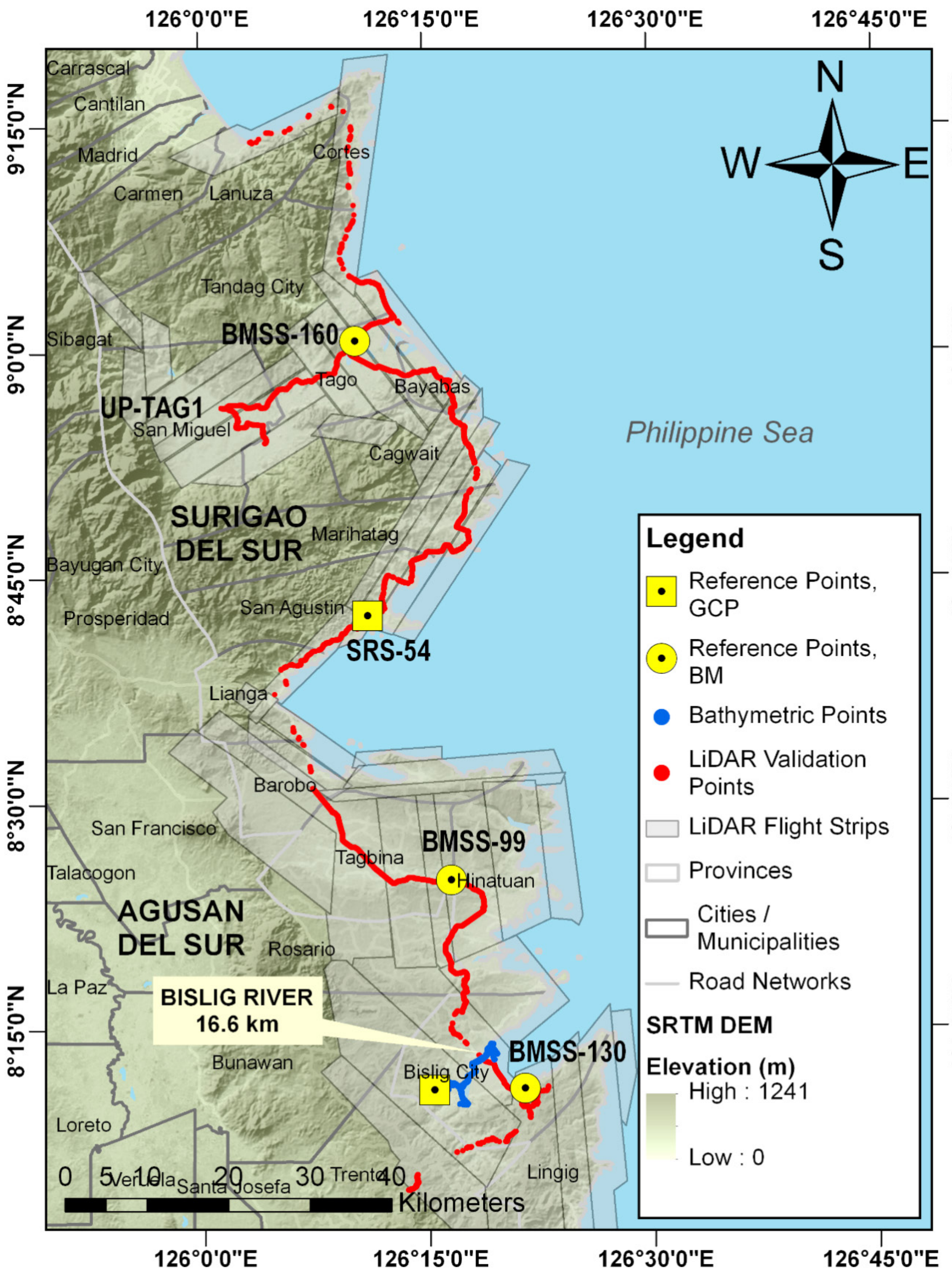


Figure 52. LiDAR Ground validation points acquisition survey extent in Bislig River Basin

4.7 River Bathymetric Survey

Bathymetric survey was executedon September 1-2, 2015 using Trimble® SPS 882 in GNSS PPK survey technique and an installed Ohmex™ Single Beam echo sounder mounted at the side of a boat as shown inFigure 52.

Figure 53. Bathymetry Set-up using OHMEX™ single beam echo sounder with a Trimble® SPS 882

The survey started at two different location in Brgy. Mone, Bislig City with coordinates 8°10'56.82616"N, 126°15'26.93720"Eand 8°09'59.70792"N, 126°17'02.60332"E, down to the mouth of the river in Brgy. Kahayag, also in Bislig City with coordinates 8°13'39.245212"N, 126°19'06.68723"E.The NAMRIA established control point SS-130 was used as base station all throughout the bathymetric survey.

There is a total of 17,194 points covering 16.6 km of the river were gathered during the survey traversing five (5) barangays namely: Burboanan, Kahayag, Mone, Poblacion and San Fernando. A CAD drawing was also produced to illustrate the Bislig riverbed profile. As shown in Figure C-23 and Figure C-24, the highest and lowest elevation garnered 11-meter difference. The highest elevation observed was -0.164meter below mean sea level located in Brgy. Kahayagwhile the lowest was -11.532 meter below mean sea level locate in Brgy. San Fernando, both in Bislig City.

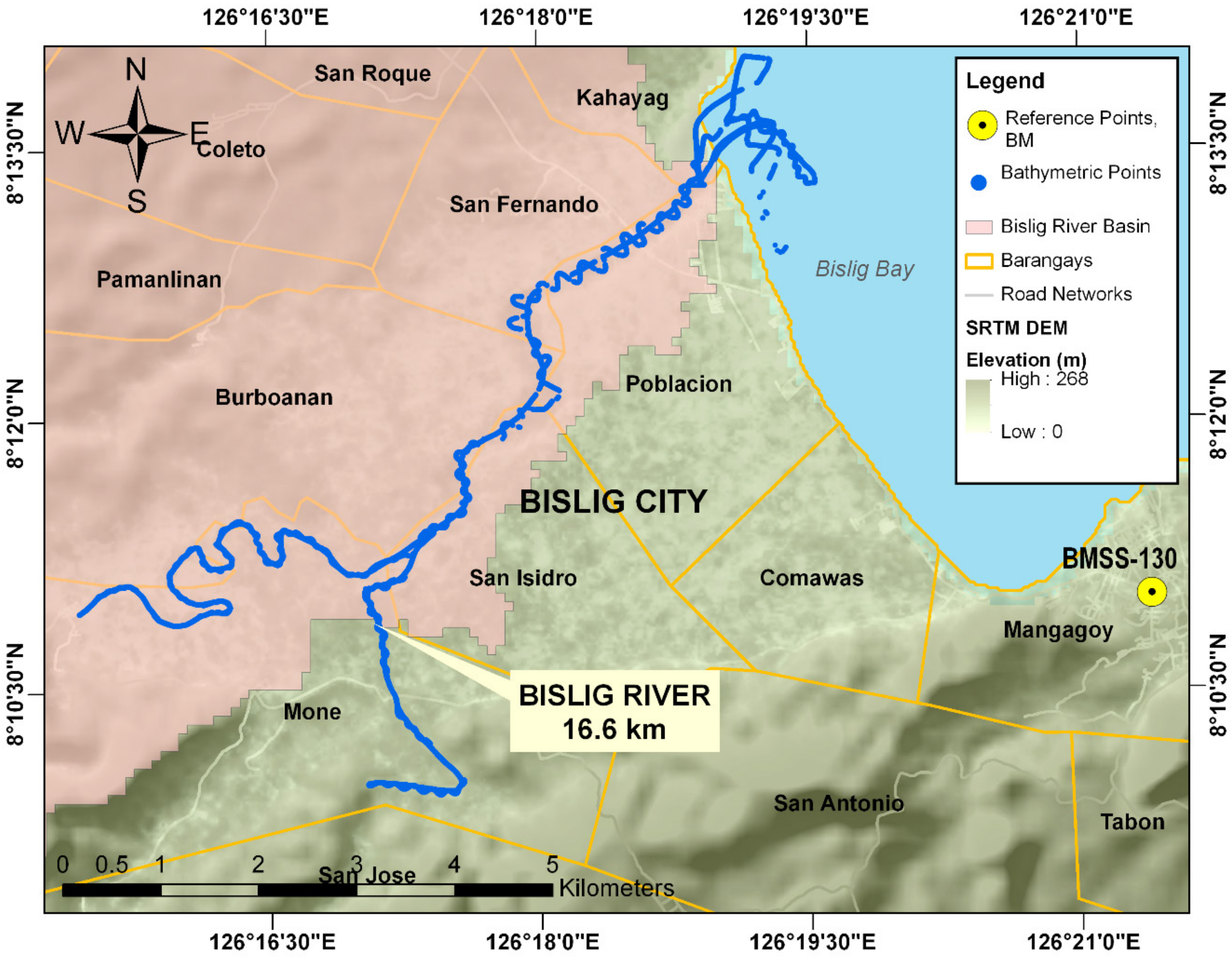


Figure 54. Bathymetric survey of Bislig River

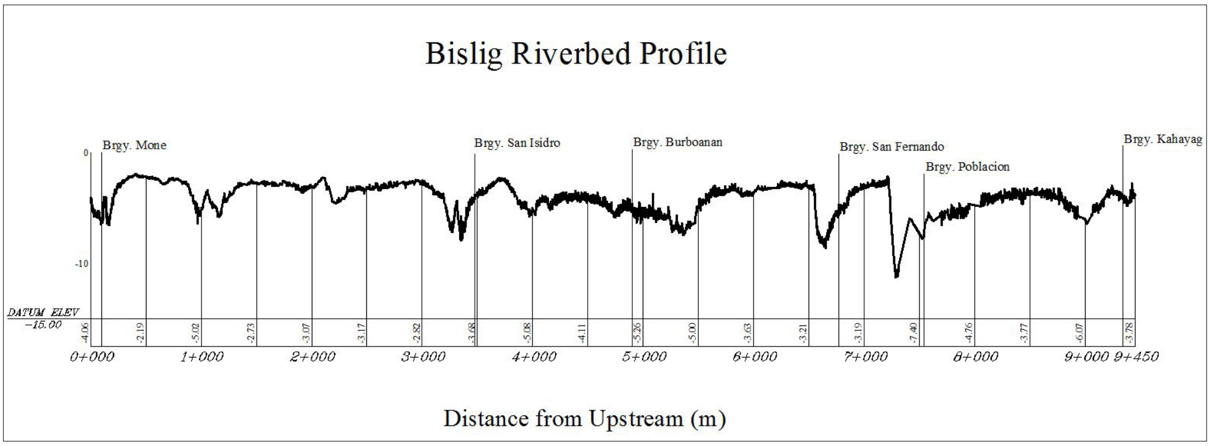


Figure 55. Riverbed profile of from left upstream tributary down to the mouth of Bislig River

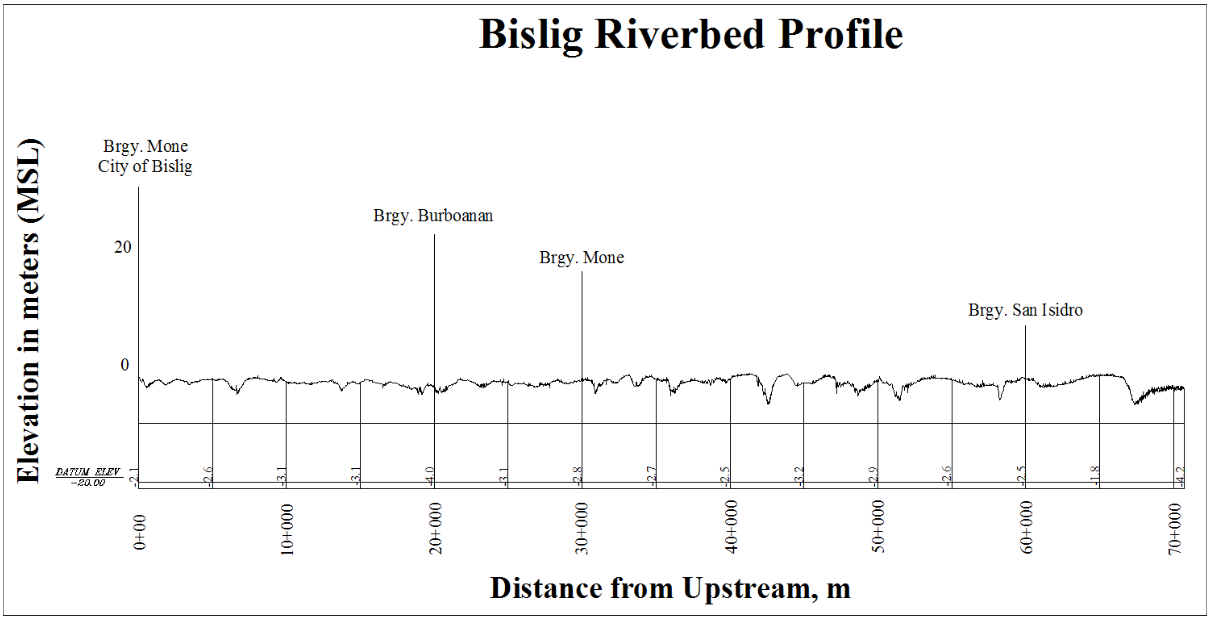


Figure 56. Riverbed profile of from right upstream tributary until the intersection of tributaries

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 (Lagmay, et al., 2014) and further enhanced and updated in Paringit, et al. (2017).

5.1 Data Used for Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

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

5.1.2 Precipitation

Precipitation data was taken from two automatic rain gauges (ARG) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). This is Manat Elementary School ARG and Bislig National High School ARG. (Figure 56).

The total precipitation for this event in Manat rain gauge from 20 November 2015 11:00 to 25 November 2015 00:15 is 73.4 mm. It has a peak rainfall of 79.8 mm on 21 November 2015 12:30. The lag time between the peak rainfall and its corresponding peak discharge at Burboanan Bridge is 3 hours and 45 minutes.

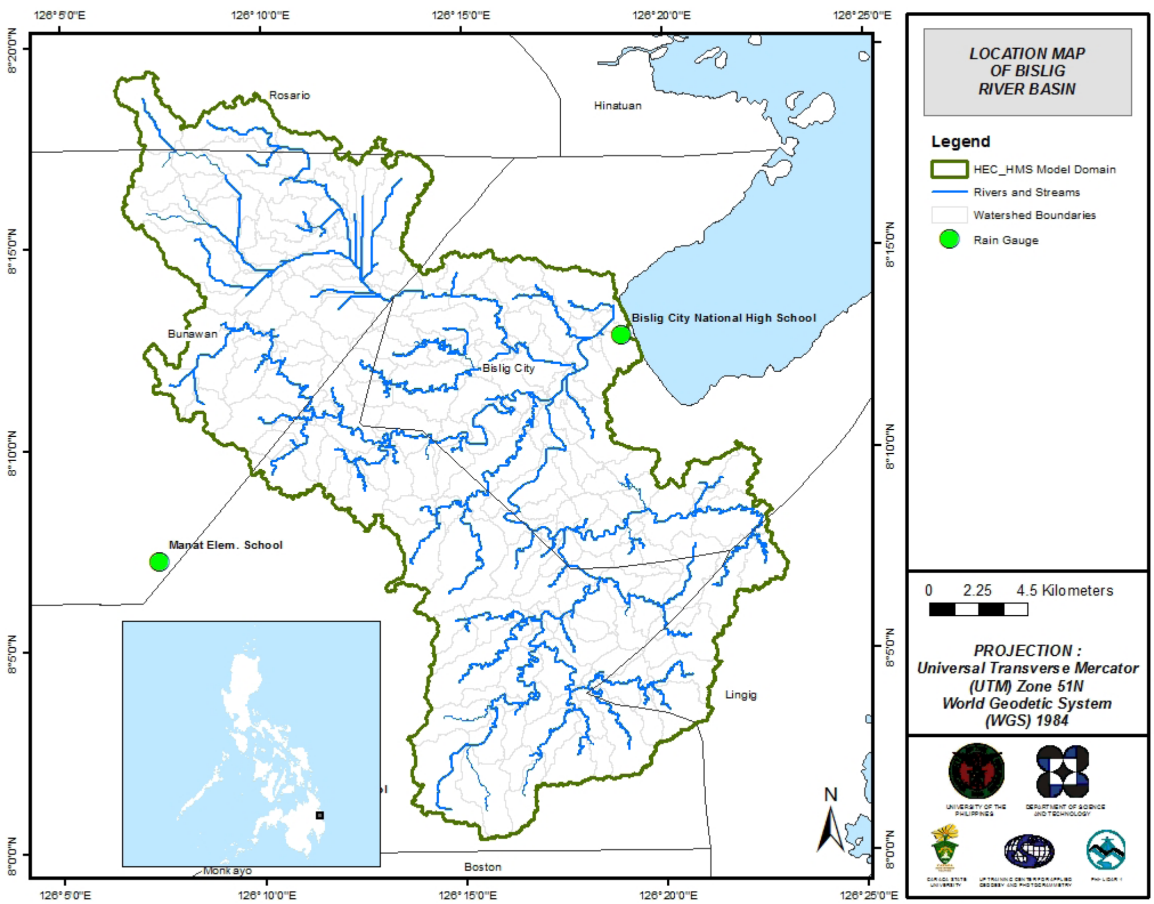


Figure 57. Location map of Bislig HEC-HMS model used for calibration

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Burboanan Bridge, Bislig City, Surigao del Sur (8°10'54.46"N, 126°15'23.23"E). It gives the relationship between the observed water levels from Burboanan Bridge and outflow of the watershed at this location.

For Burboanan Bridge, the rating curve is expressed as $Q = 48.992H^2 + 15.978H + 6.9255$ as shown in Figure 58.

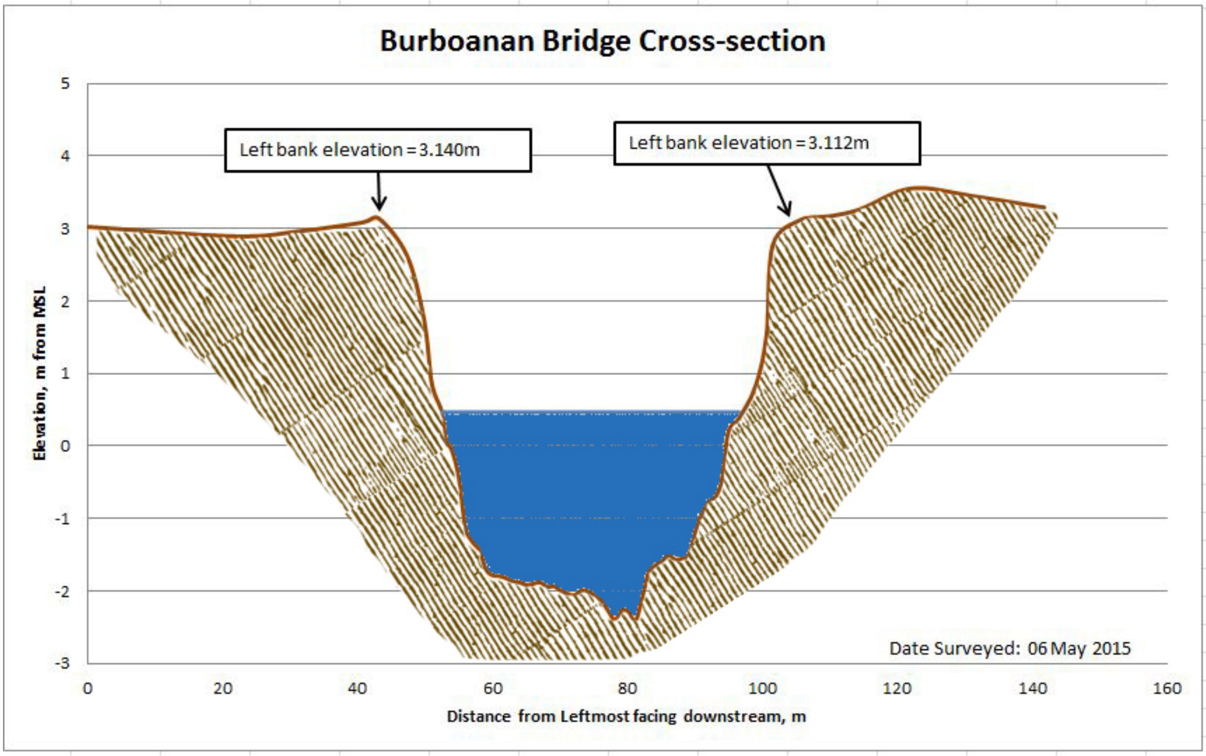


Figure 58. Cross-Section Plot of Burboanan Bridge

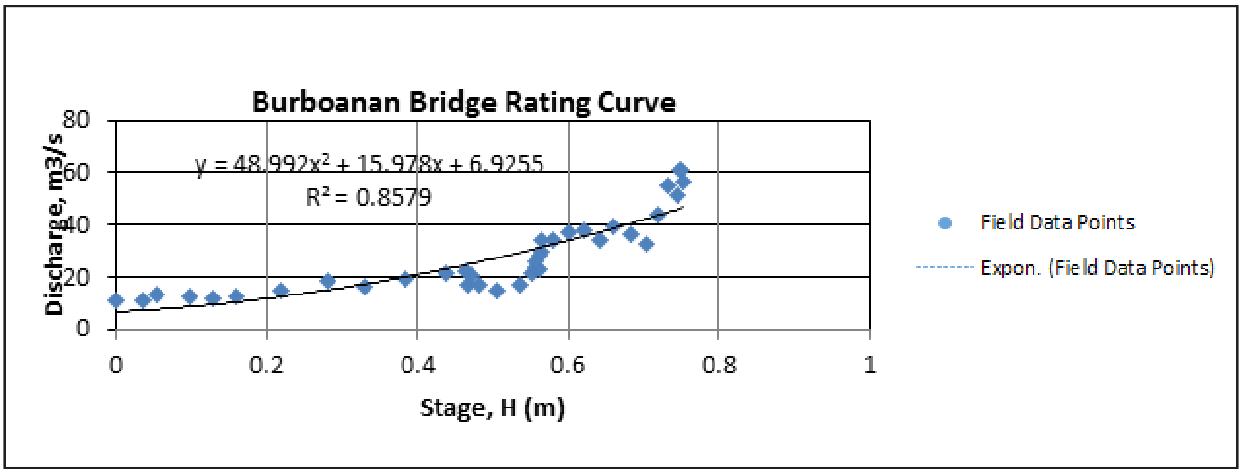


Figure 59. Rating Curve at Burboanan Bridge, Bislig City, Surigao del Sur

This rating curve equation was used to compute the river outflow at Burboanan Bridge (Figure 58) and was utilized for the calibration of the HEC-HMS model. Peak discharge is 77.76 cubic meter per second (cms) at 06:30 AM, November 19, 2015.

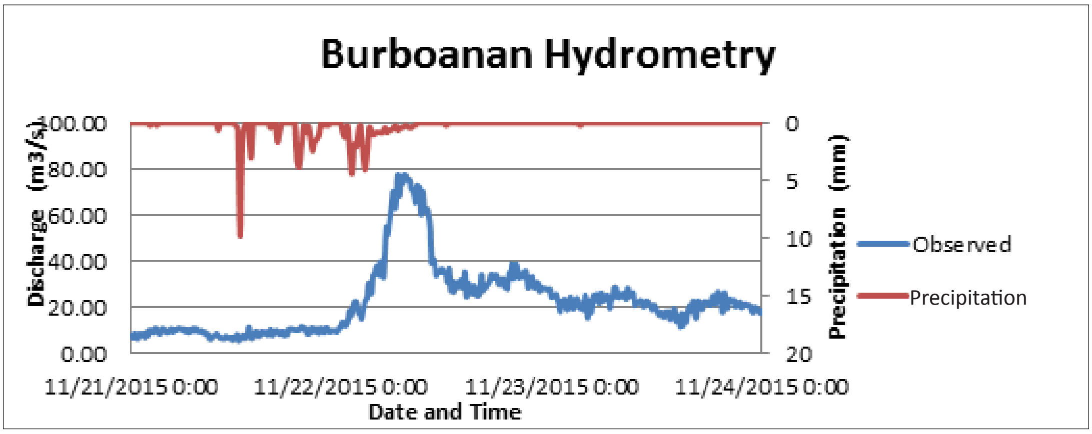


Figure 60. Rainfall at Manat ARG and outflow data at Burboanan Bridge used for modeling

5.2 RIDF Station

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed for Rainfall Intensity Duration Frequency (RIDF) values for the Hinatuan Rain Gauge. The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and re-arranging the values in such a way a certain peak value will be attained at a certain time. This station is chosen based on its proximity to the Bislig watershed. The extreme values for this watershed were computed based on a 42-year record.

Table 30. RIDF values for Hinatuan Rain Gauge computed by PAGASA

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION											
T (yrs)	5 min	10 min	15 min	20 min	30 min	1 hr	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
2	12.1	24.2	27.2	36.2	45.4	61.8	85.8	103.8	132.7	164.3	201
5	15.9	31.9	35.9	47.8	60.4	82.8	116.9	141.9	190.6	230.6	276.5
10	18.5	41.8	41.7	55.5	70.2	96.6	137.5	167.2	228.9	274.4	326.5
25	21.7	43.3	49	65.3	82.7	114.2	163.5	199.1	277.3	329.8	389.7
50	24.1	48.1	54.4	72.5	92	127.2	182.8	222.8	313.2	370.9	436.6
100	26.4	52.8	59.8	79.7	101.2	140.1	202	246.3	348.8	411.7	483.1

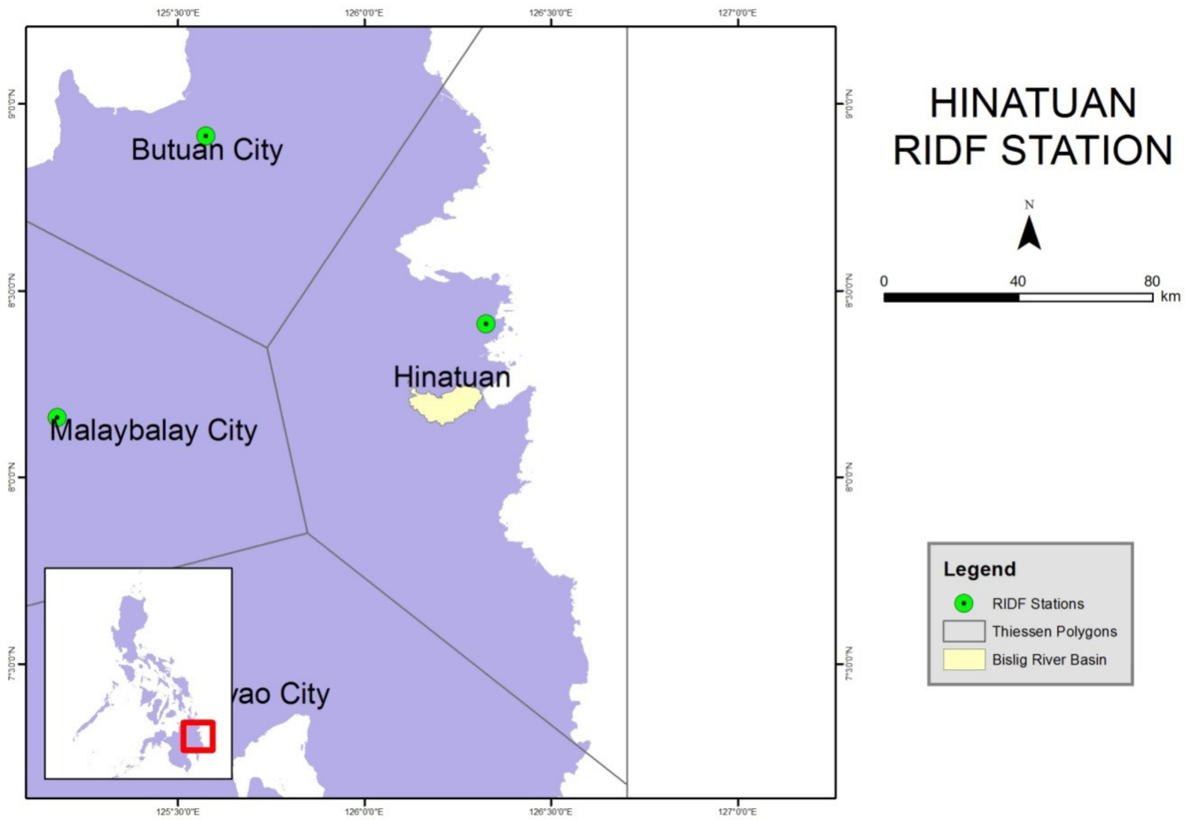


Figure 61. Location of Hinatuan RIDF Station relative to Bislig River Basin

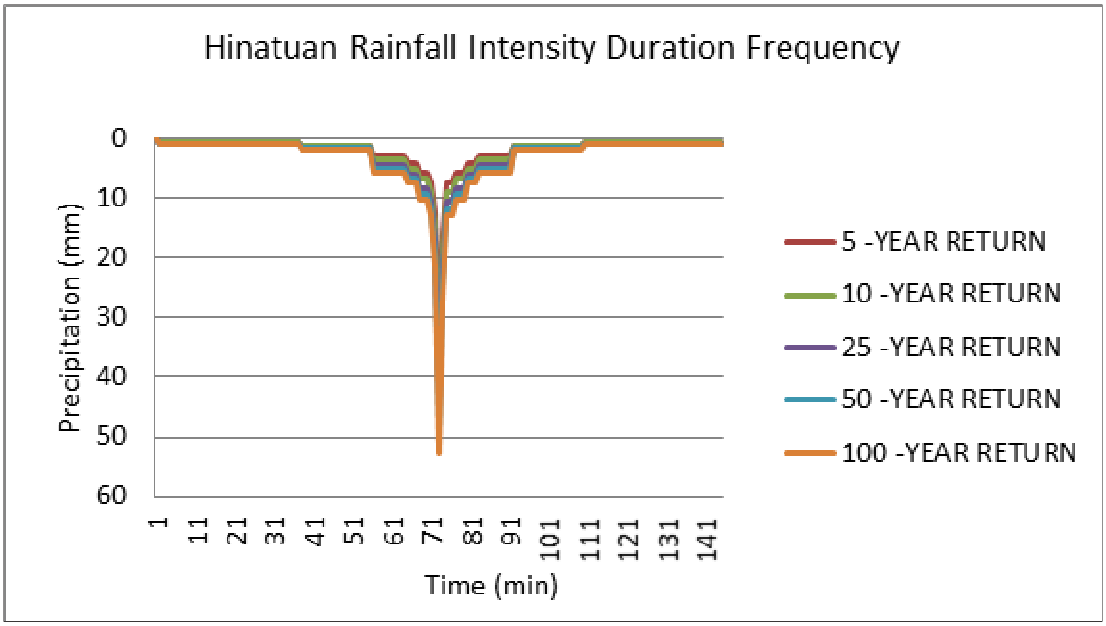


Figure 62. Synthetic storm generated for a 24-hr period rainfall for various return periods

5.3 HMS Model

Using the SAR-based DEM, the Bislig basin was delineated and further subdivided into subbasins. The model consists of 189 sub basins, 96 reaches and 97 junctions. This basin model is illustrated in Figure 62. It was calibrated using data gathered through hydrological measurement at Burboanan Bridge.

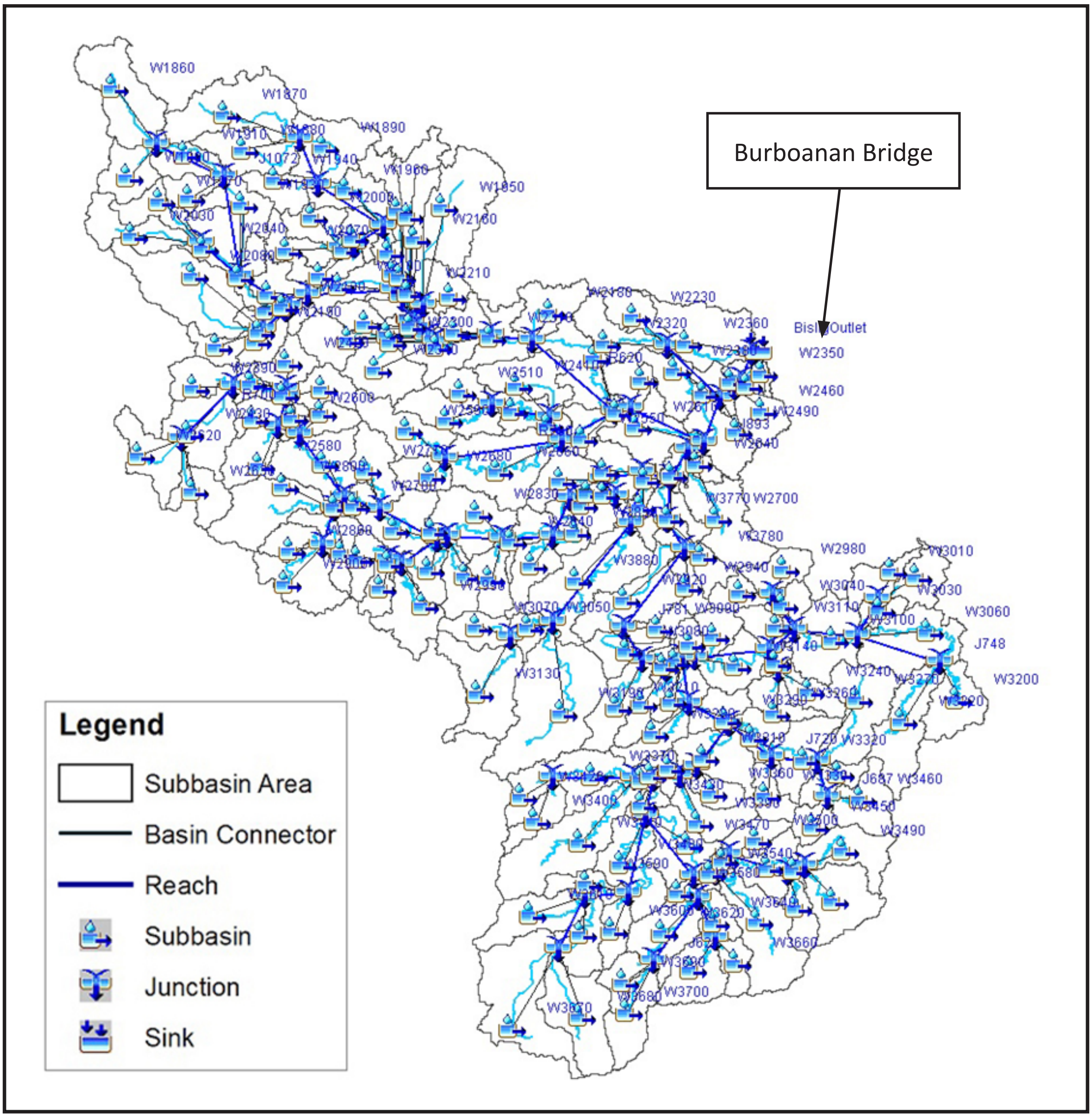


Figure 63. The Bislig river basin model generated using HEC-HMS

5.4 Cross-Section Data

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

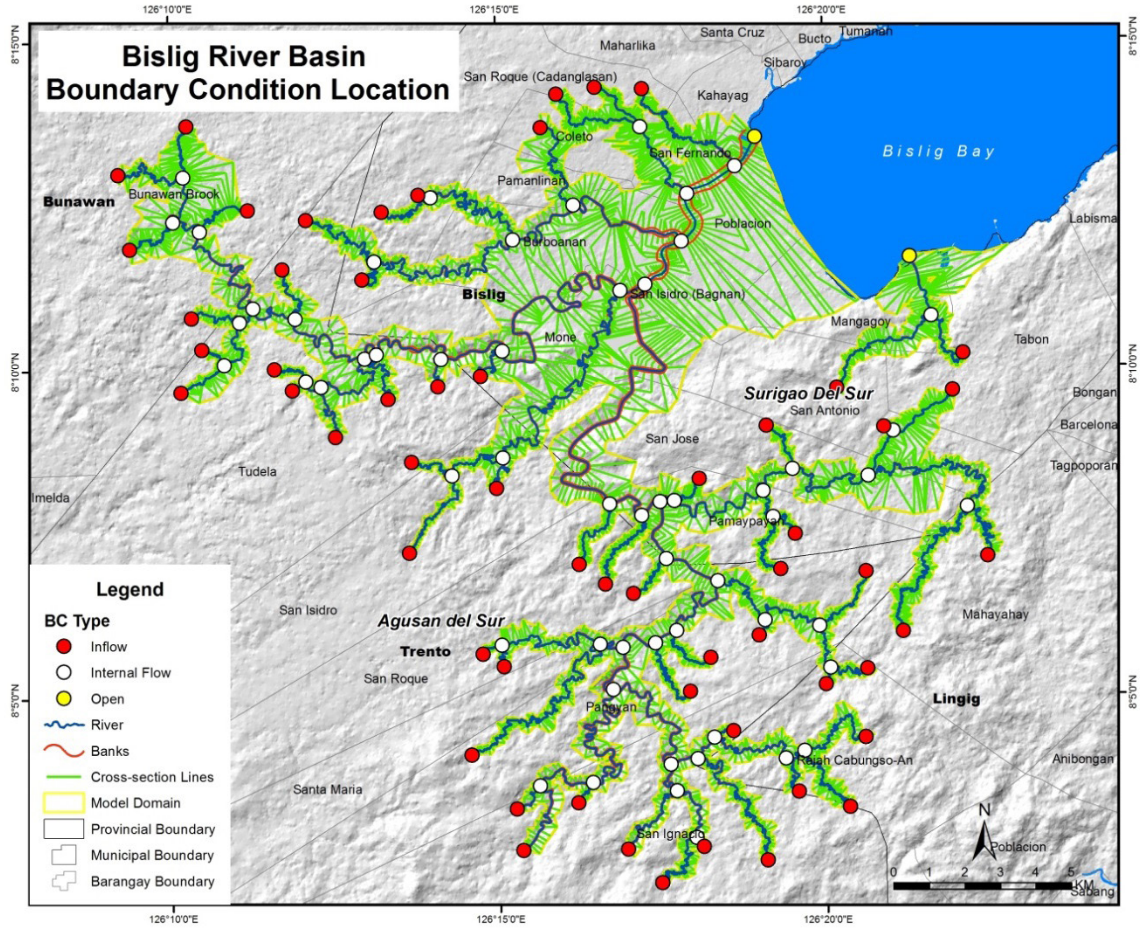


Figure 64. River cross-section of Bislig River generated through Arcmap HEC GeoRAS tool

5.5 Flo 2D Model

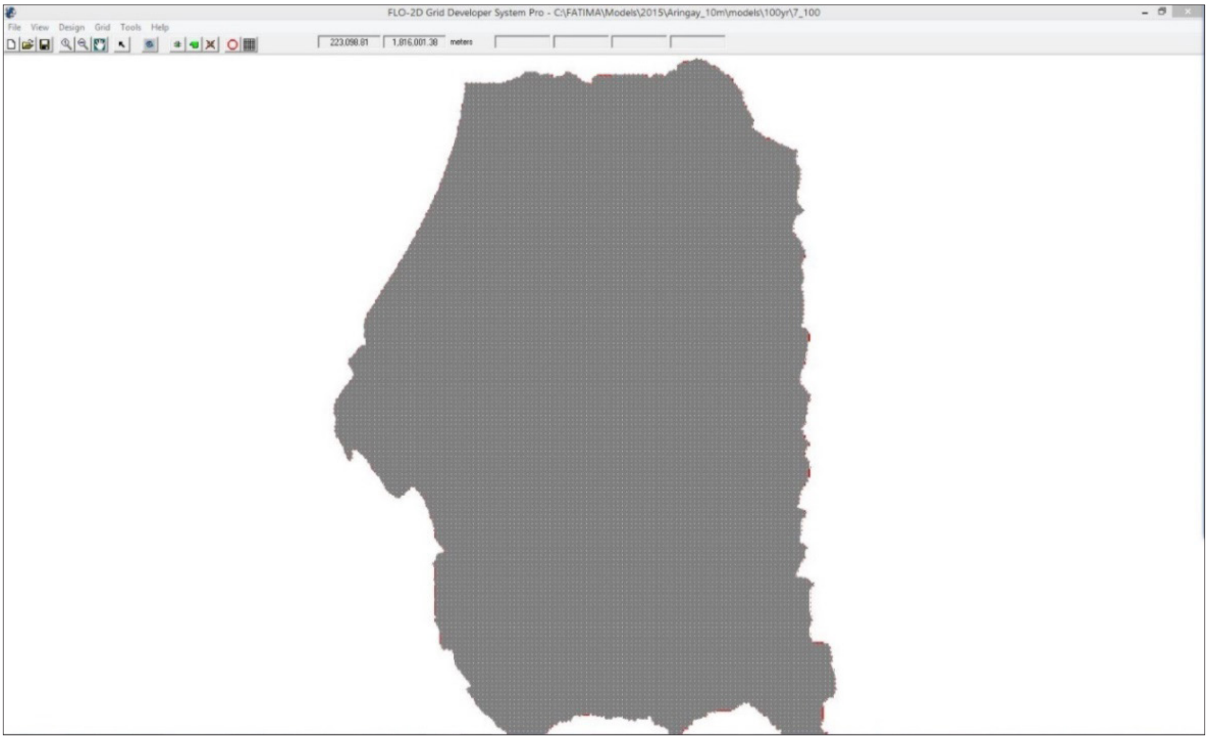


Figure 65. Screenshot of subcatchment with the computational area to be modeled in FLO-2D GDS Pro

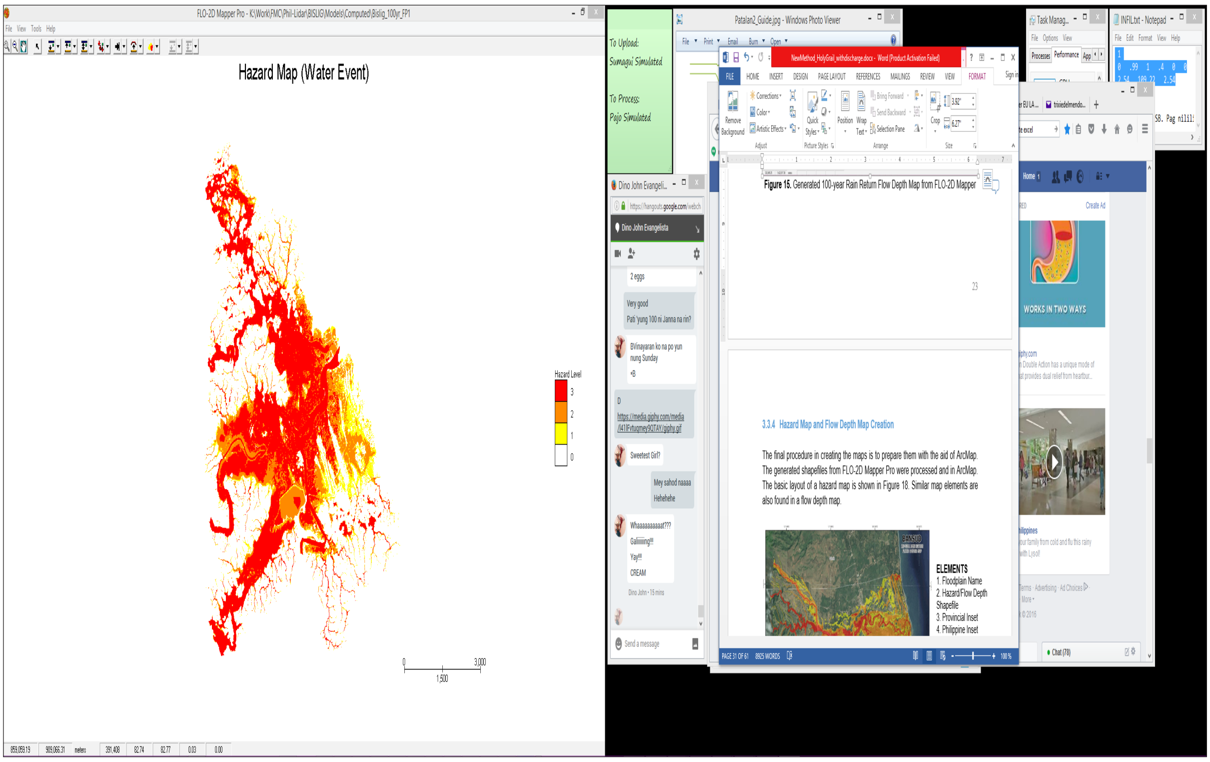


Figure 66. Generated 100-year rain return hazard map from FLO-2D Mapper

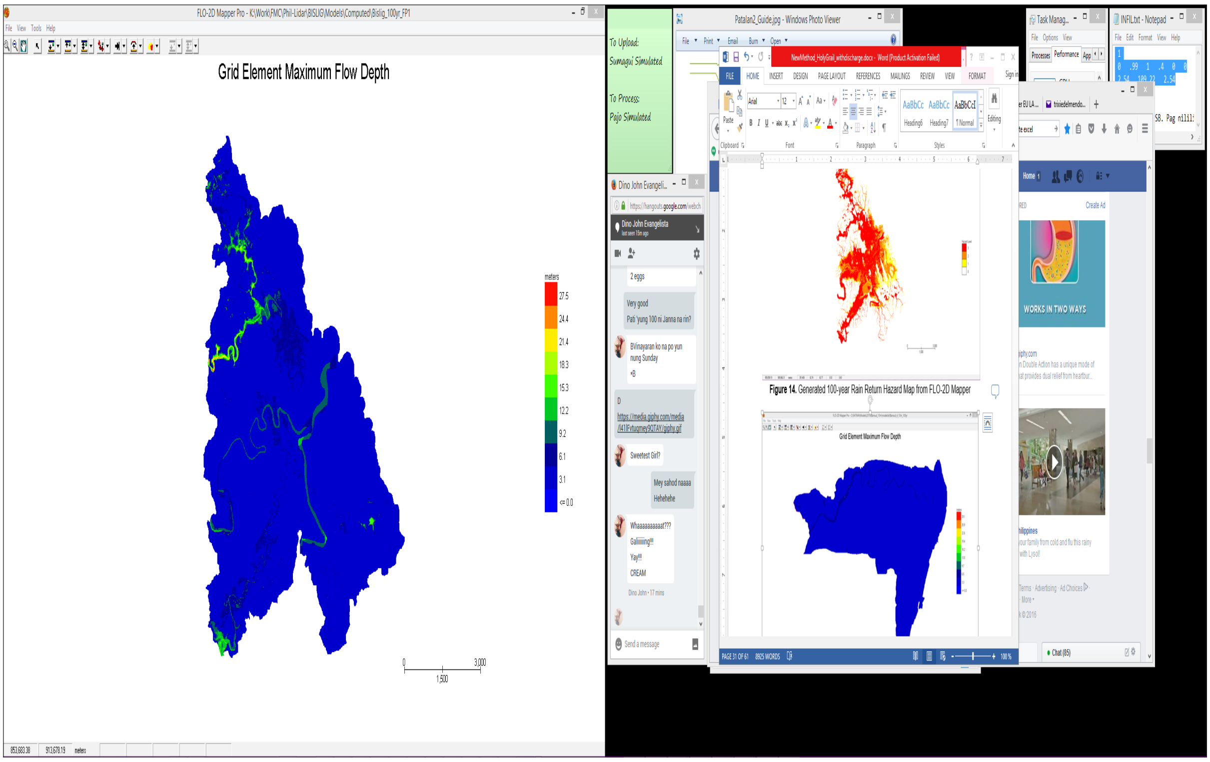


Figure 67. Generated 100-year rain return flow depth map from FLO-2D Mapper

5.6 Results of HMS Calibration

After calibrating the Bislig HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 67 shows the comparison between the two discharge data.

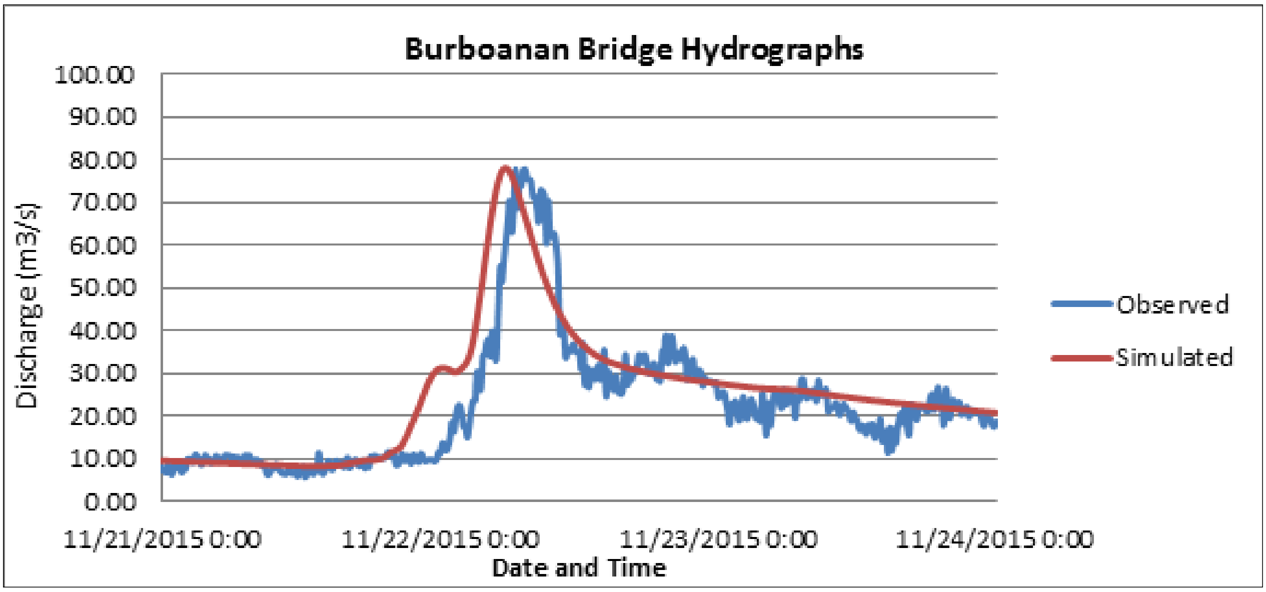


Figure 68. Outflow Hydrograph of Puyo Bridge produced by the HEC-HMS model compared with observed outflow

Enumerated in Table 31 are the adjusted ranges of values of the parameters used in calibrating the model.

Table 31. Range of Calibrated Values for Silaga

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	1.54-80.12
			Curve Number	36 - 97
	Transform	SCS Unit Hydrograph	Lag Time (min)	8.68 to 189
	Baseflow	Recession	Recession Constant	0.75
			Ratio to Peak	0.25
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.05

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 1.54-80.12mm 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 36 to 97 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area. For Bislig, the basin mostly consists of grasslands and the soil consists of clay, clay loam, and hydrosol and undifferentiated.

Lag time is the travel time of runoff in a watershed. The range of calibrated values from 8.68 to 189 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 he ratio of the baseflow discharge to the peak discharge. Recession constant of 0.75 indicates that the basin is unlikely to quickly go back to its original discharge and instead, will be higher. Bislig model basin parameters are presented in Annex 9.

Manning's roughness coefficient of 0.05 corresponds to the common roughness of Philippine watersheds. Bislig river basin is determined to anopen forests.

Table 32. Summary of the Efficiency Test of Bislig HMS Model

r^2	0.7444
NSE	0.677
PBIAS	-22.737
RSR	0.568

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified to be 0.043 m^3/s.

The Pearson correlation coefficient (r^2) 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 0.7444.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model, with E = 1 being the optimal value. The model attained an efficiency coefficient of 0.677.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. The optimal value is 0. In the model, the PBIAS is -22.737.

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 0.568.

After calibrating the Bislig HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 15 shows the comparison between the two discharge data.

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

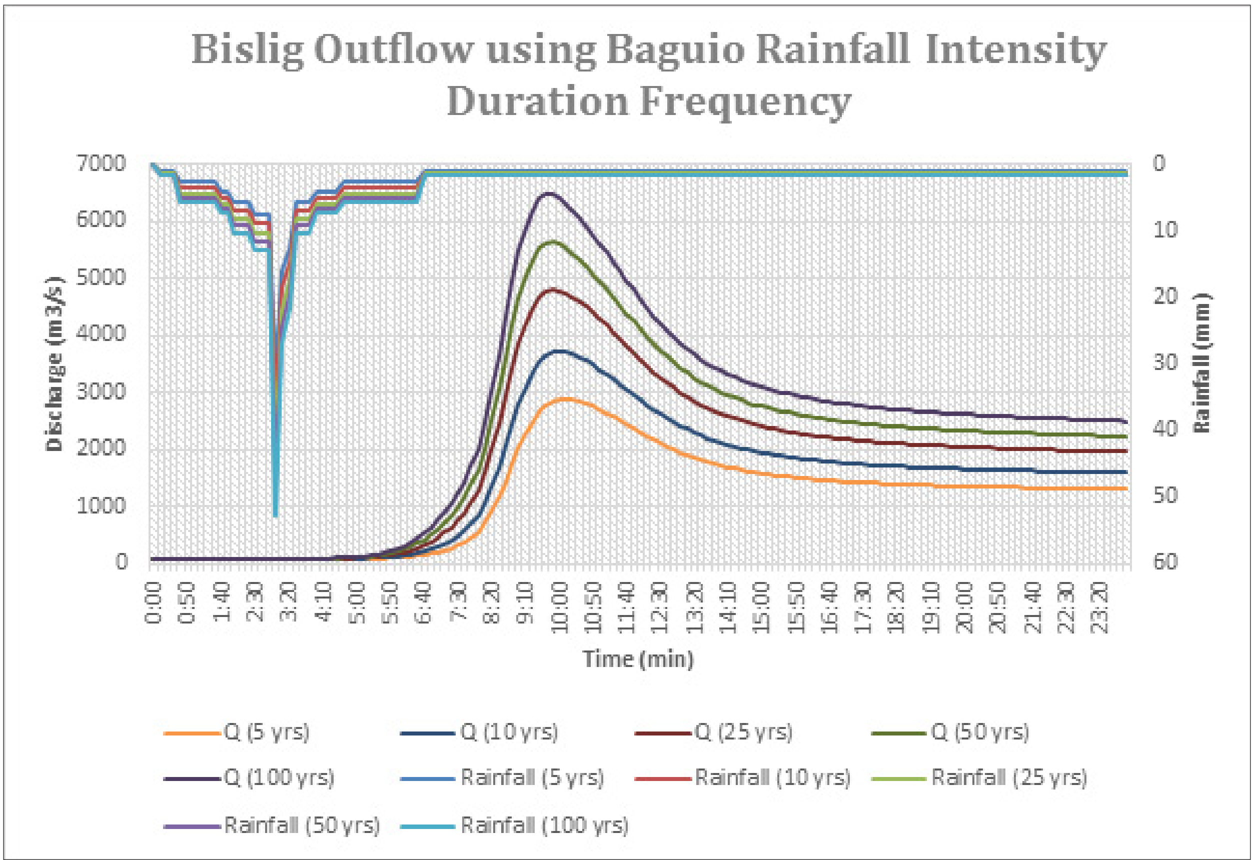


Figure 69. Outflow hydrograph at Bislig Station generated using the Hinatuan RIDF simulated in HEC-HMS.

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Bislig discharge using the Hinatuan Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 33.

Table 33. Peak values of the Bislig HEC-HMS Model outflow using the Hinatuan RIDF

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m3/s)	Time to Peak
5-Year	200.93	20.97	1,621.24	2 hours and 40 minutes
10-Year	276.41	27.65	2,745.35	2 hours and 20 minutes
25-Year	326.39	32.13	3,548.52	2 hours and 10 minutes
50-Year	389.57	37.74	4,592.40	2 hours and 0 minute
100-Year	436.45	41.90	1,288.11	2 hours and 0 minute

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. The sample generated map of Bislig River using the HMS outflow of Typhoon Seniang is shown in Figure 69.

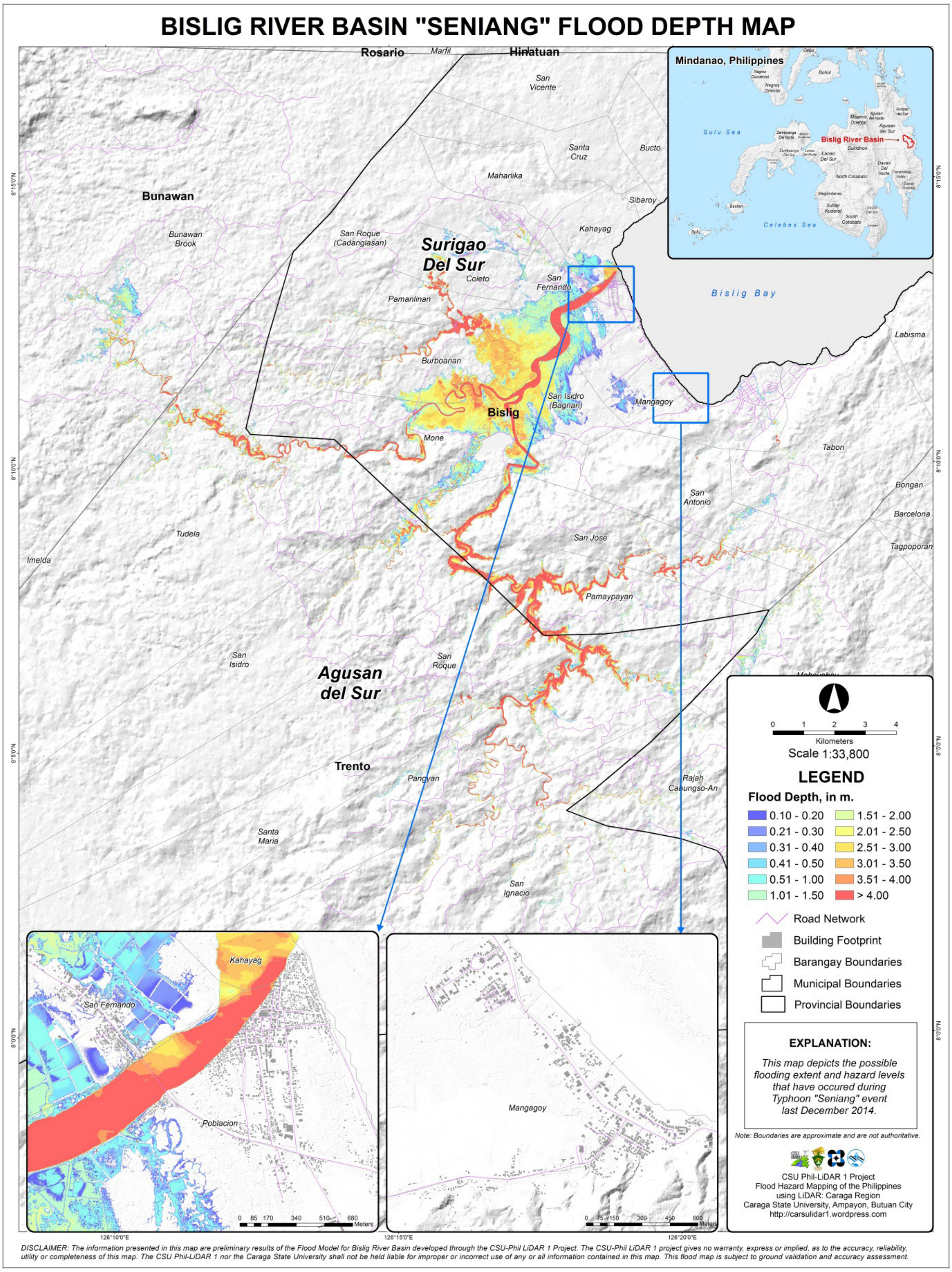


Figure 70. Sample output of Bislig RAS Model. Flood depth and extent at Bislig River basin during typhoon "Seniang"

5.9 Flood Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. The 5-, 25-, and 100-year rain return scenarios of the Bislig floodplain are shown in Figures 18 to 23.

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

Table 34. 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	8.22	8	8.09
Medium	13.5	15	14.93
High	10.9	13	17.69

insert assessment

The resulting hazard and flow depth maps for the 5-, 25-, and 100-year rain return scenarios of the Bislig floodplain are shown in Figure 70 to Figure 75.

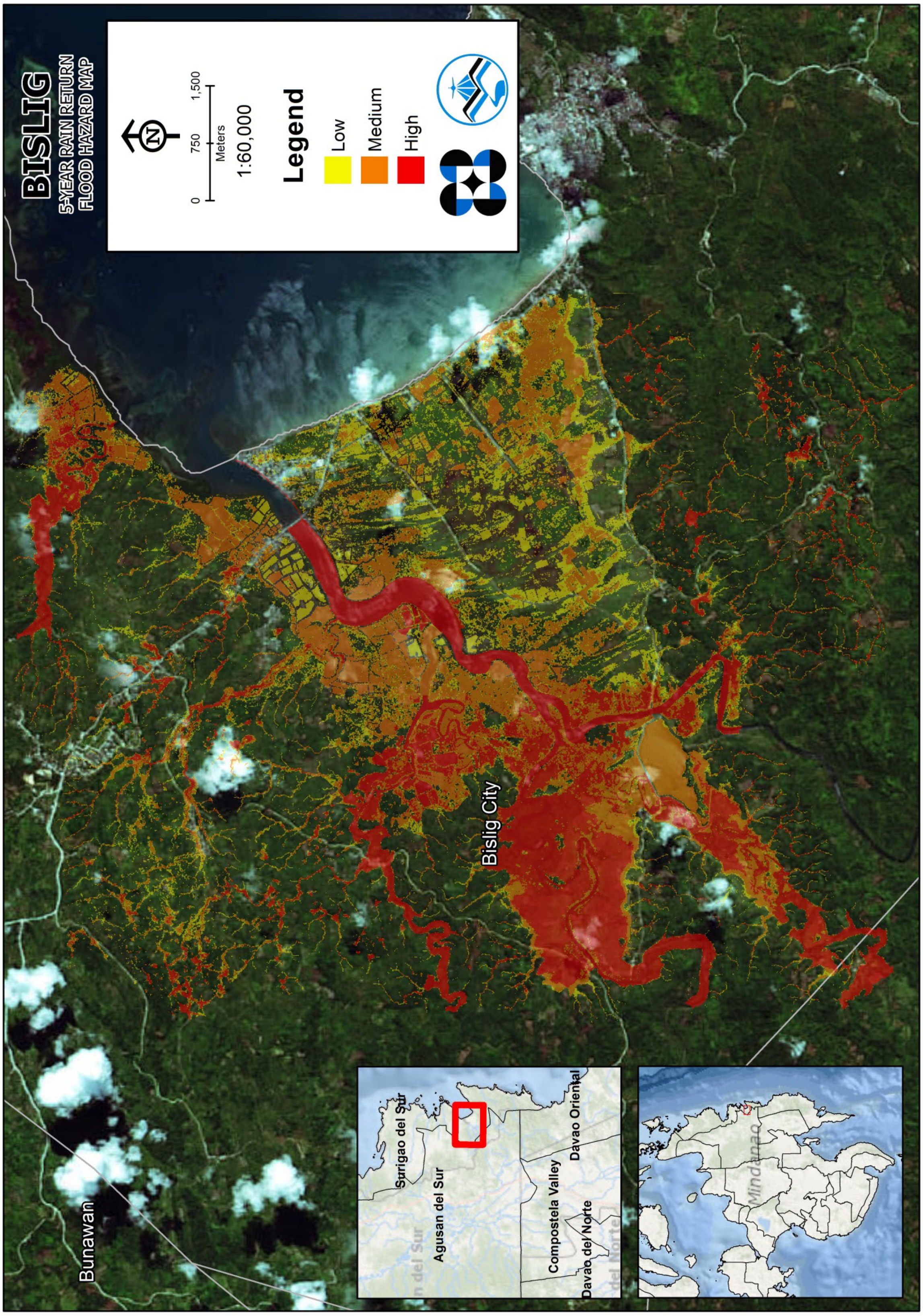


Figure 71. 5-year Flood Hazard Map for Bislig Floodplain

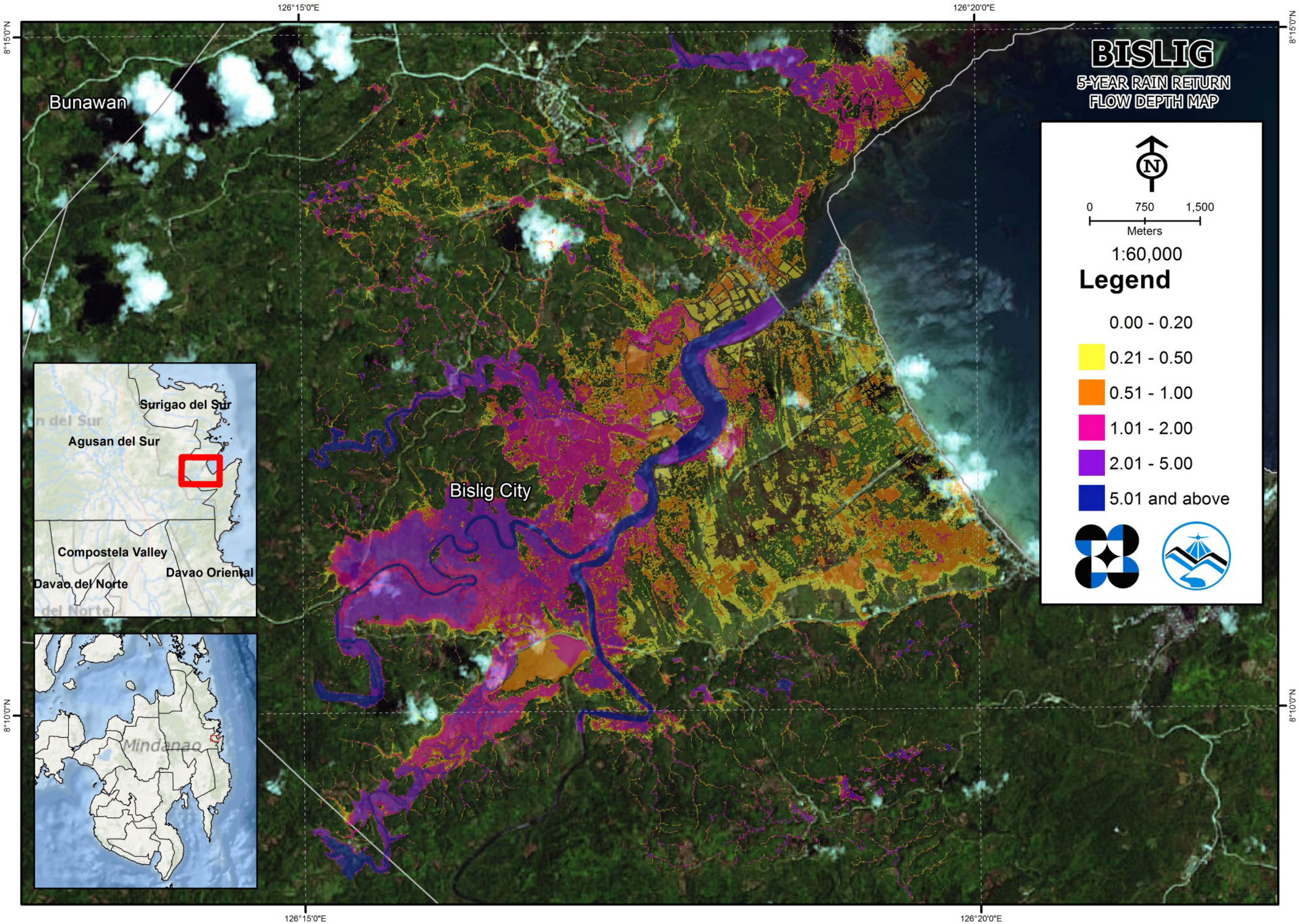


Figure 72. 5-year rain return flow depth map for Bislig Floodplain

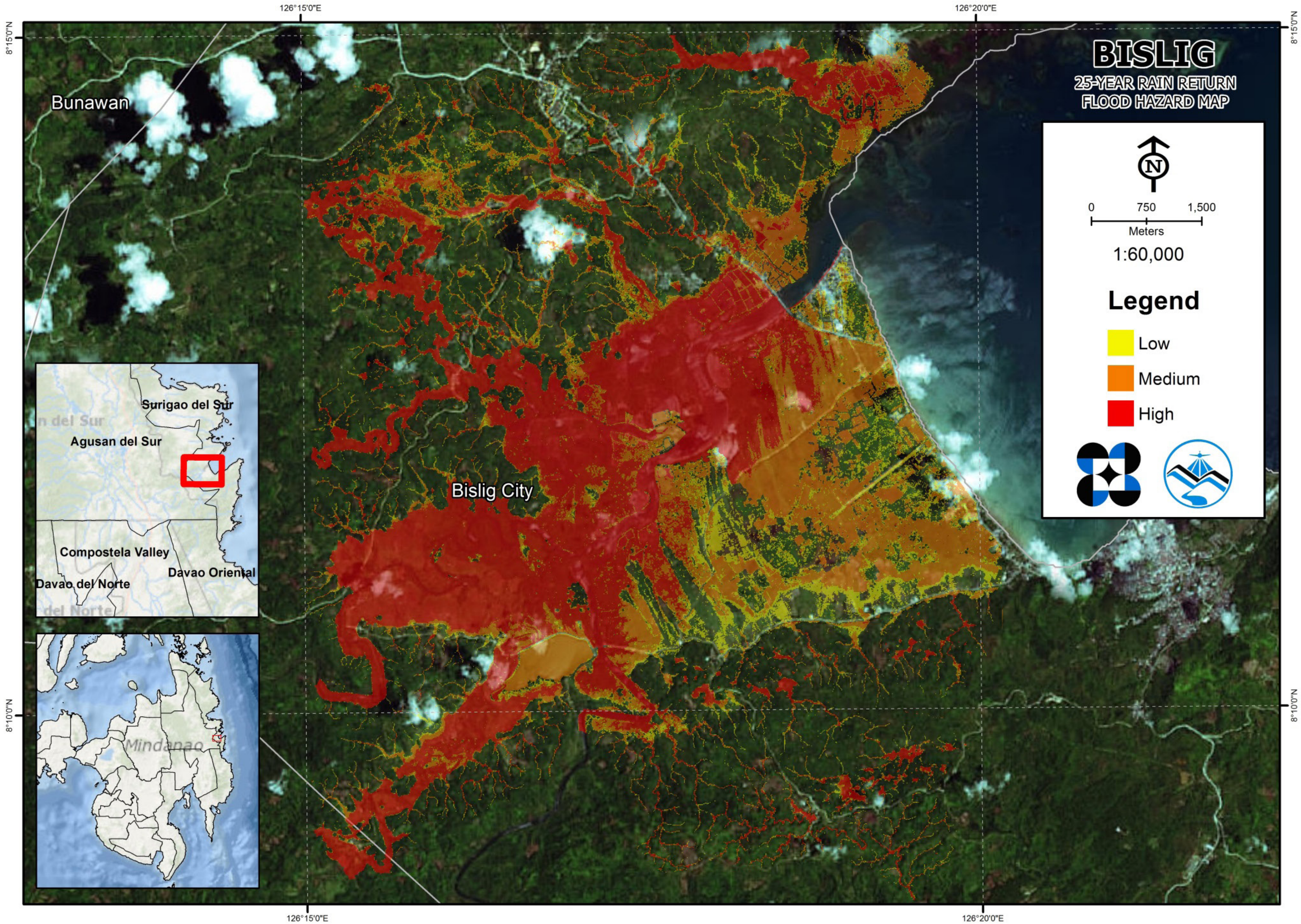


Figure 73. 25-year Flood Hazard Map for Bislig Floodplain

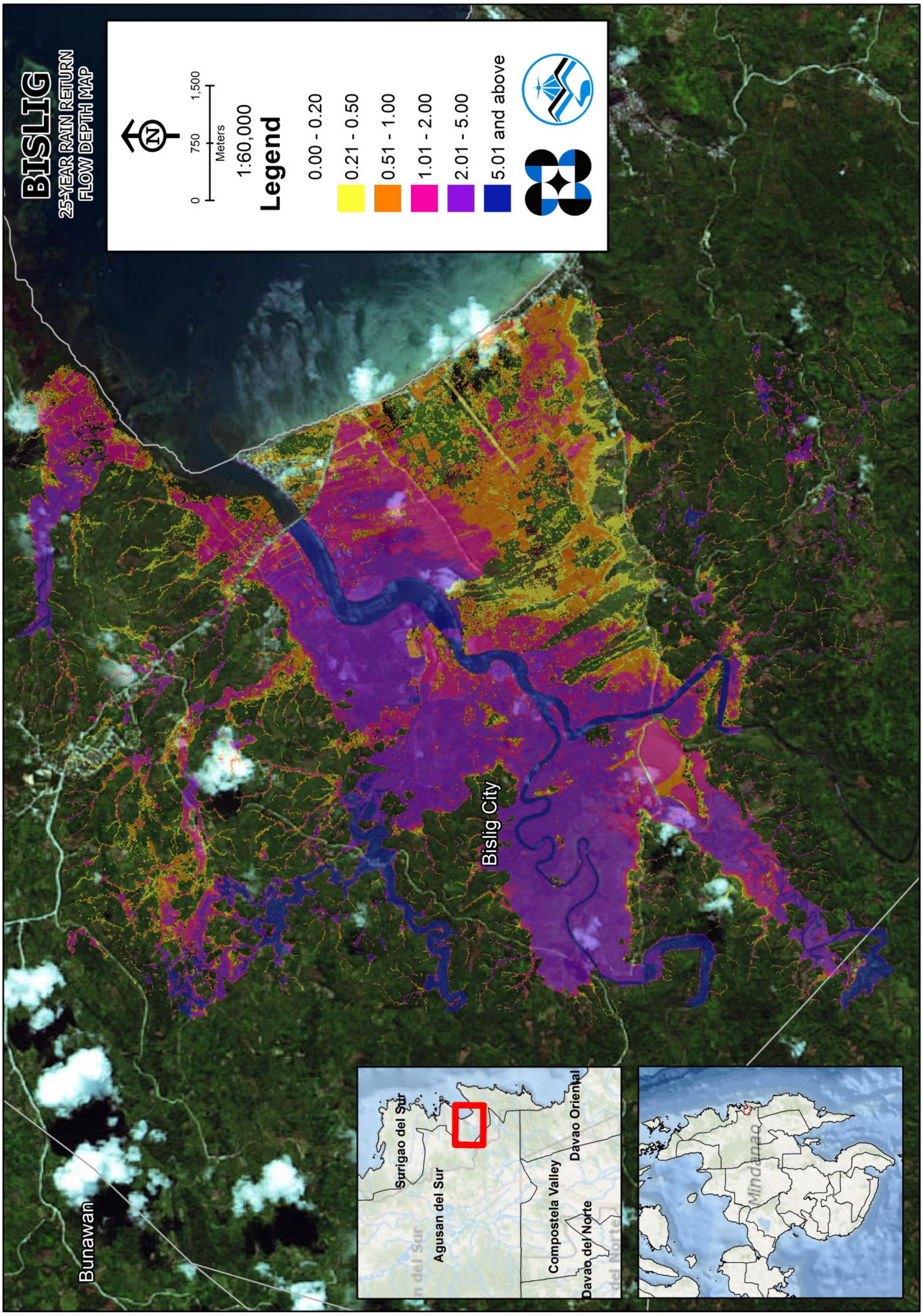


Figure 74. 25-year Flow Depth Map for Bislig Floodplain

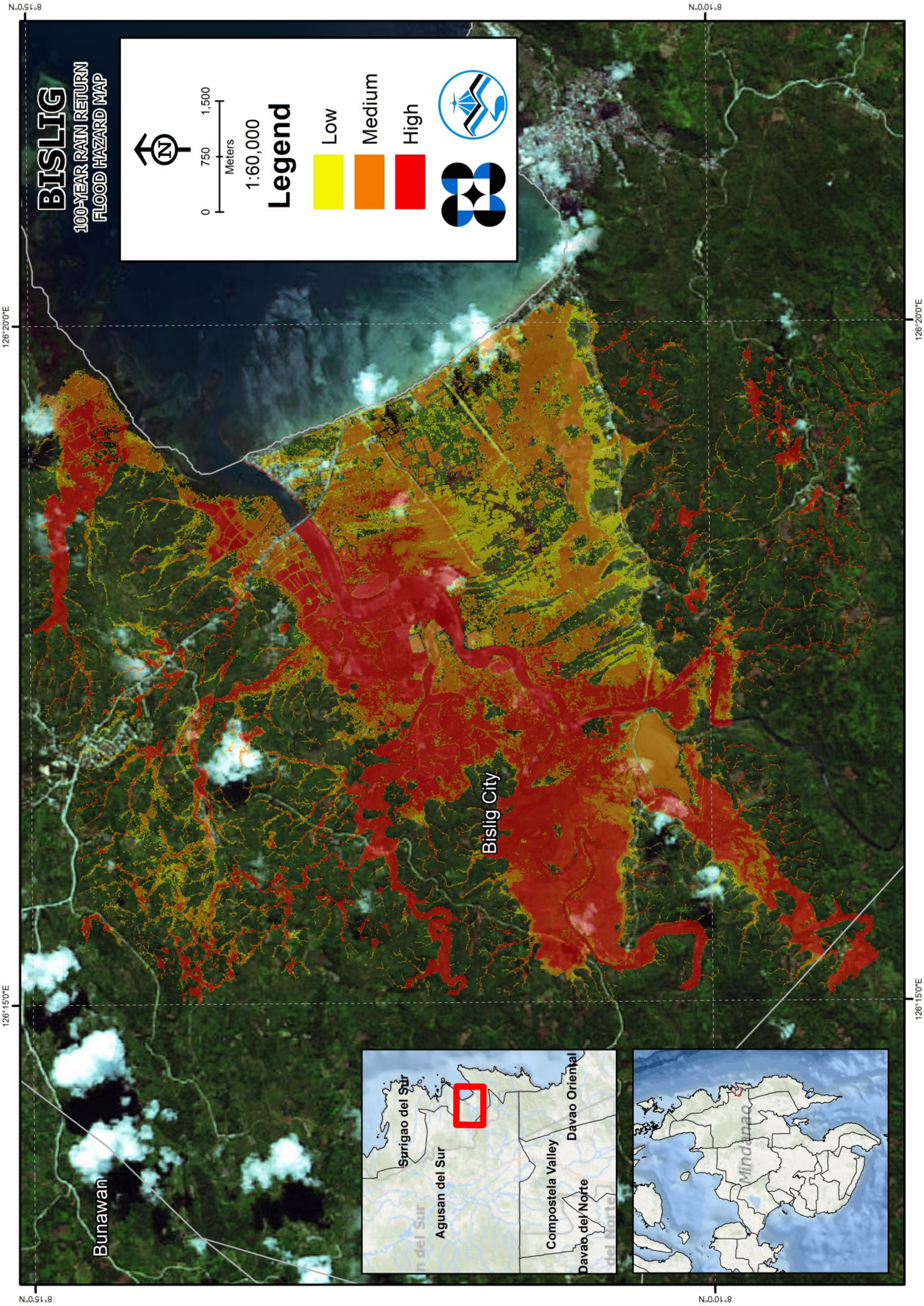


Figure 75. 100-year Flood Hazard Map for Bislig Floodplain

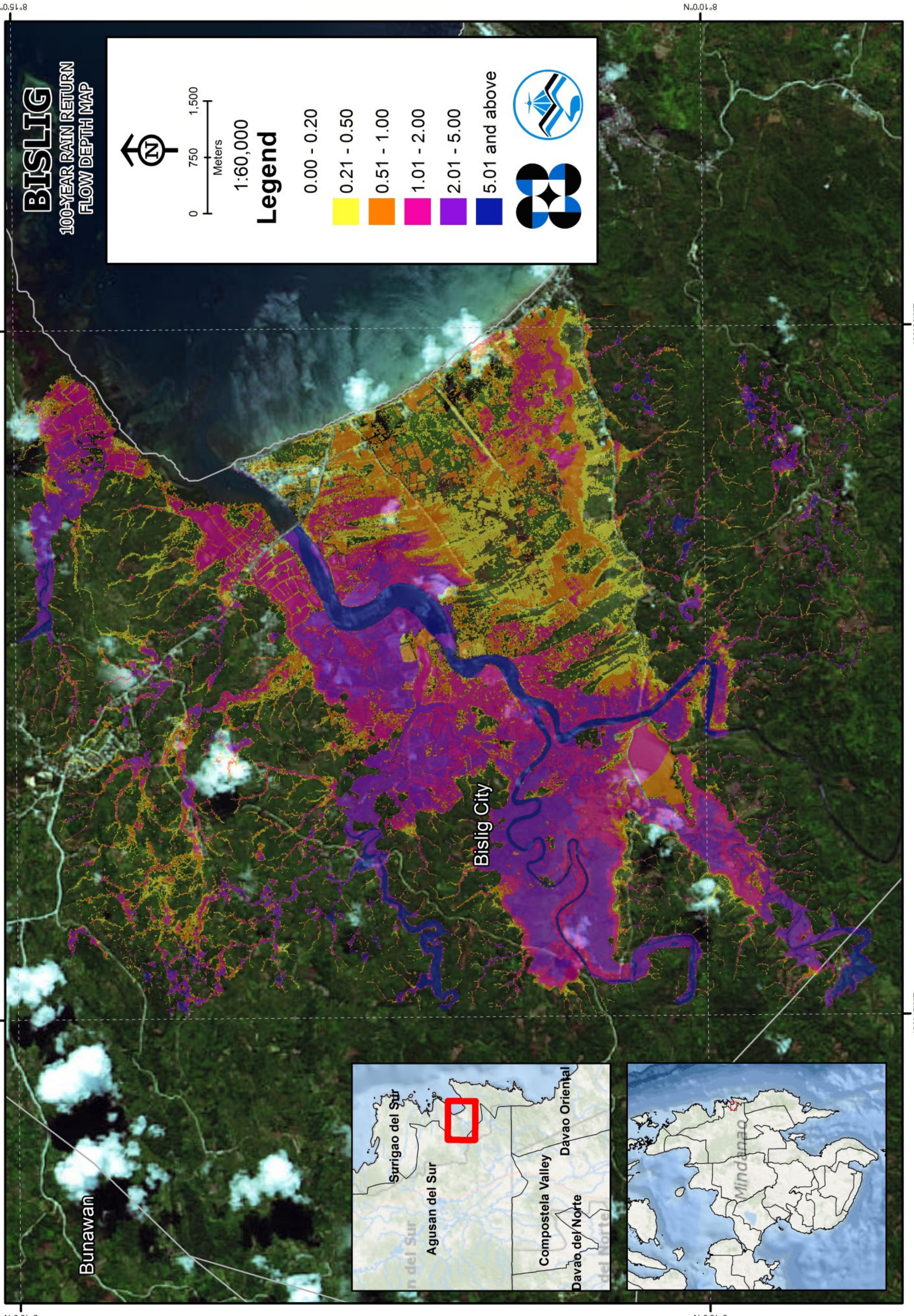


Figure 76. 100-year Flow Depth Map for Bislig Floodplain

5.10 Inventory of Areas Exposed to Flooding

Affected barangays in Bislig River Basin, grouped by municipality, are listed below. For the said basin, two municipalities consisting of 18 barangays are expected to experience flooding when subjected to 5-, 25- and 100-yr rainfall return period. Annexes 12 and 13 list the educational and health institutions, respectively, that will be affected by flooding in Bislig River Basin.

For the 5-year return period, 0.06% of the municipality of Trento with an area of 555.7 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%, 0.02%, and 0.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 35. Affected Areas in Trento during 5-Year Rainfall Return Period

BISLIG BASIN	Affected Barangays in Trento (sq. km.)	
	San Isidro	Tudela
1	0.343739	0.016564
2	0.011737	0.0001
3	0.011719	0.00019
4	0.023302	0.0001
5	0.084487	0
6	0.145219	0

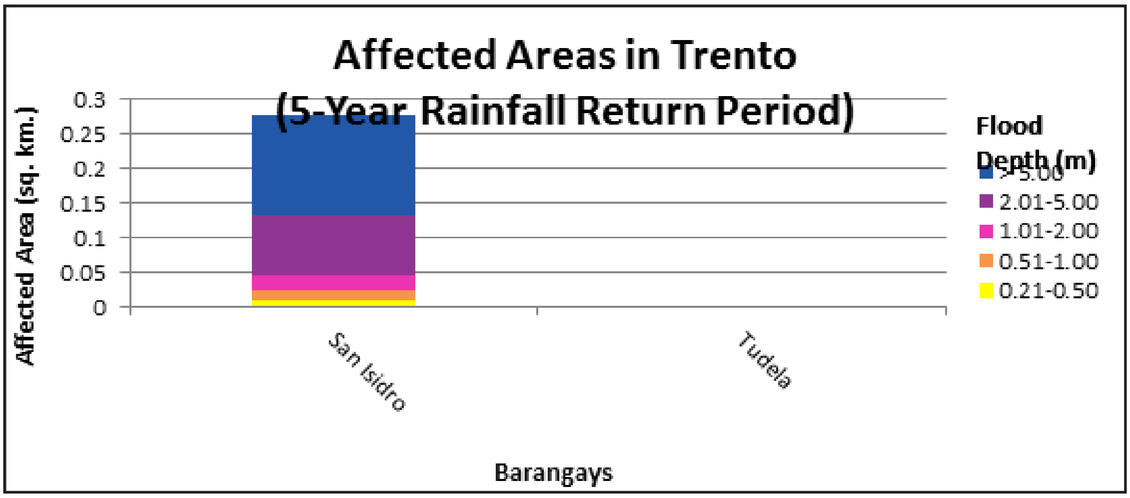


Figure 77. Affected Areas in Trento during 5-Year Rainfall Return Period

For the 5-year return period, 15.80% of the municipality of Bislig City with an area of 331.8 sq. km. will experience flood levels of less than 0.20 meters. 1.94% of the area will experience flood levels of 0.21 to 0.50 meters while 2.16%, 2.63%, 1.44%, and 0.52% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 36. Affected Areas in Bislig City during 5-Year Rainfall Return Period

BISLIG BASIN	Affected Area (sq. km.)					
	1	2	3	4	5	6
Burboanan	5.355405	0.630108	1.177065	2.778807	1.221811	0.51225
Coleto	5.243453	0.457245	0.387269	0.301191	0.15189	0.0141
Comawas	2.371736	0.852049	1.172328	0.064071	0.012678	0.003025
Kahayag	3.115882	0.372069	0.375485	0.613451	0.230711	0
Maharlika	2.143248	0.080239	0.057112	0.061819	0.298918	0.037583
Mangagoy	0.034153	0.001202	1.91E-06	0	0	0
Mone	7.265391	0.777851	1.742984	3.406909	1.511861	0.605237
Pamanlinan	2.342655	0.095458	0.073312	0.086438	0.116868	0.012642
Poblacion	4.290089	1.701236	0.772067	0.102078	0.393195	0.13948
San Antonio	5.983591	0.187832	0.122845	0.138963	0.140819	0.037825
San Fernando	2.916295	0.663185	0.650742	0.536473	0.056907	0.157234
San Isidro	0.343739	0.011737	0.011719	0.023302	0.084487	0.145219
San Jose	5.914436	0.152969	0.156085	0.241637	0.450747	0.035314
San Roque	4.505012	0.319522	0.257528	0.191708	0.096663	0.0118
Santa Cruz	0.394461	0.018878	0.006462	0.001961	0	0
Sibaroy	0.2067	0.111294	0.195348	0.189208	0.000664	0

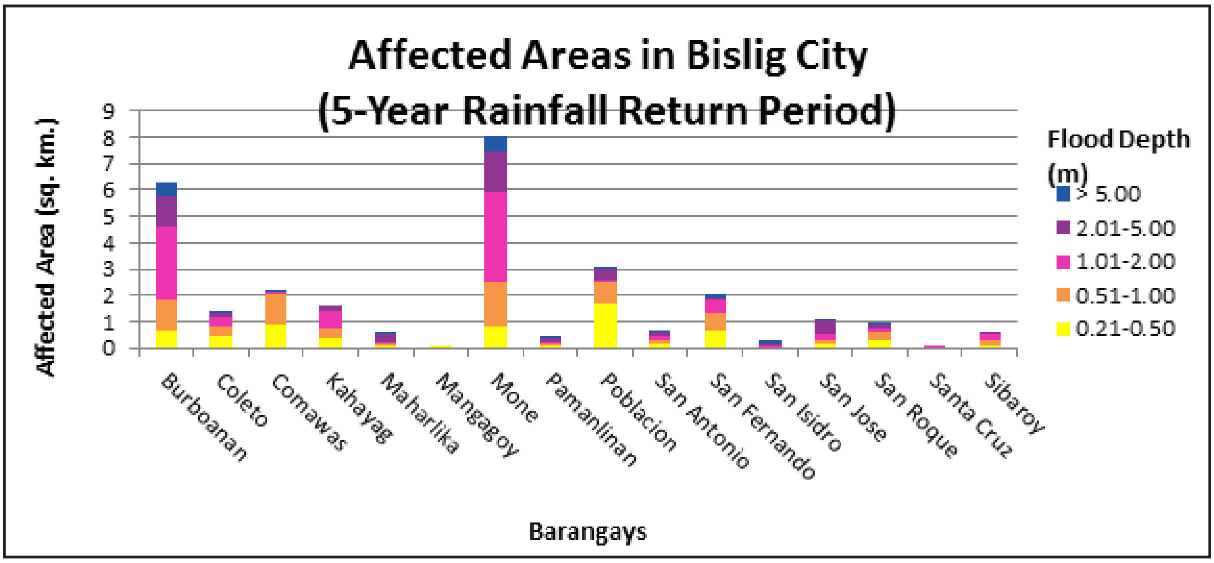


Figure 78. Affected Areas in Bislig City during 5-Year Rainfall Return Period

For the 25-year return period, 0.06% of the municipality of Trento with an area of 555.7 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%, 0.02%, and 0.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 37. Affected Areas in Trento during 25-Year Rainfall Return Period

BISLIG BASIN	Affected Barangays in Trento (sq.km.)	
	San Isidro	Tudela
1	0.342464	0.016564
2	0.012091	0.0001
3	0.01245	0.00019
4	0.023692	0.0001
5	0.084351	0
6	0.145155	0

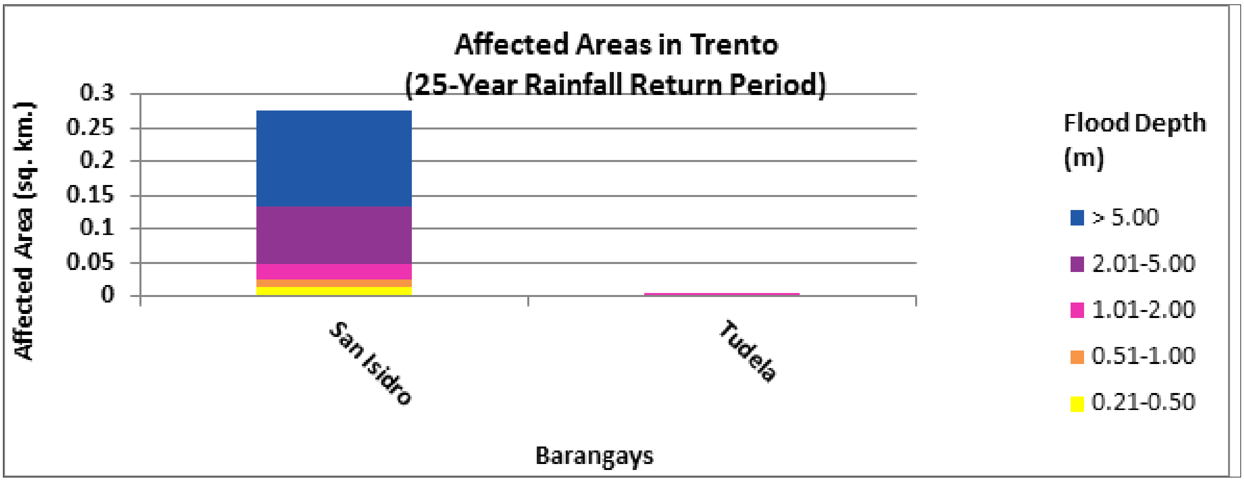


Figure 79. Affected Areas in Trento during 25-Year Rainfall Return Period

For the 25-year return period, 14.81% of the municipality of Bislig City with an area of 331.8 sq. km. will experience flood levels of less than 0.20 meters. 1.91% of the area will experience flood levels of 0.21 to 0.50 meters while 2.31%, 3.17%, 1.69%, and 0.58% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 38. Affected Areas in Bislig City during 25-Year Rainfall Return Period

BISLIG BASIN	Affected Barangays in Bislig City (sq. km.)					
	1	2	3	4	5	6
Burboanan	5.105792	0.535564	1.047424	2.930324	1.506629	0.549712
Coleto	5.042753	0.500843	0.446802	0.35693	0.192119	0.0157
Comawas	2.002168	0.762632	1.311256	0.378928	0.015978	0.004925
Kahayag	2.875121	0.409362	0.367192	0.663546	0.392376	0
Maharlika	2.10067	0.092038	0.065166	0.066243	0.300552	0.054249
Mangagoy	0.034153	0	0.001204	0	0	0
Mone	7.02331	0.814841	1.611578	3.50108	1.742597	0.616827
Pamanlinan	2.294284	0.103066	0.084313	0.09373	0.135533	0.016447
Poblacion	3.205068	1.852799	1.303021	0.494502	0.319533	0.223221
San Antonio	5.831809	0.203337	0.144991	0.153251	0.207374	0.071114
San Fernando	2.603319	0.441487	0.636253	1.047707	0.071609	0.180462
San Isidro	0.342464	0.012091	0.01245	0.023692	0.084351	0.145155
San Jose	5.841141	0.155859	0.162558	0.253896	0.48912	0.048614
San Roque	4.333981	0.35187	0.294707	0.2474	0.140708	0.013568
Santa Cruz	0.379889	0.025719	0.011856	0.004136	0.000161	0
Sibaroy	0.133642	0.08772	0.164079	0.299534	0.018239	0

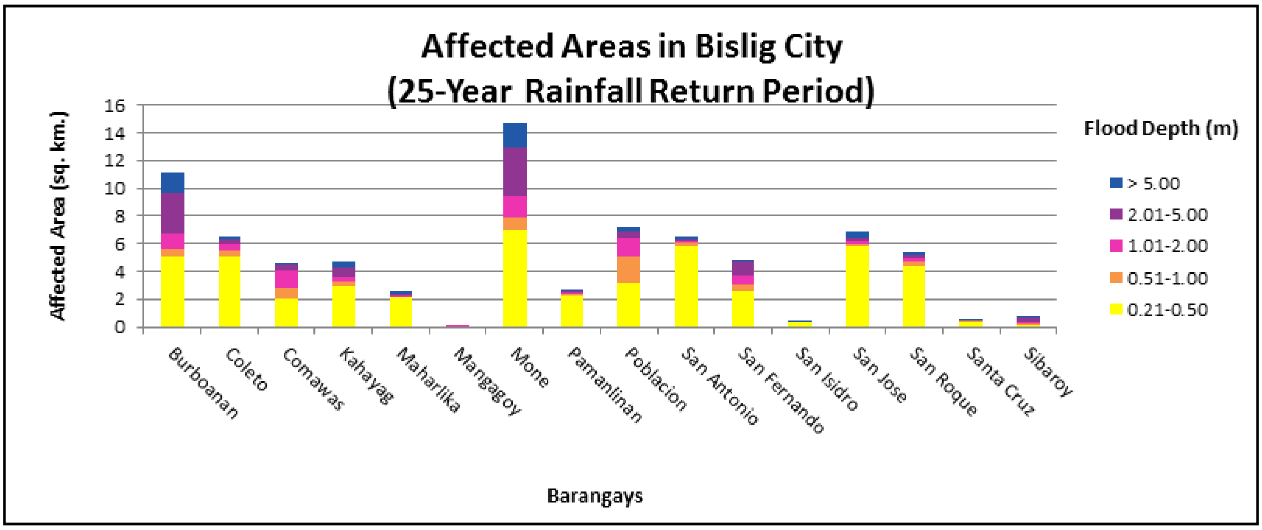


Figure 80. Affected Areas in Bislig City during 25-Year Rainfall Return Period

For the 100-year return period, 0.06% of the municipality of Trento with an area of 555.7 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%, 0.01%, and 0.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 39. Affected Areas in Trento during 100-Year Rainfall Return Period

BISLIG BASIN	Affected Barangays in Trento (sq. km.)	
	San Isidro	Tudela
1	0.328561	0.016364
2	0.008889	0.0003
3	0.011876	0.00019
4	0.02171	0
5	0.062588	0.0001
6	0.18658	0

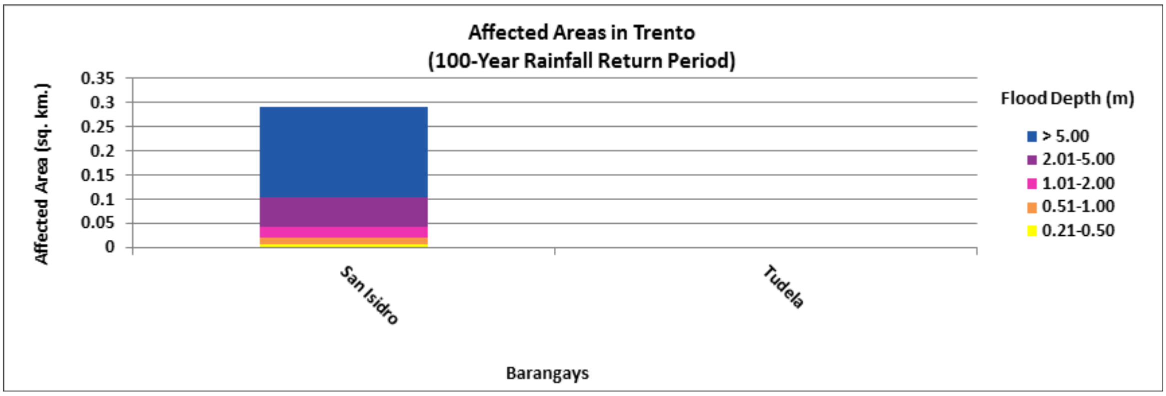


Figure 81. Affected Areas in Trento during 100-Year Rainfall Return Period

For the 100-year return period, 13.83% of the municipality of Bislig City with an area of 331.8 sq. km. will experience flood levels of less than 0.20 meters. 1.83% of the area will experience flood levels of 0.21 to 0.50 meters while 2.20%, 3.16%, 2.74%, and 0.73% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 40. Affected Areas in Bislig City during 100-Year Rainfall Return Period

BISLIG BASIN	Affected Area (sq. km.)					
	1	2	3	4	5	6
Burboanan	4.815261	0.404789	0.725154	2.212117	2.848554	0.669571
Coleto	4.815244	0.52253	0.499287	0.432921	0.263616	0.02155
Comawas	1.773716	0.74222	1.222012	0.713258	0.019055	0.005625
Kahayag	2.733416	0.454796	0.370493	0.693624	0.455268	0
Maharlika	2.063178	0.104218	0.071857	0.071585	0.286054	0.082026
Mangagoy	0.034153	0	0.001204	0	0	0
Mone	6.5543	0.711051	1.090051	3.224513	3.060552	0.669765
Pamanlinan	2.230454	0.11014	0.093301	0.104772	0.153514	0.035193
Poblacion	2.078104	1.77781	1.883183	0.917389	0.384572	0.357086
San Antonio	5.718708	0.214931	0.160245	0.168174	0.249749	0.100067
San Fernando	2.280929	0.375747	0.512687	1.078674	0.542803	0.189996
San Isidro	0.328561	0.008889	0.011876	0.02171	0.062588	0.18658
San Jose	5.772257	0.154621	0.160133	0.240333	0.548934	0.074909
San Roque	4.193128	0.373893	0.317766	0.295865	0.184163	0.017418
Santa Cruz	0.36936	0.03239	0.014254	0.005597	0.000161	0
Sibaroy	0.115656	0.084981	0.149711	0.319704	0.033162	0

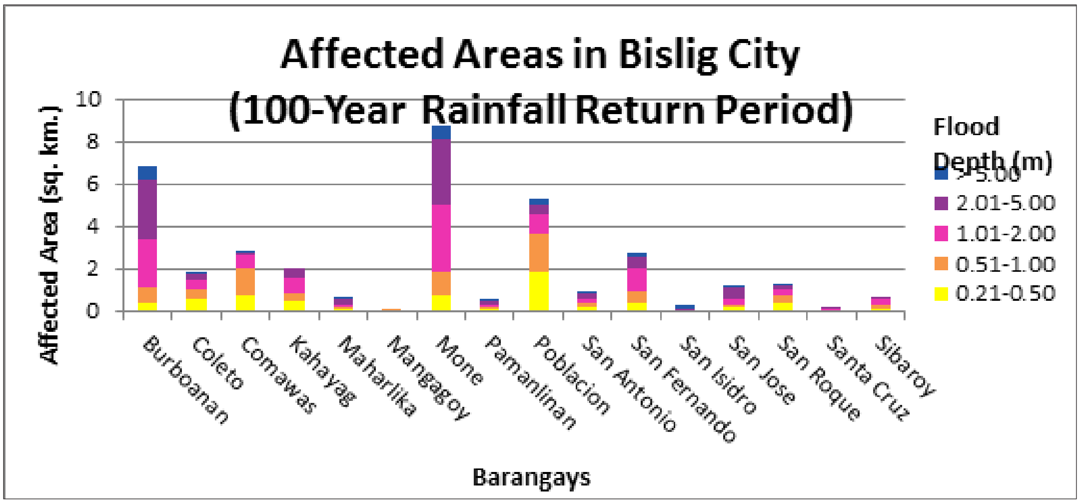


Figure 82. Affected Areas in Bislig City during 100-Year Rainfall Return Period

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 gather secondary data regarding flood occurrence in the area within the major river system in the Philippines.

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

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

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

The flood validation consists of 277 points (Annex 11) randomly selected all over the Bislig flood plain. It has an RMSE value of 0.82.

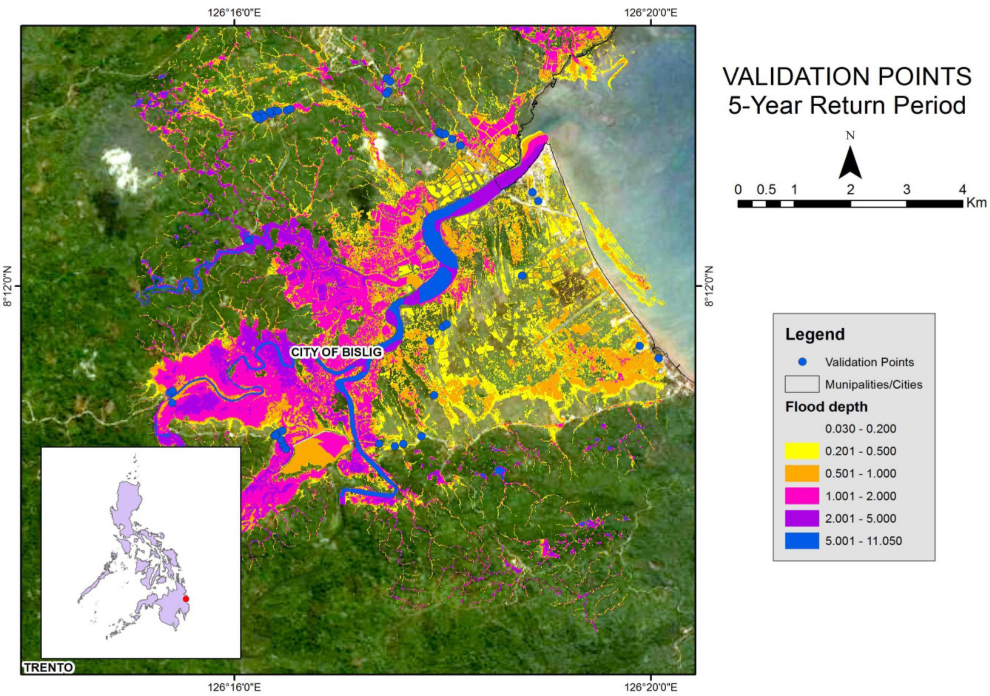


Figure 83. Flood Validation Points of Aringay River Basin

Table 41. Actual Flood Depth vs Simulated Flood Depth in Bislig

BISLIG BASIN		Modeled Flood Depth (m)						
		0-0.20	0.21-0.50	0.51-1.00	1.01-2.00	2.01-5.00	> 5.00	Total
Actual Flood Depth (m)	0-0.20	124	30	22	11	2	0	189
	0.21-0.50	20	7	9	3	0	0	39
	0.51-1.00	10	3	9	4	2	2	30
	1.01-2.00	6	0	0	8	2	2	18
	2.01-5.00	0	0	0	0	0	0	0
	> 5.00	0	0	0	0	0	0	0
	Total	160	40	40	26	6	4	276

The overall accuracy generated by the flood model is estimated at 53.62%, with 148 points correctly matching the actual flood depths. In addition, there were 68 points estimated one level above and below the correct flood depths while there were 39 points and 21 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 89 points were overestimated while a total of 39 points were underestimated in the modelled flood depths of Bislig.

Table 42. Summary of Accuracy Assessment in Bislig

	No. of Points	%
Correct	148	**53.62**
Overestimated	89	**32.25**
Underestimated	39	**14.13**
Total	276	**100.00**

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ANNEXES

Annex 1. Technical Specifications of the LiDAR Sensors used in the Bislig Floodplain Survery

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

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

SRS-61

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

August 15, 2014

CERTIFICATION

To whom it may concern:

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

Province: **SURIGAO DEL SUR**
Station Name: **SRS-61**
Order: **2nd**

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

Location Description

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

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

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

9908152014160628

CIP/4701/12/09/814

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

SRS-63

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

September 05, 2014

CERTIFICATION

To whom it may concern:

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

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

Location Description

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

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

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

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CERTIFICATION INTERNATIONAL ISO 9001:2008
ACCREDITED
CIP/4701/12/09/814

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ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

SRS-60

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

August 08, 2014

CERTIFICATION

To whom it may concern:

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

Province: **SURIGAO DEL SUR**
Station Name: **SRS-60**
Order: **2nd**

Island: **MINDANAO**		Barangay: **STA. CRUZ**
Municipality: **BISLIG**		MSL Elevation:
	PRS92 Coordinates	
Latitude: **8° 15' 26.63928"**	Longitude: **126° 17' 56.66192"**	Ellipsoidal Hgt: **83.08300 m.**
	WGS84 Coordinates	
Latitude: **8° 15' 23.26276"**	Longitude: **126° 18' 2.07013"**	Ellipsoidal Hgt: **155.22600 m.**
	PTM / PRS92 Coordinates	
Northing: **913248.992 m.**	Easting: **643129.132 m.**	Zone: **5**
	UTM / PRS92 Coordinates	
Northing:	Easting:	Zone:

Location Description

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

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

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

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CIP/4701/12/09/814

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ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

SRS-56

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

August 15, 2014

CERTIFICATION

To whom it may concern:

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

Province: **SURIGAO DEL SUR**
Station Name: **SRS-56**
Order: **2nd**

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

Location Description

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

Requesting Party: **Engr. Cristopher Cruz**
Pupose: **Reference**
OR Number: **8799719 A**
T.N.: **2014-1852**

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

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CIP/4701/12/09/814

NAMRIA OFFICES:
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ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

SRS-57

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

August 08, 2014

CERTIFICATION

To whom it may concern:

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

Province: **SURIGAO DEL SUR**
Station Name: **SRS-57**
Order: **2nd**

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

Location Description

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

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

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

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CERTIFICATION INTERNATIONAL ISO 9001:2008 ACCREDITED CIP/4701/12/09/814

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ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

SRS-58

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

August 29, 2014

CERTIFICATION

To whom it may concern:

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

Province: **SURIGAO DEL SUR**

Station Name: **SRS-58**

Order: **2nd**

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

Location Description

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

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

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

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CIP/4701/12/09/814

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

SS-124

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

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
BMSS-124 --- SRS-60 (B1)	SRS-60	BMSS-124	Fixed	0.004	0.016	168°53'56"	4369.046	-79.262

Acceptance Summary

Processed	Passed	Flag	Fail
1	1	0	0

BMSS-124 - SRS-60 (8:56:33 AM-10:21:47 AM) (S1)

Baseline observation:	BMSS-124 --- SRS-60 (B1)
Processed:	10/13/2016 12:59:34 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.004 m
Vertical precision:	0.016 m
RMS:	0.003 m
Maximum PDOP:	2.274
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	8/3/2014 8:56:33 AM (Local: UTC+8hr)
Processing stop time:	8/3/2014 10:21:47 AM (Local: UTC+8hr)
Processing duration:	01:25:14
Processing interval:	1 second

Vector Components (Mark to Mark)

From:	SRS-60				
Grid		Local		Global	
Easting	863521.635 m	Latitude	N8°15'26.63928"	Latitude	N8°15'23.26276"
Northing	914200.696 m	Longitude	E126°17'56.66192"	Longitude	E126°18'02.07013"
Elevation	86.358 m	Height	83.083 m	Height	155.226 m

To:	BMSS-124				
Grid		Local		Global	
Easting	864399.330 m	Latitude	N8°13'07.07643"	Latitude	N8°13'03.71088"
Northing	909915.188 m	Longitude	E126°18'24.14676"	Longitude	E126°18'20.56843"
Elevation	7.131 m	Height	3.821 m	Height	76.062 m

Vector					
ΔEasting	877.695 m	NS Fwd Azimuth	168°53'56"	ΔX	-995.278 m
ΔNorthing	-4285.508 m	Ellipsoid Dist.	4369.046 m	ΔY	-66.246 m
ΔElevation	-79.227 m	ΔHeight	-79.262 m	ΔZ	-4254.421 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.005 m
σ ΔNorthing	0.002 m	σ Ellipsoid Dist.	0.002 m	σ ΔY	0.006 m
σ ΔElevation	0.008 m	σ ΔHeight	0.008 m	σ ΔZ	0.002 m

Aposteriori Covariance Matrix (Meter²)

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

Occupations

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

Tracking Summary

Annex 4. The LiDAR Survey Team Composition

Data Acquisition Component Sub-Team	Designation	Name	Agency/ Affiliation
PHIL-LIDAR 1	Program Leader	ENRICO PARINGIT, D.ENG	UP-TACAGP
Data Acquisition Component Leader	Data Component Project Leader – I	ENGR. CZAR JAIKIRI SARMIENTO	UP-TCAGP
	Data Component Project Leader – I	ENGR. LOUIE P. BALICANTA	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP-TCAGP
	Supervising Science Research Specialist (SupSRS)	ENGR. LOVELYN ASUNCION	UP-TCAGP
		LOVELY GRACIA ACUNA	UP-TCAGP
FIELD TEAM			
LiDAR Operation	Research Associate (RA)	MARY CATHERINE ELIZABETH BALIGUAS	UP-TCAGP
	RA	MA. REMEDIOS VILLANUEVA	UP-TCAGP
Ground Survey, Data Download and Transfer	RA	JONATHAN ALMALVEZ	UP-TCAGP
LiDAR Operation	Airborne Security	SSG. OLIVER SACLOT	PHILIPPINE AIR FORCE (PAF)
LiDAR Operation	Pilot	CAPT. JEFFREY JEREMY ALAJAR	ASIAN AEROSPACE CORPORATION (AAC)
LiDAR Operation		CAPT. ANGELO GARCHITORENA	AAC

Annex 5. Data Transfer Sheet for Bislig Floodplain

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

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
9-5-2014	1910A	3BLK66CS248A	AQUARIUS	NA	1156	1.7	257	76.7	567	12.3	NA	14.6	1KB	1KB	13	NA	Z:\DAC\RAW DATA
9-5-2015	1912A	3BLK66RS248B	AQUARIUS	NA	237	402	108	12.4	149	3.92	NA	14.6	1KB	1KB	11	NA	Z:\DAC\RAW DATA
9-9-2014	1918A	3BLK66RS250A	AQUARIUS	NA	228	1.03	237	NA	NA	10.1	NA	11	1KB	1KB	11	NA	Z:\DAC\RAW DATA

Received from

Name C JOAQUIN
Position RA
Signature [signature]

Received by

Name JOIDA PRIETO
Position SSRS
Signature [signature] 10/1/14

DATA TRANSFER SHEET

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

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
7/25/2014	1742A	3BLK61K206A, 3BLK61BCDES206A	Aquarius	NA	290	721	258	34.1	260	8.78	NA	8.53	1KB	1KB	5/14	37	Z:\AIRBORNE_RAW
7/27/2014	1750A	3BLK61L208A	Aquarius	NA	283	385	144	20	96	4.23	NA	15	1KB	1KB	4	197	Z:\DAC\RAWDATA
7/27/2014	1752A	3BLK61L208B	Aquarius	NA	283	322	130	5.41	46	3.35	NA	15	1KB	1KB	5/4	12	Z:\DAC\RAWDATA
7/29/2014	1758A	3BLK61FGHKMSN210A	Aquarius	NA	158/371/255	1.01	271	15.7	0	12.7	NA	8.76	1KB	1KB	6/7/5	5/17	Z:\DAC\RAWDATA
8/4/2014	1784A	3BLK66HSI216B	Aquarius	NA	81	2.05	191	41/17.9	318/166	10.7	NA	17.4	1KB	1KB	4/4	8/9	Z:\DAC\RAWDATA
8/8/2014	1798A	3BLK66N220A	Aquarius	NA	641	1.03	235	75.7	309	11.4	522	15.5	1KB	1KB	6	6	Z:\DAC\RAWDATA
8/8/2014	1800A	3BLK66O220B	Aquarius	NA	385	645	162	42.2	329	7.27	944	15.5	1KB	1KB	6	11	Z:\DAC\RAWDATA
8/8/2014	1804A	3BLK66OSP221B	Aquarius	NA	268/276	893	231	58.9	463	10.1	NA	14.1	1KB	1KB	6/6	11/12	Z:\DAC\RAWDATA
8/11/2014	1812A	3BLK66QS223B	Aquarius	NA	359	593	143	28.9	237	6.66	NA	18.3	1KB	1KB	6	13	Z:\DAC\RAWDATA
8/12/2014	1814A	3BLK66KR224A	Aquarius	NA	529/71	1	257	87.1	306	10.3	459	16.9	1KB	1KB	6/7	12/15	Z:\DAC\RAWDATA
8/12/2014	1816A	3BLK66RS224B	Aquarius	NA	212	457	169	NA	NA	9.21	NA	16.9	1KB	1KB	6	13	Z:\DAC\RAWDATA
8/12/2014	1818A	3BLK66D225A	Aquarius	NA	382	644	257	32.1	156	10.3	NA	9.12	1KB	1KB	7	15	Z:\DAC\RAWDATA
8/17/2014	1834A	3BLK66ASB229A	Aquarius	NA	170	405	175	NA	NA	7.71	NA	16.5	1KB	1KB	6	NA	Z:\DAC\RAWDATA
8/17/2014	1836A	3BLK66DS229B	Aquarius	NA	430	686	178	30.7	180	9.01	NA	16.5	1KB	1KB	7	6	Z:\DAC\RAWDATA

Received from

Name KRISTINE ANDAYA
Position RA
Signature

Received by

Name JOIDA PRIETO
Position SSRS
Signature 9/1/14

DATA TRANSFER SHEET

08/18/2014(Surigao del Sur(Tandag/Bislig)- ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
3/2014	1778A	3BLK66GH215A	Aquarius	NA	477/245	1.19	257	81.9	605	13	2.39	9.32	1KB	1KB	4/3	9/8	Z:\DAC\RAWDATA
3/2014	1780A	3BLK66HS215B	Aquarius	NA	563	922	174	53.7	462	9.9	NA	9.32	1KB	1KB	4	8	Z:\DAC\RAWDATA
4/2014	1782A	3BLK66F216A	Aquarius	NA	529	909	212	61.2	437	9.97 GB	616 MB	17.4	1KB	1KB	4	9	Z:\DAC\RAWDATA
5/2014	1786A	3BLK66ISJ217A	Aquarius	NA	301/475	1.51	244	100	674	14.2	NA	17.8	1KB	1KB	5	10/11	Z:\DAC\RAWDATA
5/2014	1788A	3BLK66EGS217B	Aquarius	NA	589/45	1.06	228	50.4	500	10.4	1.07	17.8	1KB	1KB	4/4	11/9	Z:\DAC\RAWDATA
6/2014	1790A	3BLK66M218A	Aquarius	NA	557	958	245	4.25/56.4	31/400	10.3	520 MB	11.9	1KB	1KB	5	11	Z:\DAC\RAWDATA
7/2014	1794A	3BLK66LMS219A	Aquarius	NA	324/239	0.99	261	48.6	337	13.9	NA	17.8	1KB	1KB	6/5	13/12	Z:\DAC\RAWDATA
7/2014	1796A	3BLK66LSJS219B	Aquarius	NA	352/578	1.1	226	54.9	524	10.8	NA	17.8	1KB	1KB	4/6	11/13	Z:\DAC\RAWDATA

Received from

Name TIN ANDAYA

Position RA

Signature

Received by

Name JOIDA PRIETO

Position SSRS

Signature 8/20/14

DATA TRANSFER SHEET

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

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/ CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION (S)	Base Info (.txt)		Actual	KML	
8/5/2014	1788A	3BLK66EGS217B	Aquarius	NA	589/45	1.06	228	50.4	500	10.4	1.07	17.8	1KB	1KB	4/4	11/9	Z:\DAC\RAWDATA
8/6/2014	1790A	3BLK66M218A	Aquarius	NA	557	958	245	4.25/56.4	31/400	10.3	520	11.9	1KB	1KB	5	11	Z:\DAC\RAWDATA
8/7/2014	1794A	3BLK66LMS219A	Aquarius	NA	324/239	0.99	261	48.6	337	13.9	NA	17.8	1KB	1KB	6/5	13/12	Z:\DAC\RAWDATA
8/7/2014	1796A	3BLK66LSJS219B	Aquarius	NA	352/578	1.1	226	54.9	524	10.8	NA	17.8	1KB	1KB	4/6	11/13	Z:\DAC\RAWDATA
8/18/2014	1838A	3BLK66SS230A	Aquarius	NA	646	1.4	245	45.8/21.3	1/343/129	12	NA	11.3	1KB	1KB	4/8	13/25	Z:\DAC\RAWDATA
8/19/2014	1842A	3BLK66T231A	Aquarius	NA	505	1.6	272	56.6	428	9.83	NA	9.7	1KB	1KB	7	16	Z:\DAC\RAWDATA
8/21/2014	1850A	3BLK66VW233A	Aquarius	NA	196/687	1.42	260	97.4	739	15.2	NA	10.6	1KB	1KB	4/9/6	8	Z:\DAC\RAWDATA
8/22/2014	1854A	3BLK66BWS234A	Aquarius	NA	45/395	872	248	45.5	352	8.36	NA	9.63	1KB	1KB	6/7	6/14	Z:\DAC\RAWDATA
8/26/2014	1870A	3BLK66ASB238A	Aquarius	NA	306/715	1.43	267	105	760	16.1	NA	10.5	1KB	1KB	4/5/5/5	8/9	Z:\DAC\RAWDATA

Received from

Name: TIN ANDAYA

Position: RA

Signature:

Received by

Name: JOIDA PRIETO 9/5/14

Position: SSRS

Signature:

DATA TRANSFER SHEET
7/3/2014(BISLIG)

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	
11-Aug-14	1810A	3BLK66PSQ223A	AQUARIUS	NA	353/763	1.44	269	15.9	650	13.7	13.3	18.3	1KB	1KB	5/6	11/12	Z:\DAC\RAW DATA
14-Aug-14	1822A	3BLK66S226A	AQUARIUS	NA	500	825	218	6.94	366	10.2	NA	11.7	1KB	1KB	23	23	Z:\DAC\RAW DATA
16-Aug-14	1830A	3BLK66A228A	AQUARIUS	NA	737	1.15	273	5.3	546	11.4	NA	12.1	1KB	1KB	6	6	Z:\DAC\RAW DATA

Received from

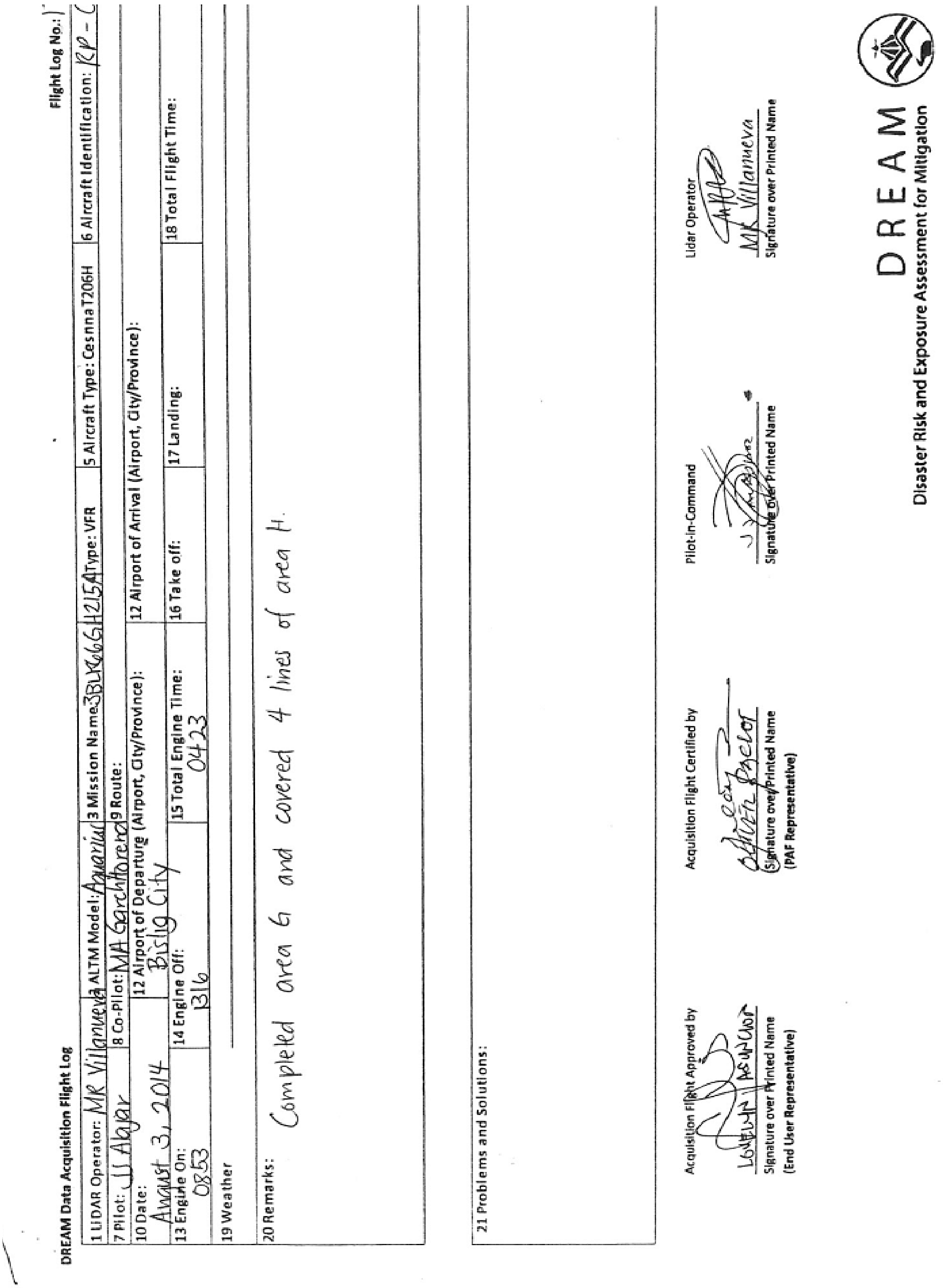
Name C.JOAQUIN
Position
Signature

Received by

Name JOIDA F. PRIETO
Position SSRS 9/1/2014
Signature

Annex 6. Flight Logs for the Flight Missions

Flight Log for 3BLK66GH215A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1

1 LiDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66GH215A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C
7 Pilot: JJ Abjar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 3, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0853	14 Engine Off: 1316	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks: Completed area 6 and covered 4 lines of area H.

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Lovelyn Asuncion	Oliver Bacior		MR Villanueva
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66HS215B Mission

DREAM Data Acquisition Flight Log

Flight Log No.:

1 LIDAR Operator: MCE Baliguas	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66HS215B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 3, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1507	14 Engine Off: 1812	15 Total Engine Time: 0305	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Hazy				

20 Remarks:

Mission completed but there are gaps due to strong gust of wind.

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Loveleen Asuncion	Olivia Sabelot	JJ Alajar	MCE Baliguas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66HSI216B Mission

DREAM Data Acquisition Flight Log

Flight Log No.: /

1 LIDAR Operator: MCE Baliguas	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66HSI216B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 4, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1443	14 Engine Off: 1800	15 Total Engine Time: 0317	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Hazy					

20 Remarks:

Covered gaps in area H and 13 lines of area I. Re-start the Di-ops in line 8 due to Camera Assertion failure.

21 Problems and Solutions:

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

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66ISJ217A Mission

Flight Log No.: 1

DREAM Data Acquisition Flight Log

1 LIDAR Operator: MCE Baliguas	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66ISJ217A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 5, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0803	14 Engine Off: 1220	15 Total Engine Time: 0417	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks:

Completed BLK66I and surveyed 10 lines over BLK66J; no digitizer.

21 Problems and Solutions:

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

DREAM

Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66EGS217B Mission

DREAM Data Acquisition Flight Log

Flight Log No.:

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66EGS217B	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 5, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1419	14 Engine Off: 1812	15 Total Engine Time: 0353	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Partly cloudy					

20 Remarks:

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

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Lovelyn Asuncion		JJ Alajar	MR Villanueva
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66LSJS219B Mission

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

1 LiDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66LSJS219B	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 7, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1428	14 Engine Off: 1821	15 Total Engine Time: 0353	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

Completed BLK66J and BLK66L; no digitizer

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Lovely Acuyangoa	[illegible]	JJ Alajar	MR Villanueva
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66D225A Mission

Flight Log No.: 1818A

DREAM Data Acquisition Flight Log

1 LiDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66D225A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 13, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0841	14 Engine Off: 1304	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: partly cloudy					

20 Remarks:

Covered 13 lines over BLK66D with voids due to high terrain. Camera not triggering from line 22.1 to 18; no digitizer.

21 Problems and Solutions:

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

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

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

Lidar Operator: MR Villanueva — Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66A228A Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 183

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66A228A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C91
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 16, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0925	14 Engine Off: 1348	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Partly cloudy				

20 Remarks:

Bathy survey over BLK66A; no digitizer data in line 4.2 and 6.2.

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Lovely Asuncion	Oliver Sibelot	JJ Alajar	MR Villanueva
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66AS229A Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 183[illegible]

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66AS229A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C912[illegible]
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 17, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0941	14 Engine Off: 1304	15 Total Engine Time: 0323	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Low cloud ceiling				

20 Remarks:

Supplementary bathy flight over BLK66A; no camera

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
[illegible]	[illegible]	JJ Alajar	MR Villanueva
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66DS229B Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 183[illegible]

1 LiDAR Operator: MCE Baliguas	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66DS229B	4 Type: VFR	5 Aircraft Type: CesnnaT206H
6 Aircraft Identification: RP-C9[illegible]				
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:		
10 Date: August 17, 2014	12 Airport of Departure (Airport, City/Province): Bislig City	12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1502	14 Engine Off: 1807	15 Total Engine Time: 0305	16 Take off:	17 Landing:
18 Total Flight Time:				
19 Weather: Cloudy				

20 Remarks:

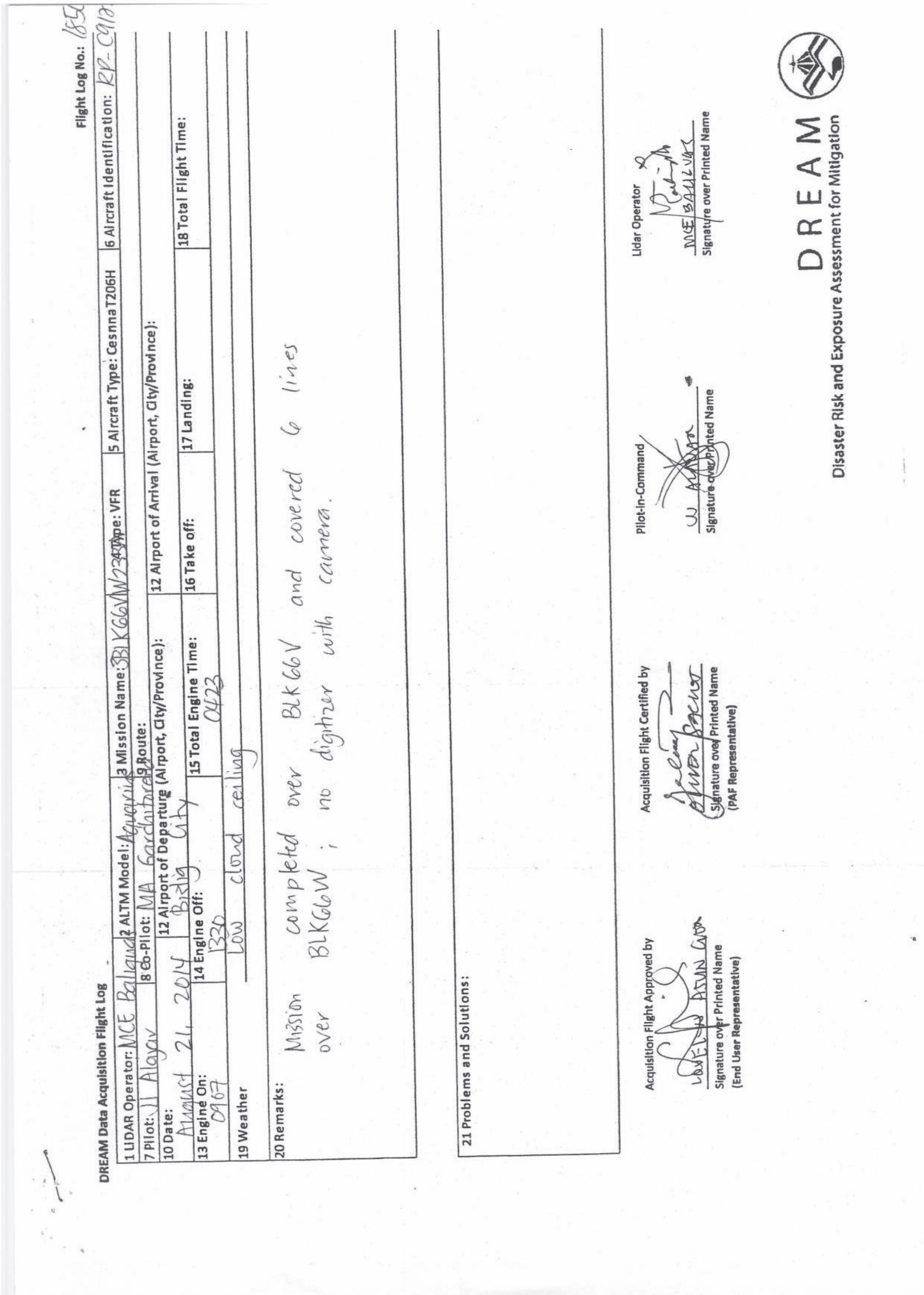
Surveyed 10 lines over BLK66D. Experienced error opening camera COM port; dark images at 1622H. No digitizer.

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Lovelyn Asuncion	[illegible]	JJ Alajar	MCE Baliguas
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66VW233A Mission



Flight Log No.: 1850

DREAM Data Acquisition Flight Log

1 LiDAR Operator: MCE Baliguas	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66VW233A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 21, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0907	14 Engine Off: 1330	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Low cloud ceiling				

20 Remarks:

Mission completed over BLK66V and covered 6 lines over BLK66W; no digitizer with camera.

21 Problems and Solutions:

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

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

Pilot-in-Command
JJ Alajar
Signature over Printed Name

Lidar Operator
MCE Baliguas
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66BWS234A Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 1854A

1 LIDAR Operator: MR Villanueva	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66BWS234A	4 Type: VFR	5 Aircraft Type: Cesnna T206H
6 Aircraft Identification: RP-C9122				
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garlitorena	9 Route:		
10 Date: August 22, 2014	12 Airport of Departure (Airport, City/Province): Bislig City	12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0917	14 Engine Off: 1340	15 Total Engine Time: 0423	16 Take off:	17 Landing:
18 Total Flight Time:				
19 Weather: Low cloud ceiling				

20 Remarks:

Changed area from BLK66B to BLK66W (11 lines) due to heavy clouds build up.

21 Problems and Solutions:

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

Acquisition Flight Certified by: Jhem? Opeñor — Signature over Printed Name (PAF Representative)

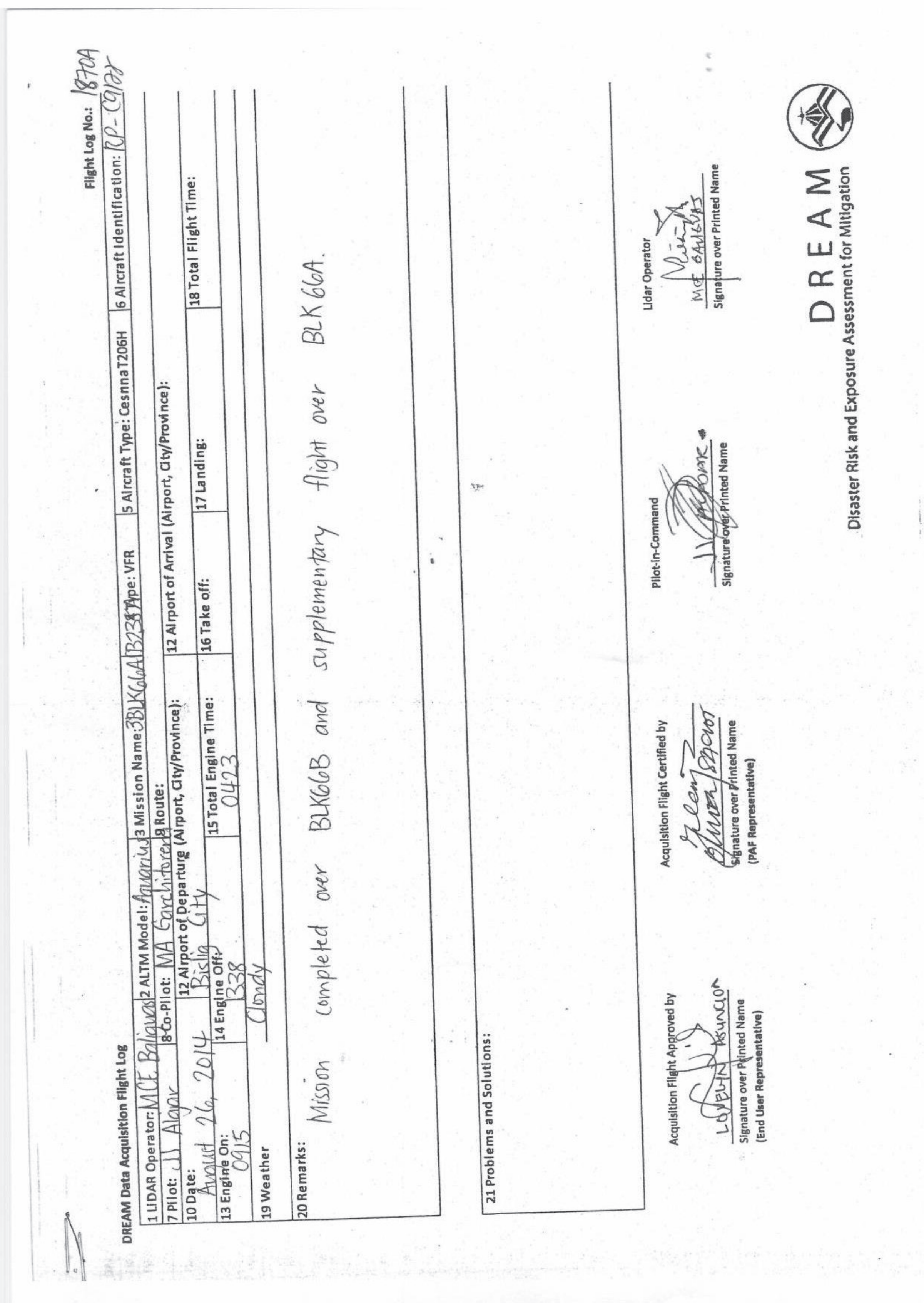
Pilot-in-Command: JJ Alajar — Signature over Printed Name

Lidar Operator: MR Villanueva — Signature over Printed Name

DREAM

Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66ASB238A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 1870A

1 LiDAR Operator: MCE Baligues	2 ALTM Model: Aquarius	3 Mission Name: 3BLK66ASB238A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: JJ Alajar	8 Co-Pilot: MA Garchitorena	9 Route:			
10 Date: August 26, 2014	12 Airport of Departure (Airport, City/Province): Bislig City		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0915	14 Engine Off: 1338	15 Total Engine Time: 0423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Cloudy					

20 Remarks: Mission completed over BLK66B and supplementary flight over BLK66A.

21 Problems and Solutions:

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

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

Pilot-in-Command: Signature over Printed Name

Lidar Operator: MCE Baligues — Signature over Printed Name

DREAM — Disaster Risk and Exposure Assessment for Mitigation

Flight Log for 3BLK66C245A Mission

PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 1898

1 LiDAR Operator: L- ASUNCION	2 ALTM Model: AQUA	3 Mission Name: 3BLK66C254A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9122
7 Pilot: JJ ALAJAR	8 Co-Pilot: MA GARCHITORENA	9 Route:			
10 Date: Sept. 2, 2014	12 Airport of Departure (Airport, City/Province): BISLIG		12 Airport of Arrival (Airport, City/Province): BISLIG		
13 Engine On: 0907	14 Engine Off: 1330	15 Total Engine Time: 4+23	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					
20 Remarks: completed Blk 66 C.					

21 Problems and Solutions:

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

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

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

Lidar Operator: LOVELYN ASUNCION — Signature over Printed Name

Flight Log for 3BLK66CSU248A Mission

PHIL-LiDAR 1 Data Acquisition Flight Log — **Flight Log No.:** 1910A

1 LiDAR Operator: L. ASUNCION	2 ALTM Model: AQUA	3 Mission Name: 3BLK66CSU248A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: JJ ALAJAR	8 Co-Pilot: MA SARCHITORENA	9 Route:			
10 Date: Sept. 5, 2014	12 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0850	14 Engine Off: 1313	15 Total Engine Time: 4+23	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Partly cloudy				

20 Remarks:

Covered remaining strips and data voids over BLK66C & BLK66U

21 Problems and Solutions:

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

Annex 7. Flight Status Reports

FLIGHT NO.	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1778A	BLK66G & BLK66H	3BLK66GH215A	MR. VILLANUEVA	03-Aug-14	Completed area G and covered 4 lines of area H.
1780A	BLK66H	3BLK66HS215B	MCE BALIGUAS	03-Aug-14	Mission completed but there are gaps due to strong gust of wind
1784A	BLK66H & BLK66I	3BLK66HSI216B	MCE BALIGUAS	04-Aug-14	Covered gaps in area H and 13 lines of area I. Restart the Di-ops in line 8 due to Camera Assertion failure.
1786A	BLK66I & BLK66J	3BLK66ISJ217A	MR. VILLANUEVA	05-Aug-14	Completed area I and 9 lines of area J
1788A	BLK66E & BLK66G	3BLK66EGS217B	MCE BALIGUAS	05-Aug-14	Completed area G and E. (Bathy survey on area E @ 500m.
1796A	BLK66L & BLK66J	3BLK66LSJS219B	MR. VILLANUEVA	07-Aug-14	Completed area L and J.
1798A	BLK66N	3BLK66N220A	MR. VILLANUEVA	08-Aug-14	Mission completed. Digitizer error in line 1, lines 4 onwards has digitizer.
1818A	BLK66D	3BLK66D225A	MR. VILLANUEVA	13-Aug-14	Covered 13 lines. Camera is not triggering in some lines.
1830A	BLK66A	3BLK66A228A	MR. VILLANUEVA	16-Aug-14	Covered 12 lines
1834A	BLK66A	3BLK66AS229A	MR. VILLANUEVA	17-Aug-14	Mission completed. No camera for this flight.
1836A	BLK66D	3BLK66DS229B	MCE BALIGUAS	17-Aug-14	One line left for this mission. No digitzer, camera not triggering in lines 13, 15 & 16
1850A	BLK66V & BLK66W	3BLK66VW233A	MCE BALIGUAS	21-Aug-14	Competed area V. Covered several strips of area W. No digitizer for this flight.
1854A	BLK66B & BLK66W	3BLK66BWS234A	MR. VILLANUEVA	22-Aug-14	Covered 10 lines of area W and 1 line/tieline in area B.
1870A	BLK66A & BLK66B	3BLK66ASB238A	MCE BALIGUAS	26-Aug-14	Completed area B and and area AS (additional/ supplementary flight for area A)
1898A	BLK66C	3BLK66C245A	L. ASUNCION	2-Sep-14	Covered several strips of area C. Camera error in line 3.No images in line 3 onwards. New cam ssd used in line 9. No digitizer
1910A	BLK66C	3BLK66CSU248A	L. ASUNCION	5-Sep-14	Supplementary flight for area C. Completed area C and 4 strips of area U, including tie line. Lost connection with pilot display, pilots had a hard time navigate the line. No digitizer

1. Swath Coverage of Mission 3BLK66GH215A

FLIGHT LOG NO. 1778A

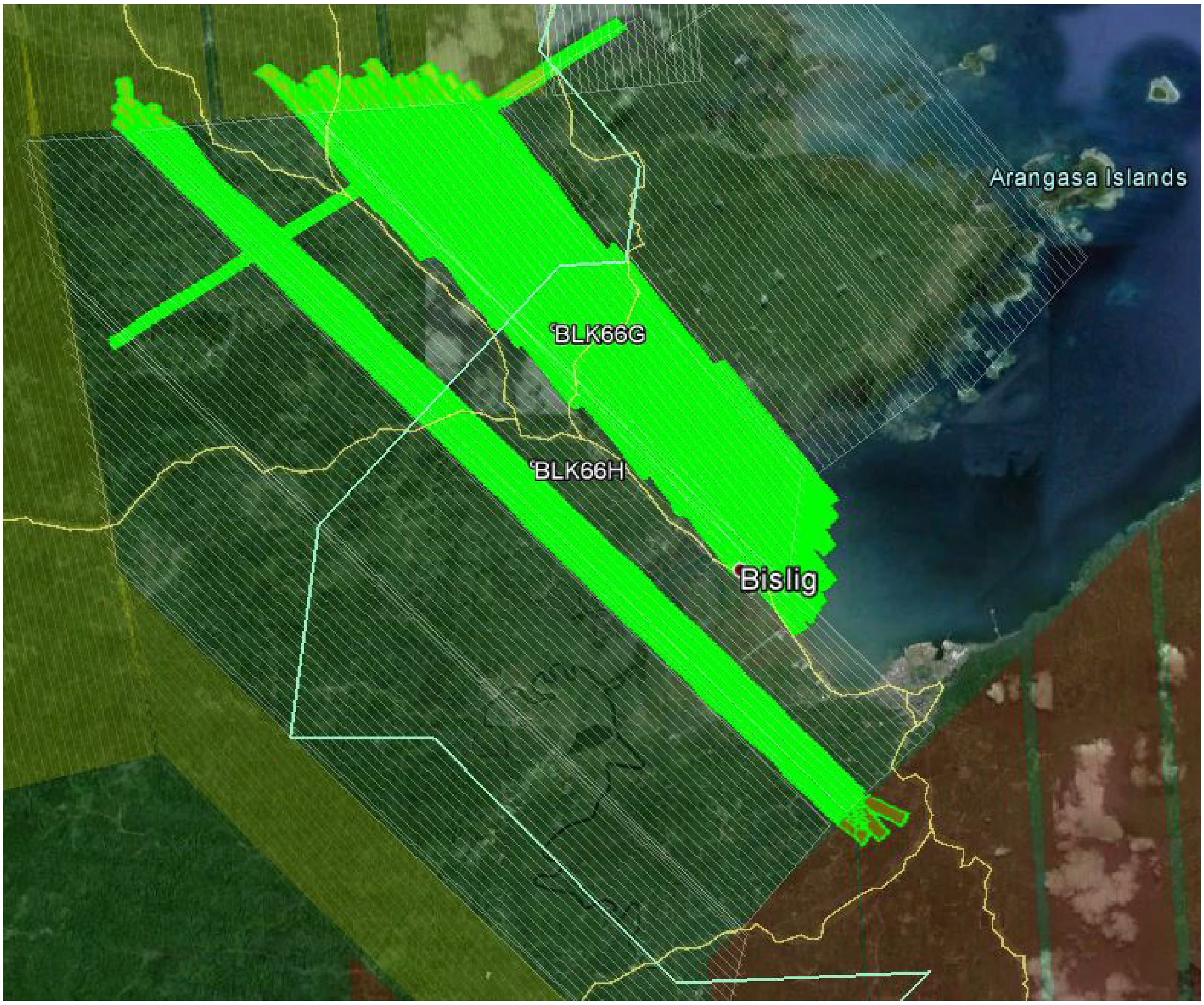
AREA: BLK66G & BLK66H

MISSION NAME: 3BLK66GH215A

SWATH AREA: 97.59 sq.km

PARAMETERS: Alt: 600 m Scan Freq: 40 kHz Scan Angle: 18 deg

SURVEY COVERAGE:



2. Swath Coverage of Mission 3BLK66HS215B

FLIGHT LOG NO. 1780

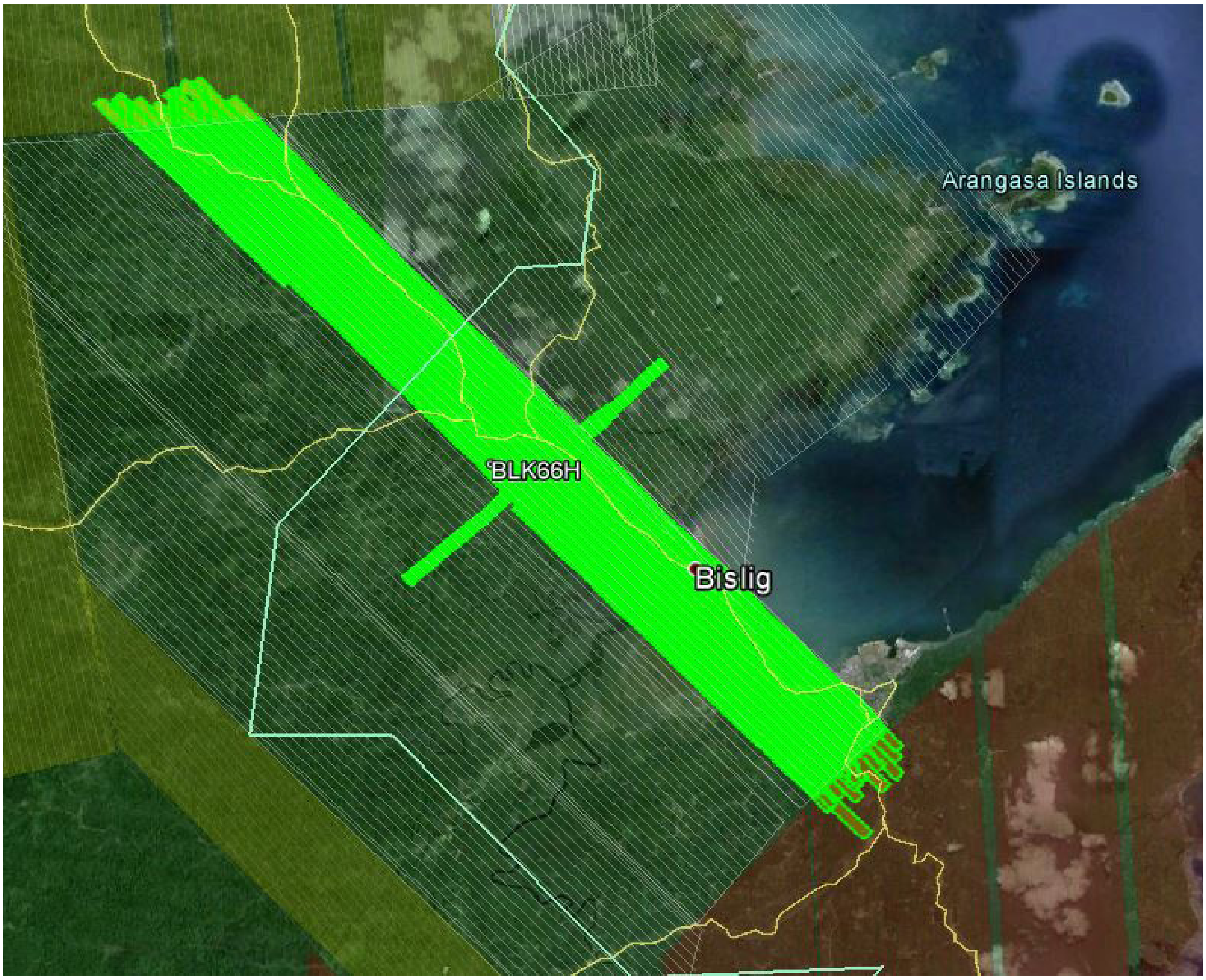
AREA: BLK66H

MISSION NAME: 3BLK66HS215B

SWATH AREA: 72.83 sq.km

PARAMETERS: Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg

SURVEY COVERAGE:

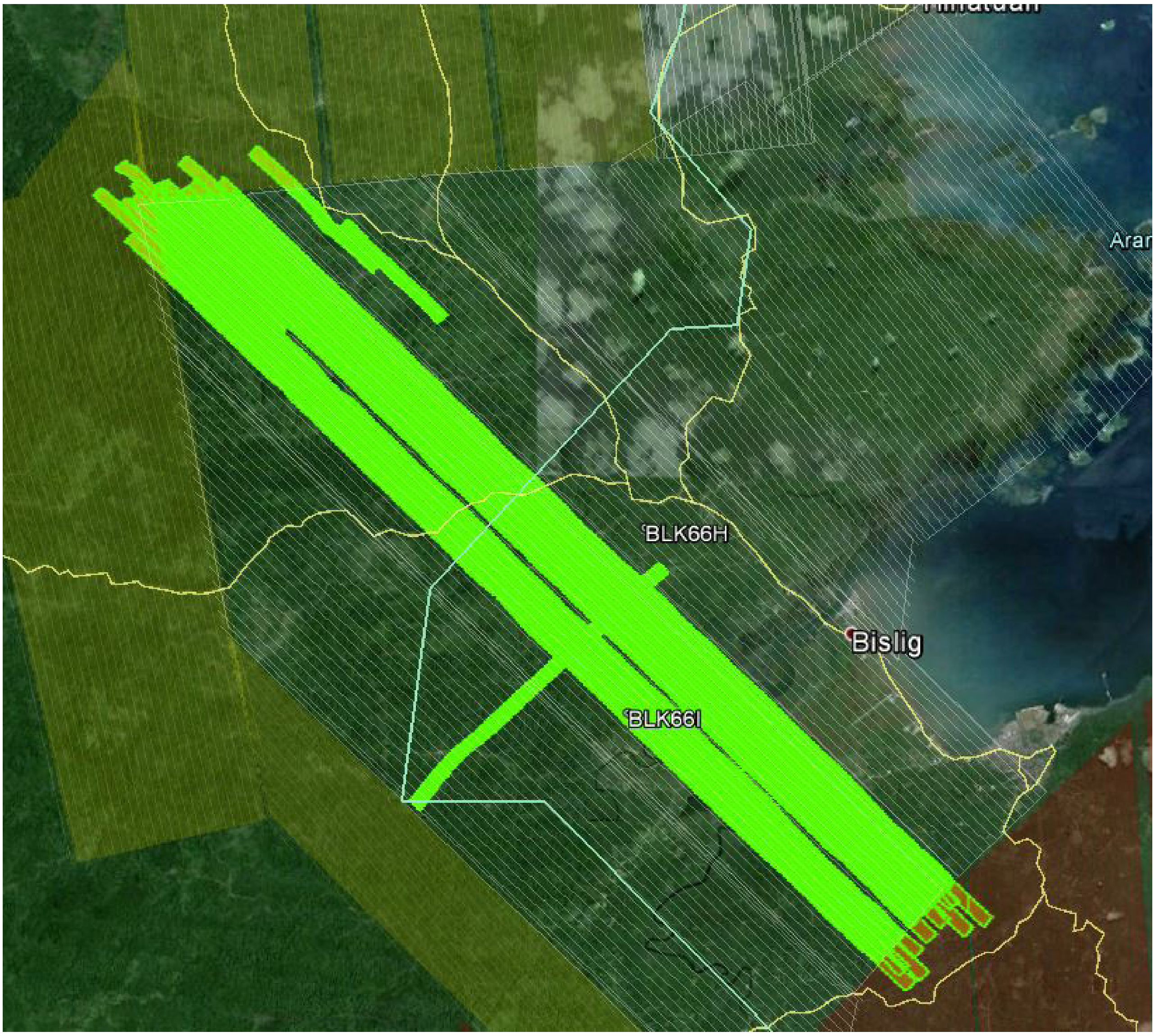


3. Swath Coverage of Mission 3BLK66F216A

FLIGHT LOG NO.	1782A
AREA:	BLK66F
MISSION NAME:	3BLK66F216A
SWATH AREA:	61.16 sq.km
PARAMETERS:	Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg
SURVEY COVERAGE:	

4. Swath Coverage of Mission 3BLK66HSI216B

FLIGHT LOG NO.	1784A
AREA:	BLK66H & BLK66I
MISSION NAME:	3BLK66HSI216B
SWATH AREA:	85.07 sq.km
PARAMETERS:	Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg
SURVEY COVERAGE:	



5. Swath Coverage of Mission 3BLK66ISJ217A

FLIGHT LOG NO. 1786A

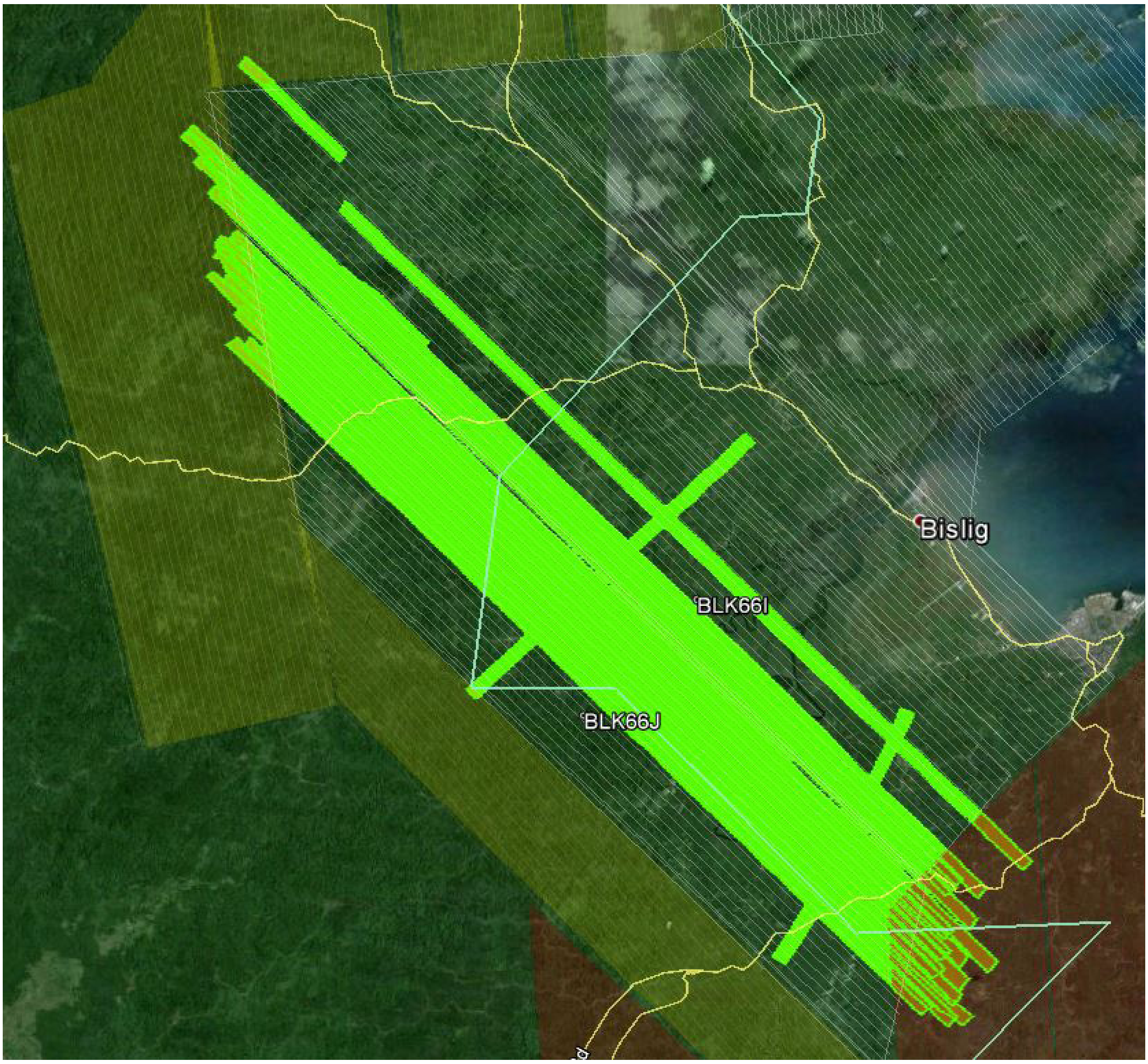
AREA: BLK66I & BLK66J

MISSION NAME: 3BLK66ISJ217A

SWATH AREA: 109.02 sq.km

PARAMETERS: Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg

SURVEY COVERAGE:



6. Swath Coverage of Mission 3BLK66EGS217B

FLIGHT LOG NO. 1788A

AREA: BLK66E & BLK66G

MISSION NAME: 3BLK66EGS217B

SWATH AREA: 80.67 sq.km

PARAMETERS: Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg

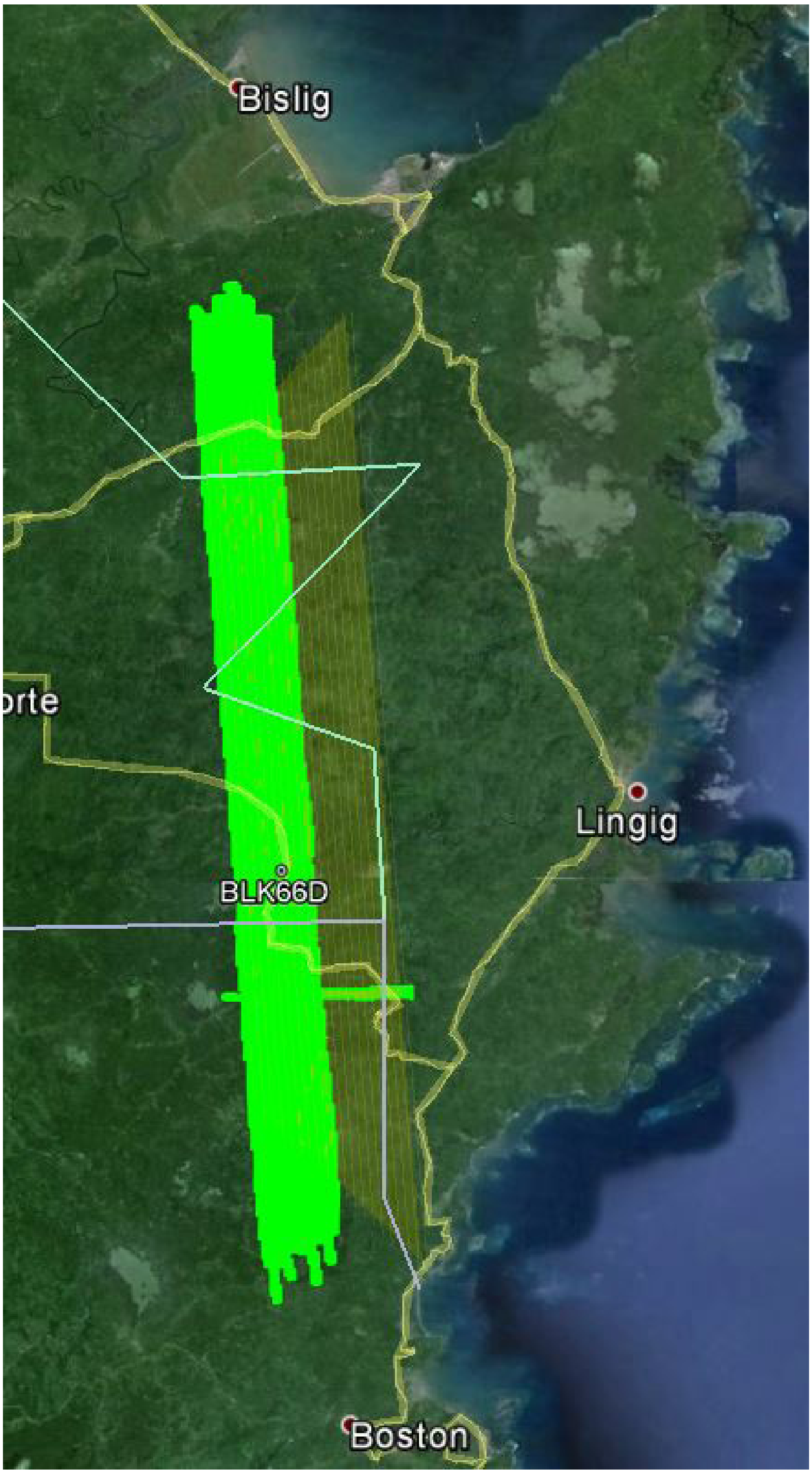
SURVEY COVERAGE:

7. Swath Coverage of Mission 3BLK66LSJS219B

FLIGHT LOG NO. 1796A
AREA: BLK66L & BLK66J
MISSION NAME: 3BLK66LSJS219B
SWATH AREA: 93.57 sq.km
PARAMETERS: Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg
SURVEY COVERAGE:

8. Swath Coverage of Mission 3BLK66D225A

FLIGHT LOG NO.	1818A
AREA:	BLK66D
MISSION NAME:	3BLK66D225A
SWATH AREA:	58.99 sq.km
PARAMETERS:	Alt: 600 m Scan Freq: 40 kHz Scan Angle: 25 deg
SURVEY COVERAGE:	



9. Swath Coverage of Mission 3BLK66A228A

FLIGHT LOG NO.	1830A		
AREA:	BLK66A		
MISSION NAME:	3BLK66A228A		
SWATH AREA:	71.64 sq.km		
PARAMETERS:	Alt: 500 m	Scan Freq: 45 kHz	Scan Angle: 18 deg
SURVEY COVERAGE:			

10.Swath Coverage of Mission 3BLK66AS229A

FLIGHT LOG NO. 1834A

AREA: BLK66A

MISSION NAME: 3BLK66AS229A

SWATH AREA: 60.36 sq.km.

PARAMETERS: Alt: 500 m Scan Freq: 45 kHz Scan Angle: 18 deg

SURVEY COVERAGE:

11. Swath Coverage of Mission 3BLK66DS229B

FLIGHT LOG NO. 1836A

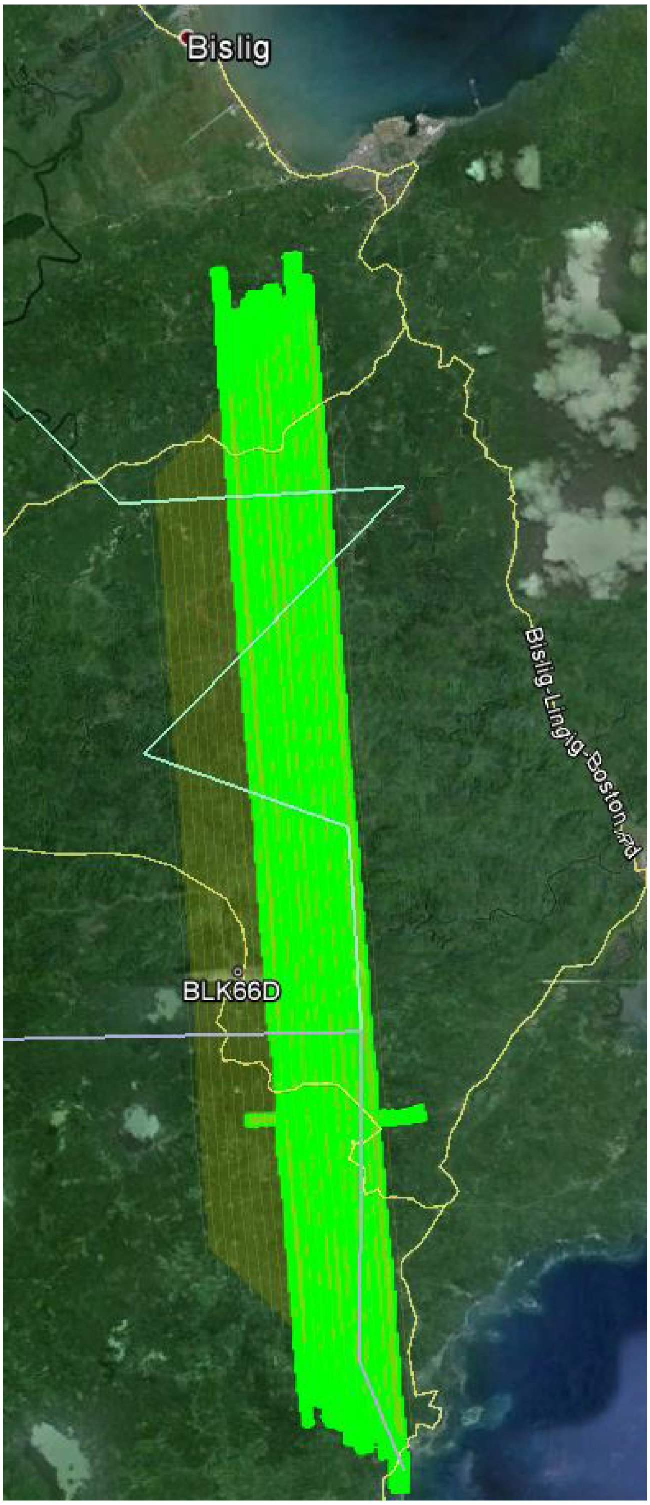
AREA: BLK66D

MISSION NAME: 3BLK66DS229B

SWATH AREA: 64.78 sq.km

PARAMETERS: Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg

SURVEY COVERAGE:



12.Swath Coverage of Mission 3BLK66VW233A

FLIGHT LOG NO. 1850A

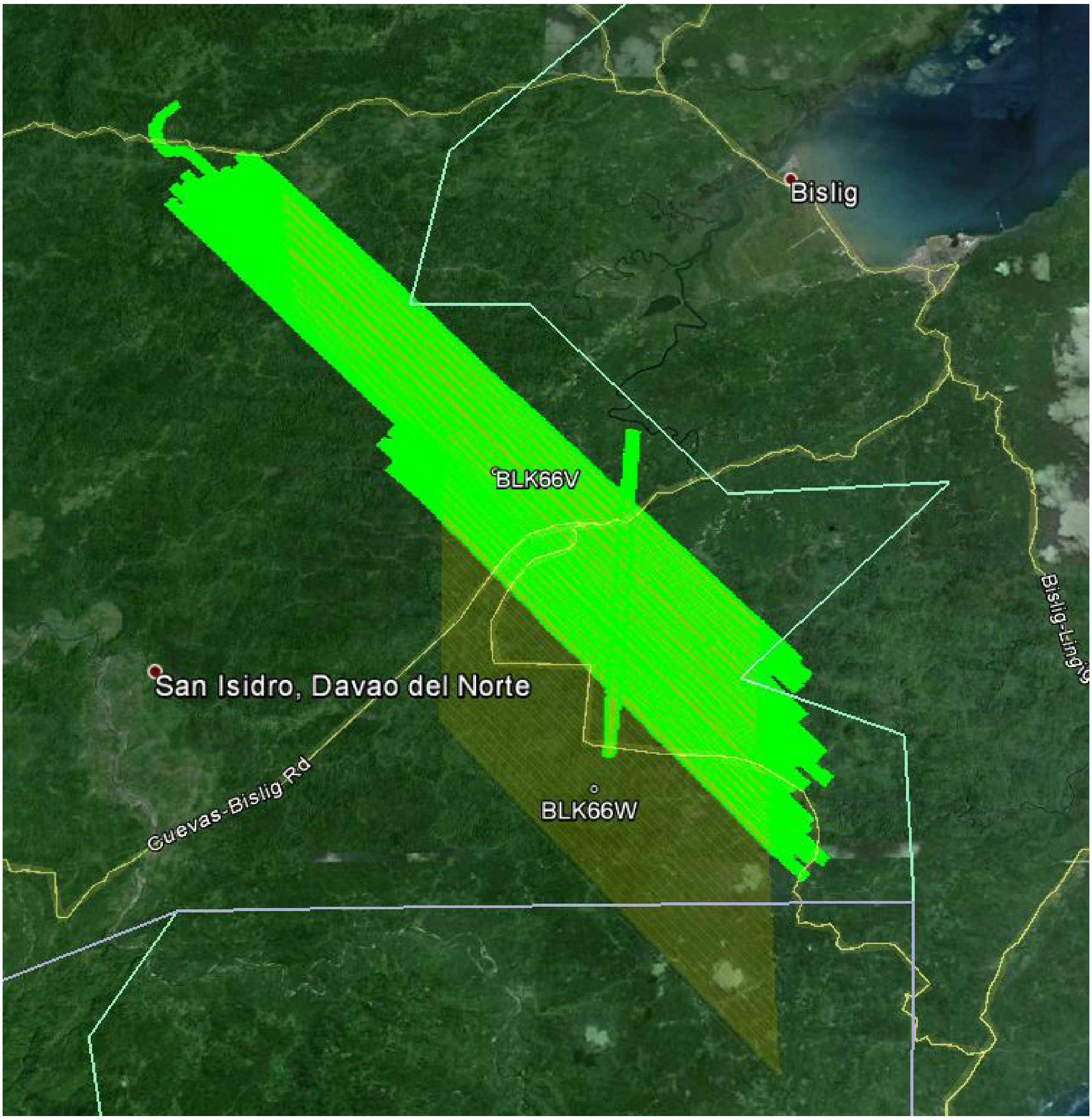
AREA: BLK66V and BLK66W

MISSION NAME: 3BLK66VW233A

SWATH AREA: 114.26 sq.km

PARAMETERS: Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg

SURVEY COVERAGE:



13.Swath Coverage of Mission 3BLK66BWS234A

FLIGHT LOG NO. 1854A

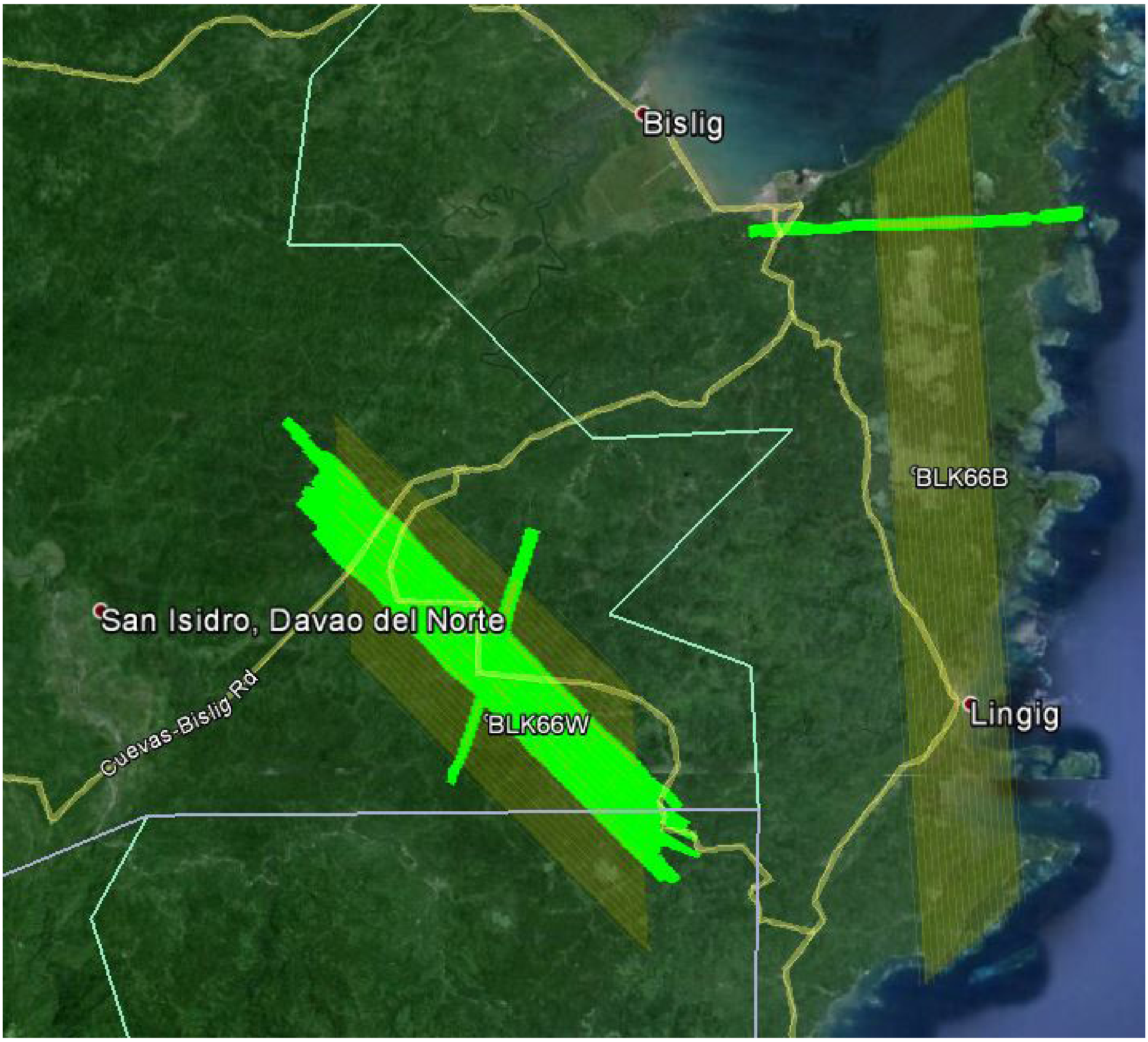
AREA: BLK66B and BLK66W

MISSION NAME: 3BLK66BWS234A

SWATH AREA: 42.76 sq.km

PARAMETERS: Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg

SURVEY COVERAGE:



14. Swath Coverage of Mission 3BLK66ASB238A

FLIGHT LOG NO.	1870A
AREA:	BLK66B and BLK66W
MISSION NAME:	3BLK66ASB238A
SWATH AREA:	133.12 sq.km
PARAMETERS:	Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg

SURVEY COVERAGE:

15. Swath Coverage of Mission 3BLK66C245A

FLIGHT LOG NO. 1898A

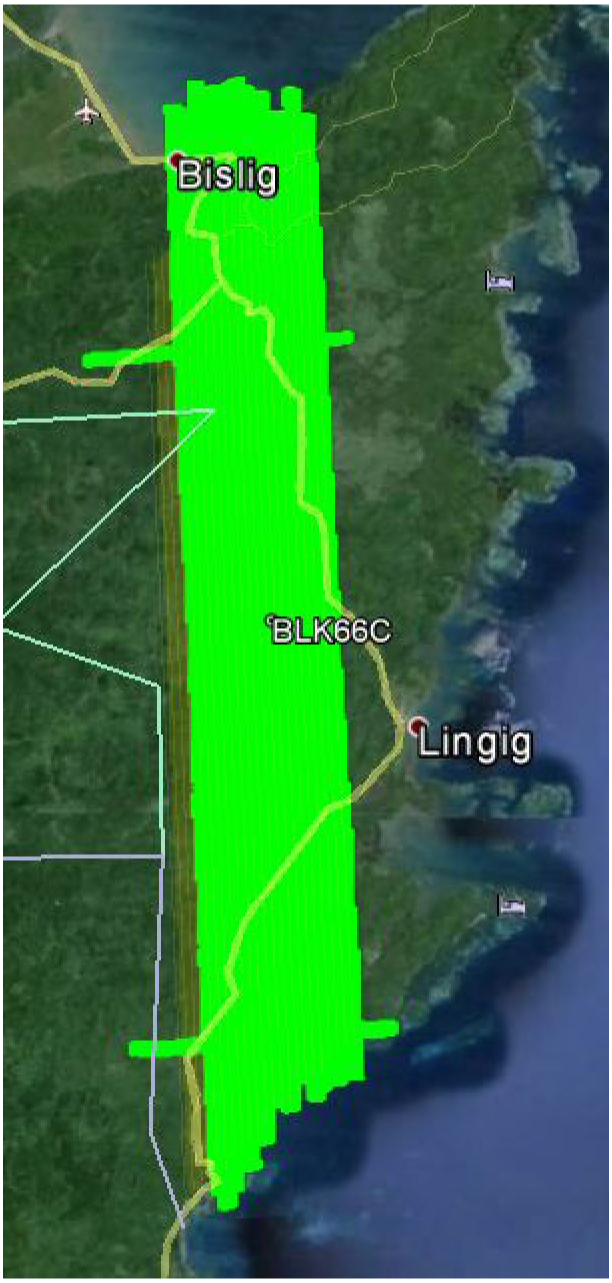
AREA: BLK66C

MISSION NAME: 3BLK66C245A

SWATH AREA: 125.17 sq.km

PARAMETERS: Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg

SURVEY COVERAGE:



16. Swath Coverage of Mission 3BLK66CSU248A

FLIGHT LOG NO. 1910A

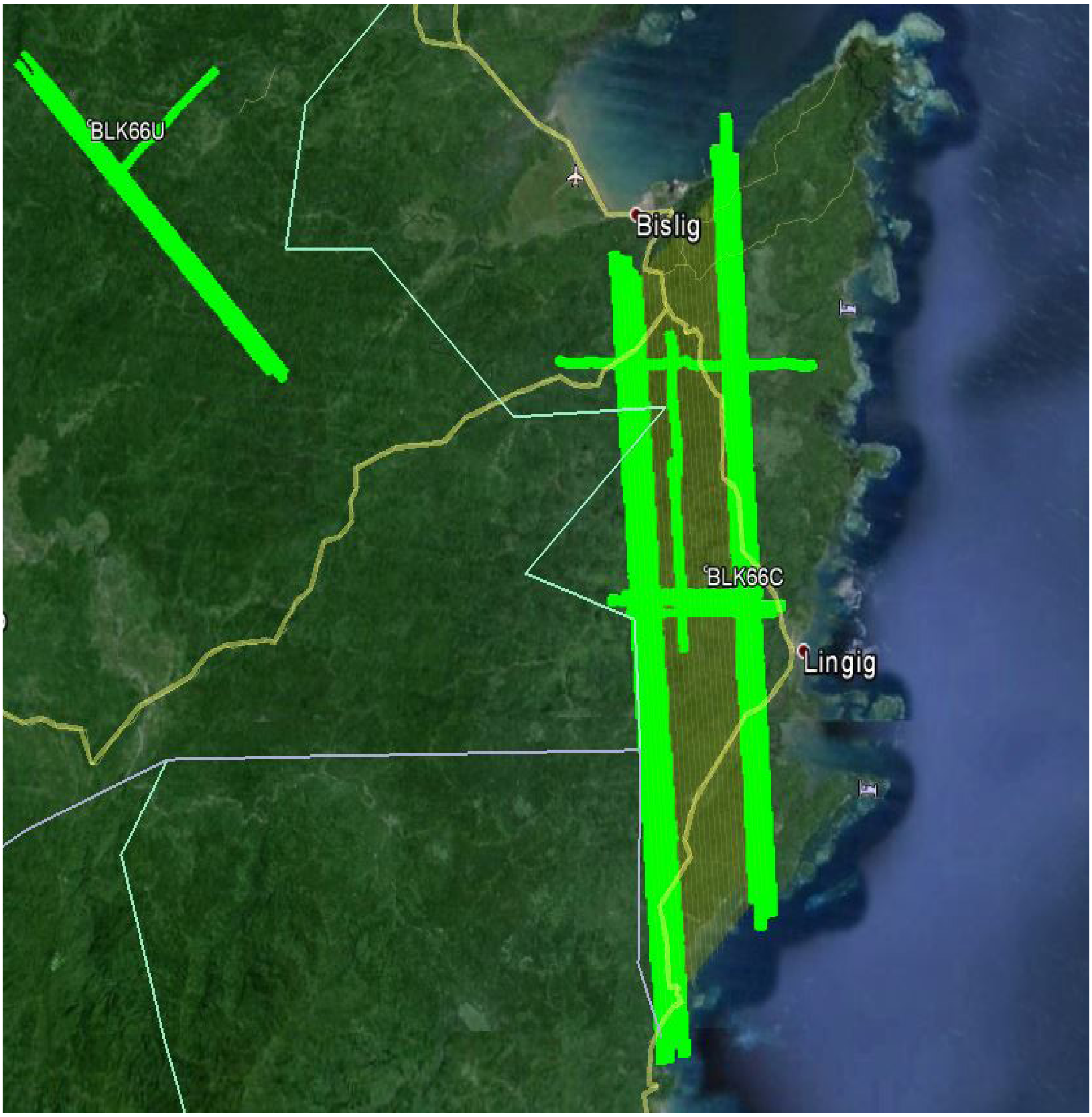
AREA: BLK66C and BLK66U

MISSION NAME: 3BLK66CSU248A

SWATH AREA: 90.41 sq.km

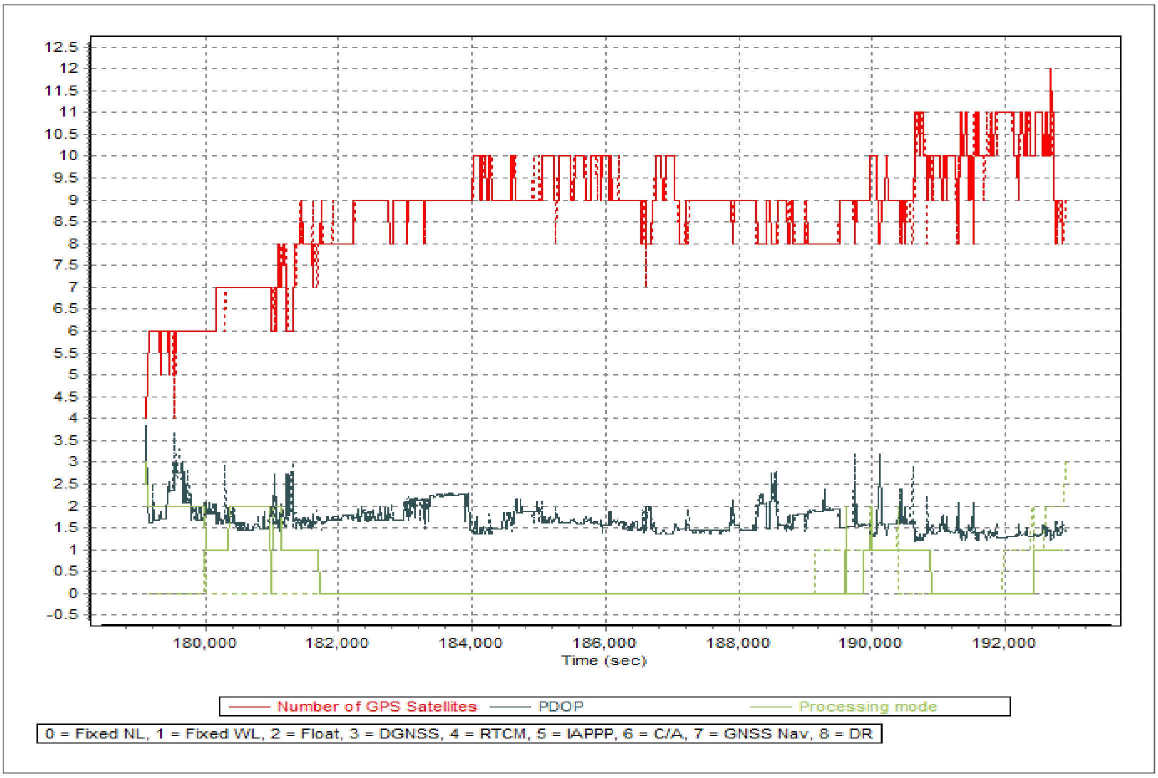
PARAMETERS: Alt: 600 m Scan Freq: 45 kHz Scan Angle: 18 deg

SURVEY COVERAGE:

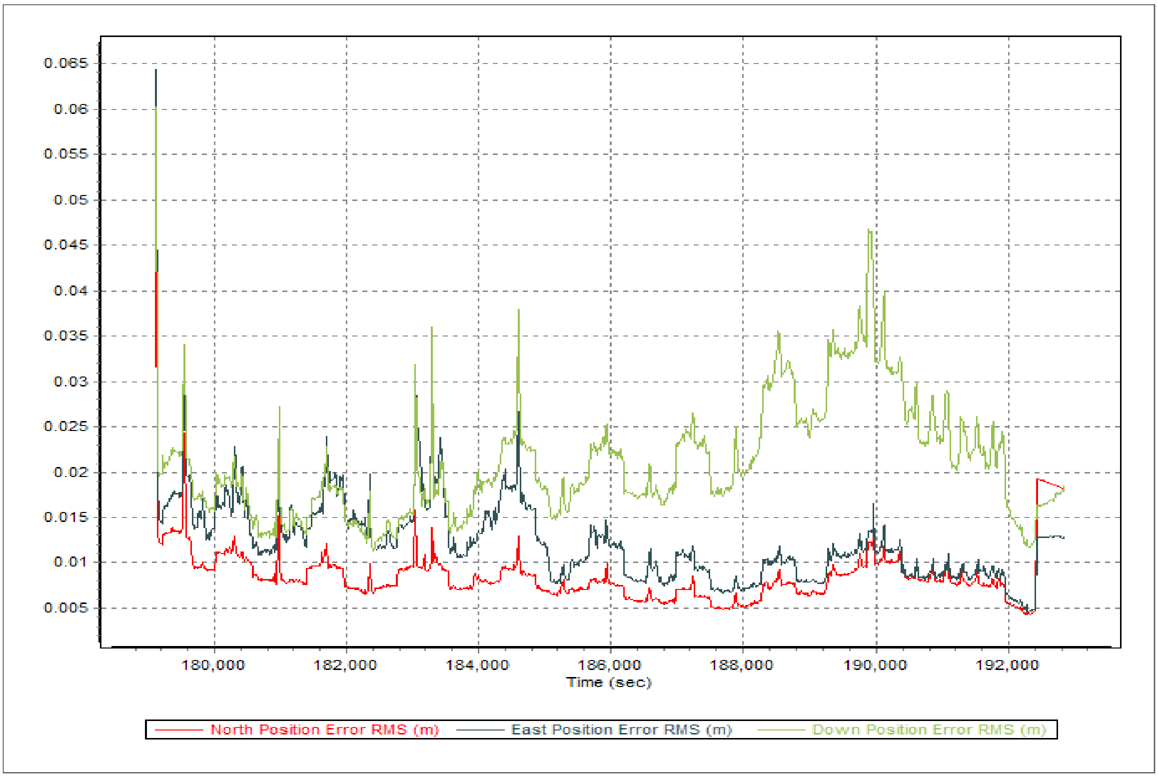


Annex 8. Mission Summary Report

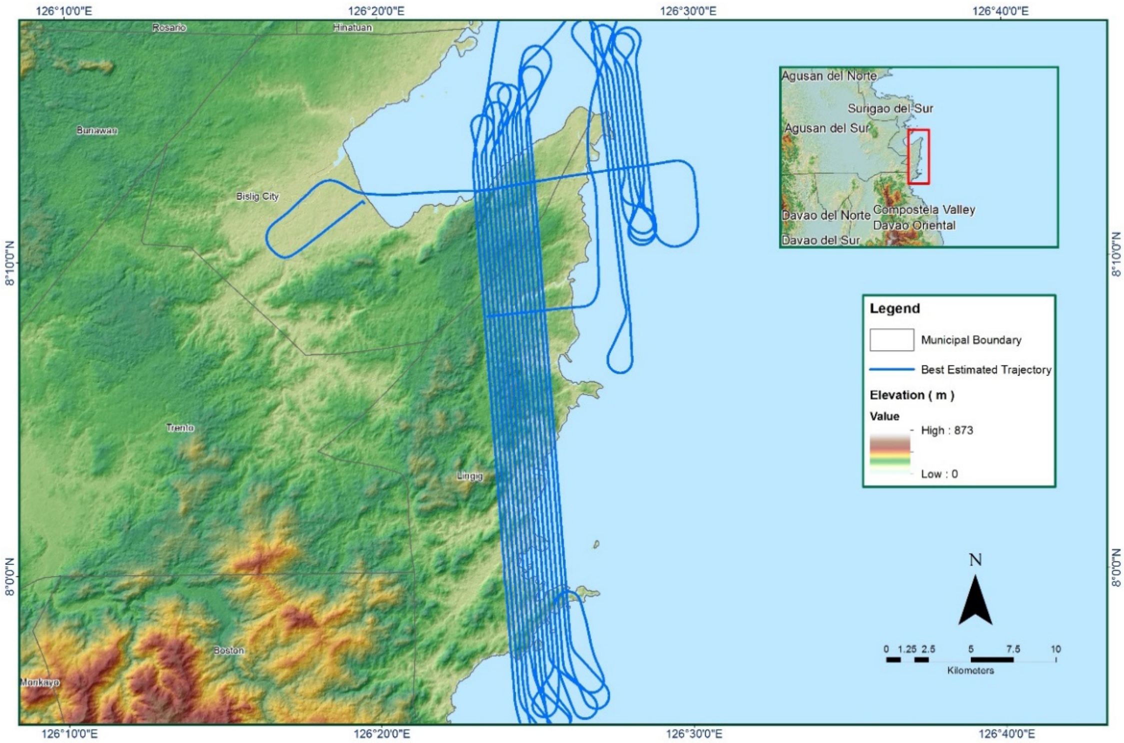
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66AB**
Inclusive Flights	1830A, 1834A, 1854A & 1870A
Range data size	43.57 GB
POS	963 MB
Base Data	36.63 MB
Image	5.30 GB
Transfer date	September 1 & September 5, 2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics(in cm)	
RMSE for North Position (<4.0 cm)	2.40
RMSE for East Position (<4.0 cm)	3.40
RMSE for Down Position (<8.0 cm)	6.00
Boresight correction stdev (<0.001deg)	0.000551
IMU attitude correction stdev (<0.001deg)	0.003793
GPS position stdev (<0.01m)	0.0042
Minimum % overlap (>25)	42.51
Ave point cloud density per sq.m. (>2.0)	2.91
Elevation difference between strips (<0.20m)	Yes
Number of 1km x 1km blocks	315
Maximum Height	348.55 m
Minimum Height	46.6 m
Classification (# of points)	
Ground	89560497
Low vegetation	90607261
Medium vegetation	176120797
High vegetation	185784702
Building	4444415
Orthophoto	Yes
Processed by	Engr. Angelo Carlo Bongat, Engr. Chelou Prado, Engr. Elainne Lopez



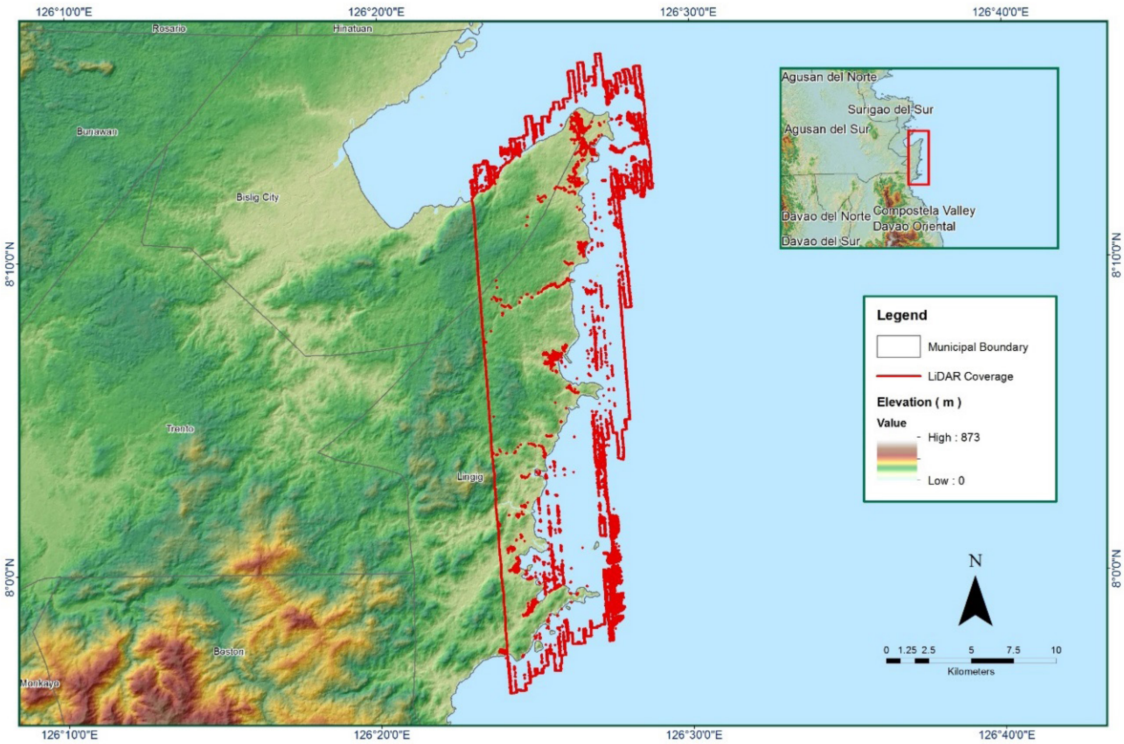
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

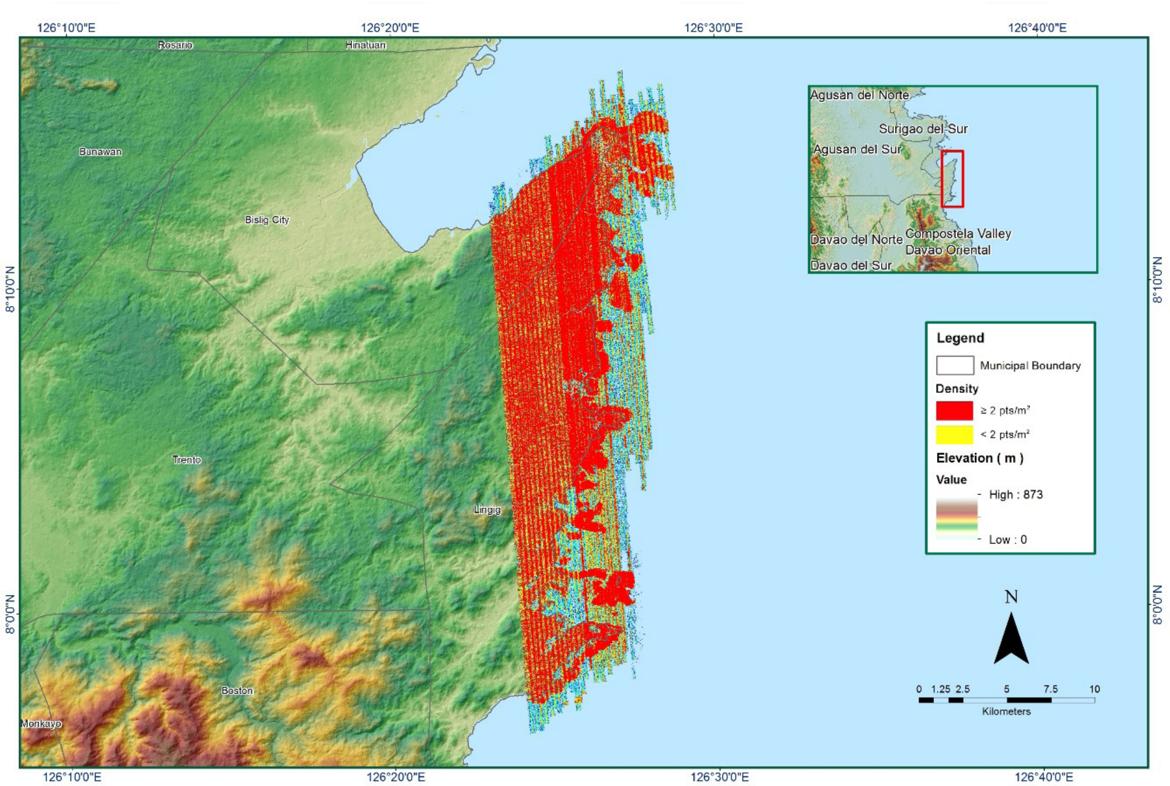
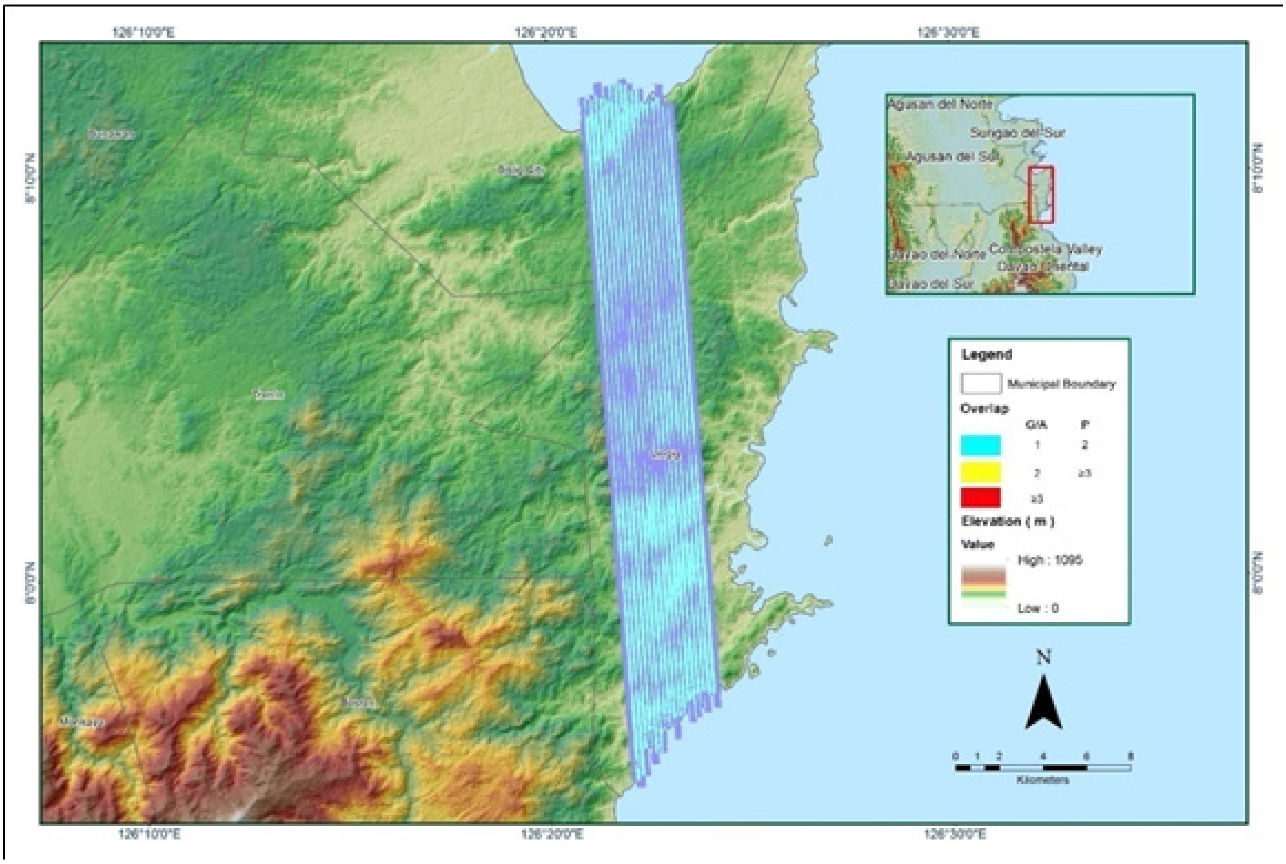
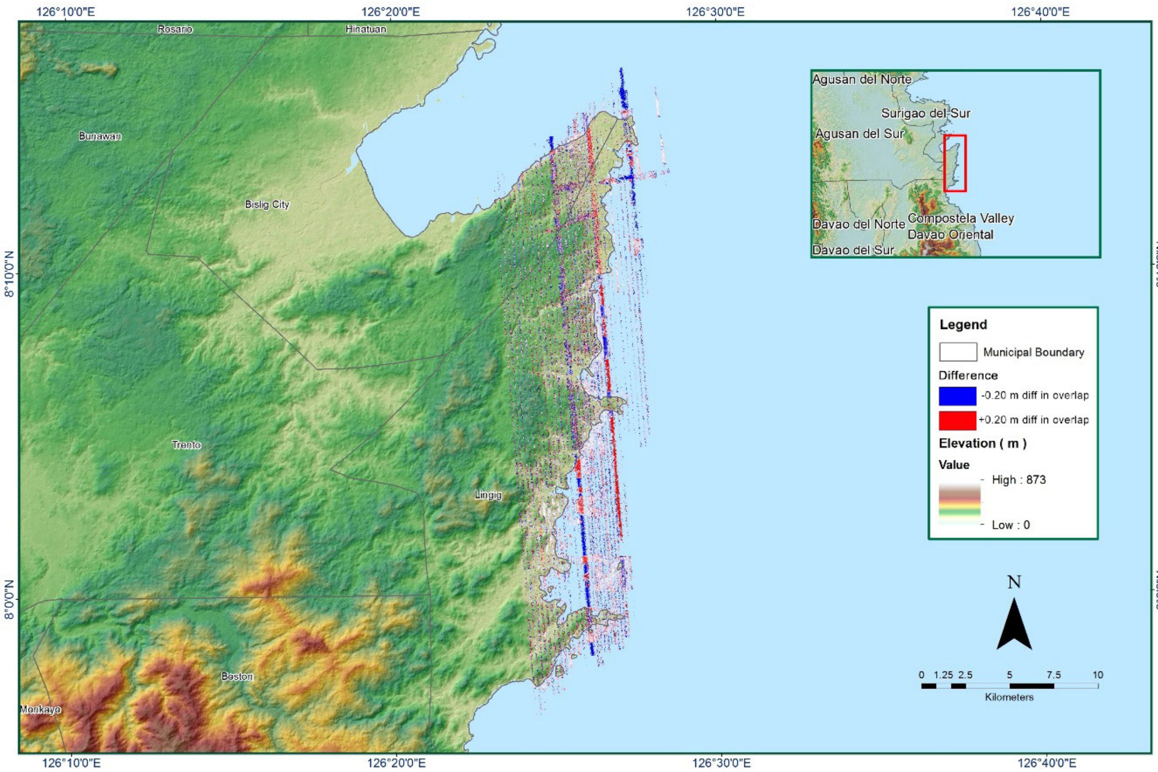


Image of data overlap

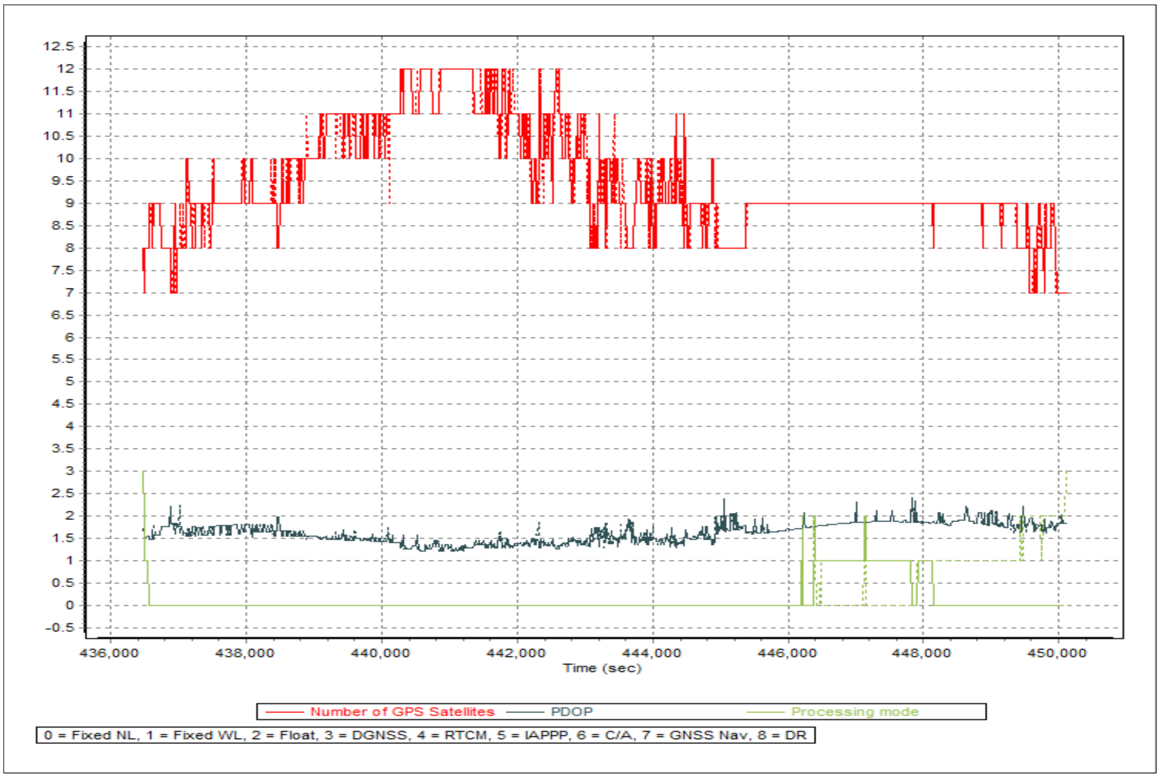


Density map of merged LiDAR data

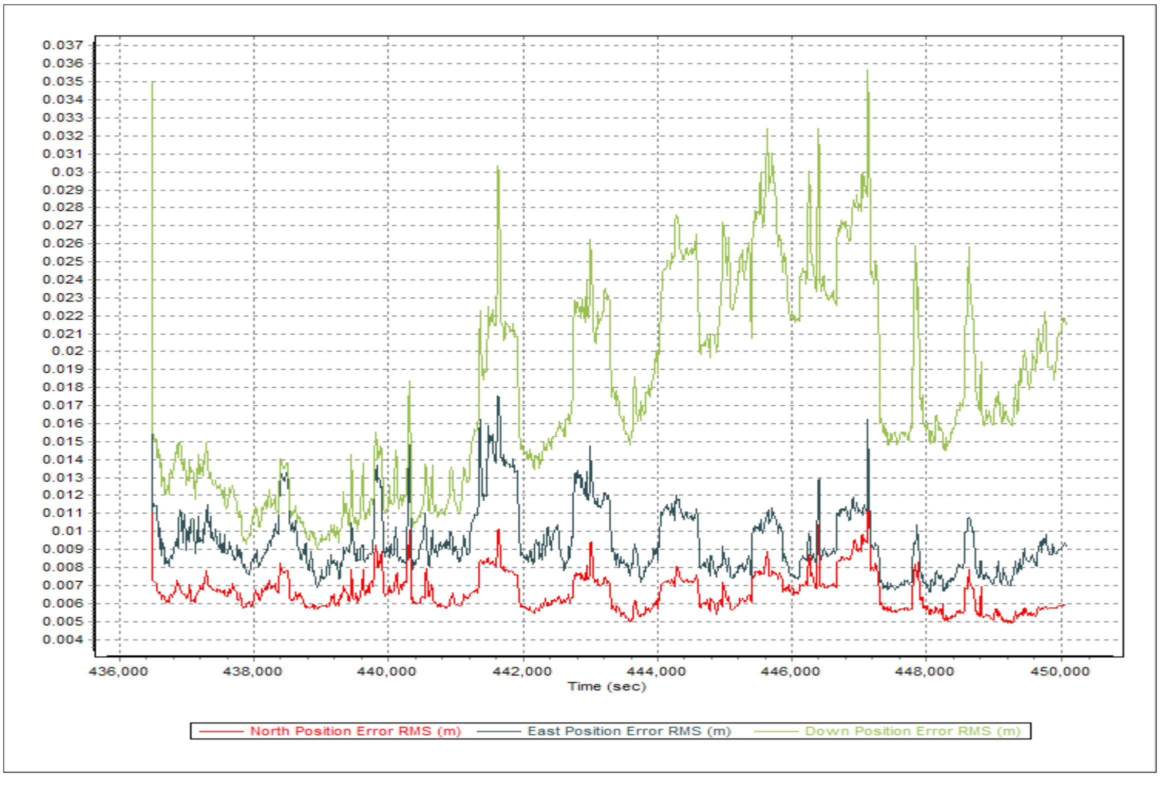


Elevation difference between flight lines

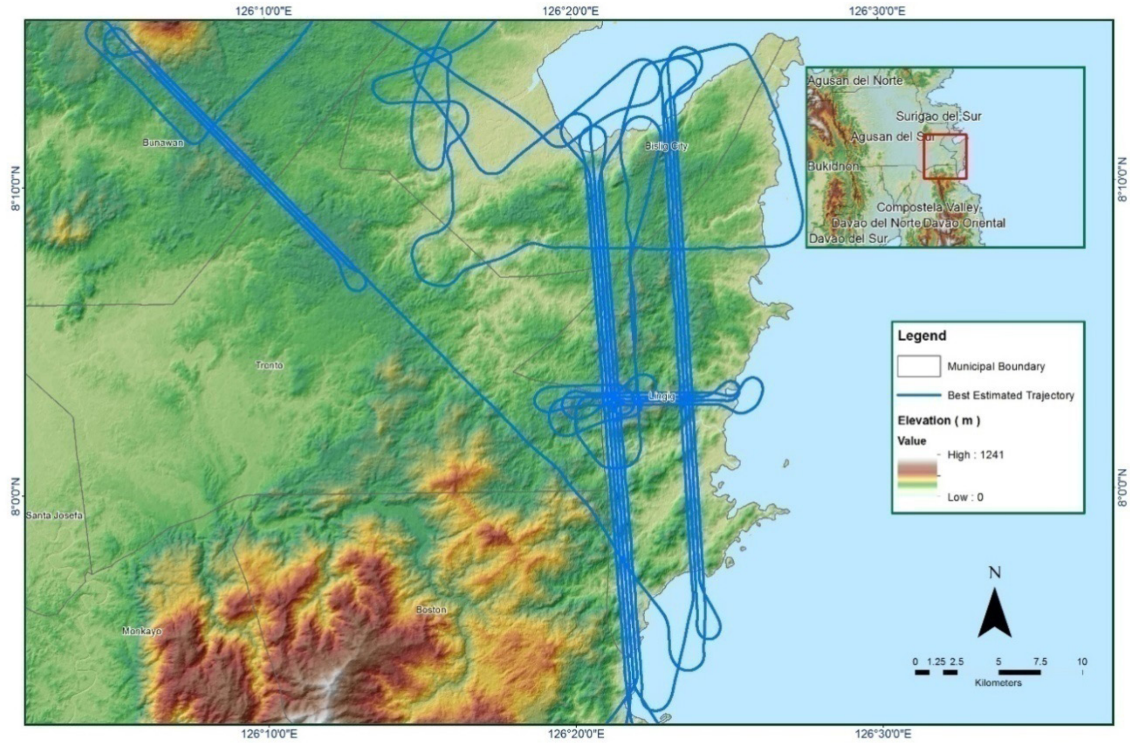
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66C**
Inclusive Flights	1910A
Range data size	12.30 GB
POS	257 MB
Base Data	14.6 MB
Image	76.70 MB
Transfer date	October 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.50
RMSE for East Position (<4.0 cm)	2.45
RMSE for Down Position (<8.0 cm)	3.60
Boresight correction stdev (<0.001deg)	--
IMU attitude correction stdev (<0.001deg)	--
GPS position stdev (<0.01m)	--
Minimum % overlap (>25)	34.48
Ave point cloud density per sq.m. (>2.0)	3.63
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	199
Maximum Height	488.53 m
Minimum Height	58.26 m
Classification (# of points)	
Ground	23872937
Low vegetation	17575938
Medium vegetation	86039694
High vegetation	136585716
Building	1909135
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Edgardo Gubatanga, Jr., JovyNarisma



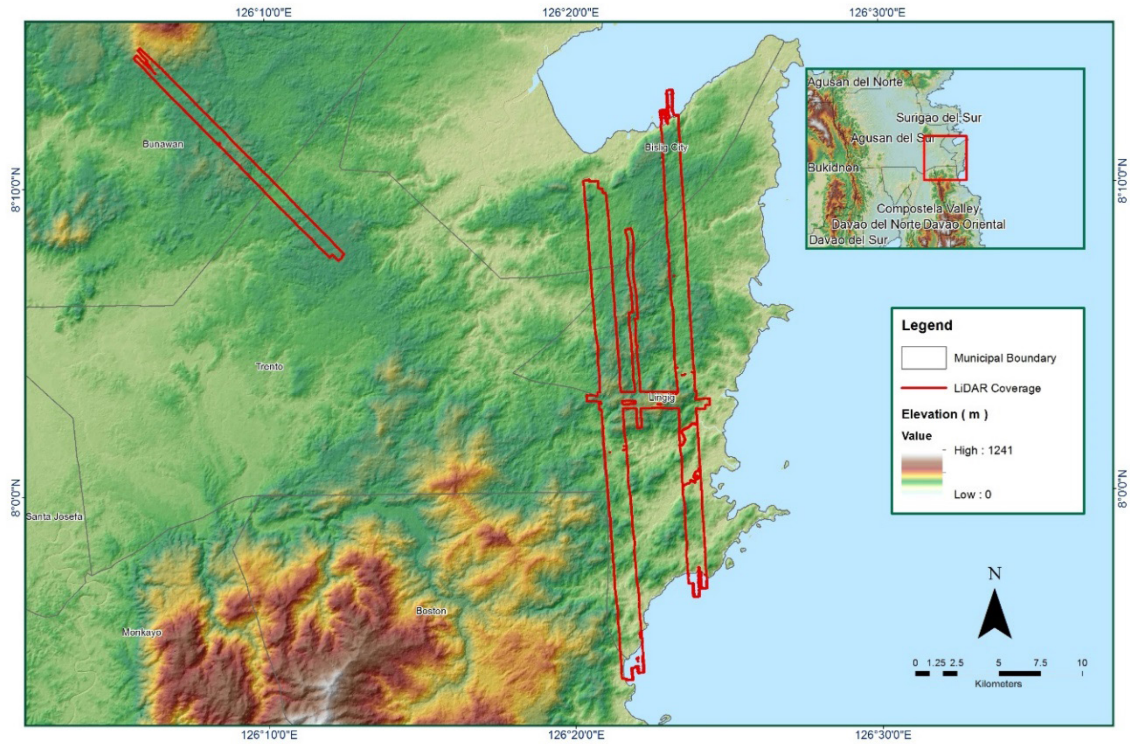
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

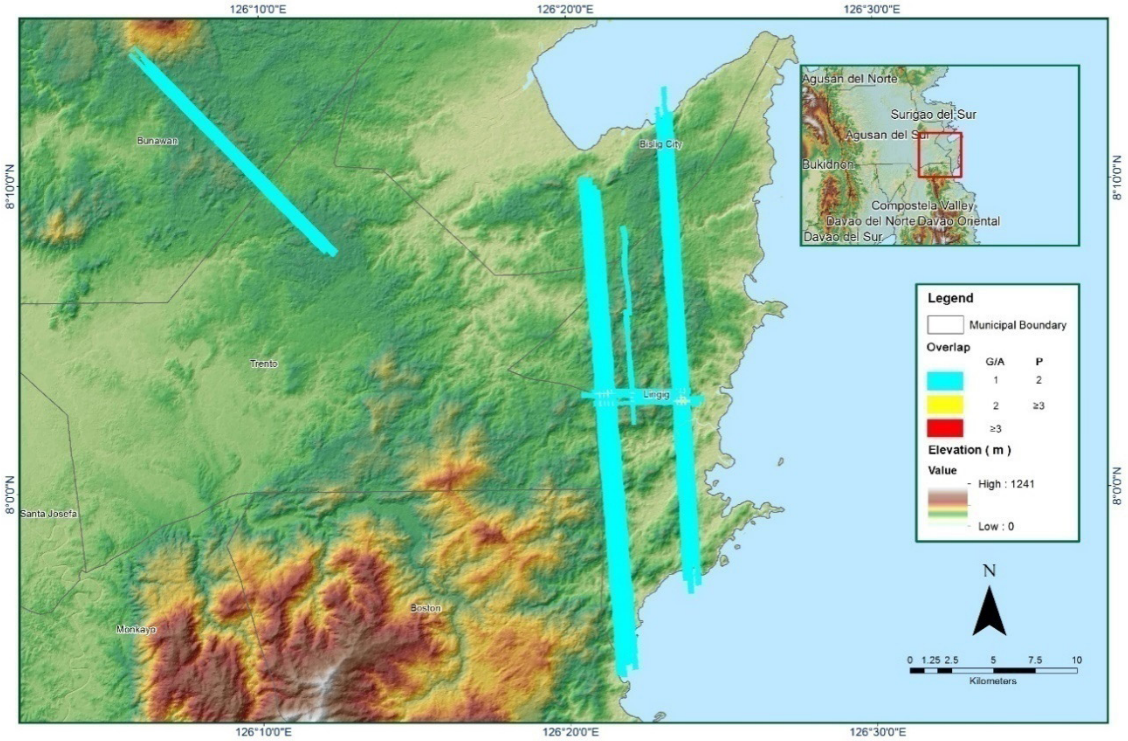
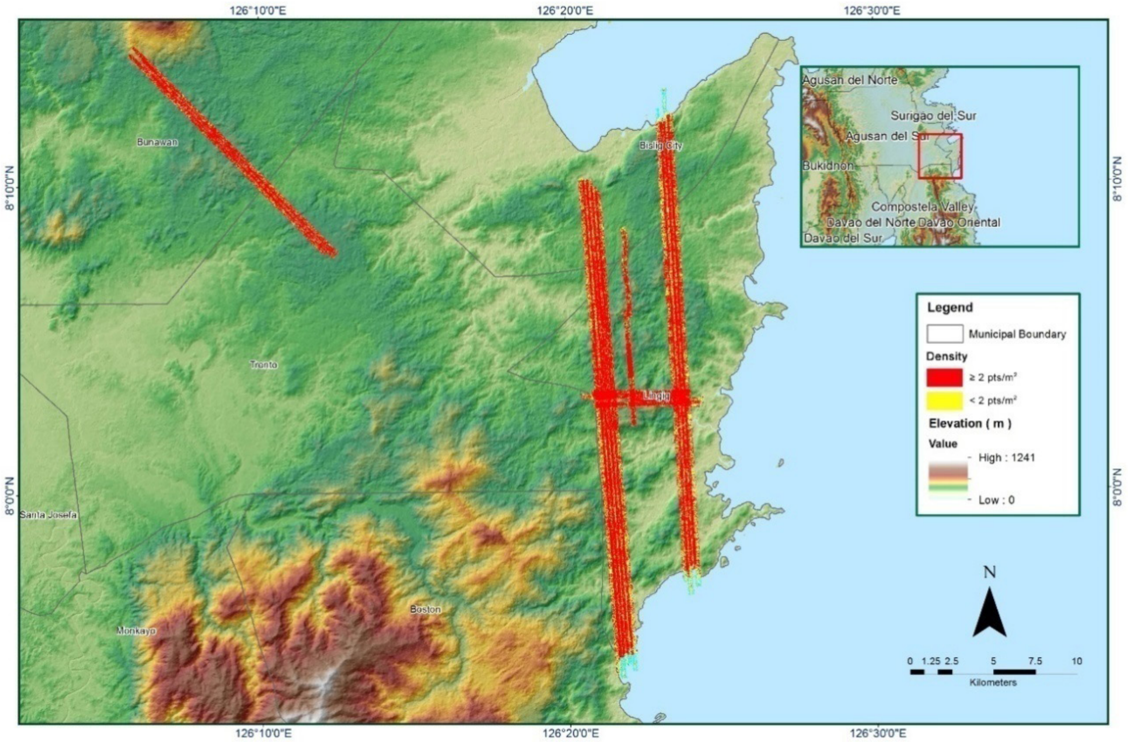
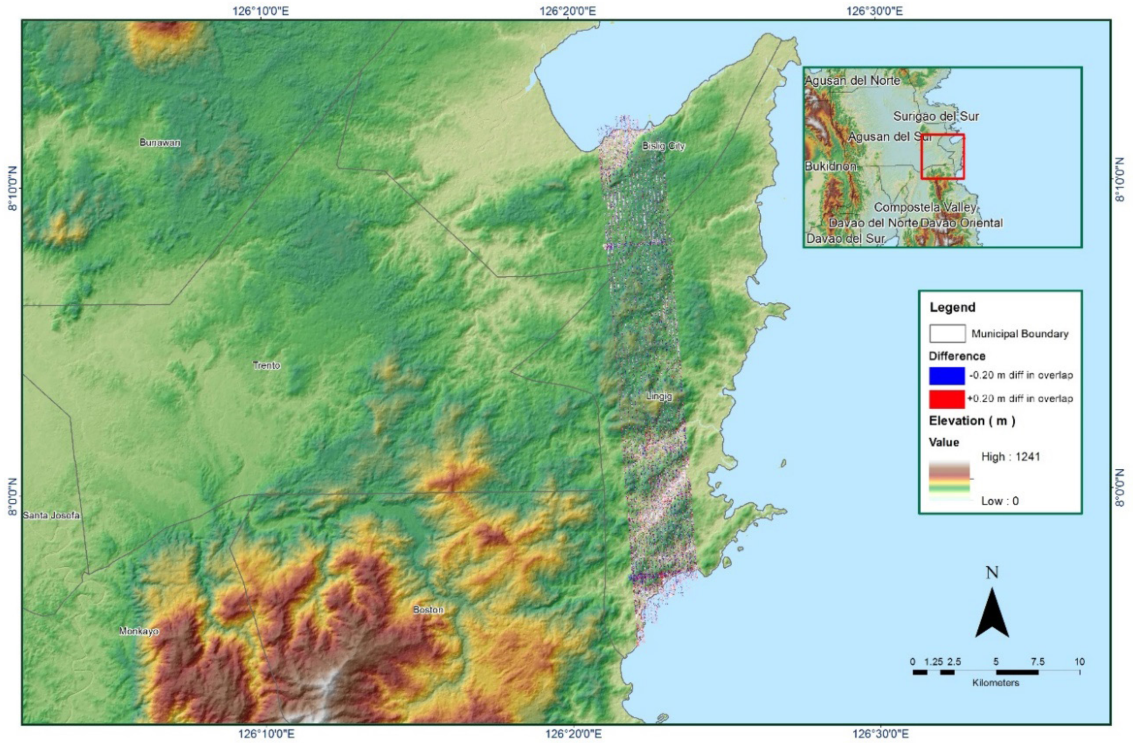


Image of data overlap

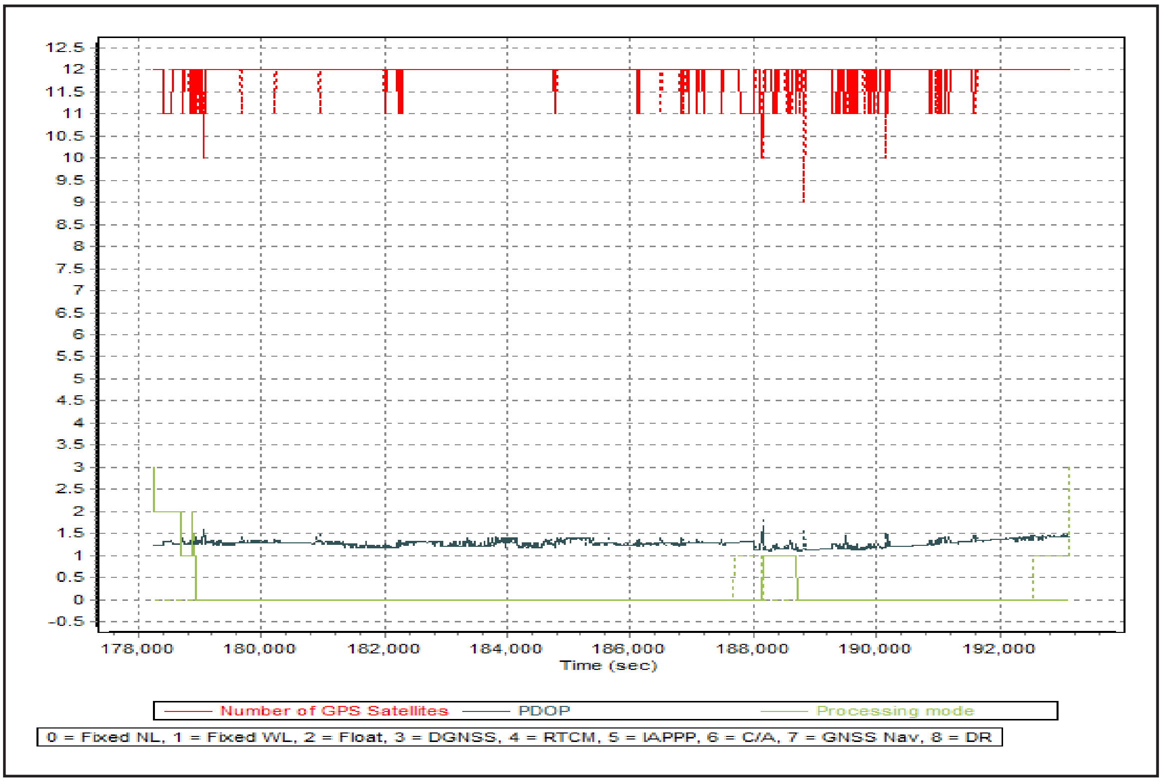


Density map of merged LiDAR data

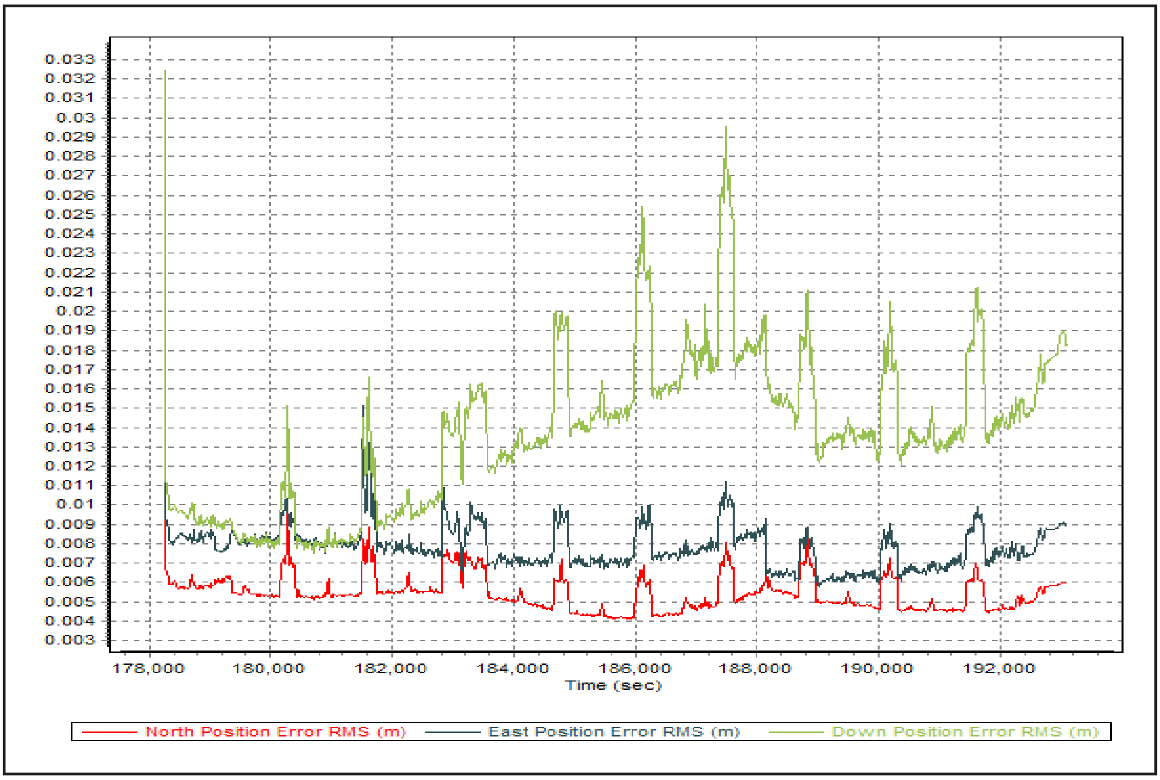


Elevation difference between flight lines

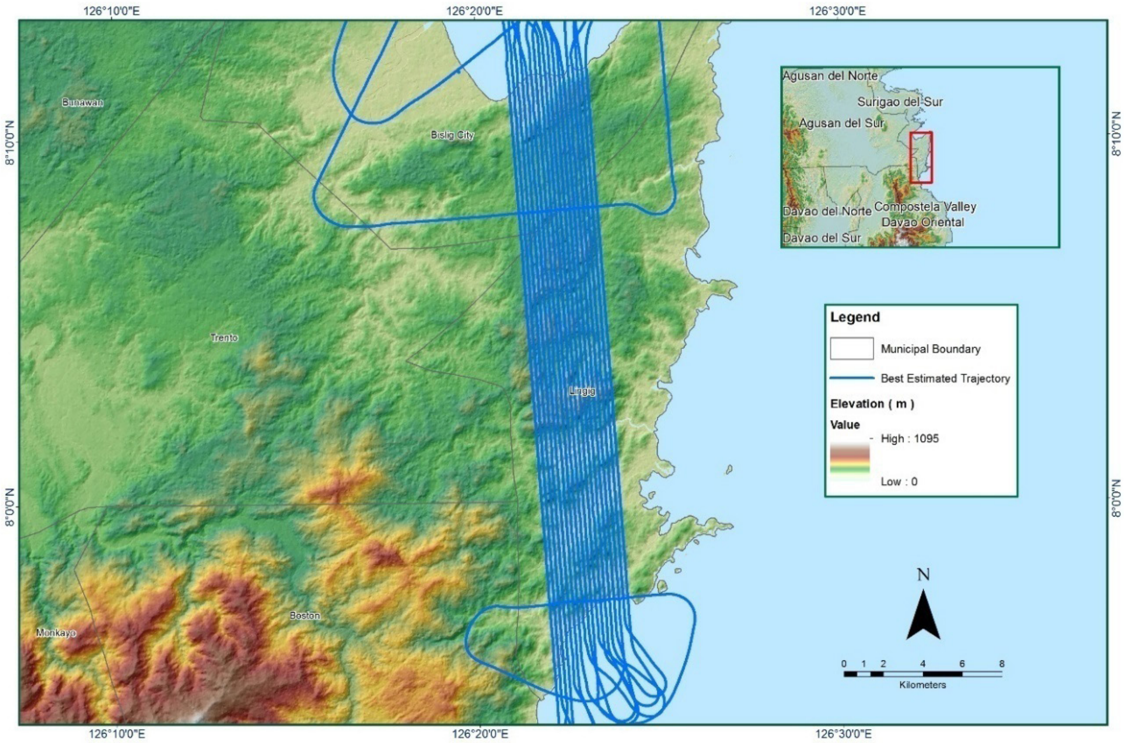
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66C Supplement**
Inclusive Flights	1898A
Range data size	17.50 GB
POS	286 MB
Base Data	11.6 MB
Image	NA
Transfer date	December 9, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.70
RMSE for East Position (<4.0 cm)	3.00
RMSE for Down Position (<8.0 cm)	3.33
Boresight correction stdev (<0.001deg)	0.000305
IMU attitude correction stdev (<0.001deg)	0.001336
GPS position stdev (<0.01m)	0.0022
Minimum % overlap (>25)	46.08
Ave point cloud density per sq.m. (>2.0)	3.80
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	171
Maximum Height	453.89 m
Minimum Height	55.99 m
Classification (# of points)	
Ground	40234643
Low vegetation	31804155
Medium vegetation	149257312
High vegetation	195565131
Building	5253064
Orthophoto	No
Processed by	Engr. Angelo Carlo Bongat, Engr. Edgardo Gubatanga, Jr., Engr. Elainne Lopez



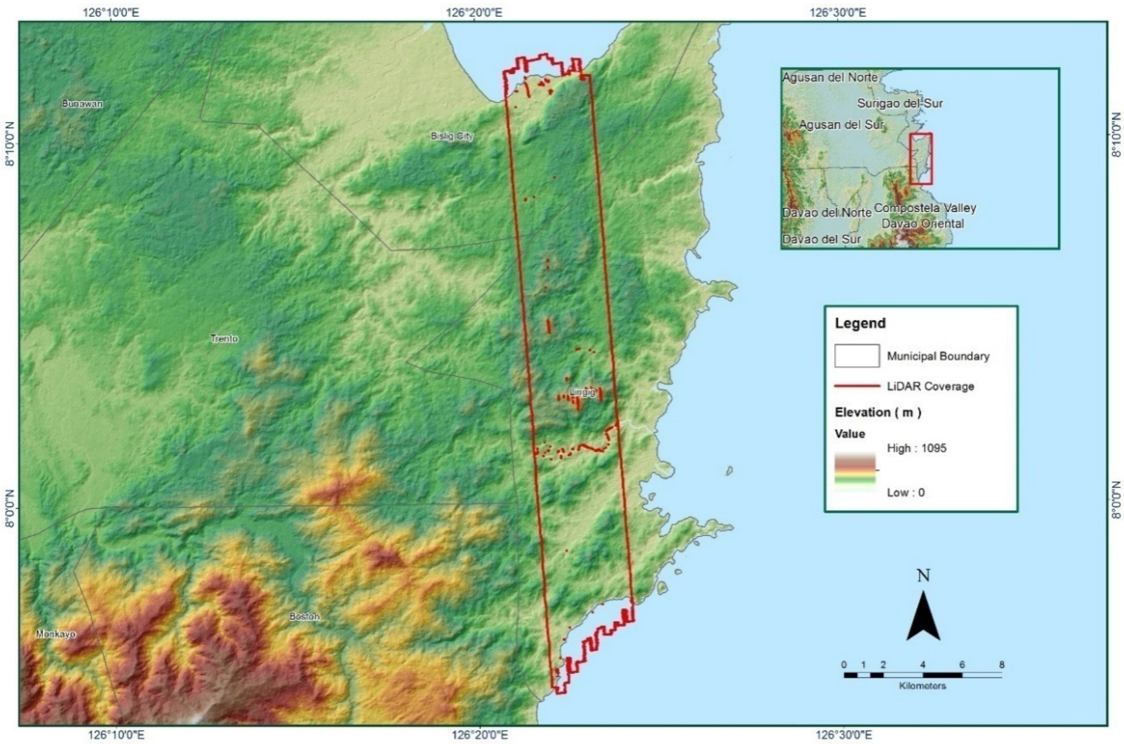
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

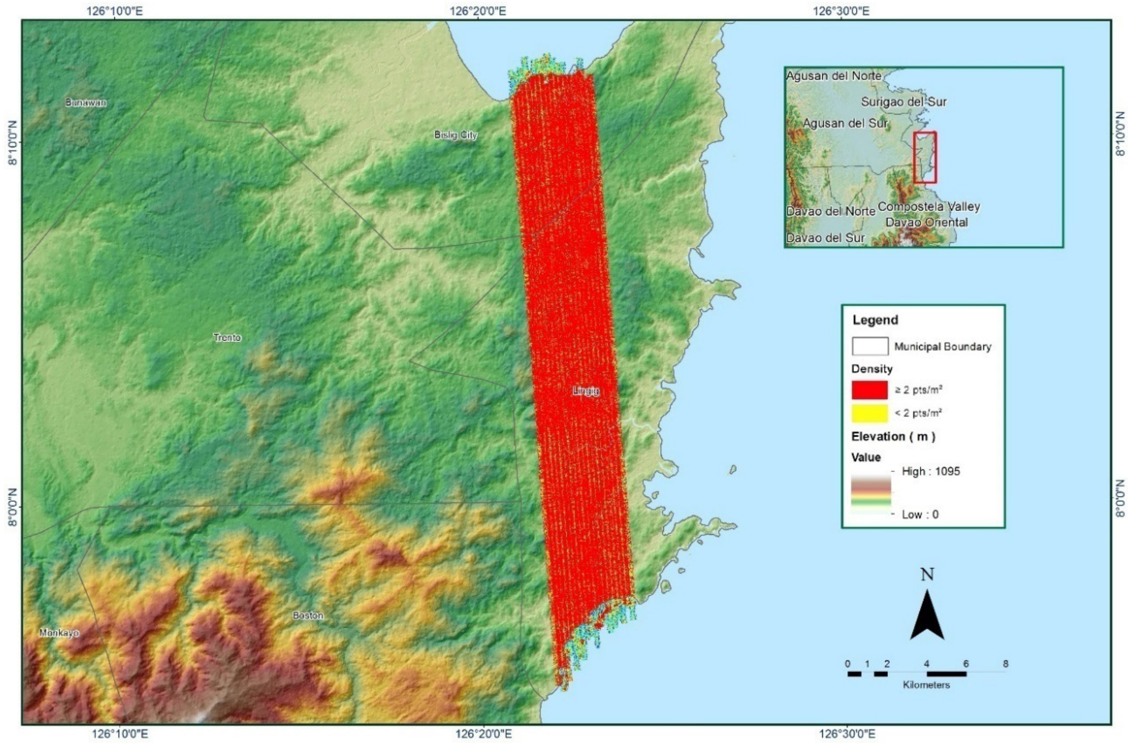
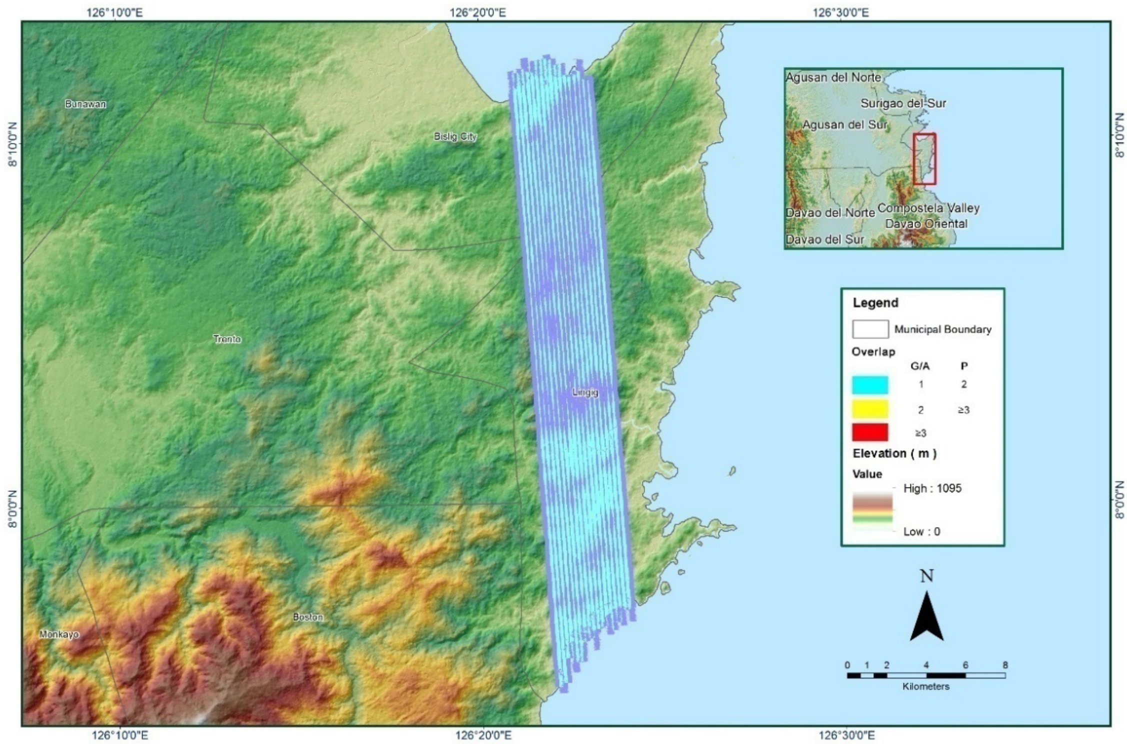
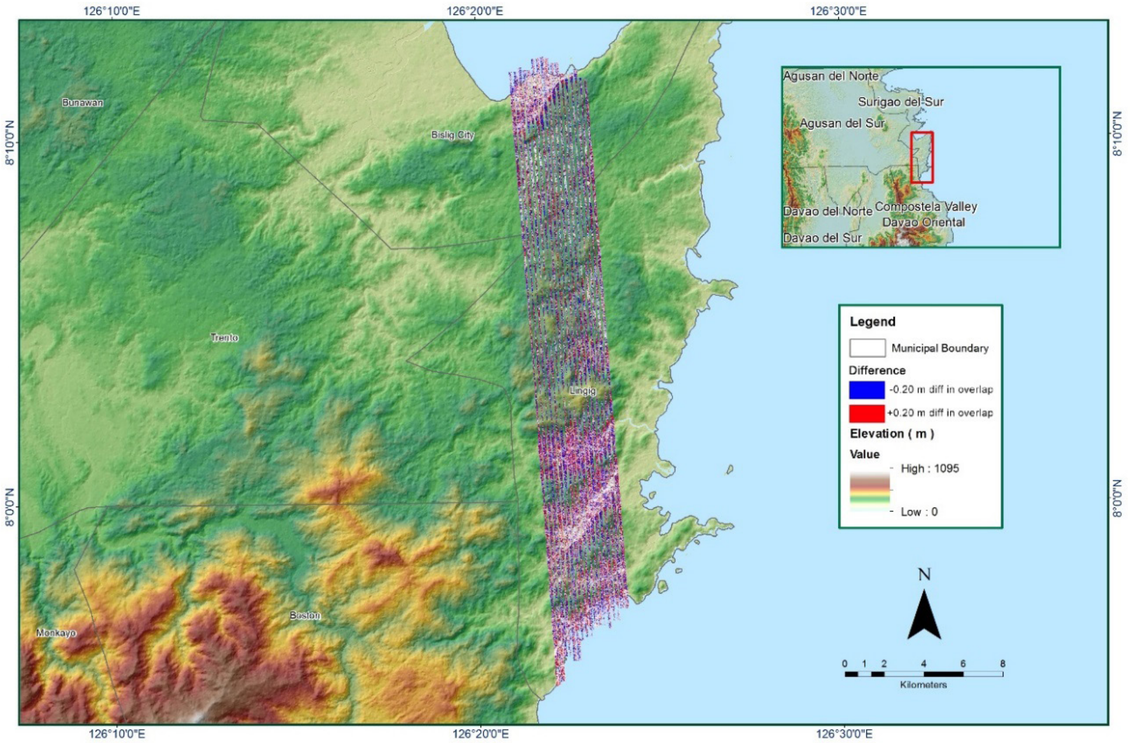


Image of data overlap

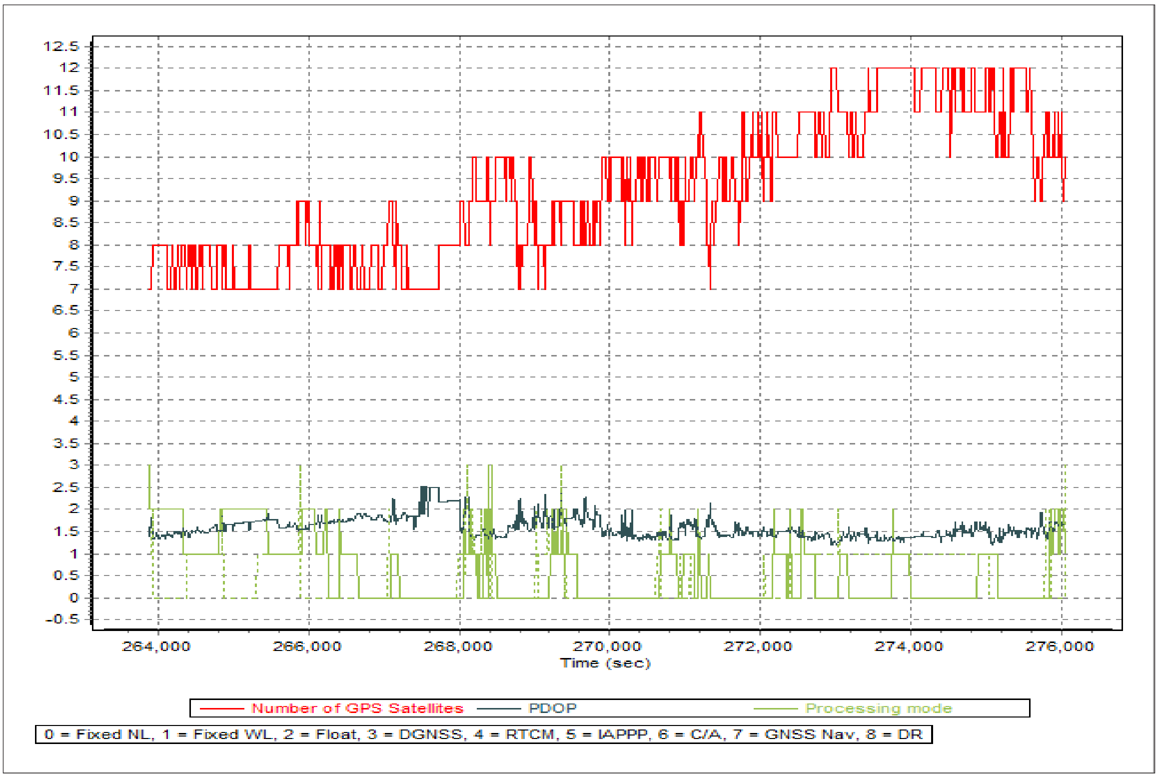


Density map of merged LiDAR data

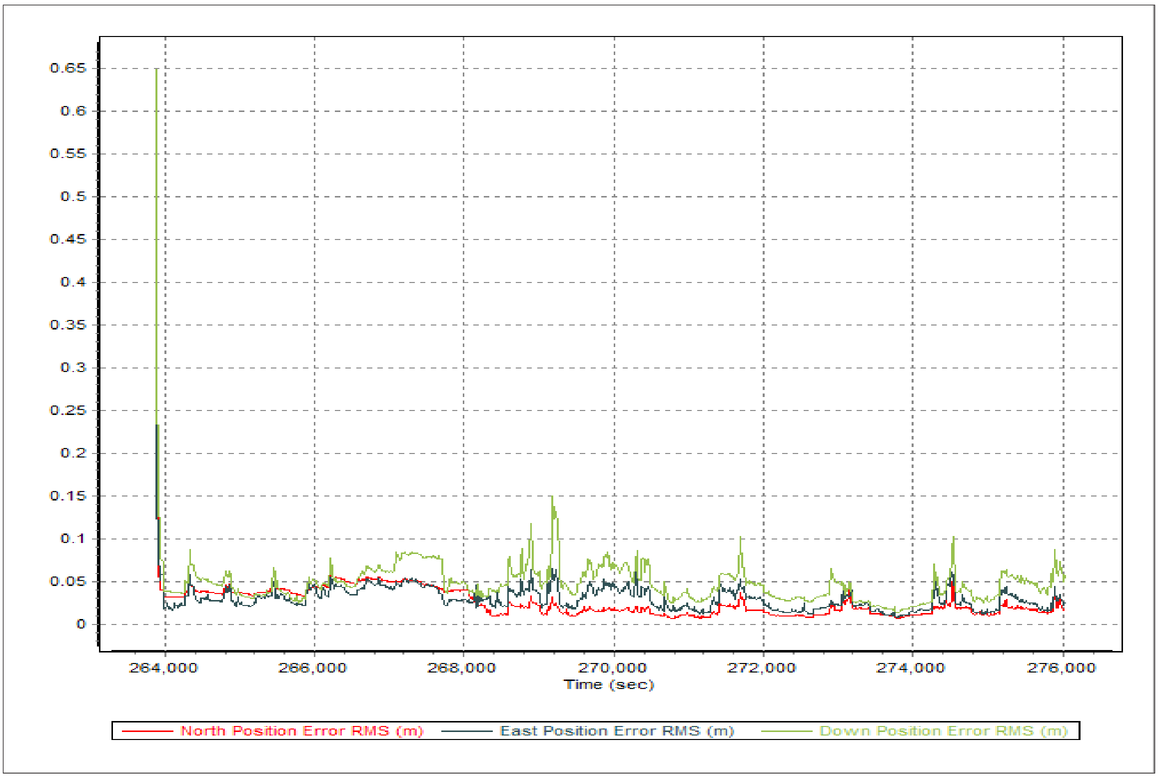


Elevation difference between flight lines

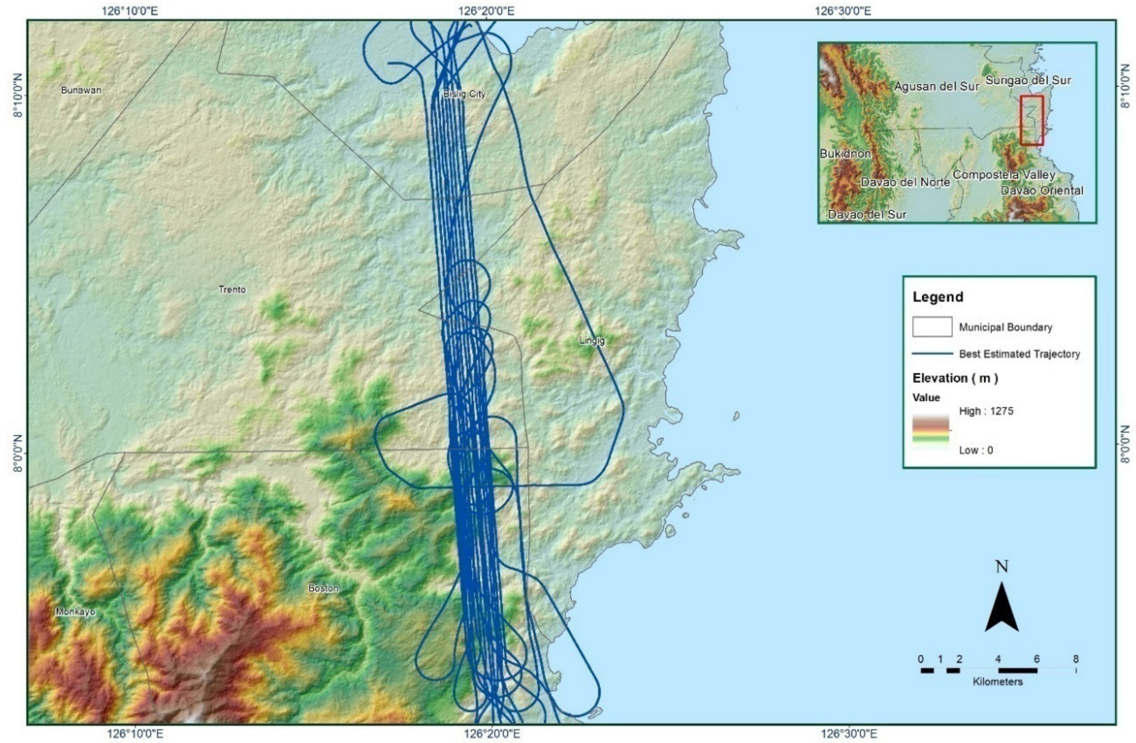
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66D**
Inclusive Flights	1818A
Range data size	10.30 GB
POS	257 MB
Base Data	9.12 MB
Image	32.10 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.90
RMSE for East Position (<4.0 cm)	4.44
RMSE for Down Position (<8.0 cm)	6.40
Boresight correction stdev (<0.001deg)	0.002140
IMU attitude correction stdev (<0.001deg)	0.207778
GPS position stdev (<0.01m)	0.0340
Minimum % overlap (>25)	55.57
Ave point cloud density per sq.m. (>2.0)	4.72
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	109
Maximum Height	596.83 m
Minimum Height	67.34 m
Classification (# of points)	
Ground	16433399
Low vegetation	11267866
Medium vegetation	97149477
High vegetation	167635044
Building	1708000
Orthophoto	Yes
Processed by	Engr. AnalynNaldo, Engr. Christy Lubiano, Engr. John Dill Macapagal



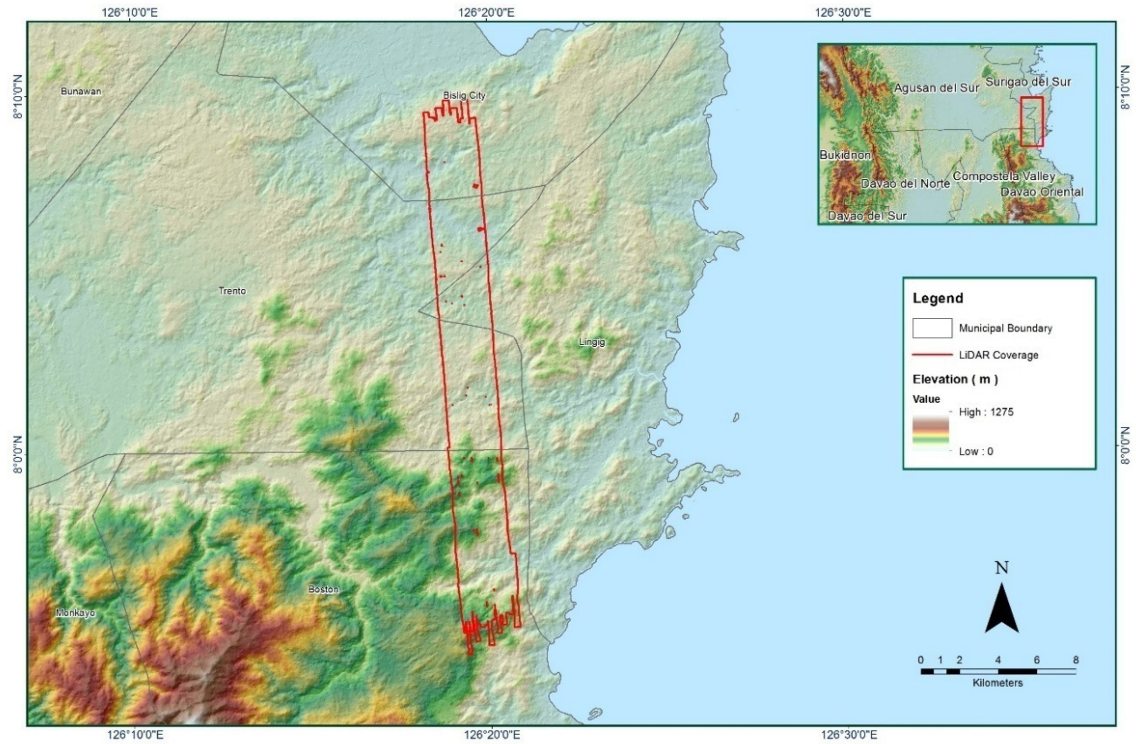
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

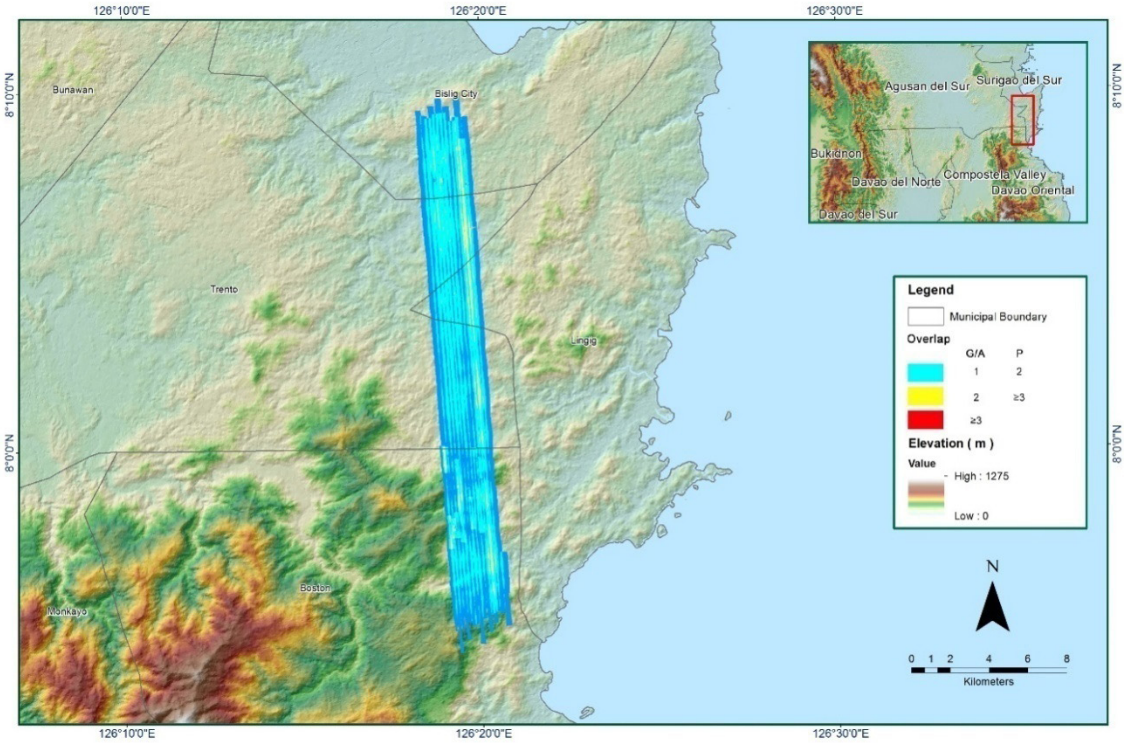
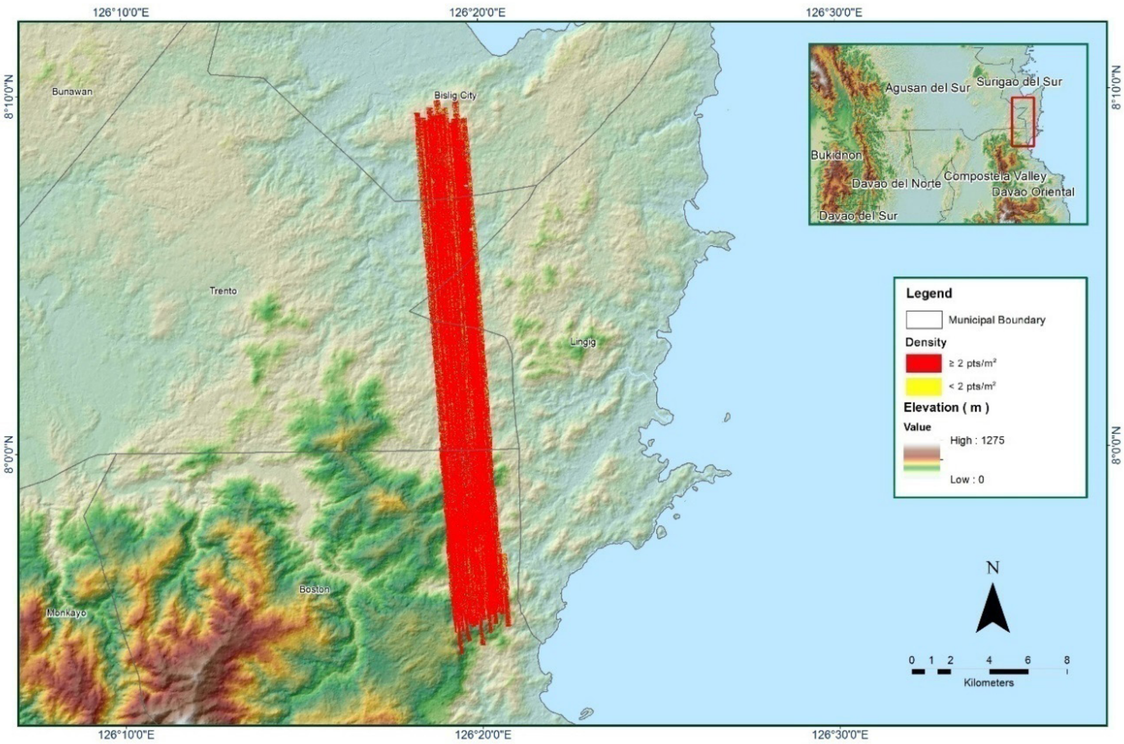
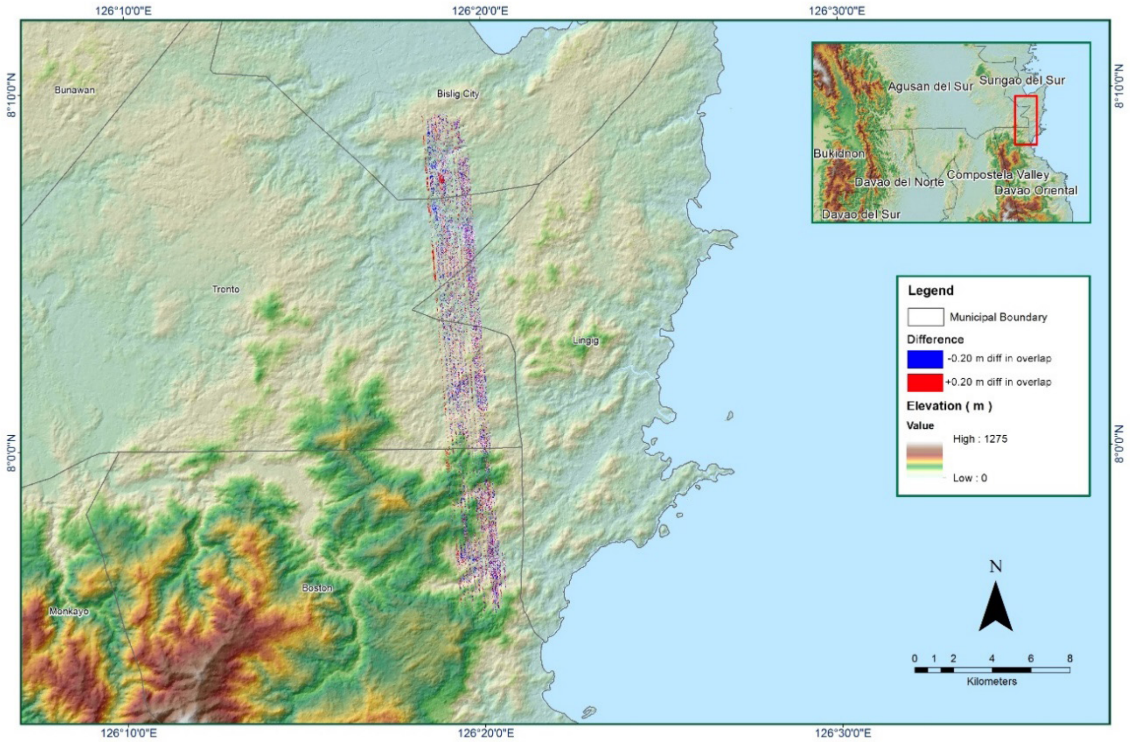


Image of data overlap

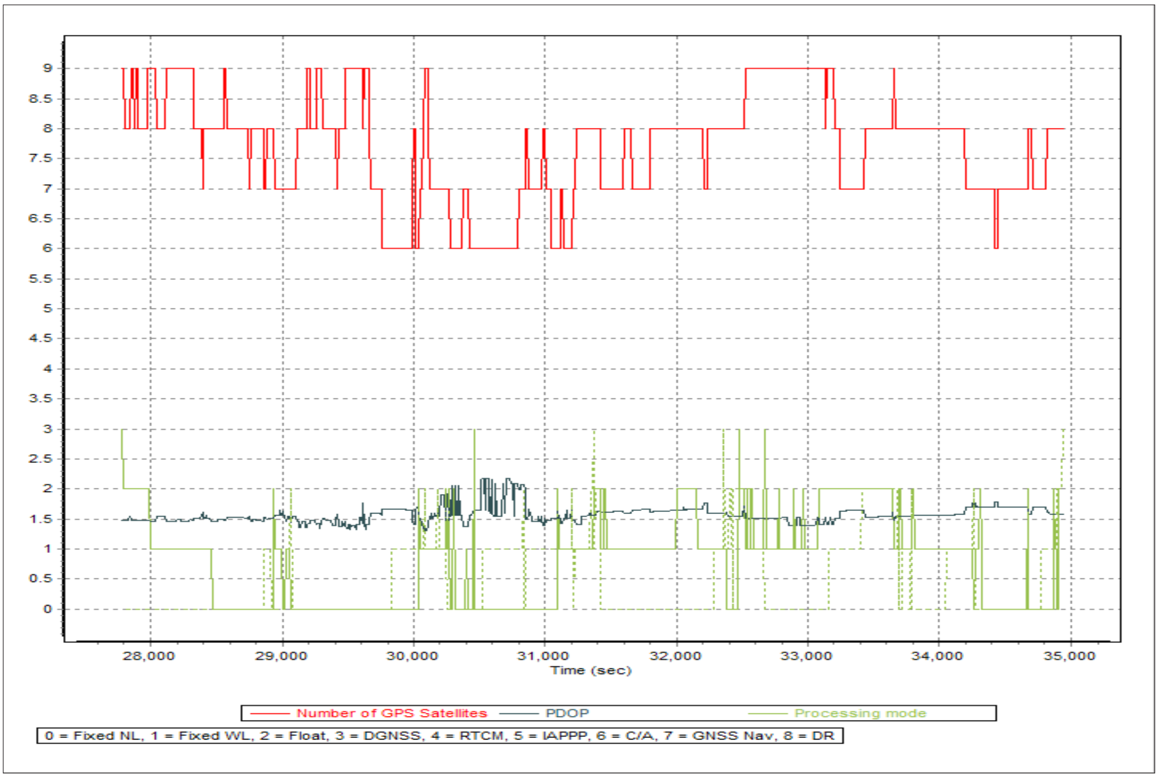


Density map of merged LiDAR data

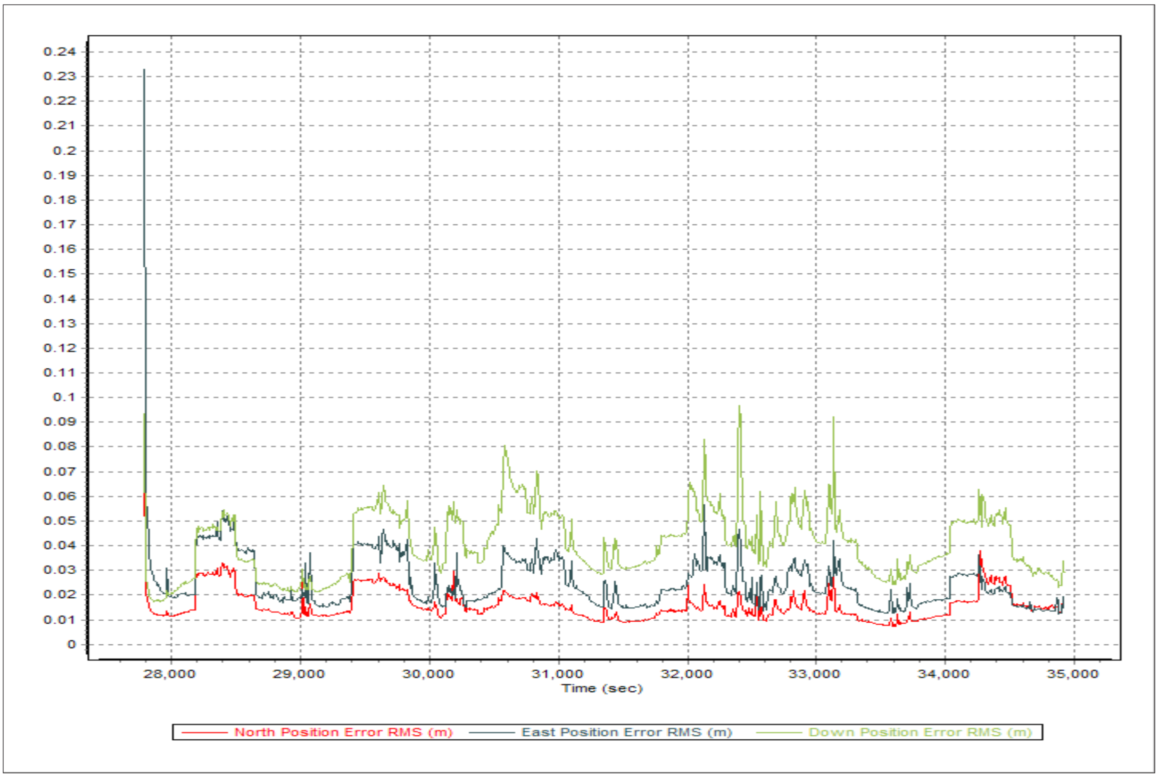


Elevation difference between flight lines

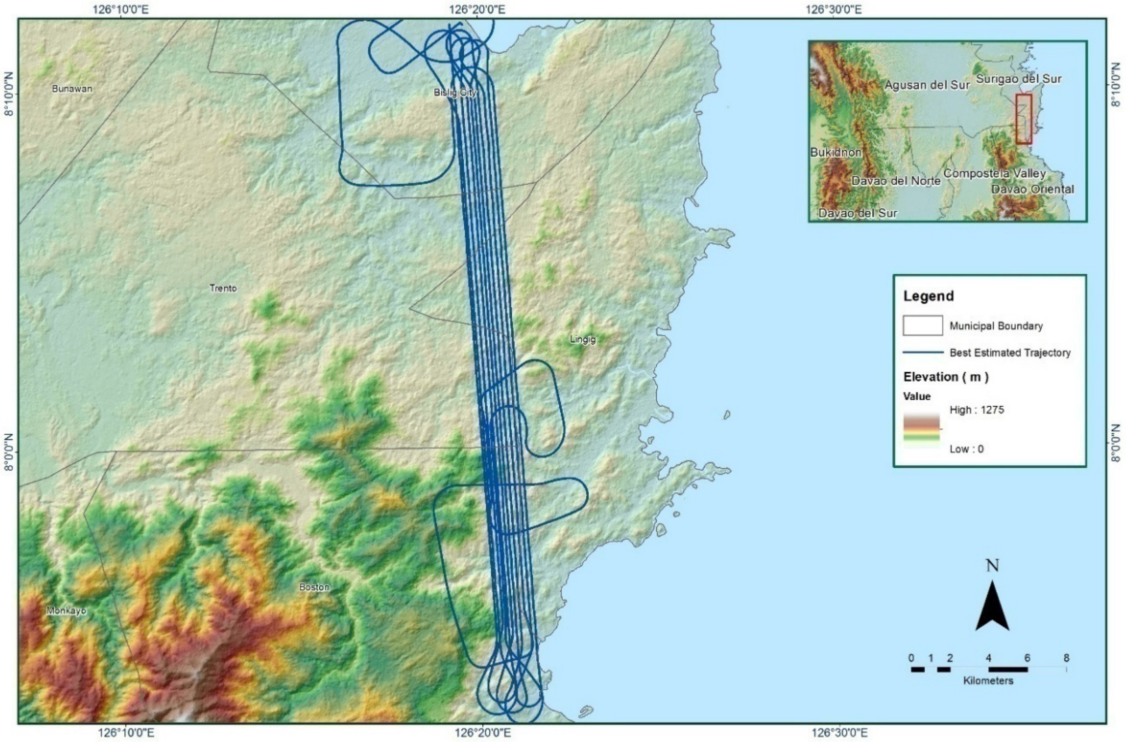
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66D Additional**
Inclusive Flights	1836A
Range data size	9.01 GB
POS	178 MB
Base Data	16.5 MB
Image	30.70 MB
Transfer date	September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	4.00
RMSE for East Position (<4.0 cm)	2.30
RMSE for Down Position (<8.0 cm)	9.50
Boresight correction stdev (<0.001deg)	0.002140
IMU attitude correction stdev (<0.001deg)	0.207778
GPS position stdev (<0.01m)	0.0340
Minimum % overlap (>25)	44.29
Ave point cloud density per sq.m. (>2.0)	3.66
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	86
Maximum Height	474.01 m
Minimum Height	68.93 m
Classification (# of points)	
Ground	21019440
Low vegetation	7224792
Medium vegetation	53328590
High vegetation	69534254
Building	627386
Orthophoto	Yes
Processed by	Engr. AnalynNaldo, Engr. Antonio Chua, Jr., Ryan James Nicholai Dizon



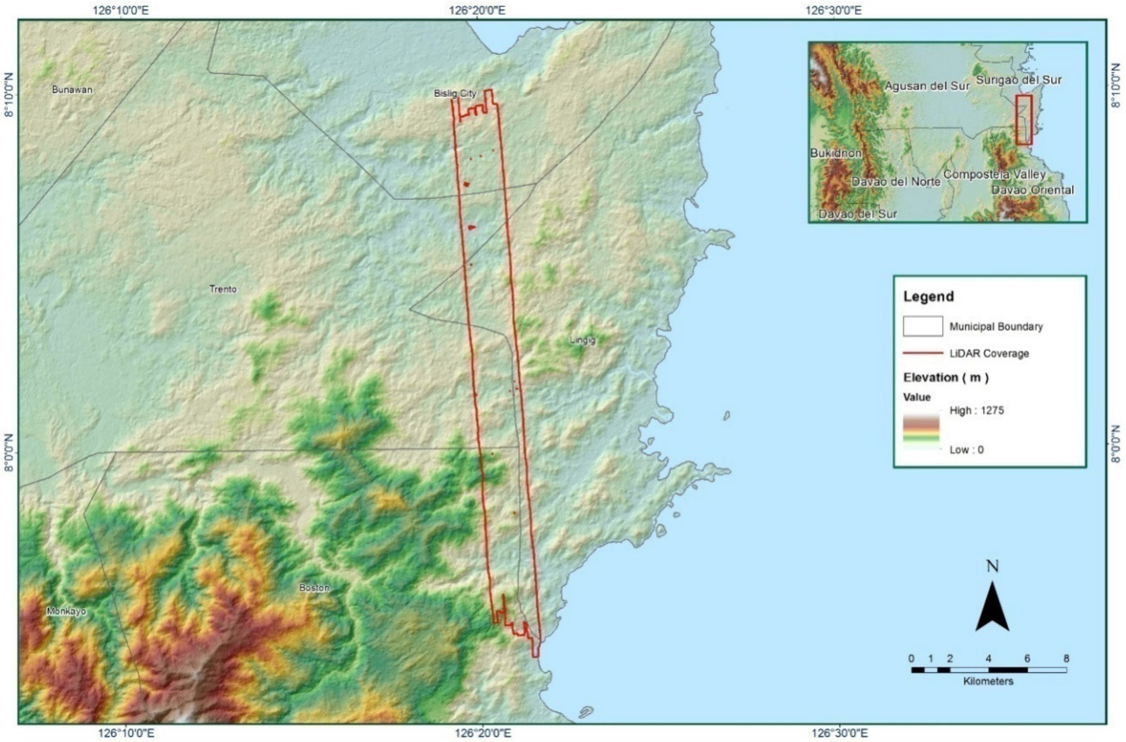
Solution Status



moothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

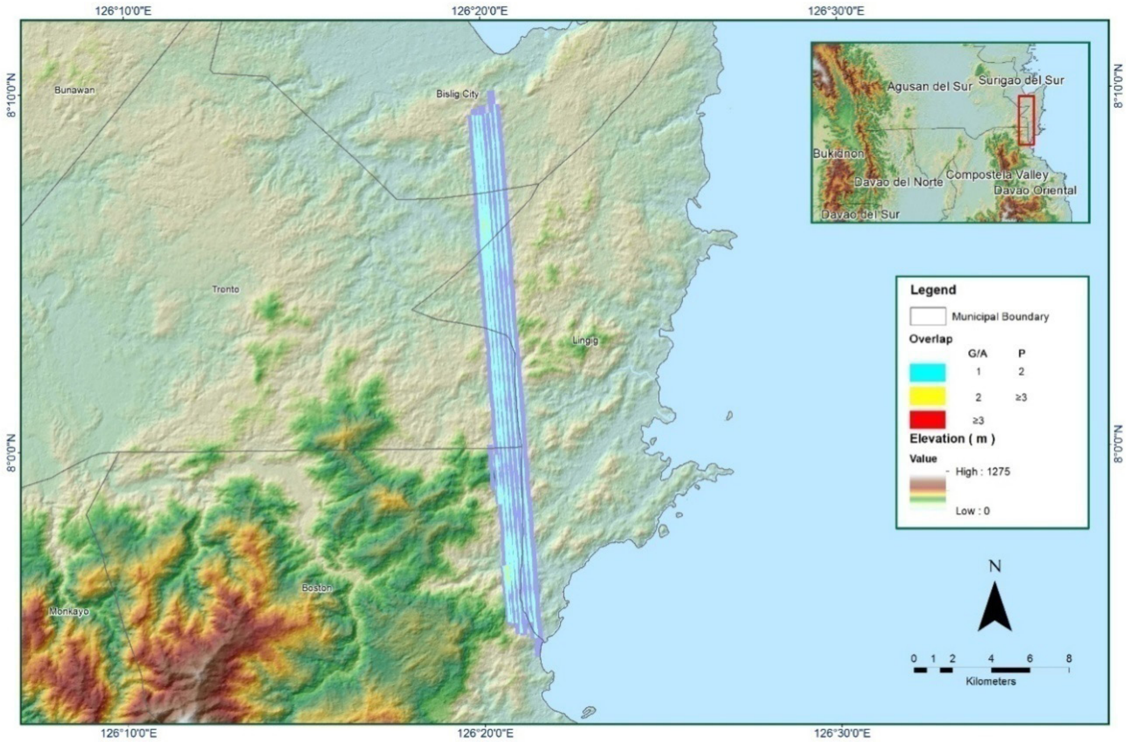
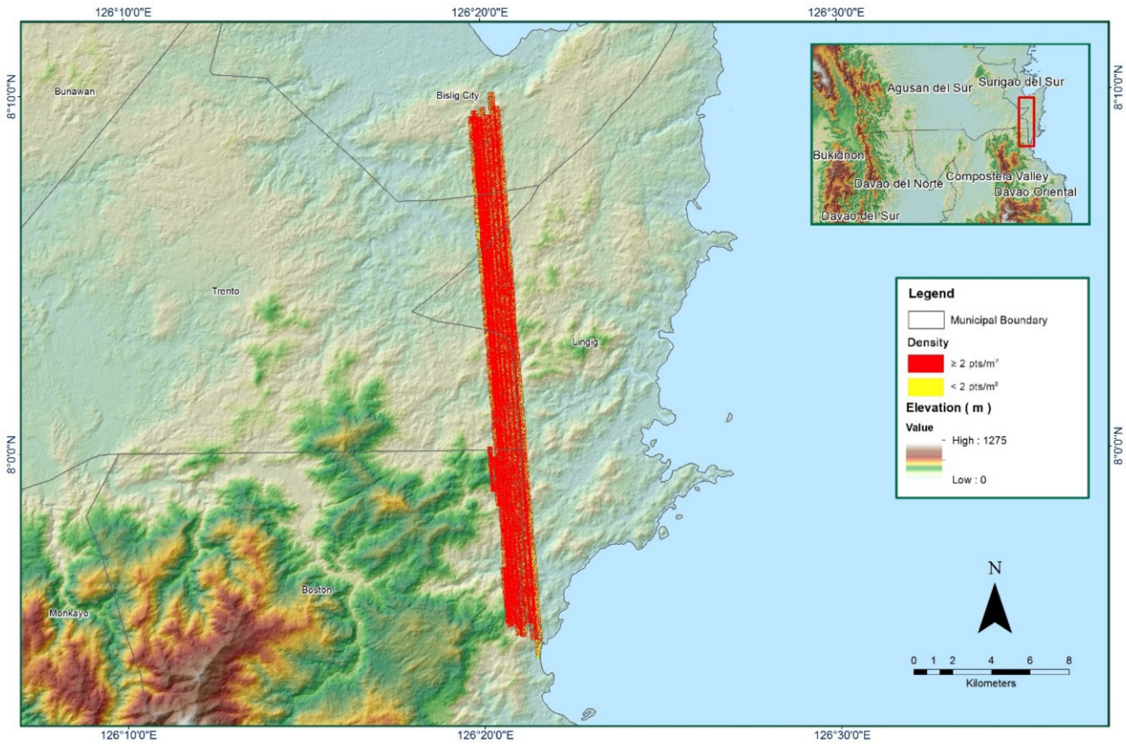
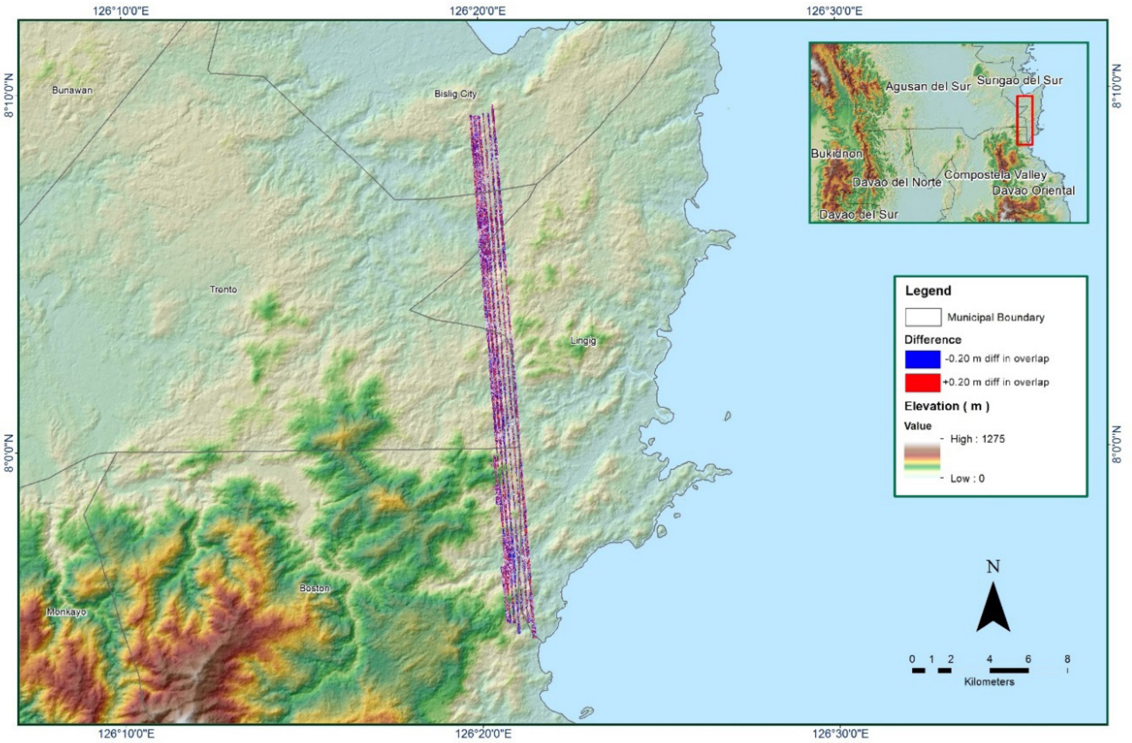


Image of data overlap

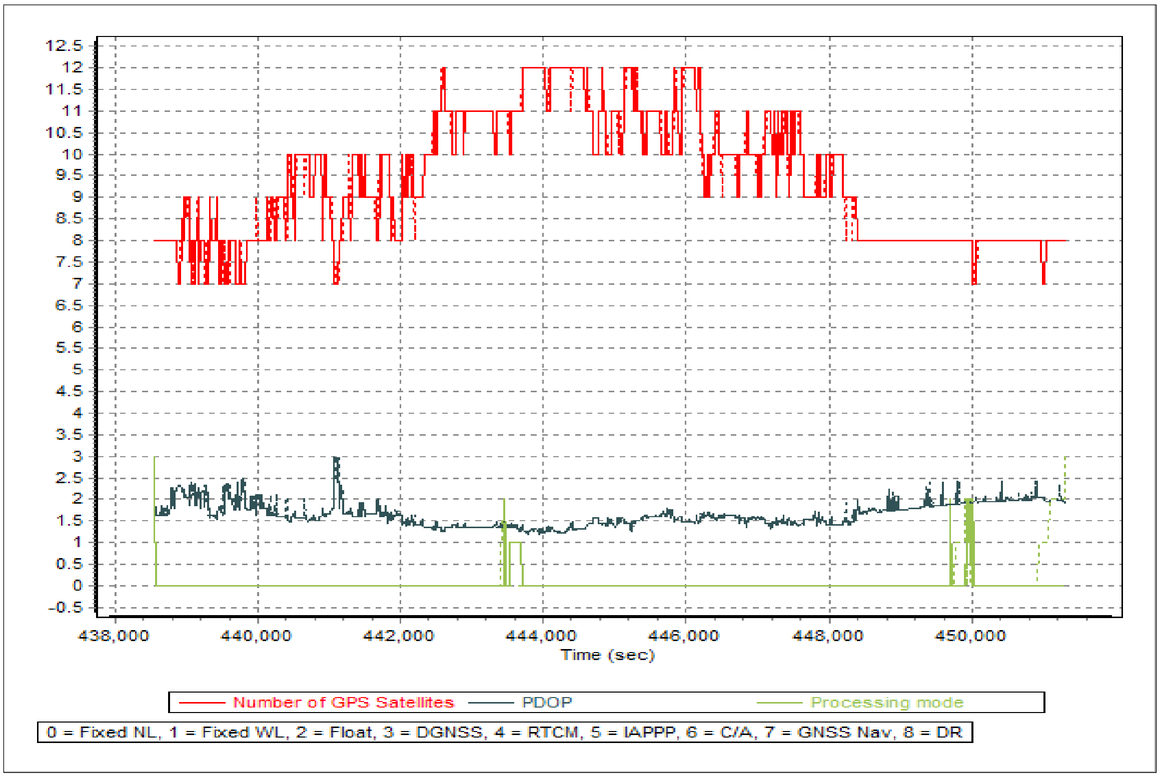


Density map of merged LiDAR data

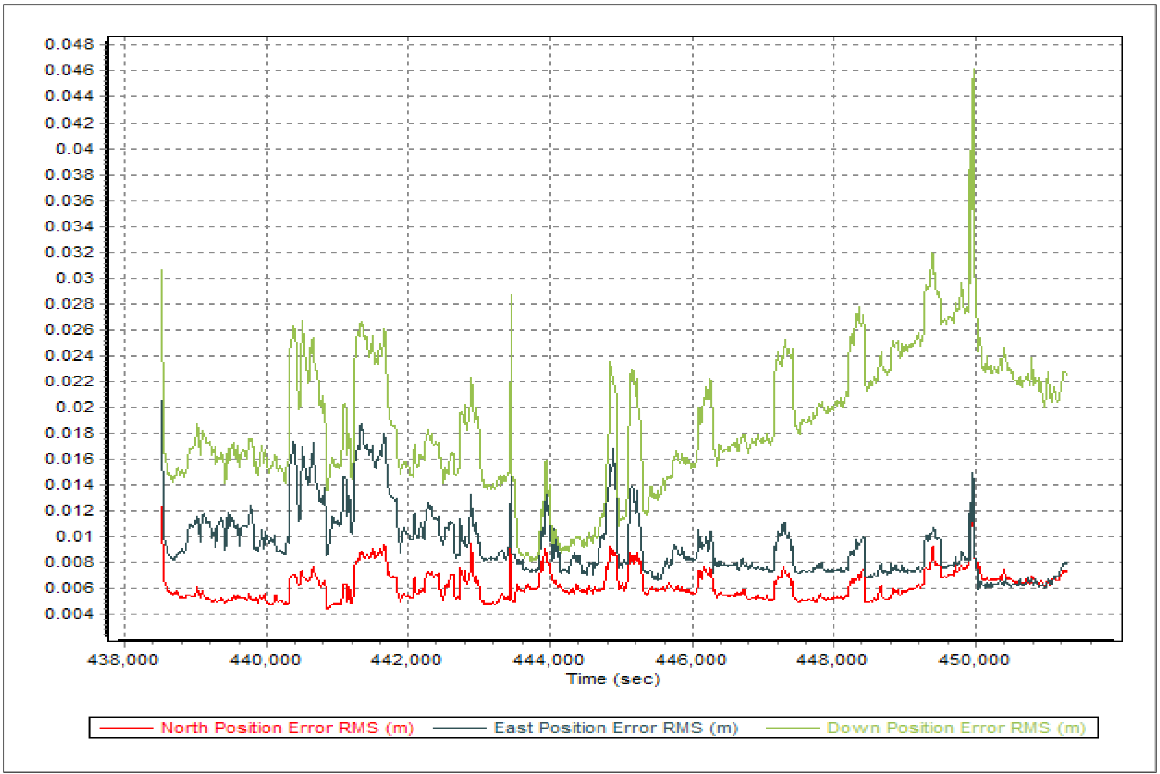


Elevation difference between flight lines

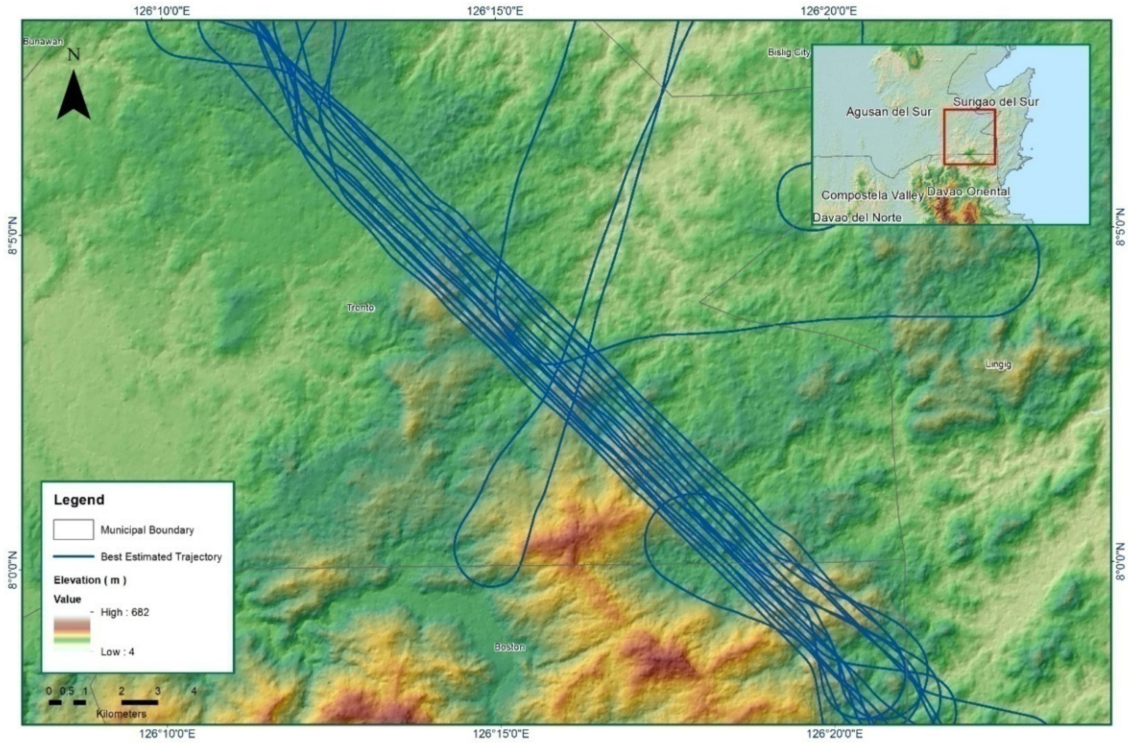
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66W**
Inclusive Flights	1854A
Range data size	8.36 GB
POS	248 MB
Base Data	9.63 MB
Image	45.50 MB
Transfer date	September 5, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.35
RMSE for East Position (<4.0 cm)	2.00
RMSE for Down Position (<8.0 cm)	4.60
Boresight correction stdev (<0.001deg)	0.000562
IMU attitude correction stdev (<0.001deg)	0.690700
GPS position stdev (<0.01m)	0.0044
Minimum % overlap (>25)	49.70
Ave point cloud density per sq.m. (>2.0)	5.05
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	69
Maximum Height	525.37 m
Minimum Height	121.84 m
Classification (# of points)	
Ground	10,295,205
Low vegetation	7,695,619
Medium vegetation	57,212,416
High vegetation	116,387,163
Building	2,448,182
Orthophoto	Yes
Processed by	Engr. Irish Cortez, AljonRieAraneta, Engr. Melissa Fernandez



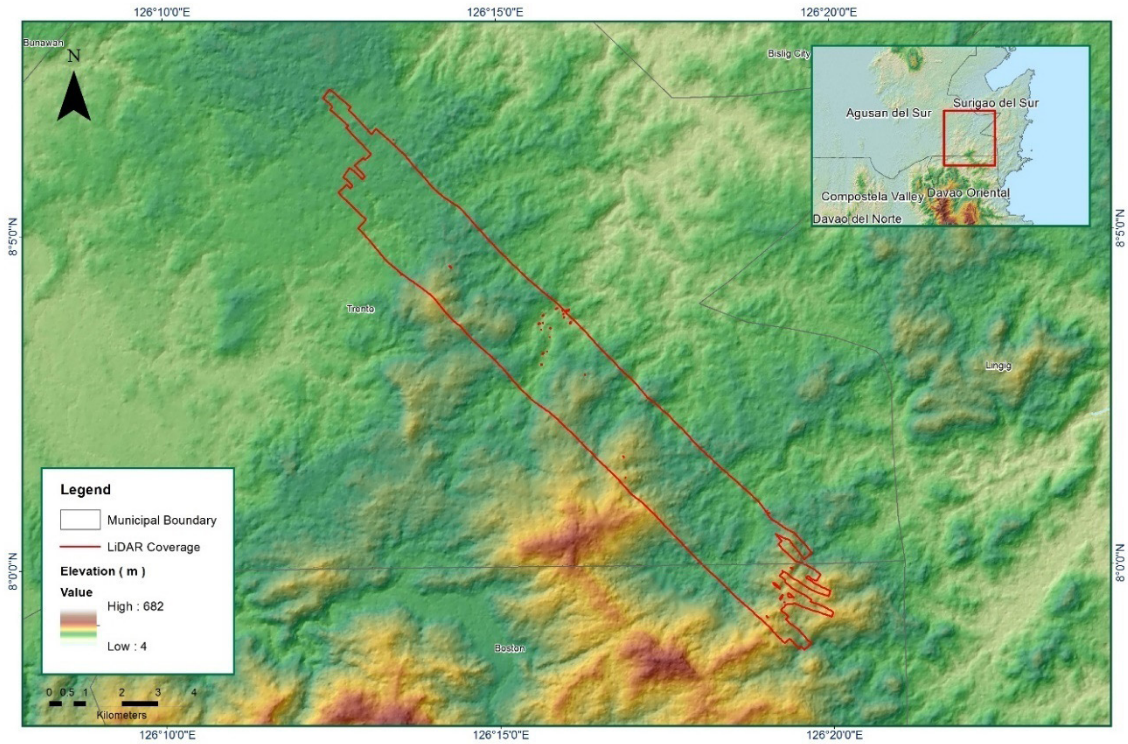
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

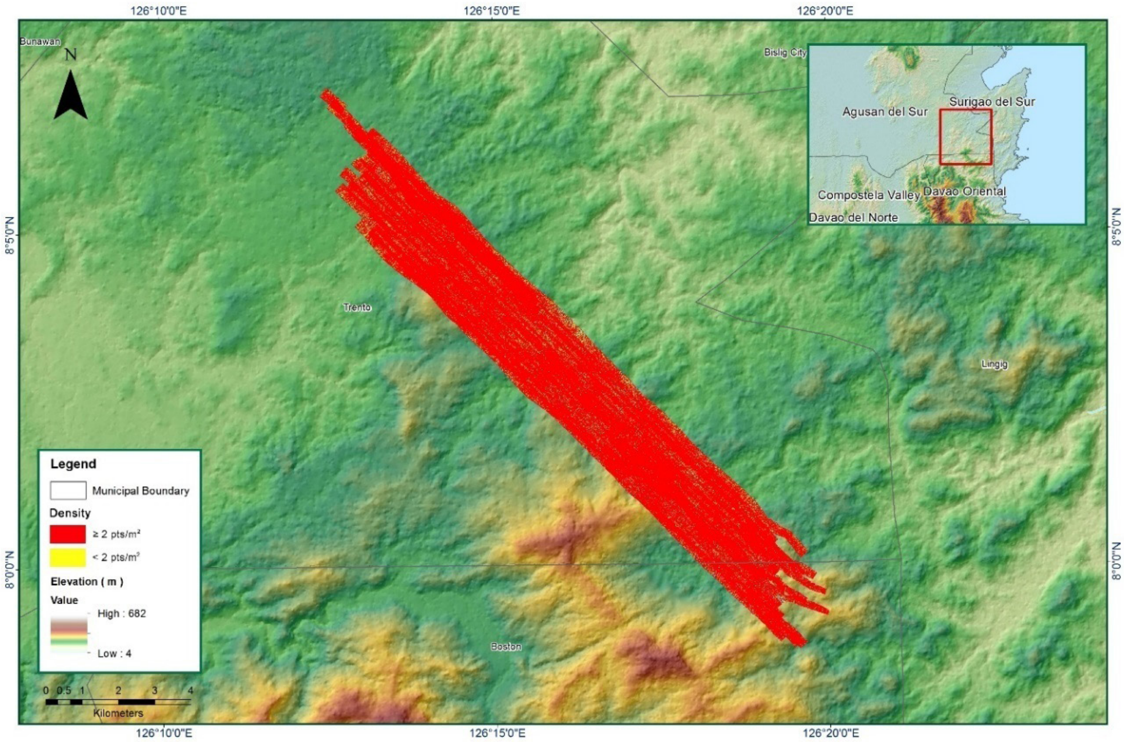
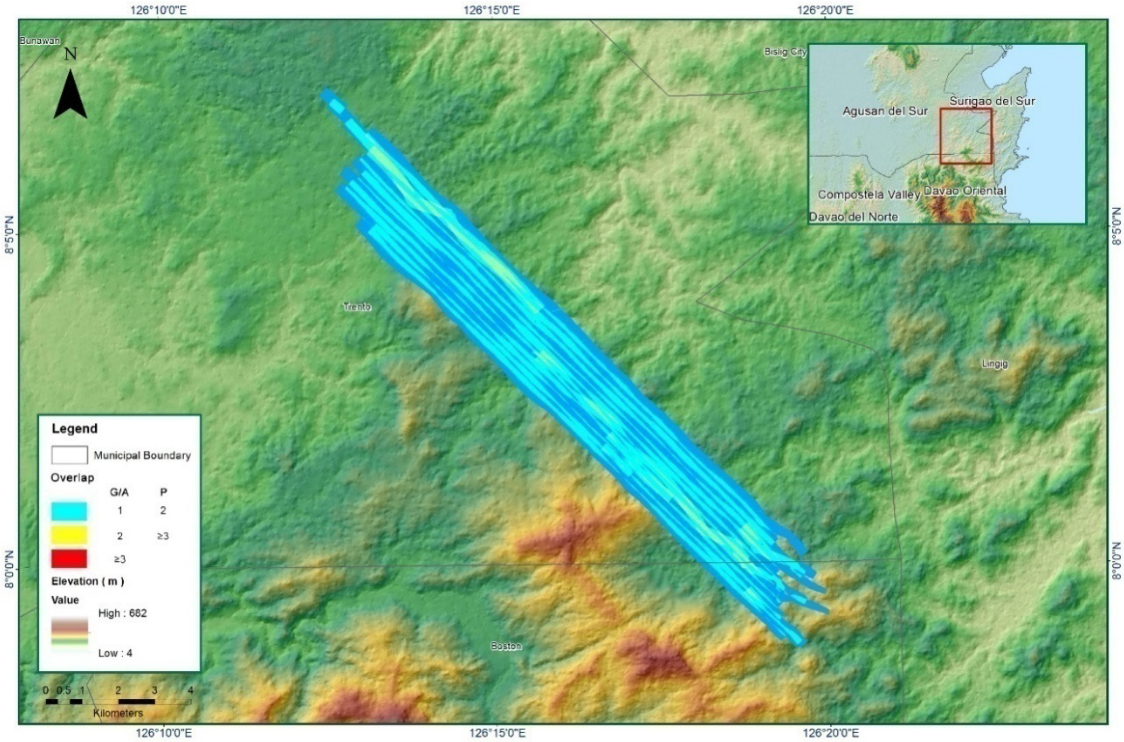


Image of data overlap



Density map of merged LiDAR data

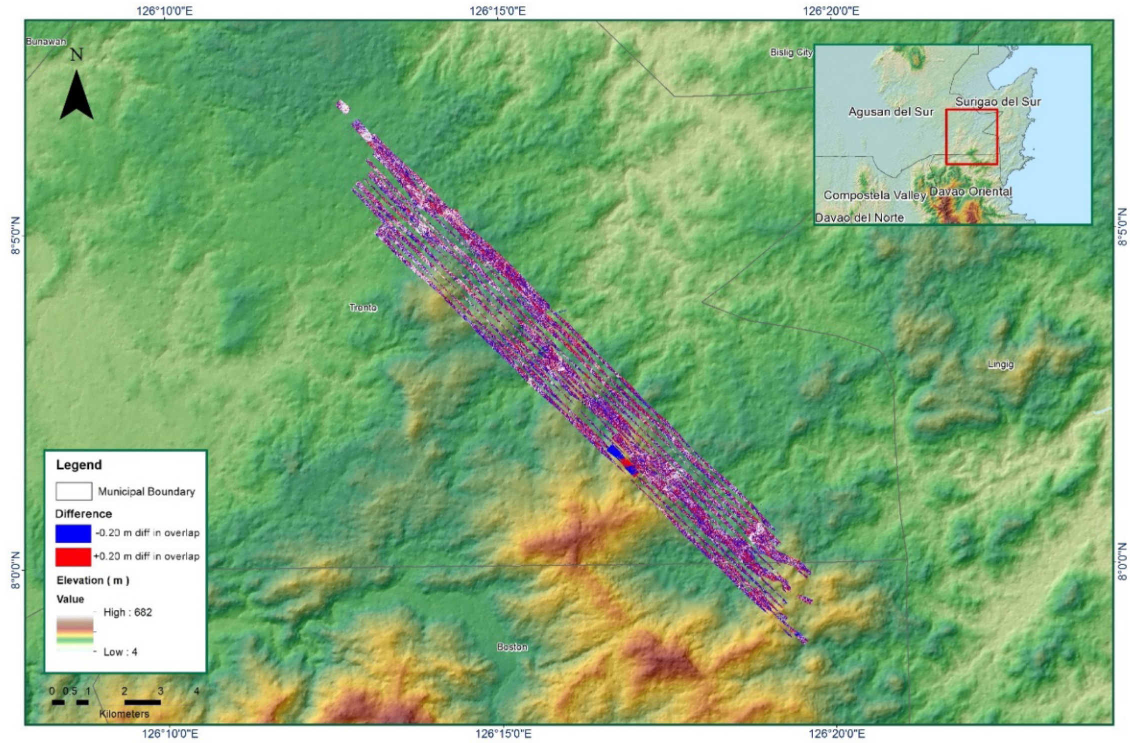
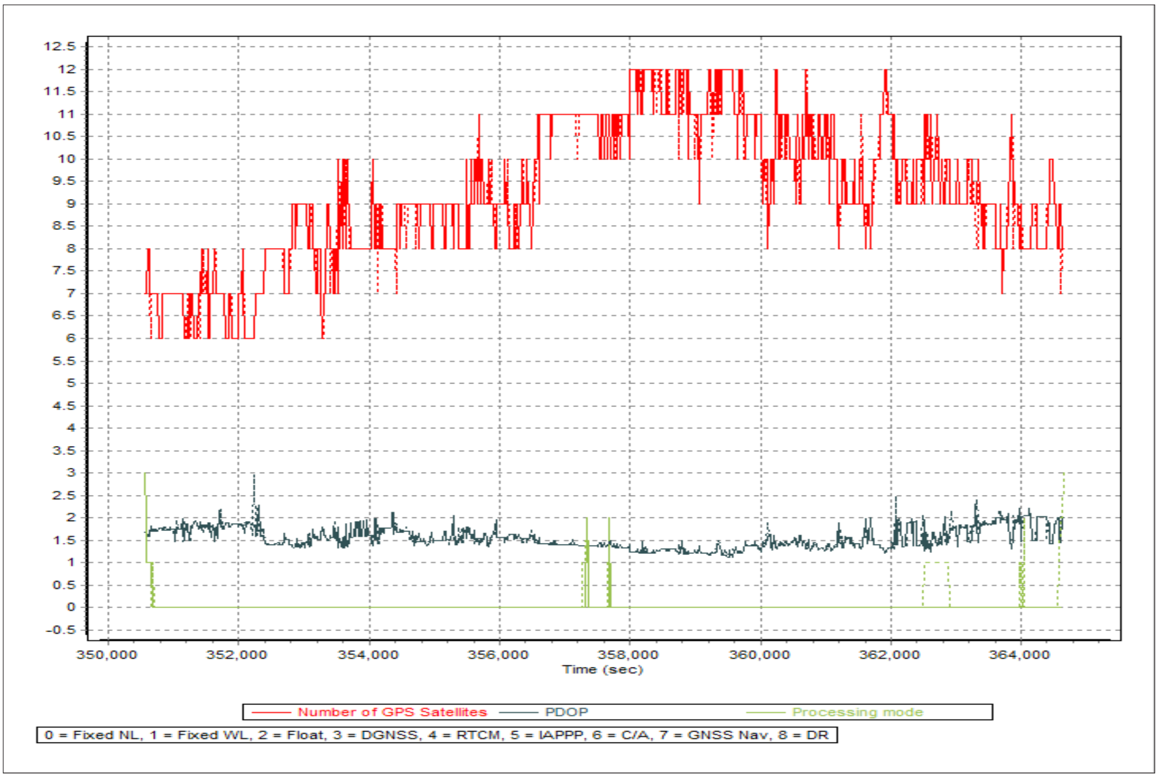
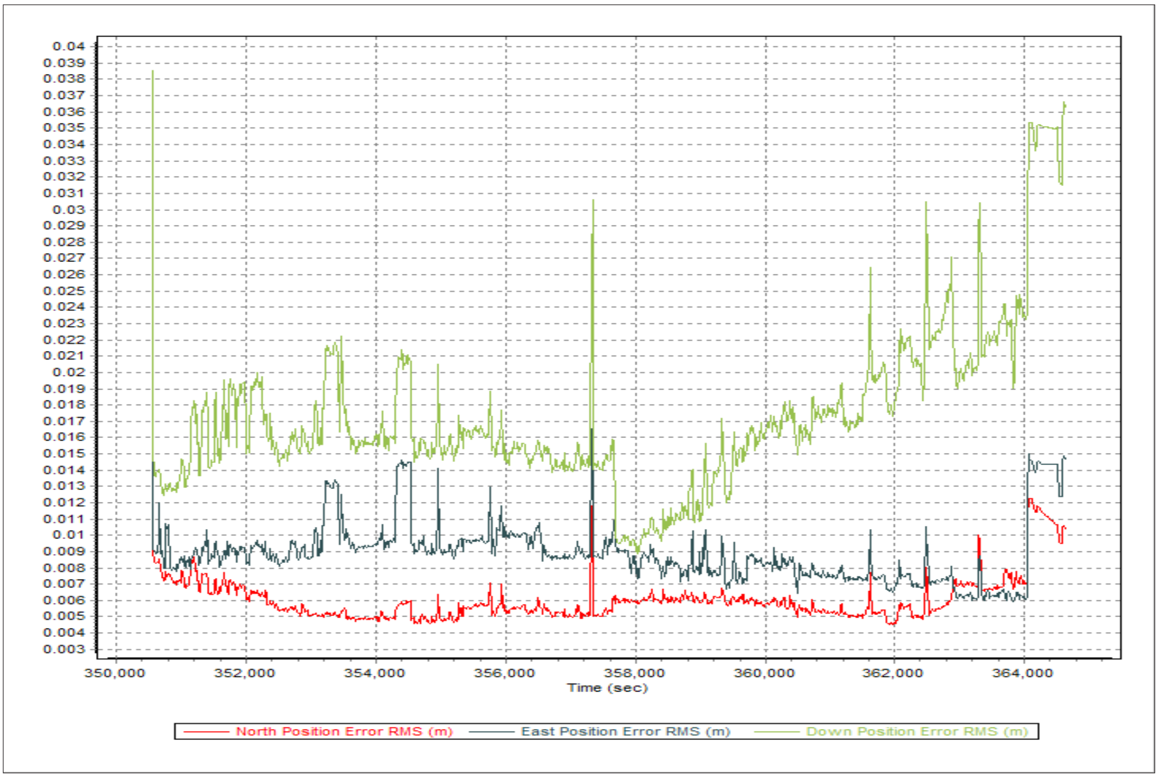


Figure 1.6.7Elevation difference between flight lines

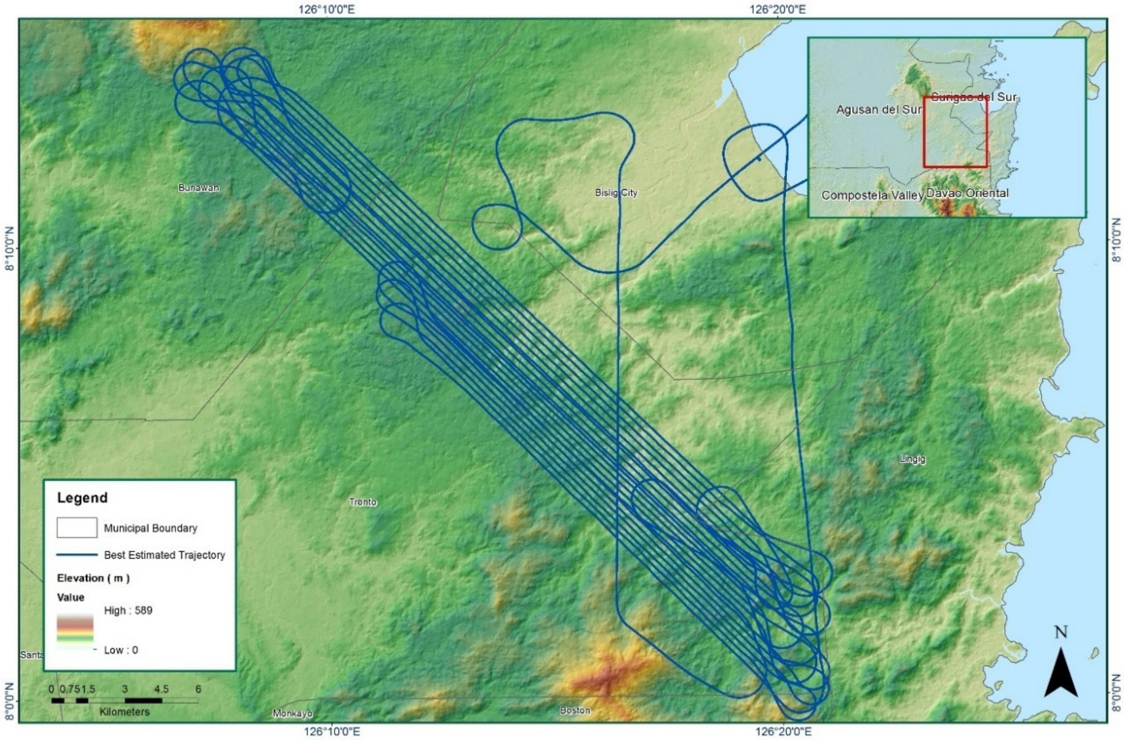
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66V**
Inclusive Flights	1850A
Range data size	15.20 GB
POS	260 MB
Base Data	10.6 MB
Image	97.40 MB
Transfer date	September 5, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.95
RMSE for East Position (<4.0 cm)	2.80
RMSE for Down Position (<8.0 cm)	3.90
Boresight correction stdev (<0.001deg)	0.000725
IMU attitude correction stdev (<0.001deg)	0.003001
GPS position stdev (<0.01m)	0.0029
Minimum % overlap (>25)	46.56
Ave point cloud density per sq.m. (>2.0)	3.82
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	175
Maximum Height	398.12 m
Minimum Height	69.57 m
Classification (# of points)	
Ground	22,755,718
Low vegetation	15,550,523
Medium vegetation	97,044,962
High vegetation	229,154,643
Building	3,586,890
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Mark Joshua Salvacion, Engr. Melissa Fernandez



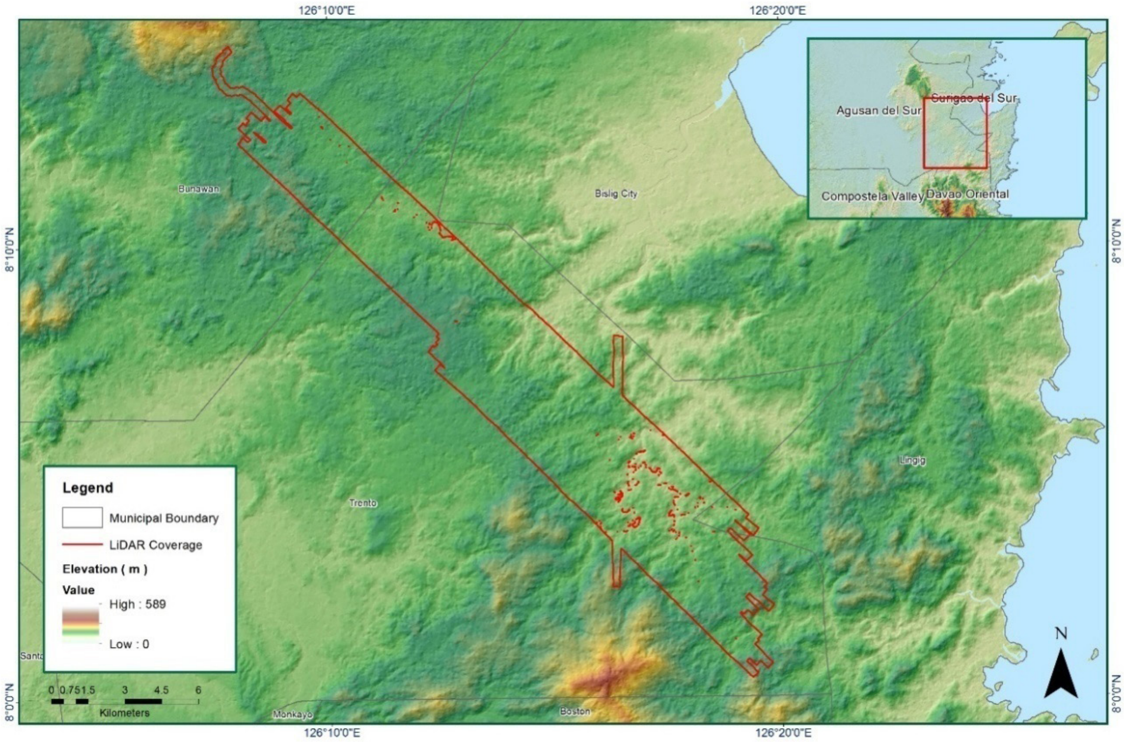
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

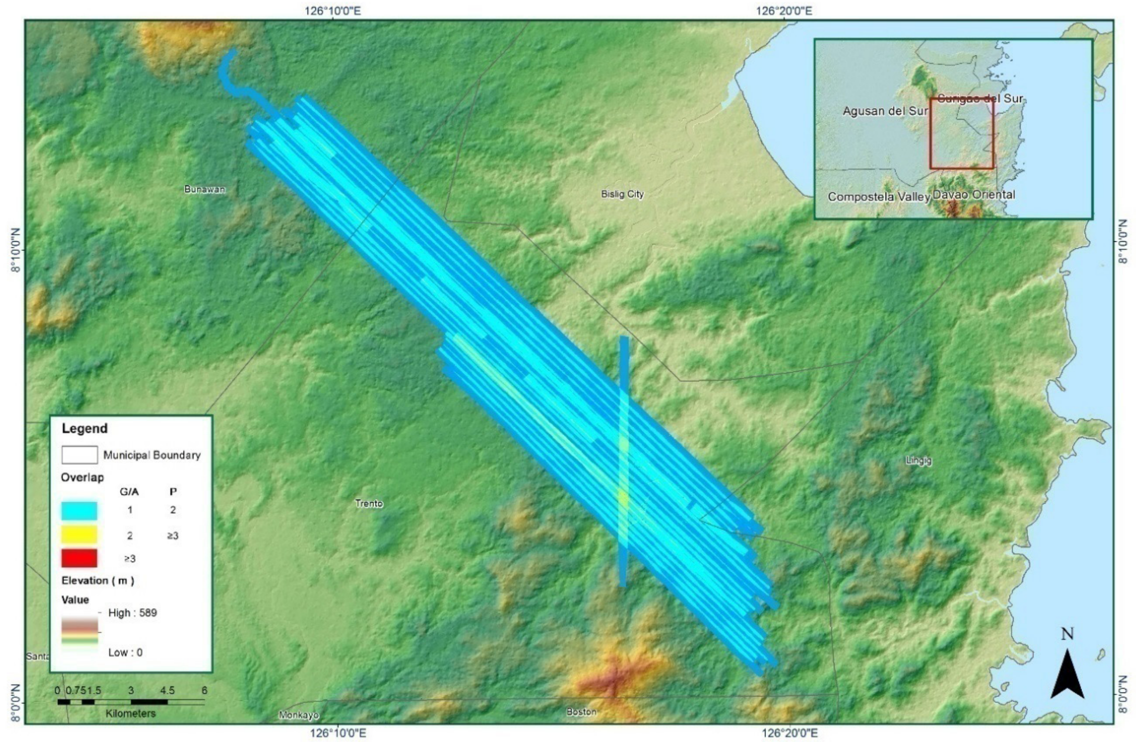
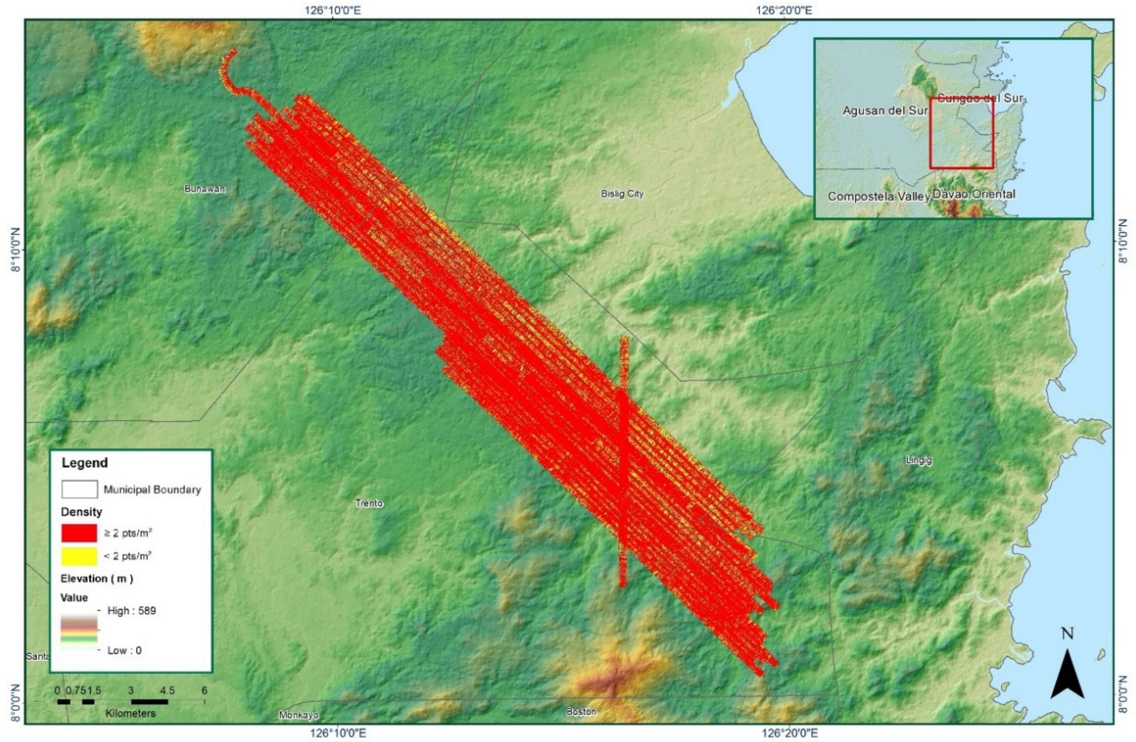
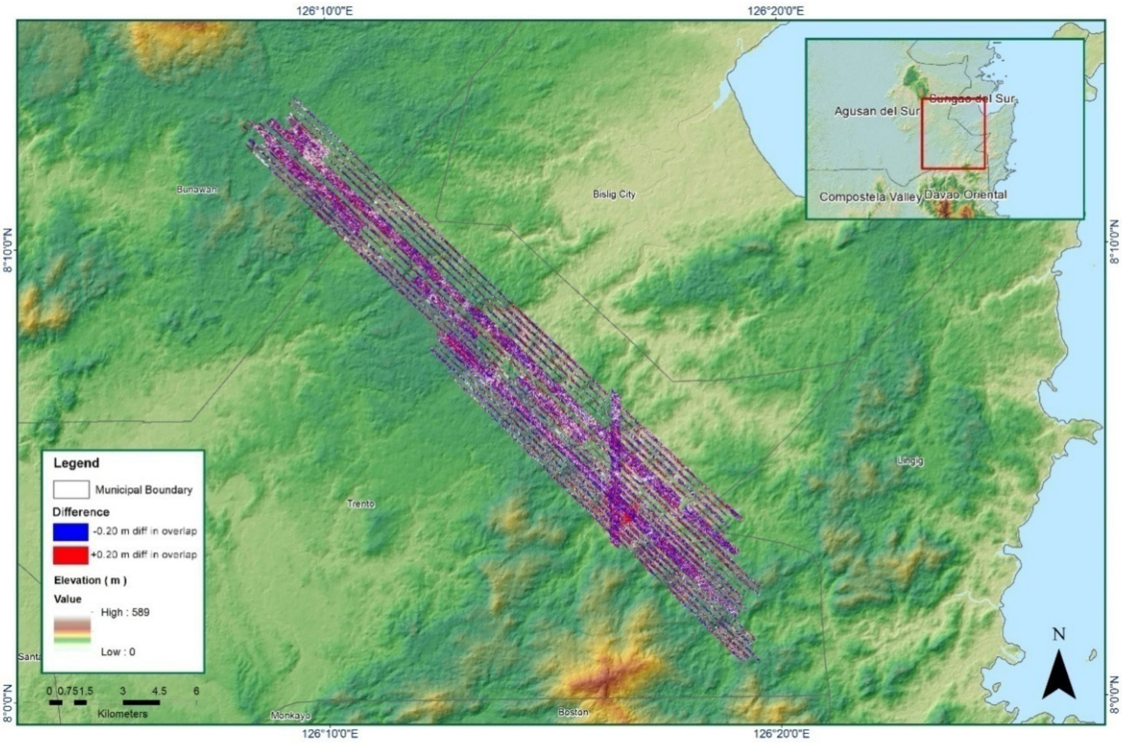


Image of data overlap

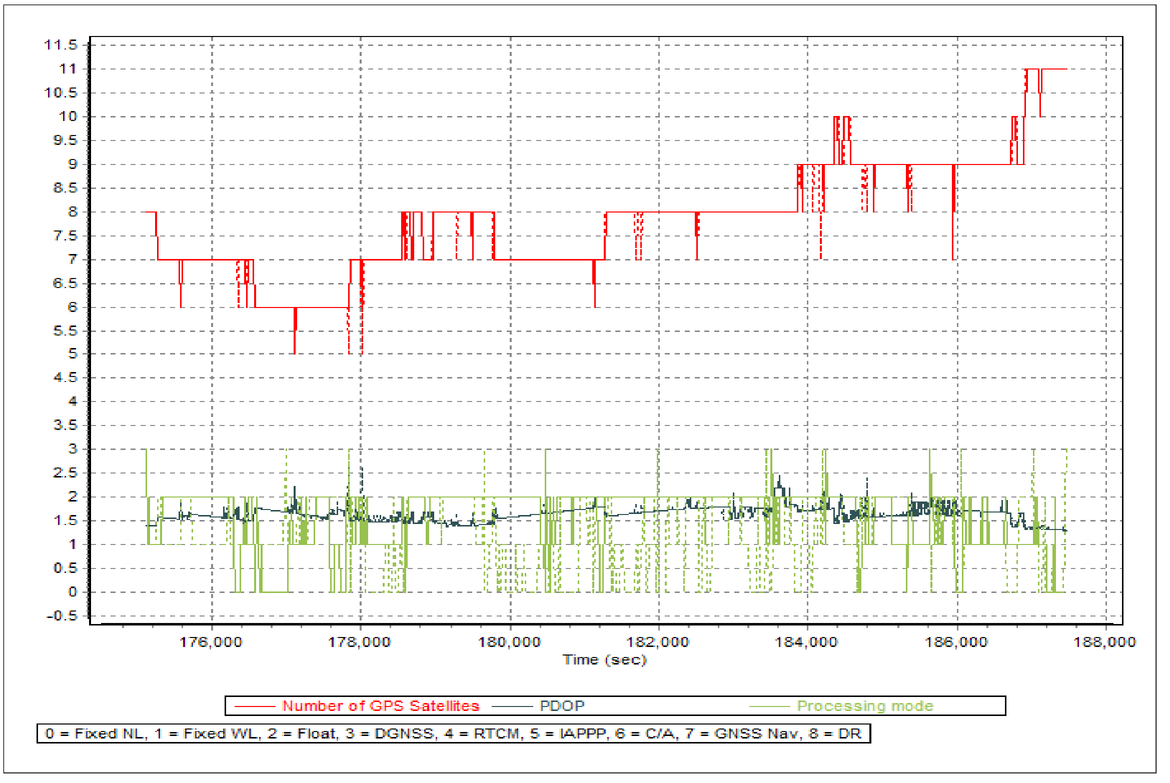


Density map of merged LiDAR data

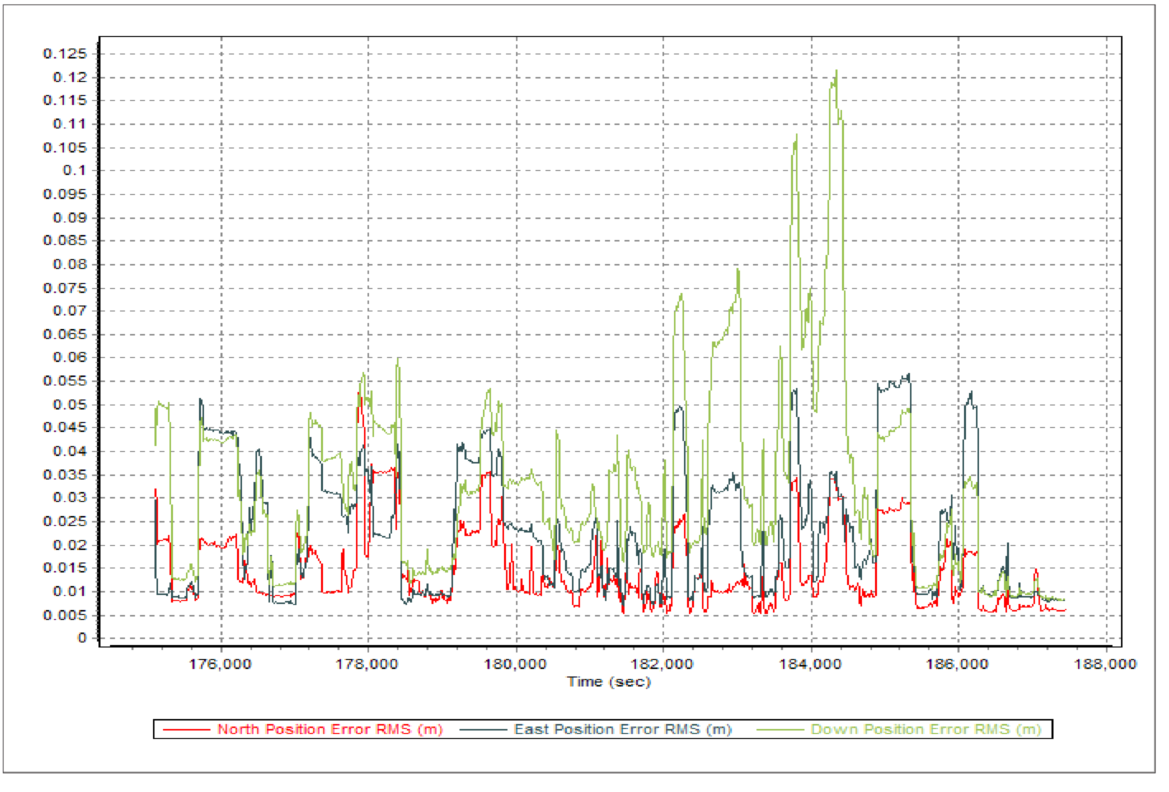


Elevation difference between flight lines

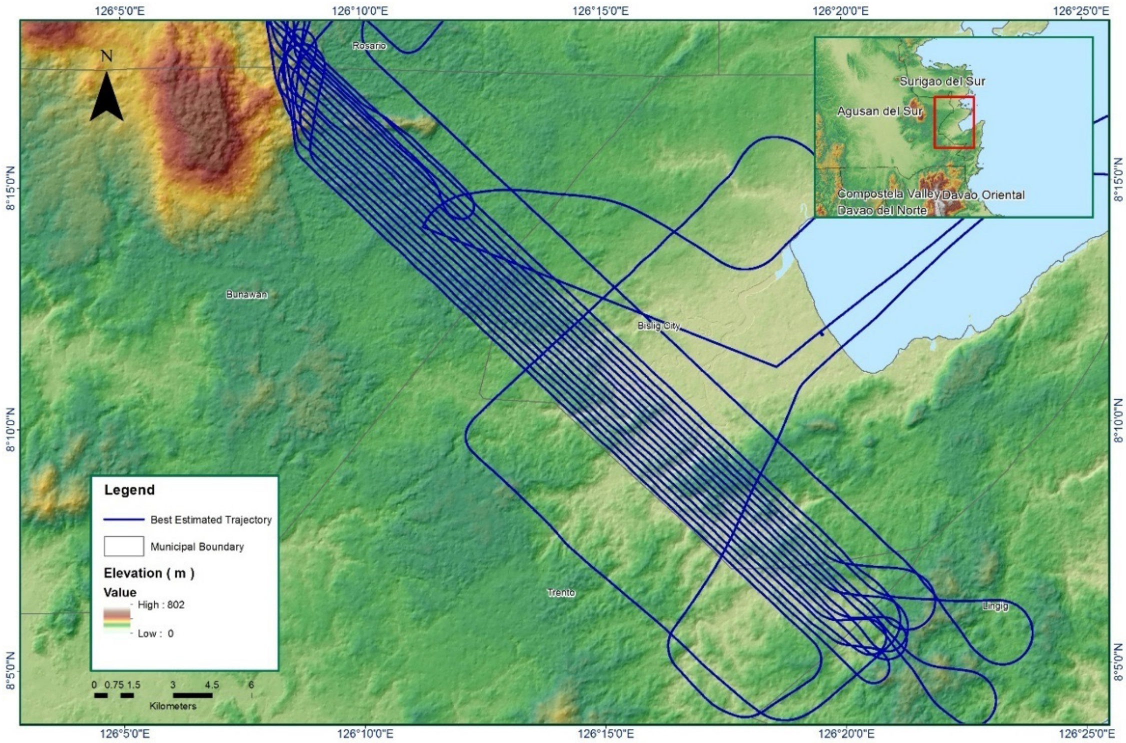
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66J**
Inclusive Flights	1786A & 1796A
Range data size	25.00 GB
POS	470 MB
Base Data	35.6 MB
Image	154.90 MB
Transfer date	August 20, 2014
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	5.20
RMSE for East Position (<4.0 cm)	5.60
RMSE for Down Position (<8.0 cm)	9.50
Boresight correction stdev (<0.001deg)	0.000575
IMU attitude correction stdev (<0.001deg)	0.010816
GPS position stdev (<0.01m)	0.0275
Minimum % overlap (>25)	48.46
Ave point cloud density per sq.m. (>2.0)	3.53
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	172
Maximum Height	456.37 m
Minimum Height	64.83 m
Classification (# of points)	
Ground	27,475,354
Low vegetation	19,235,361
Medium vegetation	86,561,167
High vegetation	219,738,869
Building	1,807,121
Orthophoto	Yes
Processed by	Engr. AnalynNaldo, Engr. Antonio Chua, Jr., Engr. John Dill Macapagal



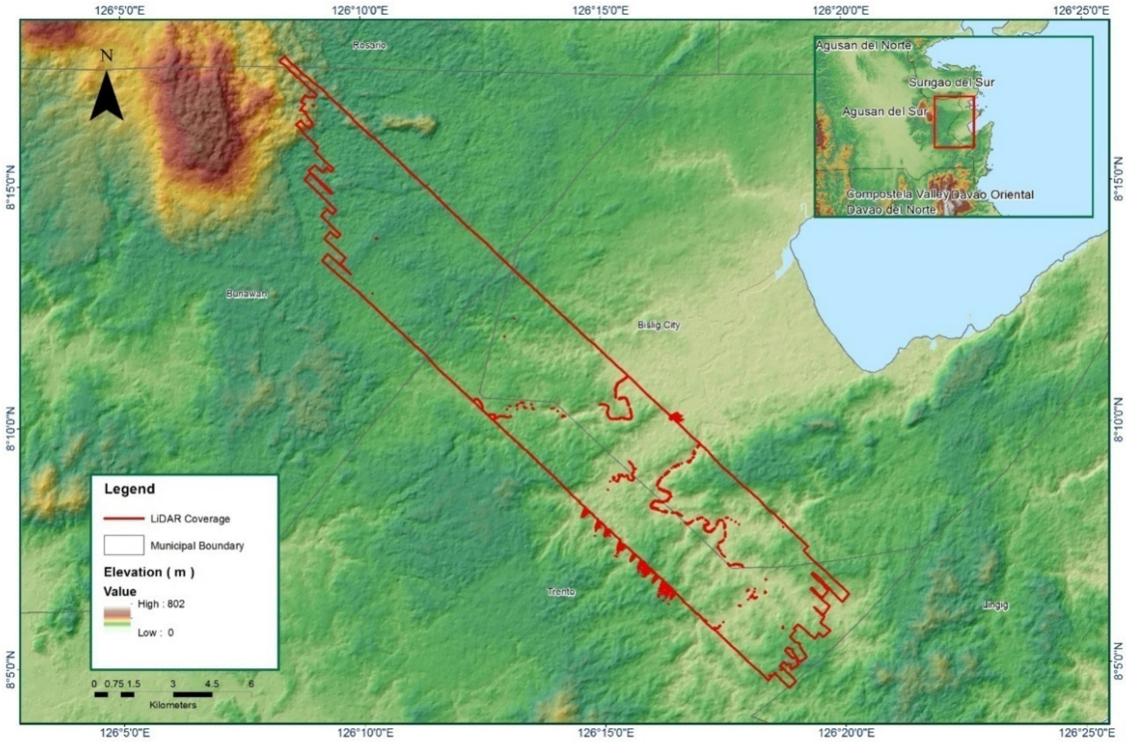
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

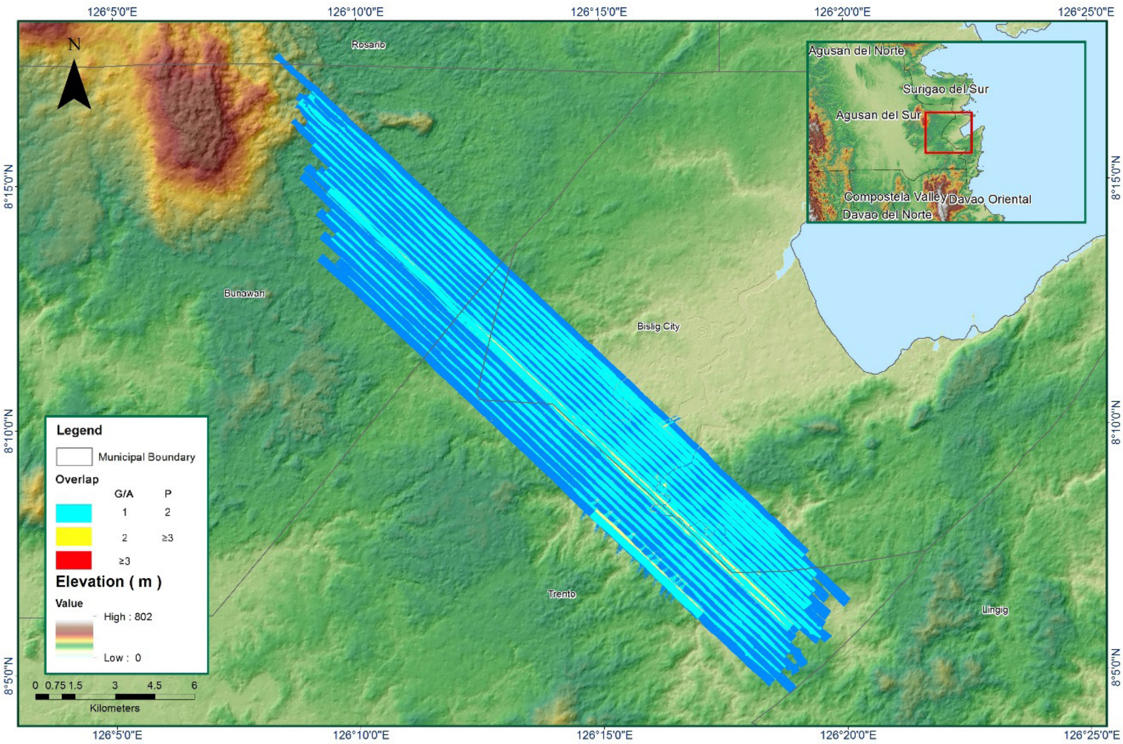
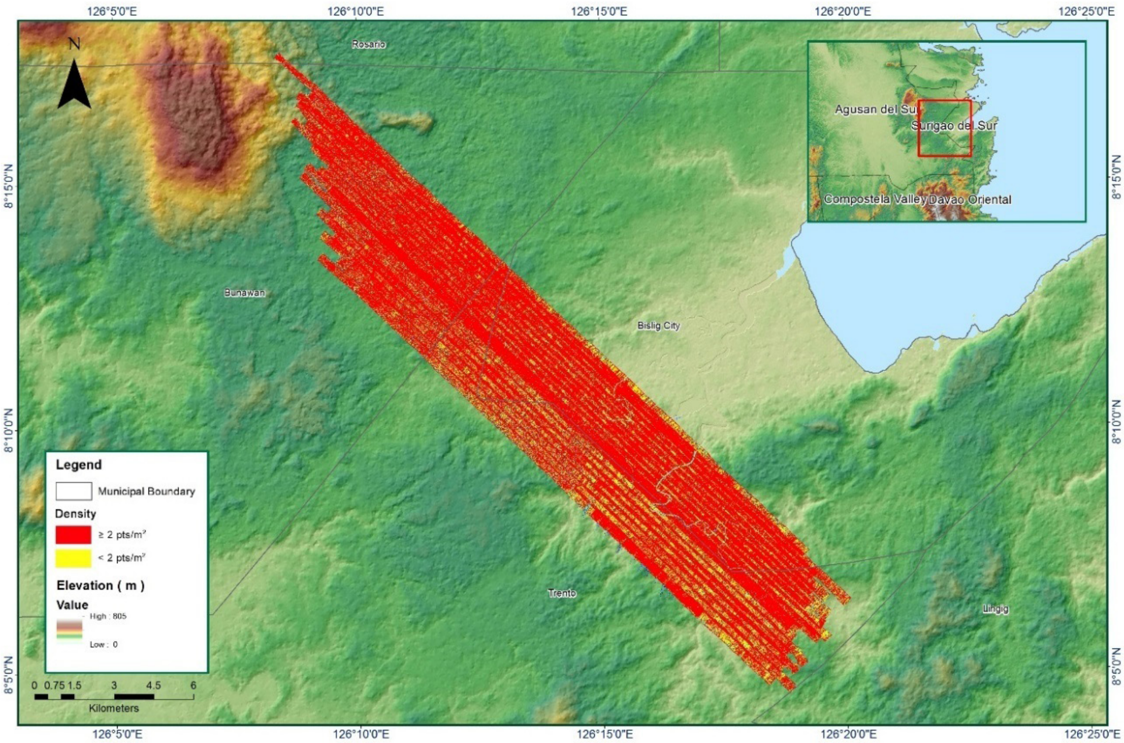
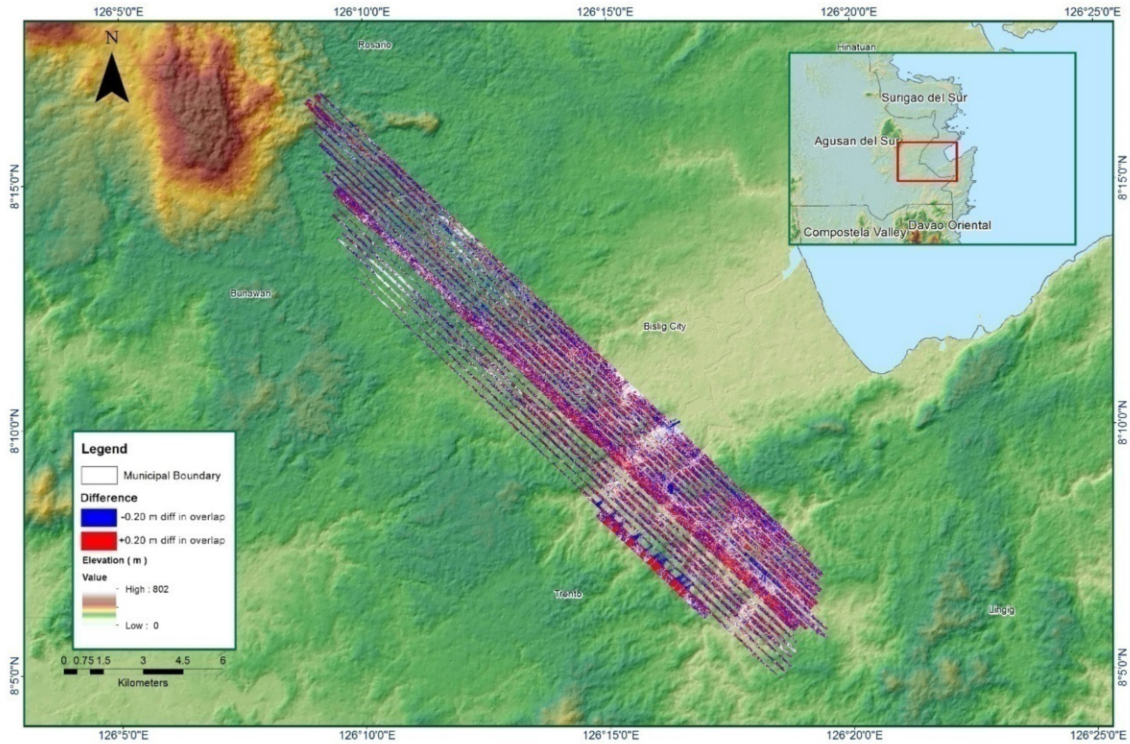


Image of data overlap

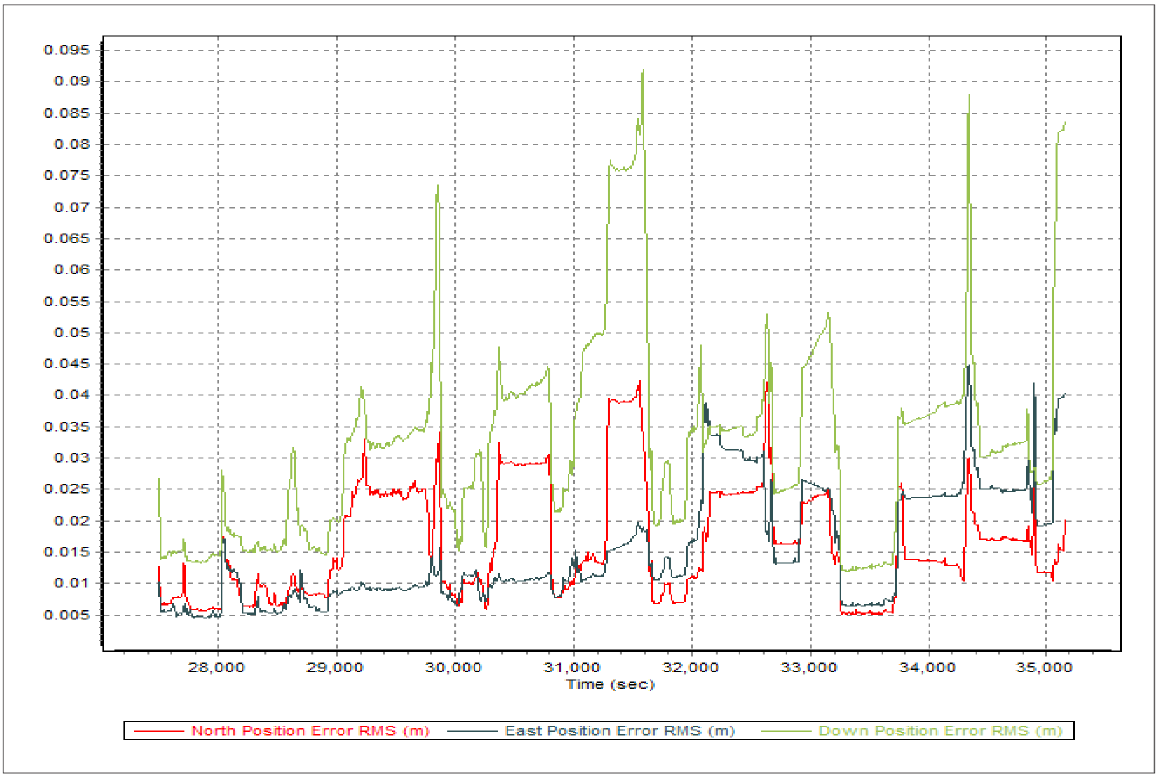


Density map of merged LiDAR data

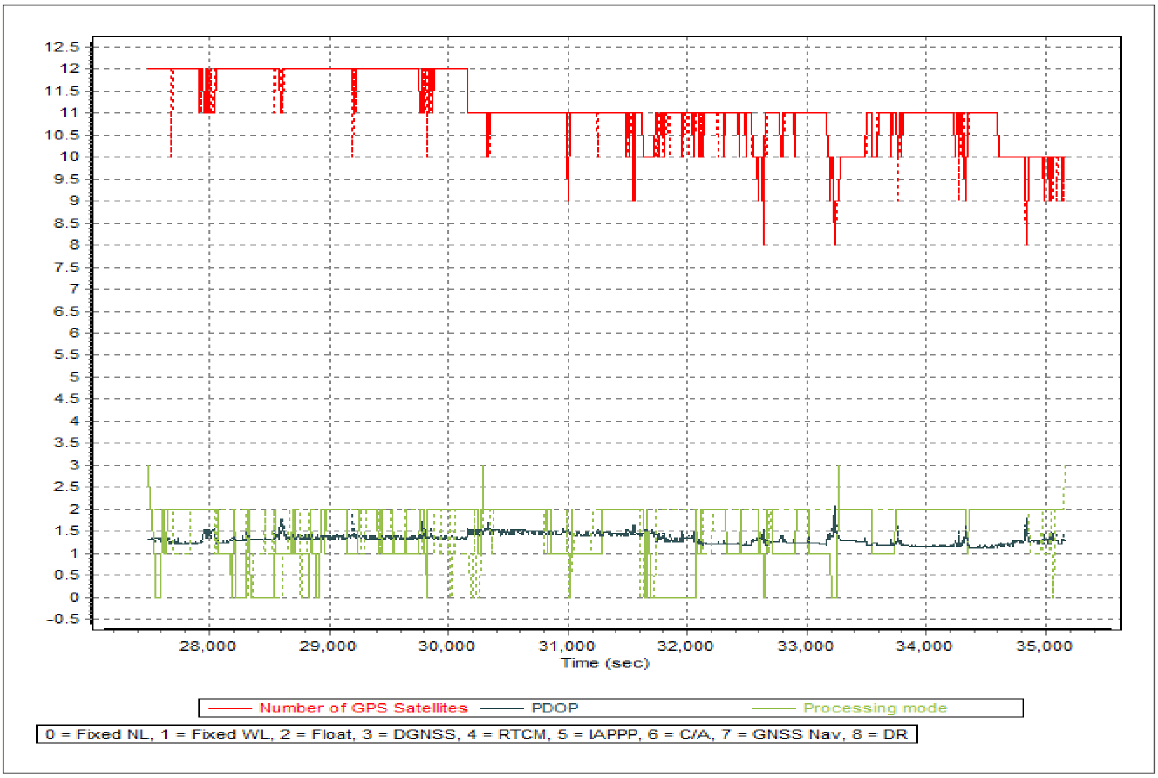


Elevation difference between flight lines

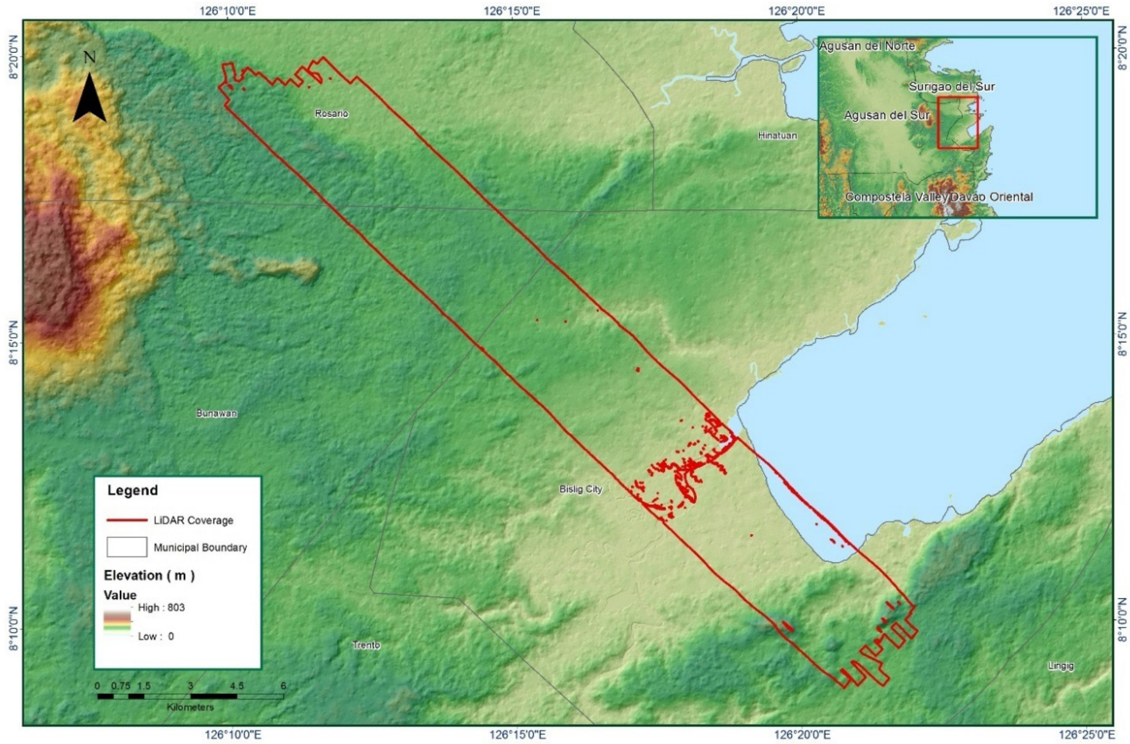
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66H**
Inclusive Flights	1778A, 1780A & 1784A
Range data size	33.60 GB
POS	622 MB
Base Data	
Image	176.60 MB
Transfer date	August 20 and September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	4.20
RMSE for East Position (<4.0 cm)	4.44
RMSE for Down Position (<8.0 cm)	9.00
Boresight correction stdev (<0.001deg)	0.000419
IMU attitude correction stdev (<0.001deg)	0.009927
GPS position stdev (<0.01m)	0.0274
Minimum % overlap (>25)	50.99
Ave point cloud density per sq.m. (>2.0)	4.32
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	145
Maximum Height	358.35 m
Minimum Height	66.38 m
Classification (# of points)	
Ground	39942266
Low vegetation	41221922
Medium vegetation	105018009
High vegetation	150978733
Building	3482900
Orthophoto	Yes
Processed by	Engr. AnalynNaldo, Engr. Harmond Santos, Ryan James Nicholai Dizon



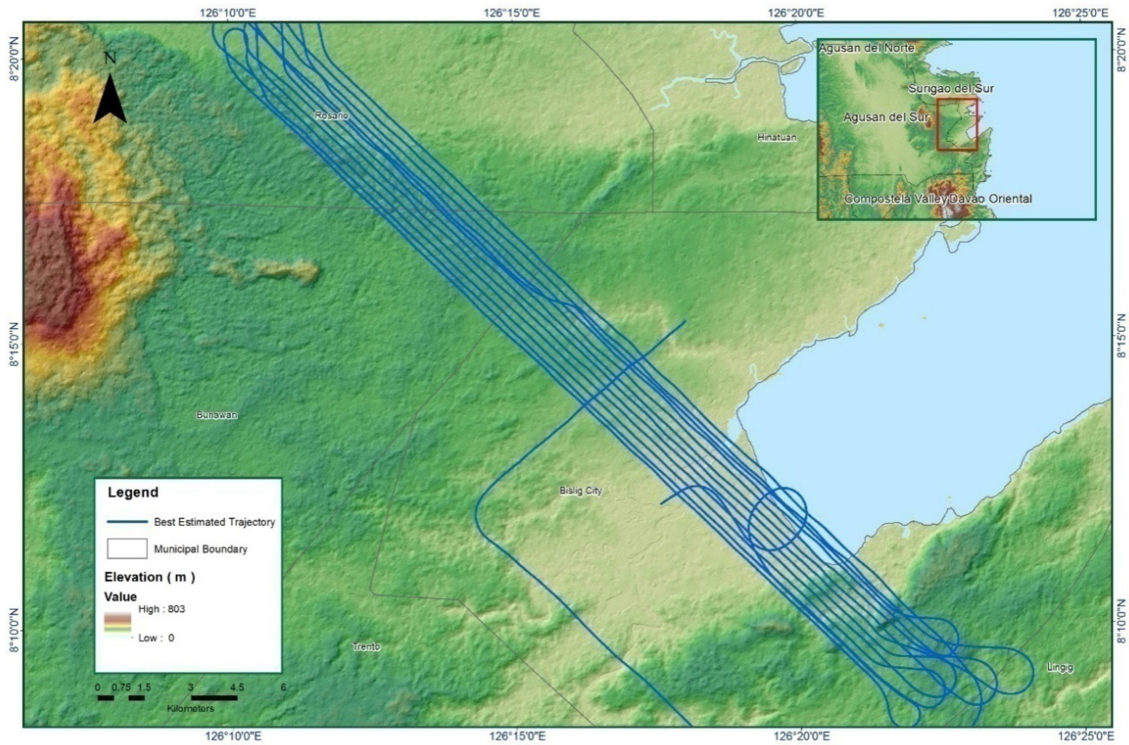
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

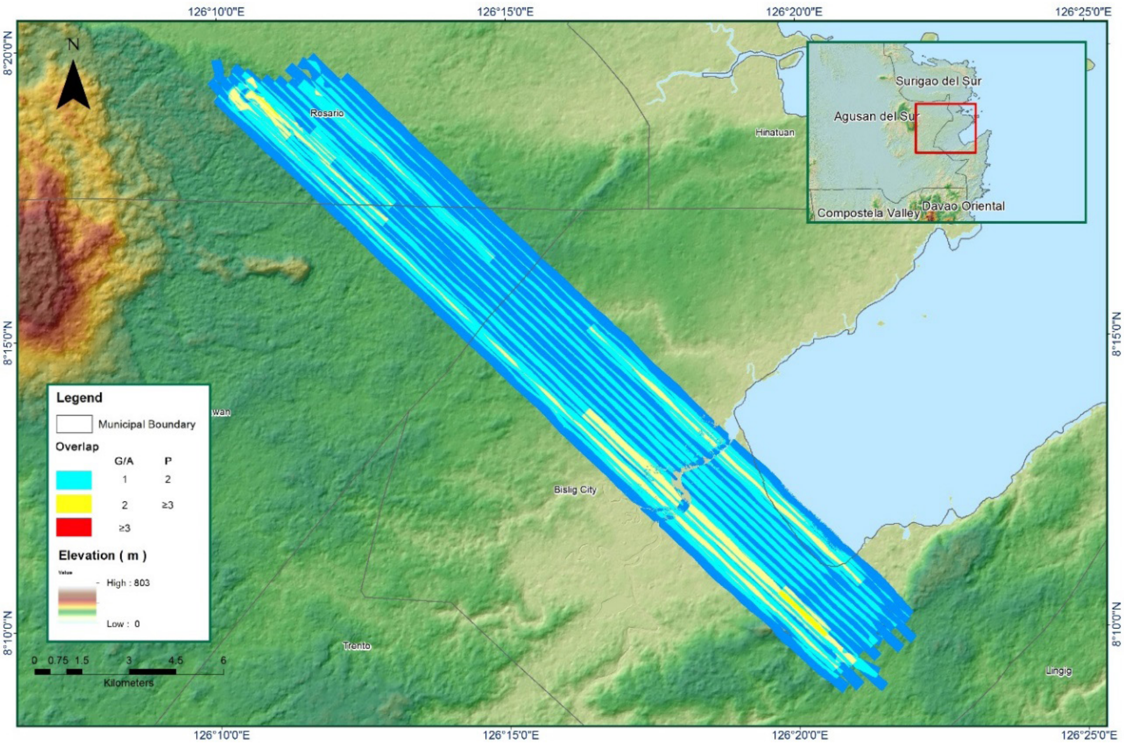
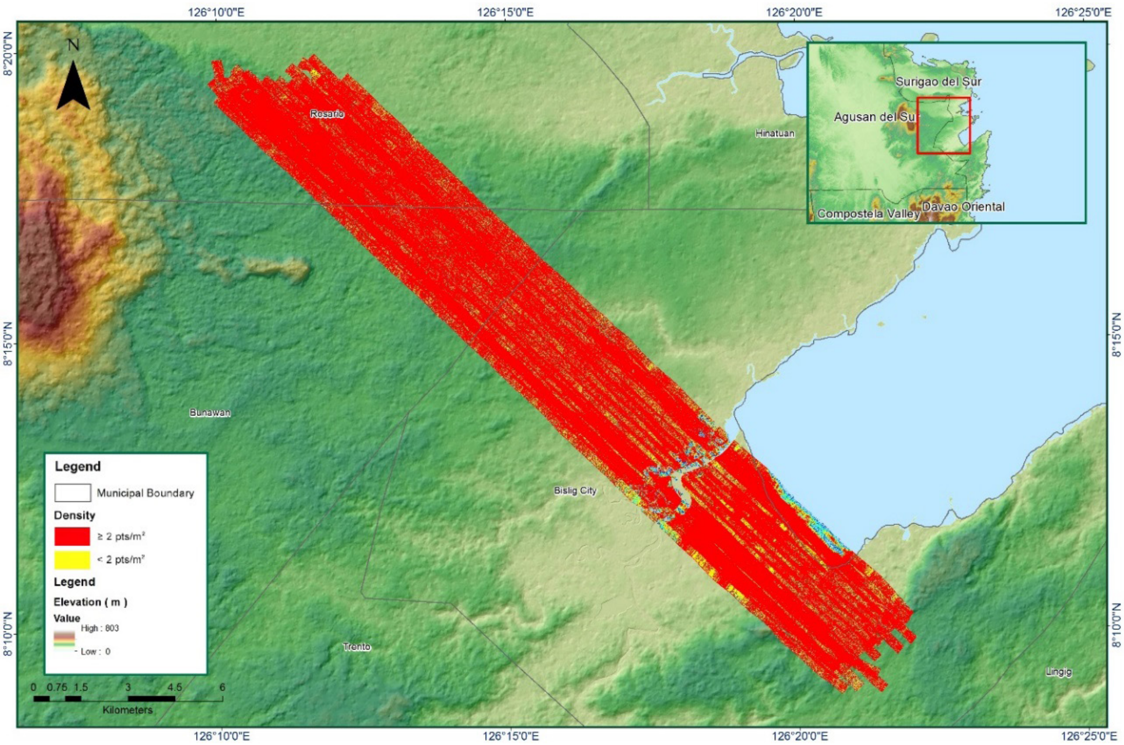
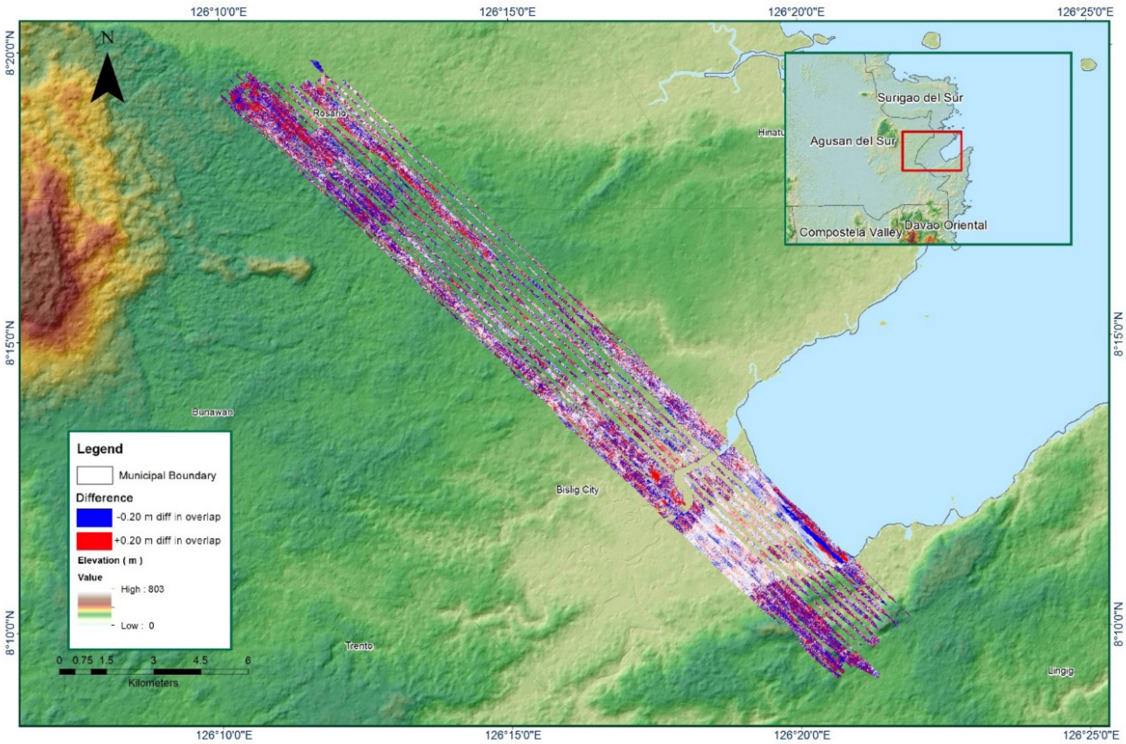


Image of data overlap

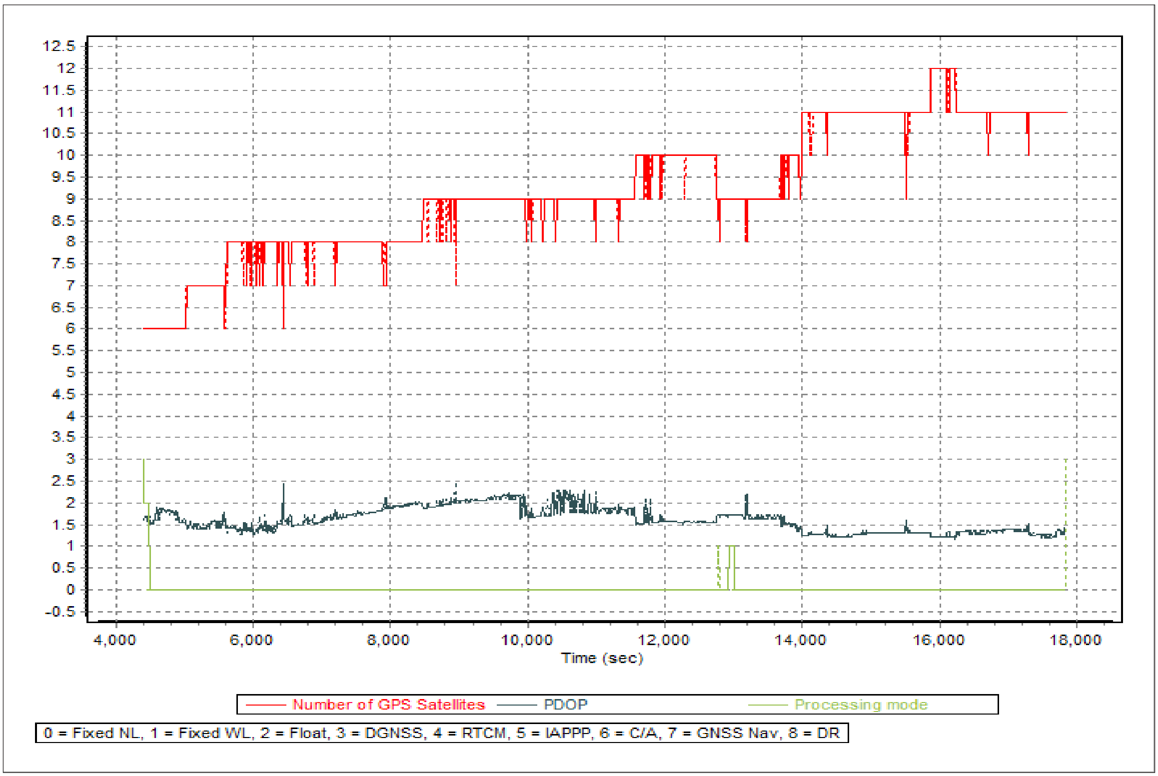


Density map of merged LiDAR data

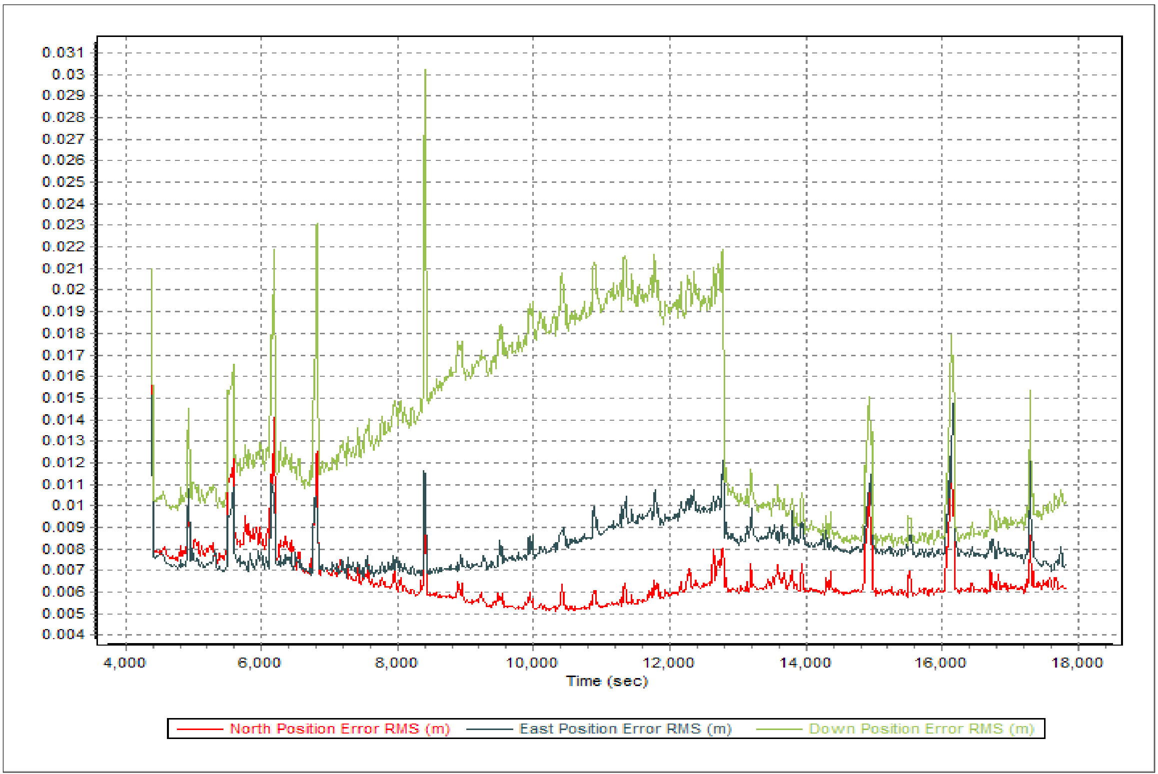


Elevation difference between flight lines

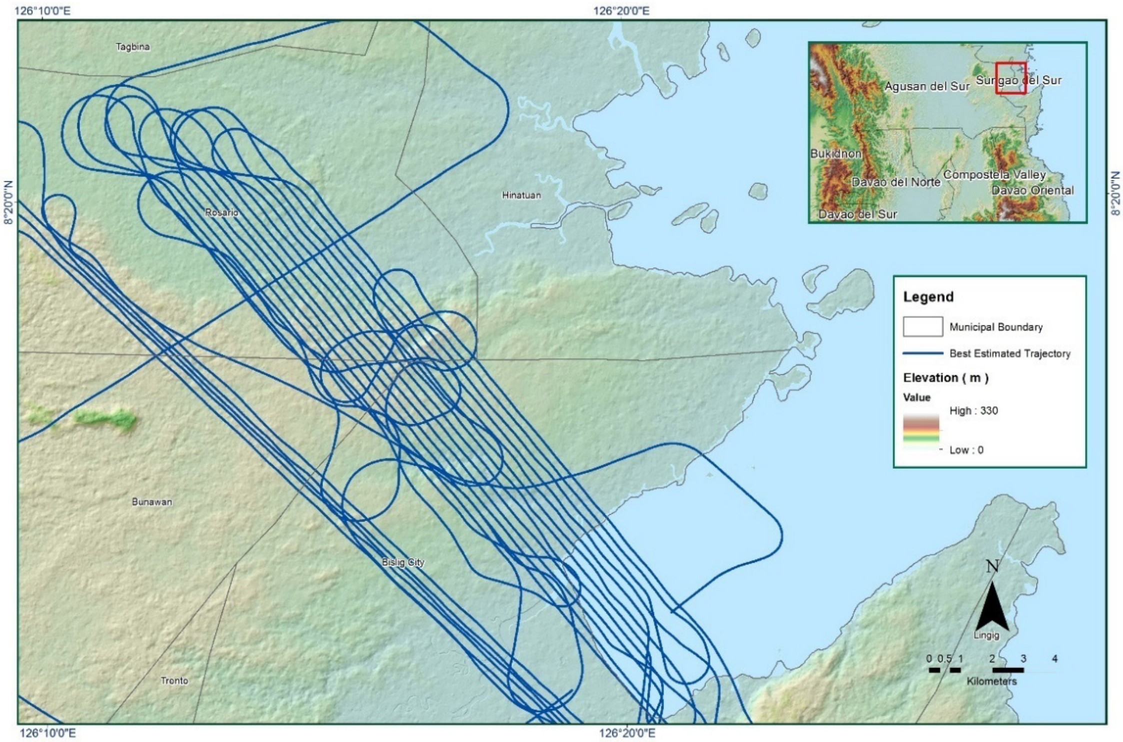
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66G**
Inclusive Flights	1778A
Range data size	13.00 GB
POS	257 MB
Base Data	9.32 MB
Image	81.90 MB
Transfer date	August 20, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.60
RMSE for East Position (<4.0 cm)	1.50
RMSE for Down Position (<8.0 cm)	3.00
Boresight correction stdev (<0.001deg)	0.000278
IMU attitude correction stdev (<0.001deg)	0.001175
GPS position stdev (<0.01m)	0.0149
Minimum % overlap (>25)	26.16
Ave point cloud density per sq.m. (>2.0)	3.29
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	78
Maximum Height	276.11 m
Minimum Height	66.52 m
Classification (# of points)	
Ground	9760314
Low vegetation	7804910
Medium vegetation	19940917
High vegetation	32586969
Building	968426
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Chelou Prado, Engr. Jeffrey Delica



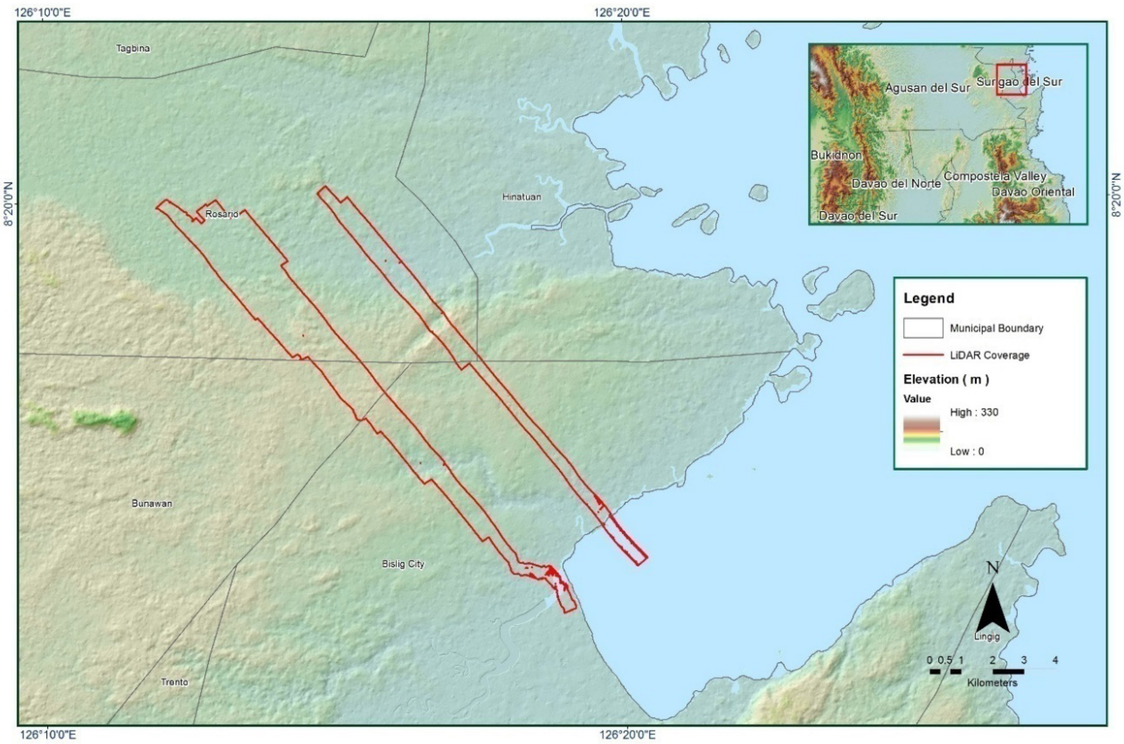
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

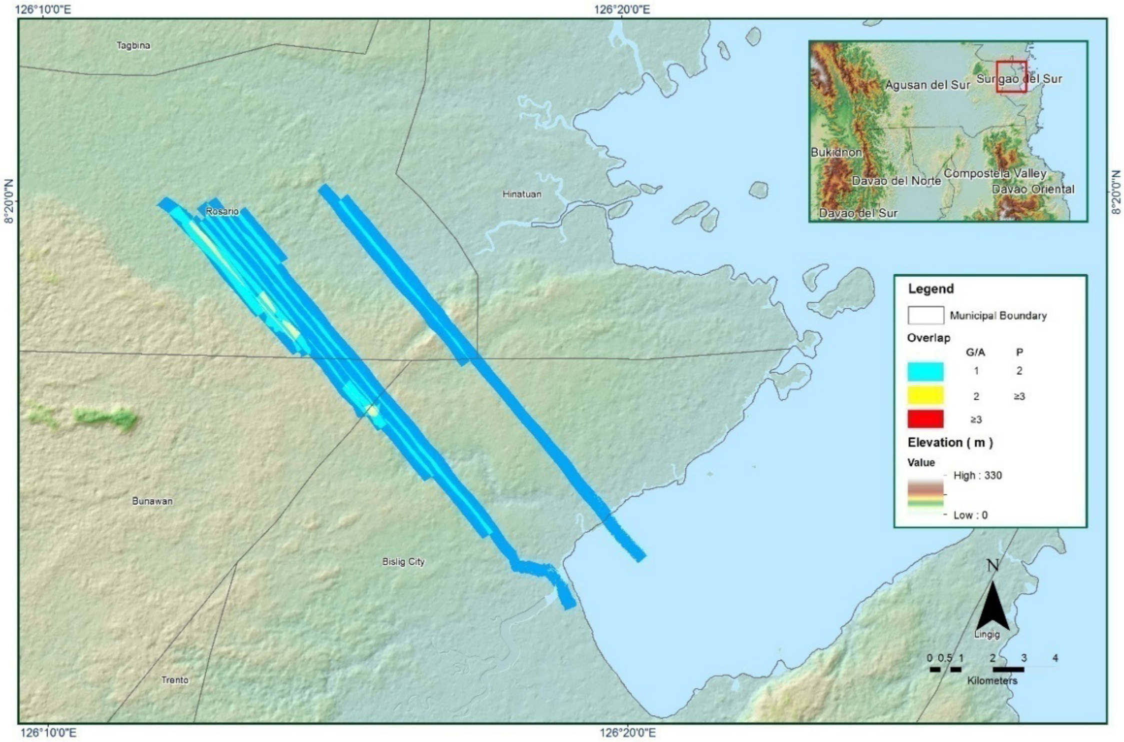
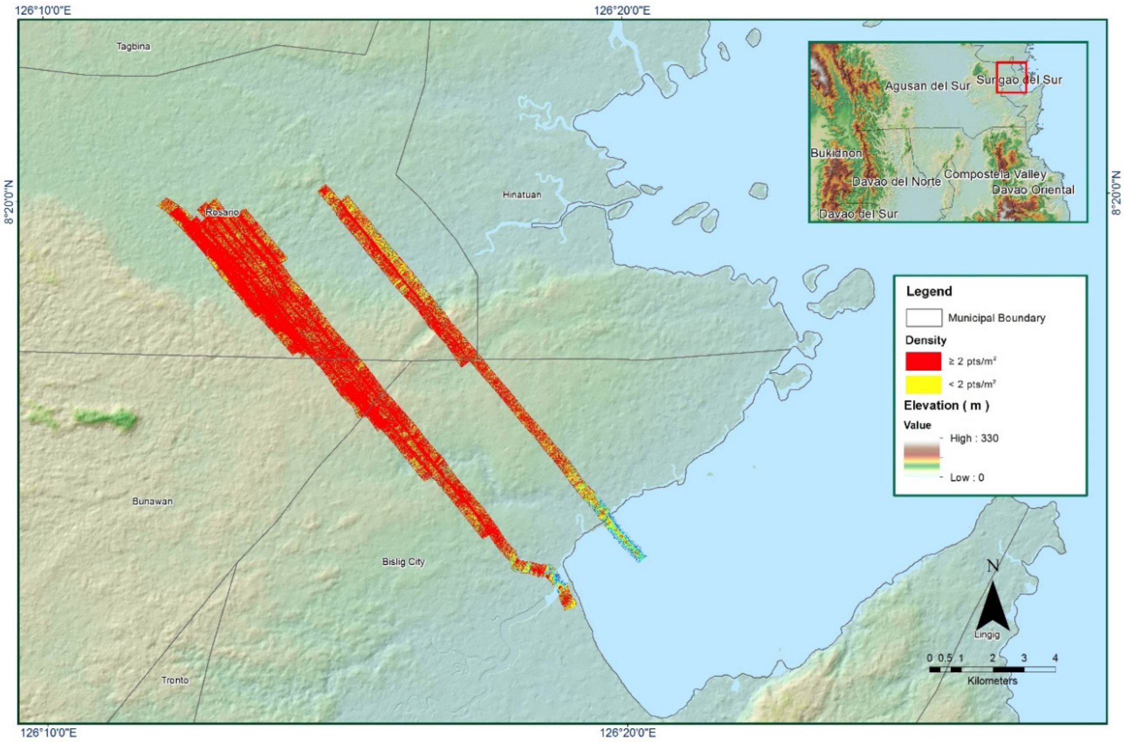
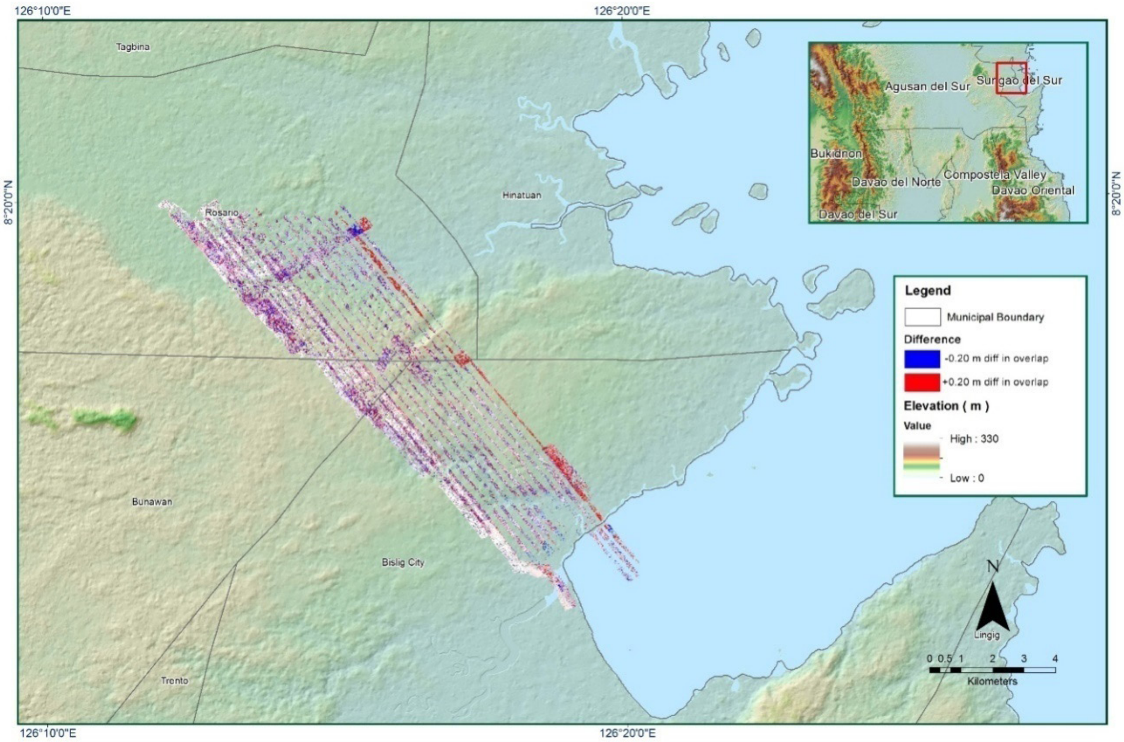


Image of data overlap

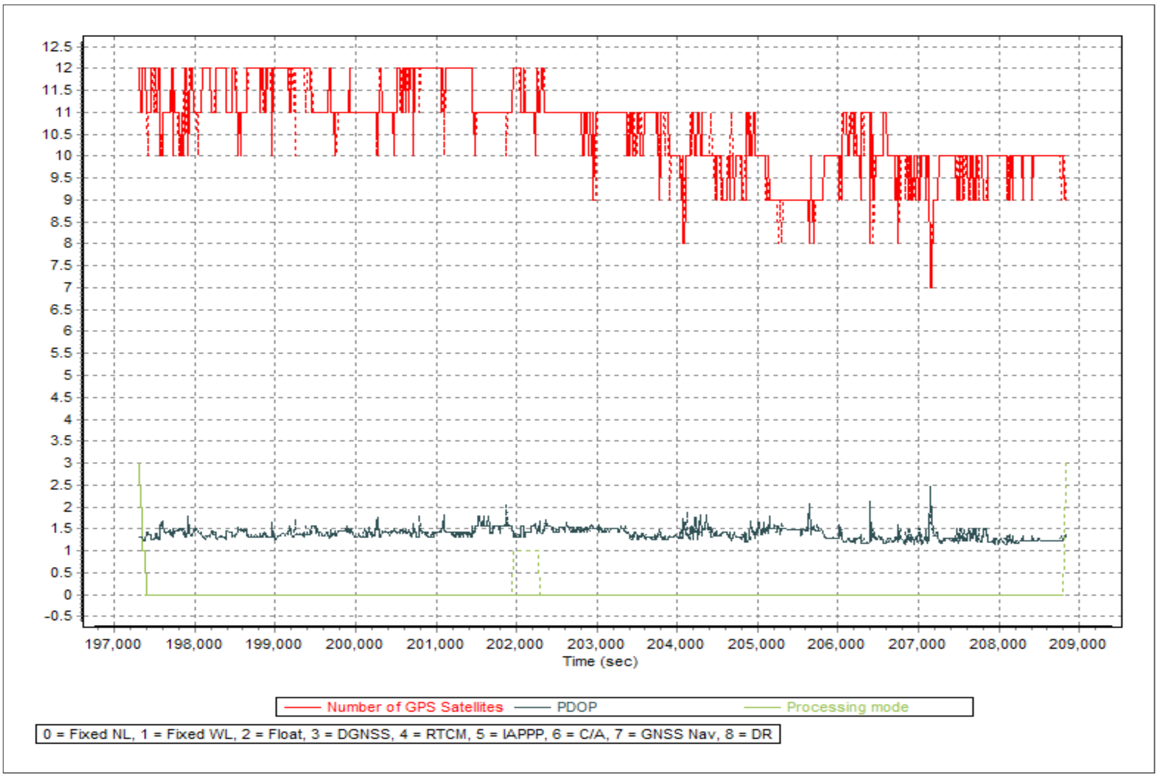


Density map of merged LiDAR data

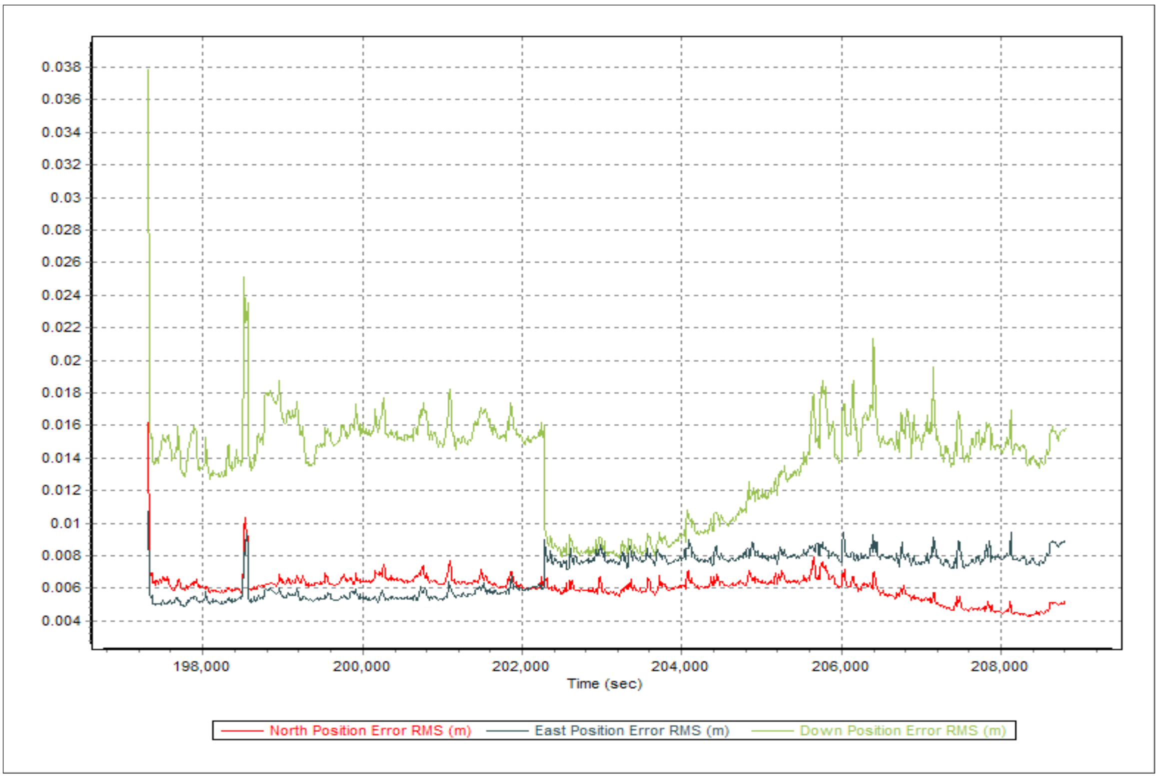


Elevation difference between flight lines

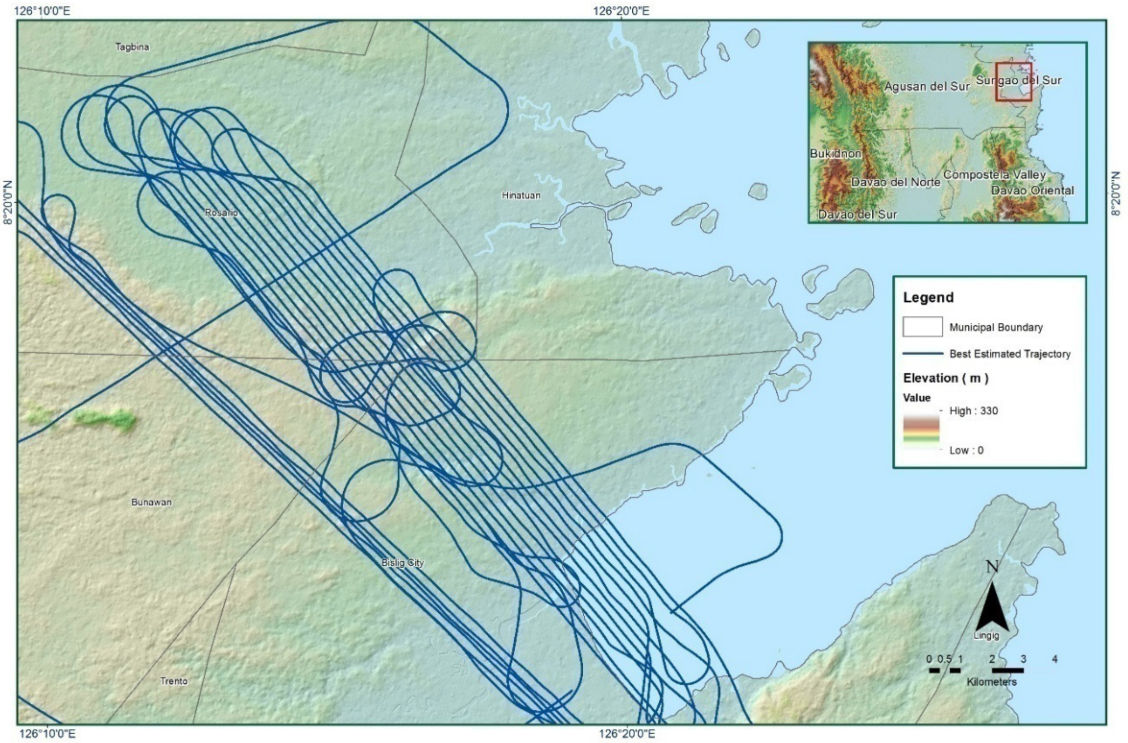
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66G Additional**
Inclusive Flights	1788A
Range data size	10.40 GB
POS	228 MB
Base Data	17.8 MB
Image	50.40 MB
Transfer date	August 20, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.60
RMSE for East Position (<4.0 cm)	1.08
RMSE for Down Position (<8.0 cm)	3.80
Boresight correction stdev (<0.001deg)	0.001353
IMU attitude correction stdev (<0.001deg)	0.003331
GPS position stdev (<0.01m)	0.0035
Minimum % overlap (>25)	35.71
Ave point cloud density per sq.m. (>2.0)	3.00
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	78
Maximum Height	291.93 m
Minimum Height	64.46 m
Classification (# of points)	
Ground	16874507
Low vegetation	14027224
Medium vegetation	38836740
High vegetation	52670726
Building	1294329
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Melanie Hingpit, Engr. Elainne Lopez



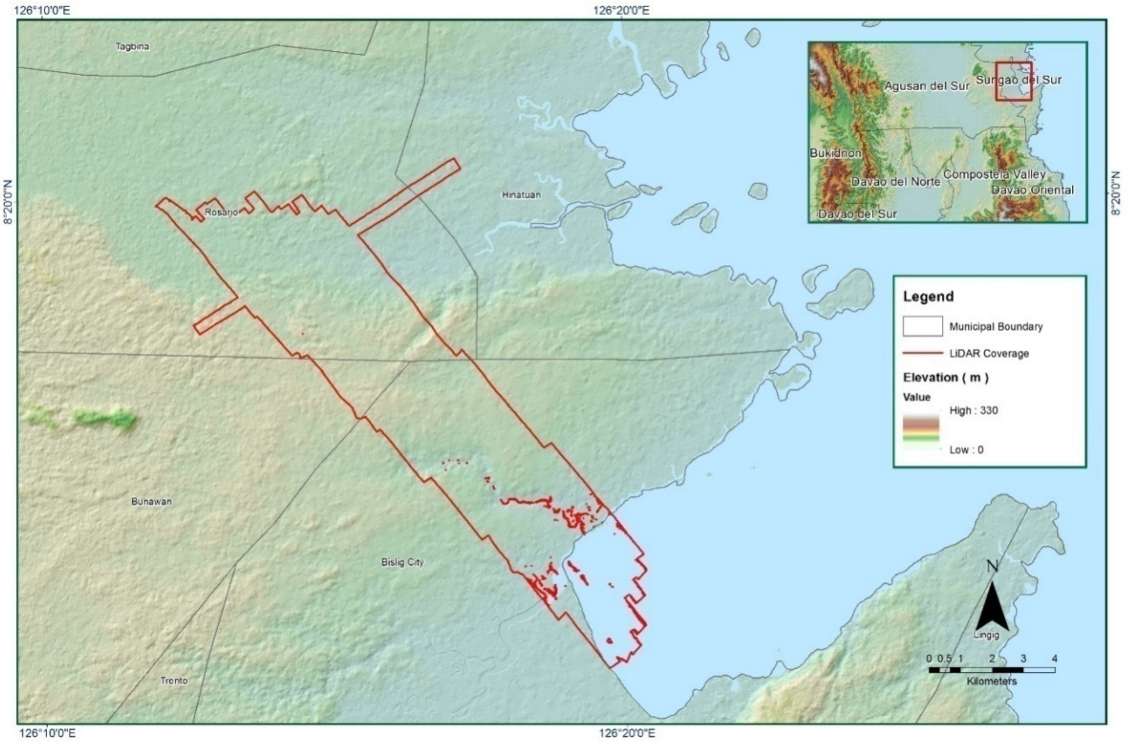
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

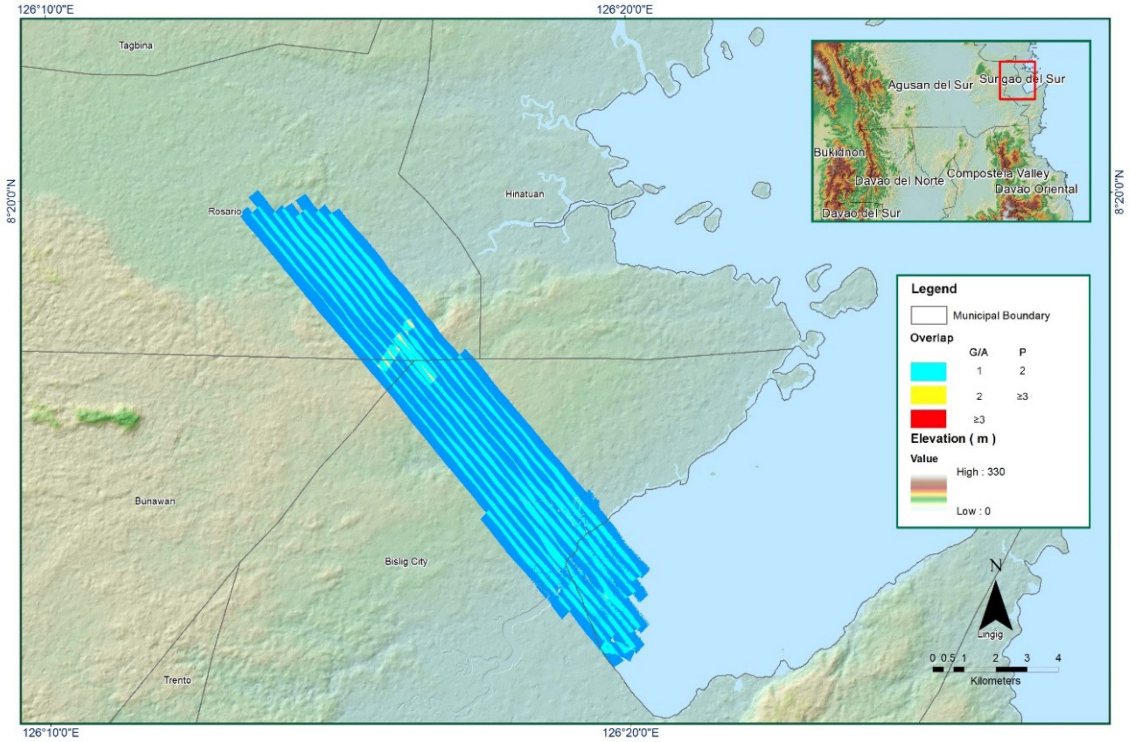


Figure 1.11.5 Image of data overlap

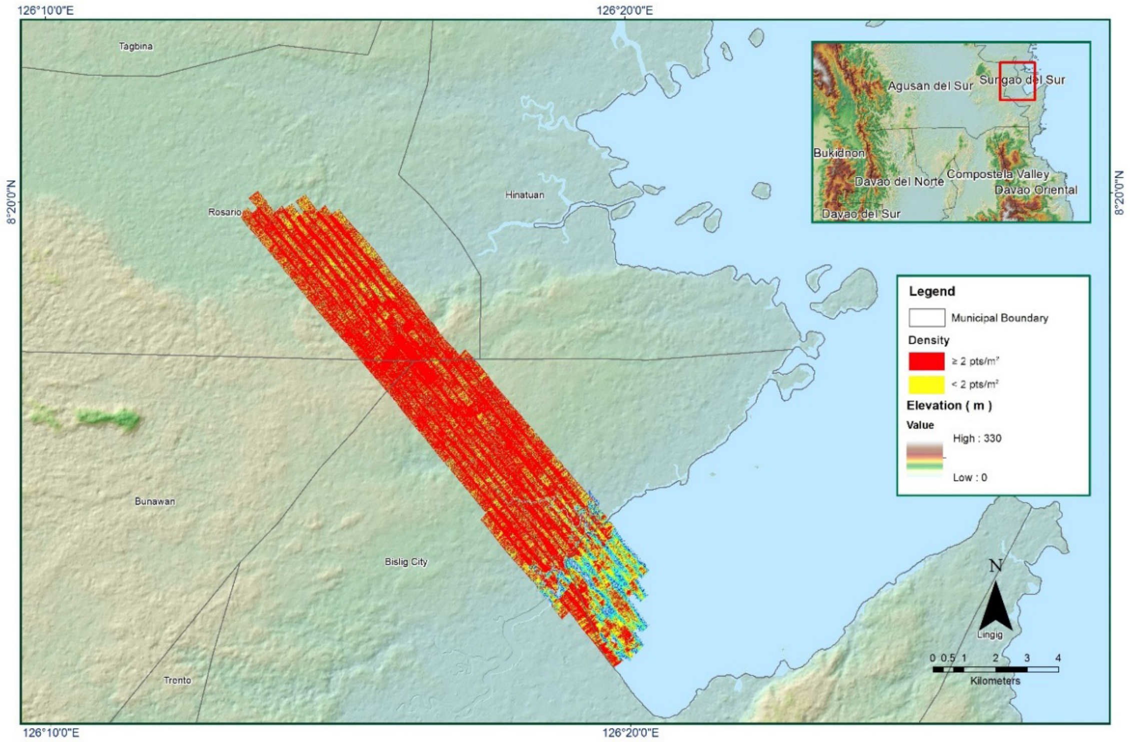


Figure 1.11.6Density map of merged LiDAR data

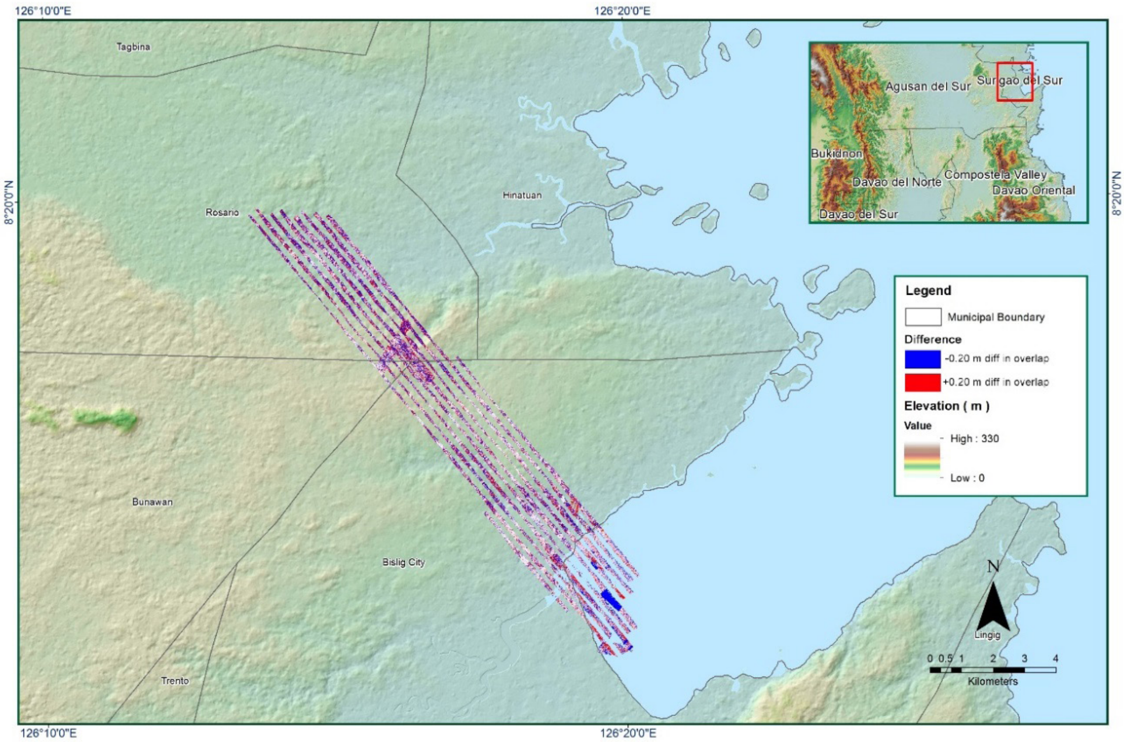
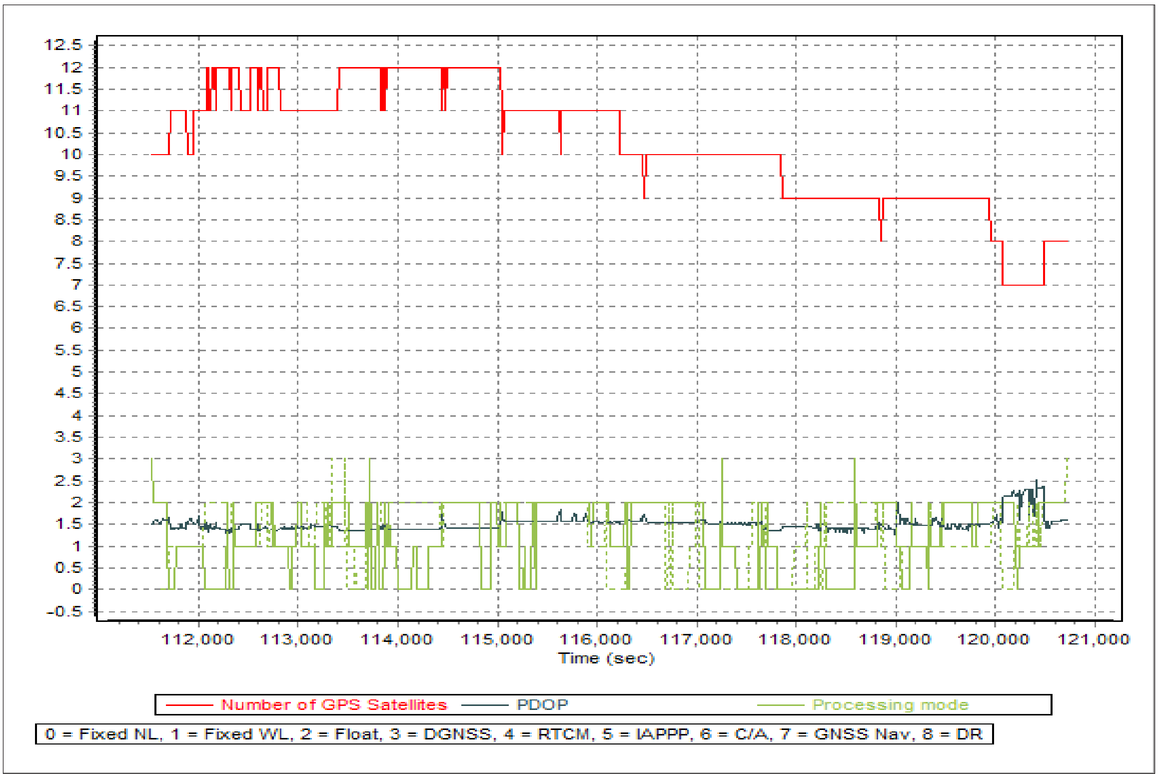
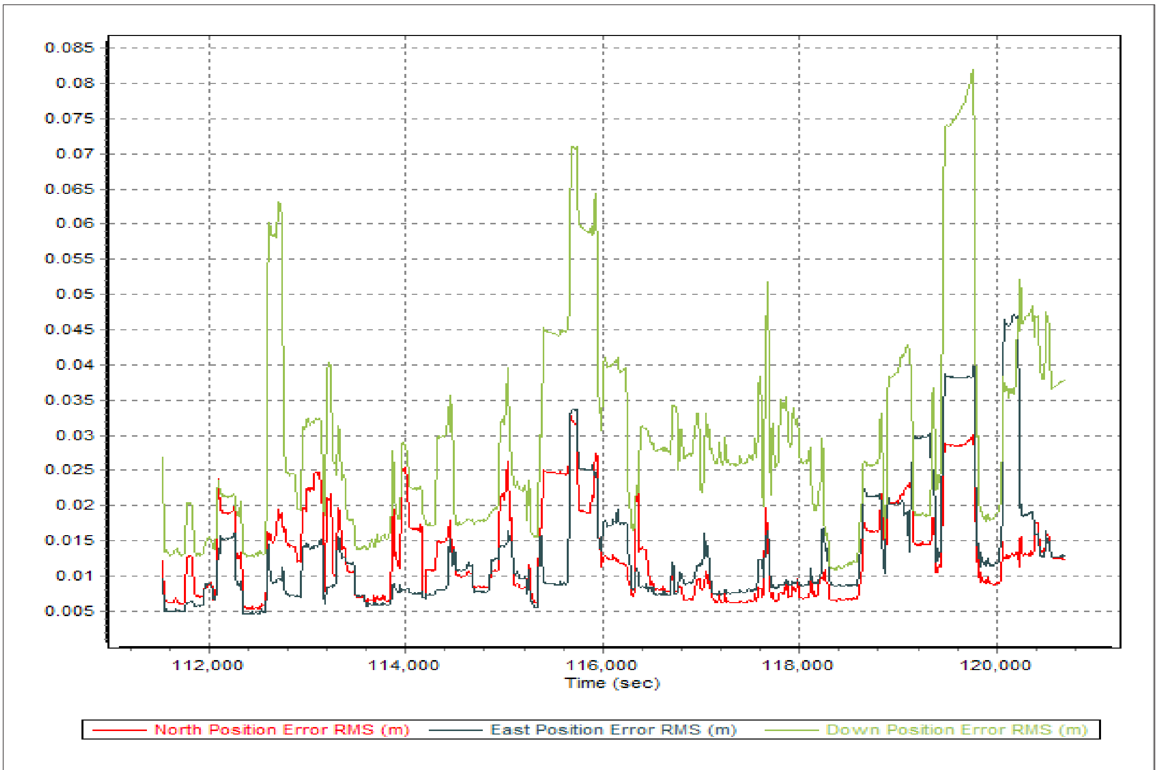


Figure 1.11.7Elevation difference between flight lines

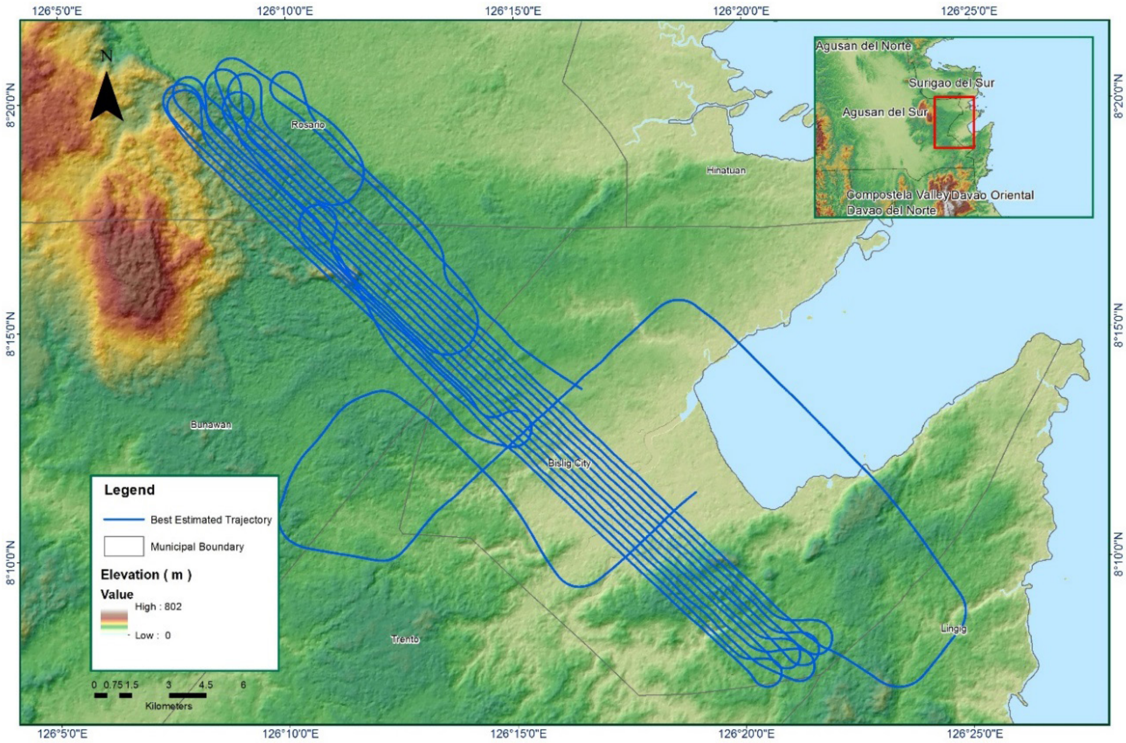
Flight Area	Bislig (Surigao Del Sur)
Mission Name	**Block 66I**
Inclusive Flights	1784A & 1786A
Range data size	24.90 GB
POS	435 MB
Base Data	35.2 MB
Image	141 MB
Transfer date	August 20 and September 1, 2014
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.33
RMSE for East Position (<4.0 cm)	4.60
RMSE for Down Position (<8.0 cm)	8.00
Boresight correction stdev (<0.001deg)	0.000009
IMU attitude correction stdev (<0.001deg)	0.001444
GPS position stdev (<0.01m)	0.0076
Minimum % overlap (>25)	42.57
Ave point cloud density per sq.m. (>2.0)	3.63
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	169
Maximum Height	484.66 m
Minimum Height	67.48 m
Classification (# of points)	
Ground	31,140,156
Low vegetation	24,917,356
Medium vegetation	83,699,378
High vegetation	208,401,071
Building	1,450,399
Orthophoto	Yes
Processed by	Engr. AnalynNaldo, Engr. Harmond Santos, Engr. John Dill Macapagal



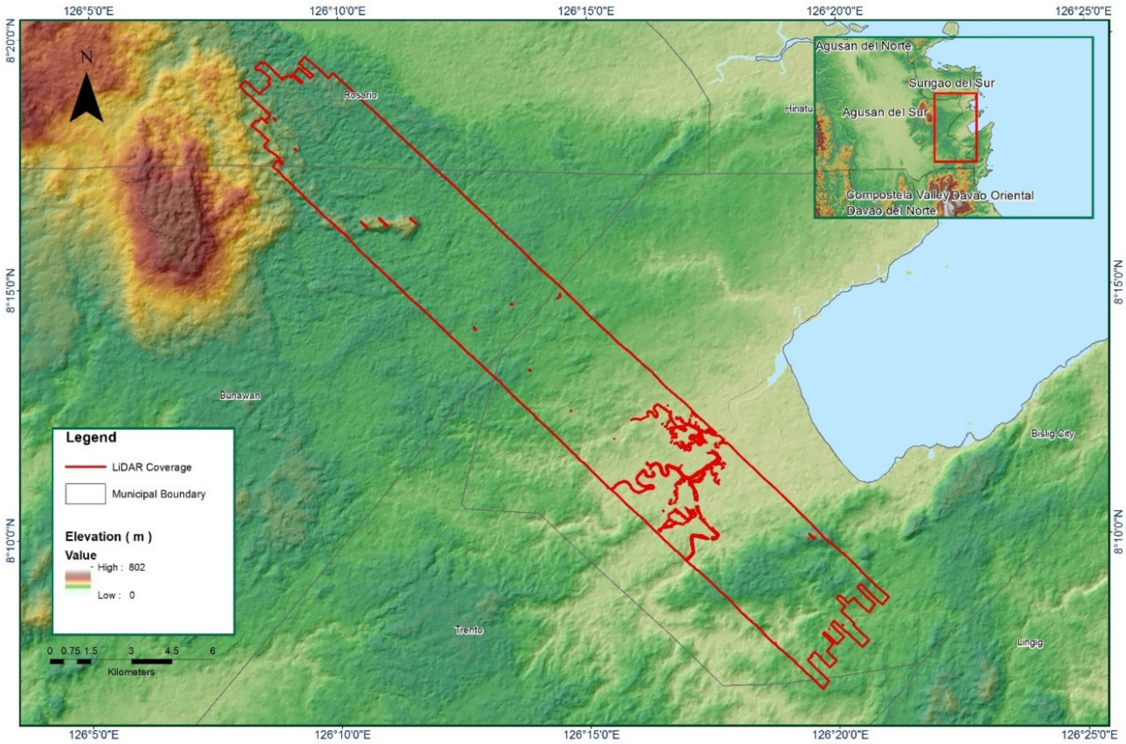
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

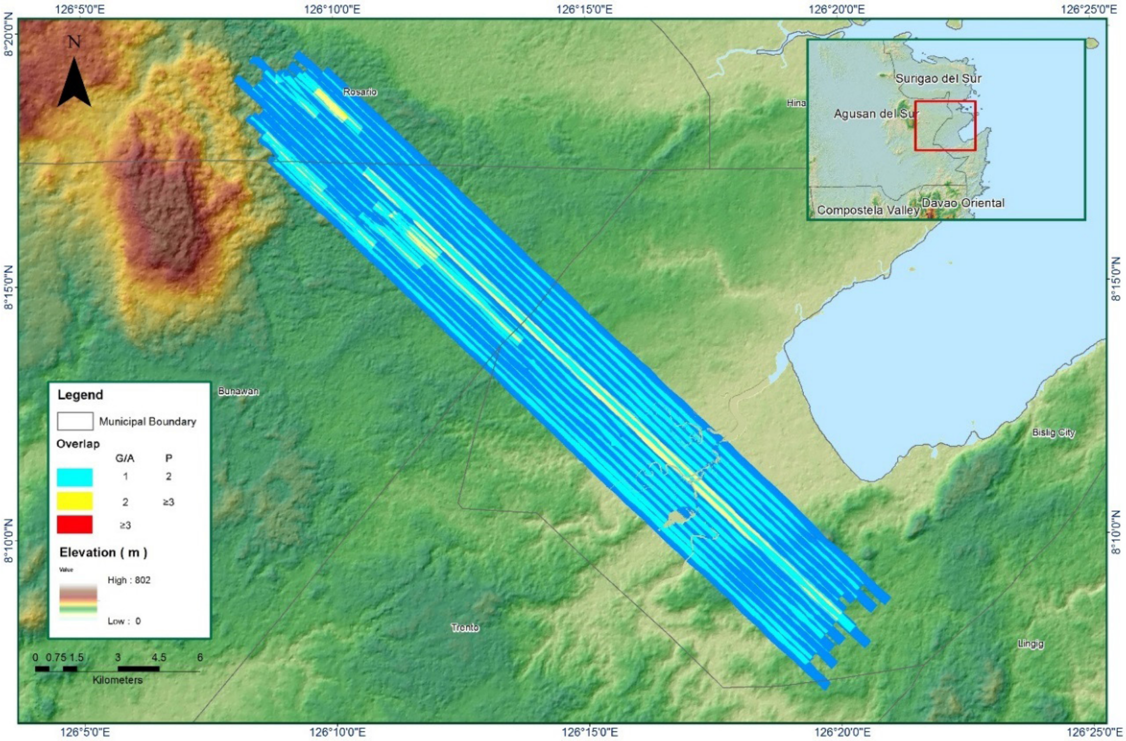
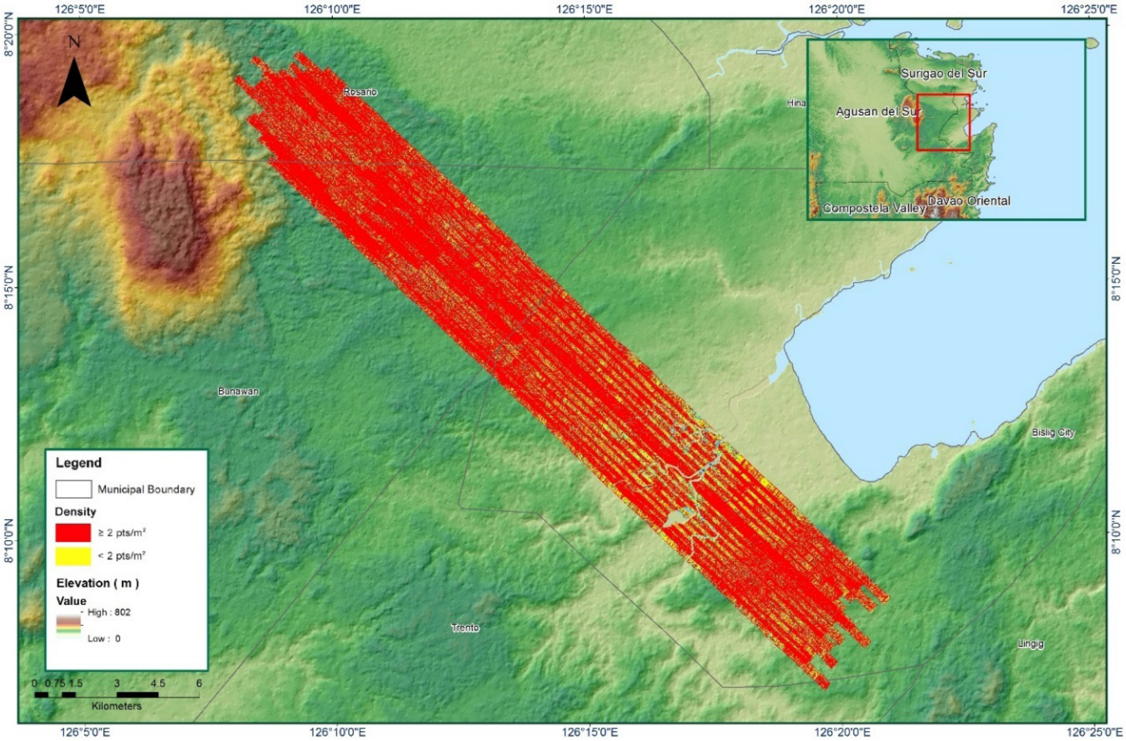
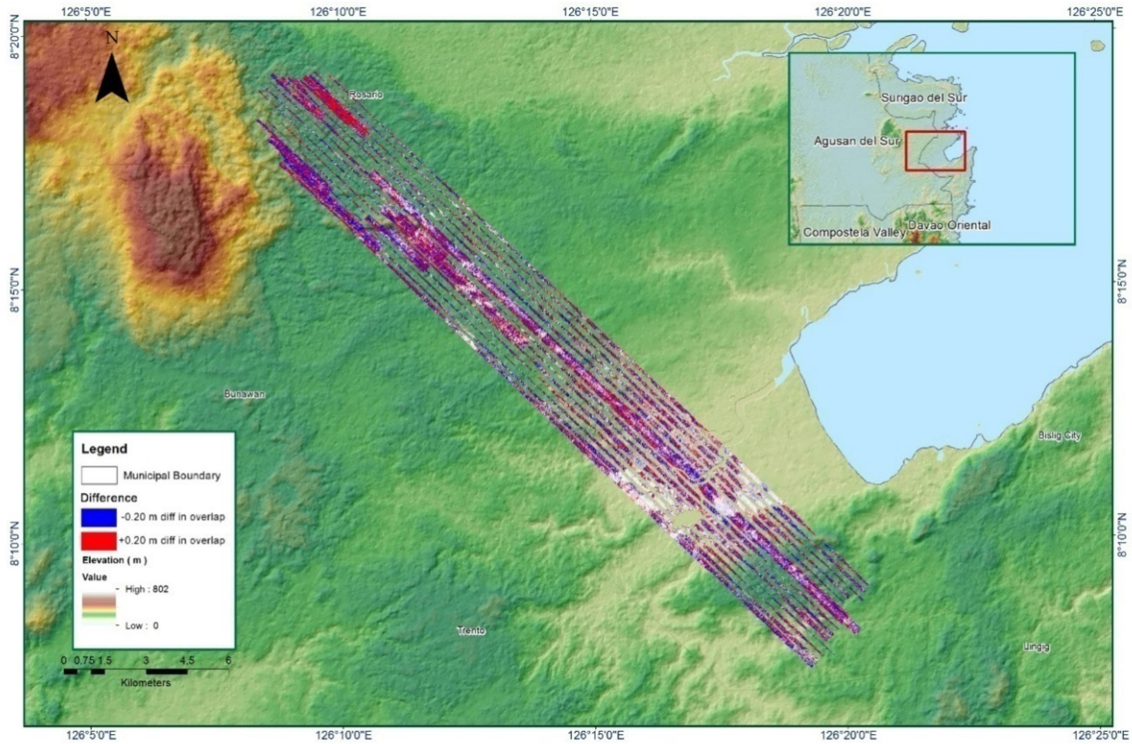


Image of data overlap



Density map of merged LiDAR data



Elevation difference between flight lines

Annex 9. Bislig Model Basin Parameters

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W1860	11.88	79	0	65.304144	Discharge	0.82421	0.75	Ratio to Peak	0.25
W1870	12.084	79	0	80.447904	Discharge	0.93789	0.75	Ratio to Peak	0.25
W1880	12.079	79	0	65.327796	Discharge	0.52629	0.75	Ratio to Peak	0.25
W1890	13.145	77	0	59.509512	Discharge	0.63093	0.75	Ratio to Peak	0.25
W1900	11.88	79	0	42.79986	Discharge	0.3836	0.75	Ratio to Peak	0.25
W1910	11.88	79	0	49.168944	Discharge	0.33892	0.75	Ratio to Peak	0.25
W1920	11.88	79	0	38.745864	Discharge	0.21411	0.75	Ratio to Peak	0.25
W1930	11.99	79	0	59.856408	Discharge	0.37512	0.75	Ratio to Peak	0.25
W1940	11.9784368	79	0	45.007164	Discharge	0.29426	0.75	Ratio to Peak	0.25
W1950	12.254	79	0	112.097844	Discharge	0.95146	0.75	Ratio to Peak	0.25
W1960	12.424	78	0	57.031668	Discharge	0.37956	0.75	Ratio to Peak	0.25
W1970	11.894	79	0	56.962656	Discharge	0.3065	0.75	Ratio to Peak	0.25
W1980	12.4498088	78	0	88.97904	Discharge	0.32501	0.75	Ratio to Peak	0.25
W1990	12.035	79	0	32.863644	Discharge	0.21946	0.75	Ratio to Peak	0.25
W2000	12.621	78	0	41.479992	Discharge	0.28826	0.75	Ratio to Peak	0.25
W2010	11.871	79	0	37.979712	Discharge	0.10825	0.75	Ratio to Peak	0.25
W2020	12.672	78	0	85.272912	Discharge	0.25048	0.75	Ratio to Peak	0.25
W2030	12.146	79	0	69.374664	Discharge	0.47281	0.75	Ratio to Peak	0.25
W2040	11.88	79	0	48.482604	Discharge	0.429	0.75	Ratio to Peak	0.25
W2050	11.88	79	0	10.836396	Discharge	0.0084302	0.75	Ratio to Peak	0.25
W2060	11.88	79	0	56.725272	Discharge	0.24466	0.75	Ratio to Peak	0.25
W2070	12.027	79	0	58.200768	Discharge	0.2930038	0.75	Ratio to Peak	0.25
W2080	12.049	79	0	112.827384	Discharge	1.0536	0.75	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W2090	11.88	79	0	60.180516	Discharge	0.21	0.75	Ratio to Peak	0.25
W2100	11.852	79	0	60.042708	Discharge	0.35586	0.75	Ratio to Peak	0.25
W2110	11.282	80	0	43.767108	Discharge	0.11435	0.75	Ratio to Peak	0.25
W2120	11.88	79	0	38.780316	Discharge	0.22715	0.75	Ratio to Peak	0.25
W2130	11.88	79	0	32.917536	Discharge	0.0828973	0.75	Ratio to Peak	0.25
W2140	11.241	80	0	44.704224	Discharge	0.27563	0.75	Ratio to Peak	0.25
W2150	10.948	80	0	58.568508	Discharge	0.1501	0.75	Ratio to Peak	0.25
W2160	11.3559688	80	0	91.730232	Discharge	0.36752	0.75	Ratio to Peak	0.25
W2170	11.868	79	0	27.70524	Discharge	0.0803524	0.75	Ratio to Peak	0.25
W2180	10.771	81	0	64.104804	Discharge	0.42447	0.75	Ratio to Peak	0.25
W2190	12.1190652	79	0	48.511116	Discharge	0.10788	0.75	Ratio to Peak	0.25
W2200	11.883	79	0	60.507864	Discharge	0.20585	0.75	Ratio to Peak	0.25
W2210	10.420608	81	0	52.01604	Discharge	0.0060443	0.75	Ratio to Peak	0.25
W2220	9.812	82	0	8.679852	Discharge	0.0043079	0.75	Ratio to Peak	0.25
W2230	8.9423	83	11.85272	67.329036	Discharge	0.30743	0.75	Ratio to Peak	0.25
W2240	9.9203	82	0	53.834544	Discharge	0.22615	0.75	Ratio to Peak	0.25
W2250	8.6323	84	0	60.876684	Discharge	0.0802596	0.75	Ratio to Peak	0.25
W2260	12.418	78	0	77.308992	Discharge	0.23525	0.75	Ratio to Peak	0.25
W2270	11.987	79	0	40.777344	Discharge	0.20975	0.75	Ratio to Peak	0.25
W2280	10.709	81	0	75.071556	Discharge	0.36273	0.75	Ratio to Peak	0.25
W2290	11.093	80	0	62.6805	Discharge	0.36198	0.75	Ratio to Peak	0.25
W2300	9.0881736	83	0	51.399576	Discharge	0.0768	0.75	Ratio to Peak	0.25
W2310	12.932	78	0	60.079428	Discharge	0.37128	0.75	Ratio to Peak	0.25
W2320	9.1542	83	0	102.667284	Discharge	0.41359	0.75	Ratio to Peak	0.25
W2330	10.241	81	0	93.676932	Discharge	0.57482	0.75	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W2340	9.7864	82	0	63.925416	Discharge	0.51411	0.75	Ratio to Peak	0.25
W2350	1.547304	97	45.36058	78.596352	Discharge	0.0854026	0.75	Ratio to Peak	0.25
W2360	8.9887	83	4.712589	118.992888	Discharge	0.75692	0.75	Ratio to Peak	0.25
W2380	7.8217	86	2.157191	94.339944	Discharge	0.38772	0.75	Ratio to Peak	0.25
W2390	11.4185016	80	0	71.862768	Discharge	0.31437	0.75	Ratio to Peak	0.25
W2400	10.302	81	0	70.17246	Discharge	0.16135	0.75	Ratio to Peak	0.25
W2410	12.1676764	79	0	69.342804	Discharge	0.50147	0.75	Ratio to Peak	0.25
W2420	9.7757	82	0	56.92734	Discharge	0.29573	0.75	Ratio to Peak	0.25
W2430	11.1167584	80	0	82.163916	Discharge	0.66848	0.75	Ratio to Peak	0.25
W2440	4.6358	92	0.990958	63.911916	Discharge	0.18325	0.75	Ratio to Peak	0.25
W2450	8.5184	84	0	12.546468	Discharge	0.003274	0.75	Ratio to Peak	0.25
W2460	3.7218	94	0.104963	124.39494	Discharge	0.32649	0.75	Ratio to Peak	0.25
W2470	9.6318	82	0	68.602356	Discharge	0.3166	0.75	Ratio to Peak	0.25
W2480	9.278566	83	0	53.012124	Discharge	0.24065	0.75	Ratio to Peak	0.25
W2490	4.1916	93	0	199.76166	Discharge	0.48628	0.75	Ratio to Peak	0.25
W2500	11.312	80	0	69.453396	Discharge	0.28306	0.75	Ratio to Peak	0.25
W2510	12.947	78	0	63.718164	Discharge	0.22964	0.75	Ratio to Peak	0.25
W2520	10.221	81	0	58.19256	Discharge	0.2739	0.75	Ratio to Peak	0.25
W2530	10.474	81	0	25.478604	Discharge	0.0465254	0.75	Ratio to Peak	0.25
W2540	12.21495	79	0	80.104356	Discharge	0.44752	0.75	Ratio to Peak	0.25
W2550	10.126	82	0	42.770376	Discharge	0.24233	0.75	Ratio to Peak	0.25
W2560	9.812	82	0	581236	Discharge	0.21064	0.75	Ratio to Peak	0.25
W2570	10.355	81	0	27.36936	Discharge	0.0846072	0.75	Ratio to Peak	0.25
W2580	9.5087432	82	0	59.337684	Discharge	0.37177	0.75	Ratio to Peak	0.25
W2590	11.43	80	0	78.617628	Discharge	0.52619	0.75	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W2600	9.6406	82	0	41.42556	Discharge	0.0829106	0.75	Ratio to Peak	0.25
W2610	11.44	80	0	122.598036	Discharge	0.57426	0.75	Ratio to Peak	0.25
W2620	12.328	78	0	81.731484	Discharge	0.47135	0.75	Ratio to Peak	0.25
W2630	11.211	80	0	67.731984	Discharge	0.36665	0.75	Ratio to Peak	0.25
W2640	5.3488	91	0	122.1885	Discharge	0.13091	0.75	Ratio to Peak	0.25
W2650	10.4788464	82	0	117.705528	Discharge	0.13357	0.75	Ratio to Peak	0.25
W2660	11.286	80	0	97.048152	Discharge	0.92694	0.75	Ratio to Peak	0.25
W2670	10.94	80	0	85.529952	Discharge	0.67802	0.75	Ratio to Peak	0.25
W2680	10.651	81	0	59.193396	Discharge	0.26233	0.75	Ratio to Peak	0.25
W2690	10.577	81	0	61.150896	Discharge	0.33018	0.75	Ratio to Peak	0.25
W2700	8.0924	86	0	91.456236	Discharge	0.70818	0.75	Ratio to Peak	0.25
W2710	10.942	80	0	62.231976	Discharge	0.38008	0.75	Ratio to Peak	0.25
W2720	9.2562	83	0	55.665576	Discharge	0.38637	0.75	Ratio to Peak	0.25
W2730	10.034	83	0	95.93802	Discharge	0.0477051	0.75	Ratio to Peak	0.25
W2760	6.8006	87	0	55.217268	Discharge	0.0405473	0.75	Ratio to Peak	0.25
W2770	8.3112	85	0	50.082732	Discharge	0.27184	0.75	Ratio to Peak	0.25
W2780	12.388	78	0	52.271784	Discharge	0.1259	0.75	Ratio to Peak	0.25
W2790	12.47	78	0	32.421276	Discharge	0.0332305	0.75	Ratio to Peak	0.25
W2800	11.204	80	0	77.001732	Discharge	0.75072	0.75	Ratio to Peak	0.25
W2810	12.519	78	0	62.057232	Discharge	0.38244	0.75	Ratio to Peak	0.25
W2830	11.384	80	0	70.429284	Discharge	0.5798	0.75	Ratio to Peak	0.25
W2840	11.659	79	0	43.736328	Discharge	0.23644	0.75	Ratio to Peak	0.25
W2850	11.8358064	79	0	23.307912	Discharge	0.0421777	0.75	Ratio to Peak	0.25
W2860	12.647	78	0	49.679244	Discharge	0.22565	0.75	Ratio to Peak	0.25
W2870	11.88	79	0	71.202348	Discharge	0.32134	0.75	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W2880	11.603	79	0	67.970556	Discharge	0.51195	0.75	Ratio to Peak	0.25
W2890	11.88	79	0	49.229532	Discharge	0.33986	0.75	Ratio to Peak	0.25
W2900	12.446	78	0	87.316272	Discharge	0.57222	0.75	Ratio to Peak	0.25
W2910	11.88	79	0	62.964972	Discharge	0.34059	0.75	Ratio to Peak	0.25
W2920	11.513	80	0	69.491952	Discharge	0.7162	0.75	Ratio to Peak	0.25
W2930	11.929	79	0	51.863652	Discharge	0.24184	0.75	Ratio to Peak	0.25
W2940	12.4527524	78	0	48.342528	Discharge	0.204	0.75	Ratio to Peak	0.25
W2950	11.88	79	0	49.836492	Discharge	0.27499	0.75	Ratio to Peak	0.25
W2960	11.88	79	0	43.389972	Discharge	0.20262	0.75	Ratio to Peak	0.25
W2970	11.88	79	0	16.517304	Discharge	0.0389965	0.75	Ratio to Peak	0.25
W2980	12.613	78	0	39.853836	Discharge	0.30511	0.75	Ratio to Peak	0.25
W2990	11.88	79	0	64.785528	Discharge	0.484	0.75	Ratio to Peak	0.25
W3000	12.725	78	0	65.614968	Discharge	0.34031	0.75	Ratio to Peak	0.25
W3010	12.578	78	0	65.6883	Discharge	0.31368	0.75	Ratio to Peak	0.25
W3020	12.419	78	0	57.960144	Discharge	0.22051	0.75	Ratio to Peak	0.25
W3030	12.083	79	0	58.761396	Discharge	0.1453951	0.75	Ratio to Peak	0.25
W3040	12.135	79	0	32.775192	Discharge	0.2094	0.75	Ratio to Peak	0.25
W3050	11.636	79	0	42.05952	Discharge	0.18215	0.75	Ratio to Peak	0.25
W3060	12.3519968	78	0	107.46864	Discharge	0.79353	0.75	Ratio to Peak	0.25
W3070	11.88	79	0	45.79524	Discharge	0.29177	0.75	Ratio to Peak	0.25
W3080	11.951	79	0	52.000056	Discharge	0.28733	0.75	Ratio to Peak	0.25
W3090	11.9617872	79	0	51.509088	Discharge	0.2115	0.75	Ratio to Peak	0.25
W3100	12.72	78	0	63.335304	Discharge	0.67779	0.75	Ratio to Peak	0.25
W3110	11.881	79	0	34.522956	Discharge	0.23279	0.75	Ratio to Peak	0.25
W3120	11.995	79	0	44.927028	Discharge	0.24562	0.75	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W3130	12.469	78	0	69.06276	Discharge	0.83895	0.75	Ratio to Peak	0.25
W3140	12.4337752	78	0	62.45424	Discharge	0.40783	0.75	Ratio to Peak	0.25
W3150	12.018	79	0	32.515128	Discharge	0.13258	0.75	Ratio to Peak	0.25
W3160	10.94	81	0	33.599232	Discharge	0.0869799	0.75	Ratio to Peak	0.25
W3170	10.666	81	0	20.867328	Discharge	0.035802	0.75	Ratio to Peak	0.25
W3180	11.874	79	0	50.274	Discharge	0.25234	0.75	Ratio to Peak	0.25
W3190	12.777	78	0	112.660524	Discharge	1.5186	0.75	Ratio to Peak	0.25
W3200	12.215	79	0	77.594436	Discharge	0.4922	0.75	Ratio to Peak	0.25
W3210	13.033	77	0	65.113956	Discharge	0.44762	0.75	Ratio to Peak	0.25
W3220	12.417	78	0	114.214212	Discharge	0.7236	0.75	Ratio to Peak	0.25
W3230	12.385252	78	0	27.257148	Discharge	0.086516	0.75	Ratio to Peak	0.25
W3240	12.445	78	0	55.925748	Discharge	0.26904	0.75	Ratio to Peak	0.25
W3250	12.498	78	0	63.827784	Discharge	0.28745	0.75	Ratio to Peak	0.25
W3260	13.058	77	0	68.021748	Discharge	0.28286	0.75	Ratio to Peak	0.25
W3270	12.532	78	0	88.90668	Discharge	0.76433	0.75	Ratio to Peak	0.25
W3280	12.075	79	0	62.877168	Discharge	0.30183	0.75	Ratio to Peak	0.25
W3290	13.052996	78	0	50.361588	Discharge	0.29959	0.75	Ratio to Peak	0.25
W3300	12.571	78	0	49.967388	Discharge	0.2663213	0.75	Ratio to Peak	0.25
W3310	11.461	80	0	71.6688	Discharge	0.52523	0.75	Ratio to Peak	0.25
W3320	12.956	78	0	66.619584	Discharge	0.48239	0.75	Ratio to Peak	0.25
W3330	12.721	78	0	55.044576	Discharge	0.26684	0.75	Ratio to Peak	0.25
W3340	13.009	77	0	38.284704	Discharge	0.26331	0.75	Ratio to Peak	0.25
W3350	11.194	80	0	32.878332	Discharge	0.0854688	0.75	Ratio to Peak	0.25
W3360	12.4739824	78	0	48.27006	Discharge	0.20974	0.75	Ratio to Peak	0.25
W3370	11.35	80	0	67.33314	Discharge	0.47961	0.75	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W3380	13.16	77	0	23.013828	Discharge	0.0373131	0.75	Ratio to Peak	0.25
W3390	12.493	78	0	75.775284	Discharge	0.38592	0.75	Ratio to Peak	0.25
W3400	40.844	59	0	107.11116	Discharge	0.27186	0.75	Ratio to Peak	0.25
W3410	12.444	78	0	32.470308	Discharge	0.10589	0.75	Ratio to Peak	0.25
W3420	24.3818212	70	0	52.655508	Discharge	0.27162	0.75	Ratio to Peak	0.25
W3430	12.798	78	0	31.152384	Discharge	0.12786	0.75	Ratio to Peak	0.25
W3440	61.051	48	0	287.126856	Discharge	1.1043	0.75	Ratio to Peak	0.25
W3450	12.542	78	0	39.597984	Discharge	0.20655	0.75	Ratio to Peak	0.25
W3460	12.638	78	0	54.53082	Discharge	0.46429	0.75	Ratio to Peak	0.25
W3470	21.256	73	0	85.667544	Discharge	0.54018	0.75	Ratio to Peak	0.25
W3480	65.0381248	45	0	228.540744	Discharge	0.65415	0.75	Ratio to Peak	0.25
W3490	12.702	78	0	71.283888	Discharge	0.50373	0.75	Ratio to Peak	0.25
W3500	12.661	78	0	51.673788	Discharge	0.2464	0.75	Ratio to Peak	0.25
W3510	12.449	78	0	22.92516	Discharge	0.0625773	0.75	Ratio to Peak	0.25
W3520	12.926	78	0	57.072708	Discharge	0.40034	0.75	Ratio to Peak	0.25
W3530	12.8318828	78	0	23.12766	Discharge	0.0380023	0.75	Ratio to Peak	0.25
W3540	21.167	73	0	26.535708	Discharge	0.0636244	0.75	Ratio to Peak	0.25
W3550	71.702	41	0	268.03278	Discharge	0.83827	0.75	Ratio to Peak	0.25
W3560	45.870154	56	0	112.460292	Discharge	0.26488	0.75	Ratio to Peak	0.25
W3570	15.761	76	0	72.65538	Discharge	0.63795	0.75	Ratio to Peak	0.25
W3580	76.488	38	0	80.599428	Discharge	0.10717	0.75	Ratio to Peak	0.25
W3590	80.123	36	0	172.44252	Discharge	0.24461	0.75	Ratio to Peak	0.25
W3600	79.473	36	0	156.663072	Discharge	0.24661	0.75	Ratio to Peak	0.25
W3610	79.8	36	0	239.07582	Discharge	0.54819	0.75	Ratio to Peak	0.25
W3620	79.488	36	0	188.258904	Discharge	0.53201	0.75	Ratio to Peak	0.25

Basin Number	SCS Curve Number Loss			SCS Unit Hydrograph	Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Lag Time (min)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W3630	79.473	36	0	189.01512	Discharge	0.39311	0.75	Ratio to Peak	0.25
W3640	79.842	36	0	125.076744	Discharge	0.23464	0.75	Ratio to Peak	0.25
W3650	71.5533016	41	0	171.591048	Discharge	0.49986	0.75	Ratio to Peak	0.25
W3660	78.404	37	0	148.422564	Discharge	0.22328	0.75	Ratio to Peak	0.25
W3670	27.303	67	0	156.329676	Discharge	1.1842	0.75	Ratio to Peak	0.25
W3680	28.325	66	0	123.294096	Discharge	0.81617	0.75	Ratio to Peak	0.25
W3690	66.549	44	0	126.960264	Discharge	0.23761	0.75	Ratio to Peak	0.25
W3700	29.919	65	0	93.665916	Discharge	0.45404	0.75	Ratio to Peak	0.25
W3720	4.1819888	93	21.48002	71.224812	Discharge	0.12014	0.75	Ratio to Peak	0.25
W3730	5.4997008	91	0.279018	44.915256	Discharge	0.0237531	0.75	Ratio to Peak	0.25
W3770	8.0354	86	0	80.959716	Discharge	0.32946	0.75	Ratio to Peak	0.25
W3780	12.2721896	79	0	60.563916	Discharge	0.30894	0.75	Ratio to Peak	0.25
W3820	6.0984	88	0	48.893868	Discharge	0.0208635	0.75	Ratio to Peak	0.25
W3830	11.114	80	0	43.504668	Discharge	0.22336	0.75	Ratio to Peak	0.25
W3870	8.6174	85	0	103.632156	Discharge	0.13548	0.75	Ratio to Peak	0.25
W3880	9.8644	82	0	103.339152	Discharge	1.0452	0.75	Ratio to Peak	0.25

Annex 10. Bislig Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R1000	Automatic Fixed Interval	2194.8	0.01	0.05	Rectangle	10.07
R1010	Automatic Fixed Interval	1741.2	0.00	0.05	Rectangle	79.71
R1070	Automatic Fixed Interval	662.84	0.01	0.05	Rectangle	4.18
R1090	Automatic Fixed Interval	3629.2	0.00	0.05	Rectangle	10.57
R1160	Automatic Fixed Interval	3688.9	0.00	0.05	Rectangle	19.84
R1170	Automatic Fixed Interval	4825.6	0.00	0.05	Rectangle	67.32
R1180	Automatic Fixed Interval	1996.5	0.03	0.05	Rectangle	7.89
R120	Automatic Fixed Interval	1324.8	0.00	0.05	Rectangle	4.18
R1200	Automatic Fixed Interval	1595.1	0.01	0.05	Rectangle	4.18
R1210	Automatic Fixed Interval	2894.2	0.00	0.05	Rectangle	8.19
R1230	Automatic Fixed Interval	3604	0.01	0.05	Rectangle	10.68
R1240	Automatic Fixed Interval	1801	0.02	0.05	Rectangle	12.08
R1260	Automatic Fixed Interval	548.7	0.00	0.05	Rectangle	18.46
R1270	Automatic Fixed Interval	2576.9	0.00	0.05	Rectangle	58.98
R1280	Automatic Fixed Interval	8292.3	0.00	0.05	Rectangle	10.74
R1290	Automatic Fixed Interval	1402	0.00	0.05	Rectangle	52.04
R1300	Automatic Fixed Interval	791.54	0.00	0.05	Rectangle	45.23
R1310	Automatic Fixed Interval	1317.8	0.03	0.05	Rectangle	4.18
R1320	Automatic Fixed Interval	4308.2	0.00	0.05	Rectangle	15.11
R1380	Automatic Fixed Interval	1848.2	0.00	0.05	Rectangle	40.08
R140	Automatic Fixed Interval	448.99	0.05	0.05	Rectangle	4.18
R1400	Automatic Fixed Interval	1689.2	0.00	0.05	Rectangle	35.62
R1440	Automatic Fixed Interval	2969.5	0.00	0.05	Rectangle	11.09
R1460	Automatic Fixed Interval	2891.1	0.00	0.05	Rectangle	9.38
R1470	Automatic Fixed Interval	3593.6	0.00	0.05	Rectangle	30.29
R1490	Automatic Fixed Interval	722.55	0.00	0.05	Rectangle	26.75
R1510	Automatic Fixed Interval	1454.4	0.00	0.05	Rectangle	35.65
R1520	Automatic Fixed Interval	1264	0.02	0.05	Rectangle	22.59
R1540	Automatic Fixed Interval	5247.7	0.01	0.05	Rectangle	14.75
R1560	Automatic Fixed Interval	1765.8	0.00	0.05	Rectangle	11.64
R1590	Automatic Fixed Interval	2067.5	0.00	0.05	Rectangle	44.62
R1640	Automatic Fixed Interval	998.11	0.01	0.05	Rectangle	21.48
R1650	Automatic Fixed Interval	3857.2	0.00	0.05	Rectangle	14.22
R1660	Automatic Fixed Interval	1168.1	0.00	0.05	Rectangle	7.86
R1670	Automatic Fixed Interval	5304.3	0.00	0.05	Rectangle	29.92
R1680	Automatic Fixed Interval	894.26	0.01	0.05	Rectangle	21.63
R1690	Automatic Fixed Interval	8108.8	0.00	0.05	Rectangle	30.37
R170	Automatic Fixed Interval	1831.5	0.01	0.05	Rectangle	4.18
R1710	Automatic Fixed Interval	2418.7	0.01	0.05	Rectangle	24.30
R1720	Automatic Fixed Interval	1447.8	0.01	0.05	Rectangle	25.71
R1760	Automatic Fixed Interval	2329.4	0.01	0.05	Rectangle	15.25

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R1780	Automatic Fixed Interval	3427.1	0.01	0.05	Rectangle	23.25
R180	Automatic Fixed Interval	3749.4	0.01	0.05	Rectangle	4.18
R1800	Automatic Fixed Interval	4155.9	0.02	0.05	Rectangle	17.76
R190	Automatic Fixed Interval	2316.7	0.00	0.05	Rectangle	4.18
R210	Automatic Fixed Interval	3376.9	0.00	0.05	Rectangle	4.18
R220	Automatic Fixed Interval	424.26	0.00	0.05	Rectangle	4.18
R260	Automatic Fixed Interval	2251.7	0.00	0.05	Rectangle	4.18
R270	Automatic Fixed Interval	775.69	0.00	0.05	Rectangle	4.18
R280	Automatic Fixed Interval	155.56	0.01	0.05	Rectangle	4.18
R300	Automatic Fixed Interval	827.7	0.00	0.05	Rectangle	4.18
R320	Automatic Fixed Interval	42.426	0.00	0.05	Rectangle	4.18
R330	Automatic Fixed Interval	719.83	0.00	0.05	Rectangle	4.18
R350	Automatic Fixed Interval	288.7	0.00	0.05	Rectangle	4.18
R370	Automatic Fixed Interval	1077.5	0.00	0.05	Rectangle	4.18
R3740	Automatic Fixed Interval	282.84	0.00	0.05	Rectangle	4.18
R3790	Automatic Fixed Interval	1285.8	0.00	0.05	Rectangle	79.71
R3850	Automatic Fixed Interval	3090.7	0.00	0.05	Rectangle	37.87
R390	Automatic Fixed Interval	494.26	0.00	0.05	Rectangle	4.18
R3900	Automatic Fixed Interval	8553.8	0.00	0.05	Rectangle	19.84
R420	Automatic Fixed Interval	366.27	0.02	0.05	Rectangle	4.18
R440	Automatic Fixed Interval	2035.1	0.01	0.05	Rectangle	4.18
R470	Automatic Fixed Interval	2329.2	0.01	0.05	Rectangle	4.18
R480	Automatic Fixed Interval	335.77	0.00	0.05	Rectangle	256.88
R50	Automatic Fixed Interval	3255	0.05	0.05	Rectangle	4.18
R520	Automatic Fixed Interval	1101.5	0.00	0.05	Rectangle	4.18
R550	Automatic Fixed Interval	3437.8	0.00	0.05	Rectangle	10.39
R560	Automatic Fixed Interval	349.71	0.00	0.05	Rectangle	10.82
R580	Automatic Fixed Interval	3627.5	0.01	0.05	Rectangle	20.43
R590	Automatic Fixed Interval	647.4	0.00	0.05	Rectangle	254.01
R620	Automatic Fixed Interval	6516.1	0.01	0.05	Rectangle	18.42
R640	Automatic Fixed Interval	1197.8	0.00	0.05	Rectangle	28.05
R650	Automatic Fixed Interval	5284.6	0.00	0.05	Rectangle	9.58
R670	Automatic Fixed Interval	1587.5	0.01	0.05	Rectangle	13.92
R680	Automatic Fixed Interval	1231.2	0.00	0.05	Rectangle	13.46
R70	Automatic Fixed Interval	3057.6	0.00	0.05	Rectangle	4.18
R700	Automatic Fixed Interval	3103.9	0.01	0.05	Rectangle	4.18
R710	Automatic Fixed Interval	1249.8	0.03	0.05	Rectangle	9.34
R720	Automatic Fixed Interval	3271.1	0.00	0.05	Rectangle	17.24
R730	Automatic Fixed Interval	3379.1	0.00	0.05	Rectangle	87.23
R740	Automatic Fixed Interval	2475.9	0.00	0.05	Rectangle	326.96
R760	Automatic Fixed Interval	625.27	0.00	0.05	Rectangle	184.41
R790	Automatic Fixed Interval	9131.5	0.01	0.05	Rectangle	12.50
R810	Automatic Fixed Interval	1228.5	0.00	0.05	Rectangle	210.16

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R830	Automatic Fixed Interval	2208.7	0.00	0.05	Rectangle	53.52
R840	Automatic Fixed Interval	1173.7	0.00	0.05	Rectangle	79.00
R860	Automatic Fixed Interval	1180.5	0.00	0.05	Rectangle	37.81
R870	Automatic Fixed Interval	5593.3	0.01	0.05	Rectangle	16.38
R890	Automatic Fixed Interval	2018.2	0.00	0.05	Rectangle	20.14
R90	Automatic Fixed Interval	3304.3	0.00	0.05	Rectangle	4.18
R910	Automatic Fixed Interval	1041.5	0.00	0.05	Rectangle	7.41
R940	Automatic Fixed Interval	3513.3	0.01	0.05	Rectangle	29.91
R950	Automatic Fixed Interval	2396.5	0.00	0.05	Rectangle	32.91
R960	Automatic Fixed Interval	1166.4	0.00	0.05	Rectangle	35.71
R970	Automatic Fixed Interval	3470.5	0.00	0.05	Rectangle	25.34
R980	Automatic Fixed Interval	1927.2	0.00	0.05	Rectangle	37.87

Annex 11. Silage Field Validation Points

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
1	8.191	126.3	0.05	0	-0.05	Agaton/ January 2014	5 -Year
2	8.1933	126.3	0.07	0	-0.07	Agaton/ January 2014	5 -Year
3	8.1937	126.3	0.22	0	-0.22	Agaton/ January 2014	5 -Year
4	8.2017	126.31	0.03	0.8	0.77	Agaton/ January 2014	5 -Year
5	8.2231	126.3	0.31	0	-0.31	Agaton/ January 2014	5 -Year
6	8.2241	126.3	0.1	0	-0.1	Agaton/ January 2014	5 -Year
7	8.2249	126.3	0.03	0	-0.03	Agaton/ January 2014	5 -Year
8	8.2283	126.27	0.24	0.6	0.36	Agaton/ January 2014	5 -Year
9	8.2282	126.27	0.06	0	-0.06	Agaton/ January 2014	5 -Year
10	8.174	126.27	1.33	0.1	-1.23	Agaton/ January 2014	5 -Year
11	8.1748	126.27	1.4	1.5	0.1	Agaton/ January 2014	5 -Year
12	8.1759	126.27	0.03	0	-0.03	Agaton/ January 2014	5 -Year
13	8.1737	126.29	0.04	0	-0.04	Agaton/ January 2014	5 -Year
14	8.1821	126.3	0.13	0.5	0.37	Agaton/ January 2014	5 -Year
15	8.1825	126.26	0.74	0	-0.74	Agaton/ January 2014	5 -Year
16	8.1828	126.26	0.76	0.09	-0.67	Agaton/ January 2014	5 -Year
17	8.1808	126.26	1.38	0.1	-1.28	Agaton/ January 2014	5 -Year
18	8.1741	126.29	0.19	0.7	0.51	Agaton/ January 2014	5 -Year
19	8.1733	126.27	0.7	0.26	-0.44	Agaton/ January 2014	5 -Year
20	8.2273	126.27	0.06	0.5	0.44	Agaton/ January 2014	5 -Year
21	8.2278	126.27	0.03	0	-0.03	Agaton/ January 2014	5 -Year
22	8.2281	126.27	0.61	0.8	0.19	Agaton/ January 2014	5 -Year
23	8.2288	126.27	0.03	0	-0.03	Agaton/ January 2014	5 -Year
24	8.2286	126.27	0.41	0.1	-0.31	Agaton/ January 2014	5 -Year
25	8.2288	126.28	0.03	0	-0.03	Agaton/ January 2014	5 -Year
26	8.2291	126.28	0.06	0	-0.06	Agaton/ January 2014	5 -Year
27	8.2341	126.29	0.03	0	-0.03	Agaton/ January 2014	5 -Year
28	8.2336	126.29	0.03	0	-0.03	Agaton/ January 2014	5 -Year
29	8.232	126.29	0.03	0	-0.03	Agaton/ January 2014	5 -Year
30	8.2316	126.29	0.03	0	-0.03	Agaton/ January 2014	5 -Year
31	8.2252	126.3	0.06	0.49	0.43	Agaton/ January 2014	5 -Year
32	8.2253	126.3	0.03	0	-0.03	Agaton/ January 2014	5 -Year
33	8.2251	126.3	1.8	1.2	-0.6	Agaton/ January 2014	5 -Year
34	8.225	126.3	0.03	1.3	1.27	Agaton/ January 2014	5 -Year
35	8.1754	126.27	0.03	0.42	0.39	Agaton/ January 2014	5 -Year
36	8.1755	126.27	0.03	0.1	0.07	Agaton/ January 2014	5 -Year
37	8.1763	126.27	0.03	0	-0.03	Agaton/ January 2014	5 -Year
38	8.1741	126.29	0.26	0	-0.26	Agaton/ January 2014	5 -Year
39	8.1753	126.3	0.03	0.2	0.17	Agaton/ January 2014	5 -Year
40	8.1881	126.33	0.8	0.16	-0.64	Agaton/ January 2014	5 -Year
41	8.1902	126.33	0.15	0.05	-0.1	Agaton/ January 2014	5 -Year
42	8.214	126.32	0.04	0	-0.04	Agaton/ January 2014	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
43	8.2154	126.31	0.26	0.14	-0.12	Agaton/ January 2014	5 -Year
44	8.2287	126.27	0.03	0	-0.03	Agaton/ January 2014	5 -Year
45	8.2276	126.27	0.03	0	-0.03	Agaton/ January 2014	5 -Year
46	8.2075	126.27	4.96	1.22	-3.74	Agaton/ January 2014	5 -Year
47	8.191	126.3	0.05	0	-0.05	Seniang/ December 2014	5 -Year
48	8.1933	126.3	0.07	0	-0.07	Seniang/ December 2014	5 -Year
49	8.1937	126.3	0.22	0	-0.22	Seniang/ December 2014	5 -Year
50	8.2017	126.31	0.03	0.8	0.77	Seniang/ December 2014	5 -Year
51	8.2231	126.3	0.31	0.08	-0.23	Seniang/ December 2014	5 -Year
52	8.2241	126.3	0.1	0.31	0.21	Seniang/ December 2014	5 -Year
53	8.2249	126.3	0.03	0	-0.03	Seniang/ December 2014	5 -Year
54	8.2283	126.27	0.24	0.6	0.36	Seniang/ December 2014	5 -Year
55	8.2282	126.27	0.06	0	-0.06	Seniang/ December 2014	5 -Year
56	8.174	126.27	1.33	0.3	-1.03	Seniang/ December 2014	5 -Year
57	8.1748	126.27	1.4	1.5	0.1	Seniang/ December 2014	5 -Year
58	8.1759	126.27	0.03	0	-0.03	Seniang/ December 2014	5 -Year
59	8.1737	126.29	0.04	0	-0.04	Seniang/ December 2014	5 -Year
60	8.1821	126.3	0.13	0.5	0.37	Seniang/ December 2014	5 -Year
61	8.1825	126.26	0.74	0	-0.74	Seniang/ December 2014	5 -Year
62	8.1828	126.26	0.76	0.13	-0.63	Seniang/ December 2014	5 -Year
63	8.1808	126.26	1.38	0.1	-1.28	Seniang/ December 2014	5 -Year
64	8.1741	126.29	0.19	0.5	0.31	Seniang/ December 2014	5 -Year
65	8.1733	126.27	0.7	0.26	-0.44	Seniang/ December 2014	5 -Year
66	8.2273	126.27	0.06	0.5	0.44	Seniang/ December 2014	5 -Year
67	8.2278	126.27	0.03	0	-0.03	Seniang/ December 2014	5 -Year
68	8.2281	126.27	0.61	0.9	0.29	Seniang/ December 2014	5 -Year
69	8.2288	126.27	0.03	0.9	0.87	Seniang/ December 2014	5 -Year
70	8.2286	126.27	0.41	0.3	-0.11	Seniang/ December 2014	5 -Year
71	8.2288	126.28	0.03	0	-0.03	Seniang/ December 2014	5 -Year
72	8.2291	126.28	0.06	0	-0.06	Seniang/ December 2014	5 -Year
73	8.2341	126.29	0.03	0	-0.03	Seniang/ December 2014	5 -Year
74	8.2336	126.29	0.03	0	-0.03	Seniang/ December 2014	5 -Year
75	8.232	126.29	0.03	0	-0.03	Seniang/ December 2014	5 -Year
76	8.2316	126.29	0.03	0	-0.03	Seniang/ December 2014	5 -Year
77	8.2252	126.3	0.06	1.44	1.38	Seniang/ December 2014	5 -Year
78	8.2253	126.3	0.03	0	-0.03	Seniang/ December 2014	5 -Year
79	8.2251	126.3	1.8	0.95	-0.85	Seniang/ December 2014	5 -Year
80	8.225	126.3	0.03	0	-0.03	Seniang/ December 2014	5 -Year
81	8.1754	126.27	0.03	0.42	0.39	Seniang/ December 2014	5 -Year
82	8.1755	126.27	0.03	0.1	0.07	Seniang/ December 2014	5 -Year
83	8.1763	126.27	0.03	0	-0.03	Seniang/ December 2014	5 -Year
84	8.1741	126.29	0.26	0.2	-0.06	Seniang/ December 2014	5 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
85	8.1753	126.3	0.03	0.2	0.17	Seniang/ December 2014	5 -Year
86	8.1881	126.33	0.8	0.19	-0.61	Seniang/ December 2014	5 -Year
87	8.1902	126.33	0.15	0.05	-0.1	Seniang/ December 2014	5 -Year
88	8.214	126.32	0.04	0	-0.04	Seniang/ December 2014	5 -Year
89	8.2154	126.31	0.26	0.14	-0.12	Seniang/ December 2014	5 -Year
90	8.2287	126.27	0.03	0	-0.03	Seniang/ December 2014	5 -Year
91	8.2276	126.27	0.03	0	-0.03	Seniang/ December 2014	5 -Year
92	8.2075	126.27	4.96	0.9	-4.06	Seniang/ December 2014	5 -Year
93	8.191	126.3	0.06	0	-0.06	Agaton/ January 2014	25 -Year
94	8.1933	126.3	0.11	0	-0.11	Agaton/ January 2014	25 -Year
95	8.1937	126.3	0.24	0	-0.24	Agaton/ January 2014	25 -Year
96	8.2017	126.31	0.03	0.8	0.77	Agaton/ January 2014	25 -Year
97	8.2231	126.3	0.51	0	-0.51	Agaton/ January 2014	25 -Year
98	8.2241	126.3	0.15	0	-0.15	Agaton/ January 2014	25 -Year
99	8.2249	126.3	0.03	0	-0.03	Agaton/ January 2014	25 -Year
100	8.2283	126.27	0.55	0.6	0.05	Agaton/ January 2014	25 -Year
101	8.2282	126.27	0.15	0	-0.15	Agaton/ January 2014	25 -Year
102	8.174	126.27	1.38	0.1	-1.28	Agaton/ January 2014	25 -Year
103	8.1748	126.27	1.45	1.5	0.05	Agaton/ January 2014	25 -Year
104	8.1759	126.27	0.03	0	-0.03	Agaton/ January 2014	25 -Year
105	8.1737	126.29	0.09	0	-0.09	Agaton/ January 2014	25 -Year
106	8.1821	126.3	0.31	0.5	0.19	Agaton/ January 2014	25 -Year
107	8.1825	126.26	0.84	0	-0.84	Agaton/ January 2014	25 -Year
108	8.1828	126.26	0.87	0.09	-0.78	Agaton/ January 2014	25 -Year
109	8.1808	126.26	1.45	0.1	-1.35	Agaton/ January 2014	25 -Year
110	8.1741	126.29	0.27	0.7	0.43	Agaton/ January 2014	25 -Year
111	8.1733	126.27	0.75	0.26	-0.49	Agaton/ January 2014	25 -Year
112	8.2273	126.27	0.06	0.5	0.44	Agaton/ January 2014	25 -Year
113	8.2278	126.27	0.03	0	-0.03	Agaton/ January 2014	25 -Year
114	8.2281	126.27	0.92	0.8	-0.12	Agaton/ January 2014	25 -Year
115	8.2288	126.27	0.03	0	-0.03	Agaton/ January 2014	25 -Year
116	8.2286	126.27	0.67	0.1	-0.57	Agaton/ January 2014	25 -Year
117	8.2288	126.28	0.03	0	-0.03	Agaton/ January 2014	25 -Year
118	8.2291	126.28	0.47	0	-0.47	Agaton/ January 2014	25 -Year
119	8.2341	126.29	0.03	0	-0.03	Agaton/ January 2014	25 -Year
120	8.2336	126.29	0.03	0	-0.03	Agaton/ January 2014	25 -Year
121	8.232	126.29	0.03	0	-0.03	Agaton/ January 2014	25 -Year
122	8.2316	126.29	0.03	0	-0.03	Agaton/ January 2014	25 -Year
123	8.2252	126.3	0.06	0.49	0.43	Agaton/ January 2014	25 -Year
124	8.2253	126.3	0.03	0	-0.03	Agaton/ January 2014	25 -Year
125	8.2251	126.3	1.95	1.2	-0.75	Agaton/ January 2014	25 -Year
126	8.225	126.3	0.03	1.3	1.27	Agaton/ January 2014	25 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
127	8.1754	126.27	0.03	0.42	0.39	Agaton/ January 2014	25 -Year
128	8.1755	126.27	0.04	0.1	0.06	Agaton/ January 2014	25 -Year
129	8.1763	126.27	0.04	0	-0.04	Agaton/ January 2014	25 -Year
130	8.1741	126.29	0.3	0	-0.3	Agaton/ January 2014	25 -Year
131	8.1753	126.3	0.03	0.2	0.17	Agaton/ January 2014	25 -Year
132	8.1881	126.33	0.93	0.16	-0.77	Agaton/ January 2014	25 -Year
133	8.1902	126.33	0.31	0.05	-0.26	Agaton/ January 2014	25 -Year
134	8.214	126.32	0.07	0	-0.07	Agaton/ January 2014	25 -Year
135	8.2154	126.31	0.36	0.14	-0.22	Agaton/ January 2014	25 -Year
136	8.2287	126.27	0.03	0	-0.03	Agaton/ January 2014	25 -Year
137	8.2276	126.27	0.03	0	-0.03	Agaton/ January 2014	25 -Year
138	8.2075	126.27	5.13	1.22	-3.91	Agaton/ January 2014	25 -Year
139	8.191	126.3	0.06	0	-0.06	Seniang/ December 2014	25 -Year
140	8.1933	126.3	0.11	0	-0.11	Seniang/ December 2014	25 -Year
141	8.1937	126.3	0.24	0	-0.24	Seniang/ December 2014	25 -Year
142	8.2017	126.31	0.03	0.8	0.77	Seniang/ December 2014	25 -Year
143	8.2231	126.3	0.51	0.08	-0.43	Seniang/ December 2014	25 -Year
144	8.2241	126.3	0.15	0.31	0.16	Seniang/ December 2014	25 -Year
145	8.2249	126.3	0.03	0	-0.03	Seniang/ December 2014	25 -Year
146	8.2283	126.27	0.55	0.6	0.05	Seniang/ December 2014	25 -Year
147	8.2282	126.27	0.15	0	-0.15	Seniang/ December 2014	25 -Year
148	8.174	126.27	1.38	0.3	-1.08	Seniang/ December 2014	25 -Year
149	8.1748	126.27	1.45	1.5	0.05	Seniang/ December 2014	25 -Year
150	8.1759	126.27	0.03	0	-0.03	Seniang/ December 2014	25 -Year
151	8.1737	126.29	0.09	0	-0.09	Seniang/ December 2014	25 -Year
152	8.1821	126.3	0.31	0.5	0.19	Seniang/ December 2014	25 -Year
153	8.1825	126.26	0.84	0	-0.84	Seniang/ December 2014	25 -Year
154	8.1828	126.26	0.87	0.13	-0.74	Seniang/ December 2014	25 -Year
155	8.1808	126.26	1.45	0.1	-1.35	Seniang/ December 2014	25 -Year
156	8.1741	126.29	0.27	0.5	0.23	Seniang/ December 2014	25 -Year
157	8.1733	126.27	0.75	0.26	-0.49	Seniang/ December 2014	25 -Year
158	8.2273	126.27	0.06	0.5	0.44	Seniang/ December 2014	25 -Year
159	8.2278	126.27	0.03	0	-0.03	Seniang/ December 2014	25 -Year
160	8.2281	126.27	0.92	0.9	-0.02	Seniang/ December 2014	25 -Year
161	8.2288	126.27	0.03	0.9	0.87	Seniang/ December 2014	25 -Year
162	8.2286	126.27	0.67	0.3	-0.37	Seniang/ December 2014	25 -Year
163	8.2288	126.28	0.03	0	-0.03	Seniang/ December 2014	25 -Year
164	8.2291	126.28	0.47	0	-0.47	Seniang/ December 2014	25 -Year
165	8.2341	126.29	0.03	0	-0.03	Seniang/ December 2014	25 -Year
166	8.2336	126.29	0.03	0	-0.03	Seniang/ December 2014	25 -Year
167	8.232	126.29	0.03	0	-0.03	Seniang/ December 2014	25 -Year
168	8.2316	126.29	0.03	0	-0.03	Seniang/ December 2014	25 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
169	8.2252	126.3	0.06	1.44	1.38	Seniang/ December 2014	25 -Year
170	8.2253	126.3	0.03	0	-0.03	Seniang/ December 2014	25 -Year
171	8.2251	126.3	1.95	0.95	-1	Seniang/ December 2014	25 -Year
172	8.225	126.3	0.03	0	-0.03	Seniang/ December 2014	25 -Year
173	8.1754	126.27	0.03	0.42	0.39	Seniang/ December 2014	25 -Year
174	8.1755	126.27	0.04	0.1	0.06	Seniang/ December 2014	25 -Year
175	8.1763	126.27	0.04	0	-0.04	Seniang/ December 2014	25 -Year
176	8.1741	126.29	0.3	0.2	-0.1	Seniang/ December 2014	25 -Year
177	8.1753	126.3	0.03	0.2	0.17	Seniang/ December 2014	25 -Year
178	8.1881	126.33	0.93	0.19	-0.74	Seniang/ December 2014	25 -Year
179	8.1902	126.33	0.31	0.05	-0.26	Seniang/ December 2014	25 -Year
180	8.214	126.32	0.07	0	-0.07	Seniang/ December 2014	25 -Year
181	8.2154	126.31	0.36	0.14	-0.22	Seniang/ December 2014	25 -Year
182	8.2287	126.27	0.03	0	-0.03	Seniang/ December 2014	25 -Year
183	8.2276	126.27	0.03	0	-0.03	Seniang/ December 2014	25 -Year
184	8.2075	126.27	5.13	0.9	-4.23	Seniang/ December 2014	25 -Year
185	8.191	126.3	0.06	0	-0.06	Agaton/ January 2014	100 -Year
186	8.1933	126.3	0.13	0	-0.13	Agaton/ January 2014	100 -Year
187	8.1937	126.3	0.26	0	-0.26	Agaton/ January 2014	100 -Year
188	8.2017	126.31	0.03	0.8	0.77	Agaton/ January 2014	100 -Year
189	8.2231	126.3	0.62	0	-0.62	Agaton/ January 2014	100 -Year
190	8.2241	126.3	0.22	0	-0.22	Agaton/ January 2014	100 -Year
191	8.2249	126.3	0.03	0	-0.03	Agaton/ January 2014	100 -Year
192	8.2283	126.27	0.74	0.6	-0.14	Agaton/ January 2014	100 -Year
193	8.2282	126.27	0.25	0	-0.25	Agaton/ January 2014	100 -Year
194	8.174	126.27	1.63	0.1	-1.53	Agaton/ January 2014	100 -Year
195	8.1748	126.27	1.69	1.5	-0.19	Agaton/ January 2014	100 -Year
196	8.1759	126.27	0.03	0	-0.03	Agaton/ January 2014	100 -Year
197	8.1737	126.29	0.14	0	-0.14	Agaton/ January 2014	100 -Year
198	8.1821	126.3	0.43	0.5	0.07	Agaton/ January 2014	100 -Year
199	8.1825	126.26	1.54	0	-1.54	Agaton/ January 2014	100 -Year
200	8.1828	126.26	1.56	0.09	-1.47	Agaton/ January 2014	100 -Year
201	8.1808	126.26	2.1	0.1	-2	Agaton/ January 2014	100 -Year
202	8.1741	126.29	0.78	0.7	-0.08	Agaton/ January 2014	100 -Year
203	8.1733	126.27	0.98	0.26	-0.72	Agaton/ January 2014	100 -Year
204	8.2273	126.27	0.07	0.5	0.43	Agaton/ January 2014	100 -Year
205	8.2278	126.27	0.03	0	-0.03	Agaton/ January 2014	100 -Year
206	8.2281	126.27	1.15	0.8	-0.35	Agaton/ January 2014	100 -Year
207	8.2288	126.27	0.03	0	-0.03	Agaton/ January 2014	100 -Year
208	8.2286	126.27	0.87	0.1	-0.77	Agaton/ January 2014	100 -Year
209	8.2288	126.28	0.03	0	-0.03	Agaton/ January 2014	100 -Year
210	8.2291	126.28	0.94	0	-0.94	Agaton/ January 2014	100 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
211	8.2341	126.29	0.03	0	-0.03	Agaton/ January 2014	100 -Year
212	8.2336	126.29	0.03	0	-0.03	Agaton/ January 2014	100 -Year
213	8.232	126.29	0.03	0	-0.03	Agaton/ January 2014	100 -Year
214	8.2316	126.29	0.03	0	-0.03	Agaton/ January 2014	100 -Year
215	8.2252	126.3	0.07	0.49	0.42	Agaton/ January 2014	100 -Year
216	8.2253	126.3	0.03	0	-0.03	Agaton/ January 2014	100 -Year
217	8.2251	126.3	2.26	1.2	-1.06	Agaton/ January 2014	100 -Year
218	8.225	126.3	0.03	1.3	1.27	Agaton/ January 2014	100 -Year
219	8.1754	126.27	0.03	0.42	0.39	Agaton/ January 2014	100 -Year
220	8.1755	126.27	0.04	0.1	0.06	Agaton/ January 2014	100 -Year
221	8.1763	126.27	0.05	0	-0.05	Agaton/ January 2014	100 -Year
222	8.1741	126.29	0.34	0	-0.34	Agaton/ January 2014	100 -Year
223	8.1753	126.3	0.03	0.2	0.17	Agaton/ January 2014	100 -Year
224	8.1881	126.33	1	0.16	-0.84	Agaton/ January 2014	100 -Year
225	8.1902	126.33	0.4	0.05	-0.35	Agaton/ January 2014	100 -Year
226	8.214	126.32	0.09	0	-0.09	Agaton/ January 2014	100 -Year
227	8.2154	126.31	0.41	0.14	-0.27	Agaton/ January 2014	100 -Year
228	8.2287	126.27	0.03	0	-0.03	Agaton/ January 2014	100 -Year
229	8.2276	126.27	0.03	0	-0.03	Agaton/ January 2014	100 -Year
230	8.2075	126.27	6.25	1.22	-5.03	Agaton/ January 2014	100 -Year
231	8.191	126.3	0.06	0	-0.06	Seniang/ December 2014	100 -Year
232	8.1933	126.3	0.13	0	-0.13	Seniang/ December 2014	100 -Year
233	8.1937	126.3	0.26	0	-0.26	Seniang/ December 2014	100 -Year
234	8.2017	126.31	0.03	0.8	0.77	Seniang/ December 2014	100 -Year
235	8.2231	126.3	0.62	0.08	-0.54	Seniang/ December 2014	100 -Year
236	8.2241	126.3	0.22	0.31	0.09	Seniang/ December 2014	100 -Year
237	8.2249	126.3	0.03	0	-0.03	Seniang/ December 2014	100 -Year
238	8.2283	126.27	0.74	0.6	-0.14	Seniang/ December 2014	100 -Year
239	8.2282	126.27	0.25	0	-0.25	Seniang/ December 2014	100 -Year
240	8.174	126.27	1.63	0.3	-1.33	Seniang/ December 2014	100 -Year
241	8.1748	126.27	1.69	1.5	-0.19	Seniang/ December 2014	100 -Year
242	8.1759	126.27	0.03	0	-0.03	Seniang/ December 2014	100 -Year
243	8.1737	126.29	0.14	0	-0.14	Seniang/ December 2014	100 -Year
244	8.1821	126.3	0.43	0.5	0.07	Seniang/ December 2014	100 -Year
245	8.1825	126.26	1.54	0	-1.54	Seniang/ December 2014	100 -Year
246	8.1828	126.26	1.56	0.13	-1.43	Seniang/ December 2014	100 -Year
247	8.1808	126.26	2.1	0.1	-2	Seniang/ December 2014	100 -Year
248	8.1741	126.29	0.78	0.5	-0.28	Seniang/ December 2014	100 -Year
249	8.1733	126.27	0.98	0.26	-0.72	Seniang/ December 2014	100 -Year
250	8.2273	126.27	0.07	0.5	0.43	Seniang/ December 2014	100 -Year
251	8.2278	126.27	0.03	0	-0.03	Seniang/ December 2014	100 -Year
252	8.2281	126.27	1.15	0.9	-0.25	Seniang/ December 2014	100 -Year

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
253	8.2288	126.27	0.03	0.9	0.87	Seniang/ December 2014	100 -Year
254	8.2286	126.27	0.87	0.3	-0.57	Seniang/ December 2014	100 -Year
255	8.2288	126.28	0.03	0	-0.03	Seniang/ December 2014	100 -Year
256	8.2291	126.28	0.94	0	-0.94	Seniang/ December 2014	100 -Year
257	8.2341	126.29	0.03	0	-0.03	Seniang/ December 2014	100 -Year
258	8.2336	126.29	0.03	0	-0.03	Seniang/ December 2014	100 -Year
259	8.232	126.29	0.03	0	-0.03	Seniang/ December 2014	100 -Year
260	8.2316	126.29	0.03	0	-0.03	Seniang/ December 2014	100 -Year
261	8.2252	126.3	0.07	1.44	1.37	Seniang/ December 2014	100 -Year
262	8.2253	126.3	0.03	0	-0.03	Seniang/ December 2014	100 -Year
263	8.2251	126.3	2.26	0.95	-1.31	Seniang/ December 2014	100 -Year
264	8.225	126.3	0.03	0	-0.03	Seniang/ December 2014	100 -Year
265	8.1754	126.27	0.03	0.42	0.39	Seniang/ December 2014	100 -Year
266	8.1755	126.27	0.04	0.1	0.06	Seniang/ December 2014	100 -Year
267	8.1763	126.27	0.05	0	-0.05	Seniang/ December 2014	100 -Year
268	8.1741	126.29	0.34	0.2	-0.14	Seniang/ December 2014	100 -Year
269	8.1753	126.3	0.03	0.2	0.17	Seniang/ December 2014	100 -Year
270	8.1881	126.33	1	0.19	-0.81	Seniang/ December 2014	100 -Year
271	8.1902	126.33	0.4	0.05	-0.35	Seniang/ December 2014	100 -Year
272	8.214	126.32	0.09	0	-0.09	Seniang/ December 2014	100 -Year
273	8.2154	126.31	0.41	0.14	-0.27	Seniang/ December 2014	100 -Year
274	8.2287	126.27	0.03	0	-0.03	Seniang/ December 2014	100 -Year
275	8.2276	126.27	0.03	0	-0.03	Seniang/ December 2014	100 -Year
276	8.2075	126.27	6.25	0.9	-5.35	Seniang/ December 2014	100 -Year

Annex 12. Educational Institutions Affected by Flooding in Bislig Floodplain

Agusan del Sur				
Trento				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
R. Castillo Preliminary School	San Isidro			

Surigao del Sur				
Bislig City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Pamanlinan Elementary School	Burboanan	0	0	0
Coleto Elementary School	Coleto	0	0	0
Ricardo Rosario Elementary School	Comawas	2	2	2
Borbuanan Elementary School	Mone	2	2	3
Mone National High School	Mone	2	2	3
San Isidro Elementary School	Mone	0	0	0
San Isidro National High School	Mone	0	0	0
Ser-Fel Mone Elementary School	Mone	2	2	2
Pamanlinan Elementary School	Pamanlinan	0	0	0
Bislig Central Special Science Elementary School	Poblacion	0	0	0
Bislig City National High School	Poblacion	0	0	0
San Fernando Elementary School	San Fernando	0	1	1
San Antonio Elementary School	San Jose	0	0	0
Jose M. Soriano Learning Center	San Roque	0	0	0
San Roque Central Elementary School	San Roque	0	0	0
Simon Edgar A. Garay Elementary School	San Roque	0	0	0
Bebiano Alba Elementary School	Santa Cruz	0	0	0

Annex 13. Health Institutions Affected byFlooding in Bislig Floodplain

Surigao del Sur				
Bislig City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Bislig District Hospital	Poblacion	1	1	1