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

LiDAR Surveys and Flood Mapping of Abulog-Apayao River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
Isabela State University (ISU)

APRIL 2017

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

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

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

E.C. Paringit, and J.P. Floresca, (Eds.). (2017), LiDAR Surveys and Flood Mapping of Abulog-Apayao River. Quezon City: University of the Philippines Training Center for Applied Geodesy and Photogrammetry 311pp

For questions/queries regarding this report, contact:

Januel P. Floresca, Ph.D.
Project Leader, PHIL-LIDAR 1 Program
Isabela State University
Echague, Philippines 3309
januelpf@yahoo.com.ph

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

National Libraruy of the Philippines
ISBN: 978-621-430-032-7

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

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

CHAPTER 1: OVERVIEW OF THE PROGRAM AND ABULOG- APAYAO RIVER

Enrico C. Paringit, Dr. Eng.,and

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 methods applied in this report are thoroughly described in a separate publication entitled "FLOOD MAPPING OF RIVERS IN THE PHILIPPINES USING AIRBORNE LIDAR: METHODS" (Paringit, et. Al. 2017).

The implementing partner university for the Phil-LiDAR 1 Program is the Isabela State University (ISU). ISU 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 10 river basins in the Cagayan Valley Region. The university is located in Echague in the province of Isabela.

1.2 Overview of the Abulog-Apayao River Basin

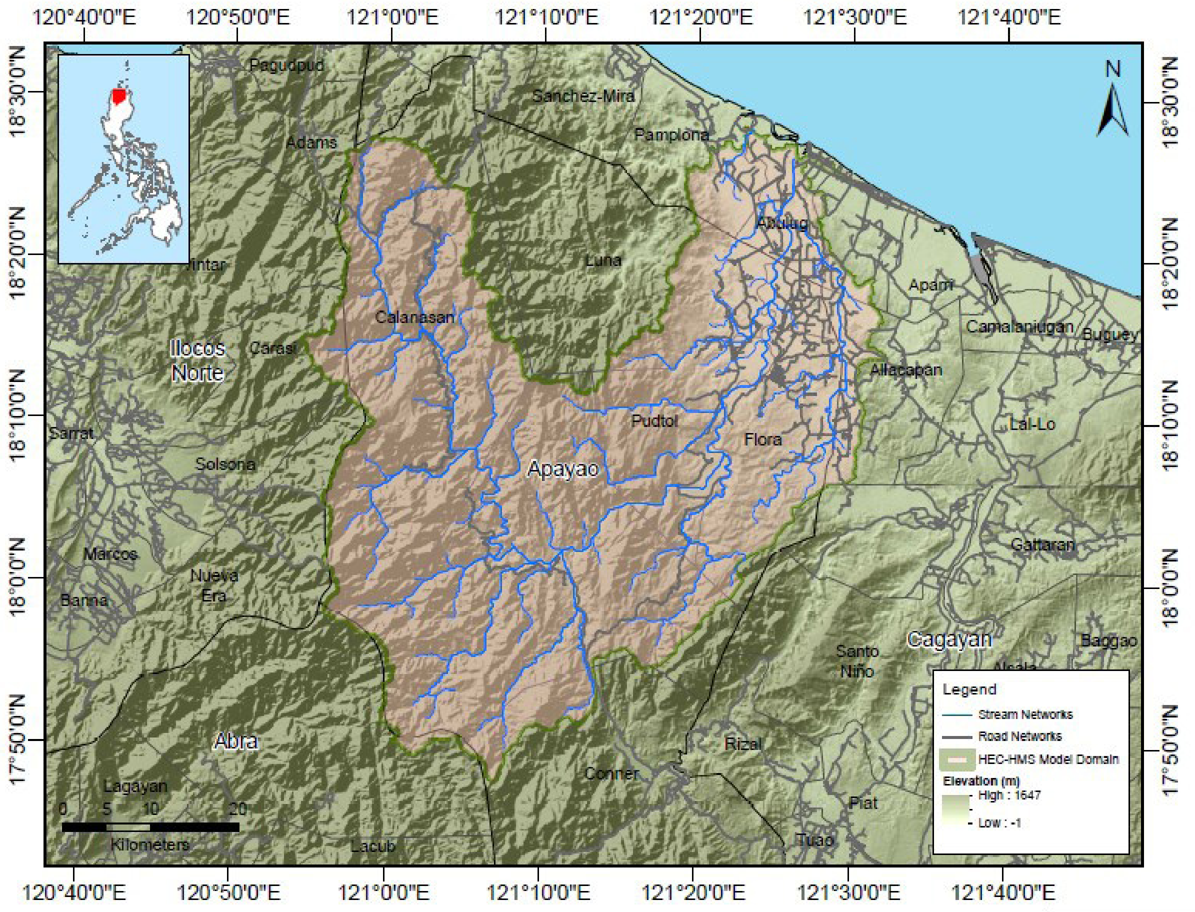


Figure 1. Map of the Abulog-Apayao River Basin (in brown)

Abulog-Apayao River Basin (Figure 1) is found in northern part of Luzon Island. This river basin ranks 6th among the Philippine's largest river systems with drainage area spanning 5,042 square kilometers and stretching to a length of 175 kilometers.

Spotting the massive water-bearing capacity of the Apayao and Abulug rivers along with other river basins in the Cordillera, named as the watershed cradle of Northern Luzon, the Marcos government has decreed a land area of 195,659 ha as the Abulog-Apayao River Basin Forest Reserve to protect its potential for hydropower and irrigation purposes. The Abulog-Apayao River Basin is also classified by the Department of Environment and Natural Resources (DENR) as one of the 140 Critical Watersheds in the country in consideration of its vital role in supporting irrigation water for agriculture and its dire need for rehabilitation.

Apayao is a landlocked province in the Philippines in the Cordillera Administrative Region in Luzon. The province has a population of 119, 184 (as of the 2015 census) and is basically situated within the Cordillera Central mountains, traversed by many rivers. The province covers an area of 4,413.35 square kilometers forming the northern tip of the Cordillera Administrative Region, and is bounded on the north and east by Cagayan, west by Ilocos Norte, southwest by Abra and south by Kalinga. It is basically composed of farmlands. Plains and valleys are used for farming.

Apayao comprises of seven (7) municipalities, out of this, four (4) municipalities lies along in the river basin namely: Flora, Luna, Pudtol and Santa Marcela. Flora is sited as 3rd municipal income class and covers sixteen (16) barangays. It has a land area of 324.40 square kilometers with a population of 17,391 at the 2015 census. Luna is situated as 2nd municipal income class and consists of twenty two (22) barangays. It has a land area of 606.04 square kilometers with a population of 19,063 at the 2015 census. Pudtol is positioned as 4th municipal income class and involves twenty two (22) barangays. It has a land area of 401.02 square kilometers with a population of 14,925 at the 2015 census. And, Santa Marcela is placed as 4th municipal income class and includes thirteen (13) barangays. It has a land area of 196.32 square kilometers with a population of 13,613 at the 2015 census.

Cagayan is a province located in the northeast of Luzon Island, and includes the Babuyan Islands to the north. The province is a neighbour to Ilocos Norte and Apayao to the west, and Kalinga and Isabela to the south. The total land area is 9, 295.75 square kilometers with a population of 1, 199, 320 people according to 2015 census. Agricultural products are rice, corn, peanut, beans, and fruits. Livestock products include cattle, hogs, carabaos, and poultry. Fishing various species of fish from the coastal towns also comprise the people's economic activities.

Cagayan comprises of twenty eight (28) municipalities. Abulug, Allacapan, Ballesteros and Pamplona are the municipalities that lie along in the said river basin. Abulug and Allacapan are 3rd class municipality; Ballesteros is 5th class municipality and Pamplona is a 4th class municipality in the province of Cagayan. According to the 2015 census, the population are 32,497, 33,571, 34,299 and 23,596 people, respectively. The total land area in Abulug is 162.6 square kilometer and subdivided into twenty (20) barangays; Allacapan is 306.8 square kilometer and subdivided into twenty seven (27) barangays; Ballesteros is 120 square kilometer and subdivided into nineteen (19) barangays; and Pamplona is 173.3 square kilometer and subdivided into eighteen (18) barangays.

The Philippines may be classified into four (4) climatological regions based on two climatic classifications namely, Coronas and Hernandez Classifications.

Based on the Coronas classification, the western part of the basin falls under Type I climate. This is characterized by two pronounce season, i.e., dry from November to April and wet the rest of the year. The northern part falls under Type II climate. This is characterized as no dry season with a very pronounced rainfall from November to January. The central and eastern part falls under Type III, where the seasons are not very pronounced, being relatively dry from November to April and wet the rest of the year. The heaviest rain occurs during December to February while the month of May is the warmest.

Hernandez classification further defined the basins' climate as wet (Type A) in the north-eastern and humid (Type B) for the rest. Type A climate is described as an almost year round rainy weather where there are only at most 1½ dry months. In the humid Type B climate is evenly distributed throughout the entire year and having at most three dry months.

The Apayao River belongs to the Abulog-Apayao Watershed Area that has 18 tributaries that ultimately drains to the Babuyan Channel. Based on the 18-year observatory period conducted by the National Irrigation Administration (NIA), the average water discharge of the Apayao River is estimated to be at 2,709 m^3. This water body is presently being used for irrigation, power generation, communal fishing ground and reliable alternative transport system.

In total, there are only 45 registered water users in the basin with only 17 in Apayao and 29 in Cagayan. All water users in Apayao and Cagayan are for irrigation purposes.

There are eleven (11) small irrigation systems in the river basin supported by the Department of Agriculture; five (5) in Cagayan and six (6) in Apayao. Out of these, nine (9) are SWIP and two (2) Diversion dams. Total irrigated service is 390 hectares benefiting 298 farmers. However, more than half are reportedly not operational due to damage of embankment, irrigation canal and spillway.

Another major concern in the area is the lack of river bank protection. This has caused damages in irrigation canals and constant flooding of the service areas. There are also a need for major rehabilitation and repair of head works and canals.

Typhoons are the major hydro meteorological hazards that pose risk of floods, landslides and erosions as well as property and crop damages.

Apayao has been identified by the Department of Agriculture as one of the drought-prone provinces/areas experiencing seasonal aridity.

Drought and flood inundation problems have been a main constraint in the promotion of socioeconomic development and improvement of the living condition of the people in the River Basin.

The Abulug River is usually flooded for several hours during heavy rains and is also prone to flashfloods. Luna has low susceptibility ratings to landslides while Pudtol is only moderately susceptible to landslides.

According to the Municipal Planning Development Coordinator (MPDC)-Luna, Apayao the following are the typhoons that occurred and caused floods:

Table 1. Typhoon Occurences in Abulog-Apayao River Basin

Local Name	**International Name**	**Date of Occurrence**	**Speed, pressure**

Trining		October 28-29, 1983	
Pepang	Lynn	October 9-11, 1987	
Juaning	Warren	September 1988	
Paeng	Cimaron	October 26-28, 2006	
Mina	Mitag	November 25, 2007	
Cosme	Halong	May 16-17, 2008	
Helen	Kalmaegi	July 15 – 17, 2008	
Karen	Nuri	August 20, 2008	
Kiko	Morakot	August 6-9, 2009	
Ondoy	Ketsana	September 27-29, 2009	130km/h (80mph); 980 hPa
Pepeng	Parma	October 2-8, 2009	185 km/hr (115 mph); 938 hPa
Juan	Megi	October 10, 2010	Super typhoon; 230 km/h (145 mph); 885 hPa
Mina	Nanmadol	July 31, 2011	185 km/h (115 mph); 925 hPa
Helen	Kai-tak	August 14, 2012	
Igme	Tembin	August 18, 2012	
Vinta	Krosa	October 31, 2013	
Yolanda	Haiyan	November 8, 2013	Super typhoon, 230 km/h (145 mph); 895 hPa
Luis	Lamaegi	September 14, 2014	
Mario	Fung-wong	September 18, 2014	Tropical storm, 85 km/h (50 mph); 985 hPa
Dodong	Noul	May 10, 2015	
Goring	Halola	July 23-24, 2015	
Ineng	Goni	August 20-21, 2015	
Lando	Koppu	October 16 – 20, 2015	185 km/h (115 mph); 920 hPa
Karen	Sarika	October 12, 2016	
Lawin	Haima	October 20, 2016	

The Department of Interior and Local Government, is tasked to adapt river basin approach in the implementation of Climate Change Adaptation and Disaster Risk Reduction as per RA 9729 (Climate Change Act) and RA 10121(Disaster Risk Reduction and Management Act) respectively. In the implementation of RA 10121, it is expected that, aside from the National Disaster Risk Reduction Management Plan (NDRRMP), Regional and Local Disaster Risk Reduction Plans will be formulated to serve as the principal guide to disaster risk reduction and management (DRRM) efforts of the country where the staging focus of DILG is on the river basins and the thrust is to build alliances amongst the local government units and other government and non-government agencies.

CHAPTER 2: LIDAR DATA ACQUISITION OF THE ABULOG-APAYAO FLOODPLAIN

Engr. Louie P. Balicanta, Engr. Christopher Cruz, Lovely Gracia Acuña, Engr. Gerome Hipolito, Ms. Jasmine T. Alviar, Mr. Darryl M. Austria

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

2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Abulog floodplain in Apayao and Cagayan. These missions were planned for 14 lines that run 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 used are found in Table 2 and Table 3. Figure 2 shows the flight plan for Abulog floodplain.

Table 2. Flight planning parameters for Gemini LiDAR system

Block Name	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (Hz)	Scan Fre-quency (kHz)	Average Speed (kts)	Average Turn Time (Minutes)
CAG 2F	1000	30	40	100	50	130	5
CAG 2G	1000	30	40	100	50	130	5
CAG 2H	1000	30	40	100	50	130	5
CAG 51A	1000	30	40	100	50	130	5
CAG 51C	1000	30	40	100	50	130	5
CAG 51F	1000	30	40	100	50	130	5
CAG 61A	1000	30	40	100	50	130	5
CAG 61C	1000	30	40	100	50	130	5

Table 3. Flight planning parameters for Pegasus LiDAR system

Block Name	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Fre-quency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK 2A	1000	30	50	200	30	130	5
BLK 2B	1000	30	50	200	30	130	5
BLK 2C	1000	30	50	200	30	130	5
BLK 2D	1000	30	50	200	30	130	5
BLK 2E	1000	30	50	200	30	130	5
BLK 2F	1000	30	50	200	30	130	5
BLK 2C	1000	30	50	200	30	130	5
BLK 2G	1000	30	50	200	30	130	5
BLK 2H	1000	30	50	200	30	130	5

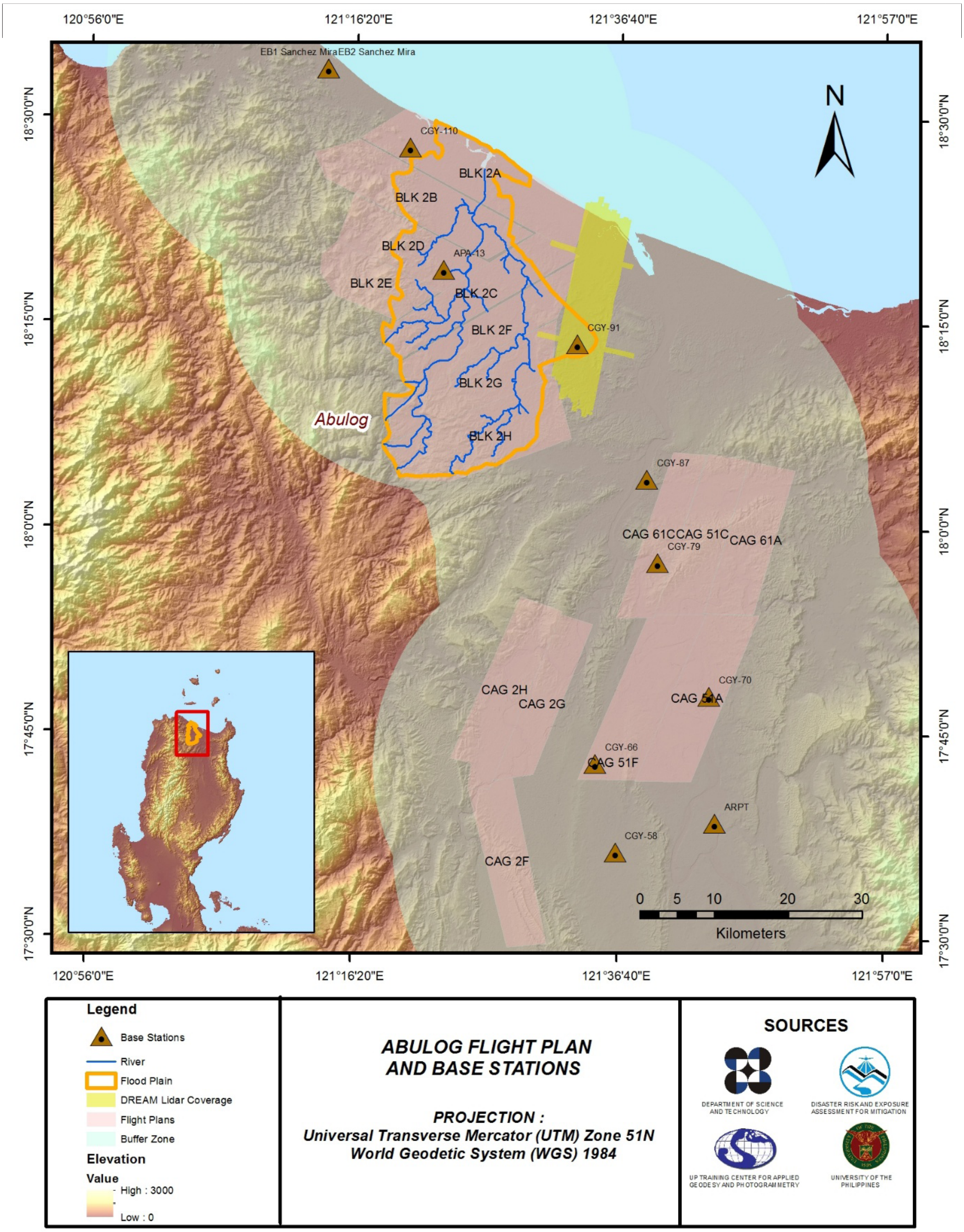


Figure 2. Flight plans and base stations used for Abulog-Apayao Floodplain survey

2.2 Ground Base Stations

The project team was able to recover eight (8) NAMRIA ground control points: CGY-79, which is of first (1st) order accuracy; APA-13, CGY-58, CGY-66, CGY-70, CGY-87, CGY-91, and CGY-110 which are of second (2nd) order accuracy. The project team also established three (3) ground control points (EB Luna, EB2 Sanchez Mira, and ARPT). The certifications for the NAMRIA reference points are found in Annex 2 and baseline processing reports for the established control points are in Annex 3. These were used as base stations during flight operations for the entire duration of the survey (November 9 – 21, 2015 and April 27 – 30, 2016). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852, TRIMBLE SPS 985 and TRIMBLE SPS 882. Flight plans and location of base stations used during the aerial LiDAR acquisition in Abulog floodplain are shown in Figure 2.

Figure 3 to Figure 11 show the recovered NAMRIA control stations within the area, in addition Table 4 to Table 14 show the details about the following NAMRIA control stations and established points, and Table 15 shows the list of all ground control points occupied during the acquisition together with the dates they were utilized during the survey.

(a)

(b)

Figure 3. a) GPS set-up over APA-13 located on the barangay property lot of the barangay hall of Tumog in Luna, 8 m. from the north edge of the PCCP, and 70 meters northeast of a waiting shed, and b) NAMRIA reference point APA-13 as recovered by field team

Table 4. Details of the recovered NAMRIA horizontal control point APA-13 used as base station for the LiDAR acquisition

Station Name	APA-13	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18° 19’ 2.39624” 121° 22’ 58.62210” 17.982 m
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 5 PRS 92)	Easting Northing	540482.023 m 2025924.156 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	18° 18’ 56.17679” 121° 23’ 3.20117” 51.005 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting Northing	329102.89 m 2025930.60 m

(a)

(b)

Figure 4. a) GPS set-up over CGY-58 located 15 m. E of the junction of the road leading to barangay. Karilukud, and is situated 10 meters southeast of Barangay. Ubong welcome monument. b) NAMRIA reference point CGY-58 as recovered by field team

Table 5. Details of the recovered NAMRIA horizontal control point CGY-58 used as base station for the LiDAR acquisition

Station Name	CGY-58	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	17° 36’ 27.61645” 121° 36’ 25.76184” 40.716 m
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 5 PRS 92)	Easting Northing	564440.235 m 1947447.881 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	17° 36’ 21.57004” 121° 36’ 30.39868” 76.590 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting Northing	352213.18 m 1947206.45 m

(a)

(b)

Figure 5. a) GPS set-up over CGY-66 located within the compound of Warat barangay. hall, along G. Cusupig St., approximately 15 meters south of the waiting shed. b) NAMRIA reference point CGY-66 as recovered by field team

Table 6. Details of the recovered NAMRIA horizontal control point CGY-66 used as base station for the LiDAR acquisition

Station Name	CGY-66	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	17° 42’ 56.12254” 121° 34’ 50.13936” 51.902 m
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 5 PRS 92)	Easting Northing	561584.309 m 1959382.34 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	17° 42’ 50.05073” 121° 34’ 54.76735” 87.364 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting Northing	349484.16 m 1959169.01 m

(a)

(b)

Figure 6. a) GPS set-up over CGY-70, located inside Estefania elementary school, and situated 1 meter east of the northeast corner of the basketball court. b) NAMRIA reference point CGY-70 as recovered by field team

Table 7. Details of the recovered NAMRIA horizontal control point CGY-70 used as base station for the LiDAR acquisition

Station Name	CGY-70	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	17° 47’ 54.79038” 121° 43’ 31.26837” 26.859 m
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 5 PRS 92)	Easting Northing	576904.118 m 1968617.425 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	17° 47’ 48.71170” 121° 43’ 35.88859” 62.400 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting Northing	364899.00 m 1968239.03 m

(a)

(b)

Figure 7. a) GPS set-up over CGY-87, located on a solar dryer at Barangay. Cabayabasan, fronting the barangay hall. b) NAMRIA reference point CGY-87 as recovered by field team

Table 8. Details of the recovered NAMRIA horizontal control point CGY-87 used as base station for the LiDAR acquisition

Station Name	CGY-87	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18° 3’ 46.30032” 121° 38’ 38.76326” 37.212 m
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 5 PRS 92)	Easting Northing	568188.029 m 1997837.978 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	18° 3’ 40.15861” 121° 38’ 43.36193” 71.696 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting Northing	356498.94 m 1997546.44 m

(a)

(b)

Figure 8. a) GPS set-up over CGY-91, located inside Allacapan’s town plaza’s circle ground, on the north path walk, near the center of the grounds. b) NAMRIA reference point CGY-91 as recovered by field team

Table 9. Details of the recovered NAMRIA horizontal control point CGY-91 used as base station for the LiDAR acquisition

Station Name	CGY-91	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18° 13' 39.87307" 121° 33' 17.08273" 13.564 m
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 5 PRS 92)	Easting Northing	558673.063 m 2016055.507 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	18° 13' 33.68932" 121° 33' 21.66825" 47.293 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting Northing	347183.80 m 2015863.99 m

Figure 9. GPS set-up over CGY-110, located inside the school compound, behind the first school building to the left of the entrance gate of Pamplona Central School, across Pamplona Municipal Hall

Table 10. Details of the recovered NAMRIA horizontal control point CGY-110 used as base station for the LiDAR acquisition

Station Name	CGY-110	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18° 27' 58.94151" 121° 20' 19.10441" 16.839 m
Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 5 PRS 92)	Easting Northing	535767.119 m 2042410.05 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	18° 27' 52.69074" 121° 20' 23.67135" 49.262 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting Northing	324569.86 m 2042467.48 m

Table 11. Details of the recovered NAMRIA horizontal control point CGY-79 used as base station for the LiDAR acquisition

Station Name	CGY-79	
Order of Accuracy	1st	
Relative Error (horizontal positioning)	1 in 20,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	17° 57’ 33.77158 121° 39’ 32.24272” 23.915 m
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	569801.488 m 1986390.847 m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	17° 57’ 27.65319” 121° 39’ 36.84994” 58.773 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92)	Easting Northing	357988.51 m 1986084.36 m

Figure 10. EB1 Sanchez Mira as established beside Sanchez Mira Municipal Hall flagpole

Table 12. Details of the established ground control point EB1 Sanchez Mira

Station Name	EB1 Sanchez Mira	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18° 33' 41.42270" North 121° 13 ' 58.98381 " East 10.810 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	18° 33' 35.14382" North 121° 14' 3.54316" East 42.675 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	313520.647 meters 2053102.450 meters

Figure 11. EB2 Sanchez Mira as established in front of Sanchez Mira Municipal Hall near EB1 Sanchez Mira

Table 13. Details of the established ground control point EB2 Sanchez Mira

Station Name	EB2 Sanchez Mira	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	18° 33' 41.30634" North 121° 13 ' 58.98517 " East 10.864 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	18° 33' 35.02752" North 121° 14' 03.54483" East 42.719 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	313520.652 meters 2053098.872 meters

Table 14. Details of the established ground control point ARPT

Station Name	ARPT	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	17° 38’ 35.74536” North 121° 44’ 2.31321” East 27.155 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	17° 38’ 29.70094” North 121° 44’ 6.94633” East 63.218 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	365697.564 meters 1951050.094 meters

Table 15. Ground control points used during LiDAR data acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
November 9, 2015	2830P	1CAGS1DB313A	CGY-87 and CGY-79
November 11, 2015	2838P	1BLK2CF315A	APA-13, CGY-87 and CGY-91
November 12, 2015	2842P	1BLK2B316A	CGY-110 and APA-13
November 13, 2015	2846P	1BLK2FSBSA317A	CGY-110, CGY-87 and APA-13
November 13, 2015	2848P	1BLK2FSAS317B	CGY-110, CGY-87 and APA-13
November 14, 2015	2850P	1BLK2DE318A	CGY-110, CGY-87 and APA-13
November 14, 2015	2852P	1BLK2AS318B	CGY-110, CGY-87 and APA-13
November 15, 2015	2854P	1BLK2DSG319A	CGY-110, CGY-87 and APA-13
November 18, 2015	2866P	1BLK2D322A	CGY-87 and APA-13
November 18, 2015	2868P	1BLK2H322B	CGY-87 and APA-13
November 20, 2015	2874P	1BLK21C324A	APA-13, EB1 and EB2 Sanchez Mira
November 21, 2015	2880P	1BLK21C325A	APA-13, EB1 and EB2 Sanchez Mira
April 27, 2016	3965G	2CAG2DGH118A	CGY-66 and ARPT
April 29, 2016	3973G	2CAG2GSHS120A	CGY-58 and CGY-66
April 30, 2016	3977G	2CAG2FG121A	CGY-58 and CGY-66

2.3 Flight Missions

Two (2) missions under the DREAM Program covered 43.52 square kilometers of within Abulog floodplain. These missions are listed in Table 16. Fifteen (15) missions were conducted to complete the LiDAR data acquisition in Abulog floodplain, for a total of 54 hours and 15 minutes (54+15) of flying time for RP-C9022 and RP-C9122. All missions were acquired using the Pegasus and Gemini LiDAR systems. Table 17 shows the total area of actual coverage per mission and the flying length for each mission, while Table 18 presents the actual parameters used during the LiDAR data acquisition.

Table 16. Flight missions under the DREAM Program which covered parts of Abulog-Apayao floodplain

Flight Number	Mission Name	Area Surveyed within the Floodplain (km^2)
750G	2CAG11B320A	16.96
752G	2CAG11BS320A	26.56

Table 17. Flight missions for LiDAR data acquisition in Abulog-Apayao 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
November 9, 2015	2830P	719.47	195.13	0	195.13	334	2	59
November 11, 2015	2838P	259.64	260.54	201.05	59.49	0	4	05
November 12, 2015	2842P	175.55	130.95	78.89	52.06	351	2	59
November 13, 2015	2846P	500.34	298.85	163.34	135.51	742	4	23
November 13, 2015	2848P	200.78	37.9	10.92	26.98	128	2	29
November 14, 2015	2850P	209.65	195.17	79.74	115.43	0	3	35
November 14, 2015	2852P	200.78	91.37	31.32	60.05	287	3	23
November 15, 2015	2854P	272.3	199.12	160.86	38.26	590	3	53
November 18, 2015	2866P	151.91	205.14	189.96	15.18	0	4	23
November 18, 2015	2868P	187.81	178.06	143.21	34.85	411	2	29
November 20, 2015	2874P	187.81	76.15	0	76.15	107	3	05
November 21, 2015	2880P	187.81	163.25	45.38	117.87	0	3	47
April 27, 2016	3965P	272.73	268.18	0	268.18	0	4	25
April 29, 2016	3973G	272.73	443.76	0	443.76	0	4	41
April 30, 2016	3977G	246.77	584.70	0	584.70	0	3	39
TOTAL		4046.08	3328.27	1104.67	2223.6	2950	54	15

Table 18. Actual parameters used during LiDAR Data acquisiton

Flight Number	Flying Height (m AGL)	Overlap (%)	FOV (θ)	PRF (khz)	Scan Frequen-cy (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
2830P	900	30	50	125	50	130	5
2838P	1100	30	50	200	30	130	5
2842P	850	30	50	200	30	130	5
2846P	1100	30	50	200	30	130	5
2848P	900	30	50	200	30	130	5
2850P	1100	30	40	100	50	130	5
2852P	900	30	50	200	30	130	5
2854P	900 - 1000	30	50	200	50	130	5
2866P	700 - 900	30	50	200	30	130	5
2868P	700 - 900	30	50	200	30	130	5
2874P	700 - 900	30	50	200	30	130	5
2880P	700 - 900	30	50	200	30	130	5
3965G	800 - 1000	30	50	200	30	130	5
3973G	800 - 1000	30	34	200	56	130	5
3977G	800 - 1000	30	50	200	30	130	5

2.4 Survey Coverage

Abulog floodplain is located within the provinces of Apayao and Cagayan with majority of the floodplain situated within the municipality of Flora in Apayao. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 19. The actual coverage of the LiDAR acquisition for Abulog Floodplain is presented in Figure 12.

Table 19. List of municipalities/cities surveyed in Apayao, Cagayan, Kalinga and Isabela

Province	Municipality/City	Area of Municipality/City	Total Area Surveyed	Percentage of Area Surveyed (%)
Apayao	Flora	321.67	261.67	81.35
	Luna	603.01	255.84	42.43
	Pudtol	283.66	133.67	47.12
	Santa Marcela	47.23	47.19	99.92
	Conner	775.14	24.32	3.14
Cagayan	Allacapan	252.24	220.63	87.47
	Pamplona	206.55	182.01	88.12
	Peñablanca	1213.01	128.46	10.59
	Santo Niño	437.82	119.67	27.33
	Abulug	123.19	118.61	96.28
	Ballesteros	117.92	116.06	98.42
	Piat	153.74	91.46	59.49
	Tuao	161.93	91.18	56.31
	Baggao	1009.05	78.91	7.82
	Aparri	254.03	78.53	30.91
	Solana	238.48	77.33	32.43
	Enrile	161.25	69.27	42.96
	Amulung	231.16	63.62	27.52
	Gattaran	557.09	61.82	11.10
	Lasam	215.36	58.6	27.21
	Alcala	182.93	55.7	30.45
	Rizal	166.32	28.55	17.17
	Iguig	97.59	23.26	23.83
	Lal-lo	760.44	23.14	3.04
	Tuguegarao	129.61	17.78	13.72
	Sanchez-Mira	205.31	15.74	7.67
	Santa Praxedes	86.19	4.04	4.69
Kalinga	Pinukpuk	477.11	90.12	18.89
	Tabuk	748.12	74.6	9.97
	Rizal	187.91	44.76	23.82
Isabela	Santa Maria	116.4	39.67	34.08
	Cabagan	340.26	15.65	4.60
	San Pablo	635.99	7.28	1.14
	Total	**11,497.71**	**2,719.14**	**23.65%**

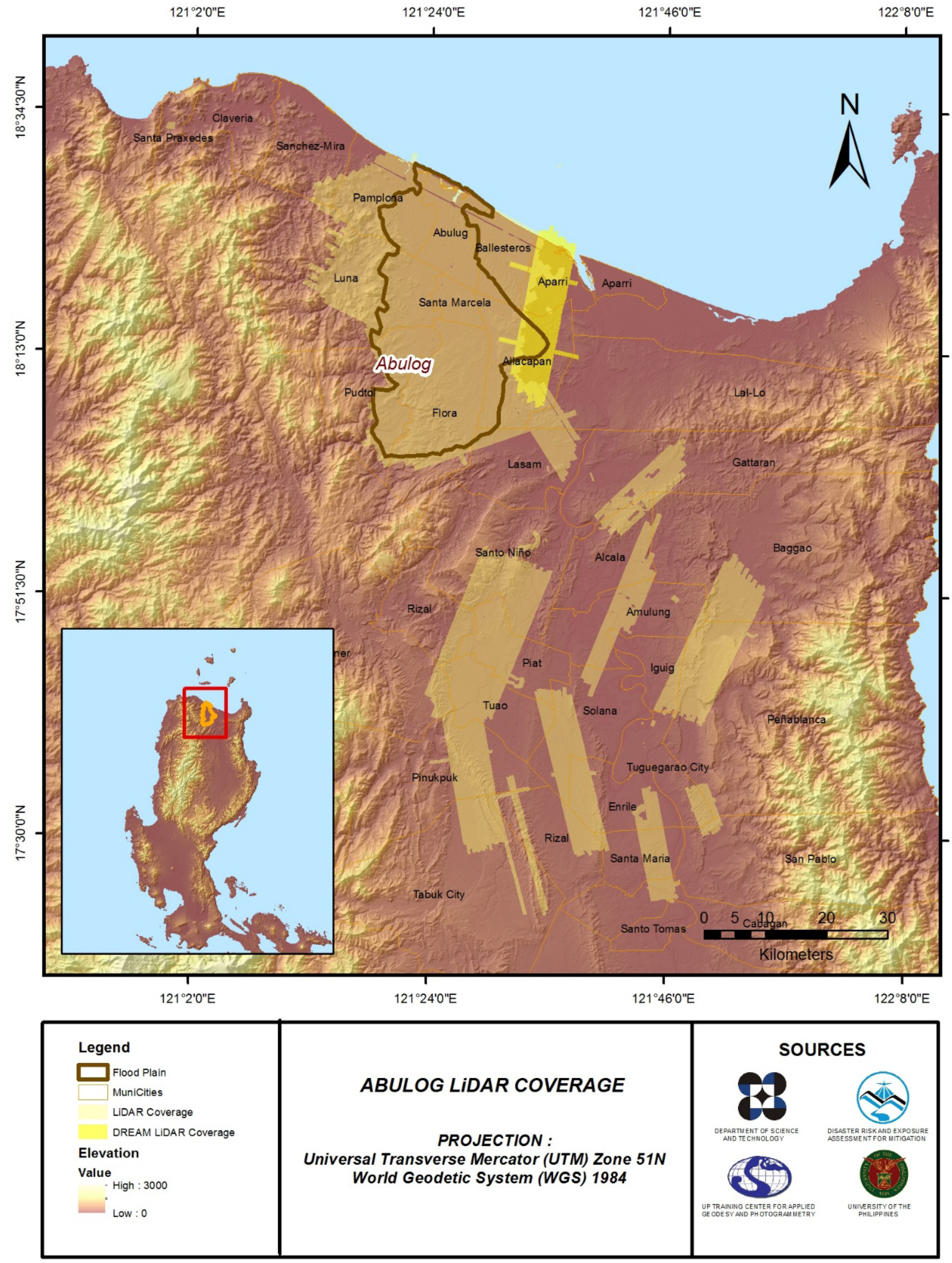


Figure 12. Actual LiDAR survey coverage for Abulog floodplain

CHAPTER 3: LIDAR DATA PROCESSING FOR ABULOG-APAYAO FLOODPLAIN

Engr. Ma. Rosario Concepcion O. Ang, Engr. John Louie D. Fabila, Engr. Sarah Jane D. Samalburo , Engr. Joida F. Prieto , Engr. Edgardo V. Gubatanga Jr. , Engr. Analyn M. Naldo, Engr. Merven Mattew D. Natino, Maria Tamsyn C. Malabanan , Engr. Don Matthew B. Banatin, Engr. Sheila-Maye F. Santillan

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 Date Pre-Processing

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

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

These processes are summarized in the flowchart shown in Figure 13.

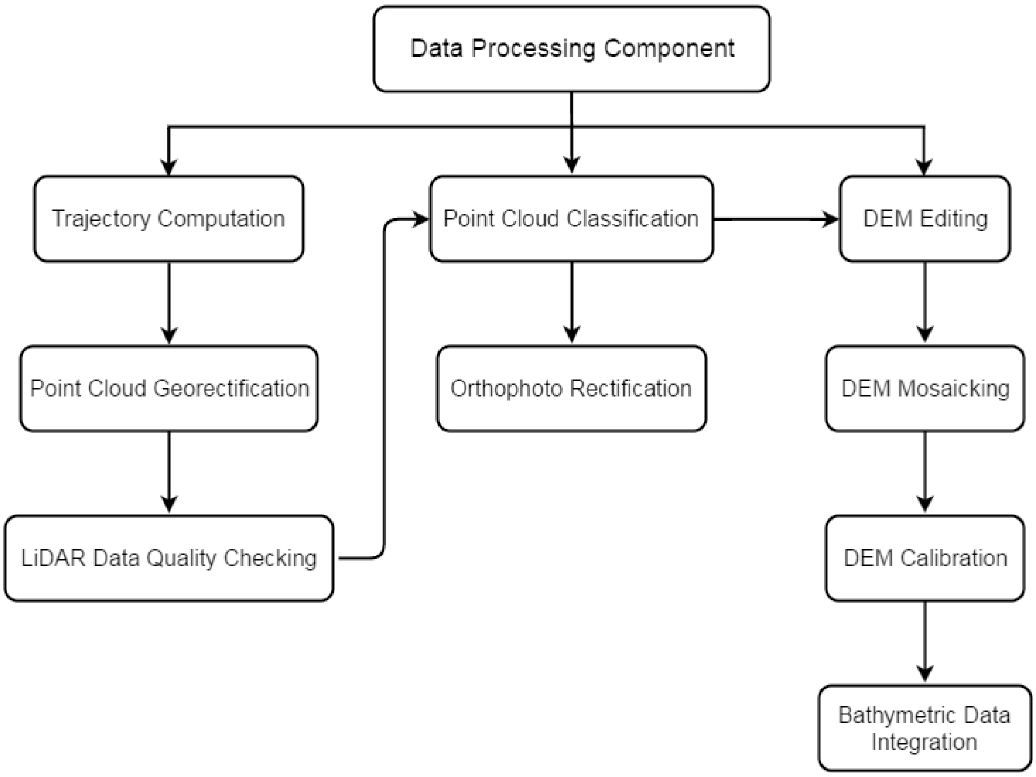


Figure 13. Schematic Diagram for Data Pre-Processing Component

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Abulog-Apayao floodplain can be found in **Annex A-5**. Missions flown during the first survey conducted on May 2014 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Gemini system while missions acquired during the second survey on December 2015 were flown using the Pegasus system over Abulug, Cagayan. The Data Acquisition Component (DAC) transferred a total of 348.38 Gigabytes of Range data, 3.69 Gigabytes of POS data, 286.10 Megabytes of GPS base station data, and 408.59 Gigabytes of raw image data to the data server on June 4, 2014 for the first survey and February 6, 2016 for the second survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Abulog-Apayao was fully transferred on December 4, 2015, as indicated on the Data Transfer Sheets for Abulog-Apayao floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metric parameters of the computed trajectory for flight 2838P, one of the Abulog-Apayao flights, which is the North, East, and Down position RMSE values are shown in Figure 14. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell on November 23, 2015 00:00AM. The y-axis is the RMSE value for that particular position.

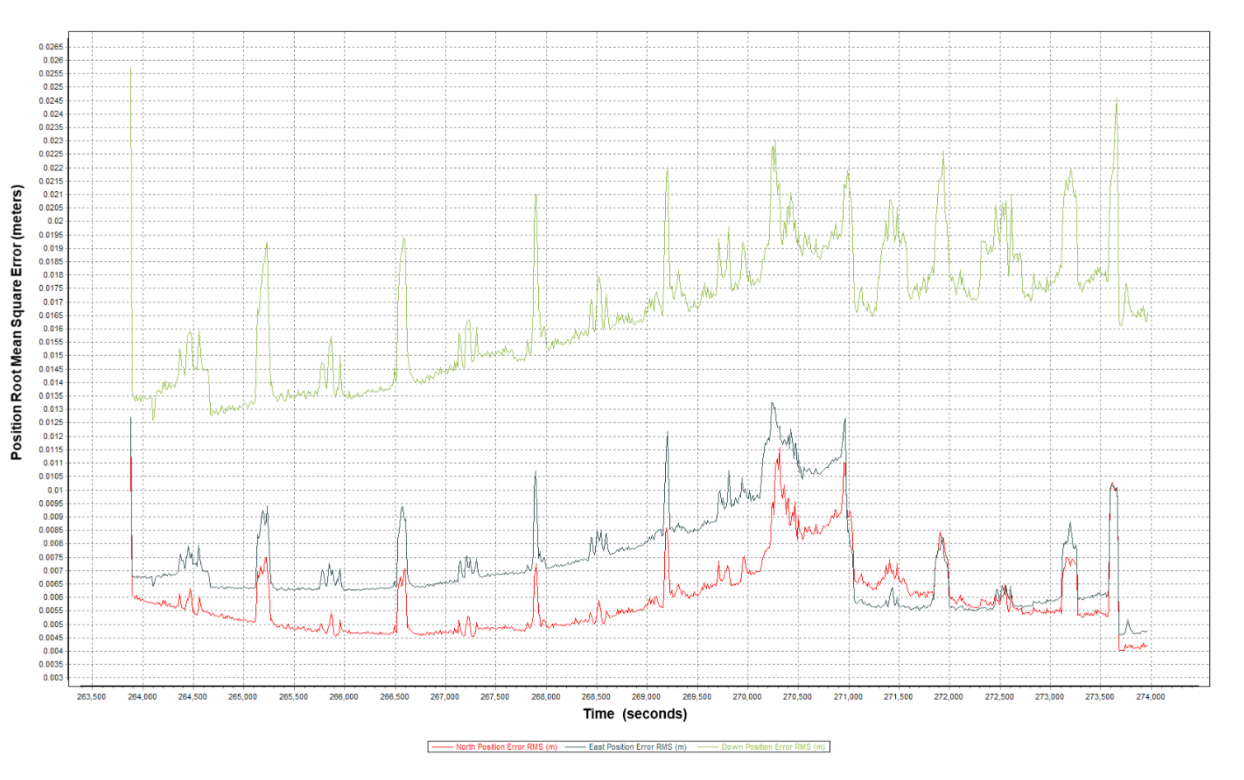


Figure 14. Smoothed Performance Metric Parameters of Abulog-Apayao Flight 2838P

The time of flight was from 263,900 seconds to 274,000 seconds, which corresponds to morning of November 23, 2015. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 14 shows that the North position RMSE peaks at 1.20 centimeters, the East position RMSE peaks at 1.40 centimeters, and the Down position RMSE peaks at 2.50 centimeters, which are within the prescribed accuracies described in the methodology.

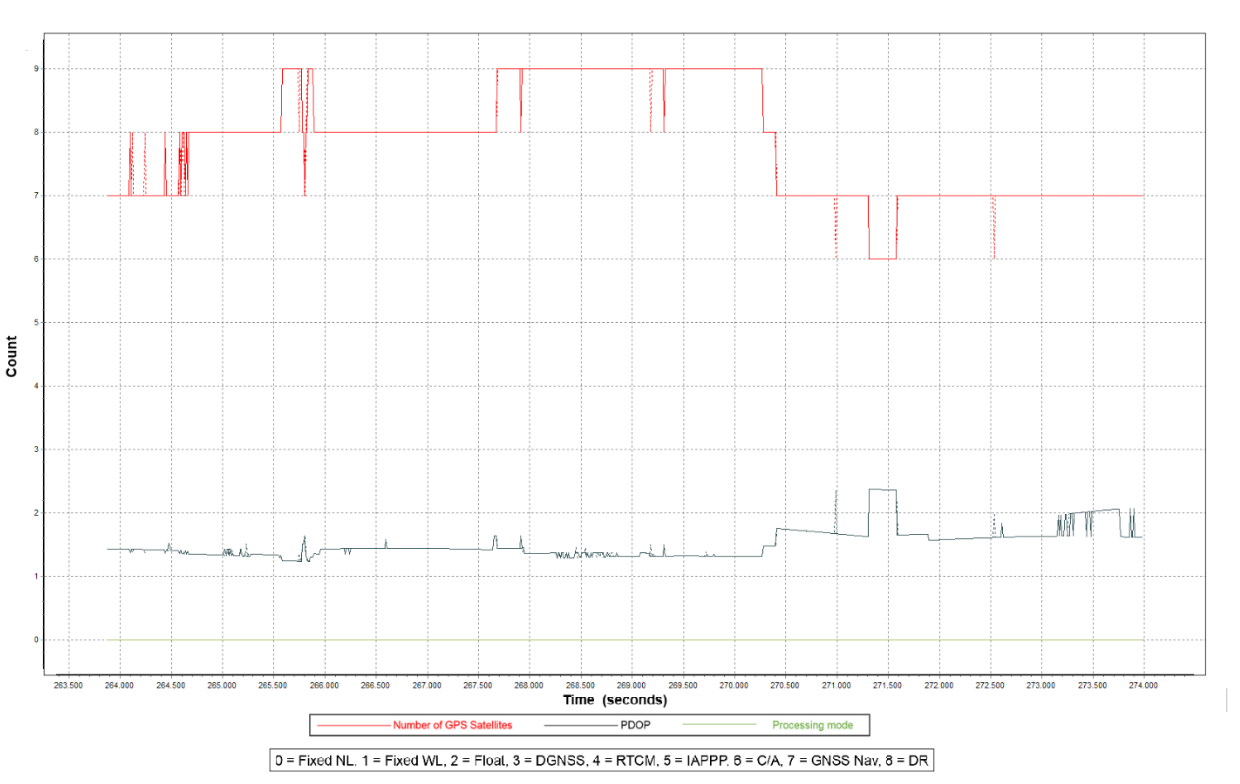


Figure 15. Solution Status Parameters of Abulog-Apayao Flight 2838P

The Solution Status parameters of flight 2838P, one of the Abulog-Apayao flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 15. The graphs indicate that the number of satellites during the acquisition did not go down to 6. Majority of the time, the number of satellites tracked was between 6 and 9. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode stayed at the value of 0. 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 Abulog-Apayao flights is shown in Figure 16.

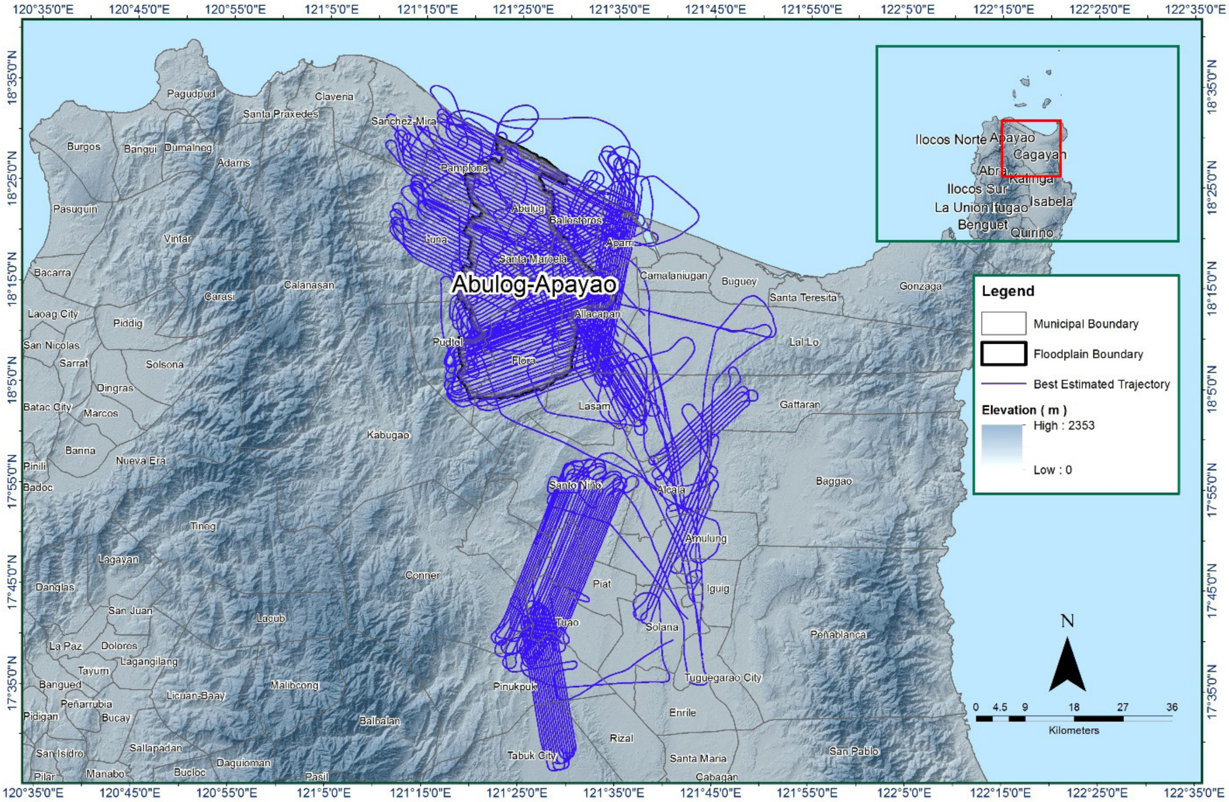


Figure 16. The best estimated trajectory of the LiDAR missions conducted over Abulog-Apayao floodplain

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 214 flight lines, with each flight line containing one channel for Gemini system and two channels for Pegasus system. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Abulog-Apayao floodplain are given in Table 20.

Table 20. Self-Calibration Results values for Abulog-Apayao flights

Parameter	Value	Computed Value
Boresight Correction stdev	(<0.001degrees)	0.000324
IMU Attitude Correction Roll and Pitch Corrections stdev	(<0.001degrees)	0.000995
GPS Position Z-correction stdev	(<0.01meters)	0.0017

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

3.5 LiDAR Data Quality Checking

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

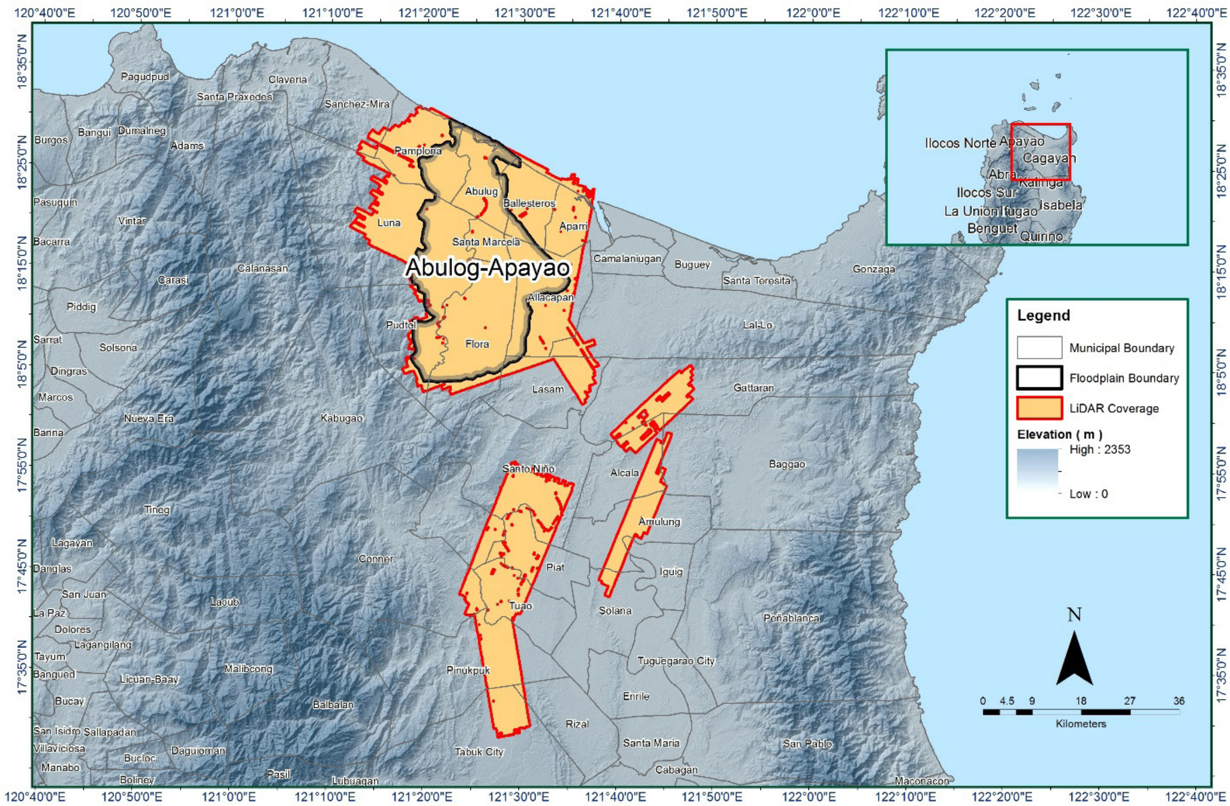


Figure 17. Boundary of the processed LiDAR data over Abulog-Apayao Floodplain

The total area covered by the Abulog-Apayao missions is 2,486.51 sq.km that is comprised of sixteen (16) flight acquisitions grouped and merged into twenty-two (22) blocks as shown in Table 21.

Table 21. List of LiDAR blocks for Abulog-Apayao floodplain

LiDAR Blocks	Flight Numbers	Area (sq. km)
Cagayan_reflights_Tuguegarao_Blk2H_supplement	2874P	72.16
Cagayan_reflights_Tuguegarao_Blk2F	2838P	258.60
Cagayan_reflights_Tuguegarao_Blk2H	2868P	172.74
Cagayan_reflights_Tuguegarao_Blk2H_additional	2880P	68.40
Cagayan_reflights_Tuguegarao_Blk2D_supplement_Blk2E	2850P	193.17
Cagayan_reflights_Tuguegarao_Blk2D	2854P	72.26
Cagayan_reflights_Tuguegarao_Blk2G	2866P	204.29
Cagayan_reflights_Tuguegarao_Blk2F_supplement	2846P	71.96
Cagayan_reflights_Tuguegarao_Blk2B	2842P	130.71
Cagayan_reflights_Tuguegarao_Blk2A_supplement	2846P	199.64
Cagayan_reflights_Tuguegarao_Blk2A	2852P	131.64
Cagayan_reflights_Tuguegarao_Blk2A_additional	2848P	53.85
Cagayan_reflights_Tuguegarao_CAGS1B	2830P	105.19
Cagayan_reflights_Tuguegarao_CAGS1D	2830P	89.82
Cagayan_reflights_Tuguegarao_Blk2H_supplement2	2880P	55.01
Cagayan_reflights_Blk101A	3977G	146.01
Cagayan_reflights_Blk101A_additional	3977G	11.50
Cagayan_reflights_Blk51E	3973G	151.23
Cagayan_reflights_Blk51D	3973G	109.26
Cagayan_reflights_Blk51D_additional	3965G	101.11
Cagayan_Blk11B	750G	44.31
Cagayan_Blk11Bs	752G	43.65
TOTAL		2,486.51

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location is shown in Figure 18. Since the Gemini system employs one channel and the Pegasus system employs two channels, 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.

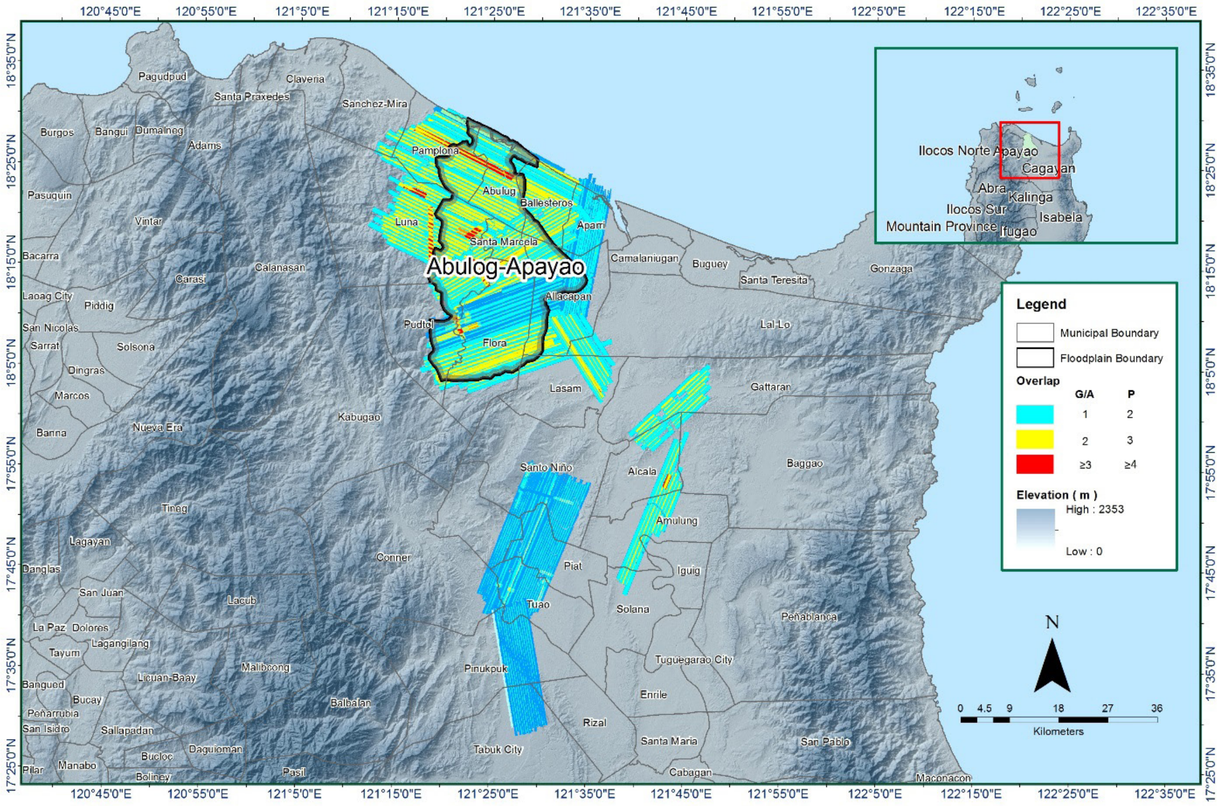


Figure 18. Image of data overlap for Abulog-Apayao floodplain

The overlap statistics per block for the Abulog-Apayao floodplain can be found in **Annex B-1**. One pixel corresponds to 25.0 square meters on the ground. For this area, the maximum percent overlap is 51.57% respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion is shown in Figure 19. It was determined that all LiDAR data for Abulog-Apayao floodplain satisfy the point density requirement, and the average density for the entire survey area is 3.44 points per square meter.

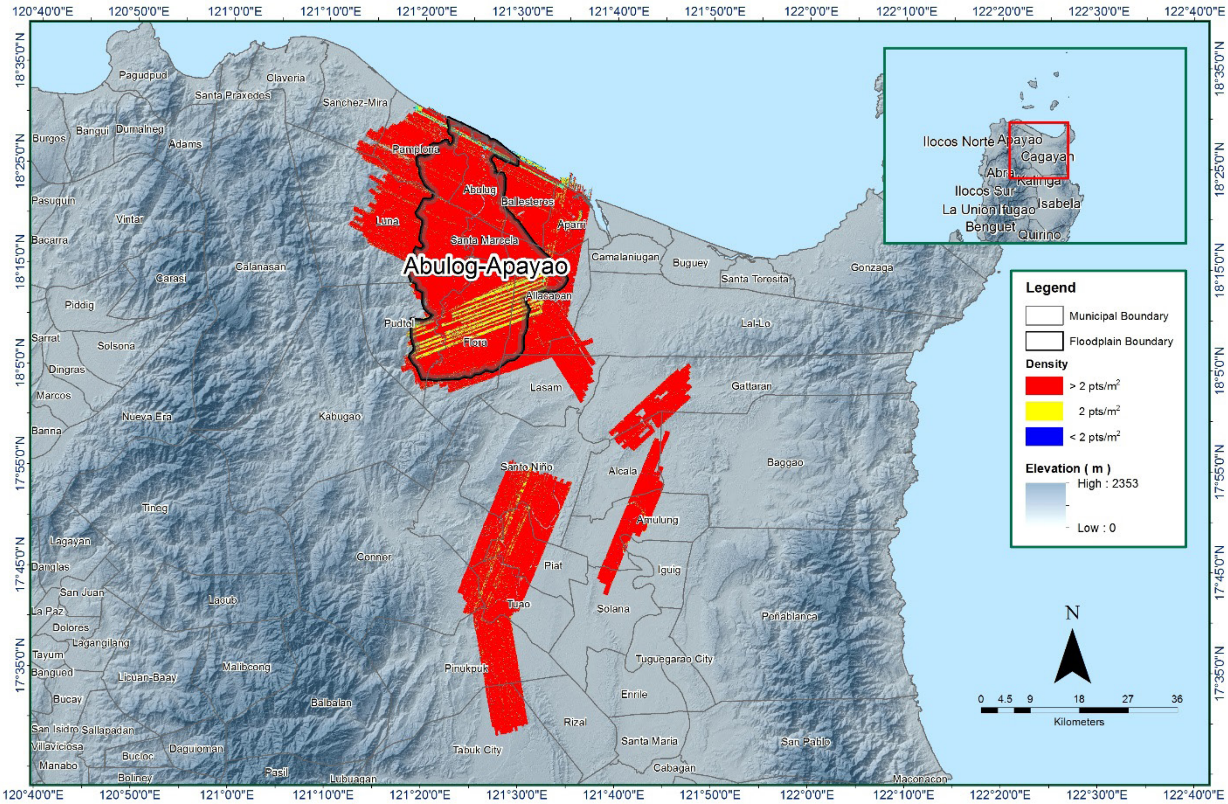


Figure 19. Pulse density map of merged LiDAR data for Abulog-Apayao floodplain

The elevation difference between overlaps of adjacent flight lines is shown in Figure 20. 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.

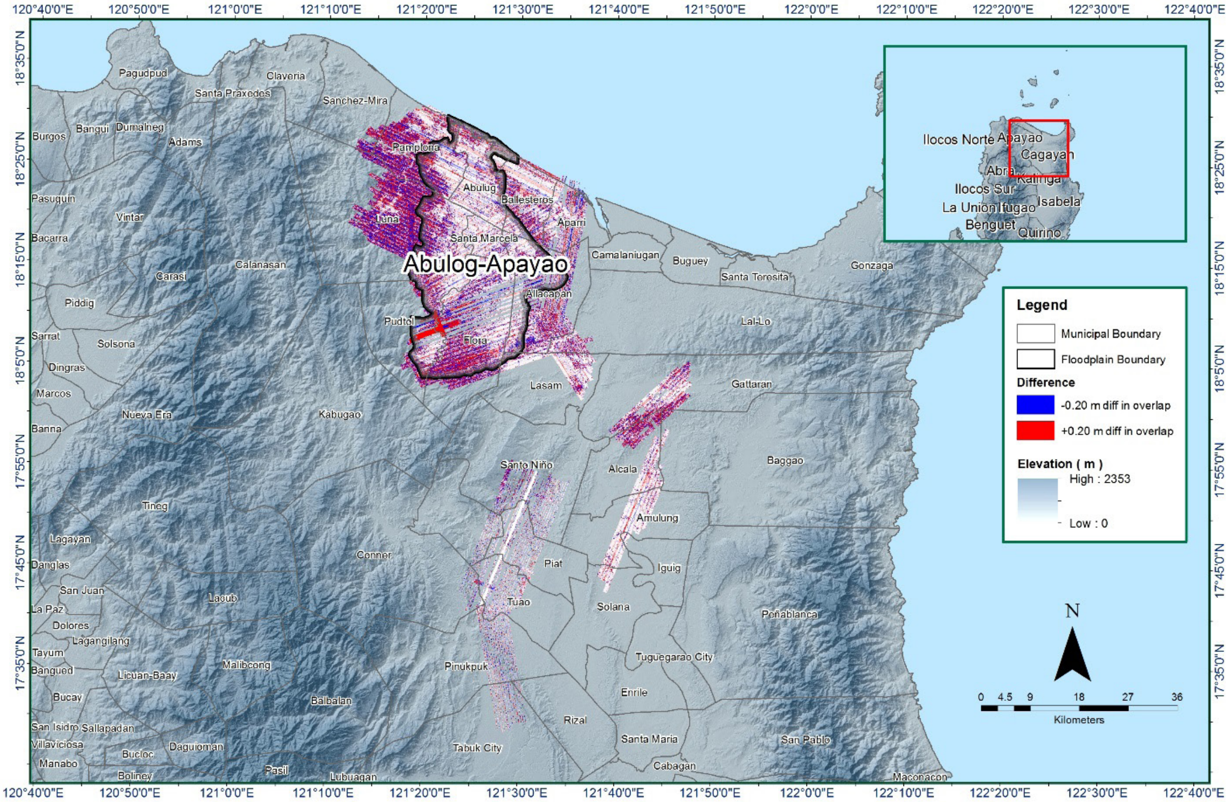


Figure 20. Elevation difference map between flight lines for Abulog-Apayao floodplain

A screen capture of the processed LAS data from Abulog-Apayao flight 2838P loaded in QT Modeler is shown in Figure 20. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed yellow line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

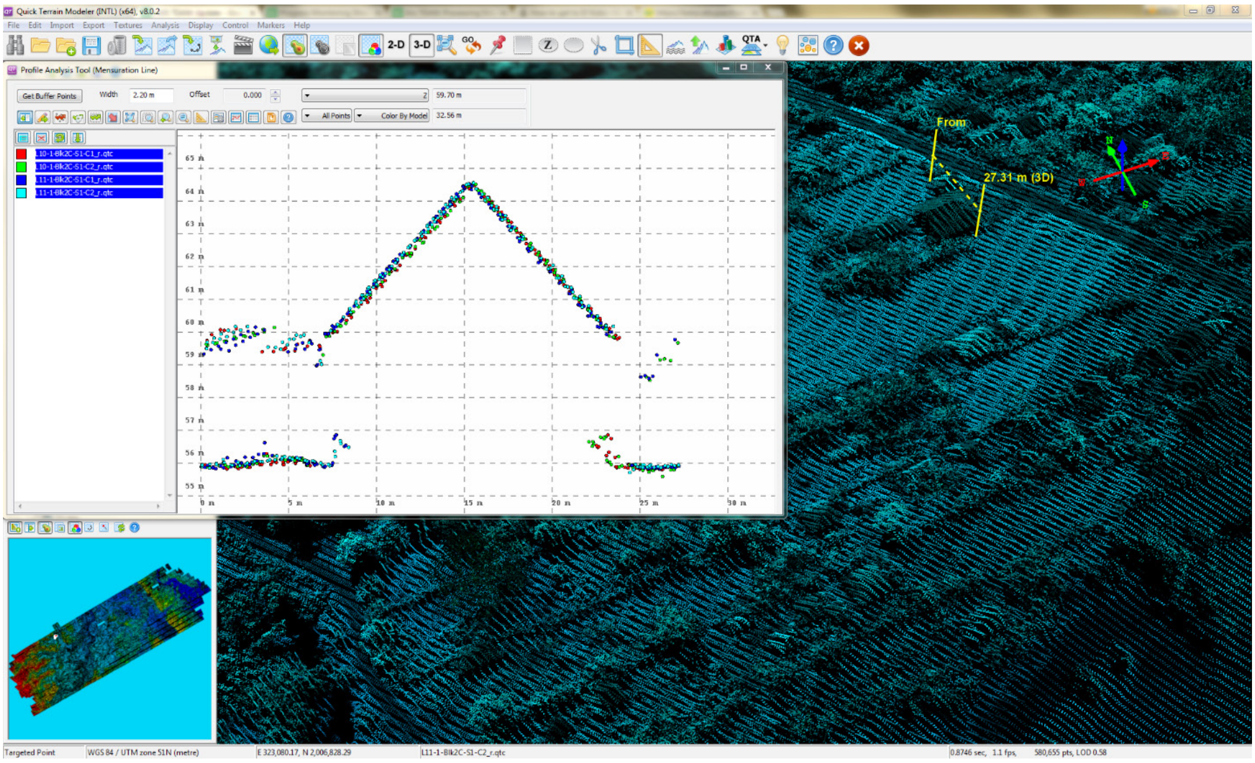


Figure 21. Quality checking for a Abulog-Apayao flight 2838P using the Profile Tool of QT Modeler

3.6 LiDAR Point Cloud Classification and Rasterization

Table 22. Abulog-Apayao classification results in TerraScan

Pertinent Class	Total Number of Points
Ground	2,600,857,290
Low Vegetation	1,975,378,064
Medium Vegetation	2,655,554,435
High Vegetation	4,471,696,735
Building	80,825,272

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Abulog-Apayao floodplain is shown in Figure 22. A total of 3,342 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 22. The point cloud has a maximum and minimum height of 607.35 meters and 27.66 meters respectively.

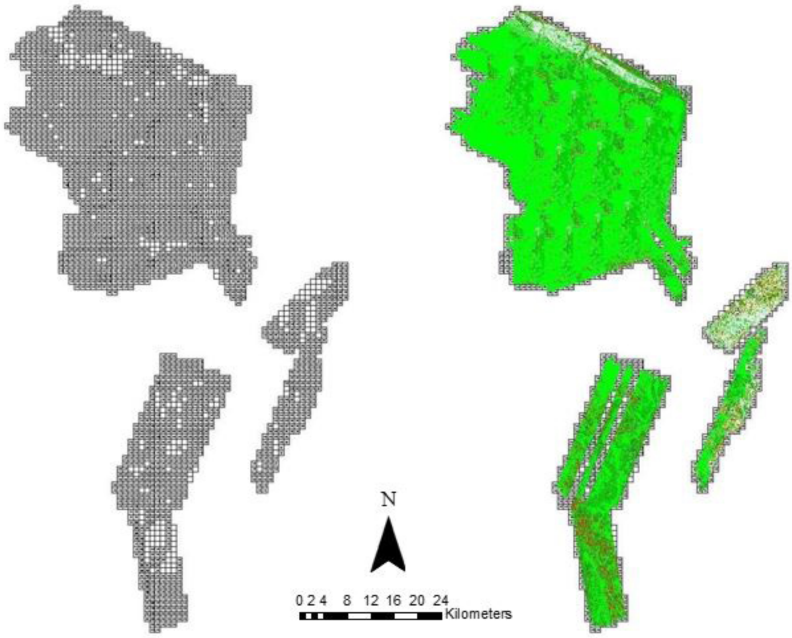


Figure 22. Tiles for Abulog-Apayao floodplain (a) and classification results (b) in TerraScan

An isometric view of an area before and after running the classification routines is shown in Figure 23. The ground points are in orange, the vegetation is in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below canopy are classified correctly, due to the density of the LiDAR data.

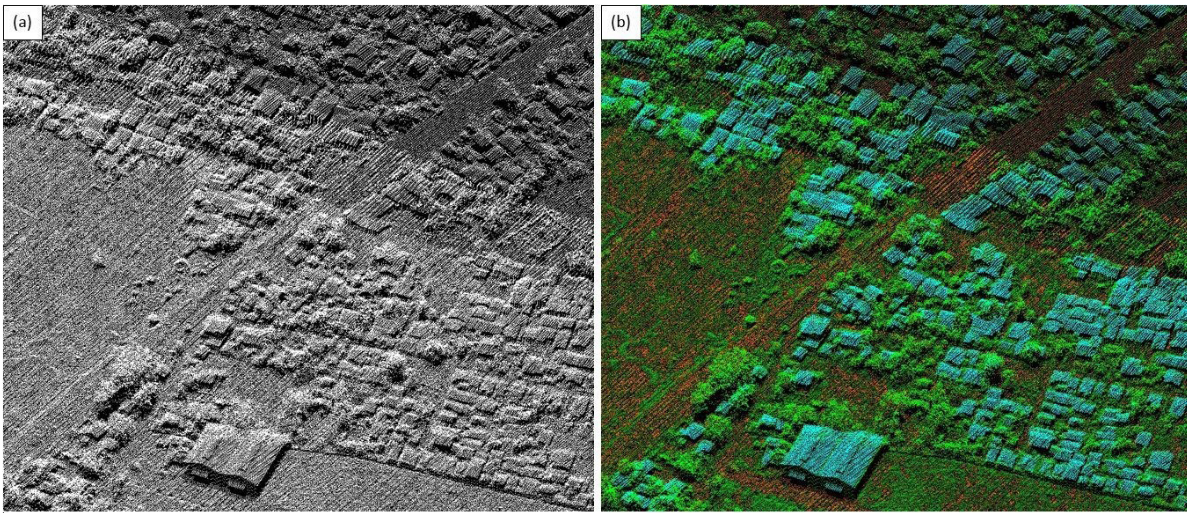


Figure 23. Point cloud before (a) and after (b) classification

The production of last return (V_ASCII) and the secondary (T_ ASCII) DTM, first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 24. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

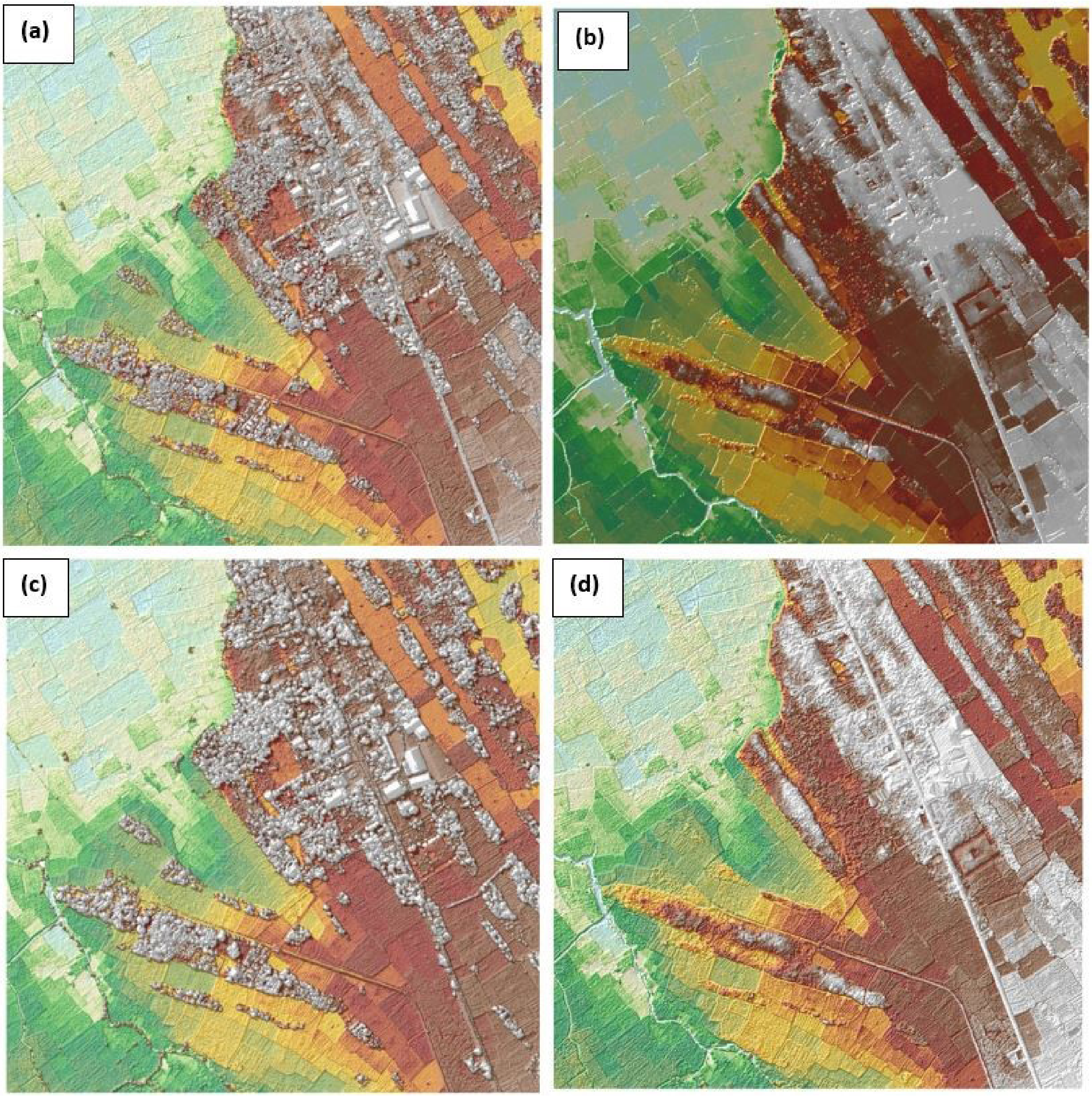


Figure 24. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Abulog-Apayao floodplain

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 2,889 1km by 1km tiles area covered by Abulog-Apayao floodplain is shown in Figure 25. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Abulog-Apayao floodplain survey has attained a total of 1,574.63 km^2 in orthophotogaph coverage comprised of 5,731 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 26.

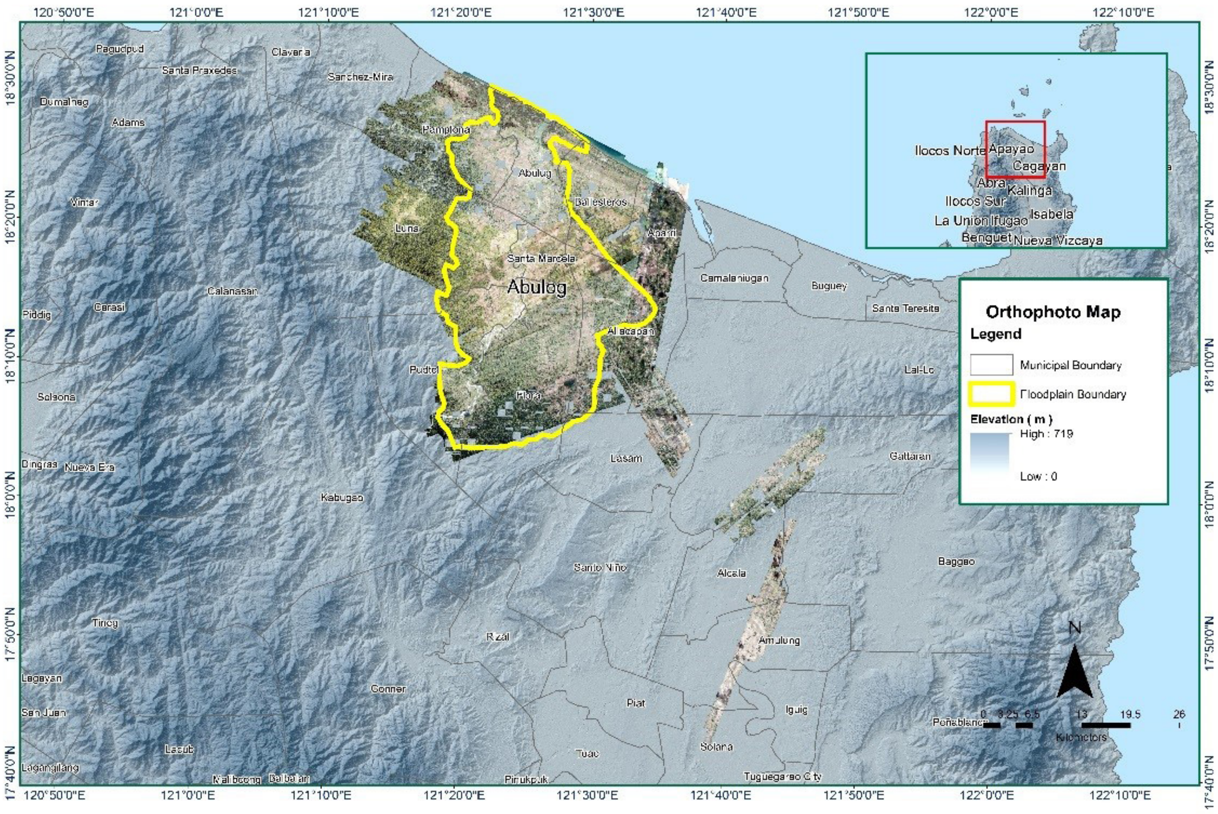


Figure 25. Abulog-Apayao floodplain with available orthophotographs

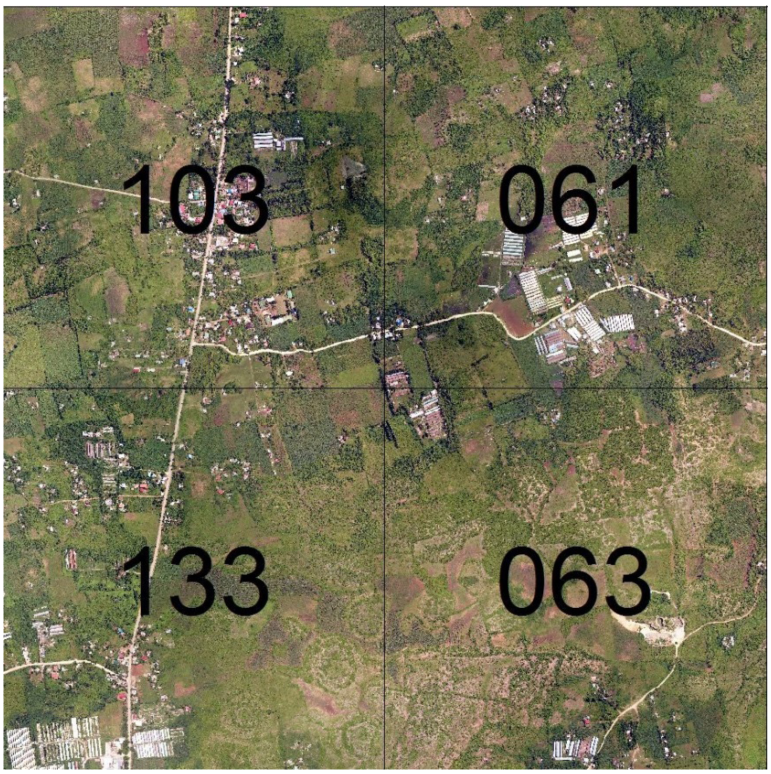


Figure 26. Sample orthophotograph tiles for Abulog-Apayao floodplain

3.8 DEM Editing and Hydro-Correction

Twenty-two (22) mission blocks were processed for Abulog-Apayao flood plain. These blocks are composed of Cagayan, Cagayan_reflights, and Cagayan_reflights_Tugegarao with a total area of 2,486.51 square kilometers. Table 23 shows the name and corresponding area of each block in square kilometers.

Blocks with asterisk sign in Table 23 were not edited by Isabela State University Phil – LiDAR 1 (ISU Phil – LiDAR 1). The area coverage of these blocks was already covered by other blocks previously edited by ISU Phil – LiDAR 1. The area values written in Table 23 are based on the area coverage of their corresponding LiDAR point cloud data.

Table 23. LiDAR blocks with its corresponding area

LiDAR Blocks	Area (sq.km.)
Cagayan_reflights_Tuguegarao_Blk2H_supplement	72.16
Cagayan_reflights_Tuguegarao_Blk2F*	258.60
Cagayan_reflights_Tuguegarao_Blk2H	172.74
Cagayan_reflights_Tuguegarao_Blk2H_additional	68.40
Cagayan_reflights_Tuguegarao_Blk2D_supplement_Blk2E	193.17
Cagayan_reflights_Tuguegarao_Blk2D	72.26
Cagayan_reflights_Tuguegarao_Blk2G	204.29
Cagayan_reflights_Tuguegarao_Blk2F_supplement	71.96
Cagayan_reflights_Tuguegarao_Blk2B	130.71
Cagayan_reflights_Tuguegarao_Blk2A_supplement	199.64
Cagayan_reflights_Tuguegarao_Blk2A	131.64
Cagayan_reflights_Tuguegarao_Blk2A_additional*	53.85
Cagayan_reflights_Tuguegarao_CAGS1B	105.19
Cagayan_reflights_Tuguegarao_CAGS1D*	89.82
Cagayan_reflights_Tuguegarao_Blk2H_supplement2	55.01
Cagayan_reflights_Blk101A*	146.01
Cagayan_reflights_Blk101A_additional*	11.50
Cagayan_reflights_Blk51E	151.23
Cagayan_reflights_Blk51D	109.26
Cagayan_reflights_Blk51D_additional*	101.11
Cagayan_Blk11B*	44.31
Cagayan_Blk11Bs*	43.65
TOTAL	2,486.51 sq.km

Portions of DTM before and after manual editing are shown in Figure 27. A bridge (Figure 27a) has been misclassified and removed during classification process and has to be interpolated to complete the surface (Figure 27b) to allow the correct flow of water. An interpolated irrigation (Figure 27c) was retrieved (Figure 27d) in order to hydrologically correct the irrigation system. Another example is an interpolated ridge (Figure 27e) has to be retrieved using object retrieval to achieve the actual surface (Figure 27f). Another example is a building that is still present in the DTM after classification (Figure 27g) and has to be removed through manual editing (Figure 27h).

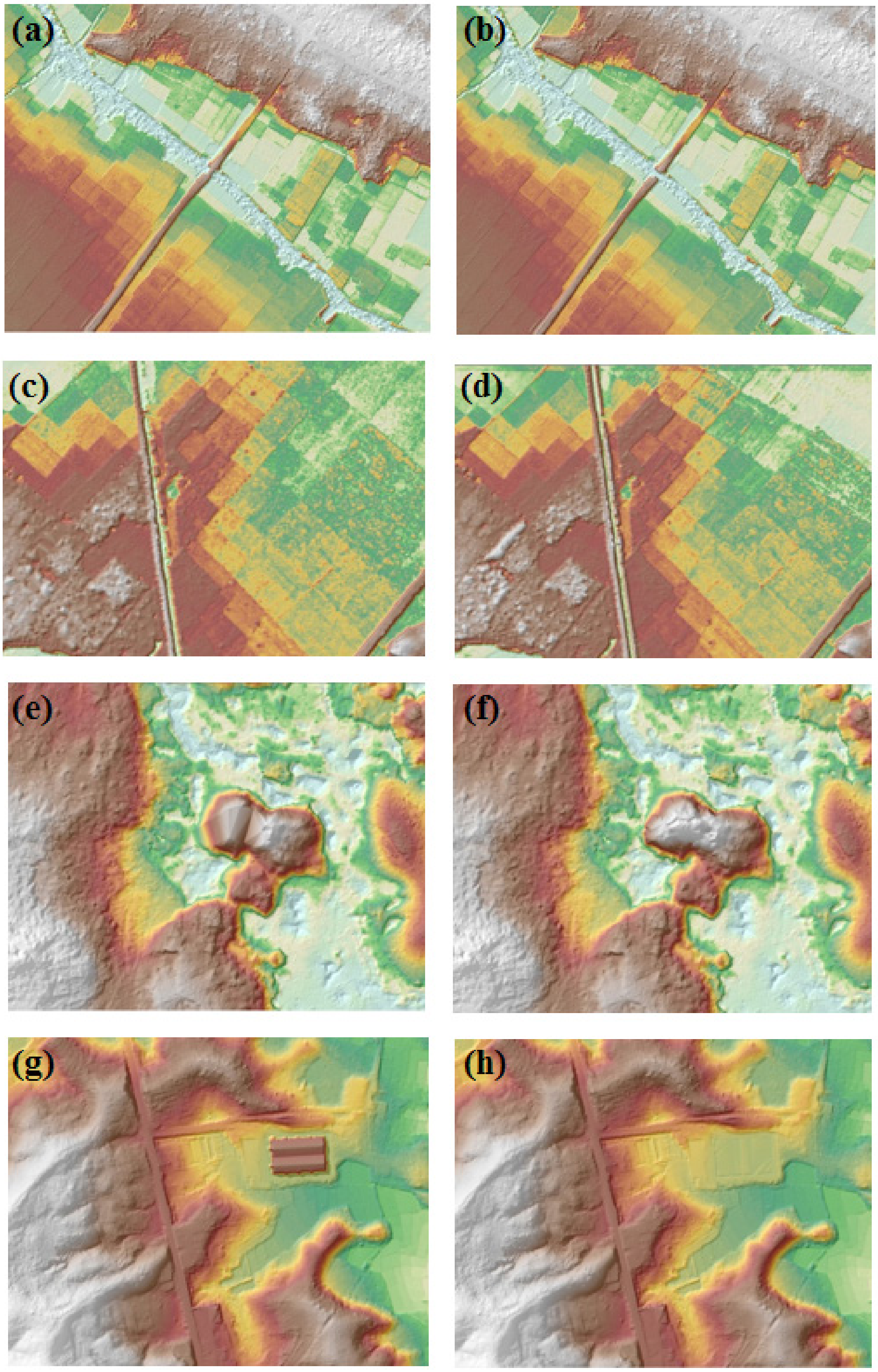


Figure 27. Portions in the DTM of Abulog-Apayao floodplain – a road before (a) and after (b) manual editing; an irrigation before (c) and after (d); interpolated ridge before (e) and after (f) object retrieval; and a building before (g) and after (h) manual editi

3.9 Mosaicking of Blocks

No assumed reference block was used in mosaicking because the identified reference for shifting was an existing calibrated Cagayan DEM overlapping with the blocks to be mosaicked. Table 24 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Abulog-Apayao floodplain is shown in Figure 28. It can be seen that the entire Abulog-Apayao floodplain is 100% covered by LiDAR data.

Table 24. Shift Values of each LiDAR Block of Abulog-Apayao floodplain

Mission Blocks	Shift Values (meters)		
	x	y	z
Cagayan_reflights_Tuguegarao_Blk2A_supplement	-1.71	0.77	-3.92
Cagayan_reflights_Tuguegarao_Blk2B	-2.72	2.77	-5.14
Cagayan_reflights_Tuguegarao_Blk2A_additional*	covered by CRT_2Ar		
Cagayan_reflights_Tuguegarao_Blk2C	-0.24	1.78	-1.51
Cagayan_reflights_Tuguegarao_Blk2D	-1.18	1.69	-4.45
Cagayan_reflights_Tuguegarao_Blk2D_supplement_Blk2E	-0.72	1.78	-1.
Cagayan_reflights_Tuguegarao_Blk2F*	same area as CRT_2C		
Cagayan_reflights_Tuguegarao_Blk2F_supplement	-0.72	1.78	-3.77
Cagayan_reflights_Tuguegarao_Blk2G	0.28	2.29	-4.38
Cagayan_reflights_Tuguegarao_Blk2H	-0.64	3.65	-5.08
Cagayan_reflights_Tuguegarao_Blk2H_additional	1.29	4.76	-1.23
Cagayan_reflights_Tuguegarao_Blk2H_supplement	-0.97	2.84	-1.63
Cagayan_reflights_Tuguegarao_Blk2H_supplement2	-0.90	3.12	-1.67
Cagayan_reflights_Tuguegarao_Blk2A	-5.72	-5.22	-4.97
Cagayan_reflights_Tuguegarao_CAGS1B	-4.42	0.00	0.00
Cagayan_reflights_Blk101A	-4.35	0.00	0.00
Cagayan_reflights_Blk51E	-3.64	0.00	0.00
Cagayan_reflights_Blk51D_additional	-4.01	0.00	0.00
Cagayan_reflights_Blk1D	-5.79	-5.03	-4.30
Cagayan_reflights_Blk51D			
Cagayan_reflights_Blk101A_additional			
Cagayan_reflights_Tuguegarao_CAGS1D			
Cagayan_reflights_Tuguegarao_Blk2E			
Cagayan_Blk11Bs			
Cagayan_Blk11B			

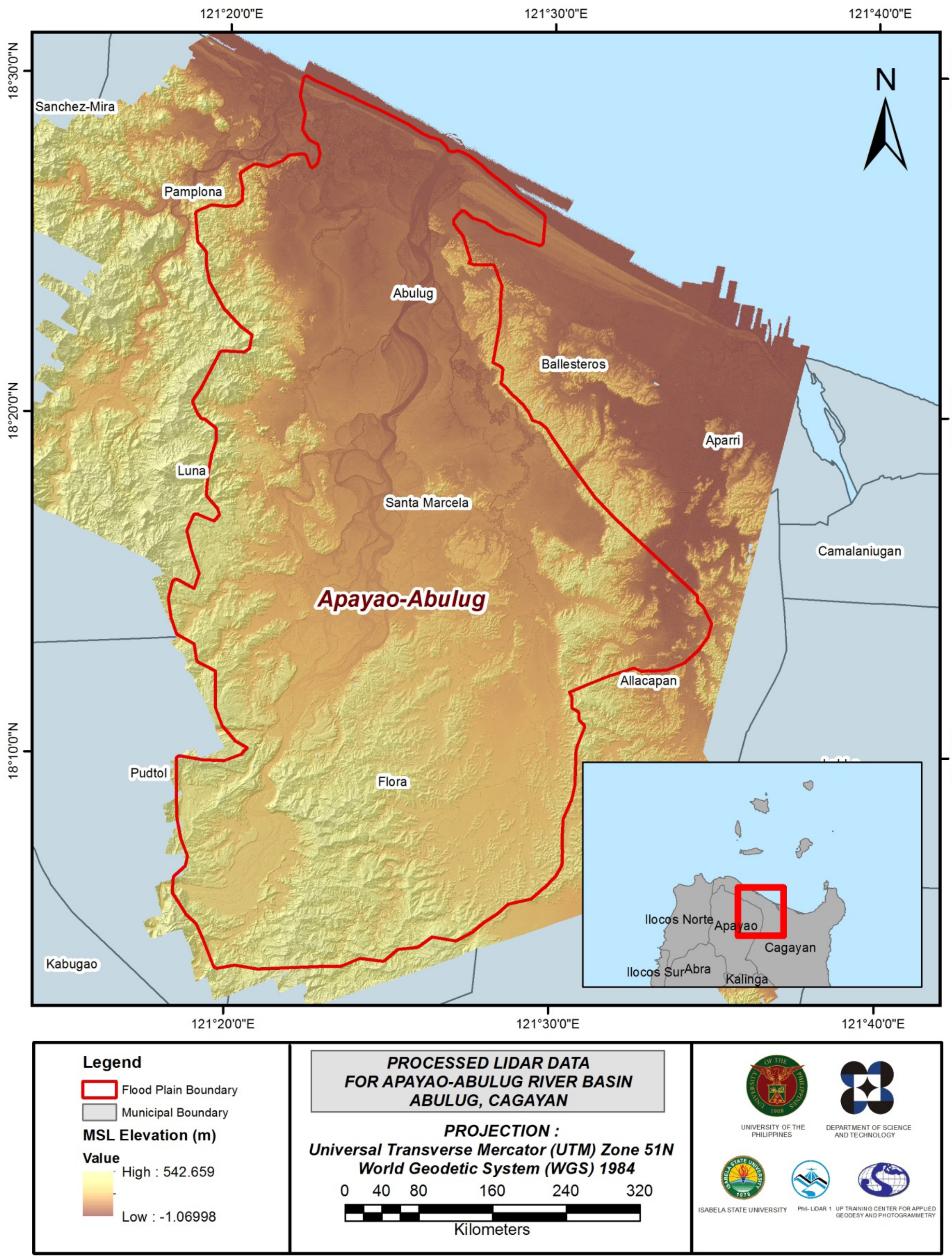


Figure 28. Map of Processed LiDAR Data for Abulog-Apayao Flood Plain

3.10 Calibration and Validation of Mosaicked LiDAR DEM

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Cagayan to collect points with which the LiDAR dataset is validated is shown in Figure 29. A total of 5,477 survey points were gathered for all the floodplains within Northern Cagayan wherein the Abulog-Apayao is located. However, the point dataset was not used for the calibration of the LiDAR data for Abulog-Apayao because during the mosaicking process, each LiDAR block was referred to the calibrated Cagayan DEM. Therefore, the mosaicked DEM of Abulog-Apayao can already be considered as a calibrated DEM.

A good correlation between the uncalibrated Cagayan LiDAR DTM and ground survey elevation values is shown in Figure 30. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration points is 4.07 meters with a standard deviation of 0.14 meters. Calibration of Cagayan LiDAR data was done by subtracting the height difference value, 4.07 meters, to Cagayan mosaicked LiDAR data. Table 25 shows the statistical values of the compared elevation values between Cagayan LiDAR data and calibration data. These values were also applicable to the Abulog-Apayao DEM.

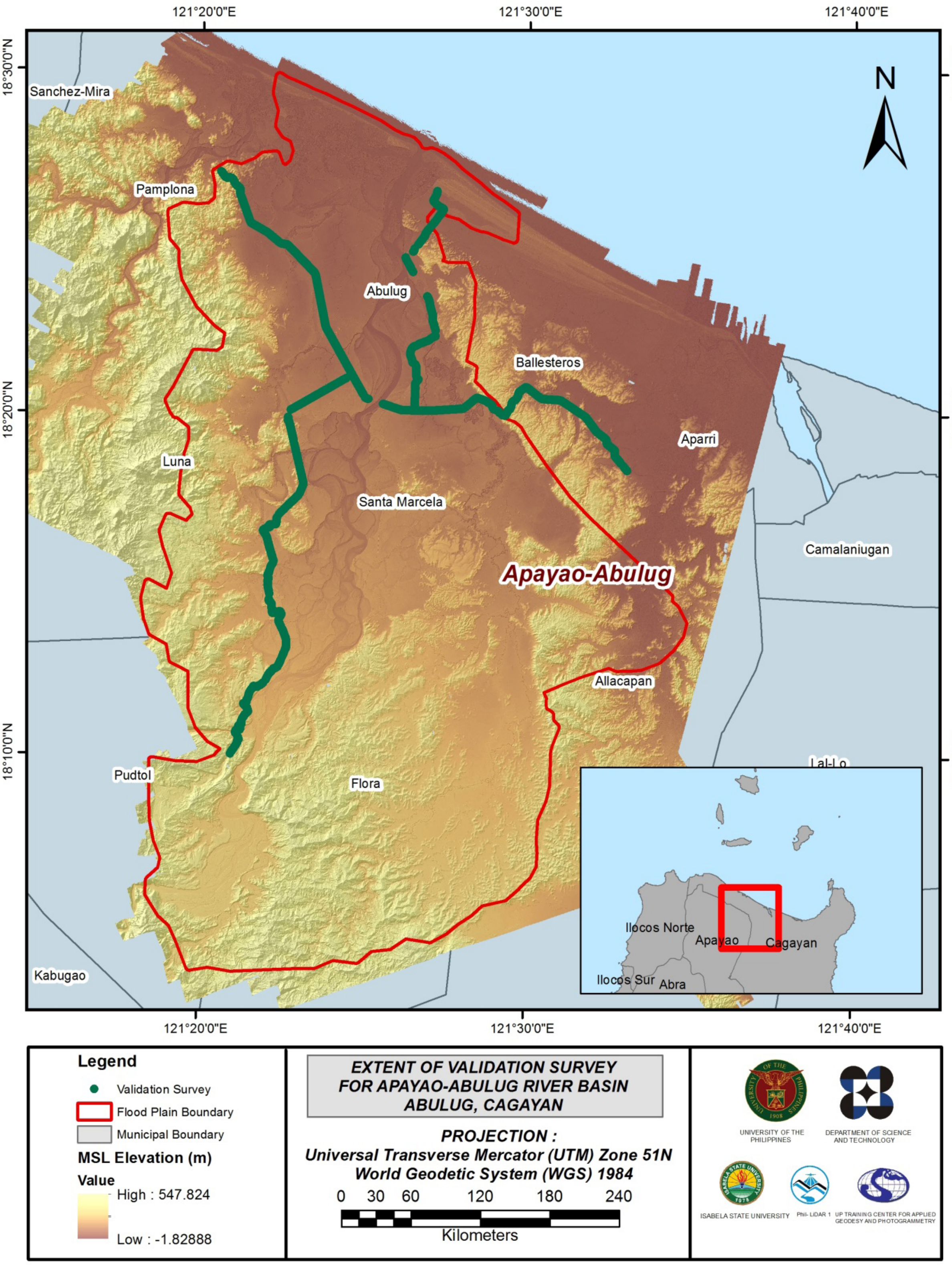


Figure 29. Map of Abulog-Apayao Flood Plain with validation survey points in green

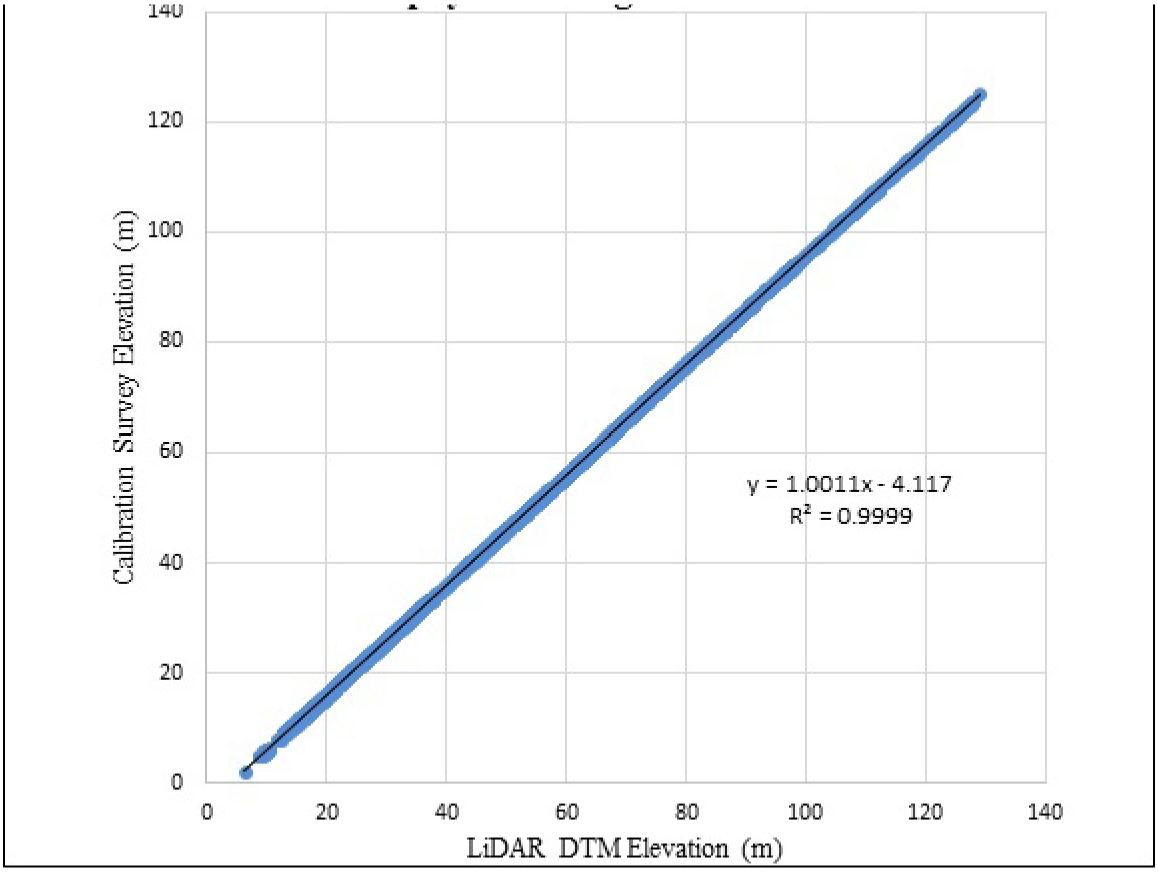


Figure 30. Correlation plot between calibration survey points and LiDAR data

Table 25. Calibration Statistical Measures

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

The remaining 20% of the total survey points, resulting to 1164 points, were used for the validation of calibrated Abulog-Apayao DTM. The good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM is shown in Figure 31. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.19 meters with a standard deviation of 0.18 meters, as shown in Table 26.

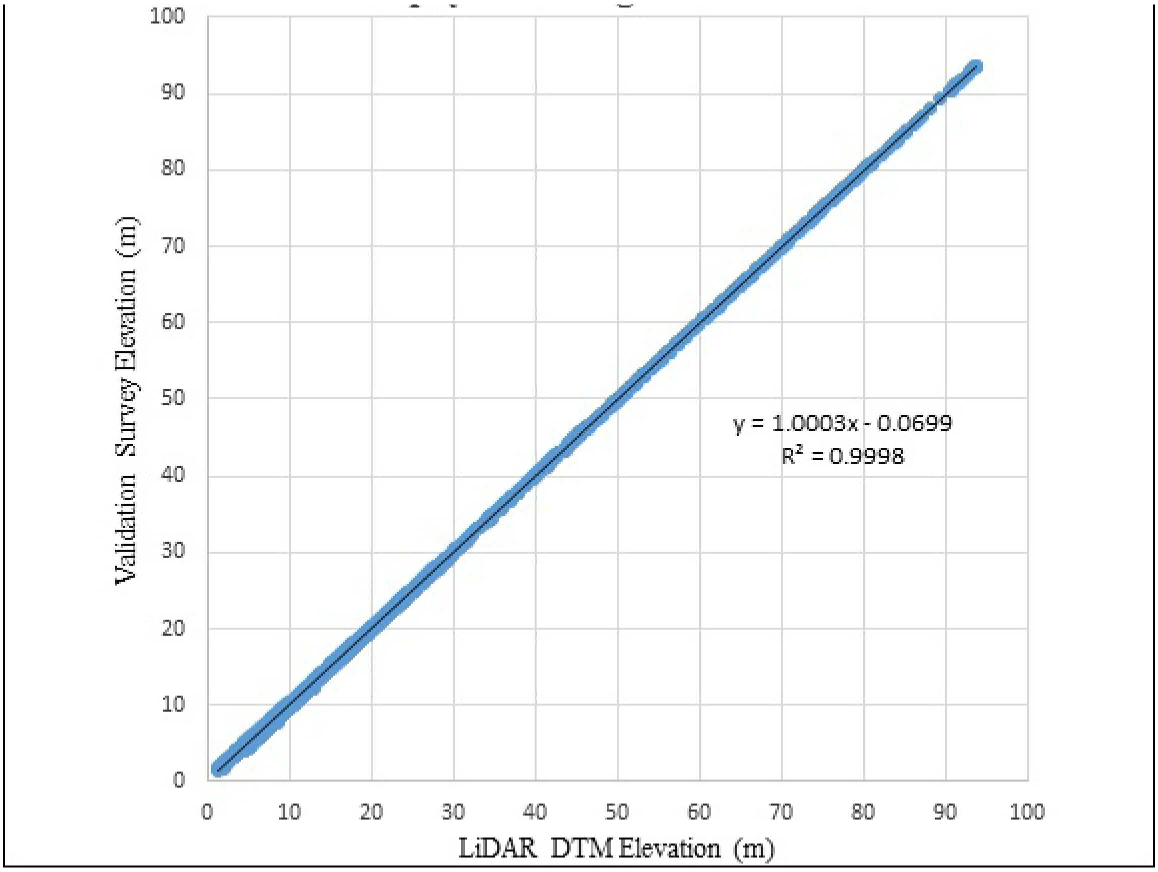


Figure 31. Correlation plot between validation survey points and LiDAR data

Table 26. Validation Statistical Measures

Validation Statistical Measures	Value (meters)
RMSE	0.19
Standard Deviation	0.18
Average	0.06
Minimum	-0.51
Maximum	0.86

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, zigzag and centerline data were available for Abulog-Apayao with 27,754 bathymetric survey points. The resulting raster surface produced was done by Inverse Distance Weighted (IDW) interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.25 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Abulog-Apayao integrated with the processed LiDAR DEM is shown in Figure 32.

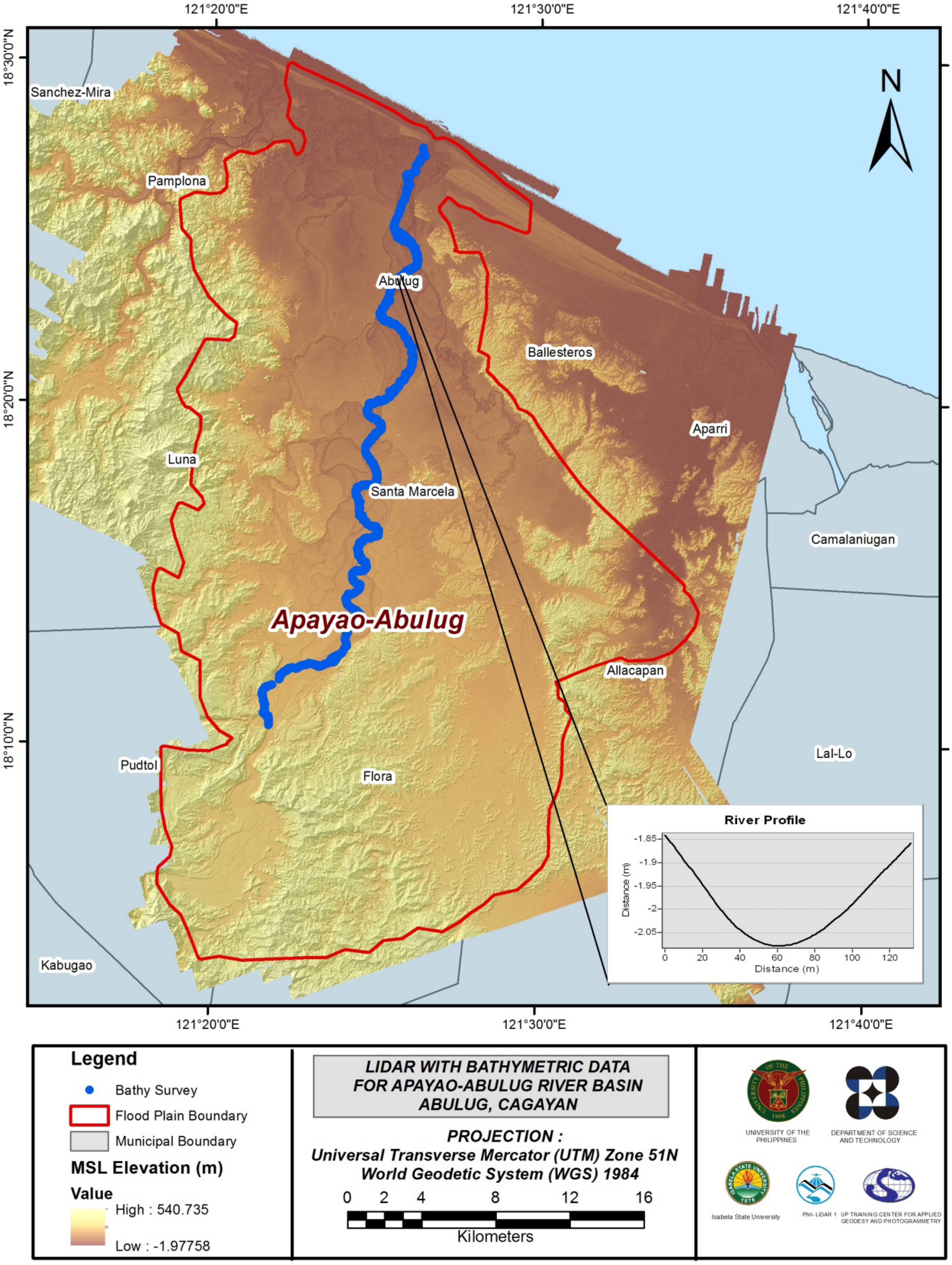


Figure 32. Map of Abulog-Apayao Flood Plain with bathymetric survey points shown in blue

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

Abulog-Apayao floodplain, including its 200 m buffer, has a total area of 866.23 sq km. For this area, a total of 25.00 sq km, corresponding to a total of 5322 building features, are considered for QC. Figure 33 shows the QC blocks for Abulog-Apayao floodplain.

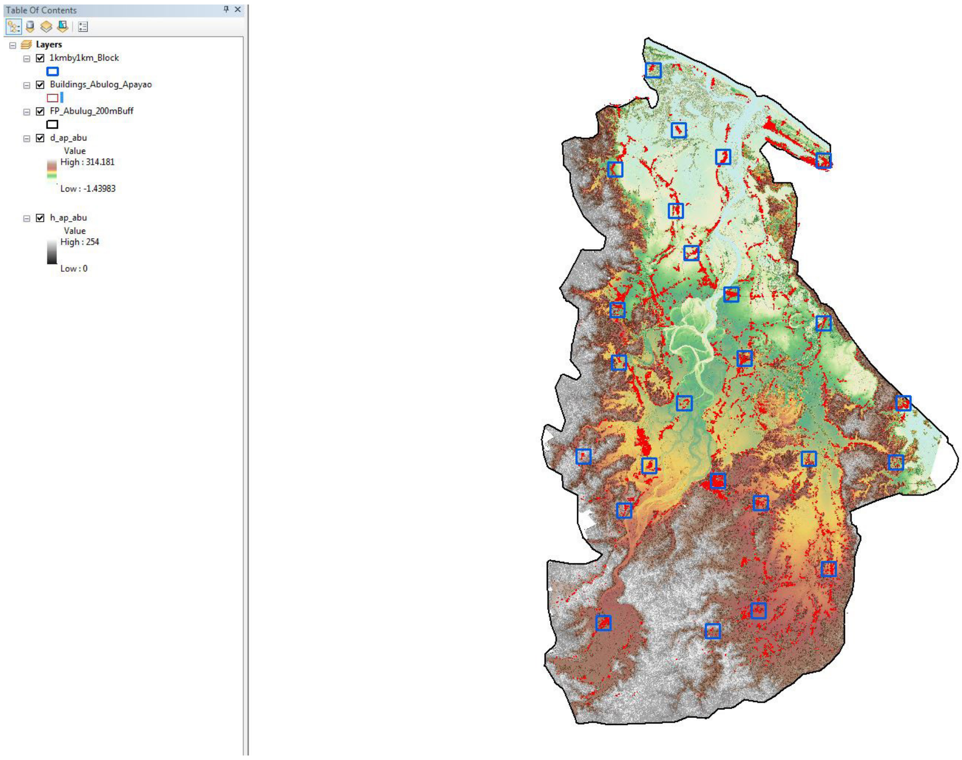


Figure 33. Blocks (in blue) of Abulog-Apayao building features that were subjected to QC

Quality checking of Abulog-Apayao building features resulted in the ratings shown in Table 27.

Table 27. Quality Checking Ratings for Abulog-Apayao Building Features

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Abulog-Apayao	99.38	99.94	98.03	PASSED

3.12.2 Height Extraction

Height extraction was done for 42,657 building features in Abulog-Apayao floodplain. Of these building features, 1,962 were filtered out after height extraction, resulting to 40,695 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 6.48 m.

3.12.3 Feature Attribution

The digitized features were identified using participatory mapping. Stakeholders (preferably barangay officials) were invited in a forum and were given maps of their respective barangays. They attributed first non-residential buildings like barangay hall, schools, churches, commercial buildings, etc. then other building left were then coded as residential. An nDSM was generated using the LiDAR DEMs to extract the heights of the buildings. A minimum height of 2 meters was used to filter out the terrain features that were digitized as buildings. Buildings that were not yet constructed during the time of LiDAR acquisition were noted as new buildings in the attribute table.

Table 28 summarizes the number of building features per type. On the other hand, Table 29 shows the total length of each road type, while Table 30 shows the number of water features extracted per type.

Table 28. Building Features Extracted for Abulog-Apayao Floodplain

Facility Type	No. of Features
Residential	38073
School	852
Market	38
Agricultural/Agro-Industrial Facilities	374
Medical Institutions	54
Barangay Hall	83
Military Institution	1
Sports Center/Gymnasium/Covered Court	65
Telecommunication Facilities	0
Transport Terminal	2
Warehouse	207
Power Plant/Substation	2
NGO/CSO Offices	28
Police Station	12
Water Supply/Sewerage	17
Religious Institutions	153
Bank	5
Factory	0
Gas Station	9
Fire Station	2
Other Government Offices	255
Other Commercial Establishments	463
Total	**40695**

Table 29. Total Length of Extracted Roads for Abulog-Apayao Floodplain

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Abu-log-Apayao	946.77	34.15	36.03	80.18	0.00	**1,097.13**

Table 30. Number of Extracted Water Bodies for Abulog-Apayao Floodplain

Floodplain	Water Body Type					Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Abulog-Apa-yao	44	47	0	0	0	**91**

A total of 22 bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

3.12.4 Final Quality Checking of Extracted Features

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

Figure 34 shows the Digital Surface Model (DSM) of Abulog-Apayao floodplain overlaid with its ground features.

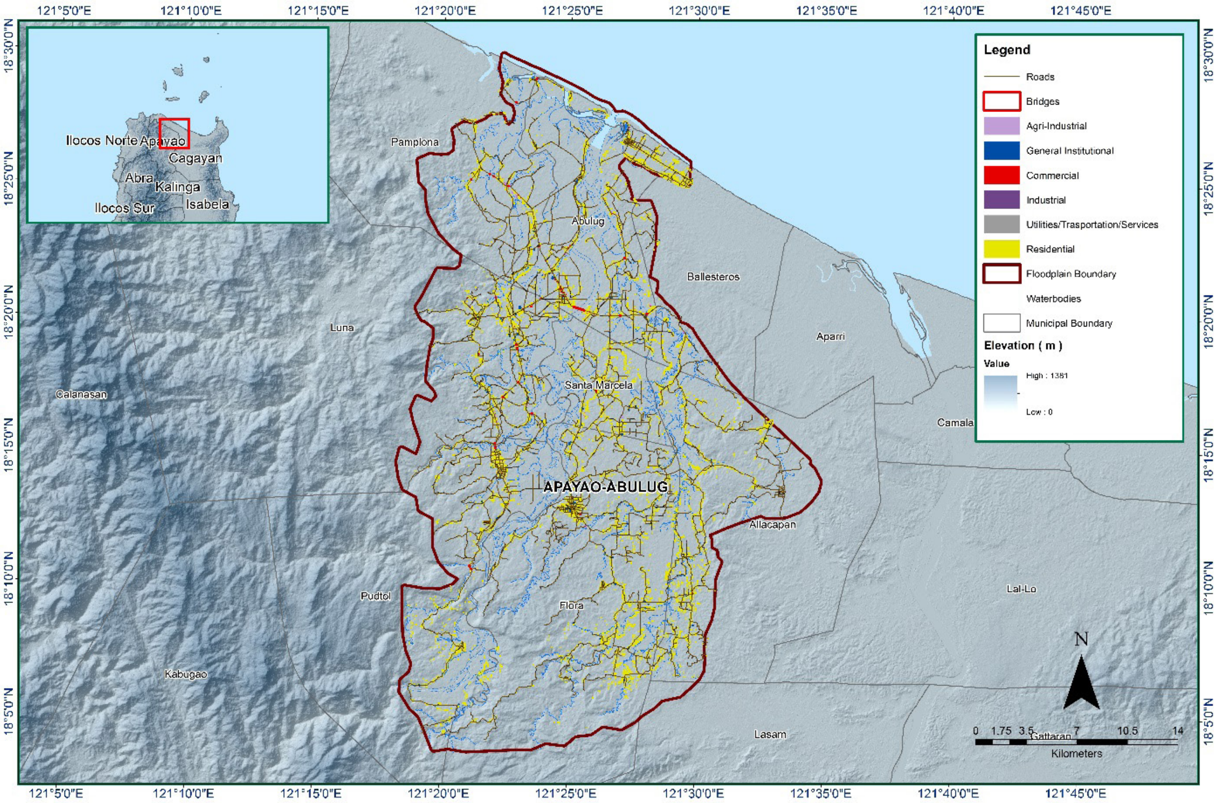


Figure 34. Extracted features for Abulog-Apayao Floodplain

CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE ABULOG-APAYAO RIVER BASIN

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

4.1 Summary of Activities

A field survey in Abulug River on August 19 to August 25, 2015 with the following scope of work: reconnaissance survey to determine the viability of traversing the planned routes for bathymetric survey; courtesy call with Isabela State University, LGU Abulug; control survey, cross-section, bridge-as-built and water level marking; LiDAR acquired ground validation survey with estimated distance of 71.7 km; and bathymetric survey of Abulug River with an approximate length of 42.3 km utilizing GNSS PPK survey technique.

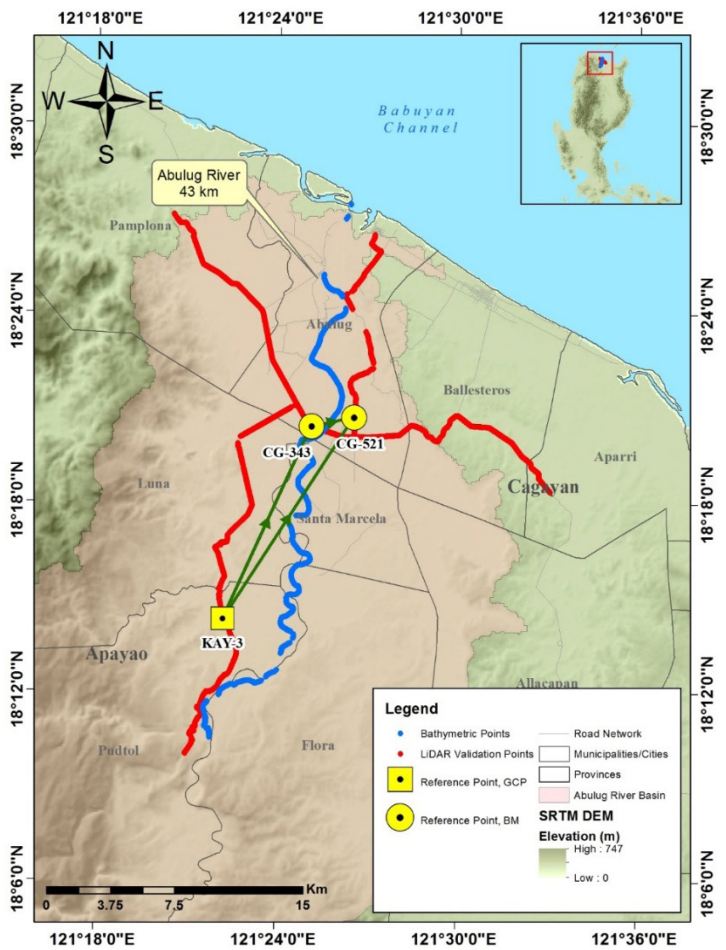


Figure 35. Extent of the bathymetric survey (in blue line) in Abulog-Apayao River and the LiDAR survey (in red)

4.2 Control Survey

The GNSS network used in Abulug Survey was composed of a single loop established on September 18, 2015 occupying the following reference points: CG-343, a first order BM in Brgy. Libertad, Municipality of Abulug, Cagayan; CG-521, also a first order BM in Brgy. Guiddam, Municipality of Abulug, Cagayan; and KAY-3, a second order GCP in Brgy. Imelda, Municipality of Pudtol, Apayao.

The list of control points used in the survey is summarized in Table 31. While the established GNSS network is illustrated in Figure 36.

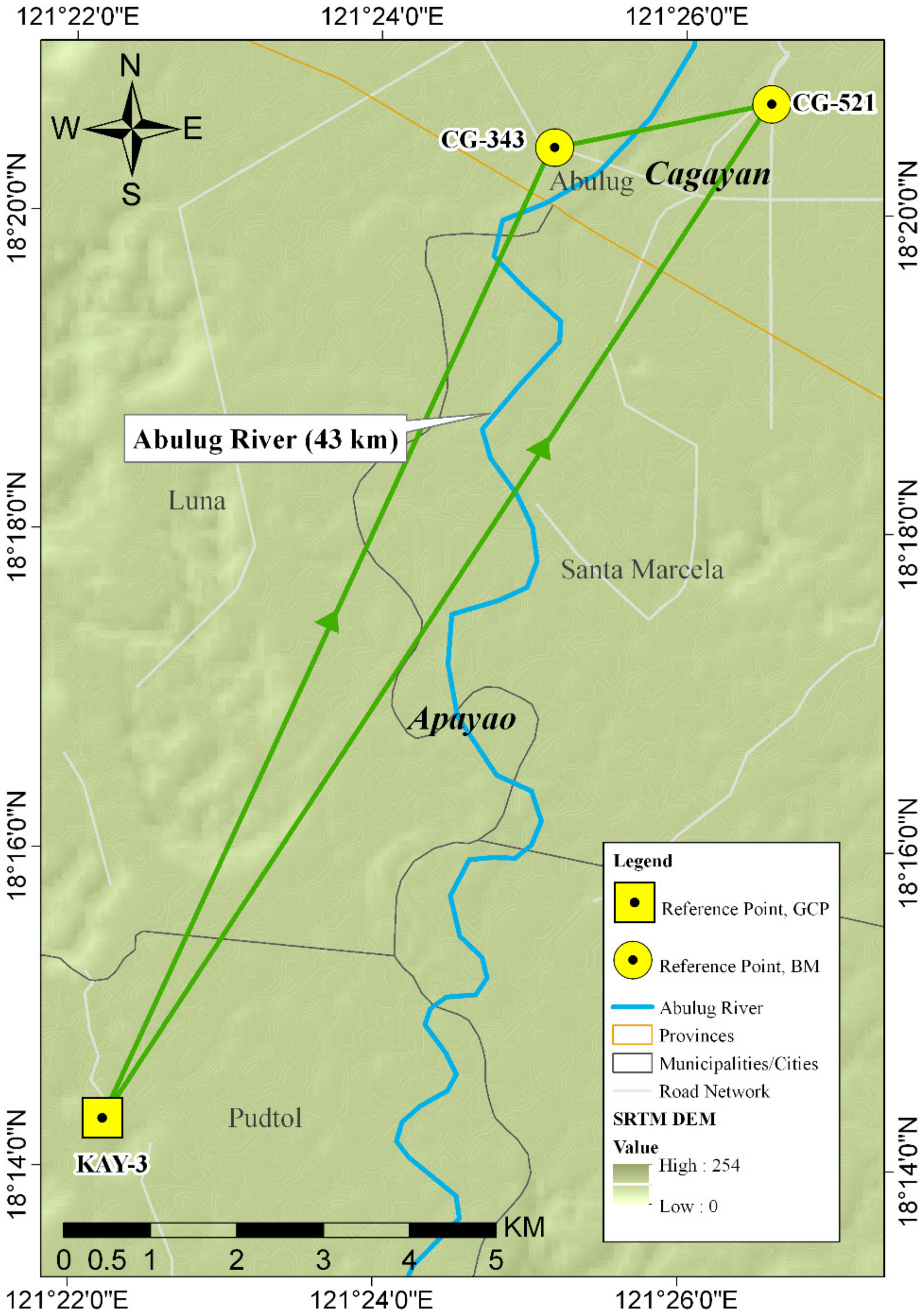


Figure 36. GNSS network covering the Abulug River

Table 31. List of Reference and Control points occupied during Abulug River Survey (Source: NAMRIA, UP-TCAGP)

Control point Name	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoid Height, (m)	BM Ortho (m)	Date Established
CG-343	1st order BM	-	-	50.943	13.119	2007
CG-521	1st order BM	-	-	46.397	8.657	2008
KAY-3	2nd order GCP	18°14’17.68665”	121°22’13.38974”	58.235	-	1990

The GNSS set up on the recovered reference points, CG-343, CG-521 and KAY-3 are shown in Figure 37 to Figure 39, respectively.

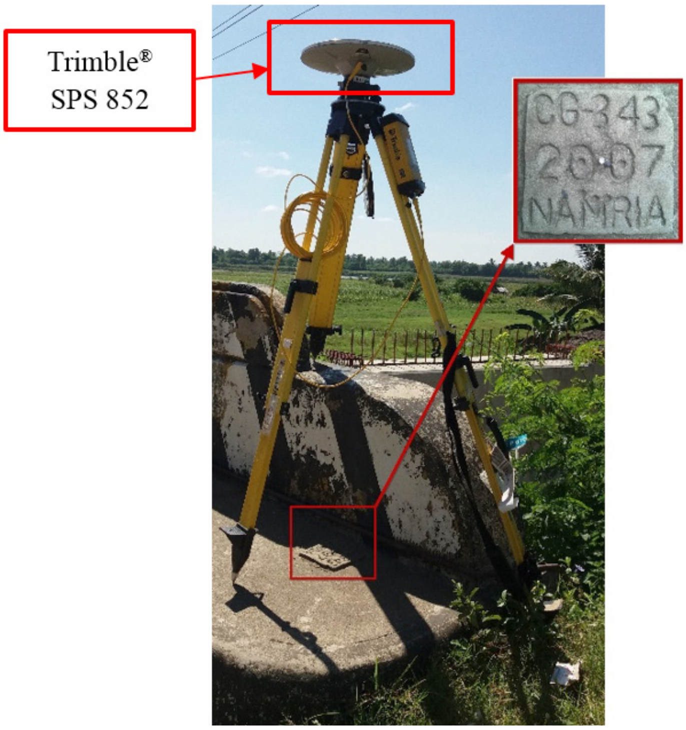


Figure 37. GNSS setup of Trimble® SPS 852 at CG-343, located at the corner of the bridge approach of Lukban Bridge, Brgy. Libertad, Municipality of Abulug, Cagayan

Figure 38. GNSS base setup of Trimble® SPS 852 at CG-521 situated on the pavement pf the concrete barangay sign board of Sittio Maquirre, Brgy. Guiddam, Municipality of Abulog, Cagayan

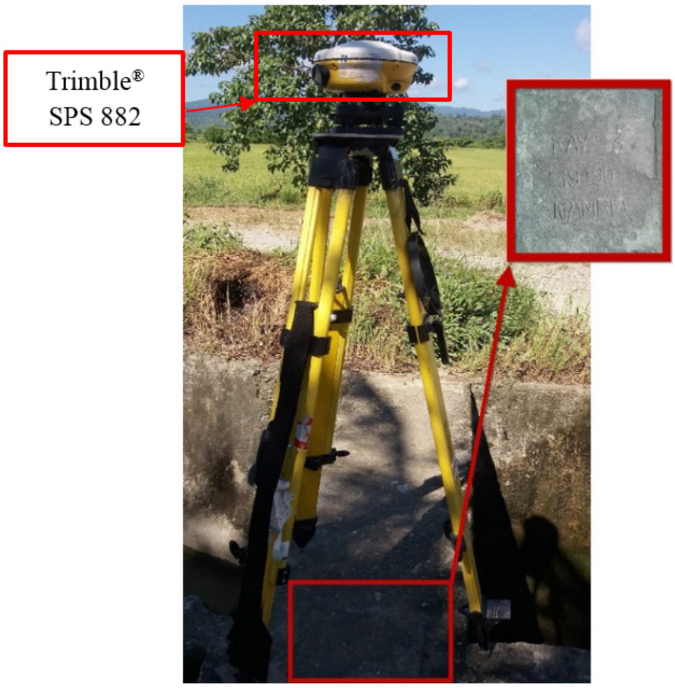


Figure 39. GNSS receiver setup of Trimble® SPS 882 at KAY-3 located on top of a concrete flood gate near the municipal building in Brgy. Imelda, Municipality of Pudtol, Apayao

4.3 Baseline Processing

GNSS baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within +/- 20 cm and +/- 10 cm requirement, respectively. In case where one or more baselines did not meet all of these criteria, masking is performed. Masking is done by removing/masking portions of these baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, resurvey is initiated. Baseline processing result of control points used in Abulog-Apayao River Basin survey is summarized in Table 32 generated by TBC software.

Table 32. Baseline processing report for Abulug River control survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
CG-521 --- KAY-3 (B2)	9-18-2015	Fixed	0.004	0.024	32°55’01”	14061.715	-11.881
CG-521 --- CG-343 (B3)	9-18-2015	Fixed	0.003	0.013	258°09’12”	2562.872	4.599
CG-343 --- KAY-3 (B1)	9-18-2015	Fixed	0.004	0.020	204°29’26”	12390.495	7.263

Three control points, CG-343, KAY-3 and CG-521 were occupied simultaneously to form a GNSS loop. All 3 baselines that formed the GNSS loop acquired fixed solutions and passed the required ±20cm and ±10cm for horizontal and vertical precision respectively as shown in Table 32.

4.4 Network Adjustment

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

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

Where:

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

for each control point. The succeeding tables show the results of GNSS processing.

The coordinates of KAY-3 and elevation values of CG-343 and CG-521, were held fixed during the processing of the control points as presented in Table 33. Through these reference points, the coordinates and elevation of the unknown control points were computed.

Table 33. Control Point Constraints

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
CG-343	Grid				Fixed
CG-521	Grid				Fixed
KAY-3	Global	Fixed	Fixed		
Fixed = 0.000001(Meter)					

The list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 34. The fixed control points KAY-3 and CG-343 and CG-521 have no values for grid errors and elevation error, respectively.

Table 34. Adjusted Grid Coordinates for the control points used in the Abulog-Apayao floodplain survey

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
CG-343	332932.782	0.011	2028541.842	0.010	13.119	?	e
CG-521	335445.328	0.011	2029046.471	0.010	8.657	?	e
KAY-3	327699.141	?	2017311.527	?	19.604	0.080	LL

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

a. CG-343

Horizontal accuracy = √ ((1.1) ² + (1.0)²
= √(1.21 + 1.0)
= 1.49 cm < 20 cm

Vertical accuracy = Fixed

b. CG-521

Horizontal accuracy = √((1.1) ² + (1.0)²
= √(1.21 + 1.0)
= 1.49 cm < 20 cm

Vertical accuracy = Fixed

c. **KAY-3**

Horizontal accuracy = Fixed

Vertical accuracy = 8.0 cm < 10 cm

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

Table 35. Adjusted geodetic coordinates

Point ID	Latitude	Longitude	Ellipsoidal Height (Meter)	Height Error (Meter)	Constraint
CG343	N18°20’24.45296”	E121°25’08.22629”	50.943	?	e
CG521	N18°20’41.57087”	E121°26’33.65510”	46.397	?	e
KAY3	N18°14’17.68665”	E121°22’13.38974”	58.235	0.080	LL

The adjusted geodetic coordinates are shown in Table 35. The height errors for CG-343 and CG-521 are less than the 10 cm accuracy requirement by the project. All of the points complied with the vertical accuracy required by the program.

The summary of reference and control points used is indicated in Table 36.

Table 36. List of Reference and Control points occupied during Abulog-Apayao River survey (Source: NAMRIA, UP-TCAGP)

Control point Name	Order of Accu-racy	Geographic Coordinates (WGS 84)			UTM Zone 51 N		
		Latitude	Longitude	Ellip-soid Height, (m)	Northing (m)	Easting (m)	BM Ortho (m)
CG-343	1st order BM	18°20'24.45296"	121°25'08.22629"	50.943	2028542	332932.8	13.119
CG-521	1st order BM	18°20'41.57087"	121°26'33.65510"	46.397	2029046	335445.3	8.657
KAY-3	2nd order GCP	18°14'17.68665"	121°22'13.38974"	58.235	2017312	327699.1	19.604

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

Cross-section and as-built survey were conducted on September, 20, 2015 using Topcon Digital Level as shown in Figure 40 and Trimble® SPS 882 in GNSS PPK survey technique with Ohmex™ Single Beam Echosounder. The cross-sectional line for the Abulug Bridge is about 859.84 meters with 77 cross-sectional points.

Figure 40. Cross-section and bridge as-built survey for Lucban Bridge, Brgy. Libertad, Abulug, Cagayan

The cross-sectional line for the Abulug Bridge is about 859.84 meters with 77 cross-sectional points acquired using CG-343 as the GNSS base station. The summary of gathered location map, bridge cross-section, and as-built data for Lucban Bridge is displayed in Figure 41 to Figure 44, respectively.

Water surface elevation in MSL of Abulug River was determined using Trimble® SPS 882 in PPK mode survey on September 20, 2015 at 9:46 AM. This was translated onto marking the bridge's pier using a digital level. The marked pier, shall serve as reference for flow data gathering and depth gauge deployment by the accompanying HEI, ISU, who is responsible for Abulug River as illustrated in Figure 45.

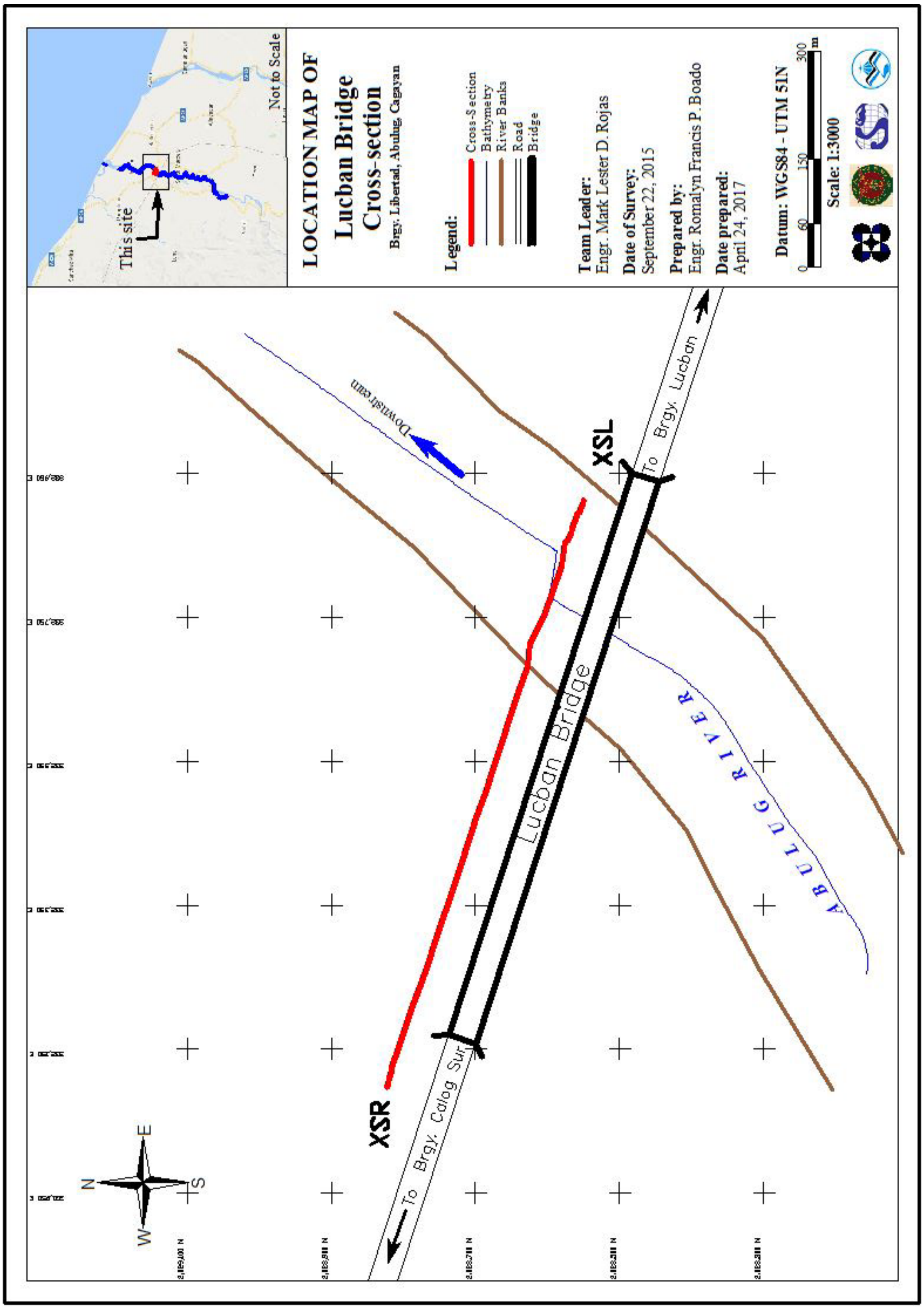


Figure 41. Lucban Bridge cross section location map

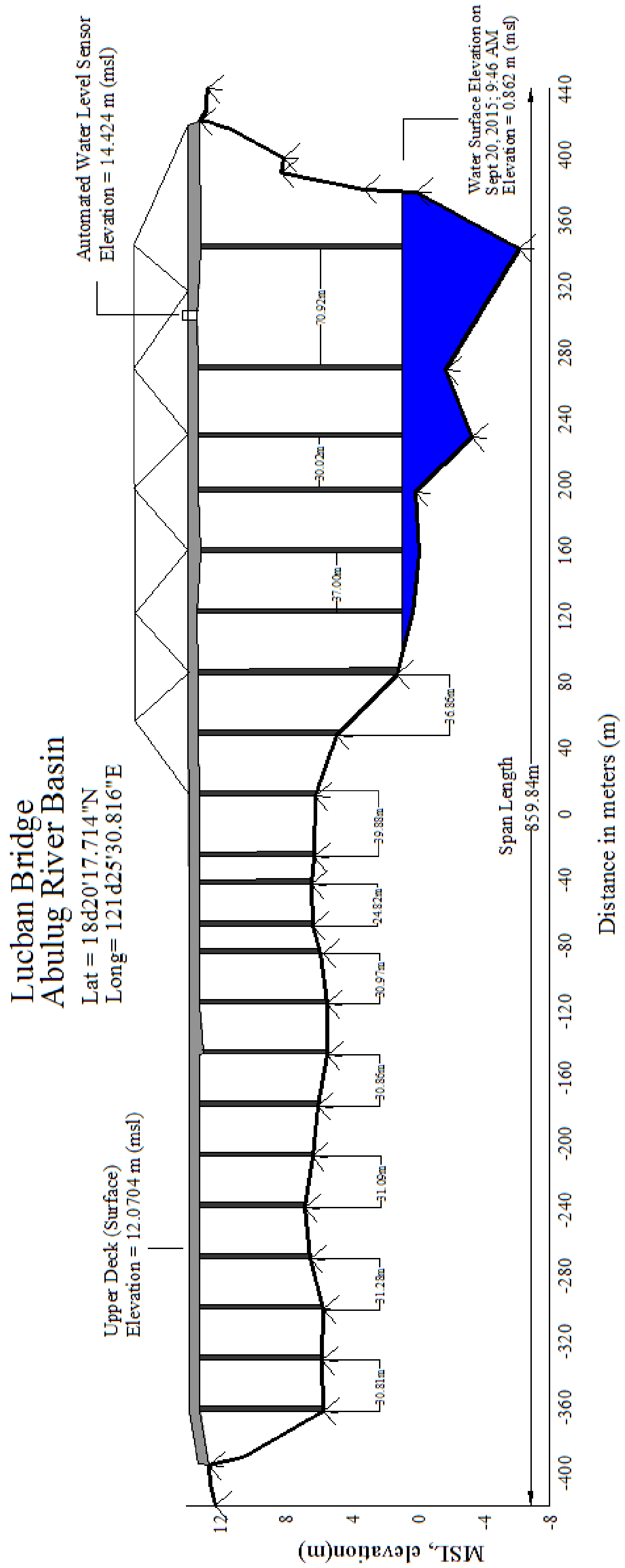


Figure 42. Abulug Bridge cross-sectional diagram

Bridge Data Form

Bridge Name: LUKBAN BRIDGE **Date:** September 22, 2015

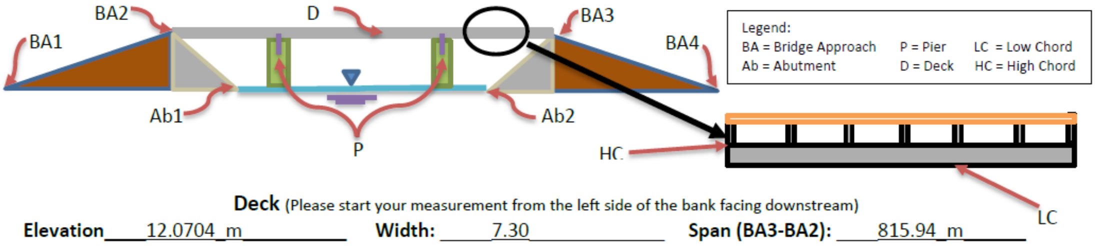
River Name: ABULUG RIVER BASIN **Time:** 9:57 AM

Location (Brgy, City, Region): Brgy. Libertad, Abulug Cagayan

Survey Team: Mark Lester D. Rojas, Dona Rina Patricia Tajora, Caren Joy Ordona, Erika Coloma

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

Latitude: 18d20'17.71425" N **Longitude:** 121d25'30.81657"E



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

Elevation 12.0704 m **Width:** 7.30 **Span (BA3-BA2):** 815.94 m

	Station	High Chord Elevation	Low Chord Elevation
1	149.867	13.195	11.645
2	304.134	13.210	11.660
3	467.435	13.341	11.791
4	615.090	13.289	11.739
5	688.912	13.319	11.769

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	12.273	BA3	839.988	13.194
BA2	24.048	12.683	BA4	859.839	12.773

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

	Station (Distance from BA1)	Elevation
Ab1	29.21812617	10.587
Ab2	808.693251	8.287

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

Shape: Round /Truss **Number of Piers:** 22 **Height of column footing:** N/A

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	57.234002	5.7266	
Pier 2	88.04730494	5.7794	
Pier 3	118.9920417	5.6918	
Pier 4	149.8669484	6.5501	
Pier 5	180.5859341	6.8313	
Pier 6	211.6738776	6.3989	

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

Figure 43. Abulug Bridge Data Form (Page 1)

	Station (Distance from BA1)	Elevation	Pier Width
Pier 7	242.4244588	6.0758	
Pier 8	273.2799682	5.479	
Pier 9	304.1342723	5.5147	
Pier 10	335.0999388	5.8574	
Pier 11	351.8758582	6.3286	
Pier 12	376.6956655	6.4541	
Pier 13	393.5016028	6.3052	
Pier 14	430.398832	6.2083	
Pier 15	467.4352156	4.8887	
Pier 16	504.2914256	1.2585	
Pier 17	541.1881294	0.2801	
Pier 18	578.191066	-0.137	
Pier 19	615.0901659	0.127	
Pier 20	648.1128408	-3.286	
Pier 21	688.9123547	-1.682	
Pier 22	762.8116108	-6.172	

Figure 44. Abulug Bridge Data Form (Page 2)

Figure 45.Water level markings on the post of Abulug Bridge

4.6 Validation Points Acquisition Survey

Validation points acquisition survey was conducted on September 21, 2015 using a survey-grade GNSS Rover receiver, Trimble® SPS 882, mounted on a range pole which was attached in front of the vehicle as shown in Figure 46. It was secured with a cable-tie to ensure that it was horizontally and vertically balanced. The antenna height was measured and recorded to be 2.192 from the ground up to the bottom of notch of the GNSS Rover receiver.

The survey was conducted using PPK technique on a continuous topography mode, which covered the municipalities of Abulug, Luna, and Pudtol, then starting again from Apari, Ballesteros, Abulug, and Pamplona.

Figure 46. Validation Set-up for Abulug River

The validation gathered a total of 7,554 points covering an approximate distance of 71.7 kilometers. The gaps in the validation line as were due to some difficulties in acquiring satellite due to the presence of obstruction such as dense canopy cover of trees along the roads shown in the map in Figure 47.

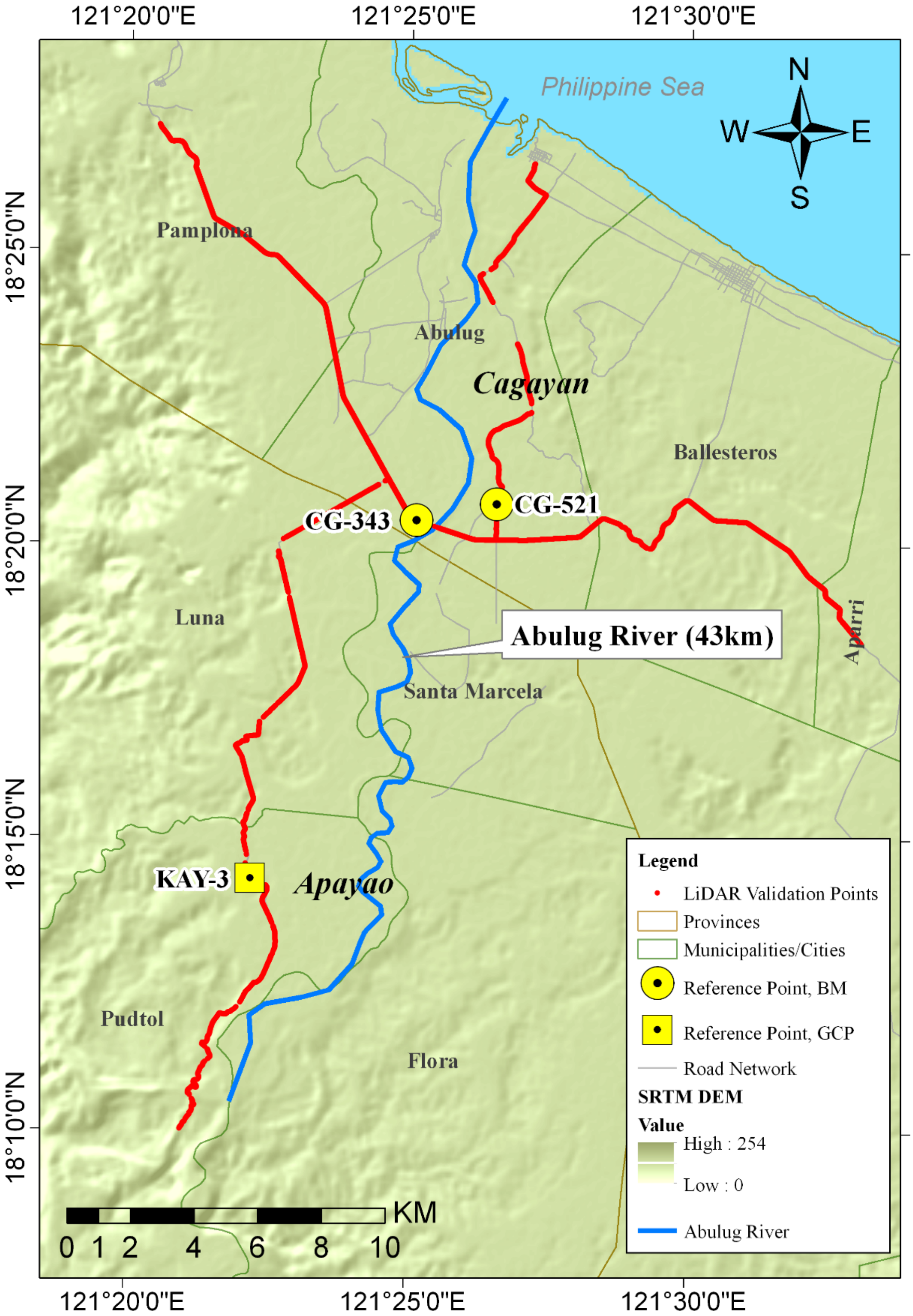


Figure 47. LiDAR ground validation survey coverage for Abulug River Basin

4.7 River Bathymetric Survey

Bathymetric survey in Abulug River was conducted on September 19, 25, 26 & 27 using Trimble® SPS 882 in GNSS PPK survey technique as shown in Figure 48. The survey started in the upstream part of the river in Brgy. Mataguisi, Municipality of Pudtol, Apayao with coordinates 18°10'38.10359" 121°21'48.09686", down to the mouth of the river in Brgy. Santa Rosa, Municipality of Abulug, Cagayan, with coordinates 18°27'26.92506" 121°26'24.08807". The control point CG-343 was used as base station.

Figure 48. Bathymetric survey setup in Abulug River

The entire bathymetric data gathered for Abulug River cover an estimated length of 43 km with a total of 27,884 bathymetric poitns acquired using the control point CG-343 as the GNSS base station as shown in the map in Figure 49. This was generated into three sets of CAD drawings to illustrate the Abulug River profile as shown in Figure 50 to Figure 52. An elevation drop of 43.45 meters in MSL was observed within the distance of approximately 43 km. The highest and lowest elevation observed were 22.041 m in MSL in Brgy. Mataguisi, and -10.585 m below MSL in Brgy. Simayung.

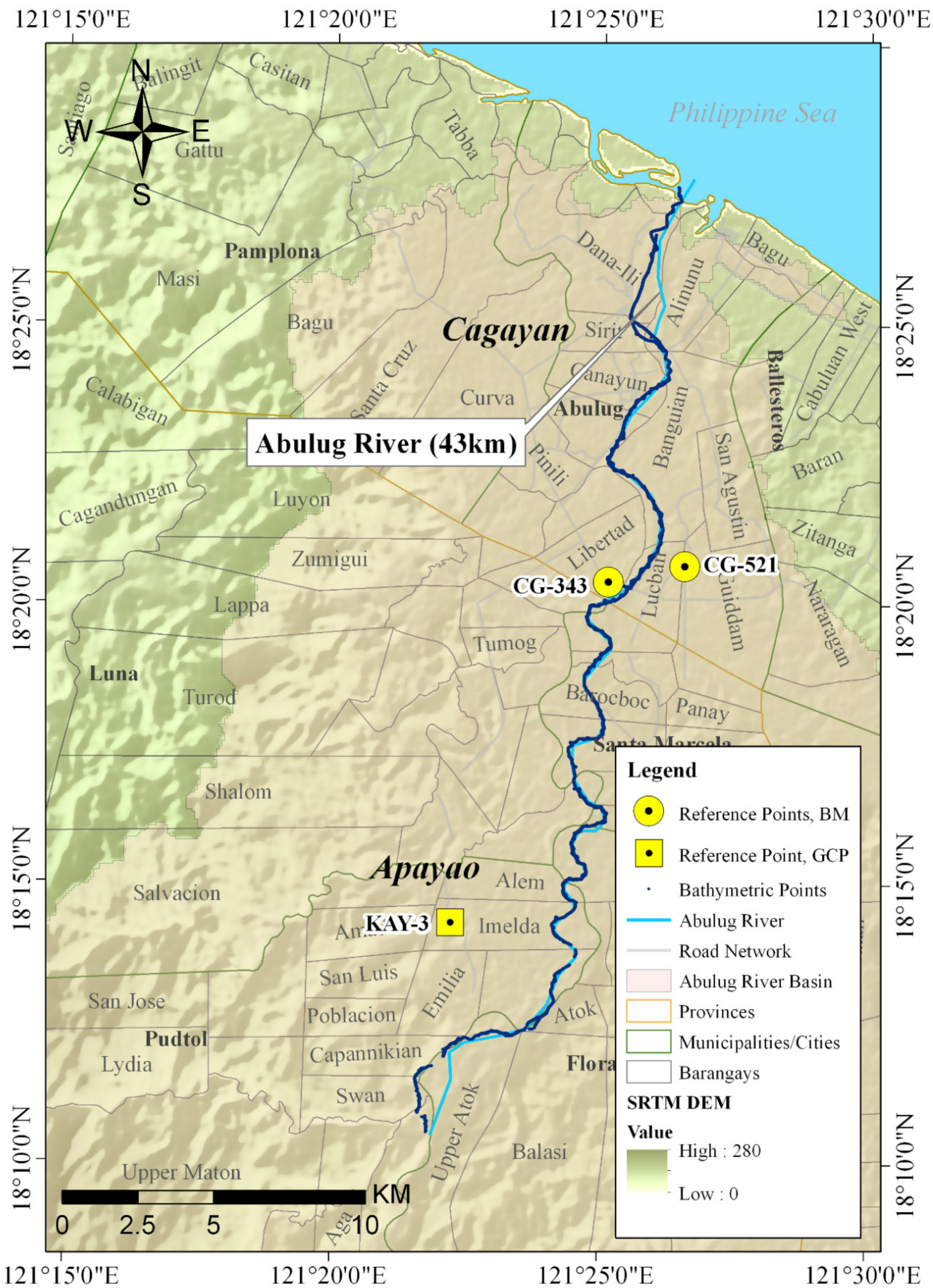


Figure 49. Bathymetric survey of Abulug River

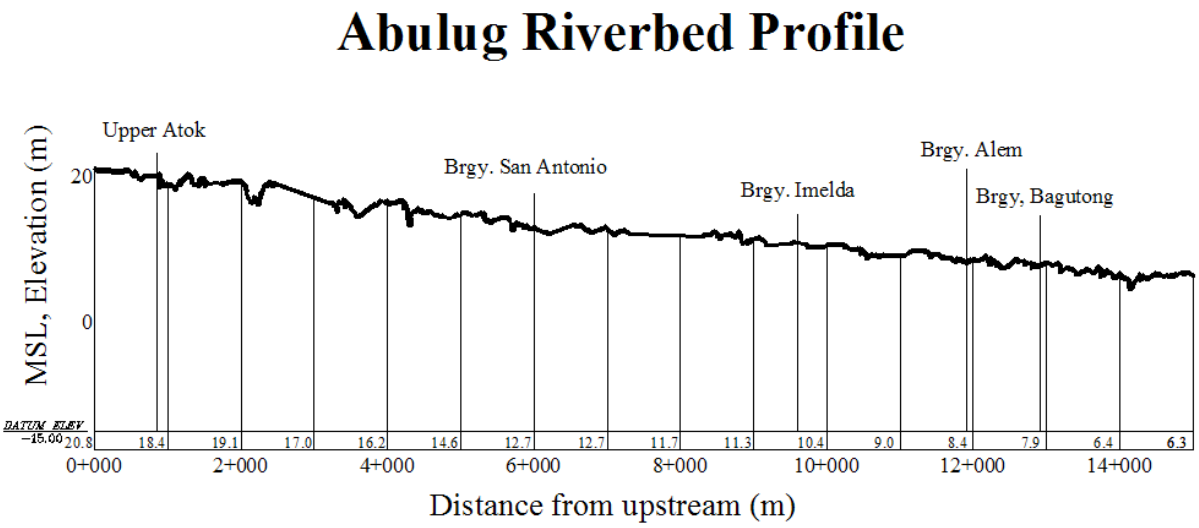


Figure 50. Abulug River Profile 1

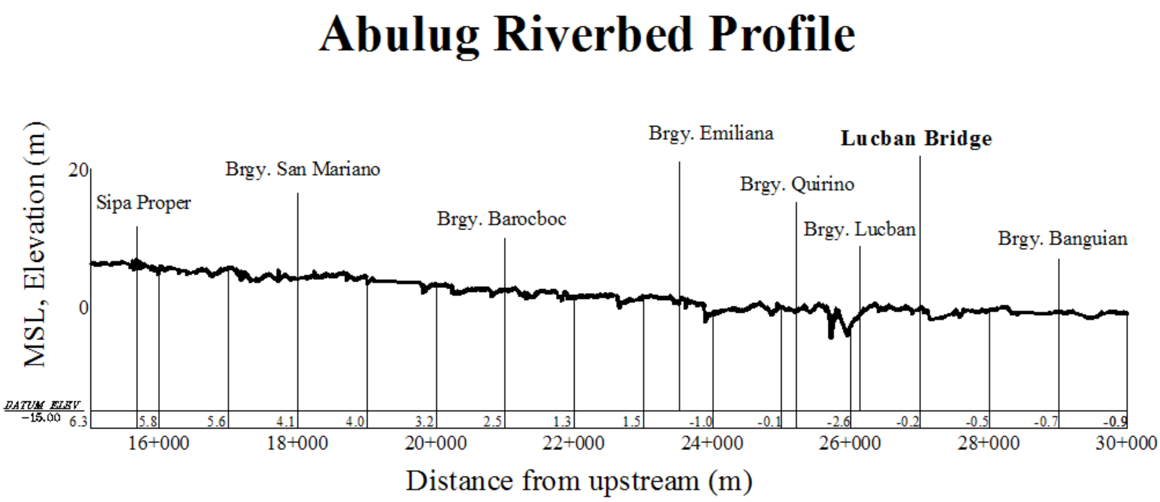


Figure 51. Abulug Riverbed Profile 2

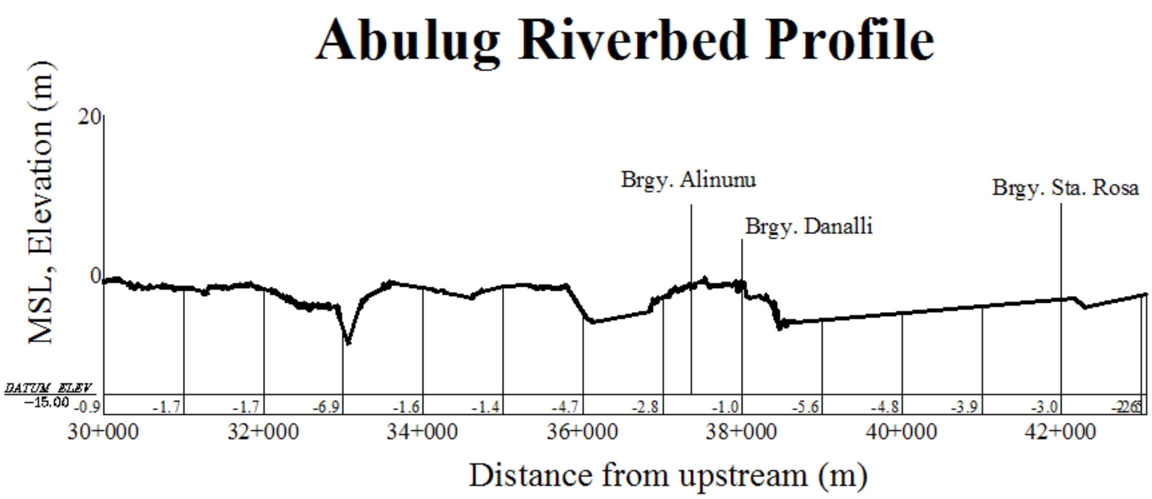


Figure 52. Abulug Riverbed Profile 3

CHAPTER 5: FLOOD MODELING AND MAPPING

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

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

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

5.1.2 Precipitation

Precipitation data was taken from the two automatic rain gauges (ARGs) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI) within the watershed of Apayao- Abulug. These were the Swan Dam and Pudtol ARGs. The location of the rain gauges is seen in Figure 53.

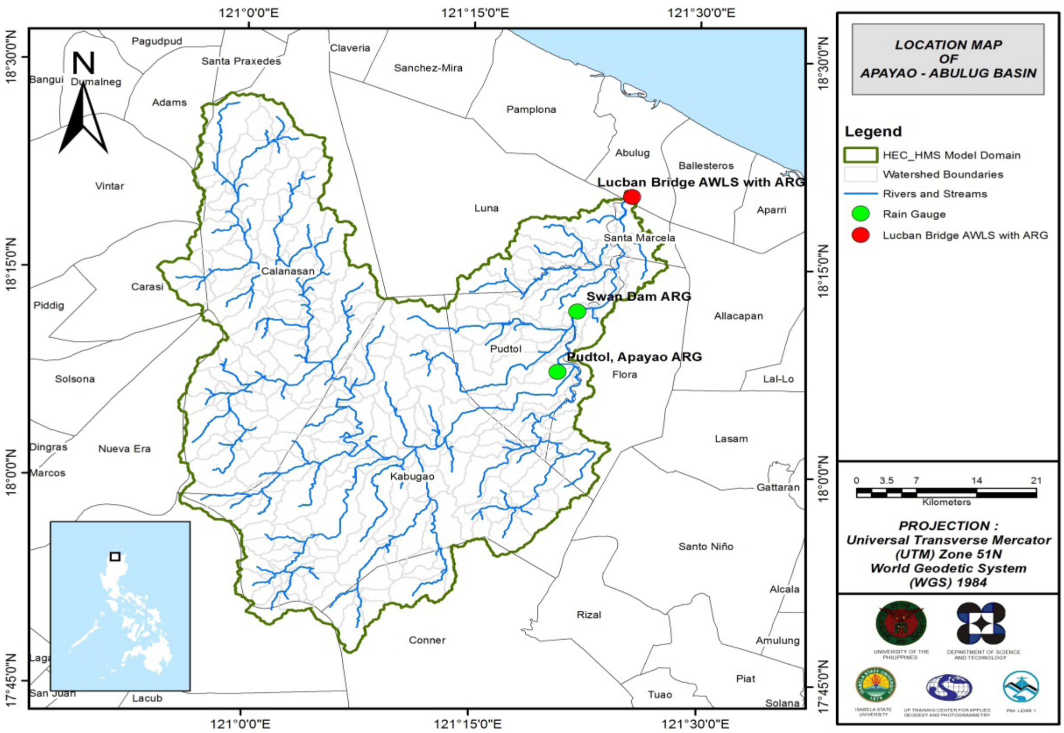


Figure 53. The location map of Abulog-Apayao HEC-HMS model used for calibration

5.1.3 Rating Curves and River Outflow

Tropical Storm Carina that occurred on 30 July – 2 August 2016 contributed to a 2.86 meter water level rise with peak discharge of 550.60 m^3/s recorded at 7:50 AM on 1 August 2016 with accumulated rainfall of 121.92mm. These hydrologic data is the actual event of Apayao - Abulug River and inputted to hydrologic modeling. Hydrologic measurements were taken from Lucban Bridge, Lucban, Abulug, Cagayan.

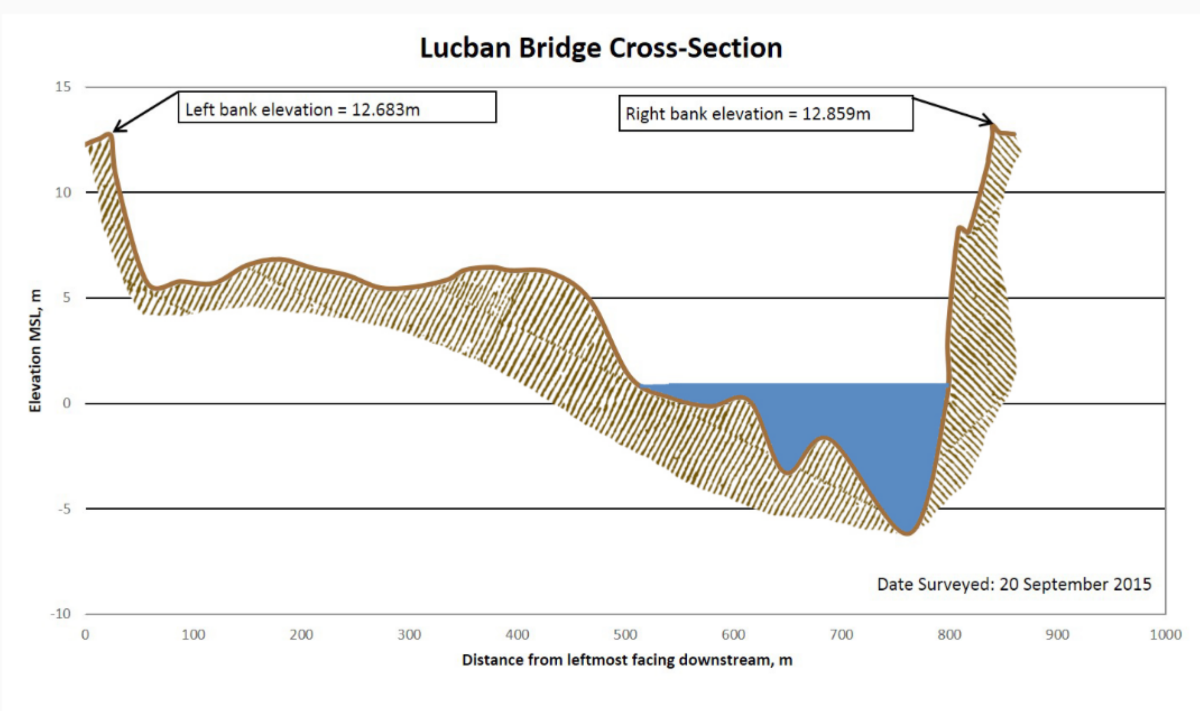


Figure 54. Cross-Section Plot of Abulog-Apayao Bridge

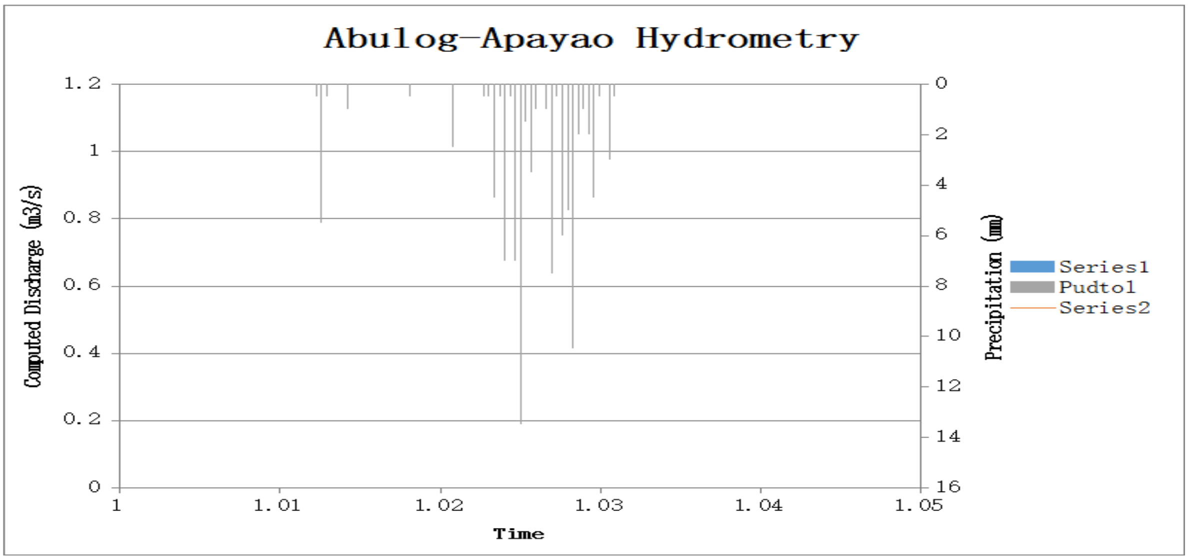


Figure 55. Rainfall and outflow data used for modeling

A rating curve was generated for the observed flow and water level. It shows the relationship of the two hydrologic data. It is expressed in the form of the following equation:

Q=anh

where, Q : Discharge (m3/s),

h : Gauge height (reading from Lucban Bridge AWLS), and

a and n : Constants.

The Apayao - Abulug River Rating Curve measured at Lucban Bridge is expressed as Q = 233.01e0.3007x (Figure 56).

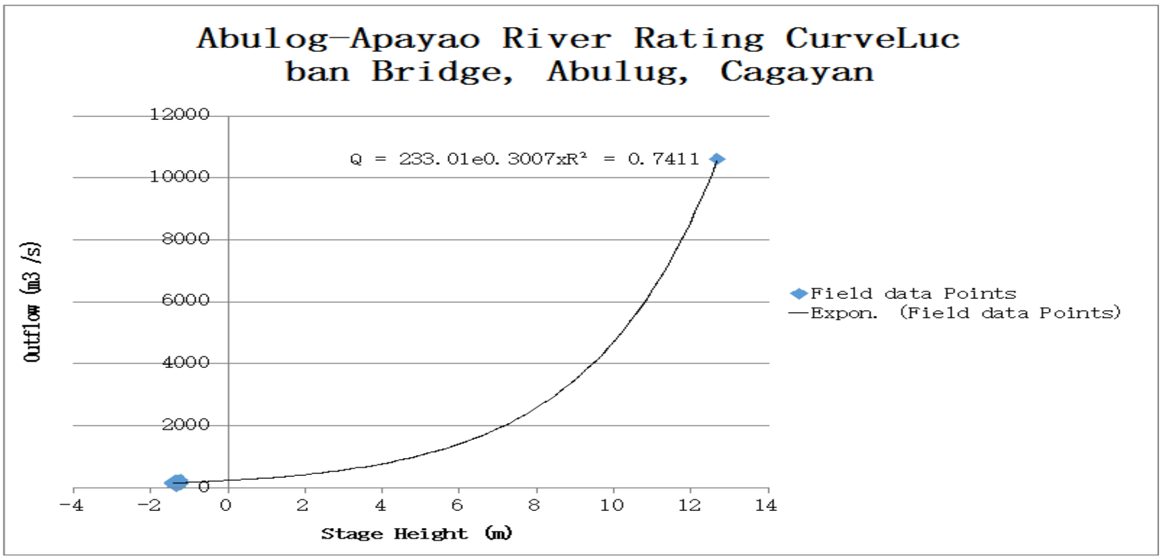


Figure 56. HQ Curve of HEC-HMS model

5.2 RIDF Station

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed for Rainfall Intensity Duration Frequency (RIDF) values for the Aparri 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 Apayao–Abulug watershed. The extreme values for this watershed were computed based on a 47-year record.

Table 37. RIDF values for Aparri Gauge computed by PAGASA

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION									
T (yrs)	**10 mins**	**20 mins**	**30 mins**	**1 hr**	**2 hrs**	**3 hrs**	**6 hrs**	**12 hrs**	**24 hrs**
2	20.1	31.4	39.4	53.3	75.6	92.2	119.4	147.7	167.9
5	28.5	44.9	55.8	78.7	110.4	137	173.6	221.2	252.5
10	34.1	53.8	66.6	95.6	133.4	166.6	209.5	269.9	308.5
15	37.2	58.8	72.7	105.1	146.5	183.4	229.7	297.4	340.2
20	39.4	62.3	77	111.8	155.6	195.1	243.9	316.6	362.3
25	41.1	65	80.3	116.9	162.6	204.1	254.8	331.4	379.3
50	46.3	73.4	90.5	132.7	184.2	231.9	288.4	377.1	431.9
100	51.4	81.7	100.6	148.4	205.6	259.5	321.7	422.4	484

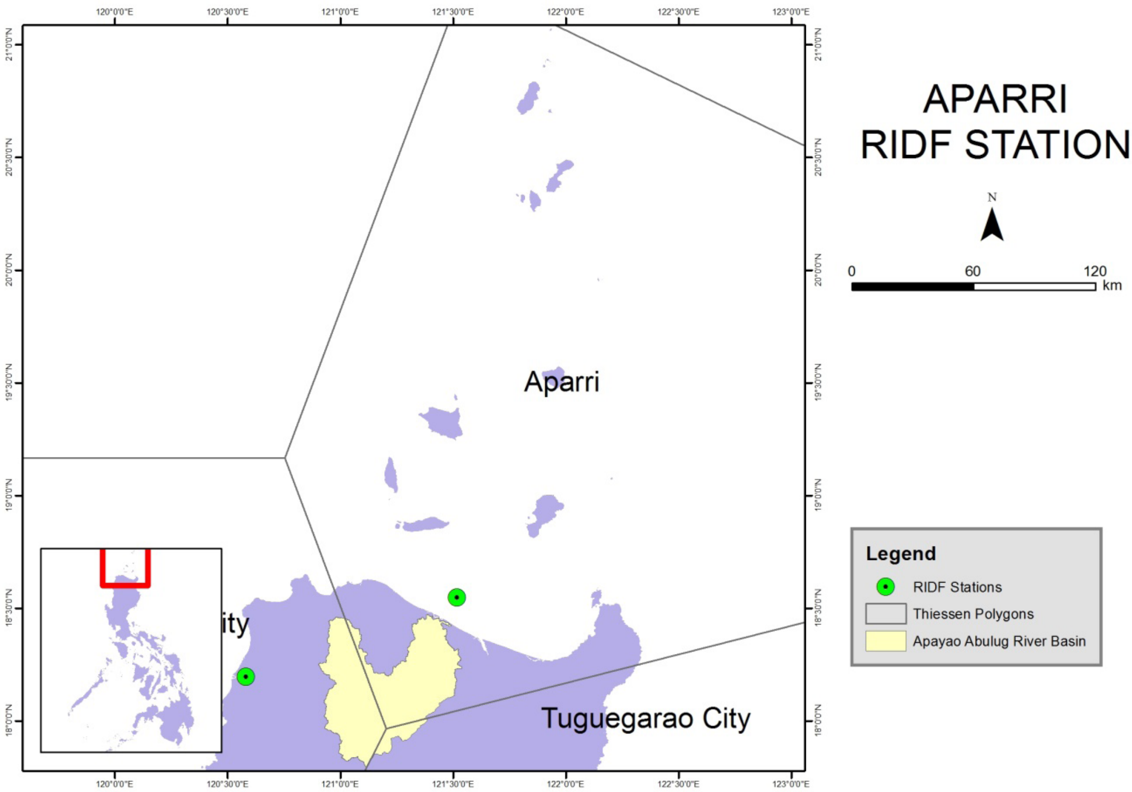


Figure 57. Location of Aparri RIDF Station relative to Abulog-Apayao River Basin

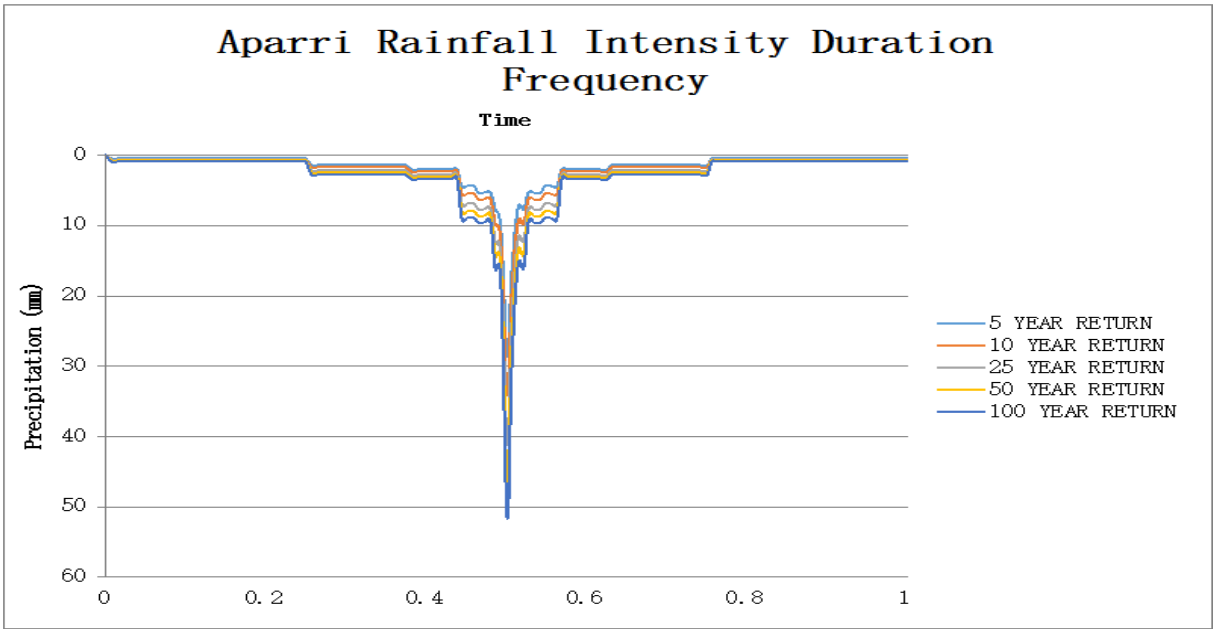


Figure 58. Synthetic storm generated for a 24-hr period rainfall for various return periods

5.3 HMS Model

The soil shapefile was taken before 2004 from the Bureau of Soils under the Department of Agriculture. The land cover dataset is taken from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Abulog-Apayao River Basin are shown in Figures 59 and 60, respectively.

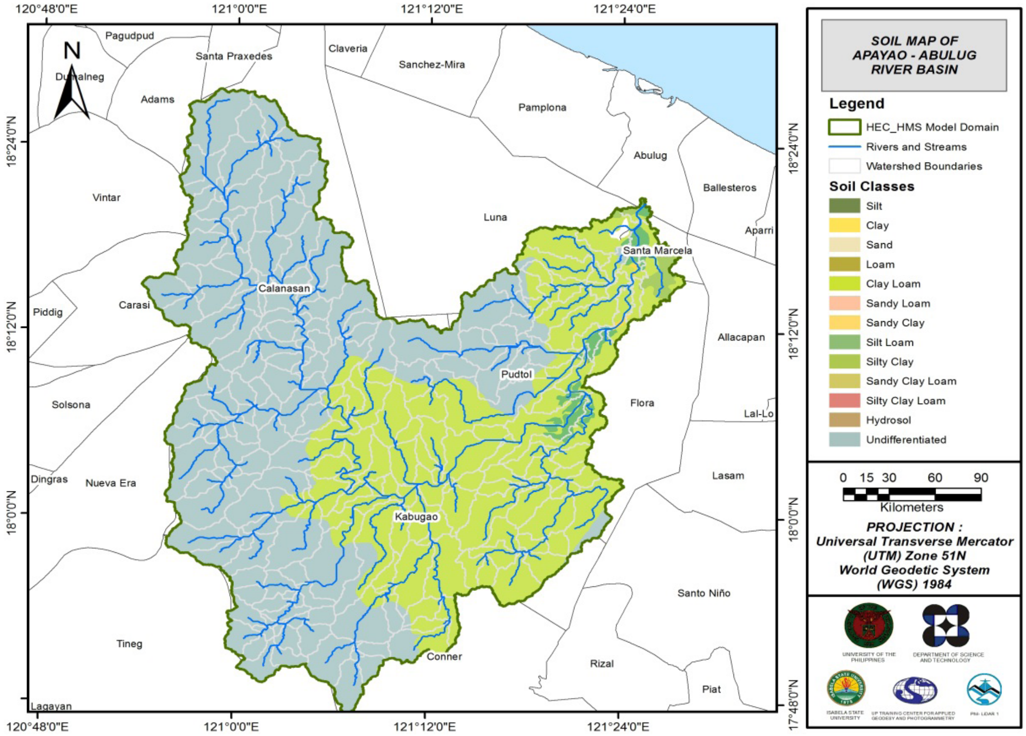


Figure 59. The soil map of the Abulog-Apayao River Basin

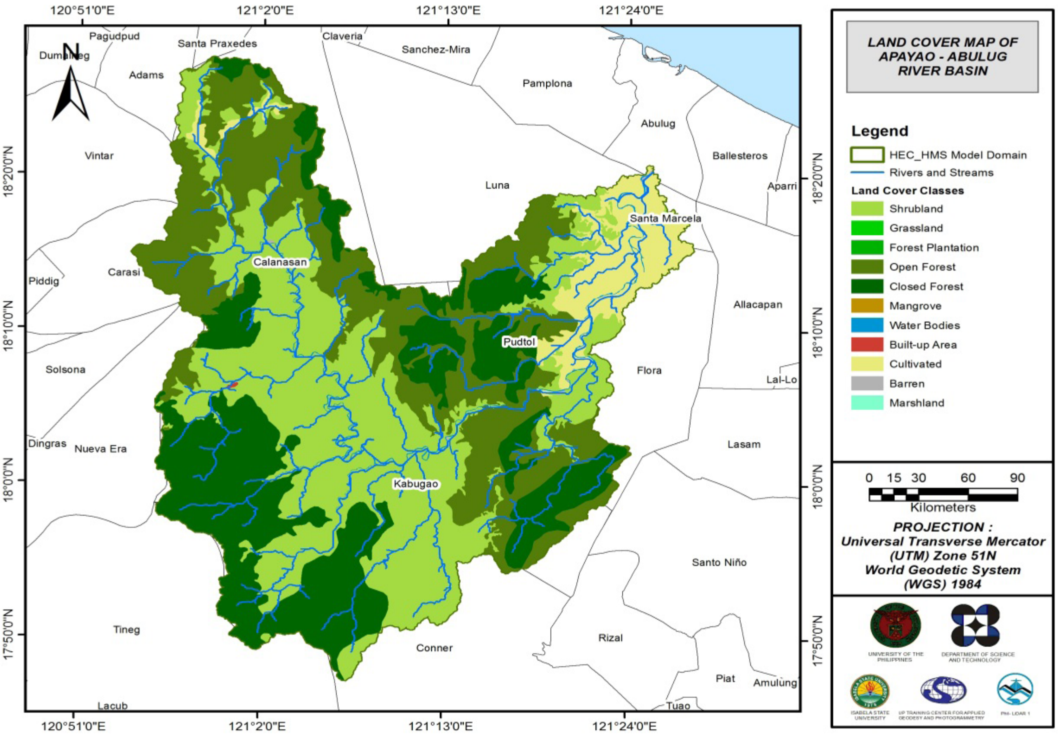


Figure 60. Land Cover Map of the Abulog-Apayao River Basin (Source: NAMRIA)

For Abulog-Apayao, thirteen (13) soil classes were identified. These are silt, clay, sand, loam, clayloam, sandy loam, sandy clay, silt loam, silty clay, sandy clay loam, silty clay loam, hydrosol and undifferentiated soil. Moreover, eleven (11) land cover classes were identified. These are shrubland, grassland, forest plantation, open forest, closed forest, mangrove, water bodies, built-up areas, cultivated, barren and marshland.

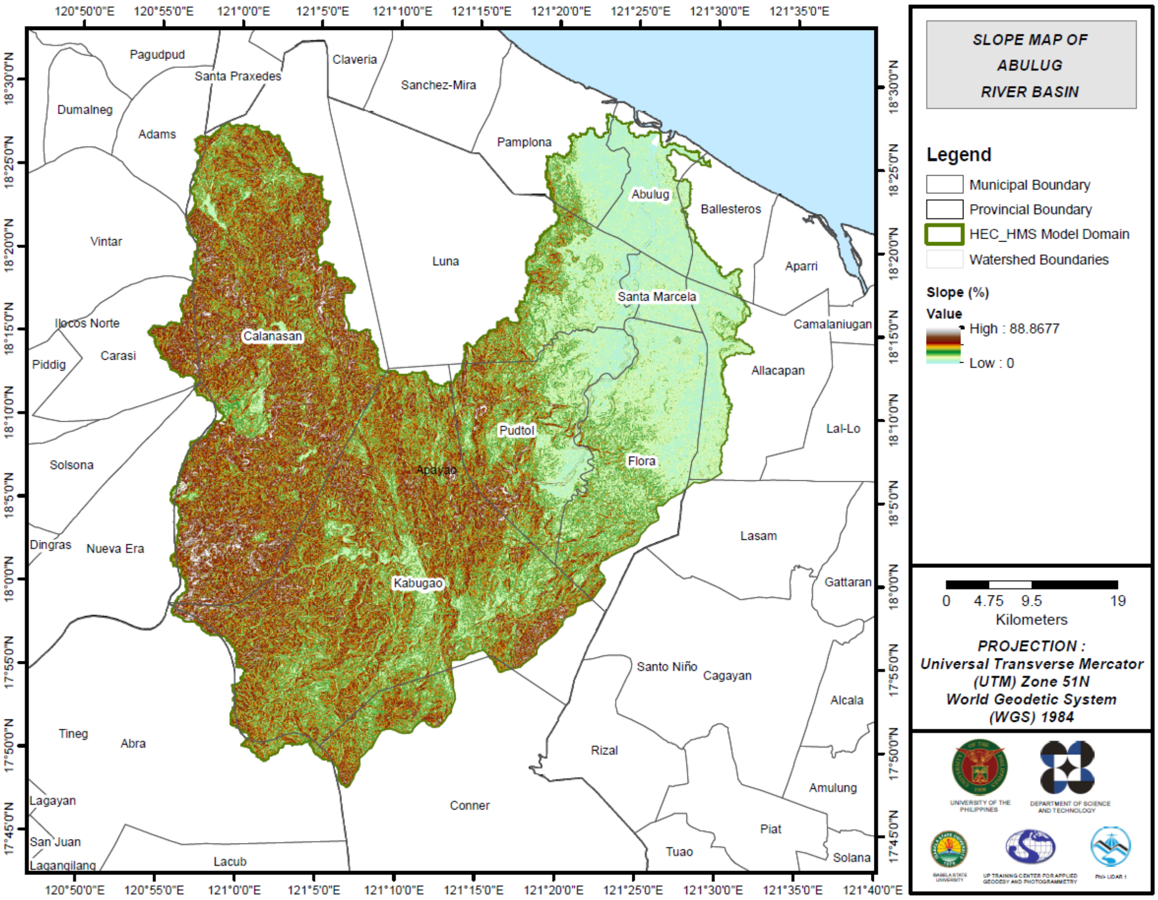


Figure 61. Soil map of the Abulog-Apayao River Basin

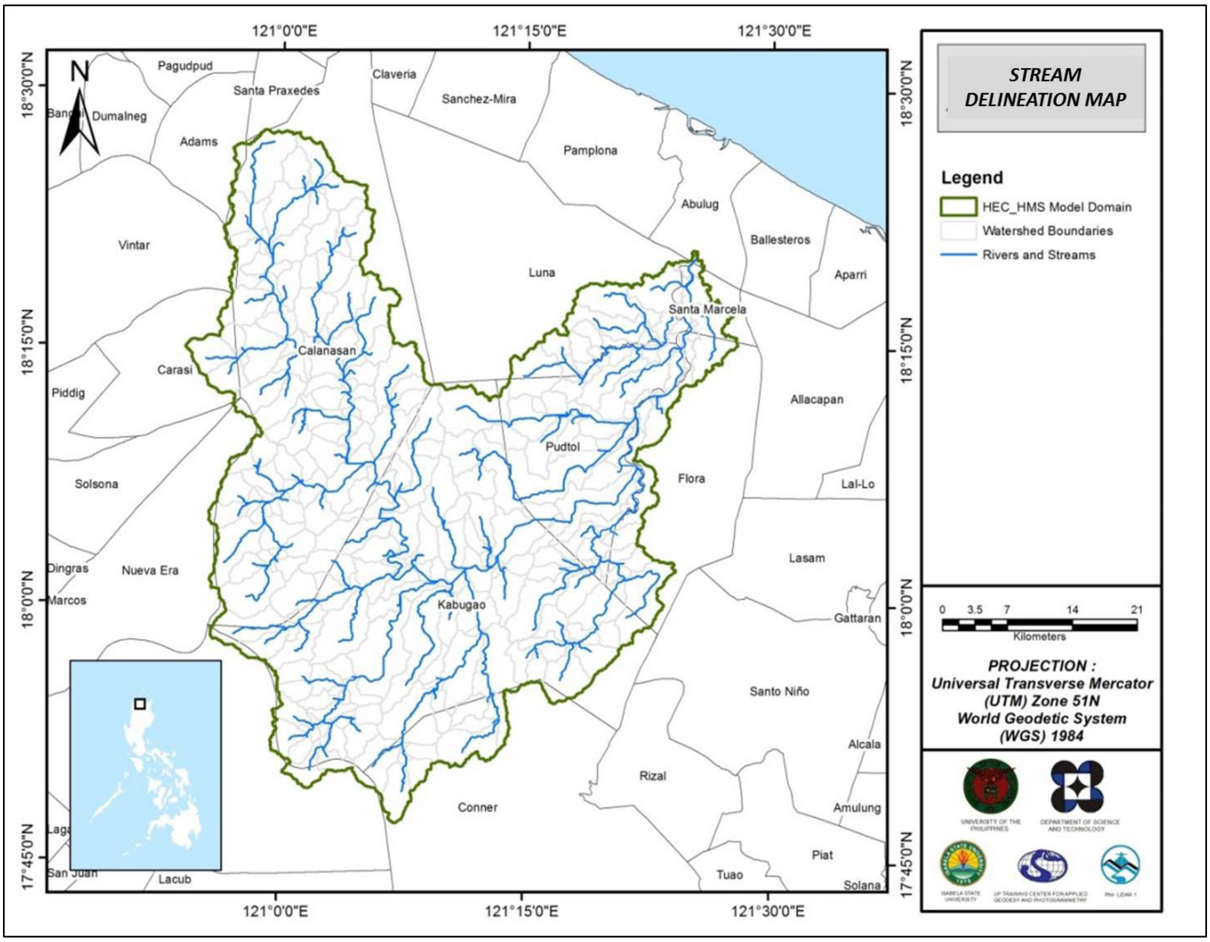


Figure 62. Stream delineation map of Abulog-Apayao River Basin

A drainage system includes the basin boundary, subbasin and the stream networks of the basin. Using ArcMap 10.1 with HEC-GeoHMS version 10.1 extension, the Abulog-Apayao River centerline and SAR-DEM 10m resolution served as primary data, delineating the drainage system of **the** Abulog-Apayao river basin. The river centerline was digitized starting from upstream towards downstream in Google Earth (2014). Default threshold area used is 140 hectares.

Using the SAR-based DEM, the Apayao - Abulug basin was delineated and further subdivided into subbasins. The Abulog-Apayao basin model consists of 257 sub basins, 131 reaches, and 132 junctions. The main outlet is Outlet 1. This basin model is illustrated in Figure 63. The basins were identified based on soil and land cover characteristics of the area. Precipitation from the 30-31 July 2016 (Tropical Storm Carina) was taken from DOST rain gauges. Finally, it was calibrated using data from the Lucban Bridge using AWLS and depth gauge sensor.

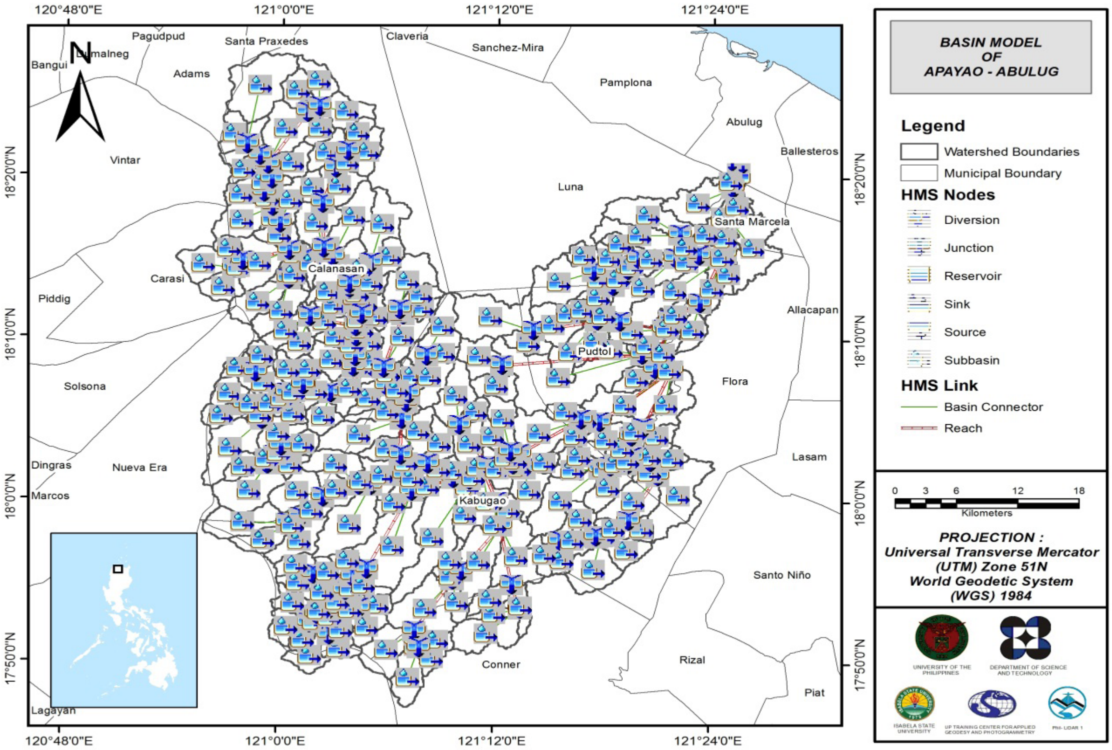


Figure 63. The Abulog-Apayao River Basin Model generated in HEC-HMS

5.4 Cross-section Data

Riverbed cross-sections of the watershed were necessary in the HEC-RAS model setup. The cross-section data for the HEC-RAS model was derived from the LiDAR DEM data. It was defined using the Arc GeoRAS tool and was post-processed in ArcGIS (Figure 64).

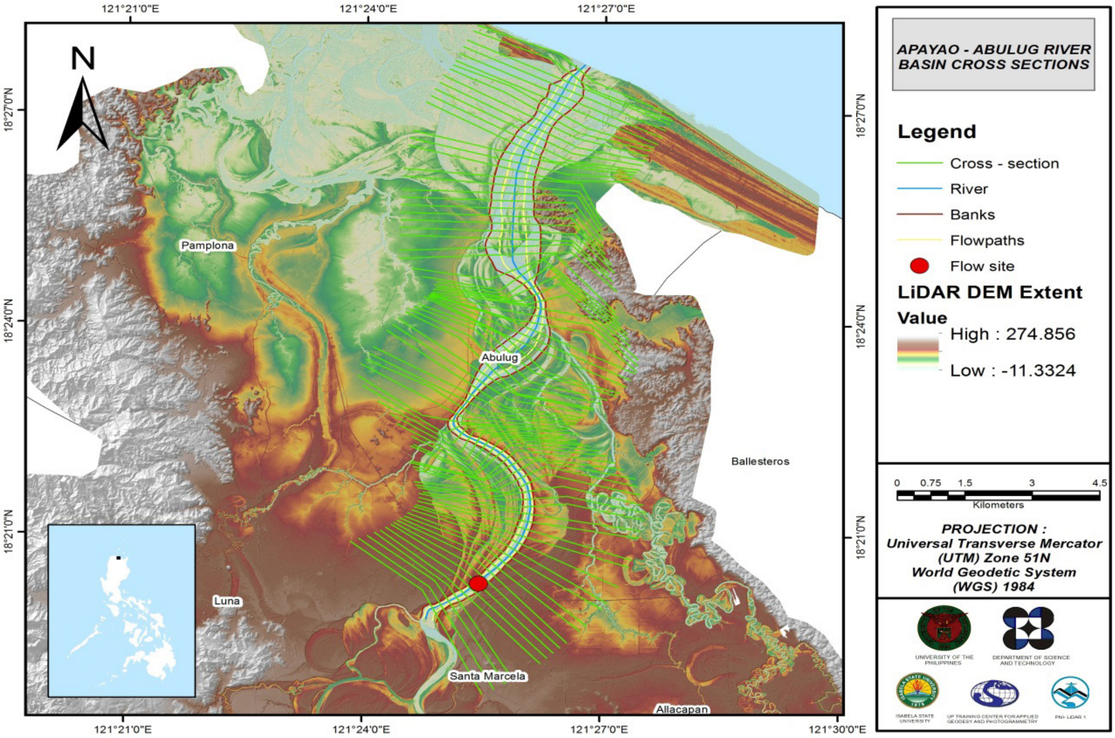


Figure 64. Abulog-Apayao River Cross-section generated using HEC GeoRAS tool

5.5 Flo 2D Model

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

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

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

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 39.55225 hours. After the simulation, FLO-2D Mapper Pro is used to transform the simulation results into spatial data that shows flood hazard levels, as well as the extent and inundation of the flood. Assigning the appropriate flood depth and velocity values for Low, Medium, and High creates the following food hazard map. Most of the default values given by FLO-2D Mapper Pro are used, except for those in the Low hazard level. For this particular level, the minimum *h* (Maximum depth) is set at 0.2 m while the minimum *vh* (Product of maximum velocity (*v*) times maximum depth (*h*) is set at 0 m^2/s.

The creation of a flood hazard map from the model also automatically creates a flow depth map depicting the maximum amount of inundation for every grid element. The legend used by default in Flo-2D Mapper is not a good representation of the range of flood inundation values, so a different legend is used for the layout. In this particular model, the inundated parts cover a maximum land area of 39 385 900.00 m2.

5.6 Results of HMS Calibration

After calibrating the Abulog-Apayao HEC-HMS river basin model, its accuracy was measured against the observed values (See Annex 9). Figure 66 shows the comparison between the two discharge data.

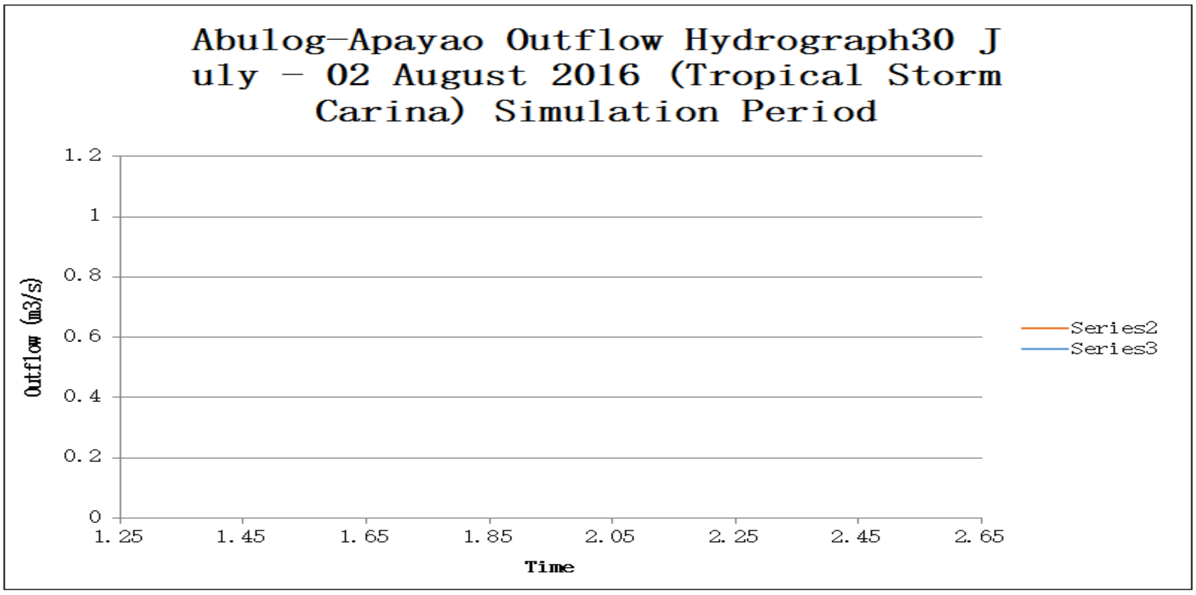


Figure 66. Outflow Hydrograph of Alubijid produced by the HEC-HMS model compared with observed outflow

Table 38 shows adjusted ranges of values of the parameters used in calibrating the model.

Table 38. adjusted ranges of values of the parameters used in calibrating the model

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	3.99 – 46.78
			Curve Number	72 - 99
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.46 – 43.22
			Storage Coefficient (hr)	0.93 – 88.17
	Baseflow	Recession	Recession Constant	0.4
			Ratio to Peak	0.4
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.015

Initial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as initial abstraction decreases. The range of values from 3.99mm to 46.78mm signifies that there is minimal to average amount of infiltration or rainfall interception by vegetation.

The 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 72 to 99 has values outside the advisable range for curve number for Philippine watersheds (70-80) depending on the soil and land cover of the area. (M. Horritt, personal communication, 2012). For Abulog-Apayao, the basin's land cover consists mostly of shrubland and forest; and the soil consists mostly of clay loam and undifferentiated soil.

The time of concentration and storage coefficient are the travel time and index of temporary storage of runoff in a watershed. The range of calibrated values from 0.46 hour (27.6 min) to 88.17 hours determines the reaction time of the model with respect to the rainfall. The peak magnitude of the hydrograph also decreases when these parameters are increased.

Recession constant is the rate at which baseflow recedes between storm events, while ratio to peak is the ratio of the baseflow discharge to the peak discharge. Recession constant of 0.4 indicates that the basin is unlikely to quickly go back to its original discharge and instead, will be higher. Ratio to peak of 0.4 indicates a steeper receding limb of the outflow hydrograph.

Manning's roughness coefficient of 0.015 for Abulog-Apayao corresponds to the roughness for built up areas (Brunner, 2010).

Table 39. Summary of the Efficiency Test of Abulog-Apayao HMS Model

Accuracy measure	Value
RMSE	54.9
r^2	0.9297
NSE	0.77
PBIAS	-12.16
RSR	0.48

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 54.9 (m3/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 0.9297.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.77.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is -12.16.

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 0.48.

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

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 67) shows the Abulog-Apayao River outflow using the Aparri 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.

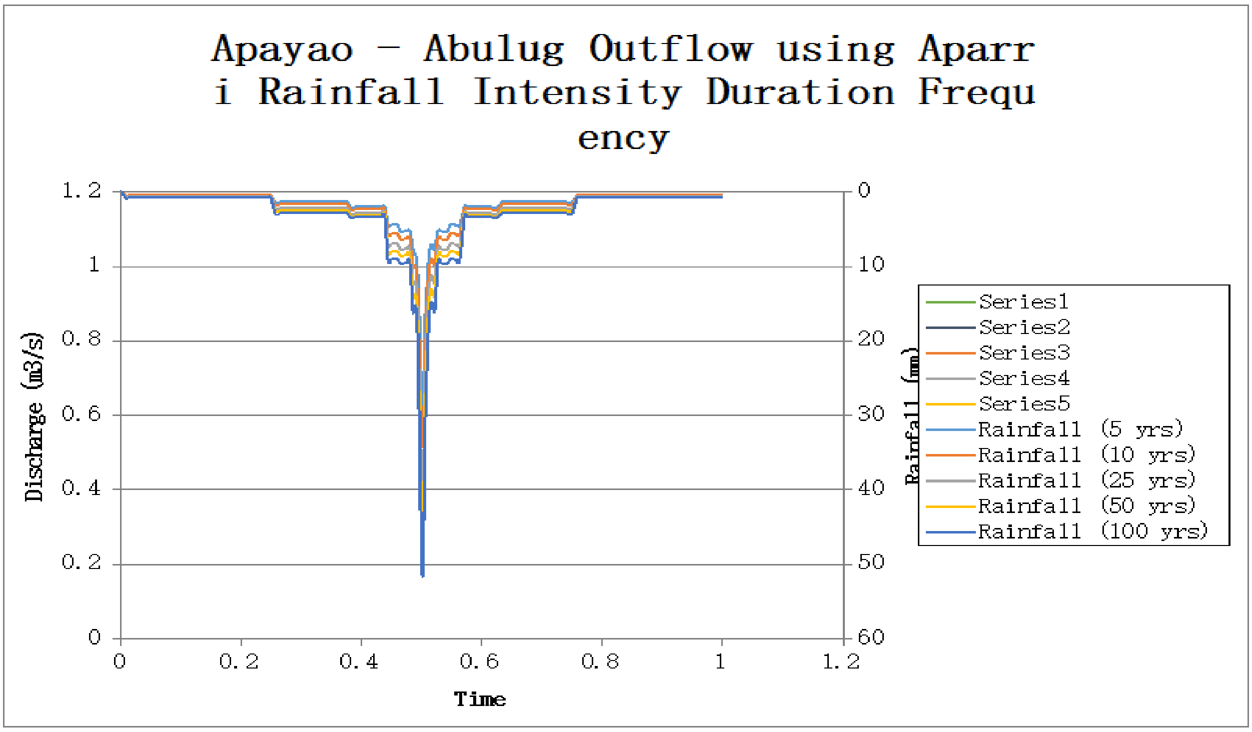


Figure 67. Outflow hydrograph at Abulog-Apayao Station generated using Aparri RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Alubijid discharge using the Aparri Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 40.

Table 40. Peak values of the Alubijid HECHMS Model outflow using the Cagayan de Oro RIDF

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m^3s)	Time to Peak
5-Year	252.5	28.5	4718.1	13 hours, 50 minutes
10-Year	308.5	34.1	6095.2	13 hours
25-Year	379.3	41.1	7830.4	12 hours, 10 minutes
50-Year	431.9	46.3	9105.3	11 hours, 40 minutes
100-Year	484	51.4	10391.8	11 hours, 20 minutes

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

The river discharge for the river entering the floodplain is shown in Figure 68 to Figure 72 and the peak values are summarized in Table 41-Table 45.

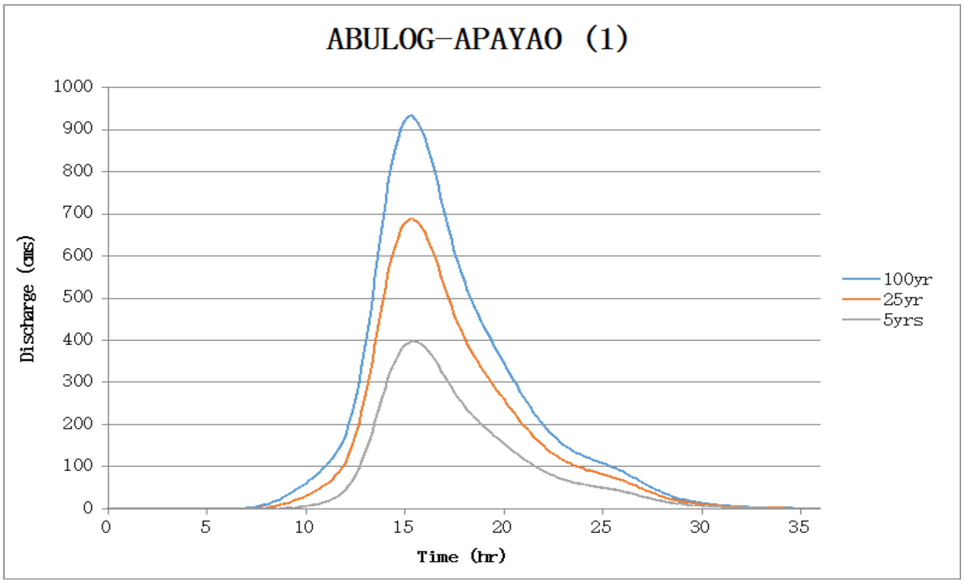


Figure 68. Abulog-Apayao river (1) generated discharge using 5-, 25-, and 100-year Aparri rainfall intensity-duration-frequency (RIDF) in HEC-HMS

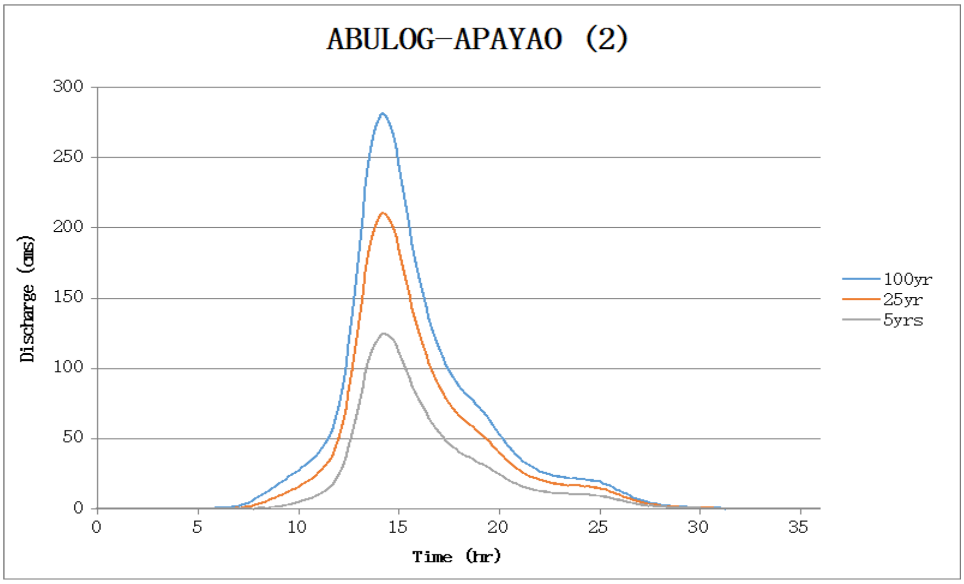


Figure 69. Abulog-Apayao river (2) generated discharge using 5-, 25-, and 100-year Aparri rainfall intensity-duration-frequency (RIDF) in HEC-HMS

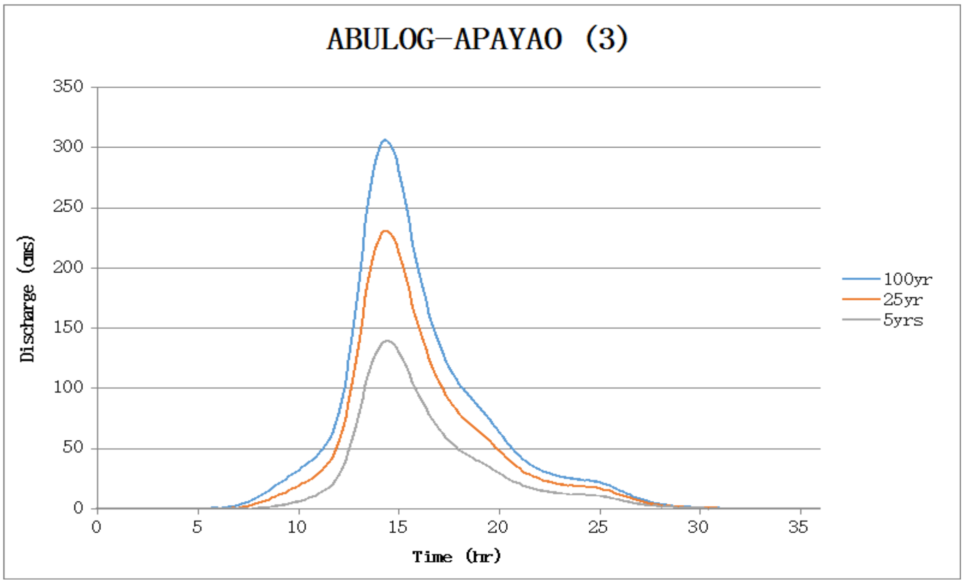


Figure 70. Abulog-Apayao river (3) generated discharge using 5-, 25-, and 100-year Aparri rainfall intensity-duration-frequency (RIDF) in HEC-HMS

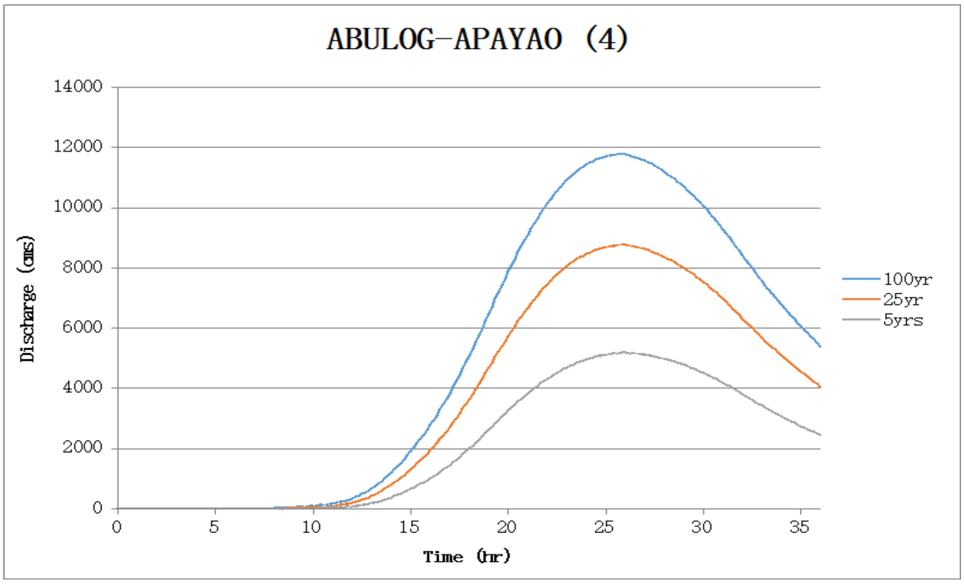


Figure 71. Abulog-Apayao river (4) generated discharge using 5-, 25-, and 100-year Aparri rainfall intensity-duration-frequency (RIDF) in HEC-HMS

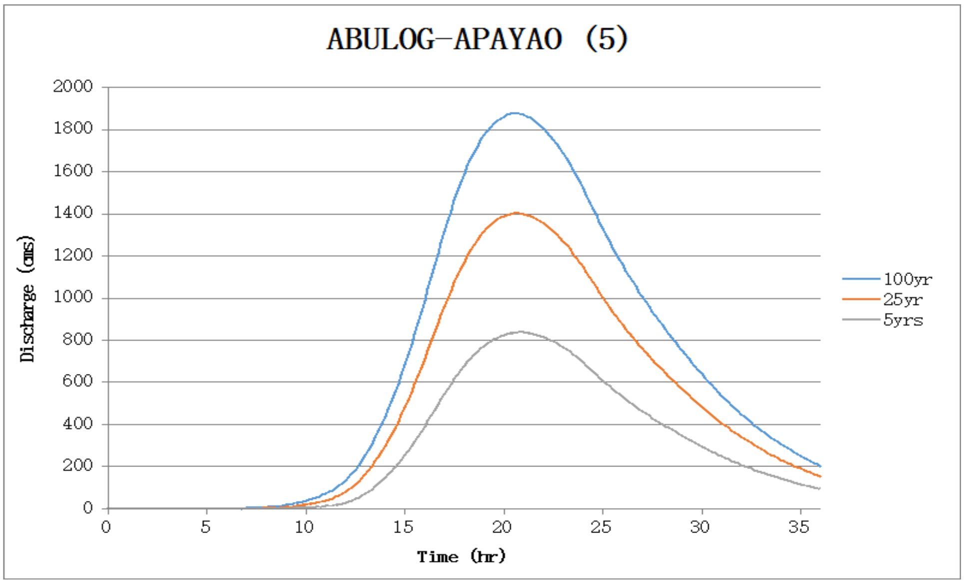


Figure 72. Abulog-Apayao river (5) generated discharge using 5-, 25-, and 100-year Aparri rainfall intensity-duration-frequency (RIDF) in HEC-HMS

Table 41. Summary of Abulog-Apayao river (1) discharge generated in HEC-HMS

RIDF Period	Peak discharge (cms)	Time-to-peak
100-Year	931.8	15 hours, 20 minutes
25-Year	688.2	15 hours, 20 minutes
5-Year	397.2	15 hours, 30 minutes

Table 42. Summary of Abulog-Apayao river (2) discharge generated in HEC-HMS

RIDF Period	Peak discharge (cms)	Time-to-peak
100-Year	281.2	14 hours, 10 minutes
25-Year	210.3	14 hours, 10 minutes
5-Year	124.6	14 hours, 20 minutes

Table 43. Summary of Abulog-Apayao river (3) discharge generated in HEC-HMS

RIDF Period	Peak discharge (cms)	Time-to-peak
100-Year	306.3	14 hours, 20 minutes
25-Year	230.9	14 hours, 20 minutes
5-Year	139.3	14 hours, 20 minutes

Table 44. Summary of Abulog-Apayao river (4) discharge generated in HEC-HMS

RIDF Period	Peak discharge (cms)	Time-to-peak
100-Year	11780	25 hours, 40 minutes
25-Year	8764.4	25 hours, 50 minutes
5-Year	5178.6	25 hours, 50 minutes

Table 45. Summary of Abulog-Apayao river (5) discharge generated in HEC-HMS

RIDF Period	Peak discharge (cms)	Time-to-peak
100-Year	1877.1	20 hours, 30 minutes
25-Year	1404.1	20 hours, 40 minutes
5-Year	837.6	20 hours, 50 minutes

The comparison of the discharge results using Dr. Horritt's recommended hydrological method against the bankful and specific discharge estimates is shown in Table 46.

Table 46. Validation of river discharge estimates

Discharge Point	$Q_{MED(SCS)}$, cms	$Q_{BANKFUL}$, cms	$Q_{MED(SPEC)}$, cms	VALIDATION	
				Bankful Discharge	Specific Discharge
Abulog-Apayao (1)	349.536	666.078	471.908	PASS	PASS
Abulog-Apayao (2)	109.648	148.321	165.371	PASS	PASS
Abulog-Apayao (3)	122.584	175.397	178.548	PASS	PASS
Abulog-Apayao (4)	4557.168	4359.139	3135.988	PASS	PASS
Abulog-Apayao (5)	737.088	1020.123	1038.018	PASS	PASS

All five from the HEC-HMS river discharge estimates were able to satisfy the conditions for validation using the bankful and specific discharge methods. The passing values are based on theory but such are supported using other discharge computation methods so they were good to use for flood modeling. These values will need further investigation for the purpose of validation. It is therefore recommended to obtain actual values of the river discharges for higher-accuracy modeling.

5.8 River Analysis (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. For this publication, only a sample output map river was to be shown. The sample generated map of Alubijid River using the calibrated HMS base flow is shown in Figure 73.

Figure 73. Sample output of Abulog-Apayao RAS Model

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 74 to Figure 79 shows the 5-, 25-, and 100-year rain return scenarios of THE Abulog-Apayao floodplain. The floodplain, with an area of 492.74 sq. km., covers eight municipalites namely Abulug, Allacapan, Ballesteros, Pamplona, Flora, Luna, Pudtol, Santa Marcel. Table 47 shows the percentage of area affected by flooding per municipality.

Table 47. Municipalities affected in Abulog-Apayao Floodplain

Municipality	Total Area	Area Flooded	% Flooded
Abulug	132.65	128.28	96.71%
Allacapan	230.60	20.71	8.98%
Ballesteros	129.41	34.82	26.91%
Pamplona	213.08	75.31	35.34%
Flora	243.71	17.47	7.17%
Luna	320.66	127.88	39.88%
Pudtol	302.26	28.75	9.51%
Santa Marcel	64.91	59.42	91.54%

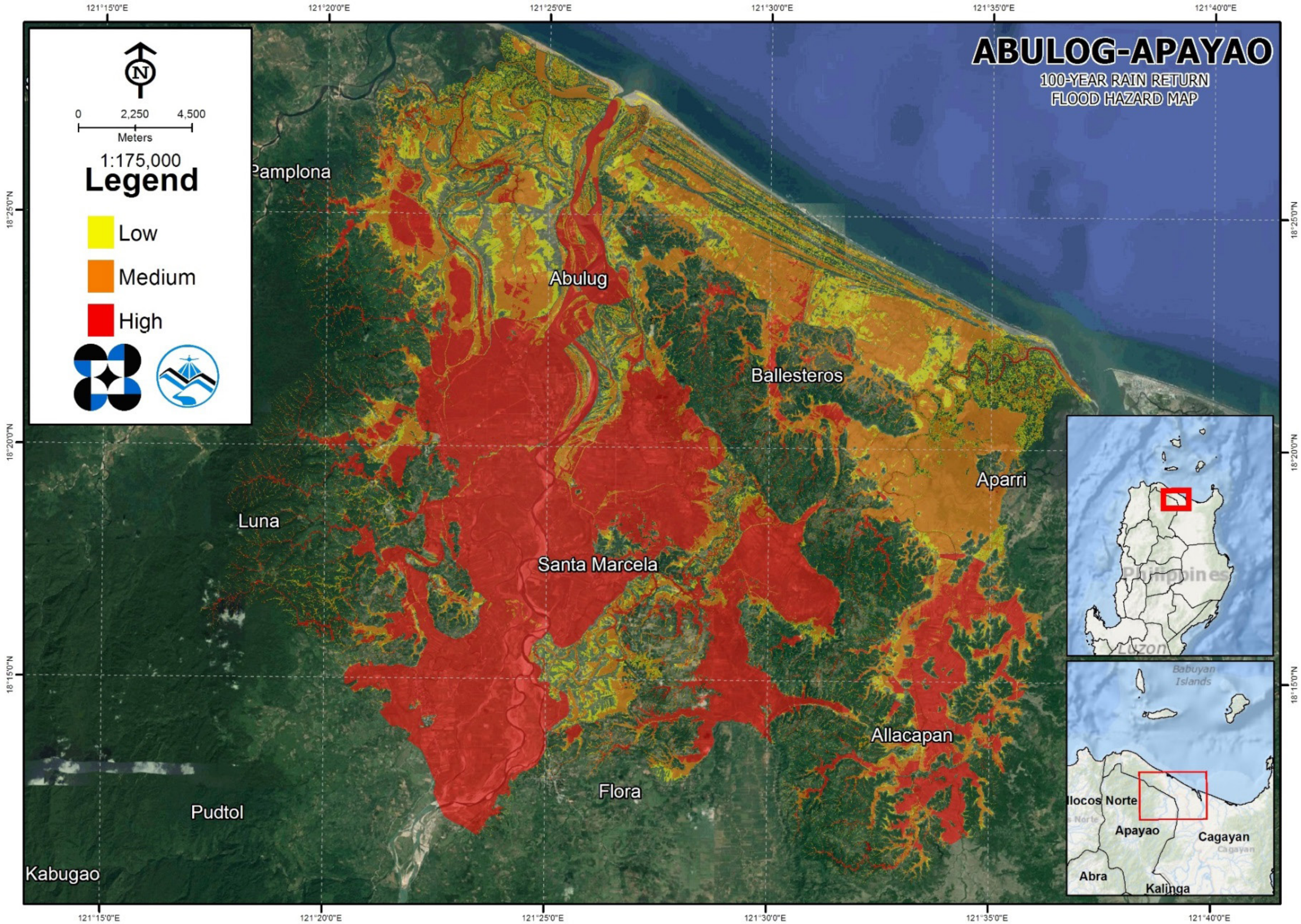


Figure 74. 100-year Flood Hazard Map for Abulog-Apayao Floodplain

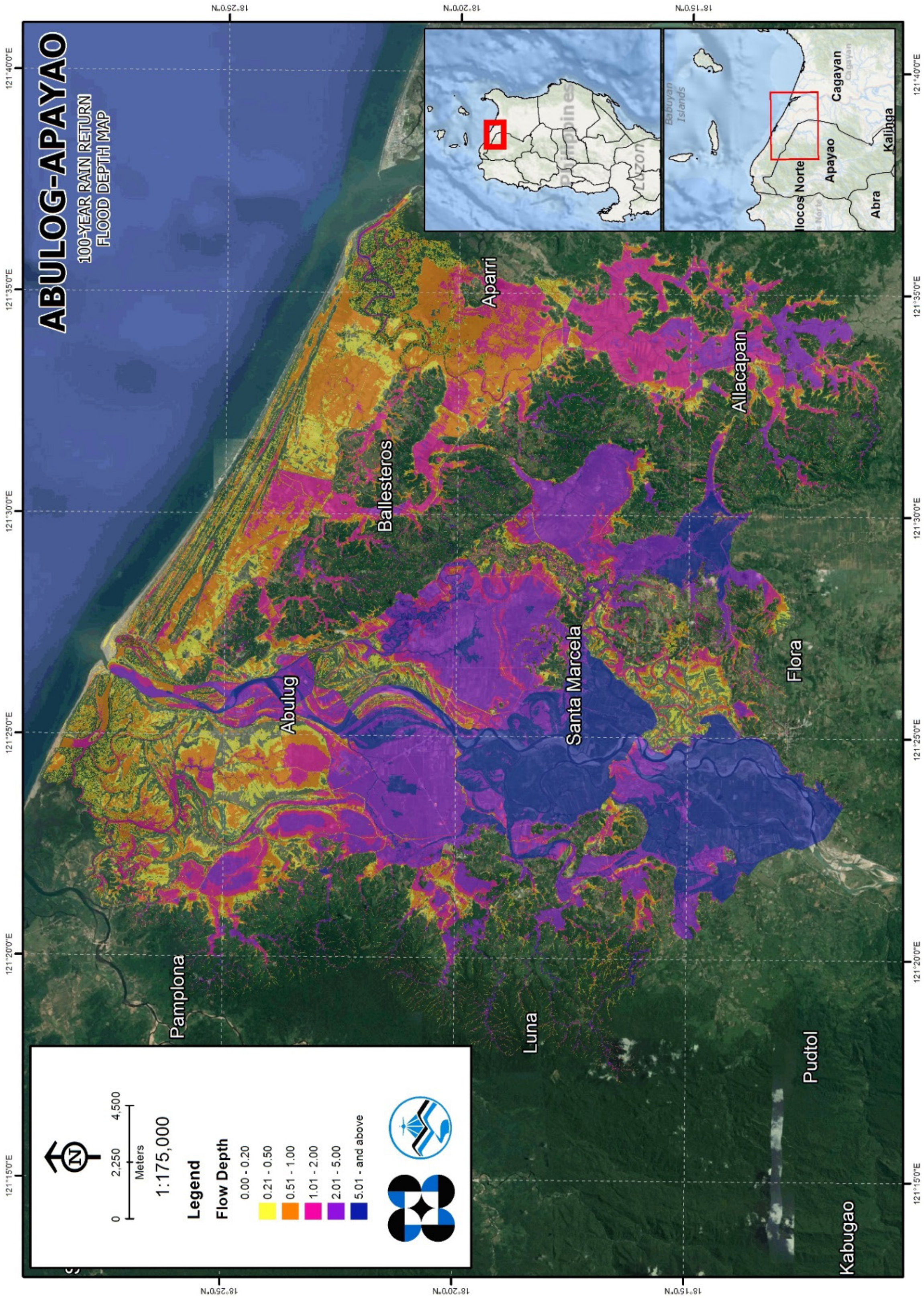


Figure 75. 100-year Flow Depth Map for Abulog-Apayao Floodplain

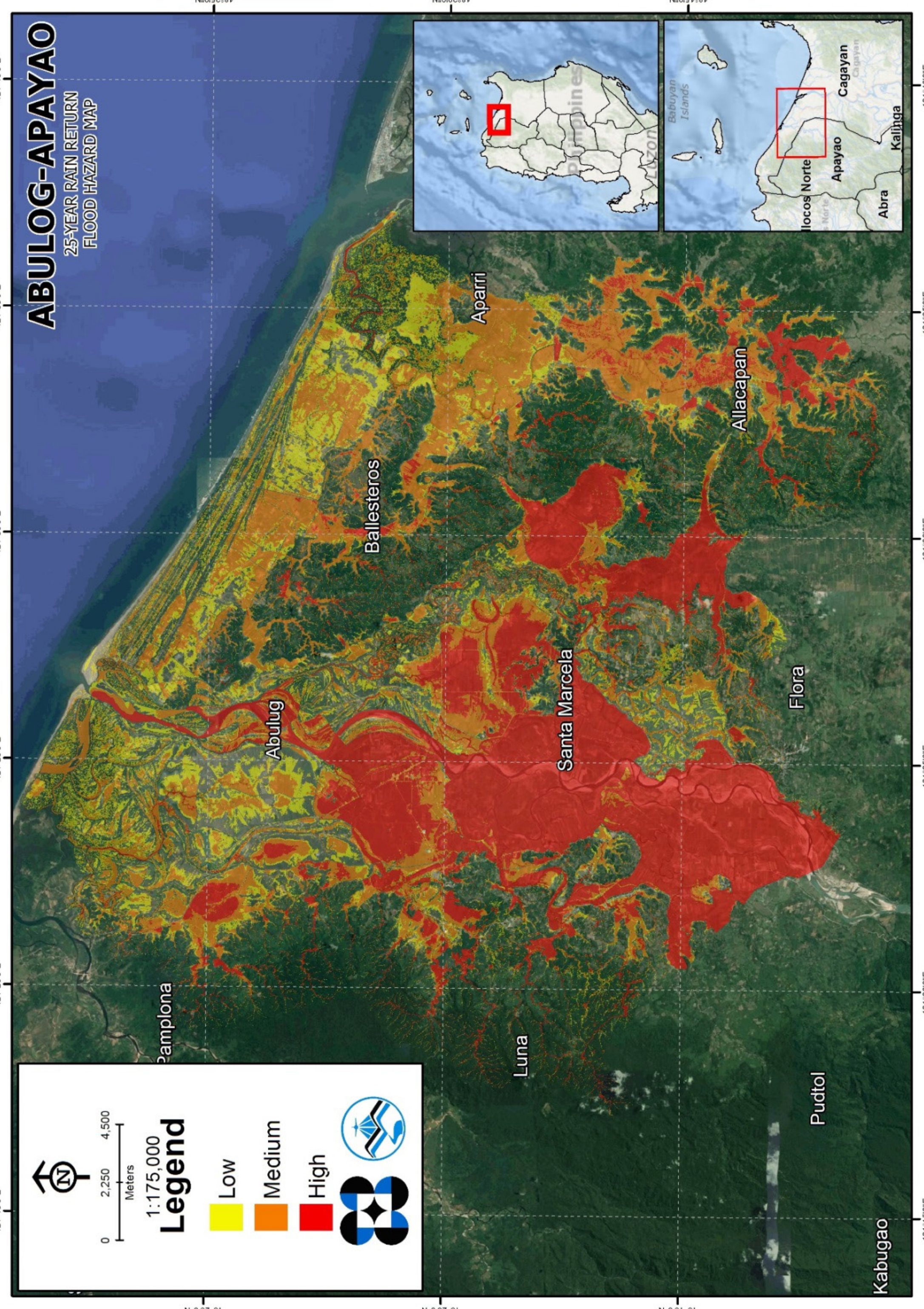


Figure 76. 25-year Flood Hazard Map for Abulog-Apayao Floodplain

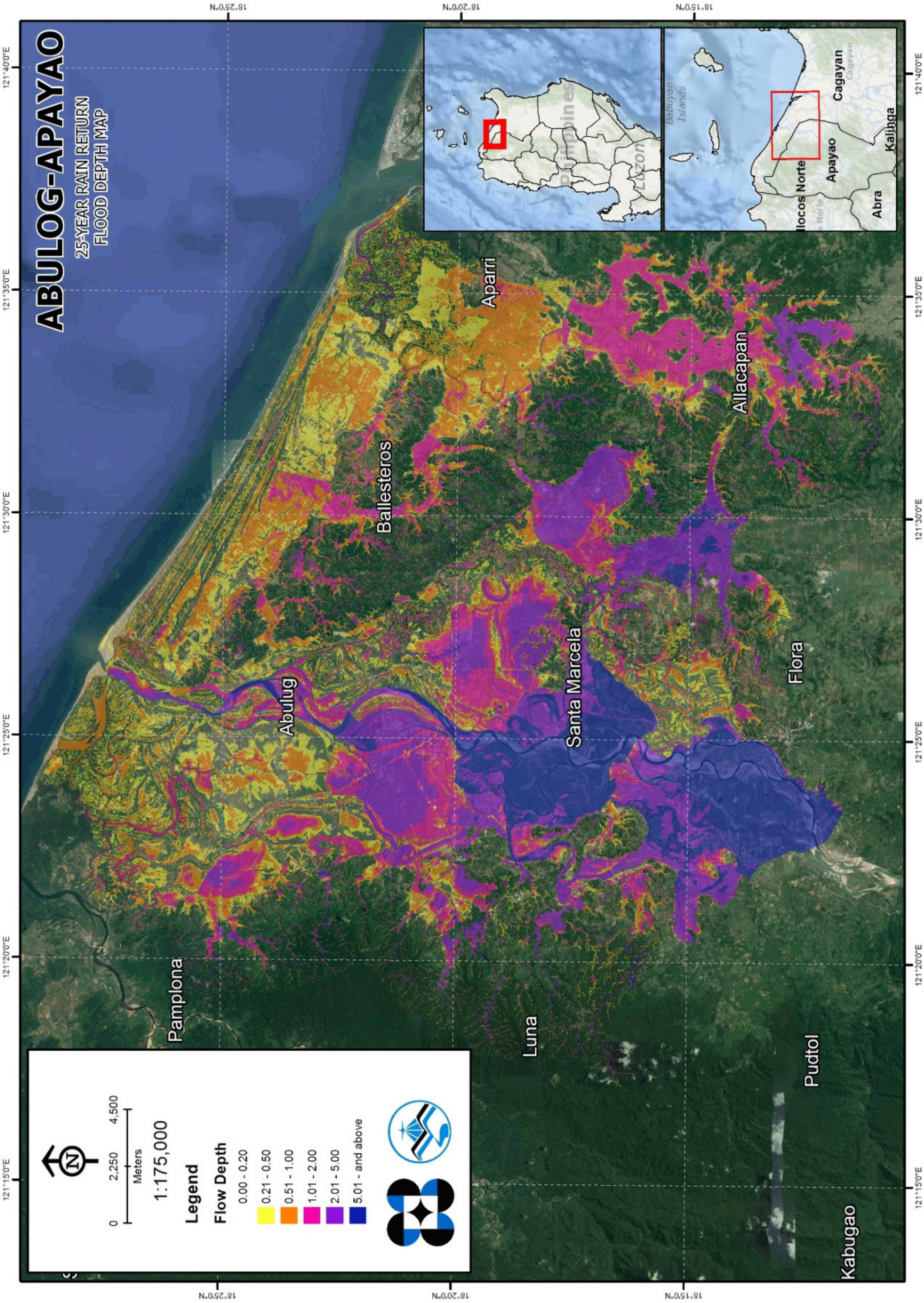


Figure 77. 25-year Flow Depth Map for Abulog-Apayao Floodplain

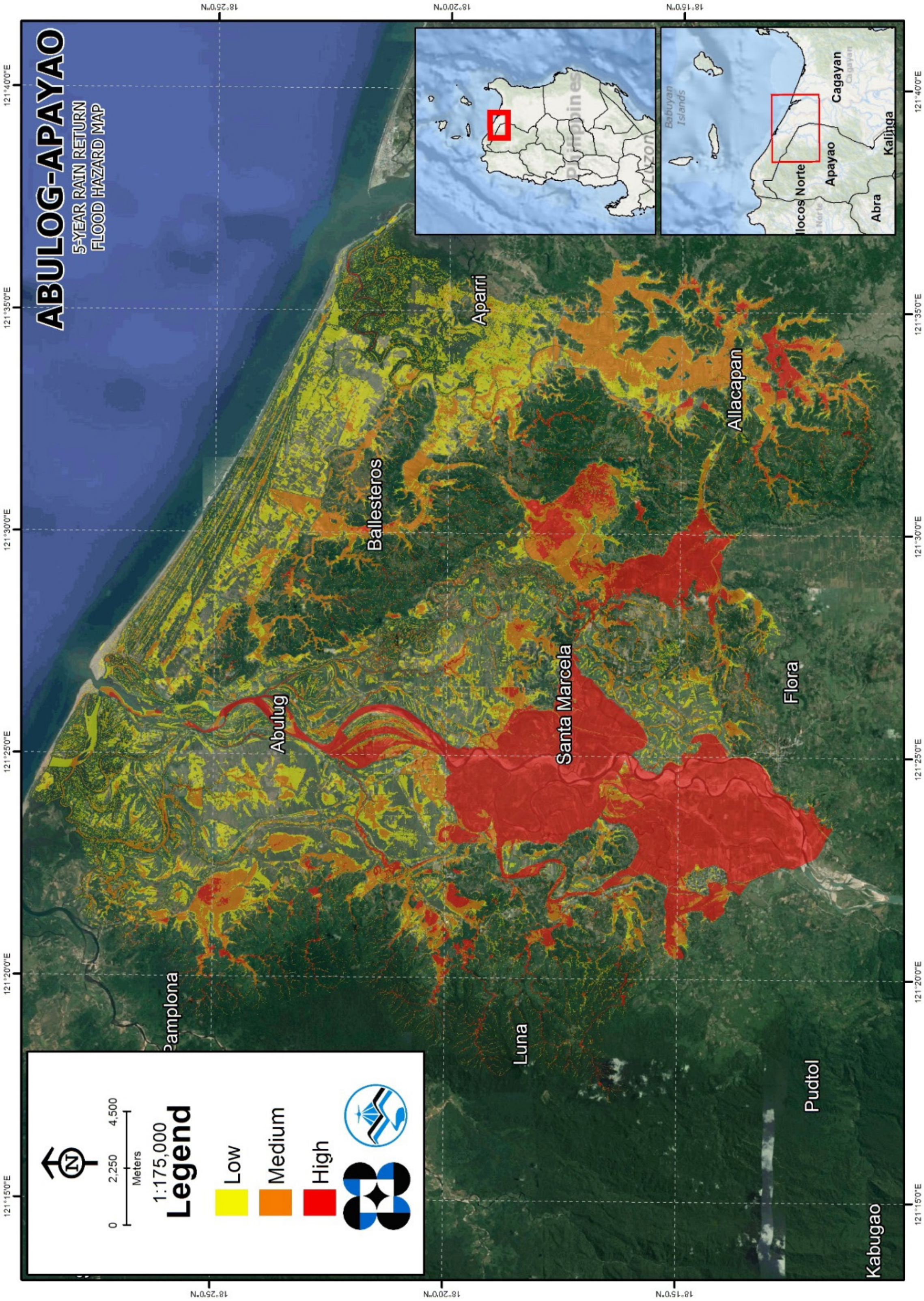


Figure 78. 5-year Flood Hazard Map for Abulog-Apayao Floodplain

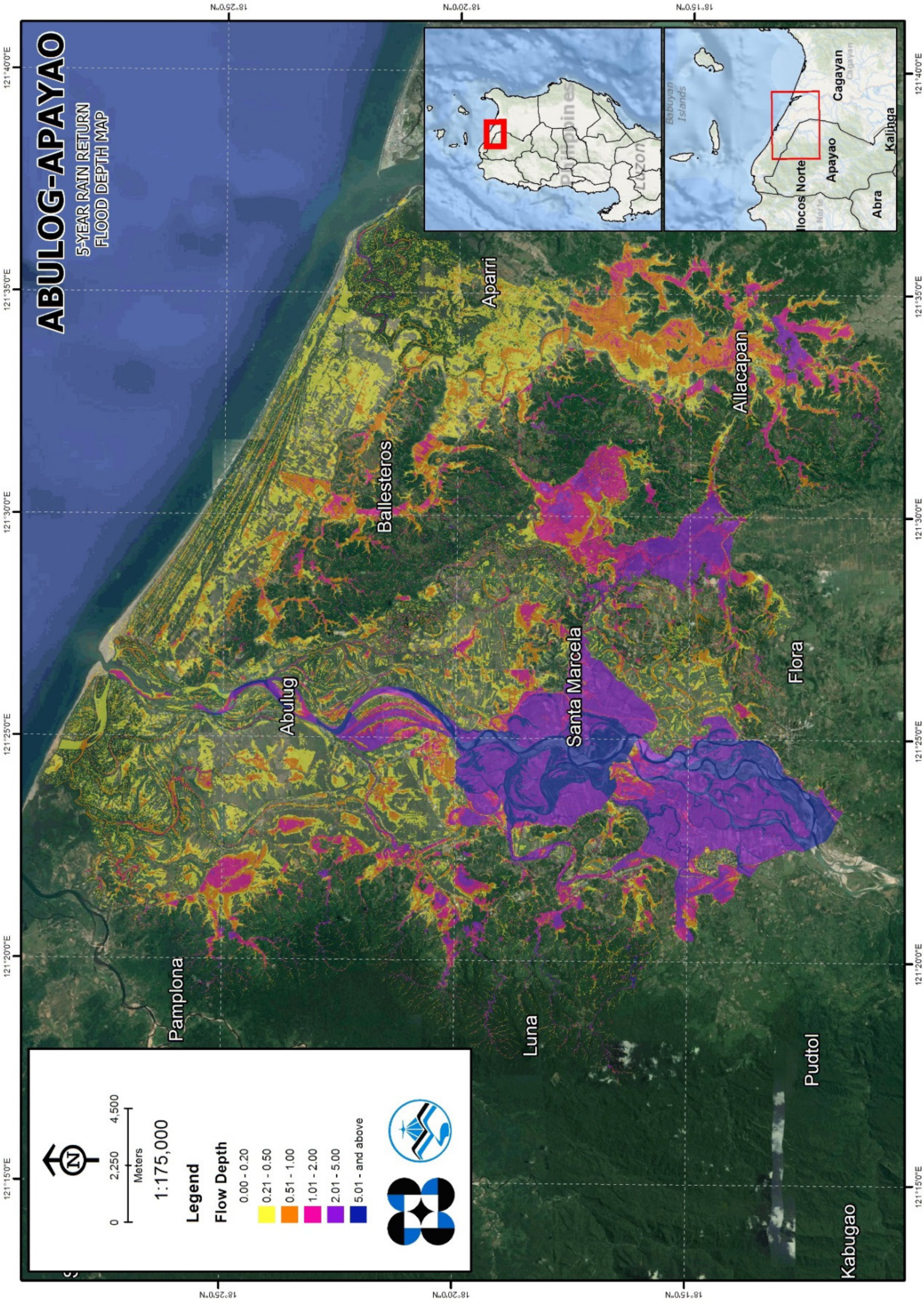


Figure 79. 5-year Flood Depth Map for Abulog-Apayao Floodplain

5.10 Inventory of Areas Exposed to Flooding of Affected Areas

Affected barangays in Abulog-Apayao river basin, grouped by municipality, are listed below. For the said basin, 8 municipalities consisting of 80 barangays are expected to experience flooding when subjected to 5-yr rainfall return period (see Annexes 12 and 13).

For the 5-year return period, 7.13% of the municipality of Allacapan with an area of 252.24 sq. km. will experience flood levels of less than 0.20 meters. 1.04% of the area will experience flood levels of 0.21 to 0.50 meters while 1.41%, 3.10%, 2.42%, and 0.07% 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 48. Affected Areas in Allacapan, Cagayan during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Allacapan (in sq. km)	
	Cataratan	Silangan
0.03-0.20	4.66	13.32
0.21-0.50	0.5	2.12
0.51-1.00	0.53	3.03
1.01-2.00	0.59	7.23
2.01-5.00	1.53	4.57
> 5.00	0.027	0.15

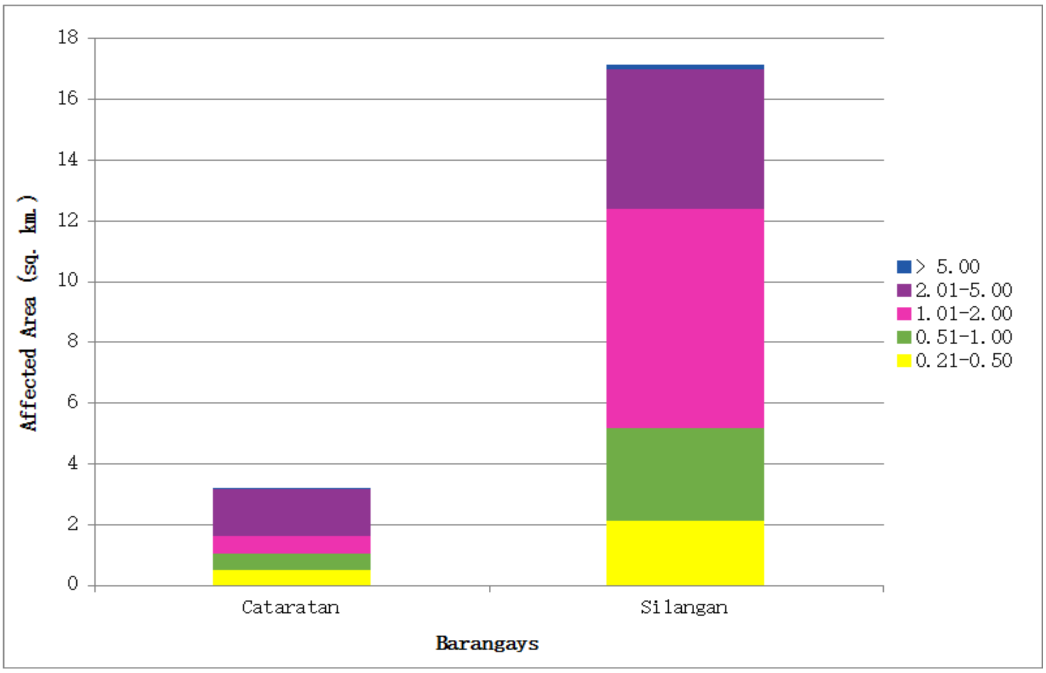


Figure 80. Affected Areas in Allacapan, Cagayan during 5-Year Rainfall Return Period

For the 5-year return period, 13.56% of the municipality of Ballesteros with an area of 117.917 sq. km. will experience flood levels of less than 0.20 meters. 2.31% of the area will experience flood levels of 0.21 to 0.50 meters while 1.47%, 1.86%, 0.77%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in Table 49 are the affected areas in square kilometers by flood depth per barangay.

Table 49. Affected Areas in Ballesteros, Cagayan during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Ballesteros (in sq. km)								
	Baran	Cabaritan East	Cabaritan West	Cabayu	Cabuluan West	Fugu	Nararagan	San Juan	Zitanga
0.03-0.20	0.24	0.71	1.95	3.28	0.015	0.41	6.43	2.22	0.75
0.21-0.50	0.0052	0.14	0.62	0.82	0.00017	0.029	0.92	0.17	0.036
0.51-1.00	0.0056	0.066	0.33	0.62	0	0.03	0.46	0.18	0.038
1.01-2.00	0.0085	0.0023	0.0061	1.68	0	0.031	0.24	0.2	0.03
2.01-5.00	0.0079	0	0.0001	0.61	0	0.0008	0.16	0.11	0.012
> 5.00	0	0	0	0	0	0	0.0003	0	0

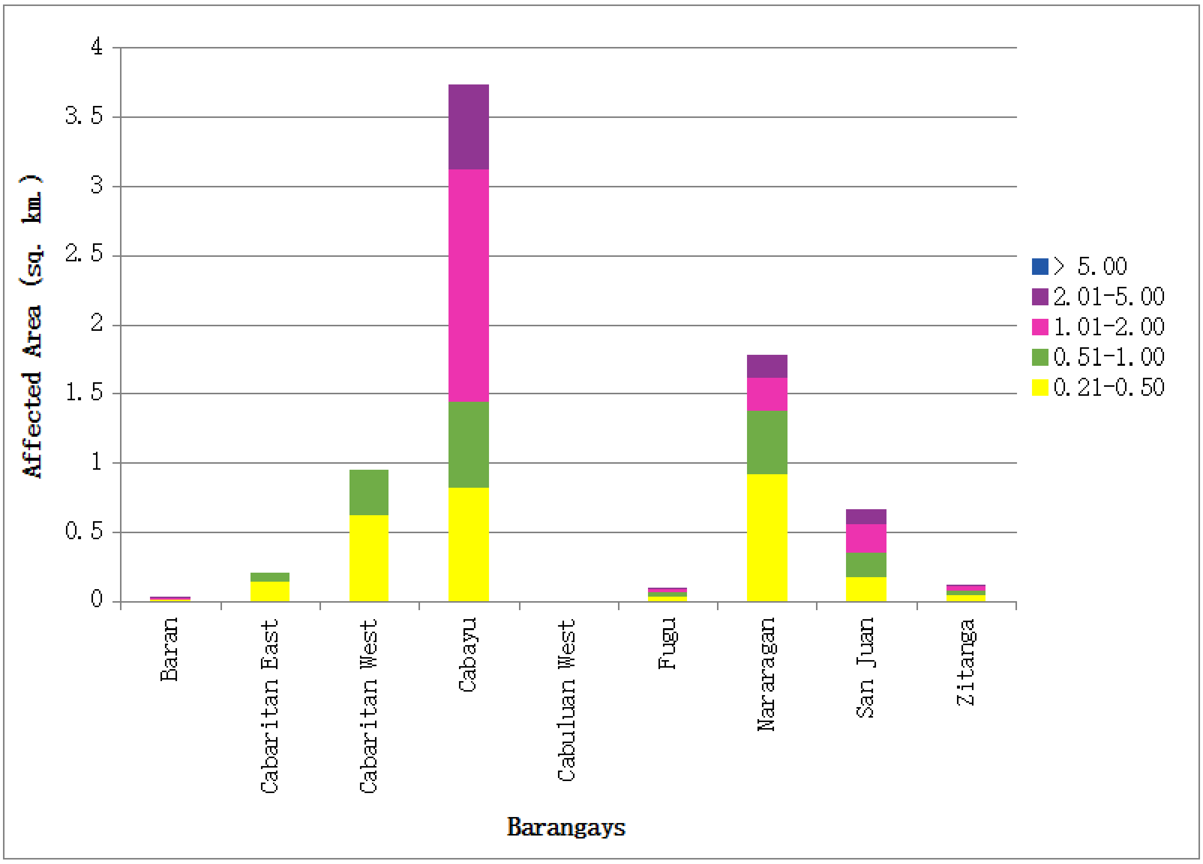


Figure 81. Affected Areas in Ballesteros, Cagayan during 5-Year Rainfall Return Period

For the 5-year return period, 58.08% of the municipality of Abulug with an area of 123.18878 sq. km. will experience flood levels of less than 0.20 meters. 20.55% of the area will experience flood levels of 0.21 to 0.50 meters while 8.80%, 4.06%, 3.62%, and 1.10% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 50. Affected Areas in Abulug, Cagayan during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Abulug (in sq. km)									
	Alinunu	Bagu	Banguian	Calog Norte	Calog Sur	Canayun	Centro	Dana-Ili	Guiddam	Libertad
0.03-0.20	5.85	2.47	7.54	2.43	1.27	3.81	0.95	11.91	9.1	1.92
0.21-0.50	2.09	0.63	1.95	1.22	0.58	1.19	0.28	5.18	2.32	1
0.51-1.00	0.88	0.35	1.12	0.79	0.4	0.57	0.14	1.19	1.19	1.12
1.01-2.00	0.16	0.027	0.52	0.21	0.38	0.24	0.019	0.2	0.63	1.7
2.01-5.00	0.12	0.24	0.89	0.17	1.13	0.28	0	0.098	0.14	0.91
> 5.00	0.042	0.006	0.37	0.014	0.025	0.11	0	0.028	0	0.11

Table 51. Affected Areas in Abulug, Cagayan during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Abulug (in sq. km)									
	Lucban	Pinili	San Agustin	San Julian	Santa Filomena	Santa Rosa	Santo Tomas	Siguiran	Simayung	Sirit
0.03-0.20	2.89	3.19	3.77	0.94	3.57	0.8	1.84	2.25	2.79	2.24
0.21-0.50	0.9	1.33	0.77	0.34	1.64	0.28	0.85	0.92	1.32	0.53
0.51-1.00	0.4	0.37	0.54	0.1	0.6	0.081	0.18	0.18	0.45	0.18
1.01-2.00	0.092	0.0071	0.32	0.0007	0.065	0.092	0.045	0.0046	0.17	0.12
2.01-5.00	0.2	0.0032	0.046	0	0.0082	0.012	0	0	0.18	0.035
> 5.00	0.51	0.00057	0	0	0	0	0	0	0.14	0.0015

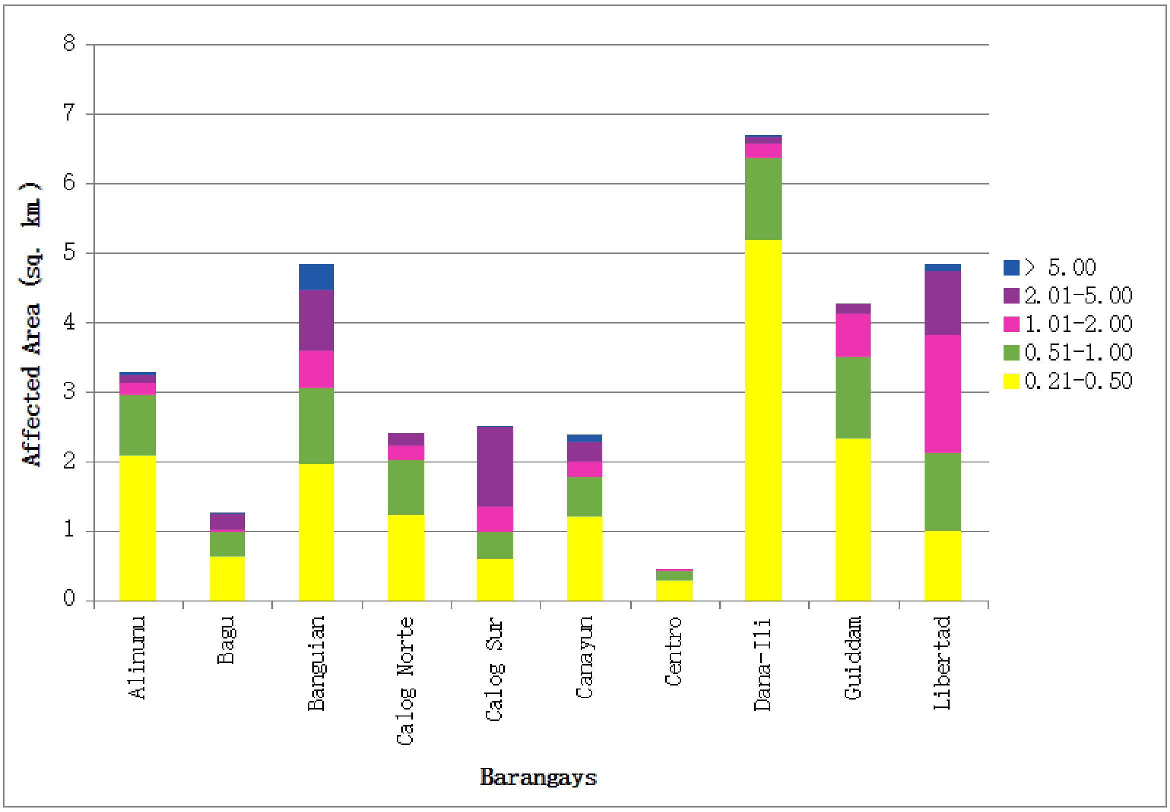


Figure 82. Affected Areas in Abulug, Cagayan during 5-Year Rainfall Return Period

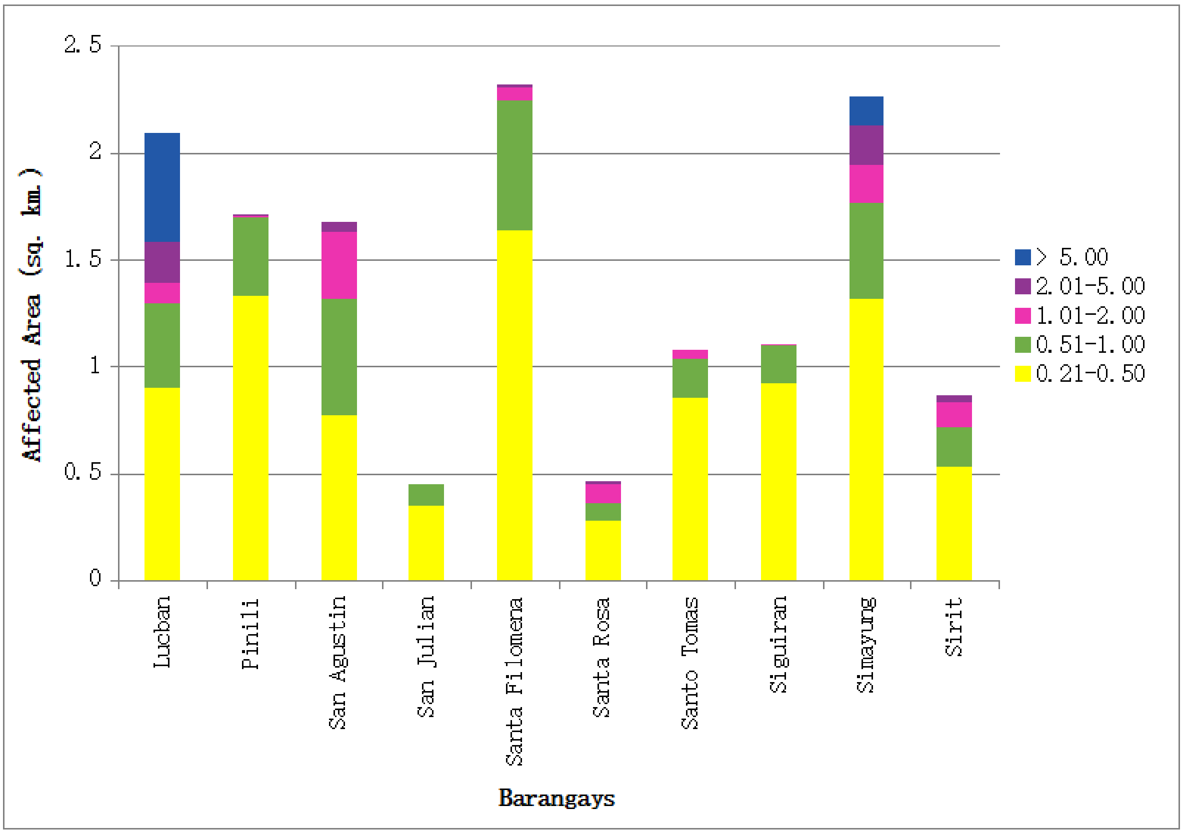


Figure 83. Affected Areas in Abulug, Cagayan during 5-Year Rainfall Return Period

For the 5-year return period, 19.04% of the municipality of Pamplona with an area of 206.54514 sq. km. will experience flood levels of less than 0.20 meters. 4.28% of the area will experience flood levels of 0.21 to 0.50 meters while 3.14%, 2.00%, 0.31%, and 0.01% 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 52. Affected Areas in Pamplona, Cagayan during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Pamplona (in sq. km)				
	Abanqueruan	Bagu	Curva	Santa Cruz	Tabba
0.03-0.20	2.9	2.47	16.84	16.78	0.34
0.21-0.50	0.37	0.63	4.36	3.4	0.075
0.51-1.00	0.29	0.35	2.81	2.97	0.062
1.01-2.00	0.11	0.027	1.71	2.28	0.0016
2.01-5.00	0.011	0.24	0.2	0.2	0
> 5.00	0	0.006	0.013	0.0051	0

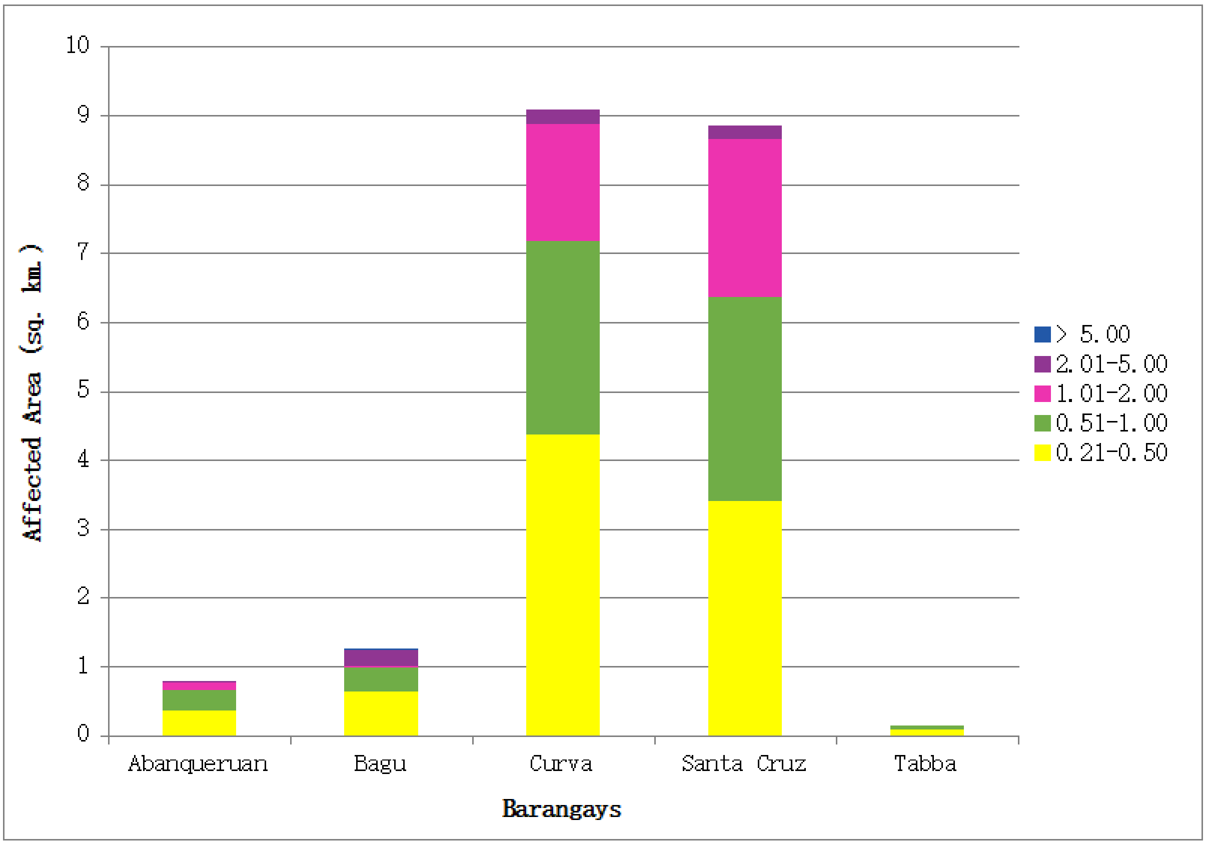


Figure 84. Affected Areas in Pamplona, Cagayan during 5-Year Rainfall Return Period

For the 5-year return period, 13.45% of the municipality of Luna with an area of 603.00757 sq. km. will experience flood levels of less than 0.20 meters. 1.21% of the area will experience flood levels of 0.21 to 0.50 meters while 1.19%, 1.36%, 1.94%, and 0.71% 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 53. Affected Areas in Luna, Apayao during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Luna (in sq. km)									
	Bacsay	Calabigan	Cangisitan	Capagaypayan	Dagupan	Lappa	Luyon	Poblacion	Quirino	Salvacion
0.03-0.20	5.23	0.19	0.67	1	3.56	6.08	8.45	2.46	1.75	2.48
0.21-0.50	0.34	0.0032	0.2	0.3	0.47	0.28	0.27	0.45	0.74	0.16
0.51-1.00	0.35	0.0015	0.27	0.19	0.53	0.39	0.26	0.46	0.81	0.19
1.01-2.00	0.67	0.00071	0.42	0.25	0.58	0.79	0.31	0.56	0.11	0.31
2.01-5.00	0.55	0.001	1.93	0.091	1.02	0.43	0.14	0.24	0.22	0.043
> 5.00	0.035	0	1.36	0.00014	0.011	0.0005	0.0035	0.0004	0.29	0.0001

Table 54. Affected Areas in Luna, Apayao during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Luna (in sq. km)								
	San Francisco	San Gregorio	San Isidro Norte	San Isidro Sur	San Sebastian	Shalom	Tumog	Turod	Zumigui
0.03-0.20	4.83	4.08	0.83	1.4	0.14	13.32	1.12	16.35	7.16
0.21-0.50	0.67	0.35	0.33	0.39	0.091	0.9	0.15	0.54	0.7
0.51-1.00	0.64	0.35	0.00087	0.47	0.23	0.67	0.26	0.35	0.72
1.01-2.00	0.5	0.53	0	0.44	0.76	0.49	0.5	0.35	0.63
2.01-5.00	1.53	0.26	0	0.78	2.37	0.28	1.18	0.45	0.19
> 5.00	0.25	0.0002	0	0.21	1.8	0.089	0.15	0.046	0.0033

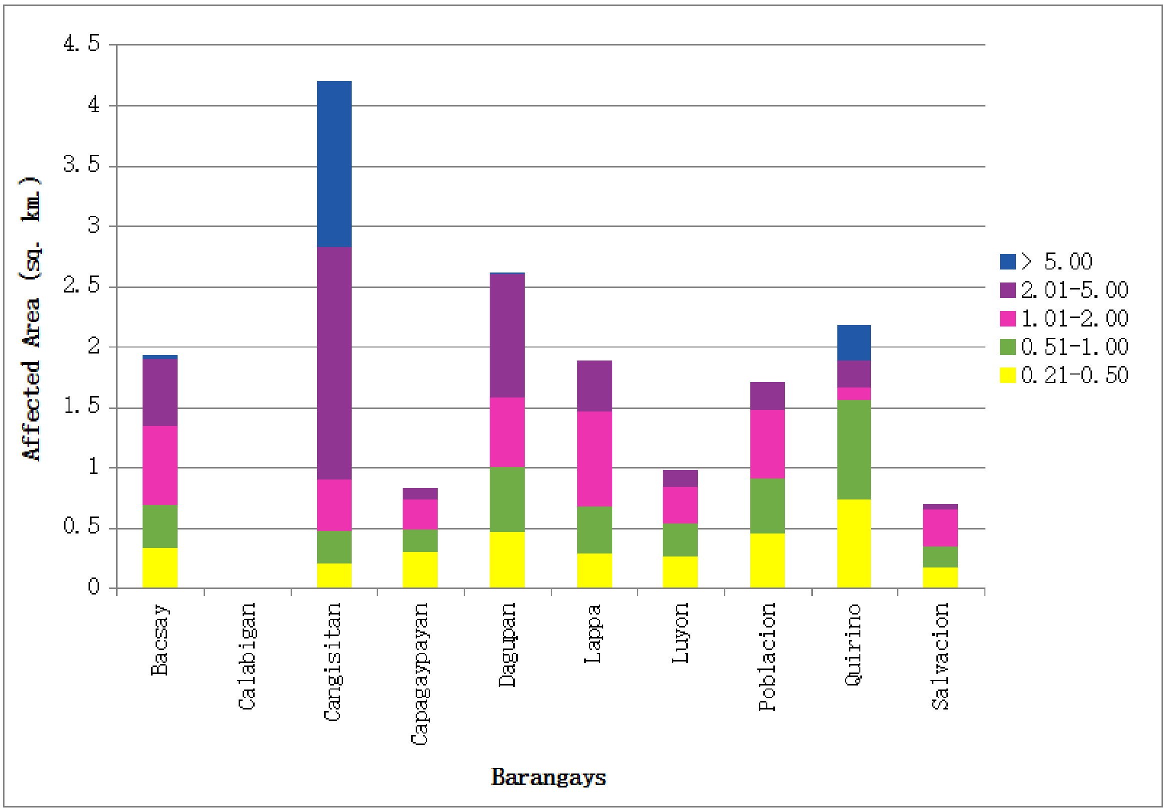


Figure 85. Affected Areas in Luna, Apayao during 5-Year Rainfall Return Period

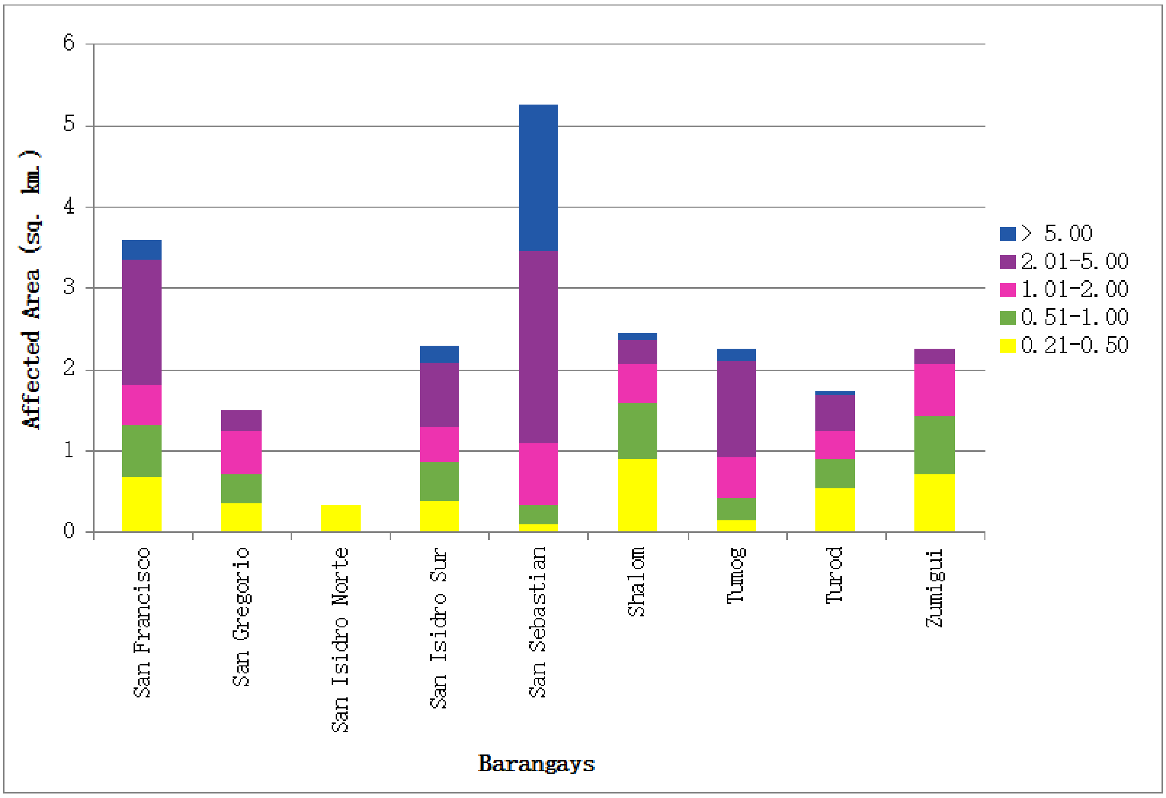


Figure 86. Affected Areas in Luna, Apayao during 5-Year Rainfall Return Period

For the 5-year return period, 7.37% of the municipality of Flora with an area of 321.67048 sq. km. will experience flood levels of less than 0.20 meters. 1.21% of the area will experience flood levels of 0.21 to 0.50 meters while 0.99%, 0.76%, 1.51%, and 1.24% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 55. Affected Areas in Flora, Apayao during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Flora (in sq. km)						
	Atok	Bagutong	Balasi	Poblacion East	Poblacion West	Tamalunog	Upper Atok
0.03-0.20	1.06	10.94	1.07	7.94	0.51	2.21	0.0037
0.21-0.50	0.065	2.01	0.058	1.28	0.035	0.42	0.0027
0.51-1.00	0.045	1.62	0.037	1.1	0.023	0.34	0.007
1.01-2.00	0.053	1.58	0.07	0.57	0.054	0.11	0.015
2.01-5.00	0.076	3.33	0.19	0.49	0.39	0.0044	0.38
> 5.00	0.32	1.09	0.18	0.018	0.83	0	1.55

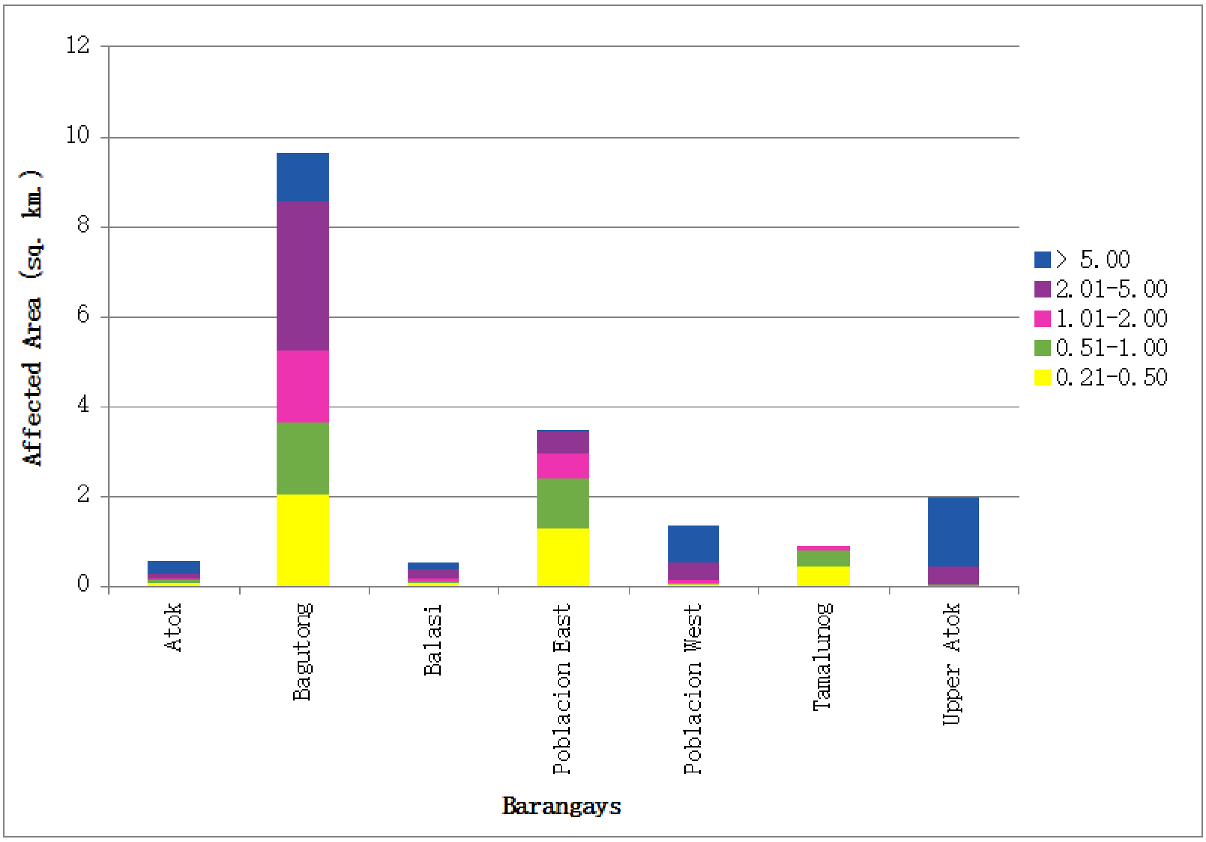


Figure 87. Affected Areas in Flora, Apayao during 5-Year Rainfall Return Period

For the 5-year return period, 30.26% of the municipality of Santa Marcela with an area of 47.22664 sq. km. will experience flood levels of less than 0.20 meters. 6.85% of the area will experience flood levels of 0.21 to 0.50 meters while 7.07%, 5.66%, 31.03%, and 21.55% 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 56. Affected Areas in Santa Marcela, Apayao during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Santa Marcela (in sq. km)											
	Barocboc	Consuelo	Emiliana	Malekkeg	Marcela	Nueva	Panay	San Antonio	San Carlos	San Juan	San Mariano	Sipa Proper
0.03-0.20	0.16	3.23	1.23	1.39	1.72	1.42	2	0.00011	0.5	2.22	0.084	0.34
0.21-0.50	0.021	0.29	0.49	0.64	0.3	0.26	0.41	0.00004	0.51	0.17	0.009	0.12
0.51-1.00	0.038	0.32	0.19	0.76	0.53	0.13	0.47	0.0001	0.61	0.18	0.033	0.072
1.01-2.00	0.12	0.13	0.088	0.39	0.39	0.24	0.18	0.0044	0.5	0.2	0.36	0.074
2.01-5.00	3.48	0.63	0.97	0.0098	0.38	1.07	0.0015	2.96	0.53	0.11	3.09	1.44
> 5.00	1.76	0.00015	1.02	0	0.0033	0.019	0	3.67	0.36	0	3.03	0.32

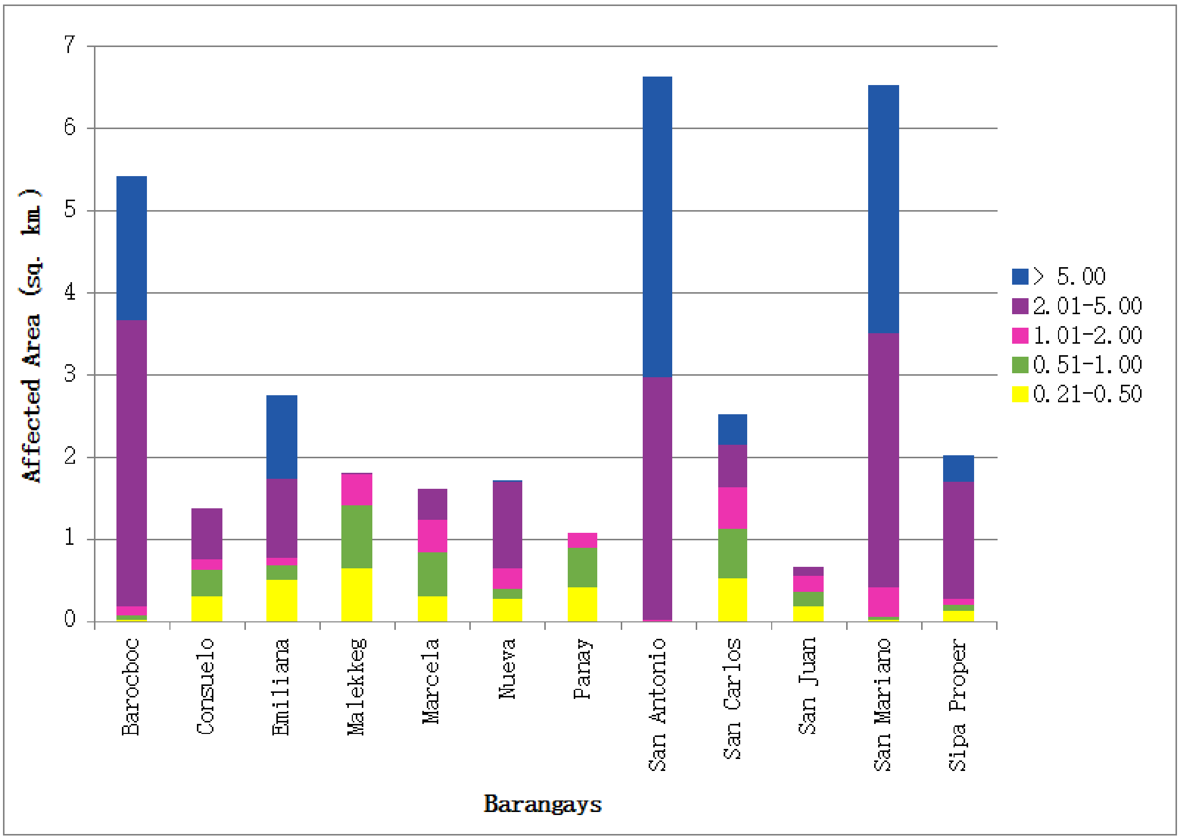


Figure 88. Affected Areas in Santa Marcela, Apayao during 5-Year Rainfall Return Period

For the 5-year return period, 0.86% of the municipality of Pudtol with an area of 283.65926 sq. km. will experience flood levels of less than 0.20 meters. 0.13% of the area will experience flood levels of 0.21 to 0.50 meters while 0.20%, 0.57%, 5.37%, and 2.49% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 57. Affected Areas in Pudtol, Apayao during 5-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Pudtol (in sq. km)					
	Alem	Amado	Cabatacan	Emilia	Imelda	San Antonio
0.03-0.20	0.095	0.46	0.79	0.05	1.03	0.00011
0.21-0.50	0.03	0.032	0.12	0.0066	0.18	0.00004
0.51-1.00	0.074	0.036	0.28	0.019	0.15	0.0001
1.01-2.00	0.27	0.33	0.63	0.071	0.31	0.0044
2.01-5.00	4.01	0.46	1.3	1.84	4.67	2.96
> 5.00	0.75	0	0.043	0.16	2.43	3.67

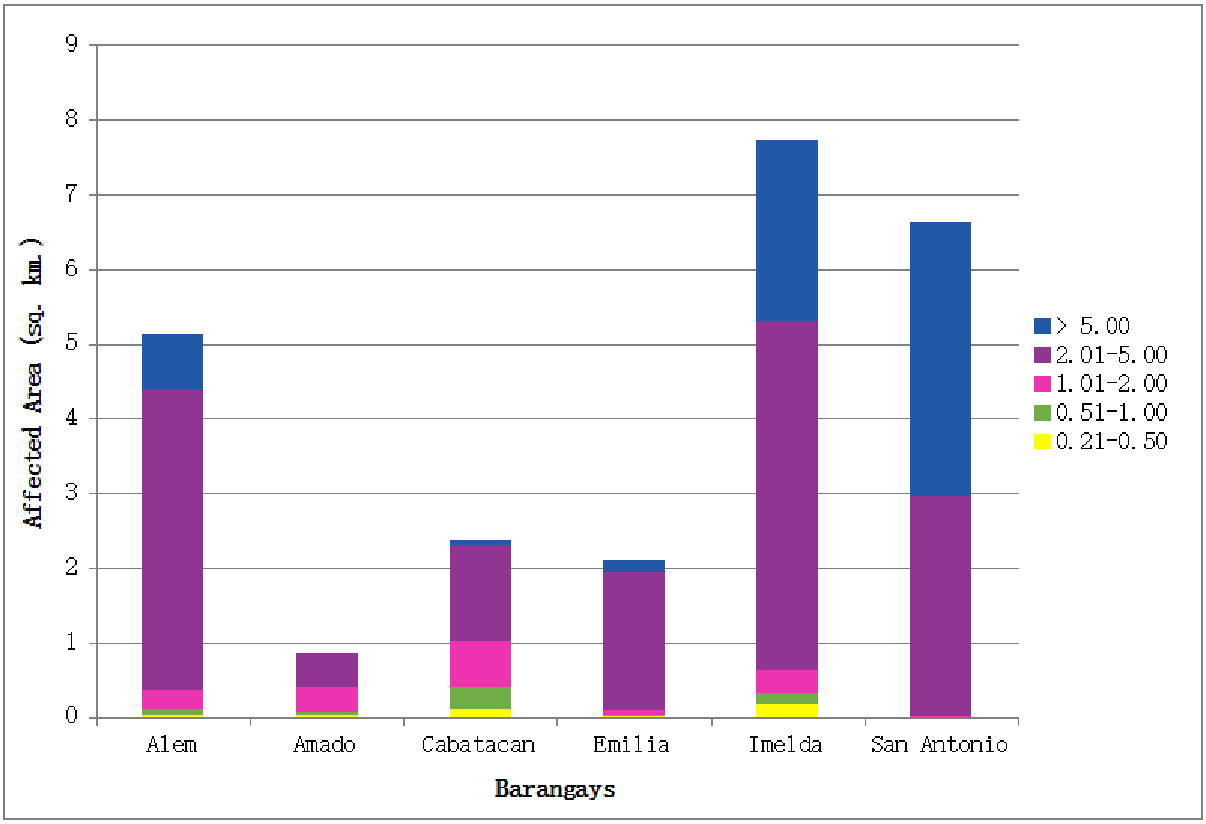


Figure 89. Affected Areas in Pudtol, Apayao during 5-Year Rainfall Return Period

For the 25-year return period, 6.17% of the municipality of Allacapan with an area of 252.24 sq. km. will experience flood levels of less than 0.20 meters. 0.73% of the area will experience flood levels of 0.21 to 0.50 meters while 0.90%, 2.05%, 4.82%, and 0.50% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 58. Affected Areas in Allacapan, Cagayan during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Allacapan (in sq. km)	
	Cataratan	Silangan
0.03-0.20	4.3	11.26
0.21-0.50	0.34	1.49
0.51-1.00	0.4	1.88
1.01-2.00	0.54	4.63
2.01-5.00	1.69	10.47
> 5.00	0.57	0.7

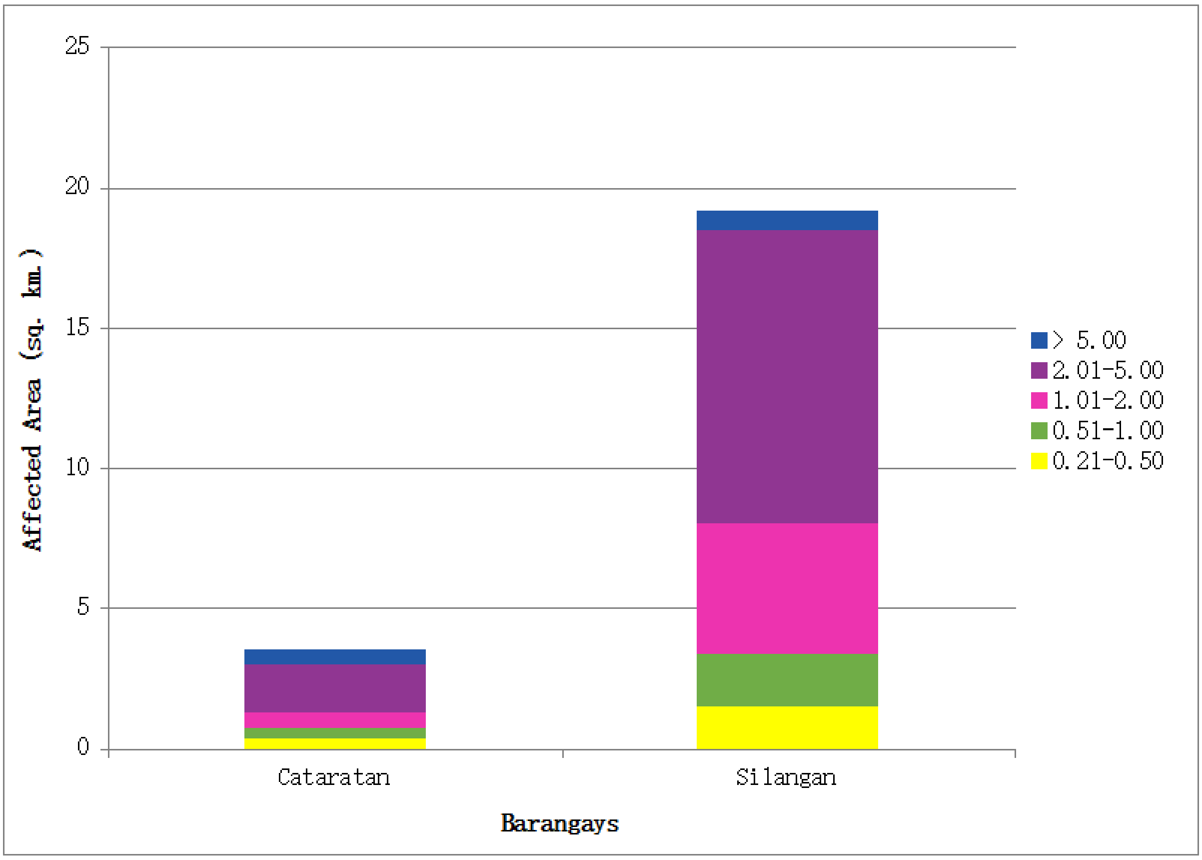


Figure 90. Affected Areas in Allacapan, Cagayan during 25-Year Rainfall Return Period

For the 25-year return period, 10.84% of the municipality of Ballesteros with an area of 117.917 sq. km. will experience flood levels of less than 0.20 meters. 2.38% of the area will experience flood levels of 0.21 to 0.50 meters while 2.21%, 1.74%, 2.80%, and 0.02% 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 59. Affected Areas in Ballesteros, Cagayan during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Ballesteros (in sq. km)								
	Baran	Cabaritan East	Cabaritan West	Cabayu	Cabuluan West	Fugu	Nararagan	San Juan	Zitanga
0.03-0.20	0.23	0.64	1.5	2.13	0.015	0.39	5.07	2.09	0.73
0.21-0.50	0.0065	0.14	0.78	0.48	0.00056	0.028	1.17	0.16	0.042
0.51-1.00	0.007	0.12	0.49	0.81	0.00003	0.027	0.94	0.17	0.034
1.01-2.00	0.0085	0.0055	0.12	0.99	0	0.04	0.61	0.23	0.045
2.01-5.00	0.013	0	0.0001	2.6	0	0.023	0.41	0.23	0.019
> 5.00	0.0022	0	0	0.0045	0	0	0.015	0.00087	0

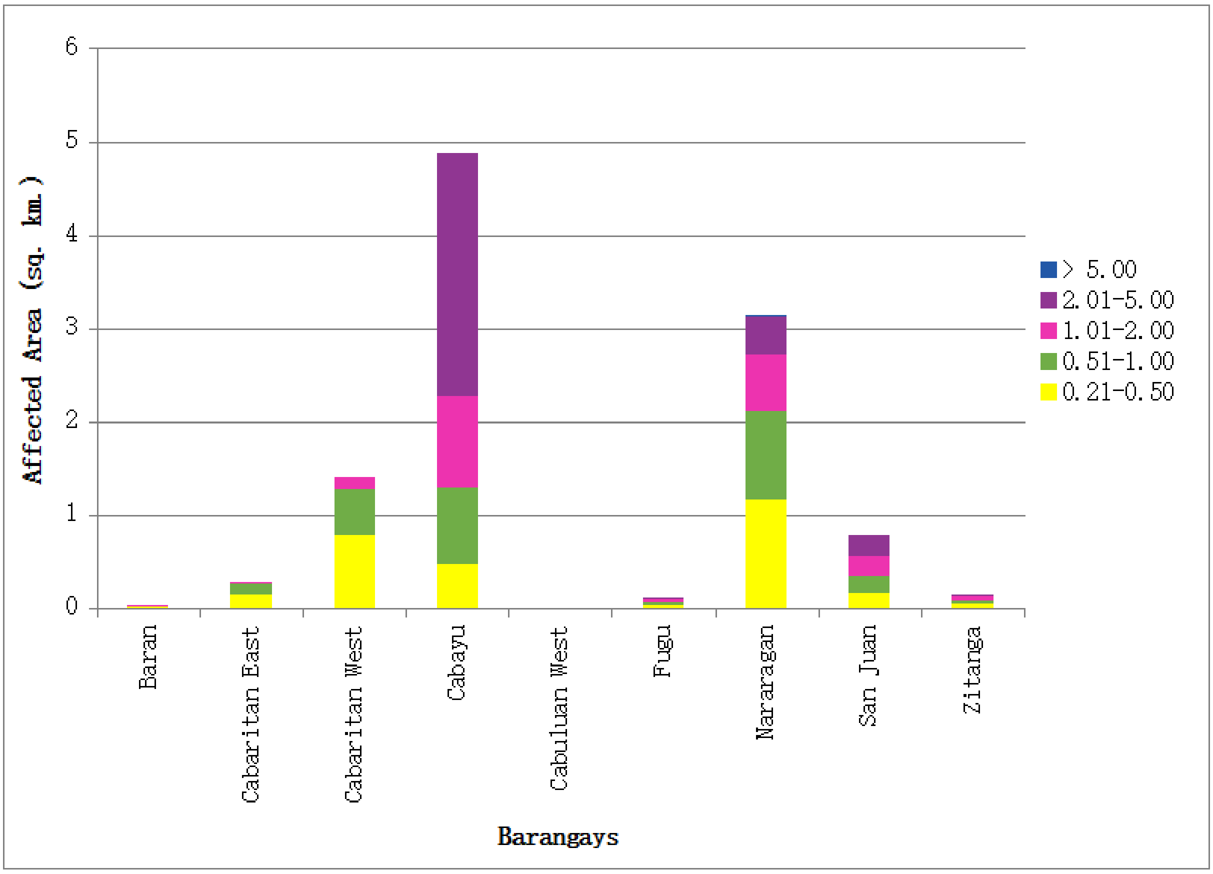


Figure 91. Affected Areas in Ballesteros, Cagayan during 25-Year Rainfall Return Period

For the 25-year return period, 33.19% of the municipality of Abulug with an area of 123.18878 sq. km. will experience flood levels of less than 0.20 meters. 13.75% of the area will experience flood levels of 0.21 to 0.50 meters while 7.97%, 4.22%, 1.91%, and 1.12% 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 60. Affected Areas in Abulug, Cagayan during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Abulug (in sq. km)									
	Alinunu	Bagu	Banguian	Calog Norte	Calog Sur	Canayun	Centro	Dana-Ili	Guiddam	Libertad
0.03-0.20	1.25	1.44	3.13	0.77	2.85	0.57	1.3	1.88	1.81	1.61
0.21-0.50	0.56	0.83	0.78	0.45	1.11	0.32	1.02	0.94	1.43	0.61
0.51-1.00	0.69	0.61	0.77	0.11	1.72	0.15	0.52	0.52	1.19	0.43
1.01-2.00	1.6	1.29	0.55	0.045	0.17	0.085	0.078	0.014	0.18	0.27
2.01-5.00	0.35	0.73	0.21	0	0.034	0.13	0	0	0.25	0.17
> 5.00	0.53	0.0027	0	0	0	0	0	0	0.19	0.014

Table 61. Affected Areas in Abulug, Cagayan during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Abulug (in sq. km)									
	Lucban	Pinili	San Agustin	San Julian	Santa Filome-na	Santa Rosa	Santo Tomas	Siguiran	Simayung	Sirit
0.03-0.20	2.89	3.19	3.77	0.94	3.57	0.8	1.84	2.25	2.79	2.24
0.21-0.50	0.9	1.33	0.77	0.34	1.64	0.28	0.85	0.92	1.32	0.53
0.51-1.00	0.4	0.37	0.54	0.1	0.6	0.081	0.18	0.18	0.45	0.18
1.01-2.00	0.092	0.0071	0.32	0.0007	0.065	0.092	0.045	0.0046	0.17	0.12
2.01-5.00	0.2	0.0032	0.046	0	0.0082	0.012	0	0	0.18	0.035
> 5.00	0.51	0.00057	0	0	0	0	0	0	0.14	0.0015

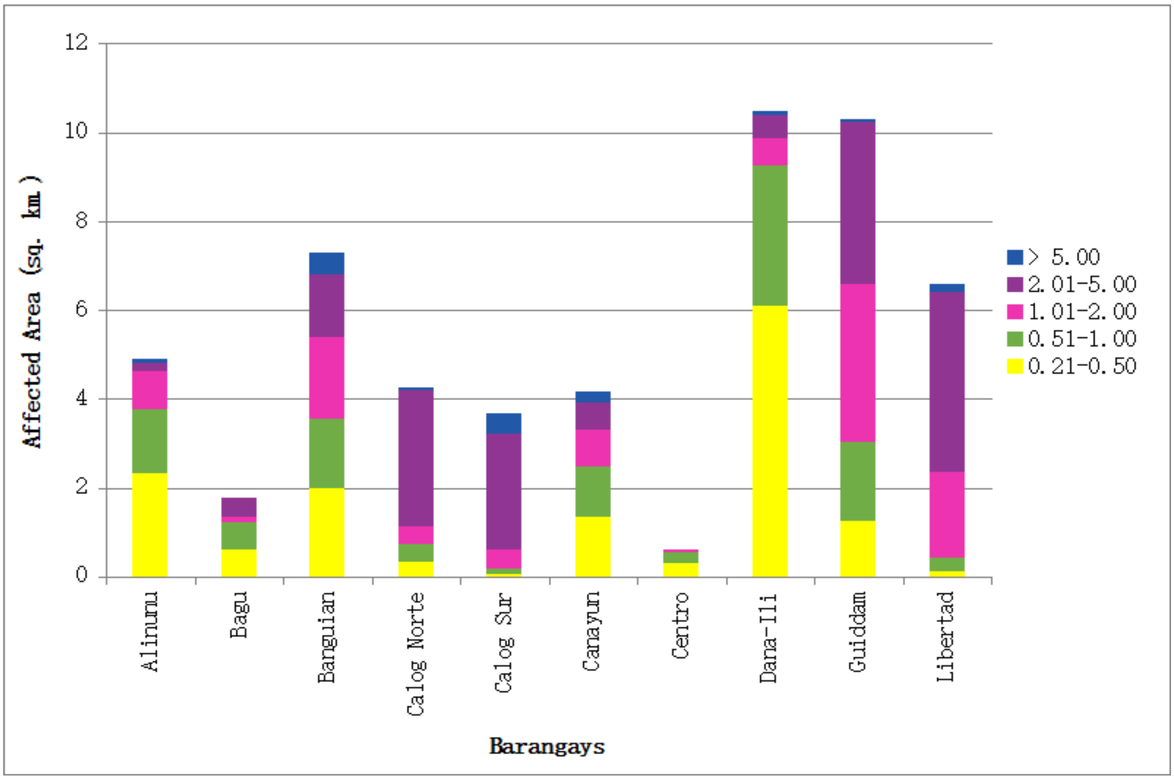


Figure 92. Affected Areas in Abulug, Cagayan during 25-Year Rainfall Return Period

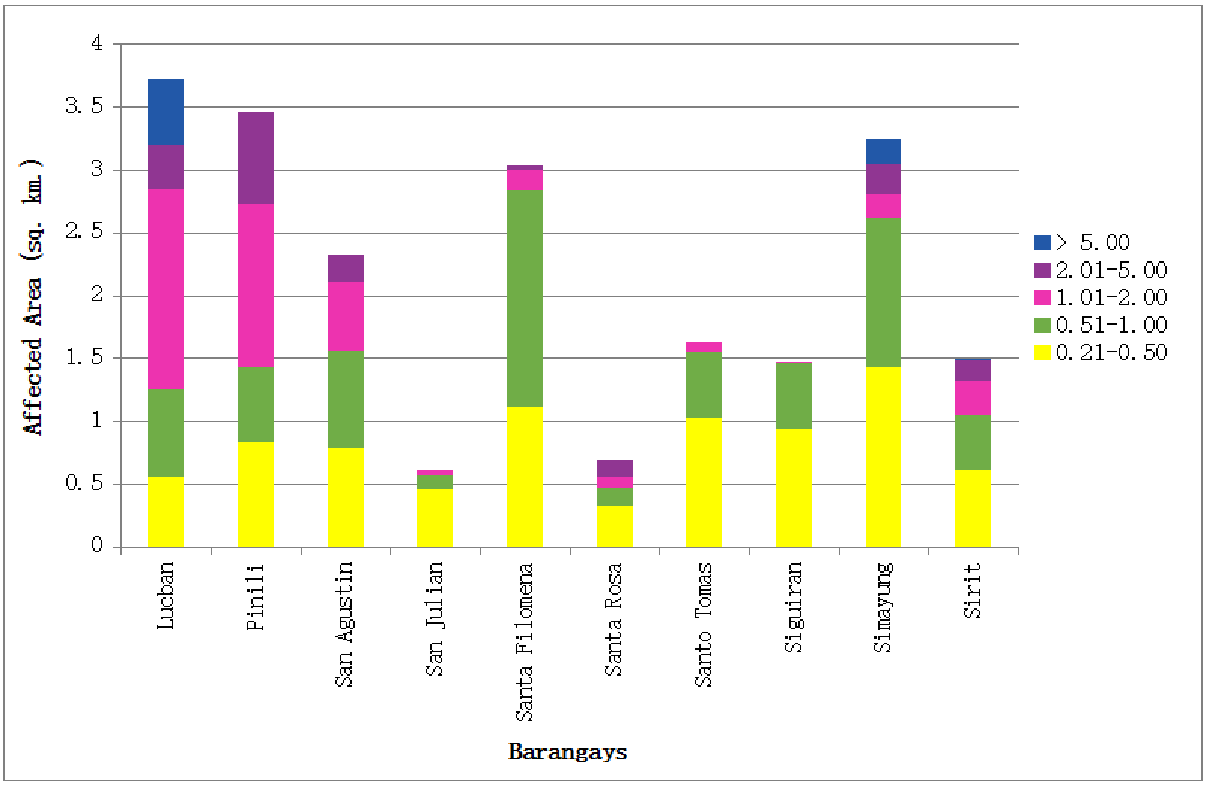


Figure 93. Affected Areas in Abulug, Cagayan during 25-Year Rainfall Return Period

For the 25-year return period, 15.98% of the municipality of Pamplona with an area of 206.54514 sq. km. will experience flood levels of less than 0.20 meters. 4.22% of the area will experience flood levels of 0.21 to 0.50 meters while 4.03%, 3.50%, 1.11%, and 0.04% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 62. Affected Areas in Pamplona, Cagayan during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Pamplona (in sq. km)				
	Abanqueruan	Bagu	Curva	Santa Cruz	Tabba
0.03-0.20	2.72	2.14	13.25	14.6	0.31
0.21-0.50	0.37	0.61	4.62	3.03	0.092
0.51-1.00	0.34	0.6	3.87	3.47	0.039
1.01-2.00	0.23	0.13	3.53	3.29	0.045
2.01-5.00	0.017	0.42	0.61	1.25	0
> 5.00	0.0001	0.014	0.049	0.013	0

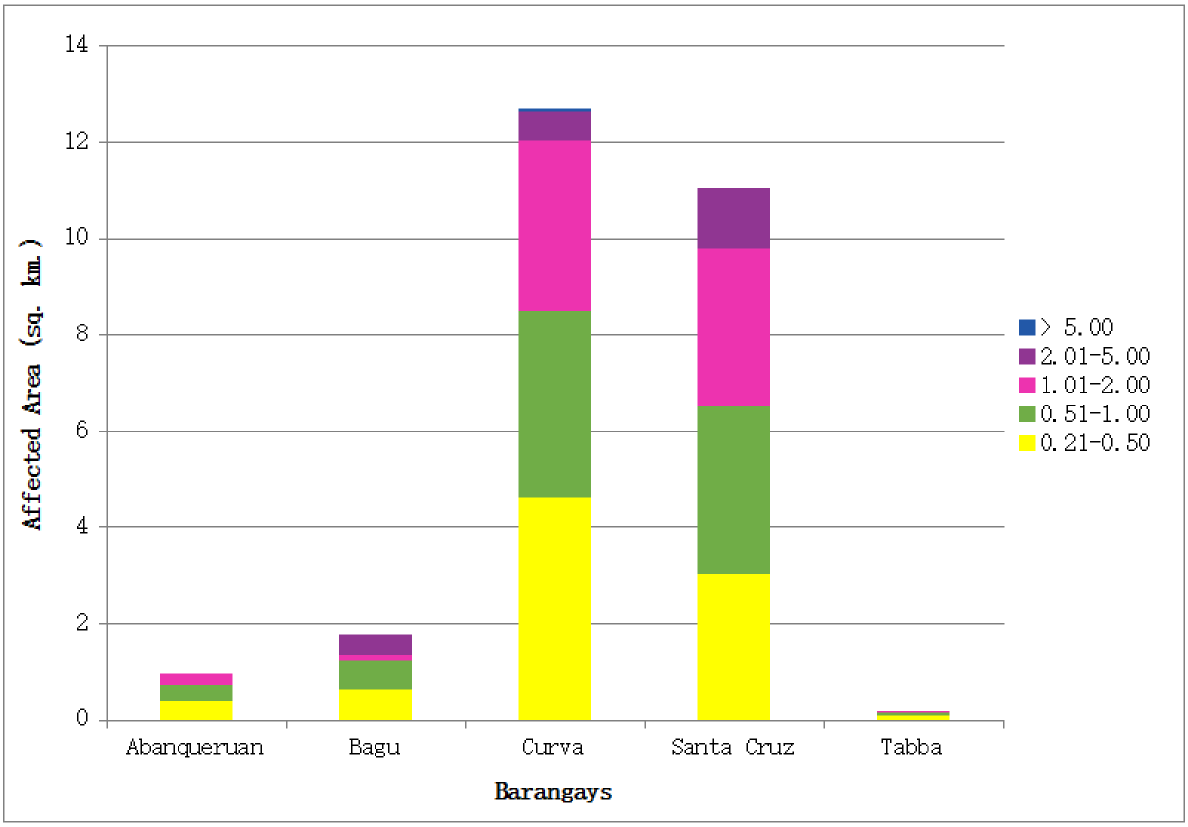


Figure 94. Affected Areas in Pamplona, Cagayan during 25-Year Rainfall Return

For the 25-year return period, 11.86% of the municipality of Luna with an area of 603.00757 sq. km. will experience flood levels of less than 0.20 meters. 0.85% of the area will experience flood levels of 0.21 to 0.50 meters while 1.05%, 2.08%, 2.62%, and 1.41% 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 63. Affected Areas in Luna, Apayao during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Luna (in sq. km)									
	Bacsay	Calabigan	Cangisitan	Capagaypayan	Dagupan	Lappa	Luyon	Poblacion	Quirino	Salvacion
0.03-0.20	4.62	0.19	0.57	0.26	2.67	5.92	8.3	2.02	0.096	2.38
0.21-0.50	0.34	0.0036	0.16	0.26	0.26	0.26	0.26	0.42	0.085	0.14
0.51-1.00	0.37	0.0019	0.23	0.49	0.48	0.3	0.18	0.51	0.35	0.17
1.01-2.00	0.63	0.0011	0.36	0.42	0.9	0.71	0.3	0.66	2.27	0.27
2.01-5.00	0.99	0.001	0.53	0.39	1.7	0.77	0.37	0.57	0.78	0.21
> 5.00	0.22	0	3.01	0.0021	0.16	0.0082	0.011	0.0004	0.35	0.0076

Table 64. Affected Areas in Luna, Apayao during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Luna (in sq. km)								
	San Francisco	San Gregorio	San Isidro Norte	San Isidro Sur	San Sebastian	Shalom	Tumog	Turod	Zumigui
0.03-0.20	3.48	3.83	0.029	0.57	0.085	12.75	0.89	16.05	6.81
0.21-0.50	0.37	0.34	0.0072	0.12	0.014	0.83	0.065	0.61	0.61
0.51-1.00	0.59	0.25	0.055	0.25	0.092	0.84	0.1	0.39	0.66
1.01-2.00	1.29	0.54	0.54	1.05	0.4	0.65	0.29	0.35	0.88
2.01-5.00	1.57	0.62	0.53	1.4	2.12	0.54	1.67	0.58	0.44
> 5.00	1.12	0.0061	0	0.31	2.67	0.15	0.35	0.11	0.0052

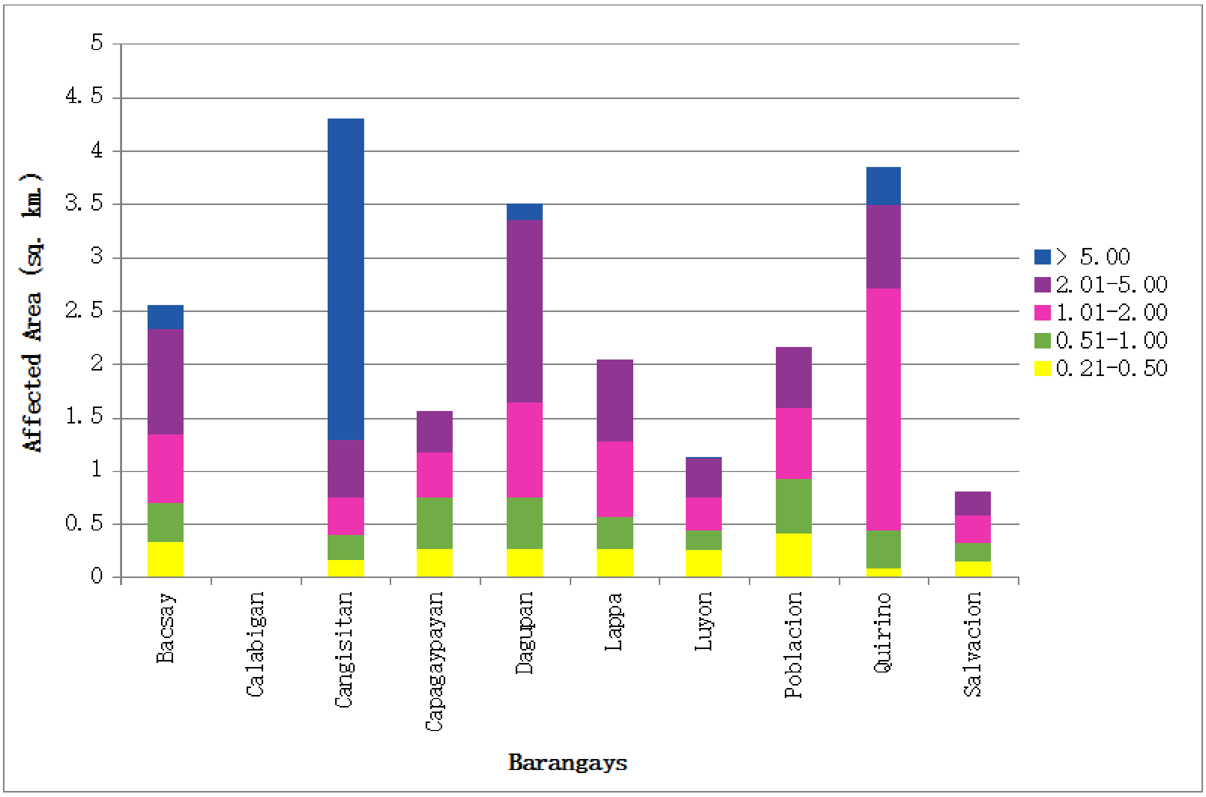


Figure 95. Affected Areas in Luna, Apayao during 25-Year Rainfall Return Period

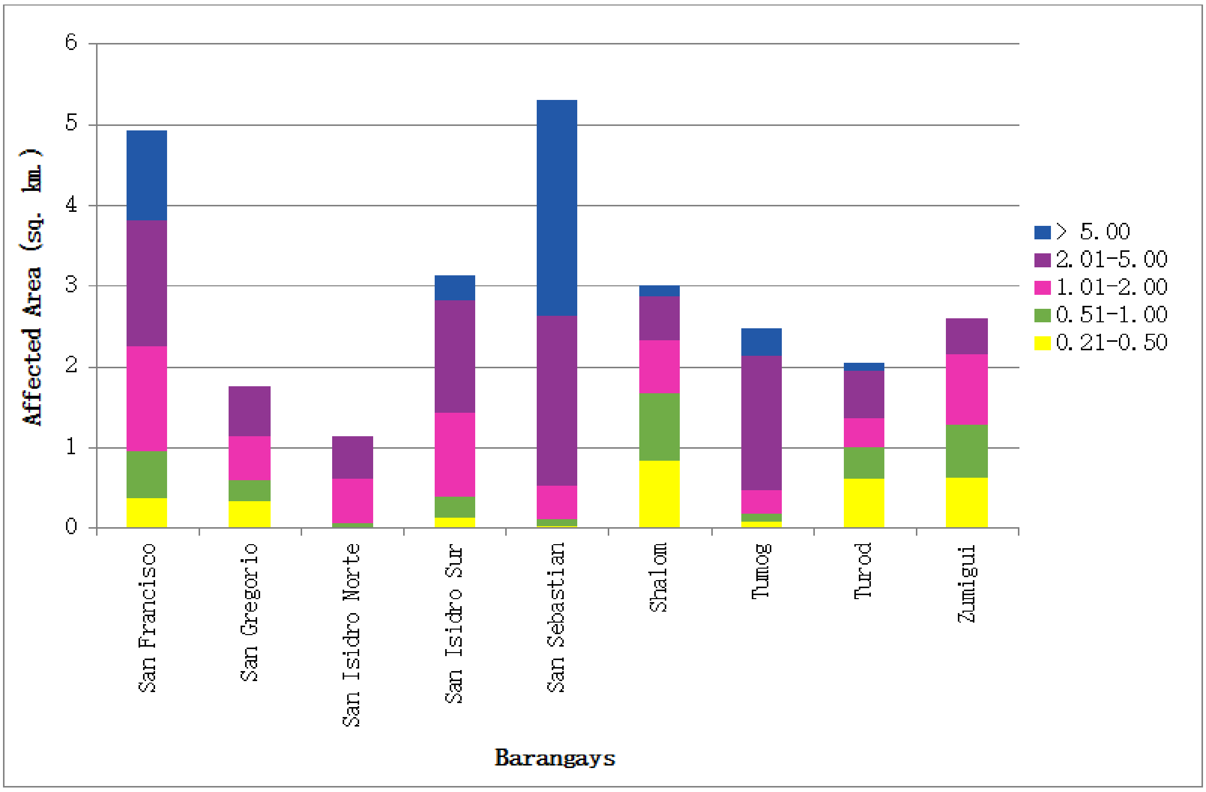


Figure 96. Affected Areas in Luna, Apayao during 25-Year Rainfall Return Period

For the 25-year return period, 6.47% of the municipality of Flora with an area of 321.67048 sq. km. will experience flood levels of less than 0.20 meters. 1.18% of the area will experience flood levels of 0.21 to 0.50 meters while 1.07%, 0.82%, 1.49%, and 1.44% 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 65. Affected Areas in Flora, Apayao during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Flora (in sq. km)					
	Atok	**Bagutong**	**Balasi**	**Poblacion East**	**Poblacion West**	**Tamalunog**
0.03-0.20	0.9	9.38	0.89	7.24	0.45	1.95
0.21-0.50	0.041	2.12	0.035	1.15	0.034	0.43
0.51-1.00	0.031	1.58	0.03	1.36	0.014	0.44
1.01-2.00	0.037	1.32	0.043	0.93	0.032	0.26
2.01-5.00	0.15	3.97	0.1	0.44	0.12	0.0061
> 5.00	0.45	2.21	0.5	0.27	1.2	0

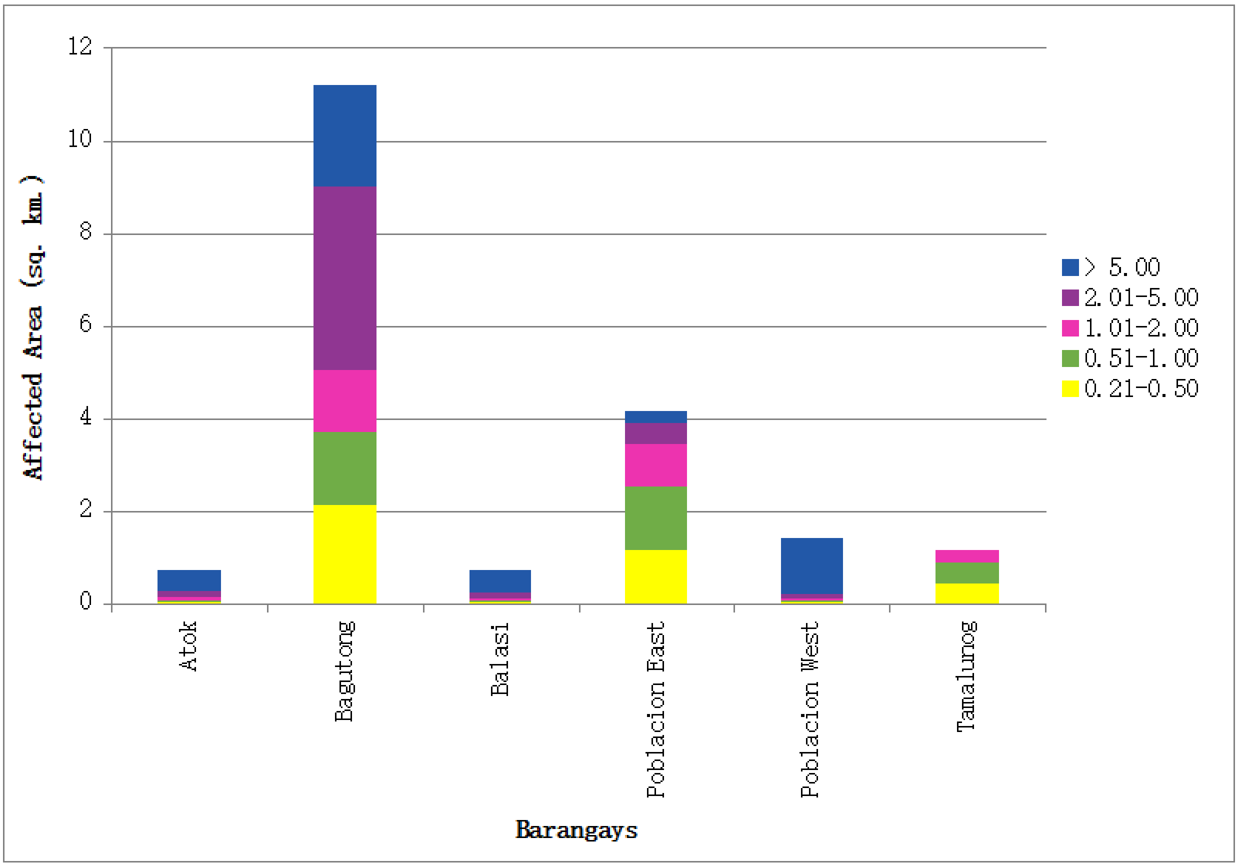


Figure 97. Affected Areas in Flora, Apayao during 25-Year Rainfall Return Period

For the 25-year return period, 23.50% of the municipality of Santa Marcela with an area of 47.22664 sq. km. will experience flood levels of less than 0.20 meters. 3.82% of the area will experience flood levels of 0.21 to 0.50 meters while 5.71%, 12.44%, 18.79%, and 42.85% 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 66. Affected Areas in Santa Marcela, Apayao during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Santa Marcela (in sq. km)											
	Barocboc	Consuelo	Emiliana	Malekkeg	Marcela	Nueva	Panay	San Antonio	San Carlos	San Juan	San Mariano	Sipa Proper
0.03-0.20	0.11	2.99	0.14	0.16	1.32	1.12	1.25	1.5	0.066	2.09	0.069	0.27
0.21-0.50	0.0068	0.31	0.15	0.11	0.25	0.29	0.23	0.14	0.042	0.16	0.0017	0.1
0.51-1.00	0.016	0.36	0.48	0.2	0.42	0.29	0.22	0.21	0.19	0.17	0.0049	0.13
1.01-2.00	0.071	0.3	1.15	0.79	0.81	0.2	0.55	0.37	1.34	0.23	0.017	0.048
2.01-5.00	1.72	0.26	0.5	1.93	0.22	0.71	0.81	0.00066	0.74	0.23	1.64	0.12
> 5.00	3.65	0.38	1.56	0	0.29	0.52	0	6.63	0.63	0.00087	4.88	1.69

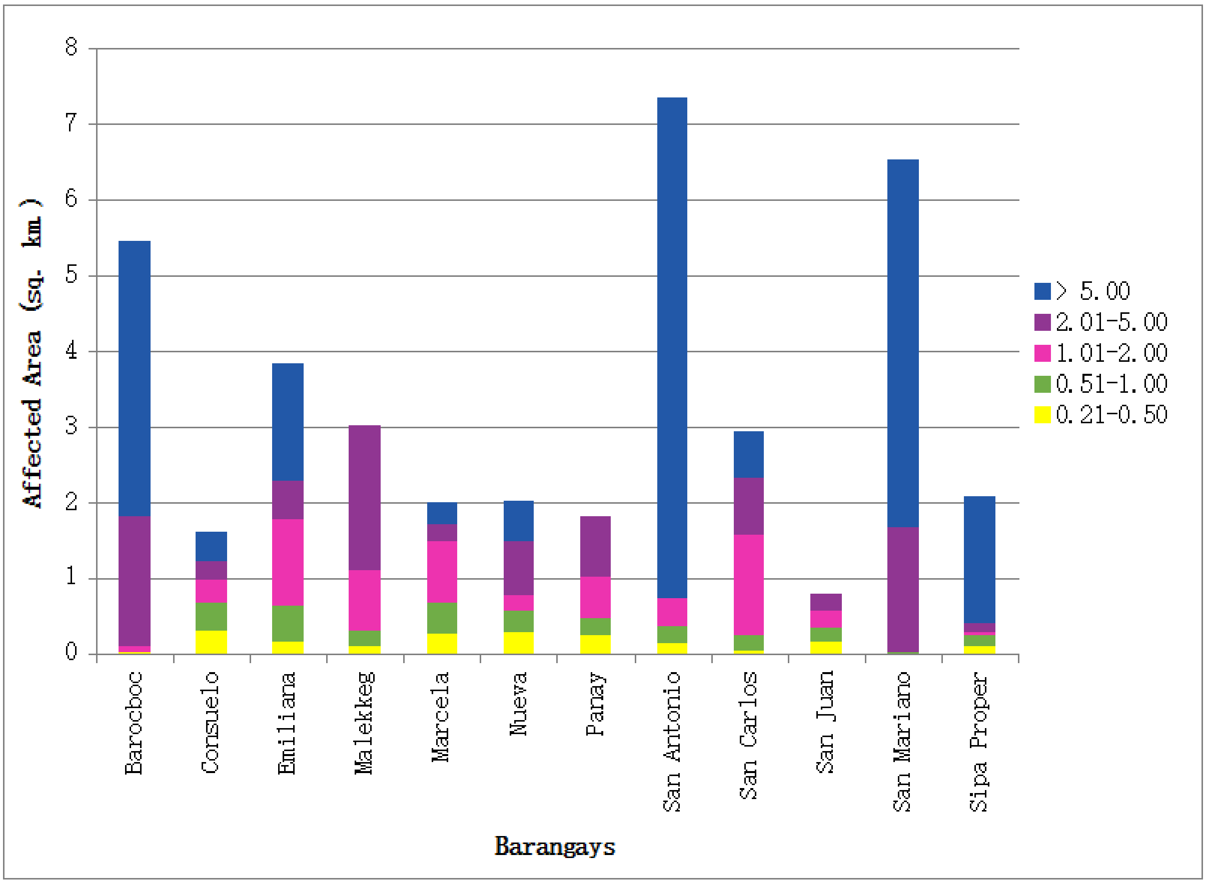


Figure 98. Affected Areas in Santa Marcela, Apayao during 25-Year Rainfall Return Period

For the 25-year return period, 0.52% of the municipality of Pudtol with an area of 283.65926 sq. km. will experience flood levels of less than 0.20 meters. 0.05% of the area will experience flood levels of 0.21 to 0.50 meters while 0.10%, 0.28%, 1.98%, and 4.34% 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 67. Affected Areas in Pudtol, Apayao during 25-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Pudtol (in sq. km)				
	Alem	Amado	Cabatacan	Emilia	Imelda
0.03-0.20	0.00045	0.41	0.67	0.033	0.36
0.21-0.50	0.00008	0.018	0.042	0.00058	0.074
0.51-1.00	0.014	0.014	0.048	0.0006	0.22
1.01-2.00	0.069	0.027	0.3	0.0012	0.4
2.01-5.00	2.14	0.69	1.71	0.067	0.99
> 5.00	3	0.16	0.38	2.05	6.72

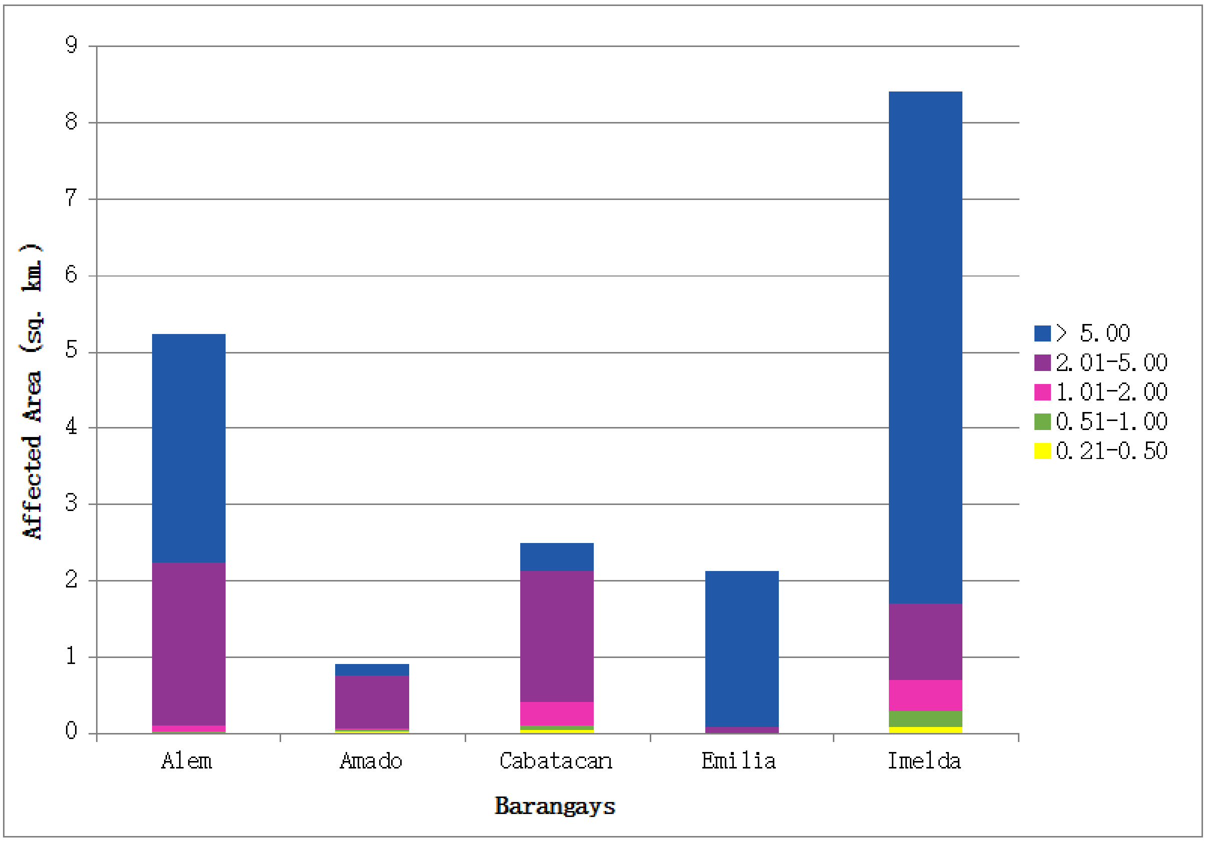


Figure 99. Affected Areas in Pudtol, Apayao during 25-Year Rainfall Return Period

For the 100-year return period, 5.66% of the municipality of Allacapan with an area of 252.24 sq. km. will experience flood levels of less than 0.20 meters. 0.57% of the area will experience flood levels of 0.21 to 0.50 meters while 0.69%, 1.45%, 5.51%, and 1.30% 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 68. Affected Areas in Allacapan, Cagayan during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Allacapan (in sq. km)	
	Cataratan	Silangan
0.03-0.20	4.08	10.21
0.21-0.50	0.25	1.18
0.51-1.00	0.3	1.44
1.01-2.00	0.4	3.26
2.01-5.00	1.05	12.85
> 5.00	1.76	1.5

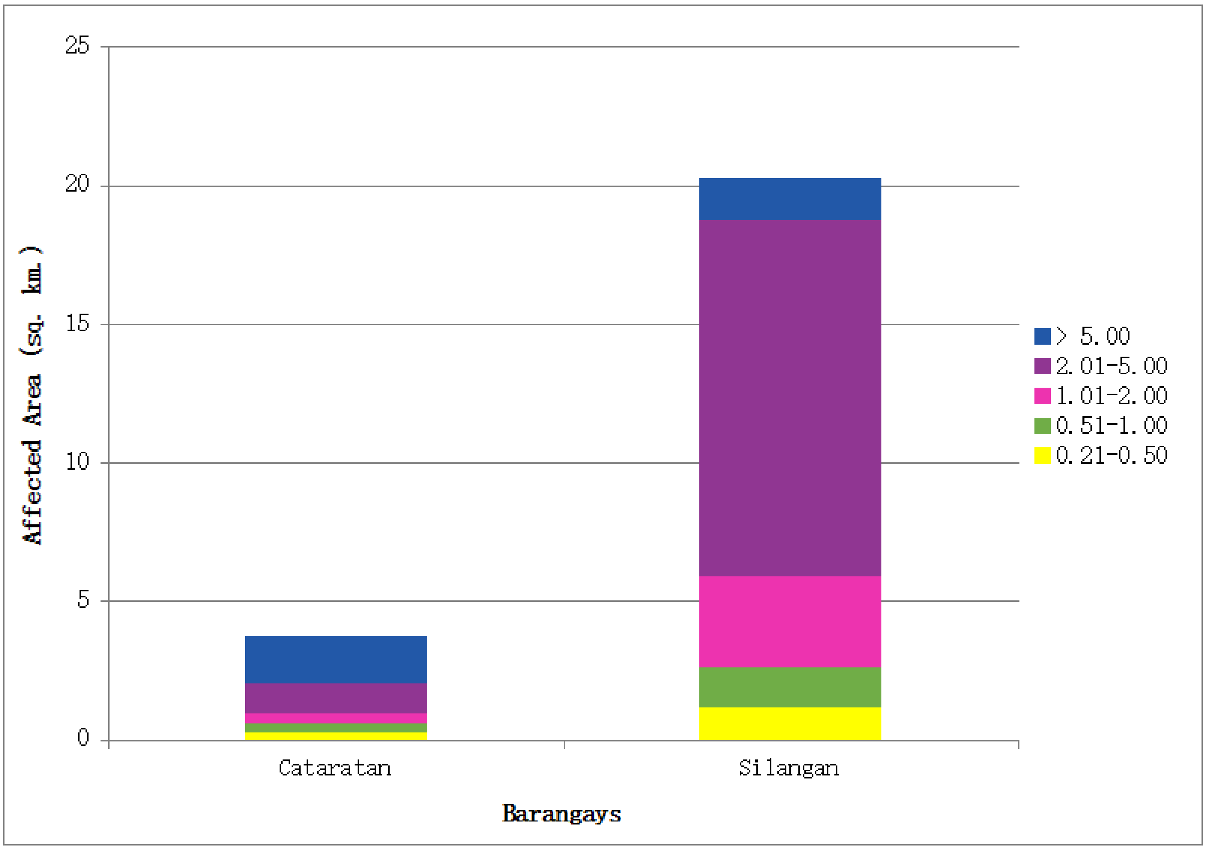


Figure 100. Affected Areas in Allacapan, Cagayan during 100-Year Rainfall Return Period

For the 100-year return period, 8.35% of the municipality of Ballesteros with an area of 117.917 sq. km. will experience flood levels of less than 0.20 meters. 1.70% of the area will experience flood levels of 0.21 to 0.50 meters while 1.90%, 2.98%, 4.84%, and 0.25% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 69. Affected Areas in Ballesteros, Cagayan during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Ballesteros (in sq. km)								
	Baran	**Cabaritan East**	**Cabaritan West**	**Cabayu**	**Cabuluan West**	**Fugu**	**Nararagan**	**San Juan**	**Zitanga**
0.03-0.20	0.22	0.61	1.3	1.61	0.015	0.37	3.03	1.98	0.7
0.21-0.50	0.0073	0.14	0.7	0.23	0.0006	0.02	0.67	0.2	0.03
0.51-1.00	0.0072	0.12	0.69	0.38	0.00003	0.023	0.84	0.15	0.032
1.01-2.00	0.0098	0.047	0.21	0.95	0	0.036	1.96	0.25	0.042
2.01-5.00	0.015	0	0.0003	3.81	0	0.055	1.48	0.29	0.064
> 5.00	0.0037	0	0	0.044	0	0	0.24	0.00087	0

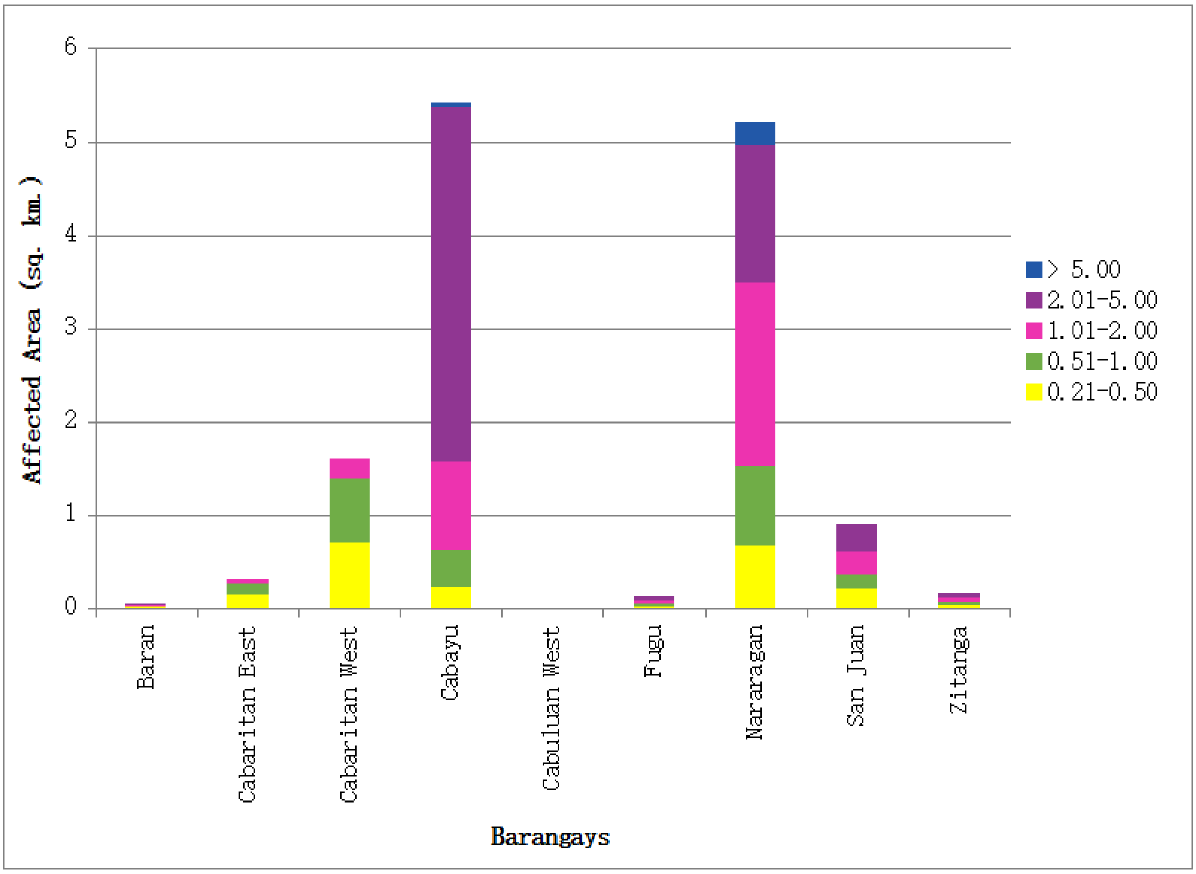


Figure 101. Affected Areas in Ballesteros, Cagayan during 100-Year Rainfall Return Period

For the 100-year return period, 22.15% of the municipality of Abulug with an area of 123.18878 sq. km. will experience flood levels of less than 0.20 meters. 14.00% of the area will experience flood levels of 0.21 to 0.50 meters while 15.84%, 12.24%, 25.44%, and 6.41% 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 70. Affected Areas in Abulug, Cagayan during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Abulug (in sq. km)									
	Alinunu	Bagu	Banguian	Calog Norte	Calog Sur	Canayun	Centro	Dana-Ili	Guiddam	Libertad
0.03-0.20	3.34	1.95	3.91	0.035	0.058	1.01	0.7	5.87	0.17	0.15
0.21-0.50	2.18	0.56	1.72	0.04	0.034	1.11	0.31	5.13	0.056	0.077
0.51-1.00	2.05	0.74	1.43	0.1	0.085	1.47	0.3	5.19	0.17	0.2
1.01-2.00	0.84	0.22	1.88	0.48	0.18	0.9	0.088	1.52	1.77	0.5
2.01-5.00	0.54	0.0001	2.68	3.59	2.13	1.37	0.0004	0.74	9.64	4.32
> 5.00	0.18	0.021	0.79	0.6	1.3	0.34	0	0.15	1.56	1.53

Table 71. Affected Areas in Abulug, Cagayan during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Abulug (in sq. km)									
	Lucban	Pinili	San Agustin	San Julian	Santa Filomena	Santa Rosa	Santo Tomas	Siguiran	Simayung	Sirit
0.03-0.20	0.59	0.32	1.6	0.66	2.57	0.48	0.92	1.66	0.21	1.07
0.21-0.50	0.38	0.3	0.47	0.5	0.86	0.34	1.08	0.93	0.5	0.63
0.51-1.00	0.61	0.78	0.64	0.14	2.05	0.2	0.77	0.73	1.37	0.47
1.01-2.00	1.02	1.22	0.89	0.075	0.36	0.043	0.15	0.039	2.4	0.5
2.01-5.00	1.84	2.28	1.28	0	0.043	0.19	0	0	0.33	0.37
> 5.00	0.54	0.0036	0.56	0	0	0	0	0	0.24	0.079

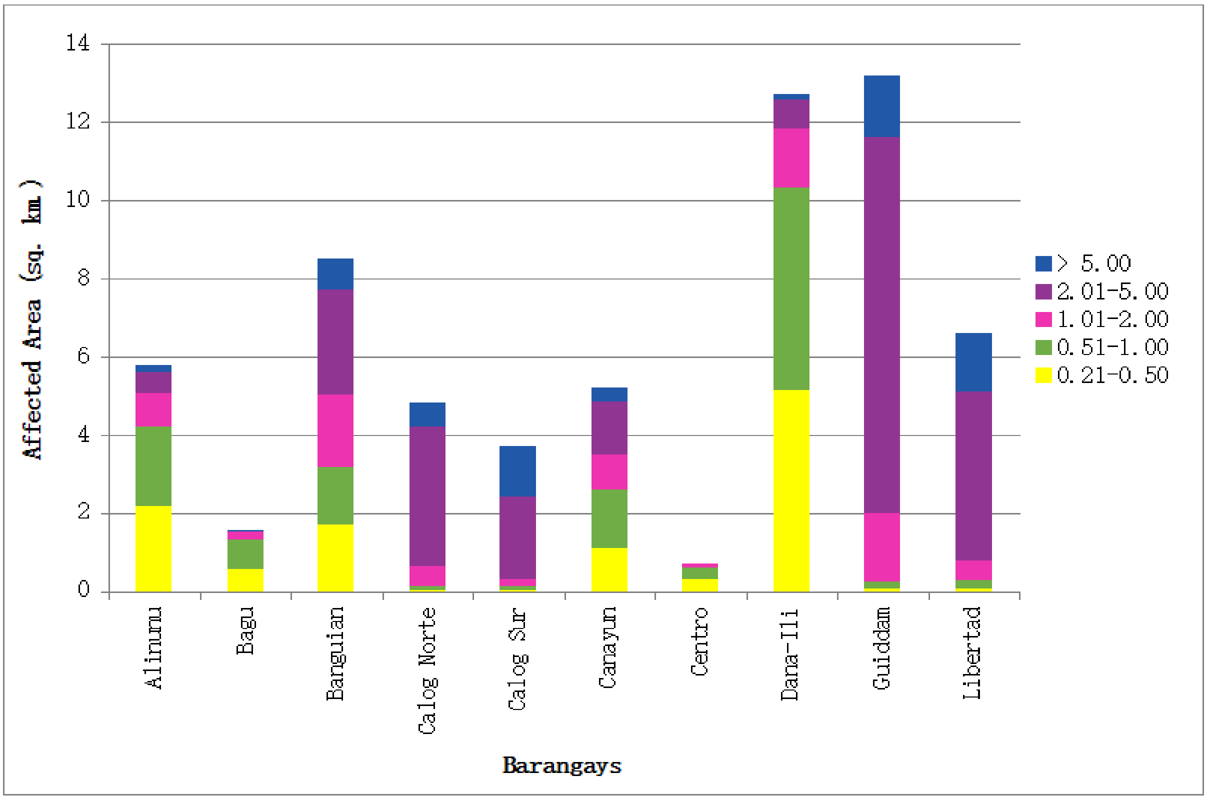


Figure 102. Affected Areas in Abulug, Cagayan during 100-Year Rainfall Return Period

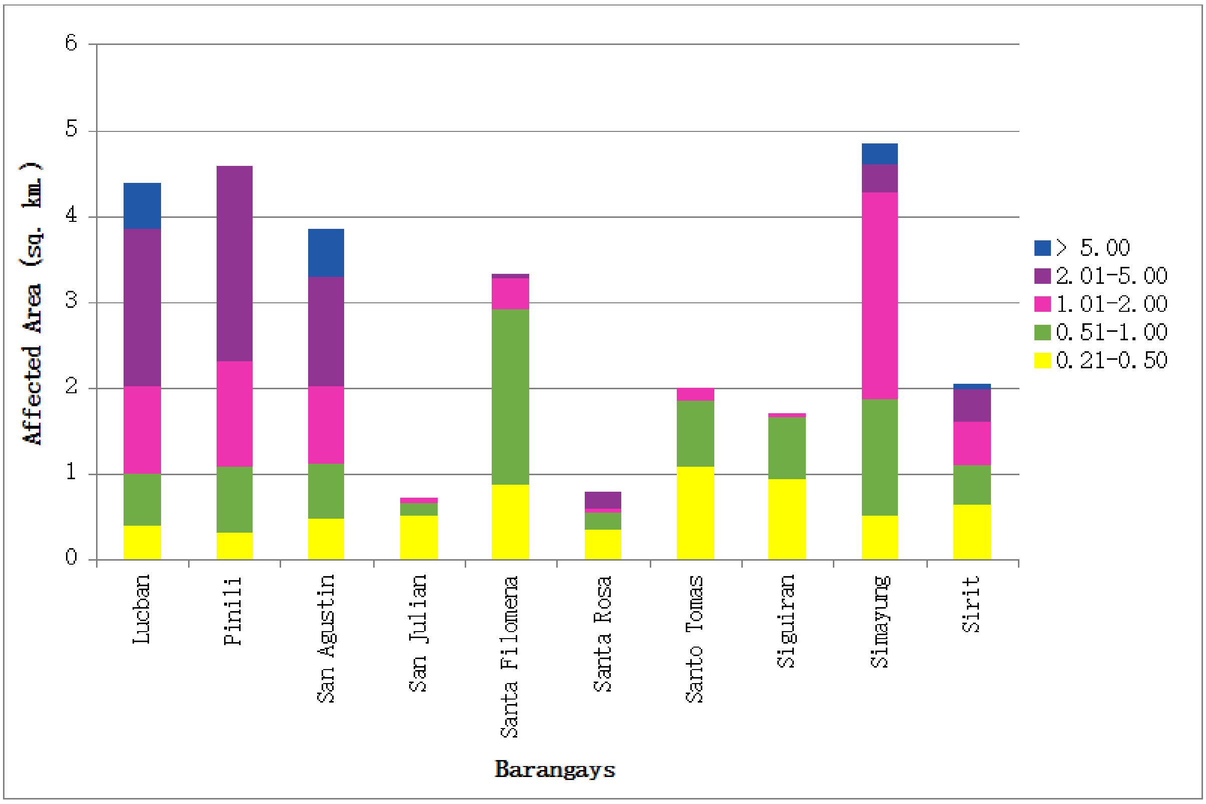


Figure 103. Affected Areas in Abulug, Cagayan during 100-Year Rainfall Return Period

For the 100-year return period, 13.74% of the municipality of Pamplona with an area of 206.54514 sq. km. will experience flood levels of less than 0.20 meters. 3.67% of the area will experience flood levels of 0.21 to 0.50 meters while 4.41%, 4.47%, 2.33%, and 0.06% 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 72. Affected Areas in Pamplona, Cagayan during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Pamplona (in sq. km)				
	Abanqueruan	Bagu	Curva	Santa Cruz	Tabba
0.03-0.20	2.6	1.95	10.23	13.33	0.27
0.21-0.50	0.38	0.56	3.8	2.74	0.1
0.51-1.00	0.37	0.74	4.39	3.55	0.06
1.01-2.00	0.3	0.22	4.7	3.96	0.049
2.01-5.00	0.031	0.0001	2.74	2.04	0
> 5.00	0.0001	0.021	0.075	0.023	0

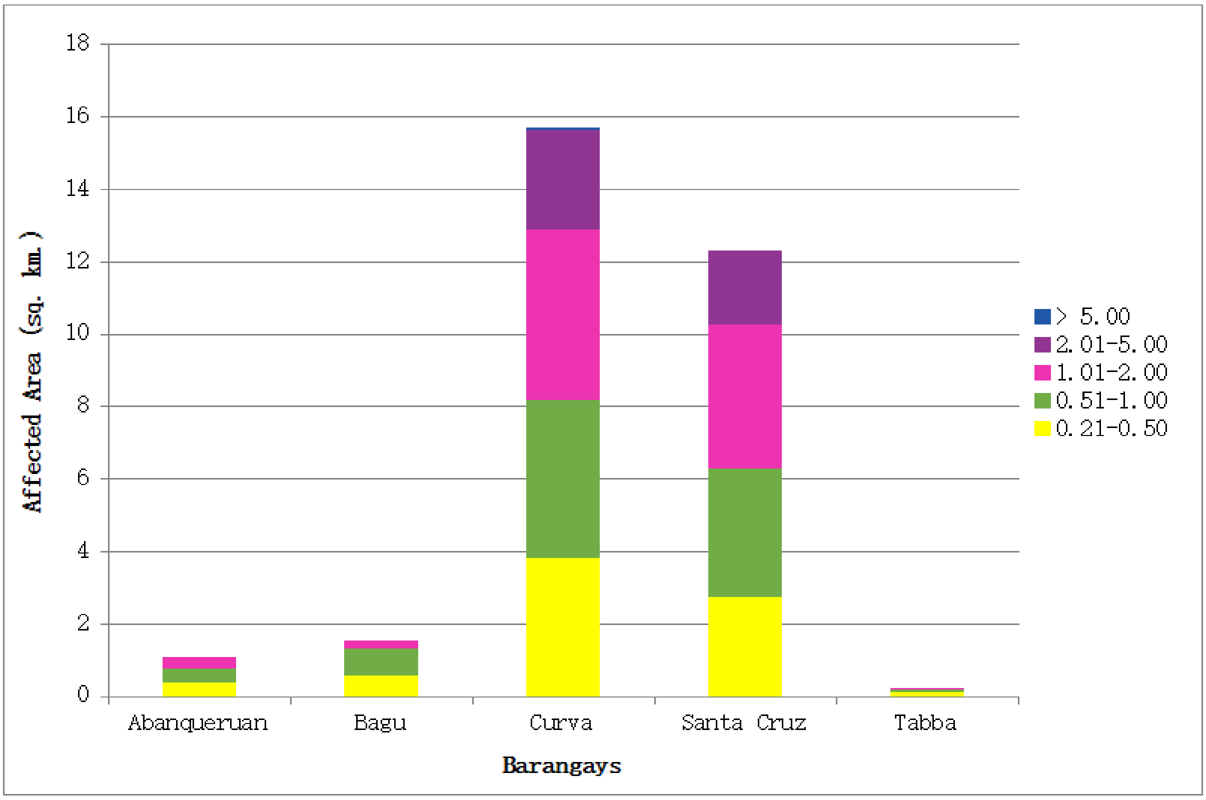


Figure 104. Affected Areas in Pamplona, Cagayan during 100-Year Rainfall Return Period

For the 100-year return period, 11.43% of the municipality of Luna with an area of 603.00757 sq. km. will experience flood levels of less than 0.20 meters. 0.75% of the area will experience flood levels of 0.21 to 0.50 meters while 0.82%, 1.22%, 3.62%, and 2.02% 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 73. Affected Areas in Luna, Apayao during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Luna (in sq. km)									
	Bacsay	Calabigan	Cangisitan	Capagaypayan	Dagupan	Lappa	Luyon	Poblacion	Quirino	Salvacion
0.03-0.20	4.41	0.19	0.52	0.099	2.35	5.83	8.21	1.83	0.039	2.32
0.21-0.50	0.27	0.0036	0.14	0.088	0.17	0.26	0.27	0.39	0.031	0.14
0.51-1.00	0.26	0.0021	0.24	0.27	0.36	0.27	0.16	0.51	0.058	0.16
1.01-2.00	0.52	0.0014	0.25	0.22	0.63	0.61	0.23	0.69	0.059	0.28
2.01-5.00	1.34	0.0011	0.59	1.04	1.88	0.97	0.52	0.76	3.37	0.27
> 5.00	0.36	0	3.13	0.1	0.79	0.022	0.041	0.0013	0.39	0.019

Table 74. Affected Areas in Luna, Apayao during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Luna (in sq. km)								
	San Francisco	San Gregorio	San Isidro Norte	San Isidro Sur	San Sebastian	Shalom	Tumog	Turod	Zumigui
0.03-0.20	3.15	3.69	0.005	0.45	0.076	12.44	0.82	15.84	6.66
0.21-0.50	0.32	0.35	0.0014	0.056	0.0072	0.79	0.041	0.65	0.56
0.51-1.00	0.44	0.24	0.003	0.056	0.029	0.81	0.063	0.43	0.6
1.01-2.00	0.83	0.42	0.021	0.23	0.26	0.76	0.23	0.38	0.75
2.01-5.00	1.99	0.87	1.13	2.1	1.54	0.75	1.28	0.63	0.83
> 5.00	1.69	0.023	0	0.8	3.49	0.2	0.94	0.17	0.015

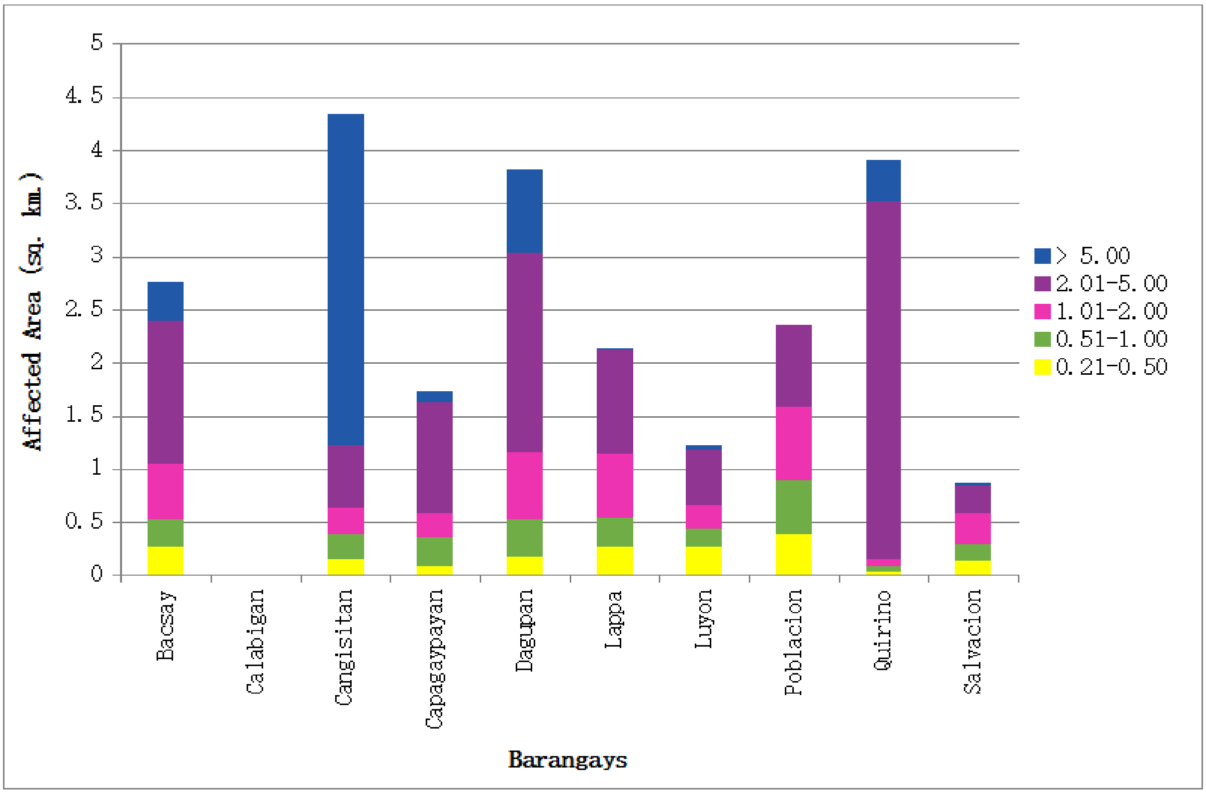


Figure 105. Affected Areas in Luna, Apayao during 100-Year Rainfall Return Period

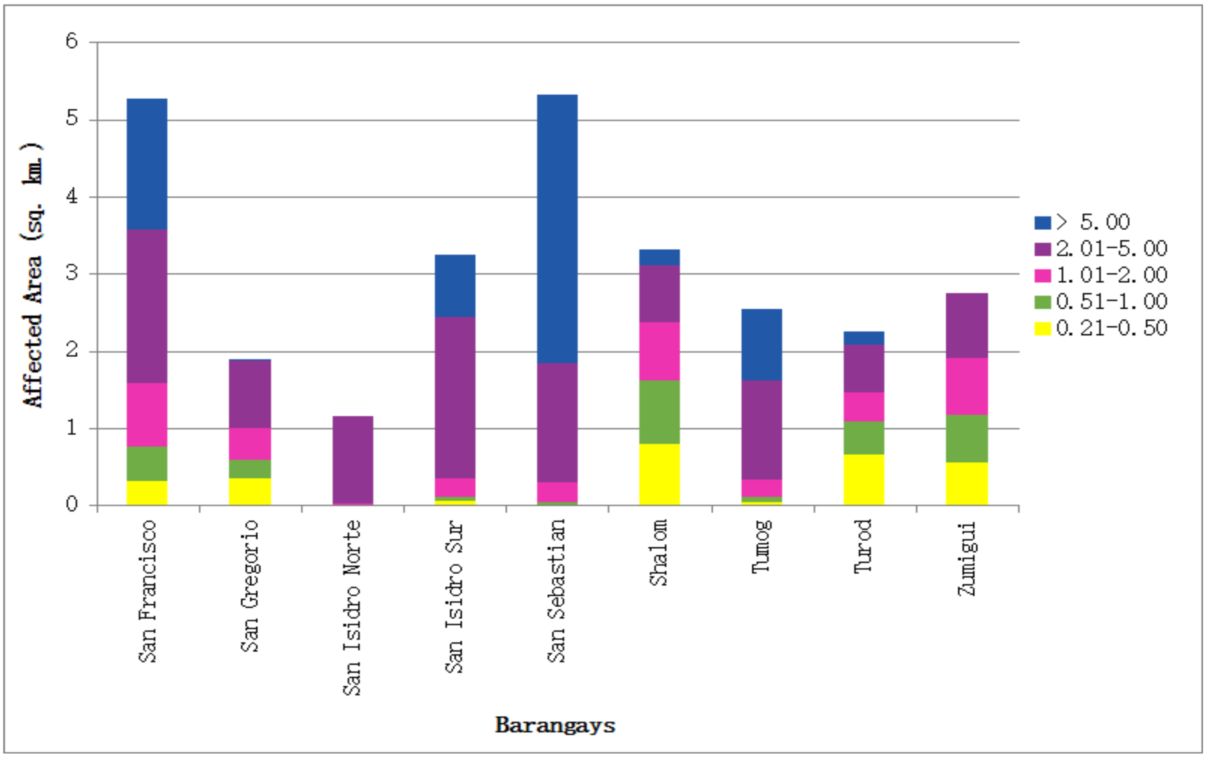


Figure 106. Affected Areas in Luna, Apayao during 100-Year Rainfall Return Period

For the 100-year return period, 5.94% of the municipality of Flora with an area of 321.67048 sq. km. will experience flood levels of less than 0.20 meters. 1.13% of the area will experience flood levels of 0.21 to 0.50 meters while 1.10%, 0.97%, 1.10%, and 2.24% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 75. Affected Areas in Flora, Apayao during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Flora (in sq. km)					
	Atok	Bagutong	Balasi	Poblacion East	Poblacion West	Tamalunog
0.03-0.20	0.83	8.48	0.81	6.8	0.42	1.76
0.21-0.50	0.034	2.09	0.031	1.13	0.041	0.3
0.51-1.00	0.026	1.76	0.021	1.34	0.014	0.39
1.01-2.00	0.032	1.53	0.028	1.05	0.013	0.47
2.01-5.00	0.084	2.56	0.074	0.59	0.066	0.16
> 5.00	0.61	4.17	0.64	0.48	1.3	0.0004

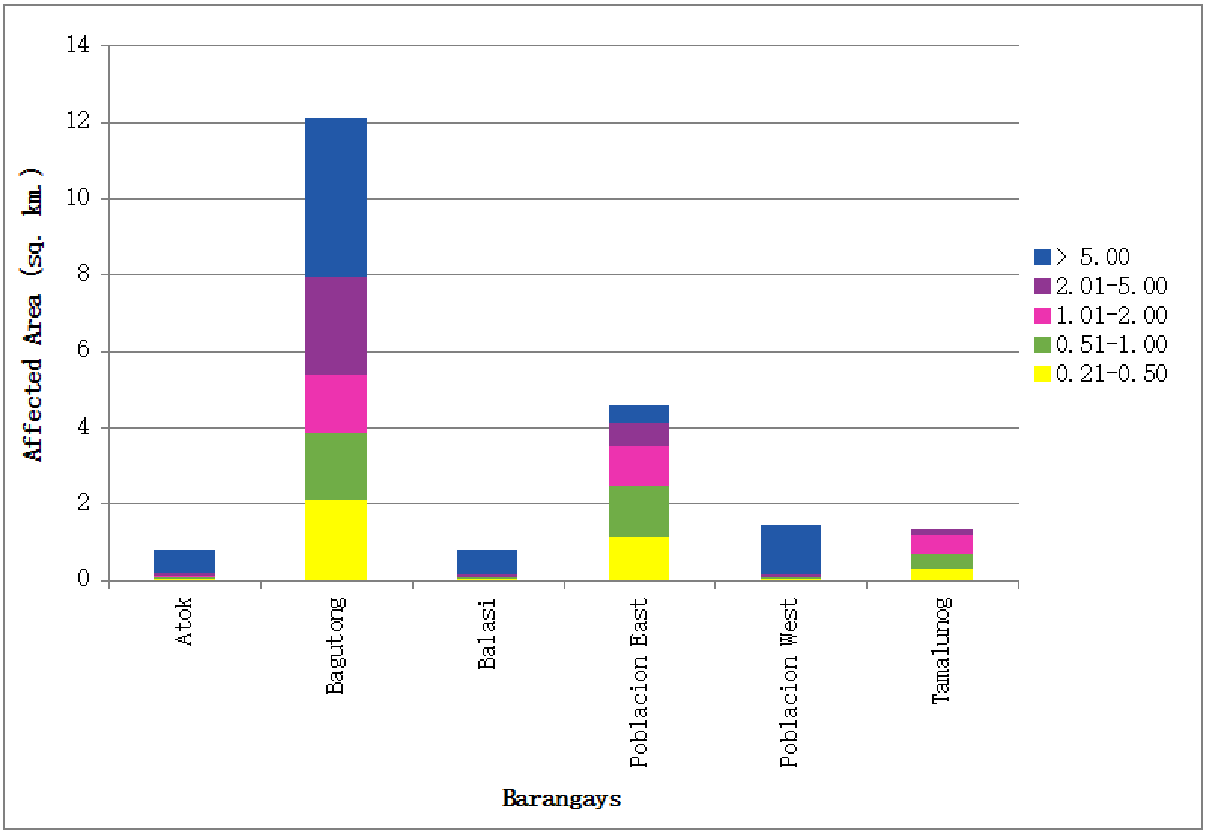


Figure 107. Affected Areas in Flora, Apayao during 100-Year Rainfall Return Period

For the 100-year return period, 20.71% of the municipality of Santa Marcela with an area of 47.22664 sq. km. will experience flood levels of less than 0.20 meters. 3.19% of the area will experience flood levels of 0.21 to 0.50 meters while 4.47%, 9.04%, 22.03%, and 48.55% 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 76. Affected Areas in Santa Marcela, Apayao during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Santa Marcela (in sq. km)											
	Barocboc	Consuelo	Emiliana	Malekkeg	Marcela	Nueva	Panay	San Antonio	San Carlos	San Juan	San Mariano	Sipa Proper
0.03-0.20	0.1	2.82	0.055	0.068	1.1	0.88	1.05	1.38	0.042	1.98	0.062	0.22
0.21-0.50	0.0048	0.3	0.049	0.016	0.21	0.33	0.17	0.13	0.0085	0.2	0.0016	0.083
0.51-1.00	0.0095	0.37	0.25	0.052	0.4	0.34	0.18	0.16	0.045	0.15	0.005	0.15
1.01-2.00	0.037	0.45	0.65	0.4	0.92	0.28	0.37	0.3	0.51	0.25	0.0077	0.084
2.01-5.00	1.14	0.11	1.29	2.58	0.39	0.45	1.26	0.65	1.67	0.29	0.53	0.063
> 5.00	4.28	0.55	1.7	0.071	0.3	0.86	0.032	6.63	0.74	0.00087	6.01	1.75

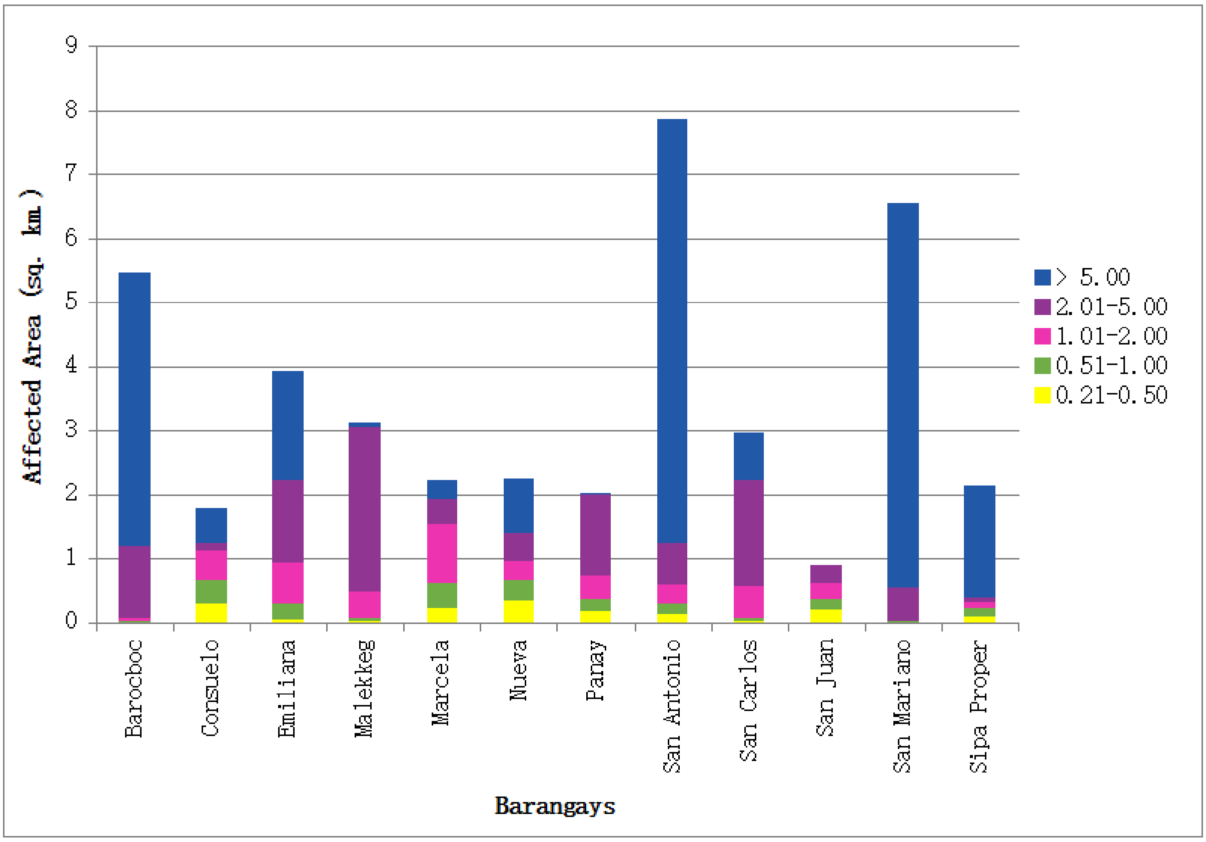


Figure 108. Affected Areas in Santa Marcela, Apayao during 100-Year Rainfall Return Period

For the 100-year return period, 0.47% of the municipality of Pudtol with an area of 283.65926 sq. km. will experience flood levels of less than 0.20 meters. 0.02% of the area will experience flood levels of 0.21 to 0.50 meters while 0.02%, 0.09%, 1.06%, and 5.61% 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 77. Affected Areas in Pudtol, Apayao during 100-Year Rainfall Return Period

Affected Area (sq. km.) by flood depth (in m.)	Affected Barangays in Pudtol (in sq. km)				
	Alem	Amado	Cabatacan	Emilia	Imelda
0.03-0.20	0	0.4	0.61	0.031	0.28
0.21-0.50	0	0.015	0.036	0.00058	0.012
0.51-1.00	0.00034	0.013	0.029	0.00098	0.024
1.01-2.00	0.00032	0.018	0.079	0.0012	0.16
2.01-5.00	0.71	0.12	1.35	0.012	0.83
> 5.00	4.52	0.76	1.05	2.11	7.46

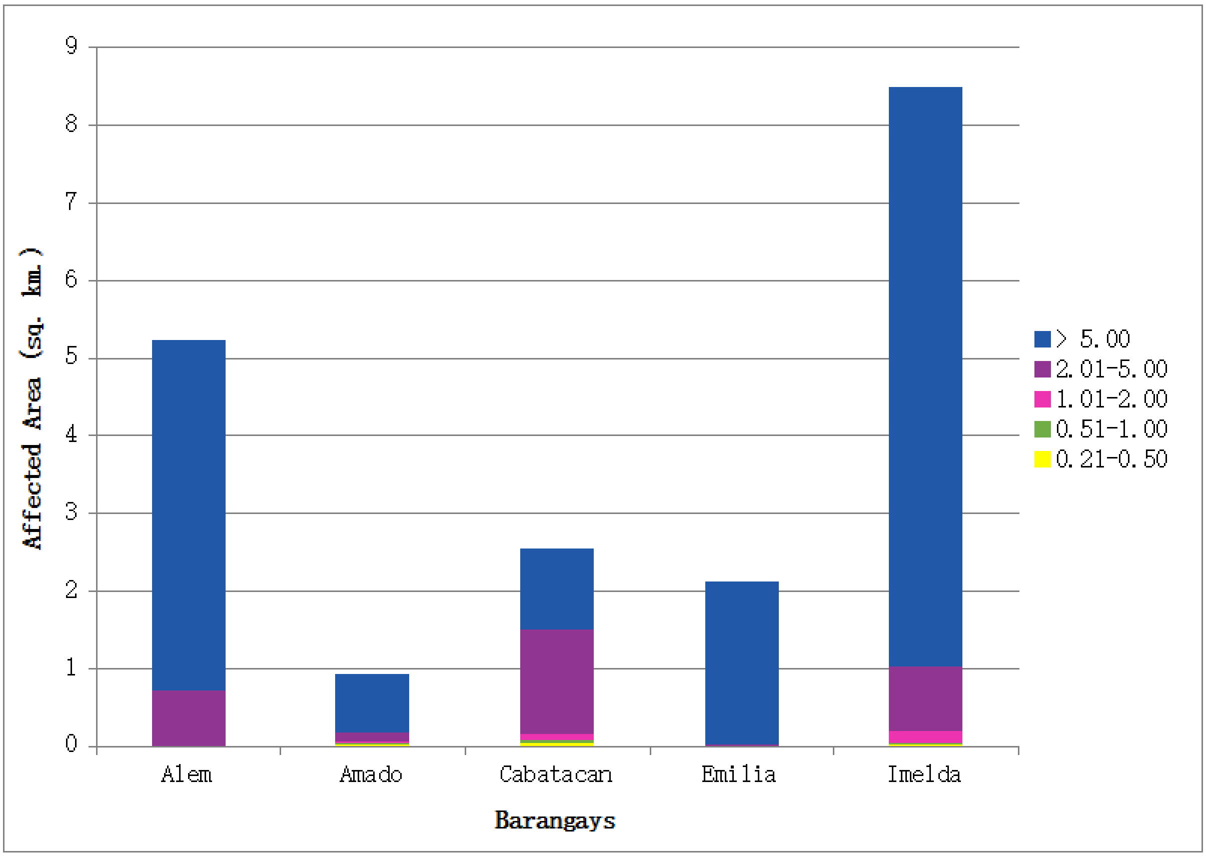


Figure 109. Affected Areas in Pudtol, Apayao during 100-Year Rainfall Return Period

Among the barangays in the municipality of Allacapan in Cagayan, Silangan is projected to have the highest percentage of area that will experience flood levels at 12.07%. Meanwhile, Cataratan posted the second highest percentage of area that may be affected by flood depths at 3.11%.

Among the barangays in the municipality of Ballesteros in Cagayan, Nararagan is projected to have the highest percentage of area that will experience flood levels at 6.96%. Meanwhile, Cabayu posted the second highest percentage of area that may be affected by flood depths at 5.94%.

.

Among the barangays in the municipality of Abulug in Cagayan, Dana-Ili is projected to have the highest percentage of area that will experience flood levels at 15.11%. Meanwhile, Guiddam posted the second highest percentage of area that may be affected by flood depths at 10.85%.

Among the barangays in the municipality of Pamplona in Cagayan, Curva is projected to have the highest percentage of area that will experience flood levels at 12.56%. Meanwhile, Santa Cruz posted the second highest percentage of area that may be affected by flood depths at 12.41%.

Among the barangays in the municipality of Luna in Apayao, Turod is projected to have the highest percentage of area that will experience flood levels at 3.00%. Meanwhile, Shalom posted the second highest percentage of area that may be affected by flood depths at 2.61%.

Among the barangays in the municipality of Flora in Apayao, Bagutong is projected to have the highest percentage of area that will experience flood levels at 6.40%. Meanwhile, Poblacion East posted the second highest percentage of area that may be affected by flood depths at 3.54%.

Among the barangays in the municipality of Pudtol in Apayao, Imelda is projected to have the highest percentage of area that will experience flood levels at 3.09%. Meanwhile, San Antonio posted the second highest percentage of area that may be affected by flood depths at 2.34%.

Among the barangays in the municipality of Santa Marcela in 0, San Antonio is projected to have the highest percentage of area that will experience flood levels at 14.04%. Meanwhile, San Mariano posted the second highest percentage of area that may be affected by flood depths at 14.00%.

.

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

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

Table 78. Affected Areas in Pudtol, Apayao during 100-Year Rainfall Return Period

Warning Level	Area Covered in sq. km.		
	5 year	25 year	100 year
Low	56.49	47.87	39.00
Medium	58.16	74.34	70.99
High	100.38	152.74	195.85
TOTAL	215.03	274.95	305.83

Of the 116 identified educational institutions in the Abulog-Apayao floodplain, 15 schools were assessed to be highly prone to flooding as they are exposed to the High level flooding for all three rainfall scenarios. Seven other institutions were found to be also susceptible to flooding, experiencing Medium level flooding in the 5-year return period, and High level flooding in the 25- and 100-year rainfall scenarios. See **Appendix D.**

21 medical institutions were identified in the Abulog-Apayao floodplain. Cabatacan Health Center and Imelda Barangay Clinic in Brgy. Alem, Swan Rural Health Center in Brgy. Emilia, Barangay Health Center in Brgy. Nueva, and Dental Clinic in Brgy. San Mariano were found to be highly prone to flooding, having High level flooding in all three rainfall scenarios. See **Appendix E.**

5.11 Flood Validation

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

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

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

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

The flood validation consists of 293 points randomly selected all over the Abulog-Apayao flood plain. It has an RMSE value of 1.54. The validation points can be seen in Annex 11.

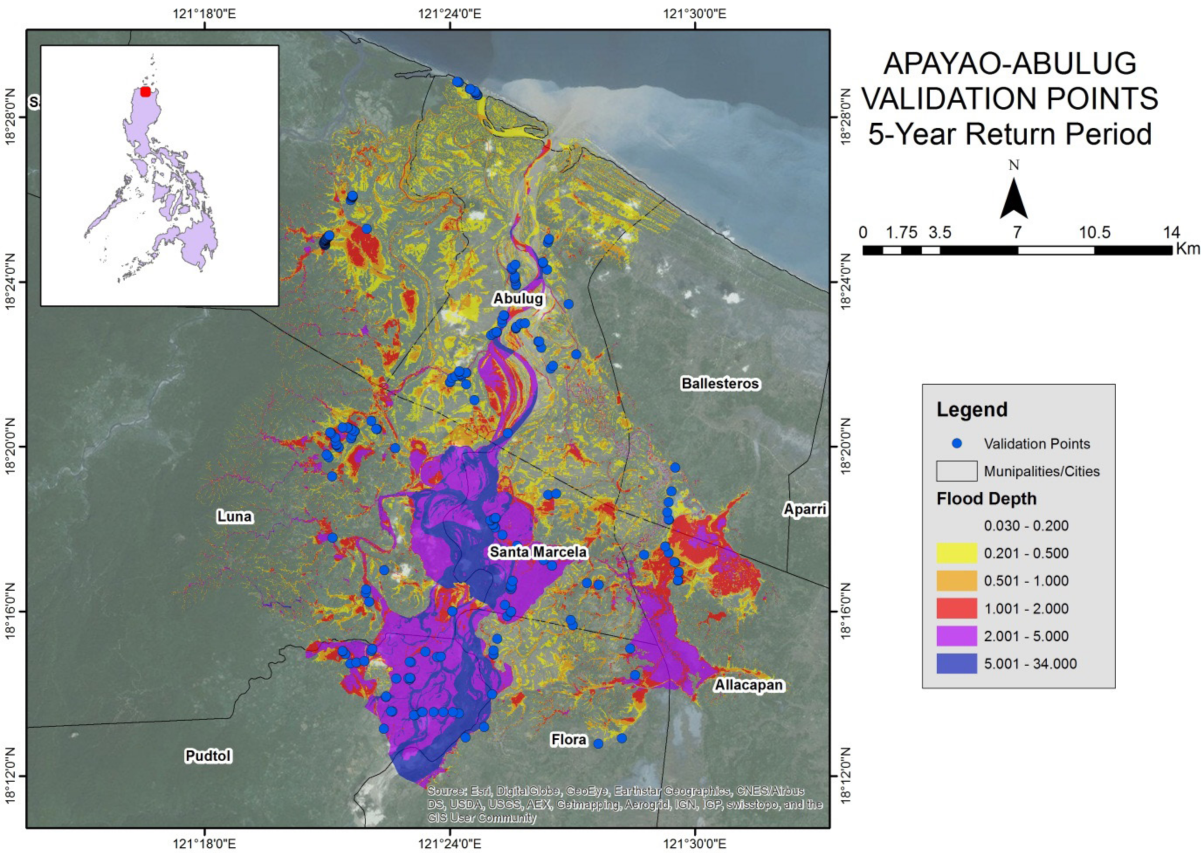


Figure 110. Abulog-Apayao Flood Validation Points

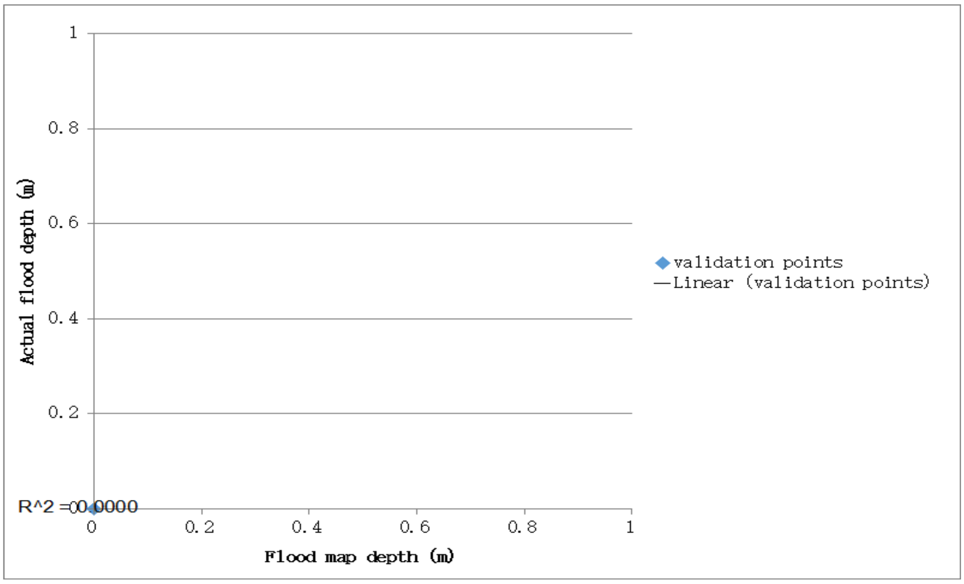


Figure 111. Flood map depth vs actual flood depth

Table 79. Actual flood vs simulated flood depth at different levels in the Abulog-Apayao River Basin.

ABULOG-APAYAO 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	25	2	0	5	9	3	44
	0.21-0.50	34	5	9	2	11	1	62
	0.51-1.00	65	27	13	7	6	1	119
	1.01-2.00	20	10	2	4	8	0	44
	2.01-5.00	8	2	1	3	9	1	24
	> 5.00	0	0	0	0	0	0	0
	Total	152	46	25	21	43	6	293

The overall accuracy generated by the flood model is estimated at 19.05%, with 56 points correctly matching the actual flood depths. In addition, there were 93 points estimated one level above and below the correct flood depths while there were 84 points and 61 points estimated two levels above and below, and three or more levels above and below the correct flood depth. A total of 66 points were overestimated while a total of 172 points were underestimated in the modelled flood depths of Abulog-Apayao. Table 80 depicts the summary of the Accuracy Assessment in the Abulog-Apayao River Basin Survey.

Table 80. The summary of the Accuracy Assessment in the Abulog-Apayao River Basin Survey

	No. of Points	%
Correct	56	19.11
Overestimated	65	22.18
Underestimated	172	58.70
Total	293	100

REFERENCES

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

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

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

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

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

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

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

ANNEXES

Annex 1. Technical Specifications of the LIDAR Sensors used in the Abulog-Apayao Floodplain Survey

GEMINI SENSOR

Table A-1.1. Technical Specifications of the LiDAR Sensors used in the Abulog-Apayao Floodplain Survey

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

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

1. CGY-79

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

November 11, 2015

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: **CAGAYAN**
Station Name: **CGY-79**
Order: **1st**

Island: **LUZON**
Municipality: **ALCALA**
Barangay: **PIGATAN**
MSL Elevation:

		PRS92 Coordinates			
Latitude:	**17° 57' 33.77158"**	Longitude:	**121° 39' 32.24272"**	Ellipsoidal Hgt:	**23.91500 m.**
		WGS84 Coordinates			
Latitude:	**17° 57' 27.65319"**	Longitude:	**121° 39' 36.84994"**	Ellipsoidal Hgt:	**58.77300 m.**
		PTM / PRS92 Coordinates			
Northing:	**1986390.847 m.**	Easting:	**569801.488 m.**	Zone:	**3**
		UTM / PRS92 Coordinates			
Northing:	**1,986,084.36**	Easting:	**357,988.51**	Zone:	**51**

Location Description

CGY-79
Is located on top of a riprap about 5 m. from the road centerline and 40 m. N of the NE end of Pigatan Bridge located along the nat'l. highway 20 km. from Gattaran or 10 km. from Alcala Proper. Mark is the head of a 3 in. copper nail centered on a 30 cm. x 30 cm. cement putty, with inscriptions "CGY-79 2007 NAMRIA".

Requesting Party: **UP DREAM**
Purpose: **Reference**
OR Number: **8088606 I**
T.N.: **2015-3726**

for

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

9 9 1 1 1 1 2 0 1 5 1 5 0 3 5 7

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.1. CGY-79

2. APA-13

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

December 18, 2013

CERTIFICATION

To whom it may concern:

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

	Province: **APAYAO**	
	Station Name: **APA-13**	
Island: **LUZON**	Order: **2nd**	Barangay: **TUMOG**
Municipality: **LUNA**		
	PRS92 Coordinates	
Latitude: **18° 19' 2.39264"**	Longitude: **121° 22' 58.62210"**	Ellipsoidal Hgt: **17.98200 m.**
	WGS84 Coordinates	
Latitude: **18° 18' 56.17679"**	Longitude: **121° 23' 3.20117"**	Ellipsoidal Hgt: **51.00500 m.**
	PTM Coordinates	
Northing: **2025924.156 m.**	Easting: **540482.023 m.**	Zone: **3**
	UTM Coordinates	
Northing: **2,025,930.60**	Easting: **329,102.89**	Zone: **51**

Location Description

APA-13

From the Mun. Hall of Luna, travel towards the direction going to Pudtol. In approx. 15 mins., you will reach the brgy. hall of Tumog in Luna. 30 m fromt he said brgy. hall, an access road is located. This access road will lead you to the brgy. property lot where the station was established. Station is located 8 m from the N edge of the PCCP, and 70 m NE of a waiting shed. Mark is the head of a brass rod with cross cut on top set flushed at the center of a 30 cm x 30 cm x 120 cm concrete monument with inscriptions, "APA-13, 2007, NAMRIA".

Requesting Party:	**UP-DREAM**
Pupose:	**Reference**
OR Number:	**8794962 A**
T.N.:	**2013-1593**

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

9 9 1 2 1 8 2 0 1 3 1 3 3 6 4 7

CERTIFICATION INTERNATIONAL ISO 9001:2008
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

Figure A-2.2. APA-13

3. CGY-58

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

October 22, 2013

CERTIFICATION

To whom it may concern:

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

Province: **CAGAYAN**
Station Name: **CGY-58**
Order: **2nd**

Island: **LUZON**
Municipality: **SOLANA**
Barangay: **UBONG**

	PRS92 Coordinates	
Latitude: **17° 36' 27.61645"**	Longitude: **121° 36' 25.76184"**	Ellipsoidal Hgt: **40.71600 m.**
	WGS84 Coordinates	
Latitude: **17° 36' 21.57004"**	Longitude: **121° 36' 30.39868"**	Ellipsoidal Hgt: **76.59000 m.**
	PTM Coordinates	
Northing: **1947447.881 m.**	Easting: **564440.235 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,947,206.45**	Easting: **352,213.18**	Zone: **51**

Location Description

CGY-58
Is located 15 m. E of the junction of the road leading to Brgy. Ubong and the road leading to Brgy. Karilukud. It is situated 10 m. SE of Brgy. Ubong welcome monument. Mark is the head of a 3 in. copper nail set flushed on top of a standard concrete monument, with inscriptions "CGY-58 2007 NAMRIA".

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **3947072 B**
T.N.: **2013-1136**

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

9 9 1 0 2 2 2 0 1 3 1 6 5 3 3 4

CERTIFICATION INTERNATIONAL ISO 9001:2008
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

Figure A-2.3. CGY-58

4. CGY-66

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

October 29, 2013

CERTIFICATION

To whom it may concern:

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

Province: **CAGAYAN**
Station Name: **CGY-66**
Order: **2nd**

Island: **LUZON**
Municipality: **PIAT**
Barangay: **WARAT**

	PRS92 Coordinates	
Latitude: **17° 42' 56.12254"**	Longitude: **121° 34' 50.13936"**	Ellipsoidal Hgt: **51.90200 m.**
	WGS84 Coordinates	
Latitude: **17° 42' 50.05073"**	Longitude: **121° 34' 54.76735"**	Ellipsoidal Hgt: **87.36400 m.**
	PTM Coordinates	
Northing: **1959382.34 m.**	Easting: **561584.309 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,959,169.01**	Easting: **349,484.16**	Zone: **51**

Location Description

CGY-66
Is located within the compound of Warat Brgy. Hall, along G. Cusupig St., approx. 15 m. S of the waiting shed. Mark is the head of a 3 in. copper nail set flushed on top of a standard concrete monument, with inscriptions "CGY-66 2007 NAMRIA".

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **3947072 B**
T.N.: **2013-1167**

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

9 9 1 0 2 9 2 0 1 3 1 2 3 3 0 1

CERTIFICATION INTERNATIONAL ISO 9001:2008
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

Figure A-2.4. CGY-66

5. CGY-70

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

November 05, 2013

CERTIFICATION

To whom it may concern:

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

Province: **CAGAYAN**
Station Name: **CGY-70**
Order: **2nd**

Island: **LUZON**
Municipality: **AMULUNG**
Barangay: **ESTEFANIA**

PRS92 Coordinates

Latitude:	**17° 47' 54.79038"**	Longitude:	**121° 43' 31.26837"**	Ellipsoidal Hgt:	**26.85900 m.**

WGS84 Coordinates

Latitude:	**17° 47' 48.71170"**	Longitude:	**121° 43' 35.88859"**	Ellipsoidal Hgt:	**62.40000 m.**

PTM Coordinates

Northing:	**1968617.425 m.**	Easting:	**576904.118 m.**	Zone:	**3**

UTM Coordinates

Northing:	**1,968,239.03**	Easting:	**364,899.00**	Zone:	**51**

Location Description

CGY-70
Is located inside Estefania Elem. School campus. It is situated 1 m. E of the NE corner of the basketball court. Mark is the head of a 3 in. copper nail set flushed on top of a standard concrete monument, with inscriptions "CGY-70 2007 NAMRIA".

Requesting Party:	**UP-TCAGP**
Pupose:	**Reference**
OR Number:	**3947129 B**
T.N.:	**2013-1200**

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

9 9 1 1 0 5 2 0 1 3 1 1 0 0 4 1

CERTIFICATION INTERNATIONAL ISO 9001:2008
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

Figure A-2.5. CGY-70

6. CGY-87

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

November 05, 2013

CERTIFICATION

To whom it may concern:

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

Province: **CAGAYAN**
Station Name: **CGY-87**
Order: **2nd**

Island: **LUZON**
Municipality: **LAL-LO**
Barangay: **CABAYABASAN**

	PRS92 Coordinates	
Latitude: **18° 3' 46.30032"**	Longitude: **121° 38' 38.76326"**	Ellipsoidal Hgt: **37.21200 m.**
	WGS84 Coordinates	
Latitude: **18° 3' 40.15861"**	Longitude: **121° 38' 43.36193"**	Ellipsoidal Hgt: **71.69600 m.**
	PTM Coordinates	
Northing: **1997837.978 m.**	Easting: **568188.029 m.**	Zone: **3**
	UTM Coordinates	
Northing: **1,997,546.44**	Easting: **356,498.94**	Zone: **51**

Location Description

CGY-87
Is located on a solar dryer at Brgy. Cabayabasan, fronting the brgy. hall. Mark is the head of a copper nail centered and flushed on a 30 cm. x 30 cm. concrete monument, with inscriptions "CGY-87 2007 NAMRIA".

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **3947129 B**
T.N.: **2013-1201**

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

9 9 1 1 0 5 2 0 1 3 1 1 0 1 2 2

CERTIFICATION INTERNATIONAL ISO 9001:2008
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

Figure A-2.6. CGY-87

7. CGY-91

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

November 11, 2015

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: **CAGAYAN**	
	Station Name: **CGY-91**	
	Order: **2nd**	
Island: **LUZON**	Barangay: **CENTRO WEST**	
Municipality: **ALLACAPAN**	MSL Elevation:	
	PRS92 Coordinates	
Latitude: **18° 13' 39.87307"**	Longitude: **121° 33' 17.08273"**	Ellipsoidal Hgt: **13.56400 m.**
	WGS84 Coordinates	
Latitude: **18° 13' 33.68932"**	Longitude: **121° 33' 21.66825"**	Ellipsoidal Hgt: **47.29300 m.**
	PTM / PRS92 Coordinates	
Northing: **2016055.507 m.**	Easting: **558673.063 m.**	Zone: **3**
	UTM / PRS92 Coordinates	
Northing: **2,015,863.99**	Easting: **347,183.80**	Zone: **51**

Location Description

CGY-91
From Magapit Bridge, travel along the nat'l. highway to Ilocos. Turn left to Allacapan Mun. Hall, which is between Km. Posts 695 and 694 (on the left side of the road). Station is located inside the town plaza's circle ground, on the N pathwalk, near the center of the grounds. Mark is the head of a copper nail centered and flushed on a 30 cm. x 30 cm. concrete monument, with inscriptions "CGY-91 2007 NAMRIA".

Requesting Party: **UP DREAM**
Purpose: **Reference**
OR Number: **8088606 I**
T.N.: **2015-3728**

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

9 9 1 1 1 1 2 0 1 5 1 5 0 4 4 8

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.7. CGY-91

8. CGY-110

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

November 11, 2015

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: **CAGAYAN**
Station Name: **CGY-110 (BLLM-1A)**
Order: **2nd**

Island:	**LUZON**	Barangay:	**CENTRO**		
Municipality:	**PAMPLONA**	MSL Elevation:			
		PRS92 Coordinates			
Latitude:	**18° 27' 58.94151"**	Longitude:	**121° 20' 19.10441"**	Ellipsoidal Hgt:	**16.83900 m.**
		WGS84 Coordinates			
Latitude:	**18° 27' 52.69074"**	Longitude:	**121° 20' 23.67135"**	Ellipsoidal Hgt:	**49.26200 m.**
		PTM / PRS92 Coordinates			
Northing:	**2042410.05 m.**	Easting:	**535767.119 m.**	Zone:	**3**
		UTM / PRS92 Coordinates			
Northing:	**2,042,467.48**	Easting:	**324,569.86**	Zone:	**51**

Location Description

CGY-110 (BLLM 1A)
From Magapit Bridge, travel along the nat'l. highway to Ilocos until reaching Pamplona Central School, which is across Pamplona Mun. Hall. Station is located inside the school compound, behind the first school bldg. to the left of the entrance gate. Mark is the head of a steel bolt centered and flushed on a 35 cm. x 35 cm. concrete monument, with inscriptions "BLLM No. 1A".

Requesting Party: **UP DREAM**
Purpose: **Reference**
OR Number: **8088606 I**
T.N.: **2015-3727**

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

9 9 1 1 1 1 2 0 1 5 1 5 0 4 2 1

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.8. CGY-110

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

1. EB1 Sanchez Mira

Table A-3.1. EB1 Sanchez Mira

Vector Components (Mark to Mark)

From:	EB Luna				
Grid		Local		Global	
Easting	329102.783 m	Latitude	N18°19'01.91041"	Latitude	N18°18'55.69460"
Northing	2025915.779 m	Longitude	E121°22'58.62268"	Longitude	E121°23'03.20176"
Elevation	12.523 m	Height	17.596 m	Height	50.619 m

To:	EB Sanchez Mira				
Grid		Local		Global	
Easting	313520.647 m	Latitude	N18°33'41.42270"	Latitude	N18°33'35.14388"
Northing	2053102.450 m	Longitude	E121°13'58.98381"	Longitude	E121°14'03.54346"
Elevation	6.180 m	Height	10.810 m	Height	42.665 m

Vector					
ΔEasting	-15582.136 m	NS Fwd Azimuth	329°40'08"	ΔX	17977.979 m
ΔNorthing	27186.671 m	Ellipsoid Dist.	31335.728 m	ΔY	916.409 m
ΔElevation	-6.342 m	ΔHeight	-6.786 m	ΔZ	25649.184 m

2. EB2 Sanchez Mira

Table A-3.2. EB2 Sanchez Mira

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
APA-13 --- EB2 Sanchez Mira (B3)	APA-13	EB2 Sanchez Mira	Fixed	0.004	0.014	329°39'07"	31319.818	-7.119
APA-13 --- EB2 Sanchez Mira (B6)	APA-13	EB2 Sanchez Mira	Fixed	0.005	0.027	329°39'07"	31319.803	-7.174

Acceptance Summary

Processed	Passed	Flag	Fail
2	2	0	0

Vector Components (Mark to Mark)

From:	APA-13				
Grid		Local		Global	
Easting	329102.897 m	Latitude	N18°19'02.39263"	Latitude	N18°18'56.17679"
Northing	2025930.604 m	Longitude	E121°22'58.62210"	Longitude	E121°23'03.20117"
Elevation	12.909 m	Height	17.982 m	Height	51.005 m

To:	EB2 Sanchez Mira				
Grid		Local		Global	
Easting	313520.652 m	Latitude	N18°33'41.30634"	Latitude	N18°33'35.02752"
Northing	2053098.872 m	Longitude	E121°13'58.98517"	Longitude	E121°14'03.54483"
Elevation	6.234 m	Height	10.864 m	Height	42.719 m

Vector					
ΔEasting	-15582.246 m	NS Fwd Azimuth	329°39'07"	ΔX	17975.077 m
ΔNorthing	27168.268 m	Ellipsoid Dist.	31319.818 m	ΔY	921.061 m
ΔElevation	-6.675 m	ΔHeight	-7.119 m	ΔZ	25631.615 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.004 m
σ ΔNorthing	0.002 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.006 m
σ ΔElevation	0.007 m	σ ΔHeight	0.007 m	σ ΔZ	0.003 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000146916		
Y	-0.0000202166	0.0000343022	
Z	-0.0000103500	0.0000150551	0.0000095610

3. ARPT

Table A-3.3. ARPT

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.004 m
σ ΔNorthing	0.001 m	σ Ellipsoid Dist.	0.001 m	σ ΔY	0.006 m
σ ΔElevation	0.007 m	σ ΔHeight	0.007 m	σ ΔZ	0.002 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000127245		
Y	-0.0000196861	0.0000358238	
Z	-0.0000069331	0.0000122190	0.0000056523

Vector Components (Mark to Mark)

From:	CGY-66				
Grid		Local		Global	
Easting	349484.163 m	Latitude	N17°42'56.12254"	Latitude	N17°42'50.05073"
Northing	1959169.007 m	Longitude	E121°34'50.13937"	Longitude	E121°34'54.76735"
Elevation	48.886 m	Height	51.902 m	Height	87.364 m

To:	ARPT				
Grid		Local		Global	
Easting	365697.564 m	Latitude	N17°38'35.74536"	Latitude	N17°38'29.70094"
Northing	1951050.094 m	Longitude	E121°44'02.31321"	Longitude	E121°44'06.94633"
Elevation	24.276 m	Height	27.155 m	Height	63.218 m

Vector					
ΔEasting	16213.401 m	NS Fwd Azimuth	116°10'06"	ΔX	-15115.447 m
ΔNorthing	-8118.914 m	Ellipsoid Dist.	18135.300 m	ΔY	-6491.935 m
ΔElevation	-24.610 m	ΔHeight	-24.747 m	ΔZ	-7633.540 m

Annex 4. The LIDAR Survey Team Composition

Table A-4.1. The LiDAR Survey Team Composition

Data Acquisition Component Sub -Team	Designation	Name	Agency / Affiliation
PHIL-LIDAR 1	Program Leader	ENRICO C. PARINGIT, D.ENG	UP-TCAGP
Data Acquisition Component Leader	Data Component Project Leader – I	ENGR. CZAR JAKIRI S. SARMIENTO	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP-TCAGP
	Supervising Science Research Specialist	LOVELY GRACIA ACUNA	UP-TCAGP
	Supervising Science Research Specialist	ENGR. LOVELYN ASUNCION	UP-TCAGP
FIELD TEAM			
LiDAR Operation	Senior Science Research Specialist (SSRS)	AUBREY MATIRA - PAGADOR	UP-TCAGP
	SSRS	JASMINE ALVIAR	UP-TCAGP
	SSRS	ENGR. GEROME HIPOLITO	UP-TCAGP
	SSRS	ENGR. IRO NIEL ROXAS	UP-TCAGP
	Research Associate (RA)	KRISTINE JOY ANDAYA	UP-TCAGP
	RA	ENGR. KENNETH QUISADO	UP-TCAGP
	RA	ENGR. GRACE SINADJAN	UP-TCAGP
	RA	ENGR. FRANK NICOLAS ILEJAY	UP-TCAGP
	RA	SANDRA POBLETE	UP-TCAGP
	RA	JONATHAN ALMALVEZ	UP-TCAGP
Ground Survey, Data Download and Transfer	RA	ENGR. GEF SORIANO	UP-TCAGP
	RA	FOR. MA. REMEDIOS VILLANUEVA	UP-TCAGP
	RA	DARRYL AUSTRIA	UP-TCAGP
Flight Crew	Airborne Security	SSG. RAYMUND DOMINE	PHILIPPINE AIR FORCE (PAF)
	Airborne Security	SSG. ERWIN DELOS SANTOS	PHILIPPINE AIR FORCE (PAF)
	Airborne Security	SSG. DIOSCORRO SOBERANO	PHILIPPINE AIR FORCE (PAF)
	Airborne Security	SSG. JOHN ERIC CACANINDIN	PHILIPPINE AIR FORCE (PAF)
	Pilot	CAPT. SHERWIN ALFONSO III	ASIAN AEROSPACE CORPORATION (AAC)
		CAPT. FERDINAND DE OCAMPO	AAC
		CAPT. JERICO JECIEL	AAC
		CAPT. JEROME MOONEY	AAC
		CAPT. DOMMER CORPUZ	AAC

Annex 5. Data Transfer Sheet for Abulog-Apayao Floodplain

DATA TRANSFER SHEET
Nov 26, 2013

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	POS	RAW IMAGES	MISSION LOG FILE	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
Nov 16, 2013	760G	2CAG11B320A	GEMINI	NA	504KB	809KB	229MB	48GB	389KB	24.1GB	89.1GB	CGY 70 - 10330KB, CGY 92 - 8154KB, CGY 93 - 8171KB	1KB	1KB	9KB	12KB	Z:\Airborne_Raw\760G
Nov 16, 2013	762G	2CAS11B320B	GEMINI	NA	628KB	1.48MB	116MB	1.45GB/1.45GB/6.62GB	13KB/78KB	5.45GB	35.8GB	CGY 70 - 10330KB, CGY 92 - 8154KB, CGY 93 - 8171KB	1KB	1KB	9KB	12KB	Z:\Airborne_Raw\762G
Nov 18, 2013	760G	2CAS22B322A	GEMINI	NA	318KB	999KB	176MB	29.5GB	394KB	12.5GB	51.7GB	CGY 66 - 4533KB, CGY 70 -8972KB, CGY 93 - 7399KB	1KB	1KB	9KB	9KB	Z:\Airborne_Raw\760G
Nov 19, 2013	762G	2CAS23B323A	GEMINI	NA	15KB	974KB	222MB	29.7GB/2.11GB	22KB/241KB/20KB	13.3GB/5.20GB	97.5GB	CGY 70 - 9991KB, CGY 92-8191KB, CGY 93-8106KB	1KB	1KB	9KB	9KB	Z:\Airborne_Raw\762G

Received from
Name Pearl Mars 11/26/13
Position
Signature

Received by
Name JOIDA PRIETO 11/27/13
Position SSRS
Signature

Verified by
Name
Position
Signature

Figure A-5.1. Transfer Sheet for Abulog-Apayao Floodplain-A

Figure A-5.2. Transfer Sheet for Abulog-Apayao Floodplain-B

DATA TRANSFER SHEET
cagayan2 12/2/15

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	
18-Nov	2866P	1BLK2G323A	pegasus	2.33	na	11.8	255	34.7	258	22.8	na	15.8	1KB	1KB	129	NA	Z:\DAC\RAW DATA
18-Nov	2868P	1BLK2H322B	pegasus	1.87	na	7.34	157	27.7	207	18	na	15.9	1KB	1KB	74	NA	Z:\DAC\RAW DATA
19-Nov	2870P	1BLK21AB323A	pegasus	2.11	na	11.8	266	23.2	211	22.6	na	10.3	1KB	1KB	48	NA	Z:\DAC\RAW DATA
20-Nov	2874P	1BLK21C324A	pegasus	1.22	na	8.12	195	7.3	80	12	na	10.8	1KB	1KB	57/90	NA	Z:\DAC\RAW DATA
21-Nov	2880P	1BLK2HS325A	pegasus	1.76	na	12.2	231	30	240/1	17.7	na	11.4	1KB	1KB	84/76/74	NA	Z:\DAC\RAW DATA

Received from

Name Chris Joaquin
Position
Signature

Received by

Name AC Bongat 12/4/15
Position
Signature

Figure A-5.3. Transfer Sheet for Abulog-Apayao Floodplain-C

DATA TRANSFER SHEET
21/06/2016 TUGUEGARAO

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	
4/27/2016	3965G	2CAG2DGH118A	GEMINI	NA	367	585	251	NA	NA	28.2	NA	9.67	1KB	1KB	252	NA	Z:\DAC\RAWDATA
4/28/2016	3971G	2BLK3CAG2MQR119A	GEMINI	NA	193	559	252	NA	NA	21	NA	9.78	1KB	1KB	65.1	NA	Z:\DAC\RAWDATA
4/29/2016	3973G	2CAG2GSHS120A	GEMINI	NA	740	662	274	NA	NA	28.6	NA	9.24	1KB	1KB	506	NA	Z:\DAC\RAWDATA
4/30/2016	3977G	2CAG2FG121A	GEMINI	NA	392/99.5/404/107	767	255	NA	NA	29.4	NA	12.1	1KB	1KB	NA	NA	Z:\DAC\RAWDATA
4/30/2016	3979G	2CAG2E121B	GEMINI	NA	99.5	193	71.1	NA	NA	7.37	NA	12.1	1KB	1KB	67.2	NA	Z:\DAC\RAWDATA
5/1/2016	3981G	2CAG2I122A	GEMINI	NA	404	730	263	NA	NA	30.2	NA	8.23	1KB	1KB	23.2/20.6/276/129	NA	Z:\DAC\RAWDATA
5/1/2016	3983G	2CAG2CJ122B	GEMINI	NA	107	220	103	NA	NA	8.25	NA	8.23	1KB	1KB	72.4	NA	Z:\DAC\RAWDATA
5/3/2016	3989G	2BLK3CAG2QSR124A	GEMINI	NA	136/319	514	245	NA	NA	17.1	NA	14.6	1KB	1KB	NA	NA	Z:\DAC\RAWDATA
5/3/2016	3991G	2BLK3CAG2MNSQS124B	GEMINI	NA	204	228	143	NA	NA	8.65	NA	14.6	1KB	1KB	137	NA	Z:\DAC\RAWDATA
5/4/2016	3993G	2BLK3CAG2LMNQR125A	GEMINI	NA	435	161	244	NA	NA	21.2	NA	8.65	1KB	1KB	294	NA	Z:\DAC\RAWDATA
5/5/2016	3997G	2BLK3CAG2NO126A	GEMINI	NA	353	691	272	NA	NA	26.4	NA	13.9	1KB	1KB	239	NA	Z:\DAC\RAWDATA
5/5/2016	3999G	2CAG2P126B	GEMINI	NA	151	290	137	NA	NA	11.6	NA	13.9	1KB	1KB	102	151	Z:\DAC\RAWDATA
5/6/2016	4001G	2BLK3CAG2MRS127A	GEMINI	NA	208	459	245	NA	NA	16.1	NA	9.35	1KB	1KB	138	NA	Z:\DAC\RAWDATA
5/7/2016	4005G	2CAG2ABC128A	GEMINI	NA	316	NA	257	NA	NA	24	NA	8.88	1KB	1KB	215	NA	Z:\DAC\RAWDATA
5/8/2016	4009G	2CAG2K129A	GEMINI	NA	132	286	118	NA	NA	10	NA	5.85	1KB	1KB	114	NA	Z:\DAC\RAWDATA

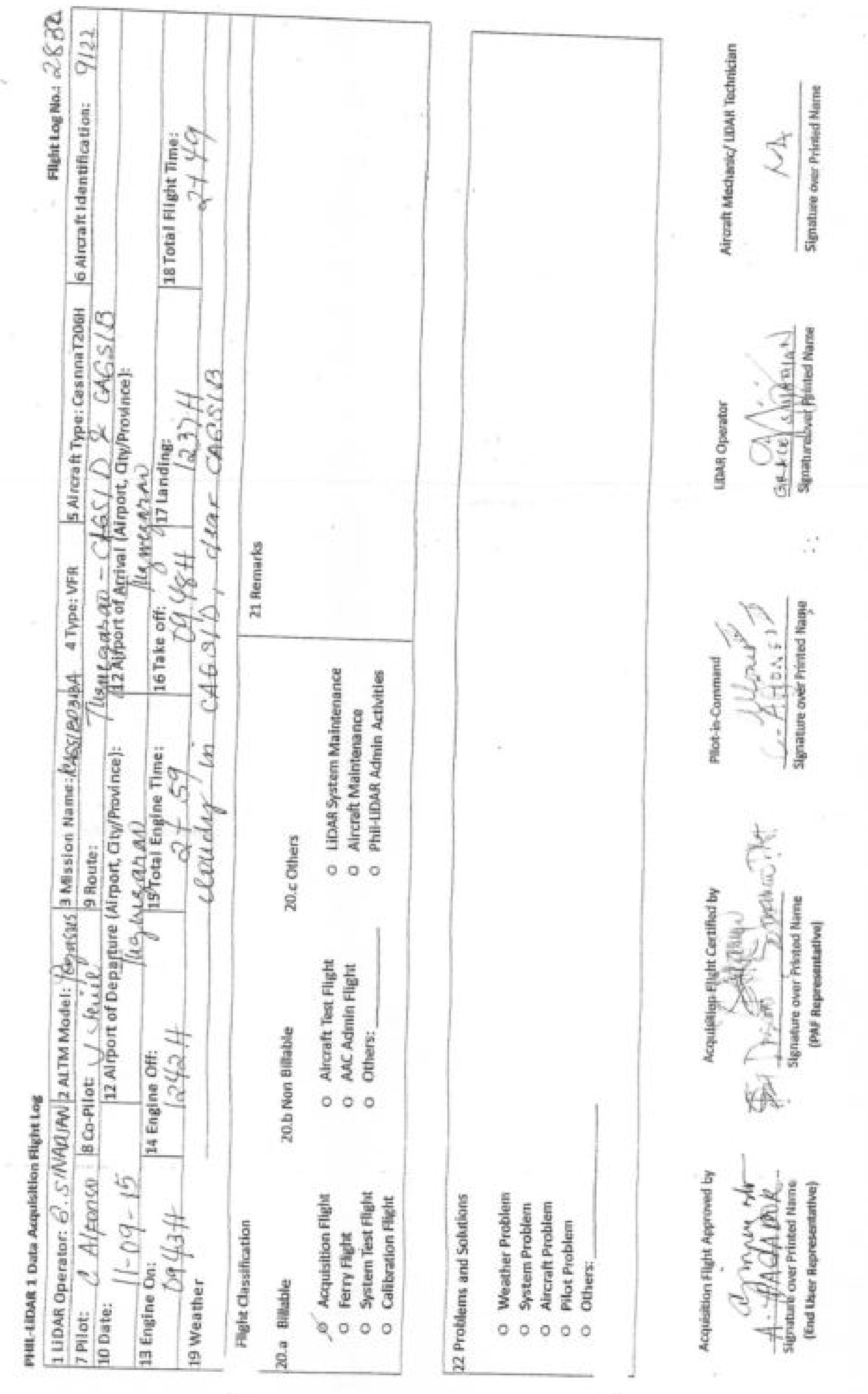
Name DARRYL AUSTRIA
Position R.A.
Signature

Name AC Bongat
Position SSRS
Signature 6/21/16

Figure A-5.4. Transfer Sheet for Abulog-Apayao Floodplain-D

Annex 6. Flight Logs for the Flight Missions

1. Flight Log for Mission 2830P


PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 2830

1 LIDAR Operator: G. SINADJAN	2 ALTM Model: Pegasus	3 Mission Name: 2BLK51BD313A	4 Type: VFR	5 Aircraft Type: Cesnna T206H
6 Aircraft Identification: 9122				
7 Pilot: C. Alfonso	8 Co-Pilot: J. Schuile	9 Route: Tuguegarao – CAG51D & CAG51B		
10 Date: 11-09-15	12 Airport of Departure (Airport, City/Province): Tuguegarao	12 Airport of Arrival (Airport, City/Province): Tuguegarao		
13 Engine On: 0943H	14 Engine Off: 1242H	15 Total Engine Time: 2+59	16 Take off: 0948H	17 Landing: 1237H
18 Total Flight Time: 2+49				
19 Weather: cloudy in CAG51D, clear CAG51B				

Flight Classification

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

20.b Non Billable
- o Aircraft Test Flight
- o AAC Admin Flight
- o Others: ____

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

21 Remarks

22 Problems and Solutions
- o Weather Problem
- o System Problem
- o Aircraft Problem
- o Pilot Problem
- o Others: ____

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

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

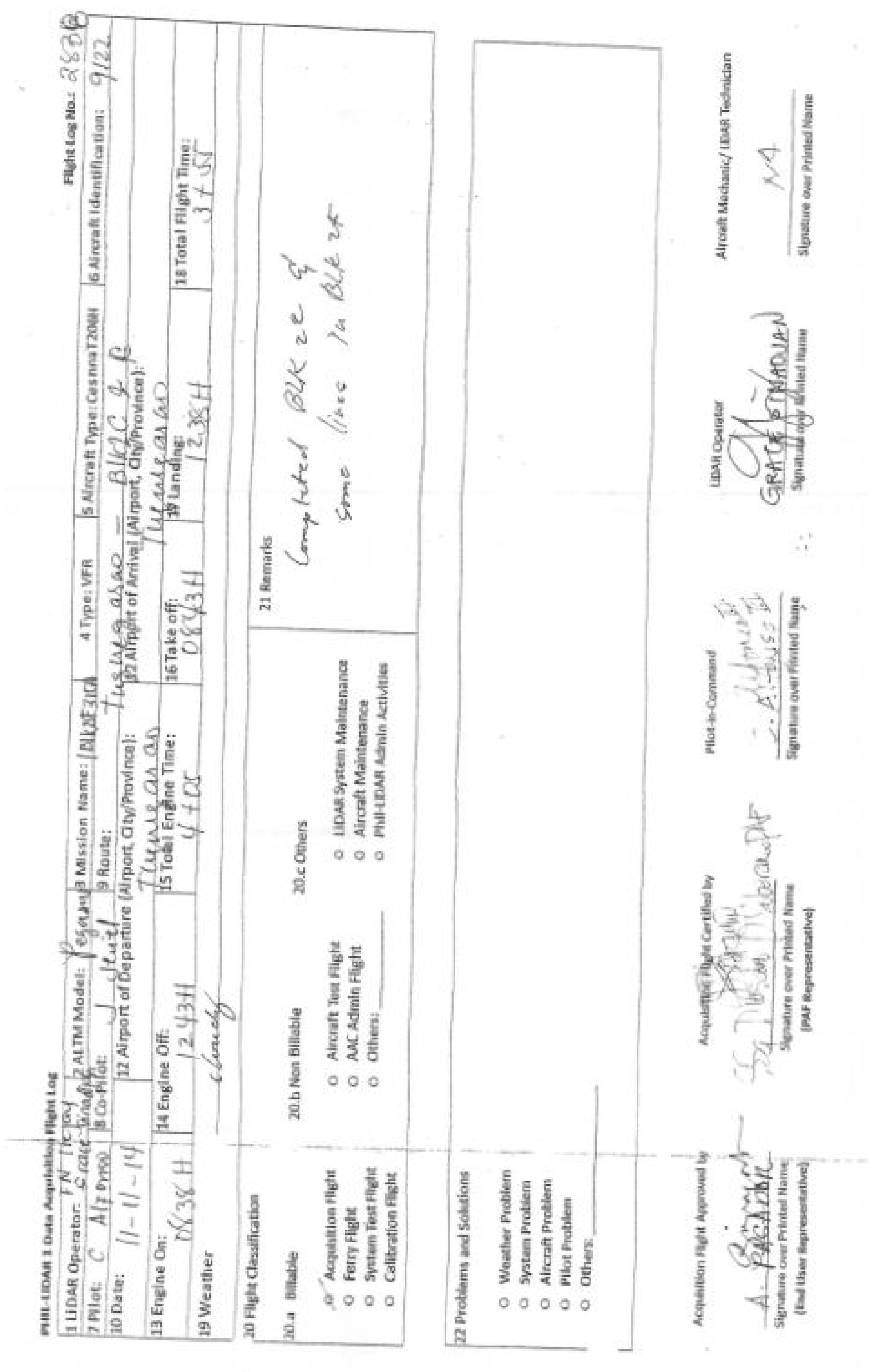
Pilot-in-Command: C. Alfonso — Signature over Printed Name

LIDAR Operator: G. Sinadjan — Signature over Printed Name

Aircraft Mechanic/ LIDAR Technician: Signature over Printed Name

Figure A-6.1. Flight log for Mission 2830P

2. Flight Log for 2838P Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 2838P

1 LiDAR Operator: Grace Sinadjan	2 ALTM Model: Pegasus	3 Mission Name: 1BLK2E310A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: C. Alfonso	8 Co-Pilot: J. Jecoy	9 Route: Tuguegarao – BLK 2E & F			
10 Date: 11-11-14	12 Airport of Departure (Airport, City/Province): Tuguegarao		12 Airport of Arrival (Airport, City/Province): Tuguegarao		
13 Engine On: 0838H	14 Engine Off: 1243H	15 Total Engine Time: 4+05	16 Take off: 0843H	17 Landing: 1238H	18 Total Flight Time: 3+55
19 Weather: cloudy					

20 Flight Classification

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

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

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

21 Remarks

Completed BLK 2E & some lines in BLK 2F

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

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

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

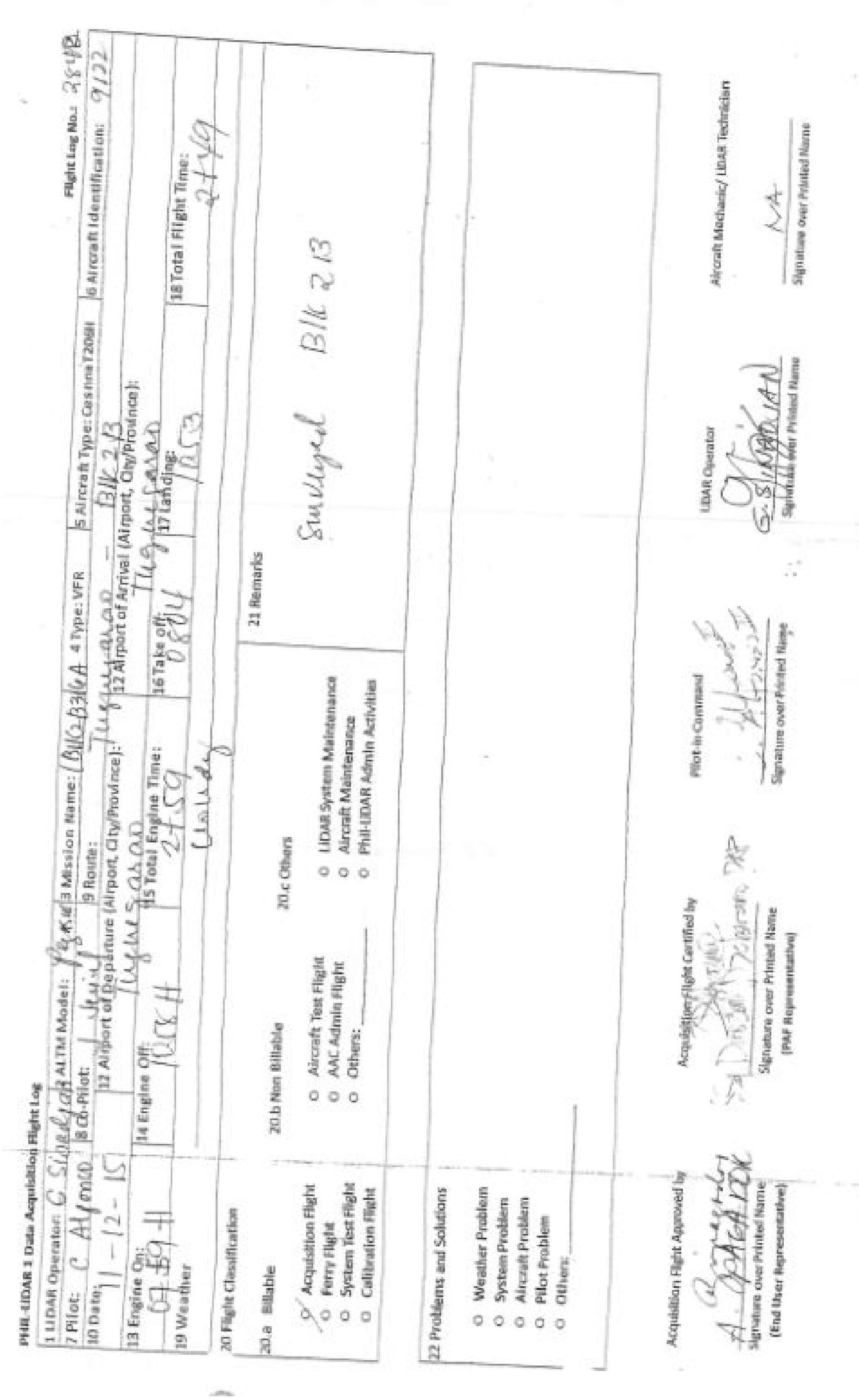
Pilot-in-Command: C. Alfonso — Signature over Printed Name

LiDAR Operator: Grace Sinadjan — Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician: NA — Signature over Printed Name

Figure A-6.2. Flight log for Mission 2838P

3. Flight Log for 2842P Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 2842

1 LIDAR Operator: G Sinadjan	2 ALTM Model: Pegasus	3 Mission Name: 1BLK2B316A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: C Alfonso	8 Co-Pilot: J. Jerez	9 Route: Tuguegarao – Blk 2B			
10 Date: 11-12-15	12 Airport of Departure (Airport, City/Province): Tuguegarao	12 Airport of Arrival (Airport, City/Province): Tuguegarao			
13 Engine On: 0759 H	14 Engine Off: 1058 H	15 Total Engine Time: 2+59	16 Take off: 0804	17 Landing: 1053	18 Total Flight Time: 2+49
19 Weather: Cloudy					

20 Flight Classification

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

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

20.c Others
- LIDAR System Maintenance
- Aircraft Maintenance
- Phil-LIDAR Admin Activities

21 Remarks

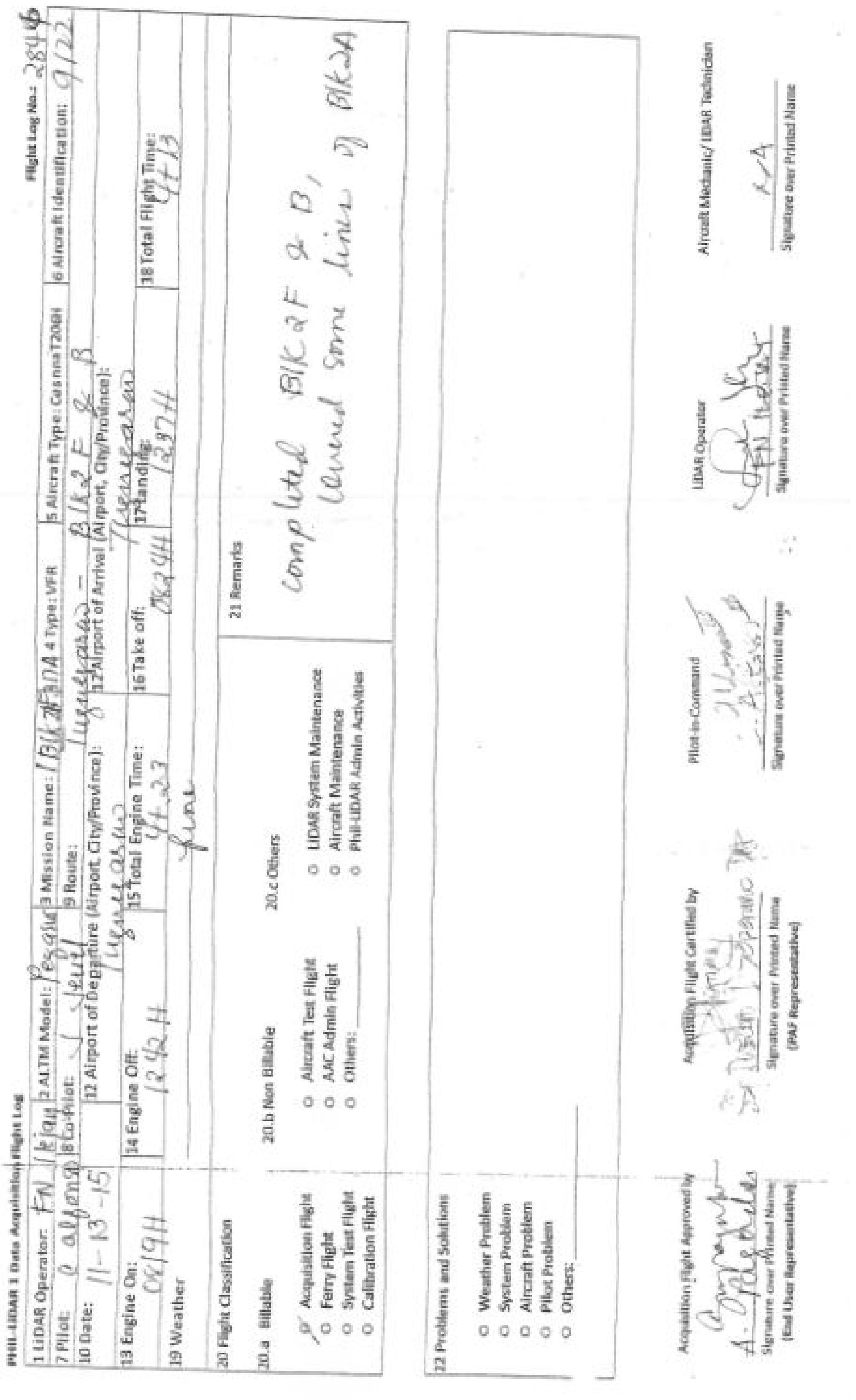
Surveyed Blk 2B

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LIDAR Operator	Aircraft Mechanic/ LIDAR Technician
A. [illegible]	[illegible]	[illegible]	G. Sinadjan	NA
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.3. Flight log for Mission 2842P

4. Flight Log for 2846P Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 2846

1 LiDAR Operator: FN Ikjay	2 ALTM Model: Pegasus	3 Mission Name: 1BLK2F3A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: C. Alfonso	8 Co-Pilot: J. Jeruel	9 Route: Tuguegarao - Blk2F & B			
10 Date: 11-13-15	12 Airport of Departure (Airport, City/Province): Tuguegarao		12 Airport of Arrival (Airport, City/Province): Tuguegarao		
13 Engine On: 0819H	14 Engine Off: 1242H	15 Total Engine Time: 4+23	16 Take off: 0824H	17 Landing: 1237H	18 Total Flight Time: 4+13
19 Weather: fine					

20 Flight Classification

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

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

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

21 Remarks

completed Blk 2F & B, covered some lines of Blk 2A

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

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

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

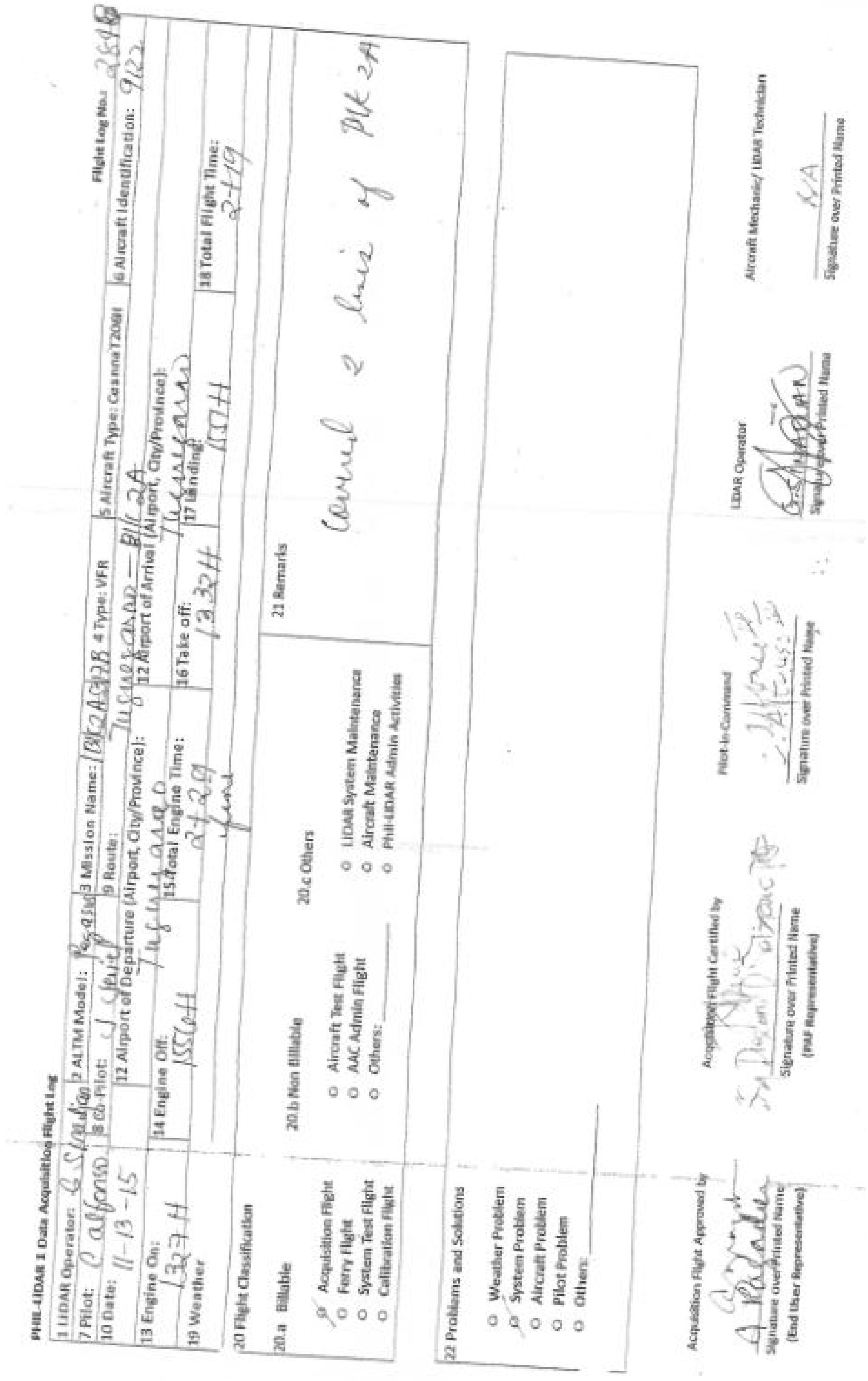
Pilot-in-Command: Signature over Printed Name

LiDAR Operator: FN Ikjay — Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician: Signature over Printed Name

Figure A-6.4. Flight log for Mission 2846P

5. Flight Log for 2848P Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 2848P

1 LIDAR Operator: G. Sinadjan	2 ALTM Model: Pegasus	3 Mission Name: 1BLK2AS327B	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: C. Alfonso	8 Co-Pilot: J. Jeruel	9 Route: Tuguegarao — BLK 2A			
10 Date: 11-13-15	12 Airport of Departure (Airport, City/Province): Tuguegarao		12 Airport of Arrival (Airport, City/Province): Tuguegarao		
13 Engine On: 1327H	14 Engine Off: 1556H	15 Total Engine Time: 2+29	16 Take off: 1332H	17 Landing: 1551H	18 Total Flight Time: 2+19
19 Weather: fine					

20 Flight Classification

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

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

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

21 Remarks

Covered 2 lines of BLK 2A

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

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

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

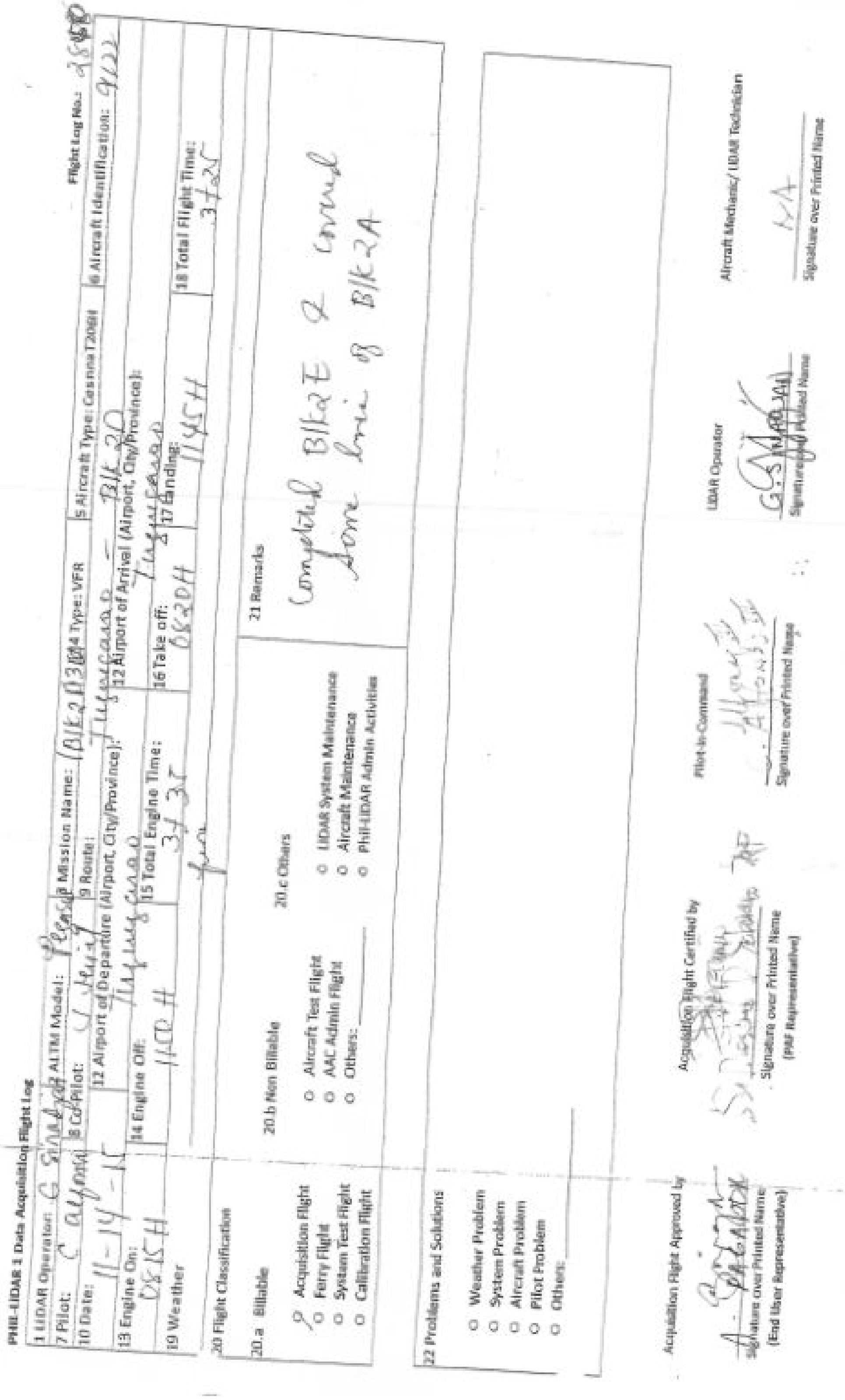
Pilot-in-Command: C. Alfonso — Signature over Printed Name

LIDAR Operator: G. Sinadjan — Signature over Printed Name

Aircraft Mechanic/ LIDAR Technician: NA — Signature over Printed Name

Figure A-6.5. Flight log for Mission 2848P

6. Flight Log for 2850P Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 2850P

1 LiDAR Operator: G. Sinadjan	2 ALTM Model: Pegasus	3 Mission Name: 1BLK2D320A	4 Type: VFR	5 Aircraft Type: Cessna T206H
6 Aircraft Identification: 9122	7 Pilot: C. Alfonso	8 Co-Pilot: J. Heria	9 Route: Tuguegarao – BLK 2D	
10 Date: 11-14-15	12 Airport of Departure (Airport, City/Province): Tuguegarao	12 Airport of Arrival (Airport, City/Province): Tuguegarao		
13 Engine On: 0815H	14 Engine Off: 1150 H	15 Total Engine Time: 3+35	16 Take off: 0820H	17 Landing: 1145H
18 Total Flight Time: 3+25	19 Weather: fair			

20 Flight Classification

20.a Billable: Acquisition Flight; Ferry Flight; System Test Flight; Calibration Flight

20.b Non Billable: Aircraft Test Flight; AAC Admin Flight; Others:

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

21 Remarks: Completed BLK2E & covered some lines of BLK2A

22 Problems and Solutions: Weather Problem; System Problem; Aircraft Problem; Pilot Problem; Others:

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

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

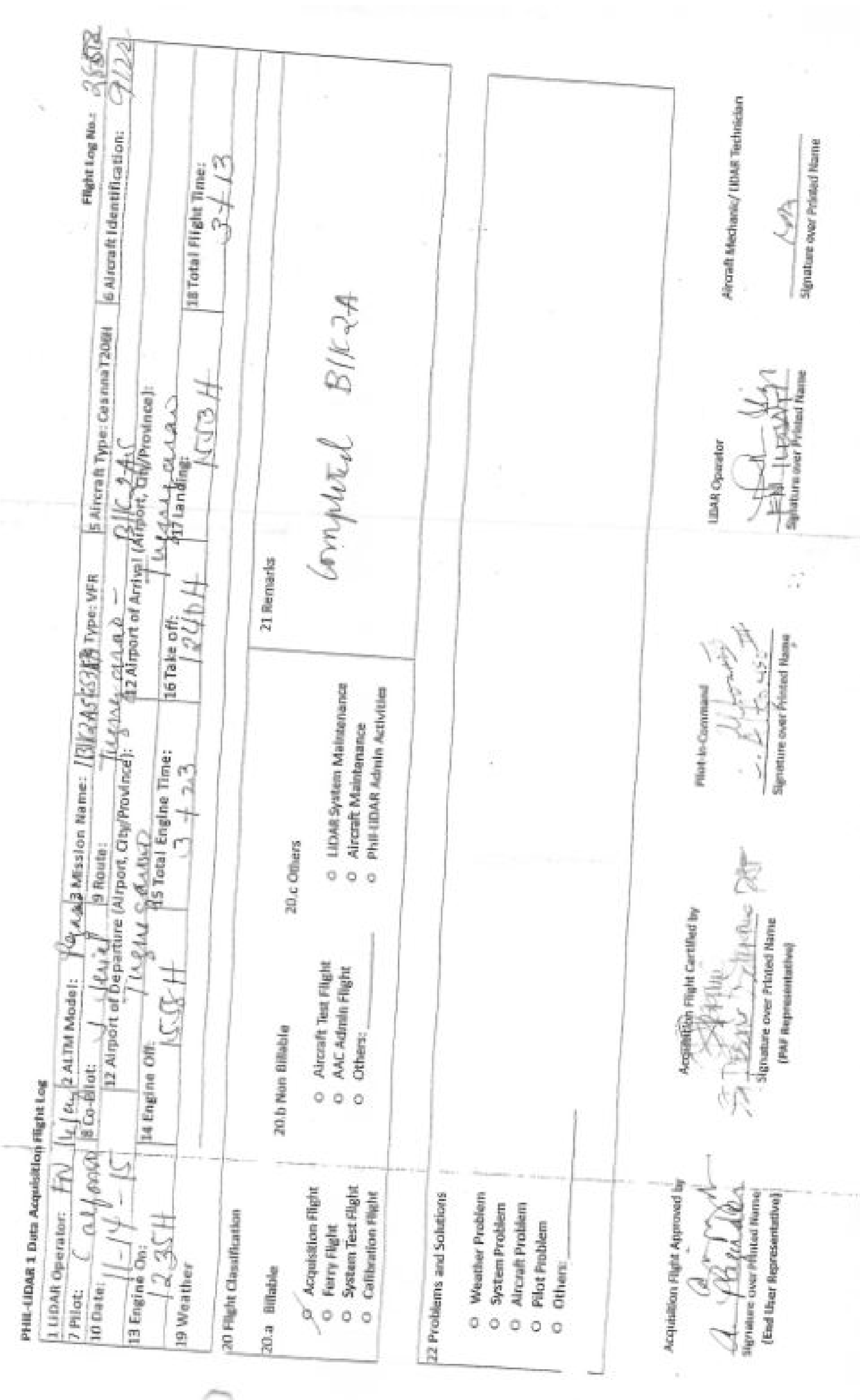
Pilot-in-Command: C. Alfonso III — Signature over Printed Name

LiDAR Operator: G. Sinadjan — Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician: NA — Signature over Printed Name

Figure A-6.6. Flight log for Mission 2850P

7. Flight Log for 2852P Mission


PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 2852P

1 LIDAR Operator: FN Llejer	2 ALTM Model: Pegasus	3 Mission Name: 1BLK2AS153B	4 Type: VFR
5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122		
7 Pilot: C Alfonso	8 Co-Pilot: J Heria	9 Route: Tuguegarao – BLK 2AS	
10 Date: 11-14-15	12 Airport of Departure (Airport, City/Province): Tuguegarao	12 Airport of Arrival (Airport, City/Province): Tuguegarao	
13 Engine On: 1235H	14 Engine Off: 1558H	15 Total Engine Time: 3+23	
16 Take off: 1240H	17 Landing: 1553H	18 Total Flight Time: 3+13	
19 Weather			

20 Flight Classification

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

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

20.c Others
- LIDAR System Maintenance
- Aircraft Maintenance
- Phil-LIDAR Admin Activities

21 Remarks

Completed BLK2A

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

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

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

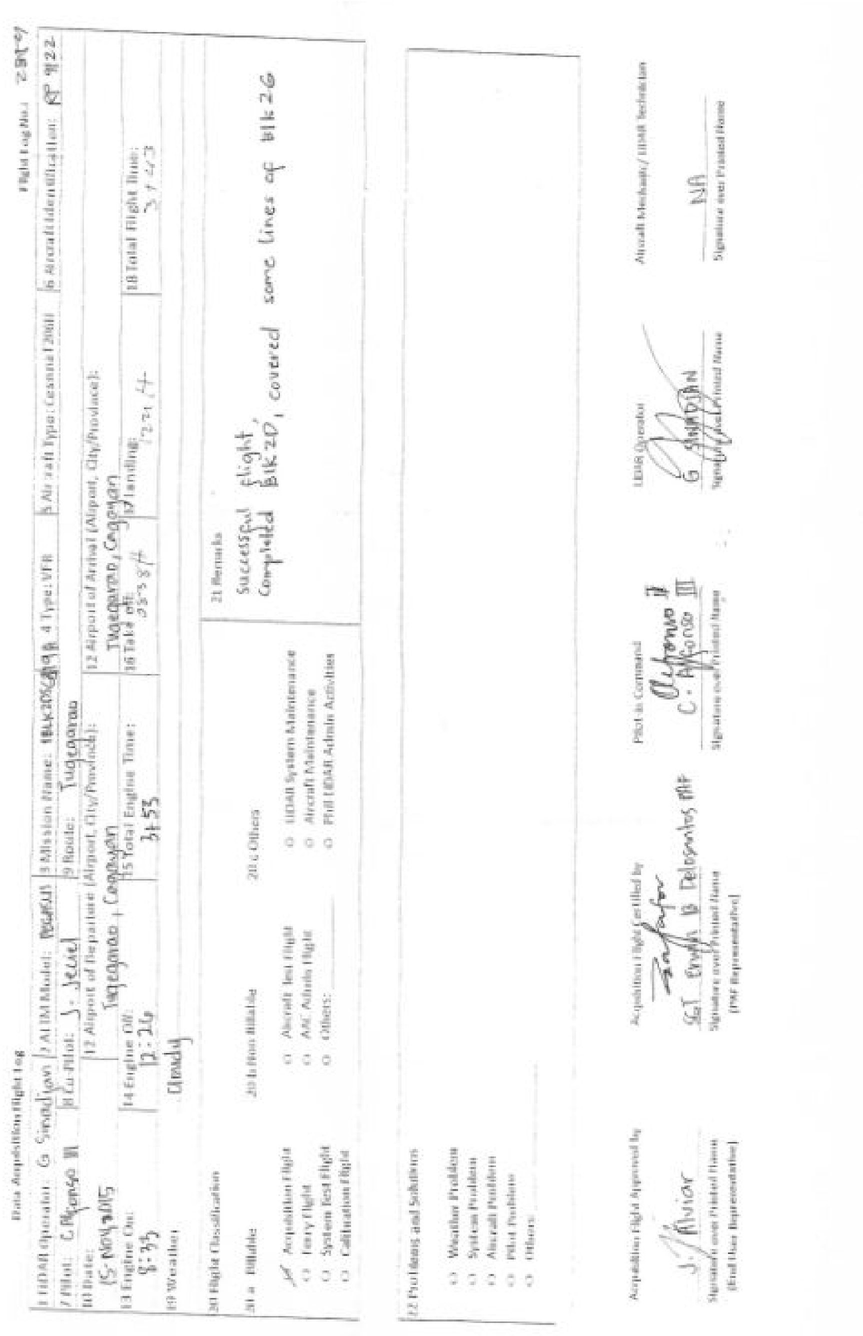
Pilot-in-Command — Signature over Printed Name

LIDAR Operator — Signature over Printed Name

Aircraft Mechanic/ LIDAR Technician — Signature over Printed Name

Figure A-6.7. Flight log for Mission 2852P

8. Flight Log for 2854P Mission



Data Acquisition Flight Log

Flight Log No.: 2854P

1 LiDAR Operator: G. Sinadjan	2 ALTM Model: Pegasus	3 Mission Name: 1BLK20S321A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP 9122
7 Pilot: C. Alfonso III	8 Co-Pilot: J. Jeciel	9 Route: Tuguegarao			
10 Date: 15-Nov-2015	12 Airport of Departure (Airport, City/Province): Tuguegarao, Cagayan		12 Airport of Arrival (Airport, City/Province): Tuguegarao, Cagayan		
13 Engine On: 8:33	14 Engine Off: 12:26	15 Total Engine Time: 3+53	16 Take off: 0838H	17 Landing: 1221H	18 Total Flight Time: 3+43
19 Weather: Cloudy					

20 Flight Classification

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

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

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

21 Remarks

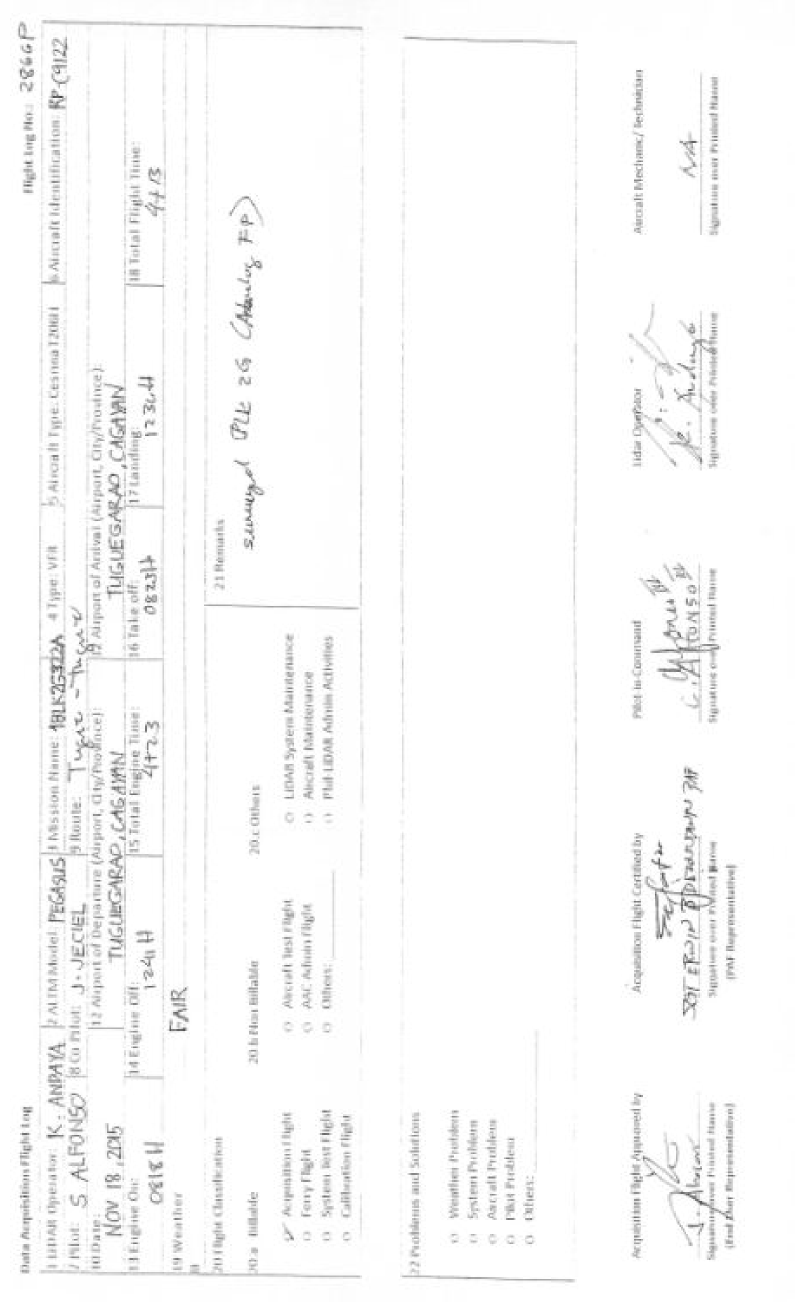
Successful flight, Completed BLK20, covered some lines of BLK26

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LiDAR Operator	Aircraft Mechanic/ LiDAR Technician
J. Alviar	SGT Ervin B Delosantos PAF	C. Alfonso III	G. Sinadjan	NA
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.8. Flight log for Mission 2854P

9. Flight Log for 2866P Mission


Data Acquisition Flight Log

Flight Log No.: 2866P

1 LIDAR Operator: K. ANDAYA	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK25322A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: S. ALFONSO	8 Co-Pilot: J. JECIEL	9 Route: Tugue - Tugue			
10 Date: NOV 18, 2015	12 Airport of Departure (Airport, City/Province): TUGUEGARAO, CAGAYAN		12 Airport of Arrival (Airport, City/Province): TUGUEGARAO, CAGAYAN		
13 Engine On: 0818 H	14 Engine Off: 1241 H	15 Total Engine Time: 4+23	16 Take off: 0823H	17 Landing: 1236H	18 Total Flight Time: 4+13
19 Weather: FAIR					

20 Flight Classification

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

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

20.c Others
- LIDAR System Maintenance
- Aircraft Maintenance
- Phil-LIDAR Admin Activities

21 Remarks

surveyed BLK 25 (Abulug FP)

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

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

Acquisition Flight Certified by: SSGT ERWIN DELOSANTOS PAF — Signature over Printed Name (PAF Representative)

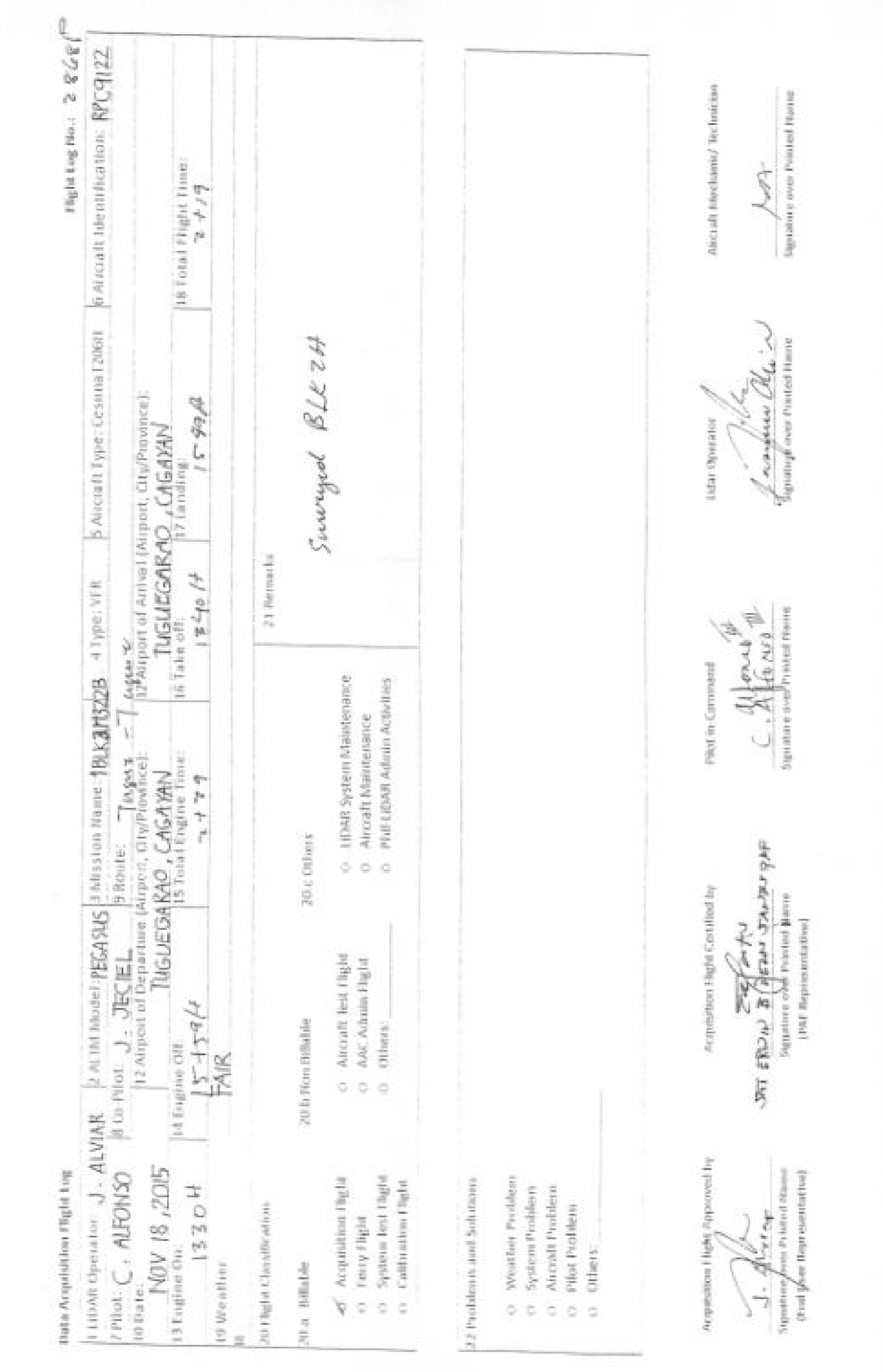
Pilot-in-Command: C. ALFONSO III — Signature over Printed Name

Lidar Operator: K. Andaya — Signature over Printed Name

Aircraft Mechanic/ Technician: N/A — Signature over Printed Name

Figure A-6.9. Flight log for Mission 2866P

10. Flight Log for 2868P Mission


Data Acquisition Flight Log

Flight Log No.: 2868P

1 LiDAR Operator: J. ALVIAR	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK2H322B	4 Type: VFR	5 Aircraft Type: Cesnna T206H
6 Aircraft Identification: RPC9122				
7 Pilot: C. ALFONSO	8 Co-Pilot: J. JECIEL	9 Route: Tuguegarao - Tuguegarao		
10 Date: NOV 18, 2015	12 Airport of Departure (Airport, City/Province): TUGUEGARAO, CAGAYAN	12 Airport of Arrival (Airport, City/Province): TUGUEGARAO, CAGAYAN		
13 Engine On: 1330H	14 Engine Off: 1559H	15 Total Engine Time: 2+29	16 Take off: 1340H	17 Landing: 1549H
18 Total Flight Time: 2+09				
19 Weather: FAIR				

20 Flight Classification

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

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

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

21 Remarks

Surveyed BLK2H

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

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

Acquisition Flight Certified by: SGT ERWIN B. [illegible] PAF — Signature over Printed Name (PAF Representative)

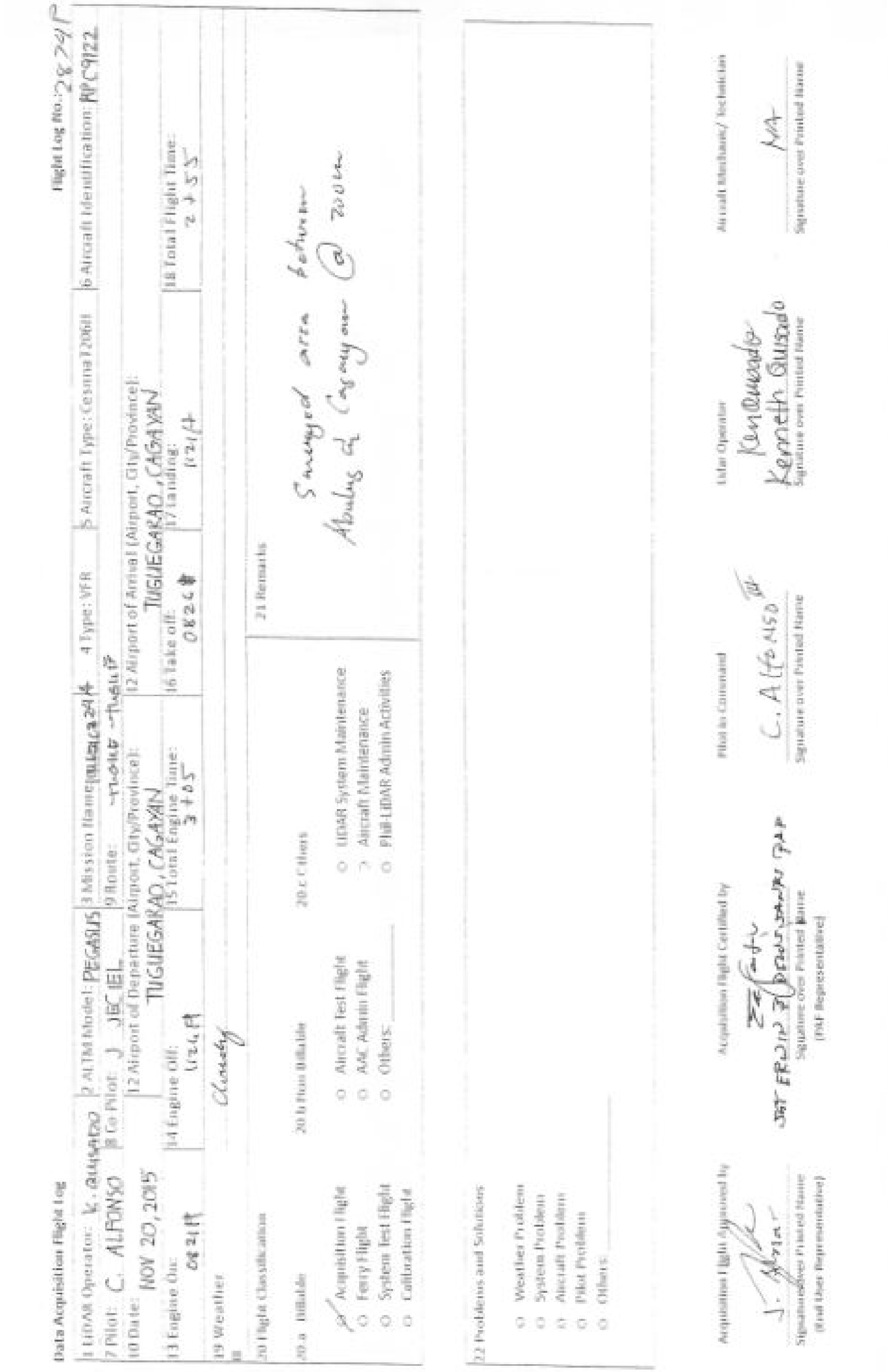
Pilot-in-Command: C. ALFONSO III — Signature over Printed Name

Lidar Operator: [illegible] — Signature over Printed Name

Aircraft Mechanic/ Technician: [illegible] — Signature over Printed Name

Figure A-6.10. Flight log for Mission 2868P

11. Flight Log for 2874P Mission



Data Acquisition Flight Log

Flight Log No.: 2874P

1 LiDAR Operator: K. QUISADO	2 ALTM Model: PEGASUS	3 Mission Name: [illegible]	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RPC9122
7 Pilot: C. ALFONSO	8 Co Pilot: J. JECIEL	9 Route: TUGUE - TUGUE			
10 Date: NOV 20, 2015	12 Airport of Departure (Airport, City/Province): TUGUEGARAO, CAGAYAN		12 Airport of Arrival (Airport, City/Province): TUGUEGARAO, CAGAYAN		
13 Engine On: 0821H	14 Engine Off: 1126H	15 Total Engine Time: 3+05	16 Take off: 0826H	17 Landing: 1121H	18 Total Flight Time: 2+55
19 Weather: Cloudy					

20 Flight Classification

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

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

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

21 Remarks

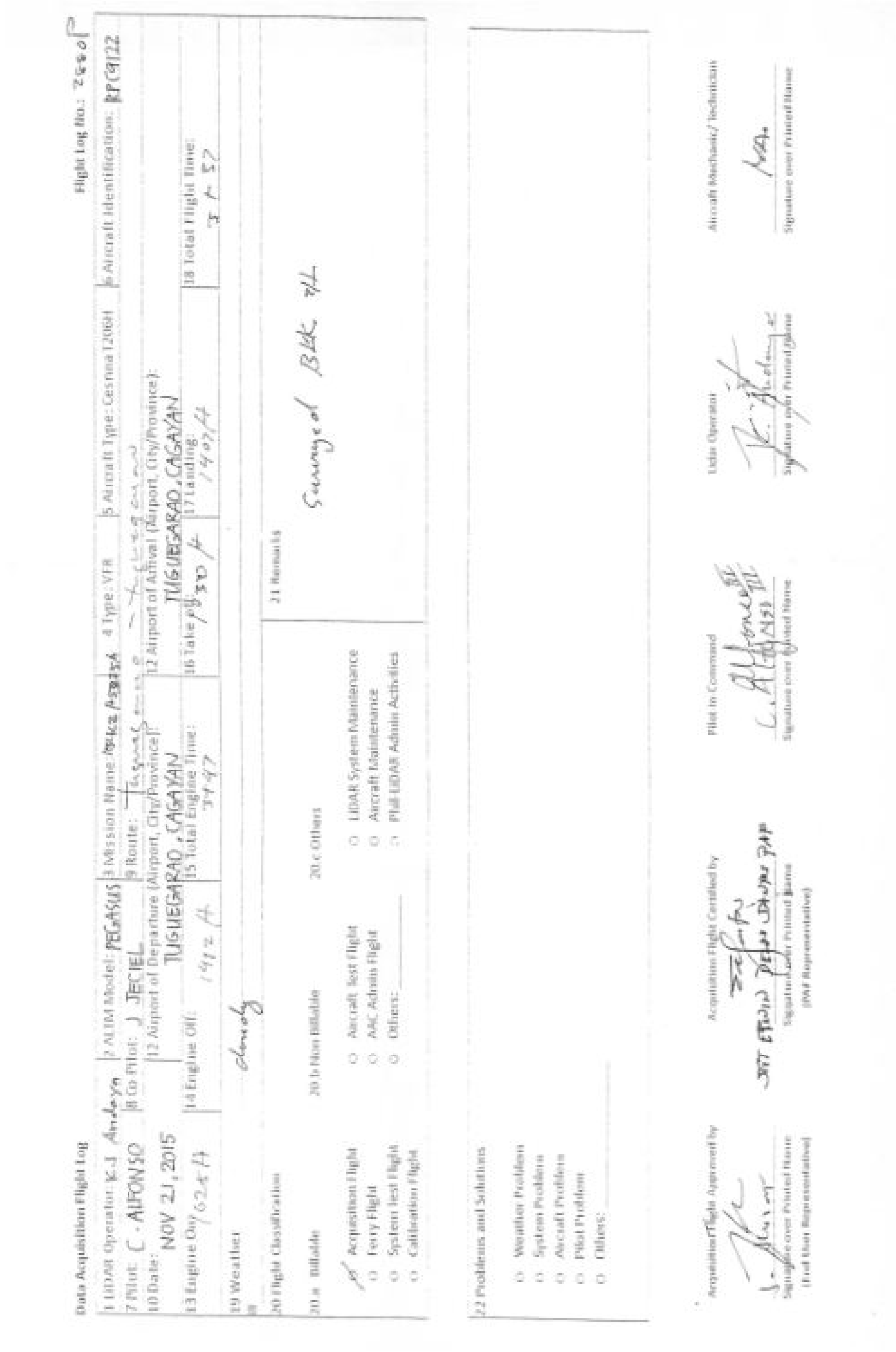
Surveyed area between Abulug & Cagayan @ 200m

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator	Aircraft Mechanic/ Technician
J. Alviar	SGT ERWIN F. [illegible] PAF	C. Alfonso III	Kenneth Quisado	MA
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.11. Flight log for Mission 2874P

12. Flight Log for 2880P Mission



Flight Log No.: 2880P

Data Acquisition Flight Log

1 LiDAR Operator: K.J. Andaya	2 ALTM Model: PEGASUS	3 Mission Name: 1BLK2A325A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: C. ALFONSO	8 Co-Pilot: J. JECIEL	9 Route: Tuguegarao – Tuguegarao			
10 Date: NOV 21, 2015	12 Airport of Departure (Airport, City/Province): TUGUEGARAO, CAGAYAN		12 Airport of Arrival (Airport, City/Province): TUGUEGARAO, CAGAYAN		
13 Engine On: 0625H	14 Engine Off: 1412H	15 Total Engine Time: 7+47	16 Take off: 0630H	17 Landing: 1407H	18 Total Flight Time: 7+37
19 Weather: Cloudy					

20 Flight Classification

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

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

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

21 Remarks

Surveyed BLK 7L

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator	Aircraft Mechanic/ Technician
J. Alviar	SSgt Efren De Jesus Jr PAF	C. Alfonso III	K. Andaya	
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.12. Flight log for Mission 2880P

13. Flight Log for 3965G Mission

UP DREAM **Data Acquisition Flight Log** — **Flight Log No.:** 3965

1 LiDAR Operator: J. ALMALVEZ	2 ALTM Model: GEMINI	3 Mission Name: 2CAG2DGH118A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: J. Mooney	8 Co-Pilot: D. Corpuz	9 Route: local Tuguegarao			
10 Date: APRIL 27, 2016	12 Airport of Departure (Airport, City/Province): Tuguegarao		12 Airport of Arrival (Airport, City/Province): Tuguegarao		
13 Engine On: 0900H	14 Engine Off: 1335 H	15 Total Engine Time: 4 + 35	16 Take off: 0905H	17 Landing: 1330H	18 Total Flight Time: 4 + 25
19 Weather: FAIR					

20 Flight Classification

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

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

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

21 Remarks

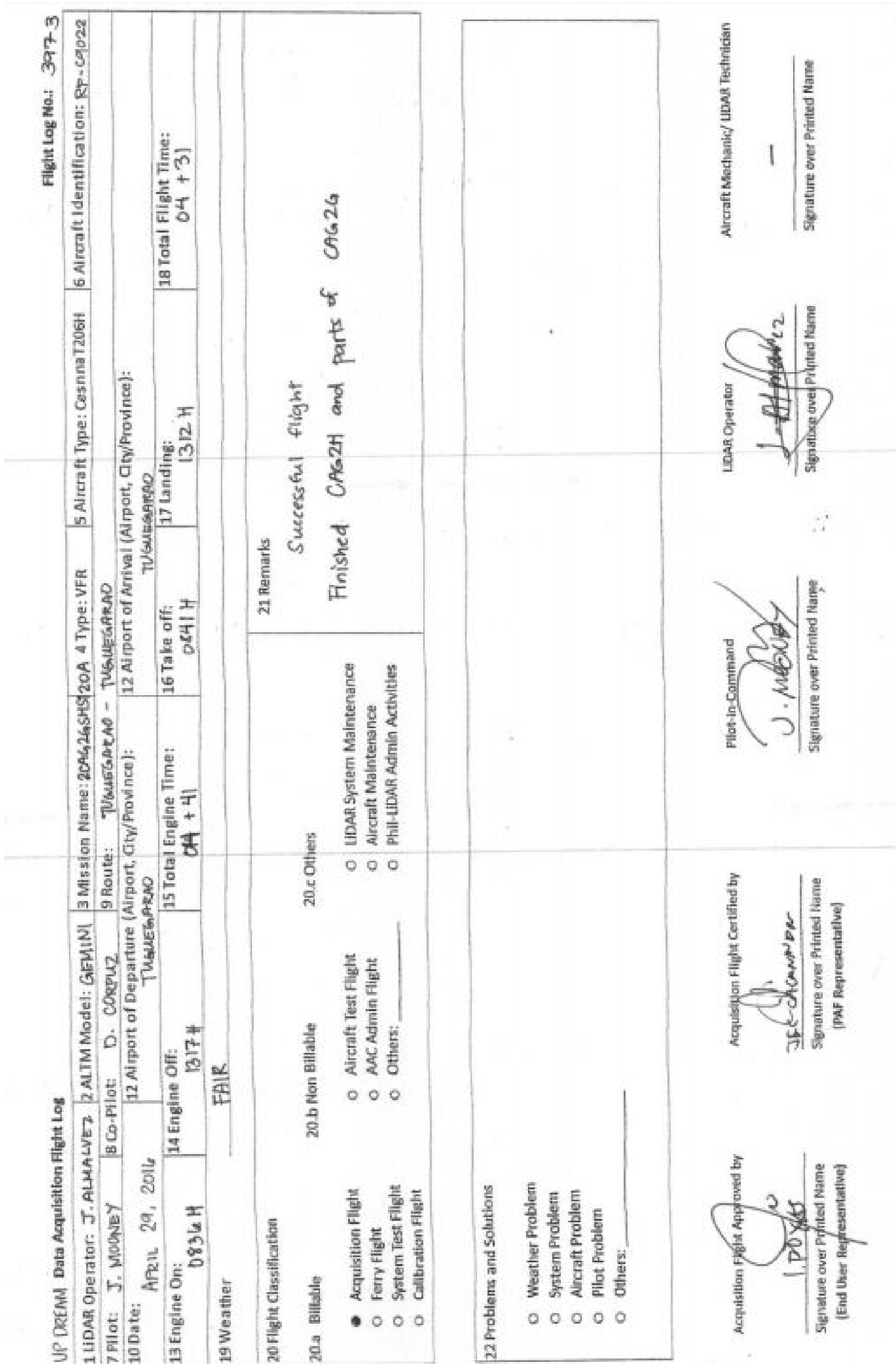
Successful flight.
Covered CAG2D, G and H

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

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LIDAR Operator	Aircraft Mechanic/ LIDAR Technician
I. Roxas	[illegible]	J. Mooney	J. Almalvez	–
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

Figure A-6.13. Flight log for Mission 3965G

14. Flight Log for 3973G Mission



UP DREAM Data Acquisition Flight Log

Flight Log No.: 3973

1 LiDAR Operator: J. ALMALVEZ	2 ALTM Model: GEMINI	3 Mission Name: 2CAG2GSHS120A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: J. MOONEY	8 Co-Pilot: D. CORPUZ	9 Route: TUGUEGARAO - TUGUEGARAO			
10 Date: APRIL 29, 2016	12 Airport of Departure (Airport, City/Province): TUGUEGARAO		12 Airport of Arrival (Airport, City/Province): TUGUEGARAO		
13 Engine On: 0836 H	14 Engine Off: 1317 H	15 Total Engine Time: 04 + 41	16 Take off: 0841 H	17 Landing: 1312 H	18 Total Flight Time: 04 + 31
19 Weather: FAIR					

20 Flight Classification

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

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

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

21 Remarks

Successful flight

Finished CAG2H and parts of CAG2G

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

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

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

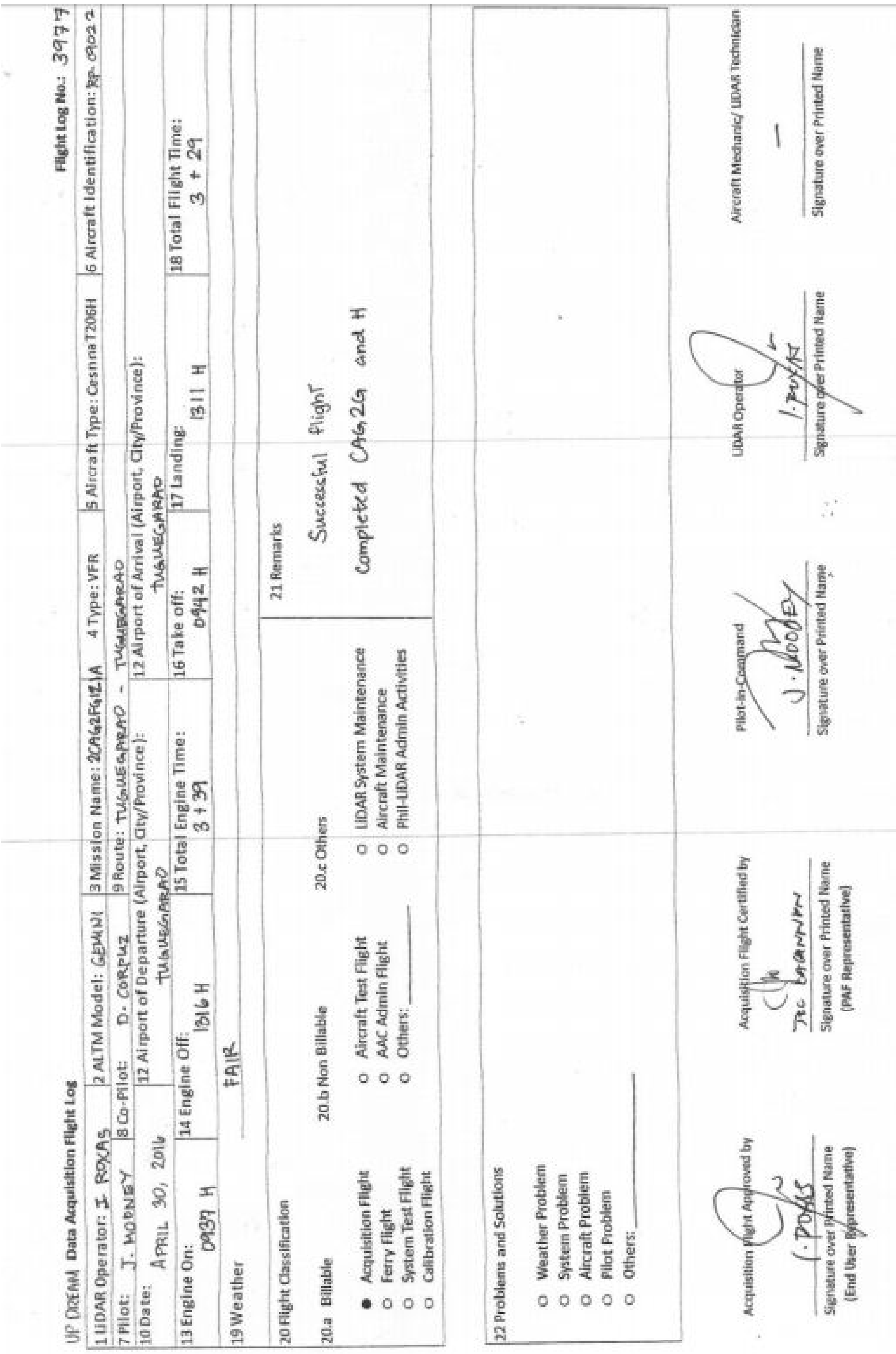
Pilot-in-Command: J. MOONEY — Signature over Printed Name

LiDAR Operator: J. Almalvez — Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician: — Signature over Printed Name

Figure A-6.14. Flight log for Mission 3973G

15. Flight Log for 3977G Mission



UP DREAM Data Acquisition Flight Log

Flight Log No.: 3977

1 LIDAR Operator: I. ROXAS	2 ALTM Model: GEMINI	3 Mission Name: 2CAG2FG121A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: J. MOONEY	8 Co-Pilot: D. CORPUZ	9 Route: TUGUEGARAO - TUGUEGARAO			
10 Date: APRIL 30, 2016	12 Airport of Departure (Airport, City/Province): TUGUEGARAO		12 Airport of Arrival (Airport, City/Province): TUGUEGARAO		
13 Engine On: 0937 H	14 Engine Off: 1316 H	15 Total Engine Time: 3+39	16 Take off: 0942 H	17 Landing: 1311 H	18 Total Flight Time: 3 + 29
19 Weather	FAIR				

20 Flight Classification

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

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

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

21 Remarks

Successful flight

Completed CAG2G and H

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

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

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

Pilot-in-Command: J. MOONEY — Signature over Printed Name

LIDAR Operator: I. ROXAS — Signature over Printed Name

Aircraft Mechanic/ LIDAR Technician: — Signature over Printed Name

Figure A-6.15. Flight log for Mission 3977G

Annex 7. Flight Status Reports

FLIGHT STATUS REPORT
November 9 - 21, 2015 and April 27 – 30, 2016

Table A-7.1. Flight Status Report

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
2830P	CAGS1B AND CAGS1D	1CAGS1BD313A	G SINADJAN	November 9, 2015	SUCCESSFUL FLIGHT; COMPLETED CAGS1B AND CAGS1D
2838P	BLK2C, BLK2F	1BLK2CF315A	G SINADJAN, FN ILEJAY	November 11, 2015	SURVEYED 13 LINES FOR BLK2C AND F
2842P	BLK2B	1BLK2B316A	G SINADJAN	November 12, 2015	SURVEYED 6 LINES FOR BLK2B
2846P	BLK2FS, BLK2BS, BLK2A	1BLK2FSBSA317A	FN ILEJAY	November 13, 2015	SURVEYED 16 LINES FOR BLK2F, BLK2B AND BLK2A
2848P	BLK2A	1BLK2AS317B	G SINADJAN	November 13, 2015	SURVEYED 2 LINES FOR BLK2A
2850P	BLK2D, BLK2E	1BLK2DE318A	G SINADJAN	November 14, 2015	SURVEYED 15 LINES FOR BLK2D AND BLK2E
2852P	BLK3AS, BLK2CS	1BLK2AS318B	FN ILEJAY	November 14, 2015	SURVEYED 4 LINES FOR BLK2A, AND VOIDS OVER BLK2C
2854P	BLK2DS, BLK2G	1BLK2DSG319A	G SINADJAN	November 15, 2015	SURVEYED 18 LINES FOR BLK2D AND BLK2G
2866P	BLK 2G ABULUG FP	1BLK2G322A	KJ ANDAYA	November 18, 2015	SURVEYED BLK 2G IN ABULUG FP; RESTARTED LASER, 2 SETS OF RANGE FILES; 202 SQ.KM
2868P	BLK 2H ABULUG FP	1BLK2H322B	J ALVIAR	November 18, 2015	SURVEYED BLK 2H; 1100M ALT; 195.06 SQ.KM
2874P	BLK 2HS (ADD'L AREA)	1BLK21C324A	K QUISADO	November 20, 2015	SURVEYED GAP BETWEEN ABULUG AND CAGAYAN FPS DUE TO HEAVY BUILD UP IN OTHER AREAS; 700M 90.3 SQ.KM
2880P	BLK 2HS	1BLK2HS325A	KJ ANDAYA	November 21, 2015	SURVEYED GAPS IN ABULUG FP AND ADDITIONAL AREA FROM FLIGHT 2874A; 194.75 SQ.KM
3965G	CAG2H, CAG2G	2CAG2DGH118A	J ALMALVEZ	April 27, 2016	Covered CAG2D,G and H
3973G	CAG2G, CAG2H	2CAG2GSHS120A	J ALMALVEZ	April 29, 2016	Finished CAG2H and parts of CAG2G
3977G	CAG2F, CAG2G	2CAG2FG121A	I ROXAS	April 30, 2016	Completed CAG2G and H

Flight No.:	2830P
Area:	CAGS1B AND CAGS1D
Mission Name:	1CAGS1BD313A
Parameters:	Altitude: 900; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

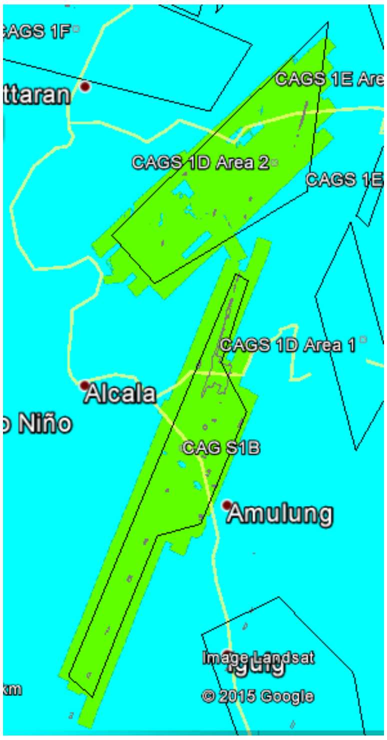


Figure A-7.1. Swath for Flight No. 2830P

Flight No.: 2838P
Area: BLK 2C & F
Mission Name: 1BLK2CF315A
Parameters: Altitude: 1100; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

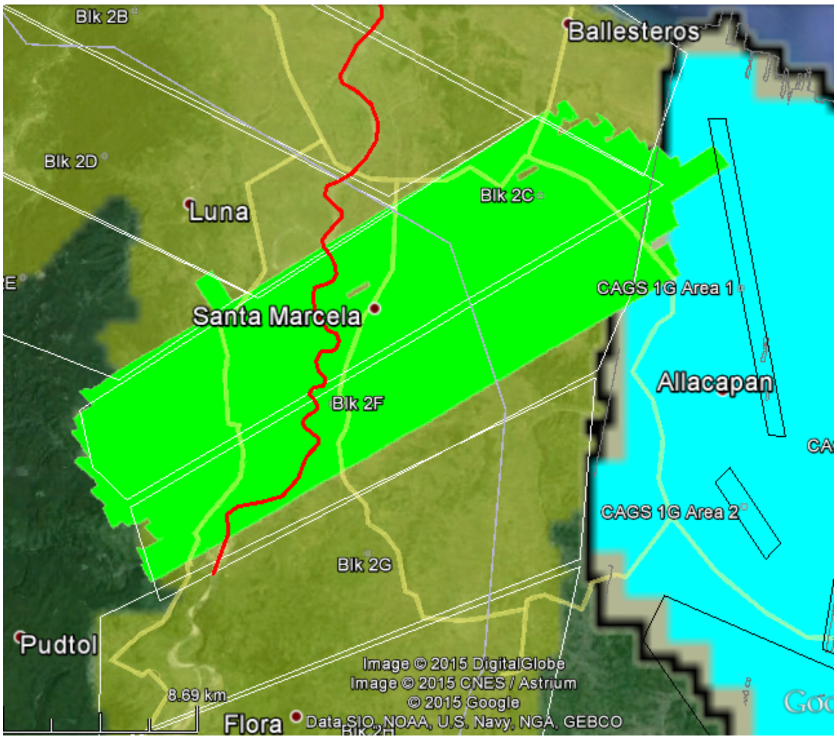


Figure A-7.2. Swath for Flight No. 2838P

Flight No.: 2842P
Area: BLK 2B
Mission Name: 1BLK2B316A
Parameters: Altitude: 850; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

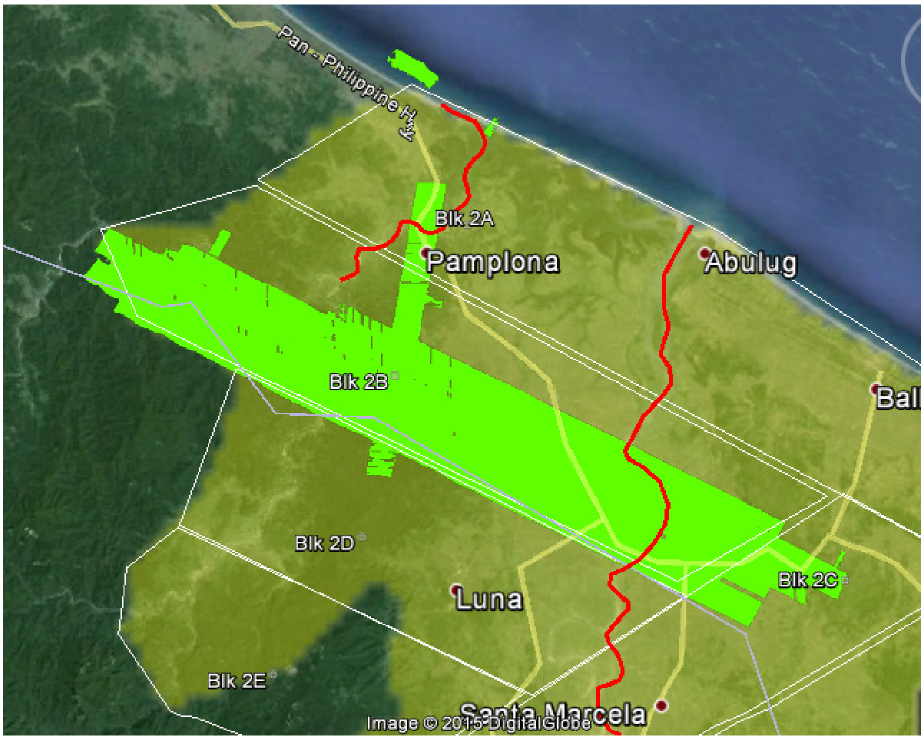


Figure A-7.3. Swath for Flight No. 2842P

Flight No.: 2846P
Area: BLK2FS, BLK2BS, BLK2A
Mission Name: 1BLK2FSBSA317A
Parameters: Altitude: 1100; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

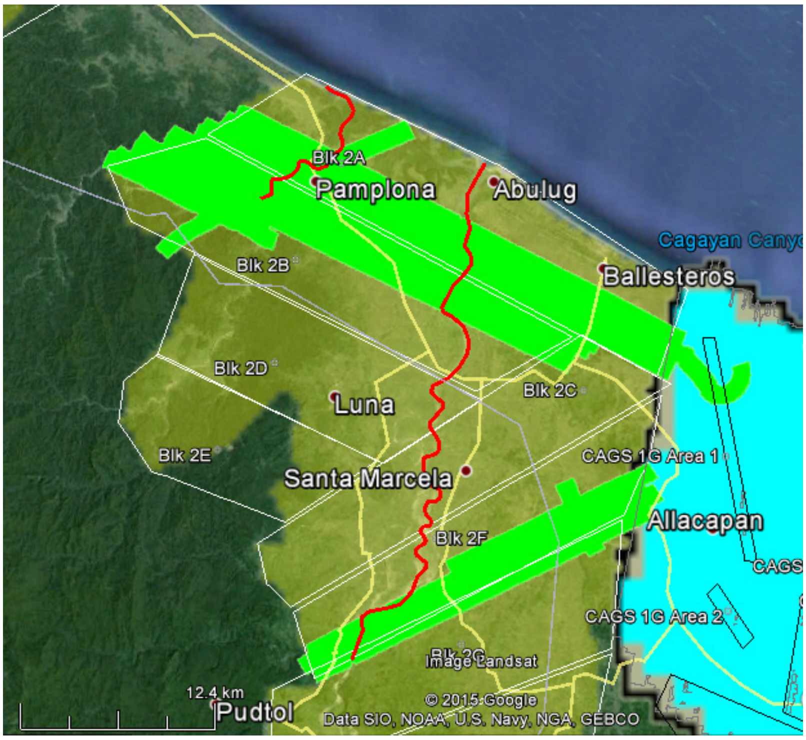


Figure A-7.4. Swath for Flight No. 2846P

Flight No.: 2848P
Area: BLK 2A
Mission Name: 3BLK331P224A
Parameters: Altitude: 900; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

Figure A-7.5. Swath for Flight No. 2848P

Flight No.: 2850P
Area: BLK2D, BLK2E
Mission Name: 1BLK2DE318A
Parameters: Altitude: 1100; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

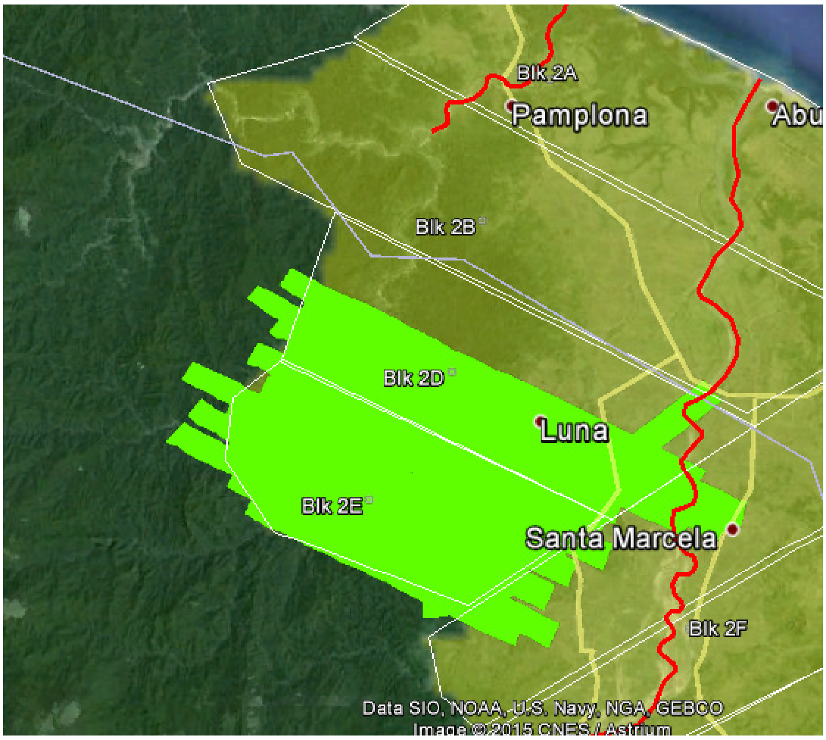


Figure A-7.6. Swath for Flight No. 2850P

Flight No.: 2852P
Area: BLK2A, BLK2CS
Mission Name: 1BLK2AS318B
Parameters: Altitude: 900; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

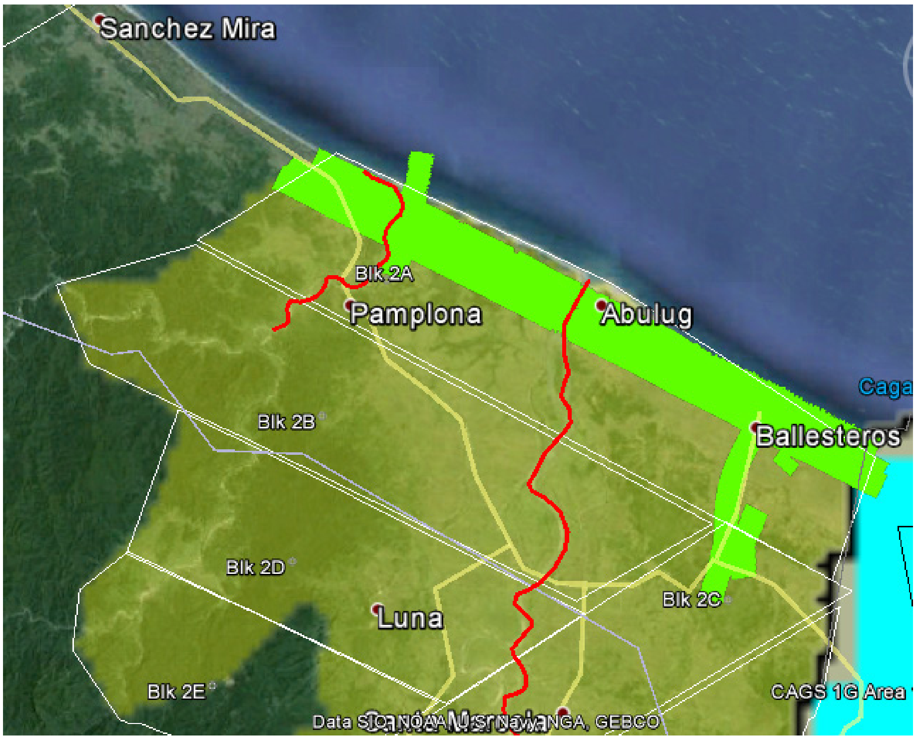


Figure A-7.7. Swath for Flight No. 2852P

Flight No.: 2854P
Area: BLK2A, BLK2CS
Mission Name: 1BLK2AS318B
Parameters: Altitude: 1000; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

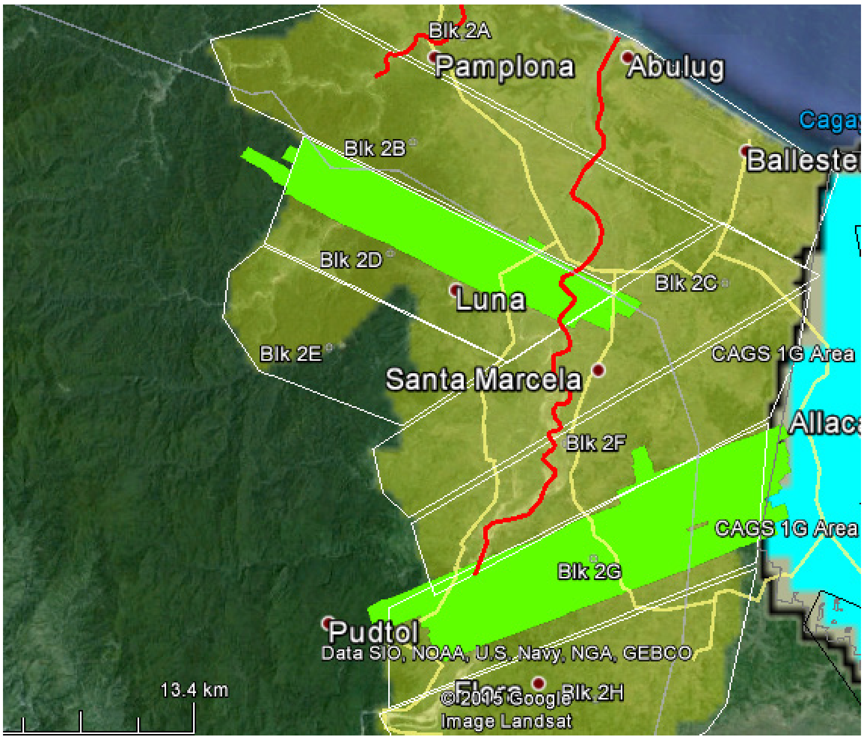


Figure A-7.8. Swath for Flight No. 2854P

Flight No.: 2866P
Area: BLK 2G
Mission Name: 1BLK2G322A
Parameters: Altitude: 700 - 900; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

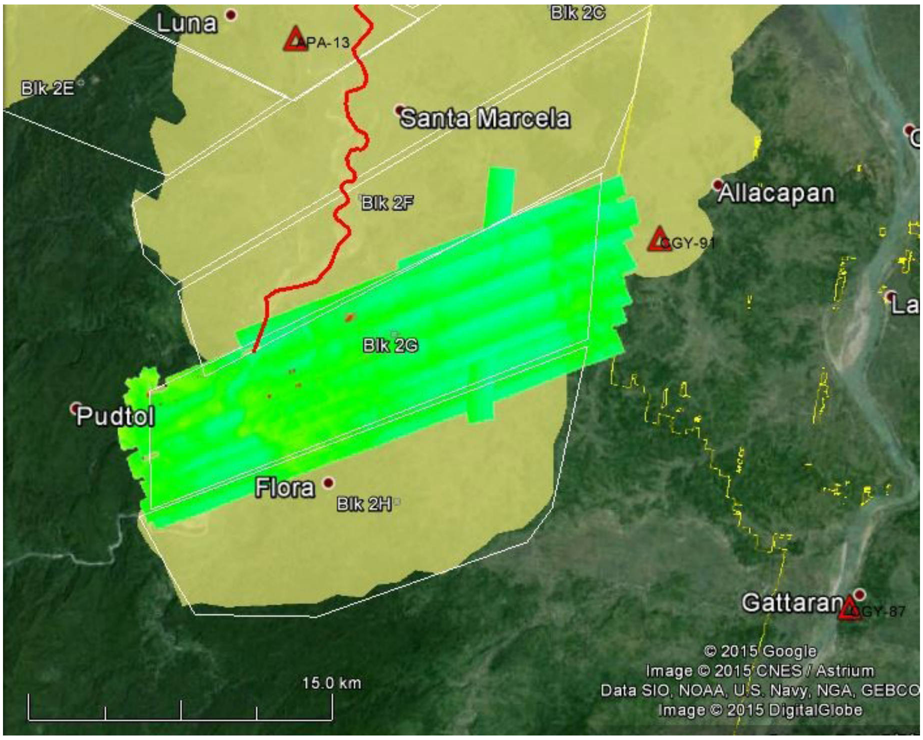


Figure A-7.9. Swath for Flight No. 2866P

Flight No.: 2868P
Area: BLK 2H
Mission Name: 1BLK2H322B
Parameters: Altitude: 700 - 900; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

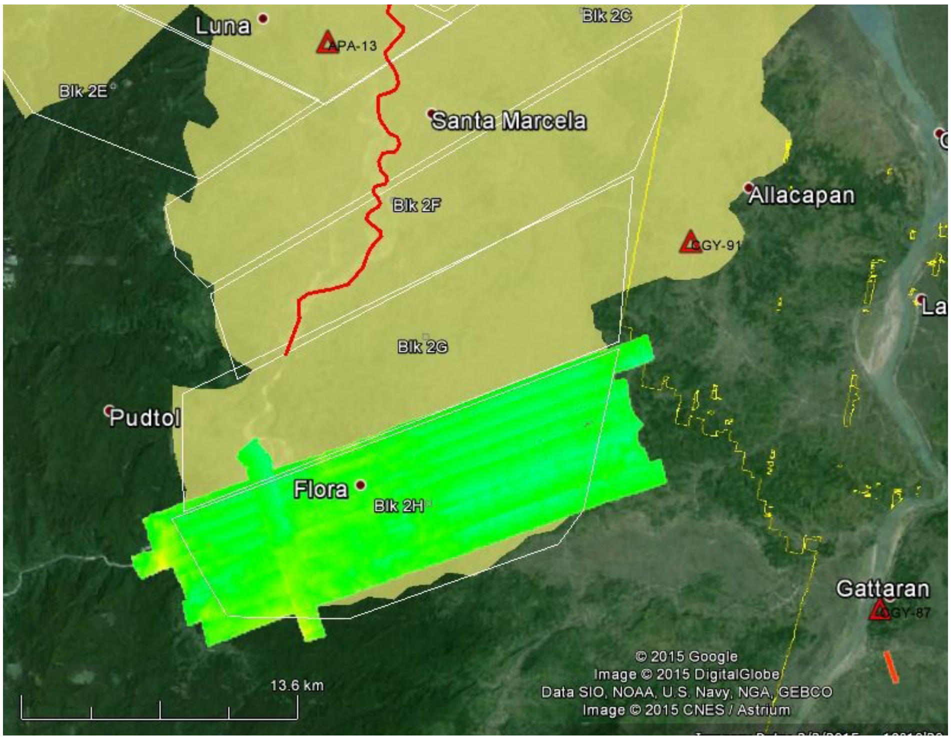


Figure A-7.10. Swath for Flight No. 2868P

Flight No.: 2874P
Area: BLK 2HS
Mission Name: 1BLK21324A
Parameters: Altitude: 700 - 900; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

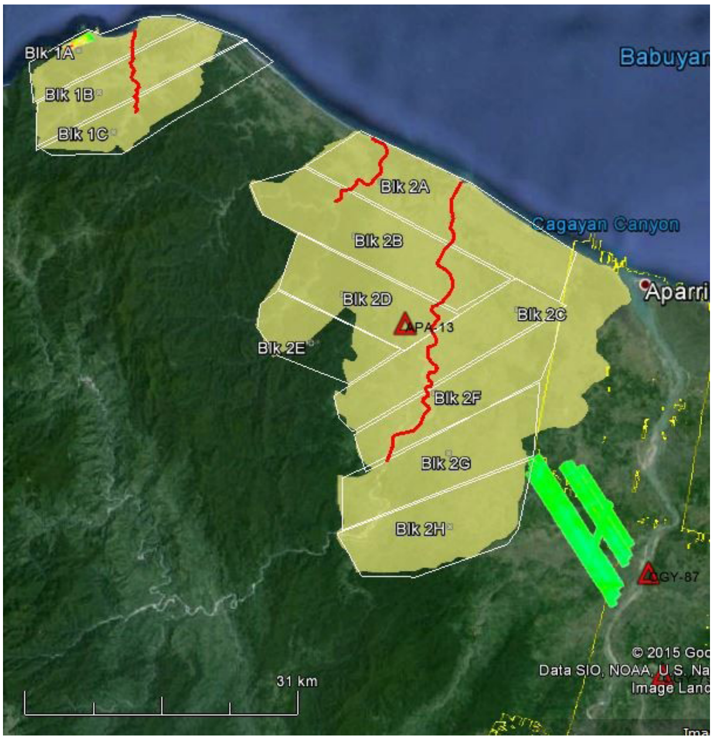


Figure A-7.11. Swath for Flight No. 2874P

Flight No.: 2880P
Area: BLK 2HS
Mission Name: 1BLK2HS325A
Parameters: Altitude: 700 - 900; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

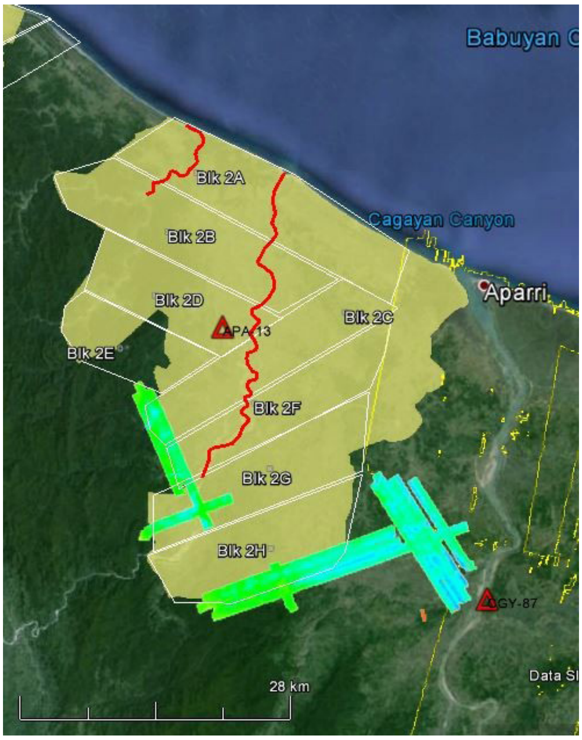


Figure A-7.12. Swath for Flight No. 2880P

Flight No.: 3965G
Area: CAG2H, CAG2G
Mission Name: 2CAG2DGH118A
Parameters: Altitude: 800-1000; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

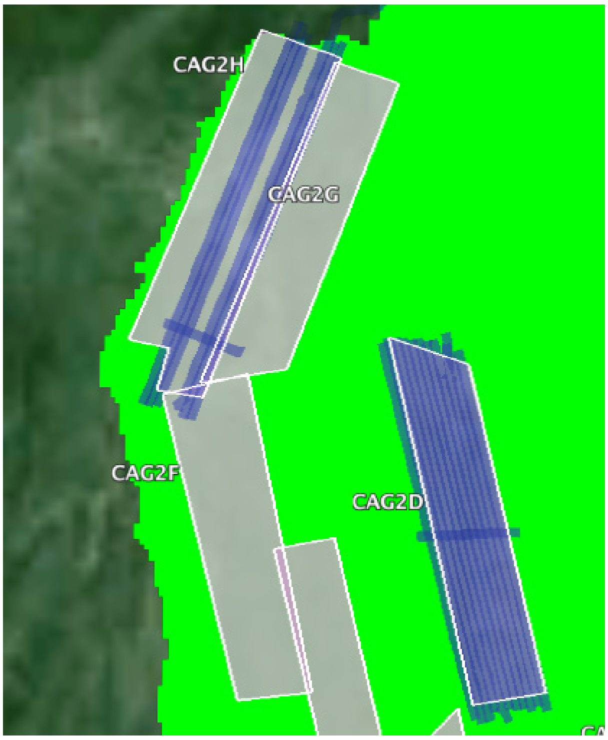


Figure A-7.13. Swath for Flight No. 3965G

Flight No.: 3973G
Area: CAG2H, CAG2G
Mission Name: 2CAG2GSHS120A
Parameters: Altitude: 800-1000; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

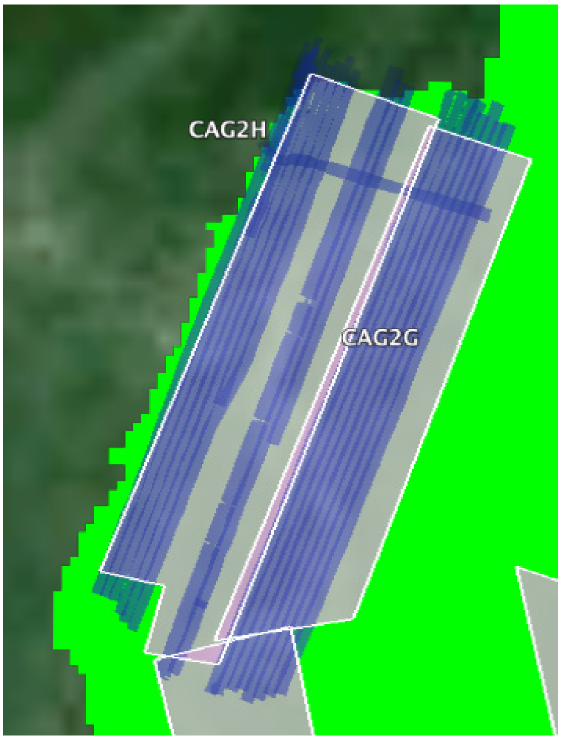


Figure A-7.14. Swath for Flight No. 3973G

Flight No.: 3977G
Area: CAG2F, CAG2G
Mission Name: 2CAG2FG121A
Parameters: Altitude: 800-1000; Scan Frequency: 30; Scan Angle: 25; Overlap: 30%

LAS

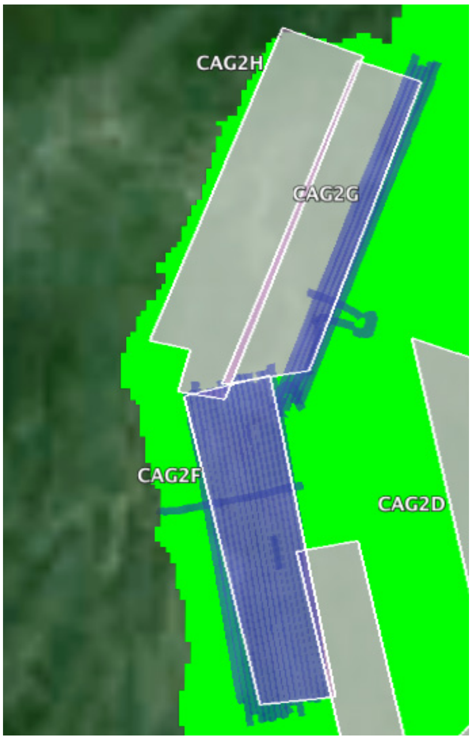


Figure A-7.15. Swath for Flight No. 3977G

Annex 8. Mission Summary Reports

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**Blk2H_supplement**
Inclusive Flights	2874P
Range data size	12GB
POS	195MB
Image	7.3MB
Transfer date	December 4, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.30
RMSE for East Position (<4.0 cm)	1.09
RMSE for Down Position (<8.0 cm)	4.47
Boresight correction stdev (<0.001deg)	0.000335
IMU attitude correction stdev (<0.001deg)	0.000577
GPS position stdev (<0.01m)	0.0012
Minimum % overlap (>25)	37.40
Ave point cloud density per sq.m. (>2.0)	4.525
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	120
Maximum Height	216.79 m
Minimum Height	34.72 m
Classification (# of points)	
Ground	126,443,976
Low vegetation	107,441,642
Medium vegetation	114,792,801
High vegetation	250,898,469
Building	10,206,821
Orthophoto	Yes
Processed by	Engr. Sheila Maye Santillan, Engr. Antonio Chua Jr., JovyNarisma

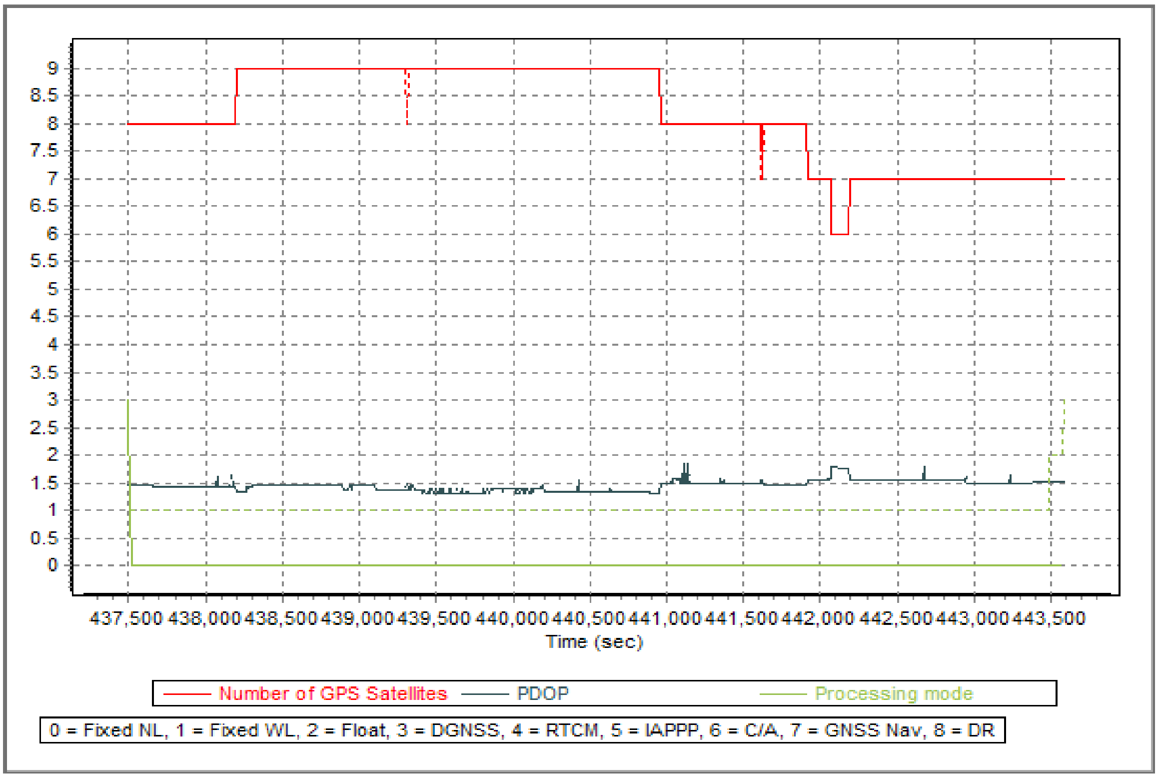


Figure 1.1.1. Solution Status

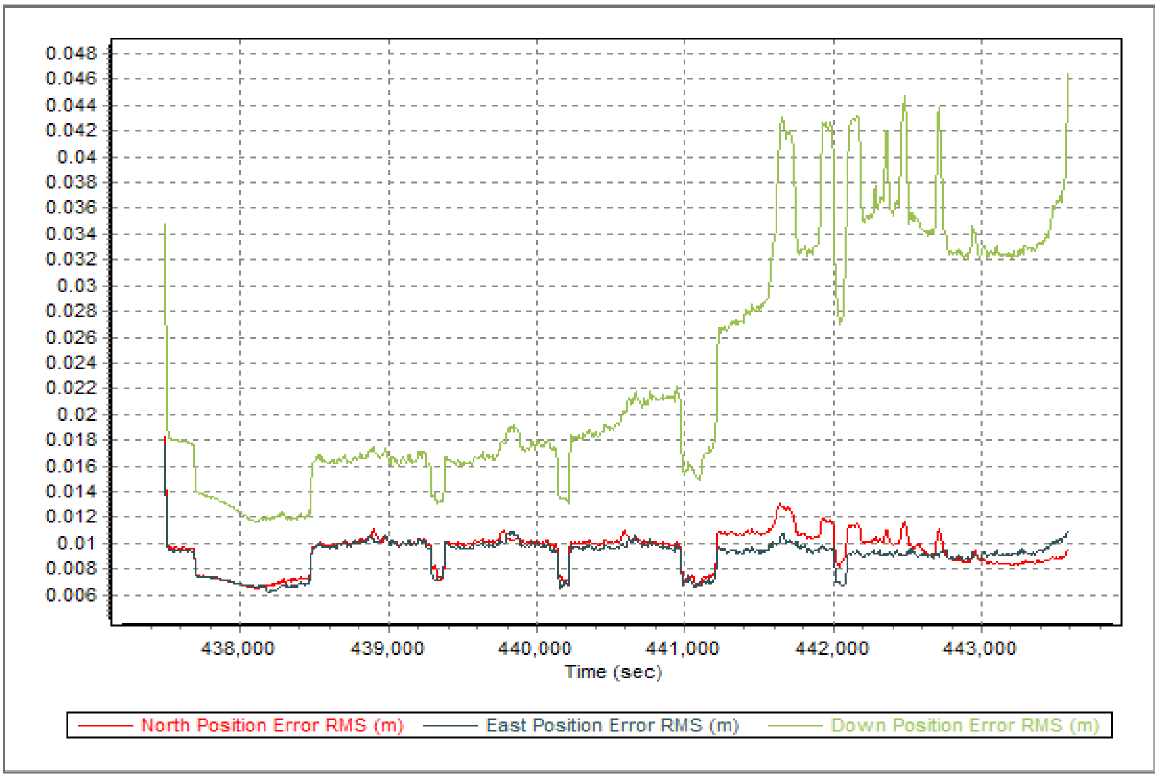


Figure 1.1.2. Smoothed Performance Metric Parameters

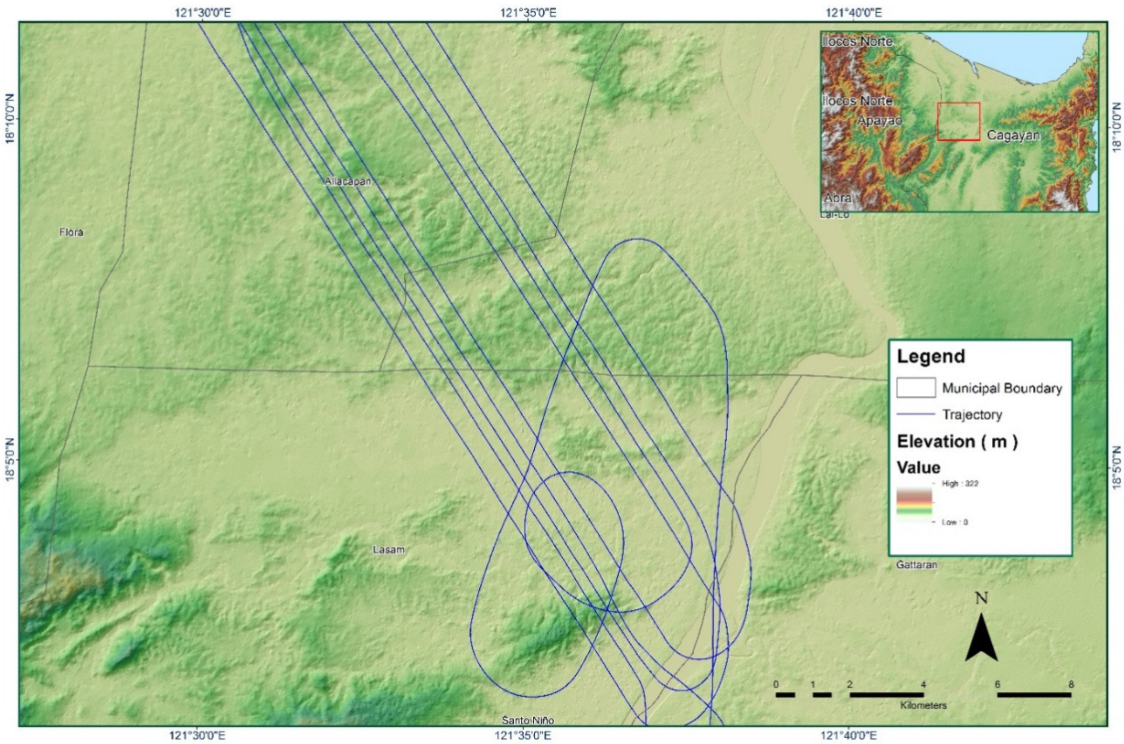


Figure 1.1.3 Best Estimated Trajectory

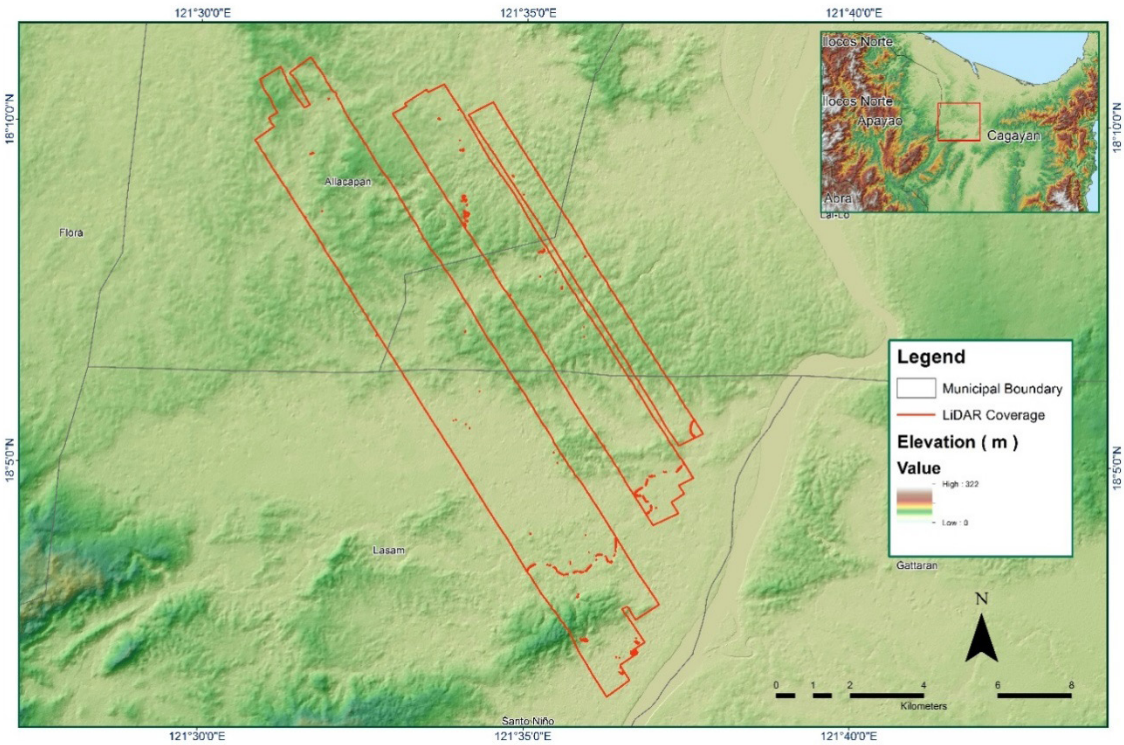


Figure 1.1.4 Coverage of LiDAR data

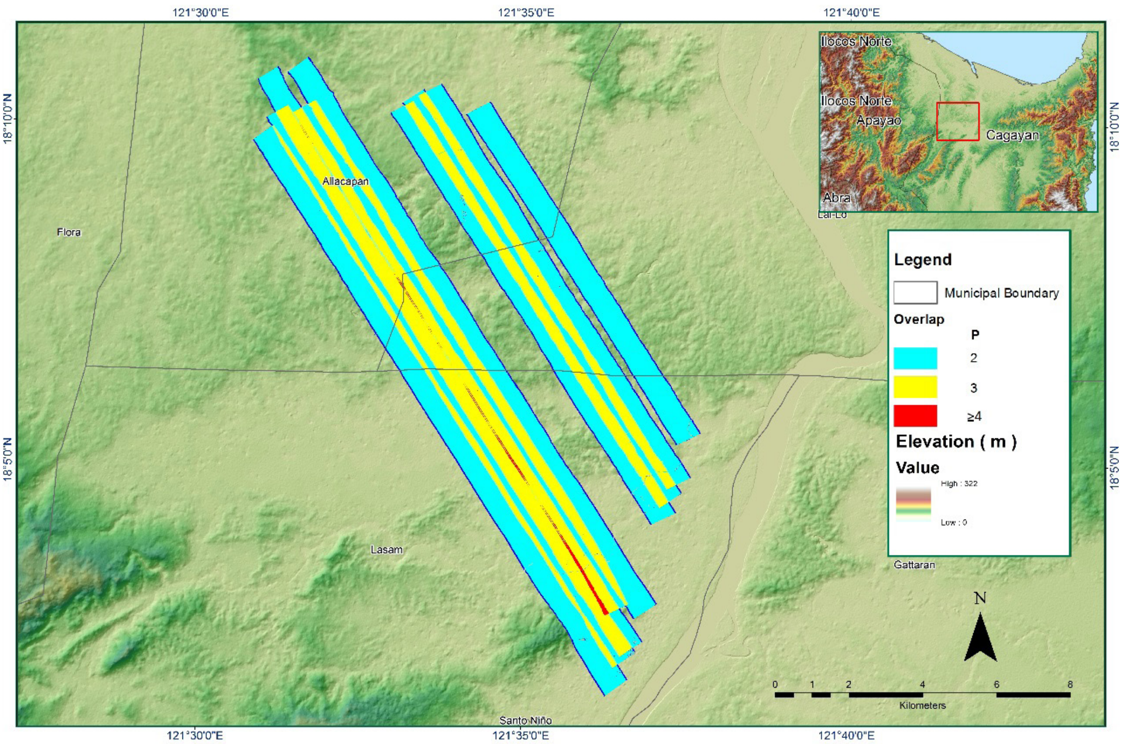


Figure 1.1.5 Image of data overlap

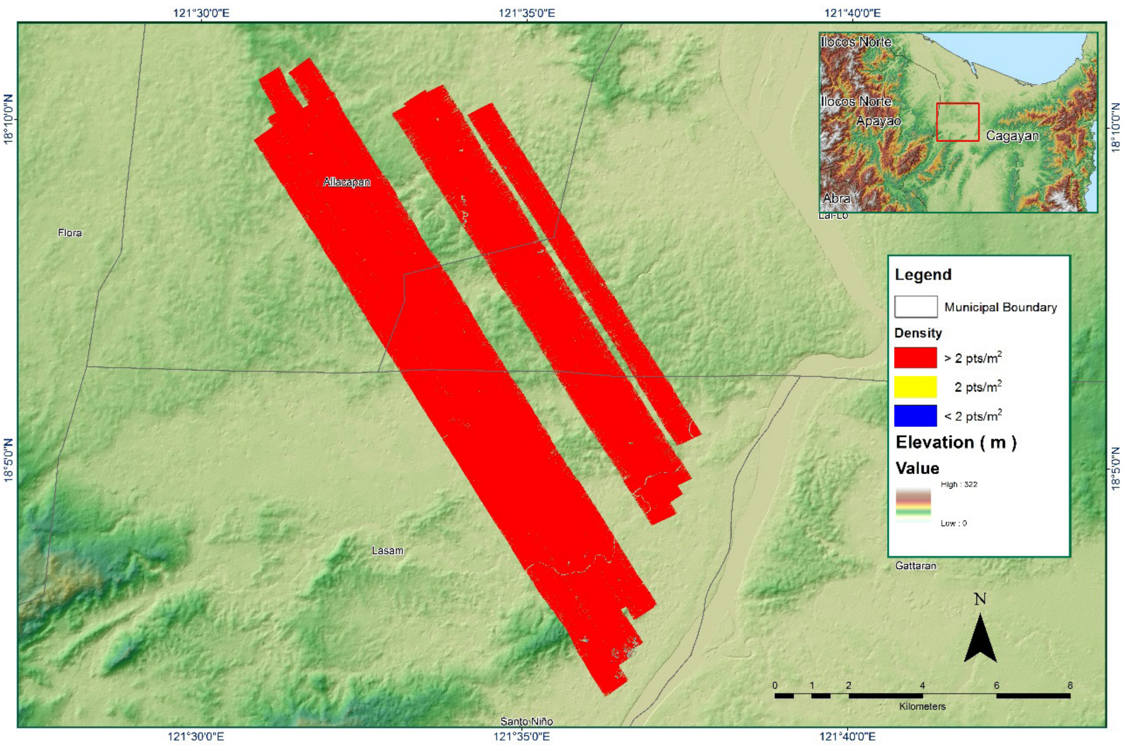


Figure 1.1.6 Density map of merged LiDAR data

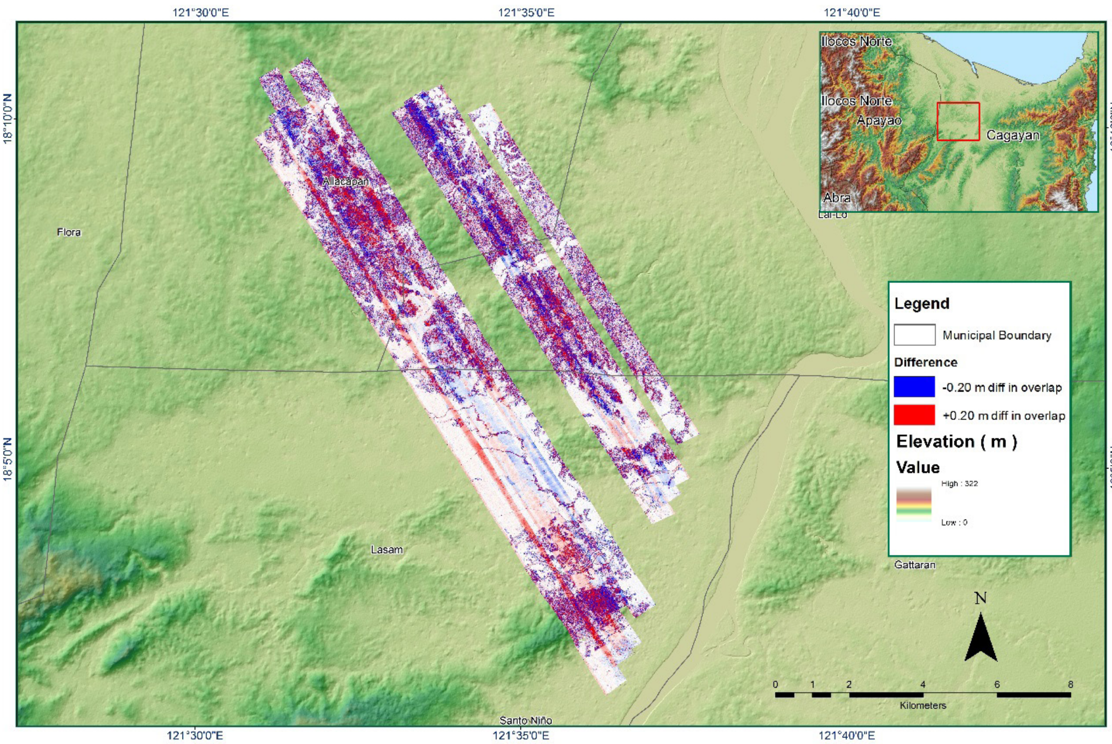


Figure 1.1.7 Elevation difference between flight lines

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**Blk2F**
Inclusive Flights	2838P
Range data size	28.9GB
POS	254MB
Image	46.7MB
Transfer date	November 24, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.16
RMSE for East Position (<4.0 cm)	1.33
RMSE for Down Position (<8.0 cm)	2.30
Boresight correction stdev (<0.001deg)	0.000324
IMU attitude correction stdev (<0.001deg)	0.001354
GPS position stdev (<0.01m)	0.0017
Minimum % overlap (>25)	42.36
Ave point cloud density per sq.m. (>2.0)	3.27
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	318
Maximum Height	927.58 m
Minimum Height	26.44 m
Classification (# of points)	
Ground	321,229,000
Low vegetation	311,186,721
Medium vegetation	332,571,906
High vegetation	529,282,178
Building	18,727,068
Orthophoto	Yes
Processed by	Engr. RaymundRhommel Sta. Ana, Engr. Harmond Santos, Alex Escobido

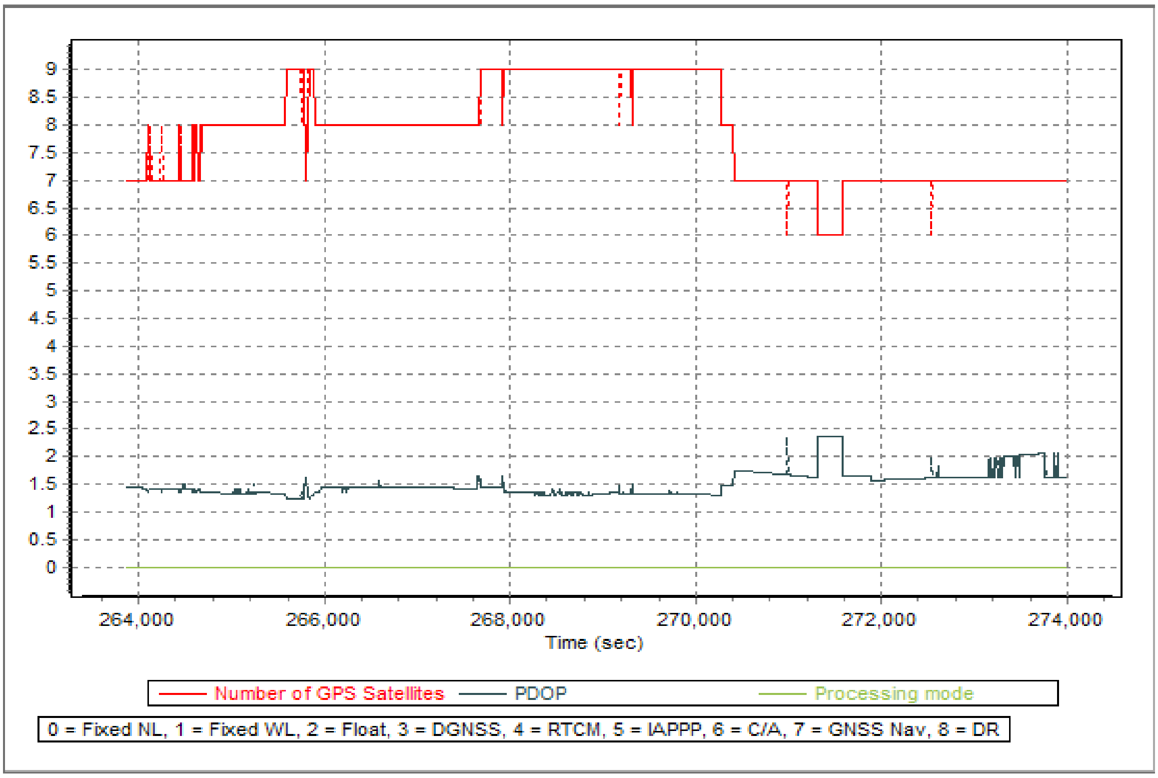


Figure 1.2.1. Solution Status

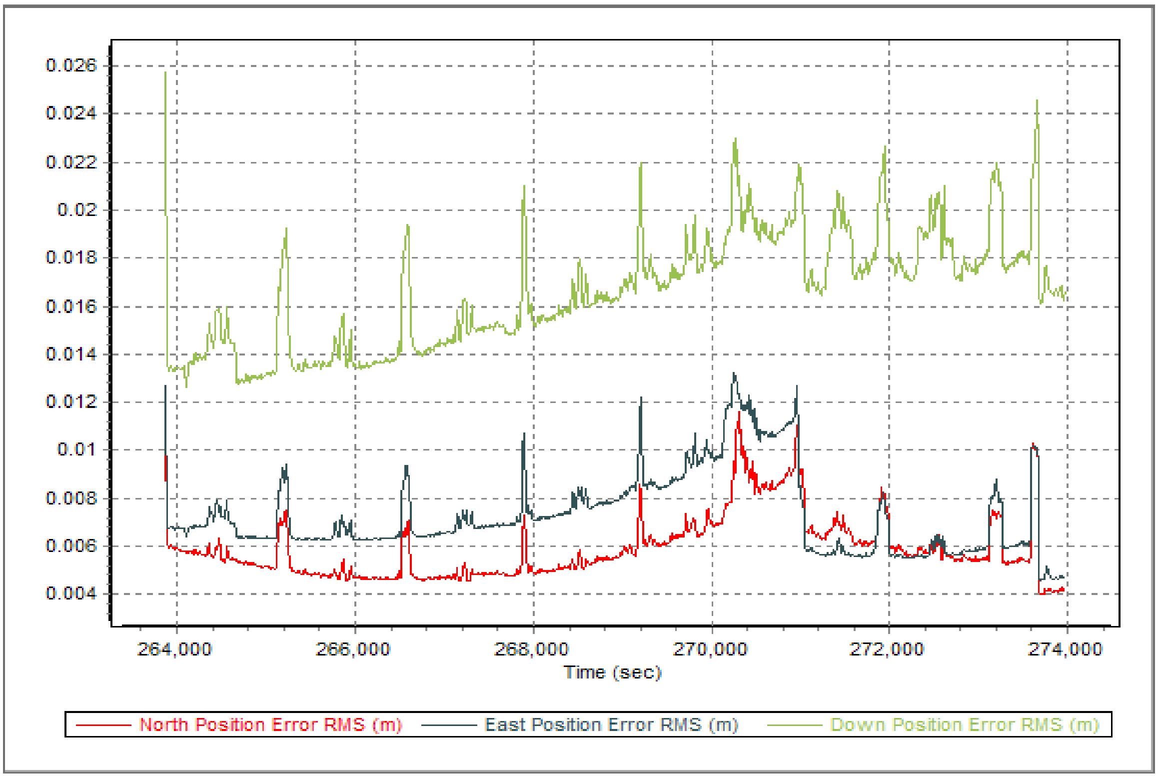


Figure 1.2.2. Smoothed Performance Metric Parameters

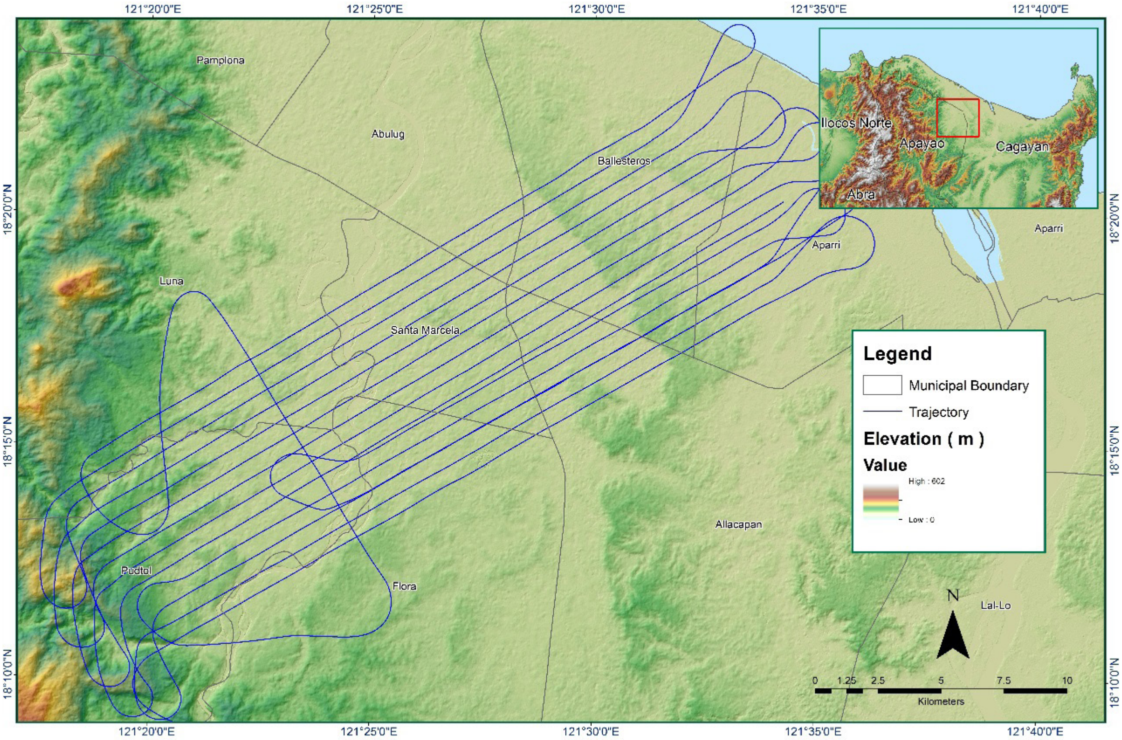


Figure 1.2.3. Best Estimated Trajectory

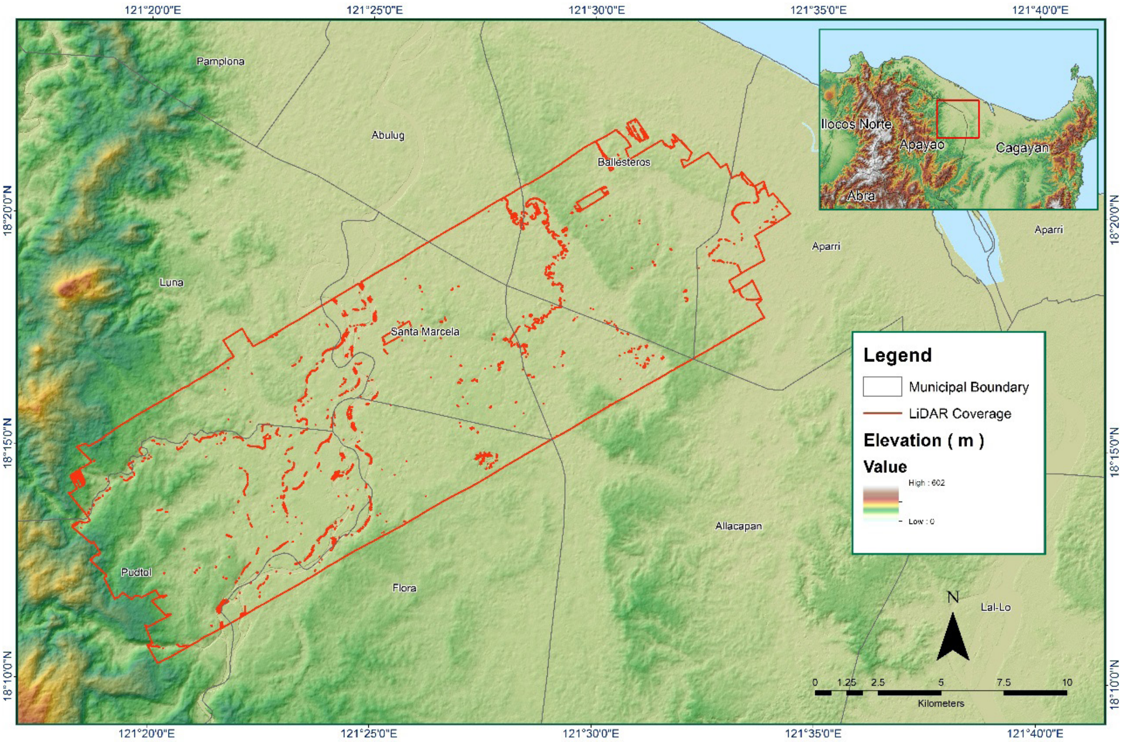


Figure 1.2.4 Coverage of LiDAR data

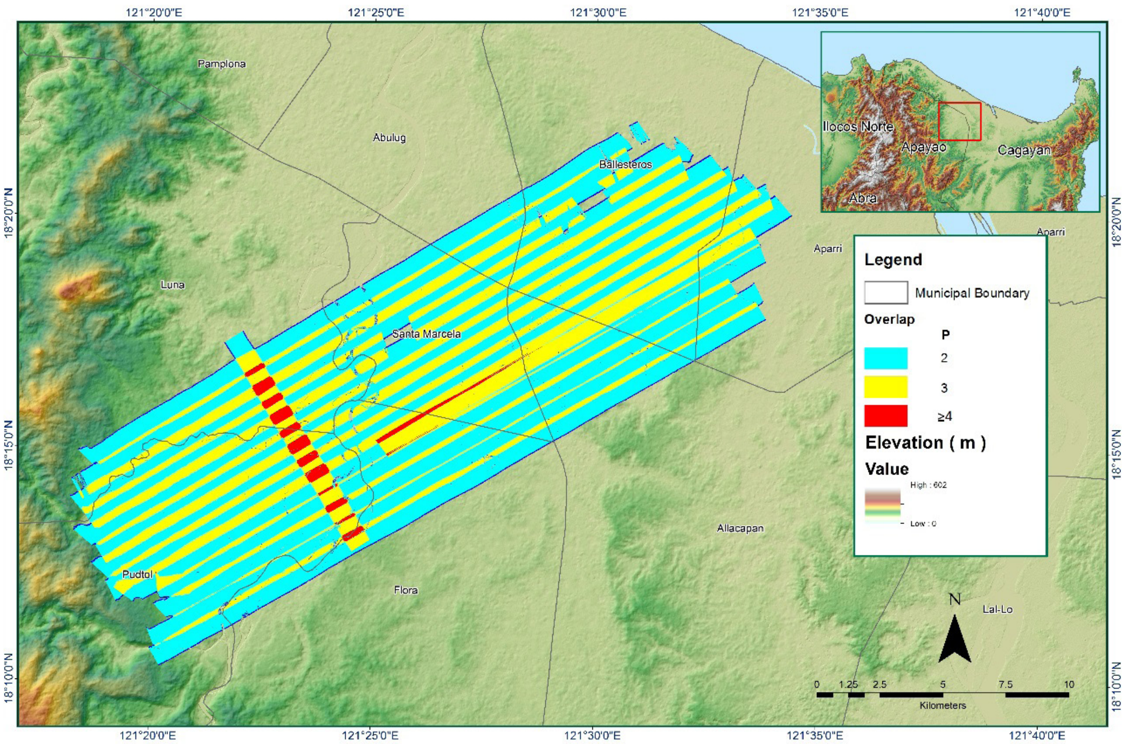


Figure 1.2.5 Image of data overlap

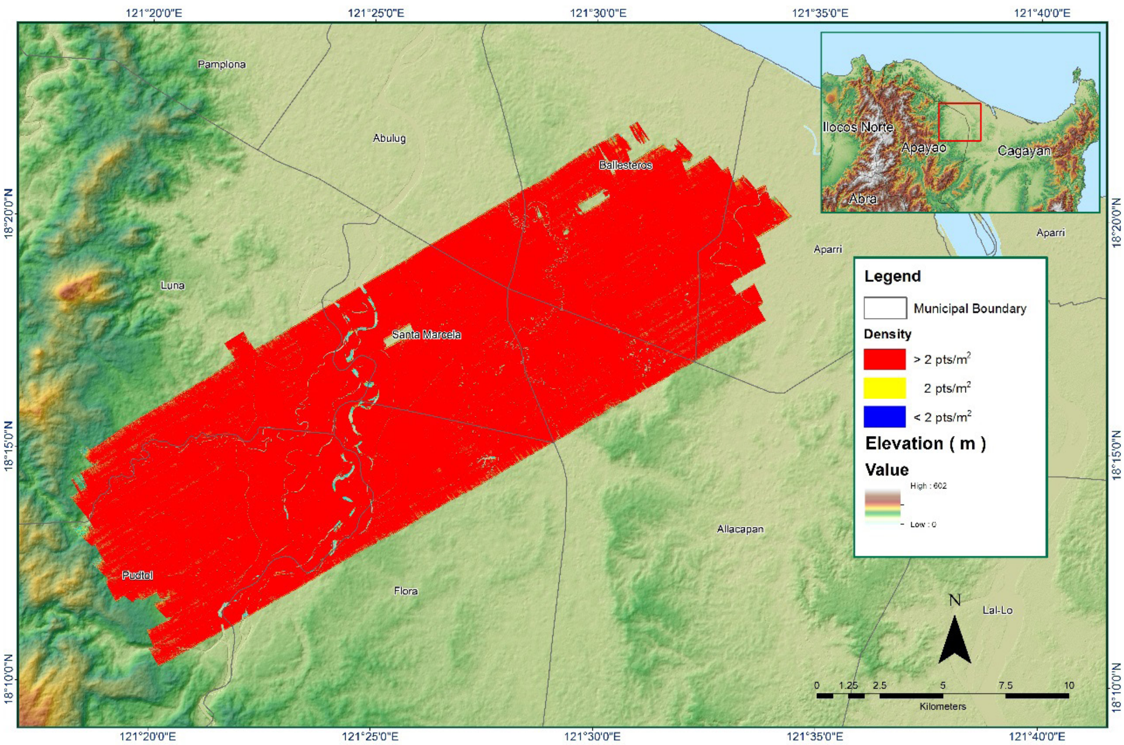


Figure 1.2.6 Density map of merged LiDAR data

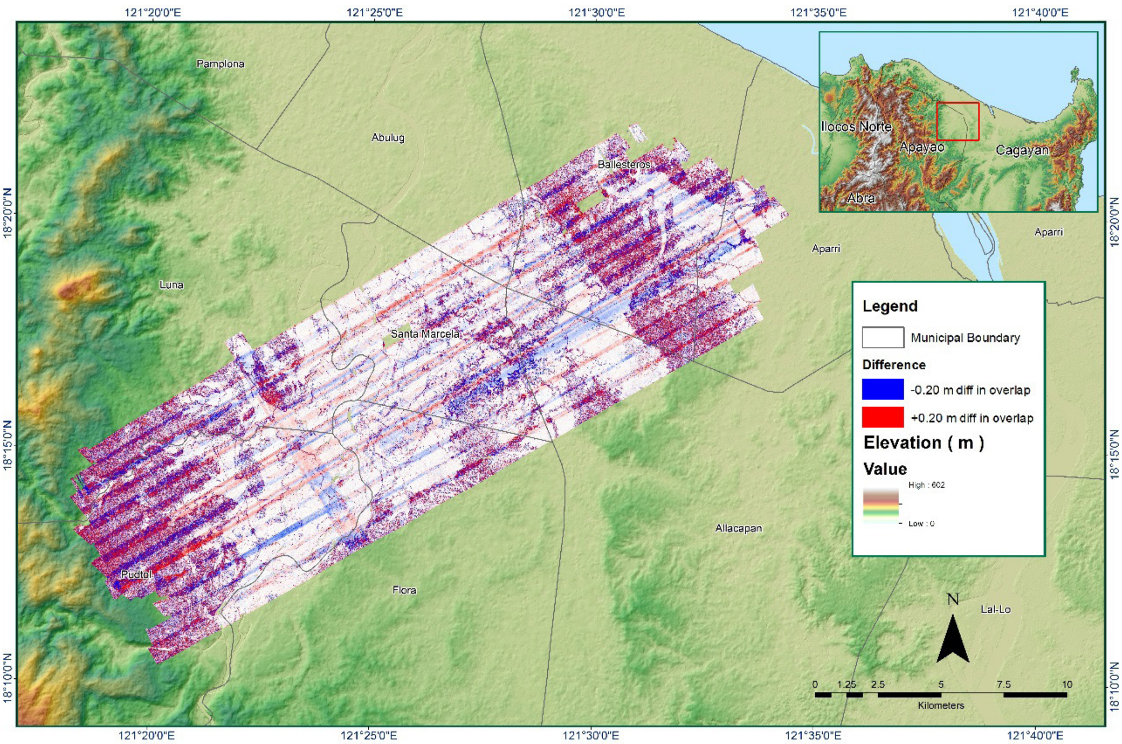


Figure 1.2.7 Elevation difference between flight lines

MISSION SUMMARY REPORT

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**Blk2H**
Inclusive Flights	2868P
Range data size	18GB
POS	157MB
Image	27.7MB
Transfer date	December 4, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.14
RMSE for East Position (<4.0 cm)	1.18
RMSE for Down Position (<8.0 cm)	3.59
Boresight correction stdev (<0.001deg)	0.000336
IMU attitude correction stdev (<0.001deg)	0.000684
GPS position stdev (<0.01m)	0.0025
Minimum % overlap (>25)	44.94
Ave point cloud density per sq.m. (>2.0)	3.225
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	220
Maximum Height	504.11 m
Minimum Height	53.95 m
Classification (# of points)	
Ground	153,039,669
Low vegetation	118,662,014
Medium vegetation	193,898,058
High vegetation	588,458,495
Building	9,030,250
Orthophoto	Yes
Processed by	Engr. Angelo Carlo Bongat, Engr. RdgardoGubatanga Jr., Kathryn Claudine Zarate

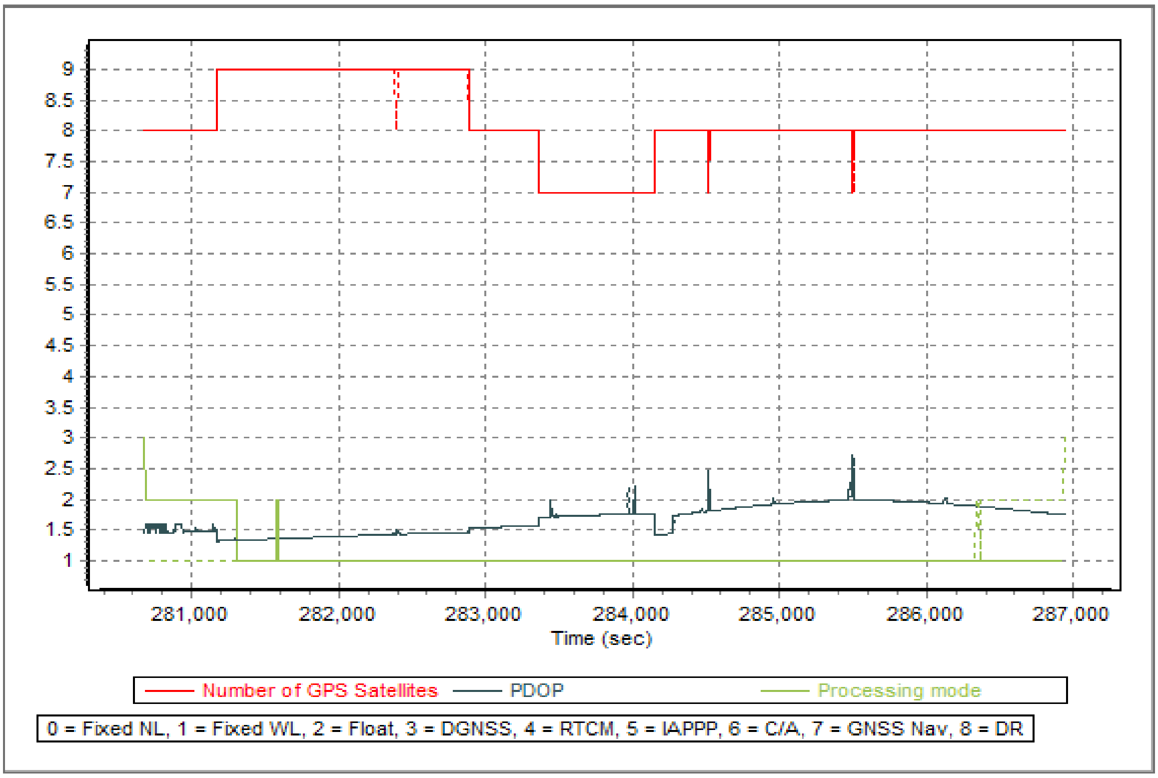


Figure 1.3.1. Solution Status

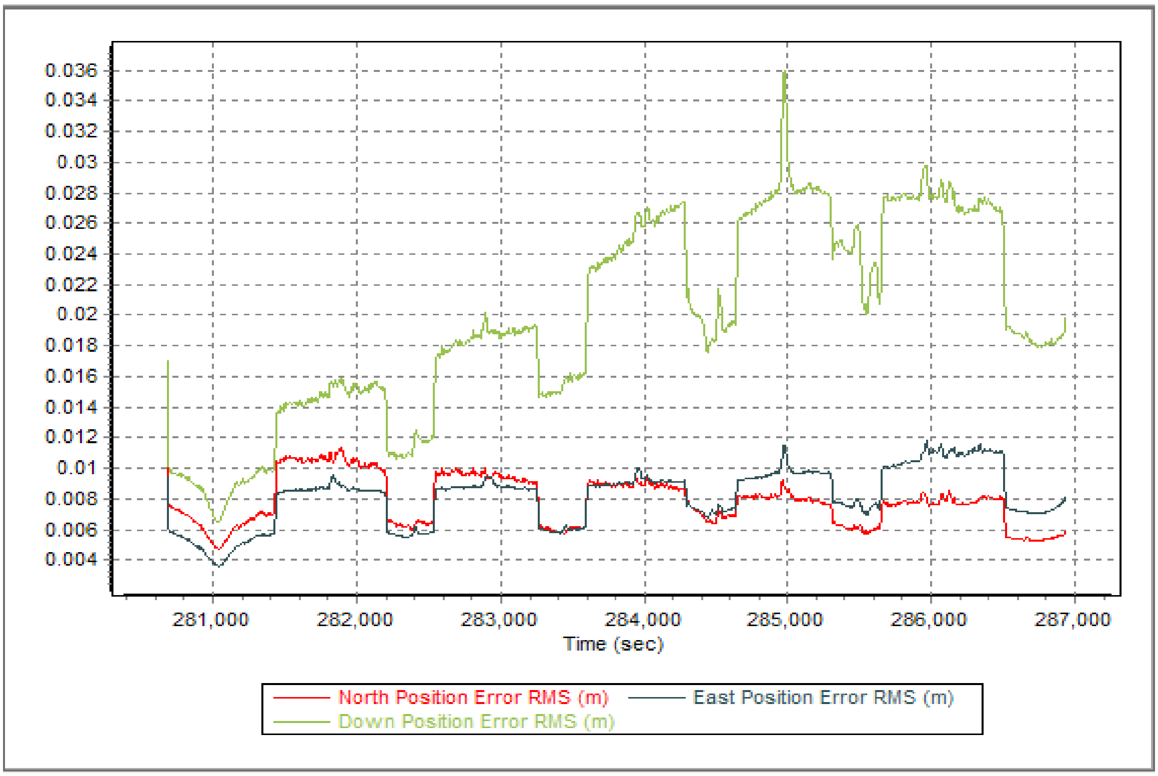


Figure 1.3.2. Smoothed Performance Metric Parameters

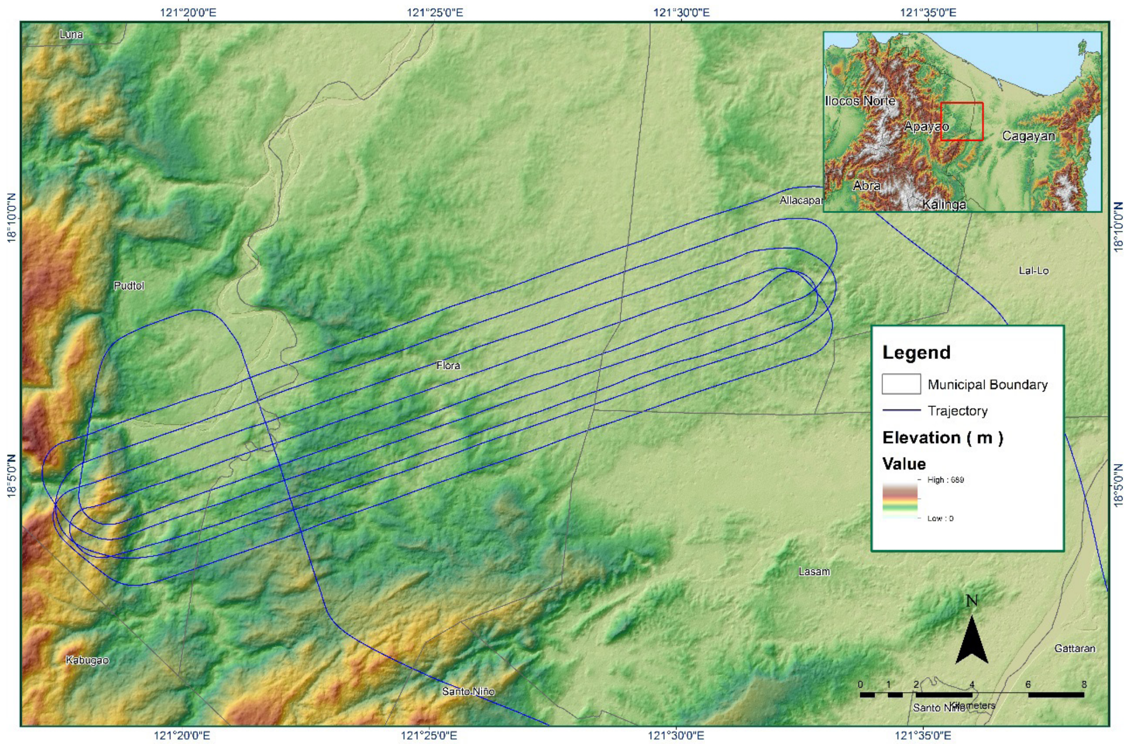


Figure 1.3.3. Best Estimated Trajectory

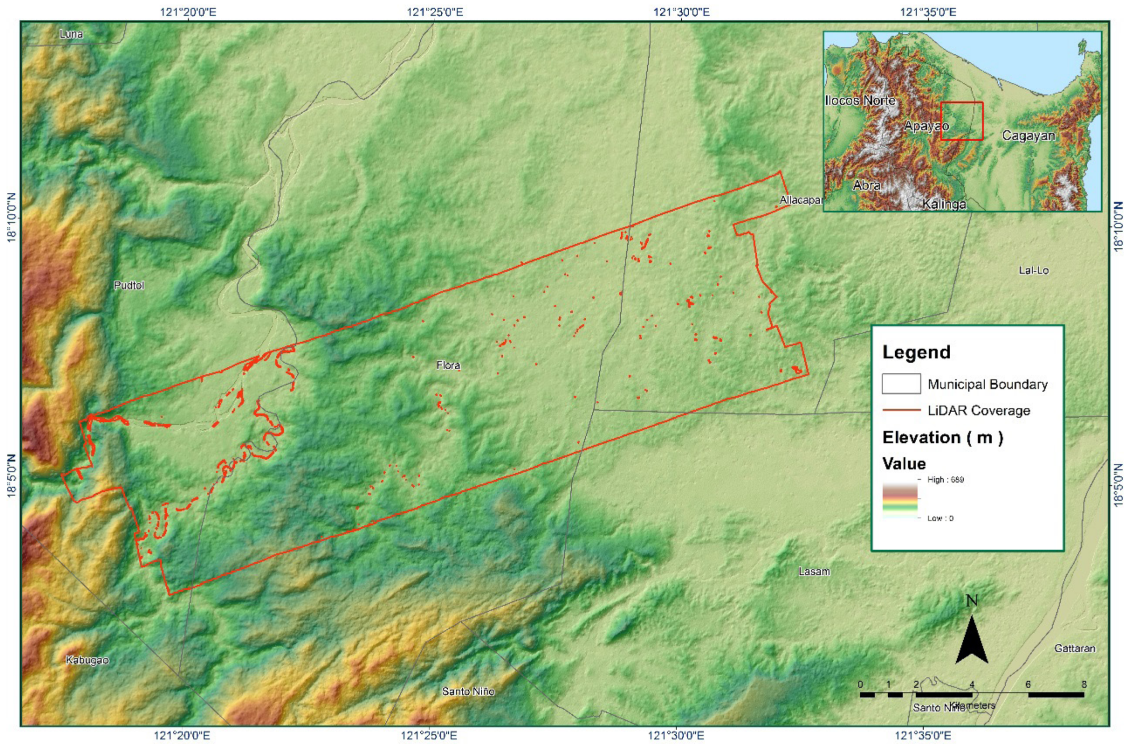


Figure 1.3.4 Coverage of LiDAR data

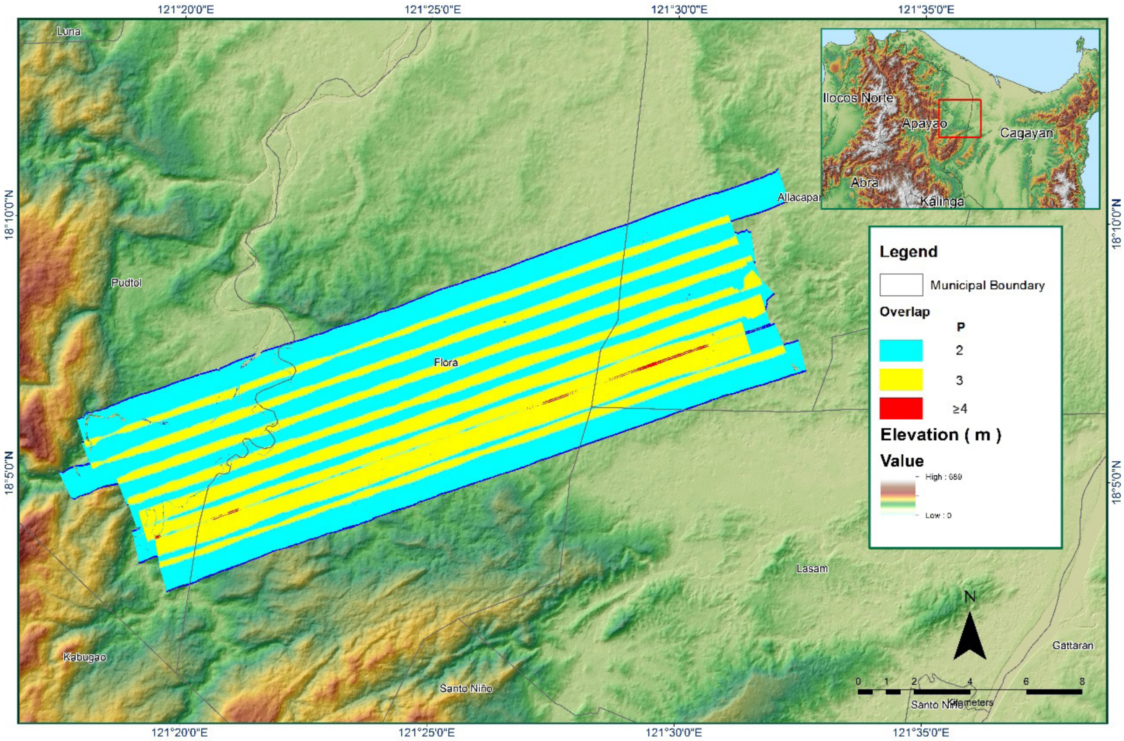


Figure 1.3.5 Image of data overlap

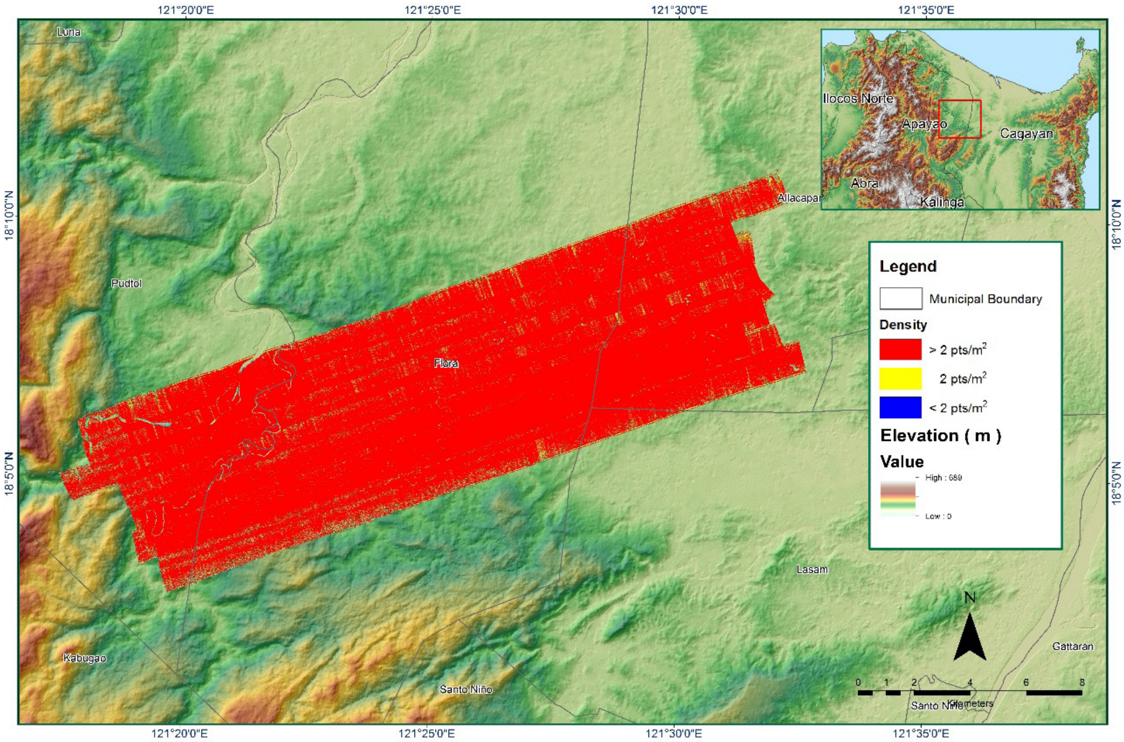


Figure 1.3.6 Density map of merged LiDAR data

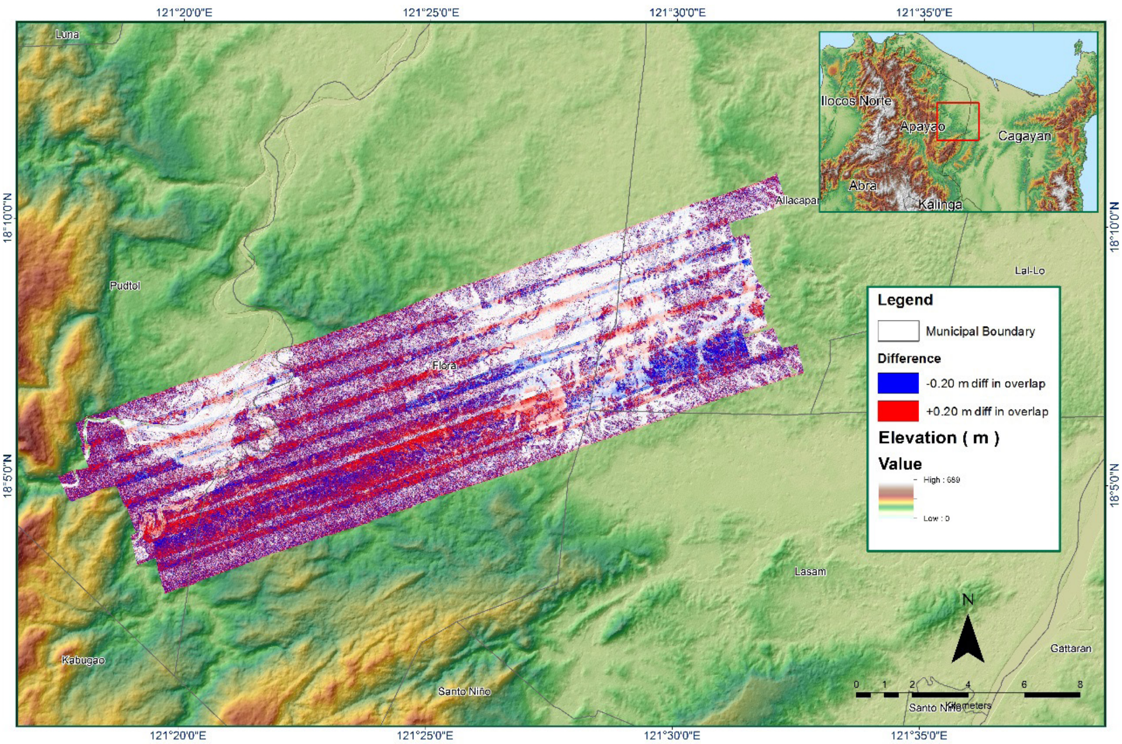


Figure 1.3.7 Elevation difference between flight lines

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**Blk2H_additional**
Inclusive Flights	2880P
Range data size	17.7GB
POS	231MB
Image	30MB
Transfer date	December 4, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.04
RMSE for East Position (<4.0 cm)	1.12
RMSE for Down Position (<8.0 cm)	3.84
Boresight correction stdev (<0.001deg)	0.000183
IMU attitude correction stdev (<0.001deg)	0.000168
GPS position stdev (<0.01m)	0.0106
Minimum % overlap (>25)	20.63
Ave point cloud density per sq.m. (>2.0)	3.695
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	110
Maximum Height	404.94 m
Minimum Height	45.04 m
Classification (# of points)	
Ground	70,962,745
Low vegetation	38,355,970
Medium vegetation	58,687,685
High vegetation	304,434,322
Building	2,803,730
Orthophoto	Yes
Processed by	Engr. Sheila Maye Santillan, Engr. Christy Lubiano, JovyNarisma

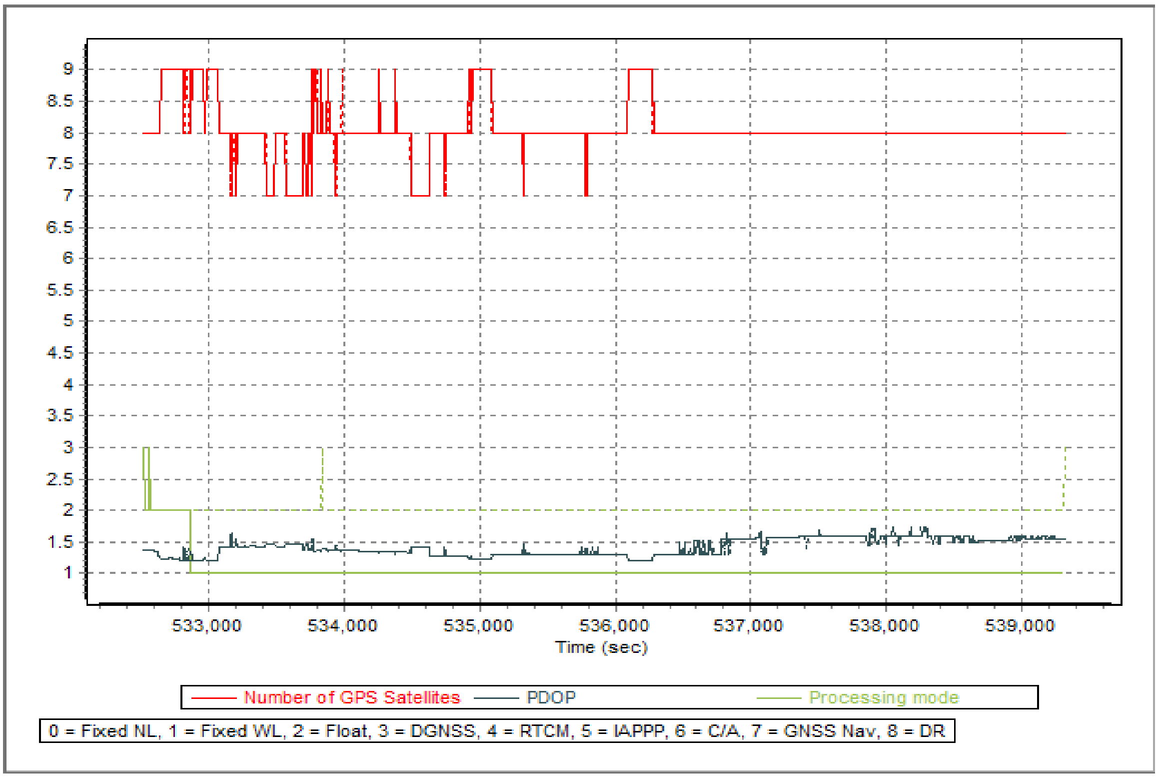


Figure 1.4.1 Solution Status

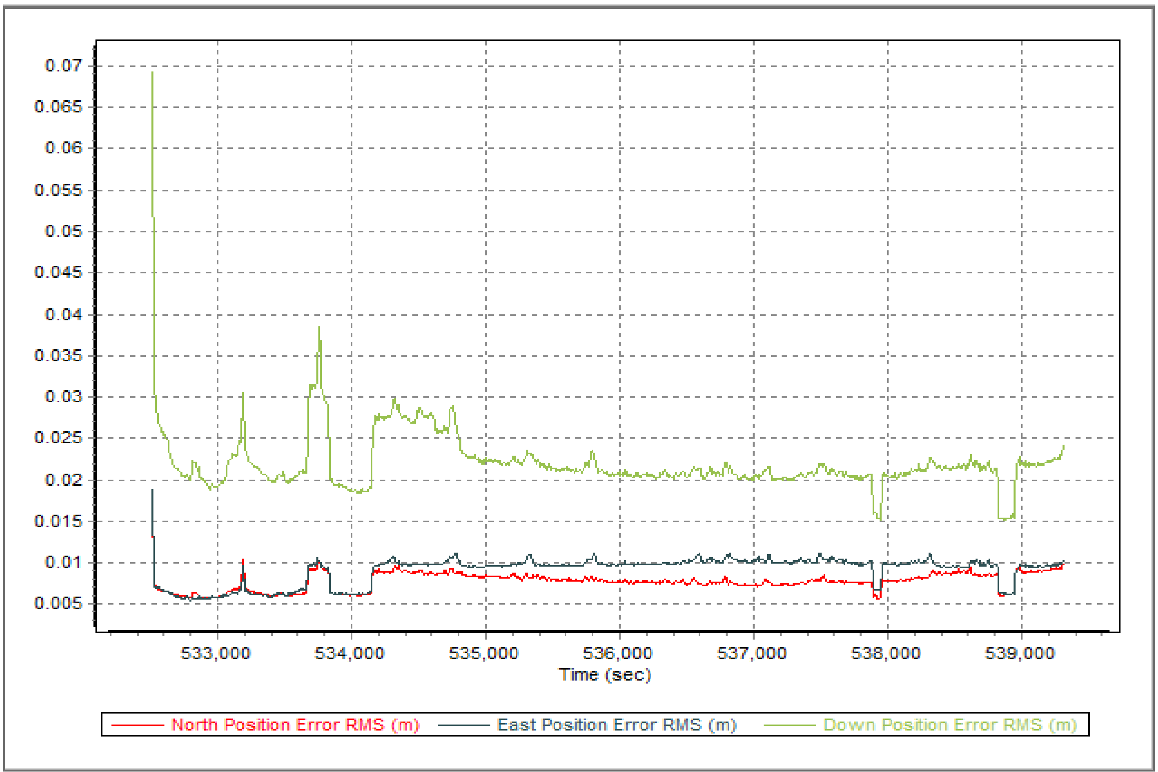


Figure 1.4.2. Smoothed Performance Metric Parameters

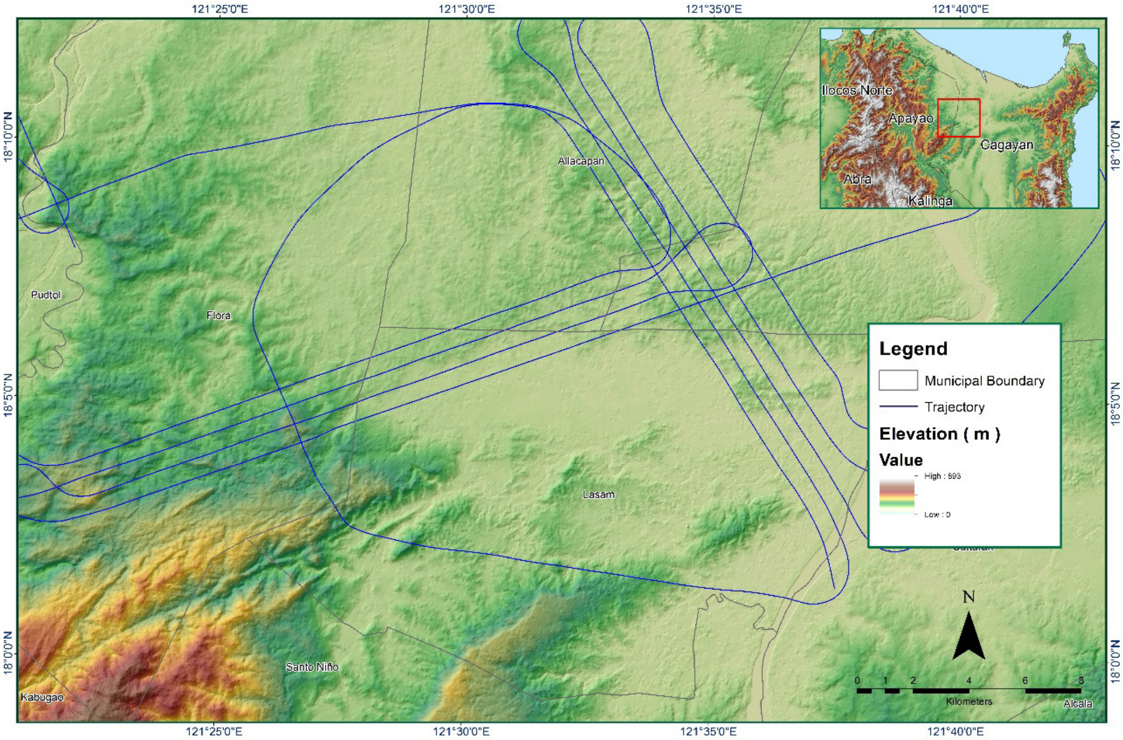


Figure 1.4.3. **Best Estimated Trajectory**

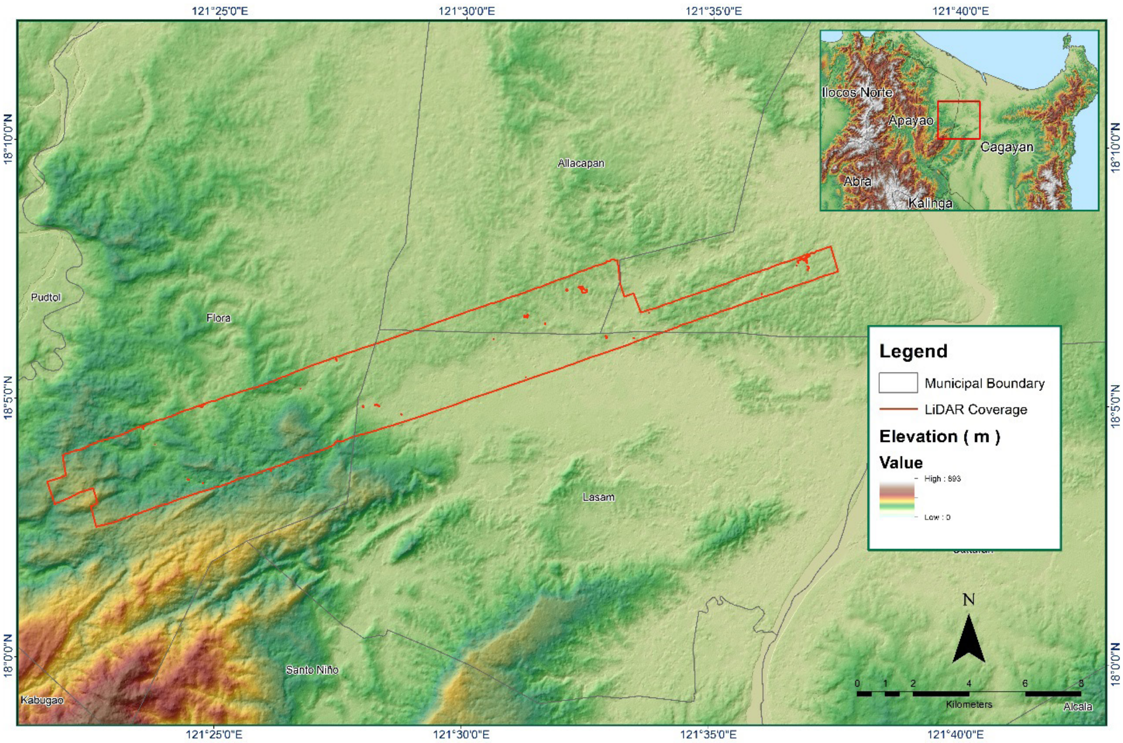


Figure 1.4.4. Coverage of LiDAR data

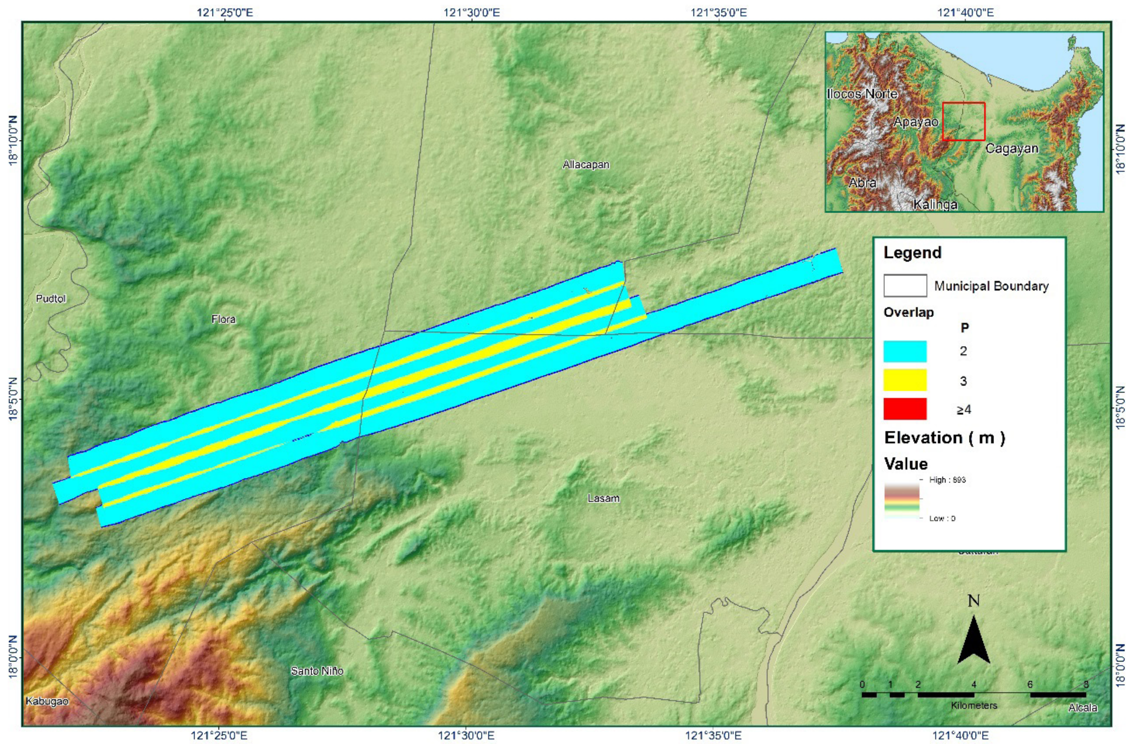


Figure 1.4.5. Image of data overlap

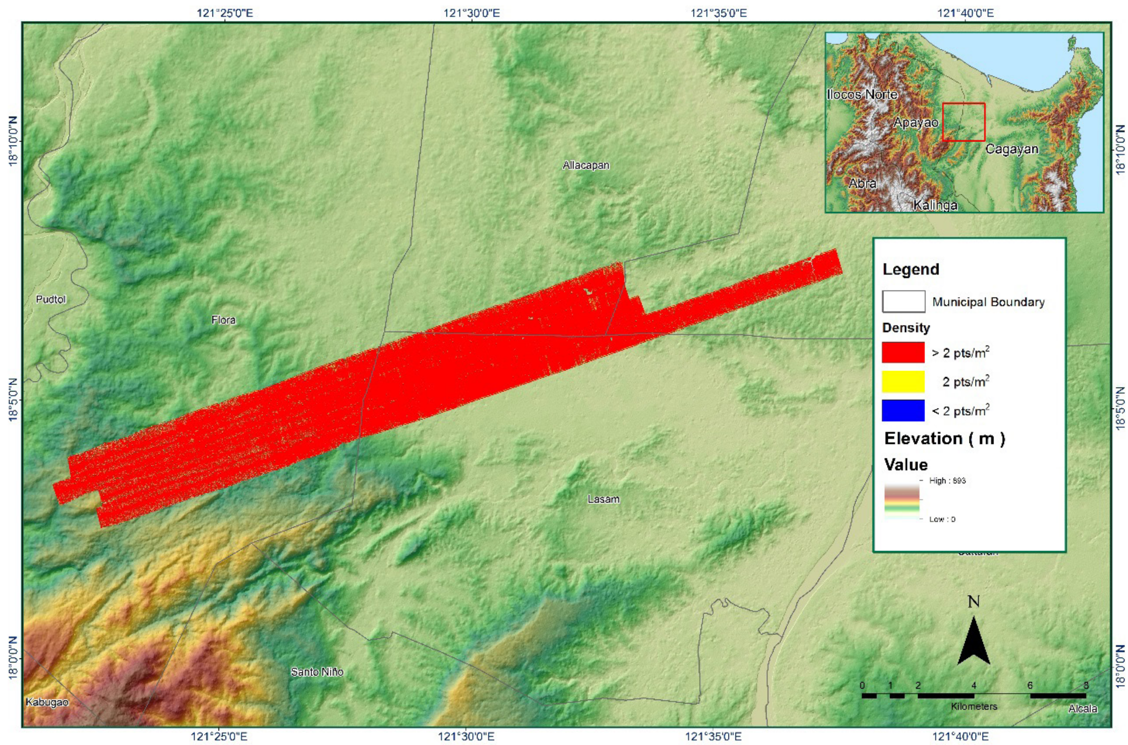


Figure 1.4.6. Density map of merged LiDAR data

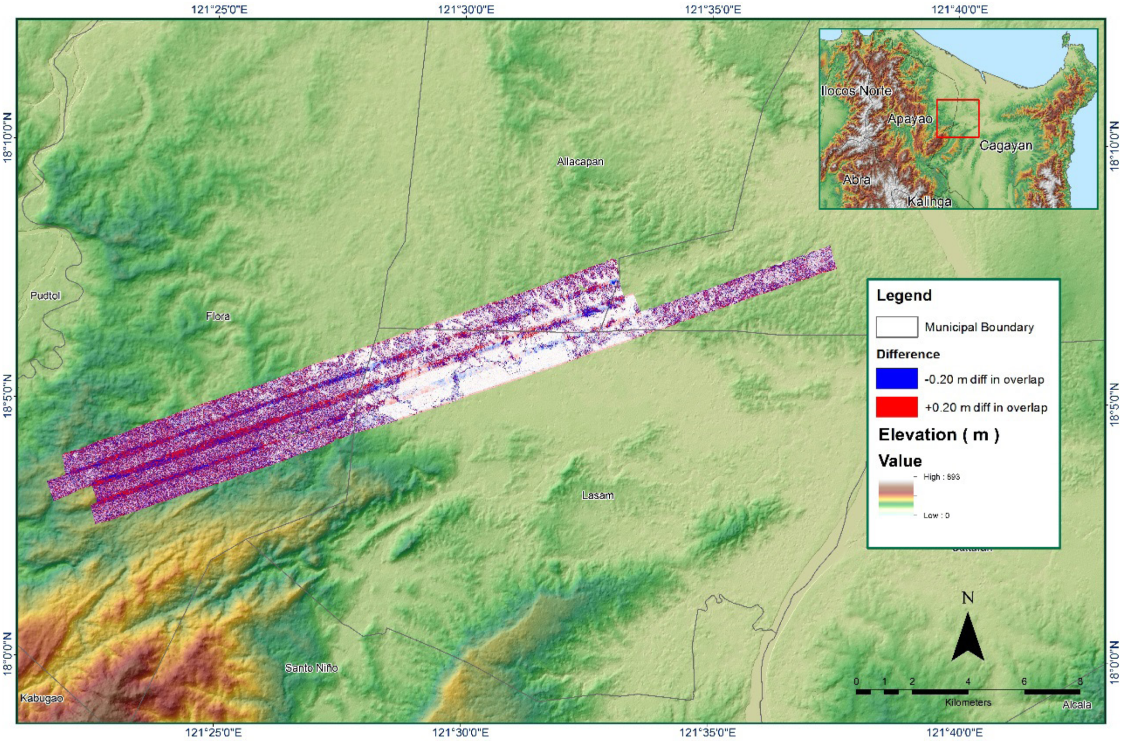


Figure 1.4.7. Elevation difference between flight lines

Flight Area	Cagayan Reflights(Tuguegarao)
Mission Name	**Blk2D_supp_Blk2E**
Inclusive Flights	2850P
Range data size	23.3GB
POS	230MB
Image	35.2MB
Transfer date	November 24, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.17
RMSE for East Position (<4.0 cm)	1.62
RMSE for Down Position (<8.0 cm)	3.60
Boresight correction stdev (<0.001deg)	0.000255
IMU attitude correction stdev (<0.001deg)	0.001669
GPS position stdev (<0.01m)	0.0147
Minimum % overlap (>25)	51.38
Ave point cloud density per sq.m. (>2.0)	4.52
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	243
Maximum Height	629.94 m
Minimum Height	33.11 m
Classification (# of points)	
Ground	114,681,685
Low vegetation	86,249,217
Medium vegetation	179,801,226
High vegetation	1,312,535,704
Building	12,298,531
Orthophoto	Yes
Processed by	Engr. Jennifer B. Saguran, Engr. Chelou Prado, Marie Denise Bueno

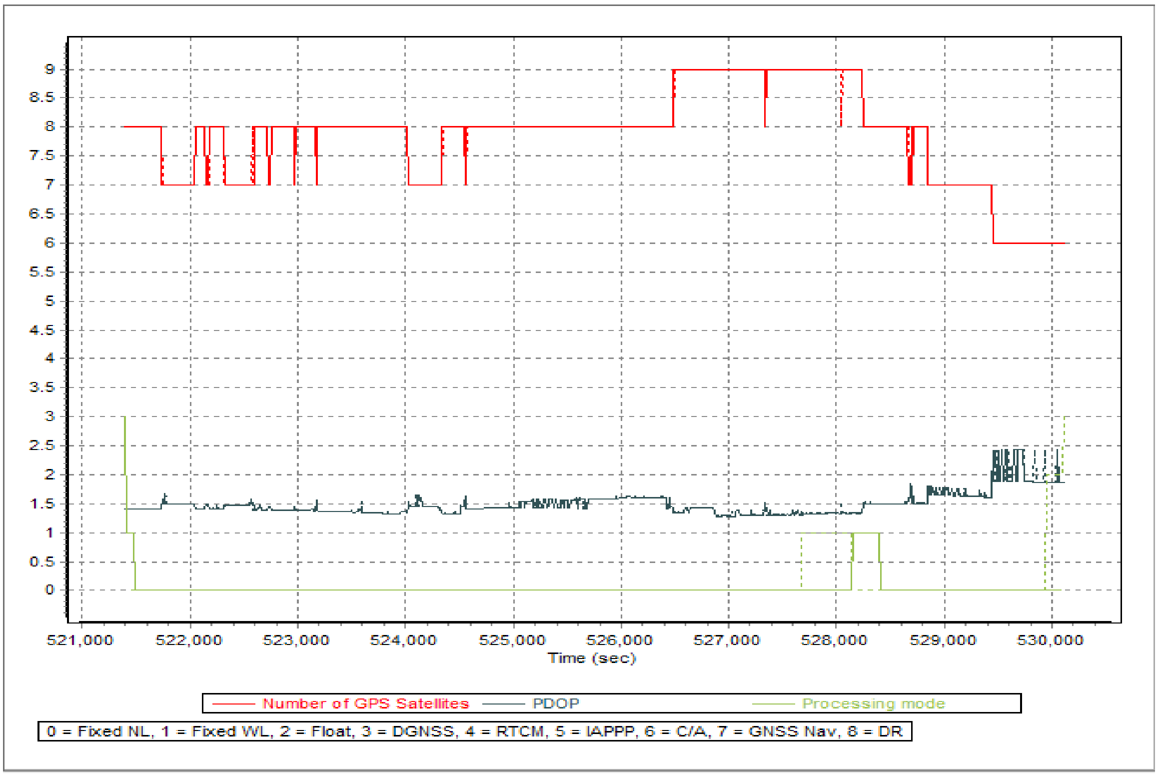


Figure 1.5.1. Solution Status

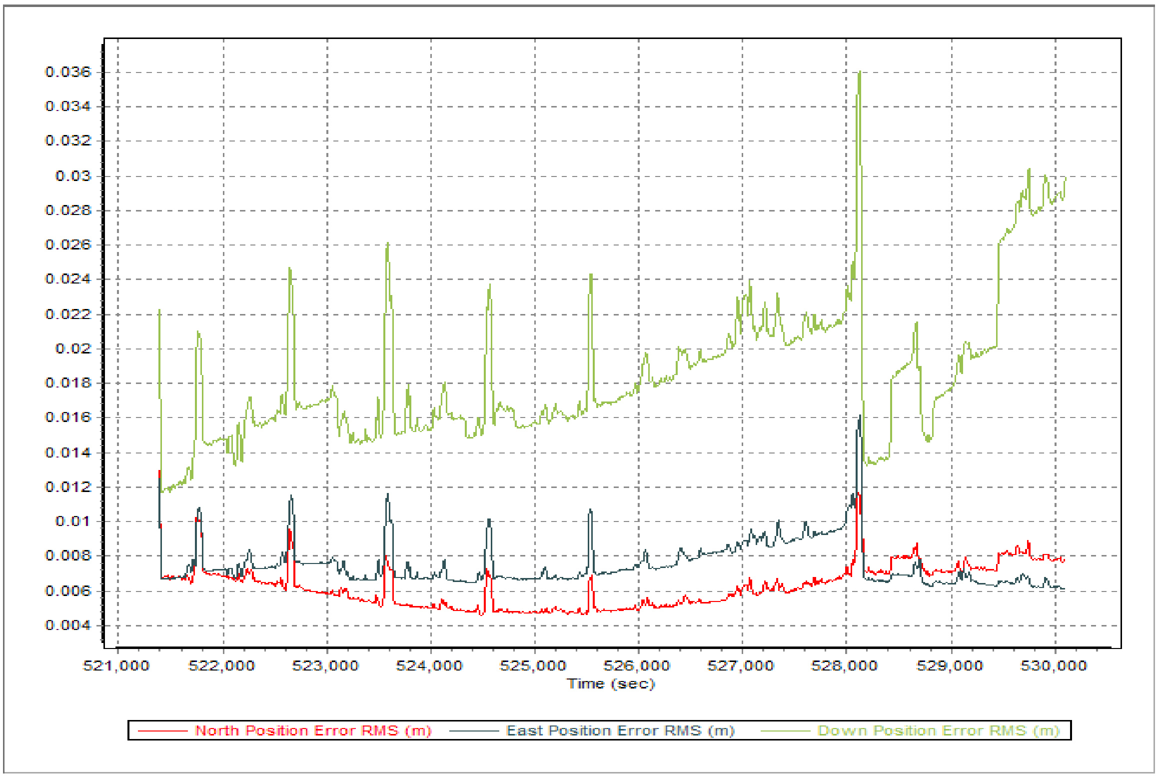


Figure 1.5.2. Smoothed Performance Metric Parameters

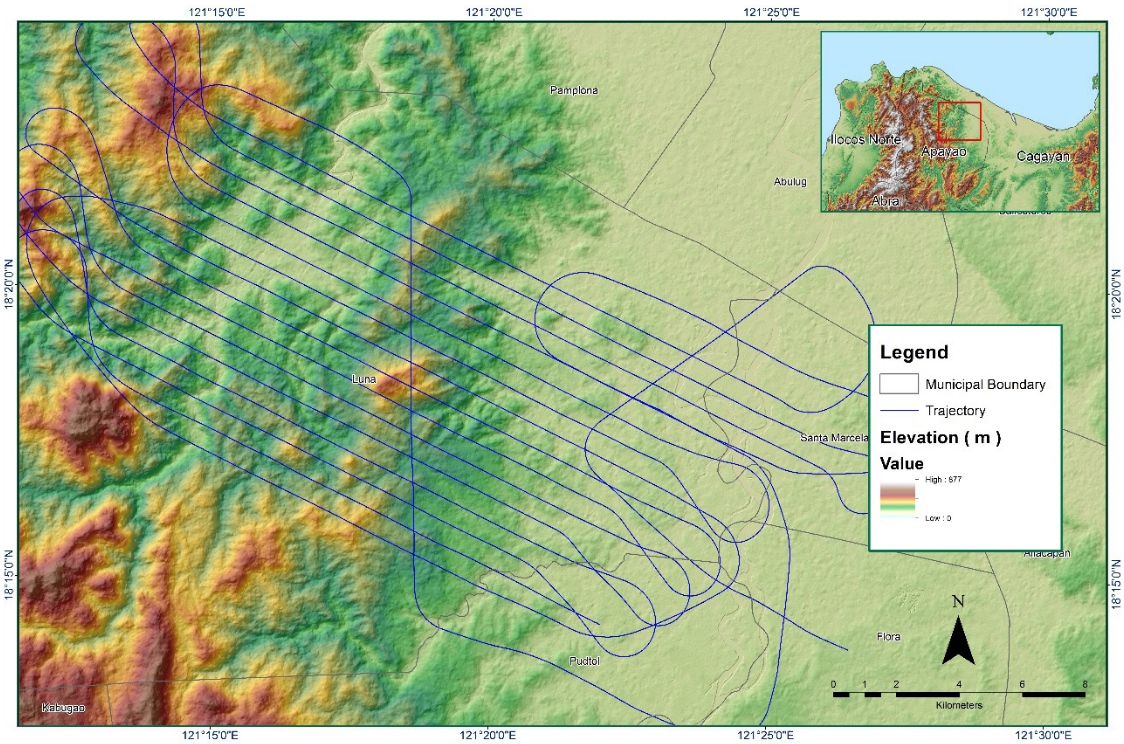


Figure 1. 5. 3. Best Estimated Trajectory

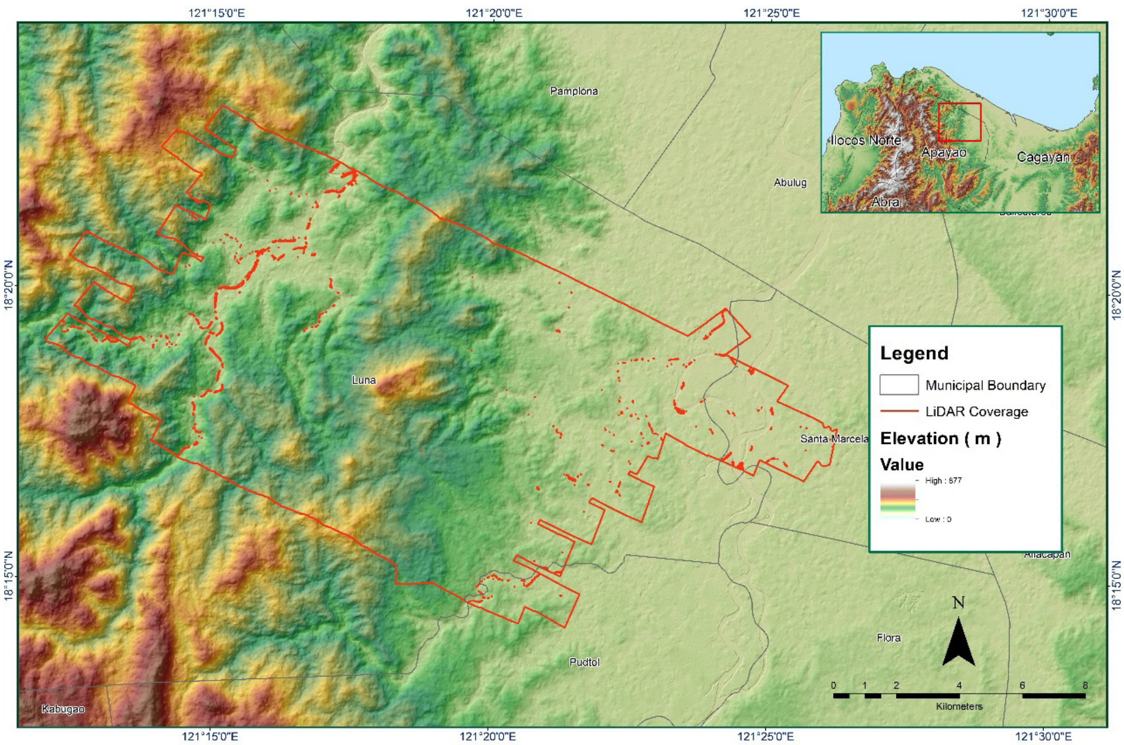


Figure 1. 5. 4. Coverage of LiDAR data

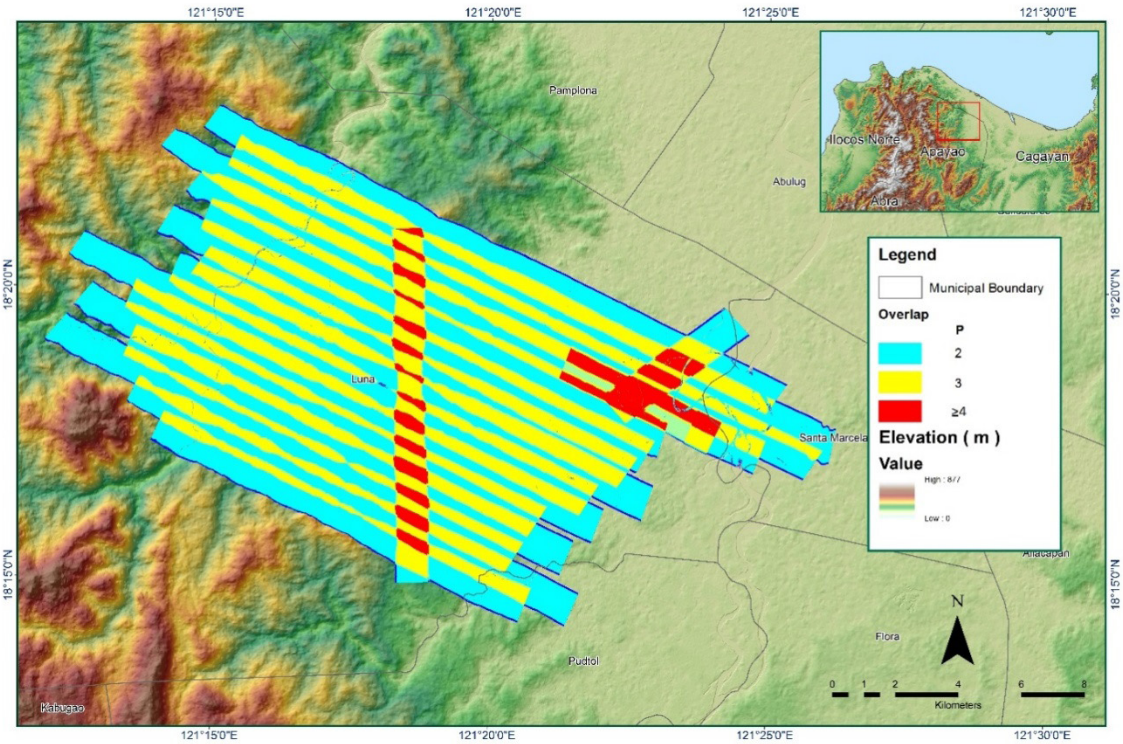


Figure 1. 5. 5. Image of data overlap

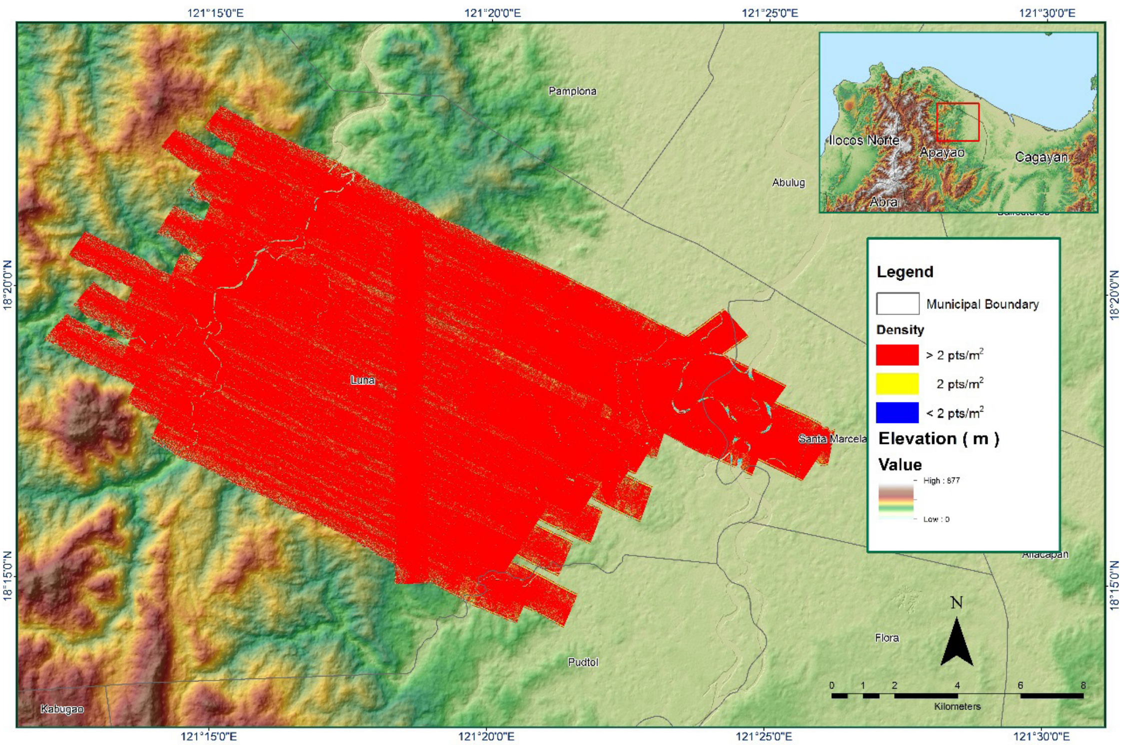


Figure 1. 5. 6. Density map of merged LiDAR data

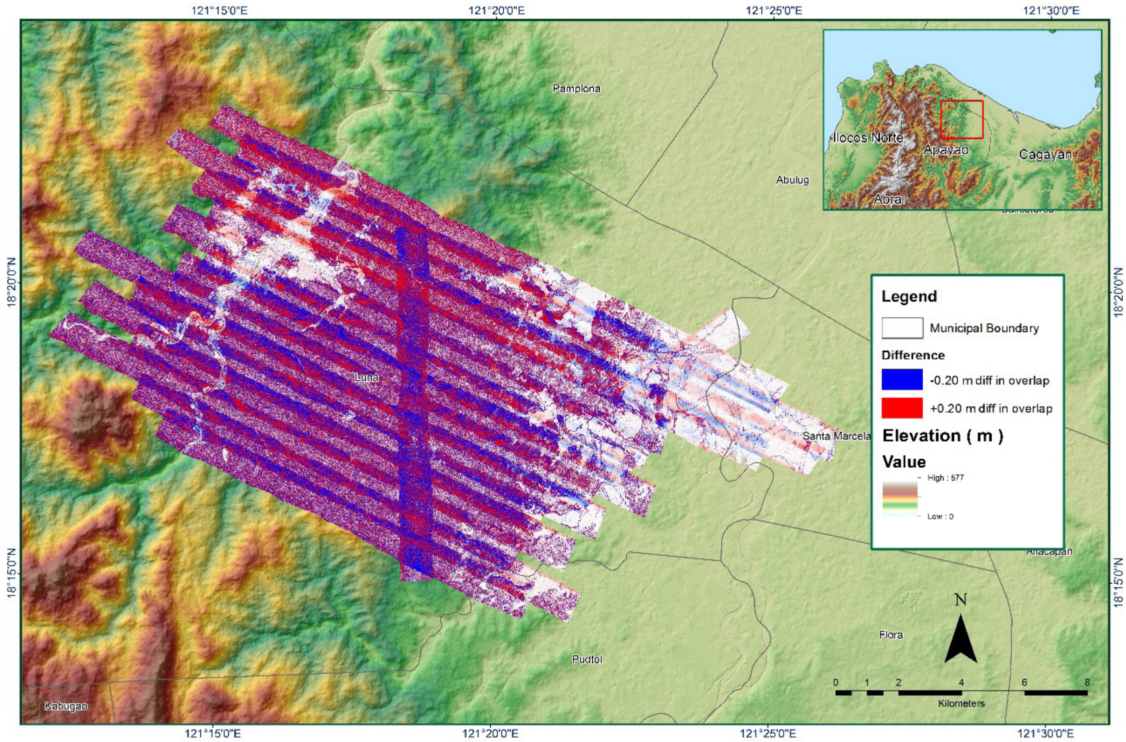


Figure 1. 5. 7. Elevation difference between flight lines

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**Blk2D**
Inclusive Flights	2854P
Range data size	26.1GB
POS	247MB
Image	40.5MB
Transfer date	November 24, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.01
RMSE for East Position (<4.0 cm)	1.33
RMSE for Down Position (<8.0 cm)	2.99
Boresight correction stdev (<0.001deg)	0.000449
IMU attitude correction stdev (<0.001deg)	0.000777
GPS position stdev (<0.01m)	0.0096
Minimum % overlap (>25)	46.71
Ave point cloud density per sq.m. (>2.0)	4.135
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	113
Maximum Height	579.99 m
Minimum Height	42.78 m
Classification (# of points)	
Ground	54,696,025
Low vegetation	48,721,614
Medium vegetation	57,326,160
High vegetation	399,639,419
Building	5,543,063
Orthophoto	Yes
Processed by	Engr. Kenneth Solidum, Engr. Mark Joshua Salvacion, Kathryn Claudine Zarate

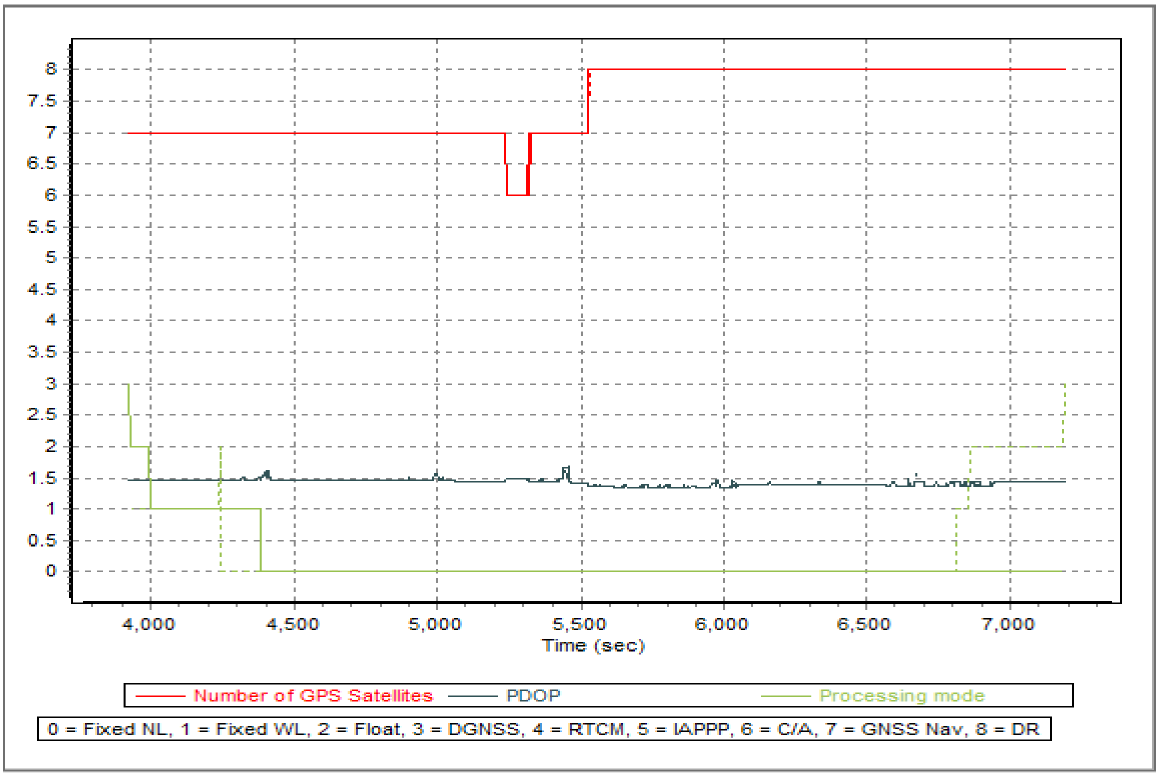


Figure 1. 6. 1. Solution Status

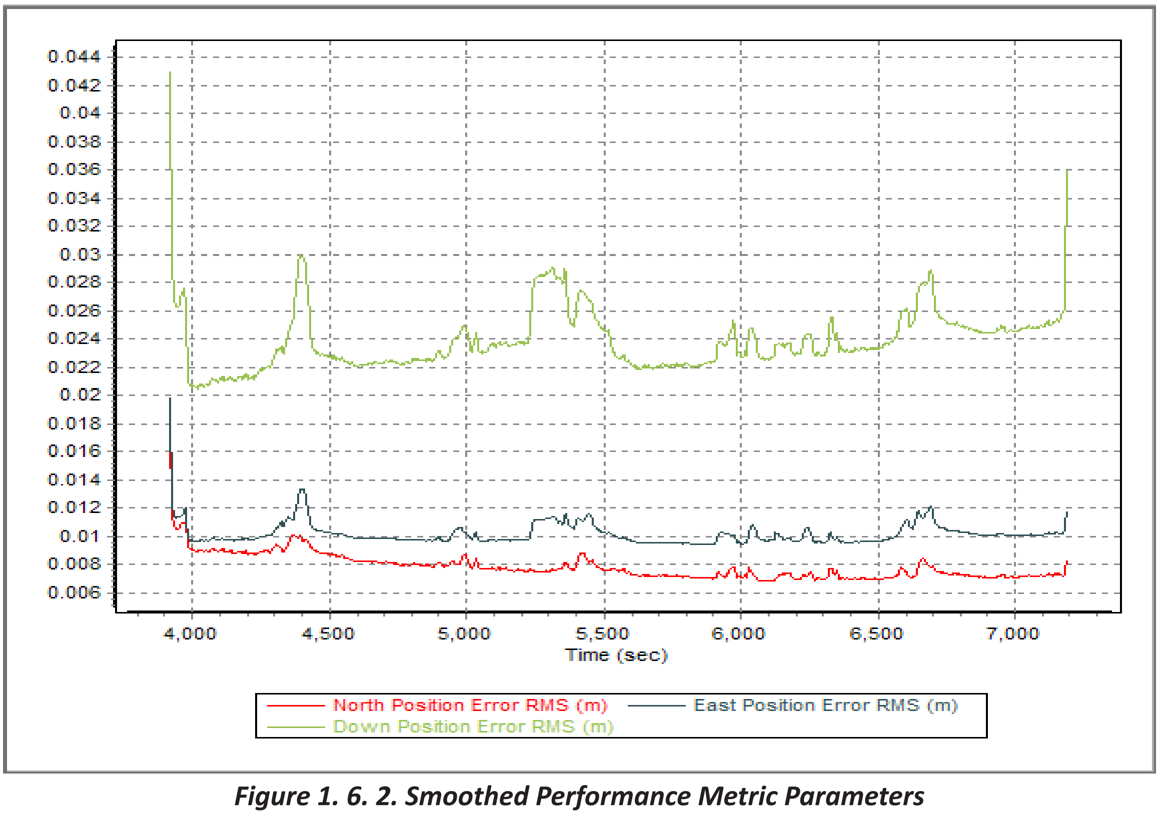


Figure 1. 6. 2. Smoothed Performance Metric Parameters

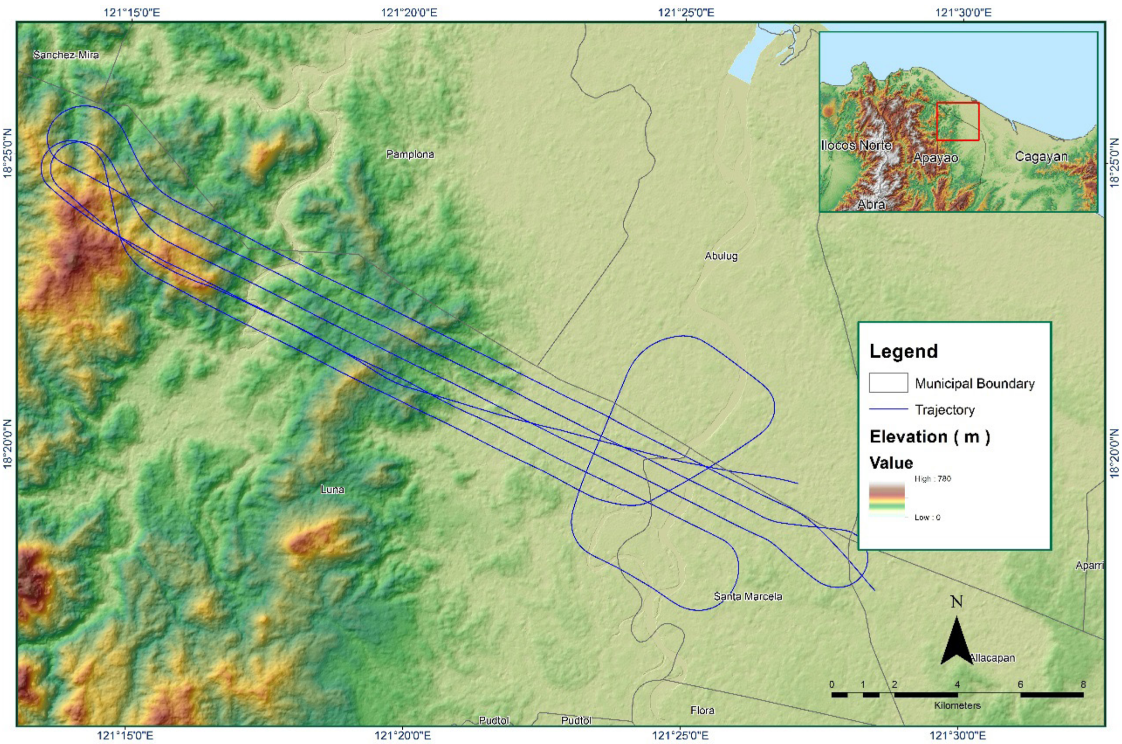


Figure 1. 6. 3. Best Estimated Trajectory

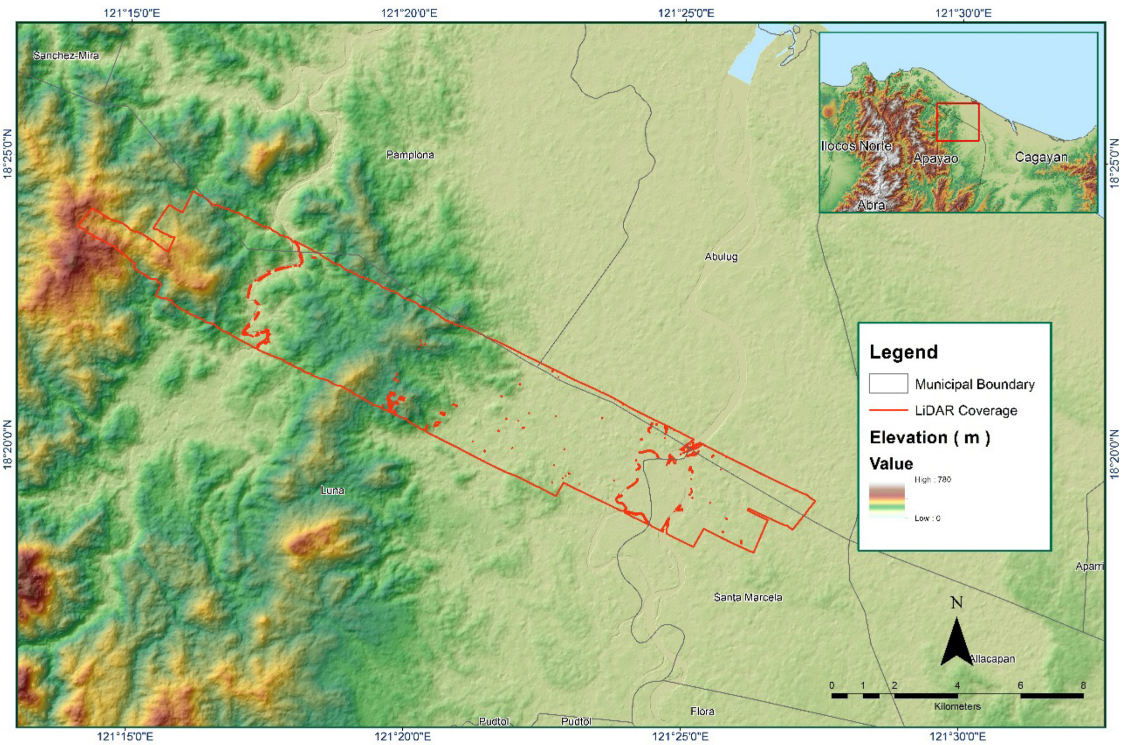


Figure 1. 6. 4. Coverage of LiDAR data

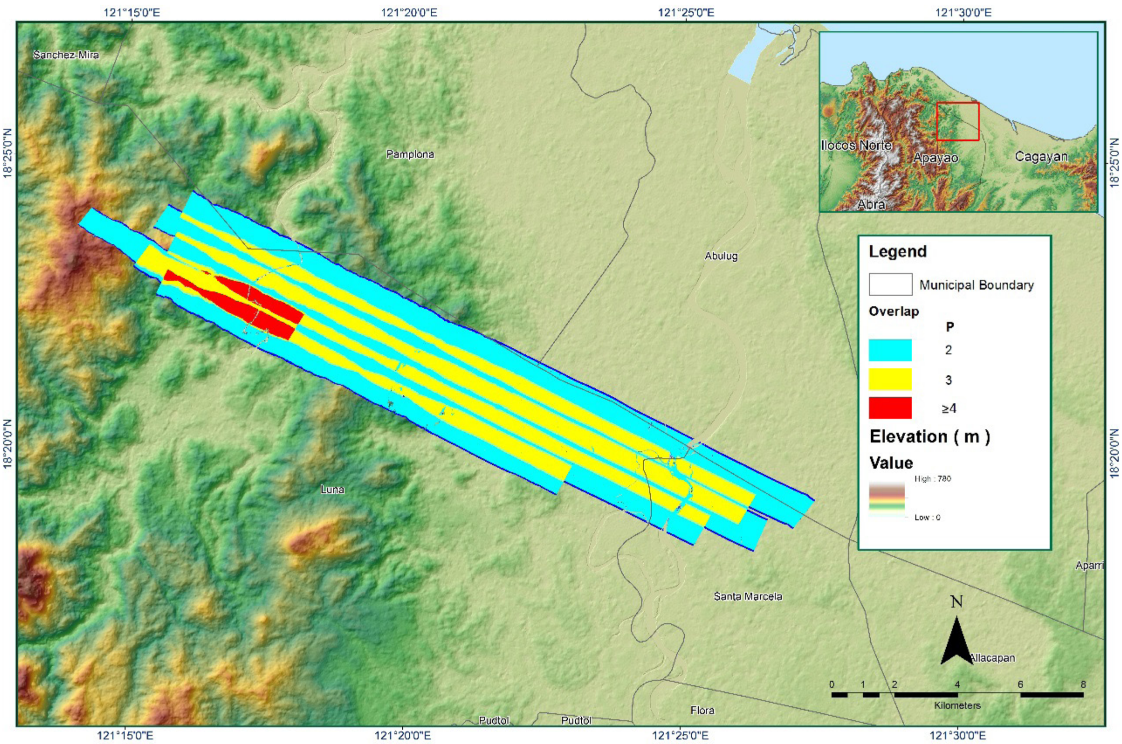


Figure 1. 6. 5. Image of data overlap

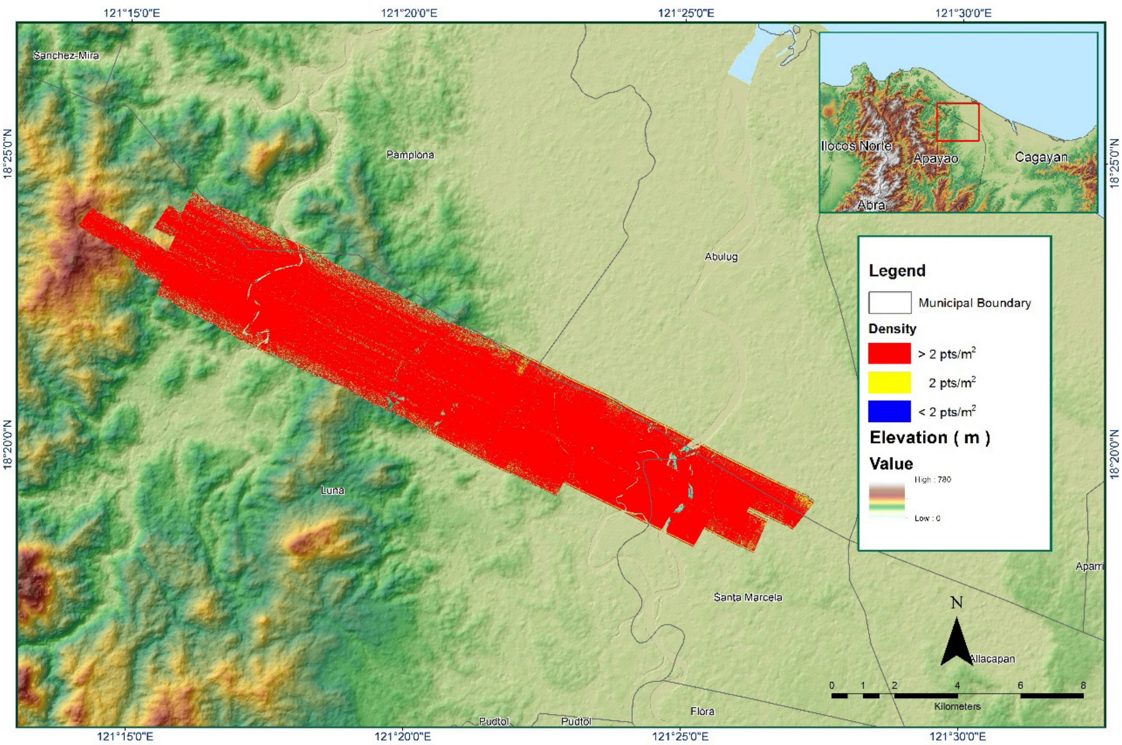


Figure 1. 6. 6. Density map of merged LiDAR data

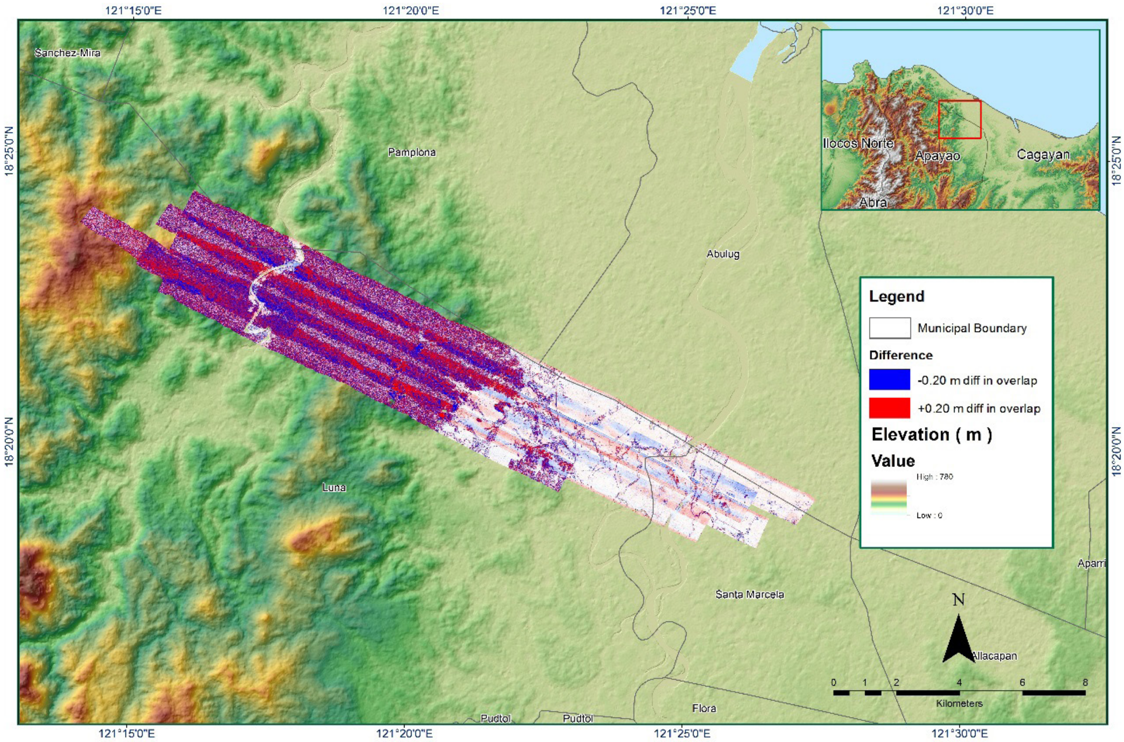


Figure 1. 6. 7. Elevation difference between flight lines

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**Blk2G**
Inclusive Flights	2866P, 2880P, 2854P
Range data size	66.6GB
POS	744MB
Image	105.2MB
Transfer date	December 4. 2015
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.04

RMSE for East Position (<4.0 cm)	1.77
RMSE for Down Position (<8.0 cm)	10.92
Boresight correction stdev (<0.001deg)	0.000273
IMU attitude correction stdev (<0.001deg)	0.000704
GPS position stdev (<0.01m)	0.0071
Minimum % overlap (>25)	7.44
Ave point cloud density per sq.m. (>2.0)	1.89
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	253
Maximum Height	390.24 m
Minimum Height	48.52 m
Classification (# of points)	
Ground	183,314,311
Low vegetation	153,369,392
Medium vegetation	374,947,609
High vegetation	807,134,303
Building	11,904,295
Orthophoto	Yes
Processed by	Engr. Kenneth Solidum, Engr. Velina Angela Bemida, Kathryn Claudine Zarate

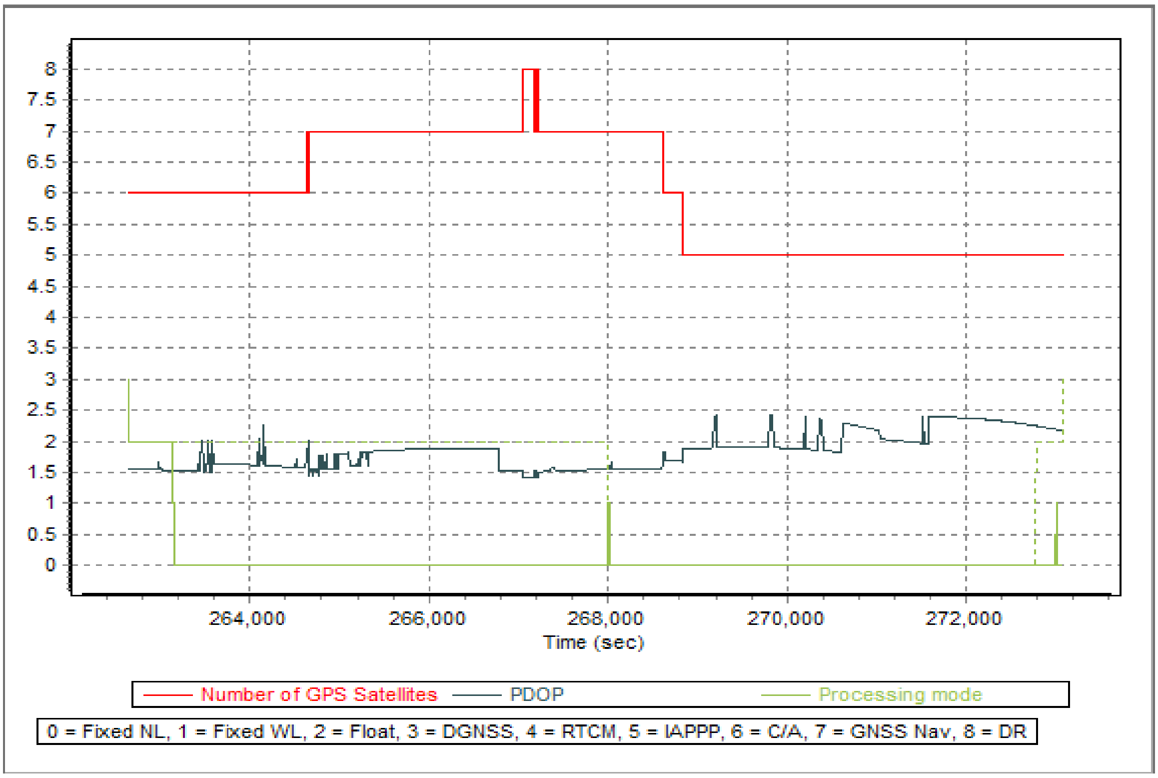


Figure 1. 7. 1. Solution Status

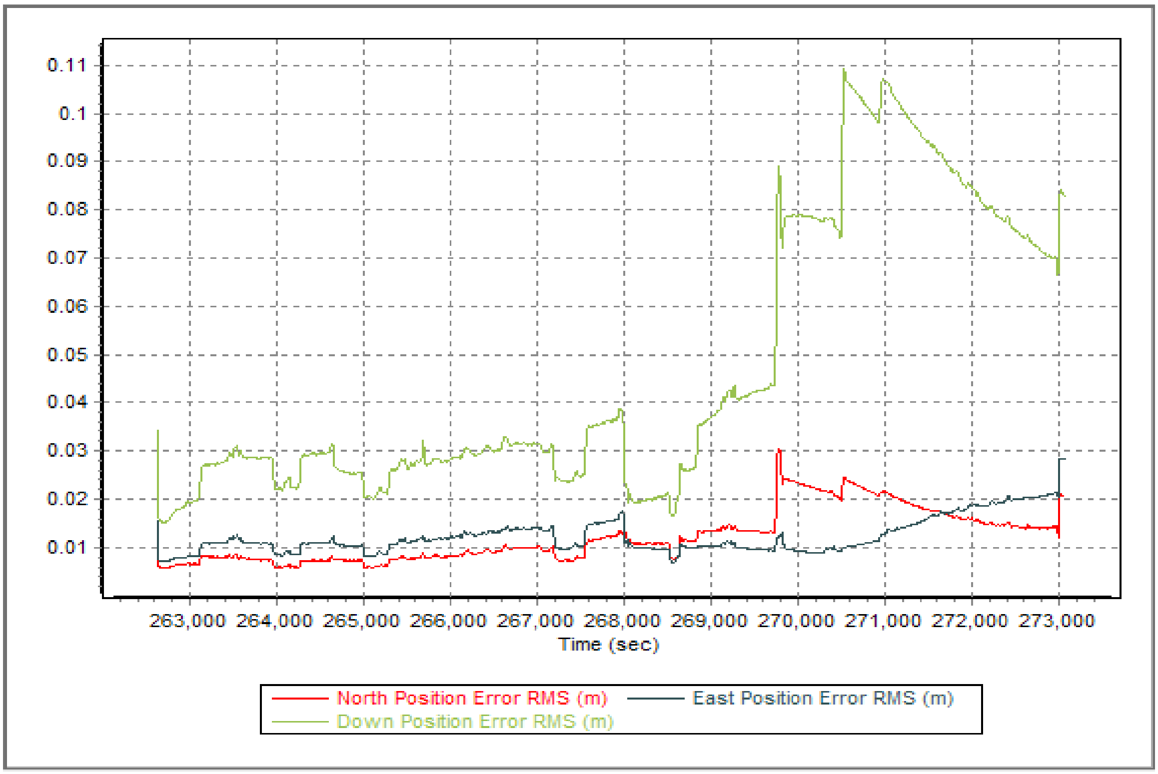


Figure 1. 7. 2. Smoothed Performance Metric Parameters

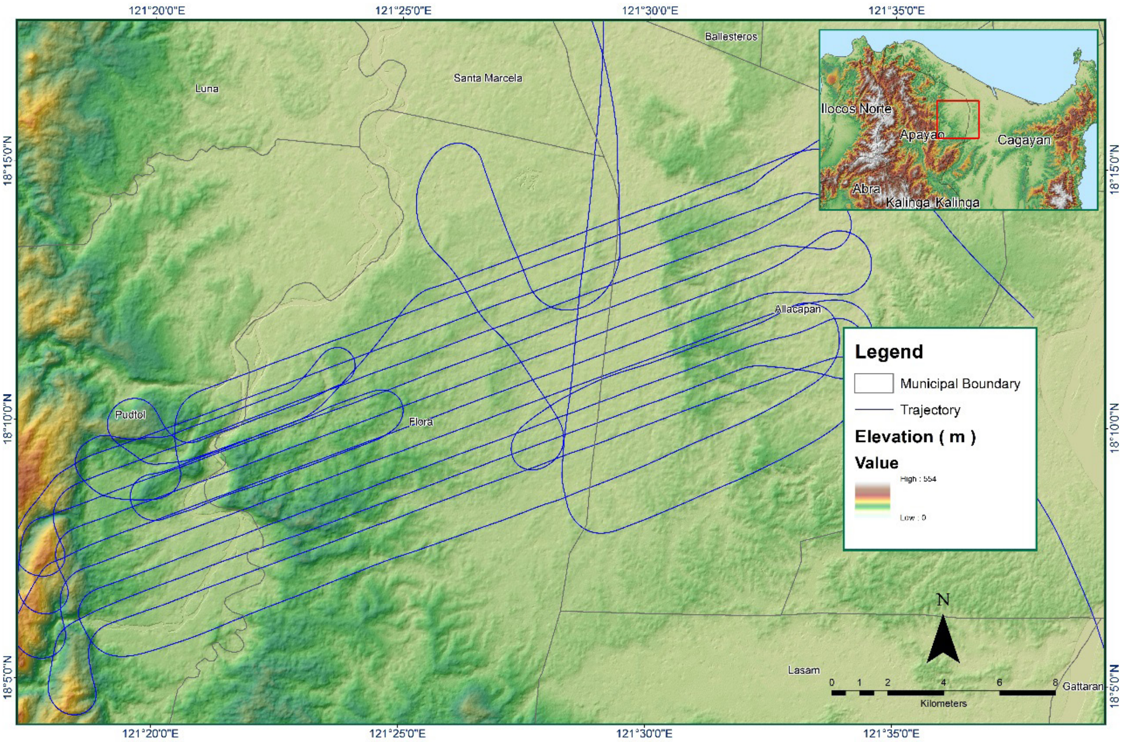


Figure 1. 7. 3. Best Estimated Trajectory

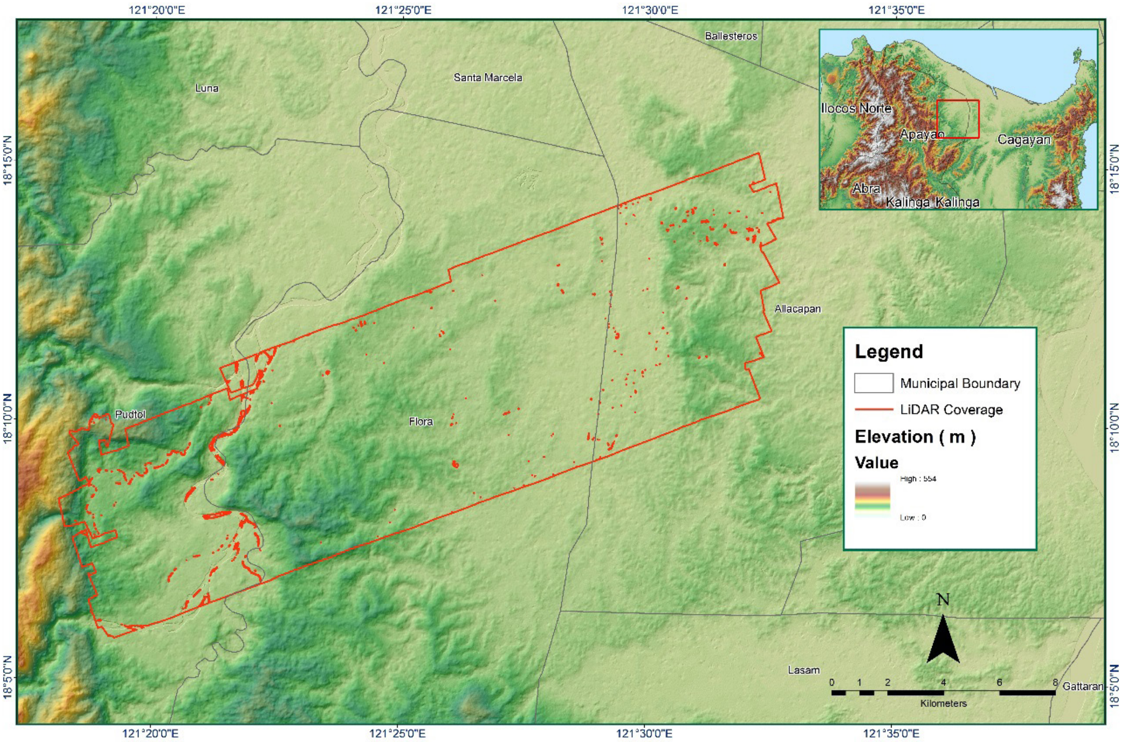


Figure 1. 7. 4. Coverage of LiDAR data

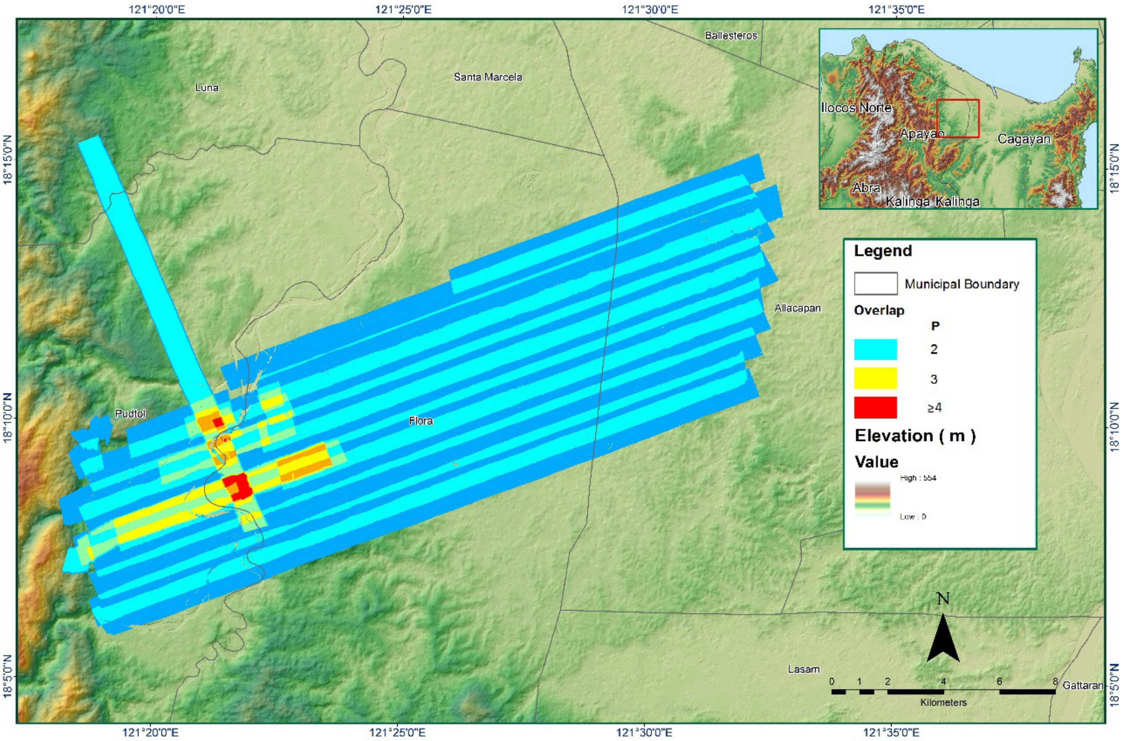


Figure 1. 7. 5. Image of data overlap

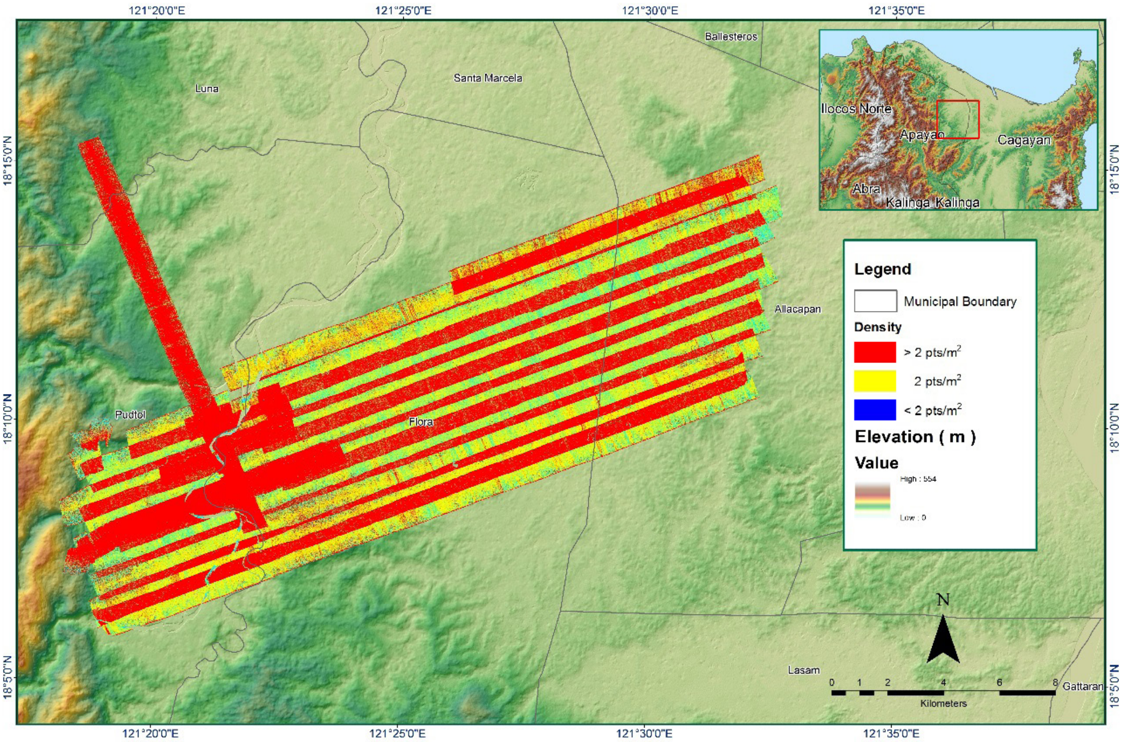


Figure 1. 7. 6. Density map of merged LiDAR data

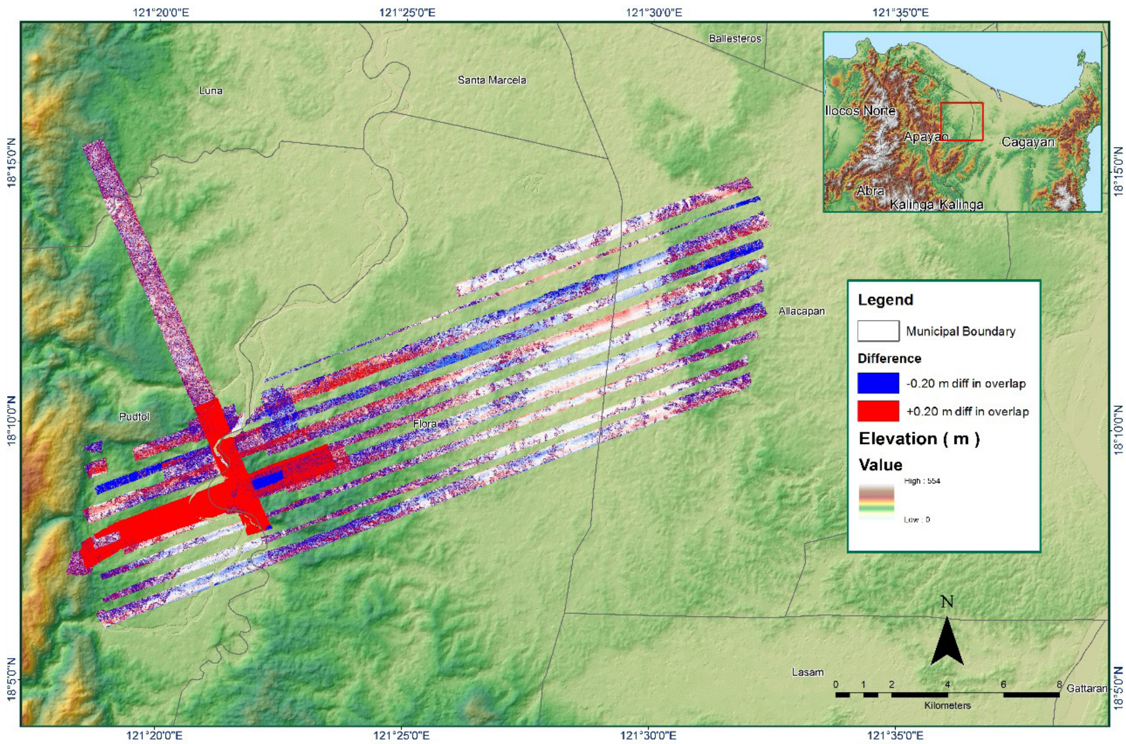


Figure 1. 7. 7. Elevation difference between flight lines

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**Blk2F_supplement**
Inclusive Flights	2846P
Range data size	31.3GB
POS	299MB
Image	50.8MB
Transfer date	November 24, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.48
RMSE for East Position (<4.0 cm)	2.73
RMSE for Down Position (<8.0 cm)	8.94
Boresight correction stdev (<0.001deg)	0.000335
IMU attitude correction stdev (<0.001deg)	0.002483
GPS position stdev (<0.01m)	0.0025
Minimum % overlap (>25)	38.58
Ave point cloud density per sq.m. (>2.0)	2.79
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	110
Maximum Height	269.14 m
Minimum Height	42.36 m
Classification (# of points)	
Ground	89,975,674
Low vegetation	45,492,631
Medium vegetation	76,938,547
High vegetation	162,740,157
Building	3,963,915
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Velina Angela Bemida, Maria Tamsyn Malabanan

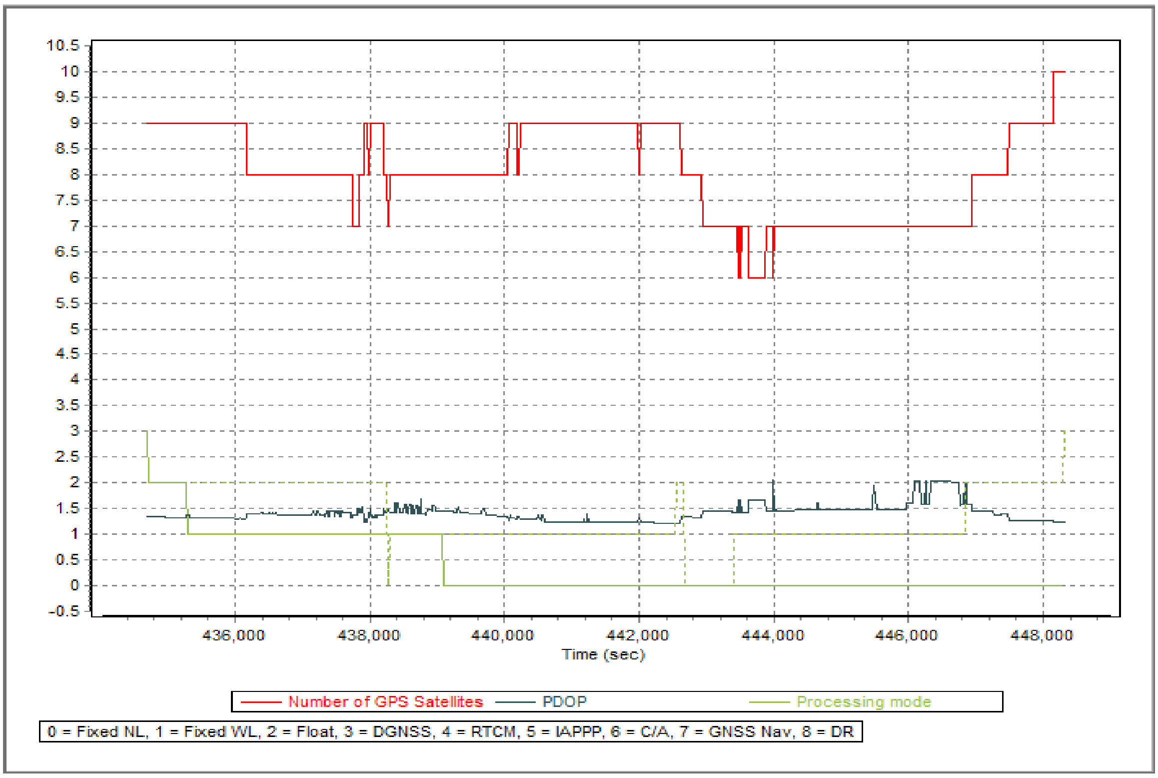


Figure 1.8.1. Solution Status

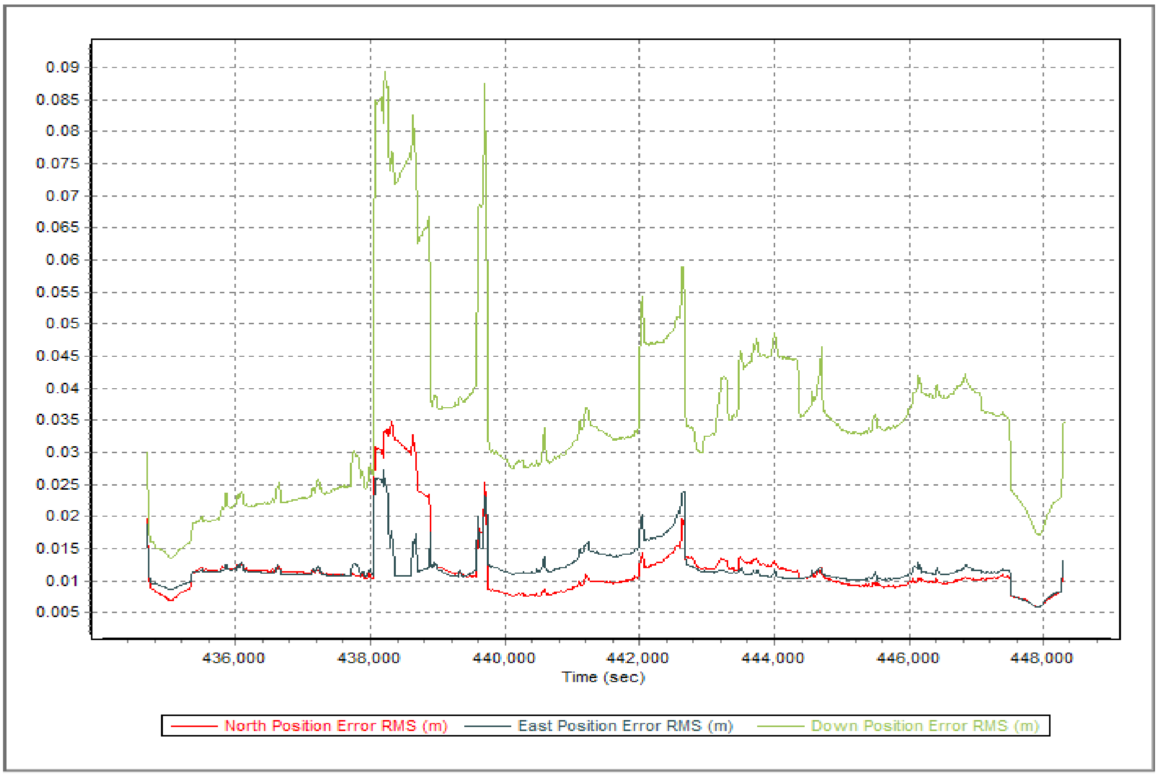


Figure 1.8.2. Smoothed Performance Metric Parameters

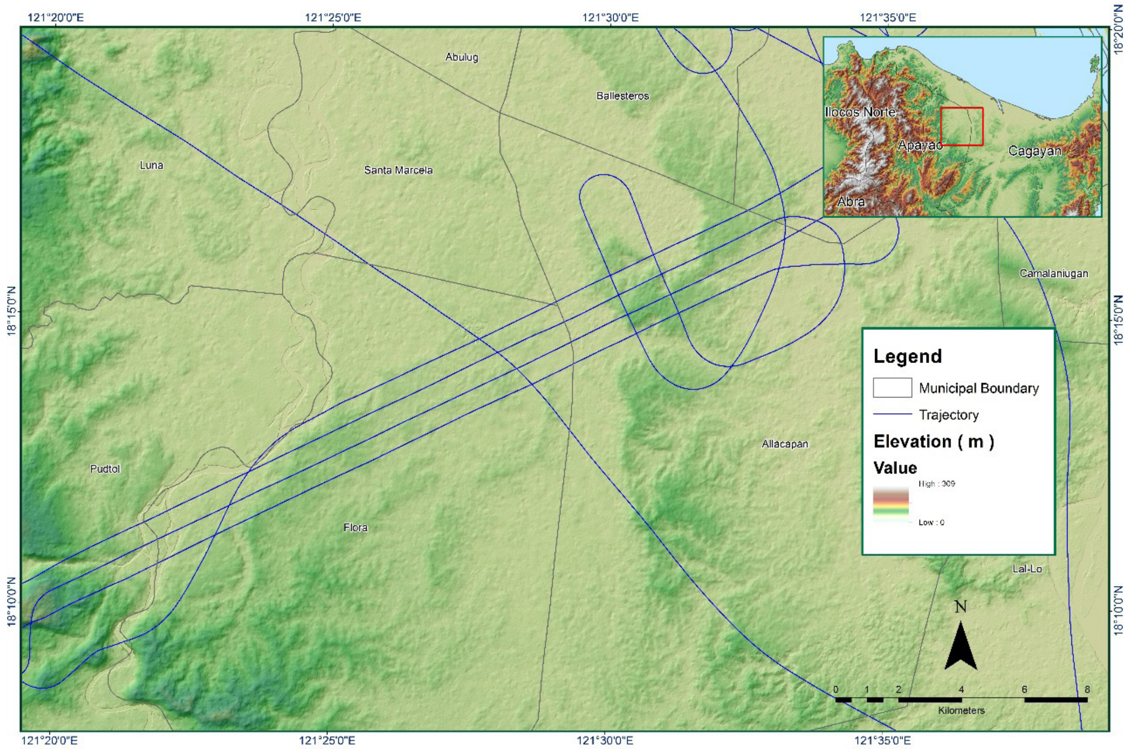


Figure 1. 8. 3. Best Estimated Trajectory

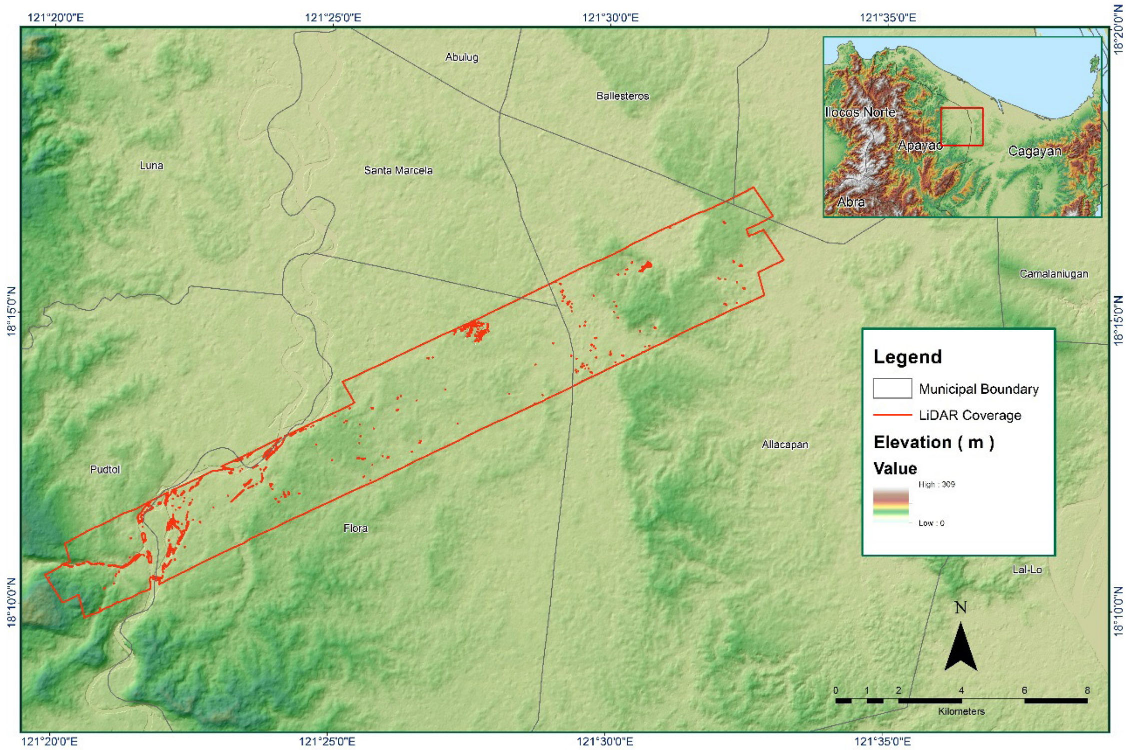


Figure 1. 8. 4. Coverage of LiDAR data

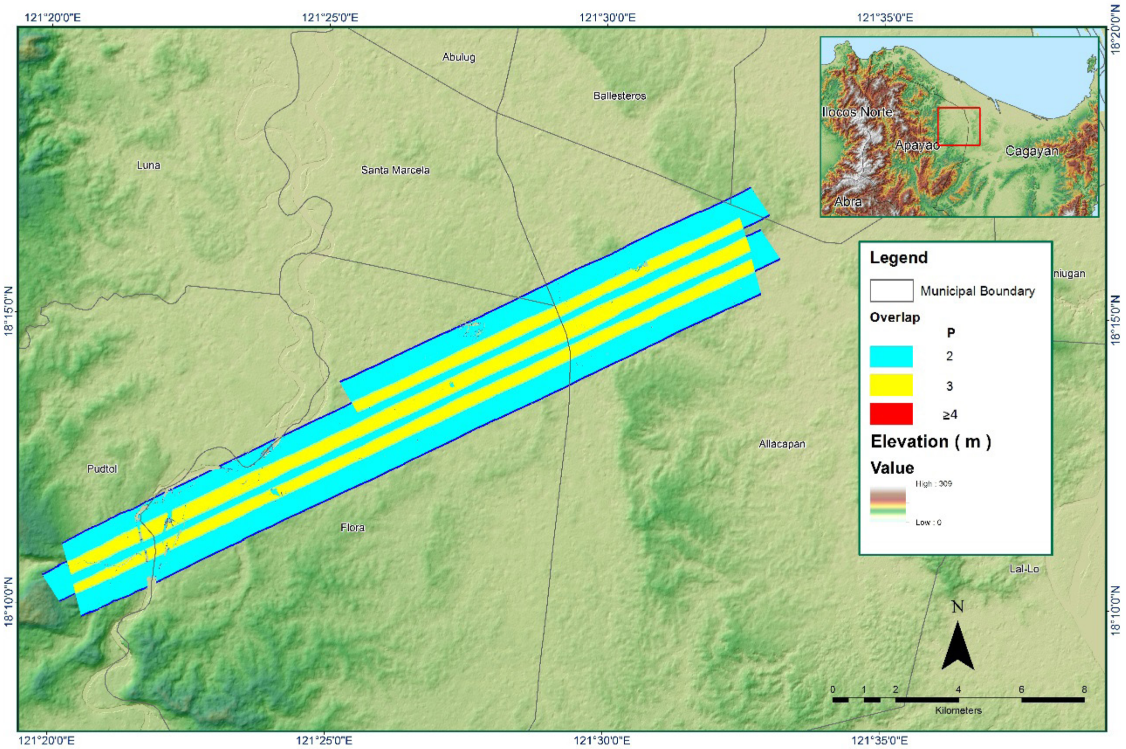


Figure 1.8.5 Image of data overlap

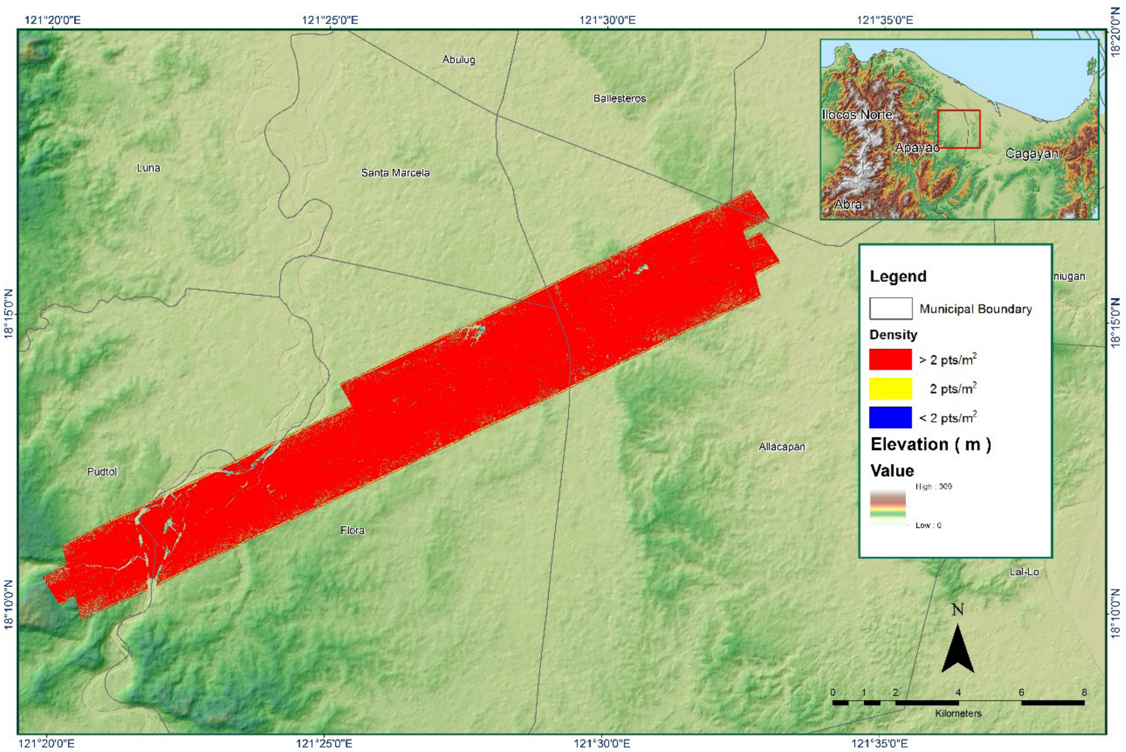


Figure 1.8.6 Density map of merged LiDAR data

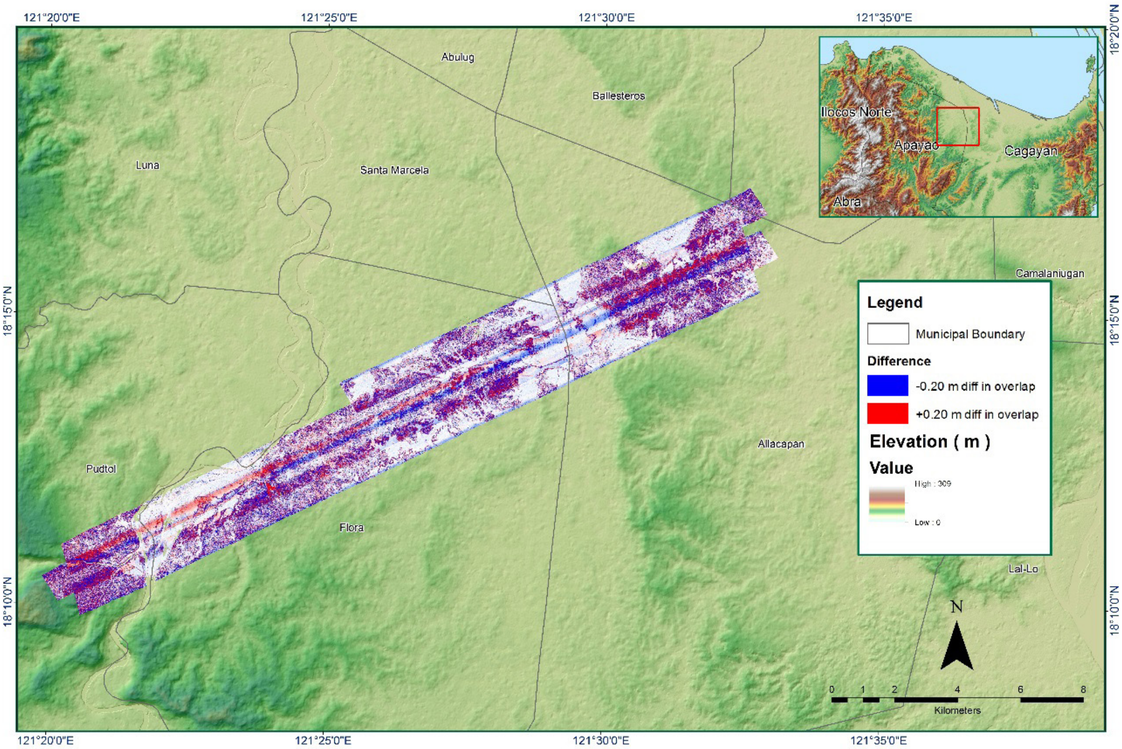


Figure 1.8.7 Elevation difference between flight lines

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**Blk2B**
Inclusive Flights	2842P
Range data size	14.3GB
POS	185MB
Image	24.1MB
Transfer date	November 24, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.53
RMSE for East Position (<4.0 cm)	1.39
RMSE for Down Position (<8.0 cm)	3.00
Boresight correction stdev (<0.001deg)	0.000693
IMU attitude correction stdev (<0.001deg)	0.001224
GPS position stdev (<0.01m)	0.0024
Minimum % overlap (>25)	44.96
Ave point cloud density per sq.m. (>2.0)	3.25
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	182
Maximum Height	583.61 m
Minimum Height	35.45 m
Classification (# of points)	
Ground	141,569,019
Low vegetation	70,602,147
Medium vegetation	96,691,357
High vegetation	456,013,846
Building	4,544,117
Orthophoto	Yes
Processed by	Engr. Abigail Ching, Engr. Jovelle Canlas, Maria Tamsyn Malabanan

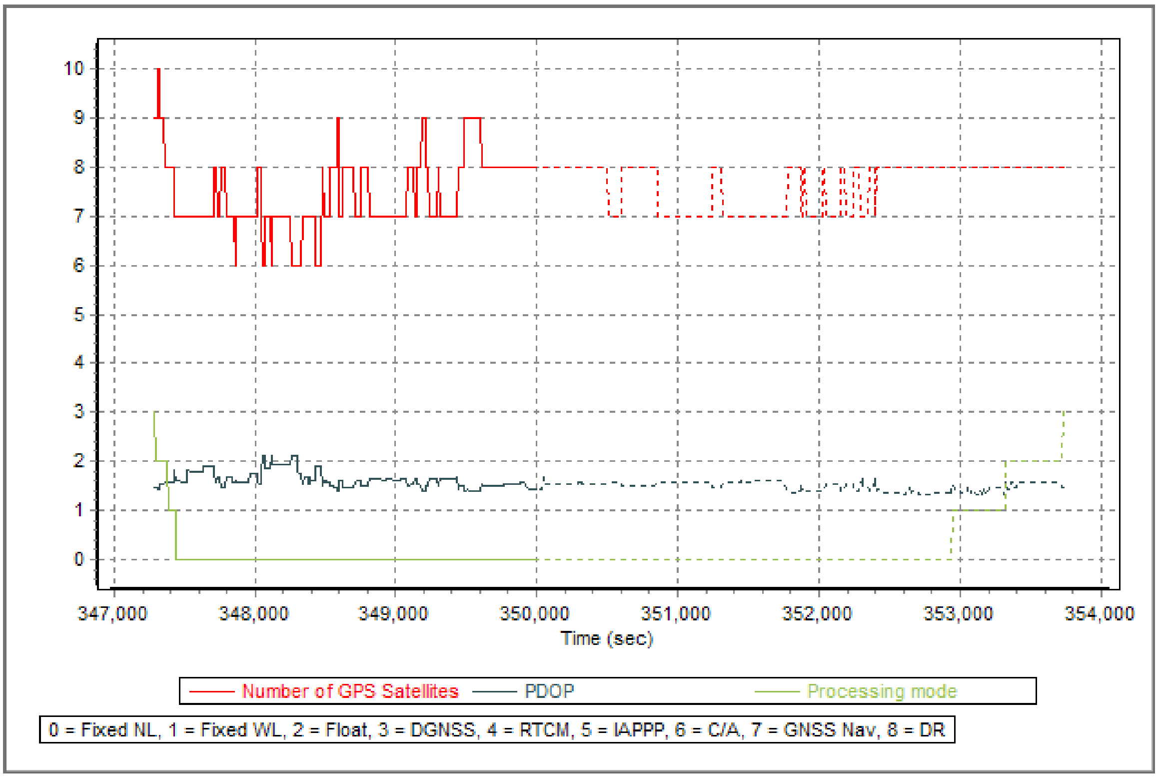


Figure 1.9.1. Solution Status

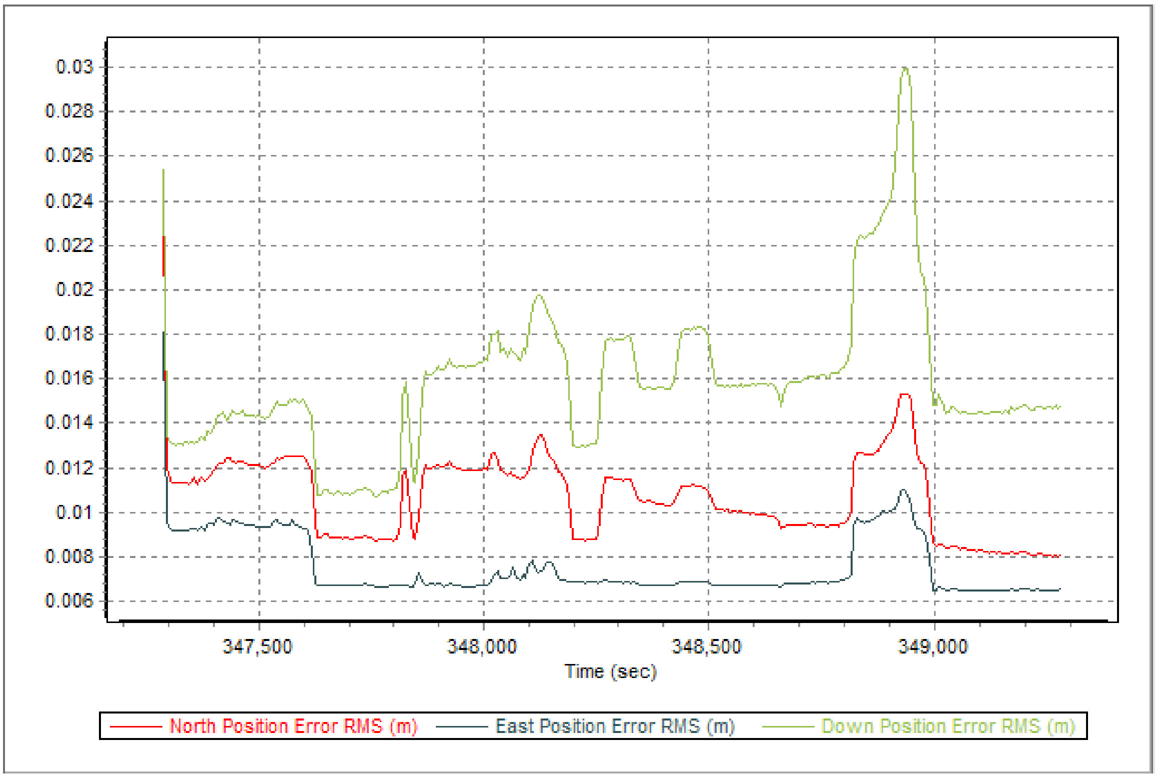


Figure 1.9.2. Smoothed Performance Metric Parameters

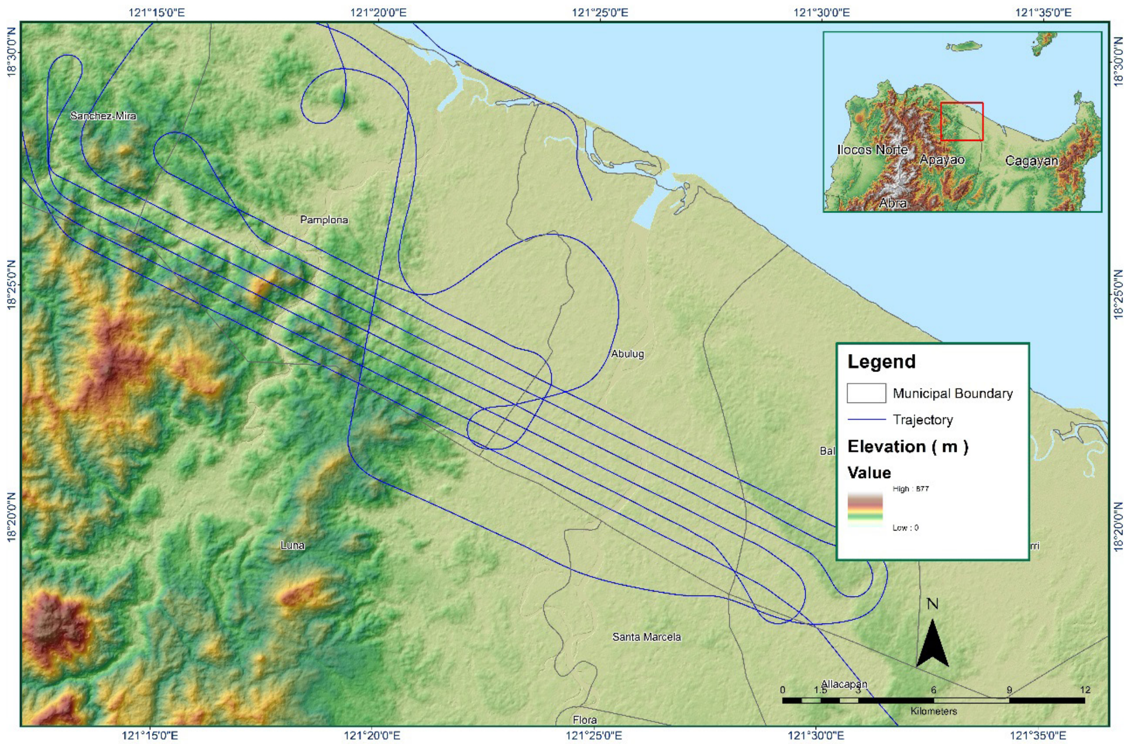


Figure 1. 9. 3. Best Estimated Trajectory

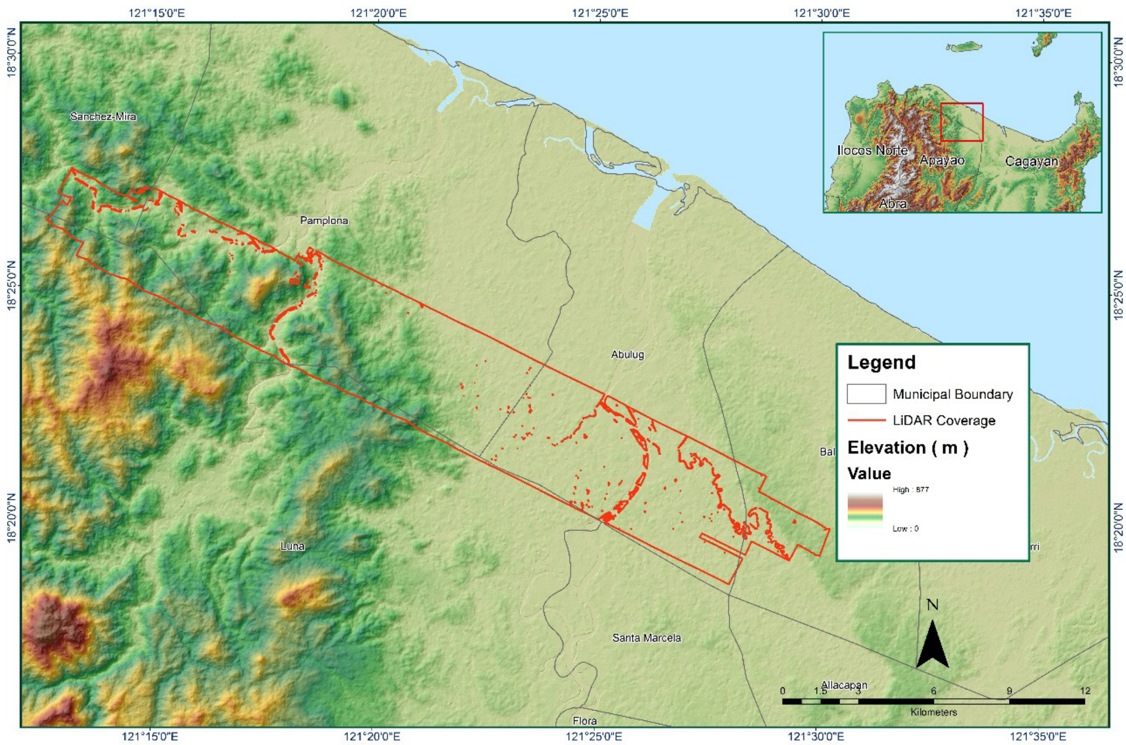


Figure 1. 9. 4. Coverage of LiDAR data

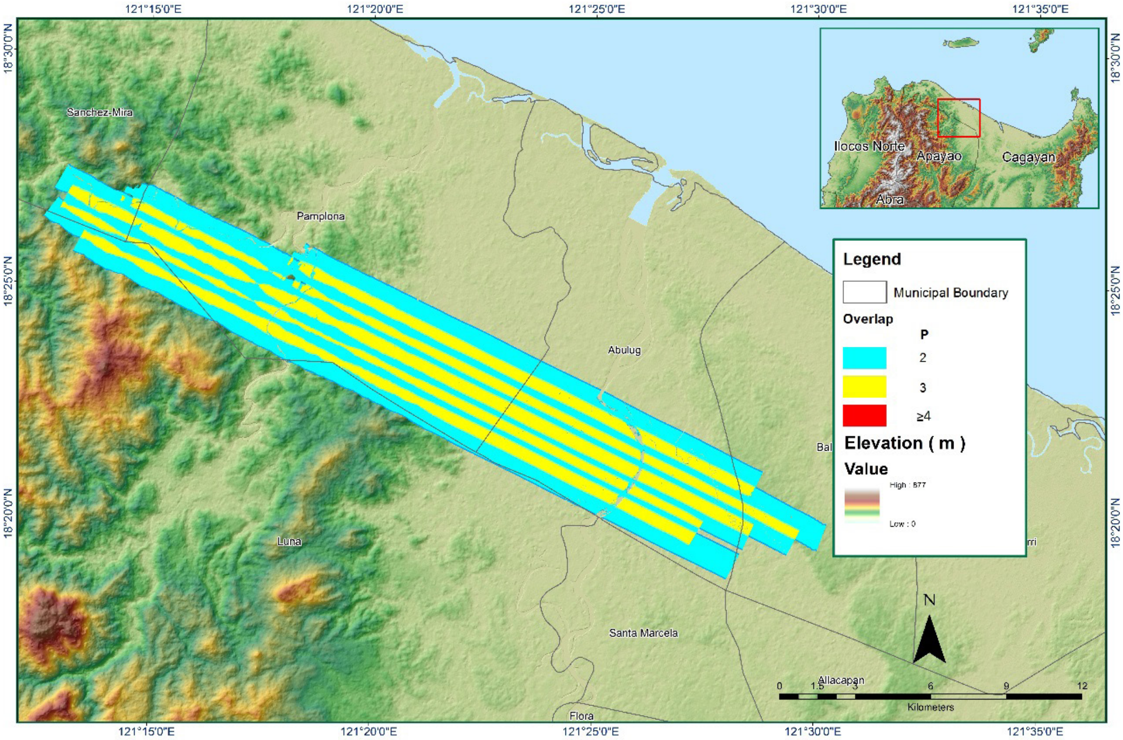


Figure 1. 9. 5. Image of data overlap

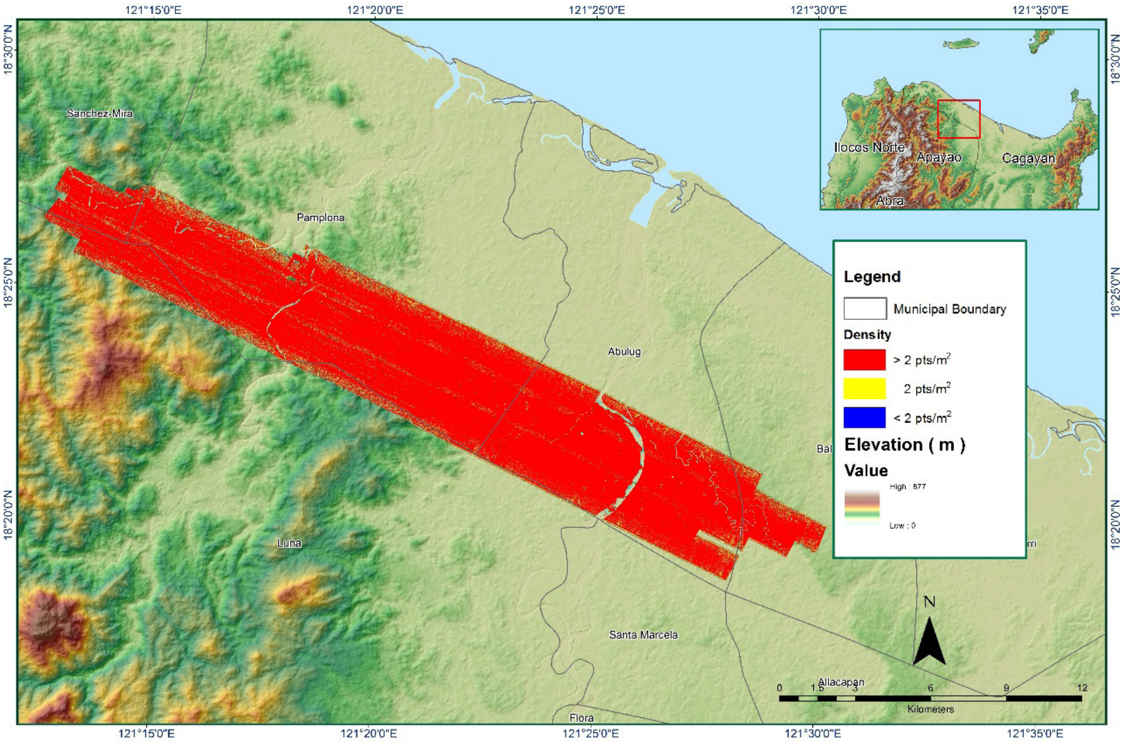


Figure 1. 9. 6. Density map of merged LiDAR data

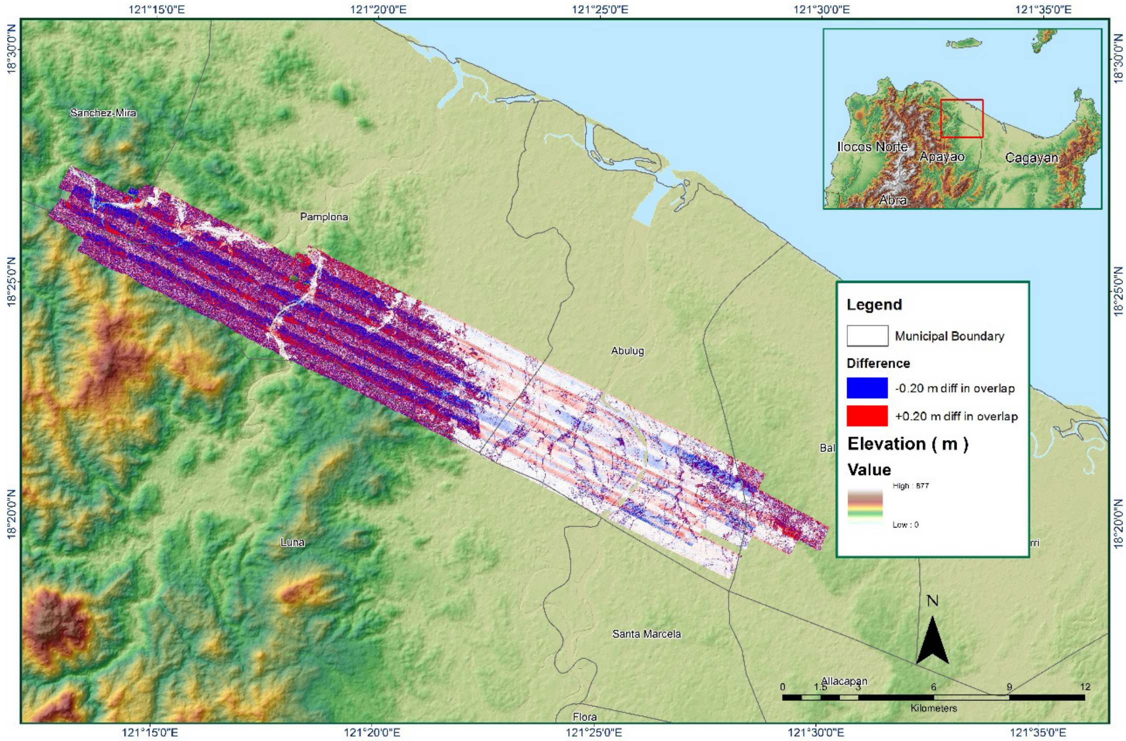


Figure 1. 9. 7. Elevation difference between flight lines

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**Blk2A_supplement**
Inclusive Flights	2846P
Range data size	31.3GB
POS	299MB
Image	50.8MB
Transfer date	November 24, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	3.48
RMSE for East Position (<4.0 cm)	2.73
RMSE for Down Position (<8.0 cm)	8.94
Boresight correction stdev (<0.001deg)	0.000335
IMU attitude correction stdev (<0.001deg)	0.002483
GPS position stdev (<0.01m)	0.0025
Minimum % overlap (>25)	51.57
Ave point cloud density per sq.m. (>2.0)	3.165
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	267
Maximum Height	487.63 m
Minimum Height	38.22 m
Classification (# of points)	
Ground	199,764,057
Low vegetation	206,231,885
Medium vegetation	240,445,037
High vegetation	623,968,966
Building	16,265,221
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Edgardo Gubatanga Jr., Engr. Krisha Marie Bautista

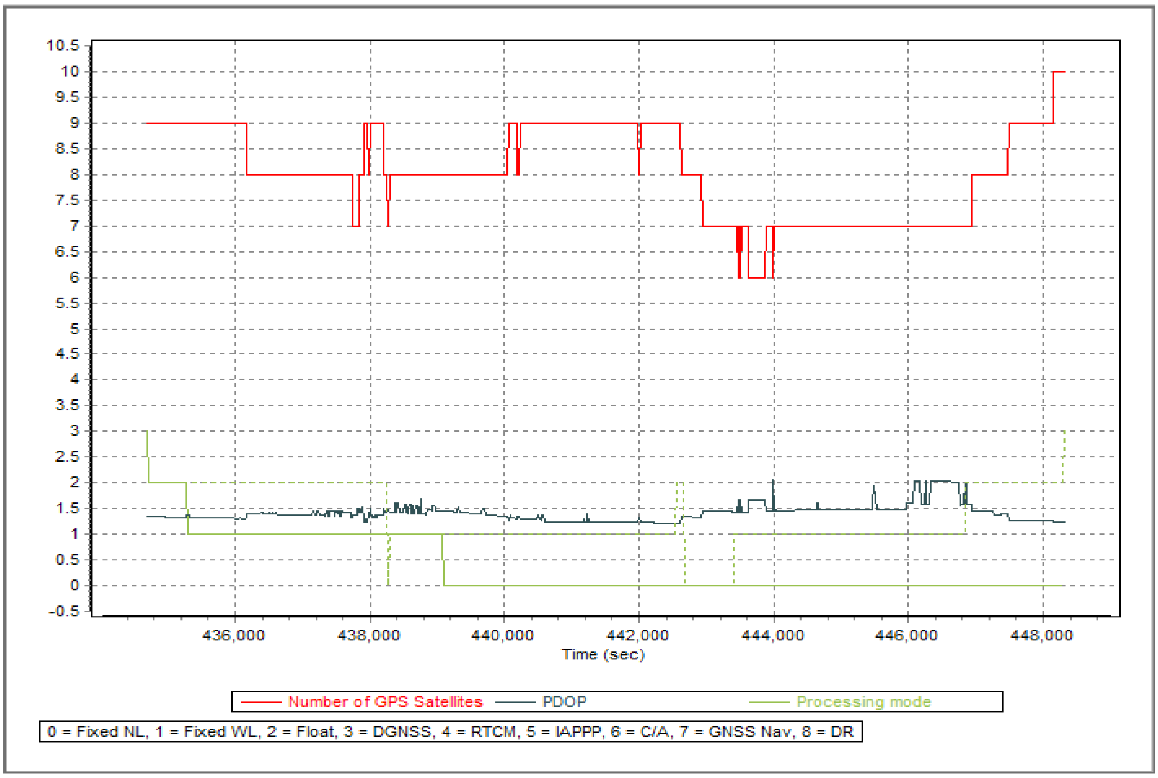


Figure 1.10.1. Solution Status

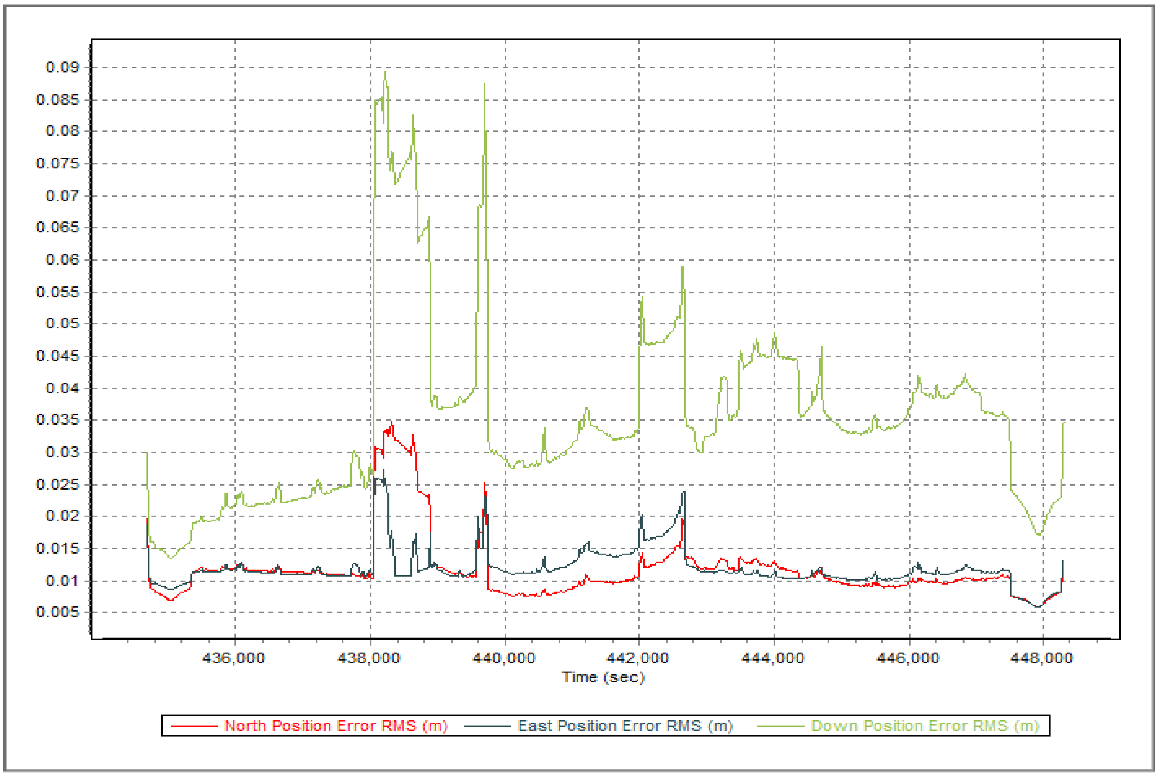


Figure 1.10.2. Smoothed Performance Metric Parameters

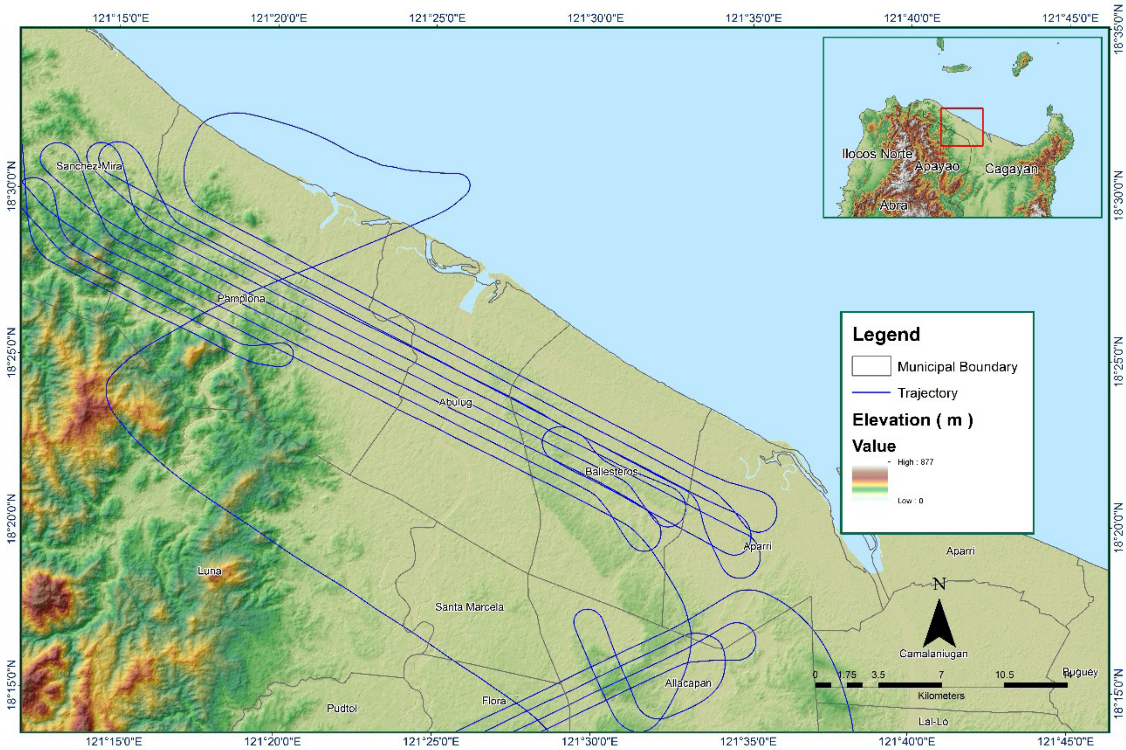


Figure 1. 10. 3. Best Estimated Trajectory

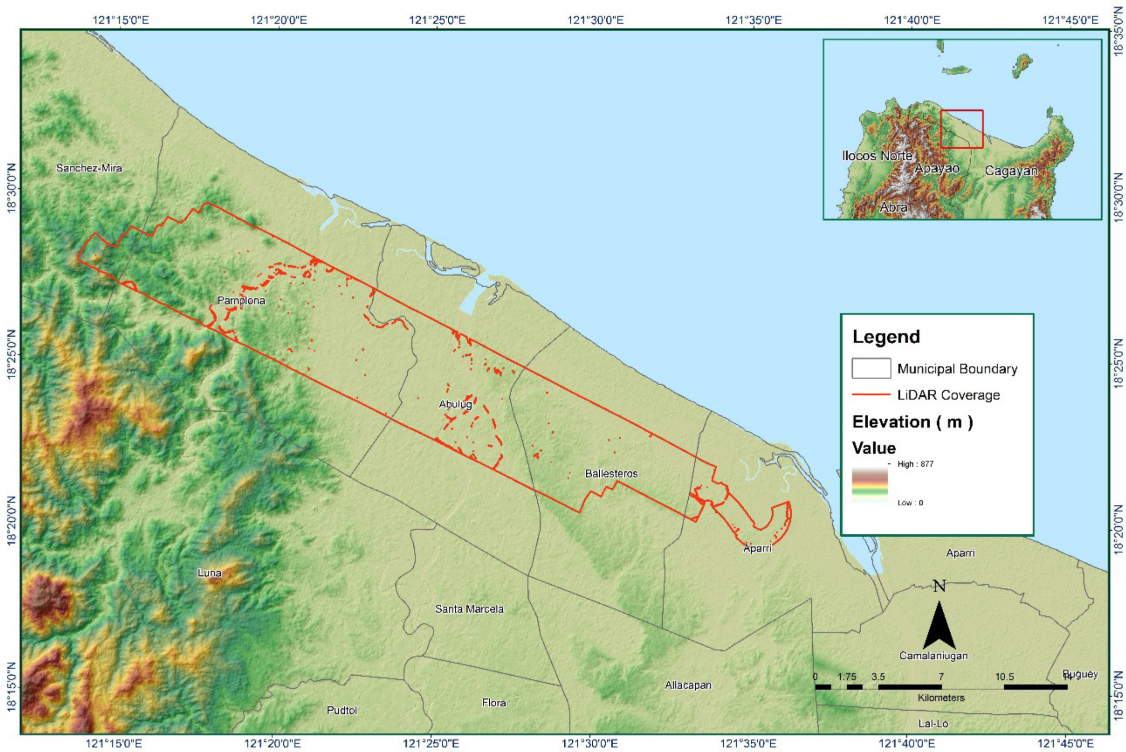


Figure 1. 10. 4. Coverage of LiDAR data

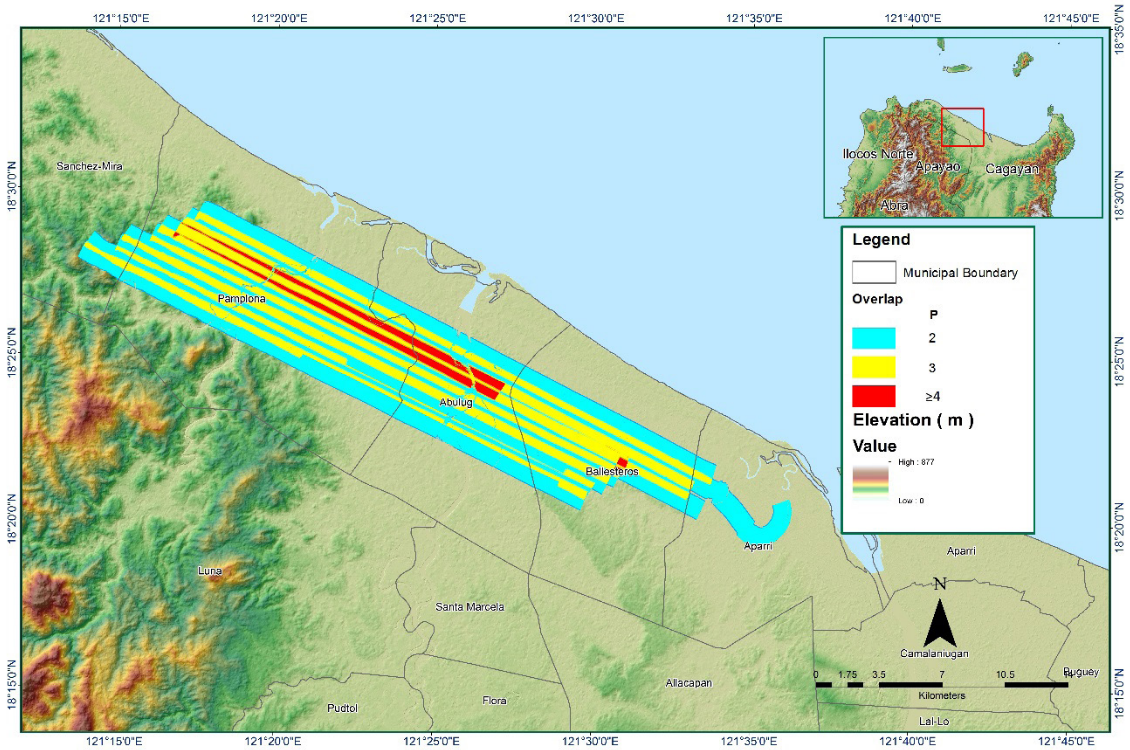


Figure 1. 10. 5. Image of data overlap

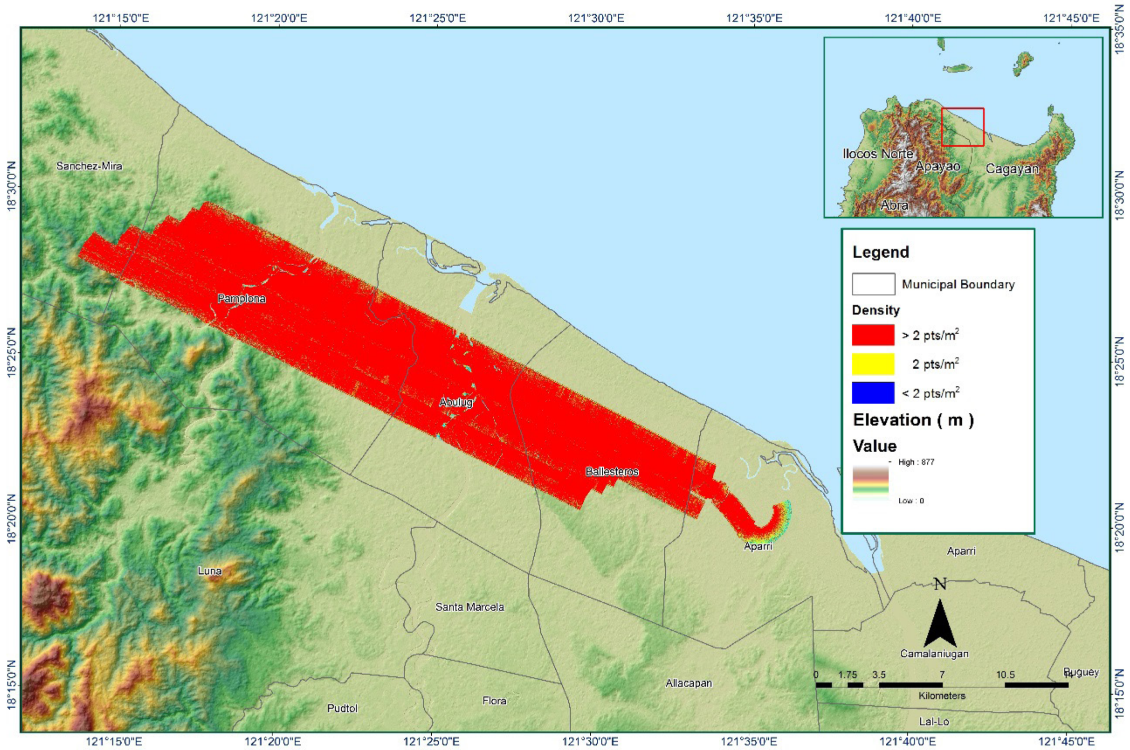


Figure 1. 10. 6. Density map of merged LiDAR data

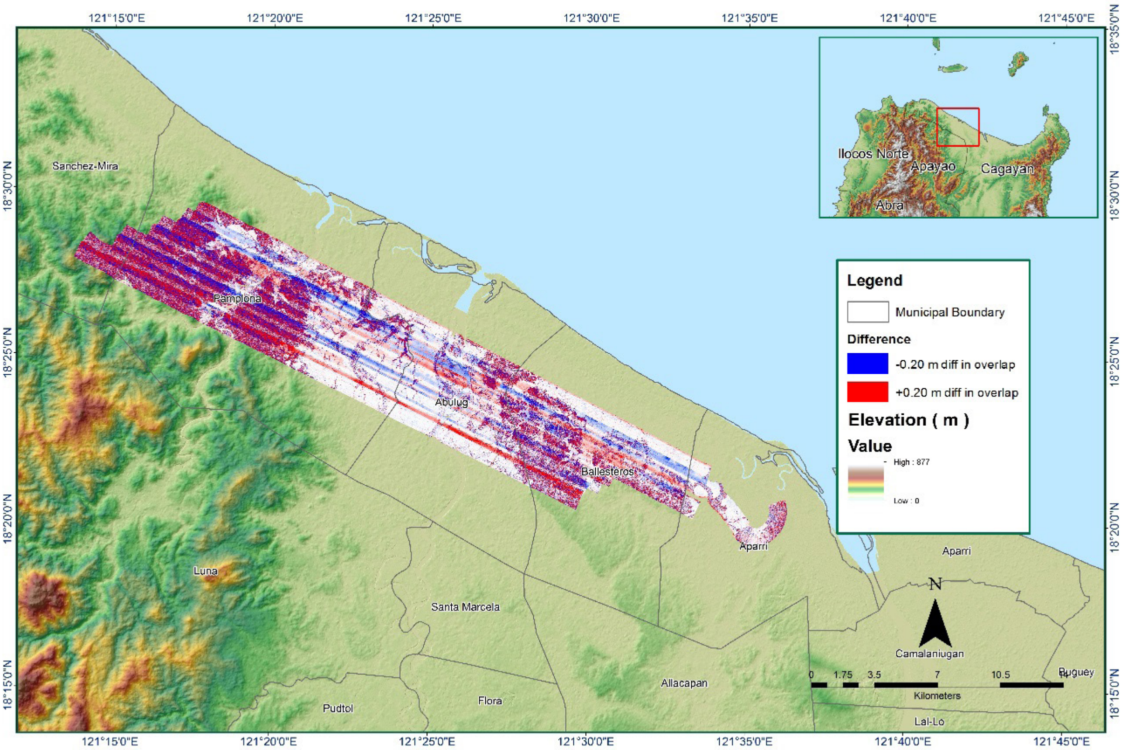


Figure 1. 10. 7. Elevation difference between flight lines

Flight Area	Cagayan Reflights(Tuguegarao)
Mission Name	**Blk2A**
Inclusive Flights	2852P, 2848P
Range data size	17.63GB
POS	301MB
Image	28.87MB
Transfer date	November 24, 2015
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)	3.58
RMSE for East Position (<4.0 cm)	3.08
RMSE for Down Position (<8.0 cm)	5.22
Boresight correction stdev (<0.001deg)	0.000481
IMU attitude correction stdev (<0.001deg)	0.000374
GPS position stdev (<0.01m)	0.0021
Minimum % overlap (>25)	38.74
Ave point cloud density per sq.m. (>2.0)	1.82
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	183
Maximum Height	266.52 m
Minimum Height	40.70 m
Classification (# of points)	
Ground	193,048,741
Low vegetation	109,905,536
Medium vegetation	147,785,042
High vegetation	258,391,125
Building	5,416,447
Orthophoto	Yes
Processed by	Engr. Regis Guhiting, Engr. Mark Joshua Salvacion, Engr. Krisha Marie Bautista, Engr. Wilbert Ian San Juan

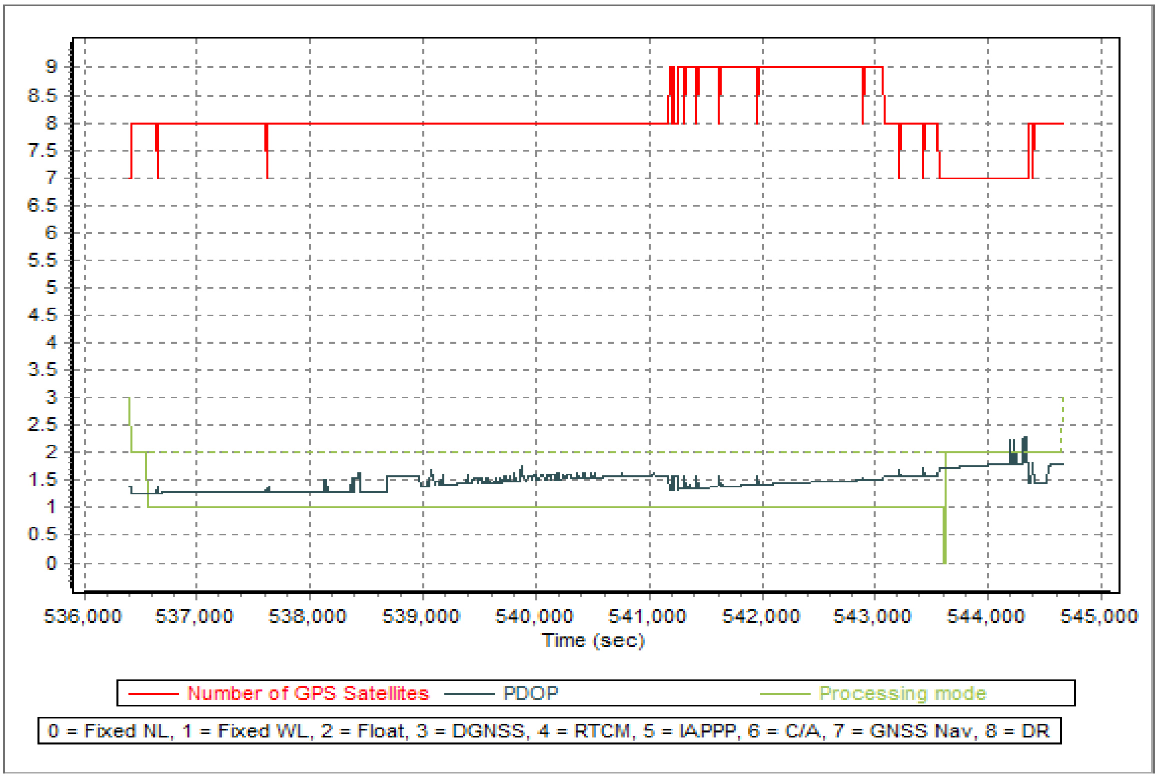


Figure 1.11.1. Solution Status

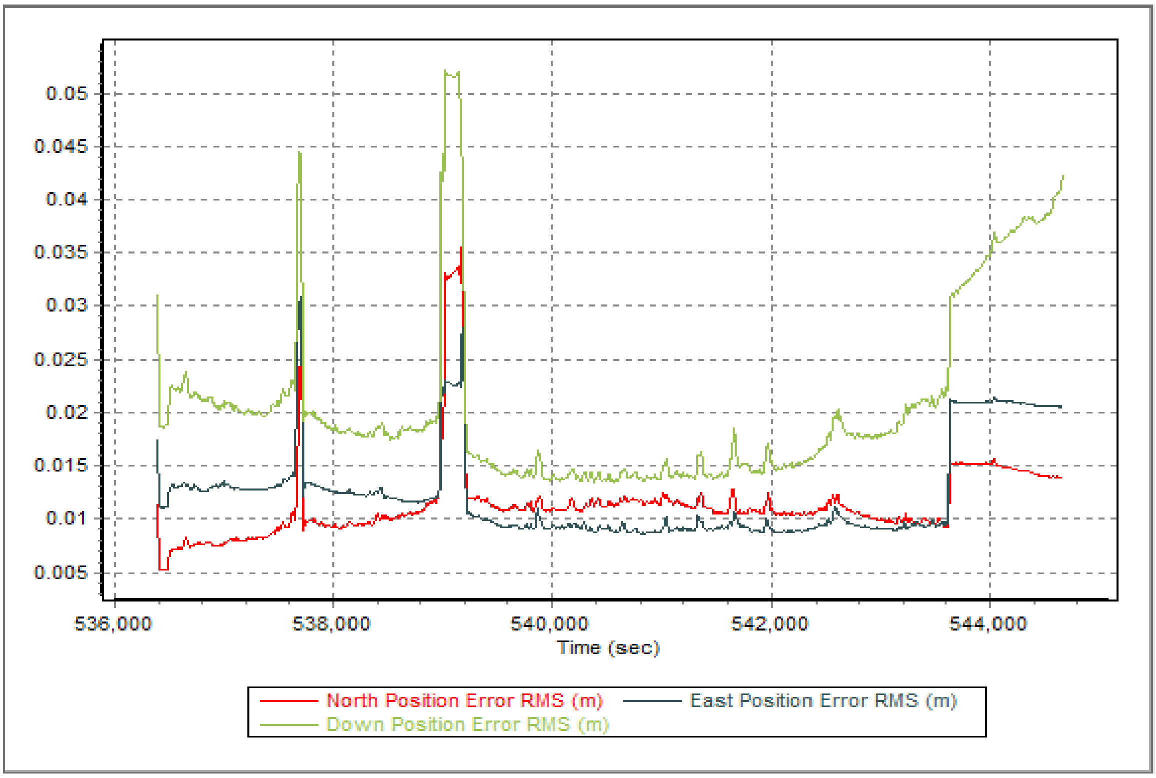


Figure 1.11.2. Smoothed Performance Metric Parameters

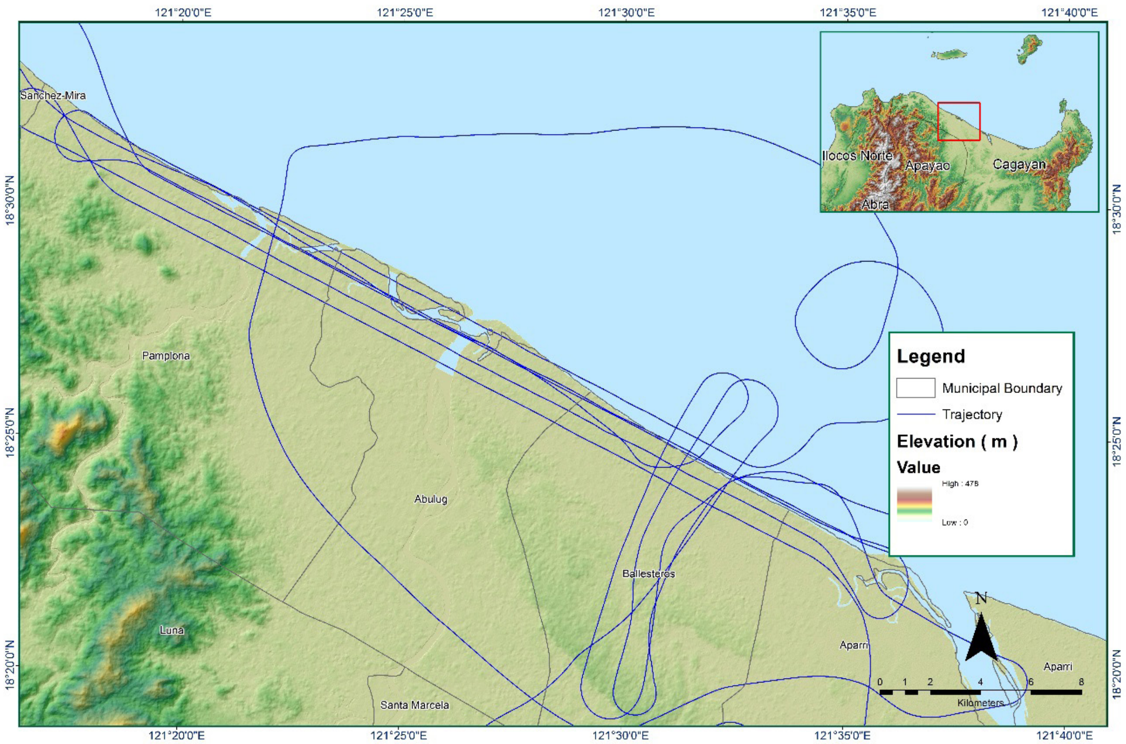


Figure 1. 11. 3. Best Estimated Trajectory

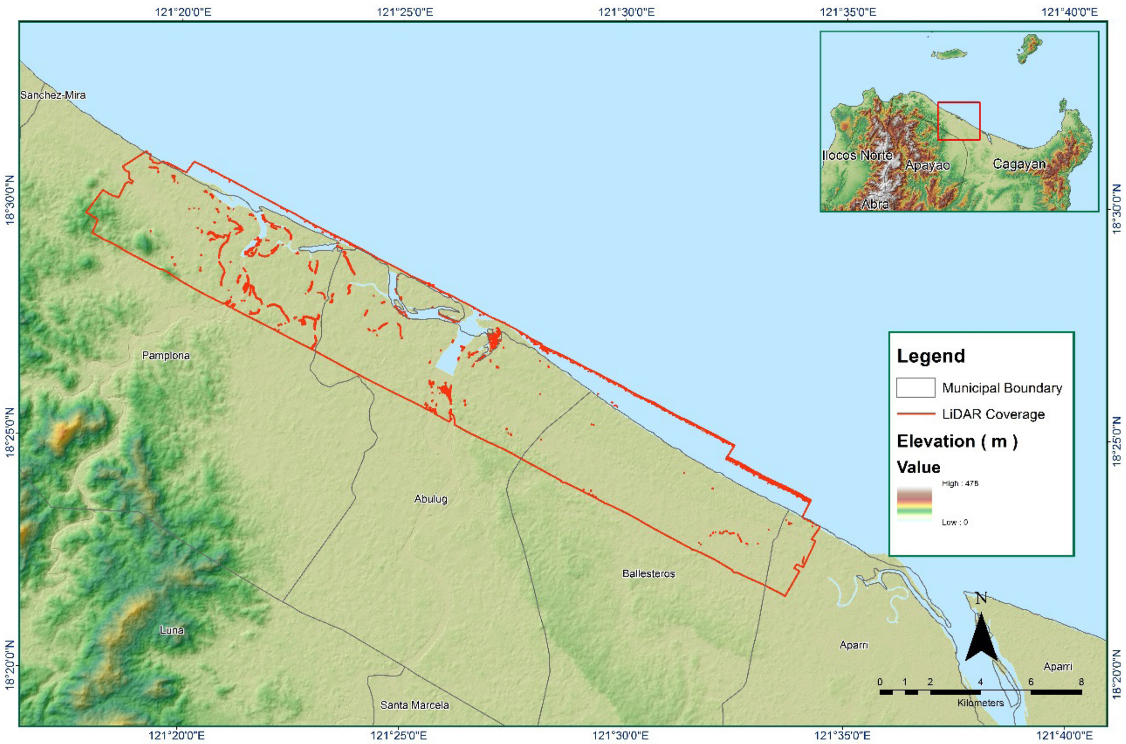


Figure 1. 11. 4. Coverage of LiDAR data

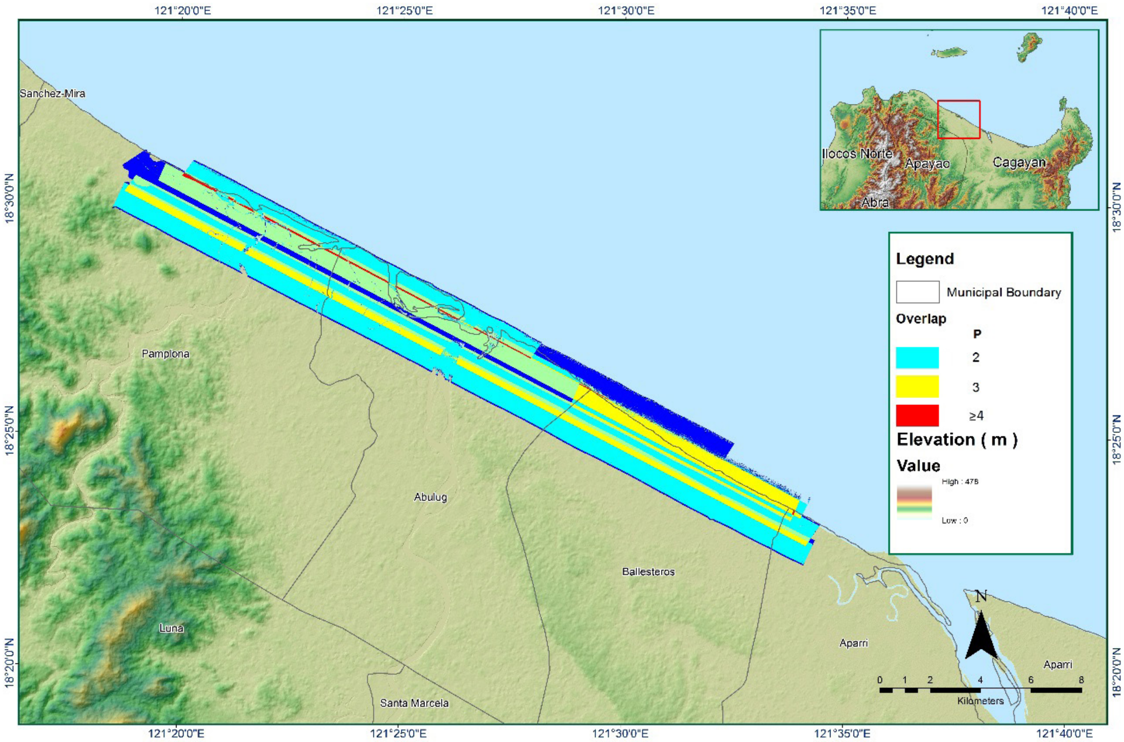


Figure 1. 11. 5. Image of data overlap

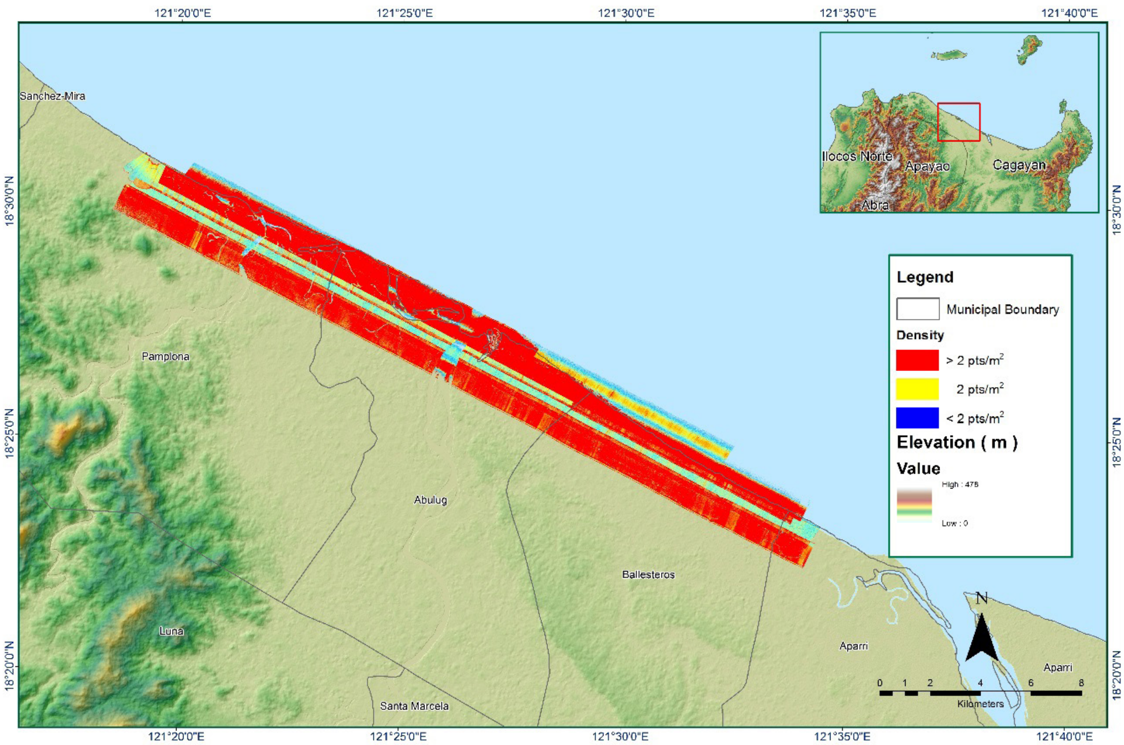


Figure 1. 11. 6. Density map of merged LiDAR data

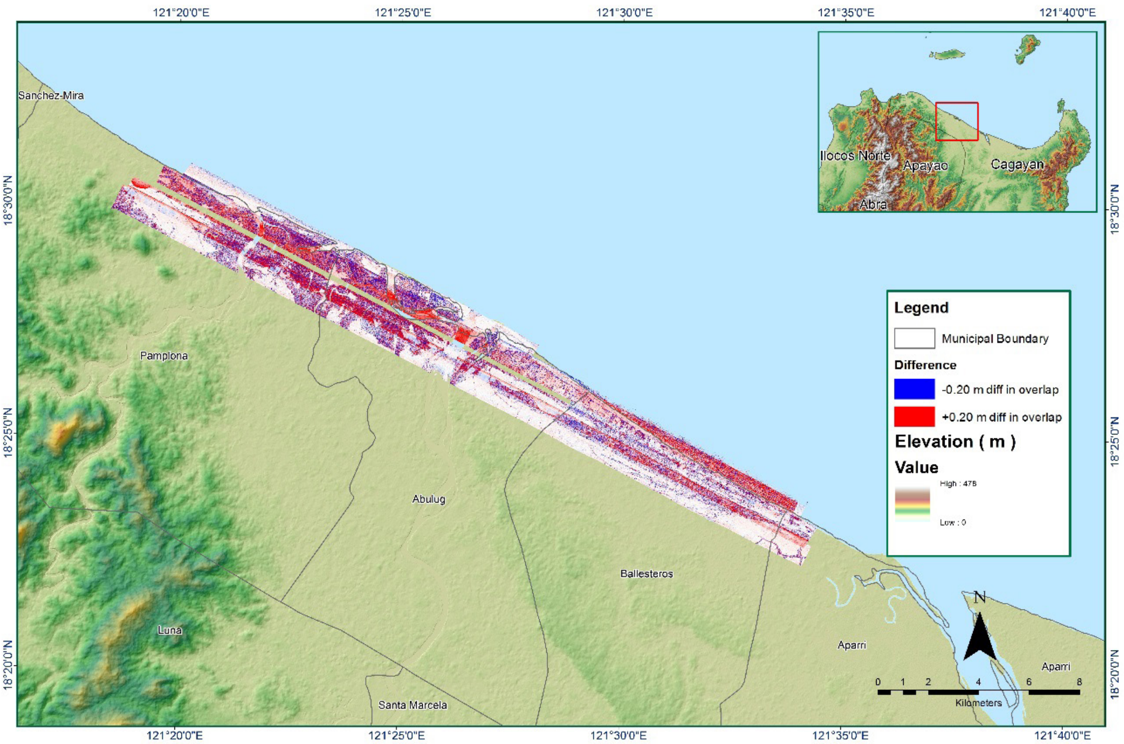


Figure 1. 11. 7. Elevation difference between flight lines

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**CAGS1B**
Inclusive Flights	2830P
Range data size	20.6GB
POS	184MB
Image	23.3MB
Transfer date	November 24, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.39
RMSE for East Position (<4.0 cm)	1.10
RMSE for Down Position (<8.0 cm)	4.33
Boresight correction stdev (<0.001deg)	0.000304
IMU attitude correction stdev (<0.001deg)	N/A
GPS position stdev (<0.01m)	0.0011
Minimum % overlap (>25)	24.50
Ave point cloud density per sq.m. (>2.0)	2.5
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	155
Maximum Height	138.95 m
Minimum Height	35.59 m
Classification (# of points)	
Ground	
Low vegetation	331,765,181
Medium vegetation	343,095,514
High vegetation	155,210,392
Building	148,874,282
Orthophoto	Yes
Processed by	Engr. Sheila Maye Santillan, Engr. Justine Francisco, Marie Denise Bueno

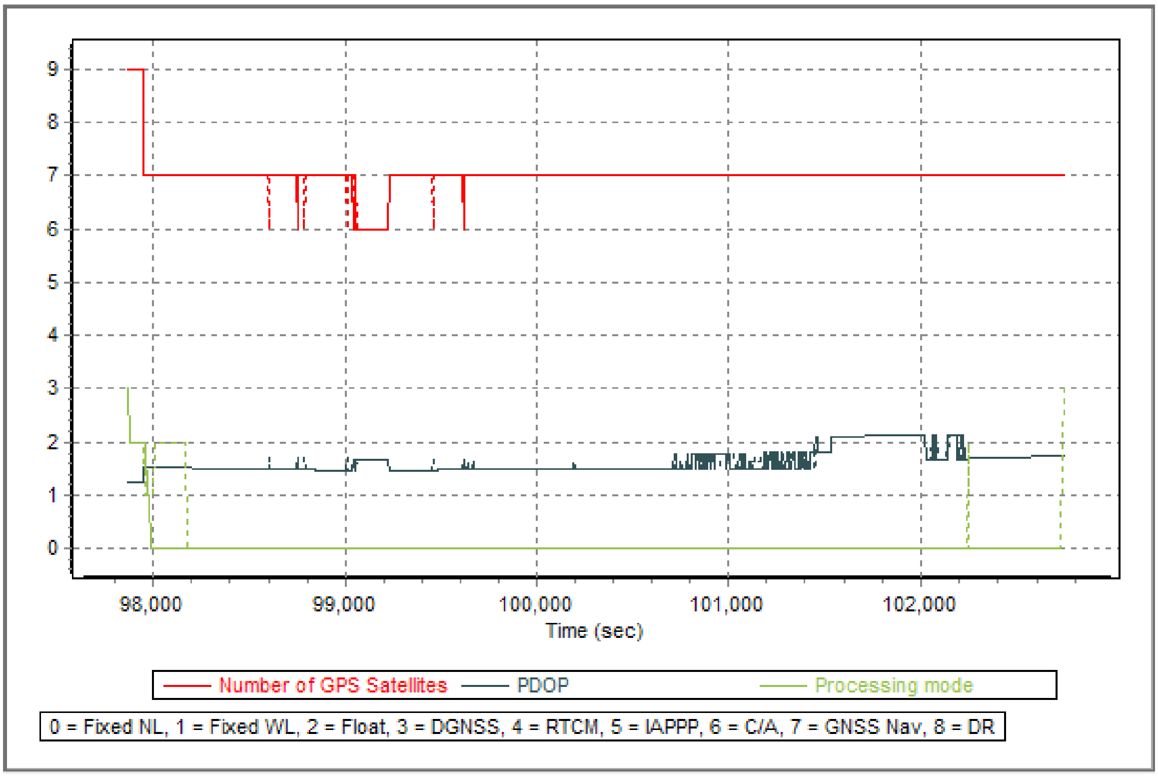


Figure 1.12.1. Solution Status

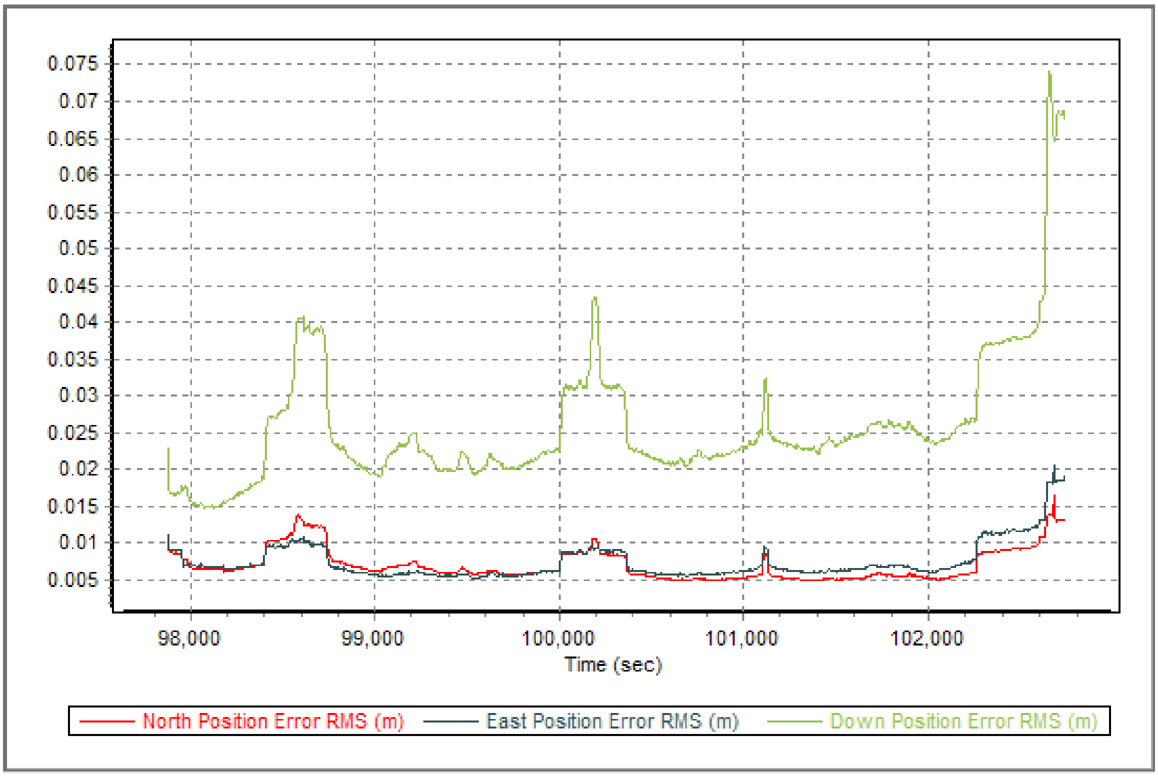


Figure 1.12.2. Smoothed Performance Metric Parameters

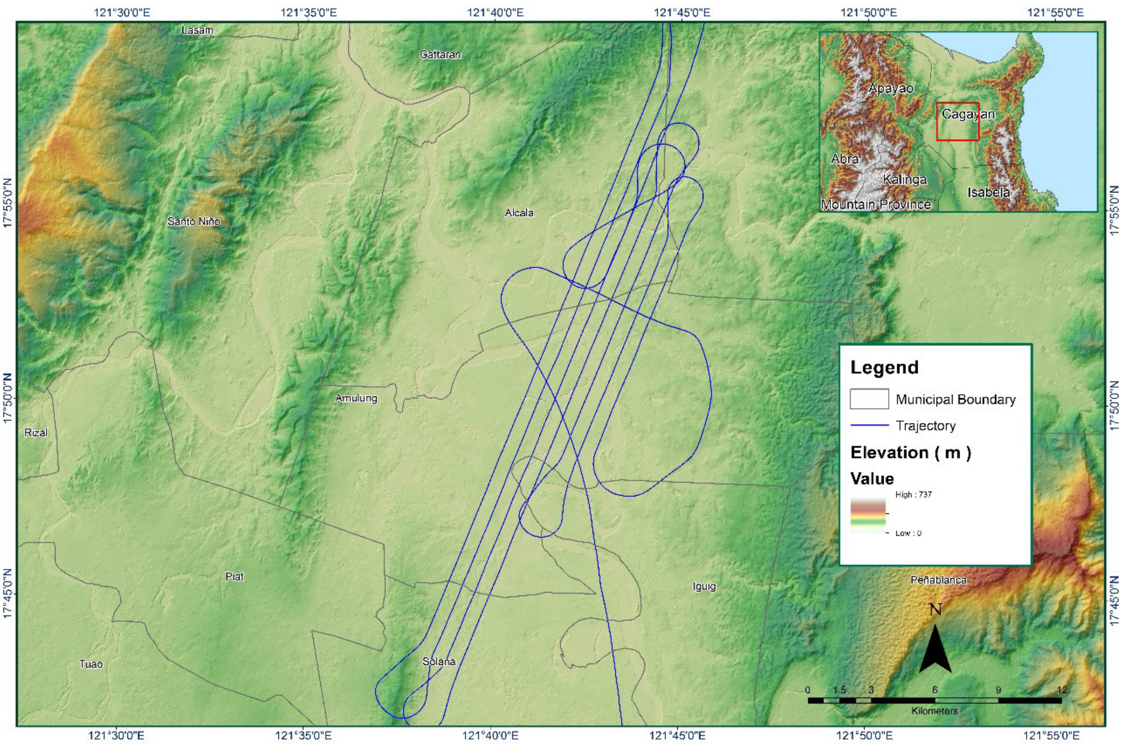


Figure 1. 12. 3. Best Estimated Trajectory

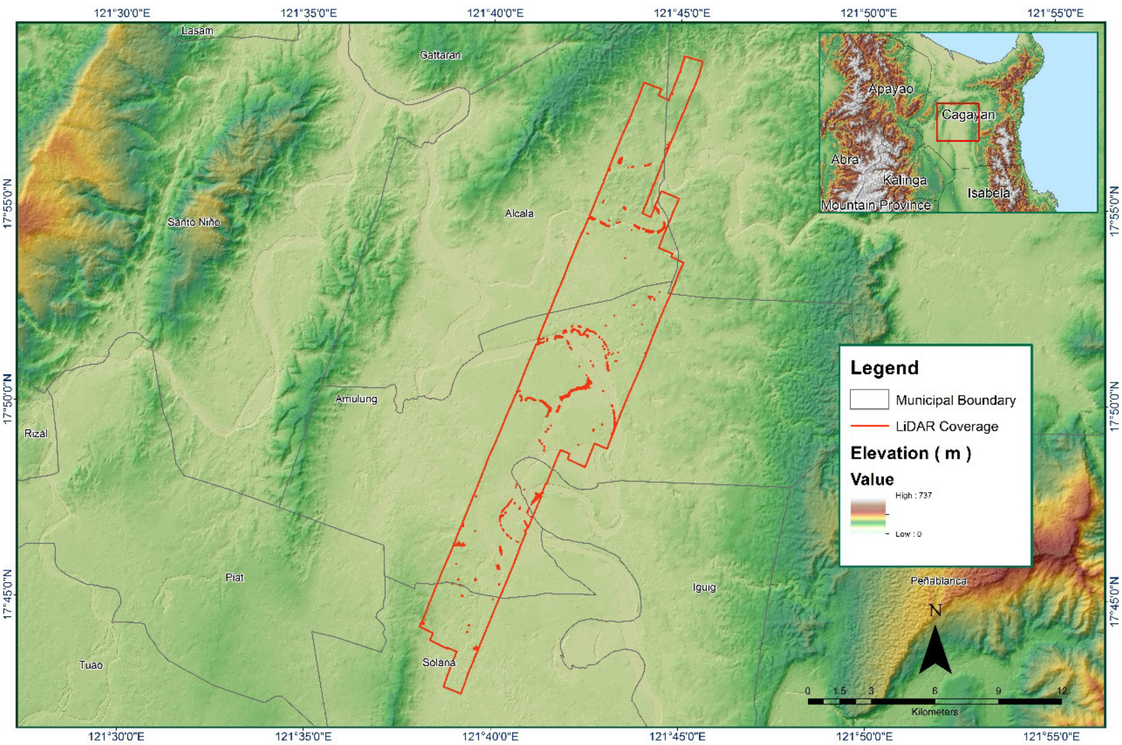


Figure 1. 12. 4. Coverage of LiDAR data

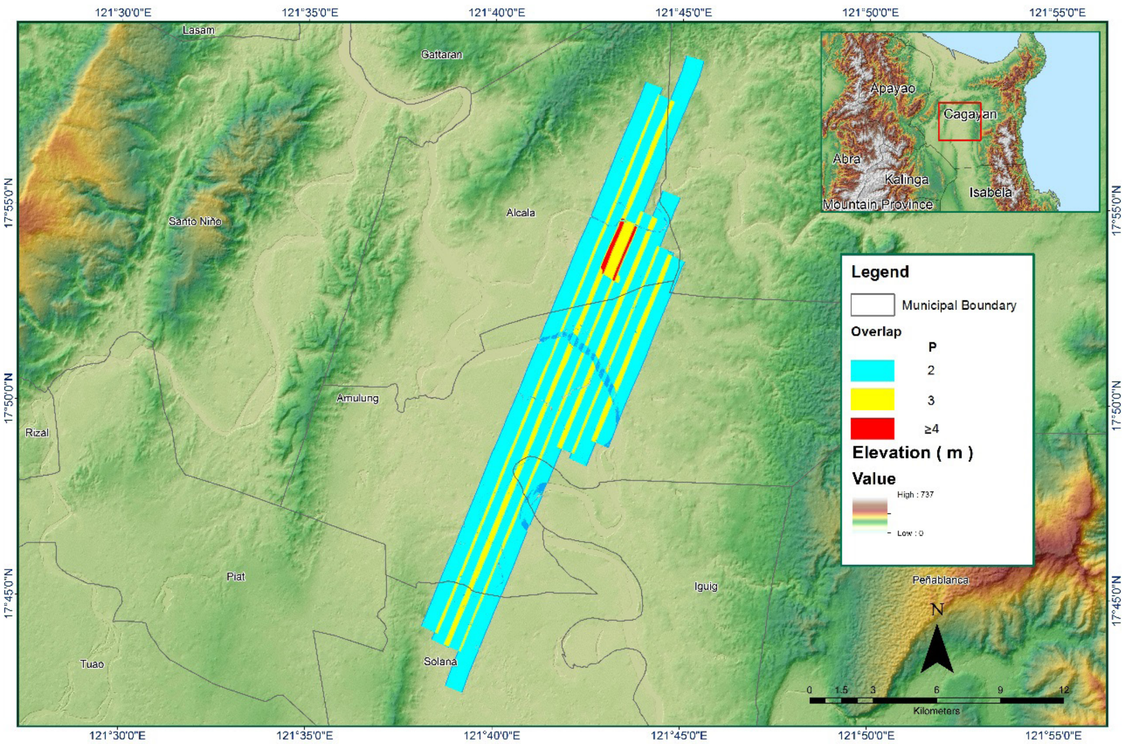


Figure 1. 12. 5. Image of data overlap

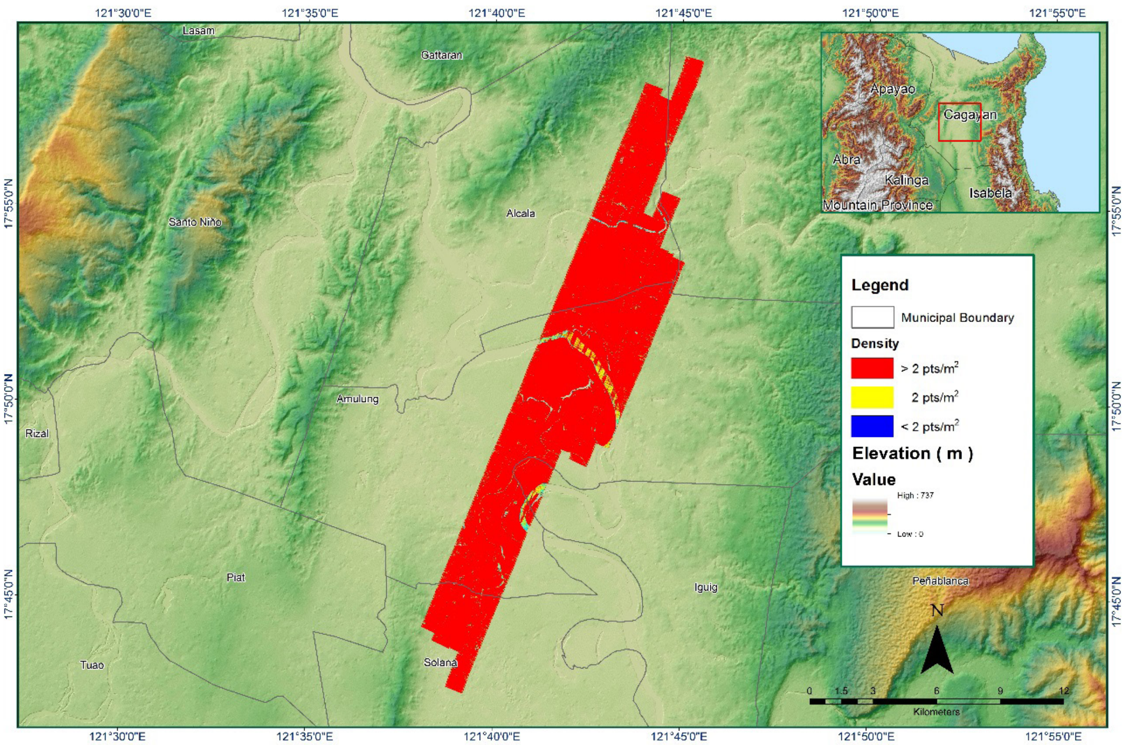


Figure 1. 12. 6. Density map of merged LiDAR data

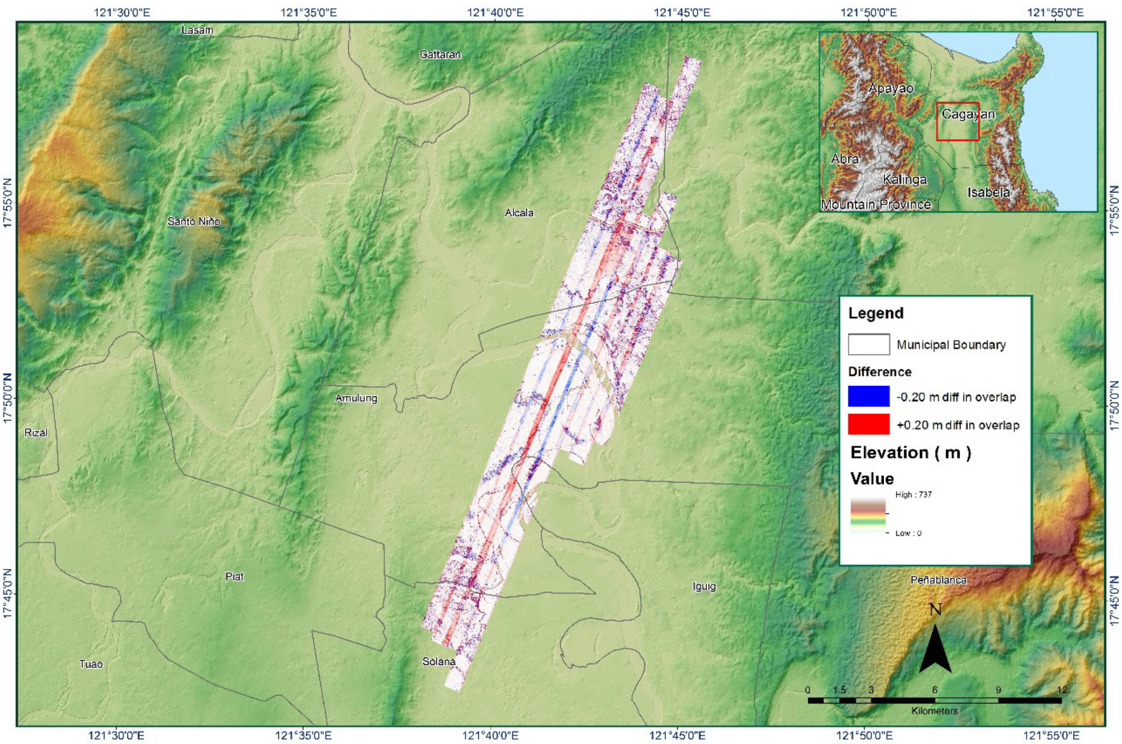


Figure 1. 12. 7. Elevation difference between flight lines

Flight Area	Cagayan Reflights(Tuguegarao)
Mission Name	**CAGS1D**
Inclusive Flights	2830P
Range data size	20.6GB
POS	184MB
Image	23.3MB
Transfer date	November 24, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.13
RMSE for East Position (<4.0 cm)	1.12
RMSE for Down Position (<8.0 cm)	1.92
Boresight correction stdev (<0.001deg)	0.000159
IMU attitude correction stdev (<0.001deg)	0.000190
GPS position stdev (<0.01m)	0.0020
Minimum % overlap (>25)	27.74
Ave point cloud density per sq.m. (>2.0)	3.265
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	130
Maximum Height	344.31 m
Minimum Height	48.59 m
Classification (# of points)	
Ground	
Low vegetation	132,881,618
Medium vegetation	50,519,810
High vegetation	62,411,596
Building	115,778,110
Orthophoto	Yes
Processed by	Engr. Sheila Maye Santillan, Engr. Justine Francisco, Alex Escobido

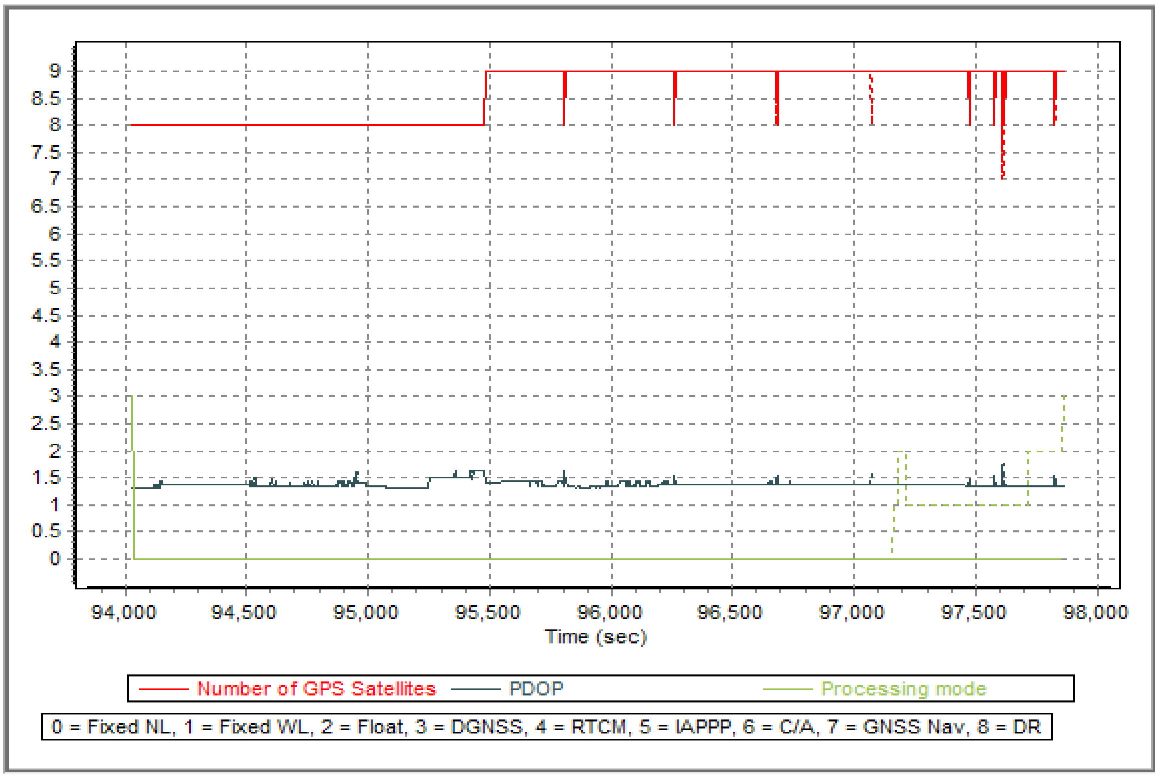


Figure 1.13.1. Solution Status

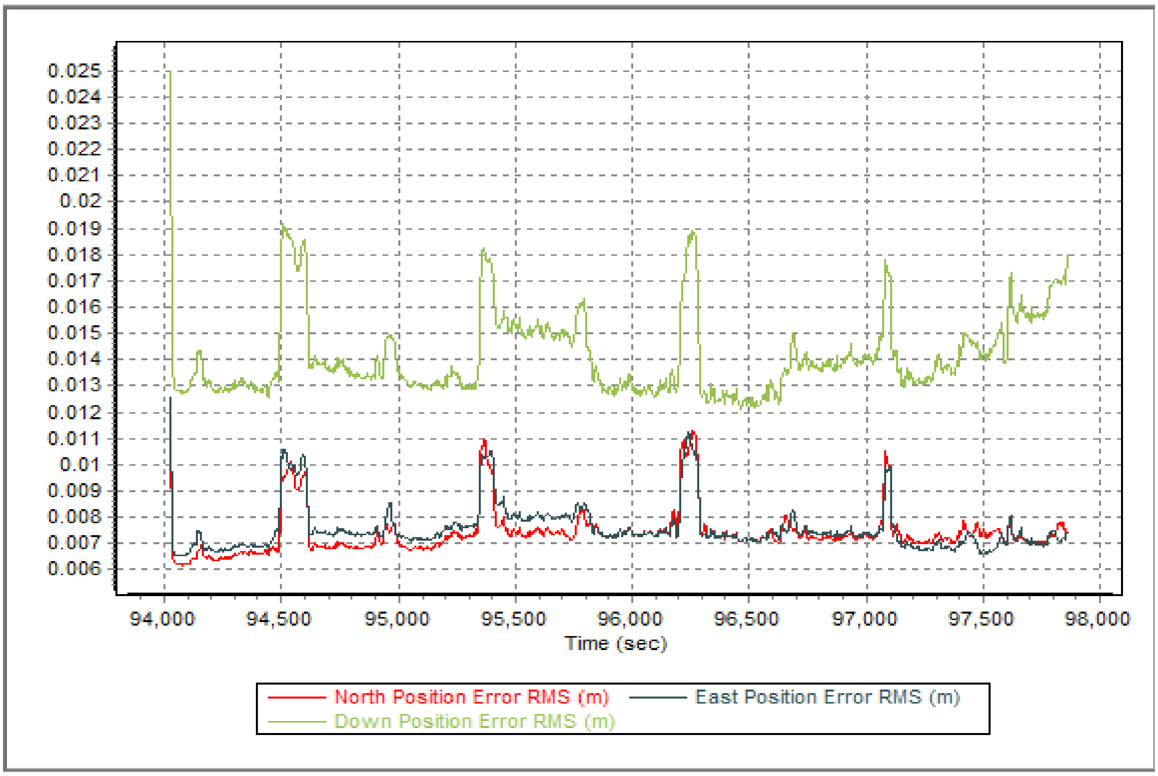


Figure 1.13.2. Smoothed Performance Metric Parameters

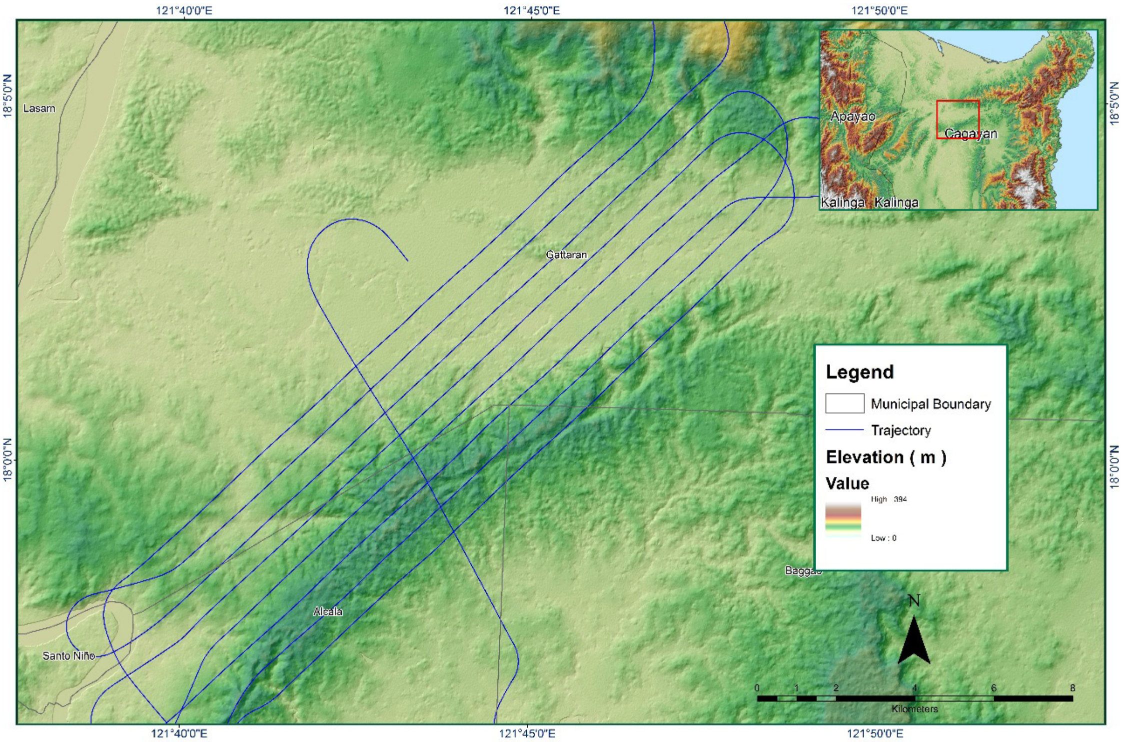


Figure 1. 13. 3. Best Estimated Trajectory

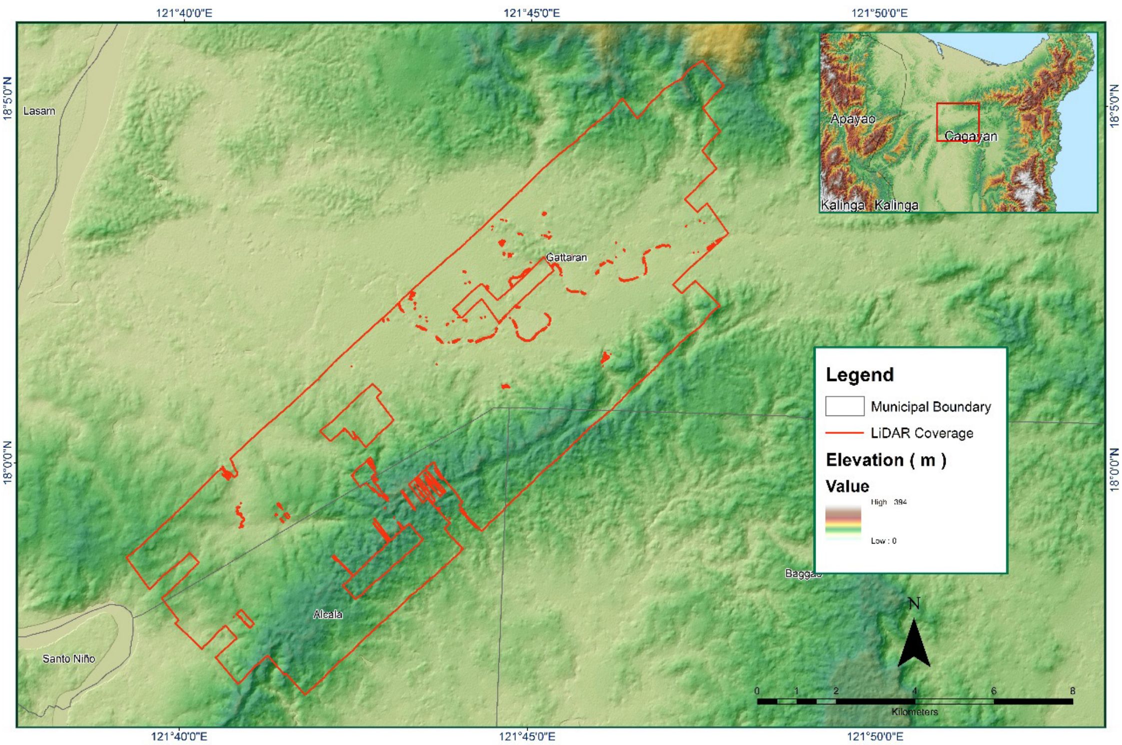


Figure 1. 13. 4. Coverage of LiDAR data

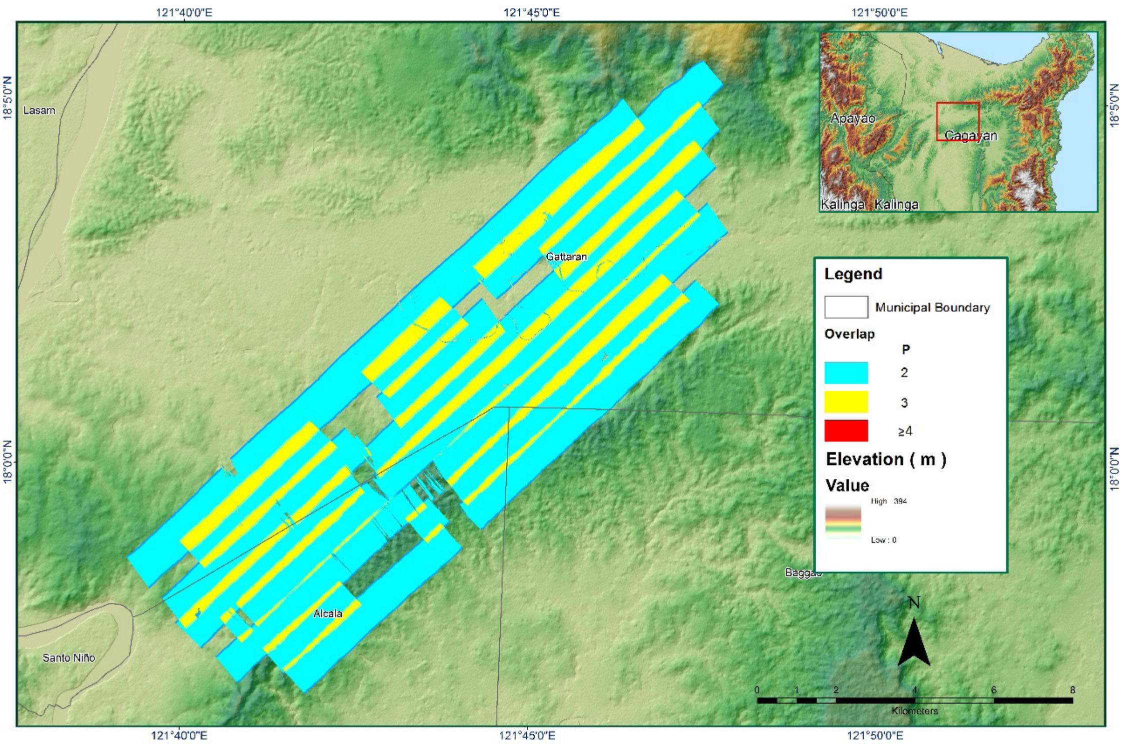


Figure 1. 13. 5. Image of data overlap

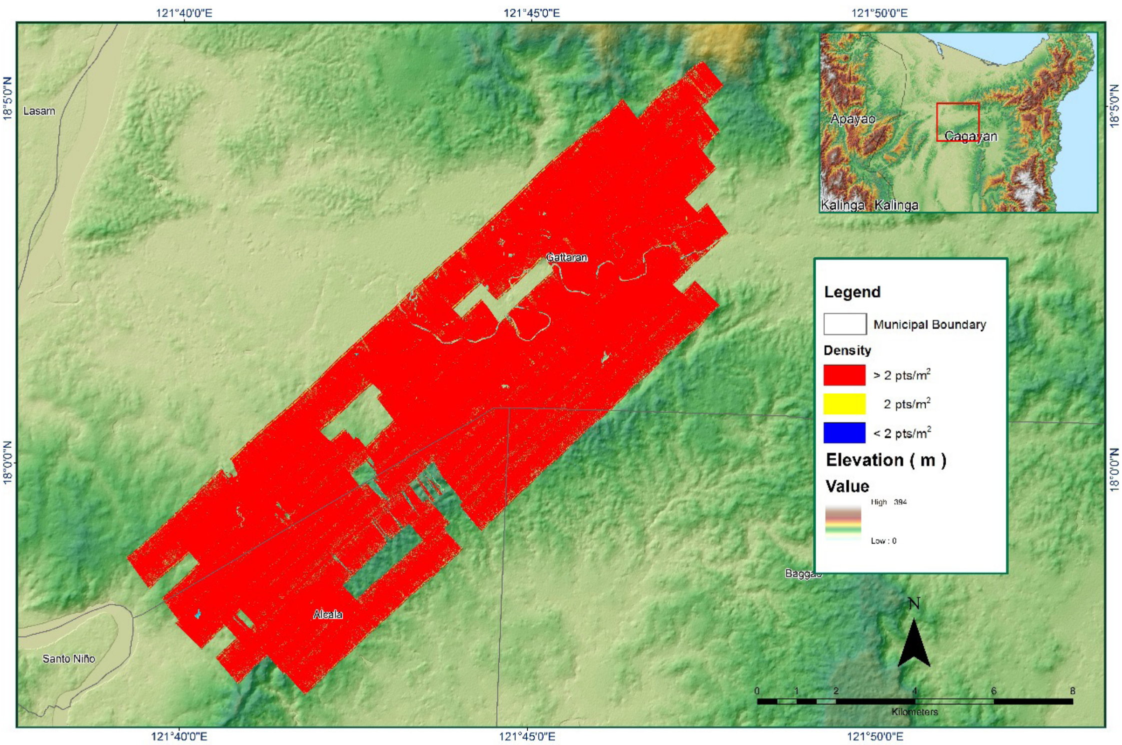


Figure 1. 13. 6. Density map of merged LiDAR data

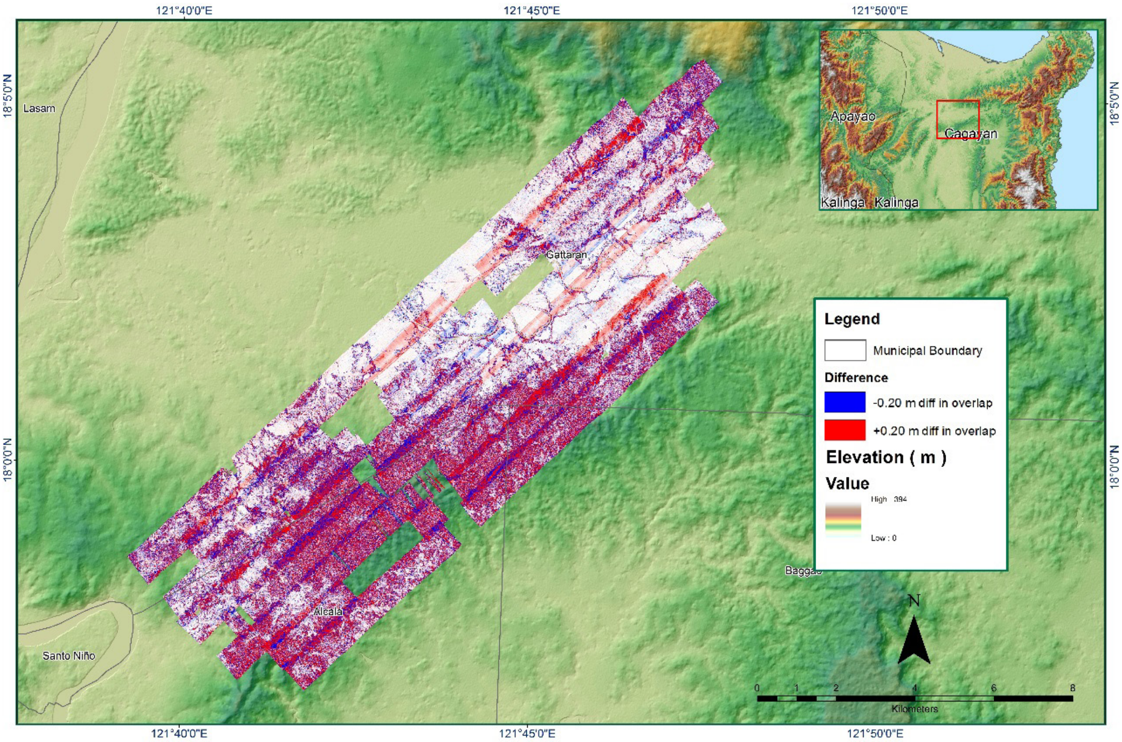


Figure 1. 13. 7. Elevation difference between flight lines

Flight Area	**Cagayan Reflights(Tuguegarao)**
Mission Name	**Blk2H_supplement2**
Inclusive Flights	2880P
Range data size	17.7GB
POS	231MB
Image	30MB
Transfer date	December 4, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.04
RMSE for East Position (<4.0 cm)	1.12
RMSE for Down Position (<8.0 cm)	3.84
Boresight correction stdev (<0.001deg)	0.000183
IMU attitude correction stdev (<0.001deg)	0.000168
GPS position stdev (<0.01m)	0.0106
Minimum % overlap (>25)	18.58
Ave point cloud density per sq.m. (>2.0)	3.065
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	89
Maximum Height	175.21 m
Minimum Height	39.65 m
Classification (# of points)	
Ground	71,777,200
Low vegetation	41,792,819
Medium vegetation	51,985,898
High vegetation	145,398,901
Building	3,567,593
Orthophoto	Yes
Processed by	Engr. NalynNaldo, Engr. Velina Angela Bemida, Maria Tamsyn Malabanan

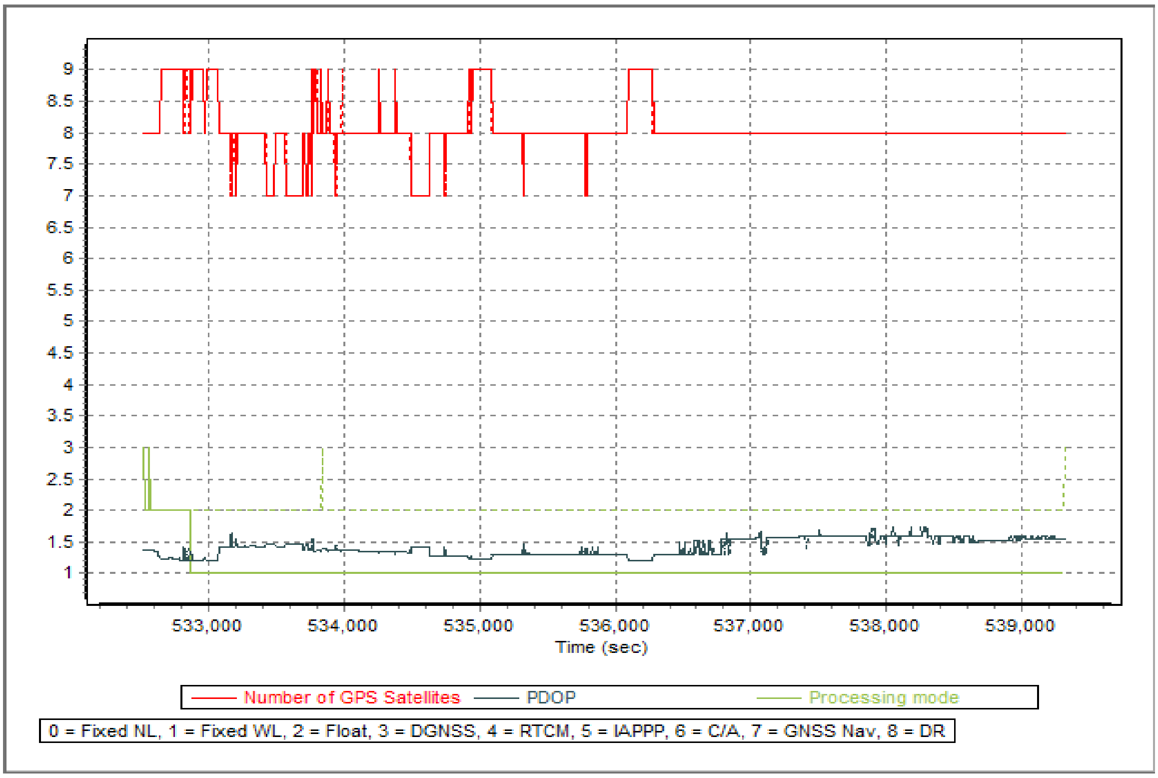


Figure 1.14.1. Solution Status

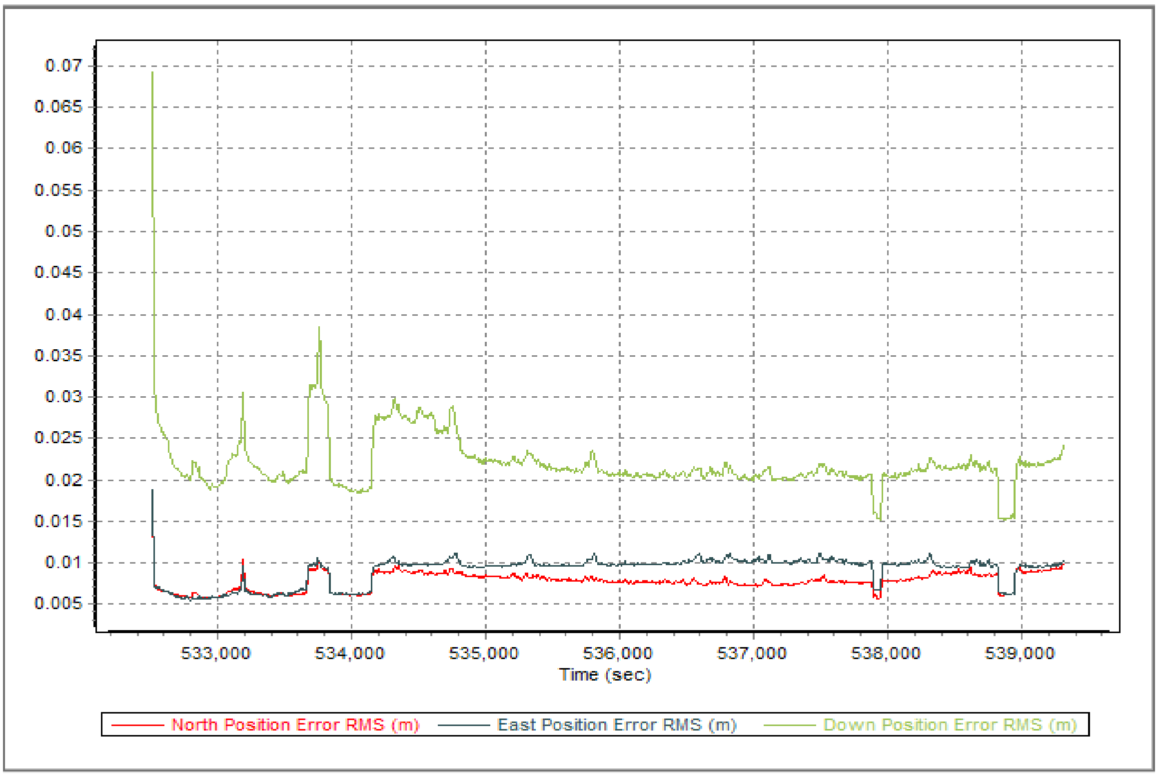


Figure 1.14.2. Smoothed Performance Metric Parameters

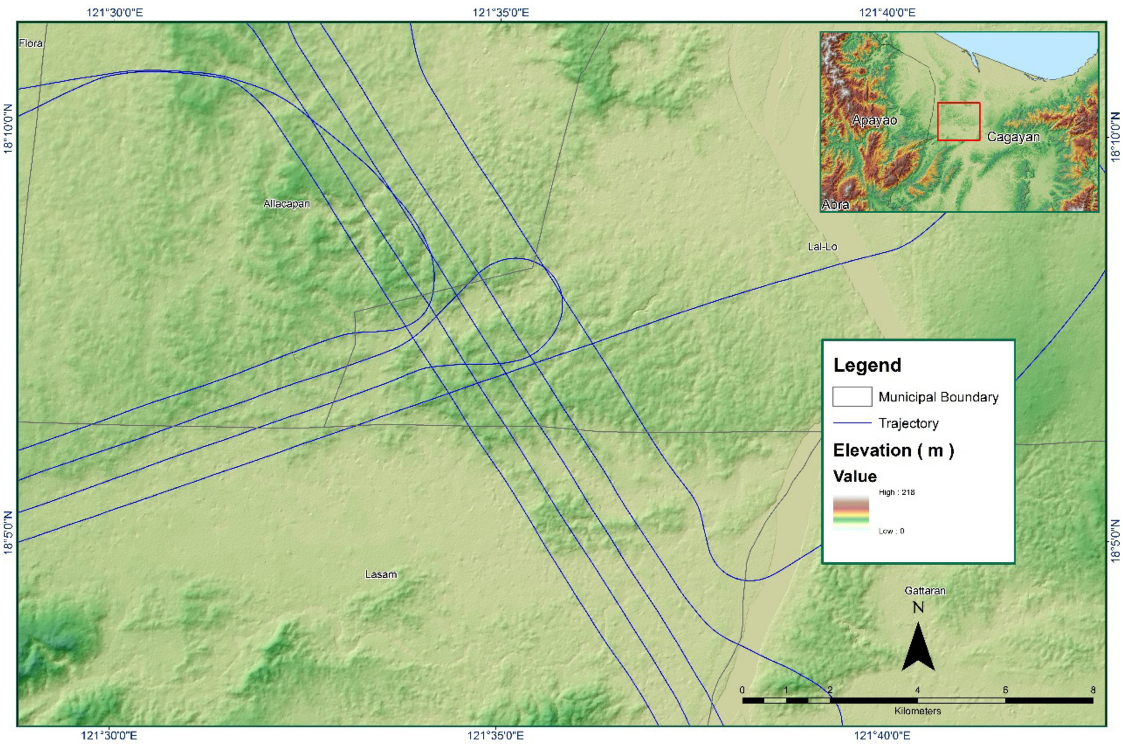


Figure 1. 14. 3. Best Estimated Trajectory

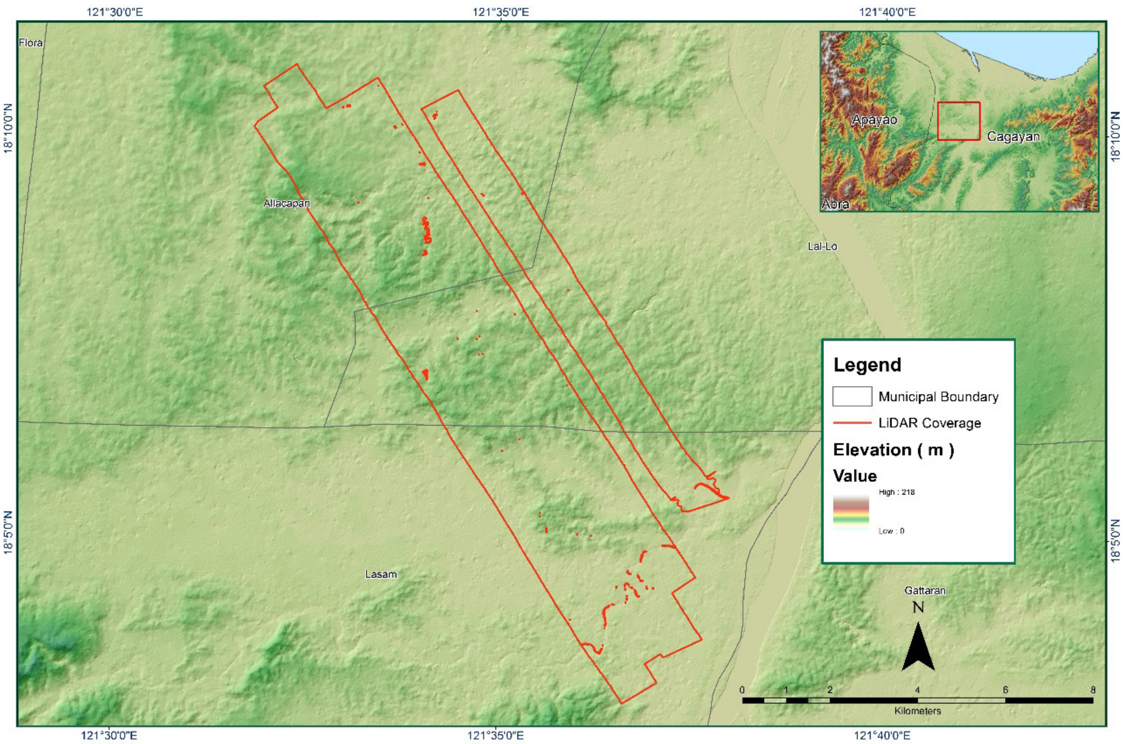


Figure 1. 14. 4. Coverage of LiDAR data

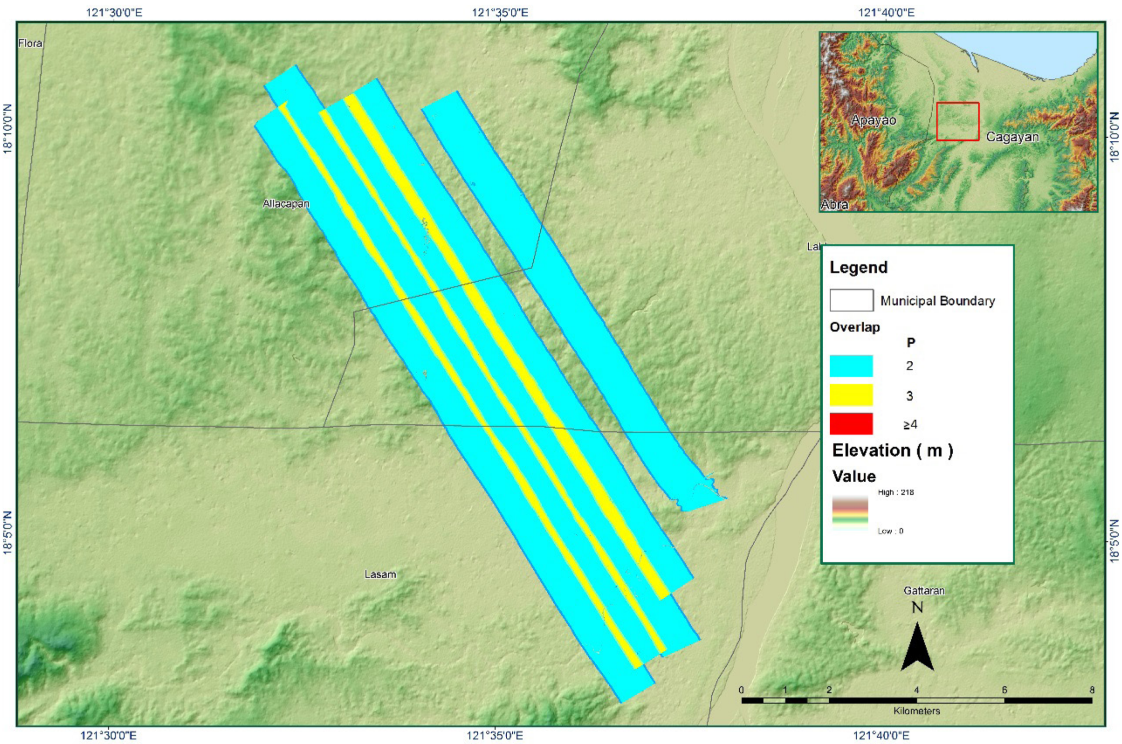


Figure 1. 14. 5. Image of data overlap

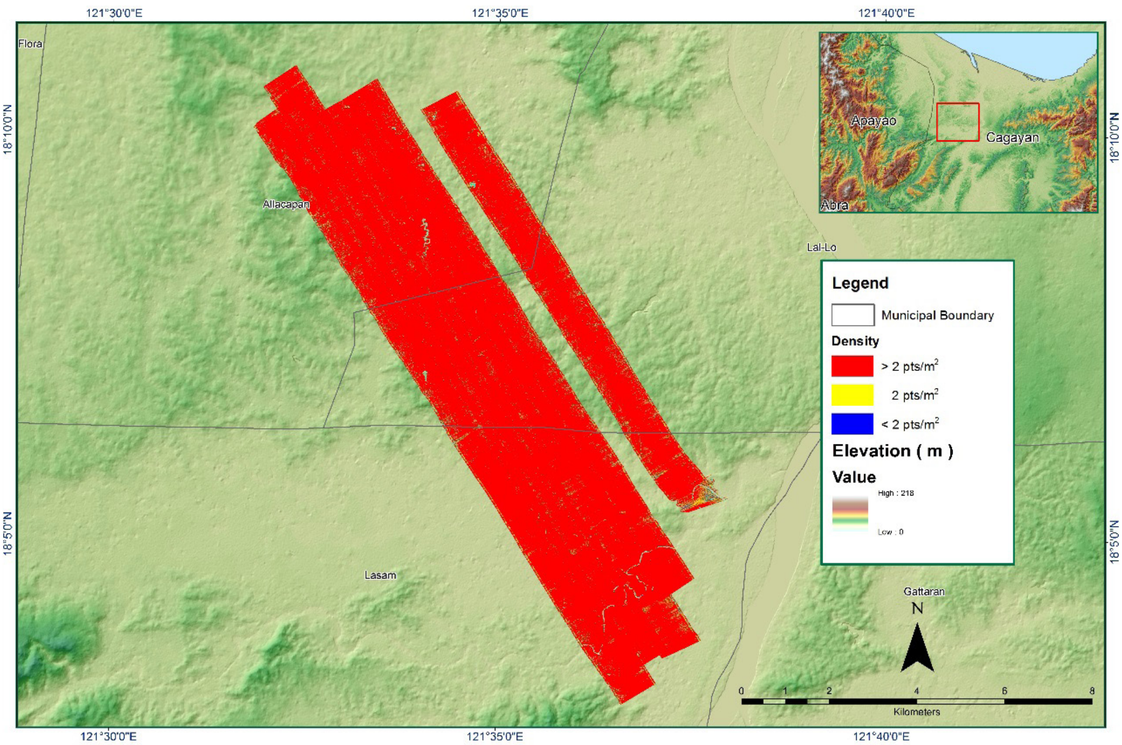


Figure 1. 14. 6. Density map of merged LiDAR data

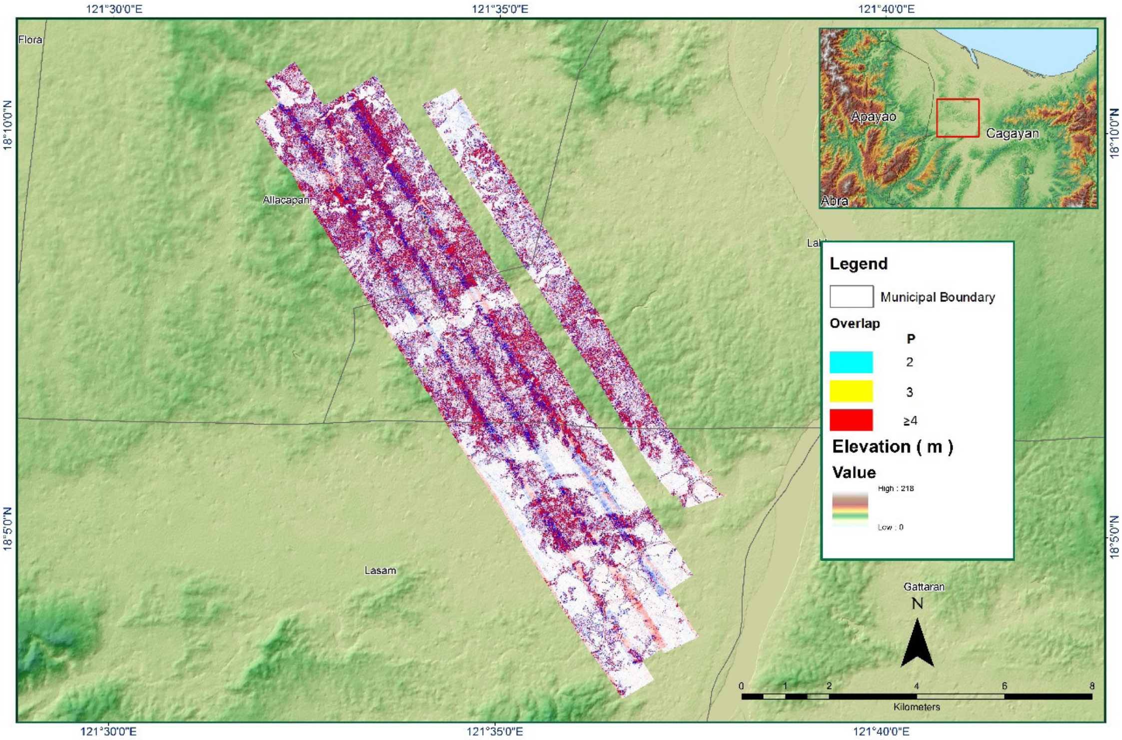


Figure 1. 14. 7. Elevation difference between flight lines

Flight Area	**Cagayan_Reflights**
Mission Name	**Cagayan_Reflights_BLK101A**
Inclusive Flights	3977G
Range data size	29.4 GB
POS data size	255 MB
Base data size	12. 1 MB
Image	n/a
Transfer date	June 21,2016
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.4
RMSE for East Position (<4.0 cm)	1.5
RMSE for Down Position (<8.0 cm)	4.5
Boresight correction stdev (<0.001deg)	0.001176
IMU attitude correction stdev (<0.001deg)	0.009819
GPS position stdev (<0.01m)	0.0232
Minimum % overlap (>25)	25.06
Ave point cloud density per sq.m. (>2.0)	4.18
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	184
Maximum Height	415.67 m
Minimum Height	73.64 m
Classification (# of points)	
Ground	157,975,007
Low vegetation	128,332,202
Medium vegetation	199,440,559
High vegetation	108,709,288
Building	1,374,055
Orthophoto	No
Processed by	Engr. James Kevin Dimaculangan, Engr. Edgardo Gubatanga Jr., Engr. Czarina Aonuevo

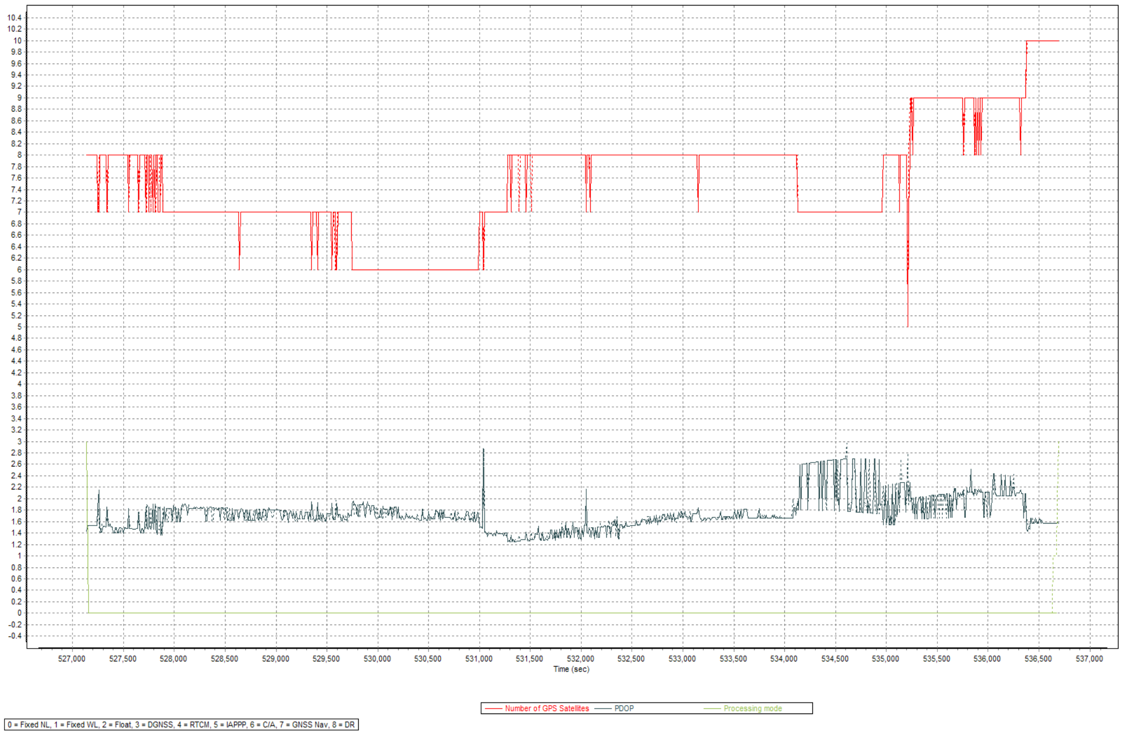


Figure 1.15.1. Solution Status

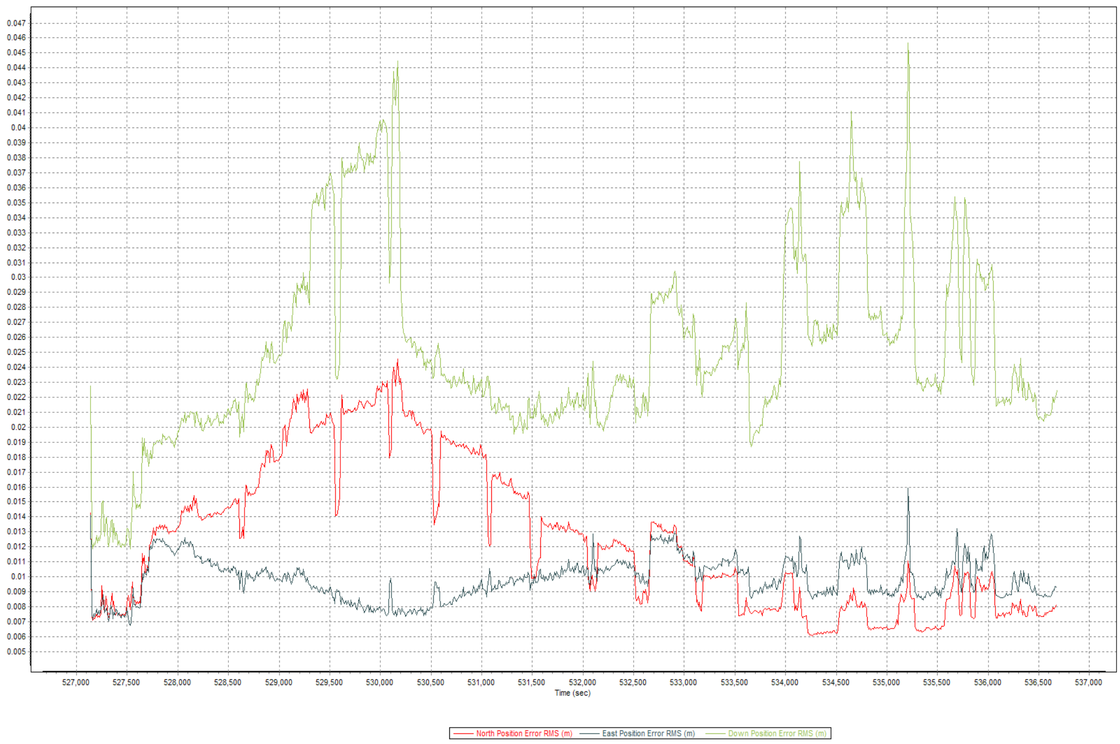


Figure 1.15.2. Smoothed Performance Metric Parameters

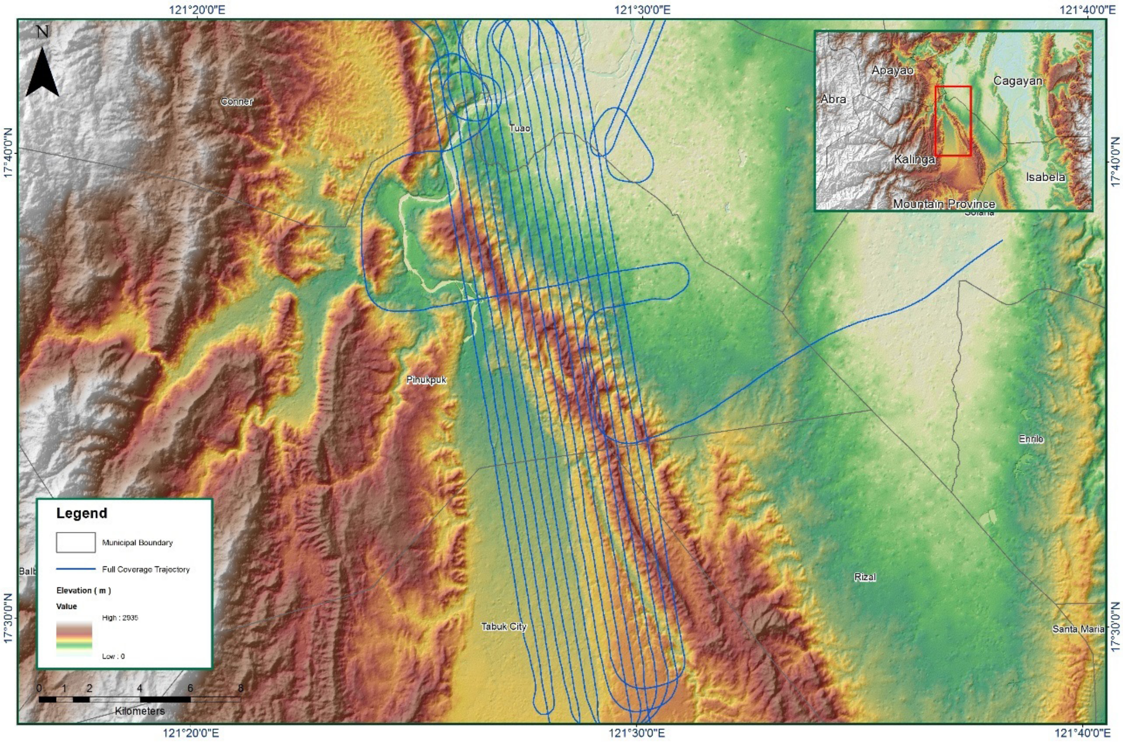


Figure 1.15.3. Best Estimated Trajectory

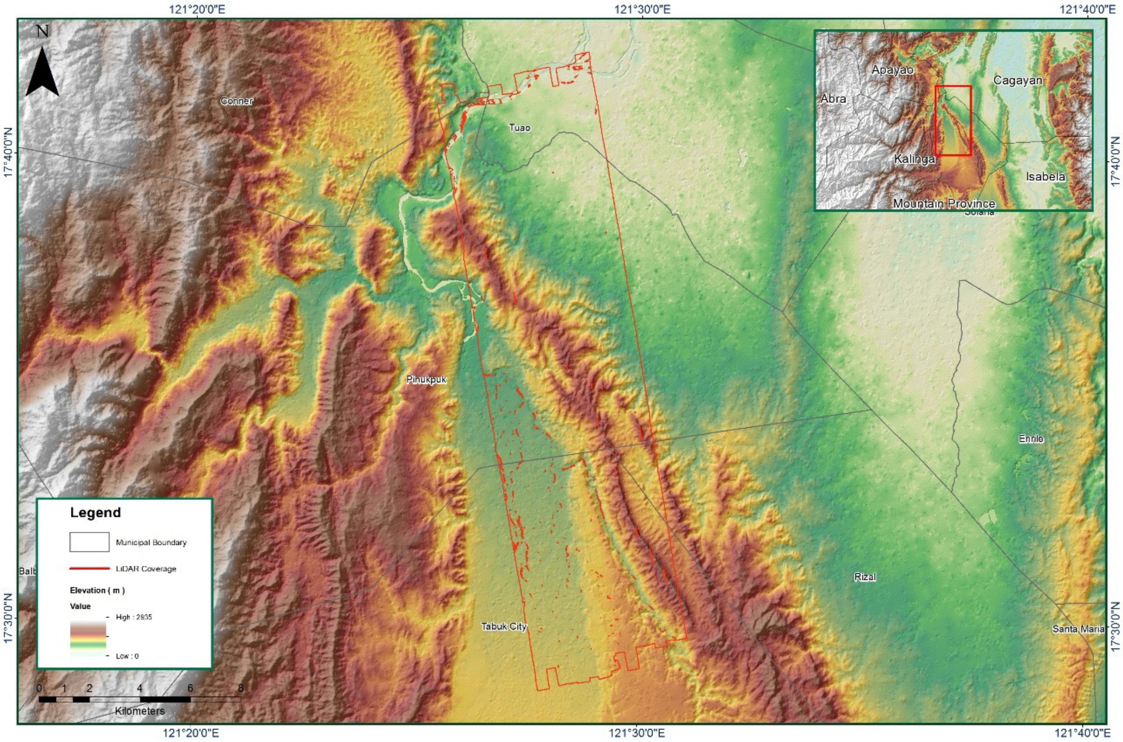


Figure 1.15.4. Coverage of LiDAR Data

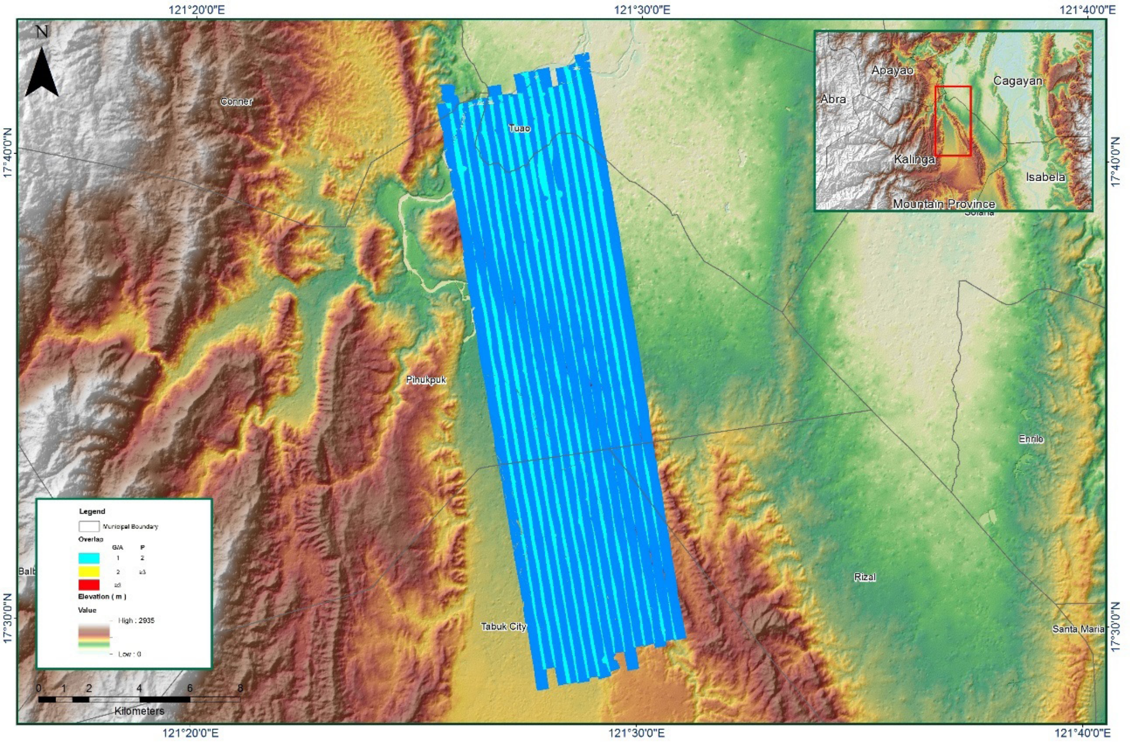


Figure 1.15.5. Image of data overlap

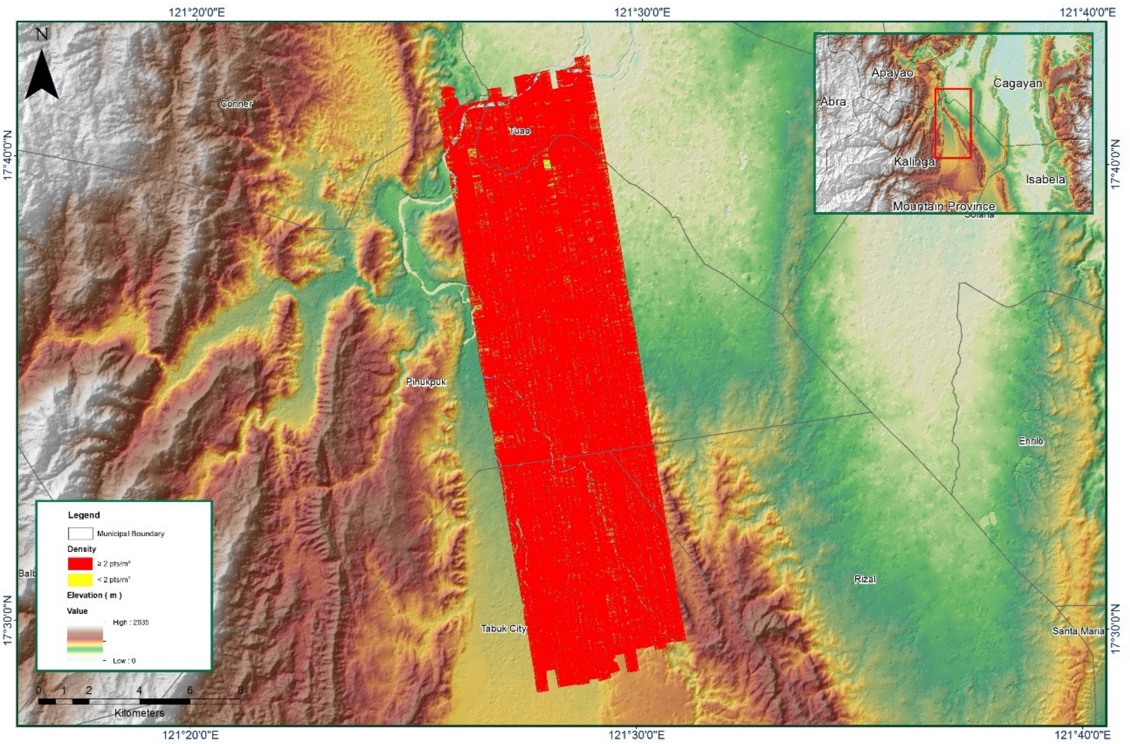


Figure 1.15.6. Density map of merged LiDAR data

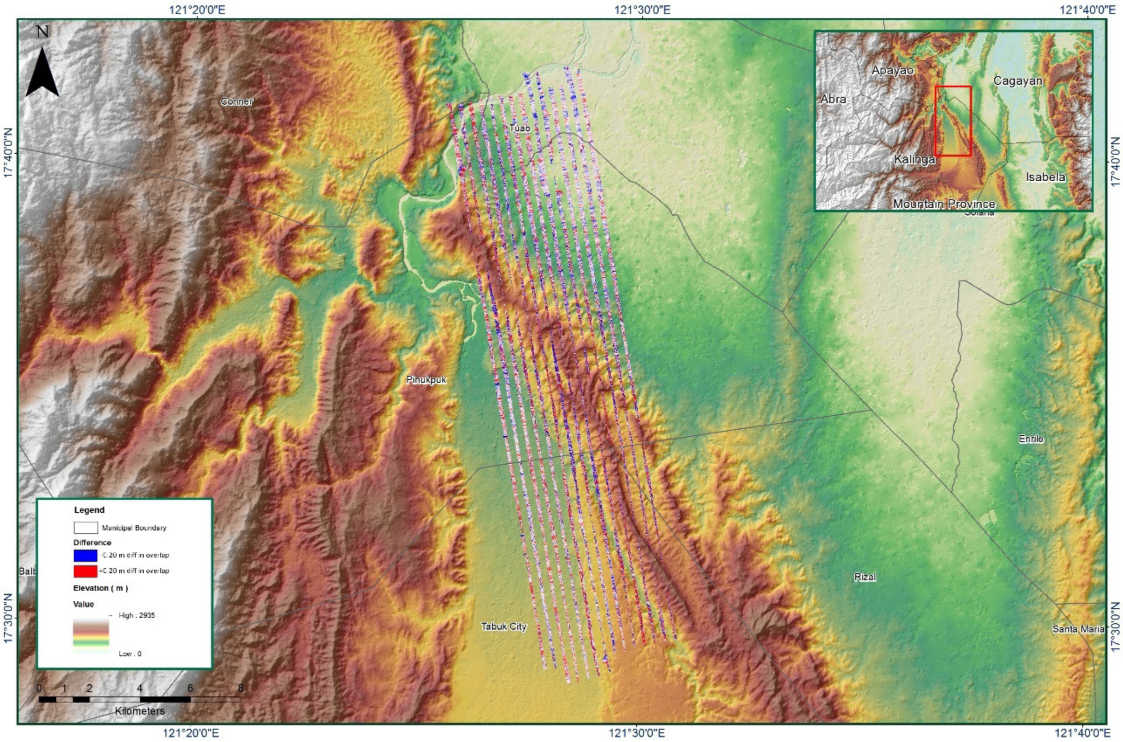


Figure 1.15.7. Elevation difference between flight lines

Flight Area	Cagayan_Reflights
Mission Name	**Cagayan_Reflights_BLK101A_Additional**
Inclusive Flights	3977G
Range data size	29.4 GB
POS data size	255 MB
Base data size	12.1 MB
Image	n/a
Transfer date	June 21,2016
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	Yes
Baseline Length (<30km)	Yes
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.4
RMSE for East Position (<4.0 cm)	1.5
RMSE for Down Position (<8.0 cm)	4.5
Boresight correction stdev (<0.001deg)	0.001176
IMU attitude correction stdev (<0.001deg)	0.009819
GPS position stdev (<0.01m)	0.0232
Minimum % overlap (>25)	n/a
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	39
Maximum Height	342.75 m
Minimum Height	87.33 m
Classification (# of points)	
Ground	8,210,271
Low vegetation	10,144,174
Medium vegetation	14,283,799
High vegetation	2,487,630
Building	34,424
Orthophoto	No
Processed by	Engr. James Kevin Dimaculangan, Engr. Jovelle Canlas, Engr. Czarina Añonuevo

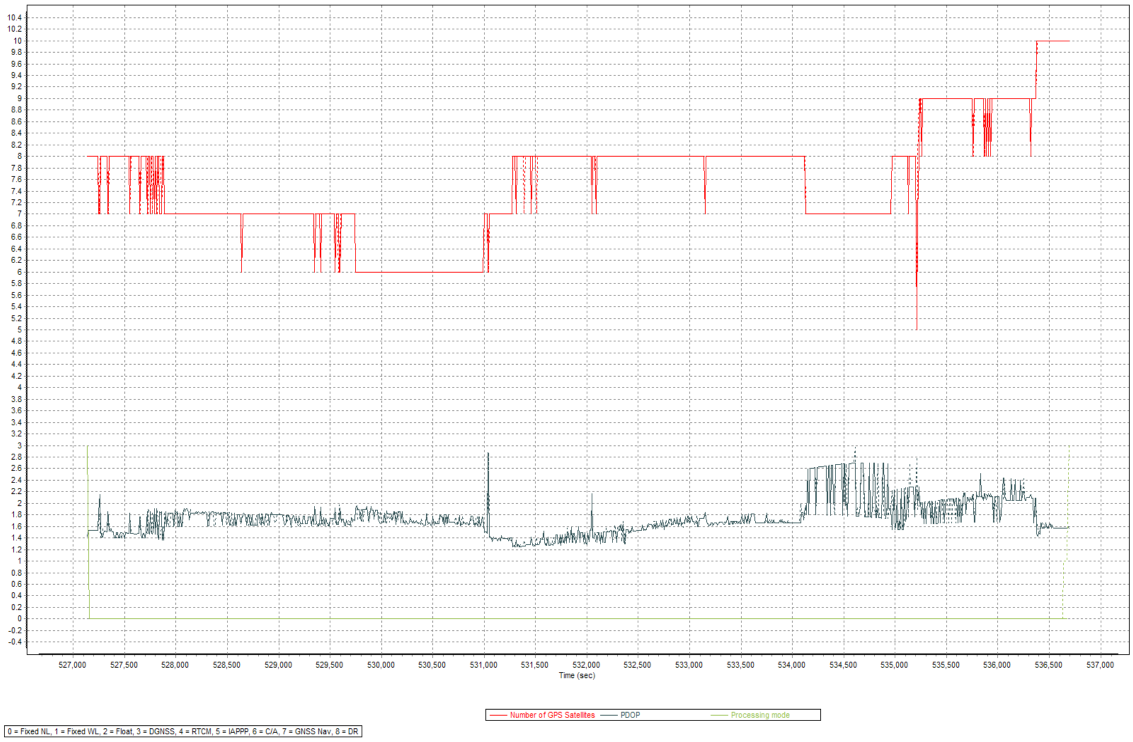


Figure 1.16.1. Solution Status

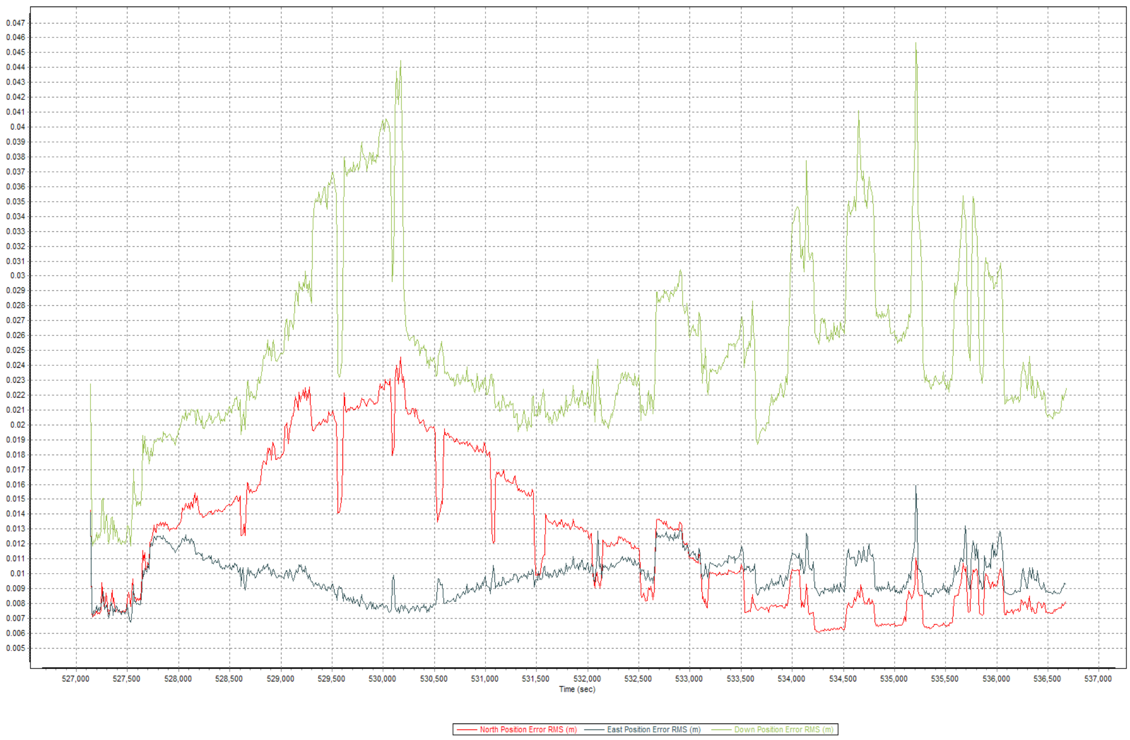


Figure 1.16.2. Smoothed Performance Metric Parameters

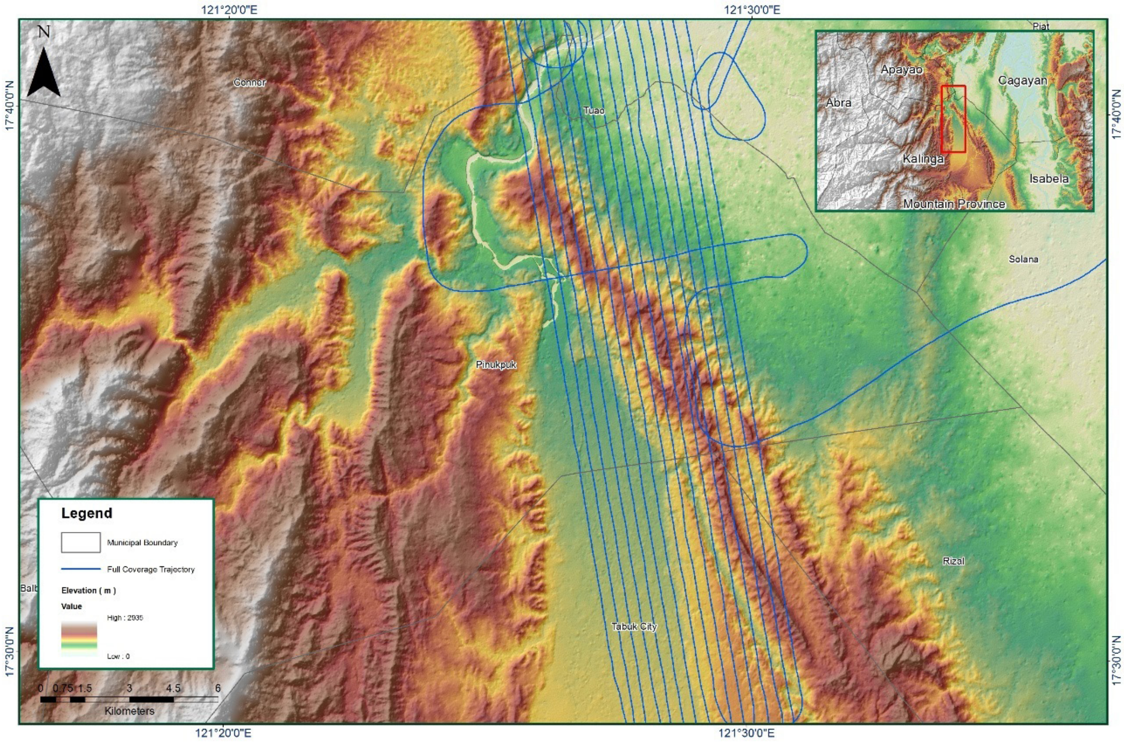


Figure 1.16.3. Best Estimated Trajectory

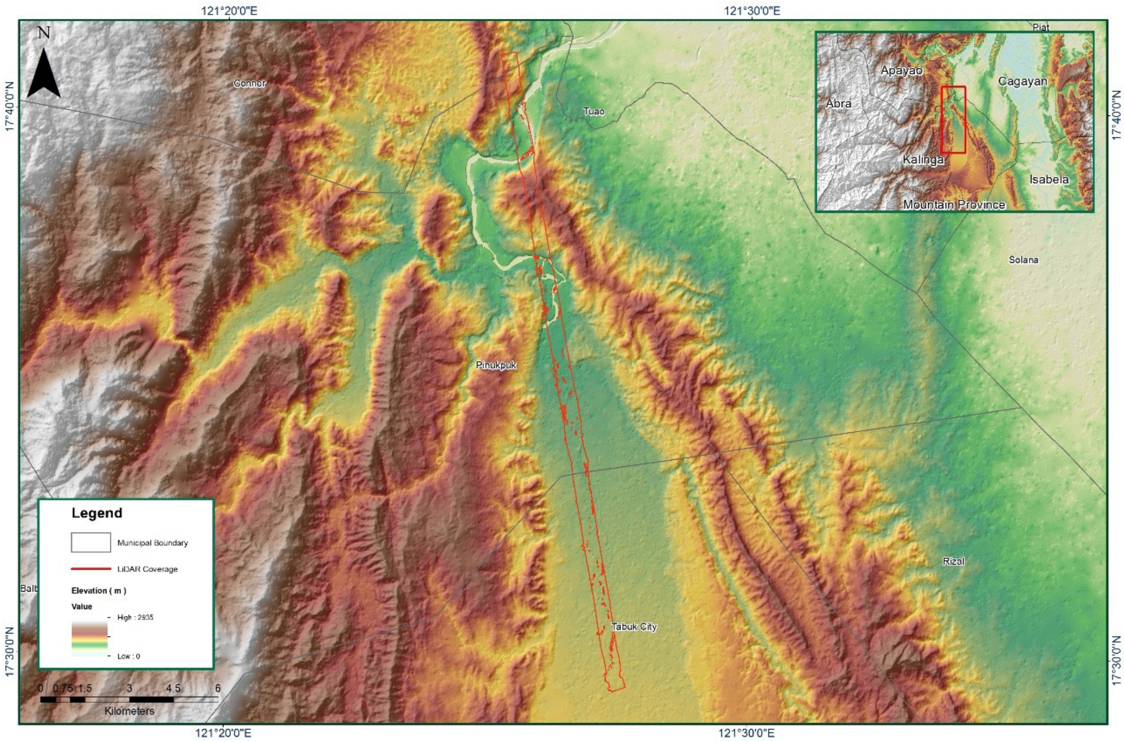


Figure 1.16.4. Coverage of LiDAR Data

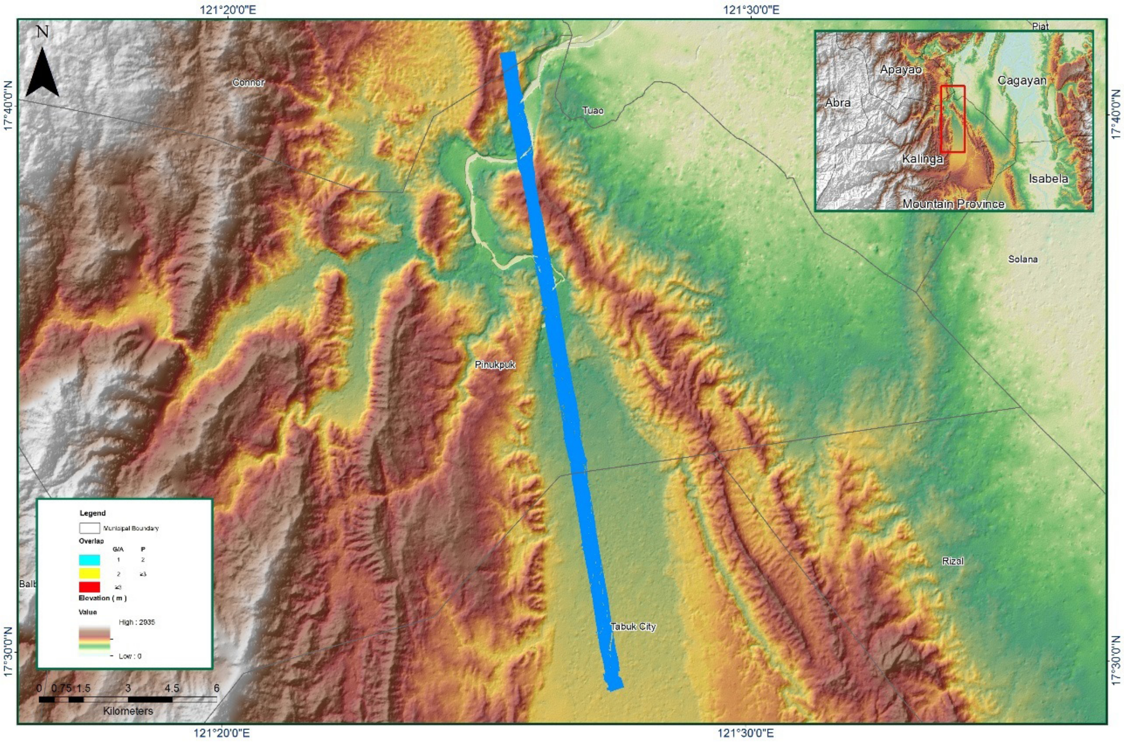


Figure 1.16.5. Image of data overlap

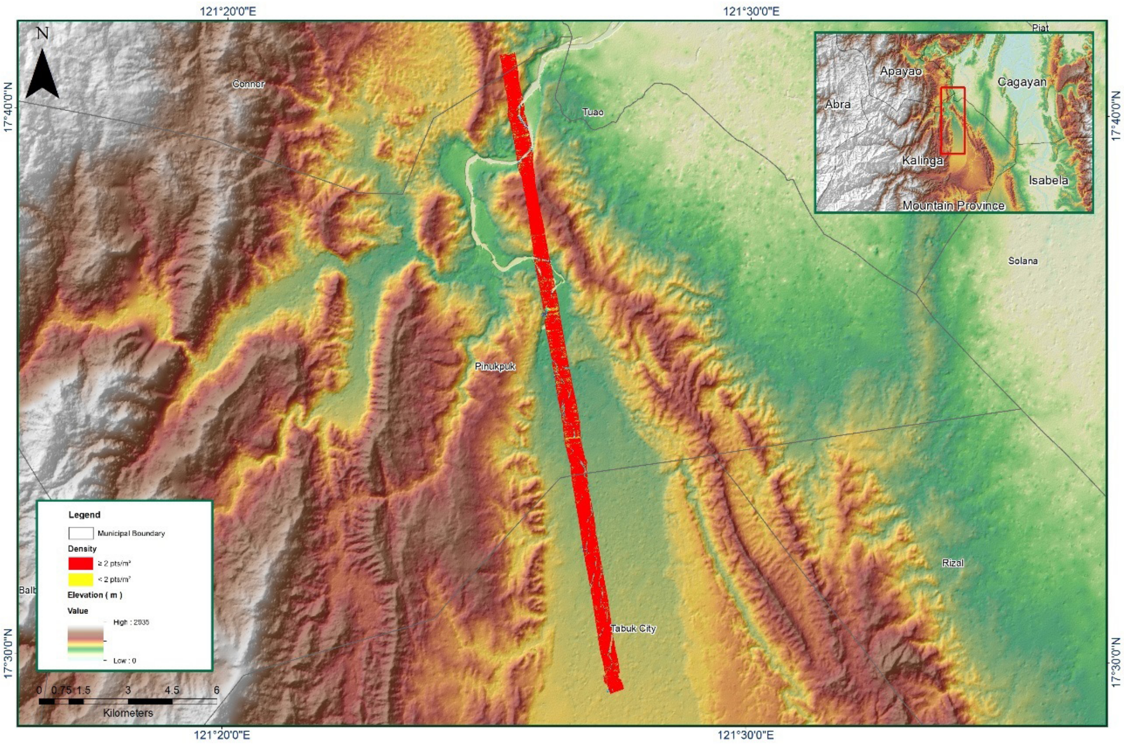


Figure 1.16.6. Density map of merged LiDAR data

Flight Area	**Cagayan**
Mission Name	**Cagayan_reflights_Blk51E**
Inclusive Flights	3973G, 3977G
Range data size	58 GB
POS data size	529 MB
Base data size	21.34 MB
Image	NA
Transfer date	June 21, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.1
RMSE for East Position (<4.0 cm)	2.8
RMSE for Down Position (<8.0 cm)	4.2
Boresight correction stdev (<0.001deg)	0.000177
IMU attitude correction stdev (<0.001deg)	0.010575
GPS position stdev (<0.01m)	0.0064
Minimum % overlap (>25)	38.36%
Ave point cloud density per sq.m. (>2.0)	4.26
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	206
Maximum Height	404.90 m
Minimum Height	46.91 m
Classification (# of points)	
Ground	97,747,568
Low vegetation	176,626,669
Medium vegetation	239,499,903
High vegetation	95,108,046
Building	2,384,939
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Engr. Ma. Joanne Balaga, JovyNarisma

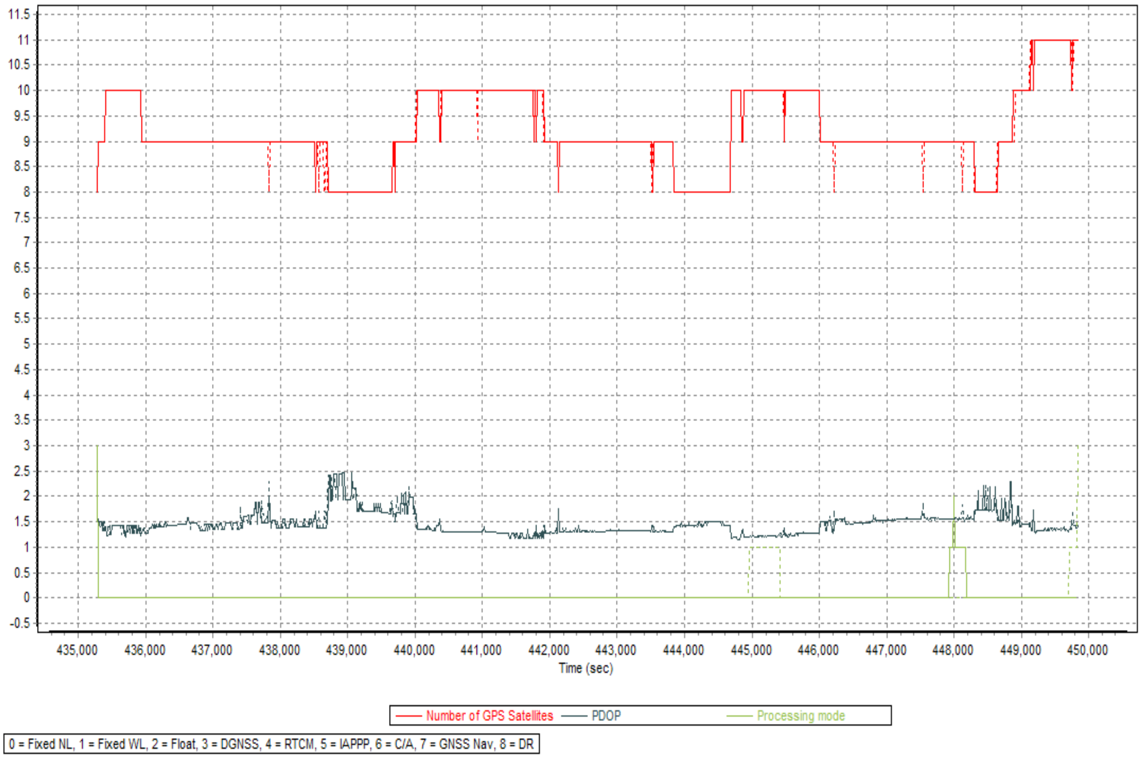


Figure 1.17.1. Solution Status

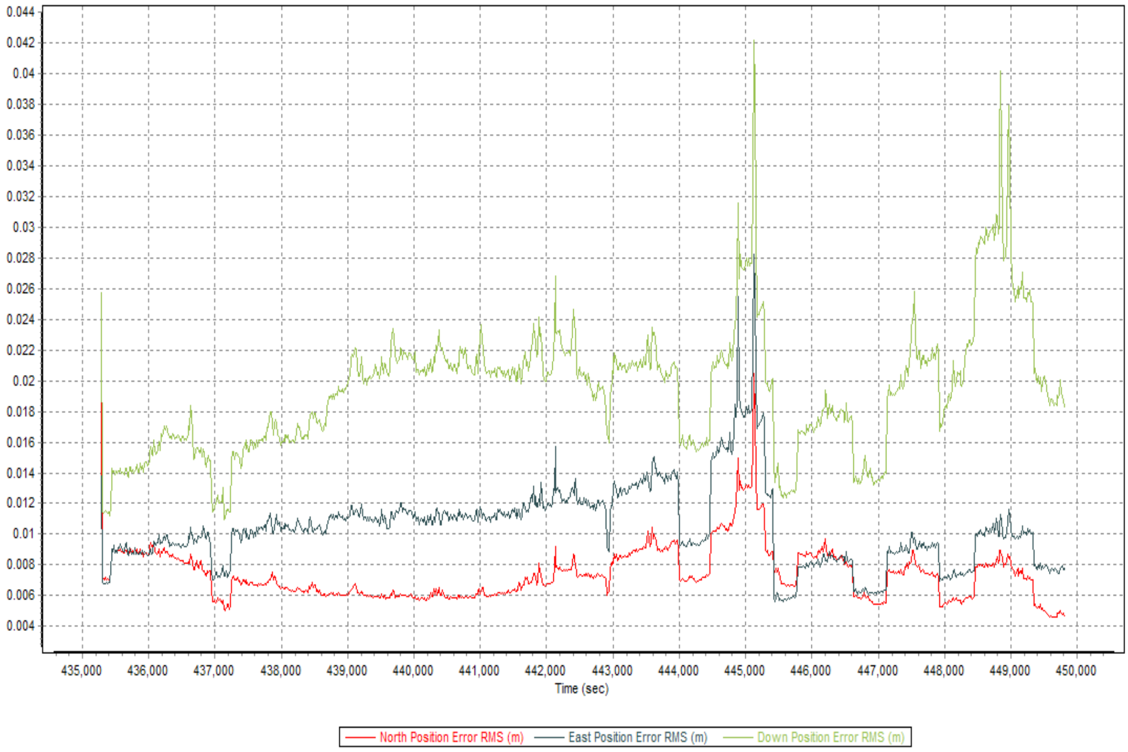


Figure 1.17.2. Smoothed Performance Metric Parameters

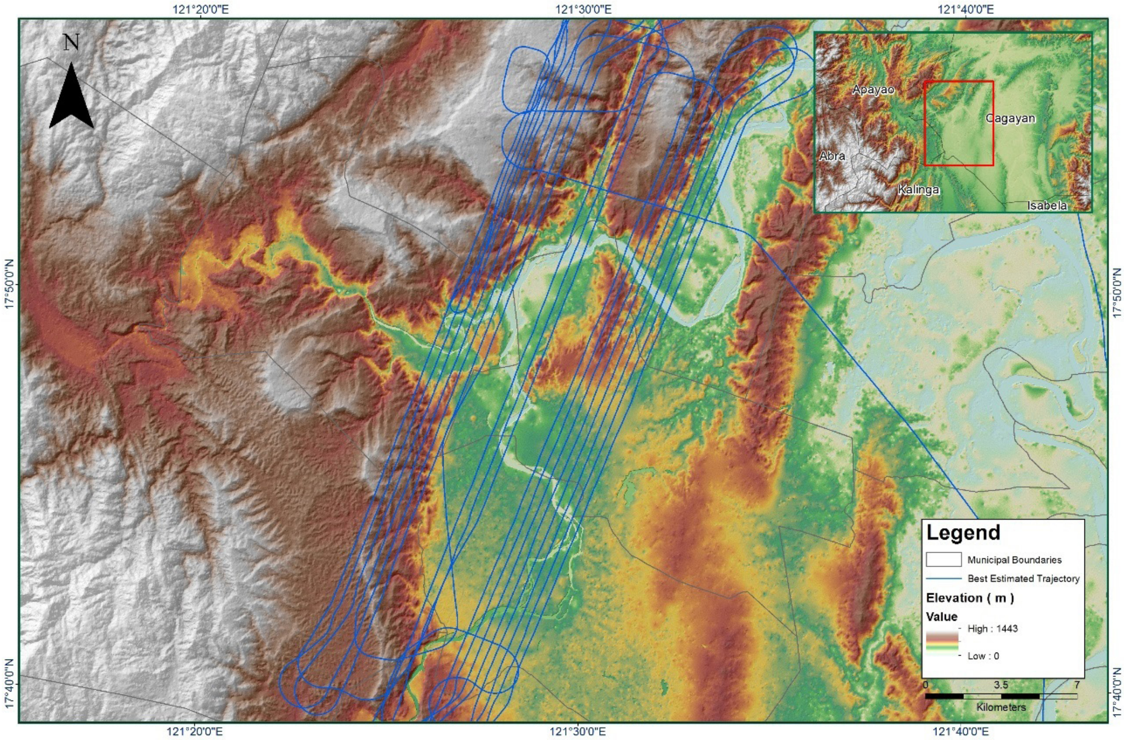


Figure 1.17.3. Best Estimated Trajectory

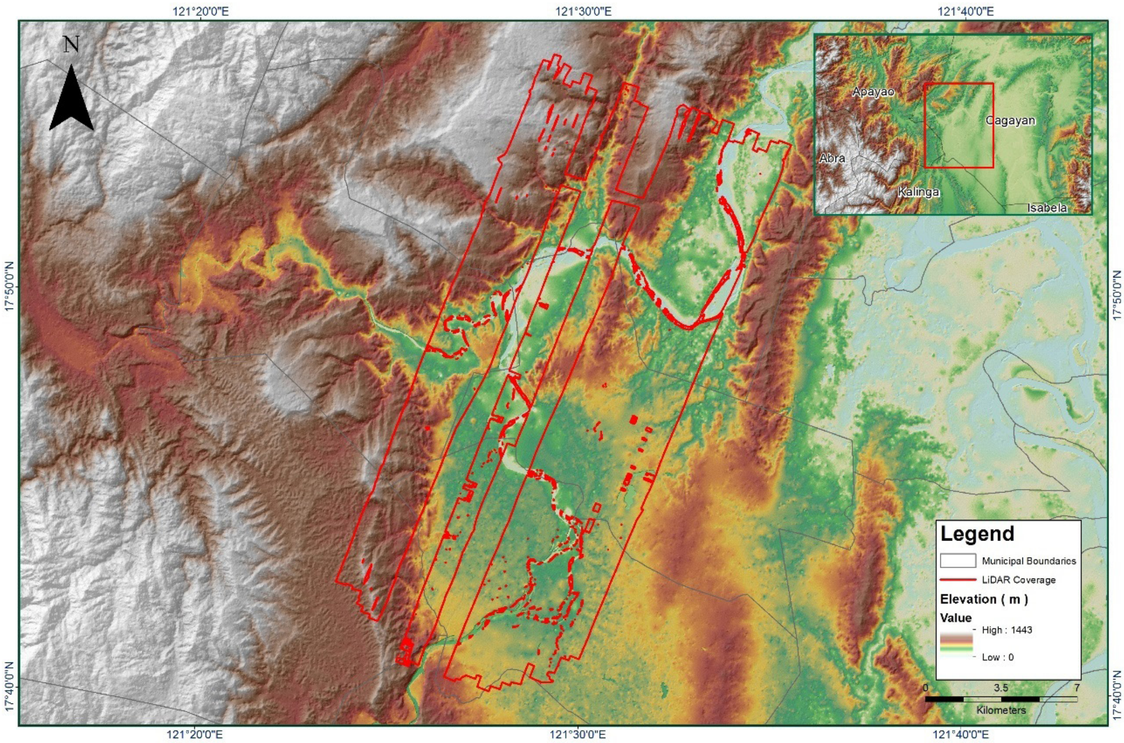


Figure 1.17.4. Coverage of LiDAR Data

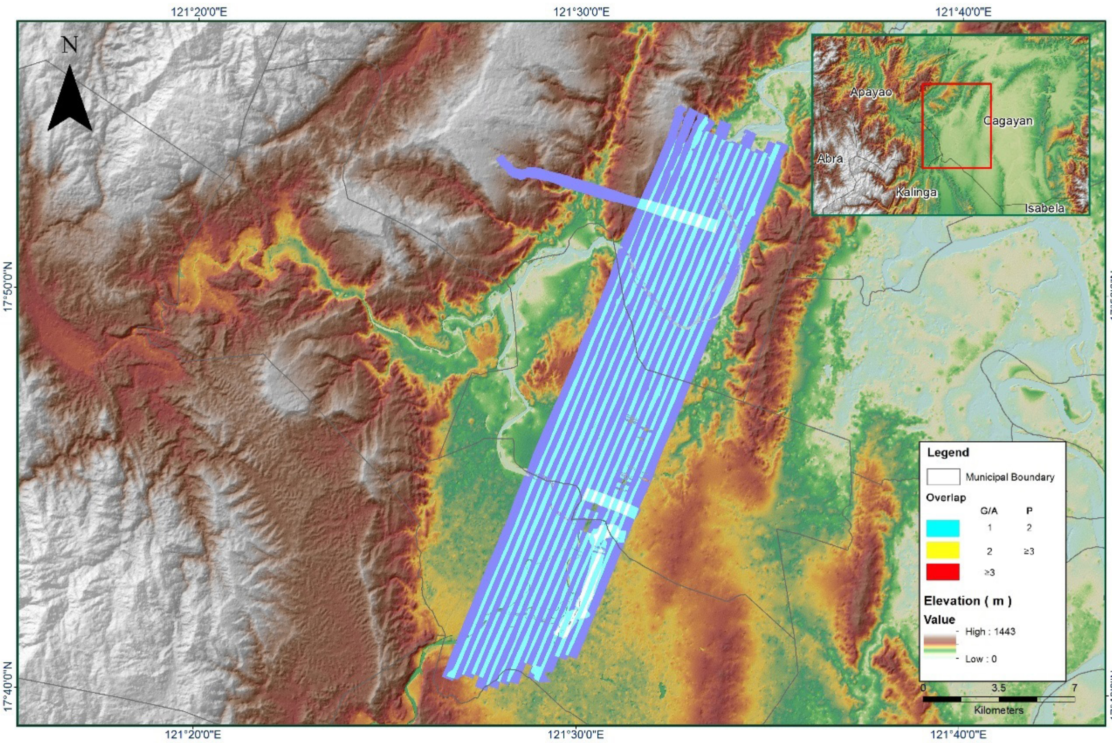


Figure 1.17.5. Image of data overlap

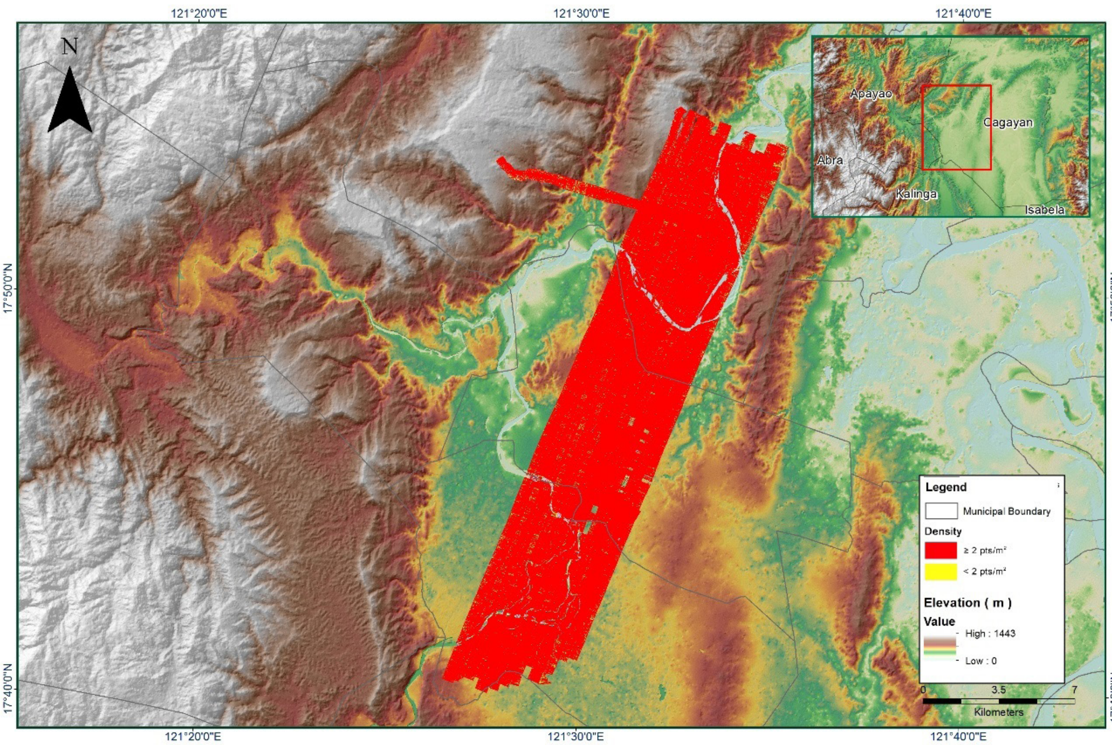


Figure 1.17.6. Density map of merged LiDAR data

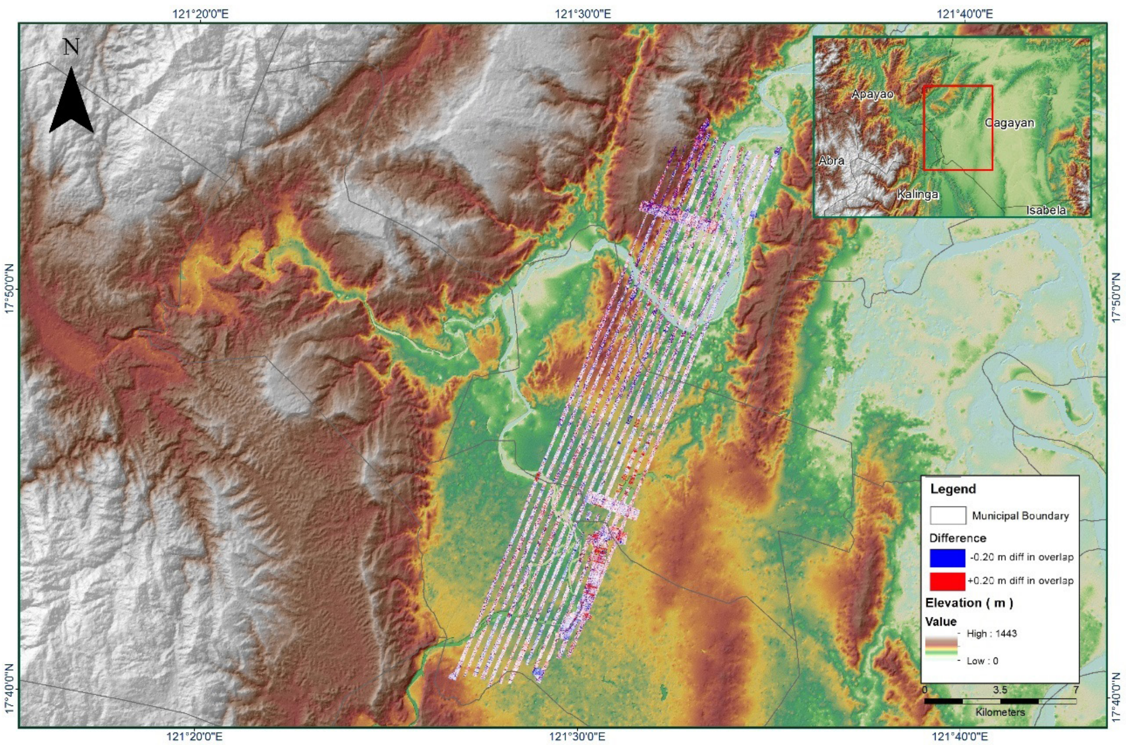


Figure 1.17.7. Elevation difference between flight lines

Flight Area	Cagayan
Mission Name	**Cagayan_reflights_Blk51D_additional**
Inclusive Flights	3965G
Range data size	28.2 GB
POS data size	251 MB
Base data size	9.67 MB
Image	NA
Transfer date	June 21, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.1
RMSE for East Position (<4.0 cm)	1.1
RMSE for Down Position (<8.0 cm)	3.6
Boresight correction stdev (<0.001deg)	0.003381
IMU attitude correction stdev (<0.001deg)	0.083392
GPS position stdev (<0.01m)	0.0274
Minimum % overlap (>25)	38.42%
Ave point cloud density per sq.m. (>2.0)	3.67
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	173
Maximum Height	429.19 m
Minimum Height	53.05 m
Classification (# of points)	
Ground	49,232,432
Low vegetation	60,467,946
Medium vegetation	146,565,244
High vegetation	93,756,242
Building	1,030,364
Orthophoto	No
Processed by	Engr. Jennifer Saguran, Engr. Ma. Joanne Balaga, Engr. MonalyneRabino

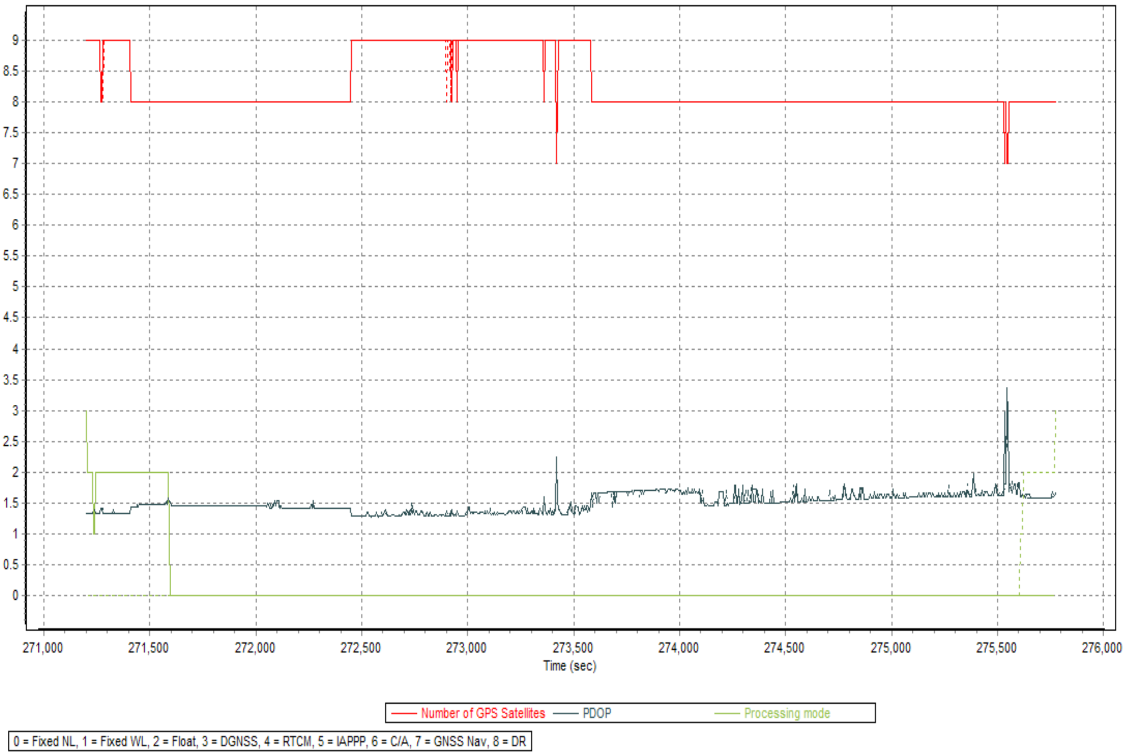


Figure 1.18.1. Solution Status

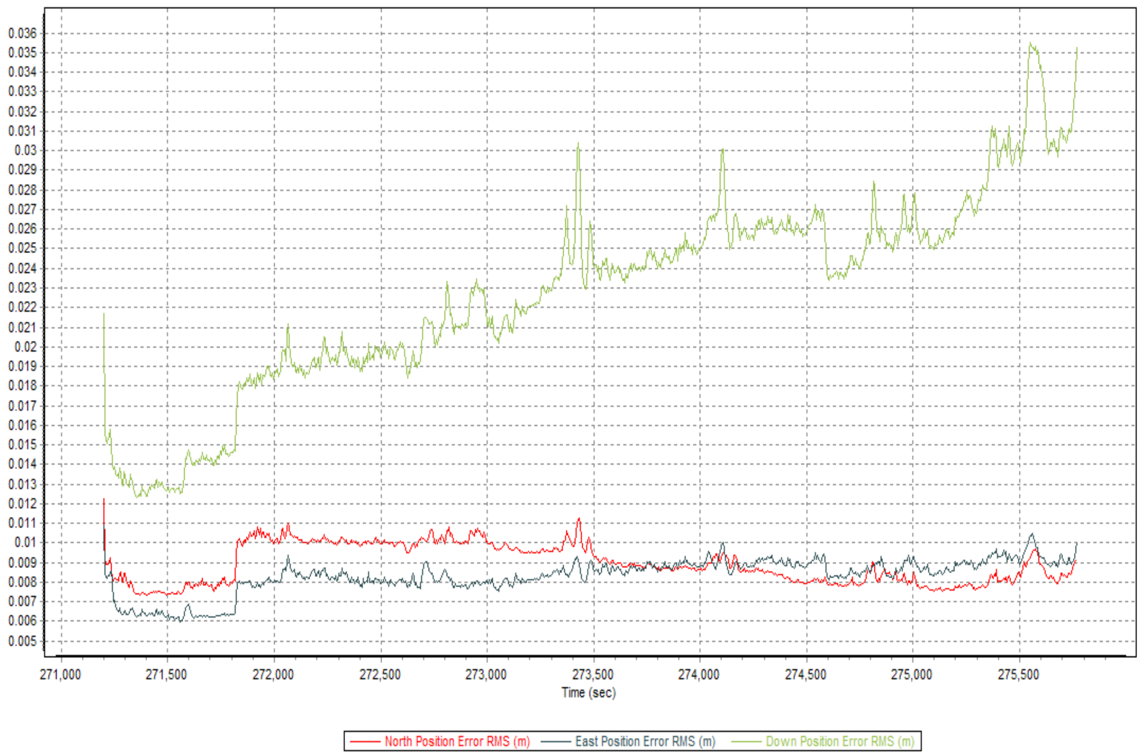


Figure 1.18.2. Smoothed Performance Metric Parameters

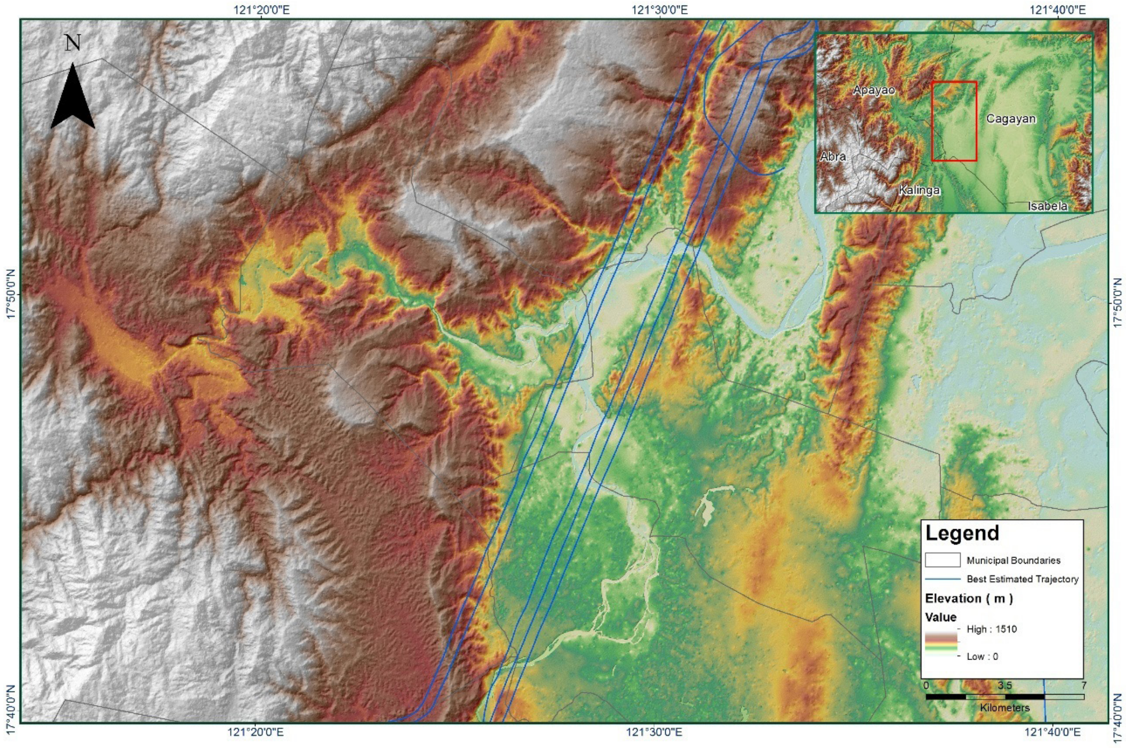


Figure 1.18.3. Best Estimated Trajectory

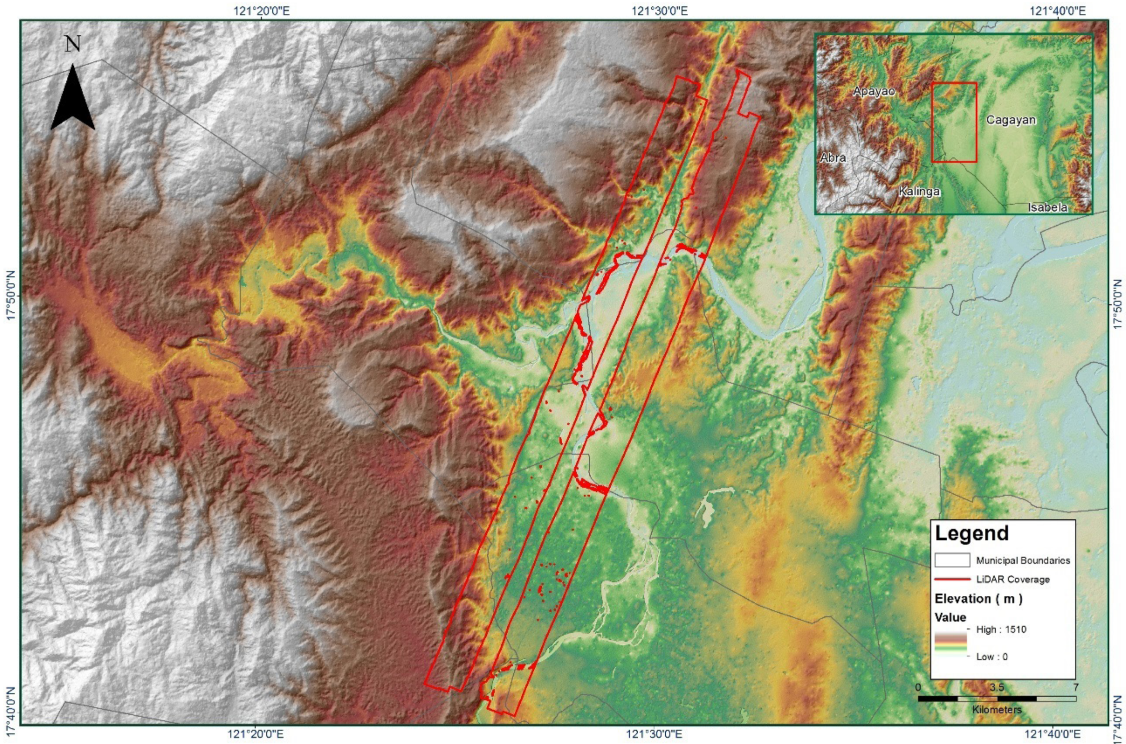


Figure 1.18.4. Coverage of LiDAR Data

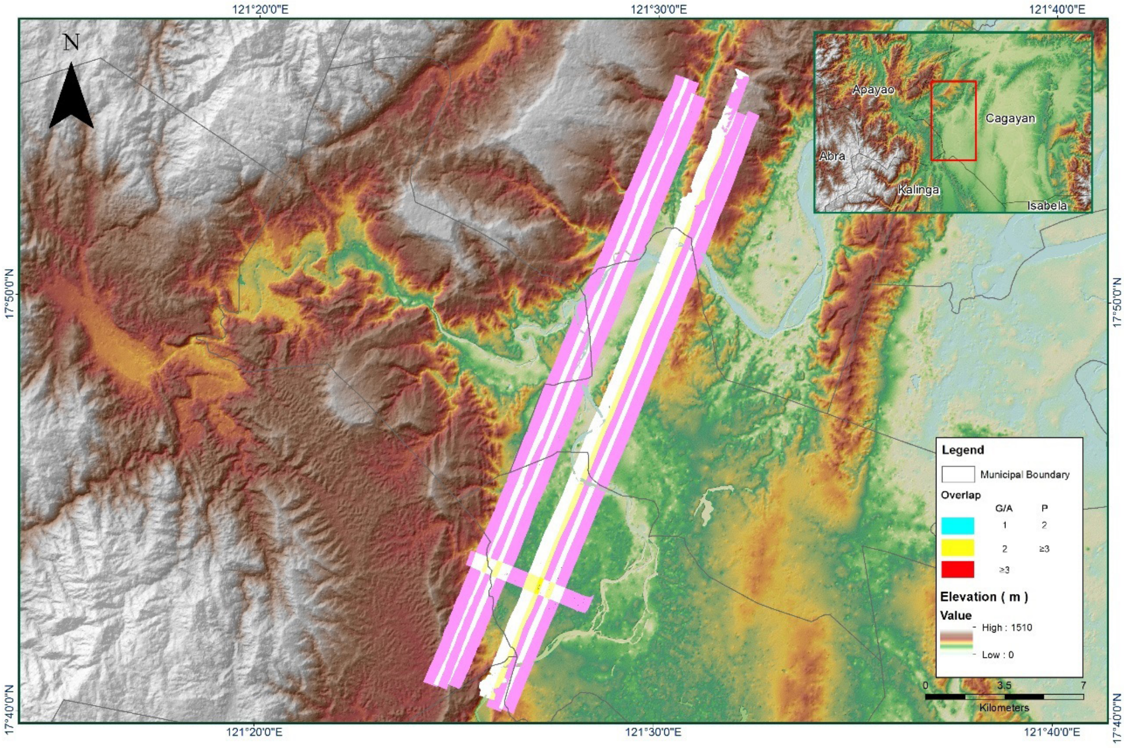


Figure 1.18.5. Image of data overlap

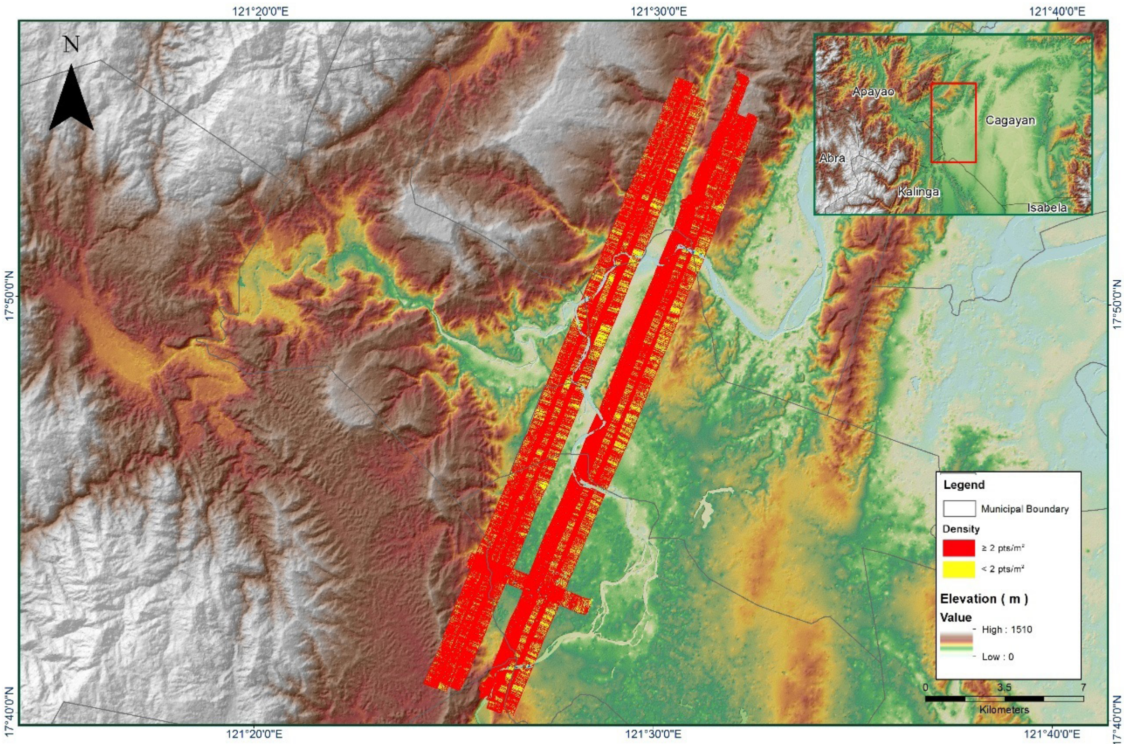


Figure 1.18.6. Density map of merged LiDAR data

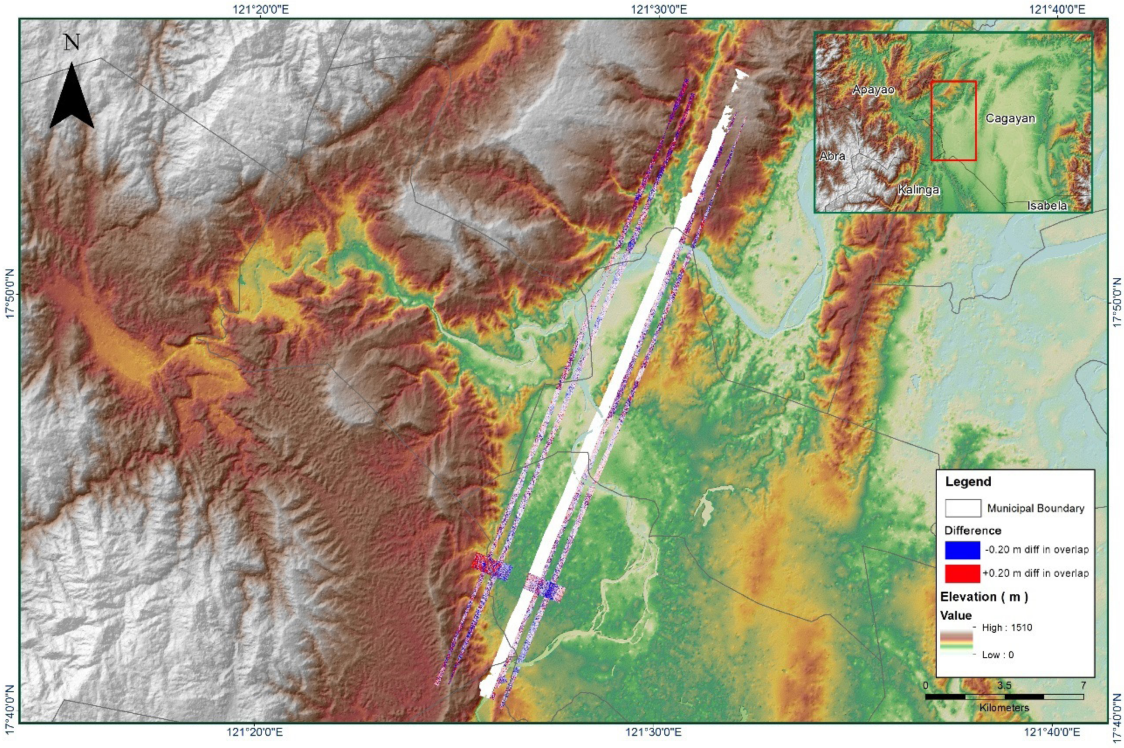


Figure 1.18.7. Elevation difference between flight lines

Flight Area	**Cagayan**
Mission Name	**Cagayan_reflights_Blk51D**
Inclusive Flights	3973G
Range data size	28.6 GB
POS data size	274 MB
Base data size	9.24 MB
Image	NA
Transfer date	June 21, 2016
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.1
RMSE for East Position (<4.0 cm)	2.8
RMSE for Down Position (<8.0 cm)	4.2
Boresight correction stdev (<0.001deg)	0.000177
IMU attitude correction stdev (<0.001deg)	0.010575
GPS position stdev (<0.01m)	0.0064
Minimum % overlap (>25)	25.18%
Ave point cloud density per sq.m. (>2.0)	4.65
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	186
Maximum Height	527.54 m
Minimum Height	53.58 m
Classification (# of points)	
Ground	83,791,847
Low vegetation	74,135,073
Medium vegetation	117,221,443
High vegetation	211,498,690
Building	2,019,356
Orthophoto	No
Processed by	Engr. James Kevin Dimaculangan, Engr. Ma. Joanne Balaga,

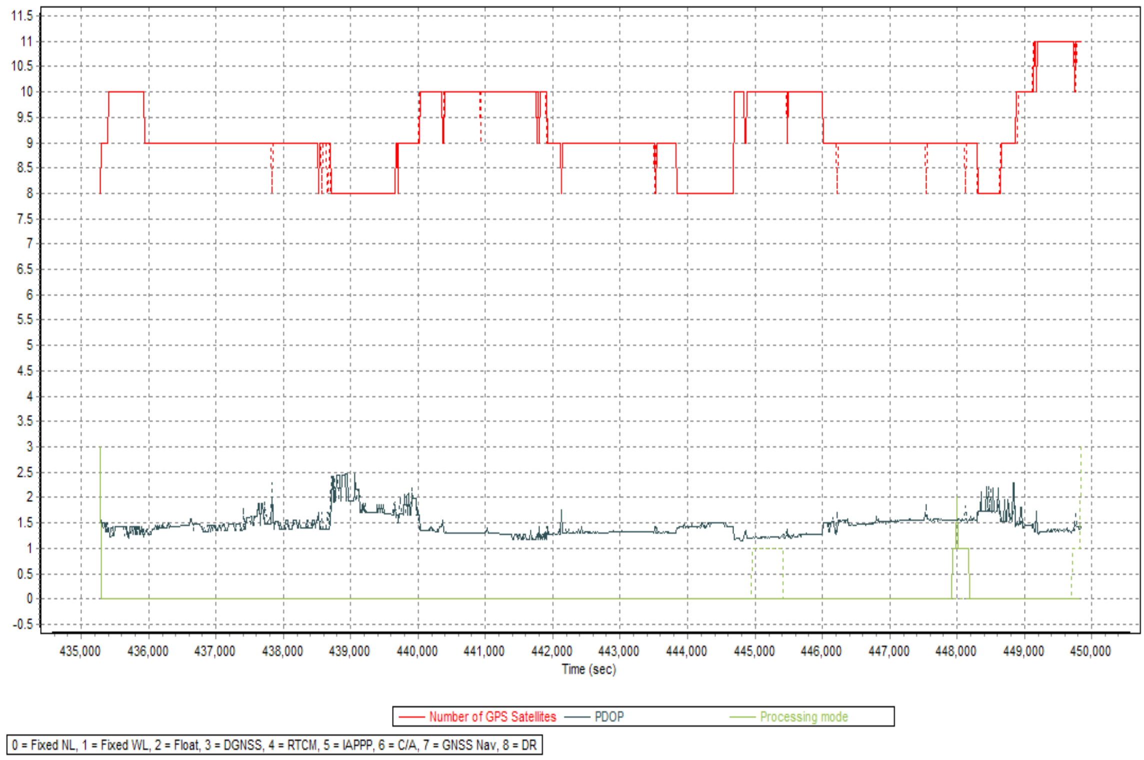


Figure 1.19.1. Solution Status

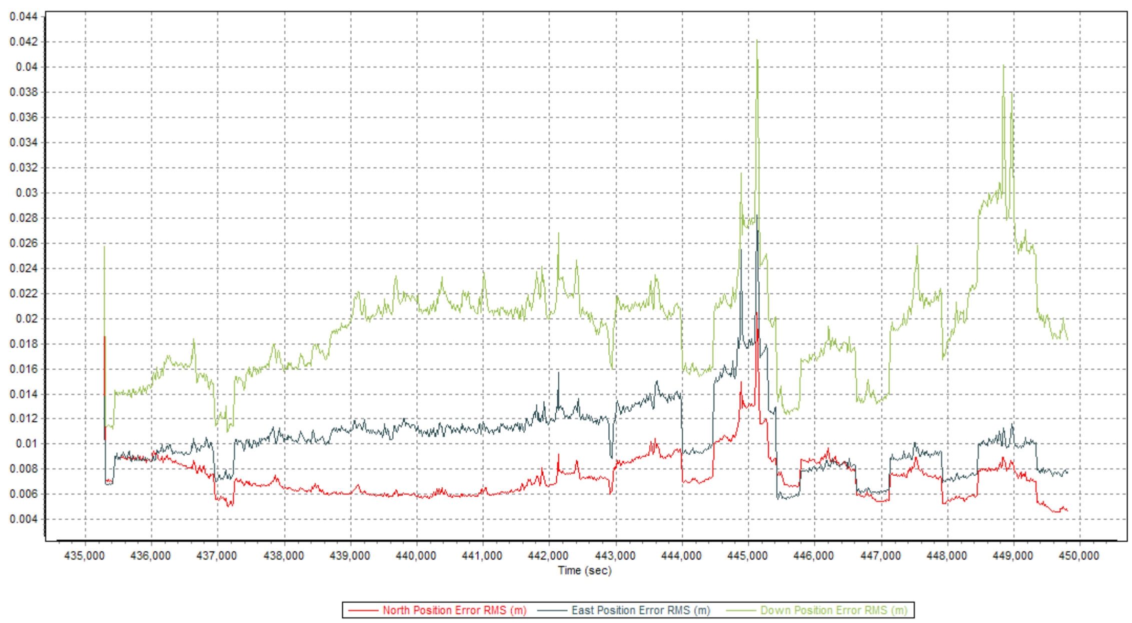


Figure 1.19.2. Smoothed Performance Metric Parameters

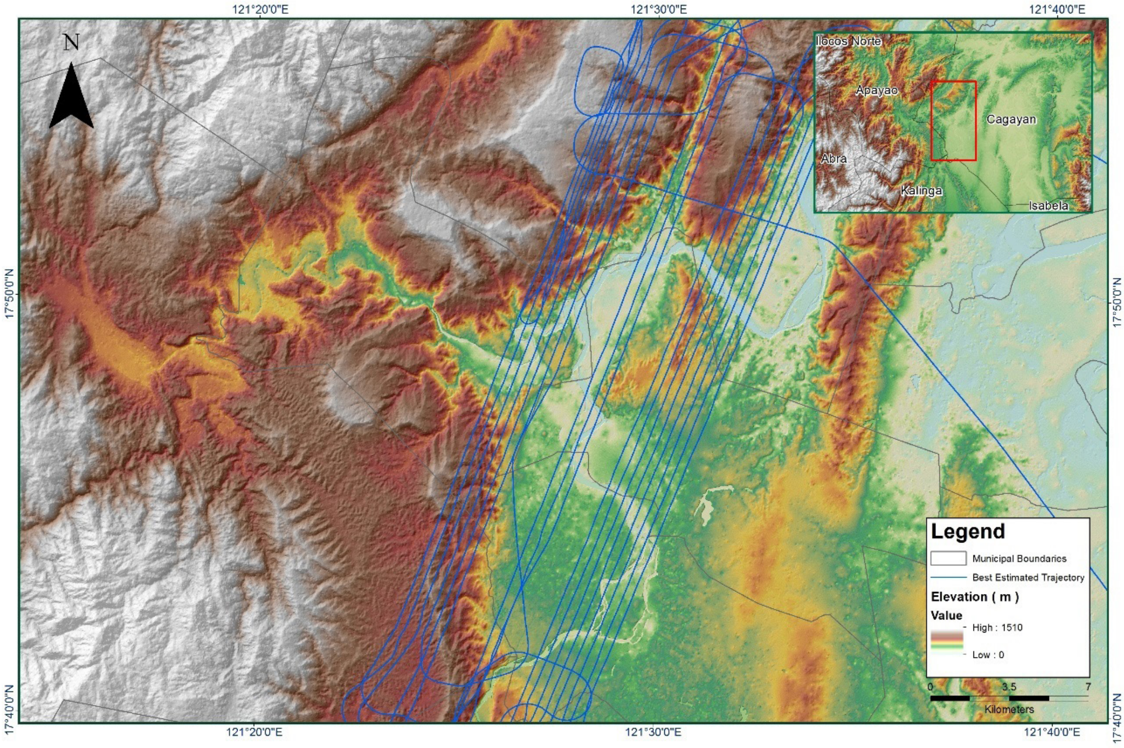


Figure 1.19.3. Best Estimated Trajectory

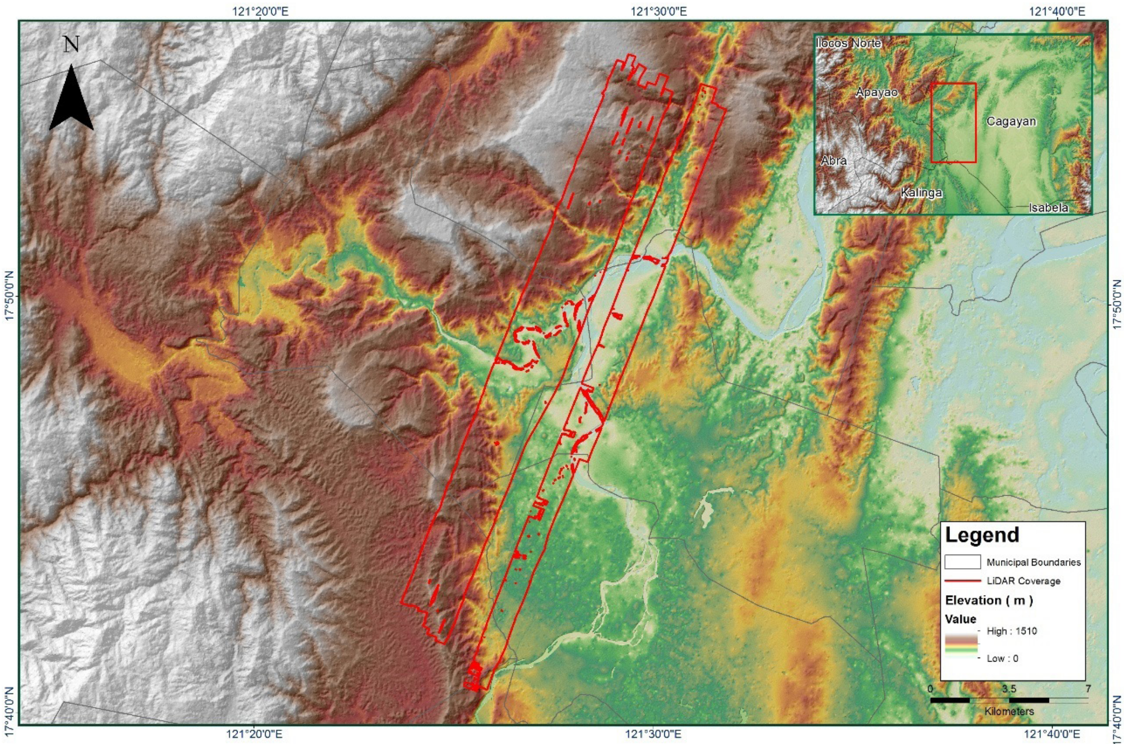


Figure 1.19.4. Coverage of LiDAR Data

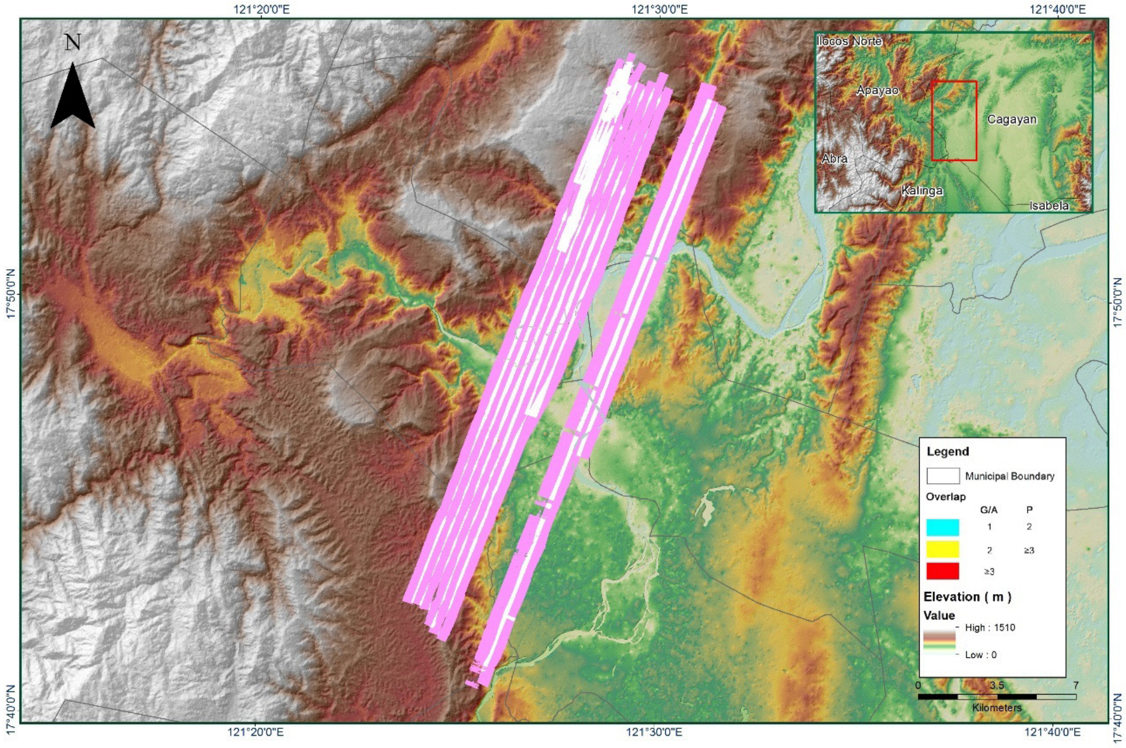


Figure 1.19.5. Image of data overlap

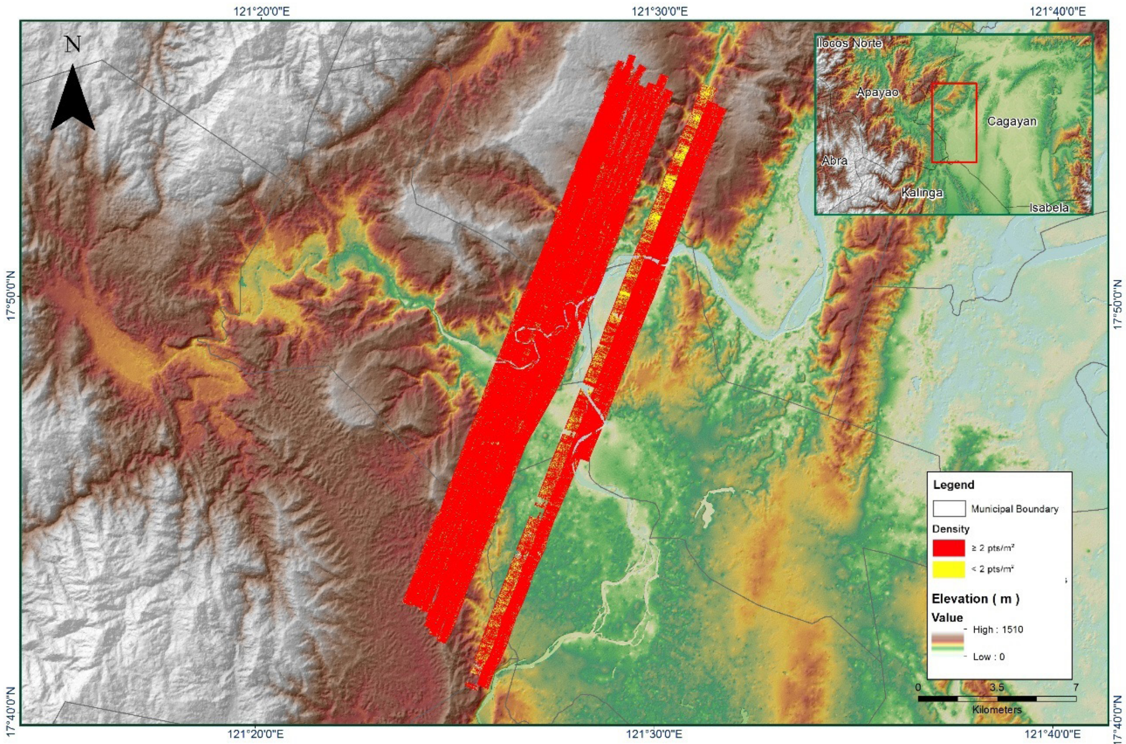


Figure 1.19.6. Density map of merged LiDAR data

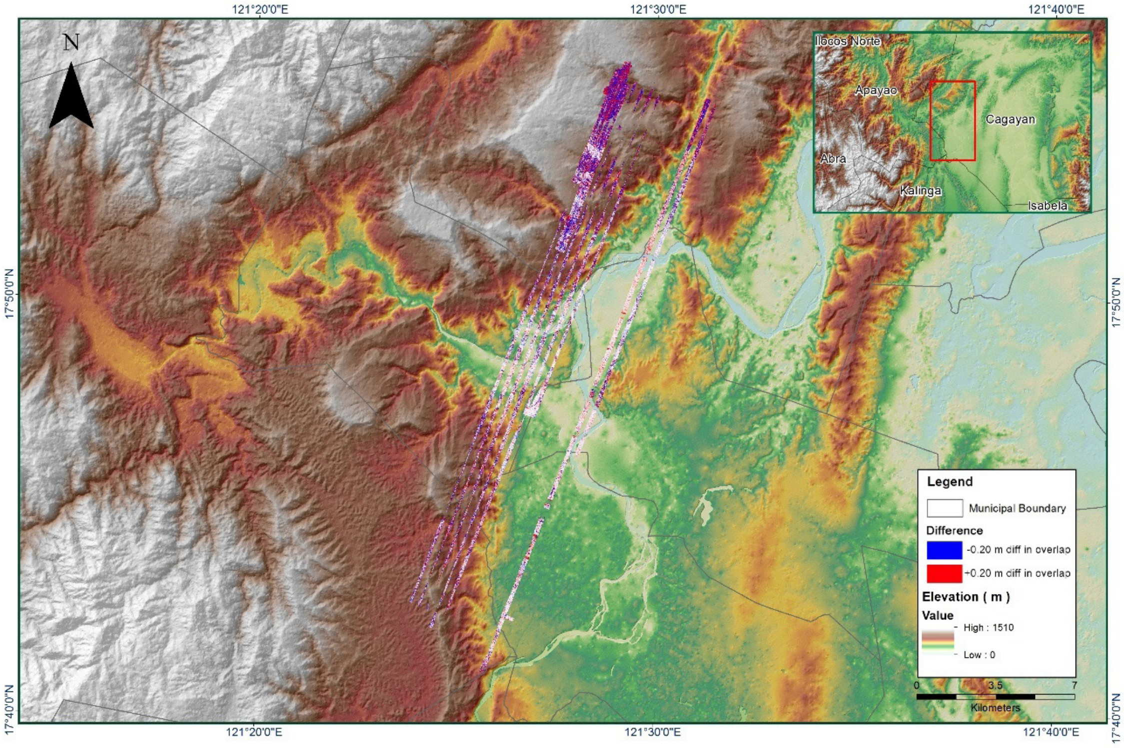


Figure 1.19.7. Elevation difference between flight lines

Annex 8. Mission Summary Reports

Annex 9. Abulog-Apayao Model Basin Parameters

Table A-8.1. Abulog-Apayao Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W2580	35.84	81.966	0	5.2152	10.681	Discharge	2.7402	0.4	Ratio to Peak	0.4
W2590	31.222	87.054	0	5.2152	10.681	Discharge	0.85416	0.4	Ratio to Peak	0.4
W2600	29.517	89.096	0	5.2152	10.681	Discharge	0.80970	0.4	Ratio to Peak	0.4
W2610	28.572	90.27	0	8.476	17.291	Discharge	0.99495	0.4	Ratio to Peak	0.4

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W2620	29.9241937	88.6	0	3.75128	7.6526	Discharge	0.0864224	0.4	Ratio to Peak	0.4
W2630	15.817	99	0	0.641072	1.3078	Discharge	0.0326085	0.4	Ratio to Peak	0.4
W2640	33.481	84.489	0	22.9048	46.725	Discharge	0.58630	0.4	Ratio to Peak	0.4
W2650	28.528	90.324	0	5.2152	10.681	Discharge	1.6921	0.4	Ratio to Peak	0.4
W2660	35.891	81.913	0	5.2152	10.681	Discharge	0.72165	0.4	Ratio to Peak	0.4
W2670	22.961	97.927	0	5.2152	10.681	Discharge	0.74201	0.4	Ratio to Peak	0.4
W2680	32.157	85.974	0	5.2152	10.681	Discharge	0.50066	0.4	Ratio to Peak	0.4
W2690	32.135	85.99851	0	12.3464	25.187	Discharge	0.85041	0.4	Ratio to Peak	0.4
W2700	28.787	90	0	5.2152	10.681	Discharge	0.25753	0.4	Ratio to Peak	0.4
W2710	30.756	87.603	0	5.2152	10.681	Discharge	0.43201	0.4	Ratio to Peak	0.4
W2720	31.669	86.535	0	5.2152	10.681	Discharge	0.17529	0.4	Ratio to Peak	0.4
W2730	28.787	90	0	5.2152	10.681	Discharge	0.83339	0.4	Ratio to Peak	0.4
W2740	29.325	89.331	0	13.2544	27.04	Discharge	0.89336	0.4	Ratio to Peak	0.4
W2750	38.048	79.738	0	5.2152	10.681	Discharge	0.0750191	0.4	Ratio to Peak	0.4
W2760	31.237	87.037	0	6.55504	13.372	Discharge	1.1189	0.4	Ratio to Peak	0.4
W2770	6.5887	99	0	5.2152	10.681	Discharge	0.38429	0.4	Ratio to Peak	0.4
W2780	33.889	84.042	0	5.2152	10.681	Discharge	0.62389	0.4	Ratio to Peak	0.4
W2790	5.1553	99	0	2.01	4.1005	Discharge	0.56922	0.4	Ratio to Peak	0.4
W2800	28.9928559	89.743	0	5.2152	10.681	Discharge	0.42337	0.4	Ratio to Peak	0.4
W2810	34.931	82.921	0	5.2152	10.681	Discharge	0.24613	0.4	Ratio to Peak	0.4
W2820	9.0268	99	0	4.20528	8.5787	Discharge	1.6032	0.4	Ratio to Peak	0.4
W2830	32.013	86.139	0	5.2152	10.681	Discharge	0.50509	0.4	Ratio to Peak	0.4
W2840	32.429	85.665	0	5.2152	10.681	Discharge	0.72941	0.4	Ratio to Peak	0.4
W2850	39.549	78.292	0	5.2152	10.681	Discharge	1.3422	0.4	Ratio to Peak	0.4
W2860	11.631	99	0	7.75512	15.82	Discharge	1.7431	0.4	Ratio to Peak	0.4

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W2870	37.23	80.55	0	5.2152	10.681	Discharge	1.4540	0.4	Ratio to Peak	0.4
W2880	29.009	89.723	0	5.2152	10.681	Discharge	1.3231	0.4	Ratio to Peak	0.4
W2890	34.795	83.065	0	5.2152	10.681	Discharge	0.23011	0.4	Ratio to Peak	0.4
W2900	33.876	84.05541	0	5.2152	10.681	Discharge	1.6382	0.4	Ratio to Peak	0.4
W2910	21.421	99	0	5.2152	10.681	Discharge	0.0115354	0.4	Ratio to Peak	0.4
W2920	8.9649	99	0	5.2152	10.681	Discharge	0.53773	0.4	Ratio to Peak	0.4
W2930	4.9577	99	0	11.3448	23.144	Discharge	0.49130	0.4	Ratio to Peak	0.4
W2940	35.766	82.044	0	5.2152	10.681	Discharge	0.73749	0.4	Ratio to Peak	0.4
W2950	5.7457	99	0	6.81744	13.908	Discharge	2.1666	0.4	Ratio to Peak	0.4
W2960	7.8431	99	0	5.2152	10.681	Discharge	0.28298	0.4	Ratio to Peak	0.4
W2970	13.429	99	0	5.2152	10.681	Discharge	1.3725	0.4	Ratio to Peak	0.4
W2980	42.675	75.441	0	5.2152	10.681	Discharge	0.37335	0.4	Ratio to Peak	0.4
W2990	34.18	83.726	0	5.2152	10.681	Discharge	0.13355	0.4	Ratio to Peak	0.4
W3000	33.822	84.115	0	5.2152	10.681	Discharge	1.5127	0.4	Ratio to Peak	0.4
W3010	3.9885	99	0	0.458024	0.93438	Discharge	0.0198294	0.4	Ratio to Peak	0.4
W3020	4.8262	99	0	3.2452	6.6202	Discharge	0.39850	0.4	Ratio to Peak	0.4
W3030	14.925	99	0	5.2152	10.681	Discharge	0.54928	0.4	Ratio to Peak	0.4
W3040	6.1416	99	0	5.2152	10.681	Discharge	0.27132	0.4	Ratio to Peak	0.4
W3050	44.493	73.877	0	5.2152	10.681	Discharge	1.2169	0.4	Ratio to Peak	0.4
W3060	13.682	99	0	5.2152	10.681	Discharge	0.40083	0.4	Ratio to Peak	0.4
W3070	42.414	75.671	0	5.2152	10.681	Discharge	0.31507	0.4	Ratio to Peak	0.4
W3080	45.139	73.336	0	24.528	50.037	Discharge	0.54873	0.4	Ratio to Peak	0.4
W3090	28.787	90	0	5.2152	10.681	Discharge	0.57864	0.4	Ratio to Peak	0.4
W3100	6.0878	99	0	5.2152	10.681	Discharge	2.1682	0.4	Ratio to Peak	0.4
W3110	16.661	99	0	15.3592	31.333	Discharge	1.3534	0.4	Ratio to Peak	0.4

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W3120	5.5616	99	0	14.976	30.551	Discharge	0.79854	0.4	Ratio to Peak	0.4
W3130	14.3517047	99	0	4.11264	8.3899	Discharge	0.28046	0.4	Ratio to Peak	0.4
W3140	28.787	90	0	5.2152	10.681	Discharge	0.46528	0.4	Ratio to Peak	0.4
W3150	28.787	90	0	7.3496	14.993	Discharge	0.13777	0.4	Ratio to Peak	0.4
W3160	45.944	72.674	0	6.9436	14.165	Discharge	0.32642	0.4	Ratio to Peak	0.4
W3170	32.7748194	85.274	0	4.45136	9.0807	Discharge	0.67606	0.4	Ratio to Peak	0.4
W3180	28.787	90	0	5.2152	10.681	Discharge	1.1056	0.4	Ratio to Peak	0.4
W3190	28.787	90	0	15.228	31.065	Discharge	0.86698	0.4	Ratio to Peak	0.4
W3200	17.338	99	0	5.2152	10.681	Discharge	0.50161	0.4	Ratio to Peak	0.4
W3210	16.109	99	0	7.33216	14.958	Discharge	0.31994	0.4	Ratio to Peak	0.4
W3220	31.944	86.218	0	5.2152	10.681	Discharge	1.8298	0.4	Ratio to Peak	0.4
W3230	30.817	87.531	0	5.2152	10.681	Discharge	0.32871	0.4	Ratio to Peak	0.4
W3240	30.629	87.754	0	5.2152	10.681	Discharge	1.5549	0.4	Ratio to Peak	0.4
W3250	30.9	87.433	0	9.0344	18.431	Discharge	1.2830	0.4	Ratio to Peak	0.4
W3260	34.946	82.905	0	9.4	19.176	Discharge	1.1569	0.4	Ratio to Peak	0.4
W3270	40.32	77.569	0	19.0328	38.826	Discharge	0.51510	0.4	Ratio to Peak	0.4
W3280	4.1559	99	0	5.2152	10.681	Discharge	.000458618	0.4	Ratio to Peak	0.4
W3290	35.372	82.455	0	7.6208	15.546	Discharge	0.44143	0.4	Ratio to Peak	0.4
W3300	24.281	96.011	0	5.2152	10.681	Discharge	0.0042597	0.4	Ratio to Peak	0.4
W3310	43.619	74.621	0	5.2152	10.681	Discharge	0.43802	0.4	Ratio to Peak	0.4
W3320	40.068	77.804	0	5.2152	10.681	Discharge	0.14621	0.4	Ratio to Peak	0.4
W3330	46.311	72.376	0	5.2152	10.681	Discharge	0.55218	0.4	Ratio to Peak	0.4
W3340	31.66	86.545	0	5.2152	10.681	Discharge	0.46937	0.4	Ratio to Peak	0.4
W3350	43.2430457	74.945	0	5.2152	10.681	Discharge	0.42622	0.4	Ratio to Peak	0.4
W3360	8.5893	99	0	5.2152	10.681	Discharge	0.56440	0.4	Ratio to Peak	0.4

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W3370	13.641	99	0	24.8256	50.645	Discharge	0.73690	0.4	Ratio to Peak	0.4
W3380	46.778	72	0	5.2152	10.681	Discharge	0.0297713	0.4	Ratio to Peak	0.4
W3390	30.542	87.857	0	16.0016	32.644	Discharge	0.44303	0.4	Ratio to Peak	0.4
W3400	31.507	86.721801	0	5.2152	10.681	Discharge	2.4648	0.4	Ratio to Peak	0.4
W3410	46.337	72.355	0	7.83288	15.979	Discharge	0.39201	0.4	Ratio to Peak	0.4
W3420	41.116	76.837	0	5.2152	10.681	Discharge	0.14286	0.4	Ratio to Peak	0.4
W3430	31.1	87.197	0	5.2152	10.681	Discharge	1.4738	0.4	Ratio to Peak	0.4
W3440	35.3460716	82.482	0	5.2152	10.681	Discharge	0.61632	0.4	Ratio to Peak	0.4
W3450	38.4937511	79.303	0	5.2152	10.681	Discharge	0.17044	0.4	Ratio to Peak	0.4
W3460	35.336	82.493	0	5.2152	10.681	Discharge	0.67634	0.4	Ratio to Peak	0.4
W3470	37.631	80.15	0	5.2152	10.681	Discharge	0.45657	0.4	Ratio to Peak	0.4
W3480	7.2111	99	0	1.04736	2.1366	Discharge	0.0518861	0.4	Ratio to Peak	0.4
W3490	8.2061	99	0	6.73288	13.735	Discharge	0.79532	0.4	Ratio to Peak	0.4
W3500	35.343	82.485	0	11.8264	24.125	Discharge	0.18672	0.4	Ratio to Peak	0.4
W3510	31.667	86.537041	0	5.2152	10.681	Discharge	1.1977	0.4	Ratio to Peak	0.4
W3520	33.773	84.168	0	43.22	88.169	Discharge	1.1034	0.4	Ratio to Peak	0.4
W3530	30.894	87.439	0	13.584	27.711	Discharge	0.58377	0.4	Ratio to Peak	0.4
W3540	44.284	74.054	0	5.2152	10.681	Discharge	0.71154	0.4	Ratio to Peak	0.4
W3550	30.5	87.907215	0	5.2152	10.681	Discharge	1.1840	0.4	Ratio to Peak	0.4
W3560	40.911577	77.023	0	5.2152	10.681	Discharge	0.15532	0.4	Ratio to Peak	0.4
W3570	20.646	99	0	5.2152	10.681	Discharge	0.84711	0.4	Ratio to Peak	0.4
W3580	7.4815	99	0	11.648	23.762	Discharge	0.41685	0.4	Ratio to Peak	0.4
W3590	32.604	85.466	0	4.51336	9.2072	Discharge	0.69160	0.4	Ratio to Peak	0.4
W3600	46.259	72.418	0	5.2152	10.681	Discharge	0.46742	0.4	Ratio to Peak	0.4
W3610	40.804	77.121578	0	5.2152	10.681	Discharge	0.12493	0.4	Ratio to Peak	0.4

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W3620	45.3	73.203	0	7.54384	15.39	Discharge	0.40577	0.4	Ratio to Peak	0.4
W3630	24.517	95.676	0	5.2152	10.681	Discharge	0.39554	0.4	Ratio to Peak	0.4
W3640	14.807	99	0	2.56048	5.2235	Discharge	0.38910	0.4	Ratio to Peak	0.4
W3650	15.083	99	0	6.18528	12.618	Discharge	1.2724	0.4	Ratio to Peak	0.4
W3660	38.14	79.648	0	5.2152	10.681	Discharge	0.0687306	0.4	Ratio to Peak	0.4
W3670	23.047	97.799	0	5.2152	10.681	Discharge	1.0935	0.4	Ratio to Peak	0.4
W3680	46.341	72.352	0	5.2152	10.681	Discharge	0.91753	0.4	Ratio to Peak	0.4
W3690	37.32	80.459	0	5.2152	10.681	Discharge	0.56325	0.4	Ratio to Peak	0.4
W3700	12.74	99	0	6.42032	13.097	Discharge	0.92156	0.4	Ratio to Peak	0.4
W3710	43.201	74.981	0	5.2152	10.681	Discharge	0.34046	0.4	Ratio to Peak	0.4
W3720	37.584	80.196	0	5.2152	10.681	Discharge	0.0032647	0.4	Ratio to Peak	0.4
W3730	45.6707416	72.898	0	35.9672	73.374	Discharge	1.1038	0.4	Ratio to Peak	0.4
W3740	16.462	99	0	5.2152	10.681	Discharge	0.36324	0.4	Ratio to Peak	0.4
W3750	4.608	99	0	0.732984	1.4953	Discharge	0.0127014	0.4	Ratio to Peak	0.4
W3760	31.999	86.154	0	5.2152	10.681	Discharge	0.41768	0.4	Ratio to Peak	0.4
W3770	17.223	99	0	26.2344	53.518	Discharge	4.3591	0.4	Ratio to Peak	0.4
W3780	11.314	99	0	2.6368	5.3791	Discharge	0.73084	0.4	Ratio to Peak	0.4
W3790	18.116	99	0	25.0848	51.173	Discharge	1.5283	0.4	Ratio to Peak	0.4
W3800	44.523	73.851	0	5.2152	10.681	Discharge	0.58768	0.4	Ratio to Peak	0.4
W3810	45.7	72.874	0	5.2152	10.681	Discharge	0.39624	0.4	Ratio to Peak	0.4
W3820	16.617	99	0	5.2152	10.681	Discharge	0.42156	0.4	Ratio to Peak	0.4
W3830	42.816	75.317	0	5.2152	10.681	Discharge	0.25486	0.4	Ratio to Peak	0.4
W3840	46.778	72	0	5.2152	10.681	Discharge	0.0057366	0.4	Ratio to Peak	0.4
W3850	42.792	75.338	0	5.2152	10.681	Discharge	0.69258	0.4	Ratio to Peak	0.4
W3860	15.8492757	99	0	6.1936	12.635	Discharge	0.47060	0.4	Ratio to Peak	0.4

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W3870	46.77	72.006	0	5.2152	10.681	Discharge	0.58000	0.4	Ratio to Peak	0.4
W3880	14.651	99	0	5.2152	10.681	Discharge	1.4578	0.4	Ratio to Peak	0.4
W3890	45.404	73.117	0	5.2152	10.681	Discharge	0.78205	0.4	Ratio to Peak	0.4
W3900	43.845	74.427	0	5.2152	10.681	Discharge	0.81151	0.4	Ratio to Peak	0.4
W3910	31.274	86.993	0	5.57992	11.383	Discharge	0.0777086	0.4	Ratio to Peak	0.4
W3920	15.852	99	0	5.2152	10.681	Discharge	0.0262734	0.4	Ratio to Peak	0.4
W3930	43.203	74.98	0	10.868	22.171	Discharge	0.25276	0.4	Ratio to Peak	0.4
W3940	39.987	77.88	0	9.6712	19.73	Discharge	0.46307	0.4	Ratio to Peak	0.4
W3950	15.242	99	0	12.2464	24.982	Discharge	2.3223	0.4	Ratio to Peak	0.4
W3960	18.499	99	0	5.2152	10.681	Discharge	0.73505	0.4	Ratio to Peak	0.4
W3970	43.722	74.533	0	5.2152	10.681	Discharge	0.25402	0.4	Ratio to Peak	0.4
W3980	44.2573855	74.076	0	16.8424	34.358	Discharge	0.28069	0.4	Ratio to Peak	0.4
W3990	30.839	87.504	0	5.2152	10.681	Discharge	0.74675	0.4	Ratio to Peak	0.4
W4000	37.738	80.044	0	16.656	33.978	Discharge	0.65048	0.4	Ratio to Peak	0.4
W4010	12.507	99	0	4.91056	10.018	Discharge	0.92736	0.4	Ratio to Peak	0.4
W4020	14.865	99	0	5.8576	11.95	Discharge	1.1012	0.4	Ratio to Peak	0.4
W4030	12.108	99	0	5.2152	10.681	Discharge	0.46451	0.4	Ratio to Peak	0.4
W4040	37.577	80.203	0	18.9568	38.672	Discharge	1.8578	0.4	Ratio to Peak	0.4
W4050	36.219	81.575	0	9.9528	20.303	Discharge	0.88482	0.4	Ratio to Peak	0.4
W4060	29.1166377	89.589	0	14.4088	29.394	Discharge	1.6980	0.4	Ratio to Peak	0.4
W4070	12.641	99	0	5.2152	10.681	Discharge	1.8638	0.4	Ratio to Peak	0.4
W4080	11.244	99	0	5.2152	10.681	Discharge	0.0842148	0.4	Ratio to Peak	0.4
W4090	12.66	99	0	5.37768	10.971	Discharge	0.40460	0.4	Ratio to Peak	0.4
W4100	11.2146102	99	0	9.38	19.135	Discharge	0.42189	0.4	Ratio to Peak	0.4
W4110	12.804	99	0	5.2152	10.681	Discharge	0.63477	0.4	Ratio to Peak	0.4

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W4120	15.443	99	0	1.156	2.3583	Discharge	0.11476	0.4	Ratio to Peak	0.4
W4130	15.879	99	0	5.2152	10.681	Discharge	1.0563	0.4	Ratio to Peak	0.4
W4140	14.0971043	99	0	2.23552	4.5605	Discharge	0.59923	0.4	Ratio to Peak	0.4
W4150	13.7496486	99	0	4.326	8.825	Discharge	0.53369	0.4	Ratio to Peak	0.4
W4160	35.329	82.5	0	5.6468	11.519	Discharge	0.59260	0.4	Ratio to Peak	0.4
W4170	35.329	82.5	0	2.31392	4.7204	Discharge	0.14010	0.4	Ratio to Peak	0.4
W4180	13.287	99	0	5.2152	10.681	Discharge	0.43144	0.4	Ratio to Peak	0.4
W4190	16.74	99	0	6.56712	13.397	Discharge	0.75481	0.4	Ratio to Peak	0.4
W4200	15.707	99	0	5.2152	10.681	Discharge	0.12740	0.4	Ratio to Peak	0.4
W4210	15.949	99	0	5.2152	10.681	Discharge	0.82721	0.4	Ratio to Peak	0.4
W4220	13.706	99	0	0.92384	1.8847	Discharge	0.0808101	0.4	Ratio to Peak	0.4
W4230	35.329	82.5	0	3.2024	6.5328	Discharge	0.20499	0.4	Ratio to Peak	0.4
W4240	35.329	82.5	0	7.36248	15.019	Discharge	0.40585	0.4	Ratio to Peak	0.4
W4250	15.971	99	0	5.2152	10.681	Discharge	0.0547077	0.4	Ratio to Peak	0.4
W4260	12.336	99	0	3.20992	6.5482	Discharge	0.47458	0.4	Ratio to Peak	0.4
W4270	11.984	99	0	5.2152	10.681	Discharge	0.51728	0.4	Ratio to Peak	0.4
W4280	13.054	99	0	5.2152	10.681	Discharge	0.22943	0.4	Ratio to Peak	0.4
W4290	11.517	99	0	5.5396	11.301	Discharge	0.41516	0.4	Ratio to Peak	0.4
W4300	12.347	99	0	4.09248	8.3487	Discharge	0.31753	0.4	Ratio to Peak	0.4
W4310	35.329	82.5	0	5.2152	10.681	Discharge	0.59365	0.4	Ratio to Peak	0.4
W4320	14.56	99	0	4.04264	8.2469	Discharge	0.74803	0.4	Ratio to Peak	0.4
W4330	35.323	82.506	0	32.9688	67.257	Discharge	1.8142	0.4	Ratio to Peak	0.4
W4340	14.018	99	0	4.84768	9.8893	Discharge	0.47744	0.4	Ratio to Peak	0.4
W4350	13.037	99	0	5.2152	10.681	Discharge	0.12678	0.4	Ratio to Peak	0.4
W4360	11.89	99	0	6.51904	13.299	Discharge	1.0470	0.4	Ratio to Peak	0.4

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W4370	13.328	99	0	4.99152	10.183	Discharge	0.43246	0.4	Ratio to Peak	0.4
W4380	13.309	99	0	0.89144	1.8186	Discharge	0.0380809	0.4	Ratio to Peak	0.4
W4390	12.01	99	0	5.2152	10.681	Discharge	0.43440	0.4	Ratio to Peak	0.4
W4400	35.537	82.282	0	5.2152	10.681	Discharge	1.1185	0.4	Ratio to Peak	0.4
W4410	11.563	99	0	0.81128	1.655	Discharge	0.0653959	0.4	Ratio to Peak	0.4
W4420	14.592	99	0	3.56176	7.266	Discharge	0.30828	0.4	Ratio to Peak	0.4
W4430	15.96	99	0	12.056	24.595	Discharge	0.94872	0.4	Ratio to Peak	0.4
W4440	15.42	99	0	1.34568	2.7452	Discharge	0.0962632	0.4	Ratio to Peak	0.4
W4450	14.9889986	99	0	19.2176	39.203	Discharge	1.1142	0.4	Ratio to Peak	0.4
W4460	11.805	99	0	15.0904	30.785	Discharge	1.9618	0.4	Ratio to Peak	0.4
W4470	13.643	99	0	5.2152	10.681	Discharge	0.23515	0.4	Ratio to Peak	0.4
W4480	15.86	99	0	14.4088	29.393	Discharge	2.3370	0.4	Ratio to Peak	0.4
W4490	17.021	99	0	5.2152	10.681	Discharge	0.99544	0.4	Ratio to Peak	0.4
W4500	12.433	99	0	5.66104	11.548	Discharge	1.5693	0.4	Ratio to Peak	0.4
W4510	14.791	99	0	3.49352	7.1268	Discharge	0.35319	0.4	Ratio to Peak	0.4
W4520	14.71	99	0	5.34472	10.903	Discharge	0.47598	0.4	Ratio to Peak	0.4
W4530	14.978	99	0	0.736304	1.5021	Discharge	0.0158884	0.4	Ratio to Peak	0.4
W4540	17.305	99	0	2.43744	4.9723	Discharge	0.13137	0.4	Ratio to Peak	0.4
W4550	24.586	95.578	0	6.32264	12.898	Discharge	0.86940	0.4	Ratio to Peak	0.4
W4560	36.221	81.574	0	21.5568	43.976	Discharge	2.3344	0.4	Ratio to Peak	0.4
W4570	20.211	99	0	41.488	84.636	Discharge	3.0303	0.4	Ratio to Peak	0.4
W4580	15.83	99	0	10.684	21.795	Discharge	0.72221	0.4	Ratio to Peak	0.4
W4590	20.164	99	0	6.73528	13.74	Discharge	0.48715	0.4	Ratio to Peak	0.4
W4600	34.551	83.326	0	29.5448	60.271	Discharge	3.2305	0.4	Ratio to Peak	0.4
W4610	35.329	82.5	0	5.2152	10.681	Discharge	1.2867	0.4	Ratio to Peak	0.4

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W4620	35.453	82.37	0	12.496	25.492	Discharge	0.49277	0.4	Ratio to Peak	0.4
W4630	15.971	99	0	2.53896	5.1794	Discharge	0.11271	0.4	Ratio to Peak	0.4
W4640	15.971	99	0	2.68008	5.4673	Discharge	0.44789	0.4	Ratio to Peak	0.4
W4650	35.329	82.5	0	4.018	8.1967	Discharge	0.21257	0.4	Ratio to Peak	0.4
W4660	35.329	82.5	0	13.5192	27.579	Discharge	1.1173	0.4	Ratio to Peak	0.4
W4670	12.187	99	0	5.2152	10.681	Discharge	0.75397	0.4	Ratio to Peak	0.4
W4680	35.329	82.5	0	5.2152	10.681	Discharge	1.6173	0.4	Ratio to Peak	0.4
W4690	12.892	99	0	2.9076	5.9316	Discharge	0.44121	0.4	Ratio to Peak	0.4
W4700	12.49	99	0	2.23992	4.5695	Discharge	0.45057	0.4	Ratio to Peak	0.4
W4710	35.329	82.5	0	19.9096	40.616	Discharge	0.84951	0.4	Ratio to Peak	0.4
W4720	16.8256363	99	0	11.6832	23.834	Discharge	1.9966	0.4	Ratio to Peak	0.4
W4730	15.63	99	0	12.4568	25.412	Discharge	2.0494	0.4	Ratio to Peak	0.4
W4740	12.513	99	0	5.2152	10.681	Discharge	0.69722	0.4	Ratio to Peak	0.4
W4750	12.898	99	0	0.872	1.7789	Discharge	0.0400009	0.4	Ratio to Peak	0.4
W4760	12.989	99	0	4.16056	8.4875	Discharge	0.85548	0.4	Ratio to Peak	0.4
W4770	12.898	99	0	5.2152	10.681	Discharge	0.0201481	0.4	Ratio to Peak	0.4
W4780	12.383	99	0	19.3136	39.399	Discharge	1.5586	0.4	Ratio to Peak	0.4
W4790	15.228	99	0	5.6576	11.542	Discharge	0.59252	0.4	Ratio to Peak	0.4
W4800	14.667	99	0	5.36	10.934	Discharge	0.45455	0.4	Ratio to Peak	0.4
W4810	36.901	80.88	0	5.2152	10.681	Discharge	0.60033	0.4	Ratio to Peak	0.4
W4820	42.519	75.578	0	5.2152	10.681	Discharge	0.43446	0.4	Ratio to Peak	0.4
W4830	41.985	76.052	0	30.88	62.995	Discharge	0.54348	0.4	Ratio to Peak	0.4
W4840	14.944	99	0	5.2152	10.681	Discharge	0.43683	0.4	Ratio to Peak	0.4
W4850	42.725	75.397	0	5.2152	10.681	Discharge	0.61752	0.4	Ratio to Peak	0.4
W4860	15.838	99	0	5.25128	10.713	Discharge	0.13116	0.4	Ratio to Peak	0.4

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Recession Constant	Threshold Type	Ratio to Peak
W4870	36.4237936	81.365	0	7.87256	16.06	Discharge	0.47833	0.4	Ratio to Peak	0.4
W4880	46.778	72	0	3.922	8.0009	Discharge	0.13754	0.4	Ratio to Peak	0.4
W4890	32.133	86.001	0	20.9896	42.818	Discharge	2.2739	0.4	Ratio to Peak	0.4
W4900	38.3058184	79.486	0	9.736	19.861	Discharge	0.53829	0.4	Ratio to Peak	0.4
W4910	15.971	99	0	4.45656	9.0914	Discharge	0.64081	0.4	Ratio to Peak	0.4
W4920	18.597	99	0	4.15672	8.4796	Discharge	0.65396	0.4	Ratio to Peak	0.4
W4930	43.927	74.356	0	5.2152	10.681	Discharge	0.41657	0.4	Ratio to Peak	0.4
W4940	45.853	72.748	0	26.5552	54.172	Discharge	0.46381	0.4	Ratio to Peak	0.4
W4950	46.676	72.082	0	6.0344	12.31	Discharge	0.21492	0.4	Ratio to Peak	0.4
W4960	35.941	81.861	0	21.4424	43.743	Discharge	0.76934	0.4	Ratio to Peak	0.4
W4970	35.544	82.275	0	10.2768	20.965	Discharge	0.45891	0.4	Ratio to Peak	0.4
W4980	27.364	91.815	0	12.1104	24.705	Discharge	1.6351	0.4	Ratio to Peak	0.4
W4990	17.732	99	0	4.97912	10.157	Discharge	0.41196	0.4	Ratio to Peak	0.4
W5000	35.329	82.5	0	5.2152	10.681	Discharge	0.64770	0.4	Ratio to Peak	0.4
W5010	42.022	76.019	0	3.38392	6.9032	Discharge	0.10101	0.4	Ratio to Peak	0.4
W5020	45.156	73.322	0	2.54008	5.1817	Discharge	0.11245	0.4	Ratio to Peak	0.4
W5030	40.002	77.866	0	20.1224	41.049	Discharge	0.5237267	0.4	Ratio to Peak	0.4
W5040	36.148	81.648	0	5.70576	11.64	Discharge	0.18843	0.4	Ratio to Peak	0.4
W5050	35.329	82.5	0	5.2152	10.681	Discharge	0.76711	0.4	Ratio to Peak	0.4
W5060	35.332	82.497	0	9.4096	19.195	Discharge	0.40152	0.4	Ratio to Peak	0.4
W5070	35.329	82.5	0	8.3944	17.124	Discharge	1.5383	0.4	Ratio to Peak	0.4
W5080	35.329	82.5	0	1.07008	2.1829	Discharge	0.0443383	0.4	Ratio to Peak	0.4
W5090	36.498	81.29	0	5.2152	10.681	Discharge	0.79688	0.4	Ratio to Peak	0.4
W5100	35.6930457	82.119	0	21.2928	43.437	Discharge	0.53985	0.4	Ratio to Peak	0.4
W5110	35.329	82.5	0	4.04736	8.2567	Discharge	0.0996834	0.4	Ratio to Peak	0.4
W5120	35.767	82.042	0	8.8296	18.013	Discharge	0.41020	0.4	Ratio to Peak	0.4
W5130	39.5724234	78.27	0	10.472	21.362	Discharge	1.1334	0.4	Ratio to Peak	0.4
W5140	36.573	81.213	0	4.71456	9.6177	Discharge	0.49418	0.4	Ratio to Peak	0.4

Annex 10. Abulog-Apayao Model Reach Parameters

Table A-9.1. Abulog-Apayao Model Reach Parameters

Reach Number	MuskingumCunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R30	Automatic Fixed Interval	863.55	0.001	0.015	Trapezoid	705.57	0.209
R50	Automatic Fixed Interval	593.97	0.001	0.015	Trapezoid	705.57	0.209
R110	Automatic Fixed Interval	1809.5	0.001	0.015	Trapezoid	705.57	0.209
R130	Automatic Fixed Interval	1337.2	0.001	0.015	Trapezoid	705.57	0.209
R140	Automatic Fixed Interval	8284.4	0.001	0.015	Trapezoid	705.57	0.209
R160	Automatic Fixed Interval	2744.2	0.001	0.015	Trapezoid	705.57	0.209
R170	Automatic Fixed Interval	1875.7	0.001	0.015	Trapezoid	705.57	0.209
R190	Automatic Fixed Interval	2328	0.001	0.015	Trapezoid	705.57	0.209
R210	Automatic Fixed Interval	1881.4	0.001	0.015	Trapezoid	705.57	0.209
R230	Automatic Fixed Interval	4980.1	0.001	0.015	Trapezoid	705.57	0.209
R250	Automatic Fixed Interval	1998.7	0.001	0.015	Trapezoid	705.57	0.209
R270	Automatic Fixed Interval	3901.6	0.016916	0.015	Trapezoid	705.57	0.209
R280	Automatic Fixed Interval	113.14	0.35355	0.015	Trapezoid	705.57	0.209
R290	Automatic Fixed Interval	2198.2	0.001	0.015	Trapezoid	705.57	0.209
R330	Automatic Fixed Interval	6176.1	0.001	0.015	Trapezoid	705.57	0.209
R340	Automatic Fixed Interval	3679.8	0.001	0.015	Trapezoid	705.57	0.209
R350	Automatic Fixed Interval	5229.1	0.001	0.015	Trapezoid	705.57	0.209
R370	Automatic Fixed Interval	3394	0.005598	0.015	Trapezoid	705.57	0.209
R380	Automatic Fixed Interval	6199	0.001	0.015	Trapezoid	705.57	0.209
R390	Automatic Fixed Interval	1356.9	0.001	0.015	Trapezoid	705.57	0.209
R410	Automatic Fixed Interval	2642.3	0.001	0.015	Trapezoid	705.57	0.209
R420	Automatic Fixed Interval	2501.2	0.004398	0.015	Trapezoid	705.57	0.209
R430	Automatic Fixed Interval	760.12	0.038152	0.015	Trapezoid	705.57	0.209
R440	Automatic Fixed Interval	2665.5	0.01238	0.015	Trapezoid	705.57	0.209
R460	Automatic Fixed Interval	4254	0.001	0.015	Trapezoid	705.57	0.209
R470	Automatic Fixed Interval	5454.5	0.001	0.015	Trapezoid	705.57	0.209
R510	Automatic Fixed Interval	1274.8	0.014904	0.015	Trapezoid	705.57	0.209
R550	Automatic Fixed Interval	2480.7	0.004837	0.015	Trapezoid	705.57	0.209
R570	Automatic Fixed Interval	3896.2	0.00308	0.015	Trapezoid	705.57	0.209
R590	Automatic Fixed Interval	4018.8	0.001	0.015	Trapezoid	705.57	0.209
R600	Automatic Fixed Interval	3760.6	0.001	0.015	Trapezoid	705.57	0.209
R620	Automatic Fixed Interval	2738.9	0.001095	0.015	Trapezoid	705.57	0.209
R630	Automatic Fixed Interval	2479.9	0.005242	0.015	Trapezoid	705.57	0.209
R640	Automatic Fixed Interval	470	0.001	0.015	Trapezoid	705.57	0.209
R670	Automatic Fixed Interval	166.57	0.001	0.015	Trapezoid	705.57	0.209
R720	Automatic Fixed Interval	1918.7	0.001	0.015	Trapezoid	705.57	0.209
R740	Automatic Fixed Interval	6887.6	0.001597	0.015	Trapezoid	705.57	0.209
R780	Automatic Fixed Interval	2134.6	0.001	0.015	Trapezoid	705.57	0.209
R790	Automatic Fixed Interval	21.213	0.001	0.015	Trapezoid	705.57	0.209
R800	Automatic Fixed Interval	744.26	0.001	0.015	Trapezoid	705.57	0.209

R830	Automatic Fixed Interval	4242.6	0.012728	0.015	Trapezoid	705.57	0.209
R850	Automatic Fixed Interval	113.14	0.061872	0.015	Trapezoid	705.57	0.209
R860	Automatic Fixed Interval	2982.1	0.001	0.015	Trapezoid	705.57	0.209
R870	Automatic Fixed Interval	5298.5	0.001	0.015	Trapezoid	705.57	0.209
R880	Automatic Fixed Interval	1604.4	0.001	0.015	Trapezoid	705.57	0.209
R910	Automatic Fixed Interval	4812.5	0.003533	0.015	Trapezoid	705.57	0.209
R920	Automatic Fixed Interval	1336.1	0.016466	0.015	Trapezoid	705.57	0.209
R940	Automatic Fixed Interval	7313	0.001	0.015	Trapezoid	705.57	0.209
R970	Automatic Fixed Interval	1237.3	0.001	0.015	Trapezoid	705.57	0.209
R1010	Automatic Fixed Interval	3952.3	0.004554	0.015	Trapezoid	705.57	0.209
R1030	Automatic Fixed Interval	21.213	0.001	0.015	Trapezoid	705.57	0.209
R1040	Automatic Fixed Interval	2501	0.001	0.015	Trapezoid	705.57	0.209
R1080	Automatic Fixed Interval	1244.6	0.001	0.015	Trapezoid	705.57	0.209
R1090	Automatic Fixed Interval	1872.4	0.001	0.015	Trapezoid	705.57	0.209
R1100	Automatic Fixed Interval	1289.8	0.001	0.015	Trapezoid	705.57	0.209
R1110	Automatic Fixed Interval	7615.8	0.001	0.015	Trapezoid	705.57	0.209
R1120	Automatic Fixed Interval	7418.7	0.0031	0.015	Trapezoid	705.57	0.209
R1130	Automatic Fixed Interval	1698.7	0.033555	0.015	Trapezoid	705.57	0.209
R1190	Automatic Fixed Interval	127.28	0.001	0.015	Trapezoid	705.57	0.209
R1210	Automatic Fixed Interval	2371	0.001	0.015	Trapezoid	705.57	0.209
R1220	Automatic Fixed Interval	3310.2	0.006948	0.015	Trapezoid	705.57	0.209
R1230	Automatic Fixed Interval	1972.1	0.001	0.015	Trapezoid	705.57	0.209
R1250	Automatic Fixed Interval	5061.4	0.002371	0.015	Trapezoid	705.57	0.209
R1270	Automatic Fixed Interval	5619.8	0.001	0.015	Trapezoid	705.57	0.209
R1280	Automatic Fixed Interval	7001	0.001	0.015	Trapezoid	705.57	0.209
R1290	Automatic Fixed Interval	1064.4	0.013153	0.015	Trapezoid	705.57	0.209
R1300	Automatic Fixed Interval	23300	0.001803	0.015	Trapezoid	705.57	0.209
R1320	Automatic Fixed Interval	3849.9	0.001	0.015	Trapezoid	705.57	0.209
R1330	Automatic Fixed Interval	1149.4	0.001	0.015	Trapezoid	705.57	0.209
R1340	Automatic Fixed Interval	1379.5	0.002175	0.015	Trapezoid	705.57	0.209
R1360	Automatic Fixed Interval	2595.4	0.002312	0.015	Trapezoid	705.57	0.209
R1390	Automatic Fixed Interval	2448.7	0.002859	0.015	Trapezoid	705.57	0.209
R1400	Automatic Fixed Interval	5249.5	0.001	0.015	Trapezoid	705.57	0.209
R1420	Automatic Fixed Interval	1956	0.011248	0.015	Trapezoid	705.57	0.209
R1430	Automatic Fixed Interval	12022	0.002995	0.015	Trapezoid	705.57	0.209
R1470	Automatic Fixed Interval	11195	0.001	0.015	Trapezoid	705.57	0.209
R1500	Automatic Fixed Interval	1861.2	0.032774	0.015	Trapezoid	705.57	0.209
R1520	Automatic Fixed Interval	3925.9	0.003821	0.015	Trapezoid	705.57	0.209
R1560	Automatic Fixed Interval	8407.7	0.001	0.015	Trapezoid	705.57	0.209
R1570	Automatic Fixed Interval	1275.1	0.024312	0.015	Trapezoid	705.57	0.209
R1590	Automatic Fixed Interval	7928.4	0.001	0.015	Trapezoid	705.57	0.209
R1600	Automatic Fixed Interval	3782.3	0.001851	0.015	Trapezoid	705.57	0.209
R1630	Automatic Fixed Interval	2205.1	0.013605	0.015	Trapezoid	705.57	0.209
R1650	Automatic Fixed Interval	1450.2	0.010343	0.015	Trapezoid	705.57	0.209
R1680	Automatic Fixed Interval	2177.8	0.001	0.015	Trapezoid	705.57	0.209
R1690	Automatic Fixed Interval	1485.1	0.026934	0.015	Trapezoid	705.57	0.209

R1700	Automatic Fixed Interval	1034	0.028047	0.015	Trapezoid	705.57	0.209
R1710	Automatic Fixed Interval	7406.4	0.001	0.015	Trapezoid	705.57	0.209
R1730	Automatic Fixed Interval	1924	0.007277	0.015	Trapezoid	705.57	0.209
R1740	Automatic Fixed Interval	623.55	0.016037	0.015	Trapezoid	705.57	0.209
R1750	Automatic Fixed Interval	3023.9	0.004961	0.015	Trapezoid	705.57	0.209
R1770	Automatic Fixed Interval	1976.7	0.036425	0.015	Trapezoid	705.57	0.209
R1790	Automatic Fixed Interval	1094.3	0.007311	0.015	Trapezoid	705.57	0.209
R1800	Automatic Fixed Interval	4181.4	0.001	0.015	Trapezoid	705.57	0.209
R1810	Automatic Fixed Interval	2248.9	0.002223	0.015	Trapezoid	705.57	0.209
R1820	Automatic Fixed Interval	2922.7	0.001	0.015	Trapezoid	705.57	0.209
R1830	Automatic Fixed Interval	3317.2	0.001	0.015	Trapezoid	705.57	0.209
R1840	Automatic Fixed Interval	1880.9	0.002658	0.015	Trapezoid	705.57	0.209
R1850	Automatic Fixed Interval	1865.8	0.009647	0.015	Trapezoid	705.57	0.209
R1880	Automatic Fixed Interval	4448.1	0.004946	0.015	Trapezoid	705.57	0.209
R1890	Automatic Fixed Interval	1409.5	0.010642	0.015	Trapezoid	705.57	0.209
R1900	Automatic Fixed Interval	1061.8	0.022602	0.015	Trapezoid	705.57	0.209
R1910	Automatic Fixed Interval	4933.5	0.001	0.015	Trapezoid	705.57	0.209
R1940	Automatic Fixed Interval	4212.2	0.001	0.015	Trapezoid	705.57	0.209
R1970	Automatic Fixed Interval	4417.5	0.001358	0.015	Trapezoid	705.57	0.209
R2010	Automatic Fixed Interval	3503.2	0.005709	0.015	Trapezoid	705.57	0.209
R2020	Automatic Fixed Interval	7152.6	0.004893	0.015	Trapezoid	705.57	0.209
R2030	Automatic Fixed Interval	1571	0.008912	0.015	Trapezoid	705.57	0.209
R2060	Automatic Fixed Interval	2924.7	0.016754	0.015	Trapezoid	705.57	0.209
R2090	Automatic Fixed Interval	2988.5	0.016396	0.015	Trapezoid	705.57	0.209
R2120	Automatic Fixed Interval	607.28	0.00494	0.015	Trapezoid	705.57	0.209
R2130	Automatic Fixed Interval	803.55	0.017423	0.015	Trapezoid	705.57	0.209
R2140	Automatic Fixed Interval	4341.2	0.001	0.015	Trapezoid	705.57	0.209
R2210	Automatic Fixed Interval	8057.8	0.002482	0.015	Trapezoid	705.57	0.209
R2230	Automatic Fixed Interval	13719	0.001166	0.015	Trapezoid	705.57	0.209
R2270	Automatic Fixed Interval	4584	0.001091	0.015	Trapezoid	705.57	0.209
R2280	Automatic Fixed Interval	1895.1	0.035882	0.015	Trapezoid	705.57	0.209
R2290	Automatic Fixed Interval	1742.7	0.023527	0.015	Trapezoid	705.57	0.209
R2300	Automatic Fixed Interval	9158.2	0.002293	0.015	Trapezoid	705.57	0.209
R2330	Automatic Fixed Interval	2166.1	0.006463	0.015	Trapezoid	705.57	0.209
R2360	Automatic Fixed Interval	3778.8	0.015084	0.015	Trapezoid	705.57	0.209
R2370	Automatic Fixed Interval	3698.5	0.003515	0.015	Trapezoid	705.57	0.209
R2390	Automatic Fixed Interval	1082.5	0.028636	0.015	Trapezoid	705.57	0.209
R2400	Automatic Fixed Interval	2687.4	0.001	0.015	Trapezoid	705.57	0.209
R2420	Automatic Fixed Interval	1325.4	0.02188	0.015	Trapezoid	705.57	0.209
R2440	Automatic Fixed Interval	1738.5	0.002301	0.015	Trapezoid	705.57	0.209
R2470	Automatic Fixed Interval	8427.9	0.001305	0.015	Trapezoid	705.57	0.209
R2480	Automatic Fixed Interval	3000.5	0.001	0.015	Trapezoid	705.57	0.209
R2490	Automatic Fixed Interval	970.42	0.054616	0.015	Trapezoid	705.57	0.209
R2530	Automatic Fixed Interval	1250.8	0.004797	0.015	Trapezoid	705.57	0.209
R2540	Automatic Fixed Interval	21.213	0.1	0.015	Trapezoid	705.57	0.209

Annex 11. Abulog-Apayao Field Validation Points

Table A-10.1. Abulog-Apayao Field Validation Points

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
1	18.47799	121.40831	0.139	1.2	1.061	TS Vinta/ Oct 31, 2013	5yr
2	18.47799	121.40831	0.139	1.2	1.061	TS Vinta/ Oct 31, 2013	5yr
3	18.47795	121.40830	0.139	1.2	1.061	TS Vinta/ Oct 31, 2013	5yr
4	18.47795	121.40828	0.139	1.2	1.061	TS Vinta/ Oct 31, 2013	5yr
5	18.47795	121.40827	0.139	1.2	1.061	TS Vinta/ Oct 31, 2013	5yr
6	18.47795	121.40830	0.139	1.2	1.061	TS Vinta/ Oct 31, 2013	5yr
7	18.47800	121.40834	0.030	1.2	1.170	TS Vinta/ Oct 31, 2013	5yr
8	18.47803	121.40836	0.030	1.2	1.170	TS Vinta/ Oct 31, 2013	5yr
9	18.47697	121.41000	0.064	0.5	0.436	TS Vinta/ Oct 31, 2013	5yr
10	18.47696	121.41000	0.030	0.5	0.470	TS Vinta/ Oct 31, 2013	5yr
11	18.47653	121.41055	0.030	0.8	0.770	TS Vinta/ Oct 31, 2013	5yr
12	18.47650	121.41054	0.030	0.8	0.770	TS Vinta/ Oct 31, 2013	5yr
13	18.47646	121.41052	0.239	0.8	0.561	TS Vinta/ Oct 31, 2013	5yr
14	18.47647	121.41050	0.239	0.8	0.561	TS Vinta/ Oct 31, 2013	5yr
15	18.47656	121.41057	0.030	0.8	0.770	TS Vinta/ Oct 31, 2013	5yr
16	18.47630	121.41073	0.030	0.8	0.770	TS Vinta/ Oct 31, 2013	5yr
17	18.47558	121.41113	0.030	0.8	0.770	TS Queenie	5yr
18	18.47558	121.41113	0.030	0.8	0.770	TS Queenie	5yr
19	18.47558	121.41113	0.030	0.8	0.770	TS Queenie	5yr
20	18.47542	121.41128	0.032	0.8	0.768	TS Queenie	5yr
21	18.47540	121.41132	0.231	0.8	0.569	TS Queenie	5yr
22	18.47709	121.41020	0.030	0.2	0.170	TS Lawin/ Oct 20, 2016	5yr
23	18.48066	121.40367	0.031	0.5	0.469	TS Lawin/ Oct 20, 2016	5yr
24	18.48073	121.40350	0.030	0.5	0.470	TS Lawin/ Oct 20, 2016	5yr
25	18.48098	121.40301	0.030	0.5	0.470	TS Lawin/ Oct 20, 2016	5yr
26	18.41485	121.34913	0.518	0.75	0.232	Amihan/ Dec 2016	5yr
27	18.41483	121.34914	0.518	0.75	0.232	Amihan/ Dec 2016	5yr
28	18.41486	121.34924	0.269	0.75	0.481	TS Vinta/ Oct 31, 2013	5yr
29	18.41511	121.34918	0.328	0.75	0.422	TS Vinta/ Oct 31, 2013	5yr
30	18.41519	121.34917	0.362	0.75	0.388	TS Vinta/ Oct 31, 2013	5yr
31	18.41532	121.34912	0.403	0.75	0.347	TS Vinta/ Oct 31, 2013	5yr
32	18.41542	121.34909	0.305	0.75	0.445	TS Vinta/ Oct 31, 2013	5yr
33	18.41562	121.34899	0.301	0.8	0.499	TS Lawin/ Oct 20, 2016	5yr
34	18.41562	121.34893	0.301	1.2	0.899	TS Lawin/ Oct 20, 2016	5yr
35	18.41561	121.34890	0.798	1.2	0.402	TS Lawin/ Oct 20, 2016	5yr
36	18.41564	121.34871	0.239	1.2	0.961	TS Lawin/ Oct 20, 2016	5yr
37	18.41584	121.34882	0.446	1.2	0.754	TS Yolanda/ Nov 2013	5yr
38	18.41587	121.34889	0.446	1.2	0.754	TS Yolanda/ Nov 2013	5yr
39	18.41587	121.34888	0.446	1.2	0.754	TS Yolanda/ Nov 2013	5yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
40	18.41581	121.34897	0.131	0.6	0.469	Amihan/ Dec 2016	5yr
41	18.41598	121.34902	0.334	0.6	0.266	Amihan/ Dec 2016	5yr
42	18.41619	121.34905	0.215	0.6	0.385	Amihan/ Dec 2016	5yr
43	18.41643	121.34911	0.208	0.6	0.392	Amihan/ Dec 2016	5yr
44	18.41657	121.34919	0.223	0.6	0.377	Amihan/ Dec 2016	5yr
45	18.41674	121.34929	0.201	0.6	0.399	Amihan/ Dec 2016	5yr
46	18.41690	121.34938	0.172	0.8	0.628	Amihan/ Dec 2016	5yr
47	18.41709	121.34958	0.252	0.8	0.548	Amihan/ Dec 2016	5yr
48	18.41723	121.34968	0.136	0.48	0.344	Amihan/ Dec 2016	5yr
49	18.41732	121.34973	0.137	0.35	0.213	Amihan/ Dec 2016	5yr
50	18.41757	121.34994	0.053	0.35	0.297	Amihan/ Dec 2016	5yr
51	18.41758	121.34994	0.053	0.35	0.297	Amihan/ Dec 2016	5yr
52	18.41757	121.34997	0.053	0.35	0.297	Amihan/ Dec 2016	5yr
53	18.41778	121.34999	0.485	0.7	0.215	Amihan/ Dec 2016	5yr
54	18.41781	121.34994	0.485	0.4	-0.085	Amihan/ Dec 2016	5yr
55	18.41795	121.35023	0.040	0.4	0.360	Amihan/ Dec 2016	5yr
56	18.41796	121.35022	0.040	0.78	0.740	Amihan/ Dec 2016	5yr
57	18.41798	121.35020	0.040	0.78	0.740	Amihan/ Dec 2016	5yr
58	18.41796	121.35031	0.132	0.48	0.348	Amihan/ Dec 2016	5yr
59	18.41802	121.35035	0.030	0.48	0.450	Amihan/ Dec 2016	5yr
60	18.41836	121.35062	0.508	0.48	-0.028	Amihan/ Dec 2016	5yr
61	18.41850	121.35065	0.650	0.48	-0.170	Amihan/ Dec 2016	5yr
62	18.41854	121.35063	1.139	0.4	-0.739	Amihan/ Dec 2016	5yr
63	18.41880	121.35094	0.521	0.4	-0.121	Amihan/ Dec 2016	5yr
64	18.41881	121.35095	0.521	1	0.479	Amihan/ Dec 2016	5yr
65	18.43485	121.36044	0.030	1	0.970	Amihan/ Dec 2016	5yr
66	18.43476	121.36041	0.068	1	0.932	TS Lawin/ Oct 20, 2016	5yr
67	18.43476	121.36036	0.030	1	0.970	Amihan/ Dec 2016	5yr
68	18.43473	121.36039	0.068	1	0.932	Amihan/ Dec 2016	5yr
69	18.43463	121.36036	0.031	1	0.969	Amihan/ Dec 2016	5yr
70	18.43440	121.36030	0.030	1	0.970	Amihan/ Dec 2016	5yr
71	18.43431	121.36039	0.030	1	0.970	Amihan/ Dec 2016	5yr
72	18.43431	121.36041	0.030	0.4	0.370	TS Ondoy/ Sept 2009	5yr
73	18.43430	121.36040	0.030	0.3	0.270	TS Karen/ Oct 17, 2016	5yr
74	18.43435	121.36038	0.030	0.5	0.470	TS Lawin/ Oct 20, 2016	5yr
75	18.43459	121.36024	0.030	0.8	0.770	TS Pepang/ Oct 1987	5yr
76	18.43457	121.36028	0.030	0.8	0.770	TS Pepang/ Oct 1987	5yr
77	18.43424	121.36021	0.030	0.8	0.770	TS Pepang/ Oct 1987	5yr
78	18.43390	121.36013	0.030	0.8	0.770	TS Pepang/ Oct 1987	5yr
79	18.43389	121.36006	0.124	0.8	0.676	TS Pepang/ Oct 1987	5yr
80	18.43304	121.35964	0.078	0.8	0.722	TS Pepang/ Oct 1987	5yr
81	18.42136	121.36616	1.446	0.8	-0.646	TS Pepang/ Oct 1987	5yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
82	18.25557	121.41943	0.030	0.38	0.350	1974/1975	5yr
83	18.24914	121.41783	0.030	0.84	0.810	TS Pepang/ Oct 1987	5yr
84	18.24937	121.41779	0.060	1.00	0.940	TS Goring/ July 2015	5yr
85	18.25081	121.41783	0.030	1.00	0.970	1990	5yr
86	18.29324	121.42745	1.694	0.00	-1.694		5yr
87	18.30048	121.41858	1.376	0.00	-1.376		5yr
88	18.29756	121.42154	2.301	0.00	-2.301		5yr
89	18.30341	121.41669	3.422	0.00	-3.422		5yr
90	18.30355	121.41662	3.074	3.00	-0.074	2004	5yr
91	18.30453	121.41875	2.746	1.00	-1.746	2004	5yr
92	18.30435	121.41862	2.580	1.00	-1.580	TS Pepang/ Oct 1987	5yr
93	18.30414	121.41814	2.761	3.00	0.239	TS Pepang/ Oct 1987	5yr
94	18.30419	121.41807	3.058	4.00	0.942	TS Pepang/ Oct 1987	5yr
95	18.30180	121.41762	3.060	1.00	-2.060	TS Lawin/ Oct 20, 2016	5yr
96	18.30158	121.41787	2.523	1.50	-1.023	TS Pepang/ Oct 1987	5yr
97	18.30055	121.41850	1.666	0.00	-1.666		5yr
98	18.26650	121.42501	1.980	0.00	-1.980		5yr
99	18.26618	121.42493	2.049	0.00	-2.049		5yr
100	18.26925	121.42244	3.520	0.38	-3.140	TS Pepang/ Oct 1987	5yr
101	18.26474	121.42349	2.276	0.00	-2.276		5yr
102	18.27643	121.42538	2.458	0.00	-2.458		5yr
103	18.27893	121.42556	1.503	3.00	1.497	TS Pepang/ Oct 1987	5yr
104	18.27702	121.42509	2.708	0.84	-1.868	TS Pepang/ Oct 1987	5yr
105	18.27628	121.42499	2.075	5.00	2.925	TS Pepang/ Oct 1987	5yr
106	18.27560	121.42487	1.584	5.00	3.416	TS Pepang/ Oct 1987	5yr
107	18.29154	121.43614	2.492	0.00	-2.492		5yr
108	18.27814	121.45589	0.030	0.00	-0.030		5yr
109	18.27744	121.46075	0.041	0.00	-0.041		5yr
110	18.28746	121.43829	1.304	0.00	-1.304		5yr
111	18.31381	121.44008	0.480	0.00	-0.480		5yr
112	18.31424	121.44344	0.462	0.00	-0.462		5yr
113	18.28513	121.44167	2.631	0.00	-2.631		5yr
114	18.26312	121.44928	0.069	0.00	-0.069		5yr
115	18.24084	121.47552	0.030	0.00	-0.030		5yr
116	18.21537	121.47020	0.030	0.46	0.430	heavy long duration rain	5yr
117	18.21300	121.46065	0.030	0.46	0.430	heavy long duration rain	5yr
118	18.25151	121.47360	1.366	0.42	-0.946	heavy long duration rain	5yr
119	18.26105	121.45016	0.030	0.00	-0.030	TS Lawin/ Oct 20, 2016	5yr
120	18.33419	121.35391	0.870	0.91	0.040	TS Lawin/ Oct 20, 2016	5yr
121	18.33419	121.35391	0.870	0.91	0.040	Habagat/ Dec 29, 2016	5yr
122	18.33382	121.35373	0.566	1.00	0.434	TS Lawin/ Oct 20, 2016	5yr
123	18.33382	121.35373	0.566	1.00	0.434	Habagat/ Dec 29, 2016	5yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
124	18.33399	121.35373	0.561	1.00	0.439	TS Lawin/ Oct 20, 2016	5yr
125	18.33399	121.35373	0.561	1.00	0.439	Habagat/ Dec 29, 2016	5yr
126	18.33546	121.35340	0.433	0.61	0.177	TS Lawin/ Oct 20, 2016	5yr
127	18.33694	121.35328	0.609	0.61	0.001	Habagat/ Dec 29, 2016	5yr
128	18.33695	121.35338	0.299	0.61	0.311	Habagat/ Dec 29, 2016	5yr
129	18.33855	121.35170	0.030	0.61	0.580	Habagat/ Dec 29, 2016	5yr
130	18.33905	121.35126	0.184	0.61	0.426	Habagat/ Dec 29, 2016	5yr
131	18.33902	121.35130	0.030	0.61	0.580	TS Lawin/ Oct 20, 2016	5yr
132	18.33902	121.35130	0.030	0.61	0.580	Habagat/ Dec 29, 2016	5yr
133	18.34108	121.35636	0.589	0.30	-0.289	TS Lawin/ Oct 20, 2016	5yr
134	18.34108	121.35636	0.589	0.30	-0.289	Habagat/ Dec 29, 2016	5yr
135	18.34097	121.35841	0.374	0.30	-0.074	TS Lawin/ Oct 20, 2016	5yr
136	18.34097	121.35841	0.374	0.30	-0.074	Habagat/ Dec 29, 2016	5yr
137	18.34099	121.35837	0.374	1.00	0.626	Habagat/ Dec 29, 2016	5yr
138	18.34035	121.35998	0.767	1.00	0.233	Habagat/ Dec 29, 2016	5yr
139	18.33795	121.36032	0.158	1.00	0.842	Habagat/ Dec 29, 2016	5yr
140	18.33662	121.35970	0.060	1.00	0.940	Habagat/ Dec 29, 2016	5yr
141	18.33660	121.35981	0.314	0.30	-0.014	Habagat/ Dec 29, 2016	5yr
142	18.33954	121.36120	0.078	0.30	0.222	Habagat/ Dec 29, 2016	5yr
143	18.33956	121.36112	0.083	0.91	0.827	Habagat/ Dec 29, 2016	5yr
144	18.34370	121.36806	0.235	0.61	0.375	TS Lawin/ Oct 20, 2016	5yr
145	18.34043	121.36996	0.496	0.61	0.114	TS Lawin/ Oct 20, 2016	5yr
146	18.34033	121.37040	0.555	1.50	0.945	TS Lawin/ Oct 20, 2016	5yr
147	18.34040	121.37016	0.135	1.50	1.365	TS Lawin/ Oct 20, 2016	5yr
148	18.26664	121.40108	0.487	1.50	1.013	TS Lawin/ Oct 20, 2016	5yr
149	18.26673	121.40100	1.134	1.50	0.366	TS Pepang/ Oct 1987	5yr
150	18.27548	121.36590	0.030	1.50	1.470	TS Pepang/ Oct 1987	5yr
151	18.27413	121.36582	0.169	1.00	0.831	TS Lawin/ Oct 20, 2016	5yr
152	18.27043	121.36713	0.030	0.61	0.580	TS Lawin/ Oct 20, 2016	5yr
153	18.29637	121.35219	0.656	0.70	0.044	TS Lawin/ Oct 20, 2016	5yr
154	18.32123	121.35207	1.510	2.30	0.790	Habagat/ Dec 29, 2016	5yr
155	18.32886	121.35066	0.147	2.30	2.153	Habagat/ Dec 29, 2016	5yr
156	18.32994	121.34985	0.220	0.91	0.690	Habagat/ Dec 29, 2016	5yr
157	18.33295	121.35478	0.030	0.91	0.880	Habagat/ Dec 29, 2016	5yr
158	18.31088	121.48922	0.217	0.61	0.393	Habagat/ Dec 29, 2016	5yr
159	18.30676	121.48871	0.059	0.61	0.551	TS Vinta/ Oct 31, 2013	5yr
160	18.30676	121.48871	0.059	0.61	0.551	Habagat/ Dec 29, 2016	5yr
161	18.30361	121.48939	0.030	0.61	0.580	TS Vinta/ Oct 31, 2013	5yr
162	18.30361	121.48939	0.030	0.61	0.580	Habagat/ Dec 29, 2016	5yr
163	18.30397	121.48926	0.030	1.00	0.970	Habagat/ Dec 29, 2016	5yr
164	18.28954	121.47915	0.036	1.00	0.964	Habagat/ Dec 29, 2016	5yr
165	18.29296	121.48777	0.453	0.91	0.457	TS Lawin/ Oct 20, 2016	5yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
166	18.29043	121.48928	0.296	0.61	0.314	TS Lawin/ Oct 20, 2016	5yr
167	18.28641	121.49185	1.018	0.61	-0.408	TS Lawin/ Oct 20, 2016	5yr
168	18.28651	121.49160	0.456	1.50	1.044	TS Lawin/ Oct 20, 2016	5yr
169	18.28262	121.49326	0.129	0.25	0.121	Habagat/ Dec 29, 2016	5yr
170	18.27910	121.49299	0.030	0.25	0.220	Habagat/ Dec 29, 2016	5yr
171	18.27915	121.49297	0.030	0.25	0.220	Habagat/ Dec 29, 2016	5yr
172	18.31514	121.49031	0.030	0.91	0.880	Habagat/ Dec 29, 2016	5yr
173	18.32473	121.49193	1.347	0.91	-0.437	Habagat/ Dec 29, 2016	5yr
174	18.21915	121.37307	3.602	0.50	-3.102	TS Pepang/ Oct 1987	5yr
175	18.28330	121.37326	0.030	0.00	-0.030		5yr
176	18.33267	121.37776	0.030	0.00	-0.030		5yr
177	18.35213	121.41012	0.058	0.00	-0.058		5yr
178	18.22468	121.38596	4.639	1.20	-3.439	TS Pepang/ Oct 1987	5yr
179	18.22586	121.38867	3.323	1.20	-2.123	Heavy rain	5yr
180	18.22586	121.38867	3.323	2.50	-0.823	TS Pepang/ Oct 1987	5yr
181	18.22587	121.38885	3.180	0.00	-3.180		5yr
182	18.22594	121.39340	4.482	1.20	-3.282	Heavy rain	5yr
183	18.22594	121.39340	4.482	2.50	-1.982	TS Pepang/ Oct 1987	5yr
184	18.22595	121.39731	3.954	1.20	-2.754	Heavy rain	5yr
185	18.22595	121.39731	3.954	2.50	-1.454	TS Pepang/ Oct 1987	5yr
186	18.22594	121.40132	3.587	1.20	-2.387	Heavy rain	5yr
187	18.22594	121.40132	3.587	2.50	-1.087	TS Pepang/ Oct 1987	5yr
188	18.22531	121.40370	4.736	1.20	-3.536	Heavy rain	5yr
189	18.22531	121.40370	4.736	2.50	-2.236	TS Pepang/ Oct 1987	5yr
190	18.22468	121.38534	7.566	2.50	-5.066	Heavy rain, most of the TS	5yr
191	18.22618	121.37661	2.628	0.00	-2.628		5yr
192	18.22618	121.37608	2.632	0.50	-2.132	TS Pepang/ Oct 1987	5yr
193	18.22600	121.37647	2.510	0.50	-2.010	TS Pepang/ Oct 1987	5yr
194	18.23200	121.37394	1.806	1.20	-0.606	Heavy rain	5yr
195	18.23221	121.37410	5.134	0.00	-5.134		5yr
196	18.23952	121.38314	2.781	0.50	-2.281	Heavy rain	5yr
197	18.23972	121.38378	2.653	0.50	-2.153	Heavy rain	5yr
198	18.23957	121.38399	7.013	1.00	-6.013	Heavy rain	5yr
199	18.23907	121.38358	2.630	1.00	-1.630	Heavy rain	5yr
200	18.23942	121.37817	3.138	0.50	-2.638	Heavy rain	5yr
201	18.24617	121.38369	2.427	0.50	-1.927	TS Juaning/ Sept 1988	5yr
202	18.24617	121.38369	2.427	0.50	-1.927	TS Lando/ Between Oct 16-20, 2015	5yr
203	18.24602	121.38420	7.121	0.50	-6.621	Heavy rain	5yr
204	18.25026	121.39005	2.534	0.90	-1.634	TS Pepang/ Oct 1987	5yr
205	18.24835	121.39636	7.875	0.00	-7.875		5yr
206	18.24824	121.39479	2.978	0.50	-2.478	Heavy rain	5yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
207	18.24595	121.36202	0.674	0.50	-0.174	TS Pepang/ Oct 1987	5yr
208	18.24546	121.35937	3.242	0.50	-2.742	TS Pepang/ Oct 1987	5yr
209	18.24931	121.35750	1.182	0.70	-0.482	TS Lawin/ Oct 20, 2016	5yr
210	18.25058	121.35631	1.973	0.70	-1.273	TS Lawin/ Oct 20, 2016	5yr
211	18.25048	121.35639	2.000	0.70	-1.300	TS Lawin/ Oct 20, 2016	5yr
212	18.24651	121.36524	1.174	1.20	0.026	TS Lawin/ Oct 20, 2016	5yr
213	18.25052	121.36808	1.766	2.00	0.234	TS Lawin/ Oct 20, 2016	5yr
214	18.25136	121.36839	0.030	0.00	-0.030		5yr
215	18.39091	121.44849	0.035	0.00	-0.035		5yr
216	18.40497	121.43971	0.032	0.00	-0.032		5yr
217	18.41599	121.43993	0.030	0.00	-0.030		5yr
218	18.41729	121.44037	0.030	0.900	0.870	TS Pepang/ Oct 1987	5yr
219	18.41699	121.44038	0.030	0.700	0.670	TS Pepang/ Oct 1987	5yr
220	18.40783	121.43807	0.136	0.900	0.764	TS Pepang/ Oct 1987	5yr
221	18.40762	121.43808	0.030	0.700	0.670	TS Pepang/ Oct 1987	5yr
222	18.37063	121.45159	0.030	0.00	-0.030		5yr
223	18.36601	121.44205	0.030	0.00	-0.030		5yr
224	18.36489	121.44112	0.030	0.00	-0.030		5yr
225	18.37566	121.43620	0.030	0.90	0.870	TS Lawin/ Oct 20, 2016	5yr
226	18.37585	121.43647	0.183	1.00	0.817	TS Lawin/ Oct 20, 2016	5yr
227	18.37581	121.43609	0.060	0.90	0.840	TS Lawin/ Oct 20, 2016	5yr
228	18.38313	121.43069	0.212	1.00	0.788	TS Lawin/ Oct 20, 2016	5yr
229	18.38311	121.42888	0.030	1.00	0.970	TS Lawin/ Oct 20, 2016	5yr
230	18.38173	121.42721	0.030	1.20	1.170	TS Lawin/ Oct 20, 2016	5yr
231	18.38130	121.42695	0.049	2.00	1.951	TS Lawin/ Oct 20, 2016	5yr
232	18.38130	121.42695	0.049	0.50	0.451	Heavy rain	5yr
233	18.38126	121.42693	0.051	2.00	1.949	TS Lawin/ Oct 20, 2016	5yr
234	18.38101	121.42698	0.030	2.00	1.970	TS Lawin/ Oct 20, 2016	5yr
235	18.37325	121.43728	0.030	0.00	-0.030		5yr
236	18.33868	121.42356	8.453	0.00	-8.453		5yr
237	18.36265	121.40428	0.030	0.00	-0.030		5yr
238	18.36159	121.40467	0.030	0.50	0.470	TS Karen/ Oct 17, 2016	5yr
239	18.36249	121.40528	0.076	0.90	0.824	TS Karen/ Oct 17, 2016	5yr
240	18.36249	121.40528	0.076	1.50	1.424	TS Igme/ Aug 18, 2012	5yr
241	18.36249	121.40528	0.076	2.50	2.424	TS Pepang/ Oct 1987	5yr
242	18.36313	121.40666	1.198	0.90	-0.298	TS Karen/ Oct 17, 2016	5yr
243	18.36320	121.40654	0.268	0.90	0.632	TS Karen/ Oct 17, 2016	5yr
244	18.36224	121.40456	0.030	0.00	-0.030		5yr
245	18.36367	121.40394	0.031	0.70	0.669	TS Lawin/ Oct 20, 2016	5yr
246	18.36367	121.40394	0.031	2.50	2.469	TS Pepang/ Oct 1987	5yr
247	18.36358	121.40389	0.060	0.00	-0.060		5yr
248	18.35915	121.40012	0.285	0.50	0.215	TS Karen/ Oct 17, 2016	5yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
249	18.35915	121.40012	0.285	2.00	1.715	TS Igme/ Aug 18, 2012	5yr
250	18.35915	121.40012	0.285	2.50	2.215	TS Pepang/ Oct 1987	5yr
251	18.35968	121.40030	0.030	0.00	-0.030		5yr
252	18.36102	121.40086	0.030	0.00	-0.030		5yr
253	18.36179	121.40234	0.030	0.00	-0.030		5yr
254	18.37843	121.41690	0.031	0.00	-0.031		5yr
255	18.37927	121.41801	0.030	0.00	-0.030		5yr
256	18.37951	121.41923	0.518	2.50	1.982	TS Pepang/ Oct 1987	5yr
257	18.37962	121.41915	0.030	0.90	0.870	TS Igme/ Aug 18, 2012	5yr
258	18.37962	121.41915	0.030	0.50	0.470	TS Lawin/ Oct 20, 2016	5yr
259	18.37962	121.41915	0.030	2.50	2.470	TS Pepang/ Oct 1987	5yr
260	18.37961	121.41908	0.030	0.90	0.870	TS Igme/ Aug 18, 2012	5yr
261	18.37961	121.41908	0.030	0.50	0.470	TS Lawin/ Oct 20, 2016	5yr
262	18.37961	121.41908	0.030	2.50	2.470	TS Pepang/ Oct 1987	5yr
263	18.38326	121.42143	0.708	0.30	-0.408	TS Pepang/ Oct 1987	5yr
264	18.38326	121.42143	0.708	0.30	-0.408	TS Igme/ Aug 18, 2012	5yr
265	18.38326	121.42143	0.708	0.30	-0.408	TS Ondoy/ Sept 2009	5yr
266	18.38474	121.42143	0.031	0.50	0.469	TS Lawin/ Oct 20, 2016	5yr
267	18.38474	121.42143	0.031	0.50	0.469	TS Ineng/ Aug 20-22, 2015	5yr
268	18.38641	121.42204	0.031	0.50	0.469	TS Lawin/ Oct 20, 2016	5yr
269	18.38641	121.42204	0.031	2.50	2.469	TS Igme/ Aug 18, 2012	5yr
270	18.38635	121.42227	0.030	1.00	0.970	TS Lawin/ Oct 20, 2016	5yr
271	18.40121	121.42645	0.030	0.30	0.270	TS Lawin/ Oct 20, 2016	5yr
272	18.40023	121.42669	0.030	0.70	0.670	TS Lawin/ Oct 20, 2016	5yr
273	18.40023	121.42669	0.030	2.50	2.470	TS Pepang/ Oct 1987	5yr
274	18.40023	121.42669	0.030	2.50	2.470	TS Igme/ Aug 18, 2012	5yr
275	18.40158	121.42646	0.057	0.70	0.643	TS Lawin/ Oct 20, 2016	5yr
276	18.40223	121.42664	0.113	0.90	0.787	TS Pepang/ Oct 1987	5yr
277	18.40223	121.42664	0.113	0.60	0.487	TS Lawin/ Oct 20, 2016	5yr
278	18.40223	121.42664	0.113	1.50	1.387	TS Igme/ Aug 18, 2012	5yr
279	18.40518	121.42537	0.030	0.90	0.870	TS Pepang/ Oct 1987	5yr
280	18.40518	121.42537	0.030	0.60	0.570	TS Lawin/ Oct 20, 2016	5yr
281	18.40691	121.42672	0.047	0.50	0.453	TS Lawin/ Oct 20, 2016	5yr
282	18.40579	121.42529	0.772	0.90	0.128	TS Lawin/ Oct 20, 2016	5yr
283	18.40505	121.42546	0.030	0.50	0.470	TS Lawin/ Oct 20, 2016	5yr
284	18.39883	121.42701	0.342	2.00	1.658	TS Lawin/ Oct 20, 2016	5yr
285	18.39883	121.42701	0.342	2.50	2.158	TS Lawin/ Oct 20, 2016	5yr
286	18.39883	121.42701	0.342	2.00	1.658	TS Igme/ Aug 18, 2012	5yr
287	18.39861	121.42697	0.198	0.90	0.702	TS Pepang/ Oct 1987	5yr
288	18.35851	121.40674	0.030	0.50	0.470	TS Lawin/ Oct 20, 2016	5yr
289	18.23315	121.41727	3.907	1.60	-2.307	TS Lawin/ Oct 20, 2016	5yr

Point Number	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
290	18.21552	121.40641	0.031	1.60	1.569	TS Lawin/ Oct 20, 2016	5yr
291	18.21552	121.40641	0.031	1.60	1.569	TS Igme/ Aug 18, 2012	5yr
292	18.21981	121.41405	0.184	1.60	1.416	TS Lawin/ Oct 20, 2016	5yr
293	18.21981	121.41405	0.184	1.60	1.416	TS Igme/ Aug 18, 2012	5yr

Annex 12. Educational Institutions Affected by flooding in Abulog-Apayao Floodplain

Table A-11.1. Educational Institutions Affected by flooding in Abulog-Apayao Floodplain

Apayao				
Flora				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
FLORA CENTRAL SCHOOL	Atok			
SAN JUAN DAY CARE CENTER	Bagutong			
SAN JUAN ELEMENTARY SCHOOL	Bagutong			
SIPA ELEMENTARY SCHOOL	Bagutong			
SIPA-IMELDA NATIONAL HIGH SCHOOL	Bagutong			
BAGUTONG ELEMENTARY SCHOOL	Poblacion West	High	High	High
FLORA NATIONAL HIGH SCHOOL	Tamalunog			
Luna				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
SAN GREGORIO DAY CARE CENTER	Bacsay			
CANGISITAN DAY CARE CENTER	Cangisitan			
CANGISITAN PRIMARY SCHOOL	Cangisitan			
SAN FRANCISCO NATIONAL ARTS AND TRADE HIGH SCHOOL	Cangisitan			Low
SAN SEBASTIAN PRIMARY SCHOOL	Cangisitan	High	High	High
SCHOOL	Cangisitan			
CAPAGAYPAYAN PRIMARY SCHOOL	Capagaypayan		Medium	High
SAN ISIDRO NORTE ELEMENTARY SCHOOL	Capagaypayan		Medium	High
DAGUPAB ELEMENTARY SCHOOL	Dagupan		High	High
DAGUPAN DAY CARE CENTER	Dagupan		High	High
DAGUPAN DAY CARE CENTER	Dagupan			Low
DAGUPAN ELEMENTARY SCHOOL	Dagupan		High	High
DAGUPAN ELEMENTARY SCHOOL	Dagupan		High	High
DAGUPAN SCHOOL	Dagupan		High	High
PALUNGCADA ELEMENTARY SCHOOL	Dagupan		Low	Medium
LAPPA DAY CARE CENTER	Lappa	Medium	Medium	Medium

LUYON DAY CARE CENTER	Luyon	Low	Low	Low
LUNA CENTRAL SCHOOL	Poblacion	Low	Low	Medium
LUNA NATIONAL HIGH SCHOOL	Poblacion	Medium	Medium	Medium
TUROD DAY CARE CENTER	Poblacion			
QUIRINO DAY CARE CENTER	Quirino	Medium	Medium	High
STA. LINA ELEMENTARY SCHOOL	San Francisco	Medium	High	High
APAYAO STATE COLLEGE	San Isidro Sur		Medium	High
QUIRINO ELEMENTARY SCHOOL	San Isidro Sur	Medium	Medium	High
SAN ISIDRO SUR ELEMENTARY SCHOOL	San Isidro Sur		Medium	High
SAN SEBASTIAN DAY CARE CENTER	San Sebastian	High	High	High
SAN SEBASTIAN ELEMENTARY SCHOOL	San Sebastian	High	High	High
SAN SEBASTIAN ELEMENTARY SCHOOL]	San Sebastian	High	High	High
SCHOOL	San Sebastian			
BACSAY ELEMENTARY SCHOOL	Shalom			
BAG-DA NATIONAL HIGH SCHOOL	Shalom			
APAYAO SCIENCE HIGH SCHOOL	Tumog			
LUNA NATIONLA HIGH SCHOOL AN-NEX	Tumog		Low	Low
LUYON DAY CARE CENTER	Zumigui		Low	Low
MARCELO CARIAGA LEARNING CEN-TER	Zumigui	Low	Medium	Medium
ZUMIGUI DAY CARE CENTER	Zumigui			
Pudtol				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
ALEM BARANGAY HALL	Alem	Medium	High	High
ALEM DAY CARE CENTER	Alem	High	High	High
ALEM ELEMENTARY SCHOOL	Alem	High	High	High
CABATACAN DAY CARE CENTER	Alem	High	High	High
CABATACAN ELEMENTARY SCHOOL	Alem	Medium	High	High
IMELDA DAY CARE CENTER	Alem	High	High	High
CAPANNIKIAN ELEMENENTARY SCHOOL	Emilia	High	High	High
CAPANNIKIAN ELEMENTARY SCHOOL	Emilia	High	High	High

AMADO DAY CARE CENTER	Imelda		Medium	High
EMILIA DAY CARE CENTER	Imelda	Low	High	High
PUDTOL CENTRAL SCHOOL	Imelda	Low	Medium	High
PVHS	Imelda			
SAN KUIS DAY CARE CENTER	Imelda		Medium	High
SCHOOL	Imelda			
SCHOOL	Imelda			
Santa Marcela				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
EMILINA ELEMENTARY SCHOOL	Barocboc	Medium	High	High
SANTA MARCELA CENTRAL SCHOOL	Consuelo			
SAN MARIANO ELEMENTARY SCHOOL	Imelda	High	High	High
EMILIANA DAY CARE CENTER	Malekkeg	Low	Medium	High
MALEKKEG ELEMENTARY SCHOOL	Malekkeg		Medium	High
MGATMSAT	Marcela			
PANAY ELEMENTARY SCHOOL	Marcela			
SAN ANTONIO DAY CARE CENTER	Nueva	High	High	High
SAN ANTONIO ELEMENTARY SCHOOL	Nueva	High	High	High
EMILINA ELEMENTARY SCHOOL	San Carlos	High	High	High
BARUCBOC ELEMENTARY SCHOOL	San Mariano	High	High	High
SANTA MARCELA WEST CENTRAL SCHOOL	San Mariano	High	High	High
IMELDA ELEMENTARY SCHOOL	Sipa Proper	High	High	High

Table A-11.2. Educational Institutions Affected by flooding in Abulog-Apayao Floodplain

Cagayan				
Abulug				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
ALINUNU ELEMENTARY SCHOOL	Alinunu	Low	Low	Low
SCHOOL	Alinunu	Low	Low	Low
BAGU ELEMENTARY SCHOOL	Bagu			
BANGUIAN ELEMENTARY SCHOOL	Banguian			Low

DAYCARE CENTER	Banguian			Medium
DUGO ELEMENTARY SCHOOL	Banguian		Low	Low
STA. ROSA ELEMENTARY SCHOOL	Banguian			
CALOG NORTE ELEMENTARY SCHOOL	Calog Norte	Low	Medium	High
DAY CARE CENTER	Calog Norte		High	High
CALOG SUR DAY CARE CENTER	Calog Sur		High	High
FLORENCIO L. VARGAS COLLEGE	Calog Sur		High	High
SCHOOL	Canayun		Low	Medium
SCHOOL	Centro	Low	Low	Low
SAN JULIAN DAY CARE CENTER	Dana-Ili			Low
SAN JULIAN ELEMENTARY SCHOOL	Dana-Ili			Low
STO. TOMAS ELEMENTARY SCHOOL	Dana-Ili			
GUIDDAM DAY CARE CENTER	Guiddam		Medium	High
GUIDDAM ELEMENTARY SCHOOL	Guiddam		Low	High
LIBERTAD DAY CARE CENTER	Libertad	Medium	High	High
LIBERTAD ELEMENTARY SCHOOL	Libertad	Medium	High	High
LIBERTAD NATIONA HIGH SCHOOL	Libertad	Medium	High	High
LIBERTAD NATIONA HIGH SCHOOL GUARDHOUSE	Libertad	Low	Medium	High
SCHOOL	Lucban		Low	Medium
NURSERY SCHOOL	Pinili			Medium
PINILI ELEMENTARY SCHOOL	Pinili			Medium
SAN AGUSTIN DAY CARE CENTER	San Agustin	Medium	Medium	High
SAN AGUSTIN ELEMENTARY SCHOOL	San Agustin	Low	Low	High
SAWANG ELEMENTARY SCHOOL	Siguiran		Low	Low
SCHOOL	Simayung		Low	Medium
DANA ILI ELEMENTARY SCHOOL	Sirit		Low	Low
DIVINE WORD HIGH SCHOOL	Sirit			
SIRIT ELEMENTARY SCHOOL	Sirit			

Allacapan				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
CATARATAN INTEGRATED SCHOOL	Cataratan	Low	Low	Medium

CABAYU ELEMENTARY SCHOOL	Silangan			
CARANNAN BABBAY PRIMARY SCHOOL	Silangan			
SAN JUAN DAY CARE CENTER	Silangan	Low	Medium	Medium
SAN JUAN ELEMENTARY SCHOOL	Silangan			
Ballesteros				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
CABARITAN WEST DAY CARE CENTER	Cabaritan West	Low	Medium	Medium
CABARITAN WEST ELEM SCHOOL	Cabaritan West	Low	Medium	Medium
NARARAGAN DAY CARE CENTER	Nararagan	Low	Low	Low
NARARAGAN ELEMENTARY SCHOOL	Nararagan			
Pamplona				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
ABBANGKERUAN ELEMENTARY SCHOOL	Abanqueruan			
CURVA ELEMENTARY SCHOOL	Curva			
DAVID M. PUZON MEM NARIONAL HIGH SCHOOL	Curva			
SCHOOL	Santa Cruz		Medium	Medium

Annex 13. Health Institutions affected by flooding in Abulog-Apayao Flood Plain

Table A-12.1. Educational Health Institutions affected by flooding in Abulog-Apayao Flood Plain

Apayao				
Flora				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
DISTRICT HOSPITAL	Poblacion West		Low	Low
Luna				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
BARANGAY HEALTH STATION	Bacsay			Medium
DAGUPAN BIRTHING CENTER	Dagupan		Medium	High
LUYON HEALTH CENTER	Luyon	Low	Low	Low
RHU	Poblacion	Low	Low	Medium
FAR NORTH LUZON GENERAL HOSPITAL AND TRAINING CENT	Quirino	Medium	Medium	High
FAR NORTH LUZON GENERAL HOSPITAL AND TRAINING CENT	San Isidro Sur		Low	High
Pudtol				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
CABATACAN HEALTH CENTER	Alem	High	High	High
IMELDA BARANGAY CLINIC	Alem	High	High	High
SWAN RURAL HEALTH CENTER	Emilia	High	High	High
AMA JADSAC HOSPITAL	Imelda	Medium	Medium	Medium
PUDTOL MAIN HEALTH CENTER	Imelda			
Santa Marcela				
Building Name	**Barangay**	**Rainfall Scenario**		
		5-year	**25-year**	**100-year**
BARANGAY HEALTH CENTER	Nueva	High	High	High
DENTAL CLINIC	San Mariano	High	High	High

Table A-12.2. Educational Health Institutions affected by flooding in Abulog-Apayao Flood Plain