HAZARD MAPPING OF THE PHILIPPINES USING LIDAR | PHIL-LIDAR 1

# LiDAR Surveys and Flood Mapping of Dipolog River

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 Program and is to be cited as:

E.C. Paringit and A.E. Milano (eds.) 2017, LiDAR Surveys and Flood Mapping of Dipolog River, Quezon City: University of the Philippines Training Center for Applied Geodesy and Photogrammetry-223pp.



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National Library of the Philippines
ISBN: 978-621-430-073-0

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| | |
|---|---|
| AAC | Asian Aerospace Corporation |
| Ab | abutment |
| ALTM | Airborne LiDAR Terrain Mapper |
| ARG | automatic rain gauge |
| AWLS | Automated Water Level Sensor |
| BA | Bridge Approach |
| BM | benchmark |
| CAD | Computer-Aided Design |
| CN | Curve Number |
| CSRS | Chief Science Research Specialist |
| 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 |
| MCM | |
| MMS | Mobile Mapping Suite |
| MSL | mean sea level |
| NSTC | Northern Subtropical Convergence |
| PAF | Philippine Air Force |
| PAGASA | Philippine Atmospheric Geophysical and Astronomical Services Administration |
| PDOP | Positional Dilution of Precision |
| PPK | Post-Processed Kinematic [technique] |
| PRF | Pulse Repetition Frequency |
| PTM | Philippine Transverse Mercator |
| QC | Quality Check |
| QT | Quick Terrain [Modeler] |
| RA | Research Associate |
| RCBO | River Basin Control Office |
| RIDF | Rainfall-Intensity-Duration-Frequency |
| RMSE | Root Mean Square Error |
| SAR | Synthetic Aperture Radar |
| SCS | Soil Conservation Service |
| SRTM | Shuttle Radar Topography Mission |
| SRS | Science Research Specialist |
| SSG | Special Service Group |
| TBC | Thermal Barrier Coatings |
| MSU-IIT | Mindanao State University - Iligan Institute of Technology |
| UP-TCAGP | University of the Philippines – Training Center for Applied Geodesy and Photogrammetry |
| UTM | Universal Transverse Mercator |
| WGS | World Geodetic System |

# CHAPTER 1: OVERVIEW OF THE PROGRAM AND DIPOLOG RIVER

Enrico C. Paringit, Dr. Eng., Engr. Alan Milano, and Engr. Elizabeth Albiento

## 1.1 Background of the Phil-LIDAR 1 Program

The University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) launched a research program entitled "Nationwide Hazard Mapping using LiDAR" or Phil-LiDAR 1 in 2014, 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 the Rivers in the Philippines Using Airborne LiDAR: Methods (Paringit, et.al., 2017) available separately.

The implementing partner university for the Phil-LiDAR 1 Program is the Mindanao State University – Iligan Institute of Technology (MSU-IIT). MSU-IIT 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 16 river basins in the Northern Mindanao Region. The university is located in Iligan City in the province of Lanao Del Norte.

## 1.2 Overview of the Dipolog River Basin

Dipolog river basin is located in the Northwestern part of the province of Zamboanga del Norte under Region IX, Philippines. The Dipolog river, which traverses Dipolog City, is one of the thirteen (13) river systems in Mindanao region. Its water, according to its beneficial use is categorized as Class B for primary contact recreation and tourism purposes such as bathing, swimming, and skin diving. Dipolog City belongs to the fourth type of climate, mild and moderate where rainfall is more or less evenly distributed throughout the year. It has a generally favorable type of climate. The cool and fresh air from the eastern and highlands mixed with the air from the Sulu Sea creates an invigorating atmosphere for sustained good health. The topography of Dipolog consists mostly of rolling terrain with lowlands along its western coast facing the Sulu Sea. It has a number of waterways, more common of these are the Diwan, Layawan, Katipunan Rivers, Miputak, Gusawan and Olingan creeks. The city has an elevation ranging from zero to 2.5 meters above sea level.

The whole area of the delineated river basin traverses the municipalities of Polanco, Piñan, Mutia, La Libertad, Sergio Osmeña Sr., Don Victoriano Chiongbian and the cities of Dipolog and Dapitan. The basin is bounded on the North by Dapitan City, on the East by the municipality of Polanco, on the South by the municipality of Katipunan and on the West by the Sulu Sea. All of the barangays in Dipolog City are found within the river basin. The said city is composed of 21 barangays including the poblacion, which is divided into 5 barangays districts namely; Barangay District No.1 – Estaka; Barangay District No.2 - Biasong; Barangay District No.3 – Barra; Barangay District No.4 – Central and Barangay District No.5 – Miputak. The barangays are Cogon, Dicayas, Diwan, Galas, Gulayon, Lugdungan, Minaog, Olingan, Punta, Sangkol, San Jose, Sicayab, Sinaman, Sta. Filomena, Sta. Isabel and Turno. All these barangays are found within the river basin and are accessible by barangay, city and national roads from the poblacion. The outlet of the basin, where flow measurements were obtained, is located at the municipality of Polanco, Zamboanga del Norte.

The floodplain area delineated within the basin is 150 sq.km, which is 55.35% of 373.98 sq.km., the whole area of the basin. The DENR RCBO identified the basin to have a draingae area of 471 km2 and an estimated 353 million cubic meters (MCM) annual run-off. The municipalities of Polanco and Piñan; and cities of Dipolog and Dapitan are found within the floodplain, wherein a total of 15,500 features were extracted.

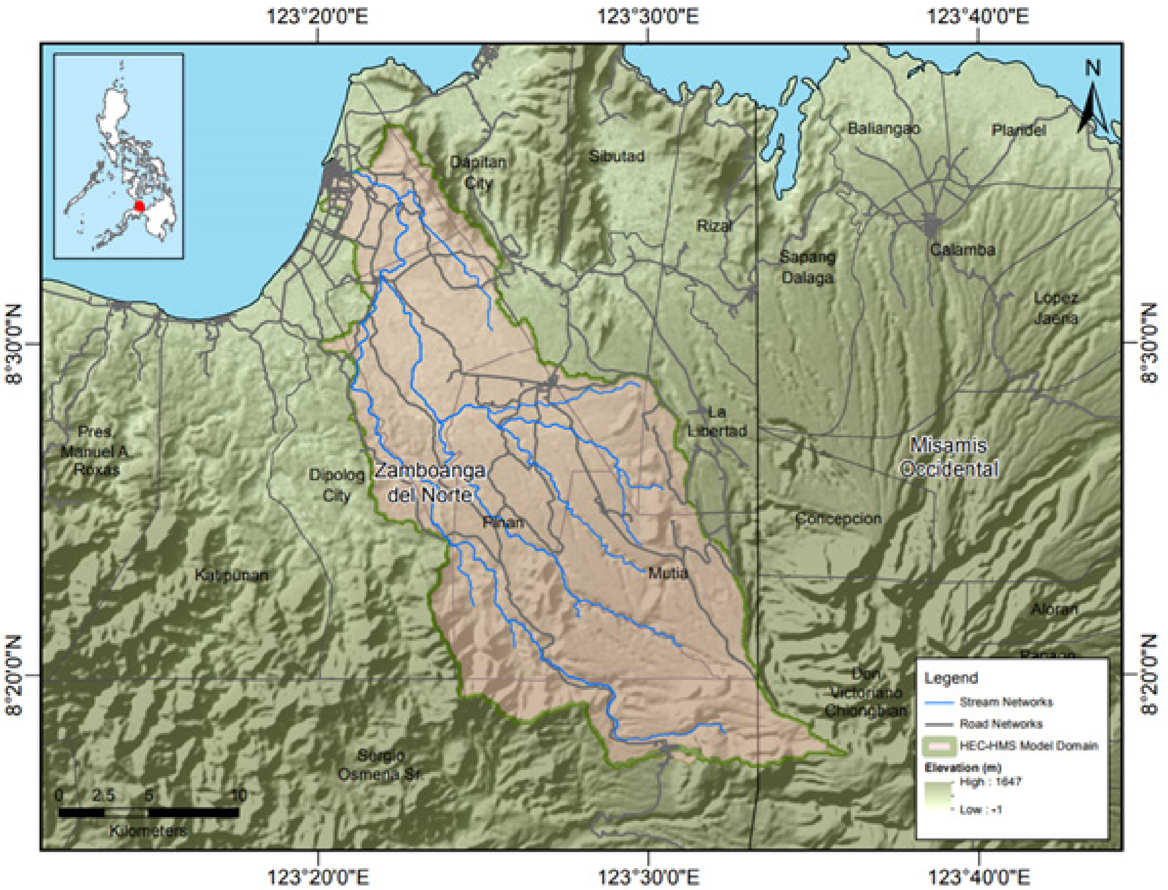



Figure 1. Map of Dipolog River Basin (in brown)

A flooding incident in Dipolog happened last January 2013 due to heavy rains caused by tropical depression Auring. At least 90 families have evacuated their homes in Dipolog City because of this. NDRRMC executive director, Dir. Benito Ramos, told INQUIRER.net that the residents fled as Lubungan River in San Jose village swelled. "In some areas, the floodwaters reached neck-deep level that's why residents were being evacuated to safer grounds," Ramos said. Knee-deep floodwaters also forced the local government units to close the main highways and a bridge in the municipality of Katipunan and other nearby towns in Zamboanga del Norte, Ramos added. It was also reported that some roads were also impassable and one bridge was destroyed due to the floods. This news published by Inquirer on January 3, 2013 reported that there were no casualties as of latest (Philippine Daily Inquirer 2013).

On the same year, GMA network published online news last February 1, which reported that 9,465 people were affected by floods that hit part of Zamboanga del Norte in Mindanao on January 31, 2013. According to the National Disaster Risk Reduction & Management Council (NDRRMC), continuous rainfall caused the river banks along the Polanco National Highway's Guilles section to overflow at 0.8 meter. They added that the river in San Jose in Dipolog City reached critical level. The affected areas reported were: Dipolog City particularly San Jose, Olingan, Diwan, Lugdungan, Punta, Dicayas, Gulayon, and Turno villages; Polanco town, particularly: barangays Pian, Poblacion South, Labrador, Guinies, Obay, Anastacio, Villahermosa, Lingasad, ang Poblacion North; and Katipunan town: Basagan village. The affected families in Barangay Dcayas were evacuated to the barangay hall, while the other families were brought to the nearby schools and to higher ground. Furthermore, at least 32 people from Barangay San Antonio in Katipunan town were rescued. Generally, the NDRRMC said the floods affected 1,855 families or 9,465 people and 422 hectares of agriculture (LBG, GMA News 2013).

Another flood related incident happened on 2016 in Dipolog City. ABS-CBN News posted an article on December 5, 2016 that a total of 398 families were affected by flooding in the city over the weekend. Residents of Barangays Lugdungan, Turno, Estaka, Minaog, Dicayas, Sta. Isabel and Biasong were affected by floods brought about by non-stop rains in the city. City Disaster Risk Reduction and Management Officer, Thata Manguila said the affected areas are low lying barangays located near the river. CDRRMO called for pre-emptive evacuation on Sunday afternoon as the water continues to rise. There are some individuals, however, who refused to evacuate. Residents also returned to their homes early Monday that time. CDRRMO has yet to assess the amount of damage on property according to the report (ABS-CBN News, 2016).

# CHAPTER 2: LIDAR ACQUISITION IN DIPOLOG FLOODPLAIN

Engr. Louie P. Balicanta, Engr. Christopher Cruz, Lovely Gracia Acuña, Engr. Gerome Hipolito, Ms. Julie Pearl S. Mars, and Ms. Kristine Joy P. Andaya

## 2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Dipolog floodplain in Zamboanga del Norte. These missions were planned for 14 lines and ran for at most four and a half (4.5) hours including take-off, landing and turning time. The flight planning parameters for the LiDAR system is found in Table 1. Figure 2 shows the flight plans for Dipolog floodplain.

Table 1. Flight planning parameters for Pegasus LiDAR system

| Block Name | Flying Height (AGL) | Overlap (%) | Field of View | Pulse Repetition Frequency (PRF) (kHz) | Scan Fre-quency | Average Speed | Average Turn Time (Minutes) |
|---|---|---|---|---|---|---|---|
| BLK69A | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| BLK69B | 750/800/ 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| BLK69C | 750/800/ 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| BLK69D | 800/1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| BLK70A | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| BLK70B | 850/1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| BLK70C | 850 | 30 | 50 | 200 | 30 | 130 | 5 |

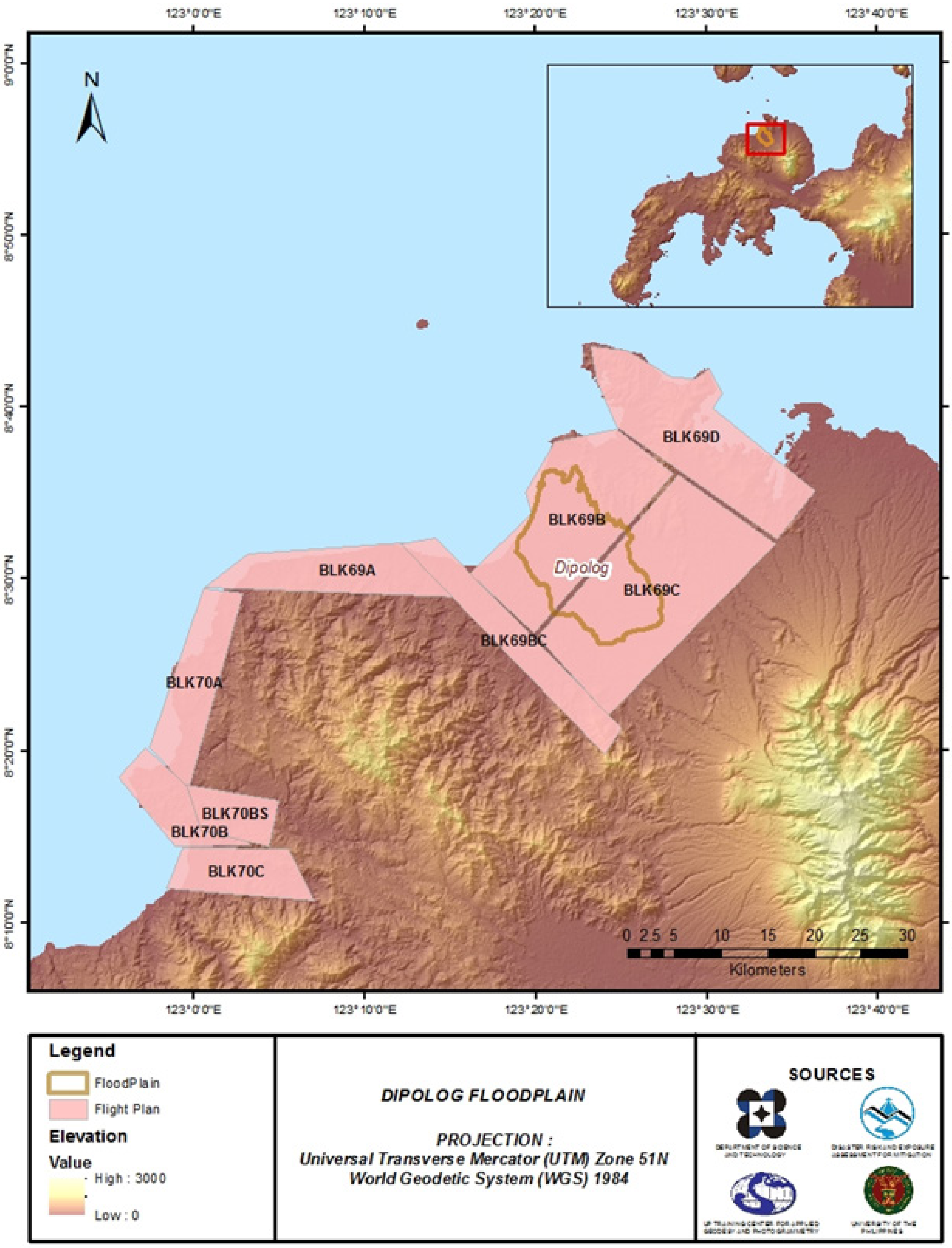



Figure 2. Flight plan used for Dipolog Floodplain.

## 2.2 Ground Base Station

The project team was able to recover five (5) NAMRIA ground control points: ZGN-138, ZGN-132, ZGN-137, ZGN-60 and MSW-05 which are of second (2nd) order accuracy and five (5) bench mark points: ZN-53, ZN-74, ZN-52, ZN-11 and ZN-123.

The certifications for the NAMRIA reference points and processing report for the established points are found in Annex 2, while the baseline processing reports for the established control points are found in Annex 3. These were used as base stations during flight operations for the entire duration of the survey (October 8-November 11, 2014; February 4-March 4, 2016; November 18-December 2, 2016). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 882, SPS 852, SPS 985 and Topcon GR-5. Flight plans and location of base stations used during the aerial LiDAR acquisition in Dipolog floodplain are shown in Figure 3. Annex 4 shows the list of team members.

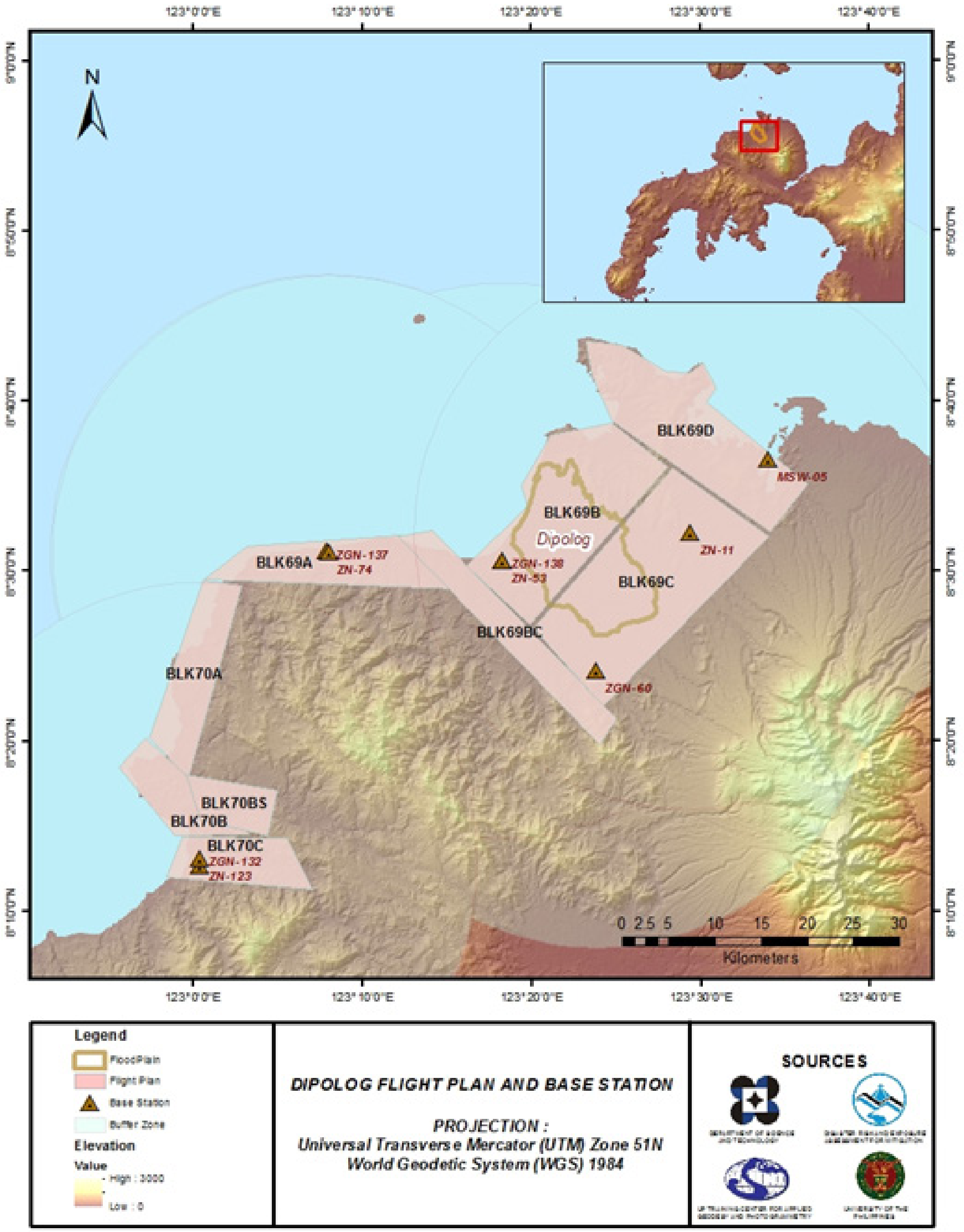



Figure 3. Flight plans and base stations for Dipolog Floodplain.

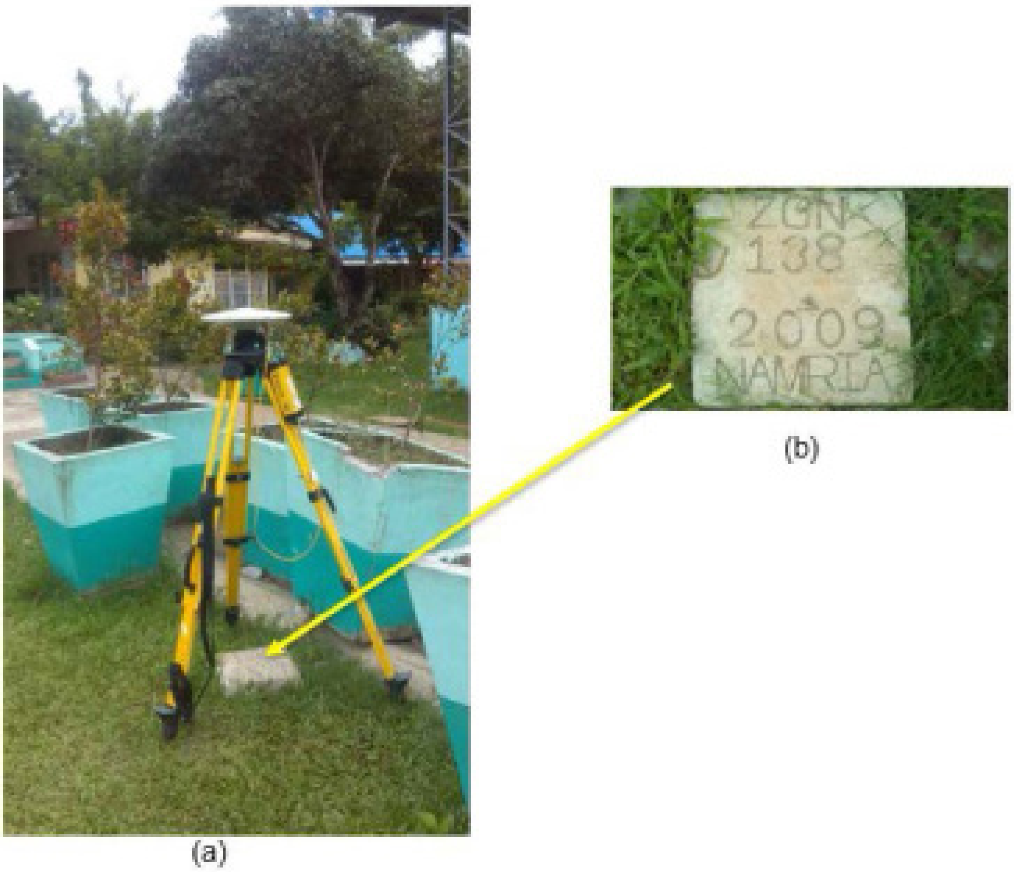



Figure 4. GPS set-up over ZGN-138 (a) in Katipunan Zamboanga del Norte and NAMRIA reference point ZGN-138 (b) as recovered by the field team.

Table 2. Details of the recovered NAMRIA horizontal control point ZGN-138 used as base station for the LiDAR Acquisition.

| **Station Name** | **ZGN-138** | |
|---|---|---|
| **Order of Accuracy** | **2rd** | |
| **Relative Error (horizontal positioning)** | **1 in 50,000** | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 8° 30’ 40.65974”North<br>122° 18’ 14.44217”East<br>6.715 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92) | Easting<br>Northing | 533471.036 meters<br>941106.14 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 8° 30’ 36.94779” North<br>123° 18’ 19.85548”East<br>70.925 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984) | Easting<br>Northing | 533459.32 meters<br>940776.74 meters |

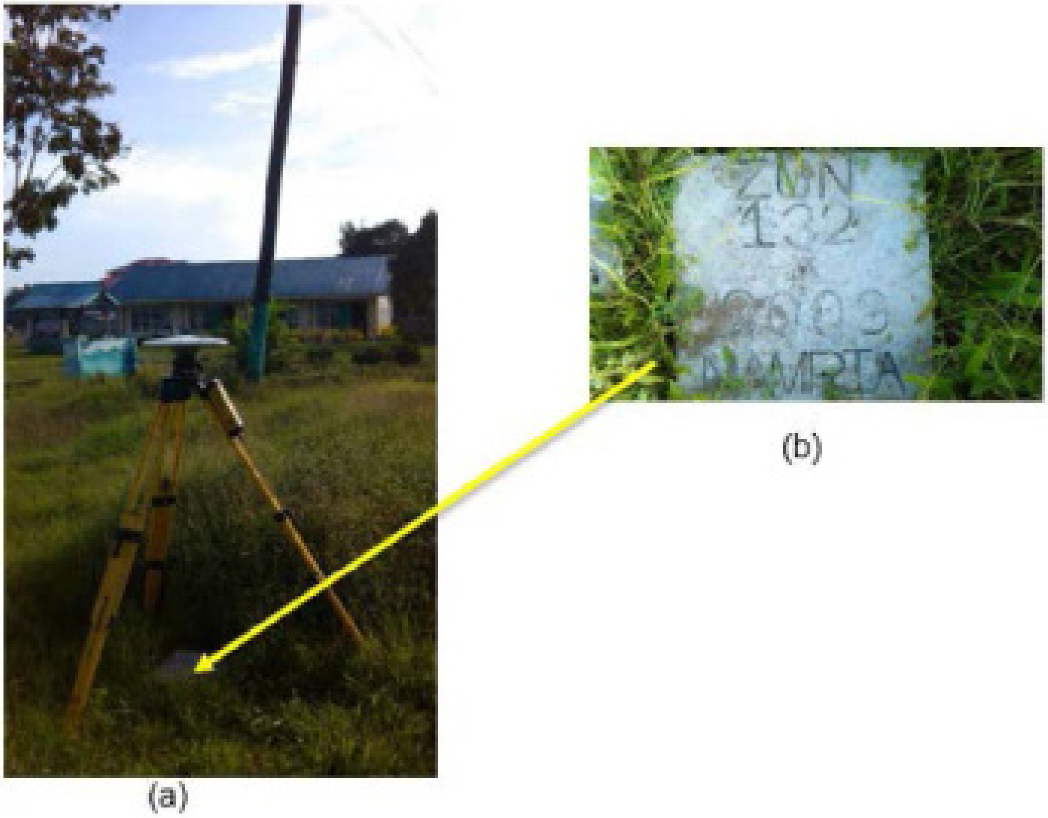



Figure 5. GPS set-up over ZGN-132 (a) in Brgy. Mandih, Sindangan, Zamboanga del Norte and NAMRIA reference point ZGN-132 (b) as recovered by the field team.

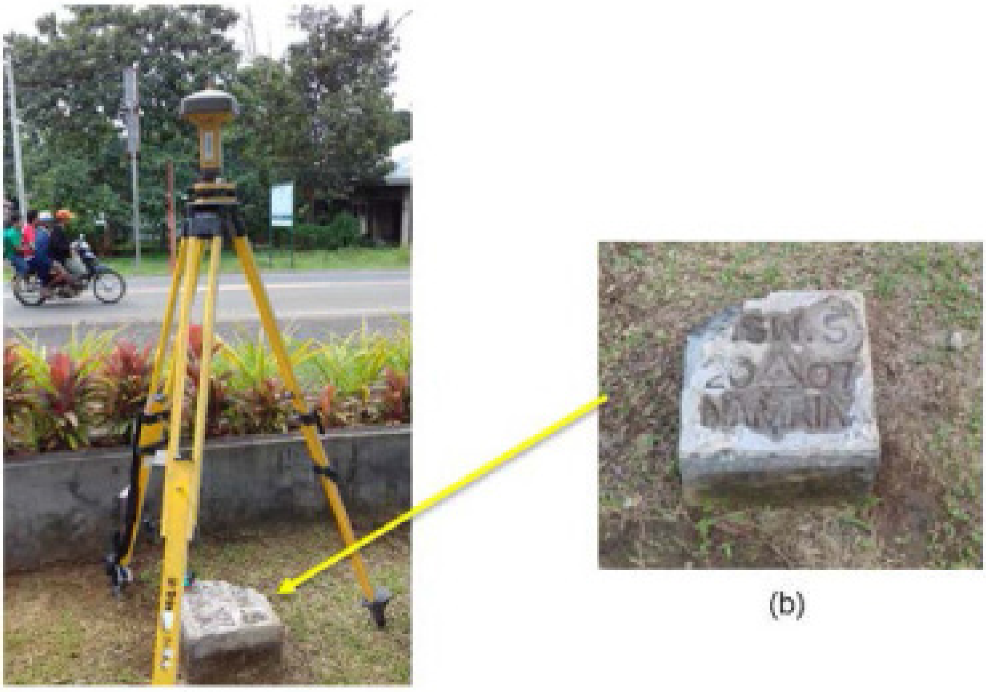
Table 3. Details of the recovered NAMRIA horizontal control point ZGN-132 used as base station for the LiDAR Acquisition.

| Station Name | ZGN-132 | |
|---|---|---|
| Order of Accuracy | 2rd | |
| Relative Error (horizontal positioning) | 1 in 50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 8° 12’ 44.29460” North<br>123° 0’ 19.12667” East<br>11.502 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 4 (PTM Zone 5 PRS 92) | Easting<br>Northing | 500585.398 meters<br>908029.029 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 8° 12’ 40.63408” North<br>123° 0’ 24.56923”East<br>75.58 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRD 1992) | Easting<br>Northing | 500585.18 meters<br>907.711.20 meters |


Figure 6. GPS set-up over ZGN-60 (a) in Layawan Bridge, Brgy. San Pedro, Polanco, Zamboanga del Norte and NAMRIA reference point ZGN-60 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point ZGN-60 used as base station for the LiDAR Acquisition.

| Station Name | MSW-05 | |
|---|---|---|
| Order of Accuracy | 2rd | |
| Relative Error (horizontal positioning) | 1 in 50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 8° 32’ 35.68185” North<br>123° 33’ 56.01853” East<br>113.481 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 4 (PTM Zone 5 PRS 92) | Easting<br>Northing | 562262.537 meters<br>944671.948 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 8° 32’ 31.98501” North<br>123° 34’ 1.42685”East<br>178.247 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRD 1992) | Easting<br>Northing | 562240.75 meters<br>944341.30 meters |



(a) (b)

Figure 7. GPS set-up over MSW-05 (a) in Sapang Dalaga, Misamis Occidental and NAMRIA reference point MSW-05 (b) as recovered by the field team.

Table 5. Details of the recovered NAMRIA horizontal control point MSW-05 used as base station for the LiDAR Acquisition.

| Station Name | MSW-05 | |
|---|---|---|
| Order of Accuracy | 2rd | |
| Relative Error (horizontal positioning) | 1 in 50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 8° 32’ 35.68185” North<br>123° 33’ 56.01853” East<br>113.481 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 4 (PTM Zone 5 PRS 92) | Easting<br>Northing | 562262.537 meters<br>944671.948 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 8° 32’ 31.98501” North<br>123° 34’ 1.42685”East<br>178.247 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRD 1992) | Easting<br>Northing | 562240.75 meters<br>944341.30 meters |

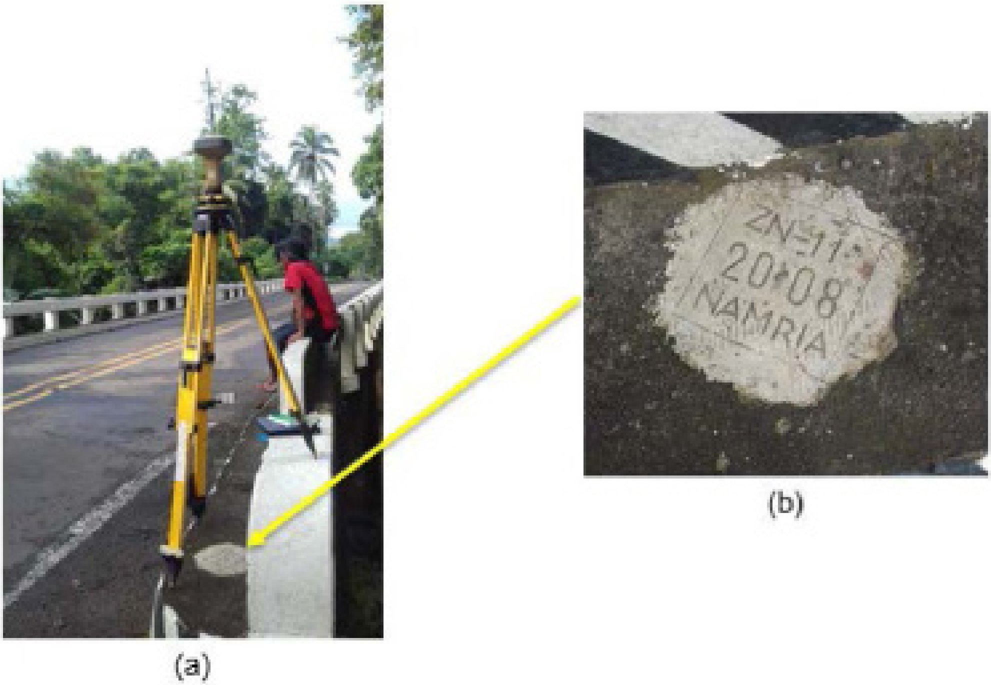



Figure 8. GPS set-up over ZN-11 at Potungan Bridge, Dapitan, Zamboanga del Norte (a) reference point ZN-11 (b) as established by the field team.

Table 6. Details of the established point ZN- 11 used as base station for the LiDAR Acquisition.

| Station Name | ZN-11 | |
|---|---|---|
| **Order of Accuracy (benchmark)** | **2nd** | |
| **Elevation (horizontal positioning)** | **1:50,000** | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 8°32'19.31150" North<br>123°29'19.41683" East<br>21.953 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 8°32'15.60892" North<br>123°29'24.82623" East<br>86.565 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92) | Easting<br>Northing | 553,785.501 meters<br>943,827.025 meters |


(a) (b)

Figure 9. GPS set-up over ZN-53 at Brgy. Daanglungsod, Katipunan, Zamboanga del Norte (a) reference point ZN-53 (b) as established by the field team.

Table 7. Details of the established point ZN- 53 used as base station for the LiDAR Acquisition.

| Station Name | ZN-53 | |
|---|---|---|
| Order of Accuracy (benchmark) | 2nd | |
| Elevation (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 8°30’41.04428” North<br>123°18’14.33457” East<br>7.072 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 8°30’37.33230” North<br>123°18’19.74787” East<br>71.282 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92) | Easting<br>Northing | 533456.022 meters<br>940788.542 meters |

Table 8. Details of the recovered NAMRIA horizontal control point ZGN-137 used as base station for the LiDAR Acquisition.

| Station Name | ZGN-137 | |
|---|---|---|
| Order of Accuracy | 2rd | |
| Relative Error (horizontal positioning) | 1 in 50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 8° 31' 13.43575" North<br>123° 07' 49.35667" East<br>7.151 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 4 (PTM Zone 5 PRS 92) | Easting<br>Northing | 514353.819 meters<br>942102.244 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 8° 31' 09.70588" North<br>123° 07' 54.77045"East<br>70.912 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984) | Easting<br>Northing | 562240.75 meters<br>944341.30 meters |

Table 9. Details of the recovered NAMRIA horizontal control point ZN-74 used as base station for the LiDAR Acquisition.

| Station Name | ZN-74 | |
|---|---|---|
| Order of Accuracy (benchmark) | 2nd | |
| Elevation (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 8°31'09.41014" North<br>123°07'56.70026" East<br>10.249 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 8°31'05.68075" North<br>123°08'02.11413" East<br>74.017 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92) | Easting<br>Northing | 514573.340 meters<br>941648.951 meters |

Table 10. Details of the recovered NAMRIA horizontal control point ZN-123 used as base station for the LiDAR Acquisition.

| Station Name | ZN-123 | |
|---|---|---|
| Order of Accuracy (benchmark) | 2nd | |
| Elevation (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 8°13'08.18558" North<br>123°00'19.36053" East<br>10.101 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 8°13'04.52332" North<br>123°00'24.80249" East<br>74.166 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 92) | Easting<br>Northing | 500592.329 meters<br>908444.828 meters |

Table 11. Ground control points used during LiDAR data acquisition

| Date Surveyed | Flight Number | Mission Name | Ground Control Points |
|---|---|---|---|
| October 22, 2014 | 2111P | 1BLK69B295A | ZGN-138 and ZN-53 |
| October 23, 2014 | 2113P | 1BLK69B296A | ZGN-138 and ZN-53 |
| October 24, 2014 | 2117P | 1BLK69B297A | ZGN-138 and ZN-53 |
| October 26, 2014 | 2125P | 1BLK69C299A | ZGN-138 and ZN-53 |
| October 26, 2014 | 2127P | 1BLK6970A299B | ZGN-138 and ZN-53 |
| October 31, 2014 | 2145P | 1BLk69C304A | ZGN-138 and ZN-53 |
| November 1, 2014 | 2149P | 1BLK70B305A | ZGN-137 and ZN-74 |
| November 8, 2014 | 2177P | 1BLK70C312A | ZGN-132 and ZN-123 |
| February 21, 2016 | 23120P | 1BLK69D052A | ZGN-60 |
| February 22, 2016 | 23124P | 1BLK69AB053A | ZGN-60 |
| November 20, 2016 | 23558P | 1BLK69BC325A | MSW-05 and ZN-11 |
| November 21, 2016 | 23562P | 1BLK69BD326A | MSW-05 and ZN-11 |

## 2.3 Flight Missions

Twelve (12) missions were conducted to complete LiDAR data acquisition in Dipolog Floodplain, for a total of 42 hours and 31 minutes (42+31) of flying time for RP-C9022. All missions were acquired using the Pegasus system (See Annex 6). Table 12 shows the total area of actual coverage per mission and the flying hours per mission and Table 13 presents the actual parameters used during the LiDAR data acquisition.

Table 12. Flight missions for LiDAR data acquisition in Dipolog 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 |
| October 22, 2014 | 2111P | 219.61 | 177.11 | 58.92 | 118.19 | 578 | 4 | 5 |
| October 23, 2014 | 2113P | 196.35 | 164.11 | 10.9 | 153.21 | 514 | 3 | 35 |
| October 24, 2014 | 2117P | 146.69 | 109.93 | 0 | 109.93 | 323 | 3 | 23 |
| October 26, 2014 | 2125P | 291.99 | 106.67 | 32.26 | 74.41 | 475 | 2 | 5 |
| October 26, 2014 | 2127P | 127.95 | 121.41 | 0 | 121.41 | 295 | 1 | 17 |
| October 31, 2014 | 2145P | 177.1 | 154.73 | 60.6 | 94.13 | 675 | 3 | 17 |
| November 1, 2014 | 2149P | 157.48 | 200.43 | 0 | 200.43 | 446 | 3 | 17 |
| November 8, 2014 | 2177P | 131.76 | 134.3 | 0 | 134.3 | 404 | 3 | 29 |
| February 21, 2016 | 23120P | 227.63 | 167.99 | 18.59 | 149.4 | 392 | 4 | 30 |
| February 22, 2016 | 23124P | 123.34 | 124.91 | 29.23 | 95.68 | NA | 4 | 35 |
| November 20, 2016 | 23558P | 163.59 | 142.5 | 45.84 | 96.66 | NA | 4 | 29 |
| November 21, 2016 | 23562P | 152.77 | 193.37 | 37.65 | 155.72 | NA | 4 | 29 |
| TOTAL | | 2116.26 | 1620.35 | 293.99 | 1503.47 | 4102 | 42 | 31 |

Table 13. Actual parameters used during LiDAR data acquisition.

| Flight Number | Flying Height (AGL) | Overlap (%) | Field of View (θ) | Pulse Repetition Frequency (PRF) (kHz) | Scan Frequency (Hz) | Average Speed (kts) | Average Turn Time (Minutes) |
|---|---|---|---|---|---|---|---|
| 2111P | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| 2113P | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| 2117P | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| 2125P | 800 | 30 | 50 | 200 | 30 | 130 | 5 |
| 2127P | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| 2145P | 750 | 30 | 50 | 200 | 30 | 130 | 5 |
| 2149P | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| 2177P | 850 | 30 | 50 | 200 | 30 | 130 | 5 |
| 23120P | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| 23124P | 1000 | 30 | 50 | 200 | 30 | 130 | 5 |
| 23558P | 800 | 30 | 50 | 200 | 30 | 130 | 5 |
| 23562P | 800 | 30 | 50 | 200 | 30 | 130 | 5 |

## 2.4 Survey Coverage

Dipolog floodplain is located in the province of Zamboanga del Norte with the floodplain situated within the municipalities of Dapitan City, Dipolog City, Pinan, and Polanco. The list of municipalities and cities surveyed with at least one (1) square kilometer coverage, is shown in Table 14. The actual coverage of the LiDAR acquisition for Dipolog floodplain is presented in Figure 10. Annex 7 shows the flight status reports.

Table 14. List of municipalities and cities surveyed in Dipolog Floodplain LiDAR survey.

| Province | Municipality/City | Area of Municipality/City (km2) | Total Area Surveyed (km2) | Percentage of Area Surveyed |
|---|---|---|---|---|
| Misasmis Occidental | Baliangao | 58.16 | 3.98 | 7% |
| | Sapang Dalaga | 85.68 | 25.13 | 29% |
| Zamboanga del Norte | Dapitan City | 222.95 | 214.26 | 96% |
| | Dipolog City | 184.42 | 143.45 | 78% |
| | Jose Dalman | 182.76 | 37.36 | 20% |
| | Katipunan | 189.62 | 64.06 | 34% |
| | La Libertad | 66.24 | 21.81 | 33% |
| | Manukan | 222.49 | 57.41 | 26% |
| | Pinan | 135.87 | 63.33 | 47% |
| | Polanco | 86.49 | 85.24 | 99% |
| | Pres. Manuel A. Roxas | 163.6 | 42.94 | 26% |
| | Rizal | 61.97 | 51.94 | 84% |
| | Sergio Osmena Sr. | 461.22 | 3.73 | 1% |
| | Siayan | 461.46 | 26.01 | 6% |
| | Sibutad | 75.69 | 72.27 | 95% |
| | Sindangan | 295.62 | 135.74 | 46% |
| Total | | 2954.24 | 1048.66 | 35.50% |

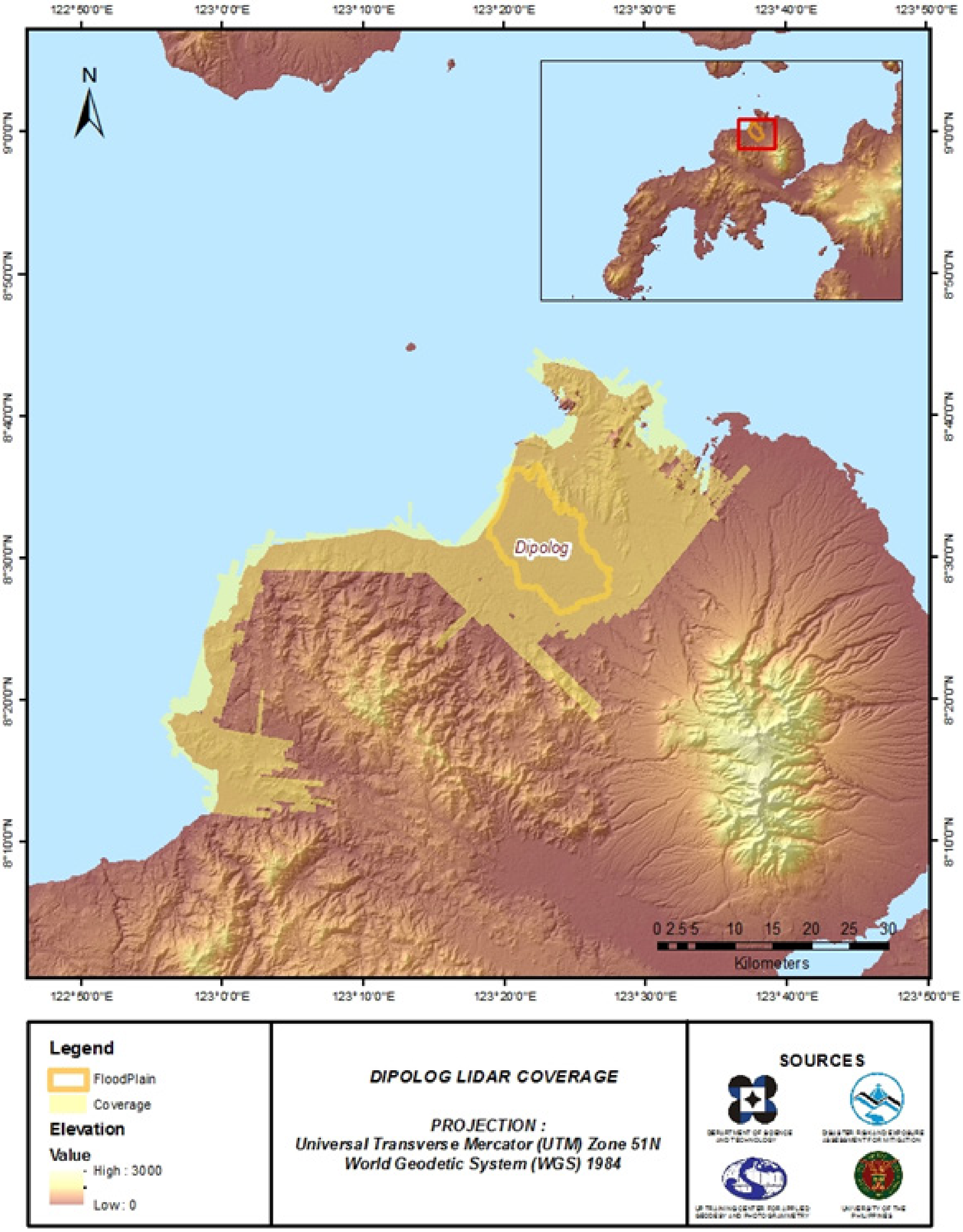



Figure 10. Actual LiDAR data acquisition for Dipolog Floodplain.

# CHAPTER 3: LIDAR DATA PROCESSING FOR DIPOLOG FLOODPLAIN

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## 3.1 Overview of LiDAR Data Pre-Processing

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

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

These processes are summarized in the flowchart shown in Figure 11.

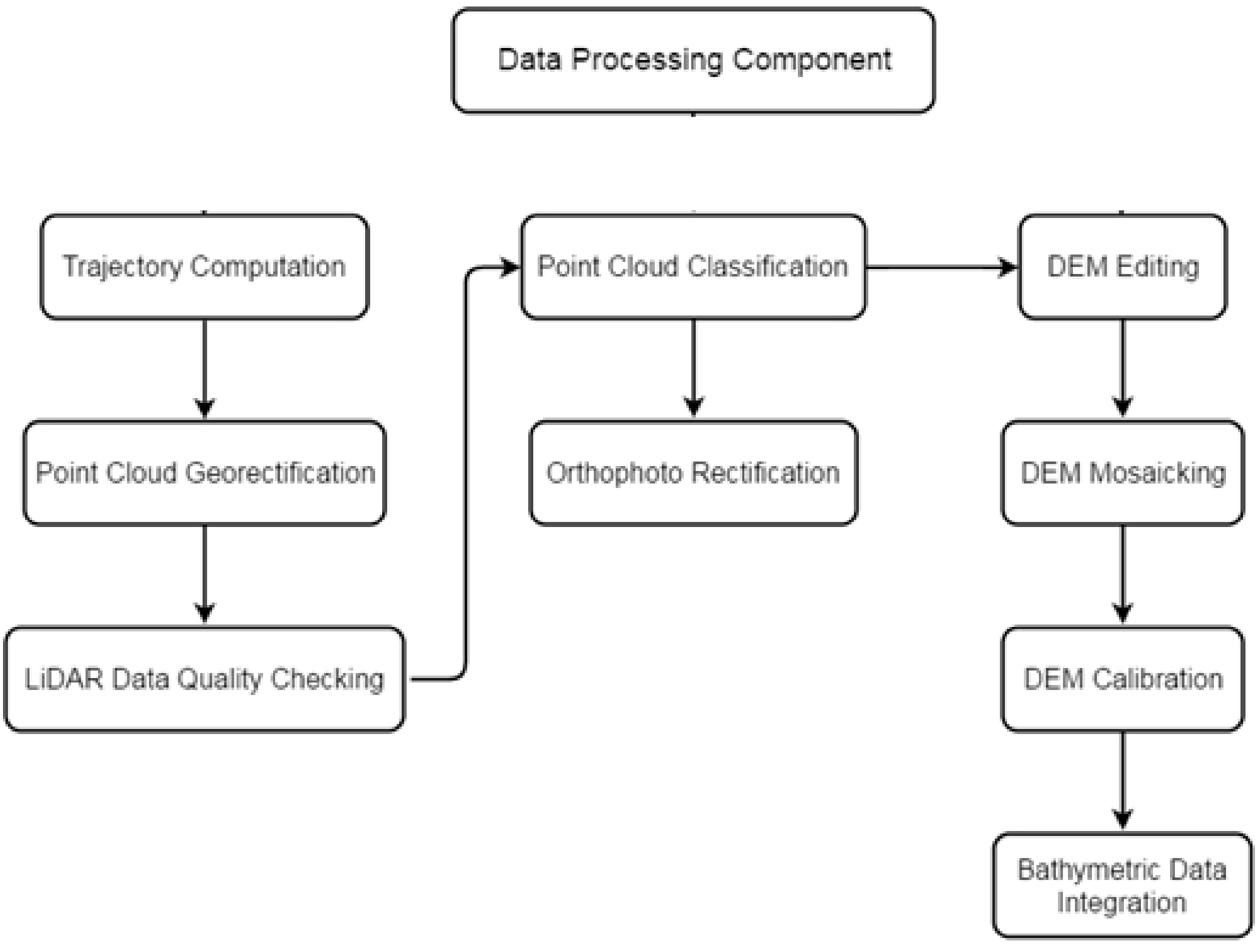


Figure 11. Schematic Diagram for Data Pre-Processing Component

## 3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Dipolog floodplain can be found in Annex 5. Missions flown during the first survey and second survey conducted on November 2014 and March 2016 both used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system over Dipolog, Polanco and Piñan, Zamboanga del Norte.The Data Acquisition Component (DAC) transferred a total of 244.20 Gigabytes of Range data, 2.59 Gigabytes of POS data, 561.40 Megabytes of GPS base station data, and 258.80 Gigabytes of raw image data to the data server on November 17, 2014 for the first survey and March 7, 2016 for the second survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Dipolog was fully transferred on March 10, 2016, as indicated on the Data Transfer Sheets for Dipolog floodplain.

## 3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for flight 2177P, one of the Dipolog flights, which is the North, East, and Down position RMSE values are shown in Figure 12. 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 17, 2014 00:00AM. The y-axis is the RMSE value for that particular position.

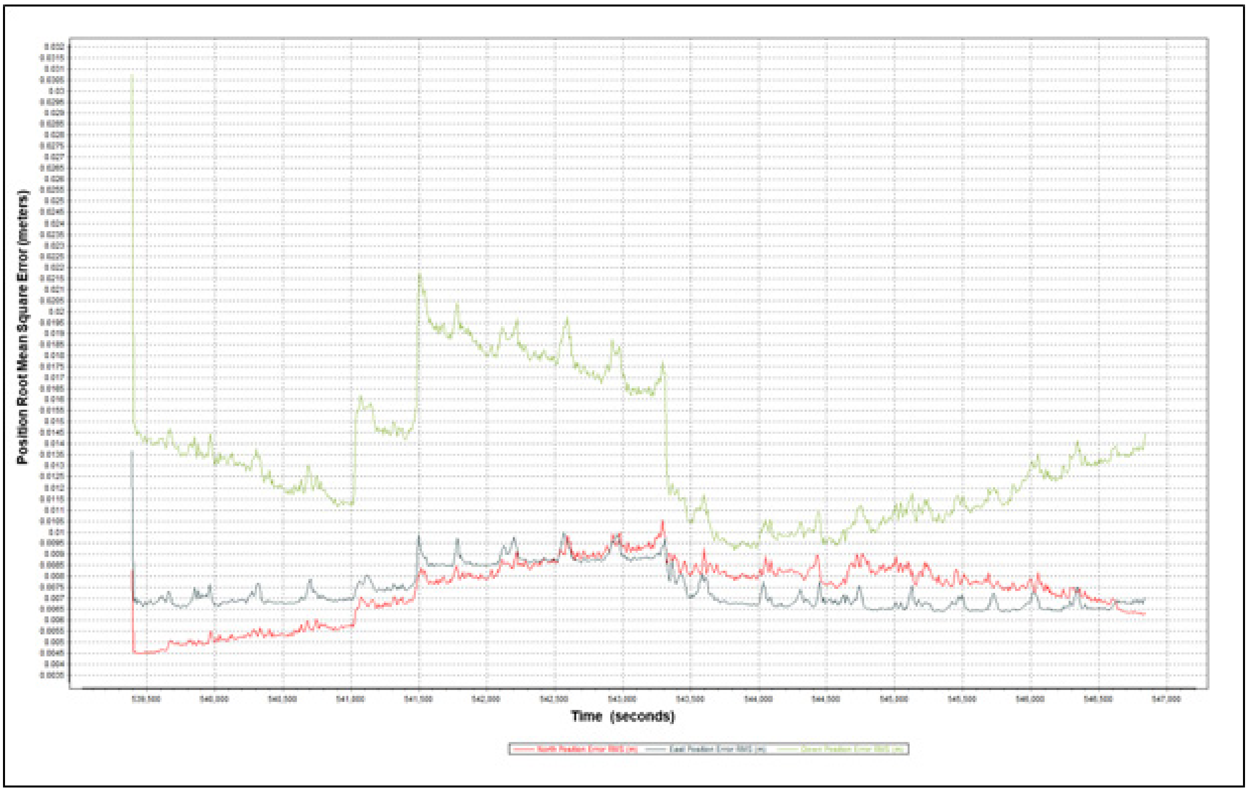


Figure 12. Smoothed Performance Metrics of a Dipolog Flight 2177P.

The time of flight was from 539,400 seconds to 546,800 seconds, which corresponds to morning of November 17, 2014. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 11 shows that the North position RMSE peaks at 1.05 centimeters, the East position RMSE peaks at 1.00 centimeters, and the Down position RMSE peaks at 2.20 centimeters, which are within the prescribed accuracies described in the methodology.

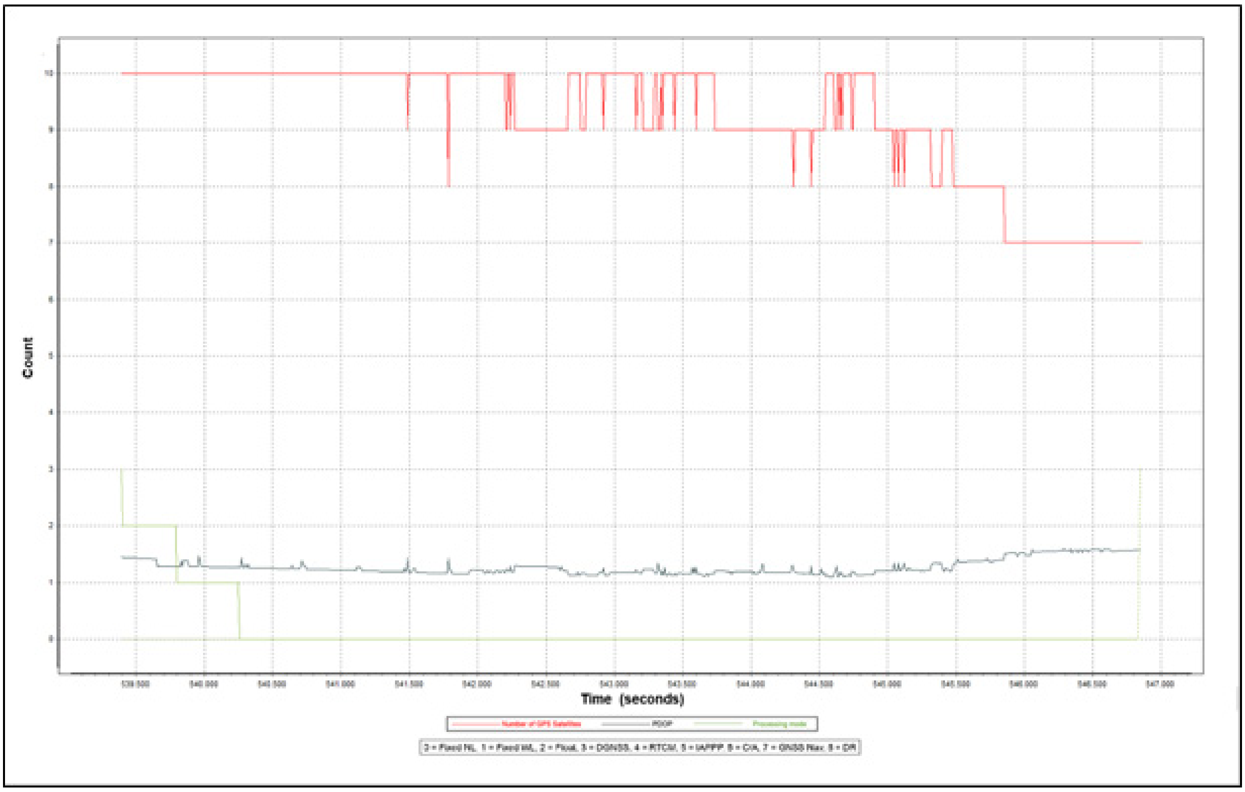


Figure 13. Solution Status Parameters of Dipolog Flight 2177P.

The Solution Status parameters of flight 2177P, one of the Dipolog flights, which indicate the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 13. The graphs indicate that the number of satellites during the acquisition did not go down to 6. Most of the time, the number of satellites tracked was between 7 and 10. The PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode remained at 0 for majority of the survey with some peaks up to 1 attributed to the turns performed by the aircraft. The value of 0 corresponds to a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters adhered to the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Dipolog flights is shown in Figure 14.

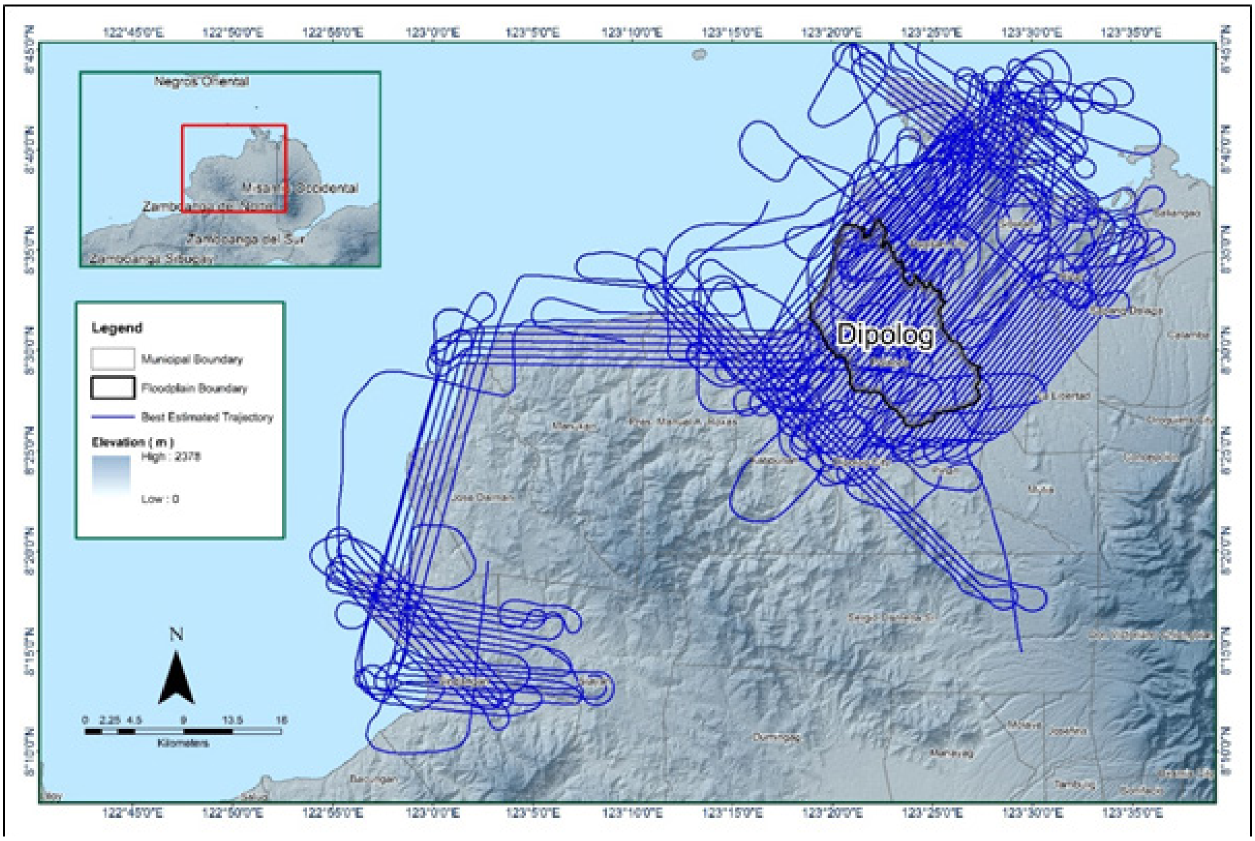


Figure 14. Best estimated trajectory of the LiDAR missions conducted over the Dipolog Floodplain.

## 3.4 LiDAR Point Cloud Computation

The produced LAS data contains 229 flight lines, with each flight line containing two channels, since the Pegasus system contains two channels. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Dipolog floodplain are given in Table 15.

Table 15. Self-Calibration Results values for Dipolog flights

| Parameter | Acceptable Value | Value |
|---|---|---|
| Boresight Correction stdev | (<0.001degrees) | 0.000 |
| IMU Attitude Correction Roll and Pitch Corrections stdev | (<0.001degrees) | 0.001 |
| GPS Position Z-correction stdev | (<0.01meters) | 0.009 |

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

## 3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data is shown in Figure 15. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

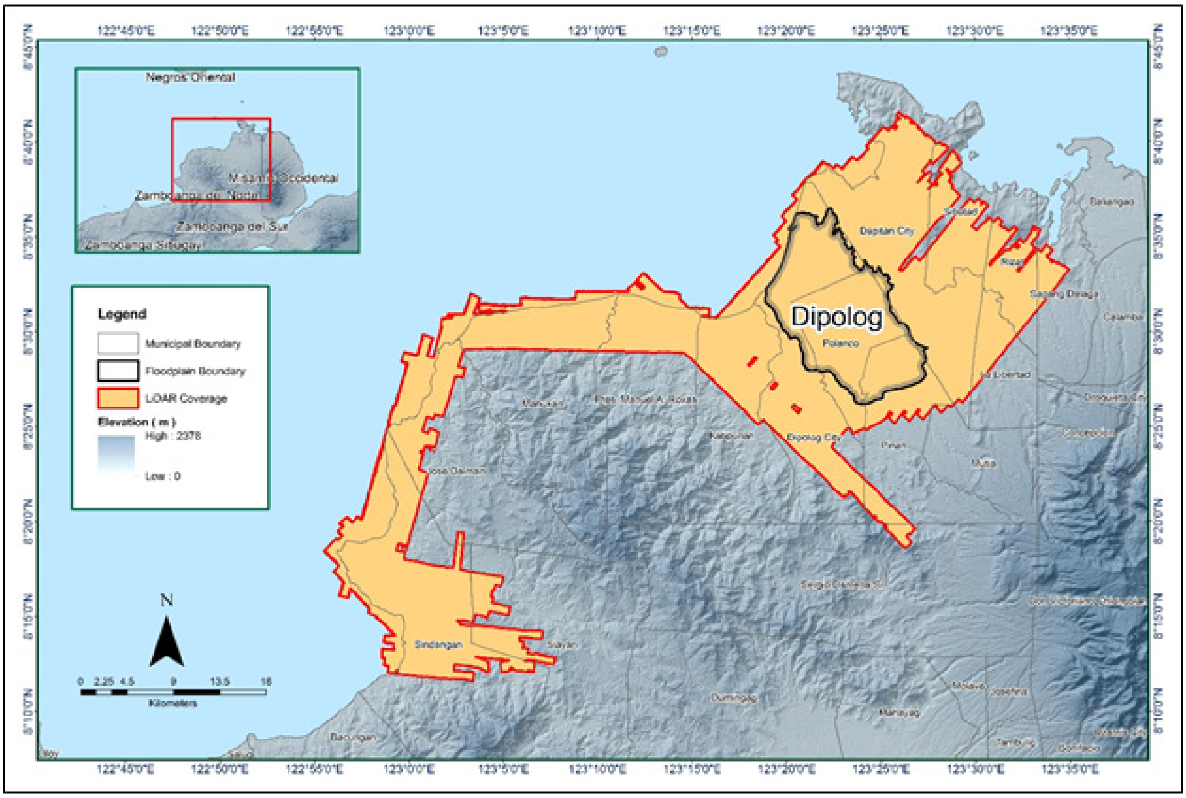


Figure 15. Boundary of the processed LiDAR data on top of a SAR Elevation Data over Dipolog Floodplain.

The total area covered by the Dipolog missions is 1,503.16 sq.km that is comprised of twelve (12) flight acquisitions grouped and merged into nine (9) blocks as shown in Table 16.

Table 16. List of LiDAR blocks for Dipolog Floodplain.

| LiDAR Blocks | Flight Numbers | Area (sq. km) |
|---|---|---|
| Pagadian_Blk69A | 23124P | 117.93 |
| Pagadian_Blk69D | 23120P | 166.98 |
| Dipolog_Blk69ABC | 2117P | 104.48 |
| Dipolog_Blk69A | 2127P | 115.82 |
| Dipolog_Blk69B | 2111P | 345.02 |
| | 2113P | |
| | 2145P | |
| Dipolog_Blk69C | 2125P | 92.17 |
| Dipolog_Blk70ABC | 2177P | 263.45 |
| | 2149P | |
| Dipolog_reflights_Blk69B | 23558P | 141.49 |
| Dipolog_reflights_Blk69D | 23562P | 155.82 |
| TOTAL | | 1,503.16 sq.km |

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location is shown in Figure 16. Since the Pegasus system employs two channels, we would expect an average value of 2 (blue) for areas where there is limited overlap, and a value of 3 (yellow) or more (red) for areas with four or more overlapping flight lines.

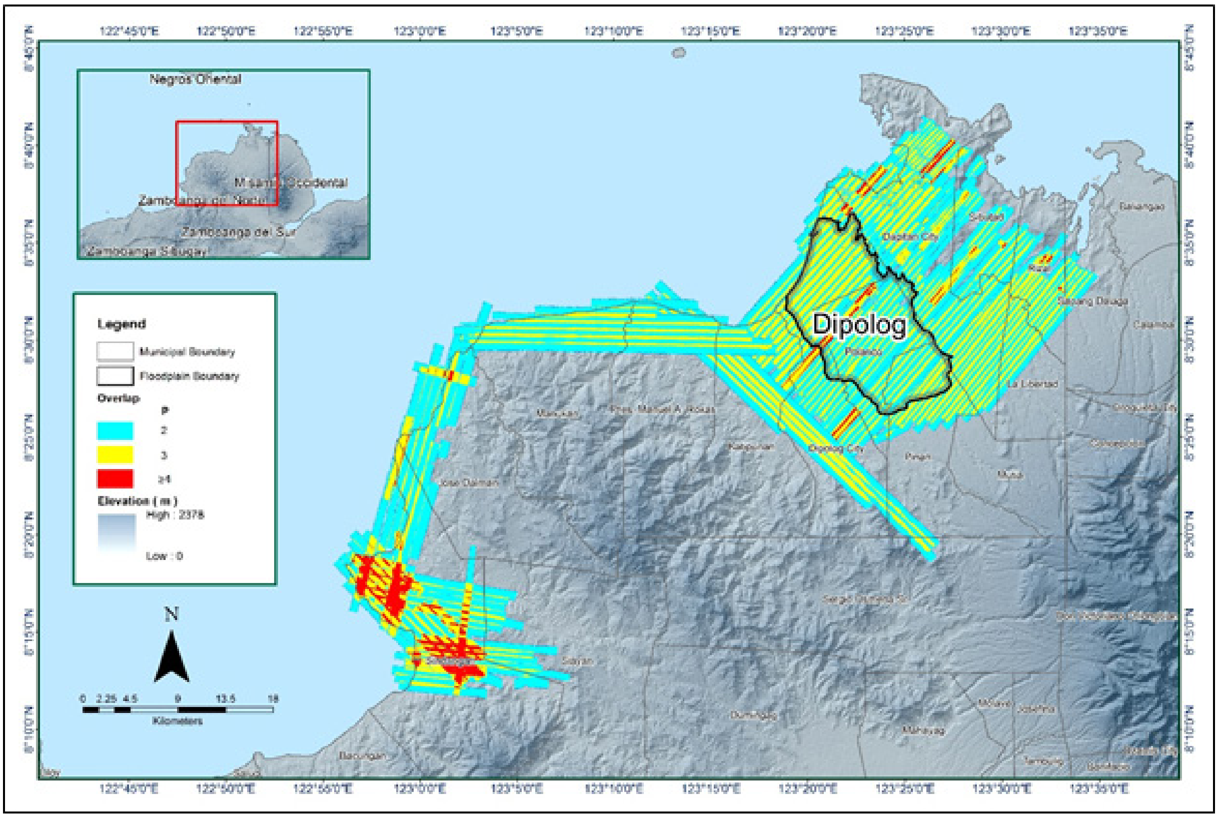


Figure 16. Image of data overlap for Dipolog Floodplain.

The overlap statistics per block for the Dipolog floodplain can be found in Annex 8. One pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 33.55% and 45.89% 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 17. It was determined that all LiDAR data for Dipolog floodplain satisfy the point density requirement, and the average density for the entire survey area is 4.44 points per square meter.

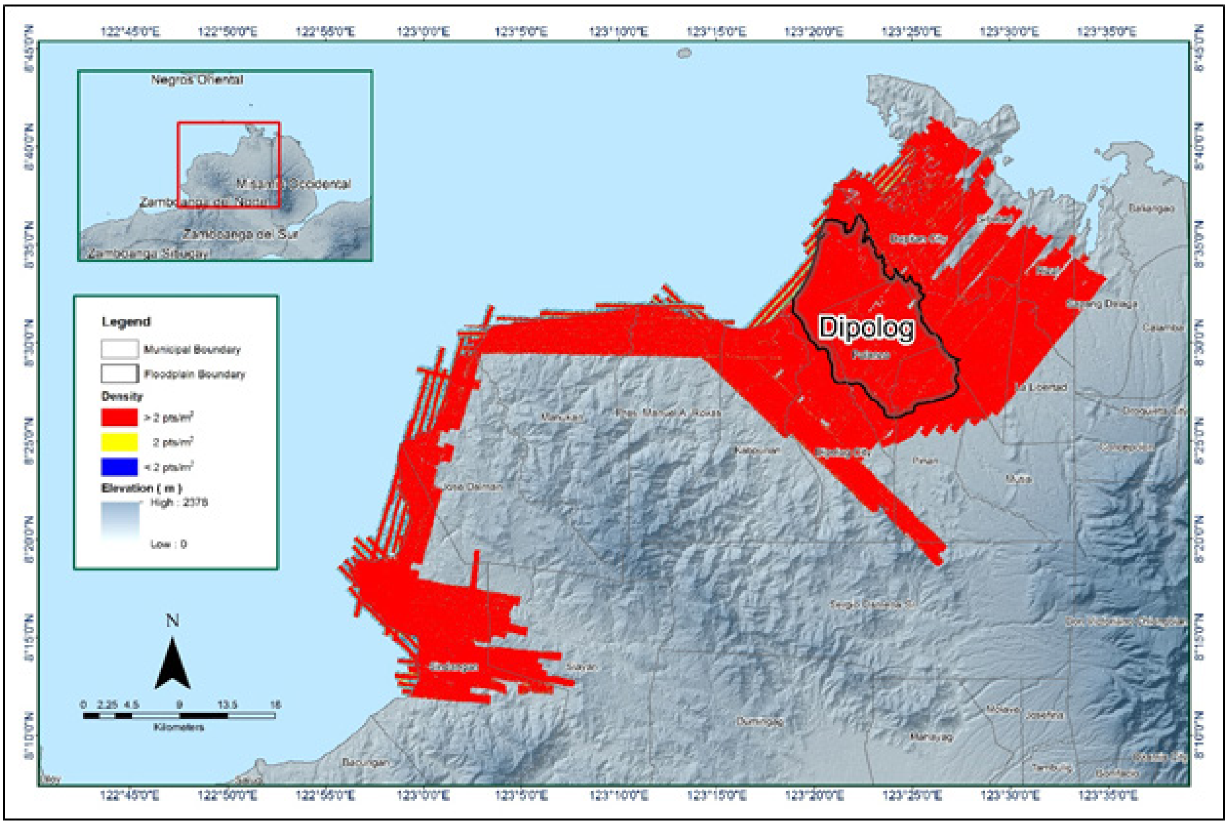


Figure 17. Pulse density map of merged LiDAR data for Dipolog Floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 18. The default color range is from blue to red, where bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20m relative to elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m relative to elevations of its adjacent flight line. Areas with bright red or bright blue need to be investigated further using Quick Terrain Modeler software.

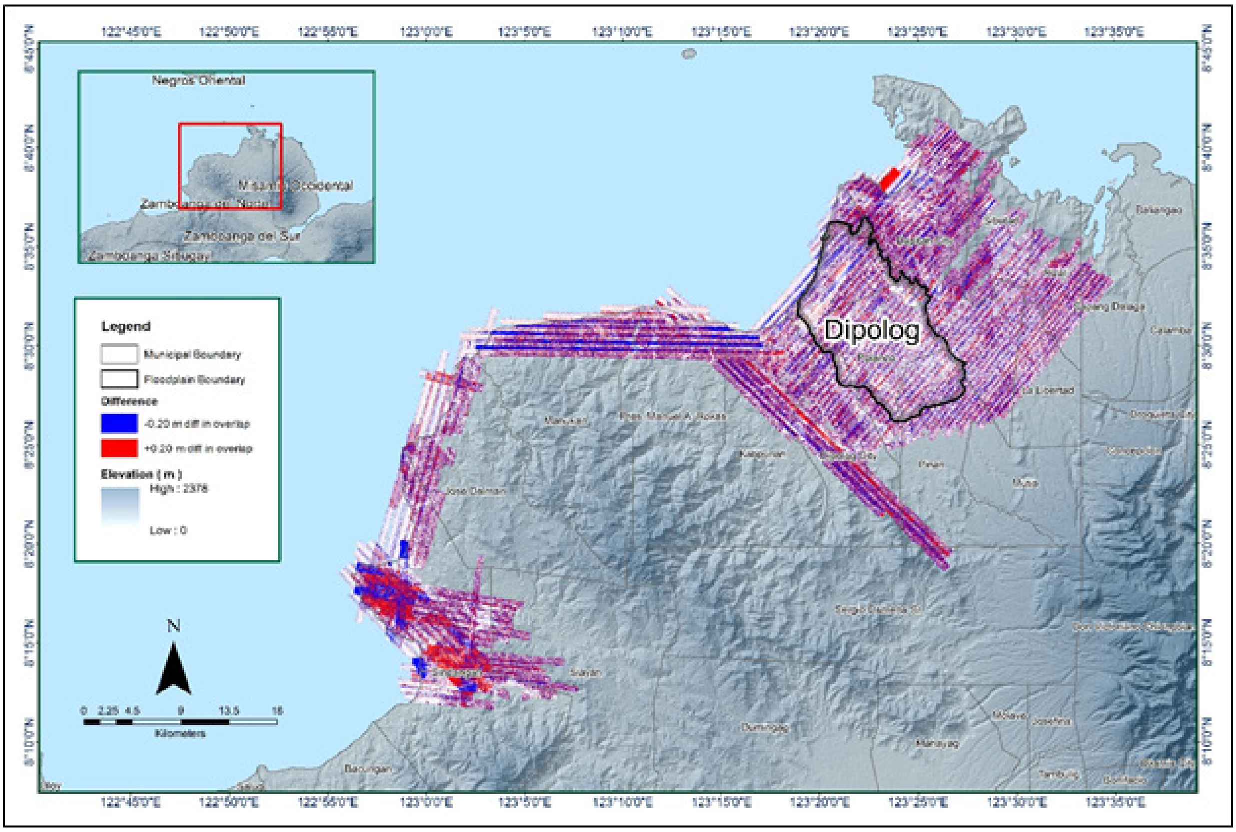


Figure 18. Elevation difference map between flight lines for Dipolog Floodplain.

A screen capture of the processed LAS data from a Dipolog flight 2177P loaded in QT Modeler is shown in Figure 19. 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.

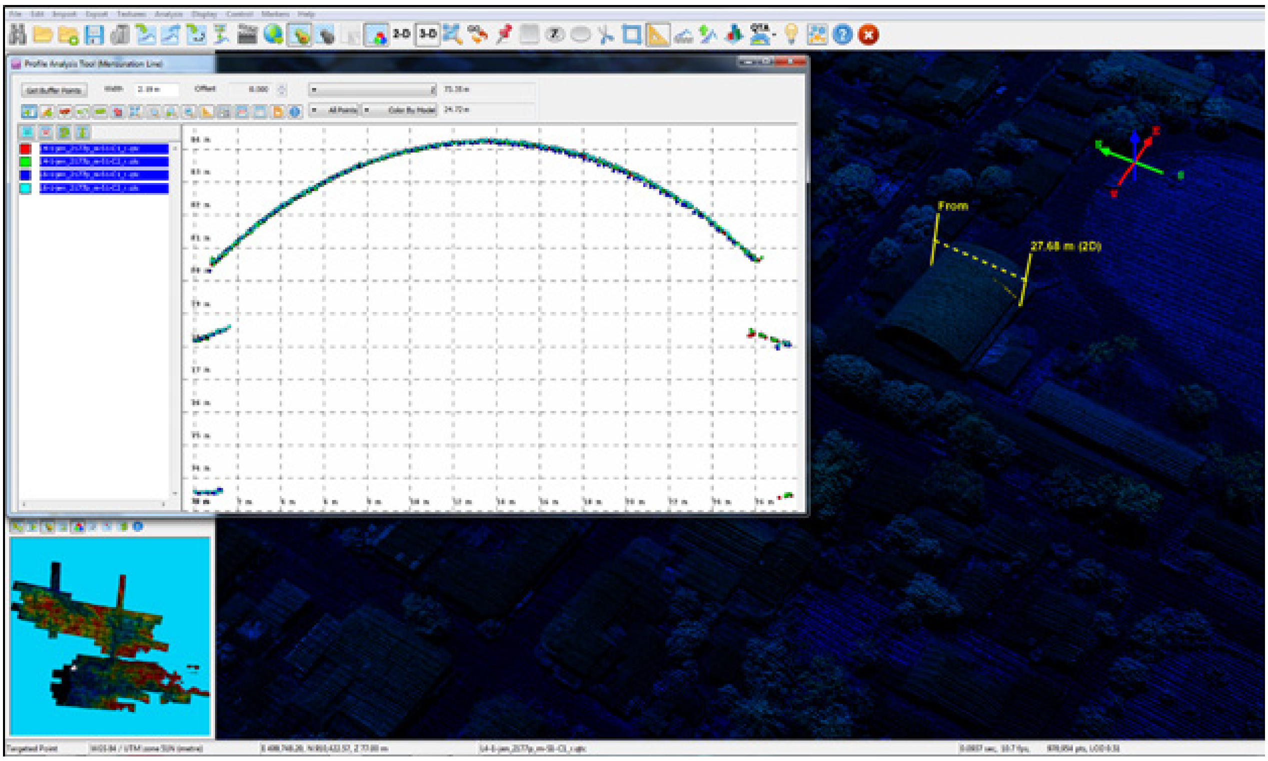


Figure 19. Quality checking for a Dipolog flight 2177P using the Profile Tool of QT Modeler.

## 3.6 LiDAR Point Cloud Classification and Rasterization

Table 17. Summary of point cloud classification results in TerraScan for Dipolog River Floodplain.

| Pertinent Class | Total Number of Points |
|---|---|
| Ground | 1,671,353,935 |
| Low Vegetation | 1,393,085,988 |
| Medium Vegetation | 2,602,262,739 |
| High Vegetation | 4,815,400,126 |
| Building | 86,113,170 |

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Dipolog floodplain is shown in Figure 20. A total of 2,106 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 17. The point cloud has a maximum and minimum height of 944.28 meters and 51.02 meters respectively.

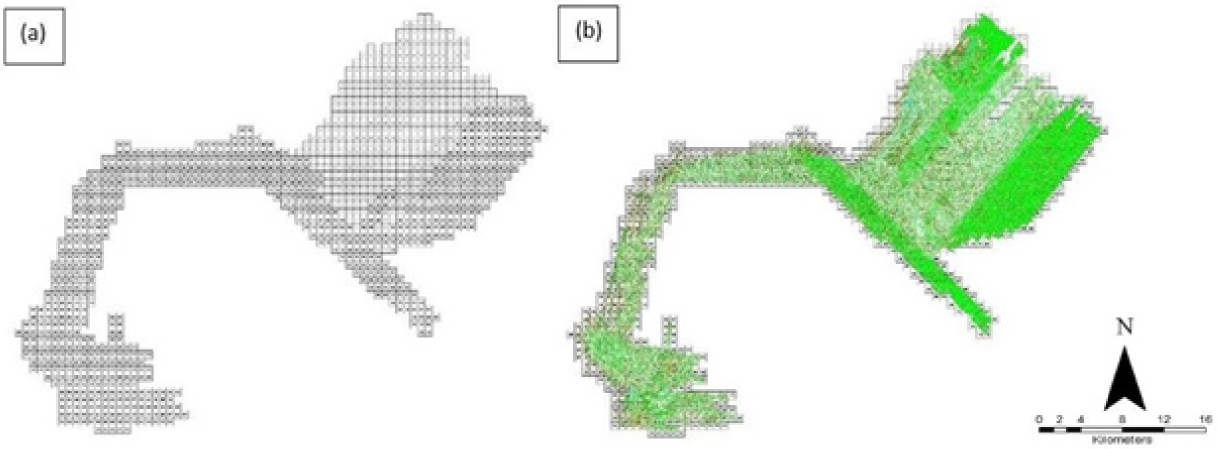


Figure 20. Tiles for Dipolog floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 21. The ground points are in orange, the vegetation is in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below canopy are classified correctly, due to the density of the LiDAR data.

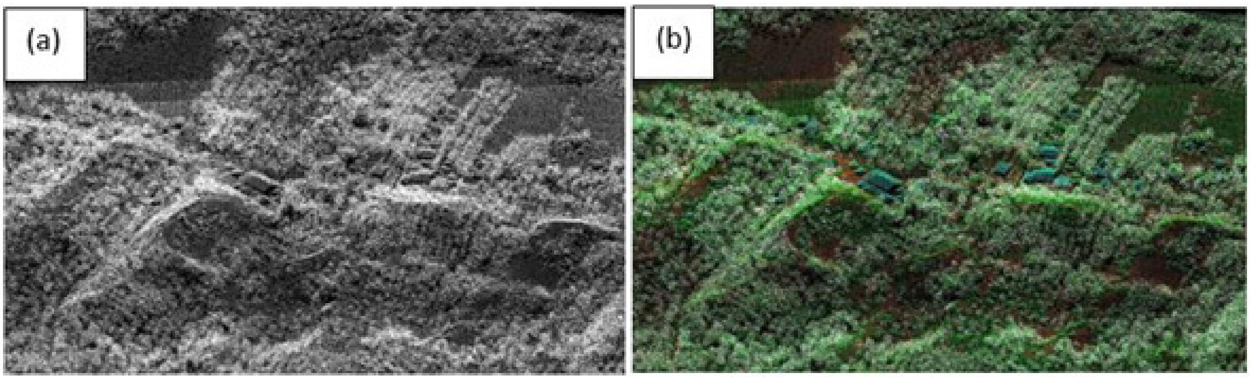


Figure 21. Point cloud before (a) and after (b) classification.

The production of last return (V_ASCII) and the secondary (T_ ASCII) DTM, first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 22. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

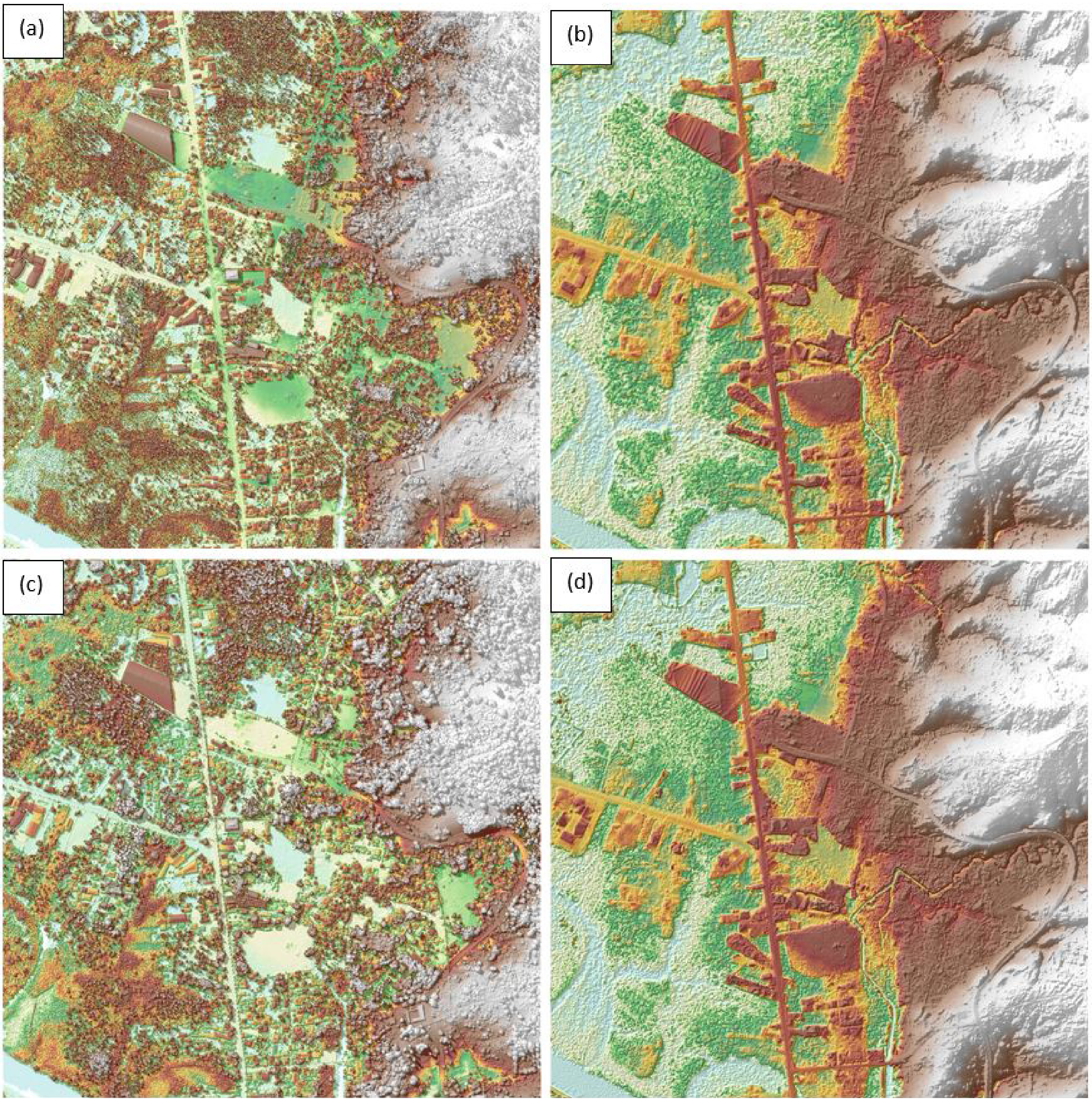


Figure 22. Photo (a) features the production of the last return DSM; (b) depicts the production of the DTM; (c) portrays the production of the first return DSM, and (D) presents the generation of the secondary DTM in some portions of the Dipolog Floodplain.

## 3.7 LiDAR Image Processing and Orthophotograph Rectification

The 991 1km by 1km tiles area covered by Dipolog floodplain is shown in Figure 23. After tie point selection to fix photo misalignments, color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Dipolog floodplain survey attained a total of 753.88 sq.km in orthophotogaph coverage comprised of 2,733 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 24.

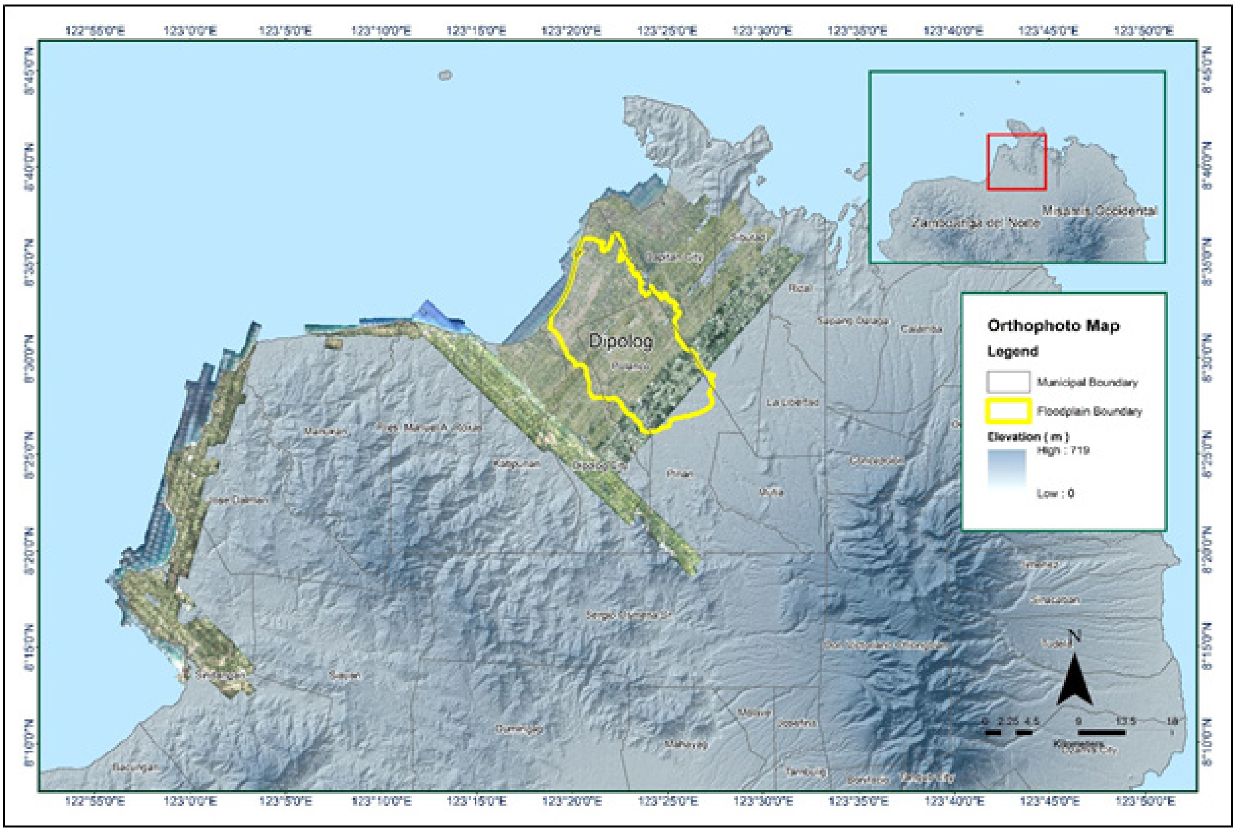


Figure 23. Dipolog Floodplain with available orthophotographs.


Figure 24. Sample orthophotograph tiles for Dipolog Floodplain.

## 3.8 DEM Editing and Hydro-Correction

Nine (9) mission blocks were processed for Dipolog flood plain. These blocks are composed of Dipolog and Pagadian blocks with a total area of 1,503.16 square kilometers. Table 18 shows the name and corresponding area of each block in square kilometers.

Table 18. LiDAR blocks with its corresponding area.

| LiDAR Blocks | Area (sq.km) |
|---|---|
| Pagadian_Blk69A | 117.93 |
| Pagadian_Blk69D | 166.98 |
| Dipolog_Blk69ABC | 104.48 |
| Dipolog_Blk69A | 115.82 |
| Dipolog_Blk69B | 345.02 |
| Dipolog_Blk69C | 92.17 |
| Dipolog_Blk70ABC | 263.45 |
| Dipolog_reflight_Blk69B | 141.49 |
| Dipolog_reflight_Blk69D | 155.82 |
| TOTAL | 1,503.16 sq.km |

Portions of DTM before and after manual editing are shown in Figure 25. The bridge (Figure 25a) is considered to be an impedance to the flow of water along the river and has to be removed (Figure 25b) in order to hydrologically correct the river. The river embankment (Figure 25c) has been misclassified and removed during classification process and has to be retrieved to complete the surface (Figure 25d) to allow the correct flow of water.

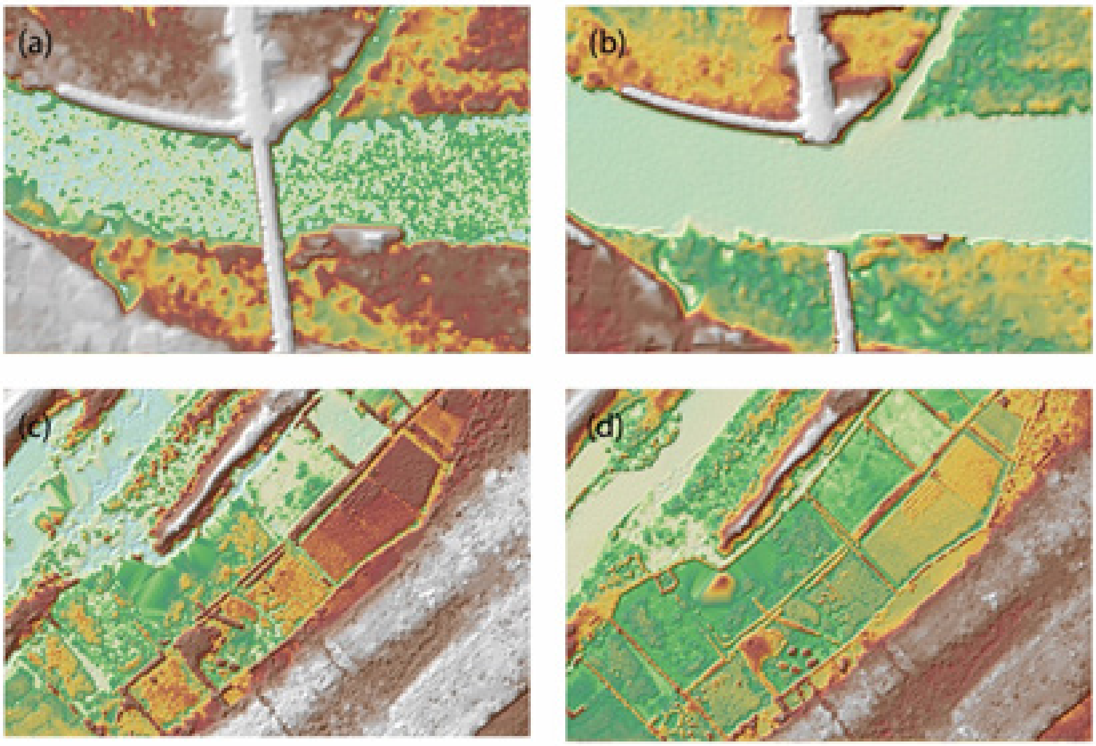


Figure 25. Portions in the DTM of Dipolog Floodplain – a bridge before (a) and after (b) manual editing; a paddy field before (c) and after (d) data retrieval.

## 3.9 Mosaicking of Blocks

Dipolog_Blk69B was used as the reference block at the start of mosaicking because it has the largest area among the mission blocks and it covers most of the Dipolog flood plain. Table 19 shows the shift values applied to each LiDAR block during mosaicking.

Table 19. Shift Values of each LiDAR Block of Dipolog Floodplain.

| Mission Blocks | Shift Values (meters) | | |
|---|---|---|---|
| | x | y | z |
| Pagadian_Blk69A | 0.00 | 0.00 | 0.96 |
| Pagadian_Blk69D | 0.00 | 0.00 | 0.66 |
| Dipolog_Blk69ABC | -1.50 | -0.30 | -0.38 |
| Dipolog_Blk69A | -1.60 | -0.30 | 1.51 |
| Dipolog_Blk69B | 0.00 | 0.00 | 0.00 |
| Dipolog_Blk69C | 0.00 | 0.00 | 0.00 |
| Dipolog_Blk70ABC | -1.00 | -0.80 | 0.00 |
| Dipolog_reflight_Blk69B | -0.40 | 0.00 | 0.00 |
| Dipolog_reflight_Blk69D | -0.50 | 2.40 | 0.30 |

Mosaicked LiDAR DTM for Dipolog floodplain is shown in Figure 26. It can be seen that the entire Dipolog floodplain is 99.98% covered by LiDAR data.

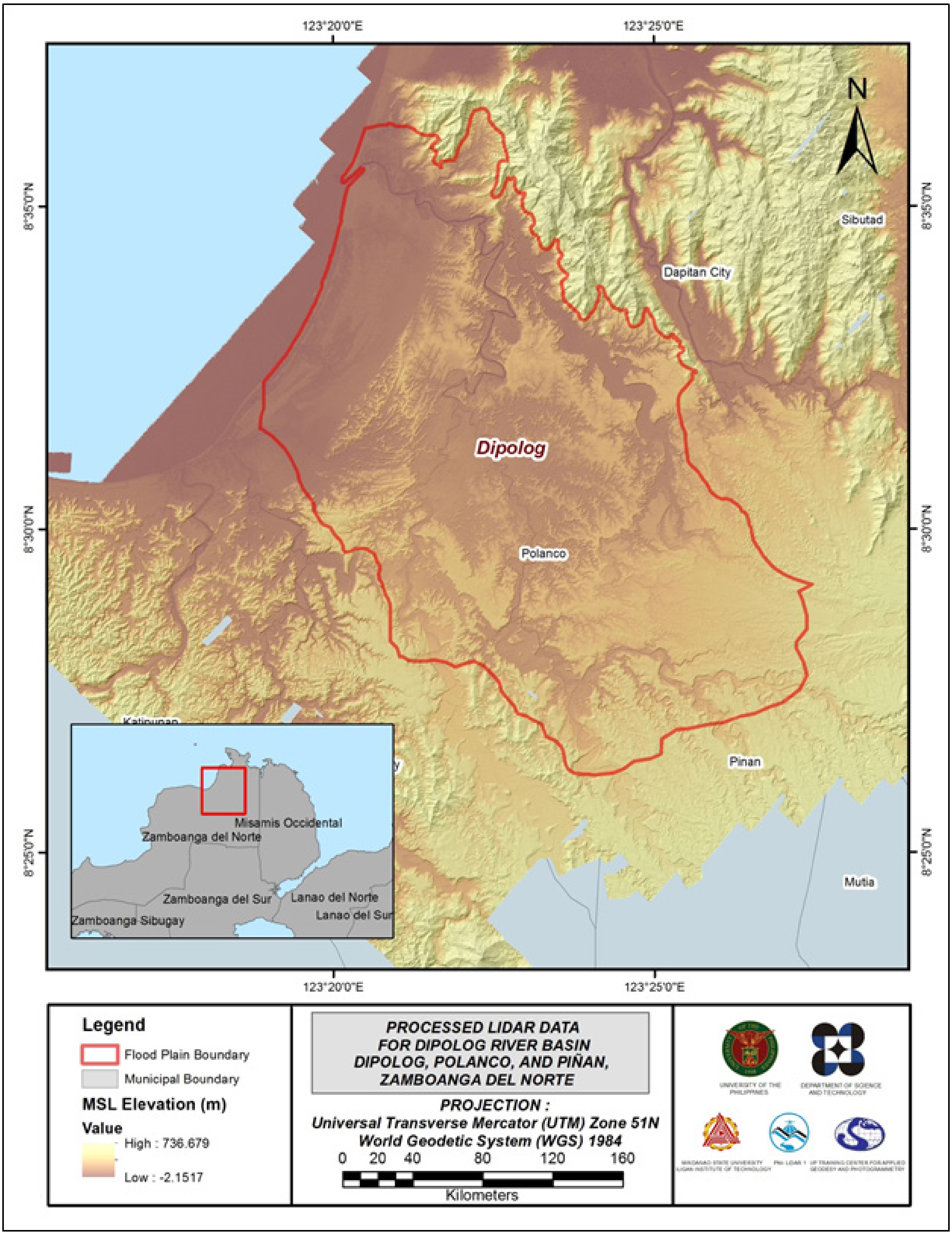


Figure 26. Map of Processed LiDAR Data for Dipolog Floodplain.

## 3.10 Calibration and Validation of Mosaicked LiDAR Digital Elevation Model

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Dipolog to collect points with which the LiDAR dataset is validated is shown in Figure 27. A total of 12,287 survey points were gathered for all the flood plains within the provinces of Zamboanga del Norte and Misamis Occidental wherein the Dipolog floodplain is located. Random selection of 80% of the survey points, resulting to 9,830 points, were used for calibration.

A good correlation between the uncalibrated mosaicked LiDAR DTM and ground survey elevation values is shown in Figure 28. 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 4.25 meters with a standard deviation of 0.15 meters. Calibration of the LiDAR data was done by adding the height difference value, 4.25 meters, to the mosaicked LiDAR data. Table 20 shows the statistical values of the compared elevation values between the LiDAR data and calibration data.

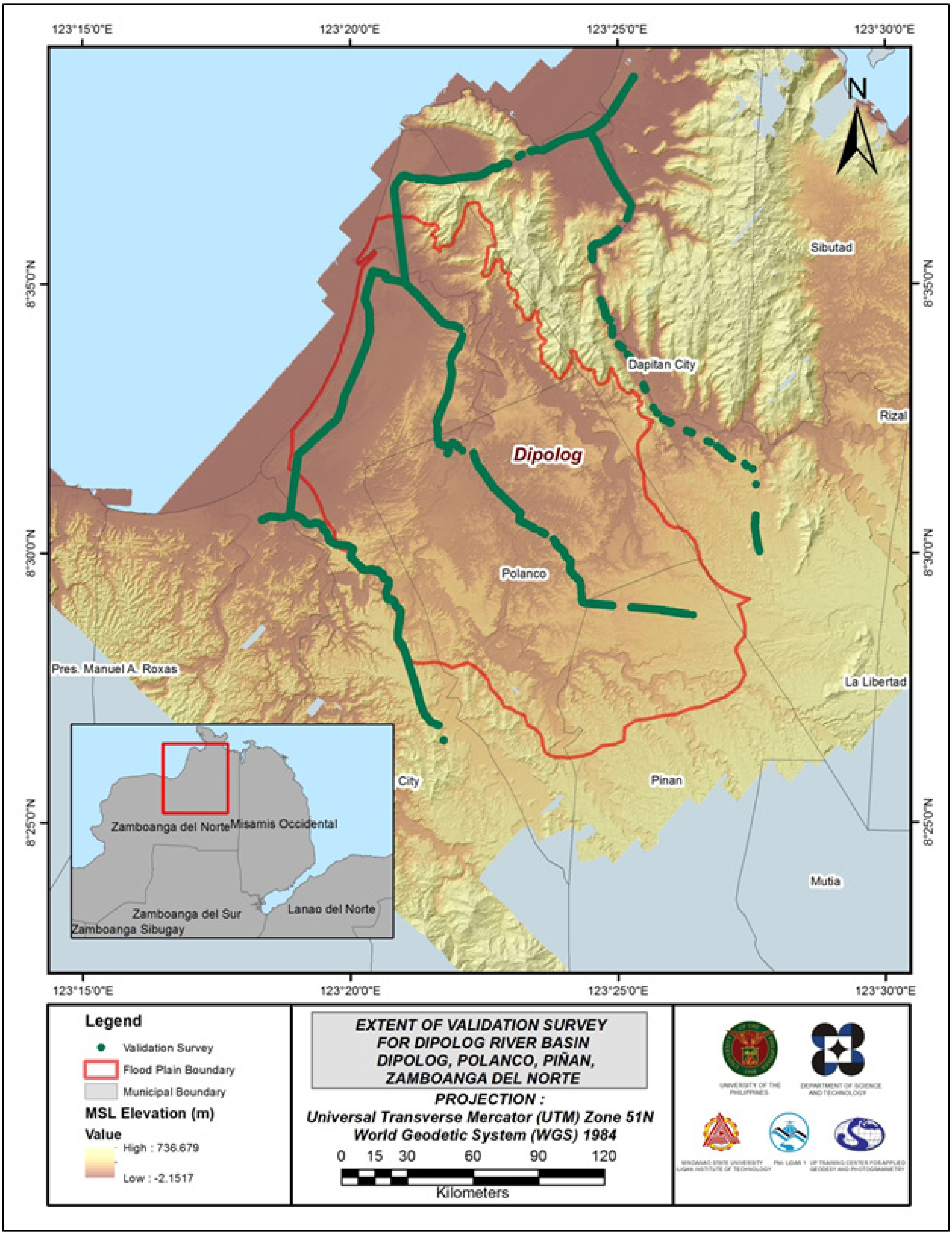


Figure 27. Map of Dipolog Floodplain with validation survey points in green.

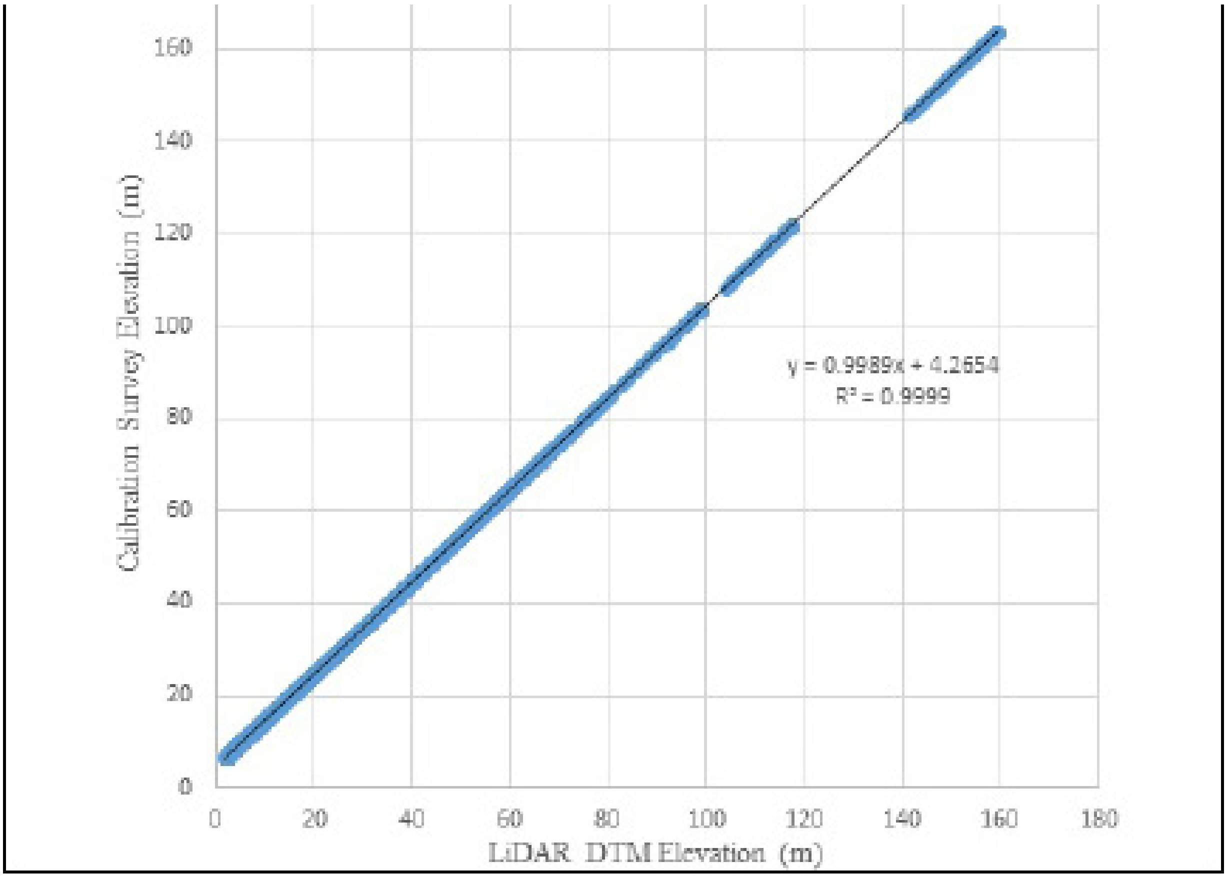


Figure 28. Correlation plot between calibration survey points and LiDAR data.

Table 20. Calibration Statistical Measures.

| Calibration Statistical Measures | Value (meters) |
| --- | --- |
| Height Difference | 4.25 |
| Standard Deviation | 0.15 |
| Average | 4.25 |
| Minimum | 3.90 |
| Maximum | 4.60 |

The remaining 20% of the total survey points were intersected to the flood plain, resulting to 405 points, were used for the validation of calibrated Dipolog DTM. A good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM is shown in Figure 29. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.15 meters with a standard deviation of 0.06 meters, as shown in Table 21.

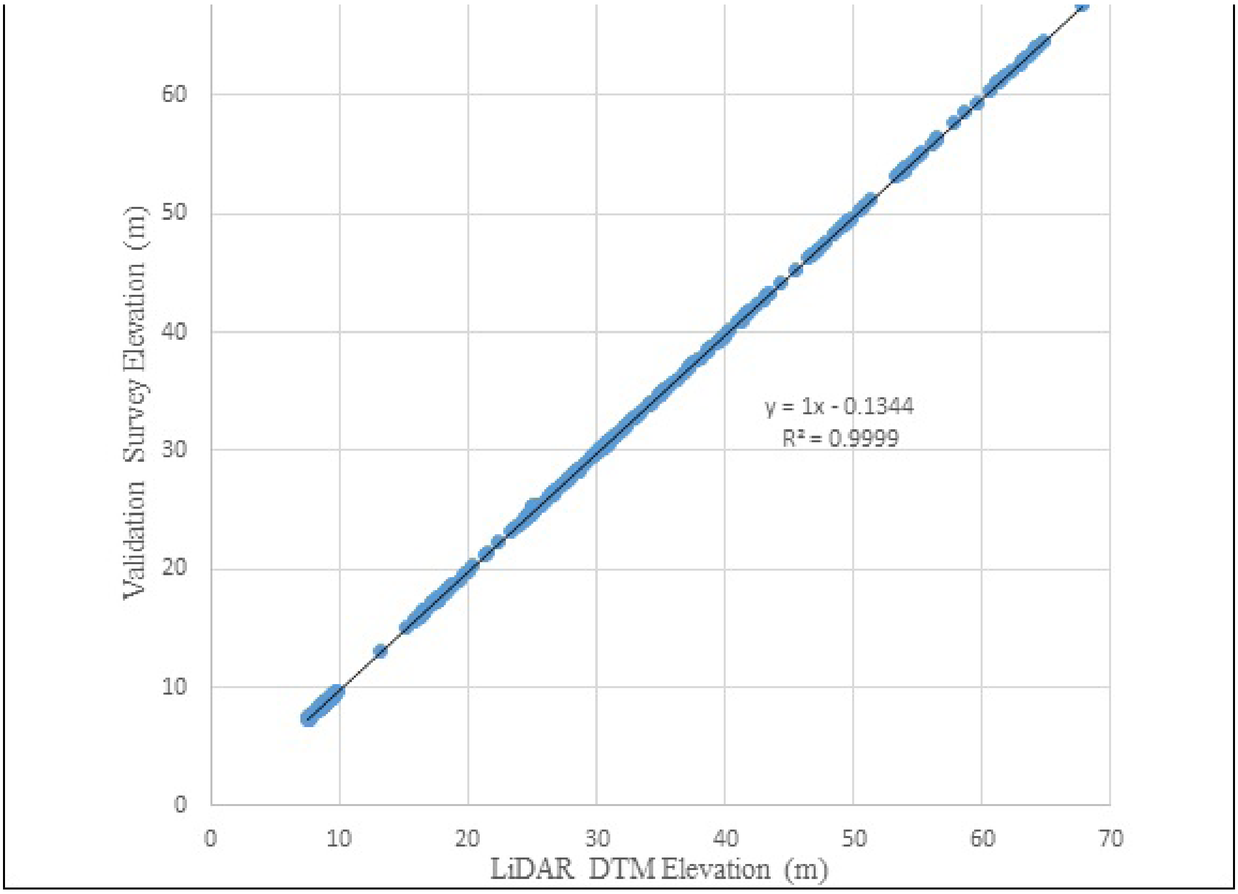


Figure 29. Correlation plot between validation survey points and LiDAR data.

Table 21. Validation Statistical Measures.

| Validation Statistical Measures | Value (meters) |
|---|---|
| RMSE | 0.15 |
| Standard Deviation | 0.06 |
| Average | -0.13 |
| Minimum | -0.26 |
| Maximum | 0.30 |

## 3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, centerline and zigzag data were available for Dipolog with 15,917 bathymetric survey points. The resulting raster surface produced was done by Kernel interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.48 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Dipolog integrated with the processed LiDAR DEM is shown in Figure 30.

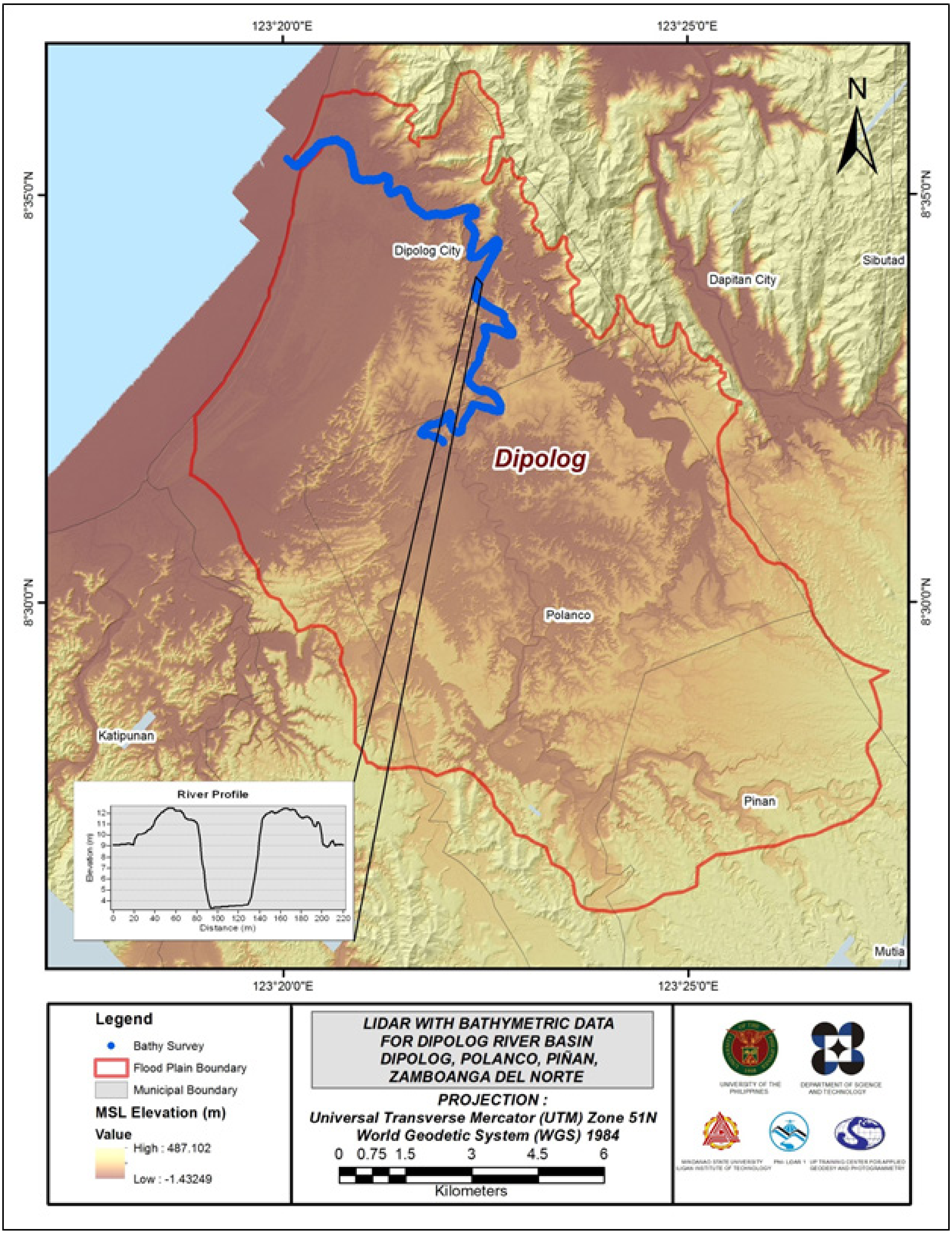


Figure 30. Map of Dipolog Floodplain with bathymetric survey points shown in blue.

## 3.12 Feature Extraction

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

### 3.12.1 Quality Checking of Digitized Features' Boundary

Dipolog floodplain, including its 200 m buffer, has a total area of 175.47 sq km. For this area, a total of 6.0 sq km, corresponding to a total of 4,709 building features, are considered for QC. Figure 31 shows the QC blocks for Dipolog floodplain.

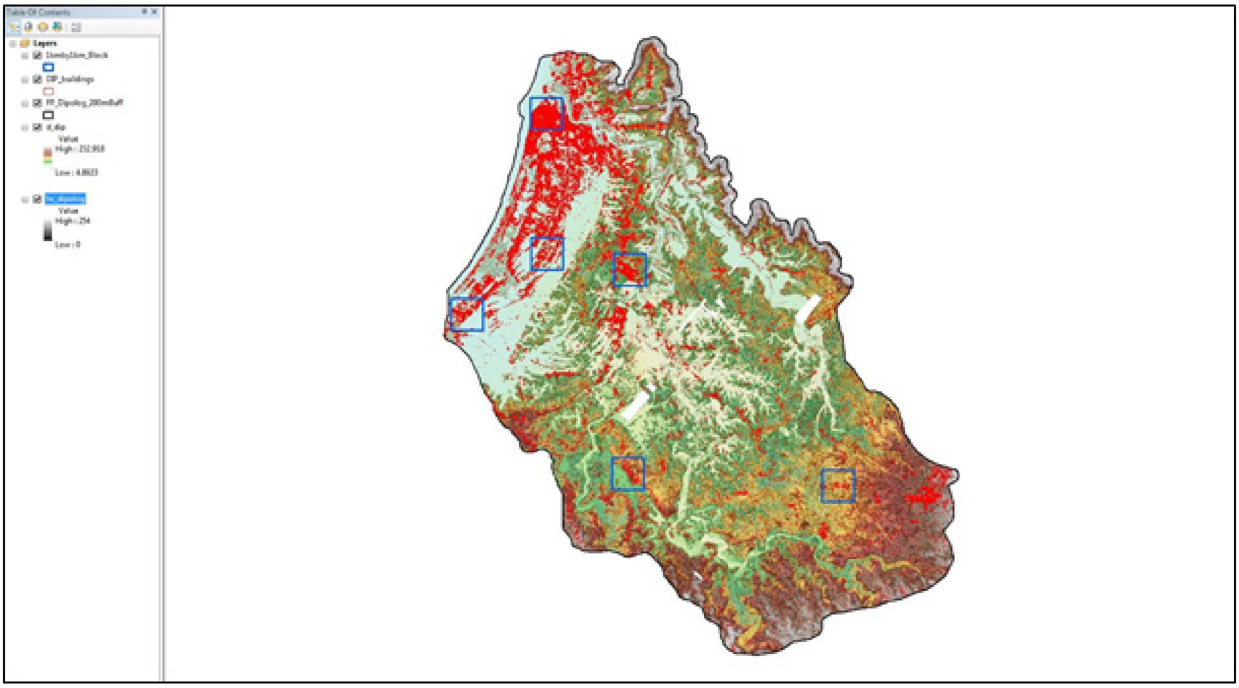

Figure 31. Blocks (in blue) of Silaga building features that were subjected to QC.

Quality checking of Dipolog building features resulted in the ratings shown in Table 22.

Table 22. Quality Checking Ratings for Dipolog Building Features.

| FLOODPLAIN | COMPLETENESS | CORRECTNESS | QUALITY | REMARKS |
|---|---|---|---|---|
| Dipolog | 96.81 | 99.79 | 90.68 | PASSED |

### 3.12.2 Height Extraction

Height extraction was done for 47,544 building features in Dipolog floodplain. Of these building features, none was filtered out after height extraction, resulting to 46,489 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 18.16 m.

### 3.12.3 Feature Attribution

Dipolog floodplain is shared by three (3) municipalities and cities namely the city of Dipolog, municipality of Polanco, and municipality of Piñan. The building attribution on the city of Dipolog was done with the Barangay Registry Information System (BRIS) approach while that on the municipalities of Polanco and Piñan was done with the Google Earth approach. In BRIS approach, trainings, assistance and a database system were delivered to barangays, municipalities and cities for them to conduct the building attribution. In Google Earth approach, aid from Purok representatives were sought for participatory mapping over the Google Earth software. The attributions of road, bridge and water body features were done using NAMRIA maps, municipal and city records, and participatory mapping of municipals and cities.

Table 23 summarizes the number of building features per type. On the other hand, Table 24 shows the total length of each road type, while Table B-11 shows the number of water features extracted per type.

Table 23. Building Features Extracted for Dipolog Floodplain.

| Facility Type | No. of Features |
|---|---|
| Residential | 44,833 |
| School | 331 |
| Market | 29 |
| Agricultural/Agro-Industrial Facilities | 220 |
| Medical Institutions | 41 |
| Barangay Hall | 40 |
| Military Institution | 0 |
| Sports Center/Gymnasium/Covered Court | 28 |
| Telecommunication Facilities | 3 |
| Transport Terminal | 10 |
| Warehouse | 74 |
| Power Plant/Substation | 3 |
| NGO/CSO Offices | 19 |
| Police Station | 4 |
| Water Supply/Sewerage | 2 |
| Religious Institutions | 126 |
| Bank | 28 |
| Factory | 0 |
| Gas Station | 25 |
| Fire Station | 0 |
| Other Government Offices | 117 |
| Other Commercial Establishments | 556 |
| Total | 46,489 |

Table 24. Total Length of Extracted Roads for Dipolog Floodplain.

| Floodplain | Road Network Length (km) | | | | | Total |
|---|---|---|---|---|---|---|
| | Barangay Road | City/Municipal Road | Provincial Road | National Road | Others | |
| Dipolog | 353.56 | 59.62 | 144.39 | 0 | 0 | 557.57 |

Table 25. Number of Extracted Water Bodies for Dipolog Floodplain.

| Floodplain | Water Body Type | | | | | Total |
|---|---|---|---|---|---|---|
| | Rivers/Streams | Lakes/Ponds | Sea | Dam | Fish Pen | |
| Dipolog | 113 | 0 | 0 | 0 | 6 | 119 |

A total of 67 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 32 shows the Digital Surface Model (DSM) of Dipolog floodplain overlaid with its ground features.

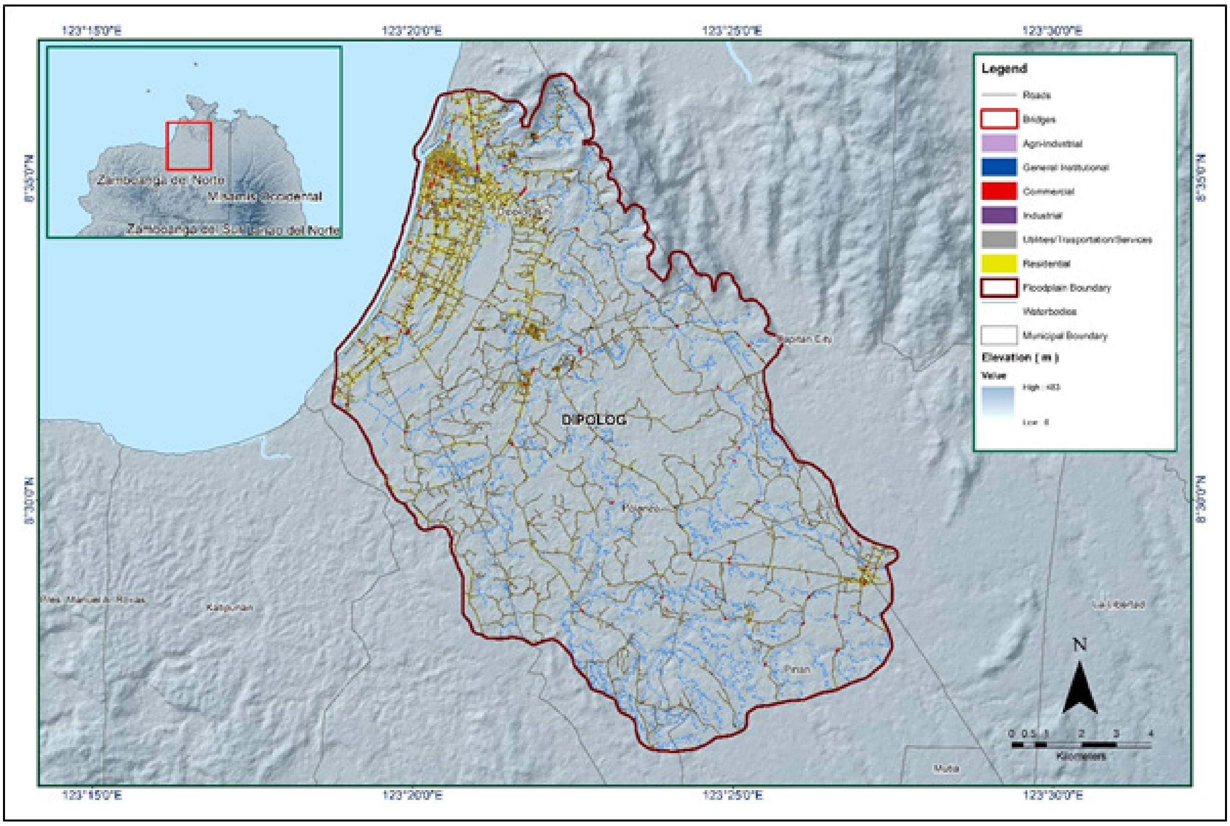


Figure 32. Extracted features for Dipolog Floodplain.

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

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## 4.1 Summary of Activities

The Data Validation and Bathymetry Component (DVBC) conducted a survey in Dipolog River last June 4 to16, 2015 with the following scope of work: reconnaissance; control survey for the establishment of a control point; cross-section, bridge as-built and water level marking in MSL of Polanco Bridge piers; validation points data acquisition of about 44.768 km; and bathymetric survey from Brgy. Obay, Polanco, Zamboanga del Norte down to the mouth of the river in Brgy. Dipolog City, Zamboanga del Norte with an estimated length of 16.921 km, as shown in Figure 33, using an OHMEX™ single beam echo sounder and Trimble® SPS 882 GNSS PPK survey technique.

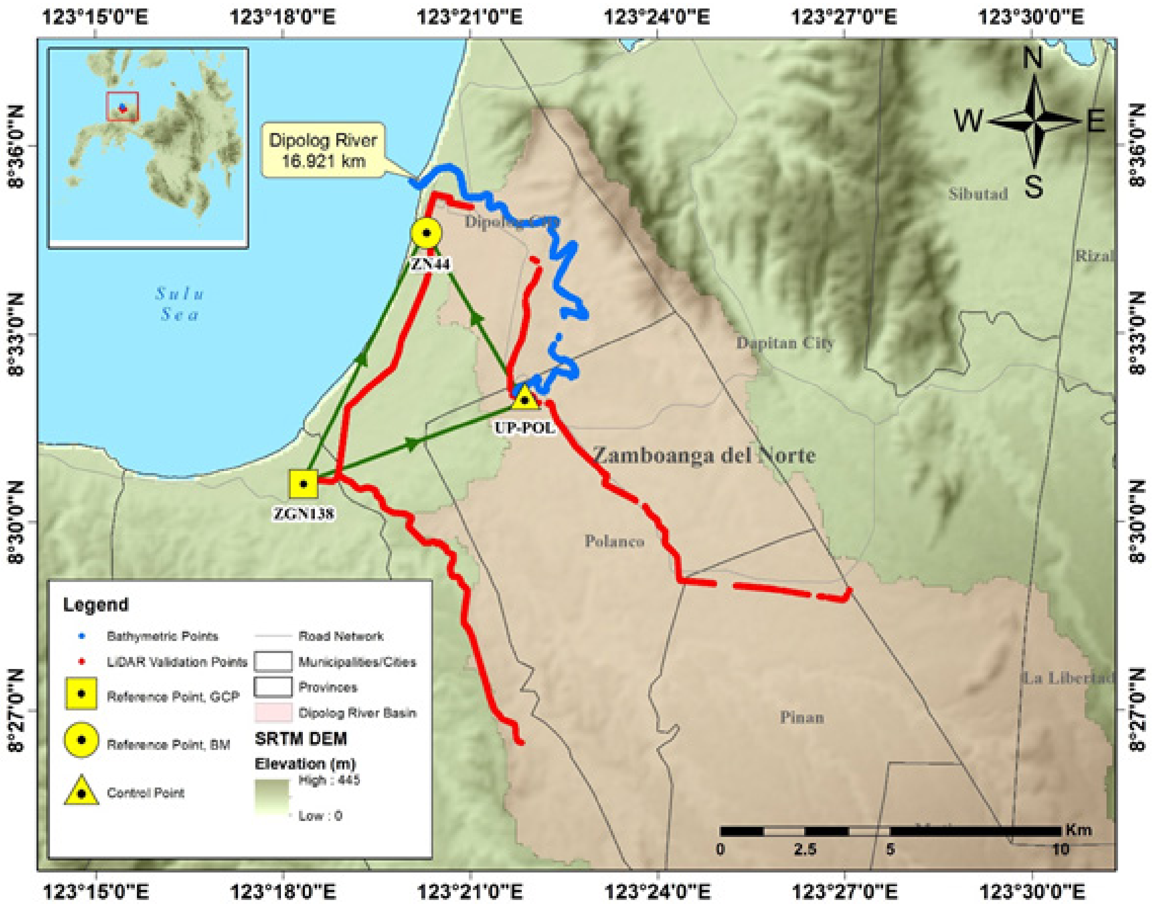



Figure 33. Extent of the bathymetric survey (in blue line) in Dipolog River and the LiDAR data validation survey (in red).

## 4.2 Control Survey

A GNSS network was established on June 6, 2015 for a previous Phil-LiDAR 1 survey in Paro Dapitan River occupying the reference points ZGN-138, a second order GCP located in Brgy. Daang Lugsod, Municipality of Katipunan, Zamboanga Del Norte; and ZN-44, a first order BM in Brgy. Miputak, Dipolog City, Zamboanga Del Norte.

The GNSS network used in Dipolog survey is composed of a single loop established on June 7, 2015 occupying the reference points: ZGN-138, a second order GCP located in Brgy. Daang Lugsod, Municipality of Katipunan, Zamboanga Del Norte; and ZN-44, a first order BM in Brgy. Miputak, Dipolog City, Zamboanga Del Norte; with values fixed from Paro Dapitan Survey.

A control point was established along approach of Polanco Bridge in Brgy. Obay, Municipality of Polanco, Zamboanga Del Norte, to use as marker during the survey.

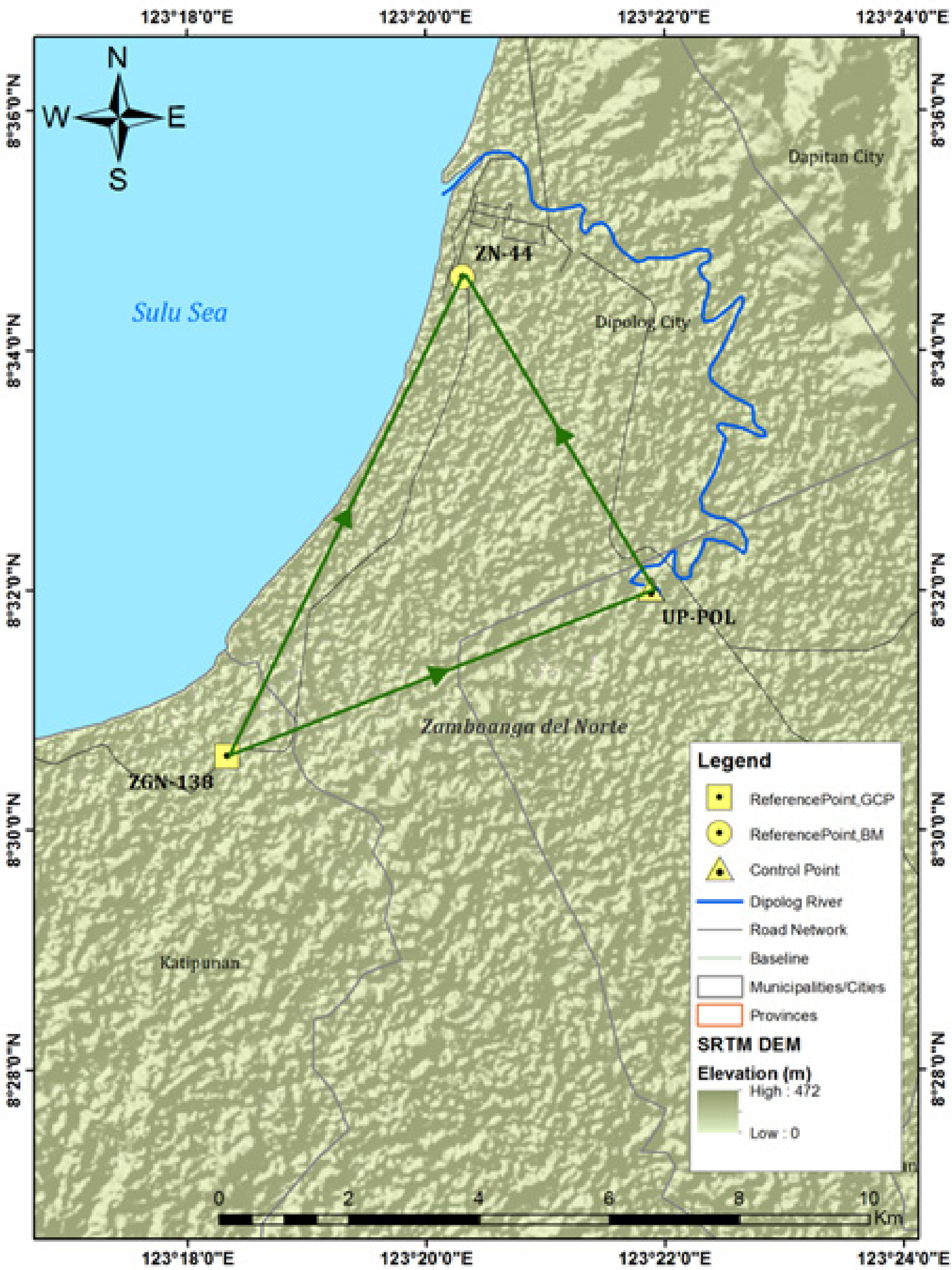



Figure 34. GNSS Network of Dipolog Field Survey

Table 26. List of References and Control Points used in Dipolog River Survey
(Source: NAMRIA, UP-TCAGP)

| Control Point | Order of Accuracy | Geographic Coordinates (WGS 84) | | | | |
|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Ellipsoidal Height (Meter) | Elevation in MSL (Meter) | Date Established |
| ZGN-138 | 2nd | 8°30’36.94779”E | 123°18’19.85548”N | 70.925 | 9.727 | 2009 |
| ZN-44 | 1st | 8°34’36.67923”E | 123°20’18.51204”N | 70.802 | 9.726 | 2007 |
| UP-POL | UP Established | - | - | - | - | June 7, 2015 |

The GNSS set up for control points used in the Dipolog survey are shown in Figure 35 to Figure 37.

Figure 35. GNSS receiver occupation, Trimble® SPS 882 at ZN-44, Miputak Bridge, in Brgy. Miputak, Dipolog City, Zamboanga del Norte


Figure 36. GNSS base receiver setup, Trimble® SPS 852 at ZGN-138 in Taga Central School Brgy. Taga, Municipality of Katipunan, Zamboanga del Norte


Figure 37. GNSS base receiver, Trimble® SPS 882, setup at UP-ILA in Ilaya Bridge, Brgy. Ilaya, Dapitan City

## 4.3 Baseline Processing

The GNSS baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within +/- 20 cm and +/- 10 cm requirement, respectively. In cases where one or more baselines did not meet all of these criteria, masking is performed. Masking is done by removing portions of these baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, resurvey is initiated. Baseline processing result of control points in Dipolog River Basin is summarized in Table 27, generated by TBC software.

Table 27. Baseline Processing Report for Dipolog River Basin Static Survey

| Observation | Date of Observation | Solution Type | H. Prec. (Meter) | V. Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) |
|---|---|---|---|---|---|---|
| ZGN-138 ---UP-POL (B4780) | June 7, 2015 | Fixed | 0.003 | 0.023 | 68°29’31” | 10.094 |
| ZN-44 --- UP- POL (B4781) | June 7, 2015 | Fixed | 0.004 | 0.013 | 149°05’44” | 10.259 |
| ZGN-138 --- ZN-44 (B4779) | June 7, 2015 | Fixed | 0.003 | 0.016 | 26°13’36” | -0.138 |

As shown in Table 27, a total of three (3) baselines were processed with coordinates of ZGN-138 and elevation value of ZN-44 held fixed. All of them passed the required accuracy.

## 4.4 Network Adjustment

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

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

Where:

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

for each control point. See the Network Adjustment Report in the next page for complete details.

The three control points ZGN-138, ZN-44 and UP-POL were occupied and observed simultaneously to form a GNSS loop. Coordinates and elevation values of ZGN-138 and ZN-44 were held fixed during the processing of the control point as presented in Table 28.

Table 28. Control Point Constraints

| Point ID | Type | East σ (Meter) | North σ (Meter) | Height σ (Meter) | Elevation σ (Meter) |
|---|---|---|---|---|---|
| ZGN-138 | Global | Fixed | Fixed | Fixed | |
| ZN-44 | Global | Fixed | Fixed | Fixed | |
| Fixed = 0.000001(Meter) | | | | | |

The list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 29. The fixed controls ZGN-138 and Z-44 have no values for elevation error.

Table 29. Adjusted Grid Coordinates

| Point ID | Easting | Easting Error (Meter) | Northing (Meter) | Northing Error (Meter) | Elevation (Meter) | Elevation Error (Meter) | Constraint |
|---|---|---|---|---|---|---|---|
| UP-POL | 540123.515 | 0.008 | 943289.237 | 0.006 | 15.285 | 0.038 | |
| ZGN-138 | 533624.515 | ? | 940722.222 | ? | 5.484 | ? | LLh |
| ZN-44 | 537245.631 | ? | 948087.419 | ? | 5.483 | ? | LLh |

The network is fixed at reference points ZGN-138 and ZN-44. The easting error of UP-POL is 0.8 cm and the northing error is 0.6 cm. With the mentioned equation, $\sqrt{((x_e)^2 + (y_e)^2)} < 20cm$ and z_e<10 cm for the vertical, the computations for the horizontal and vertical accuracy are as follows:

**ZGN-138**
Horizontal accuracy = fixed
Vertical accuracy = fixed

**ZN-44**
Horizontal accuracy = fixed
Vertical accuracy = fixed

**UP-POL**
horizontal accuracy = $\sqrt{((0.8)^2 + (0.6)^2}$
= $\sqrt{(0.64 + 0.36)}$
= 1 cm < 20 cm
vertical accuracy = 3.8 < 10 cm

Following the given formula, the horizontal and vertical accuracy result of the three (3) occupied control points are within the required accuracy of the program.

Table 30. Adjusted Geodetic Coordinates

| Point ID | Latitude | Longitude | Height (Meter) | Height Error (Meter) | Constraint |
|---|---|---|---|---|---|
| UP-POL | N8°32’00.35305” | E123°21’52.51378” | 81.053 | 0.038 | |
| ZGN138 | N8°30’36.94779” | E123°18’19.85548” | 70.925 | ? | LLh |
| ZN44 | N8°34’36.67923” | E123°20’18.51204” | 70.802 | ? | LLh |

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 30. Based on the result of the computation, the accuracy conditions are satisfied; hence, the required accuracy for the program was met.

The summary of reference and control points used is indicated in Table 31.

Table 31. Reference and control points used and its location
(Source: NAMRIA, UP-TCAGP)

| Control Point | Order of Accuracy | Geographic Coordinates (WGS 84) | | | UTM ZONE 51 N | | |
|---|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Ellipsoidal Height (m) | Northing | Easting | MSL Elevation (m) |
| ZGN-138 | 2nd order, GCP | 8°30'36.94779" | 123°18'19.85548" | 70.925 | 940722.222 | 533624.515 | 9.727 |
| ZN-44 | 1st order BM | 8°34'36.67923" | 123°20'18.51204" | 70.802 | 948087.419 | 537245.631 | 9.726 |
| UP-POL | Used as Marker | 8°32'00.35305" | 123°21'52.51378" | 81.053 | 943289.237 | 540123.515 | 19.528 |

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

Cross-section and as-built surveys were done simultaneously on June 7 and 9, 2015 along the downstream side of Polanco Bridge in Brgy. Obay, Polanco, Zamboanga del Norte, using Trimble® SPS 882 in GNSS PPK survey technique. The control point UP-POL was used as the GNSS base station.

Figure 38. As-built Survey in Polanco Bridge in Brgy. Obay, Polanco, Zamboanga del Norte

A total of seventeen (17) points were gathered with an approximate length of 129.64 m surveyed for Polanco Bridge cross-section. The cross-section diagram, planimetric map, and bridge as-built form are shown in Figure 39 to Figure 41, respectively.

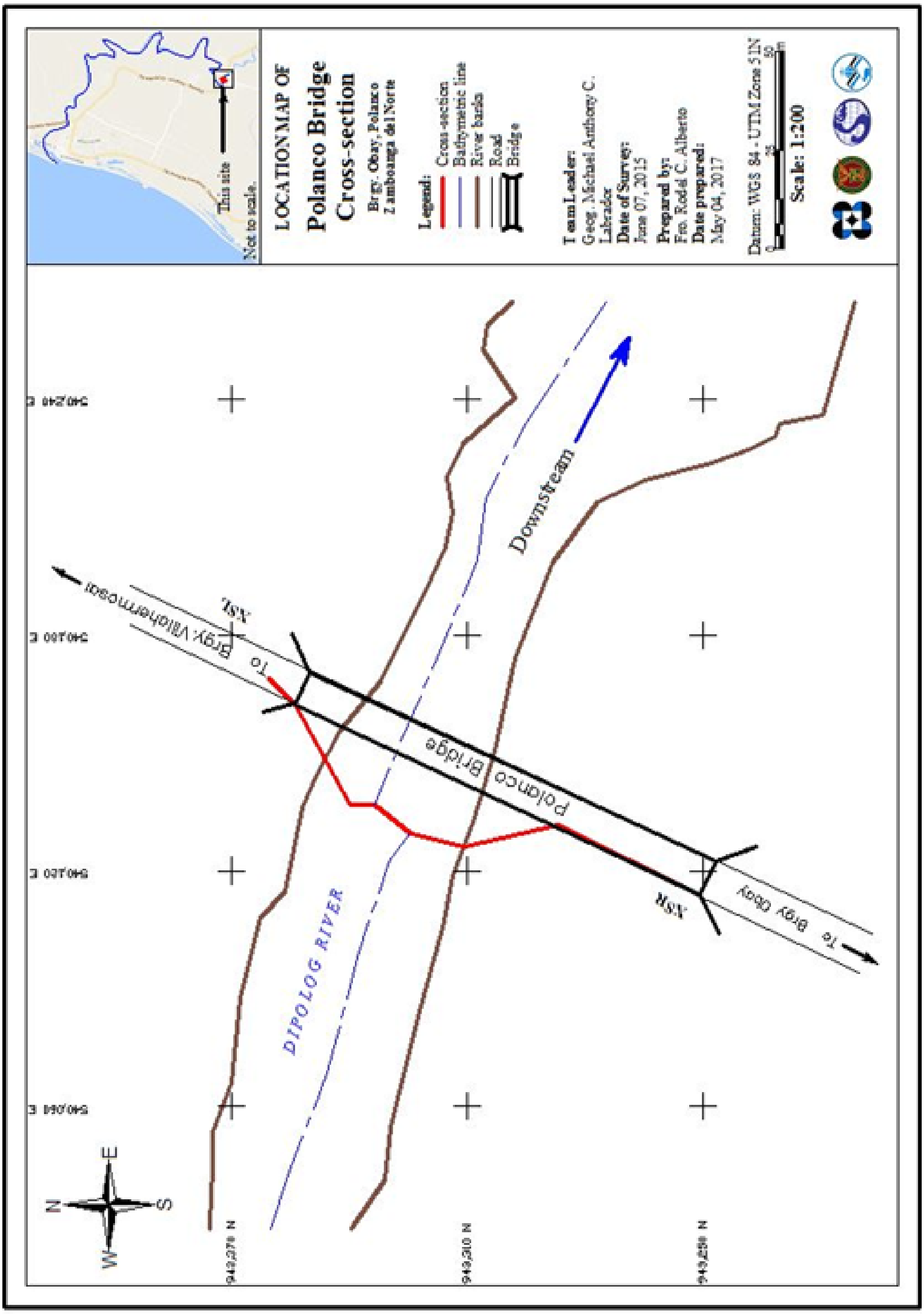



Figure 39. Polanco bridge cross-section planimetric map

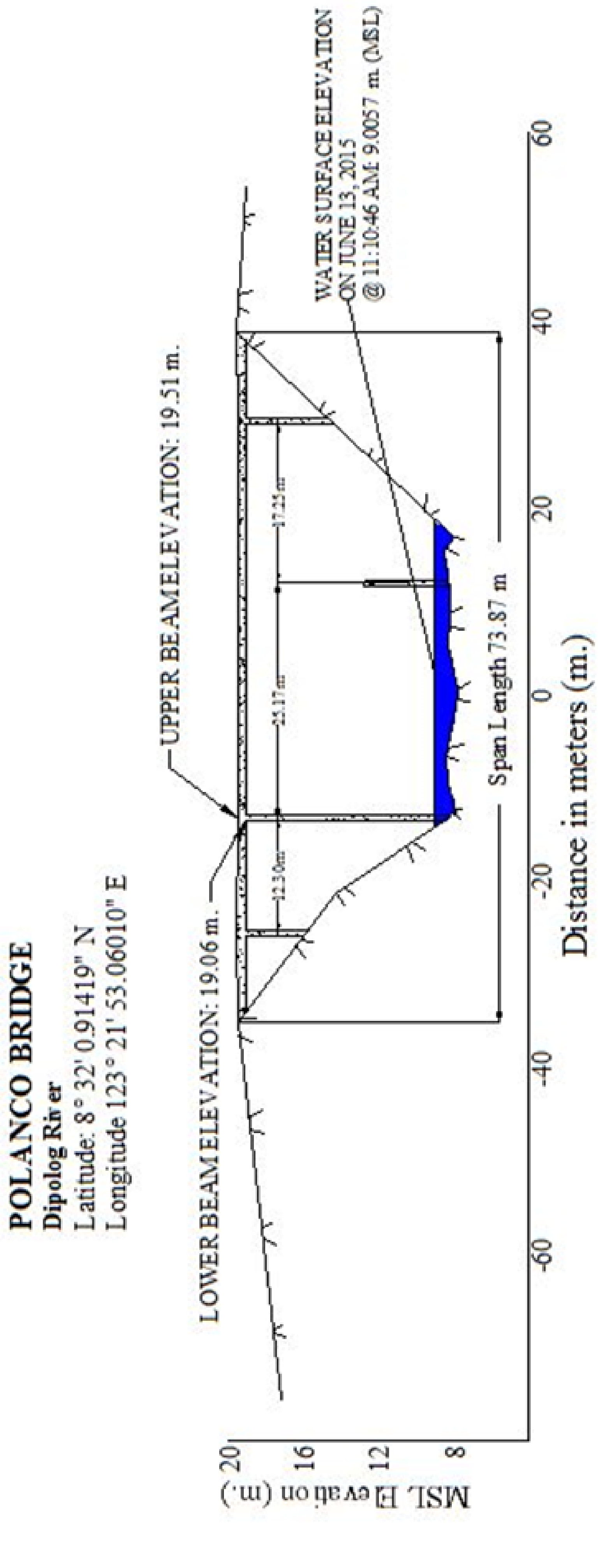



Figure 40. Polanco Bridge cross-section diagram

Bridge Name: Polanco Bridge Date: 06/07/15

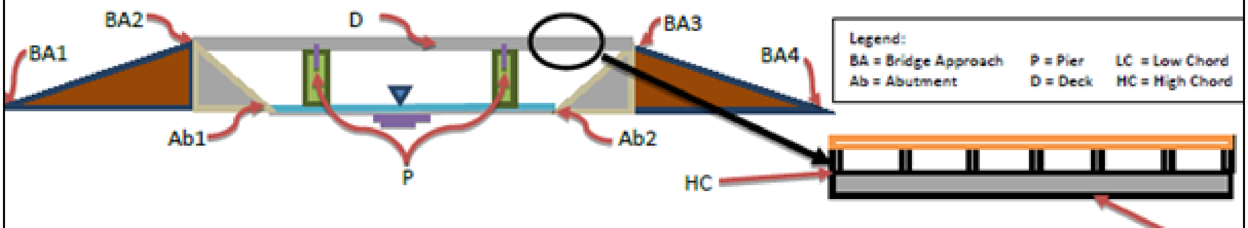
River Name: Dipolog River Time: 2:30 PM

Location: Polanco, Dipolog City

Survey Team:

Flow condition: low normal high Weather Condition: fair rainy

Latitude: 8d32'0.91439" Longitude: 123d21'53.06010"




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

Elevation: 19.51m Width: 9.00m Span (BA3-BA2): 73.35m

| | Station (Distance from BA1) | High Chord Elevation, MSL | Low Chord Elevation, MSL |
|---|---|---|---|
| 1 | 40.34m | 19.54m | 19.06m |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

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

| | Station(Distance from BA1) | Elevation, MSL | | Station(Distance from BA1) | Elevation, MSL |
|---|---|---|---|---|---|
| BA1 | 0 | 17.20m | BA3 | 114.22m | 19.61m |
| BA2 | 40.34m | 19.54m | BA4 | 129.64m | 19.09m |

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

| | Station (Distance from BA1) | Elevation |
|---|---|---|
| Ab1 | 54.21m | 14.23m |
| Ab2 | | |

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

Shape: Rectangle Number of Piers: 4

| | Station (Distance from BA1) | Elevation, MSL | Pier Width |
|---|---|---|---|
| Pier 1 | 49.86m | 19.56m | .65m |
| Pier 2 | 62.16m | 19.50m | .65m |
| Pier 3 | 87.33m | 15.24m | .65m |
| Pier 4 | 104.58m | 19.50m | .65m |

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

Figure 41. Polanco Bridge Data Form

The water surface elevation of Dipolog River was acquired using PPK survey technique on June 13, 2015 at 11:10:46 AM. The resulting water surface elevation data is 9.0057 m above MSL. The markings on the bridge pier shall serve as a reference for flow data gathering and depth gauge deployment of Mindanao State University - Iligan Institute of Technology Phil-LiDAR 1. The actual (A) and the finished (B) water level marking are shown in Figure 42.

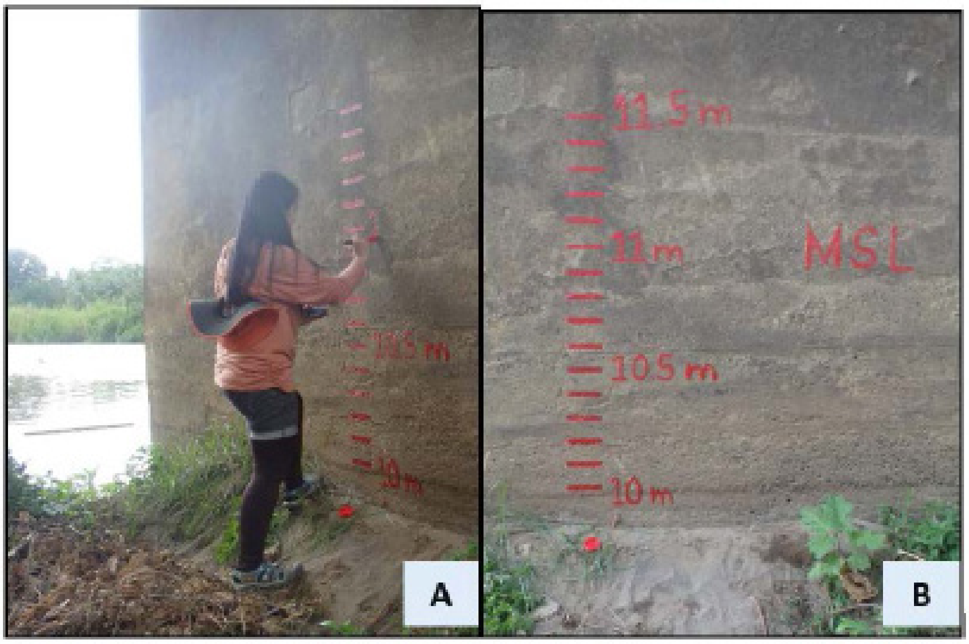



Figure 42. MSL water level markings in Polanco Bridge's Pier

## 4.6 Validation Points Acquisition Survey

Validation Points Acquisition Survey was conducted on June 9 and 10, 2015 using a survey-grade GNSS Rover receiver mounted on a pole which was attached in front of the vehicle as shown in Figure 43. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height of 1.945 m was measured from the ground up to the bottom of the notch of the GNSS Rover receiver. The survey was conducted using PPK technique on a continuous topography mode.


Figure 43. Validation Points Acquisition Set-up

The survey acquired 6,426 ground validation points with an approximate length of 44.768 km, covered the major roads of Dipolog-Polanco-Oroquieta, Dipolog Zamboanga Highway and Dipolog Punta Dansullan-Serio Osmeña as shown in the map in Figure 44. The control point UP-POL was used as the GNSS base station all throughout the survey.

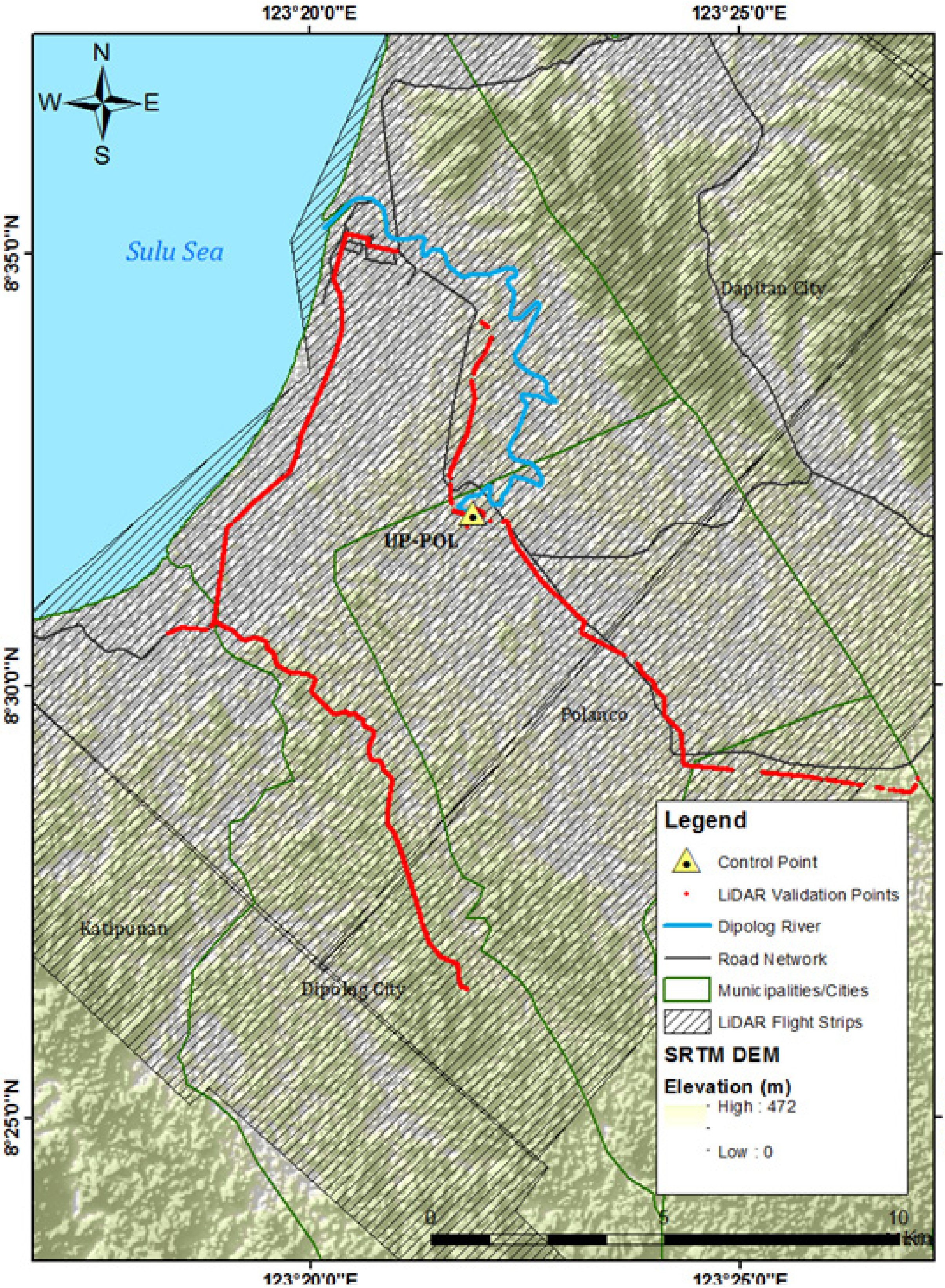



Figure 44. LiDAR Ground Validation Survey along Dipolog City

## 4.7 Bathymetric Survey

Bathymetric survey was executed on June 9 and 10, 2015 using Trimble® SPS 882 in GNSS PPK survey technique and an Ohmex™ Single Beam Echo Sounder mounted to a boat as shown in Figure 45. The survey began in Brgy. Villahermosa, Municipality of Polanco with coordinates 8°32'24.43863" 123°22'41.20246", down to the mouth of the river in Brgy. Barra, Dipolog City with coordinates 8°35'26.35898" 123°20'03.55581".


Figure 45. OHMEX™ Single Beam Echo Sounder set up on a rubber boat for the Dipolog River bathymetric survey

Manual bathymetry was performed on June 10, 2015 using Trimble® SPS-882 in GNSS PPK survey technique on the shallow part of Dipolog River as shown in Figure 46. The survey began in the upstream part of the river in Brgy. Obay, Municipality of Polanco with coordinates 8°31'58.53832" 123°21'58.54168", traversed down the river by foot and ended at the starting point of bathymetric survey using boat.


Figure 46. Manual bathymetric survey in Dipolog River

The bathymetric line length is approximately 16.921 km with a total of 15,442 points acquired using UP-POL as GNSS base station. The processed data were generated into a map using GIS software as shown in Figure 47.

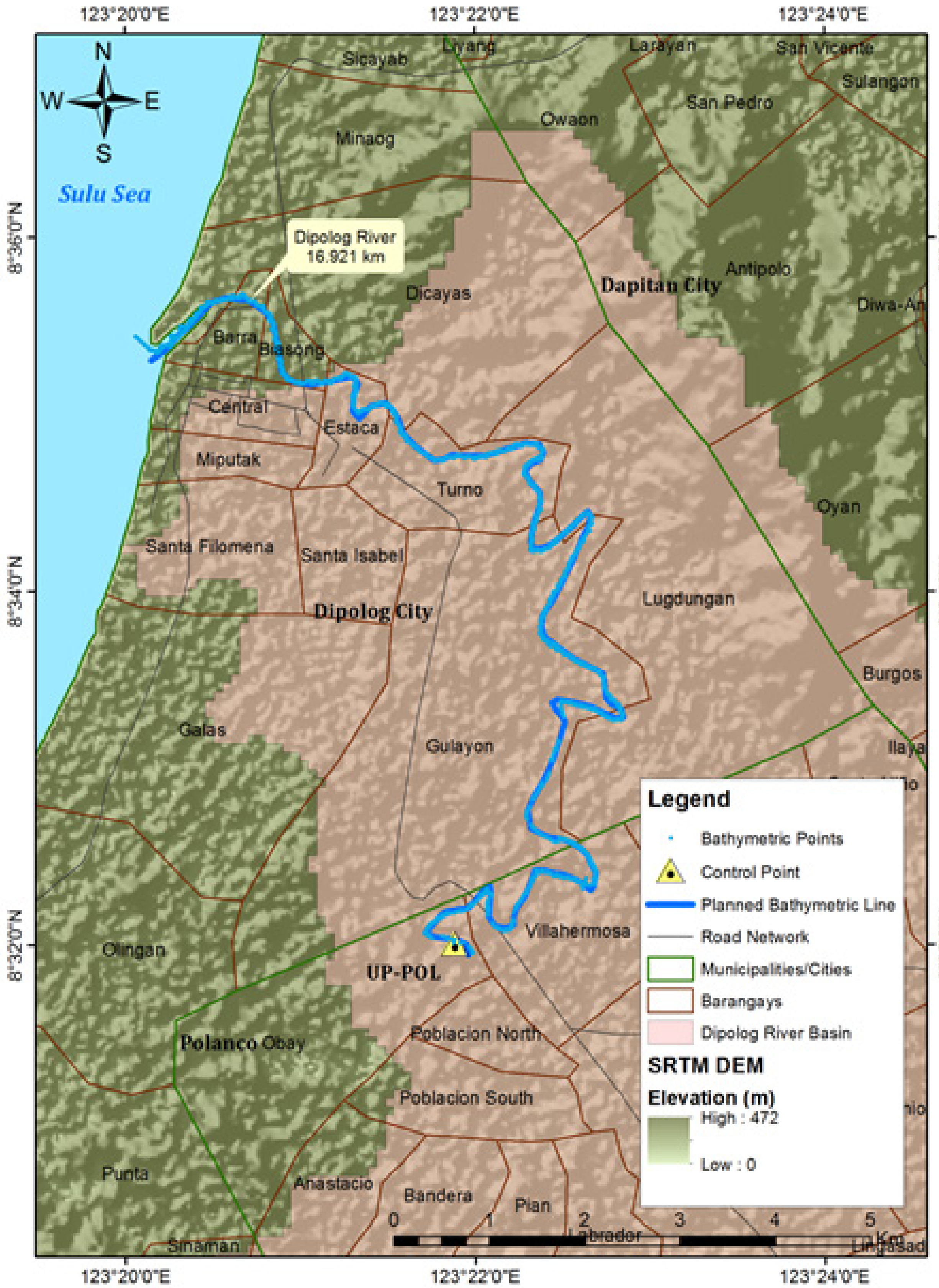



Figure 47. Bathymetric points gathered from Dipolog River

A CAD drawing was also produced to illustrate the Dipolog riverbed profile. As shown in Figure 48, it has a less than 2 m change in elevation for every 1 km. Additionally, the deepest portion or the lowest elevation recorded is about nine (9) m (MSL), which is located in Brgy. Dicayas, Dipolog City, while the highest elevation was 11.62 m in MSL in Brgy. Villahermosa.

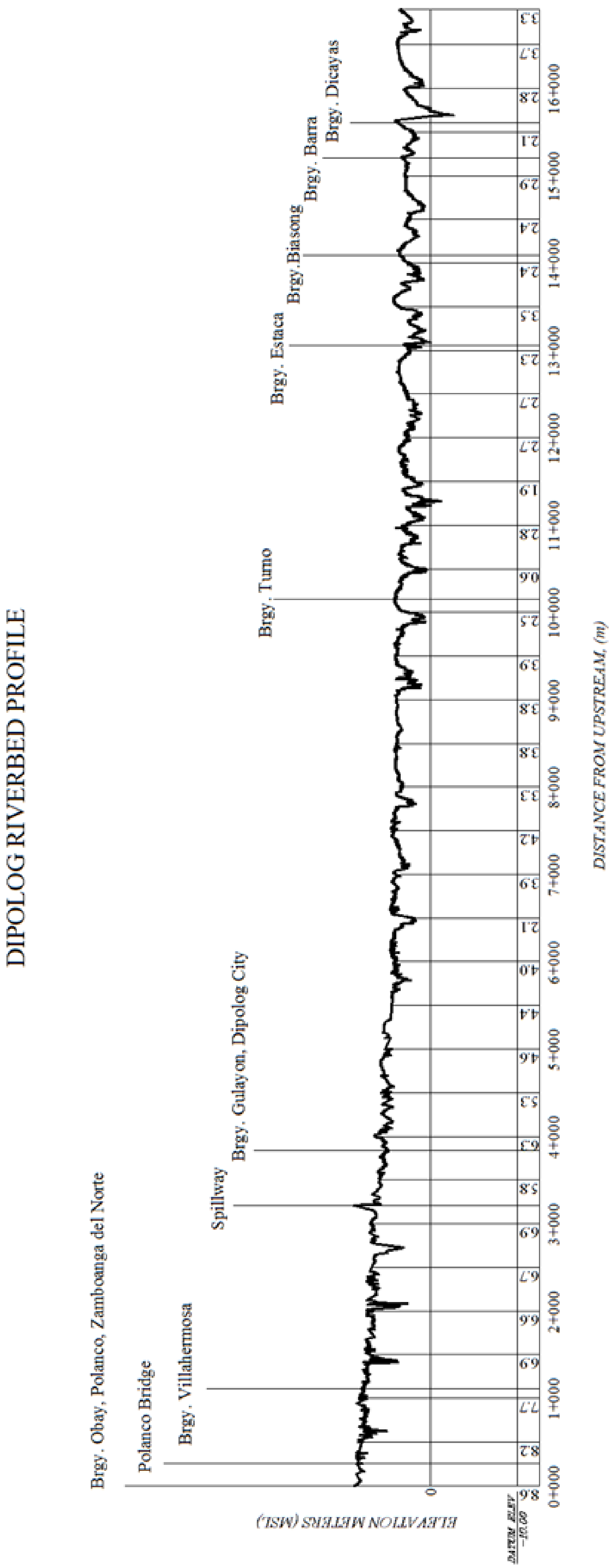



Figure 48. Dipolog riverbed centerline profile

# CHAPTER 5: FLOOD MODELING AND MAPPING

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

## 5.1 Data used for Hydrologic Modeling

### 5.1.1 Hydrometry and Rating Curves

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

### 5.1.2 Precipitation

Precipitation data was taken from the Automatic Rain Gauge (ARG) installed upstream by the DOST. The ARG was specifically installed in the municipality of Sergio Osmeña Sr. with coordinates 8°17'6.00"N Latitude and 123°31'50.88"E Longitude. The location of the rain gauge is shown in Figure 49 below.

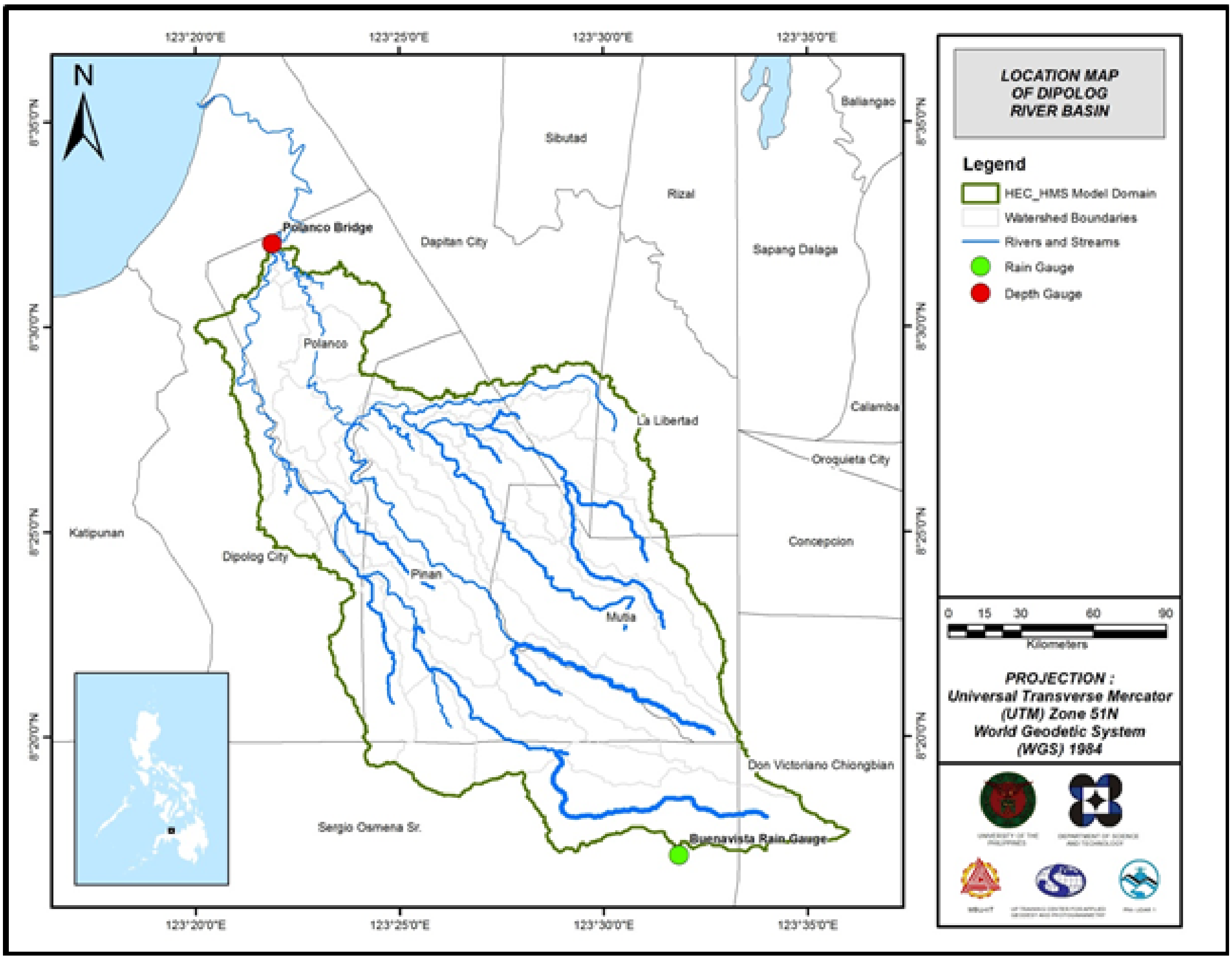



Figure 49. The location map of Dipolog HEC-HMS model used for calibration

### 5.1.3 Rating Curves and River Outflow

HQ curve analysis is important in determining the equation to be used in establishing Q values with R-Squared values closer to 1. A trendline is more accurate if the R-Squared value is closer or at 1.

Figure 51 shows the highest R-Squared value of 0.9501 compared to the graphs using the original Q. In this case, Q boxed values with Q at bank-full were plotted versus the stage.

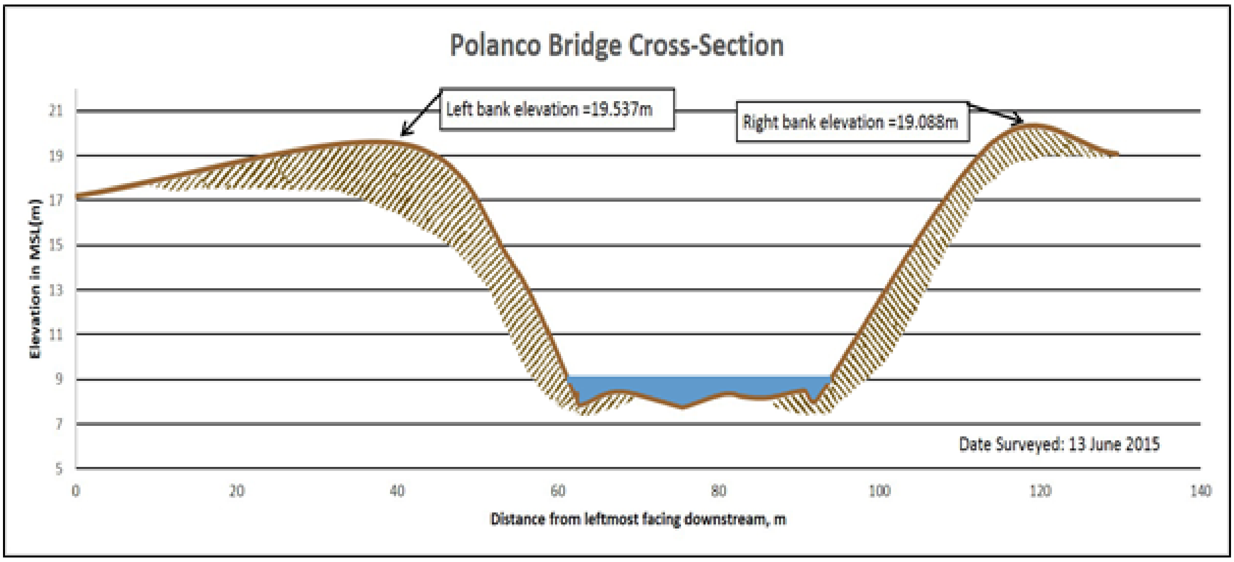



Figure 50. Cross-Section Plot of Polanco Bridge

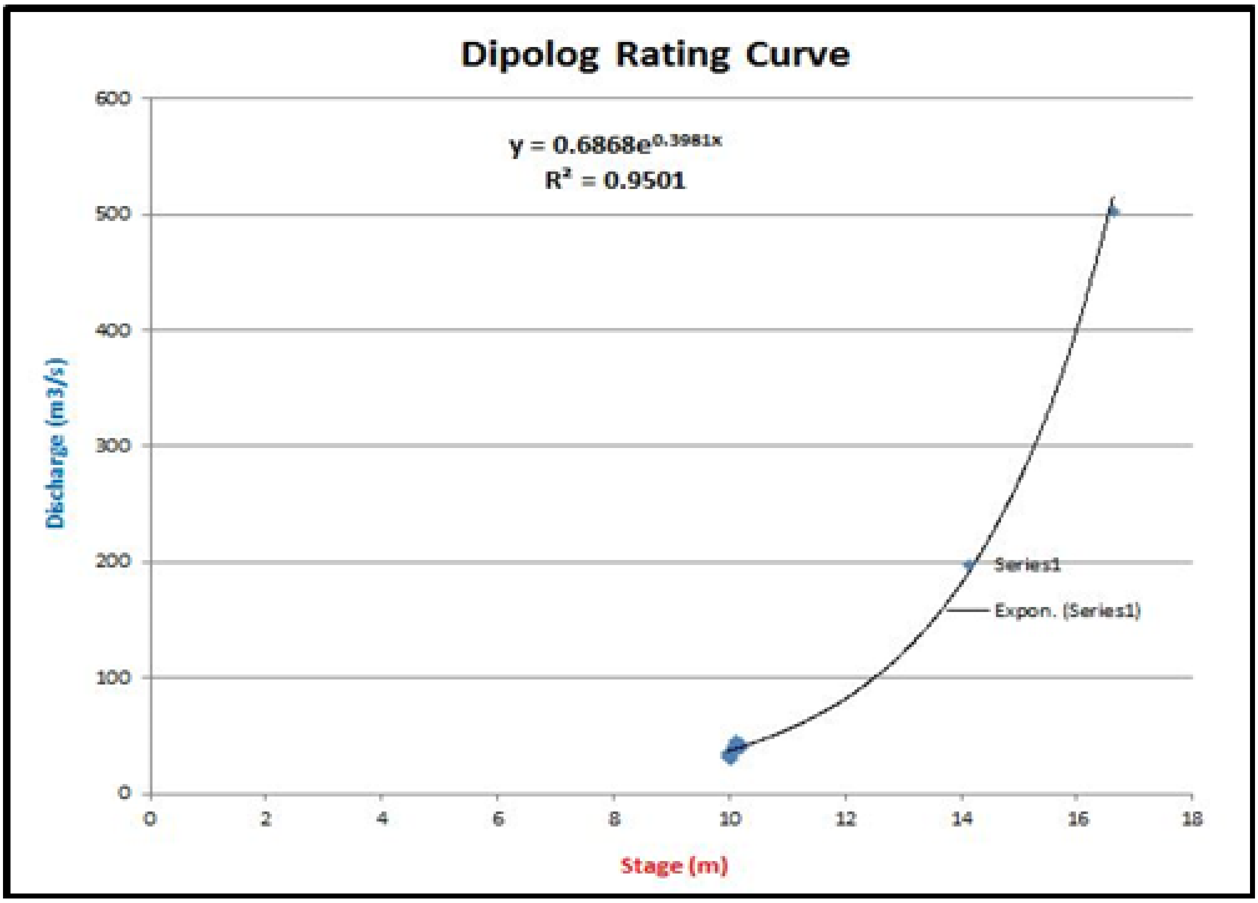



Figure 51. Rating Curve at Polanco Bridge

This rating curve equation was used to compute the river outflow at Polanco Bridge for the calibration of the HEC-HMS model.

Total rainfall taken from the ARG at Buenavista, Sergio Osmeña Sr. was 113 mm. It peaked to 25 mm on 26 June 2016, 13:45. The lag time between the peak rainfall and discharge is 9 hours and 45 minutes, as shown in Figure 52.

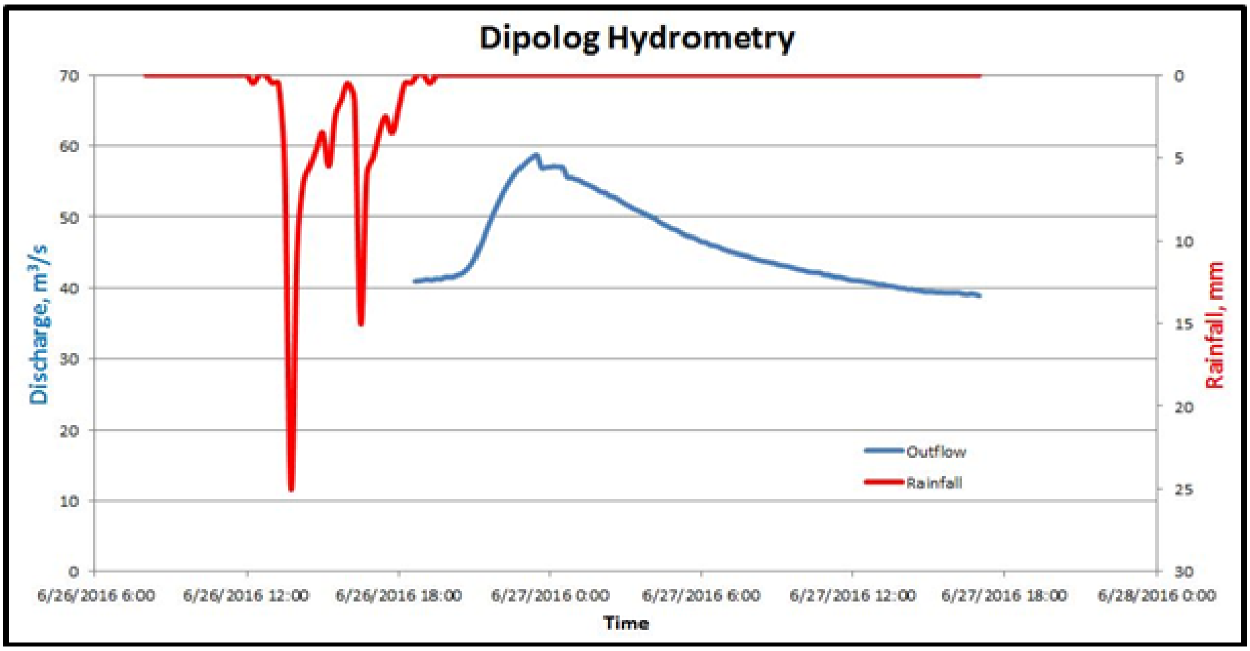



Figure 52. Rainfall and outflow data at Polanco Bridge used for modeling

## 5.2 RIDF Station

The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed Rainfall Intensity Duration Frequency (RIDF) values for the Dipolog Rain Gauge (Table 32). The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and re-arranging the value in such a way certain peak value will be attained at a certain time (Figure 54). This station chosen based on its proximity to the Dipolog watershed. The extreme values for this watershed were computed based on a 51-year record.

Table 32. RIDF values for Dipolog Rain Gauge computed by PAGASA

| COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| T (yrs) | 10 mins | 20 mins | 30 mins | 1 hr | 2 hrs | 3 hrs | 6 hrs | 12 hrs | 24 hrs |
| 2 | 19.7 | 30.9 | 38.7 | 53.8 | 73.6 | 85.5 | 105.7 | 120.3 | 136.2 |
| 5 | 25.9 | 39.6 | 50.1 | 72.6 | 99.7 | 117.3 | 140.9 | 158.3 | 178.5 |
| 10 | 30 | 45.4 | 57.6 | 85.1 | 117 | 138.3 | 164.3 | 183.4 | 206.5 |
| 15 | 32.3 | 48.6 | 61.8 | 92.1 | 126.8 | 150.2 | 177.4 | 197.6 | 222.4 |
| 20 | 34 | 50.9 | 64.8 | 97.1 | 133.6 | 158.5 | 186.6 | 207.6 | 233.4 |
| 25 | 35.2 | 52.7 | 67.1 | 100.9 | 138.9 | 164.9 | 193.7 | 215.2 | 242 |
| 50 | 39 | 58.1 | 74.1 | 112.5 | 155.1 | 184.6 | 215.6 | 238.8 | 268.3 |
| 100 | 42.9 | 63.4 | 81.1 | 124.1 | 171.2 | 204.2 | 237.3 | 262.1 | 294.4 |

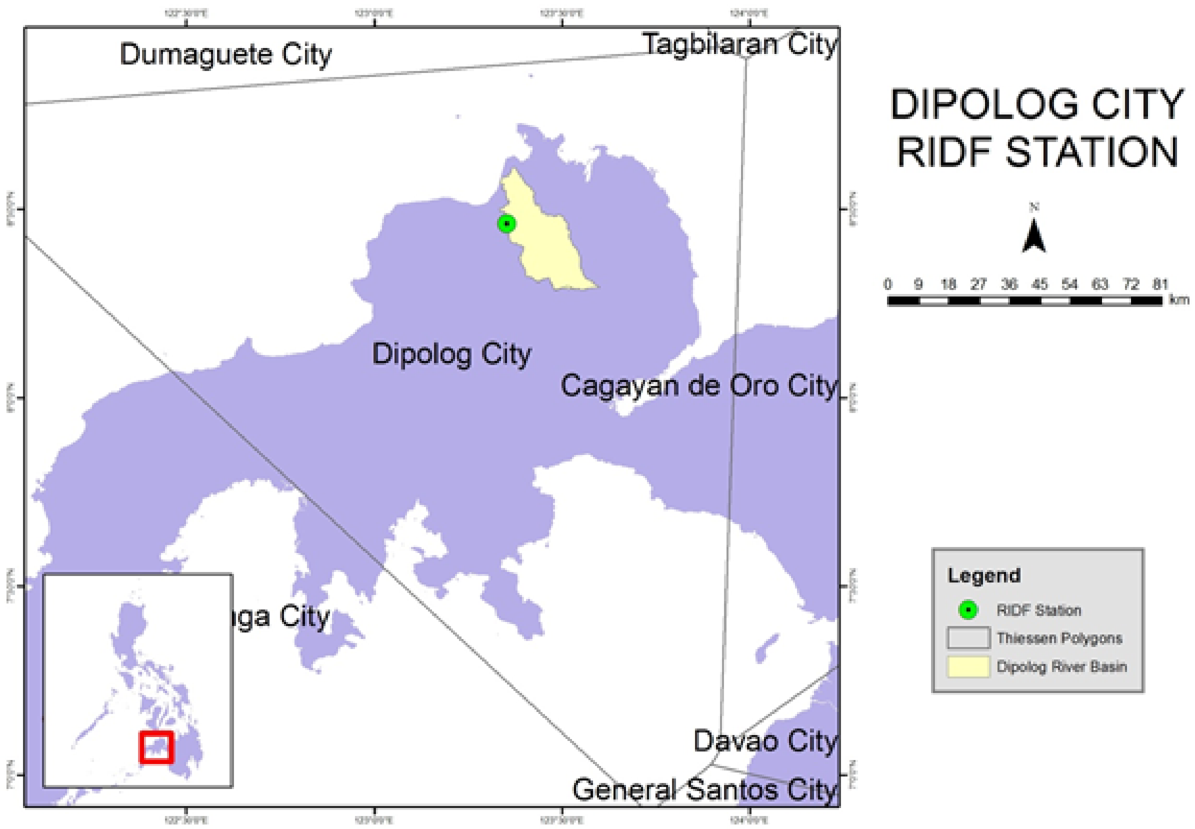



Figure 53. Location of Dipolog RIDF station relative to Dipolog River Basin

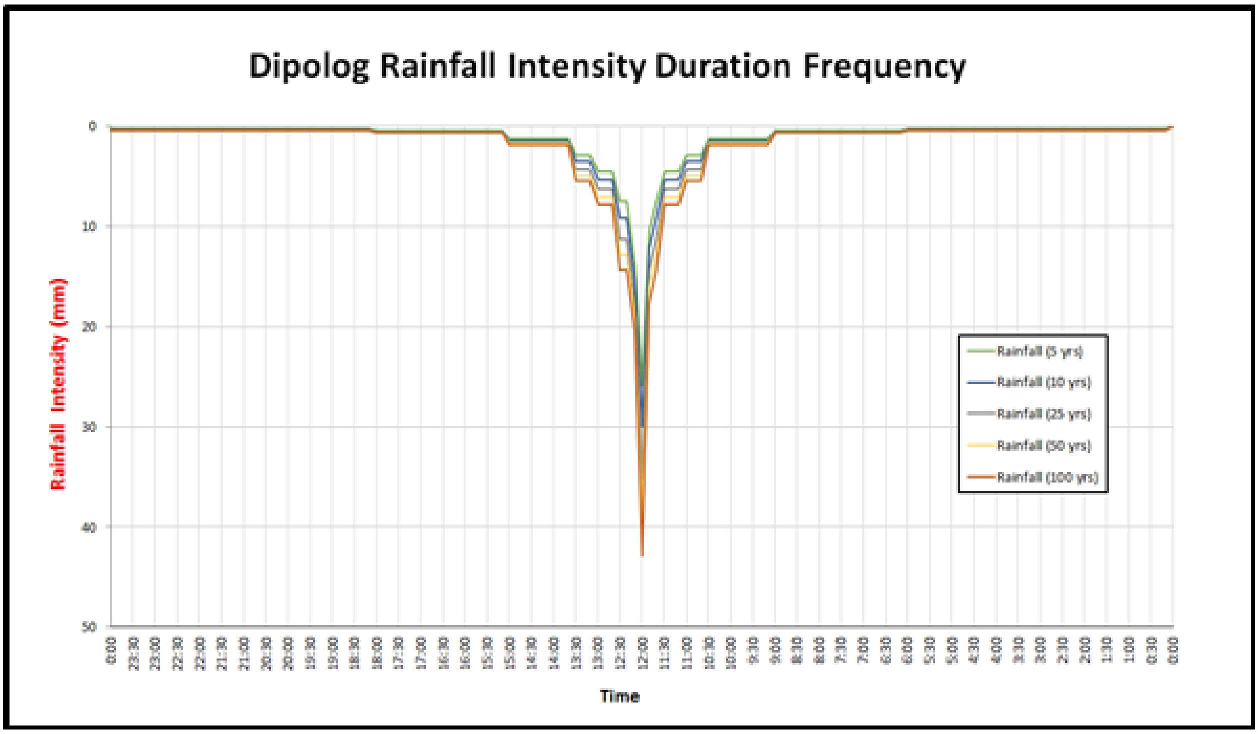



Figure 54. Synthetic storm generated for a 24-hr period rainfall for various return periods

## 5.3 HMS Model

The soil texture dataset was generated before 2004 from the Bureau of Soils and Water Management (BSWM) under the Department of Agriculture (DA). The soil texture map (Figure 55) of the Dipolog River basin was used as one of the factors for the estimation of the CN parameter.

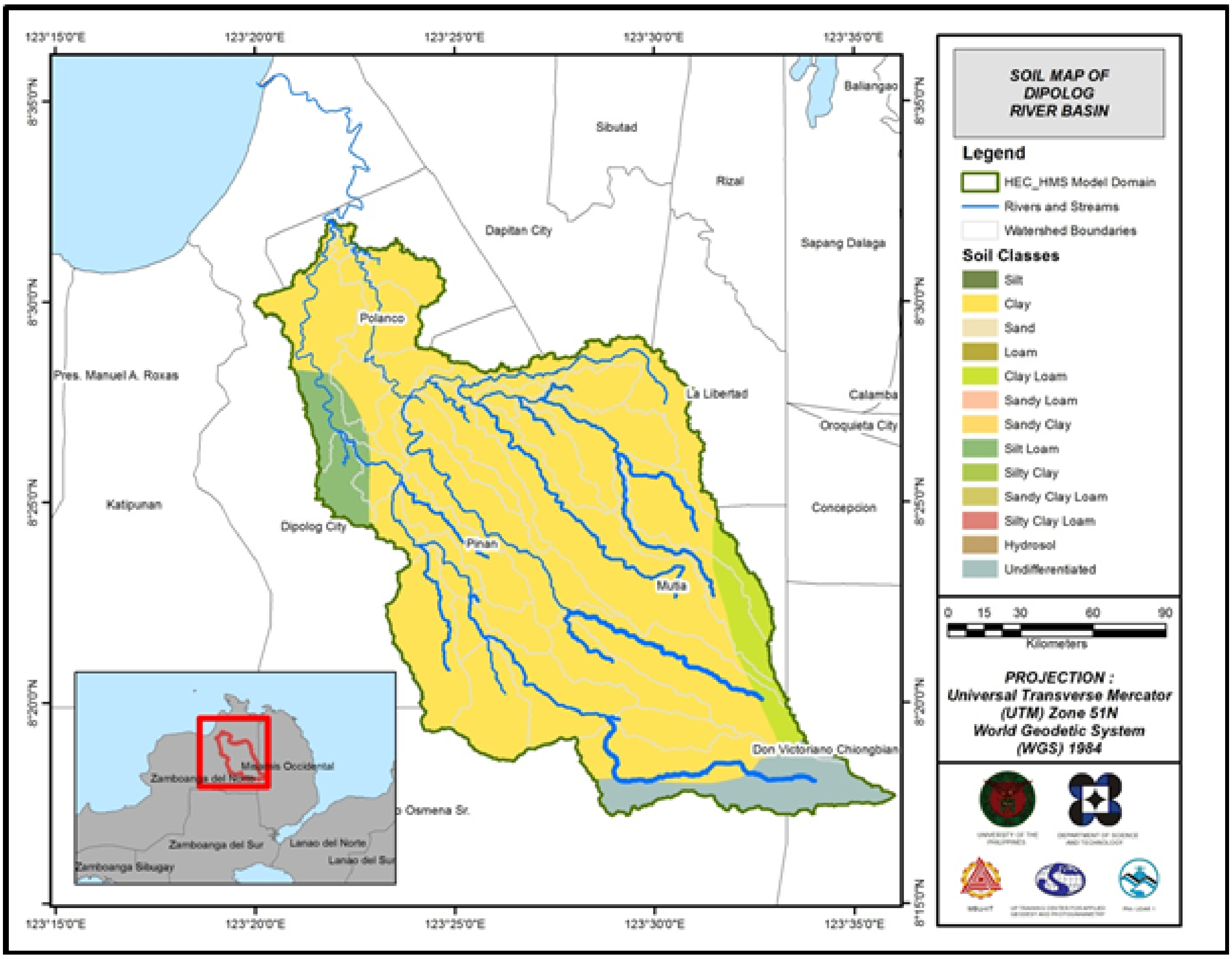



Figure 55. Soil Map of Dipolog River Basin

The land cover data was generated in 2003 from the National Mapping and Resource information Authority (NAMRIA), DENR. Figure 56 shows the Land Cover inside Dipolog River Basin. The land cover map of Dipolog River Basin was used as another factor for the estimation of the CN and watershed lag parameters of the rainfall-runoff model.

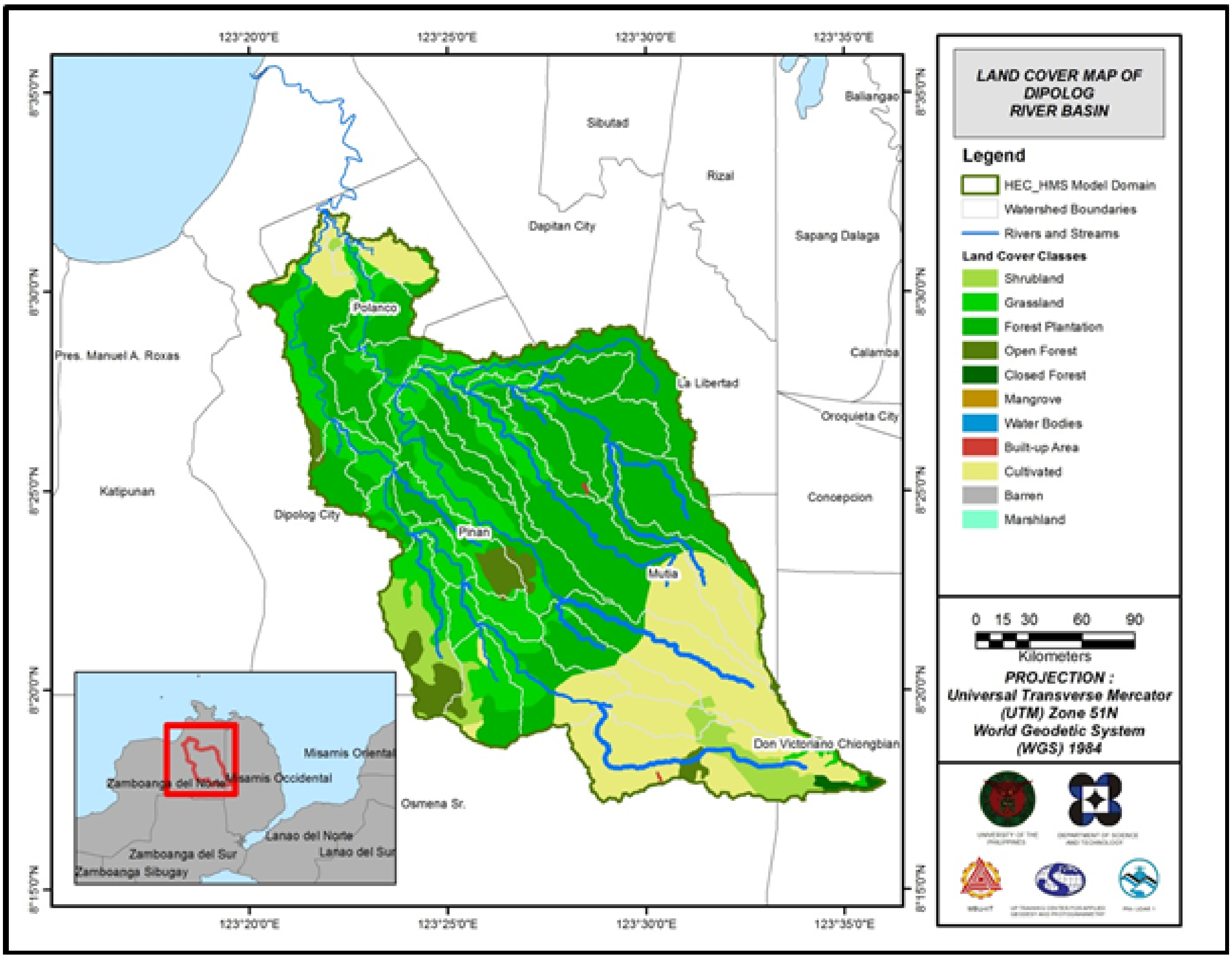



Figure 56. Land Cover Map of Dipolog River Basin (Source: NAMRIA)

For Dipolog, the soil classes identified were silt, clay, sand, loam, clay loam, sandy loam, sandy clay, silt loam, silty clay, sandy clay loam, silty clay loam, hydrosol, and undifferentiated. The land cover types identified were shrubland, grassland, forest plantation, open forest, closed forest, and cultivated area.

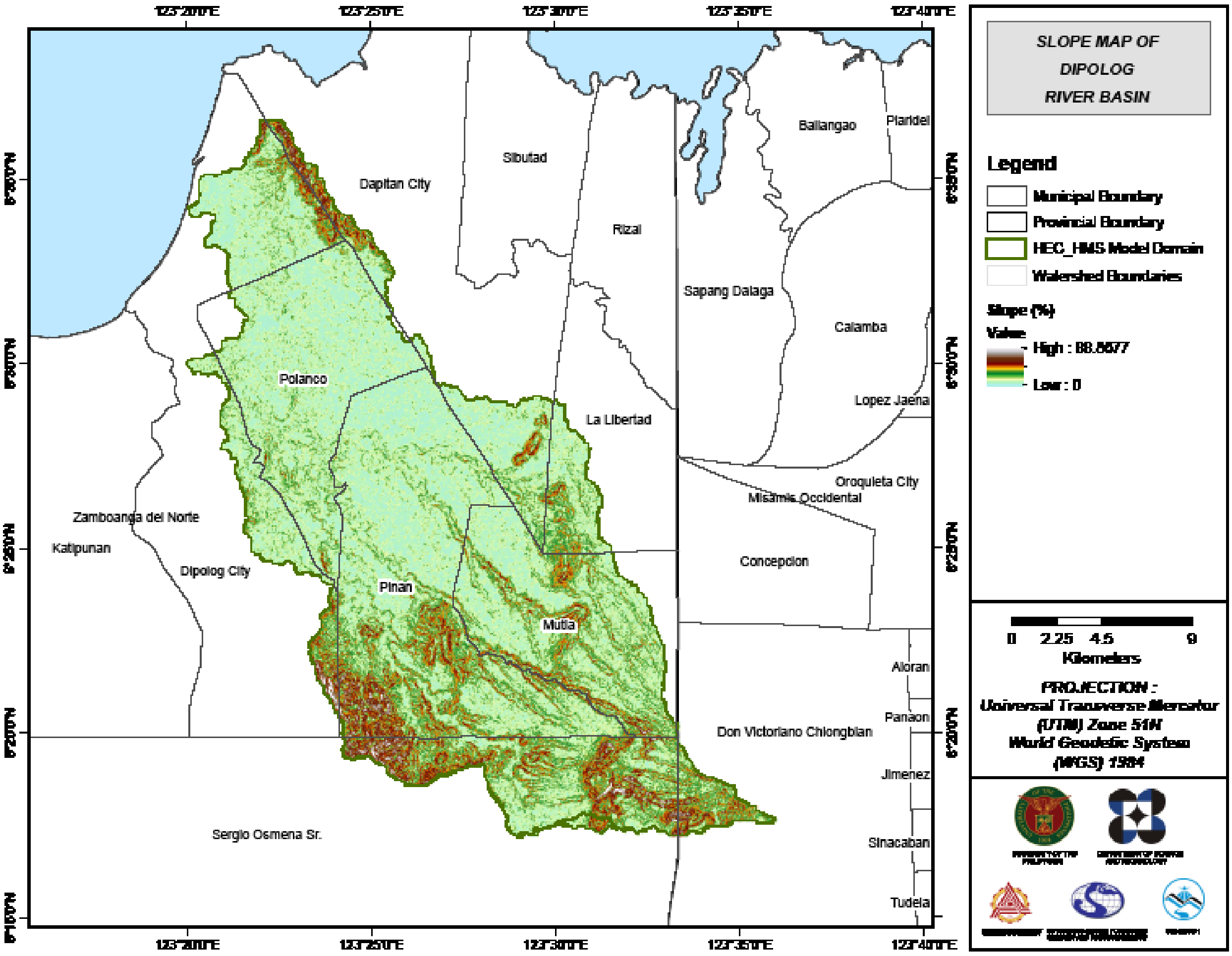



Figure 57. Slope Map of Dipolog River Basin

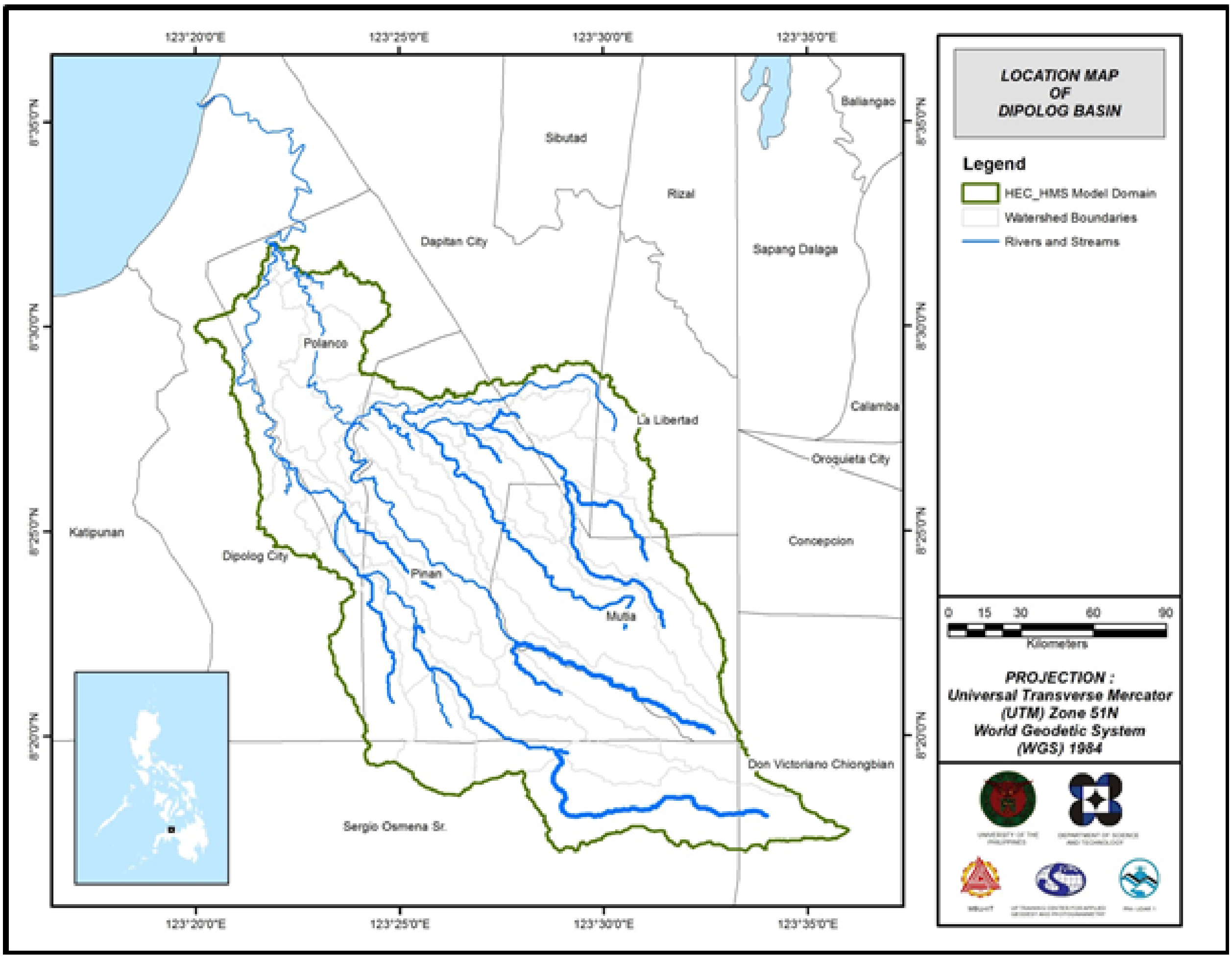



Figure 58. Stream Delineation Map of the Dipolog River Basin

Using the SAR-based DEM, the Dipolog basin was delineated and further subdivided into subbasins. The model consists of 32 sub basins, 18 reaches, and 18 junctions. The main outlet is located at Polanco Bridge, Dipolog. This basin model is illustrated in Figure 59. Finally, it was calibrated using hydrological data derived from the depth gauge and flow meter deployed at Polanco Bridge. Annex 10 shows the Dipolog Model Reach Parameters.

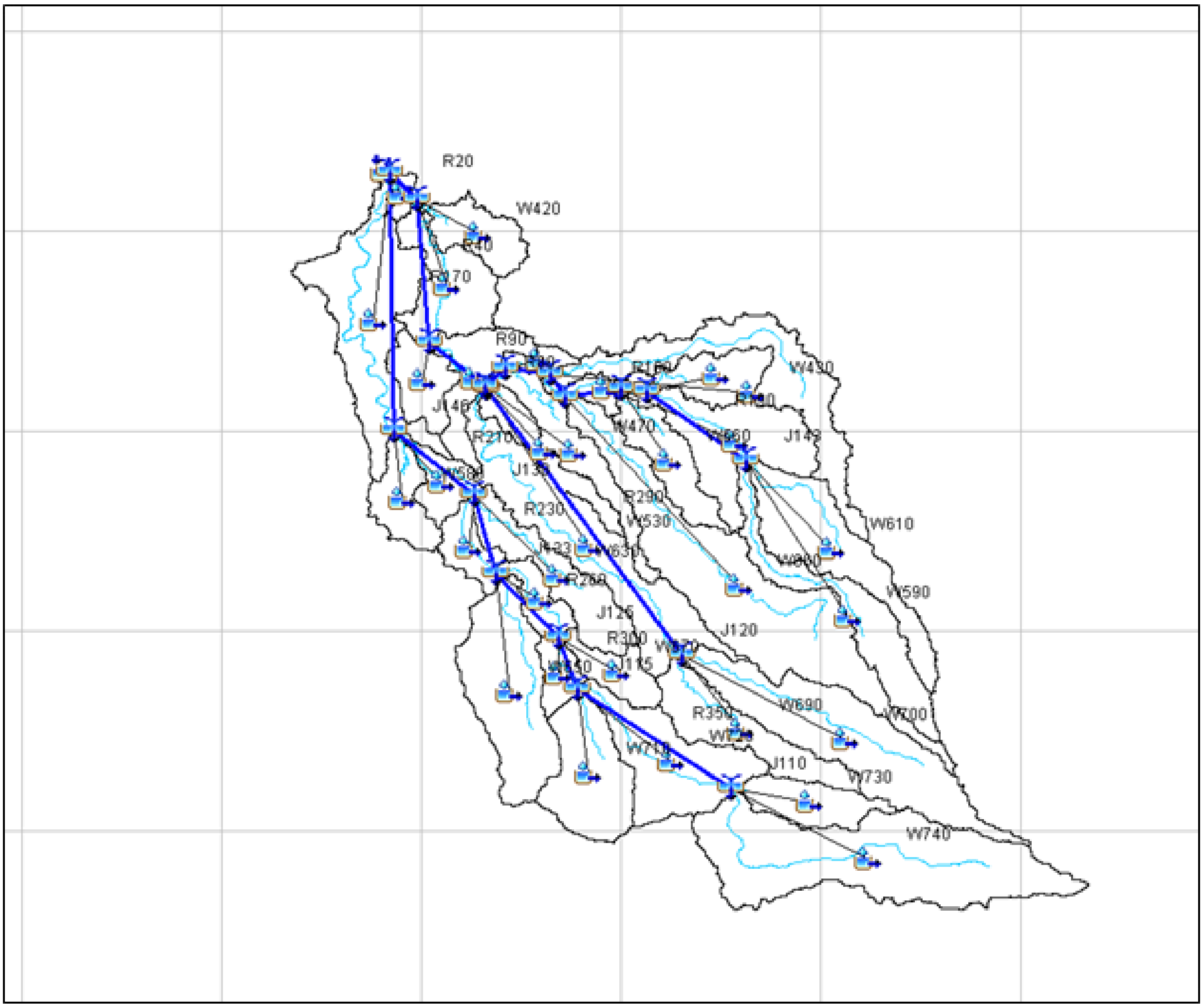



Figure 59. The Dipolog Hydrologic Model generated in HEC-GeoHMS

## 5.4 Cross-section Data

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

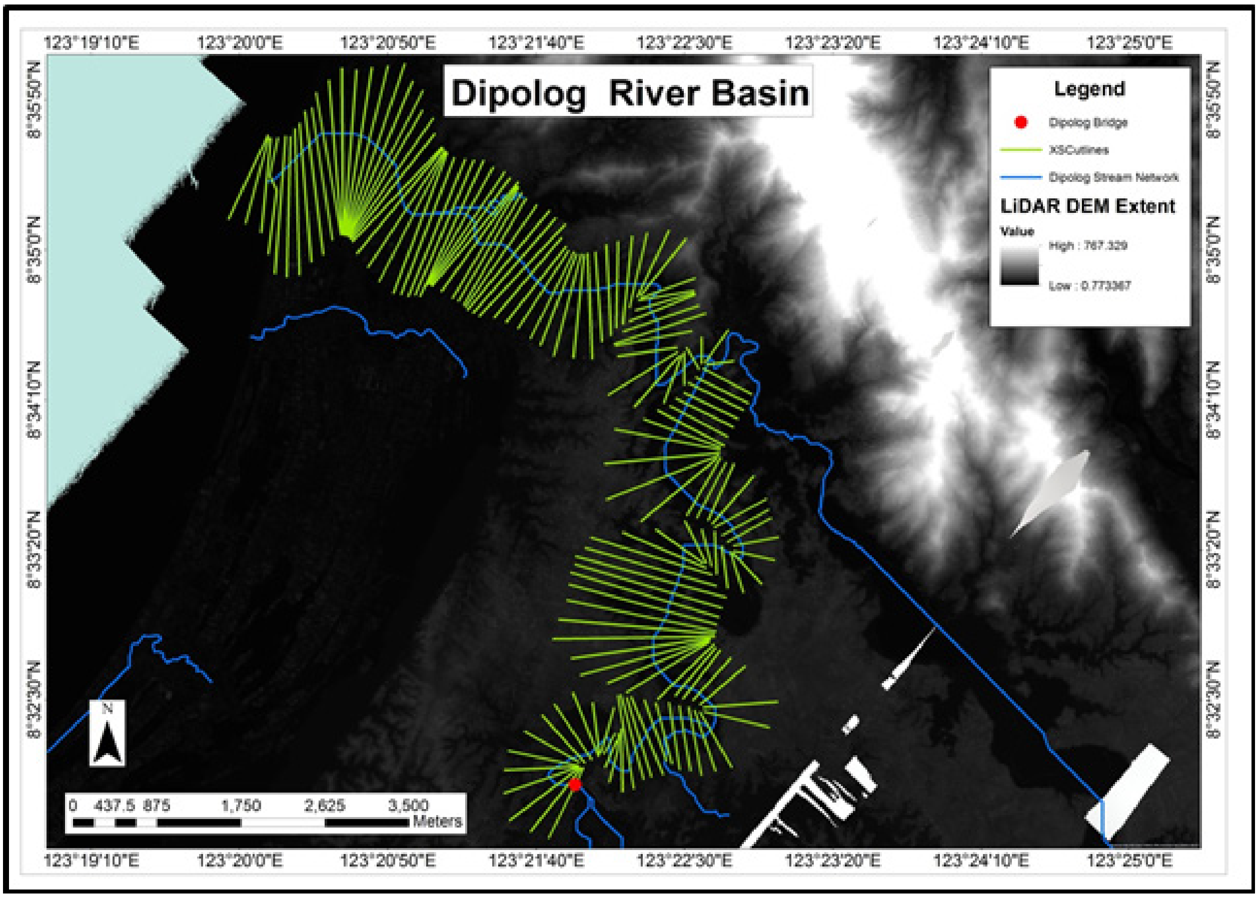



Figure 60. River cross-section of Dipolog River generated through Arcmap HEC GeoRAS tool

## 5.5 Flo 2D Model

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

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

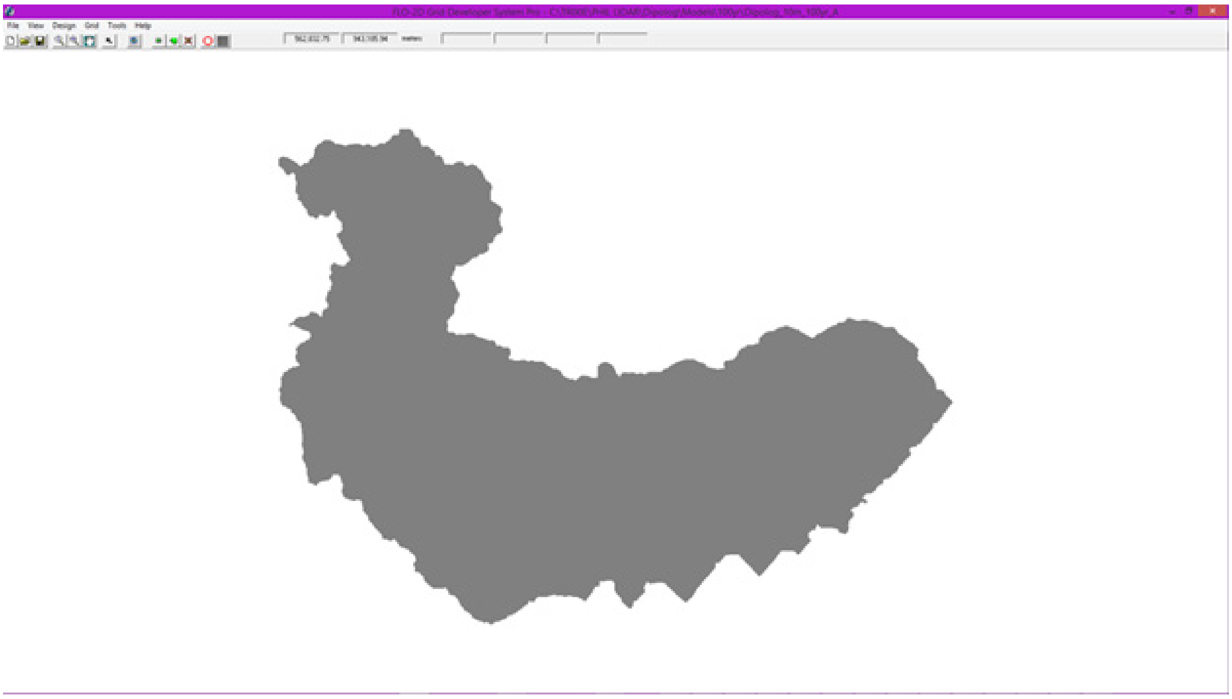


Figure 61. Screenshot of subcatchment with the computational area to be modeled in FLO-2D Grid Developer System Pro (FLO-2D GDS PRO)

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 104.85547 hours. After the simulation, FLO-2D Mapper Pro is used to transform the simulation results into spatial data that shows flood hazard levels, as well as the extent and inundation of the flood. Assigning the appropriate flood depth and velocity values for Low, Medium, and High creates the following food hazard map. Most of the default values given by FLO-2D Mapper Pro are used, except for those in the Low hazard level. For this particular level, the minimum h (Maximum depth) is set at 0.2 m while the minimum vh (Product of maximum velocity (v) times maximum depth (h)) is set at 0 m2/s. The generated hazard maps for Dipolog are in Figures 72, 74, and 76.

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 93 429 792.00 m2. The generated flood depth maps for Dipolog are in Figures 73, 75, and 77.

There is a total of 35 106 936.49 m3 of water entering the model. Of this amount, 21 523 892.07 m3 is due to rainfall while 13 583 044.41 m3 is inflow from other areas outside the model. 7 433 152.00 m3 of this water is lost to infiltration and interception, while 25 116 497.39 m3 is stored by the flood plain. The rest, amounting up to 2 557 374.05 m3, is outflow.

## 5.6 Results of HMS Calibration

After calibrating the Dipolog HEC-HMS river basin model, its accuracy was measured against the observed values (See Annex 9). Figure 62 shows the comparison between the two discharge data.

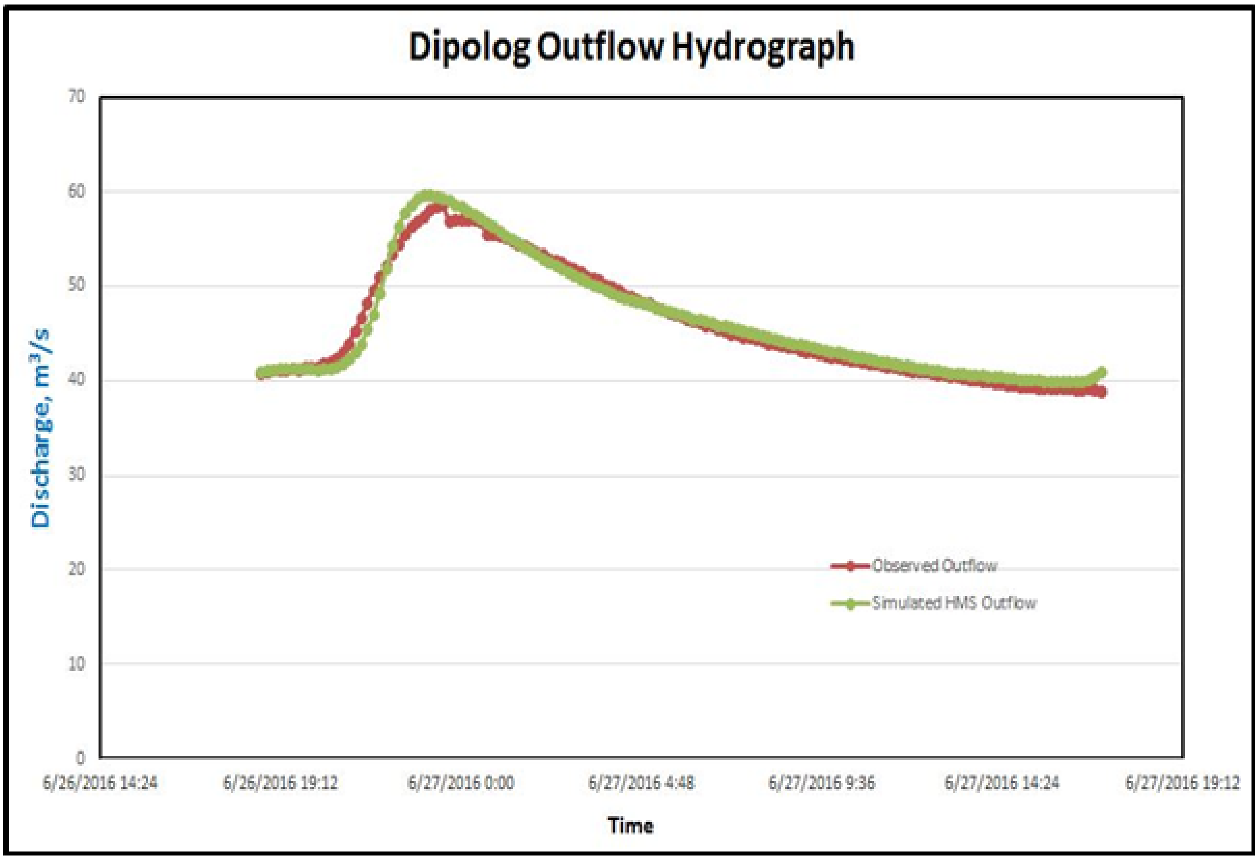



Figure 62. Outflow Hydrograph of Dipolog Bridge generated in HEC-HMS model compared with observed outflow

Enumerated in Table 33 are the adjusted ranges of values of the parameters used in calibrating the model.

Table 33. Range of Calibrated Values for Dipolog

| Hydrologic Element | Calculation Type | Method | Parameter | Range of Calibrated Values |
|---|---|---|---|---|
| Basin | Loss | SCS Curve number | Initial Abstraction (mm) | 68 - 298 |
| | | | Curve Number | 64 - 89 |
| | Transform | Clark Unit Hydrograph | Time of Concentration (hr) | 0.5 - 6 |
| | | | Storage Coefficient (hr) | 2 - 28 |
| | Baseflow | Recession | Recession Constant | 0.85 |
| | | | Ratio to Peak | 0.4 |
| Reach | Routing | Muskingum-Cunge | Manning's Coefficient | 0.017 |

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 68mm to 298mm means that there is a high amount of infiltration or rainfall interception by vegetation.

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range of 64 to 89 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area (M. Horritt, personal communication, 2012). For Dipolog, the basin mostly consists of grassland, forest plantation, cultivated areas and the soil consists of clay.

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 0.5 hours to 28 hours determines the reaction time of the model with respect to the rainfall. The peak magnitude of the hydrograph also decreases when these parameters are increased.

Recession constant is the rate at which baseflow recedes between storm events and ratio to peak is the ratio of the baseflow discharge to the peak discharge. Recession constant of 0.85 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 0.017 is relatively low compared to the common roughness of watersheds (Brunner, 2010).

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

| | |
|---|---|
| RMSE | 0.9 |
| r2 | 0.95 |
| NSE | 0.98 |
| PBIAS | -0.59 |
| RSR | 0.15 |

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 0.90 (m3/s).

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.95.

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 0.98.

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 -0.59.

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 0.15.

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

### 5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 63) shows the Dipolog outflow using the Dipolog 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.

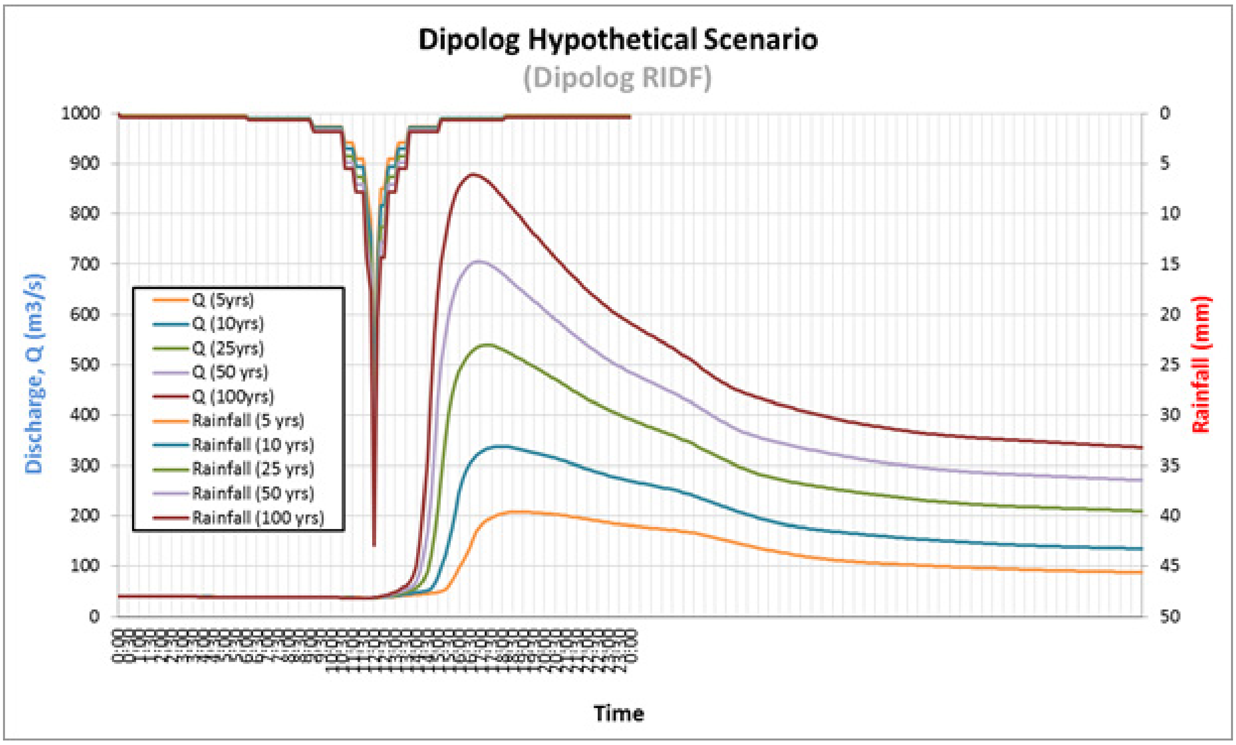



Figure 63. Outflow hydrograph at Dipolog Station generated using Dipolog RIDF simulated in HEC-HMS

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Dipolog discharge using the Dipolog Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 35.

Table 35. Peak values of the Dipolog HECHMS Model outflow using Dipolog RIDF

| RIDF Period | Total Precipitation (mm) | Peak rainfall (mm) | Peak outflow (m 3/s) | Time to Peak |
|---|---|---|---|---|
| 5-Year | 178.32 | 25.9 | 207.7 | 18 hours 40 mins |
| 10-Year | 206.37 | 30 | 338.1 | 17 hours 50 mins |
| 25-Year | 241.91 | 35.2 | 540.2 | 17 hours 20 mins |
| 50-Year | 268.14 | 39 | 705.2 | 17 hours |
| 100-Year | 294.55 | 42.9 | 877.9 | 16 hours 40 mins |

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

The river discharges for the three rivers entering the floodplain are shown in Figure 64 to Figure 70 and the peak values are summarized in Table 36 to Table 42.

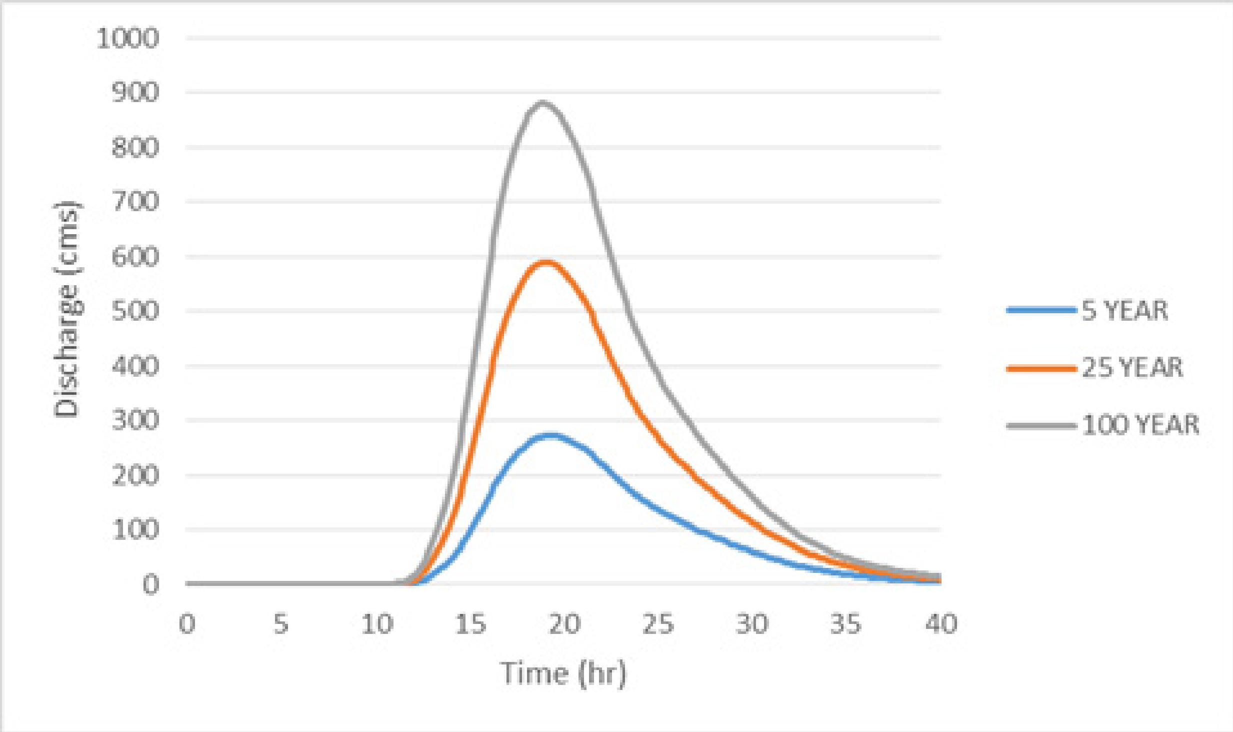



Figure 64. Dipolog river (1) generated discharge

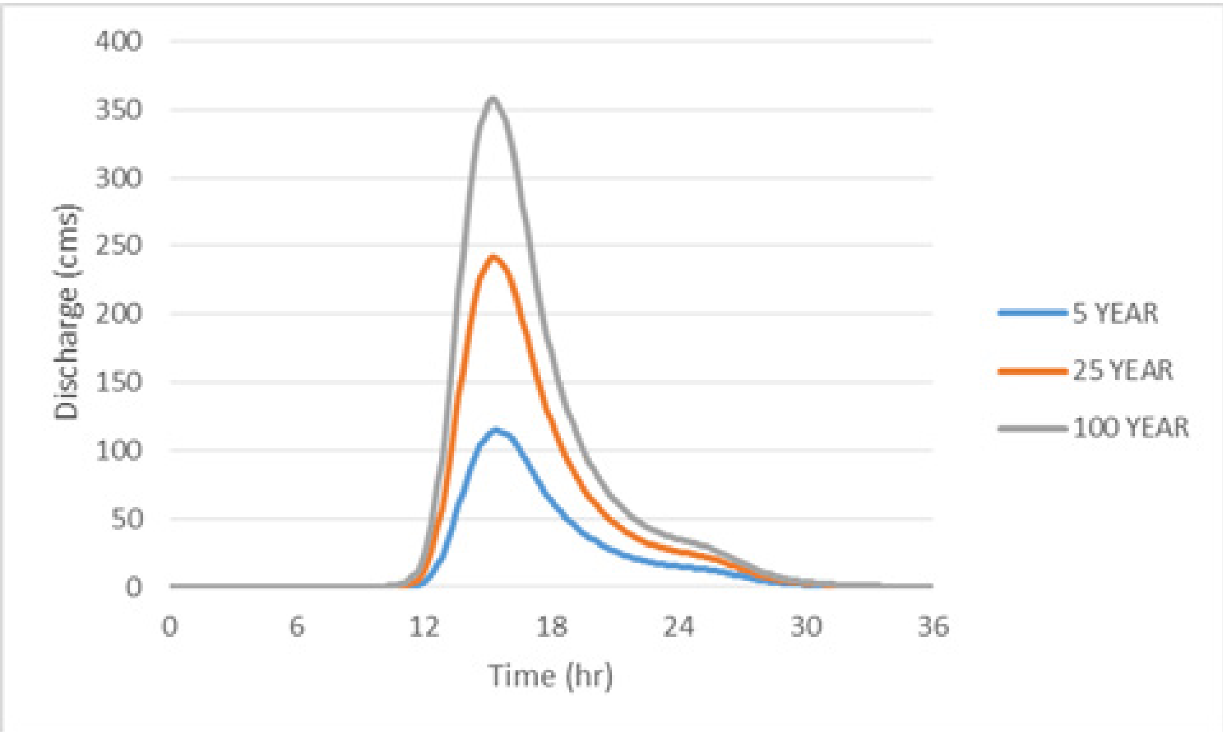



Figure 65. Dipolog river (2) generated discharge

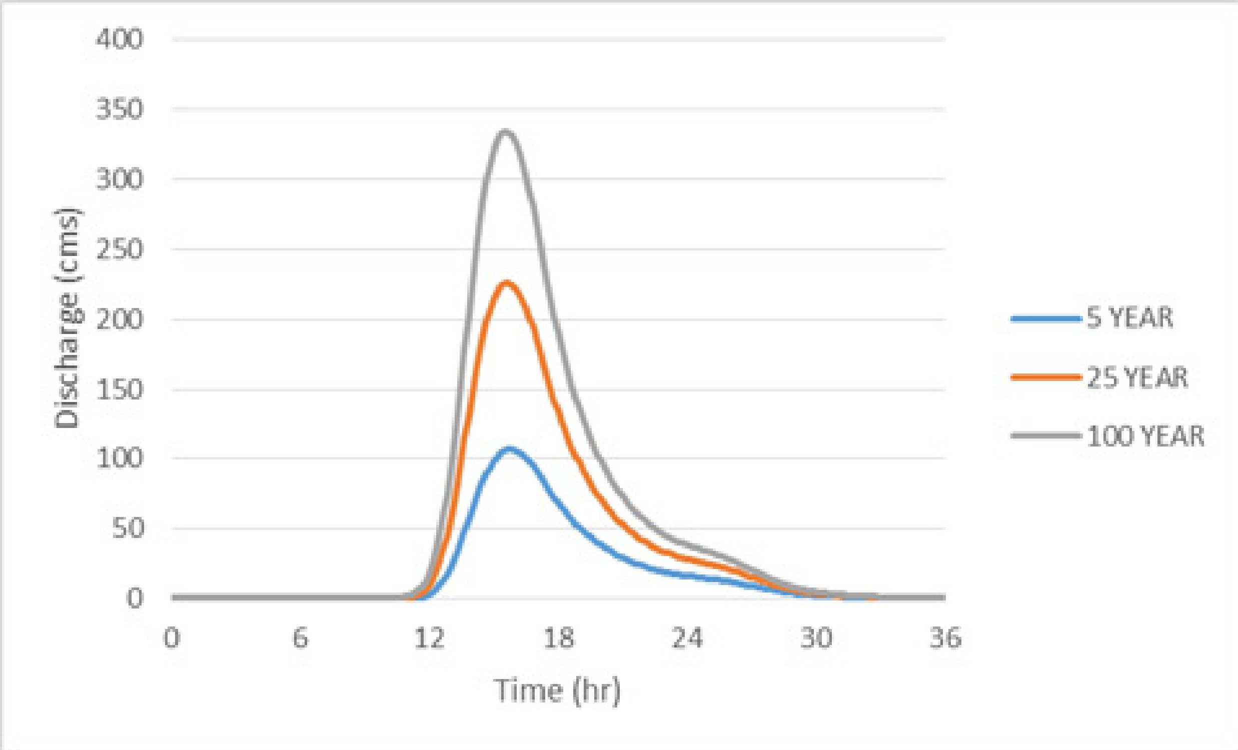



Figure 66. Dipolog river (3) generated discharge

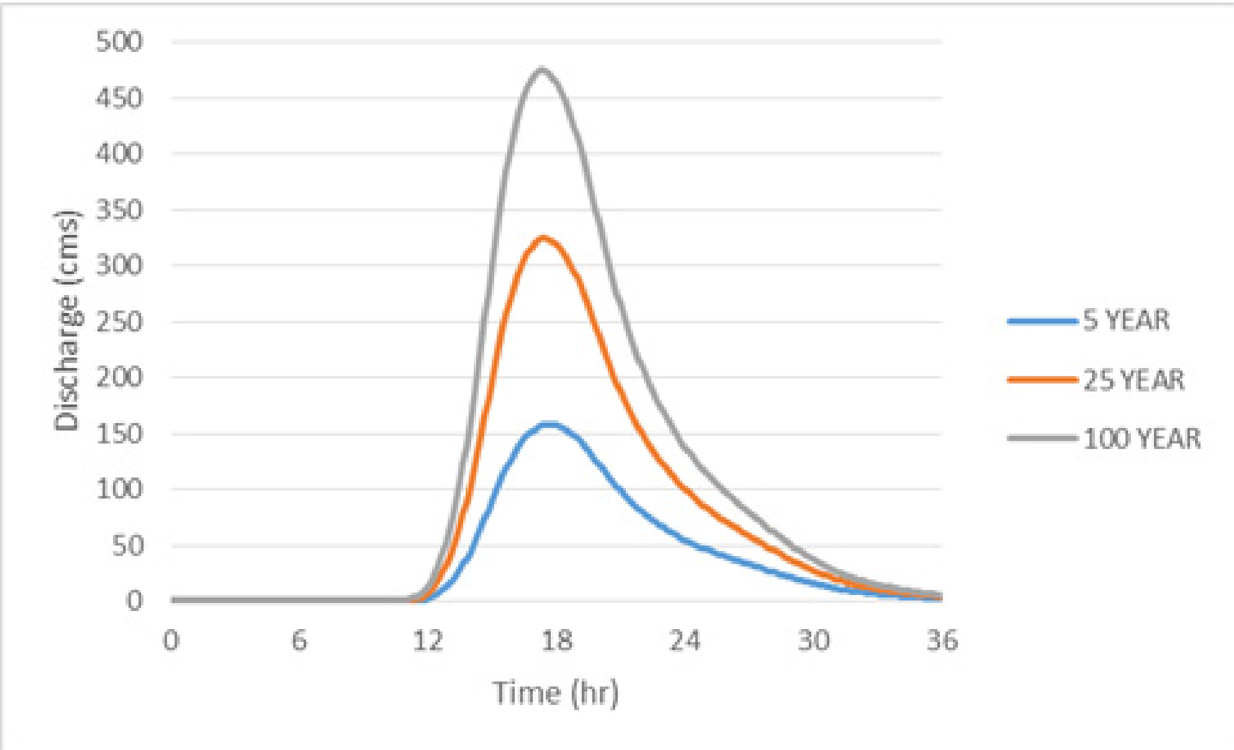



Figure 67. Dipolog river (4) generated discharge

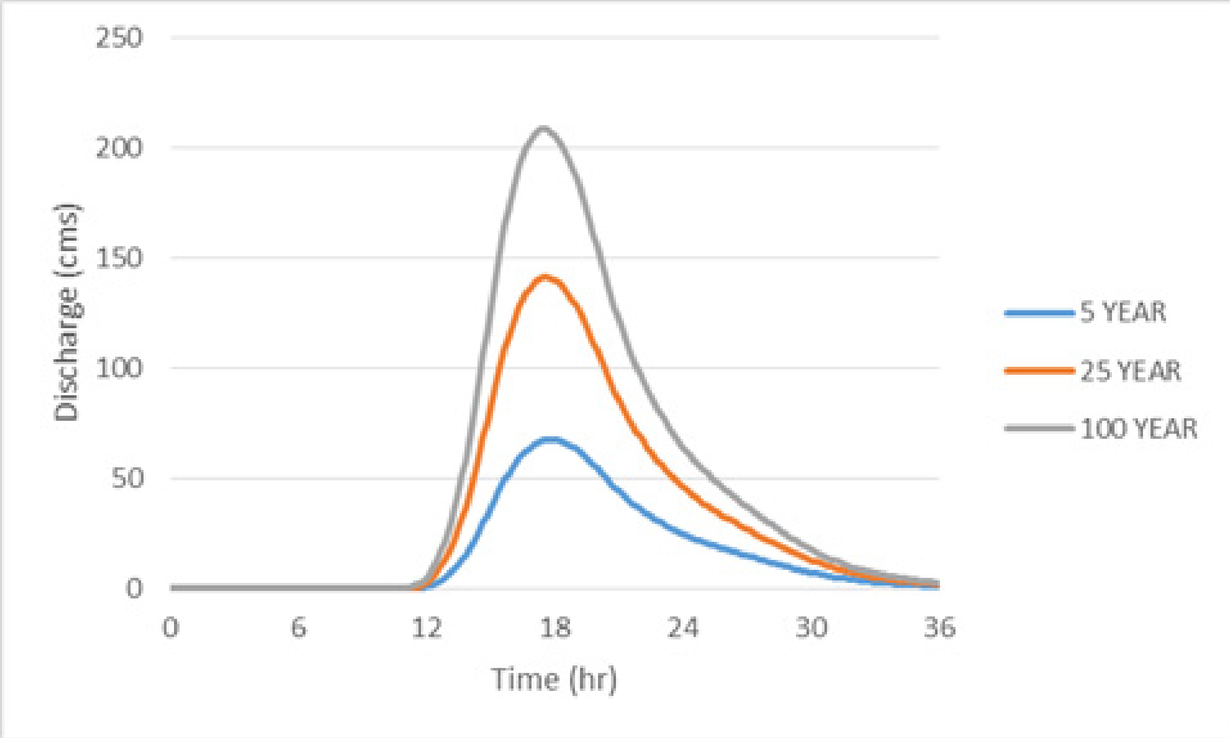



Figure 68. Dipolog river (5) generated discharge

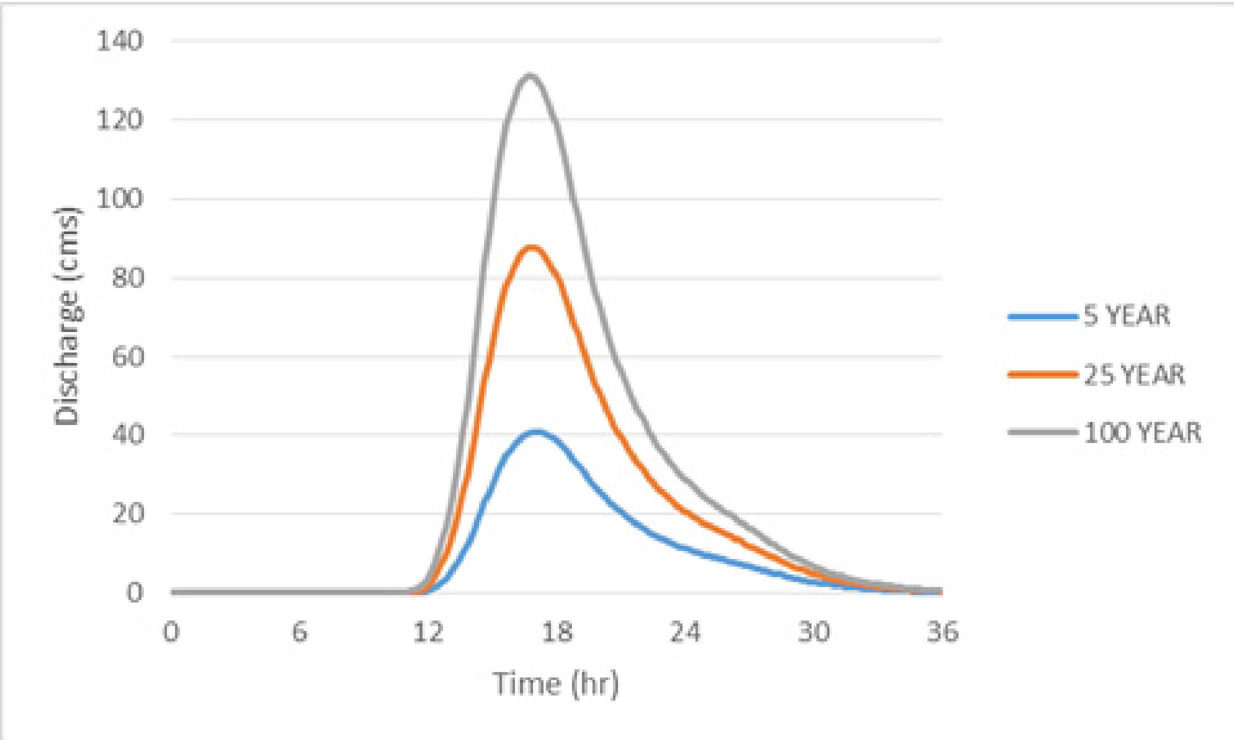



Figure 69. Dipolog river (6) generated discharge

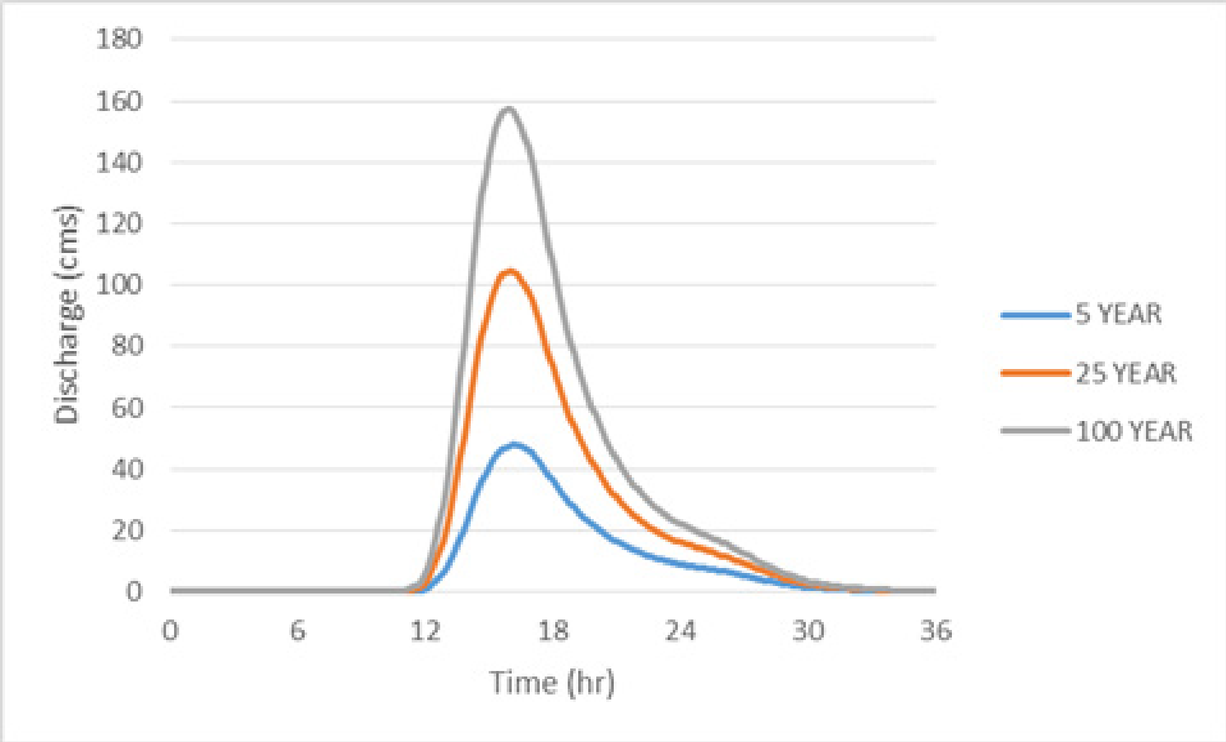



Figure 70. Dipolog river (7) generated discharge

Table 36. Summary of Dipolog river (1) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 881.8 | 388.63 minutes |
| 25-Year | 590 | 388.63 minutes |
| 5-Year | 272.2 | 388.63 minutes |

Table 37. Summary of Dipolog river (2) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 357.2 | 184.21 minutes |
| 25-Year | 241.9 | 184.21 minutes |
| 5-Year | 114.5 | 184.21 minutes |

Table 38. Summary of Dipolog river (3) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 334.7 | 200.14 minutes |
| 25-Year | 226 | 200.14 minutes |
| 5-Year | 106.7 | 200.14 minutes |

Table 39. Table 39. Summary of Dipolog river (4) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 475.6 | 302.61 minutes |
| 25-Year | 324.6 | 302.61 minutes |
| 5-Year | 158.1 | 302.61 minutes |

Table 40. Summary of Dipolog river (5) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 209.2 | 308.78 minutes |
| 25-Year | 141.6 | 308.78 minutes |
| 5-Year | 67.9 | 308.78 minutes |

Table 41. Summary of Dipolog river (6) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 131.2 | 265.95 minutes |
| 25-Year | 87.8 | 265.95 minutes |
| 5-Year | 40.9 | 265.95 minutes |

Table 42. Summary of Dipolog river (7) discharge generated in HEC-HMS

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 157.3 | 217.56 minutes |
| 25-Year | 104.5 | 217.56 minutes |
| 5-Year | 47.9 | 217.56 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 43.

Table 43. Validation of river discharge estimates

| Discharge Point | QMED(SCS), cms | QBANKFUL, cms | QMED(SPEC), cms | VALIDATION | |
|---|---|---|---|---|---|
| | | | | Bankful Discharge | Specific Discharge |
| Dipolog (1) | 239.536 | 179.473 | 576.551 | TRUE | FALSE |
| Dipolog (2) | 100.76 | 181.457 | 215.179 | TRUE | FALSE |
| Dipolog (3) | 93.896 | 19258.451 | 215.936 | FALSE | FALSE |
| Dipolog (4) | 139.128 | 155.213 | 330.582 | TRUE | FALSE |
| Dipolog (5) | 59.752 | 58.07 | 199.8 | TRUE | FALSE |
| Dipolog (6) | 35.992 | 39.497 | 136.047 | TRUE | FALSE |
| Dipolog (7) | 42.152 | 618.83 | 140.505 | FALSE | FALSE |

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

## 5.8 River Analysis Model Simulation

The HEC-RAS Flood Model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. The sample generated map of Dipolog River using the calibrated HMS base flow is shown in Figure 71.

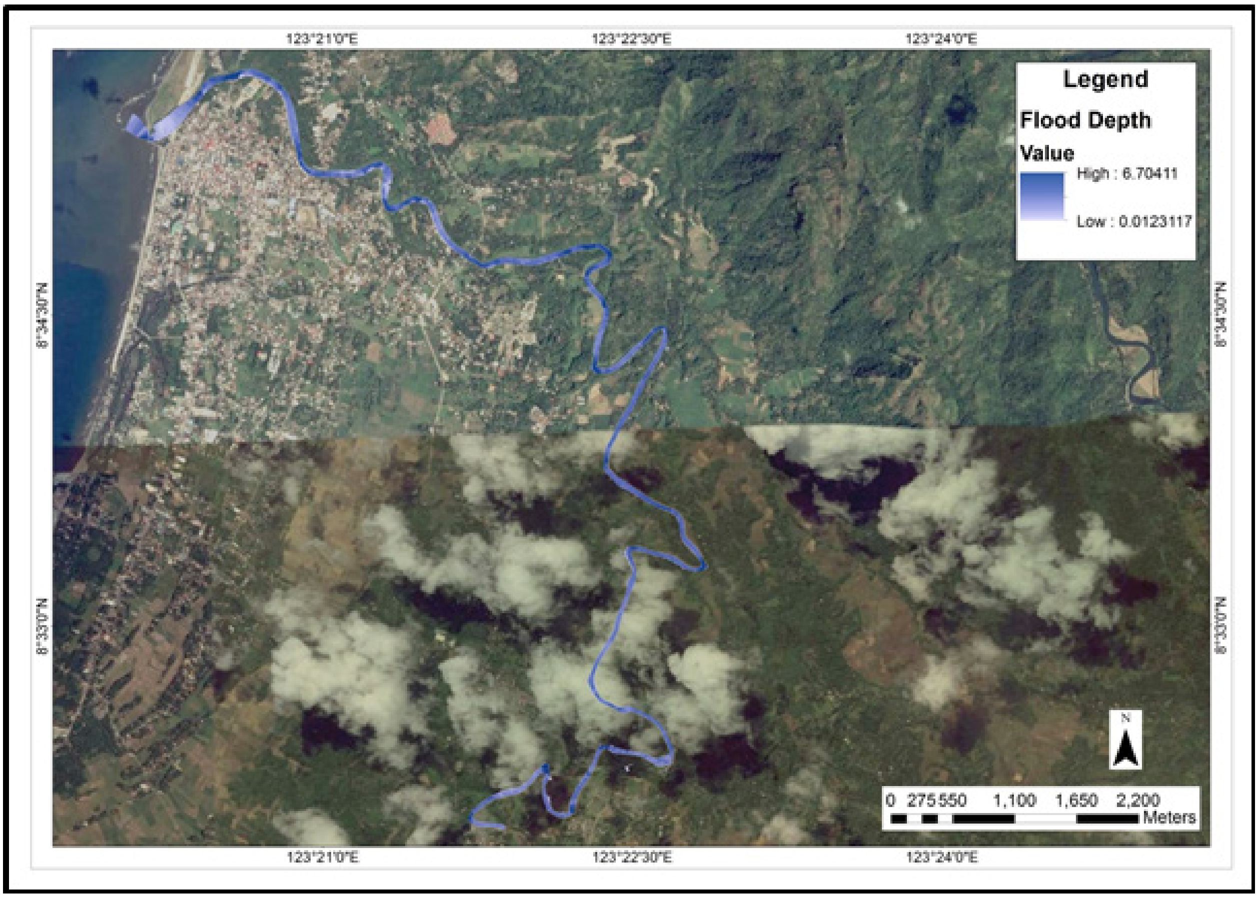



Figure 71. Sample output of Dipolog RAS Model

## 5.9 Flood Hazard and Flow Depth Map

The resulting hazard and flow depth maps have a 10m resolution. Figure 72 to Figure 77 shows the 5-, 25-, and 100-year rain return scenarios of the Dipolog floodplain.

The floodplain, with an area of 218.63 sq. km., covers two cities namely Dapitan City, and Dipolog City, and five municipalities namely Katipunan, La Libertad, Mutia, Pinan, and Polanco. Table 44 shows the percentage of area affected by flooding per municipality.

Table 44. Municipalities affected in Dipolog Floodplain

| City / Municipality | Total Area | Area Flooded | % Flooded |
|---|---|---|---|
| Dapitan City | 222.95 | 16.39 | 7% |
| Dipolog City | 184.42 | 93.37 | 51% |
| Katipunan | 189.62 | 32 | 17% |
| La Libertad | 66.24 | 3.28 | 5% |
| Mutia | 83.22 | 0.75 | 1% |
| Pinan | 135.87 | 40.41 | 30% |
| Polanco | 86.49 | 65.41 | 76% |

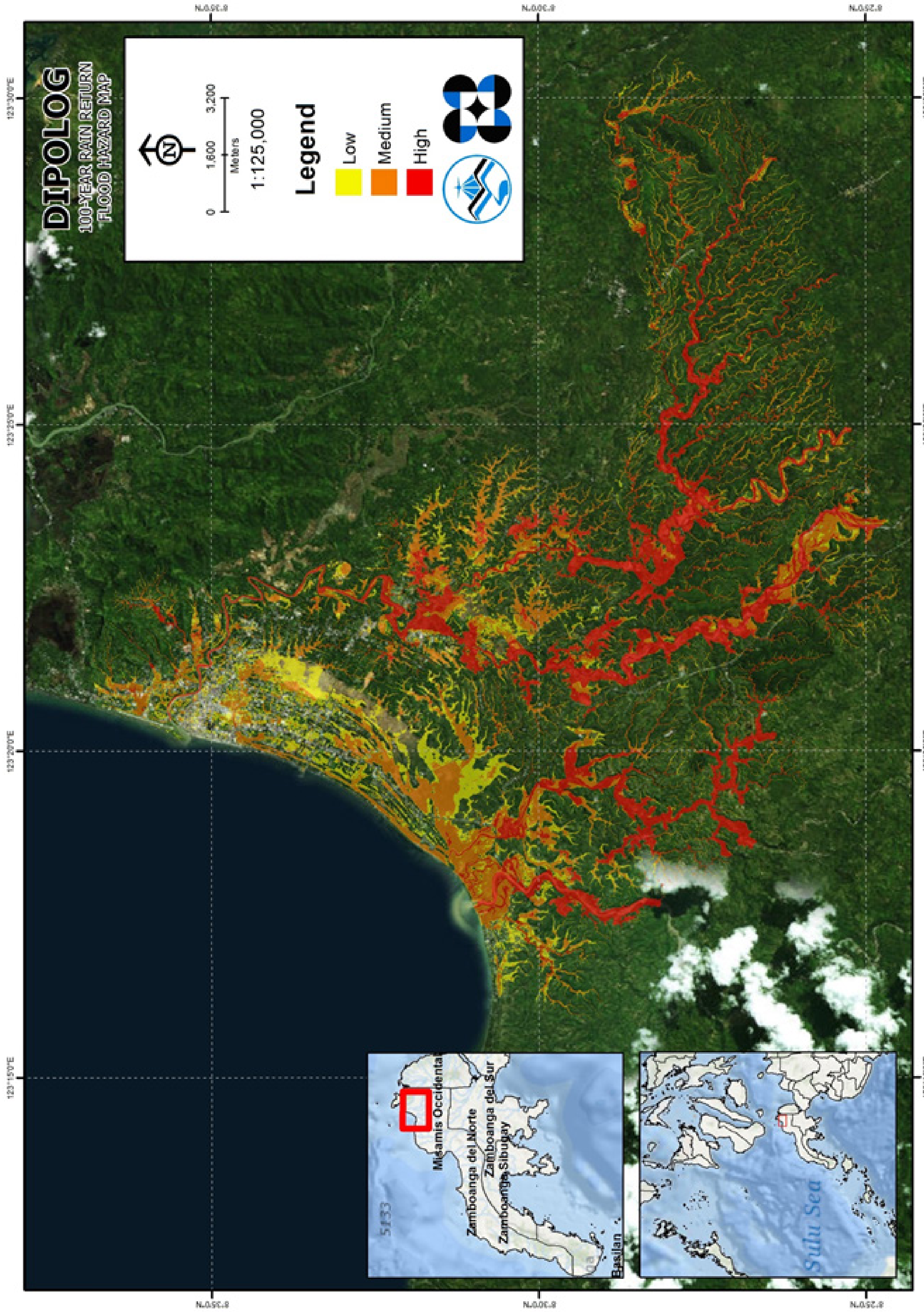



Figure 72. 100-year Flood Hazard Map for Dipolog Floodplain overlaid in Google Earth imagery

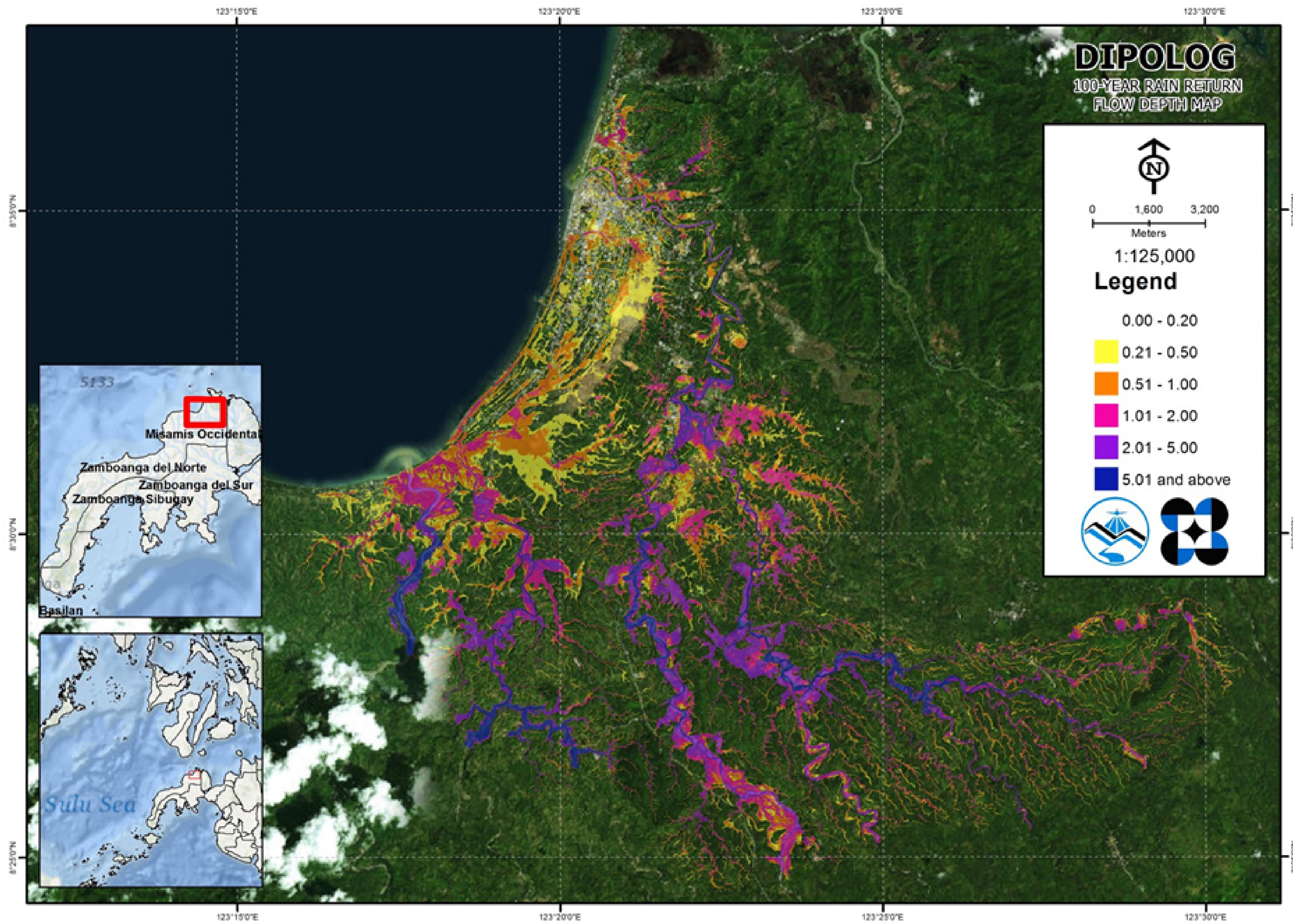



Figure 73. 100-year Flow Depth Map for Dipolog Floodplain overlaid in Google Earth imagery

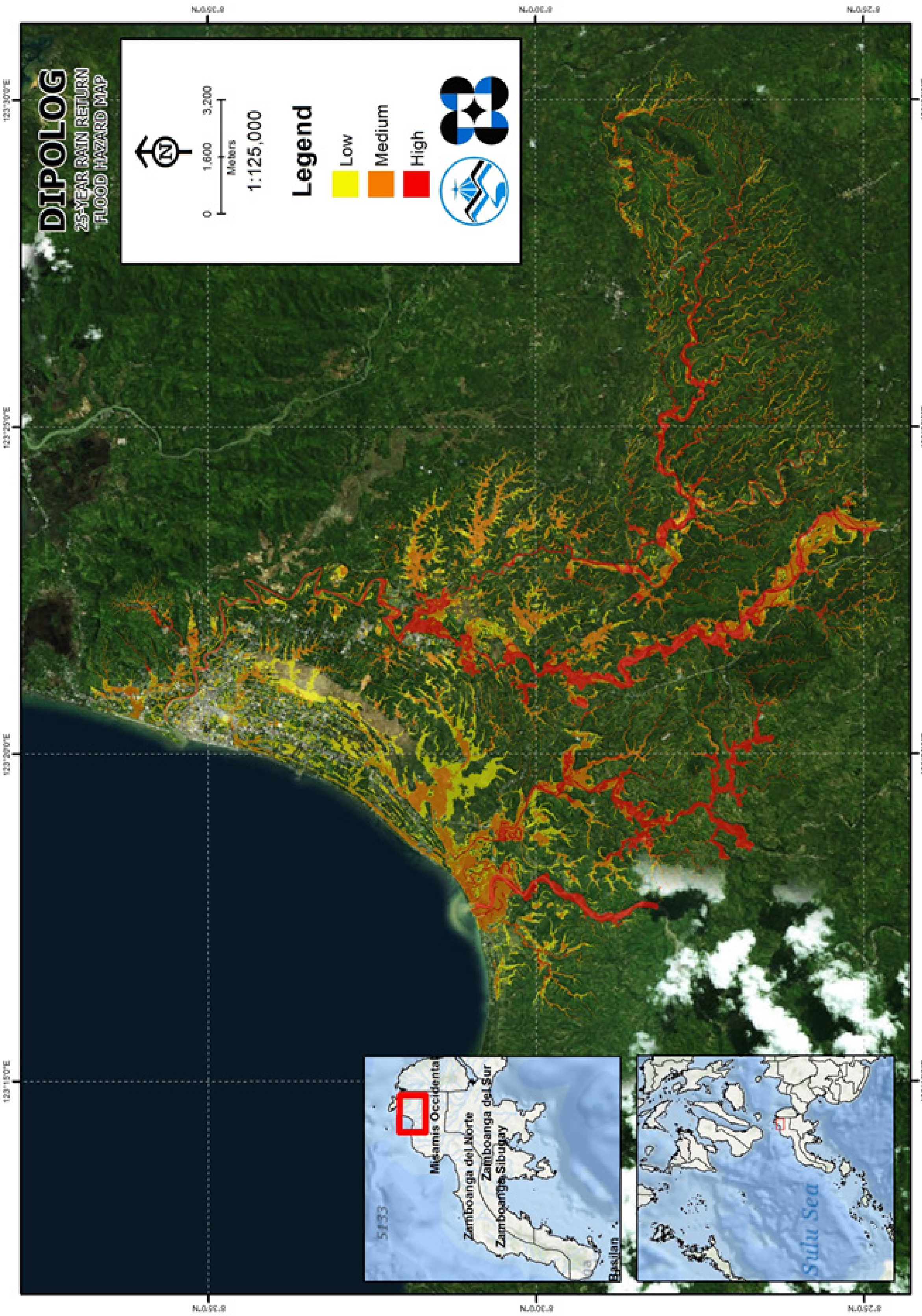



Figure 74. 25-year Flood Hazard Map for Dipolog Floodplain overlaid in Google Earth imagery

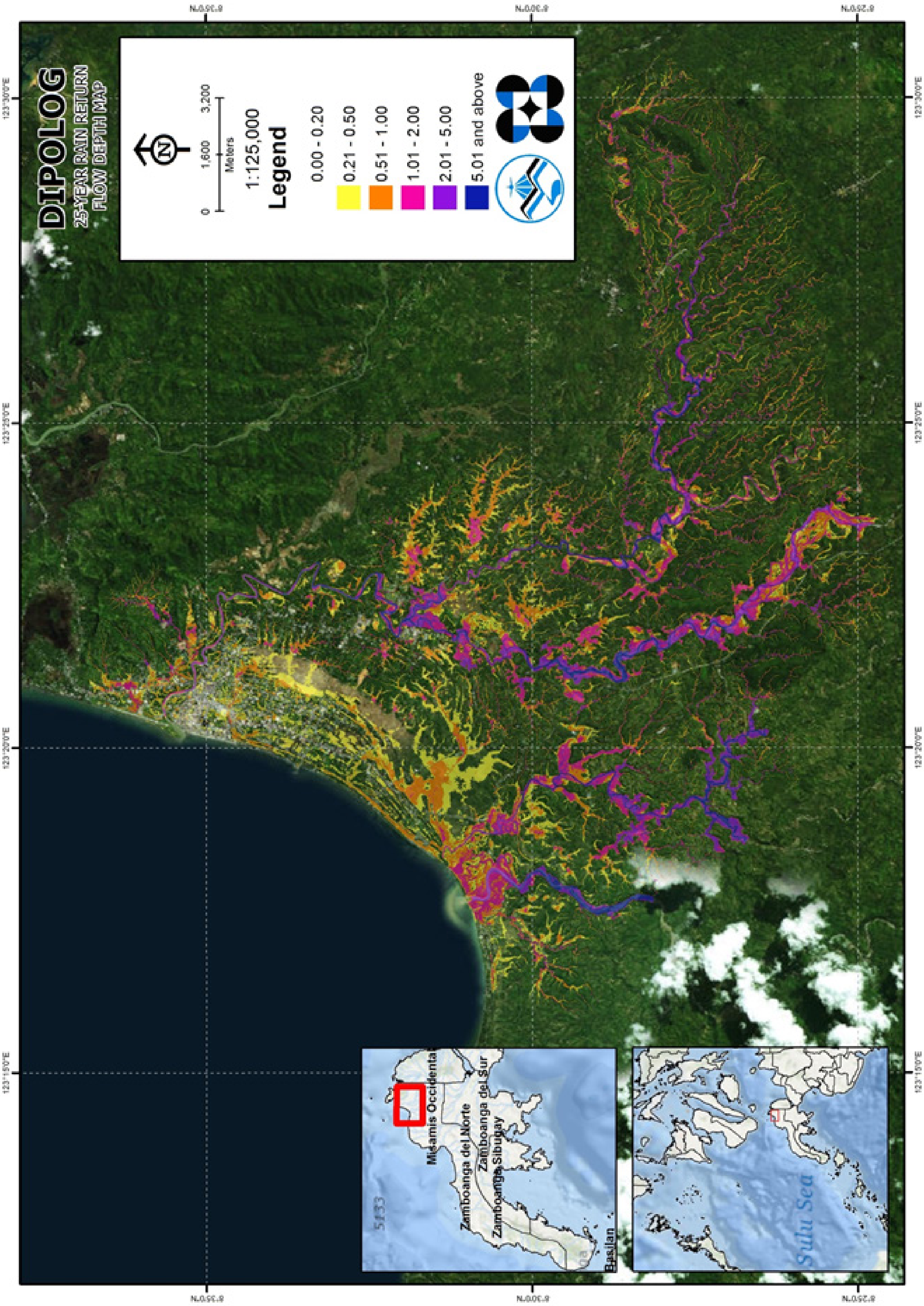



Figure 75. 25-year Flow Depth Map for Dipolog Floodplain overlaid in Google Earth imagery

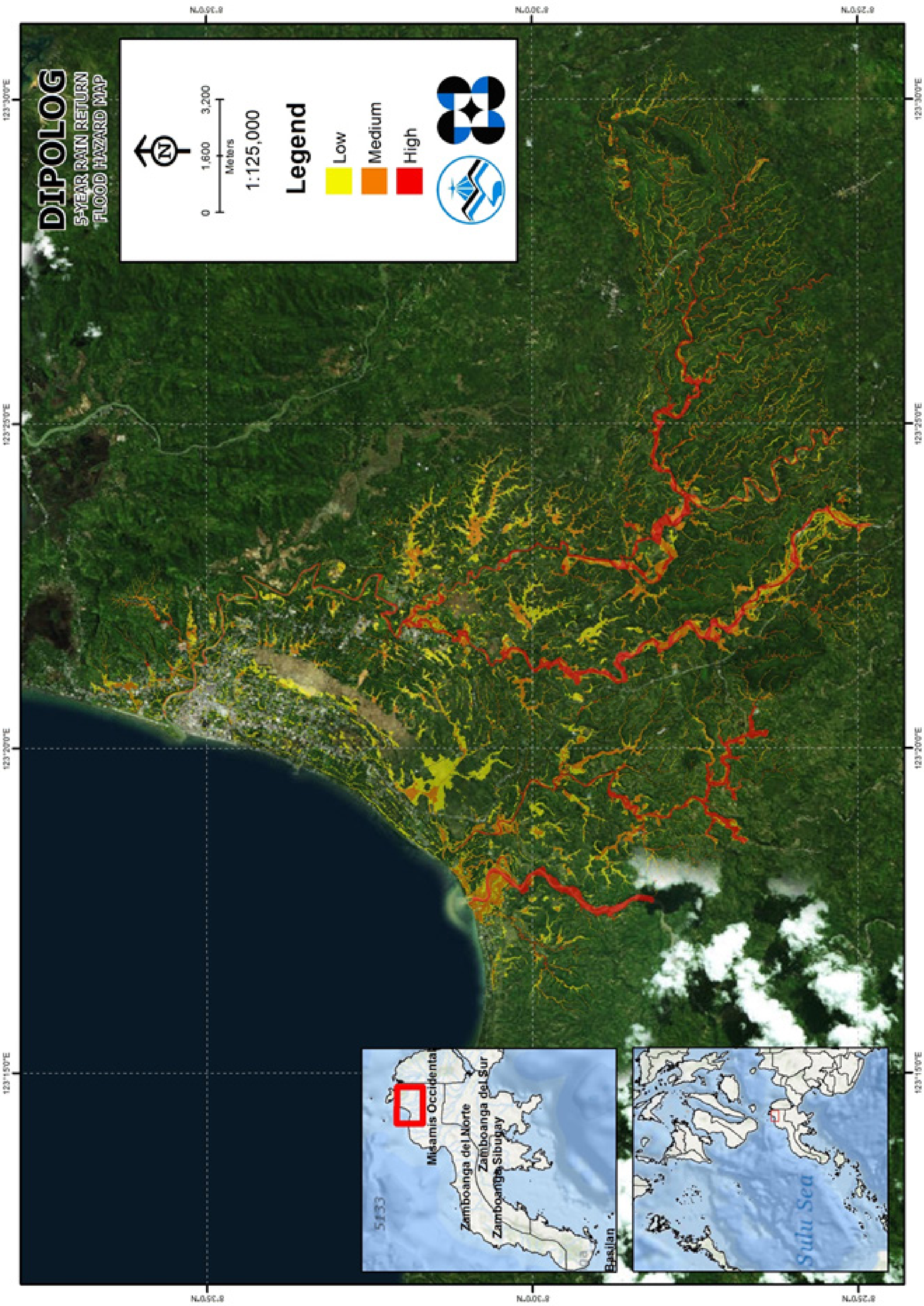



Figure 76. 5-year Flood Hazard Map for Dipolog Floodplain overlaid in Google Earth imagery

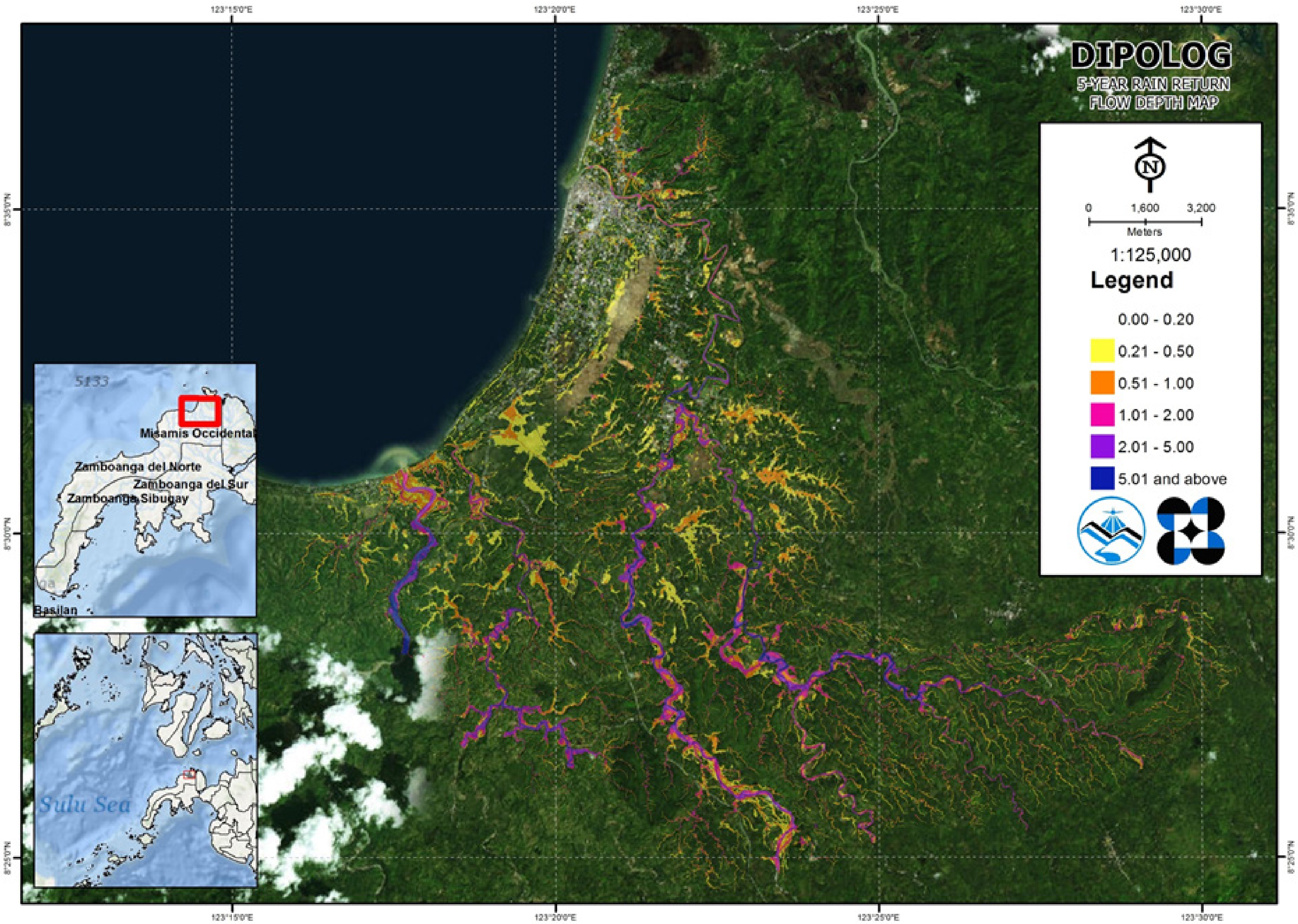



Figure 77. 5-year Flow Depth Map for Dipolog Floodplain overlaid in Google Earth imagery

## 5.10 Inventory of Areas Exposed to Flooding

Affected barangays in Dipolog river basin, grouped by municipality, are listed below. For the said basin, seven municipalities consisting of 83 barangays are expected to experience flooding when subjected to 5-, 25-, and 100-yr rainfall return period.

For the 5-year return period, 6.59% of the city of Dapitan with an area of 222.95 sq. km. will experience flood levels of less 0.20 meters. 0.34% of the area will experience flood levels of 0.21 to 0.50 meters while 0.23%, 0.16%, and 0.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 45 are the affected areas in square kilometres by flood depth per barangay.

Annex 12 and Annex 13 shows the educational and medical institutions affected in the Dipolog Floodplain.

Table 45. Affected Areas in Dapitan City, Zamboanga del Norte during 5-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Dapitan City (in sq. km.) | | | | |
|---|---|---|---|---|---|
| | Antipolo | Aseniero | Owaon | San Francisco | Sigayan |
| 0.03-0.20 | 0.5 | 3.36 | 0.79 | 3.66 | 6.4 |
| 0.21-0.50 | 0.008 | 0.25 | 0.018 | 0.15 | 0.34 |
| 0.51-1.00 | 0.003 | 0.18 | 0.008 | 0.11 | 0.21 |
| 1.01-2.00 | 0.000 | 0.13 | 0.004 | 0.092 | 0.12 |
| 2.01-5.00 | 0 | 0.028 | 0 | 0.025 | 0.022 |
| > 5.00 | 0 | 0 | 0 | 0 | 0 |

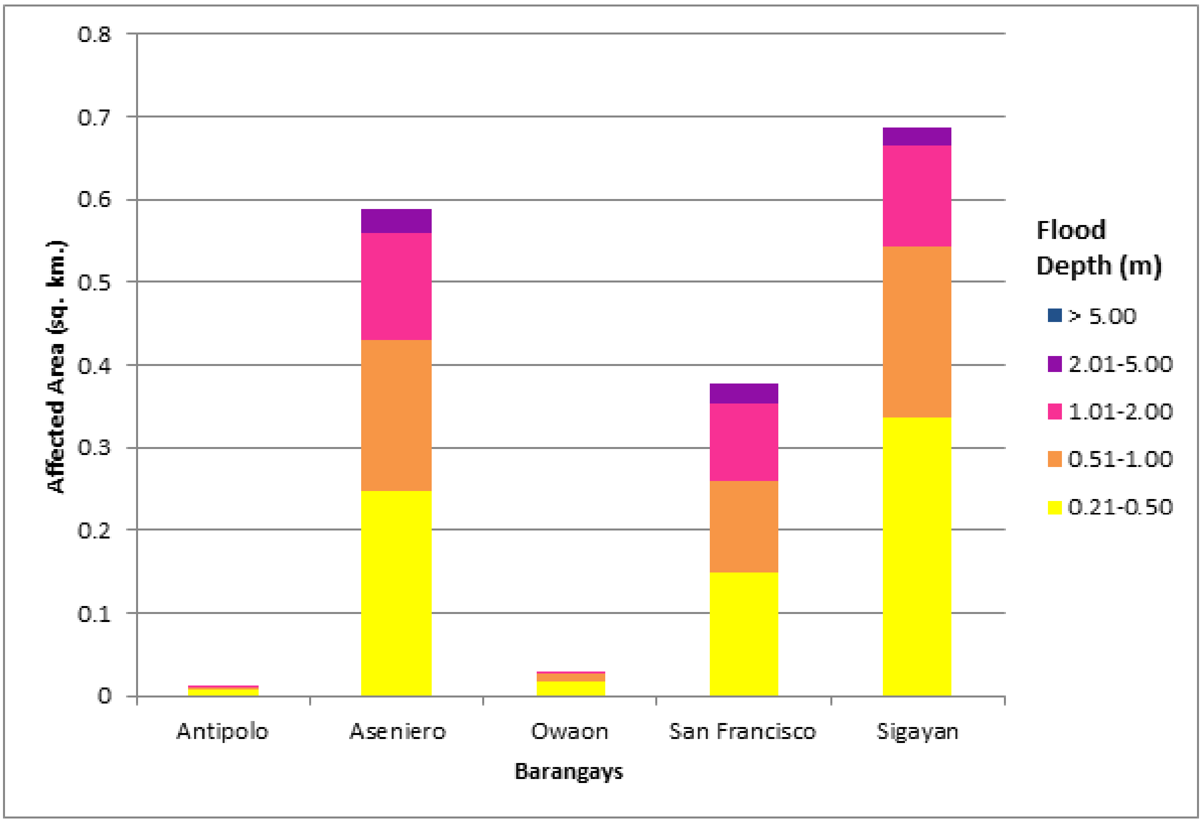



Figure 78. Affected Areas in Dapitan City, Zamboang

For the city of Dipolog, with an area of 184.42 sq. km., 42.60% will experience flood levels of less 0.20 meters. 4.22% of the area will experience flood levels of 0.21 to 0.50 meters while 1.84%, 1.03%, 0.78%, and 0.16% 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.

Table 46. Affected Areas in Dipolog City, Zamboanga del Norte during 5-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Dipolog City (in sq. km.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Barra | Biasong | Central | Cogon | Dicayas | Diwan | Estaca | Galas | Gulayon | Lugdungan |
| 0.03-0.20 | 0.51 | 0.37 | 1.02 | 16.94 | 6.23 | 3.28 | 0.63 | 6.72 | 8.55 | 1.36 |
| 0.21-0.50 | 0.069 | 0.065 | 0.11 | 0.86 | 0.57 | 0.12 | 0.064 | 0.85 | 0.73 | 0.1 |
| 0.51-1.00 | 0.011 | 0.034 | 0.007 | 0.86 | 0.4 | 0.13 | 0.023 | 0.068 | 0.36 | 0.034 |
| 1.01-2.00 | 0.006 | 0.022 | 0 | 0.81 | 0.17 | 0.22 | 0.026 | 0.009 | 0.16 | 0.011 |
| 2.01-5.00 | 0.001 | 0.007 | 0 | 0.46 | 0.031 | 0.35 | 0.014 | 0 | 0.12 | 0.015 |
| > 5.00 | 0 | 0 | 0 | 0.059 | 0 | 0.078 | 0 | 0 | 0 | 0.000 |

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Dipolog City (in sq. km.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Minaog | Miputak | Olingan | Punta | San Jose | Sangkol | Santa Filomena | Santa Isabel | Sinaman | Turno |
| 0.03-0.20 | 2.5 | 0.69 | 6.24 | 5.14 | 8.88 | 3.15 | 2.1 | 1.15 | 1.49 | 1.61 |
| 0.21-0.50 | 0.22 | 0.093 | 1.3 | 1.04 | 0.58 | 0.22 | 0.35 | 0.2 | 0.066 | 0.18 |
| 0.51-1.00 | 0.15 | 0.01 | 0.2 | 0.23 | 0.56 | 0.15 | 0.025 | 0.033 | 0.05 | 0.074 |
| 1.01-2.00 | 0.019 | 0.000 | 0.007 | 0.036 | 0.23 | 0.11 | 0 | 0.001 | 0.010 | 0.065 |
| 2.01-5.00 | 0.001 | 0 | 0 | 0.002 | 0.12 | 0.29 | 0 | 0 | 0 | 0.023 |

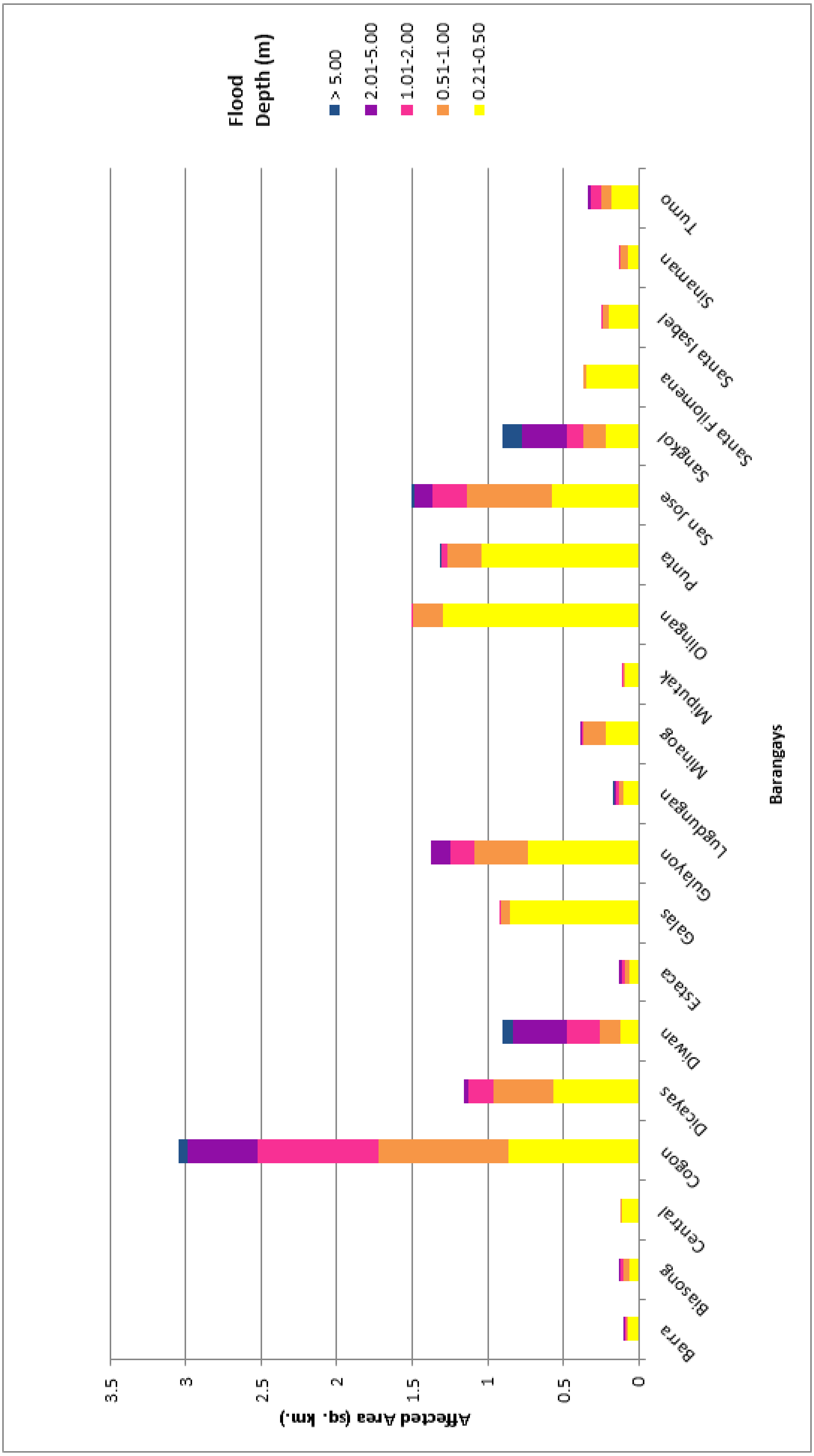



Figure 79. Affected Areas in Dipolog City, Zamboanga del Norte during 5-Year Rainfall Return Period

For the municipality of Katipunan, with an area of 189.621 sq. km., 12.99% will experience flood levels of less 0.20 meters. 1.49% of the area will experience flood levels of 0.21 to 0.50 meters while 0.96%, 0.55%, 0.54%, and 0.34% 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.

Table 47. Affected Areas in Katipunan, Zamboanga del Norte during 5-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Katipunan (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Barangay Dos | Barangay Uno | Basagan | Biniray | Daanglungsod | Dr. Jose Rizal | Loyuran | Malugas |
| 0.03-0.20 | 0.71 | 1.1 | 2.4 | 0.77 | 1.35 | 1.22 | 2.78 | 2.54 |
| 0.21-0.50 | 0.28 | 0.091 | 0.28 | 0.034 | 0.19 | 0.091 | 0.14 | 0.41 |
| 0.51-1.00 | 0.43 | 0.026 | 0.17 | 0.013 | 0.19 | 0.043 | 0.14 | 0.14 |
| 1.01-2.00 | 0.19 | 0.016 | 0.14 | 0.013 | 0.12 | 0.057 | 0.2 | 0.083 |
| 2.01-5.00 | 0.1 | 0.015 | 0.12 | 0.041 | 0.071 | 0.25 | 0.23 | 0.082 |
| > 5.00 | 0.005 | 0 | 0.063 | 0.23 | 0.002 | 0.24 | 0.064 | 0.018 |

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Katipunan (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Mias | Nanginan | New Tambo | San Antonio | San Vicente | Santo Niño | Singatong | Tuburan |
| 0.03-0.20 | 1.84 | 0.20 | 1.28 | 1.15 | 1.2 | 3 | 1.15 | 1.95 |
| 0.21-0.50 | 0.19 | 0.004 | 0.16 | 0.35 | 0.098 | 0.33 | 0.045 | 0.12 |
| 0.51-1.00 | 0.066 | 0.002 | 0.054 | 0.25 | 0.043 | 0.18 | 0.022 | 0.059 |
| 1.01-2.00 | 0.02 | 0.002 | 0.021 | 0.11 | 0.005 | 0.044 | 0.014 | 0.017 |
| 2.01-5.00 | 0.003 | 0.001 | 0.014 | 0.043 | 0.008 | 0.036 | 0.003 | 0.001 |
| > 5.00 | 0 | 0 | 0 | 0 | 0 | 0.029 | 0 | 0 |

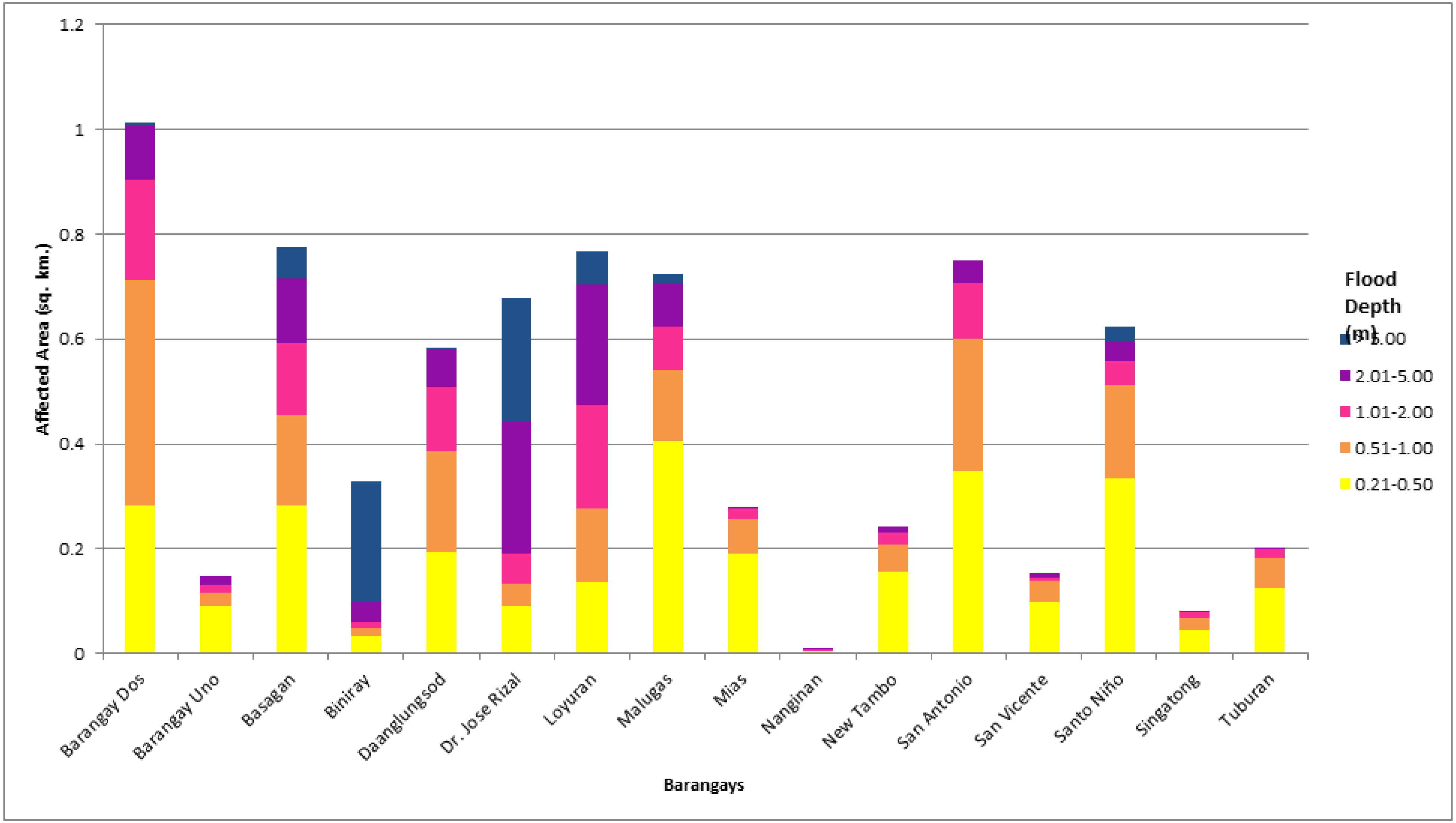



Figure 80. Affected Areas in Katipunan, Zamboanga del Norte during 5-Year Rainfall Return Period

For the municipality of La Libertad, with an area of 66.24 sq. km., 2.74% will experience flood levels of less 0.20 meters. 0.56% of the area will experience flood levels of 0.21 to 0.50 meters while 0.69%, 0.32%, 0.18%, 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.

Table 48. Affected Areas in La Libertad, Zamboanga del Norte during 5-Year Rainfall

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in La Libertad (in sq. km.) | |
|---|---|---|
| | Barangay Dos | Barangay Uno |
| 0.03-0.20 | 0.71 | 1.1 |
| 0.21-0.50 | 0.28 | 0.091 |
| 0.51-1.00 | 0.43 | 0.026 |
| 1.01-2.00 | 0.19 | 0.016 |
| 2.01-5.00 | 0.1 | 0.015 |
| > 5.00 | 0.005 | 0 |

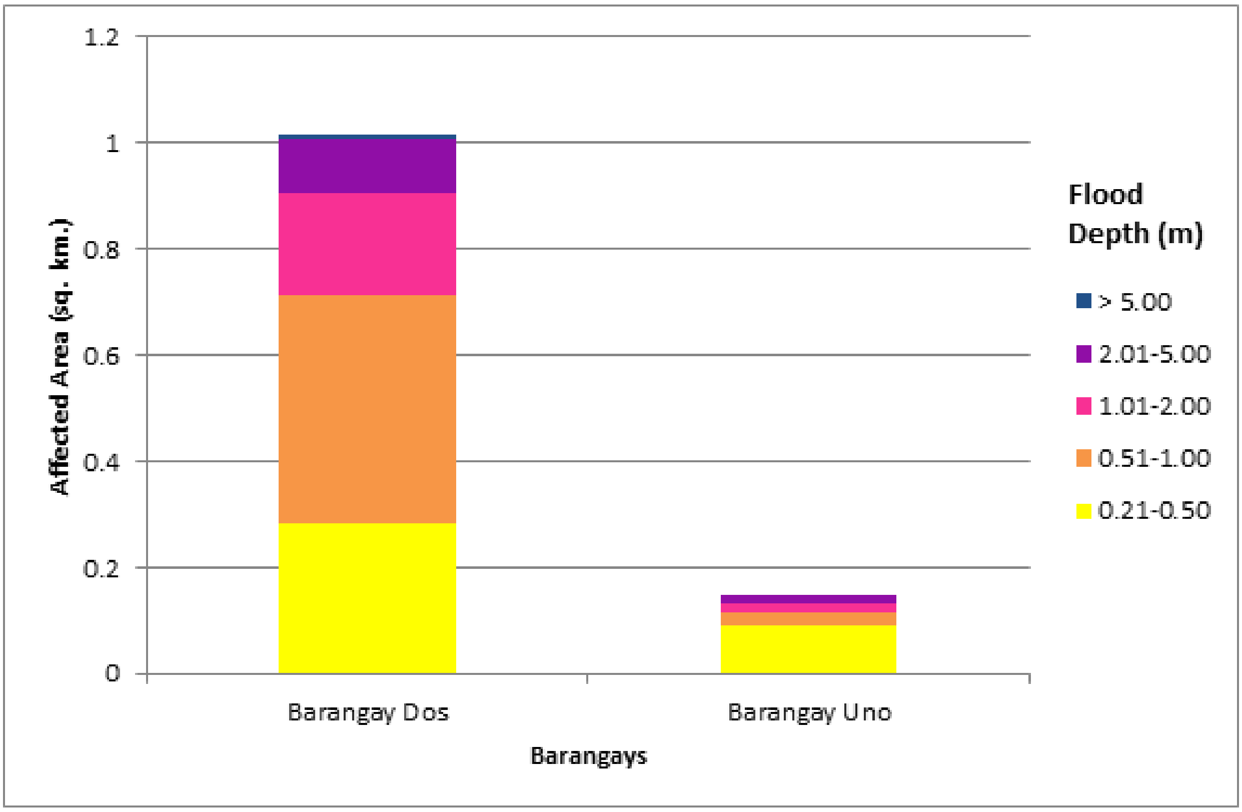



Figure 81. Affected Areas in La Libertad, Zamboanga del Norte during 5-Year Rainfall Return Period

For the municipality of Mutia, with an area of 83.22sq. km., 0.86% will experience flood levels of less 0.20 meters. 0.04% of the area will experience flood levels of 0.21 to 0.50 meters while 0.01%, and 0.001% of the area will experience flood depths of 0.51 to 1 meter, and 1.01 to 2 meters, respectively.

Table 49. Affected Areas in Mutia, Zamboanga del Norte during 5-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Mutia (in sq. km.) |
|---|---|
| | San Miguel |
| 0.03-0.20 | 0.71 |
| 0.21-0.50 | 0.033 |
| 0.51-1.00 | 0.008 |
| 1.01-2.00 | 0.001 |
| 2.01-5.00 | 0 |
| > 5.00 | 0 |

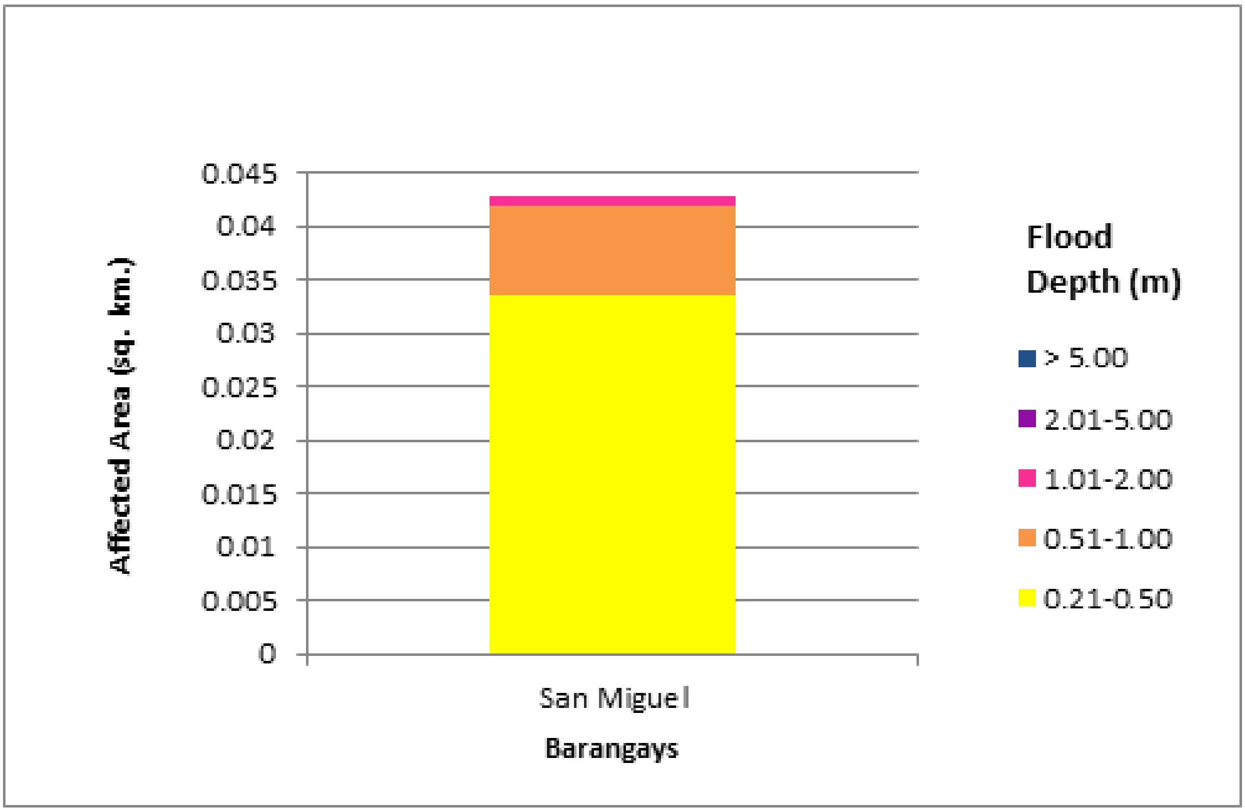



Figure 82. Affected Areas in Mutia, Zamboanga del Norte during 5-Year Rainfall Return Period

For the municipality of Pinan, with an area of 135.87 sq. km., 25.91% will experience flood levels of less 0.20 meters. 1.32% of the area will experience flood levels of 0.21 to 0.50 meters while 1.01%, 0.73%, 0.60%, and 0.17% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters respectively.

Table 50. Affected Areas in Pinan, Zamboanga del Norte during 5-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Pinan (in sq. km.) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calican | Del Pilar | Desin | Dionum | Lapu-Lapu | Lower Gumay | Santa Fe | Segabe | Silano | Tinaytayan | Ubay | Upper Gumay | Villarico |
| 0.03-0.20 | 6.45 | 1.96 | 2.2 | 5.17 | 0.39 | 3.33 | 2.3 | 0.98 | 1.4 | 2.88 | 0.42 | 4.5 | 3.25 |
| 0.21-0.50 | 0.33 | 0.094 | 0.13 | 0.28 | 0.034 | 0.18 | 0.08 | 0.046 | 0.071 | 0.14 | 0.014 | 0.23 | 0.16 |
| 0.51-1.00 | 0.29 | 0.072 | 0.09 | 0.2 | 0.023 | 0.13 | 0.05 | 0.04 | 0.038 | 0.14 | 0.013 | 0.16 | 0.13 |
| 1.01-2.00 | 0.21 | 0.085 | 0.077 | 0.12 | 0.018 | 0.14 | 0.024 | 0.011 | 0.04 | 0.1 | 0.008 | 0.12 | 0.03 |
| 2.01-5.00 | 0.15 | 0.15 | 0.072 | 0.044 | 0.002 | 0.22 | 0.038 | 0 | 0.012 | 0.052 | 0 | 0.067 | 0.004 |
| > 5.00 | 0.057 | 0.097 | 0 | 0 | 0 | 0.042 | 0 | 0 | 0 | 0.028 | 0 | 0 | 0 |

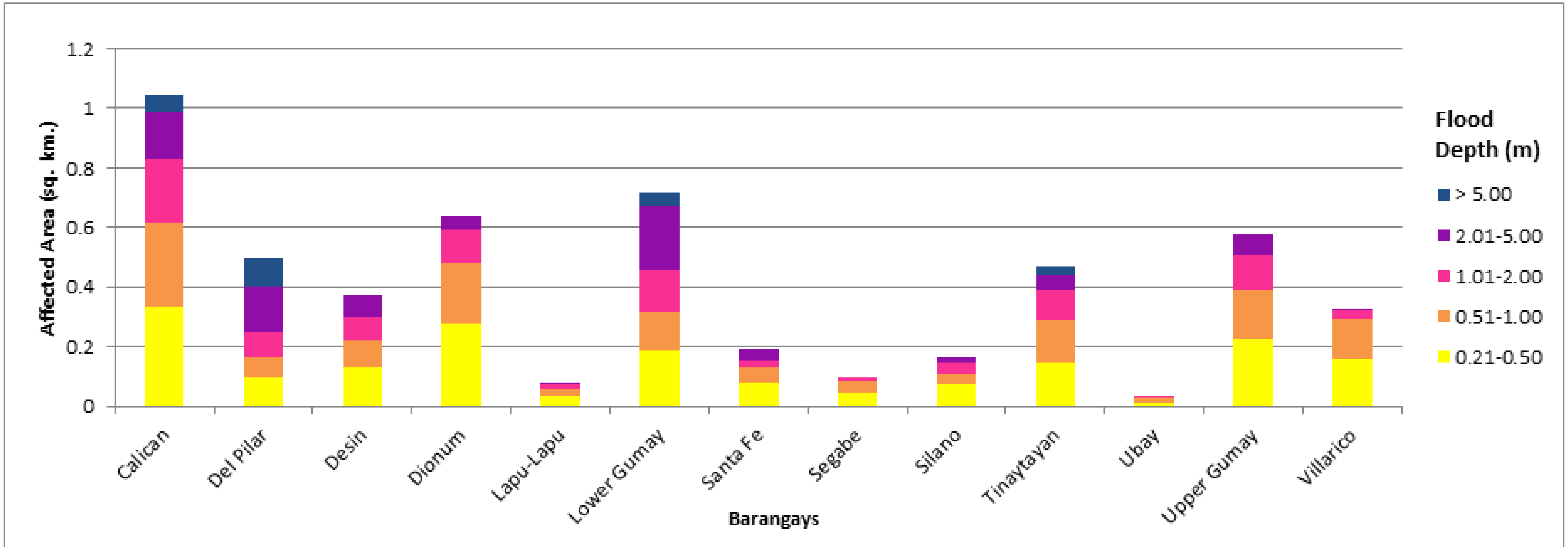



Figure 83. Affected Areas in Pinan, Zamboanga del Norte during 5-Year Rainfall Return Period

For the municipality of Polanco, with an area of 86.49 sq. km., 60.11% will experience flood levels of less 0.20 meters. 6.82% of the area will experience flood levels of 0.21 to 0.50 meters while 4.46%, 2.54%, 1.95%, and 0.52% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters respectively.

Table 51. Affected Areas in Polanco, Zamboanga del Norte during 5-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Polanco(in sq. km.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Anasta-cio | Bandera | Bethle-hem | Dangi | Dansul-lan | De Venta Perla | Guinles | Isis | Labra-dor | Lapayan-baja | Letapan | Linabo | Lin-gasad | Macle-odes |
| 0.03-0.20 | 1.52 | 2.35 | 1.02 | 1.08 | 0.54 | 1.38 | 5.52 | 1.79 | 0.97 | 2.99 | 1.88 | 1.76 | 2.28 | 1.57 |
| 0.21-0.50 | 0.13 | 0.19 | 0.07 | 0.046 | 0.014 | 0.061 | 1.06 | 0.18 | 0.069 | 0.23 | 0.21 | 0.39 | 0.21 | 0.079 |
| 0.51-1.00 | 0.13 | 0.13 | 0.043 | 0.038 | 0.021 | 0.044 | 0.57 | 0.083 | 0.037 | 0.19 | 0.11 | 0.25 | 0.14 | 0.075 |
| 1.01-2.00 | 0.071 | 0.17 | 0.026 | 0.021 | 0.02 | 0.033 | 0.012 | 0.019 | 0.029 | 0.13 | 0.1 | 0.18 | 0.005 | 0.086 |
| 2.01-5.00 | 0.056 | 0.22 | 0.013 | 0.007 | 0.004 | 0.006 | 0.014 | 0.002 | 0.088 | 0.059 | 0.056 | 0.15 | 0 | 0.017 |
| > 5.00 | 0 | 0.049 | 0 | 0.000 | 0 | 0.001 | 0 | 0 | 0.002 | 0.009 | 0.056 | 0 | 0 | 0 |

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Polanco(in sq. km.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magan-gon | Maligaya | Milad | New Leban-gon | New Sicayab | Obay | Pian | Pobla-cion North | Pobla-cion South | San An-tonio | San Pedro | Sianib | Silawe | Villaher-mosa |
| 0.03-0.20 | 4.68 | 0.95 | 0.44 | 0.93 | 1.35 | 4.18 | 2.32 | 0.45 | 1.31 | 1.15 | 1.12 | 1.72 | 2.26 | 2.49 |
| 0.21-0.50 | 0.23 | 0.11 | 0.035 | 0.065 | 0.072 | 0.53 | 0.47 | 0.1 | 0.16 | 0.35 | 0.039 | 0.15 | 0.34 | 0.31 |
| 0.51-1.00 | 0.27 | 0.1 | 0.031 | 0.11 | 0.094 | 0.14 | 0.21 | 0.13 | 0.083 | 0.25 | 0.049 | 0.24 | 0.078 | 0.21 |
| 1.01-2.00 | 0.24 | 0.061 | 0.027 | 0.12 | 0.007 | 0.066 | 0.007 | 0.1 | 0.078 | 0.11 | 0.031 | 0.34 | 0.049 | 0.067 |
| 2.01-5.00 | 0.085 | 0.049 | 0.011 | 0.17 | 0.003 | 0.081 | 0 | 0.1 | 0.087 | 0.043 | 0.002 | 0.24 | 0.017 | 0.1 |
| > 5.00 | 0.01 | 0 | 0 | 0.010 | 0 | 0.035 | 0 | 0.009 | 0.031 | 0 | 0 | 0.16 | 0.017 | 0.057 |

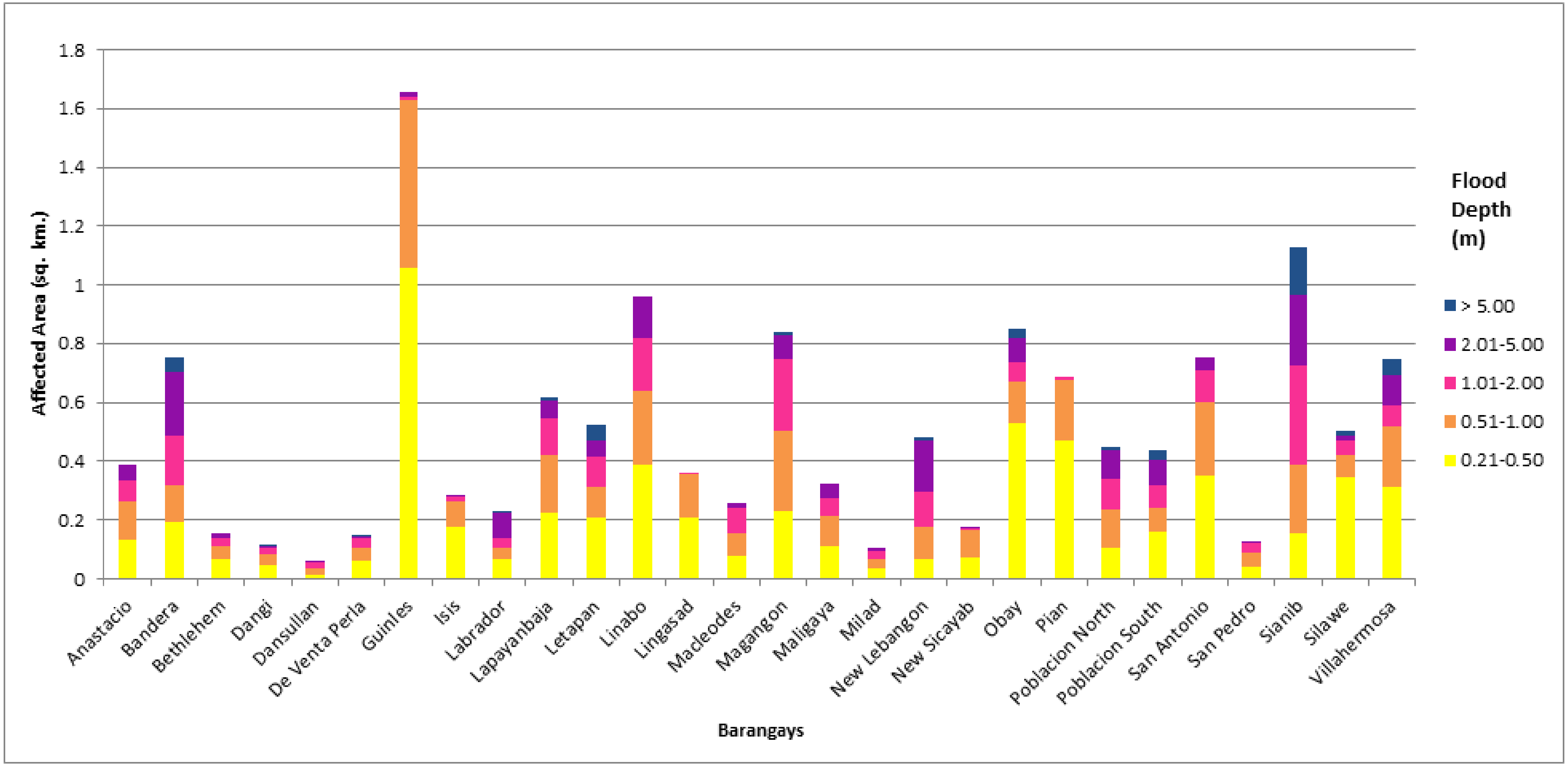



Figure 84. Affected Areas in Polanco, Zamboanga del Norte during 5-Year Rainfall Return Period

For the 25-year return period, 6.36% of the city of Dapitan with an area of 222.95 sq. km. will experience flood levels of less 0.20 meters. 0.37% of the area will experience flood levels of 0.21 to 0.50 meters while 0.30%, 0.22%, and 0.11% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 52 are the affected areas in square kilometres by flood depth per barangay.

Table 52. Affected Areas in Dapitan City, Zamboanga del Norte during 25-Year Rainfall

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Dapitan City (in sq. km.) | | | | |
|---|---|---|---|---|---|
| | Antipolo | Aseniero | Owaon | San Francisco | Sigayan |
| 0.03-0.20 | 0.49 | 3.14 | 0.78 | 3.62 | 6.15 |
| 0.21-0.50 | 0.010 | 0.29 | 0.02 | 0.17 | 0.33 |
| 0.51-1.00 | 0.004 | 0.25 | 0.011 | 0.11 | 0.29 |
| 1.01-2.00 | 0.000 | 0.18 | 0.007 | 0.092 | 0.21 |
| 2.01-5.00 | 0.000 | 0.09 | 0.000 | 0.049 | 0.099 |
| > 5.00 | 0 | 0 | 0 | 0 | 0 |

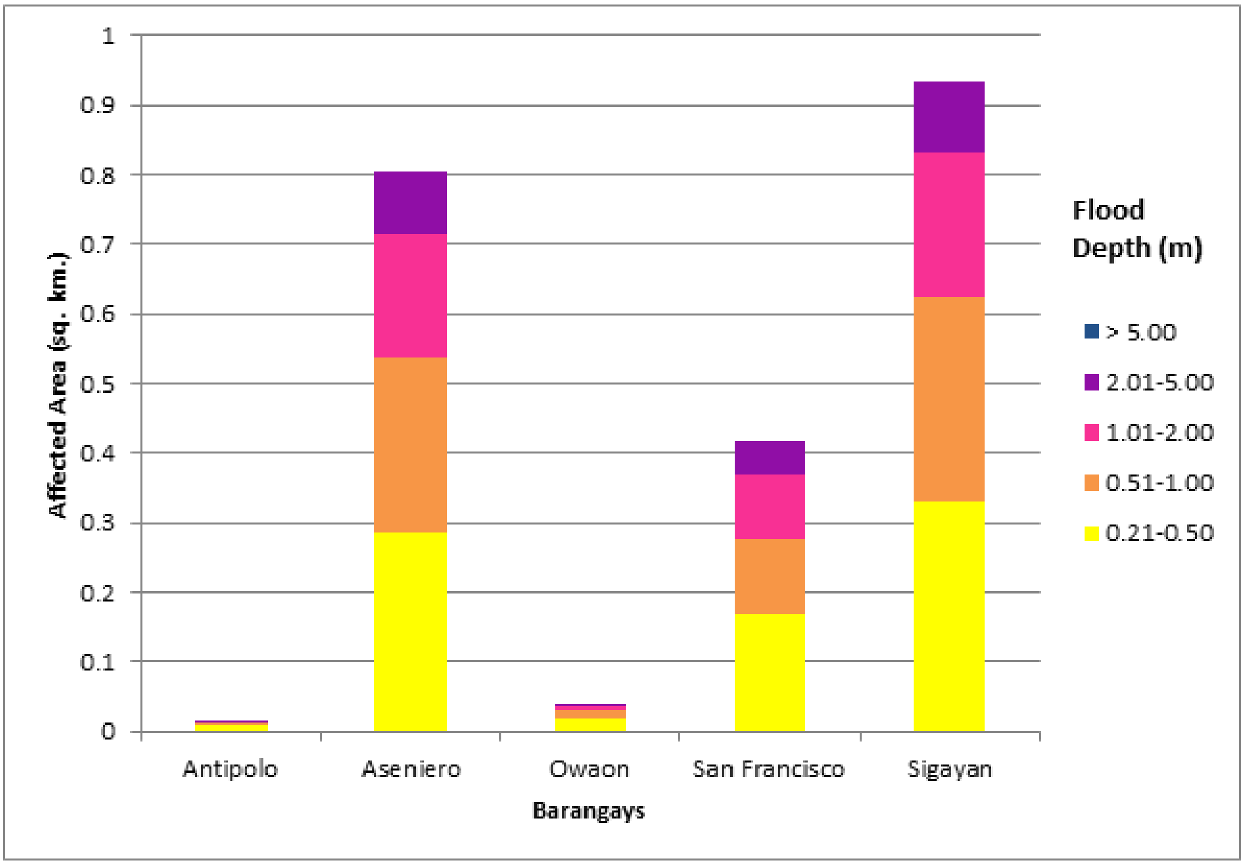



Figure 85. Affected Areas in Dapitan City, Zamboanga del Norte during 25-Year Rainfall Return Period

For the city of Dipolog, with an area of 184.42 sq. km., 38.26% will experience flood levels of less 0.20 meters. 5.35% of the area will experience flood levels of 0.21 to 0.50 meters while 3.27%, 1.83%, 1.43%, and 0.49% 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.

Table 53. Affected Areas in Dipolog City, Zamboanga del Norte during 25-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Dipolog City (in sq. km.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Barra | Biasong | Central | Cogon | Dicayas | Diwan | Estaca | Galas | Gulayon | Lugdungan |
| 0.03-0.20 | 0.43 | 0.31 | 0.92 | 16.16 | 5.81 | 3.1 | 0.55 | 5.43 | 8.1 | 1.28 |
| 0.21-0.50 | 0.11 | 0.077 | 0.19 | 0.76 | 0.6 | 0.1 | 0.11 | 1.93 | 0.7 | 0.12 |
| 0.51-1.00 | 0.032 | 0.056 | 0.025 | 0.79 | 0.57 | 0.084 | 0.032 | 0.26 | 0.59 | 0.087 |
| 1.01-2.00 | 0.01 | 0.03 | 0.000 | 1.17 | 0.33 | 0.11 | 0.021 | 0.027 | 0.27 | 0.014 |
| 2.01-5.00 | 0.004 | 0.024 | 0 | 0.97 | 0.087 | 0.54 | 0.042 | 0 | 0.18 | 0.02 |
| > 5.00 | 0 | 0 | 0 | 0.13 | 0 | 0.26 | 0.000 | 0 | 0.088 | 0.009 |

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Dipolog City (in sq. km.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Minaog | Miputak | Olingan | Punta | San Jose | Sangkol | Santa Filomena | Santa Isabel | Sinaman | Turno |
| 0.03-0.20 | 2.37 | 0.56 | 4.92 | 4.05 | 8.38 | 2.76 | 1.68 | 0.8 | 1.46 | 1.48 |
| 0.21-0.50 | 0.21 | 0.19 | 1.6 | 1.48 | 0.4 | 0.13 | 0.53 | 0.37 | 0.065 | 0.21 |
| 0.51-1.00 | 0.19 | 0.036 | 1.18 | 0.76 | 0.48 | 0.2 | 0.27 | 0.19 | 0.065 | 0.12 |
| 1.01-2.00 | 0.11 | 0.005 | 0.033 | 0.15 | 0.69 | 0.31 | 0.006 | 0.017 | 0.019 | 0.049 |
| 2.01-5.00 | 0.002 | 0 | 0 | 0.008 | 0.37 | 0.3 | 0 | 0 | 0.003 | 0.097 |
| > 5.00 | 0 | 0 | 0 | 0.000 | 0.068 | 0.35 | 0 | 0 | 0 | 0 |

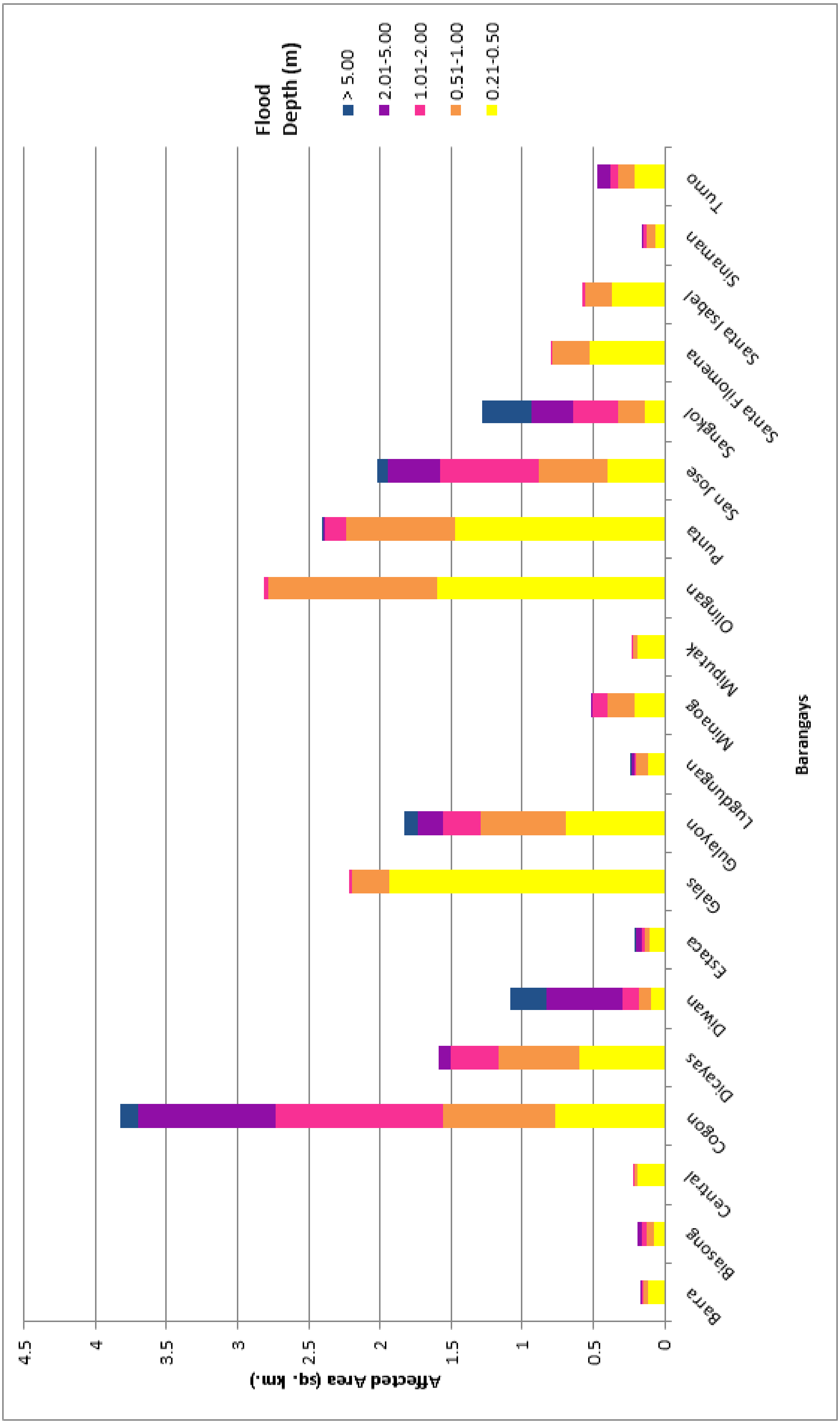



Figure 86. Affected Areas in Dipolog City, Zamboanga del Norte during 25-Year Rainfall Return Period

For the municipality of Katipunan, with an area of 189.621 sq. km., 10.98% will experience flood levels of less 0.20 meters. 1.60% of the area will experience flood levels of 0.21 to 0.50 meters while 1.45%, 1.39%, 0.97%, and 0.48% 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.

Table 54. Affected Areas in Katipunan, Zamboanga del Norte during 25-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Katipunan (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Barangay Dos | Barangay Uno | Basagan | Biniray | Daang lungsod | Dr. Jose Rizal | Loyuran | Malugas |
| 0.03-0.20 | 0.53 | 0.94 | 1.94 | 0.75 | 1 | 1.13 | 2.51 | 1.84 |
| 0.21-0.50 | 0.12 | 0.2 | 0.15 | 0.043 | 0.21 | 0.12 | 0.084 | 0.56 |
| 0.51-1.00 | 0.31 | 0.053 | 0.3 | 0.02 | 0.23 | 0.071 | 0.088 | 0.38 |
| 1.01-2.00 | 0.58 | 0.028 | 0.36 | 0.019 | 0.32 | 0.048 | 0.18 | 0.27 |
| 2.01-5.00 | 0.17 | 0.023 | 0.34 | 0.044 | 0.16 | 0.24 | 0.48 | 0.15 |
| > 5.00 | 0.014 | 0 | 0.087 | 0.23 | 0.002 | 0.29 | 0.22 | 0.051 |

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Katipunan (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Mias | Nanginan | New Tambo | San Antonio | San Vicente | Santo Niño | Singatong | Tuburan |
| 0.03-0.20 | 1.7 | 0.19 | 1.11 | 0.3 | 1.1 | 2.78 | 1.13 | 1.86 |
| 0.21-0.50 | 0.25 | 0.004 | 0.25 | 0.42 | 0.15 | 0.27 | 0.043 | 0.15 |
| 0.51-1.00 | 0.13 | 0.003 | 0.11 | 0.66 | 0.063 | 0.19 | 0.033 | 0.11 |
| 1.01-2.00 | 0.041 | 0.003 | 0.047 | 0.44 | 0.023 | 0.22 | 0.02 | 0.035 |
| 2.01-5.00 | 0.010 | 0.001 | 0.021 | 0.074 | 0.009 | 0.12 | 0.007 | 0.002 |
| > 5.00 | 0 | 0 | 0 | 0 | 0 | 0.031 | 0 | 0 |

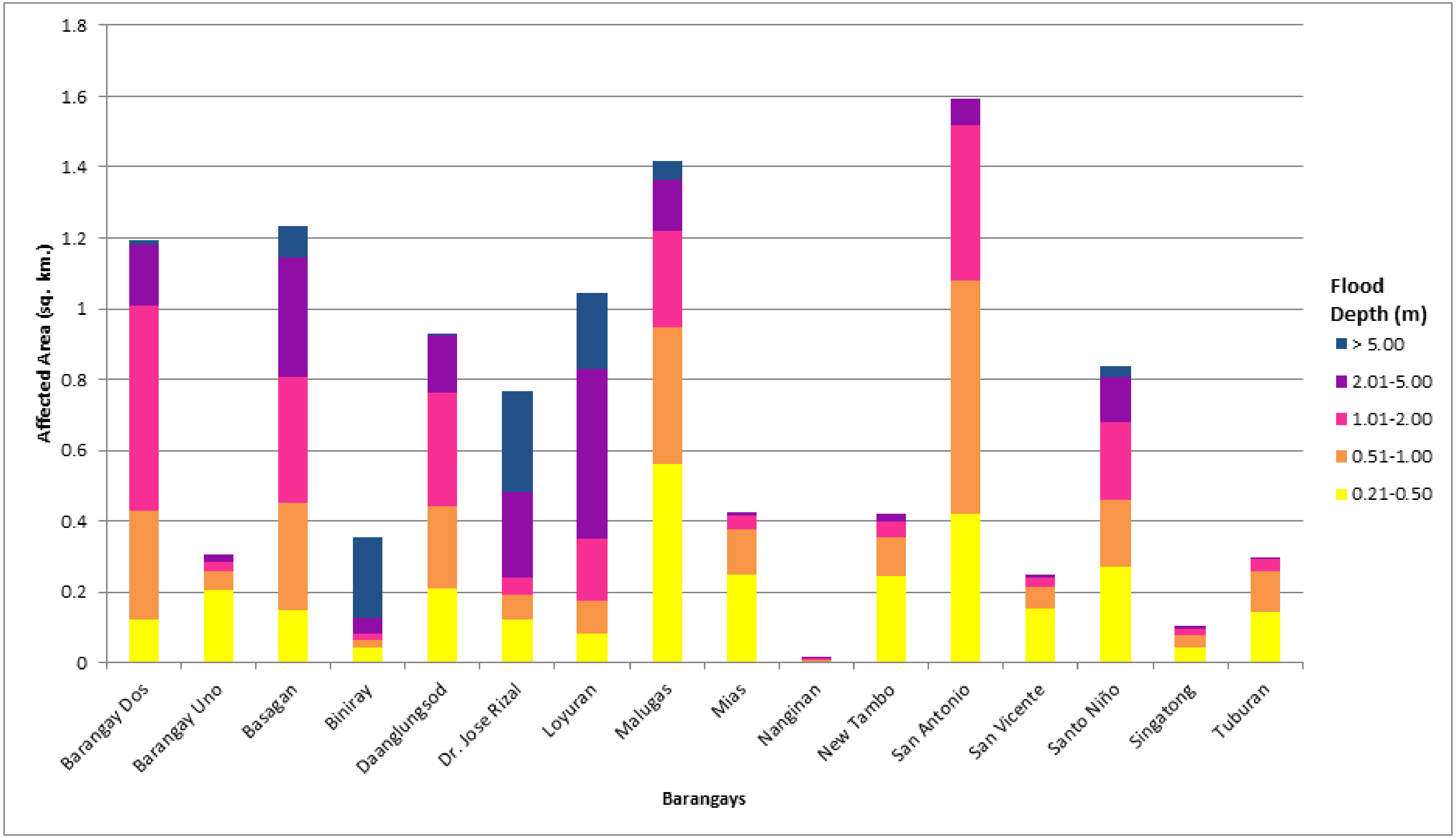



Figure 87. Affected Areas in Katipunan, Zamboanga del Norte during 25-Year Rainfall Return Period

For the municipality of La Libertad, with an area of 66.24 sq. km., 2.23% will experience flood levels of less 0.20 meters. 0.49% of the area will experience flood levels of 0.21 to 0.50 meters while 0.54%, 0.92%, 0.29%, 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.

Table 55. Affected Areas in La Libertad, Zamboanga del Norte during 25-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in La Libertad (in sq. km.) | |
|---|---|---|
| | Barangay Dos | Barangay Uno |
| 0.03-0.20 | 0.53 | 0.94 |
| 0.21-0.50 | 0.12 | 0.2 |
| 0.51-1.00 | 0.31 | 0.053 |
| 1.01-2.00 | 0.58 | 0.028 |
| 2.01-5.00 | 0.17 | 0.023 |
| > 5.00 | 0.014 | 0 |

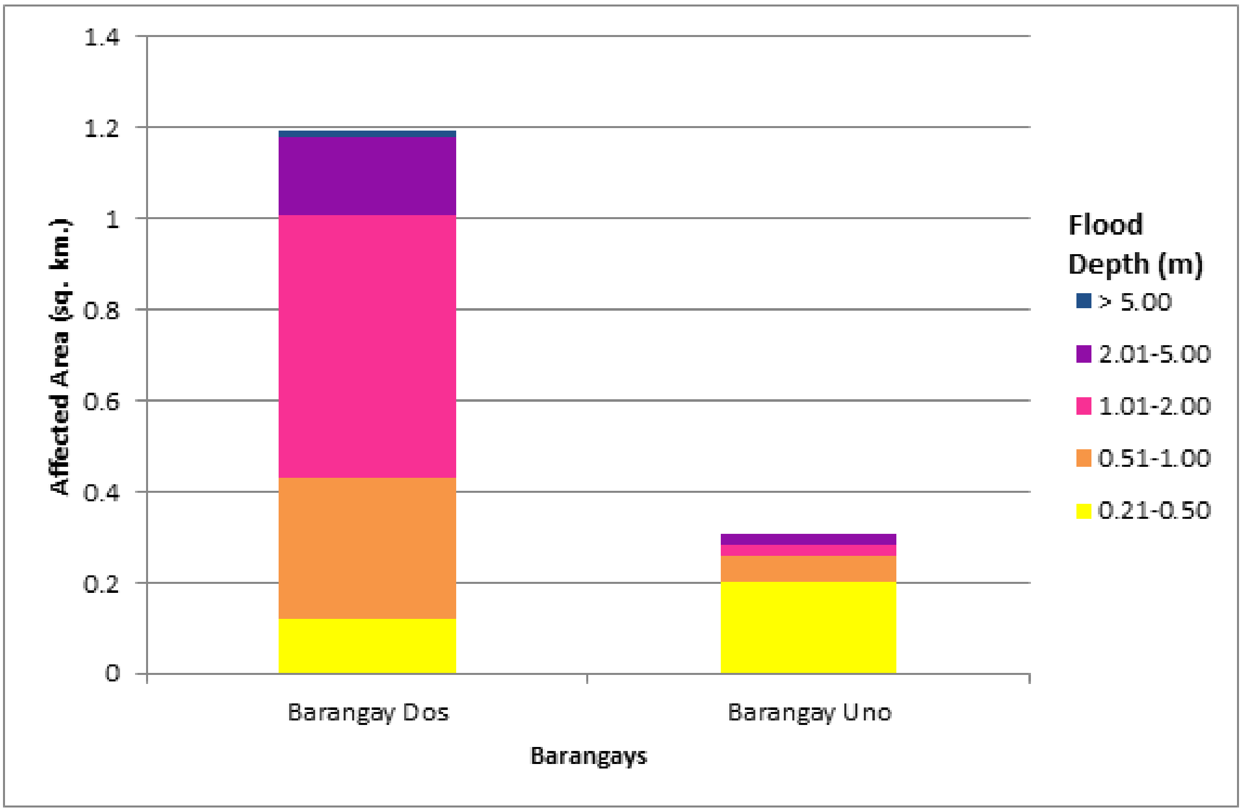



Figure 88. Affected Areas in La Libertad, Zamboanga del Norte during 25-Year Rainfall Return Period

For the municipality of Mutia, with an area of 83.22sq. km., 0.84% will experience flood levels of less 0.20 meters. 0.04% of the area will experience flood levels of 0.21 to 0.50 meters while 0.02%, 0.003%, and 0.0001% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively.

Table 56. Affected Areas in Mutia, Zamboanga del Norte during 25-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Mutia (in sq. km.) |
|---|---|
| | San Miguel |
| 0.03-0.20 | 0.7 |
| 0.21-0.50 | 0.036 |
| 0.51-1.00 | 0.016 |
| 1.01-2.00 | 0.003 |
| 2.01-5.00 | 0.000 |
| > 5.00 | 0 |

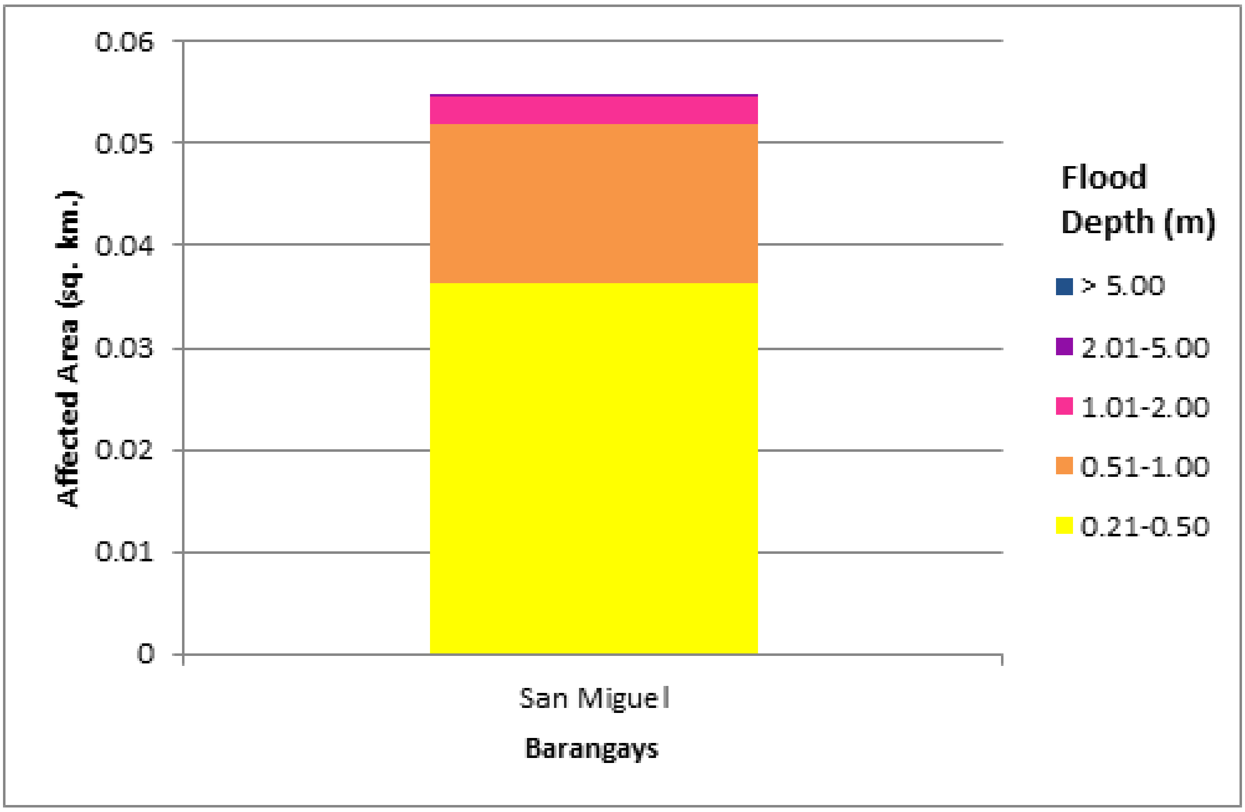



Figure 89. Affected Areas in Mutia, Zamboanga del Norte during 25-Year Rainfall Return Period

For the municipality of Pinan, with an area of 135.87 sq. km., 25.14% will experience flood levels of less 0.20 meters. 1.31% of the area will experience flood levels of 0.21 to 0.50 meters while 1.17%, 1.02%, 0.86%, 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.

Table 57. Affected Areas in Pinan, Zamboanga del Norte during 25-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Pinan (in sq. km.) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calican | Del Pilar | Desin | Dionum | Lapu-Lapu | Lower Gumay | Santa Fe | Segabe | Silano | Tinay-tayan | Ubay | Upper Gumay | Villarico |
| 0.03-0.20 | 6.23 | 1.89 | 2.24 | 4.98 | 0.36 | 3.13 | 2.29 | 0.96 | 1.35 | 2.78 | 0.41 | 4.36 | 3.16 |
| 0.21-0.50 | 0.3 | 0.11 | 0.13 | 0.27 | 0.04 | 0.18 | 0.085 | 0.044 | 0.075 | 0.13 | 0.016 | 0.23 | 0.17 |
| 0.51-1.00 | 0.31 | 0.08 | 0.1 | 0.25 | 0.029 | 0.17 | 0.066 | 0.045 | 0.056 | 0.15 | 0.01 | 0.18 | 0.14 |
| 1.01-2.00 | 0.34 | 0.091 | 0.075 | 0.18 | 0.024 | 0.17 | 0.043 | 0.029 | 0.045 | 0.14 | 0.013 | 0.15 | 0.086 |
| 2.01-5.00 | 0.25 | 0.17 | 0.018 | 0.13 | 0.014 | 0.28 | 0.008 | 0.002 | 0.034 | 0.1 | 0.002 | 0.14 | 0.008 |
| > 5.00 | 0.071 | 0.11 | 0 | 0.001 | 0 | 0.12 | 0.000 | 0 | 0.000 | 0.034 | 0 | 0.009 | 0 |

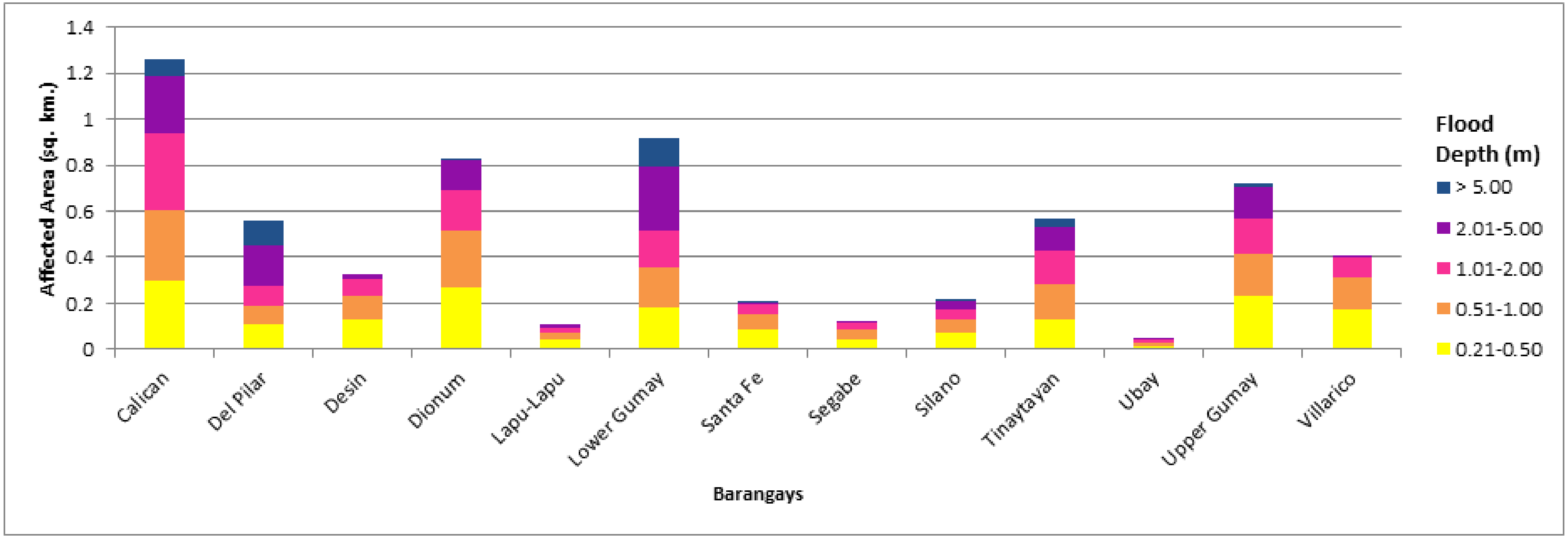



Figure 90. Affected Areas in Pinan, Zamboanga del Norte during 25-Year Rainfall Return Period

For the municipality of Polanco, with an area of 86.49 sq. km., 53.17% will experience flood levels of less 0.20 meters. 6.48% of the area will experience flood levels of 0.21 to 0.50 meters while 7.21%, 5.69%, 3.00%, and 0.85% 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.

Table 58. Affected Areas in Polanco, Zamboanga del Norte during 25-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Polanco(in sq. km.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Anastacio | Bandera | Bethlehem | Dangi | Dansullan | De Venta Perla | Guinles | Isis | Labrador | Lapayan-baja | Letapan | Linabo | Lingasad | Macleodes |
| 0.03-0.20 | 1.28 | 1.79 | 0.97 | 0.99 | 0.53 | 1.32 | 4.94 | 1.69 | 0.93 | 2.75 | 1.79 | 1.24 | 2.14 | 1.54 |
| 0.21-0.50 | 0.099 | 0.38 | 0.062 | 0.045 | 0.014 | 0.069 | 0.89 | 0.18 | 0.09 | 0.17 | 0.21 | 0.31 | 0.2 | 0.079 |
| 0.51-1.00 | 0.12 | 0.22 | 0.074 | 0.063 | 0.015 | 0.067 | 1.04 | 0.16 | 0.053 | 0.22 | 0.18 | 0.54 | 0.24 | 0.078 |
| 1.01-2.00 | 0.22 | 0.22 | 0.048 | 0.064 | 0.023 | 0.055 | 0.29 | 0.039 | 0.036 | 0.34 | 0.11 | 0.41 | 0.055 | 0.096 |
| 2.01-5.00 | 0.2 | 0.38 | 0.02 | 0.025 | 0.019 | 0.016 | 0.014 | 0.009 | 0.09 | 0.084 | 0.054 | 0.23 | 0.000 | 0.03 |
| > 5.00 | 0.002 | 0.11 | 0 | 0.000 | 0 | 0.001 | 0.004 | 0 | 0.002 | 0.035 | 0.061 | 0.001 | 0 | 0 |

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Polanco(in sq. km.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magangon | Maligaya | Milad | New Lebangon | New Sicayab | Obay | Pian | Poblacion North | Poblacion South | San Antonio | San Pedro | Sianib | Silawe | Villahermosa |
| 0.03-0.20 | 4.55 | 0.77 | 0.44 | 0.9 | 1.28 | 3.68 | 2.01 | 0.21 | 0.99 | 0.3 | 1.09 | 1.72 | 2.12 | 2.02 |
| 0.21-0.50 | 0.21 | 0.09 | 0.032 | 0.098 | 0.046 | 0.7 | 0.32 | 0.078 | 0.18 | 0.42 | 0.035 | 0.18 | 0.2 | 0.22 |
| 0.51-1.00 | 0.24 | 0.15 | 0.035 | 0.11 | 0.078 | 0.32 | 0.51 | 0.077 | 0.15 | 0.66 | 0.04 | 0.25 | 0.19 | 0.36 |
| 1.01-2.00 | 0.36 | 0.18 | 0.027 | 0.12 | 0.12 | 0.13 | 0.17 | 0.22 | 0.23 | 0.44 | 0.056 | 0.32 | 0.21 | 0.31 |
| 2.01-5.00 | 0.14 | 0.077 | 0.017 | 0.18 | 0.005 | 0.11 | 0.001 | 0.24 | 0.14 | 0.074 | 0.017 | 0.22 | 0.025 | 0.2 |
| > 5.00 | 0.01 | 0 | 0 | 0.007 | 0 | 0.084 | 0 | 0.07 | 0.046 | 0 | 0 | 0.16 | 0.018 | 0.12 |

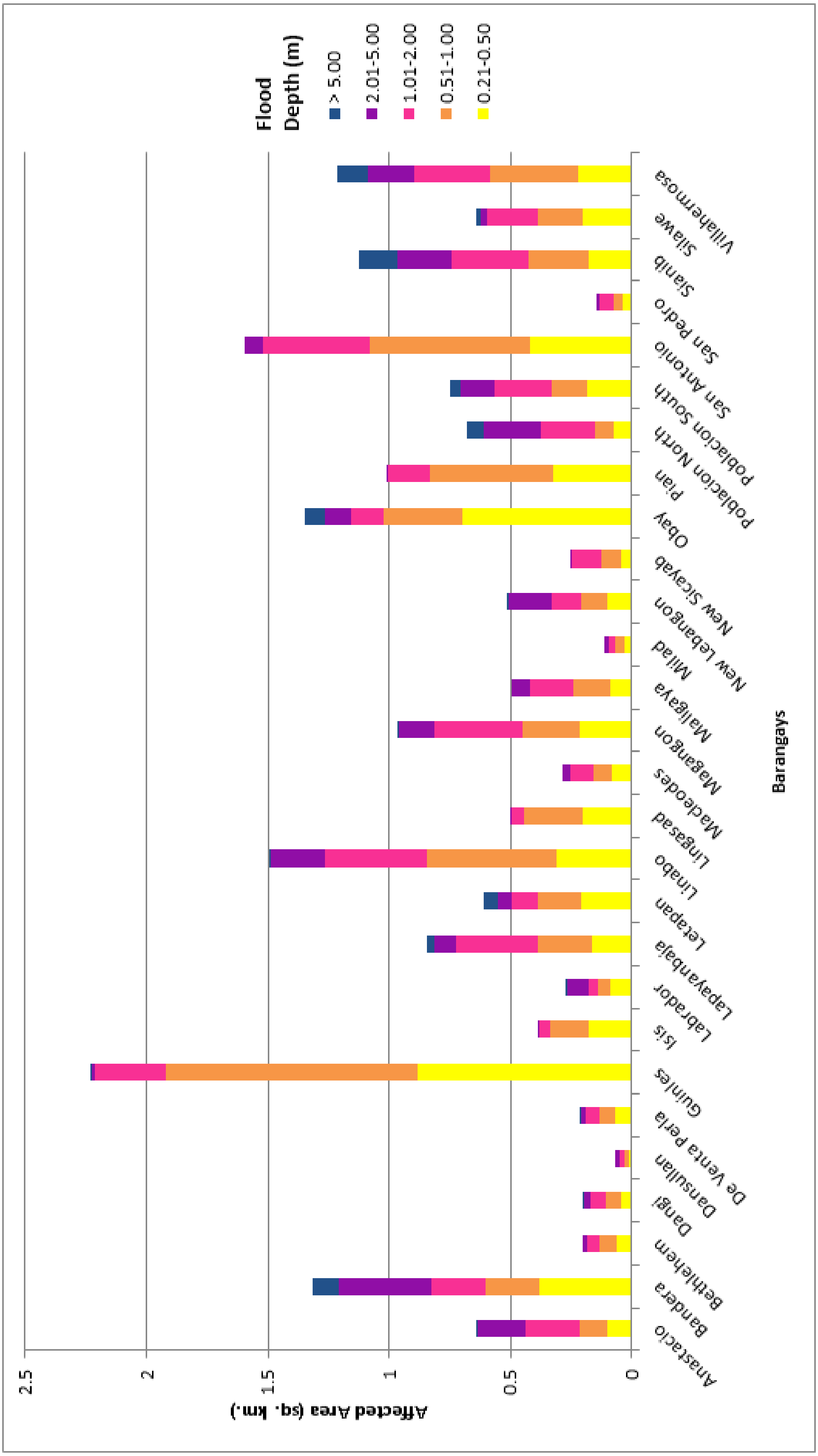



Figure 91. Affected Areas in Polanco, Zamboanga del Norte during 25-Year Rainfall Return Period

For the 100-Year return period, 6.14% of the city of Dapitan with an area of 222.95 sq. km. will experience flood levels of less 0.20 meters. 0.36% of the area will experience flood levels of 0.21 to 0.50 meters while 0.35%, 0.32%, and 0.19% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively. Listed in Table 59 are the affected areas in square kilometres by flood depth per barangay.

Table 59. Affected Areas in Dapitan City, Zamboanga del Norte during 100-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Dapitan City (in sq. km.) | | | | |
|---|---|---|---|---|---|
| | Antipolo | Aseniero | Owaon | San Francisco | Sigayan |
| 0.03-0.20 | 0.49 | 2.96 | 0.77 | 3.46 | 6.02 |
| 0.21-0.50 | 0.012 | 0.24 | 0.027 | 0.18 | 0.35 |
| 0.51-1.00 | 0.004 | 0.27 | 0.012 | 0.16 | 0.33 |
| 1.01-2.00 | 0.001 | 0.31 | 0.007 | 0.14 | 0.25 |
| 2.01-5.00 | 0.000 | 0.17 | 0.001 | 0.11 | 0.14 |
| > 5.00 | 0 | 0 | 0 | 0 | 0 |

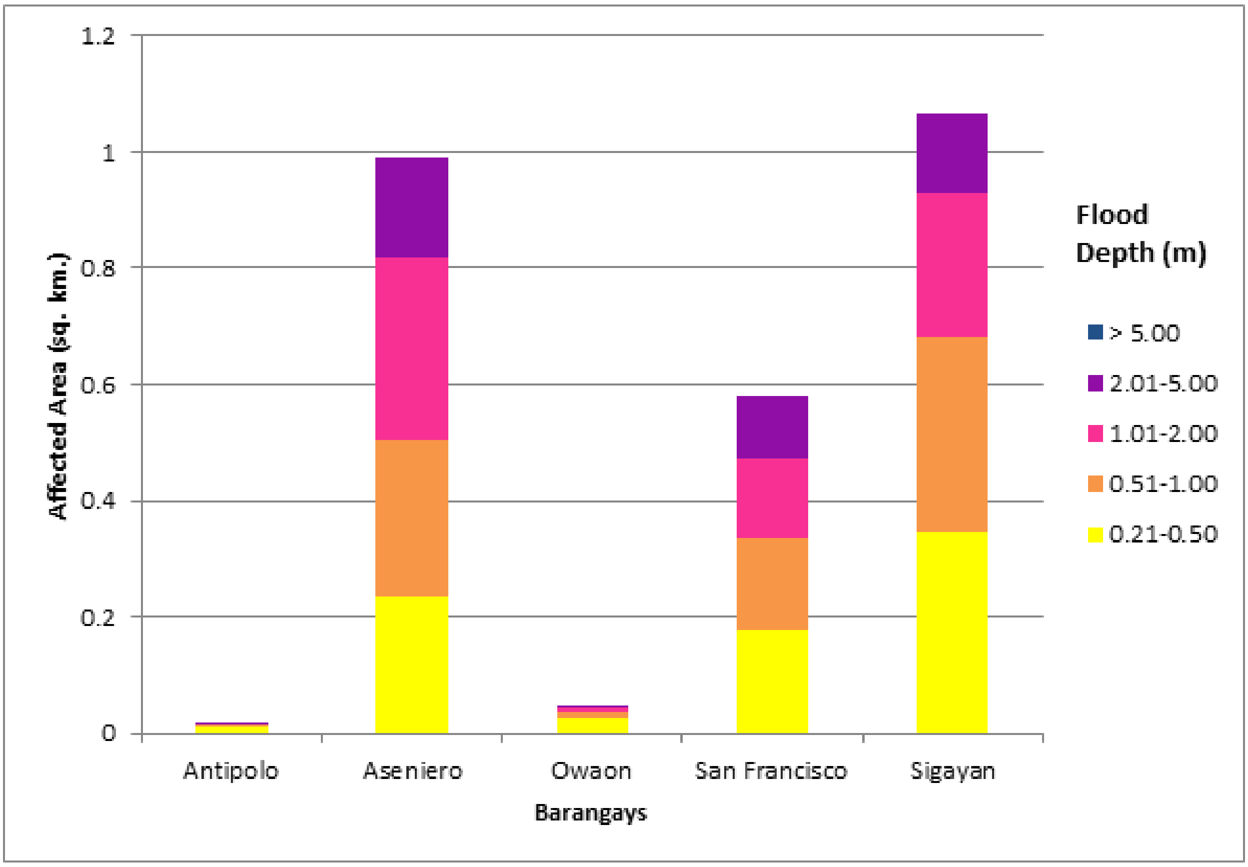



Figure 92. Affected Areas in Dapitan City, Zamboanga del Norte during 100-Year Rainfall Return Period

For the city of Dipolog, with an area of 184.42 sq. km., 35.76% will experience flood levels of less 0.20 meters. 5.62% of the area will experience flood levels of 0.21 to 0.50 meters while 4.18%, 2.34%, 1.84%, and 0.88% 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.

Table 60. Affected Areas in Dipolog City, Zamboanga del Norte during 100-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Dipolog City (in sq. km.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Barra | Biasong | Central | Cogon | Dicayas | Diwan | Estaca | Galas | Gulayon | Lugdungan |
| 0.03-0.20 | 0.38 | 0.27 | 0.85 | 15.88 | 5.6 | 3.02 | 0.49 | 4.42 | 7.8 | 1.23 |
| 0.21-0.50 | 0.14 | 0.086 | 0.23 | 0.68 | 0.6 | 0.096 | 0.14 | 2.36 | 0.64 | 0.12 |
| 0.51-1.00 | 0.054 | 0.068 | 0.042 | 0.66 | 0.61 | 0.085 | 0.051 | 0.84 | 0.67 | 0.12 |
| 1.01-2.00 | 0.014 | 0.037 | 0.000 | 1.04 | 0.44 | 0.09 | 0.017 | 0.035 | 0.47 | 0.027 |
| 2.01-5.00 | 0.005 | 0.033 | 0 | 1.51 | 0.14 | 0.3 | 0.051 | 0 | 0.17 | 0.015 |
| > 5.00 | 0 | 0 | 0 | 0.23 | 0 | 0.6 | 0.004 | 0 | 0.17 | 0.019 |

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Dipolog City (in sq. km.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Minaog | Miputak | Olingan | Punta | San Jose | Sangkol | Santa Fi-lomena | Santa Isabel | Sinaman | Turno |
| 0.03-0.20 | 2.3 | 0.42 | 4.19 | 3.56 | 8.26 | 2.54 | 1.41 | 0.51 | 1.45 | 1.39 |
| 0.21-0.50 | 0.21 | 0.21 | 1.54 | 1.46 | 0.37 | 0.13 | 0.53 | 0.52 | 0.062 | 0.24 |
| 0.51-1.00 | 0.2 | 0.14 | 1.57 | 1.07 | 0.37 | 0.15 | 0.5 | 0.3 | 0.053 | 0.14 |
| 1.01-2.00 | 0.17 | 0.019 | 0.43 | 0.36 | 0.66 | 0.32 | 0.038 | 0.06 | 0.043 | 0.046 |
| 2.01-5.00 | 0.003 | 0 | 0 | 0.01 | 0.57 | 0.47 | 0 | 0 | 0.004 | 0.12 |
| > 5.00 | 0 | 0 | 0 | 0 | 0.16 | 0.45 | 0 | 0 | 0 | 0.009 |

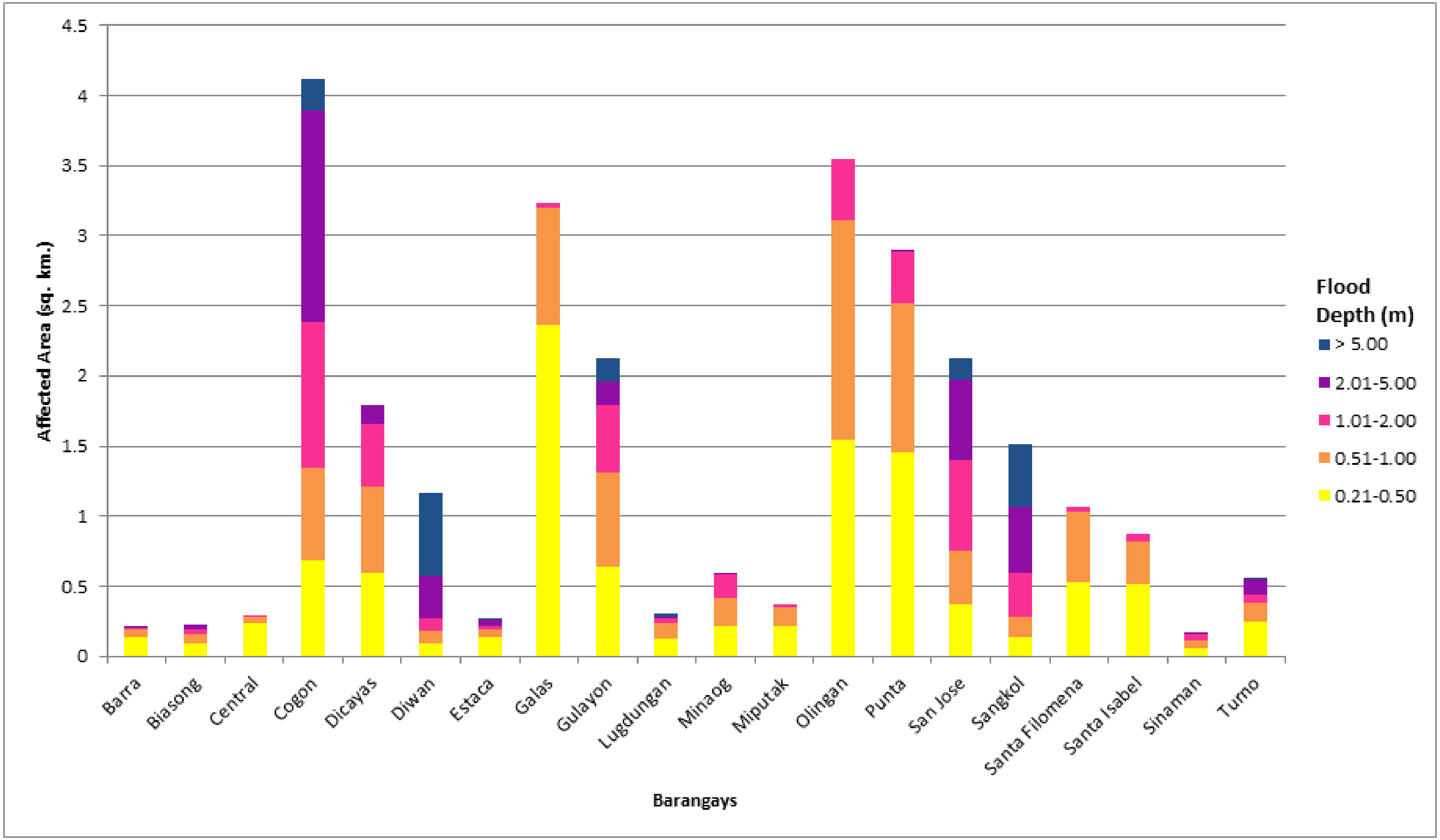



Figure 93. Affected Areas in Dipolog City, Zamboanga del Norte during 100-Year Rainfall Return Period

For the municipality of Katipunan, with an area of 189.621 sq. km., 9.76% will experience flood levels of less 0.20 meters. 1.39% of the area will experience flood levels of 0.21 to 0.50 meters while 1.71%, 1.82%, 1.38%, and 0.81% 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.

Table 61. Affected Areas in Katipunan, Zamboanga del Norte during 100-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Katipunan (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Barangay Dos | Barangay Uno | Basagan | Biniray | Daang lungsod | Dr. Jose Rizal | Loyuran | Malugas |
| 0.03-0.20 | 0.45 | 0.79 | 1.88 | 0.61 | 0.67 | 0.7 | 2.43 | 1.53 |
| 0.21-0.50 | 0.14 | 0.3 | 0.11 | 0.021 | 0.25 | 0.14 | 0.075 | 0.31 |
| 0.51-1.00 | 0.23 | 0.094 | 0.2 | 0.017 | 0.34 | 0.092 | 0.064 | 0.56 |
| 1.01-2.00 | 0.67 | 0.047 | 0.36 | 0.024 | 0.4 | 0.11 | 0.11 | 0.55 |
| 2.01-5.00 | 0.2 | 0.026 | 0.52 | 0.065 | 0.26 | 0.4 | 0.43 | 0.25 |
| > 5.00 | 0.028 | 0 | 0.1 | 0.36 | 0.006 | 0.46 | 0.44 | 0.055 |

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Katipunan (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Mias | Nanginan | New Tambo | San Antonio | San Vicente | Santo Niño | Singatong | Tuburan |
| 0.03-0.20 | 1.63 | 0.19 | 1.03 | 0.13 | 0.85 | 2.67 | 1.12 | 1.84 |
| 0.21-0.50 | 0.21 | 0.003 | 0.28 | 0.22 | 0.14 | 0.23 | 0.043 | 0.14 |
| 0.51-1.00 | 0.18 | 0.004 | 0.13 | 0.8 | 0.2 | 0.17 | 0.038 | 0.13 |
| 1.01-2.00 | 0.096 | 0.003 | 0.063 | 0.66 | 0.12 | 0.17 | 0.021 | 0.042 |
| 2.01-5.00 | 0.009 | 0.002 | 0.021 | 0.091 | 0.03 | 0.31 | 0.011 | 0.001 |
| > 5.00 | 0 | 0 | 0 | 0 | 0.005 | 0.074 | 0 | 0 |

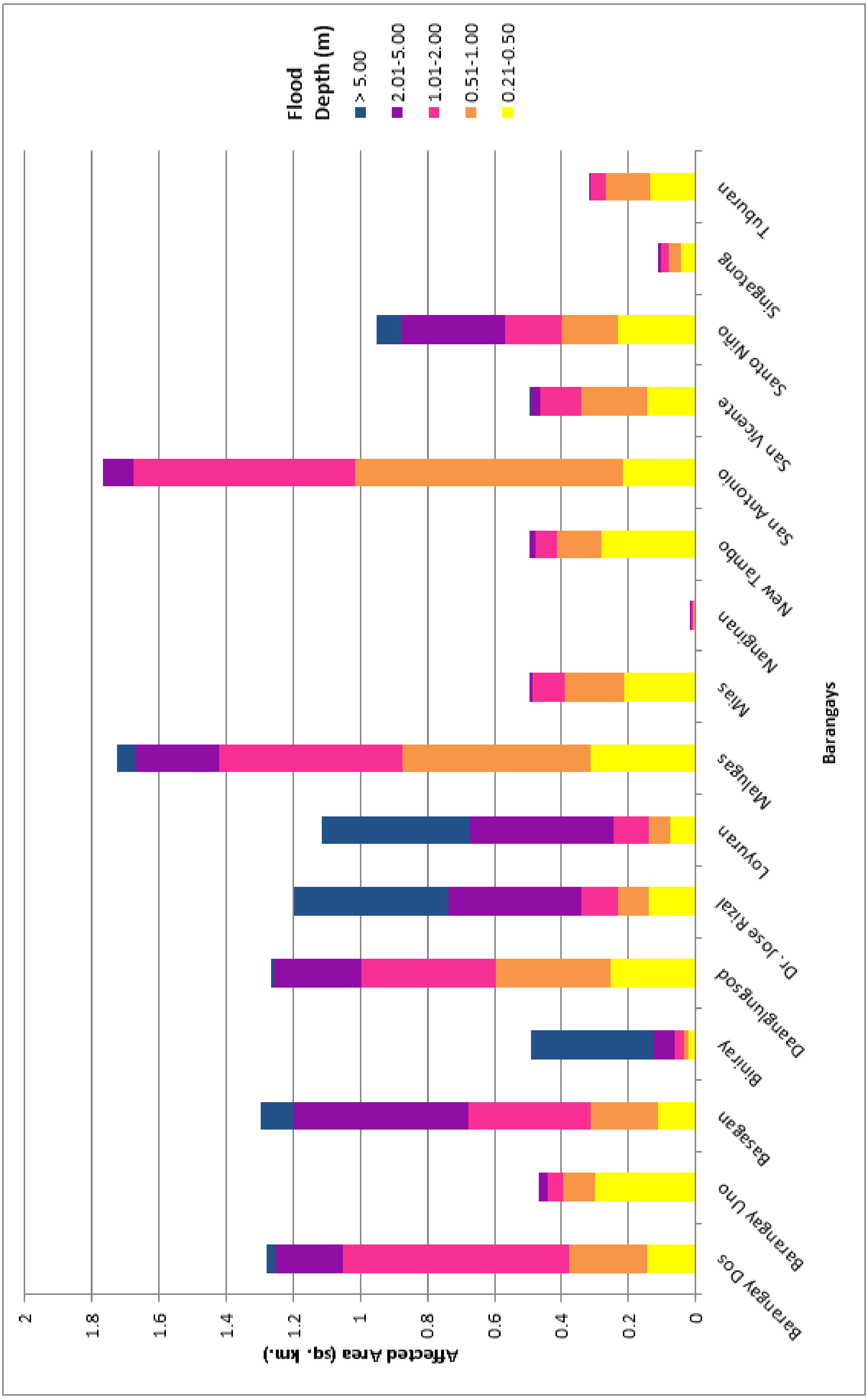



Figure 94. Affected Areas in Katipunan, Zamboanga del Norte during 100-Year Rainfall Return Period

For the municipality of La Libertad, with an area of 66.24 sq. km., 1.86% will experience flood levels of less 0.20 meters. 0.67% of the area will experience flood levels of 0.21 to 0.50 meters while 0.50%, 1.09%, 0.34%, 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.

Table 62. Affected Areas in La Libertad, Zamboanga del Norte during 100-Year Rainfall

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in La Libertad (in sq. km.) | |
|---|---|---|
| | Barangay Dos | Barangay Uno |
| 0.03-0.20 | 0.45 | 0.79 |
| 0.21-0.50 | 0.14 | 0.3 |
| 0.51-1.00 | 0.23 | 0.094 |
| 1.01-2.00 | 0.67 | 0.047 |
| 2.01-5.00 | 0.2 | 0.026 |
| > 5.00 | 0.028 | 0 |

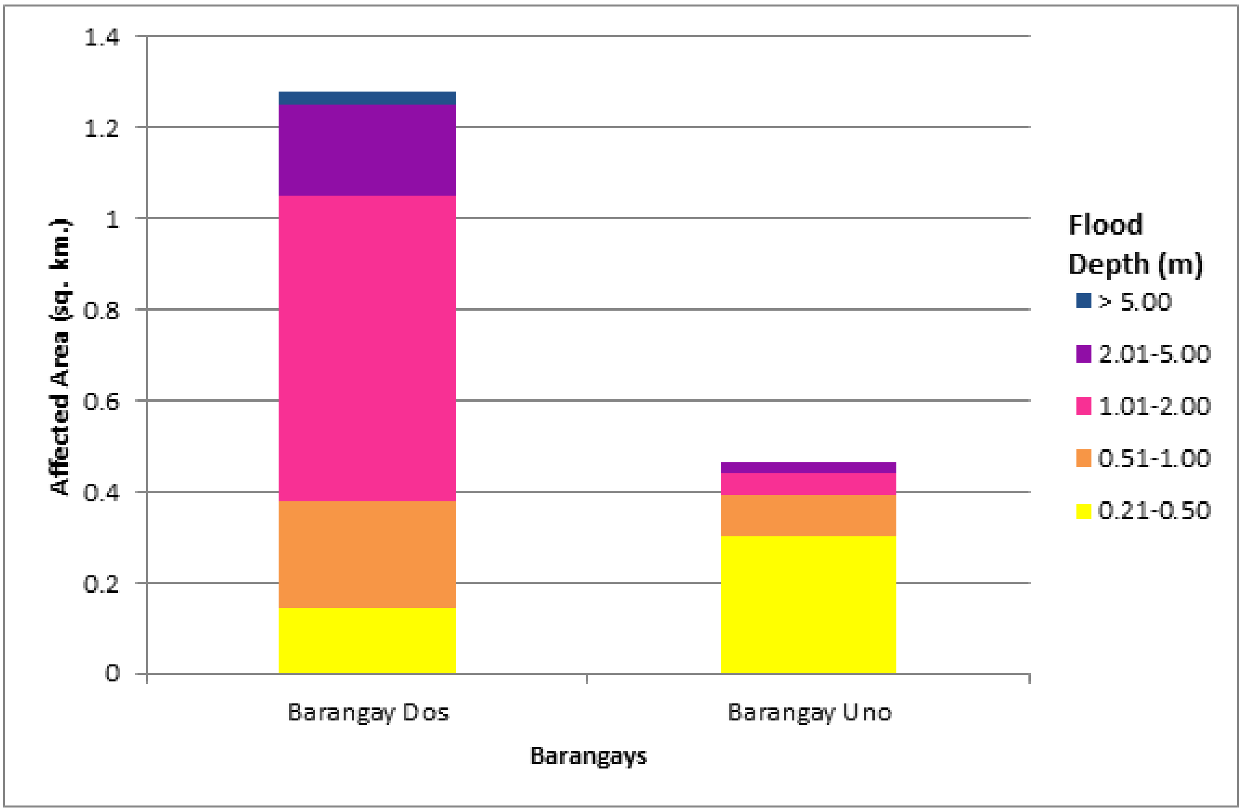



Figure 95. Affected Areas in La Libertad, Zamboanga del Norte during 100-Year Rainfall Return Period

For the municipality of Mutia, with an area of 83.22sq. km., 0.83% will experience flood levels of less 0.20 meters. 0.05% of the area will experience flood levels of 0.21 to 0.50 meters while 0.03%, 0.003%, and 0.0002% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, and more than 2 meters, respectively.

Table 63. Affected Areas in Mutia, Zamboanga del Norte during 100-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Mutia (in sq. km.) |
|---|---|
| | San Miguel |
| 0.03-0.20 | 0.69 |
| 0.21-0.50 | 0.04 |
| 0.51-1.00 | 0.023 |
| 1.01-2.00 | 0.003 |
| 2.01-5.00 | 0.000 |
| > 5.00 | 0 |

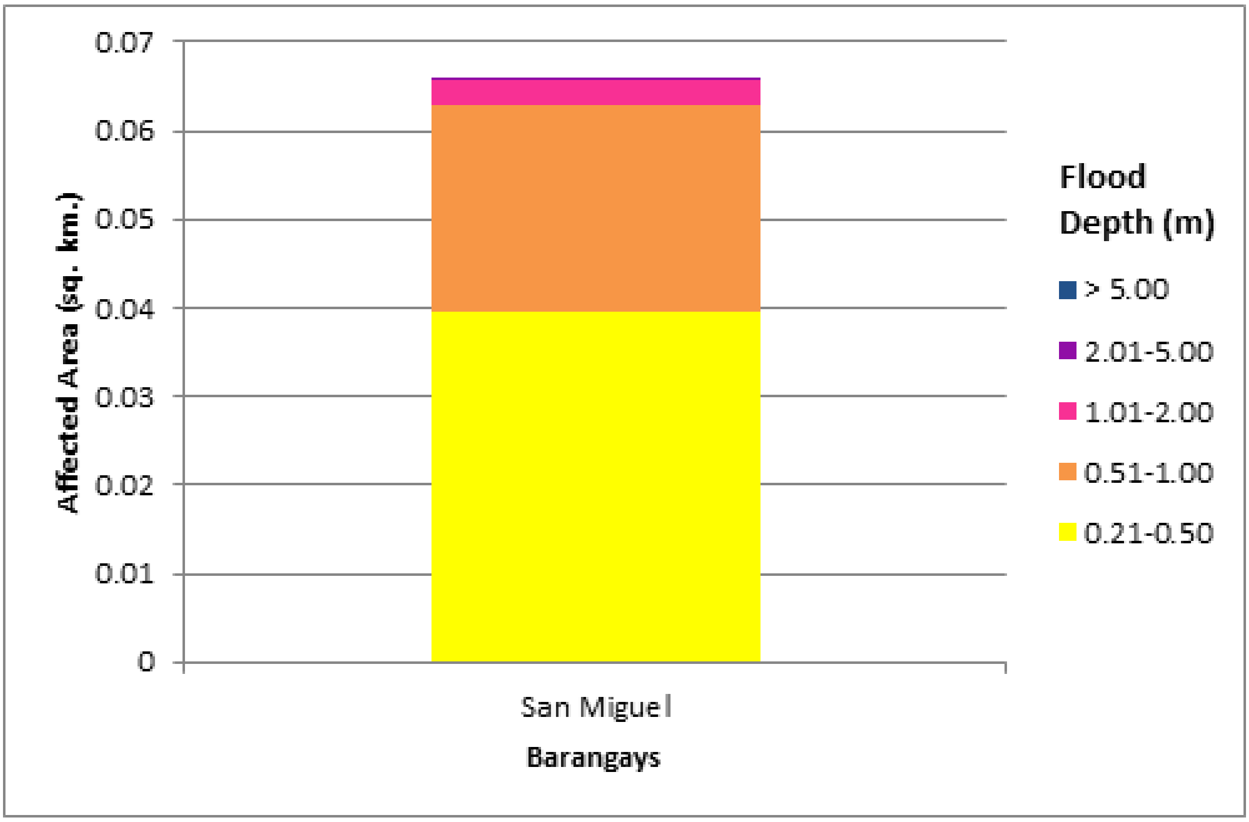



Figure 96. Affected Areas in Mutia, Zamboanga del Norte during 100-Year Rainfall Return Period

For the municipality of Pinan, with an area of 135.87 sq. km., 23.91% will experience flood levels of less 0.20 meters. 1.32% of the area will experience flood levels of 0.21 to 0.50 meters while 1.33%, 1.13%, 1.32%, and 0.73% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters respectively.

Table 64. Affected Areas in Pinan, Zamboanga del Norte during 100-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Pinan (in sq. km.) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Calican | Del Pilar | Desin | Dionum | Lapu-Lapu | Lower Gumay | Santa Fe | Segabe | Silano | Tinay-tayan | Ubay | Upper Gumay | Villarico |
| 0.03-0.20 | 5.98 | 1.73 | 1.94 | 4.82 | 0.33 | 2.95 | 2.21 | 0.93 | 1.31 | 2.6 | 0.4 | 4.2 | 3.08 |
| 0.21-0.50 | 0.28 | 0.1 | 0.15 | 0.27 | 0.046 | 0.17 | 0.095 | 0.051 | 0.073 | 0.13 | 0.017 | 0.24 | 0.17 |
| 0.51-1.00 | 0.29 | 0.076 | 0.17 | 0.3 | 0.038 | 0.17 | 0.079 | 0.052 | 0.067 | 0.15 | 0.015 | 0.22 | 0.17 |
| 1.01-2.00 | 0.29 | 0.087 | 0.15 | 0.24 | 0.036 | 0.16 | 0.038 | 0.036 | 0.049 | 0.15 | 0.018 | 0.16 | 0.12 |
| 2.01-5.00 | 0.46 | 0.2 | 0.16 | 0.15 | 0.015 | 0.27 | 0.055 | 0.003 | 0.058 | 0.17 | 0.002 | 0.24 | 0.018 |
| > 5.00 | 0.19 | 0.25 | 0 | 0.037 | 0 | 0.32 | 0.015 | 0 | 0.005 | 0.15 | 0 | 0.024 | 0 |

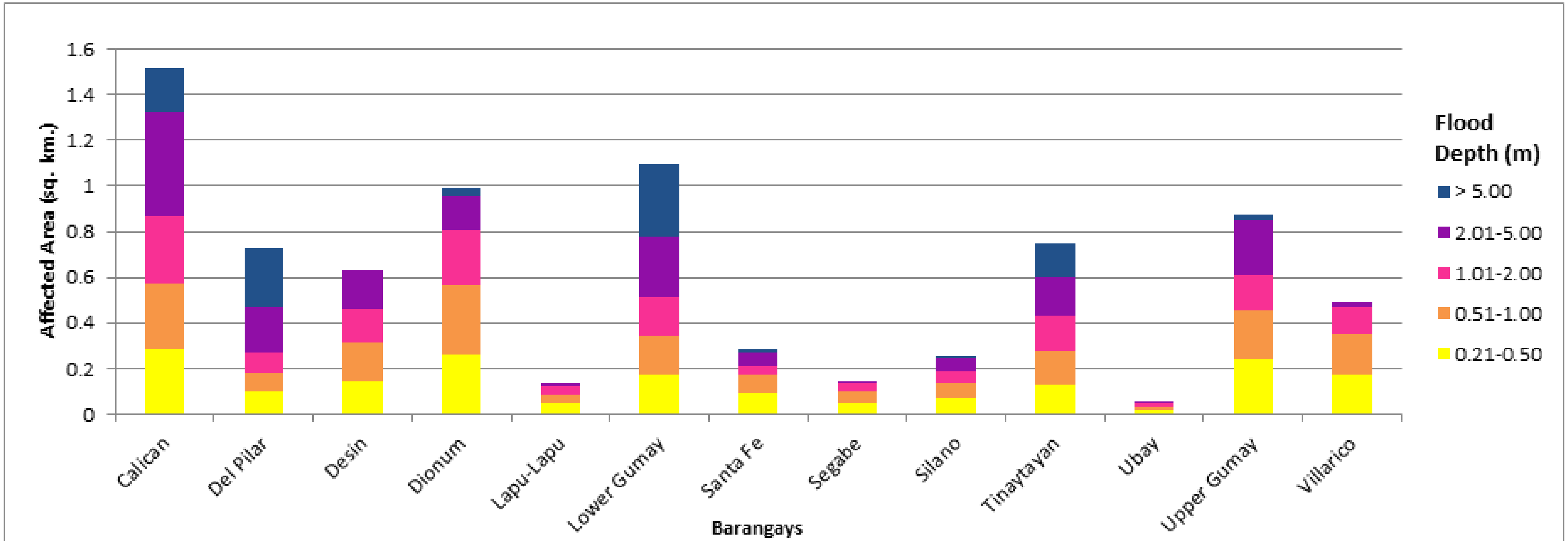



Figure 97. Affected Areas in Pinan, Zamboanga del Norte during 100-Year Rainfall Return Period

For the municipality of Polanco, with an area of 86.49 sq. km., 47.30% will experience flood levels of less 0.20 meters. 5.02% of the area will experience flood levels of 0.21 to 0.50 meters while 6.73%, 8.14%, 7.65%, and 1.57% 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.

Table 65. Affected Areas in Polanco, Zamboanga del Norte during 100-Year Rainfall Return Period

| Affected area (sq. km.) by flood depth (in m.) | Area of affected barangays in Polanco(in sq. km.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Anasta-cio | Bandera | Bethle-hem | Dangi | Dansul-lan | De Ven-ta Perla | Guinles | Isis | Labrador | Lapayan -baja | Letapan | Linabo | Lin-gasad | Macle-odes |
| 0.03-0.20 | 1.18 | 1.55 | 0.87 | 0.96 | 0.51 | 1.28 | 4.35 | 1.64 | 0.76 | 2.47 | 1.45 | 1.07 | 2.01 | 1.39 |
| 0.21-0.50 | 0.097 | 0.44 | 0.041 | 0.032 | 0.015 | 0.064 | 0.63 | 0.17 | 0.12 | 0.095 | 0.18 | 0.21 | 0.12 | 0.081 |
| 0.51-1.00 | 0.13 | 0.29 | 0.06 | 0.055 | 0.019 | 0.078 | 0.98 | 0.16 | 0.1 | 0.11 | 0.22 | 0.46 | 0.18 | 0.11 |
| 1.01-2.00 | 0.2 | 0.24 | 0.11 | 0.092 | 0.027 | 0.076 | 1 | 0.085 | 0.084 | 0.23 | 0.18 | 0.68 | 0.26 | 0.14 |
| 2.01-5.00 | 0.3 | 0.41 | 0.089 | 0.053 | 0.022 | 0.025 | 0.2 | 0.018 | 0.082 | 0.63 | 0.28 | 0.29 | 0.073 | 0.11 |
| > 5.00 | 0.005 | 0.17 | 0 | 0.000 | 0 | 0.001 | 0.005 | 0 | 0.049 | 0.061 | 0.091 | 0.006 | 0 | 0 |

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Polanco (in sq. km.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magan-gon | Maligaya | Milad | New Leban-gon | New Sicayab | Obay | Pian | Pobla-cion North | Pobla-cion South | San An-tonio | San Pedro | Sianib | Silawe | Villaher-mosa |
| 0.03-0.20 | 4.29 | 0.73 | 0.38 | 0.73 | 1.23 | 3.4 | 1.69 | 0.12 | 0.86 | 0.13 | 1.07 | 1.05 | 1.99 | 1.74 |
| 0.21-0.50 | 0.21 | 0.057 | 0.03 | 0.023 | 0.036 | 0.65 | 0.22 | 0.04 | 0.18 | 0.22 | 0.037 | 0.036 | 0.16 | 0.15 |
| 0.51-1.00 | 0.2 | 0.12 | 0.042 | 0.034 | 0.061 | 0.49 | 0.44 | 0.088 | 0.13 | 0.8 | 0.041 | 0.056 | 0.12 | 0.23 |
| 1.01-2.00 | 0.28 | 0.25 | 0.047 | 0.085 | 0.097 | 0.25 | 0.48 | 0.16 | 0.24 | 0.66 | 0.071 | 0.32 | 0.098 | 0.59 |
| 2.01-5.00 | 0.47 | 0.11 | 0.048 | 0.39 | 0.1 | 0.15 | 0.18 | 0.4 | 0.27 | 0.091 | 0.023 | 1.06 | 0.36 | 0.37 |
| > 5.00 | 0.066 | 0.000 | 0 | 0.15 | 0 | 0.094 | 0 | 0.085 | 0.055 | 0 | 0 | 0.33 | 0.025 | 0.15 |

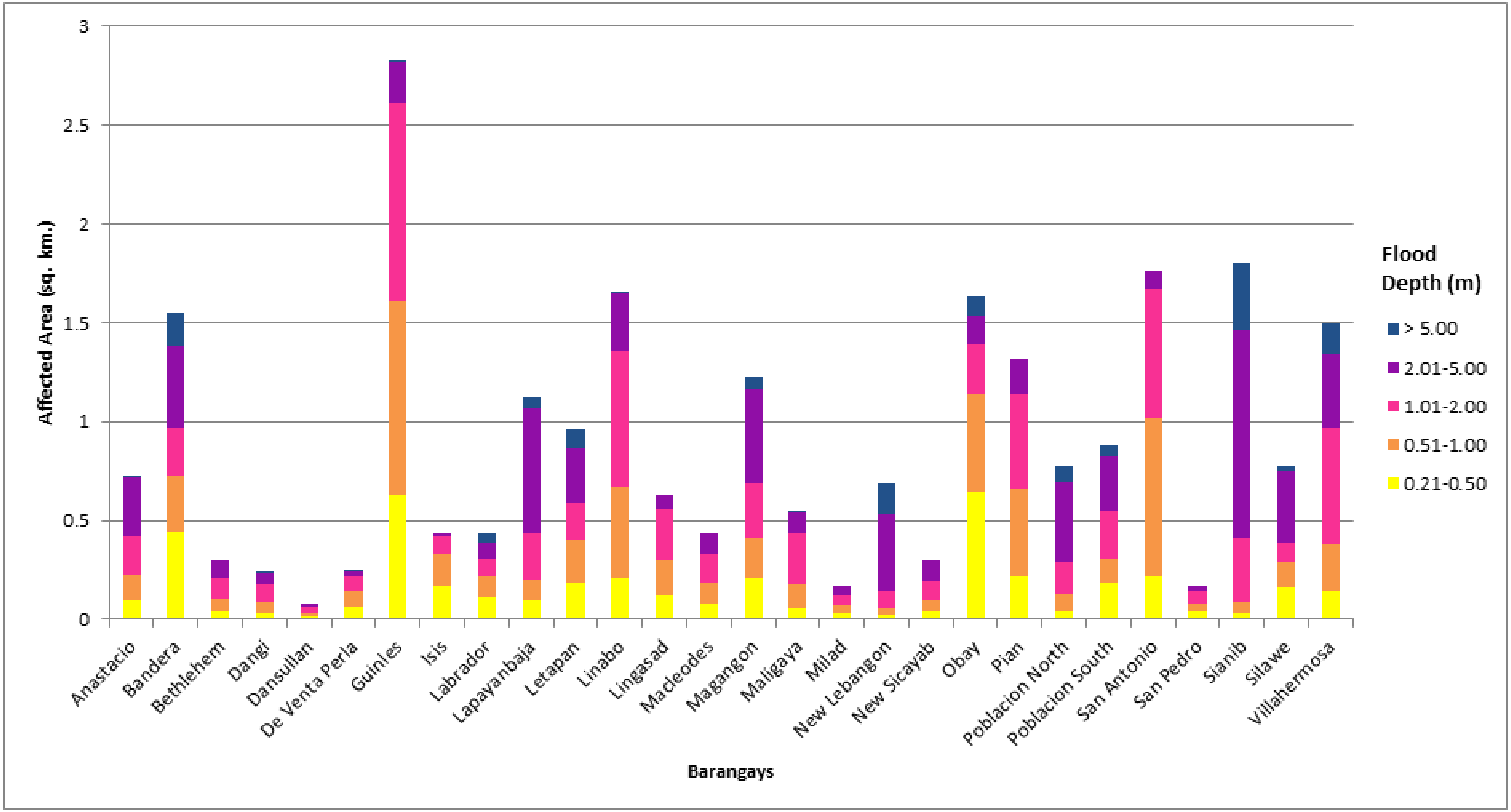



Figure 98. Affected Areas in Polanco, Zamboanga del Norte during 100-Year Rainfall Return Period

Among the barangays in the city of Dapitan, Sigayan is projected to have the highest percentage of area that will experience flood levels at 3.18%. Meanwhile, San Francisco posted the second highest percentage of area that may be affected by flood depths at 1.81%.

Among the barangays in the city of Dipolog, Cogon is projected to have the highest percentage of area that will experience flood levels at 10.84%. Meanwhile, San Jose posted the second highest percentage of area that may be affected by flood depths at 5.63%.

Among the barangays in the municipality of Katipunan, Santo Niño is projected to have the highest percentage of area that will experience flood levels of at 1.91%. Meanwhile, Loyuran posted the percentage of area that may be affected by flood depths of at 1.87%.

For the municipality of La Libertad, only two barangays are affected. Barangay Dos is projected to have 2.60% of area that will experience flood levels and 1.89% for Barangay Uno.
For the municipality of Mutia, only San Miguel is projected to experience flood levels at a percentage of 0.91%.

Among the barangays in the municipality of Pinan, Calican is projected to have the highest percentage of area that will experience flood levels of at 5.51%. Meanwhile, Dionum posted the percentage of area that may be affected by flood depths of at 4.27%.

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

Table 66. Area covered by each warning level with respect to the rainfall scenario

| Warning Level | Area Covered in sq. km. | | |
|---|---|---|---|
| | 5 year | 25 year | 100 year |
| Low | 19.57 | 21.44 | 20.39 |
| Medium | 15.11 | 24.99 | 29.34 |
| High | 9.16 | 16.08 | 26.75 |
| **TOTAL** | **43.84** | **62.51** | **76.48** |

Of the 79 identified Education Institutions in Dipolog Flood plain, 11 schools were assessed to be exposed to the Low level flooding during a 5 year scenario while none were assessed to be exposed to Medium and High level flooding in the same scenario. In the 25 year scenario, 19 schools were assessed to be exposed to the Low level flooding while no schools were assessed to be exposed to Medium and High level flooding. For the 100 year scenario, 21 school was assessed for Low level flooding and 4 schools for Medium level flooding. In the same scenario, 1 school was assessed to be exposed to High level flooding. See Annex 12 for a detailed enumeration of schools inside Dipolog floodplain.

Of the 32 identified Medical Institutions in Dipolog Flood plain, 4 were assessed to be exposed to the Low level flooding during a 5 year scenario while none were assessed to be exposed to Medium and High level flooding in the same scenario. In the 25 year scenario, 7 were assessed to be exposed to the Low level flooding while 1 was assessed to be exposed to Medium level flooding. For the 100 year scenario, 7 schools were assessed for Low level flooding and 1 for Medium level flooding. See Apppendix E for a detailed enumeration of medical institutions inside Dipolog floodplain.

## 5.11 Flood Validation

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

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

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

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 points in the flood map versus its corresponding validation depths are shown in Figure 99.

The flood validation consists of 120 points randomly selected all over the Dipolog floodplain on November 29, 2016 (Figure 99). It has an RMSE value of 0.46. Table 67 shows a contingency matrix of the comparison. The validation points are found in Annex 11.

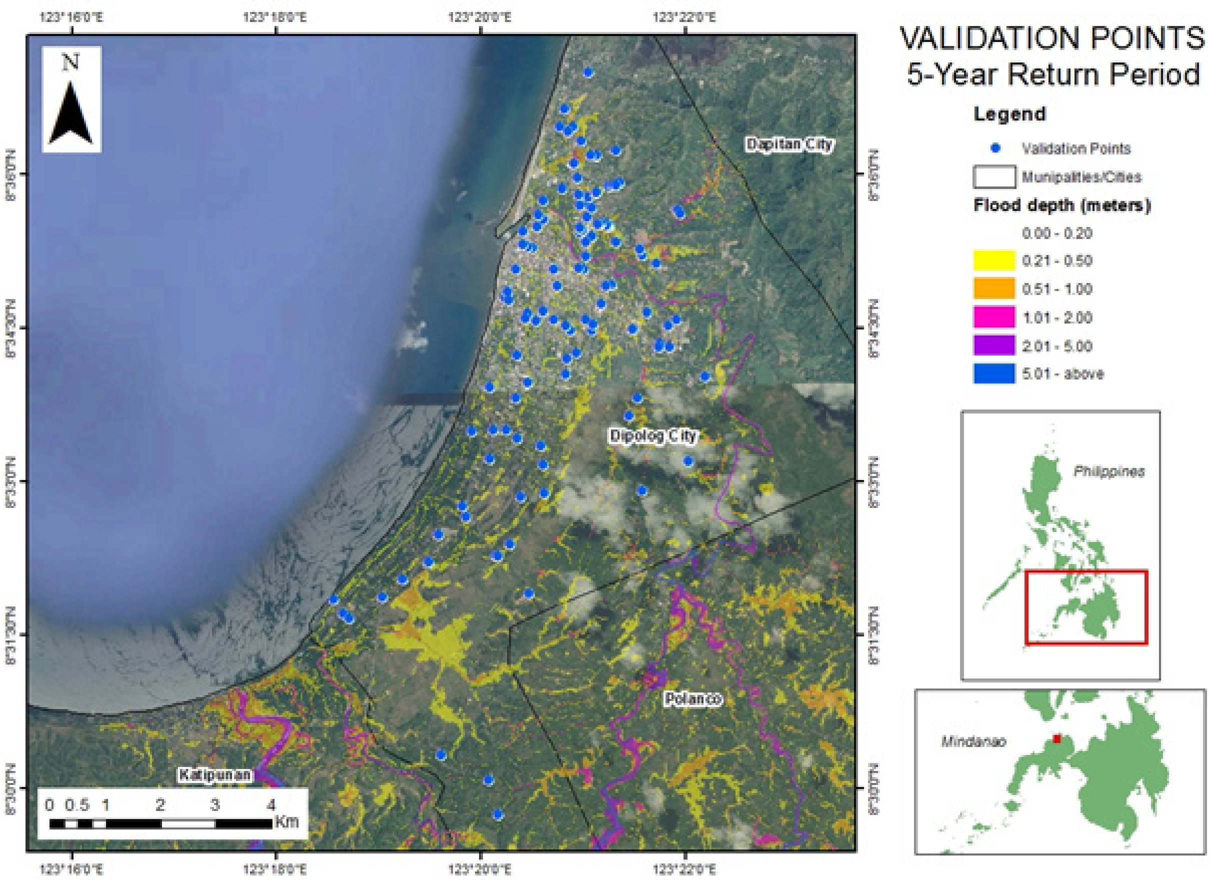



Figure 99. Validation points for 5-year Flood Depth Map of Dipolog Floodplain

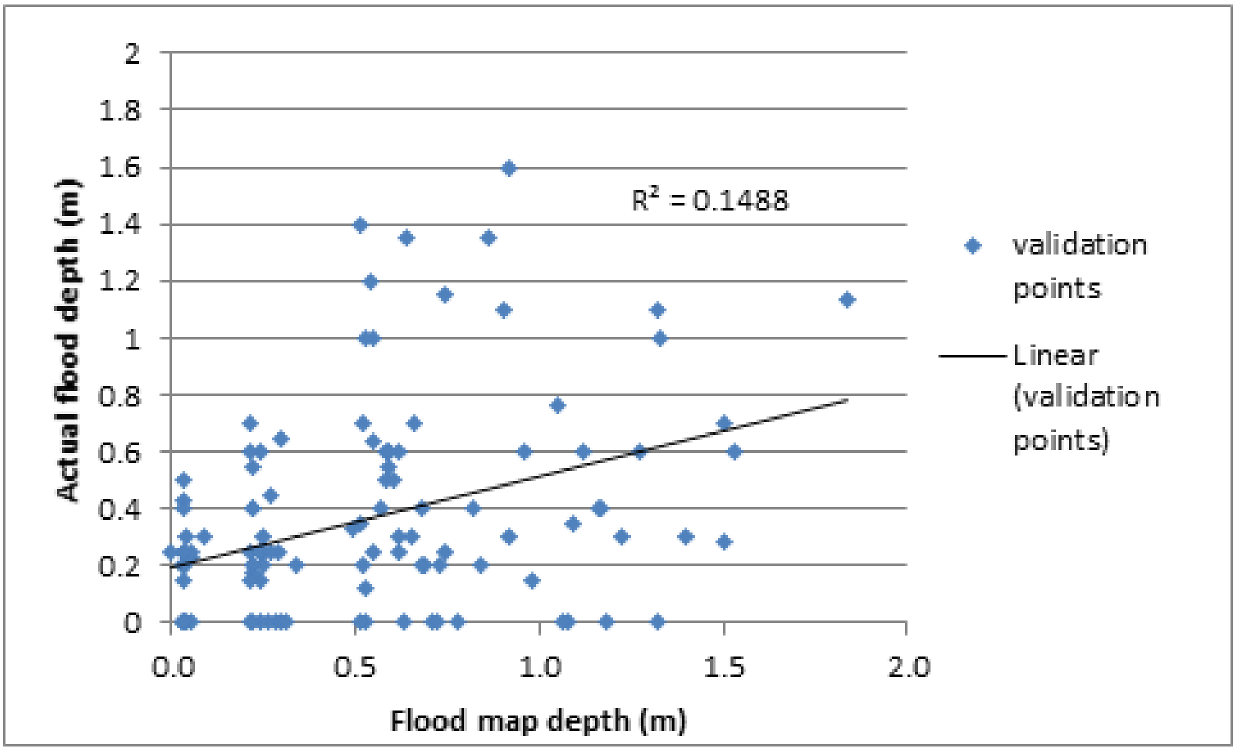



Figure 100. Flood map depth vs actual flood depth

Table 67. Actual Flood Depth vs Simulated Flood Depth in Dipolog

| DIPOLOG 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 | 19 | 14 | 13 | 4 | 0 | 0 | 50 |
| | 0.21-0.50 | 10 | 11 | 12 | 6 | 0 | 0 | 39 |
| | 0.51-1.00 | 0 | 5 | 11 | 6 | 0 | 0 | 22 |
| | 1.01-2.00 | 0 | 0 | 7 | 2 | 0 | 0 | 9 |
| | 2.01-5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 29 | 30 | 43 | 18 | 0 | 0 | 120 |

The overall accuracy generated by the flood model is estimated at 35.83%, with 43 points correctly matching the actual flood depths. In addition, there were 54 points estimated one level above and below the correct flood depths while there were 19 points and 4 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 55 points were overestimated while a total of 22 points were underestimated in the modelled flood depths of Dipolog

Table 68. Summary of Accuracy Assessment in Dipolog River Basin Survey

| | No. of Points | % |
|---|---|---|
| Correct | 43 | 35.83 |
| Overestimated | 55 | 45.83 |
| Underestimated | 22 | 18.33 |
| Total | 120 | 100 |

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

# ANNEXES

## Annex 1. Optech Technical Specification of the Sensor

Table A-1.1 Pegasus

| Parameter | Specification |
|---|---|
| Operational envelope (1,2,3,4) | 150-5000 m AGL, nominal |
| Laser wavelength | 1064 nm |
| Horizontal accuracy (2) | 1/5,500 x altitude, 1σ |
| Elevation accuracy (2) | < 5-20 cm, 1σ |
| Effective laser repetition rate | Programmable, 100-500 kHz |
| Position and orientation system | POS AV ™AP50 (OEM) |
| Scan width (FOV) | Programmable, 0-75 ˚ |
| Scan frequency (5) | Programmable, 0-140 Hz (effective) |
| Sensor scan product | 800 maximum |
| Beam divergence | 0.25 mrad (1/e) |
| Roll compensation | Programmable, ±37˚ (FOV dependent) |
| Vertical target separation distance | <0.7 m |
| 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) |
| Image capture | 5 MP interline camera (standard); 60 MP full frame (optional) |
| Full waveform capture | 12-bit Optech IWD-2 Intelligent Waveform Digitizer |
| Data storage | Removable solid state disk SSD (SATA II) |
| Power requirements | 28 V, 800 W, 30 A |
| Dimensions and weight | Sensor: 630 x 540 x 450 mm; 65 kg; |
| | Control rack: 650 x 590 x 490 mm; 46 kg |
| Operating Temperature | -10°C to +35°C |
| Relative humidity | 0-95% non-condensing |

1. Target reflectivity ≥20%
2. Dependent on selected operational parameters using nominal FOV of up to 40° in standard atmospheric conditions with 24-km visibility
3. Angle of incidence ≤20˚
4. Target size ≥ laser footprint5 Dependent on system configuration

Table A-1.2. D-8900 Aerial Digital Camera

| Parameter | Specification |
|---|---|
| Camera Head | |
| Sensor type | 60 Mpix full frame CCD, RGB |
| Sensor format (H x V) | 8, 984 x 6, 732 pixels |
| Pixel size | 6µm x 6 µm |
| Frame rate | 1 frame/2 sec. |
| FMC | Electro-mechanical, driven by piezo technology (patented) |
| Shutter | Electro-mechanical iris mechanism 1/125 to 1/500++ sec. f-stops: 5.6, 8, 11, 16 |
| Lenses | 50 mm/70 mm/120 mm/210 mm |
| Filter | Color and near-infrared removable filters |
| Dimensions (H x W x D) | 200 x 150 x 120 mm (70 mm lens) |
| Weight | ~4.5 kg (70 mm lens) |
| Controller Unit | |
| Computer | Mini-ITX RoHS-compliant small-form-factor embedded |
| | computers with AMD TurionTM 64 X2 CPU |
| | 4 GB RAM, 4 GB flash disk local storage |
| | IEEE 1394 Firewire interface |
| Removable storage unit | ~500 GB solid state drives, 8,000 images |
| Power consumption | ~8 A, 168 W |
| Dimensions | 2U full rack; 88 x 448 x 493 mm |
| Weight | ~15 kg |
| Image Pre-Processing Software | |
| Capture One | Radiometric control and format conversion, TIFF or JPEG |
| Image output | 8,984 x 6,732 pixels |
| | 8 or 16 bits per channel (180 MB or 360 MB per image) |

# Annex 2. NAMRIA Certificates of Reference Points Used

1. ZGN-138

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

October 30, 2014

**CERTIFICATION**

To whom it may concern:

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

Province: **ZAMBOANGA DEL NORTE**
Station Name: **ZGN-138**
Order: **2nd**

| | | | |
|---|---|---|---|
| Island: **MINDANAO** | Barangay: | | |
| Municipality: **KATIPUNAN** | MSL Elevation: | | |
| | *PRS92 Coordinates* | | |
| Latitude: **8° 30' 40.65974"** | Longitude: **123° 18' 14.44217"** | Ellipsoidal Hgt: | **6.71500 m.** |
| | *WGS84 Coordinates* | | |
| Latitude: **8° 30' 36.94779"** | Longitude: **123° 18' 19.85548"** | Ellipsoidal Hgt: | **70.92500 m.** |
| | *PTM / PRS92 Coordinates* | | |
| Northing: **941106.14 m.** | Easting: **533471.036 m.** | Zone: | **4** |
| | *UTM / PRS92 Coordinates* | | |
| Northing: **940,776.74** | Easting: **533,459.32** | Zone: | **51** |

Location Description

The station is marked by an 4" copper nail with its head flushed at the center of an cement putty on a concrete open canal with inscription " ZGN-138, 2009 NAMRIA".Located at brgy. Taga katipunan zamboanga del norte. The monument is situated inside taga central school 10 meters from the main gate going north west 6 meters from the flag pole going south east.

Requesting Party: **PHIL-LIDAR I**
Purpose: **Reference**
OR Number: **8075910 I**
T.N.: **2014-2584**

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

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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. ZGN-138

2. ZGN-137

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

December 09, 2014

**CERTIFICATION**

To whom it may concern:

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

Province: **ZAMBOANGA DEL NORTE**
Station Name: **ZGN-137**
Order: **2nd**

| | | |
|---|---|---|
| Island: **MINDANAO** | Barangay: **LINAY** | |
| Municipality: **MANUKAN** | MSL Elevation: | |
| | ***PRS92 Coordinates*** | |
| Latitude: **8° 31' 13.43575"** | Longitude: **123° 7' 49.35667"** | Ellipsoidal Hgt: **7.15100 m.** |
| | ***WGS84 Coordinates*** | |
| Latitude: **8° 31' 9.70588"** | Longitude: **123° 7' 54.77045"** | Ellipsoidal Hgt: **70.91200 m.** |
| | ***PTM / PRS92 Coordinates*** | |
| Northing: **942102.244 m.** | Easting: **514353.819 m.** | Zone: **4** |
| | ***UTM / PRS92 Coordinates*** | |
| Northing: **941,772.49** | Easting: **514,348.80** | Zone: **51** |

Location Description

The station is marked by an 4" copper nail with its head flushed at the center of an cement putty on a concrete open canal with inscription " ZGN-137, 2009 NAMRIA".Located at brgy. Linay manukan zamboanga del norte. The monument is situated inside linay central school 40 meters from gate going north.

Requesting Party: **Christopher Cruz**
Purpose: **Reference**
OR Number: **8077396 I**
T.N.: **2014-2987**

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

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Figure A-2.2. ZGN-137

3. ZGN-132

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

October 30, 2014

## CERTIFICATION

To whom it may concern:

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

Province: **ZAMBOANGA DEL NORTE**
Station Name: **ZGN-132**
Order: **2nd**

| | | |
|---|---|---|
| Island: **MINDANAO** | Barangay: **MANDIH** | |
| Municipality: **SINDANGAN** | MSL Elevation: | |
| | ***PRS92 Coordinates*** | |
| Latitude: **8° 12' 44.29460"** | Longitude: **123° 0' 19.12667"** | Ellipsoidal Hgt: **11.50200 m.** |
| | ***WGS84 Coordinates*** | |
| Latitude: **8° 12' 40.63408"** | Longitude: **123° 0' 24.56923"** | Ellipsoidal Hgt: **75.58000 m.** |
| | ***PTM / PRS92 Coordinates*** | |
| Northing: **908029.029 m.** | Easting: **500585.389 m.** | Zone: **4** |
| | ***UTM / PRS92 Coordinates*** | |
| Northing: **907,711.20** | Easting: **500,585.18** | Zone: **51** |

Location Description

The station is marked by an 4" copper nail with its head flushed at the center of an cement putty on a concrete open canal with inscription " ZGN-132, 2009 NAMRIA".Located at brgy. Mandih sindangan zamboanga del norte. The monument is situated inside mandih central school 30 meters from the gate going east.

Requesting Party: **PHIL-LIDAR I**
Purpose: **Reference**
OR Number: **8075910 I**
T.N.: **2014-2585**

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

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CP/4701/12/09/814

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Figure A-2.3. ZGN-132

4. ZGN-60

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

March 08, 2016

**CERTIFICATION**

To whom it may concern:

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

Province: **ZAMBOANGA DEL NORTE**
Station Name: **ZGN-60**
Order: **2nd**

| | | |
|---|---|---|
| Island: **MINDANAO** | Barangay: **SAN PEDRO** | |
| Municipality: **POLANCO** | MSL Elevation: | |
| | ***PRS92 Coordinates*** | |
| Latitude: **8° 24' 13.24705"** | Longitude: **123° 23' 43.64096"** | Ellipsoidal Hgt: **78.37100 m.** |
| | ***WGS84 Coordinates*** | |
| Latitude: **8° 24' 9.57149"** | Longitude: **123° 23' 49.06324"** | Ellipsoidal Hgt: **143.02900 m.** |
| | ***PTM / PRS92 Coordinates*** | |
| Northing: **929214.294 m.** | Easting: **543551.053 m.** | Zone: **4** |
| | ***UTM / PRS92 Coordinates*** | |
| Northing: **928,889.05** | Easting: **543,535.81** | Zone: **51** |

Location Description

ZGN-60
Is situated on the sidewalk of Layawan Bridge. It is located near the SW edge of the bridge from its center. It is about 15 m. NNE of Barbaso Family residence and 300 m. SW of ZGN-61. Mark is the head of a 4 in. copper nail embedded and centered on a 30 cm. x 30 cm. cement putty, with inscriptions "ZGN-60 2005 NAMRIA LEP-9".

| | |
|---|---|
| Requesting Party: | **UP DREAM** |
| Purpose: | **Reference** |
| OR Number: | **8089979 I** |
| T.N.: | **2016-0567** |

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

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Figure A-2.4. ZGN-60

5. MSW-05

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

December 01, 2016

CERTIFICATION

To whom it may concern:

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

Province: **MISAMIS OCCIDENTAL**

Station Name: **MSW-5**

Order: **2nd**

| | | | | | |
|---|---|---|---|---|---|
| Island: | **MINDANAO** | Barangay: | **POBLACION** | | |
| Municipality: | **SAPANG DALAGA** | MSL Elevation: | | | |
| | | *PRS92 Coordinates* | | | |
| Latitude: | **8° 32' 35.68185"** | Longitude: | **123° 33' 56.01853"** | Ellipsoidal Hgt: | **113.48100 m.** |
| | | *WGS84 Coordinates* | | | |
| Latitude: | **8° 32' 31.98501"** | Longitude: | **123° 34' 1.42685"** | Ellipsoidal Hgt: | **178.27400 m.** |
| | | *PTM / PRS92 Coordinates* | | | |
| Northing: | **944671.948 m.** | Easting: | **562262.537 m.** | Zone: | **4** |
| | | *UTM / PRS92 Coordinates* | | | |
| Northing: | **944,341.30** | Easting: | **562,240.75** | Zone: | **51** |

Location Description

MSW-5
From Dipolog City, travel along the Nat'l. Highway going to Calamba until reaching Sapang Dalaga Proper. Station is located inside Sapang Dalaga Mun. Hall compound, beside the fence near the basketball court. It is about 50 m. from the DAR office and 100 m. from the mun. hall. Mark is the head of a 4 in. copper nail embedded on a 30 cm. x 30 cm. concrete block, with inscriptions "MSW-5 2007 NAMRIA".

Requesting Party: **PHIL-LIDAR 1**
Purpose: **Reference**
OR Number: **FREE ISSUE**
T.N.: **2016-2168**

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

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Figure A-2.5. MSW-05

6. ZN-53

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

October 30, 2014

**CERTIFICATION**

To whom it may concern:

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

Province: **ZAMBOANGA DEL NORTE**
Station Name: **ZN-53**

| | | |
|---|---|---|
| Island: **Mindanao** | Municipality: **KATIPUNAN** | Barangay: **DAANGLUNGSOD** |
| Elevation: **10.0561 +/- 0.00 m.** | Order: **1st Order** | Datum: **Mean Sea Level** |
| Latitude: | Longitude: | |

Location Description

ZN-53
Along Dipolog Liloy National Road. The station is located at the compound of Taga Central School, near the flagpole and about 50 meters northwest of the centerline of the road. Mark is the head of a 4" copper nail set on a dsrilled hole and cemented flushed on top of 15cm x 15cm cement putty with inscription " ZN-53 2008 NAMRIA".

Requesting Party: **PHIL-LIDAR I**
Purpose: **Reference**
OR Number: **8075910 I**
T.N.: **2014-2589**

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

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CIP/4701/12/09/814

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Figure A-2.6. ZN-53

7. ZN-53

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

December 09, 2014

**CERTIFICATION**

To whom it may concern:

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

Province: **ZAMBOANGA DEL NORTE**
Station Name: **ZN-123**

| | | |
|---|---|---|
| Island: **Mindanao** | Municipality: **SINDANGAN** | Barangay: **GOLEO** |
| Elevation: **13.1013 +/- 0.00 m.** | Order: **1st Order** | Datum: **Mean Sea Level** |
| Latitude: | Longitude: | |

Location Description

BM ZN-123 is in the Province of Zamboanga Del Norte, Town of Sindangan, Brgy. Goleo, along the Dipolog-Sindangan National Road. The station is located west-northwest of Sindangan Bridge at KM. 1921 + 182 and about 4 meters northwest of the centerline of the road.

Mark is the head of a 4" copper nail set on a drilled hole and cemented flushed on the top of 15cm x 15cm cement putty with inscription "BM ZN-123,2009,NAMRIA".

Requesting Party: **Christopher Cruz**
Purpose: **Reference**
OR Number: **8077396 I**
T.N.: **2014-2985**

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

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Figure A-2.7. ZN-53

# Annex 3. Baseline Processing Report of Reference Points Used

1. ZN-53

## Baseline Processing Report

### Processing Summary

| Observation | From | To | Solution Type | H. Prec. (Meter) | V. Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) | ΔHeight (Meter) |
|---|---|---|---|---|---|---|---|---|
| zgn 138 --- zn 53 am (B1) | zgn 138 | zn 53 am | Fixed | 0.001 | 0.002 | 344°25'59" | 12.263 | 0.357 |
| zgn 138 --- zn 53 pm (B2) | zgn 138 | zn 53 pm | Fixed | 0.003 | 0.004 | 344°25'44" | 12.270 | 0.372 |

### Acceptance Summary

| Processed | Passed | Flag | Fail |
|---|---|---|---|
| 2 | 2 | 0 | 0 |

Vector Components (Mark to Mark)

| From: | zgn 138 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 533459.321 m | Latitude | N8°30'40.65974" | Latitude | N8°30'36.94779" |
| Northing | 940776.736 m | Longitude | E123°18'14.44217" | Longitude | E123°18'19.85548" |
| Elevation | 5.484 m | Height | 6.715 m | Height | 70.925 m |

| To: | zn 53 am | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 533456.022 m | Latitude | N8°30'41.04428" | Latitude | N8°30'37.33230" |
| Northing | 940788.542 m | Longitude | E123°18'14.33457" | Longitude | E123°18'19.74787" |
| Elevation | 5.842 m | Height | 7.072 m | Height | 71.282 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | -3.299 m | NS Fwd Azimuth | 344°25'59" | ΔX | 3.517 m |
| ΔNorthing | 11.806 m | Ellipsoid Dist. | 12.263 m | ΔY | 0.641 m |
| ΔElevation | 0.358 m | ΔHeight | 0.357 m | ΔZ | 11.736 m |

Standard Errors

| Vector errors: | | | | | |
|---|---|---|---|---|---|
| σ ΔEasting | 0.001 m | σ NS fwd Azimuth | 0°00'09" | σ ΔX | 0.001 m |
| σ ΔNorthing | 0.000 m | σ Ellipsoid Dist. | 0.000 m | σ ΔY | 0.001 m |
| σ ΔElevation | 0.001 m | σ ΔHeight | 0.001 m | σ ΔZ | 0.000 m |

Aposteriori Covariance Matrix (Meter²)

| | X | Y | Z |
|---|---|---|---|
| X | 0.0000005629 | | |
| Y | -0.0000004033 | 0.0000010310 | |
| Z | -0.0000000776 | 0.0000001462 | 0.0000001693 |

Figure A.3.1. ZN-53

2. ZN-123

## Baseline Processing Report

### Processing Summary

| Observation | From | To | Solution Type | H. Prec. (Meter) | V. Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) | ΔHeight (Meter) |
|---|---|---|---|---|---|---|---|---|
| ZGN 132 — ZN 123 AM (B1) | ZGN 132 | ZN 123 AM | Fixed | 0.001 | 0.002 | 0°33'32" | 733.953 | -1.401 |
| ZGN 132 — ZN 123 PM (B2) | ZGN 132 | ZN 123 PM | Fixed | 0.003 | 0.012 | 0°33'32" | 733.954 | -1.392 |

### Acceptance Summary

| Processed | Passed | Flag | Fail |
|---|---|---|---|
| 2 | 2 | 0 | 0 |

Vector Components (Mark to Mark)

| From: | ZGN 132 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 500585.184 m | Latitude | N8°12'44.29460" | Latitude | N8°12'40.63408" |
| Northing | 907711.203 m | Longitude | E123°00'19.12667" | Longitude | E123°00'24.56923" |
| Elevation | 10.036 m | Height | 11.502 m | Height | 75.580 m |

| To: | ZN 123 AM | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 500592.329 m | Latitude | N8°13'08.18558" | Latitude | N8°13'04.52332" |
| Northing | 908444.828 m | Longitude | E123°00'19.36053" | Longitude | E123°00'24.80249" |
| Elevation | 8.704 m | Height | 10.101 m | Height | 74.166 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | 7.145 m | NS Fwd Azimuth | 0°33'32" | ΔX | 51.898 m |
| ΔNorthing | 733.625 m | Ellipsoid Dist. | 733.953 m | ΔY | -93.002 m |
| ΔElevation | -1.333 m | ΔHeight | -1.401 m | ΔZ | 726.187 m |

Standard Errors

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

Aposteriori Covariance Matrix (Meter²)

| | X | Y | Z |
|---|---|---|---|
| X | 0.0000005039 | | |
| Y | -0.0000002536 | 0.0000007702 | |
| Z | -0.0000000601 | 0.0000000520 | 0.0000001616 |

Figure A.3.2. ZN-123

3. ZN-74

## Baseline Processing Report

### Processing Summary

| Observation | From | To | Solution Type | H. Prec. (Meter) | V. Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) | ΔHeight (Meter) |
|---|---|---|---|---|---|---|---|---|
| ZGN 137 --- ZN 74 (B1) | ZGN 137 | ZN 74 | Fixed | 0.005 | 0.005 | 118°50'18" | 256.389 | 3.098 |

### Acceptance Summary

| Processed | Passed | Flag | Fail |
|---|---|---|---|
| 1 | 1 | 0 | 0 |

Vector Components (Mark to Mark)

| From: | ZGN 137 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 514348.795 m | Latitude | N8°31'13.43575" | Latitude | N8°31'09.70588" |
| Northing | 941772.492 m | Longitude | E123°07'49.35667" | Longitude | E123°07'54.77045" |
| Elevation | 6.852 m | Height | 7.151 m | Height | 70.912 m |

| To: | ZN 74 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 514573.340 m | Latitude | N8°31'09.41014" | Latitude | N8°31'05.68075" |
| Northing | 941648.951 m | Longitude | E123°07'56.70026" | Longitude | E123°08'02.11413" |
| Elevation | 9.926 m | Height | 10.249 m | Height | 74.017 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | 224.545 m | NS Fwd Azimuth | 118°50'18" | ΔX | -199.769 m |
| ΔNorthing | -123.541 m | Ellipsoid Dist. | 256.389 m | ΔY | -104.848 m |
| ΔElevation | 3.073 m | ΔHeight | 3.098 m | ΔZ | -121.837 m |

Standard Errors

| Vector errors: | | | | | |
|---|---|---|---|---|---|
| σ ΔEasting | 0.002 m | σ NS fwd Azimuth | 0°00'01" | σ ΔX | 0.002 m |
| σ ΔNorthing | 0.001 m | σ Ellipsoid Dist. | 0.002 m | σ ΔY | 0.002 m |
| σ ΔElevation | 0.003 m | σ ΔHeight | 0.003 m | σ ΔZ | 0.001 m |

Aposteriori Covariance Matrix (Meter²)

| | X | Y | Z |
|---|---|---|---|
| X | 0.0000061286 | | |
| Y | -0.0000022456 | 0.0000042812 | |
| Z | 0.0000001684 | 0.0000004050 | 0.0000005095 |

Figure A.3.3. ZN-74

4. ZN-11

Processing Summary

| Observation | From | To | Solution Type | H. Prec. (Meter) | V. Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) | ΔHeight (Meter) |
|---|---|---|---|---|---|---|---|---|
| MSW-5 --- ZN-11 (B1) | MSW-5 | ZN-11 | Float | 0.020 | 0.073 | 266°35'44" | 8470.799 | -93.731 |

Acceptance Summary

| Processed | Passed | Flag | Fail |
|---|---|---|---|
| 1 | 1 | 0 | 0 |

Vector Components (Mark to Mark)

| From: | MSW-5 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 562405.518 m | Latitude | N8°32'31.98501" | Latitude | N8°32'31.98501" |
| Northing | 944287.571 m | Longitude | E123°34'01.42685" | Longitude | E123°34'01.42685" |
| Elevation | 111.479 m | Height | 178.274 m | Height | 178.274 m |

| To: | ZN-11 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 553953.442 m | Latitude | N8°32'15.58462" | Latitude | N8°32'15.58462" |
| Northing | 943772.319 m | Longitude | E123°29'24.92624" | Longitude | E123°29'24.92624" |
| Elevation | 18.000 m | Height | 84.543 m | Height | 84.543 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | -8452.076 m | NS Fwd Azimuth | 266°35'44" | ΔX | 7058.852 m |
| ΔNorthing | -515.252 m | Ellipsoid Dist. | 8470.799 m | ΔY | 4655.796 m |
| ΔElevation | -93.479 m | ΔHeight | -93.731 m | ΔZ | -512.194 m |

Standard Errors

| Vector errors: | | | | | |
|---|---|---|---|---|---|
| σ ΔEasting | 0.008 m | σ NS fwd Azimuth | 0°00'00" | σ ΔX | 0.023 m |
| σ ΔNorthing | 0.006 m | σ Ellipsoid Dist. | 0.008 m | σ ΔY | 0.030 m |
| σ ΔElevation | 0.037 m | σ ΔHeight | 0.037 m | σ ΔZ | 0.010 m |

Aposteriori Covariance Matrix (Meter²)

| | X | Y | Z |
|---|---|---|---|
| X | 0.0005116012 | | |
| Y | -0.0006225709 | 0.0009222780 | |
| Z | -0.0001175407 | 0.0001737952 | 0.0000909524 |

Figure A.3.4. ZN-11

# Annex 4. The Survey Team

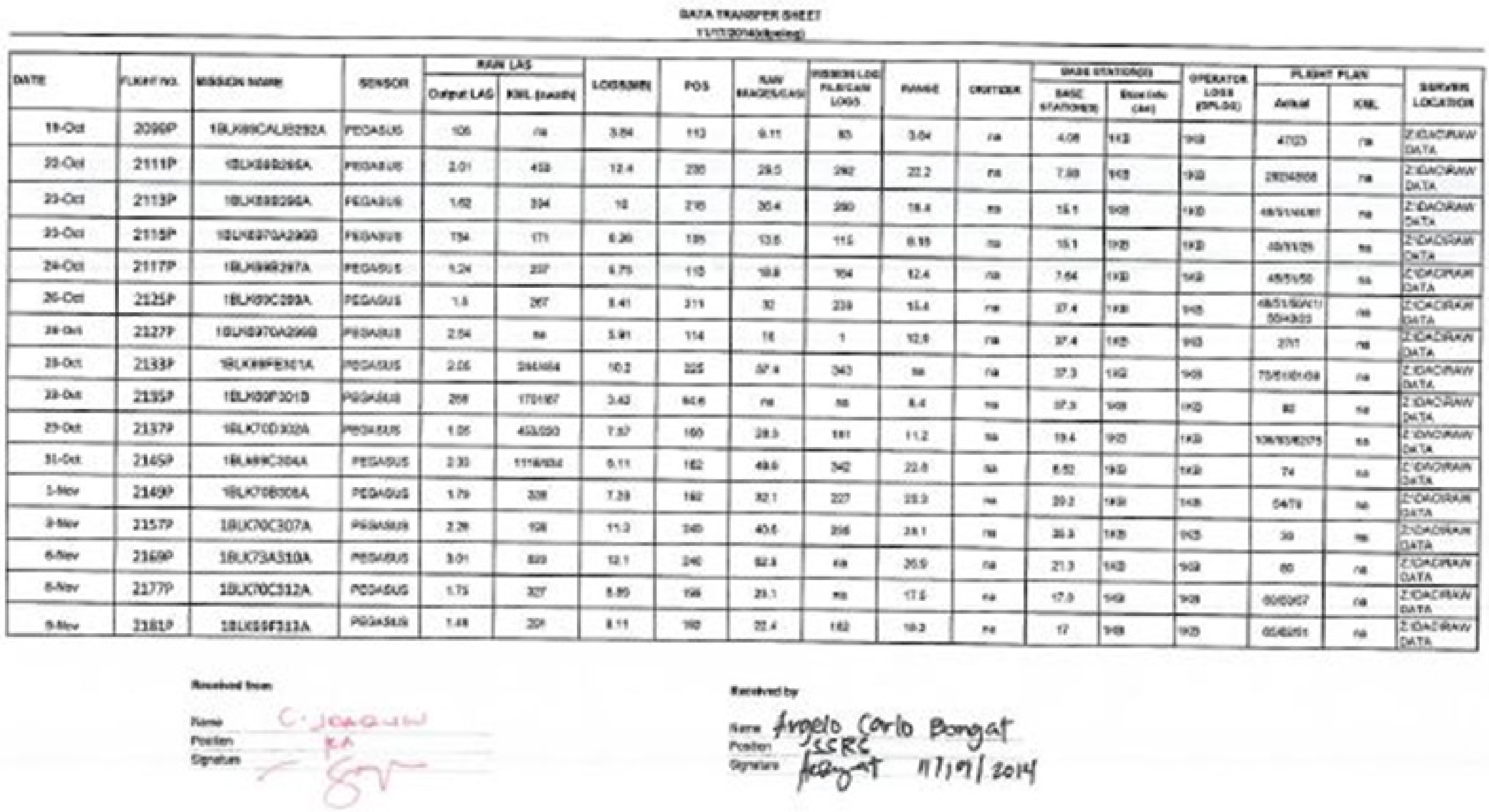
Table A-4.1. The LiDAR Survey Team Composition

| 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 SARMIENTO | UP-TCAGP |
| Survey Supervisor | Chief Science Research Specialist (CSRS) | ENGR. CHRISTOPHER CRUZ | UP-TCAGP |
| | Supervising Science Research Specialist (Supervising SRS) | LOVELY GRACIA ACUñA | UP-TCAGP |
| | | LOVELYN ASUNCION | UP-TCAGP |

FIELD TEAM

| | | | |
|---|---|---|---|
| LiDAR Operation | Senior Science Research Specialist (SSRS) | JASMINE ALVIAR | UP-TCAGP |
| | SSRS | PAULINE JOANNE ARCEO | UP-TCAGP |
| | Research Associate (RA) | ENGR. RENAN PUNTO | UP-TCAGP |
| | RA | ENGR. IRO NIEL ROXAS | UP-TCAGP |
| | RA | KRISTINE JOY ANDAYA | UP-TCAGP |
| | RA | ENGR. KENNETH QUISADO | UP-TCAGP |
| | RA | ENGR. GRACE SINADJAN | UP-TCAGP |
| | RA | JONATHAN ALMALVEZ | UP-TCAGP |
| | RA | FRANK NICOLAS ILEJAY | UP-TCAGP |
| Ground Survey, Data Download and Transfer | RA | JASMIN DOMINGO | UP-TCAGP |
| | RA | MERLIN FERNANDO | UP-TCAGP |

# Annex 5. Data Transfer Sheet For Dipolog Floodplain



DATA TRANSFER SHEET
11/17/2014(dipolog)

| 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 | |
| 19-Oct | 2096P | 1BLK89CALS292A | PEGASUS | 106 | na | 3.84 | 113 | 6.11 | 85 | 3.04 | na | 4.08 | 1KB | 1KB | 4723 | na | Z:\DAC\RAW DATA |
| 20-Oct | 2111P | 1BLK88S295A | PEGASUS | 2.01 | 459 | 12.4 | 230 | 28.5 | 292 | 22.2 | na | 7.88 | 1KB | 1KB | 28/24/508 | na | Z:\DAC\RAW DATA |
| 22-Oct | 2113P | 1BLK88S296A | PEGASUS | 1.62 | 394 | 10 | 216 | 30.4 | 280 | 18.4 | na | 15.1 | 1KB | 1KB | 48/51/46/47 | na | Z:\DAC\RAW DATA |
| 23-Oct | 2115P | 1BLK8970A296B | PEGASUS | 734 | 171 | 6.26 | 185 | 13.6 | 116 | 8.55 | na | 15.1 | 1KB | 1KB | 48/51/25 | na | Z:\DAC\RAW DATA |
| 24-Oct | 2117P | 1BLK89R297A | PEGASUS | 1.24 | 237 | 6.75 | 115 | 18.8 | 164 | 12.4 | na | 7.64 | 1KB | 1KB | 48/51/50 | na | Z:\DAC\RAW DATA |
| 26-Oct | 2125P | 1BLK89C299A | PEGASUS | 1.6 | 287 | 8.41 | 211 | 32 | 239 | 15.4 | na | 37.4 | 1KB | 1KB | 48/51/50/41/50/43/33 | na | Z:\DAC\RAW DATA |
| 28-Oct | 2127P | 1BLK8970A299B | PEGASUS | 2.54 | na | 5.91 | 114 | 16 | 1 | 12.8 | na | 37.4 | 1KB | 1KB | 27/1 | na | Z:\DAC\RAW DATA |
| 28-Oct | 2133P | 1BLK89PE301A | PEGASUS | 2.06 | 384/404 | 10.2 | 225 | 37.4 | 343 | 56 | na | 37.3 | 1KB | 1KB | 75/51/01/04 | na | Z:\DAC\RAW DATA |
| 28-Oct | 2135P | 1BLK80F301B | PEGASUS | 268 | 170/167 | 3.42 | 64.6 | na | 56 | 8.4 | na | 37.3 | 1KB | 1KB | 82 | na | Z:\DAC\RAW DATA |
| 29-Oct | 2137P | 1BLK70D302A | PEGASUS | 1.05 | 453/200 | 7.87 | 160 | 28.3 | 181 | 11.2 | na | 19.4 | 1KB | 1KB | 106/93/82/75 | na | Z:\DAC\RAW DATA |
| 31-Oct | 2145P | 1BLK69C304A | PEGASUS | 2.33 | 1116/934 | 5.11 | 162 | 48.6 | 342 | 22.8 | na | 8.52 | 1KB | 1KB | 74 | na | Z:\DAC\RAW DATA |
| 1-Nov | 2149P | 1BLK70B305A | PEGASUS | 1.79 | 338 | 7.28 | 162 | 32.1 | 227 | 23.3 | na | 20.2 | 1KB | 1KB | 54/79 | na | Z:\DAC\RAW DATA |
| 3-Nov | 2157P | 1BLK70C307A | PEGASUS | 2.28 | 108 | 11.3 | 340 | 40.6 | 356 | 28.1 | na | 26.5 | 1KB | 1KB | 39 | na | Z:\DAC\RAW DATA |
| 6-Nov | 2169P | 1BLK73A310A | PEGASUS | 3.01 | 820 | 12.1 | 246 | 62.6 | na | 26.9 | na | 21.3 | 1KB | 1KB | 60 | na | Z:\DAC\RAW DATA |
| 8-Nov | 2177P | 1BLK70C312A | PEGASUS | 1.75 | 327 | 8.85 | 196 | 23.1 | na | 17.6 | na | 17.3 | 1KB | 1KB | 60/60/67 | na | Z:\DAC\RAW DATA |
| 9-Nov | 2181P | 1BLK69F313A | PEGASUS | 1.48 | 229 | 8.11 | 182 | 22.4 | 162 | 19.3 | na | 17 | 1KB | 1KB | 65/62/51 | na | Z:\DAC\RAW DATA |

Received from
Name: C. JOAQUIN
Position: RA
Signature

Received by
Name: Angelo Carlo Bongat
Position: SSRS
Signature: 11/19/2014

Figure A-5.1. Transfer Sheet for Dipolog Floodplain - A

DATA TRANSFER SHEET
ZAMBOANGA 7/11/2016

| DATE | FLIGHT NO. | MISSION NAME | SENSOR | RAW LAS | | LOGS | 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 | |
| May 25, 2016 | 23390P | 1BLK75BS146A | PEGASUS | 518 | NA | 4.08 | 91 | NA | NA | 5.63 | NA | 95.8 | 1KB | NA | 53 | NA | Z:\DAC\RAW DATA |
| May 26, 2016 | 23392P | 1BLK75FG147A | PEGASUS | 2.28 | NA | 11 | 253 | NA | NA | 24.7 | NA | 133 | 1KB | NA | 89 | NA | Z:\DAC\RAW DATA |
| May 26, 2016 | 23394P | 1BLK75AS147B | PEGASUS | 506 | NA | 3.37 | 101 | NA | NA | 5.13 | NA | 133 | 1KB | NA | NA | NA | Z:\DAC\RAW DATA |
| May 27, 2016 | 23398P | 1BLK75CSDE148B | PEGASUS | 2.09 | NA | 11.6 | 281 | 30 | 274 | 22.6 | NA | 153 | 1KB | NA | NA | NA | Z:\DAC\RAW DATA |
| May 30, 2016 | 23408P | 1BLK75HI151A | PEGASUS | 546 | NA | 6.09 | 173 | 8.73 | 69 | 7.88 | NA | 171 | 1KB | NA | NA | NA | Z:\DAC\RAW DATA |
| May 30, 2016 | 23410P | 1BLK75CS151B | PEGASUS | 1.1 | NA | 6.75 | 192 | 15.3 | 139 | 12.6 | NA | 171 | 1KB | NA | NA | NA | Z:\DAC\RAW DATA |

Received from

Name R. Punto
Position RA
Signature

Received by

Name AC Bongat
Position SSRS
Signature 7/14/16

Figure A-5.2. Transfer Sheet for Dipolog Floodplain - B

DATA TRANSFER SHEET
DIPOLOG 12/8/2016

| DATE | FLIGHT NO. | MISSION NAME | SENSOR | RAW LAS | | LOGS | 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 | |
| November 28, 2016 | 23590P | 1BLK73DEF333A | PEGASUS | 1.56 | NA | 7.69 | 203 | 32.6 | 298 | 16.6 | NA | 42.3 | 1KB | 1KB | 1.19 | NA | Z:\DAC\RAW DATA |
| November 30, 2016 | 23598P | 1BLK76A335A | PEGASUS | 600 | NA | 6.93 | 239 | NA | NA | 7.85 | NA | 48.2 | 1KB | 1KB | 2.14 | NA | Z:\DAC\RAW DATA |
| December 01, 2016 | 23602P | 1BLK76AB336A | PEGASUS | 1.56 | NA | 9.08 | 287 | NA | NA | 16.5 | NA | 53.9 | 1KB | 1KB | 2.14 | NA | Z:\DAC\RAW DATA |

Received from
Name: R. PUNTO
Position: RA
Signature: [signature]

Received by
Name: AC Bongat
Position: SSRS
Signature: [signature] 12/8/16

Figure A-5.3. Transfer Sheet for Dipolog Floodplain - C

# Annex 6. Flight Logs

Flight Log for 2111P Mission

**PHIL-LiDAR 1 Data Acquisition Flight Log**

Flight Log No.: 2111P

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: G. SINADJAN | 2 ALTM Model: PEGASUS | 3 Mission Name: 1BLK61B 295A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9022 |
| 7 Pilot: B. DONGUINES | 8 Co-Pilot: F. DE OCAMPO | 9 Route: | | | |
| 10 Date: OCT. 22, 2014 | 12 Airport of Departure (Airport, City/Province): DIPOLOG | | 12 Airport of Arrival (Airport, City/Province): DIPOLOG | | |
| 13 Engine On: 11:17 | 14 Engine Off: 3:22 | 15 Total Engine Time: 4 HRS 5 MINS | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: CLOUDY | | | | | |
| 20 Remarks: SUCCESSFUL FLIGHT. | | | | | |

21 Problems and Solutions:

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | FERDINAND DE OCAMPO<br>Signature over Printed Name | Signature over Printed Name |

Figure A-6.1. Flight Log for 2111P Mission

Flight Log for 2113P Mission

**PHIL-LIDAR 1 Data Acquisition Flight Log**

Flight Log No.: 2113P

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: I. ROXAS | 2 ALTM Model: PEGASUS | 3 Mission Name: 1BLK 61D 296A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9022 |
| 7 Pilot: B. DONGUINES | 8 Co-Pilot: E. DE OCAMPO | 9 Route: | | | |
| 10 Date: OCT. 23, 2014 | 12 Airport of Departure (Airport, City/Province): DIPOLOG | | 12 Airport of Arrival (Airport, City/Province): DIPOLOG | | |
| 13 Engine On: 8:02 | 14 Engine Off: 11:37 | 15 Total Engine Time: 3 HRS, 35 MINS | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: VERY CLOUDY | | | | | |
| 20 Remarks: SUCCESSFUL FLIGHT. | | | | | |

| |
|---|
| 21 Problems and Solutions: |

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | FERDINAND B. DE OCAMPO Signature over Printed Name | Signature over Printed Name |

Figure A-6.2. Flight Log for 2113P Mission

Flight Log for 2117P Mission

**PHIL-LiDAR 1 Data Acquisition Flight Log** — Flight Log No.: 2117P

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: I. ROXAS | 2 ALTM Model: PEGASUS | 3 Mission Name: 1BLK69B217A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9099 |
| 7 Pilot: B. DONGUINES | 8 Co-Pilot: F. DE OCAMPO | 9 Route: | | | |
| 10 Date: OCT. 24, 2014 | 12 Airport of Departure (Airport, City/Province): DIPOLOG | | 12 Airport of Arrival (Airport, City/Province): DIPOLOG | | |
| 13 Engine On: 2:57 | 14 Engine Off: 5:02 | 15 Total Engine Time: 2 HRS 5 MINS | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: VERY CLOUDY | | | | | |

20 Remarks:

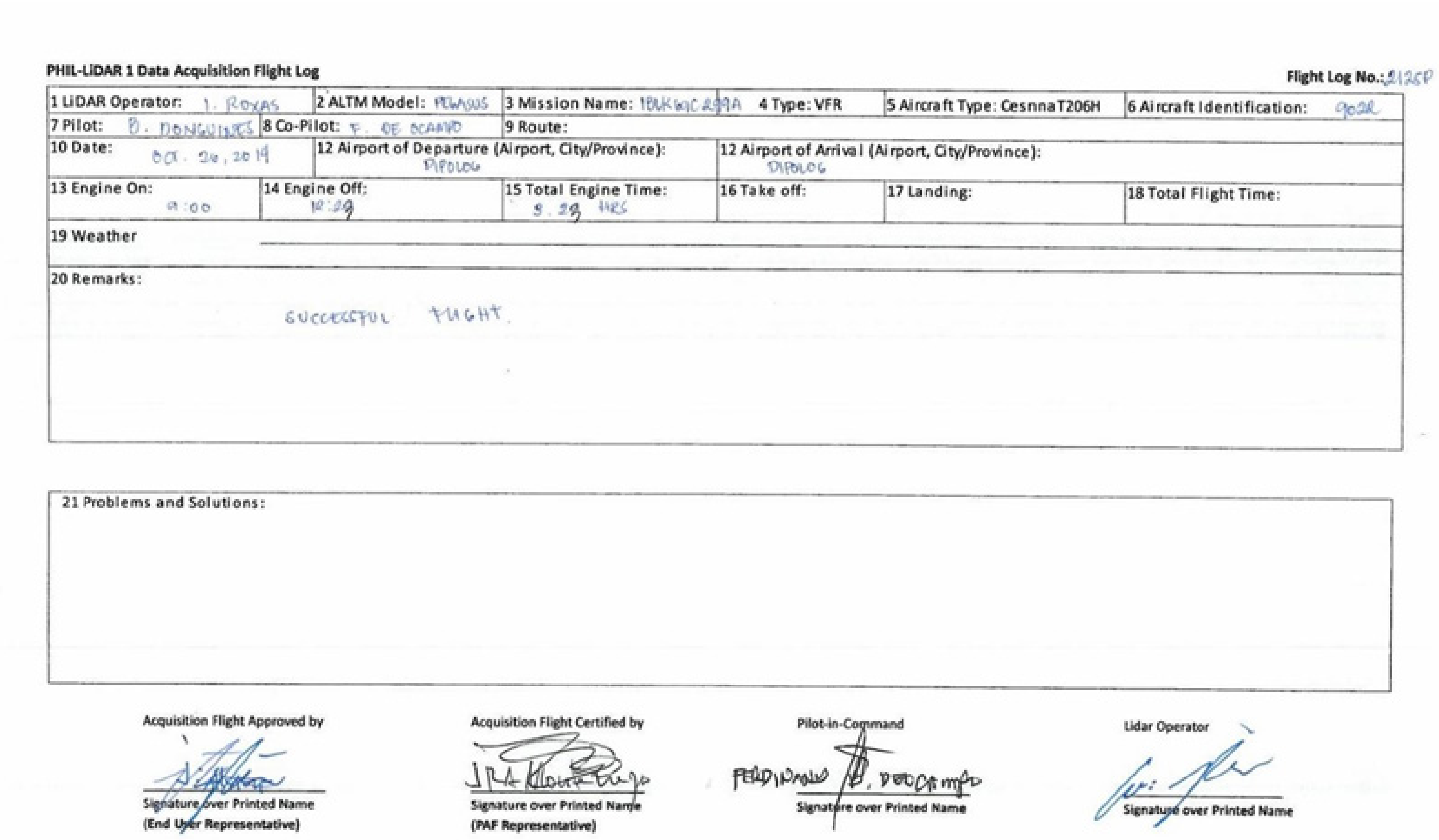
SUCCESSFUL FLIGHT.

21 Problems and Solutions:

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| J. Alcazar | J R A Monteverde | FERDINAND B. DE OCAMPO | |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name |

Figure A-6.3. Flight Log for 2117P Mission

Flight Log for 2125P Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 2125P

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: I. Roxas | 2 ALTM Model: Pegasus | 3 Mission Name: 1BLK60C299A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9022 |
| 7 Pilot: B. Dongui... | 8 Co-Pilot: F. De Ocampo | 9 Route: | | | |
| 10 Date: Oct. 26, 2014 | 12 Airport of Departure (Airport, City/Province): Dipolog | | 12 Airport of Arrival (Airport, City/Province): Dipolog | | |
| 13 Engine On: 9:00 | 14 Engine Off: 18:29 | 15 Total Engine Time: 9.29 hrs | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |
| 20 Remarks: Successful flight. | | | | | |

21 Problems and Solutions:

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

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

Pilot-in-Command: Ferdinand B. De Ocampo — Signature over Printed Name

Lidar Operator: Signature over Printed Name

Figure A-6.4. Flight Log for 2125P Mission

5. Flight Log for 2127P Mission

**PHIL-LiDAR 1 Data Acquisition Flight Log** — Flight Log No.: 2127P

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: K. PUNTO | 2 ALTM Model: PEGASUS | 3 Mission Name: 1BLK 67D A299B | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9022 |
| 7 Pilot: B. DONGUINES | 8 Co-Pilot: F. DE OCAMPO | 9 Route: | | | |
| 10 Date: OCT. 20, 2014 | 12 Airport of Departure (Airport, City/Province): DIPOLOG | | 12 Airport of Arrival (Airport, City/Province): DIPOLOG | | |
| 13 Engine On: 2:08 | 14 Engine Off: 4:53 | 15 Total Engine Time: 2:45 HRS | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |
| 20 Remarks: SUCCESSFUL FLIGHT | | | | | |

21 Problems and Solutions:

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

Figure A-6.5. Flight Log for 2127P Mission

6. Flight Log for 2145P Mission

**PHIL-LIDAR 1 Data Acquisition Flight Log** — **Flight Log No.:** 2141P

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: S. Alviar | 2 ALTM Model: Pegasus | 3 Mission Name: 1BLK69C304A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9022 |
| 7 Pilot: B. Dongguines | 8 Co-Pilot: F. Delocamp | 9 Route: | | | |
| 10 Date: Oct. 31, 2014 | 12 Airport of Departure (Airport, City/Province): Dipolog | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 8:41 | 14 Engine Off: 11:58 | 15 Total Engine Time: | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | very cloudy | | | | |
| 20 Remarks: | Successful flight. | | | | |

21 Problems and Solutions:

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| J. Alviar | JRA [signature] | Ferdinand B. Delocamp | J. Alviar |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name |

Figure A-6.6. Flight Log for 2145P Mission

7. Flight Log for 2149P Mission

**PHIL-LiDAR 1 Data Acquisition Flight Log**

**Flight Log No.:** 2149P

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: J. Alviar | 2 ALTM Model: Pegasus | 3 Mission Name: 1BLK70B&A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9022 |
| 7 Pilot: B. Donguines | 8 Co-Pilot: F. De Ocampo | 9 Route: | | | |
| 10 Date: Nov. 1, 2014 | 12 Airport of Departure (Airport, City/Province): Dipolog | | 12 Airport of Arrival (Airport, City/Province): Dipolog | | |
| 13 Engine On: 10:18 | 14 Engine Off: 13:41 | 15 Total Engine Time: | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: Cloudy | | | | | |
| 20 Remarks: Successful flight. | | | | | |

| |
|---|
| 21 Problems and Solutions: |

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Ferdinand B. De Ocampo<br>Signature over Printed Name | Signature over Printed Name |

Figure A-6.7. Flight Log for 2149P Mission

8. Flight Log for 2177P Mission

**PHIL-LiDAR 1 Data Acquisition Flight Log** Flight Log No.: 2177P

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: I. ROXAS | 2 ALTM Model: PEGASUS | 3 Mission Name: 1BLK70C312A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9022 |
| 7 Pilot: B. DONGUINES | 8 Co-Pilot: F. DE OCAMPO | 9 Route: | | | |
| 10 Date: NOV. 8, 2014 | 12 Airport of Departure (Airport, City/Province): DIPOLOG | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 13:04 | 14 Engine Off: 16:33 | 15 Total Engine Time: | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: Cloudy | | | | | |
| 20 Remarks: SUCCESSFUL FLIGHT. | | | | | |

21 Problems and Solutions:

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

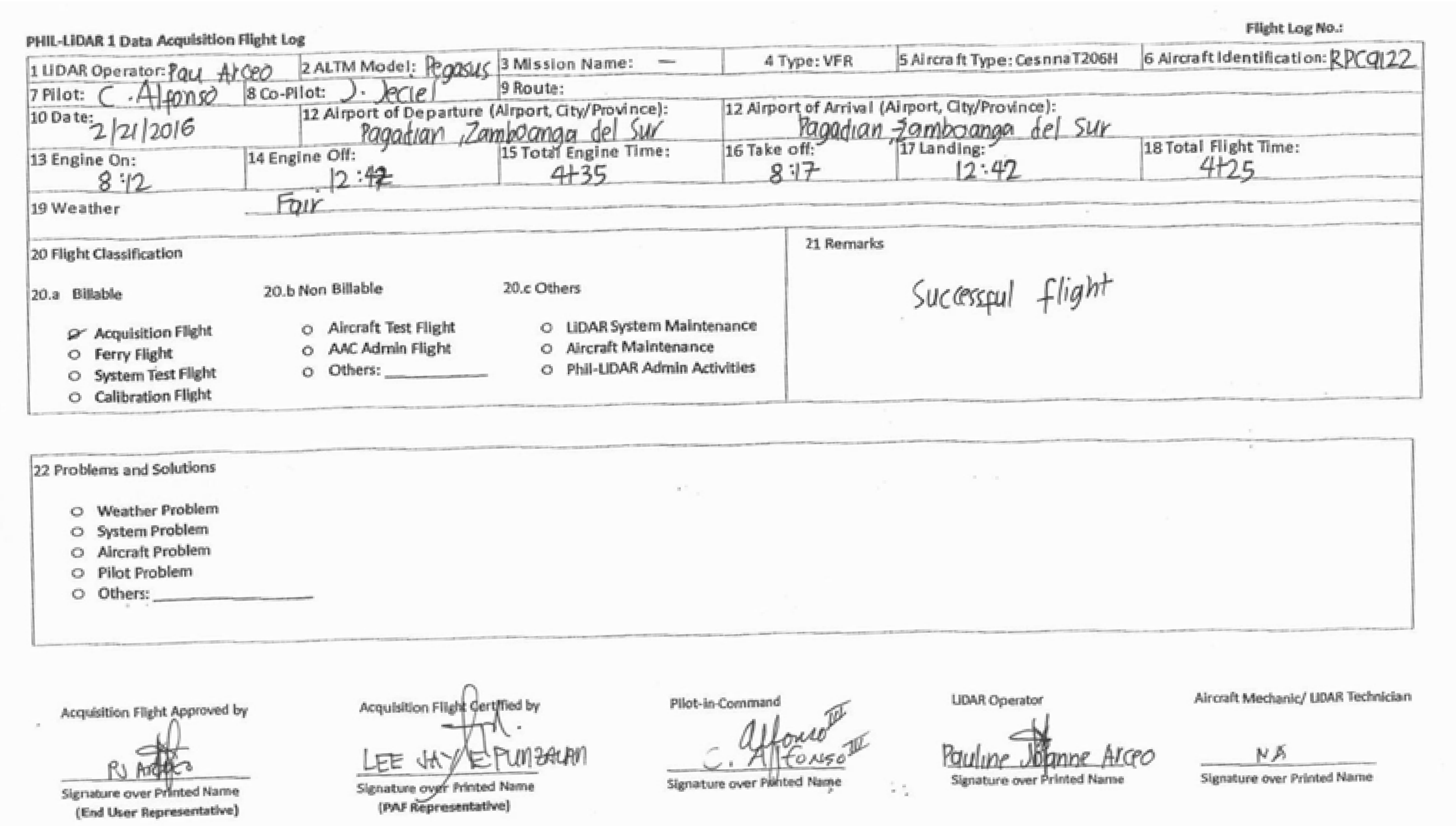
Acquisition Flight Certified by: JRA [signature] — Signature over Printed Name (PAF Representative)

Pilot-in-Command: PERLO [signature] — Signature over Printed Name

Lidar Operator: I. ROXAS — Signature over Printed Name

Figure A-6.8. Flight Log for 2177P Mission

9. Flight Log for 23120P Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.:

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: Pau Arceo | 2 ALTM Model: Pegasus | 3 Mission Name: — | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: RPC9122 |
| 7 Pilot: C. Alfonso | 8 Co-Pilot: J. Jeciel | 9 Route: | | | |
| 10 Date: 2/21/2016 | 12 Airport of Departure (Airport, City/Province): Pagadian, Zamboanga del Sur | | 12 Airport of Arrival (Airport, City/Province): Pagadian, Zamboanga del Sur | | |
| 13 Engine On: 8:12 | 14 Engine Off: 12:47 | 15 Total Engine Time: 4+35 | 16 Take off: 8:17 | 17 Landing: 12:42 | 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

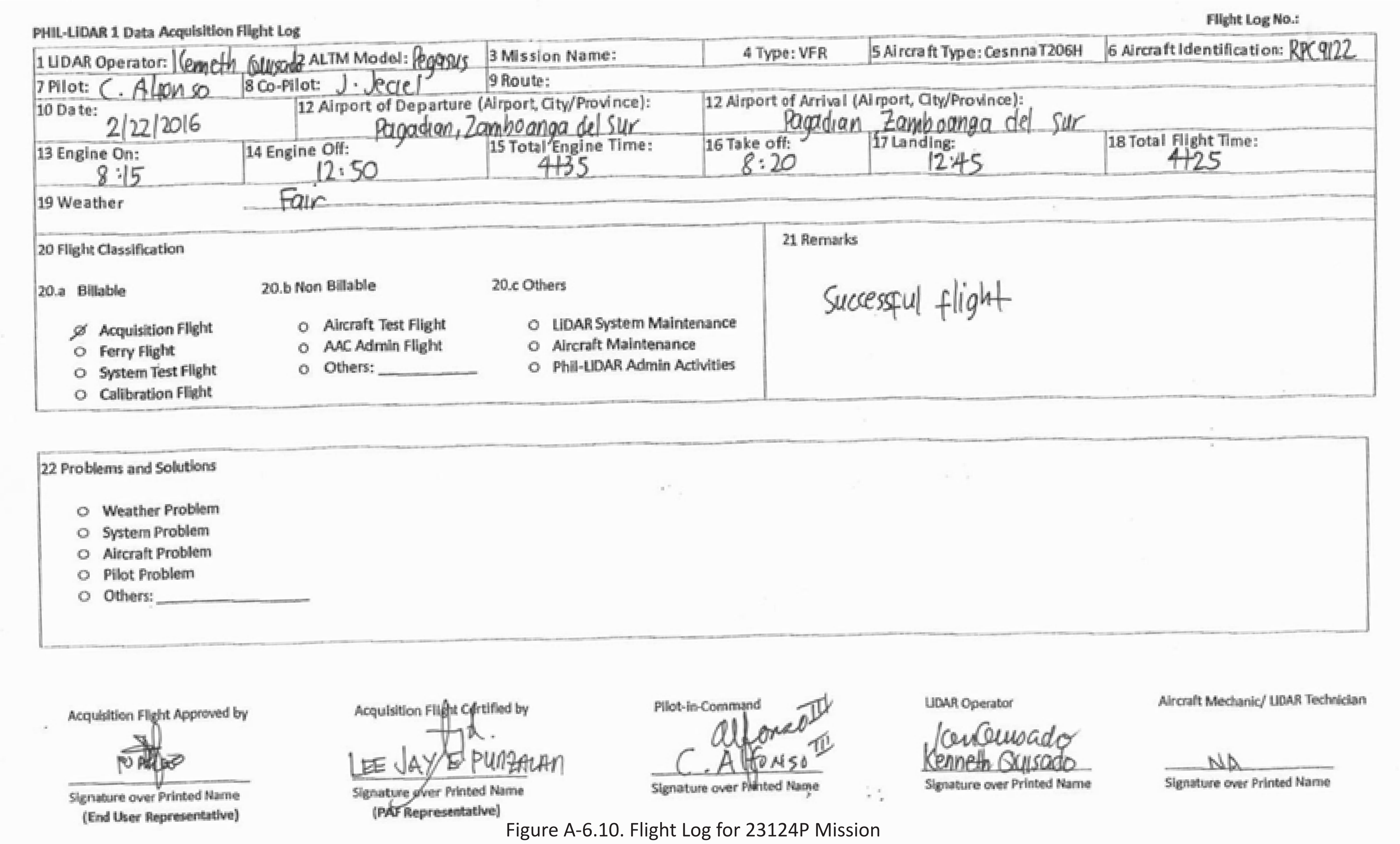
Successful flight

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 |
|---|---|---|---|---|
| RJ Andres | LEE JAY E. PUNZALAN | C. Alfonso III | Pauline Joanne Arceo | 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-6.9. Flight Log for 23120P Mission

10. Flight Log for 23124P Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.:

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: Kenneth Quisado | 2 ALTM Model: Pegasus | 3 Mission Name: | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RPC9122 |
| 7 Pilot: C. Alonso | 8 Co-Pilot: J. Jecel | 9 Route: | | | |
| 10 Date: 2/22/2016 | 12 Airport of Departure (Airport, City/Province): Pagadian, Zamboanga del Sur | | 12 Airport of Arrival (Airport, City/Province): Pagadian Zamboanga del Sur | | |
| 13 Engine On: 8:15 | 14 Engine Off: 12:50 | 15 Total Engine Time: 4+35 | 16 Take off: 8:20 | 17 Landing: 12:45 | 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

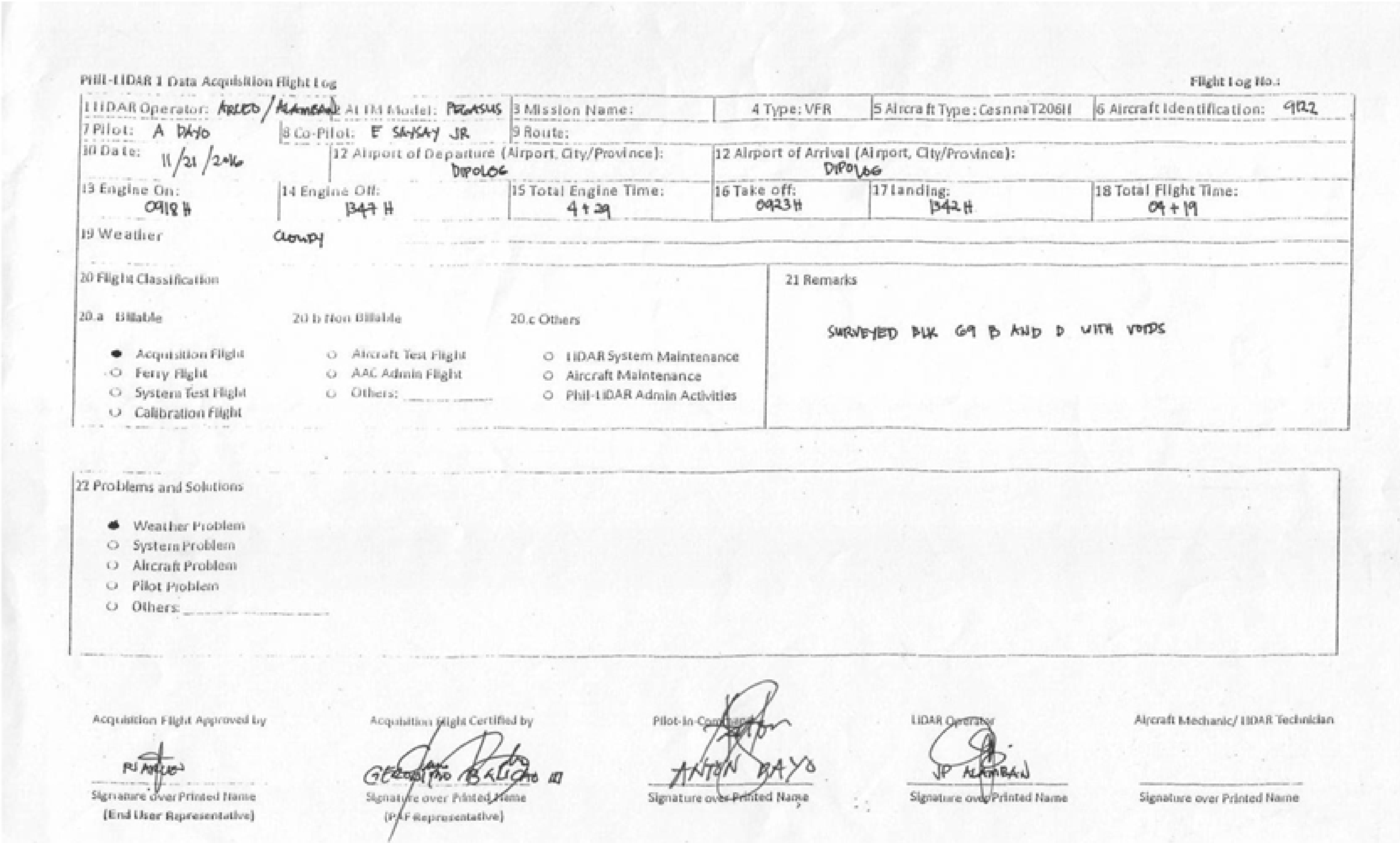
Successful flight

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 |
|---|---|---|---|---|
| [signature] | LEE JAY E PUNZALAN | C. ALFONSO III | Kenneth Quisado | 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-6.10. Flight Log for 23124P Mission

11. Flight Log for 23558P Mission



PHIL-LIDAR 1 Data Acquisition Flight Log — Flight Log No.:

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: ARCEO / ALAMBAN | 2 ALTM Model: PEGASUS | 3 Mission Name: | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9122 |
| 7 Pilot: A BAYO | 8 Co-Pilot: E SAYSAY JR | 9 Route: | | | |
| 10 Date: 11/21/2016 | 12 Airport of Departure (Airport, City/Province): DIPOLOG | | 12 Airport of Arrival (Airport, City/Province): DIPOLOG | | |
| 13 Engine On: 0918 H | 14 Engine Off: 1347 H | 15 Total Engine Time: 4 + 29 | 16 Take off: 0923 H | 17 Landing: 1342 H | 18 Total Flight Time: 04 + 19 |
| 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

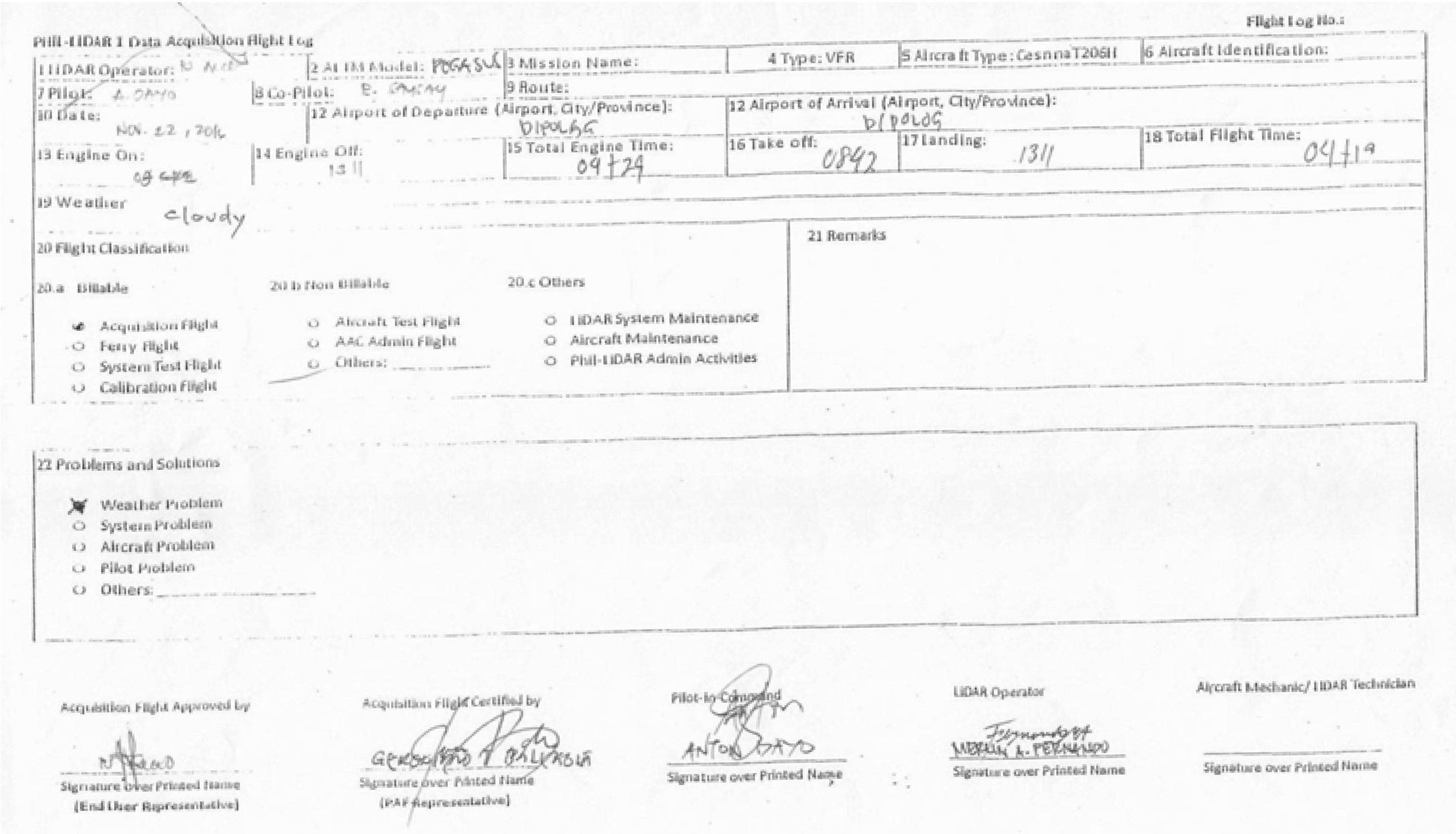
SURVEYED BLK G9 B AND D WITH VOIDS

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

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | LIDAR Operator | Aircraft Mechanic/ LIDAR Technician |
|---|---|---|---|---|
| RJ MALIG | GEROSITHO BALIGAO III | ANTON BAYO | JP ALAMBAN | |
| 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 23558P Mission

12. Flight Log for 23562P Mission



Flight Log No.:

PHIL-LIDAR 1 Data Acquisition Flight Log

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: N. NEO | 2 ALTM Model: PEGASUS | 3 Mission Name: | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: |
| 7 Pilot: A. OAYO | 8 Co-Pilot: B. GAMAY | 9 Route: | | | |
| 10 Date: NOV. 22, 2016 | 12 Airport of Departure (Airport, City/Province): DIPOLOG | | 12 Airport of Arrival (Airport, City/Province): DIPOLOG | | |
| 13 Engine On: 0838 | 14 Engine Off: 1311 | 15 Total Engine Time: 04+29 | 16 Take off: 0842 | 17 Landing: 1311 | 18 Total Flight Time: 04+19 |
| 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

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 |
|---|---|---|---|---|
| N. ARACO | GERONIMO T. BALAGBIA | ANTON DAYO | NORMAN A. FERNANDO | |
| 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 23562P Mission

# Annex 7. Flight Status

FLIGHT STATUS REPORT
Zamboanga del Norte
October 22-November 31, 2014; February 21-22, 2016; November 21-22, 2016)

Table A-7.1. Flight Status

| FLIGHT NO | AREA | MISSION | OPERATOR | DATE FLOWN | REMARKS |
|---|---|---|---|---|---|
| 2111P | BLK 69B | 1BLK69B295A | G. Sinadjan | Oct. 22, 2014 | Surveyed BLK 69B, cloudy |
| 2113P | BLK 69B | 1BLK69B296A | I. Roxas | Oct. 23, 2014 | Surveyed BLK 69 B, still cloudy |
| 2117P | BLK 69ABC | 1BLK69B297A | R. Punto | Oct. 24, 2014 | Surveyed parts of BLK 69 A, B and C; images saved in Test folder |
| 2125P | BLK 69C | 1BLK69C299A | I. Roxas | Oct. 26, 2014 | Surveyed BLK 69C |
| 2127P | BLK 69A | 1BLK6970A299B | R. Punto | Oct. 26, 2014 | Surveyed BLK 69A |
| 2145P | BLK 69CB | 1BLk69C304A | J. Alviar | Oct. 31, 2014 | Surveyed BLk 69C, gaps in the middle due to clouds and terrain |
| 2149P | BLK 70AB and 69AS | 1BLK70B305A | J. Alviar | Nov.1 , 2014 | Surveyed BLK 70A and 70B, gaps due to clouds; covered gap in BLK 69A |
| 2177P | BLK 70BC | 1BLK70C312A | I. Roxas | Nov. 8, 2014 | Filled up gaps in BLK 70B&C |
| 23120P | BLK 69D | 1BLK69D052A | PJ Arceo | Feb. 21, 2016 | Encountered lost channel A. Completed BLK69D with voids due to cloud build up |
| 23124P | BLK 69A, 69B | 1BLK69AB053A | K Quisado | Feb. 22, 2016 | Encountered lost channel A error several times. Surveyed fps over Dipolog, Zamboanga del Norte with voids due to cloud build up throughout the duration of the survey |
| 23558P | DIPOLOG, PARO DAPITAN BLK 69B,69C | 1BLK69BC325A | PJ Arceo, G Soriano | Nov. 20, 2016 | Completed Dipolog and Paro Dapitan fp with voids due to build up and strong winds |
| 23562P | DIPOLOG, PARO DAPITAN BLK 69B, 69D | 1BLK69BD326A | PJ Arceo, JP Alamban | Nov. 21, 2016 | Completed BLK69B and surveyed 69D with voids due to cloud build up |

LAS/SWATH BOUNDARIES PER MISSION FLIGHT

| | |
|---|---|
| Flight No. : | 2111P |
| Area: | BLK 69B |
| Mission Name: | 1BLK69B295A |
| Parameters: | Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50 |

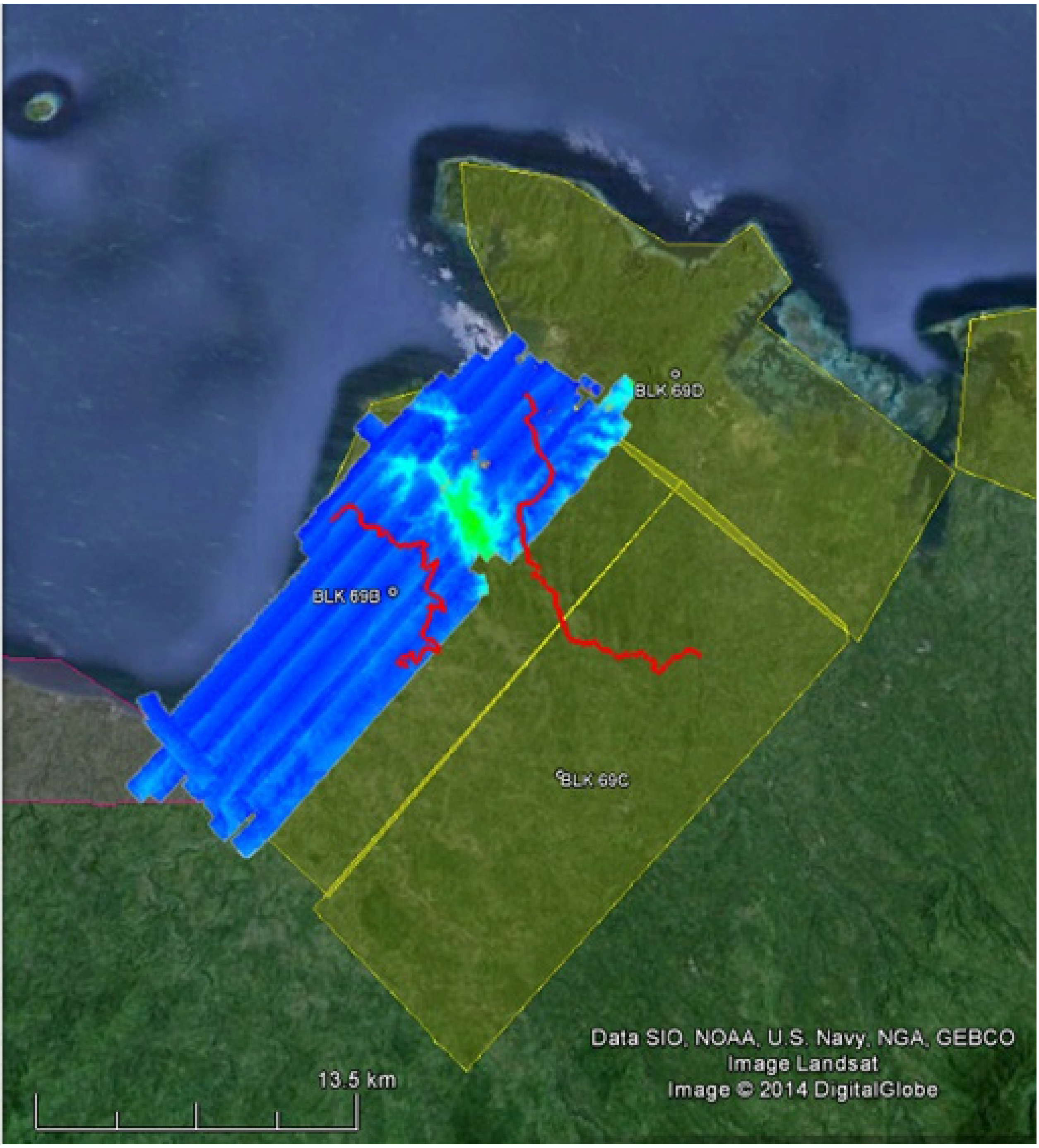



Figure A-7.1. Swath for Flight No. 2111P

| | |
|---|---|
| Flight No. : | 2113P |
| Area: | BLK 69ABD |
| Mission Name: | 1BLK69B296A |
| Parameters: | Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50 |

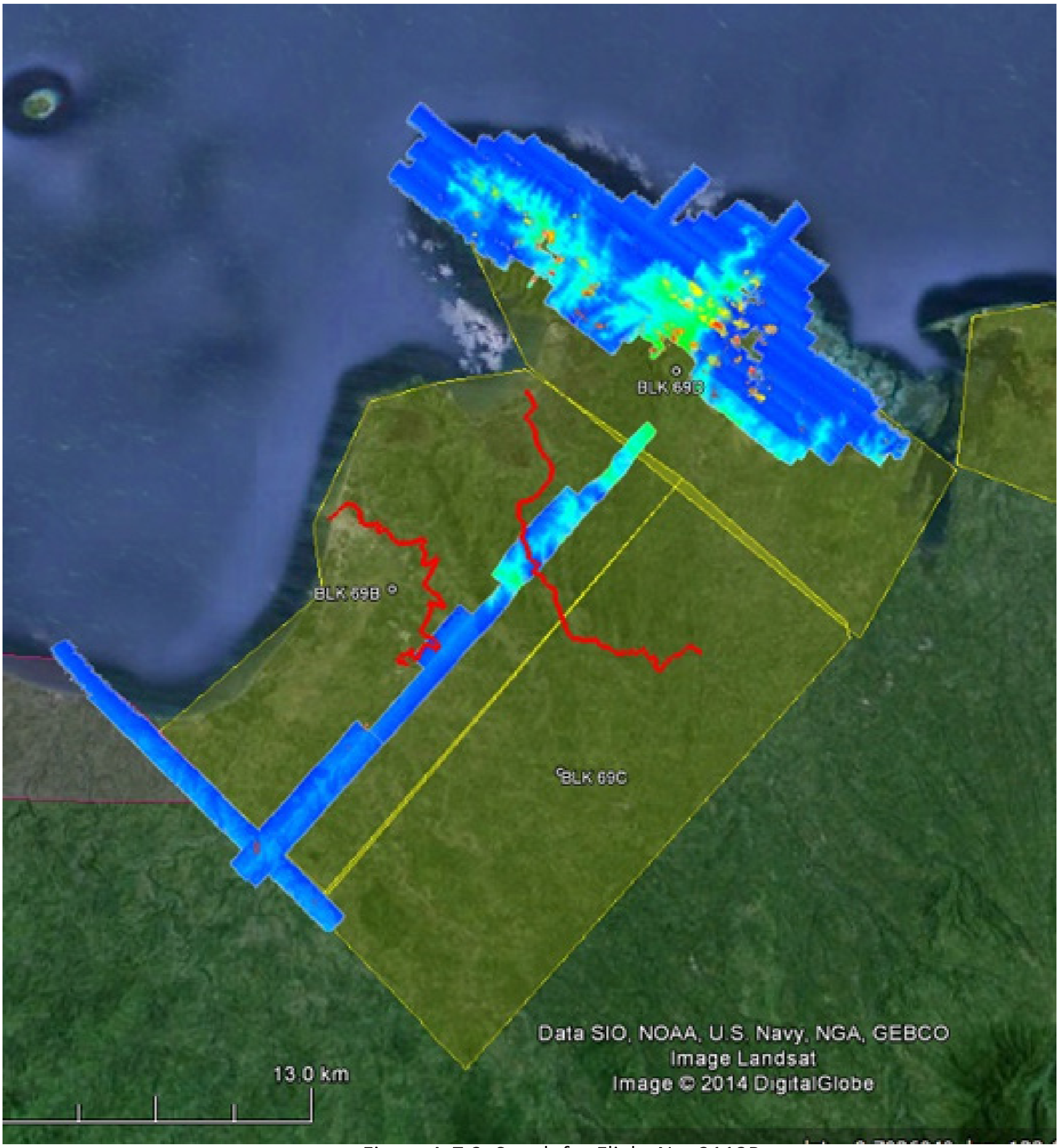



Figure A-7.2. Swath for Flight No. 2113P

| | |
|---|---|
| Flight No. : | 2117P |
| Area: | BLK 69ABC |
| Mission Name: | 1BLK69B297A |
| Parameters: | Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50 |

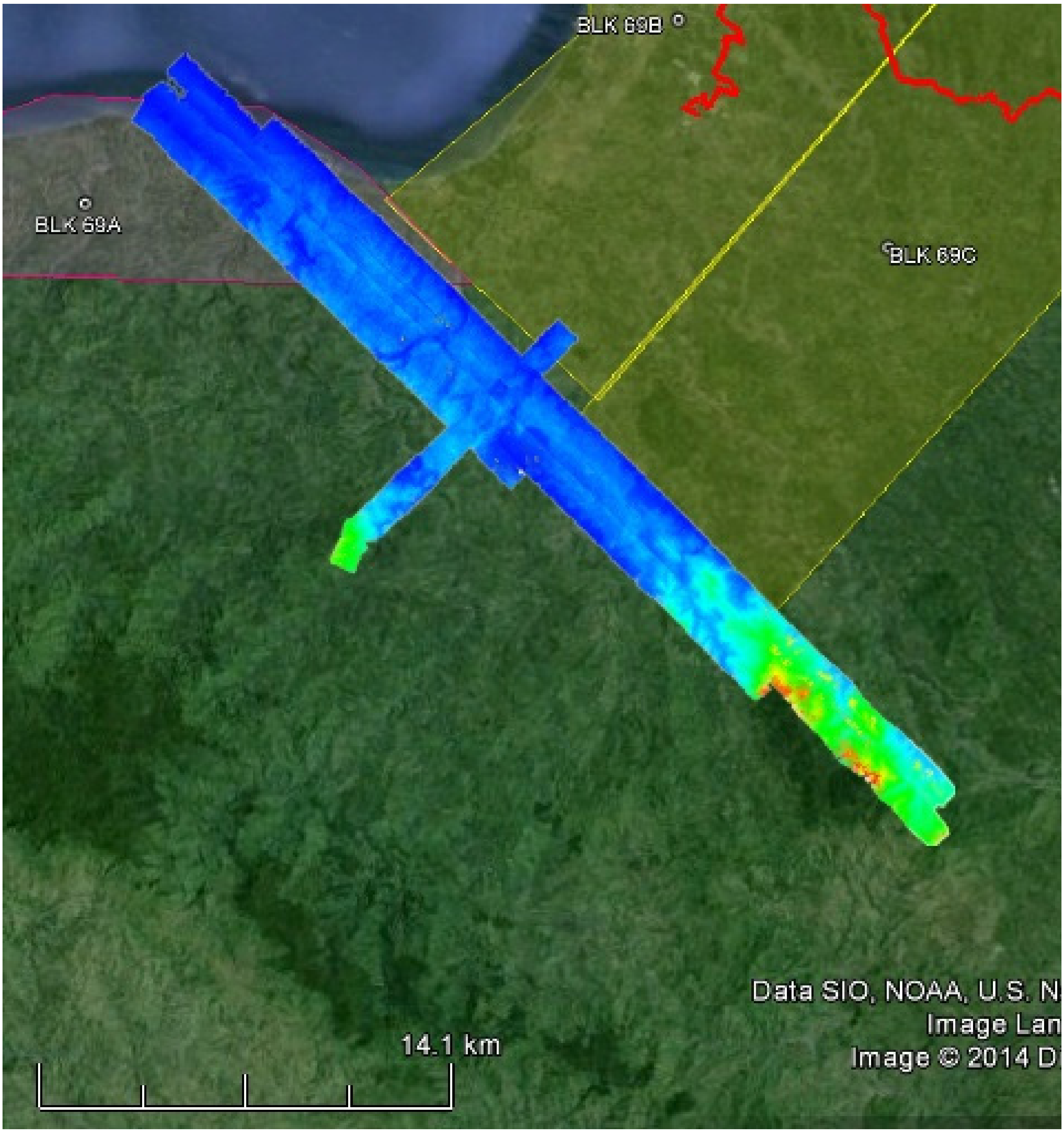


Figure A-7.3. Swath for Flight No. 2117P

| | |
|---|---|
| Flight No. : | 2125P |
| Area: | BLK 69C |
| Mission Name: | 1BLK69C299A |
| Parameters: | Altitude: 800m; Scan Frequency: 30; Scan Angle: 50 |

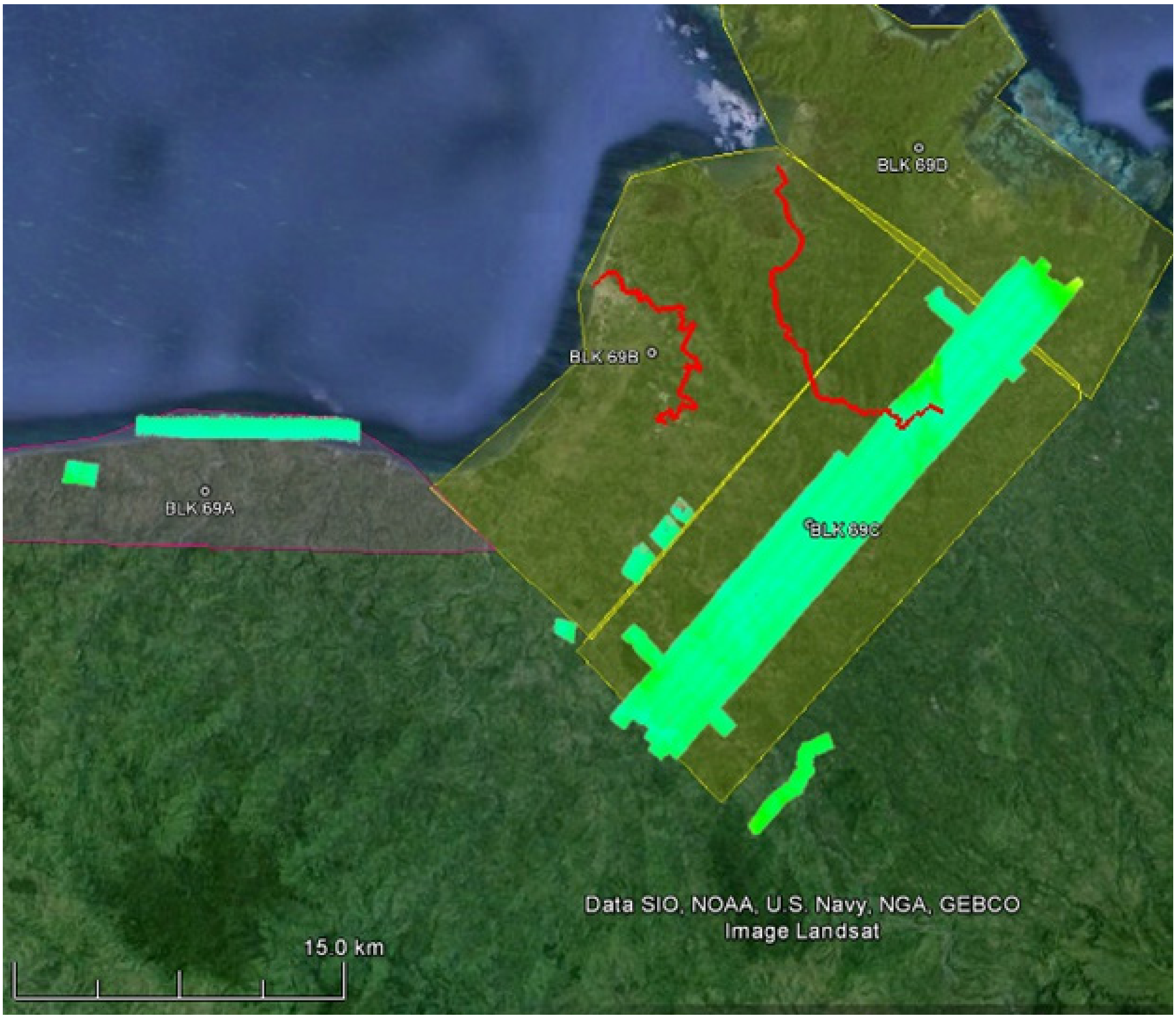



Figure A-7.4. Swath for Flight No. 2125P

| | |
|---|---|
| Flight No. : | 2127P |
| Area: | BLK 69C |
| Mission Name: | 1BLK69C299A |
| Parameters: | Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50 |

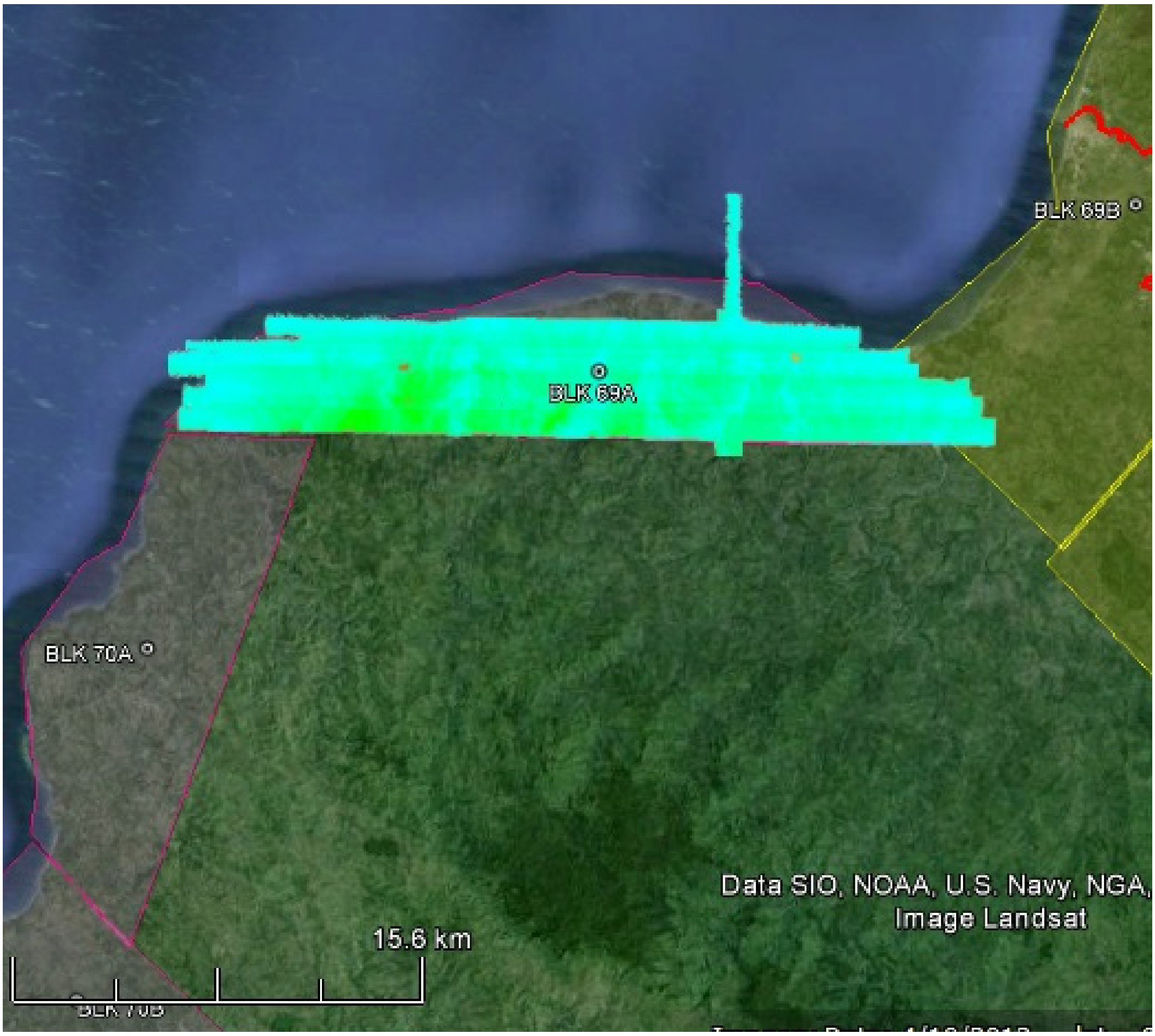



Figure A-7.5. Swath for Flight No. 2127P

| | |
|---|---|
| Flight No. : | 2145P |
| Area: | BLK 69CB |
| Mission Name: | 1BLK69304A |
| Parameters: | Altitude: 750m; Scan Frequency: 30; Scan Angle: 50 |

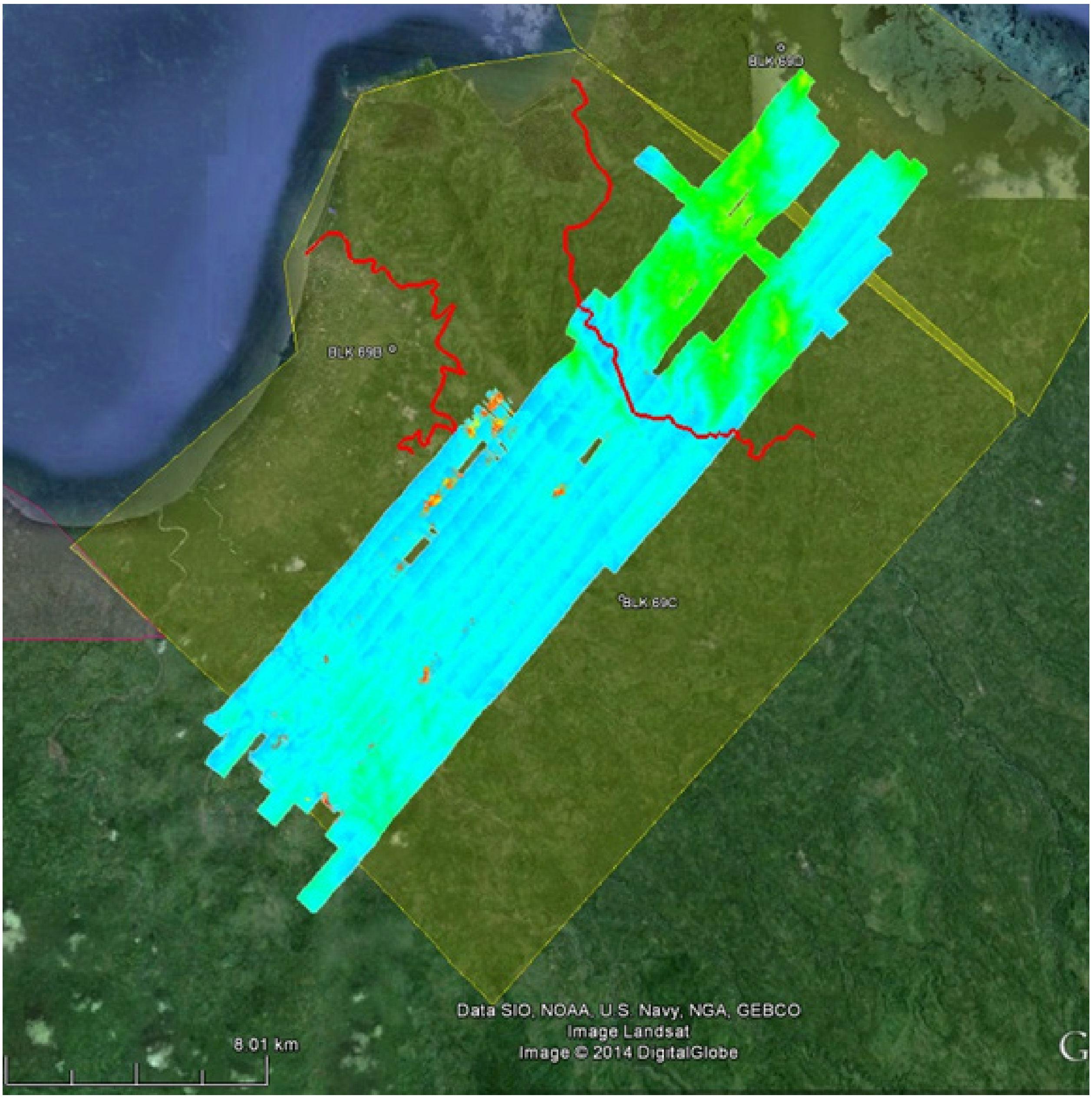



Figure A-7.6. Swath for Flight No. 2145P

| | |
|---|---|
| Flight No. : | 2149P |
| Area: | BLK 70AB, BLK 69AS |
| Mission Name: | 1BLK70B305A |
| Parameters: | Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50 |

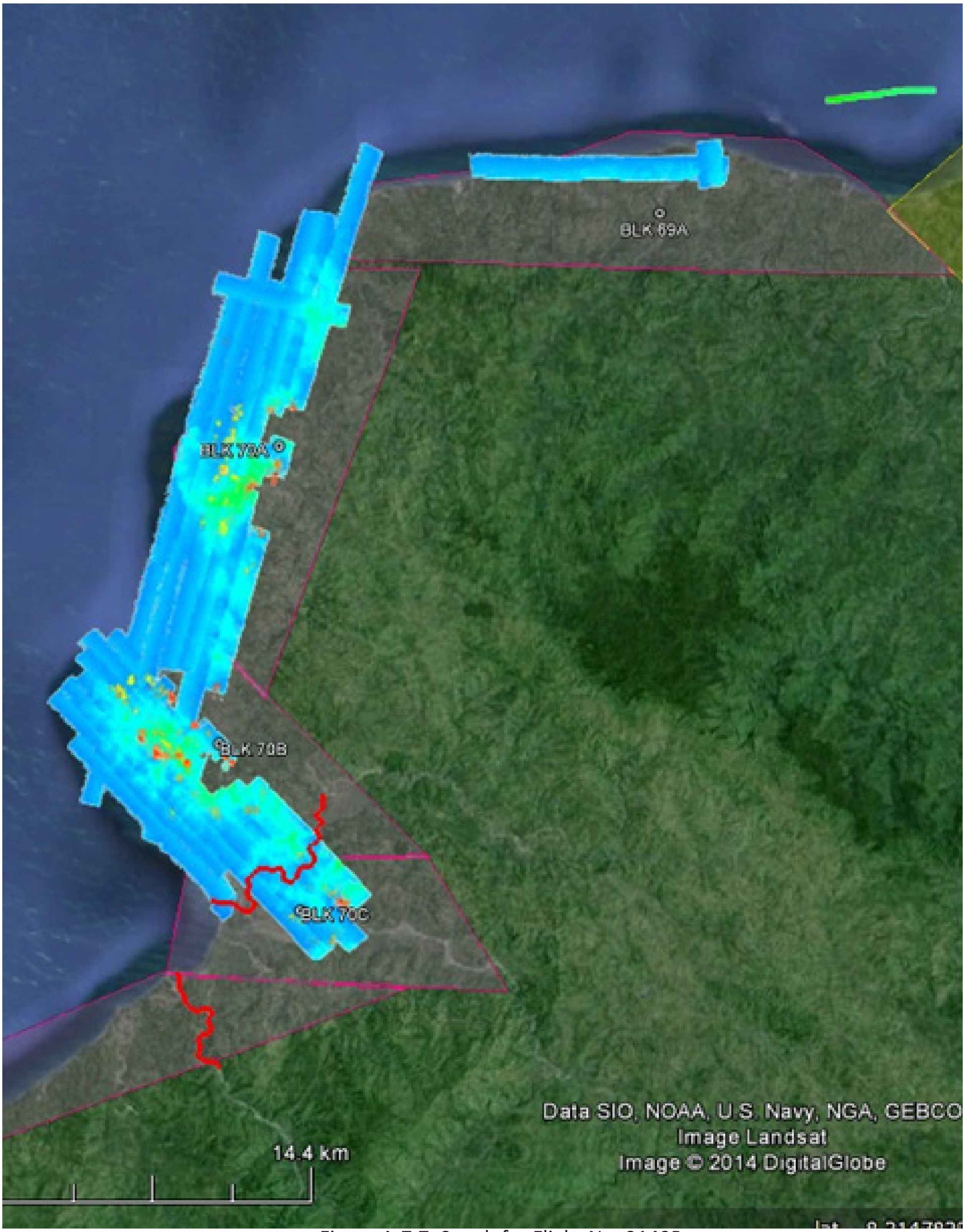



Figure A-7.7. Swath for Flight No. 2149P

| | |
|---|---|
| Flight No. : | 2177P |
| Area: | BLK 70BC |
| Mission Name: | 1BLK70C312A |
| Parameters: | Altitude: 850m; Scan Frequency: 30; Scan Angle: 50 |

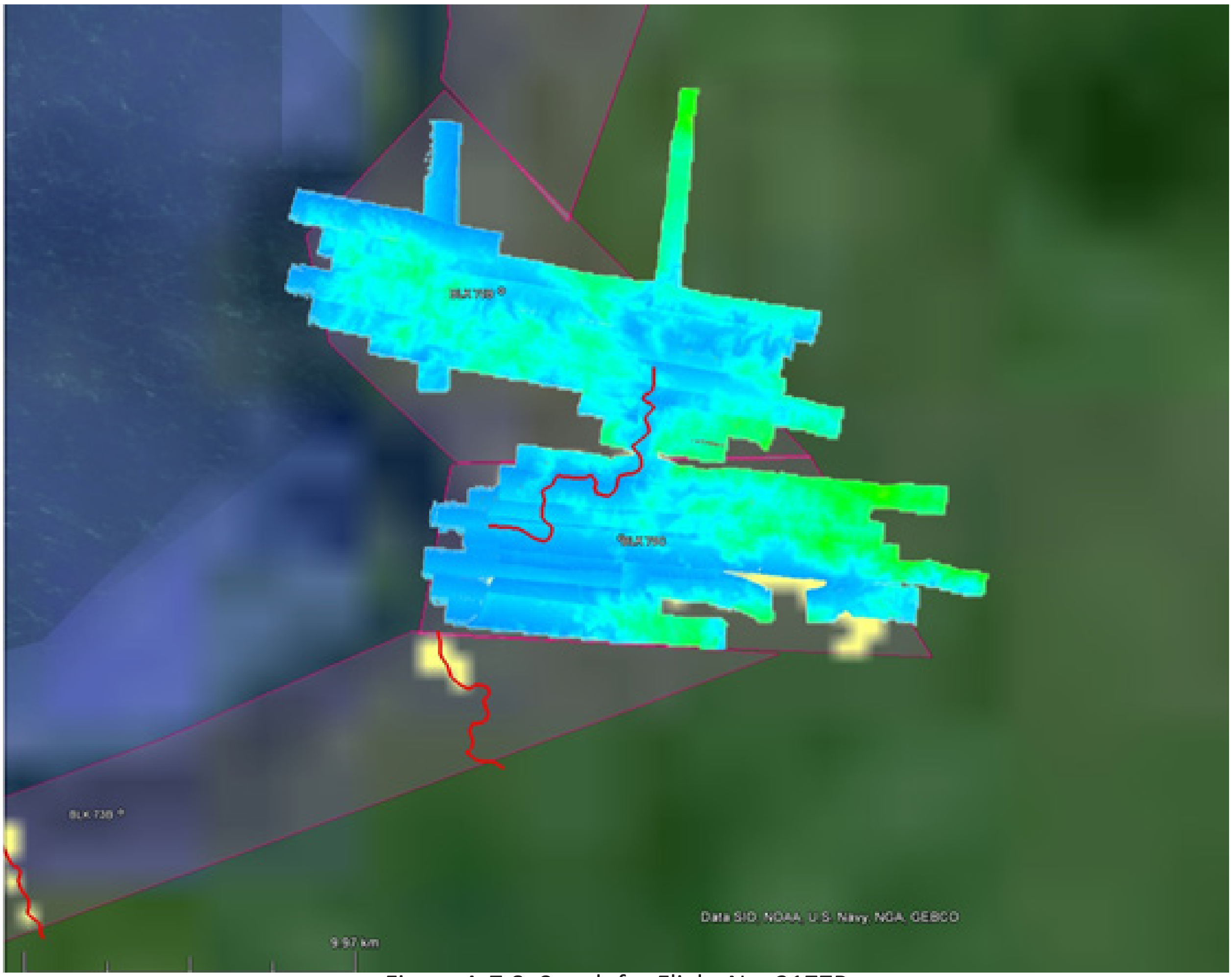



Figure A-7.8. Swath for Flight No. 2177P

Flight No. : 23120P
Area: BLK69D
Mission Name: 1BLK69D052A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

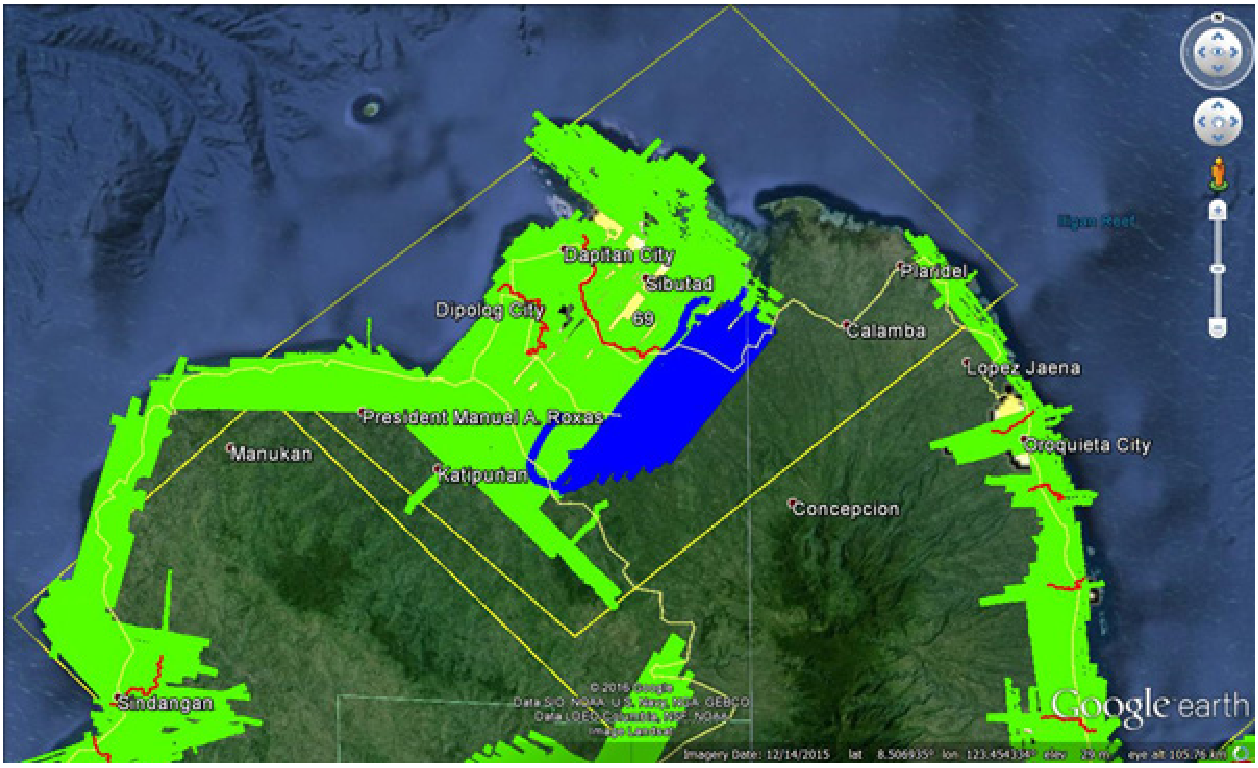



Figure A-7.9. Swath for Flight No. 23120P

Flight No. : 23124P
Area: BLK69 A, B
Mission Name: 1BLK69AB053A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

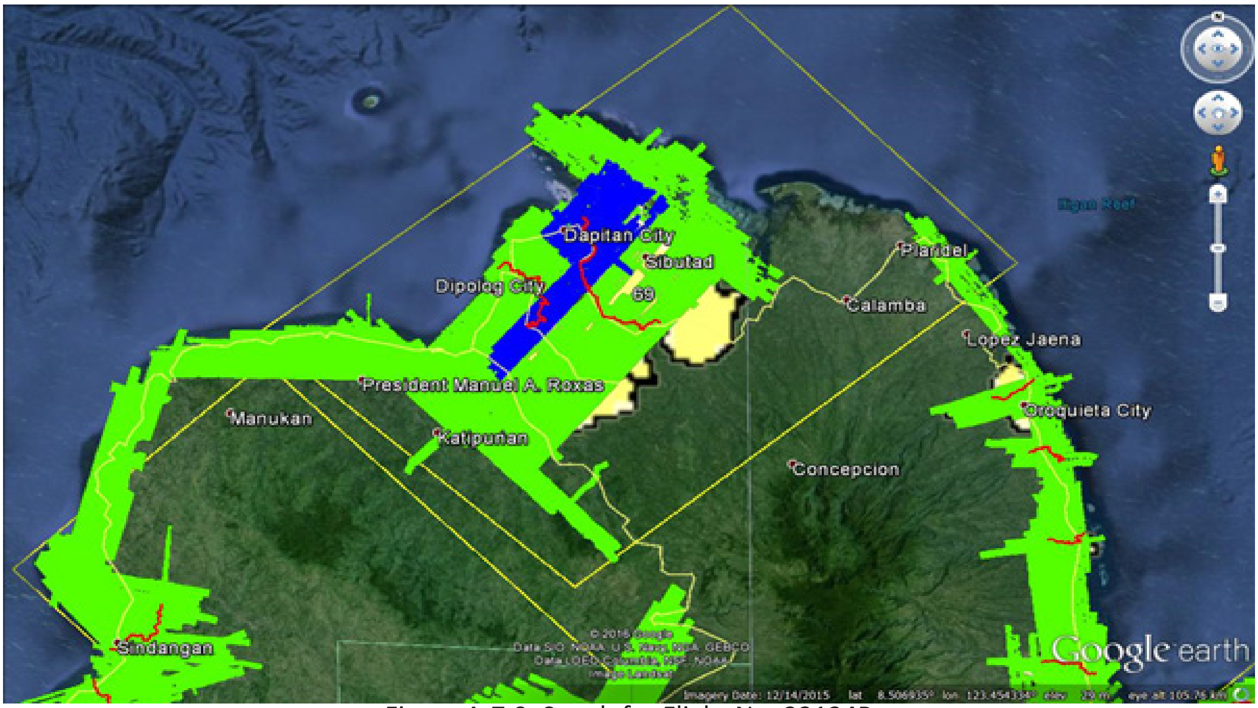



Figure A-7.9. Swath for Flight No. 23124P

Flight No. : 23558P
Area: DIPOLOG AND PARO DAPITAN
Mission Name: 1BLK69BC325A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

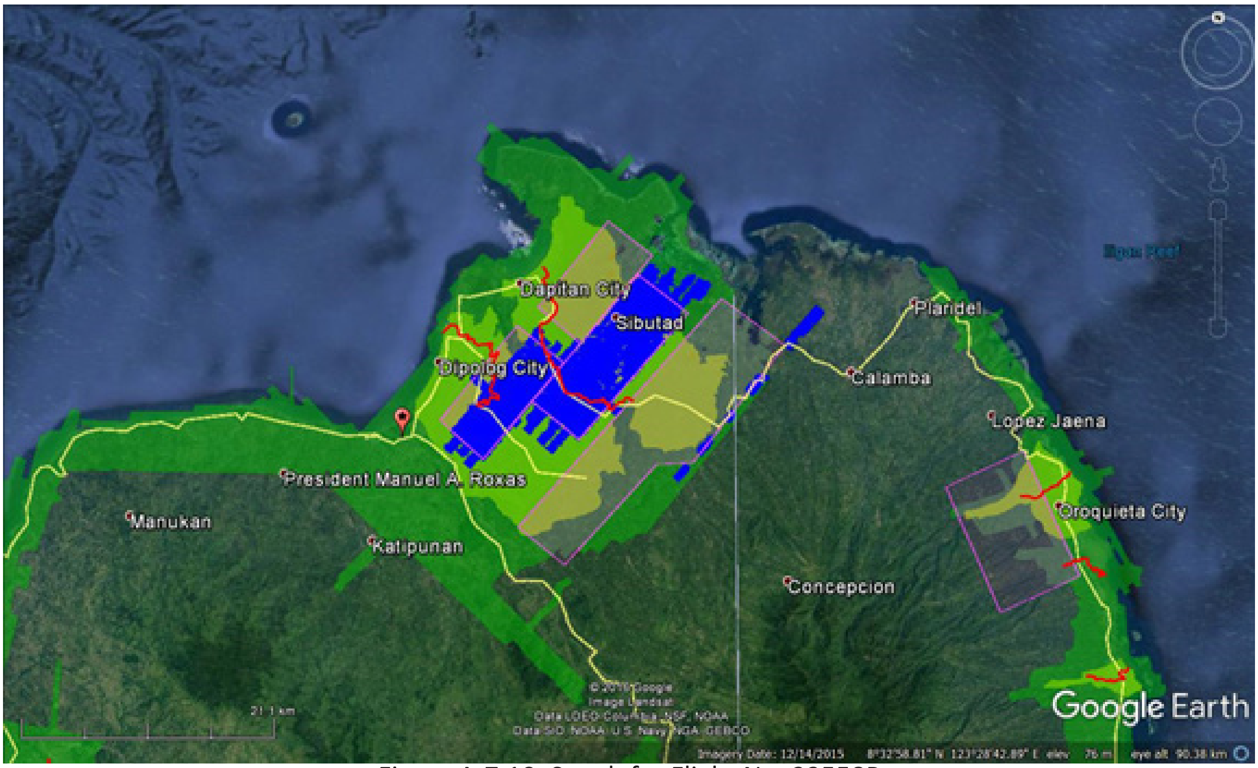



Figure A-7.10. Swath for Flight No. 23558P

Flight No. : 23562P
Area: DIPOLOG AND PARO DAPITAN
Mission Name: 1BLK69BD326A
Parameters: Altitude: 1000m; Scan Frequency: 30; Scan Angle: 50

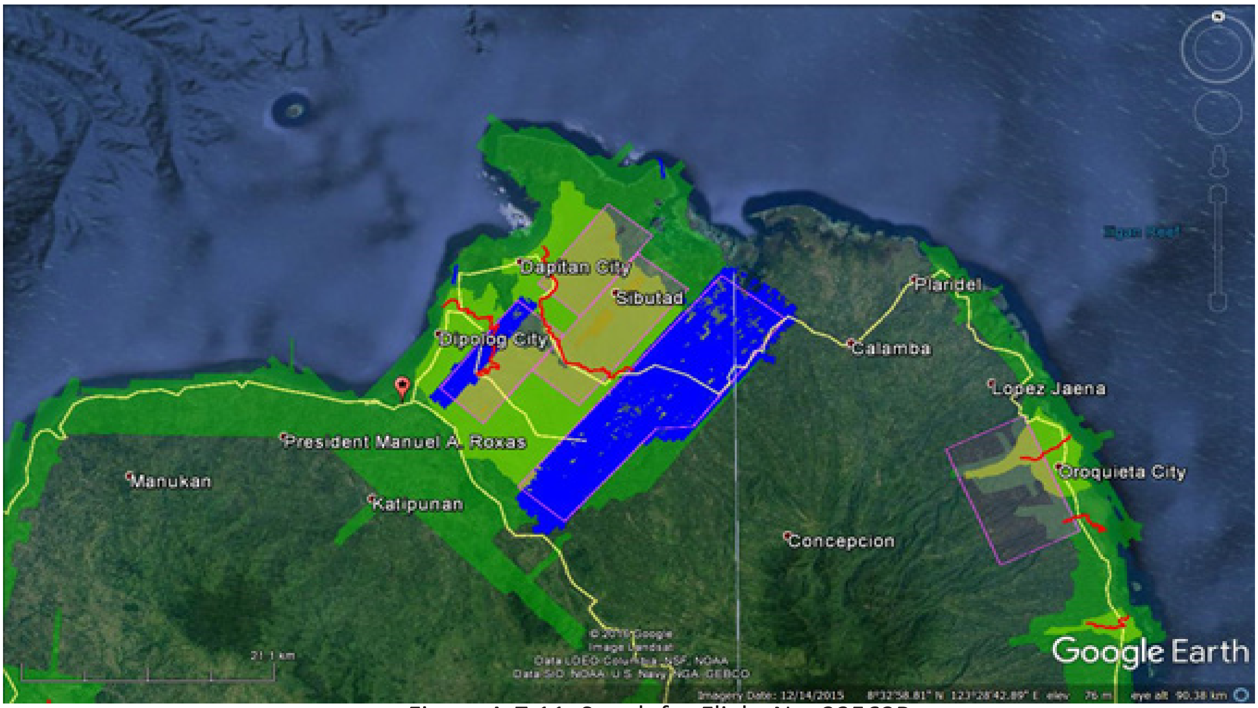



Figure A-7.11. Swath for Flight No. 23562P

# Annex 8. Mission Summary Reports

Table A-8.1. Mission Summary Report for Blk69A

| Flight Area | Pagadian |
|---|---|
| Mission Name | Blk69A |
| Inclusive Flights | 23124P |
| Range data size | 21.1 |
| POS data size | 270 |
| Base data size | 3.12 |
| Image | n/a |
| Transfer date | March 10, 2016 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | No |
| Processing Mode (<=1) | Yes |
| | |
| Smoothed Performance Metrics (in cm) | |
| RMSE for North Position (<4.0 cm) | 2.6 |
| RMSE for East Position (<4.0 cm) | 2.2 |
| RMSE for Down Position (<8.0 cm) | 3.9 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000371 |
| IMU attitude correction stdev (<0.001deg) | 0.000999 |
| GPS position stdev (<0.01m) | 0.0067 |
| | |
| Minimum % overlap (>25) | 0.25 |
| Ave point cloud density per sq.m. (>2.0) | 5.88 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 170 |
| Maximum Height | 621.53 m |
| Minimum Height | 62.16 m |
| | |
| Classification (# of points) | |
| Ground | 171,617,535 |
| Low vegetation | 150,341,707 |
| Medium vegetation | 241,301,262 |
| High vegetation | 720,916,233 |
| Building | 12,197,633 |
| | |
| Orthophoto | No |
| Processed by | Engr. Jennifer Saguran, Engr. Velina Angela Bemida, Jovy Narisma |

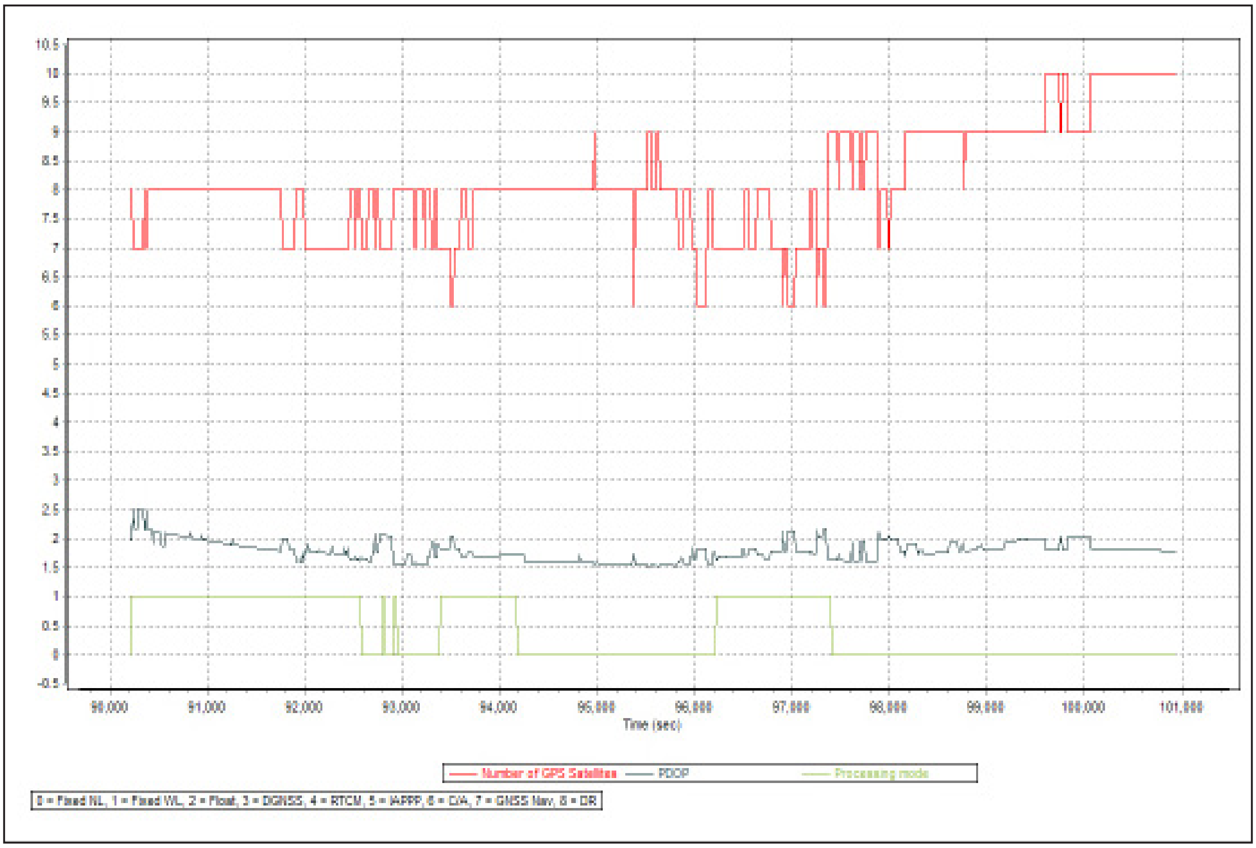



Figure A-8.1. Solution Status

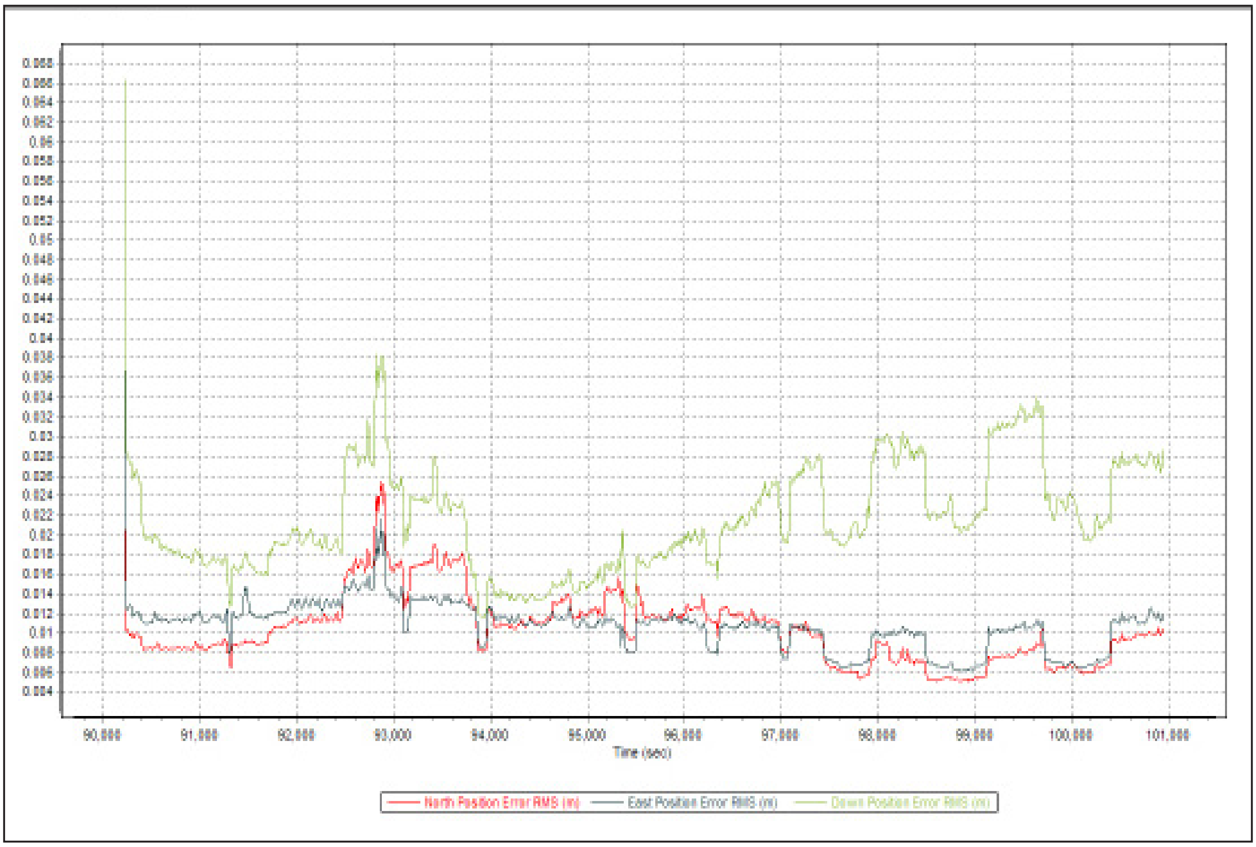



Figure A-8.2. Smoothed Performance Metric Parameters

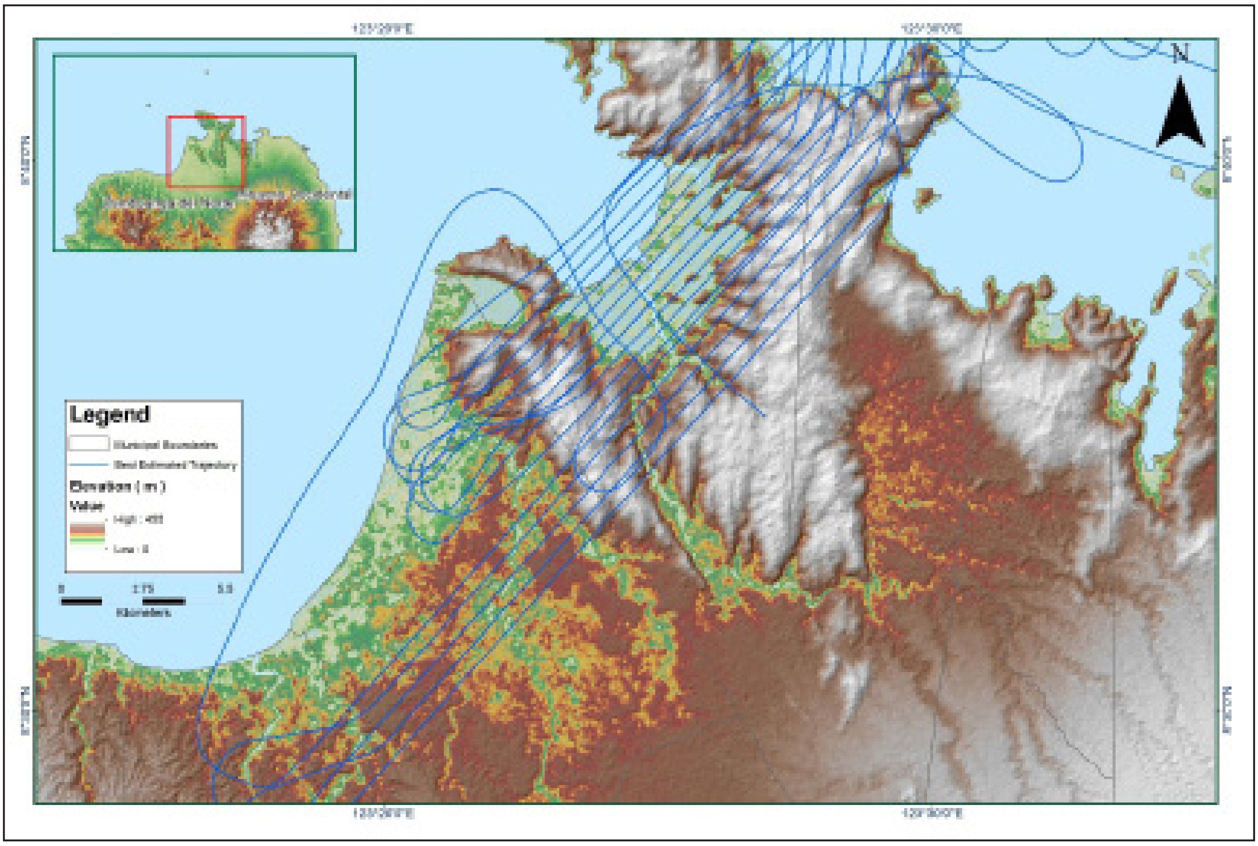



Figure A-8.3. Best Estimated Trajectory

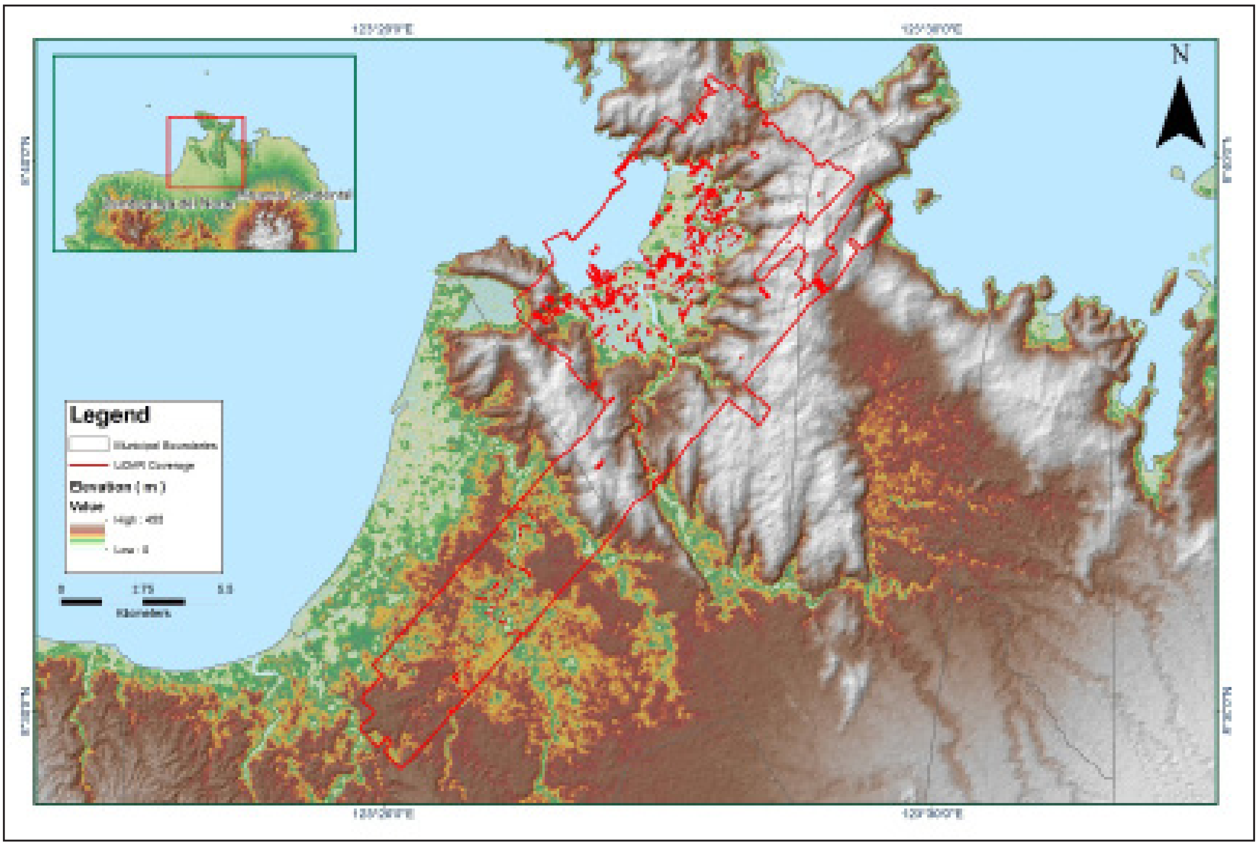



Figure A-8.4. Coverage of LiDAR data

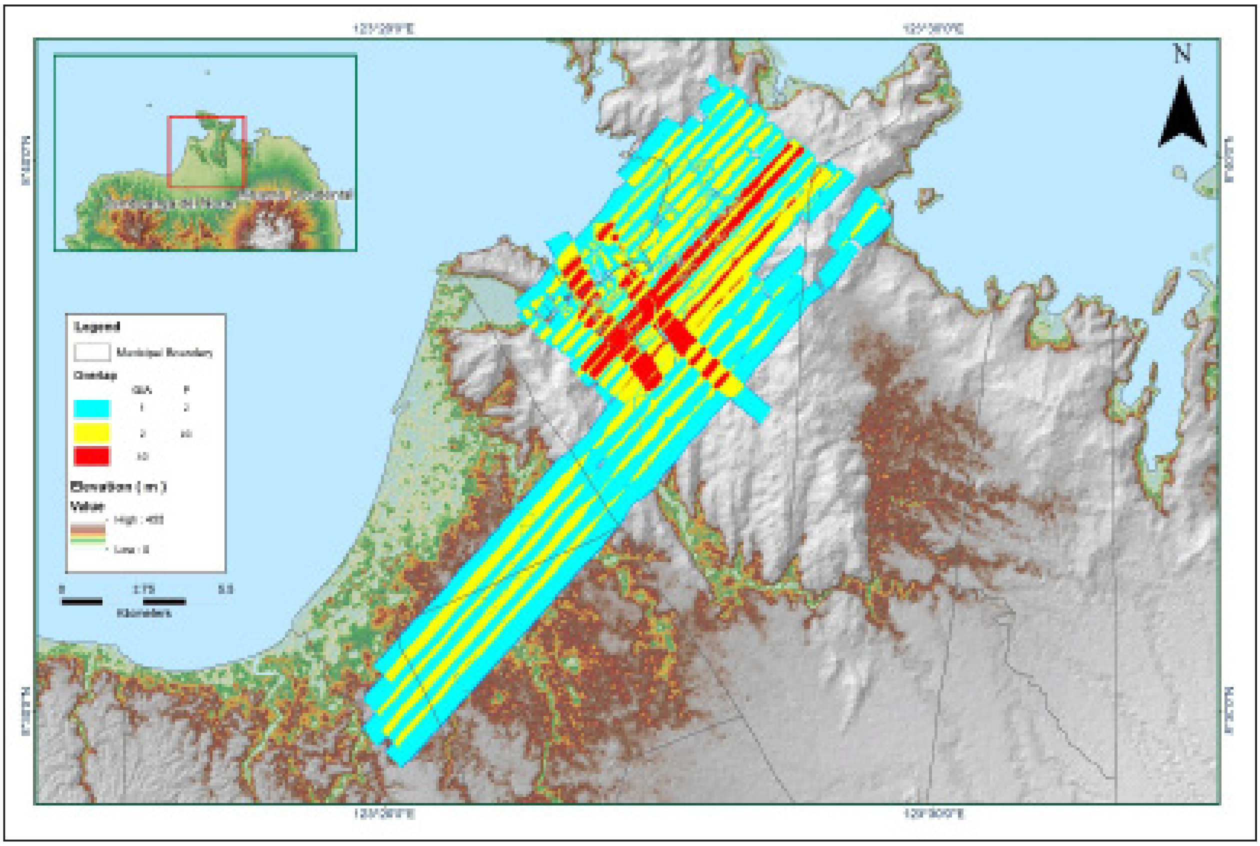



Figure A-8.5. Image of data overlap

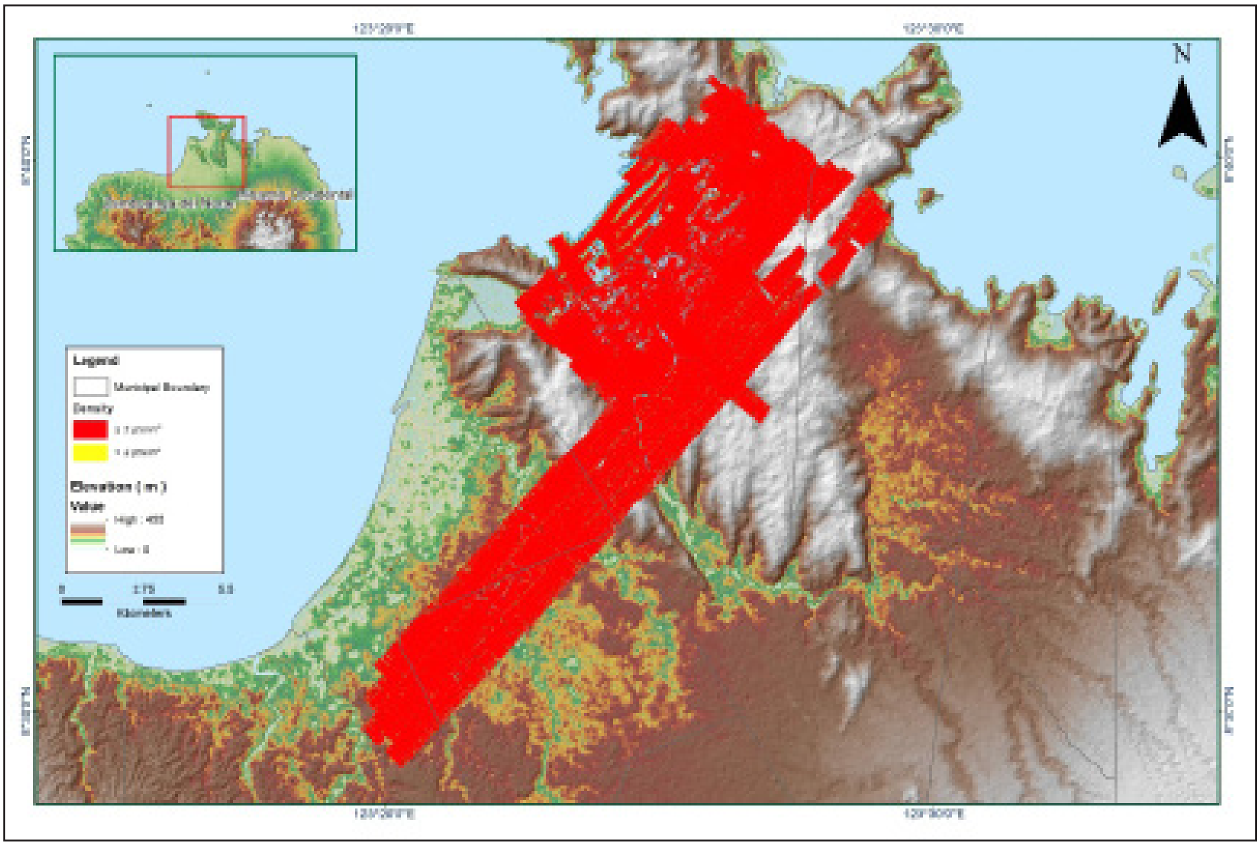



Figure A-8.6. Density map of merged LiDAR data

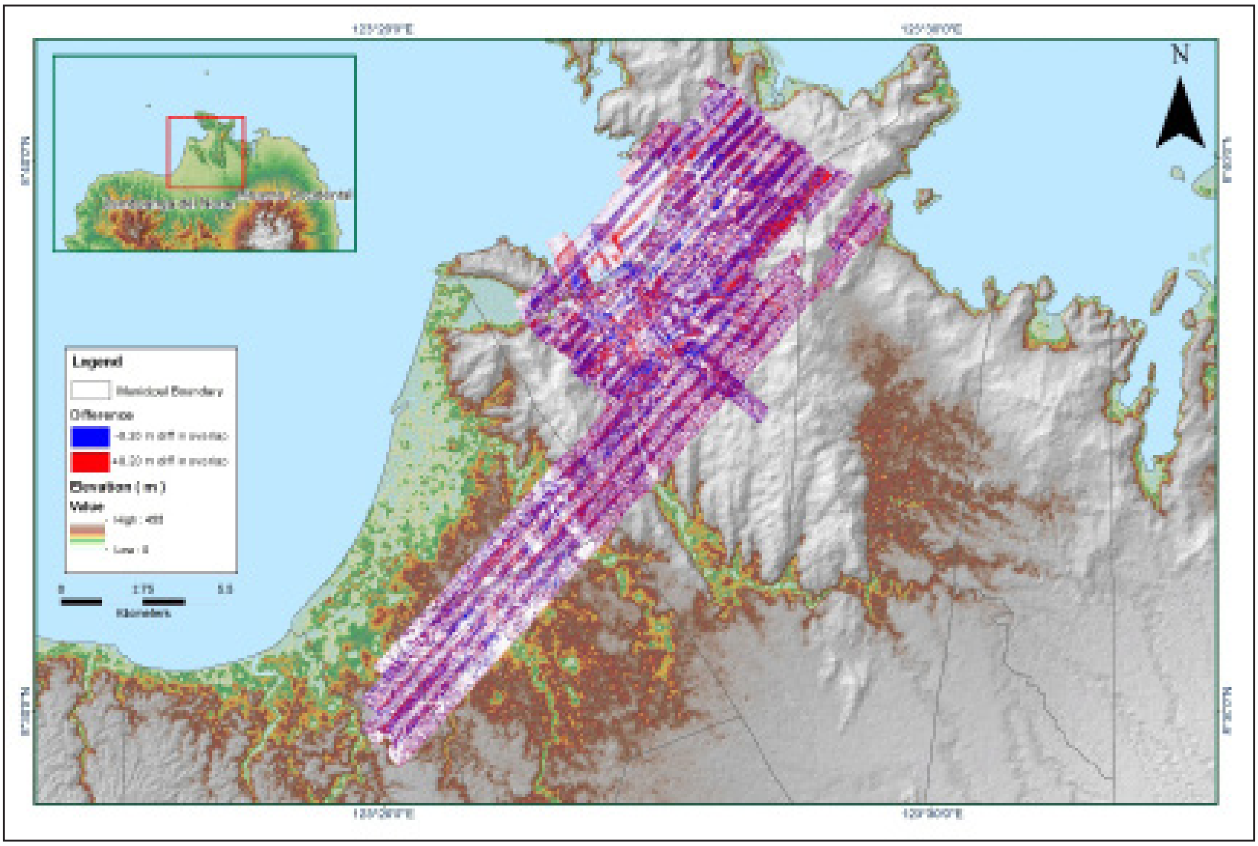



Figure A-8.7. Elevation difference between flight lines

Table A-8.2. Mission Summary Report for Blk69D

| Flight Area | Pagadian |
|---|---|
| Mission Name | Blk69D |
| Inclusive Flights | 23120P |
| Range data size | 25.9 |
| POS data size | 298 |
| Base data size | 59.6 |
| Image | n/a |
| Transfer date | March 10, 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) | 4.5 |
| RMSE for East Position (<4.0 cm) | 2.6 |
| RMSE for Down Position (<8.0 cm) | 6.3 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000249 |
| IMU attitude correction stdev (<0.001deg) | 0.002107 |
| GPS position stdev (<0.01m) | 0.0096 |
| | |
| Minimum % overlap (>25) | 45.89 |
| Ave point cloud density per sq.m. (>2.0) | 5.34 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 229 |
| Maximum Height | 415.32 m |
| Minimum Height | 66.20 m |
| | |
| Classification (# of points) | |
| Ground | 236,562,708 |
| Low vegetation | 178,296,202 |
| Medium vegetation | 347,228,341 |
| High vegetation | 954,090,523 |
| Building | 9,130,143 |
| | |
| Orthophoto | No |
| Processed by | Engr. Analyn Naldo, Engr. Justine Francisco, Maria Tamsyn Malabanan |

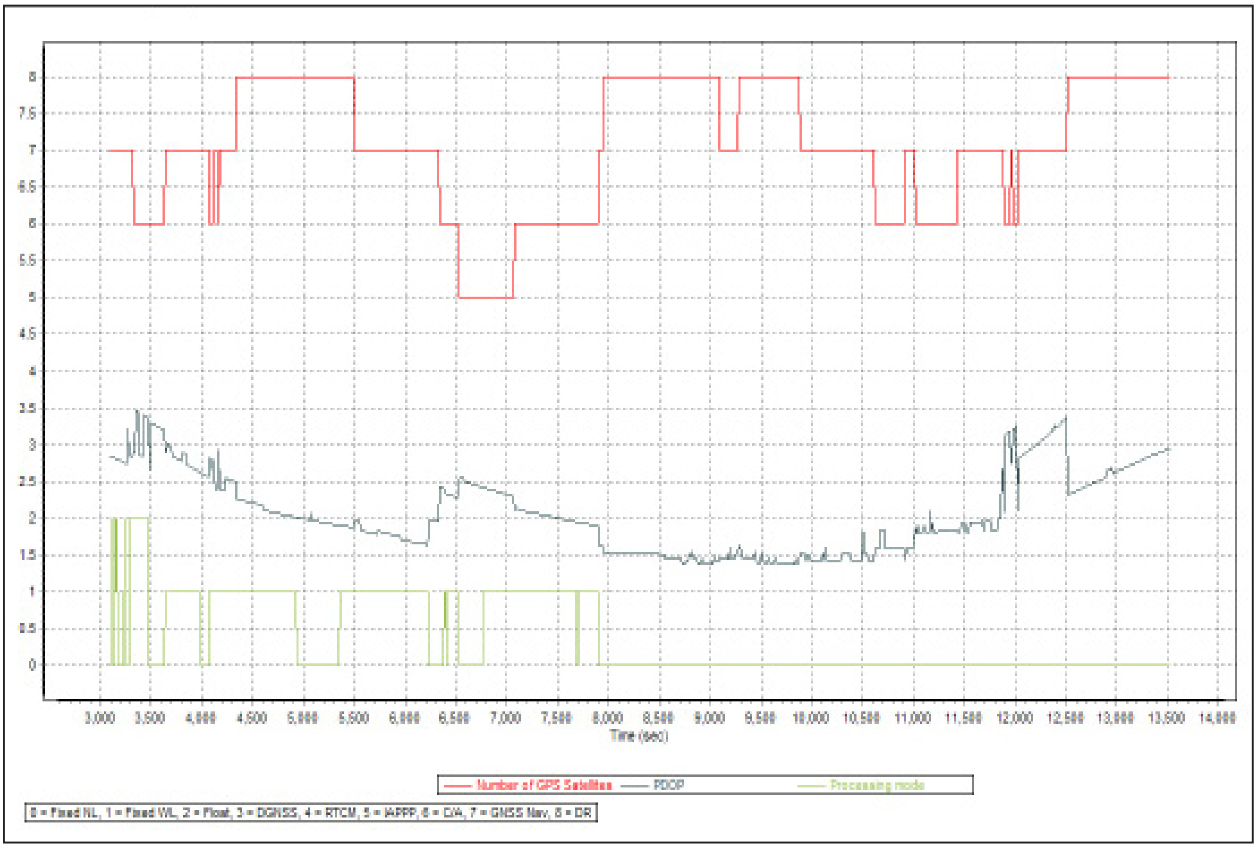



Figure A-8.8. Solution Status

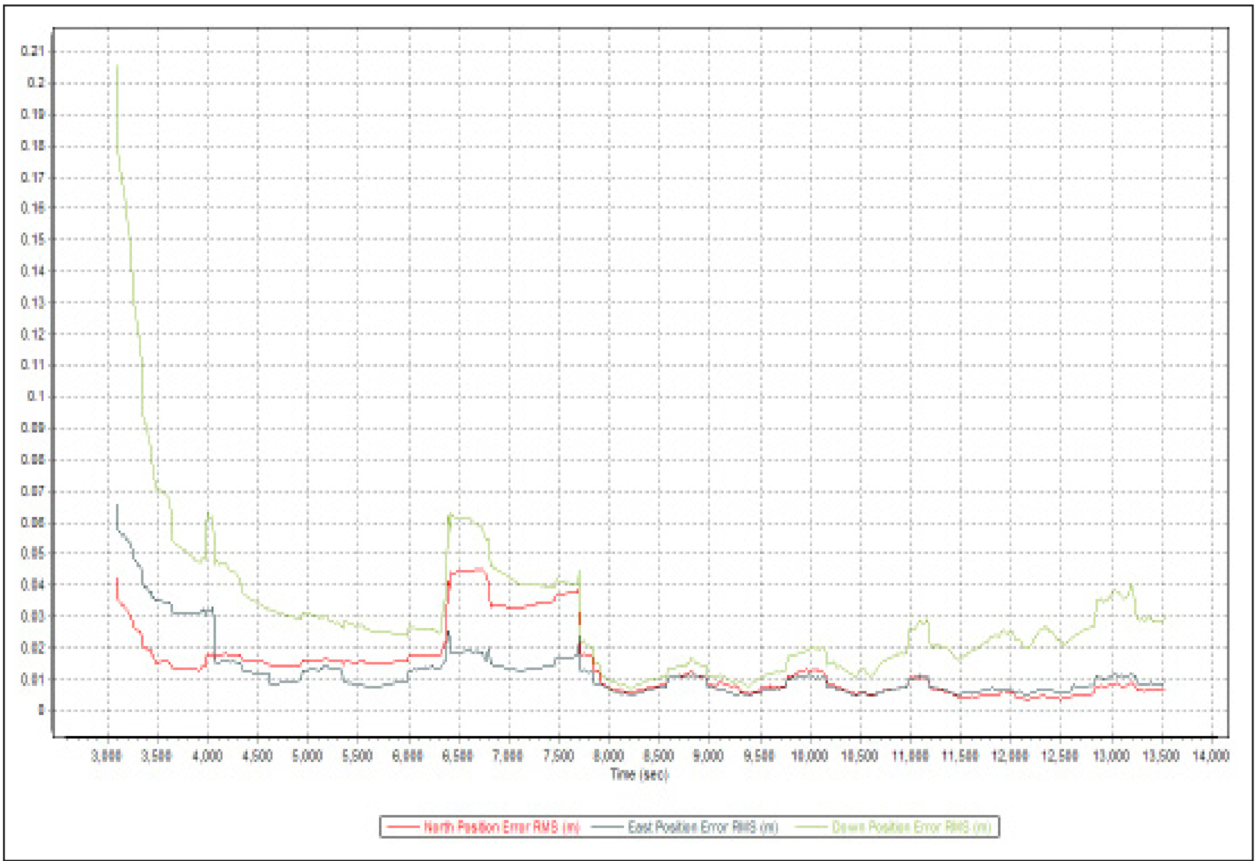



Figure A-8.9. Smoothed Performance Metric Parameters

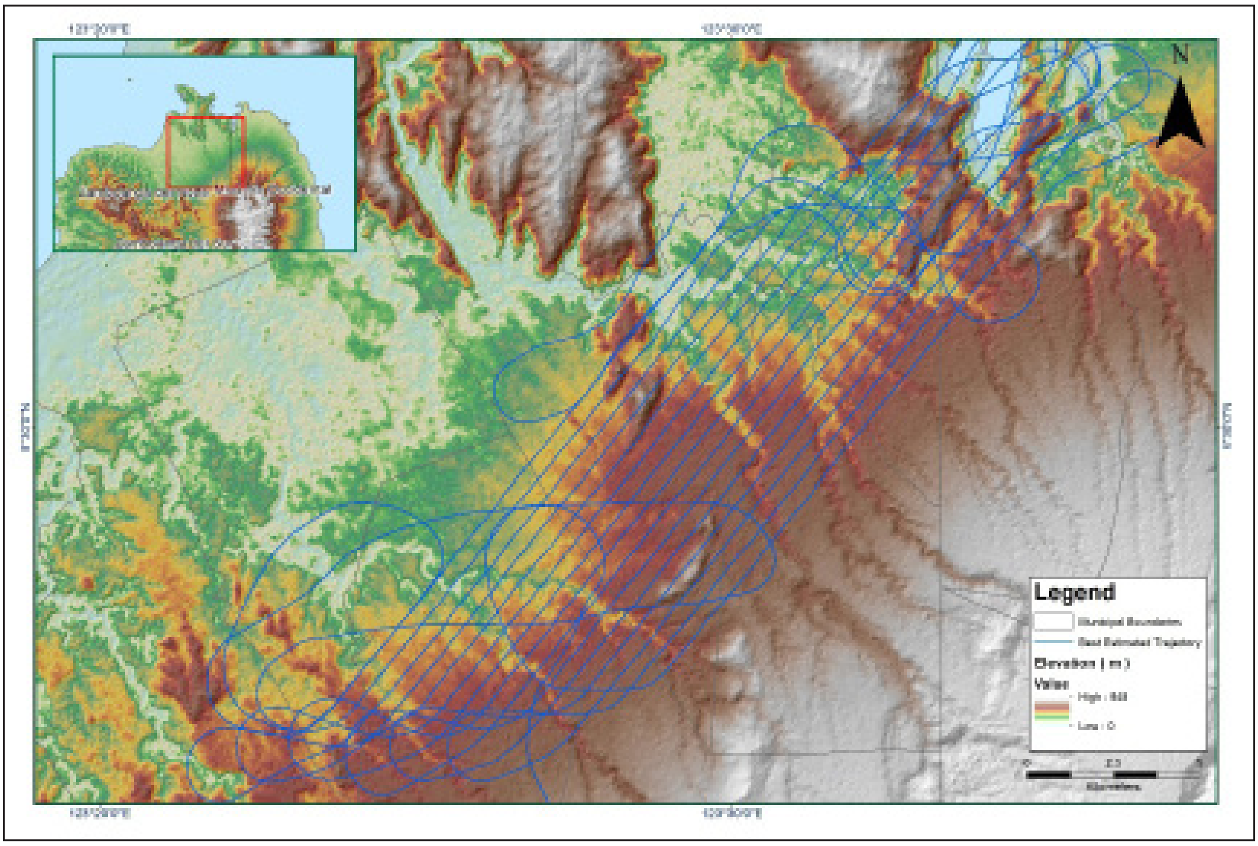



Figure A-8.10. Best Estimated Trajectory

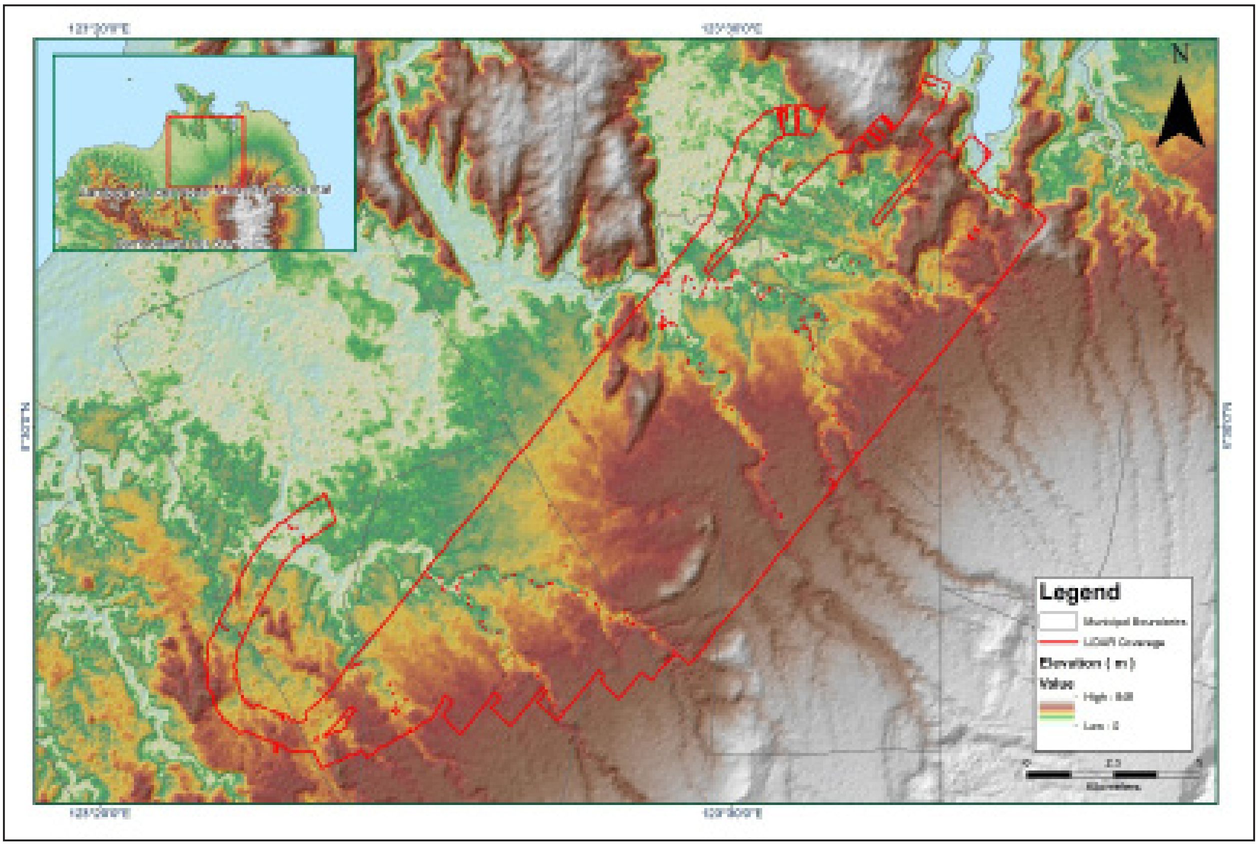



Figure A-8.11. Coverage of LiDAR data

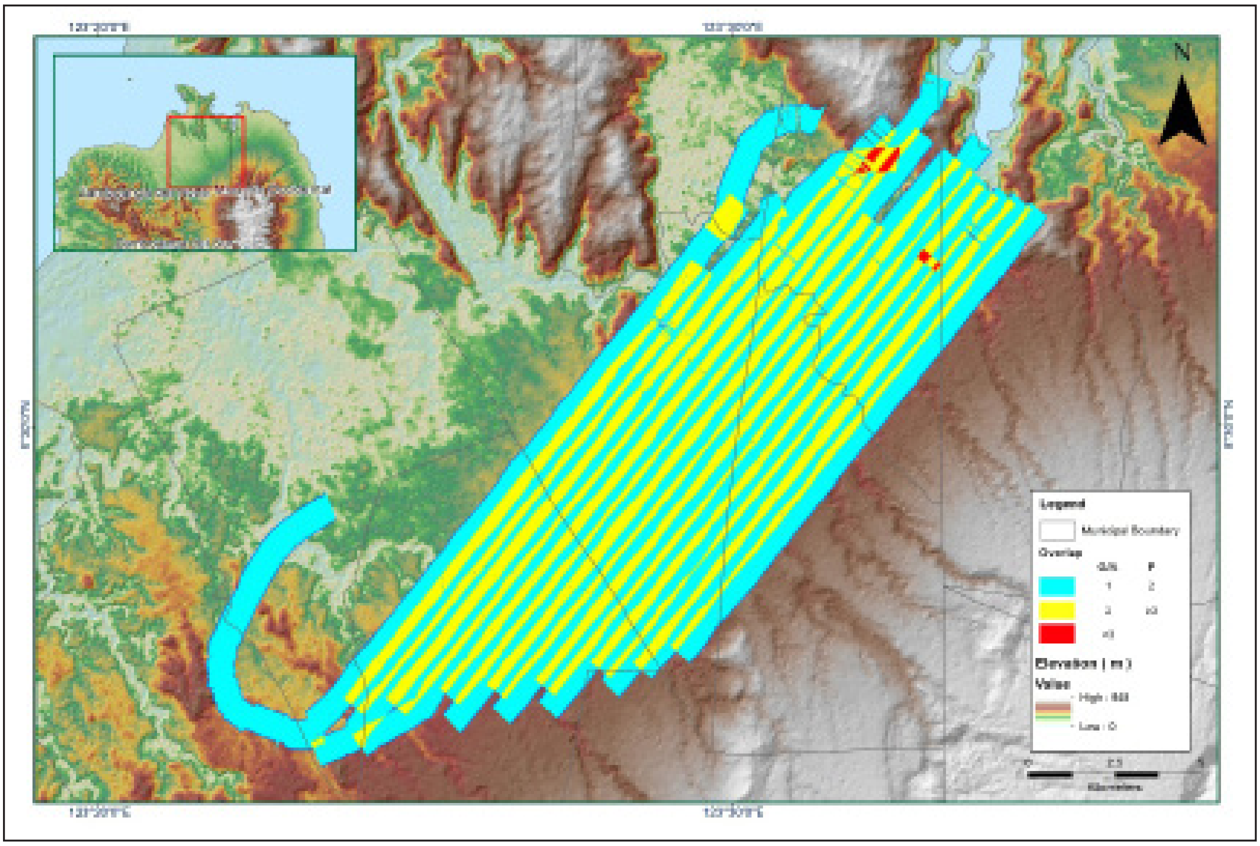



Figure A-8.12. Image of data overlap

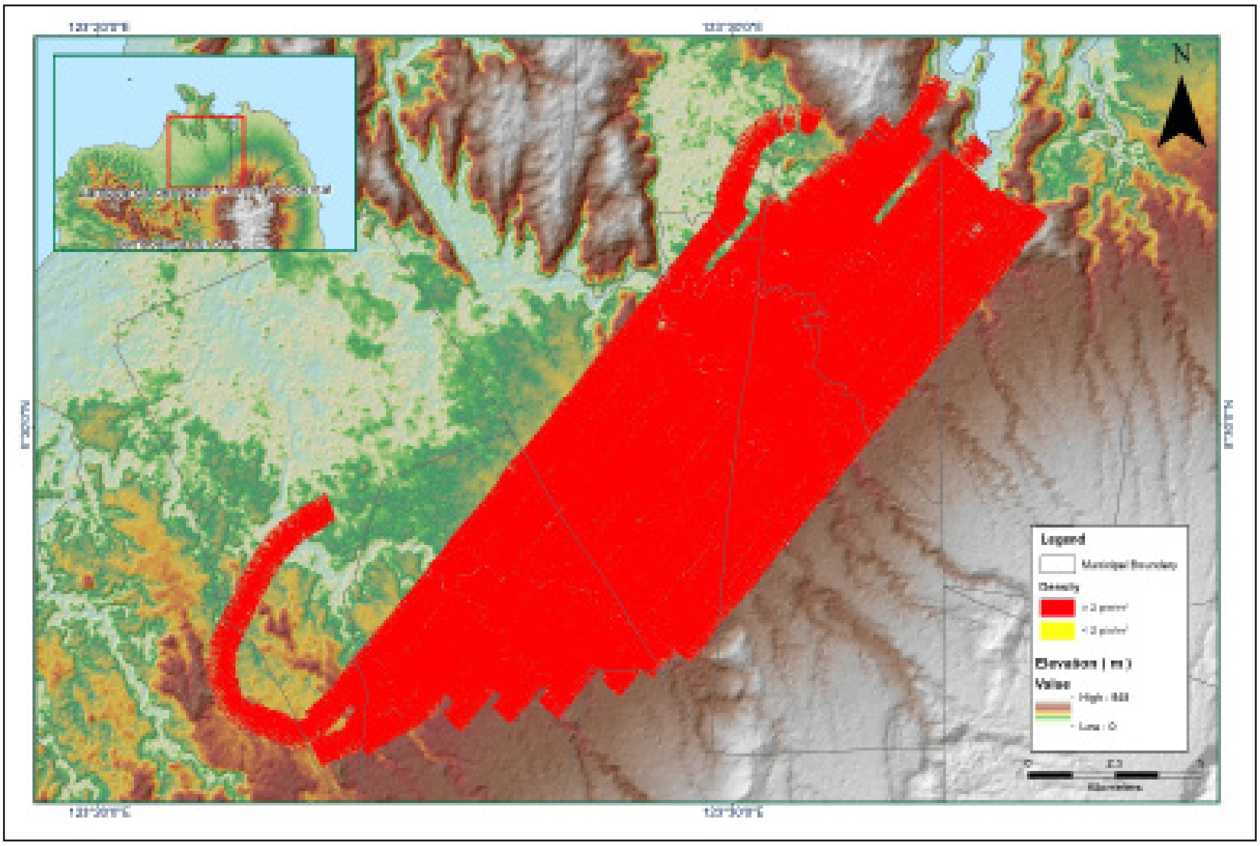



Figure A-8.13. Density map of merged LiDAR data

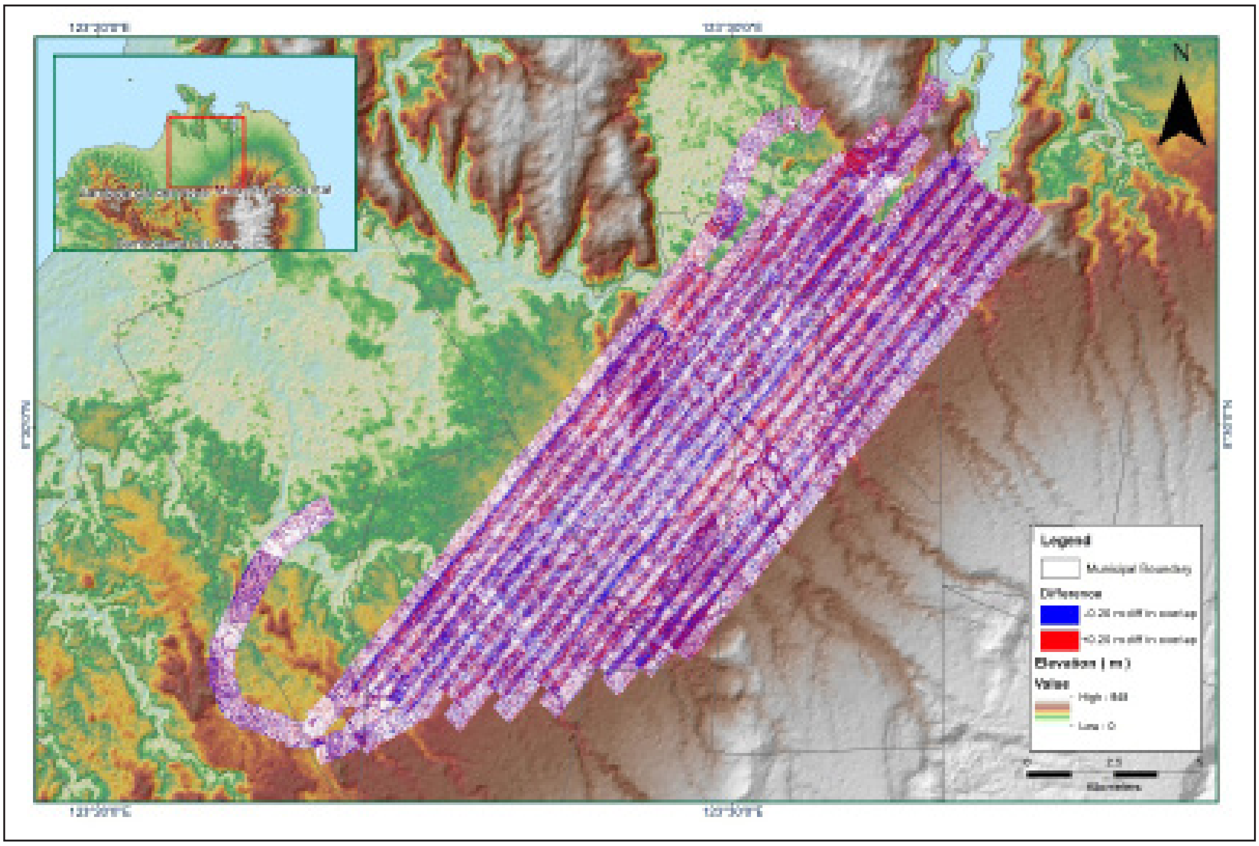



Figure A-8.14. Elevation difference between flight lines

Table A-8.3. Mission Summary Report for Blk69ABC

| Flight Area | Dipolog |
|---|---|
| Mission Name | Blk69ABC |
| Inclusive Flights | 2117P |
| Range data size | 12.4 GB |
| POS data size | 113 MB |
| Base data size | 17.8 MB |
| Image | 18.6 GB |
| Transfer date | November 19, 2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | No |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | No |
| Processing Mode (<=1) | No |
| | |
| Smoothed Performance Metrics (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.226 |
| RMSE for East Position (<4.0 cm) | 1.886 |
| RMSE for Down Position (<8.0 cm) | 2.239 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000267 |
| IMU attitude correction stdev (<0.001deg) | 0.000597 |
| GPS position stdev (<0.01m) | 0.0115 |
| | |
| Minimum % overlap (>25) | 42.90% |
| Ave point cloud density per sq.m. (>2.0) | 3.755 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 164 |
| Maximum Height | 944.28 |
| Minimum Height | 65.34 |
| | |
| Classification (# of points) | |
| Ground | 82197075 |
| Low vegetation | 52840664 |
| Medium vegetation | 165570204 |
| High vegetation | 444155218 |
| Building | 3583567 |
| | |
| Orthophoto | Yes |
| Processed by | Engr. Analyn Naldo, Engr. Merven Matthew Natino, Marie Denise Bueno |

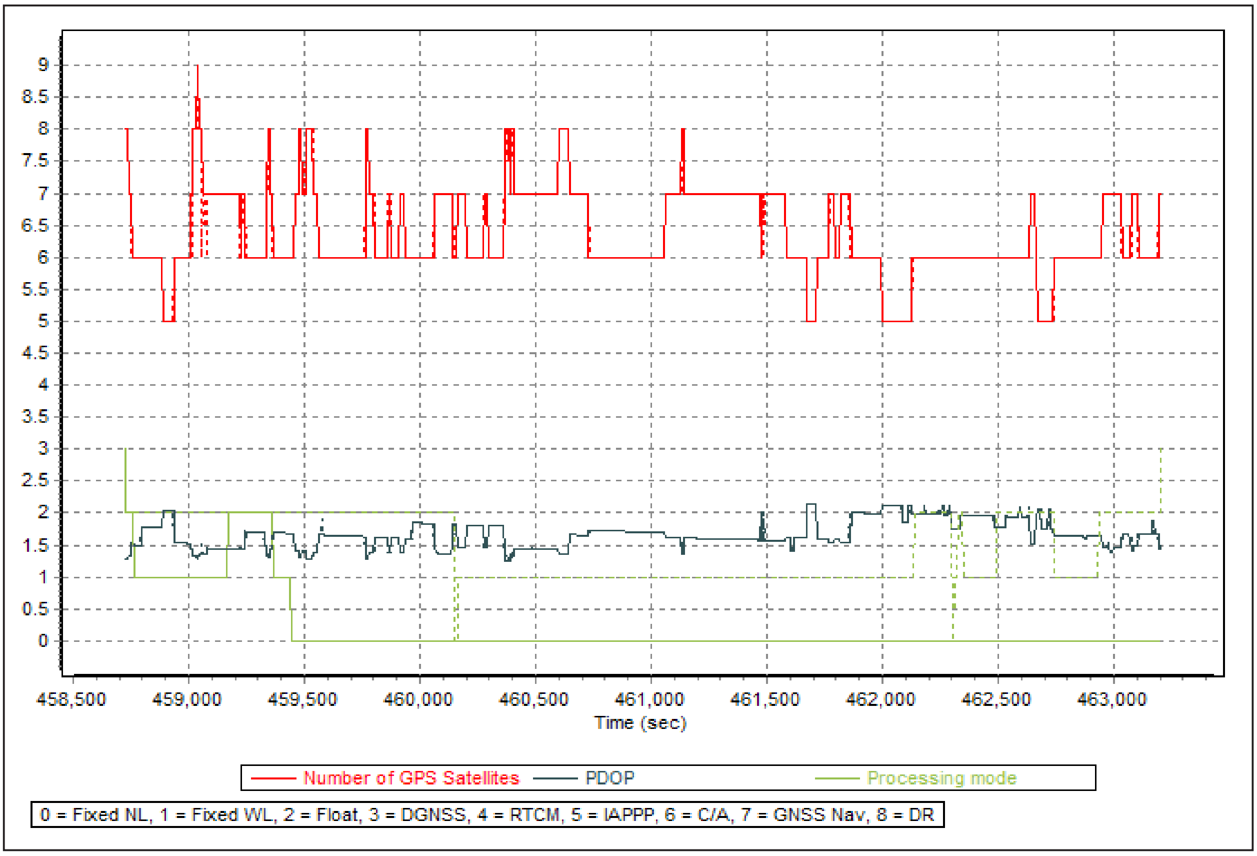



Figure A-8.15. Solution Status

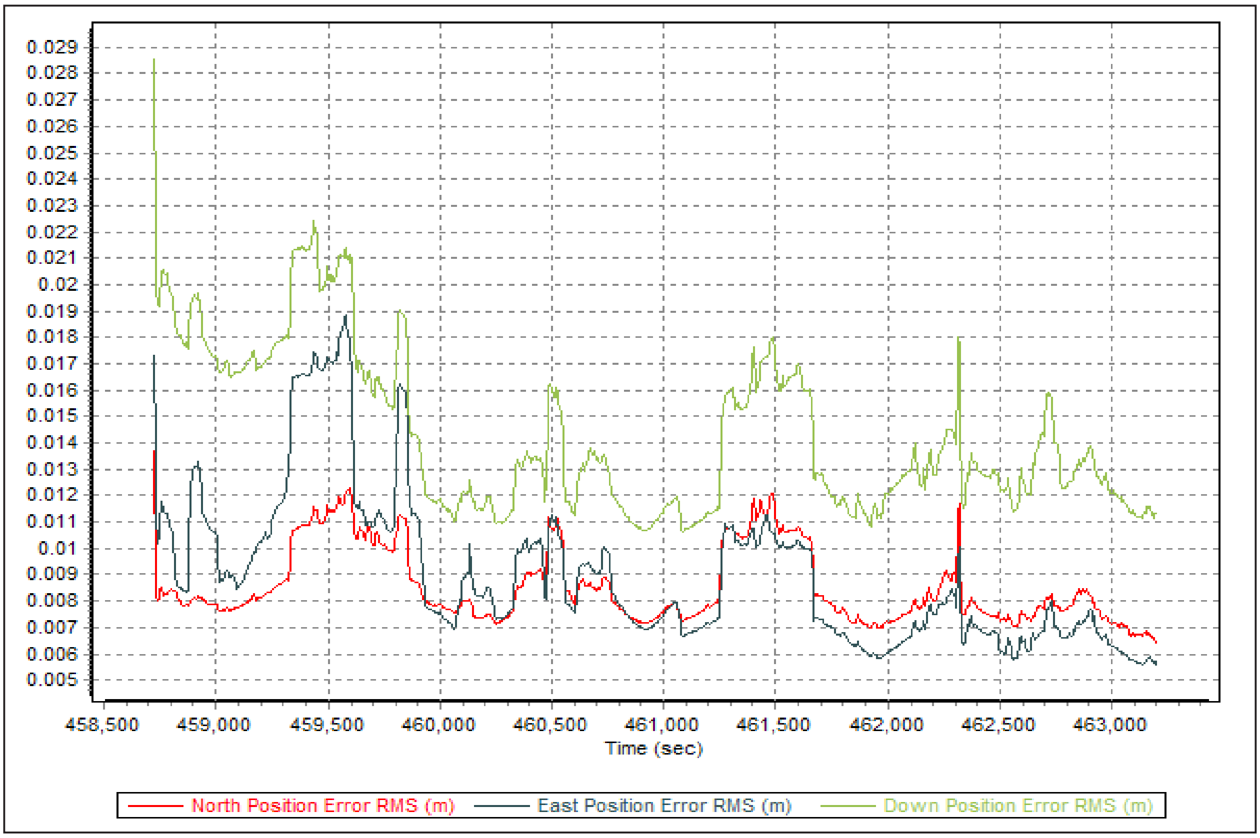



Figure A-8.16. Smoothed Performance Metric Parameters

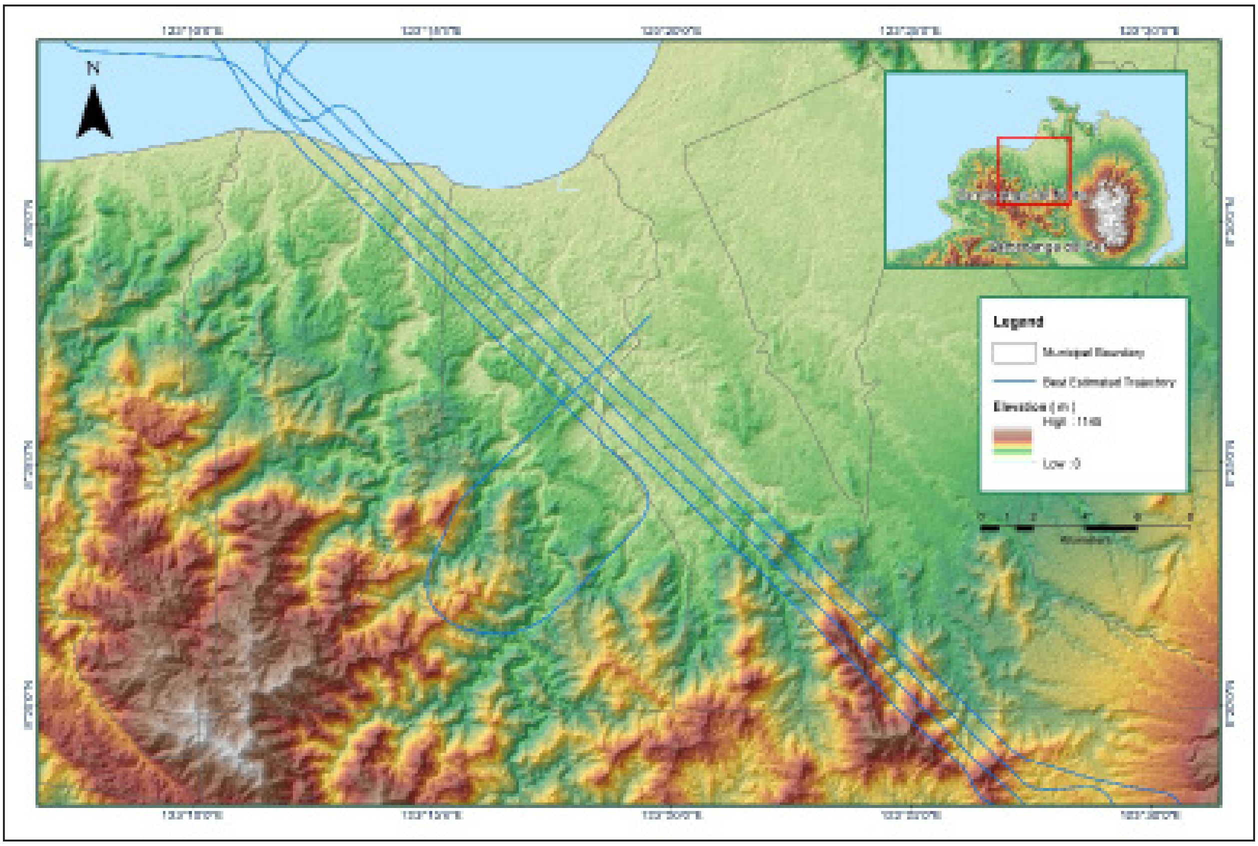



Figure A-8.17. Best Estimated Trajectory

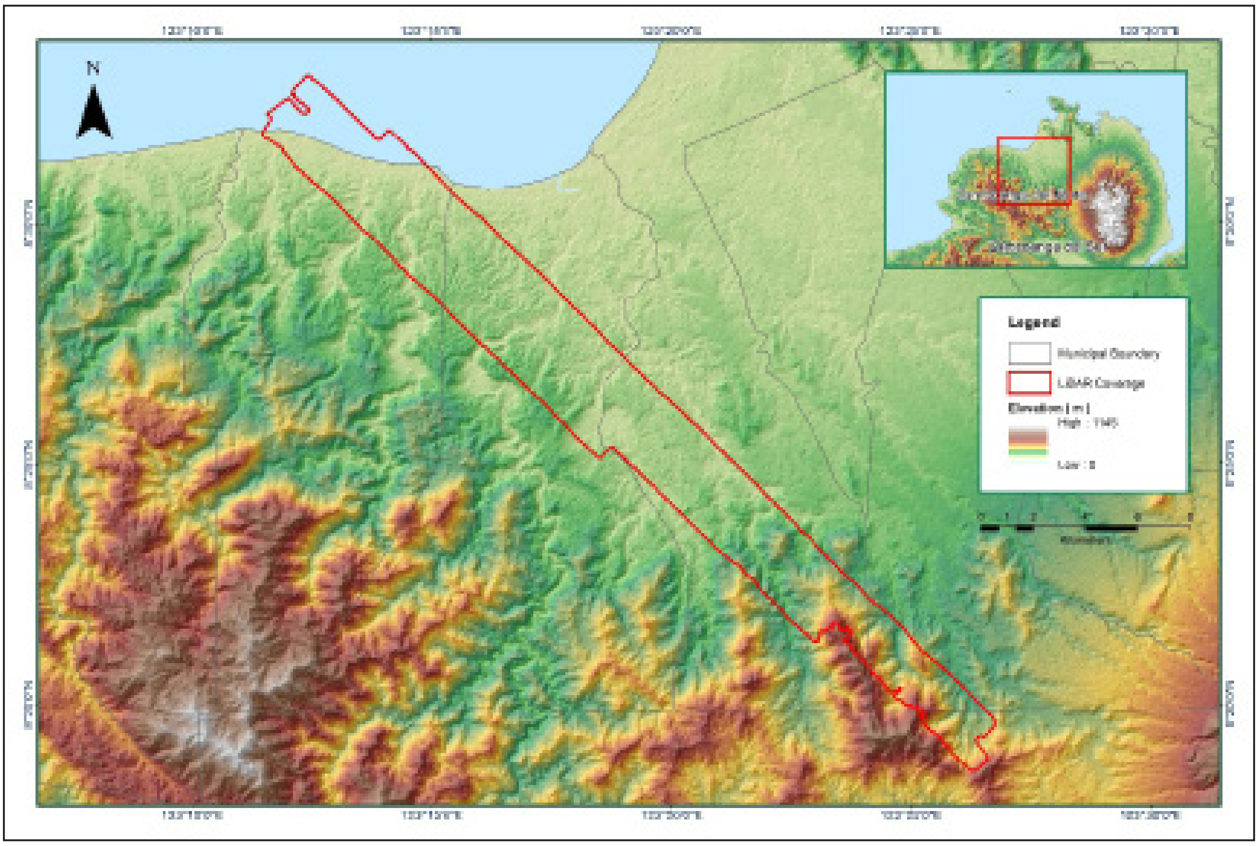



Figure A-8.18. Coverage of LiDAR data

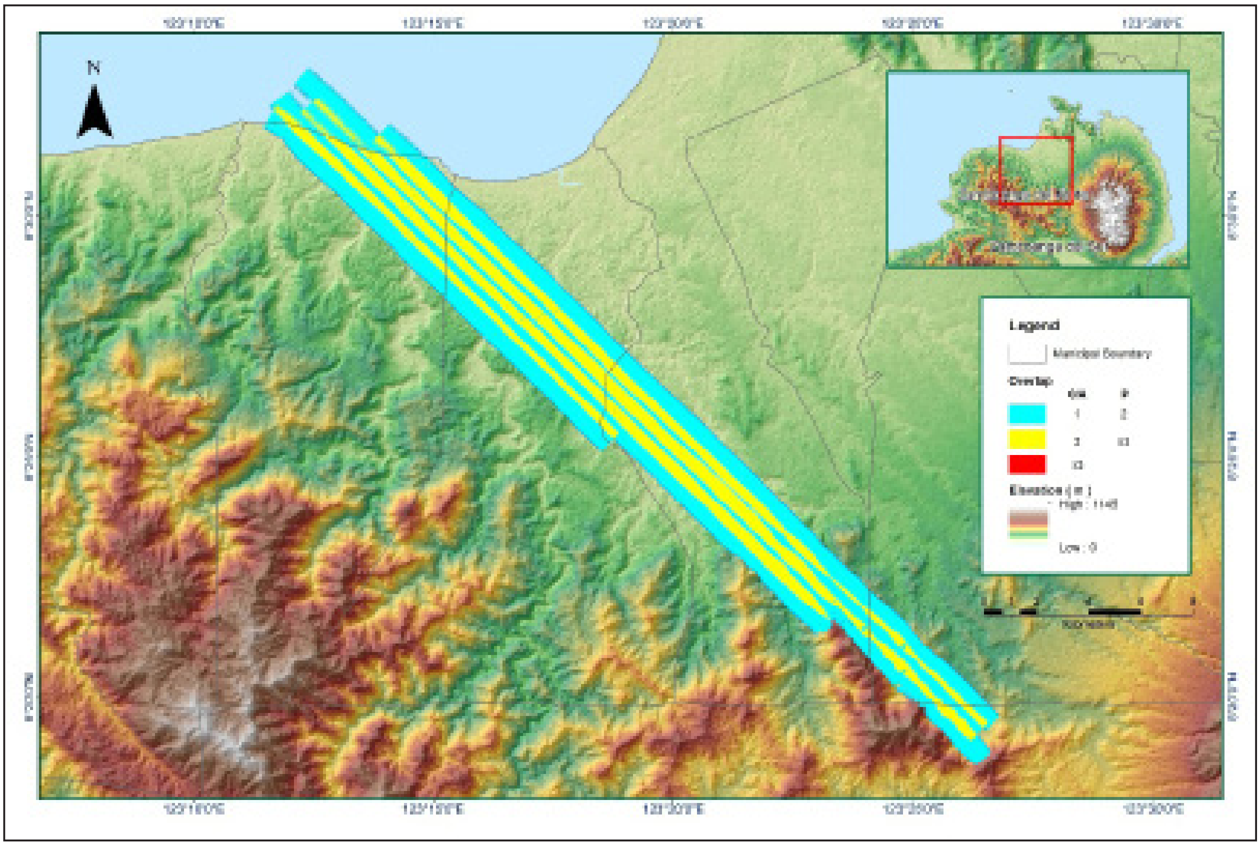



Figure A-8.19. Image of data overlap

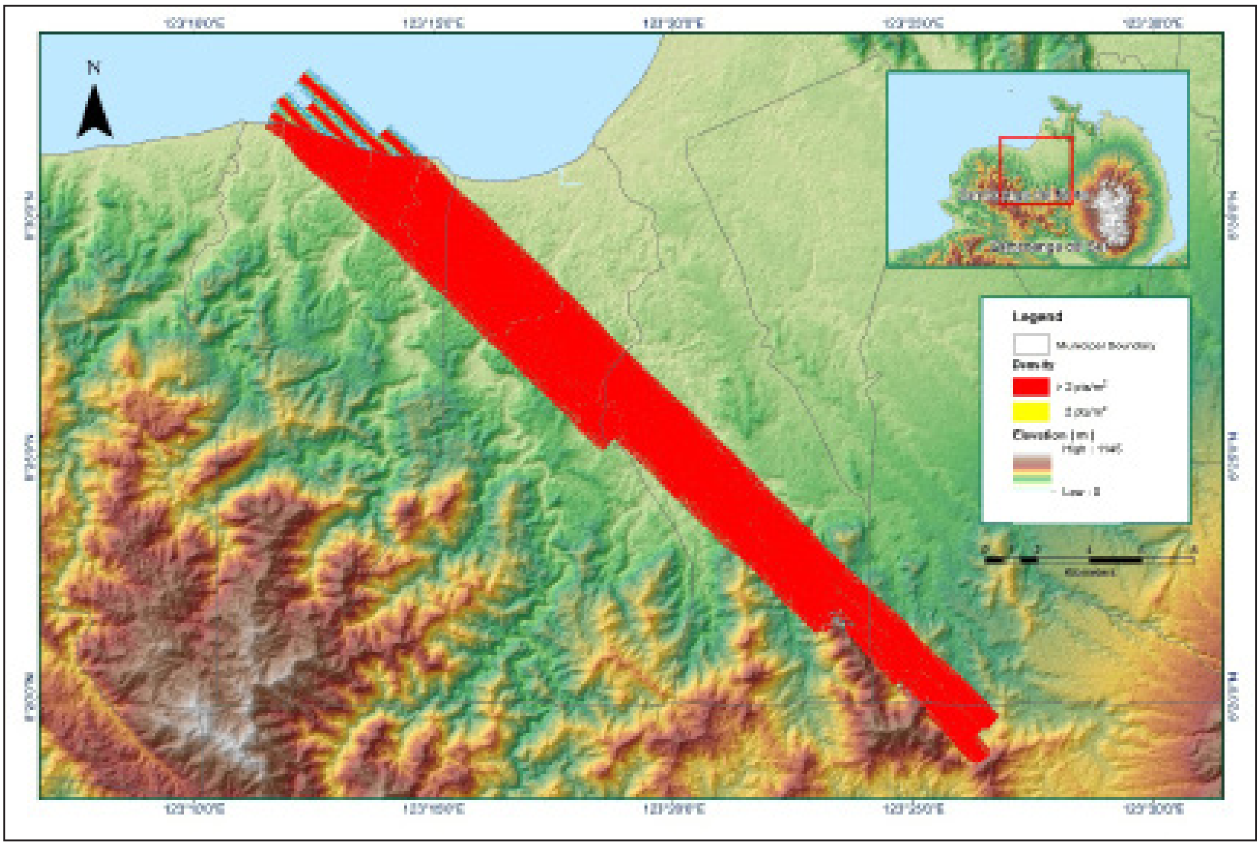



Figure A-8.20. Density map of merged LiDAR data

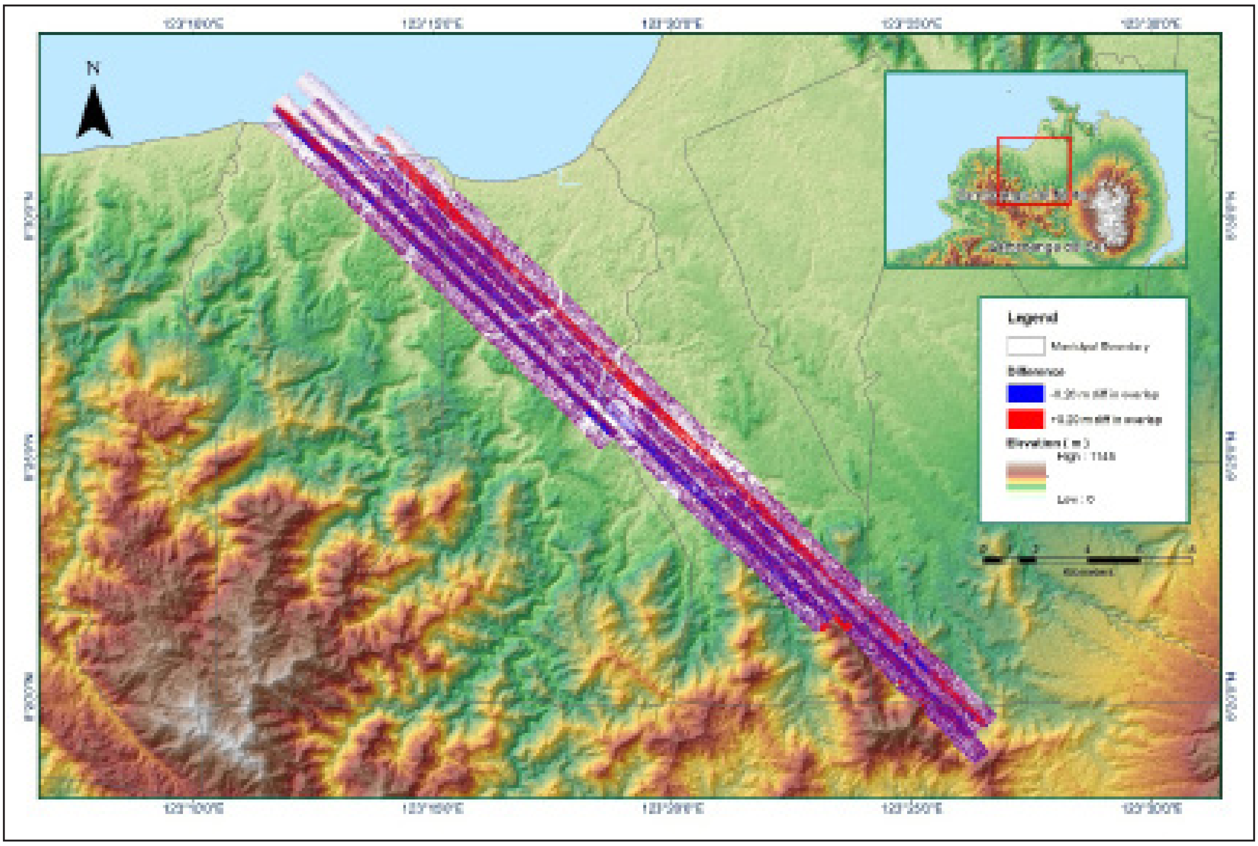



Figure A-8.21. Elevation difference between flight lines

Table A-8.4. Mission Summary Report for Blk69A

| Flight Area | Dipolog |
|---|---|
| Mission Name | Blk69A |
| Inclusive Flights | 2127P, 2125P,2149P |
| Range data size | 48.9 GB |
| POS data size | 517 MB |
| Base data size | 104 MB |
| Image | 80.1 GB |
| Transfer date | November 19, 2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| Smoothed Performance Metrics (in cm) | |
| RMSE for North Position (<4.0 cm) | 6.2 |
| RMSE for East Position (<4.0 cm) | 4.0 |
| RMSE for Down Position (<8.0 cm) | 9.2 |
| | |
| Boresight correction stdev (<0.001deg) | none |
| IMU attitude correction stdev (<0.001deg) | none |
| GPS position stdev (<0.01m) | none |
| | |
| Minimum % overlap (>25) | 33.60% |
| Ave point cloud density per sq.m. (>2.0) | 3.02 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 154 |
| Maximum Height | 355.6 m |
| Minimum Height | 51.02 m |
| | |
| Classification (# of points) | |
| Ground | 89,304,167 |
| Low vegetation | 74,944,742 |
| Medium vegetation | 138,978,598 |
| High vegetation | 125,064,187 |
| Building | 2,728,949 |
| | |
| Orthophoto | No |
| Processed by | Engr. Analyn Naldo, Engr. Chelou Prado, Engr. Elainne Lopez |

Figure A-8.22. Solution Status

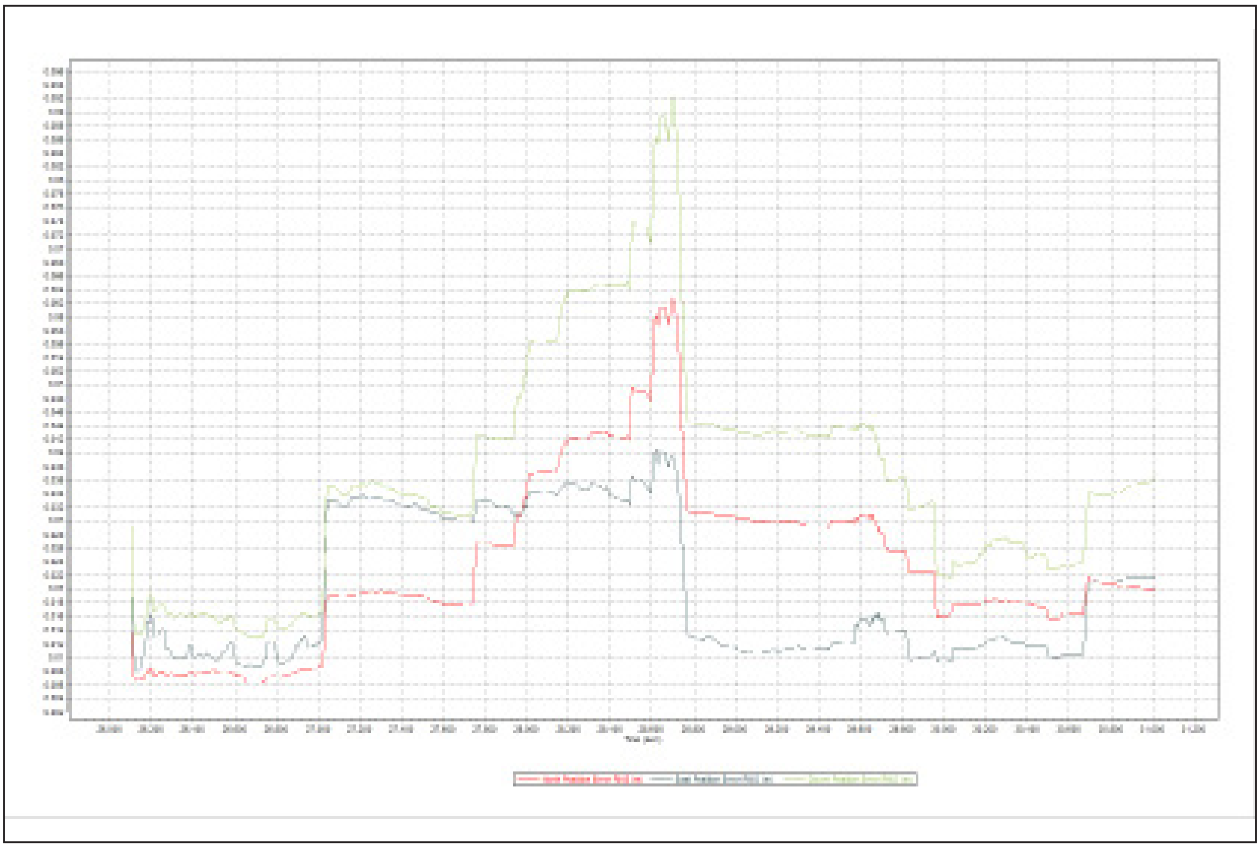


Figure A-8.23. Smoothed Performance Metric Parameters

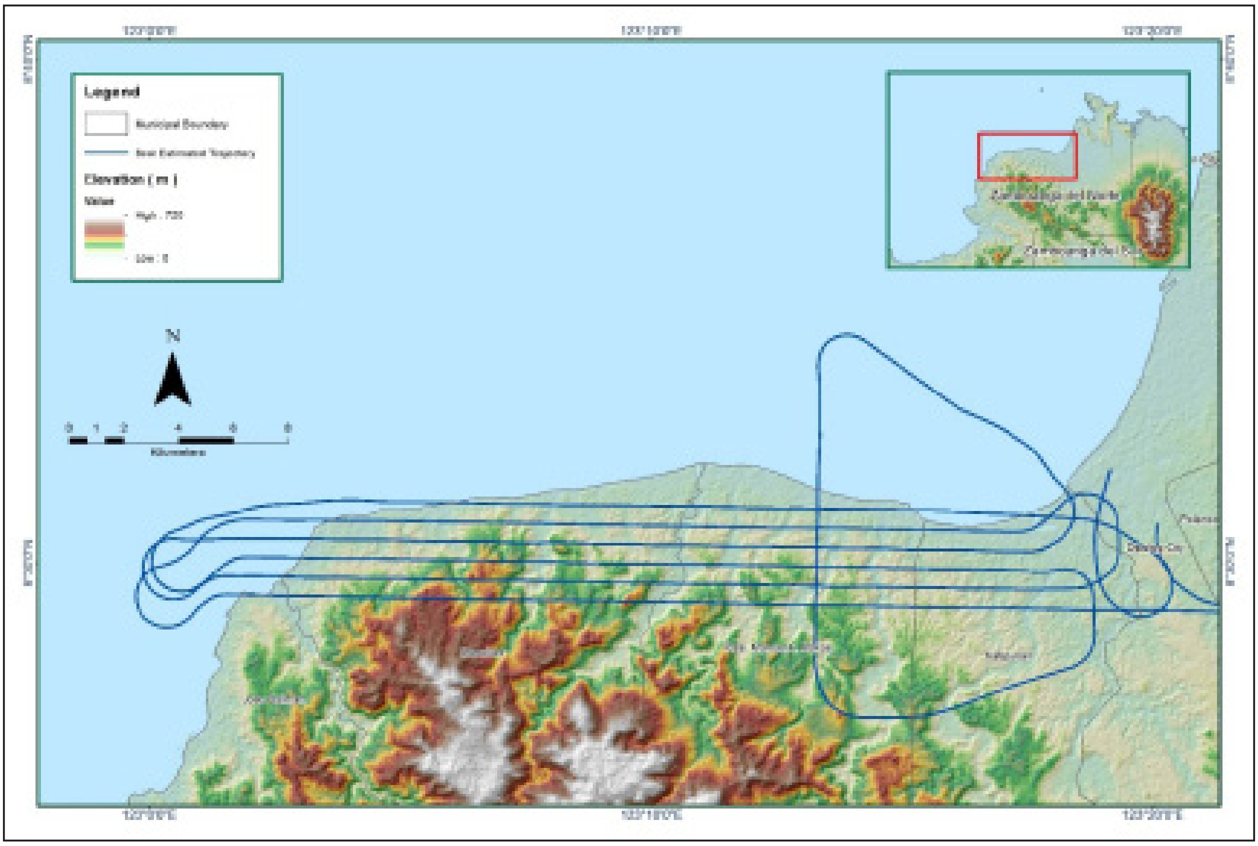



Figure A-8.24. Best Estimated Trajectory

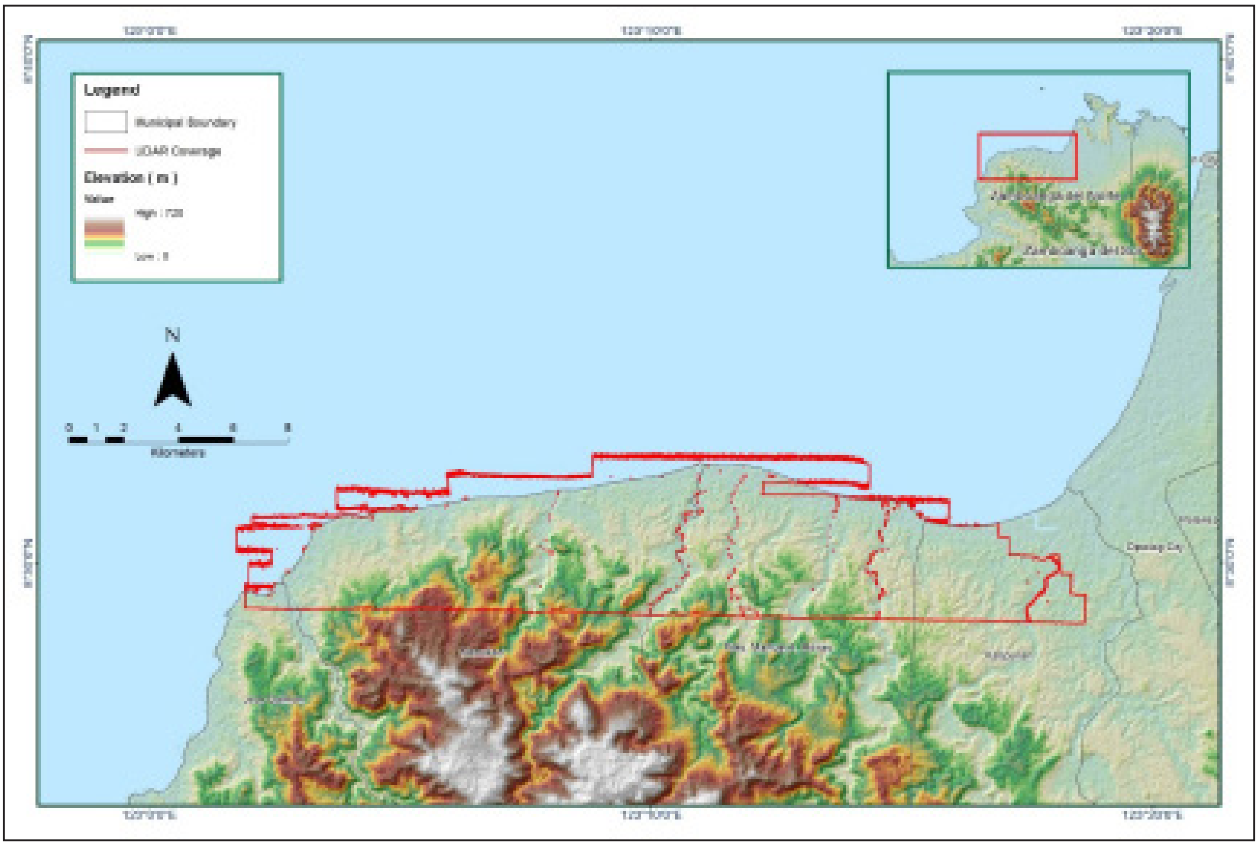



Figure A-8.25. Coverage of LiDAR data

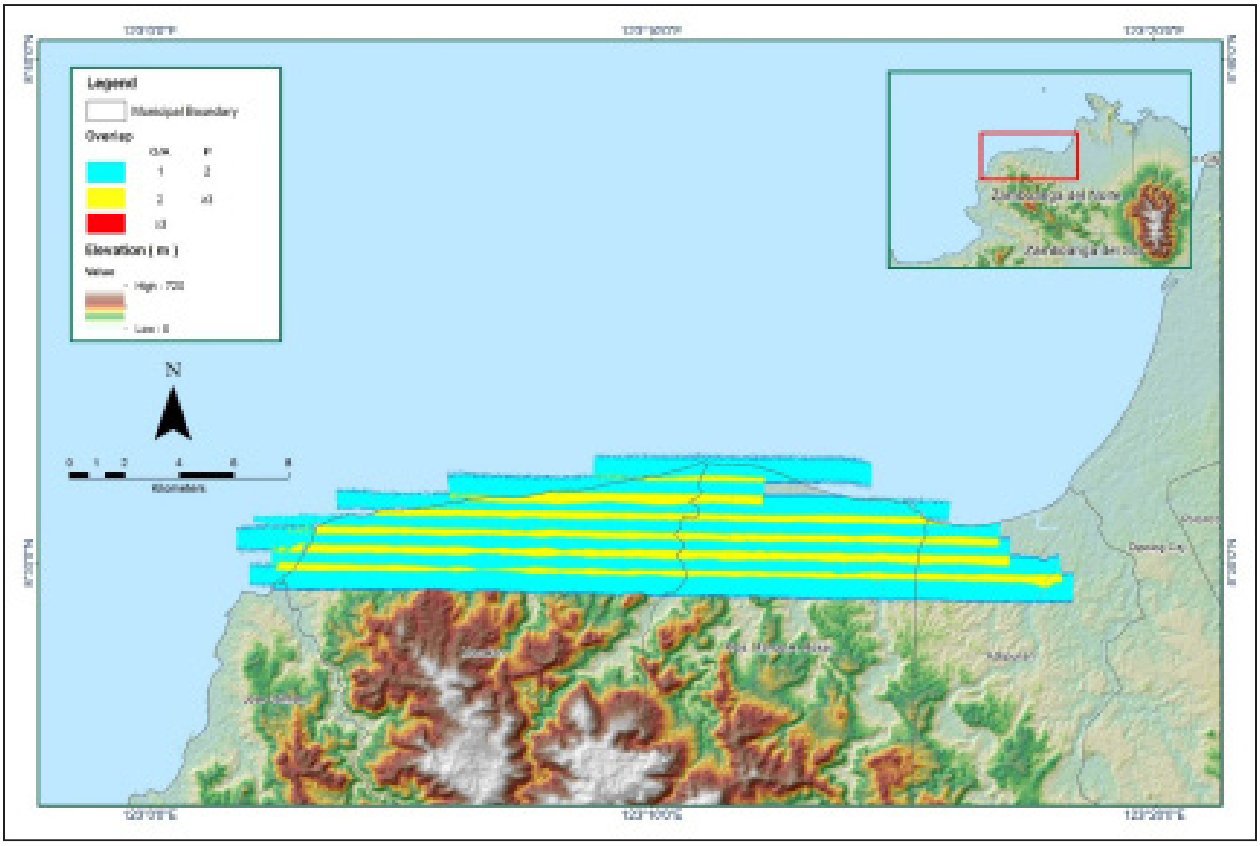



Figure A-8.26. Image of data overlap

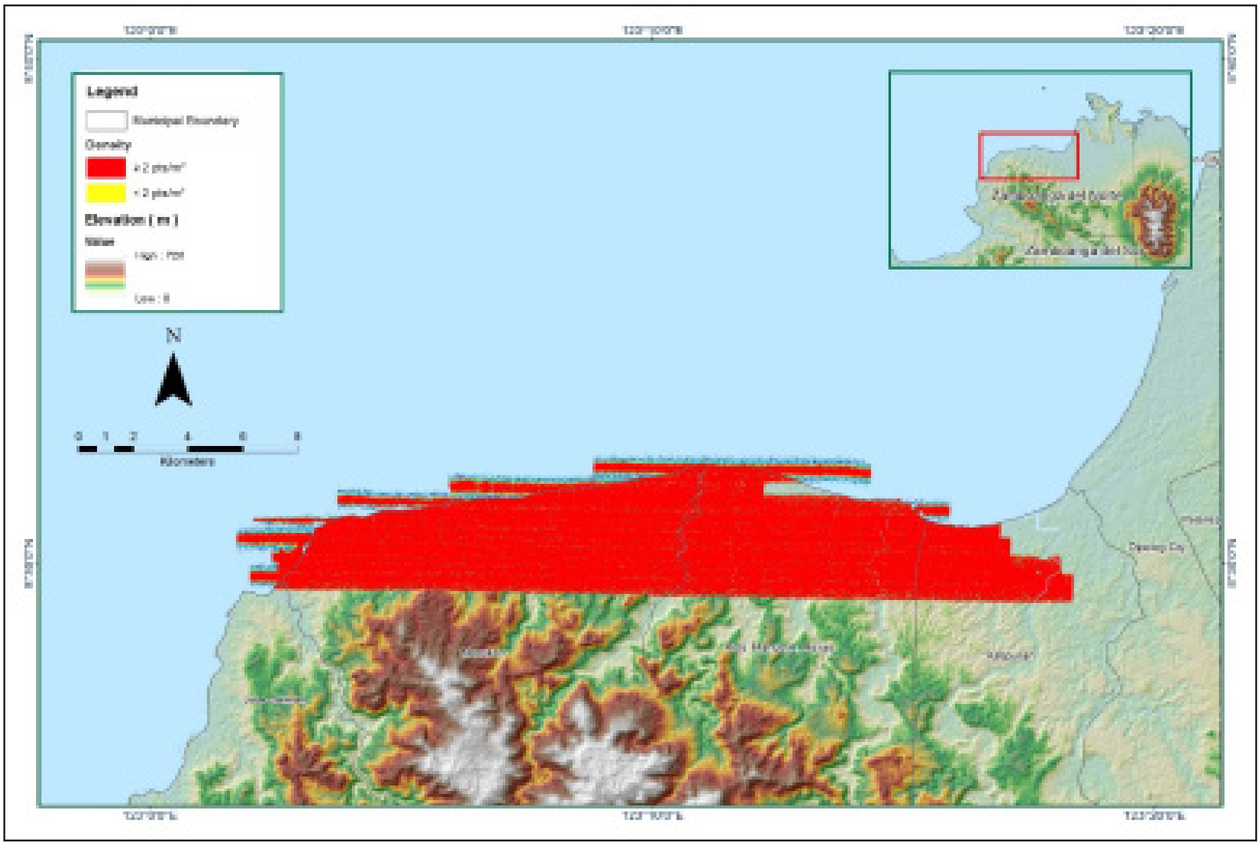



Figure A-8.27. Density map of merged LiDAR data

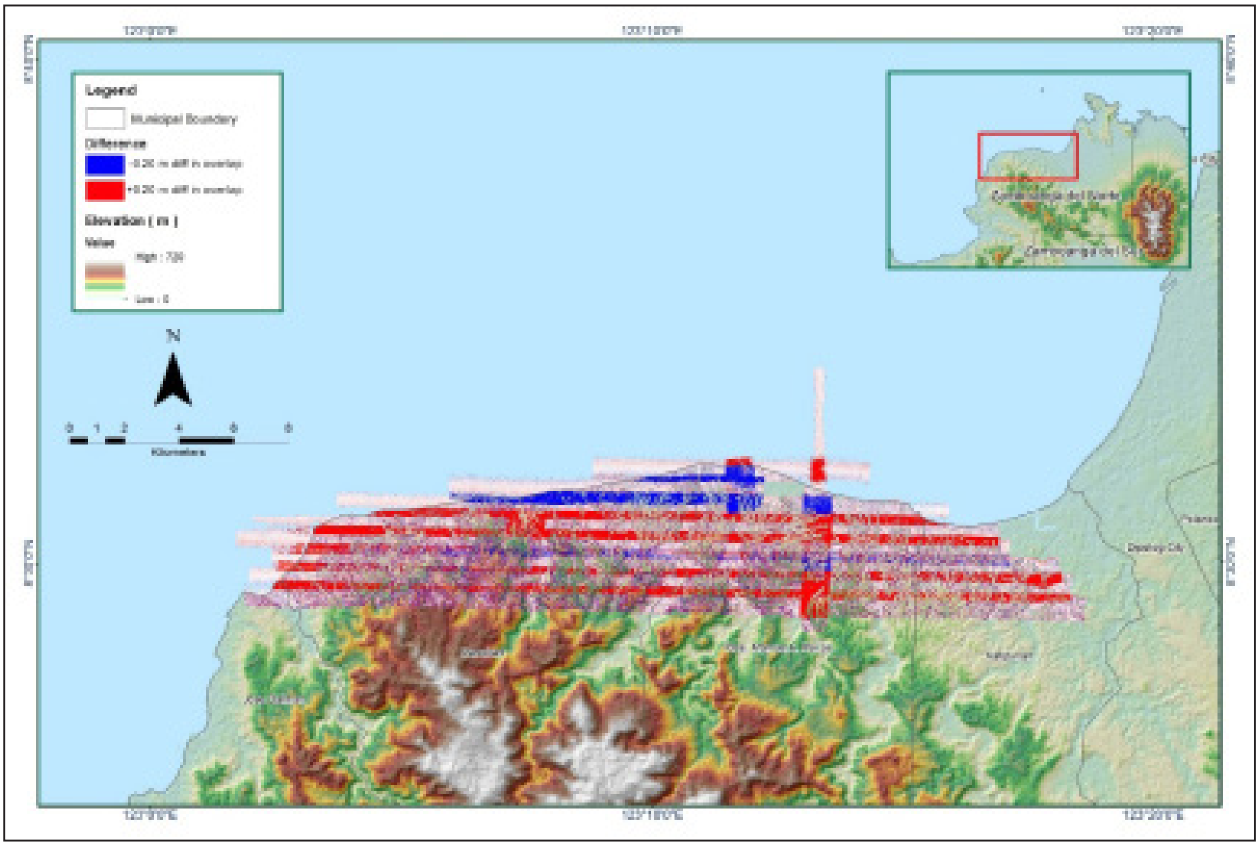


Figure A-8.28. Elevation difference between flight lines

Table A-8.5. Mission Summary Report for Blk69B

| Flight Area | Dipolog |
|---|---|
| Mission Name | Blk69B |
| Inclusive Flights | 2111P,2113P,2117P,2145P |
| Range data size | 76.8 GB |
| POS data size | 747 MB |
| Base data size | 36.85 MB |
| Image | 145.3 GB |
| Transfer date | November 19, 2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| Smoothed Performance Metrics (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.3 |
| RMSE for East Position (<4.0 cm) | 1.7 |
| RMSE for Down Position (<8.0 cm) | 3.8 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000230 |
| IMU attitude correction stdev (<0.001deg) | 0.001892 |
| GPS position stdev (<0.01m) | 0.0055 |
| | |
| Minimum % overlap (>25) | 45.84% |
| Ave point cloud density per sq.m. (>2.0) | 4.44 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 431 |
| Maximum Height | 583.31 m |
| Minimum Height | 64.64 m |
| | |
| Classification (# of points) | |
| Ground | 334,562,024 |
| Low vegetation | 335,327,811 |
| Medium vegetation | 532,124,060 |
| High vegetation | 552,692,726 |
| Building | 26,568,620 |
| | |
| Orthophoto | Yes |
| Processed by | Engr. Analyn Naldo, Engr. Melanie Hingpit, Ailyn Biñas |

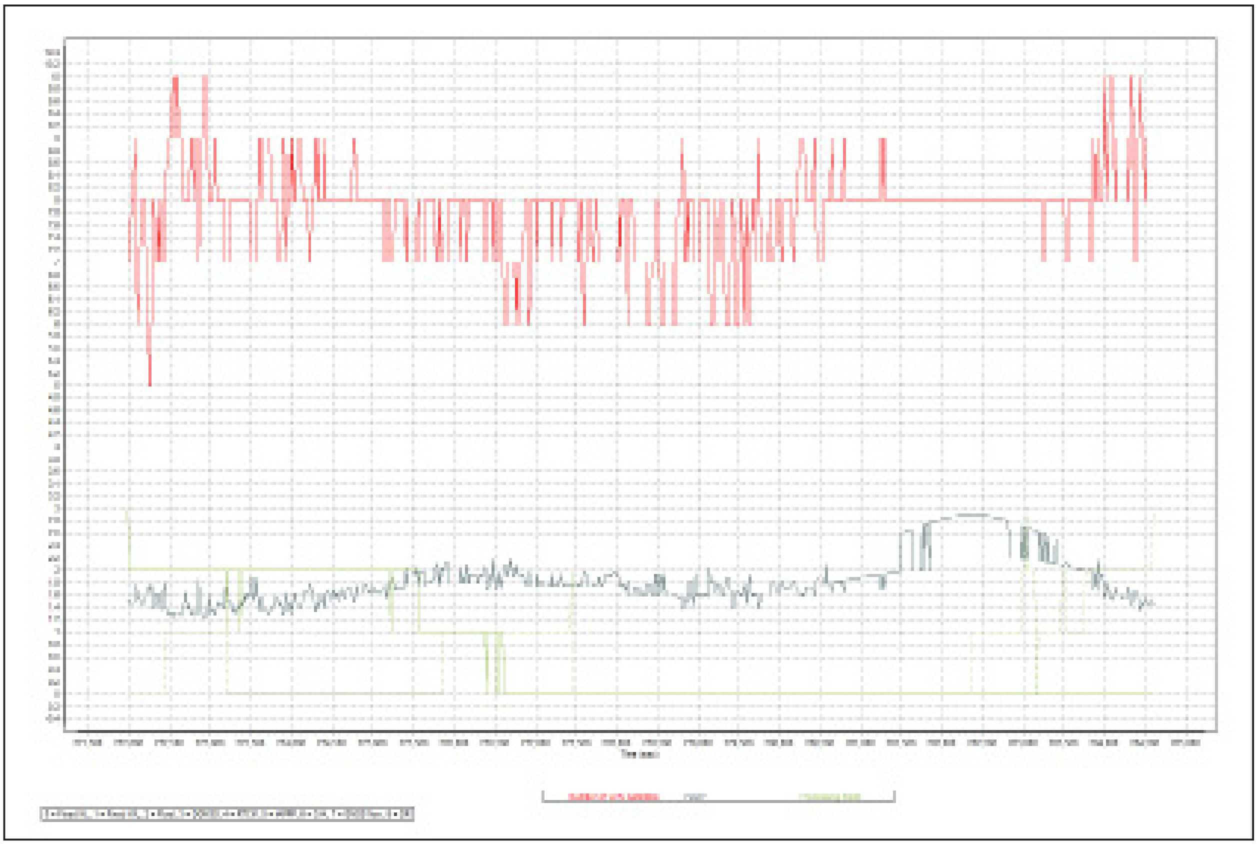


Figure A-8.29. Solution Status

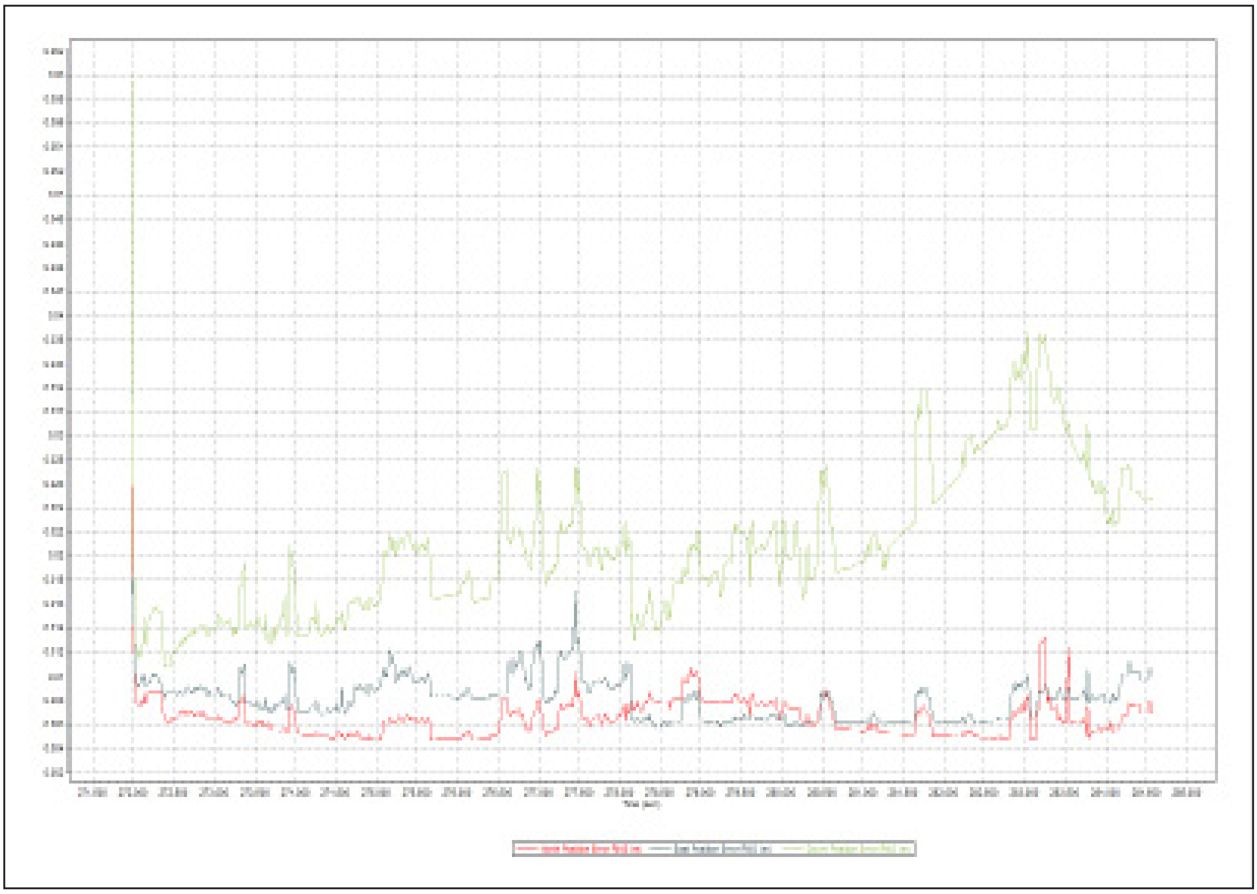


Figure A-8.30. Smoothed Performance Metric Parameters

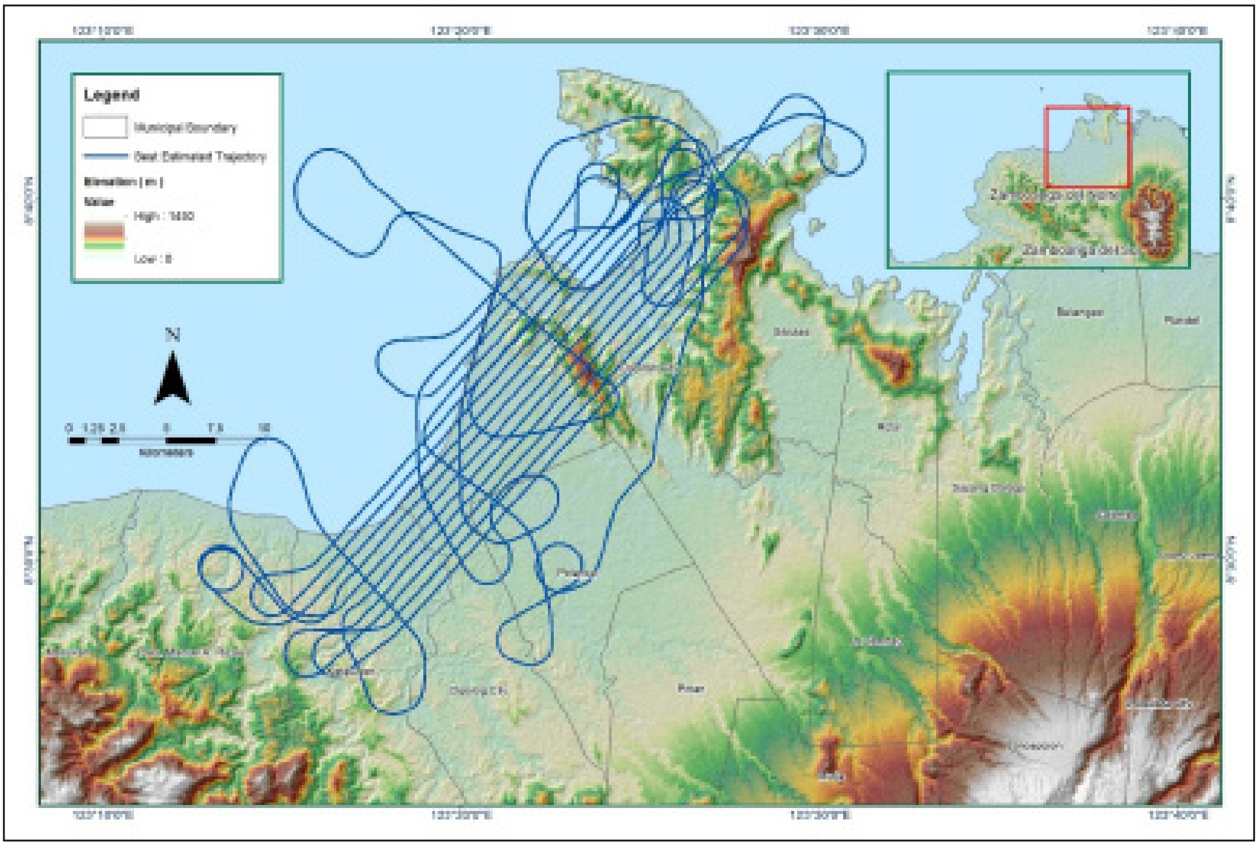



Figure A-8.31. Best Estimated Trajectory

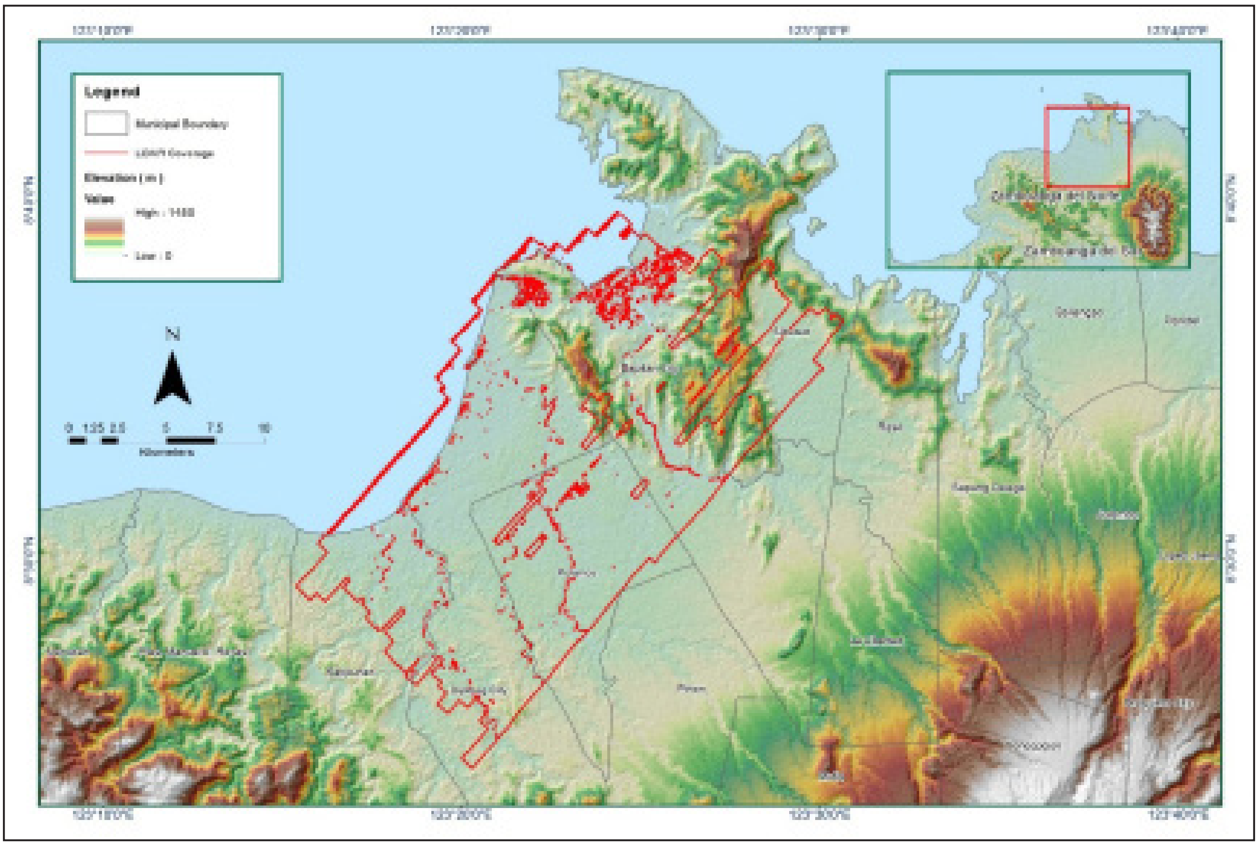



Figure A-8.32. Coverage of LiDAR data

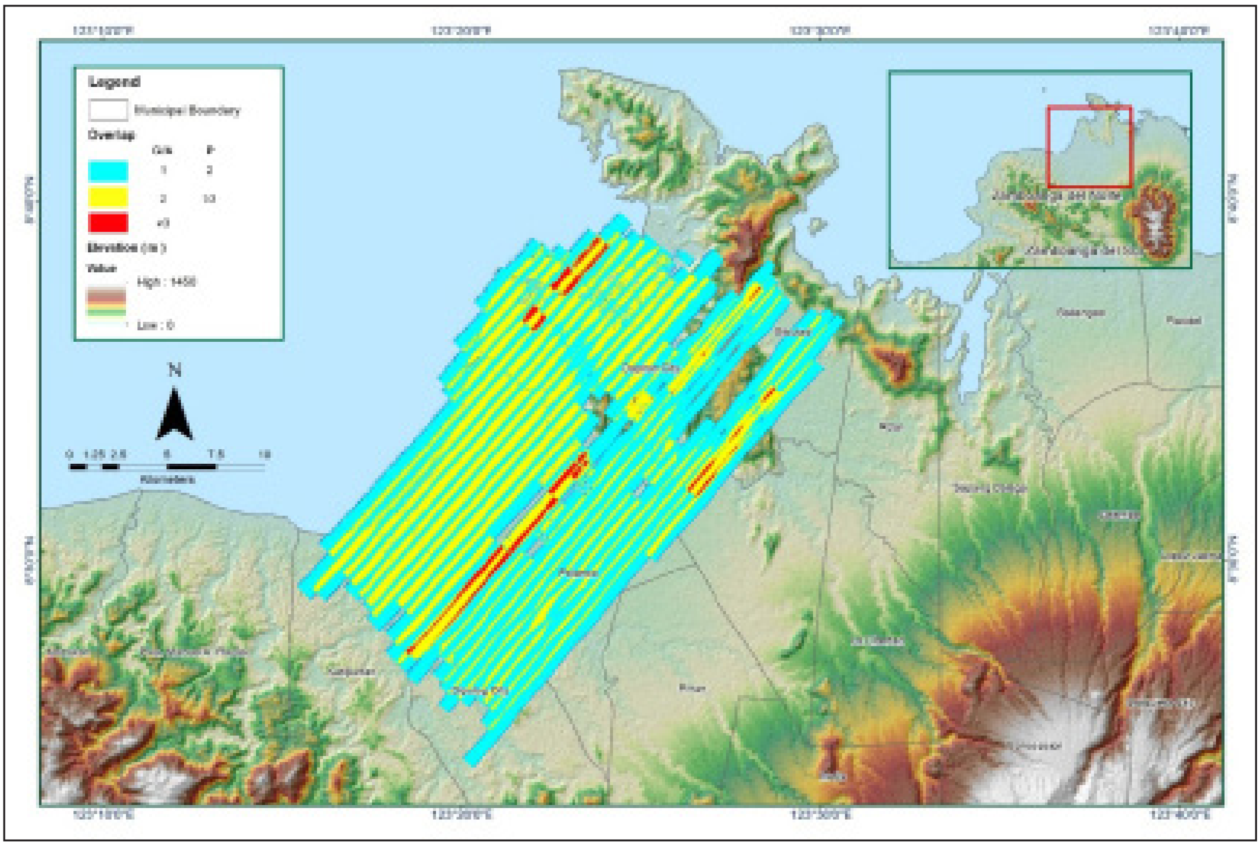



Figure A-8.33. Image of data overlap

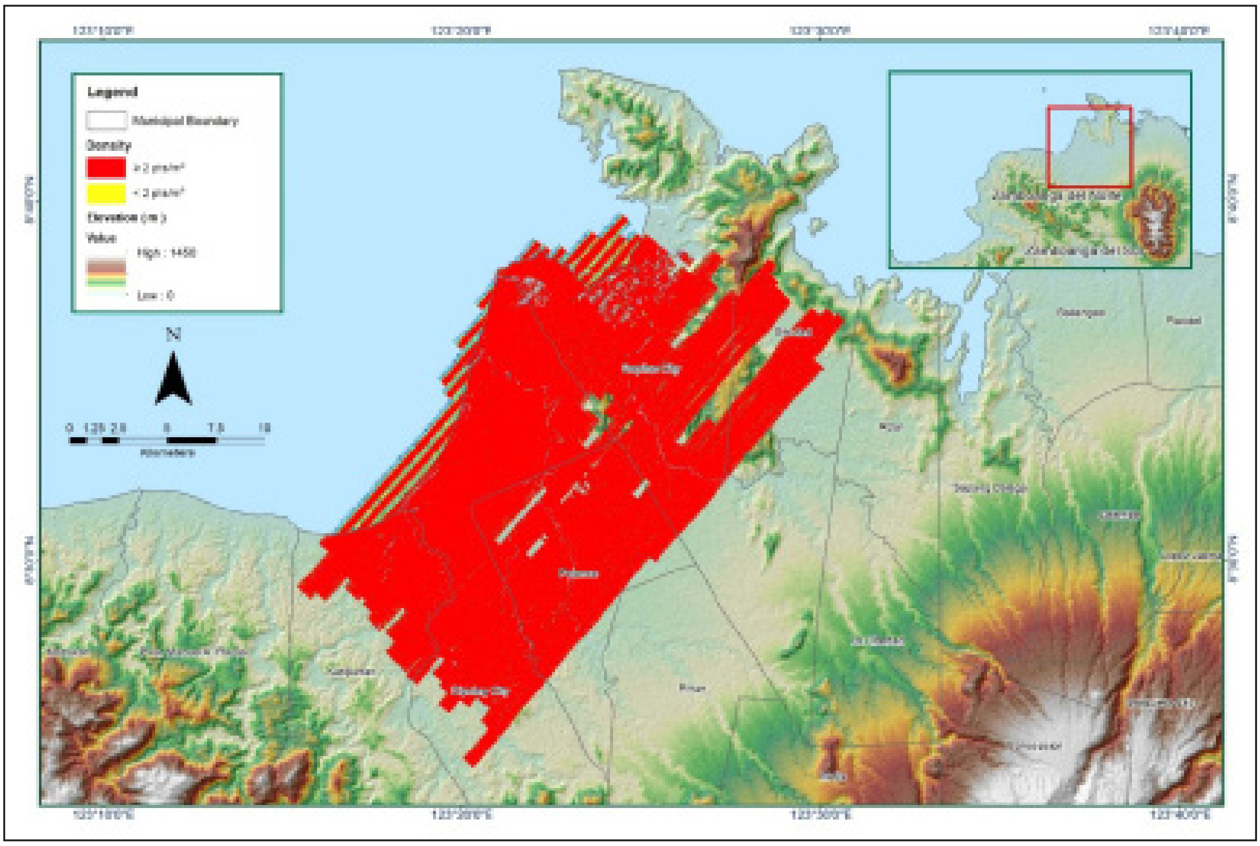



Figure A-8.34. Density map of merged LiDAR data

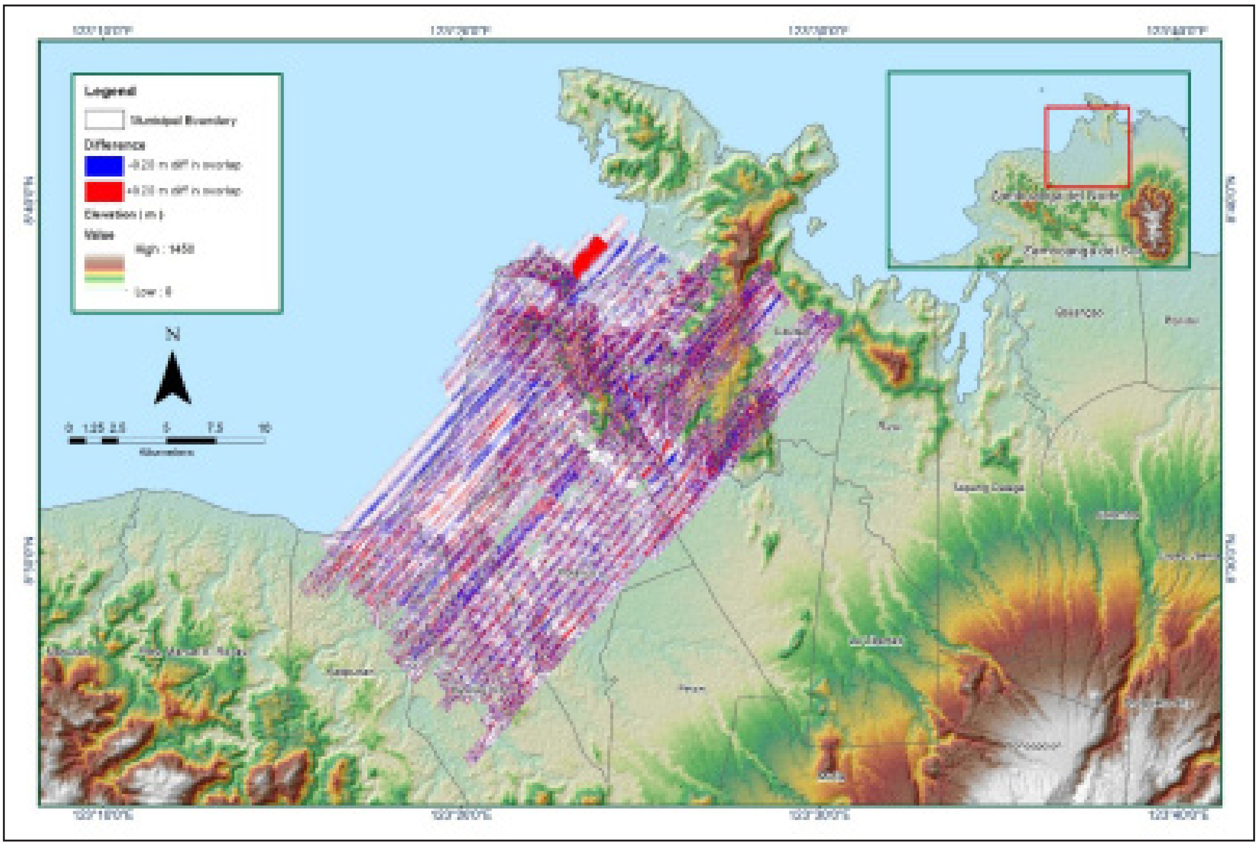



Figure A-8.35. Elevation difference between flight lines

Table A-8.6. Mission Summary Report for Blk69C

| Flight Area | Dipolog |
|---|---|
| Mission Name | Blk69C |
| Inclusive Flights | 2125P |
| Range data size | 15.4 GB |
| POS data size | 211 MB |
| Base data size | 37.4 MB |
| Image | 32.0 GB |
| Transfer date | November 19, 2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| Smoothed Performance Metrics (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.14 |
| RMSE for East Position (<4.0 cm) | 1.38 |
| RMSE for Down Position (<8.0 cm) | 2.8 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000285 |
| IMU attitude correction stdev (<0.001deg) | 0.000756 |
| GPS position stdev (<0.01m) | 0.0074 |
| | |
| Minimum % overlap (>25) | 33.55% |
| Ave point cloud density per sq.m. (>2.0) | 4.74 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 137 |
| Maximum Height | 578.40 m |
| Minimum Height | 69.46 m |
| | |
| Classification (# of points) | |
| Ground | 98,140,842 |
| Low vegetation | 88,616,617 |
| Medium vegetation | 171,027,483 |
| High vegetation | 145,166,407 |
| Building | 1,961,664 |
| | |
| Orthophoto | Yes |
| Processed by | Engr. Analyn Naldo, Engr. Christy Lubiano, Jovy Narisma |

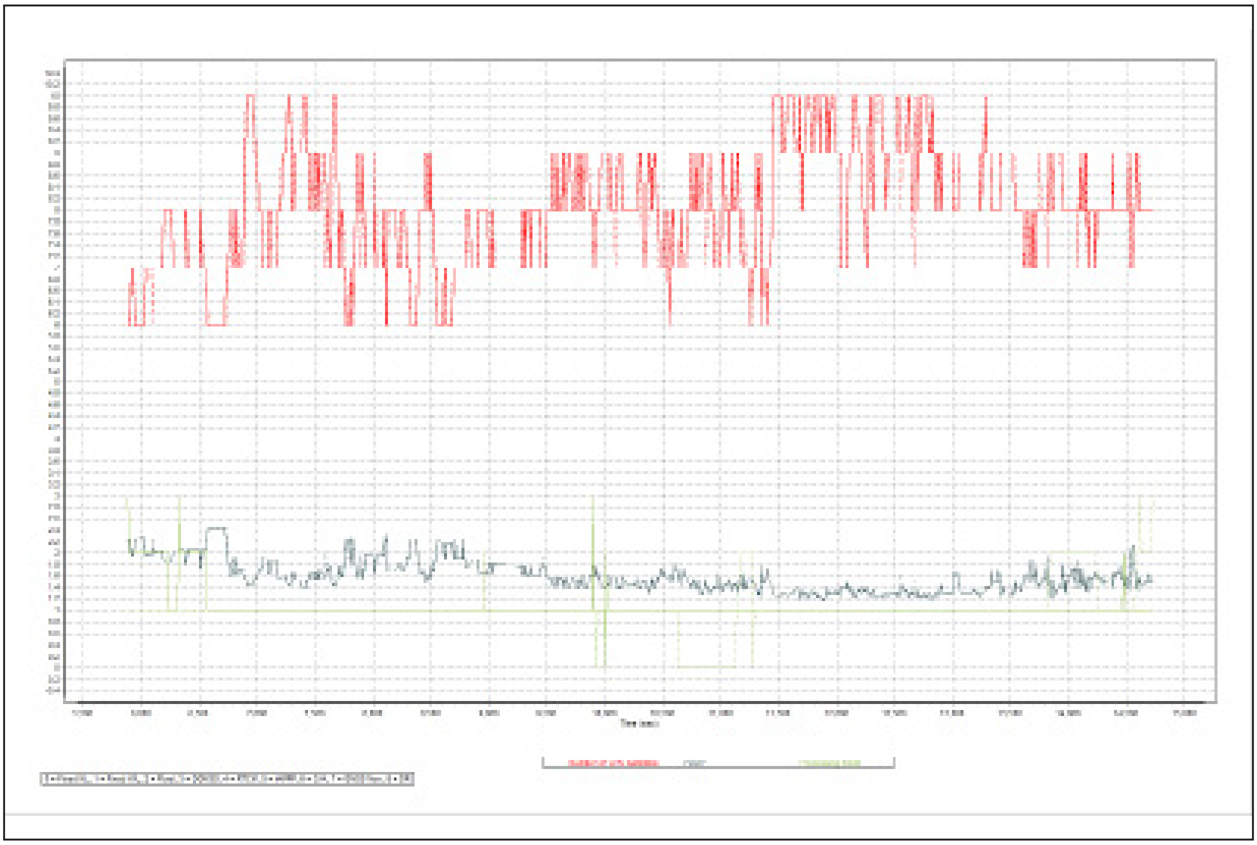


Figure A-8.36. Solution Status

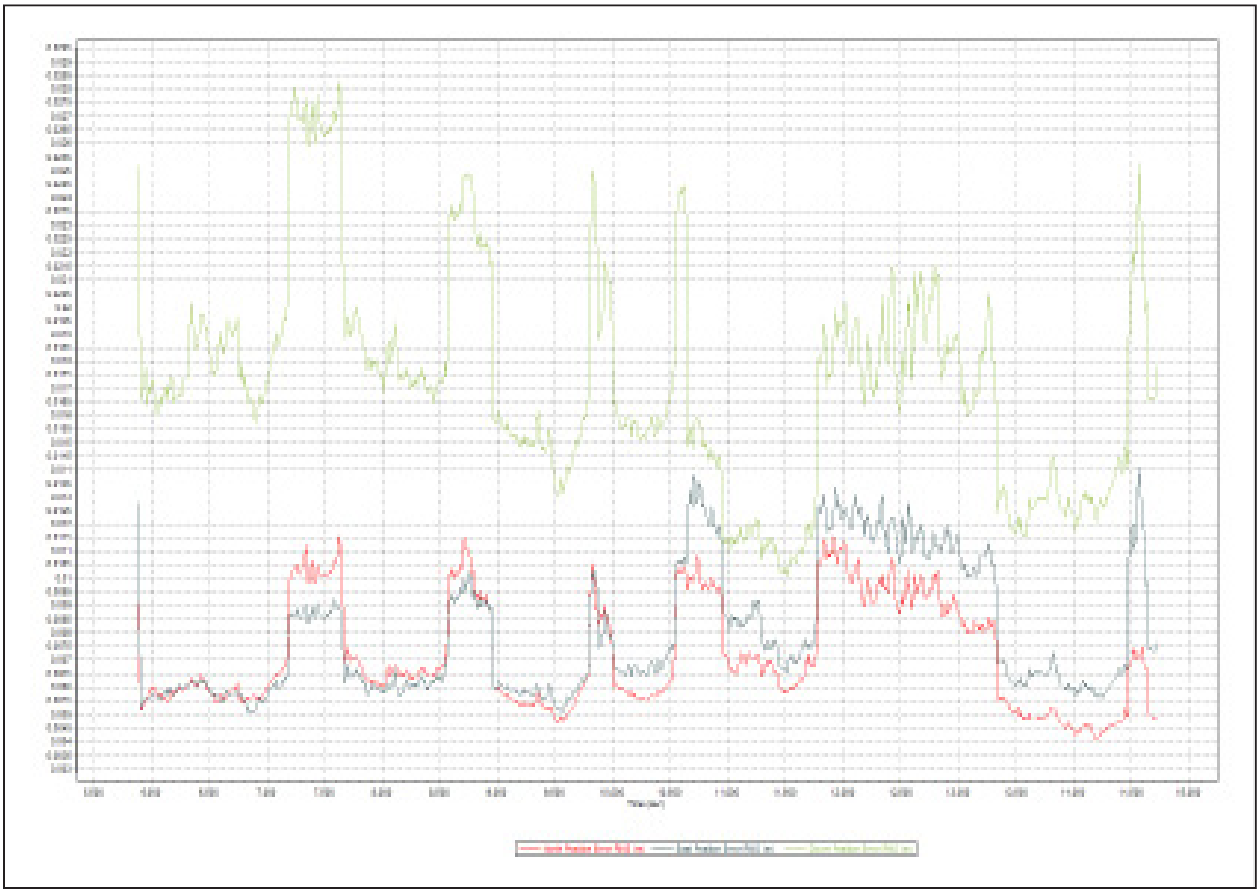


Figure A-8.37. Smoothed Performance Metric Parameters

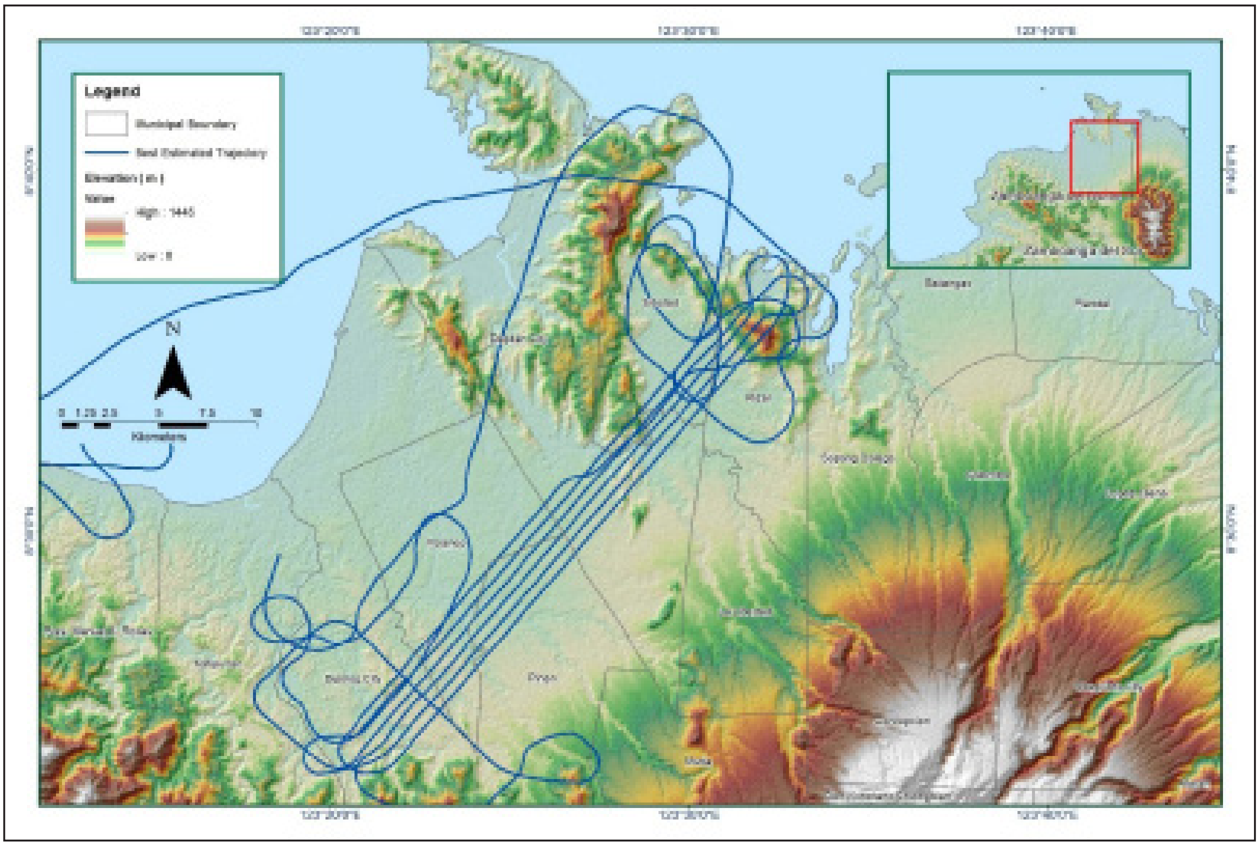



Figure A-8.38. Best Estimated Trajectory

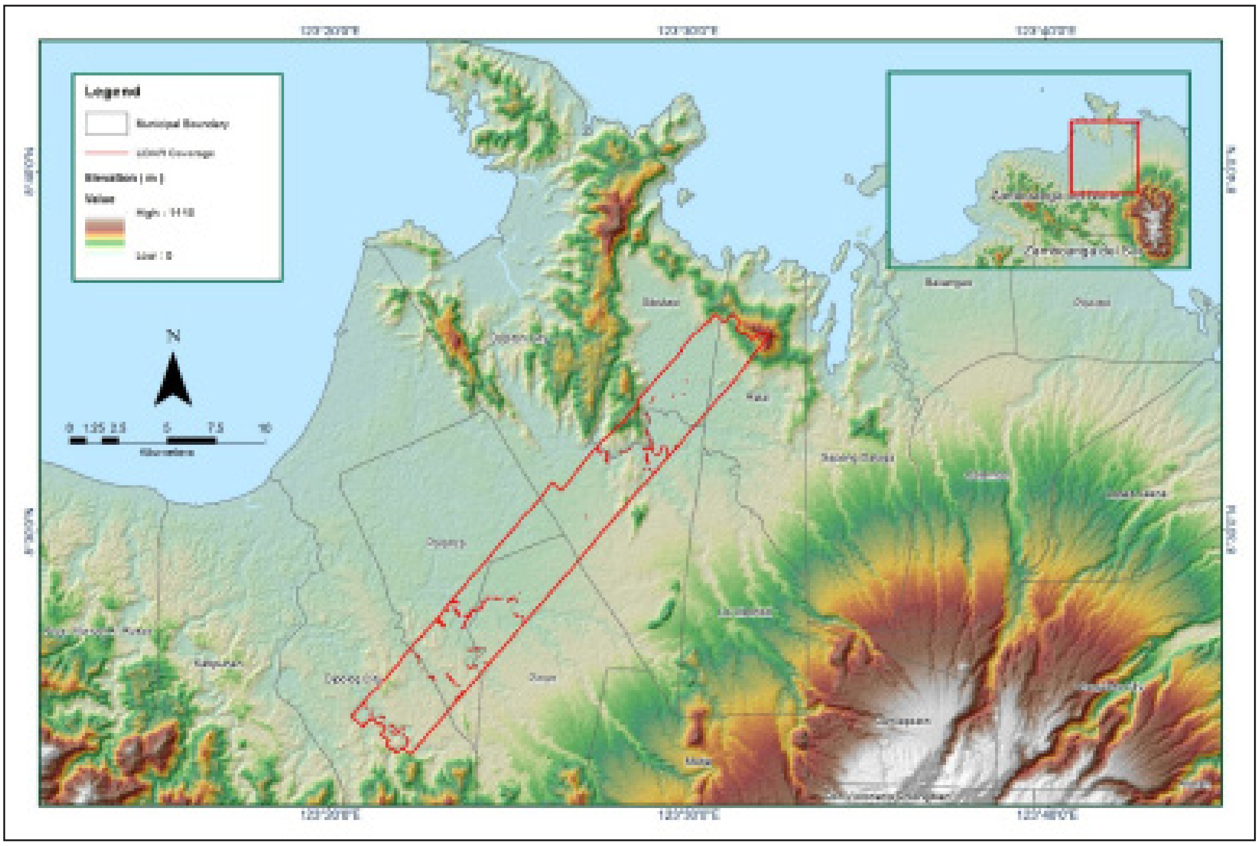



Figure A-8.39. Coverage of LiDAR data

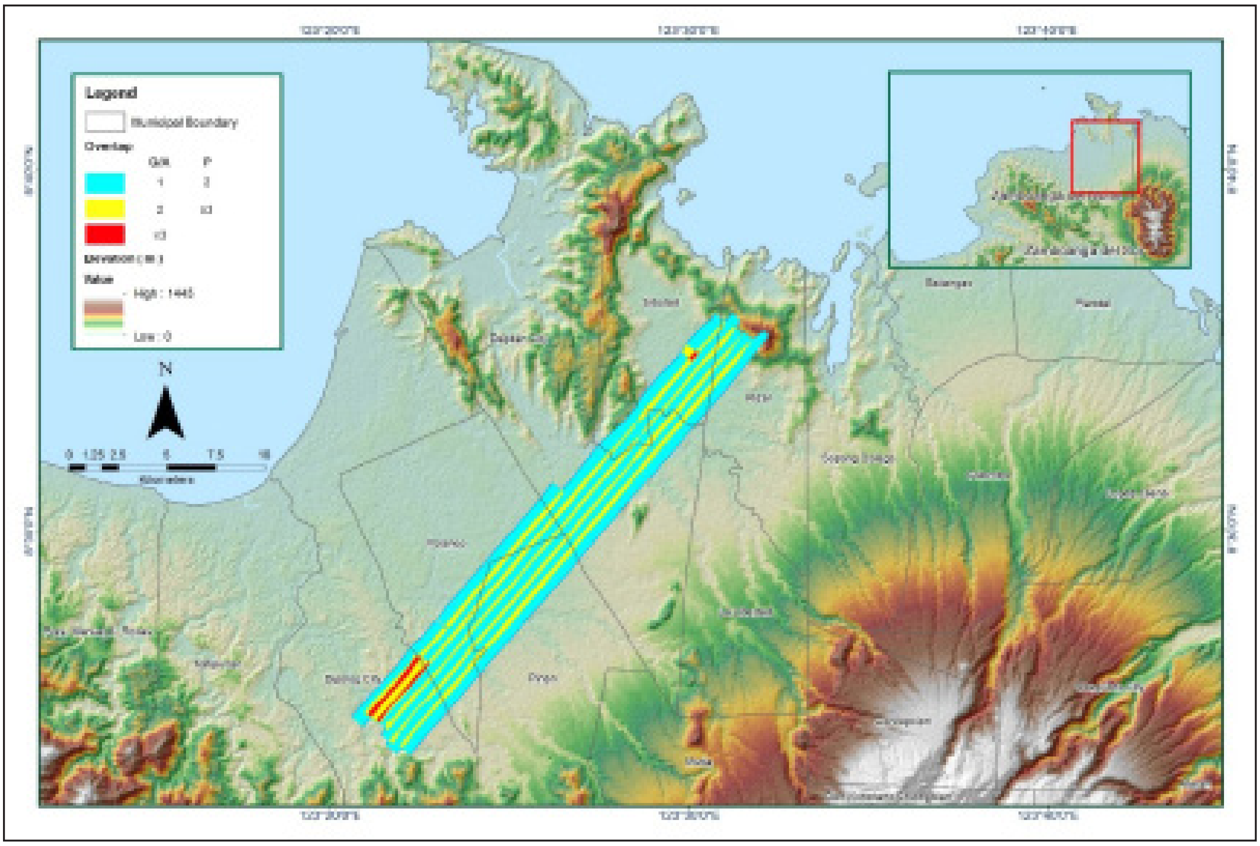



Figure A-8.40. Image of data overlap

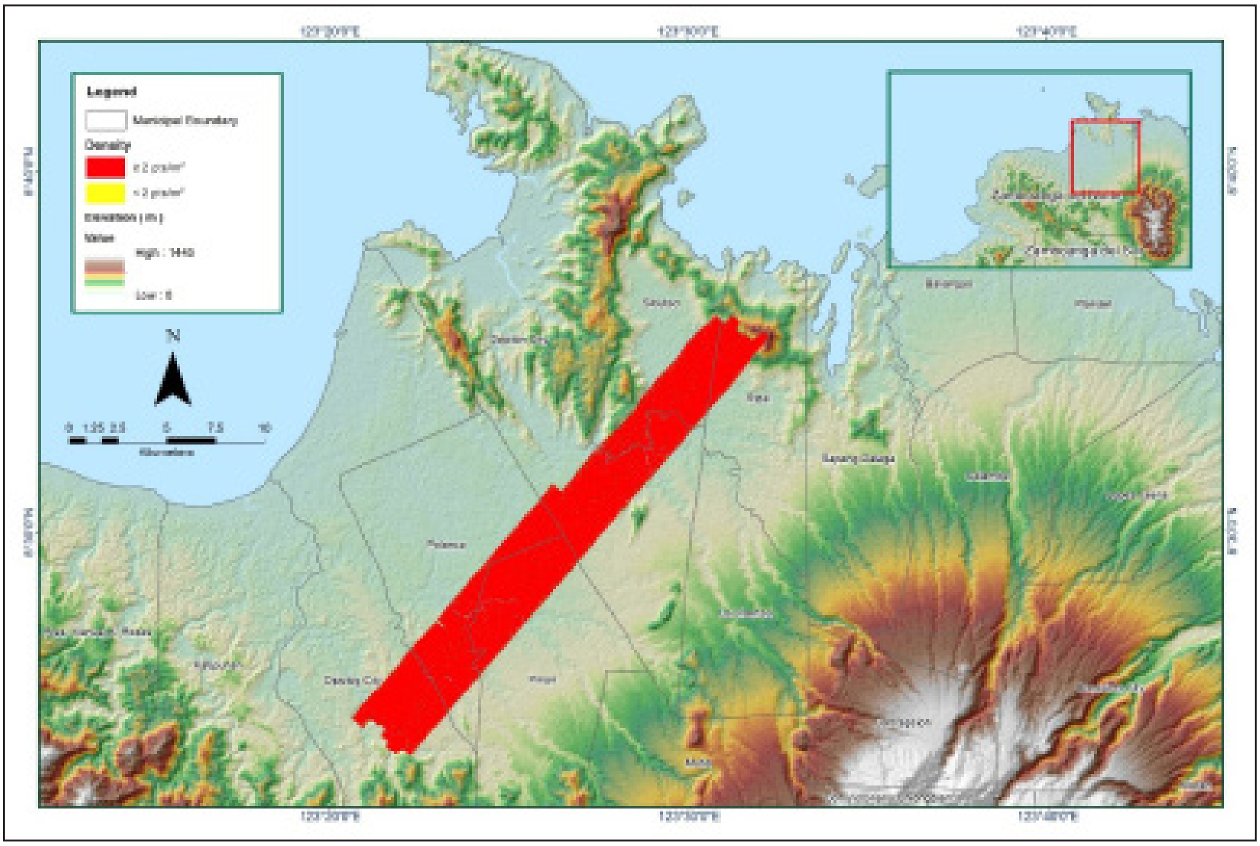



Figure A-8.41. Density map of merged LiDAR data

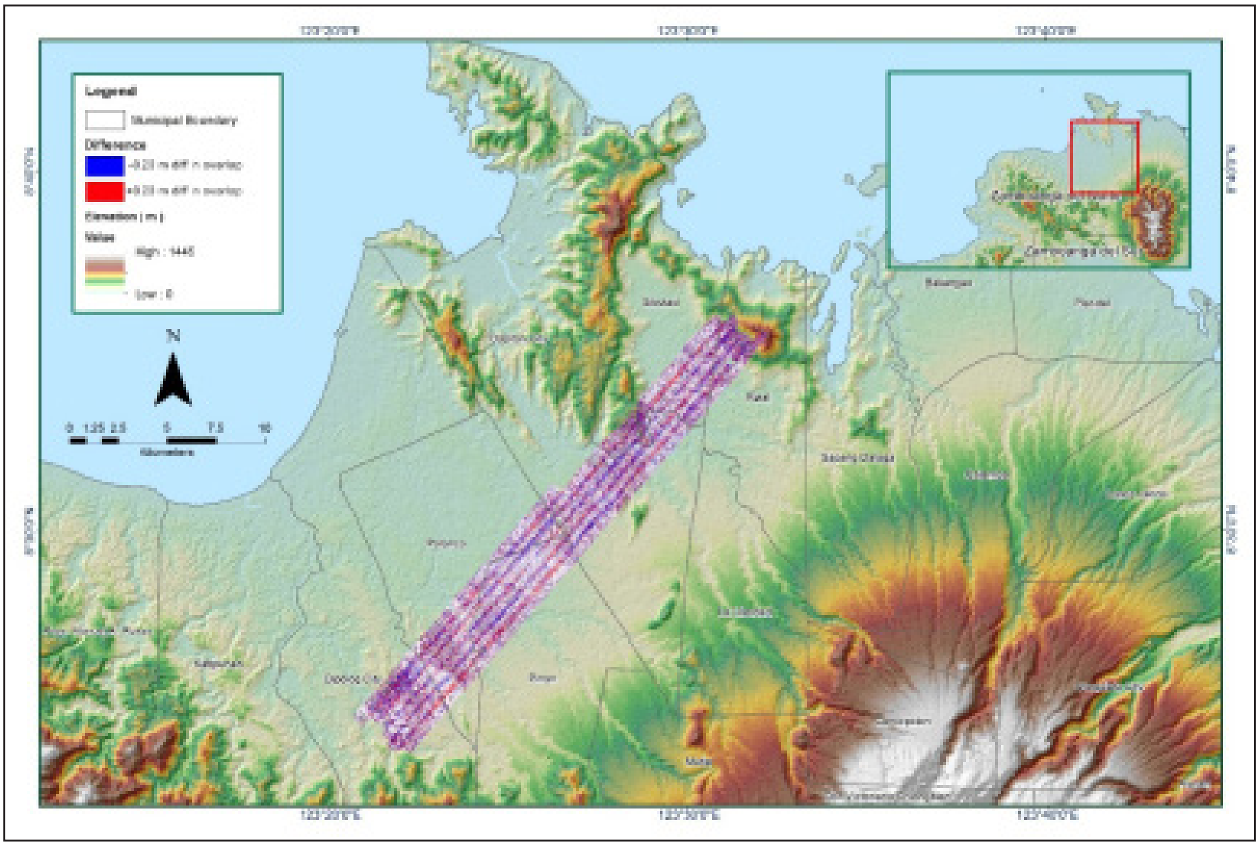



Figure A-8.42. Elevation difference between flight lines

Table A-8.7. Mission Summary Report for Blk70ABC

| Flight Area | Dipolog |
|---|---|
| Mission Name | Blk70ABC |
| Inclusive Flights | 2149P, 2177P |
| Mission Name | 1BLK70B305A |
| Range data size | 37.8 GB |
| POS data size | 391 MB |
| Base data size | 47 MB |
| Image | 55.2 GB |
| Transfer date | November 19, 2014 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| Smoothed Performance Metrics (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.35 |
| RMSE for East Position (<4.0 cm) | 1.6 |
| RMSE for Down Position (<8.0 cm) | 2.6 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000159 |
| IMU attitude correction stdev (<0.001deg) | 0.001322 |
| GPS position stdev (<0.01m) | 0.0189 |
| | |
| Minimum % overlap (>25) | 41.61% |
| Ave point cloud density per sq.m. (>2.0) | 3.95 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 359 |
| Maximum Height | 514.64 m |
| Minimum Height | 62.73 m |
| | |
| Classification (# of points) | |
| Ground | 272,242,135 |
| Low vegetation | 253,869,557 |
| Medium vegetation | 442,668,616 |
| High vegetation | 313,121,350 |
| Building | 10,785,483 |
| | |
| Orthophoto | YES |
| Processed by | Engr. Jennifer Saguran, Engr. Antonio Chua Jr., Engr. Jeffrey Delica |

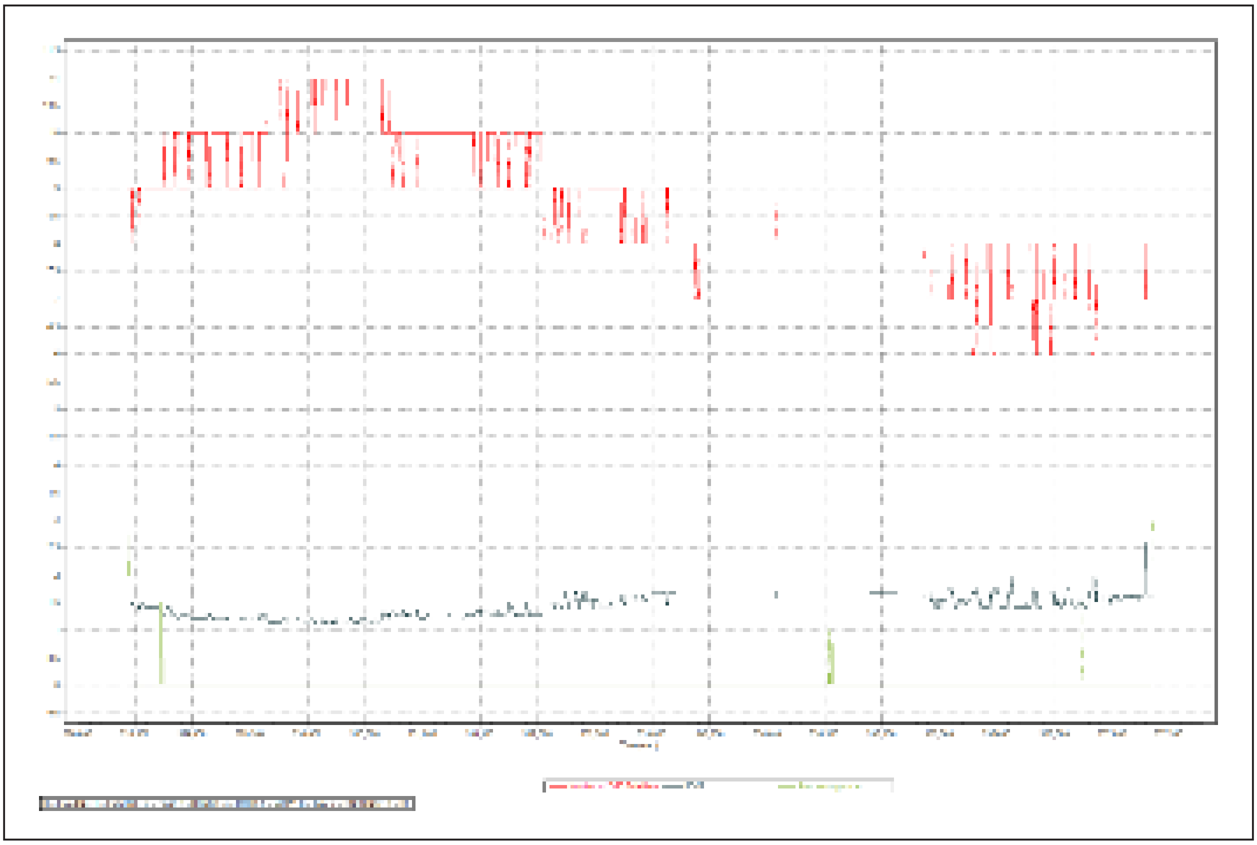


Figure A-8.43. Solution Status

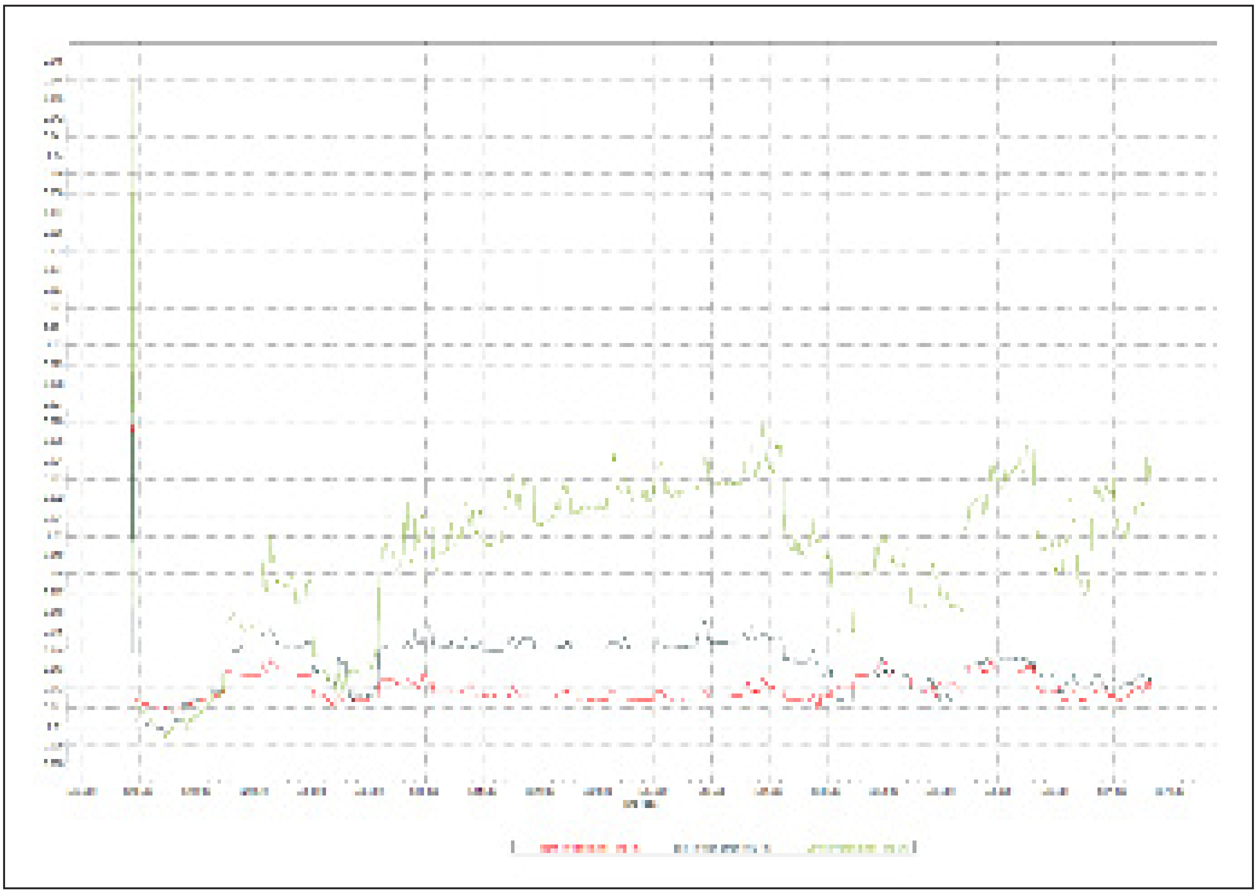


Figure A-8.44. Smoothed Performance Metric Parameters

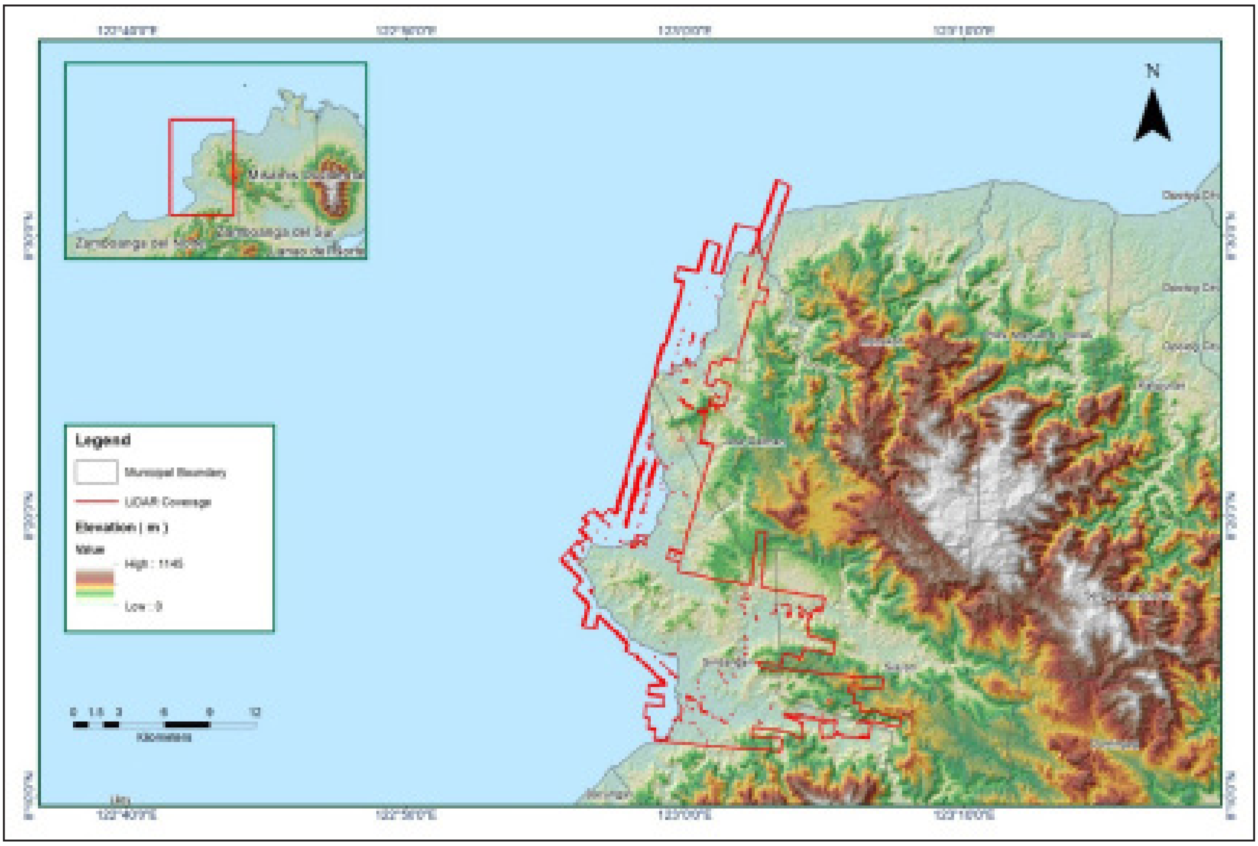



Figure A-8.45. Best Estimated Trajectory

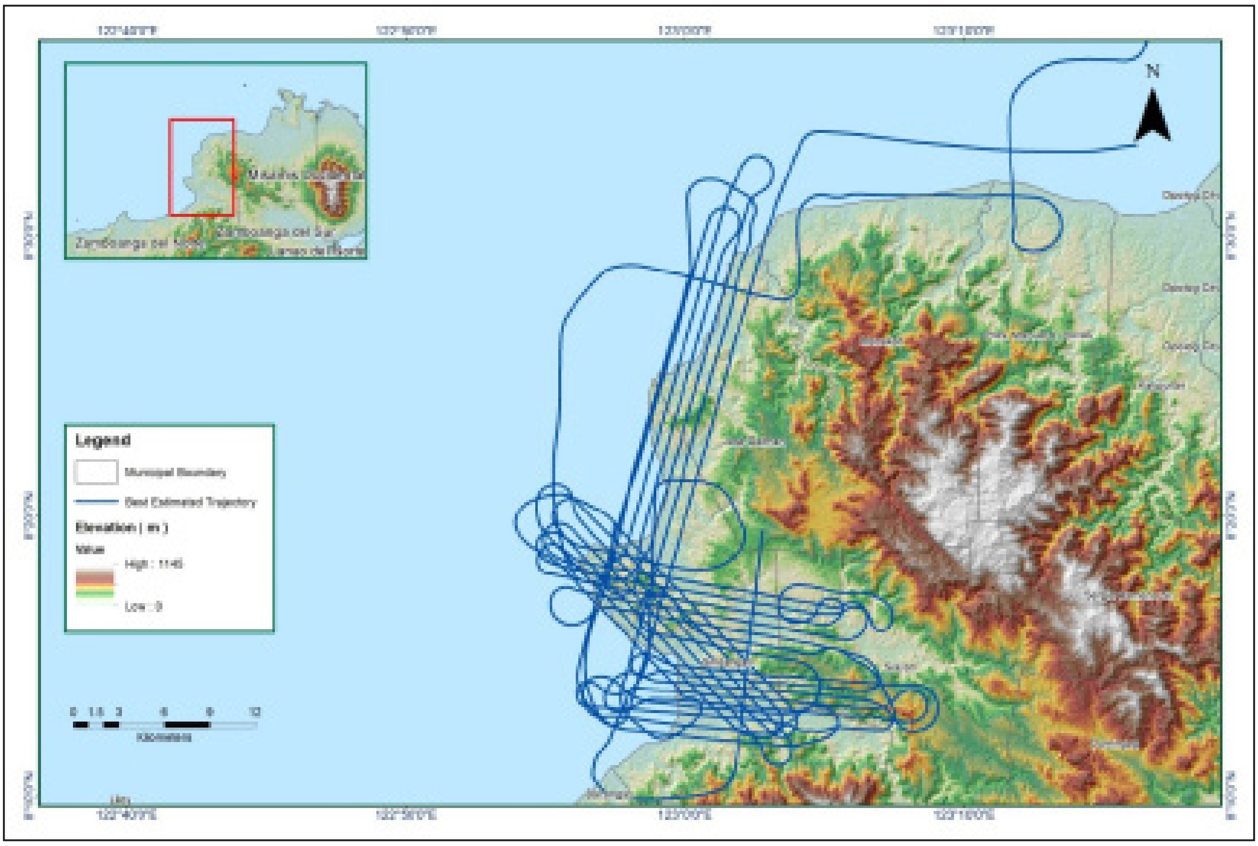



Figure A-8.46. Coverage of LiDAR data

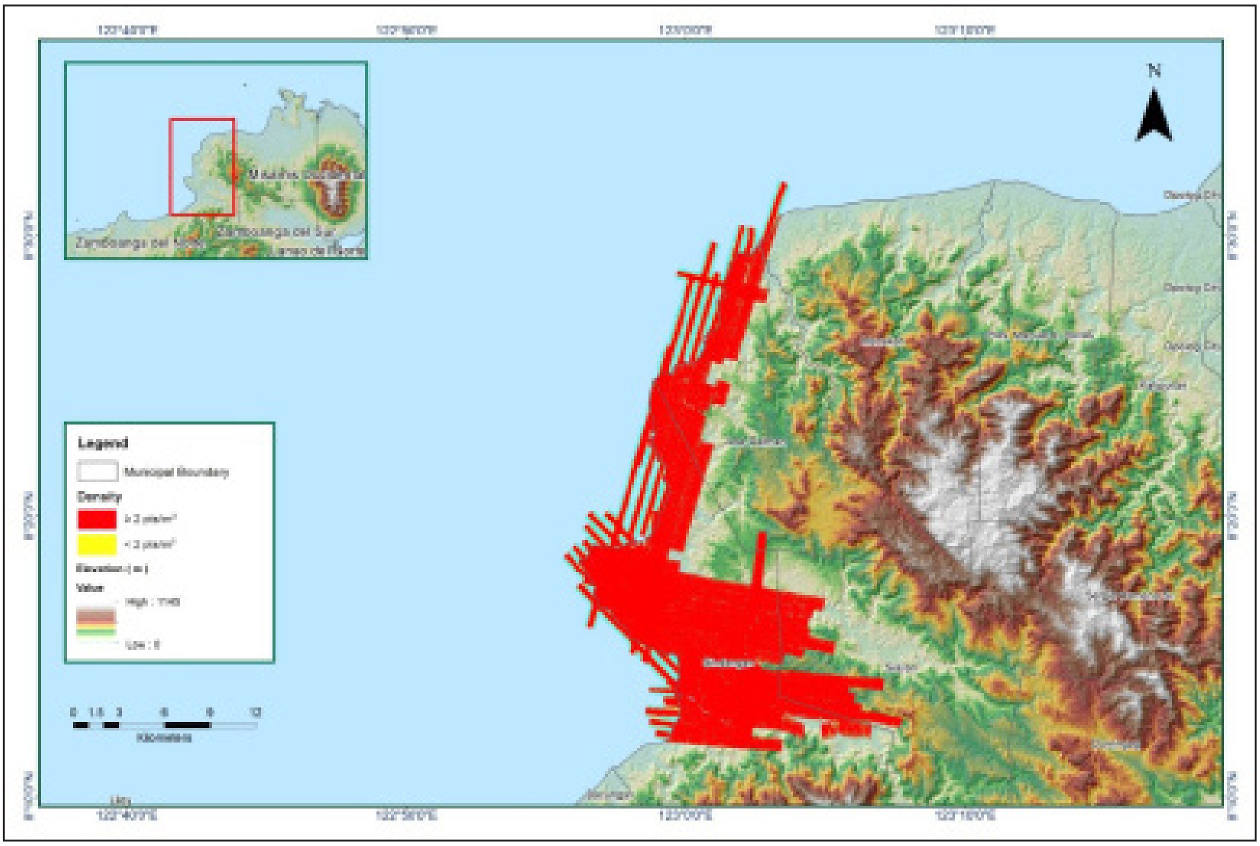


Figure A-8.47. Image of data overlap

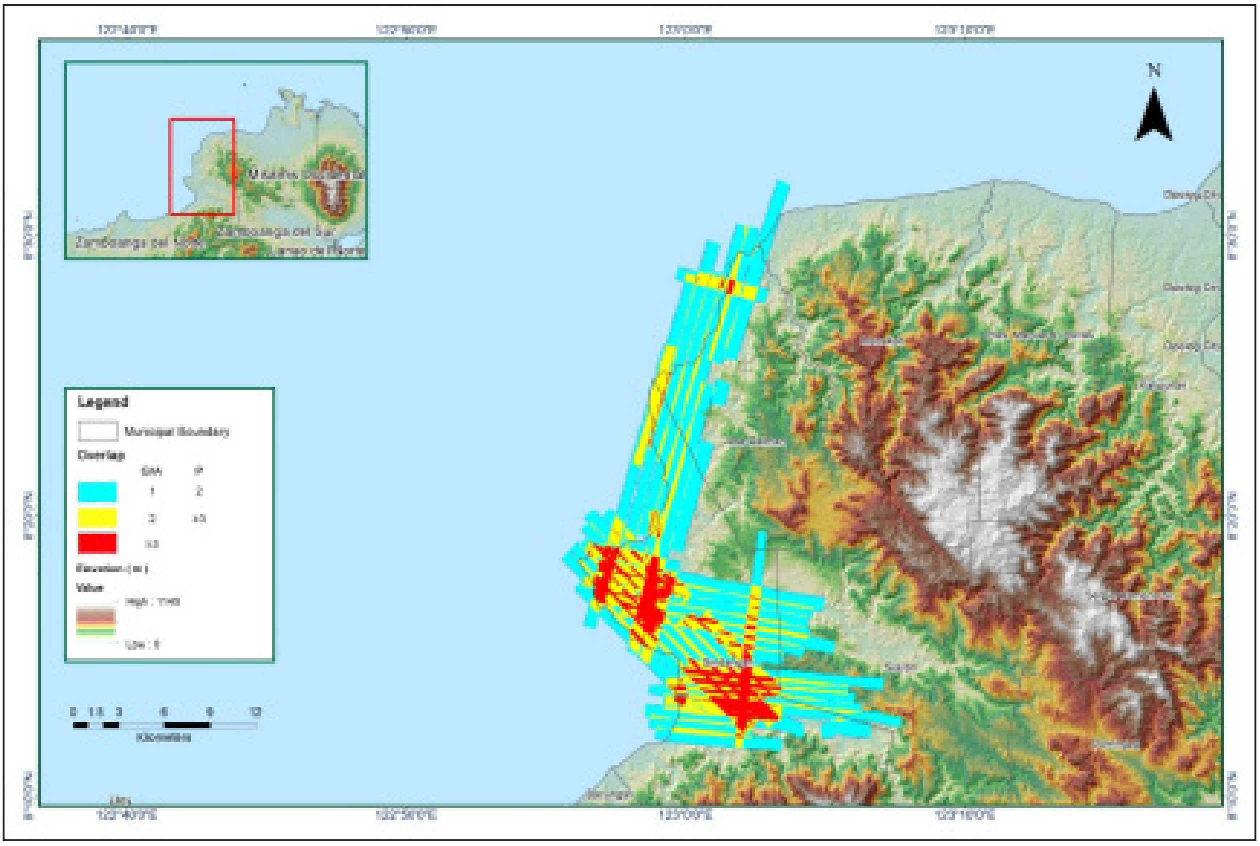


Figure A-8.48. Density map of merged LiDAR data

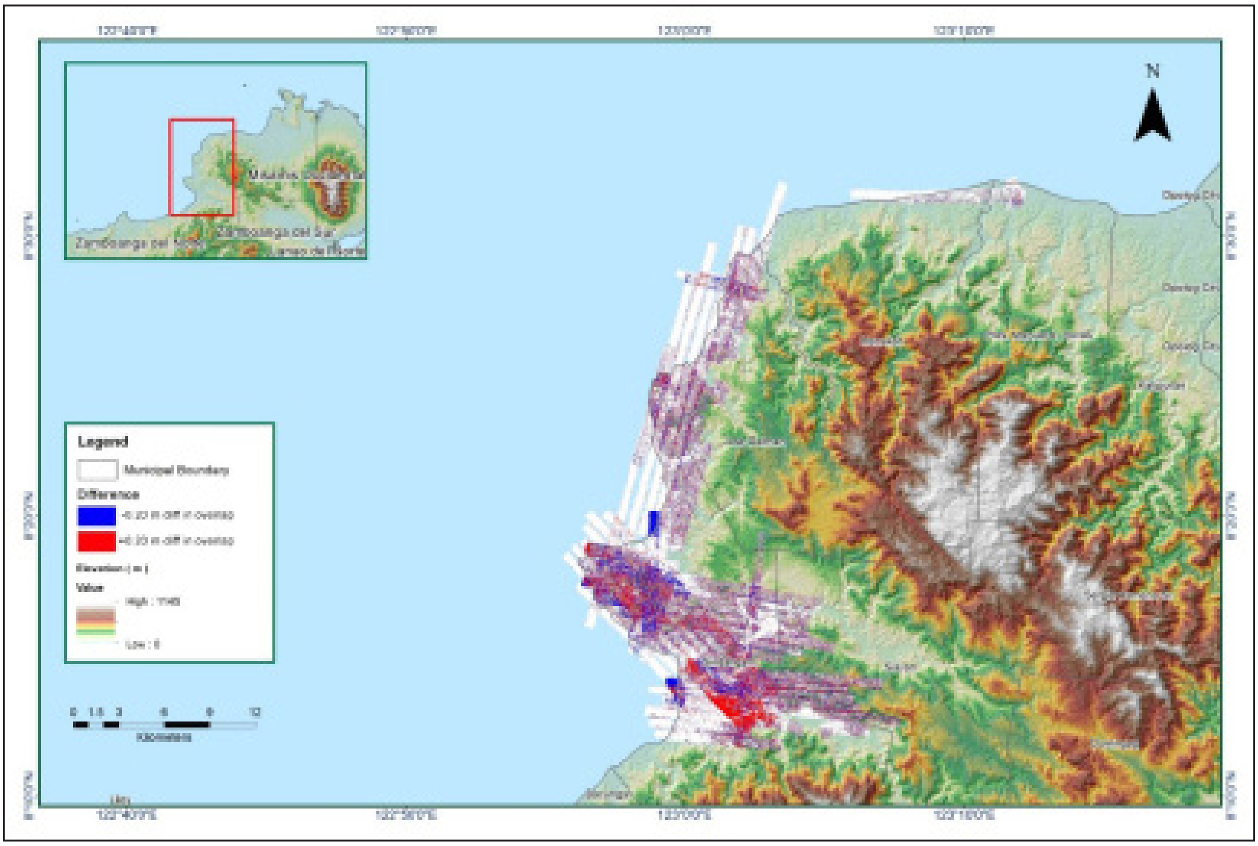



Figure A-8.49. Elevation difference between flight lines

Table A-8.8. Mission Summary Report for Blk69B

| Flight Area | Dipolog reflights |
|---|---|
| Mission Name | Blk69B |
| Inclusive Flights | 23558P |
| Range data size | 24.8 GB |
| POS data size | 274 MB |
| Base data size | 175 MB |
| Image | n/a |
| Transfer date | December 6, 2016 |
| | |
| Solution Status | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | No |
| | |
| Smoothed Performance Metrics (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.329 |
| RMSE for East Position (<4.0 cm) | 1.723 |
| RMSE for Down Position (<8.0 cm) | 3.136 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000167 |
| IMU attitude correction stdev (<0.001deg) | 0.000378 |
| GPS position stdev (<0.01m) | 0.0047 |
| | |
| Minimum % overlap (>25) | 49.03 % |
| Ave point cloud density per sq.m. (>2.0) | 5.73 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 218 |
| Maximum Height | 471.64 m |
| Minimum Height | 61.43 m |
| | |
| Classification (# of points) | |
| Ground | 147,409,242 |
| Low vegetation | 138,606,637 |
| Medium vegetation | 306,863,820 |
| High vegetation | 915,242,697 |
| Building | 9,788,405 |
| | |
| Orthophoto | No |
| Processed by | Engr. Analyn Naldo, Engr. Ma. Joanne Balaga, Engr. Gladys Mae Apat |

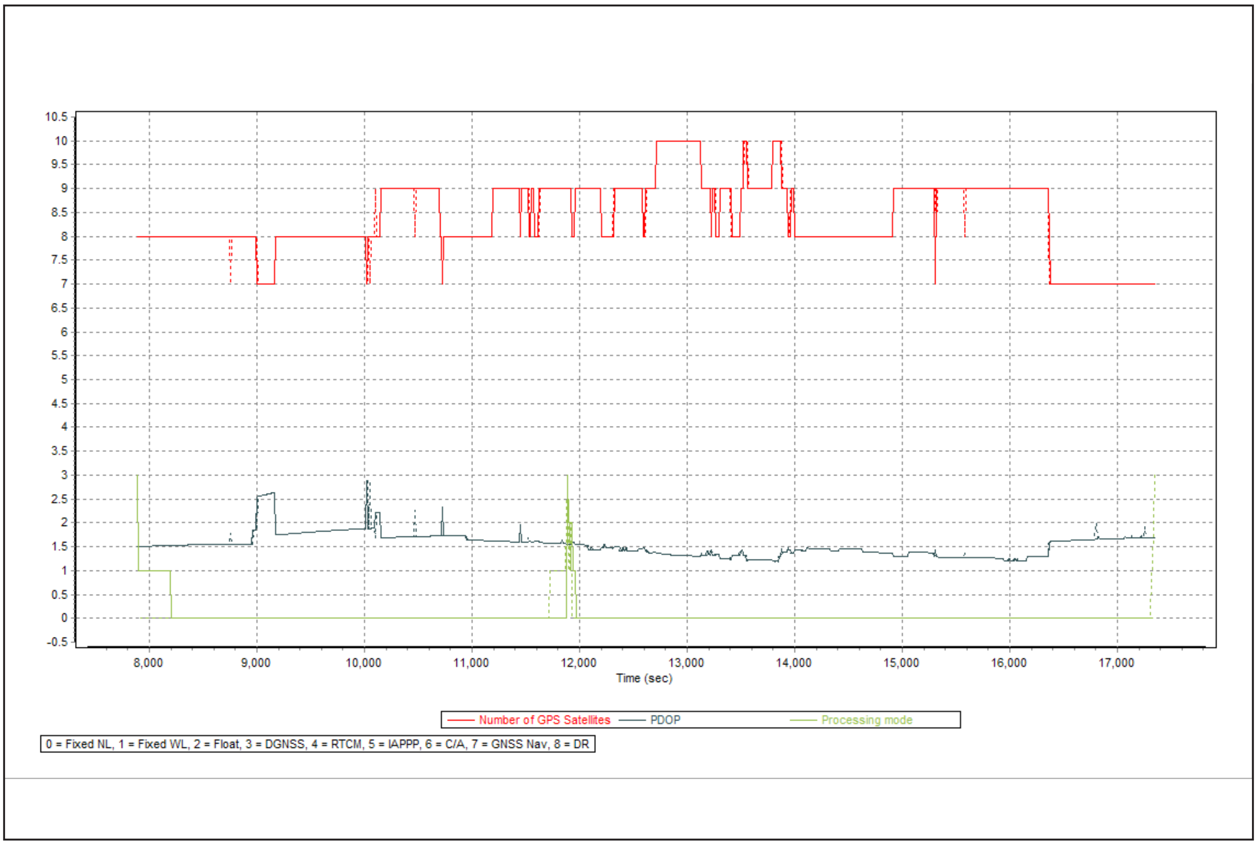



Figure A-8.50. Solution Status

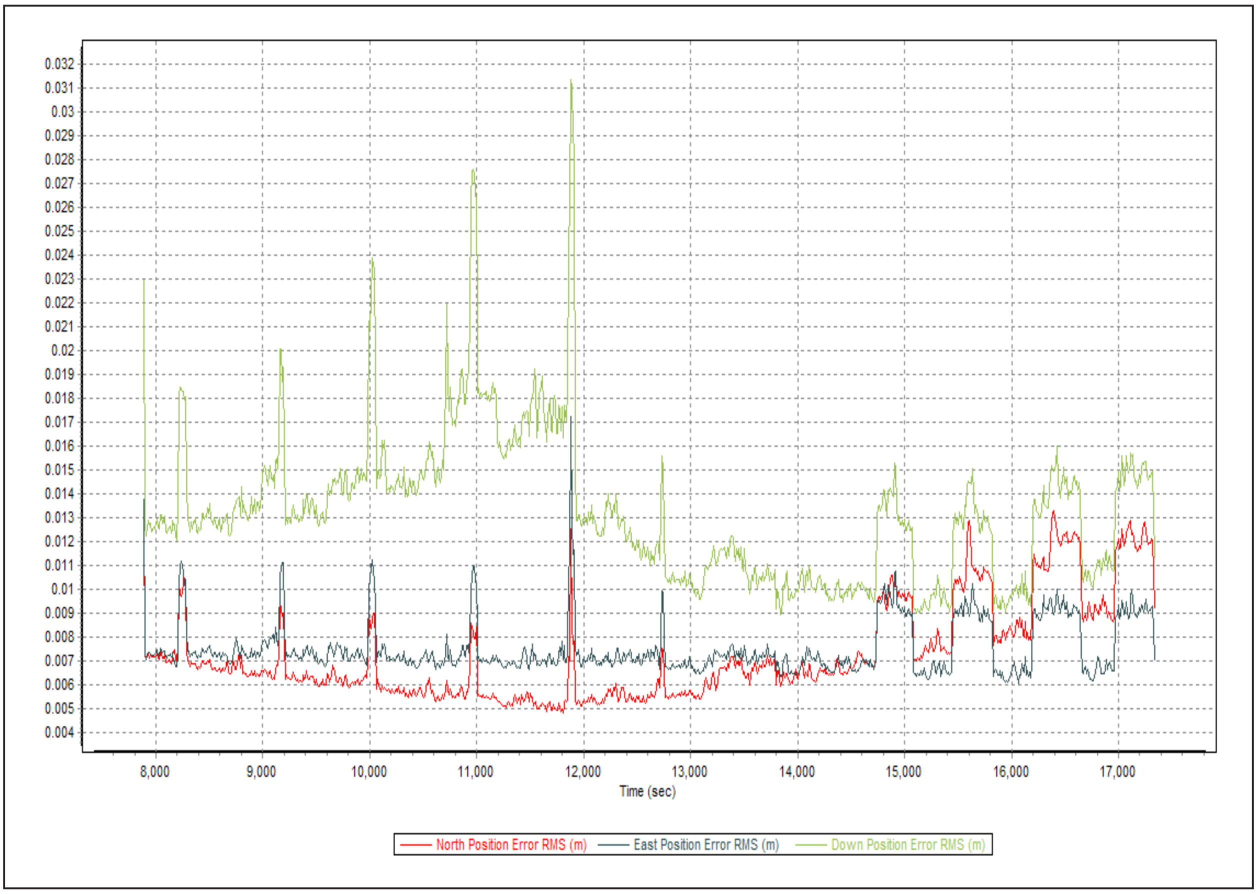



Figure A-8.51. Smoothed Performance Metric Parameters

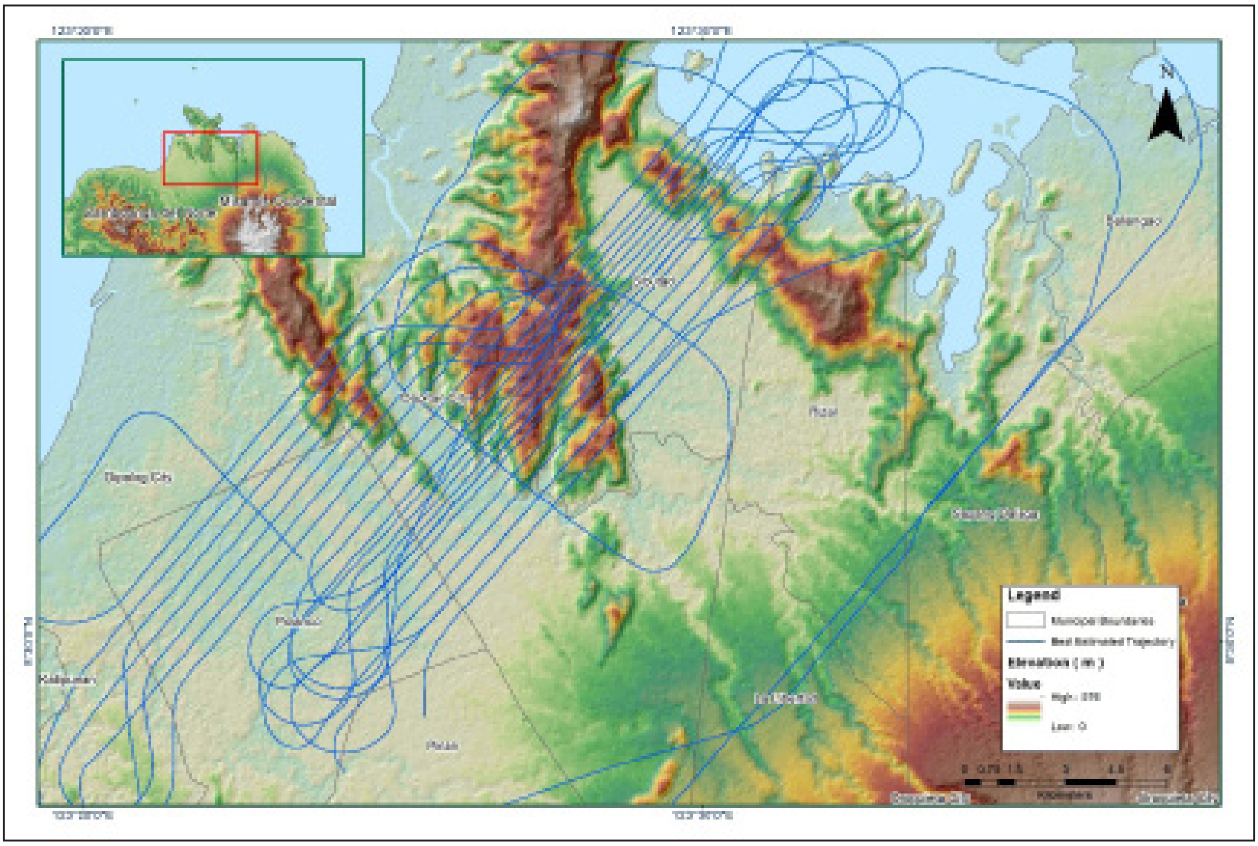



Figure A-8.52. Best Estimated Trajectory

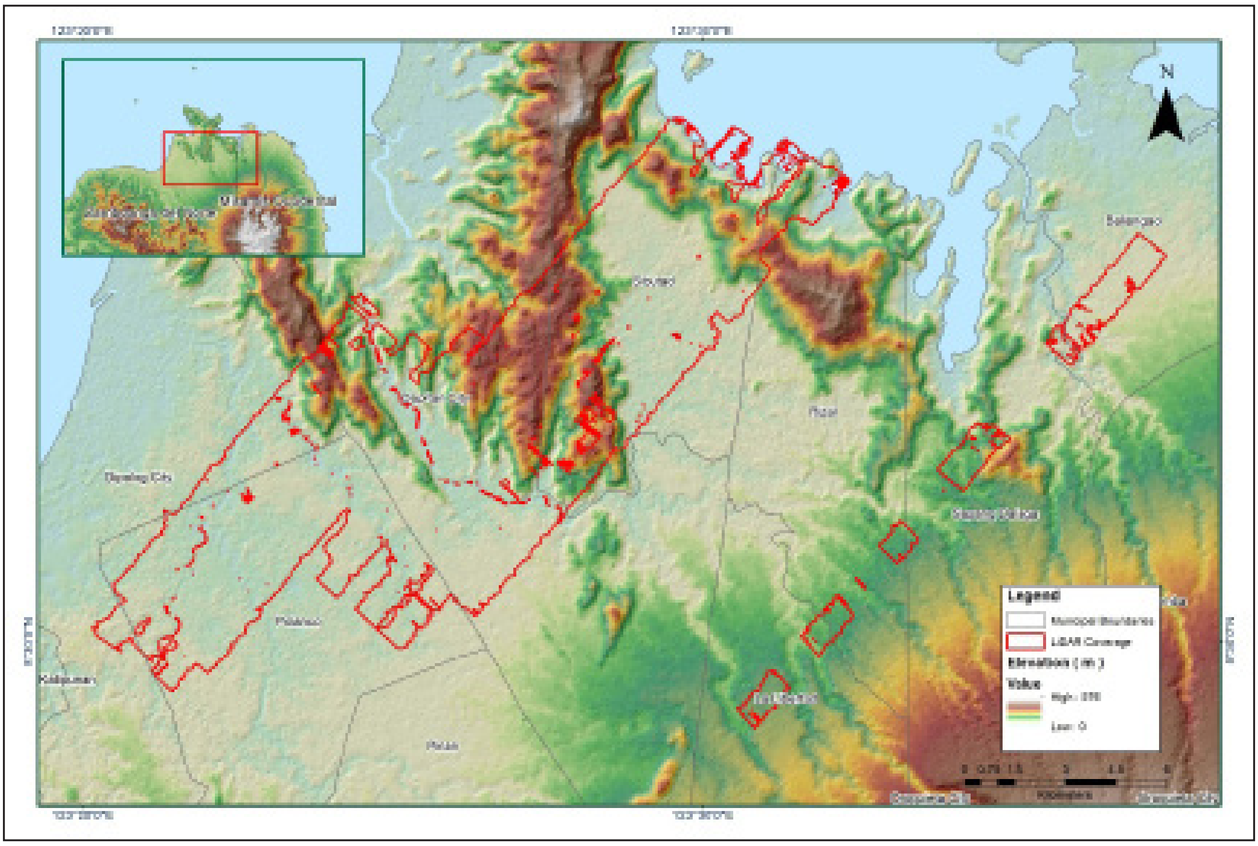



Figure A-8.53. Coverage of LiDAR data

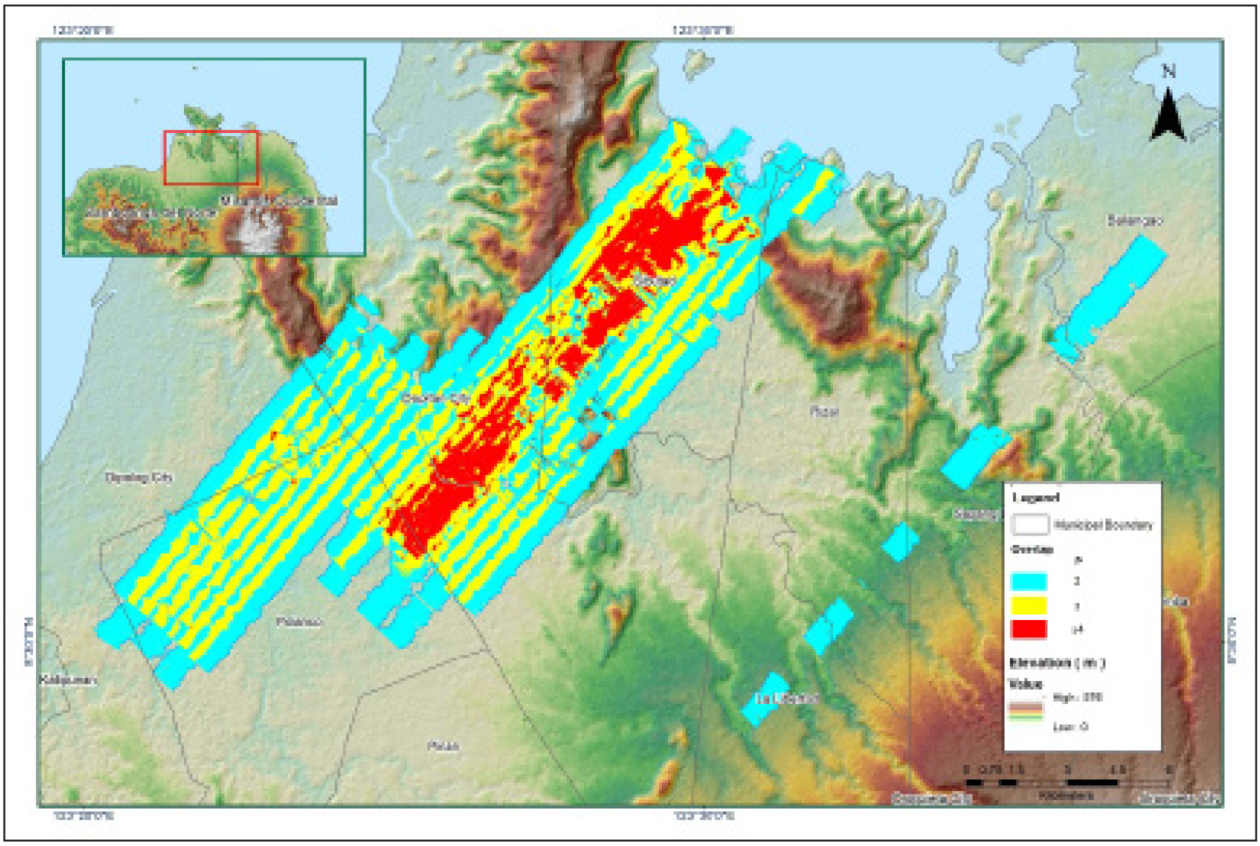


Figure A-8.54. Image of data overlap

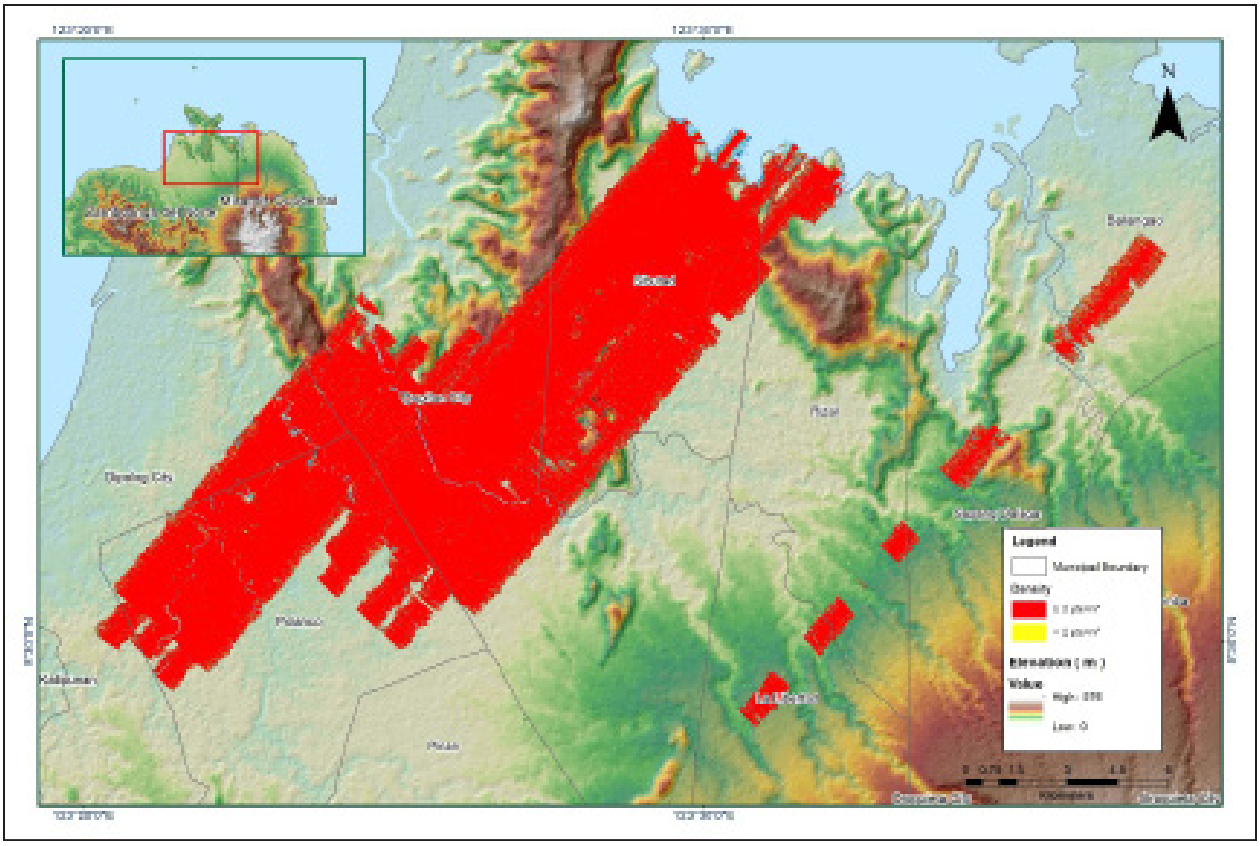


Figure A-8.55. Density map of merged LiDAR data

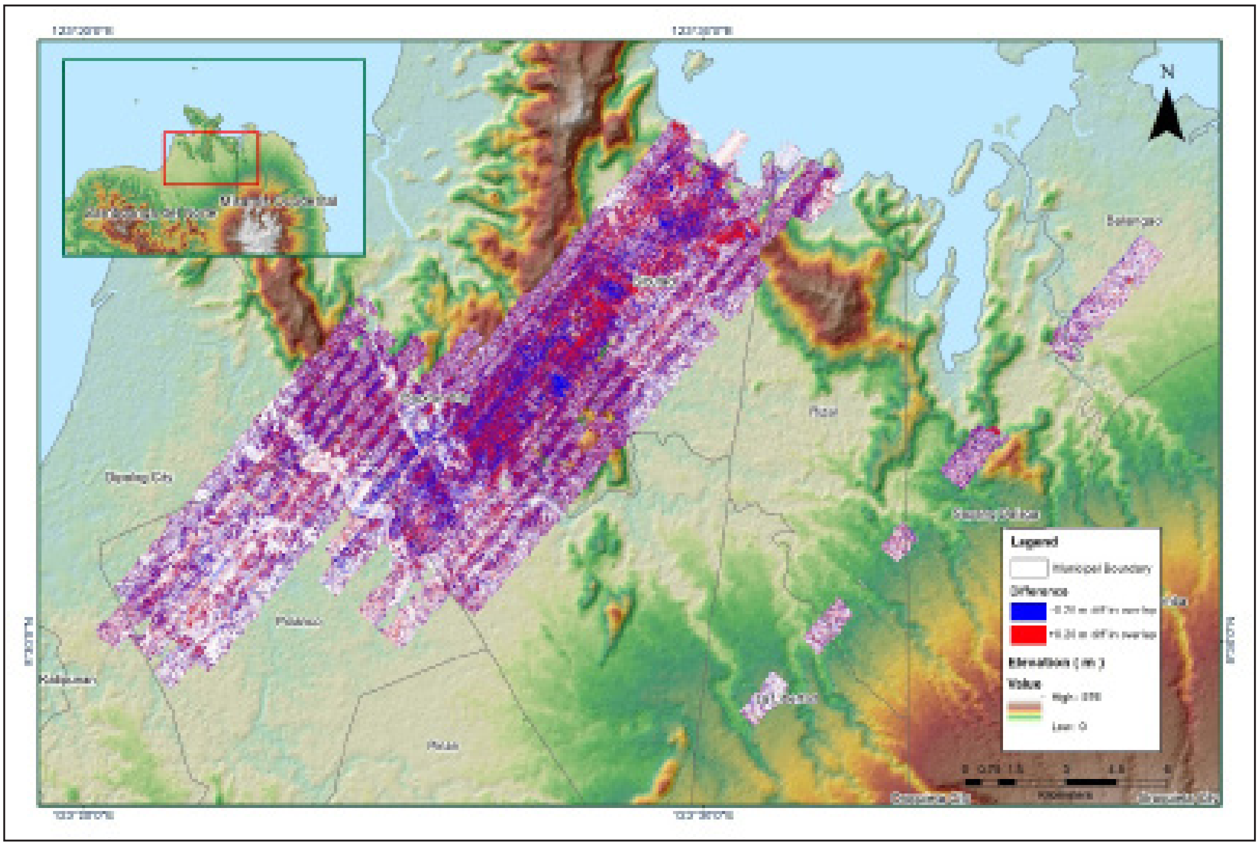


Figure A-8.56. Elevation difference between flight lines

Table A-8.9. Mission Summary Report for Blk69D

| **Flight Area** | **Dipolog** |
|---|---|
| Mission Name | Blk69D |
| Inclusive Flights | 23562P |
| Range data size | 29.5 GB |
| POS data size | 289 MB |
| Base data size | 165 MB |
| Image | n/a |
| Transfer date | December 6, 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) | 2.774 |
| RMSE for East Position (<4.0 cm) | 3.583 |
| RMSE for Down Position (<8.0 cm) | 9.222 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000156 |
| IMU attitude correction stdev (<0.001deg) | 0.001637 |
| GPS position stdev (<0.01m) | 0.0147 |
| | |
| Minimum % overlap (>25) | 35.05 % |
| Ave point cloud density per sq.m. (>2.0) | 4.79 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 244 |
| Maximum Height | 576.58 m |
| Minimum Height | 55.7 m |
| | |
| Classification (# of points) | |
| Ground | 239,317,811 |
| Low vegetation | 120,242,691 |
| Medium vegetation | 259,977,867 |
| High vegetation | 779,460,724 |
| Building | 10,280,693 |
| | |
| Orthophoto | No |
| Processed by | Engr. Kenneth Solidum, Engr. Chelou Prado, Engr. Gladys Mae Apat |

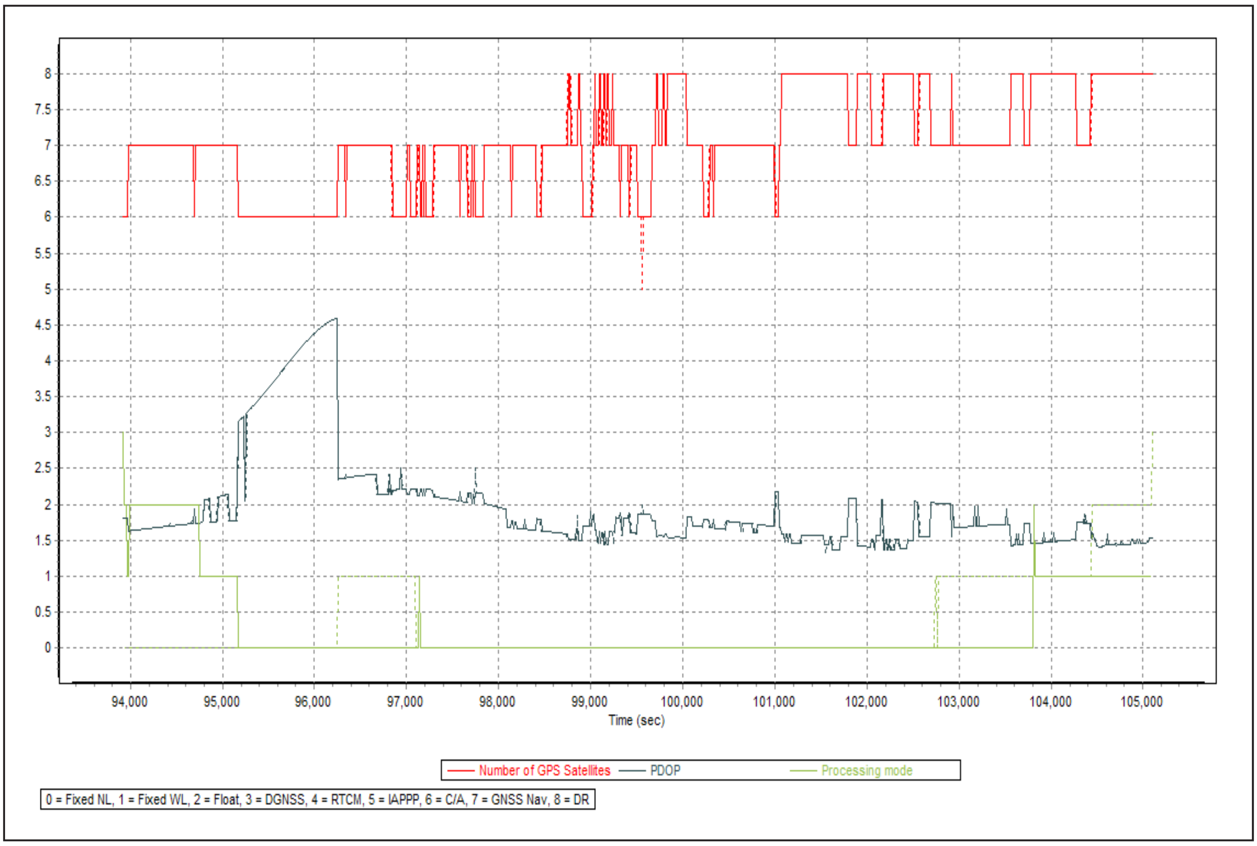



Figure A-8.57. Solution Status

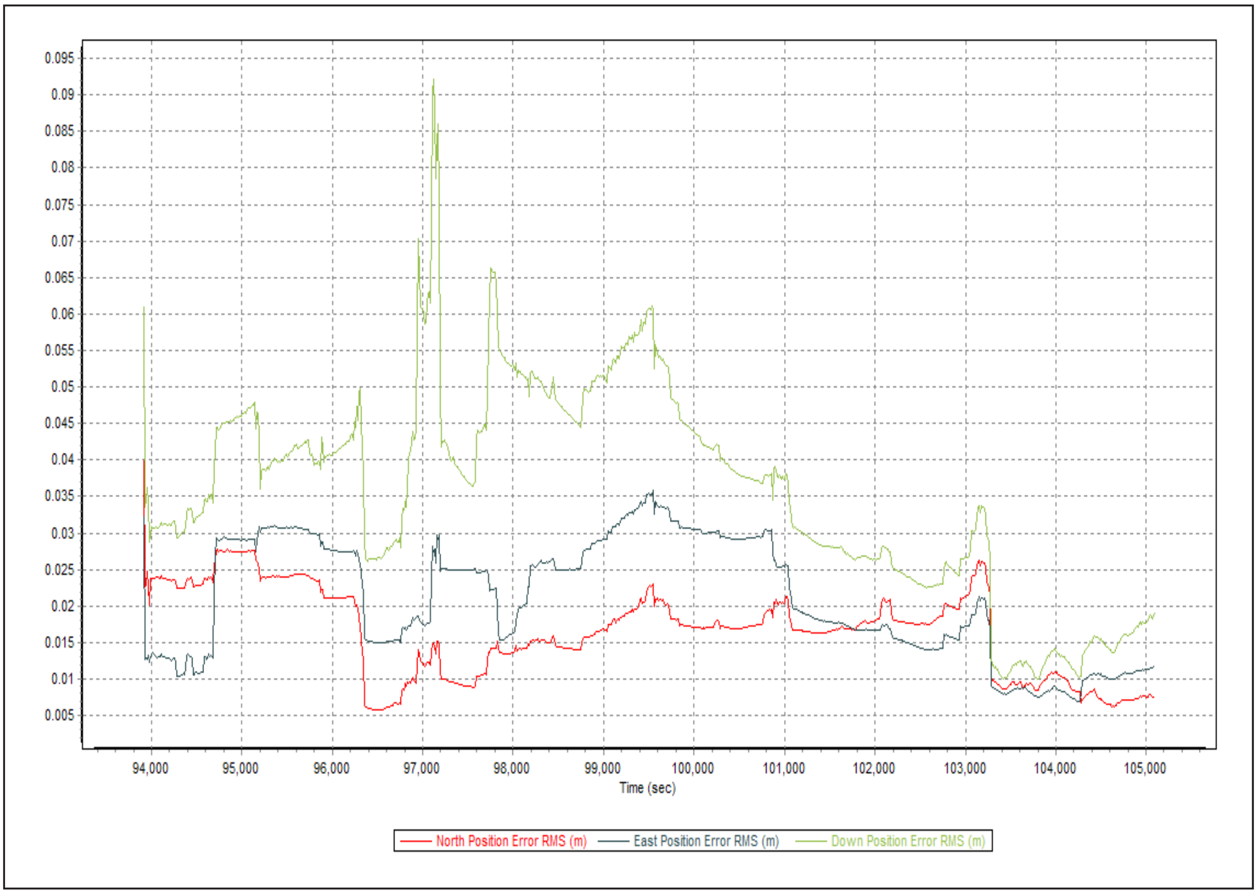



Figure A-8.58. Smoothed Performance Metric Parameters

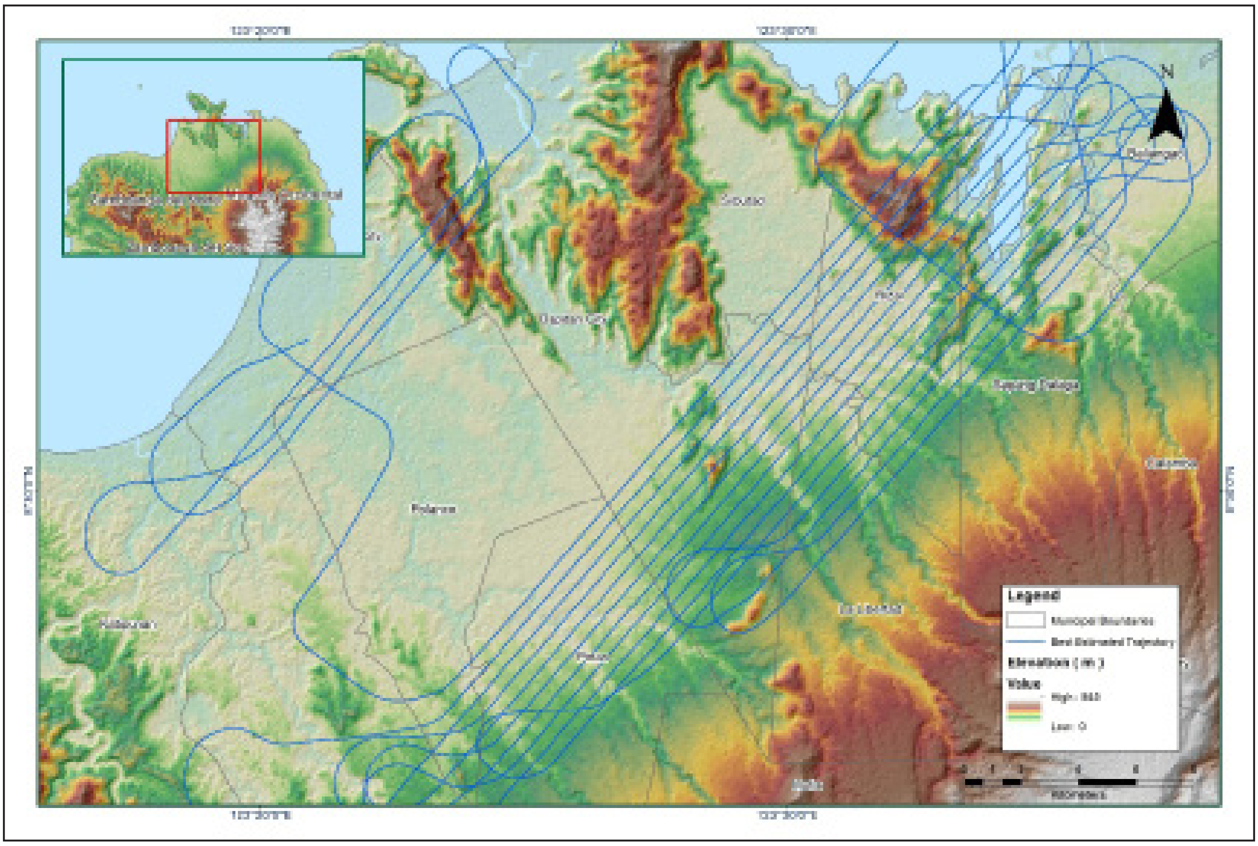



Figure A-8.59. Best Estimated Trajectory

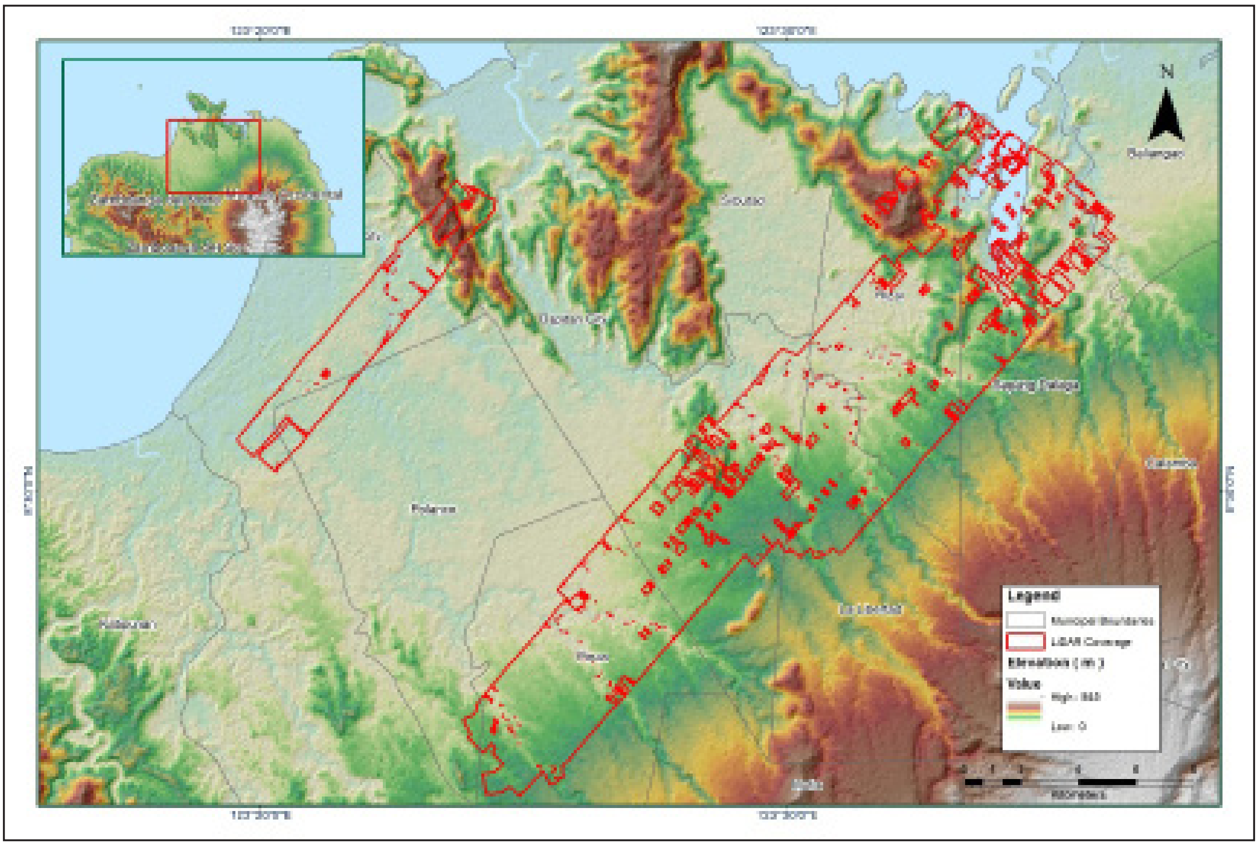



Figure A-8.60. Coverage of LiDAR data

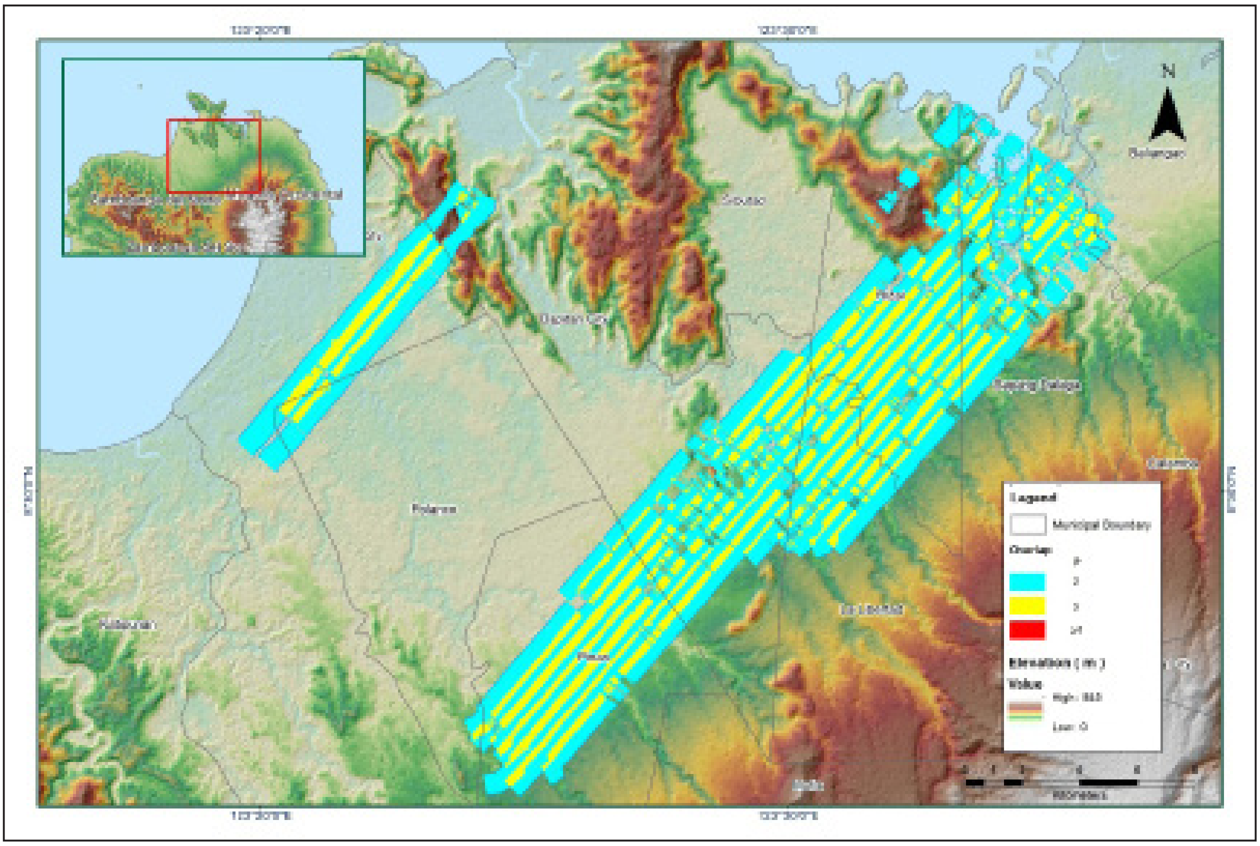



Figure A-8.61. Image of data overlap

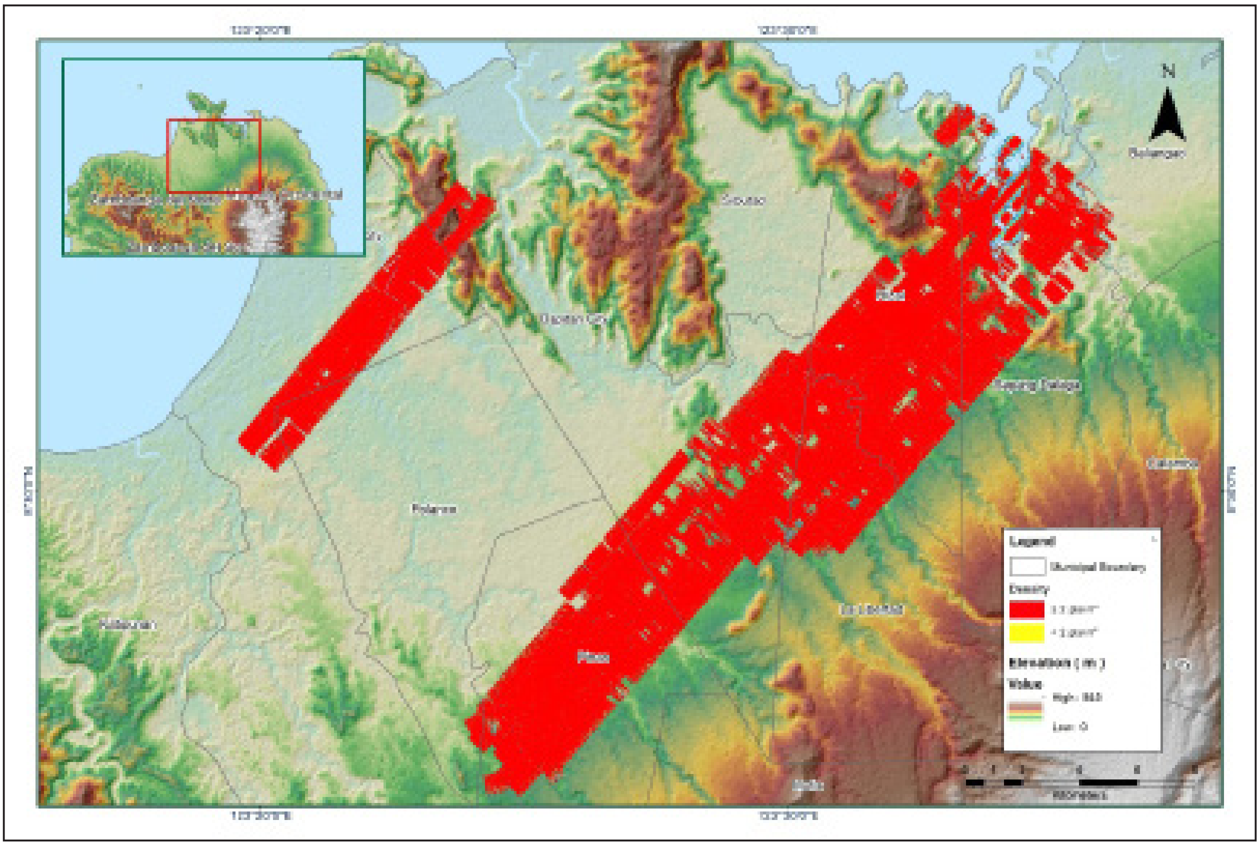



Figure A-8.62. Density map of merged LiDAR data

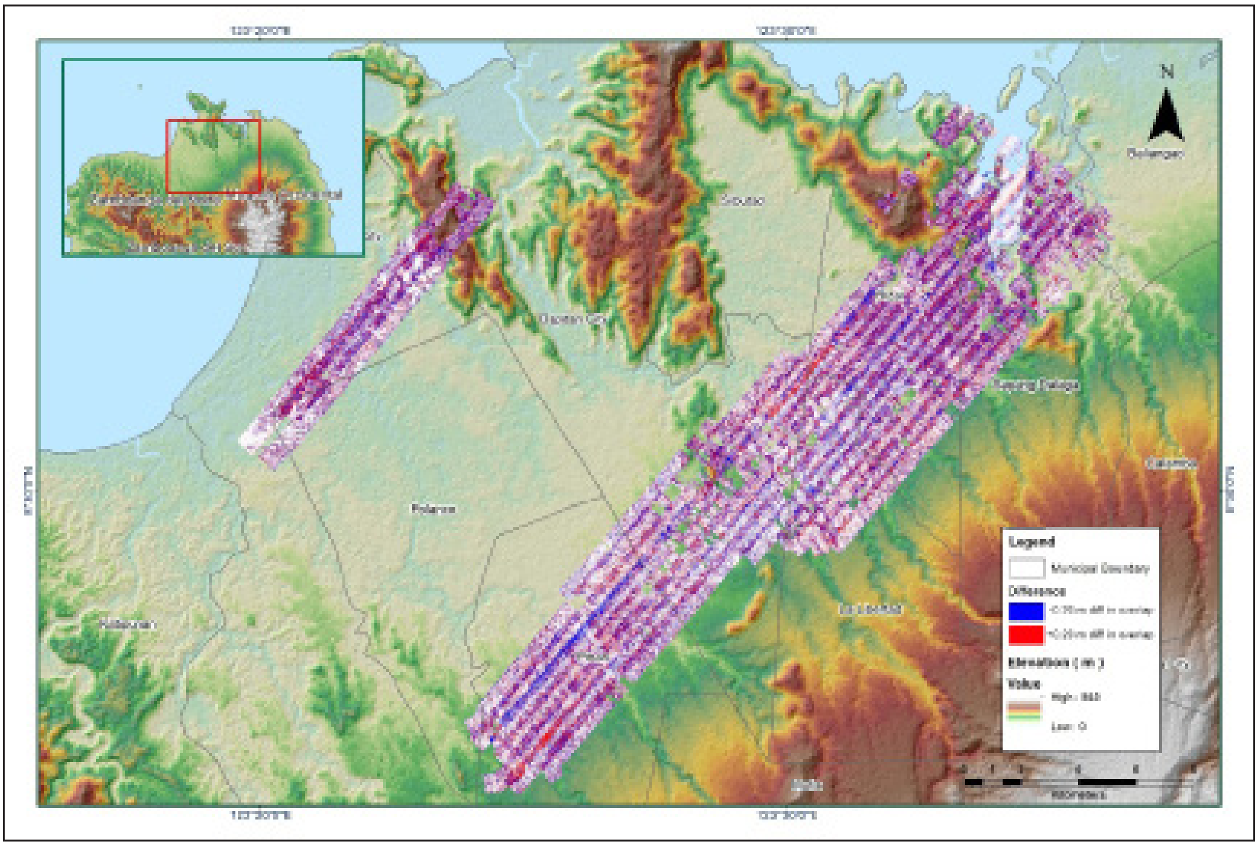



Figure A-8.63. Elevation difference between flight lines

# Annex 9. Dipolog Model Basin Parameters

Table A-9.1. Dipolog 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 |
| W390 | 157.276 | 77.06 | 0 | 5.813 | 28.461 | Discharge | 2.448 | 0.85 | Ratio to Peak | 0.4 |
| W400 | 68.429 | 88.533 | 0 | 1.342 | 6.569 | Discharge | 0.151 | 0.85 | Ratio to Peak | 0.4 |
| W410 | 118.085 | 81.732 | 0 | 3.402 | 16.656 | Discharge | 1.133 | 0.85 | Ratio to Peak | 0.4 |
| W420 | 73.076 | 87.849 | 0 | 2.727 | 13.352 | Discharge | 0.688 | 0.85 | Ratio to Peak | 0.4 |
| W430 | 113.141 | 82.362 | 0 | 3.313 | 16.220 | Discharge | 2.019 | 0.85 | Ratio to Peak | 0.4 |
| W440 | 119.377 | 81.569 | 0 | 2.644 | 12.944 | Discharge | 0.802 | 0.85 | Ratio to Peak | 0.4 |
| W450 | 138.869 | 79.186 | 0 | 1.545 | 7.563 | Discharge | 0.650 | 0.85 | Ratio to Peak | 0.4 |
| W460 | 141.712 | 78.85 | 0 | 1.555 | 7.612 | Discharge | 0.201 | 0.85 | Ratio to Peak | 0.4 |
| W470 | 119.536 | 81.549 | 0 | 2.788 | 13.649 | Discharge | 0.943 | 0.85 | Ratio to Peak | 0.4 |
| W490 | 108.794 | 82.924 | 0 | 1.242 | 6.081 | Discharge | 0.676 | 0.85 | Ratio to Peak | 0.4 |
| W500 | 137.439 | 79.356 | 0 | 1.138 | 5.571 | Discharge | 0.267 | 0.85 | Ratio to Peak | 0.4 |
| W520 | 121.624 | 81.287 | 0 | 2.371 | 11.607 | Discharge | 0.637 | 0.85 | Ratio to Peak | 0.4 |
| W530 | 130.417 | 80.202 | 0 | 3.293 | 16.122 | Discharge | 2.487 | 0.85 | Ratio to Peak | 0.4 |
| W560 | 110.790 | 82.665 | 0 | 1.514 | 7.412 | Discharge | 0.833 | 0.85 | Ratio to Peak | 0.4 |
| W570 | 111.618 | 82.558 | 0 | 1.717 | 8.409 | Discharge | 1.622 | 0.85 | Ratio to Peak | 0.4 |
| W580 | 298.006 | 63.936 | 0 | 3.879 | 18.99 | Discharge | 0.685 | 0.85 | Ratio to Peak | 0.4 |
| W590 | 83.31 | 86.379 | 0 | 1.933 | 9.462 | Discharge | 1.381 | 0.85 | Ratio to Peak | 0.4 |
| W600 | 196.886 | 72.851 | 0 | 2.260 | 11.066 | Discharge | 0.488 | 0.85 | Ratio to Peak | 0.4 |
| W610 | 103.680 | 83.595 | 0 | 1.772 | 8.677 | Discharge | 1.735 | 0.85 | Ratio to Peak | 0.4 |
| W620 | 132.534 | 79.945 | 0 | 0.830 | 4.062 | Discharge | 0.459 | 0.85 | Ratio to Peak | 0.4 |
| W630 | 129.908 | 80.264 | 0 | 1.538 | 7.531 | Discharge | 1.160 | 0.85 | Ratio to Peak | 0.4 |
| W640 | 144.888 | 78.478 | 0 | 0.971 | 4.755 | Discharge | 0.428 | 0.85 | 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 |
| W650 | 165.687 | 76.126 | 0 | 1.291 | 6.321 | Discharge | 2.027 | 0.85 | Ratio to Peak | 0.4 |
| W660 | 103.543 | 83.613 | 0 | 3.108 | 15.216 | Discharge | 3.825 | 0.85 | Ratio to Peak | 0.4 |
| W670 | 148.475 | 78.062 | 0 | 0.865 | 4.237 | Discharge | 0.518 | 0.85 | Ratio to Peak | 0.4 |
| W680 | 149.439 | 77.951 | 0 | 0.465 | 2.276 | Discharge | 0.353 | 0.85 | Ratio to Peak | 0.4 |
| W690 | 96.319 | 84.58 | 0 | 1.141 | 5.584 | Discharge | 1.209 | 0.85 | Ratio to Peak | 0.4 |
| W700 | 83.062 | 86.414 | 0 | 1.807 | 8.846 | Discharge | 2.683 | 0.85 | Ratio to Peak | 0.4 |
| W710 | 140.677 | 78.972 | 0 | 0.794 | 3.885 | Discharge | 1.380 | 0.85 | Ratio to Peak | 0.4 |
| W720 | 109.132 | 82.88 | 0 | 1.495 | 7.319 | Discharge | 1.668 | 0.85 | Ratio to Peak | 0.4 |
| W730 | 76.712 | 87.321 | 0 | 0.781 | 3.825 | Discharge | 0.747 | 0.85 | Ratio to Peak | 0.4 |
| W740 | 165.232 | 76.176 | 0 | 2.036 | 9.966 | Discharge | 3.814 | 0.85 | Ratio to Peak | 0.4 |

# Annex 10. Dipolog Model Reach Parameters

Table A-10.1. Dipolog Model Reach Parameters

| Reach Number | Muskingum Cunge Channel Routing | | | | | | |
|---|---|---|---|---|---|---|---|
| | Time Step Method | Length (m) | Slope | Manning's n | Shape | Width | Side Slope |
| R10 | Automatic Fixed Interval | 210.56 | 0.0467583 | 0.017 | Trapezoid | 33.478 | 1 |
| R110 | Automatic Fixed Interval | 1116.7 | 0.0050599 | 0.017 | Trapezoid | 22.77 | 1 |
| R140 | Automatic Fixed Interval | 1739.9 | 0.0037241 | 0.017 | Trapezoid | 27.826 | 1 |
| R150 | Automatic Fixed Interval | 2435.2 | 0.0060357 | 0.017 | Trapezoid | 23.552 | 1 |
| R170 | Automatic Fixed Interval | 16637 | 0.0018073 | 0.017 | Trapezoid | 44.444 | 1 |
| R190 | Automatic Fixed Interval | 5300.6 | 0.0116902 | 0.017 | Trapezoid | 28.172 | 1 |
| R20 | Automatic Fixed Interval | 1915.1 | 1.9885680132668504E-5 | 0.017 | Trapezoid | 35.352 | 1 |
| R210 | Automatic Fixed Interval | 5421.3 | 0.0034928 | 0.017 | Trapezoid | 46.638 | 1 |
| R230 | Automatic Fixed Interval | 3944.3 | 0.0055049 | 0.017 | Trapezoid | 50.686 | 1 |
| R260 | Automatic Fixed Interval | 4742 | 0.0079663 | 0.017 | Trapezoid | 39.774 | 1 |
| R290 | Automatic Fixed Interval | 17955 | 0.0088067 | 0.017 | Trapezoid | 33.134 | 1 |
| R300 | Automatic Fixed Interval | 2343.1 | 0.0128287 | 0.017 | Trapezoid | 19.722 | 1 |
| R350 | Automatic Fixed Interval | 8221.9 | 0.0159613 | 0.017 | Trapezoid | 16.634 | 1 |
| R40 | Automatic Fixed Interval | 7651.8 | .0004490562185971018 | 0.017 | Trapezoid | 32.506 | 1 |
| R60 | Automatic Fixed Interval | 2487.6 | .0005273111675974732 | 0.017 | Trapezoid | 37.724 | 1 |
| R70 | Automatic Fixed Interval | 1311.2 | .00018427088625382572 | 0.017 | Trapezoid | 40.064 | 1 |
| R80 | Automatic Fixed Interval | 154.85 | 4.415806103061255E-5 | 0.017 | Trapezoid | 30 | 1 |
| R90 | Automatic Fixed Interval | 4761.1 | 0.0010922 | 0.017 | Trapezoid | 41.494 | 1 |

# Annex 11. Dipolog Field Validation

Table A-11.1. Dipolog Field Validation Points

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 1 | 8.602 | 123.349 | 0.69 | 0.2 | 0.49 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 2 | 8.606 | 123.350 | 0.92 | 1.6 | -0.68 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 3 | 8.600 | 123.349 | 0.51 | 0.35 | 0.16 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 4 | 8.598 | 123.347 | 0.25 | 0.2 | 0.05 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 5 | 8.595 | 123.351 | 0.84 | 0.2 | 0.64 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 6 | 8.593 | 123.351 | 1.27 | 0.6 | 0.67 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 7 | 8.591 | 123.350 | 0.28 | 0 | 0.28 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 8 | 8.596 | 123.351 | 1.09 | 0.35 | 0.74 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 9 | 8.597 | 123.352 | 0.82 | 0.4 | 0.42 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 10 | 8.596 | 123.344 | 0.03 | 0.25 | -0.22 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 11 | 8.589 | 123.355 | 0.68 | 0.4 | 0.28 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 12 | 8.595 | 123.350 | 0.78 | 0 | 0.78 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 13 | 8.587 | 123.350 | 0.04 | 0 | 0.04 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 14 | 8.597 | 123.349 | 0.68 | 0.2 | 0.48 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 15 | 8.603 | 123.352 | 0.58 | 0.6 | -0.02 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 16 | 8.603 | 123.352 | 0.22 | 0.18 | 0.04 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 17 | 8.603 | 123.351 | 0.05 | 0.23 | -0.18 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 18 | 8.598 | 123.354 | 0.59 | 0.55 | 0.04 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 19 | 8.598 | 123.354 | 0.96 | 0.6 | 0.36 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 20 | 8.598 | 123.355 | 1.84 | 1.13 | 0.71 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 21 | 8.597 | 123.352 | 0.66 | 0.7 | -0.04 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 22 | 8.594 | 123.365 | 0.34 | 0.2 | 0.14 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 23 | 8.594 | 123.366 | 0.49 | 0.33 | 0.16 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 24 | 8.591 | 123.340 | 0.53 | 0 | 0.53 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 25 | 8.505 | 123.327 | 0.03 | 0 | 0.03 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 26 | 8.501 | 123.335 | 0.05 | 0.25 | -0.2 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 27 | 8.531 | 123.317 | 0.25 | 0.25 | 0 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 28 | 8.534 | 123.321 | 0.03 | 0 | 0.03 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 29 | 8.546 | 123.330 | 0.21 | 0.7 | -0.49 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 30 | 8.541 | 123.326 | 0.22 | 0.2 | 0.02 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 31 | 8.558 | 123.335 | 0.03 | 0.2 | -0.17 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 32 | 8.617 | 123.351 | 0 | 0.25 | -0.25 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 33 | 8.611 | 123.347 | 0.24 | 0.15 | 0.09 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 34 | 8.608 | 123.346 | 0.03 | 0.43 | -0.4 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 35 | 8.608 | 123.348 | 0.92 | 0.3 | 0.62 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 36 | 8.607 | 123.348 | 0.53 | 0.12 | 0.41 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 37 | 8.531 | 123.309 | 0.03 | 0.2 | -0.17 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 38 | 8.528 | 123.311 | 0.21 | 0.25 | -0.04 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 39 | 8.528 | 123.312 | 0.03 | 0.2 | -0.17 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 40 | 8.585 | 123.350 | 0.24 | 0.6 | -0.36 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 41 | 8.585 | 123.349 | 0.62 | 0.25 | 0.37 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 42 | 8.582 | 123.355 | 0.21 | 0.6 | -0.39 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 43 | 8.576 | 123.364 | 0.98 | 0.15 | 0.83 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 44 | 8.579 | 123.353 | 0.03 | 0.2 | -0.17 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 45 | 8.578 | 123.360 | 0.58 | 0.5 | 0.08 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 46 | 8.553 | 123.367 | 0.03 | 0 | 0.03 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 47 | 8.587 | 123.360 | 0.59 | 0.6 | -0.01 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 48 | 8.588 | 123.359 | 0.86 | 1.35 | -0.49 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 49 | 8.577 | 123.350 | 0.55 | 1 | -0.45 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 50 | 8.575 | 123.348 | 0.26 | 0 | 0.26 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 51 | 8.575 | 123.352 | 0.55 | 0.64 | -0.09 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 52 | 8.578 | 123.343 | 0.62 | 0.3 | 0.32 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 53 | 8.582 | 123.354 | 0.52 | 0.7 | -0.18 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 54 | 8.588 | 123.341 | 1.08 | 0 | 1.08 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 55 | 8.588 | 123.342 | 0.29 | 0.25 | 0.04 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 56 | 8.593 | 123.344 | 0.51 | 0 | 0.51 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 57 | 8.592 | 123.343 | 0.54 | 1.2 | -0.66 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 58 | 8.594 | 123.343 | 0.09 | 0.3 | -0.21 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 59 | 8.576 | 123.365 | 1.5 | 0.28 | 1.22 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 60 | 8.573 | 123.363 | 0.03 | 0 | 0.03 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 61 | 8.572 | 123.362 | 0.71 | 0 | 0.71 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 62 | 8.572 | 123.364 | 1.06 | 0 | 1.06 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 63 | 8.576 | 123.352 | 0.72 | 0 | 0.72 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 64 | 8.575 | 123.358 | 0.3 | 0.65 | -0.35 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 65 | 8.576 | 123.345 | 0.64 | 1.35 | -0.71 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 66 | 8.585 | 123.345 | 0.21 | 0.15 | 0.06 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 67 | 8.582 | 123.346 | 0.03 | 0 | 0.03 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 68 | 8.577 | 123.341 | 1.05 | 0.76 | 0.29 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 69 | 8.577 | 123.341 | 0.55 | 0.25 | 0.3 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 70 | 8.576 | 123.342 | 0.22 | 0.4 | -0.18 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 71 | 8.575 | 123.347 | 0.73 | 0.2 | 0.53 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 72 | 8.567 | 123.370 | 0.03 | 0 | 0.03 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 73 | 8.564 | 123.359 | 1.22 | 0.3 | 0.92 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 74 | 8.571 | 123.349 | 0.03 | 0 | 0.03 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 75 | 8.566 | 123.341 | 0.51 | 1.4 | -0.89 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 76 | 8.570 | 123.347 | 0.52 | 0.2 | 0.32 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 77 | 8.568 | 123.347 | 0.3 | 0 | 0.3 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 78 | 8.549 | 123.360 | 0.05 | 0 | 0.05 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 79 | 8.561 | 123.357 | 0.03 | 0.5 | -0.47 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 80 | 8.592 | 123.354 | 0.62 | 0.6 | 0.02 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 81 | 8.592 | 123.354 | 1.18 | 0 | 1.18 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 82 | 8.592 | 123.354 | 1.32 | 0 | 1.32 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 83 | 8.592 | 123.354 | 1.17 | 0.4 | 0.77 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 84 | 8.592 | 123.353 | 1.12 | 0.6 | 0.52 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 85 | 8.592 | 123.353 | 1.32 | 1.1 | 0.22 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 86 | 8.592 | 123.353 | 1.5 | 0.7 | 0.8 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 87 | 8.592 | 123.352 | 1.33 | 1 | 0.33 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 88 | 8.590 | 123.351 | 0.74 | 1.15 | -0.41 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 89 | 8.589 | 123.350 | 0.53 | 1 | -0.47 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 90 | 8.591 | 123.350 | 0.9 | 1.1 | -0.2 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 91 | 8.591 | 123.349 | 0.59 | 0.6 | -0.01 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 92 | 8.595 | 123.351 | 0.63 | 0 | 0.63 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 93 | 8.599 | 123.356 | 1.4 | 0.3 | 1.1 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 94 | 8.598 | 123.355 | 1.53 | 0.6 | 0.93 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 95 | 8.604 | 123.355 | 0.03 | 0.4 | -0.37 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 96 | 8.588 | 123.341 | 0.74 | 0.25 | 0.49 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 97 | 8.558 | 123.332 | 0.24 | 0.25 | -0.01 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 98 | 8.565 | 123.335 | 0.04 | 0.3 | -0.26 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 99 | 8.496 | 123.336 | 0.24 | 0.25 | -0.01 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 100 | 8.580 | 123.337 | 0.65 | 0.3 | 0.35 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 101 | 8.589 | 123.340 | 0.03 | 0.2 | -0.17 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 102 | 8.585 | 123.339 | 0.21 | 0 | 0.21 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 103 | 8.581 | 123.338 | 0.24 | 0 | 0.24 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 104 | 8.580 | 123.338 | 0.03 | 0 | 0.03 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 105 | 8.571 | 123.339 | 0.31 | 0 | 0.31 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 106 | 8.537 | 123.325 | 0.22 | 0.2 | 0.02 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 107 | 8.538 | 123.336 | 0.22 | 0.4 | -0.18 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 108 | 8.538 | 123.336 | 0.6 | 0.5 | 0.1 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 109 | 8.540 | 123.338 | 0.57 | 0.4 | 0.17 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 110 | 8.544 | 123.331 | 0.03 | 0 | 0.03 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 111 | 8.554 | 123.335 | 0.27 | 0.25 | 0.02 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 112 | 8.532 | 123.341 | 0.03 | 0.2 | -0.17 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 113 | 8.548 | 123.340 | 0.25 | 0.3 | -0.05 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 114 | 8.553 | 123.344 | 0.03 | 0 | 0.03 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |

| Point Number | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return / Scenario |
|---|---|---|---|---|---|---|---|
| | Lat | Long | | | | | |
| 115 | 8.548 | 123.344 | 0.03 | 0.25 | -0.22 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 116 | 8.557 | 123.339 | 0.03 | 0.15 | -0.12 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 117 | 8.556 | 123.343 | 0.27 | 0.45 | -0.18 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 118 | 8.558 | 123.337 | 0.22 | 0 | 0.22 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 119 | 8.564 | 123.339 | 0.22 | 0.55 | -0.33 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |
| 120 | 8.586 | 123.362 | 1.16 | 0.4 | 0.76 | Typhoon Zoraida / Nov. 11, 2013 | 5 - Year |

## Annex 12. Educational Institutions Affected in Dipolog Floodplain

Table A-12.1. Educational Institutions in Dipolog City, Zambianga del Norte affected by flooding in Dipolog Floodplain

| ZAMBOANGA DEL NORTE | | | | |
|---|---|---|---|---|
| DIPOLOG CITY | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Biasong Elementary School | Barra | | Low | Low |
| Dipolog City National High School | Barra | | | Low |
| Dipolog Pilot Demonstration School | Barra | Low | Low | Low |
| Amatong/ABC School | Central | | | Low |
| COLLEGE PRESS | Central | | | |
| DEPED BUILDING | Central | Low | Low | Low |
| DIPOLOG CITY SDA CENTRAL CHURCH | Central | | | |
| DIPOLOG CITY SDA ELEMENTARY | Central | | | |
| Dipolog Pilot Demonstration School | Central | Low | Low | Low |
| Estaka Central School | Central | | | |
| Jose Rizal Memorial State University | Central | Low | Low | Low |
| MIPUTAK EAST CENTRAL SCHOOL | Central | | Low | |
| Miputak Elementary School | Central | Low | Low | Low |
| Saint Mary’s Academy | Central | | | |
| Saint Vincent’s College | Central | | | |
| Saint Vincent’s High School | Central | | | |
| Zamboanga del Norte National High School | Central | | | |
| ANGAT PINOY Medium004 (Bagong Lipunan) | Dicayas | | | |
| FFCCC II | Dicayas | | | |
| FIL- CHINESE CHAMBER OF COMMERCE | Dicayas | | | |
| FIL-CHINESE CHAMBER OF COMMERCE | Dicayas | | | |
| GMA Cares | Dicayas | | | |
| Baptist School | Galas | | | Low |
| Galas Elem School | Galas | | Low | Low |
| Galas National High School | Galas | Low | Low | Medium |
| Galas Elem School | Galas | | Low | Low |
| Galas Elem School Gym | Galas | Low | Low | Low |
| Galas National High School | Galas | | Low | Medium |
| Daycare Center | Gulayon | Low | Low | Medium |
| Obay Elem. School | Gulayon | | | |
| Villahermosa Daycare Center | Lugdungan | | | |
| Villahermosa Elem. School | Lugdungan | | | |
| AQUMATSHS | Olingan | | | |
| AQUMATSHS Covered Court | Olingan | | | |
| Dipolog School of Fisheries | Olingan | | | |
| Laoy Elem School | Olingan | | Low | Low |
| Olingan Elem School | Olingan | | | |
| Olingan South Elem School | Olingan | | | |

| ZAMBOANGA DEL NORTE | | | | |
|---|---|---|---|---|
| DIPOLOG CITY | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| AGAPP BUILDING | Santa Filomena | | | Low |
| BAGONG LIPUNAN | Santa Filomena | | Low | |
| DAY CARE CENTER | Santa Filomena | | | |
| FERNANDEZ PRESCHOOL AND LEARNING CENTER | Santa Filomena | | | |
| GRADE Medium BLDG. | Santa Filomena | | Low | Low |
| GRADE High BUILDING | Santa Filomena | Low | Low | Low |
| GRADE 5 MABINI | Santa Filomena | | | Low |
| PRICIPAL OFFICE | Santa Filomena | Low | Low | Low |
| DAY CARE CENTER | Sinaman | | | |
| Turno Elementary School | Turno | | | |
| Turno National High School Annex | Turno | | | |

Table A-12.2. Educational Institutions in Pinan City, Zambianga del Norte affected by flooding in Dipolog Floodplain

| ZAMBOANGA DEL NORTE | | | | |
|---|---|---|---|---|
| PINAN | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Old Pinan Elementary School | Del Pilar | | | |

Table A-12.3. Educational Institutions in Polanco City, Zambianga del Norte affected by flooding in Dipolog Floodplain

| ZAMBOANGA DEL NORTE | | | | |
|---|---|---|---|---|
| POLANCO | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Daycare Center | Anastacio | | | |
| Daycare Center | Bandera | | | |
| Daycare center | Guinles | | | |
| Daycare Center | Guinles | | | |
| Guinles Elementary School | Guinles | Low | Low | Medium |
| SAN ANTONIO | Guinles | | | |
| Isis Elementary School | Isis | | | |
| Isis National High School | Isis | | | |
| Letapan Daycare Center | Letapan | | | |
| Letapan Elem. School | Letapan | | | |
| Lingasad National High School | Lingasad | | | |
| Polanco National High School Extension Lingasad | Lingasad | | | |

| ZAMBOANGA DEL NORTE | | | | |
|---|---|---|---|---|
| POLANCO | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| New Lebangon Elem.School | Macleodes | | | |
| Daycare Center | Magangon | | | |
| Magangon Elem | Magangon | | | |
| Sianib High School | New Lebangon | | | |
| Day Care Center | Obay | | | |
| ELEM. School | Obay | | | |
| Polanco Central School | Obay | | | Low |
| Polanco Central School's Office | Obay | | | |
| Polanco NHS | Obay | | | |
| Daycare Center | Pian | | | Low |
| Daycare center | San Pedro | | | |
| Daycare Center | Sianib | | | |
| Sianib Elem.School | Sianib | | | High |
| Silawe Elem. School | Silawe | | | |
| Silawe National High School | Silawe | | | Low |
| Silawe National High School Stage | Silawe | | | |
| Villahermosa Elem. School | Villahermosa | | | |

# Annex 13. Medical Institutions Affected in Dipolog Floodplain

Table A-13.1. Medical Institutions in Dipolog City, Zamboanga del Norte affected by flooding in Dipolog Floodplain

| ZAMBOANGA DEL NORTE | | | | |
|---|---|---|---|---|
| DIPOLOG CITY | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Charm Cosmetic  Dermatology Clinic | Barra | | Low | Low |
| Cherry Generic Pharmacy | Barra | | | Low |
| Friwars Pharmacy | Barra | Low | Low | Low |
| Old Provincial Hospital | Barra | | | |
| AGAPE Diagnostic Center | Central | | | |
| BEAST FRIEND VET - CLINIC PET SHOP | Central | Low | Low | Low |
| BESTFRIEND SET. CLINIC AND PET SAND | Central | | | |
| Friwars Pharmacy | Central | | | |
| Kuan's Pharmacy | Central | | | |
| LKS Pharmacy | Central | | Low | |
| BioMedika Pharma Distributor | Estaca | | | |
| Dipolog North Maternity Hospital | Estaca | | | |
| Barngay NHealth Center | Lugdungan | | | |
| Barngay Nutrition | Lugdungan | | | |
| LGE Pharmacy | Minaog | | Medium | Medium |
| LKS Pharmacy | Minaog | | | |
| Zamboanga del Norte Medical Center | Minaog | | | |
| Miputak Health Center | Miputak | | | |
| Health Center | Olingan | | Low | |
| BARANGAY HEALTH CENTER | Santa Filomena | | | |
| Dipolog City Medical Center | Santa Filomena | | | |
| HEALTH CENTER | Sinaman | | | |

Table A-13.2. Medical Institutions in Dipolog City, Zamboanga del Norte affected by flooding in Dipolog Floodplain

| ZAMBOANGA DEL NORTE | | | | |
|---|---|---|---|---|
| POLANCO | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Barangay Health Center | Bandera | | | Low |
| Old Health Center | Guinles | | | |
| San Antonio Health Center | Guinles | | | |
| Health Center | Macleodes | | | |
| Health Center | Magangon | | | |
| Health Center | New Lebangon | | | |
| Health Center | Obay | | | |
| Birthing Home | Pian | Low | Low | Low |
| Silawe Health Center | Pian | Low | Low | Low |
| Municipal health Center | Poblacion North | | | |