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

# LiDAR Surveys and Flood Mapping of Catarman River

University of the Philippines Training Center for Applied Geodesy and Photogrammetry
Visayas State University
Department of Science and Technology

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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 |
| MMS | Mobile Mapping Suite |
| MSL | mean sea level |
| NAMRIA | National Mapping and Resource Information Authority |
| NSTC | Northern Subtropical Convergence |
| PAF | Philippine Air Force |
| PAGASA | Philippine Atmospheric Geophysical and Astronomical Services Administration |
| PDOP | Positional Dilution of Precision |
| PPK | Post-Processed Kinematic [technique] |
| PRF | Pulse Repetition Frequency |
| PTM | Philippine Transverse Mercator |
| QC | Quality Check |
| QT | Quick Terrain [Modeler] |
| RA | Research Associate |
| RIDF | Rainfall-Intensity-Duration-Frequency |
| RMSE | Root Mean Square Error |
| SAR | Synthetic Aperture Radar |
| SCS | Soil Conservation Service |
| SRTM | Shuttle Radar Topography Mission |
| SRS | Science Research Specialist |
| SSG | Special Service Group |
| TBC | Thermal Barrier Coatings |
| UP-TCAGP | University of the Philippines – Training Center for Applied Geodesy and Photogrammetry |
| UTM | Universal Transverse Mercator |
| VSU | Visayas State University |
| WGS | World Geodetic System |

# CHAPTER 1: OVERVIEW OF THE PROGRAM AND CATARMAN RIVER

*Engr. Florentino Morales Jr. and Enrico C. Paringit, Dr. Eng.*

## 1.1 Background of the Phil-LIDAR 1 Program

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

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

The implementing partner university for the Phil-LiDAR 1 Program is the Visayas State University (VSU). VSU 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 28 river basins in the Eastern Visayas Region. The university is located in Baybay City in the province of Leyte.

## 1.2 Overview of the Catarman River Basin

The Catarman River Basin covers two (2) municipalities in Northern Samar; namely, the municipalities of Catarman and Lope de Vega. It also covers some portions of the municipalities of Mondragon and Bobon in Northern Samar and Calbayog City in Samar. The DENR River Basin Control Office (RBCO) states that the Catarman River Basin has drainage of 272 km$^2$ and an estimated 517 cubic meter (MCM) annual run-off (RBCO, 2015).

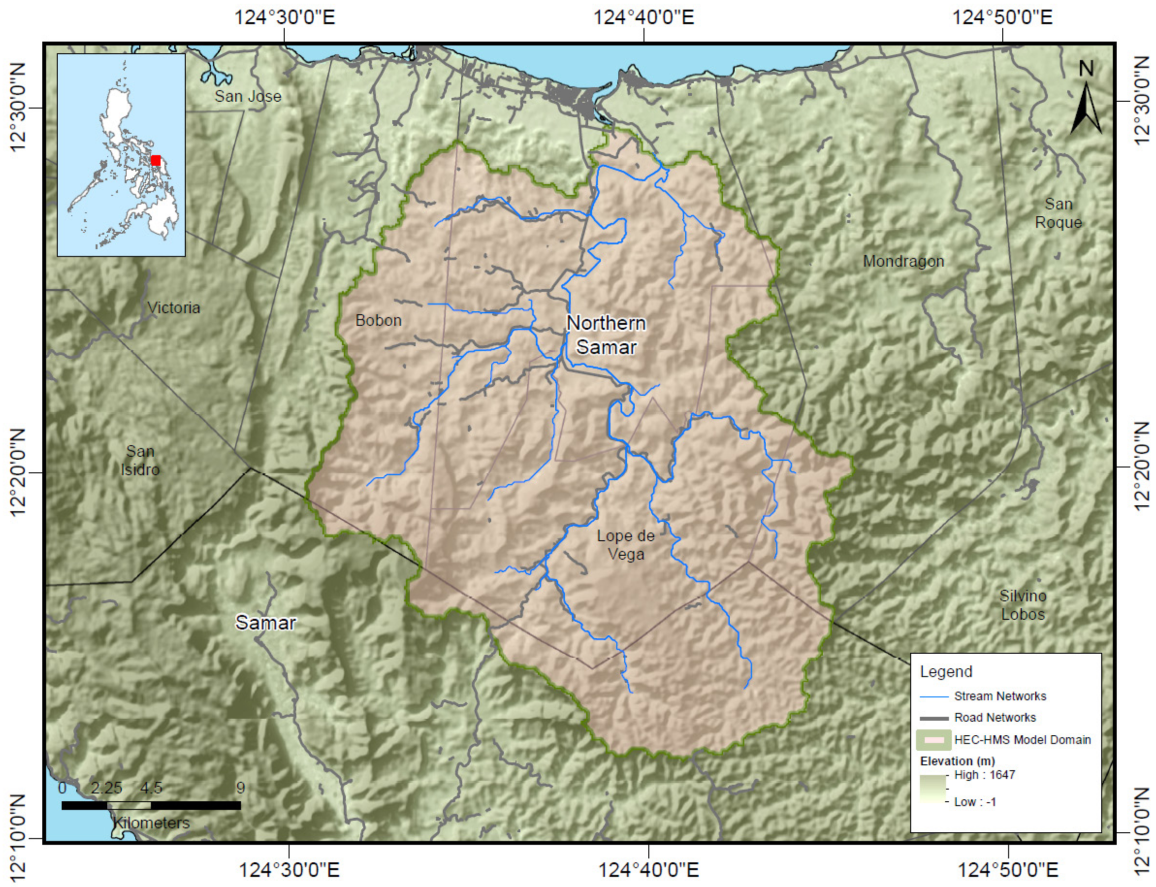


Figure 1. Map of Catarman River Basin (in brown).

Its main stem, Catarman River, is part of the twenty-eight (28) river systems in Eastern Visayas Region. According to the 2015 national census of PSA, a total of 25,275 persons residing within the immediate vicinity of the river which is distributed among barangays Somoge, Washington, San Pascual, McKinley, Hinatad, Doña Pulqueria, Galutan, Macagtas, Ipil-Ipil, Jose Abad Santos, Sampaguita, Mabolo, Baybay, and Bangkerohan in the Municipality of Catarman. In terms of economy, major industries in the province include agriculture and fishing with traditional crops such as palay, corn, vegetables, and fruits as the main products (National Economic and Development Authority, 2011). About 7,333 families (32,358 individuals) in Northern Samar were displaced by floods spawned by torrential rains in December 17, 2016 (Gabriela, J. & Dejon, R., 2016).

# CHAPTER 2: LIDAR DATA ACQUISITION OF THE CATARMANFLOODPLAIN

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

## 2.1 Flight Plans

To initiate the LiDAR acquisition survey of the Catarman floodplain, the Data Acquisition Component (DAC) created flight plans within the delineated priority area for Catarman Floodplain in Northern Samar. These flight missions were planned for 14 lines and ran for at most four and a half hours (4.5) including take-off, landing and turning time. The flight planning parameters for the LiDAR system are outlined in Table 1. Figure 2 shows the flight plan for Catarmanfloodplain survey.

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

| Block Name | Flying Height (m AGL) | Overlap (%) | Field of View (θ) | Pulse Repetition Frequency (PRF) (kHz) | Scan Frequency (Hz) | Average Speed (kts) | Average Turn Time (Minutes) |
|---|---|---|---|---|---|---|---|
| BLK331A | 600 | 35 | 36 | 50 | 50 | 120 | 5 |
| BLK331B | 500 | 35 | 36 | 50 | 45 | 120 | 5 |
| BLK331C | 500 | 35 | 36 | 50 | 45 | 120 | 5 |
| BLK331D | 500 | 35 | 36 | 50 | 45 | 120 | 5 |
| BLK331G | 600 | 35 | 36 | 50 | 50 | 120 | 5 |
| BLK331H | 600 | 25, 30, 35 | 36 | 50 | 45 | 120 | 5 |
| BLK331I | 600 | 30, 35 | 36 | 50 | 45 | 120 | 5 |
| BLK331J | 600 | 35 | 36 | 50 | 50 | 120 | 5 |
| BLK331K | 600 | 30, 35 | 36 | 50 | 50 | 120 | 5 |
| BLK331L | 500 | 35 | 40 | 50 | 45, 50 | 120 | 5 |
| BLK331N | 500 | 35 | 40 | 50 | 45 | 120 | 5 |
| BLK331O | 600 | 25 | 36 | 50 | 50 | 120 | 5 |
| BLK331T | 500 | 35 | 36 | 50 | 45 | 120 | 5 |

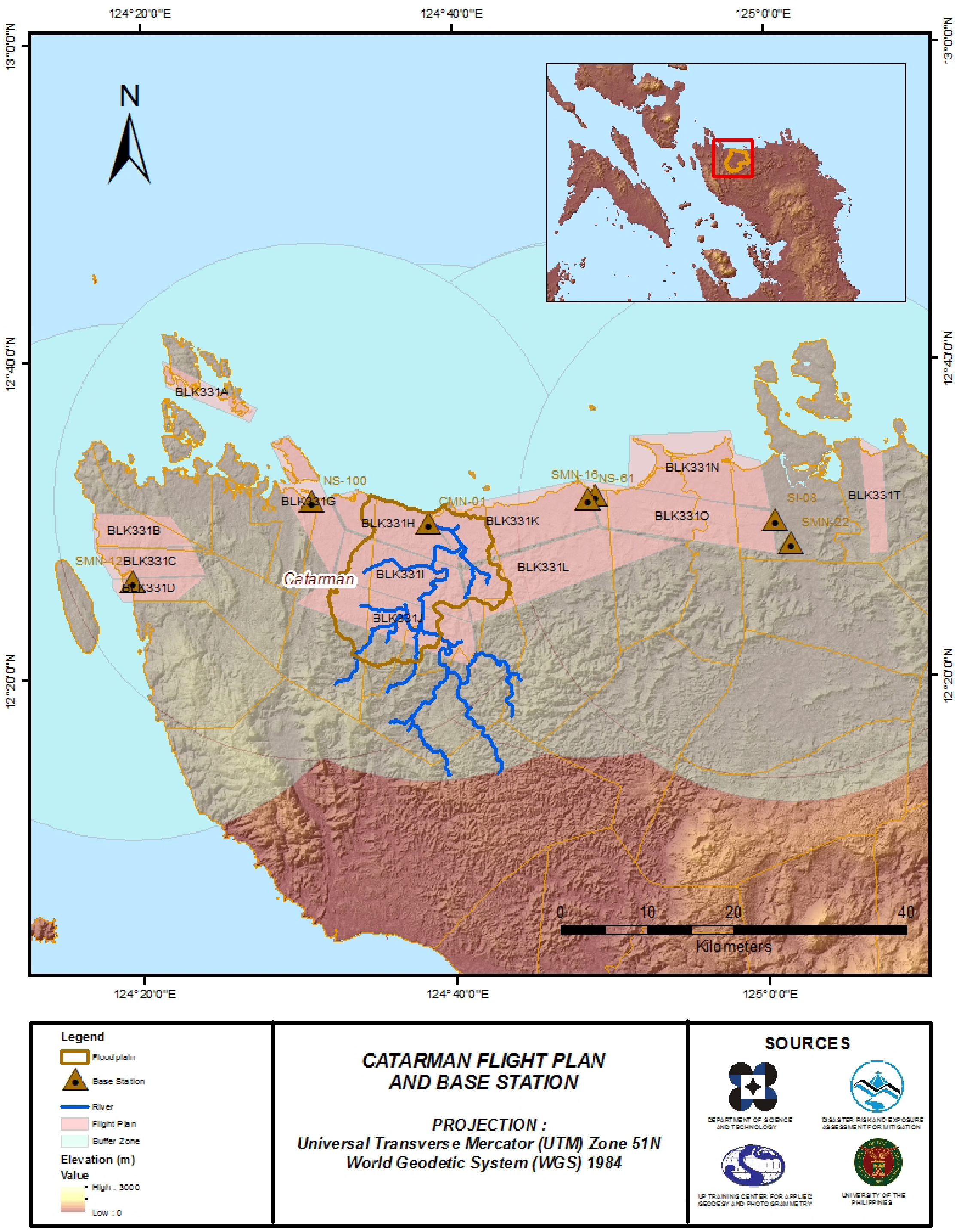



Figure 2. Flight plans and base stations used for Catarman floodplain using Aquarius LiDAR system.

## 2.2 Ground Base Stations

The project team was able to recover four (4) NAMRIA ground control points: SMN-16 (SMN-19), SMN-22, SMN-12 which are all of second ($2^{nd}$) order accuracy.

The certifications for the base stations are found in Annex 2 while the baseline processing reports for the established control points are found in Annex 3. The project team also established ground control point CMN-01. Three (3) NAMRIA benchmarks were recovered: NS-61, NS-100 and SI-08 which are all of first ($1^{st}$) order accuracy. These benchmarks were used as vertical reference points and were also established as ground control points. These were used as base stations during flight operations for the entire duration of the survey (February 21 to March 9, 2015 and August 1 to 28, 2015). Base stations were observed using dual frequency GPS receivers, TOPCON GR5, TRIMBLE SPS 852 and SPS 985. Flight plans and location of base stations used during the aerial LiDAR acquisition in Catarman floodplain are shown in Figure 2.

The succeeding sections depict the sets of reference points, control stations and established points, and the ground control points for the entire Catarman Floodplain LiDAR Survey. Figure 3 to Figure 7 show the recovered NAMRIA reference points within the area of the floodplain, while Table 2 to Table 7 show the details about the following NAMRIA control stations and established points.Table 8, on the other hand, shows the list of all ground control points occupied during the acquisition together with the corresponding dates of utilization.


(a) (b)

Figure 3. GPS set-up over SMN-16 situated in Brgy. Bagasbas, Municipality of Mondragon located inside the Basketball Court (a) and NAMRIA reference point SMN-16 (b) as recovered by the field team.

Table 2. Details of the recovered NAMRIA horizontal control point SMN-16 used as base station for the LiDAR data acquisition.

| Station Name | SMN-16 | |
|---|---|---|
| Order of Accuracy | 2nd Order | |
| Relative Error (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 12°31’32.33268” North<br>124° 48’56.69485”East<br>5.45500 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92) | Easting<br>Northing | 479974.965 meters<br>1385085.603 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 12° 31’ 27.72792” North<br>124° 49’ 1.74020”East<br>63.99100 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS1992) | Easting<br>Northing | 697302.11 meters<br>1385272.01 meters |


(a) (b)

Figure 4. GPS set-up over SMN-12 situated in the Municipality of Mondragon located inside a school (a) and NAMRIA reference point SMN-12 (b) as recovered by the field team.

Table 3. Details of the recovered NAMRIA horizontal control point SMN-12 used as base station for the LiDAR data acquisition.

| Station Name | SMN-12 | |
|---|---|---|
| Order of Accuracy | 2nd Order | |
| Relative Error (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude<br>Longitude<br>Ellipsoidal Height | 12° 26’ 15.70013” North<br>124° 19’ 13.39605”East<br>5.45500 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92) | Easting<br>Northing | 426111.163 meters<br>1375444.106 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude<br>Longitude<br>Ellipsoidal Height | 12° 26’ 11.07561” North<br>124° 19’ 18.45344” East<br>64.58200 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS1992) | Easting<br>Northing | 643513.56 meters<br>1375224.53 meters |

(a)


(b)

Figure 5. GPS set-up over SMN-22 located in Barangay Simora Elementary School, Northern Samar, and NAMRIA reference point SMN-22 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point SMN-22 used as base station for the LiDAR data acquisition.

| Station Name | SMN-22 | |
|---|---|---|
| Order of Accuracy | 2nd Order | |
| Relative Error (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude | 12°28’27.20633” North |
| | Longitude | 125°1’25.36067” East |
| | Ellipsoidal Height | -1.70407 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92) | Easting | 502577.525meters |
| | Northing | 1379390.508meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude | 12°28’22.63174” North |
| | Longitude | 125°1’30.408661” East |
| | Ellipsoidal Height | 57.47400 meters |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS1992) | Easting | 719951.32 meters |
| | Northing | 1379746.87 meters |

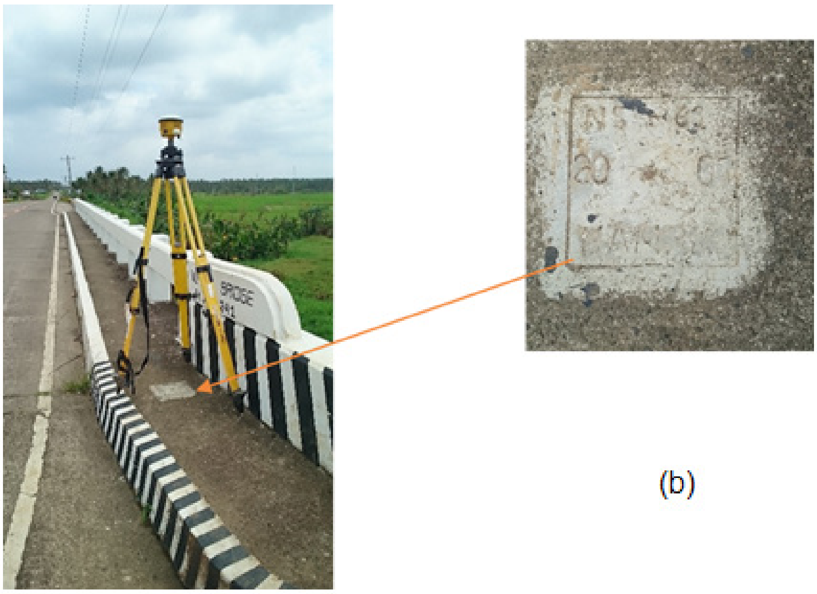

(a)


(b)

Figure 6. GPS set-up over NS-100 as situated in Geratag Bridge 1, Northern Samar, and NAMRIA reference point NS-100 (b) as recovered by the field team.

Table 5. Details of the recovered NAMRIA Benchmark NS-100 used as base station for the LiDAR data acquisition with established coordinates.

| Station Name | NS-100 | |
|---|---|---|
| Order of Accuracy | 2nd Order | |
| Relative Error (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude | 12° 31’ 15.60049” North |
| | Longitude | 124° 30’ 47.05130” East |
| | Ellipsoidal Height | 5.524 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 3 (PTM Zone 3 PRS 92) | Easting | 664407.825meters |
| | Northing | 1384550.595meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude | 12° 31’ 10.97151” North |
| | Longitude | 124° 30’ 52.09977” East |
| | Ellipsoidal Height | 63.332 meters |



(b)

(a)

Figure 7. NS-61 as situated in Muyaw Bridge, Mondragon Northern Samar (a) and NAMRIA reference point NS-61 (a) as recovered by the field team.

Table 6. Details of the recovered NAMRIA Benchmark NS-61 used as base station for the LiDAR data acquisition with established coordinates.

| Station Name | NS-61 | |
|---|---|---|
| Order of Accuracy | 2nd | |
| Relative Error (horizontal positioning) | 1:50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude | 12°31’17.86801” North |
| | Longitude | 124°48’26.40323” East |
| | Ellipsoidal Height | 5.208 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude | 12°31’13.26354” North |
| | Longitude | 124°48’31.44902” East |
| | Ellipsoidal Height | 63.733 meters |
| Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92) | Easting | 696390.555 meters |
| | Northing | 1384821.249 meters |

Table 7. Details of the established horizontal control point CMN-01 used as base station for the LiDAR acquisition.

| Station Name | CMN-01 | |
|---|---|---|
| Order of Accuracy | 2nd | |
| Relative Error (horizontal positioning) | 1 in 50,000 | |
| Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92) | Latitude | 12° 29' 53.60604" North |
| | Longitude | 124° 38' 11.46535" East |
| | Ellipsoidal Height | 12.573 meters |
| Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84) | Latitude | 12° 29' 48.99306" North 124° 38' 16.51471" East 70.742 meters |
| | Longitude | |
| | Ellipsoidal Height | |
| Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS92) | Easting | 677840.326 meters |
| | Northing | 1382111.129 meters |

Table 8. Ground control points used during the LiDAR data acquisition.

| Date Surveyed | Flight Number | Mission Name | Ground Control Points |
|---|---|---|---|
| 21-Feb-15 | 7814AC | 3BLK331I052A | SMN-16 and NS-61 |
| 24-Feb-15 | 7820AC | 3BLK331I055A | SMN-16 and NS-61 |
| 25-Feb-15 | 7822AC | 3BLK331I056A | SMN-16 and NS-61 |
| 26-Feb-15 | 7824AC | 3BLK331H057A | SMN-16 and NS-61 |
| 27-Feb-15 | 7826AC | 3BLK331K058A | SMN-16 and NS-61 |
| 28-Feb-15 | 7828AC | 3BLK331J059A | SMN-12 and NS-100 |
| 28-Feb-15 | 7829AC | 3BLK331H059B | SMN-12 and NS-100 |
| 01-Mar-15 | 7830AC | 3BLK331HSO060A | SMN-16 and NS-61 |
| 03-Mar-15 | 7834AC | 3BLK331KSOS062A | SMN-16 and NS-61 |
| 05-Mar-15 | 7838AC | 3BLK331JSB064A | SMN-12 and NS-100 |
| 05-Mar-15 | 7839AC | 3BLK331G064B | SMN-12 and NS-100 |
| 07-Mar-15 | 7842AC | 3BLK331JO066A | SMN-16 and NS-61 |
| 09-Mar-15 | 7846AC | 3BLK331L068A | SMN-16 and NS-61 |
| 01-Aug-15 | 8137AC | CASILCTF213A | SMN-19 and CMN-01 |
| 04-Aug-15 | 8142AC | AQUALCTF216A | SMN-19 and CMN-01 |
| 11-Aug-15 | 8156 AC | 3BLK331LNS223A | SMN-19 and CMN-01 |
| 24-Aug-15 | 8183AC | 3BLK33STV236B | SMN-22 and SI-08 |
| 25-Aug-15 | 8185AC | 3BUNDLEADJUSTMENT237B | SMN-22, SMN-16, SI-08 and NS-61 |
| 27-Aug-15 | 8188AC | 3BLK33S239A | SMN-12 and NS-100 |
| 28-Aug-15 | 8190AC | 3BLK33CD240A | SMN-12 and NS-100 |

## 2.3 Flight Missions

A total of 20 missions were conducted to complete the LiDAR data acquisition in Catarman floodplain, for a total of fifty-six hours and twenty-four minutes (56+24) of flying time for RP-C9322 (See Annex 6). All missions were acquired using Aquarius LiDAR system. As shown below, the total area of actual coverage per mission and the corresponding flying hours are depicted inTable 9, while the actual parameters used during the LiDAR data acquisition are presented inTable 10.

Table 9. Flight missions for LiDAR data acquisition in Catarman floodplain.

| Date Surveyed | Flight Number | Flight Plan Area ($km^2$) | Surveyed Area ($km^2$) | Area Surveyed within the Floodplain ($km^2$) | Area Surveyed Outside the Floodplain ($km^2$) | No. of Images (Frames) | Flying Hours | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | **Hr** | **Min** |
| 21-Feb-15 | 7814AC | 78.22 | 13.24 | 9.73 | 3.51 | NA | 1 | 23 |
| 24-Feb-15 | 7820AC | 78.22 | 10.51 | 8.70 | 1.81 | NA | 1 | 17 |
| 25-Feb-15 | 7822AC | 78.22 | 77.71 | 57.14 | 20.57 | NA | 3 | 53 |
| 26-Feb-15 | 7824AC | 78.71 | 80.10 | 23.97 | 56.13 | NA | 3 | 11 |
| 27-Feb-15 | 7826AC | 110.19 | 41.17 | 12.46 | 28.71 | NA | 2 | 35 |
| 28-Feb-15 | 7828AC | 218.50 | 89.26 | 56.87 | 32.39 | NA | 3 | 53 |
| 28-Feb-15 | | 61.57 | 39.76 | 27.63 | 12.13 | NA | 2 | 35 |
| 01-Mar-15 | 7830AC | 154.26 | 87.52 | 11.44 | 76.08 | NA | 3 | 59 |
| 03-Mar-15 | 7834AC | 171.76 | 59.24 | 20.91 | 38.33 | NA | 2 | 41 |
| 05-Mar-15 | 7838AC | 102.59 | 67.35 | 18.66 | 48.69 | NA | 3 | 35 |
| 05-Mar-15 | 7839AC | 56.73 | 37.04 | 0.66 | 36.38 | NA | 2 | 5 |
| 07-Mar-15 | 7842AC | 78.71 | 58.41 | 30.75 | 27.66 | NA | 4 | 5 |
| 09-Mar-15 | 7846AC | 78.22 | 127.71 | 18.72 | 108.99 | NA | 3 | 48 |
| 01-Aug-15 | 8137AC | 78.22 | 24.25 | 21.84 | 2.41 | NA | 1 | 47 |
| 04-Aug-15 | 8142AC | 78.22 | 11.74 | 2.79 | 8.95 | NA | 1 | 53 |
| 11-Aug-15 | 8156 AC | 78.71 | 153.81 | 11.66 | 142.15 | NA | 3 | 41 |
| 24-Aug-15 | 8183AC | 110.19 | 40.09 | 3.74 | 36.35 | NA | 2 | 41 |
| 25-Aug-15 | 8185AC | 218.50 | 8.30 | 7.94 | 0.36 | NA | 1 | 29 |
| 27-Aug-15 | 8188AC | 61.57 | 21.32 | 0.01 | 21.31 | NA | 2 | 11 |
| 28-Aug-15 | 8190AC | 154.26 | 55.36 | 0.01 | 55.35 | NA | 3 | 42 |
| TOTAL | | 1871.44 | 1103.89 | 345.61 | 758.28 | NA | 56 | 24 |

Table 10. Actual parameters used during LiDAR data acquisition.

| Flight Number | Flying Height (m AGL) | Overlap (%) | FOV (θ) | PRF (khz) | Scan Frequency (Hz) | Average Speed (kts) | Average Turn Time (Minutes) |
|---|---|---|---|---|---|---|---|
| 7814AC | 600 | 35 | 36 | 50 | 45 | 120 | 5 |
| 7820AC | 600 | 35 | 36 | 50 | 45 | 120 | 5 |
| 7822AC | 600 | 35 | 36 | 50 | 45 | 120 | 5 |
| 7824AC | 600 | 30,35 | 36 | 50 | 50 | 120 | 5 |
| 7826AC | 600 | 35 | 36 | 50 | 50 | 120 | 5 |
| 7828AC | 600 | 50 | 36 | 50 | 50 | 120 | 5 |
| 7829AC | 600 | 35 | 36 | 50 | 50 | 120 | 5 |
| 7830AC | 600 | 25 | 36 | 50 | 50 | 120 | 5 |
| 7834AC | 600 | 30 | 36 | 50 | 50 | 120 | 5 |
| 7838AC | 600 | 35 | 36 | 50 | 50 | 120 | 5 |
| 7839AC | 600 | 35 | 36 | 50 | 50 | 120 | 5 |
| 7842AC | 600 | 35 | 36 | 50 | 50 | 120 | 5 |
| 7846AC | 600 | 30 | 36 | 50 | 50 | 120 | 5 |
| 8137AC | 600 | 35 | 36 | 50 | 45 | 120 | 5 |
| 8142AC | 600 | 35 | 36 | 50 | 45 | 120 | 5 |
| 8156 AC | 500 | 35 | 40 | 50 | 45 | 120 | 5 |
| 8183AC | 500 | 35 | 36 | 50 | 45 | 120 | 5 |
| 8185AC | 500 | 35 | 36 | 50 | 45 | 120 | 5 |
| 8188AC | 500 | 35 | 36 | 50 | 45 | 120 | 5 |
| 8190AC | 500 | 35 | 36 | 50 | 45 | 120 | 5 |

## 2.4 Survey Coverage

This certain LiDAR acquisition survey covered the Catarman floodplain (See Annex 7). It is located in the province of Northern Samar with majority of the floodplain situated within the municipality of Catarman. Most of Catarman is covered by the survey. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 11. Figure 8, on the other hand, shows the actual coverage of the LiDAR acquisition for theCatarman floodplain.

Table 11. List of municipalities and cities surveyed during Catarman floodplain LiDAR survey.

| Province | Municipality/City | Area of Municipality/ City ($km^2$) | Total Area Surveyed ($km^2$) | Percentage of Area Surveyed |
|---|---|---|---|---|
| Northern Samar | Catarman | 255.77 | 233.39 | 91.25% |
| | Bobon | 198.53 | 105.61 | 53.20% |
| | Mondragon | 322.75 | 150.63 | 46.67% |
| | San Roque | 166.51 | 76.2 | 45.76% |
| | Victoria | 137.55 | 57.07 | 41.49% |
| | Pambujan | 150.63 | 51.62 | 34.27% |
| | Biri | 26.75 | 8.6 | 32.14% |
| | Laoang | 207.6 | 48.62 | 23.42% |
| | San Jose | 68.72 | 12.29 | 17.89% |
| | Allen | 57.16 | 9.64 | 16.87% |
| | Lope de Vega | 186.61 | 22.58 | 12.10% |
| | Palapag | 153.46 | 17.74 | 11.56% |
| Total | | 1932.04 | 793.99 | 41.10% |

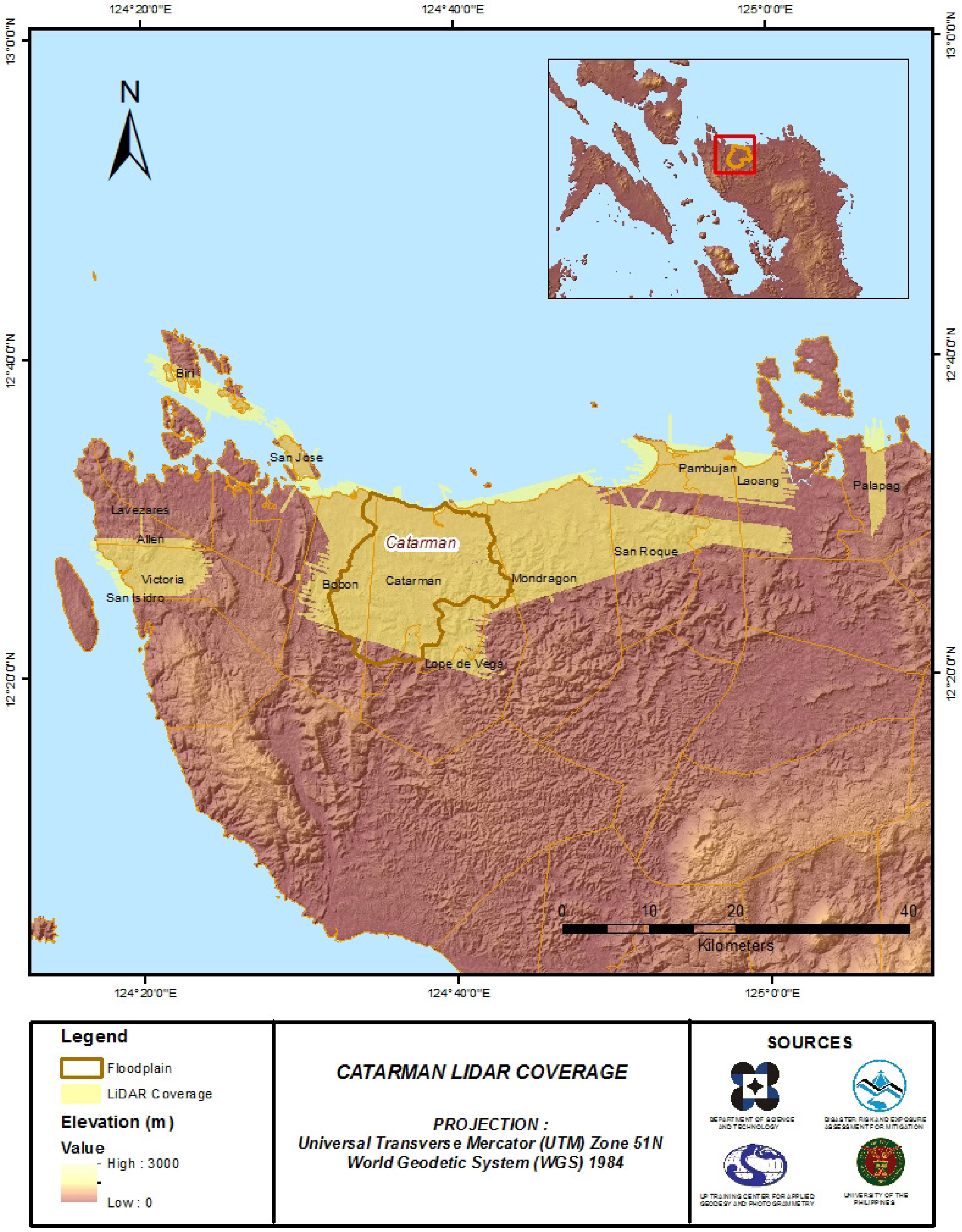



Figure 8. Actual LiDAR survey coverage for Catarman floodplain.

# CHAPTER 3: LIDAR DATA PROCESSING OF THE CATARMAN FLOODPLAIN

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

## 3.1 Overview of the LIDAR Data Pre-Processing

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

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

These processes are summarized in the flowchart shown inFigure 9.

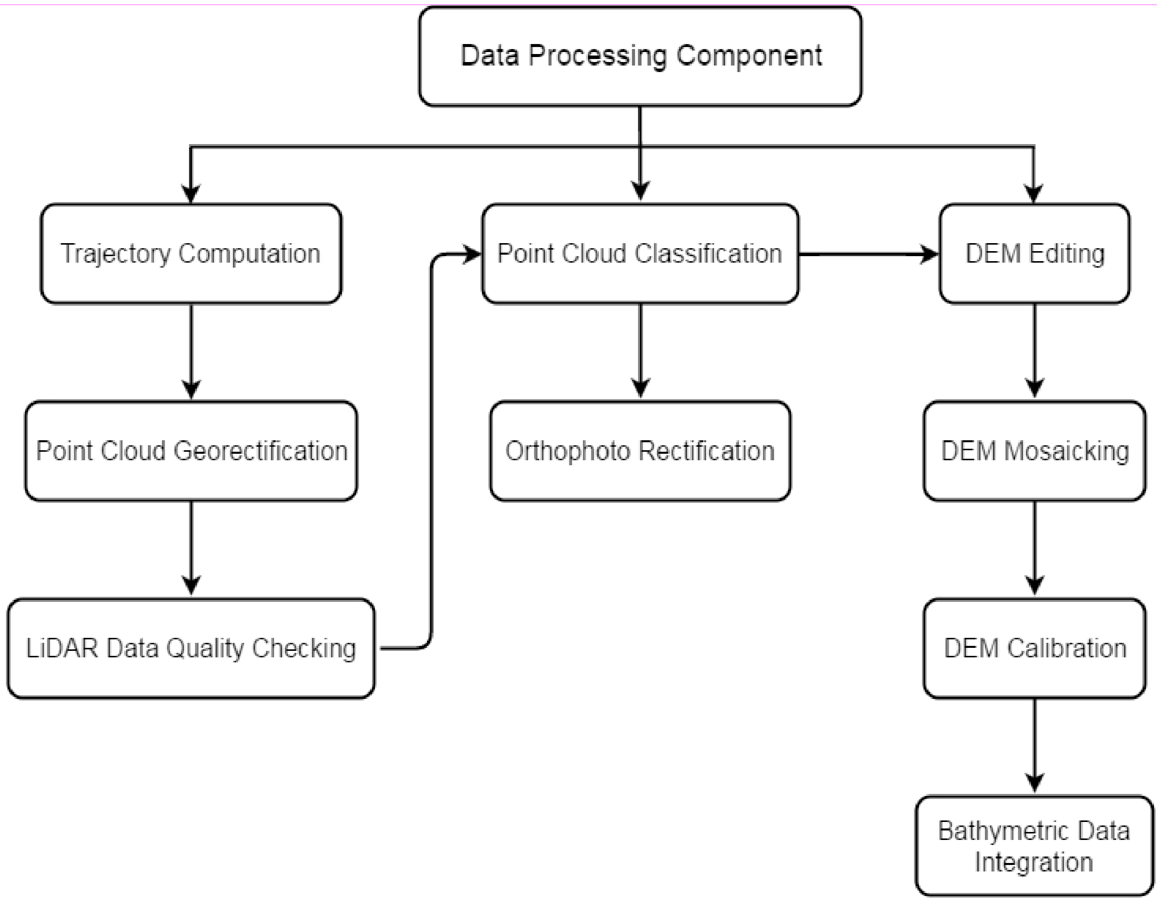


Figure 9. Schematic diagram for the data pre-processing.

## 3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions of the Catarman Floodplain can be found in Annex 5. The missions flown during the conduct of the survey in June 2015 utilized the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Aquariussystem over Catarman, Northern Samar.

The Data Acquisition Component (DAC) transferred a total of 139.23 Gigabytes of Range data, 3.07 Gigabytes of POS data, 353.98 Megabytes of GPS base station data, and 737.23 Gigabytes of raw image data to the data server on July 13, 2015 for the first survey and April 17, 2016 for the second survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Catarman was fully transferred on June 4, 2016, as indicated on the Data Transfer Sheets for Catarman floodplain.

## 3.3 Trajectory Computation

The Smoothed Performance Metric parameters of the computed trajectory for Flight 7846AC, one of the Catarman flights, which is the North, East, and Down position RMSE values are shown inFigure 10. The x-axis corresponds to the time of the flight, which was measured by the number of seconds from the midnight of the start of the GPS week, which fell on the date and time of March 9, 2015, 00:00 AM. The y-axis, on the other hand, represents the RMSE value for that particular position.

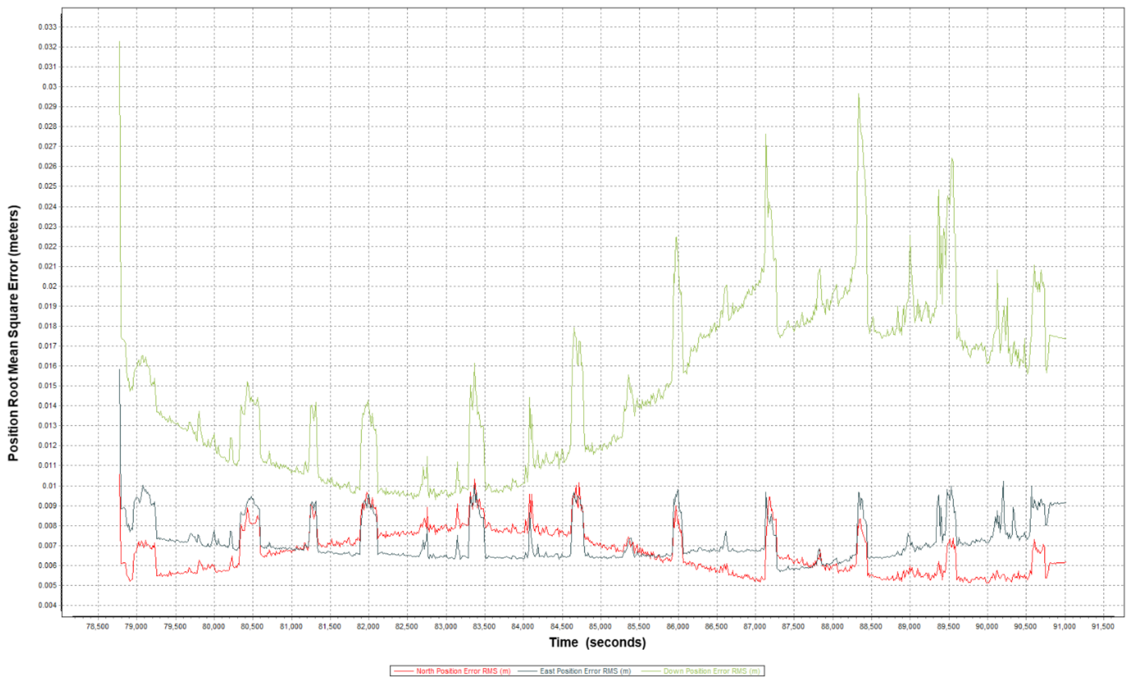


Figure 10. Smoothed Performance Metric Parameters of Catarman Flight 7846AC.

The time of flight was from 78500 seconds to 91500 seconds, which corresponds to afternoon of March 9, 2015. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft.

Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 11 shows that the North position RMSE peaks at 1.11 centimeters, the East position RMSE peaks at 1.16 centimeters, and the Down position RMSE peaks at 2.90 centimeters, which are within the prescribed accuracies described in the methodology.

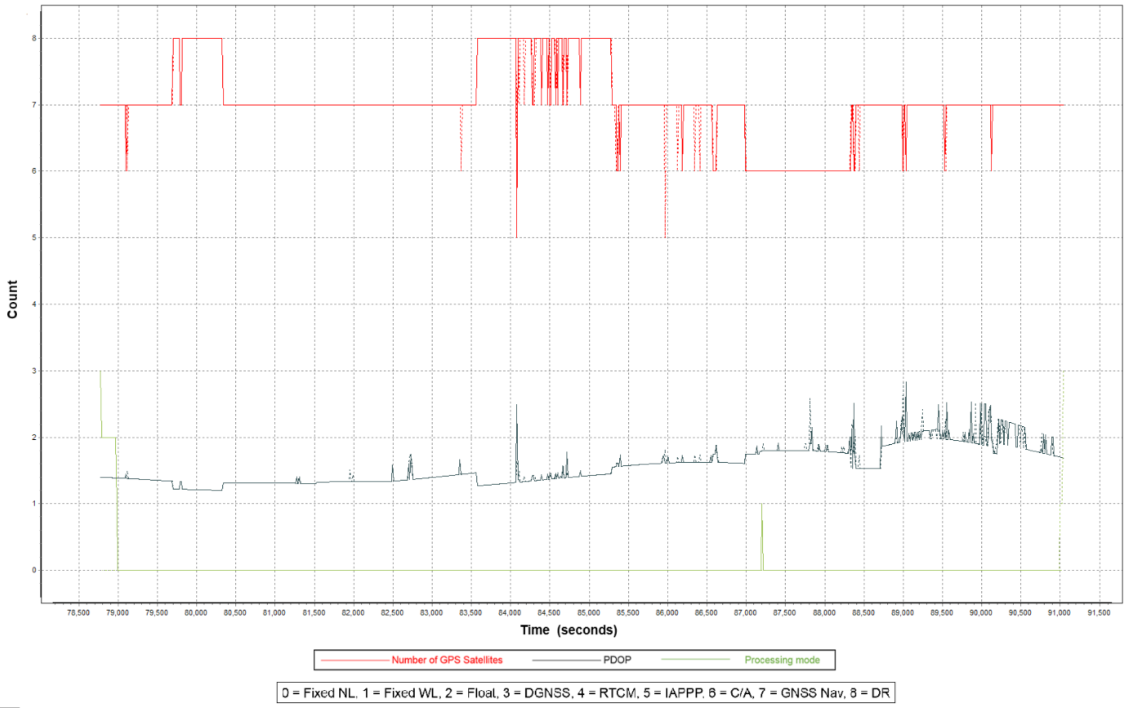


Figure 11. Solution Status Parameters of Catarman Flight 7846AC.

The Solution Status parameters, which indicate the number of GPS satellites; Positional Dilution of Precision (PDOP); and the GPS processing mode used for Catarman Flight 7846AC are shown inFigure 11. For the Solution Status parameters, the figure above signifies that the number of satellites utilized and tracked during the acquisition were between 6 and 8, not going lower than 6. Similarly, the PDOP value did not go above the value of 3, which indicates optimal GPS geometry. The processing mode also stayed at the value of 0 for the majority of the survey stayed at the value of 0 for majority of the survey with some peaks up to 1 attributed to the turns performed by the aircraft. The value of 0 corresponds to a Fixed, Narrow-Lane Mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for the POSPAC MMS. Fundamentally, all of the parameters adhered to the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Catarman flights is shown inFigure 12.

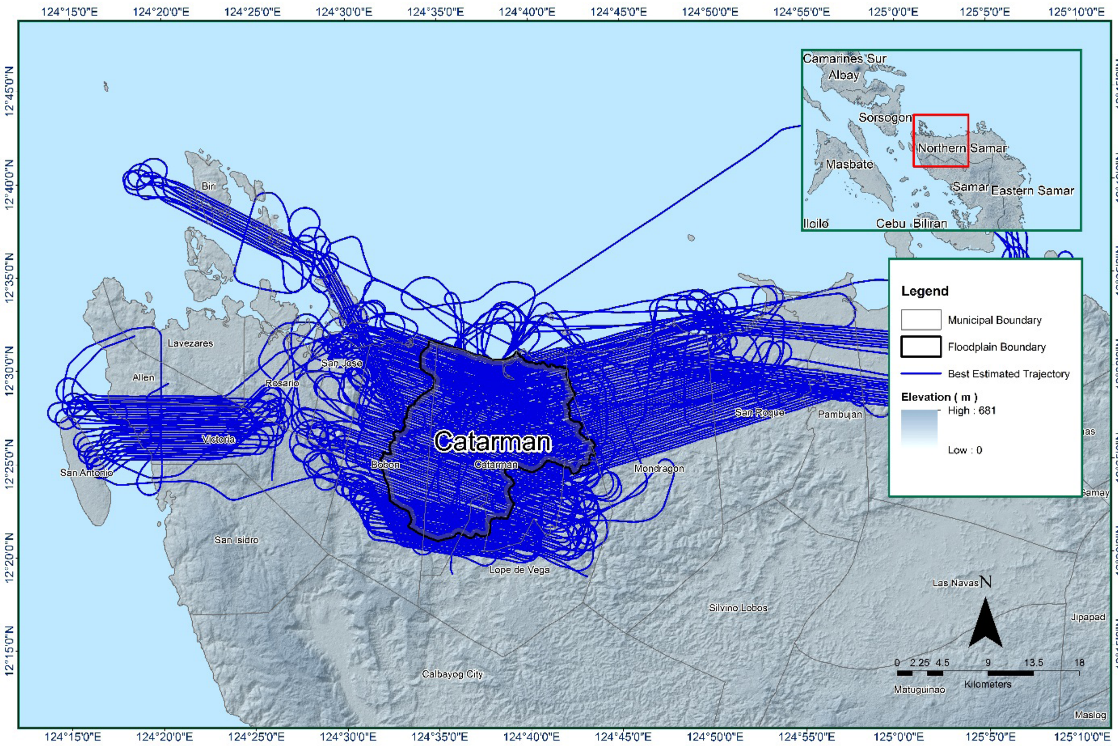


Figure 12. Best Estimated Trajectory of the LiDAR missions conducted over the Catarman Floodplain.

## 3.4 LiDAR Point Cloud Computation

The produced LAS contains 208 flight lines, with each flight line contains one channel, since the Aquarius system contains only one channel. The summary of the self-calibration results obtained from LiDAR processing in the LiDAR Mapping Suite (LMS) software for all flights over the Catarman floodplain are given inTable 12.

Table 12. Self-calibration Results values for Catarman flights.

| Parameter | Acceptable Value | Computed Value |
|---|---|---|
| Boresight Correction stdev) | <0.001degrees | 0.000404 |
| IMU Attitude Correction Roll and Pitch Corrections stdev) | <0.001degrees | 0.000905 |
| GPS Position Z-correction stdev) | <0.01meters | 0.0031 |

The optimum accuracy values for all Catarman flights were also calculated, which are based on the computed standard deviations of the corrections of the orientation parameters. The standard deviation values for individual blocks are presented in the Mission Summary Reports (Annex8).

## 3.5 LiDAR Quality Checking

The boundary of the processed LiDAR data on top of the SAR Elevation Data over the Catarman Floodplain is shown inFigure 13. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

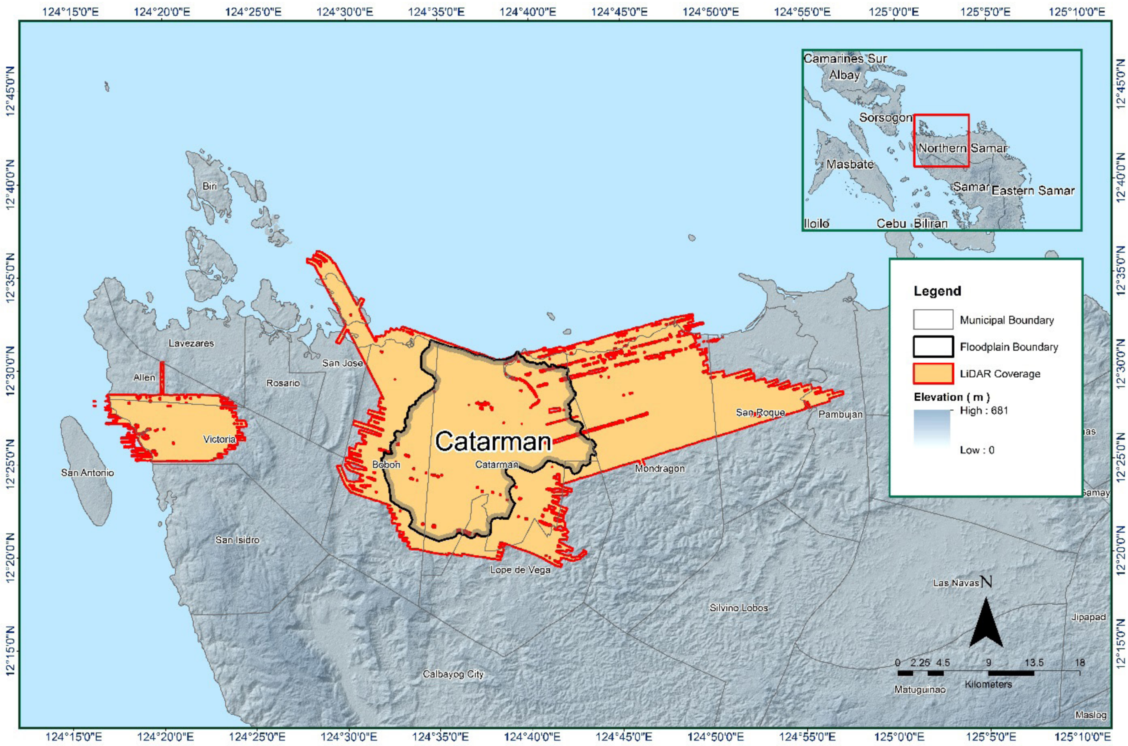


Figure 13. Boundaries of the processed LiDAR data over the Catarman Floodplain.

A total area of 779.40 square kilometers (sq.km) were covered by the Catarman flight missions as a result of eighteen (18) flight acquisitions, which were grouped and merged into twelve (12) block accordingly, as portrayed inTable 13.

Table 13. List of LiDAR blocks for the Catarman floodplain.

| LiDAR Blocks | Flight Numbers | Area (sq. km) |
|---|---|---|
| Catarman_Blk33C | 8188AC | 36.81 |
| | 8190AC | |
| Catarman_Blk33D | 8190AC | 31.47 |
| Catarman_Blk331G | 7839AC | 32.35 |
| Catarman_Blk331H | 7828AC | 77.02 |
| | 7829AC | |
| | 7830AC | |
| | 7834AC | |
| Catarman_Blk331I | 7822AC | 95.40 |
| | 7820AC | |
| Catarman_Blk331J | 7828AC | 146.87 |
| | 7838AC | |
| | 7842AC | |
| Catarman_Blk331I_ supplement | 7814AC | 10.21 |
| Catarman_Blk_331K | 7824AC | 121.02 |
| | 7826AC | |
| | 7834AC | |
| Catarman_Blk331L | 7846AC | 126.38 |
| Catarman_Blk331L_additional | 8156AC | 37.44 |
| Catarman_Blk33S | 8183AC | 13.40 |
| Catarman_reflights_Blk33F | 8445AC | 51.03 |
| **TOTAL** | | **779.40 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 14. Since the Aquarius system employs one channel, we would expect an average value of 1 (blue) for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines.

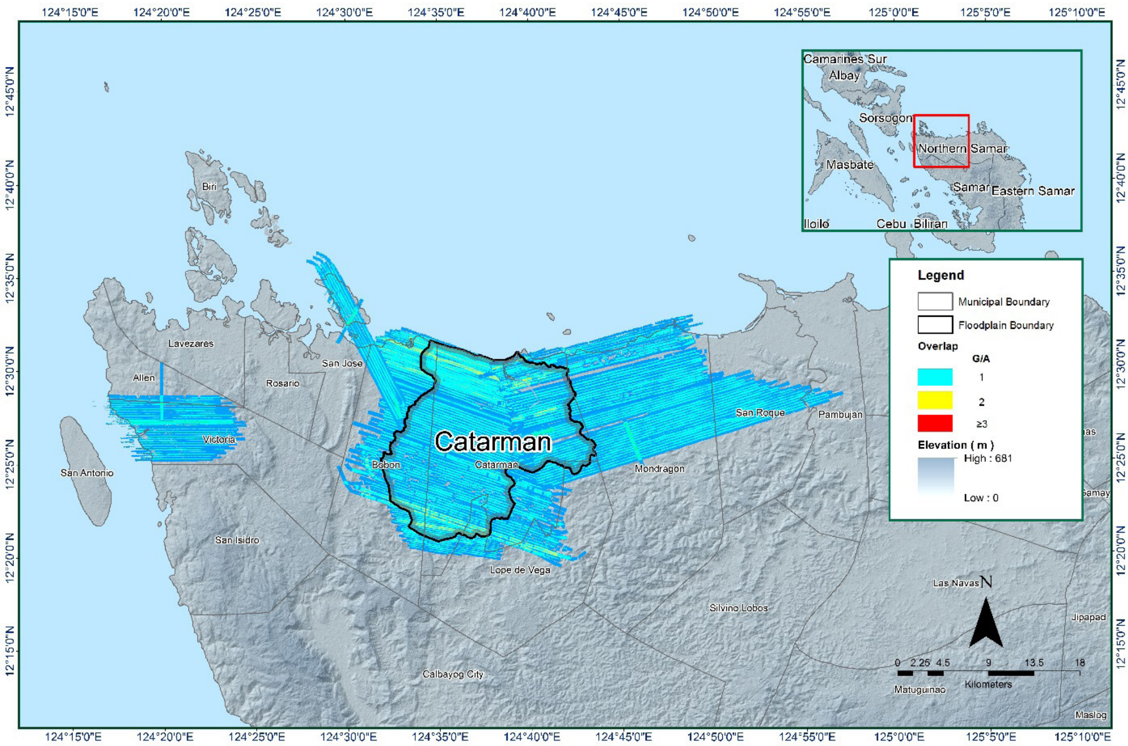


Figure 14. Image of data overlap for Catarman floodplain.

The overlap statistics per block for the Catarman floodplain can be found in the Mission Summary Reports (Annex 8). One pixel corresponds to 25.0 square meters on the ground. For this area, the percent overlaps 27.44% and 69.50% respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the two (2) points per square meter criterion is shown inFigure 15. As seen in the figure below, it was determined that all LiDAR data for the Catarman Floodplain Survey satisfy the point density requirement, as the average density for the entire survey area is 2.62 points per square meter.

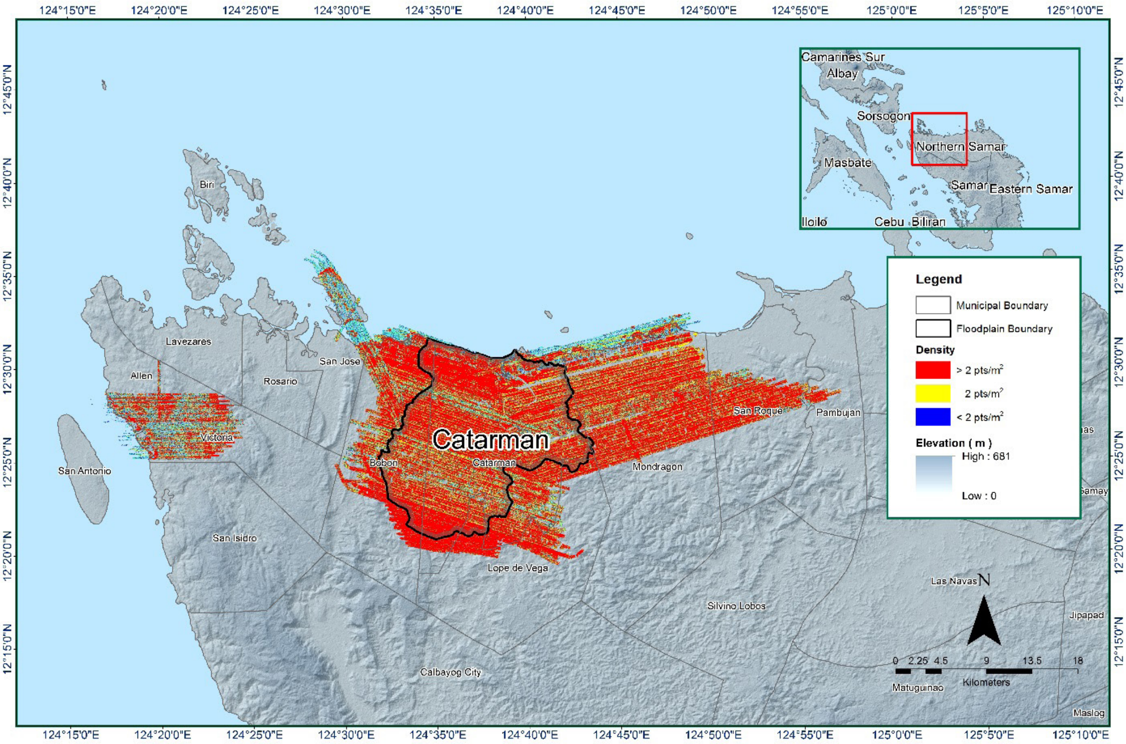


Figure 15. Pulse density map of the merged LiDAR data for Catarman floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 16. The default color range is blue to red, where bright blue areas correspond to portions where elevations of a previous flight line are higher by more than 0.20m, as identified by its acquisition time; which is relative to the elevations of its adjacent flight line. Similarly, bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m, relative to the elevations of its adjacent flight line. Areas highlighted in bright red or bright blue necessitate further investigation using the Quick Terrain Modeler software.

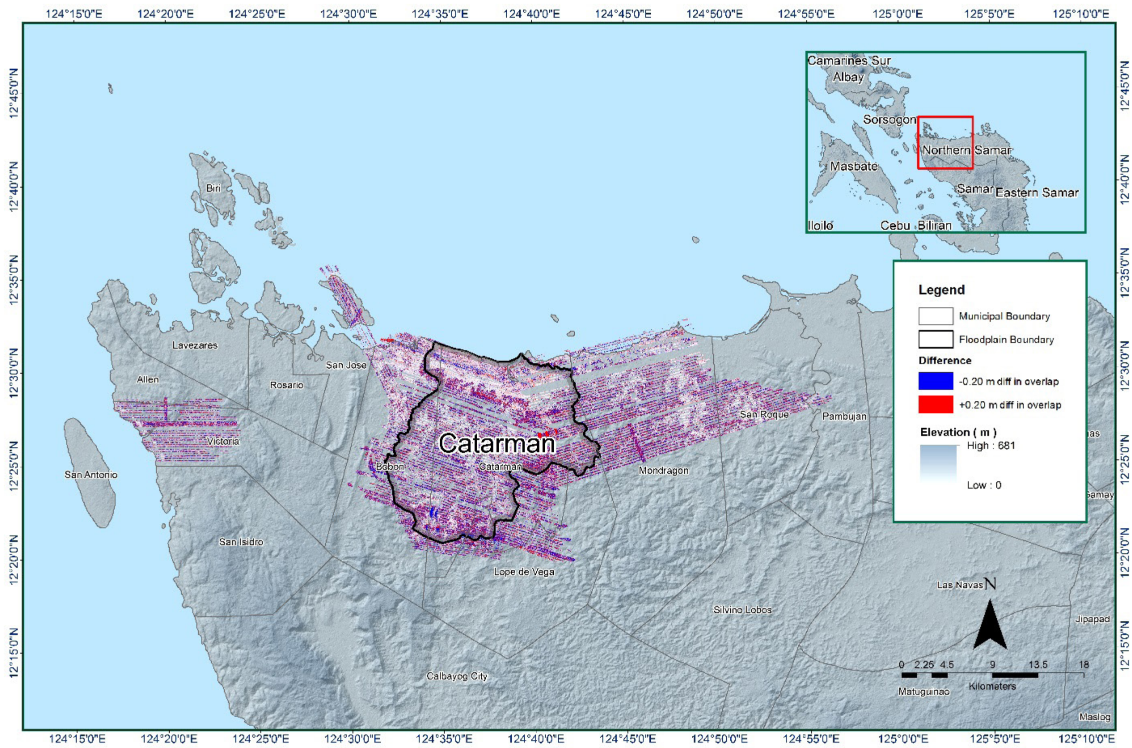


Figure 16. Elevation difference Map between flight lines for the Catarman Floodplain Survey.

A screen-capture of the processed LAS data from Catarman flight 7846AC loaded in QT Modeler is shown in Figure 17. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data generated satisfactory results. No reprocessing was done for this LiDAR dataset.

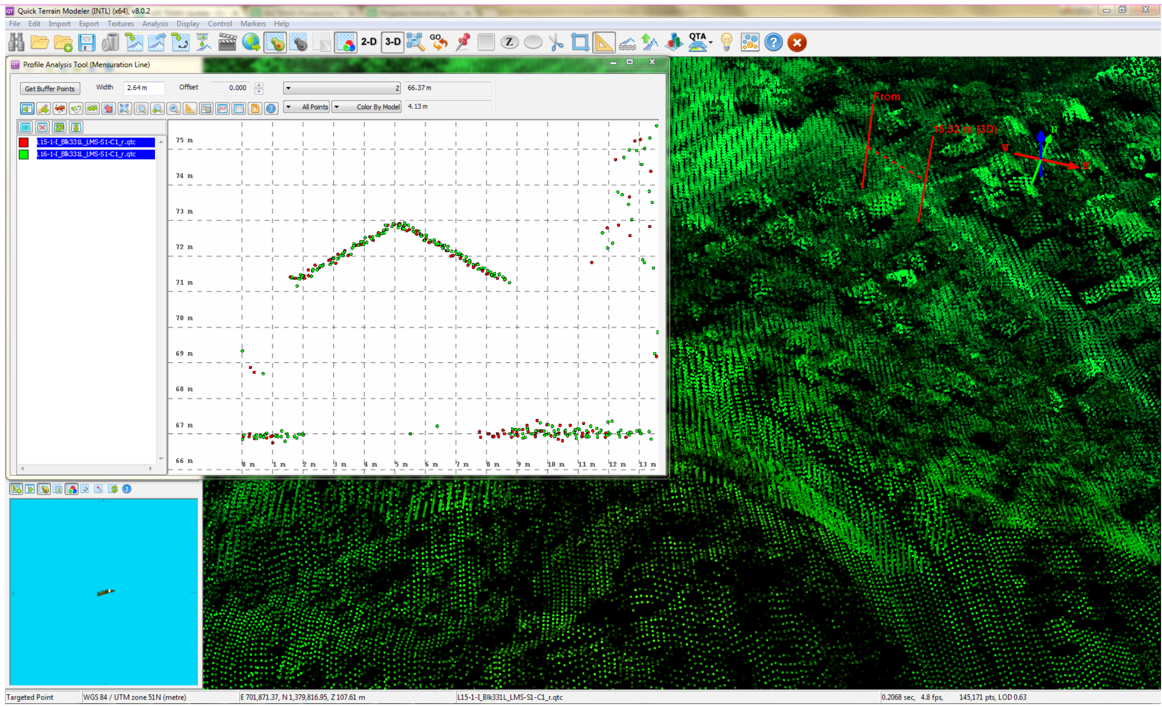

Figure 17. Quality checking for Catarman flight 7846AC using the Profile Tool of QT Modeler.

## 3.6 LiDAR Point Cloud Classification and Rasterization

Table 14. Catarman classification results in TerraScan.

| Pertinent Class | Total Number of Points |
|---|---|
| Ground | 378,125,898 |
| Low Vegetation | 262,550,711 |
| Medium Vegetation | 421,179,506 |
| High Vegetation | 1,011,467,578 |
| Building | 18,868,494 |

The tile system that TerraScan employed for the LiDAR data as well as the final classification image for a block of the Catarman floodplain is shown in Figure 18. A total of 1,264 tiles with 1 km. X 1 km. (one kilometer by one kilometer) size were produced. Correspondingly, Table 14 summarizes the number of points classified to the pertinent categories. The point cloud has a maximum and minimum height of 637.77 meters and 41.99 meters respectively.

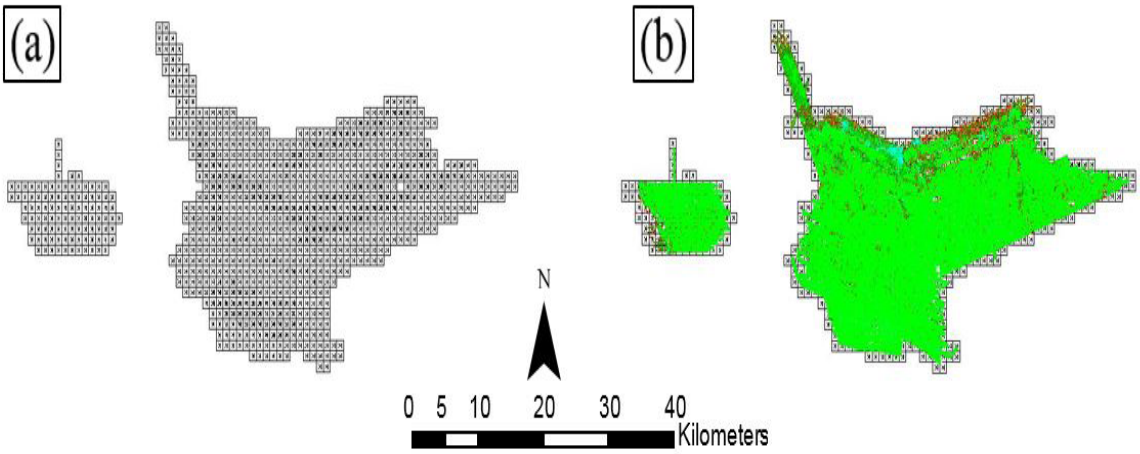


Figure 18. Tiles for Catarman floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 19. The ground points are highlighted in orange, while 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 the canopy are classified correctly, due to the density of the LiDAR data.

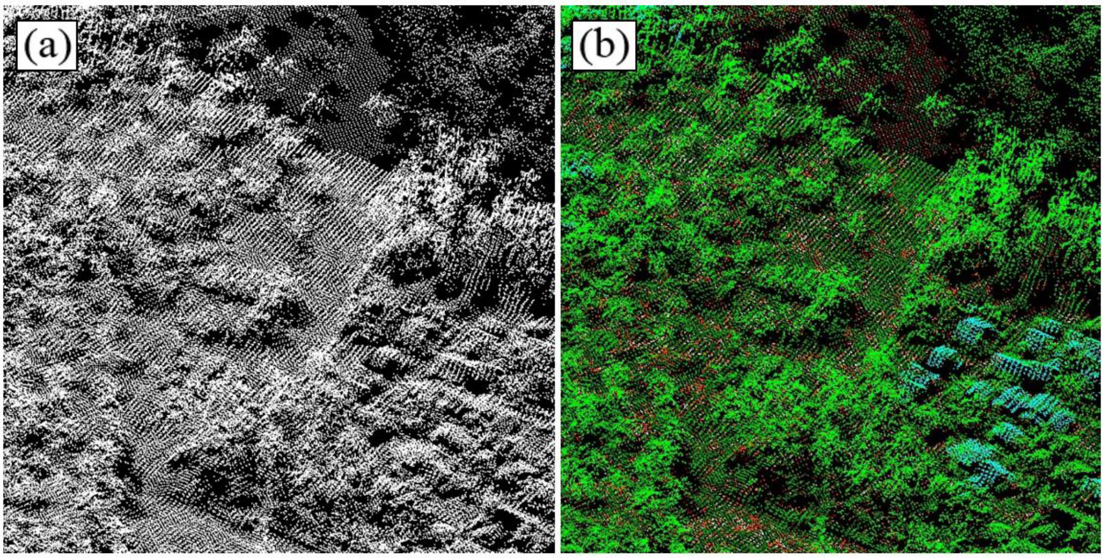


Figure 19. Point cloud before (a) and after (b) classification.

The production of the last return (V_ASCII) and secondary (T_ ASCII) DTM as well as the first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are show inFigure 20. It shows that DTMs are the representation of the bare earth, while on the DSMs, all features are present, such as buildings and vegetation.

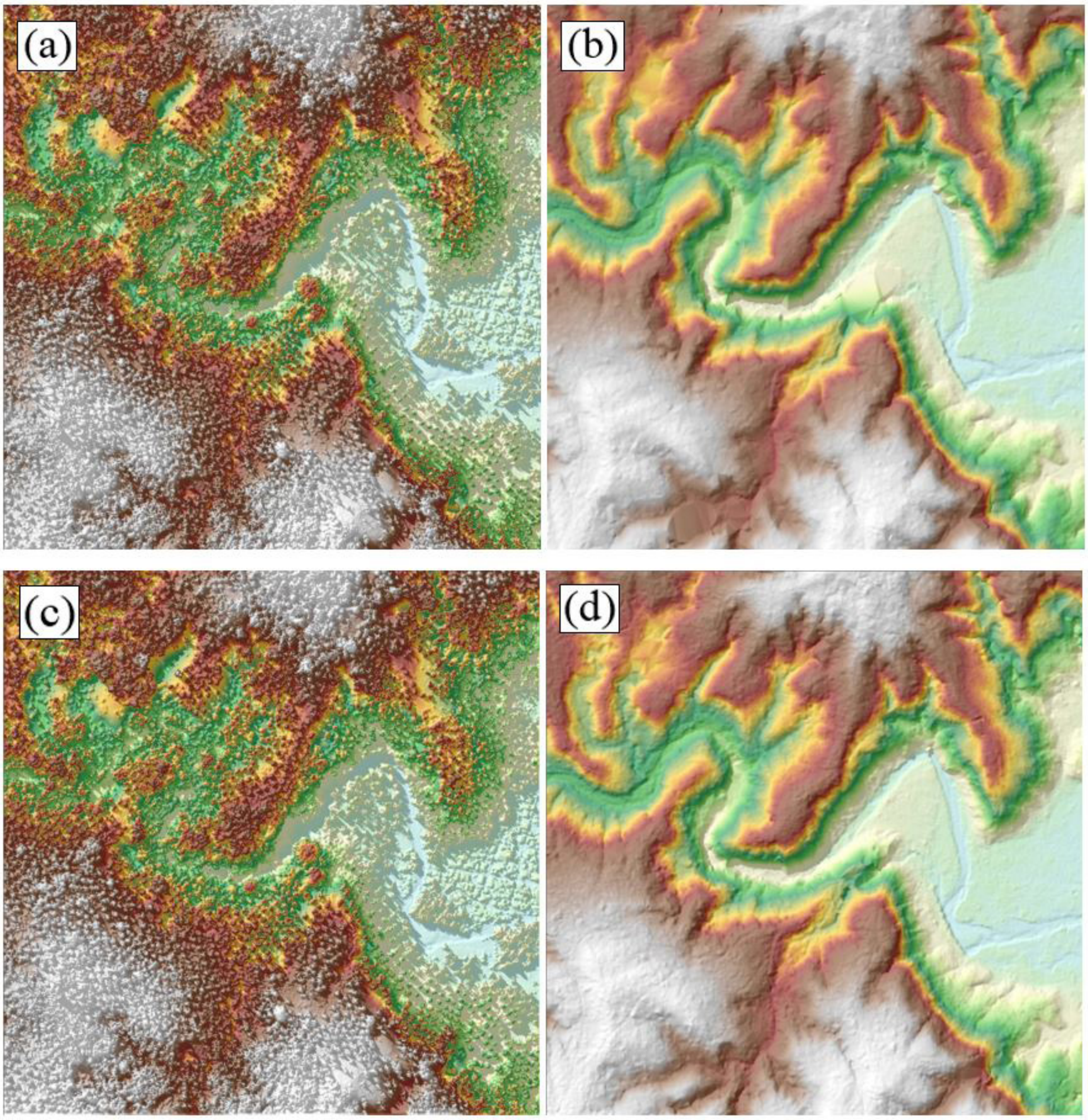


Figure 20. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Catarman floodplain.

## 3.7 LiDAR Image Processing and Orthophotograph Rectification

There are no available orthophotographs for the Catarman floodplain.

## 3.8 DEM Editing and Hydro-Correction

Twelve (12) mission blocks were processed for the Catarman Floodplain Survey. The blocks are composed of Catarman and Catarman_reflights blocks with a total area of 779.40 square kilometers. Table 15shows the name and corresponding area of each block in square kilometers.

Table 15.  LiDAR blocks with its corresponding areas.

| LiDAR Blocks | Area (sq. km.) |
|---|---|
| Catarman_Blk331G | 32.35 |
| Catarman_Blk331H | 77.02 |
| Catarman_Blk331I | 95.40 |
| Catarman_Blk331I_supplement | 10.21 |
| Catarman_Blk331J | 146.87 |
| Catarman_Blk331K | 121.02 |
| Catarman_Blk331L | 126.38 |
| Catarman_Blk331L_additional | 37.44 |
| Catarman_Blk33S | 13.40 |
| Catarman_reflights_Blk33F | 51.03 |
| Catarman_Blk33C | 36.81 |
| Catarman_Blk33D | 31.47 |
| TOTAL | 779.40 sq.km |

Figure 21 shows portions of a DTM before and after manual editing. As evident in the figure, the paddy field (Figure 21a) has been misclassifiedand removed during classification process and has to be retrieved to complete the surface (Figure 21b). The bridge ((Figure 21c) has obstructed the flow of water along the river. To correct the river hydrologically, the bridge was removed through manual editing (Figure 21d).

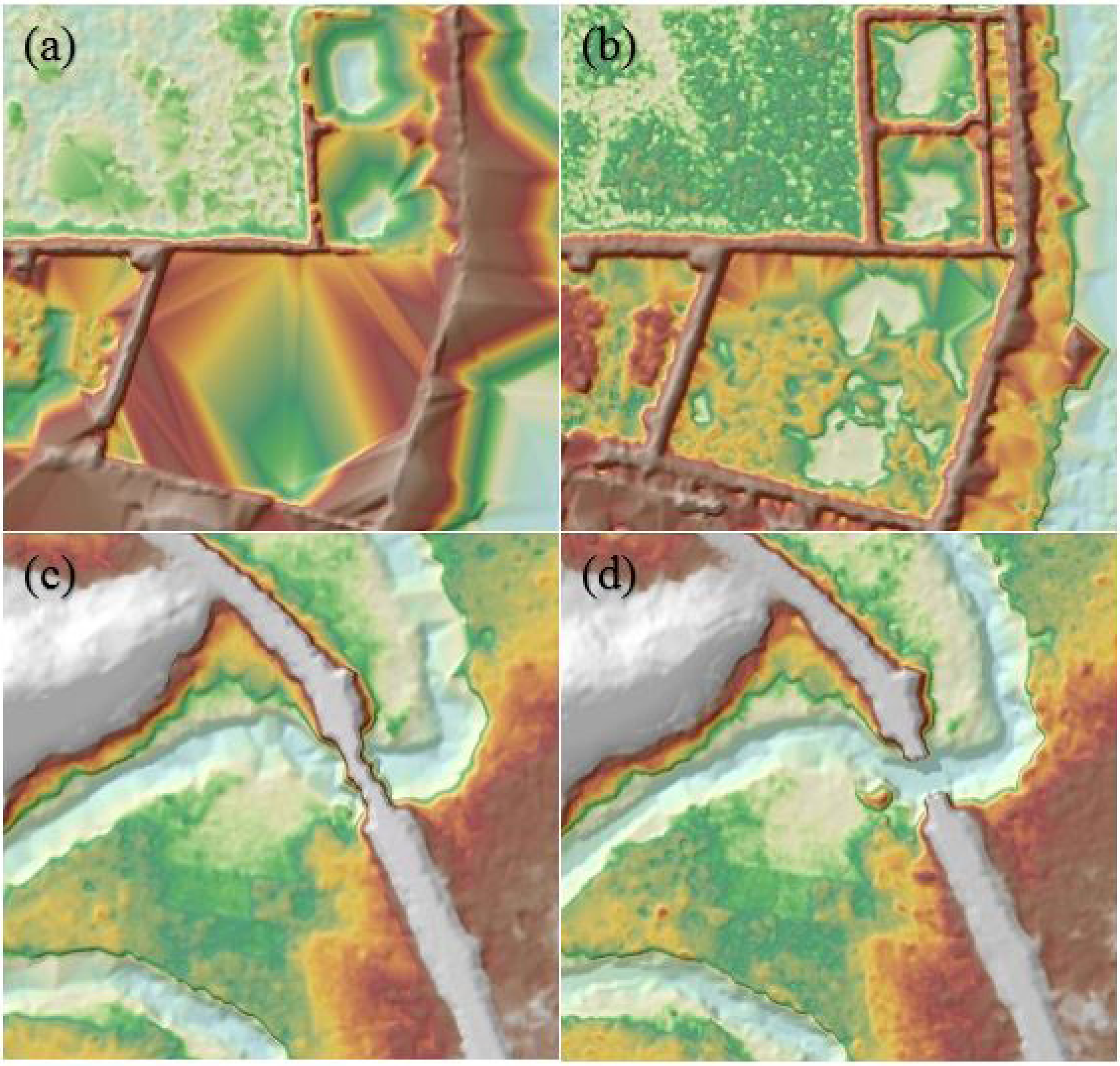


Figure 21. Portions in the DTM of the Catarman Floodplain – a paddy field before (a) and after (b) data retrieval; a bridge before (c) and after (d) manual editing.

## 3.9 Mosaicking of Blocks

Catarman_Blk331H was used as the reference block at the start of mosaicking because this block was made available for editing and mosaicking before the other blocks. Table 16 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Catarman Floodplain is shown inFigure 22. Map of processed LiDAR data for the Catarman Floodplain.. It can be seen that the entire Catarman floodplain is 98.24% covered by LiDAR data. Portions with no Lidar data were patched with the available IFSAR data.

Table 16. Shift values of each LiDAR block of Catarman Floodplain.

| Mission Blocks | Shift Values (meters) | | |
|---|---|---|---|
| | x | y | z |
| Catarman_Blk331H | 0.00 | 0.00 | 0.00 |
| Catarman_Blk331K | 0.00 | 0.00 | 0.00 |
| Catarman_Blk331G | 0.00 | 0.00 | 0.38 |
| Catarman_Blk331L | 0.00 | 0.00 | 0.00 |
| Catarman_Blk331I_supplement | 2.00 | -1.00 | 0.15 |
| Catarman_Blk331I | 0.00 | 0.00 | 0.14 |
| Catarman_Blk331J | 1.00 | 0.00 | -0.67 |
| Catarman_Blk33S | -14.00 | -17.00 | 3.94 |
| Catarman_Blk331L_additional | 0.00 | 0.00 | 0.06 |
| Catarman_reflights_Blk33F | 1.00 | 0.00 | -0.28 |
| Catarman_Blk33C | 0.00 | 0.00 | 0.00 |
| Catarman_Blk33D | 0.00 | 0.00 | 0.00 |

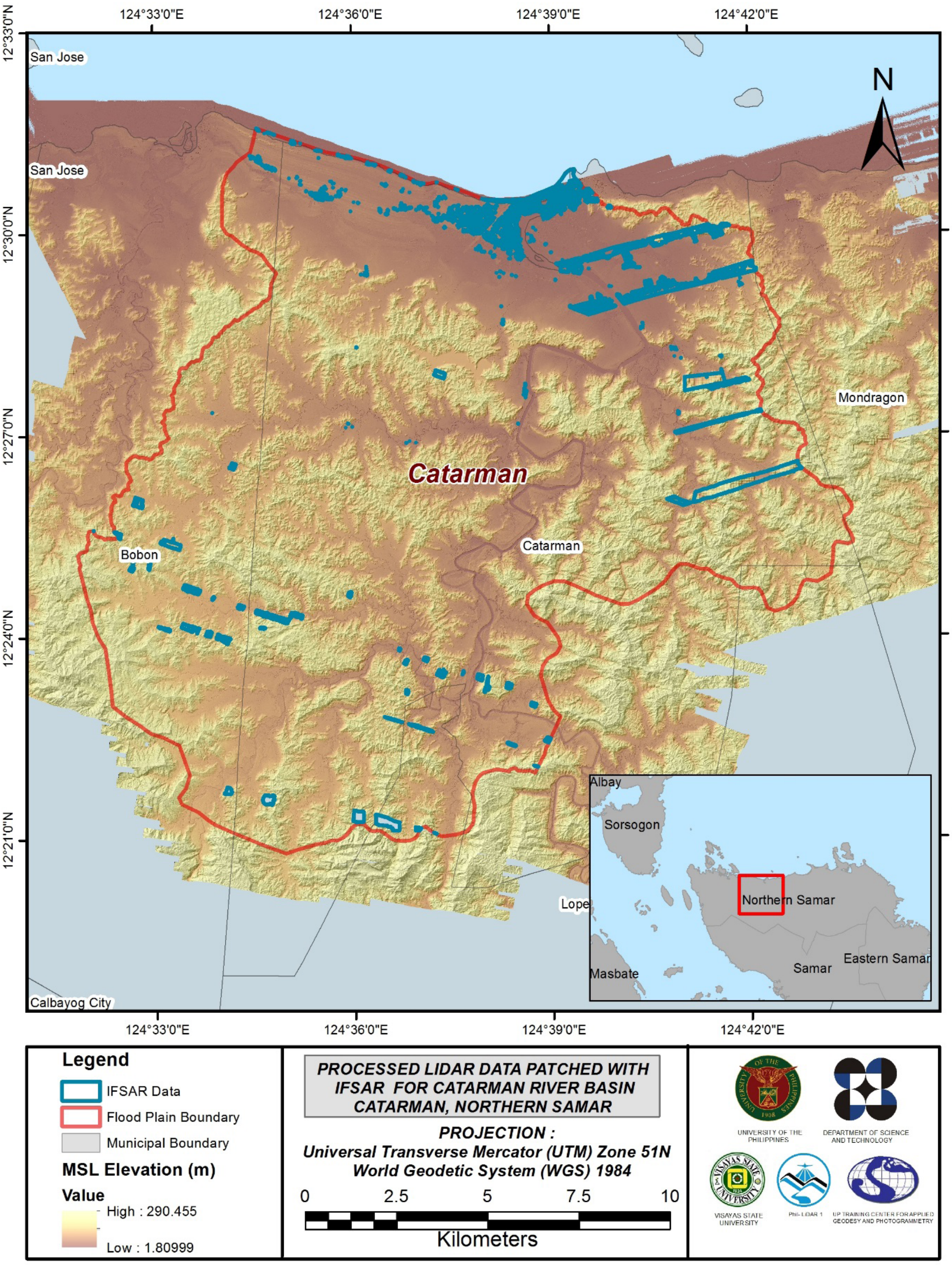


Figure 22. Map of processed LiDAR data for the Catarman Floodplain.

## 3.10 Calibration and Validation of Mosaicked LiDAR DEM

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Catarman to collect points with which the LiDAR dataset is validated is shown in Figure 23, with the validation survey points highlighted in green. A total of 14,268 survey points were gathered for the Catarman floodplain and were used for calibration. Random selection of 80% of the survey points, resulting to 11,415 points, was used for calibration.

A good correlation between the uncalibrated LiDAR DTM and the ground survey elevation values is shown in Figure 24. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of the data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration points is 2.79 meters, with a standard deviation of 0.18 meters. The calibration of theLiDAR data was accomplished by subtracting the height difference value of 2.79 meters to the mosaicked LiDAR data. Table 17 shows the statistical values of the compared elevation values between the Catarman LiDAR data and the calibration data.

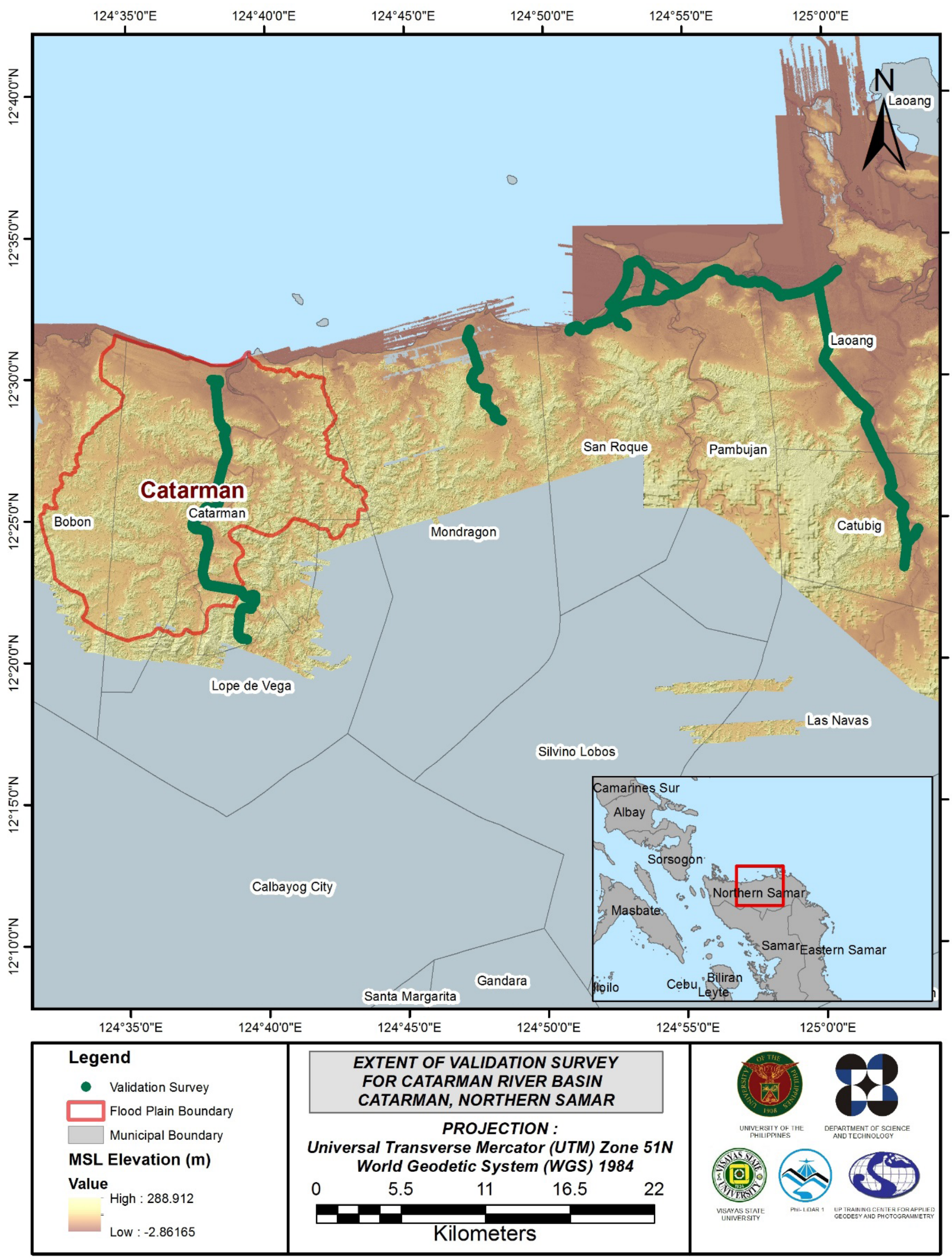


Figure 23. Map of Catarman Floodplain with validation survey points in green.

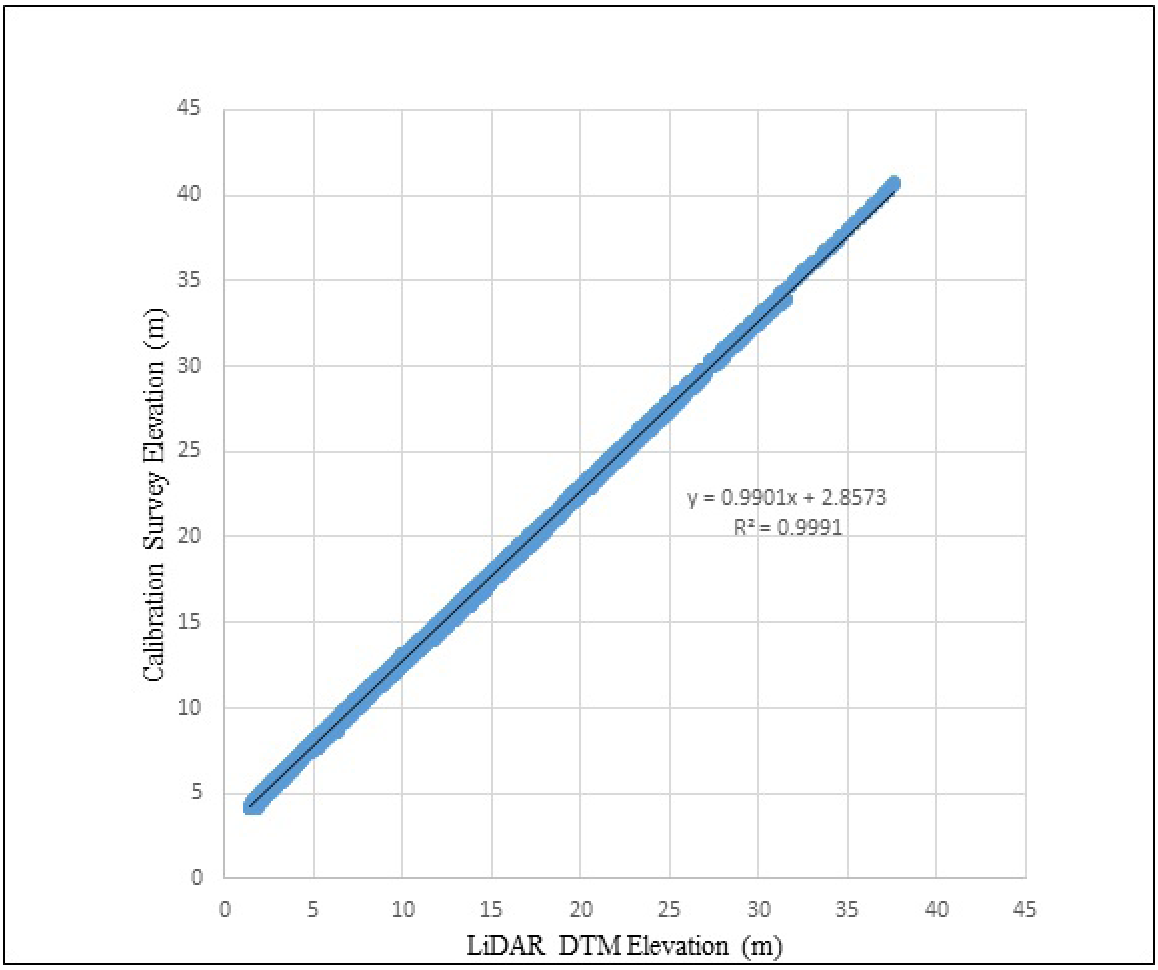


Figure 24. Correlation plot between calibration survey points and LiDAR data.

Table 17. Calibration Statistical Measures.

| Calibration Statistical Measures | Value (meters) |
|---|---|
| Height Difference | 2.79 |
| Standard Deviation | 0.18 |
| Average | -2.79 |
| Minimum | -3.15 |
| Maximum | -2.43 |

A total of 529 survey points were used to validate the calibrated Catarman DTM. A good correlation between the calibrated mosaicked LiDAR elevation and the ground survey elevation values, which point toward the quality of the LiDAR DTM is shown inFigure 25. The computed RMSE value between the calibrated LiDAR DTM and the validation elevation values is at 0.20 meters with a standard deviation of 0.20 meters, as shown inTable 18.

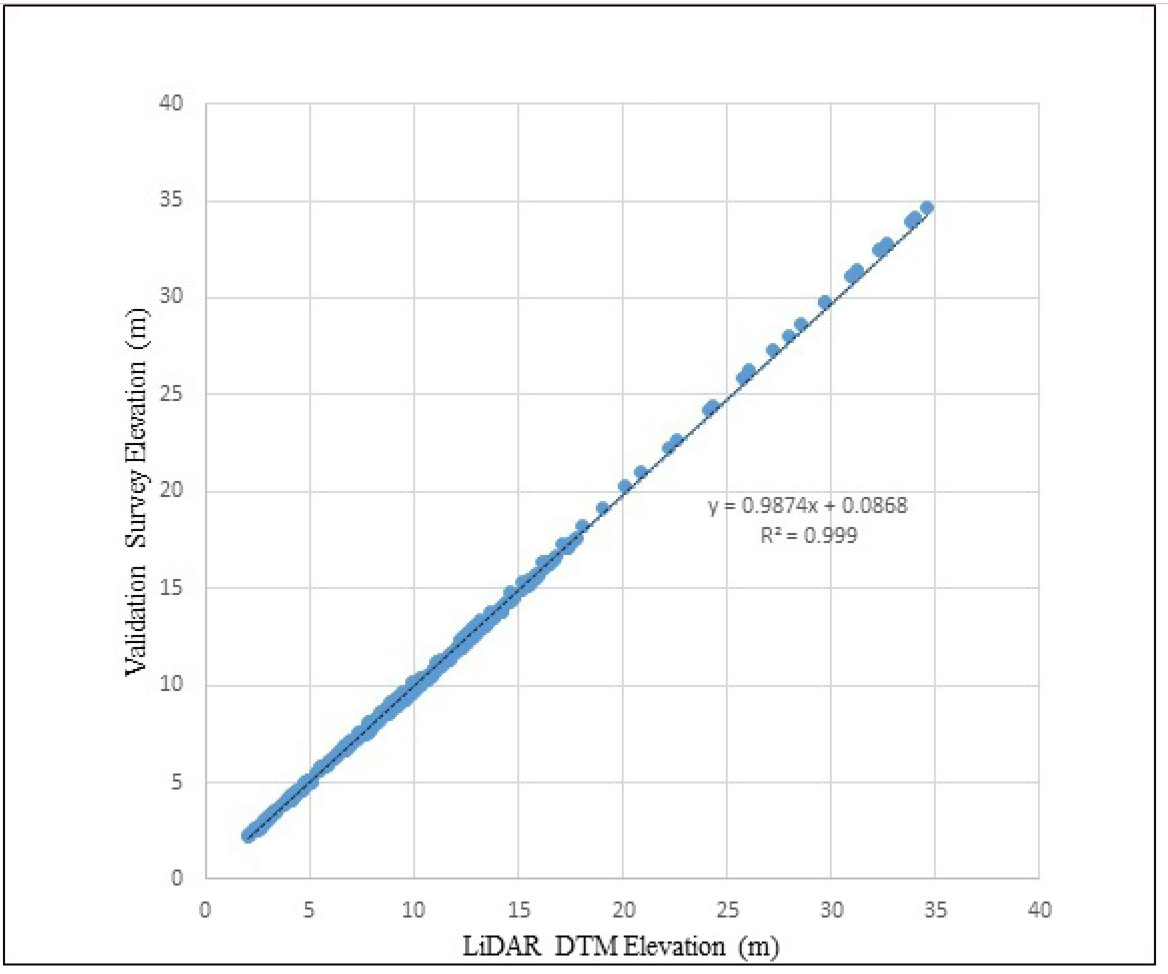


Figure 25. Correlation plot between the validation survey points and the LiDAR data.

Table 18. Validation Statistical Measures

| Validation Statistical Measures | Value (meters) |
|---|---|
| RMSE | 0.20 |
| Standard Deviation | 0.20 |
| Average | 0.04 |
| Minimum | -0.35 |
| Maximum | 0.43 |

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

For bathy integration, centerline and cross-section data were available for Catarman with a total of 9,422 bathymetric survey points. The resulting raster surface produced was done by Kernel Interpolation with Barriers interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.47 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Catarman integrated with the processed LiDAR DEM is shown inFigure 26.

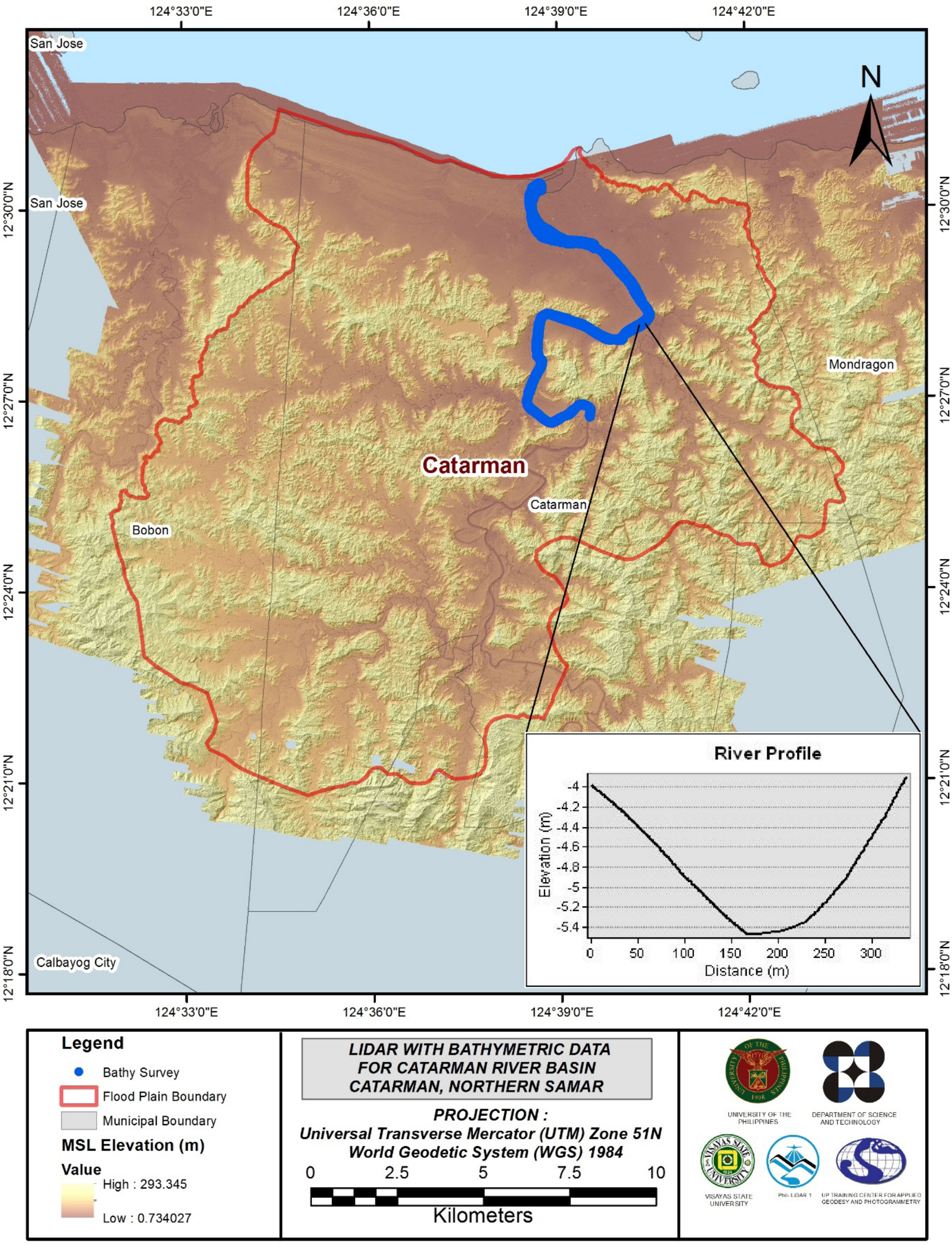


Figure 26. Map of Catarman floodplain with bathymetric survey points in blue.

## 3.12 Feature Extraction

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

### 3.12.1 Quality Checking (QC) of Digitized Features' Boundary

Catarman floodplain, including its 200-m buffer, has a total area of 272.80sq km. For this area, a total of 9.0 sq. km., corresponding to a total of 1,770building features, were considered for QC. Figure 27shows the QC blocks for the Catarman floodplain.

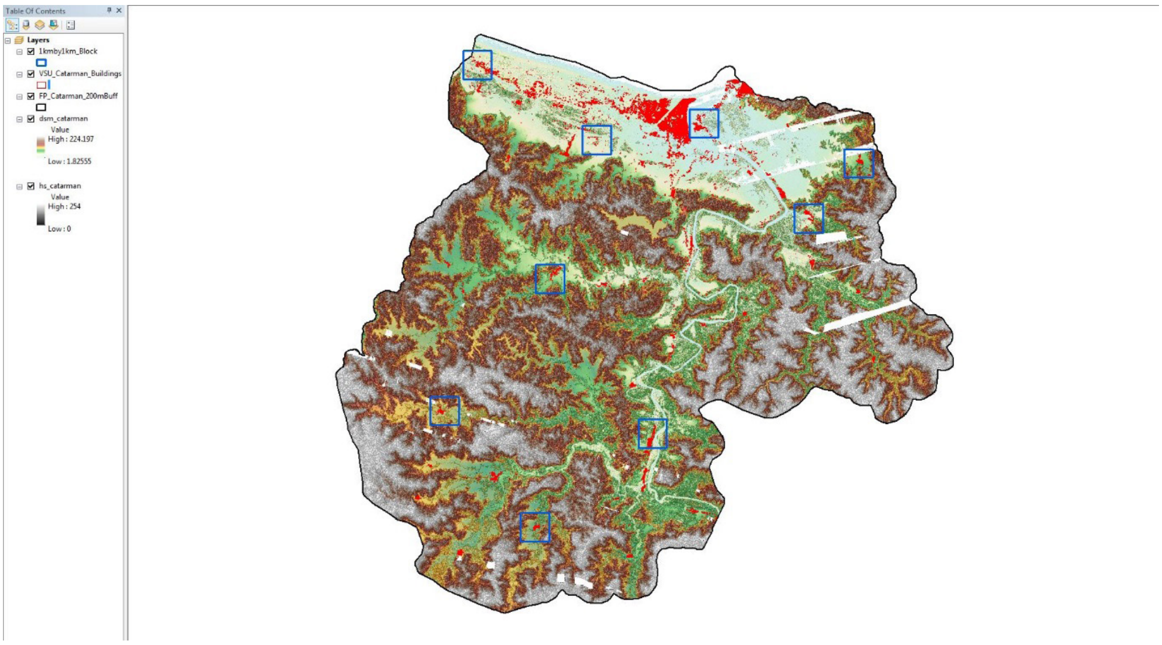

Figure 27. Block (in blue) of Catarman building features that was subjected to QC.

Quality checking of Catarman building features resulted in the ratings shown inTable 19.

Table 19. Details of the quality checking ratings for the building features extracted for the Catarman River Basin

| FLOODPLAIN | COMPLETENESS | CORRECTNESS | QUALITY | REMARKS |
|---|---|---|---|---|
| Catarman | 97.93 | 98.93 | 84.49 | PASSED |

### 3.12.2 Height Extraction

Height extraction was done for 17.941 building features in Catarman floodplain. Of these building features, 1,667 were filtered out after height extraction, resulting to 16,274 buildings with height attributes. The lowest building height is at 2.00 meters, while the highest building is at 12.20meters.

### 3.12.3 Feature Attribution

The digitized features were marked and coded in the field using handheld GPS receivers. The attributes of non-residential buildings were first identified; all other buildings were then coded as residential. A DSM was generated using the LiDAR DEMs to extract the heights of the buildings. A minimum height of 2 meters was used to filter out the terrain features that were digitized as buildings. Buildings that were not yet constructed during the time of LiDAR acquisition were noted as new buildings in the attribute table.

Table 20 summarizes the number of building features per type, while Table 21 shows the total length of each road type. Table 22, on the other hand, shows the number of water features extracted per type.

Table 20. Building features extracted for Catarman Floodplain.

| Facility Type | No. of Features |
|---|---|
| Residential | 15,248 |
| School | 321 |
| Market | 9 |
| Agricultural/Agro-Industrial Facilities | 3 |
| Medical Institutions | 36 |
| Barangay Hall | 27 |
| Military Institution | 28 |
| Sports Center/Gymnasium/Covered Court | 9 |
| Telecommunication Facilities | 0 |
| Transport Terminal | 8 |
| Warehouse | 72 |
| Power Plant/Substation | 3 |
| NGO/CSO Offices | 3 |
| Police Station | 13 |
| Water Supply/Sewerage | 5 |
| Religious Institutions | 49 |
| Bank | 13 |
| Factory | 3 |
| Gas Station | 12 |
| Fire Station | 1 |
| Other Government Offices | 87 |
| Other Commercial Establishments | 324 |
| **Total** | **16,274** |

Table 21. Total length of extracted roads for Catarman Floodplain.

| Floodplain | Road Network Length (km) | | | | | Total |
|---|---|---|---|---|---|---|
| | Barangay Road | City/Municipal Road | Provincial Road | National Road | Others | |
| Catarman | 125.69 | 19.90 | 0.00 | 29.20 | 1.00 | **175.79** |

Table 22. Number of extracted water bodies forCatarman Floodplain.

| Floodplain | Water Body Type | | | | | Total |
|---|---|---|---|---|---|---|
| | Rivers/Streams | Lakes/Ponds | Sea | Dam | Fish Pen | |
| Catarman | 192 | 1 | 0 | 2 | 0 | **195** |

A total of 68 bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

### 3.12.4 Final Quality Checking of Extracted Features

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

Figure 28 shows the completed Digital Surface Model (DSM) of the Catarman floodplain overlaid with its ground features.

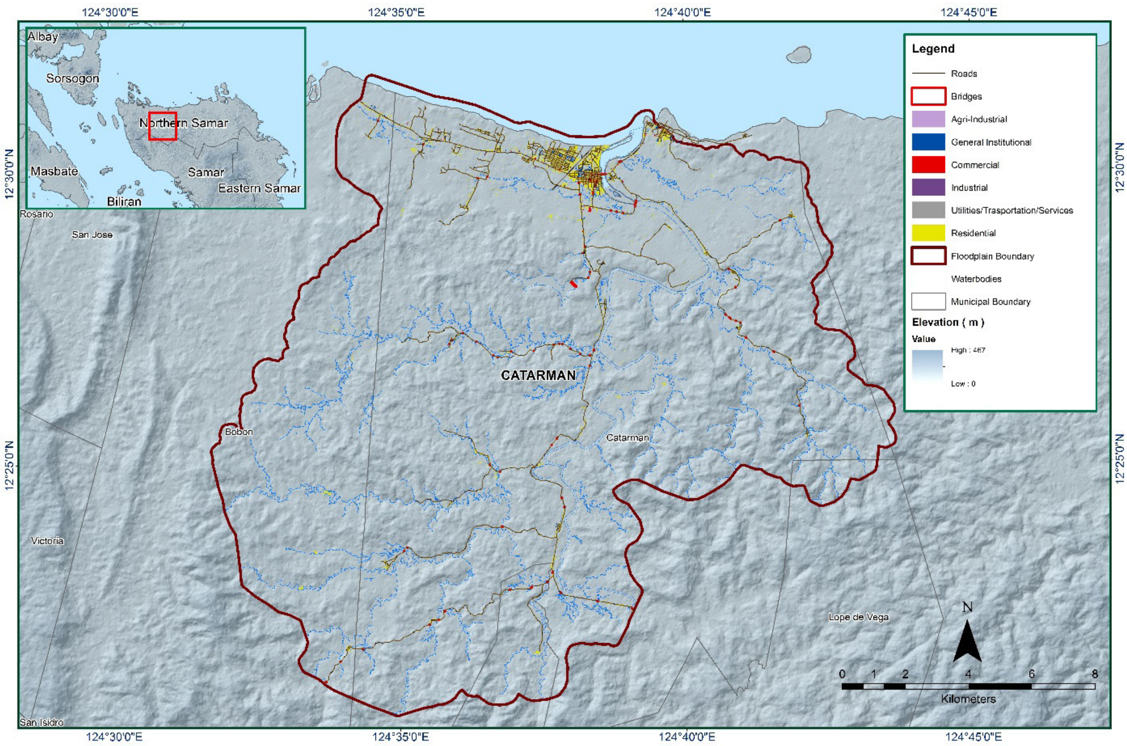


Figure 28. Extracted features of the Catarman Floodplain.

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

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

## 4.1 Summary of Activities

The H.O. Noveloso Surveying (HONS) conducted a field survey in Catarman River on November 24, 2016, December 1, 2016, January 17 to 20, 2017 and January 23 to 24, 2017; and the Data Validation and Bathymetry Component (DVBC) on August 28-September 5, October 17-26, 2016 with the following scope: reconnaissance; control survey; cross-section and as-built survey at Catarman Bridge in Brgy. Galutan, Municipality of Catarman, Northern Samar and the Philippine-Australian Friendship Bridge in Brgy. Doña Pulqueria, Municipality of Catarman, Northern Samar and bathymetric survey from its upstream in Brgy. Somoge to the mouth of the river located in Brgy. Bangkerohan, Catarman with an approximate length of 15.346 km using a Hi-Target™Single Beam Echo Sounder and Hi-Target™GNSS in RTK survey technique. The entire survey extent is illustrated in Figure 29.

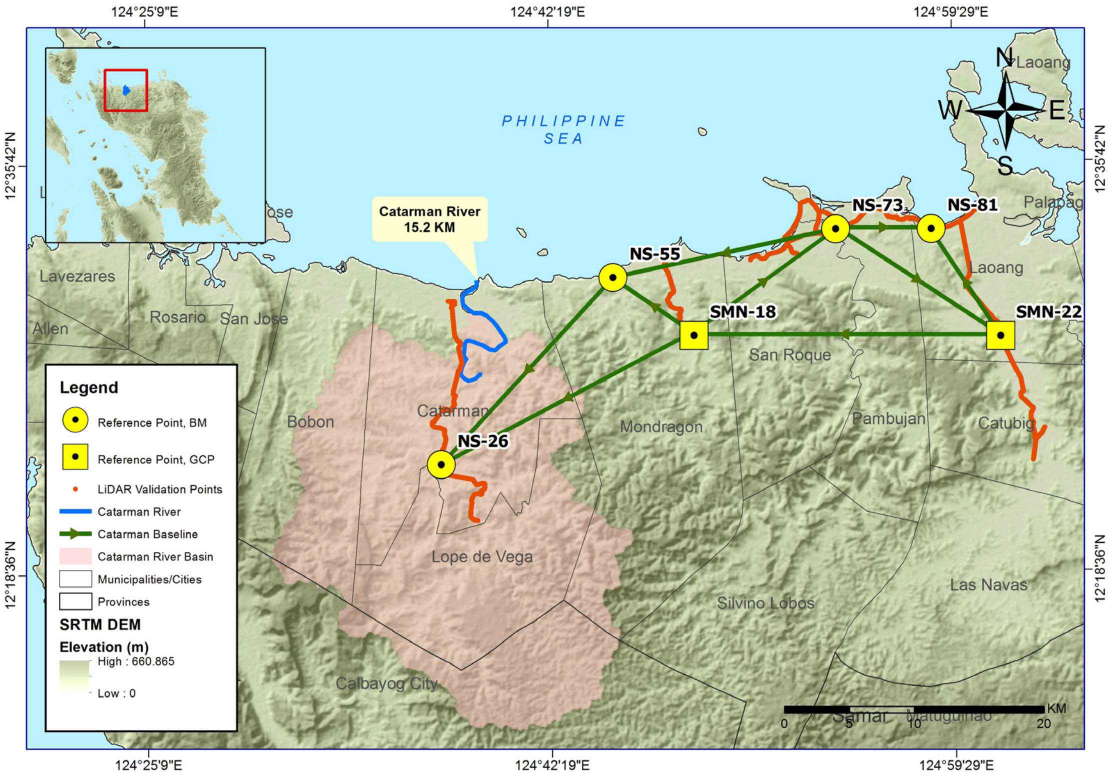



Figure 29. Catarman River Survey Extent.

## 4.2 Control Survey

The GNSS network used for Catarman River survey is composed of four (4) loops established on September 2, 2016 occupying the following control points: SMN-18, a 2nd order GCP in SMN-18, a 2nd order GCP in Brgy. Nenita, Municipality of Mondragon, Northern Samar; NS-26, a 1st order BM in Brgy. Polangi, Municipality of Catarman; NS-55, a 1st order BM in Brgy. Eco Poblacion, Municipality of Mondragon; NS-73, a 1st order BM in Brgy. Dale, Municipality of San Roque; and NS-81, a 1st order BM located in Brgy. Burabud, Municipality of Laoang, all in Northern Samar.

A NAMRIA established control point namely SMN-22 located in Brgy. Simora, Municipality of Laoang, was also used as a marker.

Table 23 depicts the summary of reference and control points utilized, with their corresponding locations, while Figure 30shows the GNSS network established in the Catarman River Survey.

Table 23. List of Reference and Control points used in Catarman River Basin Survey (Source: NAMRIA, UP-TCAGP).

| Control Point | Order of Accuracy | Geographic Coordinates (WGS 84) | | | | |
|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Ellipsoidal Height (m) | MSL Elevation (m) | Date Established |
| SMN-18 | 2nd Order, GCP | 12°28’28.14643” | 124°48’26.98399” | 64.624 | 8.910 | 09-07-16 |
| NS-26 | Acc. Class at 95%CL: 4cm | 12°23’08.14503” | 124°37’40.19430” | 70.990 | 13.480 | 09-01-16 |
| NS-55 | Acc. Class at 95%CL: 4cm | 12°30’53.61856” | 124°45’01.76667” | 61.077 | 5.710 | 05-02-16 |
| NS-73 | Acc. Class at 95%CL: 6cm | 12°32’52.45862” | 124°54’30.80700” | 60.314 | 5.945 | 09-01-16 |
| NS-81 | Acc. Class at 95%CL: 6cm | 12°32’50.94301” | 124°58’34.46636” | 59.293 | 5.105 | 04-14-16 |
| SMN-22 | Used as Marker | - | - | - | - | 09-04-15 |

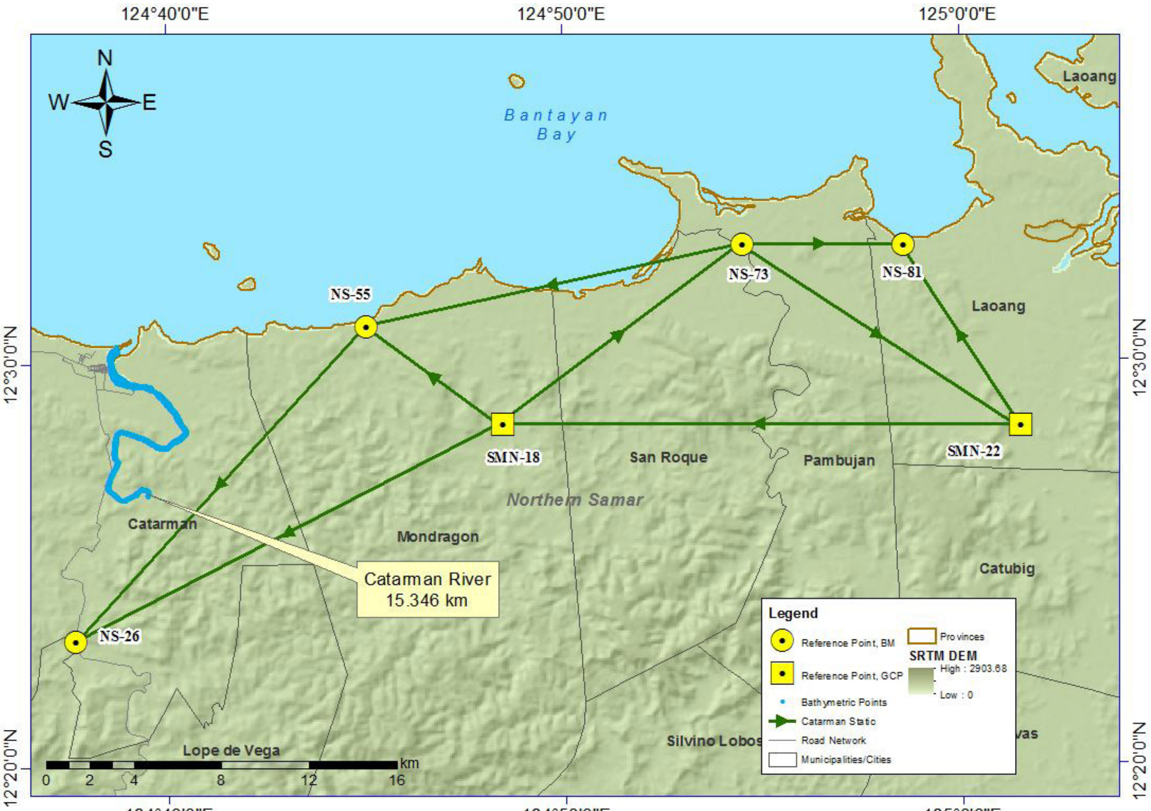



Figure 30. The GNSS Network established in the Catarman River Survey.

Figure 31 to Figure 36 depict the setup of the GNSS on recovered reference points and established control points in the Catarman River.

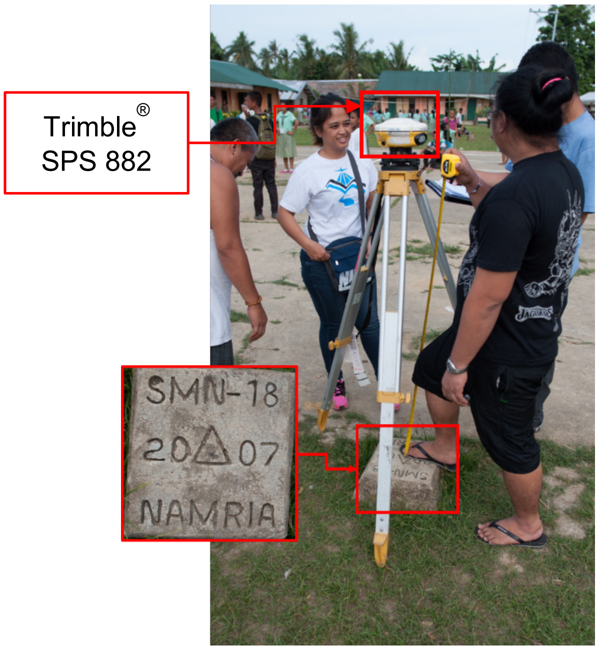



Figure 31. GNSS receiver setup, Trimble® SPS 882, at SMN-18, located inside Nenita Elementary School in Brgy. Nenita, Municipality of Mondragon, Northern Samar.

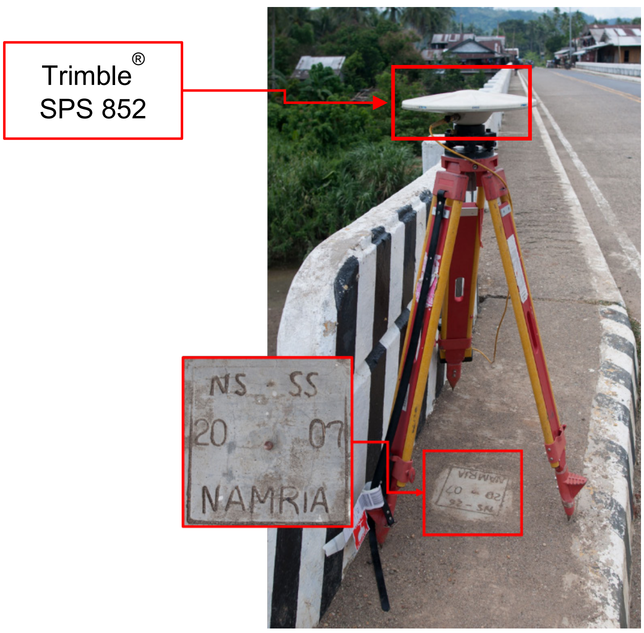



Figure 32. GNSS base set up, Trimble® SPS 852, at NS-26, located near the approach of Paticua Bridge in Brgy. Polangi, Municipality of Catarman, Northern Samar.

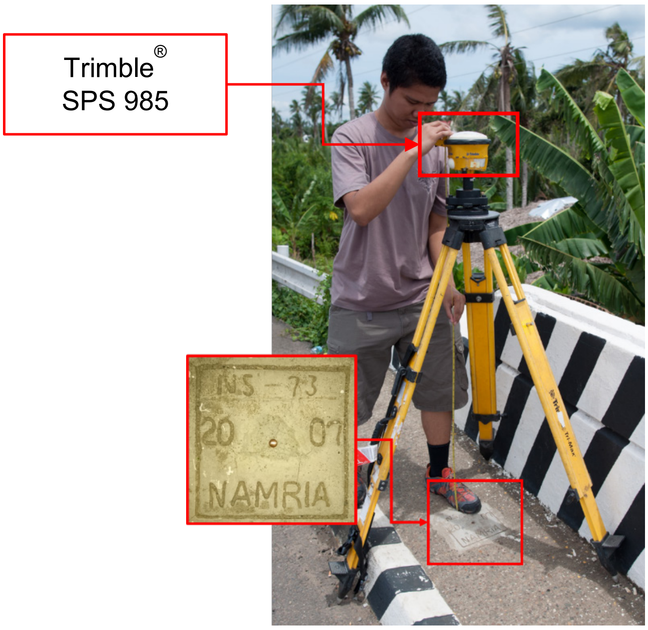



Figure 33. GNSS receiver setup, Trimble® SPS 985 at NS-55, located at the approach of Mondragon Bridge in Brgy. Eco Poblacion, Municipality of Mondragon, Northern Samar.

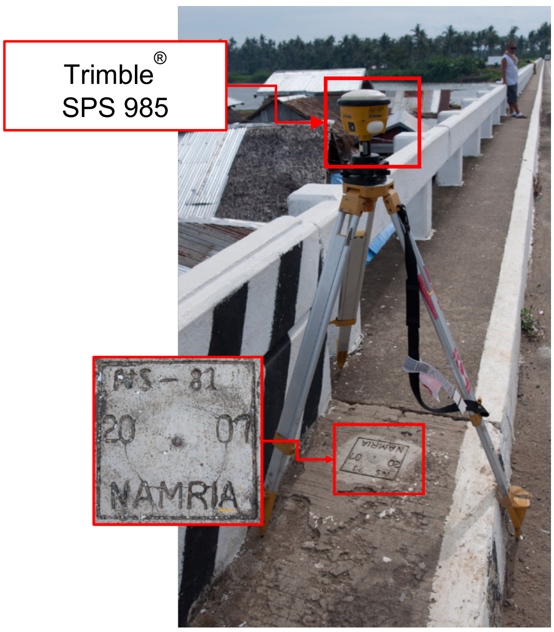



Figure 34. GNSS receiver setup, Trimble® SPS 985, at NS-73, located at the approach of Pambujan Bridge, in Brgy. Dale, Municipality of San Roque, Northern Samar.

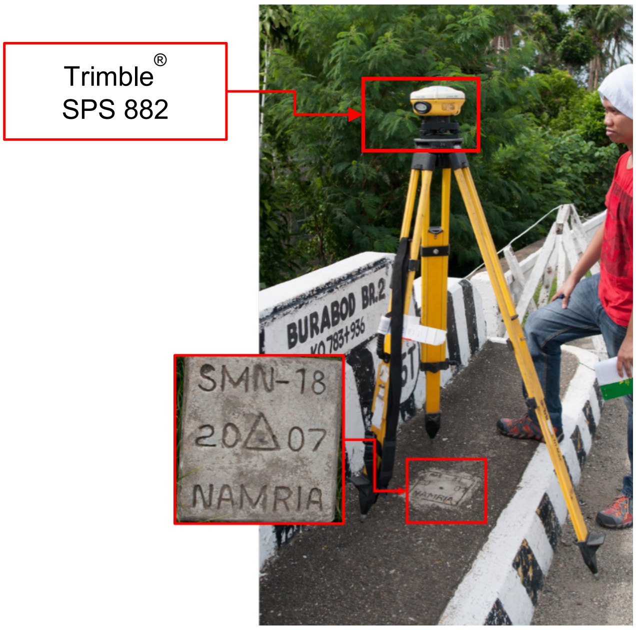



Figure 35. GNSS receiver setup, Trimble® SPS 882, at NS-81, located at the approach of Burabod Bridge in Brgy. Burabud, Municipality of Laoang, Northern Samar.


Figure 36. GNSS receiver setup, Trimble® SPS 852, at SMN-22, located at Simora Elementary School in Brgy. Simora, Municipality of Laoang, Northern Samar.

## 4.3 Baseline Processing

The GNSS Baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within +/- 20 cm and +/- 10 cm requirement respectively. In cases where one or more baselines did not meet all of these criteria, masking was performed. Masking is the removal or covering of portions of the baseline data using the same processing software. The data is then repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, a resurvey is initiated. Table 24 presents the baseline processing results of control points in the Catarman River Basin, as generated by the TBC software.

Table 24. The Baseline processing report for the Catarman River GNSS static observation survey.

| Observation | Date of Observation | Solution Type | H.Prec. (Meter) | V.Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) | Height (Meter) |
|---|---|---|---|---|---|---|---|
| NS-73 --- SMN-18 (B2) | 09-02-16 | Fixed | 0.007 | 0.019 | 53°30’34” | 13661.419 | -4.222 |
| NS-26 --- SMN-18 (B5) | 09-02-16 | Fixed | 0.003 | 0.015 | 243°17’56” | 21869.739 | 6.334 |
| NS-55 --- NS-26 (B7) | 09-02-16 | Fixed | 0.003 | 0.014 | 223°00’23” | 19555.744 | 9.752 |
| NS-73 --- NS-55 (B8) | 09-02-16 | Fixed | 0.005 | 0.013 | 258°00’58” | 17563.299 | 0.841 |
| NS-55 --- SMN-18 (B9) | 09-02-16 | Fixed | 0.004 | 0.015 | 305°48’50” | 7640.620 | -3.409 |
| NS-73 --- NS-81 (B11) | 09-02-16 | Fixed | 0.003 | 0.013 | 90°21’20” | 7355.805 | -1.057 |
| NS-73 --- SMN-22 (B18) | 09-02-16 | Fixed | 0.009 | 0.017 | 123°16’30” | 15138.600 | -2.047 |
| SMN-22 --- SMN-18 (B19) | 09-02-16 | Fixed | 0.004 | 0.015 | 270°28’32” | 23643.589 | 6.262 |
| SMN-22 --- NS-81 (B20) | 09-02-16 | Fixed | 0.004 | 0.016 | 327°20’08” | 9814.890 | 0.918 |
| NS-73 --- SMN-22 (B21) | 09-02-16 | Fixed | 0.004 | 0.014 | 123°16’30” | 15138.605 | -1.963 |

As shown in Table 24, a total of ten (10) baselines were processed with values of all reference points except SMN-22, held fixed for coordinate and elevation values; it is apparent that all baselines passed the required accuracy.

## 4.4 Network Adjustment

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

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

where:

$x_e$ is the Easting Error,

$y_e$ is the Northing Error, and

$z_e$ is the Elevation Error

For complete details, see the Network Adjustment Report shown inTable 25toTable 28.

The six (6) control points, NS-26, NS-55, NS-73, NS-81, SMN-18 and SMN-22 were occupied and observed simultaneously to form a GNSS loop. The coordinate values of SMN-18 and elevation values of all benchmarks were held fixed during the processing of the control points as presented in Table 25. Through these reference points, the coordinates and elevation of the unknown control points will be computed.

Table 25. Constraints applied to the adjustment of the control points.

| Point ID | Type | East σ (Meter) | North σ (Meter) | Height σ (Meter) | Elevation σ (Meter) |
|---|---|---|---|---|---|
| SMN-18 | Global | Fixed | Fixed | | |
| NS-26 | Grid | | | | |
| NS-55 | Grid | | | | |
| NS-73 | Grid | | | | |
| NS-81 | Grid | | | | Fixed |
| Fixed = 0.000001(Meter) | | | | | |

Likewise, the list of adjusted grid coordinates, i.e. Northing, Easting, Elevation and computed standard errors of the control points in the network is indicated in Table 26. All fixed control points have no values for grid and elevation errors.

Table 26. Adjusted grid coordinates for the control points used in the Catarman River flood plain survey.

| Point ID | Easting (Meter) | Easting Error (Meter) | Northing (Meter) | Northing Error (Meter) | Elevation (Meter) | Elevation Error (Meter) | Constraint |
|---|---|---|---|---|---|---|---|
| SMN-18 | 696441.22698 | ? | 1379691.63306 | ? | 8.9098 | 0.031 | LL |
| NS-26 | 676970.19397 | 0.007 | 1369731.98493 | 0.006 | 13.4801 | ? | e |
| NS-55 | 690214.51511 | 0.008 | 1384120.46061 | 0.006 | 5.7095 | ? | e |
| NS-73 | 707369.75759 | 0.009 | 1387891.68118 | 0.006 | 5.9447 | ? | e |
| NS-81 | 714726.67255 | 0.011 | 1387899.30448 | 0.008 | 5.1053 | ? | e |
| SMN-22 | 720088.05329 | 0.009 | 1379675.96886 | 0.006 | 3.45269 | 0.067 | |

The results of the computation for accuracy are as follows:

a. **SMN-18**

| | | |
|---|---|---|
| horizontal accuracy | = | Fixed |
| vertical accuracy | = | 3.1 cm < 10 cm |

b. **NS-26**

| | | |
|---|---|---|
| horizontal accuracy | = | $\sqrt{((0.7)^2 + (0.6)^2}$ |
| | = | $\sqrt{(0.49 + 0.36)}$ |
| | = | 0.92 < 20 cm |
| vertical accuracy | = | Fixed |

c. **NS-55**

| | | |
|---|---|---|
| horizontal accuracy | = | $\sqrt{((0.8)^2 + (0.6)^2}$ |
| | = | $\sqrt{(0.64 + 0.36)}$ |
| | = | 1.00 < 20 cm |
| vertical accuracy | = | Fixed |

d. **NS-73**

| | | |
|---|---|---|
| horizontal accuracy | = | $\sqrt{((0.9)^2 + (0.6)^2}$ |
| | = | $\sqrt{(0.81 + 0.36)}$ |
| | = | 1.08 < 20 cm |
| vertical accuracy | = | Fixed |

e. **NS-81**

| | | |
|---|---|---|
| horizontal accuracy | = | $\sqrt{((1.1)^2 + (0.8)^2}$ |
| | = | $\sqrt{(1.21 + 0.64)}$ |
| | = | 1.36 cm < 20 cm |
| vertical accuracy | = | Fixed |

f. **SMN-22**

| | | |
|---|---|---|
| horizontal accuracy | = | $\sqrt{((0.9)^2 + (0.6)^2}$ |
| | = | $\sqrt{(0.81 + 0.36)}$ |
| | = | 1.08 cm < 20 cm |
| vertical accuracy | = | 6.7 cm < 10 cm |

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

Table 27. Adjusted geodetic coordinates for control points used in the Catarman River Flood Plain validation.

| Point ID | Latitude | Longitude | Ellipsoid Height (Meter) | Height Error (Meter) | Constraint |
|---|---|---|---|---|---|
| SMN-18 | N12°28'28.14643" | E124°48'26.98399" | 64.6235 | 0.031 | LL |
| NS-26 | N12°23'08.14503" | E124°37'40.1943" | 70.99005 | ? | e |
| NS-55 | N12°30'53.61856" | E124°45'01.76667" | 61.0772 | ? | e |
| NS-73 | N12°32'52.45862" | E124°54'30.807" | 60.31401 | ? | e |
| NS-81 | N12°32'50.94301" | E124°58'34.46636" | 59.29264 | ? | e |
| SMN-22 | N12°28'22.07678" | E125°01'29.94039" | 58.56371 | 0.067 | |

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 27. Based on the results of the computation, the accuracy conditions are satisfied; hence, the required accuracy for the program was met. The computed coordinates of the reference and control points utilized in the Catarman River GNSS Static Survey are seen in Table 28.

Table 28. The reference and control points utilized in the Catarman River Static Survey, with their corresponding locations (Source: NAMRIA, UP-TCAGP)

| Control Point | Order of Accuracy | Geographic Coordinates (WGS 84) | | | UTM ZONE 51 N | | |
|---|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Ellipsoid Height (m) | Northing (m) | Easting (m) | BM Ortho (m) |
| SMN-18 | 2nd Order, GCP | 12°28'28.14643" | 124°48'26.98399" | 64.624 | 1379691.633 | 696441.227 | 8.910 |
| NS-26 | Acc. Class at 95%CL: 4cm | 12°23'08.14503" | 124°37'40.19430" | 70.990 | 1369731.985 | 676970.194 | 13.480 |
| NS-55 | Acc. Class at 95%CL: 4cm | 12°30'53.61856" | 124°45'01.76667" | 61.077 | 1384120.461 | 690214.515 | 5.710 |
| NS-73 | Acc. Class at 95%CL: 6cm | 12°32'52.45862" | 124°54'30.80700" | 60.314 | 1387891.681 | 707369.758 | 5.945 |
| NS-81 | Acc. Class at 95%CL: 6cm | 12°32'50.94301" | 124°58'34.46636" | 59.293 | 1387899.304 | 714726.673 | 5.105 |
| SMN-22 | Used as Marker | 12°28'22.07678" | 125°01'29.94039" | 58.564 | 1379675.969 | 720088.053 | 3.453 |

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

The bridge cross-section and as-built surveys were conducted on January 17, 2017 at the downstream side of Catarman Bridge in Brgy. Galutan, Municipality of Catarman, Province of Northern Samar as shown in Figure C-9. A Sokkia™ Set CX Total Station was utilized for this survey(Figure 37).


Figure 37. Downstrream side of Catarman Bridge.

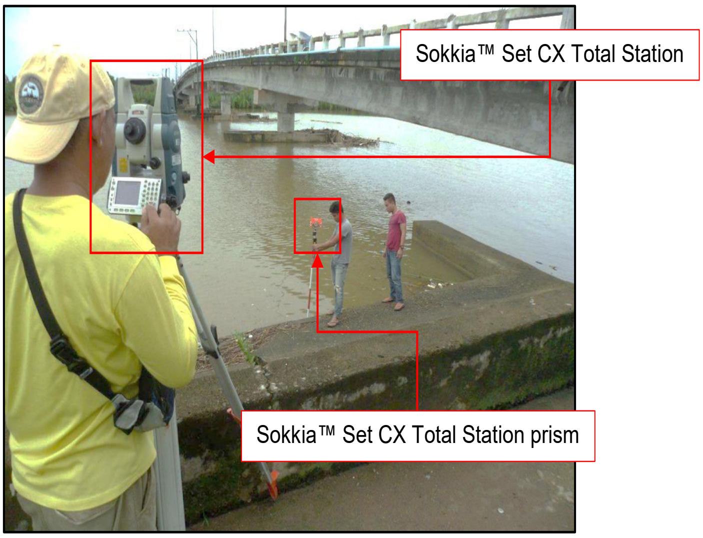



Figure 38. Cross-section survey conducted at Catarman Bridge.

The length of the cross-sectional line surveyed at Catarman Bridge is about 191.605 meters (Figure 39) with three hundred nineteen (319) cross-sectional points acquired using the established control point UP-CATA-4 as the GNSS base station. The location map, cross-section diagram, and the accomplished bridge data formare shown inFigure 39, 40 and 41 respectively.

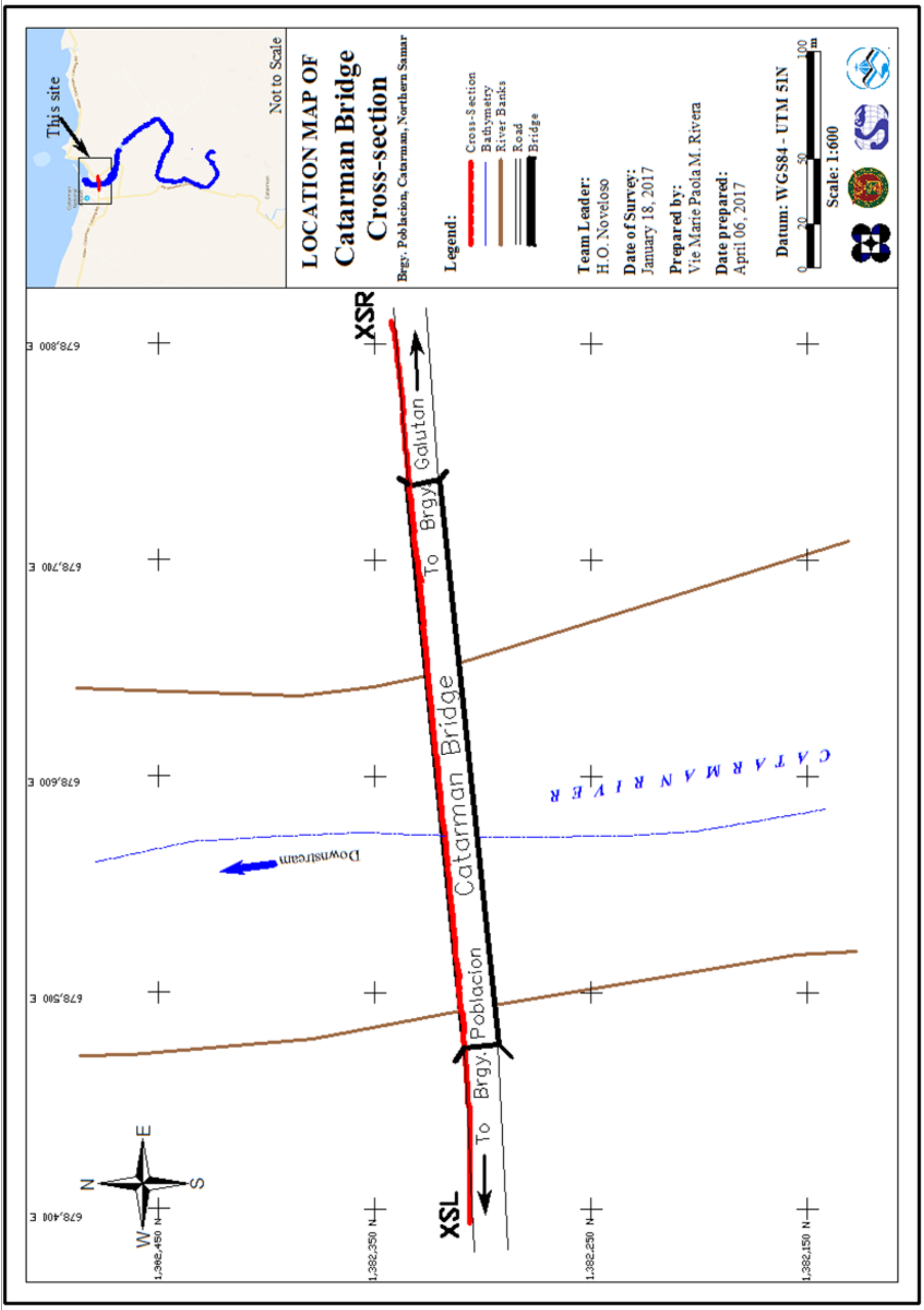



Figure 39. Location map of the Catarman Bridge cross-section survey.

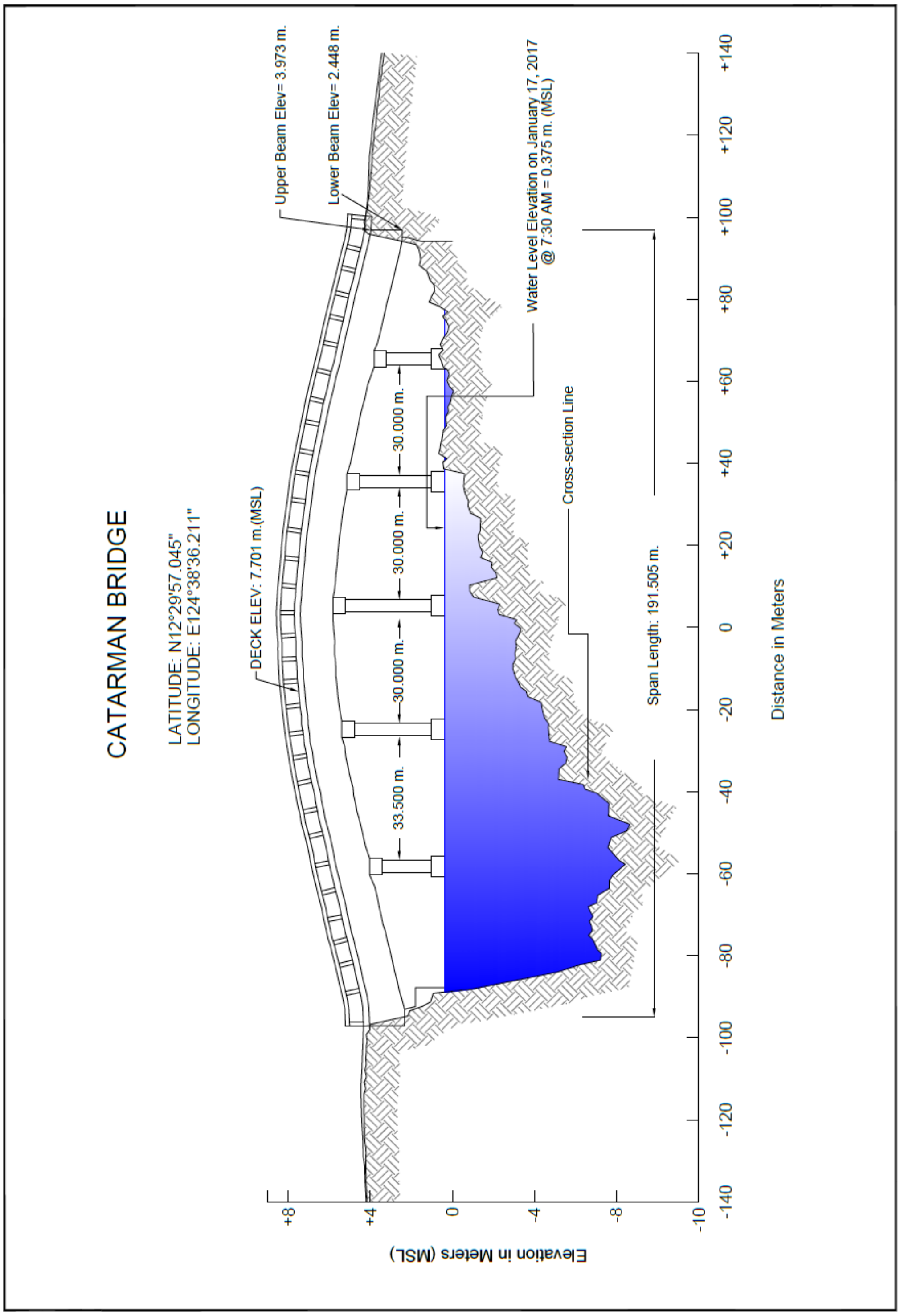



Figure 40. The Catarman Bridge cross-section survey drawn to scale.

**BRIDGE DATA FORM**

Bridge Name: Catarman Bridge

River Name: Catarman River

Location (Brgy., City, Region): Brgy. Galutan, Catarman, Northern Samar

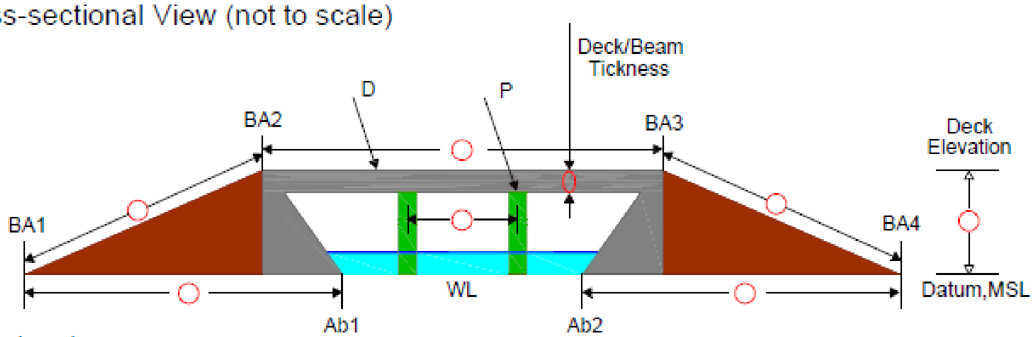
Survey Team: Julieto Cabilin, Urbano Castillo, Jefferson Orbillo, Jodel Dela Cruz, and Oscar Agustin

Date and Time: January 17, 2017 @ 7:30 am

Flow Condition: Low Normal High

Weather Condition: Fair Rainy

Cross-sectional View (not to scale)




Legend:
BA = Bridge Approach
P = Pier
Ab = Abutment
D = Deck
WL = Water Level/Surface
MSL = Mean Sea Level
○ = Measurement Value

| Line Segment | Measurement, m | Remarks |
|---|---|---|
| 1. BA1-BA2 | 2.200 m. | Concrete |
| 2. BA2-BA3 | 191.505 m. | Concrete |
| 3. BA3-BA4 | 3.556 m. | Concrete |
| 4. BA1-Ab1 | 9.337 m. | Concrete |
| 5. Ab2-BA4 | 6.202 m. | Concrete |
| 6. Deck/Beam thickness | 1.525 m. | Concrete |
| 7. Deck Elevation | 7.701 m. (MSL) | Concrete |
| 8. P1-P2 | 33.500 m. | Concrete |
| 9. P2-P3 | 30.000 m. | Concrete |
| 10. P3-P4 | 30.000 m. | Concrete |
| 11. P4-P5 | 30.000 m. | Concrete |

Note: Observer should be facing downstream

Figure 41. The Catarman Bridge as-built survey data.

The water surface elevation of Catarman River was determined by a Sokkia™ Set CX Total Station on January 17, 2017 at 7:30 AM at Catarman Bridge area with a value of 0.375m in MSL as shown in Figure 40. This was translated into marking on the bridge's deck as shown in Figure 42. It now serves as the reference for flow data gathering and depth gauge deployment of the Visayas State University (VSU), the partner HEI responsible for the monitoring of the Catarman River.


Figure 42. Water-level markings on the pier of Catarman Bridge.

Another cross-section and as-built surveys were conducted on January 18, 2017 at the downstream side of the Philippine-Australian Friendship Bridge in Brgy. Doña Pulqueria, Municipality of Catarman, Province of Northern Samar as shown inFigure 43. A Sokkia™ Set CX Total Station was also utilized for this survey as shown in Figure 44. The Automated Water Level System (AWLS) is located on the upstream side of the bridge and its elevation was measured 8.382 m above MSL.

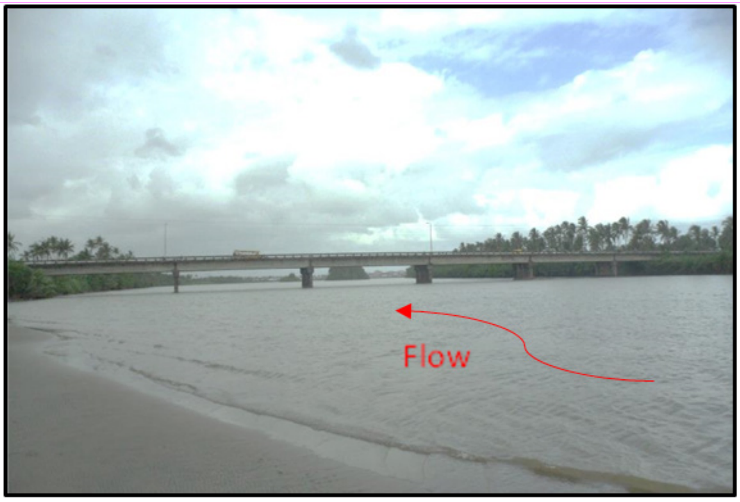



Figure 43. Philippine-Australian Friendship Bridge facing downstream.


Figure 44. As-built survey of Philippine-Australian Friendship Bridge.

The length of the cross-sectional line surveyed at Philippine-Australian Friendship Bridge is about 232.626 meters (Figure 45) with three hundred seventy-nine (379) cross-sectional points acquired using the established control point UP-CATA-3 as the GNSS base station.The location map, cross-section diagram, and the accomplished bridge data form are shown inFigure 45, 46, and 47, respectively.

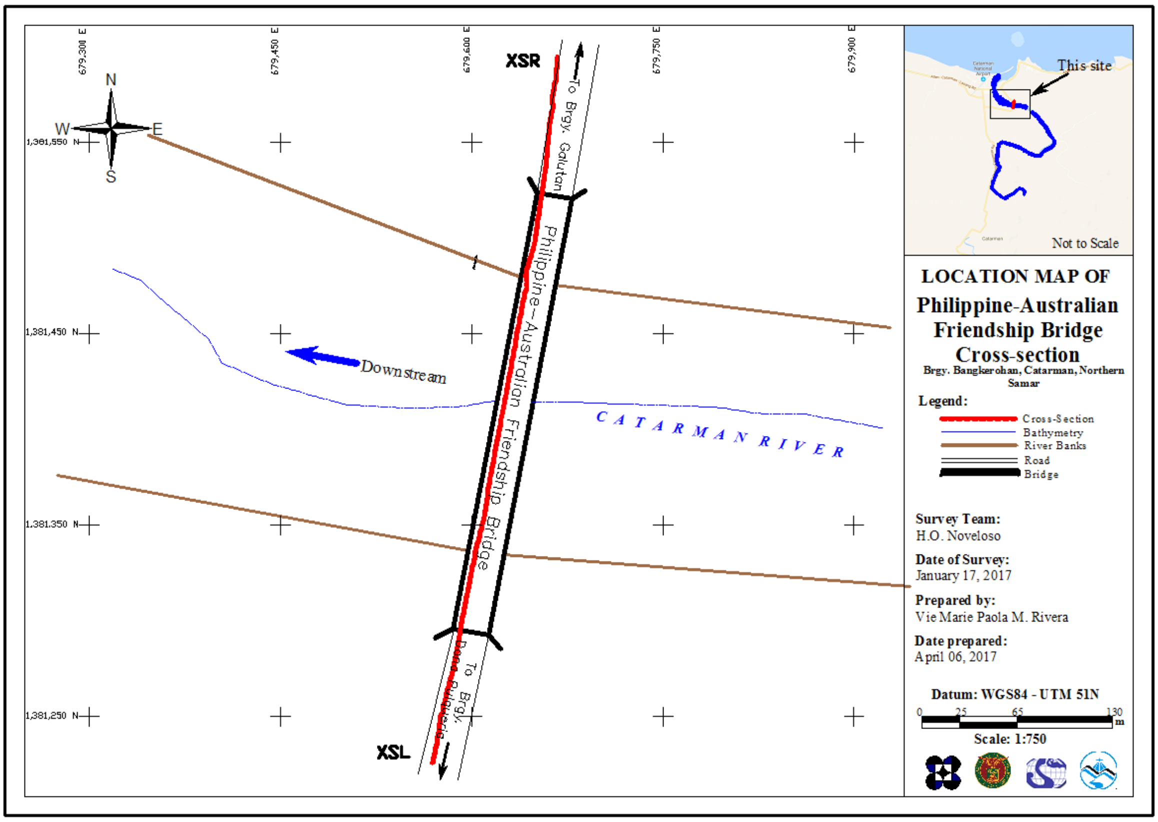



Figure 45. Location map of the Philippine-Australian Friendship Bridge cross-section survey.

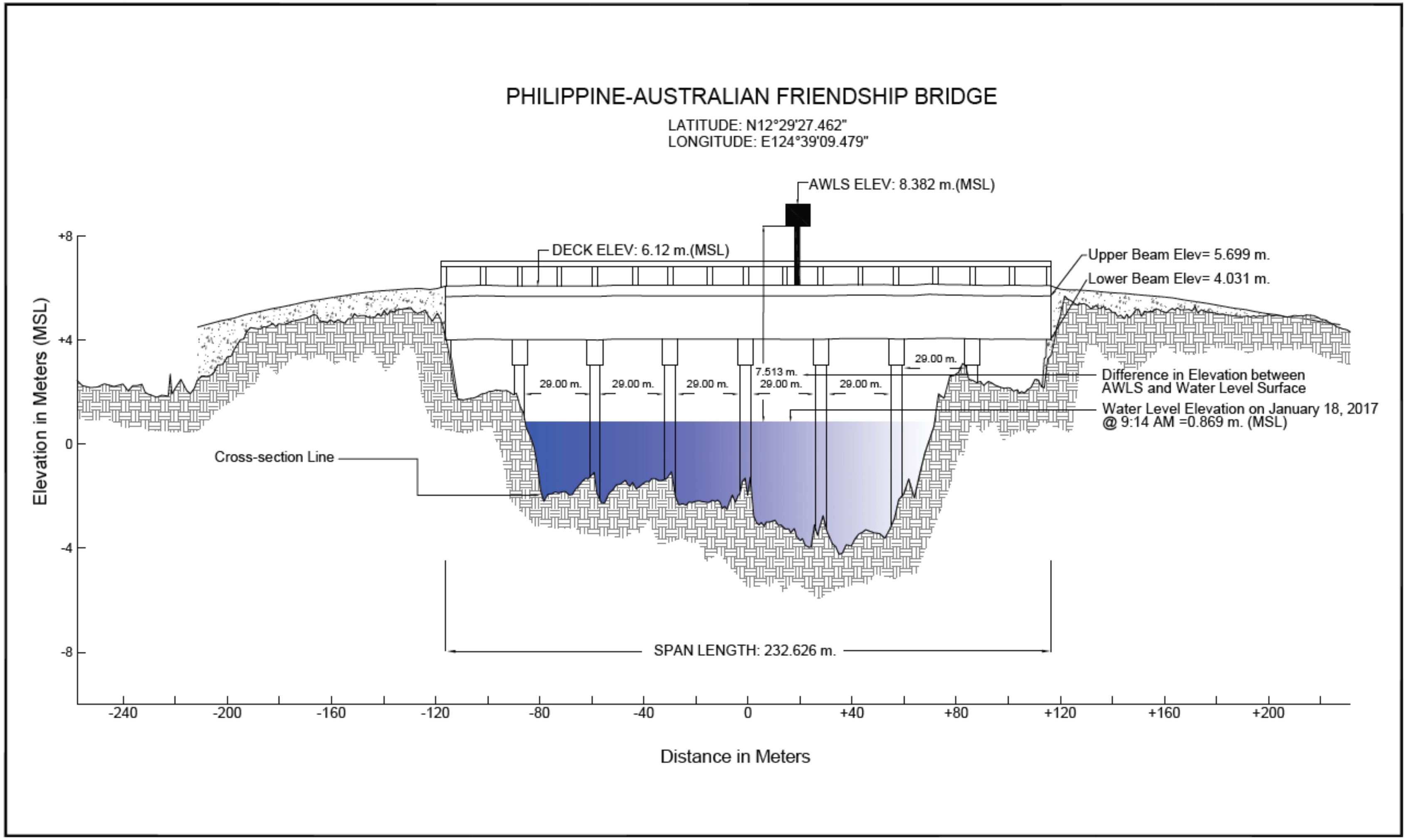



Figure 46. The Philippine-Australian Friendship Bridgecross-section survey drawn to scale.

**BRIDGE DATA FORM**

Bridge Name: Philippine - Australian Friendship Bridge

River Name: Catarman River

Location (Brgy., City, Region): Brgy. Doña Pulqueria, Catarman, Northern Samar

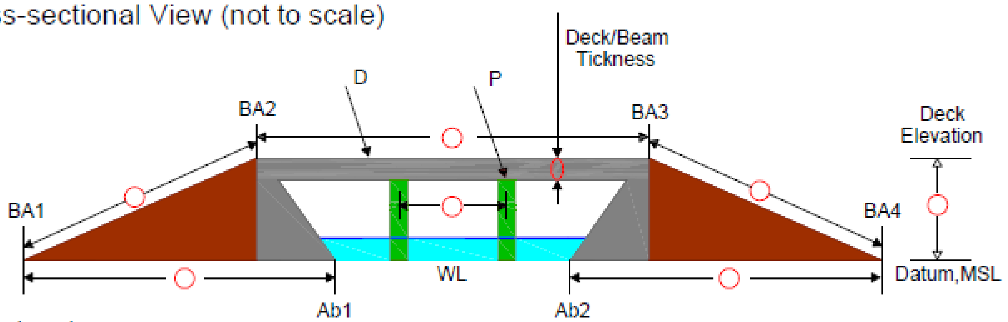
Survey Team: Julieto Cabilin, Urbano Castillo, Jefferson Orbillo, Jodel Dela Cruz, and Oscar Agustin

Date and Time: January 18, 2017 @ 9:14 am - 5:00 pm

Flow Condition: Low Normal High

Weather Condition: Fair Rainy

Cross-sectional View (not to scale)




Legend:
BA = Bridge Approach
P = Pier
Ab = Abutment
D = Deck
WL = Water Level/Surface
MSL = Mean Sea Level
= Measurement Value

| Line Segment | Measurement, m | Remarks |
|---|---|---|
| 1. BA1-BA2 | 2.960 m. | Concrete |
| 2. BA2-BA3 | 232.686 m. | Concrete |
| 3. BA3-BA4 | 4.106 m. | Concrete |
| 4. BA1-Ab1 | 10.637 m. | Concrete |
| 5. Ab2-BA4 | 7.410 m. | Concrete |
| 6. Deck/Beam thickness | 1.660 m. | Concrete |
| 7. Deck Elevation | 6.120 m. MSL | Concrete |
| 8. P1-P2 | 29.000 m. | Concrete |
| 9. P2-P3 | 29.000 m. | Concrete |
| 10. P3-P4 | 29.000 m. | Concrete |
| 11. P4-P5 | 29.000 m. | Concrete |
| 12. P5-P6 | 29.000 m. | Concrete |
| 13. P6-P7 | 29.000 m. | Concrete |

Note: Observer should be facing downstream

Figure 47. The Philippine-Australian Friendship Brigde Bridge as-built survey data.

The water surface elevation of Catarman River was also determined by a Sokkia™ Set CX Total Station on January 18, 2017 at 9:14 AM at the Philippine-Australian Friendship Bridge area with a value of 0.869 m in MSL as shown in Figure 46. This was translated into marking on the bridge's pier as shown in Figure 48.


Figure 48. Water-level markings on the pier of Philippine-Australian Friendship Bridge.

## 4.6 Validation Points Acquisition Survey

The validation points acquisition survey was conducted on August 31, September 2 and 3, 2016 using a survey-grade GNSS Rover receiver, Trimble® SPS 882, mounted in front of a vehicle as shown in Figure 49. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The antenna height was 1.907 m and measured from the ground up to the bottom of notch of the GNSS Rover receiver. The PPK technique utilized for the conduct of the survey was set to continuous topo mode with NS-26, SMN-18 and SMN-22 occupied as the GNSS base stations in the conduct of the survey.


Figure 49. The validation point acquisition setup using a GNSS Receiver Trimble® SPS 882 fixed on a vehicle along the Catarman River Basin.

The survey had three routes. The first route started in Brgy. Molave going south covering thirteen (13) barangays in Catarman and ending in Brgy. Cervantes, Municipality of Catarman. The second route started in Brgy. Bugko going south and ended in Brgy. Nenita, Municipality of Mondragon. The third route started in Brgy. Bantayan, Municipality of San Roque going east covering twelve (12) barangays of Laoang, Pambujan and San Roque and ended in Brgy. Rawis, Municipality of Laoang; and going south covering eighteen (18) more barangays and ended in Brgy. Sagudsuron, Municipality of Catubig.

The survey acquired a total 13,816 points with approximate length of 79 km using NS-26, SMN-18 and SMN-22 as GNSS base stations for the entire extent validation points acquisition survey as illustrated in the map in Figure 50.

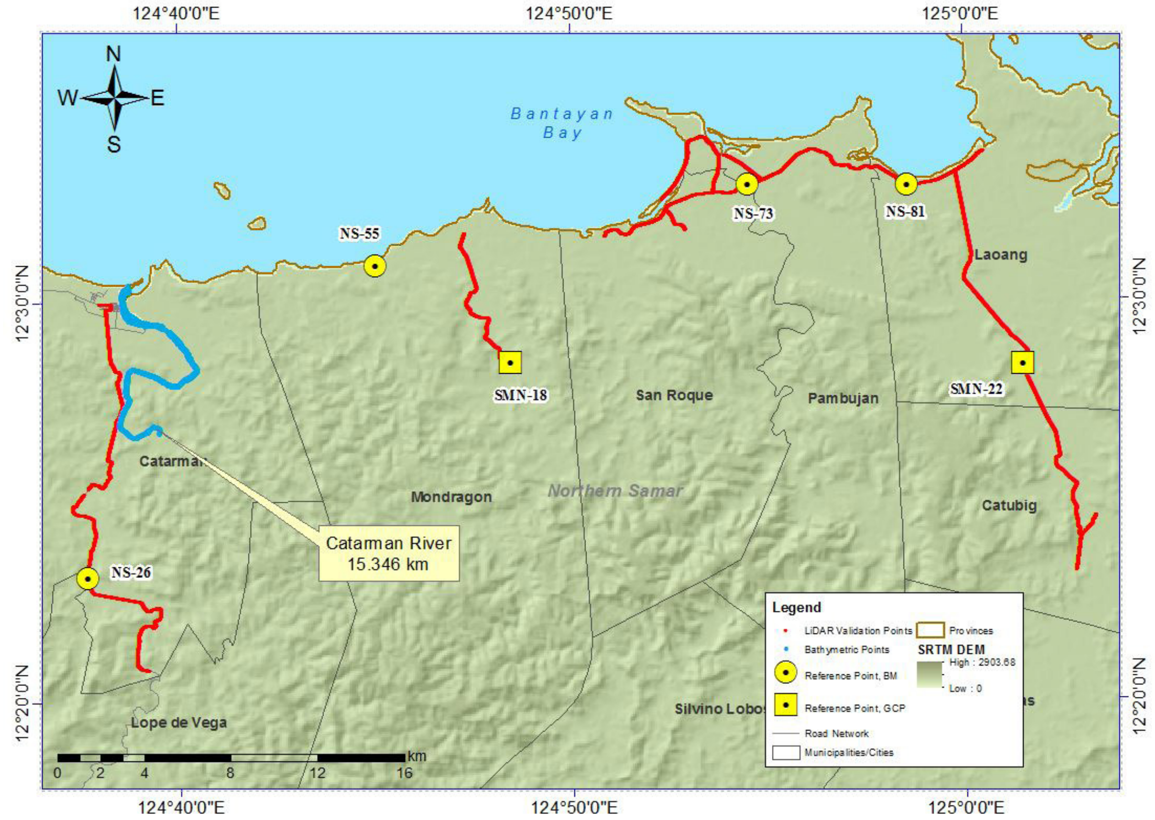



Figure 50. The extent of the LiDAR ground validation survey (in red) for Catarman River Basin.

## 4.7 River Bathymetric Survey

A bathymetric survey was performed on January 19 to 20 and 23 to 24, 2017 using Hi-Target™ V30 GNSS as shown in Figure 51. The survey started in the upstream part of the river in Brgy. Tamdagan, Municipality of Vintar with coordinates 18°18'49.21447" 120°42'44.63259", traversed down by foot to the mouth of the river and ended in Brgy. Casilian, Municipality of Catarman with coordinates 18°16'41.90157" 120°34'05.80297". The UP established control point UP-BAC was used to serve as the GNSS base all throughout the survey.


Figure 51. Set up of the bathymetric survey at Catarman River using a Hi-Target™ V30 GNSS

Overall, the bathymetric survey for Catarman River, with an estimated length of 15.346 km, gathered a total of 2,916 points of the river traversingbarangays Somoge, Washington, San Pascual, McKinley, Hinatad, Doña Pulqueria, Galutan, Macagtas, Ipil-Ipil, Jose Abad Santos, Sampaguita, Mabolo, Baybay, and Bangkerohan in the Municipality of Catarman as shown in Figure 52. To further illustrate this, a CAD drawing of the riverbed profile of the Catarman River was produced. As seen in Figure 53, the highest elevation observed was -0.41 m below MSL located in Brgy. Somoge, Municipality of Catarman; while the lowest was -8.50 m below MSL located in Brgy. Hinatad, also in the Municipality of Catarman.

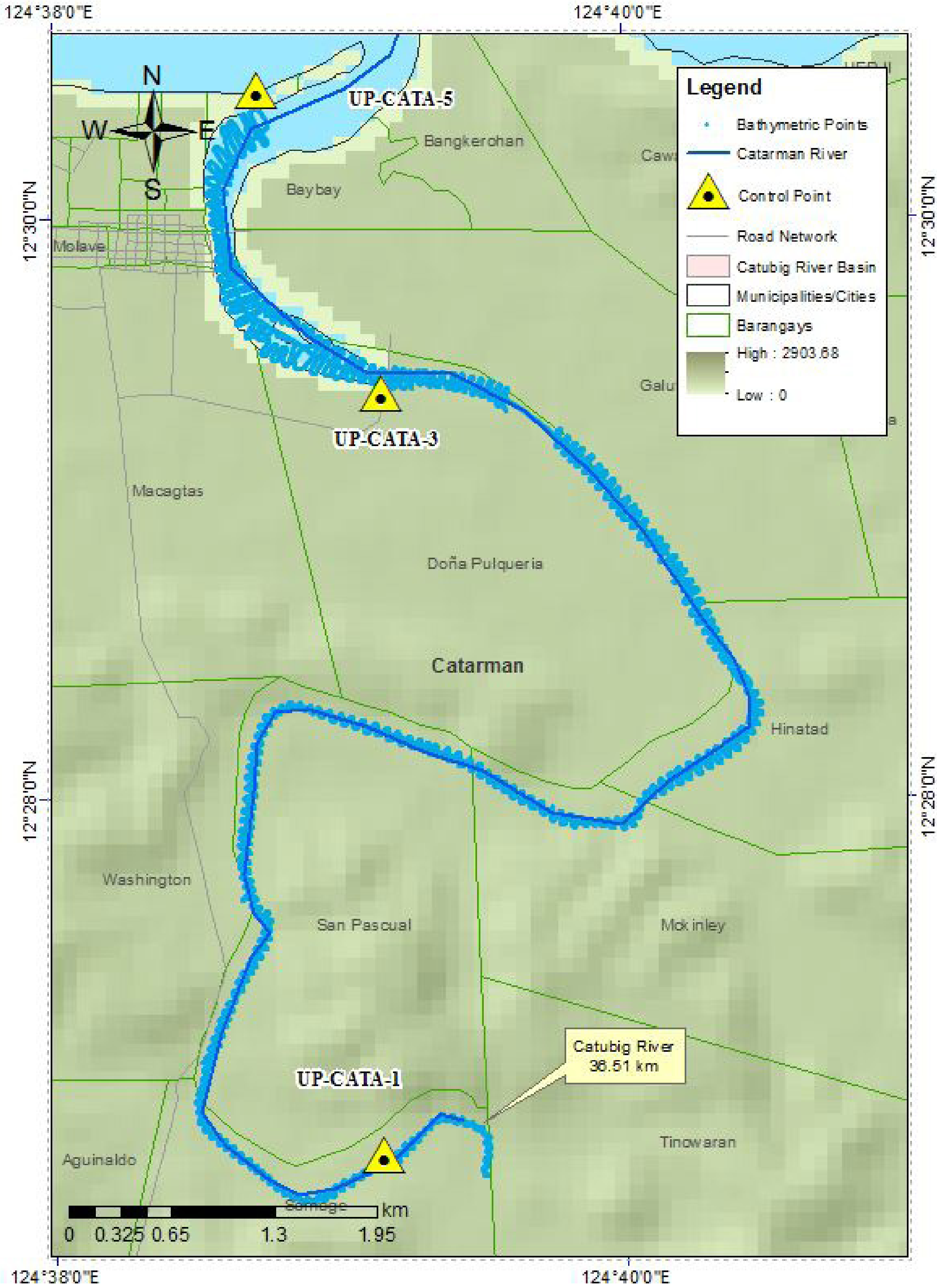



Figure 52. The extent of the Catarman River Bathymetry Survey.

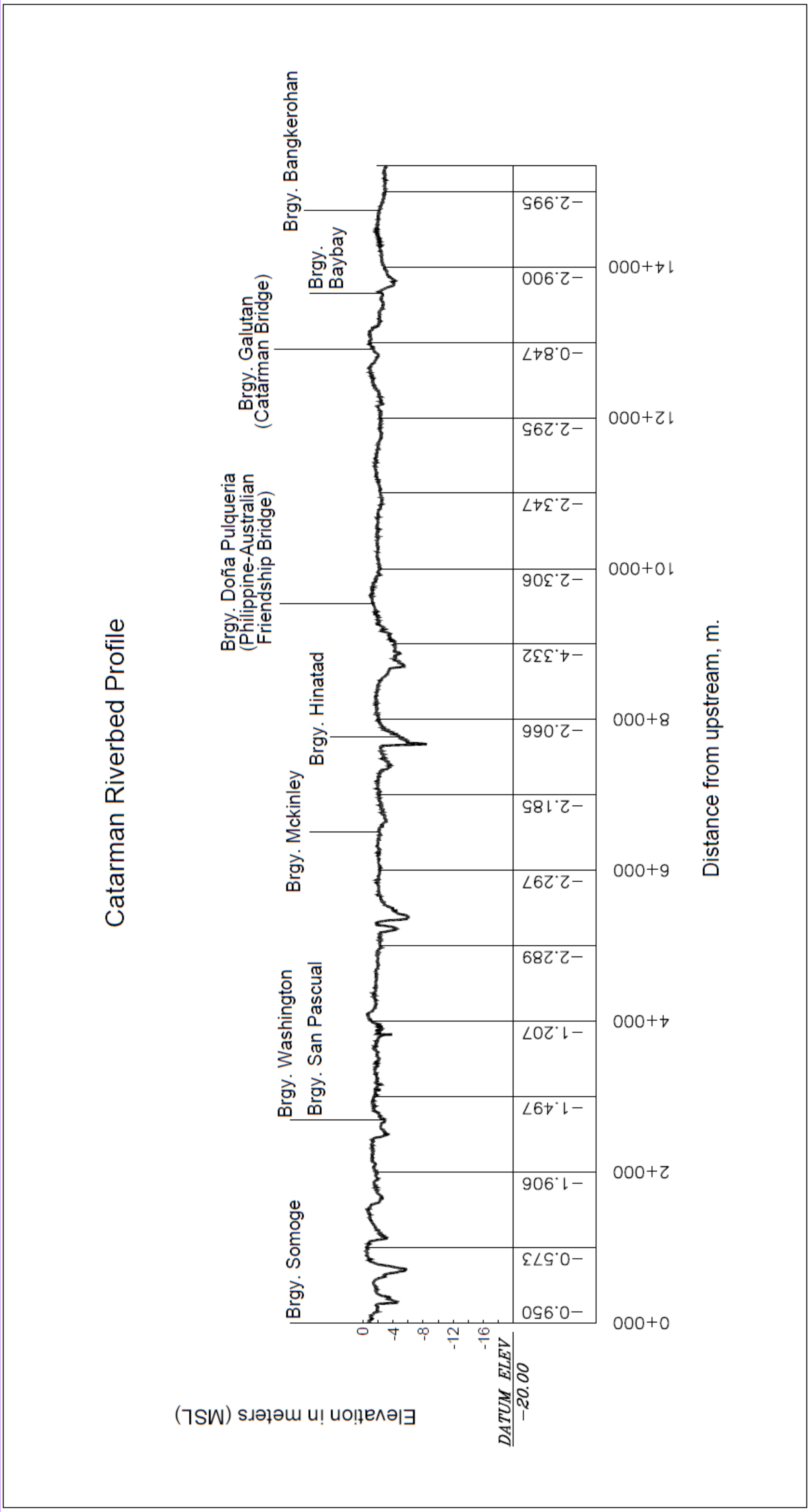



Figure 53. The Catarman Riverbed Profile.

# CHAPTER 5: FLOOD MODELING AND MAPPING

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

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

## 5.1 Data Used for Hydrologic Modeling

### 5.1.1 Hydrometry and Rating Curves

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

### 5.1.2 Precipitation

Precipitation data was taken from an automatic rain gauge (ARG) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). This rain gauge is the Catarman ARG as shown in Figure 54.

The total precipitation for this event in the Catarman ARG was 46 mm. with a peak rainfall rate of 1.8 mm on 20 January 2017 at 9:40 in the evening. The lag time between the peak rainfall and discharge is 15 hours and 20 minutes.

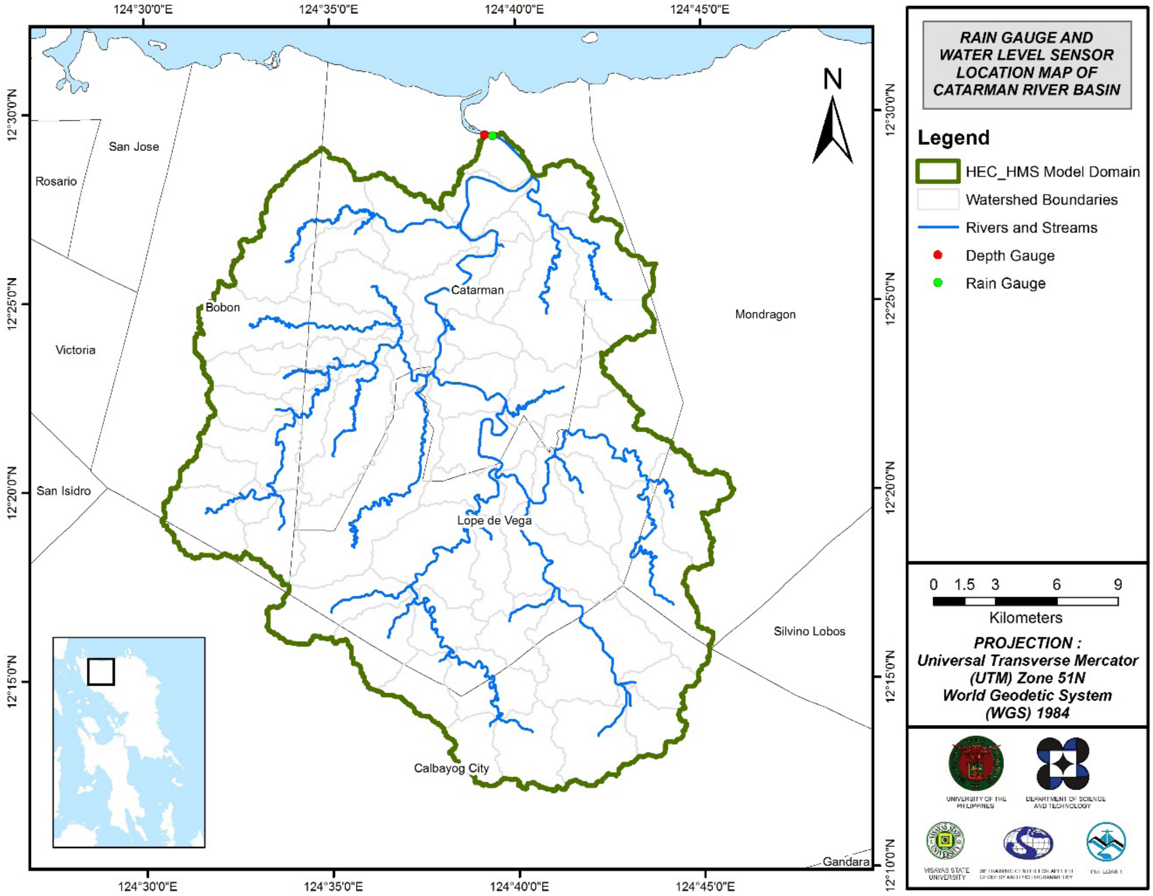



Figure 54. Location Map of the Catarman HEC-HMS model used for calibration.

## 5.1.3 Rating Curves and River Outflow

A rating curve was developed at Catarman Bridge II, Brgy. Doña Pulqueria, Catarman, Northern Samar (12.490965° N, 124.652594° E). It gives the relationship between the observed water levels from the Catarman Bridge II Automatic Water Level Sensor (AWLS) and the combined discharge from baseflow and bankfull.

For Catarman Bridge, the rating curve is expressed as $Q = 153.02e^{0.4962h}$ as shown in Figure 55.

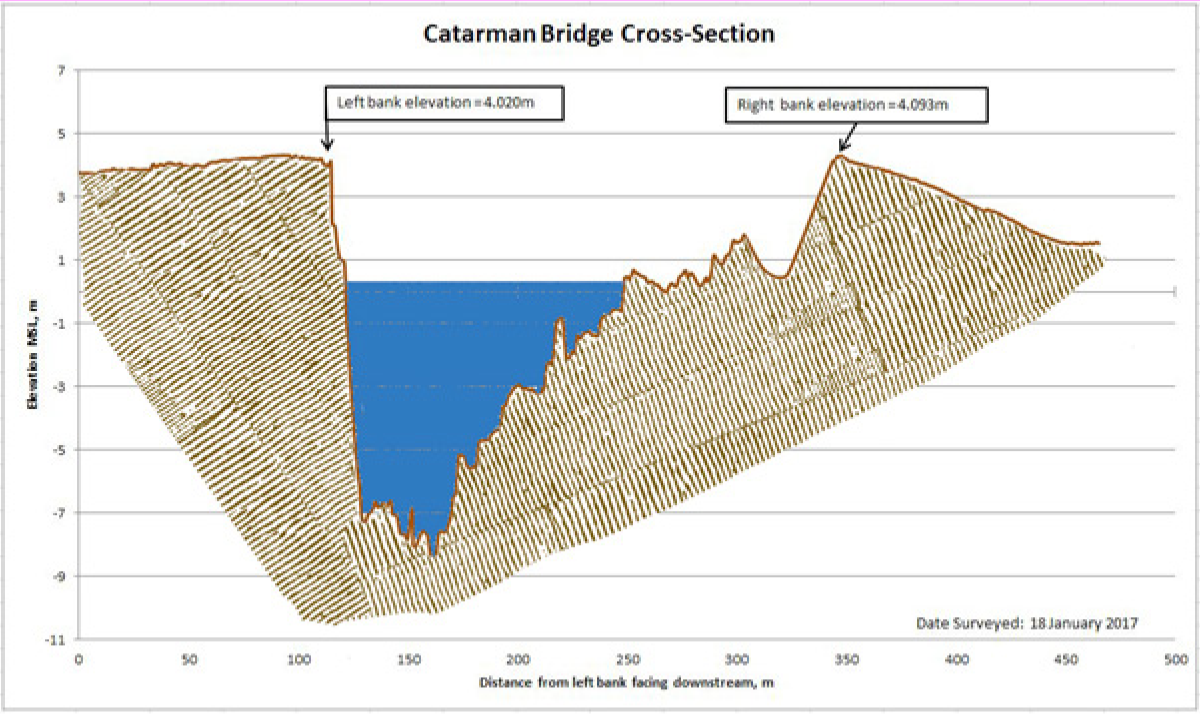



Figure 55. Cross-Section Plot of Catarman Bridge.

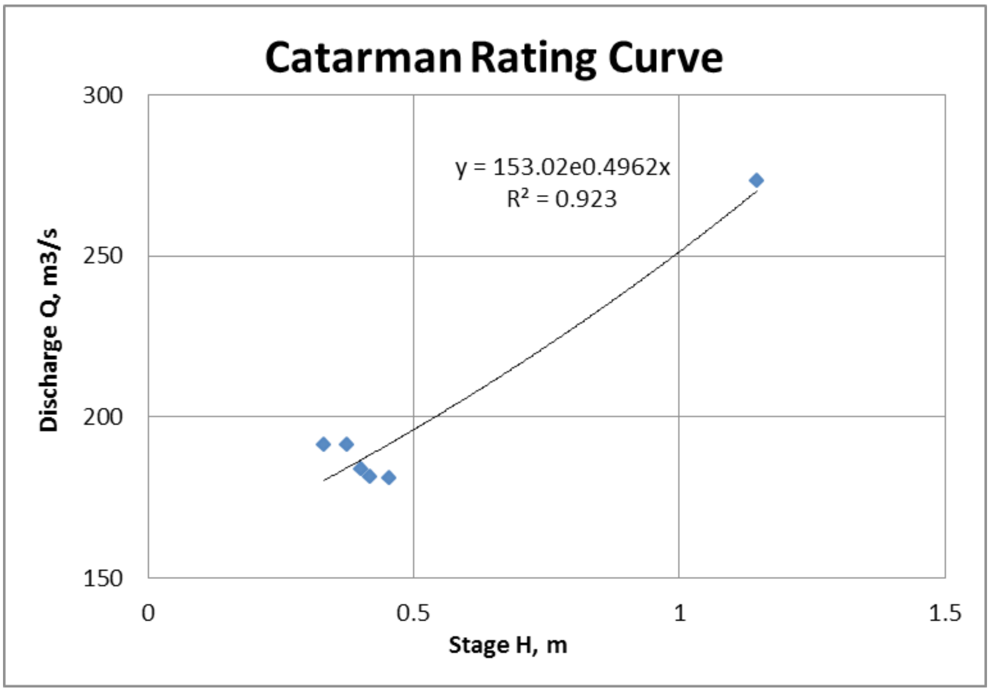



Figure 56. The rating curve at Catarman Bridge.

This rating curve equation was used to compute the river outflow at Catarman Bridge for the calibration of the HEC-HMS model for Catarman shown in Figure 57. The total rainfall for this event in rain gauge is 46 mm andit peaked to 1.8 mm on 20 January 2017, 21:40. The lag time between the peak rainfall and discharge is 15 hours and 20 minutes.

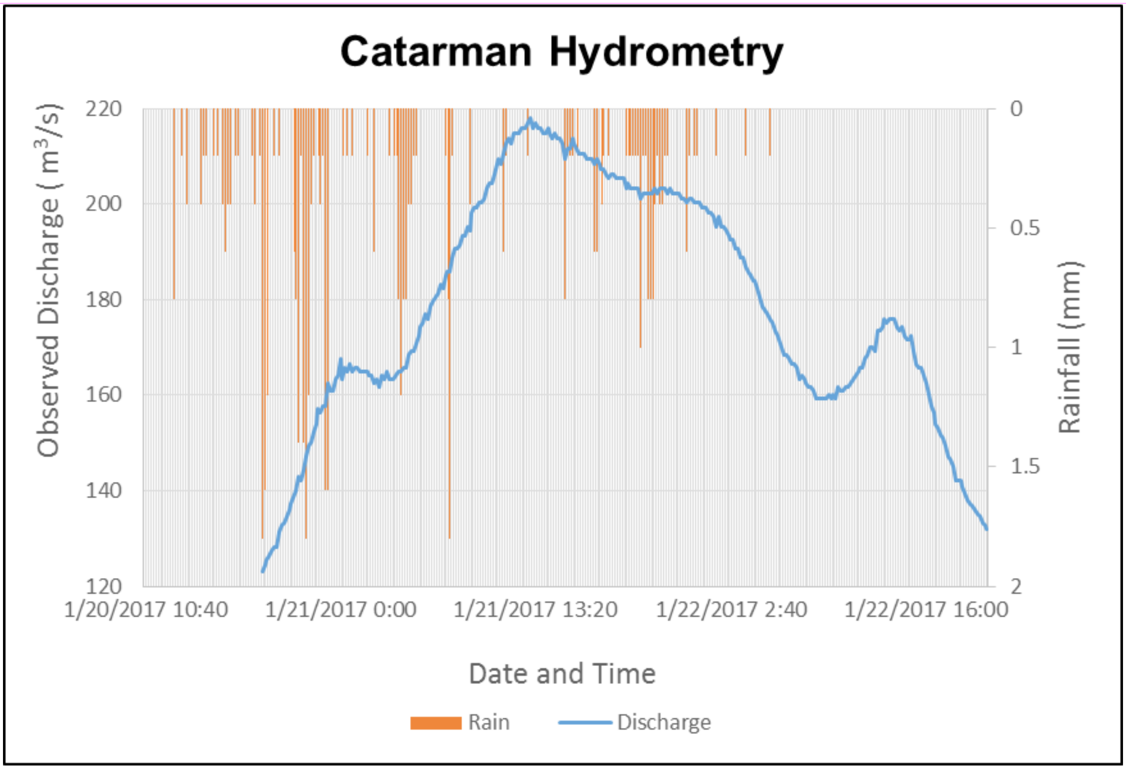



Figure 57. Rainfall and outflow data at Catarman Bridge, which was used for modeling.

## 5.2 RIDF Station

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed for Rainfall Intensity Duration Frequency (RIDF) values for the Catarman Rain Gauge. The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and re-arranging the values in such a way a certain peak value will be attained at a certain time (Table 29). This station is chosen based on its proximity to the Catarman watershed. The extreme values for this watershed were computed based on a 52-year record.

Table 29. RIDF values for the Catarman River Basin based on average RIDF data of Catarman station, as computed by PAGASA.

| COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **T (yrs)** | **10 mins** | **20 mins** | **30 mins** | **1 hr** | **2 hrs** | **3 hrs** | **6 hrs** | **12 hrs** | **24 hrs** |
| **2** | 22.5 | 34.2 | 42.4 | 57.5 | 80.9 | 96.4 | 125.2 | 156.6 | 180 |
| **5** | 29.9 | 45.4 | 56.2 | 77 | 110.3 | 135.9 | 183.5 | 229.5 | 255.4 |
| **10** | 34.7 | 52.8 | 65.4 | 90 | 129.7 | 162 | 222.1 | 277.8 | 305.4 |
| **15** | 37.5 | 57 | 70.5 | 97.3 | 140.7 | 176.7 | 243.9 | 305.1 | 333.6 |
| **20** | 39.4 | 60 | 74.2 | 102.4 | 148.4 | 187.1 | 259.1 | 324.1 | 353.3 |
| **25** | 40.9 | 62.2 | 76.9 | 106.3 | 154.3 | 195 | 270.9 | 338.8 | 368.5 |
| **50** | 45.5 | 69.2 | 85.5 | 118.4 | 172.6 | 219.5 | 307.1 | 384.1 | 415.3 |

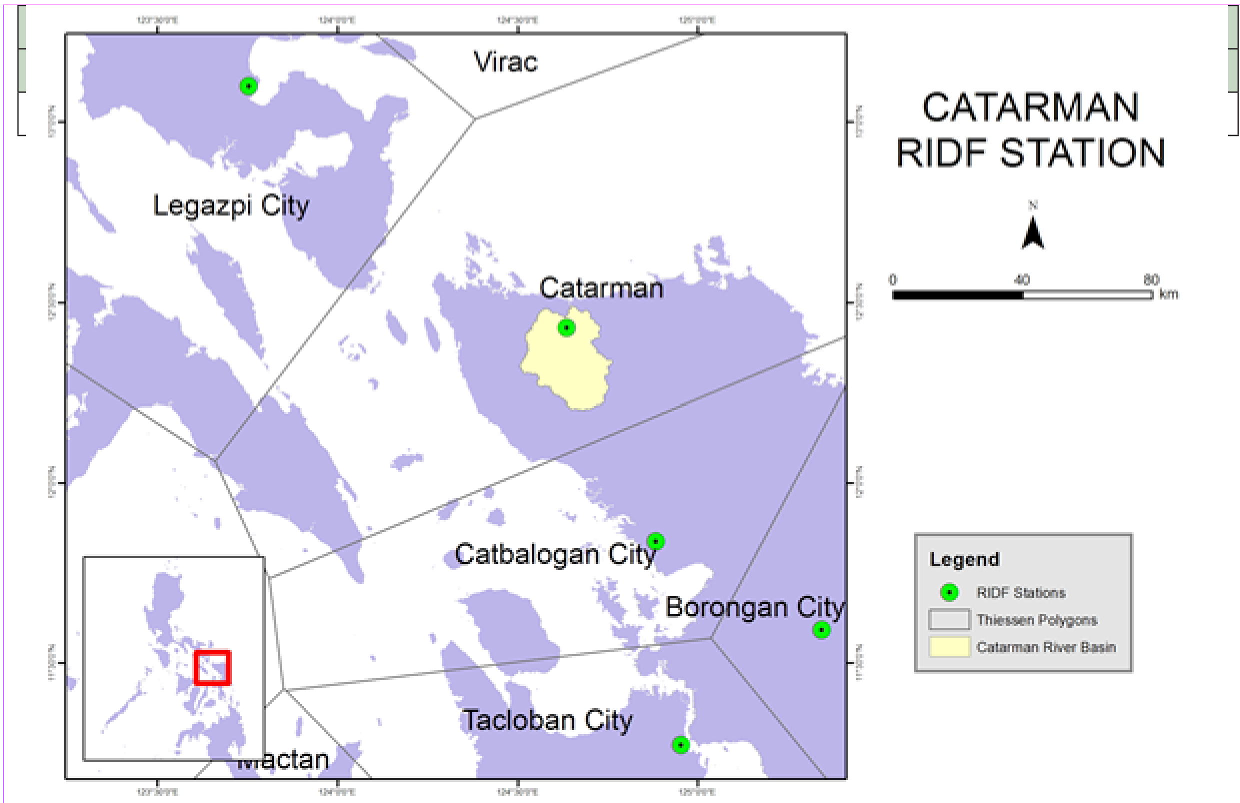



Figure 58. The location of the Catarman RIDF station relative to the Catarman River Basin.

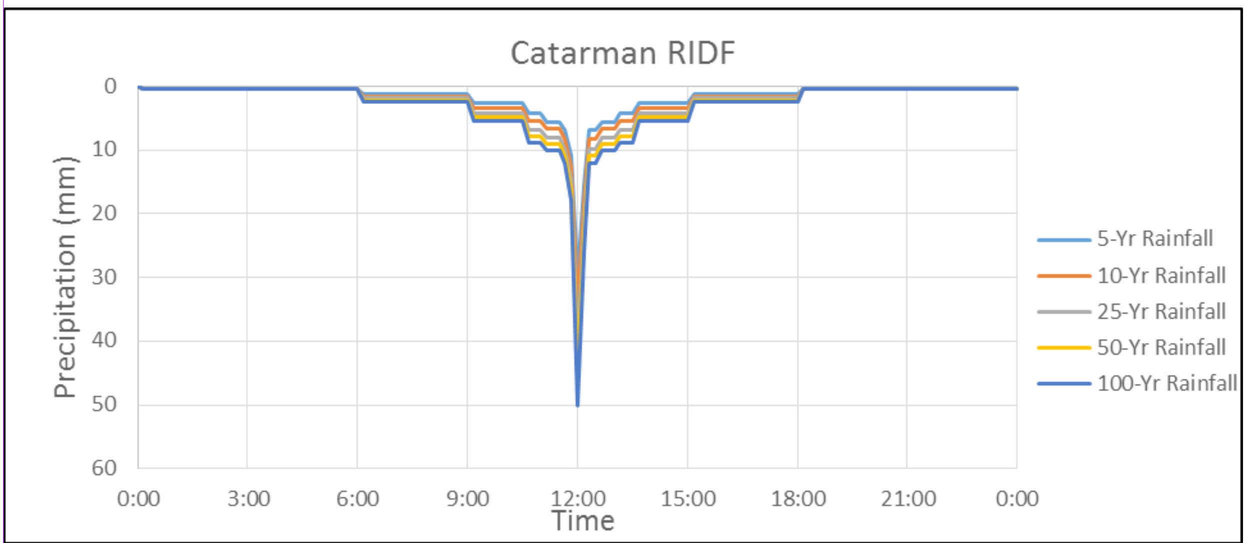



Figure 59. The synthetic storm generated for a 24-hour period rainfall for various return periods.

## 5.3 HMS Model

These soil dataset was taken in 2004 from the Bureau of Soils and Water Management (BSWM). It is under the Department of Agriculture (DA). The land cover dataset is from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Catarman River Basin are shown in Figure 60 and Figure 61,respectively.

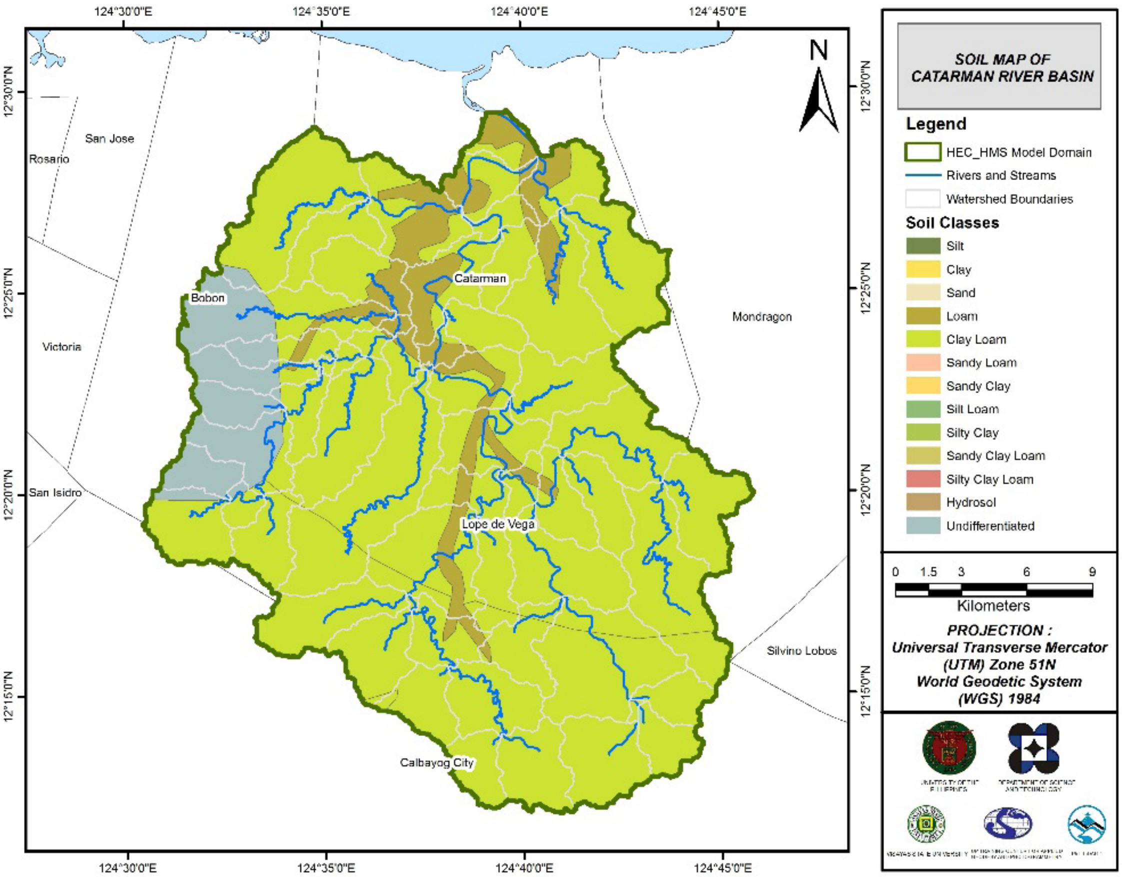



Figure 60. Soil Map of Catarman River Basin.

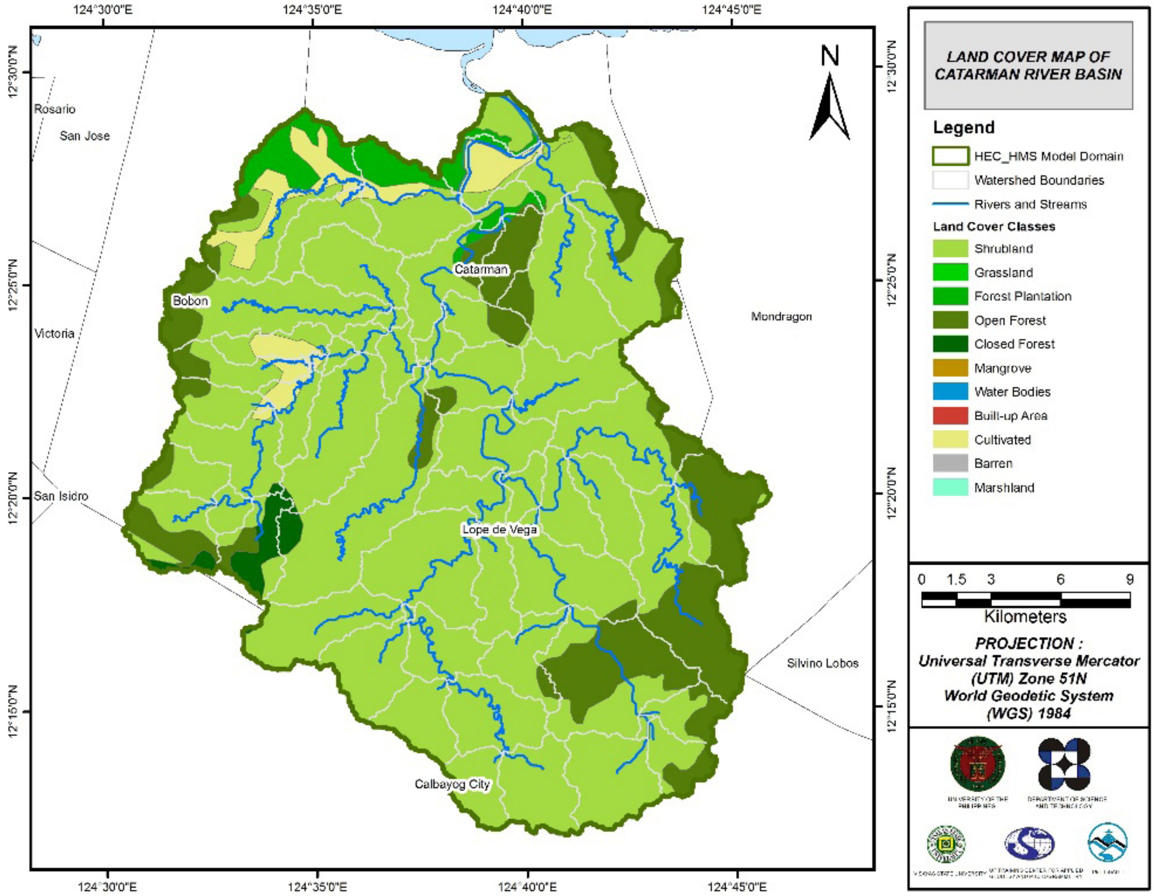



Figure 61. Land Cover Map of Catarman River Basin.

For Catarman, three (3) soil classes were identified. These are clay loam, loam, and undifferentiated land. Moreover, five (5) land cover classes were identified. These are shrubland, grassland, forest plantation, open forest, and closed forest.

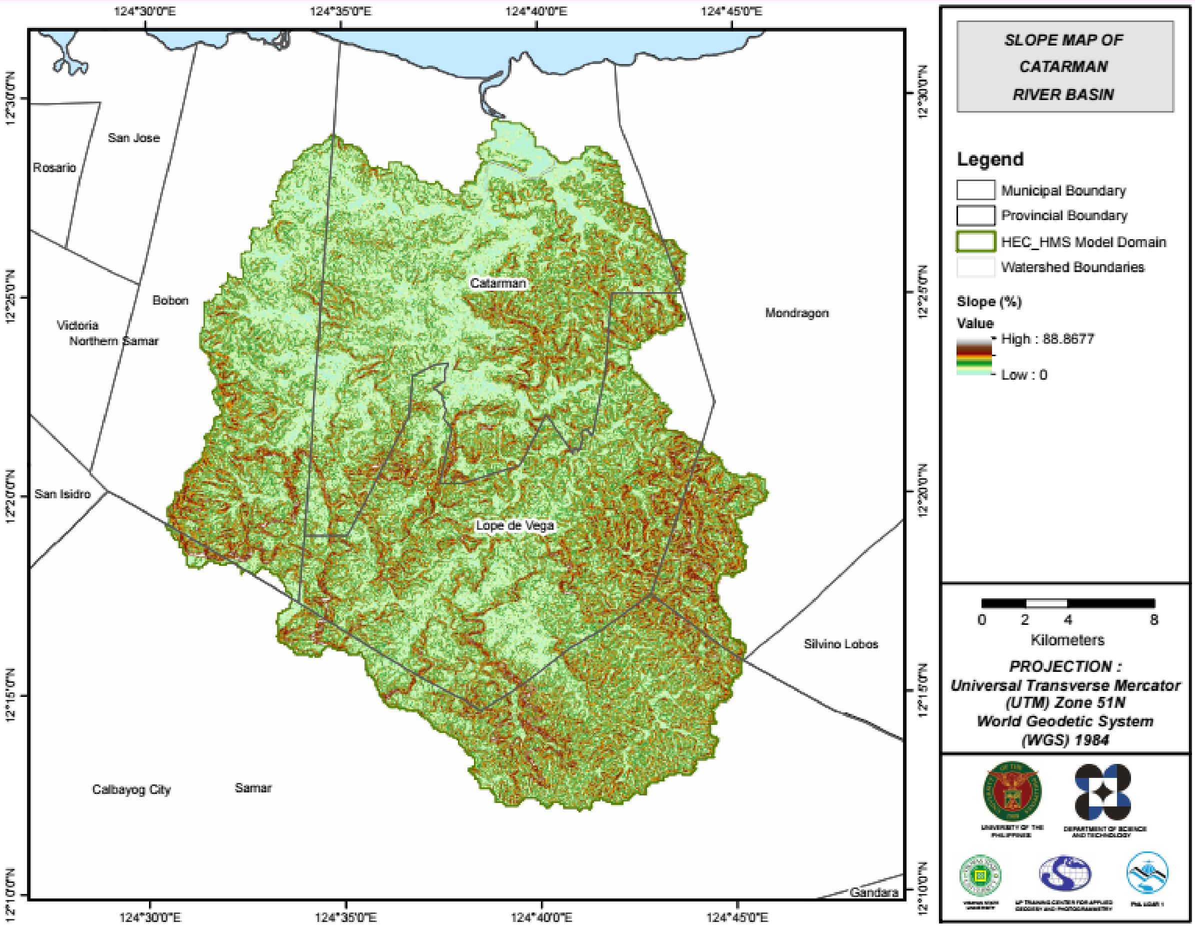



Figure 62. Slope Map of the Catarman River Basin.

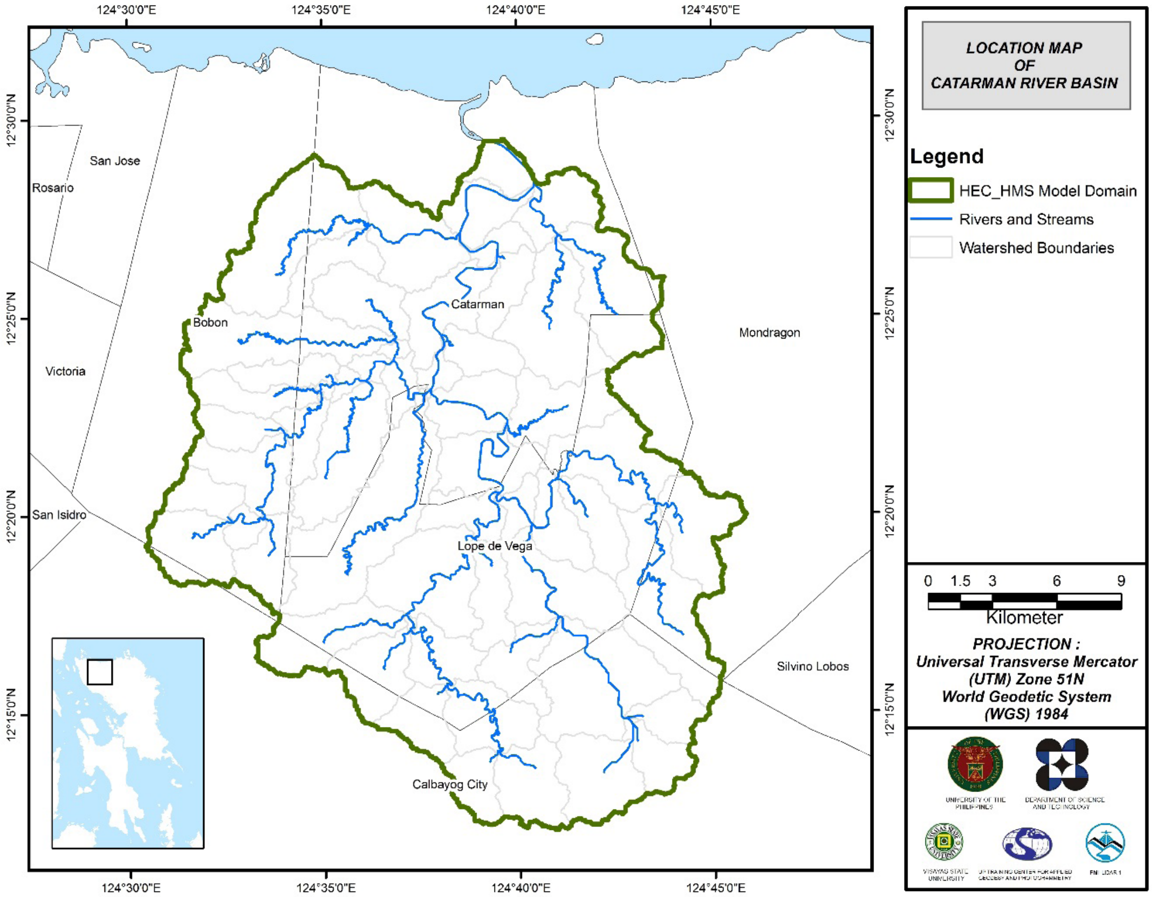



Figure 63. Stream Delineation Map of Catarman River Basin.

Using the SAR-based DEM, the Catarman basin was delineated and further subdivided into subbasins. The model consists of 59 subbasins, 29 reaches, and 29 junctions as shown in Figure 64. The main outlet is at Catarman Bridge.

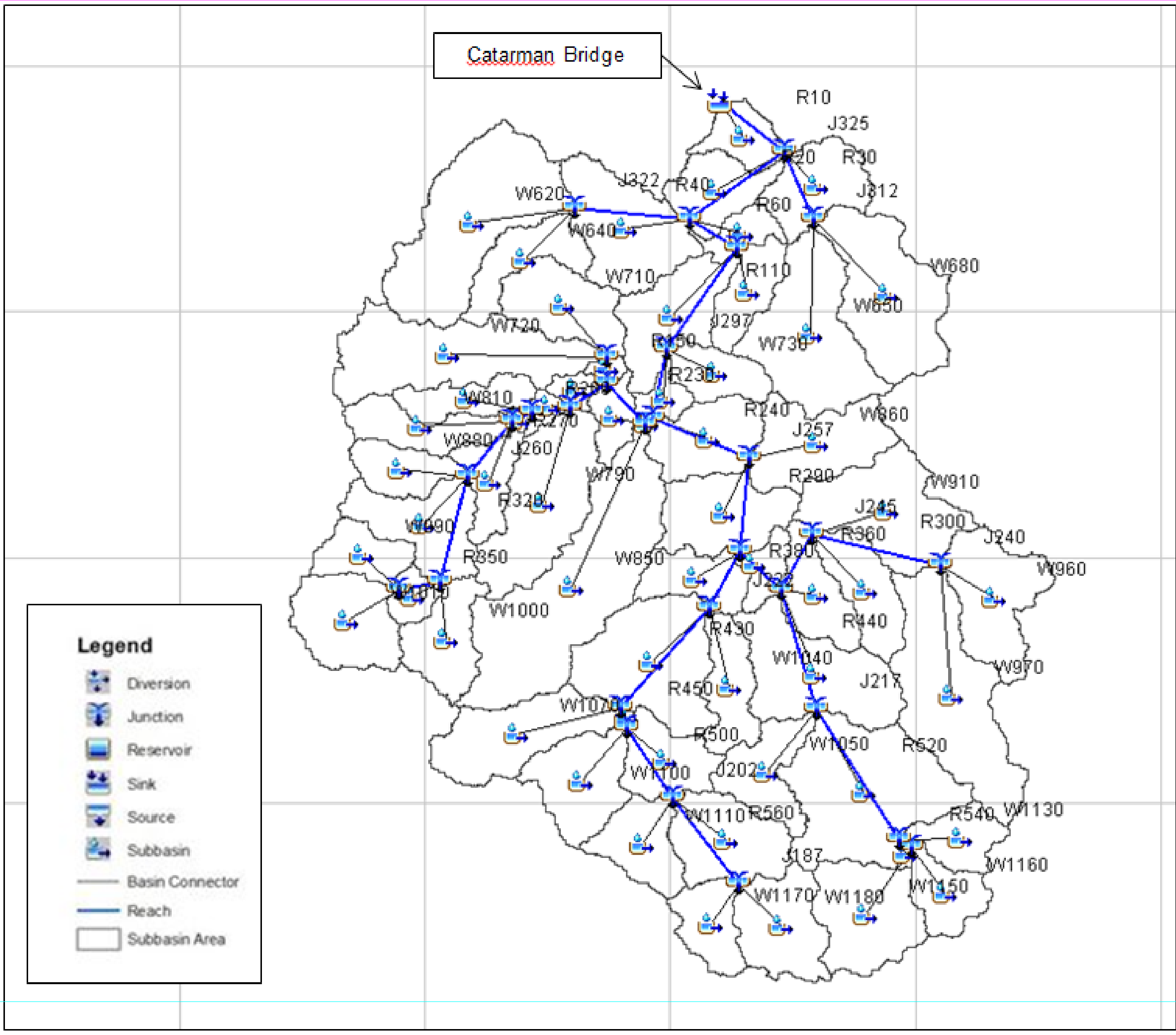



Figure 64. Catarman river basin model generated in HEC-HMS.

## 5.4 Cross-section Data

The riverbed cross-sections of the watershed were necessary in the HEC-RAS model setup. The cross-section data for the HEC-RAS model was derived from the LiDAR DEM data, which was defined using the Arc GeoRAS tool and was post-processed in ArcGIS (Figure 65).

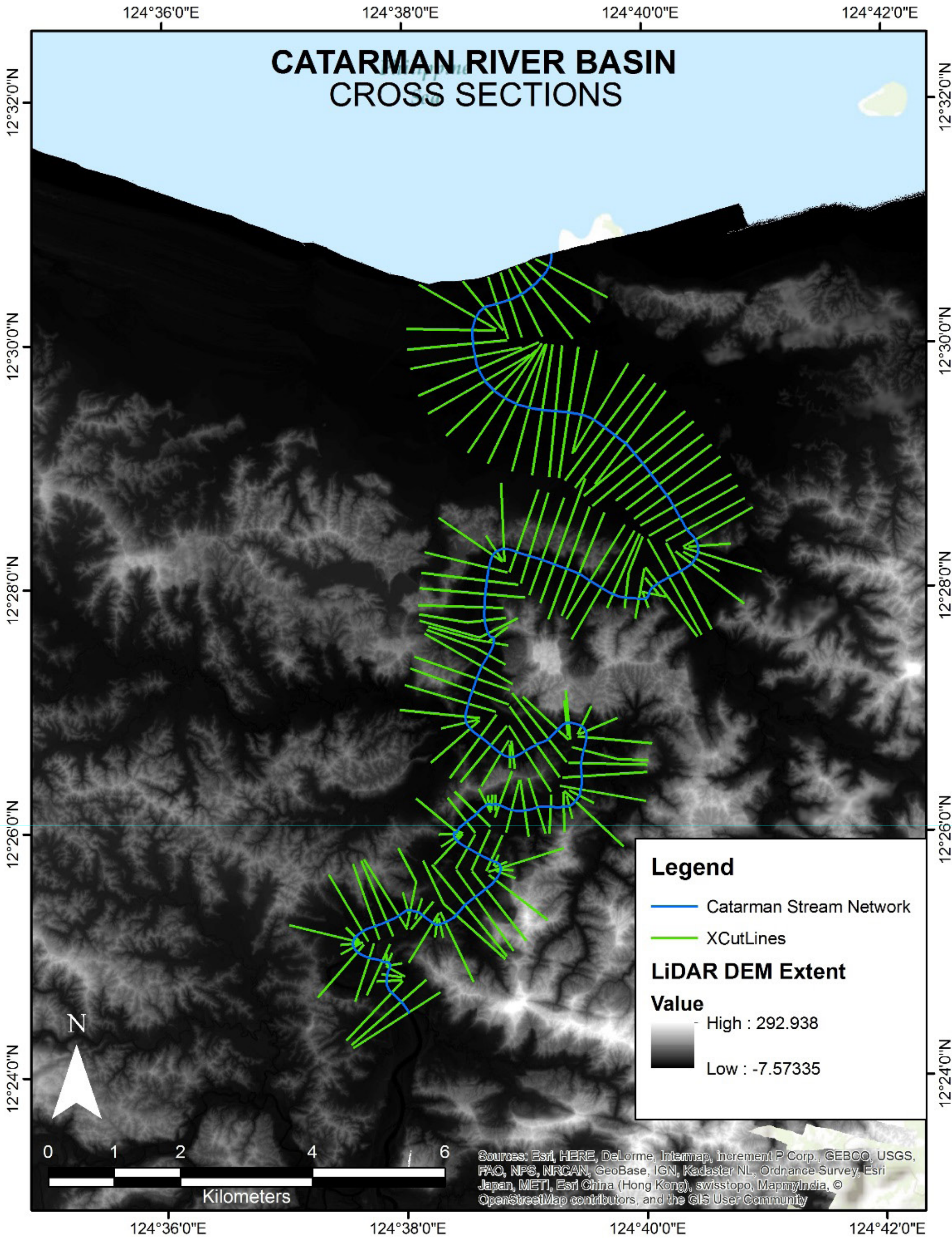



Figure 65. River cross-section of the Catarman River through the ArcMap HEC GeoRas tool.

## 5.5 Flo 2D Model

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

Based on the elevation and flow direction, it is seen that the water will generally flow from the southwest 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.

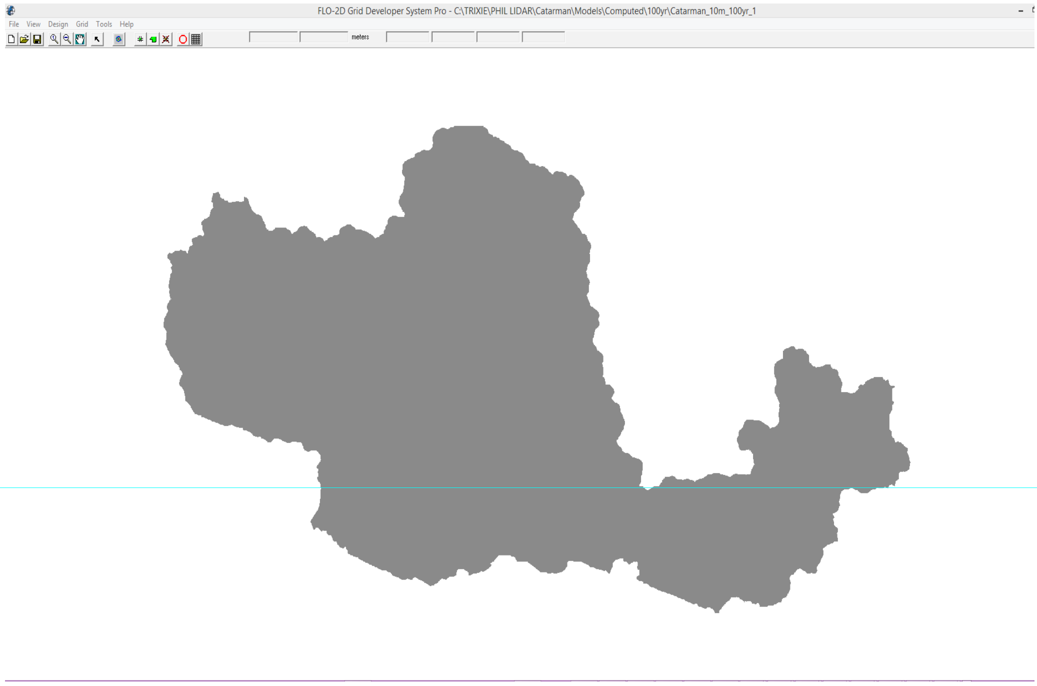



Figure 66. A screenshot of the river sub-catchment with the computational area to be modeled in FLO-2D Grid Developer System Pro (FLO-2D GDS Pro).

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 376.43188 hours. After the simulation, FLO-2D Mapper Pro is used to transform the simulation results into spatial data that shows flood hazard levels, as well as the extent and inundation of the flood. Assigning the appropriate flood depth and velocity values for Low, Medium, and High creates the following food hazard map. Most of the default values given by FLO-2D Mapper Pro are used, except for those in the Low hazard level. For this particular level, the minimum h (Maximum depth) is set at 0.2 m while the minimum vh (Product of maximum velocity (v) times maximum depth (h)) is set at 0 $m^2/s$. The generated hazard maps for Catarman are inFigure 75, 77, and 79.

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 102 342 144.00$m^2$. The generated flood depth maps for Catarman are inFigure 76, 78, and 80.

There is a total of 158 479 845.67 $m^3$ of water entering the model. Of this amount, 45 686 223.71$m^3$ is due to rainfall while 112 793 621.96 $m^3$ is inflow from other areas outside the model. 10 940 128.00$m^3$ of this water is lost to infiltration and interception, while 41 029 856.98 $m^3$ is stored by the flood plain. The rest, amounting up to 106 509 809.61$m^3$, is outflow.

## 5.6 Results of HMS Calibration

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

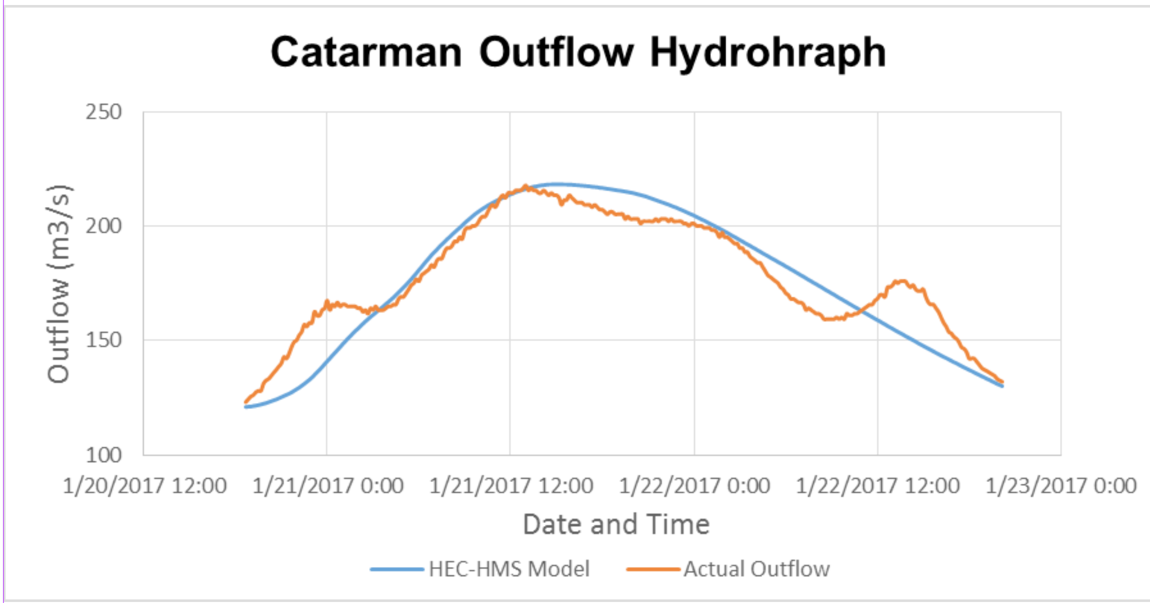



Figure 67. Outflow Hydrograph of Catarman produced by the HEC-HMS model compared with observed outflow.

Table 30 shows the adjusted ranges of values of the parameters used in calibrating the model.

Table 30. Range of calibrated values for the Catarman River Basin.

| Hydrologic Element | Calculation Type | Method | Parameter | Range of Calibrated Values |
|---|---|---|---|---|
| Basin | Loss | SCS Curve Number | Initial Abstraction (mm) | 0.6 – 5 |
| | | | Curve Number | 95 - 99 |
| | Transform | Clark Unit Hydrograph | Time of Concentration (hr) | 0.5 - 9 |
| | | | Storage Coefficient (hr) | 0.8 - 14 |
| | Baseflow | Recession | Recession Constant | 0.3 |
| | | | Ratio to Peak | 0.01 |
| Reach | Routing | Muskingum-Cunge | Manning’s Coefficient | 0.04 |

Initial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as initial abstraction decreases. The range of values from 0.6mm to 5mm means that there is a minimal amount of infiltration or rainfall interception by vegetation per subbasin.

The curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range of 95 to 99 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area (M. Horritt, personal communication, 2012).

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 14 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 valueof 0.3 indicates that the basin is likely to quickly go back to its original discharge and instead, will be higher. Values of ratio to peak of 0.01 indicates a steeper receding limb of the outflow hydrograph.

Manning's roughness coefficients of 0.04 correspond to the common roughness of Catarman watershed, which is determined to be cultivated with mature field crops (Brunner, 2010).

Table 31. Summary of the Efficiency Test of the Catarman HMS Model

| Accuracy measure | Value |
|---|---|
| RMSE | 10.3 |
| $r^2$ | 0.92 |
| NSE | 0.80 |
| PBIAS | 0.65 |
| RSR | 0.44 |

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 10.3 $m^3/s$.

The Pearson correlation coefficient ($r^2$) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.92.

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 0.80.

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 0.65.

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 0.44.

## 5.7 Calculated Outflow hydrographys and Discharge Values for different Rainfall Return Periods

### 5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 68) shows the Catarman outflow using the CatarmanRainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) data.  The simulation results reveal increasing outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

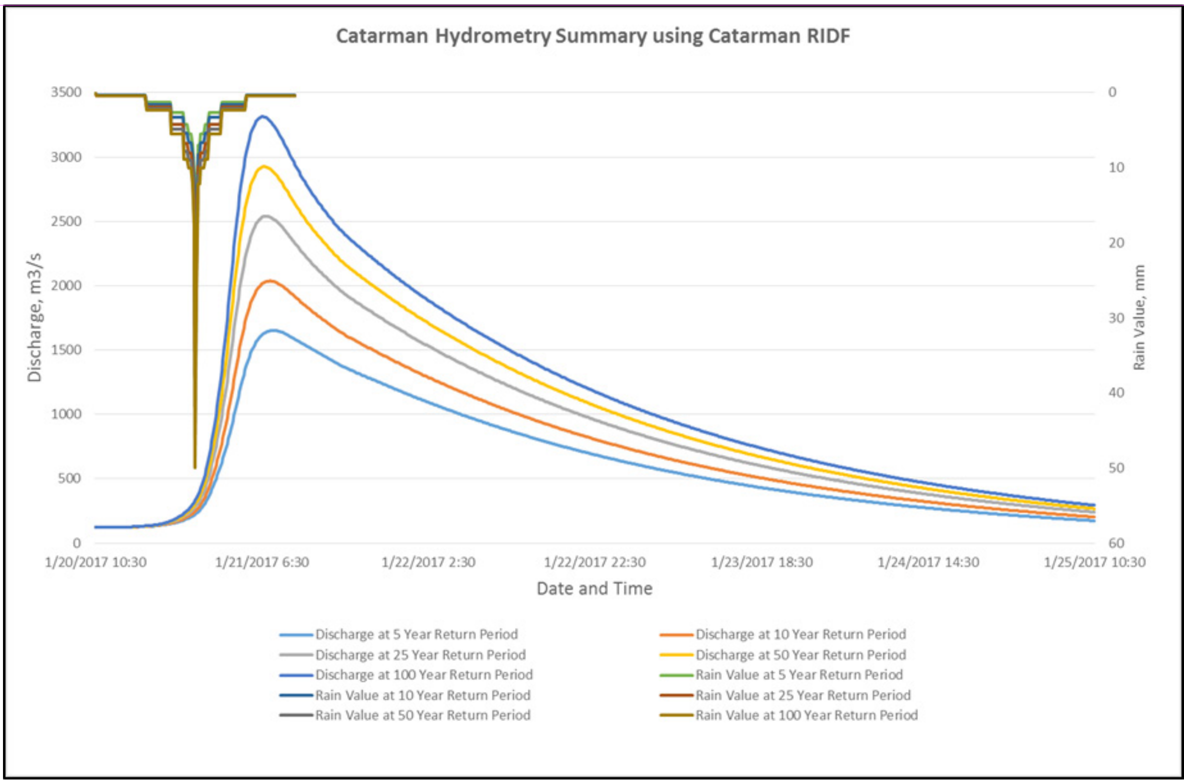



Figure 68. The Outflow hydrograph at the Catarman Station, generated using the Catarman RIDF simulated in HEC-HMS.

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Catarmandischarge using the Catarman Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown inTable 32.

Table 32. The peak values of the Catarman HEC-HMS Model outflow using the Catarman RIDF.

| RIDF Period | Total Precipitation (mm) | Peak rainfall (mm) | Peak outflow ($m^3/s$) | Time to Peak |
|---|---|---|---|---|
| 5-Year | 255.4 | 29.9 | 1652.1 | 9 hours, 20 minutes |
| 10-Year | 305.4 | 34.7 | 2036.3 | 9 hours, 00 minutes |
| 25-Year | 368.5 | 40.9 | 2539.8 | 8 hours, 30 minutes |
| 50-Year | 415.3 | 45.5 | 2924.2 | 8 hours, 20 minutes |
| 100-Year | 461.8 | 50 | 3313.1 | 8 hours, 10 minutes |

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

The river discharge values for the nine rivers entering the floodplain are shown in Figure 69 to Figure 73 and the peak values are summarized in Table 33 to Table 37.

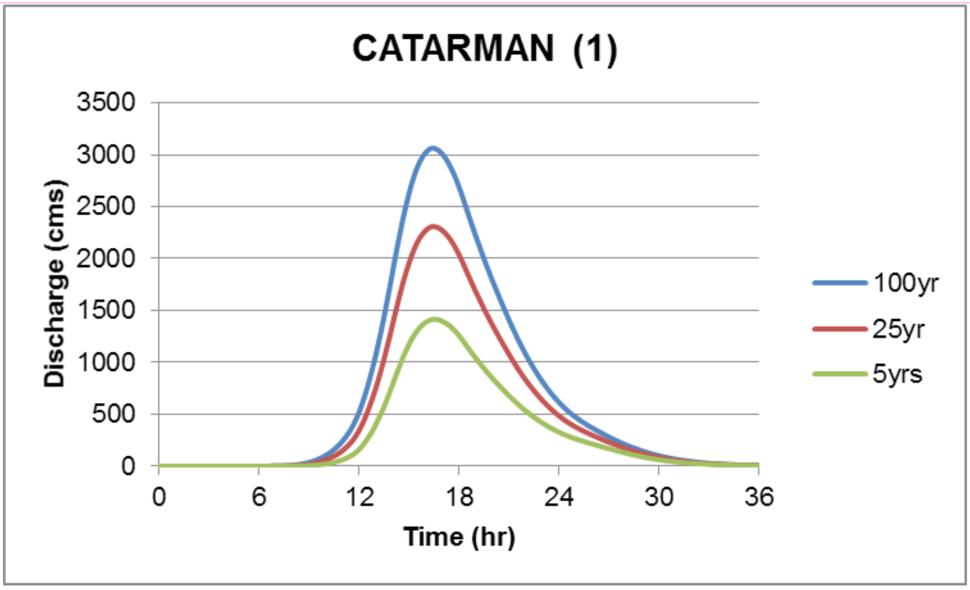



Figure 69. Catarman river (1) generated discharge using 5-, 25-, and 100-year rainfall intensity-duration-frequency (RIDF) in HEC-HMS.

Table 33. Summary of Catarman river (1) discharge generated in HEC-HMS.

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 3063.6 | 250.7 minutes |
| 25-Year | 2309 | 250.7 minutes |
| 5-Year | 2 | 250.7 minutes |

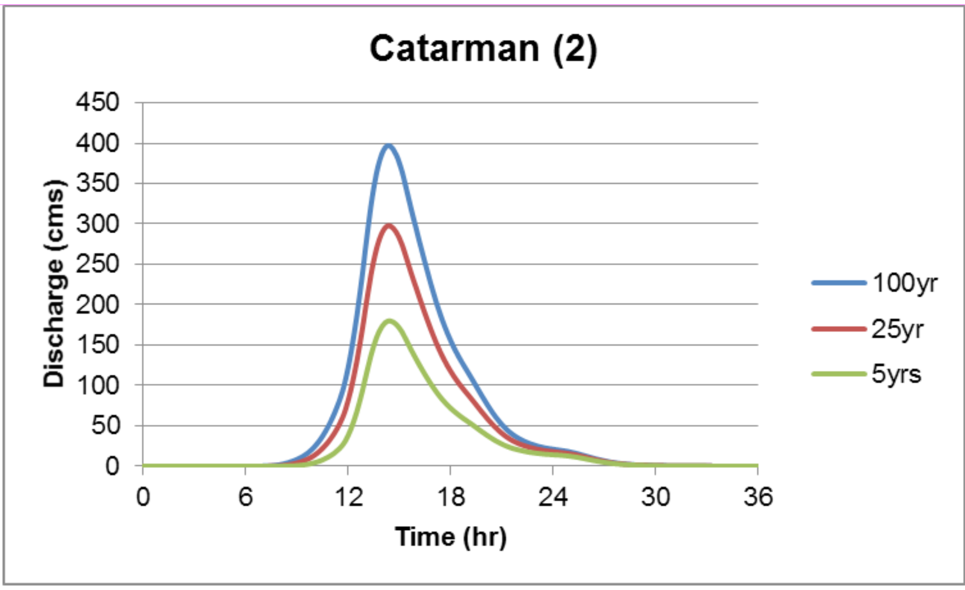



Figure 70. Catarman river (2) generated discharge using 5-, 25-, and 100-year rainfall intensity-duration-frequency (RIDF) in HEC-HMS.

Table 34. Summary of Catarman river (2) discharge generated in HEC-HMS.

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 397.1 | 136.3 minutes |
| 25-Year | 297.7 | 136.3 minutes |
| 5-Year | 179.7 | 136.3 minutes |

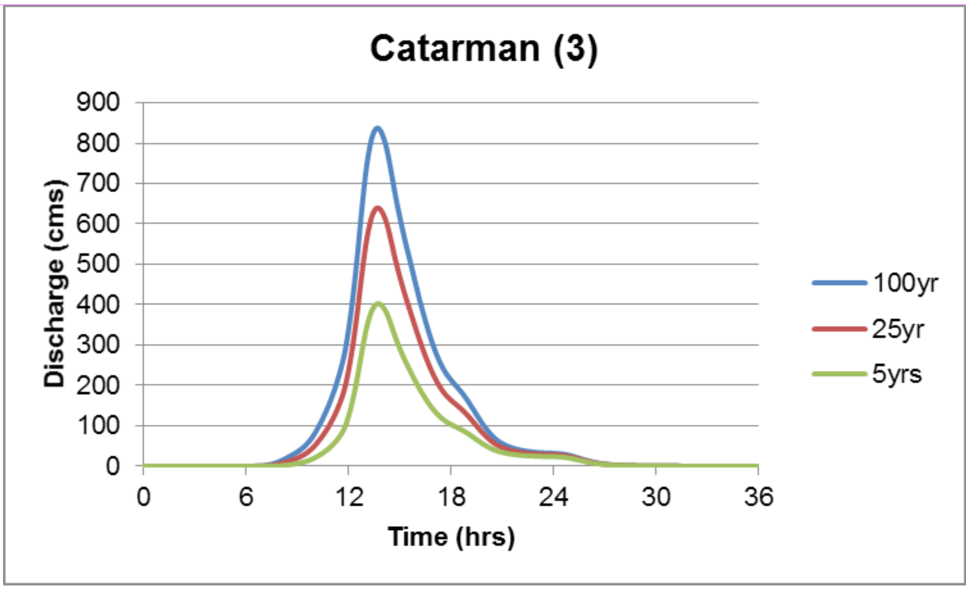



Figure 71. Catarman river (3) generated discharge using 5-, 25-, and 100-year rainfall intensity-duration-frequency (RIDF) in HEC-HMS.

Table 35. Summary of Catarman river (3) discharge generated in HEC-HMS.

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 837.8 | 102.6 minutes |
| 25-Year | 640 | 102.6 minutes |
| 5-Year | 402.2 | 102.6 minutes |

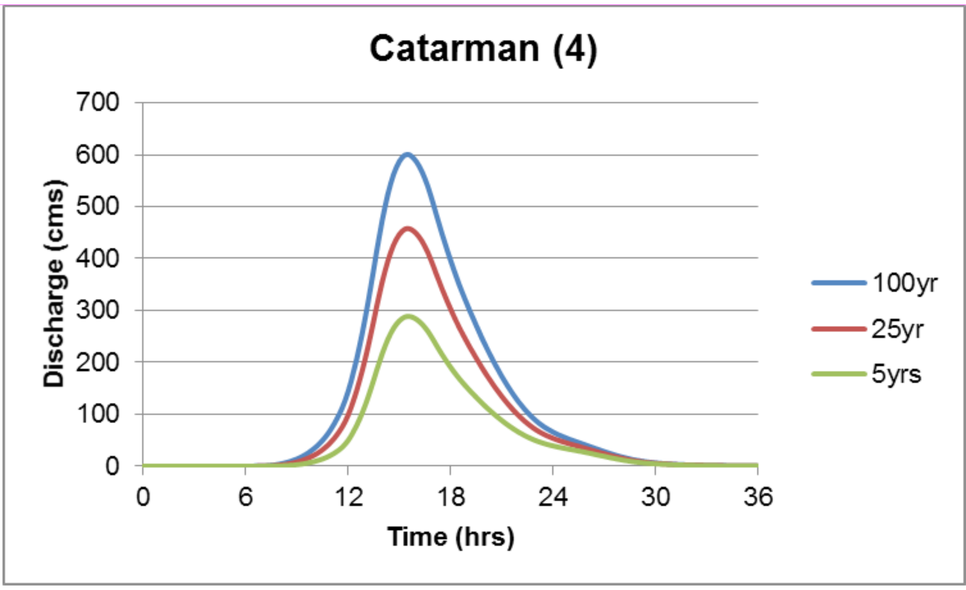



Figure 72. Catarman river (4) generated discharge using 5-, 25-, and 100-year rainfall intensity-duration-frequency (RIDF) in HEC-HMS.

Table 36. Summary of Catarman river (4) discharge generated in HEC-HMS.

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 600.7 | 198.6 minutes |
| 25-Year | 458.1 | 198.6 minutes |
| 5-Year | 288.7 | 198.6 minutes |

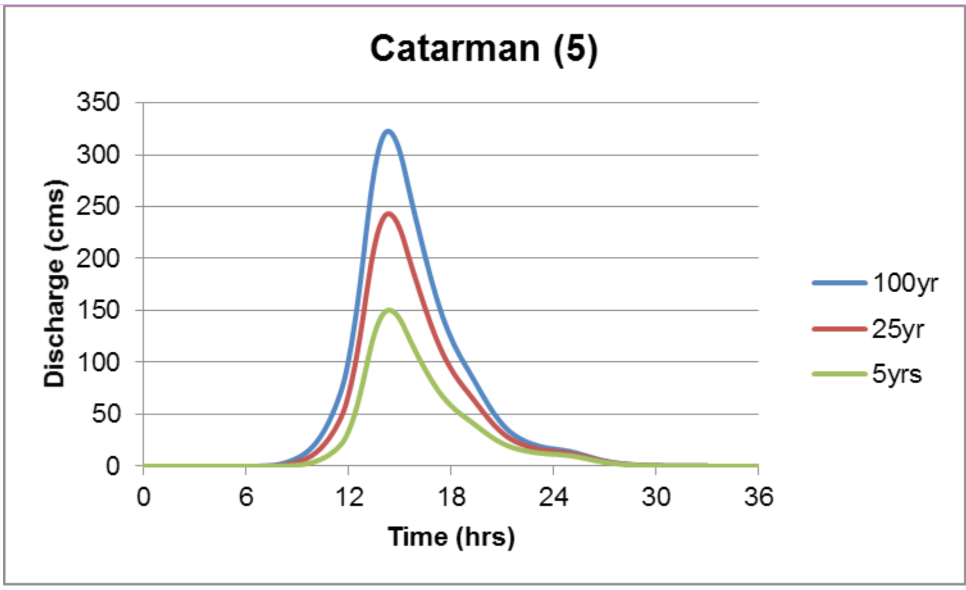



Figure 73. Catarman river (5) generated discharge using 5-, 25-, and 100-year rainfall intensity-duration-frequency (RIDF) in HEC-HMS.

Table 37. Summary of Catarman river (5) discharge generated in HEC-HMS.

| RIDF Period | Peak discharge (cms) | Time-to-peak |
|---|---|---|
| 100-Year | 322.8 | 134.7 minutes |
| 25-Year | 243.3 | 134.7 minutes |
| 5-Year | 150.3 | 134.7 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 38.

Table 38. Validation of river discharge estimates.

| Discharge Point | $Q_{MED(SCS)}$, cms | $Q_{BANKFUL}$, cms | $Q_{MED(SPEC)}$, cms | VALIDATION | |
|---|---|---|---|---|---|
| | | | | Bankful Discharge | Specific Discharge |
| Catarman (1) | 1245.024 | 1827.803 | 425.668 | Pass | Fail |
| Catarman (2) | 158.136 | 196.209 | 96.620 | Pass | Fail |
| Catarman (3) | 353.936 | 632.565 | 145.829 | Pass | Fail |
| Catarman (4) | 254.056 | 310.603 | 144.009 | Pass | Fail |
| Catarman (5) | 132.264 | 194.626 | 82.757 | Pass | Fail |

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

## 5.8 River Analysis (RAS) Model Simulation

The HEC-RAS Flood Model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. Figure 74 shows a generated sample map of the Catarman River using the calibrated HMS base flow.


Figure 74. Sample output map of the Catarman RAS Model.

## 5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 75 to Figure 80 shows the 5-, 25-, and 100-year rain return scenarios of the Catarman floodplain. The floodplain, with an area of 385.55 sq. km., covers five municipalities namely Bobon, Catarman, Lope de Vega, Mondragon, and San Jose. Table 39 shows the percentage of area affected by flooding per municipality.

Table 39. Municipalities affected in Catarman floodplain.

| Municipality | Total Area | Area Flooded | % Flooded |
|---|---|---|---|
| Bobon | 198.53 | 98.12 | 49% |
| Catarman | 255.77 | 239.9 | 94% |
| Lope de Vega | 186.61 | 15.5793 | 8% |
| Mondragon | 322.75 | 30.0557 | 9% |
| San Jose | 68.72 | 0.0392 | 0.1% |

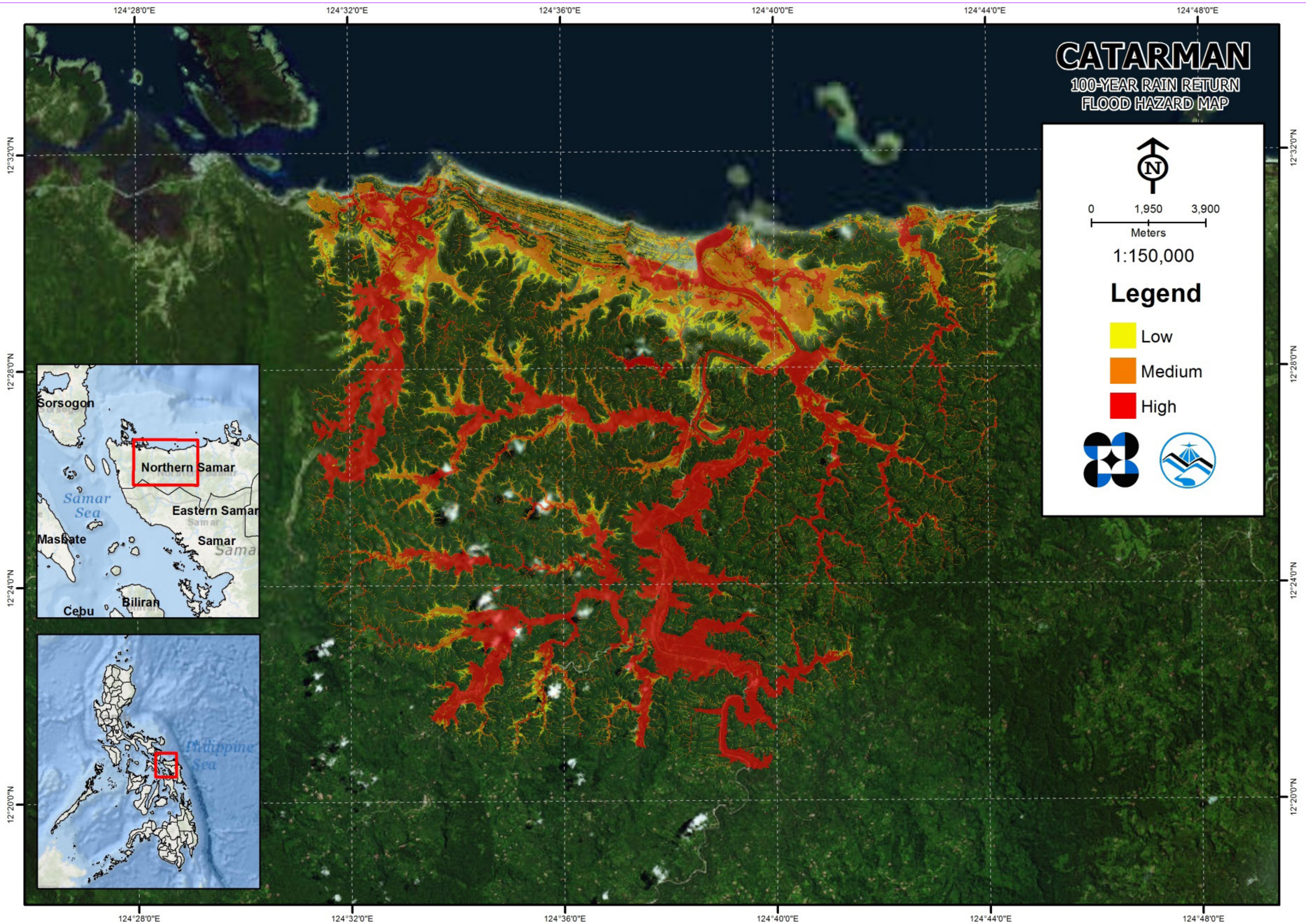



Figure 75. A 100-year Flood Hazard Map for Catarman Floodplain overlaid on Google Earth imagery.

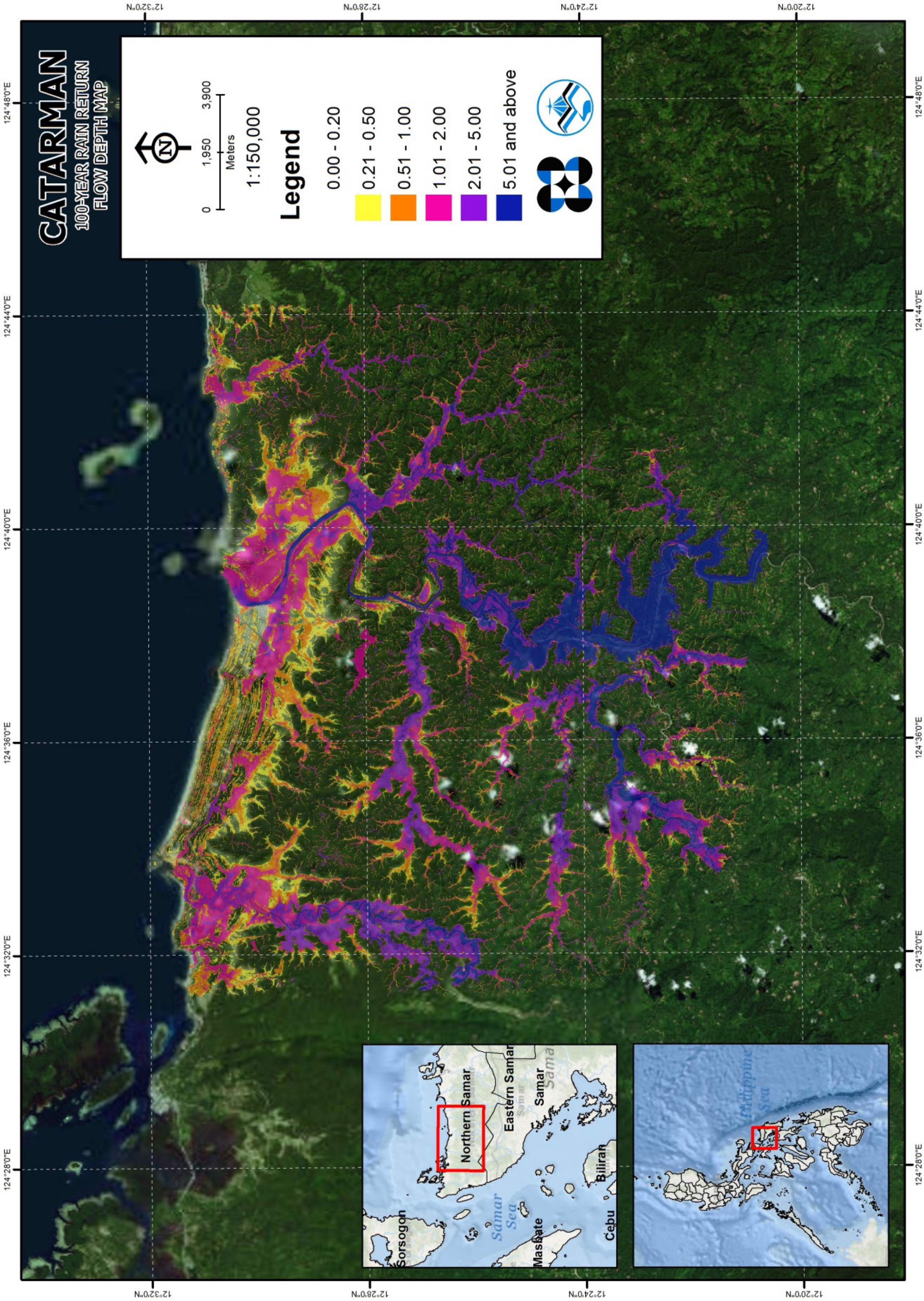



Figure 76. A 100-year Flow Depth Map for Catarman Floodplain overlaid on Google Earth imagery.

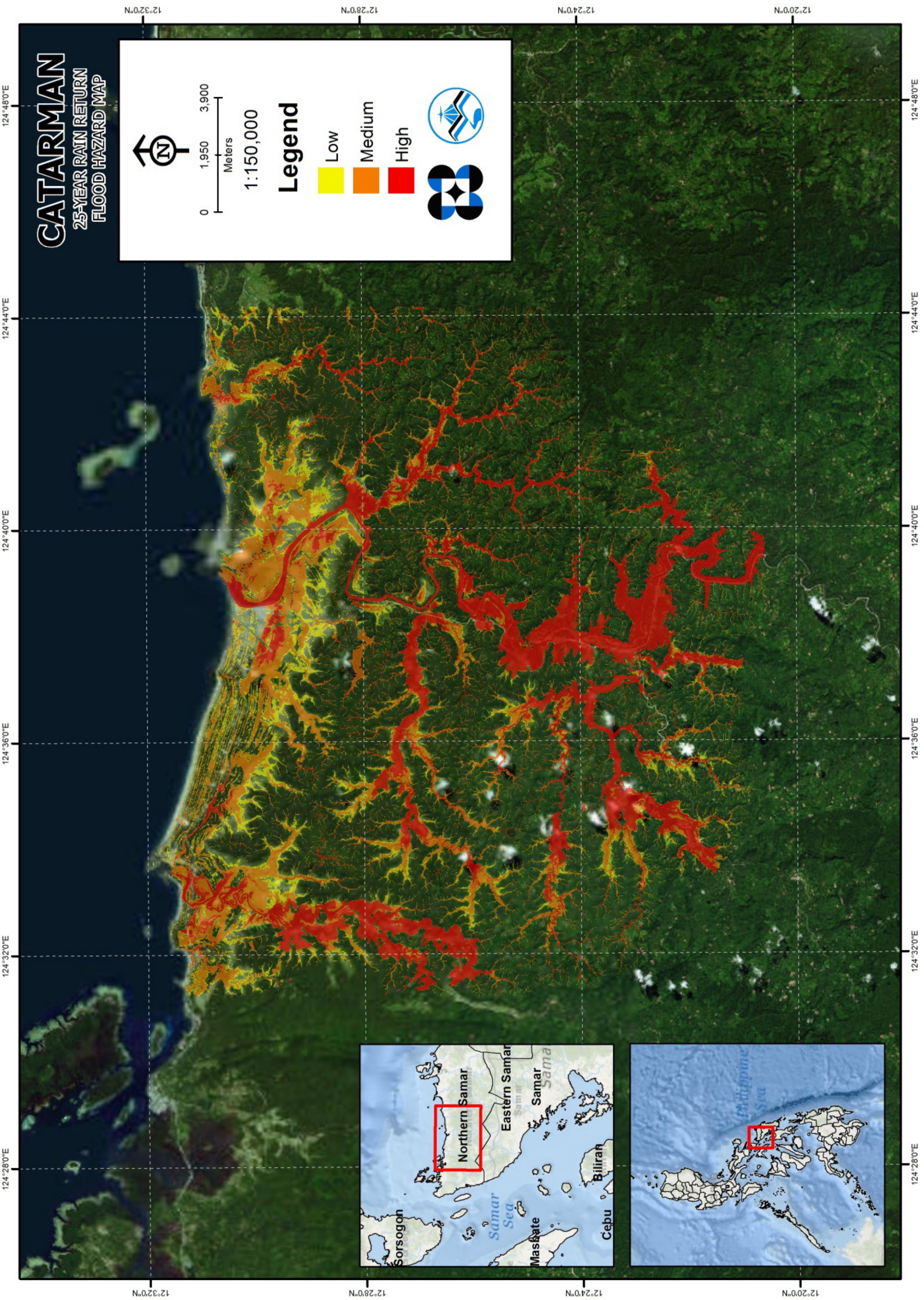



Figure 77. A 25-year Flood Hazard Map for Catarman Floodplain overlaid on Google Earth imagery.

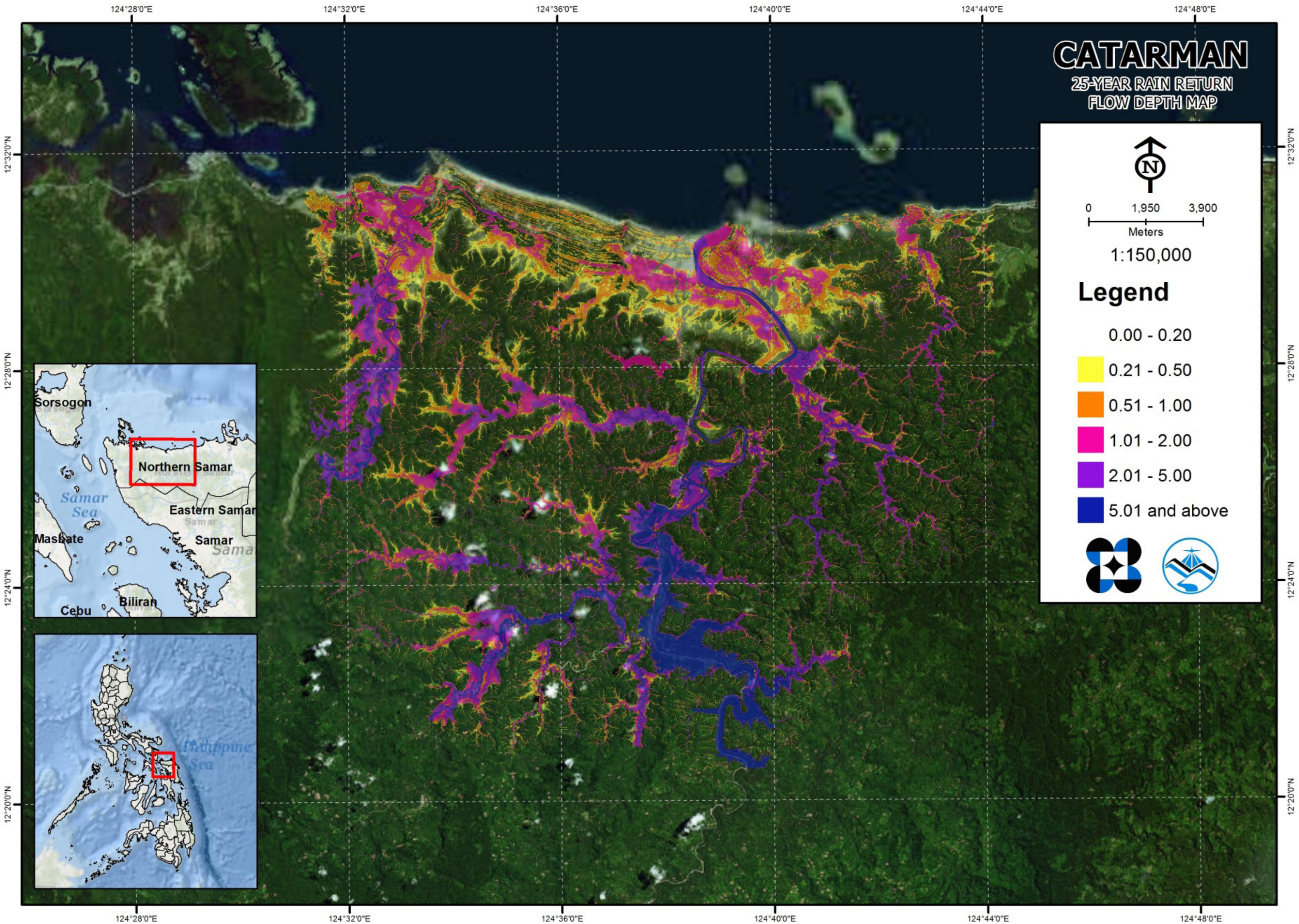



Figure 78. A 25-year Flow Depth Map for Catarman Floodplain overlaid on Google Earth imagery.

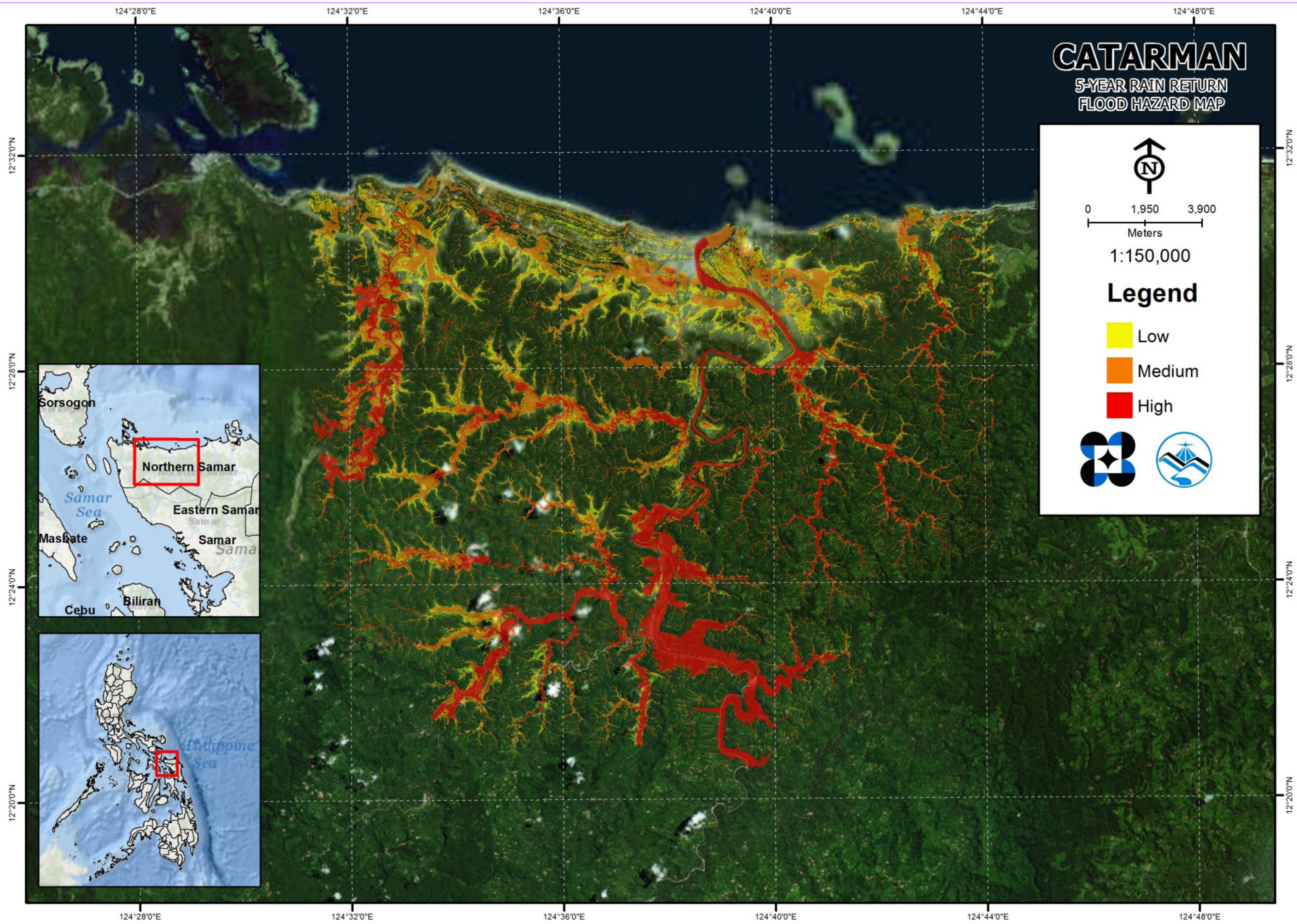



Figure 79. A 5-year Flood Hazard Map for Catarman Floodplain overlaid on Google Earth imagery.

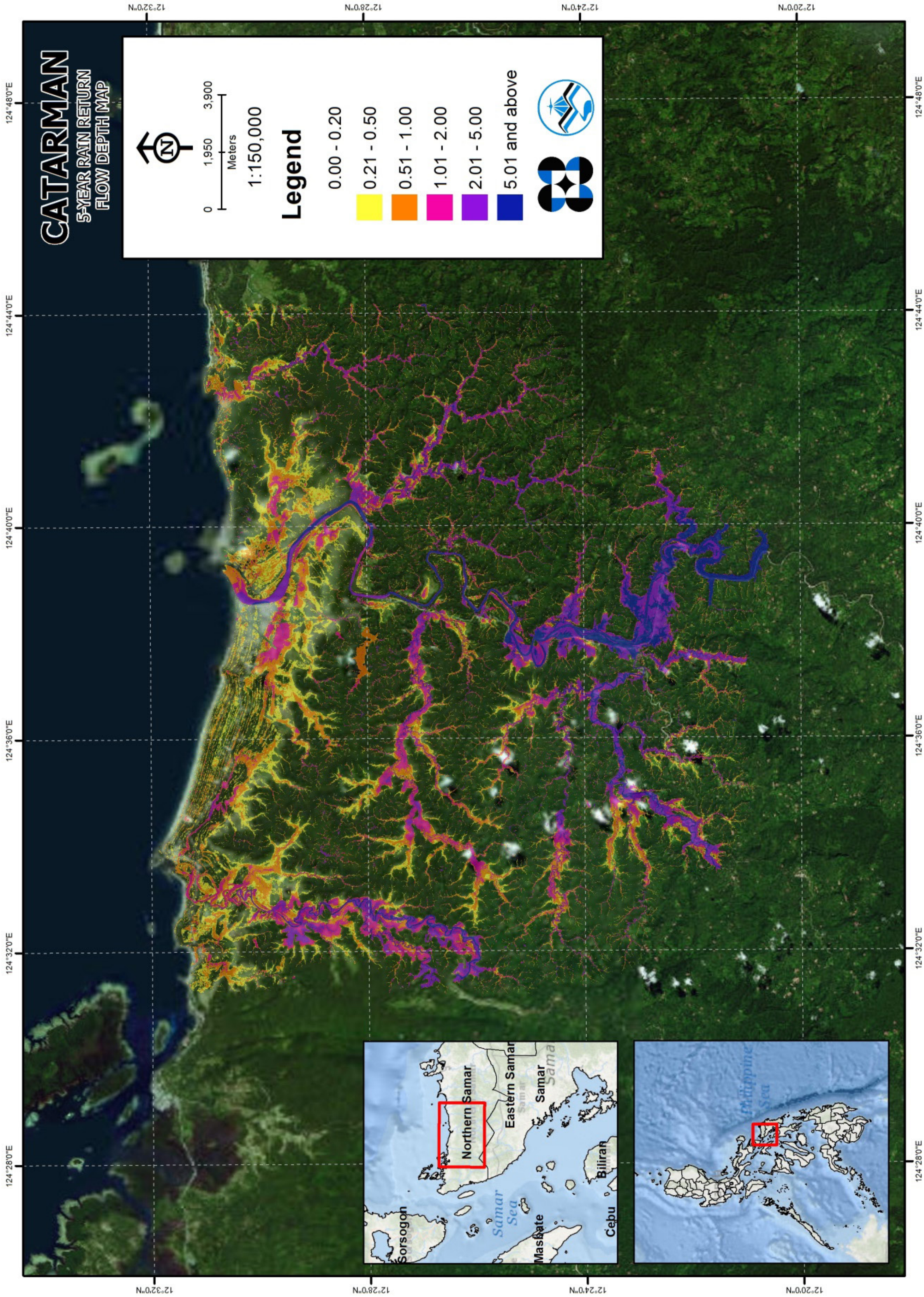



Figure 80. A 5-year Flood Depth Map for Catarman Floodplain overlaid on Google Earth imagery.

## 5.10 Inventory of Areas Exposed to Flooding of Affected Areas

Listed below are the affected barangays in the Catarman River Basin, grouped accordingly by municipality. For the said basin, five municipalities consisiting of 83 barangaysare expected to experience flooding when subjected to 5-yr rainfall return period.

For the 5-year return period, 34.94% of the municipality of Bobon with an area of 198.53 sq. km. will experience flood levels of less 0.20 meters. 4.30% of the area will experience flood levels of 0.21 to 0.50 meters while 4.25%, 3.43%, 2.10% and 0.40% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters and more than 5 meters, respectively. Listed in Table 40 and Table 41 are the affected areas in square kilometers by flood depth per barangay. Annex 12 and Annex 13 show the educational and health institutions exposed to flooding.

Table 40. Affected Areas in Bobon, Northern Samar during 5-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Bobon (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Acerida | Arellano | Balat-Balud | Calantiao | Dancalan | E. Duran | Gen. Lucban | Jose Abad Santos | Jose P. Laurel |
| 0.03-0.20 | 5.72 | 2.13 | 1.87 | 2.02 | 4.36 | 0.54 | 0.049 | 3.22 | 5.22 |
| 0.21-0.50 | 0.75 | 0.44 | 1.02 | 0.31 | 0.91 | 0.025 | 0.011 | 0.18 | 0.41 |
| 0.51-1.00 | 0.79 | 0.15 | 1.28 | 0.32 | 0.63 | 0.025 | 0.0044 | 0.39 | 0.34 |
| 1.01-2.00 | 0.75 | 0.06 | 0.66 | 0.47 | 0.19 | 0.022 | 0 | 0.94 | 0.43 |
| 2.01-5.00 | 0.42 | 0.005 | 0.26 | 0.26 | 0.045 | 0.0034 | 0 | 0.71 | 0.37 |
| > 5.00 | 0.16 | 0.0002 | 0.0042 | 0.0024 | 0 | 0 | 0 | 0.13 | 0.12 |

Table 41.Affected Areas in Bobon, Northern Samar during 5-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Bobon (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Magsaysay | Quezon | Salvacion | San Isidro | San Juan | Santa Clara | Santander | Somoroy | Trojello |
| 0.03-0.20 | 1.23 | 3.53 | 1.36 | 2.27 | 0.4 | 0.39 | 24.57 | 1.24 | 9.26 |
| 0.21-0.50 | 0.21 | 0.43 | 0.42 | 0.87 | 0.088 | 0.069 | 1.45 | 0.16 | 0.77 |
| 0.51-1.00 | 0.15 | 0.35 | 0.35 | 0.6 | 0.081 | 0.022 | 1.72 | 0.14 | 1.1 |
| 1.01-2.00 | 0.13 | 0.53 | 0.1 | 0.16 | 0.058 | 0.0037 | 1.32 | 0.019 | 0.97 |
| 2.01-5.00 | 0.051 | 0.39 | 0.0001 | 0.038 | 0.0029 | 0 | 0.89 | 0.0053 | 0.73 |
| > 5.00 | 0 | 0.092 | 0 | 0 | 0 | 0 | 0.1 | 0 | 0.18 |

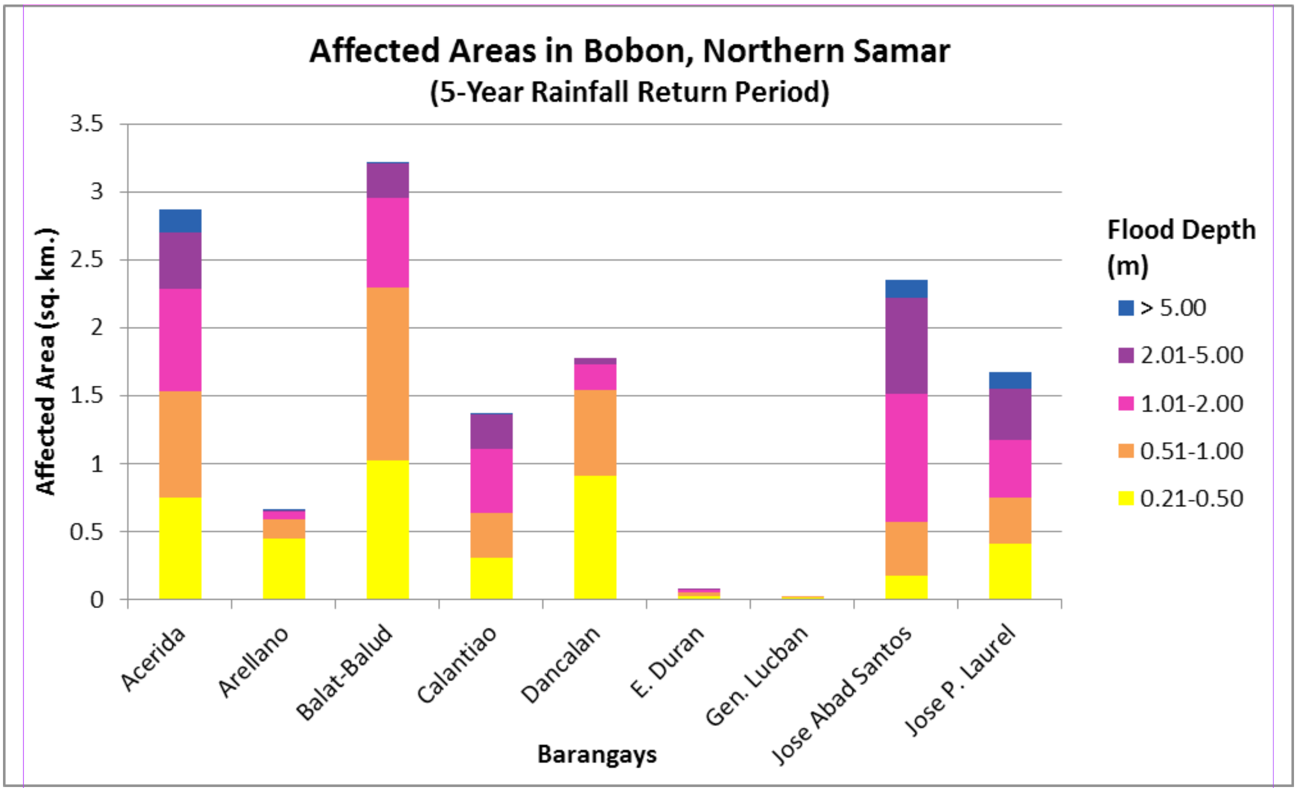



Figure 81. Affected Areas in Bobon, Northern Samar during 5-Year Rainfall Return Period

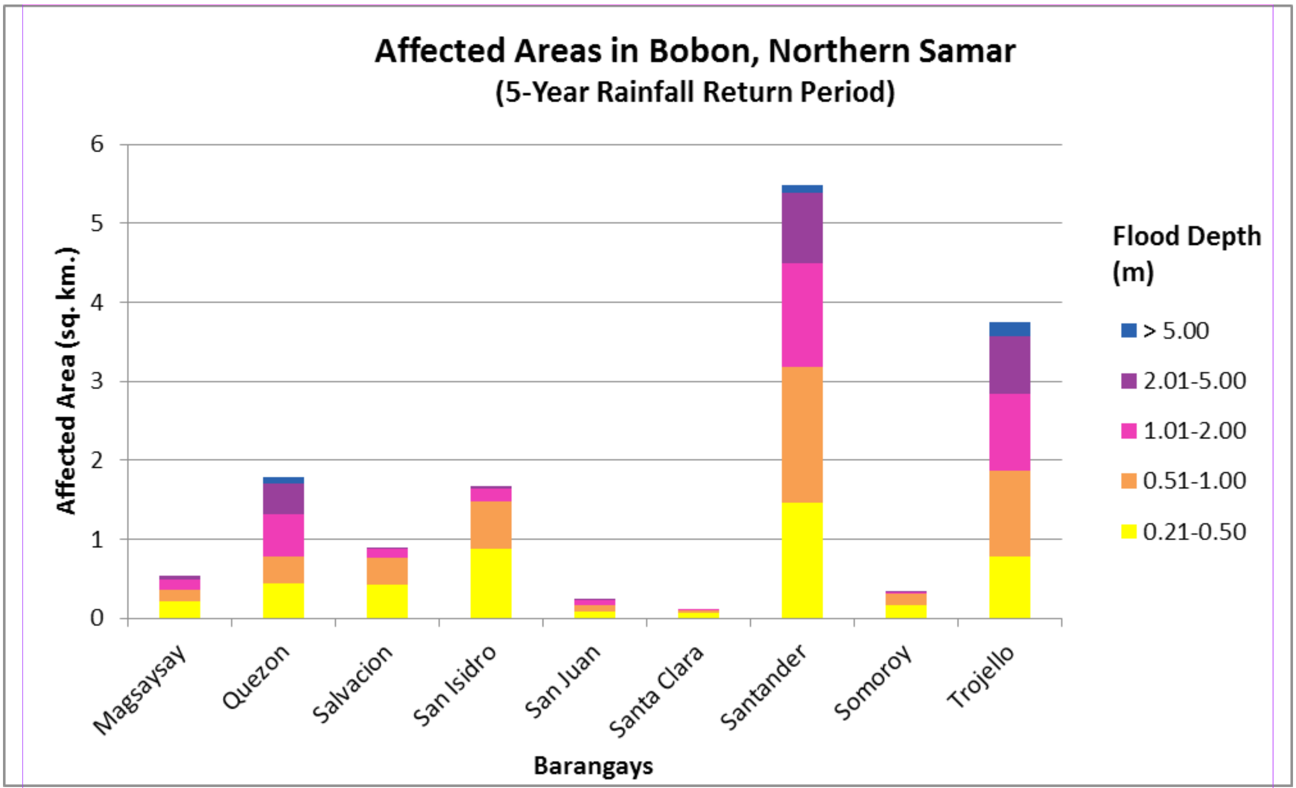



Figure 82. Affected Areas in Bobon, Northern Samar during 5-Year Rainfall Return Period

For the municipality of Catarman, with an area of 255.77 sq. km., 68.45% will experience flood levels of less 0.20 meters. 7.04% of the area will experience flood levels of 0.21 to 0.50 meters while 6.13%, 4.55%, 4.79% and 2.82% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and above 5 meters, respectively. Listed in Table 42 to Table 48 are the affected areas in square kilometers by flood depth per barangay.

Table 42. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Acacia | Aguinaldo | Airport Village | Bangkerohan | Baybay | Bocsol | Cabayhan | Cag-Abaca | Cal-Igang |
| 0.03-0.20 | 0.099 | 1.39 | 0.14 | 0.34 | 0.29 | 1.84 | 2.81 | 3.35 | 6.96 |
| 0.21-0.50 | 0.036 | 0.16 | 0.074 | 0.27 | 0.23 | 0.4 | 0.18 | 0.36 | 0.46 |
| 0.51-1.00 | 0.0091 | 0.2 | 0.018 | 0.34 | 0.18 | 0.45 | 0.21 | 0.3 | 0.83 |
| 1.01-2.00 | 0.0011 | 0.22 | 0.0035 | 0.017 | 0.044 | 0.41 | 0.27 | 0.17 | 0.74 |
| 2.01-5.00 | 0 | 0.14 | 0.0015 | 0 | 0.0093 | 0.09 | 0.1 | 0.075 | 0.31 |
| > 5.00 | 0 | 0.0027 | 0 | 0 | 0.0064 | 0.0008 | 0.022 | 0.0005 | 0.048 |

Table 43. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Calachuchi | Cawayan | Cervantes | Cularima | Daganas | Dalakit | DoÃ±a Pulqueria | Galutan | Gebalagnan |
| 0.03-0.20 | 0.14 | 1.7 | 3.6 | 1.98 | 2.09 | 0.6 | 2.64 | 1.89 | 6.25 |
| 0.21-0.50 | 0.053 | 0.32 | 0.097 | 0.15 | 0.66 | 0.22 | 1 | 1.31 | 0.24 |
| 0.51-1.00 | 0.0086 | 0.11 | 0.067 | 0.15 | 0.37 | 0.24 | 0.79 | 1.1 | 0.2 |
| 1.01-2.00 | 0 | 0.083 | 0.088 | 0.27 | 0.023 | 0.11 | 0.42 | 0.35 | 0.28 |
| 2.01-5.00 | 0 | 0.01 | 0.54 | 0.25 | 0 | 0 | 0.26 | 0.025 | 0.72 |
| > 5.00 | 0 | 0.0005 | 1.63 | 0.088 | 0 | 0 | 0.11 | 0.11 | 0.51 |

Table 44. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Gebulwangan | General Malvar | Guba | Hinatad | Imelda | Ipil-Ipil | Jose Abad Santos | Jose P. Rizal |
| 0.03-0.20 | 9.45 | 2.37 | 4.41 | 4.67 | 3.05 | 0.058 | 0.15 | 0.02 |
| 0.21-0.50 | 0.58 | 0.12 | 0.23 | 0.36 | 0.85 | 0.0019 | 0.03 | 0.012 |
| 0.51-1.00 | 0.43 | 0.11 | 0.24 | 0.34 | 0.66 | 0.0015 | 0.0085 | 0.00019 |
| 1.01-2.00 | 0.49 | 0.12 | 0.14 | 0.48 | 0.23 | 0.0013 | 0.00034 | 0 |
| 2.01-5.00 | 1.08 | 0.12 | 0.035 | 0.35 | 0.031 | 0.0002 | 0.00016 | 0 |
| > 5.00 | 0.43 | 0.033 | 0.0041 | 0.17 | 0 | 0 | 0 | 0 |

Table 45. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Kasoy | Lapu-Lapu | Liberty | Libjo | Mabini | Mabolo | Macagtas | Mckinley |
| 0.03-0.20 | 0.028 | 0.0049 | 5.78 | 10.67 | 4.47 | 0.04 | 2.91 | 16.37 |
| 0.21-0.50 | 0.0071 | 0.008 | 0.23 | 2.22 | 0.25 | 0.006 | 1.03 | 0.82 |
| 0.51-1.00 | 0.00093 | 0.0017 | 0.16 | 1.66 | 0.16 | 0.00063 | 0.6 | 0.93 |
| 1.01-2.00 | 0.00019 | 0.0001 | 0.23 | 0.56 | 0.12 | 0.0004 | 0.53 | 1.16 |
| 2.01-5.00 | 0 | 0 | 1.31 | 0.039 | 0.054 | 0.0001 | 0.038 | 0.93 |
| > 5.00 | 0 | 0 | 1.06 | 0.0001 | 0.00046 | 0 | 0.00058 | 0.2 |

Table 46. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Molave | Narra | New Rizal | Old Rizal | Paticua | Polangi | Quezon | Salvacion |
| 0.03-0.20 | 0.089 | 0.024 | 3.7 | 3.85 | 2.35 | 20.93 | 2.89 | 1.28 |
| 0.21-0.50 | 0.011 | 0.00053 | 0.26 | 1.14 | 0.24 | 0.72 | 0.28 | 0.063 |
| 0.51-1.00 | 0.018 | 0.0006 | 0.35 | 0.85 | 0.4 | 0.64 | 0.29 | 0.052 |
| 1.01-2.00 | 0.014 | 0.00011 | 0.27 | 0.2 | 0.35 | 0.9 | 0.32 | 0.038 |
| 2.01-5.00 | 0.0001 | 0 | 0.14 | 0.0005 | 0.5 | 2.14 | 0.56 | 0.009 |
| > 5.00 | 0 | 0 | 0.0025 | 0 | 0.15 | 1.34 | 0.13 | 0.0002 |

Table 47.Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sampaguita | San Julian | San Pascual | Santol | Somoge | Talisay | Tinowaran | Trangue |
| 0.03-0.20 | 0.023 | 1.95 | 3.4 | 0.019 | 7.03 | 0.084 | 14.74 | 2.86 |
| 0.21-0.50 | 0.0083 | 0.15 | 0.24 | 0.0023 | 0.54 | 0.014 | 0.52 | 0.085 |
| 0.51-1.00 | 0.0013 | 0.18 | 0.16 | 0.00017 | 0.56 | 0.0062 | 0.47 | 0.071 |
| 1.01-2.00 | 0.00022 | 0.1 | 0.16 | 0.0002 | 0.72 | 0.0017 | 0.63 | 0.11 |
| 2.01-5.00 | 0 | 0.07 | 0.22 | 0 | 1 | 0 | 0.7 | 0.17 |
| > 5.00 | 0 | 0.0019 | 0.099 | 0 | 0.89 | 0 | 0.14 | 0.037 |

Table 48. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | |
|---|---|---|---|---|---|
| | Uep I | UEP II | Uep III | Washington | Yakal |
| 0.03-0.20 | 2.3 | 0.26 | 1.21 | 3.49 | 0.053 |
| 0.21-0.50 | 0.27 | 0.045 | 0.17 | 0.25 | 0.0026 |
| 0.51-1.00 | 0.14 | 0.032 | 0.14 | 0.42 | 0.0013 |
| 1.01-2.00 | 0.052 | 0.0074 | 0.026 | 0.22 | 0.0018 |
| 2.01-5.00 | 0.012 | 0 | 0.01 | 0.2 | 0.0002 |
| > 5.00 | 0.0001 | 0 | 0.0004 | 0.011 | 0 |

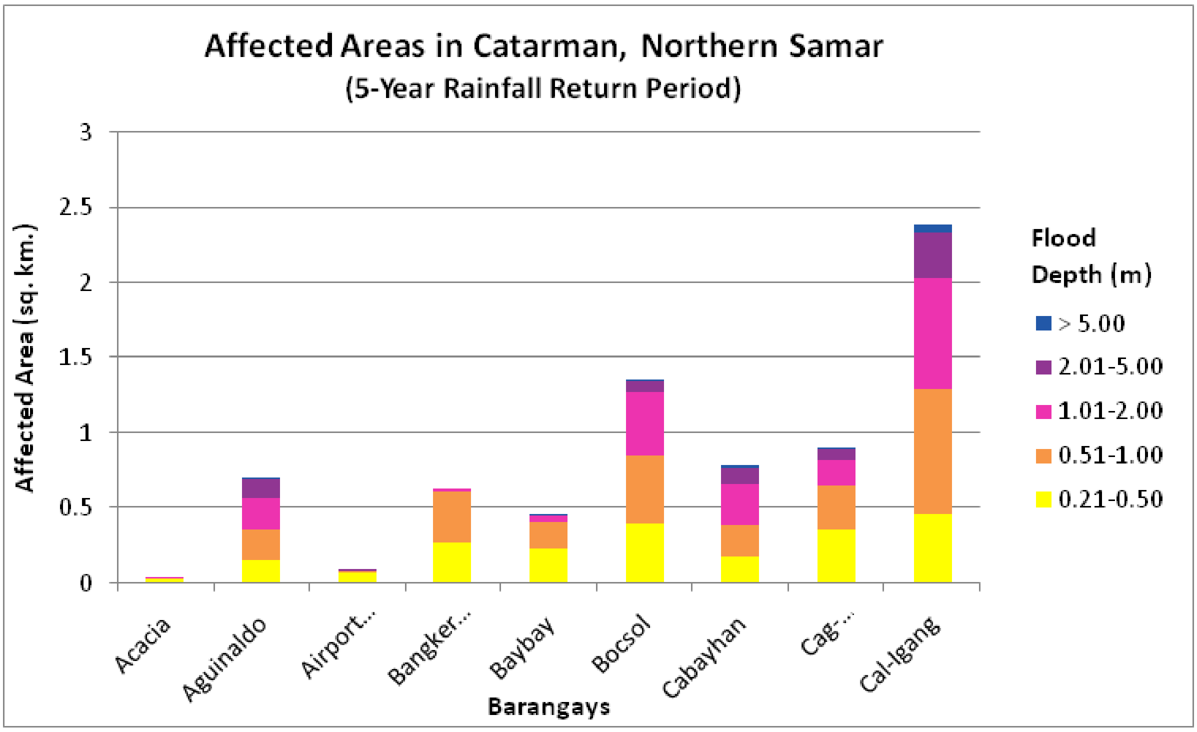



Figure 83. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period

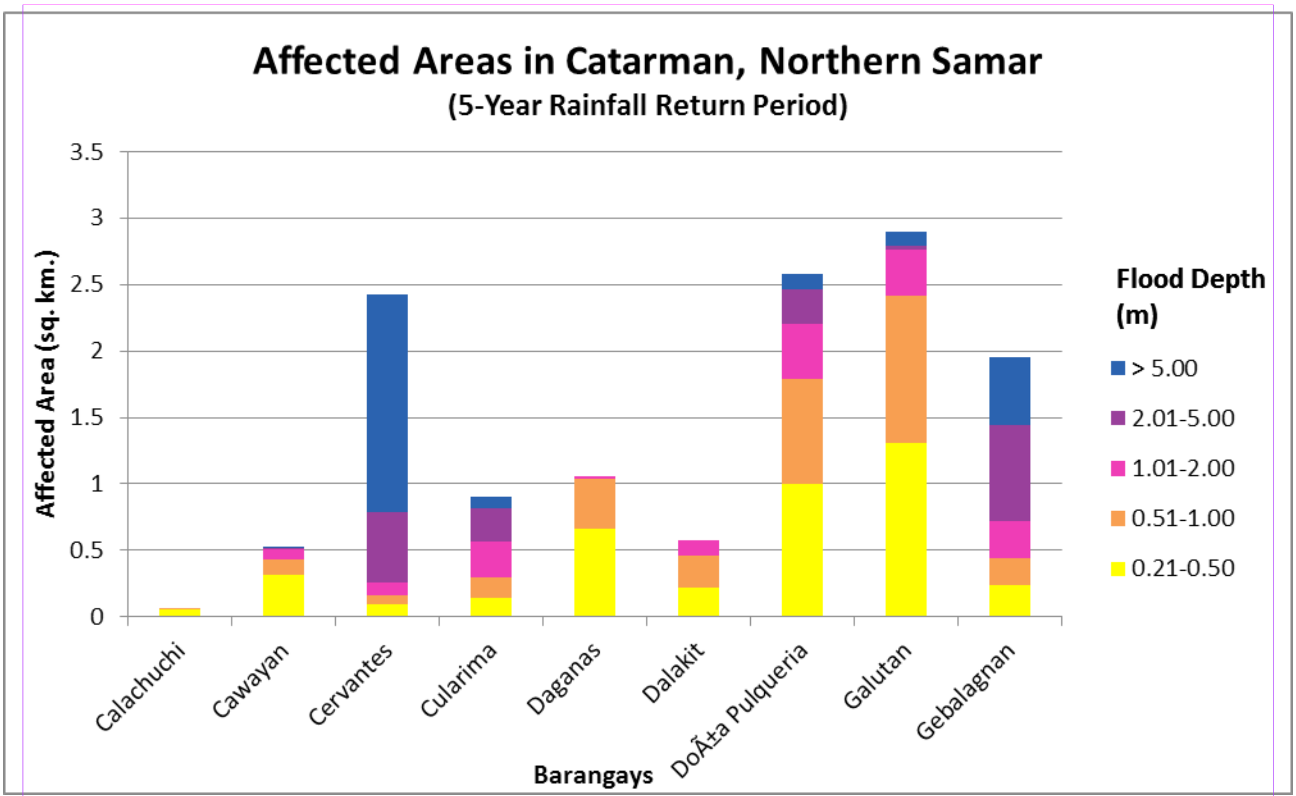



Figure 84. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

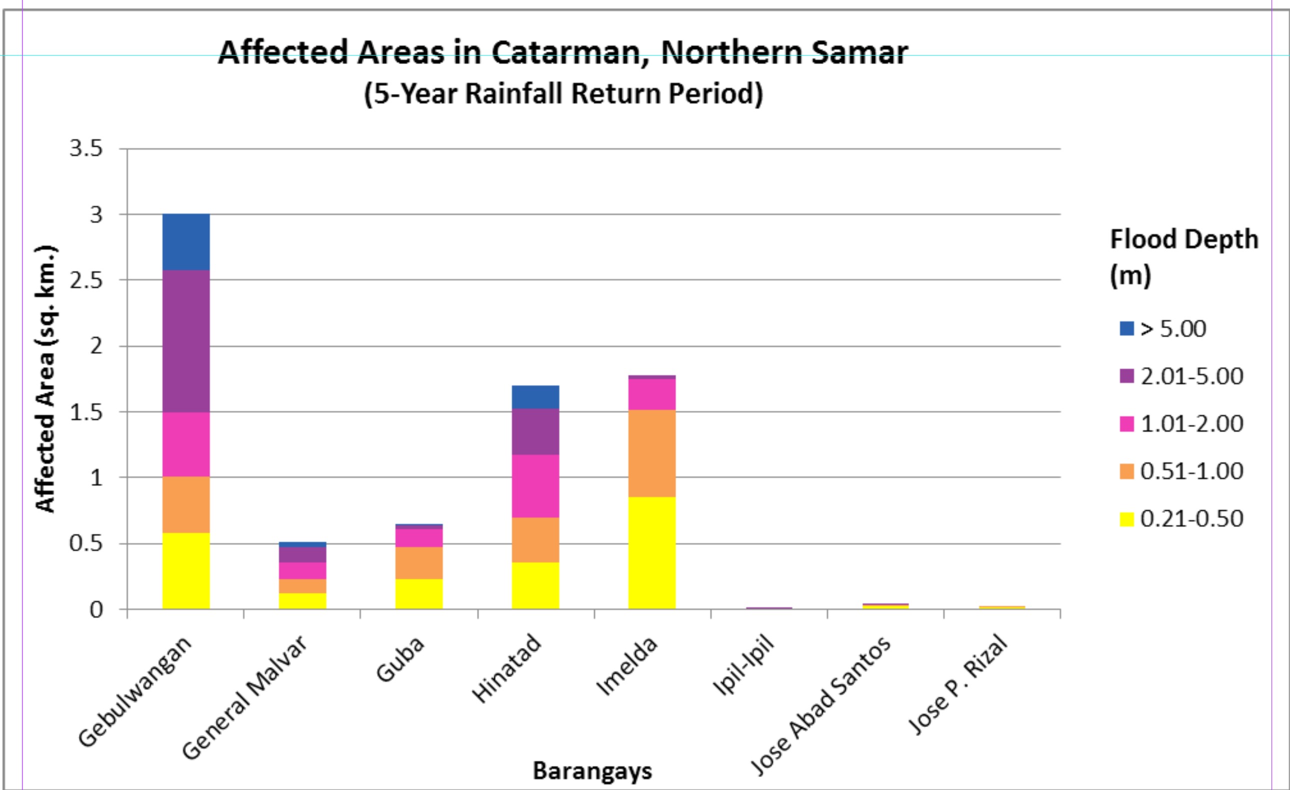



Figure 85. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

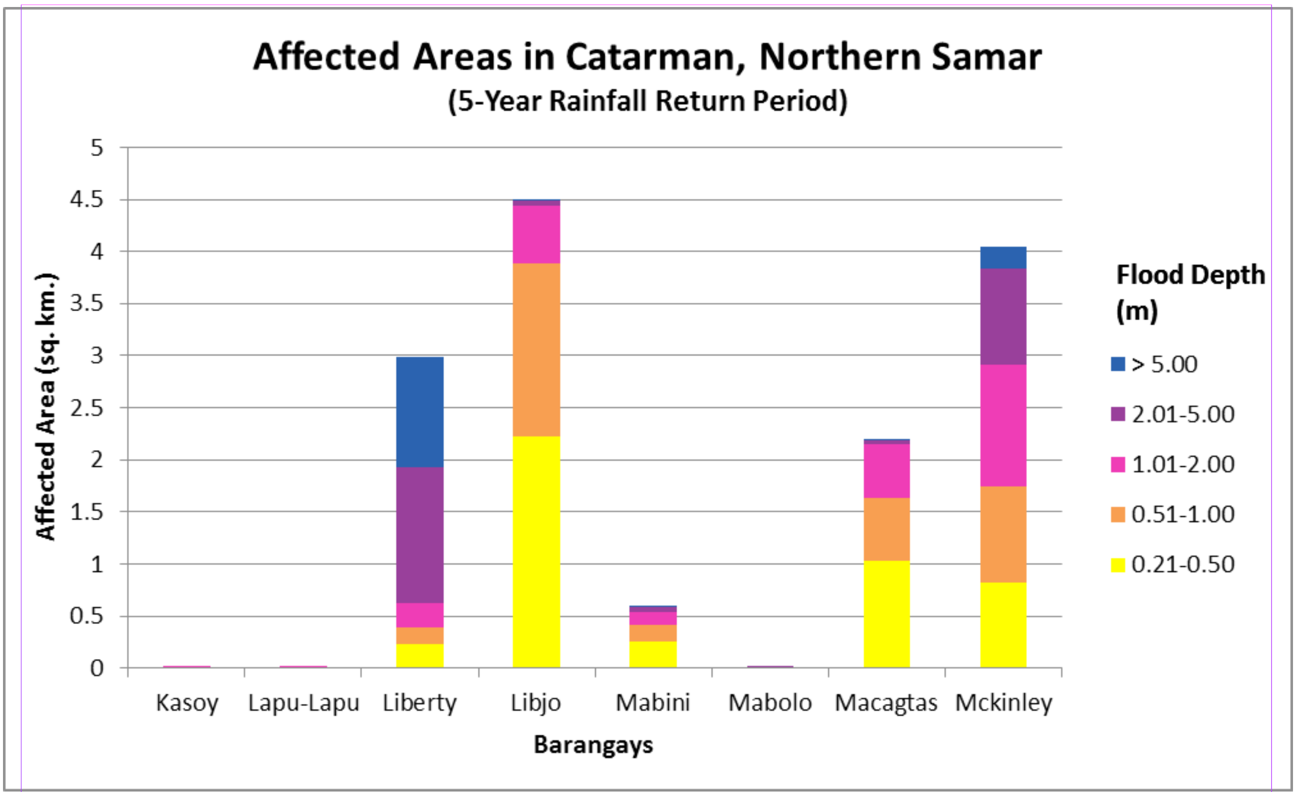



Figure 86. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

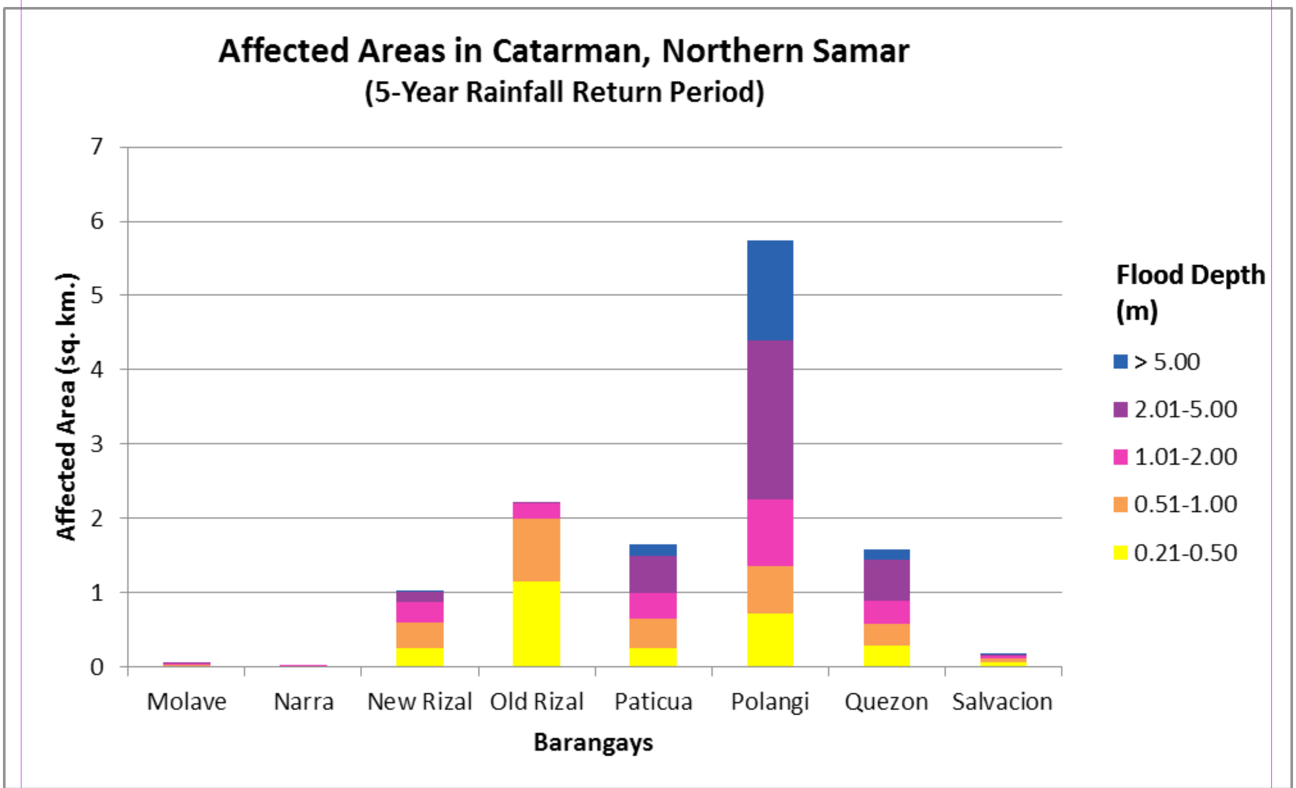



Figure 87. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

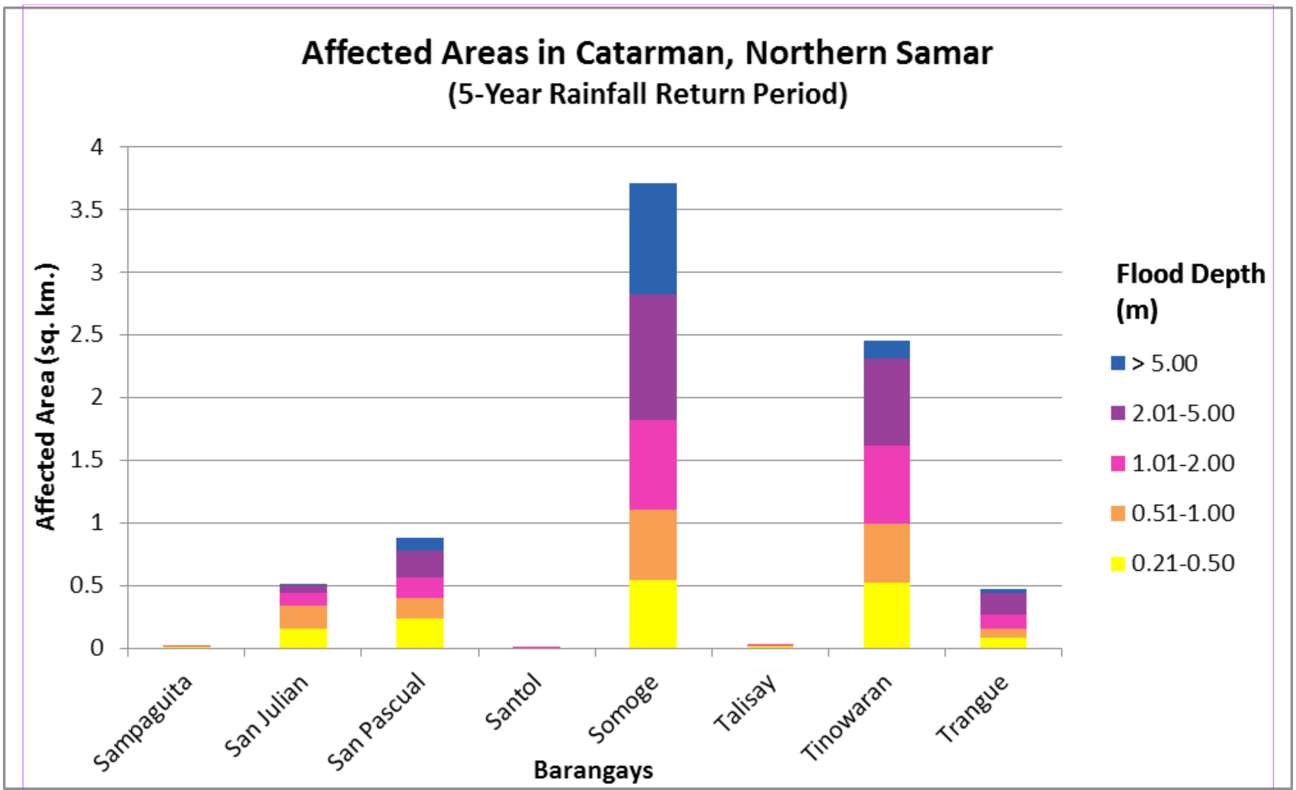



Figure 88. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

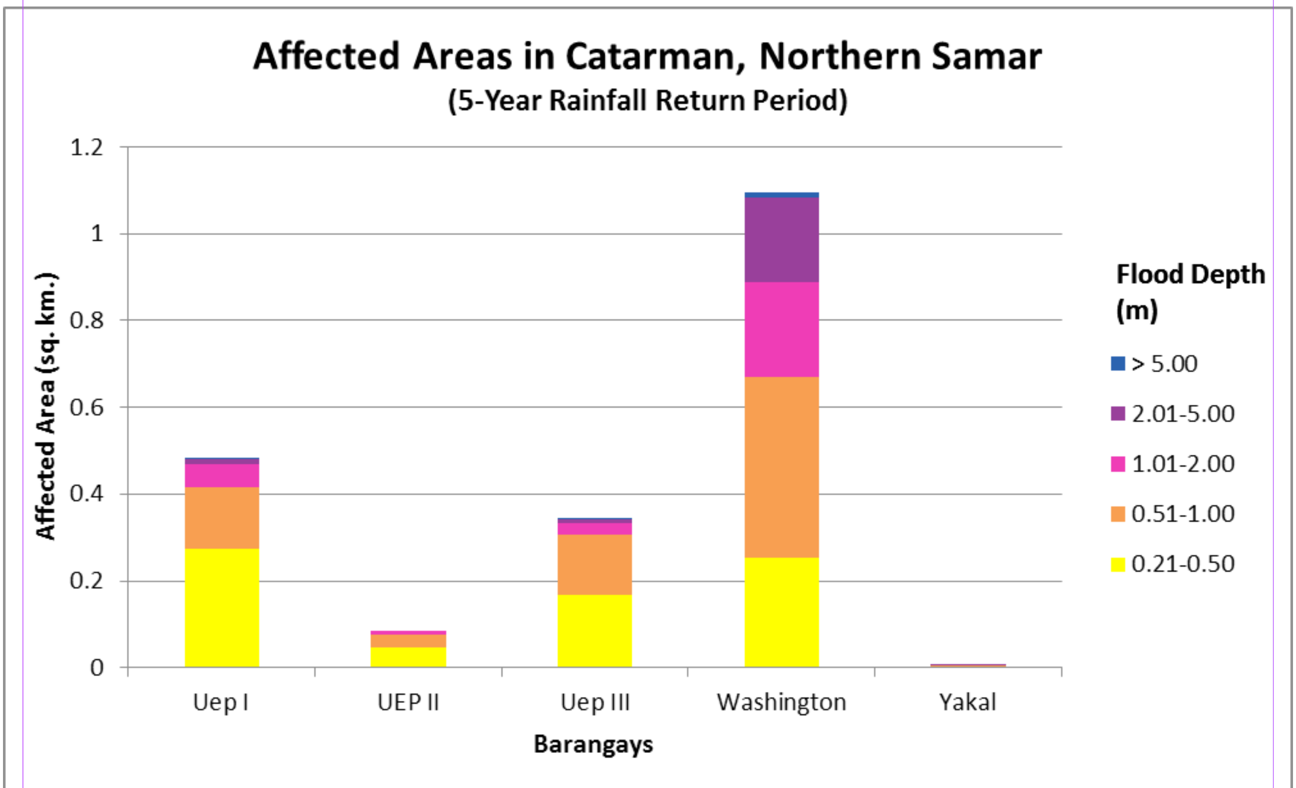



Figure 89. Affected Areas in Catarman, Northern Samar during 5-Year Rainfall Return Period.

For the municipality of Lope de Vega, with an area of 186.61 sq. km., 6.93% will experience flood levels of less 0.20 meters. 0.28% of the area will experience flood levels of 0.21 to 0.50 meters while 0.25%, 0.28%, 0.38% and 0.21% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and above 5 meters, respectively. Listed in Table 49 are the affected areas in square kilometers by flood depth per barangay.

Table 49. Affected Areas in Lope de Vega, Northern Samar during 5-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Lope de Vega (in sq. km.) | | | | | |
|---|---|---|---|---|---|---|
| | Bayho | Cag-Aguingay | Gebonawan | Gen. Luna | Maghipid | San Miguel |
| 0.03-0.20 | 0.052 | 2.44 | 5.5 | 0.98 | 2.82 | 1.15 |
| 0.21-0.50 | 0.0014 | 0.13 | 0.15 | 0.033 | 0.19 | 0.032 |
| 0.51-1.00 | 0.00065 | 0.13 | 0.094 | 0.023 | 0.21 | 0.014 |
| 1.01-2.00 | 0.00024 | 0.16 | 0.11 | 0.02 | 0.22 | 0.014 |
| 2.01-5.00 | 0.0013 | 0.34 | 0.099 | 0.0088 | 0.25 | 0.025 |
| > 5.00 | 0.0059 | 0.16 | 0.0022 | 0 | 0.024 | 0.2 |

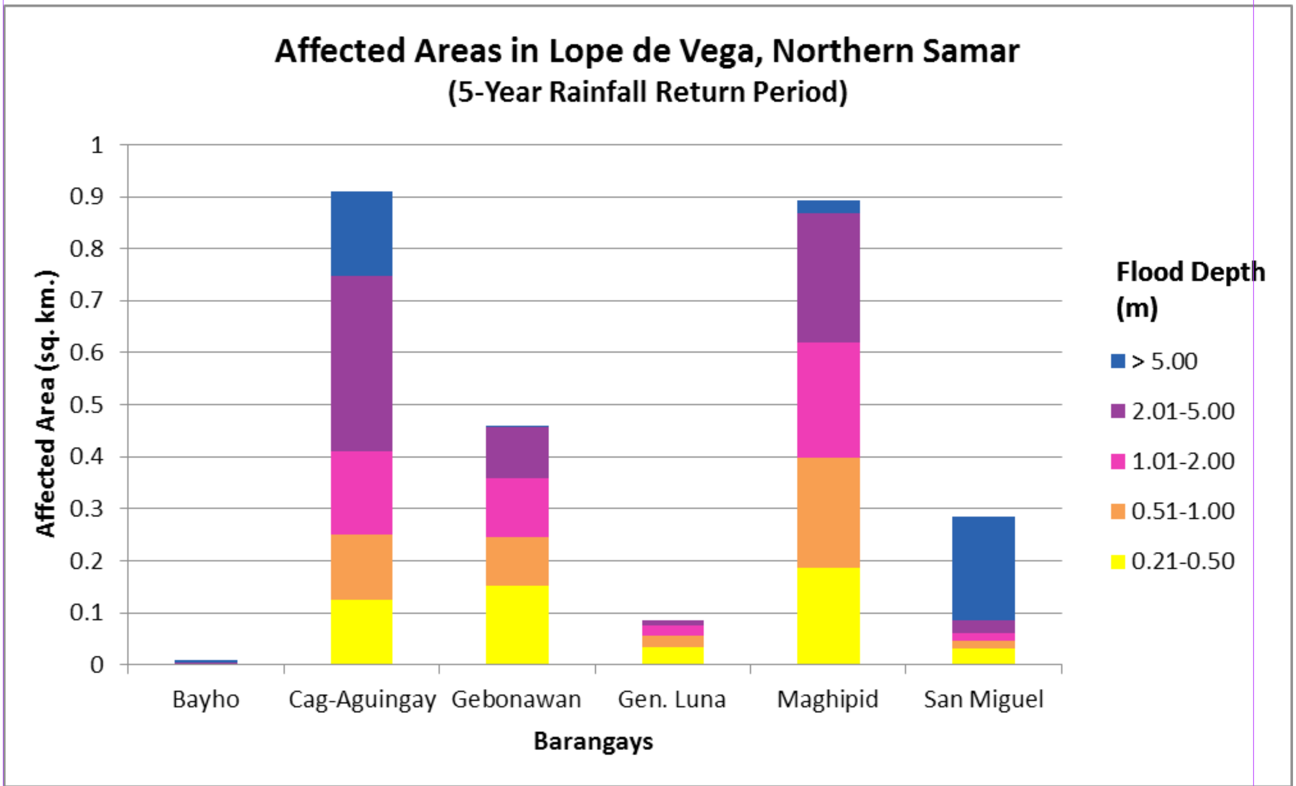



Figure 90. Affected Areas in Lope de Vega, Northern Samar during 5-Year Rainfall Return Period.

For the municipality of Mondragon, with an area of 322.75 sq. km., 6.935% will experience flood levels of less 0.20 meters. 0.52% of the area will experience flood levels of 0.21 to 0.50 meters while 0.45%, 0.33%, 0.16% 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 above 5 meters, respectively.Listed in Table 50are the affected areas in square kilometers by flood depth per barangay.

Table 50. Affected Areas in Mondragon, Northern Samar during 5-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Mondragon (in sq. km.) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cagmanaba | Doña Lucia | Imelda | La Trinidad | Makiwalo | San Agustin | San Isidro |
| 0.03-0.20 | 8.65 | 0 | 2.27 | 9.59 | 0.29 | 1.55 | 0.076 |
| 0.21-0.50 | 0.25 | 0 | 0.25 | 0.68 | 0.057 | 0.39 | 0.038 |
| 0.51-1.00 | 0.17 | 0 | 0.18 | 0.52 | 0.073 | 0.51 | 0.0094 |
| 1.01-2.00 | 0.22 | 0 | 0.084 | 0.5 | 0.03 | 0.23 | 0.0029 |
| 2.01-5.00 | 0.13 | 0 | 0.026 | 0.32 | 0.0027 | 0.047 | 0.00072 |
| > 5.00 | 0.013 | 0 | 0.0009 | 0.025 | 0 | 0.0001 | 0 |

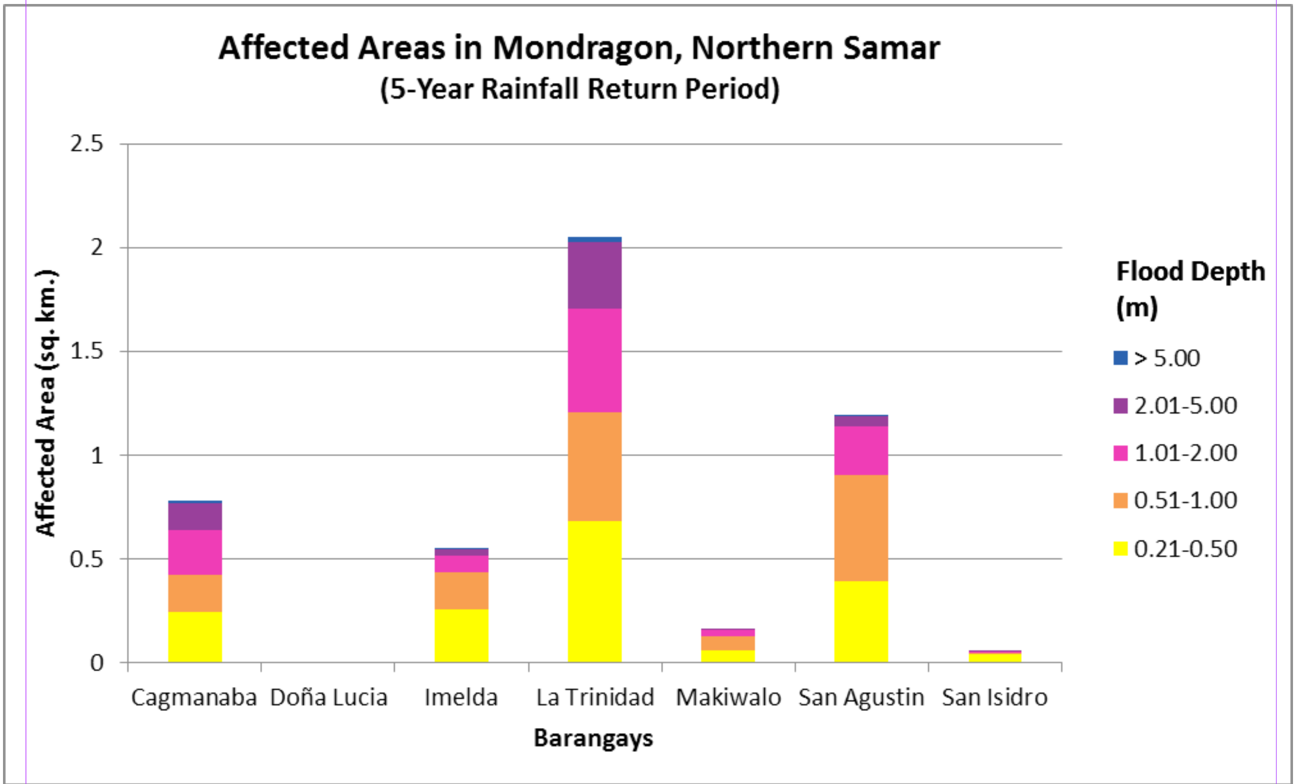



Figure 91. Affected Areas in Mondragon, Northern Samar during 5-Year Rainfall Return Period.

For the municipality of San Jose, with an area of 68.72 sq. km., 0.05% will experience flood levels of less 0.20 meters. 0.01% of the area will experience flood levels of 0.21 to 0.50 meters while 0.001%, 0%, 0% and 0% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and above 5 meters, respectively.Listed in Table 51 are the affected areas in square kilometers by flood depth per barangay.

Table 51. Affected Areas in San Jose, Northern Samar during 5-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in San Jose (in sq. km.) |
|---|---|
| | Geratag |
| 0.03-0.20 | 0.032 |
| 0.21-0.50 | 0.0065 |
| 0.51-1.00 | 0.00091 |
| 1.01-2.00 | 0 |
| 2.01-5.00 | 0 |
| > 5.00 | 0 |

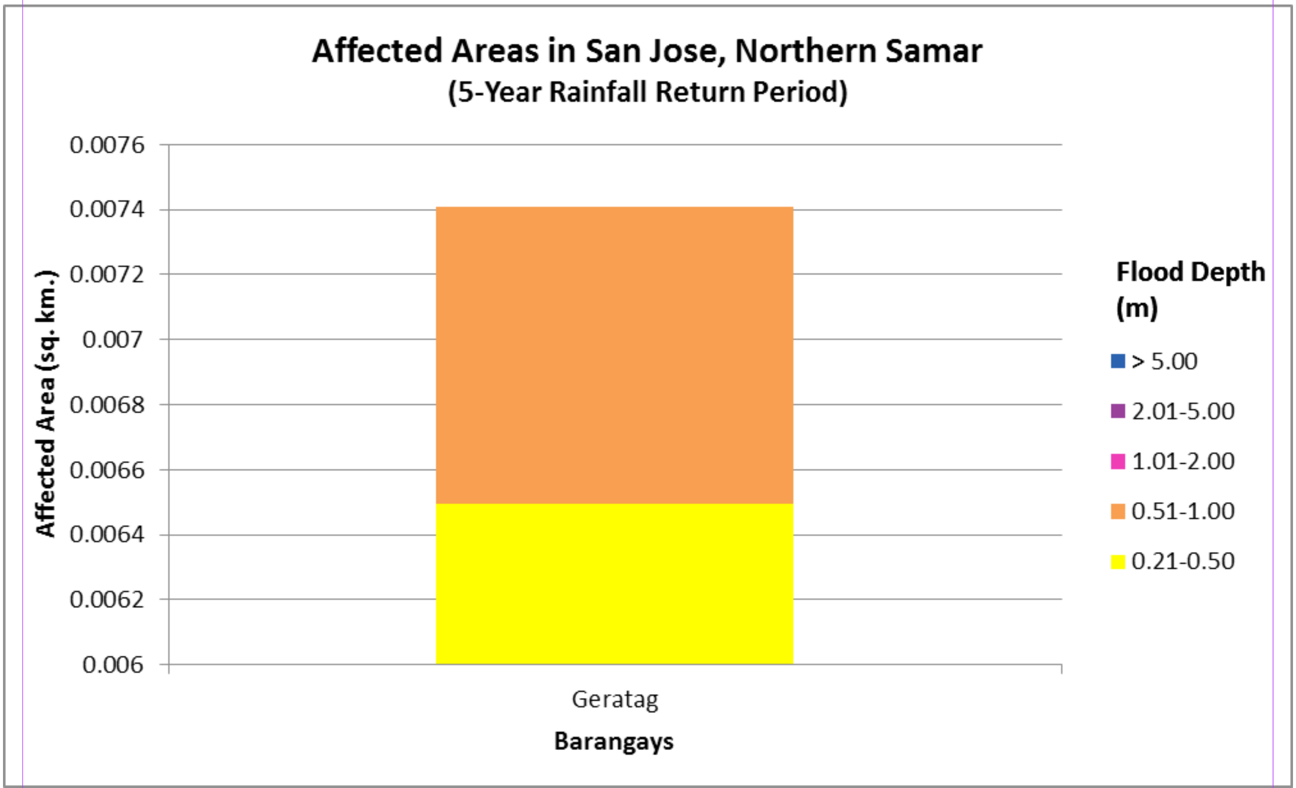



Figure 92. Affected Areas in San Jose, Northern Samar during 5-Year Rainfall Return Period.

For the 25-year return period, 32.58% of the municipality of Bobon with an area of 198.53 sq. km. will experience flood levels of less 0.20 meters. 3.51% of the area will experience flood levels of 0.21 to 0.50 meters while 3.97%, 4.93%, 3.79% and 0.64% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters and more than 5 meters, respectively. Listed in and Table 52 and Table 53 are the affected areas in square kilometers by flood depth per barangay.

Table 52. Affected Areas in Bobon, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Bobon (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Acerida | Arellano | Balat-Balud | Calantiao | Dancalan | E. Duran | Gen. Lucban | Jose Abad Santos | Jose P. Laurel |
| 0.03-0.20 | 5.41 | 1.99 | 1.25 | 1.83 | 3.9 | 0.54 | 0.046 | 3.07 | 5.02 |
| 0.21-0.50 | 0.53 | 0.46 | 0.67 | 0.25 | 0.88 | 0.025 | 0.012 | 0.15 | 0.36 |
| 0.51-1.00 | 0.68 | 0.22 | 1.14 | 0.22 | 0.84 | 0.025 | 0.0069 | 0.17 | 0.34 |
| 1.01-2.00 | 0.89 | 0.094 | 1.53 | 0.49 | 0.44 | 0.028 | 0 | 0.57 | 0.42 |
| 2.01-5.00 | 0.83 | 0.012 | 0.48 | 0.59 | 0.068 | 0.0052 | 0 | 1.41 | 0.57 |
| > 5.00 | 0.24 | 0.0002 | 0.016 | 0.0031 | 0 | 0.0001 | 0 | 0.19 | 0.18 |

Table 53.Affected Areas in Bobon, Northern Samar during 25-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Bobon (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Magsaysay | Quezon | Salvacion | San Isidro | San Juan | Santa Clara | Santander | Somoroy | Trojello |
| 0.03-0.20 | 1.13 | 3.26 | 1.05 | 1.54 | 0.36 | 0.37 | 23.79 | 1.21 | 8.92 |
| 0.21-0.50 | 0.23 | 0.42 | 0.26 | 0.49 | 0.098 | 0.086 | 1.31 | 0.12 | 0.62 |
| 0.51-1.00 | 0.18 | 0.33 | 0.34 | 0.65 | 0.078 | 0.027 | 1.54 | 0.2 | 0.9 |
| 1.01-2.00 | 0.13 | 0.51 | 0.52 | 1.13 | 0.093 | 0.0094 | 1.82 | 0.03 | 1.06 |
| 2.01-5.00 | 0.09 | 0.7 | 0.071 | 0.12 | 0.0067 | 0 | 1.41 | 0.0076 | 1.14 |
| > 5.00 | 0 | 0.12 | 0 | 0 | 0 | 0 | 0.18 | 0 | 0.36 |

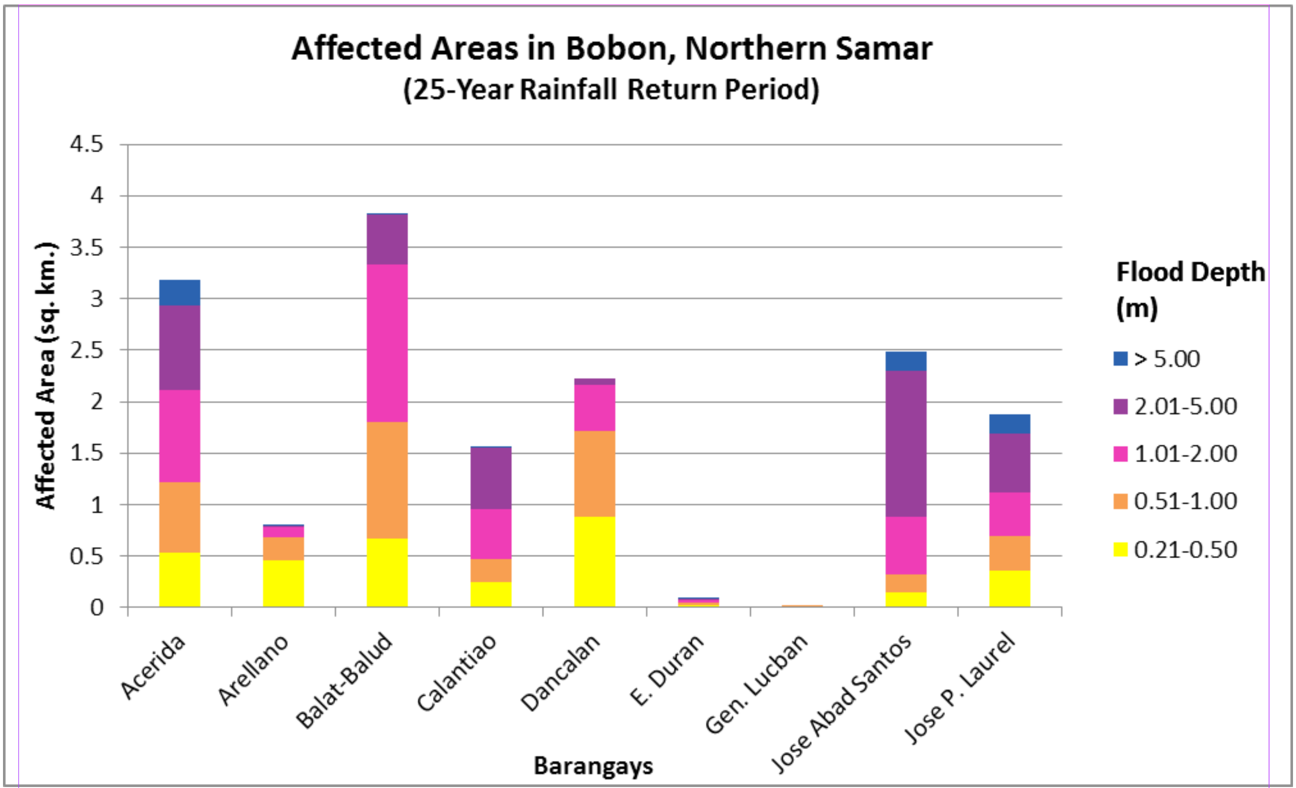



Figure 93. Affected Areas in Bobon, Northern Samar during 25-Year Rainfall Return Period.

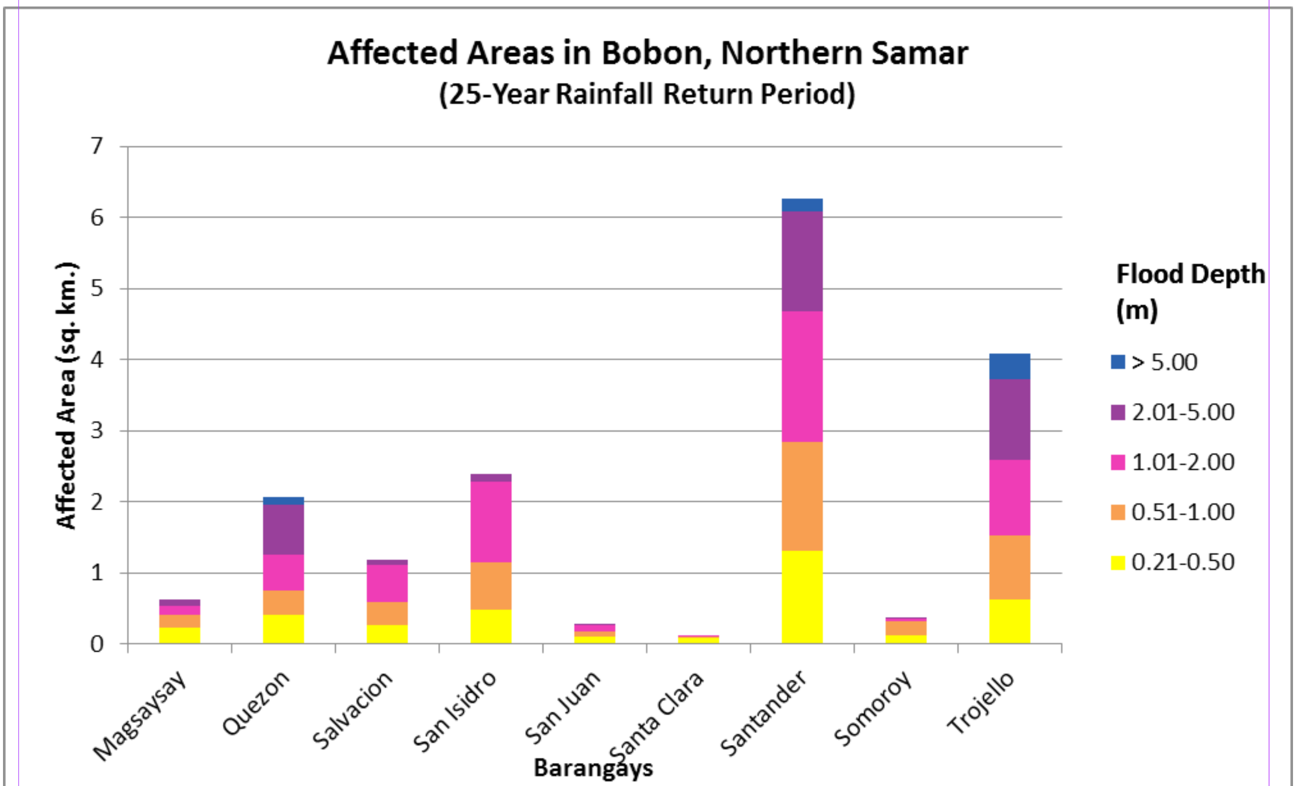



Figure 94. Affected Areas in Bobon, Northern Samar during 25-Year Rainfall Return Period

For the municipality of Catarman, with an area of 255.77 sq. km., 63.15% will experience flood levels of less 0.20 meters. 6.15% of the area will experience flood levels of 0.21 to 0.50 meters while 6.50%, 6.83%, 5.91% and 5.25% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and above 5 meters, respectively.Listed in Table 54to Table 60 are the affected areas in square kilometers by flood depth per barangay.

Table 54. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Acacia | Aguinaldo | Airport Village | Bangkerohan | Baybay | Bocsol | Cabayhan | Cag-Abaca | Cal-Igang |
| 0.03-0.20 | 0.088 | 1.28 | 0.1 | 0.19 | 0.11 | 1.68 | 2.67 | 3.2 | 6.67 |
| 0.21-0.50 | 0.038 | 0.089 | 0.087 | 0.071 | 0.083 | 0.3 | 0.16 | 0.29 | 0.37 |
| 0.51-1.00 | 0.018 | 0.18 | 0.041 | 0.27 | 0.28 | 0.36 | 0.18 | 0.3 | 0.46 |
| 1.01-2.00 | 0.0016 | 0.23 | 0.0044 | 0.44 | 0.26 | 0.58 | 0.25 | 0.34 | 1.05 |
| 2.01-5.00 | 0 | 0.3 | 0.003 | 0.003 | 0.015 | 0.29 | 0.31 | 0.12 | 0.71 |
| > 5.00 | 0 | 0.02 | 0 | 0 | 0.0081 | 0.0053 | 0.036 | 0.0018 | 0.088 |

Table 55. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Calachuchi | Cawayan | Cervantes | Cularima | Daganas | Dalakit | DoÃ±a Pulqueria | Galutan | Gebalagnan |
| 0.03-0.20 | 0.12 | 1.48 | 3.35 | 1.72 | 1.73 | 0.48 | 1.82 | 0.87 | 6.01 |
| 0.21-0.50 | 0.054 | 0.32 | 0.11 | 0.088 | 0.69 | 0.2 | 0.75 | 0.94 | 0.26 |
| 0.51-1.00 | 0.03 | 0.27 | 0.073 | 0.14 | 0.54 | 0.15 | 1.05 | 1.39 | 0.21 |
| 1.01-2.00 | 0 | 0.13 | 0.081 | 0.27 | 0.19 | 0.33 | 1.09 | 1.4 | 0.27 |
| 2.01-5.00 | 0 | 0.015 | 0.18 | 0.51 | 0 | 0.015 | 0.32 | 0.056 | 0.71 |
| > 5.00 | 0 | 0.0006 | 2.23 | 0.16 | 0 | 0 | 0.18 | 0.12 | 0.74 |

Table 56. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Gebulwangan | General Malvar | Guba | Hinatad | Imelda | Ipil-Ipil | Jose Abad Santos | Jose P. Rizal |
| 0.03-0.20 | 8.9 | 2.22 | 4.34 | 4.37 | 2.72 | 0.057 | 0.12 | 0.016 |
| 0.21-0.50 | 0.53 | 0.11 | 0.21 | 0.35 | 0.81 | 0.0024 | 0.038 | 0.015 |
| 0.51-1.00 | 0.55 | 0.16 | 0.25 | 0.31 | 0.8 | 0.0021 | 0.026 | 0.0012 |
| 1.01-2.00 | 0.56 | 0.17 | 0.21 | 0.46 | 0.45 | 0.0014 | 0.0015 | 0 |
| 2.01-5.00 | 0.99 | 0.18 | 0.054 | 0.64 | 0.047 | 0.00029 | 0.00022 | 0 |
| > 5.00 | 0.93 | 0.047 | 0.0055 | 0.23 | 0 | 0 | 0 | 0 |

Table 57. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Kasoy | Lapu-Lapu | Liberty | Libjo | Mabini | Mabolo | Macagtas | Mckinley |
| 0.03-0.20 | 0.024 | 0.0035 | 5.43 | 9.94 | 4.34 | 0.036 | 2.31 | 15.74 |
| 0.21-0.50 | 0.01 | 0.0074 | 0.22 | 2.07 | 0.29 | 0.01 | 1.02 | 0.69 |
| 0.51-1.00 | 0.0016 | 0.0038 | 0.19 | 2.06 | 0.2 | 0.0011 | 0.81 | 0.87 |
| 1.01-2.00 | 0.00019 | 0.0001 | 0.2 | 1.03 | 0.15 | 0.0004 | 0.85 | 1.4 |
| 2.01-5.00 | 0 | 0 | 0.35 | 0.061 | 0.08 | 0.0001 | 0.099 | 1.44 |
| > 5.00 | 0 | 0 | 2.37 | 0.0004 | 0.0009 | 0 | 0.00092 | 0.27 |

Table 58. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Molave | Narra | New Rizal | Old Rizal | Paticua | Polangi | Quezon | Salvacion |
| 0.03-0.20 | 0.081 | 0.024 | 3.59 | 3.28 | 1.97 | 20.02 | 2.61 | 1.26 |
| 0.21-0.50 | 0.0072 | 0.00096 | 0.21 | 1.11 | 0.074 | 0.68 | 0.16 | 0.06 |
| 0.51-1.00 | 0.015 | 0.00064 | 0.3 | 1.14 | 0.13 | 0.47 | 0.22 | 0.061 |
| 1.01-2.00 | 0.028 | 0.00011 | 0.39 | 0.51 | 0.5 | 0.66 | 0.49 | 0.049 |
| 2.01-5.00 | 0.0012 | 0 | 0.21 | 0.011 | 0.94 | 1.71 | 0.73 | 0.014 |
| > 5.00 | 0 | 0 | 0.006 | 0 | 0.38 | 3.12 | 0.25 | 0.0003 |

Table 59. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sampaguita | San Julian | San Pascual | Santol | Somoge | Talisay | Tinowaran | Trangue |
| 0.03-0.20 | 0.018 | 1.88 | 3.24 | 0.016 | 5.39 | 0.075 | 14.18 | 2.78 |
| 0.21-0.50 | 0.0096 | 0.11 | 0.28 | 0.0051 | 0.35 | 0.017 | 0.54 | 0.095 |
| 0.51-1.00 | 0.0046 | 0.19 | 0.19 | 0.00017 | 0.5 | 0.01 | 0.5 | 0.08 |
| 1.01-2.00 | 0.00037 | 0.18 | 0.18 | 0.0002 | 0.73 | 0.0029 | 0.7 | 0.1 |
| 2.01-5.00 | 0 | 0.092 | 0.22 | 0 | 2.03 | 0.0002 | 1.06 | 0.22 |
| > 5.00 | 0 | 0.0051 | 0.17 | 0 | 1.74 | 0 | 0.22 | 0.062 |

Table 60. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | |
|---|---|---|---|---|---|
| | Uep I | UEP II | Uep III | Washington | Yakal |
| 0.03-0.20 | 2.21 | 0.24 | 1.15 | 3.32 | 0.051 |
| 0.21-0.50 | 0.27 | 0.049 | 0.14 | 0.28 | 0.004 |
| 0.51-1.00 | 0.21 | 0.042 | 0.19 | 0.22 | 0.0015 |
| 1.01-2.00 | 0.069 | 0.016 | 0.065 | 0.37 | 0.0018 |
| 2.01-5.00 | 0.018 | 0 | 0.011 | 0.34 | 0.0004 |
| > 5.00 | 0.0003 | 0 | 0.001 | 0.046 | 0 |

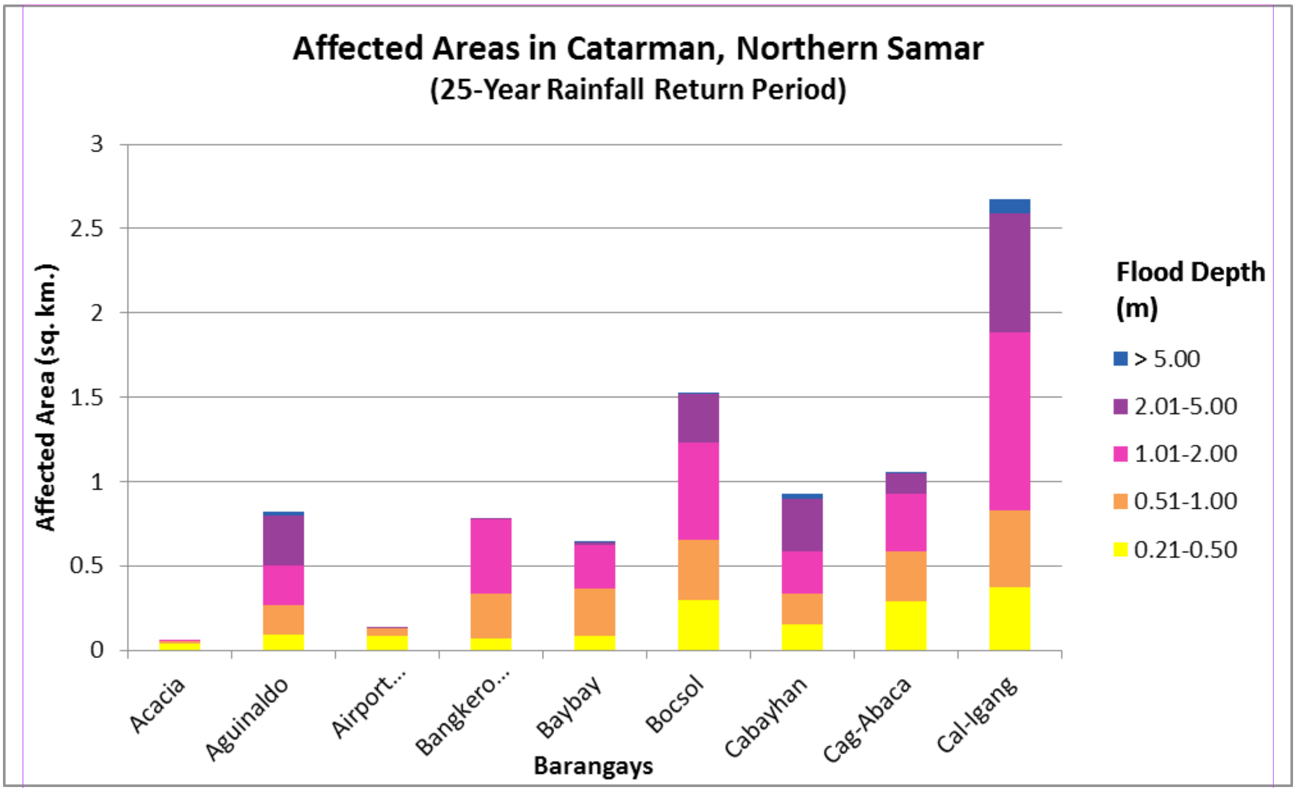



Figure 95. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period

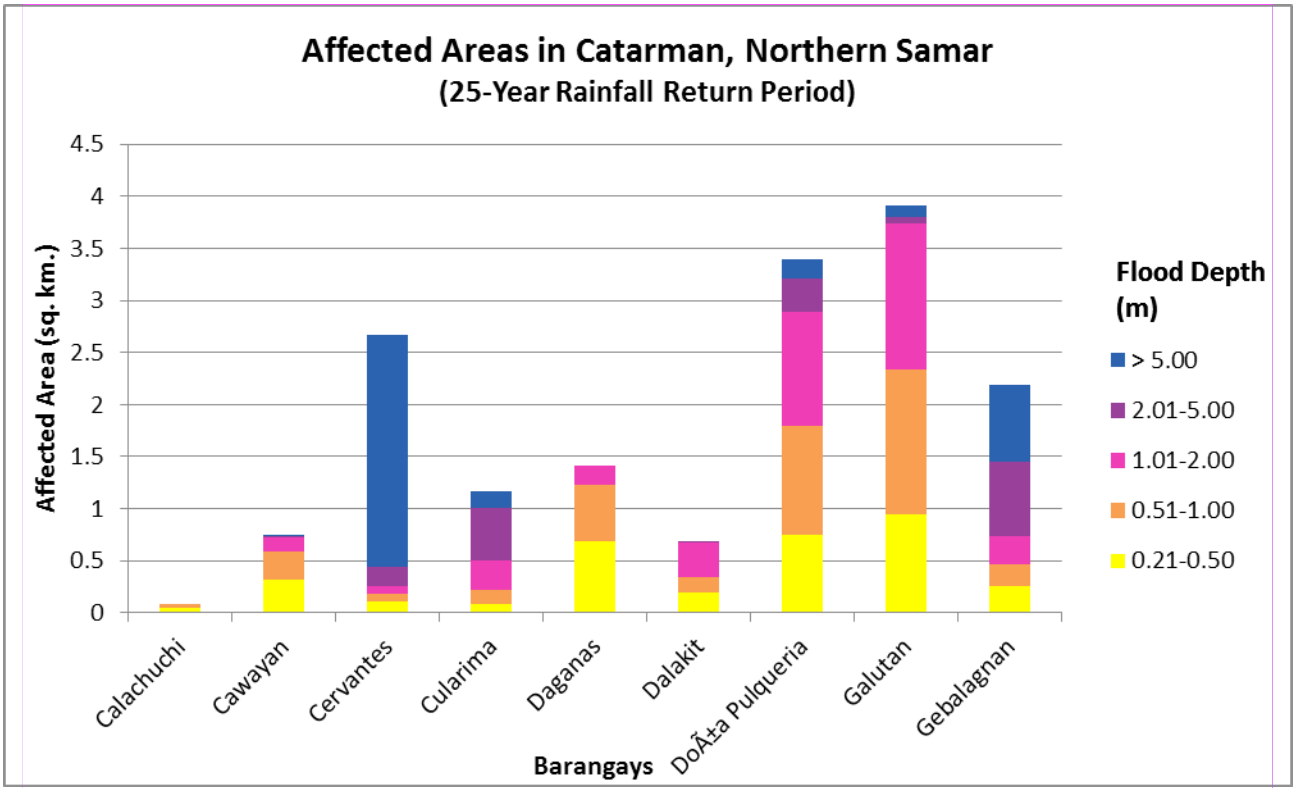



Figure 96. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

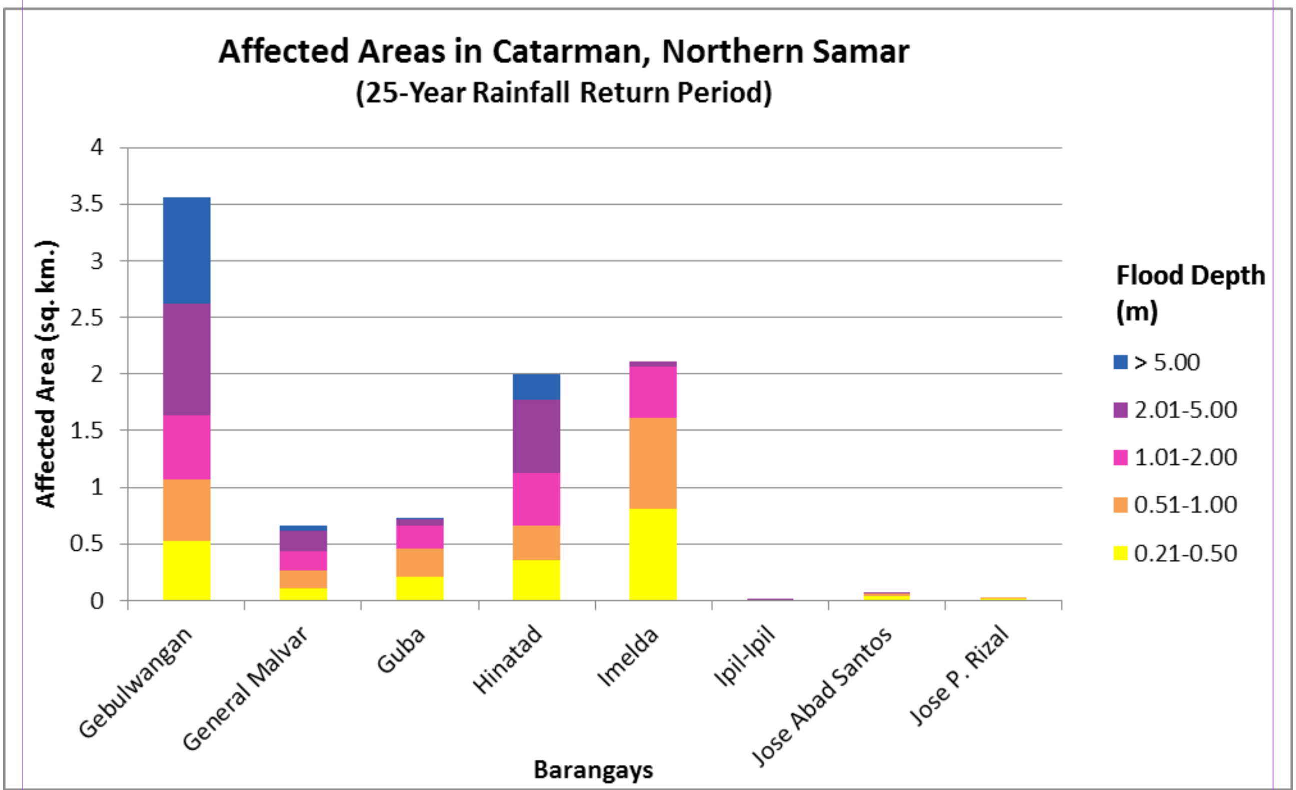



Figure 97. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

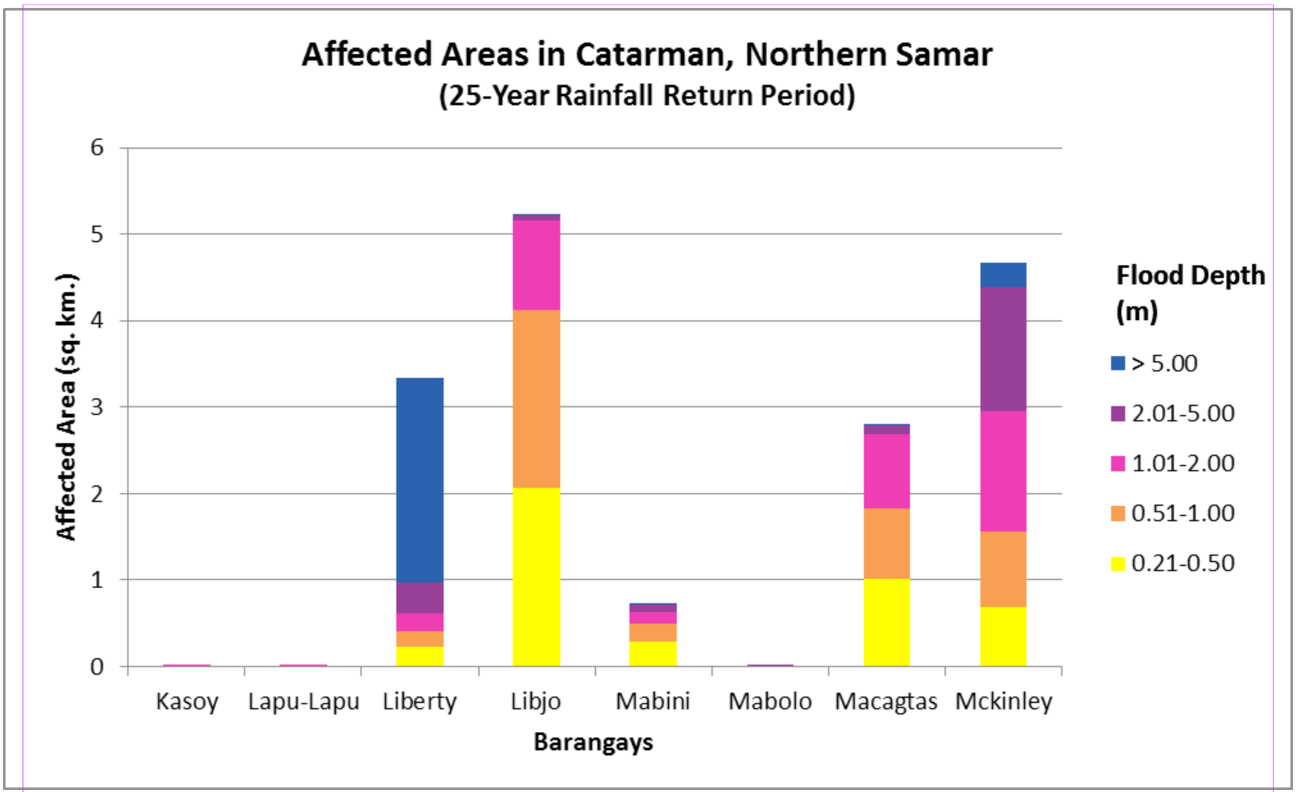



Figure 98. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

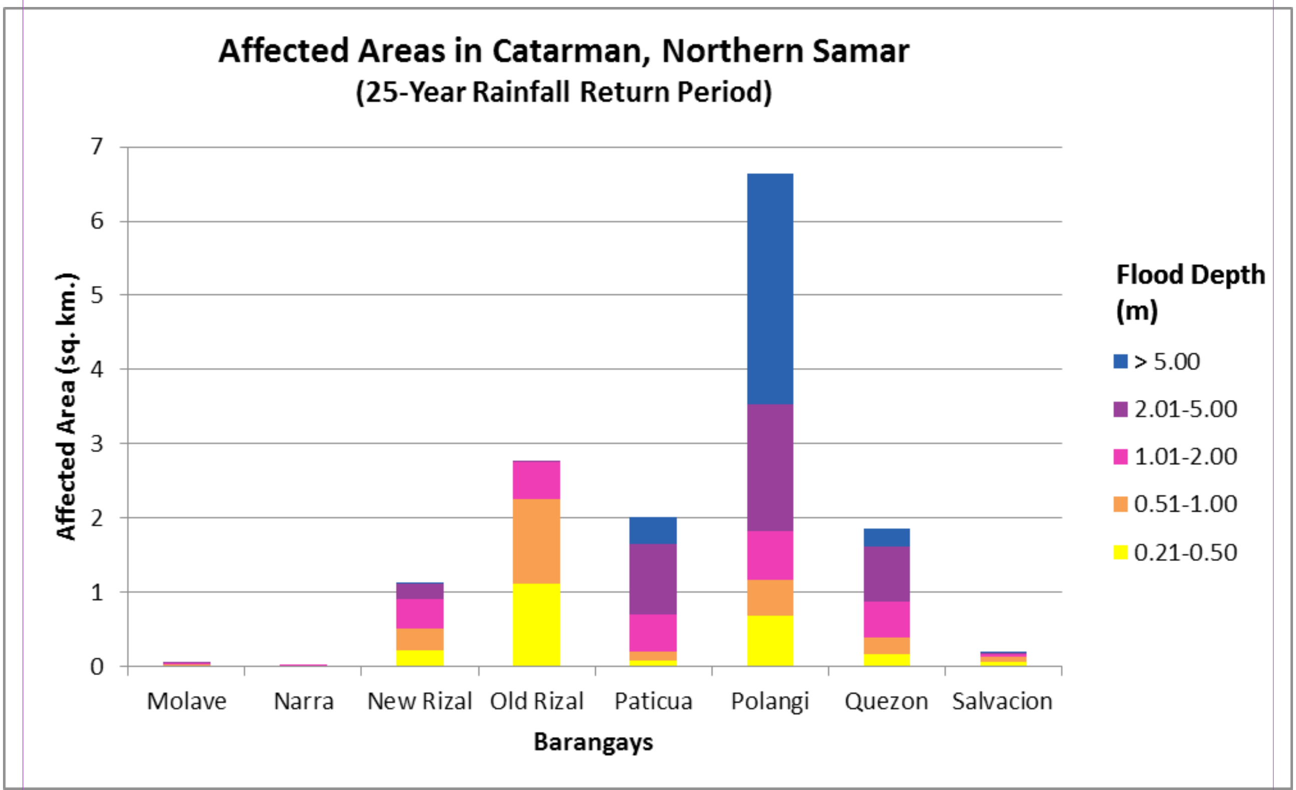



Figure 99. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

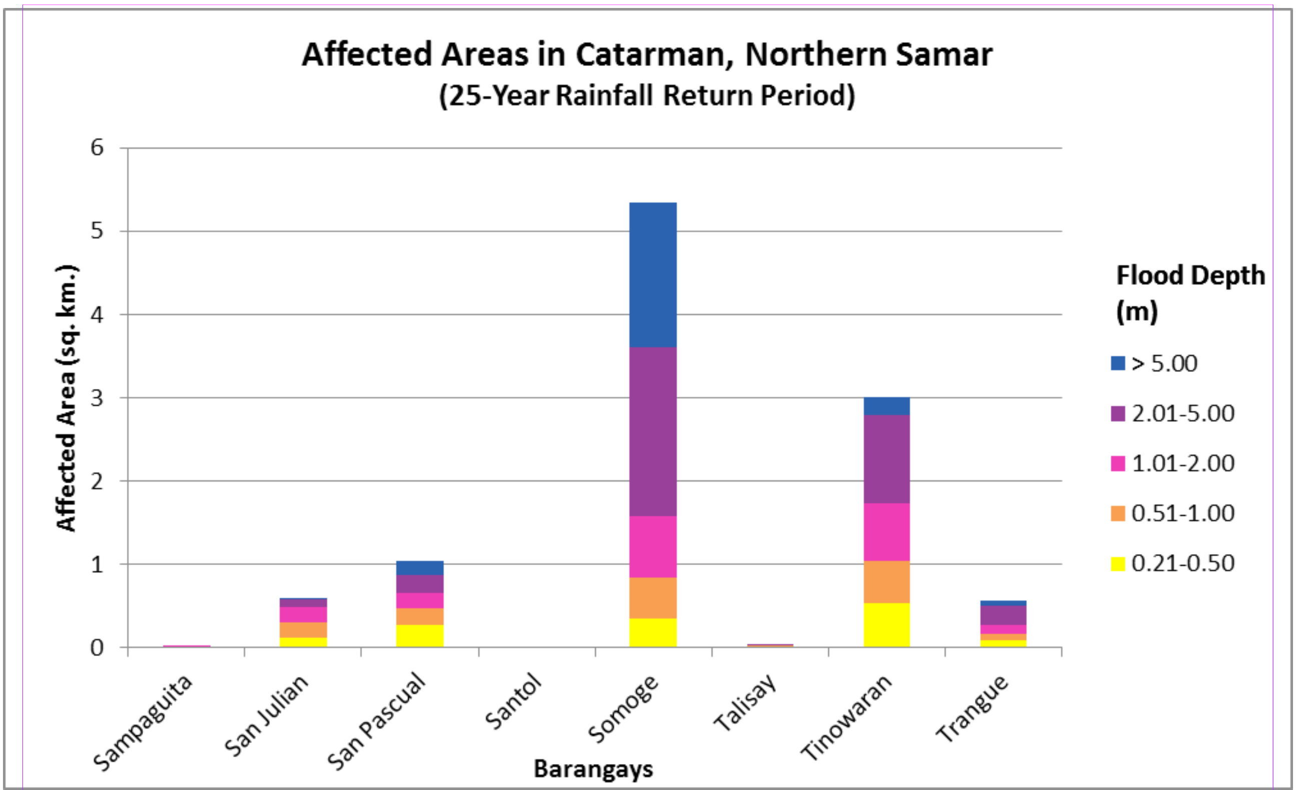



Figure 100. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

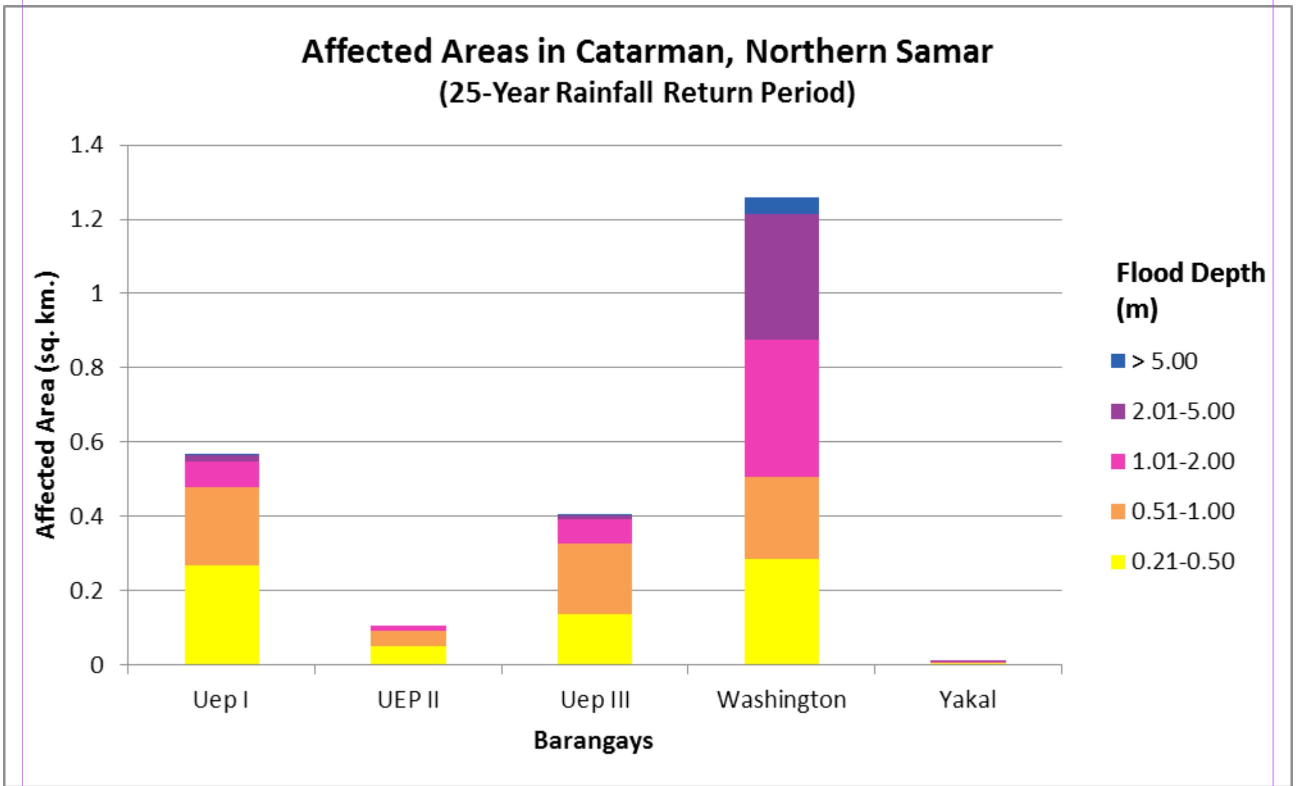



Figure 101. Affected Areas in Catarman, Northern Samar during 25-Year Rainfall Return Period.

For the municipality of Lope de Vega, with an area of 186.61 sq. km., 6.66% will experience flood levels of less 0.20 meters. 0.30% of the area will experience flood levels of 0.21 to 0.50 meters while 0.26%, 0.32%, 0.47% and 0.33% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and above 5 meters, respectively. Listed in Table 61are the affected areas in square kilometers by flood depth per barangay.

Table 61. Affected Areas in Lope de Vega, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Lope de Vega (in sq. km.) | | | | | |
|---|---|---|---|---|---|---|
| | Bayho | Cag-Aguingay | Gebonawan | Gen. Luna | Maghipid | San Miguel |
| 0.03-0.20 | 0.048 | 2.23 | 5.43 | 0.97 | 2.67 | 1.09 |
| 0.21-0.50 | 0.0017 | 0.13 | 0.18 | 0.036 | 0.18 | 0.033 |
| 0.51-1.00 | 0.001 | 0.13 | 0.1 | 0.026 | 0.2 | 0.018 |
| 1.01-2.00 | 0.00042 | 0.18 | 0.12 | 0.021 | 0.26 | 0.017 |
| 2.01-5.00 | 0.0015 | 0.36 | 0.13 | 0.013 | 0.35 | 0.026 |
| > 5.00 | 0.0091 | 0.31 | 0.0043 | 0 | 0.049 | 0.25 |

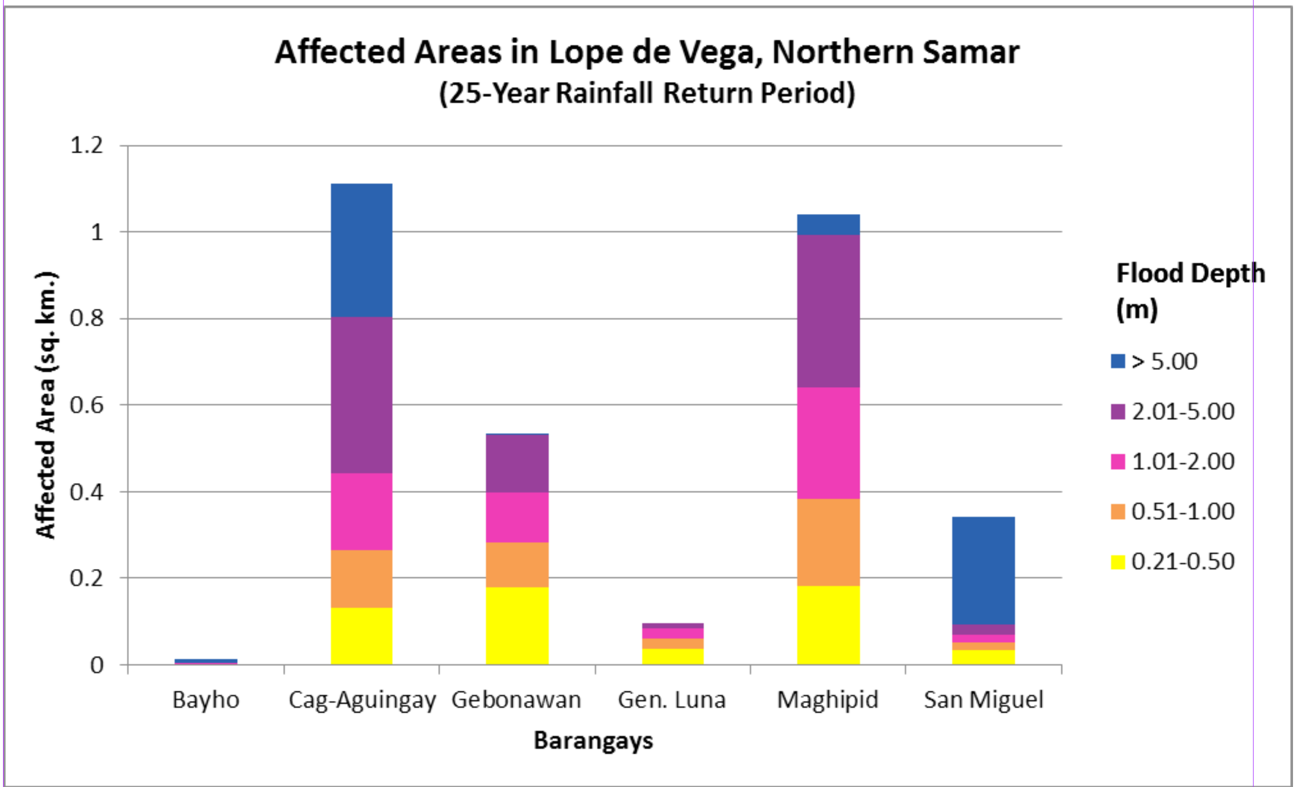



Figure 102. Affected Areas in Lope de Vega, Northern Samar during 25-Year Rainfall Return Period.

For the municipality of Mondragon, with an area of 322.75 sq. km., 6.935% will experience flood levels of less 0.20 meters. 0.52% of the area will experience flood levels of 0.21 to 0.50 meters while 0.45%, 0.33%, 0.16% 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 above 5 meters, respectively. Listed in Table 62 are the affected areas in square kilometers by flood depth per barangay.

Table 62. Affected Areas in Mondragon, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Mondragon (in sq. km.) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cagmanaba | Doña Lucia | Imelda | La Trinidad | Makiwalo | San Agustin | San Isidro |
| 0.03-0.20 | 8.53 | 0 | 2.11 | 9.24 | 0.25 | 1.35 | 0.066 |
| 0.21-0.50 | 0.27 | 0 | 0.33 | 0.66 | 0.057 | 0.29 | 0.035 |
| 0.51-1.00 | 0.18 | 0 | 0.22 | 0.63 | 0.063 | 0.46 | 0.02 |
| 1.01-2.00 | 0.24 | 0 | 0.12 | 0.61 | 0.073 | 0.56 | 0.0055 |
| 2.01-5.00 | 0.19 | 0 | 0.037 | 0.44 | 0.0087 | 0.088 | 0.0013 |
| > 5.00 | 0.019 | 0 | 0.0016 | 0.05 | 0 | 0.0017 | 0 |

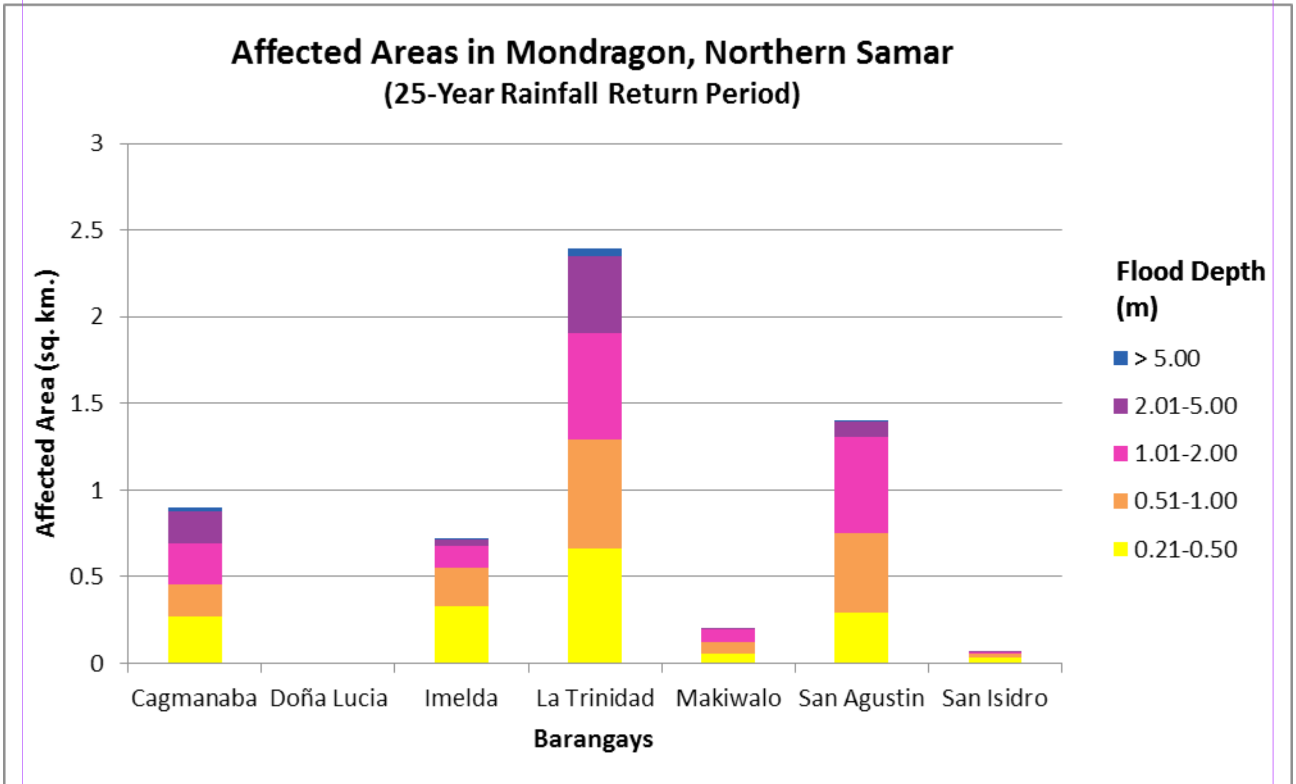



Figure 103. Affected Areas in Mondragon, Northern Samar during 25-Year Rainfall Return Period.

For the municipality of San Jose, with an area of 68.72 sq. km., 0.04% will experience flood levels of less 0.20 meters. 0.01% of the area will experience flood levels of 0.21 to 0.50 meters while 0.007%, 0%, 0% and 0% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and above 5 meters, respectively. Listed in Table 63 are the affected areas in square kilometers by flood depth per barangay.

Table 63. Affected Areas in San Jose, Northern Samar during 25-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in San Jose (in sq. km.) |
|---|---|
| | Geratag |
| 0.03-0.20 | 0.025 |
| 0.21-0.50 | 0.0092 |
| 0.51-1.00 | 0.005 |
| 1.01-2.00 | 0 |
| 2.01-5.00 | 0 |
| > 5.00 | 0 |

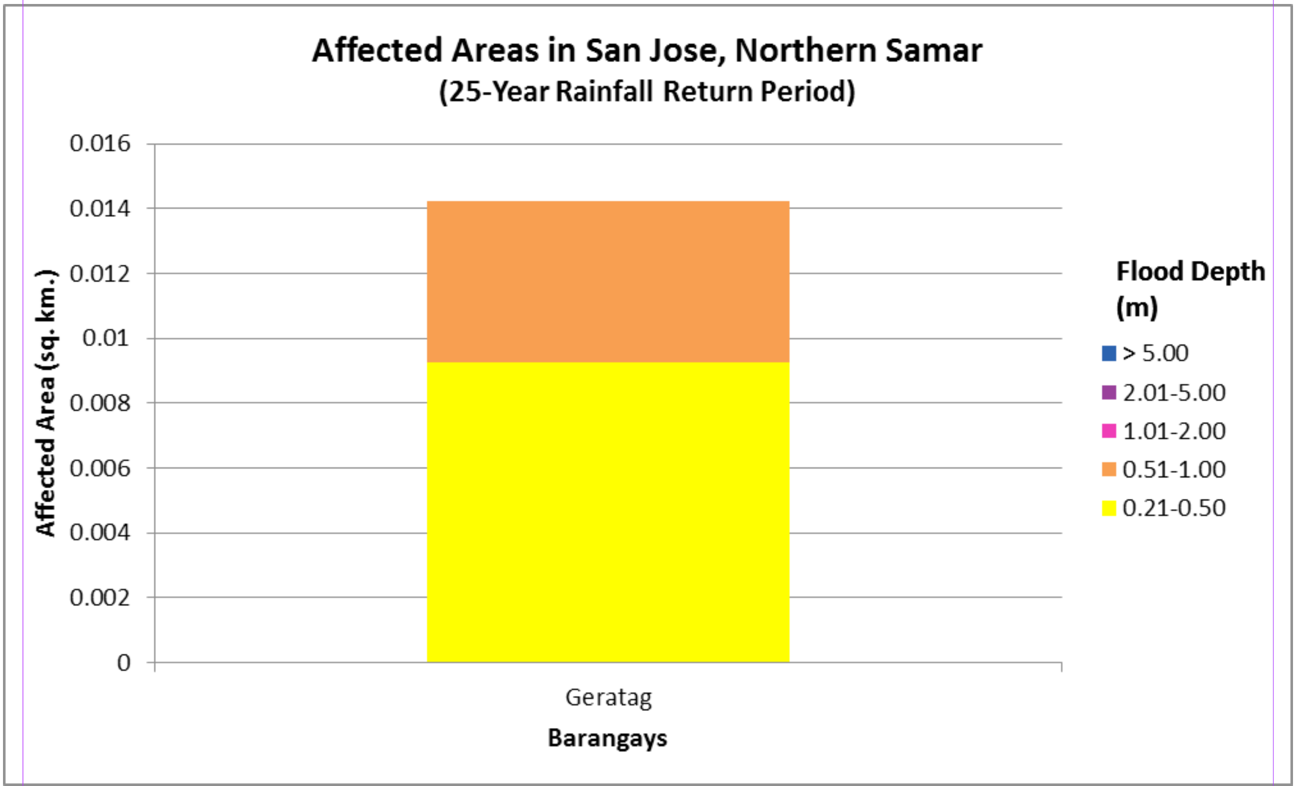



Figure 104. Affected Areas in San Jose, Northern Samar during 25-Year Rainfall Return Period.

For the 100-year return period, 31.36% of the municipality of Bobon with an area of 198.53 sq. km. will experience flood levels of less 0.20 meters. 3.32% of the area will experience flood levels of 0.21 to 0.50 meters while 3.61%, 5.10%, 5.10% and 0.93% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters and more than 5 meters, respectively. Listed in and Table 64 and Table 65 are the affected areas in square kilometers by flood depth per barangay.

Table 64. Affected Areas in Bobon, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Bobon (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Acerida | Arellano | Balat-Balud | Calantiao | Dancalan | E. Duran | Gen. Lucban | Jose Abad Santos | Jose P. Laurel |
| 0.03-0.20 | 5.26 | 1.9 | 0.97 | 1.73 | 3.6 | 0.53 | 0.042 | 2.98 | 4.91 |
| 0.21-0.50 | 0.46 | 0.46 | 0.59 | 0.22 | 0.86 | 0.024 | 0.013 | 0.14 | 0.35 |
| 0.51-1.00 | 0.62 | 0.27 | 0.8 | 0.22 | 0.89 | 0.025 | 0.0085 | 0.16 | 0.37 |
| 1.01-2.00 | 0.74 | 0.13 | 1.8 | 0.36 | 0.65 | 0.031 | 0.0001 | 0.26 | 0.37 |
| 2.01-5.00 | 1.19 | 0.021 | 0.91 | 0.86 | 0.13 | 0.0072 | 0 | 1.7 | 0.66 |
| > 5.00 | 0.32 | 0.0002 | 0.021 | 0.0049 | 0 | 0.0001 | 0 | 0.32 | 0.22 |

Table 65.Affected Areas in Bobon, Northern Samar during 100-Year Rainfall Return Period

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Bobon (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Magsaysay | Quezon | Salvacion | San Isidro | San Juan | Santa Clara | Santander | Somoroy | Trojello |
| 0.03-0.20 | 1.06 | 3.15 | 0.94 | 1.27 | 0.33 | 0.35 | 23.33 | 1.19 | 8.73 |
| 0.21-0.50 | 0.24 | 0.39 | 0.27 | 0.44 | 0.1 | 0.097 | 1.27 | 0.11 | 0.56 |
| 0.51-1.00 | 0.2 | 0.34 | 0.29 | 0.58 | 0.091 | 0.034 | 1.24 | 0.21 | 0.82 |
| 1.01-2.00 | 0.14 | 0.47 | 0.57 | 1.35 | 0.11 | 0.012 | 1.98 | 0.054 | 1.11 |
| 2.01-5.00 | 0.12 | 0.84 | 0.17 | 0.31 | 0.012 | 0.000048 | 1.96 | 0.0084 | 1.24 |
| > 5.00 | 0 | 0.14 | 0 | 0 | 0 | 0 | 0.28 | 0 | 0.55 |

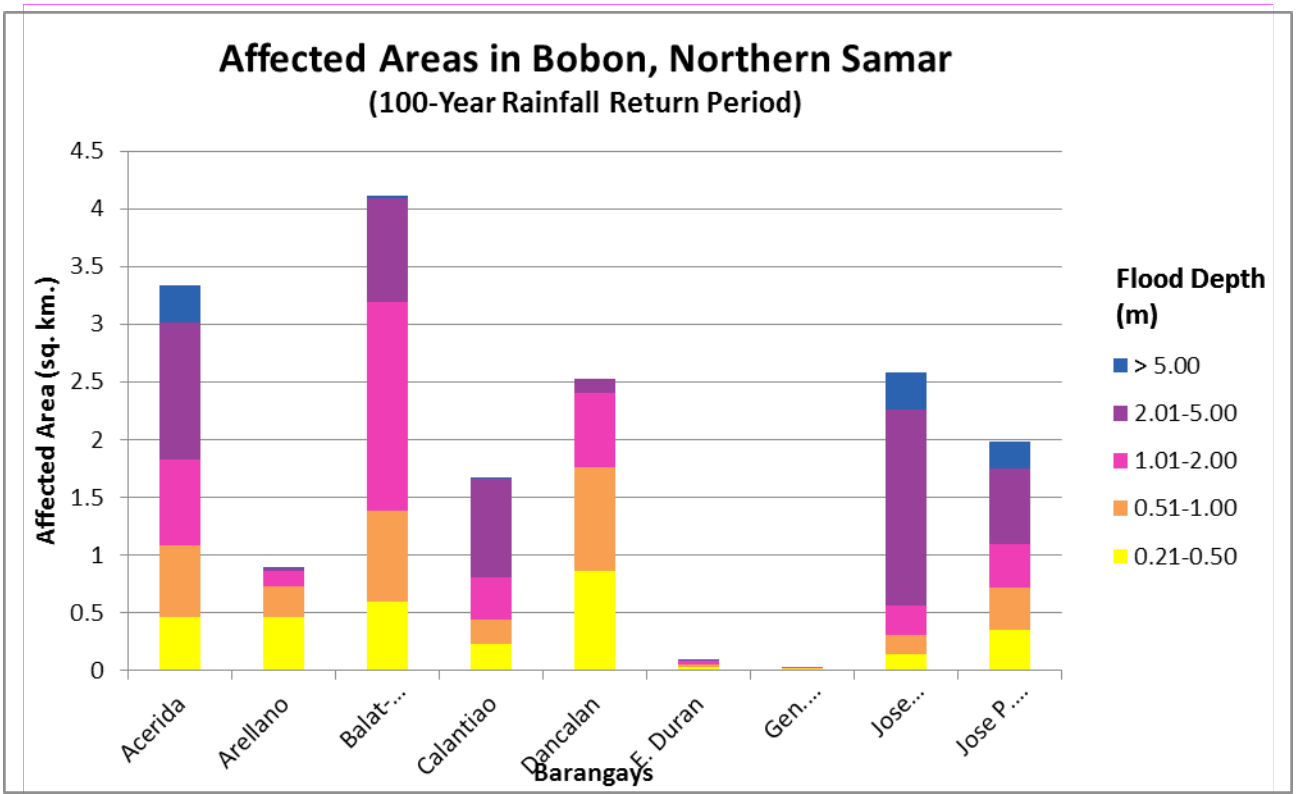



Figure 105. Affected Areas in Bobon, Northern Samar during 100-Year Rainfall Return Period.

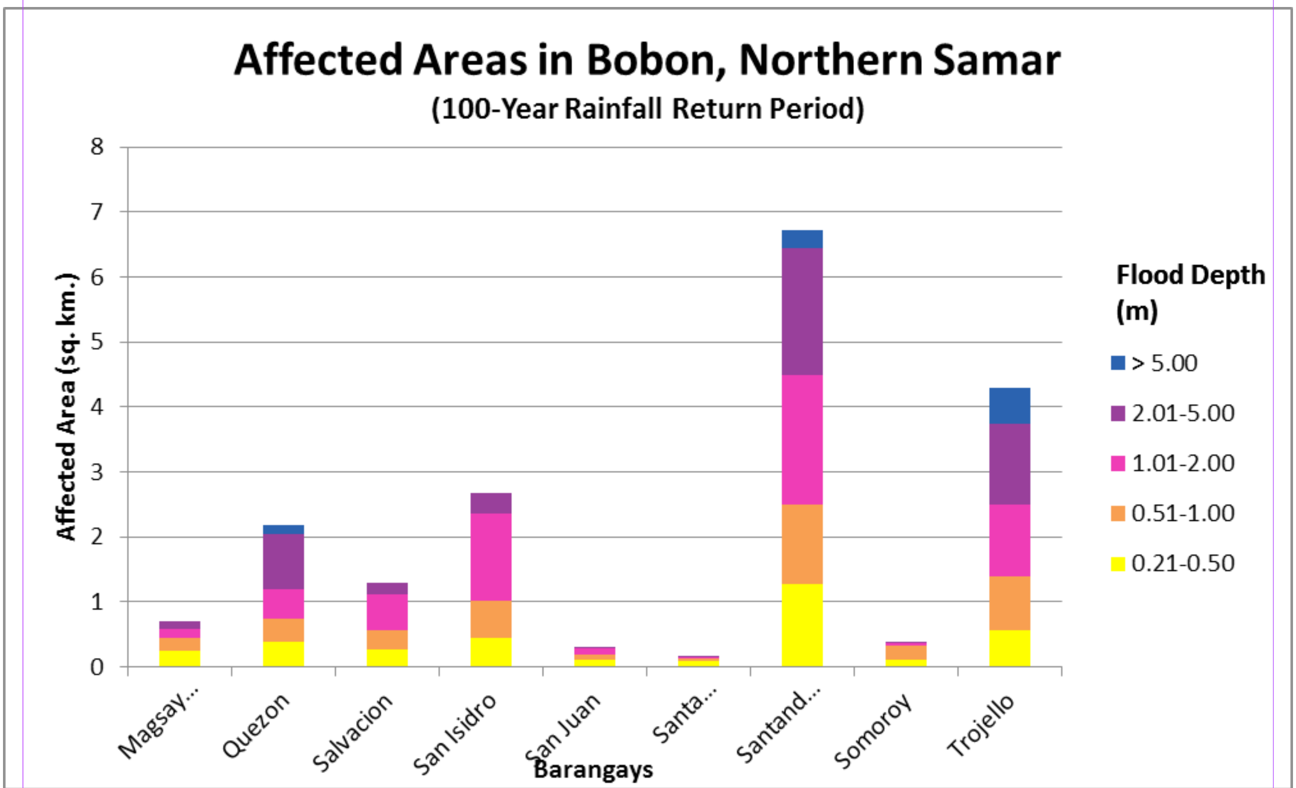



Figure 106. Affected Areas in Bobon, Northern Samar during 100-Year Rainfall Return Period

For the municipality of Catarman, with an area of 255.77 sq. km., 60.45% will experience flood levels of less 0.20 meters. 5.63% of the area will experience flood levels of 0.21 to 0.50 meters while 6.07%, 7.72%, 7.12% and 6.80% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and above 5 meters, respectively. Listed in Table 66 and Table 72 are the affected areas in square kilometers by flood depth per barangay.

Table 66. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Acacia | Aguinaldo | Airport Village | Bangkerohan | Baybay | Bocsol | Cabayhan | Cag-Abaca | Cal-Igang |
| 0.03-0.20 | 0.081 | 1.24 | 0.083 | 0.15 | 0.063 | 1.58 | 2.59 | 3.11 | 6.5 |
| 0.21-0.50 | 0.037 | 0.059 | 0.079 | 0.058 | 0.047 | 0.24 | 0.14 | 0.25 | 0.36 |
| 0.51-1.00 | 0.024 | 0.15 | 0.065 | 0.13 | 0.15 | 0.32 | 0.17 | 0.26 | 0.39 |
| 1.01-2.00 | 0.0021 | 0.24 | 0.0071 | 0.63 | 0.45 | 0.42 | 0.22 | 0.36 | 0.89 |
| 2.01-5.00 | 0 | 0.37 | 0.0036 | 0.0079 | 0.033 | 0.63 | 0.43 | 0.26 | 1.08 |
| > 5.00 | 0 | 0.039 | 0 | 0 | 0.013 | 0.013 | 0.052 | 0.0065 | 0.12 |

Table 67. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq. km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Calachuchi | Cawayan | Cervantes | Cularima | Daganas | Dalakit | DoÃ±a Pulqueria | Galutan | Gebala-gnan |
| 0.03-0.20 | 0.11 | 1.35 | 3.17 | 1.64 | 1.52 | 0.43 | 1.55 | 0.4 | 5.9 |
| 0.21-0.50 | 0.051 | 0.26 | 0.11 | 0.072 | 0.66 | 0.22 | 0.61 | 0.51 | 0.26 |
| 0.51-1.00 | 0.044 | 0.27 | 0.079 | 0.069 | 0.62 | 0.12 | 0.8 | 1.3 | 0.2 |
| 1.01-2.00 | 0.00019 | 0.3 | 0.084 | 0.22 | 0.35 | 0.36 | 1.61 | 2.24 | 0.27 |
| 2.01-5.00 | 0 | 0.038 | 0.18 | 0.62 | 0.0011 | 0.048 | 0.43 | 0.21 | 0.7 |
| > 5.00 | 0 | 0.0006 | 2.4 | 0.27 | 0 | 0 | 0.22 | 0.12 | 0.88 |

Table 68. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Gebulwangan | General Malvar | Guba | Hinatad | Imelda | Ipil-Ipil | Jose Abad Santos | Jose P. Rizal |
| 0.03-0.20 | 8.62 | 2.17 | 4.29 | 4.15 | 2.56 | 0.055 | 0.098 | 0.014 |
| 0.21-0.50 | 0.5 | 0.093 | 0.2 | 0.42 | 0.72 | 0.0041 | 0.03 | 0.015 |
| 0.51-1.00 | 0.51 | 0.12 | 0.24 | 0.31 | 0.85 | 0.002 | 0.047 | 0.0041 |
| 1.01-2.00 | 0.64 | 0.22 | 0.25 | 0.43 | 0.63 | 0.0017 | 0.011 | 0 |
| 2.01-5.00 | 0.96 | 0.22 | 0.075 | 0.8 | 0.066 | 0.00029 | 0.00031 | 0 |
| > 5.00 | 1.22 | 0.055 | 0.0059 | 0.25 | 0 | 0 | 0 | 0 |

Table 69. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Kasoy | Lapu-Lapu | Liberty | Libjo | Mabini | Mabolo | Macagtas | Mckinley |
| 0.03-0.20 | 0.02 | 0.003 | 5.25 | 9.5 | 4.23 | 0.032 | 2.02 | 15.45 |
| 0.21-0.50 | 0.013 | 0.0049 | 0.23 | 1.94 | 0.33 | 0.013 | 0.95 | 0.63 |
| 0.51-1.00 | 0.0021 | 0.0067 | 0.15 | 2.21 | 0.22 | 0.0016 | 0.89 | 0.71 |
| 1.01-2.00 | 0.00019 | 0.0001 | 0.21 | 1.38 | 0.17 | 0.0004 | 0.97 | 1.35 |
| 2.01-5.00 | 0 | 0 | 0.36 | 0.13 | 0.096 | 0.0001 | 0.27 | 1.94 |
| > 5.00 | 0 | 0 | 2.57 | 0.0007 | 0.0012 | 0 | 0.00092 | 0.34 |

Table 70. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq. km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Molave | Narra | New Rizal | Old Rizal | Paticua | Polangi | Quezon | Salvacion |
| 0.03-0.20 | 0.076 | 0.023 | 3.53 | 2.93 | 1.9 | 19.51 | 2.54 | 1.24 |
| 0.21-0.50 | 0.0077 | 0.0017 | 0.21 | 1.07 | 0.069 | 0.69 | 0.14 | 0.057 |
| 0.51-1.00 | 0.011 | 0.00064 | 0.25 | 1.2 | 0.06 | 0.44 | 0.14 | 0.064 |
| 1.01-2.00 | 0.033 | 0.00011 | 0.43 | 0.82 | 0.14 | 0.56 | 0.35 | 0.057 |
| 2.01-5.00 | 0.0053 | 0 | 0.28 | 0.037 | 1.25 | 1.35 | 0.91 | 0.019 |
| > 5.00 | 0 | 0 | 0.0096 | 0 | 0.58 | 4.12 | 0.39 | 0.0005 |

Table 71. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq. km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sampaguita | San Julian | San Pascual | Santol | Somoge | Talisay | Tinowaran | Trangue |
| 0.03-0.20 | 0.016 | 1.84 | 2.99 | 0.013 | 4.76 | 0.07 | 13.76 | 2.74 |
| 0.21-0.50 | 0.0079 | 0.098 | 0.3 | 0.0074 | 0.26 | 0.02 | 0.51 | 0.099 |
| 0.51-1.00 | 0.0077 | 0.16 | 0.23 | 0.00017 | 0.34 | 0.012 | 0.39 | 0.08 |
| 1.01-2.00 | 0.001 | 0.25 | 0.26 | 0.0002 | 0.53 | 0.0034 | 0.65 | 0.11 |
| 2.01-5.00 | 0.00023 | 0.1 | 0.26 | 0 | 1.98 | 0.0003 | 1.45 | 0.23 |
| > 5.00 | 0 | 0.0083 | 0.23 | 0 | 2.87 | 0 | 0.43 | 0.084 |

Table 72. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Catarman (in sq. km.) | | | | |
|---|---|---|---|---|---|
| | Uep I | UEP II | Uep III | Washington | Yakal |
| 0.03-0.20 | 2.15 | 0.23 | 1.12 | 3.2 | 0.049 |
| 0.21-0.50 | 0.27 | 0.048 | 0.13 | 0.3 | 0.0058 |
| 0.51-1.00 | 0.25 | 0.049 | 0.18 | 0.24 | 0.0016 |
| 1.01-2.00 | 0.082 | 0.022 | 0.12 | 0.42 | 0.0018 |
| 2.01-5.00 | 0.024 | 0 | 0.011 | 0.34 | 0.0004 |
| > 5.00 | 0.0008 | 0 | 0.0016 | 0.082 | 0 |

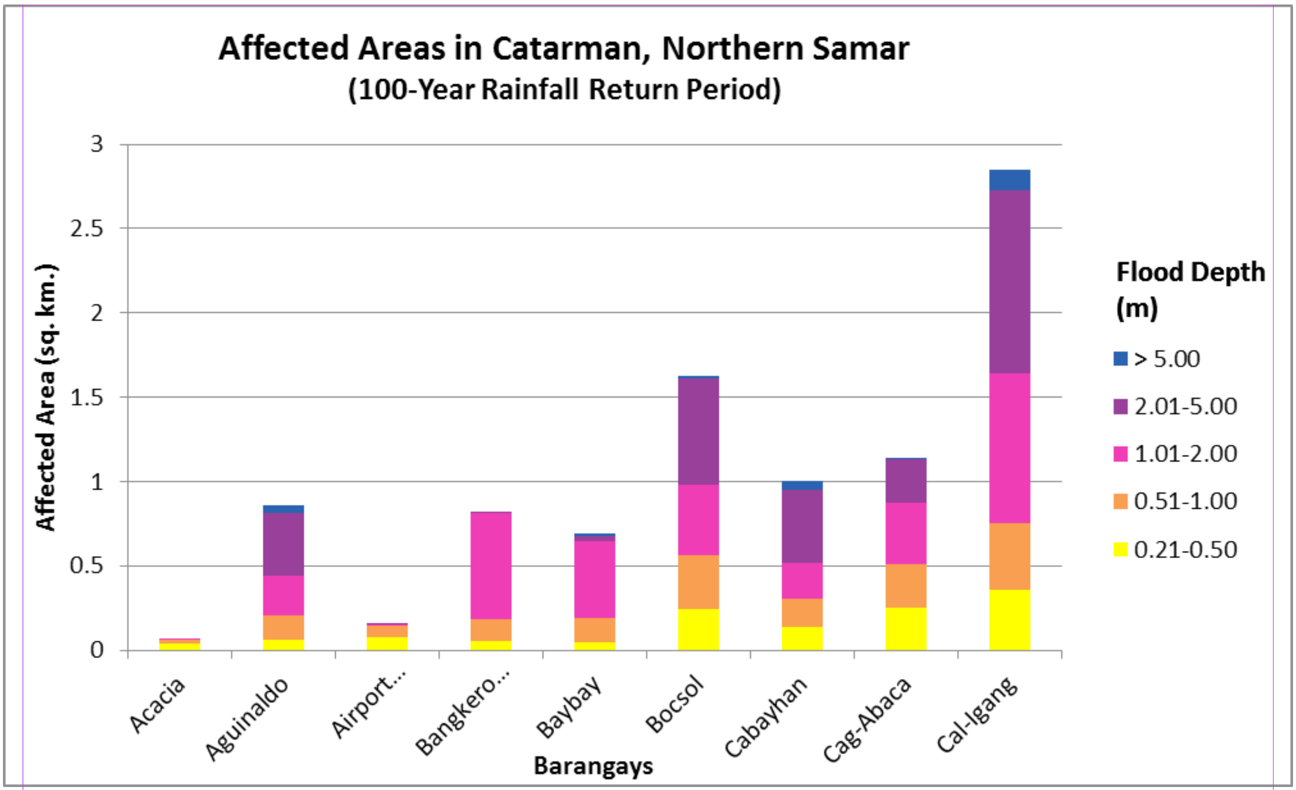



Figure 107. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period

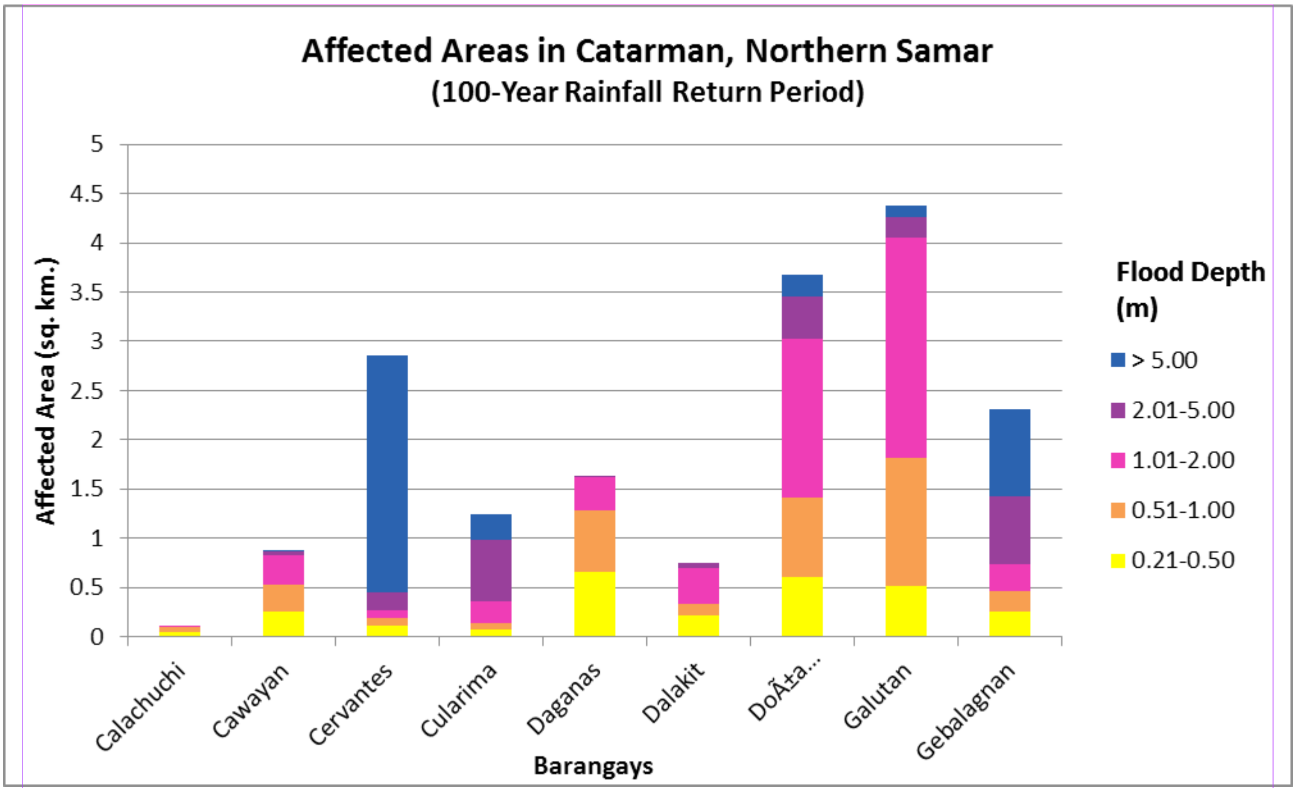



Figure 108. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

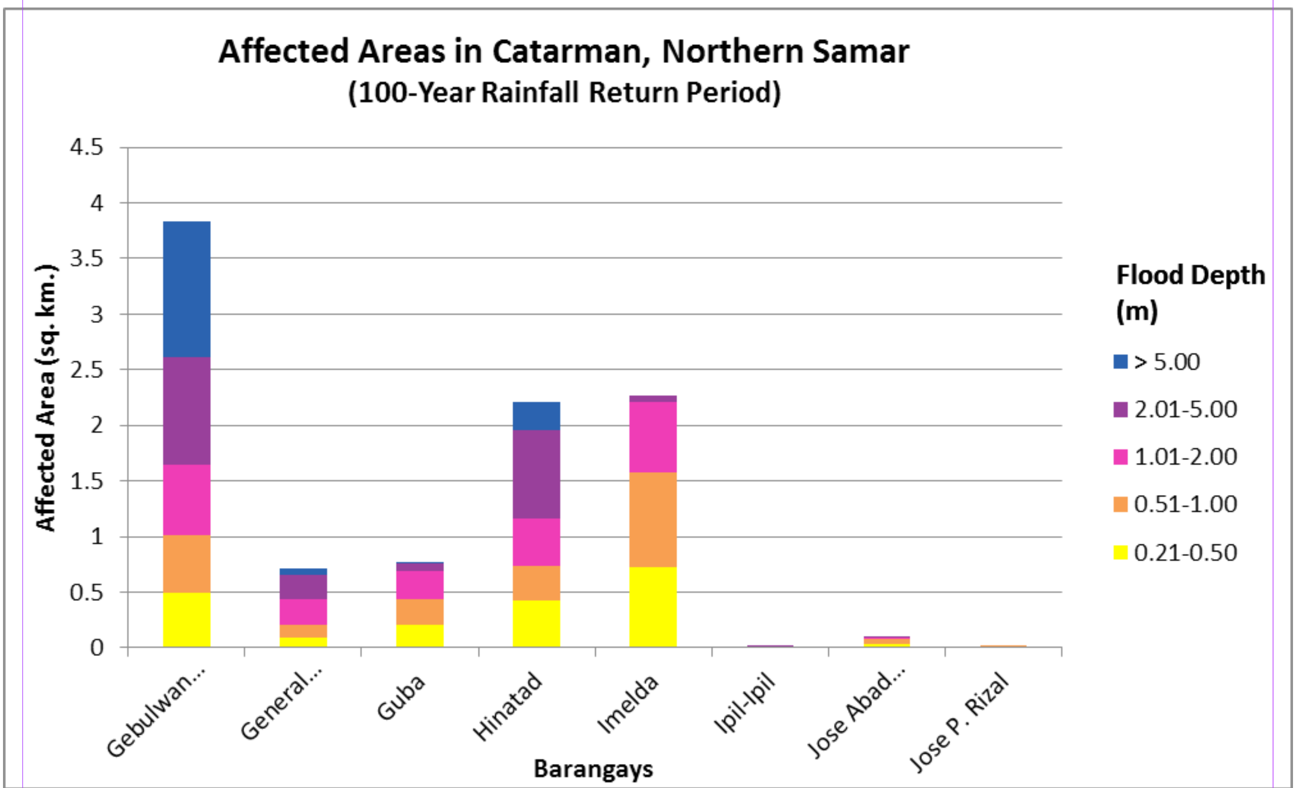



Figure 109. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

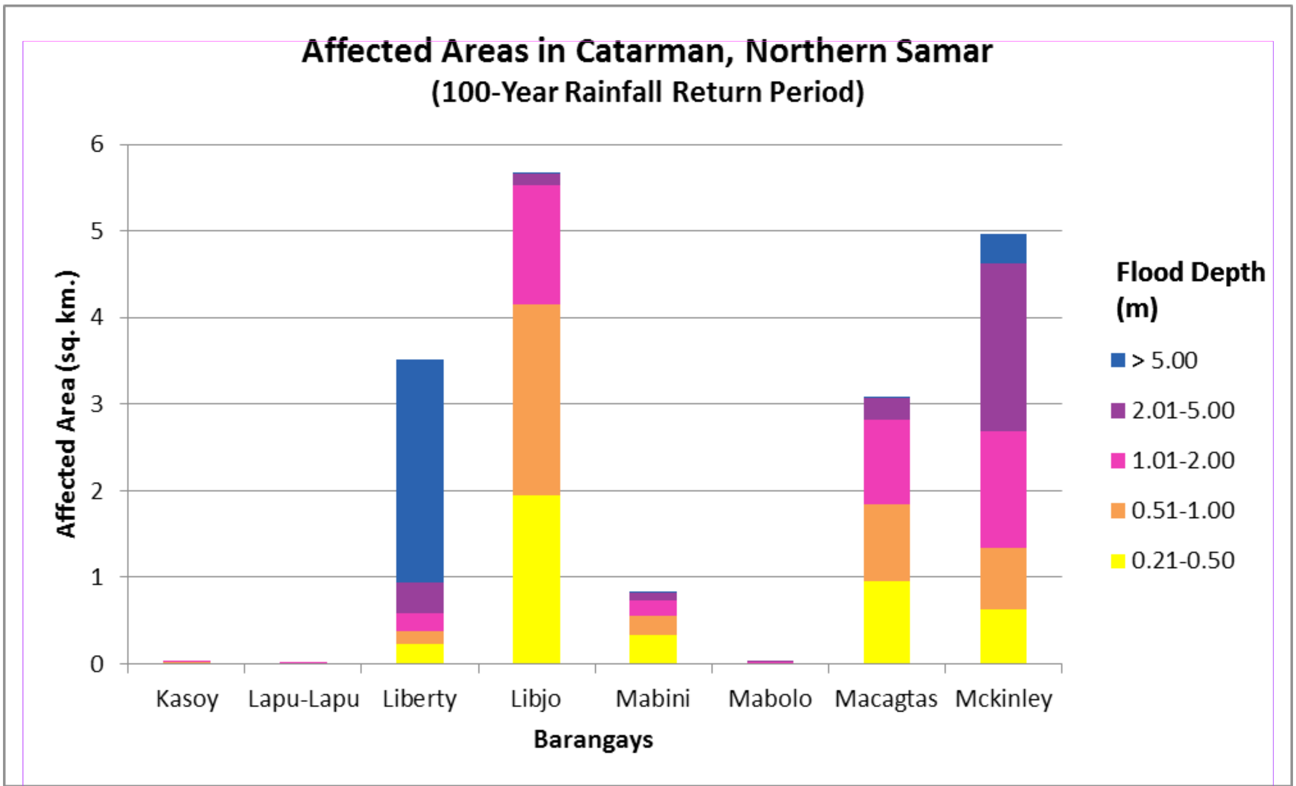



Figure 110. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

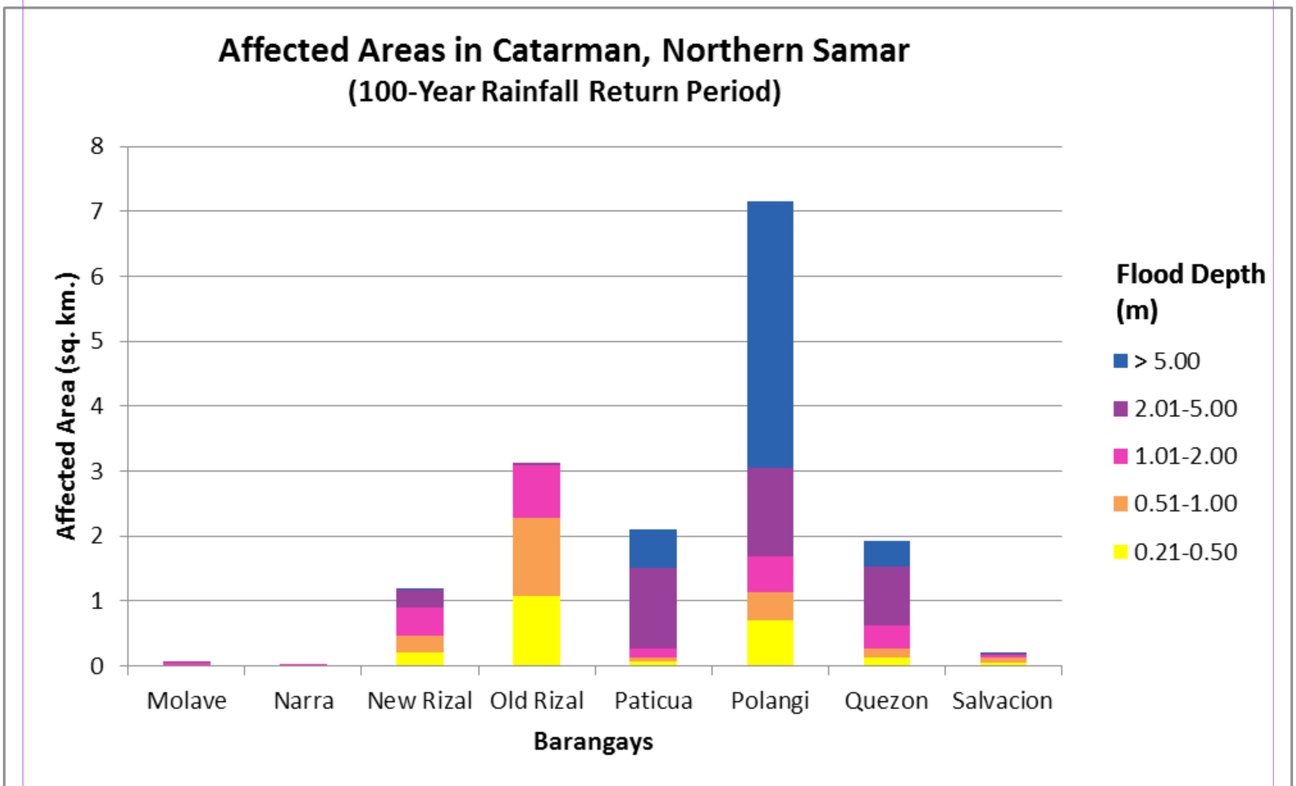



Figure 111. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

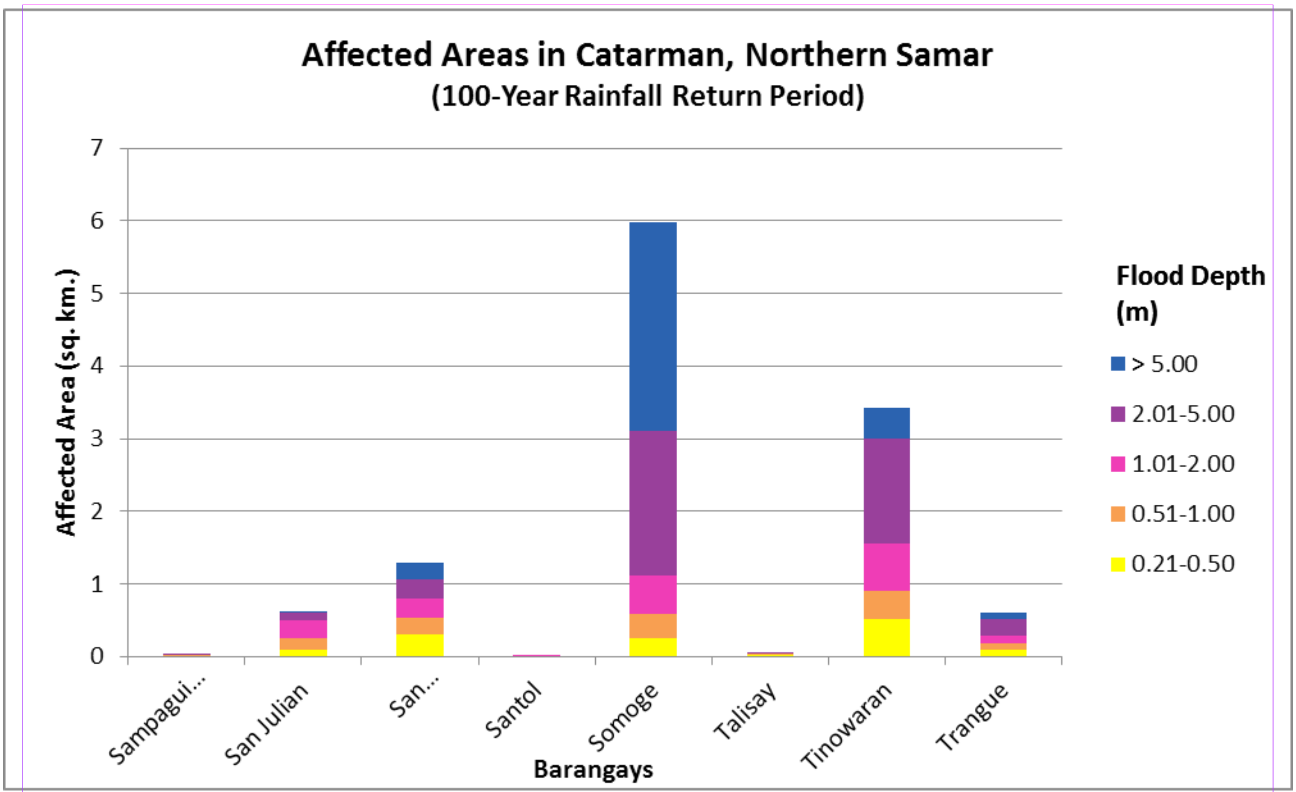



Figure 112. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

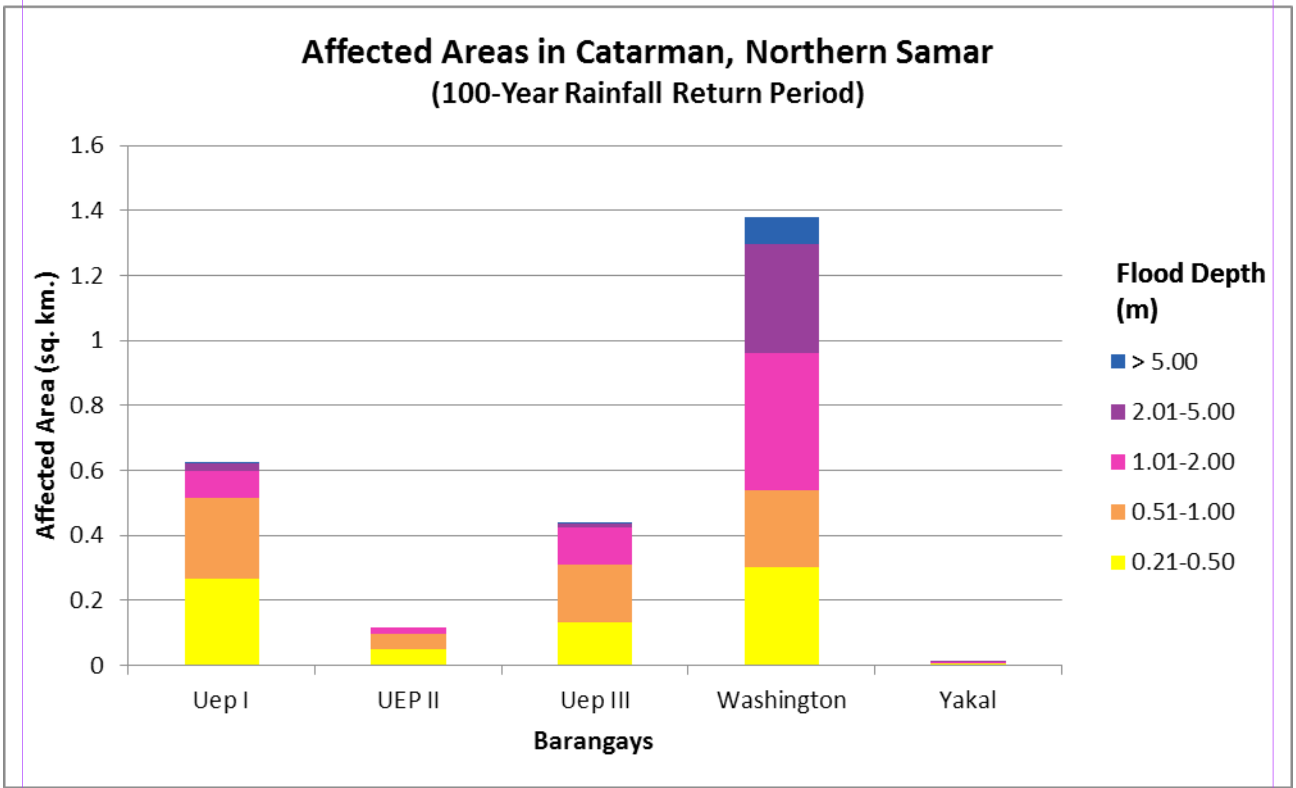



Figure 113. Affected Areas in Catarman, Northern Samar during 100-Year Rainfall Return Period.

For the municipality of Lope de Vega, with an area of 186.61 sq. km., 6.50% will experience flood levels of less 0.20 meters. 0.31% of the area will experience flood levels of 0.21 to 0.50 meters while 0.26%, 0.33%, 0.54% and 0.40% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and above 5 meters, respectively.Listed in Table 73 are the affected areas in square kilometers by flood depth per barangay.

Table 73. Affected Areas in Lope de Vega, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Lope de Vega (in sq. km.) | | | | | |
|---|---|---|---|---|---|---|
| | Bayho | Cag-Aguingay | Gebonawan | Gen. Luna | Maghipid | San Miguel |
| 0.03-0.20 | 0.045 | 2.12 | 5.37 | 0.96 | 2.59 | 1.06 |
| 0.21-0.50 | 0.002 | 0.13 | 0.19 | 0.041 | 0.18 | 0.034 |
| 0.51-1.00 | 0.0011 | 0.14 | 0.11 | 0.028 | 0.19 | 0.019 |
| 1.01-2.00 | 0.00022 | 0.19 | 0.12 | 0.021 | 0.27 | 0.18 |
| 2.01-5.00 | 0.0016 | 0.4 | 0.15 | 0.017 | 0.41 | 0.028 |
| > 5.00 | 0.011 | 0.37 | 0.008 | 0.0002 | 0.078 | 0.28 |

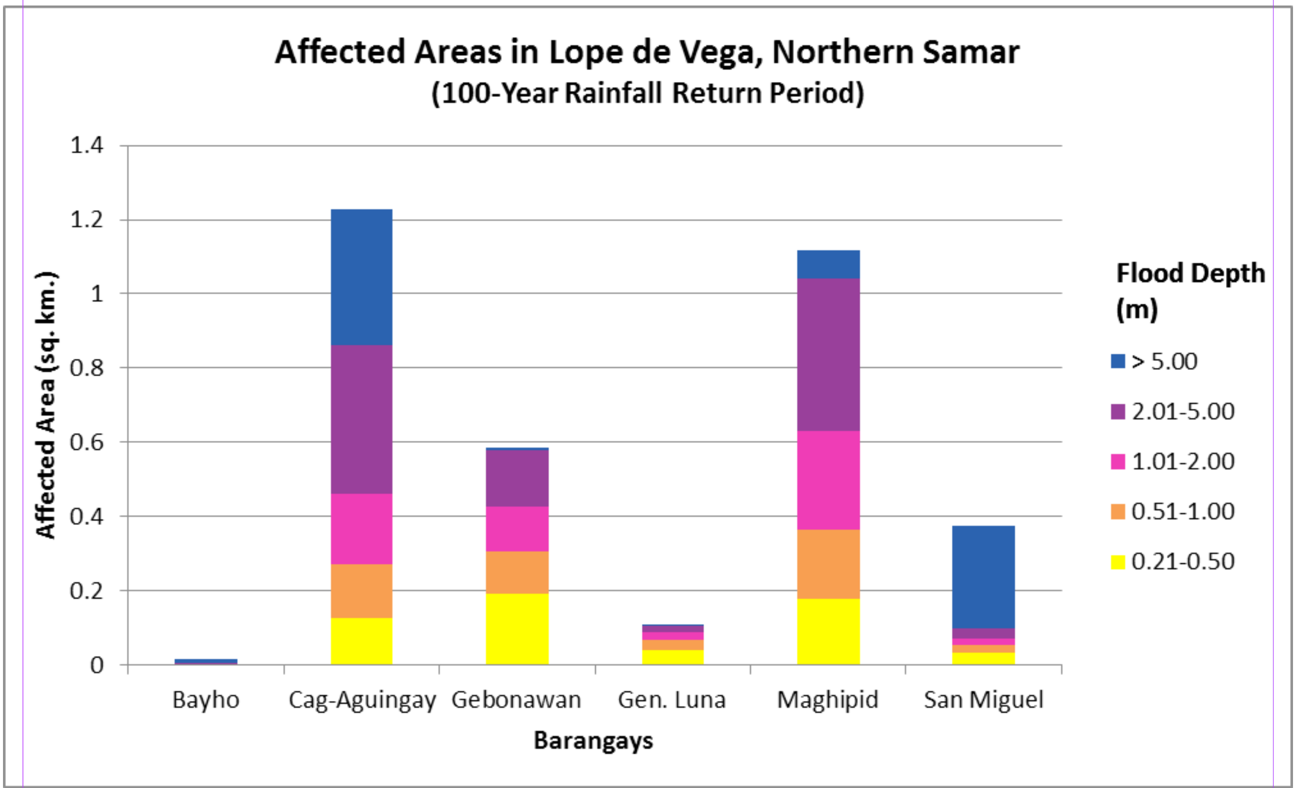



Figure 114. Affected Areas in Lope de Vega, Northern Samar during 100-Year Rainfall Return Period.

For the municipality of Mondragon, with an area of 322.75 sq. km., 6.52% will experience flood levels of less 0.20 meters. 0.50% of the area will experience flood levels of 0.21 to 0.50 meters while 0.49%, 0.58%, 0.32% and 0.03% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and above 5 meters, respectively. Listed in Table 74 are the affected areas in square kilometers by flood depth per barangay.

Table 74. Affected Areas in Mondragon, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in Mondragon (in sq. km.) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cagmanaba | Doña Lucia | Imelda | La Trinidad | Makiwalo | San Agustin | San Isidro |
| 0.03-0.20 | 8.45 | 0 | 1.99 | 9.06 | 0.23 | 1.25 | 0.058 |
| 0.21-0.50 | 0.29 | 0 | 0.36 | 0.62 | 0.056 | 0.25 | 0.032 |
| 0.51-1.00 | 0.19 | 0 | 0.26 | 0.68 | 0.063 | 0.36 | 0.028 |
| 1.01-2.00 | 0.24 | 0 | 0.17 | 0.67 | 0.087 | 0.71 | 0.0064 |
| 2.01-5.00 | 0.24 | 0 | 0.043 | 0.56 | 0.022 | 0.16 | 0.002 |
| > 5.00 | 0.024 | 0 | 0.0028 | 0.062 | 0 | 0.0033 | 0 |

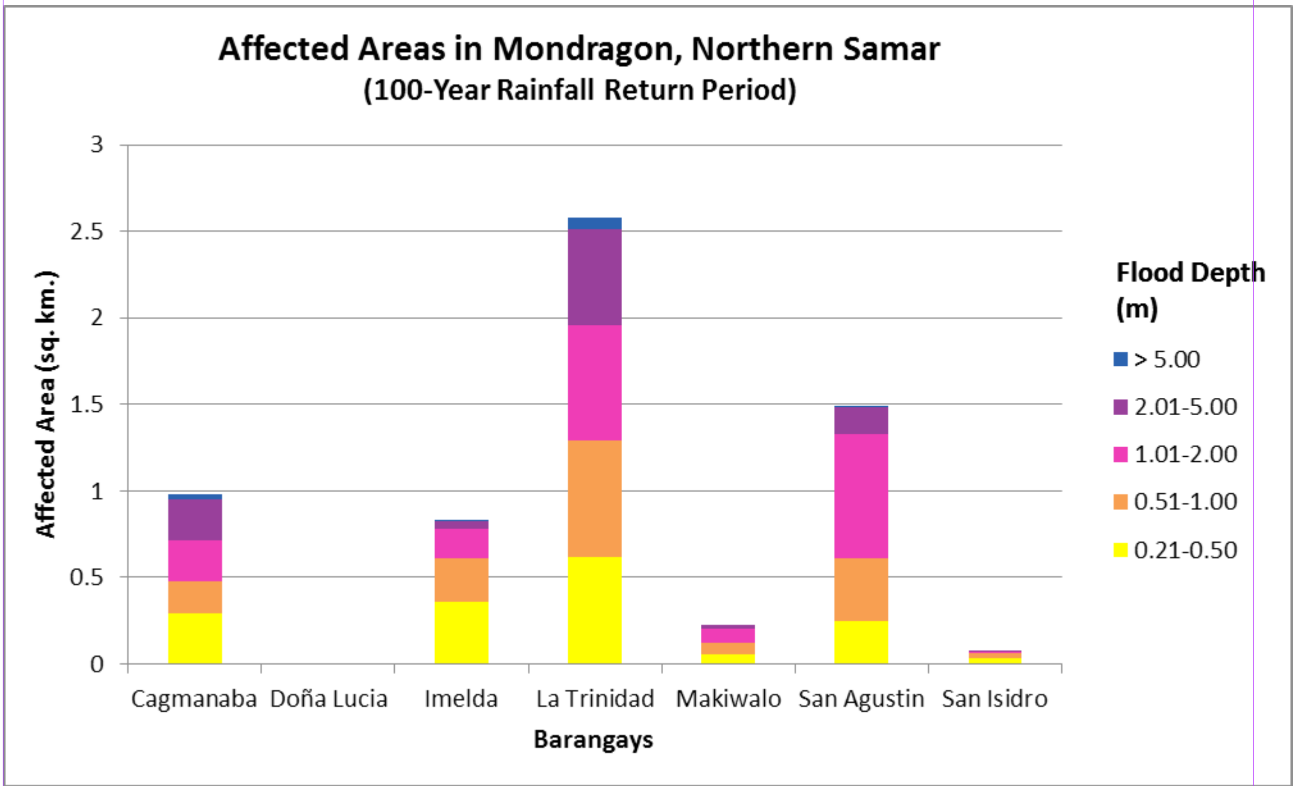



Figure 115. Affected Areas in Mondragon, Northern Samar during 100-Year Rainfall Return Period.

For the municipality of San Jose, with an area of 68.72 sq. km., 0.03% will experience flood levels of less 0.20 meters. 0.02% of the area will experience flood levels of 0.02 to 0.50 meters while 0.02%, 0.0003%, 0% and 0% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and above 5 meters, respectively.Listed in Table 75 are the affected areas in square kilometers by flood depth per barangay.

Table 75. Affected Areas in San Jose, Northern Samar during 100-Year Rainfall Return Period.

| Affected area (sq.km.) by flood depth (in m.) | Area of affected barangays in San Jose (in sq. km.) |
|---|---|
| | Geratag |
| 0.03-0.20 | 0.018 |
| 0.21-0.50 | 0.01 |
| 0.51-1.00 | 0.01 |
| 1.01-2.00 | 0.00026 |
| 2.01-5.00 | 0 |
| > 5.00 | 0 |

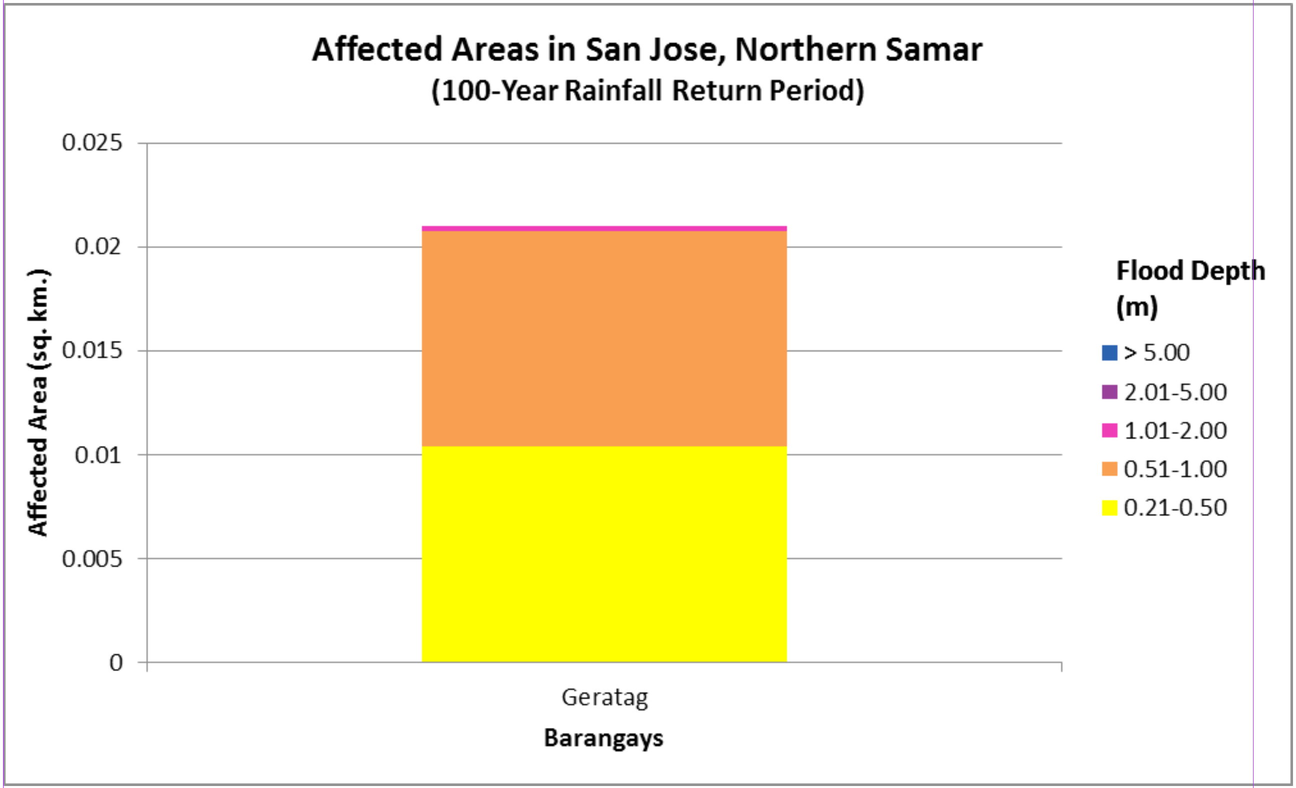



Figure 116. Affected Areas in San Jose, Northern Samar during 100-Year Rainfall Return Period.

Among the barangays in the municipality of Bobon, Santander is projected to have the highest percentage of area that will experience flood levels at 15.14%. Meanwhile, Trojello posted the second highest percentage of area that may be affected by flood depths at 6.55%.

Among the barangays in the municipality of Catarman, Polangi is projected to have the highest percentage of area that will experience flood levels at 10.43%. Meanwhile, Mckinley posted the second highest percentage of area that may be affected by flood depths at 7.98%.

Among the barangays in the municipality of Lope de Vega, Gebonawan is projected to have the highest percentage of area that will experience flood levels of at 3.19%. Meanwhile, Maghipid posted the second highest percentage of area that may be affected by flood depths of at 1.99%.

Among the barangays in the municipality of Mondragon, La Trinidad is projected to have the highest percentage of area that will experience flood levels of at 3.60%. Meanwhile, Cagmanaba posted the second highest percentage of area that may be affected by flood depths of at 2.92%.

Among the barangays in the municipality of San Jose, Geratag is the only affected barangay with 0.06% of its area is projected to experience flood.

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

Table 76. Area covered by each warning level with respect to the rainfall scenarios

| Warning Level | Area Covered in sq. km. | | |
|---|---|---|---|
| | 5 year | 25 year | 100 year |
| Low | 29.44 | 25.47 | 23.63 |
| Medium | 40.24 | 45.97 | 43.91 |
| High | 34.23 | 52.16 | 66.23 |

Of the sixty (60) identified Education Institute in Catarman Flood plain, 17 schools were assessed to be exposed to the Low level flooding during a 5 year scenario while 9 were assessed to be exposed to Medium and 1 to High level flooding in the same scenario. In the 25 year scenario, 18 schools were assessed to be exposed to the Low level flooding while 12 schools were assessed to be exposed to Medium and 8 to High level flooding. For the 100 year scenario, 18 schools were assessed for Low level flooding and 18 schools for Medium level flooding. In the same scenario, 8 school were assessed to be exposed to High level flooding.

Of the 23 identified Medical Institutions in Catarman Flood plain, 4 were assessed to be exposed to the Low level flooding during a 5 year scenario while 3 were assessed to be exposed to Medium level flooding. In the 25 year scenario, 3 were assessed to be exposed to the Low level flooding while 4 were assessed to be exposed to Medium level flooding and 4 to High level flooding. For the 100 year scenario, 4 schools were assessed for Low level flooding and 4 for Medium and High level flooding.

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

The actual data from the field were compared to the simulated data to assess the accuracy of the Flood Depth Maps produced and to improve on the results of the flood map. The points in the flood map versus its corresponding validation depths are shown in Figure 117.

The flood validation consists of 197 points randomly selected all over the Catarman flood plain comparing it with the flood depth map of the nearest storm event, the map has an RMSE value of 0.57 m. Table 77 shows a contingency matrix of the comparison. The validation points are found in Annex 11.

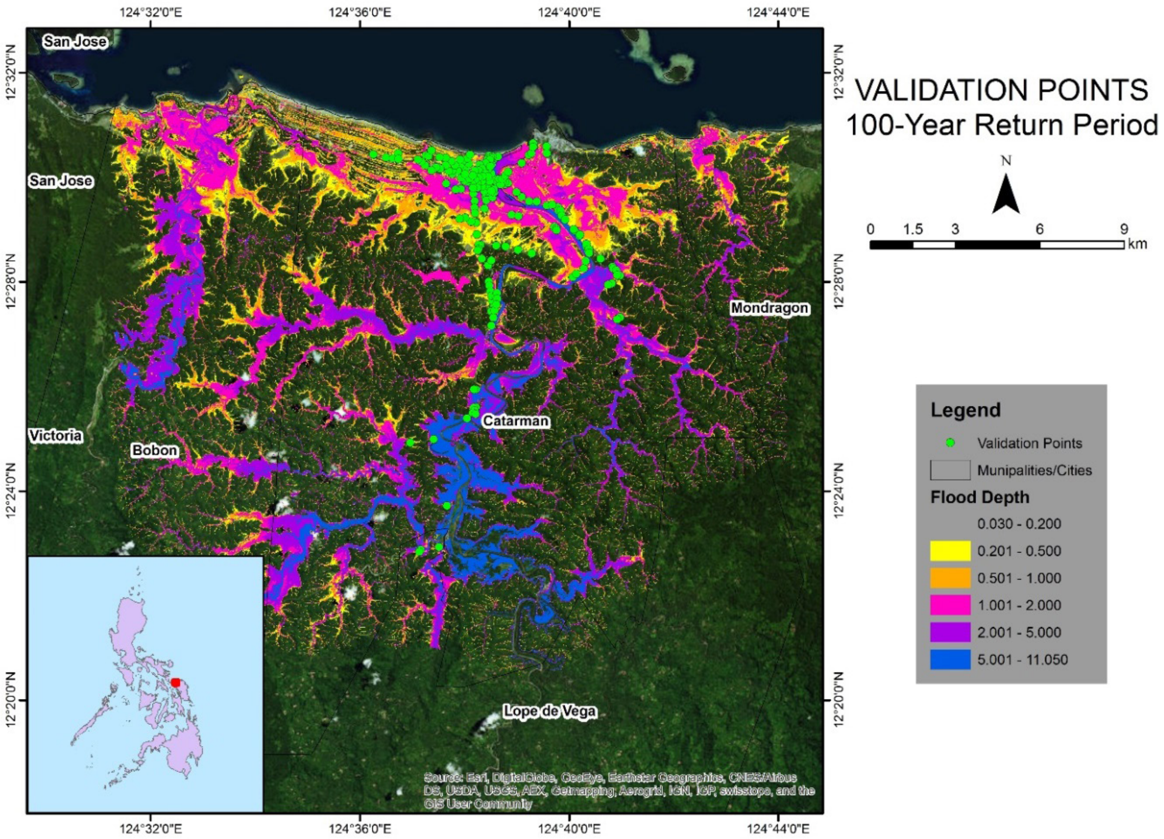



Figure 117. Validation Points for a 100-year Flood Depth Map of the Catarman Floodplain.

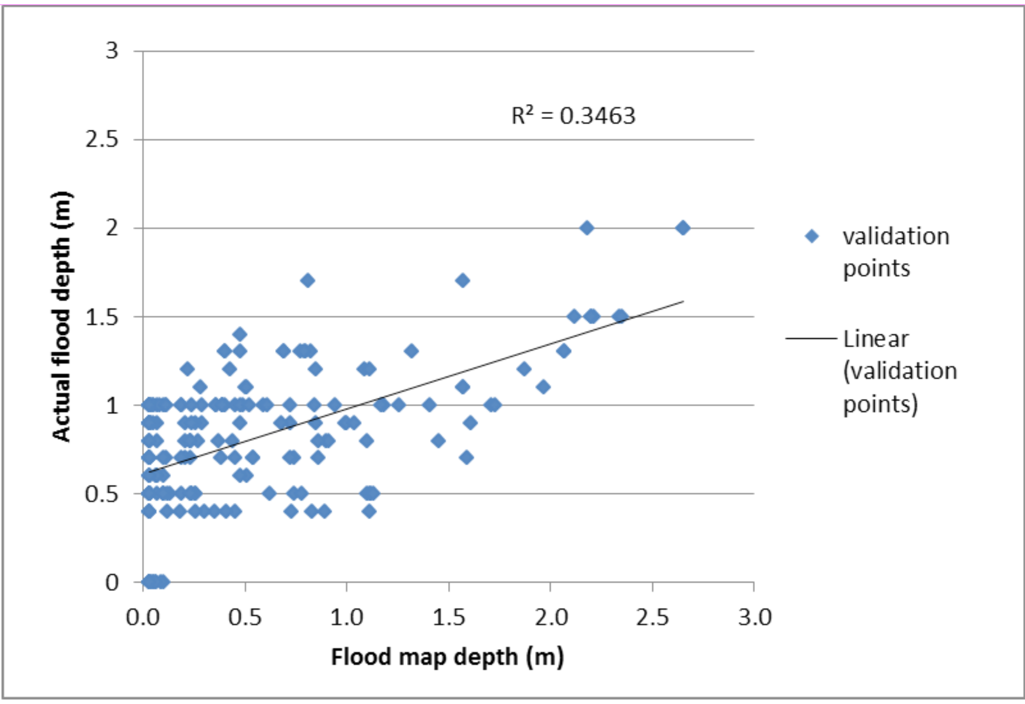



Figure 118. Flood Map depth versus Actual Flood Depth.

Table 77. Actual Flood Depth versus Simulated Flood Depth at different levels in the Catarman River Basin.

| Actual Flood Depth (m) | Modeled Flood Depth (m) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-0.20 | 0.21-0.50 | 0.51-1.00 | 1.01-2.00 | 2.01-5.00 | > 5.00 | Total |
| 0-0.20 | 13 | 0 | 0 | 0 | 0 | 0 | 13 |
| 0.21-0.50 | 22 | 10 | 6 | 5 | 0 | 0 | 43 |
| 0.51-1.00 | 46 | 28 | 20 | 11 | 0 | 0 | 105 |
| 1.01-2.00 | 0 | 8 | 9 | 8 | 11 | 0 | 36 |
| 2.01-5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| > 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 81 | 46 | 35 | 24 | 11 | 0 | 197 |

On the whole, the overall accuracy generated by the flood model is estimated at 25.89%, with 51 points correctly matching the actual flood depths. In addition, there were 87 points estimated one level above and below the correct flood depths while there were 59 points and 0 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 33 points were overestimated while a total of 113 points were underestimated in the modelled flood depths of Catarman.Table 78 depicts the summary of the Accuracy Assessment in the Catarman River Basin Flood Depth Map.

Table 78. Summary of the Accuracy Assessment in the Catarman River Basin Survey.

| | No. of Points | % |
|---|---|---|
| Correct | 51 | 25.89 |
| Overestimated | 33 | 16.75 |
| Underestimated | 113 | 57.36 |
| Total | 197 | 100 |

# REFERENCES

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

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

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

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

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

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

# ANNEXES

## Annex 1. Technical Specifications of the LIDAR Sensors used in the Catarman Floodplain Survey

1. AQUARIUS SENSOR


Figure A-1.1. Aquarius Sensor

Table A-1.1. Parameters and Specifications of Aquarius Sensor

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

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

1. SMN-16

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

July 03, 2015

**CERTIFICATION**

To whom it may concern:

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

| | | |
|---|---|---|
| | Province: **NORTHERN SAMAR** | |
| | Station Name: **SMN-16** | |
| | Order: **2nd** | |
| Island: **VISAYAS** | Barangay: **BAGASBAS** | |
| Municipality: **MONDRAGON** | MSL Elevation: | |
| | ***PRS92 Coordinates*** | |
| Latitude: **12° 31' 32.33268"** | Longitude: **124° 48' 56.69485"** | Ellipsoidal Hgt: **5.45500 m.** |
| | ***WGS84 Coordinates*** | |
| Latitude: **12° 31' 27.72792"** | Longitude: **124° 49' 1.74020"** | Ellipsoidal Hgt: **63.99100 m.** |
| | ***PTM / PRS92 Coordinates*** | |
| Northing: **1385085.603 m.** | Easting: **479974.965 m.** | Zone: **5** |
| | ***UTM / PRS92 Coordinates*** | |
| Northing: **1,385,272.01** | Easting: **697,302.11** | Zone: **51** |

Location Description

SMN-1

Station Mark SMN-16 is located in Brgy. Bagasbas, Municipality of Mondragon, Province of Northern Samar, Island of Samar. to located the station, from Mondragon Town Proper, travel in North direction for about 10 km going to Brgy. Bagasbas. the station was established 30 m North from Bagasbas Elem. School, was about 1 m East of the Basketball court and 4 m west of the chapel.

Mark is the head of a 4" copper nail flushed in a 30X30 cm. cement block embedded in the ground protruding about 20 cm., with inscriptions "SMN-16; 2007; NAMRIA."

| | |
|---|---|
| Requesting Party: | **UP-DREAM** |
| Purpose: | **Reference** |
| OR Number: | **8084005 I** |
| T.N.: | **2015-1258** |

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

G

9 9 0 7 0 3 2 0 1 5 1 6 2 6 3 8

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

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

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.1. SMN-16

2. SMN-22

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

September 04, 2015

## CERTIFICATION

To whom it may concern:

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

| | | |
|---|---|---|
| | Province: **NORTHERN SAMAR** | |
| | Station Name: **SMN-22** | |
| | Order: **2nd** | |
| Island: **VISAYAS** | Barangay: **SIMORA** | |
| Municipality: **LAOANG** | MSL Elevation: | |
| | ***PRS92 Coordinates*** | |
| Latitude: **12° 28' 27.20633"** | Longitude: **125° 1' 25.36067"** | Ellipsoidal Hgt: **-1.70407 m.** |
| | ***WGS84 Coordinates*** | |
| Latitude: **12° 28' 22.63174"** | Longitude: **125° 1' 30.40861"** | Ellipsoidal Hgt: **57.47400 m.** |
| | ***PTM / PRS92 Coordinates*** | |
| Northing: **1379390.508 m.** | Easting: **502577.525 m.** | Zone: **5** |
| | ***UTM / PRS92 Coordinates*** | |
| Northing: **1,379,746.87** | Easting: **719,951.32** | Zone: **51** |

Location Description

SMN-22
From Laoang town proper, travel about 15 km. north going to Brgy. Simora. The monument is located inside the Elementary School, 5 m. east from the School's Entrance gate, 5 m. east from the school path way, 10 m. north from the school classroom, and 25 m. north from the chapel, where the station is located. Mark is the head of a 4" copper nail flushed in a 30X30 cm. cement block embedded in the ground protruding about 20 cm., with inscriptions "SMN-22; 2007; NAMRIA."

Requesting Party: **Christopher Cruz**
Purpose: **Reference**
OR Number: **8087193 I**
T.N.: **2015-2547**

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

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

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

NAMRIA OFFICES:
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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-2.2 SMN-22

3. SMN-12

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

July 03, 2015

## CERTIFICATION

To whom it may concern:

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

| | | |
|---|---|---|
| | Province: **NORTHERN SAMAR** | |
| | Station Name: **SMN-12** | |
| | Order: **2nd** | |
| Island: **VISAYAS** | Barangay: **POBLACION** | |
| Municipality: **SAN JOSE** | MSL Elevation: | |
| | ***PRS92 Coordinates*** | |
| Latitude: **12° 26' 15.70013"** | Longitude: **124° 19' 13.39605"** | Ellipsoidal Hgt: **7.02900 m.** |
| | ***WGS84 Coordinates*** | |
| Latitude: **12° 26' 11.07561"** | Longitude: **124° 19' 18.45344"** | Ellipsoidal Hgt: **64.58200 m.** |
| | ***PTM / PRS92 Coordinates*** | |
| Northing: **1375444.106 m.** | Easting: **426111.163 m.** | Zone: **5** |
| | ***UTM / PRS92 Coordinates*** | |
| Northing: **1,375,224.53** | Easting: **643,513.56** | Zone: **51** |

Location Description

From Rosario town proper going to Municipality of San Jose travel about 10 km. north. From the School Entrance Gate going to the monument is about 10 m. northwest, and from the School Stage going to the monument is about 2 m. east. From the Teacher's Lounge and Principal's Office up to the monument is about 5 m. south, where the monument was established. Mark is the head of a 4" copper nail flushed in a 30X30 cm. cement block embedded in the ground protruding about 20 cm., with inscriptions "SMN-12; 2007; NAMRIA."

Requesting Party: **UP-DREAM**
Purpose: **Reference**
OR Number: **8084005 I**
T.N.: **2015-1259**

**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

CIP/4701/12/09/814

Figure A-2.3 SMN-12

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

1. CMN-01

Table A-3.1. CMN-01

Processing Summary

| Observation | From | To | Solution Type | H. Prec. (Meter) | V. Prec. (Meter) | Geodetic Az. | Ellipsoid Dist. (Meter) | ΔHeight (Meter) |
|---|---|---|---|---|---|---|---|---|
| CMN-01 --- SMN-19 (B1) | SMN-19 | CMN-01 | Fixed | 0.004 | 0.018 | 261°10'06" | 19716.093 | 7.117 |
| CMN-01 --- SMN-19 (B2) | SMN-19 | CMN-01 | Fixed | 0.004 | 0.016 | 261°10'06" | 19716.092 | 7.056 |

Acceptance Summary

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

Vector Components (Mark to Mark)

| From: | SMN-19 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 697302.106 m | Latitude | N12°31'32.33268" | Latitude | N12°31'27.72792" |
| Northing | 1385272.014 m | Longitude | E124°48'56.69484" | Longitude | E124°49'01.74020" |
| Elevation | 8.997 m | Height | 5.456 m | Height | 63.991 m |

| To: | CMN-01 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 677840.326 m | Latitude | N12°29'53.60604" | Latitude | N12°29'48.99306" |
| Northing | 1382111.129 m | Longitude | E124°38'11.46535" | Longitude | E124°38'16.51471" |
| Elevation | 14.613 m | Height | 12.573 m | Height | 70.742 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | -19461.780 m | NS Fwd Azimuth | 261°10'06" | ΔX | 15632.874 m |
| ΔNorthing | -3160.884 m | Ellipsoid Dist. | 19716.093 m | ΔY | 11643.556 m |
| ΔElevation | 5.615 m | ΔHeight | 7.117 m | ΔZ | -2960.605 m |

Standard Errors

| Vector errors: | | | | | |
|---|---|---|---|---|---|
| σ ΔEasting | 0.002 m | σ NS fwd Azimuth | 0°00'00" | σ ΔX | 0.005 m |
| σ ΔNorthing | 0.002 m | σ Ellipsoid Dist. | 0.002 m | σ ΔY | 0.007 m |
| σ ΔElevation | 0.009 m | σ ΔHeight | 0.009 m | σ ΔZ | 0.003 m |

Aposteriori Covariance Matrix (Meter²)

| | X | Y | Z |
|---|---|---|---|
| X | 0.0000248767 | | |
| Y | -0.0000327811 | 0.0000524301 | |
| Z | -0.0000118537 | 0.0000172626 | 0.0000085902 |

2. NS-61

Table A-3.2. NS-61

Vector Components (Mark to Mark)

| From: | SMN-16 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 697302.106 m | Latitude | N12°31'32.33268" | Latitude | N12°31'27.72792" |
| Northing | 1385272.014 m | Longitude | E124°48'56.69484" | Longitude | E124°49'01.74020" |
| Elevation | 8.997 m | Height | 5.456 m | Height | 63.991 m |

| To: | NS-61 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 696390.555 m | Latitude | N12°31'17.86801" | Latitude | N12°31'13.26354" |
| Northing | 1384821.249 m | Longitude | E124°48'26.40323" | Longitude | E124°48'31.44902" |
| Elevation | 8.653 m | Height | 5.208 m | Height | 63.733 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | -911.551 m | NS Fwd Azimuth | 244°04'53" | ΔX | 695.978 m |
| ΔNorthing | -450.765 m | Ellipsoid Dist. | 1016.833 m | ΔY | 601.027 m |
| ΔElevation | -0.345 m | ΔHeight | -0.248 m | ΔZ | -433.971 m |

Standard Errors

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

Aposteriori Covariance Matrix (Meter²)

| | X | Y | Z |
|---|---|---|---|
| X | 0.0000012353 | | |
| Y | -0.0000007094 | 0.0000013533 | |
| Z | -0.0000003640 | 0.0000003117 | 0.0000005407 |

3. NS-100

Table A-3.3. NS-100

**Vector Components (Mark to Mark)**

| From: | SMN-12 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 661608.826 m | Latitude | N12°31'53.63572" | Latitude | N12°31'49.00197" |
| Northing | 1385703.370 m | Longitude | E124°29'14.55387" | Longitude | E124°29'19.60166" |
| Elevation | 6.138 m | Height | 4.666 m | Height | 62.383 m |

| To: | NS-100 | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 664407.825 m | Latitude | N12°31'15.60049" | Latitude | N12°31'10.97151" |
| Northing | 1384550.595 m | Longitude | E124°30'47.05130" | Longitude | E124°30'52.09977" |
| Elevation | 7.016 m | Height | 5.524 m | Height | 63.332 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | 2798.999 m | NS Fwd Azimuth | 112°42'26" | ΔX | -2445.519 m |
| ΔNorthing | -1152.775 m | Ellipsoid Dist. | 3027.308 m | ΔY | -1372.200 m |
| ΔElevation | 0.878 m | ΔHeight | 0.858 m | ΔZ | -1140.653 m |

**Standard Errors**

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

**Aposteriori Covariance Matrix (Meter²)**

| | X | Y | Z |
|---|---|---|---|
| X | 0.0000121100 | | |
| Y | -0.0000138874 | 0.0000200970 | |
| Z | -0.0000045007 | 0.0000060416 | 0.0000024172 |

4. SI-08

Table A-3.4. SI-08

**Vector Components (Mark to Mark)**

| From: | SMN22 AM | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 719951.311 m | Latitude | N12°28'27.20631" | Latitude | N12°28'22.63174" |
| Northing | 1379746.868 m | Longitude | E125°01'25.36070" | Longitude | E125°01'30.40861" |
| Elevation | 2.366 m | Height | -1.704 m | Height | 57.474 m |

| To: | SI08 AM | | | | |
|---|---|---|---|---|---|
| Grid | | Local | | Global | |
| Easting | 718234.000 m | Latitude | N12°29'56.60889" | Latitude | N12°29'52.02685" |
| Northing | 1382481.546 m | Longitude | E125°00'29.18987" | Longitude | E125°00'34.23576" |
| Elevation | 4.378 m | Height | 0.111 m | Height | 59.186 m |

| Vector | | | | | |
|---|---|---|---|---|---|
| ΔEasting | -1717.312 m | NS Fwd Azimuth | 328°18'36" | ΔX | 1728.971 m |
| ΔNorthing | 2734.678 m | Ellipsoid Dist. | 3228.557 m | ΔY | 488.293 m |
| ΔElevation | 2.012 m | ΔHeight | 1.815 m | ΔZ | 2682.497 m |

**Standard Errors**

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

**Aposteriori Covariance Matrix (Meter²)**

| | X | Y | Z |
|---|---|---|---|
| X | 0.0000134710 | | |
| Y | -0.0000157423 | 0.0000227334 | |
| Z | -0.0000044486 | 0.0000064680 | 0.0000024588 |

# Annex 4. The LiDAR Survey Team Composition

<table>
<tr><th>Data Acquisition Component Sub-Team</th><th>Designation</th><th>Name</th><th>Agency/ Affiliation</th></tr>
<tr><td>PHIL-LIDAR 1</td><td>Program Leader</td><td>ENRICO C. PARINGIT, D.ENG</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="2">Data Acquisition Component Leader</td><td>Data Component Project Leader - I</td><td>ENGR. CZAR JAKIRI SARMIENTO</td><td>UP-TCAGP</td></tr>
<tr><td>Data Component Project Leader – I</td><td>ENGR. LOUIE P. BALICANTA</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="3">Survey Supervisor</td><td>Chief Science Research Specialist (CSRS)</td><td>ENGR. CHRISTOPHER CRUZ</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="2">Supervising Science Research Specialist (Supervising SRS)</td><td>LOVELY GRACIA ACUÑA</td><td>UP-TCAGP</td></tr>
<tr><td>LOVELYN ASUNCION</td><td>UP-TCAGP</td></tr>
<tr><td colspan="4">FIELD TEAM</td></tr>
<tr><td rowspan="2">LiDAR Operation</td><td>Senior Science Research Associate (SSRS)</td><td>PAULINE JOANNE ARCEO</td><td>UP-TCAGP</td></tr>
<tr><td>RA</td><td>ENGR. MILLIE SHANE REYES<br>MARY CATHERINE ELIZABETH BALIGUAS<br>JONALYN GONZALES<br>MA. VERLINA TONGA</td><td>UP-TCAGP</td></tr>
<tr><td>Ground Survey, Data Download and Transfer</td><td>RA</td><td>JONATHAN ALMALVEZ<br>IRO NIEL ROXAS</td><td>UP-TCAGP</td></tr>
<tr><td rowspan="3">LiDAR Operation</td><td>Airborne Security</td><td>SSG RAYMUND DOMINE<br>SSG JOHN ERIC CACANINDIN<br>CAPT. CESAR SHERWIN ALFONSO</td><td>PHILIPPINE AIR FORCE (PAF)</td></tr>
<tr><td rowspan="2">Pilot</td><td>CAPT. RANDY LAGCO<br>CAPT. FERDINAND DE OCAMPO</td><td>ASIAN AEROSPACE CORPORATION (AAC)</td></tr>
<tr><td>CAPT. NIEL ACHILLES AGAWIN</td><td>AAC</td></tr>
</table>

Table A-4.1. The LiDAR Survey Team Composition

# Annex 5. Data Transfer Sheet for Catarman Floodplain

DATA TRANSFER SHEET
Catarman 9/16/15

| DATE | FLIGHT NO. | MISSION NAME | SENSOR | RAW LAS | | LOGS(MB) | POS | RAW IMAGES/CASI | MISSION LOG FILE/CASI LOGS | RANGE | DIGITIZER | BASE STATION(S) | | OPERATOR LOGS (OPLOG) | FLIGHT PLAN | | SERVER LOCATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Output LAS | KML (swath) | | | | | | | BASE STATION(S) | Base Info (.txt) | | Actual | KML | |
| 23-Aug | 8180AC | 3BLK33R235A | aquarius | na | 254 | 519 | 212 | 70.2 | 2.17/26.9 | 10.6 | 64.9 | 9.67 | 1KB | 1KB | 3 | 8 | Z:\DAC\RAW DATA |
| 24-Aug | 8182AC | 3BLK33R236A | aquarius | na | 207 | 451 | 213 | na | na | 9.06 | 104 | 12.5 | 1KB | 1KB | 5 | 207 | Z:\DAC\RAW DATA |
| 24-Aug | 8183AC | 3BLK33STV236B | aquarius | na | 334 | 305 | 152 | ~~114~~ 39.2 | ~~39.2~~ 114 | 5.81 | 35.1 | 12.5 | 1KB | 1KB | 5 | na | Z:\DAC\RAW DATA |
| 25-Aug | 8184AC | 3BLK33PS2237A | aquarius | na | 62 | 173 | 109 | 14.7 | 47.7/31.1 | 2.97 | 12.6 | 9.59 | 1KB | 1KB | 4 | 11 | Z:\DAC\RAW DATA |
| 25-Aug | 8185AC | 3BUNDLEADJUSTMENT237B | aquarius | na | 40 | 108 | 74.1 | 11.5 | 109/87.3 | 2.04 | 11 | 9.59 | 1KB | 1KB | 4 | 7 | Z:\DAC\RAW DATA |
| 26-Aug | 8186AC | 3BLK33SPST238A | aquarius | na | 222 | 555 | 250 | 64.5 | 219 | 6.73 | 12.8 | 9.12 | 1KB | 1KB | 12 | 29 | Z:\DAC\RAW DATA |
| 27-Aug | 8188AC | 3BLK33S239A | aquarius | na | 85 | 200 | 115 | 22.2 | 88.6 | 3.93 | 19.8 | 3.23 | 1KB | 1KB | 4 | 107 | Z:\DAC\RAW DATA |
| 28-Aug | 8190AC | 3BLK33CD240A | aquarius | na | 273 | 460 | 222 | 59.9 | na | 8.77 | 25.3 | 7 | 1KB | 1KB | 6/5 | 14 | Z:\DAC\RAW DATA |

Received from

Name C. Joaquin
Position RA
Signature

Received by

Name JOIDA F. PRIETO
Position SSRS
Signature 09/16/15

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

DATA TRANSFER SHEET
catarman 9/8/2015

| 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 | |
| 1-Aug | 8137 | CASILCTF213A | aquarius | na | 63 | 159 | 73.2 | 13.7 | 80.9 | 3.13 | na | 1.79 | 1KB | 1KB | 5 | NA | Z:\DAC\RAW DATA |
| 4-Aug | 8142 | AQUALCTF216A | aquarius | na | 36 | 140 | 101 | na | na | 2.2 | 8.44 | 21.4 | 1KB | 1KB | 3/4 | NA | Z:\DAC\RAW DATA |
| 10-Aug | 8154 | 3BLK331NO222A | aquarius | na | 235 | 505 | 185 | na | na | 9.78 | 68 | 27.1 | 1KB | 1KB | 11/14 | NA | Z:\DAC\RAW DATA |
| 11-Aug | 8156 | 3BLK331LNS223A | aquarius | na | 271 | 1.02 | 217 | na | na | 11.4 | 77.4 | 32.8 | 1KB | 1KB | 11 | 22 | Z:\DAC\RAW DATA |
| 11-Aug | 8157 | 3BLK331NS223B | aquarius | na | 205 | 1.01 | 169 | na | na | 14 | 26.3 | 34.9 | 1KB | 1KB | 6 | NA | Z:\DAC\RAW DATA |
| 12-Aug | 8158 | 3BLK331P224A | aquarius | na | 299 | 635 | 217 | na | na | 12.4 | 51.6 | 49.3 | 1KB | 1KB | 16 | 42 | Z:\DAC\RAW DATA |
| 12-Aug | 8159 | 3BLK331NSPS224B | aquarius | na | 135 | 943 | 77.3 | na | na | 6.12 | 37.4 | 49.3 | 1KB | 1KB | 16 | NA | Z:\DAC\RAW DATA |
| 13-Aug | 8160 | 3BLK331PQRS225A | aquarius | na | 122 | 264 | 149 | na | na | 5.68 | 30.4 | 12.6 | 1KB | 1KB | 15 | 122 | Z:\DAC\RAW DATA |

Received from

Name O. JOAQUIN
Position RA
Signature

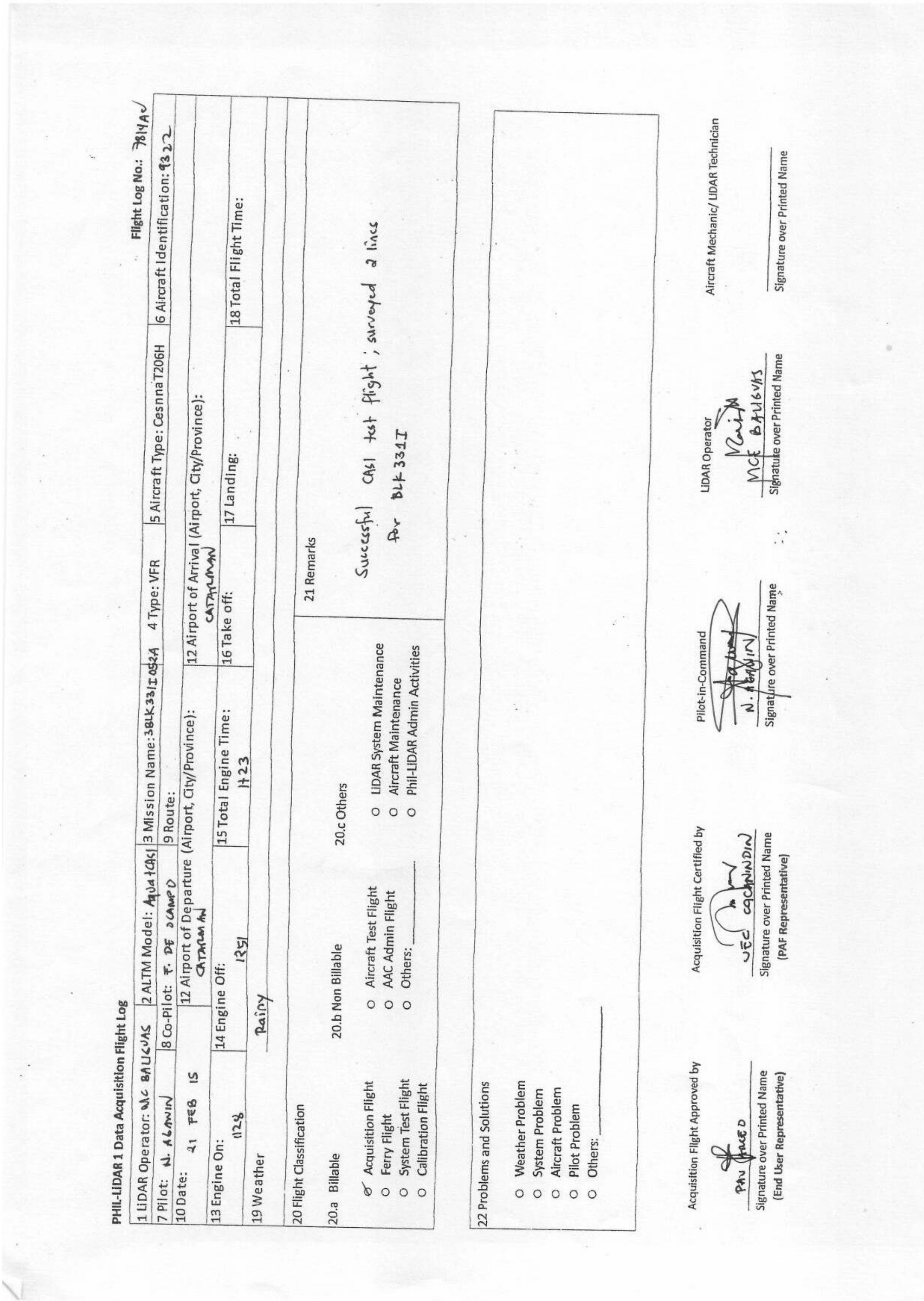
Received by

Name JOIDA F. PRIETO
Position SSRS 9/8/15
Signature

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

# Annex 6. Flight logs for the flight missions

1. Flight Log for 7814AC Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7814AC

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: MC BALUGAS | 2 ALTM Model: Aquarius | 3 Mission Name: 3BLK33I052A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N. ALMAIN | 8 Co-Pilot: F. DE OCAMPO | 9 Route: | | | |
| 10 Date: 21 FEB 15 | 12 Airport of Departure (Airport, City/Province): CATARMAN | | 12 Airport of Arrival (Airport, City/Province): CATARMAN | | |
| 13 Engine On: 1128 | 14 Engine Off: 1351 | 15 Total Engine Time: 1+23 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: Rainy | | | | | |

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 CASI test flight; surveyed 2 lines for BLK 33I

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

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

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

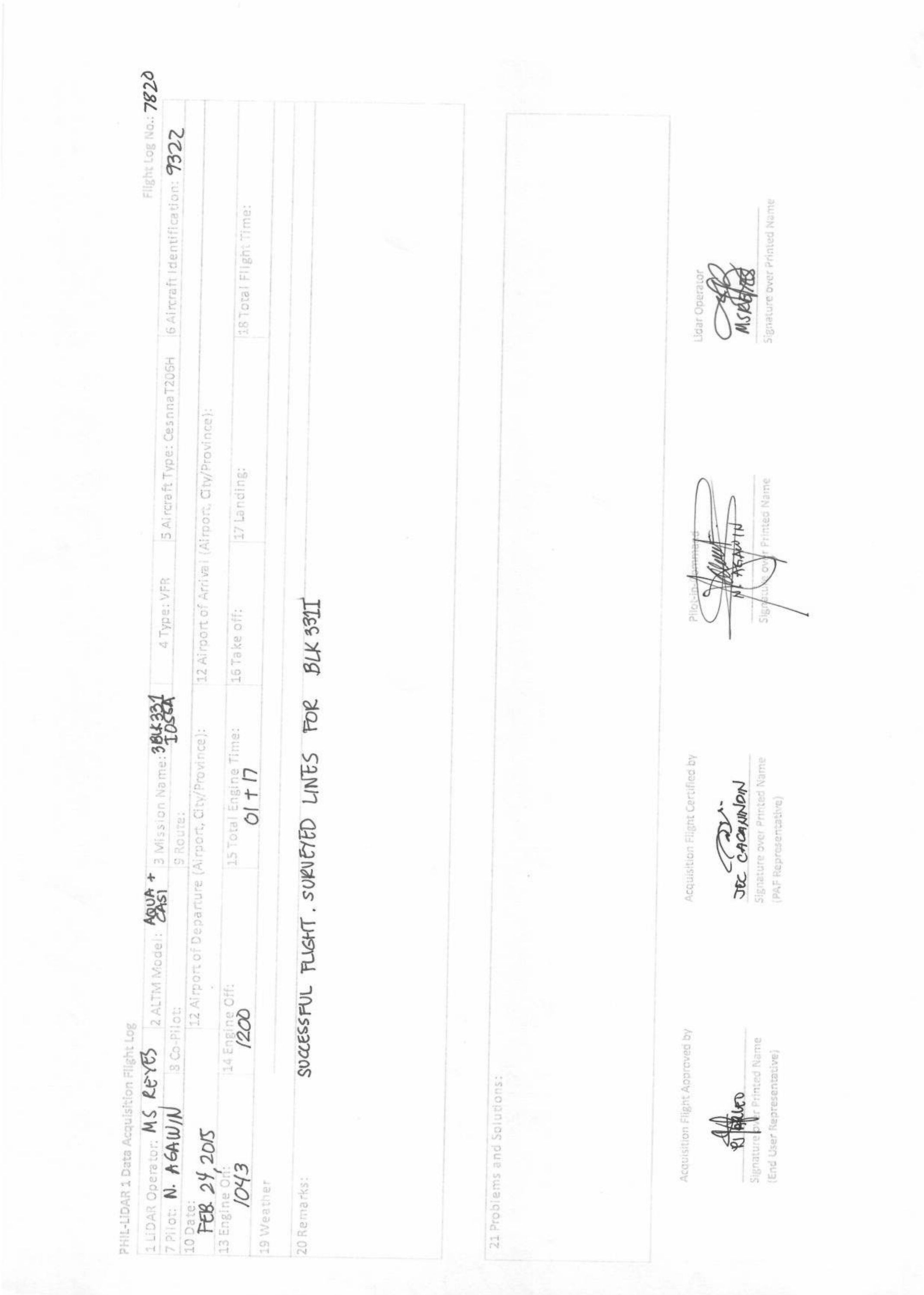
Pilot-in-Command: N. ALMAIN — Signature over Printed Name

LIDAR Operator: MCE BALUGAS — Signature over Printed Name

Aircraft Mechanic/ LIDAR Technician — Signature over Printed Name

Figure A-6.1. Flight Log for Mission 7814AC

2. Flight Log for 7820AC Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7820

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: MS REYES | 2 ALTM Model: AQUA + CASI | 3 Mission Name: 3BLK33I I055A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N. AGAWIN | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: FEB 24, 2015 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 1043 | 14 Engine Off: 1200 | 15 Total Engine Time: 01 + 17 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |
| 20 Remarks: SUCCESSFUL FLIGHT. SURVEYED LINES FOR BLK 33I | | | | | |
| 21 Problems and Solutions: | | | | | |

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| RJ Taluyo | JEC CACANINDIN | N. AGAWIN | MS REYES |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name |

Figure A-6.2. Flight Log for Mission 7820AC

3. Flight log for 7822AC Mission


PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7822

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: MC BALIGUAS | 2 ALTM Model: AQUA+CAST | 3 Mission Name: 3BLK331I056A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N AGAWIN | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: FEB 25 2015 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 0857 | 14 Engine Off: 1250 | 15 Total Engine Time: 03+53 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |
| 20 Remarks: SUCCESSFUL FLIGHT. SURVEYED LINES FOR BLK331I | | | | | |
| 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 — N AGAWIN — Signature over Printed Name

Lidar Operator — MC BALIGUAS — Signature over Printed Name

Figure A-6.3. Flight Log for Mission 7822AC

4. Flight Log for 7824AC Mission

PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7824

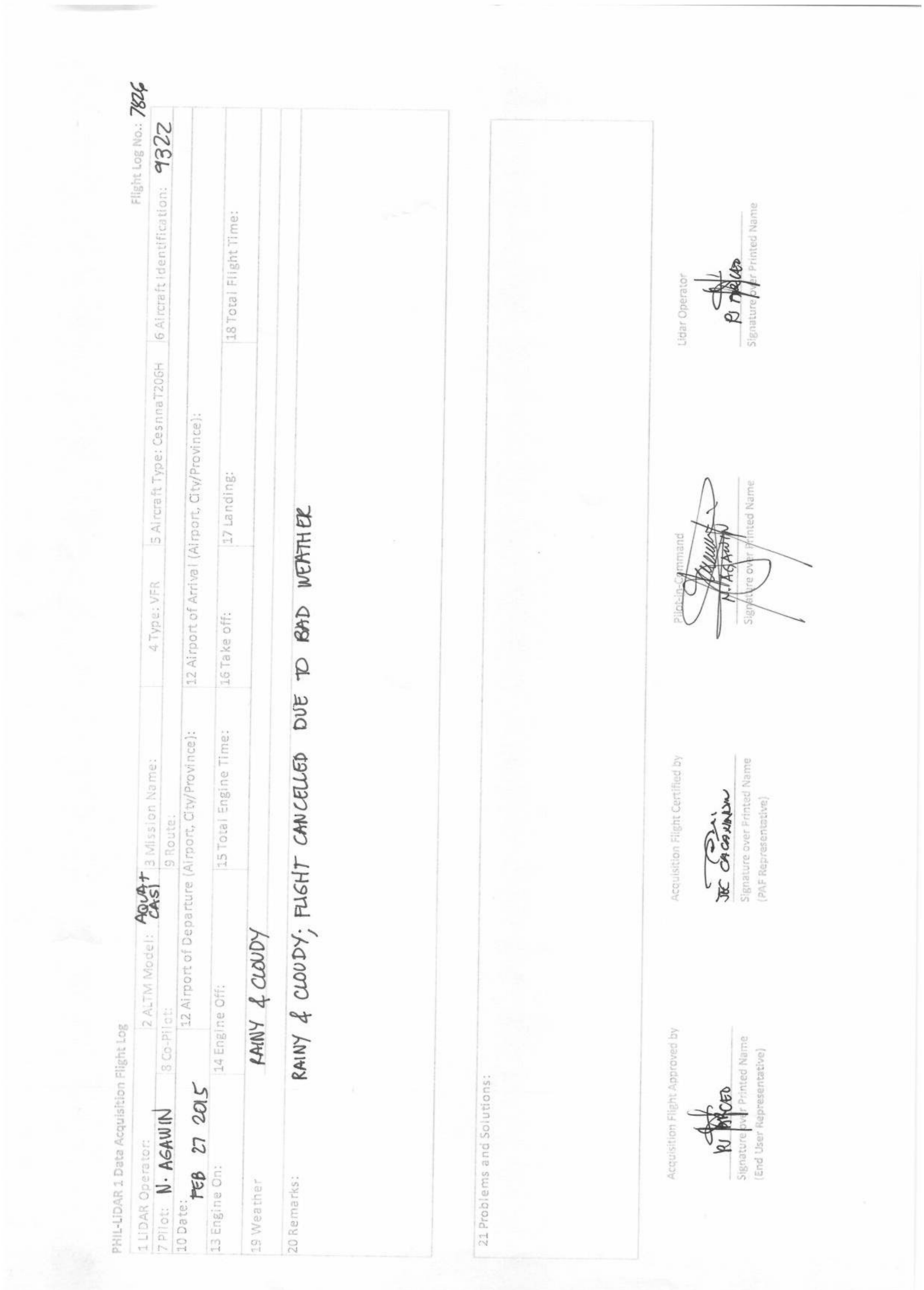
| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: MC BALIGUAS | 2 ALTM Model: AQUA + CASI | 3 Mission Name: 3BLK331 H057A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N. AGAWIN | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: FEB 26 2015 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 0704 | 14 Engine Off: 1015 | 15 Total Engine Time: 03+11 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | STRONG WINDS | | | | |
| 20 Remarks: | SUCCESSFUL FLIGHT. SURVEYED LINES FOR BLK 331H | | | | |

21 Problems and Solutions:

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator |
|---|---|---|---|
| RJ ARCES | JC SALCANINON | N. AGAWIN | MC BALIGUAS |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name |

Figure A-6.4. Flight Log for Mission 7824AC

5. Flight Log for 7826AC Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7826

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: | 2 ALTM Model: AQUA + CASI | 3 Mission Name: | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N. AGAWIN | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: FEB 27 2015 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: | 14 Engine Off: | 15 Total Engine Time: | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | RAINY & CLOUDY | | | | |
| 20 Remarks: | RAINY & CLOUDY; FLIGHT CANCELLED DUE TO BAD WEATHER | | | | |

21 Problems and Solutions:

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

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

Pilot-in-Command
Signature over Printed Name

Lidar Operator
Signature over Printed Name

Figure A-6.5. Flight Log for Mission 7826AC

6. Flight Log for 7828AC Mission

PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7828

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: RJ ARCEO | 2 ALTM Model: AQUA + CASI | 3 Mission Name: 3BLK331J038A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N. AGAWIN | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: FEB 28, 2015 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 0640 | 14 Engine Off: 1033 | 15 Total Engine Time: 03+53 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |
| 20 Remarks: | SUCCESSFUL FLIGHT. SURVEYED LINES FOR BLK 331J | | | | |

21 Problems and Solutions:

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

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

Pilot-in-Command: N AGAWIN — Signature over Printed Name

Lidar Operator: RJ ARCEO — Signature over Printed Name

Figure A-6.6. Flight Log for Mission 7828AC

7. Flight Log for 7829A Mission


PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7830

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: M S REYES | 2 ALTM Model: AQUA + CASI | 3 Mission Name: 3BLK331 HSO060A | 4 Type: VFR | 5 Aircraft Type: Cessna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N. AGAWIN | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: MARCH 01, 2015 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 0745 | 14 Engine Off: 1144 | 15 Total Engine Time: 03+59 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |

20 Remarks: SUCCESSFUL FLIGHT. SURVEYED LINES FOR BLK 331H & BLK 331O

21 Problems and Solutions:

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

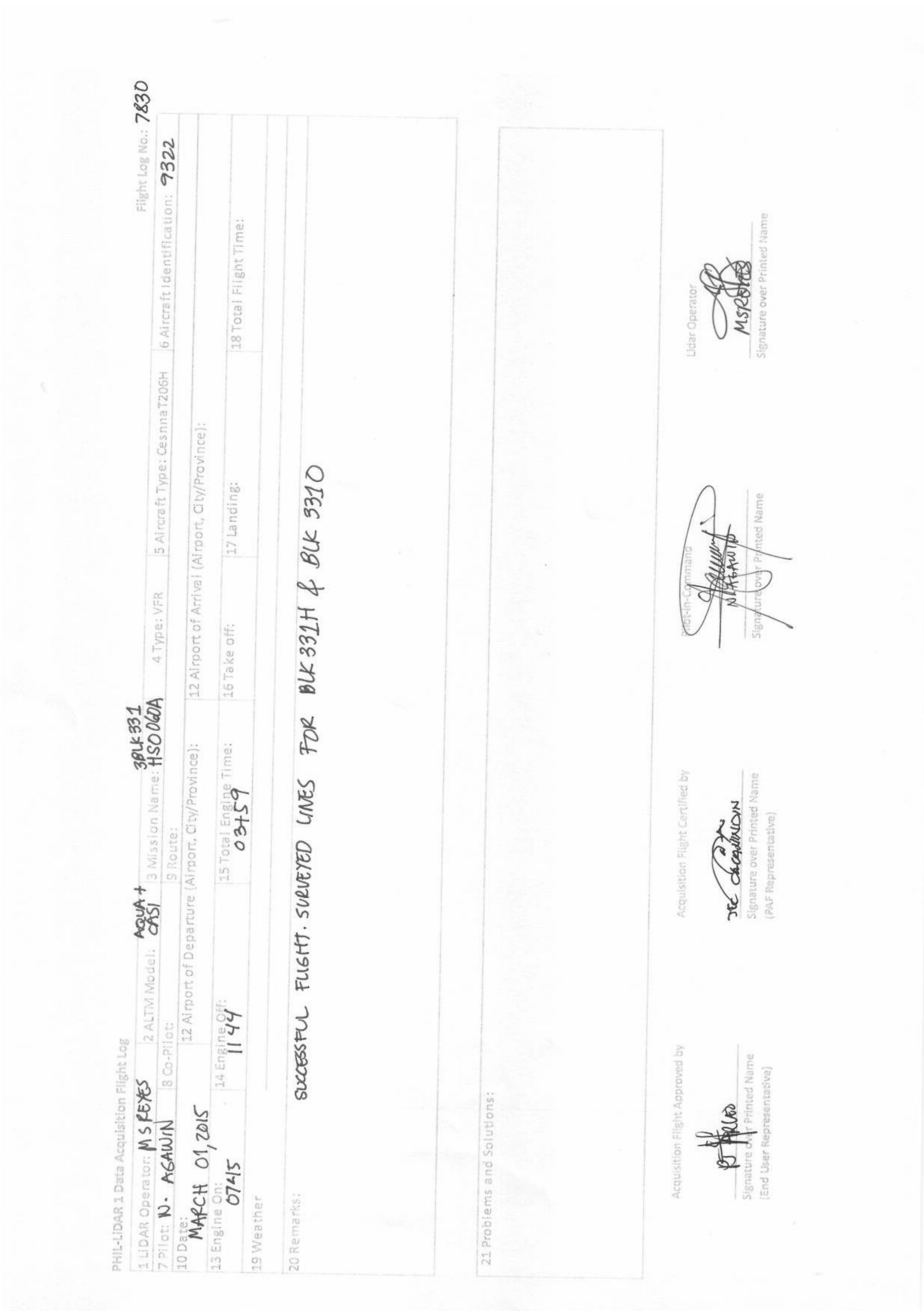
Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

Figure A-6.7. Flight Log for Mission 7829A

8. Flight Log for 7839AC Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7830

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: M S REYES | 2 ALTM Model: AQUA + CASI | 3 Mission Name: 3BLK331HSO060A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N. AGAWIN | 8 Co-Pilot: | 9 Route: | | | |
| 10 Date: MARCH 01, 2015 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 0745 | 14 Engine Off: 1144 | 15 Total Engine Time: 03+59 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | | | | | |

20 Remarks:

SUCCESSFUL FLIGHT. SURVEYED LINES FOR BLK 331H & BLK 331O

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
N. AGAWIN
Signature over Printed Name

Lidar Operator
M S REYES
Signature over Printed Name

Figure A-6.8. Flight Log for Mission 7839AC

9. Flight Log for 7834AC Mission

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

Flight Log No.: 7834AC

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: MC BALIGUAS | 2 ALTM Model: AQUA (CAS) | 3 Mission Name: | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N. AGAWIN | 8 Co-Pilot: R. LAGCO | 9 Route: | | | |
| 10 Date: 3 MAR 15 | 12 Airport of Departure (Airport, City/Province): CATARMAN | | 12 Airport of Arrival (Airport, City/Province): CATARMAN | | |
| 13 Engine On: 0428 | 14 Engine Off: 0909 | 15 Total Engine Time: 2+41 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | cloudy | | | | |

20 Flight Classification

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

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

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

21 Remarks

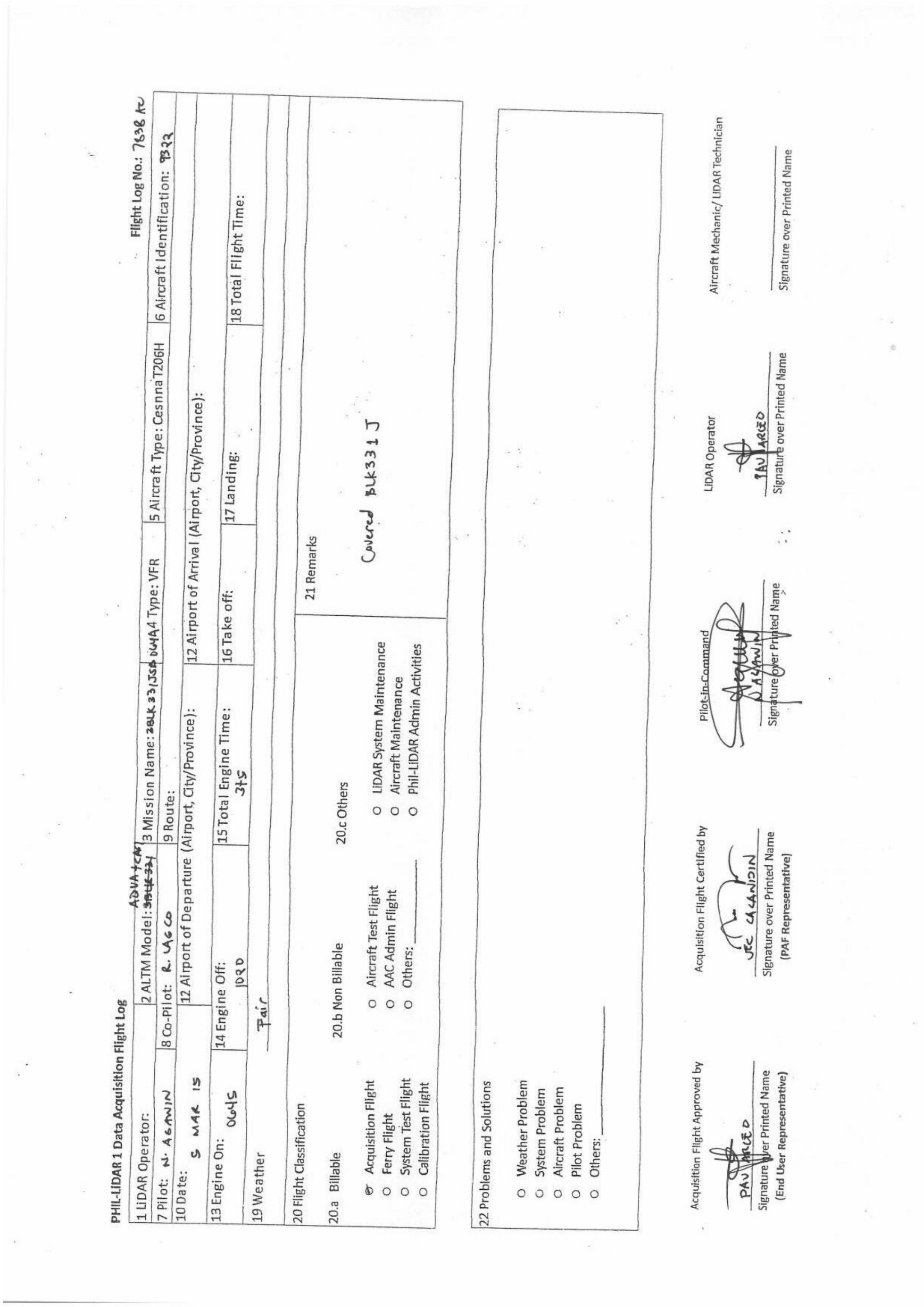
Covered BLK33IH & K

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

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | LIDAR Operator | Aircraft Mechanic/ LIDAR Technician |
|---|---|---|---|---|
| PAU ARGO | JEK CACANINDIN | N AGAWIN | MCE BALIGUAS | |
| 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 Mission 7834AC

10. Flight Log for 7838AC Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7838 AC

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: | 2 ALTM Model: ~~3BLK33J~~ ADVA+CAT | 3 Mission Name: 2BLK33/JSA 064A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N. AGAWIN | 8 Co-Pilot: R. LAGCO | 9 Route: | | | |
| 10 Date: 5 MAR 15 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: 0645 | 14 Engine Off: 1020 | 15 Total Engine Time: 3+5 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: Fair | | | | | |

20 Flight Classification

20.a Billable
- Acquisition Flight (checked)
- Ferry Flight
- System Test Flight
- Calibration Flight

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

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

21 Remarks

Covered BLK331J

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 |
|---|---|---|---|---|
| PAU ARCEO | JRC CACANINDIN | N AGAWIN | PAU ARCEO | |
| 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 Mission 7838AC

11. Flight Log for 7839AC Mission

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

Flight Log No.: 7839AC

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: MS REYES | 2 ALTM Model: AQUARIUS | 3 Mission Name: 3BLK33160648 | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: |
| 7 Pilot: N. AGAWIN | 8 Co-Pilot: R. LACSO | 9 Route: | | | |
| 10 Date: 5 MAR 15 | 12 Airport of Departure (Airport, City/Province): | | 12 Airport of Arrival (Airport, City/Province): | | |
| 13 Engine On: ~~0645~~ 1202 | 14 Engine Off: ~~1022~~ 1407 | 15 Total Engine Time: ~~3+35~~ 2+05 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 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

Covered BLK331G

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 |
|---|---|---|---|---|
| PJ ARCEO | JEC CASANINDIN | N AGAWIN | MS REYES | |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name | Signature over Printed Name |

Figure A-6.11. Flight Log for Mission 7839AC

## 12. Flight Log for 7842AC Mission

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

Flight Log No.: 7842AC

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: MS REYES | 2 ALTM Model: AQUA+CASI | 3 Mission Name: 3BLK33IJS066A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: N. ACAYAN | 8 Co-Pilot: R. LAGCO | 9 Route: | | | |
| 10 Date: 7 MAR 15 | 12 Airport of Departure (Airport, City/Province): CATARMAN | | 12 Airport of Arrival (Airport, City/Province): CATARMAN | | |
| 13 Engine On: 0619 | 14 Engine Off: 1024 | 15 Total Engine Time: 4+05 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather: windy | | | | | |

**20 Flight Classification**

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

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

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

**21 Remarks**

Covered BLK 33IJ; strong winds

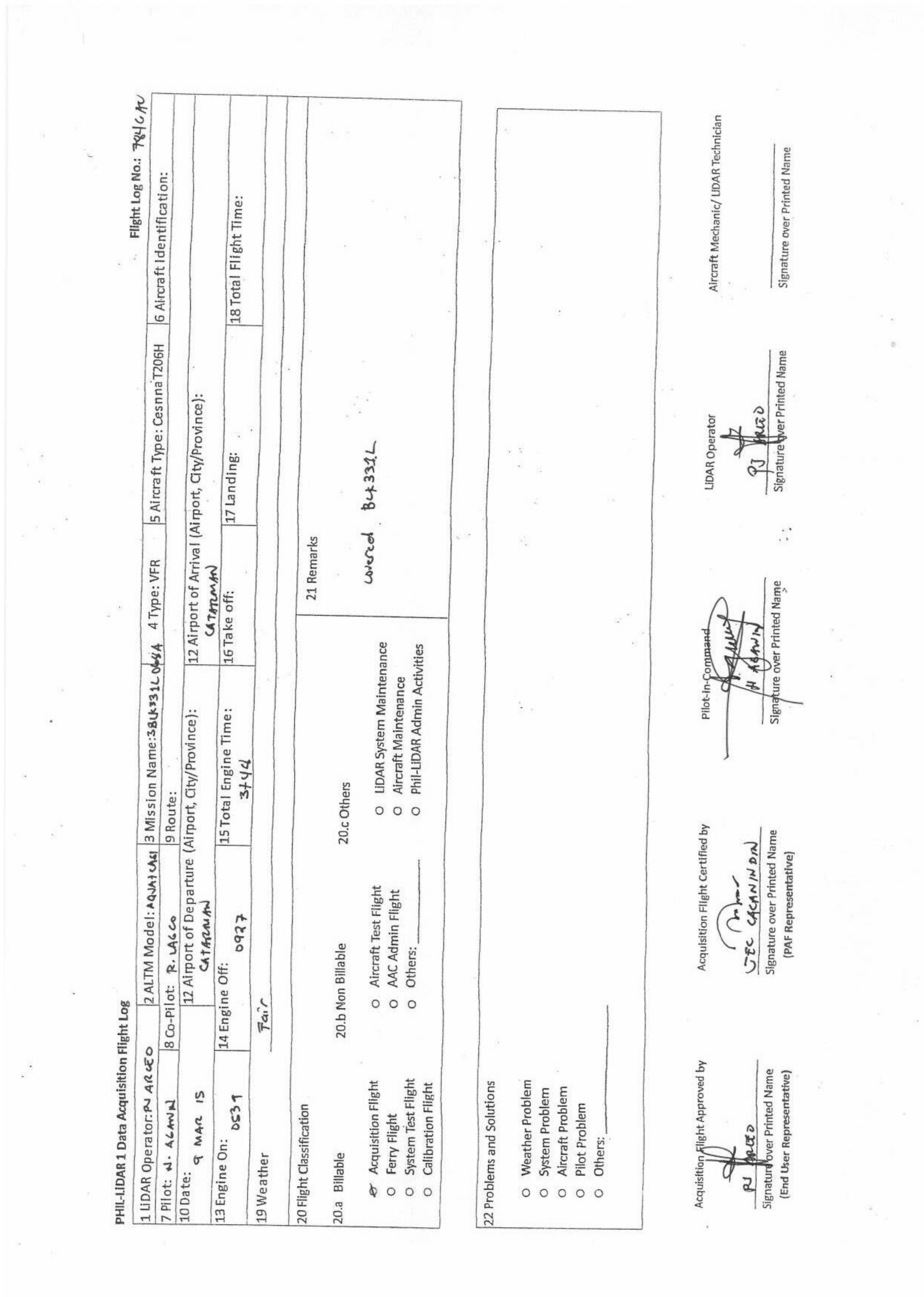
**22 Problems and Solutions**

- ○ 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 |
|---|---|---|---|---|
| PJ ARGO | JEC ACANINDIN | N. ACAYAN | MS REYES | |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name | Signature over Printed Name |

Figure A-6.12. Flight Log for Mission 7842AC

13. Flight Log for 7846AC Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 7846AC

| | | | | | |
|---|---|---|---|---|---|
| 1 LIDAR Operator: PJ ARCEO | 2 ALTM Model: AQUARIUS | 3 Mission Name: 3BLK331L068A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: |
| 7 Pilot: N. AGAWIN | 8 Co-Pilot: R. LAGCO | 9 Route: | | | |
| 10 Date: 9 MAR 15 | 12 Airport of Departure (Airport, City/Province): CATARMAN | | 12 Airport of Arrival (Airport, City/Province): CATARMAN | | |
| 13 Engine On: 0539 | 14 Engine Off: 0927 | 15 Total Engine Time: 3+44 | 16 Take off: | 17 Landing: | 18 Total Flight Time: |
| 19 Weather | Fair | | | | |

20 Flight Classification

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

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

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

21 Remarks

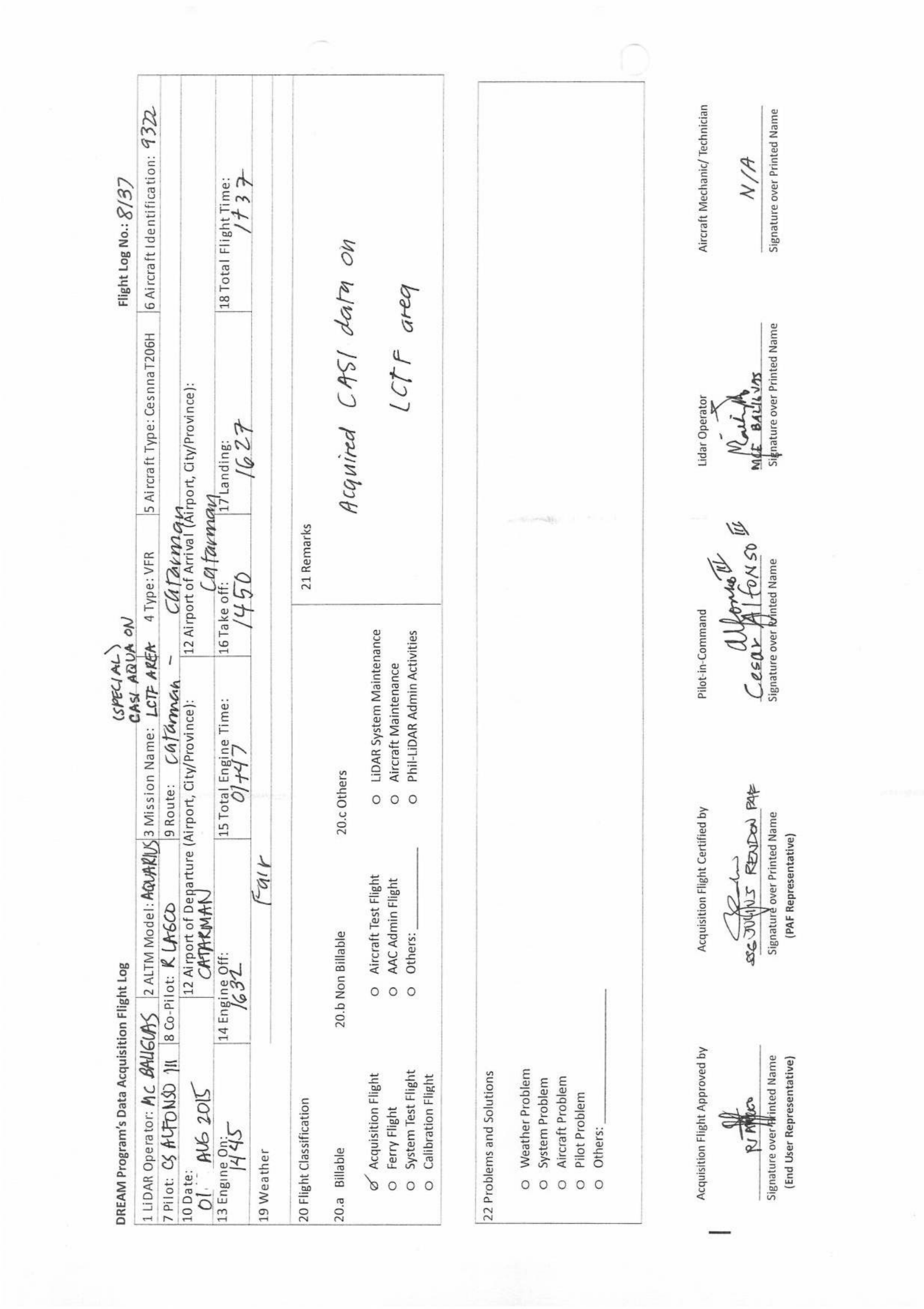
covered BLK331L

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

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | LIDAR Operator | Aircraft Mechanic/ LIDAR Technician |
|---|---|---|---|---|
| PJ ARCEO | JEC CACANINDIN | N AGAWIN | PJ ARCEO | |
| Signature over Printed Name (End User Representative) | Signature over Printed Name (PAF Representative) | Signature over Printed Name | Signature over Printed Name | Signature over Printed Name |

Figure A-6.13. Flight Log for Mission 7846AC

14. Flight Log for 8137AC Mission



DREAM Program's Data Acquisition Flight Log

Flight Log No.: 8137

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: MC BALIGUAS | 2 ALTM Model: AQUARIUS | 3 Mission Name: (SPECIAL) CASI AQUA ON LCTF AREA | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: CS ALFONSO III | 8 Co-Pilot: R LAGCO | 9 Route: Catarman - Catarman | | | |
| 10 Date: 01 AUG 2015 | 12 Airport of Departure (Airport, City/Province): CATARMAN | | 12 Airport of Arrival (Airport, City/Province): Catarman | | |
| 13 Engine On: 1445 | 14 Engine Off: 1632 | 15 Total Engine Time: 01+47 | 16 Take off: 1450 | 17 Landing: 1627 | 18 Total Flight Time: 1+37 |
| 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

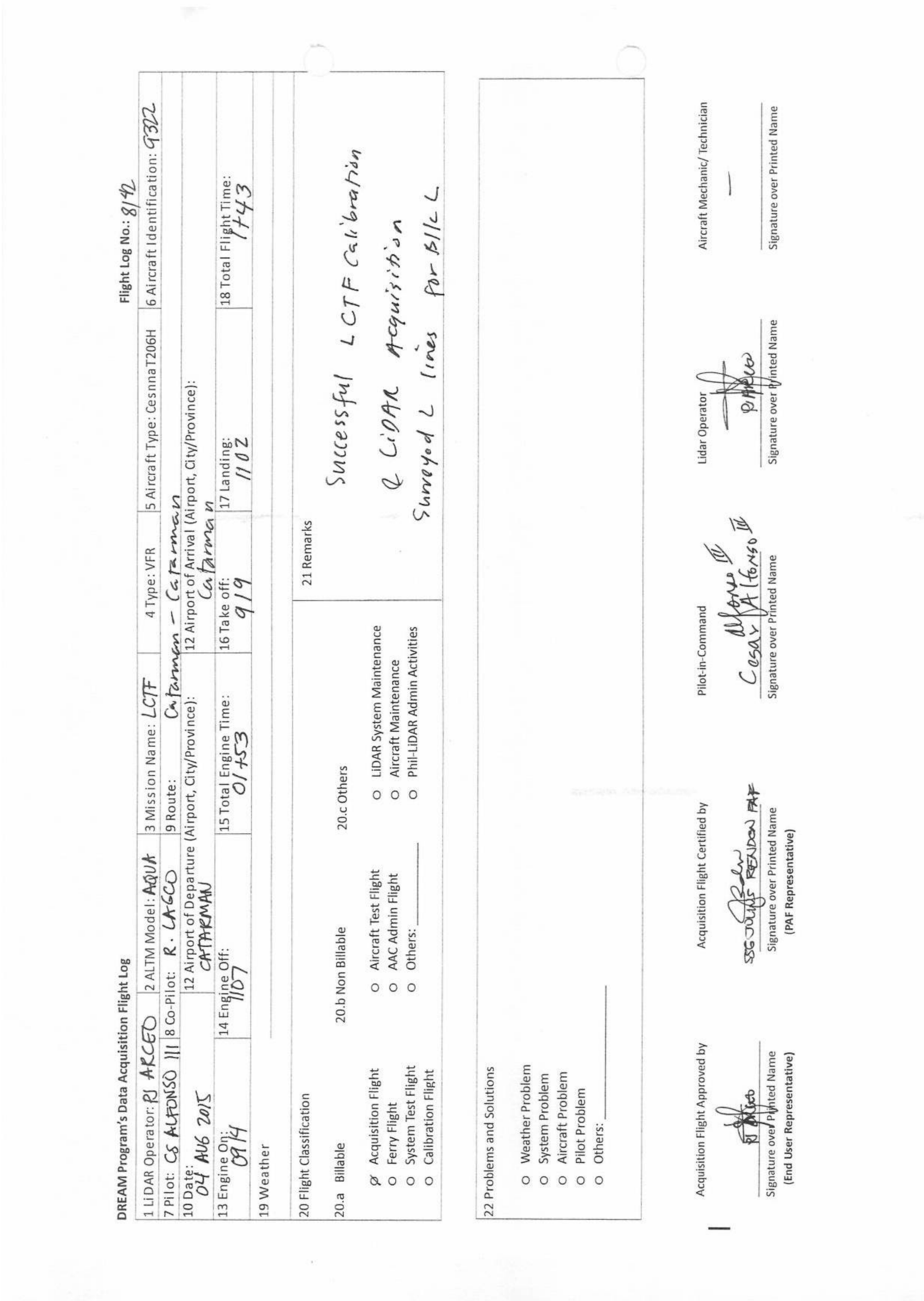
Acquired CASI data on LCTF area

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

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator | Aircraft Mechanic/ Technician |
|---|---|---|---|---|
| RJ ANGCO | SSG JULIUS RENDON PAF | Cesar Alfonso III | MCE BALIGUAS | N/A |
| 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-6.14. Flight Log for Mission 8137AC

## 15. Flight Log for 8142AC Mission



DREAM Program's Data Acquisition Flight Log

Flight Log No.: 8142

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: RJ ARCEO | 2 ALTM Model: AQUA | 3 Mission Name: LCTF | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: CS ALFONSO III | 8 Co-Pilot: R. LAGCO | 9 Route: Catarman - Catarman | | | |
| 10 Date: 04 AUG 2015 | 12 Airport of Departure (Airport, City/Province): CATARMAN | | 12 Airport of Arrival (Airport, City/Province): Catarman | | |
| 13 Engine On: 0914 | 14 Engine Off: 1107 | 15 Total Engine Time: 01+53 | 16 Take off: 919 | 17 Landing: 1102 | 18 Total Flight Time: 1+43 |
| 19 Weather | | | | | |

20 Flight Classification

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

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

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

21 Remarks

Successful LCTF Calibration & LiDAR Acquisition Surveyed 2 lines for Blk L

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

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

Acquisition Flight Certified by: SSG JULIUS RENDON PAF — Signature over Printed Name (PAF Representative)

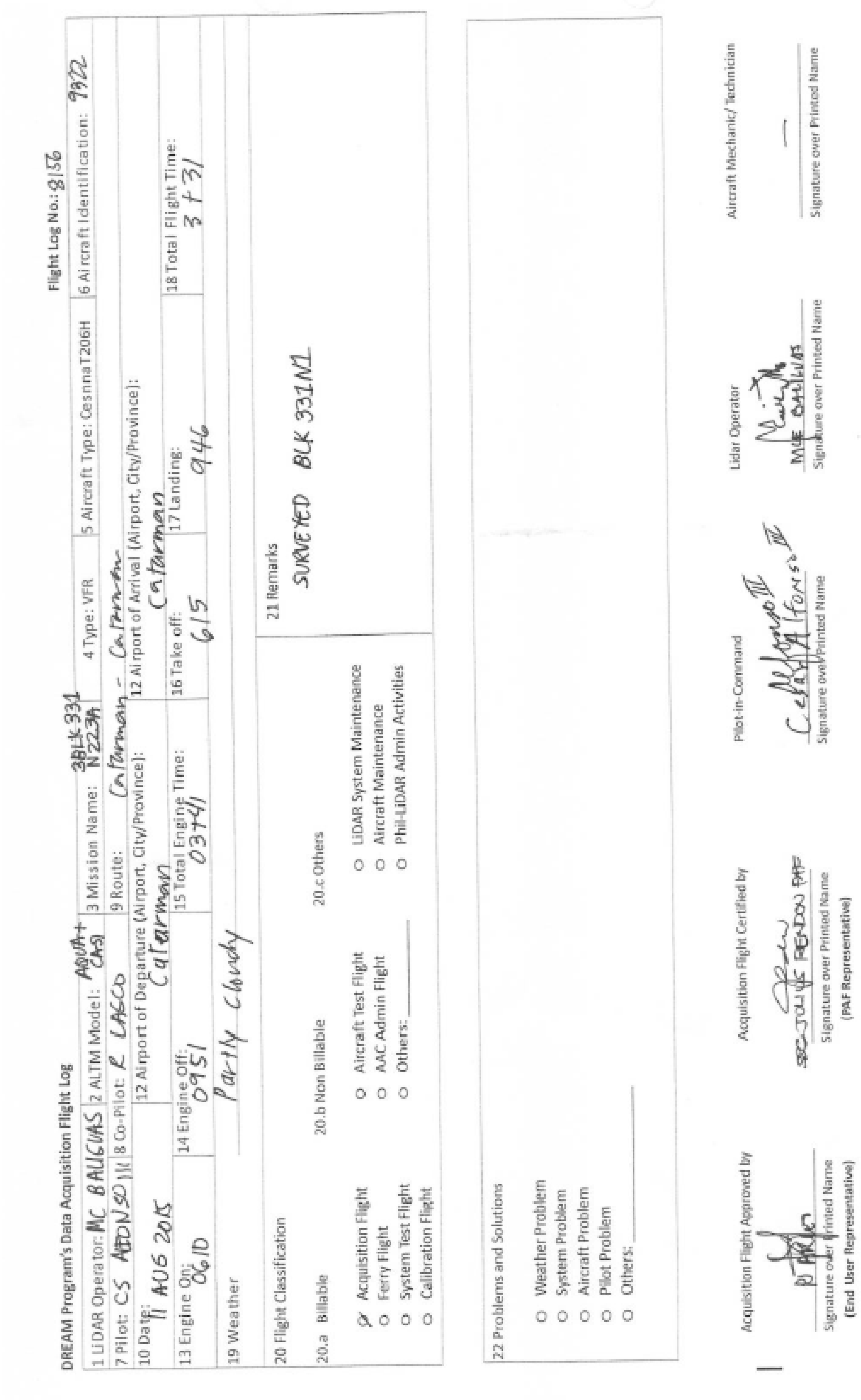
Pilot-in-Command: Cesar Alfonso III — Signature over Printed Name

Lidar Operator: Signature over Printed Name

Aircraft Mechanic/ Technician: — Signature over Printed Name

Figure A-6.15. Flight Log for Mission 8142AC

16. Flight Log for 8156AC Mission


DREAM Program's Data Acquisition Flight Log

Flight Log No.: 8156

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: MC BALICUAS | 2 ALTM Model: AQUA+ CASI | 3 Mission Name: 3BLK 331 N223A | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: CS ALFONSO III | 8 Co-Pilot: R LASCO | 9 Route: Catarman - Catarman | | | |
| 10 Date: 11 AUG 2015 | 12 Airport of Departure (Airport, City/Province): Catarman | | 12 Airport of Arrival (Airport, City/Province): Catarman | | |
| 13 Engine On: 0610 | 14 Engine Off: 0951 | 15 Total Engine Time: 03+41 | 16 Take off: 615 | 17 Landing: 946 | 18 Total Flight Time: 3+31 |
| 19 Weather | Partly 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 331N1

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

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | Lidar Operator | Aircraft Mechanic/ Technician |
|---|---|---|---|---|
| BJ ARCE | SSG JOLLIUS RENDON PAF | CESAR ALFONSO III | MCE BALICUAS | |
| 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-6.16. Flight Log for Mission 8156AC

17. Flight Log for 8183AC Mission

**Data Acquisition Flight Log**

Flight Log No.: 8183AC

| | | | | |
|---|---|---|---|---|
| 1 LiDAR Operator: MV Tonga | 2 ALTM Model: Aqua+C | 3 Mission Name: 3BLK33STY236B | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: RP-C9322 |
| 7 Pilot: C. Alfonso III | 8 Co-Pilot: R. Lagco | 9 Route: Catarman – Catarman | | | |
| 10 Date: Aug 24, 2015 | 12 Airport of Departure (Airport, City/Province): Catarman | | 12 Airport of Arrival (Airport, City/Province): Catarman | | |
| 13 Engine On: 1120H | 14 Engine Off: 1401H | 15 Total Engine Time: 2+41 | 16 Take off: 1125H | 17 Landing: 1306H | 18 Total Flight Time: 2+31 |
| 19 Weather: FAIR | | | | | |

**20 Flight Classification**

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

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

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

**21 Remarks**

Surveyed BLK 33TY

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

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

Acquisition Flight Certified by: SSG JULIUS RENDON PAF — Signature over Printed Name (PAF Representative)

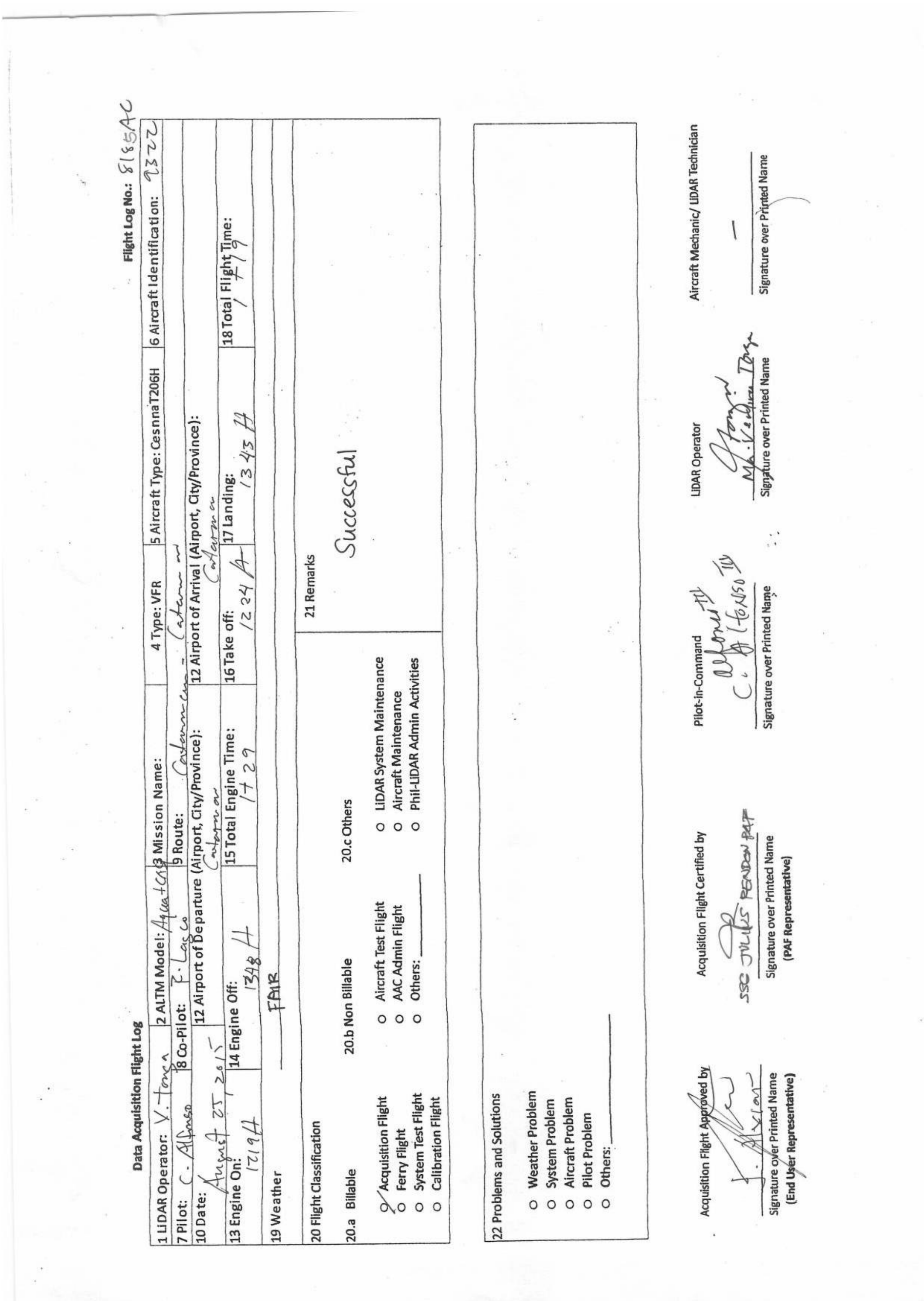
Pilot-in-Command: C. ALFONSO III — Signature over Printed Name

LIDAR Operator: MV TONGA — Signature over Printed Name

Aircraft Mechanic/ LIDAR Technician: — Signature over Printed Name

Figure A-6.17. Flight Log for Mission 8183AC

18. Flight Log for 8185AC Mission



Flight Log No.: 8185AC

Data Acquisition Flight Log

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: V. Tonga | 2 ALTM Model: Aquarius | 3 Mission Name: | 4 Type: VFR | 5 Aircraft Type: CesnnaT206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: C. Alfonso | 8 Co-Pilot: F. Lasco | 9 Route: Catarman - Catarman | | | |
| 10 Date: August 25, 2015 | 12 Airport of Departure (Airport, City/Province): Catarman | | 12 Airport of Arrival (Airport, City/Province): Catarman | | |
| 13 Engine On: 1219H | 14 Engine Off: 1348H | 15 Total Engine Time: 1+29 | 16 Take off: 1224H | 17 Landing: 1343H | 18 Total Flight Time: 1+19 |
| 19 Weather | FAIR | | | | |

20 Flight Classification

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

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

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

21 Remarks

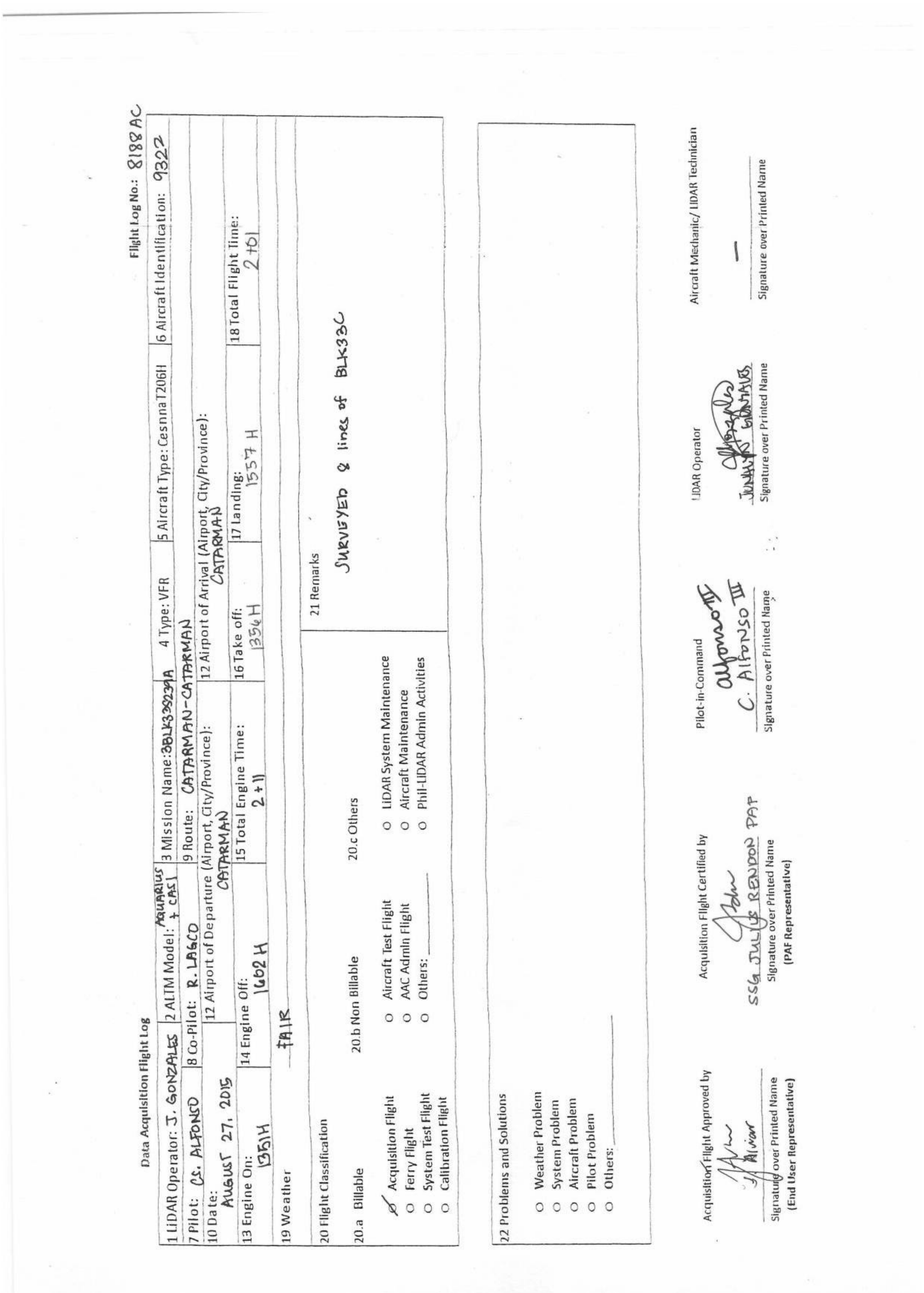
Successful

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

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | LiDAR Operator | Aircraft Mechanic/ LiDAR Technician |
|---|---|---|---|---|
| J. Alviar | SSG JULIUS RENDON PAF | C. Alfonso III | Ma. Verlina Tonga | — |
| 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-6.18. Flight Log for Mission 8185AC

19. Flight Log for 8188AC Mission



Data Acquisition Flight Log

Flight Log No.: 8188AC

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: J. GONZALES | 2 ALTM Model: AQUARIUS + CASI | 3 Mission Name: 3BLK33S239A | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: CS. ALFONSO | 8 Co-Pilot: R. LAGCO | 9 Route: CATARMAN-CATARMAN | | | |
| 10 Date: AUGUST 27, 2015 | 12 Airport of Departure (Airport, City/Province): CATARMAN | | 12 Airport of Arrival (Airport, City/Province): CATARMAN | | |
| 13 Engine On: 1351H | 14 Engine Off: 1602 H | 15 Total Engine Time: 2+11 | 16 Take off: 1356H | 17 Landing: 1557 H | 18 Total Flight Time: 2+01 |
| 19 Weather: FAIR | | | | | |

20 Flight Classification

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

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

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

21 Remarks

SURVEYED 8 lines of BLK33C

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

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

Acquisition Flight Certified by: SSG JULIUS RENDON PAF — Signature over Printed Name (PAF Representative)

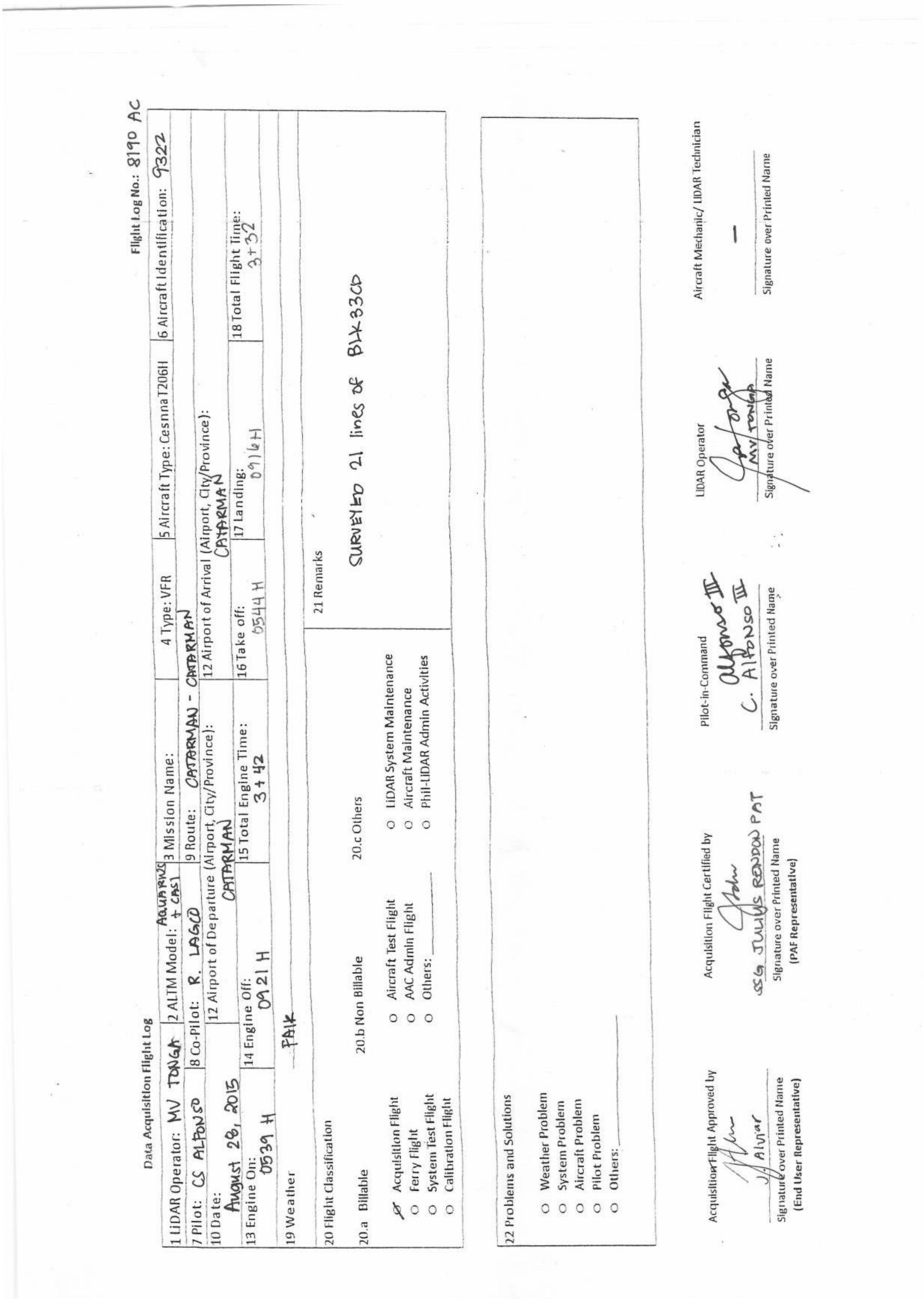
Pilot-in-Command: C. ALFONSO III — Signature over Printed Name

LiDAR Operator: JUNALYN GONZALES — Signature over Printed Name

Aircraft Mechanic/ LiDAR Technician: — Signature over Printed Name

Figure A-6.19. Flight Log for Mission 8188AC

20. Flight Log for 8190AC Mission



Data Acquisition Flight Log

Flight Log No.: 8190 AC

| | | | | | |
|---|---|---|---|---|---|
| 1 LiDAR Operator: MV TONGA | 2 ALTM Model: AQUARIUS + CAS1 | 3 Mission Name: | 4 Type: VFR | 5 Aircraft Type: Cesnna T206H | 6 Aircraft Identification: 9322 |
| 7 Pilot: CS ALFONSO | 8 Co-Pilot: R. LAGCO | 9 Route: CATARMAN - CATARMAN | | | |
| 10 Date: August 28, 2015 | 12 Airport of Departure (Airport, City/Province): CATARMAN | | 12 Airport of Arrival (Airport, City/Province): CATARMAN | | |
| 13 Engine On: 0539 H | 14 Engine Off: 0921 H | 15 Total Engine Time: 3+42 | 16 Take off: 0544 H | 17 Landing: 0916H | 18 Total Flight Time: 3+32 |
| 19 Weather: FAIR | | | | | |

20 Flight Classification

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

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

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

21 Remarks

SURVEYED 21 lines of BLK33CD

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

| Acquisition Flight Approved by | Acquisition Flight Certified by | Pilot-in-Command | LIDAR Operator | Aircraft Mechanic/ LIDAR Technician |
|---|---|---|---|---|
| J. Alviar | SSG JULIUS RENDON PAT | C. ALFONSO III | MV TONGA | – |
| 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-6.20. Flight Log for Mission 8190AC

# Annex 7. Flight status reports

Catarman Mission

February 21, 2015 to March 9, 2015, August 1-28, 2015

Table A-7.1. Flight Status Report

| FLIGHT NO | AREA | OPERATOR | MISSION NAME | DATE FLOWN | REMARKS |
|---|---|---|---|---|---|
| 7814 | BLK331I | MC BALIGUAS | 3BLK331I052A | 21-Feb-15 | Successful CASI Test Flight; surveyed 2 lines for BLK 331I |
| 7820 | BLK331I | MS REYES | 3BLK331I055A | 24-Feb-15 | Surveyed 2linesfor Blk331I. |
| 7822 | BLK331I | MC BALIGUAS | 3BLK331I056A | 25-Feb-15 | Surveyed 17lines forBlk331I. |
| 7824 | BLK331H | MC BALIGUAS | 3BLK331H057A | 26-Feb-15 | Surveyed 13linesforBlk331H |
| 7826 | BLK331K | MS REYES | 3BLK331K058A | 27-Feb-15 | Surveyed 7linesfor Blk331K. |
| 7828 | BLK331J | MC BALIGUAS | 3BLK331J059A | 28-Feb-15 | Surveyed 4linesBlk331J. |
| 7829 | BLK331H | MS REYES | 3BLK331H059B | 28-Feb-15 | Surveyed 12linesforBlk331H |
| 7830 | BLK331H &O | MS REYES | 3BLK331HSO060A | 01-Mar-15 | Surveyed 7linesfor Blk331H and11linesforBlk331O. |
| 7834 | BLK331H &K | MC BALIGUAS | 3BLK331KSOS062A | 03-Mar-15 | Surveyed 7linesforBlk331K and2linesfor Blk331H |
| 7838 | BLK331J&A | PJARCEO | 3BLK331JSB064A | 05-Mar-15 | Surveyed 5linesfor Blk331Jand1linefor Blk331A. |
| 7839 | BLK331G | MS REYES | 3BLK331G064B | 05-Mar-15 | Surveyed 7linesfor Blk331G. |
| 7842 | BLK331J | MS REYES | 3BLK331JO066A | 07-Mar-15 | Surveyed 11linesforBlk331J. |
| 7846 | BLK331L | PJARCEO | 3BLK331L068A | 09-Mar-15 | Surveyed 17linesforBlk331L. |
| 8137 | LCTF AREA | MC BALIGUAS | CASILCTF213A | 01-Aug-15 | Successful casi and aquarius flight over lctf area |
| 8142 | LCTF AREA | PJ ARCEO | AQUALCTF216A | 04-Aug-15 | Successful aquarius flight& lctf calibration; surveyed 2 lines for blk l |
| 8156 | BLK331 L & N | MC BALIGUAS | 3BLK331LNS223A | 11-Aug-15 | Surveyed 17 lines for blk331n & l |
| 8183AC | BLK 33TV | MV TONGA | 3BLK33STV236B | 24-Aug-15 | Surveyed blk 33tv; 36.34 sq.km. |
| 8185AC | CATARMAN | MV TONGA | 3BUNDLE ADJUSTMENT237B | 25-Aug-15 | Bundle adjustment flight |
| 8188AC | BLK 33BC | J GONZALES | 3BLK33S239A | 27-Aug-15 | Surveyed blk 33bc; 22.64 sq.km |
| 8190AC | BLK 33CD | MV TONGA | 3BLK33CD240A | 28-Aug-15 | Surveyed blk 33cd; 56.18 sq.km |

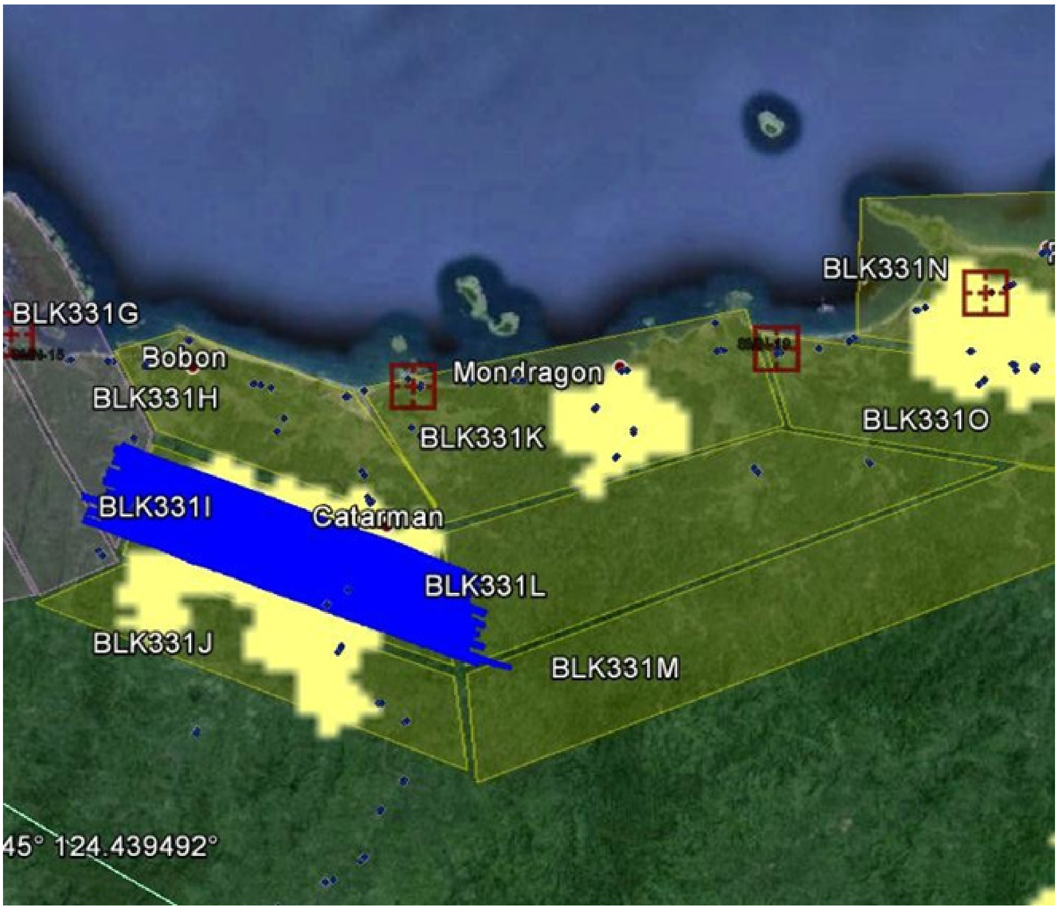
**SWATH PER FLIGHT MISSION**

Flight No. : 7820AC
Area: BLOCK 331I
Mission Name: 3BLK331I055A
Surveyed Area: 11km$^2$


| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 680 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331I.pln |
| 1 | 677 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331I.pln |
| 1 | 681 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331I.pln |
| 2 | 675 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 2 | 677 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |

Figure A-7.1. Swath for Flight No. 7820AC

FLIGHT NO.: 7822AC
AREA: BLK331I
MISSION NAME: 3BLK31I056A
SURVEYED AREA: 86.23 km$^2$



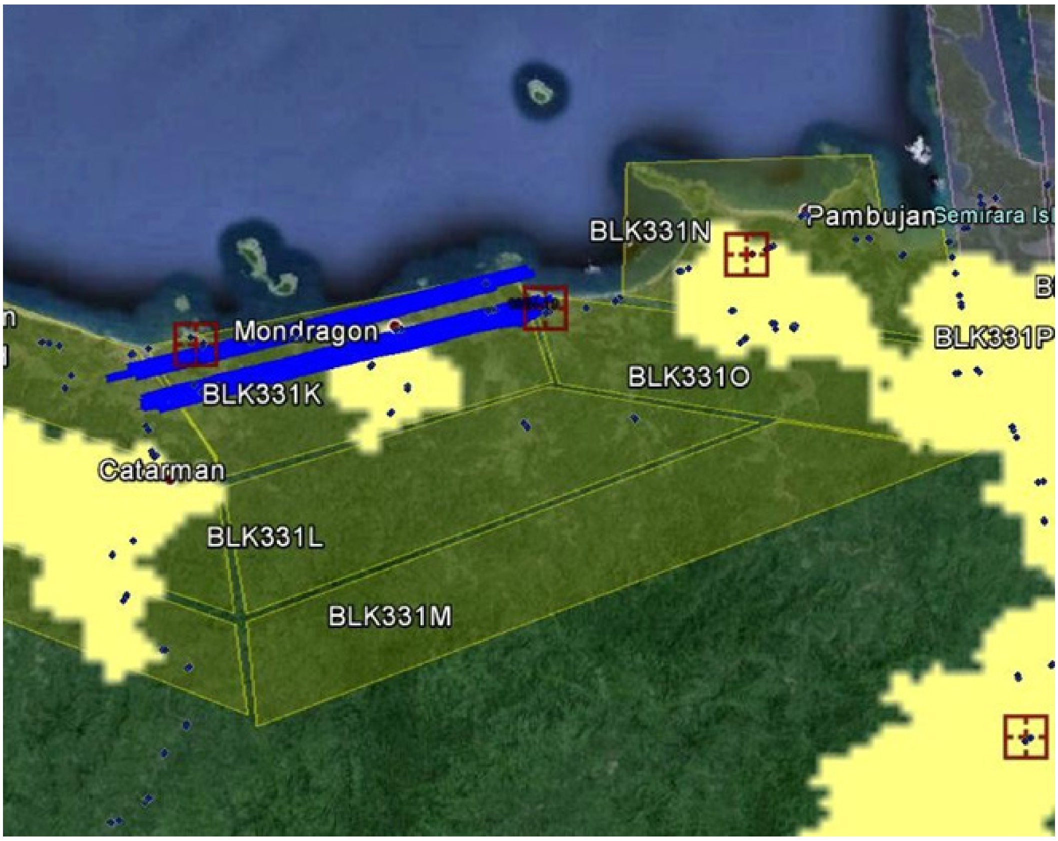

| _INE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 676 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 6 | 669 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 7 | 670 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 8 | 671 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 9 | 667 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 10 | 666 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 11 | 666 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 12 | 666 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 11 | 665 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331I.pln |
| 13 | 664 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331I.pln |
| 14 | 662 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331I.pln |
| 15 | 664 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 16 | 662 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 14 | 663 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331I.pln |
| 17 | 663 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331I.pln |
| 18 | 659 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331I.pln |
| 19 | 664 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331I.pln |
| 20 | 662 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331I.pln |

Figure A-7.2. Swath for Flight No. 7822AC

FLIGHT NO.: 7824AC
AREA: BLK331H
MISSION NAME: 3BLK331H057A
SURVEYED AREA: 78.35 km$^2$


Figure A-7.3. Swath for Flight No. 7824AC

| | |
|---|---|
| FLIGHT NO.: | 7826AC |
| AREA: | BLK331K |
| MISSION NAME: | 3BLK331K058A |
| SURVEYED AREA: | 41km2 |




| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 670 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 256.00 | BLK331K.pln |
| 13 | 666 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 76.00 | BLK331K.pln |
| 12 | 674 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 256.00 | BLK331K.pln |
| 11 | 669 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 76.00 | BLK331K.pln |
| 7 | 675 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 256.00 | BLK331K.pln |
| 6 | 672 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 76.00 | BLK331K.pln |
| 5 | 679 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 256.00 | BLK331K.pln |

Figure A-7.4. Swath for Flight No. 7826AC

FLIGHT NO.: 7828AC
AREA: BLK331J
MISSION NAME: 3BLK331J059A
SURVEYED AREA: 83.36 $km^2$


| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 679 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 308.78 | BLK331J.pln |
| 24 | 674 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | BLK331J.pln |
| 23 | 680 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |
| 22 | 676 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | BLK331J.pln |
| 21 | 677 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |

Figure A-7.5. Swath for Flight No. 7828AC

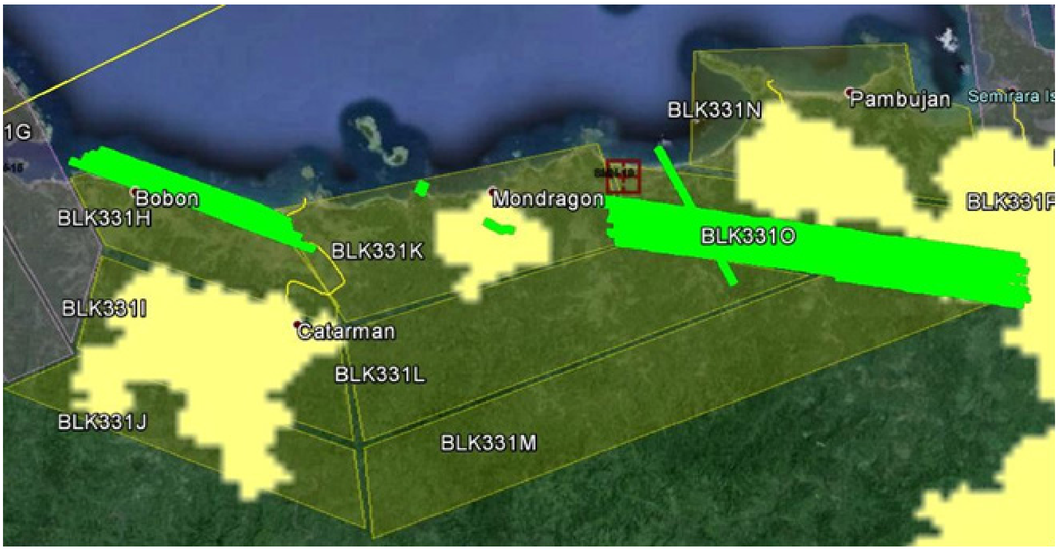
| | |
|---|---|
| FLIGHT NO.: | 7829AC |
| AREA: | BLK331H |
| MISSION NAME: | 3BLK331H059B |
| SURVEYED AREA: | 40.05 km$^2$ |


| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 662 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 10 | 649 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |
| 11 | 654 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 12 | 654 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |
| 13 | 658 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 14 | 658 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |
| 15 | 650 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 16 | 644 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |
| 17 | 603 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 17 | 597 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |
| 19 | 604 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 20 | 601 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |


| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 662 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 10 | 649 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |
| 11 | 654 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 12 | 654 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |
| 13 | 658 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 14 | 658 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |
| 15 | 650 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 16 | 644 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |
| 17 | 603 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 17 | 597 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |
| 19 | 604 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331H.pln |
| 20 | 601 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331H.pln |


Figure A-7.6. Swath for Flight No. 7829AC

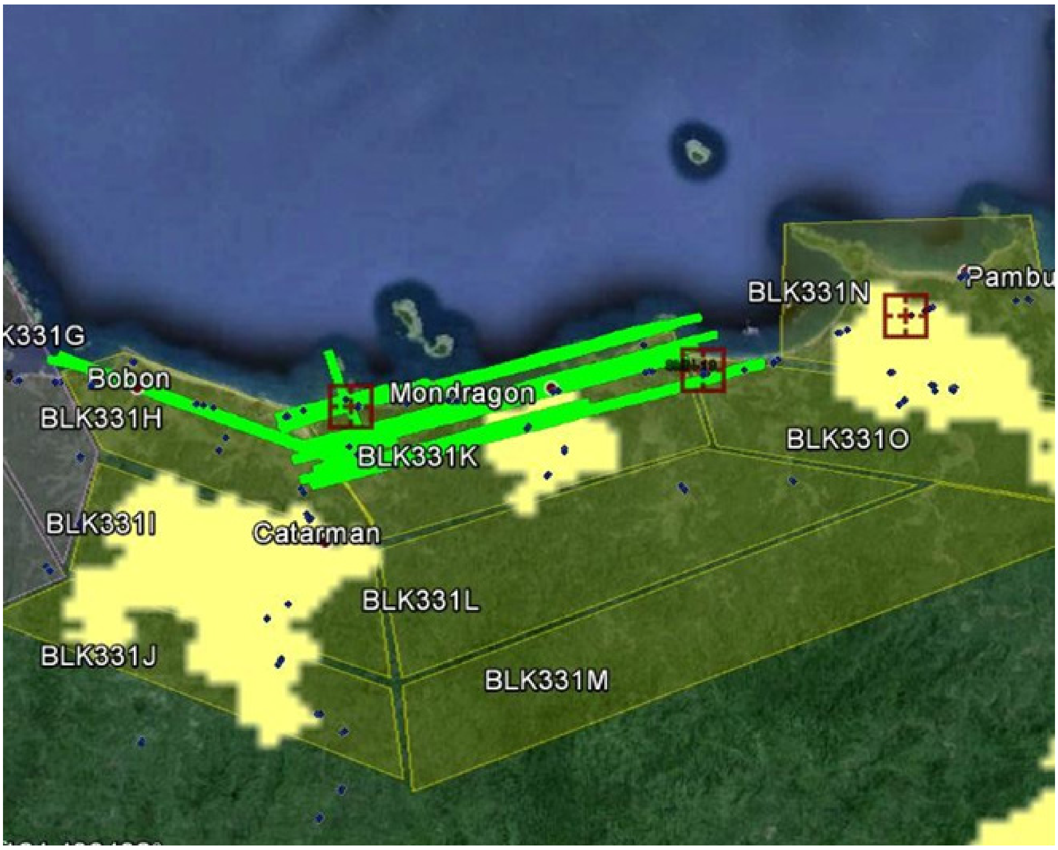
FLIGHT NO.: 7830AC
AREA: BLK331H & O
MISSION NAME: 3BLK331HS060




| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 46 | 673 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331HON_MAR01.pln |
| 46 | 684 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331HON_MAR01.pln |
| 45 | 672 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 278.00 | BLK331HON_MAR01.pln |
| 44 | 669 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331HON_MAR01.pln |
| 47 | 673 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 278.00 | BLK331HON_MAR01.pln |
| 43 | 675 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 278.00 | BLK331HON_MAR01.pln |
| 44 | 669 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331HON_MAR01.pln |
| 42 | 669 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331HON_MAR01.pln |
| 41 | 672 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 278.00 | BLK331HON_MAR01.pln |
| 40 | 669 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331HON_MAR01.pln |
| 39 | 671 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 278.00 | BLK331HON_MAR01.pln |
| 38 | 670 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331HON_MAR01.pln |
| 37 | 672 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 278.00 | BLK331HON_MAR01.pln |
| 37 | 671 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 278.00 | BLK331HON_MAR01.pln |
| 21 | 673 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331HON_MAR01.pln |
| 22 | 672 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331HON_MAR01.pln |
| 23 | 673 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331HON_MAR01.pln |
| 24 | 670 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331HON_MAR01.pln |
| 25 | 673 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331HON_MAR01.pln |
| 26 | 662 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331HON_MAR01.pln |
| 27 | 662 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331HON_MAR01.pln |

Figure A-7.7. Swath for Flight No. 7830AC

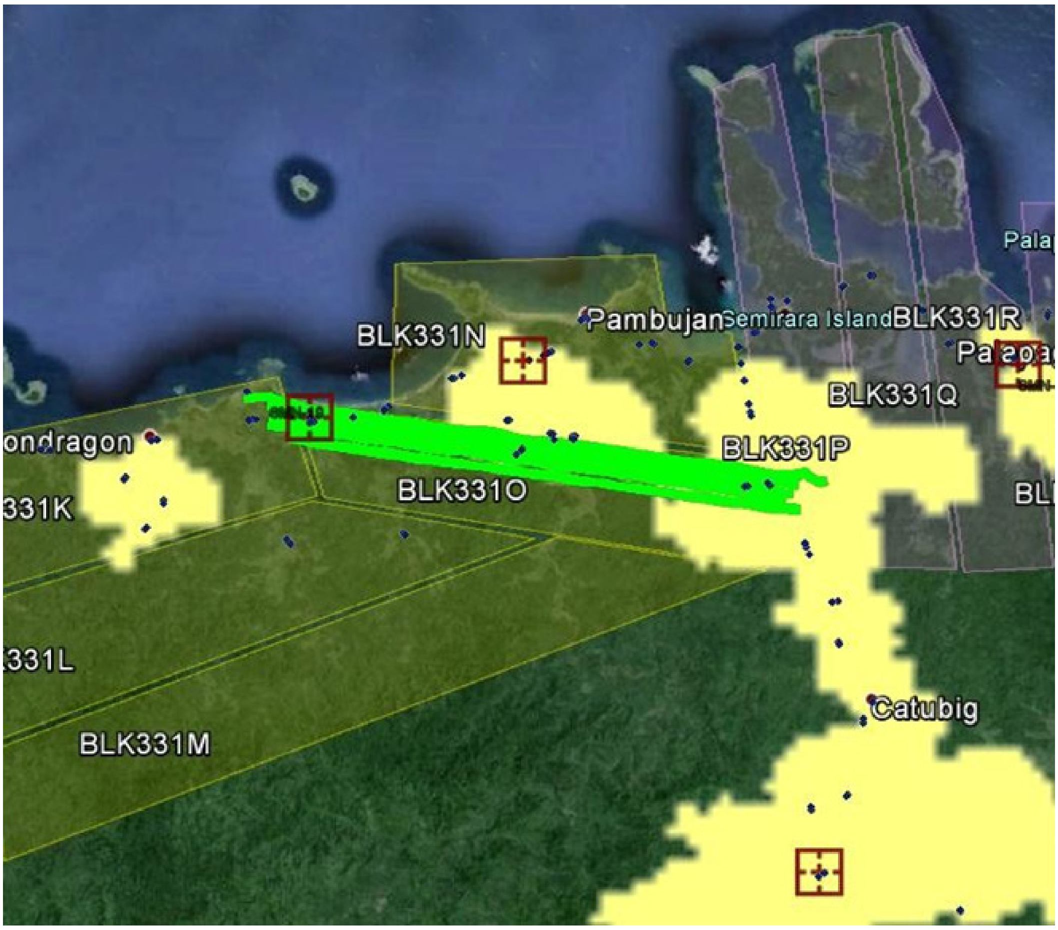
| | |
|---|---|
| FLIGHT NO.: | 7834AC |
| AREA: | BLK331H & K |
| MISSION NAME: | 3BLK331KSOS062 |
| SURVEYED AREA: | 53.42 km$^2$ |




| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 704 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 255.00 | BLK331KO.pln |
| 14 | 670 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 75.00 | BLK331KO.pln |
| 10 | 674 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 75.00 | BLK331KO.pln |
| 9 | 670 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 75.00 | BLK331KO.pln |
| 9 | 571 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 255.00 | BLK331KO.pln |
| 4 | 568 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 255.00 | BLK331KO.pln |
| 5 | 573 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 255.00 | BLK331KO.pln |
| 4 | 574 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 255.00 | BLK331KO.pln |
| 3 | 569 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 255.00 | BLK331KO.pln |
| 3 | 569 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 255.00 | BLK331KO.pln |
| 2 | 575 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 255.00 | BLK331KO.pln |
| 2 | 575 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 255.00 | BLK331KO.pln |
| 59 | 574 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 155.03 | BLK331KO.pln |
| 15 | 576 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 75.00 | BLK331KO.pln |
| 13 | 576 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 255.00 | BLK331KO.pln |
| 8 | 576 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 75.00 | BLK331KO.pln |
| 80 | 578 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 290.00 | BLK331KO.pln |
| 79 | 577 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 110.00 | BLK331KO.pln |

Figure A-7.8. Swath for Flight No. 7834AC

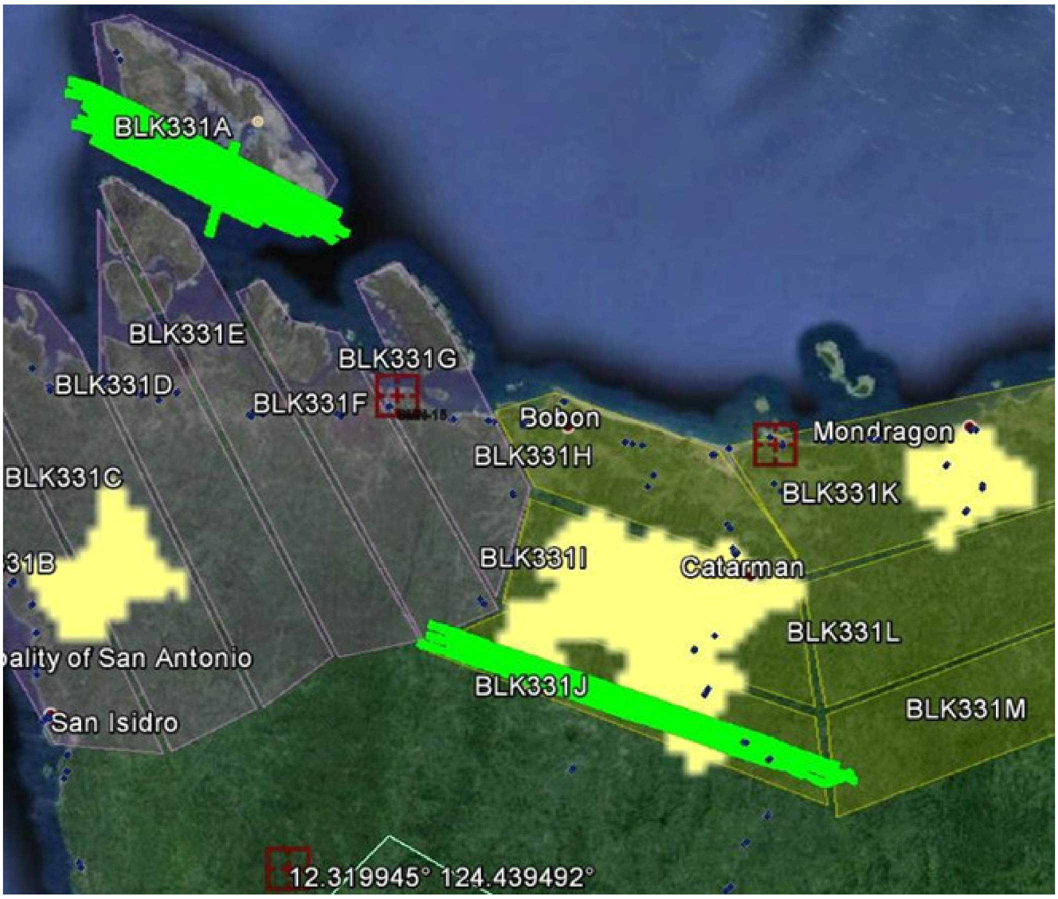
| | |
|---|---|
| FLIGHT NO.: | 7836AC |
| AREA: | BLK331O |
| MISSION NAME: | 3BLK331ON063 |
| SURVEYED AREA: | 47.23 km$^2$ |




| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 670 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331NO MAR 04.pln |
| 8 | 565 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 278.00 | BLK331NO MAR 04.pln |
| 7 | 564 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331NO MAR 04.pln |
| 6 | 570 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 278.00 | BLK331NO MAR 04.pln |
| 5 | 566 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331NO MAR 04.pln |
| 4 | 567 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 278.00 | BLK331NO MAR 04.pln |
| 3 | 565 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 98.00 | BLK331NO MAR 04.pln |

Figure A-7.9. Swath for Flight No. 7836AC

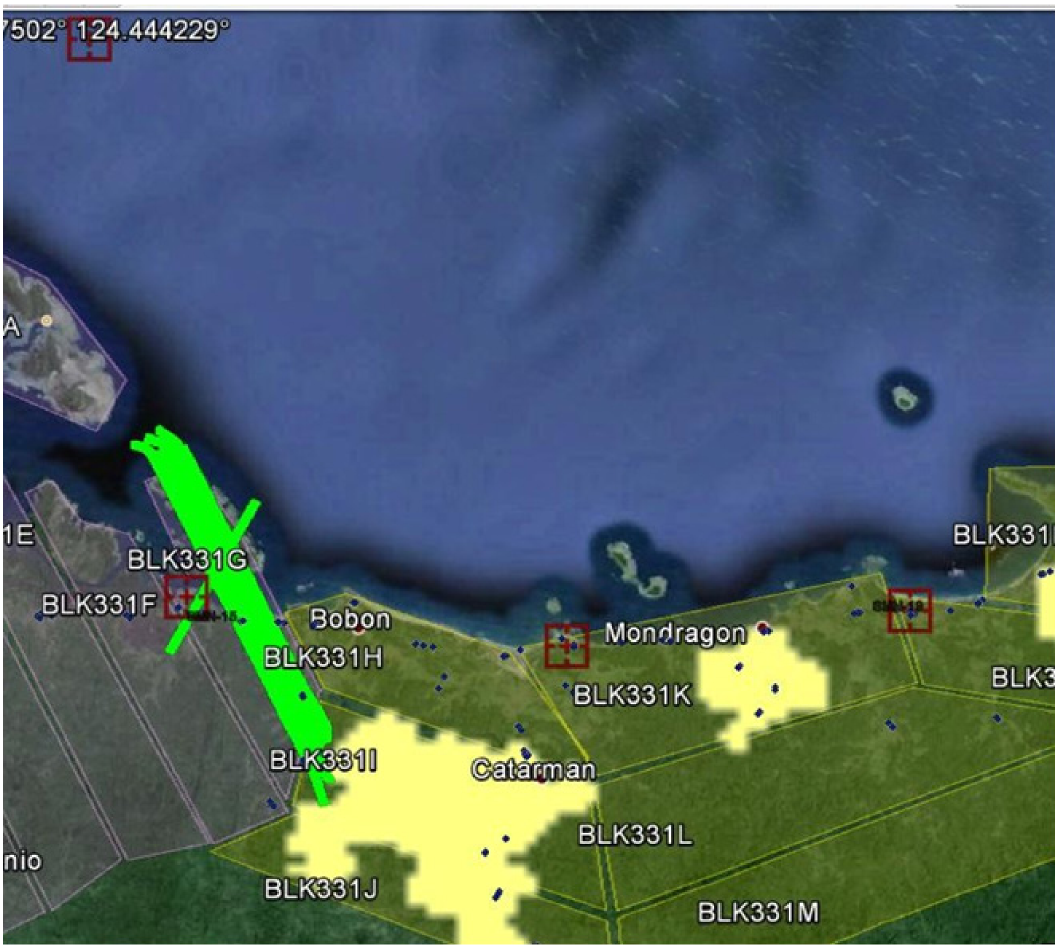
| | |
|---|---|
| FLIGHT NO.: | 7838AC |
| AREA: | BLK331J & A |
| MISSION NAME: | 3BLK331JSB064 |
| SURVEYED AREA: | 63 km$^2$ |




| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 671 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 108.99 | BLK331JB.pln |
| 15 | 673 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 288.99 | BLK331JB.pln |
| 14 | 670 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 108.99 | BLK331JB.pln |
| 13 | 671 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 288.99 | BLK331JB.pln |
| 12 | 668 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 108.99 | BLK331JB.pln |
| 74 | 676 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 297.00 | BLK331JB.pln |
| 72 | 675 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 117.00 | BLK331JB.pln |
| 72 | 678 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 297.00 | BLK331JB.pln |
| 71 | 675 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 117.00 | BLK331JB.pln |
| 70 | 677 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 297.00 | BLK331JB.pln |
| 69 | 675 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 117.00 | BLK331JB.pln |
| 68 | 680 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 297.00 | BLK331JB.pln |
| 66 | 673 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 117.00 | BLK331JB.pln |
| 65 | 680 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 297.00 | BLK331JB.pln |
| 65 | 679 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 297.00 | BLK331JB.pln |
| 64 | 674 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 117.00 | BLK331JB.pln |

Figure A-7.10. Swath for Flight No. 7838AC

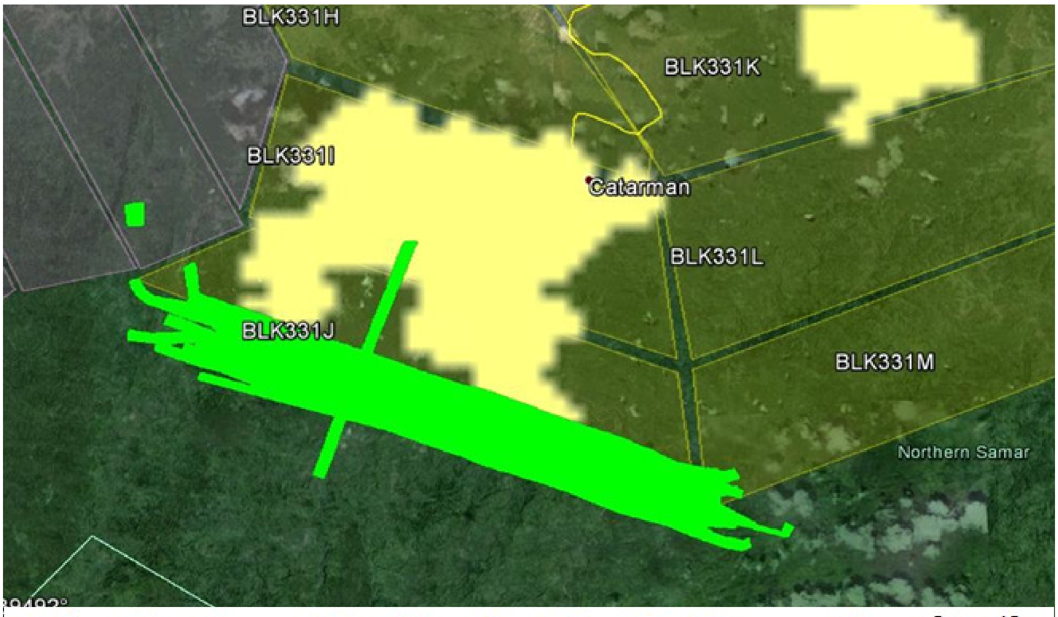
FLIGHT NO.: 7839AC
AREA: BLK331G
MISSION NAME: 3BLK331G064B
SURVEYED AREA: 30.43 $km^2$




| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 675 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 333.00 | BLK331G.pln |
| 9 | 674 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 153.00 | BLK331G.pln |
| 8 | 669 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 333.00 | BLK331G.pln |
| 7 | 671 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 153.00 | BLK331G.pln |
| 6 | 670 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 333.00 | BLK331G.pln |
| 5 | 665 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 333.00 | BLK331G.pln |
| 4 | 662 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 333.00 | BLK331G.pln |
| 3 | 665 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 333.00 | BLK331G.pln |

Figure A-7.11. Swath for Flight No. 7839AC

FLIGHT NO.: 7842AC
AREA: BLK331J
MISSION NAME: 3BLK331JO066
SURVEYED AREA: 50.42 km$^2$




| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 681 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |

| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 677 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |

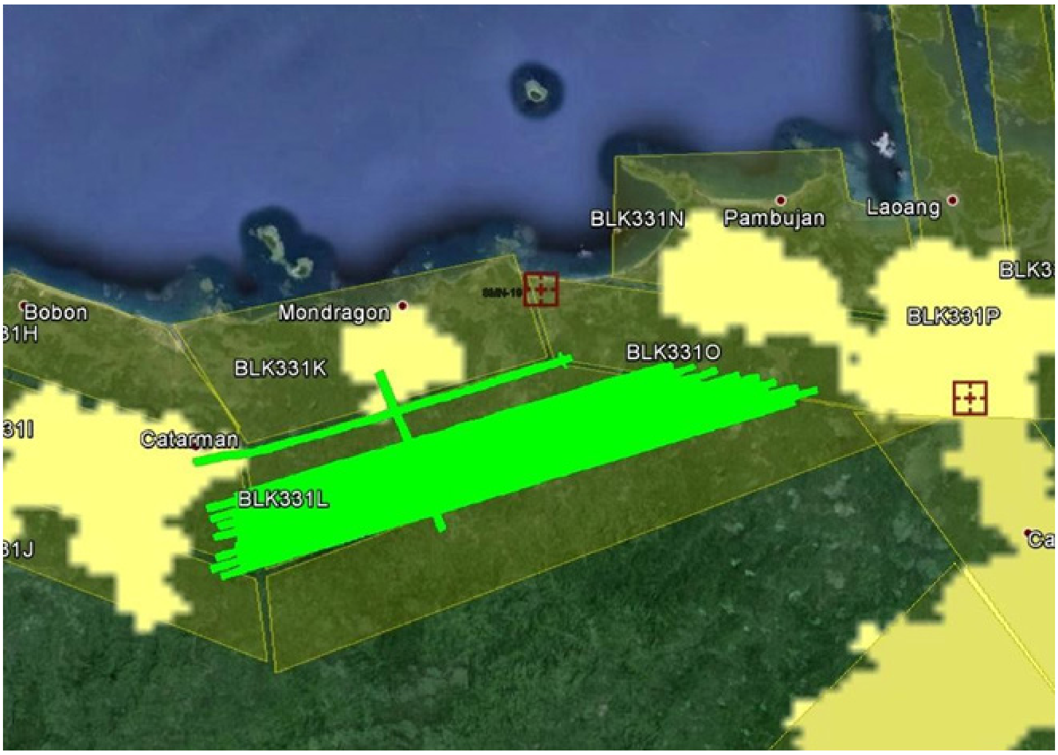
| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 677 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |
| 1 | 677 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |
| 1 | 678 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |
| 1 | 678 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |
| 1 | 678 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |
| 1 | 678 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |
| 1 | 678 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |
| 1 | 678 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |
| 1 | 680 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |

| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 679 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | Default.pln |
| 0 | 679 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | Default.pln |
| 0 | 679 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | Default.pln |
| 2 | 675 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | BLK331J.pln |
| 1 | 682 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | BLK331J.pln |
| 3 | 677 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | BLK331J.pln |
| 3 | 677 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | BLK331J.pln |
| 3 | 677 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | BLK331J.pln |

| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 683 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | Default.pln |
| 4 | 681 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | Default.pln |
| 3 | 680 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | Default.pln |
| 5 | 683 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | Default.pln |
| 6 | 684 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | Default.pln |
| 7 | 692 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | Default.pln |
| 8 | 680 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | Default.pln |
| 9 | 669 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | Default.pln |
| 10 | 674 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 109.00 | Default.pln |
| 11 | 675 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | Default.pln |
| 11 | 673 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 289.00 | Default.pln |

Figure A-7.12. Swath for Flight No. 7842AC

FLIGHT NO.: 7846AC
AREA: BLK331L
MISSION NAME: 3BLK331L068A
SURVEYED AREA: 80.45 $km^2$




| LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 695 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 73.00 | BLK331L.pln |
| 1 | 680 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 73.00 | BLK331L.pln |
| 23 | 671 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 73.00 | BLK331L.pln |
| 22 | 677 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 253.00 | BLK331L.pln |
| 21 | 671 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 73.00 | BLK331L.pln |
| 20 | 679 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 253.00 | BLK331L.pln |
| 19 | 665 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 73.00 | BLK331L.pln |
| 18 | 677 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 253.00 | BLK331L.pln |
| 17 | 672 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 253.00 | BLK331L.pln |
| 16 | 672 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 253.00 | BLK331L.pln |
| 15 | 667 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 73.00 | BLK331L.pln |
| 14 | 678 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 253.00 | BLK331L.pln |
| 13 | 672 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 253.00 | BLK331L.pln |
| 12 | 696 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 73.00 | BLK331L.pln |
| 11 | 674 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 73.00 | BLK331L.pln |
| 10 | 686 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 253.00 | BLK331L.pln |
| 9 | 670 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 73.00 | BLK331L.pln |
| 8 | 679 | 50 | 50.00 | 18.00 | OFF | NAR | ON | OFF | 253.00 | BLK331L.pln |

Figure A-7.13. Swath for Flight No. 7846AC

| | |
|---|---|
| FLIGHT NO.: | 8137 |
| AREA: | LCTF AREA |
| MISSION NAME: | CASILCTF213A |
| ALT: | 600 m |
| SCAN FREQ: | 45 |
| SCAN ANGLE: | 20 |
| SURVEYED AREA: | 22.194 km$^2$ |


Figure A-7.14. Swath for Flight No. 8137

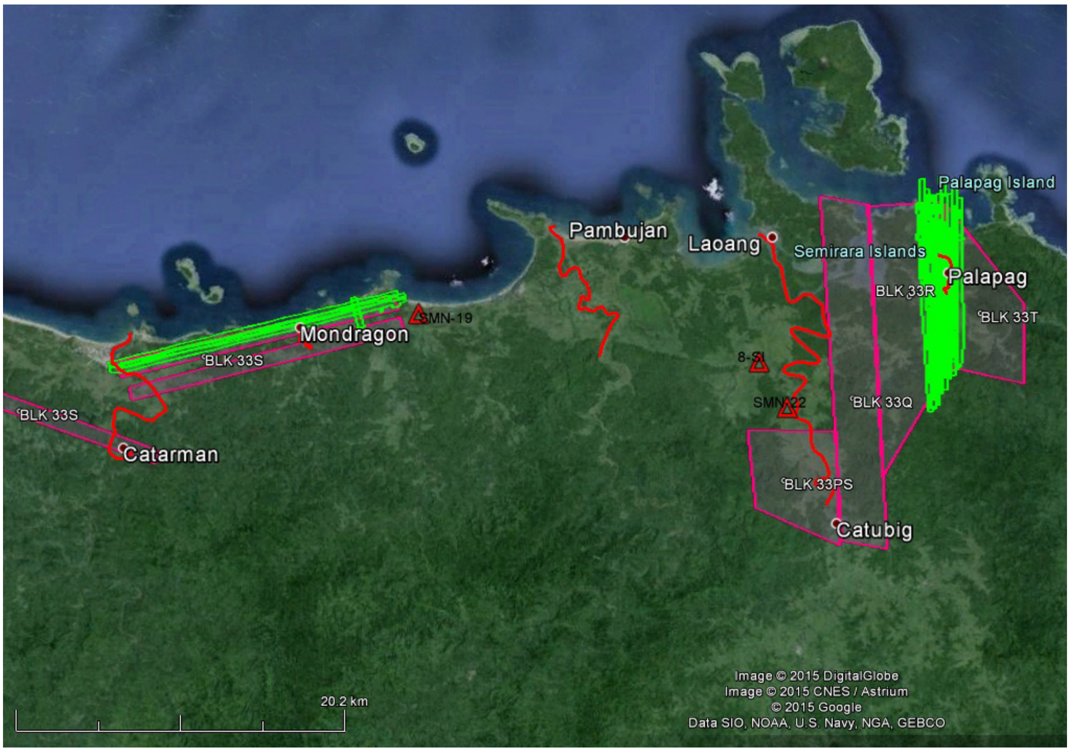
| | |
|---|---|
| FLIGHT NO.: | 8142 |
| AREA: | LCTF AREA |
| MISSION NAME: | AQUALCTF216A |
| ALT: | 600 m, 500m respectively |
| SCAN FREQ: | 45 |
| SCAN ANGLE: | 20 |
| SURVEYED AREA: | 11.986 $km^2$ |


Figure A-7.15. Swath for Flight No. 8142

| | |
|---|---|
| FLIGHT NO.: | 8156 |
| AREA: | BLK L & N |
| MISSION NAME: | 3BLK331LNS223A |
| ALT: | 500 m |
| SCAN FREQ: | 45 |
| SCAN ANGLE: | 20 |
| SURVEYED AREA: | 81.745 km² |


Figure A-7.16. Swath for Flight No. 8156

Flight No. : 8183AC
Area: BLK 33T
Mission Name: 3BLK33STV236B




| START | STOP | LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03:53:48.181 | 03:58:12.975 | 16 | 560 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 177.00 | BLK33R.pln |
| 04:01:39.329 | 04:05:02.013 | 17 | 558 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 357.00 | BLK33R.pln |
| 04:01:39.329 | 04:05:02.013 | 17 | 557 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 357.00 | BLK33R.pln |
| 04:09:08.082 | 04:12:57.711 | 18 | 591 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 177.00 | BLK33R.pln |
| 04:09:08.082 | 04:12:57.711 | 18 | 591 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 177.00 | BLK33R.pln |
| 04:16:42.75 | 04:19:51.434 | 19 | 544 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 357.00 | BLK33R.pln |
| 04:16:42.75 | 04:19:51.434 | 19 | 542 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 357.00 | BLK33R.pln |
| 04:23:06.503 | 04:27:16.157 | 20 | 555 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 177.00 | BLK33R.pln |
| 04:31:20.786 | 04:34:07.75 | 2 | 581 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 358.00 | BLK33S.pln |
| 04:31:20.786 | 04:34:07.75 | 2 | 581 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 358.00 | BLK33S.pln |
| 04:40:08.824 | 04:43:50.508 | 21 | 605 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 180.00 | BLK33S.pln |
| 04:40:08.824 | 04:43:50.508 | 21 | 605 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 180.00 | BLK33S.pln |
| 04:47:07.017 | 04:49:59.611 | 19 | 564 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 360.00 | BLK33S.pln |
| 04:47:07.017 | 04:49:59.611 | 19 | 564 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 360.00 | BLK33S.pln |
| 04:56:12.09 | 04:57:10.23 | 19 | 564 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 360.00 | BLK33S.pln |
| 04:56:12.09 | 04:57:10.23 | 19 | 564 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 360.00 | BLK33S.pln |
| 05:07:35.227 | 05:13:59.616 | 2 | 544 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 256.00 | voids.pln |
| 05:17:27.09 | 05:22:29.163 | 3 | 542 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 76.00 | voids.pln |
| 05:26:34.092 | 05:27:21.617 | 2 | 605 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 76.00 | voids.pln |
| 05:31:07.091 | 05:37:37.304 | 4 | 529 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 256.00 | voids.pln |
| 05:31:07.091 | 05:37:37.304 | 4 | 529 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 256.00 | voids.pln |

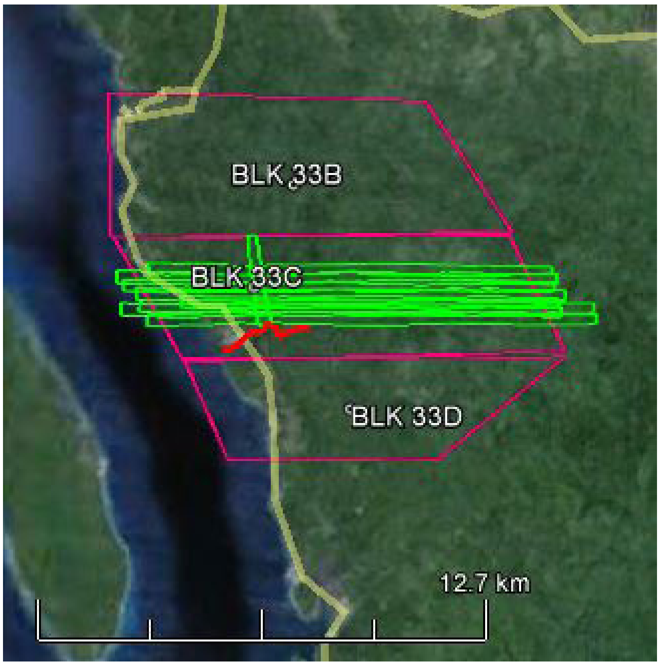
Figure A-7.17. Swath for Flight No. 8183AC

Flight No. : 8185AC
Area: CATARMAN
Mission Name: 3BUNDLEADJUSTMENT237B


| START | STOP | LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 04:45:13.673 | 04:46:43.223 | 9 | 589 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 135.00 | bundle adjustment.pln |
| 04:48:47.362 | 04:50:39.362 | 1 | 581 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | bundle adjustment.pln |
| 04:54:05.221 | 04:56:06.326 | 2 | 582 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | bundle adjustment.pln |
| 05:00:10.155 | 05:02:05.889 | 3 | 600 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | bundle adjustment.pln |
| 05:05:47.048 | 05:07:32.118 | 4 | 558 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | bundle adjustment.pln |
| 05:05:47.048 | 05:07:32.118 | 4 | 558 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | bundle adjustment.pln |
| 05:10:00.467 | 05:11:29.922 | 9 | 570 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 180.00 | bundle adjustment.pln |
| 05:10:00.467 | 05:11:29.922 | 9 | 570 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 180.00 | bundle adjustment.pln |
| 05:14:00.891 | 05:15:29.121 | 8 | 568 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 360.00 | bundle adjustment.pln |
| 05:19:26.96 | 05:21:00.645 | 7 | 557 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 180.00 | bundle adjustment.pln |
| 05:24:05.984 | 05:25:26.434 | 6 | 593 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 360.00 | bundle adjustment.pln |

Figure A-7.18. Swath for Flight No. 8185AC

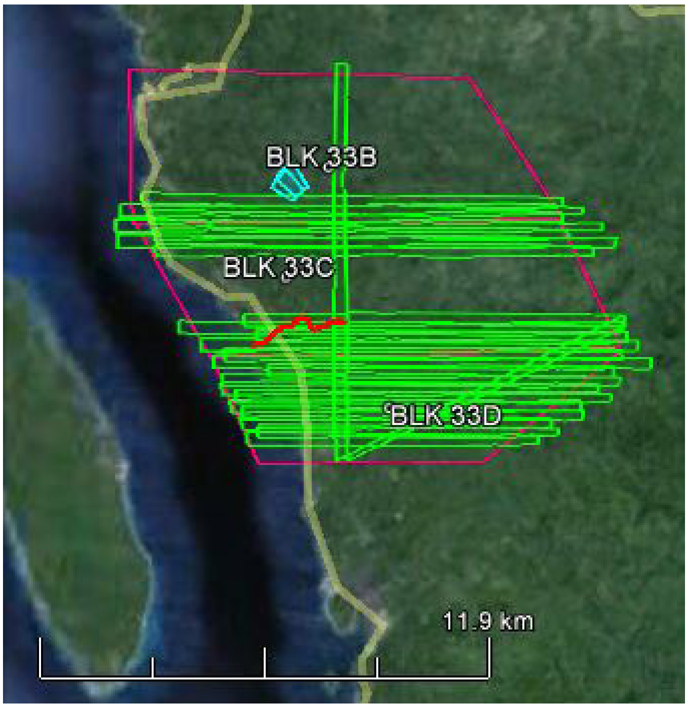
Flight No. : 8188AC
Area: BLK 33BC
Mission Name: 3BLK33S239A




| START | STOP | LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06:28:01.65 | 06:31:39.779 | 1 | 580 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 06:34:57.243 | 06:38:44.686 | 2 | 575 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 06:41:51.685 | 06:45:35.094 | 3 | 574 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 06:48:42.823 | 06:52:18.792 | 4 | 574 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 06:48:42.823 | 06:52:18.792 | 4 | 574 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 06:55:24.476 | 06:58:58.965 | 5 | 569 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 06:55:24.476 | 06:58:58.965 | 5 | 569 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 07:02:03.479 | 07:05:55.388 | 5 | 572 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 07:08:56.212 | 07:12:41.55 | 6 | 572 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 07:08:56.212 | 07:12:44.865 | 6 | 573 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 07:15:40.32 | 07:19:29.248 | 7 | 574 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 07:22:11.143 | 07:23:02.027 | 7 | 573 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 07:22:11.143 | 07:23:02.027 | 7 | 573 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |

Figure A-7.19. Swath for Flight No. 8188AC

| | |
|---|---|
| Flight No. : | 8190AC |
| Area: | BLK 33CD |
| Mission Name: | 3BLK33CD240A |




| START | STOP | LINE# | ALT | PRF | FREQ | ANGLE | MP | DIV | RC | MPM | HDG | Plan File |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22:13:37.98 | 22:15:58.084 | 22 | 575 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 22:19:06.297 | 22:21:21.611 | 21 | 576 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 22:24:15.65 | 22:26:48.368 | 20 | 577 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 22:24:15.65 | 22:26:48.368 | 20 | 577 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 22:30:03.877 | 22:32:36.581 | 19 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 22:35:38.949 | 22:38:22.773 | 18 | 576 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 22:41:31.122 | 22:44:21.811 | 17 | 576 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 22:47:15.915 | 22:50:12.298 | 16 | 576 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 22:53:35.777 | 22:56:36.406 | 15 | 577 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 22:59:22.74 | 23:02:34.369 | 14 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 22:59:22.74 | 23:02:34.369 | 14 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 23:05:40.198 | 23:09:00.617 | 13 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 23:05:40.198 | 23:09:00.617 | 13 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 23:12:03.44 | 23:15:18.679 | 12 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 23:18:38.778 | 23:22:00.777 | 11 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 23:24:48.711 | 23:28:16.85 | 10 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 23:32:02.989 | 23:35:22.993 | 9 | 579 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 23:32:02.989 | 23:35:27.553 | 9 | 579 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 23:38:15.622 | 23:41:46.375 | 8 | 580 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 23:38:15.622 | 23:41:46.375 | 8 | 579 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 23:48:34.168 | 23:51:51.587 | 22 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 23:48:34.168 | 23:51:51.587 | 22 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 23:57:24.1 | 00:01:00.924 | 23 | 579 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 00:04:17.413 | 00:08:02.487 | 22 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 00:04:17.413 | 00:08:02.487 | 22 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 270.00 | BLK33B.pln |
| 00:10:54.716 | 00:14:30.345 | 21 | 577 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 00:17:50.688 | 00:21:34.487 | 20 | 577 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 00:17:50.688 | 00:21:34.487 | 20 | 577 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 00:24:38.751 | 00:28:12.38 | 1 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 00:24:38.751 | 00:28:12.38 | 1 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 00:31:13.894 | 00:34:44.858 | 2 | 577 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 00:31:13.894 | 00:34:44.858 | 2 | 577 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 00:37:36.962 | 00:38:02.857 | 1 | 580 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 00:42:00.386 | 00:45:14.21 | 3 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |
| 00:42:00.386 | 00:45:14.21 | 3 | 578 | 50 | 45.00 | 18.00 | OFF | NAR | ON | OFF | 90.00 | BLK33B.pln |

Figure A-7.20. Swath for Flight No. 8190AC

# ANNEX 8. MISSION SUMMARY REPORT

| Flight Area | Catarman |
|---|---|
| Mission Name | **Blk33C** |
| Inclusive Flights | 8188A, 8190A |
| Range data size | 12.7 GB |
| Base data size | 10.23 MB |
| POS | 337 MB |
| Image | 82.1 GB |
| Transfer date | September 16, 2015 |
| | |
| *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) | 1.1 |
| RMSE for East Position (<4.0 cm) | 1.2 |
| RMSE for Down Position (<8.0 cm) | 2.7 |
| | |
| Boresight correction stdev (<0.001deg) | NA |
| IMU attitude correction stdev (<0.001deg) | NA |
| GPS position stdev (<0.01m) | NA |
| | |
| Minimum % overlap (>25) | 31.83 |
| Ave point cloud density per sq.m. (>2.0) | 2.24 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 66 |
| Maximum Height | 385.10 m |
| Minimum Height | 48.51 m |
| | |
| *Classification (# of points)* | |
| Ground | 9,989,786 |
| Low vegetation | 9,034,151 |
| Medium vegetation | 25,087,295 |
| High vegetation | 45,990,289 |
| Building | 711,168 |
| | |
| Orthophoto | No |
| Processed by | Engr. Irish Cortez, Engr. Chelou Prado, Maria Tamsyn Malabanan |

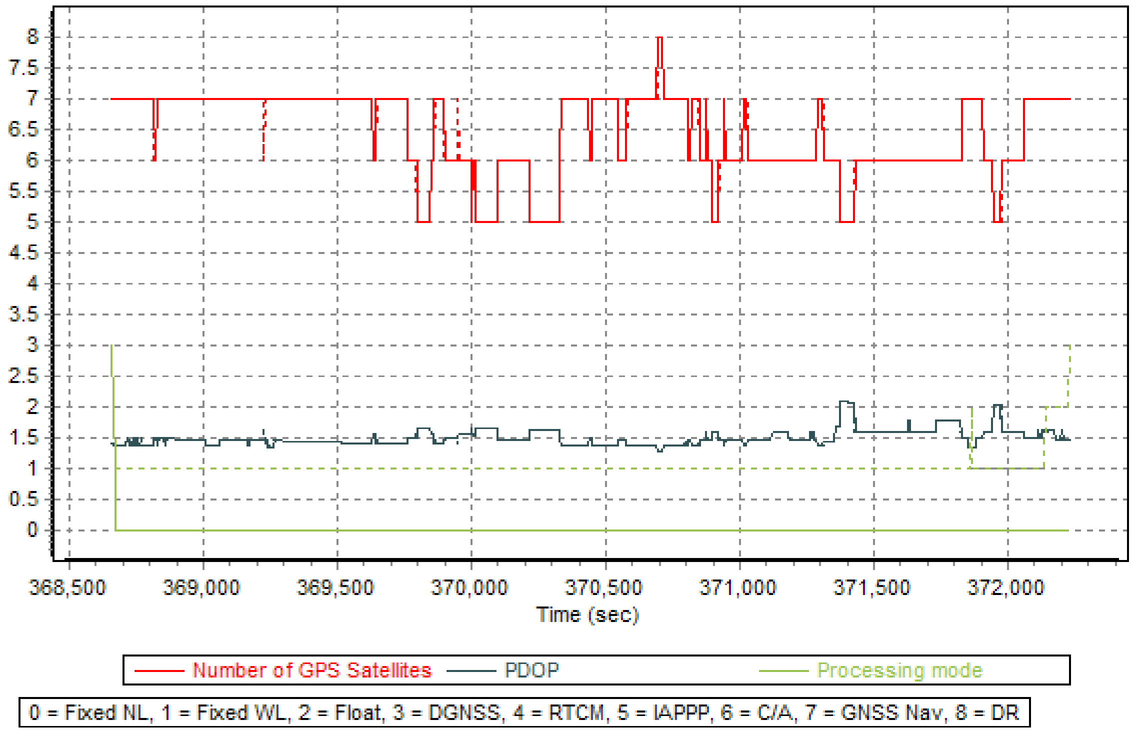



*Figure 1.1.1 Solution Status*

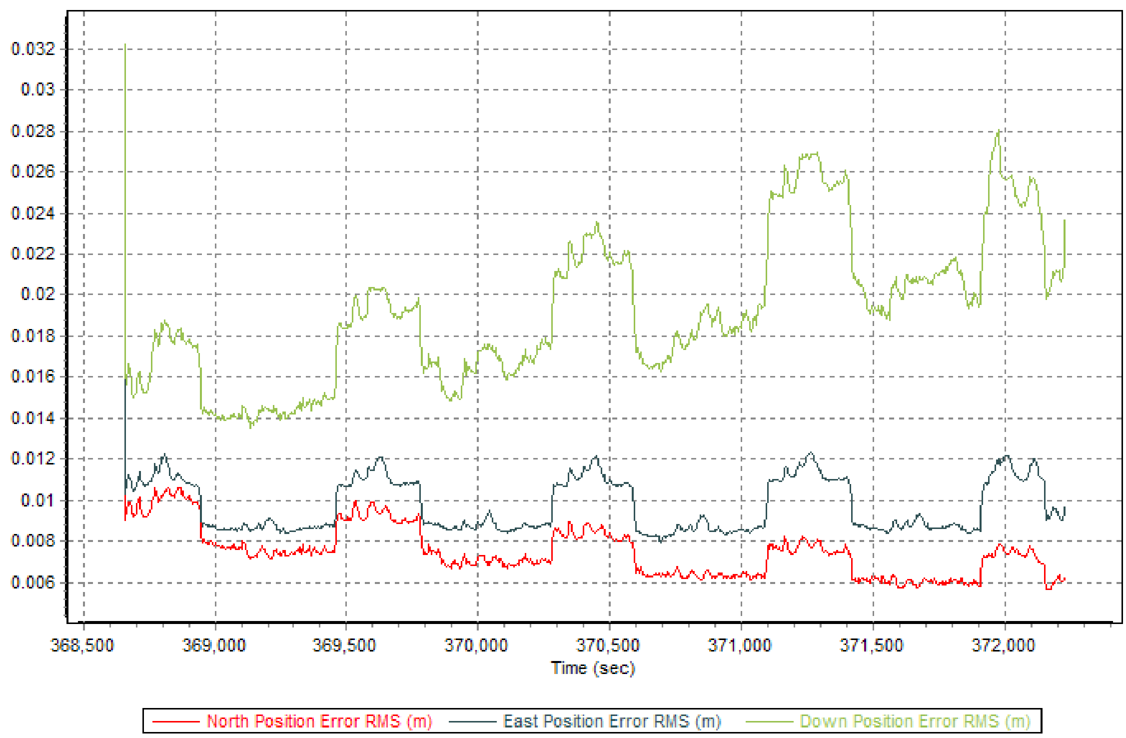



*Figure 1.1.2 Smoothed Performance Metric Parameters*

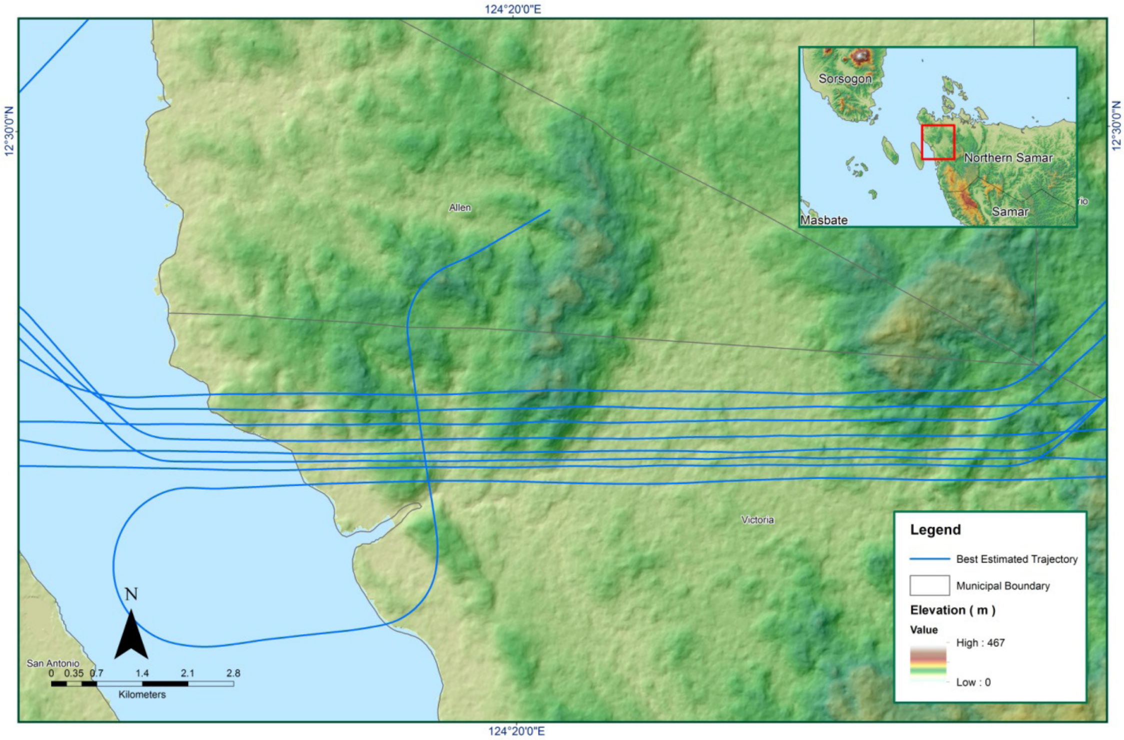



*Figure 1.1.3. Best Estimated Trajectory*

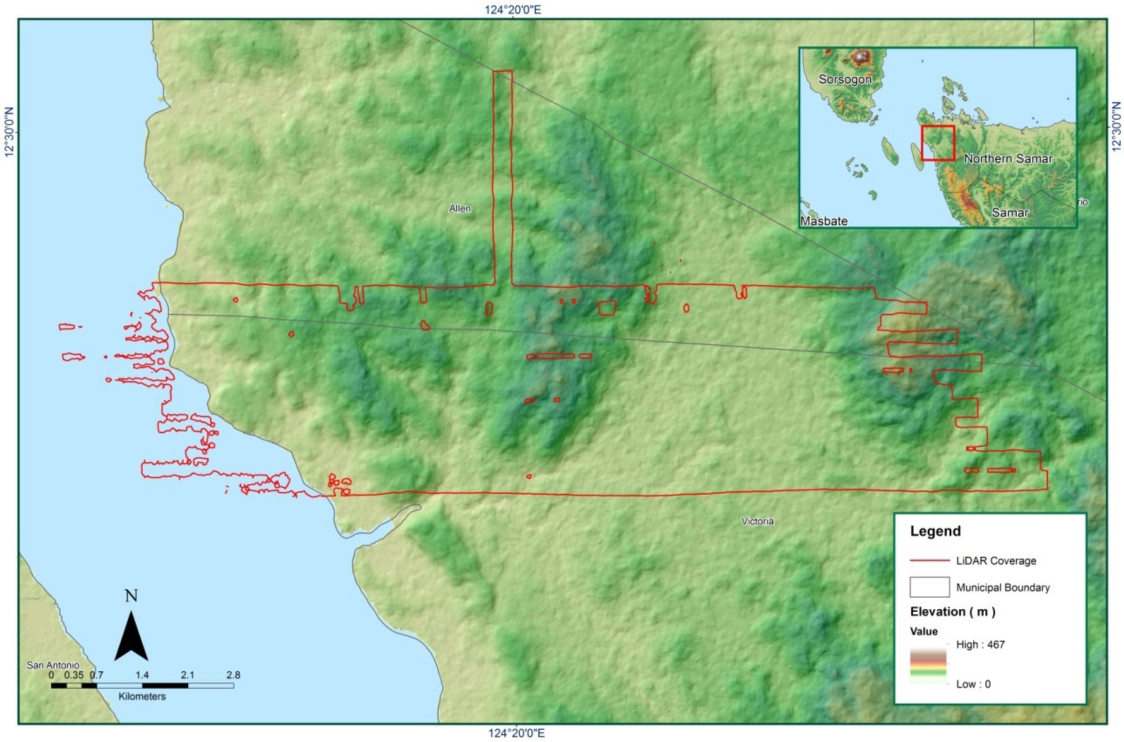



*Figure 1.1.4. Coverage of LiDAR data*

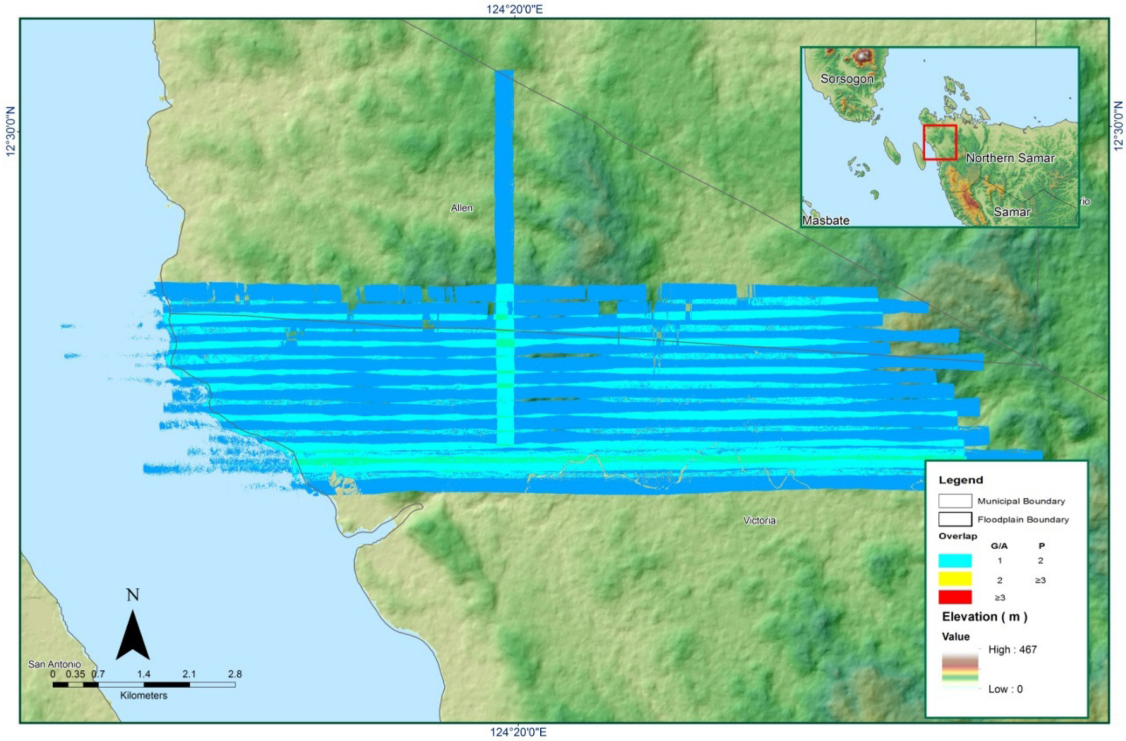



***Figure 1.1.5. Image of data overlap***

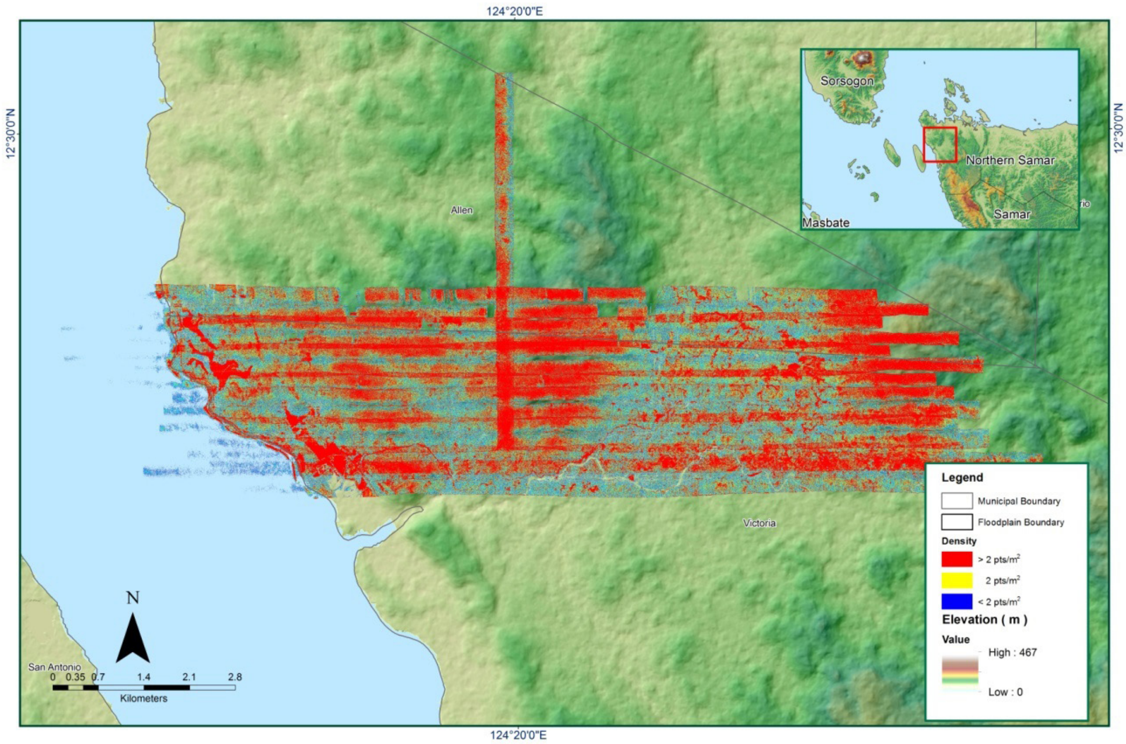



***Figure 1.1.6. Density map of merged LiDAR data***

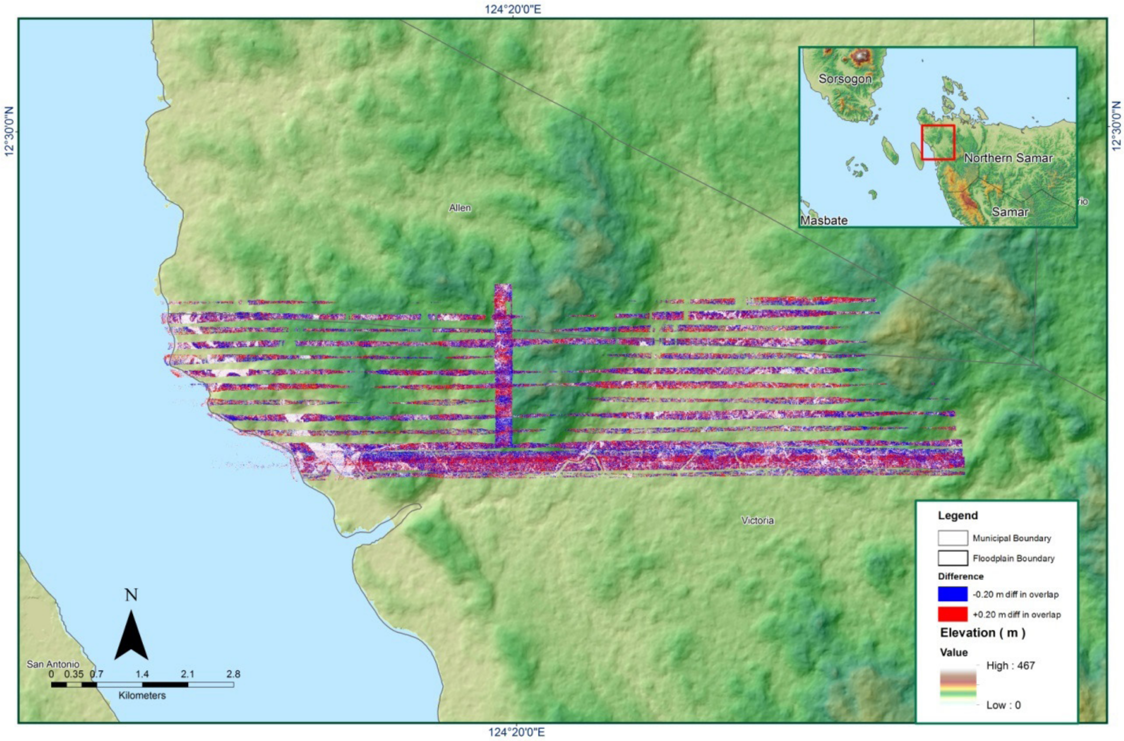



***Figure 1.1.7. Elevation difference between flight lines***

| Flight Area | Catarman |
|---|---|
| Mission Name | **Blk33D** |
| Inclusive Flights | 8190AC |
| Range data size | 8.77 GB |
| Base data size | 7.00 MB |
| POS | 222 MB |
| Image | 59.9 GB |
| Transfer date | September 16, 2015 |
| | |
| *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) | 1.05 |
| RMSE for East Position (<4.0 cm) | 1.35 |
| RMSE for Down Position (<8.0 cm) | 2.7 |
| | |
| Boresight correction stdev (<0.001deg) | 0.00130 |
| IMU attitude correction stdev (<0.001deg) | 0.004101 |
| GPS position stdev (<0.01m) | 0.0040 |
| | |
| Minimum % overlap (>25) | 27.44 |
| Ave point cloud density per sq.m. (>2.0) | 1.89 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 51 |
| Maximum Height | 358.80 m |
| Minimum Height | 51.48 m |
| | |
| *Classification (# of points)* | |
| Ground | 11,883,995 |
| Low vegetation | 5,394,582 |
| Medium vegetation | 11,261,803 |
| High vegetation | 23,048,207 |
| Building | 290,822 |
| | |
| Orthophoto | No |
| Processed by | Engr. Irish Cortez, Engr. Melanie Hingpit, Kathryn Claudine Zarate |

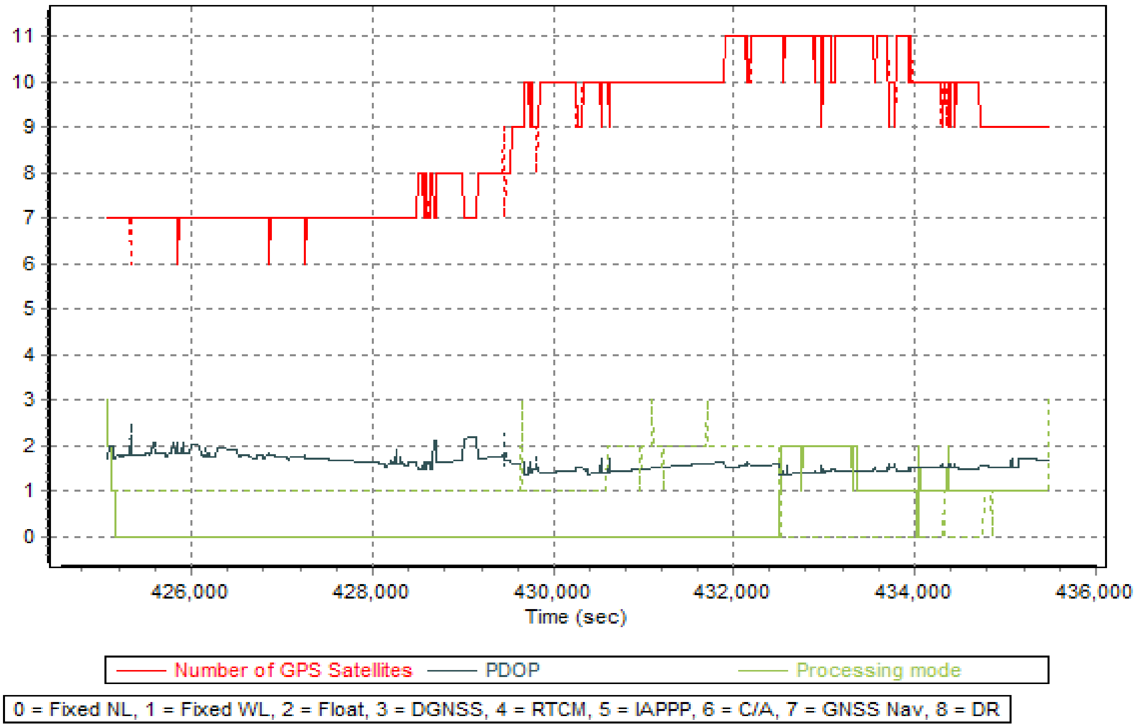



*Figure 1.2.1 Solution Status*

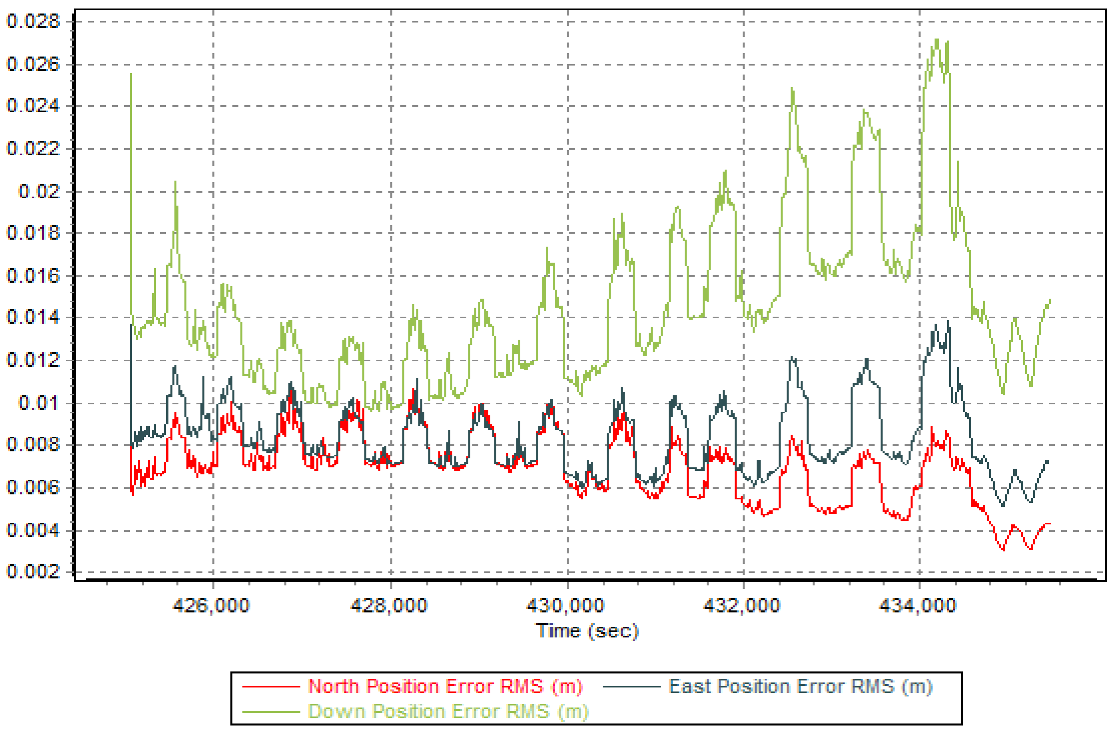



*Figure 1.2.2 Smoothed Performance Metric Parameters*

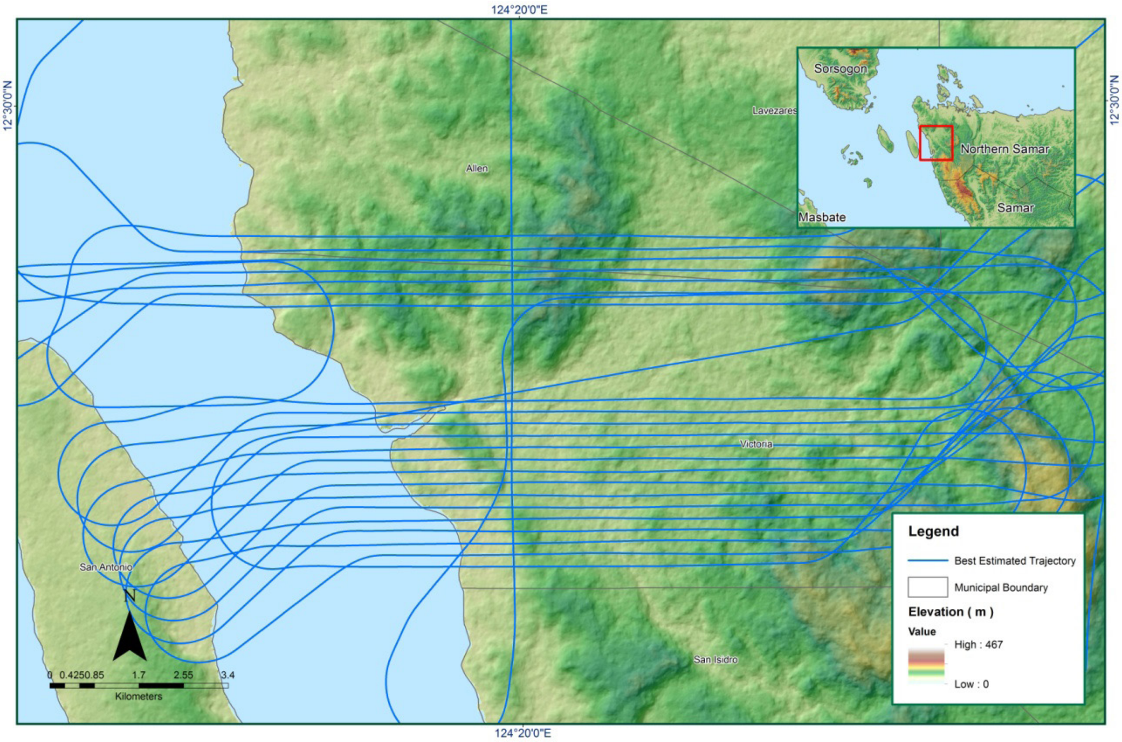



**Figure 1.2.3. Best Estimated Trajectory**

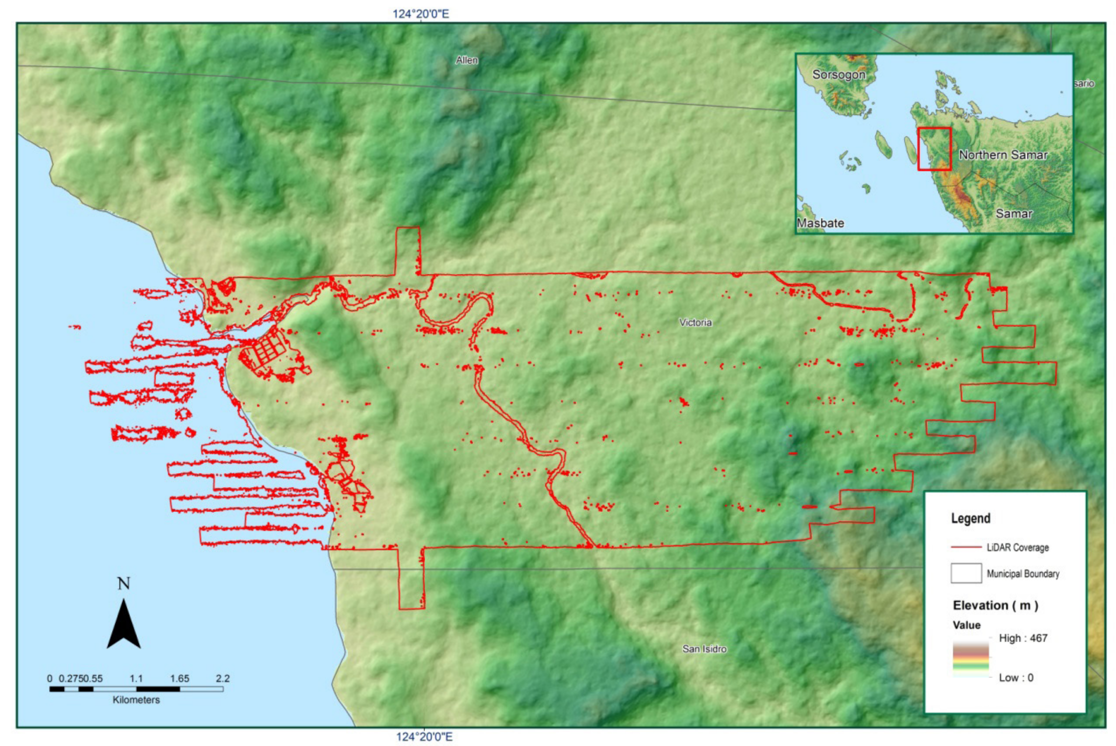



**Figure 1.2.4. Coverage of LiDAR data**

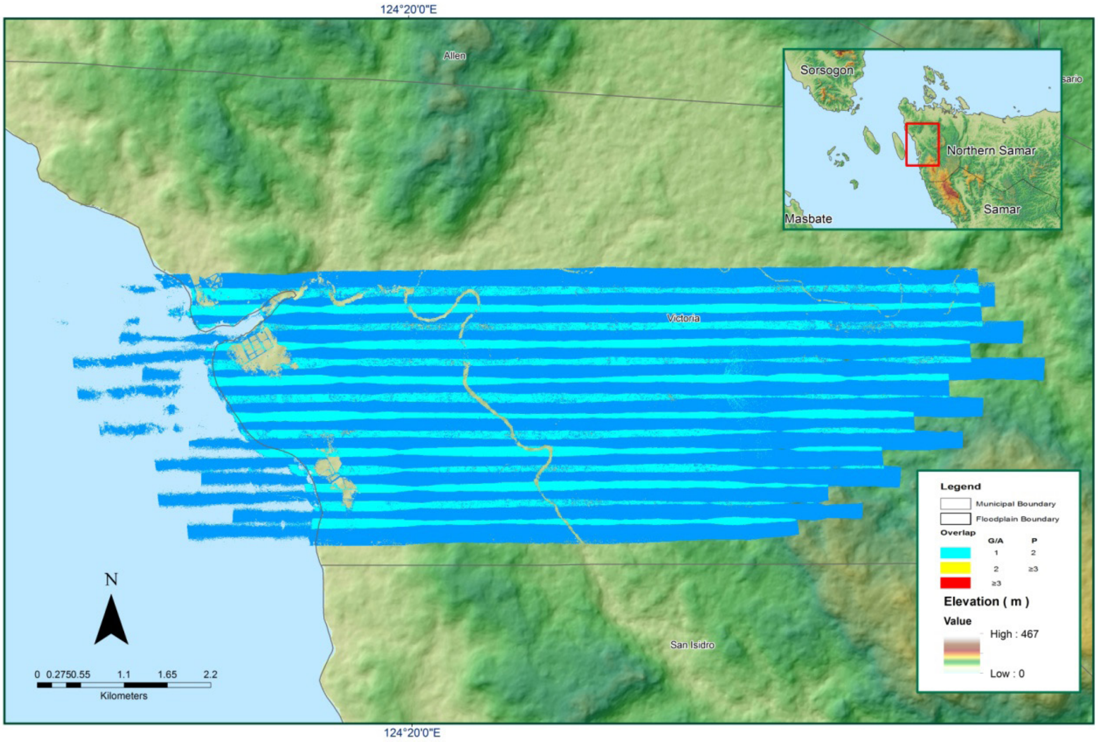



*Figure 1.2.5. Image of data overlap*

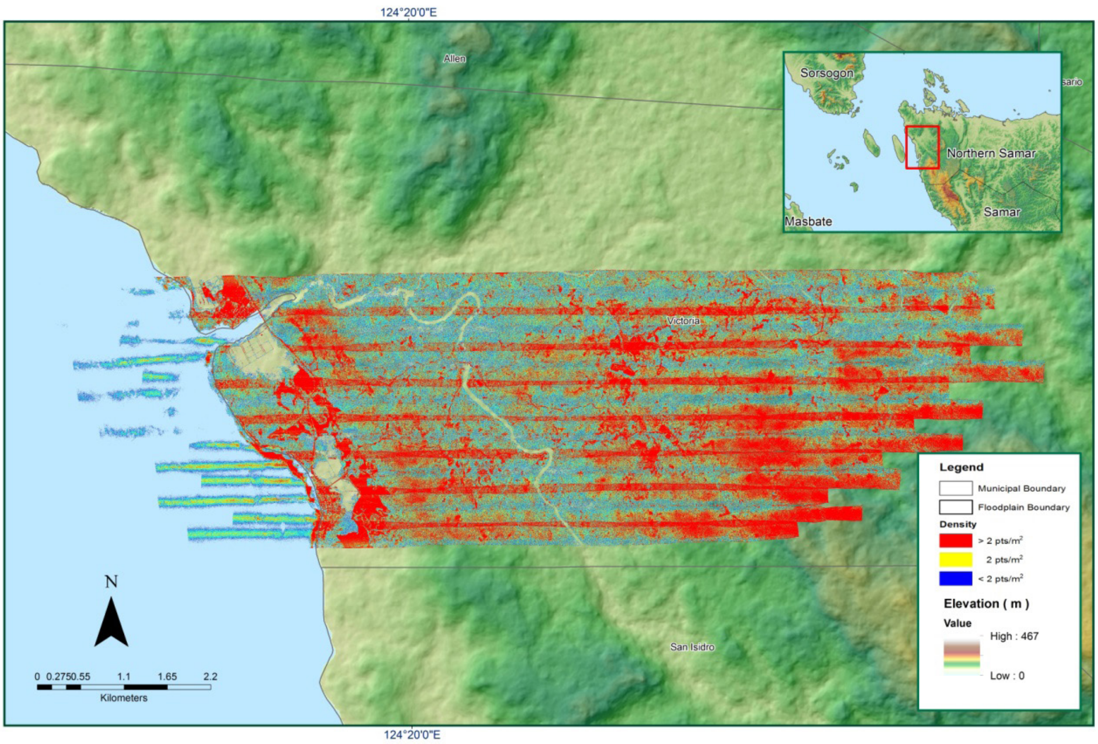



*Figure 1.2.6. Density map of merged LiDAR data*

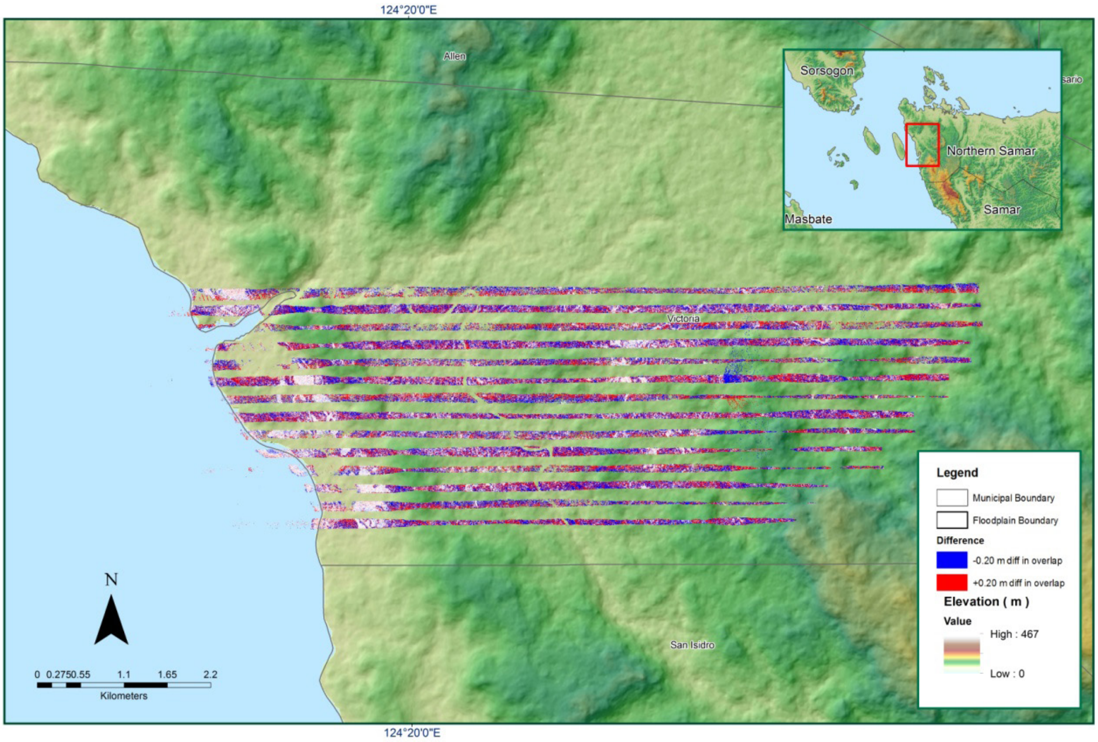



***Figure 1.2.7. Elevation difference between flight lines***

| Flight Area | Catarman |
|---|---|
| Mission Name | **Blk331G** |
| Inclusive Flights | 7839AC |
| Range data size | 4.40 GB |
| POS | 97.3 MB |
| Image | na |
| Transfer date | July 3, 2015 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.3 |
| RMSE for East Position (<4.0 cm) | 1.3 |
| RMSE for Down Position (<8.0 cm) | 1.8 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000737 |
| IMU attitude correction stdev (<0.001deg) | 0.088325 |
| GPS position stdev (<0.01m) | 0.0169 |
| | |
| Minimum % overlap (>25) | 38.23 |
| Ave point cloud density per sq.m. (>2.0) | 1.82 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 68 |
| Maximum Height | 167.23 m |
| Minimum Height | 47.84 m |
| | |
| *Classification (# of points)* | |
| Ground | 17,092,721 |
| Low vegetation | 12,685,518 |
| Medium vegetation | 14,284,243 |
| High vegetation | 7,912,569 |
| Building | 74,477 |
| | |
| Orthophoto | No |
| Processed by | Engr. Jennifer Saguran,Engr. Harmond Santos, Engr.Krisha Marie Bautista, |

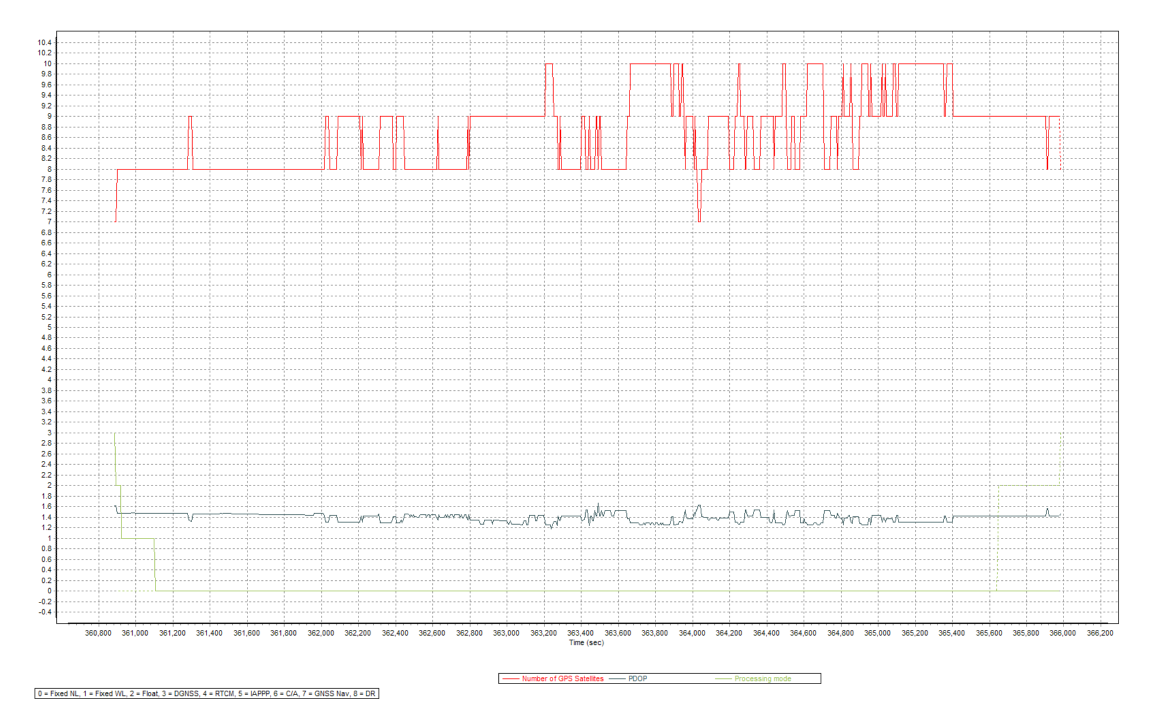



***Figure 1.3.1 Solution Status***

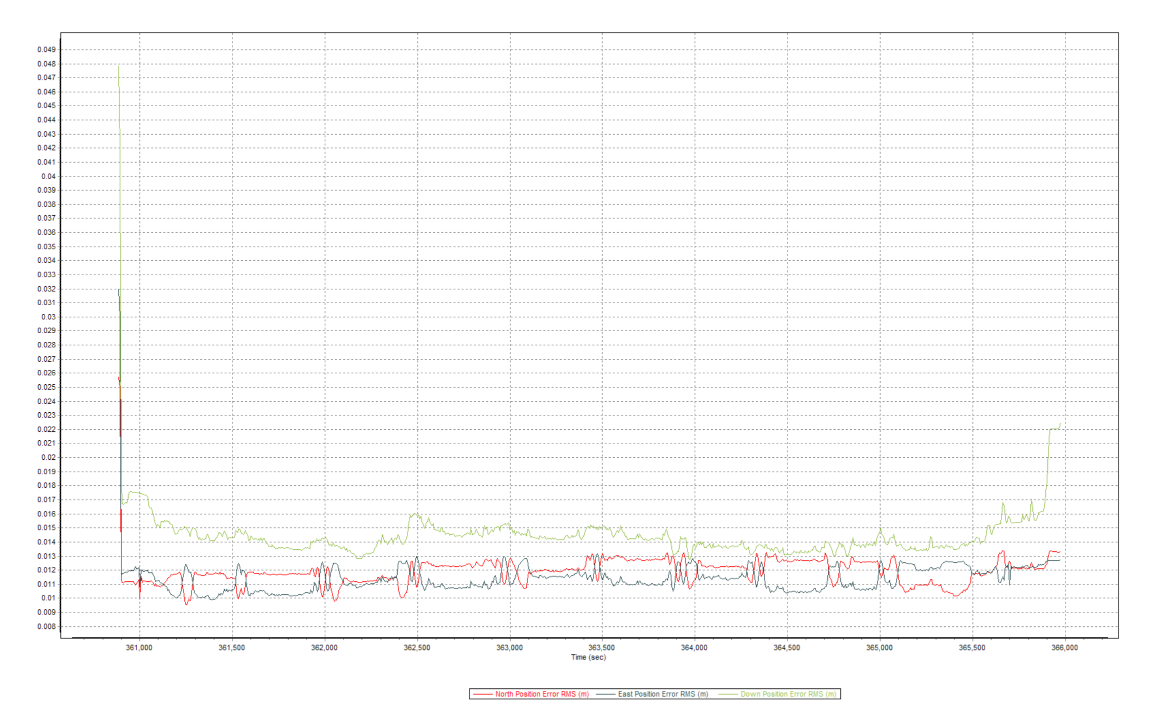



***Figure 1.3.2 Smoothed Performance Metric Parameters***

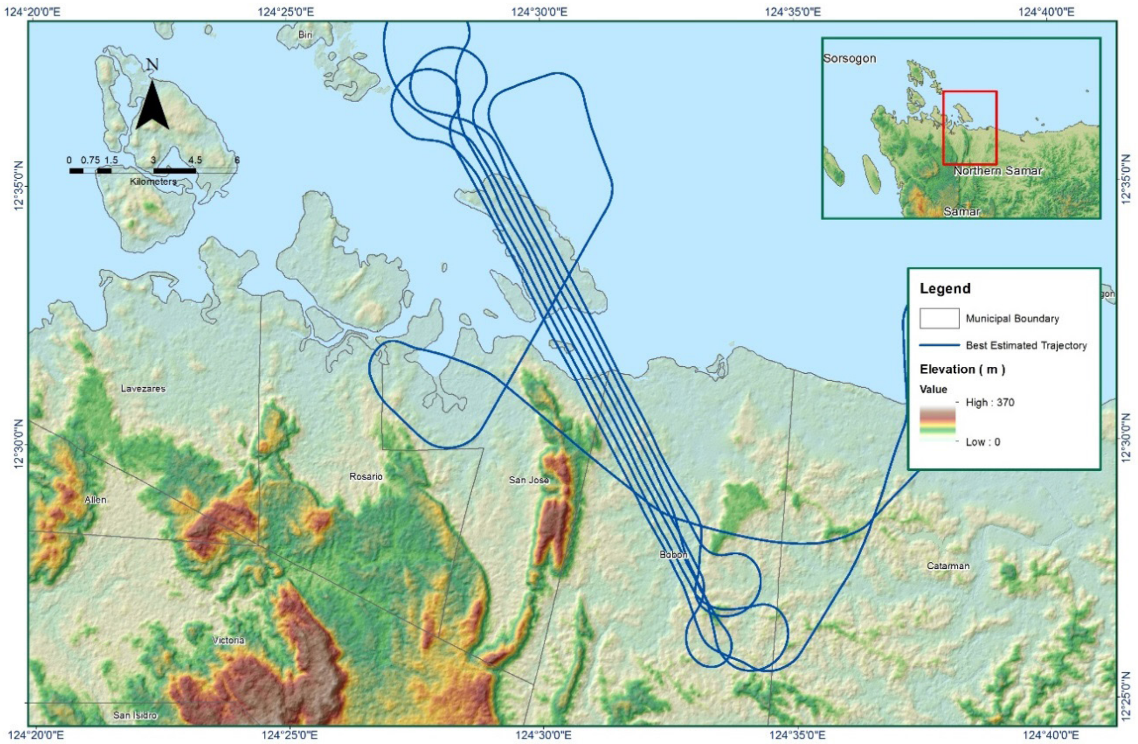



*Figure 1.3.3 Best Estimated Trajectory*

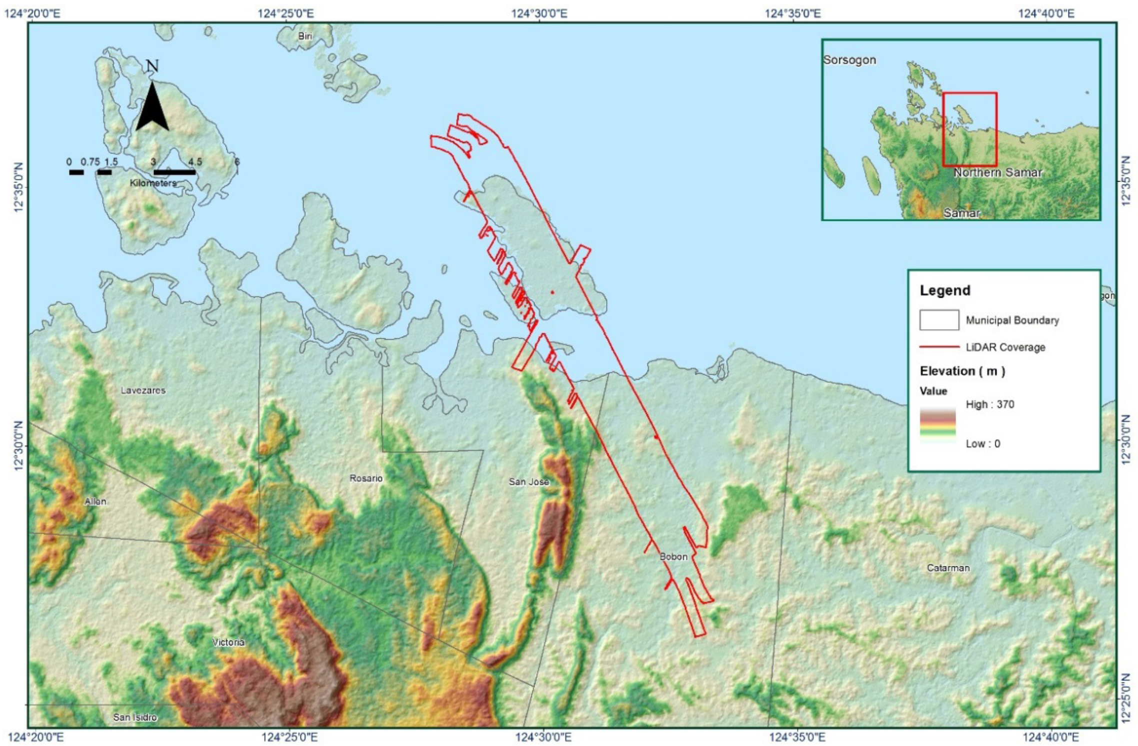



*Figure 1.3.4 Coverage of LiDAR data*

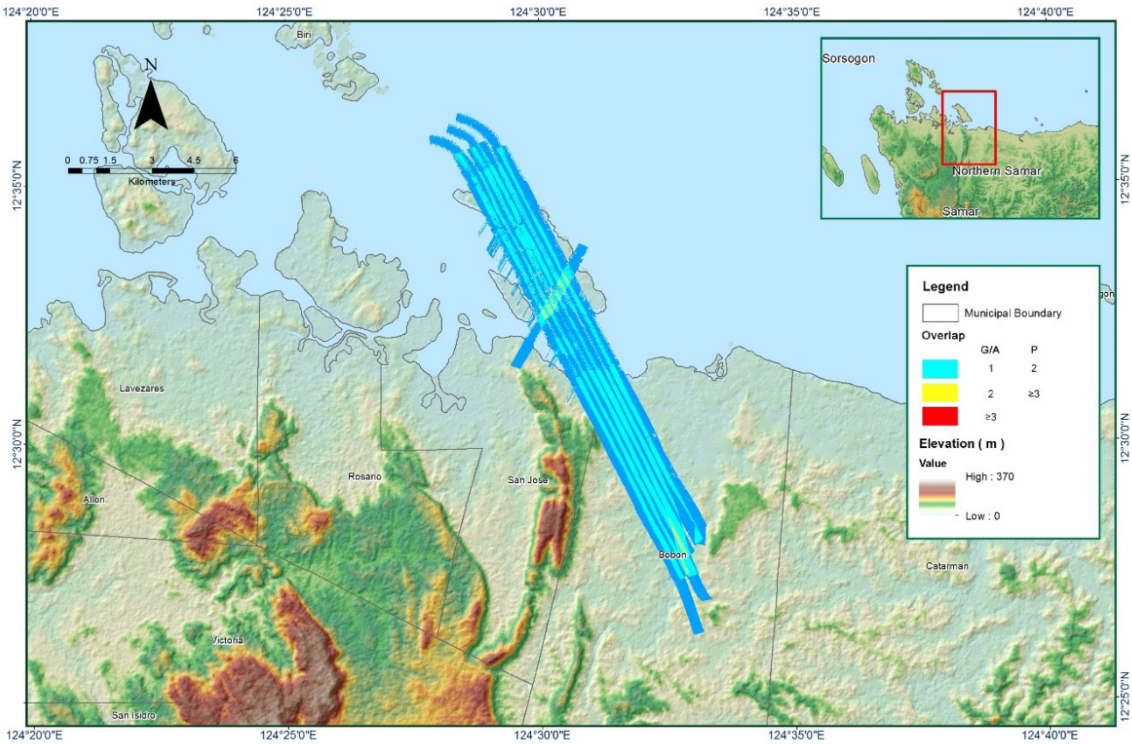



*Figure 1.3.5 Image of data overlap*

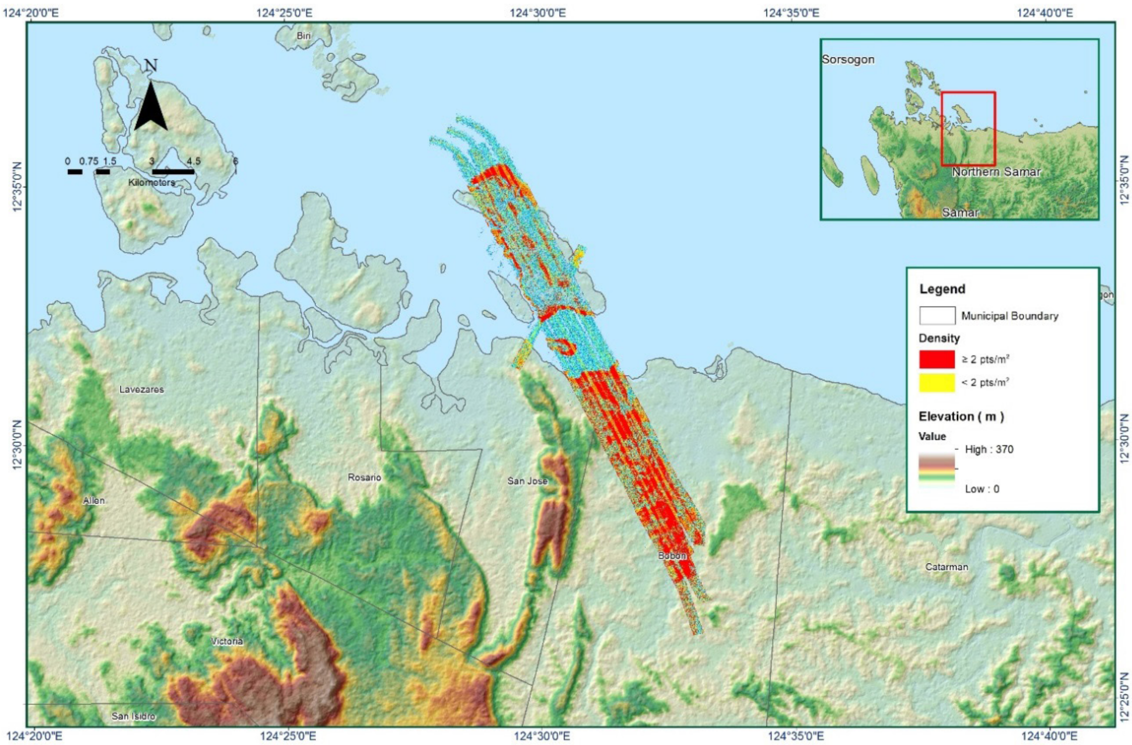



*Figure 1.3.6 Density map of merged LiDAR data*

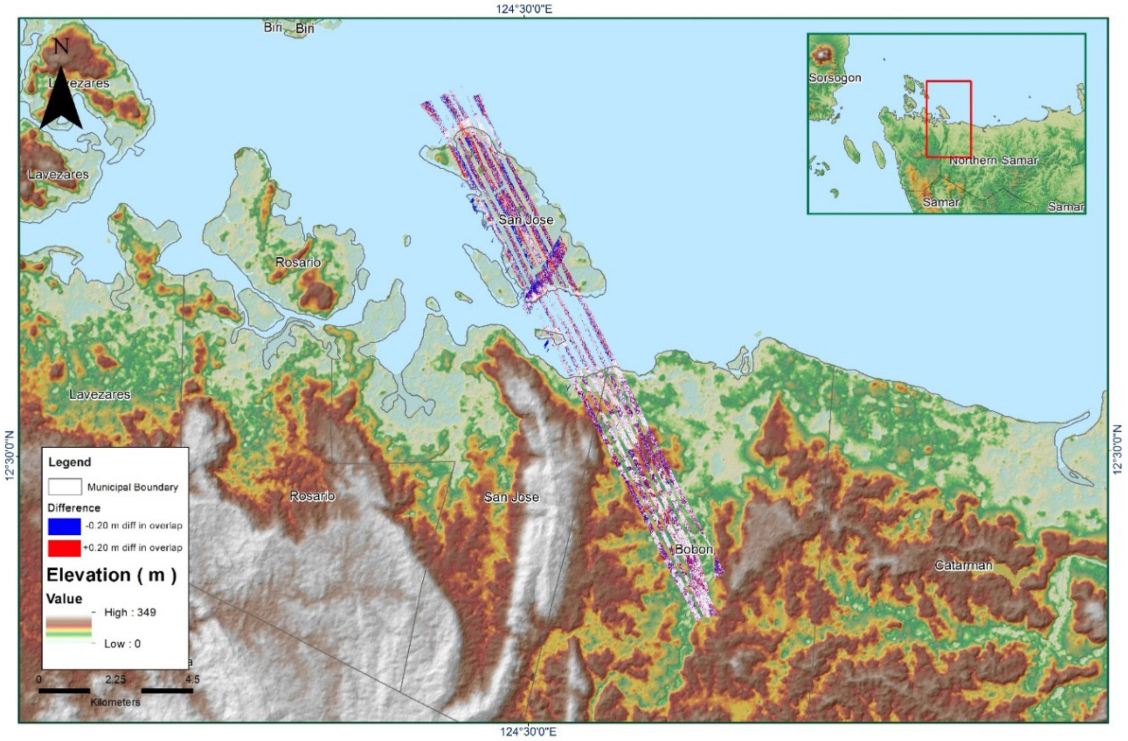



***Figure 1.6.7*** *Elevation difference between flight lines*

| Flight Area | Catarman |
|---|---|
| Mission Name | **Blk331H** |
| Inclusive Flights | 7828AC,7829AC,7830AC,7834AC |
| Range data size | 34.7 GB |
| POS | 743 MB |
| Image | na |
| Transfer date | July 3, 2015 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.1 |
| RMSE for East Position (<4.0 cm) | 1.26 |
| RMSE for Down Position (<8.0 cm) | 3.7 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000351 |
| IMU attitude correction stdev (<0.001deg) | 0.0032 |
| GPS position stdev (<0.01m) | 0.002648 |
| | |
| Minimum % overlap (>25) | 69.50 |
| Ave point cloud density per sq.m. (>2.0) | 3.16 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 113 |
| Maximum Height | 578.80 m |
| Minimum Height | 56.39 m |
| | |
| *Classification (# of points)* | |
| Ground | 41,920,729 |
| Low vegetation | 59,700,010 |
| Medium vegetation | 40,250,065 |
| High vegetation | 33,845,423 |
| Building | 2,814,214 |
| | |
| Orthophoto | No |
| Processed by | Engr. Sheila-MayeSantillan, Engr. Irish Cortez, Engr. Melanie Hingpit, Engr. Mark Sueden Lyle Magtalas |

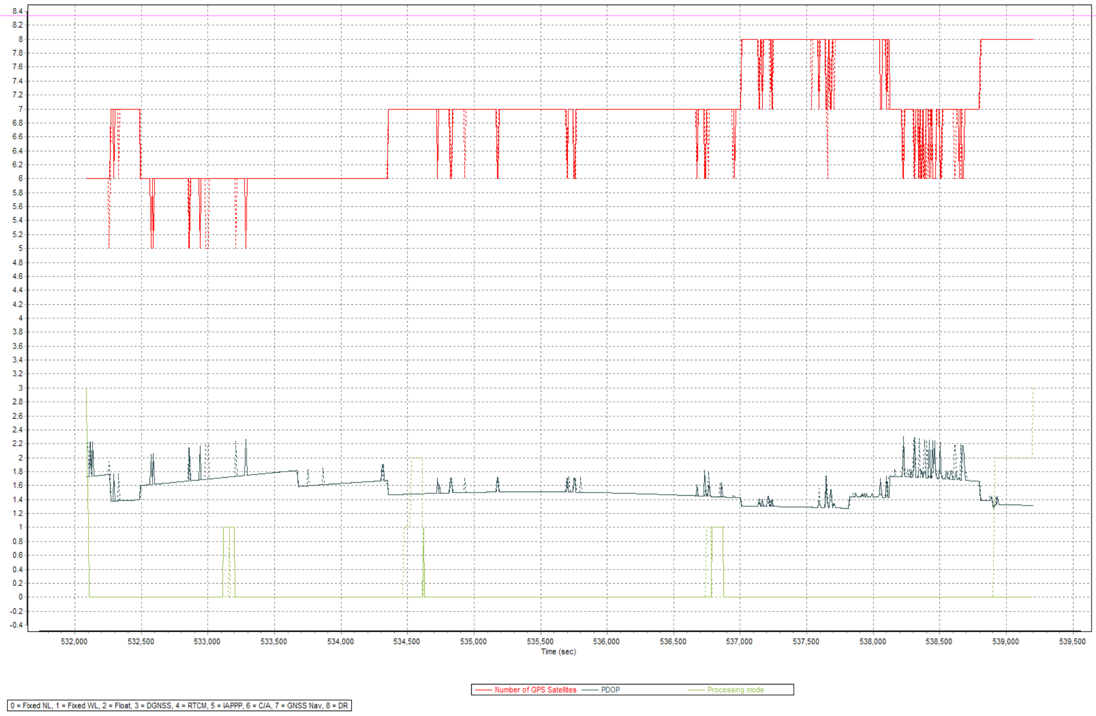



***Figure 1.4.1 Solution Status***

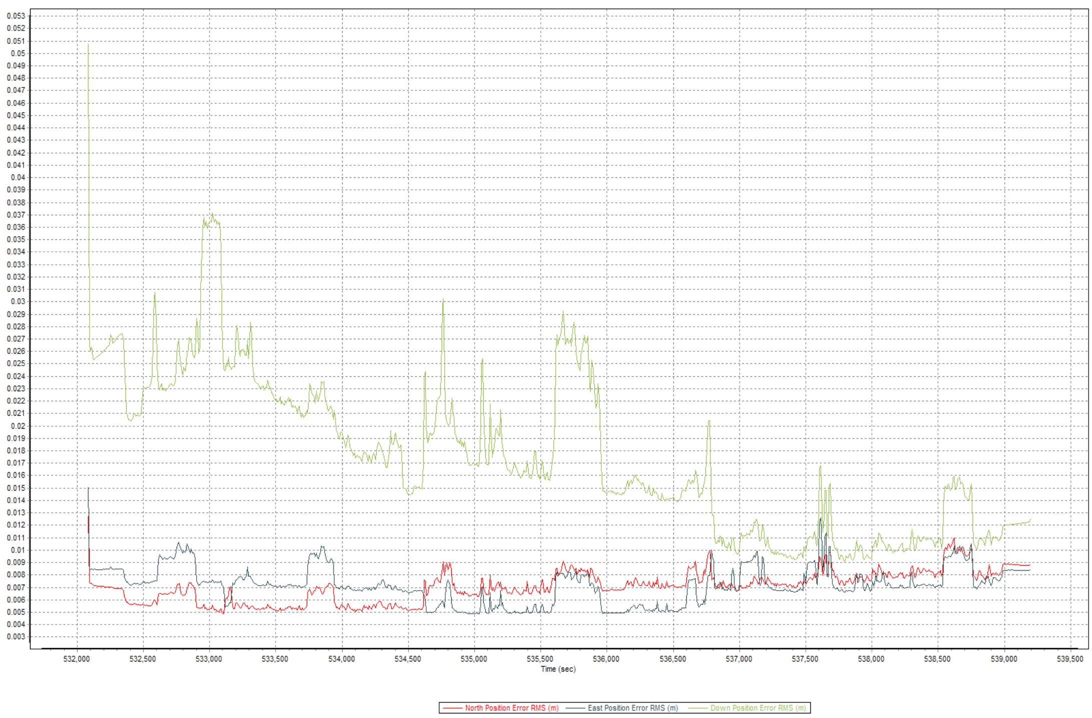



***Figure 1.4.2 Smoothed Performance Metric Parameters***

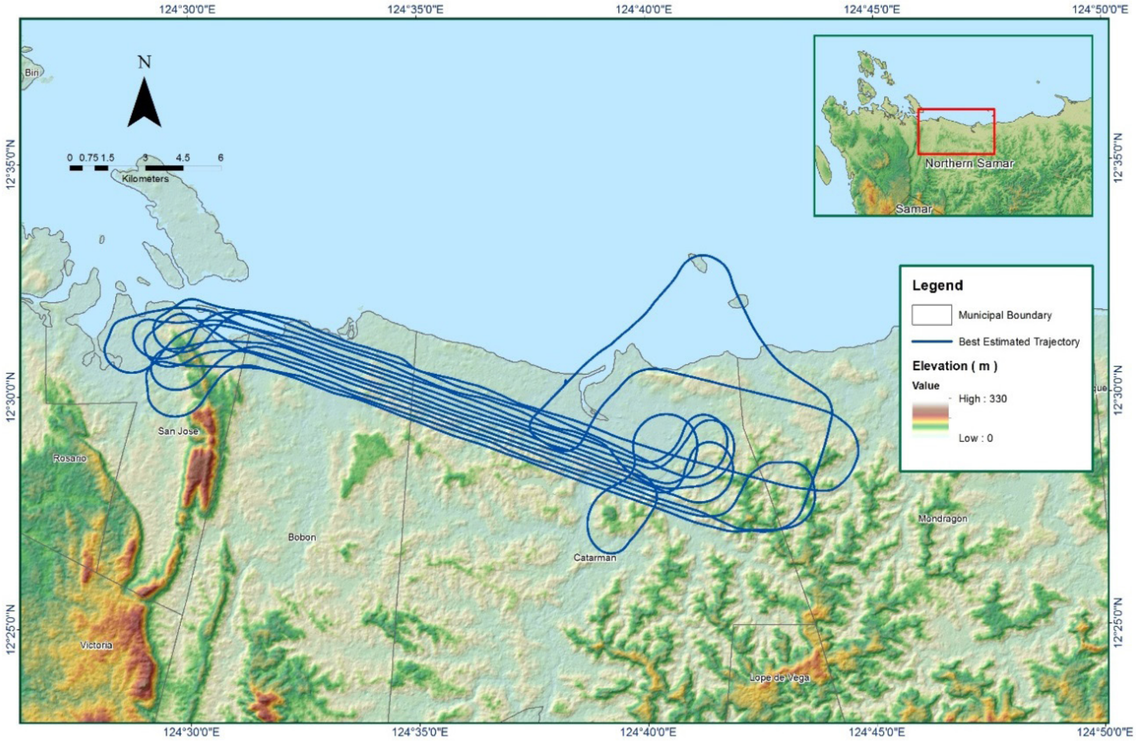



*Figure 1.4.3 Best Estimated Trajectory*

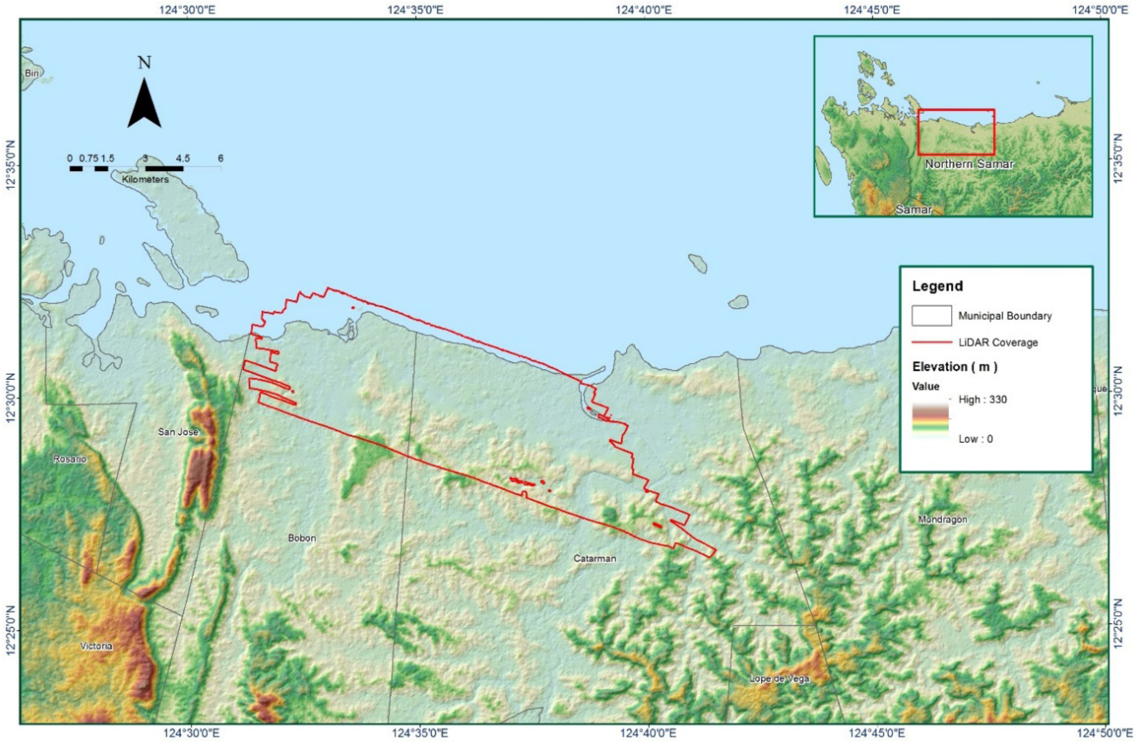



*Figure 1.4.4 Coverage of LiDAR data*

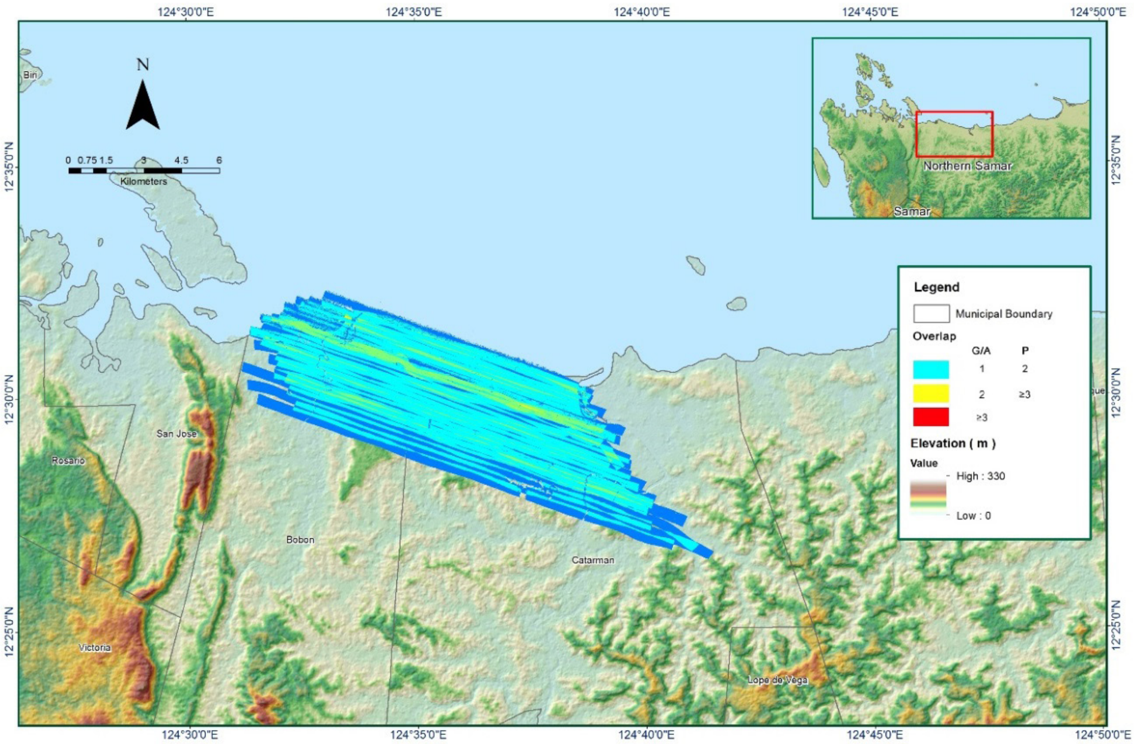



*Figure 1.4.5 Image of data overlap*

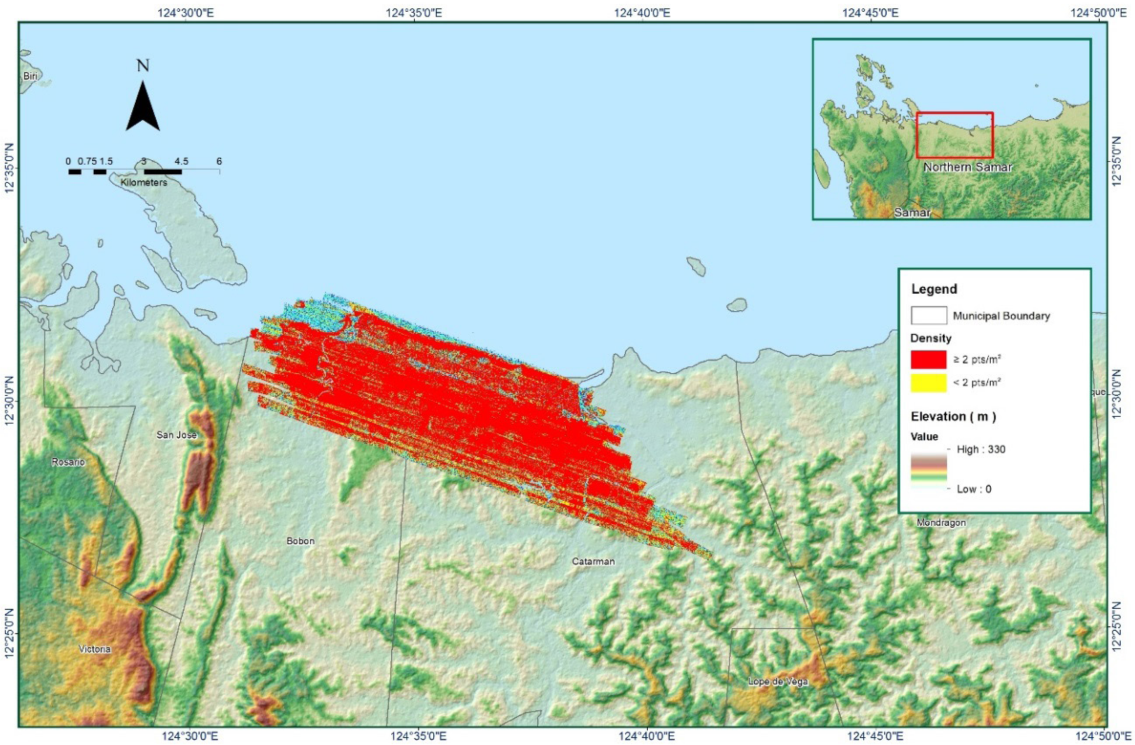



*Figure 1.4.6 Density map of merged LiDAR data*

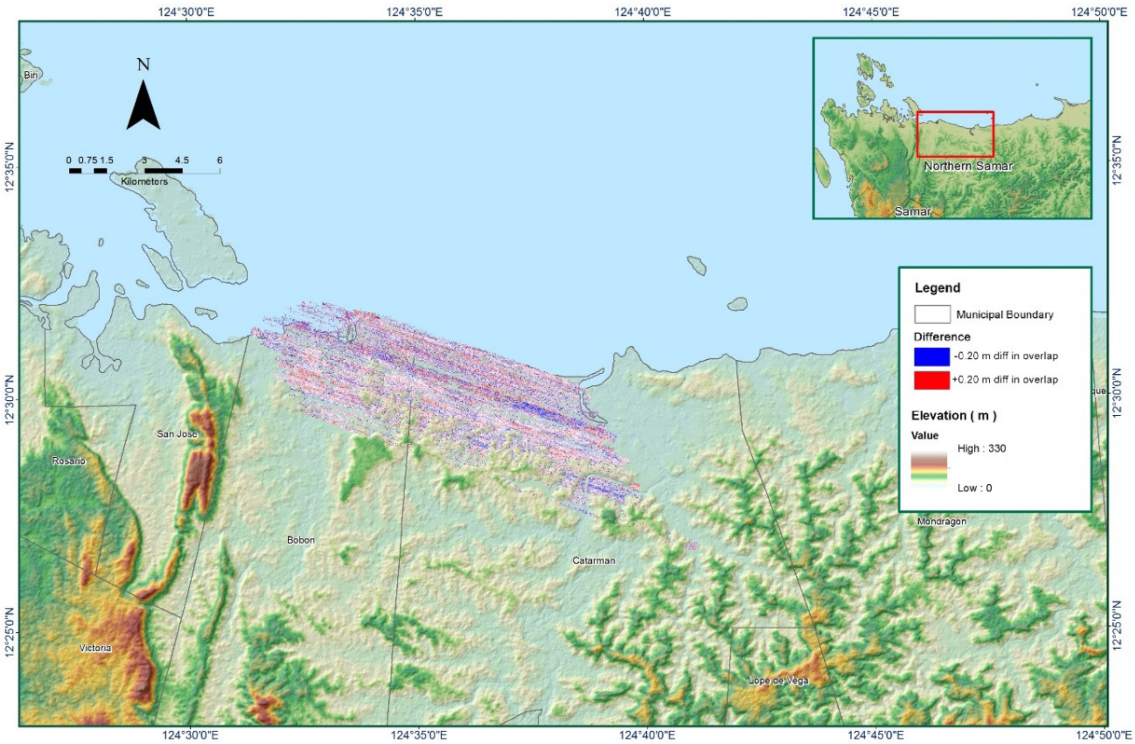



***Figure 1.4.7****Elevation difference between flight lines*

| Flight Area | Catarman |
|---|---|
| Mission Name | **Blk331I** |
| Inclusive Flights | 7820AC,7822AC,7828AC |
| Range data size | 22.15 GB |
| POS | 507.4 MB |
| Image | na |
| Transfer date | July 3, 2015 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.7 |
| RMSE for East Position (<4.0 cm) | 1.7 |
| RMSE for Down Position (<8.0 cm) | 4.0 |
| | |
| Boresight correction stdev (<0.001deg) | 0.00466 |
| IMU attitude correction stdev (<0.001deg) | 0.003351 |
| GPS position stdev (<0.01m) | 0.0121 |
| | |
| Minimum % overlap (>25) | 46.22 |
| Ave point cloud density per sq.m. (>2.0) | 2.89 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 133 |
| Maximum Height | 303.60 m |
| Minimum Height | 57.96 m |
| | |
| *Classification (# of points)* | |
| Ground | 62,554,732 |
| Low vegetation | 28,776,426 |
| Medium vegetation | 48,696,744 |
| High vegetation | 150,270,590 |
| Building | 1,248,331 |
| | |
| Orthophoto | No |
| Processed by | Engr. Kenneth Solidum, Engr. Melanie Hingpit, Engr. Mark Sueden Lyle Magtalas |

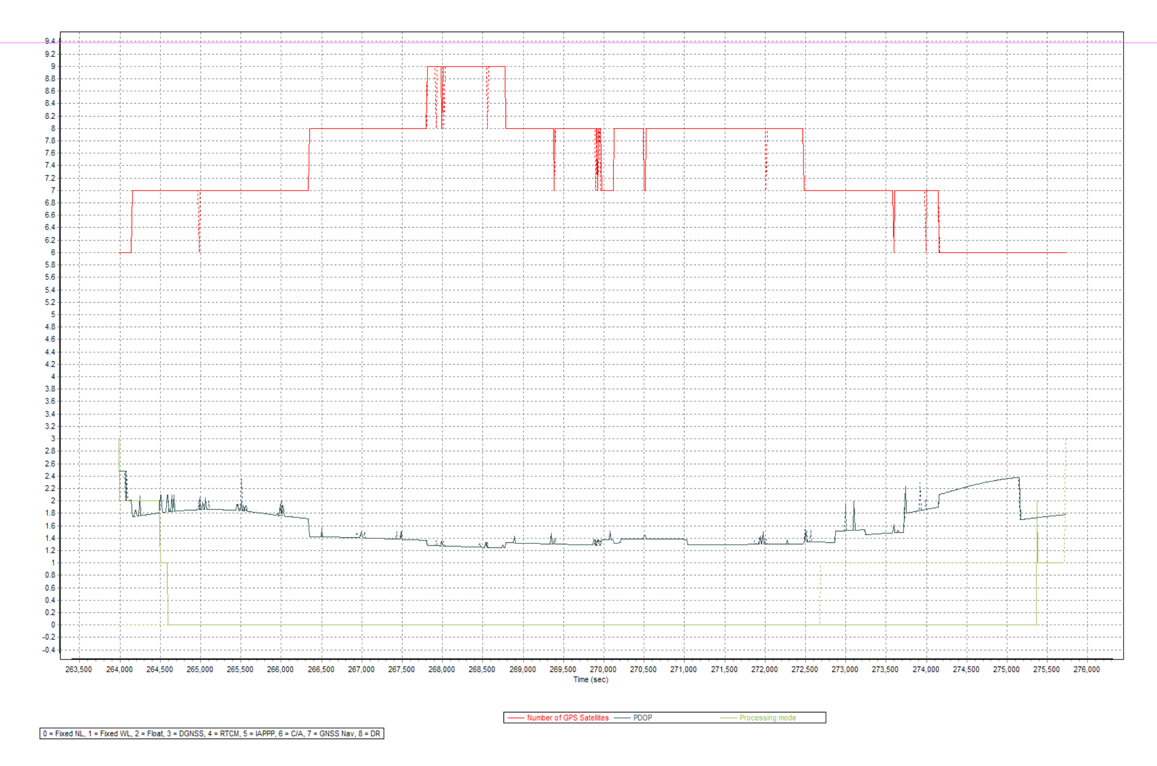



***Figure 1.5.1 Solution Status***

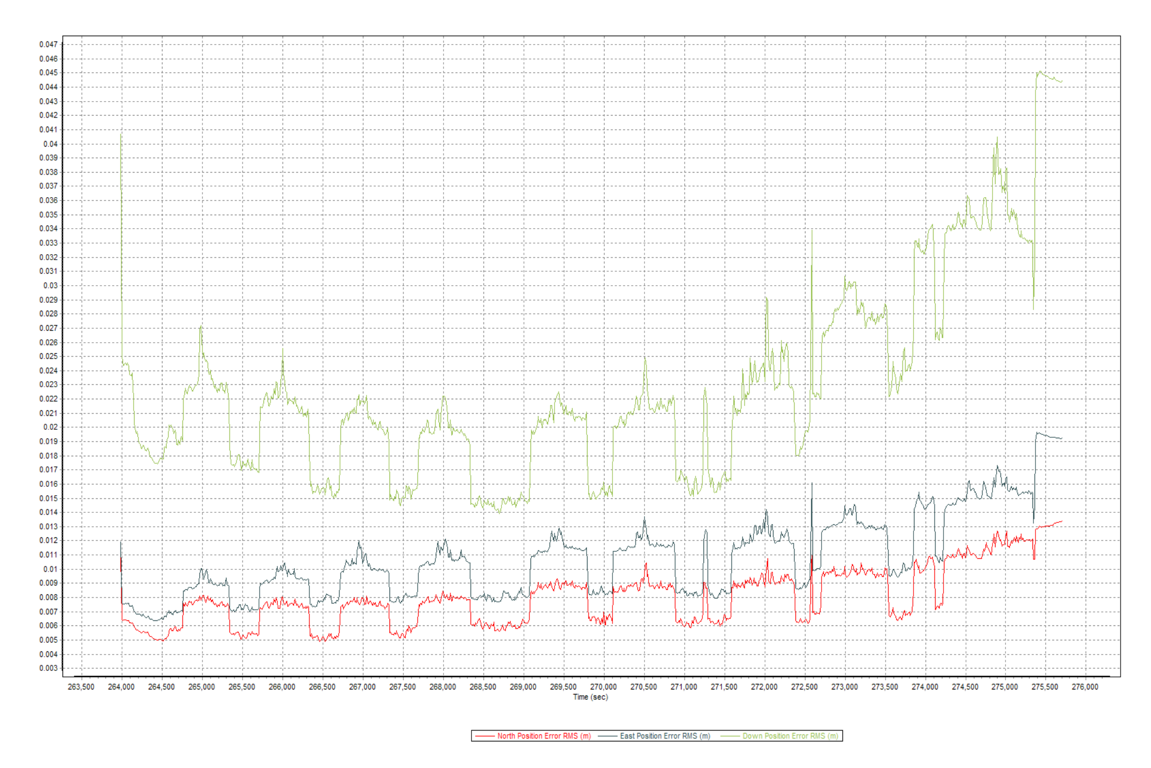



***Figure 1.5.2 Smoothed Performance Metric Parameters***

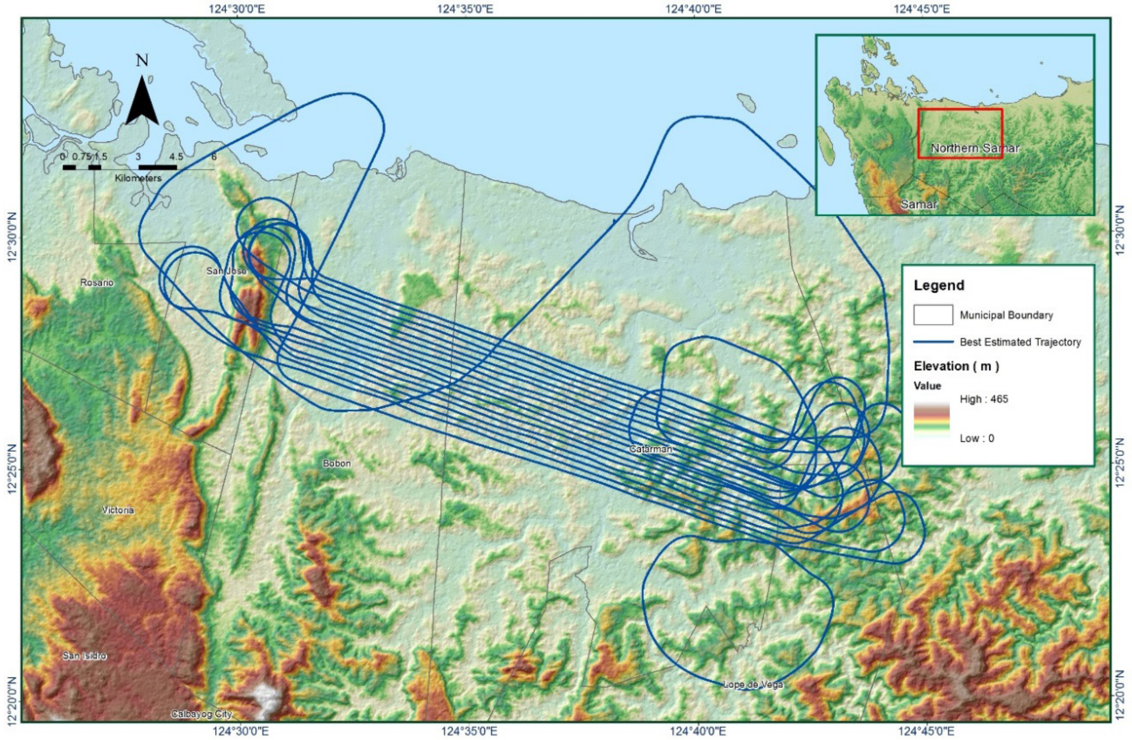



*Figure 1.5.3 Best Estimated Trajectory*

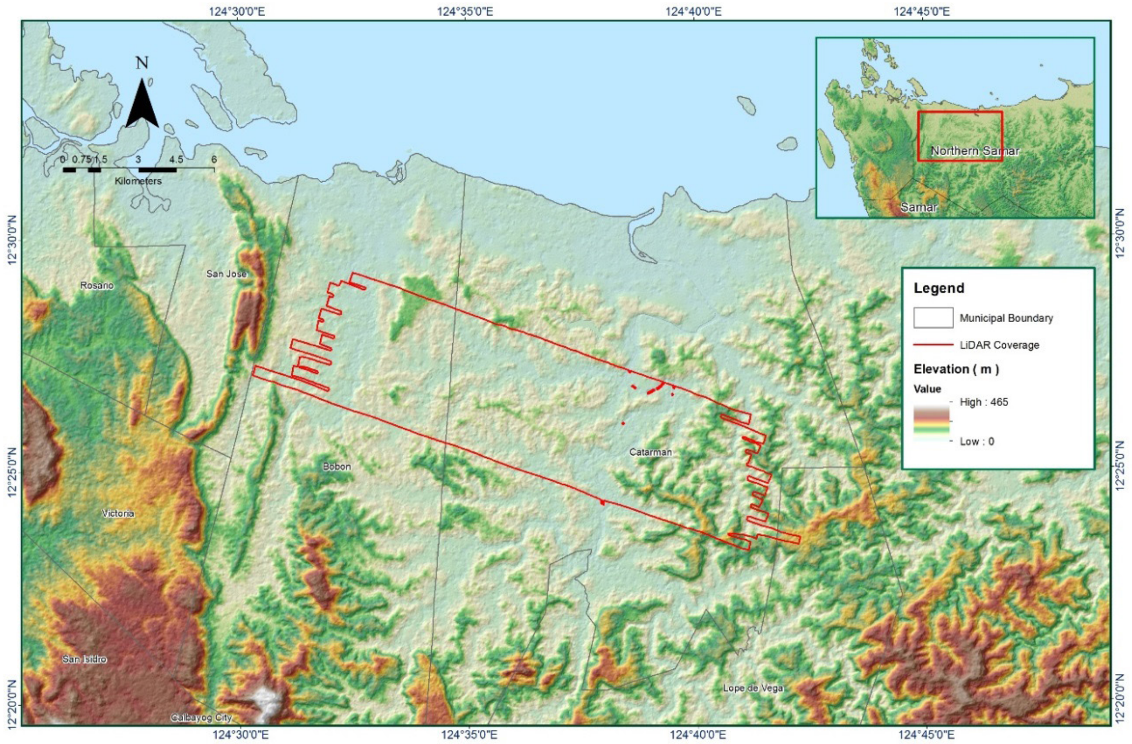



*Figure 1.5.4 Coverage of LiDAR data*

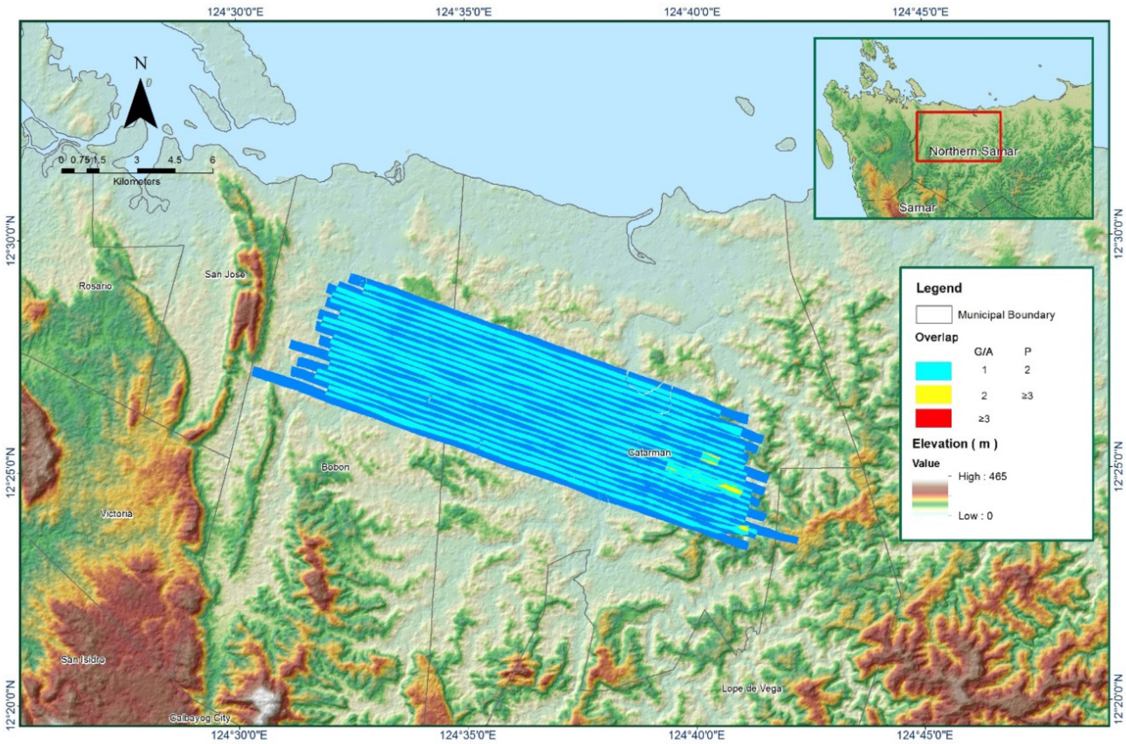



***Figure 1.5.5 Image of data overlap***

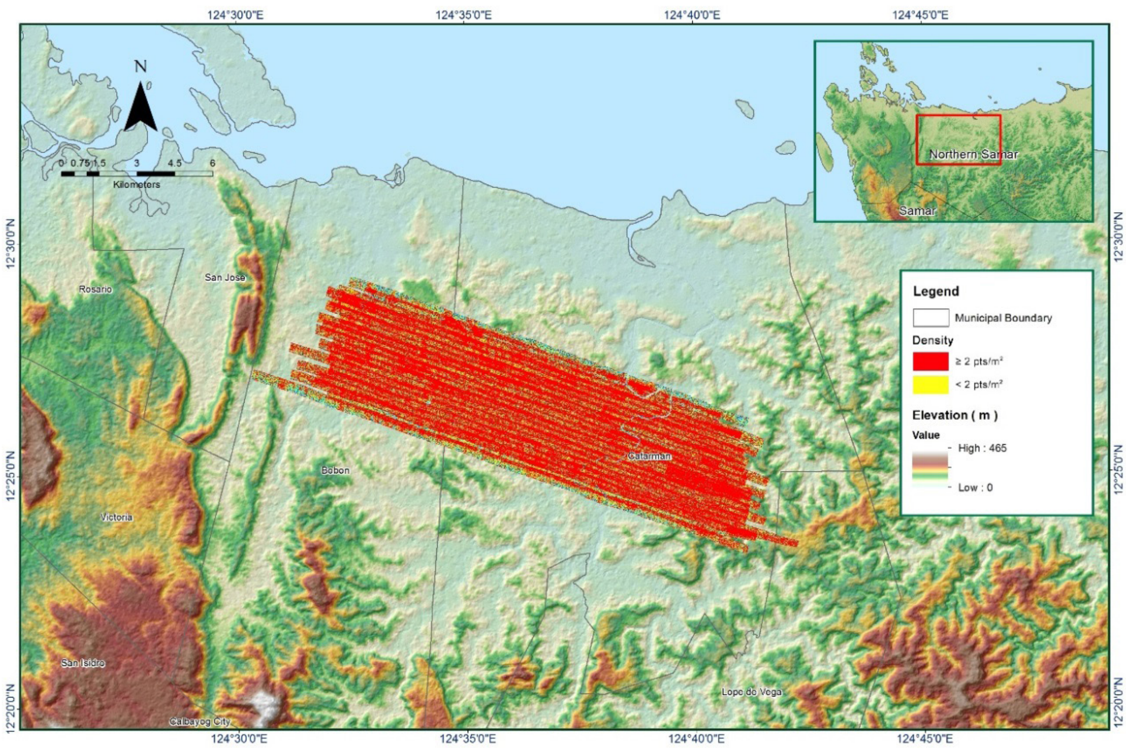



***Figure 1.5.6 Density map of merged LiDAR data***

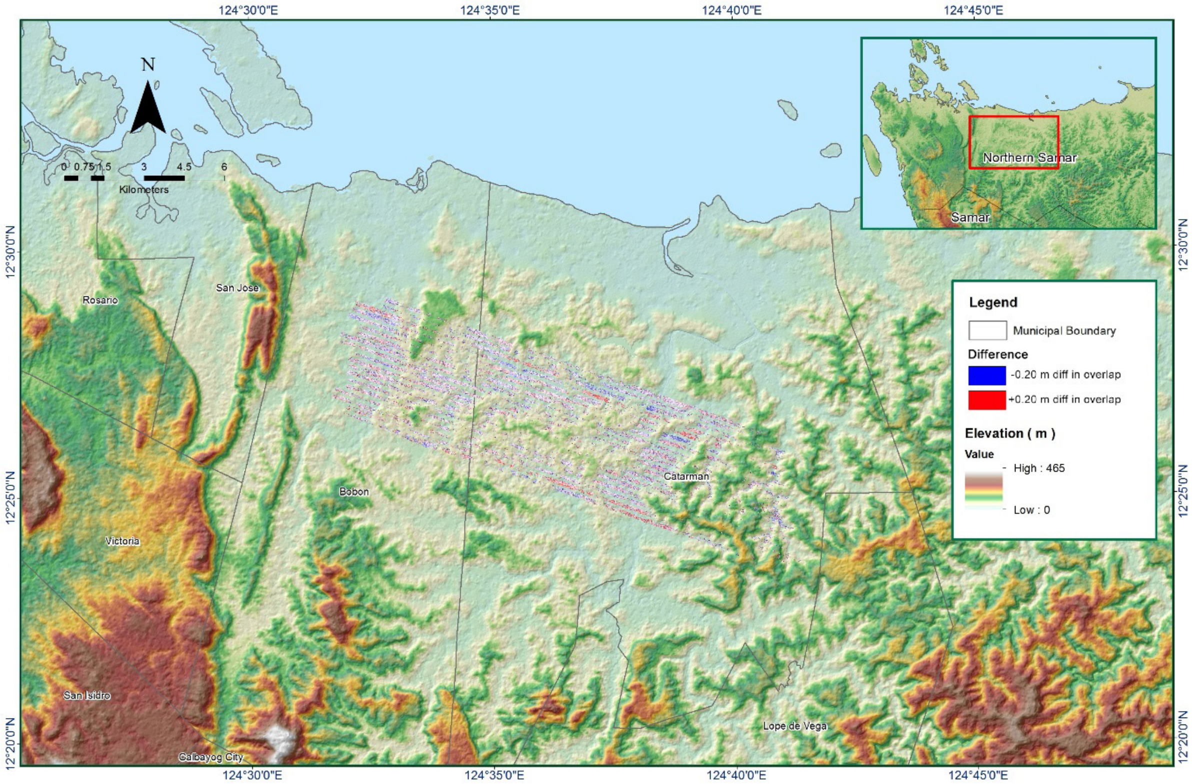



***Figure 1.5.7*** *Elevation difference between flight lines*

| **Flight Area** | **Catarman** |
|---|---|
| Mission Name | **Blk331J** |
| Inclusive Flights | 7828AC,7838AC,7842AC |
| Range data size | 29.28 GB |
| POS | 666 MB |
| Image | na |
| Transfer date | July 3, 2015 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.2 |
| RMSE for East Position (<4.0 cm) | 1.7 |
| RMSE for Down Position (<8.0 cm) | 4.0 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000520 |
| IMU attitude correction stdev (<0.001deg) | 0.003152 |
| GPS position stdev (<0.01m) | 0.0079 |
| | |
| Minimum % overlap (>25) | 45.48 |
| Ave point cloud density per sq.m. (>2.0) | 2.84 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 201 |
| Maximum Height | 637.77 m |
| Minimum Height | 60.22 m |
| | |
| *Classification (# of points)* | |
| Ground | 48,996,763 |
| Low vegetation | 48,996,763 |
| Medium vegetation | 91,713,572 |
| High vegetation | 241,068,359 |
| Building | 4,924,915 |
| | |
| Orthophoto | No |
| Processed by | Engr. AnalynNaldo, Engr. Chelou Prado, Maria Tamsyn Malabanan |

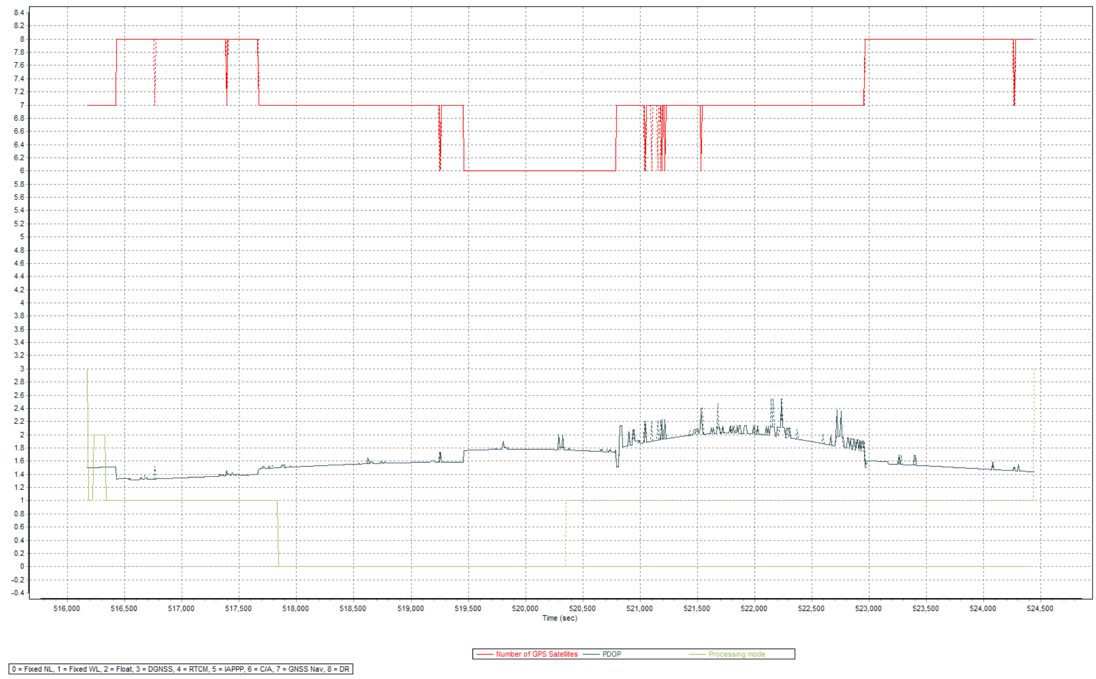



***Figure 1.6.1 Solution Status***

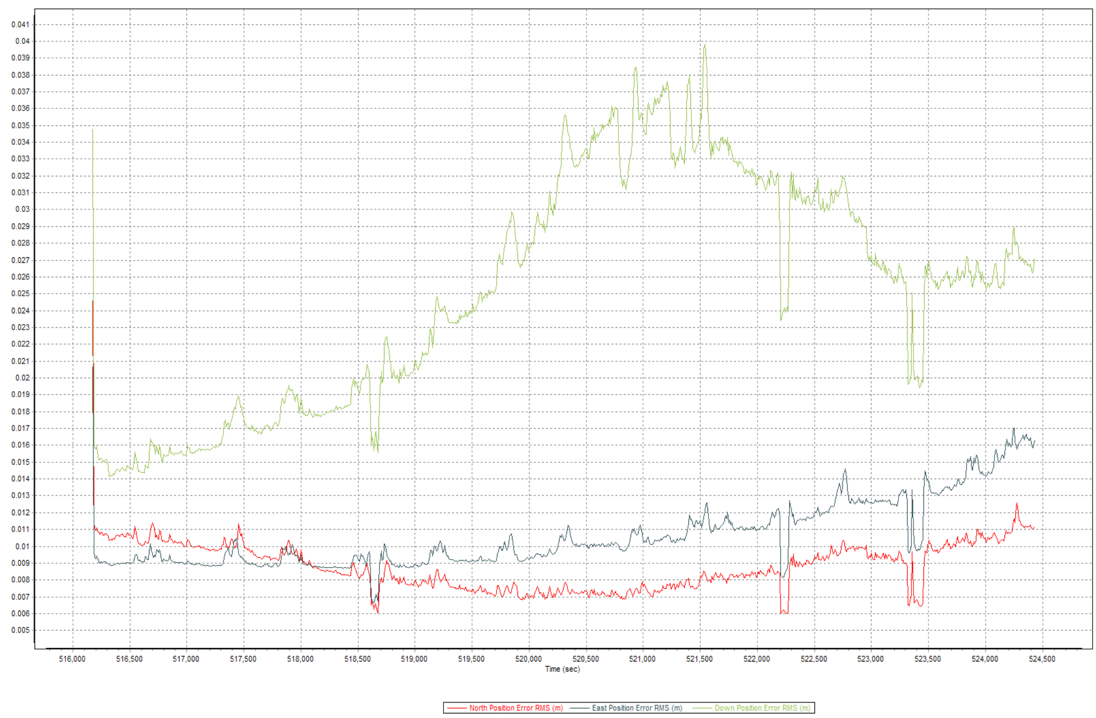



***Figure 1.6.2 Smoothed Performance Metric Parameters***

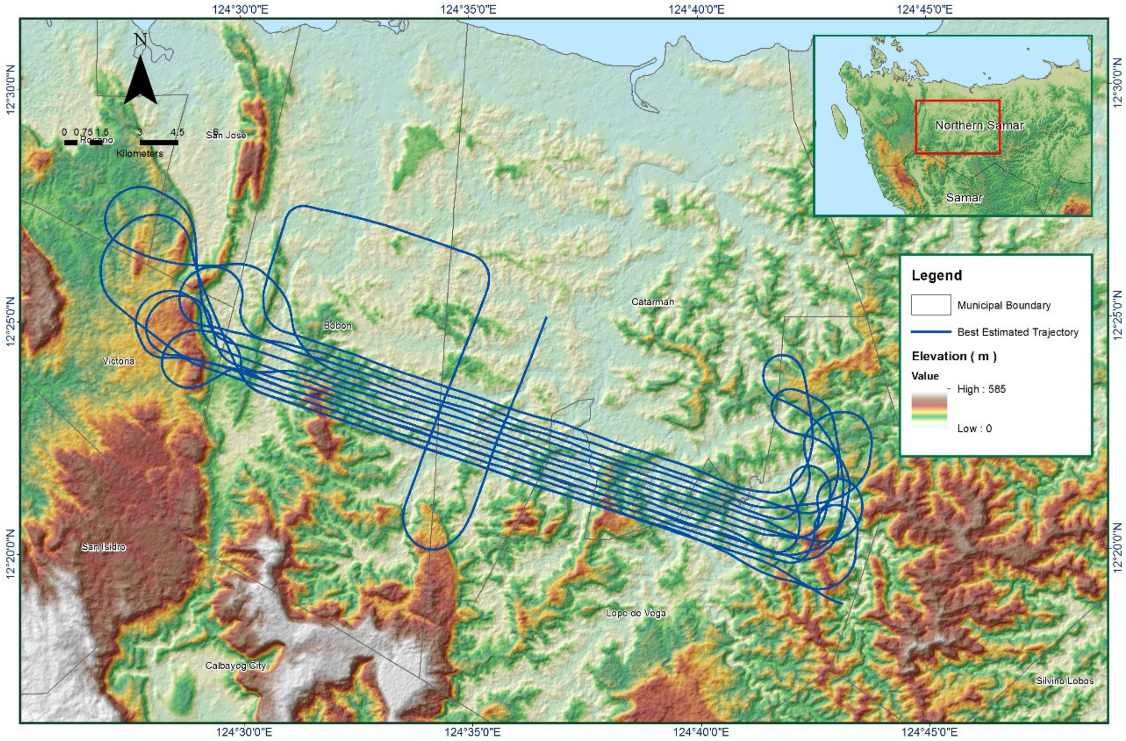



*Figure 1.6.3 Best Estimated Trajectory*

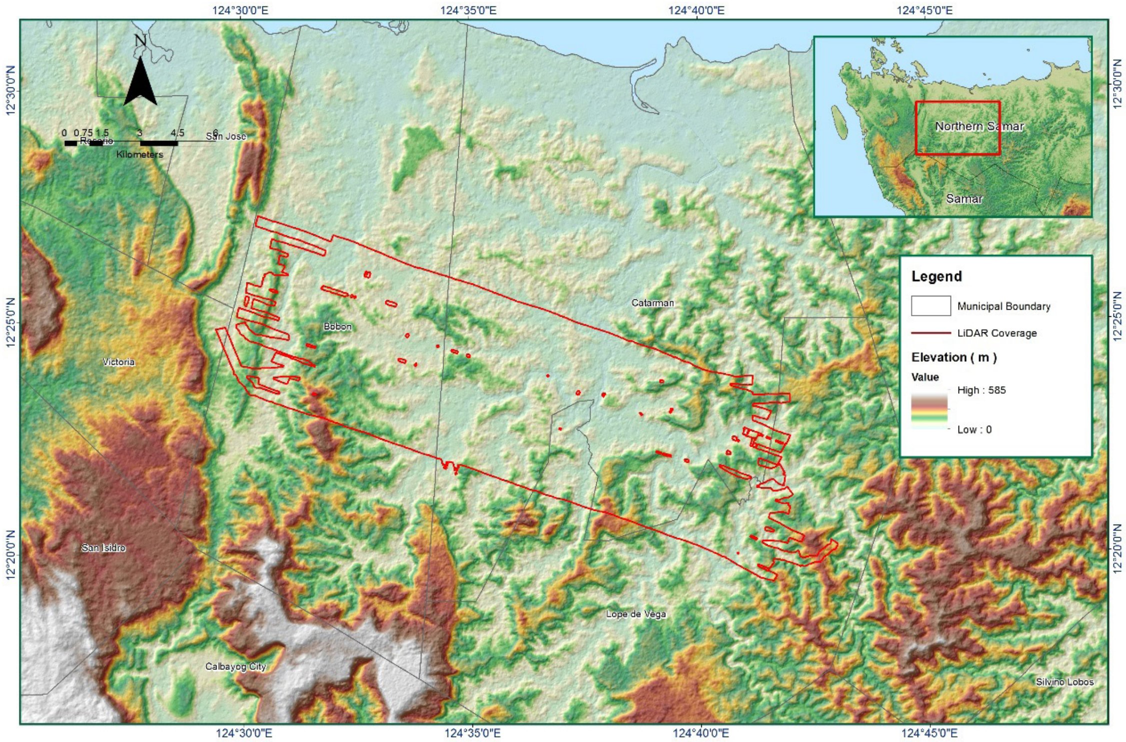



*Figure 1.6.4 Coverage of LiDAR data*

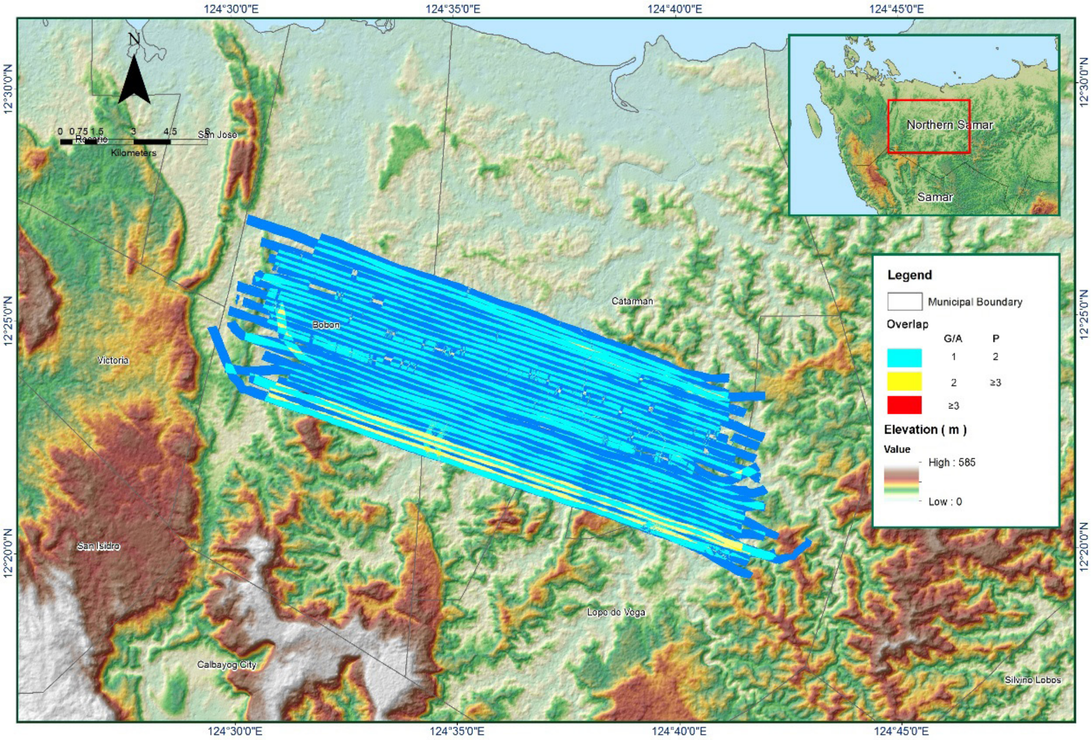



*Figure 1.6.5 Image of data overlap*

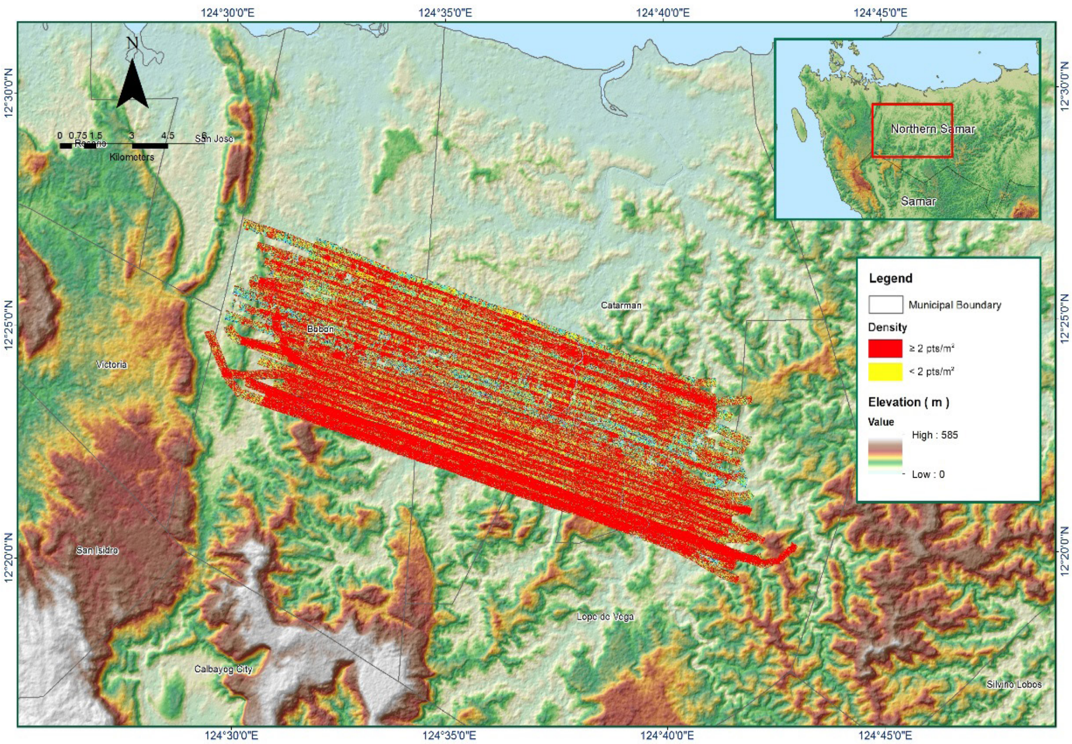



*Figure 1.6.6 Density map of merged LiDAR data*

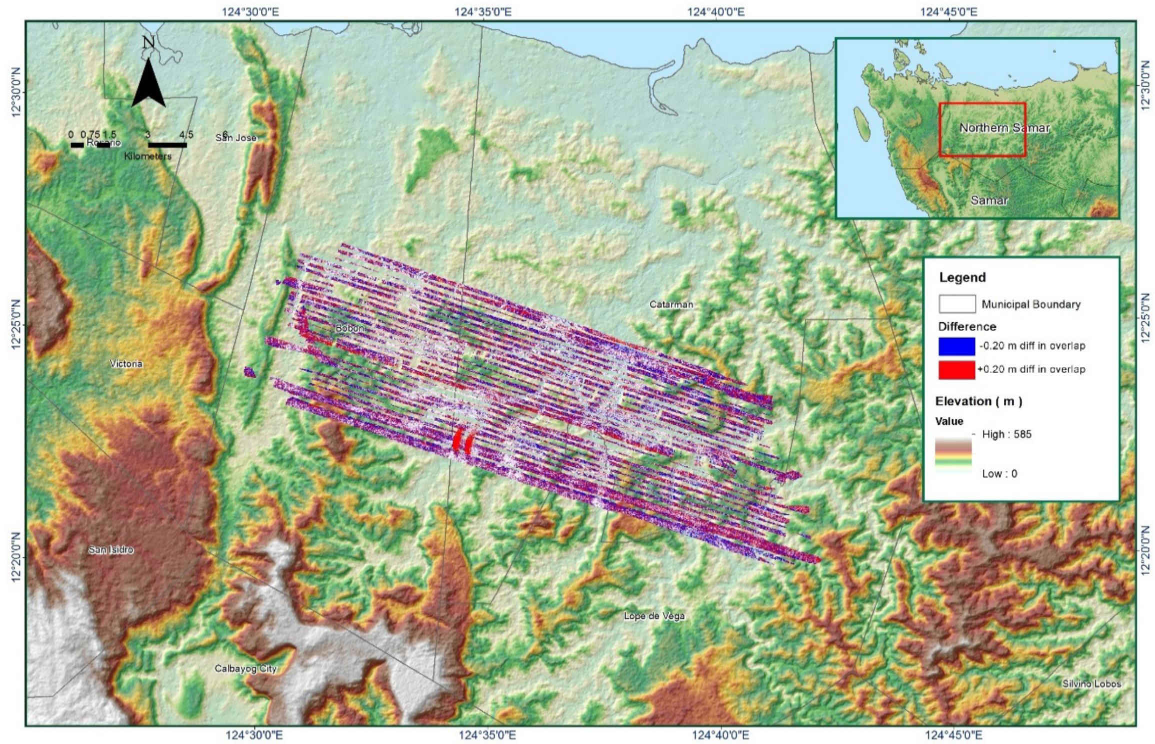



***Figure 1.6.7****Elevation difference between flight lines*

| Flight Area | Catarman |
|---|---|
| Mission Name | **Blk331I_supplement** |
| Inclusive Flights | 7814AC |
| Range data size | 1.68 GB |
| POS | 55.1 MB |
| Image | na |
| Transfer date | July 13, 2015 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 0.09 |
| RMSE for East Position (<4.0 cm) | 1.14 |
| RMSE for Down Position (<8.0 cm) | 3.2 |
| | |
| Boresight correction stdev (<0.001deg) | 0.008971 |
| IMU attitude correction stdev (<0.001deg) | 0.013047 |
| GPS position stdev (<0.01m) | 0.0226 |
| | |
| Minimum % overlap (>25) | 20.77 |
| Ave point cloud density per sq.m. (>2.0) | 1.88 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 33 |
| Maximum Height | 375.84 m |
| Minimum Height | 58.24 m |
| | |
| *Classification (# of points)* | |
| Ground | 3,892,245 |
| Low vegetation | 1,376,404 |
| Medium vegetation | 2,133,113 |
| High vegetation | 3,400,527 |
| Building | 5,182 |
| | |
| Orthophoto | No |
| Processed by | Engr. Kenneth Solidum, Engr. Velina Angela Bemida, Kathryn Claudine Zarate |

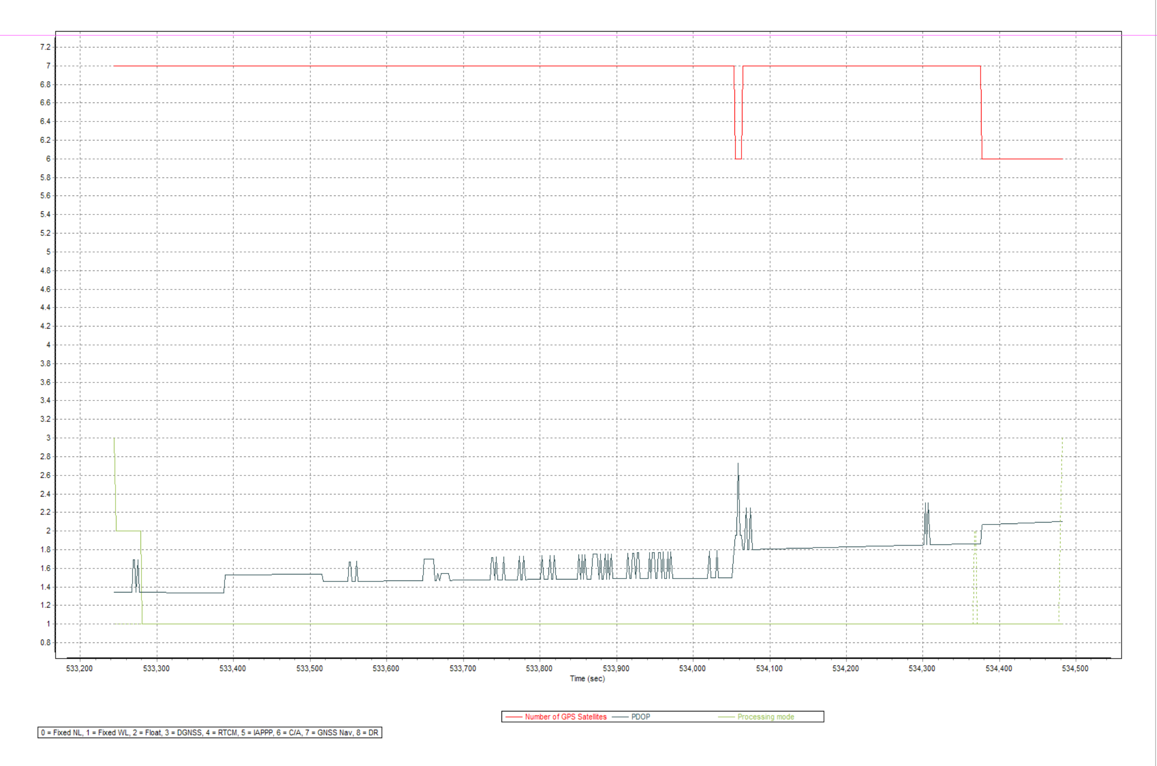



***Figure 1.7.1 Solution Status***

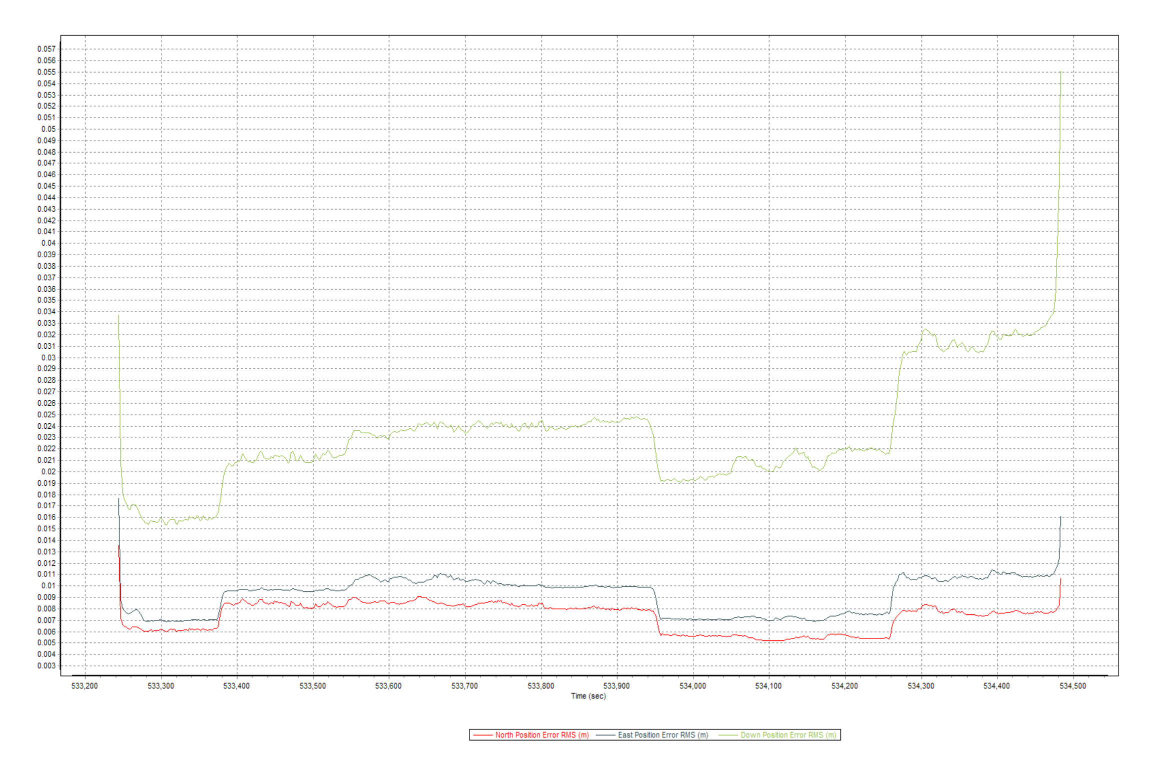



***Figure 1.7.2 Smoothed Performance Metric Parameters***

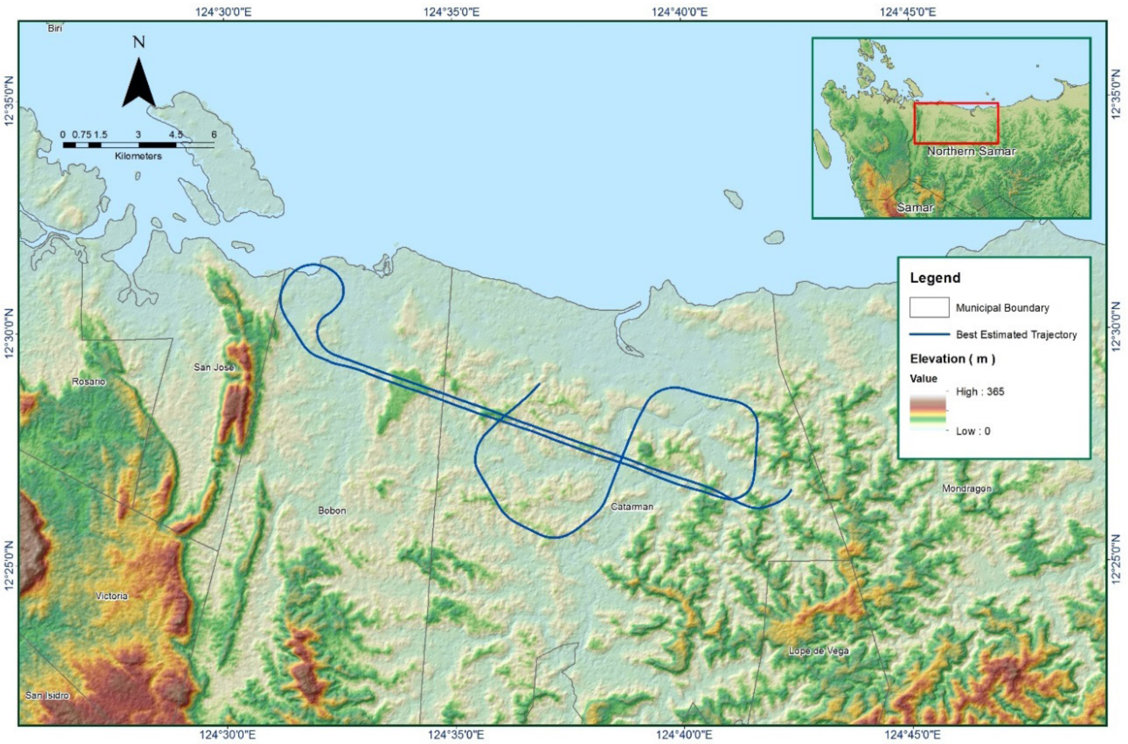



*Figure 1.7.3 Best Estimated Trajectory*

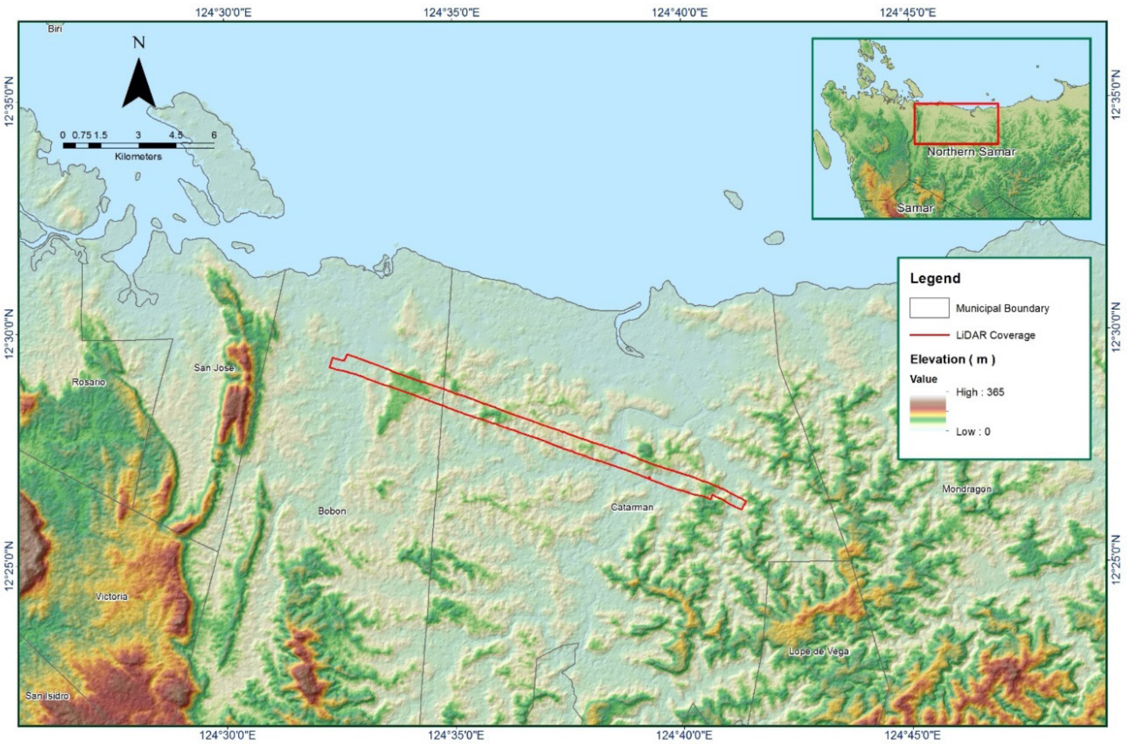



*Figure 1.7.4 Coverage of LiDAR data*

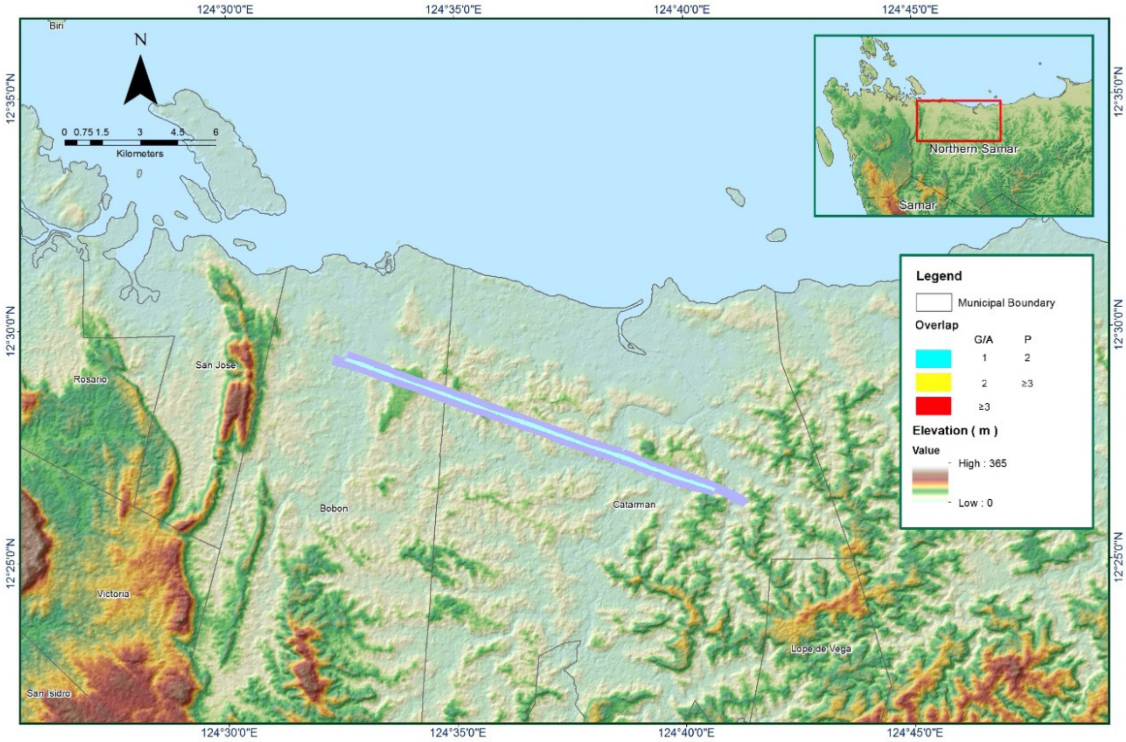



***Figure 1.7.5 Image of data overlap***

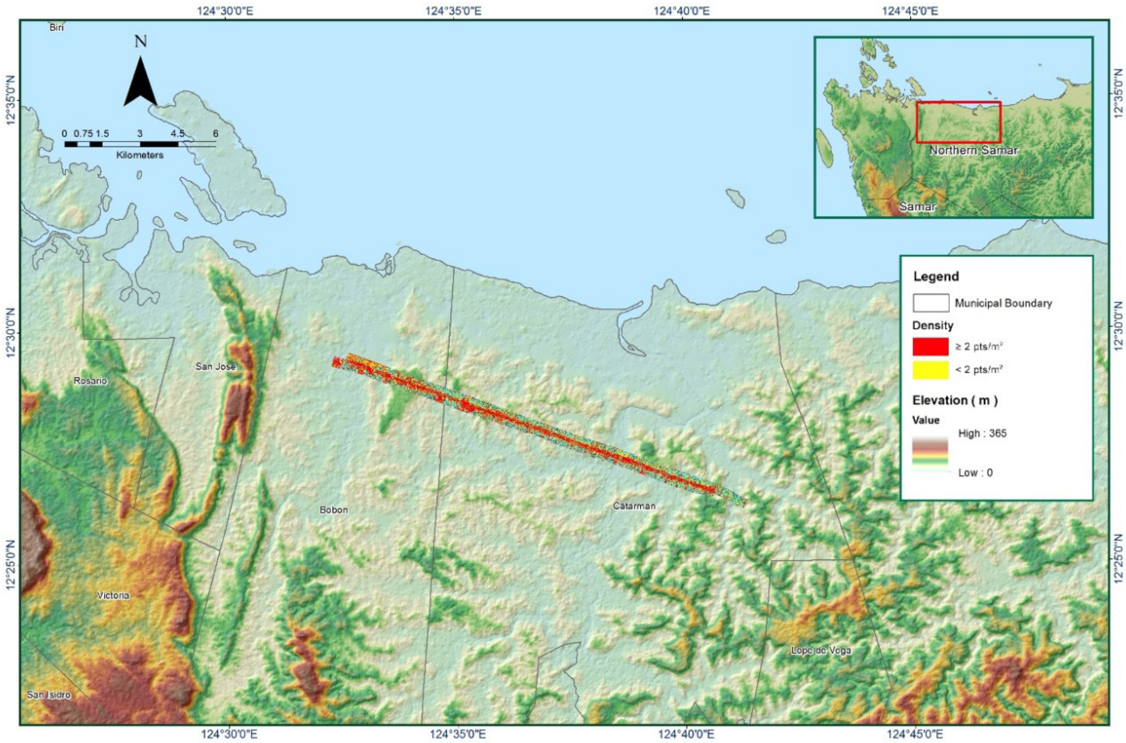



***Figure 1.7.6 Density map of merged LiDAR data***

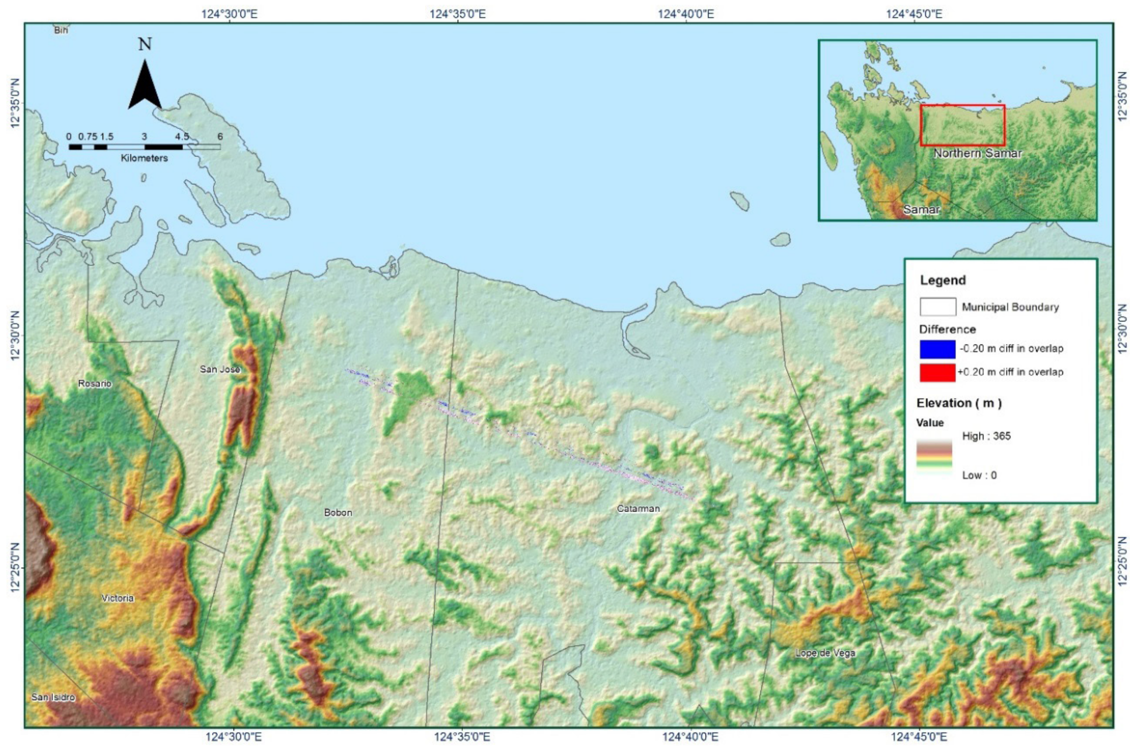



*Figure 1.7.7* Elevation difference between flight lines

| Flight Area | Catarman |
|---|---|
| Mission Name | **Blk331K** |
| Inclusive Flights | 7824AC,7826AC,7834AC |
| Range data size | 21.11 GB |
| POS | 458 MB |
| Image | na |
| Transfer date | July 3, 2015 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.08 |
| RMSE for East Position (<4.0 cm) | 1.4 |
| RMSE for Down Position (<8.0 cm) | 3.35 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000382 |
| IMU attitude correction stdev (<0.001deg) | 0.003024 |
| GPS position stdev (<0.01m) | 0.0034 |
| | |
| Minimum % overlap (>25) | 42.66 |
| Ave point cloud density per sq.m. (>2.0) | 2.49 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 188 |
| Maximum Height | 625.18 m |
| Minimum Height | 52.42 m |
| | |
| *Classification (# of points)* | |
| Ground | 81,066,901 |
| Low vegetation | 46,950,484 |
| Medium vegetation | 39,264,840 |
| High vegetation | 79,625,183 |
| Building | 2,199,303 |
| | |
| Orthophoto | No |
| Processed by | Engr. Sheila-Maye Santillan, Engr. Melanie Hingpit, RyanDizon |

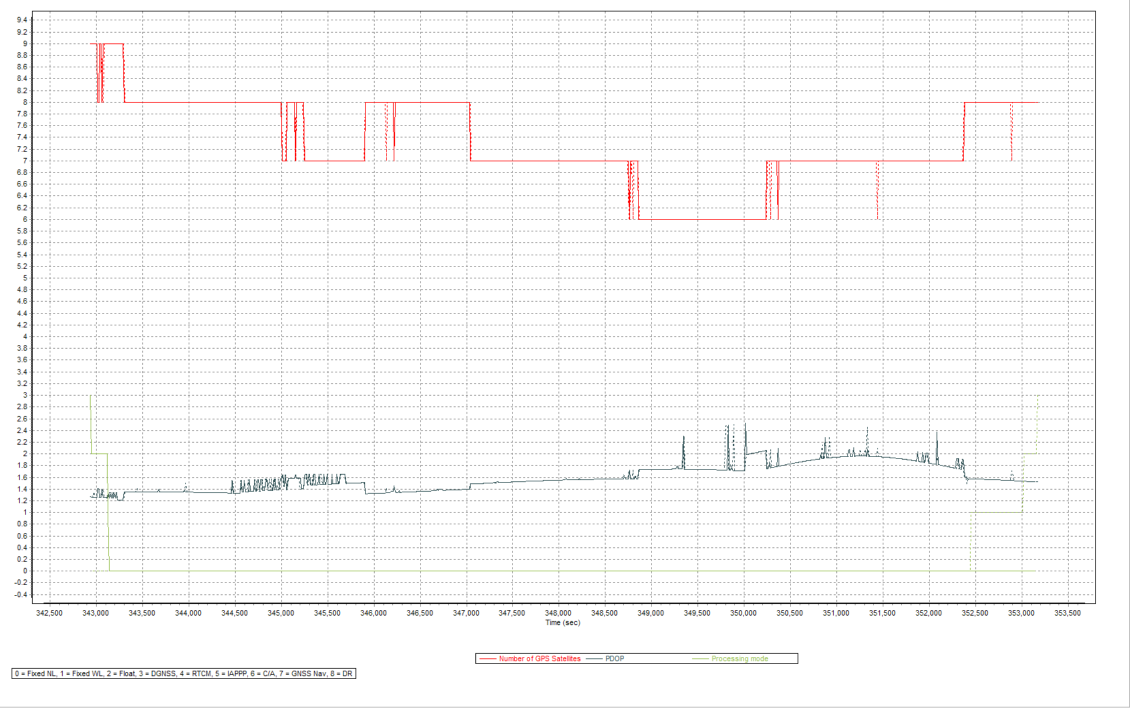



***Figure 1.8.1 Solution Status***

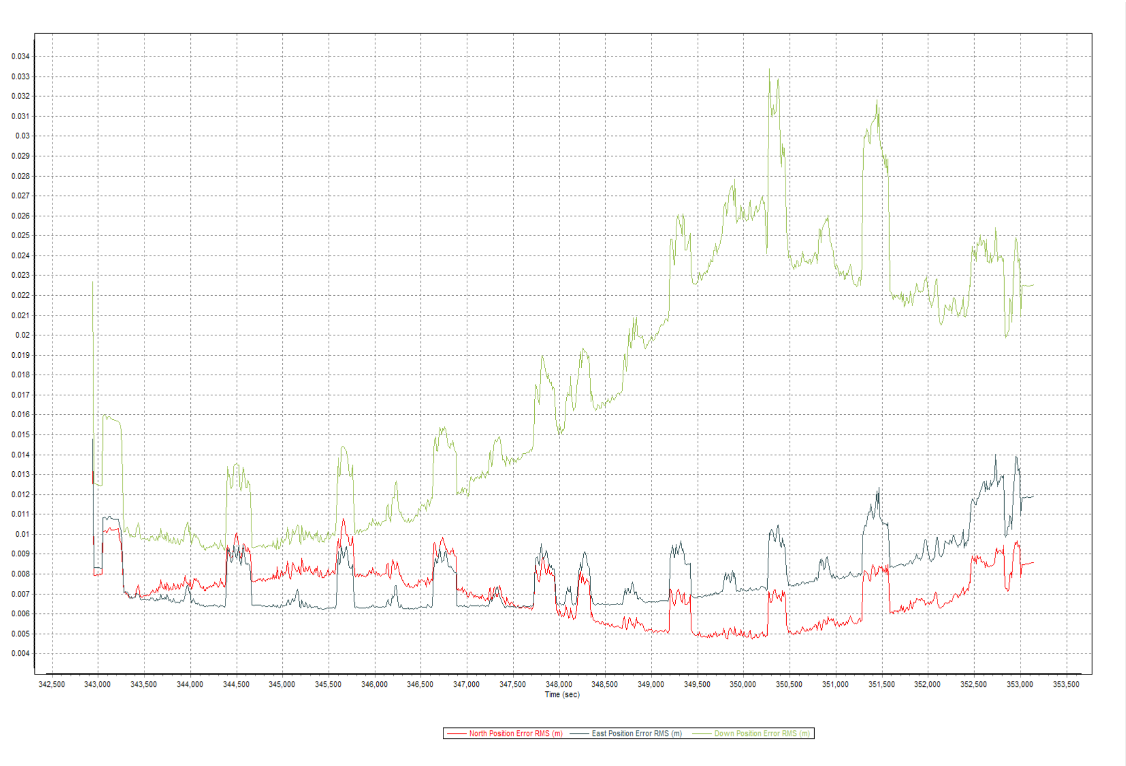



***Figure 1.8.2 Smoothed Performance Metric Parameters***

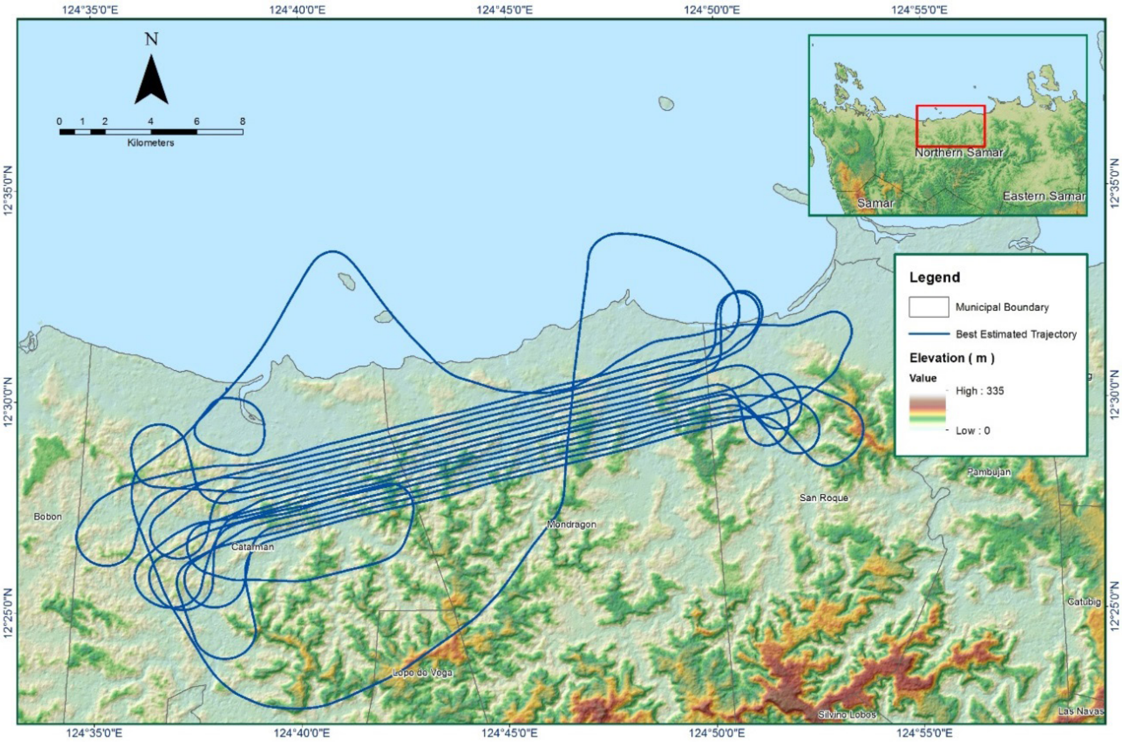



*Figure 1.8.3 Best Estimated Trajectory*

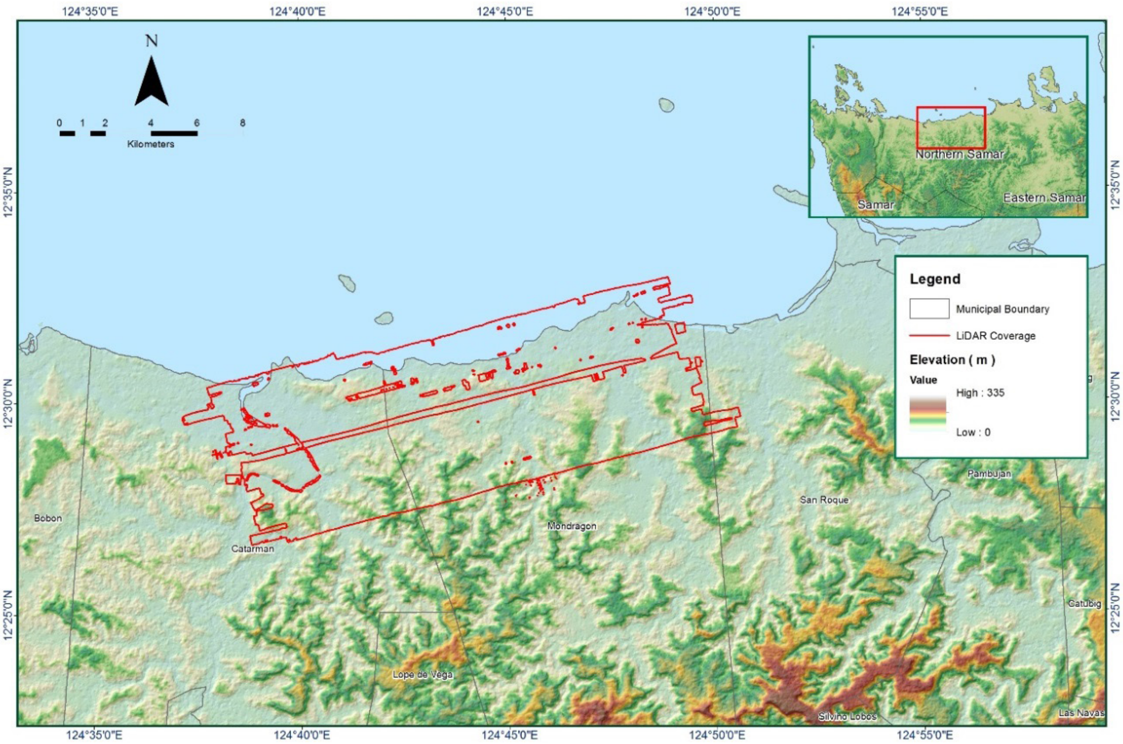



*Figure 1.8.4 Coverage of LiDAR data*

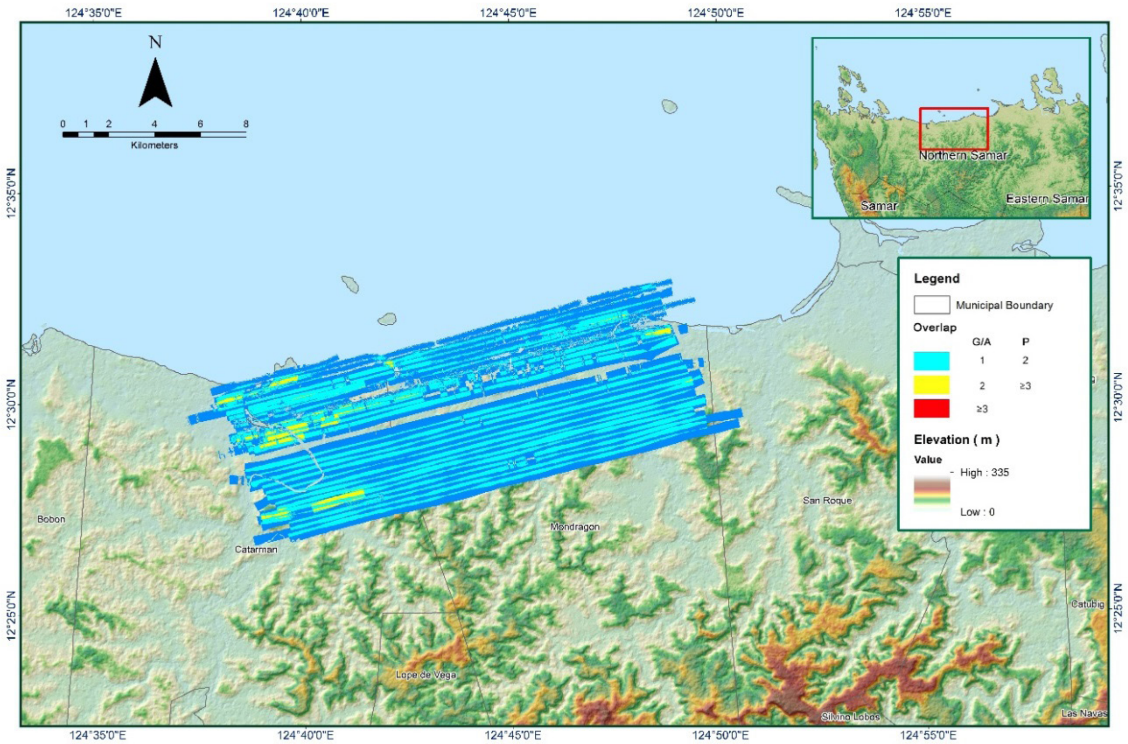



*Figure 1.8.5 Image of data overlap*

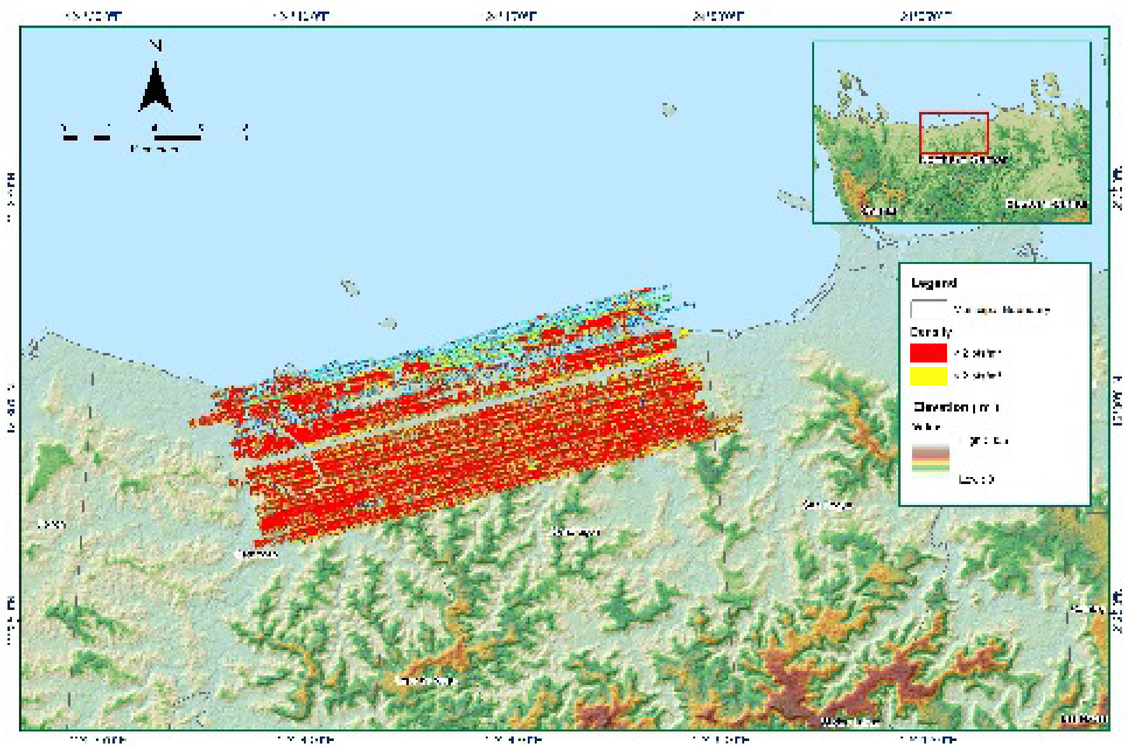


*Figure 1.8.6 Density map of merged LiDAR data*

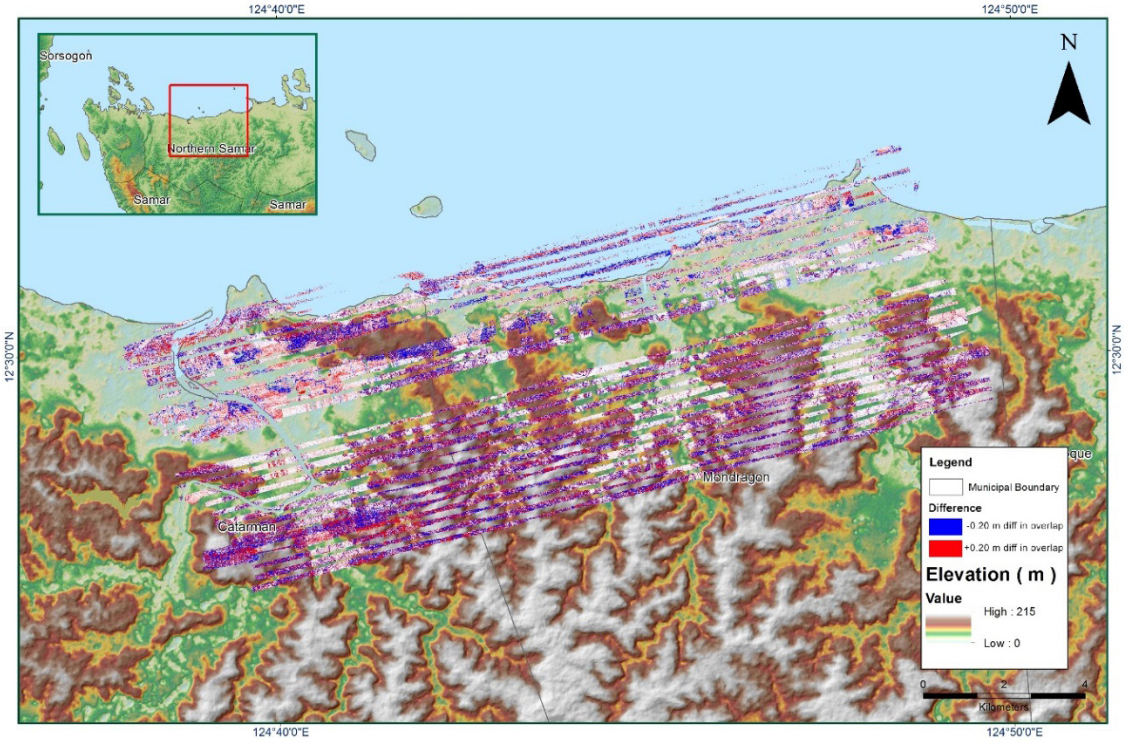



***Figure 1.8.7****Elevation difference between flight lines*

| Flight Area | Catarman |
|---|---|
| Mission Name | **Blk331L** |
| Inclusive Flights | 7846AC |
| Range data size | 14.9 GB |
| POS | 225 MB |
| Image | na |
| Transfer date | July 3, 2015 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | Yes |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.04 |
| RMSE for East Position (<4.0 cm) | 1.0 |
| RMSE for Down Position (<8.0 cm) | 3.0 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000404 |
| IMU attitude correction stdev (<0.001deg) | 0.001306 |
| GPS position stdev (<0.01m) | 0.0031 |
| | |
| Minimum % overlap (>25) | 40.05 |
| Ave point cloud density per sq.m. (>2.0) | 2.95 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 206 |
| Maximum Height | 531.87 m |
| Minimum Height | 41.99 m |
| | |
| *Classification (# of points)* | |
| Ground | 68,426,849 |
| Low vegetation | 24,906,844 |
| Medium vegetation | 66,893,807 |
| High vegetation | 201,192,687 |
| Building | 1,902,909 |
| | |
| Orthophoto | No |
| Processed by | Engr. Irish Cortez, Engr. Melanie Hingpit, Engr. Melissa Fernandez |

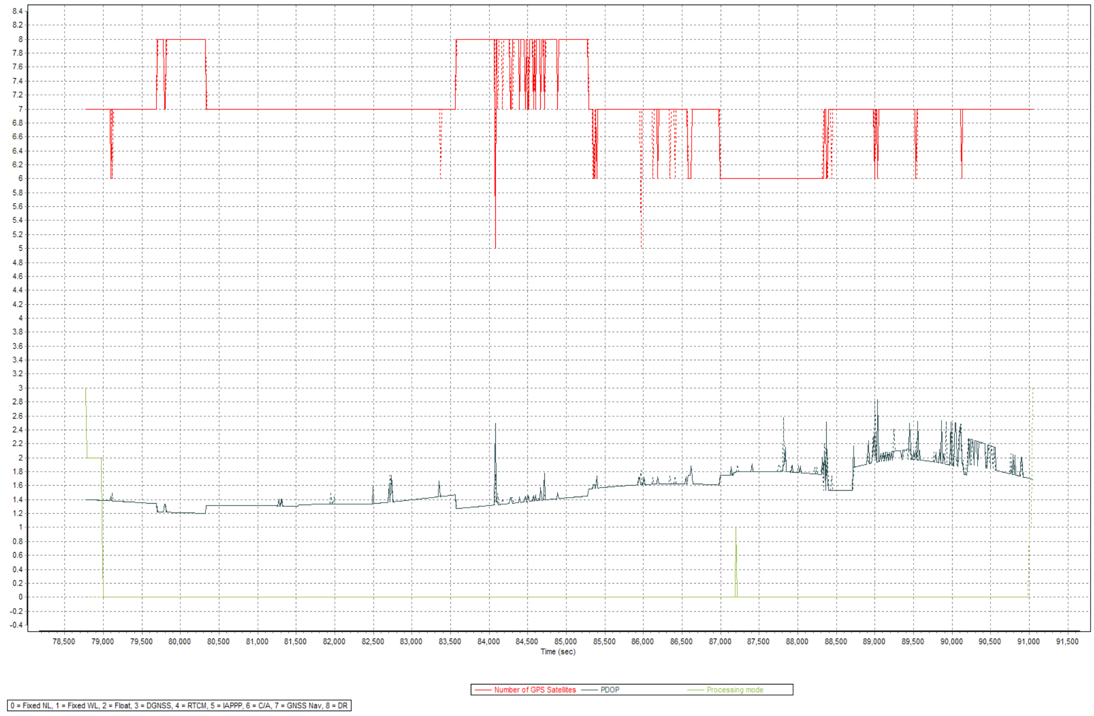



***Figure 1.9.1 Solution Status***

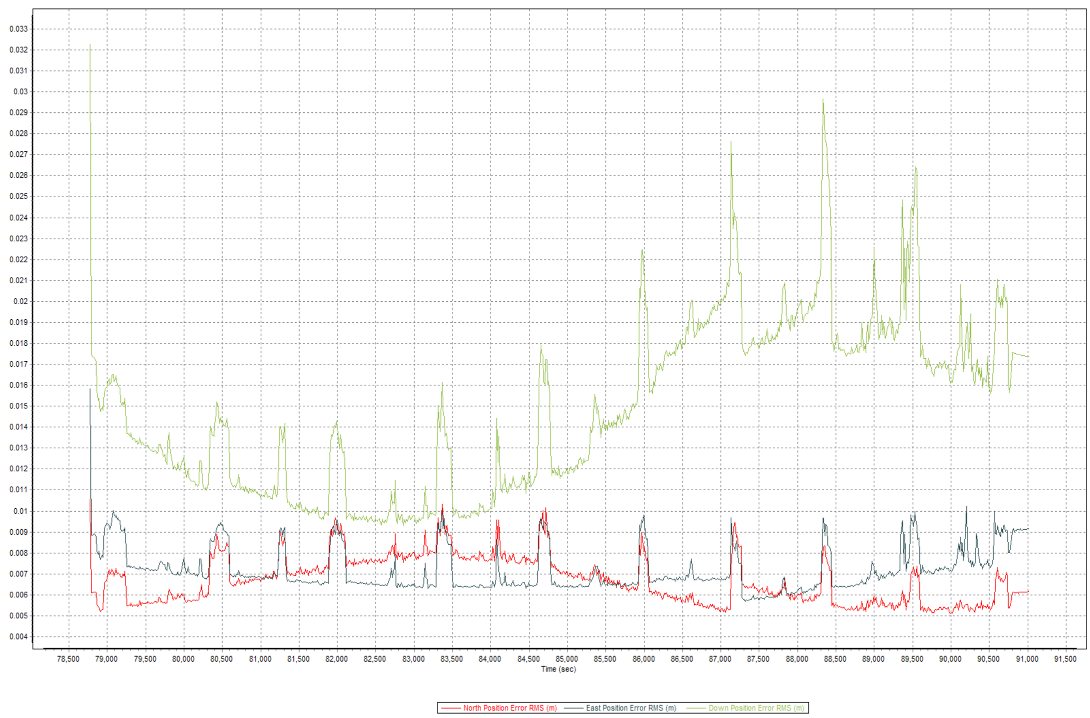



***Figure 1.9.2 Smoothed Performance Metric Parameters***

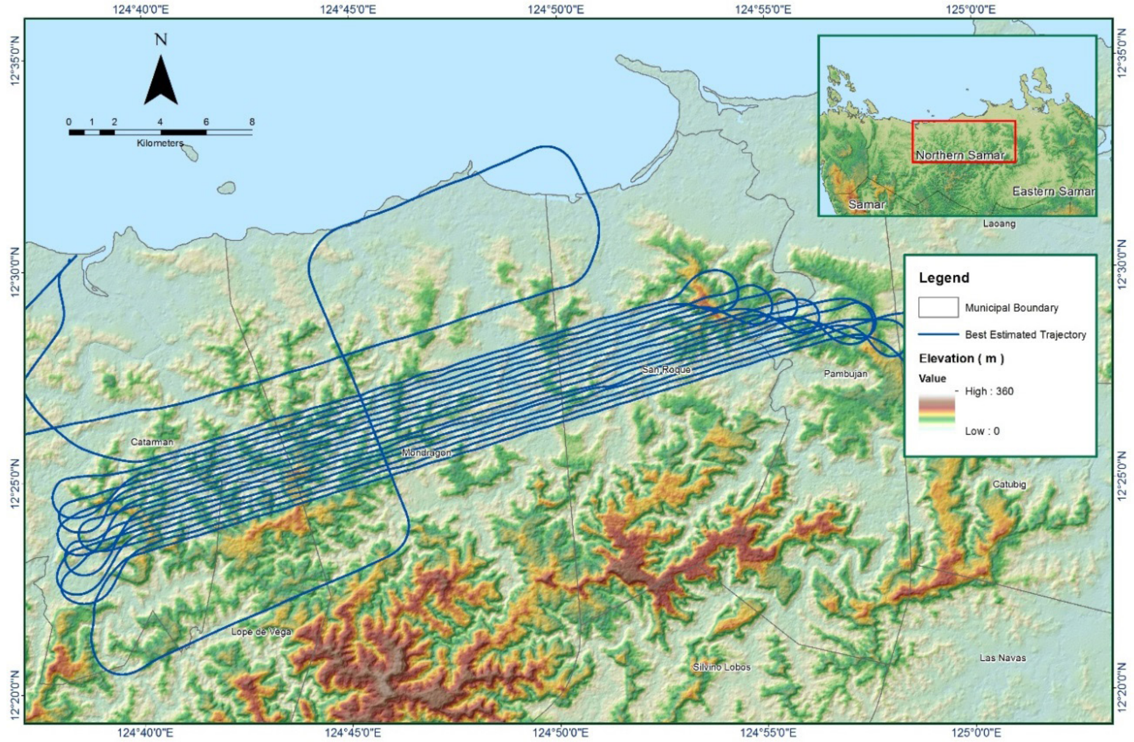



*Figure 1.9.3 Best Estimated Trajectory*

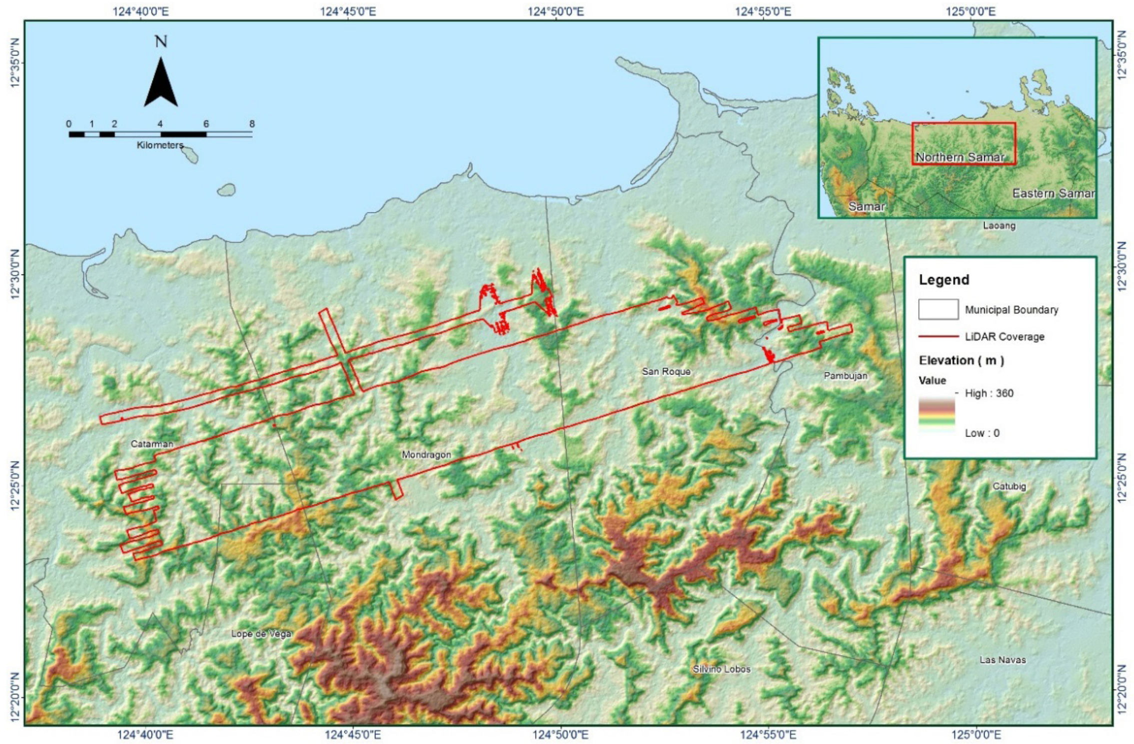



*Figure 1.9.4 Coverage of LiDAR data*

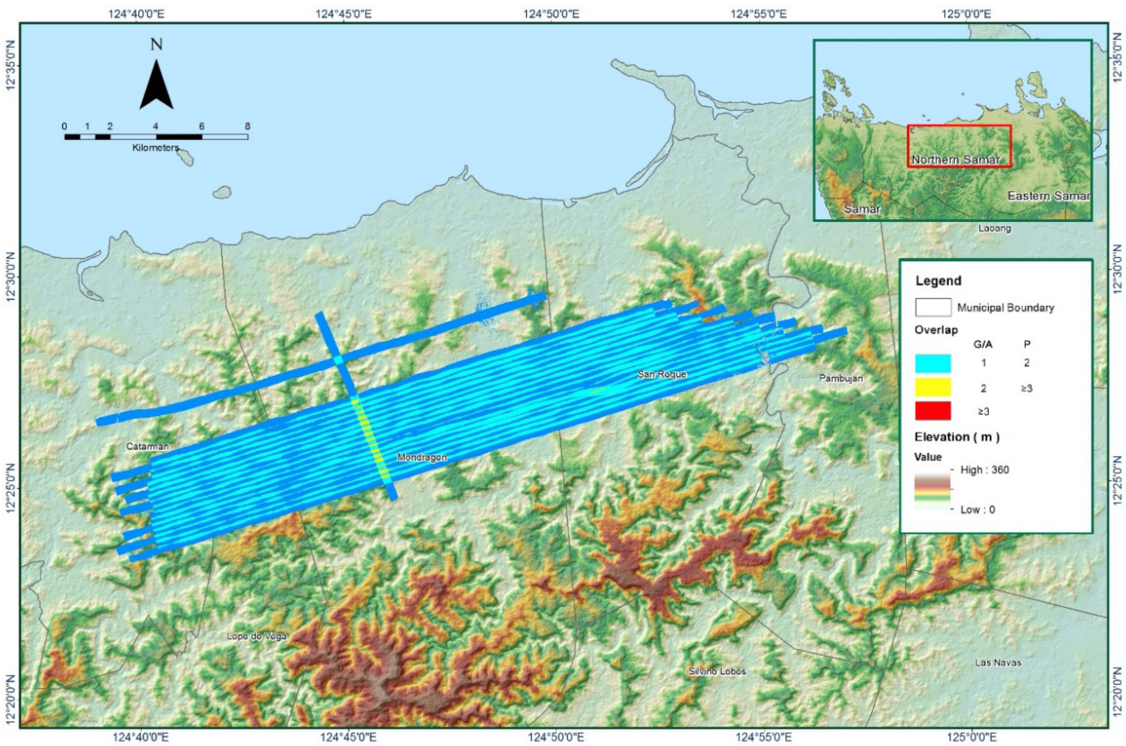



***Figure 1.9.5 Image of data overlap***

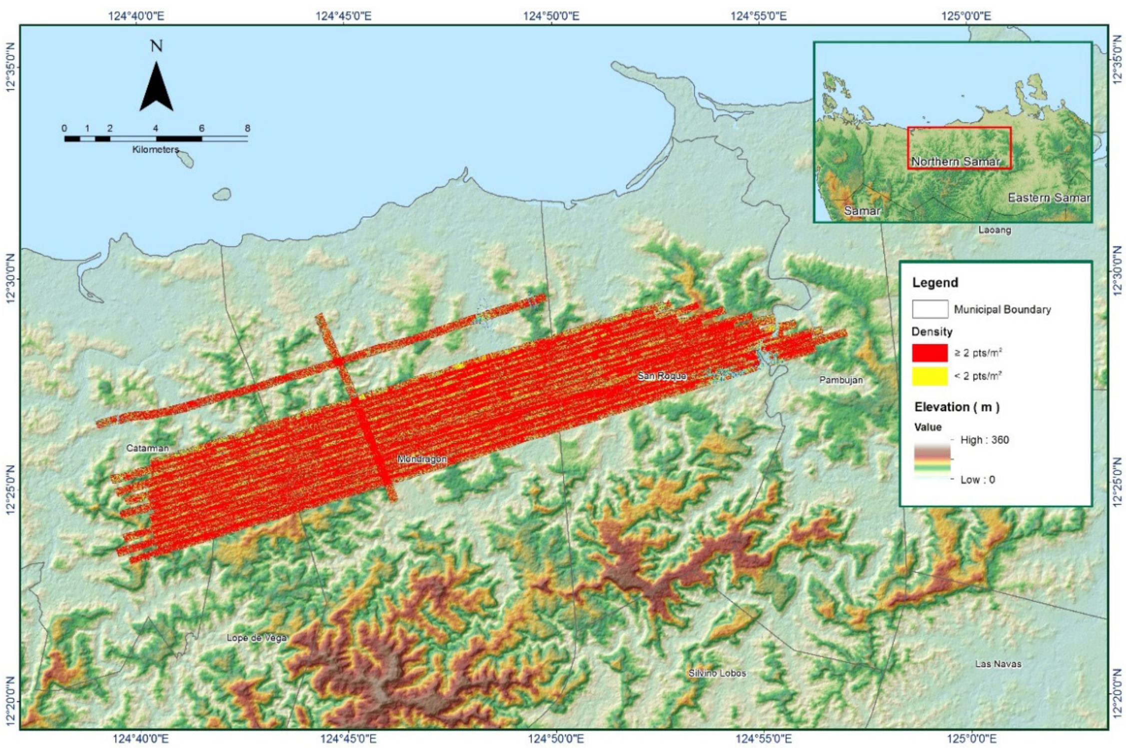



***Figure 1.9.6 Density map of merged LiDAR data***

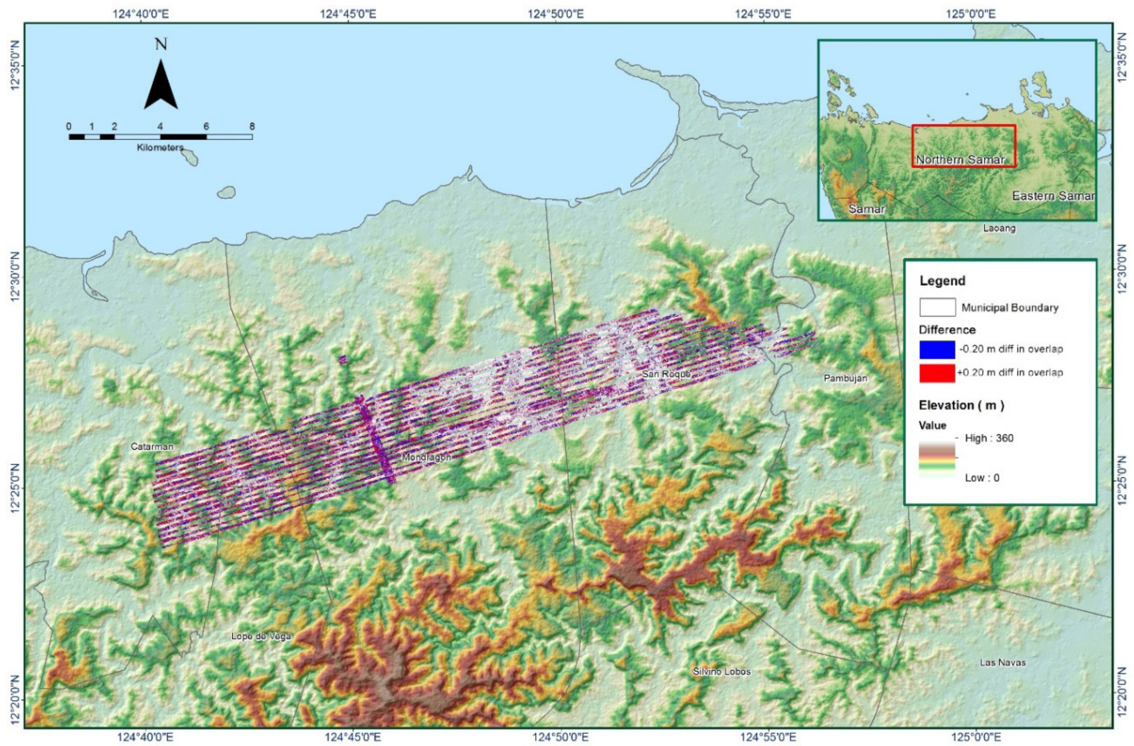



***Figure 1.9.7*** *Elevation difference between flight lines*

| **Flight Area** | **Catarman** |
|---|---|
| Mission Name | **Blk331L_additional** |
| Inclusive Flights | 8156AC |
| Range data size | 11.4 GB |
| Base data size | 32.8 MB |
| POS | 217 MB |
| Image | N/A |
| Transfer date | September 8, 2015 |
| | |
| ***Solution Status*** | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | No |
| Baseline Length (<30km) | Yes |
| Processing Mode (<=1) | No |
| | |
| ***Smoothed Performance Metrics (in cm)*** | |
| RMSE for North Position (<4.0 cm) | 1.4498 |
| RMSE for East Position (<4.0 cm) | 1.3552 |
| RMSE for Down Position (<8.0 cm) | 4.226 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000868 |
| IMU attitude correction stdev (<0.001deg) | 0.002411 |
| GPS position stdev (<0.01m) | 0.0030 |
| | |
| Minimum % overlap (>25) | 40.41% |
| Ave point cloud density per sq.m. (>2.0) | 2.29 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 206 |
| Maximum Height | 531.87 |
| Minimum Height | 41.99 |
| | |
| Classification (# of points) | |
| Ground | 68,426,849 |
| Low vegetation | 24,906,844 |
| Medium vegetation | 66,893,807 |
| High vegetation | 201,192,687 |
| Building | 1,902,909 |
| | |
| Orthophoto | None |
| Processed by | Engr. Irish Cortez, Engr. Justine Francisco, Maria Tamsyn Malabanan |

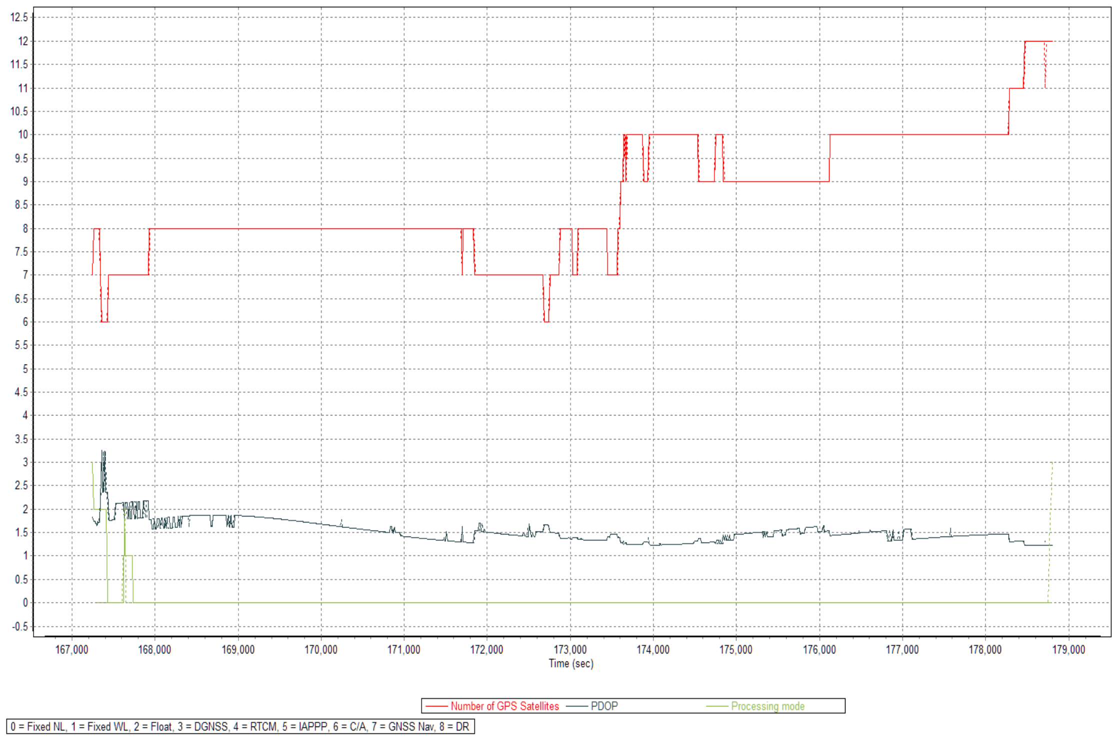



***Figure 1.10.1. Solution Status***

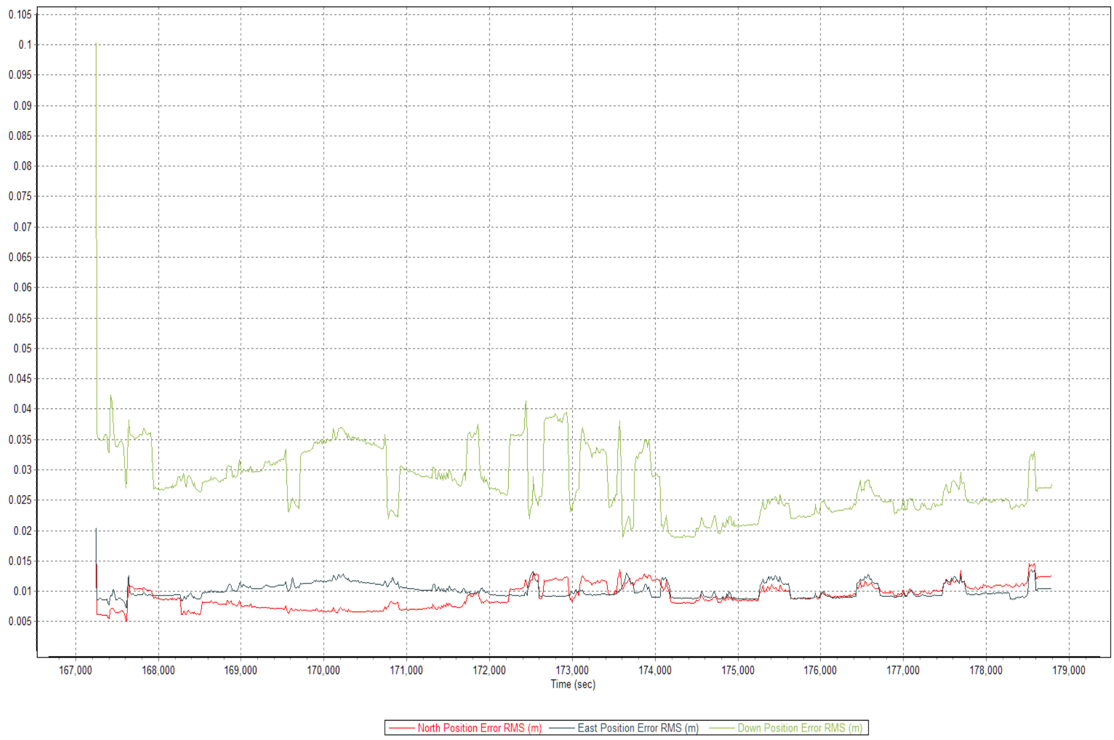



*Figure 1.10.2. Smoothed Performance Metric Parameters*

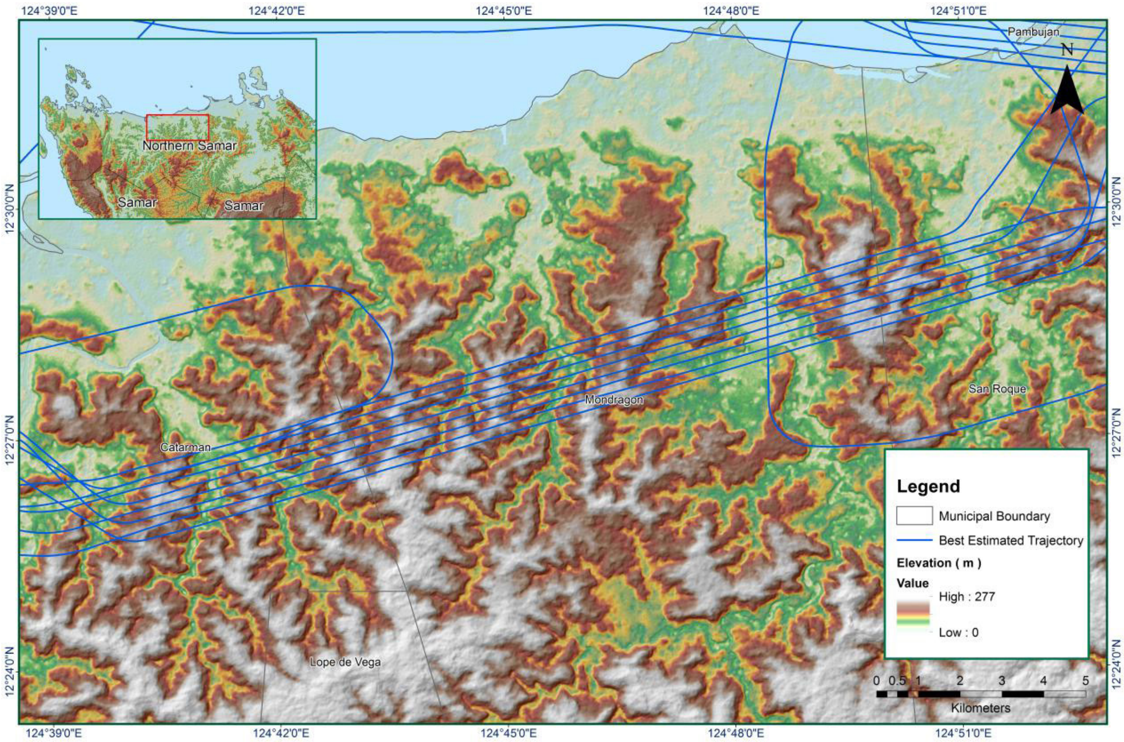



*Figure 1.10.3. Best Estimated Trajectory*

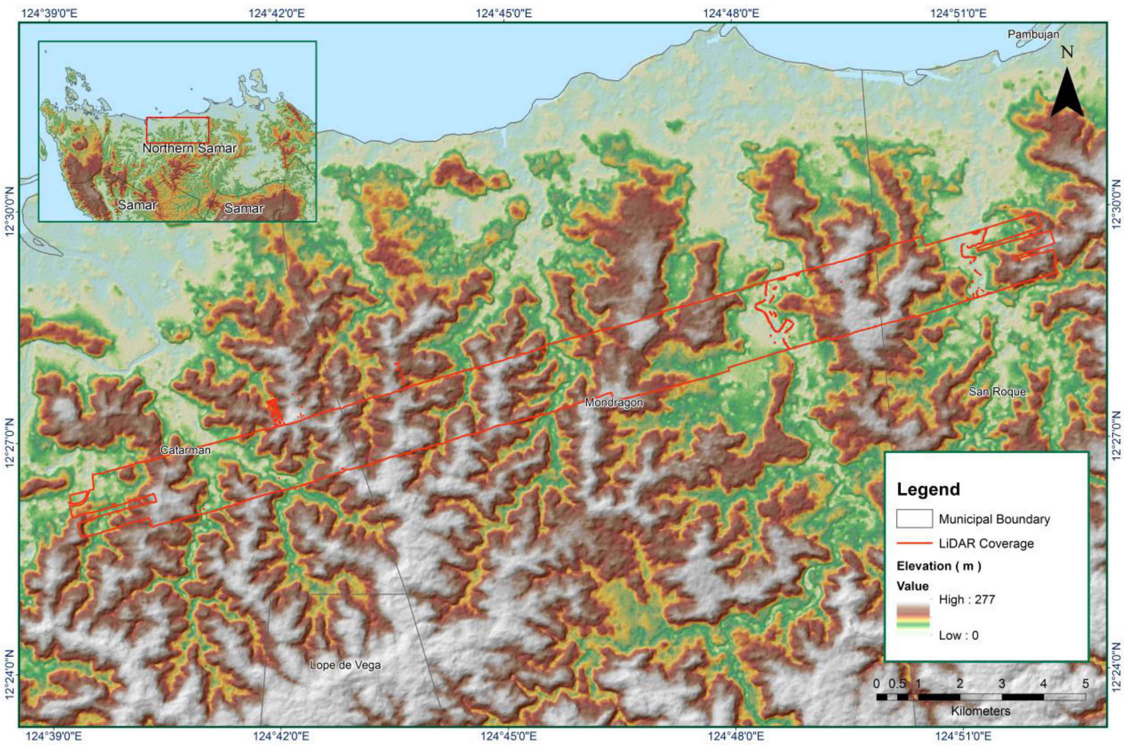



*Figure 1.10.4. Coverage of LiDAR data*

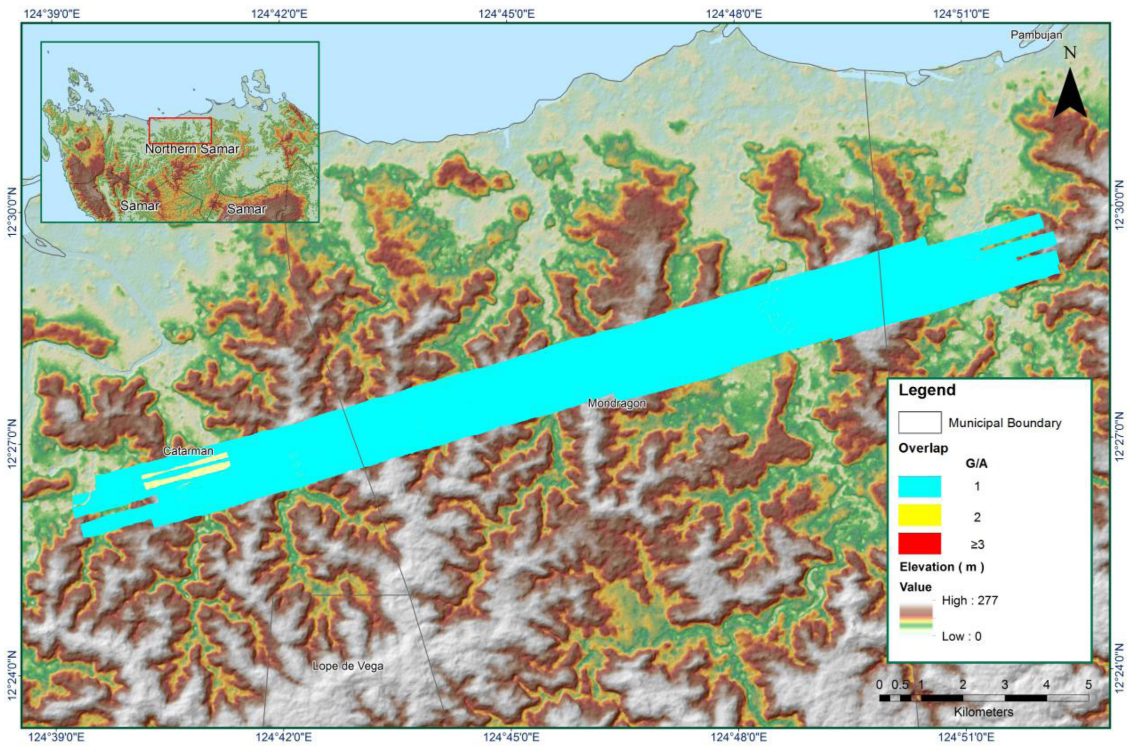



*Figure 1.10.5. Image of data overlap*

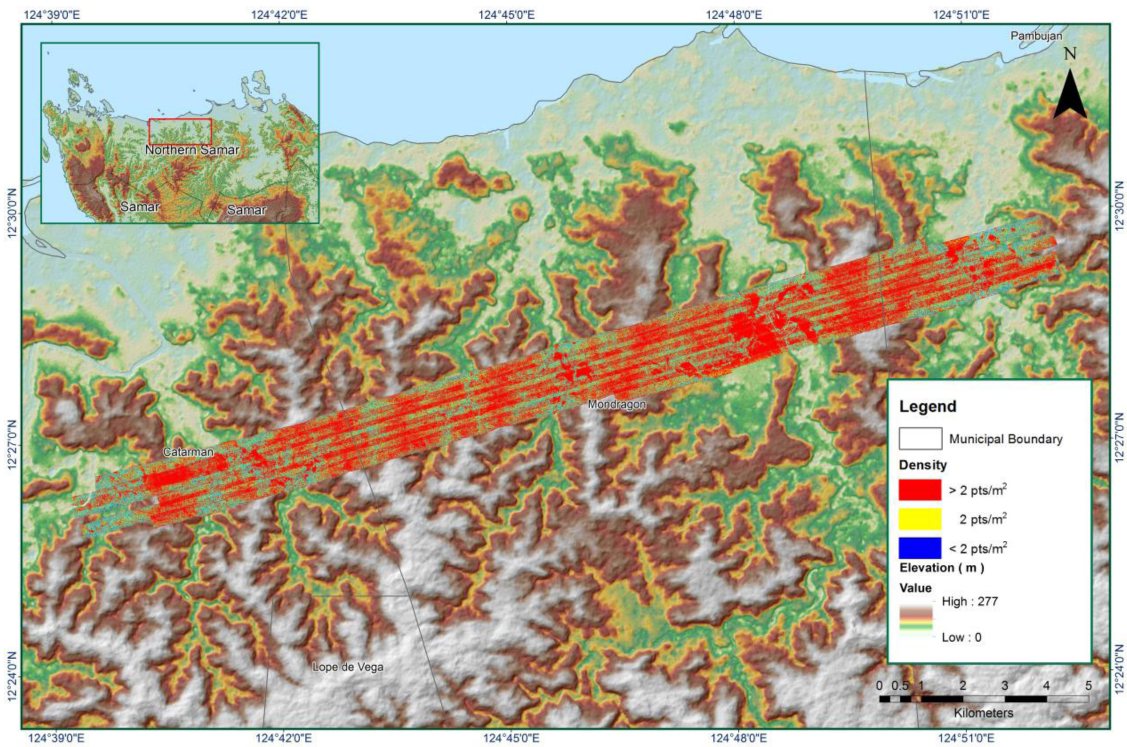



*Figure 1.10.6. Density Map of merged LiDAR data*

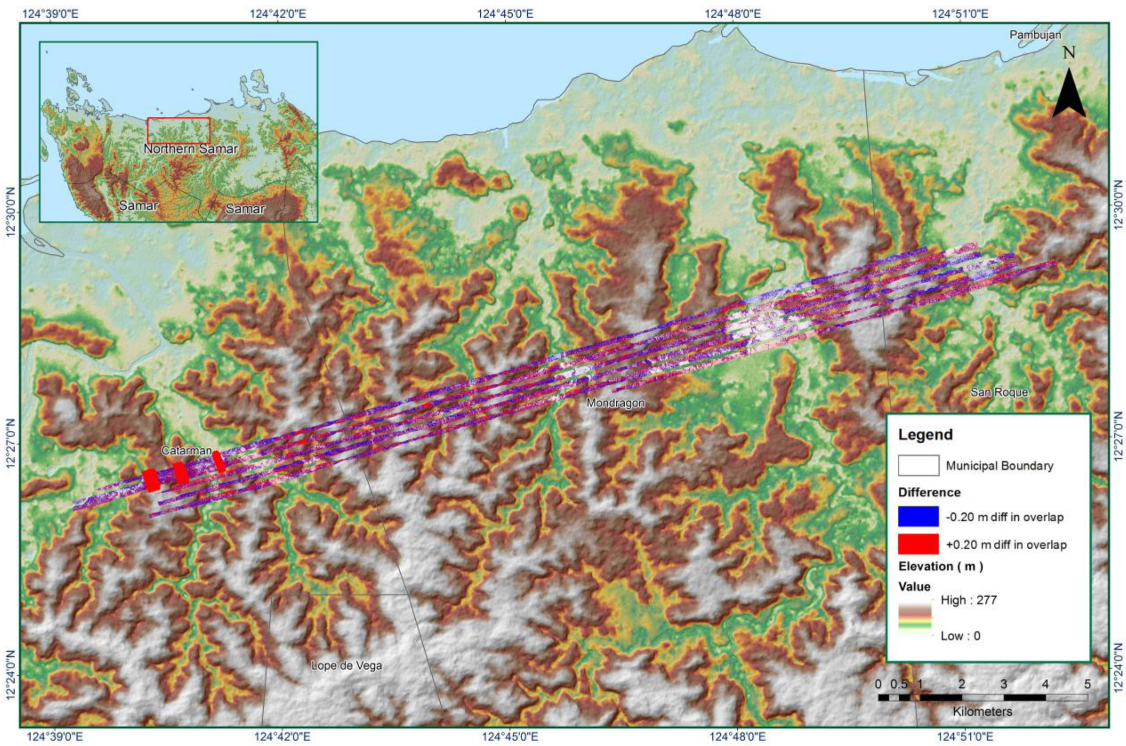



***Figure 1.10.7. Elevation Difference Between flight lines***

| Flight Area | Catarman |
|---|---|
| Mission Name | **Blk33S** |
| Inclusive Flights | 8183AC |
| Range data size | 5.81 GB |
| POS | 152 MB |
| Image | 39.2 GB |
| Transfer date | September 16, 2015 |
| | |
| *Solution Status* | |
| Number of Satellites (>6) | Yes |
| PDOP (<3) | Yes |
| Baseline Length (<30km) | No |
| Processing Mode (<=1) | No |
| | |
| *Smoothed Performance Metrics* (in cm) | |
| RMSE for North Position (<4.0 cm) | 1.6 |
| RMSE for East Position (<4.0 cm) | 1.52 |
| RMSE for Down Position (<8.0 cm) | 3.1 |
| | |
| Boresight correction stdev (<0.001deg) | 0.003843 |
| IMU attitude correction stdev (<0.001deg) | 0.004672 |
| GPS position stdev (<0.01m) | 0.0032 |
| | |
| Minimum % overlap (>25) | 19.47 |
| Ave point cloud density per sq.m. (>2.0) | 2.13 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 46 |
| Maximum Height | 150.44 m |
| Minimum Height | 51.23 m |
| | |
| *Classification (# of points)* | |
| Ground | 5,195,017 |
| Low vegetation | 6,991,805 |
| Medium vegetation | 8,890,080 |
| High vegetation | 2,315,373 |
| Building | 296,581 |
| | |
| Orthophoto | No |
| Processed by | Engr. Angelo Carlo Bongat, Engr. Mark Joshua Salvacion, Engr. Krisha Marie Bautista |

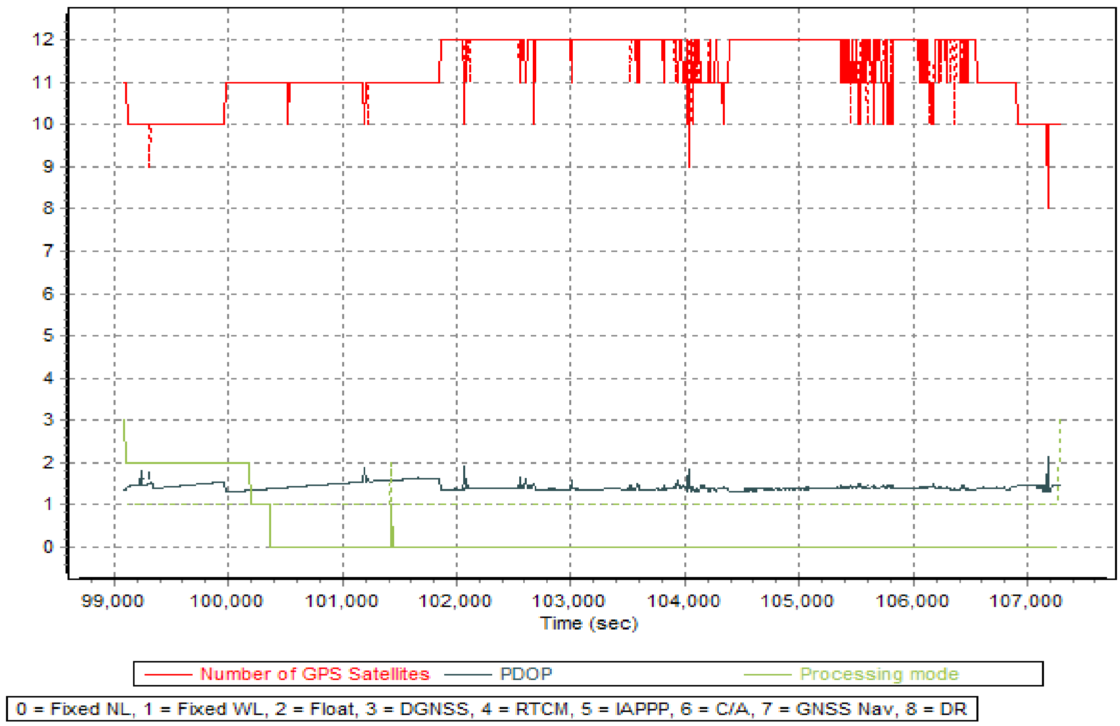



*Figure 1.11.1 Solution Status*

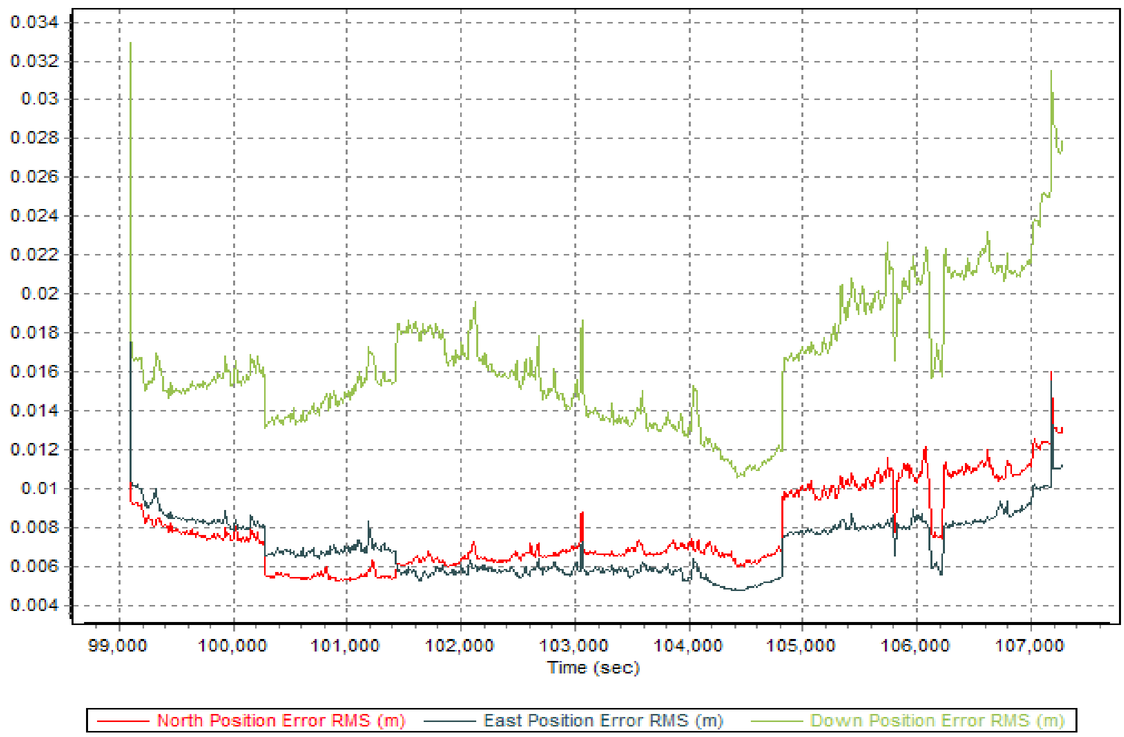



*Figure 1.11.2 Smoothed Performance Metric Parameters*

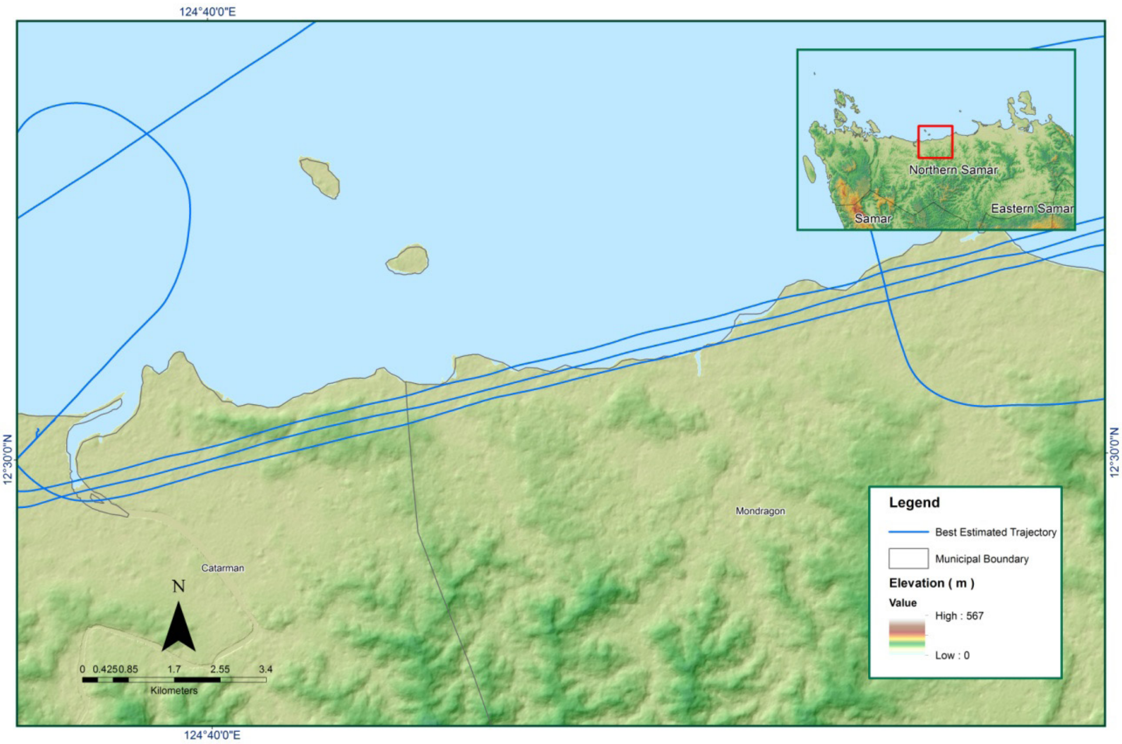



*Figure 1.11.3. Best Estimated Trajectory*

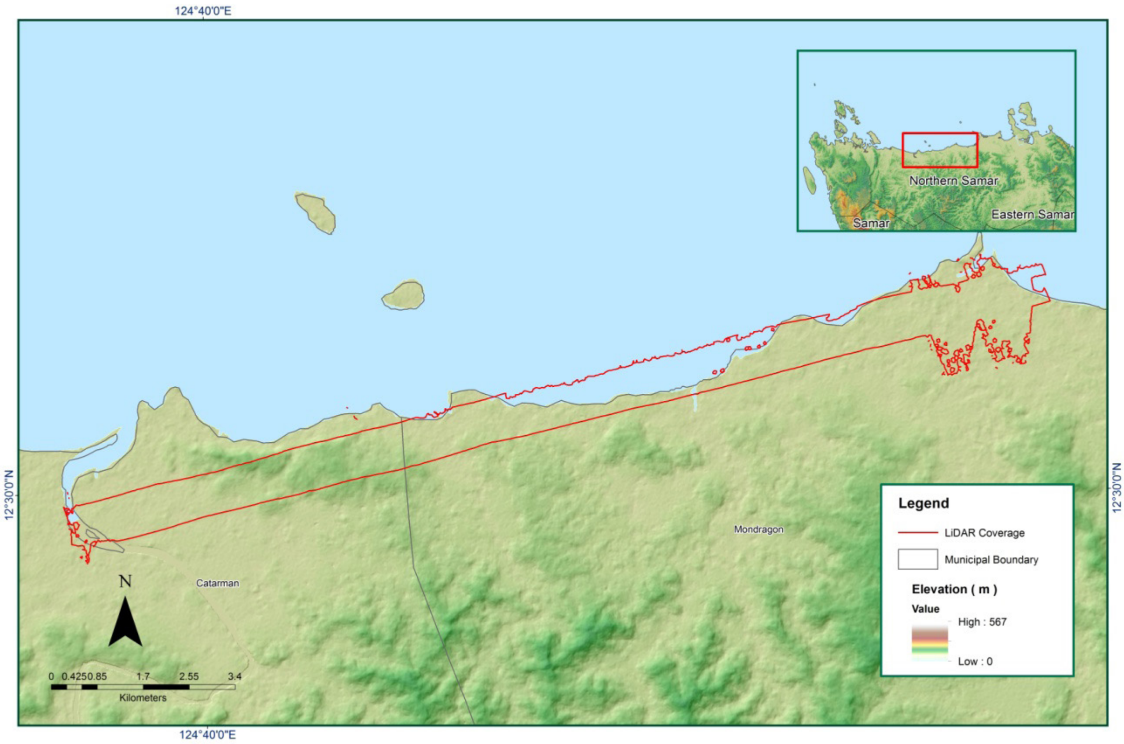



*Figure 1.11.4. Coverage of LiDAR data*

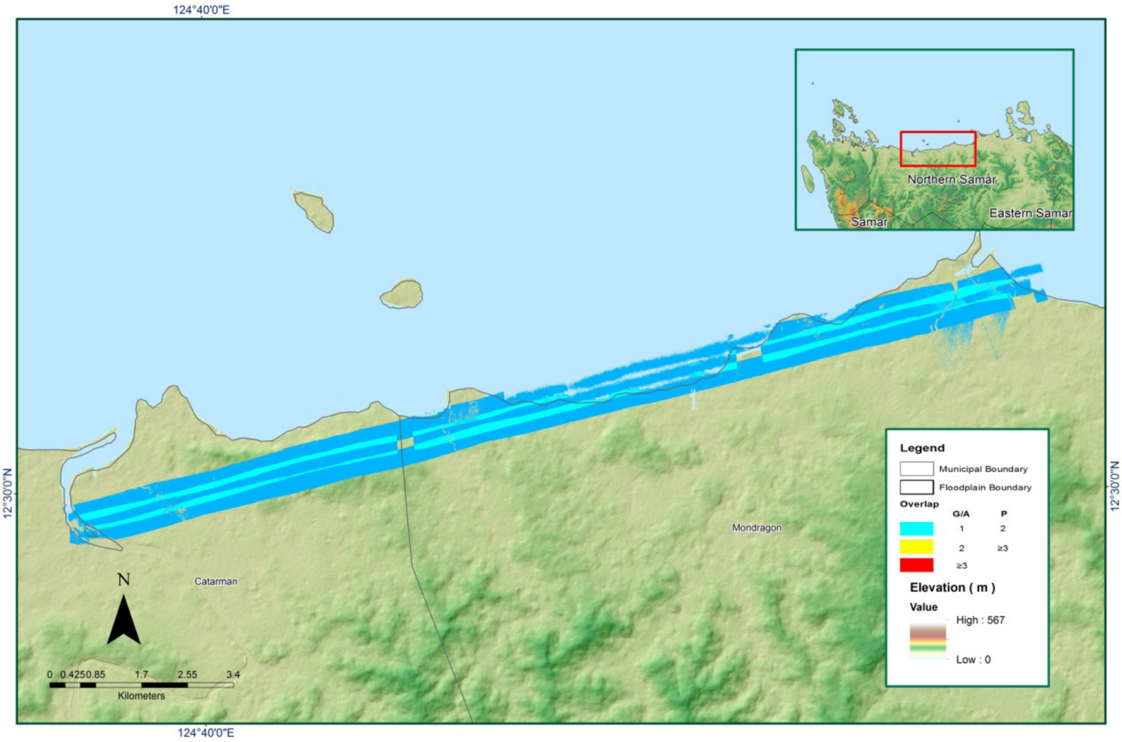



***Figure 1.11.5. Image of data overlap***

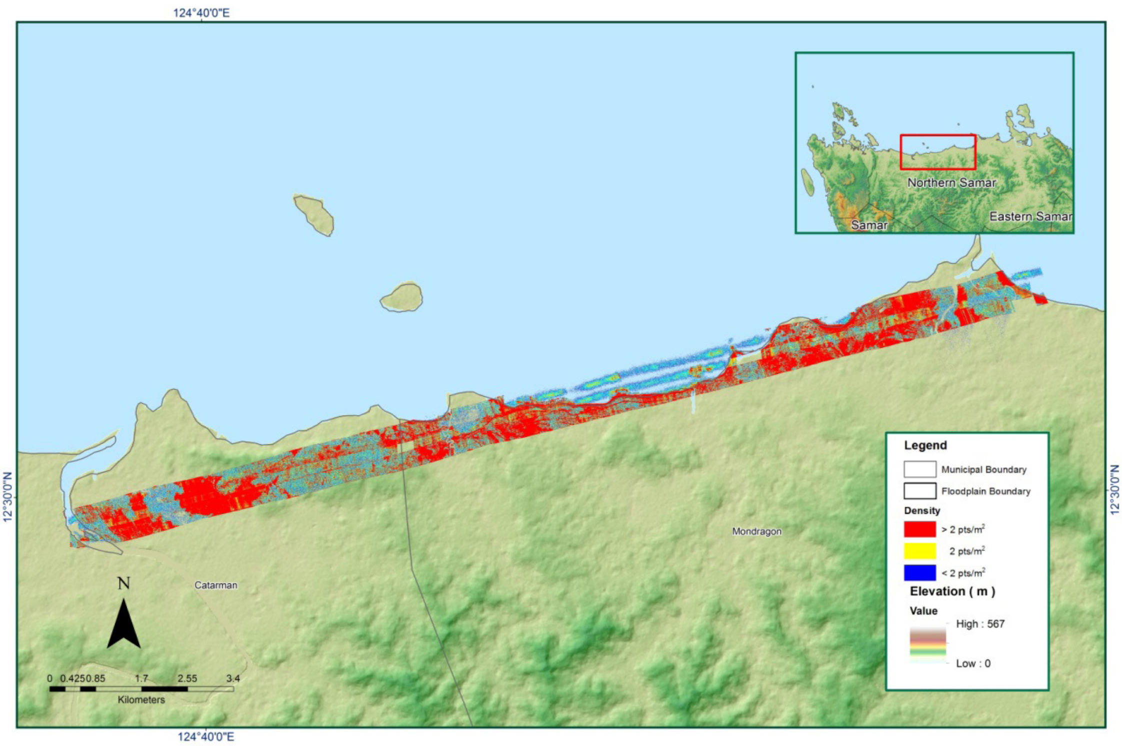



***Figure 1.11.6. Density map of merged LiDAR data***

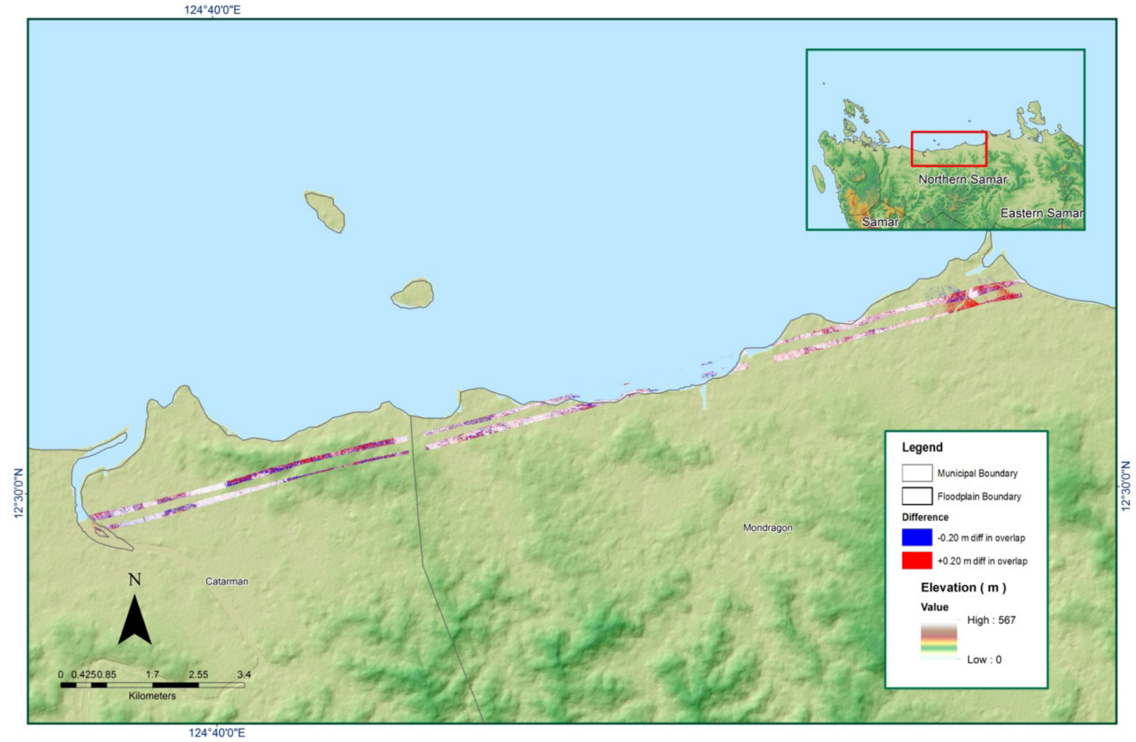



*Figure 1.11.7. Elevation difference between flight lines*

| Flight Area | CatarmanReflights |
|---|---|
| Mission Name | **Blk 33F** |
| Inclusive Flights | 8445AC |
| Range data size | 9.13 GB |
| POS data size | 216 MB |
| Base data size | 77.8 GB |
| Image | 40.3 MB |
| Transfer date | August 4, 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) | 1.4 |
| RMSE for East Position (<4.0 cm) | 1.3 |
| RMSE for Down Position (<8.0 cm) | 2.8 |
| | |
| Boresight correction stdev (<0.001deg) | 0.000950 |
| IMU attitude correction stdev (<0.001deg) | 0.020402 |
| GPS position stdev (<0.01m) | 0.0247 |
| | |
| Minimum % overlap (>25) | 48.86% |
| Ave point cloud density per sq.m. (>2.0) | 5.45 |
| Elevation difference between strips (<0.20 m) | Yes |
| | |
| Number of 1km x 1km blocks | 79 |
| Maximum Height | 380.62 m |
| Minimum Height | 64.4 m |
| | |
| *Classification (# of points)* | |
| Ground | 18,157,872 |
| Low vegetation | 11,687,930 |
| Medium vegetation | 53,303,947 |
| High vegetation | 179,792,188 |
| Building | 4,191,667 |
| | |
| Orthophoto | No |
| Processed by | Engr. Kenneth Solidum, AljonRieAraneta, Jovy Narisma |

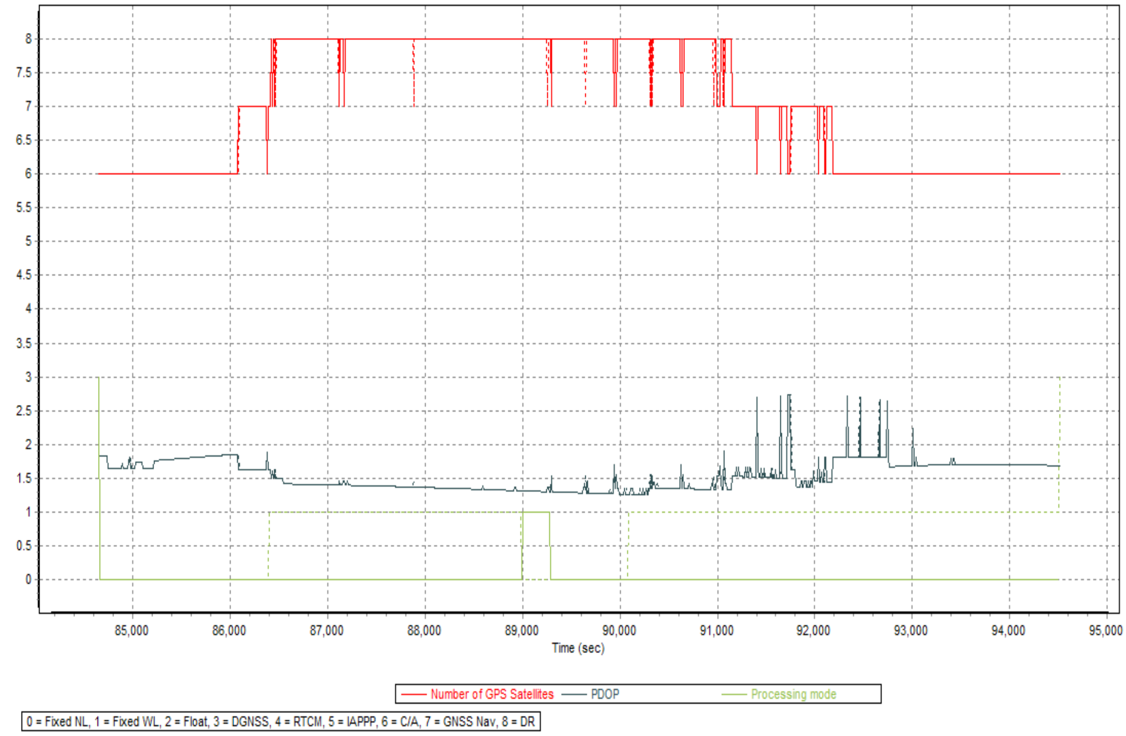



*Figure 1.12.1. Solution Status*

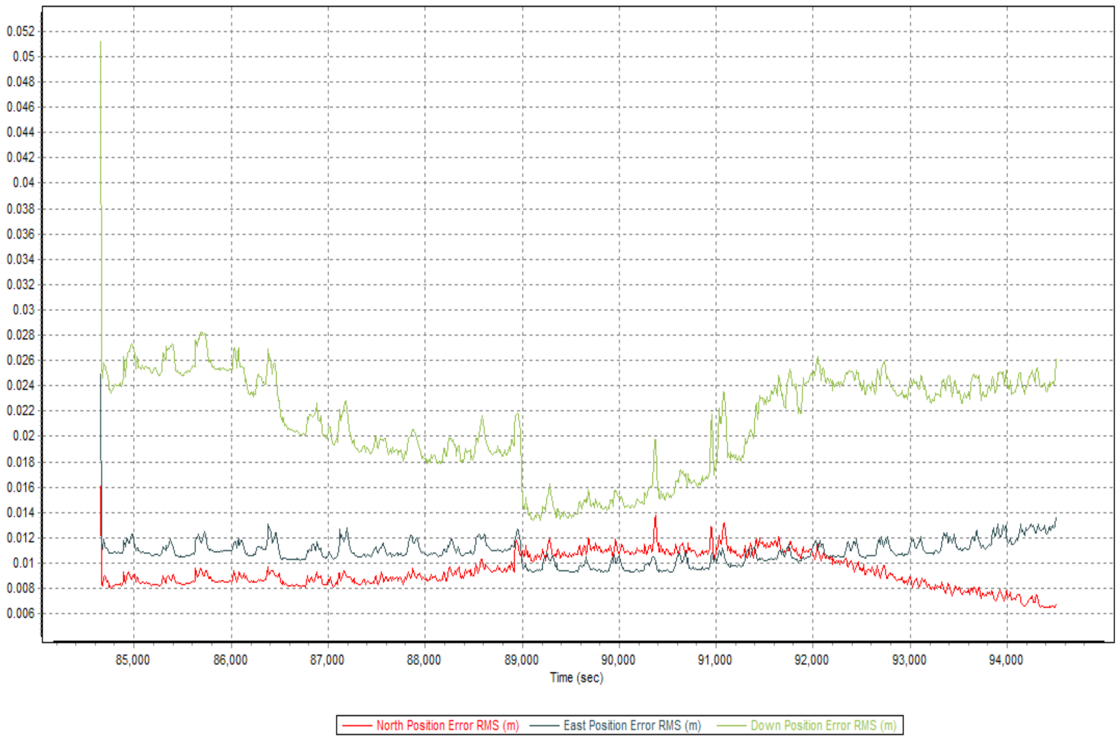



*Figure 1.12.2. Smoothed Performance Metric Parameters*

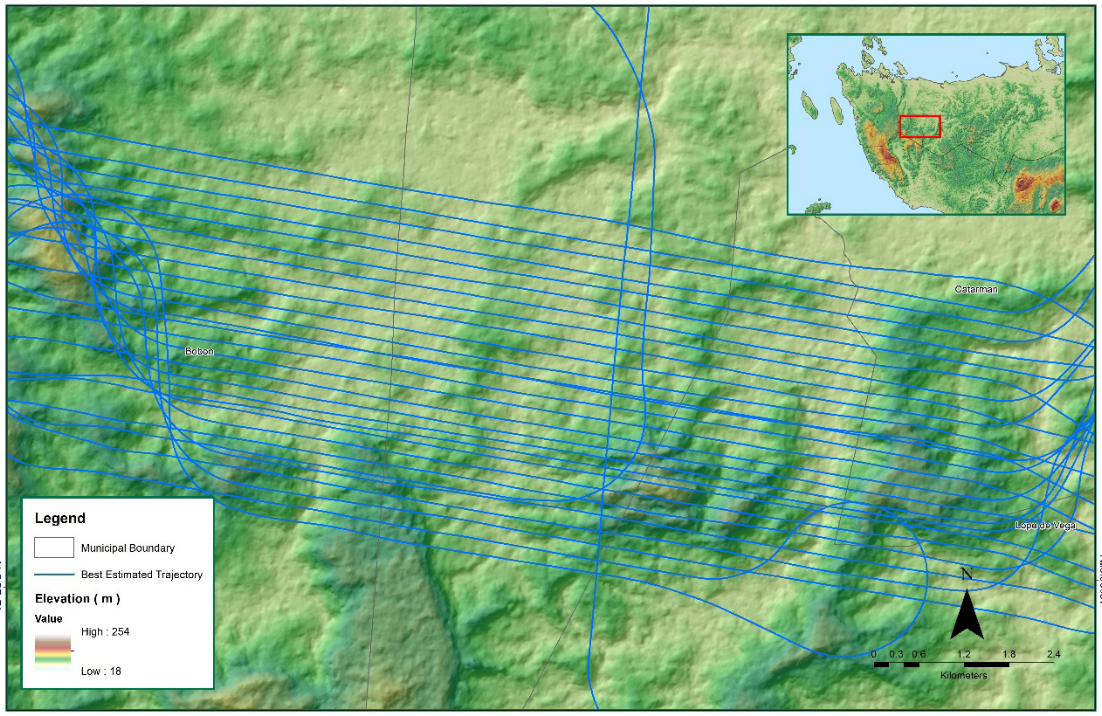



***Figure 1.12.3. Best Estimated Trajectory***

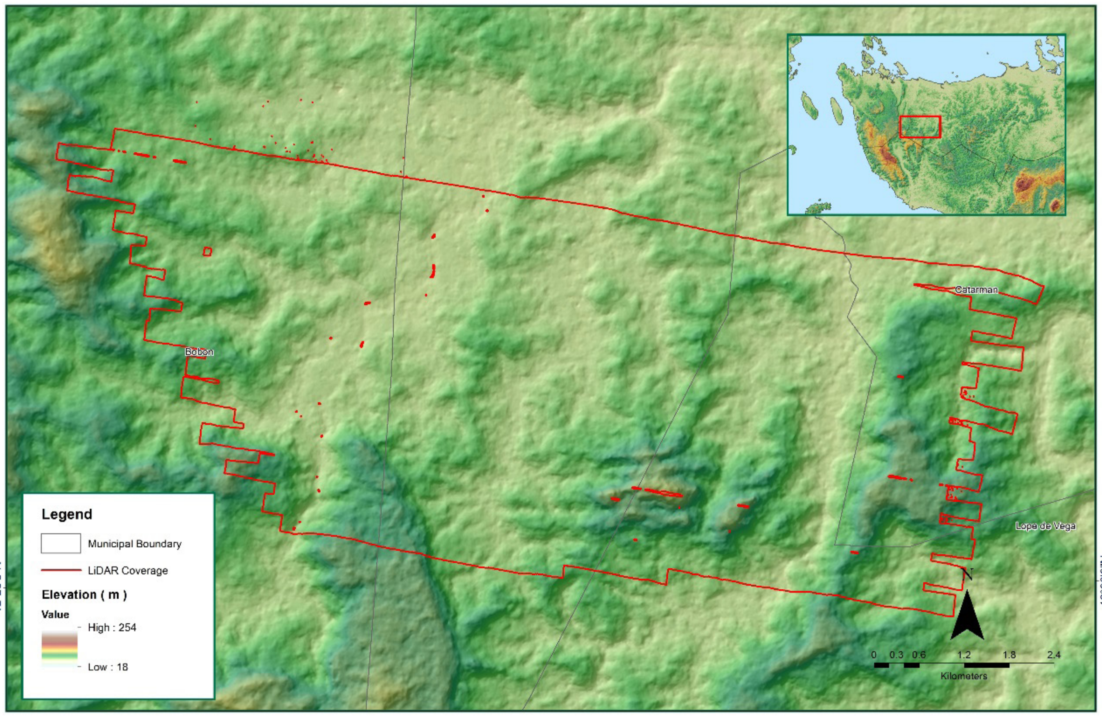



*Figure 1.12.4. Coverage of LiDAR Data*

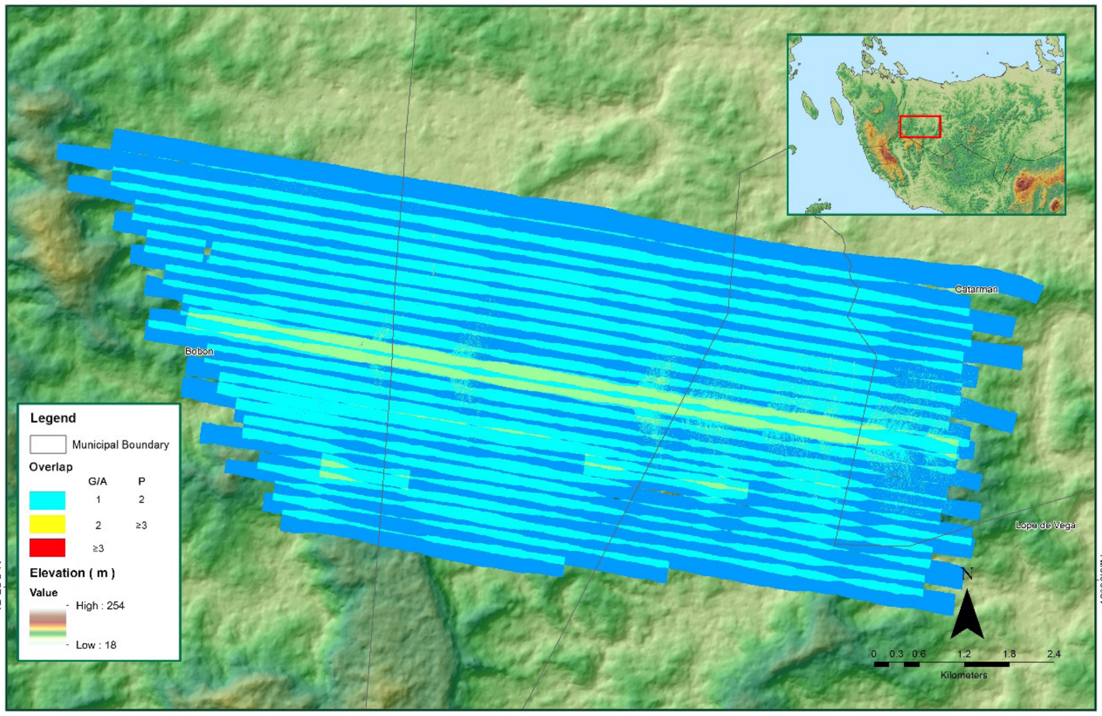



*Figure 1.12.5. Image of data overlap*

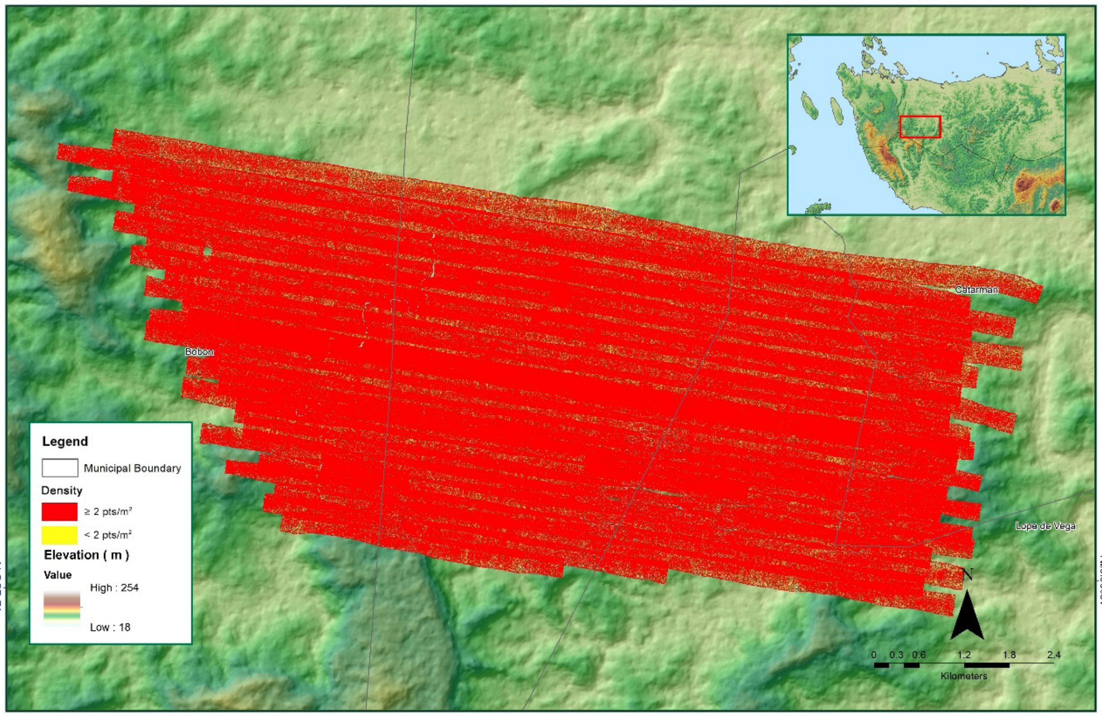



*Figure 1.12.6. Density map of merged LiDAR datat*

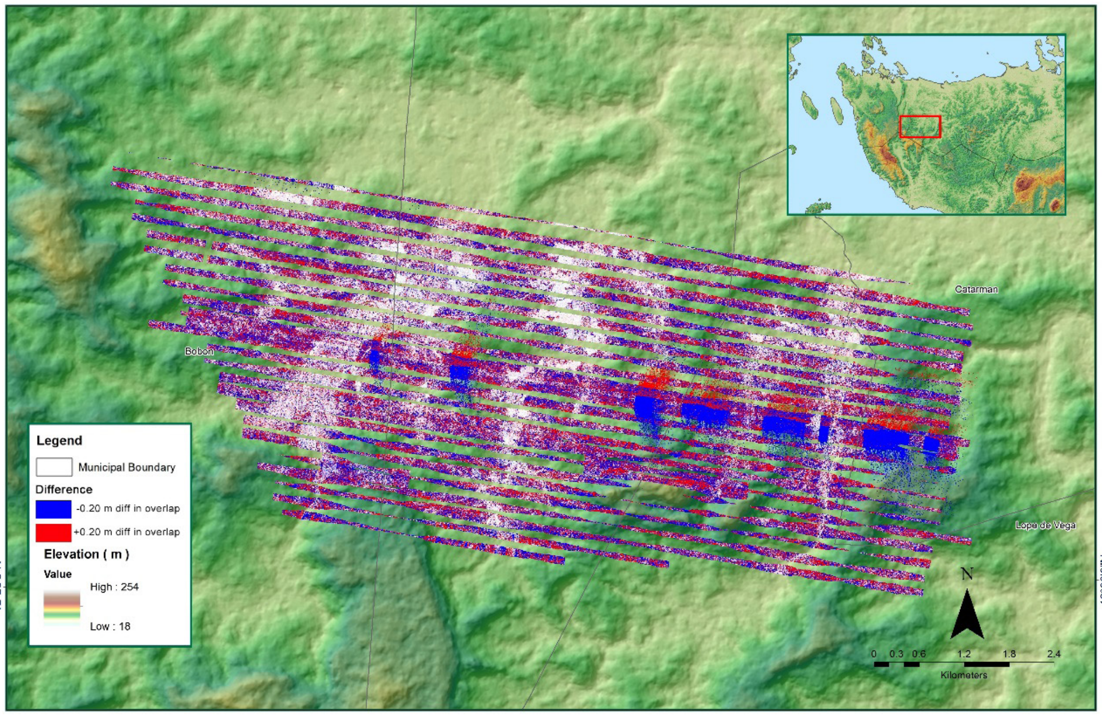



*Figure 1.12.7. Elevation difference between flight lines*

# Annex 9. Catarman Model Basin Parameters

Table A-9.1. Catarman Model Basin Parameters

| Subbasin | SCS Curve Number | | | Clark Unit Hydropgraph | | Recession Baseflow | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Initial Abstraction | Curve Number | Impervious | Time of Concentration | Storage Coefficient | Initial Type | Initial Discharge (m3/s) | Recession Constant | Threshold Type | Ratio to Peak |
| W1000 | 1.6133 | 99 | 0 | 1.1404 | 1.8611 | Discharge | 1.8333 | 0.55 | Ratio to Peak | 0.3 |
| W1010 | 1.8663 | 99 | 0 | 1.454 | 2.373 | Discharge | 2.4259 | 0.55 | Ratio to Peak | 0.3 |
| W1020 | 1.8693 | 99 | 0 | 2.4818 | 4.0502 | Discharge | 3.5575 | 0.55 | Ratio to Peak | 0.3 |
| W1030 | 2.3828 | 99 | 0 | 2.8222 | 4.6059 | Discharge | 4.0123 | 0.55 | Ratio to Peak | 0.3 |
| W1040 | 1.8978 | 99 | 0 | 1.8708 | 3.0531 | Discharge | 1.6373 | 0.55 | Ratio to Peak | 0.3 |
| W1050 | 1.9185 | 99 | 0 | 1.9924 | 3.2516 | Discharge | 1.8292 | 0.55 | Ratio to Peak | 0.3 |
| W1060 | 1.5582 | 99 | 0 | 2.5028 | 4.0846 | Discharge | 5.3371 | 0.55 | Ratio to Peak | 0.3 |
| W1070 | 1.8593 | 99 | 0 | 1.884 | 3.0747 | Discharge | 2.8865 | 0.55 | Ratio to Peak | 0.3 |
| W1080 | 2.2699 | 99 | 0 | 2.4954 | 2.715 | Discharge | 1.695 | 0.55 | Ratio to Peak | 0.3 |
| W1090 | 1.8789 | 99 | 0 | 0.4956 | 0.80885 | Discharge | 0.0613969 | 0.55 | Ratio to Peak | 0.3 |
| W1100 | 1.8789 | 99 | 0 | 1.8049 | 2.9456 | Discharge | 2.3143 | 0.55 | Ratio to Peak | 0.3 |
| W1110 | 1.8789 | 99 | 0 | 1.3046 | 2.1291 | Discharge | 1.6963 | 0.55 | Ratio to Peak | 0.3 |
| W1120 | 1.8789 | 99 | 0 | 3.2465 | 5.2982 | Discharge | 2.4694 | 0.55 | Ratio to Peak | 0.3 |
| W1130 | 1.6639 | 99 | 0 | 1.5332 | 2.5022 | Discharge | 1.2228 | 0.55 | Ratio to Peak | 0.3 |
| W1140 | 1.8789 | 99 | 0 | 0.62663 | 1.0227 | Discharge | 0.0962743 | 0.55 | Ratio to Peak | 0.3 |
| W1150 | 1.8789 | 99 | 0 | 2.3668 | 3.8625 | Discharge | 2.8143 | 0.55 | Ratio to Peak | 0.3 |
| W1160 | 1.755 | 99 | 0 | 1.7153 | 2.7993 | Discharge | 1.3013 | 0.55 | Ratio to Peak | 0.3 |
| W1170 | 1.8789 | 99 | 0 | 1.2903 | 2.1058 | Discharge | 1.373 | 0.55 | Ratio to Peak | 0.3 |
| W1180 | 1.8789 | 99 | 0 | 2.1179 | 3.4564 | Discharge | 2.3213011 | 0.55 | Ratio to Peak | 0.3 |
| W600 | 3.1723 | 99 | 0 | 3.7604 | 6.137 | Discharge | 1.071 | 0.55 | Ratio to Peak | 0.3 |
| W610 | 1.3444 | 99 | 0 | 2.8258 | 4.6118 | Discharge | 1.6357 | 0.55 | Ratio to Peak | 0.3 |
| W620 | 1.1498 | 99 | 0 | 6.848 | 11.176 | Discharge | 5.3142 | 0.55 | Ratio to Peak | 0.3 |
| W630 | 2.5484 | 99 | 0 | 2.5541 | 4.1682 | Discharge | 1.958 | 0.55 | Ratio to Peak | 0.3 |

| Subbasin | SCS Curve Number | | | Clark Unit Hydropgraph | | Recession Baseflow | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Initial Abstraction | Curve Number | Impervious | Time of Concentration | Storage Coefficient | Initial Type | Initial Discharge (m3/s) | Recession Constant | Threshold Type | Ratio to Peak |
| W640 | 1.7536 | 99 | 0 | 3.6747 | 5.9972 | Discharge | 1.6142 | 0.55 | Ratio to Peak | 0.3 |
| W650 | 2.0871 | 99 | 0 | 4.5095 | 7.3595 | Discharge | 4.2171 | 0.55 | Ratio to Peak | 0.3 |
| W660 | 2.3453 | 99 | 0 | 4.503 | 7.3488 | Discharge | 3.2121 | 0.55 | Ratio to Peak | 0.3 |
| W670 | 1.9512 | 99 | 0 | 2.5297 | 4.1284 | Discharge | 0.71767 | 0.55 | Ratio to Peak | 0.3 |
| W680 | 1.7643172 | 99 | 0 | 4.2044 | 6.8615 | Discharge | 4.0044 | 0.55 | Ratio to Peak | 0.3 |
| W690 | 3.0657 | 99 | 0 | 7.9762 | 13.017 | Discharge | 2.4378 | 0.55 | Ratio to Peak | 0.3 |
| W700 | 1.437 | 99 | 0 | 1.6247 | 2.6515 | Discharge | 1.3375 | 0.55 | Ratio to Peak | 0.3 |
| W710 | 2.7551 | 99 | 0 | 4.1867 | 6.8327 | Discharge | 2.2313 | 0.55 | Ratio to Peak | 0.3 |
| W720 | 3.37 | 99 | 0 | 8.553 | 13.958 | Discharge | 4.4326 | 0.55 | Ratio to Peak | 0.3 |
| W730 | 1.7294 | 99 | 0 | 1.9474 | 3.1781 | Discharge | 1.2799 | 0.55 | Ratio to Peak | 0.3 |
| W740 | 4.2894 | 99 | 0 | 2.6901 | 4.3903 | Discharge | 0.54987 | 0.55 | Ratio to Peak | 0.3 |
| W750 | 5.4713 | 99 | 0 | 1.4176 | 2.3135 | Discharge | 0.21167 | 0.55 | Ratio to Peak | 0.3 |
| W760 | 2.0214 | 99 | 0 | 1.4872 | 2.4271 | Discharge | 0.38546 | 0.55 | Ratio to Peak | 0.3 |
| W770 | 2.809 | 99 | 0 | 4.1534 | 6.7783 | Discharge | 1.2556 | 0.55 | Ratio to Peak | 0.3 |
| W780 | 1.7357 | 99 | 0 | 1.0642 | 1.7367 | Discharge | 0.28927 | 0.55 | Ratio to Peak | 0.3 |
| W790 | 1.8702 | 99 | 0 | 4.1981 | 6.8512 | Discharge | 3.7632 | 0.55 | Ratio to Peak | 0.3 |
| W800 | 0.62825 | 99 | 0 | 1.3809 | 2.2536 | Discharge | 0.11286 | 0.55 | Ratio to Peak | 0.3 |
| W810 | 3.3359 | 99 | 0 | 5.0213 | 8.1947 | Discharge | 1.536 | 0.55 | Ratio to Peak | 0.3 |
| W820 | 3.2193 | 99 | 0 | 1.0458 | 1.7068 | Discharge | 0.0378334 | 0.55 | Ratio to Peak | 0.3 |
| W830 | 1.4169 | 99 | 0 | 1.9564 | 3.1929 | Discharge | 1.2286 | 0.55 | Ratio to Peak | 0.3 |
| W840 | 2.5056 | 99 | 0 | 2.3186 | 3.7839 | Discharge | 0.81941 | 0.55 | Ratio to Peak | 0.3 |
| W850 | 1.8144 | 99 | 0 | 6.1318 | 10.007 | Discharge | 6.871 | 0.55 | Ratio to Peak | 0.3 |
| W860 | 1.8742 | 99 | 0 | 3.553 | 5.7985 | Discharge | 2.687322 | 0.55 | Ratio to Peak | 0.3 |
| W870 | 2.495 | 99 | 0 | 3.0336 | 4.9509 | Discharge | 2.0803 | 0.55 | Ratio to Peak | 0.3 |
| W880 | 4.6952 | 99 | 0 | 2.6332 | 4.2974 | Discharge | 1.2532 | 0.55 | Ratio to Peak | 0.3 |

| Subbasin | SCS Curve Number | | | Clark Unit Hydropgraph | | Recession Baseflow | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Initial Abstraction | Curve Number | Impervious | Time of Concentration | Storage Coefficient | Initial Type | Initial Discharge (m3/s) | Recession Constant | Threshold Type | Ratio to Peak |
| W890 | 4.0939 | 96 | 0 | 3.6645 | 5.9805 | Discharge | 2.3835 | 0.55 | Ratio to Peak | 0.3 |
| W900 | 2.5674 | 96 | 0 | 4.214 | 6.8773 | Discharge | 2.4767 | 0.55 | Ratio to Peak | 0.3 |
| W910 | 1.8272 | 96 | 0 | 4.2606 | 6.9534 | Discharge | 3.5295 | 0.55 | Ratio to Peak | 0.3 |
| W920 | 2.0586 | 96 | 0 | 2.3594 | 3.8505 | Discharge | 1.6592 | 0.55 | Ratio to Peak | 0.3 |
| W930 | 2.2892 | 96 | 0 | 3.407 | 5.5602 | Discharge | 1.4546 | 0.55 | Ratio to Peak | 0.3 |
| W940 | 2.4107 | 95 | 0 | 2.5682 | 4.1912 | Discharge | 0.75154 | 0.55 | Ratio to Peak | 0.3 |
| W950 | 1.8789 | 95 | 0 | 2.9289 | 4.78 | Discharge | 1.7916 | 0.55 | Ratio to Peak | 0.3 |
| W960 | 1.4602 | 95 | 0 | 2.1744 | 3.5486 | Discharge | 2.8038 | 0.55 | Ratio to Peak | 0.3 |
| W970 | 1.5898 | 95 | 0 | 6.8422 | 11.166 | Discharge | 5.0309 | 0.55 | Ratio to Peak | 0.3 |
| W980 | 2.259 | 99 | 0 | 1.8932 | 3.0897 | Discharge | 0.59562 | 0.55 | Ratio to Peak | 0.3 |
| W990 | 4.5614 | 99 | 0 | 2.3683 | 3.8651 | Discharge | 1.2202 | 0.55 | Ratio to Peak | 0.3 |

# Annex 10. Catarman Model Reach Parameters

Table A-10.1. Catarman Model Reach Parameters

| Reach | Time Step Method | Length | Slope | Manning's n | Shape | Width | Side Slope |
|---|---|---|---|---|---|---|---|
| R10 | Automatic Fixed Interval | 3254 | 8.28E-05 | 0.04 | Trapezoid | 121.8133333 | 45 |
| R110 | Automatic Fixed Interval | 8047.9 | 8.28E-05 | 0.04 | Trapezoid | 40.377 | 45 |
| R150 | Automatic Fixed Interval | 1255.7 | 8.28E-05 | 0.04 | Trapezoid | 9.1567 | 45 |
| R160 | Automatic Fixed Interval | 2158.2 | 0.0013451 | 0.04 | Trapezoid | 11.5 | 45 |
| R180 | Automatic Fixed Interval | 1752 | 0.000236282 | 0.04 | Trapezoid | 11.283 | 45 |
| R190 | Automatic Fixed Interval | 2898.7 | 0.000869168 | 0.04 | Trapezoid | 44.757 | 45 |
| R20 | Automatic Fixed Interval | 6242.6 | 0.000929443 | 0.04 | Trapezoid | 84.6 | 45 |
| R200 | Automatic Fixed Interval | 1261.2 | 0.00084571 | 0.04 | Trapezoid | 14.18 | 45 |
| R210 | Automatic Fixed Interval | 359.41 | 0.0069342 | 0.04 | Trapezoid | 25.063 | 45 |
| R230 | Automatic Fixed Interval | 3252.8 | 0.000686166 | 0.04 | Trapezoid | 16.42 | 45 |
| R240 | Automatic Fixed Interval | 4902.4 | 0.00068193 | 0.04 | Trapezoid | 26.92 | 45 |
| R270 | Automatic Fixed Interval | 4706.9 | 0.0019305 | 0.04 | Trapezoid | 14.223 | 45 |
| R290 | Automatic Fixed Interval | 7337.8 | 8.28E-05 | 0.04 | Trapezoid | 27.803 | 45 |
| R30 | Automatic Fixed Interval | 4190 | 0.0026977 | 0.04 | Trapezoid | 15.297 | 45 |
| R300 | Automatic Fixed Interval | 10033 | 0.000719538 | 0.04 | Trapezoid | 9.8667 | 45 |
| R320 | Automatic Fixed Interval | 6372.4 | 0.003088 | 0.04 | Trapezoid | 13.553 | 45 |
| R340 | Automatic Fixed Interval | 3005 | 0.0053649 | 0.04 | Trapezoid | 15.227 | 45 |
| R350 | Automatic Fixed Interval | 2875.7 | 0.0038383 | 0.04 | Trapezoid | 10.76 | 45 |
| R360 | Automatic Fixed Interval | 3423.9 | 8.28E-05 | 0.04 | Trapezoid | 11.483 | 45 |
| R380 | Automatic Fixed Interval | 4616.2 | 0.0020008 | 0.04 | Trapezoid | 12.61 | 45 |
| R40 | Automatic Fixed Interval | 5391.9 | 0.0013217 | 0.04 | Trapezoid | 10.597 | 45 |
| R430 | Automatic Fixed Interval | 8324.8 | 0.0015749 | 0.04 | Trapezoid | 10.53 | 45 |
| R440 | Automatic Fixed Interval | 6230.3 | 0.0089031 | 0.04 | Trapezoid | 14.827 | 45 |
| R450 | Automatic Fixed Interval | 1254.1 | 8.28E-05 | 0.04 | Trapezoid | 11.1 | 45 |
| R500 | Automatic Fixed Interval | 7629.5 | 0.000661654 | 0.04 | Trapezoid | 10.01 | 45 |

| Reach | Time Step Method | Length | Slope | Manning's n | Shape | Width | Side Slope |
|---|---|---|---|---|---|---|---|
| R520 | Automatic Fixed Interval | 6809.6 | 0.0028191 | 0.04 | Trapezoid | 21.297 | 45 |
| R540 | Automatic Fixed Interval | 571.13 | 0.0127457 | 0.04 | Trapezoid | 8.8467 | 45 |
| R560 | Automatic Fixed Interval | 9608.9 | 0.0043536 | 0.04 | Trapezoid | 11.463 | 45 |
| R60 | Automatic Fixed Interval | 3206.3 | 8.28E-05 | 0.04 | Trapezoid | 59.08 | 45 |

# Annex 11. Catarman Field Validation Points

Table A-11.1. Catarman Field Validation Points

| GPS No. | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return/ Scenario |
|---|---|---|---|---|---|---|---|
| | Latitude | Longitude | | | | | |
| 1001 | 12.46066483 | 124.6421689 | 0.10 | 0.6 | 0.50 | Ruby/December 6, 2014 | 100 Year |
| 1010 | 12.49616177 | 124.6322961 | 0.51 | 0.6 | 0.09 | Ruby/December 6, 2014 | 100 Year |
| 1011 | 12.45840817 | 124.6426886 | 0.06 | 0.6 | 0.54 | Ruby/December 6, 2014 | 100 Year |
| 1021 | 12.45721282 | 124.6419602 | 0.10 | 0 | -0.10 | Ruby/December 6, 2014 | 100 Year |
| 1031 | 12.45746328 | 124.6429007 | 0.04 | 1 | 0.96 | Ruby/December 6, 2014 | 100 Year |
| 1041 | 12.45518608 | 124.6425521 | 0.39 | 1 | 0.61 | Ruby/December 6, 2014 | 100 Year |
| 1051 | 12.45265148 | 124.6419579 | 0.49 | 1 | 0.51 | Ruby/December 6, 2014 | 100 Year |
| 1081 | 12.43233626 | 124.6369835 | 2.65 | 2 | -0.65 | Ruby/December 6, 2014 | 100 Year |
| 1091 | 12.43230885 | 124.6363719 | 2.65 | 2 | -0.65 | Ruby/December 6, 2014 | 100 Year |
| 1100 | 12.50720216 | 124.604334 | 0.50 | 1.1 | 0.60 | Ruby/December 6, 2014 | 100 Year |
| 1110 | 12.50376834 | 124.6208152 | 0.03 | 0 | -0.03 | Ruby/December 6, 2014 | 100 Year |
| 1141 | 12.42665945 | 124.6369893 | 0.37 | 0.8 | 0.43 | Ruby/December 6, 2014 | 100 Year |
| 1151 | 12.42644948 | 124.636268 | 0.03 | 0.8 | 0.77 | Ruby/December 6, 2014 | 100 Year |
| 1161 | 12.42561783 | 124.6366775 | 0.03 | 1 | 0.97 | Ruby/December 6, 2014 | 100 Year |
| 1171 | 12.42484921 | 124.6360228 | 1.71 | 1 | -0.71 | Ruby/December 6, 2014 | 100 Year |
| 1181 | 12.42445467 | 124.636906 | 2.18 | 2 | -0.18 | Ruby/December 6, 2014 | 100 Year |
| 1201 | 12.42307912 | 124.6342149 | 2.34 | 1.5 | -0.84 | Ruby/December 6, 2014 | 100 Year |
| 1210 | 12.49474498 | 124.6361435 | 0.03 | 0.9 | 0.87 | Ruby/December 6, 2014 | 100 Year |
| 1271 | 12.41644735 | 124.6235505 | 0.03 | 0.5 | 0.47 | Ruby/December 6, 2014 | 100 Year |
| 1281 | 12.41537011 | 124.616013 | 1.12 | 0.5 | -0.62 | Ruby/December 6, 2014 | 100 Year |
| 1310 | 12.49357369 | 124.639941 | 2.07 | 1.3 | -0.77 | Ruby/December 6, 2014 | 100 Year |
| 1410 | 12.49393512 | 124.6401273 | 2.07 | 1.3 | -0.77 | Ruby/December 6, 2014 | 100 Year |
| 1441 | 12.39521415 | 124.6277713 | 1.97 | 1.1 | -0.87 | Ruby/December 6, 2014 | 100 Year |
| 1510 | 12.49457566 | 124.6402429 | 0.80 | 1.3 | 0.50 | Ruby/December 6, 2014 | 100 Year |
| 1541 | 12.38214358 | 124.6252503 | 0.23 | 0.7 | 0.47 | Ruby/December 6, 2014 | 100 Year |
| 1551 | 12.38121042 | 124.6194005 | 0.03 | 0.7 | 0.67 | Ruby/December 6, 2014 | 100 Year |
| 1561 | 12.38057591 | 124.6189653 | 0.03 | 0.7 | 0.67 | Ruby/December 6, 2014 | 100 Year |
| 1601 | 12.49692762 | 124.6425894 | 0.72 | 0.9 | 0.18 | Ruby/December 6, 2014 | 100 Year |
| 1610 | 12.49267565 | 124.6402687 | 1.10 | 0.8 | -0.30 | Ruby/December 6, 2014 | 100 Year |
| 1611 | 12.4978467 | 124.6424868 | 0.21 | 0.9 | 0.69 | Ruby/December 6, 2014 | 100 Year |
| 1621 | 12.49896267 | 124.6422916 | 0.03 | 0.7 | 0.67 | Ruby/December 6, 2014 | 100 Year |
| 1641 | 12.50025851 | 124.642086 | 0.11 | 0.7 | 0.59 | Ruby/December 6, 2014 | 100 Year |
| 1651 | 12.50112025 | 124.6418856 | 0.03 | 0.9 | 0.87 | Ruby/December 6, 2014 | 100 Year |
| 1661 | 12.50259748 | 124.6410001 | 0.04 | 0.9 | 0.86 | Ruby/December 6, 2014 | 100 Year |
| 1671 | 12.50336492 | 124.6403145 | 0.29 | 0.9 | 0.61 | Ruby/December 6, 2014 | 100 Year |
| 1681 | 12.50381135 | 124.6408091 | 0.40 | 1.3 | 0.90 | Ruby/December 6, 2014 | 100 Year |
| 1691 | 12.50378511 | 124.6413551 | 0.40 | 1.3 | 0.90 | Ruby/December 6, 2014 | 100 Year |
| 1701 | 12.50406515 | 124.6421047 | 0.69 | 1.3 | 0.61 | Ruby/December 6, 2014 | 100 Year |
| 1710 | 12.49440584 | 124.6420009 | 1.09 | 1.2 | 0.11 | Ruby/December 6, 2014 | 100 Year |
| 1711 | 12.50502873 | 124.6419341 | 0.48 | 1.4 | 0.92 | Ruby/December 6, 2014 | 100 Year |

| GPS No. | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return/ Scenario |
|---|---|---|---|---|---|---|---|
| | Latitude | Longitude | | | | | |
| 1721 | 12.50559795 | 124.6426349 | 0.03 | 0 | -0.03 | Ruby/December 6, 2014 | 100 Year |
| 1731 | 12.50621921 | 124.6428708 | 0.03 | 0 | -0.03 | Ruby/December 6, 2014 | 100 Year |
| 1741 | 12.50646849 | 124.6439923 | 0.03 | 0 | -0.03 | Ruby/December 6, 2014 | 100 Year |
| 1761 | 12.5065239 | 124.6422497 | 0.09 | 0 | -0.09 | Ruby/December 6, 2014 | 100 Year |
| 1771 | 12.50677485 | 124.6411122 | 0.21 | 0.8 | 0.59 | Ruby/December 6, 2014 | 100 Year |
| 1781 | 12.50619926 | 124.6409428 | 0.23 | 0.8 | 0.57 | Ruby/December 6, 2014 | 100 Year |
| 1791 | 12.50564883 | 124.6407727 | 0.23 | 0.8 | 0.57 | Ruby/December 6, 2014 | 100 Year |
| 1801 | 12.50616037 | 124.6417511 | 0.27 | 0.8 | 0.53 | Ruby/December 6, 2014 | 100 Year |
| 1810 | 12.49348627 | 124.6423084 | 1.87 | 1.2 | -0.67 | Ruby/December 6, 2014 | 100 Year |
| 1811 | 12.5054542 | 124.6414551 | 0.48 | 1.3 | 0.82 | Ruby/December 6, 2014 | 100 Year |
| 1831 | 12.50442239 | 124.640096 | 0.85 | 1.2 | 0.35 | Ruby/December 6, 2014 | 100 Year |
| 1841 | 12.50396473 | 124.638196 | 0.59 | 1 | 0.41 | Ruby/December 6, 2014 | 100 Year |
| 1851 | 12.50269186 | 124.6389179 | 0.03 | 1 | 0.97 | Ruby/December 6, 2014 | 100 Year |
| 1861 | 12.50202633 | 124.6379305 | 0.05 | 1 | 0.95 | Ruby/December 6, 2014 | 100 Year |
| 1871 | 12.50199859 | 124.6366507 | 0.29 | 1 | 0.71 | Ruby/December 6, 2014 | 100 Year |
| 1881 | 12.50115445 | 124.6400175 | 0.07 | 1 | 0.93 | Ruby/December 6, 2014 | 100 Year |
| 1891 | 12.49976121 | 124.6398799 | 0.07 | 0.9 | 0.83 | Ruby/December 6, 2014 | 100 Year |
| 1901 | 12.49868891 | 124.6397969 | 0.10 | 1 | 0.90 | Ruby/December 6, 2014 | 100 Year |
| 1910 | 12.49509299 | 124.6428249 | 1.11 | 1.2 | 0.09 | Ruby/December 6, 2014 | 100 Year |
| 1911 | 12.4969723 | 124.6397449 | 0.19 | 1 | 0.81 | Ruby/December 6, 2014 | 100 Year |
| 1921 | 12.49557504 | 124.6396714 | 1.61 | 0.9 | -0.71 | Ruby/December 6, 2014 | 100 Year |
| 1931 | 12.49698152 | 124.6410697 | 0.36 | 1 | 0.64 | Ruby/December 6, 2014 | 100 Year |
| 1941 | 12.49861951 | 124.6414064 | 0.03 | 0.9 | 0.87 | Ruby/December 6, 2014 | 100 Year |
| 1951 | 12.5000643 | 124.6408344 | 0.05 | 0.9 | 0.85 | Ruby/December 6, 2014 | 100 Year |
| 1971 | 12.49702469 | 124.6390182 | 0.19 | 1 | 0.81 | Ruby/December 6, 2014 | 100 Year |
| 1981 | 12.49872856 | 124.6389727 | 0.03 | 1 | 0.97 | Ruby/December 6, 2014 | 100 Year |
| 1991 | 12.50015524 | 124.6390805 | 0.10 | 0.7 | 0.60 | Ruby/December 6, 2014 | 100 Year |
| 2001 | 12.49985374 | 124.6377989 | 0.21 | 0.7 | 0.49 | Ruby/December 6, 2014 | 100 Year |
| 2010 | 12.49612078 | 124.6427698 | 0.99 | 0.9 | -0.09 | Ruby/December 6, 2014 | 100 Year |
| 2011 | 12.49778585 | 124.6374351 | 0.03 | 1 | 0.97 | Ruby/December 6, 2014 | 100 Year |
| 2021 | 12.49658891 | 124.6373972 | 0.94 | 1 | 0.06 | Ruby/December 6, 2014 | 100 Year |
| 2031 | 12.49922284 | 124.6366934 | 0.05 | 1 | 0.95 | Ruby/December 6, 2014 | 100 Year |
| 2041 | 12.49785525 | 124.6357688 | 0.26 | 0.9 | 0.64 | Ruby/December 6, 2014 | 100 Year |
| 2051 | 12.49647408 | 124.6360599 | 1.00 | 0.9 | -0.10 | Ruby/December 6, 2014 | 100 Year |
| 2061 | 12.49848238 | 124.6342088 | 0.68 | 0.9 | 0.22 | Ruby/December 6, 2014 | 100 Year |
| 2071 | 12.4988532 | 124.6333974 | 0.03 | 0.9 | 0.87 | Ruby/December 6, 2014 | 100 Year |
| 2081 | 12.49945737 | 124.6349656 | 0.03 | 0.9 | 0.87 | Ruby/December 6, 2014 | 100 Year |
| 2091 | 12.50044584 | 124.6359561 | 0.24 | 0.9 | 0.66 | Ruby/December 6, 2014 | 100 Year |
| 2101 | 12.49971829 | 124.6323114 | 0.38 | 0.7 | 0.32 | Ruby/December 6, 2014 | 100 Year |
| 2110 | 12.49235555 | 124.6366608 | 0.03 | 0.8 | 0.77 | Ruby/December 6, 2014 | 100 Year |
| 2111 | 12.50277777 | 124.633689 | 0.05 | 0 | -0.05 | Ruby/December 6, 2014 | 100 Year |
| 2121 | 12.50419616 | 124.634772 | 0.45 | 0.4 | -0.05 | Ruby/December 6, 2014 | 100 Year |
| 2131 | 12.5048476 | 124.6325052 | 0.18 | 0.4 | 0.22 | Ruby/December 6, 2014 | 100 Year |

| GPS No. | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return/ Scenario |
|---|---|---|---|---|---|---|---|
| | Latitude | Longitude | | | | | |
| 2141 | 12.50353659 | 124.6318607 | 0.03 | 0.5 | 0.47 | Ruby/December 6, 2014 | 100 Year |
| 2151 | 12.50206472 | 124.6311787 | 0.62 | 0.5 | -0.12 | Ruby/December 6, 2014 | 100 Year |
| 2161 | 12.50093979 | 124.6294592 | 0.19 | 0.5 | 0.31 | Ruby/December 6, 2014 | 100 Year |
| 2171 | 12.50214594 | 124.6295735 | 0.24 | 0.5 | 0.26 | Ruby/December 6, 2014 | 100 Year |
| 2181 | 12.50373616 | 124.6303204 | 0.12 | 0.4 | 0.28 | Ruby/December 6, 2014 | 100 Year |
| 2191 | 12.50589886 | 124.6343002 | 0.83 | 0.4 | -0.43 | Ruby/December 6, 2014 | 100 Year |
| 2201 | 12.50709663 | 124.6351602 | 0.41 | 0.4 | -0.01 | Ruby/December 6, 2014 | 100 Year |
| 2210 | 12.4901309 | 124.6365752 | 0.90 | 0.8 | -0.10 | Ruby/December 6, 2014 | 100 Year |
| 2211 | 12.50553173 | 124.6320054 | 0.35 | 0.4 | 0.05 | Ruby/December 6, 2014 | 100 Year |
| 2221 | 12.50499923 | 124.6291989 | 0.07 | 0.6 | 0.53 | Ruby/December 6, 2014 | 100 Year |
| 2231 | 12.50192366 | 124.6283472 | 0.03 | 0.4 | 0.37 | Ruby/December 6, 2014 | 100 Year |
| 2241 | 12.50372275 | 124.6273286 | 0.03 | 0.4 | 0.37 | Ruby/December 6, 2014 | 100 Year |
| 2251 | 12.50611017 | 124.6273305 | 0.48 | 0.6 | 0.12 | Ruby/December 6, 2014 | 100 Year |
| 2261 | 12.50628082 | 124.6254234 | 0.07 | 0.6 | 0.53 | Ruby/December 6, 2014 | 100 Year |
| 2271 | 12.50263452 | 124.6256445 | 0.30 | 0.4 | 0.10 | Ruby/December 6, 2014 | 100 Year |
| 2281 | 12.50092411 | 124.6335575 | 0.03 | 0.5 | 0.47 | Ruby/December 6, 2014 | 100 Year |
| 2291 | 12.50341564 | 124.6415632 | 0.82 | 1.3 | 0.48 | Ruby/December 6, 2014 | 100 Year |
| 2301 | 12.49763162 | 124.6461617 | 1.73 | 1 | -0.73 | Ruby/December 6, 2014 | 100 Year |
| 2310 | 12.49001213 | 124.6397555 | 0.07 | 0.8 | 0.73 | Ruby/December 6, 2014 | 100 Year |
| 2321 | 12.50699395 | 124.653841 | 0.74 | 0.5 | -0.24 | Ruby/December 6, 2014 | 100 Year |
| 2331 | 12.51075517 | 124.655237 | 0.10 | 0.5 | 0.40 | Ruby/December 6, 2014 | 100 Year |
| 2351 | 12.48387214 | 124.6619016 | 0.77 | 1.3 | 0.53 | Ruby/December 6, 2014 | 100 Year |
| 2361 | 12.48286949 | 124.6685345 | 2.21 | 1.5 | -0.71 | Ruby/December 6, 2014 | 100 Year |
| 2371 | 12.48127459 | 124.6699855 | 0.26 | 0.5 | 0.24 | Ruby/December 6, 2014 | 100 Year |
| 2381 | 12.47771236 | 124.6723763 | 0.08 | 1 | 0.92 | Ruby/December 6, 2014 | 100 Year |
| 2391 | 12.47647863 | 124.672804 | 0.11 | 1 | 0.89 | Ruby/December 6, 2014 | 100 Year |
| 2401 | 12.47056679 | 124.6811264 | 1.57 | 1.1 | -0.47 | Ruby/December 6, 2014 | 100 Year |
| 2410 | 12.48799964 | 124.6483518 | 1.45 | 0.8 | -0.65 | Ruby/December 6, 2014 | 100 Year |
| 2411 | 12.4937513 | 124.6515458 | 0.54 | 0.7 | 0.16 | Ruby/December 6, 2014 | 100 Year |
| 2421 | 12.49789045 | 124.6274988 | 0.86 | 0.7 | -0.16 | Ruby/December 6, 2014 | 100 Year |
| 2431 | 12.50621653 | 124.6084078 | 0.03 | 0.9 | 0.87 | Ruby/December 6, 2014 | 100 Year |
| 2441 | 12.50598033 | 124.610542 | 0.03 | 0.9 | 0.87 | Ruby/December 6, 2014 | 100 Year |
| 2451 | 12.50753777 | 124.612257 | 0.85 | 0.9 | 0.05 | Ruby/December 6, 2014 | 100 Year |
| 2461 | 12.50492211 | 124.6195993 | 0.73 | 0.4 | -0.33 | Ruby/December 6, 2014 | 100 Year |
| 2471 | 12.50691969 | 124.6210313 | 0.03 | 0.4 | 0.37 | Ruby/December 6, 2014 | 100 Year |
| 2491 | 12.49557621 | 124.6418827 | 1.04 | 0.9 | -0.14 | Ruby/December 6, 2014 | 100 Year |
| 2501 | 12.4903148 | 124.6631234 | 0.81 | 1.7 | 0.89 | Ruby/December 6, 2014 | 100 Year |
| 251 | 12.50578361 | 124.6123318 | 0.48 | 0.9 | 0.42 | Ruby/December 6, 2014 | 100 Year |
| 252 | 12.48750561 | 124.6505465 | 0.89 | 0.4 | -0.49 | Ruby/December 6, 2014 | 100 Year |
| 261 | 12.49226619 | 124.6539538 | 1.59 | 0.7 | -0.89 | Ruby/December 6, 2014 | 100 Year |
| 271 | 12.49518595 | 124.6499571 | 0.74 | 0.7 | -0.04 | Ruby/December 6, 2014 | 100 Year |
| 281 | 12.4981259 | 124.6471744 | 0.72 | 1 | 0.28 | Ruby/December 6, 2014 | 100 Year |
| 291 | 12.4984398 | 124.6462351 | 1.26 | 1 | -0.26 | Ruby/December 6, 2014 | 100 Year |

| GPS No. | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return/ Scenario |
|---|---|---|---|---|---|---|---|
| | Latitude | Longitude | | | | | |
| 301 | 12.49842798 | 124.6454302 | 1.18 | 1 | -0.18 | Ruby/December 6, 2014 | 100 Year |
| 310 | 12.505535 | 124.6184633 | 0.03 | 0.4 | 0.37 | Ruby/December 6, 2014 | 100 Year |
| 311 | 12.49763472 | 124.6448357 | 1.11 | 0.4 | -0.71 | Ruby/December 6, 2014 | 100 Year |
| 321 | 12.49937279 | 124.6443668 | 1.17 | 1 | -0.17 | Ruby/December 6, 2014 | 100 Year |
| 331 | 12.49934346 | 124.6454157 | 1.41 | 1 | -0.41 | Ruby/December 6, 2014 | 100 Year |
| 341 | 12.50049454 | 124.646372 | 0.44 | 0.8 | 0.36 | Ruby/December 6, 2014 | 100 Year |
| 351 | 12.50166147 | 124.6472729 | 0.91 | 0.8 | -0.11 | Ruby/December 6, 2014 | 100 Year |
| 361 | 12.50447435 | 124.6515653 | 0.86 | 0.8 | -0.06 | Ruby/December 6, 2014 | 100 Year |
| 371 | 12.50756719 | 124.6546523 | 0.03 | 0.5 | 0.47 | Ruby/December 6, 2014 | 100 Year |
| 381 | 12.50957985 | 124.6552116 | 0.13 | 0.5 | 0.37 | Ruby/December 6, 2014 | 100 Year |
| 411 | 12.509749 | 124.6595367 | 0.03 | 0.5 | 0.47 | Ruby/December 6, 2014 | 100 Year |
| 431 | 12.50754775 | 124.6595888 | 0.03 | 0.5 | 0.47 | Ruby/December 6, 2014 | 100 Year |
| 441 | 12.49220752 | 124.6563825 | 0.72 | 0.7 | -0.02 | Ruby/December 6, 2014 | 100 Year |
| 451 | 12.49087069 | 124.6595854 | 1.57 | 1.7 | 0.13 | Ruby/December 6, 2014 | 100 Year |
| 461 | 12.49114201 | 124.6613171 | 0.07 | 0.5 | 0.43 | Ruby/December 6, 2014 | 100 Year |
| 471 | 12.48937561 | 124.6633291 | 0.26 | 0.5 | 0.24 | Ruby/December 6, 2014 | 100 Year |
| 48 | 12.48928375 | 124.6641061 | 0.24 | 0.5 | 0.26 | Ruby/December 6, 2014 | 100 Year |
| 491 | 12.48770141 | 124.6642998 | 0.10 | 0.5 | 0.40 | Ruby/December 6, 2014 | 100 Year |
| 501 | 12.4864717 | 124.6653935 | 0.24 | 1 | 0.76 | Ruby/December 6, 2014 | 100 Year |
| 510 | 12.5066829 | 124.621852 | 0.26 | 0.4 | 0.14 | Ruby/December 6, 2014 | 100 Year |
| 511 | 12.48337224 | 124.6681551 | 0.36 | 1 | 0.64 | Ruby/December 6, 2014 | 100 Year |
| 521 | 12.48161456 | 124.6701553 | 0.23 | 0.5 | 0.27 | Ruby/December 6, 2014 | 100 Year |
| 531 | 12.47868039 | 124.6722136 | 0.61 | 1 | 0.39 | Ruby/December 6, 2014 | 100 Year |
| 541 | 12.47694206 | 124.6729767 | 0.11 | 1 | 0.89 | Ruby/December 6, 2014 | 100 Year |
| 551 | 12.47582057 | 124.6731075 | 0.03 | 1 | 0.97 | Ruby/December 6, 2014 | 100 Year |
| 561 | 12.4739188 | 124.6767174 | 0.12 | 0.5 | 0.38 | Ruby/December 6, 2014 | 100 Year |
| 571 | 12.47140439 | 124.6805637 | 2.20 | 1.5 | -0.70 | Ruby/December 6, 2014 | 100 Year |
| 581 | 12.47088555 | 124.6806948 | 2.20 | 1.5 | -0.70 | Ruby/December 6, 2014 | 100 Year |
| 591 | 12.47031986 | 124.6817836 | 1.57 | 1.1 | -0.47 | Ruby/December 6, 2014 | 100 Year |
| 601 | 12.46860299 | 124.6828969 | 0.10 | 0.5 | 0.40 | Ruby/December 6, 2014 | 100 Year |
| 610 | 12.50849591 | 124.6228893 | 0.03 | 0.6 | 0.57 | Ruby/December 6, 2014 | 100 Year |
| 611 | 12.46880944 | 124.68201 | 0.78 | 0.5 | -0.28 | Ruby/December 6, 2014 | 100 Year |
| 621 | 12.46611374 | 124.6803058 | 0.03 | 0.7 | 0.67 | Ruby/December 6, 2014 | 100 Year |
| 631 | 12.46569967 | 124.6791145 | 0.54 | 0.7 | 0.16 | Ruby/December 6, 2014 | 100 Year |
| 641 | 12.455301 | 124.6829568 | 0.03 | 0.6 | 0.57 | Ruby/December 6, 2014 | 100 Year |
| 651 | 12.45465727 | 124.6820155 | 2.12 | 1.5 | -0.62 | Ruby/December 6, 2014 | 100 Year |
| 671 | 12.48414145 | 124.6620879 | 1.32 | 1.3 | -0.02 | Ruby/December 6, 2014 | 100 Year |
| 681 | 12.48363761 | 124.6627048 | 0.79 | 1.3 | 0.51 | Ruby/December 6, 2014 | 100 Year |
| 691 | 12.48308918 | 124.6627368 | 0.69 | 1.3 | 0.61 | Ruby/December 6, 2014 | 100 Year |
| 701 | 12.47677652 | 124.6503983 | 0.05 | 0 | -0.05 | Ruby/December 6, 2014 | 100 Year |
| 710 | 12.50315554 | 124.6243742 | 0.28 | 1.1 | 0.82 | Ruby/December 6, 2014 | 100 Year |
| 711 | 12.47566047 | 124.6547768 | 0.06 | 0 | -0.06 | Ruby/December 6, 2014 | 100 Year |
| 721 | 12.46813671 | 124.6679135 | 0.40 | 1 | 0.60 | Ruby/December 6, 2014 | 100 Year |

| GPS No. | Validation Coordinates | | Model Var (m) | Validation Points (m) | Error | Event/Date | Rain Return/ Scenario |
|---|---|---|---|---|---|---|---|
| | Latitude | Longitude | | | | | |
| 731 | 12.46912502 | 124.669016 | 0.45 | 1 | 0.55 | Ruby/December 6, 2014 | 100 Year |
| 741 | 12.47088161 | 124.6713141 | 0.48 | 1 | 0.52 | Ruby/December 6, 2014 | 100 Year |
| 751 | 12.47325688 | 124.6719752 | 0.52 | 1 | 0.48 | Ruby/December 6, 2014 | 100 Year |
| 761 | 12.47788302 | 124.6464445 | 0.04 | 0 | -0.04 | Ruby/December 6, 2014 | 100 Year |
| 771 | 12.47811763 | 124.6434529 | 0.06 | 0 | -0.06 | Ruby/December 6, 2014 | 100 Year |
| 781 | 12.47844477 | 124.6384866 | 0.03 | 1 | 0.97 | Ruby/December 6, 2014 | 100 Year |
| 791 | 12.47837361 | 124.6378676 | 2.35 | 1.5 | -0.85 | Ruby/December 6, 2014 | 100 Year |
| 801 | 12.48172394 | 124.6372649 | 0.84 | 1 | 0.16 | Ruby/December 6, 2014 | 100 Year |
| 810 | 12.50208593 | 124.6227528 | 0.51 | 1.1 | 0.59 | Ruby/December 6, 2014 | 100 Year |
| 811 | 12.48545598 | 124.6370373 | 0.43 | 1.2 | 0.77 | Ruby/December 6, 2014 | 100 Year |
| 821 | 12.4884194 | 124.6367199 | 0.03 | 0.8 | 0.77 | Ruby/December 6, 2014 | 100 Year |
| 831 | 12.48576854 | 124.6354551 | 0.22 | 1.2 | 0.98 | Ruby/December 6, 2014 | 100 Year |
| 841 | 12.48698509 | 124.6335847 | 0.03 | 0.5 | 0.47 | Ruby/December 6, 2014 | 100 Year |
| 851 | 12.48671394 | 124.6318537 | 0.03 | 0.5 | 0.47 | Ruby/December 6, 2014 | 100 Year |
| 861 | 12.47701692 | 124.6378262 | 0.39 | 1 | 0.61 | Ruby/December 6, 2014 | 100 Year |
| 871 | 12.47660184 | 124.6375638 | 0.39 | 1 | 0.61 | Ruby/December 6, 2014 | 100 Year |
| 881 | 12.473954 | 124.6388985 | 0.03 | 0.7 | 0.67 | Ruby/December 6, 2014 | 100 Year |
| 891 | 12.47190462 | 124.6408823 | 0.03 | 0.7 | 0.67 | Ruby/December 6, 2014 | 100 Year |
| 901 | 12.47344983 | 124.6418918 | 0.19 | 0.7 | 0.51 | Ruby/December 6, 2014 | 100 Year |
| 910 | 12.49596278 | 124.6305267 | 0.45 | 0.7 | 0.25 | Ruby/December 6, 2014 | 100 Year |
| 911 | 12.46669997 | 124.6410963 | 0.03 | 0.5 | 0.47 | Ruby/December 6, 2014 | 100 Year |
| 921 | 12.46534981 | 124.6413175 | 1.10 | 0.5 | -0.60 | Ruby/December 6, 2014 | 100 Year |
| 931 | 12.46353664 | 124.6416954 | 1.11 | 0.5 | -0.61 | Ruby/December 6, 2014 | 100 Year |
| 941 | 12.46220131 | 124.642014 | 1.13 | 0.5 | -0.63 | Ruby/December 6, 2014 | 100 Year |
| 951 | 12.46209788 | 124.6433223 | 0.23 | 0.8 | 0.57 | Ruby/December 6, 2014 | 100 Year |
| 961 | 12.46303204 | 124.643771 | 0.03 | 0 | -0.03 | Ruby/December 6, 2014 | 100 Year |
| 971 | 12.46121376 | 124.6437957 | 0.03 | 0 | -0.03 | Ruby/December 6, 2014 | 100 Year |
| 981 | 12.45934183 | 124.6435711 | 0.03 | 0.6 | 0.57 | Ruby/December 6, 2014 | 100 Year |
| 1001 | 12.46066483 | 124.6421689 | 0.10 | 0.6 | 0.50 | Ruby/December 6, 2014 | 100 Year |

# Annex 12. Educational Institutions affected by flooding in Catarman Flood Plain

Table A-12.1. Educational Institutions in Catarman, Ilocos Norte affected by flooding in Catarman Flood Plain

| NORTHERN SAMAR | | | | |
|---|---|---|---|---|
| CATARMAN | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Brgy. Airport Village Day Care Center | Acacia | | Low | Low |
| Catarman SPED Center | Acacia | | | |
| Brgy. Sampaguita Daycare Center | Baybay | | | Low |
| Brgy. Cal-igang Elementary School | Cabayhan | Medium | High | High |
| Brgy. Abaca Day Care Center | Cag-Abaca | Medium | High | High |
| Generoso R. Frigillana Memorial School | Calachuchi | Low | Medium | Medium |
| Brgy. Cag-abaca Elementary School | Cularima | Medium | High | High |
| Brgy. Daganas Daycare Center | Daganas | | | Low |
| Catarman National High School | Daganas | | | |
| Catarman National Senior High School | Daganas | Low | Low | Low |
| Daganas Elementary School | Daganas | Low | Low | Low |
| Catarman National High School | Dalakit | | Low | Low |
| Catarman National Senior High School | Dalakit | Medium | Medium | Medium |
| Eastern Visayas Central College | Dalakit | | | Low |
| Generoso R. Frigillana Memorial School | Dalakit | Medium | Medium | Medium |
| Bangkerohan Elementary School | Galutan | Low | Medium | Medium |
| Brgy. Bangkerohan Daycare Center | Galutan | Low | Medium | Medium |
| Galutan National High School | Galutan | | | Low |
| Galutan Elementary School | Hinatad | | | |
| Hinatad Elementary School | Hinatad | High | High | High |
| Catarman Chamber Elementary School Foundation Inc. | Ipil-Ipil | | | |
| Baybay Elementary School | Jose Abad Santos | Low | Low | Low |
| Brgy. Baybay Daycare Center | Jose Abad Santos | | | Medium |
| East Pacific Computer College | Jose Abad Santos | | Low | Medium |
| Catarman Central 1 School | Jose P. Rizal | Low | Low | Low |
| Catarman SPED Center | Jose P. Rizal | Low | Medium | Medium |
| Office of the Schools Division Super Intendent | Jose P. Rizal | | Low | Low |
| Colegio De San Lorenzo Ruiz De Manila of Northern Samar (House of Montessori) | Kasoy | | | |
| Eastern Visayas Central Colleges | Kasoy | Low | Low | Low |
| Catarman Central 1 School | Lapu-Lapu | Low | Medium | Medium |
| Brgy. Sampaguita Daycare Center | Mabolo | | | |
| Catarman Central 1 School | Mabolo | Low | Low | Low |
| Poppy Learning Center Catarman Inc. | Mabolo | | | |
| St. Anthony Farm Institute of Technology | Mabolo | | | |
| Barangay Narra Day Care Center | Macagtas | | Low | Medium |

| NORTHERN SAMAR | | | | |
|---|---|---|---|---|
| CATARMAN | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Brgy. Molave Daycare Center | Macagtas | | Medium | Medium |
| Catarman Central 2 School | Macagtas | | Medium | Medium |
| Cawayan Integrated School | Macagtas | | Low | Medium |
| Macagtas Elementary School | Macagtas | | | |
| Bagong Bario Elementary School | Mckinley | | Low | Medium |
| McKinley Elementary School | Mckinley | Medium | Medium | Medium |
| Colegio de San Lorenzo Ruiz de Manila of Northern Samar | Molave | Medium | Medium | Medium |
| Eastern Visayas Central Colleges | Molave | Low | Low | Low |
| St. Michael Academy | Molave | | | |
| Brgy. Old Rizal Daycare Center | Old Rizal | Low | Medium | Medium |
| Old Rizal Elementary School | Old Rizal | | Low | Low |
| Polangi Elementary School | Polangi | Medium | High | High |
| Polangi National High School | Polangi | Medium | High | High |
| Catarman Central 1 School | Santol | Low | Low | Low |
| Office of the Schools Division Super Intendent | Santol | | | |
| Gilalan-agan Elementary School | Somoge | | High | High |
| Somoge Elementary School | Somoge | Low | High | High |
| Brgy. Washington Daycare Center | Washington | | | |
| Diocesan Catholic Center | Yakal | | | |
| Northern Samar Colleges | Yakal | | | |
| St. Michael Academy | Yakal | Low | Low | Low |

| NORTHERN SAMAR | | | | |
|---|---|---|---|---|
| BOBON | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Arellano Elementary School | Arellano | | | Low |
| Arellano Elementary School | Magsaysay | | | |
| Bobon School for Philippine Craftsmen | Magsaysay | Low | Low | Medium |
| Ramon Magsaysay Elementary School | Magsaysay | | | |

# Annex 13. Medical Institutions affected by flooding in Catarman Flood Plain

Table A-13.1. Medical Institutions in Catarman, Ilocos Norte affected by flooding in Catarman Flood Plain

| NORTHERN SAMAR | | | | |
|---|---|---|---|---|
| CATARMAN | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Northern Samar Provincial Hospital | Acacia | | | Low |
| Brgy. Cal-igang Health Center | Cabayhan | Medium | High | High |
| Brgy. Dalakit Health Center | Calachuchi | Low | Low | Low |
| Bluestar Maternity Clinic | Dalakit | | | |
| Brgy. Sampaguita Health Center | Galutan | | | |
| Catarman Doctor's Hospital | Galutan | | Medium | Medium |
| Our Lady of Peace Medical Clinic | Galutan | | | |
| Brgy. Sampaguita Health Center | Ipil-Ipil | | | |
| Leoncio Uy Memorial Hospital | Ipil-Ipil | Medium | Medium | Medium |
| Our Lady of Peace Medical Clinic | Ipil-Ipil | | | |
| Northern Samar Provincial Hospital | Kasoy | Low | Low | Low |
| Oserraos' Pediatric Clinic | Mabolo | | | |
| Catarman Animal Bite Clinic | Molave | | Medium | Medium |
| Brgy. Polangi Health Center | Polangi | Low | High | High |
| Brgy. Polangi Rural Health Office II | Polangi | | High | High |
| Our Lady of La Leche Clinic | Santol | | Low | Low |
| Brgy. Somoge Health Center | Somoge | Medium | High | High |
| Brgy. Washington Health Station | Washington | | | |
| Happy Teeth Dental Clinic | Yakal | Low | Medium | Medium |
| Novak's Medical Specialist Clinic | Yakal | | | |
| Pacific Eye Institute | Yakal | | | |
| Schistomiasis Control Center | Yakal | | | |

| NORTHERN SAMAR | | | | |
|---|---|---|---|---|
| BOBON | | | | |
| Building Name | Barangay | Rainfall Scenario | | |
| | | 5-year | 25-year | 100-year |
| Brgy. Magsaysay Health Center | Magsaysay | | | |