

*Appendix-A*  
*PHOTOGRAMMETRY*  
*AND*  
*TOPOGRAPHIC MAPPING*

**THE STUDY  
ON  
CRITICAL LAND  
AND  
PROTECTION FOREST REHABILITATION  
AT TONDANO WATERSHED  
IN  
THE REPUBLIC OF INDONESIA**

**Volume-II**

**APPENDIX-A**

**PHOTOGRAMMETRY AND TOPOGRAPHIC MAPPING**

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### **Attachment**

|                |  |
|----------------|--|
| Attachment-A.1 | Data for Rainfall and Clouds in the Study Area |
| Attachment-A.2 | Official Evidence of Products Submittal        |

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**Volume-II  
APPENDIX-A**

**PHOTOGRAMMETRY AND TOPOGRAPHIC MAPPING**

**CHAPTER 1 INTRODUCTION**

This Appendix consists of Chapter 1 through Chapter 5. Appendix-A describes the topographic mapping procedures using the aerial photography, bathymetry charts, map digitizing method in order to use the topographic maps for the basic maps and background maps for the critical land and protection forest rehabilitation at Tondano watershed.

Chapter 2 describes the methods and results of the aerial photography, ground control point survey and aerial triangulation survey. For evaluation of the accuracy, the JICA Overseas Survey Specification was applied, thereby obtaining a very good result.

Chapter 3 describes the method and results of the bathymetry made at Lake Tondano. It was made clear that the deepest bottom of Lake Tondano was El. 24.75 m.

Chapter 4 describes the topographic map plotting procedures. The coding in the digital plotting method was performed. The topographic maps were plotted in the scale of 1/10,000, but the contour lines of the flat terrain were plotted in the supplementary intervals of 2.5m in order to enhance the elevation accuracy.

Chapter 5 describes the map digitizing procedures. The existing 1/50,000-scale topographic maps, the newly created land use maps, vegetation maps and watershed conservation maps were digitized and outputted in polyester bases and paper and also in CD-ROMs for versatile applications. (Refer to Tables, Figures and Attachments.).

## CHAPTER 2 PHOTGRAMMETRY

### 2.1 General

Aerial photography has been performed on the sub-contract basis. The sub-contract was made between the JICA Study Team and PT. Atlas Deltasatya on February 23, 2000. Immediately after approval on this sub-contract by JICA, the JICA Study Team took an action toward obtaining an approval on execution of aerial photography from the army. Finally, the JICA Study Team received the approval letter on March 20, 2000. In parallel to these works, PT. Atlas Deltasatya, sub-contractor sent fleets to the Study site for the control point survey.

The detailed information on the aerial photography executed is given below:

### 2.2 Data and Aerial Photographs Collected

The JICA Study Team has collected the following data and aerial photographs related to the Study:

- Coordinates and elevations of existing control points
- Coordinates and elevations of existing TTG
- Aerial photographs with a scale of 1:100,000 shot on July 17, 1982
- Aerial photographs with a scale of 1:25,000 shot on October 18, 1991
- Aerial photographs with a scale of 1:25,000 shot on March 8, 1992

### 2.3 Aerial Photography

The technical specifications to be employed for aerial photography are as follows:

- Camera : wide-angle lens with a focal distance of 15cm.
- Aerial photo size : 23cm x 23cm.
- Overlapping : 60%
- Side lap : 30%
- Photographic scale : 1:20,000
- Number of photos : 258nos.

Immediately after approval on aerial photography by the army, PT. Atlas Deltasatya sent an airplane to the Sam Ratulangi airport. Any shooting chance did not occur from March 20, 2000 to April 30, 2000, because of unsuitable weather condition as shown in Attachment-A.1. In May, however weather condition was improved, so that aerial-photo shooting works were completed by May 10, 2000. Figure A.2.1 present the index of aerial photography.

## 2.4 Control Point Survey

A control point survey consists of GPS survey and land leveling. The control point survey was performed from February 23, 2000 to April 5, 2000, to examine and determine the coordinate and elevation of control points necessary for the subsequent aerial triangulation and topographic mapping. Procedures and results of the control point survey are explained hereinafter.

### (1) GPS Survey

There are 7 existing control points in and around the Study Area. In addition, 22 control points have been newly established in the Study Area, using concrete monument of 20cm x 20cm x 100cm. The GPS survey was carried out at these new control points using TRIMBLE GPS receivers. Figure A.2.2 shows the control point survey network.

Pre-marks were crosswise set using 2 pieces of white cloth of 80cm x 200cm, prior to commencement of aerial photography.

The results of GPS survey for 22 new control points and the coordinates and elevations of 7 existing control points are shown in Table A.2.1.

### (2) Leveling

The standard for elevation was determined from the mean sea level (TTG) as shown in Table A.2.2.

The technical specifications for leveling are the allowable error of “within  $20\text{mm}\sqrt{S}$ ” and the allowable error between existing benchmark and other benchmark of “within  $50\text{mm}\sqrt{S}$ ”.

The leveling has been carried out for 146km in total, using WILD NAK2 leveling instrument. The leveling route is given in Figure A.2.2. The results of leveling for control points are given in Table A.2.2, and show the following errors, which are duly within the approved allowable ones.

### (3) Field Verification

Field verification has been performed for confirming the names of villages, rivers, and towns, administration names and other prominent objectives if any. The results of field verification will be reflected upon the photos and also the topographic maps.

## 2.5 Aerial Triangulation

Aerial triangulation has been executed using a computer, to establish the orientation elements and coordinates of pass points, tie points, etc., which are required for the digital plotting work.

The aerial triangulation for watershed of Lake Tondano (approximately 250km<sup>2</sup>) has been carried out using the aerial photos shot and the results of GPS survey and leveling. The block adjustment method was used for adjustment calculations in the aerial triangulation. Aerial triangulation has covered 141 models. Details are shown in Table A.2.3. In adjustment of computations, the discrepancy of coordinates and elevations of control points have been S (X, Y)= 0.393 m, Z= 0.489 m for standard deviation, which have been less than 0.02 % of flight height. Figure A.2.3 shows the aerial triangulation network.

## CHAPTER 3 SOUNDING (BATHYMETRY)

### 3.1 General

The National Electric Power Corporation (PLN) carried out sounding (bathymetry) for Lake Tondano in 1990 and 1994. On the other hand, the Provincial Office for Irrigation also carried out sounding for Lake Tondano in 1996. To know the sedimentation condition of Lake Tondano through comparison of these results, the sounding (bathymetry) was conducted for Lake Tondano by PT. Atlas Deltasatya from April 17, 2000 to April 28, 2000

### 3.2 Methodology

Sounding (bathymetry) for Lake Tondano has been executed using an echosounder (RAYTHEON) from April 17, 2000 to April 28, 2000. The sounding (bathymetry) has been conducted for longitudinal and cross-sectional directions for Lake Tondano for drawing more accurate contour lines, that is, mesh shape as shown in Figure A.3.1. For the longitudinal direction, the sounding (bathymetry) was made at about 500m interval, and for the cross-sectional direction, it was made using the 4 PLN lines (Nos.1, 7, 14, 21) for which the concrete monuments clearly remained at site.

### 3.3 Results

Figure A.3.2 presenting the results of sounding (bathymetry), shows that the deepest portion at Lake Tondano is El.658.75m, equivalent to 24.75m in depth.



## CHAPTER 4 TOPOGRAPHIC MAPPING

### 4.1 General

Topographic mapping covering the catchment area of Lake Tondano, has started on June 1, 2000, and was completed by end of August 2000. Figure A.4.1 presents the sheet index of 1/10,000 topographic maps.

### 4.2 Procedure

Topographic and planimetric features are digitally plotted using the aerial photos and the results of aerial triangulation. The digital plotting work is performed based on the JICA guidelines on survey. Digital compilation of topographic and planimetric features as well as annotations are carried out based on the same guidelines. The Microstation software is applied for the digital compilation. The symbols to be used for the topographic maps are shown in Table A.4.1.

### 4.3 Results

The final products of 1/10,000 topographic maps are as follows:

- (a) 1/10,000 topographic map (Original)
- (b) 1/10,000 topographic map (Second original)
- (c) 1/10,000 topographic map (Blue print)
- (d) 1/10,000 topographic map (CD-ROM)

These products were submitted to DGLRSF as shown in Attachment-A.2, in accordance with Clause V of Scope of Work for the Study on Land Rehabilitation and Social Forestry agreed between JICA and DGLRSF on September 20, 1999.

## CHAPTER 5 MAP DIGITIZING

### 5.1 Existing Topographic Maps

The existing topographic maps of 1/50,000 were digitized using the Microstation software from May 15,2000 to June 30, 2000. The area of digitizing was 569.15 km<sup>2</sup> including 544.15 km<sup>2</sup>. The items of map were boundary, roads, bridges, rivers, lake, contours, control points and annotation. The existing topographic map symbol codes are shown in Table A.5.1. After digitization of existing topographic maps, final results have been produced in the form of DGN and DXF files. Figure A.5.1 gives the copy of results of digitizing of existing topographic maps.

### 5.2 Land Use and Vegetation Map

Land Use and Vegetation Map was digitized on the existing topographic maps using the Microstation software from May 15, 2000 to June 30, 2000. The classification of land use and vegetation on the maps are as follows:

- (a) Natural/Semi-natural Forest
- (b) Secondary Forest
- (c) Planted Forest
- (d) Estate
- (e) Mixture of Estate and Upland Farming
- (f) Upland Area
- (g) Pasture
- (h) Paddy Field
- (i) Swamp
- (j) Water Body
- (k) Settlement and Others

Figure A.5.2 shows the digitized result of Land Use and Vegetation Maps.

### 5.3 Watershed Conservation Plan Map

Watershed Conservation Plan Map have been also digitized on the existing topographic map using the Microstation software from July 1,2000 to July 15, 2000. Figure A.5.3 presents a copy of results of digitizing of existing topographic maps.

# *Tables*

**Table A.2.1 Coordinates and Elevations of Control Points**

| Name of Control Point            | X-Coordinate (m) | Y-Coordinate (m) | Elevation (m) |
|----------------------------------|------------------|------------------|---------------|
| <b>1 Existing Control Points</b> |                  |                  |               |
| (1) N.14003                      | 139,065.457      | 714,960.705      | (759.17) *    |
| (2) S.18016                      | 150,686.921      | 715,985.023      | (488.13) *    |
| (3) S.18019                      | 144,138.088      | 703,585.407      | (833.93) *    |
| (4) S.18022                      | 132,718.162      | 699,092.368      | (812.16) *    |
| (5) S.18023                      | 130,170.241      | 709,445.879      | (758.07) *    |
| (6) S.18029                      | 116,553.440      | 700,596.478      | (418.03) *    |
| (7) S.18042                      | 118,040.480      | 707,428.754      | (299.32) *    |
| <b>2 New Control Points</b>      |                  |                  |               |
| (1) TDN-1                        | 148,023.81       | 708,700.51       | 1,021.84      |
| (2) TDN-2                        | 146,513.15       | 716,705.26       | 882.98        |
| (3) TDN-3                        | 142,141.70       | 716,800.72       | 710.00        |
| (4) TDN-4                        | 143,755.16       | 712,734.79       | 686.35        |
| (5) TDN-5                        | 142,791.72       | 708,733.46       | 700.97        |
| (6) TDN-6                        | 146,760.89       | 705,422.70       | 825.15        |
| (7) TDN-7                        | 141,551.59       | 704,653.59       | 879.15        |
| (8) TDN-8                        | 139,788.16       | 711,362.50       | 685.37        |
| (9) TDN-9                        | 138,093.91       | 716,986.30       | 808.06        |
| (10) TDN-10                      | 135,760.32       | 715,757.74       | 854.69        |
| (11) TDN-11                      | 133,649.12       | 712,297.95       | 683.82        |
| (12) TDN-12                      | 136,320.84       | 707,551.09       | 697.88        |
| (13) TDN-13                      | 138,078.51       | 703,947.76       | 860.74        |
| (14) TDN-14                      | 133,337.90       | 702,044.80       | 733.79        |
| (15) TDN-15                      | 132,168.42       | 706,732.17       | 701.03        |
| (16) TDN-16                      | 129,640.79       | 711,285.81       | 685.43        |
| (17) TDN-17                      | 126,212.97       | 707,875.38       | 709.37        |
| (18) TDN-18                      | 128,357.45       | 703,540.75       | 746.30        |
| (19) TDN-19                      | 128,193.10       | 697,055.92       | 656.69        |
| (20) TDN-20                      | 127,166.16       | 697,674.25       | -             |
| (21) TDN-21                      | 123,460.65       | 700,688.55       | 871.89        |
| (22) TDN-22                      | 121,793.13       | 699,601.50       | -             |

Note:

\* These elevations were not used because of application of TTG system.

**Table A.2.2 Elevation of TTG and Erros in Leveling****Elevation of TTG for each Point**

| Name    | Elevation (m) |
|---------|---------------|
| TTG 500 | 685.181       |
| TTG 501 | 687.882       |
| TTG 502 | 686.644       |
| TTG 503 | 686.644       |
| TTG 504 | 686.378       |
| TTG 505 | 687.069       |
| TTG 506 | 706.558       |
| TTG 507 | 736.930       |
| TTG 508 | 735.152       |




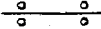

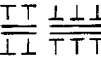

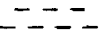









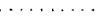

















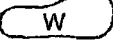


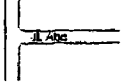




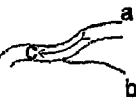

**Calculation of Error in Leveling**

| Loop  | Looped Ponits   | Distance (km) | Error in Survey (cm) | Allowable Error (cm) | Judgement |
|-------|---|---------------|----------------------|----------------------|-----------|
| I     | TTG 501 - TDN 3 - TTD 4 -<br>TTG 500 - TDN 8 - TDN 12 -<br>TDN 15 - TDN 16 - TTG 504 -<br>TTG 503 - TDN 11 - TTG 502<br>- TTG 501 | 50.76         | 0.4                  | 14.3                 | OK        |
| II    | TND 4 - TND 1 - TND 6 -<br>TND5 - TND 8   | 32.39         | 3.4                  | 11.4                 | OK        |
| III   | TND 6 - TND 7 - TND 13 -<br>TND 14 - TND 19 - TTG 508<br>- TND 18 - TTG 507 - TTG 506<br>- TND 15                                 | 51.06         | 5.2                  | 14.3                 | OK        |
| IV    | A1.001 - TND 10   | 2.73          | 0.3                  | 3.3                  | OK        |
| V     | TTG 501 - TND 9   | 2.55          | 1.2                  | 3.2                  | OK        |
| VI    | TTG 506 - TND 17  | 4.80          | 2.5                  | 4.4                  | OK        |
| VII   | 0402.2 - TND 2  | 0.40          | 0.1                  | 1.3                  | OK        |
| VIII  | A1.004 - TND 12   | 1.45          | 1.1                  | 2.4                  | OK        |
| Total |   | 146.14        |                      |                      |           |

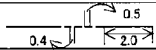
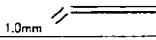
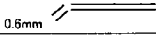
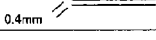



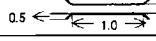
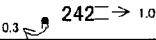
**Table A.2.3 Aerial Triangulation Models**

| No. | Flight Lines | Photos | Models |
|-----|--------------|--------|--------|
| 1   | C6           | 1-15   | 14     |
| 2   | C7           | 1-16   | 15     |
| 3   | C8-1         | 2-9    | 7      |
| 4   | C8-2         | 1-9    | 8      |
| 5   | C9-1         | 2-11   | 9      |
| 6   | C9-2         | 1-6    | 5      |
| 7   | C10          | 1-18   | 17     |
| 8   | C11-1        | 1-9    | 8      |
| 9   | C11-2        | 2-7    | 5      |
| 10  | C11-3        | 1-4    | 3      |
| 11  | C12-1        | 1-11   | 10     |
| 12  | C12-2        | 1-6    | 5      |
| 13  | C13-1        | 3-7    | 4      |
| 14  | C13-2        | 2-11   | 9      |
| 15  | C14-1        | 1-7    | 6      |
| 16  | C14-2        | 2-9    | 7      |
| 17  | C15-1        | 1-8    | 7      |
| 18  | C15-2        | 2-4    | 2      |
|     | Total        |        | 141    |

**Table A.4.1 Symbols of Topographic Maps to 1/10,000 Scale**

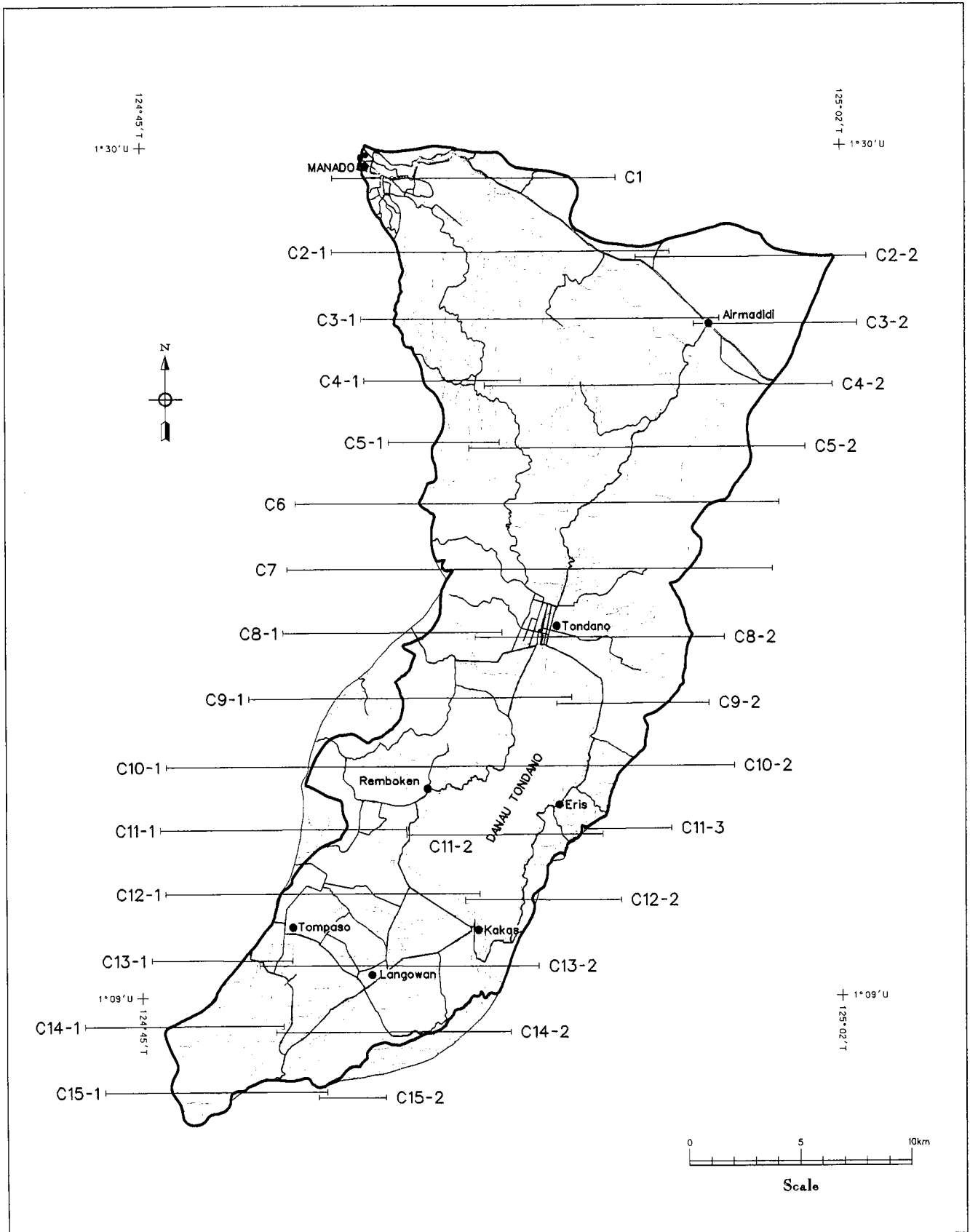
|   |  |   |   |
|---|--|---|---|
|    | <u>Existing Triangulation Point</u><br>Titik Tetap Triangulasi |    | <u>Municipality boundary</u><br>Batas Kecamatan                             |
|    | <u>GPS Point</u><br>Titik GPS                                  |    | <u>Electric Power Line</u><br>Jalur Tegangan Tinggi                         |
|    | <u>Existing Bench Mark</u><br>Bench Mark                       |    | <u>Cutting and Embankment</u><br>Kerukan dan Timbunan                       |
|    | <u>Spot Height</u><br>Titik Tinggi                             |    | <u>Swamp</u><br>Rawa  |
|    | <u>House / Building</u><br>Bangunan                            |    | <u>Muslim graves</u><br>Kuburan Muslim                                      |
|    | <u>Factory</u><br>Pabrik                                       |    | <u>Christian cemetery</u><br>Kuburan Kristen                                |
|    | <u>Public Hall</u><br>Balai Kota                               |    | <u>Chinese graves</u><br>Kuburan Cina                                       |
|    | <u>Police Station</u><br>Kantor Polisi                         |    | <u>Paddy field</u><br>Sawah   |
|    | <u>Fire Station</u><br>Stasiun Pemadam Kebakaran               |    | <u>Boundary of Vegetation</u><br>Batas Tanaman                              |
|    | <u>Post Office</u><br>Kantor Pos                               |    | <u>Field</u><br>Ladang  |
|   | <u>Mosque</u><br>Masjid  |   | <u>Forest</u><br>Hutan  |
|  | <u>Church</u><br>Gereja  |  | <u>Grass</u><br>Rumput  |
|  | <u>Hospital</u><br>Rumah Sakit                                 |  | <u>Water hole</u><br>Lubang Air   |
|  | <u>School</u><br>Sekolahan                                     |  | <u>Sluice</u><br>Pintu Air  |
|  | <u>Market</u><br>Pasar   |  | <u>Pipe Culvert</u><br>Gorong - gorong                                      |
|  | <u>Telephone Office</u><br>Kantor Telepon                      |  | <u>Monuments</u><br>Tugu  |
|  | <u>Government Office</u><br>Kantor Pemerintahan                |  | <u>Line Contour</u><br>Garis Kontur   |
|  | <u>Hotel</u><br>Hotel  |  | <u>Pond, lake</u><br>Kolam, danau   |
|  | <u>Gasoline Pump</u><br>Pompa Bensin                           |  | <u>Sand</u><br>Pasir  |
|  | <u>Road</u><br>Jalan   |  | <u>Land Slide</u><br>Tebing   |
|  | <u>Path</u><br>Jalan Setapak                                   |  | <u>Bridge</u><br>Jembatan   |
|  | <u>Provincial boundary</u><br>Batas provinsi                   |  | a. River / Sungai<br>b. Rivulet / Anak Sungai<br>c. Direction / Arah Sungai |
|  | <u>Region and district boundary</u><br>Batas Kabupaten         |   |   |

**Table A.5.1 Symbol Codes of Existing Topographic Maps**

| No. | Feature class | Feature code | Description (English)        | Description (Indonesian) | Symbol  | Color | Line | Remarks                     |
|-----|---------------|--------------|------------------------------|--------------------------|---|-------|------|-----------------------------|
| 1   | Boundary      | 1102         | Provincial boundary          | Batas propinsi           |   | Black | 5    |                             |
| 2   |               | 1103         | Region and district boundary | Batas kabupaten          |   | Black | 4    |                             |
| 3   |               | 1104         | Municipality boundary        | Batas kecamatan          |    | Black | 4    |                             |
| 4   | Road          | 2101         | Main road                    | Jalan arteri             |    | Black | 4    | Not filled in               |
| 5   |               | 2102         |                              | Jalan kolektor           |    | Black | 4    | Not filled in               |
| 6   |               | 2103         | Regional road                | Jalan lokal              |    | Black | 3    |                             |
| 7   |               | 2104         | Other road                   | Jalan lain               |    | Black | 6    |                             |
| 8   |               | 2105         | Private road                 | Jalan setapak            |    | Black | 4    |                             |
| 9   | Bridge        | 2203         | Road bridge (real shape)     | Jembatan                 |    | Black | 6    |                             |
| 10  |               | 2204         | Road bridge (symbol)         | Jembatan                 |    | Black | 5    |                             |
| 11  | Water         | 5101         | Coastline                    | Garis pantai             |   |       |      |                             |
| 12  |               | 5102         | Lake                         | Danau                    |   | Blue  | 3    |                             |
| 13  |               | 5103         | River (double line)          | Sungai                   |   | Blue  | 3    |                             |
| 14  |               | 5104         | River (single line)          | Sungai                   |   | Blue  | 4    |                             |
| 15  | Contour       | 7101         | Contour 100m (index)         | Garis kontour indeks     |   | Brown | 4    | Elevation used as attribute |
| 16  |               | 7102         | Contour 20m (intermediate)   | Garis kontour indeks     |   | Brown | 2    | Elevation used as attribute |
| 16' | Control point | 7311         | Elevation point              | Titik tinggi             |  | Black | 4    |                             |
| 17  | Annotation    | 9001         | Municipality name            |                          | DIMEMBE 2.0mm   | Black |      | All caps                    |
| 18  |               | 9002         | Urban center 1               |                          | MANADO 4.0mm  | Black |      | All caps                    |
| 19  |               | 9003         | Urban center 2               |                          | TONDANO 3.0mm   | Black |      | All caps                    |
| 20  |               | 9004         | Urban center 3               |                          | Venang<br>3.0mm + 2.0mm   | Black |      |                             |
| 21  |               | 9005         | Urban center 4               |                          | Sawangan<br>2.0mm + 1.0mm   | Black |      |                             |
| 22  |               | 9006         | Urban center 5               |                          | PEGUNUNGAN<br>3.5mm italic  | Black |      | All caps                    |
| 23  |               | 9007         |                              |                          | Kuntung<br>2.0mm + 1.0mm italic   | Black |      |                             |
| 24  |               | 9008         |                              |                          | Kentur<br>2.0mm + 1.0mm italic  | Black |      |                             |
| 25  |               | 9009         | Lake name                    |                          | DANAU TOUNDNO<br>2.5mm italic   | Black |      | All caps                    |
| 26  |               | 9010         | River name                   |                          | Kuala Tondano<br>1.5mm + 1.0mm italic   | Blue  |      |                             |
| 27  |               | 9011         | Elevation value              |                          | 200 1.0mm   | Brown |      |                             |



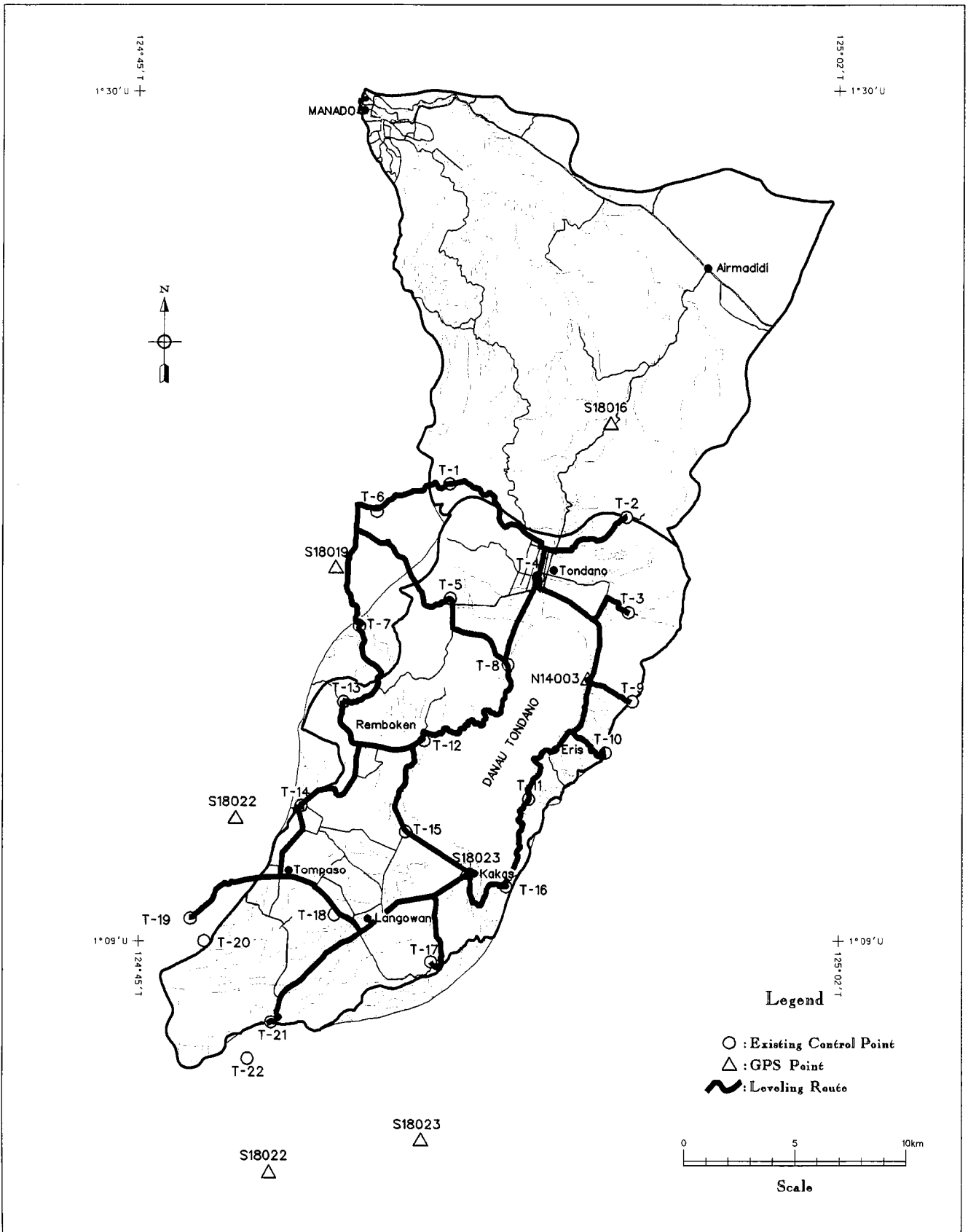
## *Figures*



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**Figure A.2.1 Aerial Photography Index**

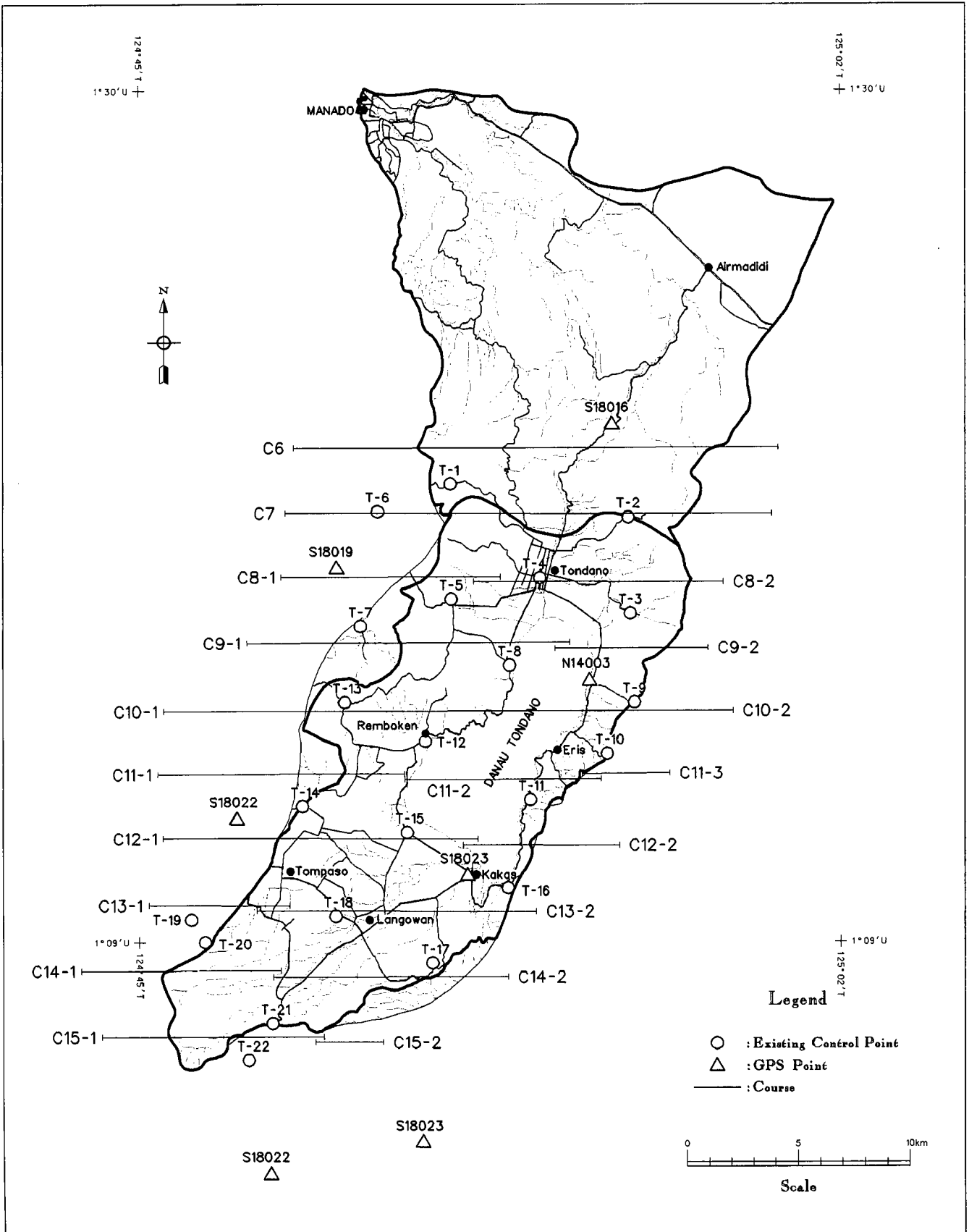
Japan International Cooperation Agency



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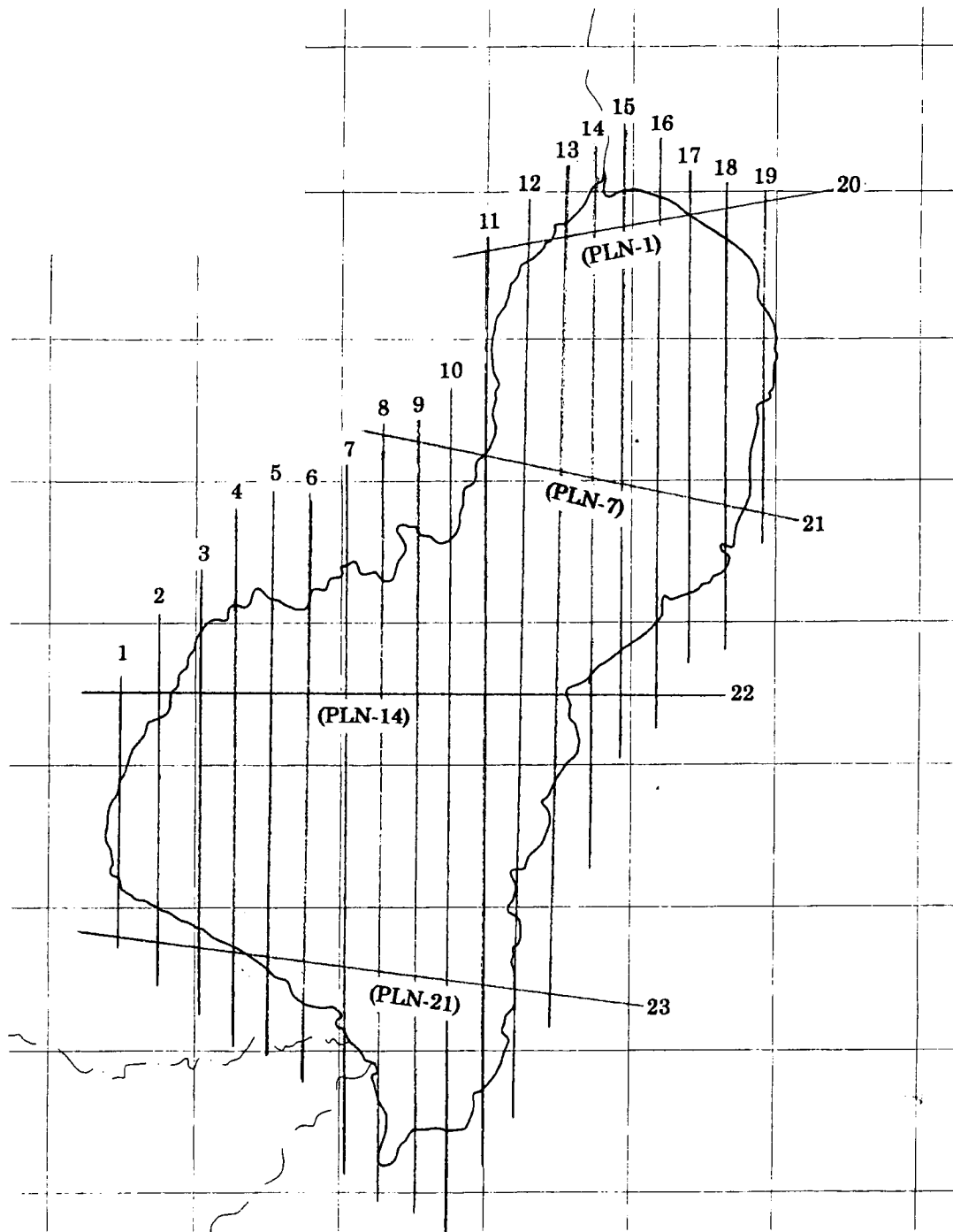
**Figure A.2.2**  
**Index of Control Point Survey Network**



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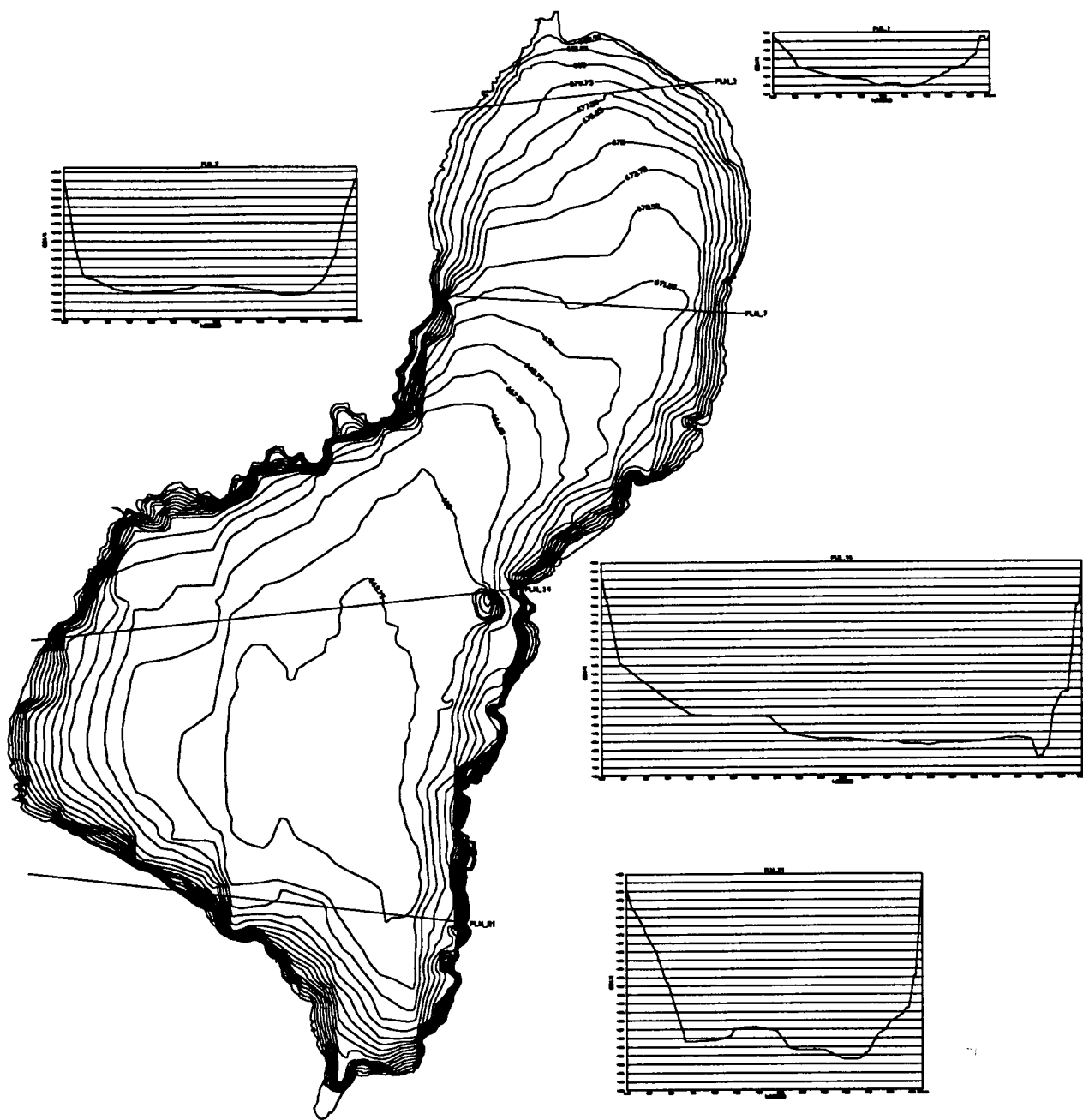
**Figure A.2.3**  
Aerial Triangulation Index



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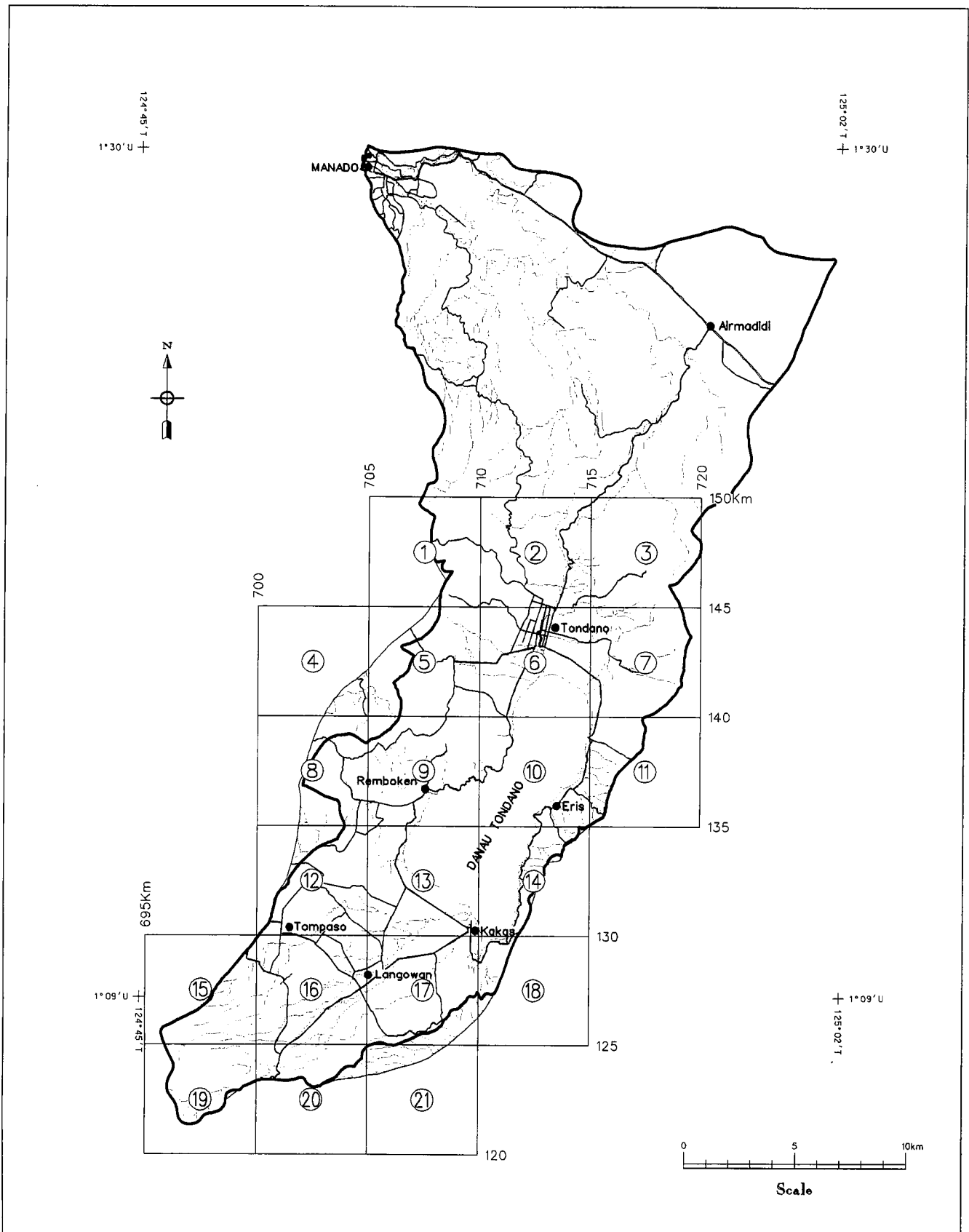
Figure A.3.1  
Routes of Sounding (Bathymetry) at Lake  
Tondano



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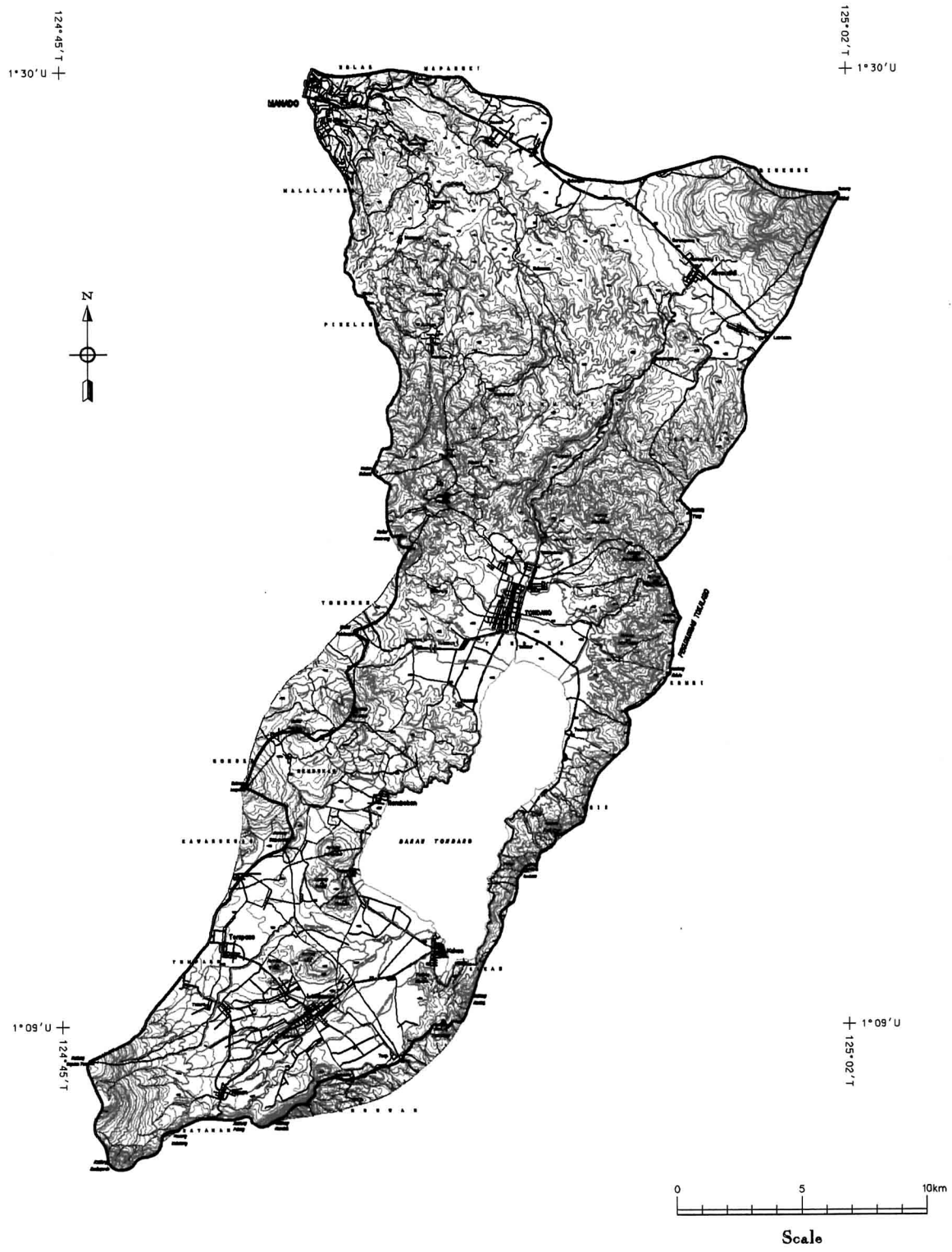
Figure A.3.2 Results of Sounding (Bathymetry) at Lake Tondano



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**Figure A.4.1  
Sheet Index of Topographic Maps  
(1/10,000)**

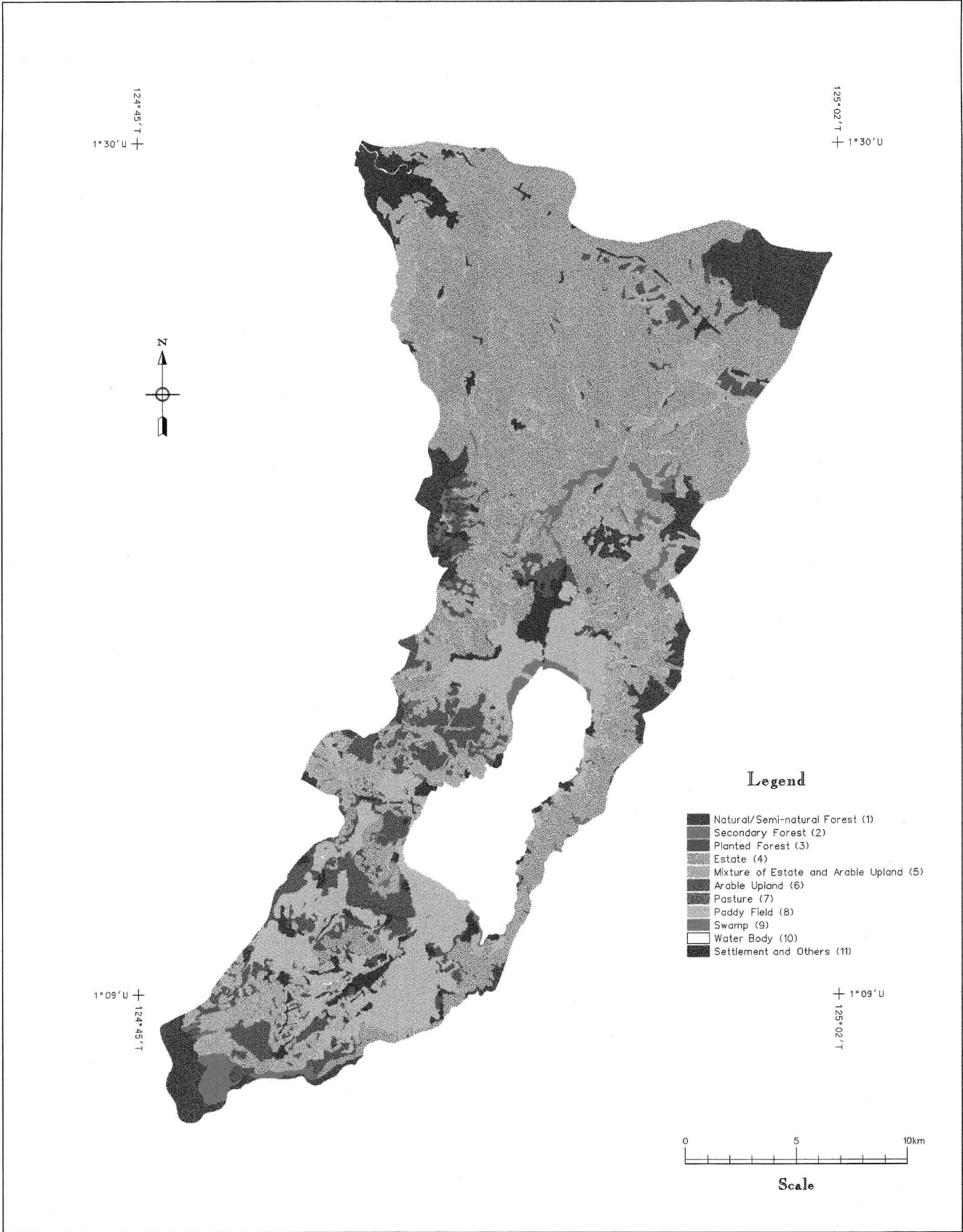


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**Figure A.5.1  
Copy of Digitized Existing Topographic Maps**

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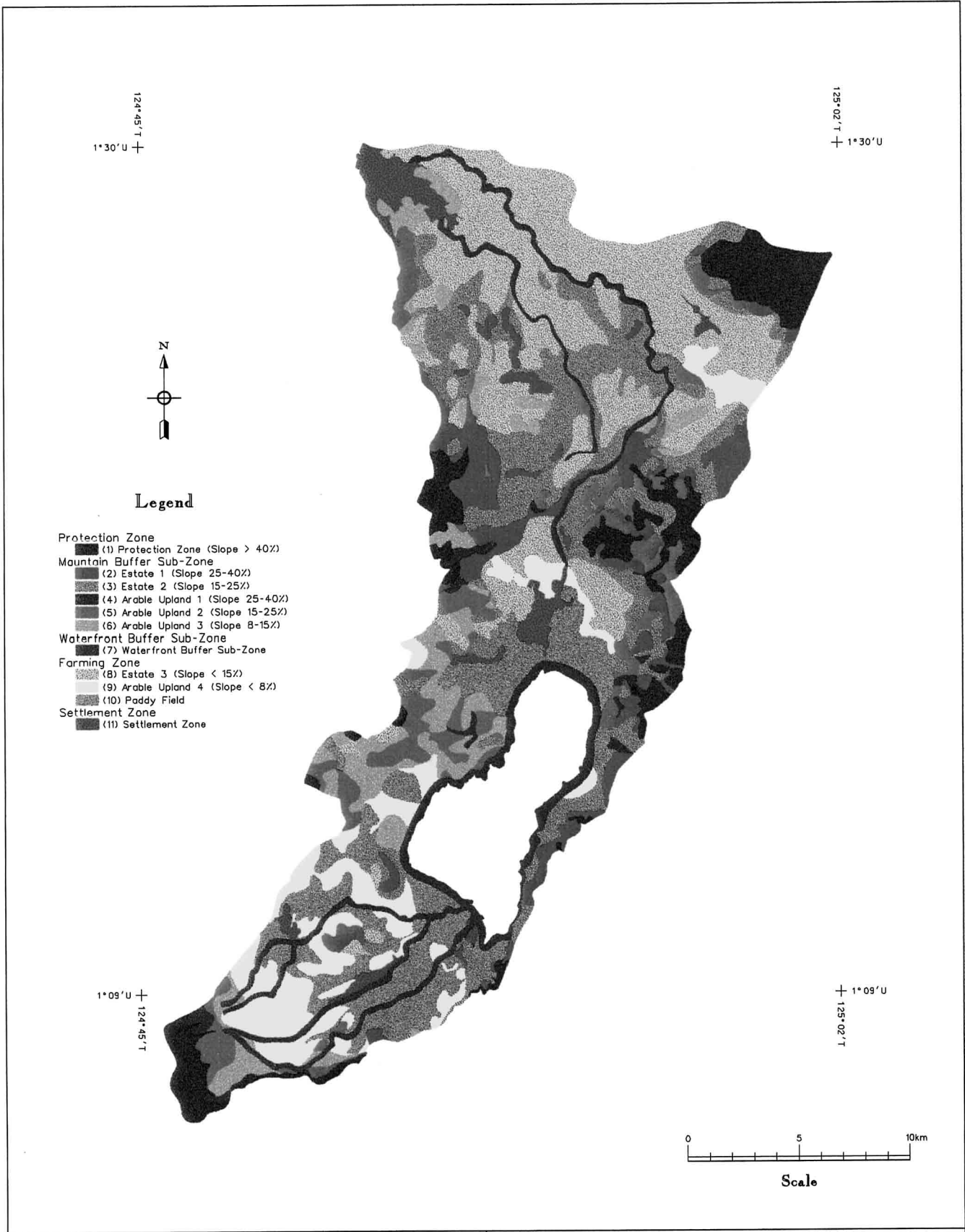




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**Figure A.5.2  
Copy of Digitized Land Use and Vegetation Maps**



|   |  |
|---|--|
| <p><b>The Study on Critical Land and Protection Forest Rehabilitation at Tondano Watershed in the Republic of Indonesia</b></p> | <p><b>Figure A.5.3</b><br/>Copy of Digitized Watershed Conservation Maps</p> |
| <p>Japan International Cooperation Agency</p>   |  |