No.	1

THE MASTER PLAN STUDY ON URBAN FACILITIES RESTORATION AND IMPROVEMENT IN MONROVIA IN THE REPUBLIC OF LIBERIA

FINAL REPORT

SUMMARY

(TOPOGRAPHIC MAPPING)

May 2009

AERO ASAHI CORPORATION

EID
JR
09-075

PREFACE

In response to a request from the Government of the Republic of Liberia, the Government of Japan decided to conduct a Topographic Mapping on the Master Plan Restoration and Improvement in Monrovia and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Takashi Harada of Aero Asahi Corporation between November 2008 and May 2009.

The team held discussions with the officials concerned of the Government of the Republic of Liberia and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Liberia for their close cooperation extended to the study.

May 2009

Eiji Hashimoto,
Vice-President
Japan International Cooperation Agency

May 2009

Mr. Eiji Hashimoto
Vice President
Japan International Cooperation Agency

Letter of Transmittal

Dear Sir

We are pleased to submit to you the final report of the Topographic Mapping on the Master Plan Restoration and Improvement in Monrovia in the Republic of Liberia.

This study was conducted by Aero Asahi Cooperation, under a contract to JICA, during the period from October 15th 2008 to May 29th 2009. In conducting the study, we have prepared Digital Topographic Maps and Ortho-photos with contour lines in Monrovia and its vicinity.

Our Study Team hopes that the final report will serve for the implementation of further studies and various development of Monrovia, and also wishes to take this opportunity to express our sincere appreciation for the kind assistance and cooperation extended by the people in Monrovia, and all other parties concerned in the Republic of Liberia.

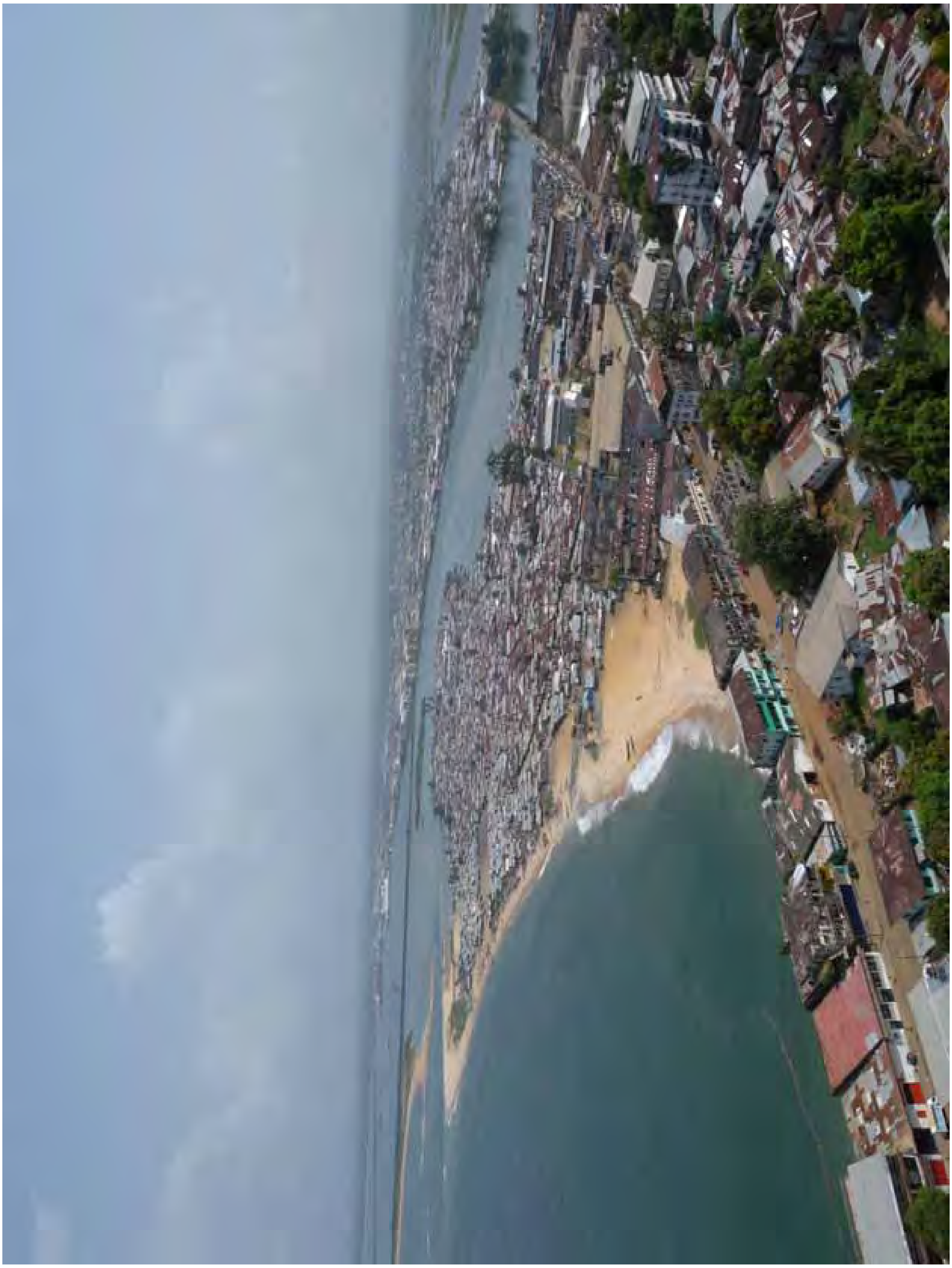
Finally, we hope that this report will contribute to further promotion of the project.

Very Truly Yours

Takashi HARADA

Study Team Leader,
Topographic Mapping team on
The Master Plan Restoration and Improvement in Monrovia

Location Map of Republic of Liberia and Monrovia City

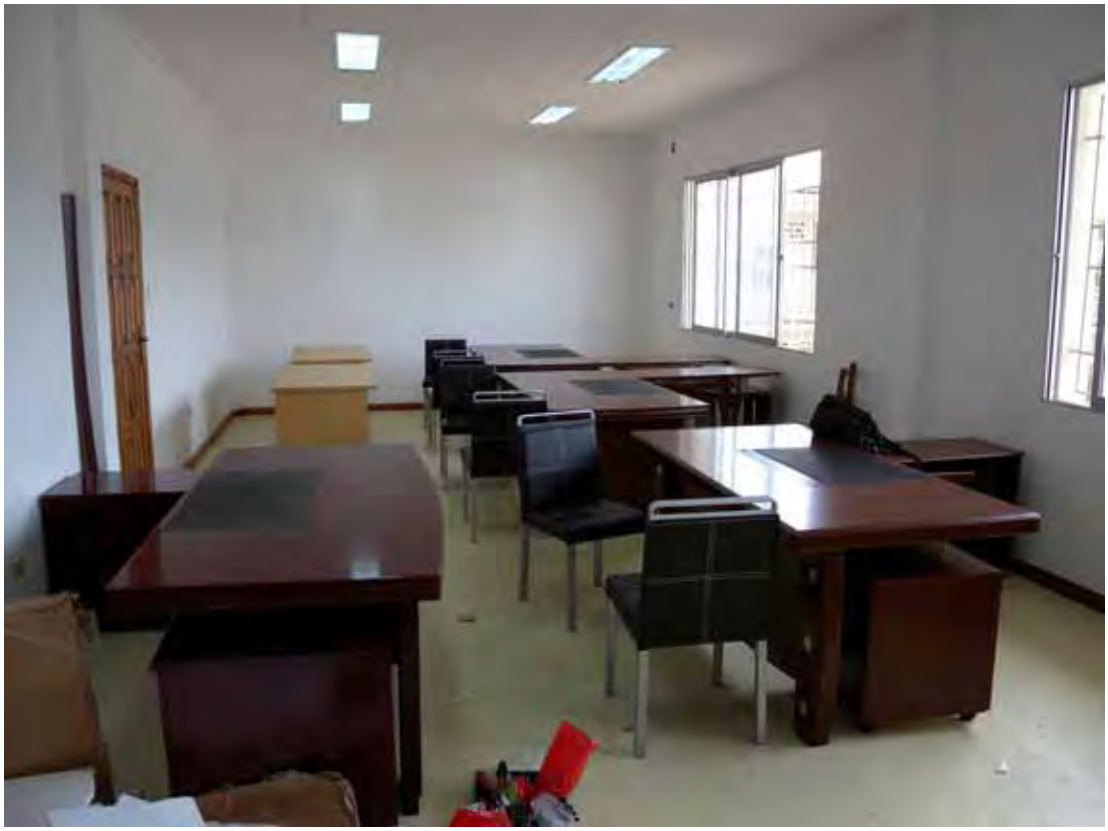


View of West Point of Monrovia

New Residential Area in Paynesville

Discussion of Inception Report

Signing of Inception Report



Study Office in MPW

Undertaking of GOL, Consultation for provision of Guide with LCS

Large sized printer printing of Topographic Maps during Field verification

Consultation and Discussion of Draft Final Report

Existing Control Station RAMROD

Existing BM BM2 under Water Tower in Free Port

PRODUCT OF THE STUDY

Category	No.	Work Items	Work Volume
1:10,000 Topographic mapping	[6]	Aerial Photography (sub-contracting)	
		Photograph Scale, 1:10,000	
		Photography Area , Approx. 287km^2	
		Negative Films	**1 roll**
		Digital Data File	**2 sets**
		Contact Prints	**2 sets**
		Flight Index	**2 sets**
	[7]	Pre-marking and Pricking (37 points)	**2 sets**
	[7]	Control Point survey (37 points)	**2 sets**
	[7]	Simple leveling, Approx. 100km	
	[8]	Production of Interpretation Key (31 objects)	**2 sets**
	[9]	Field Verification (sub-contracting)	
	[10]	Digital Compilation of Field Verification Result	
	[11]	Aerial Triangulation, DEM acquisition, Orthophoto production	
	[11]	Ortho-photo, 1/10,000 Ortho-photo, 12 sheets	**1 set**
		Digital Data File	**6 sets**
	[12]	Digital Plotting	
	[13]	Digital Compilation	
	[14]	Symbolization	
	[15]	Creation of Data File, 1:10,000 Topographic Map Data	**6 set**
	[16]	Report	
		Quality Control	**1 set**
		Inception Report	English: **5sets**
		Final Report, Main	English: **5 sets**
		Final Report, Summary	English: **5 sets**
		Final Report, Summary	Japanese: **5 sets**

THE MASTER PLAN STUDY
ON
URBAN FACILITIES RESTORATION AND IMPROVEMENT
IN MONROVIA
IN
THE REPUBLIC OF LIBERIA

TOPOGRAPHIC MAPPING

FINAL REPORT

SUMMARY

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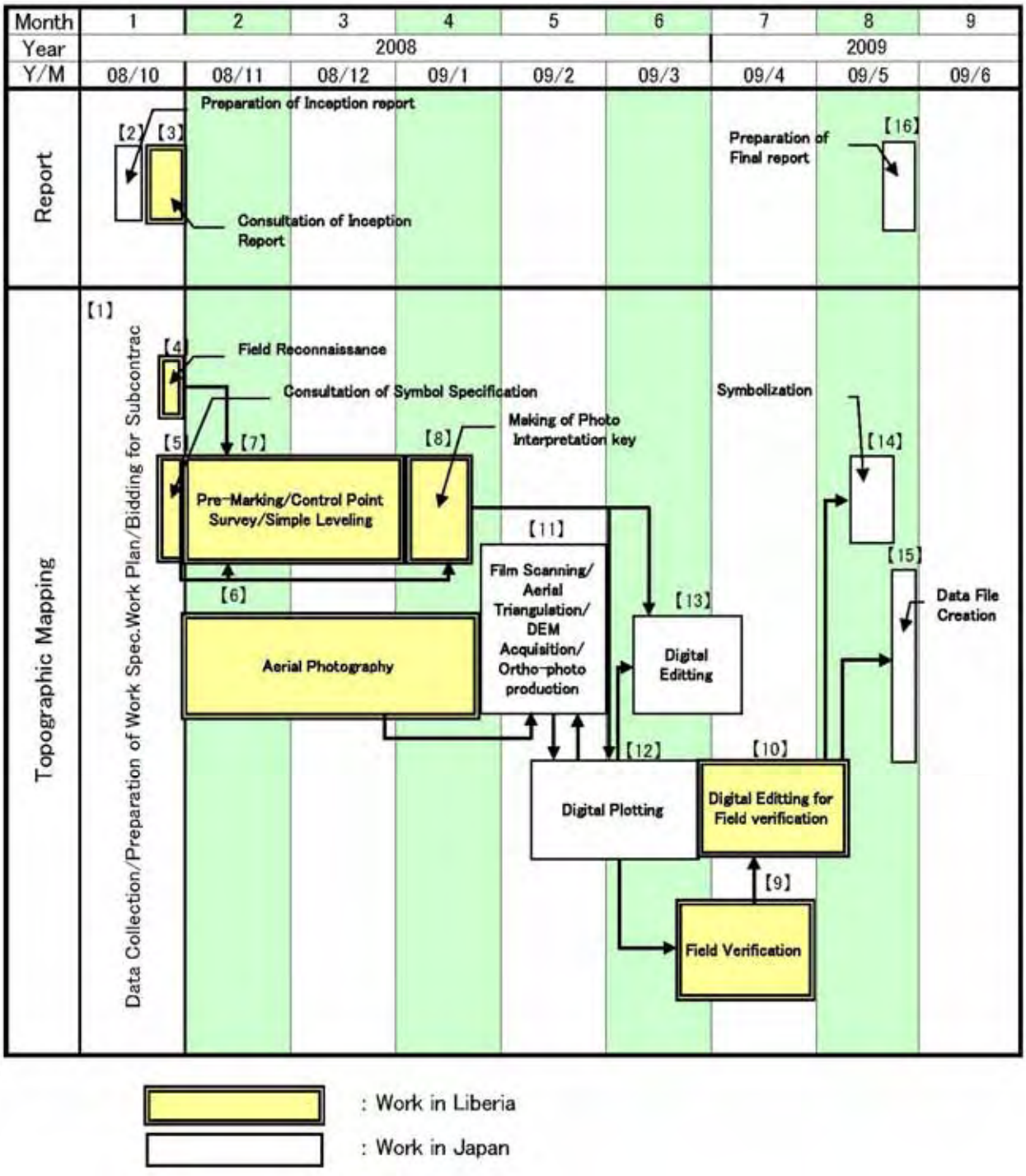
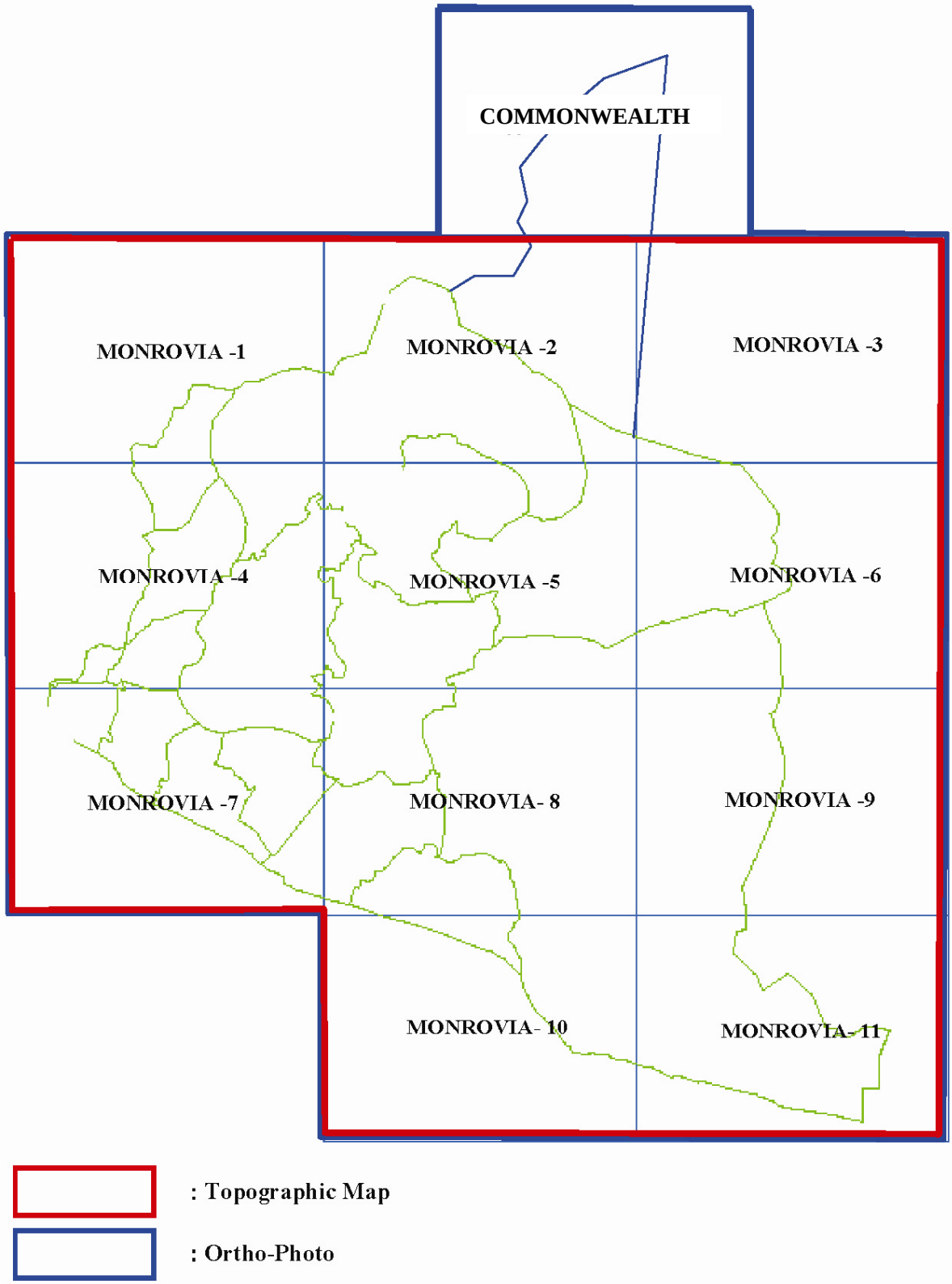
WORK FLOW & OUTLINE OF 1:10,000 TOPOGRAPHIC MAPPING



MAP SHEET LAYOUT

FOR

1:10,000 TOPOGRAPHIC MAP AND ORTHO-PHOTO



ABBREVIATIONS

GOL	Government of Liberia
GOJ	Government of Japan
LCAA	Liberian Civil Aviation Authority
LCS	Liberian Cartographic Service
LISGIS	Liberia Institute of Statics & Geo-information Service
MPW	Ministry of Public Works
MLM&E	Ministry of Lands, Mines and Energy
UNMIL	United Nations Mission in Liberia

Chapter 1. Introduction

1.1 Background

During the years of conflict, Liberia's infrastructures have been nearly completely destroyed and the majority of services ceased being rendered. Moreover, the population in Monrovia has increased twice before the conflict according to the preliminary results of 2008 National Population and Housing Census. So that, the living environment is rapidly getting worse, the improvement of infrastructures is immediately needed.

Employment and rehabilitation of the infrastructure were declared a top priority for the Government because of their direct impact on security and long- term peace process as noted in the Poverty Reduction Strategy.

As emergency projects have been conducted by some donors, it is also necessary to develop projects taking mid-term improvement and development into consideration. In order to achieve the urban facilities restoration and improvement for short- and mid-term, the Government of the Republic of Liberia (hereinafter referred to as "GOL") requested the government of Japan(hereinafter referred to as "GOJ") for Development Study "Master Plan Study on Urban Facilities Restoration and Improvement in Monrovia" (hereinafter referred to as "the Study").

In response to the request of the GOL, the GOJ has decided to conduct the Study.

Accordingly, the Japan International Cooperation Agency (hereinafter called JICA), the official agency responsible for the technical cooperation program of GOJ, will undertake the Study in close cooperation with the concerned authorities of GOL. JICA dispatched this Study Team to produce the initial step of the Study.

1.2 Undertaking of Government of Liberia

At the beginning of the study, the Study Team requested MPW as a counterpart of the project to execute following items and the GOL (MPW) conducted following tasks during the study works for the Study Team.

1. To support an acquisition of miscellaneous permissions such as flight permission, permission for handing of aerial photographs, permission for taking out of contact prints from Liberia and photograph data from Liberia and so on
2. To provide the guide for field works
3. To provide project office to the Study Team
4. To cooperate Liberian Cartographic Service to this project

Chapter 2. Outline of the Study

2.1 Study Objectives

The Objectives of the study was to produce 1:10,000 Digital Topographic Map and Ortho-photos for successive THE MASTER PLAN STUDY ON URBAN FACILITIES RESTORATION AND IMPROVEMENT IN MONROVIA.

2.2 Works and Staffing Schedule

The members of the study team and individual tasks shown in Table 1.

Table 1. Members and Assignment

Name	Assignment	No.	Works
Takashi HARADA	Team Leader	(1)	Adjustment and analysis of collected data
		(2)	Preparation of Inception Report
		(3)	Consultation of Inception Report
		(4)	Field Reconnaissance
		(5)	Consultation of Work Specification
		(6)	Aerial Photography
		(7)	Pre-marking, Control Point Survey, Simple Leveling
		(8)	Interpretation Key
		(9)	Field Verification
		(10)	Digital Compilation after Field Verification
		(11)	Aerial Triangulation, DEM production, Ortho-photo Production
		(12)	Digital Plotting
		(13)	Digital Compilation
		(14)	Symbolization
		(15)	Creation of Data File
		(16)	Final Report
Kentaro USUDA	Interpretation key	(4)	Field Reconnaissance
	Simple leveling	(5)	Consultation of Work Specification
	Pre-marking	(7)	Pre-marking, Control Point Survey, Simple Leveling
	Control point survey	(8)	Interpretation Key
	Field verification	(9)	Field Verification
	Digital compilation of Field Verification in field	(10)	Digital Compilation after Field Verification
		(16)	Final report
Nobuteru MATSUSHITA	Field verification	(9)	Field Verification
	Digital compilation of F.V.	(10)	Digital Compilation after Field Verification
Yuji OUCHI	Coordinator		

The study was conducted from October 2008 to May 2009. The individual Work Schedule of the Study is shown in Table 2. and Staffing Schedule are shown in following Table 3.

Table 2 **Work Schedule**

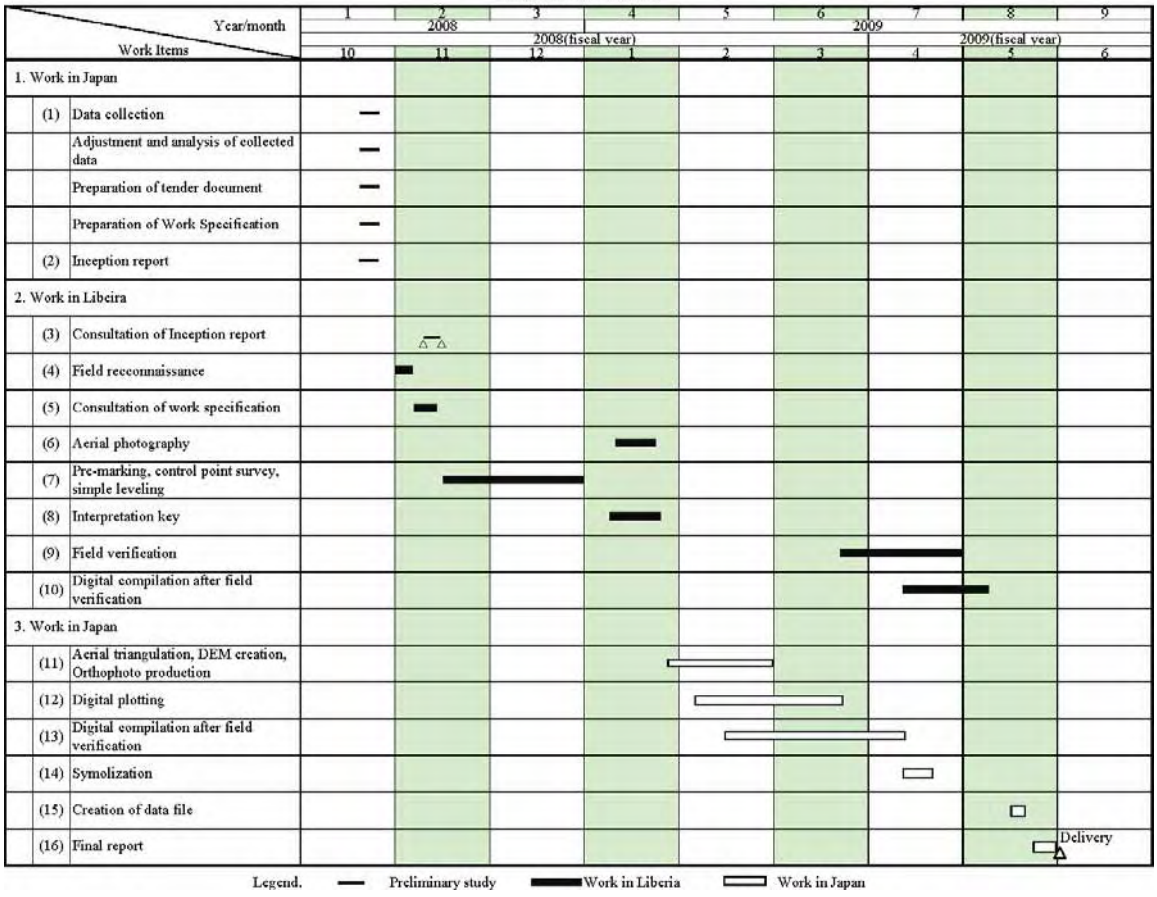
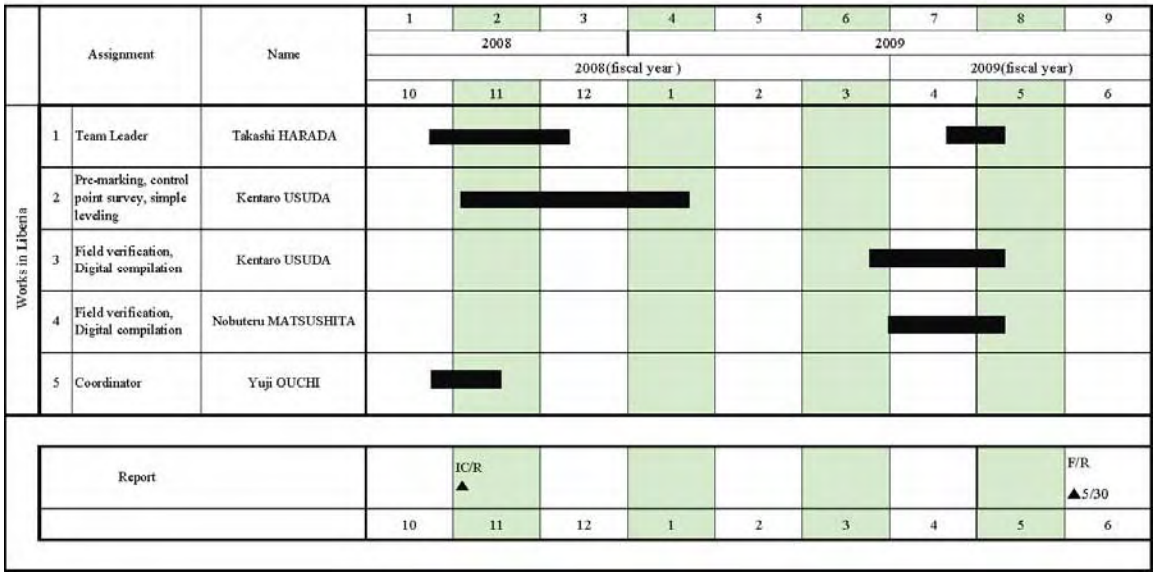


Table 3 **Staffing Schedule**



2.3 Study Area

The Study Area for Digital Topographic Mapping covers the entire city of Monrovia and adjoining areas such as Paynesville, and Johnsonville. Zone and Township names involved in the Study Area are listed in Table 4 as shown below.

The actual previous Study Area was agreed on Scope of Works signed and shown in APPENDIX 1 on June 11th 2008 between MPW and Preparatory Study Team. However the Study Area boundary was modified due to the latest change of Zone boundary such as Caldwell, Johnsonville (a part of the Commonwealth) instructed by LISGIS (Liberia Institute of Statics & Geo-Information Services). GOL and the study team agreed on this change during the Meeting on February 13th 2009 (refer to APPENDIX 2) between MPW and Study Team (Master Plan Team). As a result, Study Team (Mapping Team) acquired new boundary data from LISGIS and took place to modify the Study Area following new boundary as shown as Figure 1.

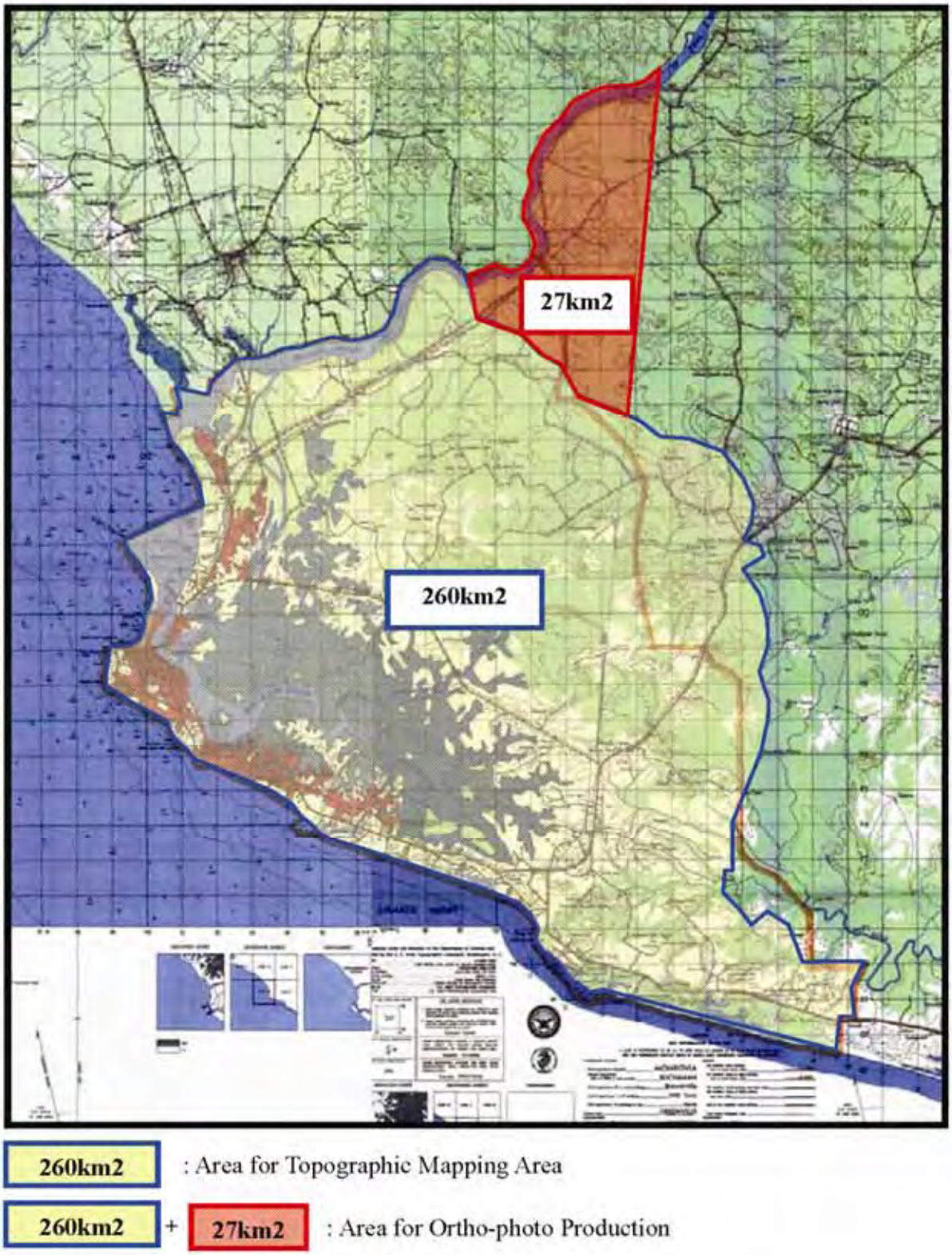


Figure 1 Area for Topographic Mapping and for Ortho-Photo production

2.4 Executed Work General

The general of executed work contents are shown in following Table 4.

Table 4. Executed Works

Category	Work Classification	Work Items	Work Contents	Work Volume
1:10,000 Topographic mapping	Preparatory works in Japan	(1)Data Collection	-Existing Data collection, information and analysis -Preparation of bidding document for the determination of sub-contractor -Preparation of Symbol Specification (draft), basic approach, work plan, schedule and so on.	1 set
		(2) Preparation of Inception Report		
	Works in Liberia	(3)Explanation and consultation of Inception Report	With counterpart	1 set
		(4)Field Reconnaissance	Collection of Existing data and information	1 set
		(5)Consultation of Work Specification	With counterpart	1 set
		(6)Aerial Photography (sub-contract)	Panchromatic film and 1:10,000 photo-scale is	Approx. 287km^2
		(7)Pre-marking, Control Point survey, Simple leveling (sub-contract)	GPS observation, leveling	Approx. 35points, 100km
		(8)Production of Interpretation Key	Main filed objects and etc	1 set
		(9)Field Verification (sub-contract)	With digitally compiled sheet	Approx. 260km^2
		(10)Digital Compilation of Field Verification Result	Data modification and addition if necessary	Approx. 260km^2
	Works in Japan	(11)Aerial Triangulation, DEM acquisition, Orthophoto production		266 models
		(12)Digital Plotting	Digitizing of various topographic features	Approx. 260km^2
		(13)Digital Compilation	Compilation of digitally plotted data	Approx. 260km^2
		(14)Symbolization	Map symbolization of digitally compiled data	Approx. 260km^2
		(15)Creation of Data File	Quality check, data file format check	1set
		(16)Final Report		1set

Chapter 3 Description of Works

The details of Executed Works for the Study are designated in following paragraphs.

<Works in Japan>

[1] Data Collection

Before work starts, following works were carried out in Japan.

- Adjustment and analysis of collected data.
- Preparation of bidding documents, bidding and selection of subcontractor for Aerial Photography, Control Point survey and Field Verification.
- Preparation of Symbol Specification
- Adjustment of approach, methodology and schedule of the project.
  Especially the bidding of subcontracting work started after the sign of the contract of JICA to immediately complete study within contracted time period.

[2] Inception Report (Draft)

Before work starts, Inception Report (draft) consists of Study Approach, Methodology and Study Schedule that was prepared for consultation with counterpart.

<Works in Liberia>

[3] Consultation of Inception Report

Consultation of work contents and methodology was carried out with counterpart MPW to discuss the finalized Inception Report for steering the study. The discussed items are;

At the same time, Minutes of Meeting for Inception report was prepared and signed for a confirmation of agreement for both sides on November 5th 2008. (APPENDIX 3)

[4] Field Reconnaissance

Field Reconnaissance was carried out at the beginning of study for data collection and confirmation of work planning. Main checking work items were as follows:

- Location of the existing control points including benchmarks
- Geographical condition and vegetation of the study area
- Transportation, accommodation for the members and preparation of study office

[5] Consultation of Topographic Mapping Work Specification

Symbol Specification for Topographic Mapping was discussed with MPW and LCS before the work starts. The agreed Draft Symbol Specification was confirmed by a Minutes of Meeting signed on December 2nd 2008 shown on APPENDIX 4. However the Study Team informed that the agreed Symbols might have minor changes during mapping works. GOL agreed with Study Team.
Symbol Specification includes Specification of Topographic Mapping as well. All digital mapping works and includes were carried out based on the Map Symbol Specification. Since 1:10,000 topographic maps don't exit in Liberia, symbols are designed following actual symbols of existing 1:50,000 topographic maps of Liberia. All symbols were adopted referring to existing map symbols and designed digitally.

[6] Aerial Photography

Aerial photography included photo processing work were required for subsequent topographic mapping works. All works related to Aerial Photography were carried out by selected subcontractor CTK NETWORK AVIATION since an aerial photography aviation company was not available in Liberia. Acquisition of flight permission was projected on sub-contractor's hands with the assist of counterpart from LCAA. (Liberian Civil Aviation Authority). The Photography was completed in January 16th 2009.

- Aerial Camera Type : RMK A 15/23, Precision Photogrammetric Camera
  Lens :PLEOGON A2
  Focal Length :153.579m/m
  Image Format :230 x 230m/m
- Platform : CESSNA C206 Registration No. 9G-CTK

Due to acceleration of the Aerial Photography Work, the proposed flight plan was modified from East to West to North to South. It didn't make an impact for further works. Target area and outline of Aerial Photography are follows.

- Flight Index

Topographical condition of target area for the photography is almost flat. However flight was attacked by strong winds from the sea sometimes causing photograph rotation and inclination. Nowadays thanks to the state of the art technology of the software for digital photogrammetry, most of such inconvenient phenomena for photogrammetric process can be solved without problem. Target area and Flight Index is shown in Figure 3.

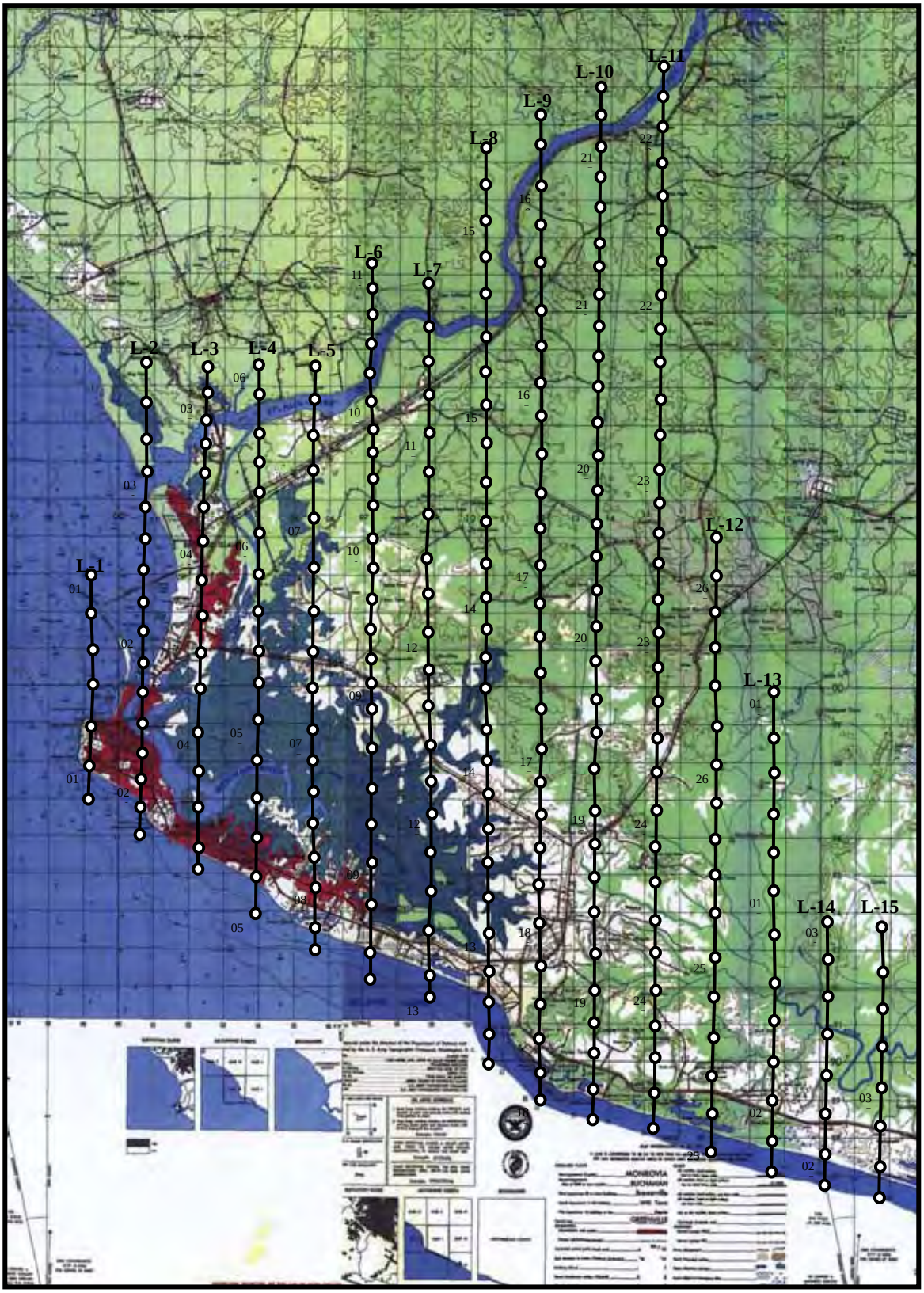


Figure 7. Flight Index

· Quality Control of Aerial Photography

Quality control of aerial photographs were carried out by sub-contractor and Study Team. The result of Quality Control is shown following Table 5.

Table 5 Quality Control Sheet

Name of Project	The Master plan Study on urban Restoration and improvement in Monrovia in the Republic of Liberia	Aircraft No.	CESSNA 206	Film	Roll No.	1,2
		Camera No.	ZEISS RMK A No.134636		Length	100m
Date of Flight		Lens No.	PLEOGON A2	GPS Diskette No.		None
		Lens f	153.579mm			

Line No.	Exposure No. -	Number of Photograph	O.L.(%) Max.	O.L.(%) Min.	S.L.(%) Max.	S.L.(%) Min.	Quality of Films Cloud	Quality of Films Smoke	Quality of Films Haze	Remarks
L1	39 - 46	8	65	61	35	30	None	None	Slight	
L2	47 - 61	16	51	74	35	30	None	None	Slight	
L3	34 - 49	16	74	57	35	30	None	None	Slight	
L4	50 - 65	16	65	57	35	30	None	None	Slight	
L5	66 - 83	18	70	51	35	30	None	None	Slight	
L6	87 - 110	24	70	54	35	30	None	None	Slight	
L7	111 - 130	20	70	51	35	30	None	None	Slight	
L8	131 - 157	27	70	57	35	30	None	None	Slight	
L9	158 - 185	28	65	52	35	30	None	None	Slight	
L10	186 - 217	32	70	63	35	30	None	None	Slight	
L11	218 - 249	32	74	59	35	30	None	None	Slight	
L12	250 - 266	17	63	52	35	30	None	None	Slight	
L13	10 - 22	13	10	22	30	27	None	None	slight	
L14	23 - 30	17	23	30	30	27	None	None	slight	
L15	31 - 38	8	31	38	30	27	None	None	slight	
	-									
	-									

Remarks			
	Check	Contractor	
		Date	
		Checked by	
	Inspection	Date	
		Inspected by	

[7] Pre-marking, Control Point Survey and Simple Leveling

Based on selected site at the scale of 1/50,000 map pre-marking and pricking were carried out while taking their keeping period and environment surrounding into account. The number of photo control points (PC) was 37 points and their descriptions were prepared. (APPENDIX 5)

The photo control points (PC) distribution is shown in Figure 4.

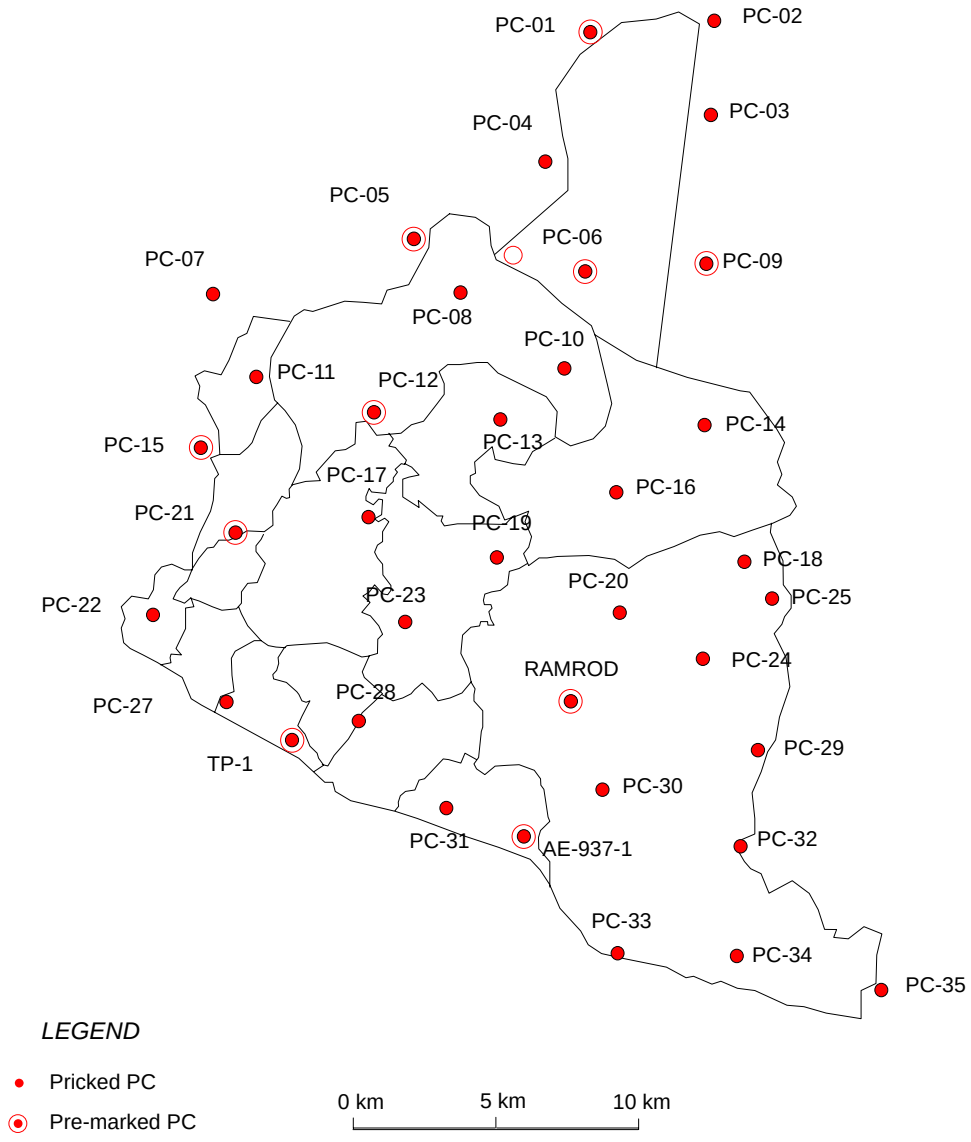


Figure 4. Distribution Map for Photo Control Points

- Pre-marking

  In particular, the pre-marking (shape: three or four wings type, size: 75 cm x 25 cm) of 11 points was placed while taking their keeping period and reality surrounding into account. After aerial photography, all of them were clearly-identified as in the shape of three or four wings on the aerial photos successfully.

- Pricking

  Since there were no places for pre-markings at a selected site, the pricking of 26 points was selected by taking an identifiable feature such as a corner of buildings/houses or a structural foundation into account. As with identification of pre-marking, all of pricking points were identified on the aerial photos clearly.

- Control Point Survey

i. At the beginning of the works, the Study Team explained that Liberian maps were produced with the local datum. The datum of Liberia 1964 was selected for the best fitting to Liberia. While newer worldwide maps are mostly produced with geocentric datum. As a result, the following coordinate system was approved on the meeting of the technical specification for mapping between MPW and Study Team on December 2nd 2008 (shown in APPENDIX 4).

Coordinate System	:	UTM
Zone Name	:	Zone 29
Geodetic Datum		
- Ellipsoid	:	WGS 84
Semi-major Axis (m)	:	6378137.000
1/f	:	298.257223563
Map Projection	:	Transverse Mercator
- Map Projection Parameters		
False Northing	:	0.000 (m)
False Easting	:	500,000.000 (m)
Longitude of the Central Meridian	:	9 °W
Latitude of the Origin of the Projection	:	Equator
Scale Reduction Factor at the Central Meridian	:	0.9996

ii. The remaining useful existing geodetic control points in the vicinity of Monrovia mainly were three (AE-937, RAMROD and TP-1). RAMROD was selected as a base station in the view of the location from among three. However, since RAMROD had not a geodetic coordinate such as the longitude and the latitude in WGS 84 coordinate system. The geodetic coordinates of RAMROD were determined by standalone positioning of GPS observation. 4 sets of Leica SR530 series were used for the observation.

iii Static GPS surveying was carried out based on RAMROD to obtain a coordinate for each photo control point (PC) used in an aerial triangulation.

iv. A height of each photo control point (PC) was determined based on existing BM 2 (located in Free Port) by leveling survey basically. However, in the case of some of photo controls located in a remote area their heights were determined by using a geoid height or interpolation from an undulation assumed on a Geoid Map. (refer to figure 5) The result of coordinates and height are listed on Table 6.

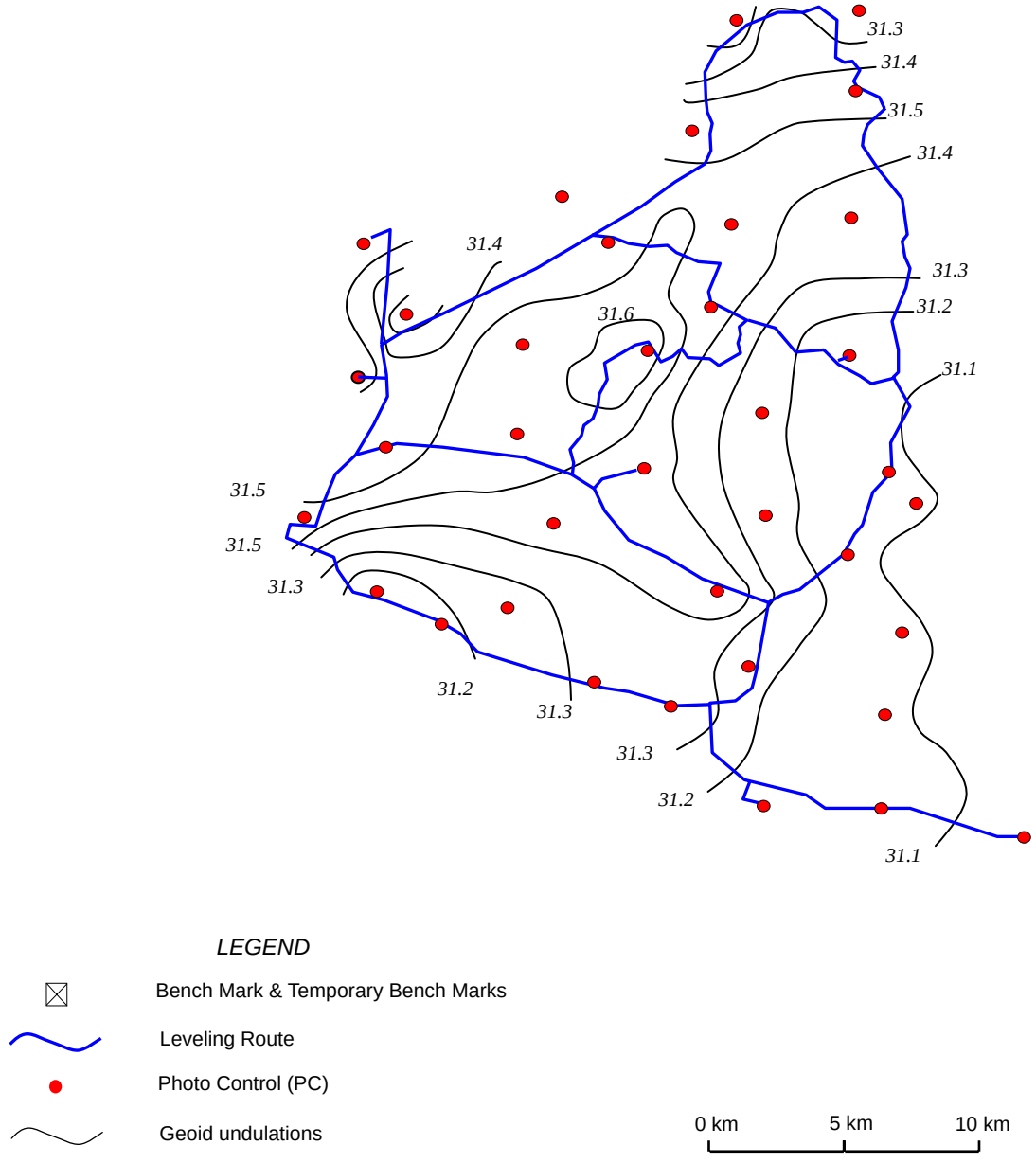


Figure 5. Geoid Map

Table 6. Coordinates & Heights for Photo Control Points

Station	WGS 84							UTM/Zone 29			Geoido Ht. (m)	Remarks
	N (ddmmss)			W (ddmmss)			Ellipsoid Ht.	X (m)	Y (m)	H (m)		
PC01	6	27	52.14956	10	41	53.61748	44.54783	714,863.728	312,196.398	13.259	31.29	by GPS
PC02	6	28	1.96593	10	40	3.36045	43.77448	715,154.075	315,585.309	12.321	31.45	by direct leveling
PC03	6	26	37.32763	10	40	1.62238	54.78433	712,553.858	315,630.206	23.235	31.55	〃
PC04	6	25	52.66390	10	42	34.48709	41.18389	711,197.323	310,928.261	9.65	31.53	by geoid map
PC05	6	24	48.03420	10	44	34.85344	39.49945	709,224.347	307,222.624	none	none	
PC06	6	24	17.80830	10	41	57.36069	47.96259	708,279.566	312,059.486	16.49	31.47	by geoid map
PC07	6	23	59.84037	10	47	39.53830	36.52087	707,763.341	301,541.726	4.930	31.59	by direct leveling
PC08	6	24	1.92572	10	43	53.04152	38.54047	707,803.523	308,502.786	6.958	31.58	〃
PC09	6	24	27.86848	10	40	5.85416	44.21806	708,577.371	315,487.207	12.85	31.37	by geoid map
PC10	6	22	52.22382	10	42	17.72574	41.39539	705,652.488	311,424.926	9.973	31.42	by direct leveling
PC11	6	22	44.67845	10	47	1.91664	35.65185	705,450.249	302,689.952	2.064	31.29	by direct leveling
PC12	6	22	10.94676	10	45	10.99027	37.14494	704,402.292	306,095.639	5.60	31.54	by geoid map
PC13	6	22	6.65497	10	43	17.79094	38.37590	704,258.740	309,574.272	6.778	31.60	by direct leveling
PC14	6	22	2.07662	10	40	7.13236	59.75127	704,098.861	315,433.412	26.022	31.16	by direct leveling
PC15	6	21	30.53409	10	47	36.43856	36.41025	703,176.114	301,621.033	4.835	31.58	〃
PC16	6	21	0.59219	10	41	26.68491	46.74789	702,218.029	312,982.327	15.47	31.28	by geoid map
PC17	6	20	33.91967	10	45	23.06726	35.87026	701,422.809	305,714.342	4.36	31.51	〃
PC18	6	20	0.26033	10	39	29.65832	38.88172	700,353.053	316,573.120	7.773	31.11	by direct leveling

PC19	6	19	58.68613	10	43	18.23474	36.10428	700,327.559	309,547.561	4.662	31.44	by direct leveling
PC20	6	19	11.94469	10	41	22.44695	41.15082	698,879.989	313,101.715	9.92	31.23	by geoid map
PC21	6	20	23.46201	10	47	17.10361	34.92039	701,113.518	302,208.190	3.436	31.48	by direct leveling
PC22	6	19	7.37343	10	48	38.42426	69.73458	698,784.626	299,700.505	38.238	31.50	〃
PC23	6	19	2.14558	10	44	45.75760	34.00491	698,599.586	306,851.611	2.54	31.46	by geoid map
PC24	6	18	29.49202	10	40	11.73653	43.02822	697,568.855	315,270.895	11.895	31.13	by direct leveling
PC25	6	19	22.35996	10	39	3.46176	37.25443	699,186.224	317,374.570	6.14	31.11	by geoid map
PC27	6	17	46.14891	10	47	25.54506	39.98030	696,281.557	301,932.103	7.301	31.10	by direct leveling
PC28	6	17	33.01114	10	45	26.04666	35.39059	695,865.480	305,604.005	4.17	31.22	by geoid map
PC29	6	17	8.92106	10	39	21.35640	35.94554	695,088.848	316,811.556	4.83	31.12	〃
PC30	6	16	27.50622	10	41	43.10740	45.29173	693,830.552	312,450.290	14.487	none	by direct leveling
PC31	6	16	10.72841	10	44	3.03382	41.72408	693,329.205	308,147.342	10.408	31.32	〃
PC32	6	15	41.98339	10	39	34.11703	33.11924	692,419.441	316,410.868	2.00	31.12	by geoid map
PC33	6	14	2.53960	10	41	27.79409	35.89765	689,375.715	312,906.683	4.789	31.11	by direct leveling
PC34	6	13	59.77687	10	39	40.59219	42.30582	689,280.374	316,201.917	11.194	31.11	〃
PC35	6	13	32.62984	10	37	21.79456	40.02923	688,433.177	320,466.076	8.940	31.09	〃
RAMROD/PC26	6	17	47.62864	10	42	9.12582	48.10356	696,294.490	311,658.518	16.666	31.44	Based point for GPS
TP1_JFK	6	17	12.66297	10	46	25.32291	71.18758	695,246.521	303,779.788	none	none	none
AE973_1	6	15	47.33092	10	42	52.11342	52.26918	692,603.268	310,325.069	20.940	31.33	by direct leveling

v. Quality Control of Control Point Survey was carried out by comparing the data of exiting control station and height from existing Benchmark with Geoid map. Details are shown on attached Quality Control Sheet shown as Table79.

Table 7 Quality Control Table (Standard Deviation of PC)

GCP	Horizontal Position S.D.			Ellipsoidal Height S.D.	
	$M_{X\,(m)}$	$M_{Y\,(m)}$	Allowance	M_H	Allowance
PC-01	0.0180	0.0190	15cm	0.0459	30cm
PC-02	0.0188	0.0199	〃	0.0521	〃
PC-03	0.028	0.0423	〃	0.0844	〃
PC-04	0.0514	0.0392	〃	0.0800	〃
PC-05	0.0184	0.0200	〃	0.0440	〃
PC-06	0.0366	0.0266	〃	0.0666	〃
PC-07	0.0179	0.0163	〃	0.0432	〃
PC-08	0.0257	0.0376	〃	0.0672	〃
PC-09	0.0308	0.0246	〃	0.0520	〃
PC-10	0.0304	0.0297	〃	0.0597	〃
PC-11	0.0282	0.0238	〃	0.0492	〃
PC-12	0.0215	0.0255	〃	0.0648	〃
PC-13	0.0351	0.0389	〃	0.1017	〃
PC-14	0.0353	0.0286	〃	0.0692	〃
PC-15	0.0221	0.0231	〃	0.0517	〃
PC-16	0.0238	0.0250	〃	0.0469	〃
PC-17	0.0213	0.0265	〃	0.0559	〃
PC-18	0.0091	0.0093	〃	0.0284	〃
PC-19	0.0228	0.0332	〃	0.0576	〃
PC-20	0.0111	0.0108	〃	0.0206	〃
PC-21	0.0132	0.0131	〃	0.0295	〃
PC-22	0.0208	0.0196	〃	0.0378	〃
PC-23	0.0212	0.0192	〃	0.0518	〃
PC-24	0.0095	0.0117	〃	0.0312	〃
PC-25	0.0192	0.0180	〃	0.0475	〃
RAMROD	0.000	0.000	〃	0.0000	〃
PC-27	0.0253	0.0251	〃	0.0570	〃
PC-28	0.0235	0.0328	〃	0.0578	〃
PC-29	0.0220	0.0304	〃	0.0838	〃
PC-30	0.0148	0.0208	〃	0.0378	〃

PC-31	0.0257	0.0262	〃	0.0492	〃
PC-32	0.0186	0.0182	〃	0.0437	〃
PC-33	0.0224	0.0228	〃	0.0570	〃
PC-34	0.0214	0.0315	〃	0.0525	〃
PC-35	0.0262	0.0358	〃	0.0872	〃
AE9731	0.0212	0.0171	〃	0.0336	〃
JFK	0.0092	0.0103	〃	0.0270	〃

- Simple Leveling

  Based on the existing BM-2 (3.034 m from mean sea level), established in 1967 by USGS located in free port, a height of some of photo control points (PC) as well as spot heights for height control of Aerial Triangulation was obtained by simple leveling. The total length of the leveling was 102 km. The routes and closure errors are as follows. (See Table 10) The leveling routes are shown below. (See Figure 6)

  Quality Control of Simple Leveling was carried out as following Table 8. Closure Error of Leveling.

Table 8. Closure Error of Leveling

No.	Route	Length	Error (Tolerances)
1	BM 2~ TBM1~TBM 2~BM2	31.5 km	- 46 mm<±224mm
2	TBM 2~ TBM 4~ PC 8~TBM 3~BM 2	27.0 km	+120 mm<±207mm
3	TBM 4~PC 8	17.0 km	-95mm <±165mm
4	PC 10~PC 19	7.0 km	- 56mm<±106mm
5	TBM 3~PC 7	7.0 km	+ 78mm<±106mm
6	TBM 1~PC 35	12.5 km	- 103mm<±141mm

*Tolerances: 40mm $\sqrt{S}$ (S is one way distance in km)

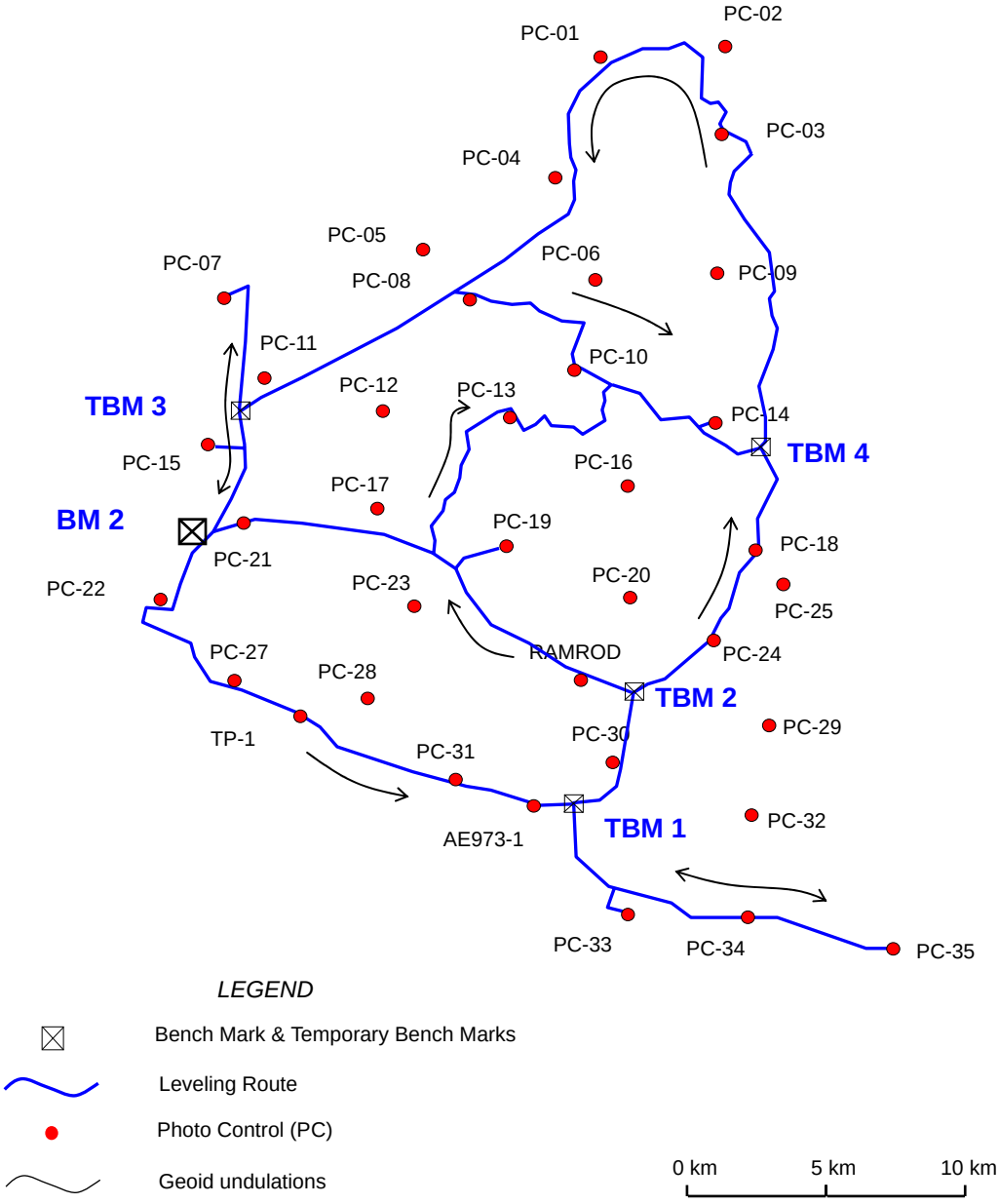


Figure 6. Leveling Route

[8] Interpretation Key

In order to secure the Digital Plotting work quality, Interpretation Key was produced by using IKONOS satellite imagery when the Interpretation key started to prepare due to incomplete aerial photography. After the aerial photography, IKONOS images used for Interpretation Key were replaced to the stereo aerial photograph images. Filed objects for Interpretation Key was selected before work starts. The list of field object prepared as Interpretation key is shown in Table 9. The interpretation key is shown in APPENDIX 6.

Table 9. List of Photo Identification Keys

No.	Objects	No.	Objects
1	Antenna 1	17	Market
2	Antenna 2	18	Mixed Forest
3	Bridge 1	19	Overpass
4	Bridge 2	20	Palm
5	Bridge 3	21	Road, less than 3m
6	Cemetery 1	22	Road, unpaved
7	Cemetery 2	23	Rubber
8	Cemetery 3	24	Separator, narrow
9	Cemetery 4	25	Separator, wide
10	Cliff, Rock, Scattered Rock	26	Vegetation
11	Crop Land	27	Water Tank
12	Culvert 1	28	Well, large 1
13	Culvert 2	29	Well, large 2
14	Disposal Area	30	Well small
15	Gas Station	31	Wreck
16	Grass Land		

[9] Field Verification

Based on the data collected from two organizations, which are UNMIL(United Nations Mission in Liberia) and LISGIS (Liberia Institute of Statistics & Geo-Information Services) as well as unidentified features in digital plotting, the field verification was carried out using an orthophoto at a scale of 1/5,000 at the site to verify their consistency and correctness. The work was held by a sub-contractor under the supervision and instruction of Study Team. The works were carried out for the duration of one (1) month from the end of April.

Data collected as SHP file format from UNMIL were as follows:

- Road and street

- Building (Governmental buildings, Post offices, Hospitals/clinics, Power plant, Market, Embassies, Theaters, Fire station, Hotel, Gas station, Schools, Churches, Mosques, Police stations, Factories and Warehouses.
- Administrative boundaries (Zone boundaries)

Data collected in Excel and PDF format from LISGIS were as follows:

- Administrative boundaries in PDF format (County, District/Zone and Township/Communication boundaries)
- Road and street
- Building (Governmental buildings, Post offices, Hospitals/clinics, Power plant, Market, Embassies, Theaters, Fire station, Hotel, Gas station, Schools, Churches, Mosques, Police stations, Factories and Warehouses.
- Small objects (Wells, Antennas and Oil tanks)

Unidentifiable items extracted in digital plotting were as follows:

- Road types (classification of paved or unpaved)
- Exact location of school, church, wells and towers/antennas and so on
- Vegetation classification (rice field, crop land, swamp, forest and plantation and so on)

Above-mentioned items were correctly verified at the site and compiled in digital format.

[10] Digital Compilation after Field Verification

Digital Compilation after Field Verification was carried out for the completion of Topographic Map data with verified information such as objects with symbol, boundary and road information and so on.

The result of Field Verification was reflected to the topographic map data especially symbolized objects such as school, church, government buildings and so on.

Positioning of some the symbols were shifted due to the low accuracy of handy GPS for checking of position. This displacement of the object symbols was corrected onto the Topographic map data digitally.

Confirmed road surface information was reflected to the Topographic Maps and polygonal representation was carried out for coloring.

<Works in Japan>

[11] Film Scanning, Aerial Triangulation, DEM Acquisition & Ortho-photo Production

- Film Scanning

  Analog/Digital conversion of aerial photographs was carried out by using a photogrammetric scanner with the resolution of 15 micron. Data was stored as uncompressed TIFF format.

  The work had been involved in subcontracting works when the study started. However due to delay of aerial photography, the work was changed to one of the "Works in Japan" to compensate the study schedule.

- Aerial Triangulation

  Aerial Triangulation was performed with scanned photograph data, result of control point and simple leveling by use of work-station and bundle adjustment software ORIMA. Index Map for Aerial Triangulation is shown in Figure 7. As for Quality Control of the Aerial Triangulation, the residuals of Aerial Triangulation are shown in Table 10.

The result of Aerial Triangulation, rotation of each photograph is stored in the final data CD_ROM.

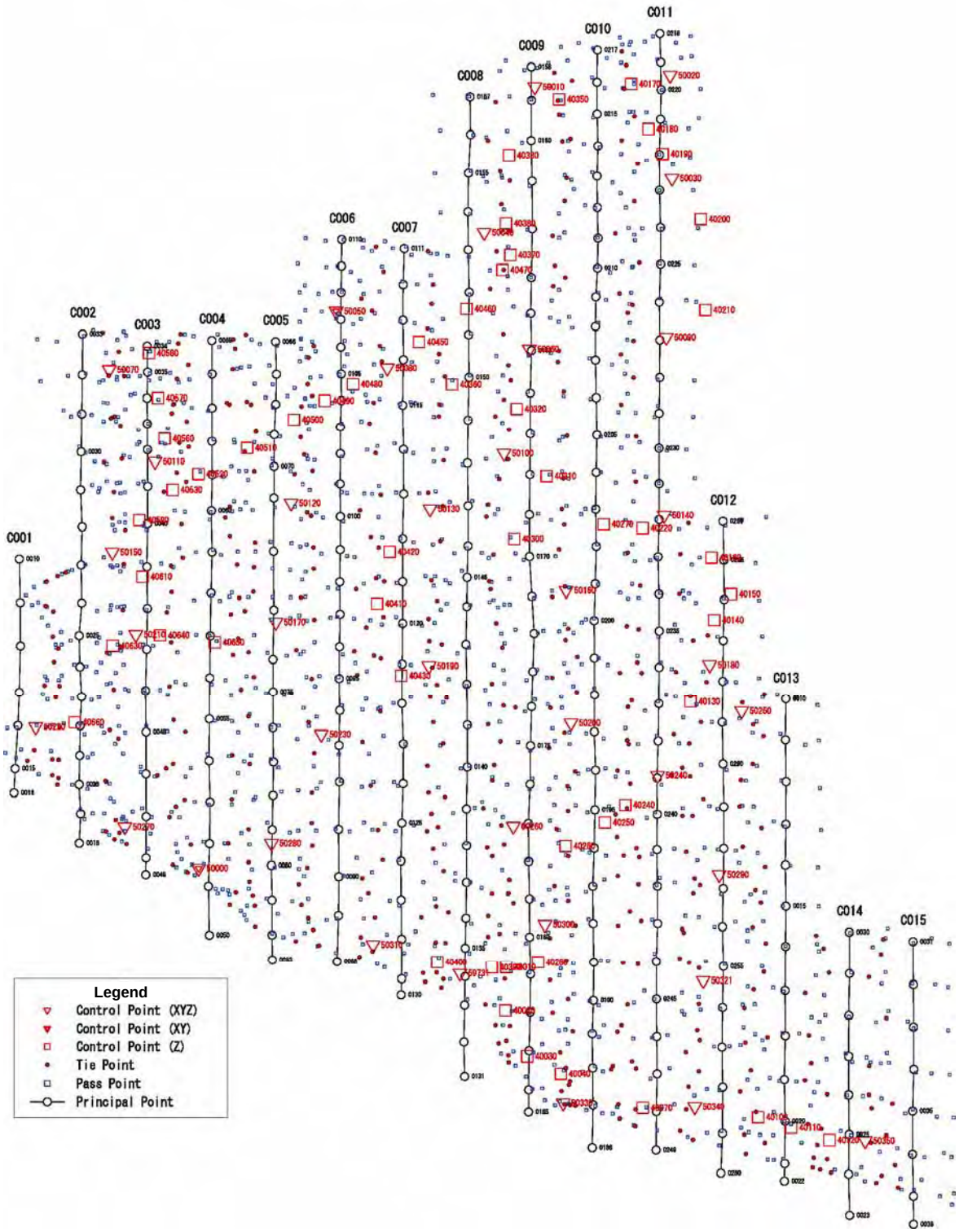


Figure 7. Index Map for Aerial Triangulation

Table 10. Residuals of Aerial Triangulation

Area	Monrovia, Liberia												
Line No.	C1-C15							Organization:			Aero Asahi Corporation		
Point No.	Transformed Coordinates			Given Cooridinates			Residuals						
	X	Y	H	X	Y	H	DX	DY	DX2+DY2	√ DX2+DY2	DH	|DH|	DH2
50010	312196.245	714863.999	13.263	312196.400	714863.730	13.259	−0.155	0.269	0.096	0.310	0.004	0.004	0.000
50020	315585.067	715153.882	14.013	315585.170	715154.000	14.200	−0.103	−0.118	0.025	0.157	−0.187	0.187	0.035
50030	315629.793	712553.645	25.433	315629.920	712553.790	25.440	−0.127	−0.145	0.037	0.193	−0.007	0.007	0.000
50040	310928.274	711197.536	11.941	310928.290	711197.420	11.950	−0.016	0.116	0.014	0.117	−0.009	0.009	0.000
50060	312059.428	708279.405	16.491	312059.490	708279.570	16.490	−0.062	−0.165	0.031	0.176	0.001	0.001	0.000
50070	301541.611	707763.222	6.638	301541.790	707763.240	6.730	−0.179	−0.018	0.032	0.180	−0.092	0.092	0.008
50080	308502.812	707803.684	8.939	308502.860	707803.640	8.860	−0.048	0.044	0.004	0.065	0.079	0.079	0.006
50090	315487.219	708577.009	12.877	315487.210	708577.370	12.850	0.009	−0.361	0.130	0.361	0.027	0.027	0.001
50100	311424.942	705652.347	10.024	311424.930	705652.490	9.973	0.012	−0.143	0.021	0.144	0.051	0.051	0.003
50110	302689.801	705450.131	4.305	302689.950	705450.250	4.290	−0.149	−0.119	0.036	0.191	0.015	0.015	0.000
50120	306095.555	704402.304	5.497	306095.640	704402.290	5.600	−0.085	0.014	0.007	0.086	−0.103	0.103	0.011
50130	309574.318	704258.677	8.953	309574.200	704258.730	8.980	0.118	−0.053	0.017	0.129	−0.027	0.027	0.001
50140	315433.339	704098.621	28.510	315433.270	704098.920	28.590	0.069	−0.299	0.094	0.307	−0.080	0.080	0.006
50150	301620.696	703176.364	4.737	301621.030	703176.110	4.835	−0.334	0.254	0.176	0.420	−0.098	0.098	0.010
50160	312982.498	702217.926	17.785	312982.410	702218.070	17.650	0.088	−0.144	0.028	0.169	0.135	0.135	0.018
50170	305714.267	701422.935	6.272	305714.300	701422.790	6.280	−0.033	0.145	0.022	0.149	−0.008	0.008	0.000
50180	316573.127	700352.652	10.076	316573.120	700353.050	9.990	0.007	−0.398	0.158	0.398	0.086	0.086	0.007
50190	309547.716	700327.550	4.879	309547.630	700327.600	4.830	0.086	−0.050	0.010	0.099	0.049	0.049	0.002
50200	313101.519	698880.268	10.236	313101.690	698880.050	10.210	−0.171	0.218	0.077	0.277	0.026	0.026	0.001
50210	302208.116	701113.640	3.607	302208.190	701113.520	3.436	−0.074	0.120	0.020	0.141	0.171	0.171	0.029
50220	299700.454	698784.852	38.281	299700.510	698784.630	38.450	−0.056	0.222	0.052	0.229	−0.169	0.169	0.029
50230	306851.685	698599.636	3.059	306851.650	698599.580	3.060	0.035	0.056	0.004	0.066	−0.001	0.001	0.000
50240	315271.020	697568.537	13.785	315270.900	697568.860	14.050	0.120	−0.323	0.119	0.345	−0.265	0.265	0.070
50250	317374.866	699185.897	6.000	317374.570	699186.220	6.140	0.296	−0.323	0.192	0.438	−0.140	0.140	0.020
50260	311658.555	696294.613	16.744	311658.520	696294.490	16.666	0.035	0.123	0.016	0.128	0.078	0.078	0.006
50270	301932.188	696281.820	8.608	301932.100	696281.560	8.880	0.088	0.260	0.075	0.274	−0.272	0.272	0.074
50280	305604.196	695865.604	4.087	305604.010	695865.480	4.170	0.186	0.124	0.050	0.224	−0.083	0.083	0.007
50290	316811.769	695088.910	6.926	316811.640	695088.890	6.870	0.129	0.020	0.017	0.131	0.056	0.056	0.003
50300	312450.421	693830.584	16.551	312450.290	693830.550	16.600	0.131	0.034	0.018	0.135	−0.049	0.049	0.002
50310	308147.223	693329.187	12.524	308147.360	693329.150	12.510	−0.137	0.037	0.020	0.142	0.014	0.014	0.000
50321	316411.067	692419.513	3.341	316410.868	692419.441	3.240	0.199	0.072	0.045	0.212	0.101	0.101	0.010
50330	312906.808	689375.741	5.987	312906.680	689375.720	6.310	0.128	0.021	0.017	0.130	−0.323	0.323	0.104
50340	316201.868	689280.715	12.335	316201.920	689280.370	12.410	−0.052	0.345	0.122	0.349	−0.075	0.075	0.006
50350	320466.235	688432.990	9.031	320466.080	688433.180	9.040	0.155	−0.190	0.060	0.245	−0.009	0.009	0.000
59731	310325.107	692603.513	20.987	310325.070	692603.270	20.940	0.037	0.243	0.060	0.246	0.047	0.047	0.002
50000	303779.920	695246.611	0.000	303779.790	695246.520	0.000	0.130	0.091	0.025	0.159	0.000	0.000	0.000
50050	307222.343	709224.374	0.000	307222.620	709224.350	0.000	−0.277	0.024	0.077	0.278	0.000	0.000	0.000
40010	0.000	0.000	13.154	0.000	0.000	13.240	0.000	0.000	0.000	0.000	−0.086	0.086	0.007
40020	0.000	0.000	9.644	0.000	0.000	9.660	0.000	0.000	0.000	0.000	−0.016	0.016	0.000
40030	0.000	0.000	12.883	0.000	0.000	12.620	0.000	0.000	0.000	0.000	0.263	0.263	0.069
40040	0.000	0.000	10.509	0.000	0.000	10.650	0.000	0.000	0.000	0.000	−0.141	0.141	0.020
40070	0.000	0.000	11.499	0.000	0.000	11.290	0.000	0.000	0.000	0.000	0.209	0.209	0.044
40100	0.000	0.000	8.270	0.000	0.000	8.230	0.000	0.000	0.000	0.000	0.040	0.040	0.002
40110	0.000	0.000	12.380	0.000	0.000	12.330	0.000	0.000	0.000	0.000	0.050	0.050	0.003
40120	0.000	0.000	10.406	0.000	0.000	10.490	0.000	0.000	0.000	0.000	−0.084	0.084	0.007
40130	0.000	0.000	11.802	0.000	0.000	11.780	0.000	0.000	0.000	0.000	0.022	0.022	0.000
40140	0.000	0.000	10.593	0.000	0.000	10.450	0.000	0.000	0.000	0.000	0.143	0.143	0.020
40150	0.000	0.000	15.215	0.000	0.000	15.260	0.000	0.000	0.000	0.000	−0.045	0.045	0.002
40160	0.000	0.000	22.041	0.000	0.000	22.130	0.000	0.000	0.000	0.000	−0.089	0.089	0.008
40170	0.000	0.000	7.185	0.000	0.000	7.220	0.000	0.000	0.000	0.000	−0.035	0.035	0.001
40180	0.000	0.000	17.831	0.000	0.000	17.710	0.000	0.000	0.000	0.000	0.121	0.121	0.015
40190	0.000	0.000	17.320	0.000	0.000	17.300	0.000	0.000	0.000	0.000	0.020	0.020	0.000
40200	0.000	0.000	22.571	0.000	0.000	22.540	0.000	0.000	0.000	0.000	0.031	0.031	0.001
40210	0.000	0.000	27.838	0.000	0.000	27.910	0.000	0.000	0.000	0.000	−0.072	0.072	0.005
40220	0.000	0.000	21.686	0.000	0.000	21.650	0.000	0.000	0.000	0.000	0.036	0.036	0.001
40240	0.000	0.000	13.435	0.000	0.000	13.250	0.000	0.000	0.000	0.000	0.185	0.185	0.034
40250	0.000	0.000	15.687	0.000	0.000	15.600	0.000	0.000	0.000	0.000	0.087	0.087	0.008
40260	0.000	0.000	18.664	0.000	0.000	18.750	0.000	0.000	0.000	0.000	−0.086	0.086	0.007
40270	0.000	0.000	24.055	0.000	0.000	24.020	0.000	0.000	0.000	0.000	0.035	0.035	0.001
40280	0.000	0.000	6.733	0.000	0.000	6.630	0.000	0.000	0.000	0.000	0.103	0.103	0.011
40300	0.000	0.000	7.622	0.000	0.000	7.640	0.000	0.000	0.000	0.000	−0.018	0.018	0.000
40310	0.000	0.000	12.895	0.000	0.000	12.950	0.000	0.000	0.000	0.000	−0.055	0.055	0.003
40320	0.000	0.000	10.336	0.000	0.000	10.350	0.000	0.000	0.000	0.000	−0.014	0.014	0.000
40330	0.000	0.000	7.234	0.000	0.000	7.150	0.000	0.000	0.000	0.000	0.084	0.084	0.007
40350	0.000	0.000	6.674	0.000	0.000	6.640	0.000	0.000	0.000	0.000	0.034	0.034	0.001
40360	0.000	0.000	6.008	0.000	0.000	6.020	0.000	0.000	0.000	0.000	−0.012	0.012	0.000
40370	0.000	0.000	2.788	0.000	0.000	2.810	0.000	0.000	0.000	0.000	−0.022	0.022	0.000
40380	0.000	0.000	5.487	0.000	0.000	5.490	0.000	0.000	0.000	0.000	−0.003	0.003	0.000
40390	0.000	0.000	7.083	0.000	0.000	6.980	0.000	0.000	0.000	0.000	0.103	0.103	0.011
40400	0.000	0.000	27.009	0.000	0.000	27.210	0.000	0.000	0.000	0.000	−0.201	0.201	0.040
40410	0.000	0.000	7.186	0.000	0.000	7.090	0.000	0.000	0.000	0.000	0.096	0.096	0.009
40420	0.000	0.000	4.726	0.000	0.000	4.740	0.000	0.000	0.000	0.000	−0.014	0.014	0.000
40430	0.000	0.000	5.386	0.000	0.000	5.310	0.000	0.000	0.000	0.000	0.076	0.076	0.006
40450	0.000	0.000	6.630	0.000	0.000	6.660	0.000	0.000	0.000	0.000	−0.030	0.030	0.001
40460	0.000	0.000	7.223	0.000	0.000	7.210	0.000	0.000	0.000	0.000	0.013	0.013	0.000
40470	0.000	0.000	6.354	0.000	0.000	6.490	0.000	0.000	0.000	0.000	−0.136	0.136	0.018
40480	0.000	0.000	6.912	0.000	0.000	7.050	0.000	0.000	0.000	0.000	−0.138	0.138	0.019
40490	0.000	0.000	4.917	0.000	0.000	4.920	0.000	0.000	0.000	0.000	−0.003	0.003	0.000
40500	0.000	0.000	4.088	0.000	0.000	4.100	0.000	0.000	0.000	0.000	−0.012	0.012	0.000
40510	0.000	0.000	3.393	0.000	0.000	3.460	0.000	0.000	0.000	0.000	−0.067	0.067	0.004
40520	0.000	0.000	3.734	0.000	0.000	3.630	0.000	0.000	0.000	0.000	0.104	0.104	0.011
40530	0.000	0.000	4.176	0.000	0.000	4.430	0.000	0.000	0.000	0.000	−0.254	0.254	0.065
40560	0.000	0.000	4.444	0.000	0.000	4.360	0.000	0.000	0.000	0.000	0.084	0.084	0.007
40570	0.000	0.000	7.010	0.000	0.000	6.900	0.000	0.000	0.000	0.000	0.110	0.110	0.012
40580	0.000	0.000	3.464	0.000	0.000	3.320	0.000	0.000	0.000	0.000	0.144	0.144	0.021
40590	0.000	0.000	5.684	0.000	0.000	5.620	0.000	0.000	0.000	0.000	0.064	0.064	0.004
40610	0.000	0.000	4.167	0.000	0.000	4.040	0.000	0.000	0.000	0.000	0.127	0.127	0.016
40630	0.000	0.000	2.154	0.000	0.000	2.320	0.000	0.000	0.000	0.000	−0.166	0.166	0.028
40640	0.000	0.000	4.685	0.000	0.000	4.840	0.000	0.000	0.000	0.000	−0.155	0.155	0.024
40650	0.000	0.000	2.783	0.000	0.000	2.430	0.000	0.000	0.000	0.000	0.353	0.353	0.125
40660	0.000	0.000	7.287	0.000	0.000	7.010	0.000	0.000	0.000	0.000	0.277	0.277	0.077
								[dX2+dY2]	2.008			[dH2]	1.250
				Tolerate Discrepancy				No. of Controls		Horizontal	37	Height	89
		Standard deviation		Horizontal		0.300		Standard deviation		Horizontal	0.233		
				Vertical		0.300				Vertical	0.118		
		Maximum		Horizontal		0.600		Maximum		Horizontal	0.438	Point Name	50250
				Vertical		0.600				Vertical	0.353	Point Name	40650
		Standard deviation		(Deviation/mm)		0.015		Standard deviation		mm, deviation	0.006		
		Maximum		(Deviation/mm)		0.030		Maximum		mm, deviation	0.019	Point Name	40660

- DEM Acquisition

  By using of the result of Aerial Triangulation, 5m grid interval of DEM (Digital Elevation Model) was generated with stereo-matching method for ortho-photo.

- Ortho-photo Production

  A scale of 1:10,000 ortho-photo was produced for the study area that includes the area of "White Plain", water pump station and water pipeline exists, by using generated DEM data. After generation of ortho-photo, contour line data was consolidated.

[12] Digital Plotting

Ground objects and topographic features were digitally plotted in spatial model created by stereo pair of aerial photograph data. Plotted and expressed topographic features were stored on each layer as a scale of 1:10,000 topographic map data. Individual features and object data were categorized based on the accuracy of aerial 1:10,000 photography as following manner.

i. Preparatory Work

Before work started following preparatory works were carried out.

i-1 Categorize of Data Structure of Topographic Data File

Topographic data file were categorized as the following 4 data types.

- Line data

  The continuous data from the starting point to the ending point.
- Area (Polygon) data

  The data to be obtained as an enclosed feature such as building and continuous data from the starting point to the ending point as enclosed line. However, coordinates of the starting point and the ending point shall coincide with each other.
- Point data

  The data to be obtained independently as isolated points such as buildings, vegetation symbol and so on.
- Text data

  The data to be shown as an annotation and explanation of features on the topographic map

Furthermore, above-mentioned data consists of following 4 attribute data.

- Layer (level)
- Color
- Line weight
- Line style

i-2 Map Feature Code

Map Feature Code (MFC) was prepared prior to actual digital data acquisition to classify the obtained data. The Digital data was acquired based on the MFC.

i-3 Map Symbols

Prior to commencement of actual work, Map Symbol Specification was consulted and agreed on during the consultation between Counterparts and JICA Study Team. Some of the map symbols were modified and finalized during the topographic mapping works. Finalized Symbols Specification is shown on APPENDIX 7.

ii. Digital Plotting Works

Following are the major points of field objects to be acquired as a digital data during the plotting based on the Symbol Specification.

ii-1 Road, bridge and railway

- National road, local main road

  Roads were obtained one side by one side (not to use the parallel lined commend). Sidewalk, roadside tree and green belt more than 3 meters width were defined and expressed on the map.
- Paved and earth road

  The paved road and earth road were judged by photo interpretation (They were verified during Field Verification). The roads and tracks within the city area were judged as a paved road and the road in countryside were mostly earth roads.
- Under-construction road

  The edges of under-construction roads are not clear and the widths of under construction road become wide and narrow depending on the condition. In this case, the lines of under-construction road were obtained by same width at the average width estimated by zoom up of photo image of digital plotter.
- Footpath

  The footpath with 100 m length (1 cm on 1:10,000 topographic map) was not expressed. However a footpath, shorter than 100m connecting between double line road and to village, connecting the double line road to double line road, were obtained according to the importance of the footpath.
- Railway

  Railway data was obtained by single line symbol at the center of railway's track.

ii-2. House and building

All houses and buildings were interpreted and plotted on 3D spatial image consists of photograph

stereo pairs. Houses under trees or behind tall building were interpreted carefully. Especially at the edge of photo model, houses behind tall buildings may often not be identified. In congested housing areas, considering the drawing limit on 1:10,000 scale topographic maps, the shape of the houses were generalized. However generalizations of houses were done only in limited areas of the study area, such as Red Light, because of 1:10,000 photograph scale.

ii-3 Fences and Revetment

The fence/wall and artificial revetment of school, factory and so on, more than 100 m (1 cm on 1:10,000 scale topographic map) were expressed. Even when shorter than 100m, if these objects were judged as important, fencing and walls were acquired.

ii-4 River, stream, lake and pond

Minimum size data acquisition of pond was 50 m×50 m (5 mm×5 mm on 1:10,000 scale topographic map). Ponds smaller than this size were omitted. Streams less than 100 m (1 cm on 1:10,000 scale topographic map) and has no connection with another stream or river were not expressed.

ii-5 Vegetation

Vegetation were obtained at approximately 200m×200m unit (2cm×2cm on 1;10,000 scale topographic map). A small non-cultivation area (5mm×5mm on 1:10,000 scale topographic map) within cultivation area were not shown on the map.

ii-6 Zone Boundary

Zone Boundaries were expressed on the map. However the boundary data was not suitable to express on to 1:10,000 topographic map due to the scale of collected boundary map. The Study Team proposed that the alignment of Administrative boundaries following natural features such as Roads, Rivers and so on, were adjusted to its shapes to distinct features when boundary runs along the lines of such features. In the open area, such as fields, forest and so on, boundary is expressed as following the collected boundary data of LISGIS.

ii-7 Spot elevation

Spot elevation were obtained the density approximately 9 (nine) points within 1km x 1km (10cm×10cm on 1:10,000 scale topographic map) due to the importance of height information for the project.

The observation point and order of observation of spot elevation were as follows:

- Intersections of main road
- Intersections of double line road
- Corners of double line road
- Intersections of footpaths or corners of footpaths

ii-8 Contour line

The project area is considerably flat. The flying height of the aerial photography was made with enough accuracy of 1:2,500 topographic map production. The contour line interval was set to 2 m because of needs of further study for Master Plan. The contour line for depression area was drawn also and spot height was observed as an additional height information if the size of depression area is large.

[13] Digital Compilation

Digital Compilation was carried out on the digital plotting data. The works include a data amendment, annotation of geographical names and other items not modified on digital plotting stage as following manner.

i. Checking of Data Structure

The checking of data structure consists of following items.

i-1 Planimetric features between adjacent sheets

The discrepancy of horizontal position of data at the neat-line was checked. In case the planimetric features do not coincide between adjacent sheets, data amendment was carried out by using orthophoto image.

i-2 Data type and attribute

The acquired topographic map data were checked according to the data type and attribute defined prior to the commencement of the actual work.

i-3 Visual check on a plotted Manuscript

After completion of digital compilation works, topographic data was plotted. Plotted data was checked with orthophoto image, field verification data and so on visually.

i-4 Control point and contour lines

- Density of geodetic points including spot heights and height values of contour lines.
  The density of geodetic points including spot heights and contour value is approximately 9 (nine) points at 10cm×10cm on 1:10,000 scale topographic map an average.
- Relation between geodetic points and contour lines
  The relation between geodetic points including spot heights and contour lines was checked.

i-5 All expressed data were checked based on following check items.

- Lack of data acquisition

- Shape
- Type
- Location

ii. Marginal information

"Marginal information" is the map information shown at the outside of neat-line of topographic map. The information such as map scale, scale bar, map symbol, history of mapping and so on are shown in marginal information.

The items to be shown in marginal information are as follows:

- Neat-line, Sheet name & number, Grid and longitude and latitude
- Administrative names, Information and history of Topographic map
- Map scale, Map symbols, Sheet index and other necessary information

Marginal information was prepared sheet by sheet. The draft of marginal information applied to the topographic maps of the study shown on Figure 8.

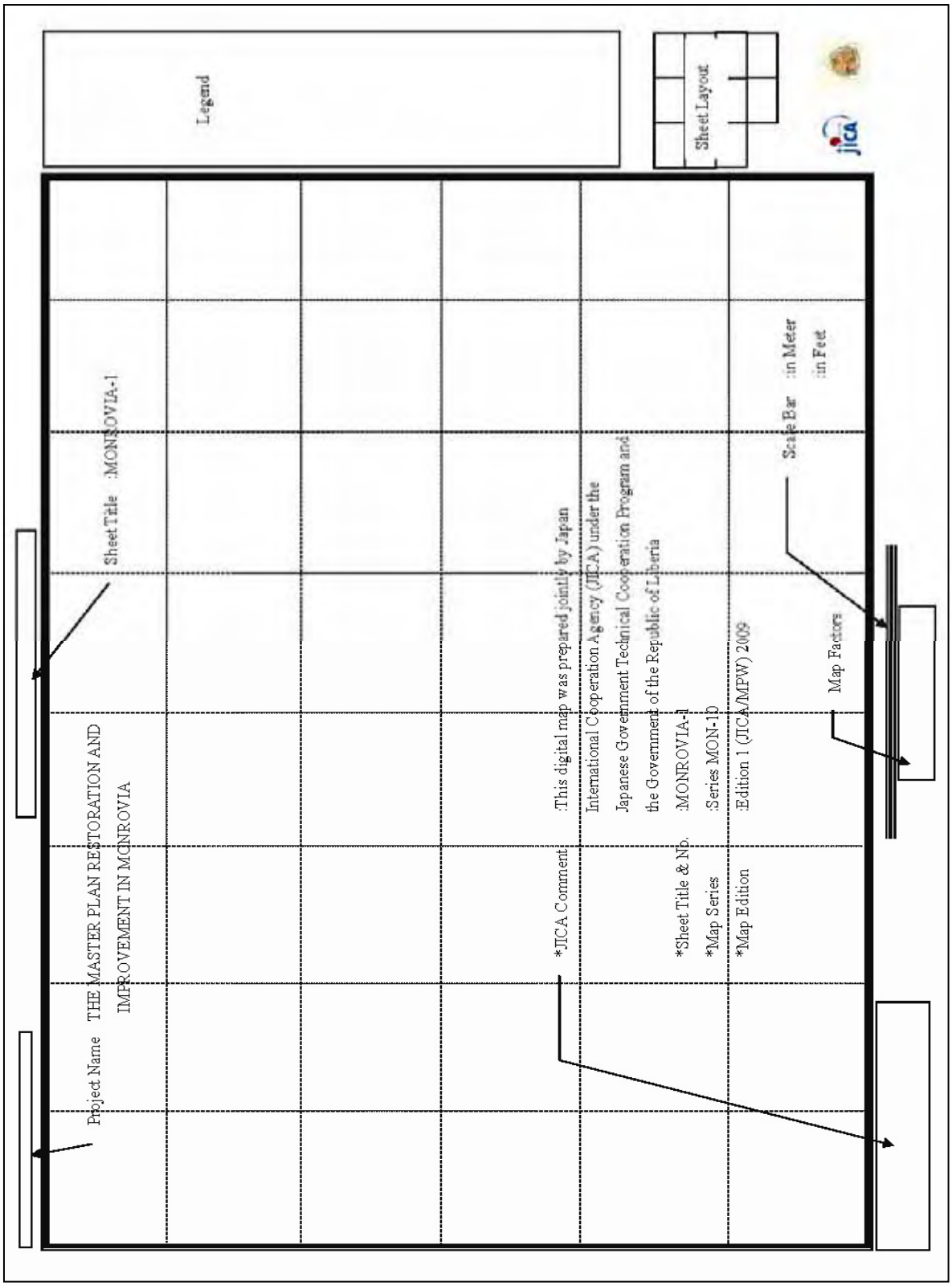


Figure 8. Instruction for Marginal Information

[14] Symbolization

Digitally compiled data (point, line and polygon) were symbolized to convert the topographic map data to printing by printer. Digitized data were symbolized based on the finalized Topographic Map Symbols shown on APPENDIX 7.

[15] Creation of Data File

Finalized topographic data were checked for matching with work specification. Topographic data were recorded in certain format agreed with counterpart. Study Team converted topographic map data into following 3 data types format.

- KML data
- DXF file
- PDF file

[16] Quality Control

Quality control of individual works was carried out as follows. Result of Quality Control of Individual Work is shown at the end of each work paragraph. List for Quality Control for major works is shown Table 11.

Table 11 List of Works for Quality Control

No.	Work Items
1	Control Point Survey
2	Simple Leveling
3	Aerial Photography
4	Digital Plotting and Compilation
5	Symbolization
6	Creation of Data File

i. Digital Plotting and Compilation and 5. Symbolization, 6. Creation of Data File are shown on APPENDIX 9.

ii. Addition to the major works, Quality Control of following works was done shown as follows.

- Ortho-photo production
- Aerial Triangulation

Chapter 4. Participation of the Seminar

The Study Team participated in the Interim Report Seminar of the Project held on April 29th 2009 in the Cape Hotel, Monrovia. The Seminar Program is shown in following Figure 9. While the seminar implementation, the Study Team presented methodology of Topographic Mapping and Ortho-photo Production and Data application simply by presentation of a Fly Through movie created by Computer Graphic software by using produced Topographic Mapping Data and IKONOS satellite image. The CD_ROM of Fly through Movie is attached to the Final Report.
At the same time the Study Team announced that the copy right of Topographic Map belongs to MPW and JICA. Map user should receive approval of one of the both organization.

Seminar for Interim Report of Master Plan Study Team

The Master Plan Study on Urban Facilities Restoration and Improvement in Monrovia in the Republic of Liberia

Interim Report Seminar
Program Outline

(1) Date: April 29, 2009
(2) Venue: Cape Hotel, Monrovia
(3) Program Schedule

Time	Speech/ Presentation	Presenter/ Speaker
9:00 – 9:30	Registration	
9:30 – 9:45	Opening Speech	Hon. Loseni Dunzo, Minister Ministry of Public Works
9:45 – 10:00	Speech by Chief Guest	Mr. Daniel G. Johnson, Chairman of City Council
10:00 - 10:20	Tea Break	
10:20 – 10:30	Presentation of Mapping Team	Mr. Takashi Harada, Team Leader, JICA Study Team for Mapping
10:30 – 10:45	Introduction of the Study by JICA Study Team Leader	Mr. Masatsugu Komiya, JICA Study Team Leader
10:45 – 11:15	Theme 1: Socio-Economic Characteristics and Land Use	Planning Sector Team
11:15 – 11:30	Questions & Answers	
11:30 – 12:00	Theme 2: Road and Transportation	Road Sector Team
12:00 – 12:15	Questions & Answers	
12:15 – 12:45	Theme 3: Water Supply / Sewerage / Storm Water Drainage	Water Sector Team
12:45 – 13:00	Questions & Answers	
13:00 – 13:10	Speech by Special Guest	Mr. Isamu Kikuchi, Country Manager, JICA Liberia Field Office
13:10 – 13:20	Vote of Thanks and Closing	Mr. Edsel Edward Smith, Assistant Minister for Technical Services, Ministry of Public Works
13:20 – 14: 20	Lunch	

Figure 9. Seminar Program

Chapter 5. Discussion of Draft Final Report

At the end of the field works of the project, discussion of Draft final Report was held by MPW and Study Team with the witness of representative of JICA Liberia field office. Following are discussed and agreed items.

1. Out line of Final Report (Draft)

Both sides discussed and agreed on the outline of the Draft Final Report for the Topographic Mapping as attached APPENDIX 8.

2. Number of Final Report to be submitted

JICA Study Team agreed that five (5) sets of Final Report are submitted to GOL after the Work Completion.

3. Final Data Type for delivery

JICA Study Team and GOL agreed that final Topographic Map Data type for delivery is DXF, PDF and KML data format and additionally SHP file data.

4. Zone Boundaries

Zone boundaries are shown to the map along the distinct features such as roads and rivers and so on when a boundary runs along the lines of them. Boundaries are not shown in the sea area.

5. Report, Result of Surveying, Topographic Map and Ortho-photo Data Disclosure

JICA Study Team requested to GOL to disclose Report, Result of Surveying, produced Topographic Map and Ortho-photo Data to the Governmental, International and Academic organization with the approval of GOL (MPW). GOL agreed with Study Team.

6. Negative Films and Contact Prints

JICA Study Team delivered following result as a part of final deliveries to GOL.

- Negative Films :2 Rolls
- Contact Prints :1 set

7. Polyester Base Sheet Map Print production

GOL (MPW) requested to JICA Study Team to produce 1 set of the maps printed on polyester base sheet adding to the delivery. JICA Study Team agreed with GOL.

8. Handover of Equipment used for Study

GOL (MPW) requested to JICA the handover of Equipment, shown in APPENDIX 3 used for the Topographic Mapping Works in Liberia by JICA Study Team. JICA Study Team promised to convey the request to JICA.

Chapter 6. Final Products

Final products to be delivered are as below. Among the final products, some of products such as Negative films and Contact prints were already delivered to GOL at the end of the field work in Liberia.
As a sample of Topographic Maps and Ortho-photo to be delivered are shown Figure 10.

(1) Final Result (Topographic Map Data and others)

1) Aerial Photography
- Negative Film : 1 set (Delivered to GOL)
- Digital Data File : 2 sets (1 set for GOL)
- Contact Print : 2 sets (1 set for GOL)
- Flight Index Map : 2 sets (1 set for GOL)

2) Field Survey
- Survey Result : 2 sets (1 sets for GOL)

3) 1:10,000 Topographic Map
- Topographic Map Data File : 6 sets (5 sets for GOL)

4) 1:10,000 Ortho-photo
- Ortho-photo Data File : 6 sets (5 sets for GOL)

(2) Reports

1) Inception Report : 5 sets (3 sets delivered to GOL)
2) Final Report
- Main Report : 5 sets (3 sets for GOL)
- Summary : 5 sets (3 sets for GOL)
- Main Report (Japanese Version) : 5 sets

3) PDF File : 5 sets

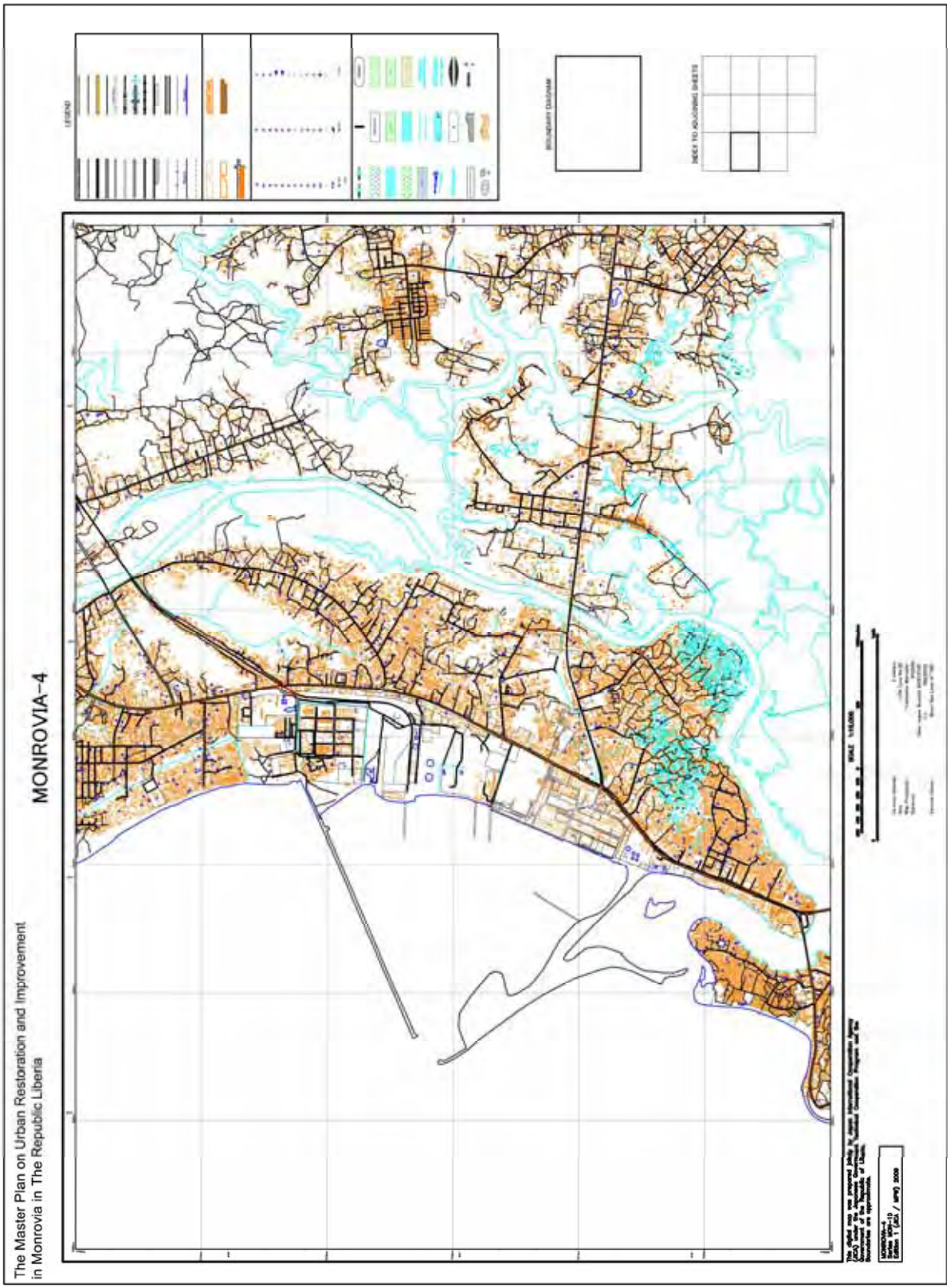
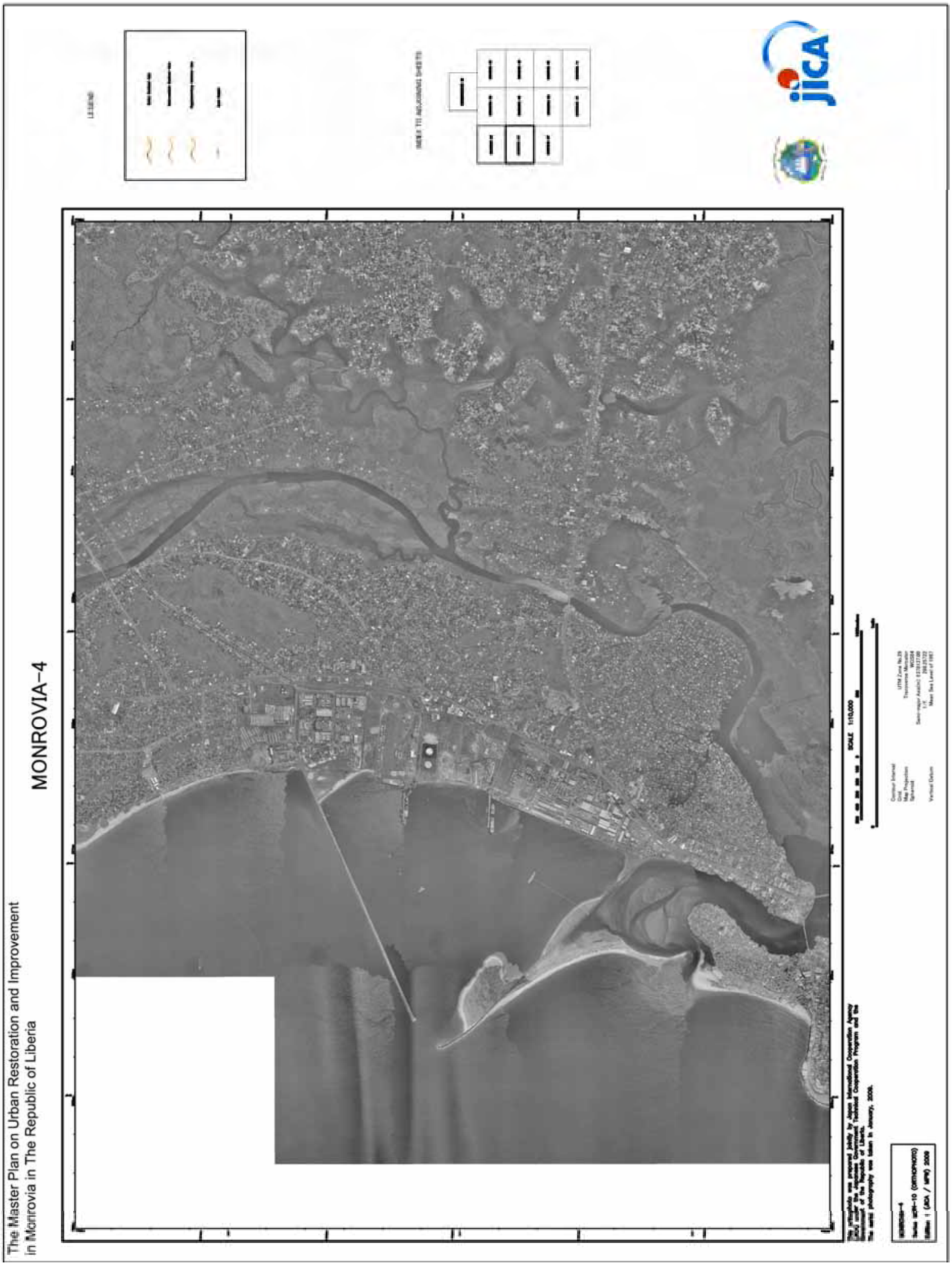


Figure 10. Sample of 1:10,000Topographic



Ortho-photo Map

Chapter 7. Conclusion

We would like to comment as a Conclusion of the Topographic Mapping on this Study during the works as below.

1. A scale of Aerial Photography

During the work planning before work start, a scale of Aerial Photography was selected to 1:10,000 due to the reasons as below.

- To secure the acquisition of aerial photograph data even though clouds existed in the sky over the area of the project.
- To make contour interval 2m to secure the purpose of further Master Plan Study. Usually standard contour interval of 1:10,000 is 5 m.

2. Training for an operation of Large sized printer

MPW asked the Study Team how to operate Large Sized Printer during the Digital Compilation of field verification. Study Team arranged and taught how to operate for the IT engineer of MPW.

3. Shape file

To make data useful and convenient, the Study Team decided to convert DWG data to SHP data for the software of MPW. However it doesn't mean that all data has attribute or structured like data for GIS. They are just Topographic Map data possible to open with ArcGIS.

4. Polyester base sheet

During the discussion and consultation of Draft Final Report, MPW asked the Study Team to provide 1 set of polyester base sheet Topographic Map due to the high humid and to avoid shrinkage and expansion of printed map. The Study Team agreed with MPW.