Chapter 5 Aerial Photography and Photo Processing

Sample of 1:5,000 scale digital topographic map
Location: Countryside of Dhaka City

Chapter 5 Aerial Photography and Photo Processing

1:20,000 scale aerial photography for 1:5,000 scale digital topographic mapping covering 960 km^2 was executed in the 1st fieldwork in Bangladesh. The outline of aerial photography was as follows:

5.1 Contract of Aerial Photography Work

Due to the reason of the weather condition and based on the instruction from the JICA Head Office in Tokyo, necessary procedures for contracting of aerial photography work has been started before Inception Report meeting.

Finally, Fugro Spatial Solution Pty. Ltd. has been selected as the sub-contractor for the execution of aerial photography work. The contract was signed between the Study team and Fugro Spatial Solution Pty. Ltd. on 18 December 2002.

5.2 Organization and Equipment Used for Aerial Photography

1:20,000 scale aerial photography was executed by the sub-contract from the Study team to Fugro Spatial Solution Pty. Ltd. Fugro Spatial Solution Pty. Ltd. sent following staff to Dhaka City for the execution of aerial photography and photo processing.

Table 5.2.1 "Crew of Aerial Photography Team"

Name	Assignment
Mr. Dennis Rose	Project Manager
Mr. Peter Hillier	Pilot
Mr. Nathan Smart	Pilot
Mr. Matthew Tindall	Navigator
Mr. Paul Simcock	Photo Lab Supervisor
Mr. Tony Dewey	Photo Lab Supervisor

Photo 5.2.1 "Crew of Aerial Photography Team of Fugro Spatial Solution Pty. Ltd."

The equipment used for aerial photography and photo processing by Fugro Spatial Solution Pty. Ltd. was as follows:

Table 5.2.2 “Aircraft”

No.	Volume	Equipment
1	1	Aircraft, Cessna 441 Conquest II S/N 441-0081 Australian Registration VH-LEM Modified as a photographic survey aircraft

Photo 5.2.2 “Cessna 441 and GPS Base Station”

Table 5.2.3 “GPS and Attachment”

No.	Volume	Equipment
1	3	Novatel Euro 4 GPS Receivers
2	1	Novatel GPS 600 Antenna
3	1	Acer 225X Laptop and accessories
4	1	Compaq Contura 400 Notebook computer including power adapters
5	2	Steering indicators and cables
6	2	Camera interface boxes and cables
7	2	Zip Drivers
8	2	4 Amp Battery chargers
9	2	Tripod
10	1	Compaq Contura 386

Photo 5.2.3 “Wild RC-30 Camera”

Table 5.2.4 “Photo Processing Equipment”

No.	Volume	Equipment
1	1	Lekta Laboratories printing box including transformer
2	1	Zeiss Aerotopo rewind film processor FE 120
3	1	Zeiss Aerophoto aerial film dryer TG 24
4	1	Rowi printer dryer model 1534 and calbes
5	2	Patterson developing trays 30 cm×30 cm
6	1	Kodak GRALAB timer type 300
7	2	Darkroom safe lights
8	1	Graphtec model MP5000 plotter

Photo 5.2.4 “GPS Observation for GPS Aerial Photography”

5.3 Progress of Aerial Photography

The progress of aerial photography was as follows:

From 26th December 2002 to 28th December 2002

Mobilization of aircraft and equipment to Dhaka City

From 29 December 2002 to 2nd January 2003

Custom clearance, preparation and discussion of flight plan

3rd January 2003

Flight operation of aerial photography

4th January 2003

Renovation of dark room in SOB

From 5th January 2003 to 15th January 2003

Photo processing

From 16th January 2003 to 17th January 2003

Demobilization of aircraft and equipment from Dhaka

19th January 2003

Delivery of final results from Fugro Spatial Solution Pty. Ltd. to the Study team

The application for flight clearance of aerial photography was submitted to the Ministry of Defense from SOB and flight permission was issued on 31st December 2002. Aircraft was mobilized to Dhaka Zia Air Port on 27th December 2002. The necessary custom clearance for aircraft and equipment to be used for aerial photography was finished on 1st January 2003 and the test flight was executed on 2nd January 2003.

The weather condition in December 2002 was not suitable for aerial photography due to the fog in the morning and the dust in daytime despite the so-called best month for aerial photography.

On 2nd January 2003, the aerial photography team of Fugro Spatial Solution Pty. Ltd. executed the test flight and the preparation for aerial photography was completed. The next day of the test flight (3rd January 2003), the weather was very fine and the dust in the air was few due to the reason of Friday (less traffic volume comparing working day). This day, 3rd January 2003, was only one suitable day for aerial photography during the 1st fieldwork in Bangladesh.

The flight operation for 1:20,000 scale aerial photography was completed in 3rd January 2003. The renovation of dark room in SOB was started immediately after completion of flight operation. The necessary photo processing was started after completion of renovation of the dark room in SOB. On 15 January 2003, the final products were submitted from Fugro Spatial Solution Pty. Ltd. to the Study team and the staff of SOB executed the masking on the positive films immediately.

5.4 Development and Check of Aerial Photographs

The list of 1:20,000 scale aerial photos is shown in Table 5.4.1 “List of Aerial Photos” and flight index map is shown in Figure 5.4.1 “Aerial Photo Index Map”.

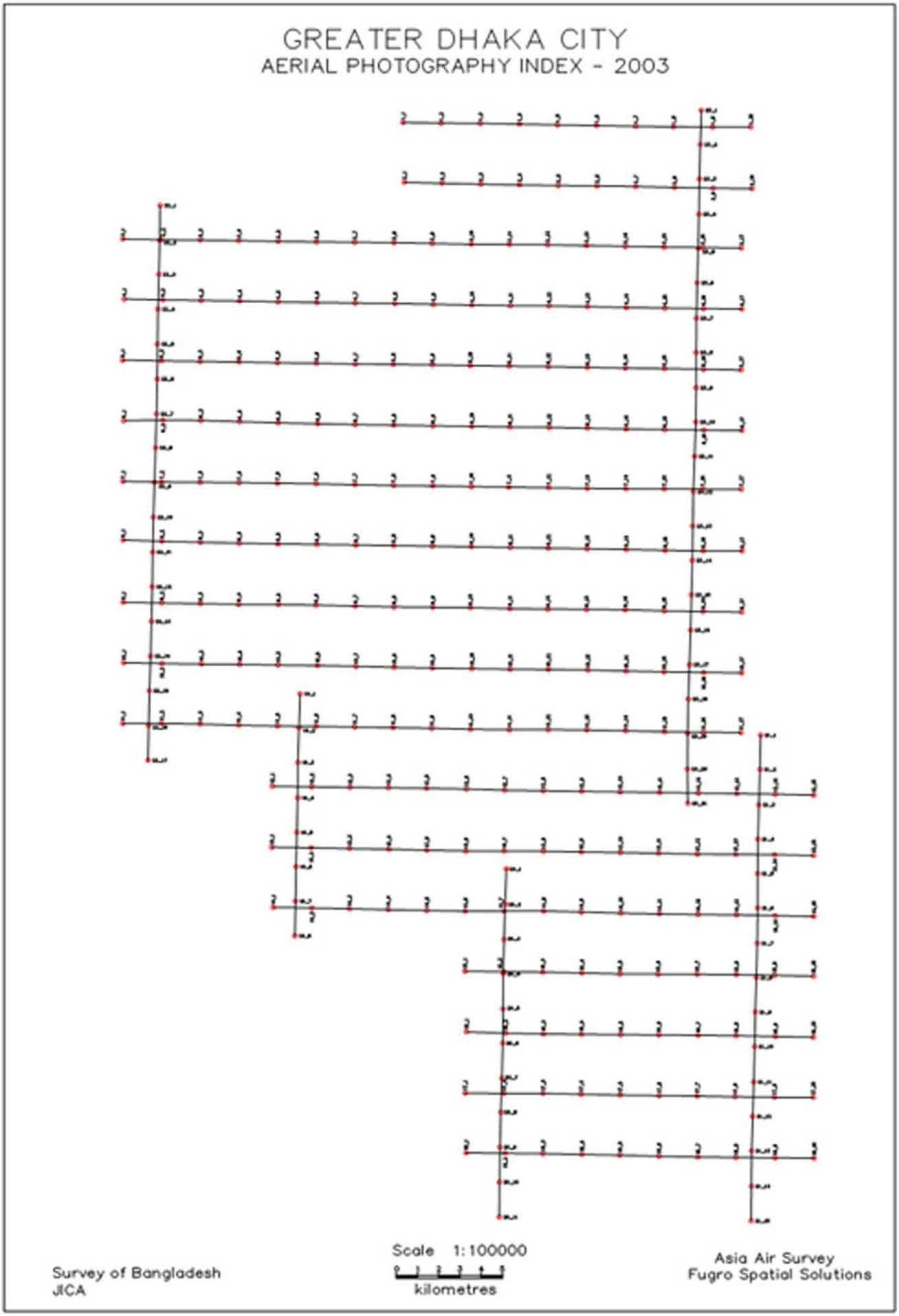


Figure 5.4.1 "Aerial Photo Index Map"

Table 5.4.1 "List of Aerial Photograph"

Film No.	Run No.	Photo No.	Number of Photo.	Date of Photography
1	1	1 ～ 10	10 sheets	3rd January 2003
1	2	1 ～ 10	10 sheets	3rd January 2003
1	3	1 ～ 17	17 sheets	3rd January 2003
1	4	1 ～ 17	17 sheets	3rd January 2003
1	5	1 ～ 17	17 sheets	3rd January 2003
1	6	1 ～ 17	17 sheets	3rd January 2003
1	7	1 ～ 17	17 sheets	3rd January 2003
1	8	1 ～ 17	17 sheets	3rd January 2003
1	9	1 ～ 17	17 sheets	3rd January 2003
1	10	1 ～ 17	17 sheets	3rd January 2003
1	11	1 ～ 17	17 sheets	3rd January 2003
1	12	1 ～ 15	15 sheets	3rd January 2003
1	13	1 ～ 15	15 sheets	3rd January 2003
1	14	1 ～ 15	15 sheets	3rd January 2003
1	15	1 ～ 10	10 sheets	3rd January 2003
2	16	1 ～ 10	10 sheets	3rd January 2003
2	17	1 ～ 10	10 sheets	3rd January 2003
2	18	1 ～ 10	10 sheets	3rd January 2003
2	19	1 ～ 8	8 sheets	3rd January 2003
2	20	1 ～ 11	11 sheets	3rd January 2003
2	21	1 ～ 15	15 sheets	3rd January 2003
2	22	1 ～ 17	17 sheets	3rd January 2003
2	23	1 ～ 21	21 sheets	3rd January 2003
Total	23 runs		330 sheets	

Immediately after the renovation of the dark room of SOB, development of negative films was executed. SOB has no automatic developing device for negative film. Therefore, development of negative films was executed by using handy manual development device (refer to Photo 5.4.1 "Developing Device Used", Photo 5.4.2 "Printing of Contact Prints" and Photo 5.4.3 "Development Procedure").

Photo 5.4.1 "Developing Device Used"

Photo 5.4.2 "Printing of Contact Print"

Photo 5.4.3 “Development Procedure”

After completion of development of negative films, contact prints were prepared. Using these contact prints, quality check by the photo processing engineer of Fugro Spatial Solution Pty. Ltd., staff of SOB and the member of the Study team was executed (refer to Photo 5.4.4 “Check of Aerial Photos” and Photo 5.4.5 “Check of Aerial Photographs”).

Photo 5.4.4 “Check of Aerial Photos”

Photo 5.4.5 “Check of Aerial Photos”

5.5 Masking on the Positive Films and Permission for Use of the Positive Films Outside of Bangladesh

Masking on the positive films is to delete the Key Point Installation (restrict areas, buildings and facilities for mapping) on the aerial photographs. This masking on the positive films is the condition to bring out the positive films from Bangladesh to Japan for necessary processing of digital topographic mapping in Japan (refer to photo 5.5.1 “Masking of the Positive Films”).

The masking on the positive films was executed to scrape the surface of the positive films and paint there with black ink one by one. It took about two weeks to mask all the positive films.

At the time of Inception Report meeting, SOB explained that it will take approximately 3 days for masking the positive films. However, it took more than 2 weeks for masking the positive films. The reason of this delay was as follows:

Photo 5.5.1 "Masking of the Positive Films"

1) There are only two staffs in SOB who know the locations of Key Point Installation. Therefore, other staffs of SOB could not execute the masking work.

2) Finally, the total numbers of Key Point Installation were approximately 80 locations. Considering the over-lap and side-lap of aerial photos, approximately 300 locations had to be masked.

Masking the positive films was completed on 28th January 2003. Finally, the masked positive films were delivered from SOB to the Study team with the approval letter of bringing out from Bangladesh to Japan on 29 January 2003 (refer to Appendix 9 "Issue of Film Positives and Topographic Maps Outside Bangladesh for Necessary Processing in Japan".

5.6 Scanning of the Positive Film

The positive films were scanned (1 pixel = 20 micron) in Japan and digital photo image data was stored in CD-ROM. This digital data were used for aerial triangulation and acquisition of digital topographic data.

5.7 1:50,000 Scale Orthophoto Making for Map Sheet Plan

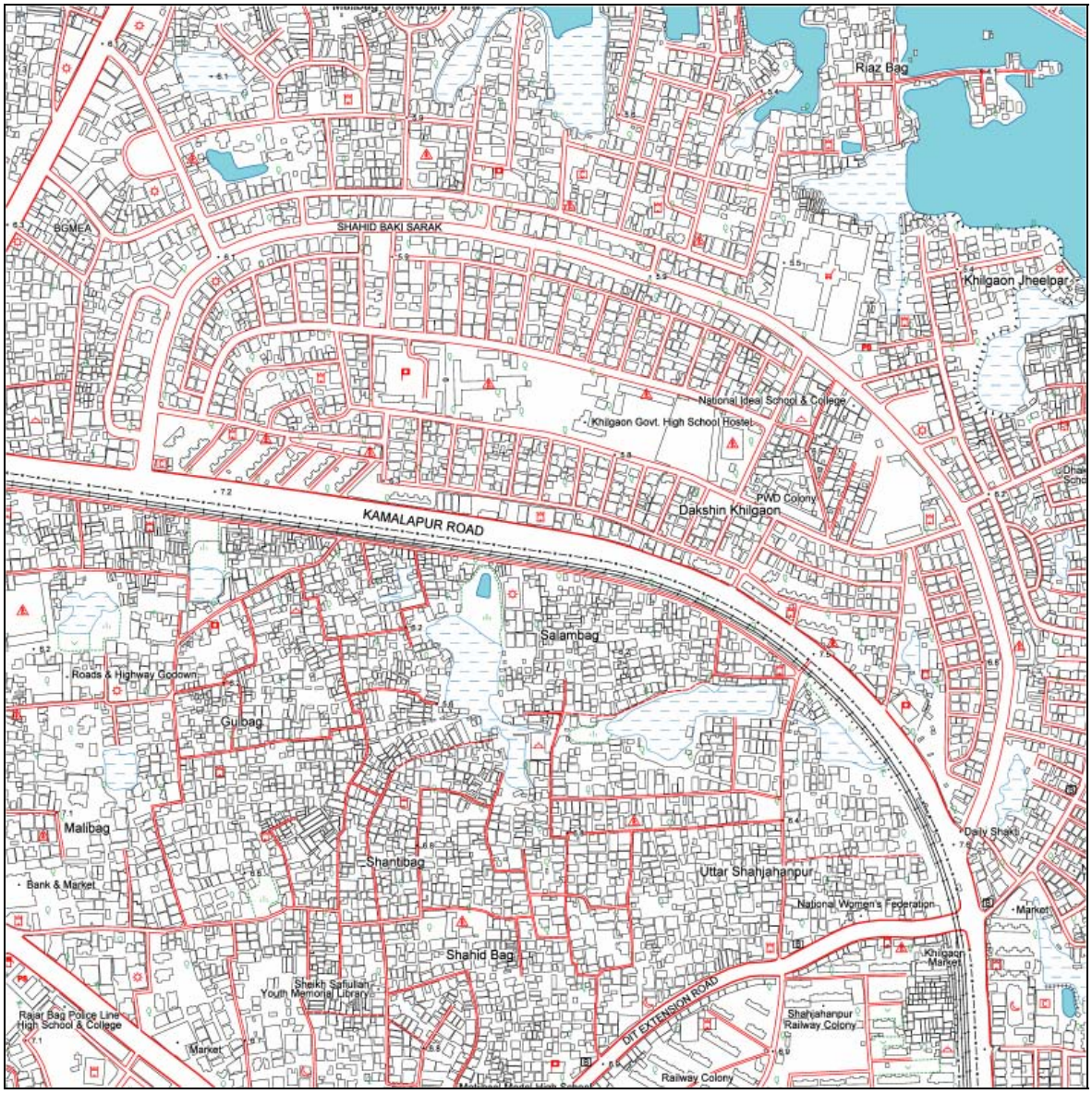
Using the digital image of aerial photographs and the coordinates of principal points of aerial photographs obtained by GPS aerial photography, 1:50,000 scale orthophoto images were prepared in the 1st year's Study.

1:5,000 scale digital topographic mapping area was transferred on this 1:50,000 scale orthophoto image from the 1:50,000 scale topographic maps and 1:5,000 scale digital topographic map sheet plan was made using this 1:50,000 scale orthophoto image.

5.8 1:5,000 Scale Orthophoto Making

Using the digital images of aerial photographs and the results of aerial triangulation, 1:5,000 scale orthophoto images were produced sheet by sheet. 1:5,000 scale orthophoto was used for determination of the exact boundary of 1:5,000 scale digital topographic mapping area and also for the field identification.

Chapter 6 Ground Control Point Survey



Sample of 1:5,000 scale digital topographic map

Location: Khilgaon Area in Dhaka City

Chapter 6 Ground Control Point Survey

For the 1:5,000 scale digital topographic mapping, ground control point survey has been executed to cover the whole 1:20,000 scale aerial photography area. The outline of ground control point survey was as follows:

6.1 Standard of Survey and Mapping

The standard of survey and mapping applied for the Study is as follows:

1) Spheroid: Everest 1830
2) Horizontal datum: Datum point at Gulshan
3) Elevation datum: Mean sea level at Bay of Bengal
4) Projection: BTM（Bangladesh Transverse Mercator Projection）

According to the Universal Transverse Mercator projection (UTM), zone is divided at an interval of 6 degrees of longitude. The longitude at almost the center of the territory of Bangladesh is 90 degrees. Therefore, in case this UTM projection is applied to Bangladesh, the territory of Bangladesh will be divided into two zones of UTM projection. Therefore, in Bangladesh, Bangladesh Transverse Mercator Projection (BTM), the central meridian is sifted 3 degrees, is applied for the projection.

Photo 6.1.1 “Horizontal Datum Point”

Photo 6.1.2 “Vertical Datum Point”

6.2 Field Location of Control Points and Checking of the Existing Points

Prior to the establishment of photo signal, field location of GPS points and checking of the existing GPS points and benchmarks were executed jointly by the counterparts of SOB and the members of the Study team.

Finally, following numbers of new GPS points, existing GPS points and existing benchmarks were located and checked in the site.

1) Field location of the new GPS point: 24 points
2) Checking of the existing GPS point: 6 points

3) Checking of the existing benchmark: 20 points

Photo 6.2.1 "Field location of Control Point"

Photo 6.2.2 "Field location of Control Point"

6.3 Establishment of Photo Signals

As already explained on the Inception Report meeting, aerial photography is the first priority work in the 1st fieldwork in Bangladesh. Therefore, considering the time schedule of aerial photography, photo signals on GPS points were decided to establish as much as possible before the starting of aerial photography and pricking method was applied for the remaining GPS points.

Photo signals were established preferentially on the points of every corners of aerial photography area. These points are the most important points to keep the horizontal accuracy of aerial triangulation. Finally, photo signals of 13 points at the corners of aerial photography area and 1 point on the roof of SOB building were established before starting aerial photography (refer to Figure 6.3.1 "Location of Photo Signal and Pricking Point").

To make clear the location of photo signals established on GPS points, descriptions of photo signals with stereo aerial photos were prepared (refer to Figure 6.3.2 "Sample of Description of Photo Signal" and Appendix 18 "Descriptions of Photo Signals & Pricking Points". The size and type of photo signal were as follows:

1) Type of photo signal: 4 blades
2) Size of photo signal: 0.5 m × 2.0 m (one blade)

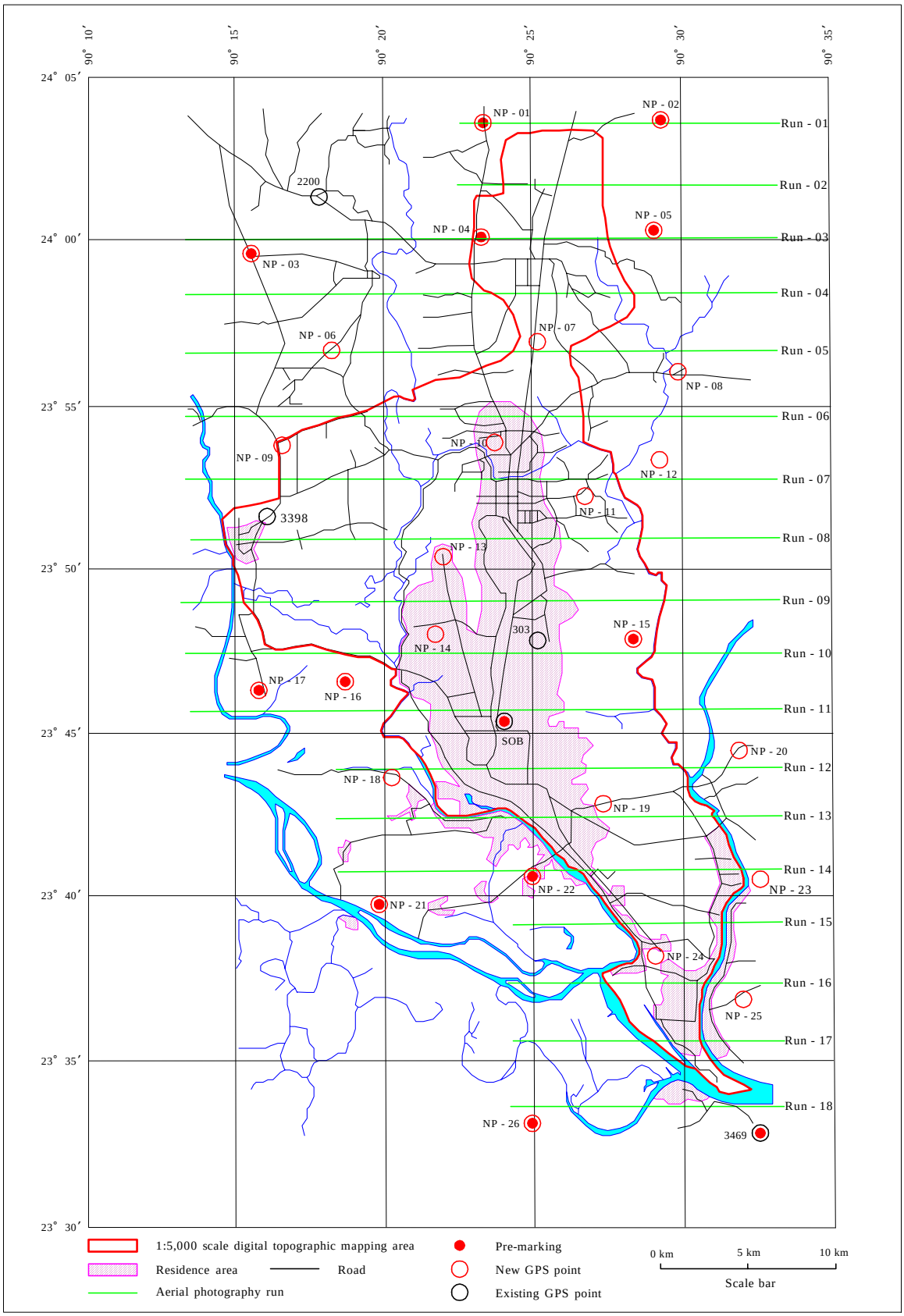
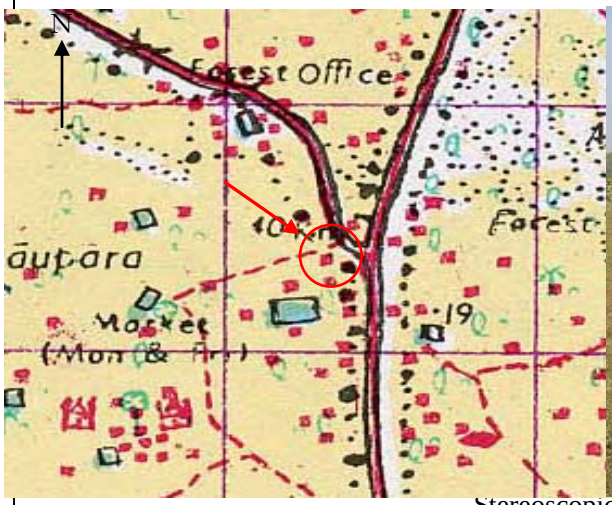


Figure 6.3.1 "Location of Photo Signals and Pricking Points"

DESCRIPTION OF AIR PHOTO SIGNAL

Station		Operated by	
NP-01		Checked by	
		Date	December 30 , 2002
Zone	Coordinate/Elevation		
	N (m)	E (m)	H (m)
Main Point	**2,660,708.89**	**539,519.69**	**13.09**
Eccentric Point	———————	———————	———

Location Map



Ground Photo

Stereoscopic Photograph

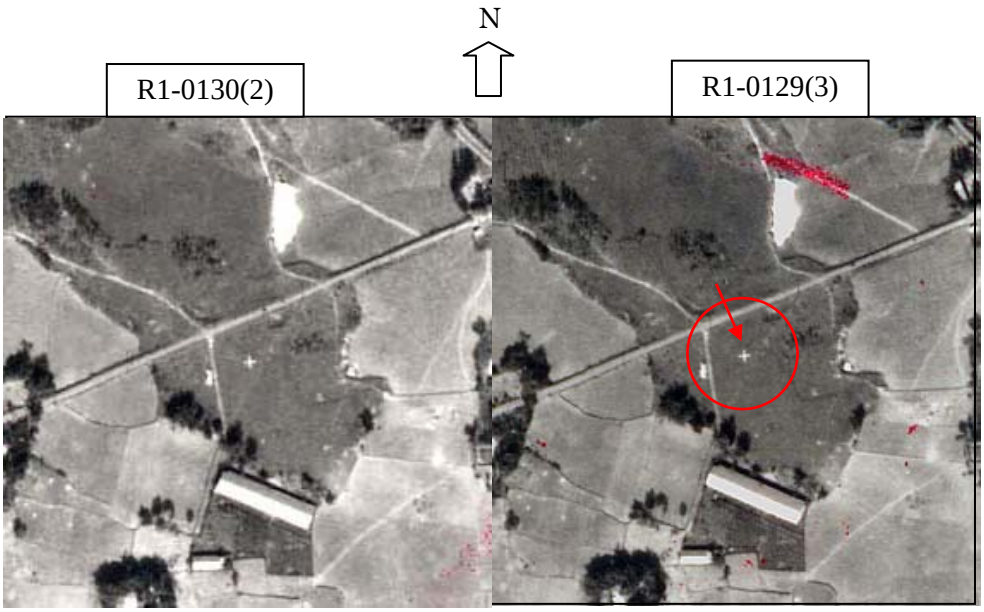


Figure 6.3.2 “Sample of Description of Photo Signal”

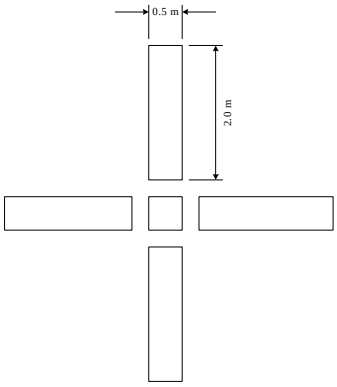


Figure 6.3.3 "Size of Photo Signal"

Photo 6.3.1 "Establishment of Photo Signal"

6.4 Pricking

New 13 GPS points and the existing 2 GPS points were pricked on the aerial photographs directly or indirectly (eccentric observation). Eccentric observation was executed by using plane table and alidade to measure the eccentric angle and distance for the calculation of horizontal coordinates. Descriptions of pricking points with stereo aerial photographs were prepared after observation (refer to Appendix 18 "Description of Photo Signal and Pricking Point".

Photo 6.4.1 "Pricking"

Photo 6.4.2 "Pricking
(Right: Mr. Saito of JICA Expert)"

Furthermore, pricking of the existing 17 benchmarks was executed to keep the vertical accuracy of aerial triangulation (refer to Appendix 19 "Description of Benchmark").

6.5 Monumentation

On the Inception Report meeting, the Study team agreed to supply the necessary materials for establishment of concrete monuments on the new GPS points to SOB. However, due to the shortage of manpower of SOB, establishment of concrete monuments on the new GPS points was not executed before starting the execution of aerial photography and GPS observation in the 1st field work.

However, SOB still hoped to establish the concrete monuments on the new GPS points even though the GPS observation had already finished. In case of monumentation after the GPS observation, it is impossible to decide the horizontal coordinates directly by the GPS observation and an additional observation is necessary to decide the horizontal coordinates.

The Study team explained SOB that it is difficult to instruct or advise this additional observation to the counterparts of SOB from the view point of work schedule of the Study and also assignment schedule of the Study team.

Finally, SOB and the Study team agreed that the monumentation on new GPS points and necessary additional observation would be executed by the responsibility of SOB and the Study team would supply the necessary materials for monumentation to SOB. The monumentaiton on the new GPS points has been executed in the 2nd fieldwork in Bangladesh and total number of monumentation was 22 points.

6.6 GPS Observation

According to the alteration of 1:20,000 scale aerial photography area requested by SOB, it was necessary to amend the locations of ground control points necessary for aerial triangulation. Furthermore, SOB informed to the Study team that three large Key Point Installations (restrict area or building for mapping, two of the three are air ports) exist in the 1:20,000 scale aerial photography area.

The stereo models in these areas would become imperfect models for the aerial triangulation by the masking of Key Point Installation. Therefore, locations of new GPS points were decided considering above-mentioned situation and final GPS point distribution plan is shown in Figure 6.6.1 “GPS Observation Network”. The outline of GPS observation is as follows:

1)	Existing GPS point:	6 points	
2)	New GPS point:	24 points	
3)	Number of GPS survey party:	5 parties	
4)	Equipment used:	Trimble 4000 SSE	2 sets
		Trimble 4000 SSI	3 sets
5)	Observation time:	1 session (70 minutes)	

The counterpart leaders of each GPS observation party were as follows:

Table 6.6.1 "Counterpart Leaders of GPS Observation Teams"

Group	Leader
1	Mr. Saidur Rahaman
2	Mr. Nurur Rahaman
3	Mr. Nizam Uddin
4	Mr. Nuru Safa
5	Mr. Prabir Kumar Das

The results of GPS observation are shown in Table 6.6.2 "Coordinates of Control Points" and the accuracy of GPS observation is shown in Table 6.6.3 "Accuracy of GPS Observation (Standard Deviation)".

Photo 6.6.1 "GPS Observation"

Photo 6.6.2 "GPS Observation"

6.7 Leveling

SOB has own leveling network. In and around Dhaka City, leveling routes are spreading in a radial manner from the center of Dhaka City. There are 20 benchmarks (first order and second order benchmarks) in the 1:20,000 scale aerial photography area and these benchmarks are available for the Study.

Accordingly, leveling survey route plan was changed from the original plan to use the existing benchmarks as much as possible. Finally, leveling route plan as shown in Figure 6.7.1 "Leveling Route Plan" was decided considering the distribution of vertical control points to keep the vertical accuracy of aerial triangulation. Outline of leveling was as follows:

1) Total distance of leveling route: Approximately 160 km
2) Observation method: Double runs observation
3) Points established by the leveling: GPS point: 12 points
   Leveling point: 34 points
4) Accuracy: $50mm\sqrt{S}$: S = leveling distance in km
5) Number of leveling party: 3 parties

6) Equipment: Wild NA 3003 3 sets

Descriptions of leveling points were prepared as shown in Figure 6.7.2 “Sample of Description of Leveling Points” and Appendix 20 “Description of Leveling Point”. The elevations of GPS points, leveling points and pricking points of the existing benchmarks decided by leveling are shown in Table 6.7.1 “Elevation of Control Points”, Table 6.7.2 “Elevation of Benchmark and Leveling Point”. The accuracy of leveling is shown in Table 6.7.3 “Accuracy of Leveling”.

The counterpart leaders of each leveling parties were as follows:

Table 6.7.4 “Counterpart Leaders of leveling Parties”

Group	Leader
1	Mr. Nizam Uddin
2	Mr. Azmat Hossan
3	Mr. Ashraf Hossan

Photo 6.7.1 “Leveling”

Photo 6.7.2 “Leveling”

6.8 Geoid Undulation Map

The geoid undulation map was prepared using the results of direct leveling and GPS observation (18 new GPS points and 4 existing GPS points) to estimate the elevations from mean sea level of GPS points that could not be decided by direct leveling (refer to Figure 6.8.1 “Geoid Undulation Map”).

Considering the accuracy of elevation decided by direct leveling and geoid undulation map, the elevations of GPS points were shown as following order.

1) Elevation decided by direct leveling 0.01 m order
2) Elevation estimated by the geoid undulation map 0.1 m order

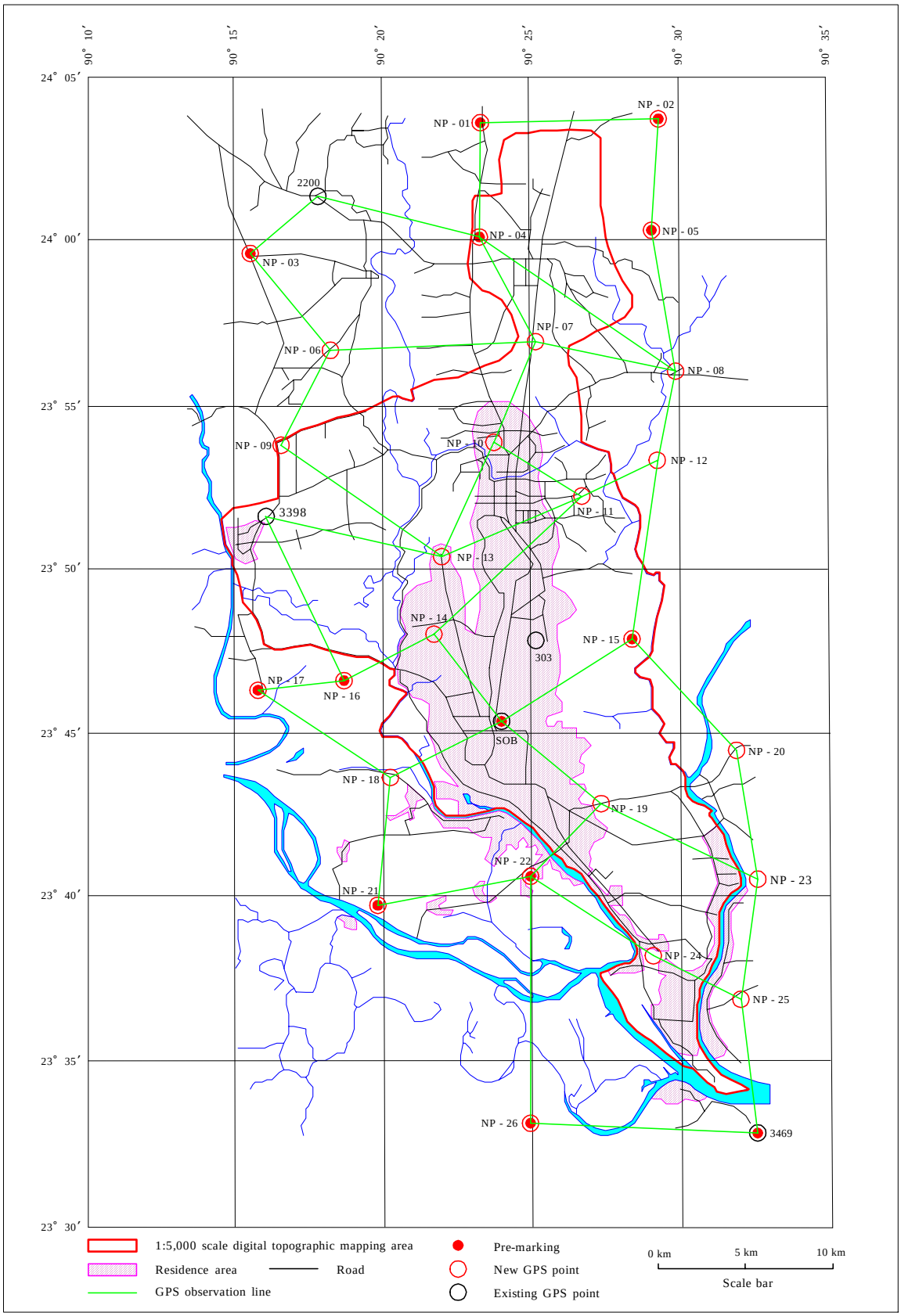


Figure 6.6.1 "GPS Observation Network"

Table 6.6.2 "Coordinates of Control Points"

WGS 84				B.T.M						
Station	B	L	Ellip. H	B	L	Ellip. H	N	E	γ	s/S
2200	24.01257589	90.17380627	-41.220	24.012329293	90.174823775	11.9007	2,656,599.856	530,171.482	-0_07_14.8887	0.999611
3398	23.51389455	90.15515199	-44.130	23.513643235	90.160166877	9.0730	2,638,547.261	527,195.658	-0_06_29.0023	0.999609
SOB	23.45236967	90.23514039	-34.360	23.452114342	90.240160499	19.5978	2,627,038.817	540,800.772	-0_09_40.7448	0.999621
3469	23.32507990	90.32181132	-48.540	23.324817378	90.322836165	6.3606	2,603,932.035	555,231.160	-0_12_58.3834	0.999638
3469EEC	23.32511390	90.32147946	-50.142	23.324851387	90.322504265	4.7540	2,603,942.138	555,137.033	-0_12_57.0603	0.999638
NP 01	24.03386325	90.23093935	-40.600	24.033617150	90.231961325	12.8946	2,660,708.889	539,519.694	-0_09_30.6210	0.999619
NP 02	24.03449128	90.29087059	-47.510	24.034244572	90.291897096	6.4425	2,660,933.510	549,666.051	-0_11_57.1850	0.999630
NP 03	23.59404411	90.15204533	-45.020	23.593796884	90.153060868	7.9644	2,653,353.338	526,290.190	-0_06_18.4240	0.999609
NP 04	24.00114065	90.23035852	-43.850	24.000892830	90.231379965	9.7135	2,654,335.370	539,373.077	-0_09_26.9717	0.999619
NP 05	24.00222720	90.28527235	-50.350	24.001978823	90.290298212	3.6568	2,654,699.843	549,236.034	-0_11_49.1015	0.999630
NP 06	23.56447235	90.18025982	-44.660	23.564223350	90.181277022	8.5958	2,647,958.402	530,882.998	-0_07_23.5158	0.999612
NP 07	23.57001037	90.24569424	-47.870	23.565760737	90.250716692	5.9095	2,648,461.127	542,593.065	-0_10_11.8114	0.999622
NP 08	23.56060941	90.29416869	-49.190	23.560358799	90.295194602	4.9751	2,646,826.072	550,647.005	-0_12_06.9886	0.999632
NP 09	23.53490077	90.16208647	-38.240	23.534650493	90.163102005	14.9517	2,642,548.685	528,017.928	-0_06_41.4467	0.999610
NP 10	23.53553942	90.23313075	-47.650	23.535288405	90.234151715	6.0888	2,642,773.683	540,188.422	-0_09_35.8785	0.999620
NP 11	23.52178472	90.26312584	-50.080	23.521532549	90.264148859	3.9261	2,639,788.745	545,285.981	-0_10_48.0974	0.999625
NP 12	23.53235758	90.29032151	-44.890	23.532105686	90.291346583	9.2865	2,641,824.215	549,576.617	-0_11_50.1135	0.999630
NP 13	23.50275477	90.21477855	-48.460	23.502502203	90.215797769	5.2244	2,636,373.855	537,277.705	-0_08_52.7175	0.999617
NP 14	23.48061110	90.21318177	-26.050	23.480357382	90.214200470	27.6674	2,632,023.059	536,837.010	-0_08_45.4444	0.999617
NP 15	23.47543964	90.28089615	-47.680	23.475185092	90.281919822	6.5511	2,631,695.563	548,075.971	-0_11_25.6550	0.999629
NP 16	23.46359238	90.18283526	-48.970	23.463338250	90.183851467	4.5471	2,629,237.337	531,651.641	-0_07_30.9452	0.999612
NP 17	23.46214622	90.15360474	-48.560	23.461892276	90.154618749	4.7429	2,628,782.855	526,775.937	-0_06_21.4075	0.999609
NP 18	23.43411685	90.20011702	-50.690	23.433861086	90.201134015	3.0121	2,623,869.019	534,291.141	-0_08_07.4304	0.999615
NP 19	23.42505289	90.27085046	-51.330	23.424795926	90.271872712	2.9393	2,622,345.087	546,394.926	-0_10_59.0432	0.999627
NP 20	23.44327047	90.31398086	-50.530	23.443013853	90.315006743	4.0494	2,625,513.765	554,065.424	-0_12_49.0386	0.999636
NP 21	23.39494160	90.19353181	-49.710	23.394683952	90.194547981	4.0478	2,616,740.298	533,575.531	-0_07_55.8045	0.999614
NP 22	23.40388220	90.24430341	-49.900	23.403624402	90.245323551	4.2330	2,618,282.217	542,287.563	-0_09_59.6562	0.999622
NP 23	23.40324638	90.32235001	-49.880	23.402987688	90.323375922	4.8481	2,618,130.186	555,330.307	-0_13_04.5471	0.999638
NP 24	23.38094305	90.28496662	-50.580	23.380683559	90.285989538	3.9277	2,613,709.830	549,288.483	-0_11_37.5596	0.999630
NP 25	23.36547138	90.31444095	-50.980	23.365210942	90.315465894	3.7820	2,611,429.551	554,247.899	-0_12_46.9936	0.999636
NP 26	23.33112514	90.24406611	-51.230	23.330863626	90.245085262	3.0733	2,604,518.055	542,259.932	-0_09_55.7349	0.999622

Table 2.6.3 "Accracy of GPS Oservation (Standard Deviation)"

Station No.	Geodetic Position		Ellipsoidal Height	
	Standard Deviation (m)	Tolerance (m)	Standard Deviation (m)	Tolerance (m)
NP - 01	0.035	0.15	0.129	0.30
NP - 02	0.042	0.15	0.161	0.30
NP - 03	0.043	0.15	0.086	0.30
NP - 04	0.026	0.15	0.097	0.30
NP - 05	0.046	0.15	0.160	0.30
NP - 06	0.036	0.15	0.071	0.30
NP - 07	0.029	0.15	0.113	0.30
NP - 08	0.028	0.15	0.177	0.30
NP - 09	0.035	0.15	0.099	0.30
NP - 10	0.029	0.15	0.086	0.30
NP - 11	0.027	0.15	0.121	0.30
NP - 12	0.028	0.15	0.028	0.30
NP - 13	0.030	0.15	0.030	0.30
NP - 14	0.031	0.15	0.075	0.30
NP - 15	0.019	0.15	0.091	0.30
NP - 16	0.036	0.15	0.106	0.30
NP - 17	0.041	0.15	0.137	0.30
NP - 18	0.043	0.15	0.104	0.30
NP - 19	0.063	0.15	0.158	0.30
NP - 20	0.021	0.15	0.125	0.30
NP - 21	0.058	0.15	0.191	0.30
NP - 22	0.056	0.15	0.145	0.30
NP - 23	0.063	0.15	0.175	0.30
NP - 24	0.056	0.15	0.134	0.30
NP - 25	0.054	0.15	0.130	0.30
NP - 26	0.026	0.15	0.129	0.30

Accuracy of observatior 3 ppm × Observation distance

Divergence of baseline less than 30 mm

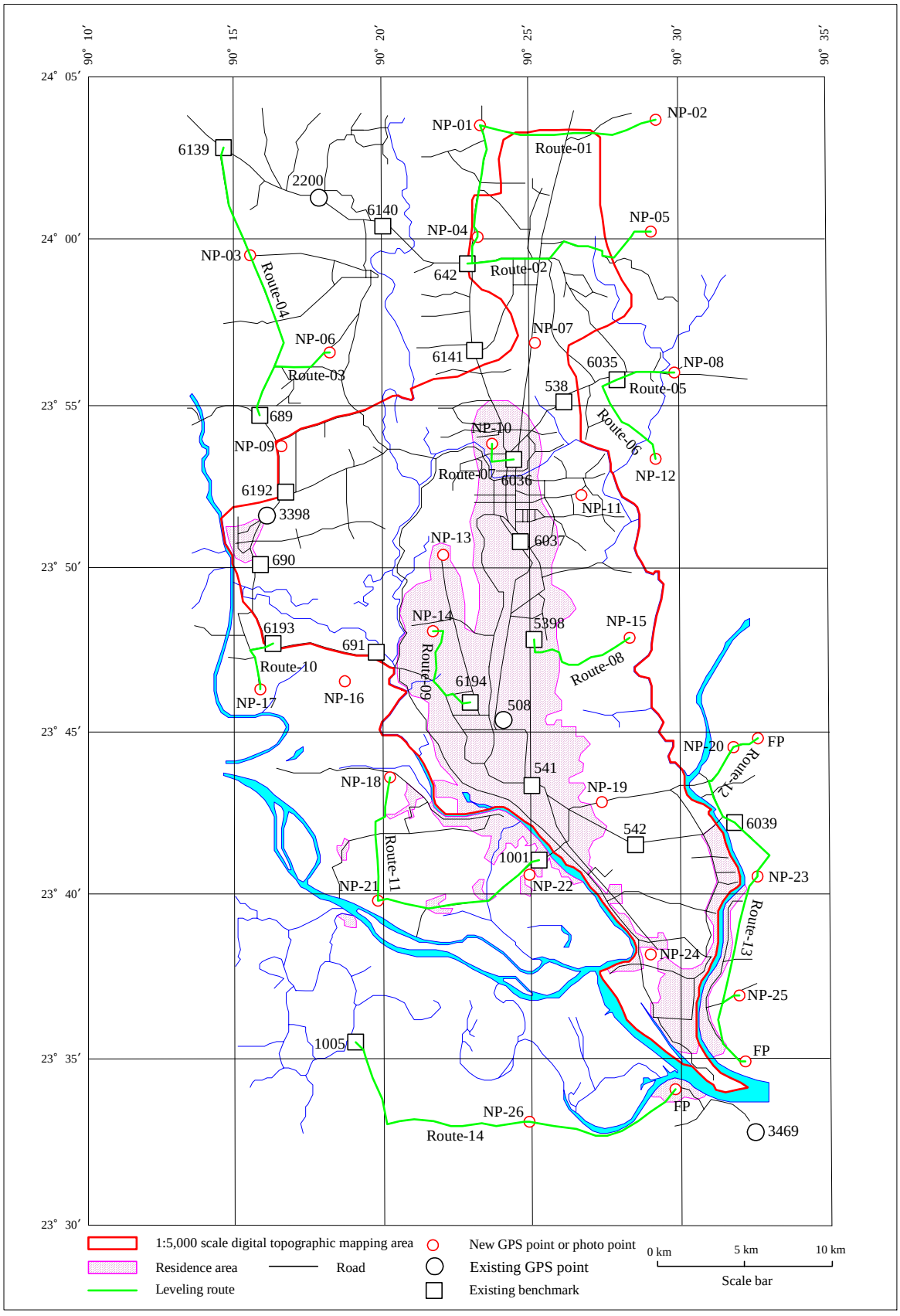


Figure 6.7.1 "Leveling Route Plan"

Description of Leveling point

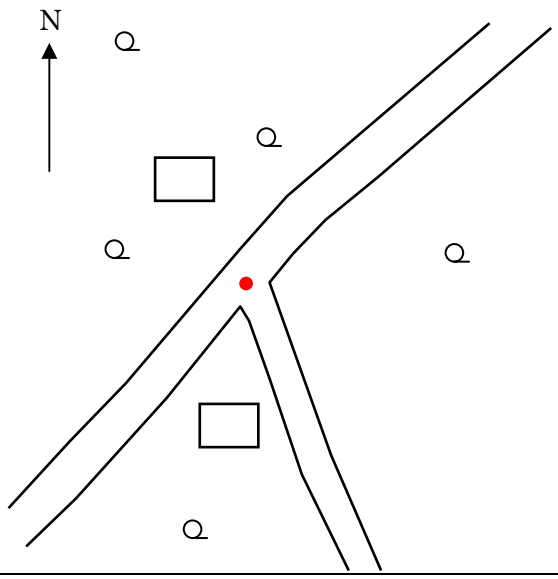
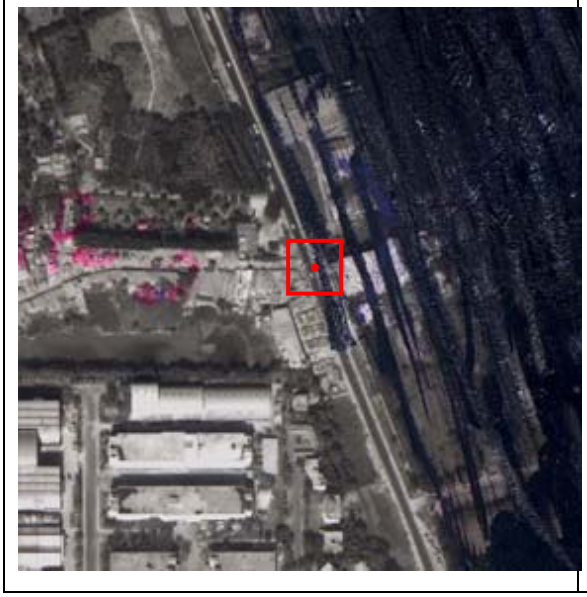
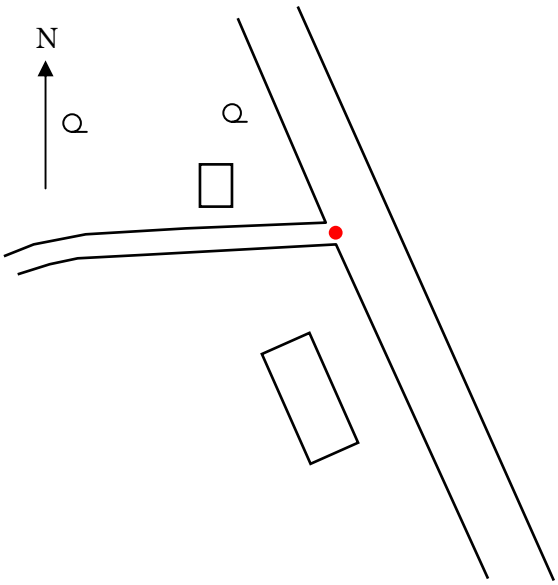
Station	P01	Coordinate (WGS84)	
Elevation of Point	9.63 m	Longitude	Latitude
Location	Route-01		
Photo No. R1_0126 (6)		Sketch	
			
Station	P02	Coordinate (WGS84)	
Elevation of Point	9.05 m	Longitude	Latitude
Location	Route-03		
Photo No. R5_0190 (3)		Sketch	
			

Figure 6.7.2 “Sample of Description of Leveling Point”

Table 6.7.1 "Elevation of Control Point"

Station No.	Main Point (m)	Eccentric Point (m)	Method of Survey
NP - 01	13.09		Direct leveling
NP - 02	5.94		Direct leveling
NP - 03	9.14		Direct leveling
NP - 04	9.91		Direct leveling
NP - 05	3.11		Direct leveling
NP - 06	9.43		Direct leveling
NP - 07	5.9	5.2	Interporation from geoid map
NP - 08	4.22		Direct leveling
NP - 09	15.9		Interporation from geoid map
NP - 10	6.22	3.29	Direct leveling
NP - 11	3.7		Interporation from geoid map
NP - 12	8.66		Direct leveling
NP - 13	5.6	5.6	Interporation from geoid map
NP - 14	28.03		Direct leveling
NP - 15	6.02		Direct leveling
NP - 16	5.4		Interporation from geoid map
NP - 17	6.03		Direct leveling
NP - 18	3.56		Direct leveling
NP - 19	2.6		Interporation from geoid map
NP - 20	-----	----	--------
NP - 21	4.79		Direct leveling
NP - 22	4.27		Direct leveling
NP -23	3.83		Direct leveling
NP -24	3.5		Interporation from geoid map
NP - 25	2.90		Direct leveling
NP - 26	3.05		Direct leveling

Table 6.7.2 "Elevation of Benchmark and Leveling Point"

Point No.	Main Elevation (m)	Pricked Elevation (m)	Point No.	Main Elevation (m)	Pricked Elevation (m)
6139	11.531		P01		9.626
6192	8.370	8.648	P02		9.049
6193	6.338	6.009	P03		9.125
6140	7.905	7.323	P04		9.277
6141	8.760		P05		9.644
6035	6.801	6.541	P06		8.060
6036	7.371	6.586	P07		7.882
6037	7.559	7.104	P08		9.392
642	11.737	11.173	P08-1		7.058
689	11.827	11.489	P08-2		7.700
690	7.735	7.994	P09		7.819
538	7.240	6.769	P10		9.815
691	6.621	7.999	P11		10.053
6194	7.101	6.41	P12		6.298
539B	6.566		P13		7.529
541	6.923	6.323	P14		5.102
542	5.528		P15		6.007
6039	6.009	4.794	P16		6.607
1001	6.776		P17		6.622
1005	6.602		P18		5.870
			P19		6.393
			P20		6.317
			P21		6.234
			P22		6.700
			P23		7.210
			P24		6.907
			P25		4.505
			P26		5.856
			P27		5.419
			P28		5.995
			P29		6.242
			P30		5.468
			P31		5.730
			P32		6.411

Table 6.7.3 "Accuracy of Leveling"

Route No.	Distance (km)	Station to Station	Misclosure (mm)	Allowable Misclosure (mm)
1	21.0	from BM642 to NP-02	152	229
2	12.0	from BM642 to NP-05	17	173
3	6.0	from BM689 to NP-06	14	122
4	17.0	from BM6139 to F4	16	206
5	3.0	BM6035 to NP08	9	86
6	7.0	BM6035 to NP12	2	132
7	4.0	BM6036 to NP-10	2	100
8	8.5	BM539B to NP-15	6	145
9	6.0	BM6194 to NP-14	25	122
10	4.0	BM6193 to NP-17	3	100
11	22.5	BM1001 to NP-18	6	237
12	7.0	BM6039 to F10	4	132
13	17.0	BM6039 to F95	42	206
14	25.0	BM1005 to F4	21	250
Total	160.0 km			

Allowable misclo: 50 mm$\sqrt{}$S, S = Distance in km

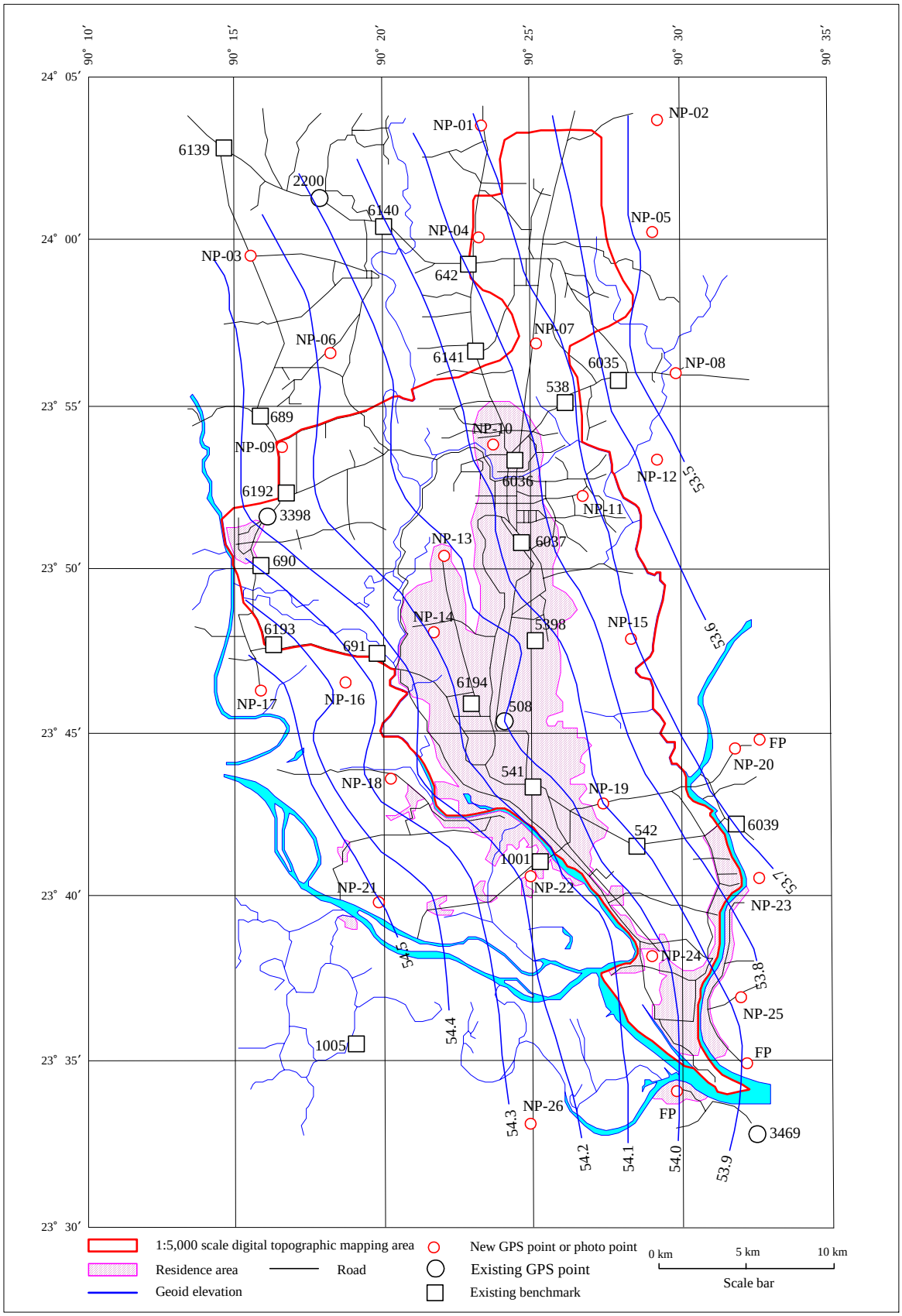


Figure 6.8.1 "Geoid Undulation Map"

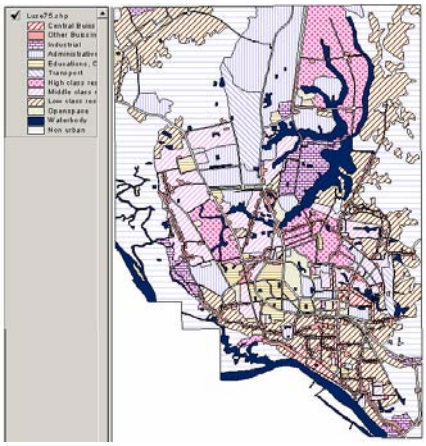
Chapter 7 Field Identification

Production of Land Use Map using Topographic Map

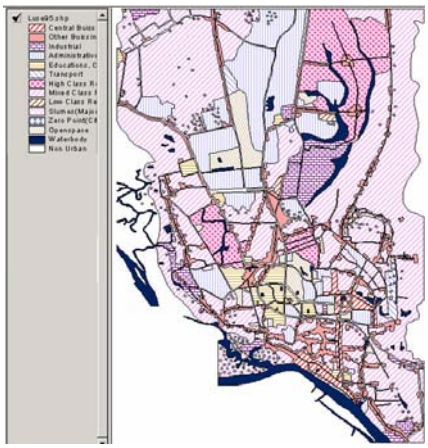
Land use map is a very important thematic map for the decision of the urban planning and it can cope with it at the same time about the monitoring of the present condition of the land development, grasping of the developable site and for the development. The land use map is produced by photo interpretation based on the orthophoto and topographic map data in the digital mapping and reference of existing land use map.

In Dhaka city, the city has been formed at the natural embankment but, according to the population concentration about 10 million and the development without order, residential area for lower income residence people become the slum to the surrounding of the city and the phenomenon of sprawlization of the urban area city progresses, so it is needed to install the proper land use management for urban planning.

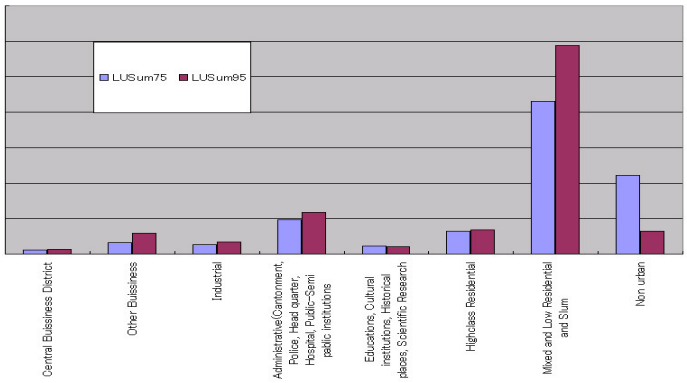
The follows is a result of compilation to thematic map from existing land uses map in 1975 and in 1995 in the Dhaka city and shows time series of change for land use development.



Land Use Map of Dhaka City – 1975



Land Use Map in 1995



Time Series of Land Use about Trend of Development

Chapter 7 Field Identification

Field identification for the collection of data and information necessary for 1:5,000 scale digital topographic maps were executed three times through the Study. The outline of field identification was as follows:

7.1 Technology Transfer of Field Identification

Up to present, SOB has no experience to produce medium to large-scale topographic maps. Therefore, SOB has no experience and knowledge of field identification for medium to large-scale topographic mapping. The field identification executed for 1:20,000 scale Dhaka Guide Map in 2001 is only the same kind of work to the field identification work for medium to large-scale topographic mapping.

SOB emphasized that the field identification of 1:20,000 scale Dhaka Guide Map was a difficult and time consumed work. Therefore, it was decided that the field identification for medium to large scale topographic mapping was one of the items of technology transfer in the Study, and practical and effective method of field identification for medium to large scale topographic mapping had to be transferred to the counterparts of SOB.

7.1.1 Methodological issues of the field identification for the 1:20,000 scale Dhaka Guide Map

According to the hearing from the counterparts of SOB through the implementation of the Study, the methodology of field identification for 1:20,000 scale Dhaka Guide Map was as follows:

1) Field identification was executed using 4 times enlarged aerial photographs (the photo scale was approximately 1:5,000).

2) Collection of the existing data and information from relevant organizations were not executed before starting the field identification.

3) The rickshaws (man-powered vehicle) were used for transportation method for fieldwork.

4) The results of field identification were compiled on the overlay sheet of 4 times enlarged aerial photos.

5) The public facility list was prepared by hand writing and the names of public facilities and roads were collected by hearing in the site.

6) The public facility list was not made by digital data such as excel data. Therefore, these data could not be used directly to the digital topographic mapping.

The workflow of the field identification for the Study is shown in Figure 7.1.1 "Workflow of Field Identification". It is presumed that the problems of SOB's methodology for the field identification of 1:20,000 scale Dhaka Guide Map are as follows:

1) The field identification was started without any preparatory work such as the existing data collection from relevant organizations. Therefore, staffs of SOB could not grasp the time necessary for field identification before starting the actual work.

2) The surveyors who engaged in the field identification could not check whether necessary topographic features were already checked or not in the site due to the reason of un-sufficient preparatory work.

3) There were many spelling mistakes in the name of public facilities. The main reason of this spelling mistake was mostly derived from the translation from Bangladesh language to English.

4) The results of field identification were assembled on the overlay of enlarged aerial photos. The information assembled on the overlay was transferred to 1:20,000 scale Dhaka Guide Map (manuscript) at the time of map compilation. It is recommended that the work steps should be minimized as much as possible to reduce the human errors.

Concerning the above-mentioned items 1) and 2) were caused mostly by the insufficient preparatory work before starting the field check. However, Concerning item 3), this problems will be happened not only Bangladesh but also other countries when the annotation was presented by English translated from the local language.

To solve the above-mentioned problems, it is necessary to collect the existing data as much as possible before starting field check and also to select and decide the items to be checked in the field. For this purpose, following preparatory work and work procedures are necessary for the smooth implementation of field identification.

1) Collection of the existing data and information from the relevant organizations as much as possible and examination of the contents and volume of field check.

2) Grasping what kind of public facilities is existing in which area by using the previously collected data and information.

3) Concerning the names of public facilities, names of administrative areas and so on should be collected from the organizations in charge as much as possible and a list of public facilities and so on should be prepared from the collected data and information. The spelling mistake should be checked on this list to avoid the human mistake.

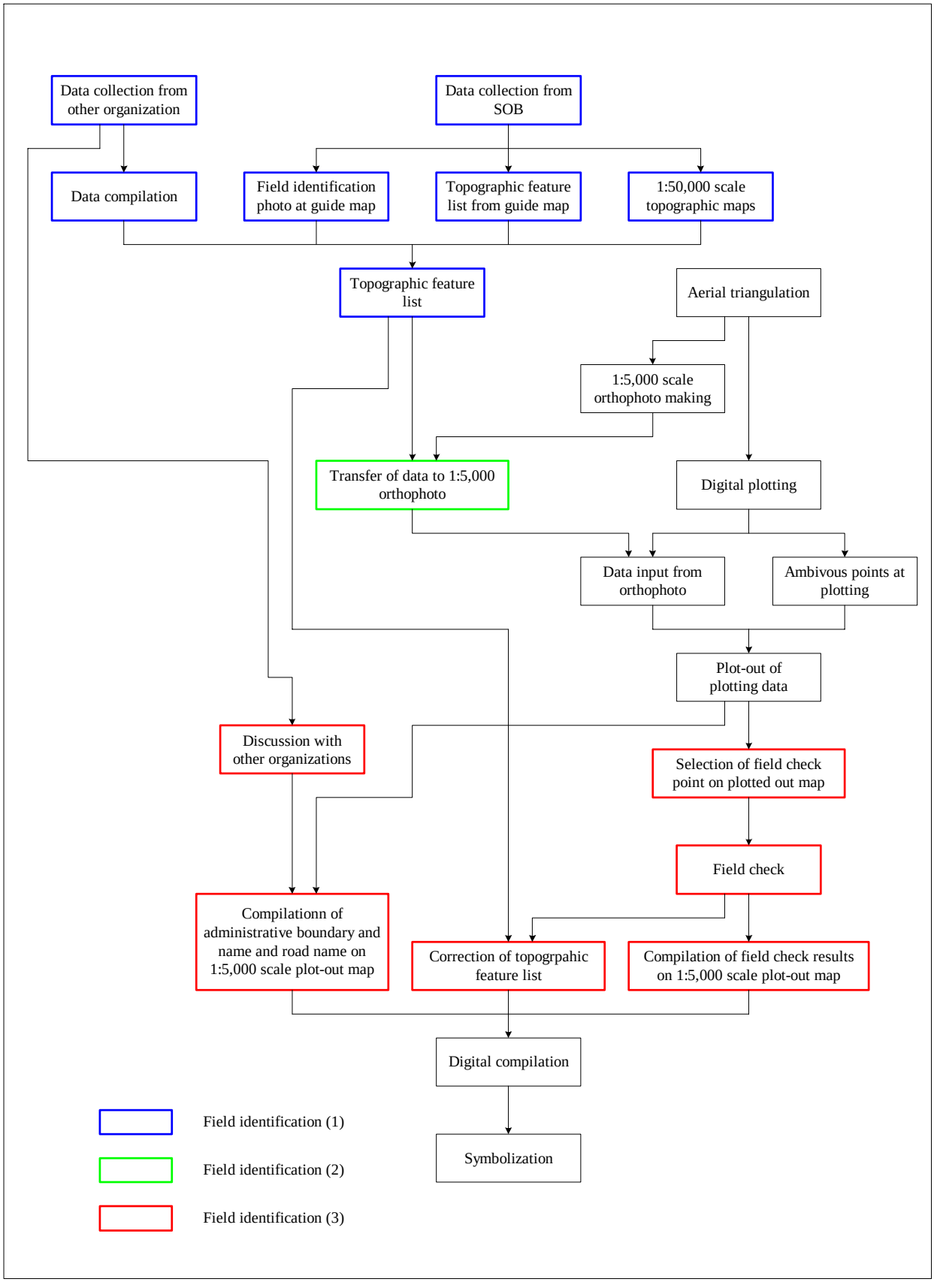


Figure 7.1.1 "Workflow of Field Indetification"

4) Some of surveyors participate to the field check may not be fluent in English. Therefore, engineers fluent in English have to check the English spelling written by the surveyors.

5) The results of field identification should be assembled directly on the 1:5,000 scale digital topographic map (plot-out manuscript map) to reduce a work steps and also to avoid the human mistake.

7.2 Method of Field Identification

The field identification for the collection of necessary information for 1:5,000 scale digital topographic maps were executed as follows:

1) Field identification (1)

The existing data and information were collected from the relevant organizations and the public facility lists were prepared in the Excel format at the 1st fieldwork in Bangladesh.

2) Field Identification (2)

At the beginning of the 2nd fieldwork in Bangladesh, the locations of public facilities were plotted on 1:5,000 scale orthophoto based on the collected data and information.

At the time of digital plotting and compilation of the 2nd year's Study, public facilities shown on 1:5,000 scale orthophoto were being digitized based on the collected data and information. Furthermore, the ambiguous features found at the stage of digital plotting were listed up and plot-out map manuscripts were produced for the field identification (3).

3) Field Identification (3)

During the later half of the 2nd year's Study, field completion was executed based on the results of field identification (2) and the ambiguous features found during the digital plotting.

The results of field identification were assembled on the 1:5,000 scale topographic maps (plot-out manuscripts). The road names, administrative names and other necessary information also assembled on 1:5,000 scale topographic maps (plot-out manuscripts).

7.2.1 Field identification (1)

Field identification (1) was executed in the 1st year's Study and the existing data in SOB and also from the relevant organizations were collected, and the public facility list was prepared. The data and information collected by the field identification (1) were as follows:

1) Data and information possessed by SOB

- Field identification data for the 1:20,000 scale Dhaka Guide Map production

(Public facility list, enlarged aerial photos used for field identification, etc.)

- 1:20,000 scale Dhaka Guide Maps
- 1:50,000 scale topographic maps

2) Data and information collected from relevant organizations

- GIS data produced by DCC (Thana Map)
- GIS data concerning school produced by BANBASE
- Public facility information collected from relevant organizations
- National statistic data

Based on the collected data and information, the public facility lists were prepared separately for each map sheet of the 1:5,000 scale topographic by Excel format. The public facility lists contain the following information.

1) Name of public facility
2) Code number
3) Map sheet number

Photo 7.2.1 "Assembling of Collected Data and Information"

Photo 7.2.2 "Creation of Public Facility List"

7.2.2 Field Identification (2)

Field identification (2) was executed in the first half of the 2nd year's Study and the collected data and information were plotted on the 1:5,000 scale orthophoto. In case the locations of public facilities were clearly identified on the 1:5,000 scale orthophoto, the location of public facilities were pointed out (?) directly on the 1:5,000 scale orthophoto. However, in case the locations of public facilities were not clearly identified on 1:5,000 scale orhtophoto, the approximate locations were shown on the 1:5,000 scale orthophoto with circle mark.

The information of public facilities shown on the 1:5,000 scale orthophoto were transferred into digital data at the stage of digital plotting and digital compilation using the results of field identification (1). The plot-out 1:5,000 scale topographic maps (map manuscripts) were prepared for field identification (3). Also, the ambiguous features found in the stage of digital plotting were verified and a public facility list was

prepared for field check in field identification (3).

Photo 7.2.3 "Assembling of Public Facility Information on Orthophoto Image"

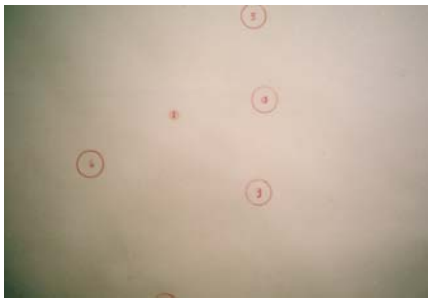


Photo 7.2.4 "Assembling of Public Facility Information on Overlay Sheet"

7.2.3 Field Identification (3)

Field identification (3) was executed in the latter half of the 2nd year's Work. Also, the public facility list was corrected based on the results of field check. Before execution of field check, features necessary to be checked in the field were sorted out under the cooperation of counterparts of SOB based on the 1:5,000 scale topographic maps (plot-out map manuscripts). The features to be checked in the site were selected by the following criteria:

1) The ambiguous features found in the digital plotting.

2) The large buildings without symbols of public facilities.

3) The public facilities shown on the results of field identification (2) are checked again if necessary. The opinions of counterparts concerning the public facilities, especially around the area near counterparts' residences should be respected.

The public facilities were checked in the site and the results were shown directly on the 1:5,000 scale topographic maps (plotted-out map manuscripts). The public facility list for each 1:5,000 scale topographic map sheet were corrected based on the results of field check.

Generally, the administrative names, administrative boundaries, names of roads and so on are already defined by the government organizations. Therefore, the Study team requested SOB to collect the necessary data concerning these items officially from the relevant organizations and put these information on the 1:5,000 scale topographic maps (plotted-out map manuscripts).

In parallel with the field check, the counterparts of SOB and the Study Team discussed the specifications and check on the contents of the 1:5,000 scale topographic maps (plotted-out map manuscripts). The main items and checkpoints of the discussion were as follows:

1) Marginal information

The numbering system of 1:5,000 scale topographic map sheet were altered considering the remaining area. Also, administrative names in the topographic sheet were shown on left top of the 1:5,000 scale topographic map sheet.

2) Map symbols, colors and letter sizes of annotation

Based on the 1:5,000 scale topographic sample map, sizes of map symbols, colors and letter sizes of annotation to be applied for the 1:5,000 scale digital topographic maps were finally decided. Also, new map symbols were created according to the new findings in the stage of digital plotting and compilation.

3) Line width

Based on the 1:5,000 scale topographic sample map, width of lines such as house, road and so on were finally decided.

4) Expression method (map symbol or annotation)

Through the discussion between the counterparts of SOB and the Study team, expression method of public facility (by map symbol, by annotation or both) was decided one by one.

5) Spelling check

The counterparts of SOB checked spelling of the names of public facilities.

6) Check of administrative name

The counterparts of SOB checked all the administrative names.

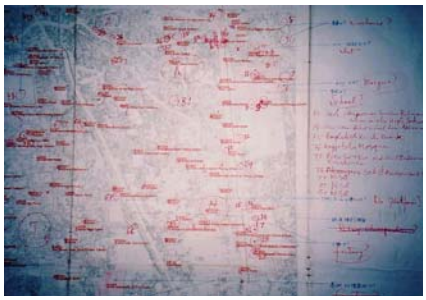


Photo 7.2.5 "Compilation of Field Identification Results on 1:5,000 Scale Topographic Map (Plotted-out Map Manuscript)"

Photo 7.2.6 "Correction of Public Facility List"

Photo 7.2.7 “Confirmation of Field Identification Results”

The main members of counterparts participated in field identification (3) were as follows:

Table 7.2.1 “Counterparts for Field Identification (3)”

No.	Name	Position
1	Mr. Ratan Kumar	Supervising Officer
2	Mr. Abul Hossain	Supervising Officer
3	Mr. Mohammed Hossain	Supervising Officer
4	Mr. Alimuzzaman Khan	Surveyor
5	Mr. Kamrul Hasan	Surveyor
6	Mr. Sirajul Haque	Surveyor
7	Mr. Delwar Hossain	Surveyor
8	Mr. Satadal Sharma	Surveyor
9	Mr. Ranjit Das	Surveyor
10	Mr. Nazrul Islam	Surveyor
11	Mr. Jahangir Hossain	Surveyor

Photo 7.2.8 “Main Members of Counterparts for Field Identification (3)”

Photo 7.2.9 “Main Members of Counterparts for Field Identification (3)”