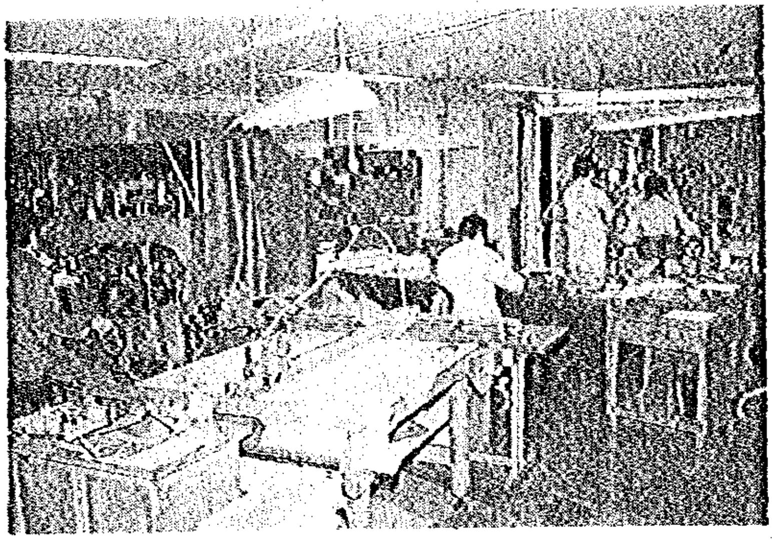
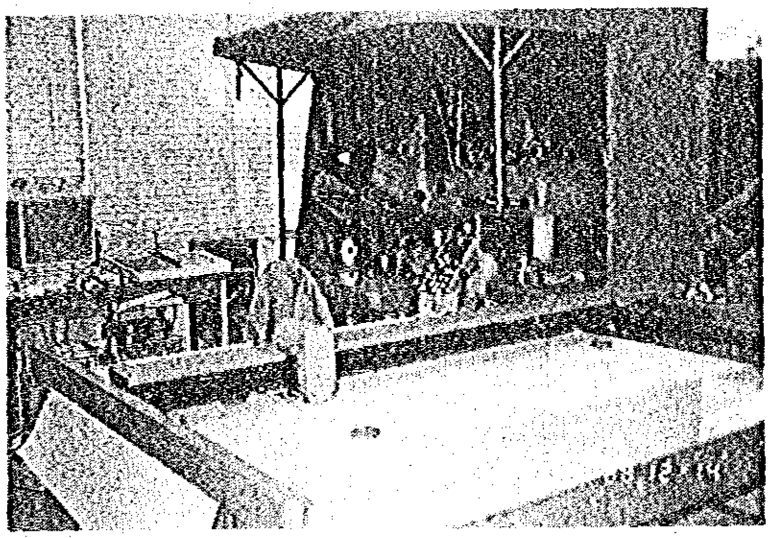
Photo - 10 Stereo Plotting and Compilation

1) Stereo plotting by Autograh A-8



2) Stereo plotting by AMH



3) Compilation of 1:50,000 topographic map

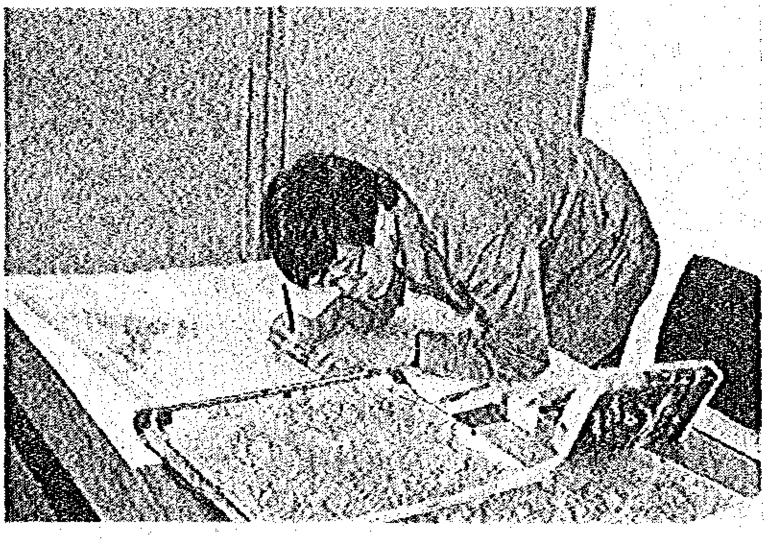
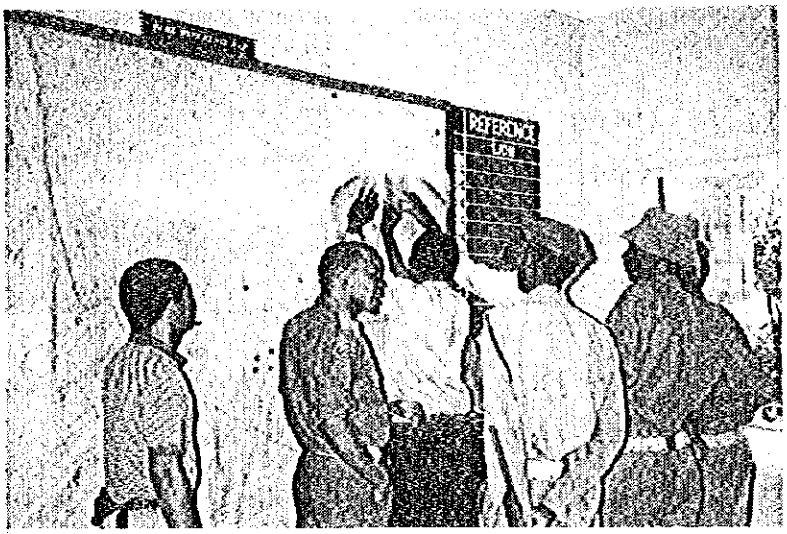
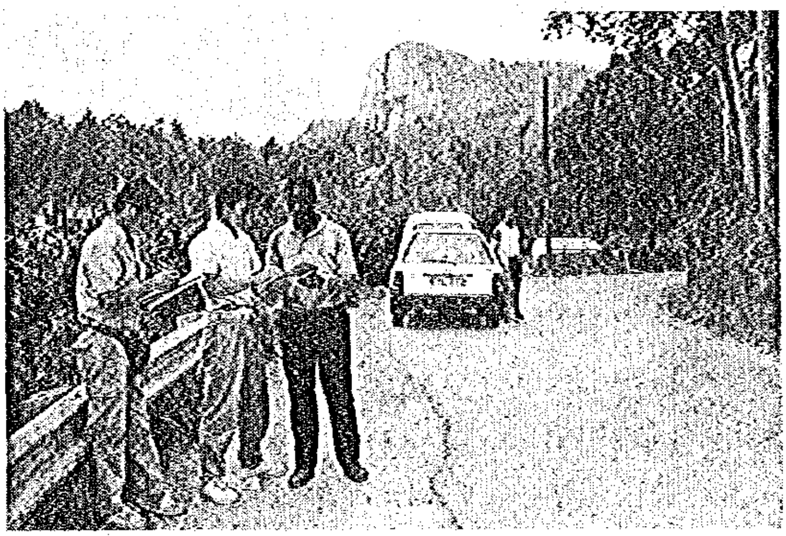


Photo - 11 Field Completion

1) Inquiry at a office of National Park



2) Hearing from residents at Taita Hills



3) Results of investigations

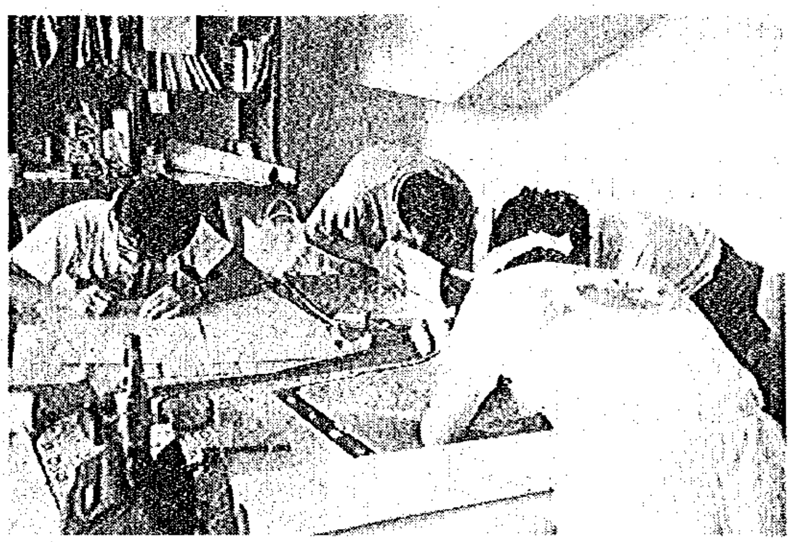
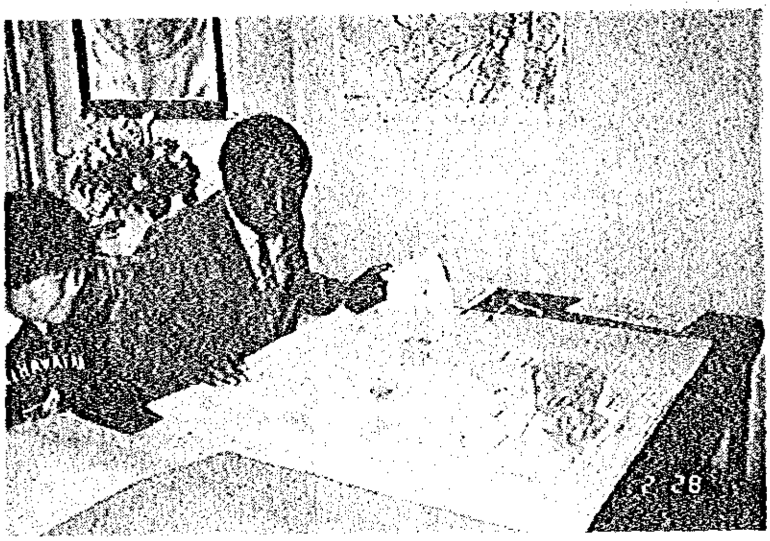


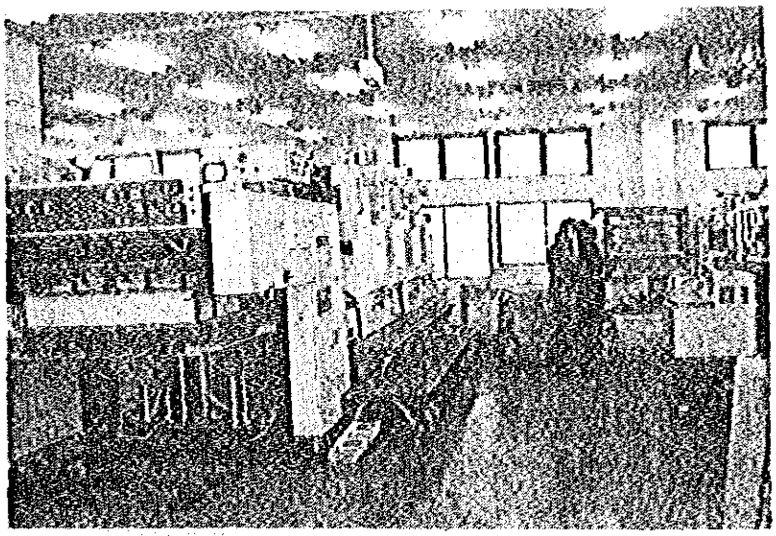
Photo - 12 Drafting and Printing

1) Scribing

2) Proof reading
by the SK counterpart



3) Printing machine



CONTENTS

ATTACHMENTS

1. INTRODUCTION

This Study of 1:50,000 scale "Topographic Mapping of South Kenya in the Republic of Kenya" (hereinafter referred to as the "Study"), conducted by the Japan International Cooperation Agency (hereinafter referred to as "JICA") at the request of the Government of the Republic of Kenya, was concluded on schedule in March 1991 taking four years since it started in October 1987.

The study area encompasses some 29,800 km² east of 37°45' E and south of 3° S. (See the Map of Study Area on the opening page). The area mostly falls in Coast Province, but partly includes Eastern Province and Rift Valley Province, facing the Indian Ocean to the east and bordering on Tanzania to the south.

The area also includes cities like Mombasa and Malindi as well as the Tsavo National Park. Coastal plains are well developed along the sea coast rising in elevation as they go inland to form hills and plateaux, ranging to highlands of Yatta Plateau, Serengeti Plains and Taita Hills in the west of the study area.

The area has Mombasa in the coastal region with the largest port in East Africa, as well as Malindi, Kilifi and Shimoni where resort development is underway making the region highly potential for further development.

This report describes the processes of the Study along with intermediate products in the respective steps. It is hoped that the topographic maps, aerial photographs, control point survey data, etc., resulting from the Study will be useful for planning and surveying of future development and conservation activities in the region and that this report will serve as a guide for use of such materials.

2. PROGRESS REPORT

2-1 Request of the Kenyan Government and Determination of Study Components

2-1-1 Background of Request

The southern parts of the Republic of Kenya (hereinafter referred to as "Kenya") with such old port cities as Mombasa and Malindi located along the coast of the Indian Ocean have high potential for development and, once developed, for growth, and therefore the region is designated as a priority area in the Fifth National Development Plan. In order to pursue their efforts most efficiently, it is essential for them to be equipped with maps of high accuracy covering the area. Hence the preparation of such maps is urgently needed.

Basic maps were made for the region during 1950 - 1963 by the British but nothing has been done since then to update these maps despite the substantial changes that have taken place over the years. Also the elevations are shown in feet in these maps whereas the metric system is in common use in every field in the country today. Thus the situation as such calls for the up-to-date basic maps in metric system that accurately represent the region as it actually exists.

From 1975 through 1984, Japan made 1:50,000 topographic maps of East Kenya under its international technical cooperation program. Against this background Kenya made a request to the Japanese Government to provide technical cooperation for preparation of the 1:50,000 topographic maps covering the region.

In response to the request, Japan sent two missions to Kenya in 1987, first in January and second in March, for discussion and consultation with the Survey of Kenya, Ministry of Lands and Housing (hereinafter referred to as "SK"), the national mapping agency. Subsequently on March 19, 1987, the two governments formally decided on the topographic mapping of South Kenya as a four-year study starting in 1987 based on the Scope of Work (hereinafter referred to as "S/W") as agreed to between the two governments.

2-1-2 Requested Study

Kenya originally requested Japanese technical cooperation on the following items.

1) 1:50,000 topographic mapping of some 32,000 sq. Km in South Kenya
2) Establishment of additional geodetic control points in the area.
3) Establishment of addional leveling routes in the area.
4) Installation of mareographic stations at four locations.
5) Mosaicking of Landsat imagery of the area.

6) Dispatching of experts for technology transfer and supplying of necessary equipment for on-site training.

In response, it was decided, from the standpoint of technical cooperation, to take up 1), 2) and 3) of the requested items for consideration in terms of a 3 to 4 year study.

2-1-3 Determination of Study Components

(1) Contact Mission

Japan sent a contact mission to Kenya in January 1987 to survey and confirm the specific contents of the Kenyan request for the topogrpahic mapping of South Kenya. The contact mission held meetings with SK to confirm the specific contents of the request, the importance of such topographic mapping and the urgency of the need. Then the mission surveyed the procedures and regulations pertaining to aerial photography and other matters related to surveying, as well as permissions involved, extent of cooperation by the Kenyan side and the accuracy and specifications of the requested mapping. Availability of the past mapping records such as aerial photographs, meteorological data, topogrpahic maps and geodetic control point data was also surveyed. In addition, the mission conucted a reconnaissance field survey of the proposed site.

(2) S/W Mission

Based on the findings as reported by the contact mission, Japan sent a S/W mission to Kenya in March of the same year. The mission discussed with SK the study area, applicable technical standards of surveying and mapping, aerial photography schedule, applicable map symbols and their application rules, etc. And the results were incorporated in S/W and the Minutes of Meetings on S/W. (see Attachment 1) The mission conducted a field survey focusing on the existing geodetic control points in preparation for the full-scale surveying.

2-2 Formulation and Implementation of the Study Plan

2-2-1 Specifications

(1) Final results

Aerial photographs : Taken by super wide angle lens at 1:60,000 scale covering 29,800km².

Topographic maps : Scale - 1:50,000, neat lines 15'X15', 43 maps sheets.

Printed copies : 6-color prints, 43 map sheets, 500 copies each map sheet. 7-color prints, 43 maps sheets, 500 copies each map sheet. (Note : Originally planned as 6-color prints, 43 sheets, 1,000 copies each map sheet, but changed as above.)

(2) Map symbols : East Africa Specifications

(3) Operational rules : Specifications of Geodetic and Photogrammetric surveying for Oversea, March 1983, JICA.

(4) Operational standards

Reference ellipsoid : Clarke 1880

Projection : UTM

Neat lines : Latitude 15' X longitude 15'

Contour interval : Intermediate -20m
auxiliary -10m for flat area

(5) Accuracy

Map : Class A of the specificaftions ibid.

Leveling : 5cm√S where S is route length, in km.

(6) Others : Marking of leveling routes shall be made approximately every 2Km.

2-2-2 Study Plans by Year

The Study was planned on the basis of S/W as a four year starting 1987. The plans for each year are outlined below. (Figure 1: Yearly Work Flow (Plan) and Table 1: Yearly Work Schedule.)

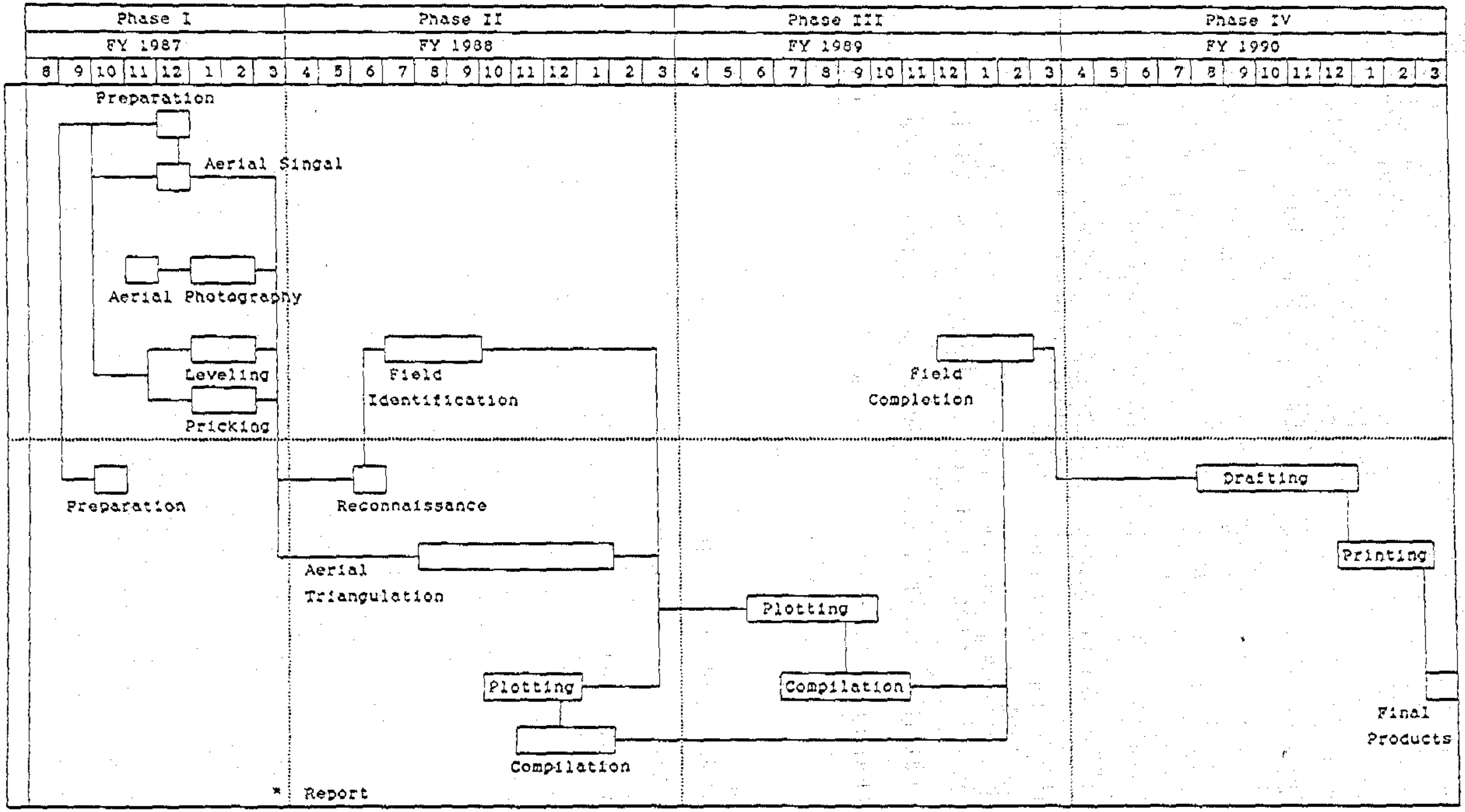


Figure 1. Yearly Work Flow (Plan)

Table 1. Yearly Work Schedule

<u>First Year</u>		Planning and preparation	
Work in Japan	:	Report	- in Japanese and English
Field work	:	Aerial signals	- 40 points
		Aerial photography	
		i) Area covered	- Approx. 29,800 km^2.
		Scale	- 1:60,000
		ii) Strip photography (along leveling routes)	- 1,500 km
		Scale	- 1:40,000
		Leveling - minor order leveling	720 km
		Pricking existing routes	700 km
		minor order routes	720 km
<u>Second Year</u>			
Work in Japan	:	Planning and preparation	
		Aerial triangulation	- 690 models
		Stereo plotting	- 11,475 Km^2
		Compilation	- 11,475 Km^2
		Report	- in Japanese and English
Field work	:	Field verification	- 29,800 km^2
<u>Third Year</u>			
Work in Japan	:	Planning and preparation	
		Stereo plotting	- 18,325 km^2
		Compilation	- 18,325 km^2
		Report	- in Japanese and English
Field work	:	Field completion	- 29,800 km^2
<u>Fourth Year</u>			
Work in Japan	:	Planning and preparation	
		Drafting	- 29,800 km^2 (43 sheets)
		Printing	- 43 sheets, 1,000 copies each
		Final report	- in Japanese and English.

2-2-3 Implementation of the Study

The Study was conducted according to the plans as above, but in the course of the work some changes were made:

(1) Some of the work of aerial photography originally scheduled for the first year was conducted in the second year due to unfavorable weather conditions.

(2) Additional geodetic control point survey and leveling were conducted in the second year due to the loss of existing triangulation points and bench marks.

(3) Field verification of the area left over from the first year's aerial photography was conducted in the third year along with field completion.

(4) At the request of SK, printing of the maps was changed to : 6-color prints for public use, 500 copies for each map sheet, and 7-color prints for government use, 500 copies for each map sheet.

Notwithstanding the changes, the Study was concluded on schedule in the fourth year as originally planned. Following is a recap of each year's work as planned and implemented.

(1) <u>First Year Work</u>

1) Work period : From October 8, 1987 to March 28, 1988.

2) Field work : From December 1, 1987 to March 8, 1988.

3) Number of people engaged in field work

: 18 Japanese and 4 SK counterparts.

4) Work planned and accomplished :

Planned	Accomplished
Aerial signal 40 points	Aerial signals 40 points (5 missing geodetic control points included)
Aerial photography :	Aerial photography :
1:60,000 - 4,000km(25 courses)	1:60,000 - 3,300km(21 courses)
1:40,000 - 1,500km (leveling routes)	1:40,000 - 1,500km
Minor order leveling : 720Km	Minor order leveling : 731.3km
Bench mark pricking :	Bench mark pricking :
On existing routes 700km	On existing routes 500km (147 points)
On minor order routes 720km	On minor order routes 731.3km (357 points)
Report	Reports in Japanese and English

(2) Second Year Work

1)Work period : From July 1, 1988 to March 28, 1989

2)Field Work : From July 25, 1988 to October 27, 1988

3)Number of people engaged in field work

: 18 Japanese and 4 SK counterparts.

4)Work planned and accomplished :

Planned	Accomplished
Aerial photography :	Aerial photography :
1:60,000 780km (14 courses)	1:60,000 780km (14 courses)
Geodetic control point survey : 9 points	Geodetic control point survey : 10 points
Minor order leveling 200km	Minor order level0ing 245.1km
Field verification : 26,800km²	Field verification : 26,800km²
Aerial triangulation : 725 models	Aerial triangulation : 757 models
Stereo plotting : 11,475 km² (15 sheets)	Stereo plotting : 11,475 km² (15 sheets)
Compilation : 11,475 km² (15 sheets)	Compilation : 11,475 km²
Report	Reports in Japanese and English

(3) Third Year Work

1)Work period : From September 4, 1989 to March 28, 1990

2)Field wrk : From January 8, 1990 to March 8, 1990

3)Number of people engaged in field work :

: 13 Japanese and 4 SK counterparts.

4)Work planned and accomplished :

Planned	Accomplished
Stereo plotting : 18,325 km² (28 sheets)	Plotting : 18,325 km² (28 sheets)
Compilation : 18,325 km² (28 sheets)	Compilation : 18,325 km² (28 sheets)
Field verification : 3,000 Km²	Field verification : 3,000 Km²
Field completion : 29,800 Km²	Field completion : 29,800 Km²
Report	Reports in Japanese and English

(4) Fourth Year Work

1) Work period : From July 12, 1990 to March 20, 1991

2) Work planned and accomplished :

Planned	Accomplished
Drafting : 29,800 Km^2	Drafting : 29,800 Km^2
Printing :	Printing :
6-color, 43 sheets, 500 copies each	6-color, 43 sheets, 500 copies each
7-color, 43 sheets, 500 copies each	7-color, 43 sheets, 500 copies each
Final report	Final reports in Japanese and English

2-2-4 Progress of the Study

The progress of the study is summarized by year as below.

(1) Official Request and Preliminary Study

Date	Item	Remarks
May 1982	Official request	Kenyan request to Japan for technical cooperation for topographic mapping
Mar. 1984	Request made again	Official request made again
Jan. 25 - Feb.10, 1984	Contact Mission	Contact Mission dispatched to Kenya for preliminary study
Feb. 20 - Mar. 23,1987	S/W Mission	S/W Mission dispatched to Kenya for discussion of S/W and field survey.

(2) First Year

Date	Item	Remarks
Oct. 8 – Nov. 30, 1987	Work in Japan	Planning and preparation, start of the first year work
Dec. 1, 1987– Mar. 3, 1988	Field work	Aerial signal, aerial photography, minor order leveling, pricking
Mar. 4 – Mar. 28, 1988	Work in Japan	Field results sorted and organized

(3) Second Year

Date	Item	Remarks
Jul. 1, – Jul. 24, 1989	Work in Japan	Planning and preparation, start of second year work
Jul. 4, – Sep. 1, 1988	Idividual training	Mr. O. M. Wainaina in Japan (for training in planning in general)
Jul. 25, – Oct. 25, 1988	Field work	Aerial photography (of remaining parts), minor order leveling, geodetic control point survey, pricking
Nov. 8, – Dec. 20, 1988	Individual training	Mr. J. Kibore in Japan (for training in aerial triangulation)
Sep. 1, 1988 – Mar. 20, 1989	Work in Japan	Aerial triangulation, stereo plotting, compilation

(4) Third Year

Date	Item	Remarks
Jul. 18, - Sep. 7, 1989	Idividual training	Mr. J. Ogutu in Japan (for training in stereo plotting and compilation)
Jul. 18, - Sep. 13, 1989	Individual training	Mr. P. Muia in Japan (for training in plotting and compilation)
Sep. 4, 1989 - Jan. 7, 1990	Work in Japan	Planning, preparation, stereo plotting, compilation
Jan. 8, - Mar. 8, 1990	Field work	Field verification (for area covered by 2nd year aerial photography) Field complation
Mar. 9, - Mar. 28, 1990	Work in Japan	Field work results sorted and organized

(5) Fourth Year

Date	Item	Remarks
Jul.12, 1990 - Mar. 20, 1991	Work in Japan	Drafting, printing
Oct. 15, - Oct. 29, 1990	Field Work	Field verification of cartographic work (Chief Engineer dispatched to site)
Feb. 8, - Mar. 30, 1991	Individual training	Mr. Z. N. Gitau in Japan (for training in mapping in general)

2-3 Outline of Fourth Year Study

Progresses of the study in each year, from the first to the third year, have been presented in detail in the yearly reports of the respective years. The report for the fourth (final) year, however, is intended to prepare an overall report as the final report so that the outline of the Study accomplished in the fourth year is given below as a part of the overall report.

2-3-1 Outline of the Study

The fourth year study involved drafting and printing based on the original manuscripts prepared by the third year, to produce the topographic maps as final products. The S/W originally called for printing of 1,000 copies, in 6 colors, for each of the 43 map sheets. But at the reqeust of SK, copies were made as follows. The 43 map sheets that were drafted and printed are as shown in Figure 2.

For public use : 6-color, 43 sheets, 500 copies each sheet

For government use :
7-color, 43 sheets, 500 cpoies each sheet

2-3-2 Work Schedule

The work was accomplished on schedule as originally planned.

Drafting : From mid-July 1990 to mid-October 1990

Field Confirmation of scribed originals :
From mid-October 1990 to late October 1990

Printing : From late October 1990 to mid-March 1991

Final report : From mid-January 1991 to mid-March 1991

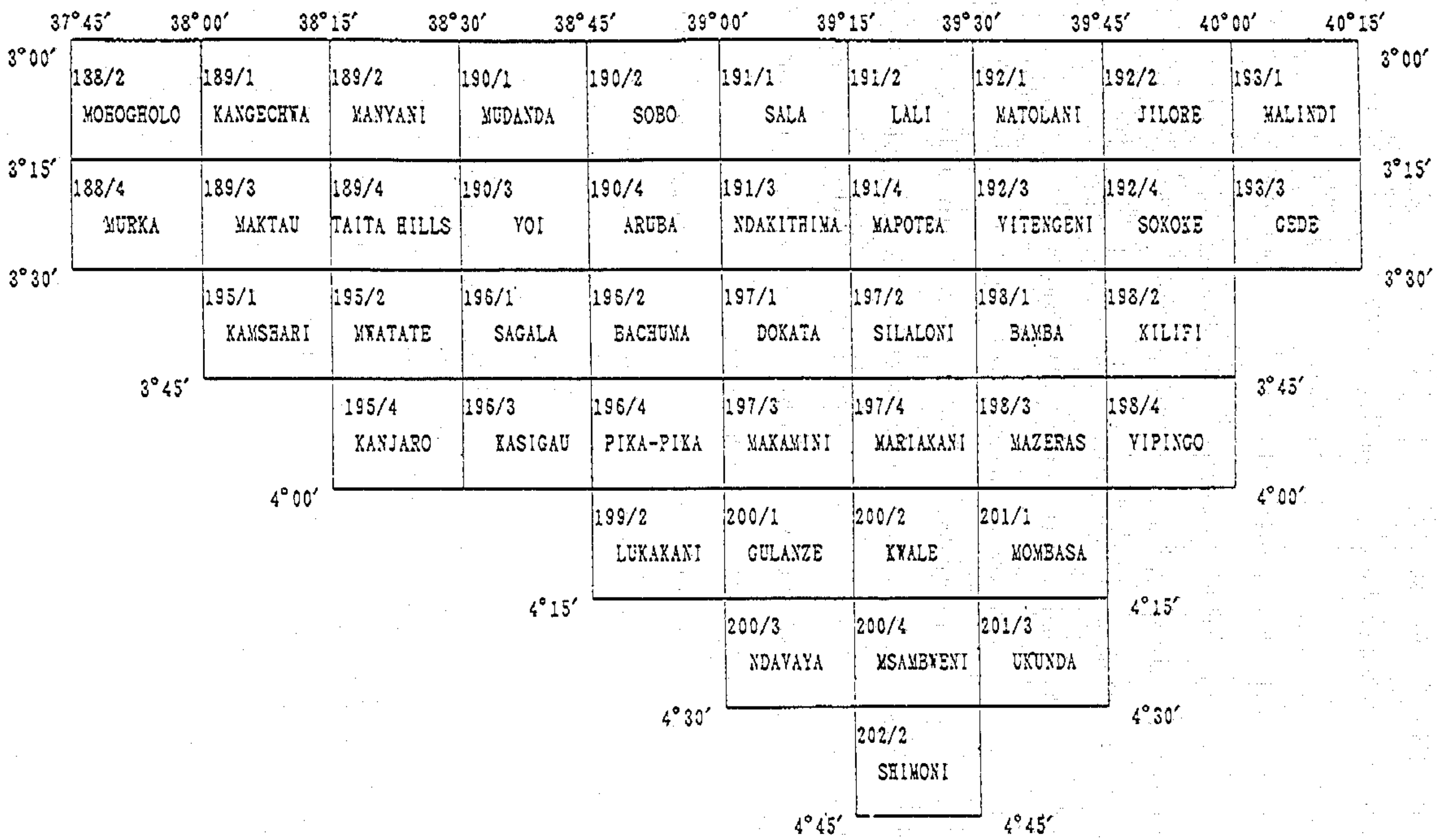


Figure 2. Map Index

2-3-3 Major Specifications

Major specifications for drafting and printing are as follows.

(1) Applicable Map Symbols

After a series of meetings for discussion on specifications of map symbols and marginal information to be applied, "East Africa Specifications" were adopted with additions, deletions, and modifications as agreed to. The agreed map symbols are the same as adopted for the "Topographic mapping of East Kenya" in the Republic of Kenya in March, 1981 (cf. Chap. 13, Final Report of the Project ibid [1].) except following points :

a. Symbols for borehole, waterhole, well and spring were changed to new symbols.

b. Symbols and annotations of sub-district boundaries and names were added.

(2) Number of Colors

Numbers and types of colors for public use and government use are as follows.

For general use : The following six colors are used.

Black (Marginal information, annotation, grid, vegetation symbols, cities)

Blue (Rivers, annotation for water system, water surface, aquatic vegetation)

Red (Roads, annotation for roads, tracks, boundaries)

Brown (Contour lines, contour values, sands or muds)

Green (Vegetation)

Grayish green (Cadastral boundaries and annotations)

For government use : Purple was added (for representation of sub-district boundaries and their names) to the six colors for public use, to make a total of 7 colors.

(3) Number of map sheets : 43 sheets

(4) Scribed originals produced : 7-color 43 sheets

(5) Numbers of printed copies :

6-color, 43 sheets, 500 copies each sheet

7-color, 43 sheets, 500 copies each sheet

2-3-4 Preparation of Scribed Originals

For final drafting, the scribed originals comprising negative scribed sheets, negative mask sheets, and positive annotation sheets, corresponding to the number of colors used, were prepared based on the original manuscripts by the color separation negative scribing method in accordance with the map symbols and their application rules. Stable material was used that were almost free from contraction or expansion.

The specific processes are described below.

(1) Image printing on scribing sheets

Reverse images of the original manuscripts were printed on scribing sheets by diazo method. Matching of respective color separation sheets was done by punching hole method.

(2) Preparation of scribed sheets

Scribing was done on the printed scribing sheets as above for respective colors in the order of black, blue, red, brown, grayish green, and purple, according to the specifications. To ensure matching between sheets, one scribed sheet was overlaid by the next sheet to be scribed and printed in a different color in a consecutive manner using punched holes. Register markings were provided as guides for sheet matching in plate making and printing : rectangular-markings on the four corners of the neat lines and cross-markings outside each neat line. The latters are taken off the printing plates at the commencement of the final printing.

(3) Preparation of mask sheets

Mask sheets of complicated figures were prepared by printing images of cut lines on the day light peeling sheet by photo mechanical method and peeling off the necessary parts. Those of simple figures were prepared by directly peeling off the necessary parts using knife superposing the peeling sheet on the original manuscript. The same type of resister marks were made as the same as for the scribed sheets.

(4) Prefaration of zip-a-tone sheets

Zip-a-tones were reproduced from the phototype supplied by SK.

(5) Preparation of UTM grids

UTM grids, being common to all sheets, were scribed by coordinategraph and made into positives, which then were adjusted to suit the respective sheets.

(6) Preparation of sheets for longitude/latitude tick marks and neat lines.

Locations of longitude/latitude ticks as well as neat lines were drawn on the black (scribed) sheets.

(7) Preparation of annotation sheets

Based on the annotation data, letters of prescribed types and sizes were made by photo-composer and then struck on places as specified.

(8) Preparation of marginal information sheets

Marginal information sheets were prepared based on the style sheets provided by SK. Since neat lines are common to all those on the same latitudes and there are many items in common such as legends and remarks, common sheets were prepared for each latitude zone, and reproduced for respective map sheets. Sheet names and numbers and other annotations were prepared by photo-composer and stuck on the sheet.

(9) Checking of scribed originals

From the scribed originals, 7-color proofs printed on polyester sheets were made for checking by "water coating" method. The final proofs were sent to SK for their approval. It was followed by dispatching of a JICA Study Team member for consultation with SK on their inspection results, and the scribed originals were corrected accordingly in Japan.

2-3-5 Printing of Topographic Maps

Final printing of topographic maps was executed by off-set printing machine. The specific processes are descibed below.

(1) Preparation of plate making film

From the scribed originals, having 2 - 5 plates for each color in negative or positive, negatives were made, where necessary, for use in plate making.

(2) Plate making

From the negatives for plate making, printing plates were made of aluminum PS plates for each color.

(3) Preparation of proof prints

Proof prints were prepared by flat-bed printing machine.

(4) Proof reading

Proof was read on matching of respective color and coloring. Re-making of printing plates was done, when necessary according to the proof reading on matching. Coloring was finally decided after discussion with SK counterpart staying in Japan for training at that time.

(5) Printing

After obtaining the agreement of SK counterpart on proof prints final printing of topographic maps was executed.

(6) Inspection of printed map

Inspection was executed on printed map sheets. Maps sheets rejected by inspection were abolished.

3. Technical Report

3-1 Planning

3-1-1 Objective

The objective of the Study is to prepare 1:50,000 topographic map covering an area of approximately 29,800km² in South Kenya from east of Long 37° 45' E to the coast and south of Lat. 3° S to the Kenyan territory of the Tanzanian border excluding the map sheets containing border.

Main study items are as follows:

1. 1:60,000 aerial photography   approx. 29,800km²
2. 1:50,000 topographic mapping   approx. 29,800km²

And, through the execution of the Study, transfer of technology shall be realized to the SK counterparts in the whole aspects of the Study from the geodetic countrol point survey in the field to the printing of topographic maps.

3-1-2 Scope of the Study

The scope of the Study (S/W) is as shown in a document agreed between the Ministry of Lands and Housing and JICA on March 19, 1987. The terms of S/W called for the following studies, though some of the terms were modified in the course of the study.

(1) Aerial photograhy : Aerial photography at a scale of 1:60,000, using a super wide angle lens and black and white Panchromatic film

(2) Leveling : Minor order leveling for vertical control necessary for aerial triangulation and plotting. Marking shall be executed every 2km.

(3) Control point survey : Establishment of control points points necessary for photo control.

(4) Aerial signal and pricking : Signalization on geodetic control points prior to aerial photography. Pricking of vertical control points.

(5) Field verification : Land-use, vegetation and other ground features are verified in the field based on the photos. Collection of other relevant information for mapping.

(6) Aerial triangulation : Aerial triangulation by analytical method. Adjustment by block adjustment.

(7) Stereo plotting and compilation : Plotting by stereo plotter at a scale of 1:50,000. Compilation by incorporating the findings of field verification.

(8) Field completion : Verification in the field of vegetation and other features not identified while plotting and their incorporation into the compiled manuscripts. (Preparation of Original Manuscripts) Confirmation of administrative boundaries and annotation of administrative and place names by SK.

(9) Drafting : Scribing by color separation negative scribing method on ployester base sheets to make the scribed originals. Application of SK map symbols (East Africa Specifications).

(10)Printing : Plate making by photo lithography based on the scribed originals. Printing by offset printing machine.

The work volumes of the above are shown in Table 2.

Table 2 : Work Volumes

Item	Specification	Volume
Aerial photography	Scale 1:60,000	29,800km² for mapping area
Leveling	Minor order leveling (pricking included)	Approx. 976 km
Geodetic control point survey	Satellite geodesy	10 points
Aerial signal		40 points
Pricking	Existing bench marks	Approx. 500 km
Field verification		Approx. 29,800 km²
Aerial triangulation		757 models
Stereo plotting/ compilation	Scale 1:50,000	Approx. 29,800 km² (about 38.9 sheets actual)
Field completion		Approx. 29,800 km²
Drafting		Approx. 38.9 sheets actual (43 sheets)
Printing	6 colors 7 colors	43 sheets, 500 copies each 43 sheets, 500 copies each

3-1-3 Description of Study Area

(1) Geography

The Study Area encompasses an area of some 29,000 km² bounded by 3° south latitude to the north, the border with Tanzania to the southwest and the coast- line of the Indian Ocean to the east, forming a reverse triangle, with Mt. Kilimanjaro, the highest mountain in Africa (5,894.8m), to the west bordering on Tanzania.

An international road runs through the central part of the study area northwest from Mombassa into Uganda. On both sides of the road is a huge expanse of the national park where wildlife such as elephants and lions abounds. About 30 km west of Voi, a city about 160 km inland via the international road, are located Taita Hills with an elevation of 2,208 m. In the northern part of the study area, the Sabaki River (Glana River upstream), one of the two major rivers in Kenya, runs east-west to flow into the Indian Ocean.

The study area has an average elevation of about 300 m, the inland parts averaging about 700 m with hills and mountains rising over 1,000 m and forming slopes down to the sea coast on the east at about 1/300 gradient. In between the mounatainous parts and the sea coast is the svannah with undulations.

In the coastal areas, coastal hill with elevations of arount 20 m are developed.

The coastal zone facing the Indian Ocean is developed as a resort with expensive hotels. But inland areas removed fom cities and main roads are semi-arid savannah with bushes, acasias and big baobabs typical of Africa, with low population densities. Mzima Spring water in Tsavo West National Park originates in Mt. Kilimanjaro and flows into the Tsavo River in tons of spring water. Part of the water is tapped by pipe-lines for water supply in Mombasa. The bulk of the river water remains in the river but seeps underground or evaporates as it runs the course of the river route and the water volume is reduced by the time it reaches the coast.

Large scale sisal plantations are developed in the inland Voi area and coastal Kilifi, offering a magnificent sight over the extensive hillsides. In addition to sisal, such cash crops as coconuts, cashewnuts, mangos are raised widely.

(2) Climate

Climatically, Kenya belongs to the dry savannah zone but there are substantial differences between regions : the arid (sands or earth) zone in the north, plateua extending from Nairobi towards Uganda, semi-arid savannah in the central eastern and southern parts, and the high temperature/high humidity oceanic climate zone on the coasts of the Indian Ocean.

The study area has both semi-arid savannah climate and ocanic high temperature/high humidity climate. The major dry season starts in January lasting through March followed by the major wet season of April - June and the minor dry season from July to October and the minor wet season November to December to complete the yearly climate cycle.

During the major dry season, maximum temperatures rise to 30℃ - 34℃ everyday wih strong sun intensity during the daytime. Annual rainfalls in the coastal areas and Taita Hills range 1,000 - 1,500 mm which occur mostly during the major wet season. In the inland, there are yearly rainfalls of 30 - 750 mm and it is relatively dry even in the wet season. During the wet season, it rarely continues to rain all day but there are inter-mittent torrential downpours. The sky is overcast throughout the wet season whereas the clear sky and dry air prevail all through the major dry season.

(3) Transportation

Capital city Nairobi and the second largest city of Mombasa are linked by roads, air, and railway. Both cities are easily accessible by buses, air planes, and trains. These inter-city roads and coastal roads are paved. Access roads to towns and villages are not paved but accessible by cars. But because of the clayish type of soil of roads, these unpaved roads become impassable or very difficult to use in the wet season.

By sea, livestock, mangrove timbers and daily supplies are transported in dhow boats between Lamu Island and Mombasa.

Nairobi and Mombasa both have city bus services. Inter-city bus services between the two cities are provided by privately run Country Buses and Peugeot Service (High speed 6 - 9 passenger-seat omnibus). Small omnibuses are the most common means of transportation especially "Matatu" as they call it is very popular among citizens for commuting and shopping since it is inexpensive, fast, and easily available.

Regular airline services are available out of Nairobi, and there are daily scheduled flights between Mombasa and Nairobi, both in the study area, and from there to Kisumu on Lake Victoria. Mobasa Airport is an international airport serving direct flights to and from Europe.

There are a number of flying service companies operating small aircraft, offering regular flights for tourists and chartered services as well.

Small towns as well as National Parks and Wildlife Reserves have runways for small aircraft. There is the Flying Doctor System available for emergency medical assitance, dispatching doctors and hospitalizing patients.

Railways services are available between Nairobi and Mombasa, Voi and Taveta, for mass transit.

3-1-4 Work Plan

The entire Study is planned for four years comprising the following four phases. The yearly work volumes are given in Table 3.

(1) First Phase (First Year, Fiscal 1987):
Aerial photography, aerial signal and pricking, leveling.

1) Aerial signal
In order to achieve the specified mapping accuracy, horizontal control points shall have the accuracy of:
0.07 mm X 1/(map scale)(=0.07 mm X 50,000 = 3.5 m)
or less

Tablo 3. Yearly Work Plan

1

Year	Job Classification	Work volume	Remarks
First year 1987	Aerial signal	40 control points	5 points missing
	Aerial Photo-graphy	Scale : 1:60,000 3,300 km 21 courses Strip photography : 1:40,000 1,500 km over leveling routes	90% covered (out of 29,800 km^2 in total)
	Minor order leveling Pricking	731.3 km Existing routes - 700 km Minor order leveling routes - 731.3 km	 500 km covered
	Report	Japanese 30 copies English 30 copies	
Second Year 1988	Aerial Photo-graphy	Scale : 1:60,000 760 km 13 courses	Unphotogaphed area in 1987
	Geodetic control point survey	10 points, satellite geodesy	
	Minor order leveling	245.1 km (Pricking included)	Missing parts of existing first order leveling route, con-nections to control points
	Field verification	26,800 km^2	Area covered by 1st year aerial photo-graphy
	Aerial triangulation	757 models	
	Stereo plotting	11,475 km^2 (15 sheets)	Scale : 1:50,000
	Compilation	11,475 km^2 (15 sheets)	Scale : 1:50,000
	Report	Japanese 30 copies English 30 copies	

Table 3. Yearly Work Plan

2

Year	Job Classification	Work volume	Remarks
Third Year 1989	Stereo plotting	18,325 km² (28 sheets)	Scale : 1:50,000
	Compilation	18,325 km² (28 sheets)	Scale : 1:50,000
	Field completion	29,800 km² (43 sheets)	
	Report	Japanese 30 copies English 30 copies	
	Field verification	3,000 km²	Area coursed by 2nd year aerial photography
Fourth Year 1990	Drafting	29,800 km² (43 sheets)	
	Printing	43 sheets, 6 - color 500 copies/sheet 7 - color 500 copies/sheet	
	Report	Japanese 30 copies English 50 copies	

Therefore, the first order and second order triangulation points and traverse points are to be used for horizontal control. The 40 horizontal control points planned for use for aerial triangulation shall be signalized prior to aerial photography. (Figure 3 shows the locations of the control points and leveling routes)

2) Aerial photography

Two types of aerial photography are prepared.

(a) Photography of leveling routes (Figure 4)

To faciliate the work process and pricking of existing leveling routes and planned leveling a distance of 1,500 km along the leveling routes is flown in a sigle course for 1:40,000 scale aerial photography.

(b) Photography of the entire study area (Figure 5)

An area of approximately 29,800 km^2 is covered by 1:60,000 scale photography.

3) Pricking of bench marks

Existing bench marks (over approx. 500 km) are pricked for aerial triangulation and plotting. Pricking of planned leveling routes is made at the time of leveling. Original aerial photos taken at a scale of 1:40,000 are enlarged two times for actual use. Pricking results are transferred to the 1:60,000 scale photos as necessary.

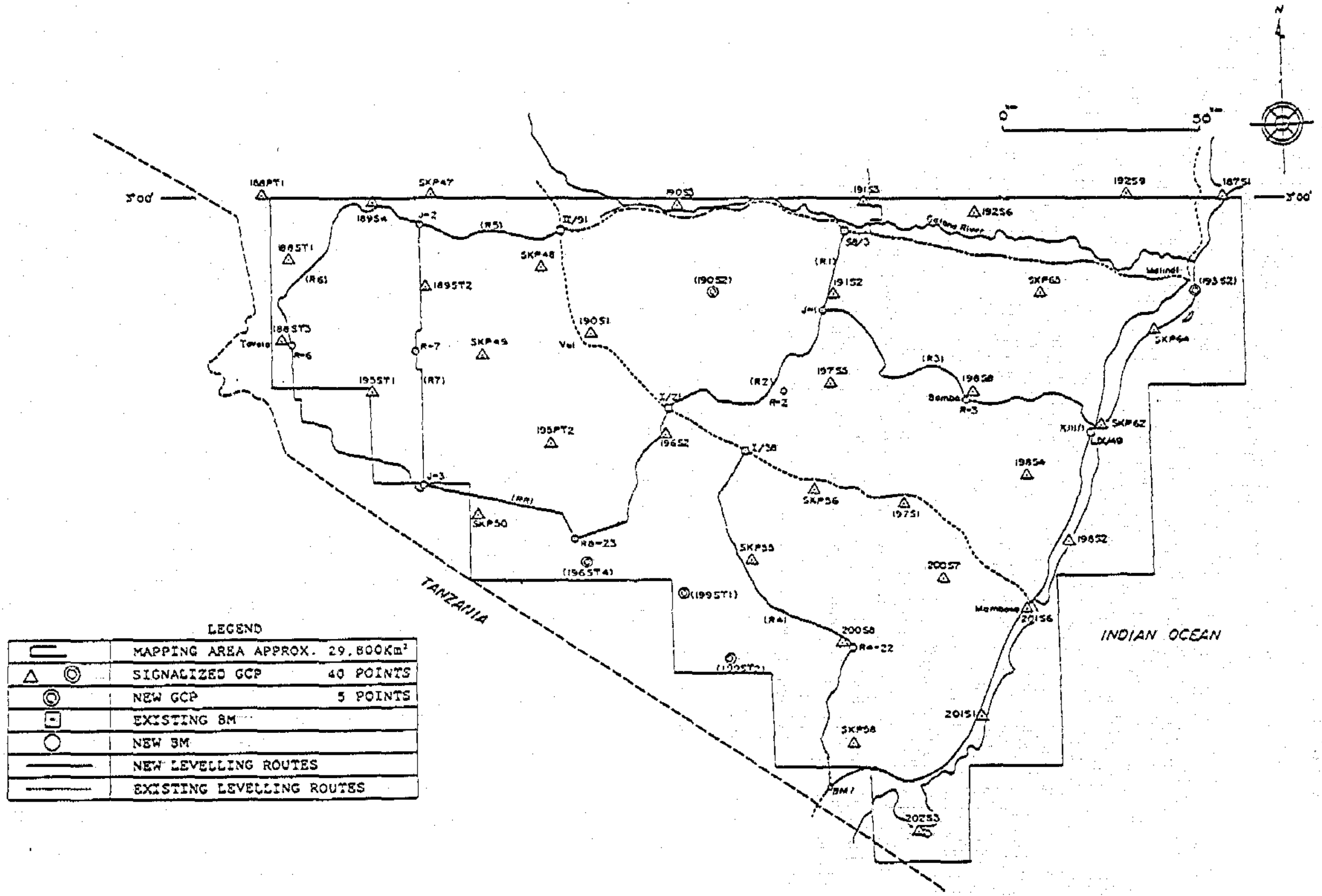


Figure 3. Aerial Signal and Levelling Route

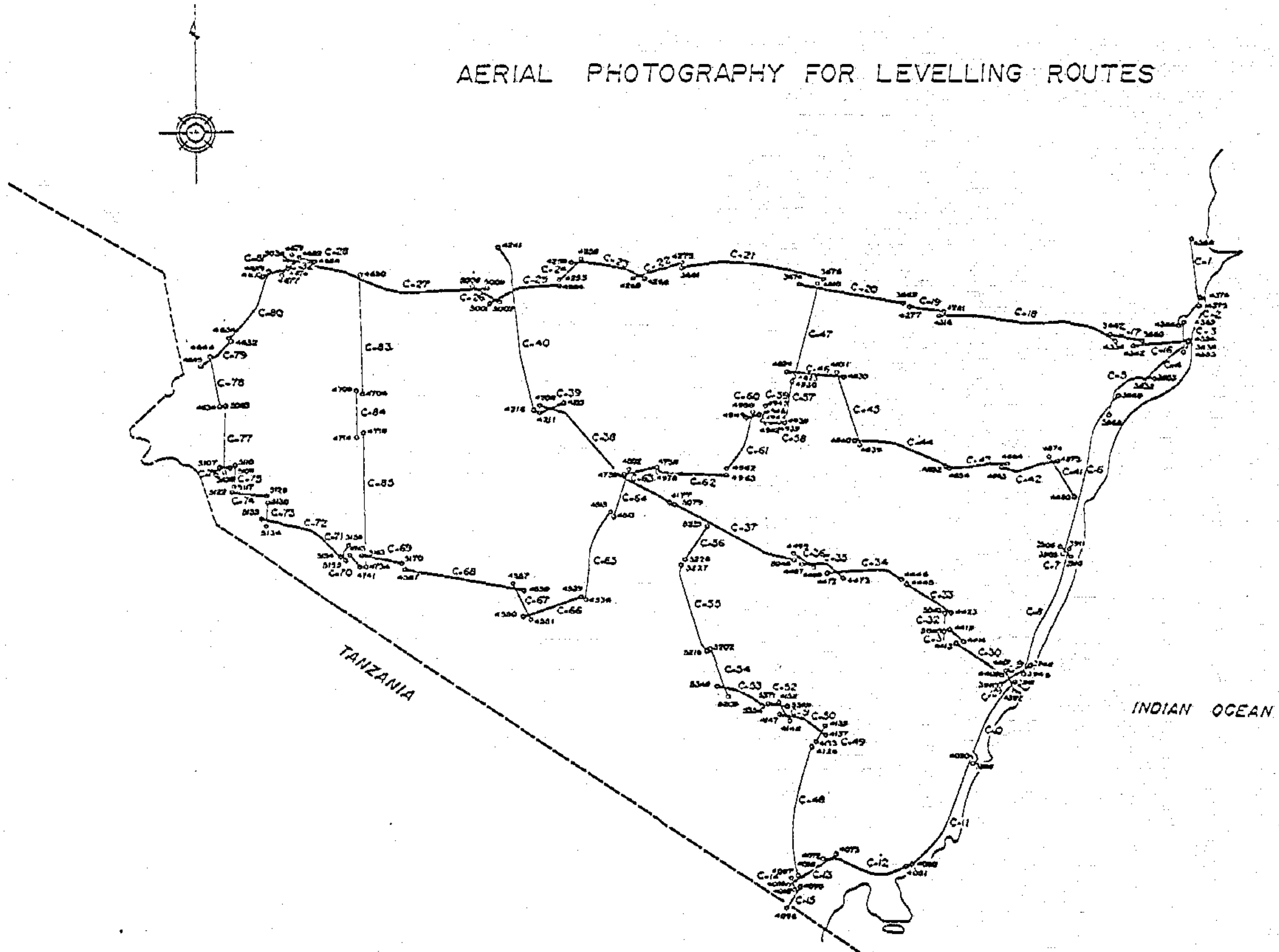


Figure 4. Aerial Photography for Levelling Route

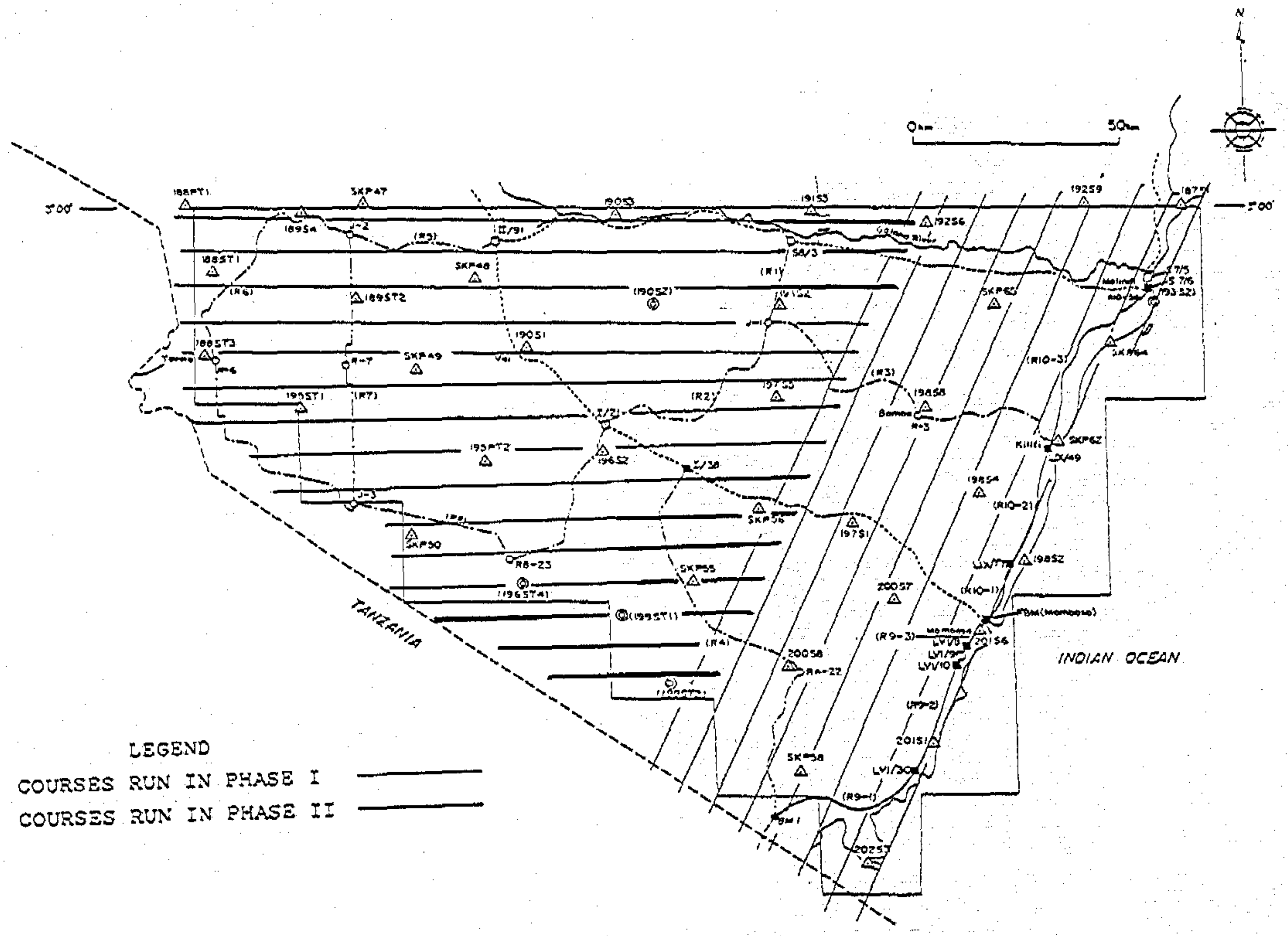


Figure 5. Aerial Photography for Mapping

4) Leveling

In order to achieve the specified mapping accuracy, verifical control points shall have the accuracy of : 0.07 x contour internal (=0.07 x 20 m = 1.4 m or less

Existing bench marks to be used for aerial triangulation and plotting are geographically scattered so that using them as given points minor order leveling (approx. 730 km) is conducted for suplementation. (Figure 3) Marking shall be executed every 2 km all along the routes or sturdy ground features shall be selected to serve as marks, and they are measured for their elevations and pricked as in the preceding process. The required accuracy is 50 mm x $\sqrt{S}$ (S : route length in km)

(2) Second Phase (Second Year, Fiscal 1988):

Aerial photography, geodetic control point survey, leveling, field verification, aerial triangulation, stereo plotting, compilation.

Based on the first year accomplishments, the initial work plan is changed as follows.

1) Aerial photography

Of the total study area of 29,800 km^2 planned for aerial photography at a scale of 1:60,000, some 3,000 km^2 that were left over from the first year are flown. (Figure 5)

2) Geodetic control point survey

Of the existing geodetic control points selected for aerial triangulation, 10 points are measured by satellite geodesy. (Figure 6)

3) Leveling

With respect to the 245 km of existing leveling route (Malindi - Lunga Lunga) where bench marks are lost, minor order leveling and pricking are undertaken. (Figure 3)

4) Field verification

Field verification is conducted covering about 26,800 km^2 of the study area that were aerially photographed in the first year, for indentification of place names, vegetation classifications and other representations that were difficult to identify on the photos, in reference to the map symbols, and for preparation of keys for photo-interpretation to help plotting to be done in Japan. Prior to the commencement of field work, reconnaissance interpretation is to be done in as much as possible based on aerial photos and other related data. Collection and verification of place names and adminisitrative names are referred to SK. (Figure 7)

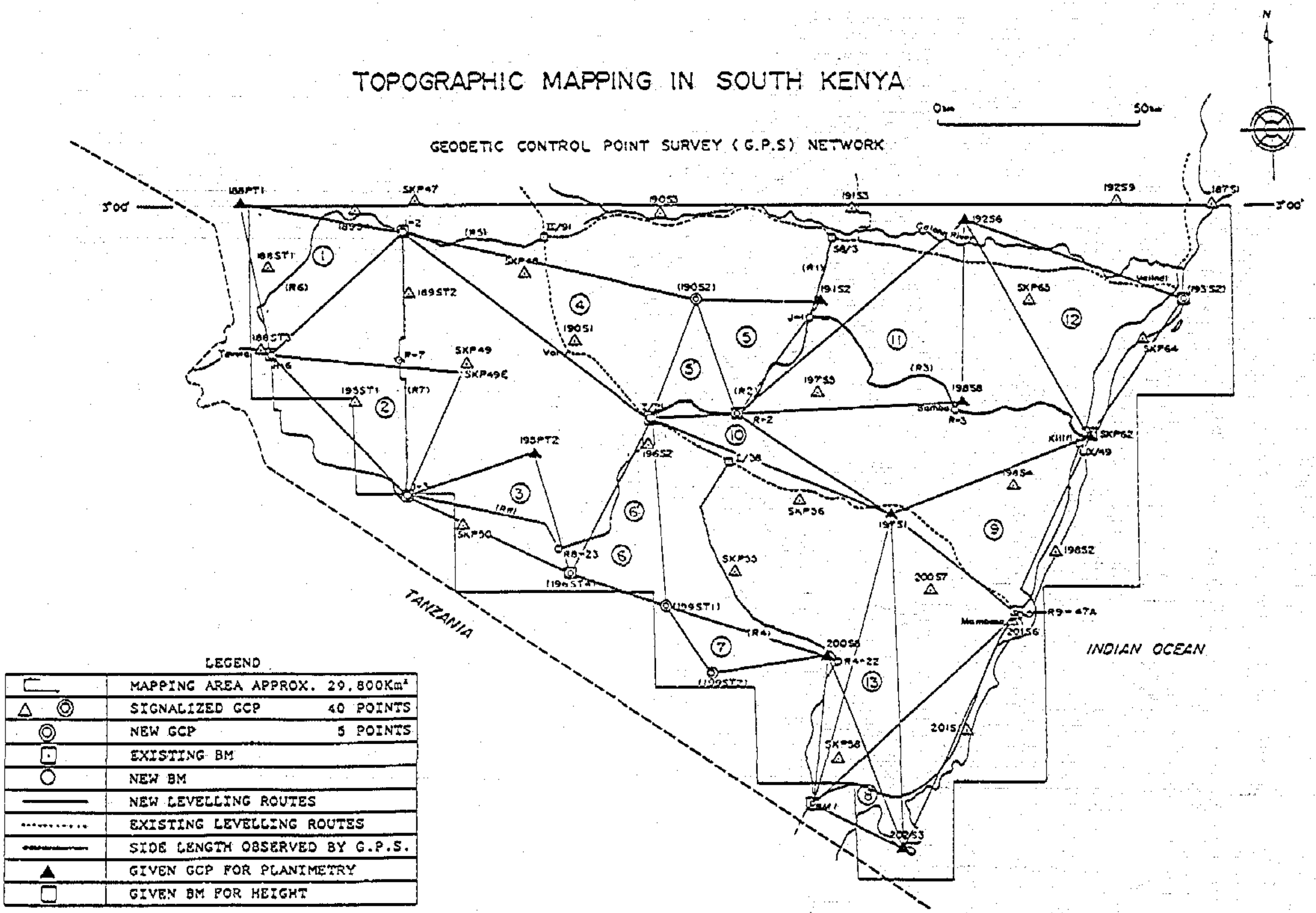


Figure 6. Geodetic Network for Observation

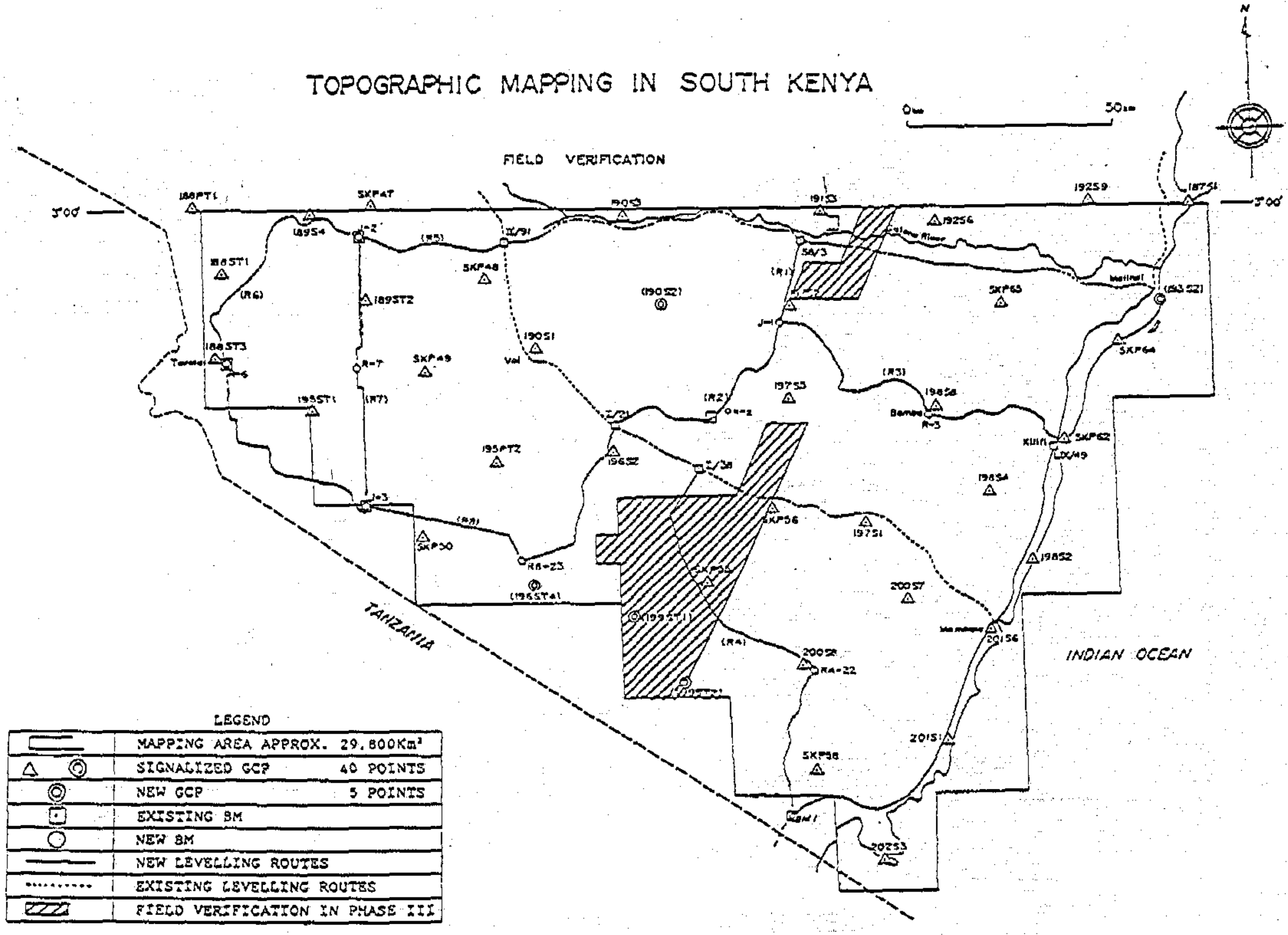


Figure 7. Field Verificaion

5) Aerial triangulation

Coordinates and elevations of pass points and tie points to be used for plotting are determined by aerial triangulation based on the ground control survey findings and 1:60,000 scale aerial photos. Block adjustment computations are made analytically of about 750 models by independent model using PAT-M43 program. Control point residuals and discprepancies of pass points and tie points shall be (for both planimetry and elevation):

Flight altitude x 1.4 ‰ (≒ 5,400 m x 1.4 ‰ ≒ 7.6 m) or less.

6) Stereo plotting and compilation

Based on the results of aerial triangulation and field verificaftion as well as aerial photos, topographic features and other representations required for mapping are delineated at a scale of 1:50,000 by stereo plotter to produce plotted manuscripts. Contour lines are drawn at invervals of 20 m inter-mediate contours and 10 m for half interval auxiliary cuntour where applicable. Spot heights are measured photogrammetrically and distibuted taking the locations of the control points into consideration and focusing on conspicuous road intersections and outstanding topographic features (mountain tops, pits, knick points, etc.). From the plotted manuscripts and field verification findings, compiled manuscripts are produced according to the map specifications, in a size of 15' x 15' neat lines.

Since there are existing maps to the north of the study area; elaborated by JICA on the east, and by Canada on the west as well as the British Ordnance Survey is working to the south on the Tanzanian side. Due attention must be paid for matching with these maps. Ask SK for information on these other areas such as pricked diapositives, aerial triangulation results and copies of original manuscript. Proper matching is ensured with existing maps, in principle, but, where difficult, consult SK.

During the second year phase, 11,475 km^2 (15 sheets) are covered. The remainder to be completed in the third year. (Figure 8)

(3) Third Phase: (Third Year, Fiscal 1989)

Stereo plotting/compilation (continued), field completion, field verification.

1) Stereo plotting, compilation

These processes are continued from the second year to complete the remaining 18,325 km^2. (28 sheets) (Figure 8)

2) Field completion

With respect to all sheets of the compiled manuscripts, topographic and other map features and geographial names as represented as well as uncertain items uncovered in the processes of stereo plotting and compilation are confirmed and/or identified on

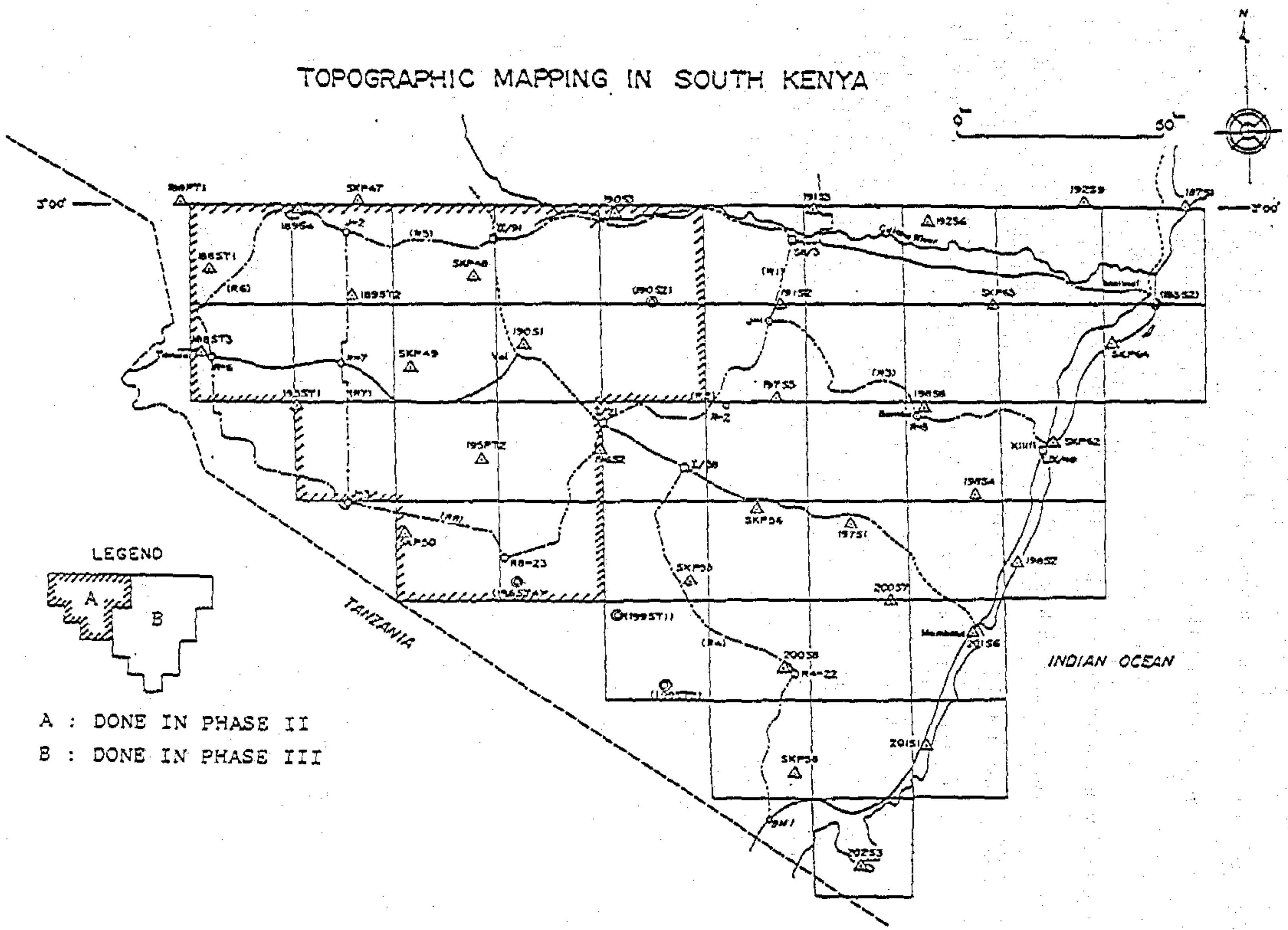


Figure 8. Stereo Plotting and Compilation

site and delineated in the manuscripts. SK is asked for study on geographical names, administrative names and boundaries.

3) Field verification

Since plotting of those parts of the study area that were photographed in the second year is done without fild verification of the photos, field survey is conducted to identify keys to assist photo interpretation.

(4) Fourth Phase (Fourth Year, Fiscal 1990)

Drafting, printing

1) Drafting

Based on the field completed compiled manuscripts (orignial manuscripts), negative scribing and preparation of masks and marginal information sheets for 7 color printing plate making are carried out. These sheets are made in composite film in such a manner as to have one color in one sheet for the sake of plate making and printing. Composite positives are also prepared consisting mainly of linear elements for the purpose of maintenance (revision) of maps.

2) Printing

Printing plates are made from negatives by photo-lithography. A total of 1,000 copies each of 43 sheets of the 1/50,000 topographic maps are printed; 500 copies in 6 colors for public use and the other 500 copies in 7 colors for government use. Specifications, including sizes, of printing paper are to be determined through consultation with SK.

(5) Work Flow

The study was completed in March 1991 as originally schedled. The work flow as actrually followed in this study in shown in Figure 9.

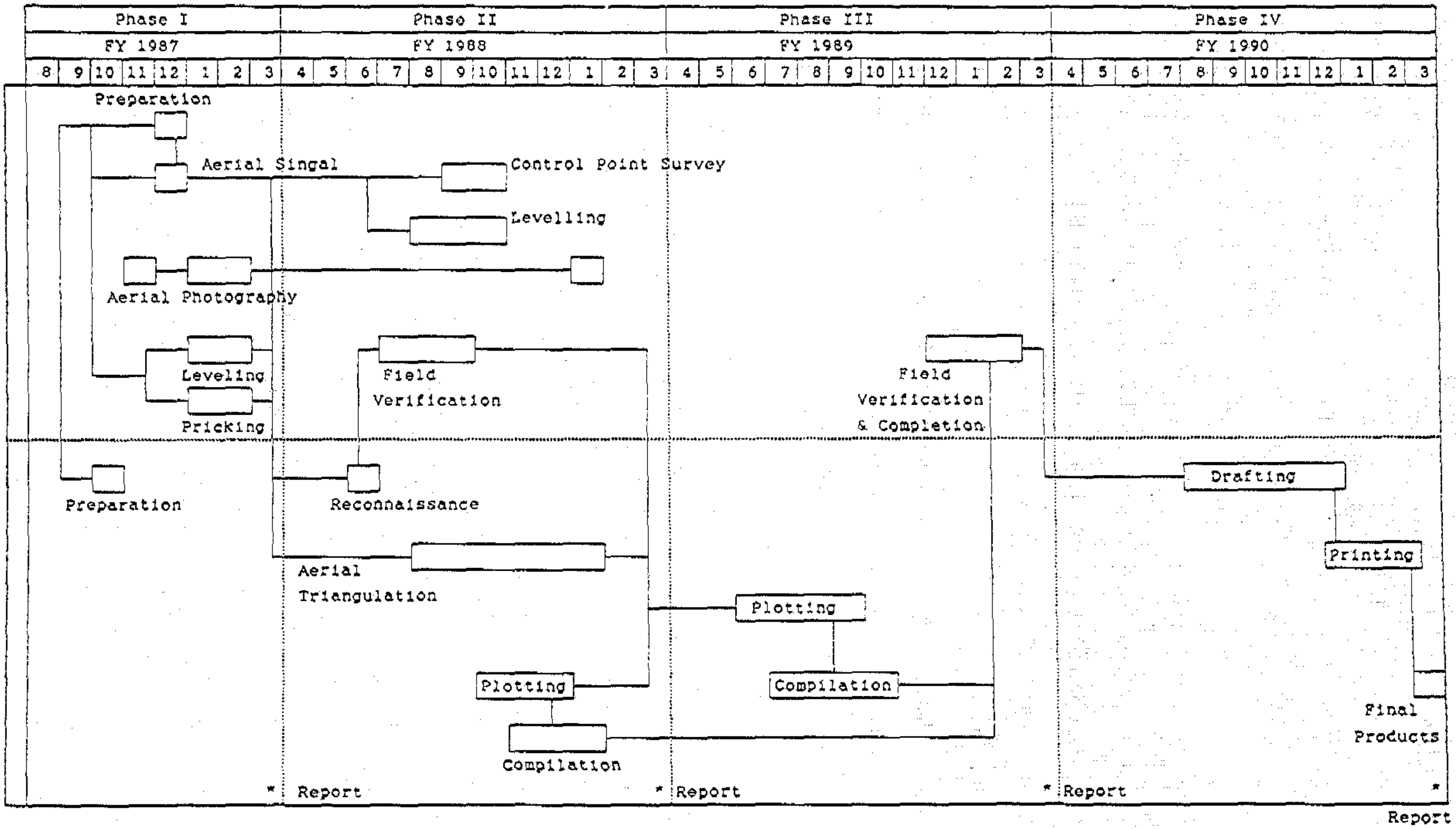


Figure 9. Yearly Work Flow (Modified)

3-2 Aerial Signal

3-2-1 Outline

For horizontal control points for aerial triangulation and plotting, out of existing triangulation points and traverse points (referred to as "geodetic control points"), 40 points were selected on the aerial photography plan map and signalized on site.

3-2-2 Signalization

Of the 40 geodetic control points, as selected above, 35 points were signalized as they were but the remaining 5 points were missing. Therefore, with respect to the missing points, signalization was made in the neighborhood of the presumed locations of these points and control point survey was conducted to determine their poistions and heights. (Figure 3)

3-2-3 Shape of Aerial Signals

The shape of the aerial signal is 4-winged in principle but occasionally 3-winged depending on the surrounding conditions. Each wing is rectangular in shape of 5m x 1m. Material and other specifications are as follows.

(1) In rocky areas with many outcrops, the signal was drawn on the exposed rocks in the specified shape with white paint.

(2) When small pieces of rocks were available, or could be brought in, in the neighborhood of a geodetic control point, they were laid out on the ground in the specified shape and painted in white.

(3) In coastal hills and inside bushes that were not easy for transportation, timber block cut from tree were laid out on the ground in the specified shape and coated with white paint or white lime.

3-3 Aerial Photography

3-3-1 Outline

PHOTOMAP, based in Nairobi, Kenya, was contracted for aerial photography for pricking and plotting.

(1) Aerial photography for pricking

1) Flight plan

Aerial photography for pricking was planned to be done with a super wide lens camera at a scale of about 1:40,000. Flight courses were planned over the leveling routes with overlaps of 10 - 15% for a distance of about 1,500 km (500 km of existing route and 976 km of minor order leveling route).

2) Bases

Voi and Malindi airports.

3) Aircraft and aerial camera

Aircraft : Cessna 404 Twin Engine Turbo Charged

Aerial Camera : Wild RC-10/88mm lens cone

4) Navigation system

Teledye Ryan Doppler

Sperry C-12 Compass System

5) Film and printing paper

Film : Kodak double x panchromatic Aerographic type 2405

Printing paper : Kodachrome 11RC

6) Flying

Photographic flying was carried out from November 9, 1987, to November 28, 1987. The original plan called for the sun's altitude being no less than 30° at the time of photography but it was forced to be eased due to unfavorable weather conditions. And for the same reason, the resulting photos had scales ranging from 1:8,000 to 1:40,000, which were accepted since they did not adversely affect the work processes.

7) Results

Except for the variation in photo scales resulting from changes in flight altitudes due to clouds as mentioned above, all the planned courses were successfully flown with results as below. (Figure 4)

Number of courses flown : 85 courses

Number of photos taken : 1,052 frames

(2) Aerial photography for plotting

1) Flight plan

The flight plan was made in accordance with S/W which specified the use of a super wide angle lens camera and the scale of 1:60,000. Flight directions and number of courses were :

Area	No. of courses	Datum plane
Eastern block : Nearly north-south	9	500 m
Western block : East-West	15	1,000 m
Tie course : along Tanzanian border	1	500 m

Forward overlaps and sidelaps were 55-60% and 25-35% respectively in principle. But 40% or more of sidelaps were allowed for the two courses along the sea coast, and for the inland side course it was so arrnged that all the principal points be located inland. The inland courses that included Taita Hills were allowed 40% more or less for sidelaps due to substantial differences in height involved so as to prevent stereo gaps.

2) Bases

Voi and Malindi airports

3) Aircraft and aerial camera

Same as (1) 3) above.

4) Navigation system

Same as (1) 4) above.

5) Film and printing paper

Same as (1) 5) above

6) Flying

Due to unfavorable weather conditions, flights took place in the following two separate periods.

a. From December 29, 1987 to February 22, 1988

b. From February 13, 1989 to February 27, 1989

7) Results

The results were as follows. (Figure 5)

Number of courses flown : 25 courses

Number of photos taken : 959 frames

3-4 Pricking

The existing bench marks in the study area were surveyed in an attempt to prick some of them as vertical control points for aerial triangulation and plotting. There were a total of 383 bench marks of which 147 points were pricked.(Figure 10) With respect to Malindi - Lunga Lunga part of the route for a distance of about 200 km where missing points were concentrated, minor order leveling and pricking were conducted.

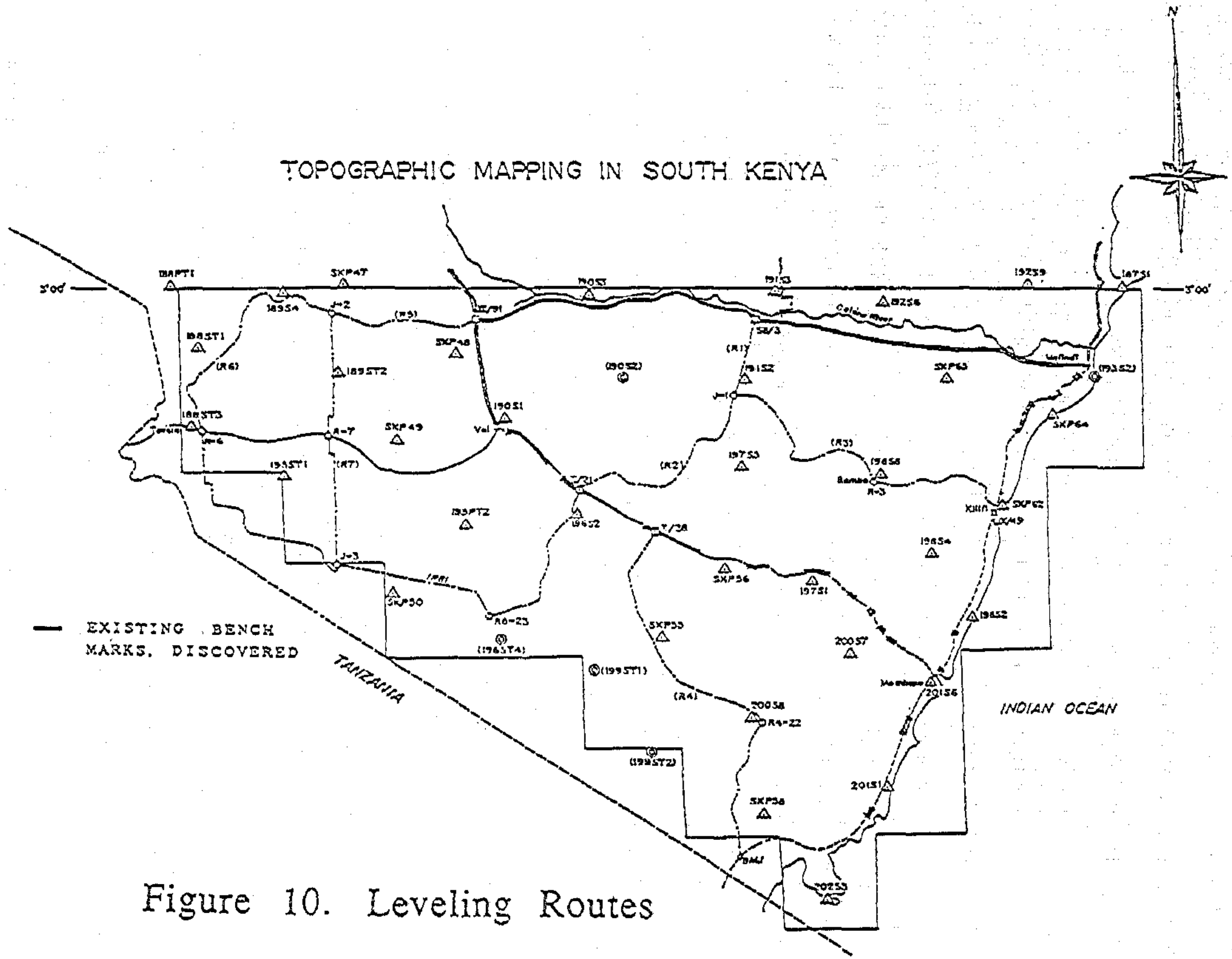


Figure 10. Leveling Routes

3-5 Control Point Survey

3-5-1 Geodetic Control Point Survey

(1) Outline

Geodetic control point survey was conducted by satellite geodesy using GPS to determine horizontal positions and heights of signalized 5 points (Figure 3) and one additional bench mark (R-2) set up by pricking, as well as to obtain heights of 4 triangulation points (not including R-2) whose elevations were not known. Specifically, the ten points actually observed were :

For horizontal positioning : 193S2, 196ST4, R-2,

For horizontal and vertical positioning : 199ST1, 199ST2, 109S2

For vertical positioning : 188PT1, SKP49, 195PT2, 202S3

1) The following points were used as given points.

a. For horizontal positioning :

188PT1, 191S2, 192S6, SKP49, 195PT2, 197S1, 198S8, SKP62, 200S8, 202S3 -- a total of 10 points

b. For vertical positioning :

J-2, J-3, R6, 196ST4, R-2, R9-47A, SKP62, 193S2, I/21, BM-1 -- a total of 10 points

Observations were made on the top of the monuments except for I/21 and BM-1 which were not suitable for such observation so that temporary markers were set up close by and their elevations were determined by direct leveling to make them serve as given points. To distinguish these temporary points from the original points, they were designated as I/21T and BM-1T respectively.

2) SKP49 was not adequate as it was for observation so that a new marker was temporarily set up about 2 km to the south and observation was made therefrom. This temporary point was designated as SKP49B to distinguish it from the original point. Only the relative height was measured between these points.

3) Four geodetic control points (190S2, 196ST4, 199ST1, 199ST2) were not found at their original locations and therefore monumentation was newly made at places considered close enough to the original locations. They were distinguished by putting N at the end of their respective identification numbers as follows.
190S2N, 196ST4N, 199ST1N, 199ST2N

(2) Observation

Using three units of Trimble (USA) 4000SX as receiving devices and starting from an existing point, observations were made simulataneously at 3 points, to close at another existing point. See Figure 6 for combinations of the observation points. Satellites Nos. 2, 6, 9, 12 and 13 were used for observation and 3 to 5 of them were observed at altitudes of 15 degrees or higher.

(3) Processing of observed data

a. During the observations of Triangle No. 4, Satellite No. 9 was found unhealthy and, therefore, this satellite was not used for computation.

b. An orbital adjustment took place during observations of Triangles Nos. 5 and 6 started and therefore this satellite was omitted from computation.

c. Satellite orbital data used for computation were based on broadcast ephemeris. Computations were made according to "Automatic Processing", a menu of Trimble program TRIVEC, and the geocentric coordinate system that corresponds to the satellites' reference ellipsoid WGS-84.

d. From the values of three points obtained by simultaneous observation, coordinate differences between two points, or side length vectors, can be computed. Though they are not srictly independent from each other, by examining their vector closures, the quality of observations can be judged. Table 4 shows the closure differences for each triangle. In the table, ΔX and ΔY concern the latitude and the longitude components respectively on the reference ellipsoid WGS-84, Δh representing the vertical conponent relative to this ellipsoid.

e. The Observation results are summarized below.

	Range	Mean	÷ 3
Total length (triangle)	87km˜280km	155km	
Side length (one side)	21km˜126km	52km	
Closure (absolorte value)			
Δx	1cm˜26cm	9cm	3cm
Δy	1cm˜108cm	37cm	12cm
Δh	0cm˜30cm	14cm	5cm

The aboves are the results of computations executed for checking purposes on site.

Table - 4 : Triangular Closures

Triangle	Δx	Δy	Δh	Total side length
1	-8cm	+30cm	±0	139.5km
2	-5cm	+48cm	-18	150.5km
3	-20cm	-45cm	+15	124.3km
4	-5cm	-34cm	+7	204.1km
5	-10cm	-6cm	+12	97.1km
5'	+1cm	+1cm	+1	97.1km
6	-26cm	-56cm	+30	135.4km
6'	-2cm	+30cm	-8	135.4km
7	+9cm	+13cm	+2	90.4km
8	+17cm	+49cm	-12	127.7km
9	-19cm	+108cm	+26	208.1km
10	+1cm	+3cm	+19	146.9km
11	+8cm	+76cm	+16	195.3km
12	-3cm	+5cm	+10	192.0km
13	-4cm	-56cm	+25	214.6km0

(4) Computation

1) Using the observed values at all the given and the proposed points except for those of Triangles Nos. 5 and 6, the coordinate differences between each two adjacent points were computed. Net adjustment was performed simultaneously, fixing the coordinates of all the given points. The reference ellipsoid of the satellites is WGS-84 whereas the Kenyan geodetic network (New Ark 1960) is referred to Clarke 1880. The two ellipsoids, however, have their thee spatial axes parallel respectively to each other, and therefore WGS-84 based GPS observed values (Δx, Δy and Δy) expressed in geocentric coordinate system can be strictly dealt with in the geocentric coordinate system referred to Clarke 1880 ellipsoid. Clarke 1880 reference ellipsoid has following dimensions.

Semi-major axis	:	6378249.145m
1/flattening	:	293.465m

2) Observation equations

With respect to Points 1 and 2, the following equations were developed. (unit : m)

$$
\begin{aligned}
v(\Delta X) = {} & [(N_1+h_1)/\rho''] \sin\lambda_1 \cdot \delta\lambda_1'' \cos\phi_1 \\
& + [(N_1+h_1)/\rho''] \sin\phi_1 \cos\lambda_1 \cdot \delta\phi_1'' - \cos\phi_1 \cos\lambda_1 \cdot \delta h_1 \\
& - [(N_2+h_2)/\rho''] \sin\lambda_2 \cdot \delta\lambda_2'' \cos\phi_2 \\
& - [(N_2+h_2)/\rho''] \sin\phi_2 \cos\lambda_2 \cdot \delta\phi_2'' + \cos\phi_2 \cos\lambda_2 \cdot \delta h_2'' \\
& + \Delta X_{ado} - \Delta X_{obs}
\end{aligned}
$$

$$
\begin{aligned}
v(\Delta Y) = {} & -[(N_1+h_1)/\rho''] \cos\lambda_1 \cdot \delta\lambda_1'' \cos\phi_1 \\
& + [(N_1+H_1)/\rho''] \sin\phi_1 \sin\lambda_1 \cdot \delta\phi_1'' + \cos\phi_1 \sin\lambda_1 \cdot \delta h_1 \\
& + [(N_2+h_2)/\rho''] \cos\lambda_2 \cdot \delta\lambda_2'' \cos\phi_2 \\
& - [(N_2+h_2)/\rho''] \sin\phi_2 \sin\lambda_2 \cdot \delta\phi_2'' + \cos\phi_2 \sin\lambda_2 \cdot \delta h_2'' \\
& + \Delta Y_{ado} - \Delta Y_{obs}
\end{aligned}
$$

$$
\begin{aligned}
v(\Delta Z) = {} & -[(N_1+h_1-e^2N_1)/\rho''] \cos\phi_1 \cdot \delta\phi_1'' - \sin\phi_1 \cdot \delta h_1 \\
& + [(N_2+h_2-e^2N_2)/\rho''] \cos\phi_2 \cdot \delta\phi_2'' + \sin\phi_2 \cdot \delta h_2 \\
& + \Delta Z_{ado} - \Delta Z_{obs}
\end{aligned}
$$

where

λ_i, ϕ_i	Geodetic longitude and latitude of point i (approximate)
h_i	Height from reference ellipsoidal surface of point i (apparoximate)
$\delta\lambda_i$, $\delta\phi_i$	Correction to λ_i, ϕ_i (unknown)
δh_i	Correction to h_i (unknown)
X, Y, Z	*Geocentric coordinates of point i* referred to the reference ellipsoid

ΔX	$=X_2-X_1$ (X component of the geocentric coordinate difference)
ΔY	$=Y_2-Y_1$ (Y component of the geocentric coordinate difference)
ΔZ	$=Z_2-Z_1$ (Z component of the geocentric coordinate dofferemce)
a	Equatorial radius of the reference ellipsoid
b	Polar redius of the reference ellipsoid
e^2	$=(a^2-b^2)/a^2$ First eccentricity
e'^2	$=(a^2-b^2)/b^2$ Second eccentricity
C	$=a^2/b$ Radius of curvature of meridional ellipse at the pole
η^2	$=e'^2\cos^2\phi$
V^2	$=1+\eta^2$
N_i	$=C/V$ Radius of prime vertical at point i
ρ''	Second corresponding to 1 radian
$\nu(\#)$	Correction to be added to obderved value # shows kind of observation
ΔX_{ado}	Approximate value of ΔX computed by using λ and ϕ
ΔY_{ado}	Approximate value of ΔY computed by using λ, ϕ
ΔZ_{ado}	Approximate value of ΔZ computed by using λ, ϕ
ΔX_{obs}	Observed value of ΔX
ΔY_{obs}	Observed value of ΔY
ΔZ_{obs}	Observed value of ΔZ

3) Adjustment computations

For adjustment computations, a newly developed geodetic network adjustment computation program, PUG-U (Universal Program for Adjustment of Any Geodetic Network) was employed. The results of the computations are given in Table 5. The reference ellipsoid and the coordinate system on which the computations were based were Clarke 1880 and New Ark 1960 respectively. In the table, H represents a height from the geoid. Table 6 shows the UTM coordinates of the proposed points.

The geometric patterns the program automatically recognized from the observed values were:

Pattern	Number
Triangle	15
Ploygon	4
Traverse	31
Straight line	0

From the results of network adjustment, the accuracies of coordinate determination are as follows.

Maximum correction to add to the observed values : 4.84m

Standard deviation of a observation of unit weight : 1.579m

The error ellipses of each point is shown in (a) of Figure 11. In the figure (b) is shown the case of the solution by free net adjustment for reference.

Table 5 (1) Adjustad Results of Proposed Points

STATION NO.	CLARKE 1880		
	Latitude	Longitude	H
	° ' "	° ' "	m
190 S 2 N	3 18 13. 1803(S)	38 52 19. 9026(E)	403.23
193 S 2	3 15 20. 9452(S)	40 07 49. 9976(E)	12.43 *
196 ST 4 N	3 56 18. 9430(S)	38 33 03. 1780(E)	606.57 *
199 ST 1 N	4 02 55. 7452(S)	38 49 11. 6783(E)	448.22
199 ST 2 N	4 11 03. 2020(S)	38 56 46. 1256(E)	340.19
R - 2	3 32 12. 3473(S)	38 59 34. 1271(E)	369.00
SKP 49	3 24 46. 0069(S)**	38 17 29. 8922(E)**	2206.99
188PT1	3 00 16. 4060(S)**	37 43 48. 4089(E)**	1218.43
195PT2	3 38 01. 3108(S)**	38 27 25. 2373(E)**	942.67
202S3	4 39 05. 7508(S)**	39 21 34. 5398(E)**	3.00

* By direct leveling

** Official result

Table 5 (2) Adjusted Results of Other Points

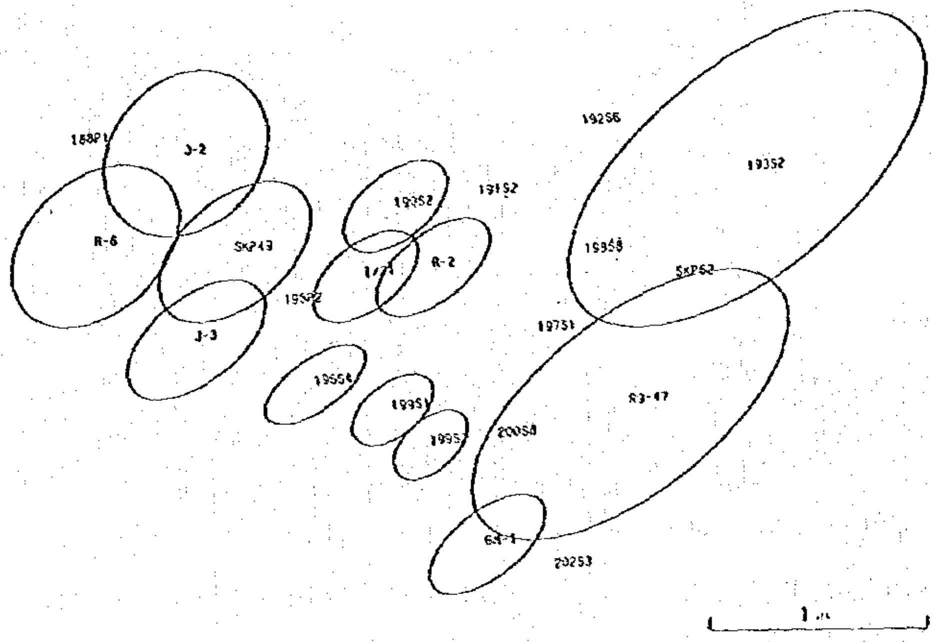
STATION NO.	CLARKE 1880		
	Latitude	Longitude	H
	° ' "	° ' "	m
SKP 49 E	3 26 01. 9461(S)	38 17 31. 2406(E)	1646.27
191 S 2	3 16 43. 0430(S)**	39 10 15. 8781(E)**	443.41
192 S 6	3 02 50. 8435(S)**	39 33 08. 9291(E)**	142.37
198 S 8	3 31 18. 1536(S)**	39 32 10. 5776(E)**	319.75
200 S 8	4 10 15. 2370(S)**	39 11 16. 4592(E)**	295.15
J - 2	3 04 04. 5013(S)	38 08 03. 1099(E)	637.32
J - 3	3 45 00. 0445(S)	38 08 00. 0236(E)	766.55 *
R - 6	3 22 59. 7944(S)	37 47 32. 0719(E)	891.05 *
1/21T	3 33 17. 1147(S)	38 45 00. 7932(E)	517.35 *
BM 1M	4 33 12. 6361(S)	39 07 27. 7634(E)	45.92 *
R9 - 47A	4 04 51. 9591(S)	39 39 51. 8402(E)	11.94 *
SKP62	3 37 38. 5626(S)**	39 51 15. 7154(E)**	45.78 *

* By direct leveling

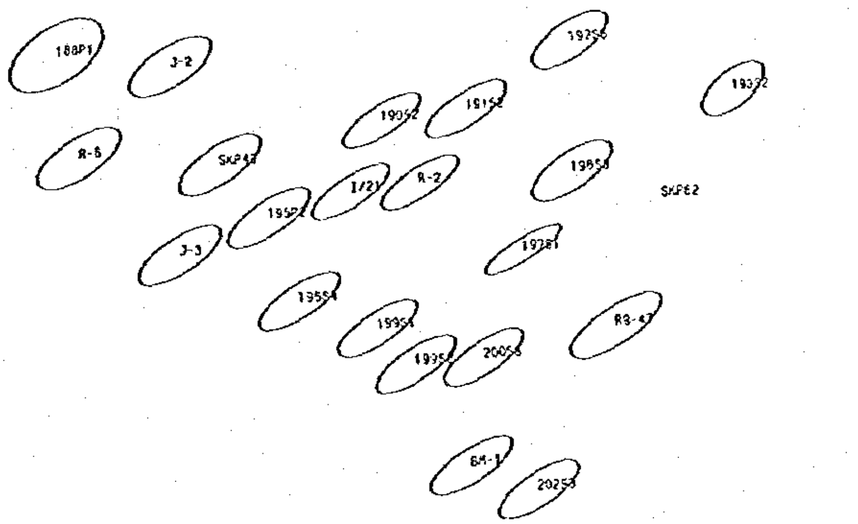
** Official result

Table - 6 UTM Coordinates of Proposed Points

Point Name	UTM Coordinates		Maxidian Convergence		
	N	E			
	m	m	°	'	"
SKP49B	9620 455. 048	421 355. 682	-0	2	32. 670
196ST4N	9564 686. 643	450 140. 343	-0	1	51. 057
199ST1N	9552 515. 435	480 009. 854	-0	0	45. 776
199ST2N	9537 551. 759	494 023. 157	-0	0	14. 146
190 S2N	9634 874. 834	485 801. 734	-0	0	26. 514
193 S2	9640 093. 143	625 611. 136	+0	3	51. 183
J - 2	9660 892. 072	403 788. 607	-0	2	46. 828
J - 3	9585 495. 572	403 762. 154	-0	3	24. 073
R - 2	9609 112. 417	499 201. 774	-0	0	1. 596
R - 6	9625 992. 937	365 827. 147	-0	4	16. 632
1/21T	9607 120. 238	472 258. 467	-0	0	55. 753
BM-1T	9496 734. 786	513 797. 102	+0	0	35. 548
R9-47A	9548 919. 276	573 747. 840	+0	2	50. 231



(a) Error Ellipses



(b) Error Ellipses (Free Net Solution)

Figure 11. Error Ellipses

4) Determination of heights

The heights derived from WGS-84 based GPS data are relative to the surface of Clarke 1880 ellipsoid, and therefore need to be converted to those of leveling. In Figure 12 plane xy is a plane on the reference ellipsoid surface : P is a unilaterally chosen spatial point and the feet of perpendiculars of P and surrounding points P_1, P_2 and P_3 on the xy plane are P_0, P_{01}, P_{02} and P_{03} repectively. Point P has height from the ellipsoidal surface h. The coordinates of these points on the ellipsoid are represented by (x, y), (x_1, y_1) (x_2, y_2) and (x_3, y_3) and the intersecting points of their perpendiculars to the geoidal surface as P'_0, P'_{01}, P'_{02}, and P'_{03}, respectively, with their geoidal heights as h_g, h_{g1}, h_{g2}, and h_{g3}. Assuming h_{g1}, h_{g2} and h_{g3} are known and the geoidal surface is flat,

put

$$D = \begin{vmatrix} x_1 & y_1 & h_{g1} \\ x_2 & y_2 & h_{g2} \\ x_3 & y_3 & h_{g3} \end{vmatrix}$$

and

$$u = (y_1 h_{g2} + y_2 h_{g3} + y_3 h_{g1} - y_2 h_{g1} - y_3 h_{g2}) / D$$

$$v = (h_{g1} x_2 + h_{g2} x_3 - h_{g1} x_3 - h_{g2} x_1 - h_{g3} x_2) / D$$

$$w = (x_1 y_2 + x_2 y_3 + x_3 y_1 - x_1 y_3 - x_2 y_1 - x_3 y_2) / D$$

then

$$h_g = (1 - ux - vy) / w.$$

Further

$$H = h + h_g$$

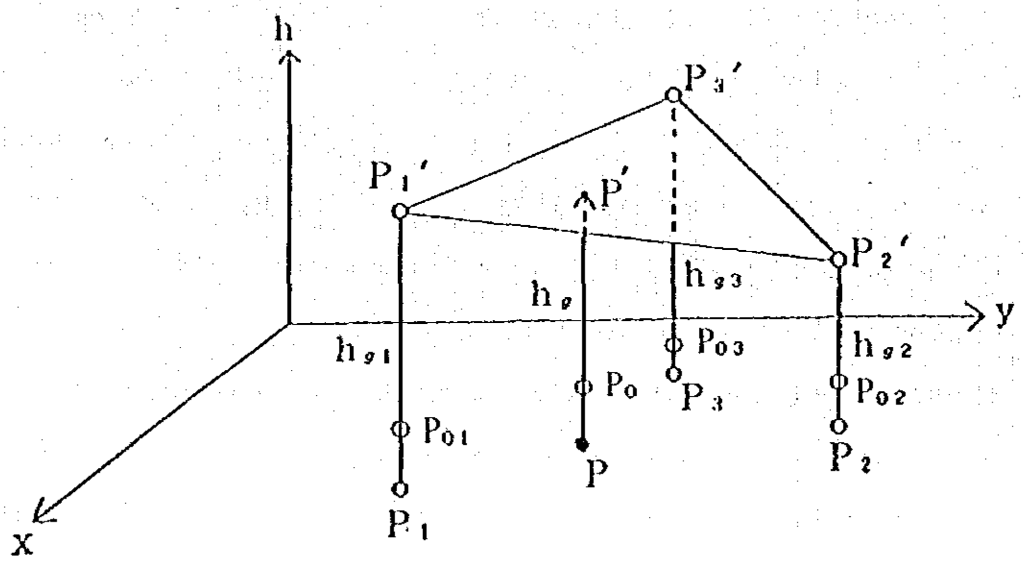


Figure 12. Geoidal Height

Actually for h_{g1}, h_{g2} and h_{g3}, only relative values are known, so that the geoidal height is assumed for one of these points to arrive at h_g of a proposed point. In the Study, however, there were not a sufficient number of points with known leveling heights available for the above computations, and therefore, as mentioned in the Report on the Second Year Work, Page 33 [3], heights of the proposed points were calculated by interporating or extraporating the values of adjoining given points.

With respect to those points whose heights were determined by leveling, heights from the ellipsoidal surface and those from the goidal surface are compared in Table 7. Further- more, by assuming the geoidal height at Point SKP62 as 0, geoidal heights of these points were caluculated with the results as shown in Table 7. Based on the above results, the heights from the geoidal surface of the proposed points are given as H in Table 5. Shape of relative geoidal heights estimated from the values of Table 7 are schematically overlaid on the map of the study area in Figure 13.

5) Results

The results of compuatations performed in 3) above are given in Tables 5 and 6. The horizontal coordinates are those derived from the adjustment compuatations of 3), while the listed heights are of the provisinal values as mentioned above [3].

Table 7 Geoidal Height at Points with Leveling Height

Point No.	Height from ellipsoid h (1)*	Height from geoid H (2)**	Geoidal height h (2)-(1)
	m	m	m
SKP62	45.78 *	45.78	0
193S2	13.87	12.43	-1.53
R2	378.19	369.00	-9.19
J-2	654.41	637.32	-17.09
R-6	909.11	891.05	-18.06
J-3	781.39	766.55	-14.84
196ST4N	617.46	606.57	-10.89
1/21T	530.92	517.35	-13.57
R9-47A	10.74	11.94	+1.20
BM-1T	48.00	45.92	-2.08

* Value on the ellipsoid Clarke 1880.
Height at SKP62 is assumed to be the same as that from geoid.

** By direct leveling

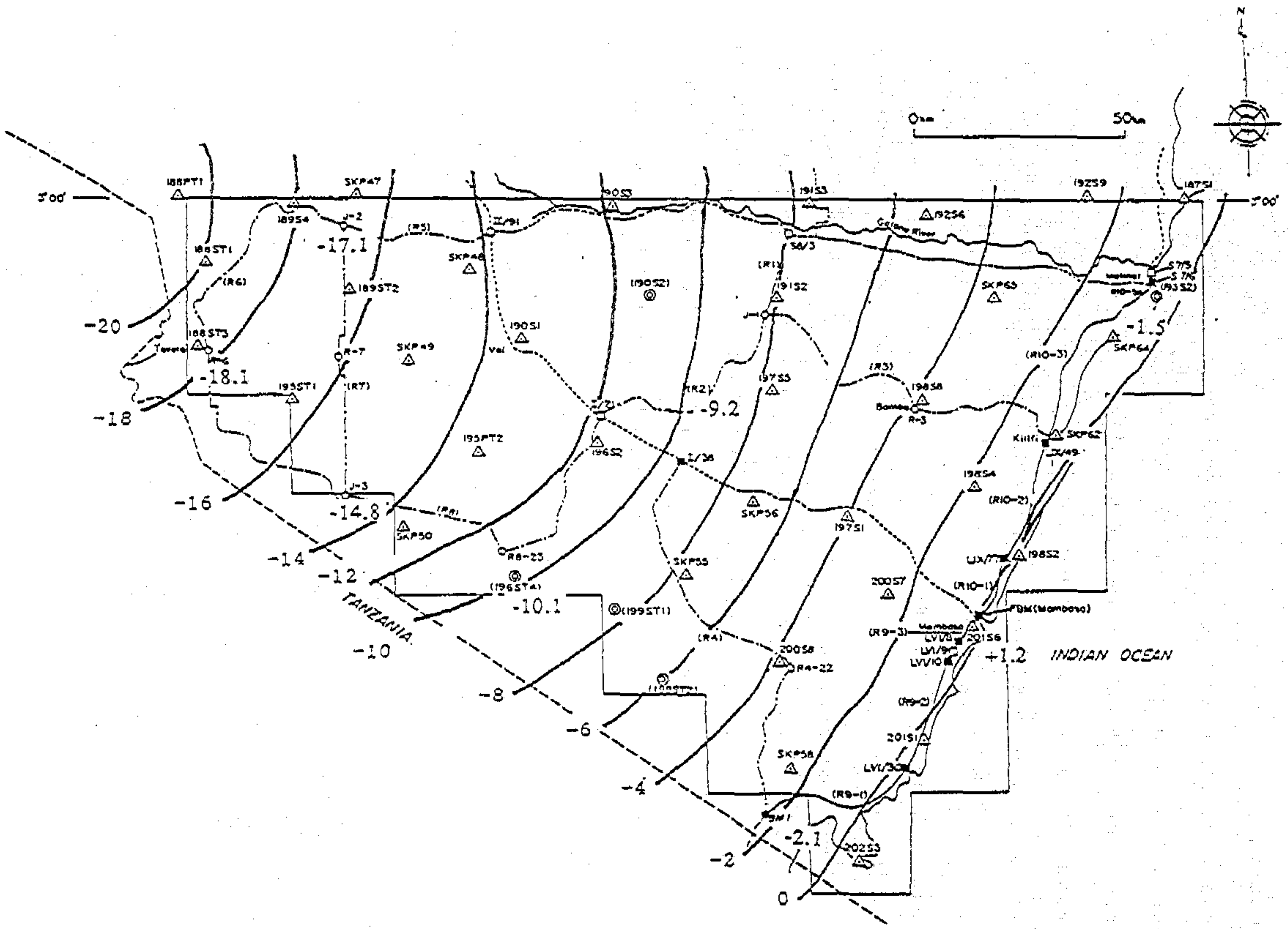


Figure 13. Relative Geoidal Height

3-5-2 Leveling

(1) Outline

Two-way minor order leveling was carried out based on the exising bernch marks using staff stands to ensure the accuracy of 5cm√S (S:km) as specified in the S/W. In addition, trigonometric cross-sea leveling was also conducted acros Kilindini Harbor in Mombasa and Kilifi Creek.

(2) Determination of routes

Since it was difficult to determine leveling routes from maps or field surveys alone, aerial photography was carried out on the basis of the preliminary findings from maps and field surveys, and photo interpretation was performed in search of feasible routes. The 10 routes thus determined were as shown in Figure 3. The descriptions of these routes are given below.

Leveling Routes

Route number	Number of markers	Route length (km)
R1	17	32.1
R2	34	69.9
R3	54	109.3
R4	64	135.8
R5	22	45.3
R6	83	161.6
R7	38	81.0
R8	45	96.3
R9	48	97.7
R10	68	129.5
Total	473 *	958.5

* Note : Existing bench marks and auxiliary points of cross-sea leveling R9-47B and R10-33B are excluded.

(3) Marking

Marking was made about every two kilometers along each route. Existing ground features such as structures, outcrops, tree stumps, traverse points, were used wherever possible for marking by nailing or riveting, and otherwise timber piles were driven into the road surface. Partly, permanent monuments were set up. (Refer to (7) of this section) The descriptions of points were prepared for their identification.

(4) Instruments

Instruments employed for leveling were:

a. Level : Nikon AS automatic level,
Carl Zeiss Ni2 automatic level.

b. Staff : Metal staves

c. Staff stand : Metal stands

d. Theodolite : WILD T2 (For cross-sea leveling)

e. Electro-optical distance meter :
WILD DI-3000 (For cross-sea leveling)

(5) Implementation

Leveling was conducted over two years :

a. First year R1 R8

b. Second year R9, R10, and 2 locations for cross-sea leveling

Prior to the start of leveling, check measurements were made of the existing bench marks to ensure the results met the accuacy requirements as specified for the present surveying. And the starting points and closing points were determined accordingly. The observed data were checked by closing to existing points or loop closure with results as shown below. They all met the required accuracy.

Route	Section	Closure(mm)	Distance(km)	Allowance(mm)
R1+R2	S8/3~I/21	98	102.0	504
R1+R3	S8/3~LIX/49	274	141.4	594
R2+R3	I/21~LIX/49	362	179.2	669
R5+R6+R8	II/91~I/21	337	303.2	870
R5+R7+R8	II/91~I/21	342	222.6	745
R6+R7	(Loop)	235	242.6	778
R4+R9-1	I/38~LVI/30	57	186.7	683
R9-2	LVI/30~LVI/10	26	32.8	286
R9-3	LVI/8~FBM	13	14.0	187
R10-1	FBM~LIX/77	68	21.0	229
R10-2	LIX/77~LIX/49	61	42.6	326
R10-3	LIX/49~S7-6	29	65.9	406
	R10-56~193S2	3(Discrepancy	5.3	115
	LIX/49~SKP62	3 of double	1.1	52
	R8-23~196ST4	1 measurements)	6.4	126

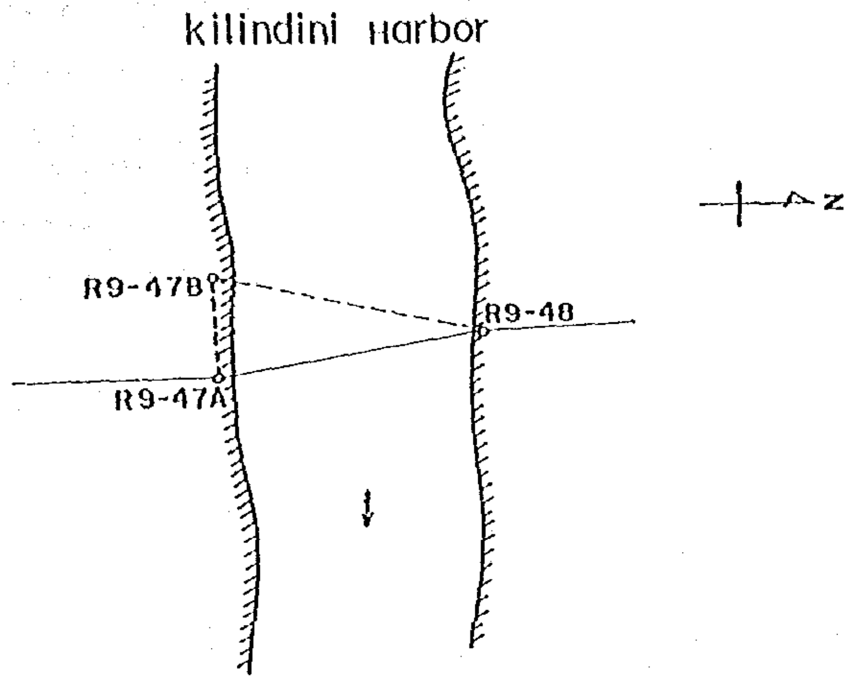
(6) Cross-sea leveling

Cross-sea leveling across Kilindini Harbor and Kilifi Creek was conducted at Likoni and Kilifi. The method employed was trigonometric leveling using two units of WILD T2 theodolite and a WILD DI-3000 electro-optical distance meter. The cross-sea distances were 540m at Likoni and 470m at Kilifi.

Observations were conducted with stations set up as shown in Figure 14. They are also shown schematically in Figure 15, where Station A is set up on one side of the sea and Stations B and C on the other side, and vertical angle measurements were made by two pairs of simultatneous observations between A and B (and between A and C) and in the meantime their distances were measured.

B and C were about 10 meters apart on the same side and the relative height between them was measured by direct leveling. Observation results with respect to AB and Ac were checked and their closure errors were found to be 2mm and 3mm respectively as shown in the table below and their respective mean values were adopted to represent the relative heights of R9-47A ~ R9-48 and R10-33A ~ R10-34.

Trigonometric Cross-sea Levelling



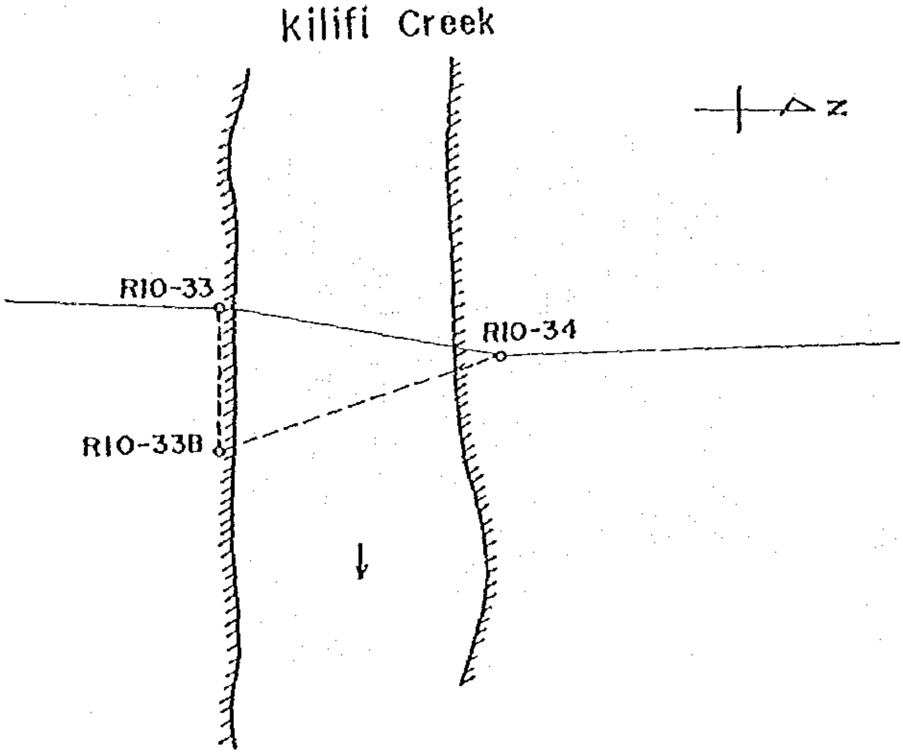


Figure 14. Cross-sea Liveling

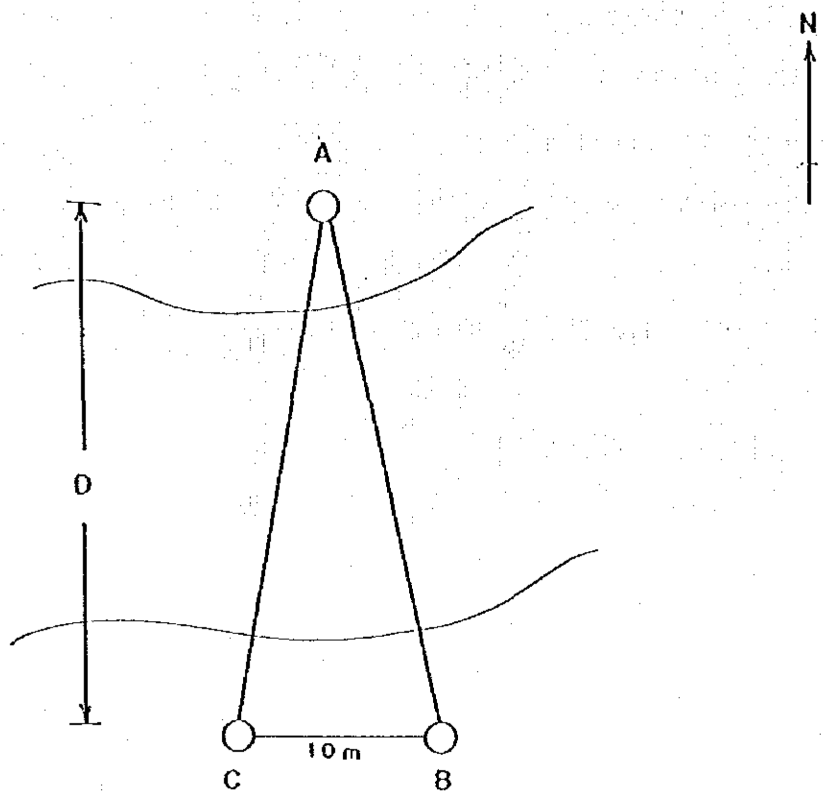


Figure 15. Schematic Configuration of Cross-sea Leveling

Closure in Cross-sea leveling

Place and Section	Distance	Relative height	Closure
Kilindini Harbor	m	m	m
R9-47A - R9-47B (Direct leveling)	7.00	-0.148	+0.002
R9-47B - R9-48 (Trigonometric leveling)	539.22	-0.576	(0.039)*
R9-48 - R9-47A (")	538.54	+0.726	
		Mean +0.725	
Kilifi Creek	m	m	m
R10-33A - R10-33B (Direct leveling)	8.30	-0.011	+0.003
R10-33B - R10-34 (Trigonometric leveling)	470.72	-0.676	(0.033)*
R10-34 - R10-33A (")	469.06	+0.684	
		Mean +0.686	

* Note : Figures enclosed by parentheses in the column of Closure stand for tolerance (= 50 mm $\sqrt{S}$: S being distance in bm).

3-6 Aerial Triangulation

3-6-1 Outline

Coordinates of the pass points and the control points to be used for plotting were measured by a stereocomparator, and by block adjustment computations based on independent models, analytical aerial triangulation was executed to obtain orientation elements as well as the coordinates of pass points.

According to the original plan, adjustment computations were to be performed for the entire study area as one block. But actually due to the delay in the aerial photography scheduled for the first year and out of consideration for the plotting and compilation work to follow, computations were made by partly splitting up the study area. The area covered accordingly was made to corespond to that of plotting scheduled for the second year as shown in Fig. 8. For the remainder, computations were performed as the relevant aerial photographs were made available, together with the rest of the study area previously covered. (Total number of models being 757.) The results, though initially provisional, fully met the purpose of 1/50,000 topographic mapping.

(1) Specifications

Photo scale : 1:60,000 (Flight altitude above ground : 5,300 m)

Number of courses : 25

Number of models : 757

Control points : Horizontal 88, elevation 434

Adjustment computations : Independent model method (PAT M 43 Program)

(2) Major instruments used

Pricking device : PUG 4 (Wild)

Stereocomparator : Stecometer (Zeiss Jena)

Computer : FACOM-M340 (Fujitsu)

(3) Aerial camera

Aerial camera : Wild RC10

Focal length 88 m

Lens 8.8 SAG II

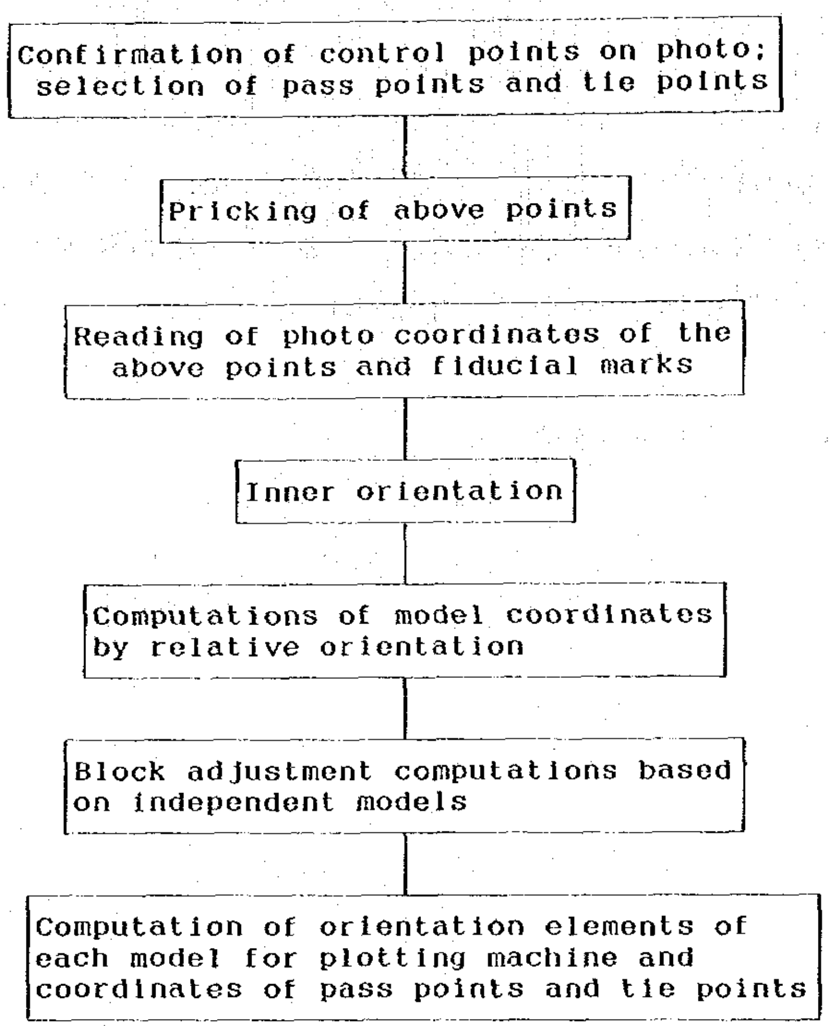
Distortions

Radius	0	10	20	30	40	50	60	70	80	90	100
Distortion	0	-2	-3	-4	-4	-4	-4	-1	1	3	4

Radius	110	120	130	140	145	Grade
Distortion	3	2	-1	0	0	μ

3-6-2 Work Procedure

The work was carried out in the following procedures.



3-6-3 Inner Orientation

The residuals of fiducial marks were transformed to the coordinate system having the center of photo projection as the origin, and the measured value of each fiducial mark was computed by the Helmert's transformation.

The standard deviations and maximums of the residuals of the fiducial marks are as follows.

SD	Maximum	Remarks
13.3 μ	20.0 μ	Tolerance by specifications Max. 30 μ

3-6-4 Relative Orientation

Relative orientation was made using all the points contained in the models, and corrections were made for atmospheric refraction.

3-6-5 Adjustment Computations

Adjustment computations were performed using the PATM 43 Program, which is based on the independent model method, taking the entire study area in one block, whereby the horizontal and vertical elements were treated simultaneously. In this process, the points originally established for aerial triangulation on the aerial photos for topographic mapping of East Kenya but covering the same area as for the present study were transferred to the present photos and applied as control points. There were 37 such points each for horizontal and vertical. They are included in the control points listed below.

Adjustment computations were made including all the control points.

Standard deviations and maximum of control point residuals and tie point discrepancies resulting from aerial triangulation are as follows.

Residuals of Control Points

Number of courses & models	Number of control points		Residual of control points (planimetry)		Residual of control points (elevation)		Remarks
	Planimetry	Elevation	SD	Maximum	SD	Maximum	
49 courses 757 models	88	434	1.24m	4.11m (0.76‰)	0.41m	2.83m (0.52‰)	Specified tolerance of flight height ratio Planimetry 1.4‰ Elevation 1.4‰

Discrepancies of Pass and Tie Points

Planimetry		Elevation		Remarks
SD	Maximum	SD	Maximum	
0.49m	3.64m (0.67‰)	0.27m	1.21m (0.22‰)	Specified tolerance of flight height ratio Planimetry 0.8‰ Elevation 0.8‰

3-7 Map Symbols

3-7-1 Map Symbols and their Applications

East Africa Specifications are basically applied as the standard symbols for mapping in Kenya with some modifications to suit the local conditions.

The present mapping is based on the map symbols and their applications as agreed between Kenya and Japan (March 1981) and applied for the Topographic Mapping Project with for East Kenya undertaken by JICA during 1975 to 1980 [1] with exceptions of (13) and (22) below. Some of the major ones include :

(1) Roads:

To be based on the symbols applied to East Kenya mapping by JICA.

(2) Embankments, fences, revetments:

To be shown if they are longer than 1 cm on the map.

(3) Water pipelines, oil pipelines:

To be shown by solid lines regardless of whether they are on the ground or underground. But not to be shown if they are under the road. Oil pipelines are shown only on the compiled manuscripts.

(4) Power lines, telephone lines:

All main lines to be shown in principle.

(5) Elevated railways:

To be shown if they have pillars by the symbol for elevated structures and, if not, by the symbol for bridges.

(6) Fills, cuts:

To be shown those for 250 m or longer and 5 m or higher.

(7) Bench marks:

To be shown only when confirmed in the field. Elevation to be rounded to meter and figures to be followed up with notation BM.

(8) Fish snares:

To be shown only if they are permanent.

(9) Principal point of photograph:

The one used for plotting to be shown on the map in three figures (Ex. 001).

(10) Hydroplane airports:

To be shown when confirmed in the field.

(11) Rivers:

To be shown if they measure 5 mm or longer on the map in principle and if they measure 1 cm or longer on the map over the flat land.

(12) Plantations:

To be shown with the initial letter of the plant name if not specified.

(13) Wells, springs, water holes, boreholes:

To be shown by new symbols.

(14) Airfields:

To be included in "Grass" if it is unpaved.

(15) Small buildings:

To be shown as around or square depending on their shape.

(16) Cemetery:

No symbol to be used but to be annotated with "Cem".

(17) Registered land:

To be shown by boundaries and reference numbers.

(18) Boundary of privato site:

Not to be shown.

(19) Bridges:

To be shown for all bridges that are confirmed in the field regardless of their sizes.

(20) Railway:

To be shown with level crossing indentified by LC.

(21) Magnetic declination:

To be shown by rounding to minute. The epoch shall be Jan. 1, 1991.

(22) Administrative boundaries:

To be shown until sub-district boundary. To override the sub-district boundary where they overlap with others.

3-8 Field Verification

3-8-1 Outline

Field verification is conducted for on-site verfication of aerial photo interpreted items and other items related to the symbols and other map representations required for topographic mapping, with its findings incorporated into the aerial photos and other related data to provide necessary information for plotting and compilation.

With respect to the entire study area of 29,800 km^2, field verification was carried out in two phases. (Figure 7)

a. Second year	26,800 km^2	(area covered by aerial photography in first year)
b. Third year	3,000 km^2	(area covered by aerial photography in second year)

3-8-2 Planning and Preparations

Prior to the field work in Kenya, reconnaissance study was made in Japan to collect following information to prepare for the field verification.

(1) Listing of data items that need to be provided by SK, based on the study of the symbols.

(2) Adjustment of inconsistencies and questions concerning data and information made available.

(3) By aerial photo interpretation, compilation of keys for interpretation, identification of items that are difficult for interpretation, and determination of the range and area to be covered by the field verification.

(4) Preparation of twice enlarged aerial photos for use in the field.

3-8-3 Items of Field Verification

The following items were surveyed and verified in the field according to the map symbols and their application rules.

(1) Confirmation of reconnaissance study and prepararion of keys for aerial photo interpretation.

(2) Features that are difficult to interpret from photos.

(3) Roads, railways, buildings (including antiquities, ruins), pipelines, control points, special districts, rivers, vegetation, topography, and other items necessary for application of the symbols.

(4) Collection of data and information on names necessary for annotations, and their verification.

(5) Place names. This was done by SK counterparts. The survey was conducted in a most efficient manner using old maps with relevant names on and the Information on Geographic Names. Starting with the examination of relevant names in the old maps and other data, and making corrections as necessary before proceeding to identifying new geographical names and other names that require annotation, the survey was carried out most efficiently.

3-8-4 Adjustment and Map Matching

(1) Adjustment

Field survey findings were incorporated onto the enlarged aerial photos according to the symbols and the work procedure by taking plotting and compilation into consideration.

(2) Matching

Due attention was paid to the matching of the sheets in the study area with those in the adjacent areas covered by the existing maps so as to fully study the edges of them.

As for such areas where matching was difficult due to changes over years, it was agreed with SK that no attempt should be made for artificial modification as long as there was justification not to do so.

3-9 Stereo Plotting

3-9-1 Outline

Based on the results of aerial triangulation and field verification, topographic features necessary for mapping were measured and delineated by a plotting machine to produce plotted manuscripts. The plotting was done in the second and third years with the areas covered in the respective years in the sheet allocation map in Figure 8.

A block (executed in the second year) 11,475km² (15 sheets)

B block (executed in the third year) 18,325km² (28 sheets)

3-9-2 Specifications

Plotting scale	:	1:50,000
Area	:	29,800km²
Number of sheets	:	43
Contour lines	:	Intermediate 20m, index line 200m, half interval auxiliary line 10m (on flat land)
Projection	:	UTM Progection
Neat line	:	15' east west X 15' north south
Sheet allocation	:	Sheet numbers and names as shown in Fig. 2.
Map sheet material	:	(Material) Ground/topographic features sheet - Polyester base #500 Control point data sheet - Polyester base #300 (Size) 60cm x 80cm

3-9-3 Instruments Employed

Plotting machine : Stereo-plotter A-8 (Wild), Metrograph (Zeiss), etc.

Coordinategraph : XP1100 (Daini-Seikosha)

3-9-4 Plotting of Control Points

Neat lines, grid lines, longitude/latitude lines, control points, existing geodetic control points (provided by SK) as well as pass points and tie points were plotted by coordinategraph, with plotting errors not to exceed 0.2 mm on the map.

3-9-5 Orientation

(1) Relative orientation was performed by using 6 pass points, with residual parallax not to exceed 0.02 mm on the contact film positives.

(2) Absolute orientation was made using pass point and tie point results from aerial triangulation as well as control points (including pricked points), pricked bench marks, with tolerances of 0.3 mm or less for planimetry on the map and 5 m or less for elevation.

3-9-6 Detail Plotting

(1) Detail plotting involved measurement and delineation of linear features, such as roads, rivers, railways, and housing, vegetation, contour lines, in that order, based on the map symbol rule as agreed between the Team and SK, and on the field verified photos.

(2) The colors used for plotting are as follows.

Black : Double line roads, railways, buildings, other linear features, vegetation symbols.

Red : Trails, indication symbols for specialized features, enclosures, small objects, revetments.

Green : Vegetation boundaries, garden paths.

Orange : Contour lines

Purple : Coast lines, rivers, lakes and ponds, fish nurseries, salt fields, aquatic plants.

(3) Buidlings were delineated truly in principle without generalization but in concentrated areas such as urban cities they were generalized to the extent not to affect the opaqueness of lines.

(4) Contour lines were delineated in such a manner as to maintain accuracy and not to affect terrain features.

(5) With respect to the Tsavo National Park, steep slopes cultivated way up to the top and dried up rivers, attention was paid so as to represent most adequately the topographic and other geographic features of the areas in which they were located.

(6) Shore lines were delineated as they were seen in the aerial photos.

(7) Control point data sheet.

- Control points were represented by the applicable symbols with their names, numbers and elevations.

- Bench marks were plotted at their locations by a plotting machine with their identification numbers and heights shown.
- Spot heights were measured two times and their mean values were shown in meters.

- Measurements of spot heights were taken at such places as major mountain tops, saddles; major intersections of roads; knick points of slopes; points typical of the area; bottoms of depression; and points necessary for clarification of the topography.

3-10 Compilation

3-10-1 Outline

Based on the plotted manuscripts, by incorporating the findings of the field verification and the research of existing data, map representations were compiled into the compiled manuscripts. The area covered was the same as for the plotted manuscripts. (See Fig. 8)

3-10-2 Specifications

Compilation scale : 1:50,000

Area : 29,800km²

Number of sheets : 43

Neat lines : 15' x 15' (UTM 37 ZONE)

Sheet :

The following types of sheet were used for the compilation work. They were selected for their stable quality.

Compiled manuscripts ..... Polyester base #500

Data maps ..... Ployester base #300

Plotting :

Neat lines and control points were plotted by coordinategraph. Errors were kept less than 0.3mm for a neat line and less than 0.4 mm for a diagonal line.

3-10-3 Compilation Work

(1) The compiled manuscripts were prepared in accordance with the map symbols as agreed between the Team and SK. In order to maintain the uniformity of map representations, a manual was prepared to ensure technical people involved comply with the same work rules.

(2) Compilation was made by the overlay method. Planimetry and contour lines were compiled on the same sheet with annotations separately on the annotation sheet. To facilitate the subsequent work of scribing, four types of data maps were separately prepared: the road data map, vegetation data map, water system data map, and the control point data map.

(3) Tick marks were entered on the neat lines at every 5' of longitudes and latitudes and UTM grid ticks every 1 km.

(4) The sheet names and sheet numbers as applied are shown in Fig. 2.

(5) The color classifications for compiled manuscripts are as follows.

Black : Double line roads, railways, buildings, spot heights, vegetation symbols, linear features, contour figures.

Red : Trails, administrative boundaries, small objects, enclosures, sub-symbols.

Green : Vegetation boundaries, parks.

Brown : Contour lines

Purple : Sea shores and rivers, lakes and other water systems, fish nurseries, salt fields.

3-10-4 Details

(1) Administraitive boundaries and names were based on SK's survey data.

(2) All roads were represented by symbol roads.

(3) Railway was shown by a double line along its center line both for single track and double track lines.

(4) Annotations for destinations were finalized at the time of the field completion.

(5) Generalization of villages was made according to the symbols rule.

(6) Dotted buildings were distributed to suit their environs.

(7) Magnetic declination was based on data provided by SK.

(8) Gas pipelines, power lines, and other pipelines could not be interpreted on the aerial photographs and, therefore, based on the data provided by SK.

(9) For matching with existing map sheets, the reproduced maps provided by SK were referred to. For matching among newly prepared map sheets, polyester base duplicate maps were used.

(10) Annotations were compiled on a separate sheet. Lettering sizes, spacing, style, and positioning were set by photo-composer as specified. But with respect the letter types that were not available in Japan, other appropriate types were chosen by consulting with SK. (See 3-12-1, (2)-4))

(11) The following four types of data sheet were produced to facilitate the subsequent work process.

a) Road data sheet :

Roads were classified by colors as follows

- All weather road with paved surface :

  Red color penciled solid line

- All weather road with soft surface :

  Green color penciled solid line

- Dry weather road :

  Yellow color penciled solid line

b) Vegetation data sheet :

With respect to such vegetation classifications as forests, bushes, plantations that require mask sheets, vegetation data sheet were prepared by representing the vegetation on the dia positive of comipled manuscripts (polyester base), as classified by colors as follows.

Forest : Green	Trees along rivers : Pink
Bush : Blue	Swamp with mangrove : Purple
Bamboo : Yellow	Swamp with trees : Brown
Plantation : Orange	Swamp with papyrus : Red

c) Water system data sheet :

With respect to those features that require mask sheets such as rivers, lakes, seas, data sheets similar to the vegetation data sheets were prepared in blue color.

d) Control point data sheet :

Geodetic control points, bench marks and spot heights were represented.

3-11 Field Completion

3-11-1 Outline

The field completion involved field survey and verificaiton of important features such as topography, ground features, geographical names, that were shown in the compiled manuscripts and the data sheets, as well as clarification of the questions raised in the course of plotting and compilation. Significant changes that took place after aerial photography were also surveyed in the field at this time.

3-11-2 Implementation

(1) The work was shared berween the Team engineers and SK counterparts : the former finalizing topography and planimetric features and the latter confirming annotations on the annotation sheet and conducting hearing surveys.

(2) Annotaitons were confirmed at District Offices, Chiefs Offices, schools and other public institutions first. Local residents were also asked for assistance on clarification of questions.

(3) Field completion proceeded most efficiently thanks to the cooperation of local SK offices as well as of local residents.

(4) Preparation of administrative names, and administrative/cadastral boundaries to be shown on the compiled manuscripts were assigned to the SK team formed specifically for this purpose.

3-11-3 Adjustment

Based on the data and findings resulting from the field completion, the compiled manuscripts were checked and corrected, to be made into the original manuscript. Data sheets generated for drafting and printing were also checked and corrected similarly. Data sheets created for the reproduction process were the road data sheet, vegetation data sheet, and water system data sheet.