REPUBLIC OF KENYA
MINISTRY OF WATER DEVELOPMENT
NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION

STUDY ON CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM FOR GREATER NAKURU WATER SUPPLY PROJECT

FINAL REPORT

VOLUME III SUPPORTING REPORT (I)

ANNEX A Topographic Survey
ANNEX B Geological Investigation

DECEMBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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FEASIBILITY STUDY REPORT

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VOLUME II MAIN REPORT

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- Annex A Topographic Survey
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Abbreviation and Local Terms

1. Abbreviation of Measures

1.1 Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer

1.2 Area

m^2, sq.m	=	square meter
ha	=	hectare
km^2, sq.km	=	square kilometer

1.3 Volume

lit, l	=	liter
lcd	=	liter per capita per day
cu.m, m^3	=	cubic meter
cu.m/day, m^3/day	=	cubic meter per day
MCM	=	million cubic meter

1.4 Weight

mg	=	milligram
mg/l	=	milligram per liter
g	=	gramme
kg	=	kilogram
t	=	ton

1.5 Time

s, sec	=	second
min	=	minute
h, hr	=	hour
d	=	day
yr	=	year

1.6 Money

Kshs.	=	Kenya Shilling(unit of Kenya currency, US$1.00 = Ksh 23.0 = ¥ 150)
US$, $	=	US dollar
¥	=	Japanese Yen

1.7 Electric Measures

kV	=	kilovolt
kW	=	kilowatt
MW	=	megawatt
kWh	=	kilowatt hour
kVA	=	kilovolt ampere

1.8 Other Measures

mmho	=	micromho = conductance
ppm	=	parts per million
ppb	=	parts per billion
MPN	=	most probable number
‰	=	mill
%	=	per cent
PS	=	0.736 kW
°	=	degree
'	=	minute
"	=	second
℃	=	degree centigrade
n.a.	=	not available
COD	=	Chemical Oxygen Demand
T-N	=	Total Nitrogen
I -	=	Inorganic -
O -	=	Organic -
T-P	=	Total - Phosphorus
DO	=	Dissolved Oxygen
pH	=	Exponent of hydrogen ion concentration

1.9 Derived Measures Based on the Same Symbols

cu.m/sec, m^3/s	=	cubic meter per second
cu.m/day, m^3/day	=	cubic meter per day
t/ha	=	ton per hectare
lpcd	=	liter per capita per day

2. Other Abbreviations

BS	=	British Standards
JIS	=	Japanese Industrial Standards
ASTM	=	American Society for Testing and Material
GNP	=	gross national products

GDP	=	gross domestic product
GRDP	=	gross regional domestic product
El.	=	elevation
FWL	=	flood water level
FSL	=	full supply level
MSL	=	minimum supply level
HWL	=	normal operation level
LWL	=	minimum operation level
f.o.b	=	free on board
c.i.f.	=	cost, insurance and freight
ICB	=	international competitive bid
LCB	=	local competitive bid

3. Abbreviation of Organizations

MOA	=	Ministry of Agriculture
MENR	=	Ministry of Environment & Natural Resources
MOF	=	Ministry of Finance
MOLD	=	Ministry of Livestock Development
MOLG	=	Ministry of Local Government
MOTW	=	Ministry of Tourism & Wildlife
MOTC	=	Ministry of Transport & Communication
MORD	=	Ministry of Regional Development
MOWD	=	Ministry of Water Development
NES	=	National Environmental Secretariat
NWCPC	=	National Water Conservation & Pipeline Corporation
SOK	=	Survey of Kenya
KWS	=	Kenya Wildlife Service
NMC	=	Nakuru Municipal Council
NTC	=	Naivasha Town Council

ASTU	=	Anti-Stock Theft Unit
KYSTC	=	National Youth Service Training Center
GMB	=	Gilgil Military Barracks
KMB	=	Kenyatta Military Barracks
WWF	=	World Wide Fund for Nature
JICA	=	Japan International Cooperation Agency
OECF	=	Overseas Economic Cooperation Fund, Japan

I. INTRODUCTION

This report is prepared for topographic survey, which was carried out for "the Study on Construction of Dam in Malewa River System for Greater Nakuru Water Supply Project, Eastern Division". The topographic survey was executed in three phases ; the first phase during the period from February to June, 1989, the second phase in November, 1989, and the third phase during the period from May to September, 1990. The survey works of each phase were as follows:

(1) First Phase

- Aerial photography covering both the proposed Malewa and Turasha reservoir areas with approximate area of 40 sq.km in a scale of 1 to 5,000 and proposed Malewa and Turasha damsites with approximate area of 2 sq.km in a scale of 1 to 3,000.

- Photogrammetric mapping covering both the proposed Malewa and Turasha reservoir areas with a total area of 22.5 sq.km in a scale of 1 to 5,000 with contour intervals of 5.0 m.

- Photogrammetric mapping covering both the proposed Malewa and Turasha damsites with a total area of 2 sq.km in a scale of 1 to 500 with contour intervals of 1.0 m.

- River cross section survey at the proposed damsites : 3 sections at the Malewa damsite and 1 section at the Turasha site.

(2) Second Phase

- Photogrammetric mapping covering the proposed East Road borrow area with a total area of 150 ha in a scale of 1 to 5,000 with contour intervals of 2.0 m.

- Photogrammetric mapping covering the proposed Kipipiri Road quarry site with total area of 150 ha in a scale of 1 to 5,000 with contour intervals of 5.0 m.

(3) Third Phase

- Aerial photography covering the Lake Nakuru area with approximate area of 140 sq.km in a scale of 1to 20,000.

- Photogrammetric mapping covering the Lake Nakuru area with approximate area of 95 sq.km in a scale of 10 10,000 with contour intervals of 2.0 m.

All the above surveying works were executed under the following four separate contracts.

Contract Works	Contractor	Contract Date
Aerial photography of Malewa and Turasha reservoir areas and damsites	Photomap (K) Ltd.	Jan. 27, 1989
Photogrammetric mappings of reservoir areas and damsites and river cross section survey	Photomap (K) Ltd.	Mar.10, 1989
Photogrammetric mappings of borrow area and quarry site	Photomap (K) Ltd.	Oct. 30, 1989
Aerial photography and photogrammetric mapping of the Lake Nakuru area	Photomap (K) Ltd.	May 24, 1990

All the above contracts works were executed in accordance with the Conditions of Contract, General Specifications and Technical Specifications under supervision of a Topo - survey Expert of the Study Team. In particular the Technical Specifications concerning the aerial photogrphy and photogrammetric mapping were prepared making reference to both the "Air Survey Contacts and Specification" by the SOK and "Geodetic and Photogrammetric Surveying for Overseas" by the JICA.

Further all the contracted works have satisfactorily completed by the times specified in the contract agreements. The progress of the works was as presented in Fig. A.1.1. The final

products of the topographic survey are as listed up inTable A.1.1 and all the topographic maps are compiled in Volume VI, Topographic Maps.

II. AVAILABLE TOPOGRAPHIC MAPS AND DATA

Prior to the commencement of the actual topographic survey, existing maps and aerial photos, survey data and information were collected from the SOK and the MOWD and the under-listed maps, aerial photos and survey results were effected for the execution of the topographic survey.

(1) Existing aerial photographs

(a) Aerial photos in a scale of 1 to 12,500 by the SOK in 1976 and 1978 covering the Malewa and Turasha reservoir areas, Kipipiri Road quarry site and East Road borrow area.

(2) Existing topographic maps

(a) Topographic maps in a scale of 1 to 50,000 with contour intervals of 20 m published by the SOK in 1975.

(b) Topographic maps in a scale of 1 to 250,000 with contour intervals of 200 ft published by the SOK in 1963.

(c) Topographic maps in a scale of 1 to 5,000 with contour intervals of 2.5 m prepared by Nippon Koei Co., Ltd. in 1988 covering the area along the middle reaches of the Malewa and Turasha rivers.

(d) Topographic maps in a scale of 1 to 500 with contour intervals of 1.0 m covering the Turasha damsite prepared by Nippon Koei Co.,Ltd. in 1988.

(3) Survey results

(a) TRIGONOMETRIC INDEX CARD by the SOK
(b) Description of Level BM by the SOK
(c) List of Permanent Points by Nippon Koei Co., Ltd
(d) Survey Mark Description by Nippon Koei Co., Ltd

III. AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRIC MAPPINGS OF RESERVOIR AREAS AND DAMSITES

3.1 Aerial Photography

Two different scales of aerial photos were produced ; one is in a scale of 1 to 25,000 to be used for photogrammetric mapping of the Malewa and Turasha reservoir areas in a scale of 1 to 5,000 and the other is in a scale of 1 to 3,000 to be used for photogrammetric mapping of the Malewa and Turasha damsites in a scale of 1 to 500. The mapping areas are as shown in Fig. A.3.1. The aerial photography works were done during the period from January 29 to January 31, 1989. Principal data and information of the aerial photography works are as follows:

(1) Equipment used

(a)	Aircraft	:	Piper, Navajo, PA31
(b)	Aerial Camera	:	Wild, RC-10, No.1053
(c)	Film Processor	:	Zeiss, FEIZO
(d)	Contact Printer	:	Milligan, Electronic Printer

(2) Data of aerial photography

		1 to 5,000 Mapping	1 to 500 Mapping
(a)	Scale of aerial photography	Appr. 1 to 25,000	Appr.1 to 3,000
(b)	Area covered by aerial photos	Appr. 40 sq.km	Appr.2 sq.km
(c)	Focal length of aerial camera	F=153 mm	F=153 mm
(d)	Over lapping	Appr.60% ± 5%	Appr.60% ± 5%
(e)	Side lapping	Appr. 30% ± 5%	Appr.30 % ± 5%
(f)	Flight direction	West-East	South-North
(g)	Flight height	Appr. 5,700 m	Appr. 2,560 m
(h)	Aerial film	Kodak Double X	Kodak Double X
(i)	Photo print	Kodak RC paper	Kodak RC paper

(3) Aerial photo index map.

Aerial photo index map was prepared after the completion of the aerial photography as shown in Fig. A.3.2.

(4) Annotation of aerial photos

The following title and information were noted on the outside of the flame of the negative film at start and end of each run.

(a) MALEWA DAM
(b) Scale of aerial photography
(c) Date of aerial photography
(d) Photo number
(e) JICA

3.2 Control Point Survey for Photogrammetric Mapping

3.2.1 Installation of Control Points

Before starting the leveling and traverse, 39 control points (having X and Y coordinates as well as height but not all points) and 31 bench marks (having height only) were established.

3.2.2 Leveling

Spirit leveling was executed to fix the heights of the bench marks and photo control points necessary for the computation of aerial triangulation. Total distance of the leveling was approximately 72 km. The leveling routes and locations of BMs are as shown in Fig. A.3.3.

(1) Datum height

The datum height used for the leveling was based on the mean sea level of Kenyan Datum which was observed by the PHOTOMAP (K) LTD. in 1988. The heights of the permanent points, TBMs and photo control points are as presented in Tables A.3.1, A.3.2 and A.3.3 respectively.

(2) Equipment used

Automatic level, Zeiss N12, was used for the leveling.

(3) Accuracy of leveling

The leveling routes were formed by closed loops and leveled twice. The accuracy of the leveling was specified to be within ± 24 mm $\sqrt{D}$ between the bench marks (D denotes distance along leveling route). The accuracy of the respective leveling route was as given in Table A.3.4.

3.2.3 Traverse Survey

The traversing work was executed to decide the coordinates of the control points and bench marks based on UTM Projection System for the computation of the aerial triangulation. The traverse routes were planned to enclose the mapping area and all the traverse routes were formed by a closed loop. The total distance for the traverse routes was approximately 40 km. The traverse routes are as shown in Fig. A.3.4.

(1) Equipment used

- Theodolite : Wild T2
- Electronic optical distance meter (EDM) : AGA 14A & Zwiss EIdil

(2) Datum coordinates

The coordinates which were observed by the PHOTOMAP (K) LTD. in 1988 were employed as the datum values of coordinates. The datum control points and their coordinates are as as shown in Table A.3.1.

(3) Correction of observed distance

The computation of the coordinates was based on the above- mentioned coordinates (UTM Grid, Zone No. 37). The scale factor used for the computation of distance is 0.999340 (mean). Mean seal level correction and slope correction on the observed distance were based on the height and observed vertical angle.

(4) Method and accuracy

The traverse routes were formed by a closed loop. The mis-closure of the traverse has been specified to be not lesser than 1:15,000 of their total lengths of the traverse routes. The actual accuracy was as shown in Table A.3.5. The method and specified accuracy of the traverse observation are as follows:

(a) Horizontal angle observation

The horizontal angles were observed by two rounds of angles at different zero settings. The discrepancy in angles between the first and second settings has been stipulated not to exceed 20 seconds of double angles difference and 10 seconds of difference of angle.

(b) Distance observation

The distance was measured twice for each traverse line by EDM having an accuracy more than 10 mm $\pm$ 3 ppm x $\sqrt{D}$. The discrepancy between the two sets has been specified not to exceed 1/40,000 of the measured distance.

3.2.4 Pricking

Planimetric features clearly identifiable on the photographs and whose position can be exactly reduced from the control point were pricked in the filed for the photo control. The coordinates and elevation of the photo control points are shown in Table A.3.3.

3.3 Aerial Triangulation (Analog Instrument Triangulation)

After preparing contact prints and diapositive of the aerial photographs, the locations of the control points were pricked on the contact prints. At least four plane and height points were transferred from the contact prints to each diapositive by Aviograph A8 so that at least four control points were included within a stereo model. All of these control points together with fiducial marks on each photograph were stereoscopically observed and measured by the Aviograph A8.

The aerial triangulation was done analogically by the mechanical orientation method using fully controlled models. The number of photo models of the aerial triangulation and control points used for the computation of aerial triangulation are as follows:

Photogrammetric Mapping Areas	Photo Models	Horizontal Control Points	Vertical Control Points
Reservoir Areas	12	22	26
Malewa Damsite	12	21	22
Turasha Damsite	15	24	28

The aerial triangulation index map is shown in Fig.A.3.5.

The accuracies of the horizontal and vertical control points which were used for the aerial triangulation in each model were as shown in Table A.3.6.

3.4 Machine Plotting and Compilation

3.4.1 Sheet Index of Maps

The photogrammetric mapping areas are as shown in Fig. A.3.2. The sheet size of the map was decided at A I size. The sheet index is as shown in Fig.A.3.6. The total sheet numbers are 8 for the reservoir areas, 13 for the Malewa Damsite and 16 for the Turasha damsite.

3.4.2 Marginal Information for Photogrammetric Maps

Aviograph A8, Wild and Aviograph B8, Wild were used for a machine plotting. The marginal information style for the photogrammetric maps were decided by the Study Team.

3.4.3 Transfer of Spot Height, Contour and Other Information by Plotting Machine

The spot heights were obtained by both the direct leveling and plotting machine and were transferred to the original plotting sheets. Five-meter interval contours for the 1/5,000-scale topographic map and one-meter interval contours for the 1/500-scale topographic map were drawn directly by the plotting machine on the original plotting sheets. The relation among the contour lines, spot heights, topographic conditions and other information were checked and the contour lines were compiled.

3.4.4 Fair Drawing

After compilation of the contour lines, spot heights, topographic conditions, name of village and other information on the plotting sheets,were drawn on the transparent polyester film sheets.

3.5 Check Survey

3.5.1 Checking of Bench Marks

Five (5) points (MT 19,TBM 31,TBM7, TBM 6 and TBM 30) were selected randomly and checked by the Topo-survey Expert of the JICA study Team. These points are situated between the proposed Turasha damsite and the proposed Malewa damsite. The reference height was run from the BMV II16 of the SOK on the C-77 Road. The results of the check leveling are tabulated as below and the check leveling routes are presented in Fig. A.3.7.

Monument		Difference in Height		Deviatiom	Distance	Allowable Difference
No.	Elevation (El.m)	By Contractor (m)	By JICA Expert (m)	(mm)	(D) (km)	(h) (mm)
MT19	2,241.300					
		138.640	138.632	-.8	1.5	± 29
TBM31	2,102.664					
		156.986	157.027	+41	4.0	± 48
TBM7	2,259.650					
		29.152	29.153	+1	2.0	± 33
TBM6	2,230.498					
		158.222	157.987	-35	3.5	± 44
TBM30	2,072.476					

Note : The allowable difference (h) is calculated based on $h = \pm 24$ mm $\sqrt{D}$ in accordance with the Technical Specifications.

The differences in heights between the PHOTOMAP (K) LTD and the Topo-Survey Expert was not exceeded allowable error $\pm$ 24 mm $\sqrt{D}$ for all the check survey points. Accordingly it was judged that these BMs have the enough accuracy.

3.5.2 Checking of Spot Height

In total 11 spot height points were randomly chosen for this check. The results of the check survey are summarized below and the comparison between the direct leveling height and the spot height is presented in Fig. A.3.8.

Sheets No.	Spot Height by Contractor (El.m)	Spot Height by JICA Expert (El.m)	Difference (m)
3	2,102·5	2,102.3	- 0.2
	2,098.5	2,098.8	+ 0.3
6	2,232.7	2,233.1	+ 0.4
	2,231.8	2,231.7	- 0.1
	2,233.5	2,233.6	+ 0.1
	2,234.0	2,233.7	- 0.3
	2,146.0	2,146.3	+ 0.2
	2,162.0	2,161.9	- 0.1
	2,114.0	2,114.2	+ 0.2
	2,071.0	2,071.3	+ 0.3

From the above, it was judged that the contour lines and spot heights shown in maps have satisfied the accuracies stipulated in the Technical Specifications.

IV. RIVER CROSS SECTION SURVEY

4.1 River Cross Section Survey

4.1.1 Surveying Sites

River cross sections were surveyed at the Malewa and Turasha damsites : three sections at the Malewa damsite and one section at the Turasha damsite. The locations of the river cross sections are as shown in Fig. A.4.1.

4.1.2 Leveling

The datum height was the same as that used in the photogrammetric mapping. The ground height along the cross section line was surveyed by a direct leveling basically at intervals of 10 m and at such points as slope changing point.

Accuracy of leveling has been specified not to exceed 20 mm $\sqrt{D}$ at the riparian area and 10 cm at the water area.

4.1.3 Drawing

The horizontal and vertical scales of the cross sectional drawing are 1 to 500 respectively. The draft cross sectional drawings were initially prepared in pencil on a milimeter graph paper for checking by the Topo-survey Expert. The final cross sectional drawings were made by inking on the AI size of polyester film.

4.2 Monumentation

Before starting the river cross section survey, four permanent bench marks were installed at both sides of the 2 selected cross section survey sites. The locations of the bench marks are as shown in Fig. A.4.1. The height of the respective bench mark is as shown in Table A.4.1.

V. PHOTOGRAMMETRIC MAPPINGS FOR BORROW AREA AND QUARRY SITE

5.1 Mapping Area and Aerial Photos

The mapping areas cover both the East Road borrow area and Kipipiri Road quarry site, locations of which are as shown in Fig. 5.1. The extent of the mapping area, scale and contour intervals of the maps are as specified below.

Mapping Area	Area (ha)	Scale	Contour Intervals (m)
Kipipiri Road quarry area	150	1 to 5,000	5.0
East Road borrow area	150	1 to 5,000	2.0

The aerial photos in a scale of 12,500 were made available from the SOK.

5.2 Control Point Survey

The aerial photos available from the SOK were used for the photogrammetric mapping of both the East Road borrow area and Kipipiri Road quarry site.

The control survey was carried out only for the photogrammetric mapping of the East Road borrow area. It was not necessary to execute the control survey for the photogrammetric mapping of the Kipipiri Road Quarry site, since the control survey results adopted for the photogrammetric mapping along the Malewa and Turasha rivers were made available.

The control survey was carried out in the same manners as described in Section 3.2 of this report.

A new traverse station, MT 20 was installed, as shown in Fig. A.5.2, linking with MTI and T17. The traverse survey was executed by using the same instruments as noted in Section 3.2 of this report. The coordinates and elevation of MT20 were surveyed as given in Table A.3.4. The coordinates and heights of photo control points are as presented in Table A.5.1.

The number of the map was one sheet each for the borrow area and quarry site as shown in Fig. A.5.3.

5.3 Aerial Triangulation (Anolog Installment Triangulation)

The same method and equipment as stated in Section 3.3 were applied for and the numbers of photo models and control points were as presented below.

Photogrammetric Mapping Areas	Photo Models	Horizontal Control Points	Vertical Control Points
Borrow Area	4	13	15
Quarry Site	3	10	10

The accuracy of the aerial triangulation was as given in Table A.5.2.

5.4 Machine Plotting and Compilation

The same manner and equipment as explained in Section 3.4 of this report are applied for.

VI. AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRIC MAPPING OF LAKE NAKURU

6.1 Aerial Photography

The aerial photos in a scale of 1 to 20,000 were produced for 1 to 10,000 scale photogrammetric mapping of the Lake Nakuru and its surrounding area. The mapping area is as shown in Fig. A.6.1. Actual aerial photography works was started from 1st June and completed on 4th June, 1990. After shooting aerial photos, the photographic processing and printing works were followed from 5th June to 8th June, 1990. The principal data and information of the aerial photography works are as follows:

(1) Equipment used

(a)	Aircraft	:	Piper, Navajo, PA31
(b)	Aerial Camera	:	Wild, RC-10, Super Wide Angle
(c)	Film Processor	:	Zeiss, FEIZO
(d)	Contact Printer	:	Milligan, Electronic Printer

(2) Data of the executed aerial photography

(a)	Scale of aerial photography	:	Appr. 1 to 20,000
(b)	Area covered by aerial photos	:	Appr. 140 sq.km
(c)	Focal length of aerial camera	:	F = 88 mm
(d)	Over lapping	:	Appr. 60% ± 5%
(e)	Side lapping	:	Appr. 25% ± 5%
(f)	Flight direction	:	North - South
(g)	Aerial film	:	Kodak Double X
(h)	Photo print	:	Kodak RC paper

(3) Aerial photo index map

Aerial photo index map was prepared after the completion of the aerial photography as shown in Fig. A.6.2.

(4) Annotation

The following title and information were noted on the outside of the flame of the negative film at start and end of each rum.

(a) MALEWA DAM
(b) Scale of aerial photography
(c) Date of aerial photography
(d) Photo number
(e) JICA

All the results of aerial photography was checked referring to the Specification by the Topo-survey Expert of JICA Study Team. It was judged that the results were acceptable for preparing the project map.

6.2 Control Point Survey for Photogrammetric Mapping

6.2.1 Installation of Control Points

Before starting the leveling and traverse, 26 control points (having X and Y coordinates and height) and 34 bench marks (having height only) were established around the mapping area.

6.2.2 Leveling

Spirit leveling was executed to fix the heights of the bench marks and photo control points necessary for the computation of the aerial triangulation. Total distance of the leveling was approximately 49.1 km. The leveling routes and locations of BMs are as shown in Fig. A.6.3 and elevation of bench mark in Table A.6.2.

(1) Datum heights

The datum heights used for the leveling was based on the mean sea level of Kenyan Datum which was published by the SOK. The heights of BMs are as presented in Table A.6.1.

(2) Equipment used

Zeiss NI12 Automatic Level No. 99462 was used for the leveling.

(3) Check of the existing BM height

Before starting leveling, the check of existing BM height was carried out by the Contractor between VI/24 and VII/23. The difference deviate from the listed values was 0.001 m. It has enough accuracy of height value for the photogrammetric mapping.

(4) Accuracy of leveling

The leveling routes were formed by a closed loop and leveled twice. The accuracy of the leveling was specified to be within ± 20 mm $\sqrt{D}$ between the bench marks. The accuracy of the respective leveling route was as shown in Table A.6.3.

6.2.3 Traversing

The traversing work was executed to decide the coordinates of the control points and bench marks based on UTM Projection System for the computation of the aerial triangulation. The traverse routes were formed by a closed loop and open. The total distance for the traverse routes were approximately 49.4 km. The traverse routes are as shown in Fig.A.6.4.

(1) Equipment used

(a) Theodolite : Wild T2, No.298781
(b) EDM : AGA 14A, No.14999

(2) Datum coordinates

The datum coordinates which were published by the SOK were employed. The list of control points and their coordinates are as shown in Table A.6.4.

(3) Correction of observed distance

The computation of the coordinates was based on UTM Zone No. was 37, which were decided by the JICA Study Team. The scale factor used for the computation of distance is 1.0008927(mean). Mean sea level correction and slope correction on the observed distance were based on the leveled height and height by observed vertical angle.

(4) Method and accuracy

The traverse routes were formed by a closed loop and fixed by polar method. The formula of fix loop was used as below.

$$M_L = \sqrt{\frac{V_N^2 + V_E^2}{2n - 4}}$$

As a result, the mis-closure of the traverse has been confirmed to be not lesser than 1:15,000 of their total lengths of the traverse routes. The actual accuracy was as shown in Table A.6.5. The method and specified accuracy of the traverse observation are as follows:

(a) Horizontal angle observation

The horizontal angles were observed by two rounds of angle at different zero settings. The discrepancy in angles between the first and second settings has been stipulated not to exceed 20 seconds of double angles difference and 10 seconds of difference of angle.

(b) Vertical angle observation

The vertical angles were observed by a round of angle. The discrepancy between 1 set was not exceeded 15 seconds.

(c) Distance observation

The distance was measured twice for each traverse line by EDM having an accuracy more than 10mm $\pm$ 3ppm x $\sqrt{D}$. The discrepancy between the two sets was less than 1:40,000 of the measured distance.

6.2.4 Pricking

Planimetric features clearly identifiable on the photographs and whose position can be exactly reduced from the control point were pricked in the filed for the photo control. The coordinates and height of the photo control points are as shown in Table A.6.3.

6.3 Aerial Triangulation (Analytical Aerial Triangulation)

Aerial triangulation was done analytically by the block adjustment method by means of independent model.

After preparing contact prints and diapositive of the aerial photographs, locations of pass points and tie points were selected on the contact prints. These points were stereoscopically observed with a pricking device on the diapositive. Three(3) pass points and two(2) tie points were pricked on the each diapositive so that at least six(6) points were included within a stereo model. The established control points and BMs were also pricked on the diapositives. All of these pricked points together with the fiducial marks on each photograph were stereoscopically observed and measured with analytical plotter. The X and Y photo coordinates obtained by analytical plotter measurement were processed by an electronic data processing system for analytical aerial triangulation.

The number of photo models of aerial triangulation and control points used for the computation of aerial triangulation are as follows:

Photo Models	:	37 models
Horizontal control point	:	33 points
Vertical control point	:	53 points

The triangulation mark index map is as shown in Fig.A.6.5. The list of control points and pass points are as shown in Table A.6.6.

(1) Equipment and program used in aerial triangulation

(a)	Pricking Device	:	Wild, PUG 4
(b)	Stereo Comparator	:	Wild, BC 1
(c)	Computer	:	VAX 11/750
(d)	Program	:	J.F.KENEFICK

(2) Accuracy of aerial triangulation

The residual of horizontal and vertical control points which were used for aerial triangulation in the block is shown Tables A.6.7 and A.6.8.

6.4 Machine Plotting and Fair Drawing

6.4.1 Sheet Index of Maps

The photogrammetric mapping area are as shown Fig.A.6.1. The map sheet size was 60 cm x 80 cm with a gross sheet size of 70 cm x 100 cm. The total sheet number are 8 for the Lake Nakuru and its surrounding area, which is as shown in Fig.A.6.6.

6.4.2 Marginal Information for Photogrammetric Maps

The marginal information style for the 1:10,000 scale photogrammetric maps were decided by the Study Team.

6.4.3 Transfer of Spot Height, Contour and Other Information by Plotting Machine

The spot heights were obtained by the direct leveling and plotting machine and were transferred to the original plotting sheets. Two-meter interval contours for the 1:10,000 scale topographic map were drawn directly by the plotting machine on the original plotting sheets. The equipment used for plotting were Wild, Aviograph A8 and Wild, Aviograph B8.

The relation among the contour line, spot heights, topographic conditions and other information were checked and the contour lines were amended by the Topo-survey Expert of JICA study Team.

6.4.4 Fair Drawing

After compilation of the contour lines, spot heights, topographic condition, name of village and other information on the plotting sheets, were drawn on the transparent polyester film sheets.

6.5 Check Survey

6.5.1 Checking of Bench Marks

Four(4) points(BM19, BM23, BM24, BM30) having heights were selected randomly and leveled for the checking by the Topo-survey Expert around Lake Nakuru. The reference height was run from VII/24 of Gilgil to Nakuru primary line on the rail road. The results of the check survey are as below and the check leveling routes is presented in Fig.A.6.7.

Monument No.	Elevation (m)	Difference in Height By Photomap (m)	By JICA Expert (m)	Difference (mm)	Distance (km)	Allowable Difference (mm)
BM 30	1761.416					
		1.964	1.992	+28	7.0	±52
BM 24	1763.380					
		3.009	3.013	+ 4	1.0	±20
BM 23	1760.371					
		0.635	0.604	+31	4.0	±40
BM 19	1759.736					

The allowable difference is calculated based on $h = \pm 20mm \sqrt{D}$ in accordance with the Technical Specifications. The difference in heights between the PHOTOMAP (K) LTD., and the Topo-survey Expert was not exceed allowable difference $\pm$ 20mm $\sqrt{D}$ for all the check survey points. Accordingly it is judged that these BMs have the enough accuracy for the 1:10,000 scale photogrammetric mapping works and hydrographic mapping works.

6.5.2 Checking of Control Points

A loop traverse route (119T4 NEW, Honeymoon Hill, Baboon Cliff, Water Tank, 119T4 NEW) were selected randomly as shown in Fig. A.6.8 and measured directly by the Topo-survey Expert around Lake Nakuru. The reference coordinates of all new control points were set up by traverse from existing control points of 119T4, 119T6 and 119T21, which have been fixed from the main loop traverse by polar method. The results of checked survey are as follows:

Station	Total Distance	Coordinates By Photomap	Coordinates By JICA Expert	Difference
(Loop traverse)				
119T4 NEW		N 9 962 937.70	N 9 962 937.51	+ 0.19
-119T4 NEW	39 357.05 m	E 180 380.42	E 180 379.79	+ 0.63
Linear mis-closure				+ 0.66

The linear mis-closure of the loop traverse is over 1/59,000 of total lengths of the traverse route. It is judged that the loop traverse points have the enough accuracy of the coordinate for the 1:10,000 scale photgrammetric mapping works and hydrographic mapping works.

VII. HYDROGRAPHIC MAPPING OF LAKE NAKURU

7.1 Generael Description

The hydrographic mapping works were carried out in the Lake Nakuru by the Topo-survey Expert of the JICA Study Team. The works consist of the detail traverse, minor leveling, sounding, plotting and fair drawing.

7.2 Hydrographic Mapping

7.2.1 Installation of Base Line Points

Before starting the detail traverse and minor leveling, 35 base line points were established at intervals of approximately 300 m along the planned base line on the west shore of Lake Nakuru. All the points have both the coordinates and heights.

7.2.2 Detail Traverse

The detail traverse work was executed to decide the coordinates of base line points(JWBMs) based on the UTM Projection System for the computation of sounding survey. Total distance of detail traverse routes were approximately 13.7 km, which was formed by closed loop. The diagram of detail traverse route and location of the base line points are as shown in Fig.A.7.1. The mis-closure of the detail traverse was lesser than 1:15,000 of their total lengths of the traverse routes. The actual accuracy of detail traverse is as shown in Table A.6.5. The coordinates and height of JWBMs are as shown in Table A.7.1.

7.2.3 Minor Leveling

The minor leveling routes were formed by closed loops. Total distance of the minor leveling was about 12 km. The datum height
used for the computation of leveling were based on the Mean Sea Level of Kenyan Datum which were observed by the PHOTOMAP (K) LTD. in 1990. The actual accuracy of minor leveling is as shown in Table A.6.5. The diagram of leveling routes is as shown in Fig.A.7.2.

7.2.4 Sounding

The sounding work started from the southern part of the Lake Nakuru. Water depth of the lake was measured directly at intervals of approximately 300 m along the base line. The position of spot heights was observed by an Automatic Positioning System Instrument(Del Norte, 542 DDMU) or Total Station System Instrument(Wild, T2 with DI3000). The total distance of sounding lines were approximately 151.6km. The diagram of sounding lines are as shown in Fig.A.7.3.

7.2.5 Plotting and Fair Drawing

The spot heights were obtained by sounding were transferred to the original plotting sheets. Fifty(50)cm interval contours for the 1:10,000 scale topographic map for all area were drawn directly by hand on the original plotting sheets.

After compilation and connection between the original photogrammetric plotting sheets and original hydrographic plotting sheets, were drawn on the transparent polyester film sheets which was prepared at photogrammetric mapping work.

TABLES

Table A.1.1 List of Final Products (1/3)

I. Aerial Photography and Photogrammetric Mapping of Reservoir Areas and Damsites

Description	Quantity
1. Aerial Photography	
(a) Diapositive, S=1:3,000 and 1:25,000	One set
(b) Contact print, S=1:3,000 and 1:25,000	One set
(c) Film report	One set
(d) Report on Equipment Used for Aerial Photography and A Copy of the Camera caliblation Certificate	One set
2. Photogrammetric Mapping	
2.1 Control point survey	
(a) List of Coordinates and Height	One set
(b) Description of Control Point	One set
(c) Accuracy of Traverse and Leveling	One set
(d) Diagram of Traverse and Leveling	One set
(e) Control Point Survey Report	One set
2.2 Aerial triangulation	
(a) Triangulation Mark Index Map	One set
(b) Orientation Elements of the Strero for Each Model	One set
(c) Type of instrument used in the aerial triangulation	One set
2.3 Photogrammetric mapping	
(a) Original plots, S=1:5,000 and 1:500	One set each
(b) Blue copy of original plots	Two sets each
(c) Original fair drawing, S=1:5,000 and 1:500	One set each
(d) Blue copy of original fair drawings	Five sets each
(e) Type of instrument used in stereo plotting	One set
3. River Cross Section Survey	
(a) Field note book	One set
(b) Computation sheets	One set
(c) Diagram of river cross section	One set
(d) List of coordinates and height of BMs	One set
(e) Description of BMs	One set
(f) Original plots, H=1:500, V=1:100	One set
(g) Blue copy of original plots	Two sets
(h) Original fair drawing, H=1:500, V=1:100	One set
(i) Blue copy of original fairdrawings	Five sets

Table A.1.1 List of Final Products (2/3)

II. Photogrammetric Mapping of Borrow Area and Quarry Site

Description		Quantity
1. Aerial Photography		
	(a) Diapositive, S=1:12,500 (produsd by Survey of Kenya)	One set
2. Photogrammetric mapping		
2.1 Control point survey		
	(a) List of coordinates and Height	One set
	(b) Description of Control Point	One set
	(c) Accuracy of Traverse and Leveling	One set
	(d) Diagram of Traverse and Leveling	One set
	(e) Control Point Survey Report	One set
2.2 Aerial triangulation		
	(a) Triangulation Mark Index Map	One set
	(b) Orientation Elements of the Stereo for Each	One set
	(c) Type of instrument used in the aerial Model triangulation	One set
2.3 Photogrammetric mapping		
	(a) Original plots, S=1:5,000	One set
	(b) Blue copy of original plots, S=1:5,000	One set
	(c) Original fair drawing, S=1:5,000	One set
	(d) Blue copy of original fair drawings, S=1:5,000 and 1:500	Five sets
	(e) Type of instrument used in stereo plotting	One set

Table A.1.1 List of Final Products (3/3)

III. Aerial Photography,Photogrammetric Mapping and Hidrographic Mapping of Lake Nakuru

Description	Quantity
1. Aerial Photography	
(a) Diapositive, S=1:20,000	One set
(b) Contact print, S=1:20,000	One set
(c) Film report	One set
(d) Report on Equipment Used for Aerial Photography and A Copy of the Camera caliblation Certificate	One set
2. Photogrammetric Mapping	
2.1 Control point survey	
(a) List of Coordinates and Height	One set
(b) Description of Control Point	One set
(c) Accuracy of Traverse and Leveling	One set
(d) Diagram of Traverse and Leveling	One set
(e) Control Point Survey Report	One set
2.2 Aerial triangulation	
(a) Triangulation Mark Index Map	One set
(b) Orientation Elements of the Strero for Each Model	One set
(c) Type of instrument used in the aerial triangulation	One set
2.3 Photogrammetric mapping	
(a) Original plots, S=1:10,000	One set each
(b) Blue copy of original plots	Two sets each
(c) Original fair drawing, S=1:10,000	One set each
(d) Blue copy of original fair drawings	Five sets each
(e) Type of instrument used in stereo plotting	One set

Table A.3.1 Coordinates and Height of Permanent Points for Photogrammetric Mappings of Reservoir Areas, Damsites, Borrow Area and Quarry Site

Station	Coordinates (m) N	E	Height (m)	Remarks
1. Existing Points				
MT 5	9 945 771.56	216 392.13	2373.61	Iron pin in concrete
MT 6	9 947 210.18	215 114.78	2324.37	Center, water tank
MD 6	9 950 944.65	211 308.06	2230.33	I.P.C (old)
MT 7	9 951 636.32	213 310.77	2277.29	Iron pin in concrete
6/4 X	9 948 315.74	212 729.35	2202.83	Hole in rock
T 17 X	9.948 143.76	207 647.38	2213.10	Hole in rock
SAT	9 951 108.37	210 045.29	2166.97	Hole in rock
119 T 15	9 957 062.05	208 723.29	-	Hole in groud
2. New Points				
MT 8	9 960 131.15	211 992.73	2306.14	Iron pin in concrete
MT 9	9 957 654.35	214 289.39	2285.15	Hole in rock
MT 10	9 954 994.89	217 576.07	2363.08	Iron pin in concrete
MT 11	9 953 226.34	218 549.17	2370.72	Iron pin in concrete
MT 12	9 953 242.58	218 997.04	2373.49	Iron pin in concrete
MT 13	9 951 146.64	219 511.52	2389.63	Iron pin in concrete
MT 14	9 949 620.33	220 305.07	2400.55	Iron pin in concrete
MT 15	9 946 038.79	216 381 51	2370.10	Iron pin in concrete
MT 16	9 952 039.00	213 316.49	2287.53	Iron pin in concrete
MT 17	9 953 325.50	213 388.50	2254.52	Iron pin in concrete
MT 18	9 950 757.17	213 662.95	2246.22	Hole in rock
MT 19	9 950 020.36	214 153.68	2241.30	Hole in rock
MT 20	9 949 870.24	207 414.79	2242.01	Hole in rock

Note (1) All new traverse points have been levelled.

(2) Coordinates and heights are based in the previous survey undertaken by PHOTOMAP in December, 1988 under Greater Nakuru Water Supply Project.

Table A.3.2 Heights of TBMs Used for Photogrammetric Mappings of Reservoir Areas and Damsites

Station	Height (m)	Remarks
TBM 1	1969.743	White painted cross, top of concrete tank
TBM 2	2057.407	White painted cross,house foundation
TBM 3	2133.827	White painted cross, culvert
TBM 4	2159.738	White painted cross, culvert
TBM 5	2206.350	Iron pin in concrete
TBM 6	2230.498	White painted cross,house foundation
TBM 7	2259.650	White painted cross, on water pipe, outlet from water trough
TBM 8	2269.461	Church foundation corner
TBM 9	2290.749	White painted cross, on concrete slab
TBM 10	2307.886	White painted cross, cattle dip
TBM 11	2367.483	Top of wood stopper, center gate at Mahindu school
TBM 12	2380.049	White painted cross, culvert
TBM 13	2315.575	White painted cross, culvert
TBM 14	2269.179	White painted cross, top of concrete pillar
TBM 15	2378.187	White painted cross, culvert
TBM 16	2367.665	White painted cross, top of stone
TBM 17	2376.953	White painted cross, on service vent of water supply
TBM 18	2003.749	White painted cross, Turasha bridge
TBM 19	2299.322	White painted cross, concrete slab
TBM 20	2156.809	White painted cross, top of stone
TBM 21	2263.233	White painted cross, on stone
TBM 22	2099.374	White painted cross, on rock
TBM 23	2230.392	White painted cross, on rock
TBM 24	2233.781	White painted cross, on rock
TBM 25	2247.489	White painted cross top of scene
TBM 26	1987.827	White painted cross, bridge foundation
TBM 27	2231.505	White painted cross, on rock
TBM 28	2279.179	White painted cross, on rock
TBM 29	2290.899	White painted cross, water trough
TBM 30	2072.476	White painted cross, dam retaining wall
TBM 31	2102.664	White painted cross, top of broken pipe on concrete

Note : Heights are based on the SOK Line XVII Provisional Height, BM XVII/6, XVII/9, XVII/14 and XVII/16. The surey results for Greater Nakuru Water Supply Project in December, 1987 was also based on this system.

Table A.3.3 Coordinates and Heights of Photo Control Points for Photogrammetric Mappings of Reservoir Areas and Damsites(1/3)

(Resevoir Areas)

Points	Coordinates (m) N	E	Height (m)
PH 5/10	9 946 029.02	214 627.44	2305.78
PH 5/11	9 945 737.40	216 366.24	2372.14
PH 6/10	9 947 681.80	212 967.06	2007.84
PH 7/1	9 951 425.11	215 309.12	2254.11
PH 8/1	9 959 596.25	212 644.74	2242.56
PH 9/1	9 956 325.60	215 807.35	2287.43
PH 9/2	9 958.158.62	214 181.21	2272.50
PH 10/1	9 954 733.14	217 227.49	2345.65
PH 11/1	9 953 285.77	218 467.95	2368.76
PH 13/1	9 951 114.61	219 644.95	2388.69
PH 14/1	9 949 465.94	220 584.37	2405.93
PH 15/1	9 949 822.43	216 689.66	2265.96
PH 15/2	9 949 171.85	217 844.94	2357.83
PH 15/3	9 948 233.91	218 867.63	2373.13
PH 16/1	9 952 489.86	213 934.53	2266.09
PH 17/1	9 954 008.61	212 605.30	2115.76
PH 115/1	9 952 862.06	208 030.83	2185.58
PH 115/2	9 955 376.76	211 160.03	2229.58
PH 115/3	9 956 829.20	209 796.16	2247.86
PH SAT/1	9 948 914.01	211 754.22	2177.49
PH SAT/2	9 949 666.46	210 733.39	2098.66
PH SAT/3	9 950 873.53	209 307.55	2015.13
H 1	-	-	2159.46
H 1/A	-	-	2160.67
H 21	-	-	2248.77
H 15/4	-	-	2365.90

Note : Coordinates and heights are based on the previous survey undertaken by PHOTOMAP in December 1987 for Greater Nakuru Water Supply Project.

Table A.3.3 Coordinates and Heights of Photo Control Points for Photgrammetric Mapping of Reservoir Areas and damsites(2/3)

(For Malewa Damsite)

Points	Coordinates (m)		Height (m)
N	E		
PH SAT/4	9 950 879.82	210 905.38	2123.18
PH SAT/5	9 951 196.36	211 345.13	2177.92
PH SAT/6	9 951 092.90	210 813.56	2098.47
PH SAT/7	9 951 410.95	210 656.92	2103.58
PH SAT/8	9 951 708.93	210 736.24	2182.98
PH SAT/9	9 952 030.14	210 737.94	2192.21
PH SAT/10	9 952 286.50	210 667.60	2197.20
PH SAT/11	9 952 276.45	210 985.11	2219.76
PH X/1	9 951 674.78	211 154.78	2121.01
PH X/2	9 952 064.64	211 242.36	2140.06
PH X/3	9 951 513.07	211 314.37	2152.11
PH X/4	9 950 949.85	211 291.35	2229.37
PH X/5	9 952 334.40	211 611.46	2166.92
PH X/6	9 951 966.83	211 624.89	2090.10
PH X/7	9 951 710 70	211 672.49	2121.60
PH X/8	9 951 479.31	211 668.62	2127.87
PH X/9	9 951 218.20	211 754.25	2154.79
PH X/10	9 952 231.38	211 930.88	2152.08
PH X/11	9 952 178.92	212 110.40	2180.18
PH X/12	9 951 782.71	211 974.14	2161.11
PH X/13	9 951.270.70	212 224.60	2217.53
H 2	-	-	2143.00

Table A.3.3 Coordinates and Heights of Photo Control Points for Photgrammetric Mapping of Reservoir Areas and damsites(3/3)

(ForTurasha Damsite)

Points	Coordinates (m)		Height (m)
	N	E	
PH Y/1	9 950 884.91	213 237.85	2230.81
PH Y/2	9 950 579.62	213 194.60	2182.65
PH Y/3	9 950 370.57	213 160.22	2169.92
PH Y/4	9 950 080.92	213 196.95	2199.21
PH Y/5	9 949 662.29	213 332.52	2045.89
PH Y/6	9 951 389.85	214 341.88	2254.50
PH Y/7	9 951 114.14	214 415.61	2227.47
PH Y/8	9 951 435.90	214 014.78	2228.80
PH Y/9	9 951 177.34	214 002.14	2189.64
PH Y/10	9 951 126.86	213 640.42	2257.74
PH Y/11	9 950 907.21	213 637.73	2259.60
PH Y/12	9 950 997.13	214 153.89	2223.94
PH Y/13	9 950 739.10	214 525.47	2114.35
PH Y/14	9 950 767.08	214 048.53	2110.74
PH Y/15	9 950 342.43	213 824.06	2132.75
PH Y/16	9 950 055.12	213 651.31	2070.39
PH Y/17	9 950 280.00	213 979.05	2172.70
PH Y/18	9 950 213.38	214 564.97	2253.01
PH Y/19	9 950 372.16	214 449.54	2248.04
PH Y/20	9 949 797.74	213 797.39	2154.78
PH Y/21	9 950 092.65	214 310.01	2254.94
PH Y/22	9 950 565.90	213 714.97	2160.91
PH Y/23	9 950 759.58	213 662.12	2246.05
CP 31/1	9 950 615.11	214 286.65	2151.91
H 3	-	-	2205.03
H 4	-	-	2207.30
H 5	-	-	2207.30
TBM31	-	-	2102.66

Table A.3.4 Accuracy of Leveling

Total Distance : 72 km
Surveying dDate : May,1989
Surveyed by : PHOTOMAP (K) Ltd.

Route (km)	Distance Closure (mm)	Allowable (mm)	Diference of Closure	Remarks
Line A	36.0	144	-79	$\pm 24mm\sqrt{D}$
Line B	9.5	73	+15	
Line C	12.0	83	-28	
Line D	8.5	69	-21	
Line E	6.0	58	-27	

Table A.3.5 Accuracy of Traverse

Total Distance : 37,750 m
Surveying Date : May, 1989
Surveyed by : PHOTOMAP (K) Ltd.

Route (km)	Distance Closure	Allowable Closure	Difference of	Remarks
(Loop traverse)				
119T15 - MT6	25.472	1:15,000	1:21,165	
MD6 - SAT	7.587	1:15,000	1:62,233	
6/4X - MD6	6.491	1:15,000	1:24,755	

Table A.3.6 Accuracy of Aerial Triangulation for Photogrammetric Mapping of Reservoir Areas and Damsites

	Run No.	Frame No.	Nos. of Model	No. of Control point	
(1)	Aerialtriangulation for Reservoir Areas				
	1	1044 - 1049	5	Horinzontal	22
	2	1060 - 1067	7	Vertical	26
	Residuals : Control points			: 0.4 (Planimetry)	
				0.3 (Altitude)	
(2)	Aerialtriangulation for Malewa Damsite				
	3	1407 - 1412	5	Horinzontal	21
	4	1393 - 1397	4	Vertical	22
	5	1380 - 1383	3		
	Residuals : Control points			: 0.2 (Planimetry)	
				0.1 (Altitude)	
(3)	Aerialtriangulation for Turasha Damsite				
	6	1351 - 1355	4	Horinzontal	24
	7	1324 - 1330	6	Vertical	28
	8	1338 - 1343	5		
	Residuals : Control points			: 0.3 (Planimetry)	
				0.2 (Altitude)	

Table A.4.1 Coordinates and Heights of BMs at Malewa and Turasha Damsites

Point	Coordinates(m)		Height (m)	Remarks
	N	E		
(1) Malewa Damsite				
BM T. 1	9,950,277.03	214,320.03	2250.83	Iron pin in concrete
BM T. 2	9,950,827.04	213,484.94	2244.93	Iron pin in concrete
(2) Turasha Damsite				
BM 1 (BMB)	9,952,001.53	210,894.82	2209.23	Iron pin in concrete
BM 2	9,951,421.38	211,399.87	2171.18	Iron pin in concrete
BM 3	9,951,827.77	211,472.77	2155.75	Iron pin in concrete
BM A	9,951,292.25	211,511.54	2161.78	Iron pin in concrete

Table A.5.1 Coordinates and Heights of Photo Control Points for Photogrammetric Maping of Borrow Area and Quarry Site

Points	Cooordinates (m) N.	E.	Heights (cm)
PH 20/1	9 949 910.26	205 219.18	2181.91
PH 20/2	9 949 787.09	205 193.96	2184.66
PH 20/3	9 949 203.48	206 181.71	2168.10
PH 20/4	9 949 702.54	206 720.46	2134.67
PH 20/5	9 948 070.46	206 798.84	2095.86
PH 20/6	9 948 039.52	205 014.96	2229.95
PH 1/10	9 947 997.80	205 971.85	2131.39
PH 1/11	9 946 036.99	204 638.39	1994.39
PH 1/12	9 946 413.55	206 008.60	2066.02
PH 1/13	9 946 200.22	206 064.44	2058.43
PH 1/14	9 946 012.09	207 114.58	2046.05

Table A.5.2 Accuracy of Aerial Triangulation for Photogrammetric Mapping of Borrow Area and Quarry Site

Run No. No.	Frame Model	Nos. of Control point	No. of
(1) Aerialtrinagulation for Kipipiri Quarry Site			
19	356 - 354	2	6
18	334 - 335	1	4
Residuals :	Control points	:	0.60 (Planimetry) 0.40 (Altitude)
(2) Aerialtriangulation for East Road Borrow Area			
1	5688 - 5690	2	7
1	7628 - 7630	2	6
Residuals :	Control points	:	0.60 (Planimetry) 0.40 (Altitude)

Table A.6.1 Coordinates and Height of Permanent Points for Photogrammetric Mapping of Lake Nakuru

Station	Coordinates(m) N	E	Height (m)	Remarks
119T4 NEW	9 962 937.70	180 380.42	2095.72	Pipe in concrte
119T6 NEW	9 953 937.16	172 843.98	1989.44	Wooden peg in concrte
119T4X	9 962 370.08	180 227.43	2087.94	Hole in rock
HONEYMOON HILL	9 965 680.21	174 272.16	1872.35	Iron pin in concrte
WATER TANK	9 953 487.10	180 566.46	1845.65	Hole in rock
H1X	9 958 326.80	170 728.72	1955.64	Hole in rock
BABOON CLIFF	9 960 719.38	172 180.85	1866.45	Hole in rock
PH1X	9 964 981.38	169 016.97	1920.16	Hole in rock
PH15X	9 949 167.62	172 832.40	2010.42	Cross in rock
BM14	9 954 787.01	178 787.20	1766.22	Iron pin in concrete

Note : (1) Coordinates of all traverse points have been fixed andtransfomed by polar method by PHOTOMAP in June, 1990.

Table A.6.2 Heights of BMs for Photogrammetric Mapping of Lake Nakuru

Station	Height(m)	Remarks
BM 4	1776.043	Iron pin in concrete
BM 5	1772.807	Iron pin in concrete
BM 6	1787.097	Iron pin in concrete
BM 7	1769.151	Iron pin in concrete
BM 8	1769.282	Iron pin in concrete
BM 9	1770.088	Iron pin in concrete
BM 10	1771.261	Iron pin in concrete
BM 11	1771.091	Iron pin in concrete
BM 12	1770.780	Iron pin in concrete
BM 13	1770.563	Iron pin in concrete
BM 14	1766.220	Iron pin in concrete
BM 15	1764.839	Iron pin in concrete
BM 16	1761.904	Iron pin in concrete
BM 17	1760.411	Iron pin in concrete
BM 18	1761.187	Iron pin in concrete
BM 19	1759.736	Iron pin in concrete
BM 20	1763.597	Iron pin in concrete
BM 21	1764.274	Iron pin in concrete
BM 22	1763.991	Iron pin in concrete
BM 23	1760.371	Iron pin in concrete
BM 24	1763.380	Iron pin in concrete
BM 25	1761.498	Iron pin in concrete
BM 26	1760.286	Iron pin in concrete
BM 27	1761.335	Iron pin in concrete
BM 28	1762.406	Iron pin in concrete
BM 29	1761.612	Iron pin in concrete
BM 30	1761.416	Iron pin in concrete
BM 31	1761.956	Iron pin in concrete
BM 32	1763.200	Iron pin in concrete
BM 33	1763.210	Iron pin in concrete
BM 34	1766.825	Iron pin in concrete
PH12X	1759.186	Iron pin in concrete
Water Level of Lake Nakuru	1758.60 (Mean)	

Note: (1) Heights are based on Survey of Kenya BM VII/23 and VII/24 of the Gilgil-Nakuru Primary Line.

(2) The water level of Lake Nakuru was measured at 4 diffrrence points by PHOTOMAP on 17th June,1990.

Table A.6.3 Accuracy of Leveling

1. Main leveling

Project : Malewa dam (Lake Nakuru)
Total Distance : 49.1 km
Surveying Date : June, 1990
Surveyed by : PHOTOMAP(K)Ltd.

Route	Distance (km)	Allowable Closure (mm)	Difference of Closure (mm)	Remarks
(Main loop)				
Line A	4.1	40	+17	$\pm 20mm\sqrt{D}$
Line B	31.3	111	+34	
(Open)				
Line C	1.0	20	- 2	
Line D	0.8	18	+ 3	
Line E	3.5	37	+27	
Line F	2.2	30	-15	
Line G	1.6	25	+ 2	
Line H	0.7	16	+ 3	
Line I	1.2	22	- 7	
Line J	0.7	17	- 4	
Line K	2.0	28	+ 2	

2. Minor Leveling

Project : Malewa dam (Lake Nakuru)
Total Distance : 12.0 km
Surveying Date : July, 1990
Surveyed by : Topo-Survey Expert of JICA Study Team.

Route	Distance Closure (km)	Allowable Closure (mm)	Difference of (mm)	Remarks
(Minor)				
NO.1	1.0	20	+18	$\pm 20mm\sqrt{D}$
NO.2	5.0	44	+28	
NO.3	0.5	14	- 1	
NO.4	1.0	20	- 4	
NO.5	4.5	42	+31	

Table A.6.4 Coordinates and Heights of Photo Control Points for Photogrammetric Mapping of Lake Nakuru

Points No.	Coordinates(m) N	E	Height(m)
PH 3A	9 967 933.16	175 817.45	1797.64
PH 1	9 964 943.69	168 917.96	1914.67
PH 2A	9 967 023.51	172 130.07	1815.36
PH 2B	9 967 044.65	172 141.26	1816.28
PH 3B	9 967 979.74	175 807.10	1797.61
PH 4	9 968 014.64	178 255.13	1845.06
PH 4A	9 967 709.41	178 712.71	1841.42
PH 5A	9 966 216.45	182 312.56	1885.07
PH 5B	9 966 193.01	182 324.04	1885.06
PH 6	9 960 999.70	170 668.33	1860.77
PH 7	9 960 876.49	172 893.00	1760.27
PH 8	9 963 809.28	175 465.86	1759.18
PH 8A	9 963 787.78	175 456.10	1759.15
PH 9	9 960 620.30	179 072.25	1762.16
PH 10	9 960 171.63	182 156.17	1893.00
PH 11	9 956 882.54	172 686.90	1791.01
PH 12	9 956 194.33	175 796.15	1758.80
PH 12A	9 956 261.60	175 803.42	1758.60
PH 13	9 955 695.89	178 409.25	1763.39
PH 14	9 954 044.31	182 296.36	1820.94
PH 15	9 949 147.40	172 788.47	2013.84
PH 16A	9 945 301.02	175 789.34	1824.85
PH 16B	9 945 323.13	175 781.85	-
PH 17	9 947 169.59	179 371.96	1805.30
PH 18	9 948 877.51	182 196.00	1826.77
H 1	9 958 296.44	170 635.76	1945.07
H 2	-	-	1775.98
H 3	-	-	1772.60
PH 119T4	9 962 922.49	180 400.14	2094.29

Table A.6.5 Accuracy of Traverse

1. Main Traverse

Project : Malewa dam (Lake Nakuru)
Total Distance : 49.4 km
Surveying Date : June, 1990
Surveyed by : PHOTOMAP(K)Ltd.

Route Closure (km)	Distance Closure	Allowable	Difference of	Remarks
(Loop traverse)				
119T6 - 119T6	49.436	1:15,000	1:482,259	

2. Detail Traverse

Project : Malewa dam (Lake Nakuru)
Total Distance : 13.7 km
Surveying Date : July, 1990
Surveyed by : Topo-Survey Expert of JICA Study Team.

Route	Distance (km)	Allowable Closure	Difference of Closure	Remarks
PH 7- HONEY MOON HILL	6.759	1:15,000	1:40,836	
PH 12- PH 7	6.980	1:15,000	1:279,214	

Table A.6.6 Coordinates and Height of Aerial Triangulation Points for Photogrammetric Mapping of LakeNakuru (1/4)

Point No.	Coordinates(m) E	N	Height(m)	Remarks
1. Control points				
1	9 964 943.690	168 917.960	1914.670	PH 1
4	9 968 014.640	178 255.130	1845.060	PH 4
6	9 960 999.700	170 668.330	1860.770	PH 6
7	9 960 876.490	172 893.000	1760.270	PH 7
8	9 963 809.280	175 465.860	1759.180	PH 8
9	9 960 620.300	179 072.250	1762.160	PH 9
10	9 960 171.630	182 156.170	1893.000	PH 10
11	9 956 882.540	172 686.900	1791.010	PH 11
12	9 956 194.330	175 796.150	1758.800	PH 12
13	9 955 695.890	178 409.250	1763.390	PH 13
14	9 954 044.310	182 296.360	1822.877	PH 14
15	9 949 145.652	172 785.235	2013.840	PH 15
17	9 947 169.590	179 371.960	1805.300	PH 17
18	9 948 877.510	182 196.000	1826.770	PH 18
21	9 967 023.510	172 130.070	1815.360	PH 2A
22	9 967 044.650	172 141.260	1817.962	PH 2B
31	9 967 933.160	175 817.450	1797.640	PH 3A
32	9 967 979.740	175 807.100	1797.610	PH 3B
41	9 967 709.410	178 712.710	1841.420	PH 4A
51	9 966 216.450	182 312.560	1885.070	PH 5A
52	9 966 193.010	182 324.040	1885.060	PH 5B
61	9 961 000.203	170 667.375	1859.900	PH 6(Ground)
81	9 963 787.780	175 456.100	1759.150	PH 8A
101	9 958 325.894	170 625.094	1945.000	H 1
102	9 952 212.544	75 772.964	1775.980	H 2
103	9 952 605.372	178 548.287	1772.600	H 3
119	9 962 922.490	180 400.140	2094.290	PH 119T4
121	9 956 261.600	175 803.420	1758.600	PH 12A
141	9 954 041.314	182 294.596	1820.940	PH 14(Ground)
161	9 945 301.020	175 789.340	1824.850	PH 16A
162	9 945 323.130	175 781.850	1823.006	PH 16B
171	9 947 169.992	179 372.278	1804.700	PH 17(Ground)
201	9 958 330.534	170 625.366	1945.070	H 1(Tree)
900	9 965 227.871	178 444.026	1758.600	Water level
901	9 964 185.166	178 456.324	1758.600	"
902	9 962 776.587	178 747.986	1758.600	"
903	9 961 014.520	178 690.030	1758.600	"
904	9 959 523.787	178 831.870	1758.600	"
905	9 958 016.637	178 702.160	1758.600	"
906	9 956 809.823	178 505.922	1758.600	"
907	9 965 956.498	177 438.594	1758.600	"
908	9 964 318.512	175 729.345	1758.600	"
909	9 964 397.509	178 509.131	1758.600	"
910	9 956 680.995	177 981.070	1758.600	"
911	9 956 328.523	175 306.681	1758.600	Water level

Table A.6.6 Coordinates and Height of Aerial Triangulation Points for Photogrammetric Mapping of Lake Nakuru (2/4)

Point No.	Coordinates(m) E	N	Height(m)	Remarks
1. Control points				
912	9 965 598.260	176 240.638	1758.600	Water level
913	9 963 231.552	175 453.004	1758.600	"
914	9 961 758.244	174 345.822	1758.600	"
915	9 961 076.786	173 314.024	1758.600	"
916	9 957 484.936	174 119.825	1758.600	"
917	9 956 276.608	176 184.696	1758.600	"
918	9 960 724.631	172 763.479	1758.600	"
919	9 958 569.975	172 612.242	1758.600	Water level
2. Pass points				
1021	9 958 220.955	172 853.530	1758.494	
1022	9 958 227.649	171 157.360	1885.302	
1023	9 958 286.315	169 340.984	1977.459	
1031	9 959 818.903	172 304.359	1758.820	
1032	9 959 803.836	170 661.433	1904.116	
1033	9 959 833.187	169 238.856	1953.259	
1041	9 961 621.347	172 291.364	1773.865	
1042	9 961 584.718	170 635.950	1842.688	
1043	9 961 565.961	169 352.982	1936.388	
1051	9 963 157.948	172 508.645	1767.543	
1052	9 963 275.022	170 579.220	1832.933	
1053	9 963 438.760	169 144.152	1909.745	
1061	9 964 907.072	172 520.563	1786.150	
1062	9 964 891.232	170 861.283	1794.189	
1063	9 965 028.066	169 366.303	1837.963	
1071	9 966 565.657	172 380.414	1804.107	
1072	9 966 922.341	170 803.437	1817.525	
1073	9 966 868.390	168 903.328	1865.151	
2501	9 968 089.353	176 133.145	1799.941	
2502	9 967 963.000	174 302.521	1812.533	
2503	9 967 781.905	172 306.284	1830.287	
2511	9 966 231.988	175 976.004	1766.825	
2512	9 966 169.578	174 265.042	1803.551	
2513	9 965 967.479	172 388.084	1792.677	
2521	9 964 512.880	175 606.554	1759.928	
2522	9 964 147.260	174 319.610	1764.786	
2523	9 964 264.624	172 710.810	1776.435	
2531	9 962 544.507	174 996.010	1758.376	
2532	9 962 734.558	173 972.568	1763.039	
2533	9 962 742.066	172 547.241	1765.314	
2541	9 961 962.357	174 378.219	1758.905	
2542	9 961 361.445	173 469.308	1758.622	
2543	9 960 897.966	172 622.296	1760.734	
2553	9 959 267.388	172 279.703	1759.092	

Table A.6.6 Coordinates and Height of Aerial Triangulation Points for Photogrammetric Mapping of Lake Nakuru (3/4)

Point No.	Coordinates(m) E	N	Height(m)	Remarks
2. Pass points				
2561	9 956 277.875	176 272.700	1758.684	
2562	9 957 145.286	173 902.194	1758.706	
2563	9 957 301.413	172 484.256	1784.996	
2565	9 957 656.174	172 534.648	1770.642	
2571	9 955 609.512	176 170.476	1762.735	
2572	9 955 691.899	174 559.458	1760.793	
2573	9 955 694.547	172 557.916	1873.076	
2581	9 953 861.325	175 964.190	1769.506	
2582	9 953 973.564	174 360.159	1765.513	
2583	9 954 211.293	172 434.170	1952.722	
2591	9 952 392.047	175 880.874	1775.948	
2592	9 952 291.970	173 784.718	1782.099	
2593	9 952 395.263	172 476.003	2015.131	
2601	9 950 611.195	175 667.954	1782.045	
2602	9 950 694.938	173 907.196	1804.762	
2603	9 950 945.972	172 270.072	2001.884	
2611	9 948 869.734	175 342.693	1795.604	
2612	9 948 924.869	174 214.519	1812.148	
2613	9 949 077.311	172 132.960	1998.575	
2621	9 947 265.720	175 631.773	1803.297	
2622	9 947 196.491	173 715.643	1863.053	
2623	9 947 176.206	172 249.750	1965.551	
2631	9 946 069.342	175 613.373	1816.633	
2632	9 945 808.997	174 100.101	1870.099	
2633	9 945 740.488	172 451.148	1968.859	
3721	9 945 483.327	179 198.615	1816.087	
3722	9 945 386.201	177 313.326	1817.748	
3723	9 945 234.522	175 475.179	1825.071	
3731	9 947 289.316	178 887.338	1806.038	
3732	9 947 238.062	177 238.261	1806.819	
3741	9 949 157.877	178 935.547	1795.433	
3742	9 949 013.469	177 280.612	1794.336	
3751	9 950 972.908	178 689.003	1781.549	
3752	9 950 915.510	177 451.763	1782.181	
3761	9 952 789.697	178 598.704	1772.674	
3762	9 952 650.367	177 417.248	1775.050	
3771	9 954 437.090	179 028.958	1765.238	
3772	9 954 340.768	177 200.161	1767.032	
3781	9 956 262.768	179 132.556	1764.721	
3782	9 956 171.237	177 304.907	1759.602	
3783	9 956 004.188	175 166.914	1761.234	
3831	9 964 276.721	179 225.605	1832.001	
3832	9 964 179.347	178 471.048	1758.709	
3833	9 964 126.203	175 545.811	1758.855	
3841	9 965 815.630	179 136.707	1786.586	

Table A.6.6 Coordinates and Height of Aerial Triangulation Points for Photogrammetric Mapping of Lake Nakuru (4/4)

Point No.	Coordinates(m) E	N	Height(m)	Remarks
2. Pass points				
3842	9 966 022.790	177 088.422	1759.853	
3843	9 965 807.040	175 287.753	1772.819	
3851	9 967 884.042	178 503.551	1841.795	
3852	9 967 618.941	176 848.475	1784.923	
3853	9 967 585.706	175 573.198	1793.379	
4001	9 957 155.056	182 059.964	1849.441	
4002	9 957 238.753	180 405.204	1902.645	
4003	9 957 349.752	178 847.585	1760.697	
4011	9 955 674.734	181 999.064	1834.967	
4012	9 955 580.481	180 466.382	1869.530	
4013	9 955 582.942	178 363.673	1763.839	
4021	9 954 014.150	182 192.983	1819.437	
4022	9 953 973.393	180 586.849	1825.325	
4023	9 954 158.391	178 588.949	1767.929	
4031	9 952 469.817	182 147.870	1822.971	
4032	9 952 478.962	180 644.116	1775.886	
4041	9 950 732.038	182 193.819	1824.338	
4042	9 950 774.665	180 358.343	1784.661	
4051	9 948 848.005	182 027.377	1823.810	
4052	9 948 856.421	180 567.178	1797.839	
4061	9 947 215.168	182 284.732	1821.910	
4062	9 947 253.328	180 344.266	1804.493	
4931	9 967 734.141	182 487.215	1890.610	
4932	9 967 916.374	180 400.686	1876.913	
4941	9 966 135.908	182 130.437	1882.053	
4942	9 966 219.541	180 516.943	1870.953	
4943	9 966 364.334	178 686.996	1787.645	
4951	9 964 665.693	181 872.005	1884.057	
4952	9 964 607.803	180 153.148	2027.871	
4953	9 964 620.281	178 991.286	1783.189	
4961	9 963 147.170	182 279.453	1888.556	
4962	9 963 133.876	180 345.655	2071.199	
4963	9 963 082.693	178 646.798	1759.035	
4971	9 961 588.744	182 329.908	1884.738	
4972	9 961 683.225	180 752.722	1931.571	
4973	9 961 626.411	178 830.818	1761.544	
4981	9 960 085.477	182 451.226	1887.571	
4982	9 960 178.770	180 988.684	1928.937	
4983	9 960 211.690	179 188.611	1761.992	
4991	9 958 461.316	182 489.341	1863.858	
4992	9 958 562.148	180 282.633	1910.753	
4993	9 958 565.038	179 102.845	1762.100	

Table A.6.7 Accuracy of Aerial Triangulation for Photogrammetric Mapping of Lake Nakuru

Project : Malewa dam (Lake Nakuru)
Mapping Area : 95.0 sq.km for 1 to 10,000 scale
Surveying : June, 1990
Surveyed by : PHOTOMAP(K)Ltd.

Run No. No.	Frame	Nos. of Model	No. of Control point
1	2-7	5	Horizontal 33
2A	50-54	4	
2B	56-63	7	Vertical 53
3A	72-78	2	
3B	83-85	6	
4	93-99-55, 55-1-6	13	

Residuals:
Maximum residuals(Control points) : 0.613m(Planmetry)
0.25 m(Altitude)

Table A.6.8 Root Mean Square Values of Residuals(1/2)

Project	:	Malewa dam (Lake Nakuru)
Total Active Rays	:	571 rays
Triangulation Points	:	174 points
RMS of Photo Residuals	:	4.6 microns
Computed by	:	PHOTOMAP(K)Ltd.

Residuals at control points

Point	VX(m)	VY(m)	VZ(m)	ACC-XY(m)	ACC-Z(m)
51	0.176	0.202	0.079	0.250	0.200
52	0.751	-0.175	-0.348	0.250	0.200
907	0.603	0.200			
4	0.011	-0.549	-0.439	0.250	0.200
32	0.237	-0.545	-0.330	0.250	0.200
31	0.120	-0.467	-0.233	0.250	0.200
21	-0.569	-0.852	0.091	0.250	0.200
22	0.203	-0.202	0.250		
900	0.039	0.200			
908	0.224	0.200			
909	0.131	0.200			
8	-0.128	0.538	0.116	0.250	0.200
81	-0.561	0.243	0.149	0.250	0.200
912	-0.038	0.200			
1	-0.374	-0.017	-0.033	0.250	0.200
901	0.009	0.200			
913	-0.020	0.200			
902	-0.138	0.200			
119	0.157	0.424	0.397	0.250	0.200
915	-0.060	0.200			
7	-0.099	-0.119	0.020	0.250	0.200
914	0.103	0.200			
9	-0.299	-0.133	-0.009	0.250	0.200
903	0.047	0.200			
10	0.713	0.379	-0.327	0.250	0.200
6	-0.858	0.430	0.106	0.250	0.200
61	0.257	0.200			
918	-0.158	0.200			
904	0.092	0.200			
201	-0.113	0.200			
101	-0.088	0.200			
919	-0.175	0.200			
917	0.142	0.200			
12	0.822	0.242	0.158	0.250	0.200
121	-0.595	0.168	0.180	0.250	0.200
916	-0.254	0.200			
11	0.909	0.176	-0.353	0.250	0.200
905	-0.089	0.200			
13	0.075	-0.723	0.006	0.250	0.200

Table A.6.8 Root Mean Square Values of Residuals(2/2)

Residuals at control points

Point	VX(m)	VY(m)	VZ(m)	ACC-XY(m)	ACC-Z(m)
910	-0.317	0.200			
911	-0.003	0.200			
906	-0.122	0.200			
102	0.534	0.200			
103	0.613	0.200			
14	0.758	0.232	0.250		
141	0.003	0.200			
15	0.308	0.200			
17	0.161	0.322	-0.216	0.250	0.200
171	0.192	0.200			
18	0.072	0.348	-0.167	0.250	0.200
161	-0.203	0.353	-0.662	0.250	0.200
162	-0.311	-0.306	0.250		

RMS X = 0.478m Y = 0.384m Z = 0.250m

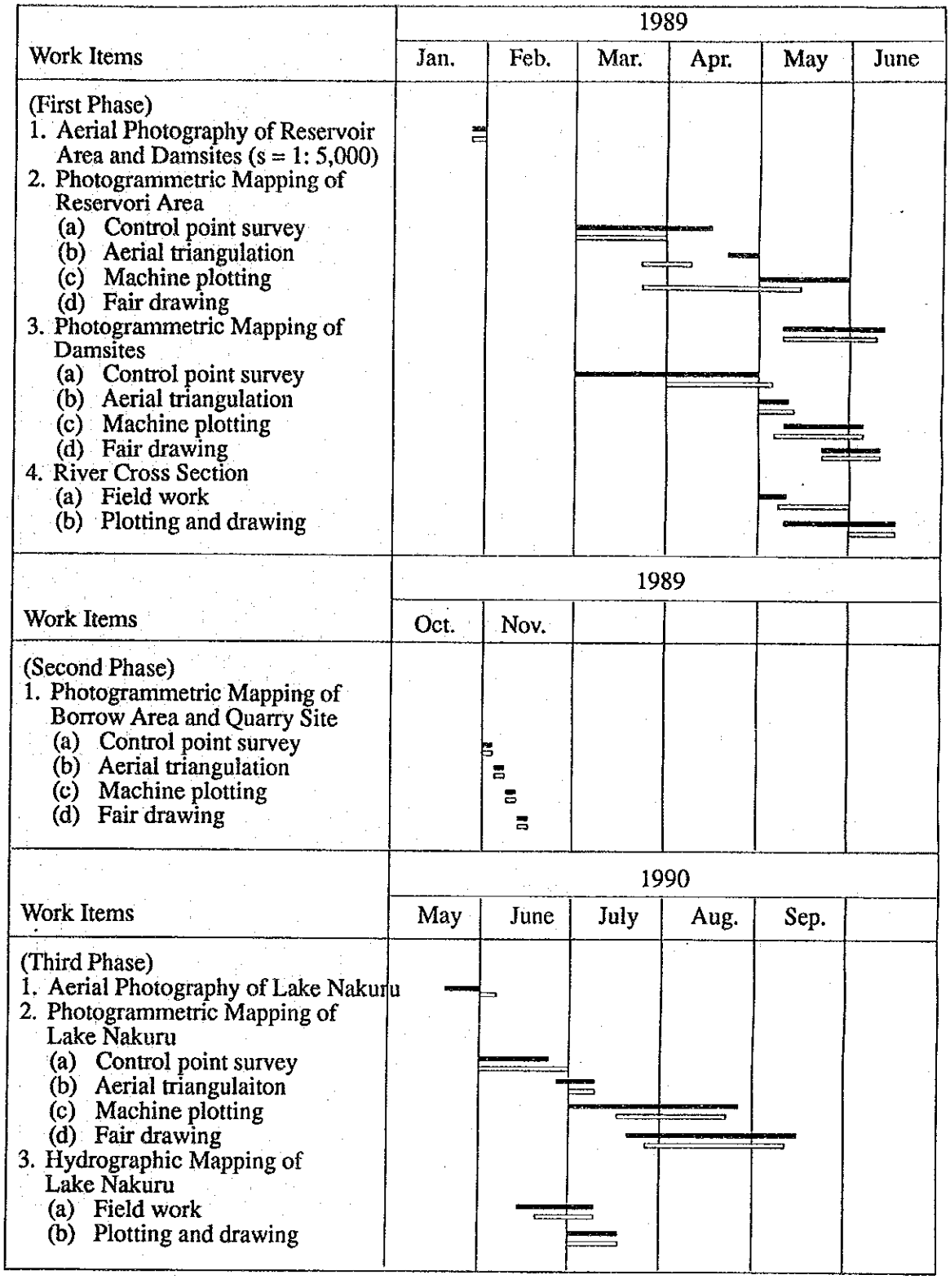
RMS P = 0.613m

Table A.7.1 Coordinates and Heights of JWBMs for Hydrographic Mapping of Lake Nakuru

Station	Coordinates(m) N	E	Height(m)	Remarks
JWBM 1	9 965 673.61	176 035.86	1759.59	50cm concrete pill
JWBM 2	9 965 399.74	175 937.66	1758.55	50cm concrete pillar
JWBM 3	9 965 136.17	175 843.15	1758.53	50cm concrete pillar
JWBM 4	9 964 880.27	175 751.40	1759.07	50cm concrete pillar
JWBM 5	9 964 615.70	175 884.16	1758.59	50cm concrete pillar
JWBM 6	9 964 254.54	175 674.81	1758.61	50cm concrete pillar
JWBM 7	9 964 010.92	175 533.61	1758.66	50cm concrete pillar
JWBM 8	9 963 706.11	175 514.53	1758.65	50cm concrete pillar
JWBM 9	9 963 341.61	175 491.71	1758.69	50cm concrete pillar
JWBM 10	9 963 086.78	175 267.85	1759.07	50cm concrete pillar
JWBM 11	9 962 836.11	175 047.64	1758.90	50cm concrete pillar
JWBM 12	9 962 611.83	174 850.61	1759.14	50cm concrete pillar
JWBM 13	9 962 370.26	174 638.40	1759.46	50cm concrete pillar
JWBM 14	9 962 128.89	174 426.36	1759.68	50cm concrete pillar
JWBM 15	9 961 899.38	174 224.78	1759.15	50cm concrete pillar
JWBM 16	9 961 745.80	173 998.52	1759.04	50cm concrete pillar
JWBM 17	9 961 572.27	173 742.88	1758.77	50cm concrete pillar
JWBM 18	9 961 404.29	173 495.43	1758.82	50cm concrete pillar
JWBM 19	9 961 164.51	173 309.18	1759.34	50cm concrete pillar
JWBM 20	9 960 921.57	173 120.48	1759.28	50cm concrete pillar
JWBM 21	9 960 767.85	172 757.81	1759.45	50cm concrete pillar
JWBM 22	9 960 439.00	172 419.66	1758.69	50cm concrete pillar
JWBM 23	9 960 105.87	172 325.50	1758.97	50cm concrete pillar
JWBM 24	9 959 827.89	172 300.38	1759.57	50cm concrete pillar
JWBM 25	9 959 331.32	172 297.82	1761.79	50cm concrete pillar
JWBM 26	9 958 955.93	172 284.69	1758.75	50cm concrete pillar
JWBM 27	9 958 571.78	172 603.97	1758.92	50cm concrete pillar
JWBM 28	9 958 192.85	172 913.54	1758.94	50cm concrete pillar
JWBM 29	9 957 979.21	173 404.16	1758.72	50cm concrete pillar
JWBM 30	9 957 764.55	173 650.21	1758.83	50cm concrete pillar
JWBM 31	9 957 500.22	173 779.10	1759.06	50cm concrete pillar
JWBM 32	9 957 216.42	173 917.48	1758.85	50cm concrete pillar
JWBM 33	9 956 957.38	174 043.80	1758.98	50cm concrete pillar
JWBM 34	9 956 662.79	174 117.77	1758.87	50cm concrete pillar
JWBM 35	9 956 492.25	174 409.49	1758.71	50cm concrete pillar

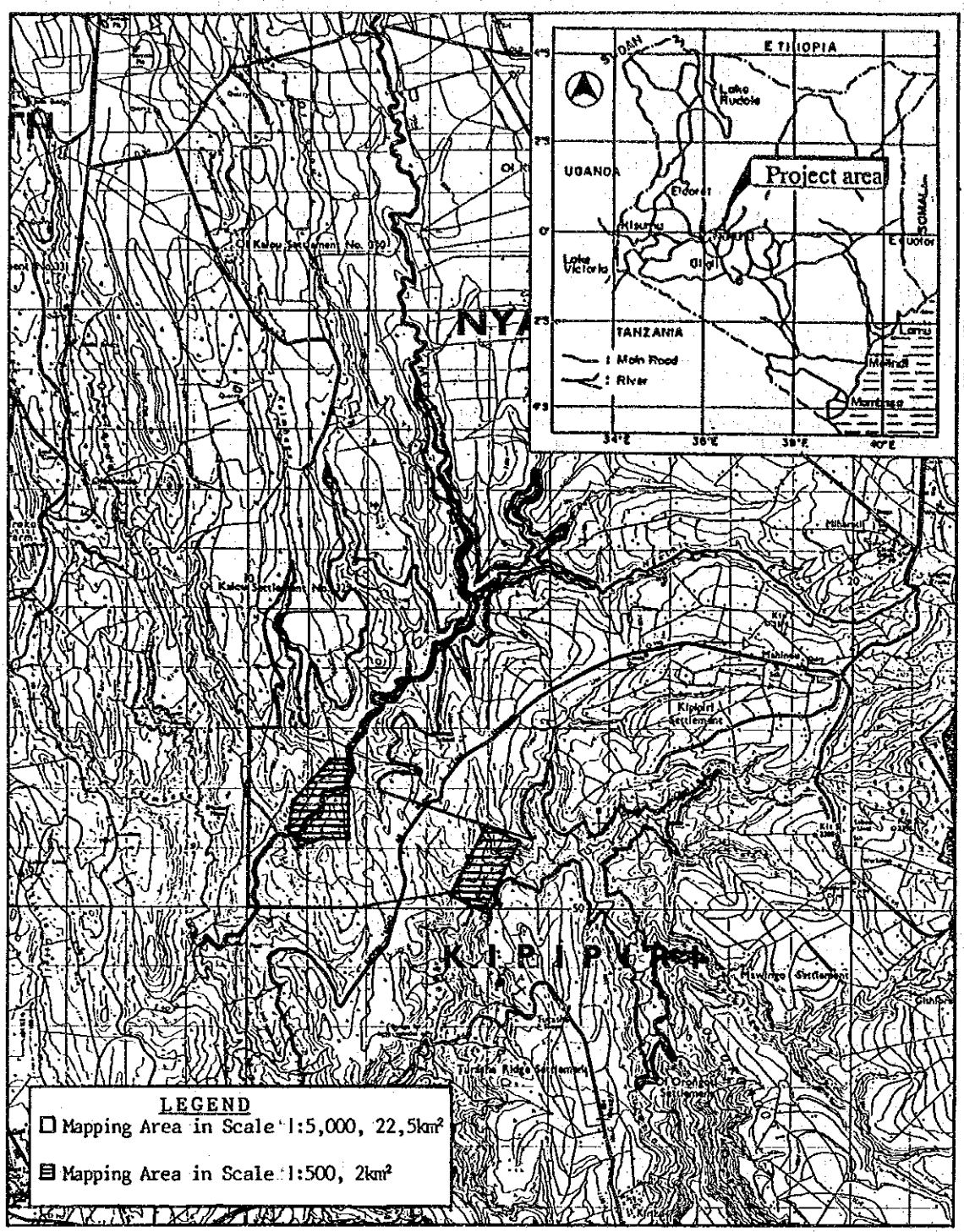
FIGURES

Fig. A.1.1



THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Work Schedule and Progress of Topographic Survey

Fig. A.3.1



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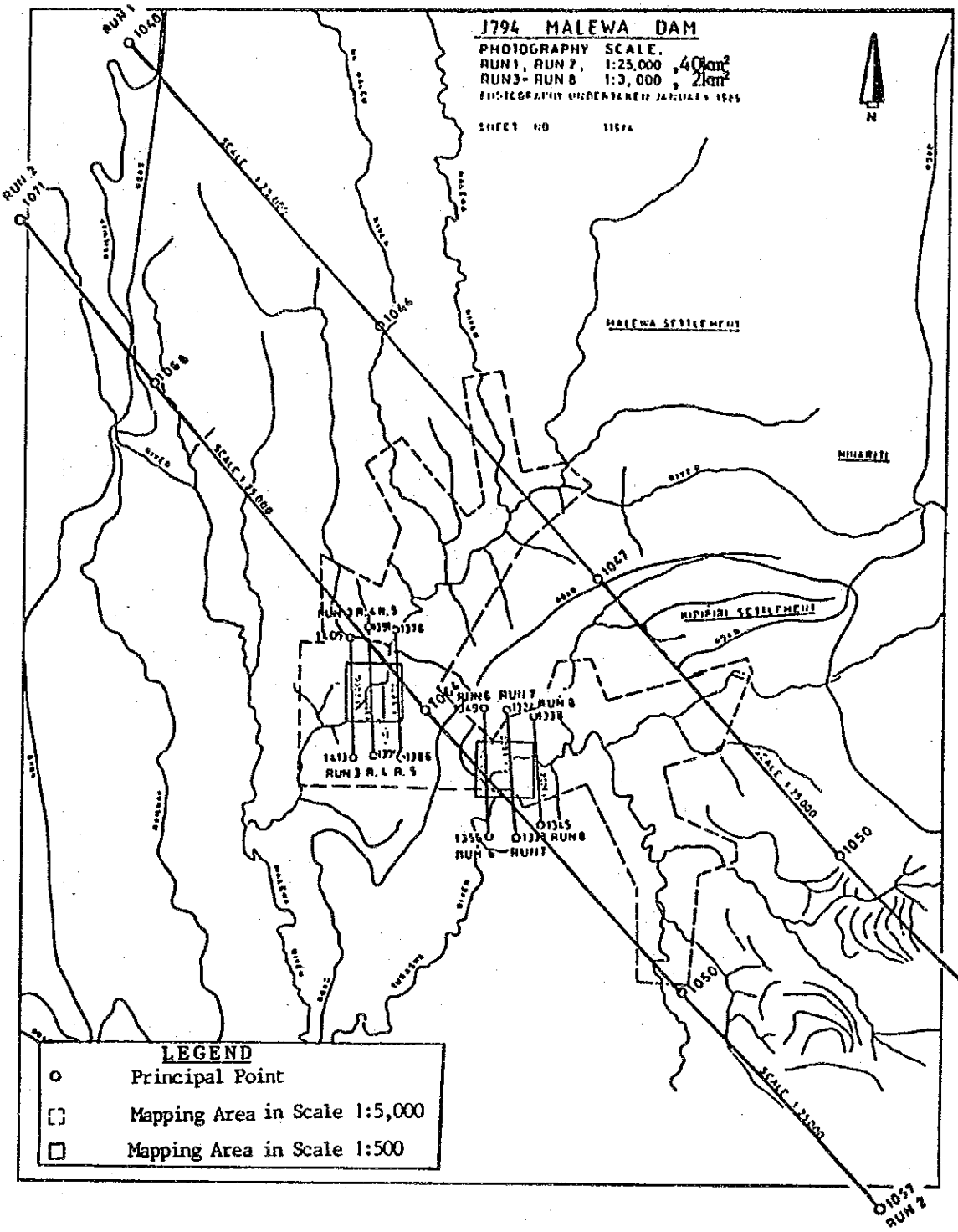
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE First Phase Mapping Area

Fig. A.3.2



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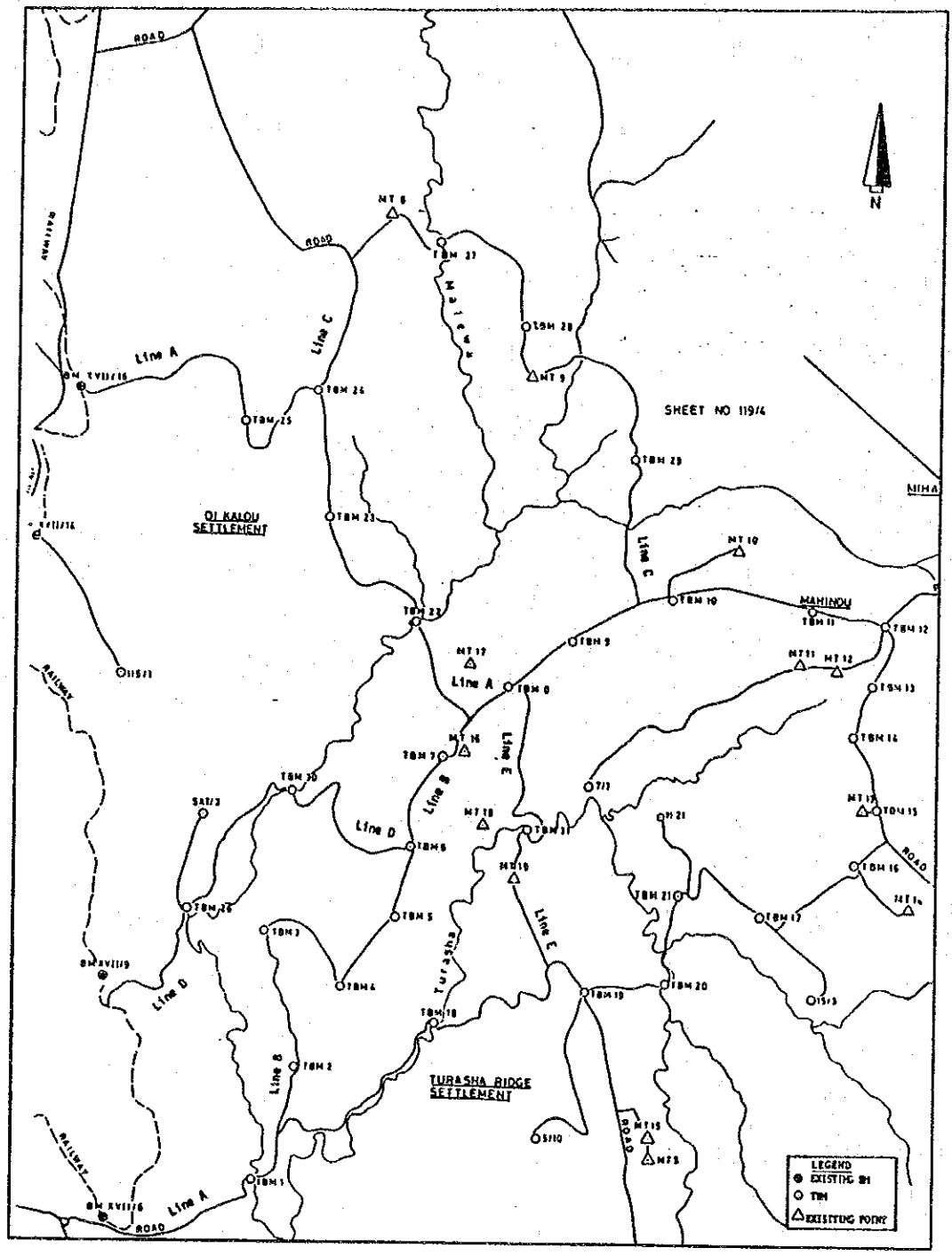
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Acrial Photo Index Map

Fig. A.3.3



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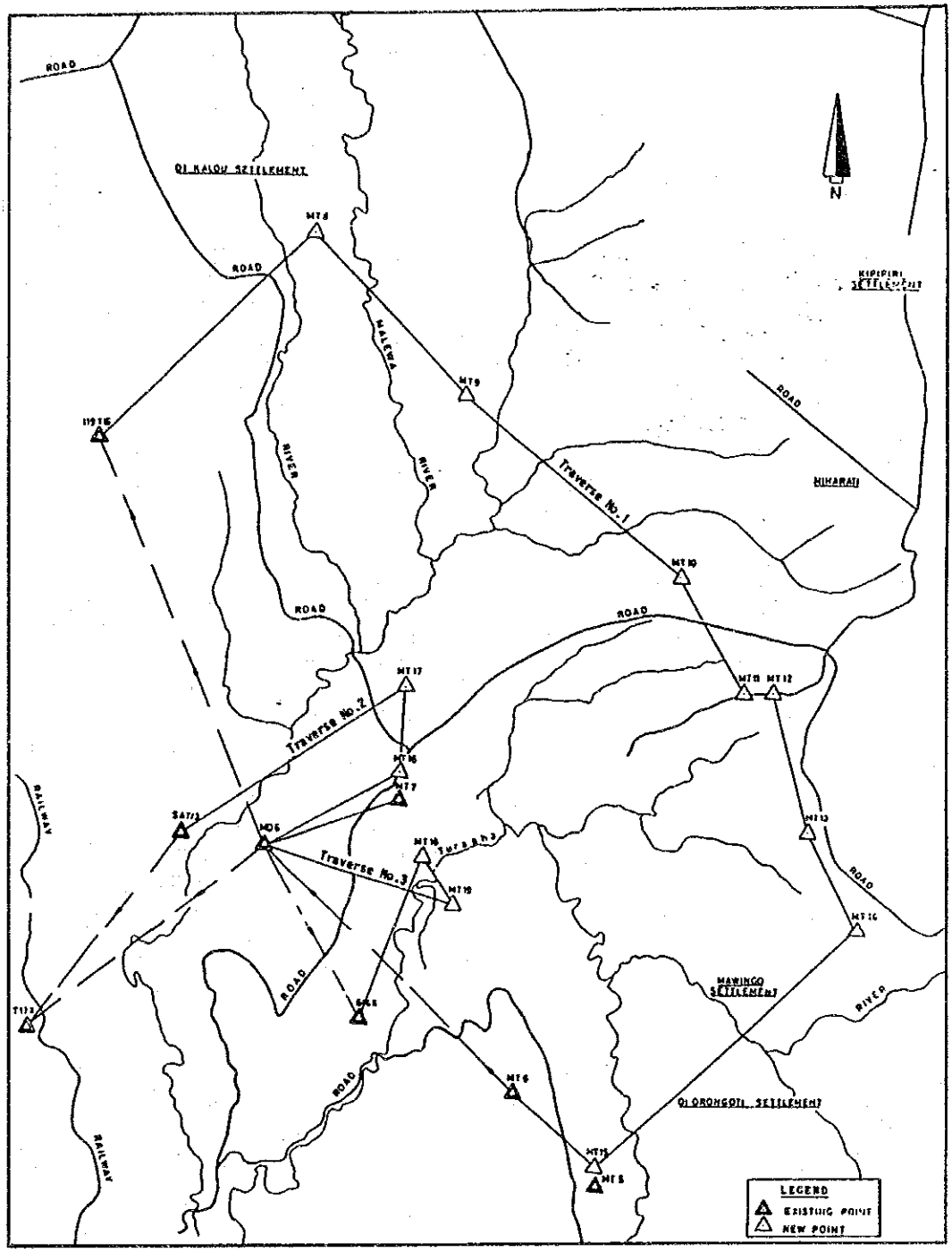
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Diagram of Leveling

Fig. A.3.4



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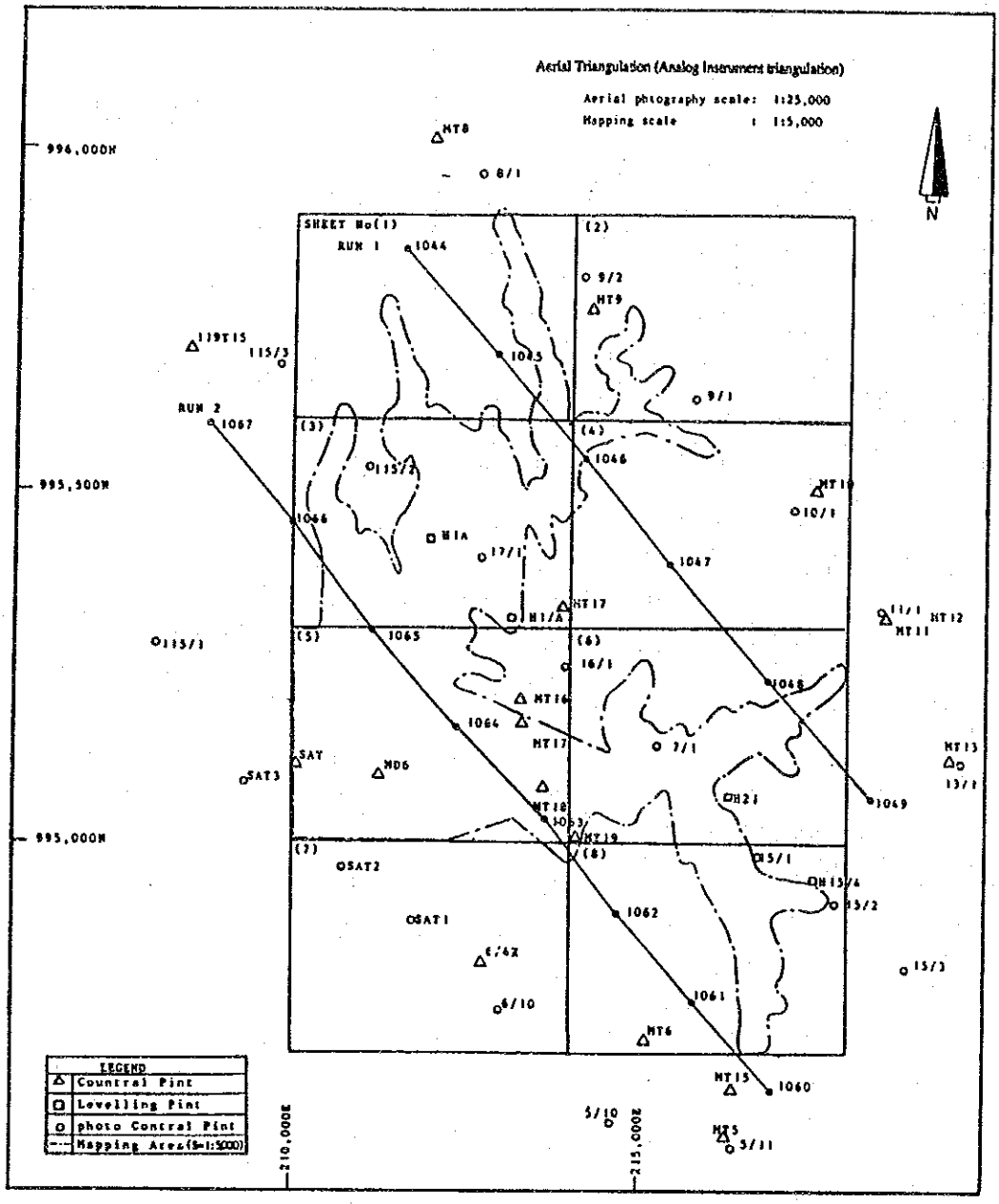
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Diagram of Traversing

Fig. A.3.5



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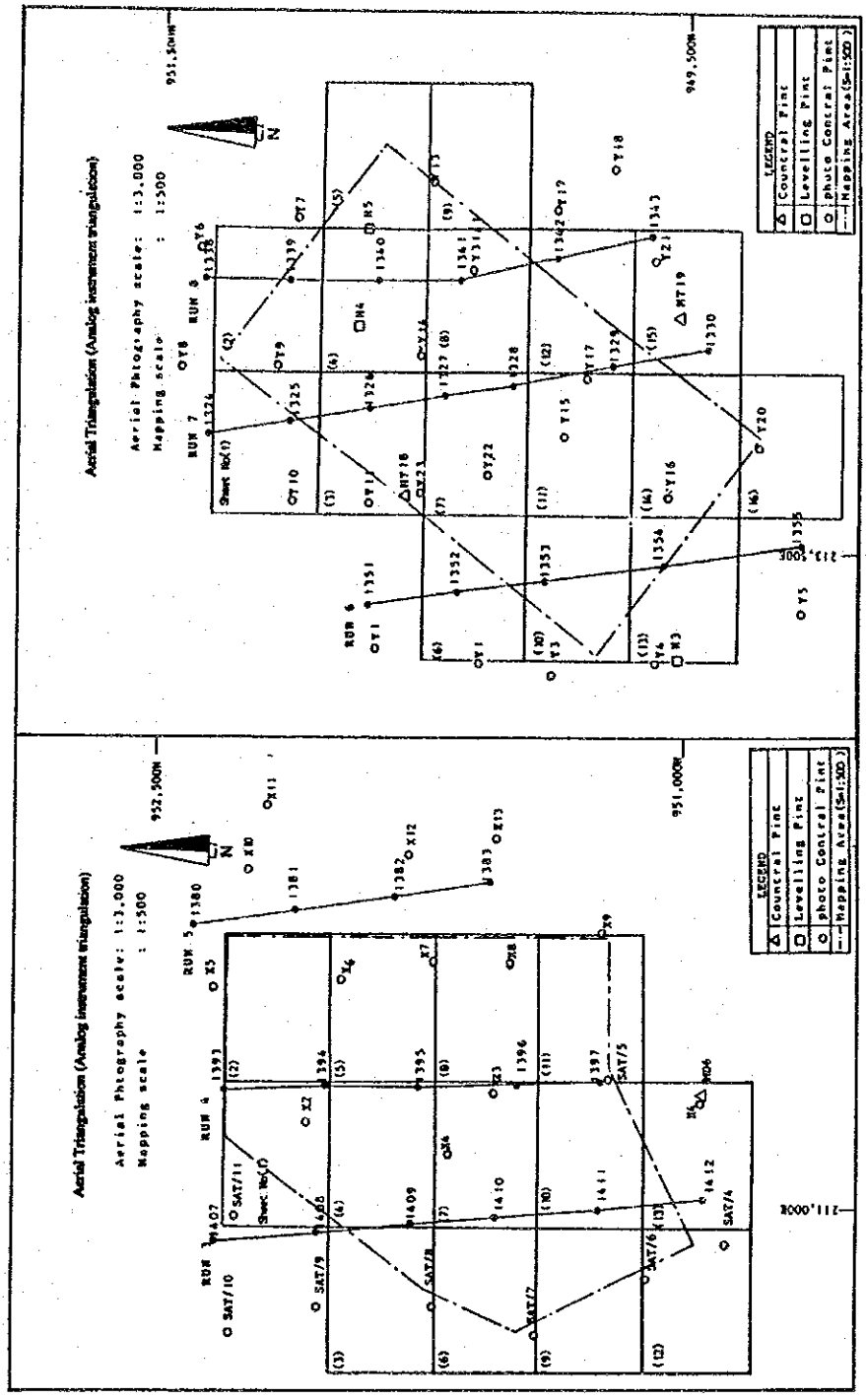
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Triangulation Mark Index Map (1/2)

Fig. A.3.5



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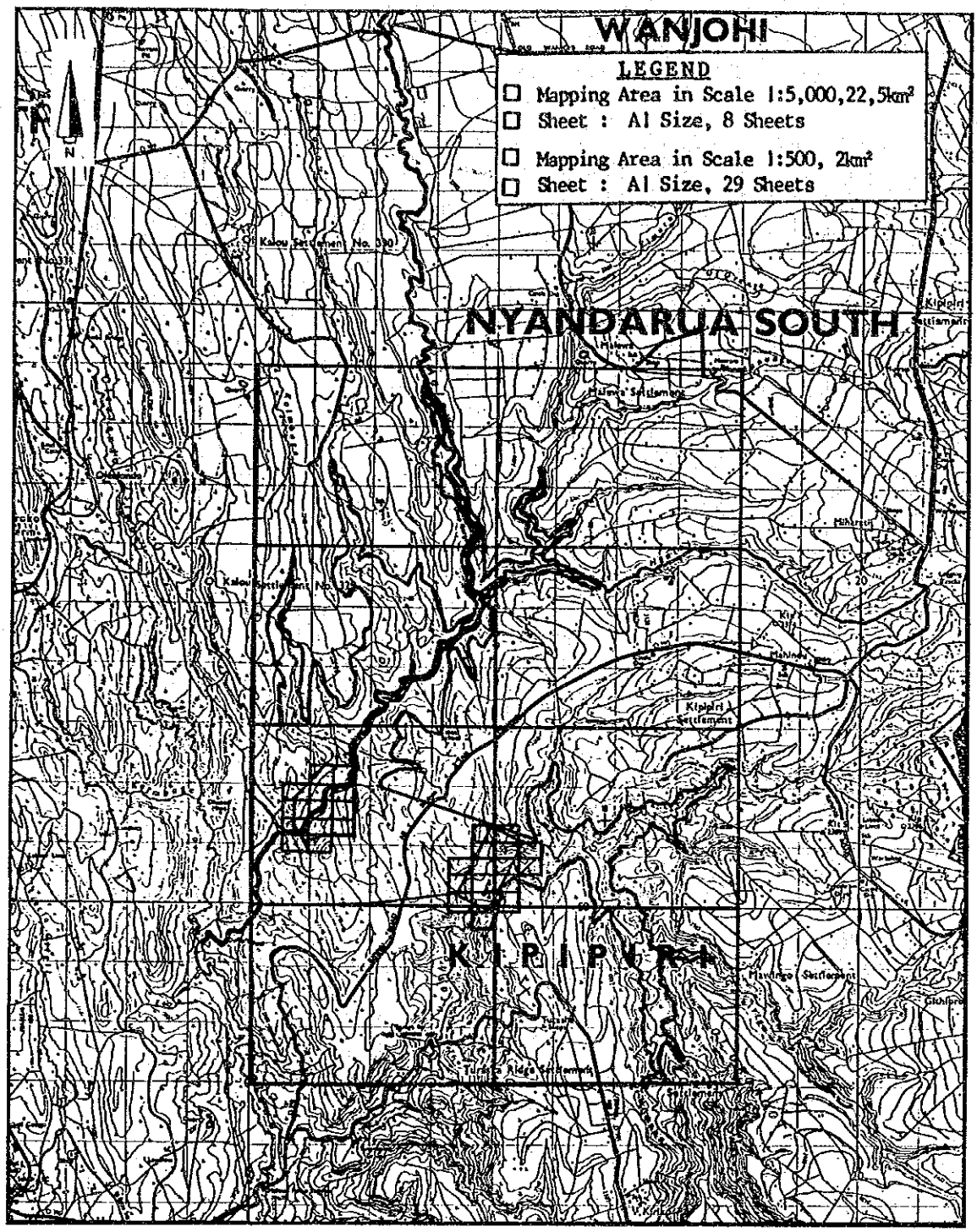
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Triangulation Mark Index Map (2/2)

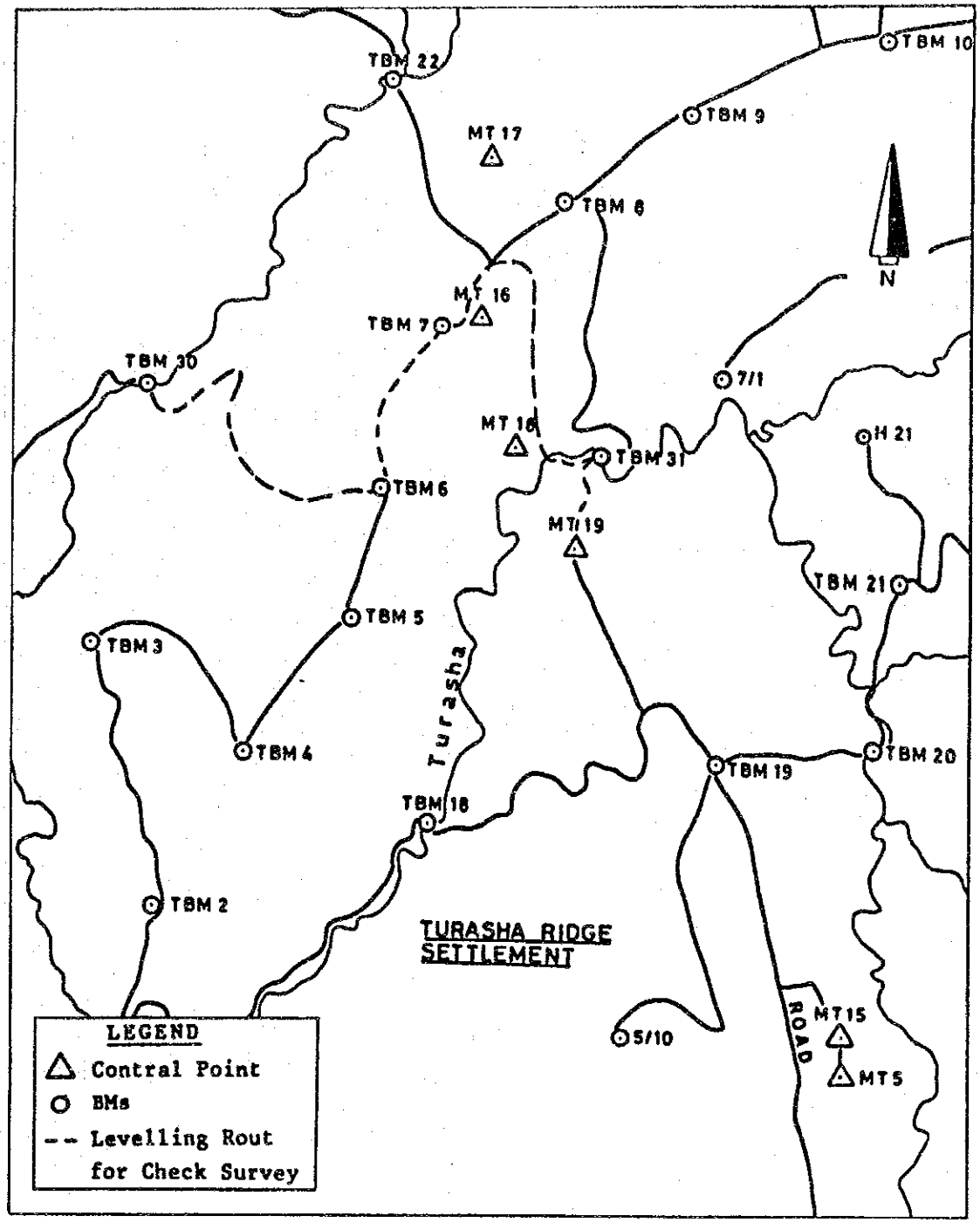
Fig. A.3.6



Scale 1 : 100,000

THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sheet Index Map

Fig. A.3.7



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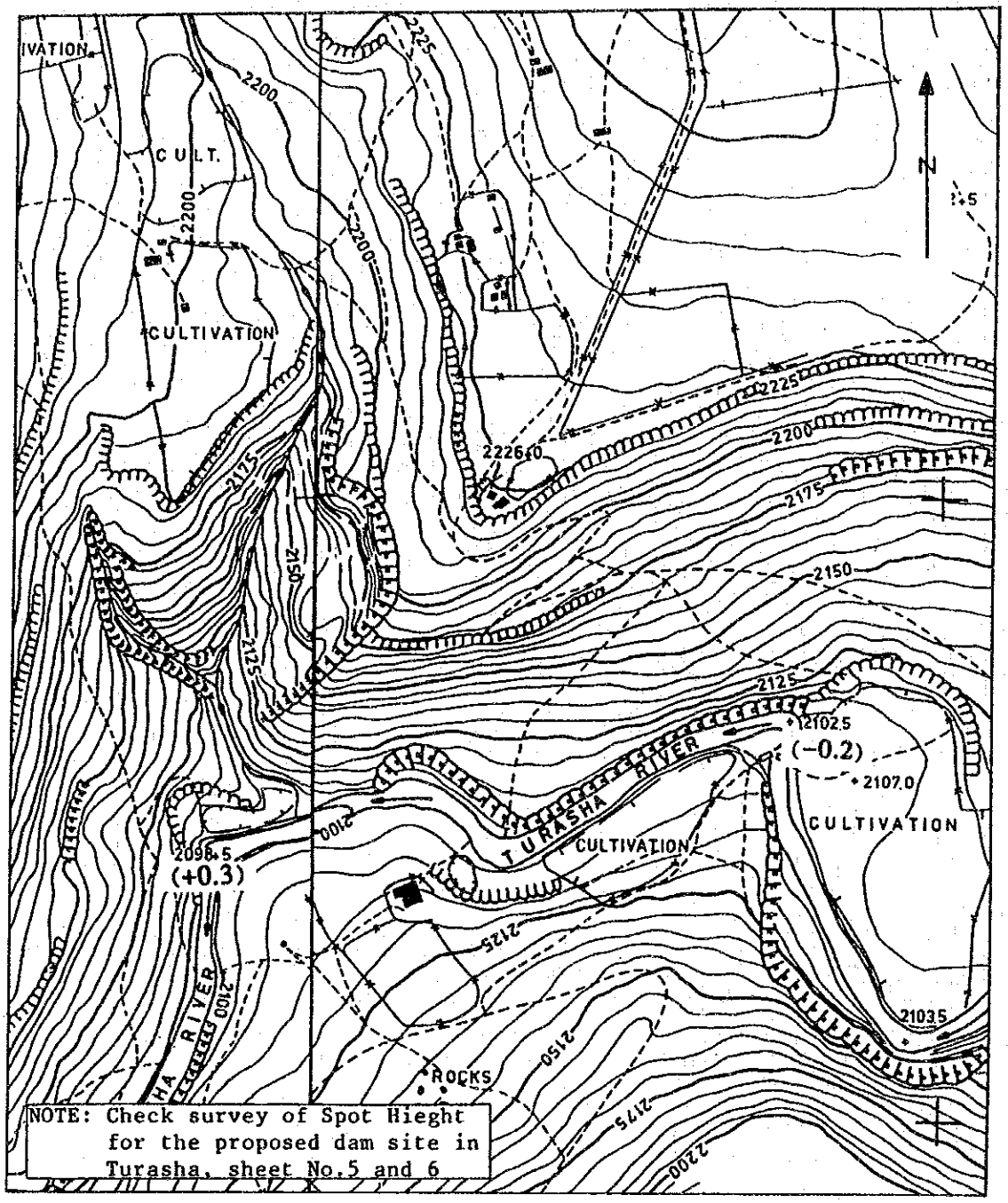
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Check Survey of Leveling

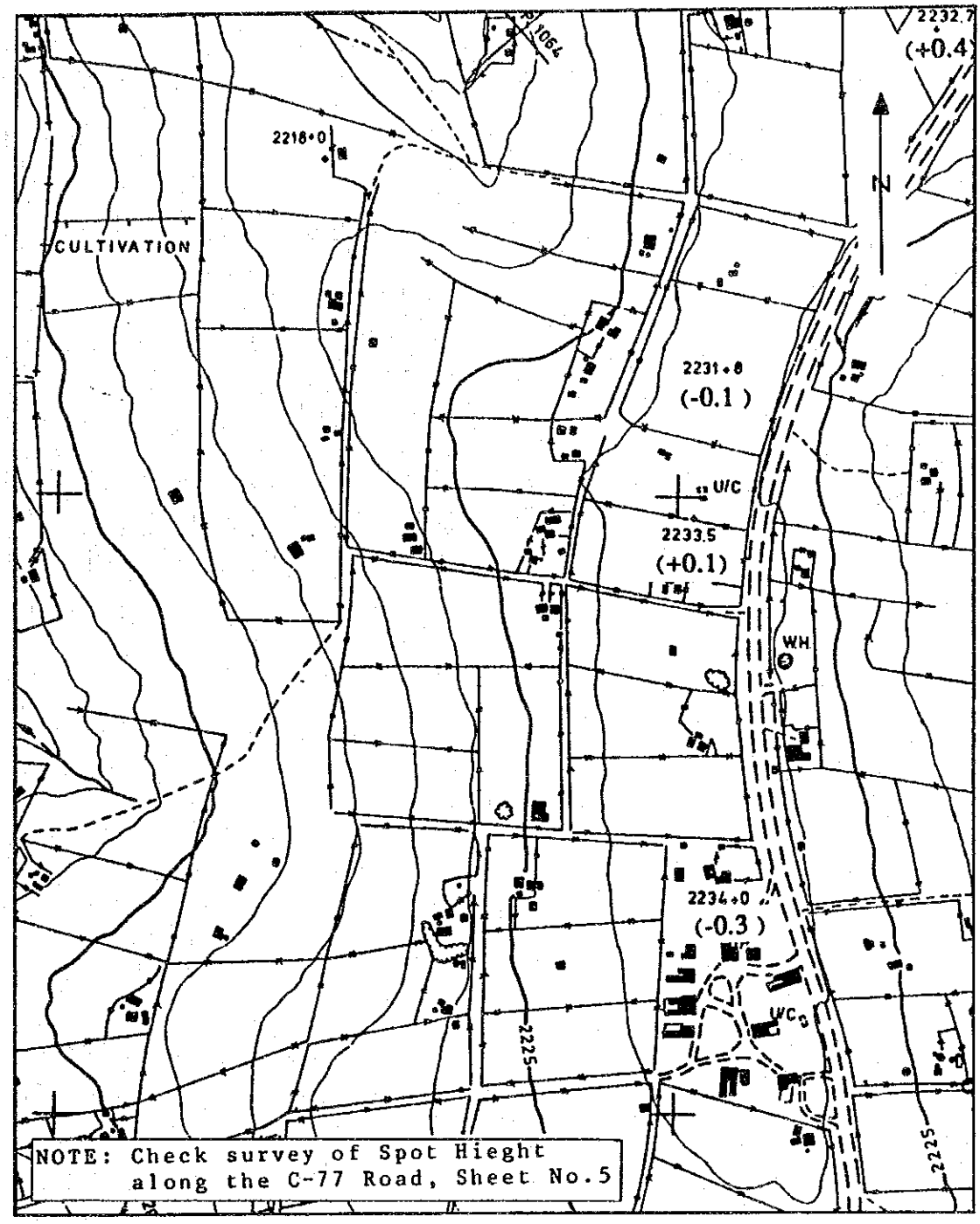
Fig. A.3.8



Scale 1 : 5,000

THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Difference of Spot Height (1/3)

Fig. A.3.8



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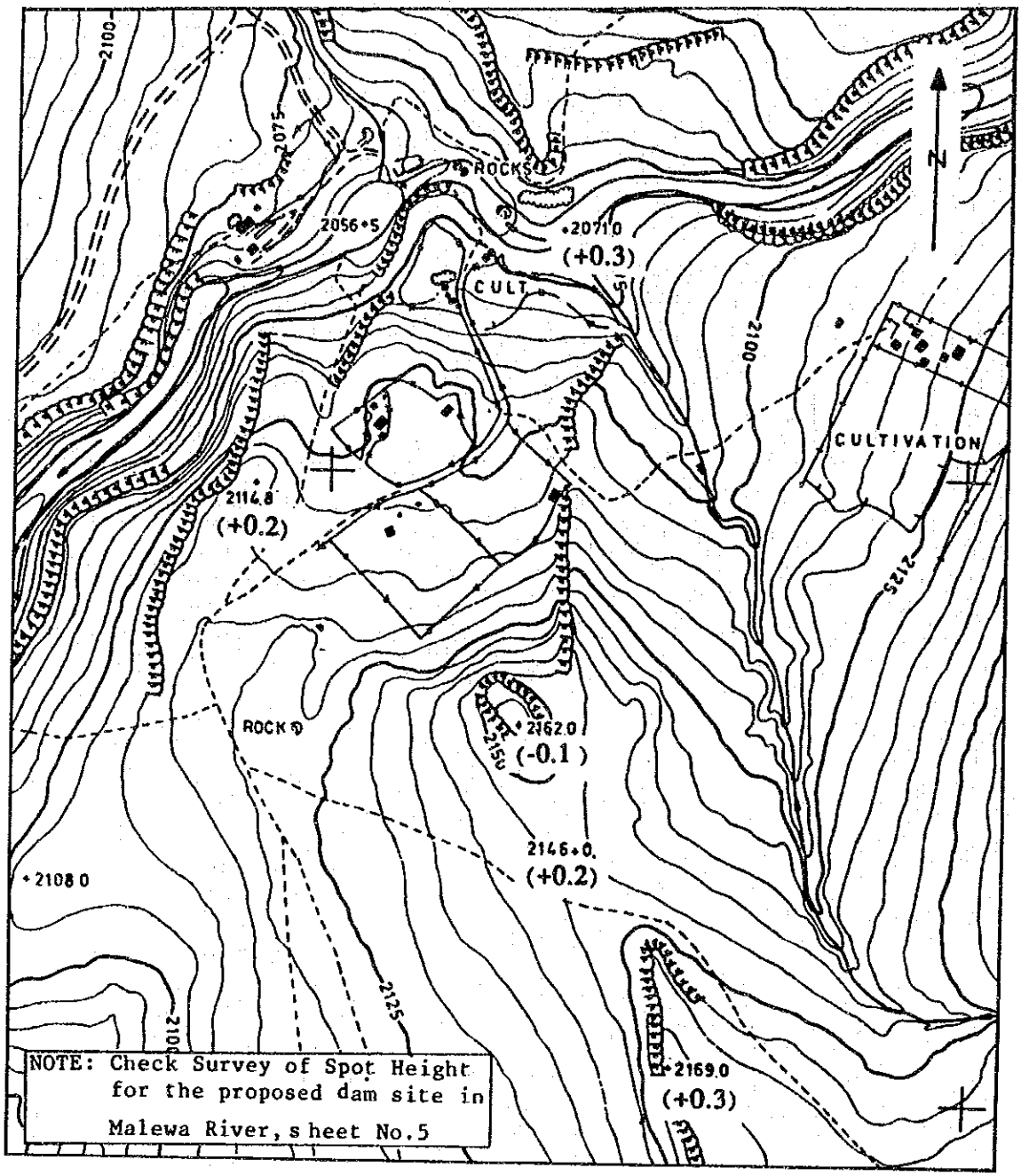
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Difference of Spot Height (2/3)

Fig. A.3.8



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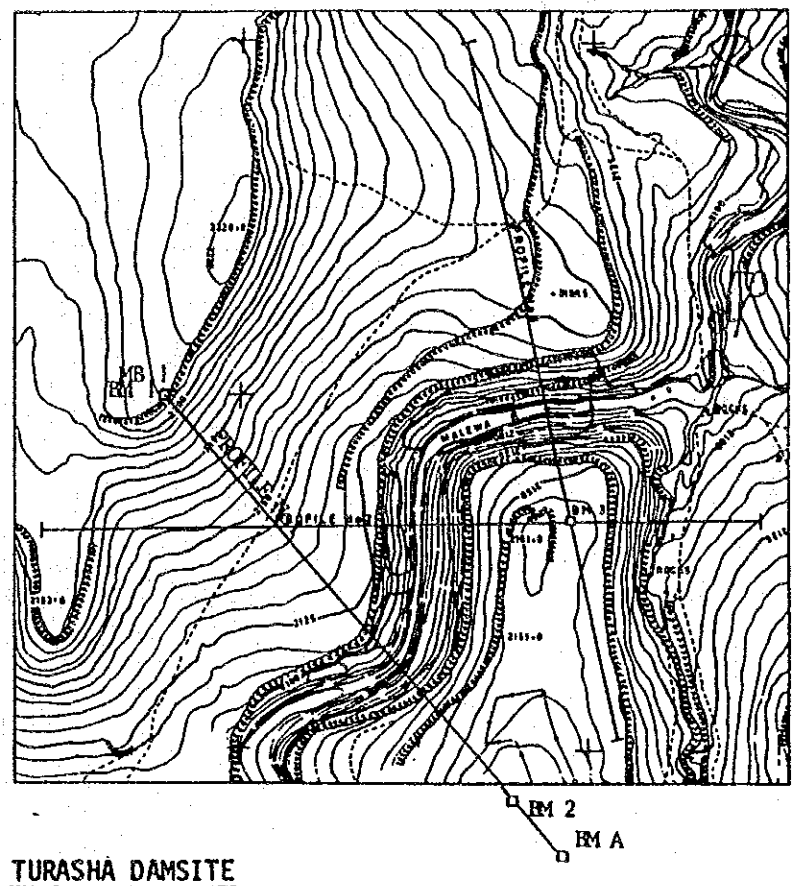
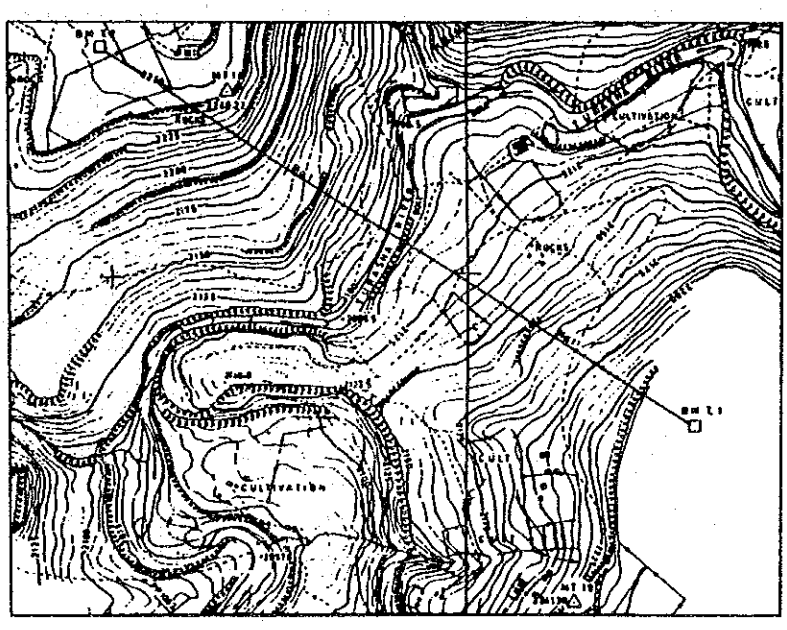
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Difference of Spot Height (3/3)

Fig. A.4.1

MALEWA DAMSITE



TURASHA DAMSITE



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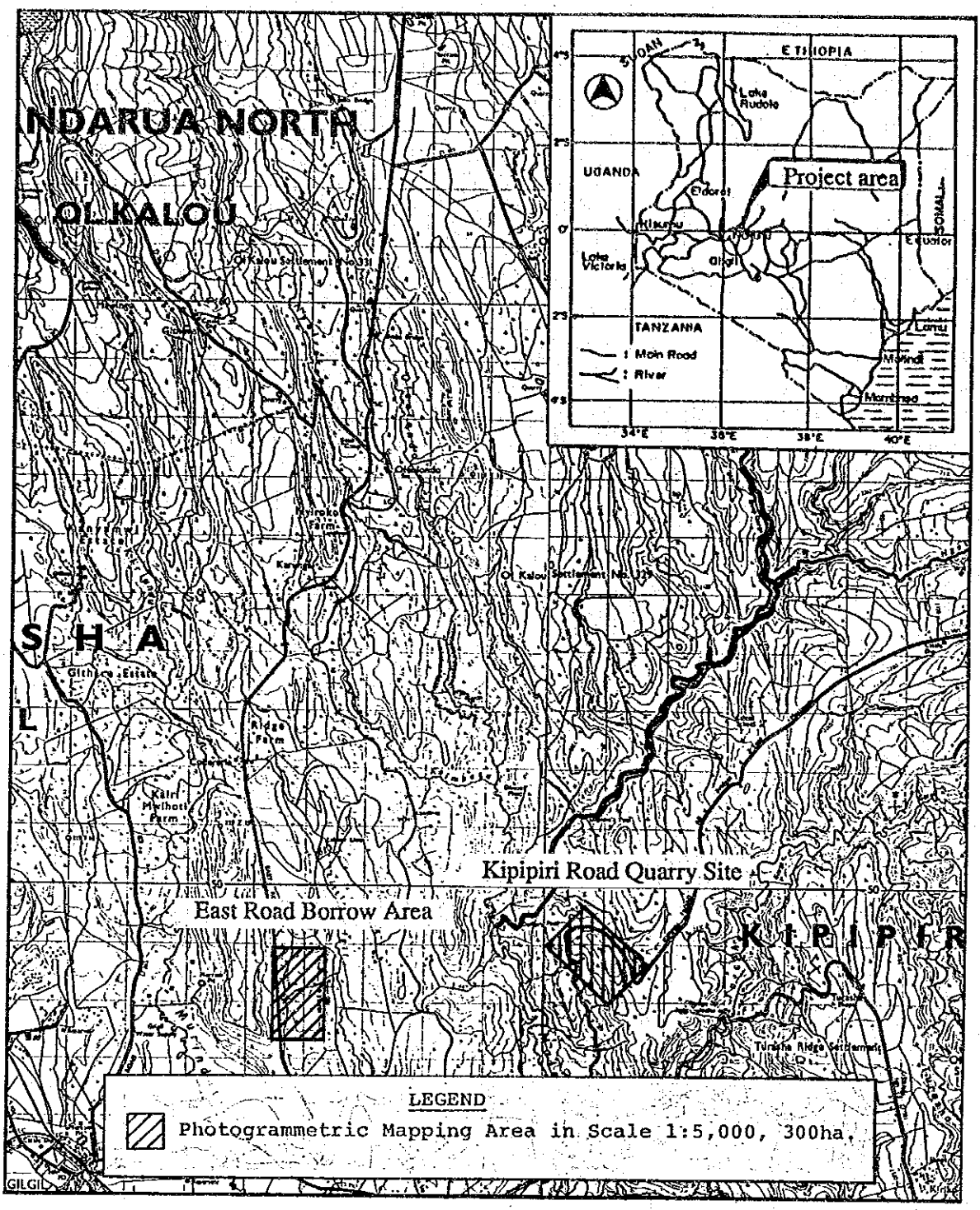
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Diagram of River Cross Section

Fig. A.5.1



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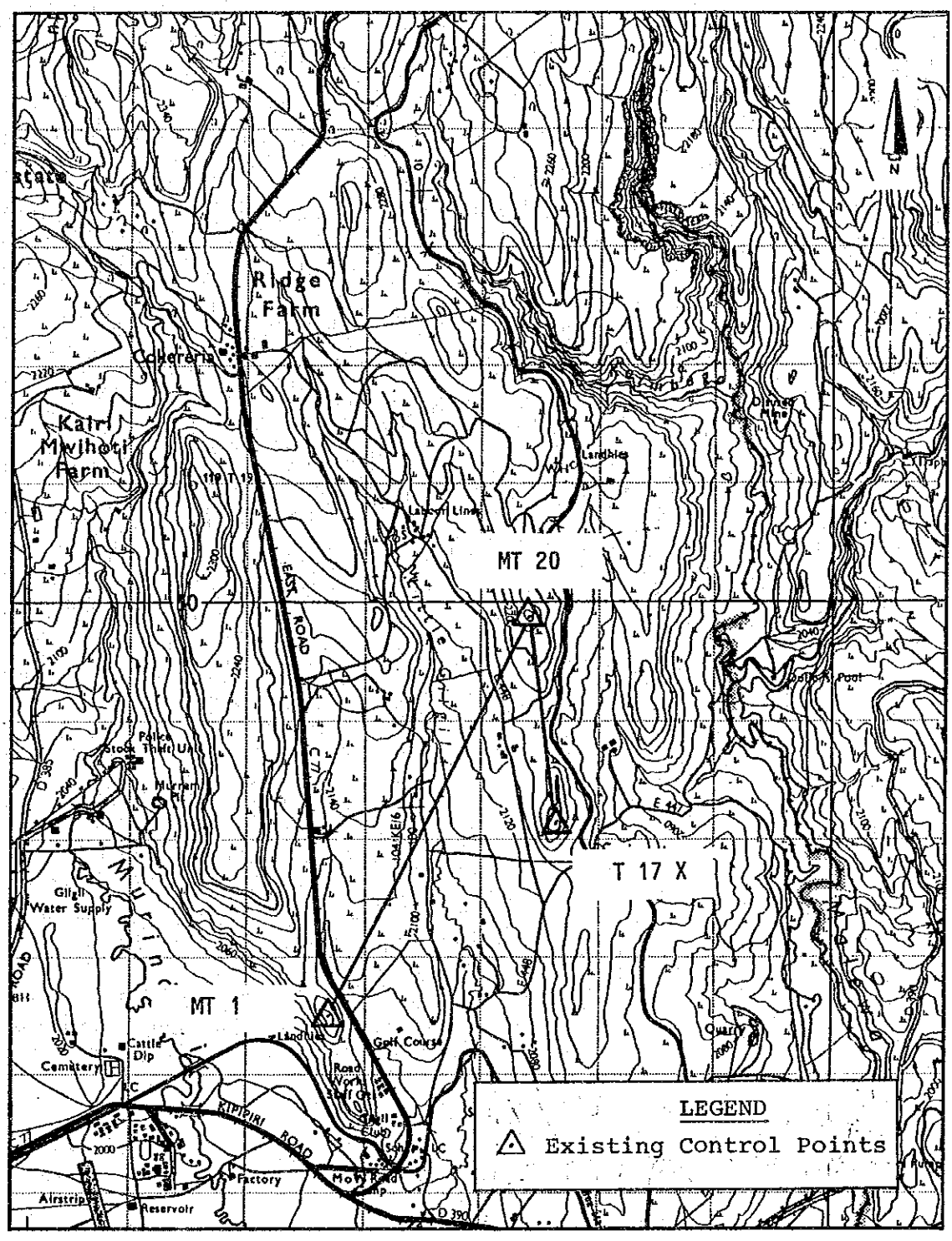
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Second Phase Mapping Area

Fig. A.5.2



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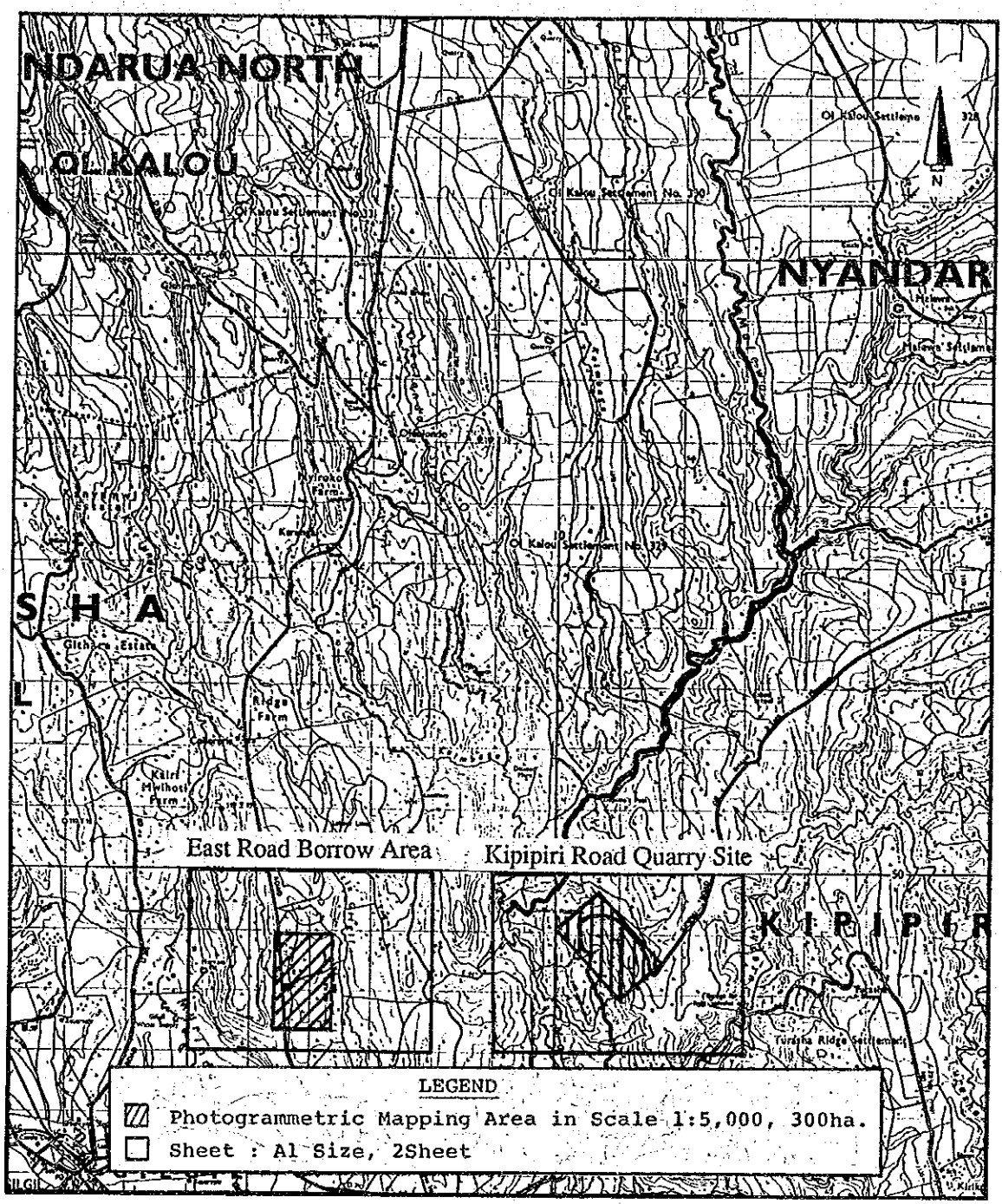
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Diagram of Traversing and Heighting

Fig. A.5.3



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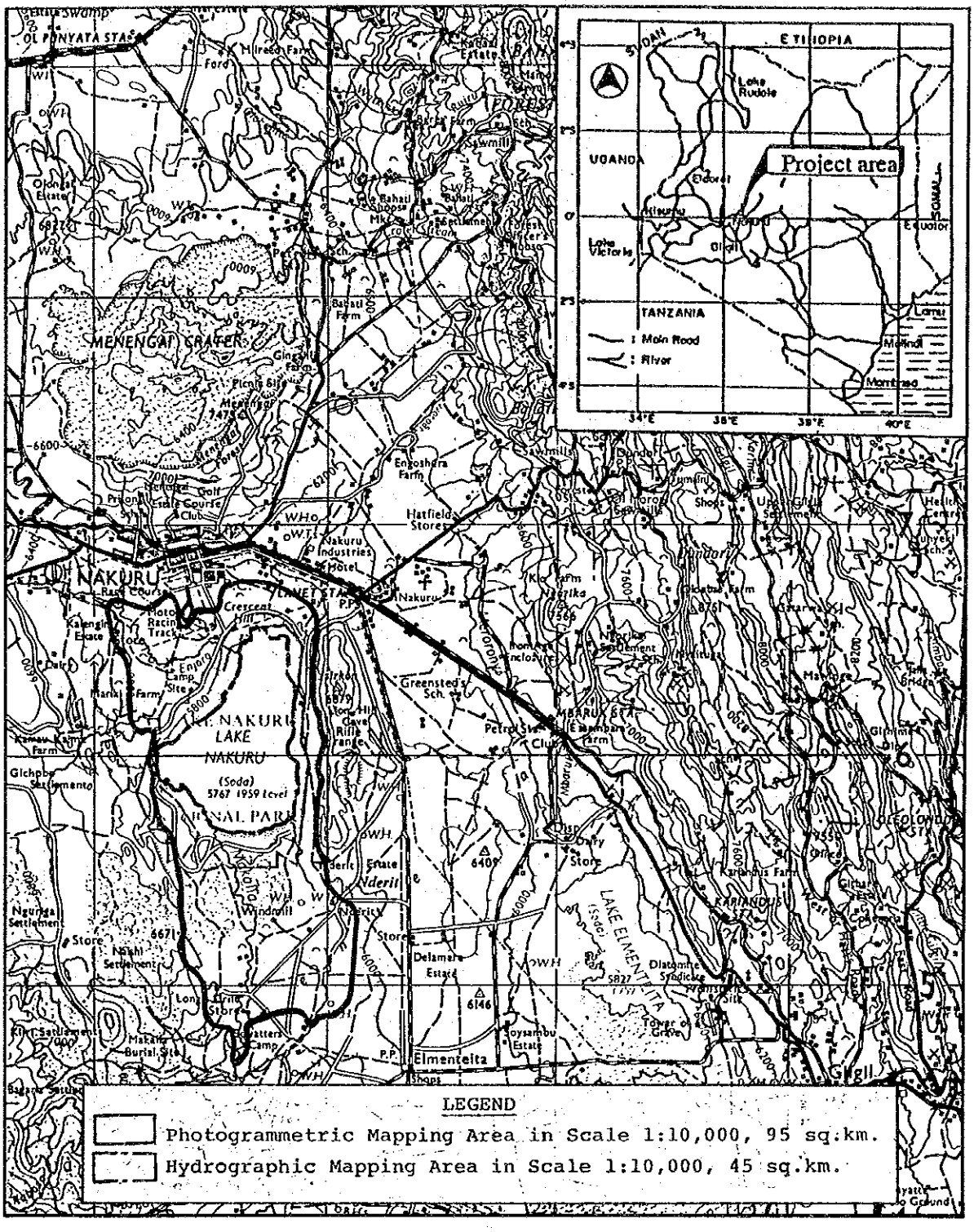
THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sheet Index Map

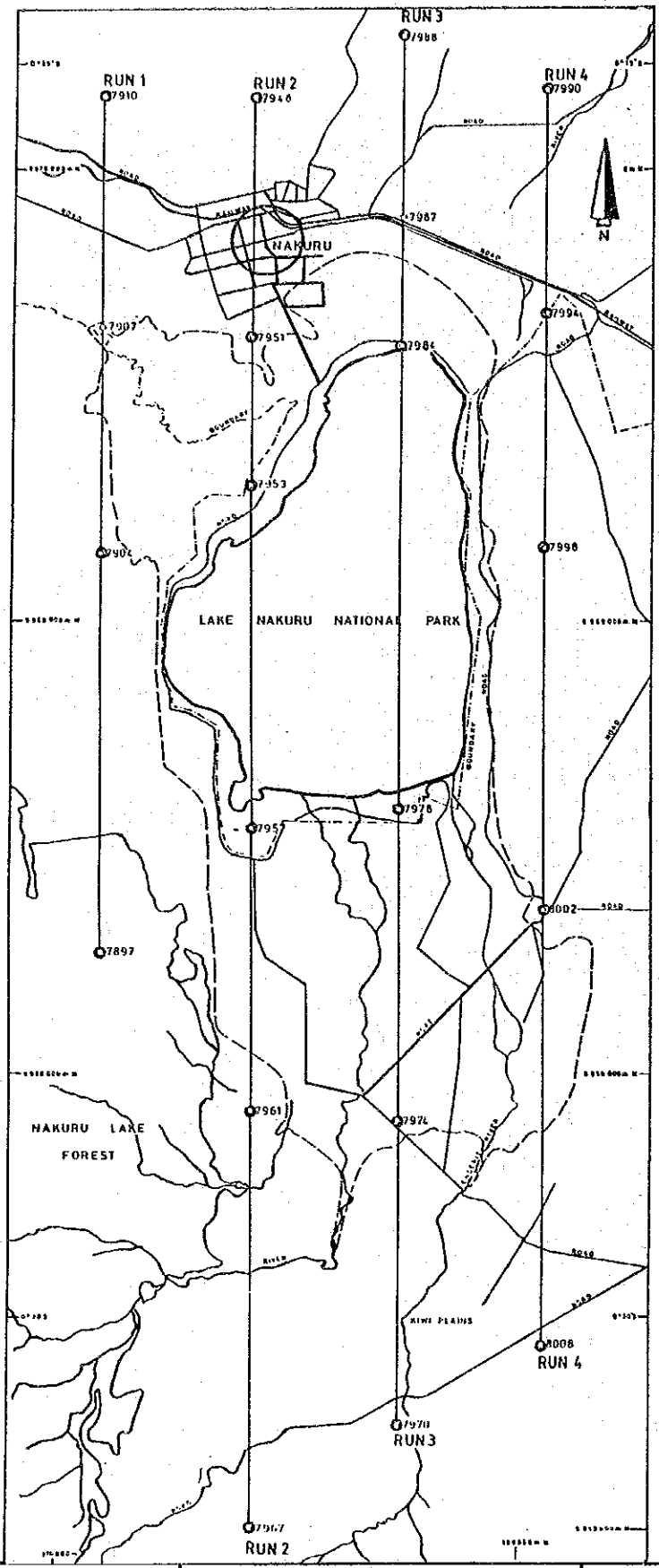
Fig. A.6.1



Scale 1 : 250,000

THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Third Phase Mapping Area

Fig. A.6.2



LEGEND

- Principal point
- Mapping Area in Scale 1:10,000

Scale 1 : 125,000

THE REPUBLIC OF KENYA

MINISTRY OF WATER DEVELOPMENT

NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION

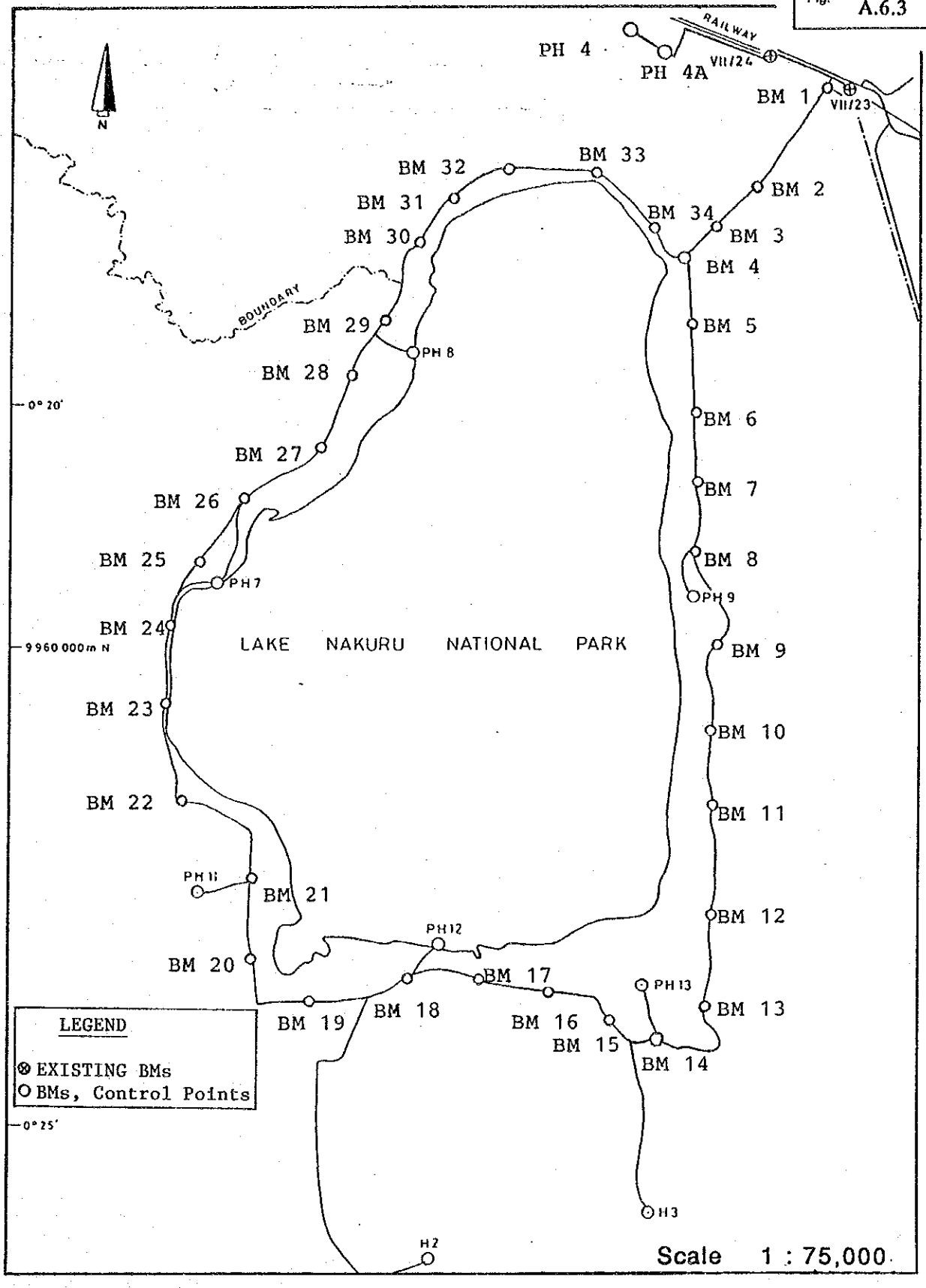
THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION

JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE

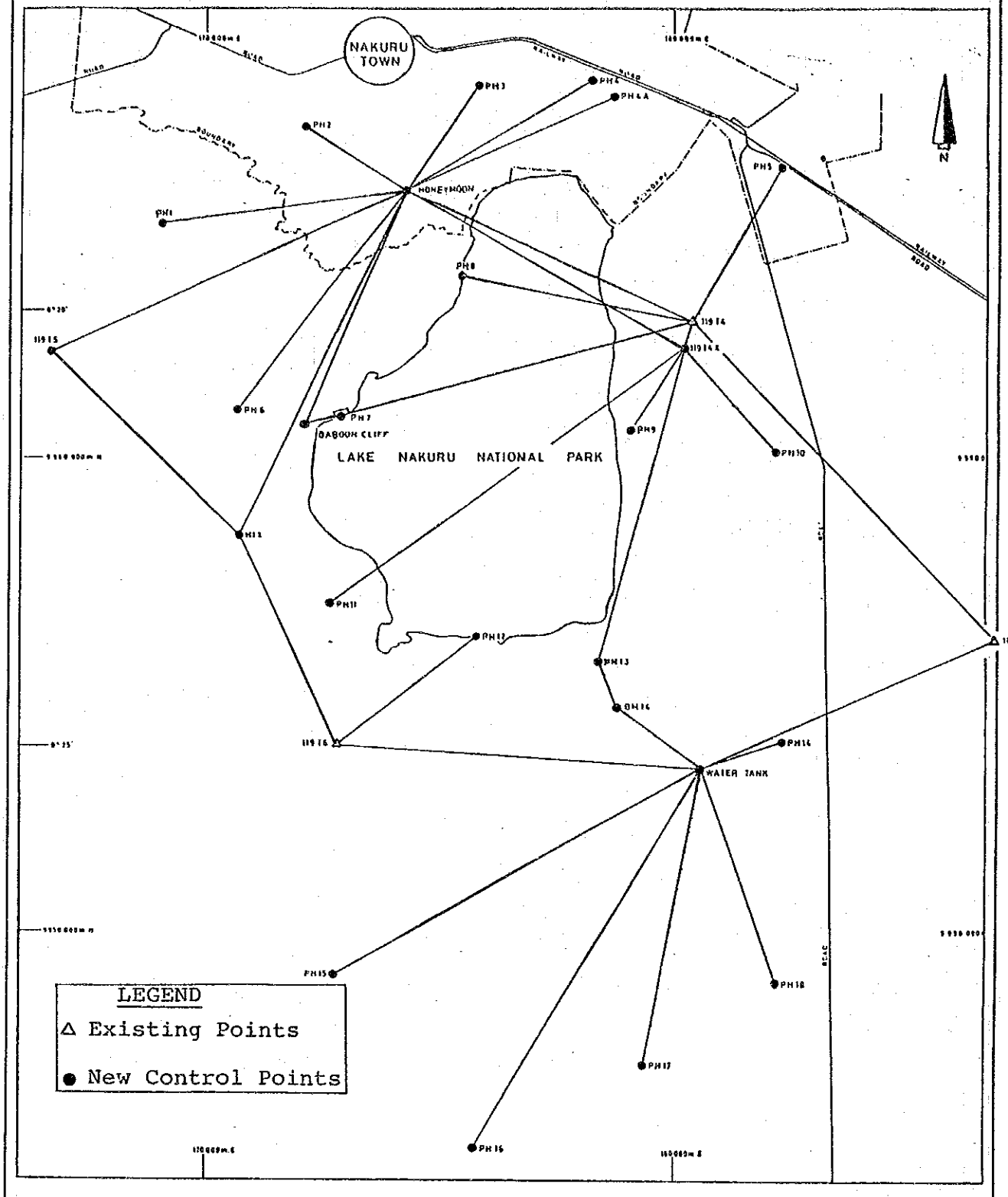
Aerial Photo Index Map

Fig. A.6.3



THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Diagram of Leveling

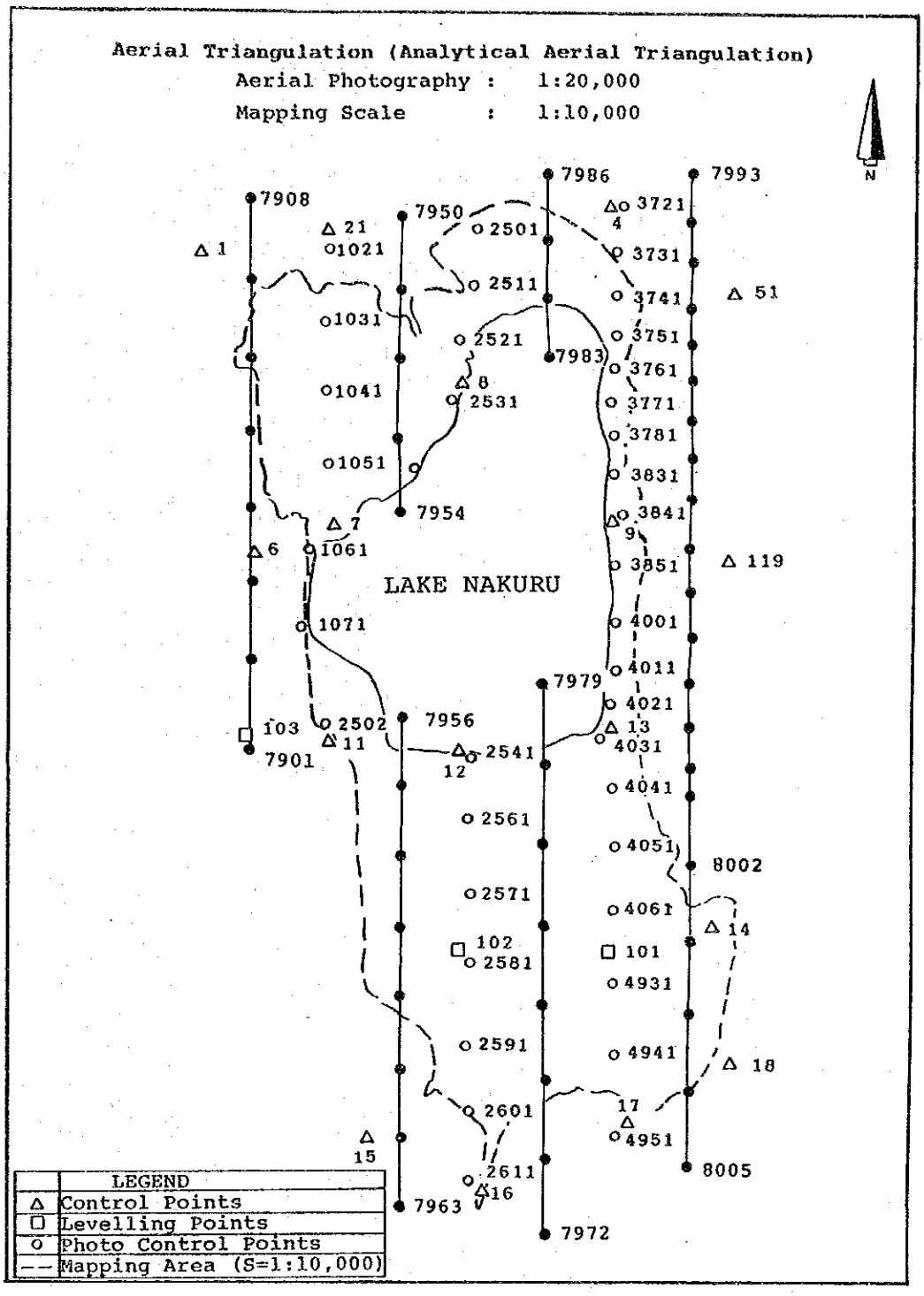
Fig. A.6.4



Scale 1 : 125,000

THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Diagram of Traversing

Fig. A.6.5



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THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Triangulation Mark Index Map