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REPUBLIC OF KENYA

MINISTRY OF WATER DEVELOPMENT

THE STUDY

ON

THE NATIONAL WATER MASTER PLAN

SECTORAL REPORT
(K)

TOPOGRAPHIC SURVEYS OF 11 DAMSITES

JULY 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

Administrative Division of Districts

In this Study, the original 41 districts were considered and various statistical data, particularly socio-economic information, were collected for these districts. During the progress of the Study, six districts were detached from the original ones and established as new districts. In the report, the data on these new districts are grouped together with the corresponding original districts as shown below.

	Original Districts	New Districts	Data included in:
1.	Machakos	Makueni	Machakos/Makueni
2.	Kisii	Nyamira	Kisii/Nyamira
3.	Kakamega	Vihiga	Kakamega/Vihiga
4.	Meru	Tharaka-Nithi	Meru/Tharaka-Nithi
5.	Kericho	Bomet	Kericho/Bomet
6.	South Nyanza	Migori	South Nyanza/Migori

(Note: The last three Districts were established very recently.
The report refers only to the names of the original 41 districts.)

The administrative boundary map used in this Study is the latest complete map set covering the whole country (41 Districts, 233 Divisions and 976 Locations), prepared in 1986 by the Survey of Kenya, Ministry of Land, Housing and Physical Planning.

Data and Information

The data and information contained in the report represent those collected in the 1990-1991 period from various documents and reports made available mostly from central government offices in Nairobi and/or those analyzed in this Study based on the collected data. Some of them may be different from those kept in files at some agencies and regional offices. Such discrepancies if any should be collated and adjusted as required in further detailed studies of the relevant development projects.

THE STUDY ON THE NATIONAL WATER MASTER PLAN

SECTORAL REPORT (K)
TOPOGRAPHIC SURVEYS OF 11 DAMSITES

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K1. INTRODUCTION

This report was prepared to describe activities relevant to the topographic survey for 11 damsites, carried out under the National Water Master Plan(hereinafter referred to as NWMP) during the period from August to December, 1990. The survey works involved the following activities.:

1. Arrangement for subletting the work to a local survey firm (contractor).
2. Aerial photography and control point survey for photogrammetric mapping, profile survey and levelling survey for establishment of site datum on 11 damsites.
3. Supervision for survey works executed by Contractor.
4. Check survey of subletting works.

Eleven (11) damsites proposed for the survey are as follows:

	Damsite	Drainage Area	River Basin	River
1.	Rambula	1	Nzoia	Nzoia
2.	Gogo	1	Yala	Yala
3.	Mushagumbo	1	Yala	Yala
4.	Namba Kodero	1	Kuja	Migori
5.	Kerio-A	2	Kerio	Kerio
6.	Molo	2	Molo	Molo
7.	Yatta	3	Athi	Athi
8.	Baricho	3	Athi	Sabaki
9.	Rumuruti	4	Ewaso Ngiro	Ewaso Narok
10.	Morun	2	Turkwel	Morun
11.	Katieno	2	Kuja	Migori

These sites had been preselected through a preliminary comparison of dam schemes (see Sectoral Report H) to have possibly relative importance for subsequent formulation of the NWMP Study. Location of these 11 damsites is shown in Figure K1.1.

The report presents the results of review of existing aerial photography, collection of existing maps and relevant data, technical specifications, survey method, survey results and mapping procedure and its products.

K2. REVIEW OF EXISTING AERIAL PHOTOGRAPHY AND COLLECTION OF EXISTING MAPS AND RELEVANT SURVEY DATA

2.1 Collection of Existing Maps and Relevant Survey Data

Prior to the commencement of actual topographic survey, existing aerial photos and maps were collected from the Survey of Kenya (SOK). Of the collected information, under-listed aerial photos, maps and survey data have been employed for topographic survey works in this study;

(1) Existing aerial photographs (for 10 damsites)

(a) Aerial photos in a scale of 1:9,000 by SOK in 1970 covering the proposed Gogo damsite.

(b) Aerial photos in a scale of 1 to 10,000 by SOK in 1987 covering the proposed Kerio-A damsite, in 1989 covering the proposed Baricho damsite and in 1990 covering the proposed Rumuruti damsite.

(c) Aerial photos in a scale of 1:12,500 by SOK in 1967 covering the proposed Namba Kodero damsite, in 1969 covering the proposed Mushagumbo damsite, in 1970 covering the proposed Rambula and Katieno damsites and in 1978 covering the proposed Morun damsite.

(d) Aerial photos in a scale of 1:20,000 by SOK in 1980 covering the proposed Yatta damsite.

(2) Existing topographic maps (for 11 damsites)

(a) Topographic maps in a scale of 1:50,000 with contour intervals of 20 m or 50 ft. published by SOK since 1962 covering the proposed 11 damsites.

(b) Topographic maps in a scale of 1:250,000 with contour intervals of 200 ft., 500 ft. or 60 m covering the proposed 11 damsites.

(4) Survey datum information

(a) Trigonometric Index Card by SOK
(b) Description of Level BM by SOK

2.2 Review of Existing Aerial Photography

Existing aerial photographs so collected for 10 damsites were checked by the Topo-survey Expert of the NWMP Study Team. The check results of aerial photography for the respective damsites are tabulated in Table K2.1.

Check of aerial photos revealed that maximum values on stereoscopic photographs of each proposed damsite meet the following specifications requirement (see Table K2.1):

Overlap	:	within 60% $\pm$ 5%
K value	:	less than 10 deg
W value	:	less than 5 g
Cloud cover	:	less than 5%

It was judged that existing photos could be used for proposed photogrammetric mapping at a scale of 1:2,000.

Since no existing photo is available for Molo damsite, it was decided to take new aerial photography for the Molo site.

K3. ARRANGEMENT FOR TOPOGRAPHIC SURVEY WORKS

3.1 General

Topographic survey work was carried out by a local survey firm; PHOTOMAP INC. in accordance with the terms, conditions, requirements of the Contract and Technical Specifications under the supervision of the Topo-survey Expert of the Study Team in the period of 24th September to 20th December, 1990.

(1) Aerial photography for the proposed Molo damsite with an approximate coverage of 0.25 sq.km in a scale of 1:10,000.

(2) Photogrammetric mapping for the proposed 11 damsites with a total of 2.85 sq.km in a scale of 1:2,000 with contour interval 2 m and supplementary contour interval 1m.

(3) Damsite valley profile survey at the proposed 11 damsites, comprising 11 section in total with an approximate length of 9.85 km.

(4) Levelling survey for establishment of site datum with a total distance of 15 km.

All above contracted topographic survey works have been satisfactorily completed by the time specified in the contract agreement. The progress of the works was as presented in Figure K3.1. The final products of topographic survey are submitted to the Study Team by the Contractor as listed in Table K3.1.

3.2 Preparation of Technical Specifications

Technical specifications for the preparation of 1:2,000 scale maps by photogrammetric method and profile survey by field method were prepared making reference to both the"Geodetic and Photogrammetric Surveying for Overseas" and "Specification of Overseas Surveying Works for Development Study" by JICA and "Air Survey Contracts and Specification" by SOK.

3.3 Procurement of Survey Works

Invitation to tender for topographic survey was issued to three(3) survey companies in Kenya by the Study Team on 4th September, 1990. They were PHOTOMAP, GEOMAP and H.P.GAUFF KG; all qualified to execute the scheduled survey works. In compliance with the invitation, the tender proposals were submitted to the Study Team by these companies on the closing day of 7th September, 1990. The selection of the contractor from the technical and financial points of view were made by means of comparison of their priced bill of quantities, survey method, work period, technical staff, available facilities and equipment, and their experiences in photogrammetric mapping works and ground survey works.

After receiving official approval of the JICA Head Office, the contract signing was made on 24th September, 1990 between the Study Team and PHOTOMAP.

K4. PHOTOGRAMMETRIC MAPPING

4.1 General

Photogrammetric mapping aims at preparing 1:2,000 scale topographic maps to be used for preliminary planning of dam development schemes in the NWMP Study.The works consisted of aerial photography, control point survey, photo control, machine plotting, and fair drawing.

Location of the proposed damsites for survey and mapping is shown in Figure K1.1. Each mapping area is as shown in Figures K4.1 to K4.11.

4.2 Aerial Photography

4.2.1 Existing aerial photography

Existing aerial photos available from SOK were prepared for 1:2,000 scale photogrammetric mapping of the proposed 10 damsites as described in Sub-section 2.2. The enlarged photos to be used for pricking work of all photogrammetric mapping areas were also prepared simultaneously.

4.2.2 New aerial photography

New aerial photos on a scale of 1 to 10,000 were shot for the proposed Molo damsite. Tho photo shooting work was started from 25th September and completed on 29th September, 1990. After shooting new aerial photos, the photographic processing and printing works were carried out from 30th September to 1st October, 1990. Principal data and information of the new aerial photography work are as follows:

(1) Equipment used

(a)	Aircraft	:	Piper Navajo, PA31
(b)	Aerial Camera	:	Wild, RC-10, No.1099
(c)	Film Processor	:	Zeiss, FE 120's
(d)	Contact Printer	:	Milligan Electronic Printers
(e)	Print Processing	:	Kodamatic 65A Automatic Processor

(2) Data of aerial photography

(a)	Scale of aerial photography	:	Approx. 1:10,000
(b)	Aerial coverage by photography	:	Approx. 0.25 sq.km
(c)	Focal length of aerial camera	:	F = 151.12 mm
(d)	Over lapping	:	Approx. 60% $\pm$ 5%
(e)	Flight direction	:	North - South
(f)	Aerial film	:	Kodak Double X
(g)	Photo print	:	Kodak RC paper

(3) New Aerial photo index map

New Aerial photo index map was prepared after completion of the aerial photography as shown in Figure K4.12.

(4) Annotation of new aerial photos

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

(a) Name of project: NWMP
(b) Scale of aerial photography
(c) Date of aerial photography
(d) Photo number

All the results of new aerial photography was checked referring to the Technical Specification by Topo-survey Expert. It was judged that the results were acceptable for preparing the project map. The check list of new aerial photography is as presented in Table K4.1.

4.3 Control Point Survey

4.3.1 Installation of control points

Before starting the traverse and levelling, four (4) control points (having X and Y coordinates and/or height) were established at the corners of stereoscopic photograph's models on enlarged aerial photos for each mapping area. The locations of control points are as shown in Figures K4.13 - K4.23, and the survey mark description is compiled in Data Book (Separate Volume).

4.3.2 Levelling

Levelling was executed to determine the heights of control points. The levelling was started in the end of September and completed on 26th November, 1990. Total distance of the levelling covering all 11 damsites was approximately 51.2km.

(1) Datum height

Tow different datum heights were applied: one is based on triangulation point height which was established by SOK, and the other is based on local height which was figured out from 1:50,000 scale topographic maps as decided by the Study Team. Those height were given directly to control points or transferred to control points. A base point having triangulation point height or extracted datum height for each mapping are tabulated as below and the height of control points for respective damsite are as presented in Table K4.2.

Photogrammetric Mapping Area	Point No.	Height (m)	Remarks
Rambula Damsite	A	1,200.00	from 1:50,000 scale map
Gogo Damsite	102T14	1,489.00	triangulation point by SOK
Mushagumbo Damsite	102T14	1,489.00	triangulation point by SOK
Namba Kodero Damsite	129S5x	1,305.40	triangulation point by SOK
Kerio-A Damsite	H 2	1,014.60	from 1:50,000 scale map
Molo Damsite	TBM 1	1,996.44	from 1:50,000 scale map
Yatta Damsite	TP 1	782.00	from 1:50,000 scale map
Baricho Damsite	H 7	55.00	from 1:50,000 scale map
Rumuruti Damsite	PH RUM/4	2,000.00	from 1:50,000 scale map
Morun Damsite	MN 1	1,120.00	from 1:50,000 scale map
Katieno Damsite	TBM 1	1,235.59	from 1:50,000 scale map

Note: The contour intervals 50 or 100 feet on 1:50,000 scale maps for the Molo, Baricho and Katieno damsites were converted to meters and used them to the datum heights.

(2) Equipment used

Zeiss NI12 Automatic level was used for the levelling.

(3) Accuracy of levelling

Levelling routes were formed by closed loops and leveled twice. The accuracy of the levelling was specified to be within $\pm$ 20mm$*$ $D^{0.5}$ between control points. The actual accuracy of respective levelling route is as presented in Table K4.3.

4.3.3 Traversing

Traversing was executed to determine X and Y coordinates of the control points for the computation of photo control. The traverse routes were planned to enclose the mapping area and formed by a closed loop and/or open. Traversing was carried out and completed simultaneously with the levelling. The total distance of traverse routes was approximately 51.4km.

(1) Equipment used

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

(2) Datum coordinates

Two different datum coordinates were applied: one is based on Kenyan datum coordinates which were established by SOK and the other is based on the temporal

local coordinates which were scaled off from 1:50,000 scale topographic maps. Those coordinates were transferred to base control points. The extracted base point having datum coordinates for each mapping area are tabulated below, and the list of control points and their coordinates for respective damsites are as presented in Table K4.2.

Photogrammetric Mapping Area	Point No.	Coordinates (m)		Remarks
Rambula Damsite	0	N	22,530.00	
		E	642,090.00	from 1:50,000 scale map
Gogo Damsite	House A	N	6,840.00	
		E	669,450.00	from 1:50,000 scale map
Mushagumbo Damsite	H 2	N	14,380.00	
		E	674,630.00	from 1:50,000 scale map
Namba Kodero Damsite	129S5X	N	9,892,658.31	
		E	643,171.43	from 129S5 Trig. point
Kerio-A Damsite	TT11X	N	98,075.00	
		E	790,625.00	from 1:50,000 scale map
Molo Damsite	ML 1	N	9,976,425.00	
		E	812,725.00	from 1:50,000 scale map
Yatta Damsite	TP 1	N	9,761,600.00	
		E	382,680.00	from 1:50,000 scale map
Baricho Damsite	H 7	N	9,655,260.00	
		E	585,550.00	from 1:50,000 scale map
Rumuruti Damsite	PH Rum/4	N	16,490.00	
		E	216,490.00	from 1:50,000 scale map
Monun Damsite	MN 1	N	170,225.00	
		E	766,750.00	from 1:50,000 scale map
Katieno Damsite	KT 4	N	9,900,050.00	
		E	650,000.00	from 1:50,000 scale map

(3) Correction of observed distance

The computation of coordinates was made based on the above base points coordinates. Height correction and slope correction on the observed distance were made based on the observed height and vertical angle.

(4) Method and accuracy

Traversing routes were formed by a closed loop and fixed by polar method. The orientation was made to magnetic North observation. Mis-closure of the traversing has been confirmed to be not larger than 1:2,000 of their total lengths of the traversing routes. Actual accuracy of the respective traversing route is as presented in Table K4.4. The method and specified accuracy of the traversing observation are as follows:

(a) Horizontal angle observation

Horizontal angle was observed by 2 rounds of angles on different zero settings. The discrepancy in angle observations between the first setting and the second setting has been stipulated not to exceed 20 seconds of double angles difference and 10 seconds difference of angle.

(b) Vertical angle observation

Vertical angles were observed by a round of angle. The discrepancy between 1 set should not exceed 15 seconds.

(c) Distance observation

Distance was measured twice for each traverse line by EDM having an accuracy of more than 10mm $\pm$ 3ppm$_*$ $D^{0.5}$. The discrepancy between the 2 sets was less than 1:40,000 of the measured distance.

4.3.4 Pricking

Planimetric features clearly identifiable on the photographs and whose position can be exactly deduced from the control point were pricked in the filed for photo control. All of these pricked points were enclosed with small red circle on each enlarged contact print. The coordinates and height of the photo control points are presented in Table K4.5.

4.4 Photo Control

The Photo control was done analogically by mechanical orientation method by means of fully controlled models.

After setting up relative orientation at a stereo model, absolute orientation was carried out by selecting model scale, fixing the model at horizontal and vertical scales and levelling the model. At least 4 plane and height points used for absolute orientation were transferred from the contact prints to each diapositive by stereo plotter so that at least 4 control points were included within a stereo model. All of these control points together with fiducial marks on each photograph were stereoscopically measured and fixed by the stereo plotter and marked with small red circle.

The number of photo models and photo control points used for the photo control on each mapping area are as shown below, and the accuracy of photo control is as presented in Table K4.6.

Photogrammetric Mapping Area	Photo Models	Horizontal Control Points	Vertical Control Points
Rambula Damsite	2	6	9
Gogo Damsite	2	5	8
Mushagumbo Damsite	1	5	5
Namba Kodero Damsite	1	4	4
Kerio-A Damsite	1	3	5
Molo Damsite	2	4	5
Yatta Damsite	1	3	6
Baricho Damsite	1	4	6
Rumuruti Damsite	2	5	7
Morun Damsite	1	4	4
Katieno Damsite	1	3	5

The photo control marks are shown in Figures K4.13 to K4.23.

4.5 Machine Plotting and Fair Drawing

4.5.1 Sheet index of photogrammetric maps

Map sheet size is 70cm x 100cm with a neat line of 60cm x 80cm. The sheet layout is as shown in Figures K4.13 to K4.23. The photogrammetric mapping area are as shown in Figures K4.1 to K4.11.

4.5.2 Marginal information of photogrammetric maps

Marginal information style for the 1:2,000 scale photogrammetric maps was specified by the Study Team and instructed to the contractor.

4.5.3 Machine plotting

Spot heights were obtained by direct levelling, and plotting machine transfers them to the original plotting sheets. Two-meter contours, one-meter supplementary contours, vegetation boundary, road/footpath, river/steam, building/house, bridge, fence/ hedge and other artificial structures were drawn directly by plotting machine on the original plotting sheets. The equipment used for plotting were Wild Aviograph A8 and B8. The machine plotting was completed on 10th December, 1990.

4.5.4 Fair drawing

After compilation of the contour lines, all information including spot heights, topographic condition, name of village and other information contained in the original plotting sheets were drawn on the transparent polyester film sheets for the fair drawing. The fair drawing was completed on 20th December, 1990.

Transferred spot heights, figure of contours lines and other information on the original pencil plotting sheets and descriptions in marginal information of the fair drawing sheets were checked by the Topo-survey Expert.

K5. PROFILE SURVEY

5.1 General

Profile section along a preliminarily selected dam axis was surveyed at the proposed 11 damsites. The profile survey was carried out and completed at the same time of the control point survey. Approximate location of the profile sections is shown Figures K4.1 - K4.11, and the exact location in the marginal information of profile section sheets and also on 1:2,000 scale topographic maps.

5.2 Installation of Profile Points

Before starting the profile survey, more than two(L and R) profile points (having coordinates and heights) were installed on both banks of the profile section survey sites. The location of profile points is shown on the 1:2,000 scale topographic maps. The height and coordinates of the profile points are as contained in Table K4.2.

5.3 Profile Levelling

Ground height along the profile section line was observed by direct or indirect levelling basically at intervals of 10 meters and at such points as slope changing point, water level of the river and waterbed. The position of those height points on the profile lines was measured by EDM and measuring tapes. The same manner and equipment as explained in Section 4.3.2 and 4.3.3, except the accuracy of levelling, were applied.

Profile levelling was formed by levelling twice. The accuracy of profile levelling has been specified not to exceed $\pm$ 60mm$*$ $D^{0.5}$ in the riparian area and $\pm$ 20cm$*$ $D^{0.5}$ in the water area.

5.4 Plotting and Fair Drawing

Profile section in a horizontal scale of 1:2,000 and vertical scale of 1:500 was prepared firstly by pencil on the millimeter graph paper(original pencil plotting sheet). The fair drawing was then made on transparent polyester film of the neat lines of 60cm x 80cm with sheet size of 70cm x 100cm. Sheet size and marginal information style for the profile section were specified by the Study Team.

The figure of profile section and transferred heights points of the original pencil plotting sheets and and marginal information of the fair drawing sheets were checked by the Topo-survey Expert.

K6. AUXILIARY SURVEY

6.1 General

Auxiliary survey was to provide topographic data and information necessary for planning some of dam development schemes. The survey work was completed simultaneously with the control point survey.

6.2 Levelling Survey for Establishment of Site Datum

The levelling survey for establishment of site datum was carried out between:

(1) the proposed Baricho damsite and the existing Baricho intake,
(2) the proposed Rambula damsite and Mushagumbo damsite and
(3) the proposed Katieno damsite and the existing Gogo dam crest.

The results of levelling are to be used for studies on dam development schemes. The total distance of the levelling survey was approximately 15.0km. The description of height points is compiled in Data Book.

The levelling survey was carried out in the same manner as described in Section 4.3.2.

K7. CHECK SURVEY

7.1 General

Check survey for ascertaining accuracies of control points and spot heights in 1:2,000 scale topographic maps and profile sections was carried out on the field by Topo-survey Expert during the period from 26th November to 30th November, 1990.

The check survey was executed by means of comparison between survey results by the Contractor and observation by Topo-survey Expert with referring to the accuracies stipulated in the Technical Specification.

7.2 Checking of Control Points

Two loop traverse routes, one each at the the proposed Molo damsite(ML1, ML2, PH1, PH2, ML1) and the proposed Namba Kodero damsite(129S5, NKR1, NKL1, 129S5), were selected for check survey. The reference coordinates of new control points at the proposed Molo damsite were set up by traverse from new control point of ML1 having local coordinates. The reference coordinates of new control points at the Namba Kodero damsite was set up by traverse from existing control point of 129S5. The results of check survey are shown in Table K7.1.

As seen in Table K7.1, linear misclosure of the loop traverses was found to be smaller than 1/10,000 of the total lengths for both routes. It was judged that the loop traverse points have enough accuracy of the coordinates for 1:2,000 scale photogrammetric mapping works.

7.3 Checking of Spot Heights

In total 23 spot height points at the proposed Baricho and Rambula damsites were chosen for this check. The results of the check survey are summarized in Table K7.2. Comparison between the direct levelling height and the spot heights is presented in Figures K7.1 to K7.4.

The results of check survey indicated that the contour lines and spot heights shown in maps represent correct elevation figures.

7.4 Checking of Profile Survey

Profile section line of the proposed Rumuruti damsite was selected for check survey of this purpose. The reference height was derived from the control point of PH RUN/4. The results of check of profile levelling and permanent points are summarized in Table K7.3.

The check survey revealed that the contractor's survey had achieved the required accuracies.

TABLES

Table K2.1 (1) Existing Aerial Photos used for Photogrammetric Survey and Mapping (1/5)

1. Aerial photos for the proposed Rambula damsite

Photo scale : 1/12,500
Aerial camera : RC-8
Flight height : 1,875m
Flight direction : East - West
Date of flight : 1970

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
140									
	59%	61%	4d	0.5g	Good	OK	0%	0%	OK
141									
	64%	64%	3d	0.5g	"	"	"	"	"
142									
Max.	59%	64%	4d	0.5g					

2. Aerial photos for the proposed Gongo damsite

Photo scale : 1/9,000
Aerial camera : RC-8
Flight height : 1,350m
Flight direction : East - West
Date of flight : 1970

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
87									
	63%	63%	2d	0.5g	Good	OK	0%	0%	OK
88									
	61%	62%	7d	0.5g	"	"	"	"	"
89									
391									
	62%	61%	4d	1.0g	"	"	"	"	"
392									
Max.	62%	63%	4d	1.0g					

Table K2.1 (2) Existing Aerial Photos used for Photogrammetric Survey and Mapping (2/5)

3. Aerial photos for the proposed Mushagumbo damsite

Photo scale : 1/12,500
Aerial camera : RC-8
Flight height : 1,875m
Flight direction : East - West
Date of flight : 1969

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
199									
	64%	62%	3d	1.0g	Fine	OK	0%	0%	OK
200									
	62%	61%	2d	1.0g	"	"	"	"	"
201									
Max.	64%	62%	3d	1.0g					

4. Aerial photos for the proposed Namba Kodero damsite

Photo scale : 1/12,500
Aerial camera : RC-8
Flight height : 1,875m
Flight direction : East - West
Date of flight : 1967

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
1308									
	61%	60%	5d	0.5g	Good	OK	0%	0%	OK
1309									
	60%	62%	1d	0.5g	"	"	"	"	"
1310									
Max.	60%	62%	5d	0.5g					

Table K2.1 (3) Existing Aerial Photos used for Photogrammetric Survey and Mapping (3/5)

5. Aerial photos for the proposed Kerio-A damsite

Photo scale : 1/10,000
Aerial camera : RC-10
Flight height : 1,500m
Flight direction : North - South
Date of flight : 1987

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
733									
	61%	63%	3d	0.5g	Good	OK	0%	0%	OK
734									
	62%	61%	5d	0.5g	"	"	"	"	"
735									
Max.	61%	63%	5d	0.5g					

6. Aerial photos for the proposed Yatta damsite

Photo scale : 1/20,000
Aerial camera : RC-10
Flight height : 3,000m
Flight direction : North - South
Date of flight : 1980

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
1432									
	63%	62%	2d	0.5g	Good	OK	0%	0%	OK
1433									
	64%	61%	4d	1.0g	"	"	"	"	"
1434									
Max.	63%	62%	4d	1.0g					

Table K2.1 (4) Existing Aerial Photos used for Photogrammetric Survey and Mapping (4/5)

7. Aerial photo for the proposed Baricho damsite

Photo scale : 1/10,000
Aerial camera : RC-10
Flight height : 1,500m
Flight direction : East - West
Date of flight : 1980

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
6090									
	60%	61%	3d	0.5g	Good	OK	0%	3%	OK
6091									
	63%	62%	5d	0.5g	"	"	"	2%	"
6092									
Max.	60%	62%	5d	0.5g					

Note: The damsite was not covered with clouds.

8. Aerial photo for the proposed Rumuruti damsite

Photo scale : 1/10,000
Aerial camera : RC-10
Flight height : 1,500m
Flight direction : South - North
Date of flight : 1990

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
1019									
	65%	64%	4d	1.0g	Fine	OK	0%	0%	OK
1020									
	62%	61%	3d	1.0g	"	"	"	"	"
1021									
Max.	62%	64%	4d	1.0g					

Table K2.1 (5) Existing Aerial Photos used for Photogrammetric Survey and Mapping (5/5)

9. Aerial photo for the proposed Marun damsite

Photo scale : 1/12,500
Aerial camera : RC-8
Flight height : 1,875m
Flight direction : West - East
Date of flight : 1978

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
9978									
	61%	62%	2d	0.5g	Good	OK	0%	0%	OK
9979									
	60%	61%	1d	1.0g	"	"	"	"	"
9980									
Max.	60%	62%	2d	1.0g					

10. Aerial photo for the proposed Katieno damsite

Photo scale : 1/12,500
Aerial camera : RC-8
Flight height : 1,875m
Flight direction : West - East
Date of flight : 1970

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
446									
	59%	61%	8d	0.5g	Good	OK	0%	0%	OK
447									
	62%	61%	3d	0.5g	"	"	"	"	"
448									
Max.	59%	61%	8d	0.5g					

Table K3.1 List of Final Products

Description	Quantity
1. Photogrammetric Mappings of 11 Damsites	
1.1 Aerial Photography	
(a) Diapositives	One set each
(b) Contact prints	One set each
(c) A copy of the Camera caliblation Certificate	One set
(d) New aerial photo index map	One set
(e) List of aerial photos	One set
1.2 Control point survey	
(a) List of coordinates and height	One set
(b) Orientation Record	One set
(c) Survey report	One set
1.3 Photo control	
(a) Photo Control Index Map	One set
(b) Orientation Record	One set
1.4 Photogrammetric mapping	
(a) Original plots, S=1:2,000	One set each
(b) Blue copy of original plots	Two sets each
(c) Original fair drawings, S=1:2,000	One set each
(d) Blue copy of original fair drawings	Five sets each
(e) Location map of dam sites	One set
2. Profile Survey of 11 Damsites	
(a) Diagram of profile section	One set each
(b) List of coordinates and heights of profile points	One set
(c) Description of profile points	One set
(d) Original plots, H=1:500, V=1:2,000	One set each
(e) Blue copy of original plots	Two sets each
(f) Original fair drawings, H=1:500, V=1:2,000	One set each
(g) Blue copy of original fair drawings	Five sets each
3. Auxiliary Survey	
3.1 Leveling survey for establishment of site datum	One set
(a) List of height points	One set
(b) Description of height points	

Table K4.1 Check List of New Aerial Photography

Mapping Area : Molo damsite
Photo Scale : 1/10,000
Aerial Camera : RC-10 (F=151.21mm)
Flight Direction : East - West
Date of Flight : September, 1990
Photography Flown by : PHOTOMAP INTERNATIONAL INC.

(1) Checking of Flight Altitude

		Photo Scale	Flight Height	Ground Height	Flight Altitude
Plan	:	1/10,000	1,500m	1,980m	3,480m
Execution	:	1/ 9,793	1,480m	1,950m	3,430m
Difference	:		20m	30m	50m

Note: Allowable difference is less than ± 10% of plan flight altitude in accordance with the Technical Specifications.

(2) Checking of Aerial Photos

Photo No.	Overlap Min.	Overlap Base	k	w	Tone	Spot Shadow	Dust & Scratch	Cloud Cov.	Fiducial Marks
1038									
	61%	62%	8d	0.5g	Good	OK	0%	0%	OK
1039									
	62%	63%	2d	0.50g	"	"	"	"	"
1040									
Max.	61%	63%	8d	0.5g					

Note: Maximum values of photographs are within overlaps of 60% ± 5%, 10 deg.in k, 5g in w and cloud volume of 5% of tolerable error in accordance with the Technical Specifications.

Table K4.2 (1) List of Coordinates and Heights of Permanent Points for Proposed 11 Damsites (1/4)

1. Rambula Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
0	22,530.00	642,090.00		Iron pin in Concrete
TP 1/1	21,828.89	641,852.13	1,207.61	Iron pin in Concrete
R 1	22,226.36	641,994.40	1,194.37	Iron pin in Concrete
R 3	22,347.52	641,725.17	1,210.82	Iron pin in Concrete
L 1	22,180.60	642,096.10	1,193.27	Iron pin in Concrete

Note: Coordinates and heights are based on local coordinates and height at point "O" which were extracted from 1:50,000 scale map.

2. Gongo Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
House A	6,840.00	669,450.00		Hole in rock
TP 2/1	6,060.16	666,402.16	1,354.15	Hole in rock
R 1	6,598.61	666,789.42	1,307.26	Iron pin in Concrete
R 7	7,163.96	666,612.18	1,371.06	Iron pin in Concrete
L 1	6,463 40	666,831.80	1,297.84	Iron pin in Concrete

Note: (1) Heights is based on the SOK 102T14 triangulation point height.
(2) Coordinates is based on local coordinates at point "House A" which were extracted from 1:50,000 scale map.

3. Mushagumbo Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
TP 3/1	13,341.89	675,085.81	1,443.89	Iron pin in concrete
TP 3/2	13,679.13	674,944.23	1,437.01	Iron pin in concrete
TP 3/3	14,108.07	674,670.64	1,406.29	Hole in rock
TP 3/4	14,839.40	674,782.41	1,431.32	Iron pin in concrete
R 3	14,083.99	675,008.79	1,416.75	Iron pin in concrete
L 2	14,631.79	674,903.85	1,414.88	Iron pin in concrete
H 2	14,380.00	674,630.00	1,404.21	Paint mark on bridge

Note: (1) Heights are based on the SOK 102T14 triangulation point height. (2) Coordinates is based on local coordinates which were extracted from 1:50,000 scale map.

Table K4.2 (2) List of Coordinates and Heights of Permanent Points for Proposed 11 Damsites (2/4)

4. Namba Kodero Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
29S 5X	9,892,658.31	643,171.43	1,305.4	Iron pin in concrete
NKR 1	9,891,055.03	643,396.72	1,224.95	Iron pin in concrete
NKL 1	9,890,620.31	643,969.37	1,195.12	Iron pin in concrete
NK 2	9,892,645.40	643,606.19	–	Iron pin in concrete
TBM 1/B	–	–	1,164.78	Iron pin in wood

Note: Coordinates and heights are based on the SOK 102T14 triangration point.

5. Kerio-A Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
TT 11X	98,075.00	790,625.00	1,136.56	Iron pin in concrete
PH 1/1	99,082.84	792,793.91	1,157.71	Iron pin in concrete
KR 1	99,136.66	791,484.71	1,053.00	Iron pin in concrete
KRR	98,897.15	792,525.81	1,036.28	Iron pin in concrete
KRL	98,957.48	791,964.92	1,031.92	Iron pin in concrete

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map.

6. Molo Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
ML 1	9,976,425.00	812,725.00	1,996.46	Iron pin in concrete
ML 2	9,976,317.93	812,763.97	2,030.88	Iron pin in concrete
R 1	9,976,337.95	813,365.12	2,046.80	Iron pin in concrete
L 1	9,976,979.13	812,721.96	2,042.62	Iron pin in concrete
TBM 1	–	–	1,996.44	Bolt in concrete

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map.

Table K4.2 (3) List of Coordinates and Heights of Permanent points for Proposed 11 Damsites (3/4)

7. Yatta Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
TP 1	9,761,600.00	382,680.00	782.00	Iron pin in concrete
TP 2	9,761,870.08	382,869.11	783.44	Iron pin in concrete
TP 3	9,762,196.74	382,970.72	789.83	Iron pin in concrete
TP 4	9,762,325.14	383,153.42	790.10	Iron pin in concrete
TP 5	9,762,286.19	383,899.33	774.77	Iron pin in concrete
R 1	9,762,332.31	384,690.01	729.82	Iron pin in concrete
R 2	9,762,332.58	384,675.07	737.36	Iron pin in concrete
R 3	9,762,333.36	384,632.39	751.42	Iron pin in concrete
R 4	9,762,334.26	384,599.50	755.52	Iron pin in concrete
R 5	9,762,336.00	384,507.39	760.87	Iron pin in concrete
R 6	9,762,336.97	384,455.58	761.76	Iron pin in concrete
R 7	9,762,339.28	384,331.22	760.87	Iron pin in concrete.
R 8	9,762,341.36	384,218.96	771.60	Iron pin in concrete
R 1	9,762,329.83	384,822.78	733.20	Iron pin in concrete
R 6	9,762,321.38	385,461.04	794.63	Hole in rock

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map.

8. Baricho Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
R 1	9,654,594.02	585,832.21	89.53	Iron pin in concrete
R 2	9,654,673.37	585,817.65	85.65	Iron pin in concrete
R 3	9,654,794.66	585,795.39	75.44	Iron pin in concrete
R 4	9,654,924.68	585,771.53	61.89	Iron pin in concrete
R 5	9,655,032.84	585,751.67	55.86	Iron pin in concrete
R 6	9,655,174.30	585,725.71	55.75	Iron pin in concrete
L 1	9,655,294.54	585,703.64	56.75	Iron pin in concrete
L 2	9,655,397.08	585,684.82	77.31	Iron pin in concrete
L 3	9,655,469.99	585,671.46	89.31	Iron pin
L 4	9,655,565.45	585,653.95	96.51	Iron pin

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map.

Table K4.2 (4) List of Coordinates and Heights of Permanent Points for Proposed 11 Damsites (4/4)

9. Rumuruti Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
Rum/4	16,490.00	216,490.00	2,000.00	Iron pin in concrete
Rum/5	16,681.71	216,507.18	2,001.43	Iron pin in concrete
Rum/6	16,565.68	216,480.04	2,001.76	Iron pin in concrete
R 1	16,527.11	216,471.05	2,002.06	Iron pin in concrete
L 1	16,524.83	216,398.87	2,001.30	Iron pin in concrete

Note: Coordinates and heights are based on local coordinates and height at point Rum/4, which were extracted from 1:50,000 scale map.

10. Marun Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
MN 1	170,225.00	766,750.00	1,120.00	Iron pin in concrete
MN 2	170,554.42	765,360.65	1,175.77	Iron pin in concrete
MNR	170,087.69	766,334.53	1,146.67	Iron pin in concrete
MNL	170,189.01	766,315.96	1,155.48	Iron pin in concrete

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map.

11. Katieno Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
KT 4	9,900,050.00	650,000.00	1,234.44	Iron pin in concrete
KT 5	9,899,791.10	650,282.55	1,298.23	Iron pin in concrete
KT 2	9,898,424.44	652,120.44	1,321.99	Iron pin in concrete
KR 1	9,899,817.24	651,841.37	1,241.80	Iron pin in concrete
KT 3	9,900,285.98	652,014.29	1,330.28	Iron pin in concrete
KL 1	9,899,458.28	651,774.99	1,240.75	Iron pin in concrete
TBM 1	–	–	1,235.59	Bolt in concrete

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map.

Table K4.3 Accuracy of Leveling

Project : National Water Master Plan
Mapping Area : Proposed 11 damsites
Total Distance : 51.4 km
Surveying Date : September - November, 1990
Surveyed by : PHOTOMAP INTERNATIONAL INC.

Route Name	Distance (km)	Allowable Closure (mm)	Difference of Closure (mm)	Remarks
Rambula	6.9	± 52	+ 23	± 20mm/D
Gongo	5.8	± 48	+ 17	
Mushagumbo	4.4	± 41	- 5	
Namba Kodero	4.8	± 43	- 19	
Kerio-A	6.1	± 49	+ 11	
Molo	2.8	± 33	- 27	
Yatta	6.3	± 50	+ 8	
Barich	1.8	± 26	+ 13	
Rumuruti	1.9	± 27	- 15	
Marun	3.8	± 38	- 3	
Katieno	6.6	± 51	+ 20	

Table K4.4 Accuracy of Traversing

Project : National Water Master Plan
Mapping Area : Proposed 11 damsites
Total Distance : 51.2 km
Surveying Date : September - November, 1990
Surveyed by : PHOTOMAP INTERNATIONAL INC.

Route Name	Distance (km)	Allowable Closure	Difference of Closure	Remarks
Rambula	6,902.37	1:2,000	1: 36,900	Loop traverse
Gongo	5,773.56	1:2,000	1: 39,400	Loop traverse
Mushagumbo	4,376.70	1:2,000	1: 34,800	Loop traverse
Namba Kodero	4,830.34	1:2,000	1: 41,000	Loop traverse
Kerio-A	6,149.93	1:2,000	1:119,500	Loop traverse
Molo	2,832.47	1:2,000	1:159,000	Loop traverse
Yatta	6,341.13	1:2,000	1: 29,500	Loop traverse
Barich	1,779.31	1:2,000	1:126,700	Loop traverse
Rumuruti	1,987.64	1:2,000	1: 78,200	Loop traverse
Marun	3,832.50	1:2,000	1:106,000	Loop traverse
Katieno	6,621.71	1:2,000	1:153,300	Loop traverse

Table K4.5 (1) List of Coordinates and Heights of Photo Control Points for Proposed 11 Damsites (1/4)

1. Rambula Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH 9	21,673.56	642,191.22	1,216.91	Wooden peg
PH 8	23,539.17	641,203.19	1,253.31	Wooden peg
PH 7	23,793.65	642,312.49	1,238.16	Wooden peg
H 8	–	–	1,211.74	Wooden peg
H 9	–	–	1,212.03	Wooden peg
H 10	–	–	1,193.73	Wooden peg

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map by SOK.

2. Gongo Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH 4	5,712.51	666,735.27	1,380.86	Wooden peg
PH 5	7,292.08	666,559.55	1,382.80	Wooden peg
PH 6	6,451.96	666,810.80	1,297.66	Wooden peg
H 3	5,975.69	667,605.63	1,348.69	Wooden peg
H 4	–	–	1,292.81	Wooden peg
H 5	–	–	1,325.45	Wooden peg
H 6	–	–	1,403.91	Wooden peg
H 7	7,345.47	667,391.75	1,377.52	Wooden peg

Note: Heights are based on the SOK 102T14 triangulation point height and Coordinates is based on local coordinates which were extracted from 1:50,000 scale map by SOK.

3. Mushagumbo Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH 1	15,105.15	674,863.50	1,441.65	Wooden peg
PH 2	13,263.35	675,245.13	1,450.87	Wooden peg
PH 3	13,234.88	674,648.72	1,435.67	Wooden peg
H 1	14,329.59	675,376.93	1,404.03	Stone edge
H 2	14,380.00	674,630.00	1,404.21	Paint mark on bridge

Note: Heights are based on the SOK 102T14 triangulation point height and Coordinates is based on local coordinates which were extracted from 1:50,000 scale map by SOK.

Table K4.5 (2) List of Coordinates and Heights of Photo Control Points for Proposed 11 Damsites (2/4)

4. Namba Kodero Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH 129/1	9,889,998.81	644,654.88	1,228.83	Wooden peg
PH NKI/2	9,890,650.90	643,357.79	1,191.06	Wooden peg
H 1	–	–	1,194.78	Wooden peg
H 2	–	–	1,163.96	Wooden peg
H 3	–	–	1,161.91	Wooden peg
H 4	–	–	1,216.93	Wooden peg
H 5	–	–	1,163.97	Wooden peg

Note: Coordinates and heights are based on the SOK 102T14 triangration point.

5. Kerio-A Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH 1/1	99,082.84	792,793.91	1,157.71	Iron pin in concrete
PH 1/2	99,106.08	791,546.24	1,050.79	Iron pin in concrete
H 1	–	–	1,002.08	Wooden peg
H 2	–	–	1,014.60	Wooden peg

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map by SOK.

6. Molo Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH 1	9,976,129.30	813,416.62	2,036.53	Iron pin in concrete
PH 2	9,976,982.01	812,604.24	2,050.72	Iron pin in concrete
H 1	–	–	2,030.71	Wooden peg
H 2	–	–	2,009.98	Wooden peg
H 3	–	–	1,996.25	Wooden peg

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map by SOK.

Table K4.5 (3) List of Coordinates and Heights of Photo Control Points for Proposed 11 Damsites (3/4)

7. Yatta Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH 1/1	9,761,612.35	382,682.74	782.22	Wooden peg
PH 4/1	9,762,328.97	383,134.90	789.52	Wooden peg
PH 6/1	9,762,400.82	385,759.12	781.52	Wooden peg
PH 6/2	9,762,357.39	385,761.80	779.79	Wooden peg
H 1	–	–	732.84	Top of rock
H 1A	–	–	731.88	Wooden peg
H 2	–	–	726.03	Wooden peg
H 3	–	–	730.49	On side of baobab
H 4	–	–	734.90	Wooden peg
H 4A	–	–	732.22	Top of rock

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map by SOK.

8. Baricho Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH 1	9,654,579.40	585,761.26	89.67	Wooden peg
PH 2	9,655,322.90	585,769.38	57.56	Wooden peg
PH 3	9,655,895.82	585,981.54	89.34	Wooden peg
H 1	–	–	57.77	Wooden peg
H 2	–	–	55.48	Wooden peg
H 3	–	–	56.68	Wooden peg
H 6	–	–	55.78	Wooden peg
H 7	9,655,260.00	585,550.00	55.00	Wooden peg

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map by SOK.

Table K4.5 (4) List of Coordinates and Heights of Photo Control Points for Proposed 11 Damsites (4/4)

9. Rumuruti Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH RUM/2	16,909.50	216,821.97	2,009.88	Wooden peg
PH RUM/3	16,156.98	216,231.95	2,005.21	Wooden peg
PH RUM/4	16,699.35	216,480.70	2,000.00	Wooden peg
H RUM/1	–		2,073.91	Wooden peg
H RUM/5	–		2,062.96	Wooden peg

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map by SOK.

10. Marun Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH 1	171,393.99	766,187.71	1,371.87	Wooden peg
PH 2	169,495.30	765,880.39	1,594.38	Wooden peg
PH 3	170,225.00	766,750.00	1,120.00	Wooden peg
H 1	–	–	1,093.44	Wooden peg
H 2	–	–	1,124.23	Wooden peg

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map by SOK.

11. Katieno Damsite

Point No.	Coordinates (m) N	Coordinates (m) E	Height (m)	Remarks
PH 2/2	9,899,000.94	651,292.61	1,290.84	Wooden peg
PH 3/1	9,900,620.91	651,824.39	1,289.74	Wooden peg
H 1	–	–	1,274.68	Wooden peg
H 2	–	–	1,234.99	Wooden peg

Note: Coordinates and heights are based on local coordinates and height which were extracted from 1:50,000 scale map by SOK.

Table K4.6 Accuracy of Photo Control

Project : National Water Master Plan
Mapping Area : Approx. 2.85 sq.km for 1:2,000 scale
Surveying Date : September - November, 1990
Surveyed by : PHOTOMAP INTERNATIONAL INC.

Photogrammetric Mapping Area	Photo Models	Horizontal Control Points	Vertical Control Points
Rambula Damsite	2	6	9
Gongo Damsite	2	5	8
Mushagumbo Damsite	1	5	5
Namba Kodero Damsite	1	4	4
Kerio-A Damsite	1	3	5
Molo Damsite	2	4	5
Yatta Damsite	1	3	6
Barich Damsite	1	4	6
Rumuruti Damsite	2	5	7
Marun Damsite	1	4	4
Katieno Damsite	1	3	5

Observation error (Control Points) : Max.0.4 (Altitude)

Table K7.1 Results of Control Points Check Survey

Route	Total Distance (m)		Coordinates by Contractor (m)	Coordinates by JICA Expert (m)	Difference (m)
1. Namba Kodero Damsite					
129S5		N	9,892,658.31	N 9,892,658.01	+ 0.30
- 129S5	4,830.34	E	643,171.43	E 643,171.69	- 0.26
				Linear mis-closure:	+ 0.40
					1/12,075 (*)
2. Molo Damsite					
ML 1		N	9,976,425.00	N 9,976,424.86	+ 0.14
- ML 1	2,832.47	E	812,720.00	E 812,724.77	+ 0.23
				Linear mis-closure:	+ 0.27
					1/10,490 (*)

Note: (*) The required accuracy of traverse is better than 1/2,000 in accordance with the Technical Specifications.

Table K7.2 Results of Spot Height Check Survey

Sheet Name	Spot Height by Contractor (El.m)	Spot Height by JICA Expert (El.m)	Difference (m)
Baricho damsite	56.2	56.1	- 0.1
	55.1	55.5	+ 0.4
	56.2	56.0	- 0.2
	54.7	54.6	- 0.1
	56.6	56.8	+ 0.2
	55.5	55.2	- 0.3
	56.1	56.2	+ 0.1
	55.3	55.1	- 0.2
	66.0	59.7	- 0.3
	62.5	62.7	+ 0.2
	59.0	59.0	± 0.0
	62.0	61.8	- 0.2
	78.5	78.8	+ 0.3
	83.0	82.9	- 0.1
	85.0	85.4	+ 0.4
	87.6	87.7	+ 0.1
	77.5	77.3	- 0.2
Rambula Damsite	1,220.2	1,220.4	+ 0.2
	1,217.2	1,217.5	+ 0.3
	1,213.7	1,213.4	- 0.3
	1,198.2	1,198.1	- 0.1
	1,195.3	1,195.4	+ 0.1
	1,195.6	1,195.8	+ 0.2

Table K7.3 (1) Results of Profile Check Survey (1/3)

(1) Permanent Points

Point No.	Elevation (El.m)	Difference in Height by Contractor (m)	Difference in Height by JICA Expert (m)	Deviation (mm)	Dist. (km)	Allowable Difference (mm)
PH RUN/2	2,009.88					
		- 9.880	- 9.887	+ 7	0.4	± 12
PH RUN/4	2,000.00					
		+ 2.060	+ 2.062	+ 2	0.2	± 9
R 1	2,002.06					
		- 0.760	- 0.757	- 3	0.1	± 6
L 1	2,001.30					
		+ 3.910	+ 3.921	+ 10	0.5	± 14
PH RUN/3	2,005.21					

Note: (1) Allowable difference is calculated based on $\pm$ 20mm$*$ $D^{0.5}$ in accordance with Technical Specifications.

(2) Difference in bench marks heights between the measurements by the Contractor and Topo-survey Expert does not exceed allowable error $\pm$ 20mm$*$ $D^{0.5}$ for all the check survey points. Accordingly it is judged that these bench marks established by the contractor have enough accuracy for the profile survey.

Table K7.3 (2) Results of Profile Check Survey (2/3)

(2) Profile Section

Chainage (m)	Ground Height by Contractor (m)	Ground Height by JICA Expert (m)	Difference (m)
0.00	2,034.34	2,034.35	+ 0.01
13.44	2,033.40	2,033.40	± 0.00
17.40	2,032.94	2,032.93	- 0.01
31.38	2,032.71	2,032.73	+ 0.02
41.30	2,033.37	2,033.37	± 0.00
52.61	2,033.77	2,033.75	+ 0.02
68.47	2,033.21	2,033.22	+ 0.01
72.37	2,032.88	2,032.87	- 0.01
85.22	2,030.77	2,030.76	- 0.01
97.74	2,027.58	2,027.60	+ 0.02
107.51	2,025.15	2,025.14	- 0.01
114.22	2,022.68	2,022.71	+ 0.03
125.11	2,018.50	2,018.52	+ 0.02
137.09	2,013.67	2,013.66	- 0.01
145.79	2,009.93	2,009.93	± 0.00
155.36	2,006.40	2,006.41	+ 0.01
160.35	2,005.21	2,005.22	+ 0.01
171.74	2,001.84	2,001.83	- 0.01
177.11	2,001.30	2,001.32	+ 0.02
187.89	2,000.74	2,000.75	+ 0.01
193.79	2,000.93	2,000.93	± 0.00
204.11	2,000.36	2,000.35	- 0.01
207.01	2,000.49	2,000.49	± 0.00
208.29	2,000.23	2,000.23	± 0.00
209.31 River	1,998.3	1,998.2	- 0.1
212.80 River	1,998.1	1,998.2	+ 0.1
215.41 River	1,998.3	1,998.4	+ 0.1
219.51	1,998.51	1,988.53	+ 0.02
222.50	1,999.33	1,999.32	- 0.01
231.14	1,999.20	1,999.21	+ 0.01
234.56	1,999.69	1,999.69	± 0.00
238.53	2,001.31	2,001.32	+ 0.01
242.28	2,001.27	2,001.26	- 0.01
249.33	2,002.06	2,002.05	- 0.01
258.17	2,001.82	2,001.83	+ 0.01
271.38	2,001.72	2,001.70	- 0.01
277.35	2,002.22	2,002.22	± 0.00
284.12	2,003.94	2,003.93	- 0.01
286.87	2,003.99	2,004.00	+ 0.01
293.58	2,002.98	2,003.01	+ 0.03
301.22	2,002.99	2,002.98	- 0.01
312.32	2,003.94	2,003.96	+ 0.02
318.90	2,005.35	2,005.37	+ 0.02
323.85	2,006.61	2,006.62	+ 0.01

- to be continued -

Table K7.3 (3) Results of Profile Check Survey (3/3)

Chainage (m)	Ground Height by Contractor (m)	Ground Height by JICA Expert (m)	Difference (m)
335.27	2,009.50	2,009.48	- 0.01
344.12	2,011.61	2,011.60	- 0.01
353.00	2,014.22	2,014.24	+ 0.02
357.12	2,015.58	2,015.58	± 0.00
362.28	2,016.77	2,016.78	+ 0.01
365.95	2,018.35	2,018.34	- 0.01
376.79	2,022.07	2,022.06	- 0.01
383.97	2,025.13	2,025.15	+ 0.03
386.86	2,025.76	2,025.77	+ 0.01
389.73	2,026.78	2,026.79	+ 0.01
393.13	2,027.76	2,027.74	- 0.02
398.34	2,028.60	2,028.59	- 0.01
407.58	2,032.02	2,032.02	± 0.00
418.63	2,034.58	2,034.58	± 0.00
430.52	2,037.16	2,037.15	- 0.01
440.72	2,038.90	2,038.88	- 0.02
452.23	2,041.41	2,041.40	- 0.01
462.84	2,043.61	2,043.62	+ 0.01
475.29	2,046.43	2,046.45	+ 0.02
476.98	2,047.17	2,047.15	- 0.02
479.57	2,047.97	2,047.98	+ 0.01

Note: Average difference heights between Contractor and the Topo-survey Expert is less than ± 1cm at the riparian area and ± 20cm at the water area. It is judged that the ground heights and profile line shown in profile section have satisfied the accuracies stipulated in the Technical Specifications.

FIGURES

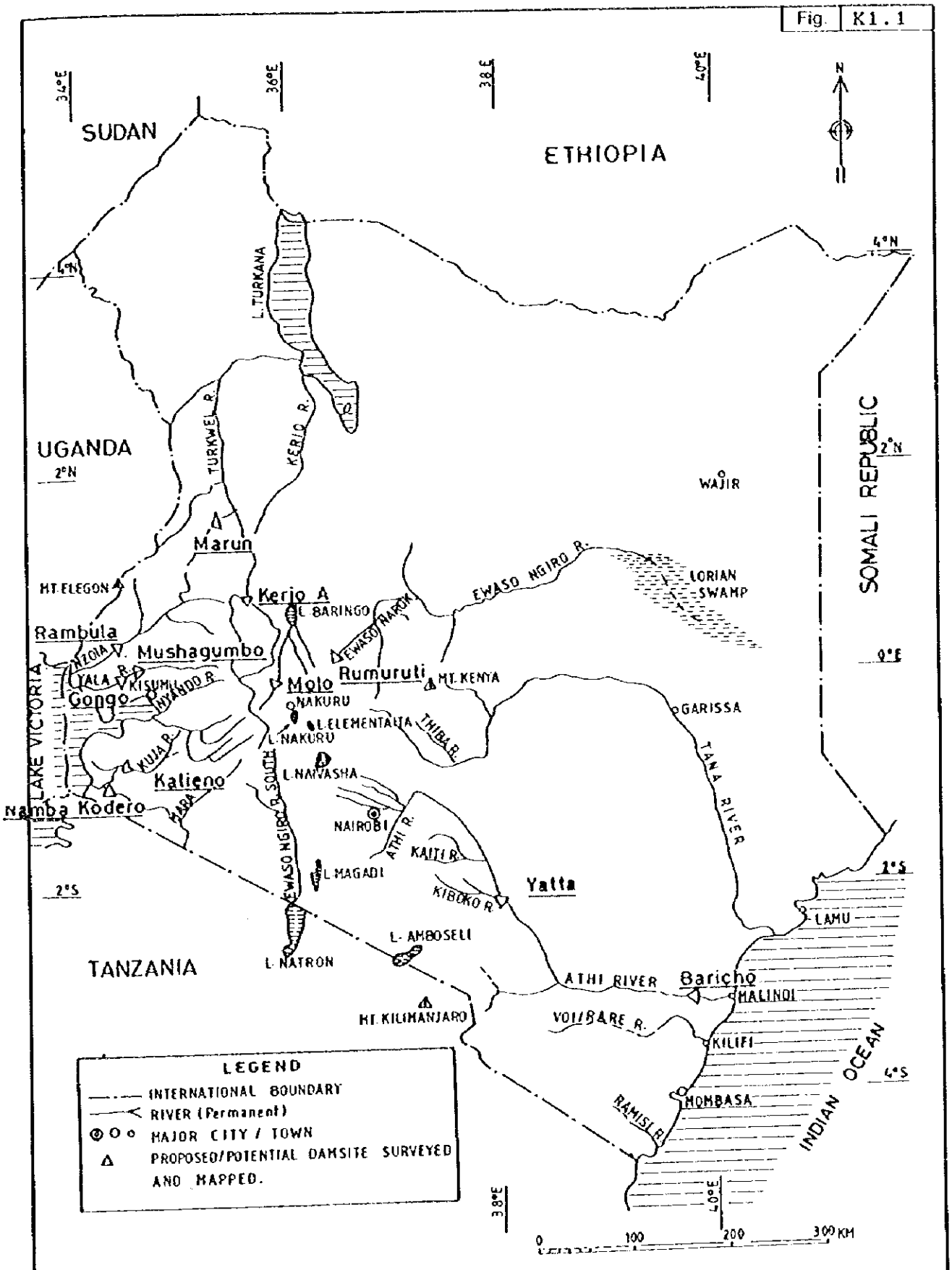


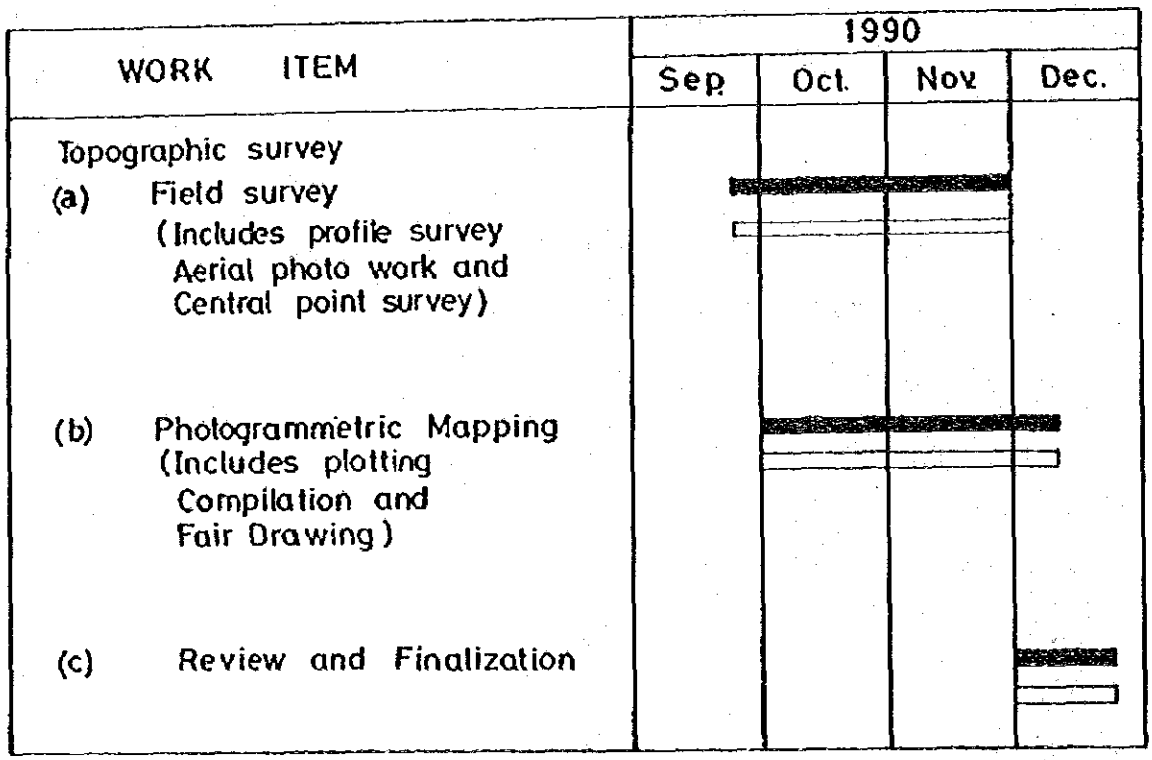
Figure K1.1

Locations of the Proposed Damsites for Survey and Mapping

THE STUDY
ON
THE NATIONAL WATER MASTER PLAN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. K3.1



Legend Plan :
Actual:

Figure K3.1

Work Schedule and Progress of Topographic Survey

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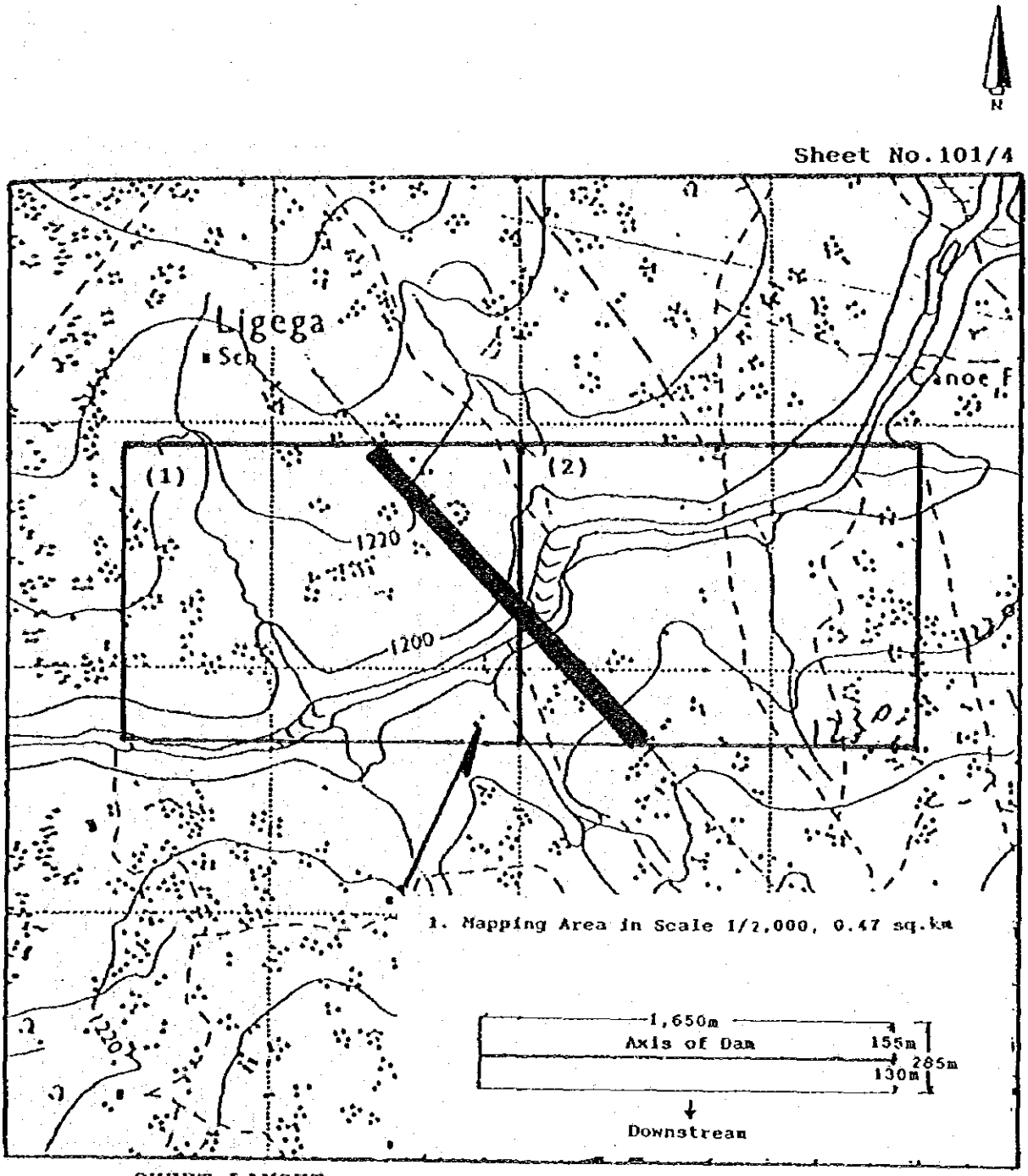
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. K4.1



SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

Note: The topographic maps of Appendices 4.1-4.15 are enlarged two times from 1/50,000 existing maps.

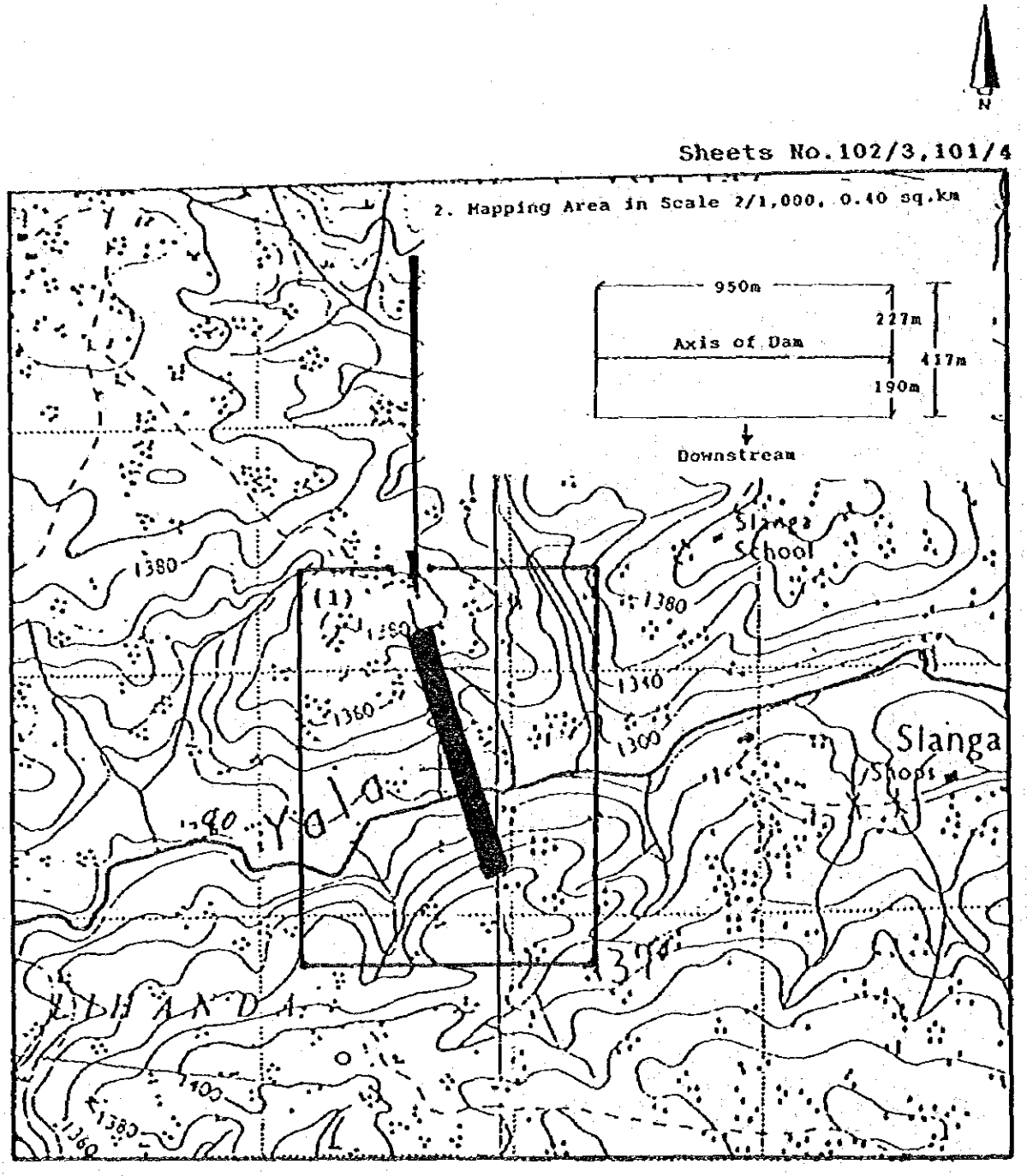
Figure K4.1

S= 1/25,000

Mapping Area of Proposed Rambula Damsite in Nzoia River

THE STUDY
ON
THE NATIONAL WATER MASTER PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. K4.2



SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

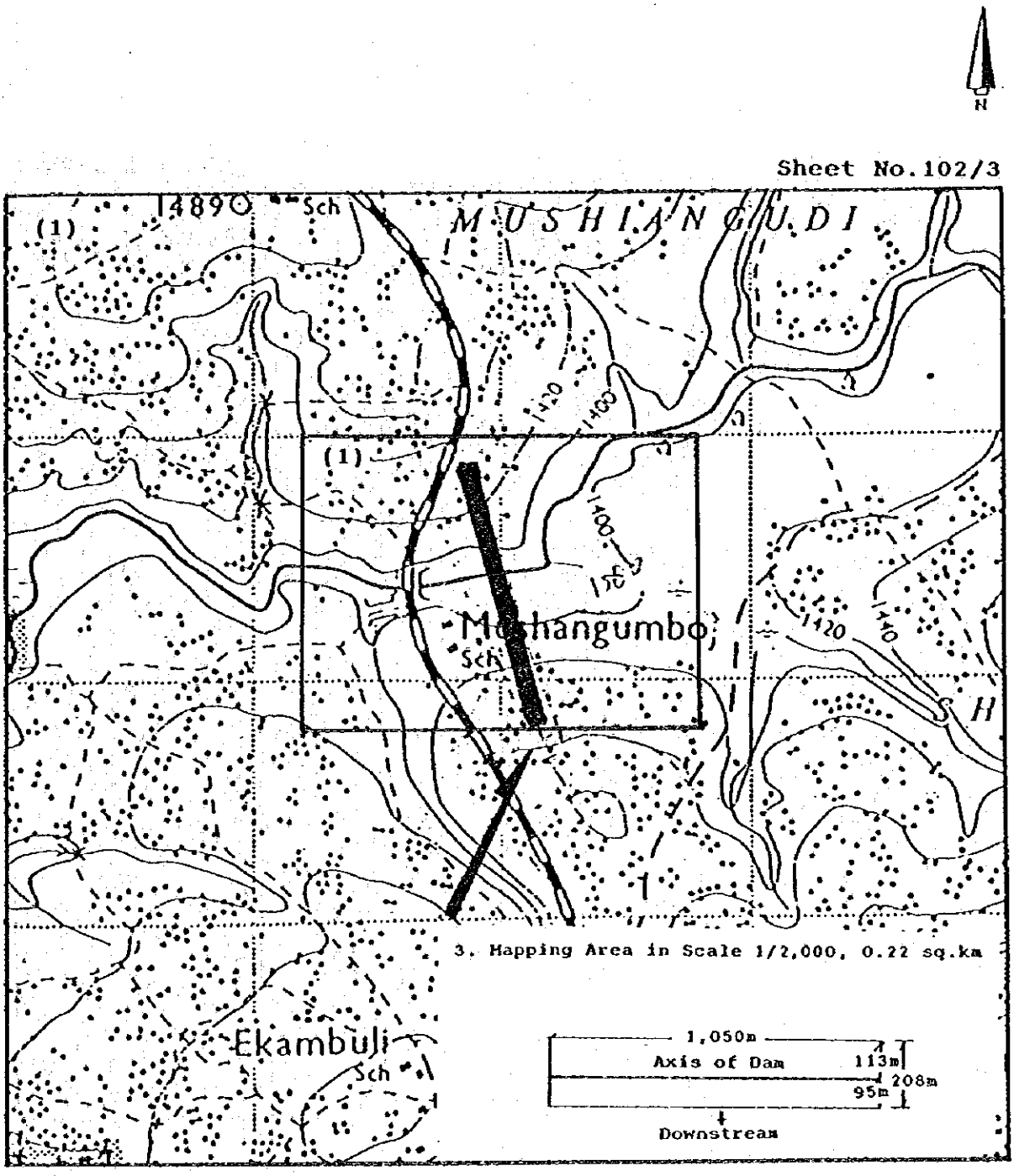
Figure K4.2

S= 1/25,000

Mapping Area of Proposed Gongo Damsite in Yala River

THE STUDY
ON
THE NATIONAL WATER MASTER PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. K4.3



SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

Figure K4.3

S= 1/25,000

Mapping Area of Proposed Mushagumbo Damsite in Yala River

THE STUDY
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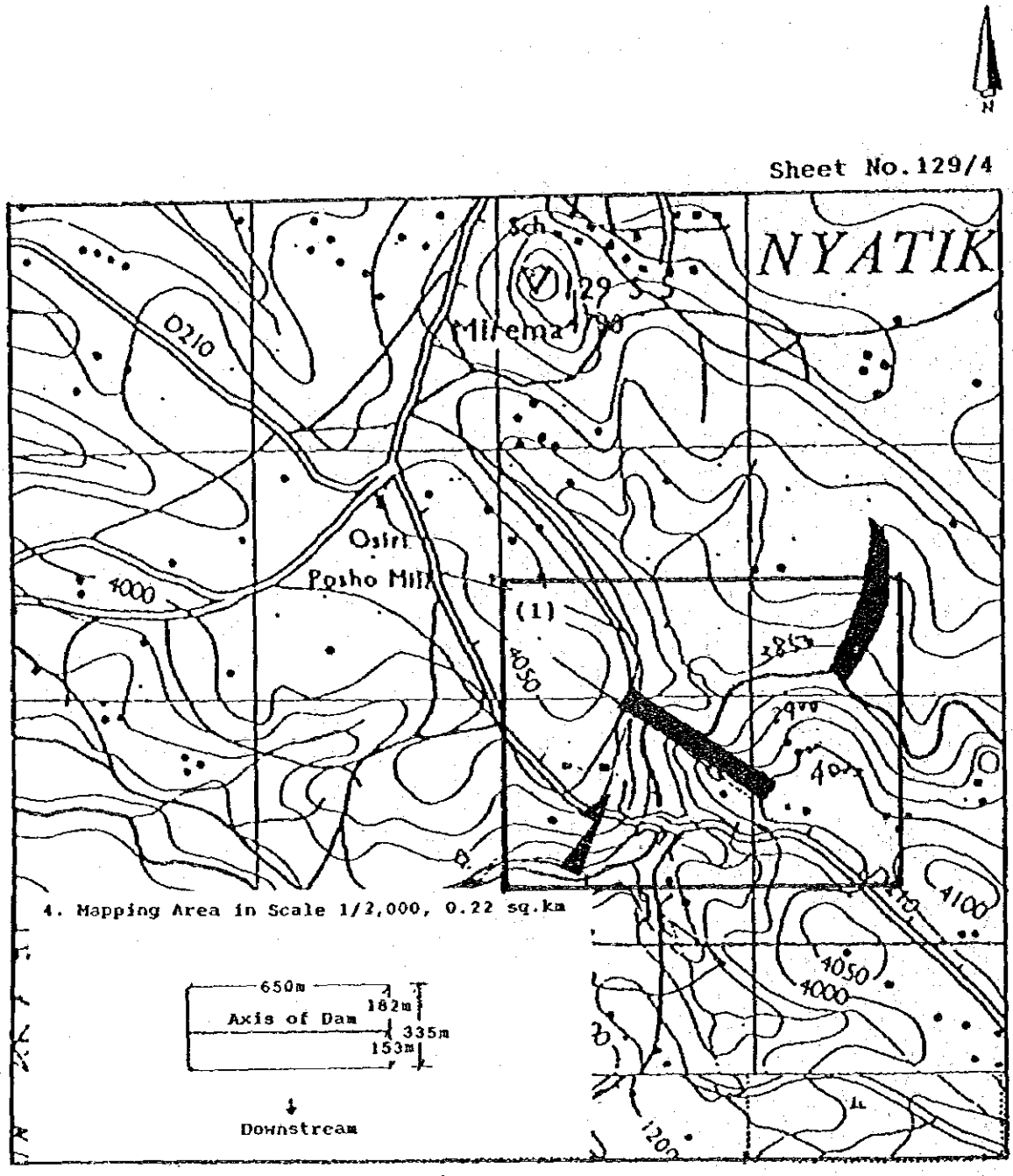
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. K4.4



SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

Figure K4.4

S= 1/25,000

Mapping Area of Proposed Namba Kodero Damsite in Migori River

THE STUDY
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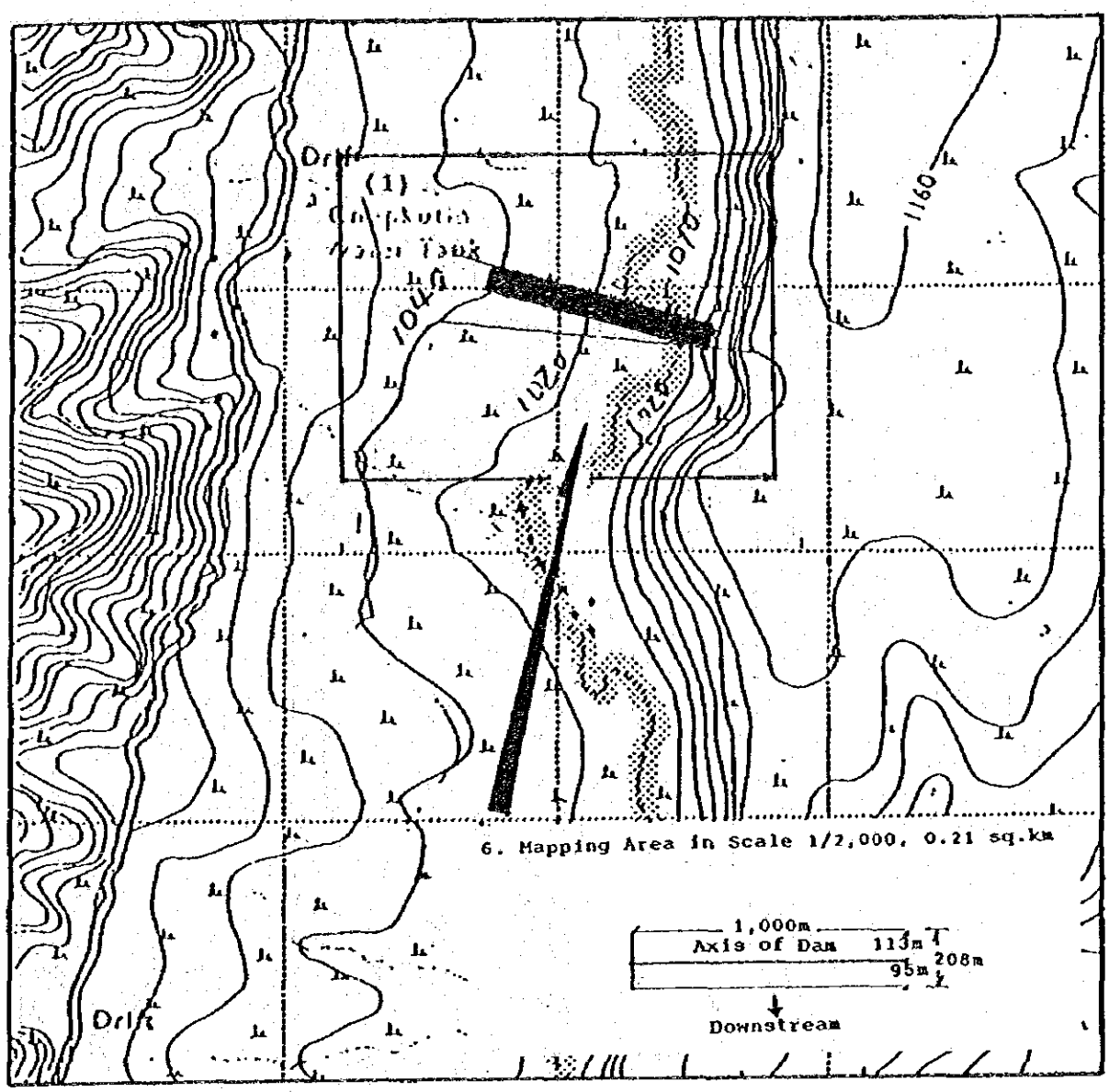
Fig. K4.5

N

Sheet No.90/1



6. Mapping Area in Scale 1/2,000, 0.21 sq.km

SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

Figure K4.5

S= 1/25,000

Mapping Area of Proposed Kerio-A Damsite in Kerio River

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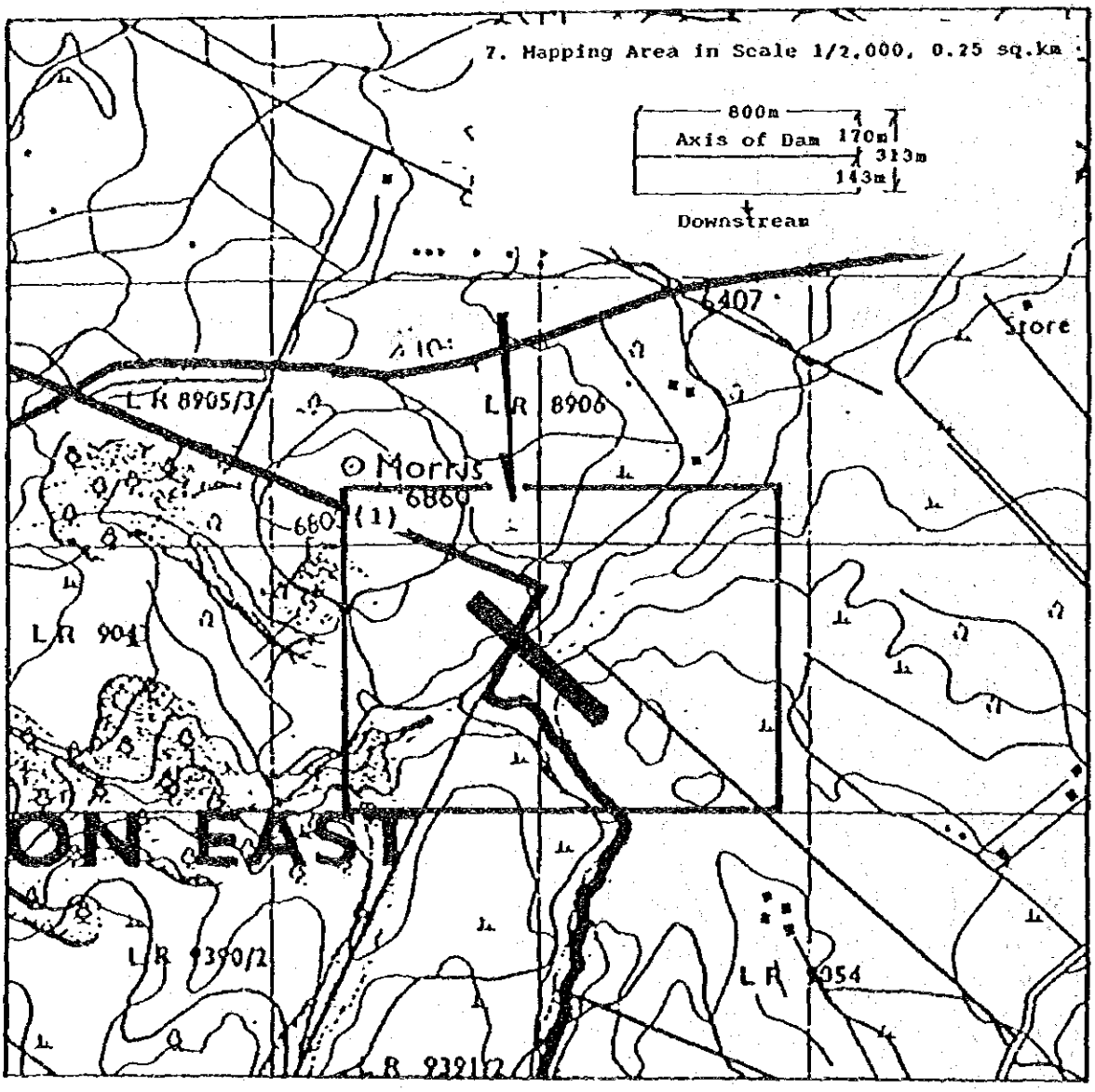
Fig. K4.6

Sheet No.118/2



SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

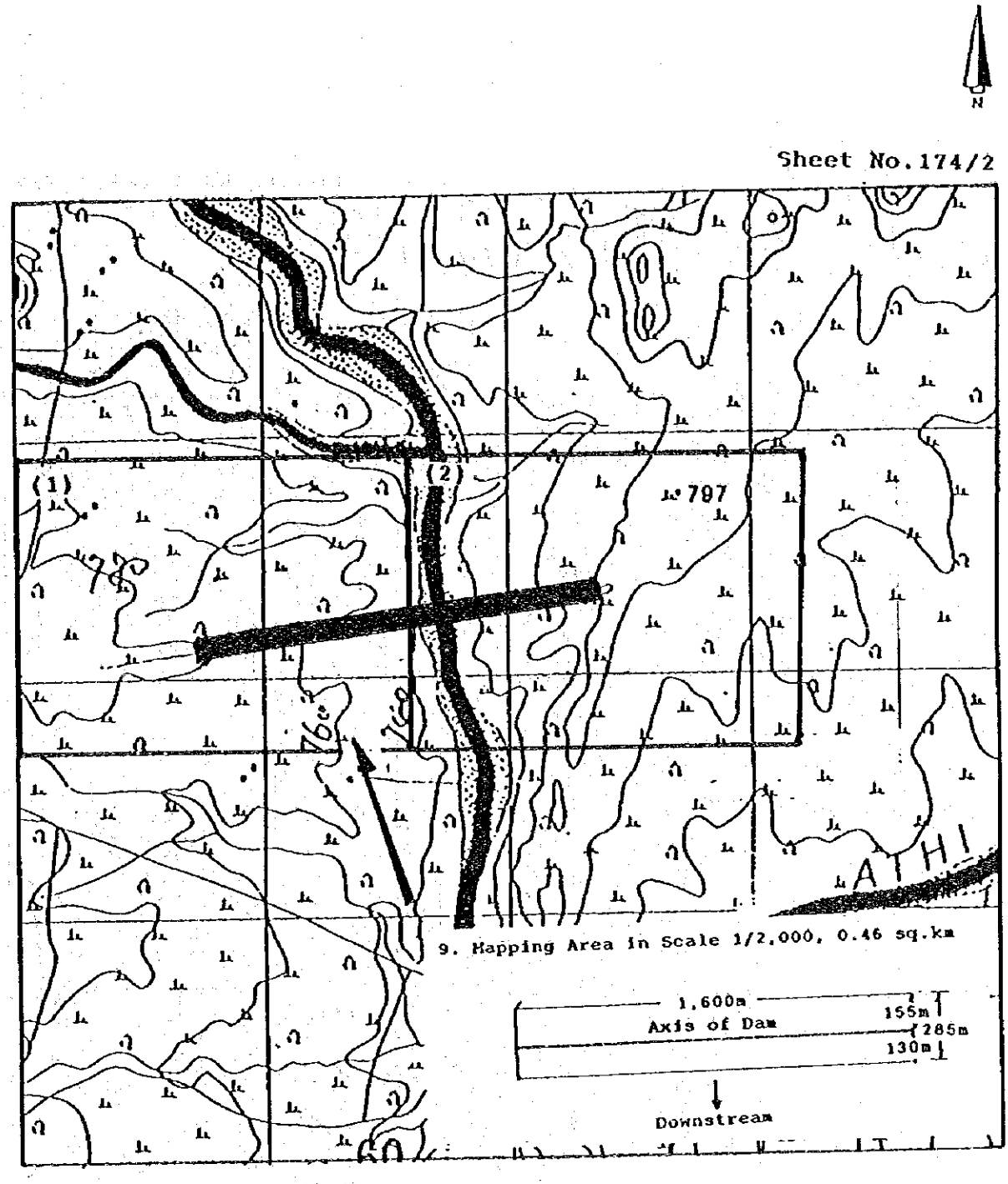
Figure K4.6

S= 1/25,000

Mapping Area of Proposed Molo Damsite in Molo River

THE STUDY
ON
THE NATIONAL WATER MASTER PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. K4.7



SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

Figure K4.7

S= 1/25,000

Mapping Area of Proposed Yatta Damsite in Athi River

THE STUDY
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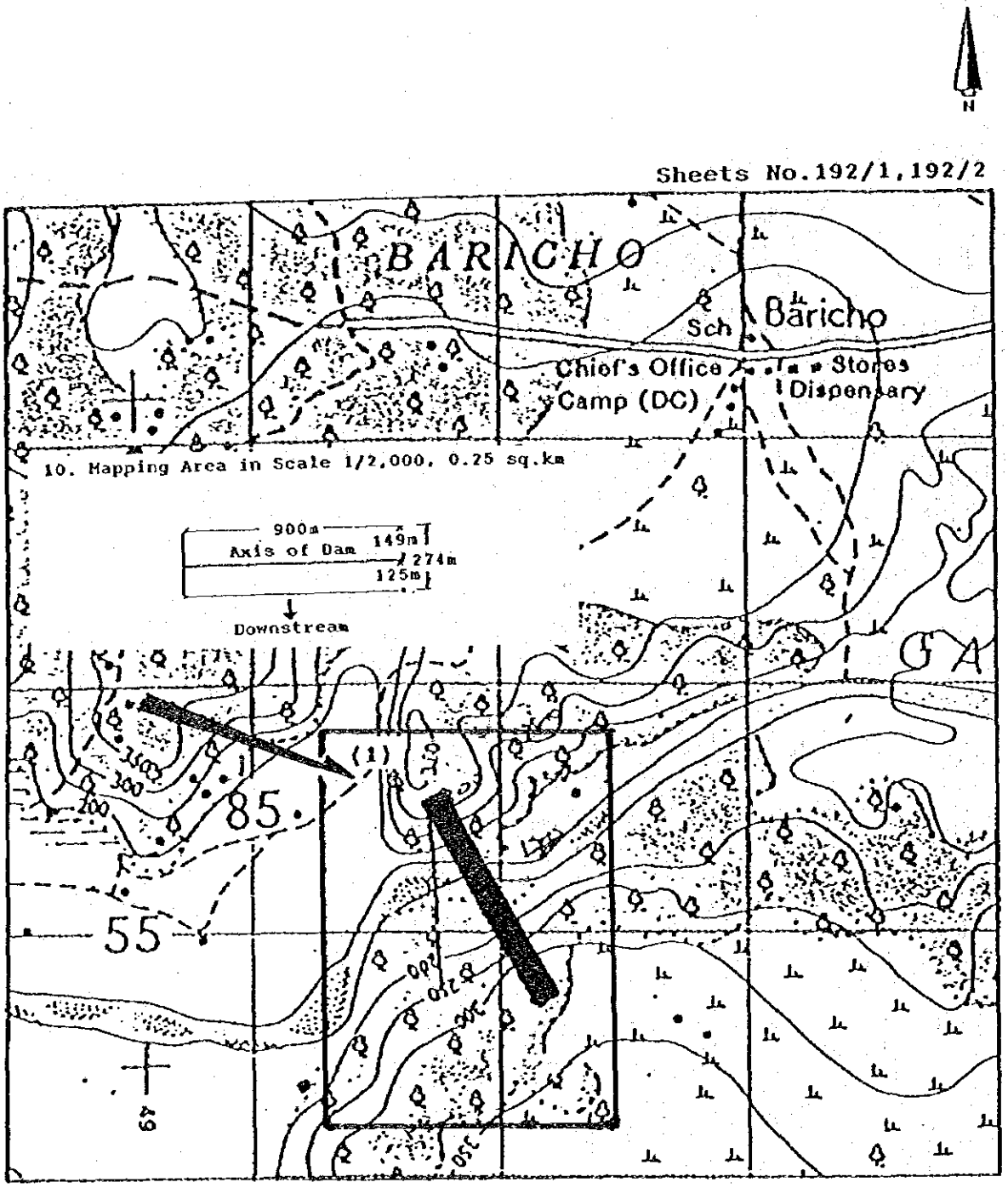
THE NATIONAL WATER MASTER PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. K4.8



SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

Figure K4.8

S= 1/25,000

Mapping Area of Proposed Baricho Damsite in Athi/Sabaki River

THE STUDY
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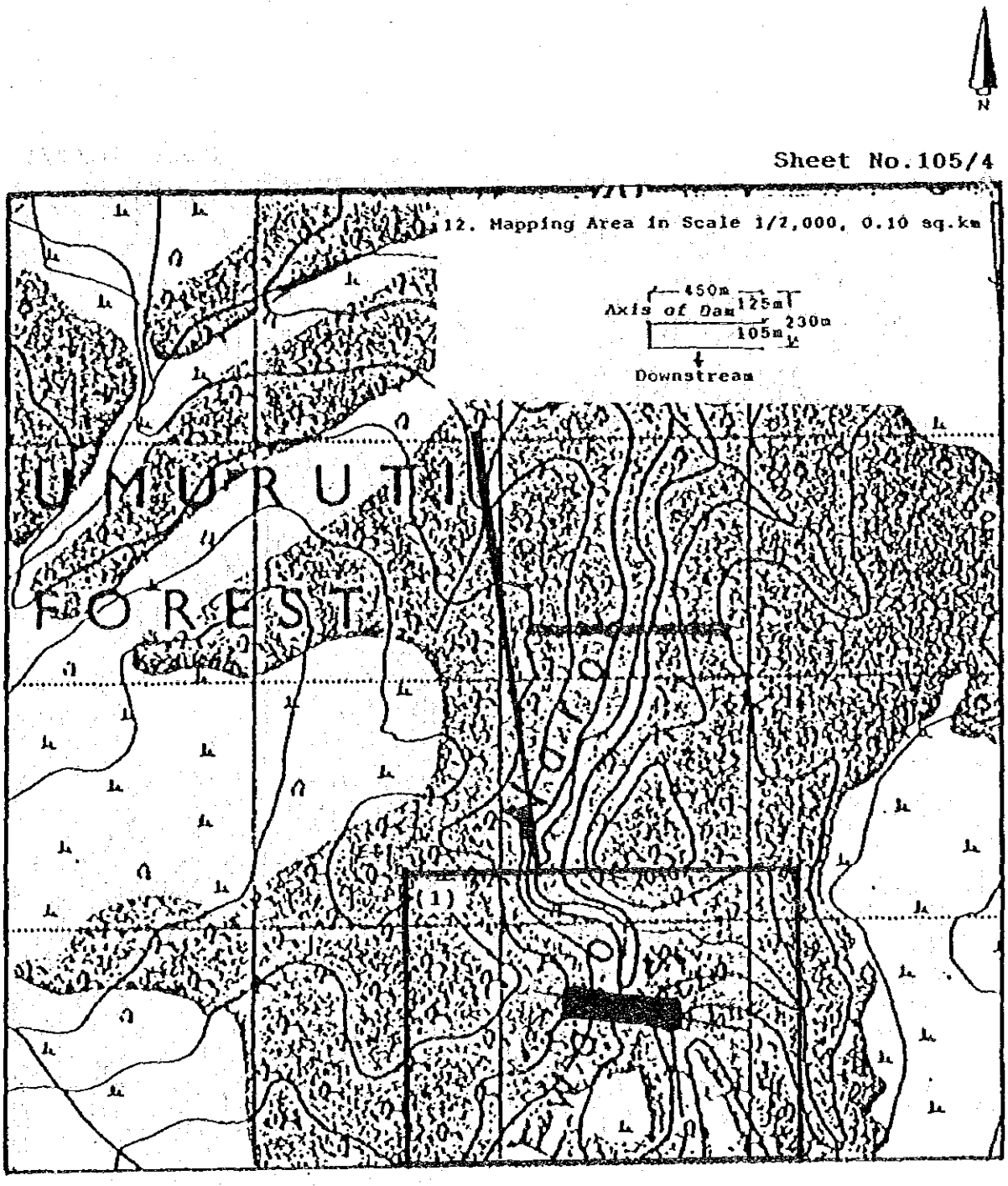
THE NATIONAL WATER MASTER PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. K4.9



SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

Figure K4.9

S= 1/25,000

Mapping Area of Proposed Rumuruti Damsite in Ngiro River

THE STUDY
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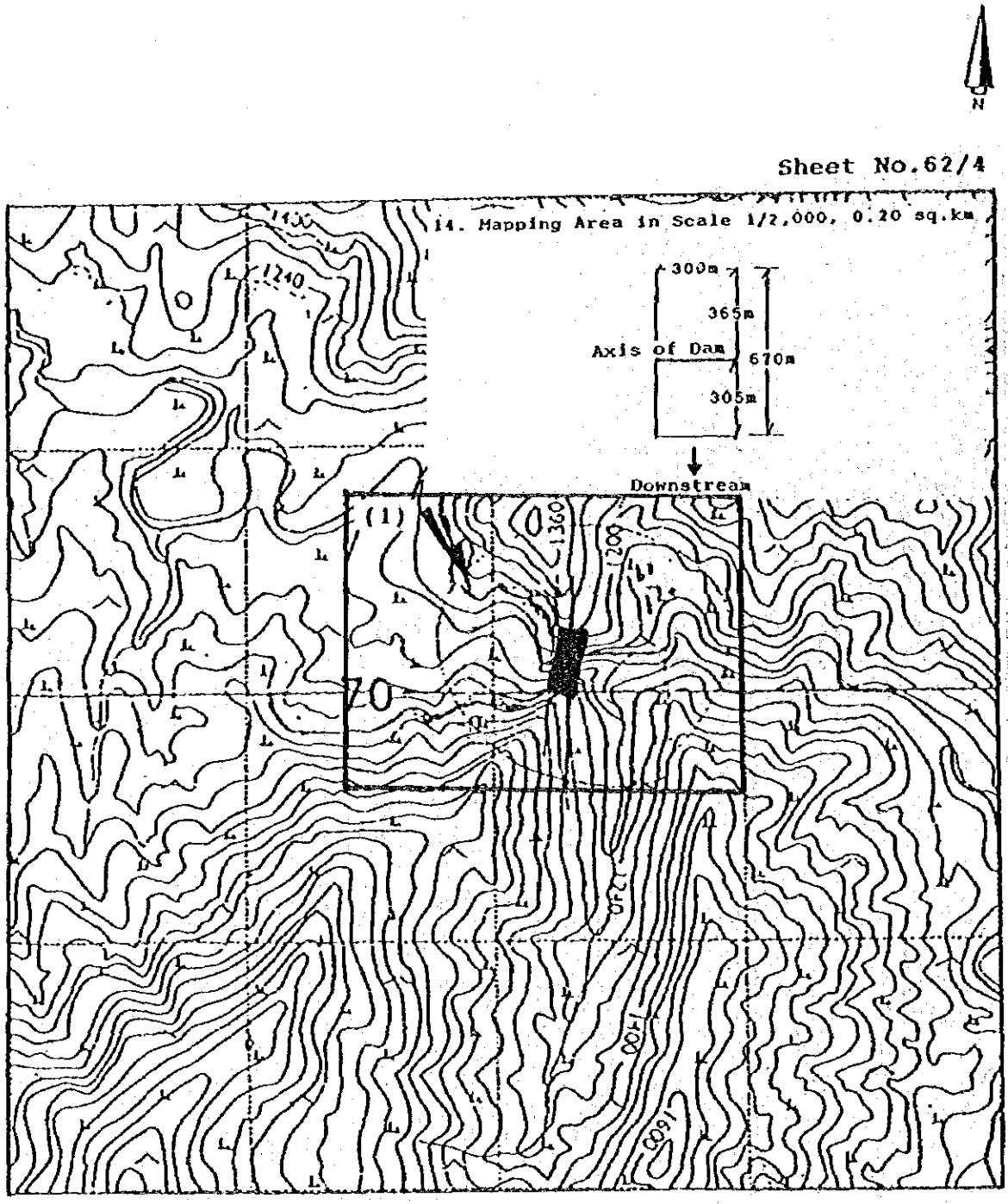
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. K4.10



SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

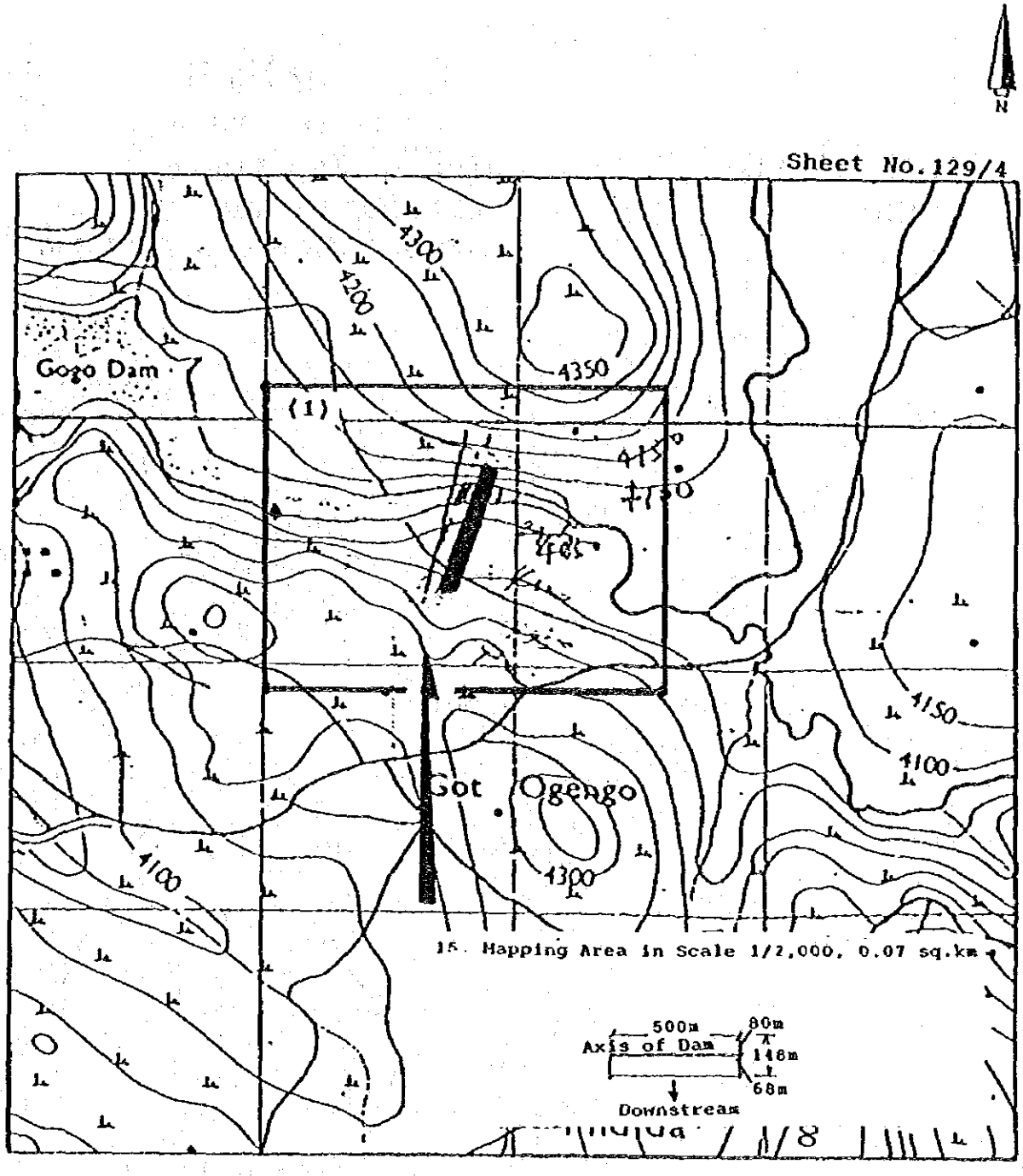
Figure K4.10

S= 1/25,000

Mapping Area of Proposed Marun Damsite in Marun River

THE STUDY
ON
THE NATIONAL WATER MASTER PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. K4.11



SHEET LAYOUT

☐ Sheet Size to be Fair Drawn
A 1 Size.

Figure K4.11

S= 1/25,000

Mapping Area of Proposed Katieno Damsite in Kuja River

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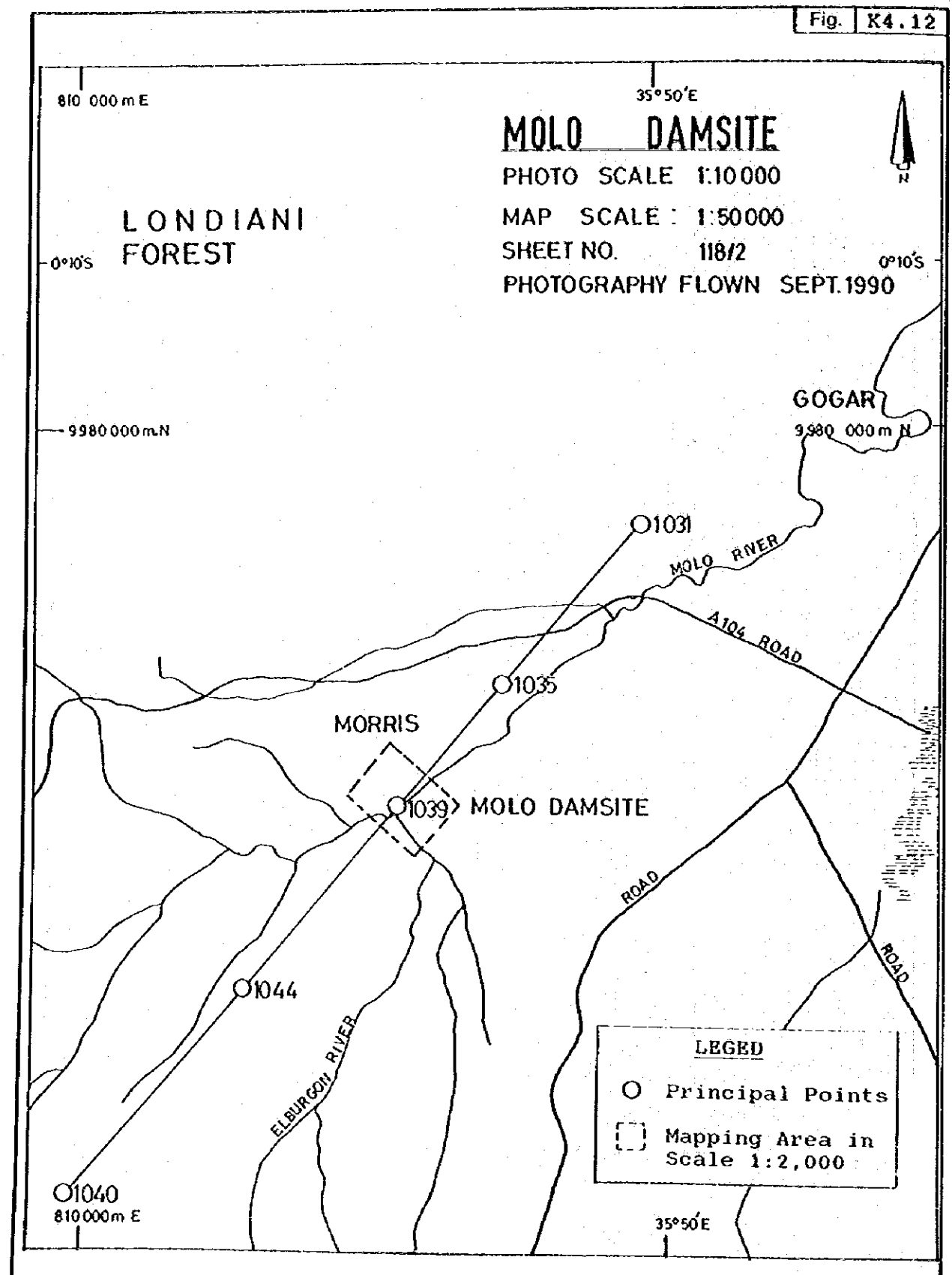

Figure K4.12

S= 1,50,000

New Aerial Photo Index Map

THE STUDY
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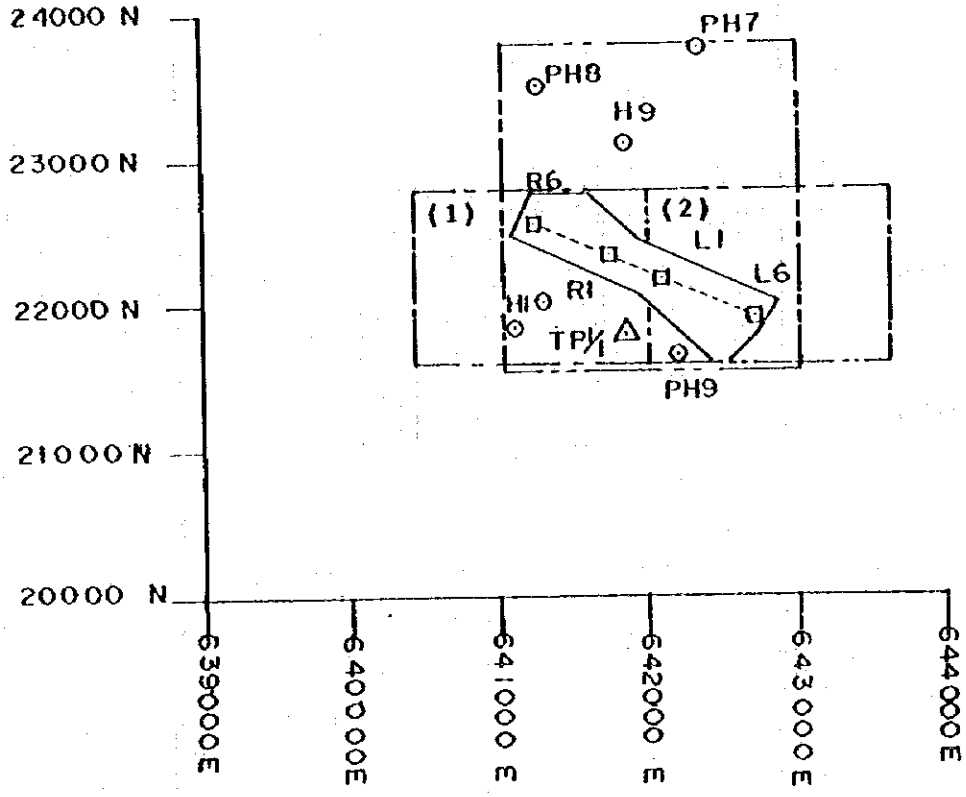
JAPAN INTERNATIONAL COOPERATION AGENCY

Rambula damsite

Photo Scale	:	1:12,500
Photo No.	:	140 -142
Mapping Scale	:	1: 2,000
Mapping Area	:	0.47 sq.km



LEGEND

- Mapping Area in Scale 1:2,000
- Sheet Size : A1 Size
- Coverage of Aerial Photo
- Profile Section Line of Axis of Dam
- △ Permanent Points
- ⊙ Photo Control Points
- ⊡ Profile Points

S= 1:50,000

Figure K4.13

Photo Control and Mapping Diagram of Proposed Rambula Damsite

THE STUDY ON THE NATIONAL WATER MASTER PLAN

JAPAN INTERNATIONAL COOPERATION AGENCY

Gongo damsite

Photo Scale : 1: 9,000
Photo No. : 391 - 392, 87 - 89
Mapping Scale : 1: 2,000
Mapping Area : 0.40 sq.km

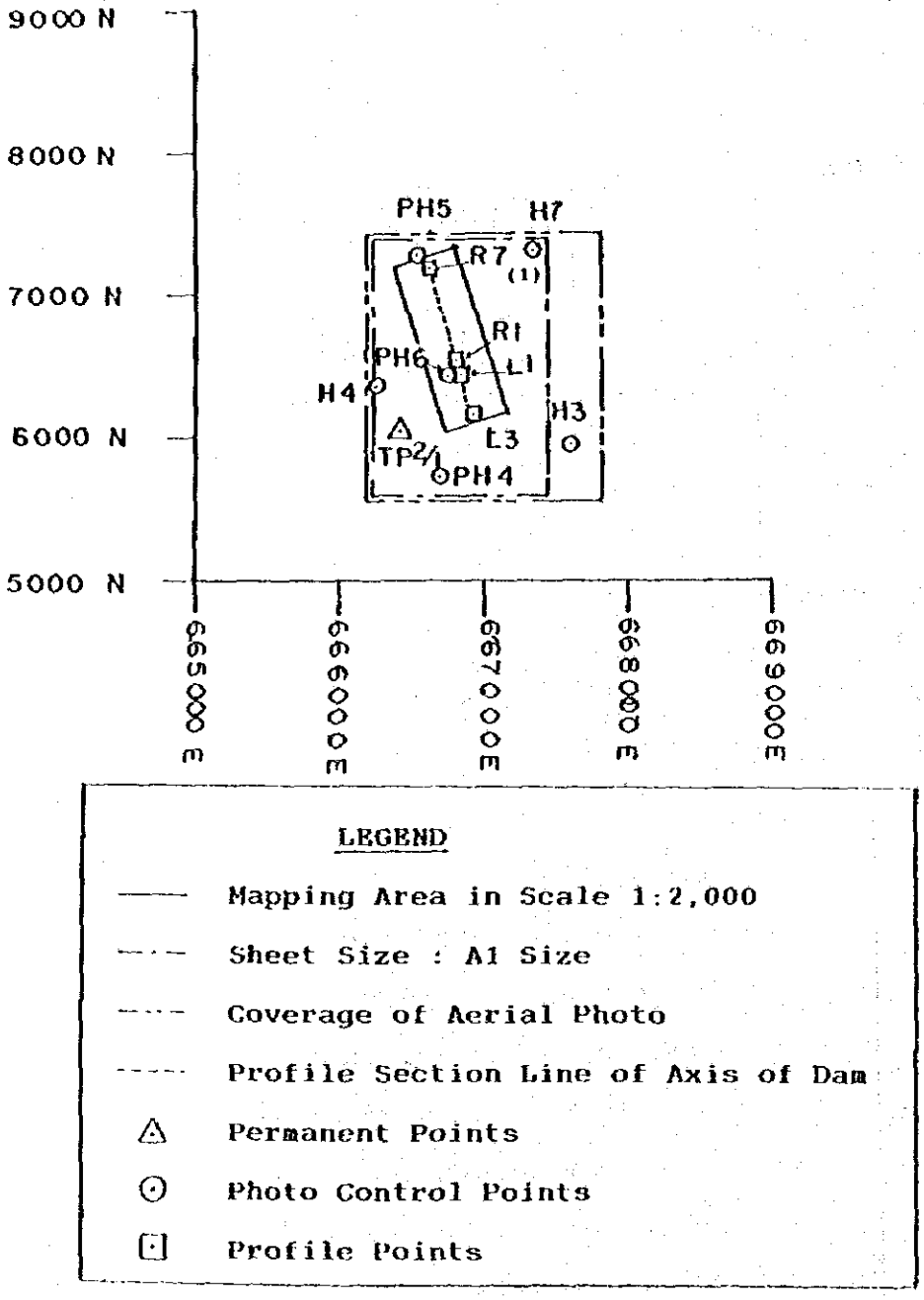


Figure K4.14

S= 1:50,000

Photo Control and Mapping Diagram of Proposed Gongo Damsite

THE STUDY ON THE NATIONAL WATER MASTER PLAN
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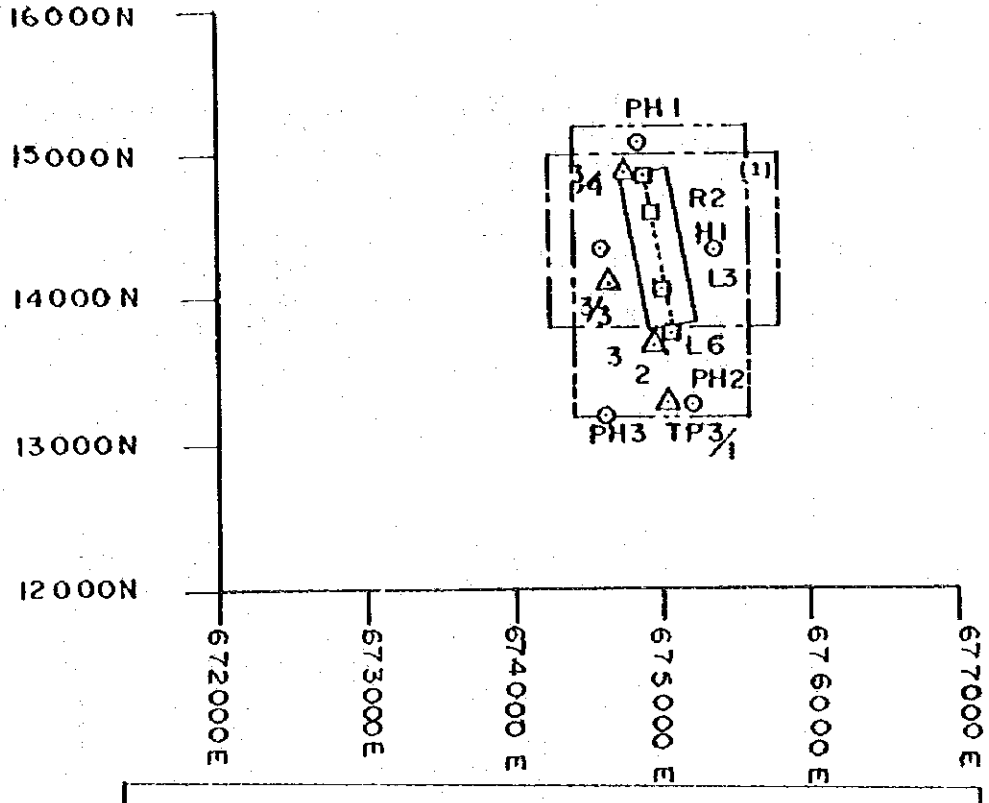
Mushagumbo damsite

Photo Scale	:	1:12,500
Photo No.	:	200 - 201
Mapping Scale	:	1: 2,000
Mapping Area	:	0.22 sq.km



LEGEND

- Mapping Area in Scale 1:2,000
- Sheet Size : A1 Size
- Coverage of Aerial Photo
- Profile Section Line of Axis of Dam
- △ Permanent Points
- ⊙ Photo Control Points
- [·] Profile Points

Figure K4.15

S= 1:50,000

Photo Control and Mapping Diagram of Proposed Mushagumbo Damsite

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JAPAN INTERNATIONAL COOPERATION AGENCY