TECHNICAL NOTE ON THE TOPOGRAPHIC SURVEYING AND PHOTOGRAMMETRIC MAPPING FOR THE FEASIBILITY STUDY ON THE NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT

DECEMBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
FEASIBILITY STUDY TEAM (TOPOGRAPHIC MAPPING)

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1. GENERAL

1.1. PURPOSE

The topographic mapping was schemed to provide base maps for the Feasibility Study on the Nias Island Irrigation Agricultural Development Project. The mapping and the Study conducted by Japan International Cooperation Agency (JICA) were detachedly executed by the Topographic Mapping Team and the Study Team.

The photogrammetric mapping including the aerial photography, the ground control survey and the topographic plotting prepared 1 : 5,000 maps with 1m contour lines covering 120 km^2 of the Study areas.

These operations were carried out by a local survey company, PT. Exsa International and JICA despatched three Japanese engineers, Messrs. H. Goto, S. Sato and T. Watanabe to supervise the survey and mapping operations.

The technical note is prepared to help users of the maps and the survey data to know the survey methods and their accuracy. The aerial photography, surveying and mapping operations, of their members, equipment and instruments, methods, accuracy, results and progress are reported. Procedures of tendering and contract to local contractors are also described.

1.2. PROJECT AREA

The Study areas are in Kabupaten Nias, Sumatra Utara Province approximately 300 km to the south from Medan, the provincial capital city.

The capital of the Kabupaten is Gunung Sitoli locates at the center of the east coast of the island.

The Study areas are scattered along the east coast of the Island from northwest to southeast as follows:

Muzoi Humiaza	2,600 ha	Torowa*	262 ha
Afia	713	Lewuoombanua*	360
To'o Hilimbowo	150		
Ndra Humene	314		
Gido Zebua	1,438		
Mezawa I	2,300		
Mezawa II	3,500		

*The areas covered by the aerial photographs but not by the mapping.

The mapping was to cover each Study area except two areas annotated above. However, in the course of the field study, the Study areas were revised due to the present condition of the areas as follows :

Areas	Changed (ha)	Originally planned (ha)	Increase/ decrease (ha)
Muzoi Humiaza	1,780	2,600	- 820
Afia and To'o Hilimbowo	770	863	- 93
Ndra Humene	314	314	0
Gido Zebua	0	1,438	-1,438
Mezawa 1 & 11	8,151	5,800	+2,351
Total	11,015	11,015	0

An irrigation project conducted by Asia Development Bank (ADB) is presently carrying on in the Gido Zebua area so that the area was excluded from the Study area.

The Muzoi area that includes swampy forest areas, was reduced its Study area from 2,600 ha into 1,780 ha.

These excluded or decreased study areas were added to the Mezawa I and II areas where higher potentiality of the agricultural development was expected.

The mapping areas are geographically situated between 97° 15' and 98°, 1° and 1° 30' N, also included in a Zone 47 of the Universal Transverse Mercator (UTM) rectangular coordinates system with its central meridian corresponds to longitude 99° E.

The terrain features are low, flat and narrow land between mountains and sea shores. Most of the areas are rain fed paddy fields, farms, coconut farms and partially secondary forests. Some of areas in Muzoi and Mezawa are covered by primeval forests and swamps. These areas are shown in Fig. 1.

1.3. SCOPE OF WORK

The scope of work of the topographic survey and mapping is as follows:

1)	1:20,000 aerial photography	: 8 flights lines 57 stereo models
2)	Monumentation for the ground controls	: 19 points
3)	Signalization for the ground controls	: 20 points
4)	Tidal observation to decide mean sea level (MSL)	: 1 point
5)	Traversing to establish horizontal ground controls	: 210 km
6)	Leveling to establish vertical ground controls	: 210 km
7)	Spot leveling for contour lines drawing and spot heights establishment	: 12,000 ha (one point/ha)
8)	Field identification for map compilation	: 12,000 ha
9)	Field completion for maps	: 12,000 ha
10)	Aerial triangulation	: 49 stereo models

11) Photogrammetric plotting : 12,000 ha
12) Editing and fair drawing : 12,000 ha
13) Second originals : 105 sheets (35x3)
14) Blue prints : 350 sheets (35 x10)

1.4 RESULTS

Results of the survey and mapping operations actually performed were as follows :

1)	1:20,000 aerial photography	: 12 flight lines 57 stereo models
2)	Monumentation for ground controls	: 19 points
3)	Signalization for the ground controls	: 24 points
4)	Tidal observation to decide mean sea level (MSL)	: 1 point (1 month) 2 point (1 week)
5)	Traversing for horizontal ground controls	: 223 km
6)	Leveling for the vertical ground controls	: 214 km
7)	Spot leveling and spot height establishment	: 12,000 ha (1 point/ha)
8)	Field identification for map compilation	: 12,000 ha
9)	Field completion	: 12,000 ha
10)	Aerial triangulation	: 10 flight lines 44 stereo models
11)	1:5000 photogrammetric plotting	: 12,000 ha

12) 1:5000 topographic maps
editing and fair drawing : 12,000 ha
13) Original 1:5,000 topographic
maps : 46 sheets
14) Second original 1:5,000 topo- : 138 sheets (46x3)
graphic maps
15) Blue prints 1:5000
topographic maps : 460 sheets (46x10)

2. PREPARATION WORKS

2.1 PLAN OF OPERATION AND SPECIFICATIONS

The Plan of Operation to show details of the field operations, previously drafted by JICA Team were discussed between officials of Directorate of Irrigation I and members of JICA Team.

After being discussed, Plan of Operation was slightly modified and agreed.

Minutes of Meeting of the discussion and modification was signed by the both parties on July 12, 1990.

The Minutes of Meeting and the Plan of Operation are hereto attached as Appendix-1.

General and technical specifications to decide the standard of the surveying and mapping, previously drafted by the JICA Team were also slightly modified in accordance with the Plan of Operation.

The Specifications are based on the Survey Standard for Overseas Development Projects 1982 issued by JICA.

The Specifications were attached to the Tender Documents for local contractors one of whom was to carry out the survey and mapping after winning the Tender.

The Specifications together with the other tender documents are attached hereto as Appendix-2.

2.2. TENDERING AND CONTRACT

For the survey and mapping work was to be carried out by a local survey and mapping company, Tendering to decide the Contractor was carried out. The procedures were as follows:

1) A short list of the candidates for the Tender was issued by the Directorate of Irrigation I.

2) Qualification data of the candidates were requested by the JICA Team and submitted by the candidates.

3) The tender documents consisted of Invitation for Tender, Instruction to Tenderers, Form of Tender, Form of Agreement, Performance Guarantee Forms and Specifications were given to the candidates and the explanation was done by the JICA Team.

4) Technical and cost proposals were submitted by the candidates to the JICA Team.

5) Evaluation of the proposals was done by the JICA Team and the evaluation report* was submitted to the Directorate of Irrigation I and JICA offices.

6) After negotiation, the Project was given to PT. Exsa International Co., Ltd. who got the highest point of the technical proposal evaluation and offered the lowest cost estimation.

* The Evaluation Report is attached hereto as Appendix-3.

While waiting for the final approval by JICA Head Office, Notice to Proceed to start the preparation of operations was issued to the Contractor by the JICA Team.

The letters and documents concerning the Tender and Contract are attached hereto as Appendix-4.

2.3 APPLICATION OF PERMISSION

1) Security clearance for aerial photography

Official letters to apply the security clearance for the aerial photography was issued and sent by the Direktorat Irigasi I through Bina Program Pengairan to SURTA ABRI on July 16, 1990 and the permission was got on August 14, 1990. The Permission Form is attached hereto as Appendix-5.

2) Permission to use survey data

An official letter to get permission to use existing survey data concerning ground control survey in the Nias Island was issued and sent by Direktorat Irigasi I to BAKOSURTANAL through Bina Program Pengairan on July 16, 1990.

Reply from BAKOSURTANAL on August 13 informed that ground controls data of GPS stations existing in the Nias Island were still under processing and were not available. However, the doppler satellite observation (DSO) data of the stations were ready to be used.

The Direktorat Irigasi I officials and the JICA Study Team discussed and agreed to use the DSO data for the reference of survey and mapping in the Nias Island.

These letters are attached hereto as Appendix-6.

2.4. MOBILIZATION, FIELD BASES AND EQUIPMENT TESTS

1) Mobilization

To mobilize Japanese members of the JICA Team to the field, Surat Keterangan Jalan (traveling permit) was applied and obtained to and from POLRI, Jakarta and approved by POLRI, Medan.

For the mobilization of members of Exsa Survey Team, Surat Keterangan Jalan was issued by Direktorat Irigasi I. Members of the Exsa Survey Team and their equipment are shown in Appendix-7.

2) Field bases

The JICA Team set up an office space in Wisata Hotel and the living accommodation in Wisma Soliga in Gunung Sitoli as the field operations bases.

The Exsa Survey Team also set up an office and living quarters in Wisata Hotel. The surveyors sometimes used flying camps in the fields when they worked in remote areas.
Two 4-wheel drive vehicles and motorcycles were used for the Team's transportation facilities.

3) Accuracy tests of survey equipment.

Before beginning the field surveying, accuracy of the equipment such as automatic levels, theodolites and Electro-optical Distance Meter (EDM) were throughly tested and adjusted, so that the instrumental errors might be avoided.
The testing and the results are shown in the report attached hereto as Appendix-8.

3. AERIAL PHOTOGRAPHY

3.1. AREA

Areas covered by the aerial photography were slightly wider than mapping areas. Areas in Torowa and Lewuoombanua were covered by the aerial photography though they were not used for the topographic mapping.
Although the area was later excluded from the Study, Gido Zebua area was also covered by the aerial photography.
The total area covered by the aerial photography were slightly over 20,000 ha. These areas and flight lines are shown in Fig. 2.

3.2. MEMBERS, EQUIPMENT AND MATERIALS

Members carried out the aerial photography were as follows :

Exsa air crew
Pilot : Mr. Jahron Burhani
Mechanic : Mr. Ganda
Navigator : Mr. Maryadi
Cameraman : Mr. Sbaryanto

Indonesian Air Force
Security officer : Peltu Ik. Gitra

JICA Expert : Mr. H. Goto

Equipment, instruments and materials used for the aerial photography were as follows:

Aircraft : Beechcraft S-18, Call sign PK-BIH
Camera : Zeiss MRB 15/23x23 lens f=152,22mm
Filter : Yellow
Film : Kodak double-X Aerographic film 2450

3.3. METHOD

3.3.1. AIR BASE

An air base for the aerial photography could have been chosen from the Polonia Airport in Medan, the Binaka Airport in Gunung Sitoli, Nias or the Tobin Airport in Padang.

The Binaka Airport* was the most convenient for the operations but the runway (800m) was too short and additional fuel supply was not available.

Though fuel availability was sufficient enough, the fyling route from Medan to Nias Island must be over the Sumatran Mountains as high 3,000m. The access was difficult especially in cloudy weather conditions.

Although farthest from the areas, the Tobin Airport was chosen out of the three because of the facilities availability and easy access (the route is over the sea) to the areas.

* Regular flights from/to Medan were operated by SMAK once a day with maximal passengers of 15 and from/to Padang once a week (Tuesday) with maximal passengers of 6, as of the time the Project was carried out in 1990.

The long distance (approximately 300 km) between the air base and the areas caused difficulty in assessment of the weather conditions of the areas on which the operations execution depended.

3.3.2. AERIAL PHOTOGRAPHY

The vertical aerial photography at a scale of approximately 1:20,000 was carried out by the crew and with the equipment described above.

The flight operations were frequently interrupted by engine troubles of the aircraft but weather condition was favourable and within 18 days the aerial photography was completed.

Before leaving the air base, all the films were developed and test printings were done, so that adequency of the coverages over/and side/laps, clearness of photo images and instrument panel etc. were confirmed.
The operations records to show details of the aerial photography are attached hereto as Appendix-9.

3.3.3. PHOTO PROCESSING.

After being approved by the Security Officer, photo printing was done to prepare necessary materials for the topographic mapping. Materials prepared for the each working stage were as follows :

1. Two sets of contact prints, one for the pricking of level points, another for field investigation by the JICA Feasibility Study Team.

2. One set of four times enlargements for the spot leveling and the field identification.

3. One set of dia positive for the aerial triangulation and photogrammetric plotting.

3.4 APPRAISALS OF AERIAL PHOTOGRAPHS

Quality of the aerial photographs, especially their suitability for the photogrammetric measurement and plotting was appraised as follows :

Run No.	Min. E.Lap	Min. S.Lap	Spot/ Haze	Clouds/ Shadows	Inst. Panel	Remarks
1	60%	18%	0	0	ok	

Run No.	Min. E.Lap	Min. S.Lap	Spot/ Haze	Clouds/ Shadows	Inst. Panel	Remarks
1	64%	80%	0	0	ok	Supplement to Run-1
2	60	18	0	One small spot	-	
3	60	30	0	0	ok	
4'	60	30	0	Ten spots	ok	Supplement to Run-3
4	60	29	0	One small spot	ok	
5	60	29	0	0	ok	
6	60	-	0	0	ok	
7	60	-	0	One spot	ok	
7'	60	-	0	Four spots	ok	Supplement to Run-7
8	60	25	0	One small spot	ok	
9	65	25	0	Four small spots	ok	

3.5. RESULTS

The results of the aerial photography are as follows :

Run No.	Photo. No.	Sheets	Remarks
1	1 - 7	7	
1'	1 - 2	2	Supplement to Run-1
2	1 - 7	7	
3	1 - 9	9	
4'	1 - 7	7	Supplement to Run-3
4	1 - 8	8	
5	1 - 4	4	
6	1 - 9	9	
7	1 - 7	7	
7'	1 - 2	2	Supplement to Run-7
8	1 -12	12	
9	1 -11	11	

These flight lines and the run number are shown in Fig. 2.

4. GROUND CONTROL SURVEY

4.1. MONUMENTATION

4.1.1. LOCATION

Nineteen (19) concrete monuments were built to establish vertical and horizontal ground controls for the aerial photogrammetric mapping. The location were chosen to be most effective to carry out the aerial triangulation as well as the observation and measurement of the traversing and leveling. Addition to these monuments, three (3) supplemental points were monumented at the proposed dam sites in Mezawa area. These code number and the location are shown in Fig. 3.

4.1.2. MEMBERS AND METHODS

Members carried out the monumentation were :

Messers. Mulyadi, Apep Supriatna, Ayi Sodikin assisted by several local labors and a 4-wheel drive vehicle.

The procedures to build the monuments were :

1. Casting concrete monuments
   The concrete monuments were casted in the base camp in the sizes and dimensions specified in the Specifications. Plaques on which code number were engraved were attached to the side of the monuments and iron bolts to show the horizontal and vertical positions were projected on top of the monuments.

2. Selection of location
   The location were selected in the actual fields due to the lack of adequate scale of maps*.

3. Building the concrete monuments
   The monuments were built at the chosen points and the descriptions were prepared at the sites. This includes

photography of the monuments and their surroundings, off-setting and sketching of the sites.

* So that the code number of the monuments were not so systematically decided but it did not cause any difficulty to the following stages of work.

4.1.3. RESULTS

The results of the monumentation and their horizontal and vertical position were shown in Table 1.

The UTM coordinates shown in the table were originated from the existing GPS stations D-956, D-957 and D-953 and established by the traversing of which details are to be described in the following chapter.

The elevation shown in the table were originated from the tidal observation of mean sea level at Gunung Sitoli Port and established by the leveling of which details are to be described in the following chapter.

4.2. SIGNALIZATION

4.2.1. LOCATION

To show the exact position of the ground controls to the aerial photographs, photo signals or pre-marks were attached to the ground controls and/or their eccentric points. The location and code number were shown in Fig. 3. Addition to the nineteen (19) ground controls, five (5) supplementary points necessary for the aerial triangulation were also signalized.

4.2.2. MEMBERS AND METHODS

Members carried out the signalization were :

Messrs. Mulyadi, Apep Supriatna, Ayi Sodkin assisted by several local laborers and a 4-wheel drive vehicle.

The signals or premarks consisted of three white plywood panels in sizes of 40cm x 150cm were radially set up surrounding the bench marks and/or their eccentric points. Descriptions including the photos, off-sets and sketches of the signals were prepared for the aerial triangulation.

4.3.2. RESULTS

The results of the signalization and their horizontal and vertical positions were shown in Table 1.

Origine of these horizontal and vertical coordinates were same to those of the bench marks.

The slight difference in the coordinates between bench marks and the signals mean that the signals were attached to the eccentric points.

4.3. TIDAL OBSERVATION

4.3.1. LOCATION

There were no existing bench marks to show an accurate elevation from mean sea level (MSL) in the Nias Island. To decide a datum elevation for the surveying and mapping, the tidal observation was carried out at three stations in Gunung Sitoli, Botohaenga and Sawo. The location are shown in Fig. 3.

4.3.2. MEMBERS AND EQUIPMENT

Members carried out the tidal observation were :

At Gunung Sitoli station:

Messers. Ayi Sodikin, Yanto Heliyanto, Mulyadi, Apep Supriatna, Dedi Supriadi, Wasiman and Harja Gunawan.

The members worked 12-hour shift 24 hours a day for one month from 8 Auguts through 6 September 1990.

At Sawo station :
Messers. Harja Gunawan and Tata Supriyadi.
The members worked 12-hour shift 24 hours a day for one week from 20 through 26 August 1990.

At Botohaenga station:
Messers. Ayi Sodikin and Apep Supriatna.
The members worked 12-hour shift 24 hours a day for one week from 25 through 31 August 1990.

The equipment used for the tidal observation were tide poles graduated 5mm intervals.

4.3.3. METHODS

Tidal poles (4 meters long) were set up at the sea shores. At every one hour 24 hours a day, levels of the sea water at the stations were manually observed by the surveyors.
To minimize the errors caused by waves, each observation consisted of several times measurements in its highest and lowest water levels. Mean level of the highest and lowest was adopted as the observations at the time.
The tidal observation was carried out at the Gunung Sitoli stations as a master station for one month, at the Sawo and Botohaenga stations as slave stations for one week. The mean sea level was decided by the data from the master station and confirmed with the data from the slave stations by connecting the stations by leveling.

The tidal observation station at Gunung Sitoli was connected to a bench mark, PUN BM-1 by leveling.
The tidal observation stations at Sawo and Botohaenga were connected to leveling points D-15 and 17-4 respectively by leveling.
Computation of MSL was done in the following manner.

1. Totals of highest sea levels (these occured usually two times a day) were divided by a number of times it occured and the monthly or weekly mean highest sea levels were obtained.

2. Totals of the lowest sea levels (these occured usually two times a day) were divided by a number of times of it occured and the monthly or weekly mean lowest sea levels were obtained.

3. The monthly or weekly highest and lowest mean sea levels were added and divided by 2 and the monthly or weekly mean sea levels were obtained.

4.3.4. ACCURACY

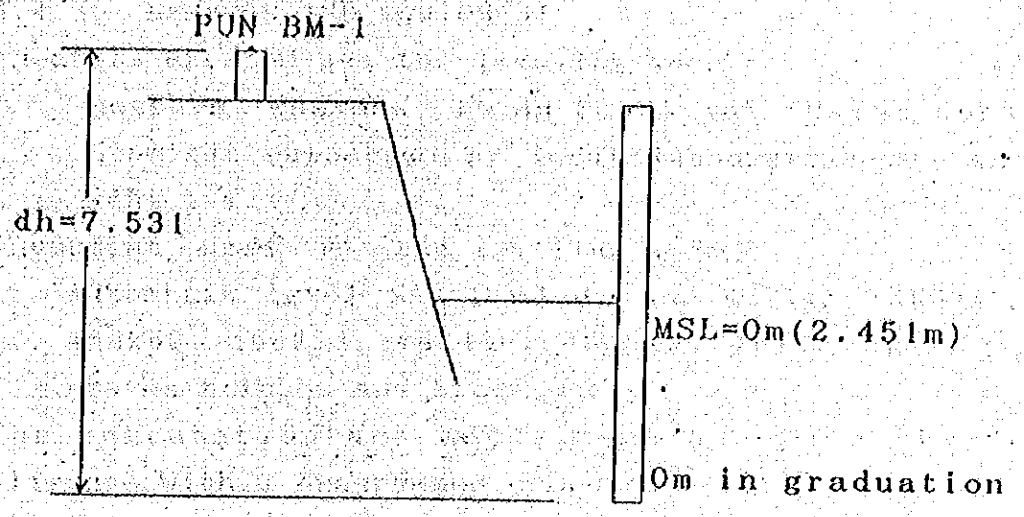
The accuracy of the tidal observation at the Gunung Sitoli station was compared and confirmed with the two slave stations' data at Sawo and Botohaenga as follows:

Point Code	Height by tidal observ.	Hight by leveling	Residual (cm)
PUN BM-1	5.080m	-	-
D-15	1.713	1.632	8.1
17-4	1.106	1.190	8.4

The MSL data at the slave stations were used only for the confirmation of accuracy. All the elevation data used for the survey and mapping are derived from the MSL at Gunung Sitoli Seaport in Nias Island.

4.3.5. RESULTS

The tidal observation station established at the Gunung Sitoli Seaport and its connected bench mark PUN BM-1 had a vertical demension as follows :



Elevation of the PUN BM-1 was determined as follows :

H= 7.531 - 2.451=5.080m

4.4. LEVELING

4.4.1. DATUM ELEVATION

There were no existing bench marks with accurate elevation above mean sea level in the Nias Island. To provide datum elevation for the surveying and mapping for the Feasibility Study, tidal observation to determine mean sea level (MSL) at Gunung Sitoli Seaport was carried out by the Exsa Survey Team. The datum elevation for the survey and mapping of the Project derives from the MSL as Om at Gunung Sitoli Seaport. Details of the determination of MSL by the tidal observation were described in the previous chapter.

4.4.2. LEVELING ROUTE

The leveling routes totaling 214 km to establish vertical control for the survey and mapping were shown in Fig. 4. All the routes were started from one reference point, PUN BM-1 of which elevation was determined from MSL at Gunung Sitoli Seaport.

4.4.3. MEMBERS AND EQUIPMENT

Members carried out the leveling were :

Messers. Wasiman, Tatan Supriyadi, Harja Gunawan, Adi Supriadi supported by local labourers and 4-wheel drive vehicles.

Equipment used for the leveling were :

Automatic level NAK-1 wild, No. 457745, 466381, 442638, 456262, 468253, 466466, 466313, 467731 with 4m wooden staves tripods and staff bases.

The computation and adjustment were done by Mr. Yanto Hliyanto with a programmed computer set.

4.4.4. METHODS

The leveling was started at a bench mark, PUN BM-1, connected all the ground control points (PUN-1 ~ PUN-18), GPS station and

TBM at proposed weir sites and ended on the PUN BM-1 again.

Double run measurement in an independent go and back method was applied to all of the leveling.

Accuracy of the leveling were detected by discrepancy in go and back measurements. When the discrepancy were negligible according to the Specification, mean values were used to determine the elevation of ground controls.

To strengthen the vertical control of the aerial triangulation, spot elevation approximately 1 km interval along the leveling routes were measured and pricked on the aerial photographs.

These spot elevation were shown with wooden pegs in the field and also used for reference to the spot leveling.

4.4.5. ACCURACY

For only a bench mark established by mean sea level at Gunung Sitoli were used as a reference for the leveling, accuracy of the leveling were checked by the residuals in go and back measurement.

The distances and residuals between bench marks were as follows:

From	To	Dist.	go	back	Resid.	10 $\sqrt{S}$
		km	m	m	mm	mm
BM-01	PUN-01	12.5	+ 2.583	- 2.580	3	35
PUN-01	PUN-04	4.1	+84.881	-84.874	7	20
PUN-04	PUN-02	9.5	+90.783	-90.773	10	31
PUN-02	PUN-03	4.1	+ 7.561	- 7.525	36	20
PUN-03	D-957	32.7	- 7.907	+ 7.953	46	57
D-957	PUN-14	2.2	- 1.055	+ 1.045	10	15
PUN-14	PUN-13	9.6	- 0.093	+ 0.103	10	31
D-957	PUN-12	15.3	+ 0.768	- 0.764	4	39
PUN-12	PUN-13	11.5	- 1.892	+ 1.896	4	34
BM-01	PUN-05	9.1	+ 4.800	- 4.775	25	30
PUN-05	PUN-07	4.0	- 8.744	+ 8.729	15	20
PUN-07	PUN-06	1.7	+10.553	-10.566	13	13
PUN-05	PUN-06	3.6	+ 1.819	- 1.815	4	19
OUN-06	PUN-08	5.5	- 2.106	+ 2.111	5	23
PUN-08	D-956	2.1	- 3.471	+ 3.468	3	14
PUN-956	PUN-10	5.7	- 4.458	+ 4.456	2	24
PUN-10	PUN-09	8.1	+14.769	-14.745	24	28
PUN-09	PUN-11	9.2	+18.660	-18.646	14	30
PUN-11	PUN-15	14.1	-34.022	+34.025	3	38
PUN-15	PUN-16	6.6	+ 0.631	- 0.629	2	26
PUN-16	PUN-17	3.8	+ 2.464	- 2.482	18	19
PUN-17	PUN-18	6.3	-10.302	+10.291	11	25

4.4.6. RESULTS

The leveling established elevation of 18 bench marks, PUN-1 ~ PUN-18, two GPS stations, D-957 and D-956 and three temporary bench marks, TBM-Gawo, TBM-Mezawa and TBM-Mola, totaled the distance of 214 km.

Elevation of these points are shwon in Tabl. 1.

4.5 TRAVERSING

4.5.1. PROJECTION, COORDINATES SYSTEM AND REFERENCE

Projection and coordinates system applied to the traversing were a plane rectangular coordinates system, Universal Transverse Mercator (UTM).
The specifications are as follows:

Projection	:	Silindorical, transversal and conformal
Spheroid	:	WGS 69 with a=6,378,160 m and F = 1:298.247
Zone	:	No. 47 with longitude of 99° E as the central meridian
Origine	:	99° E on the central meridian for X (easting) and the Equator for Y (northing)
Scale factor	:	0.9996 at the central meridian

Reference of the traversing were three Global Positioning System Stations (GPS station) existing in and around the Study areas. These stations, D-956, D-957 and D-953* were established by BAKOSURTANAL in 1989. Although the coordinates data of these GPS Stations were still under processing and not available as of September 1990, the positions of these stations were determined by the Doppler Satellite Observation and available to be used.

*D-953 was already destroyed as of August 1990.

After having discussed and agreed between Direktorat Irigasi I and JICA Study Team, DSO data of the stations were used for the reference of the traversing. The DSO data of the stations are as follows:

Geographic data :

	Longitude	Latitude
D-956	97° 41' 20" .880	1° 09' 56" .917
D-957	97° 21' 01" .913	1° 29 15" .695
D-953	97° 55' 55" .644	0° 56' 12" .427

UTM. Coordinates data :

	X (easting)	Y (northing)
D-956	366,004.717m	128,890.770m
D-957	316,490.717	164,504.302
D-953	381,180.489	103,561.467

Reference azimuth for the traversing was calculated from the coodinates of D-956, 957 and 953. Solar azimuth observation at some stations were carried out to check accuracy of angle observation of the traversing but adjustment to the solar azimuths were not done. The details of the azimuth determination are discussed in article 4.5.4.

4.5.2. TRAVERSING ROUTES

The traversing consisted of eight fixed routes and one open route, totaled 223 km to determine horizontal positions of eighteen bench marks and several premarks.
The routes and their code, reference points, bench marks and stations where the solar azimuth observation were carried out are shown in Fig. 5.

4.5.3. MEMBERS AND EQUIPMENT

Members carried out the traversing were :
Messrs. Maya Sumarya, Sobur, Kodiran
and Dedi Supriadi

Equipment used for the traversing were :
Theodolites : T2 Wild No. 464002 and 229446
with tripods
EDM. : Red 2A Sokkisya No. 26016
Red 2L Sokkisya No. 25303
with reflectors, tripods, barometers
thermometers and other accessories.

The computation and adjustment were carried out by Mr. Yanto Heliyanto with personal computer with programme discs and a printer.

4.5.4. METHODS

Before starting the field operations, the EDMs and theodolites were tested and adjusted so that instrumental errors hardly affected the accuracy of observation. The details and the results are attached hereto as Appendix -8.

The main traverse routes No. 1 and No. 5 were started at D-956 and ended on D-957 and D-953 respectively. The other routes were started at and ended on stations established by the main traversing.

The traversing established horizontal positions of becnh marks PUN-1 ~ PUN-18, PUN BM-1 and several premarks, totaled 223 km in its distance.

The measurement and observation were done in the following manner.

Distance measurement:
Three times measurement at every turning point

Horizontal angle observation:
Two sets of observation at 0° and 90°
One set consisted of left and right faces.

Vertical angle observation:
One set of observation consisted of left and right faces.

Correction to the measured distances was applied in the following manner:

Slope correction:
The measured slope distances reduced to the horizontal distance with vertical angles.

Scale factor correction:

Scales factor for the each traverse route was computed and the correction applied to the measured distances. The computation was done as follows:

$m = m_o (1 + x^2/2r^2 m_o^2)$

m_o : Scale factor at the central meridian

x : Mean value of X coodinates at the starting and the ending points of the route

r : Radius of mean curvature, $r = \sqrt{MN}$

For the areas were low and flat, mean sea level correction to the distances were not applied.

For the reference azimuth was computed from UTM, coordinates of the GPS stations and used for the traversing, the meridian convergencies were computed only at stations where the solar azimuth observation was carried out.

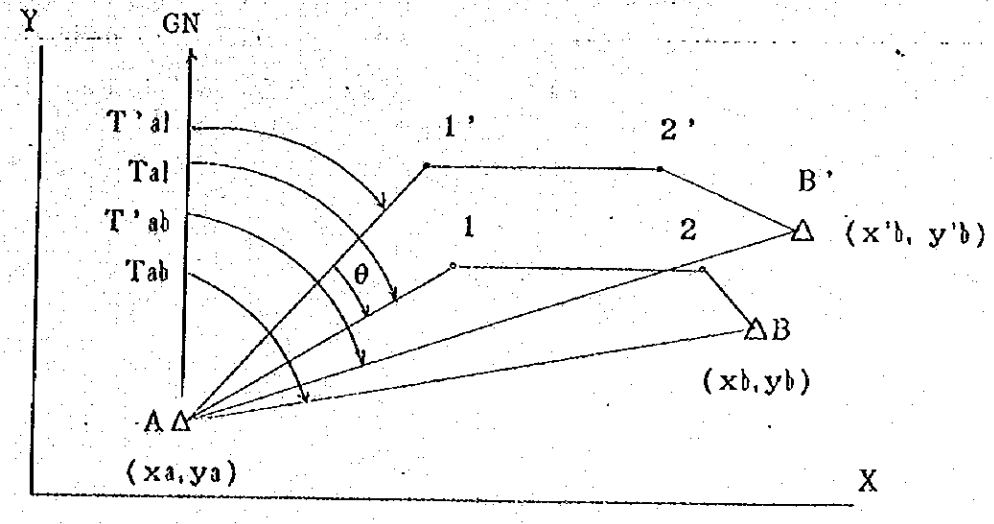
The computation of the meridian convergency was :

$\gamma = (\lambda - \lambda_0) \sin \phi$

λ: Longitude at the point ϕ: Latitude at the point

λ_0: Longitude at the central meridian

To conform to the GPS station coordinates system, the reference azimuth was computed from the coordinates of D-956 and 957. The computation were as follows:



Known factors:

A : (xa, ya) coordinates of starting station

B : (xb, yb) coordinates of ending station

Distance and horizontal angle between the stations

To know Tai azimuth from A to 1 :

T' ab = Arc tan (x b' - xa/y'b - ya)

where T'ab is a temporarily decided azimuth from A to B'

Tab = Arc (xb - xa/yb - ya)

where Tab is azimuth from A to B

Θ = Tab - T'ab Θ is correction for temporary azimuth, Tab = T'ab + θ

Some premarks for aerial triangulation together with the bench marks were measured and observed by the traversing.

4.5.5. ACCURACY

Accuracy of the traversing in each route were as follows:

Routes* No.	Dist. km	No. of point	No. of angle	Misclosures 10" $\sqrt{N}$	Linear	Ratio**
1	73.7	232	0	152	6.835	1:10,780
2	31.9	92	49	95	0.760	1:42,039
3	12.5	73	32	85	0.407	1:30,788
4	5.2	19	49	43	0.360	1:14,474
5	53.1	144	0	120	-	-***
6	12.8	31	20	55	0.938	1:13,649
7	21.7	98	102	98	0.644	1:33,680
8	9.0	44	83	66	1.841	1: 4,883
9	3.1	2	-	14	-	-***

* Traveersing routes

No.1 : from D-956 to D-957
No.2 : from M-164 to D-957
No.3 : from M-026 to M-030
No.4 : from Am/PUN-05 to PUN -06
No.5 : from K-058 to D-953
No.6 : from D-956 to D-021
No.7 : from D-069 to I-005
No.8 : from I-003 to A-075
No.9 : from M-156 to PUN-13 (Refer to Fig.5)

** Tolerancy for the linear misclosure ratio was 1:10,000
*** Monument of D-953 was already destroyed but the existed position could be detectable. The misclosures were checked by the data but not adjusted to the detected position.
**** The route was an open traverse.

Azimuth difference between the GPS stations coordinates system and the solar azimuth observation were as follows:

Station code	Azimuth by coordinates	Azimuth by solar observ.	Difference
M-118	274° 16' 08"	274° 16' 26"	0° 0' 18"
PUN/BMI	17 29 32	17 26 35	0 2 57
D-956	356 43 36	356 41 36	0 2 6
D-9	309 9 25	309 6 6	0 3 19
AD-42	225 43 22	225 41 35	0 1 47
D-953	286 24 37	286 23 55	0 0 42

4.5.6. RESULTS

The location and coordinates established by the traversing were shown in Fig. 5 and Table -1 respectively.

4.6. SPOT LEVELING

Considering the importance of elevation accuracy for the irrigation project, the spot leveling method to establish spot heights and plot contour lines on the maps was employed instead of the photogrammetric measurement.

4.6.1. AREAS

Areas covered by the spot leveling were approximately 12.000 ha of the mapping areas. Fig. 6 is an index to show enlarged aerial photographs on which the spot heights were plotted and the elvation were shown.

4.6.2. MEMBERS AND EQUIPMENT

Member carried out the spot leveling were:
Messers. Maya Sumarya, Sobur, Kodiran, Dedi
Supriadi, Wasiman, Tatang, Supriyadi
Harja Gunawan, Ade Mukti, Mulyadi,
Apep Supriana and Ayi Sodikin

Equipment used for the spot leveling were:
Automatic levels NAK-1 Wild, No. 457745, 466381, 442638, 456262, 468253, 466466, 466313, 467731 with wooden staves and tripods.

4.6.3. METHODS

The spot leveling was started at and ended on bench marks and reference points established by the leveling discussed in the previous chapter.

Spot heights were measured approximately 100m intervals in the mapping areas. Their location and elevation were plotted and shown on the 1:5,000 enlarged aerial photographs.

In areas such as forests and bushes where no charactaristic terrain features exist, distance and horizontal angles were measured to show the location of the spot heights.

4.6.4. ACCURACY

Residuals of the spot leveling started and ended at the bench marks and reference marks were kept within 5cm. Sighting of the spot heights and plotting on the enraged aerial photographs were carefully done and checked in the fields.

All the computation and the plotting of these spot heights were done twice by the JICA Experts and Exsa surveyors.

4.6.5. RESULTS

Covering approximately 12,000 ha of the mapping areas, the spot leveling established approximately 12,000 spot heights. The spot heights plotted on the enlarged aerial photographs were later transfered to the 1:5,000 topographic maps. The index of the 1:5,000 enlarged aerial photographs is shown in Fig. 6.

5. FIELD IDENTIFICATION AND FIELD COMPLETION

5.1. FIELD IDENTIFICATION

5.1.1. AREAS

Areas where the field identification was carried out were similar to the mapping areas. Index of the enlarged aerial photographs with which the field identification was carried out is shown in Fig. 6.

5.1.2. MEMBERS AND METHODS

Members carried out the field identification were the same members who carried out the spot leveling shown in the previous chapter.

The field identification was carried out to collect data and information difficult to aquire by the photo interpretation yet necessary to compile the 1:5,000 topographic maps. Those were administrative boundaries, names of towns, villages,

rivers, mountains, hills, buildings and facilities for public and official use etc.

The spot leveling teams covered the whole mapping areas to carry out the operation, simultaneously did the field identification. All of the identified and collected data and information were shown on the enlarged aerial photographs.

5.1.3. RESULTS

The areas approximately 12,000 ha were covered by the field operations and the results were shown on the enlarged aerial photographs. All of the data and information shown on the photographs were transfered to the blue prints of plotting manuscripts and later to the original maps.

5.2. FIELD COMPLETION

5.2.1. AREAS

Areas where the field completion was carried out were similar to those of the spot leveling and the field identification. The total areas were approximately 12,000 ha.

5.2.2. MEMBERS AND METHODS

Members carried out the field completion were:

Messers. Wasiman, Tatang Supriyadi, Harja Gunawan and Ade Mukti.

The field completion was carried out in the following manner.

1. Blue print of plotted manuscripts were prepared.
2. All the information collected by the field identification were shown on the blue prints.
3. Additional information supposed to be necessary for the topographic maps were suggested on the blue prints.

4. Surveyors carried the blue prints to the fields and confirmed or corrected the plotting or collected additional information.
5. All of the correction and collected information were later transfered to the original topographic maps.

As the aerial photography was done immediately before the mapping, updating for the maps were not necessary and were not carried out.

5.2.3. RESULTS

The topographic maps covering 12,000 ha were completed in the fields and proceeded to the drawing.

6. PHOTOGRAMMETRIC MAPPING

6.1. AERIAL TRIANGULATION

6.1.1. AERIAL PHOTOGRAPHS

1:20,000 scale aerial photographs taken with an aerial camera Zeiss MRB 15/23x23* for this project were used for aerial triangulation. Aerial tirangulation was executed by four (4) blocks due to the reason of scattered mapping areas.
Fourty four (44) stereo models in ten (10) flights lines of the aerial photographs were used for this aerial triangulation to cover 120 km^2 topographic mapping. The block number, names of areas, number of flight lines, number of stereo models and number of horizontal and vertical ground control points are shown in Table 2.

*The camera equipped with Aviogon lens of which the focal length was 152.22mm and the format was 23cm x 23cm.

6.1.2. AREAS AND STEREO MODELS

The aerial triangulation to establishe photo control points for every stereo model was carried out to cover the topographic mapping areas. The flights lines, stereo models, vertical and horizontal ground controls are shown in FIG. 7-a, b, c, d.

6.1.3. MEMBERS AND INSTRUMENTS

Engineer carried out the aerial triangulation were:

Photo points selection : Mr. Mawardi, Mr. Mufraim Dahlan
Precision pricking : Mr. Mawardi, Mr Mufraim Dahlan
Computation : Ir. Sofyan Zainal and Mr. Abdul Fatah

Instruments used for the aerial triangulation were :

Precision photo pricking device: Wild PUG-4, No. 4084
Stereo comparator : Zeiss Stecometer-C, No. C-247389
with Coordimeter-D
Electronic computer: HIMMEL 70MB, No. 6220-01
with a programme package for block adjustment Pat-M-R.

6.1.4. METHOD

Analytical aerial triangulation to establish photogrammetric controls such as pass points and tie points for each stereo model and for each stereo strip respectively was carried out for the 44 stereo models in 10 flights lines of aerial photographs.

Three pass points to control each stereo model were chosen on every photo, so that six points were established in every stereo model.

Two tie points were chosen in side lapped areas of every stereo model to tie the neighboring stereo strips.*

* Upper most and lower most stereo strips have only one tie point in their each stereo model.

The pass points and tie points together with the horizontal and vertical ground controls were precisely pricked on the dia positives of the aerial photographs with PUG-4.

All the pass points, tie points, horizontal and vertical ground controls together with fidisual marks of the aerial camera were stereo scopicly observed and measured their photo coordinates in the dia positives with the stereo comparator.

Restitution parameters of stereo models and stereo strips were computed with the photo coordinates data.
Inclination and scales of stereo strips were rectified by the horizontal and vertical ground control coordinates data with the block adjustment method by the PAT-M-R program package.

Nineteen (19) horizontal and one hundred and fourteen (114) vertical ground controls were used for the rectification.

6.1.5. ACCURACY

Residuals of the horizontal ground controls after the block adjustment was applied are shown in Table 3. Maximum of the residuals in the horizontal control are shown in Table 4.

Residual of the vertical ground controls after the block adjustment was applied are shown in Table 5. Maximum of the residuals were - 0.528 m in Block -IV and standard deviation of the residuals in the vertical control are shown in Table 4.

6.1.6. RESULTS

The analytical aerial triangulation resulted the pass points and the tie points for the 44 stereo models in the 10 flights lines. These results consisted of items as follows:

1. List of the aerial triangulation results
2. Index of the aerial tirangulation stereo models

3. Fifty four sheets of dia positives on which the pass points and tie points were precisely pricked.
4. Fifty four sheets of contact prints on which the pass points and tie points were shown.
5. Accuracy control results.

6.2. PHOTOGRAMMETRIC PLOTTING

6.2.1. GRID AND COORDINATES SYSTEMS

Grids and coordinates adopted for the plotting were Universal Transverse Mercator (UTM), Zone 47. The datum elevation for the vertical information such as contour lines and spot heights was mean sea level at Gunung Sitoli harbour decided by the tidal observation of this project.

6.2.2. PLOTTING AREA

The plotting area corresponded to the mapping areas shown in FIG. 8 and 9-a,-b. By the request from the Feasibility Study Team, shape of rivers, coastral lines and roads outside of the mapping areas are drawn to facilitate the Study.

6.2.3. MEMBERS AND INSTRUMENT

Operators carried out the photogrammetric plotting were:

Mr. Wawan Gunawan and Mr. Suparman

An instrument used for the photogrammetric plotting was :

Autographs A8 Wild No. 1466

6.2.4. METHODS

Photo control points such as pass points, tie points, bench marks together with 0.5 km intervals grids of UTM, were plotted at a scale of 1:5,000 on the # 300 polyester bases. The plotting of grids and points was done with the Calcom plotter No. 1043.

Relative and absolute orientations of the stereo models were done by using the pass points, tie points and bench marks. After restitution of the stereo models was completed, every natural and artificial terrain features such as roads, buildings, houses, land use and vegitation etc, were carefully plotted on the polyester bases.

Although spot heights and contour lines were plotted by the field spot leveling, their photogrammetric plotting were also done to check accuracy of each other.
The number of stereo models to cover the whole mapping areas were 44.

6.2.5. ACCURACY

To check accuracy of the plotting tables of the stereo plotter, X and Y directions were compared in their rectangualrity and graduational uniformity. The difference was within 0.1 mm.

Results of the absolute orientation of each stereo model were checked and recorded in a recording form. The residuals in the horizontal controls and in the vertical controls were within 0.1 mm and 0.9 m respectively.

The plotting manuscripts were checked with the four times enlarged aerial photographs so that features failed to be plotted were easily found and supplemented. Plotted spot heights were checked with the spot heights surveyed in the field.

6.2.6. RESULTS.

The following items were prepared by the photogrammetric plotting:

1. 29 sheets of plotting manuscrips (60cm x 80 cm) covering approximately 120 km^2.
2. 44 sheets of orientation recording forms (1 sheet for one stereo model)

6.3. EDITING

6.3.1. AREAS AND MAPPING SHEETS

Areas and mapping sheets corresponded to those of the photogrammetric plotting are shown in FIG. 8 and 9-a,b.

6.3.2. MEMBERS AND MATERIALS

Editors carried out the editing were:

Messrs. Sudarman, Baharusin Lubis, Yockie Priadi, Dien Mardenwati, Mufraini, Sugiyo, Rahman Saptani, Mursyamsidi

Materials used for the editing were the map manuscripts prepared by the photogrammetric plotting. The editing was done with pencils of several colors.

6.3.3. METHODS

The editing consisted of several works items as follows:

1. To attach annotations and map symbols to the map manuscripts.
2. To transfer all the information collected by the field identification and the field completion to the map manuscripts.
3. To transfer the spot heights obtained by the field spot leveling from the enlarged aerial photographs to the map manuscripts.
4. To draw contour lines of 1 m intervals referring to the spot heights and photogrammetric plotted guiding contour lines of 2.0 m intervals.

6.3.4. RESULTS

After completion of the editing, 29 sheets of plotting manuscripts were turned into the pencil manuscripts of the original topographic maps.

6.4. DRAWING AND REPRODUCTION

6.4.1. AREAS AND MAPPING SHEET

Areas where the fair drawing was carried out corresponded to those of the plotting areas. The marginal information, sheets size and so on were decided by the cooperation with the staff of Direktorat Irigasi I based on the standard of the Ministry of Public Works.

Total number of sheets increased from the original plan due to the reason of the sheet size (original plan is 60 cm x 80 cm, final sheet size is 50 cm x 50 cm) and the additional mapping for the shape of rivers, coastral lines and roads by the request from the Feasibility Study Team.

The number of sheets, mapping areas, names of areas and block No. are as follows:

Block No.	Name of area	Mapping area	Number of sheets
Block I	Muzoi Humiaza	1,780 ha	11 sheets
Block-II	Afia and To'o Hiumbowo	770 ha	4 sheets
Block-III	Ndra Humene	314 ha	4 sheets
Block-IV	Mezawa-I and Mezawa-II	9,136 ha	27 sheets
Total		12,000 ha	46 sheets

6.4.2. MEMBERS AND MATERIALS

Tracers carried out the fair drawing were:

Messrs. Sudarman, Baharudin, Luibis, Yockie Priadi, Dien Madenawati, Mufraini, Sugiyo, Rahman Saptani, Nursyamsidi.

Drawing instruments were Staedtler drawing pens with black ink. Various thickness of pen points from 0.1 mm to 0.4 mm were used to draw various kinds of lines to show the terrain features.

Annotations and figures for elevation and coordinates were labeled and lettered with lettering templates. Transparent polyester bases # 300 were used for the fair drawing.

6.4.3. METHODS

Maps sheets with marginal information such as title, scale legend, index and so on were prepared by the discussion with the staffs of the Ministry of Public Works.

The map sheet was overlapped onto the original pencil manuscript and every natural and artificial terrain features including ground controls, spot heights and contour lines were carefully traced and fair drawn with pens and black ink.

After the fair drawing finished, blue prints of the fair drawings were prepared and accuracy and adequency of the fair drawings were checked on the blue prints. Mistakes found on the blue prints were checked, confirmed and promptly corrected to complete the original 1:5,000 topographic maps.

Most of the mistakes or inadequency found in the fair drawing were :

1. Some of the vegitation boundaries were failed to be drawn or inadequate symbols or no symbols were attached.

2. Mistakes in drawing the countour lines.
3. Mistakes in figures of the spot heights.
4. Arrows to show flowing directions of some of rivers and streams were failed to be shown.

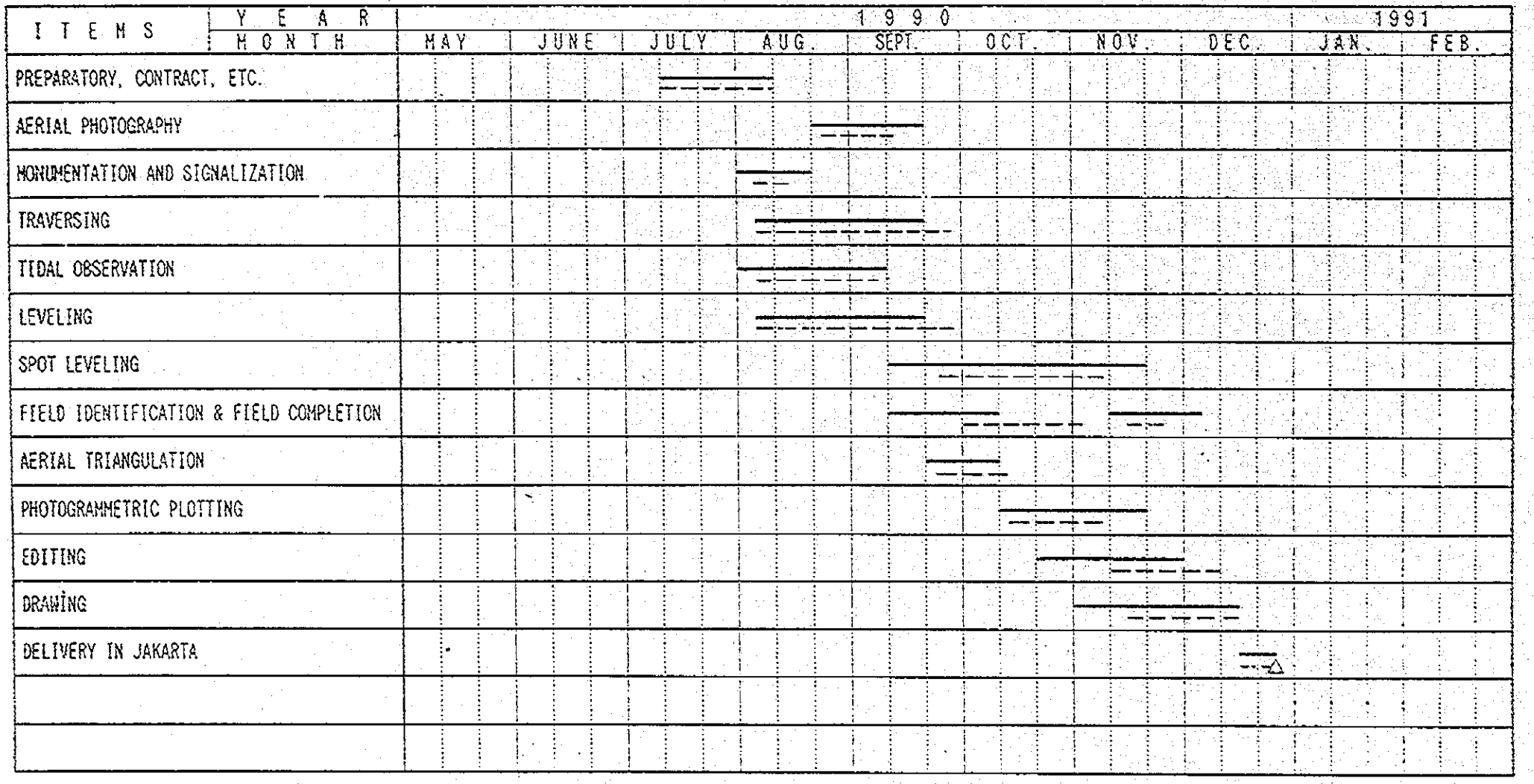
After careful proofing of the originals and having gotten approvals by Chief Engineers of DGWRD and JICA, a second original of each map were prepared with materials of # 300 polyester bases. To prevent deformation of the original, 10 blue prints of each map were reproduced from the second originals.

6.4.4. RESULTS

1:5,000 scale topographic maps for this project were finally prepared as follows:

1. 1:5,000 scale original topographic maps : 1 set (46 sheets)
2. 1:5,000 scale second original topographic maps : 3 sets (138 sheets)
3. Blue prints of the topographic maps : 10 sets (460 sheets) (46 sheets x 10 copies)

7. OPERATIONS PROGRESS



Note : —— Schedule

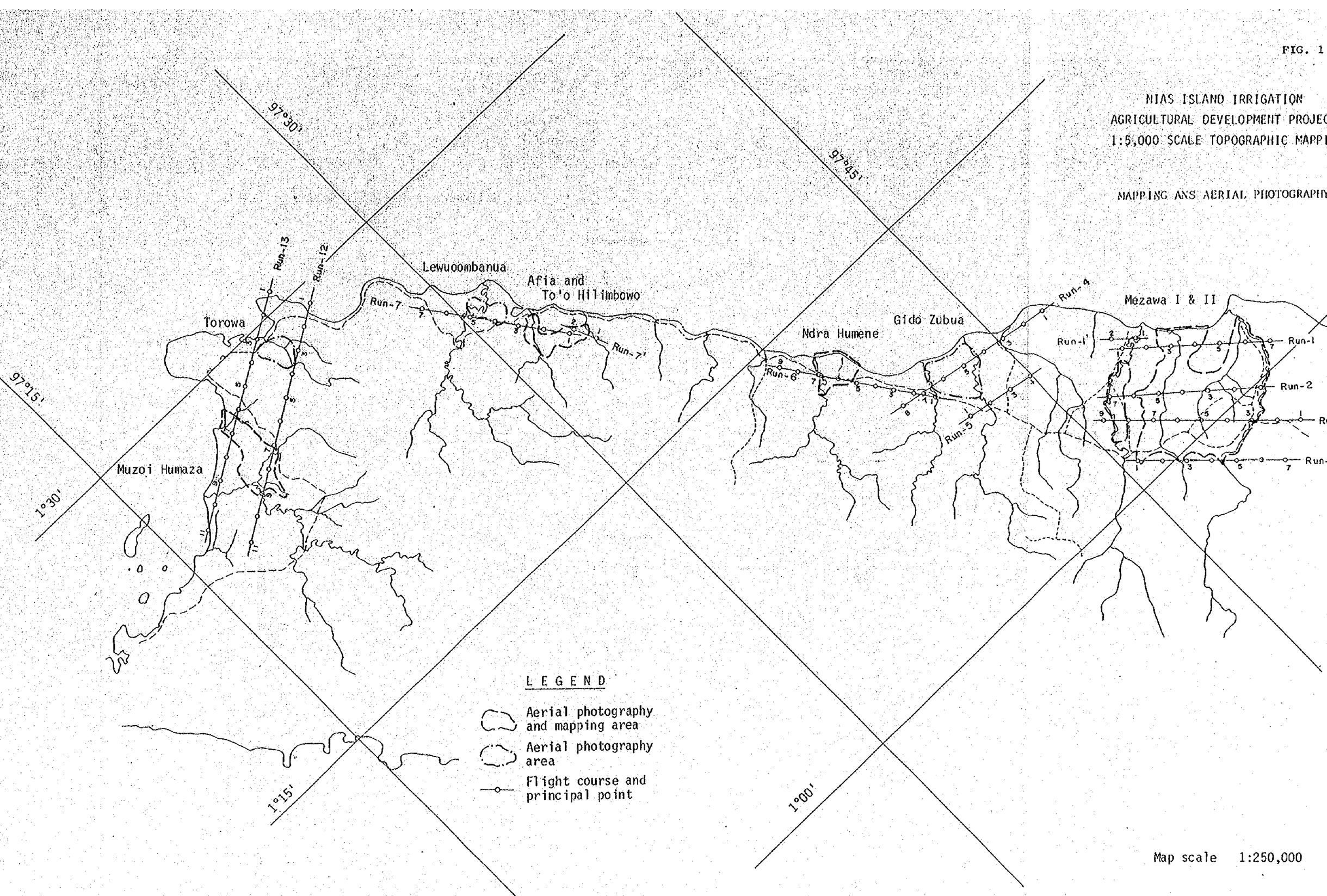
—— Actual

8. FIGURES AND TABLES

FIG. 1

NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT 1:5,000 SCALE TOPOGRAPHIC MAPPING

MAPPING ANS AERIAL PHOTOGRAPHY



LEGEND

- Aerial photography and mapping area
- Aerial photography area
- Flight course and principal point

Map scale 1:250,000

FIG. 2-a

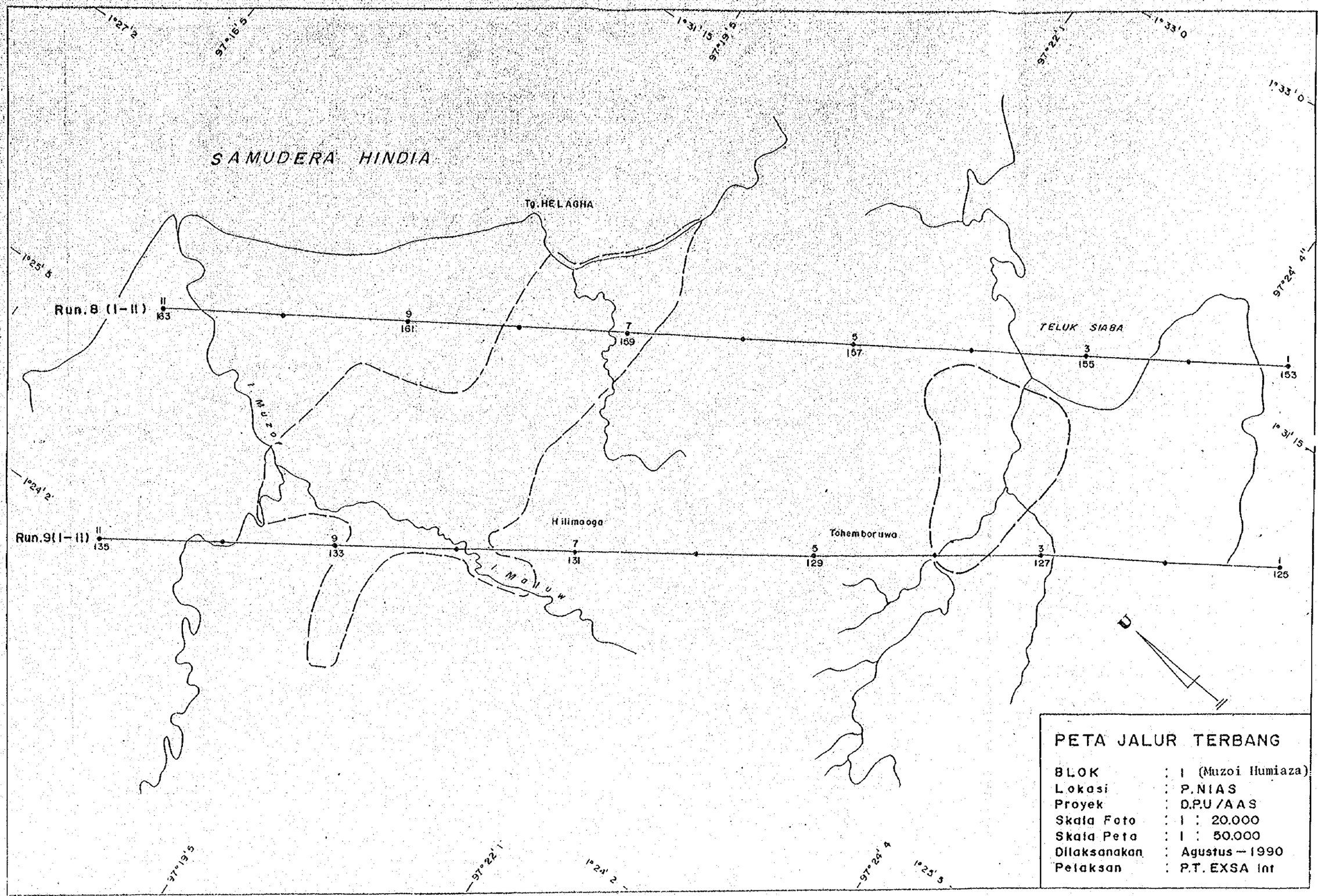
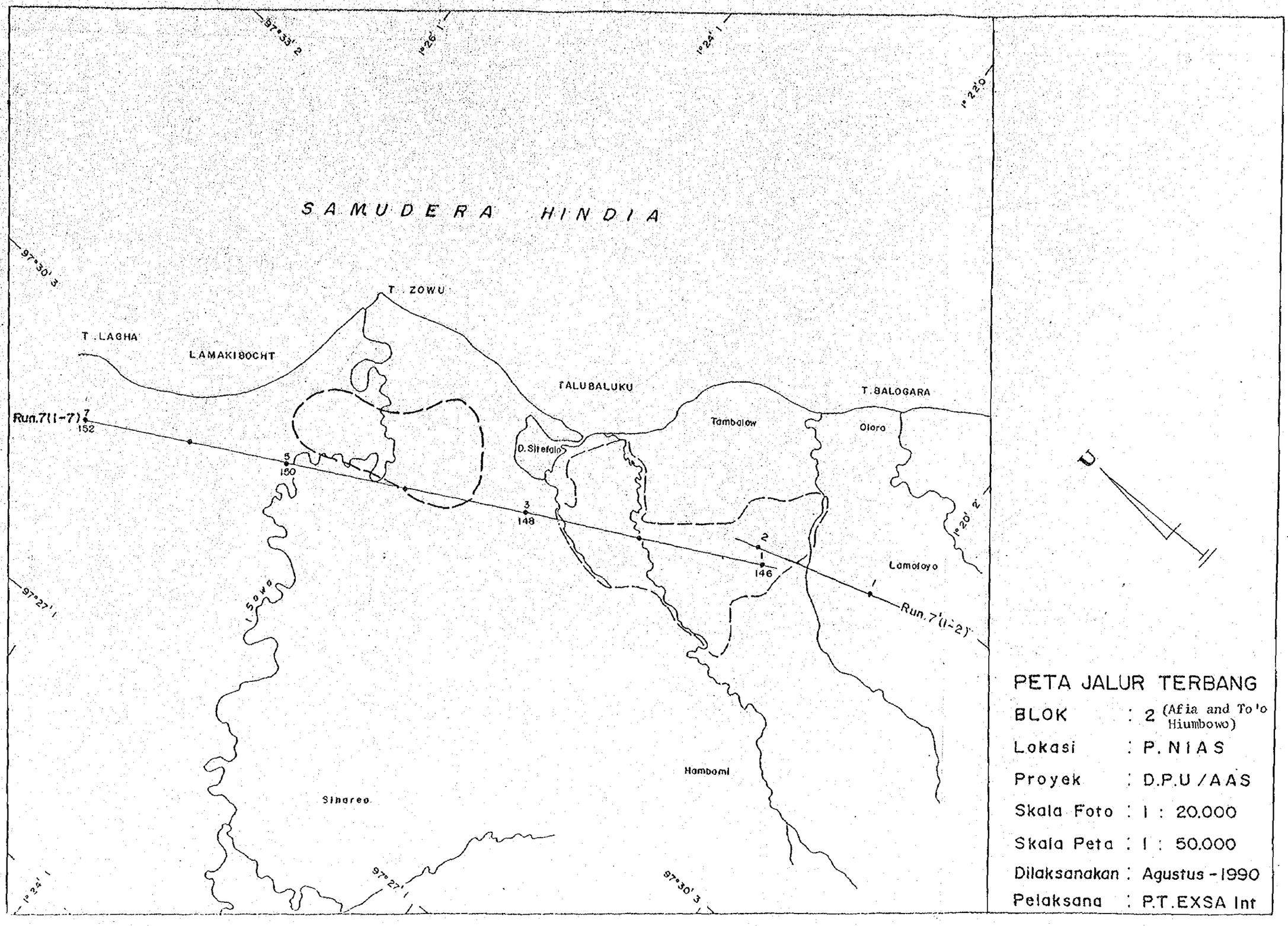

SAMUDERA HINDIA
Tg. HELAGHA
Run.8 (I–II)
II
163
9
161
7
159
5
157
3
155
I
153
TELUK SIABA
I. Muzoi
Hilimaoga
Run.9(I–II)
II
135
9
133
7
131
5
129
3
127
I
125
I. Mauw
Tohemboruwa
1°27'2
97°16'5
1°31'15
97°19'5
97°22'1
1°33'0
1°25'5
97°24'4
1°31'15
1°24'2
97°19'5
97°22'1
1°24'2
97°24'4
1°25'3
PETA JALUR TERBANG
BLOK : I (Muzoi Humiaza)
Lokasi : P. NIAS
Proyek : D.P.U /AAS
Skala Foto : 1 : 20.000
Skala Peta : 1 : 50.000
Dilaksanakan : Agustus – 1990
Pelaksan : P.T. EXSA Int

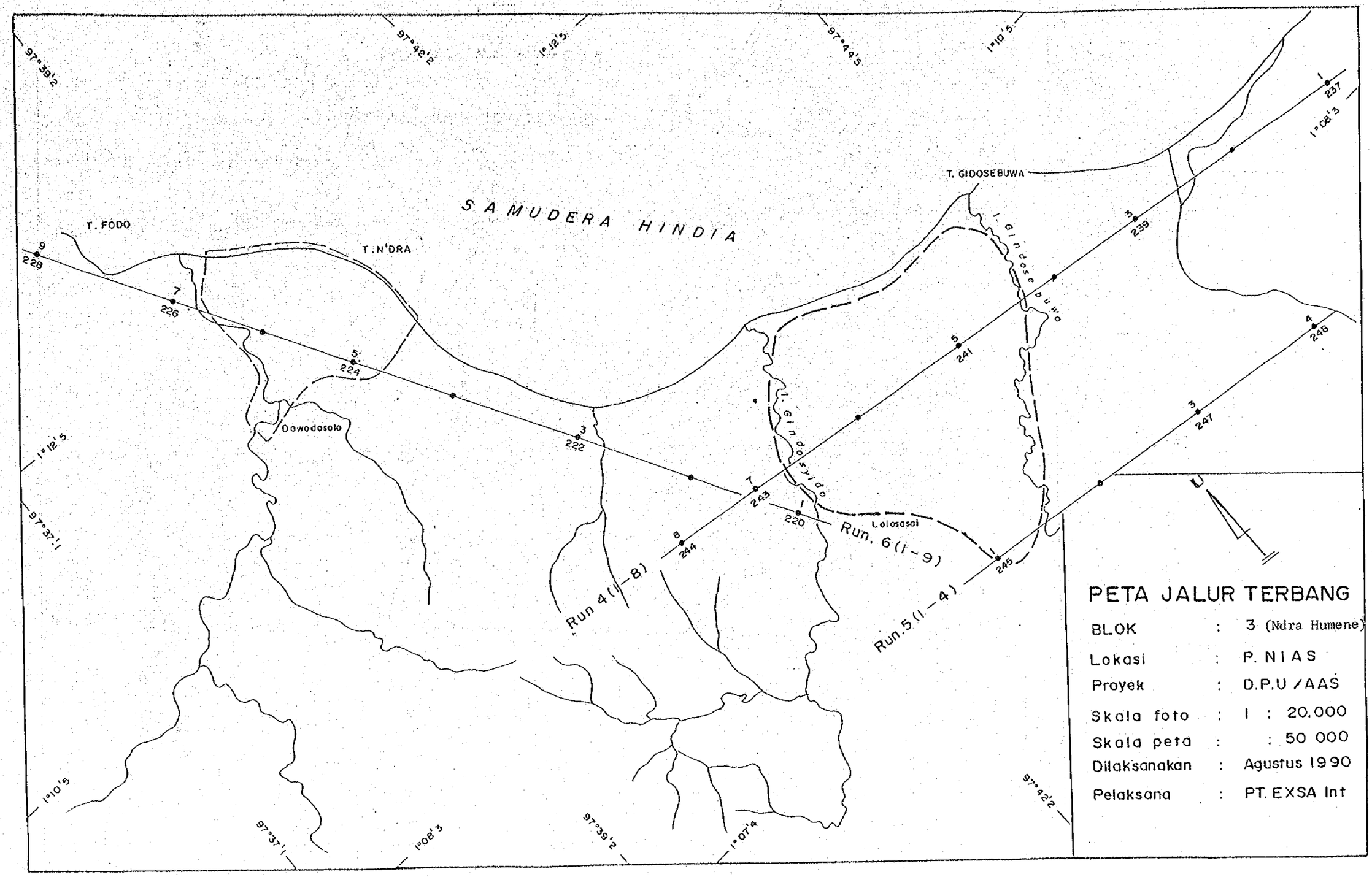
FIG. 2-b

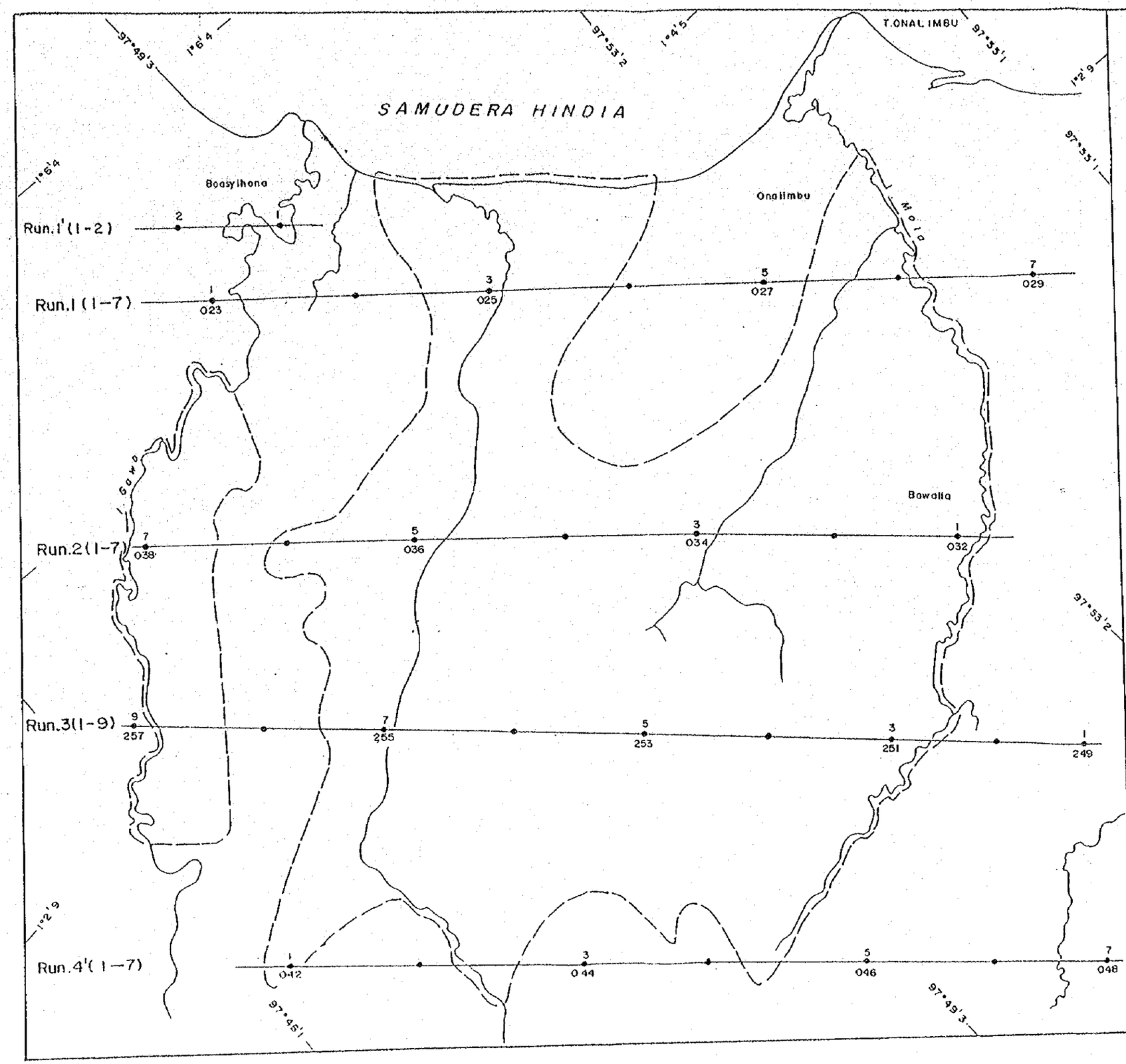


PETA JALUR TERBANG

BLOK	: 2 (Afia and To'o Hiumbowo)
Lokasi	: P. NIAS
Proyek	: D.P.U / AAS
Skala Foto	: 1 : 20.000
Skala Peta	: 1 : 50.000
Dilaksanakan	: Agustus - 1990
Pelaksana	: P.T.EXSA Int

FIG. 2-c


97°39'2
97°42'2
1°12'5
97°44'5
1°10'5
1°08'3
97°37'1
1°07'4
S A M U D E R A H I N D I A
T. FODO
T. N'DRA
T. GIDOSEBUWA
I. Gindosebuwa
I. Gindosyido
Dowodosolo
Lolosasai
Run 4 (1-8)
Run. 6 (1-9)
Run.5 (1-4)
1 237
3 239
4 248
5 241
3 247
9 228
7 226
5 224
3 222
7 243
1 220
8 244
1 245
PETA JALUR TERBANG
BLOK : 3 (Ndra Humene)
Lokasi : P. NIAS
Proyek : D.P.U / AAS
Skala foto : 1 : 20.000
Skala peta : : 50 000
Dilaksanakan : Agustus 1990
Pelaksana : PT. EXSA Int

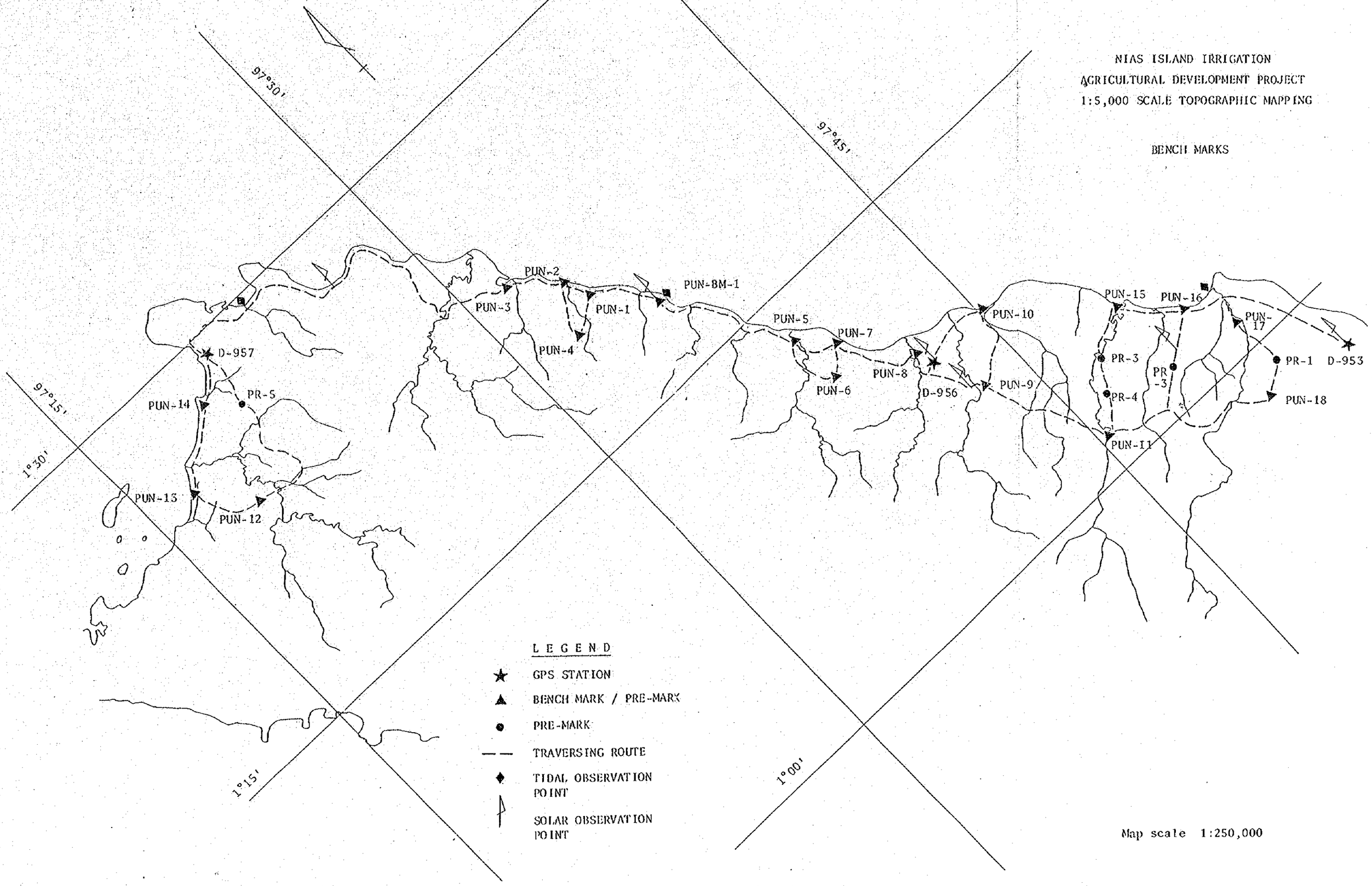


PETA JALUR TERBANG

BLOK	:	4 (Mezawa I & II)
Lokasi	:	P. NIAS
Proyek	:	D.P.U /AAS
Skala foto	:	1 : 20.000
Skala peta	:	1 : 50.000
Dilaksanakan	:	Agustus 1990
Pelaksana	:	PT.EXSA Int

NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT 1:5,000 SCALE TOPOGRAPHIC MAPPING

BENCH MARKS

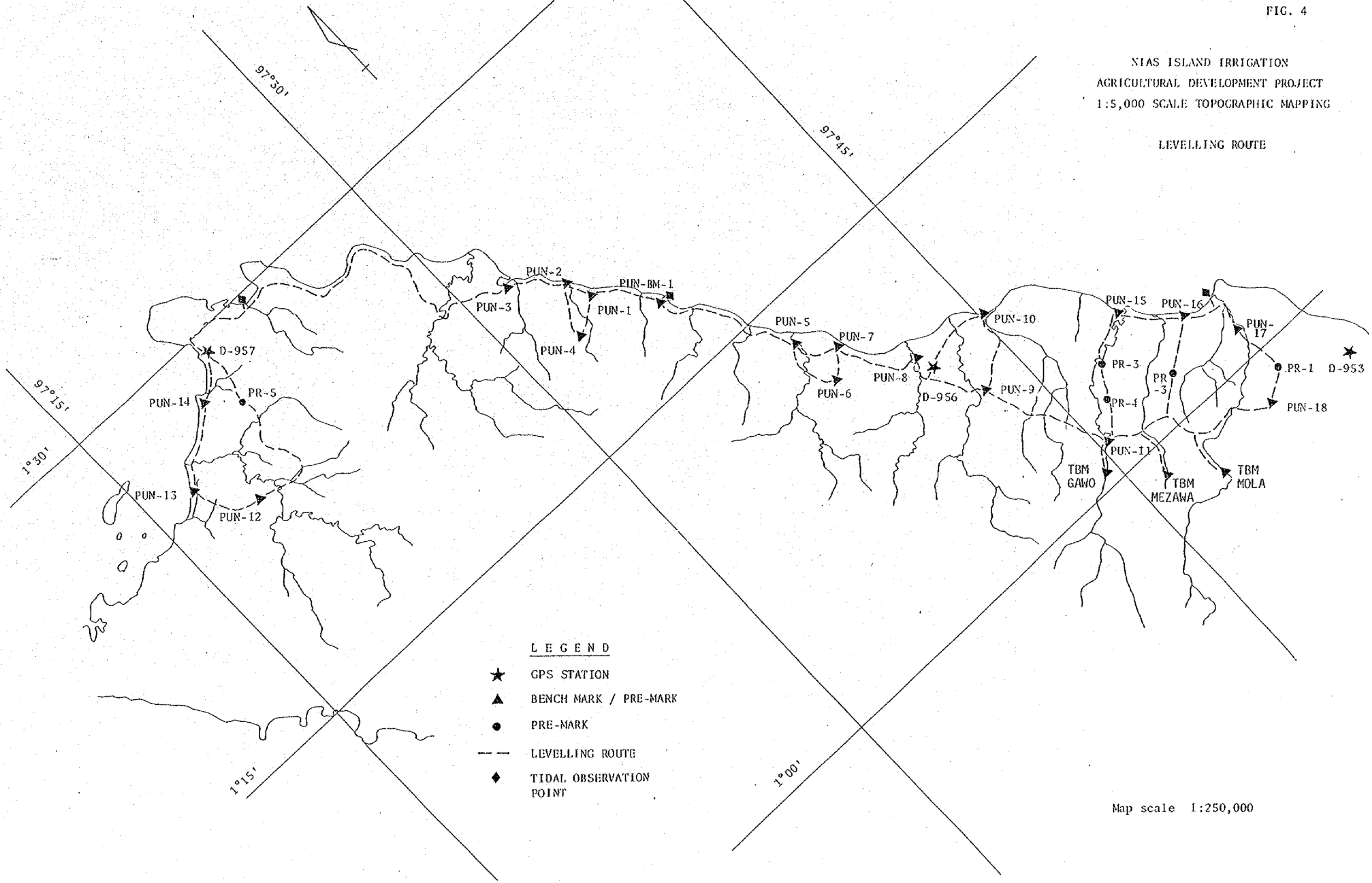


Map scale 1:250,000

FIG. 4

NIAS ISLAND IRRIGATION
AGRICULTURAL DEVELOPMENT PROJECT
1:5,000 SCALE TOPOGRAPHIC MAPPING

LEVELLING ROUTE



Map scale 1:250,000

TRAVERSING ROUTE NETWORK

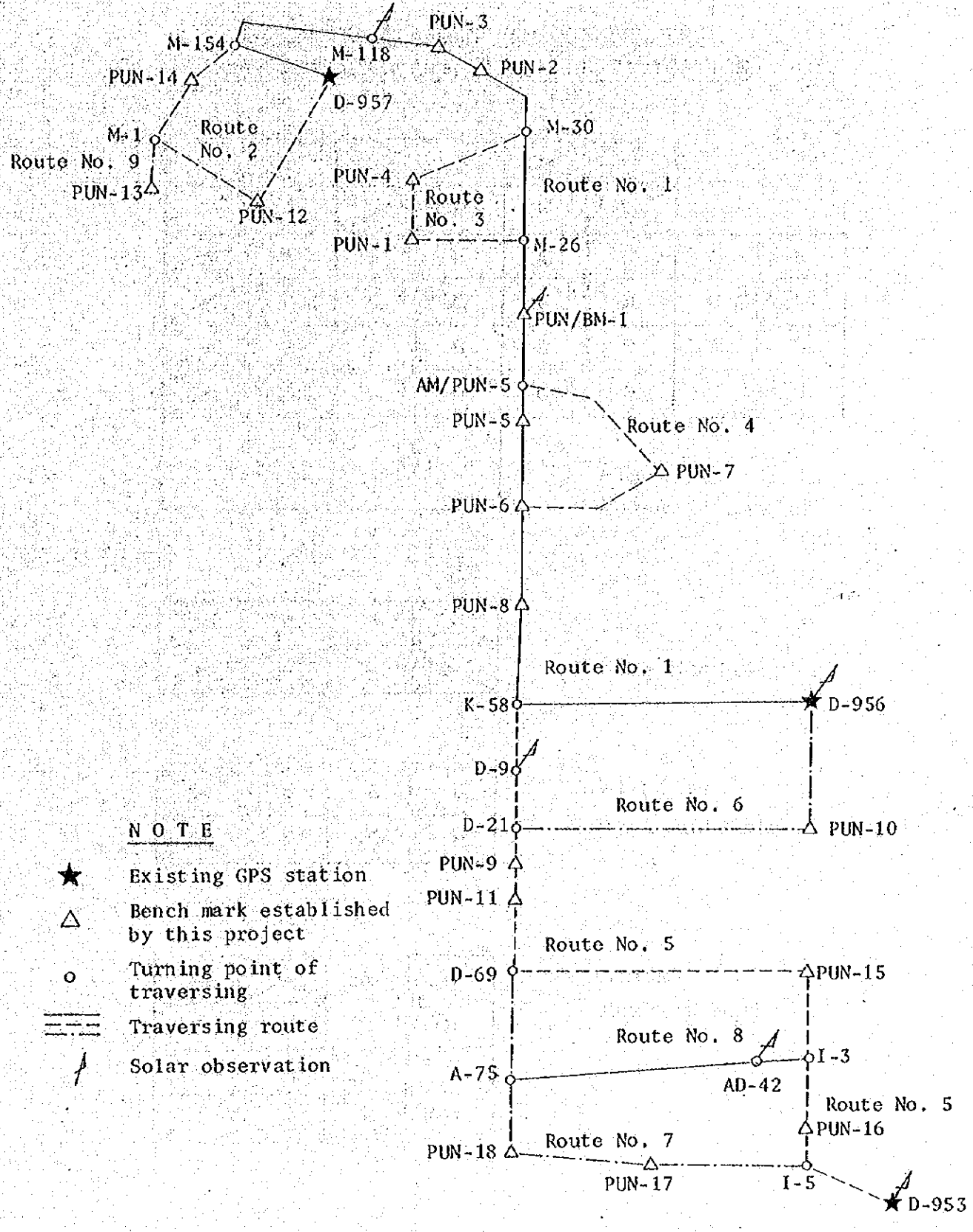
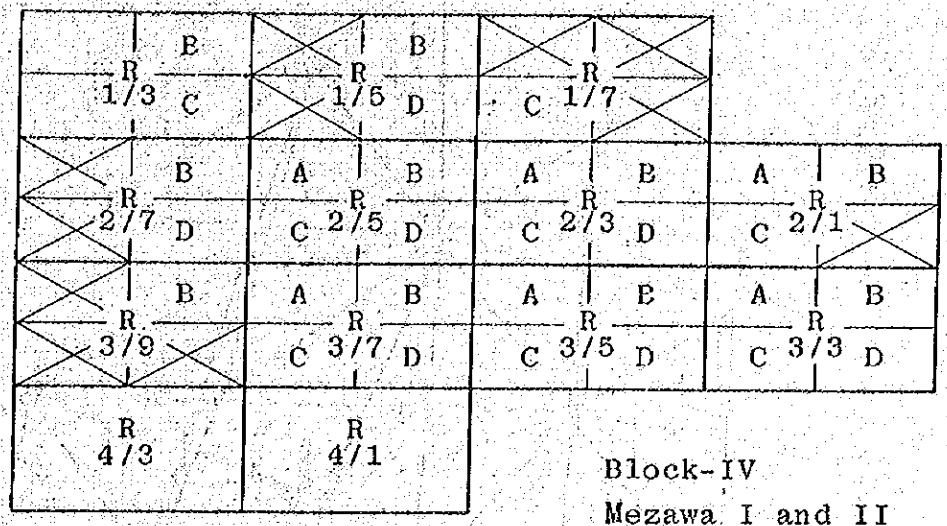
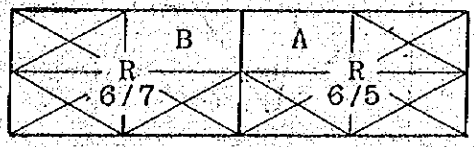


FIG. 6

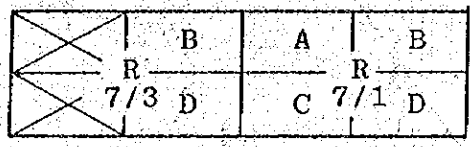
INDEX OF ENLARGED PHOTOGRAPHS FOR SPOT LEVELING AND FIELD IDENTIFICATION



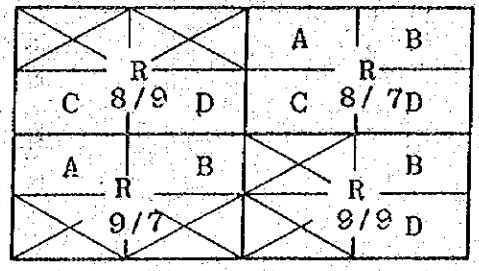
Block-IV
Mezawa I and II



Block-III
Ndra Humene



Block-II
Afia and To'o Hiumbowo



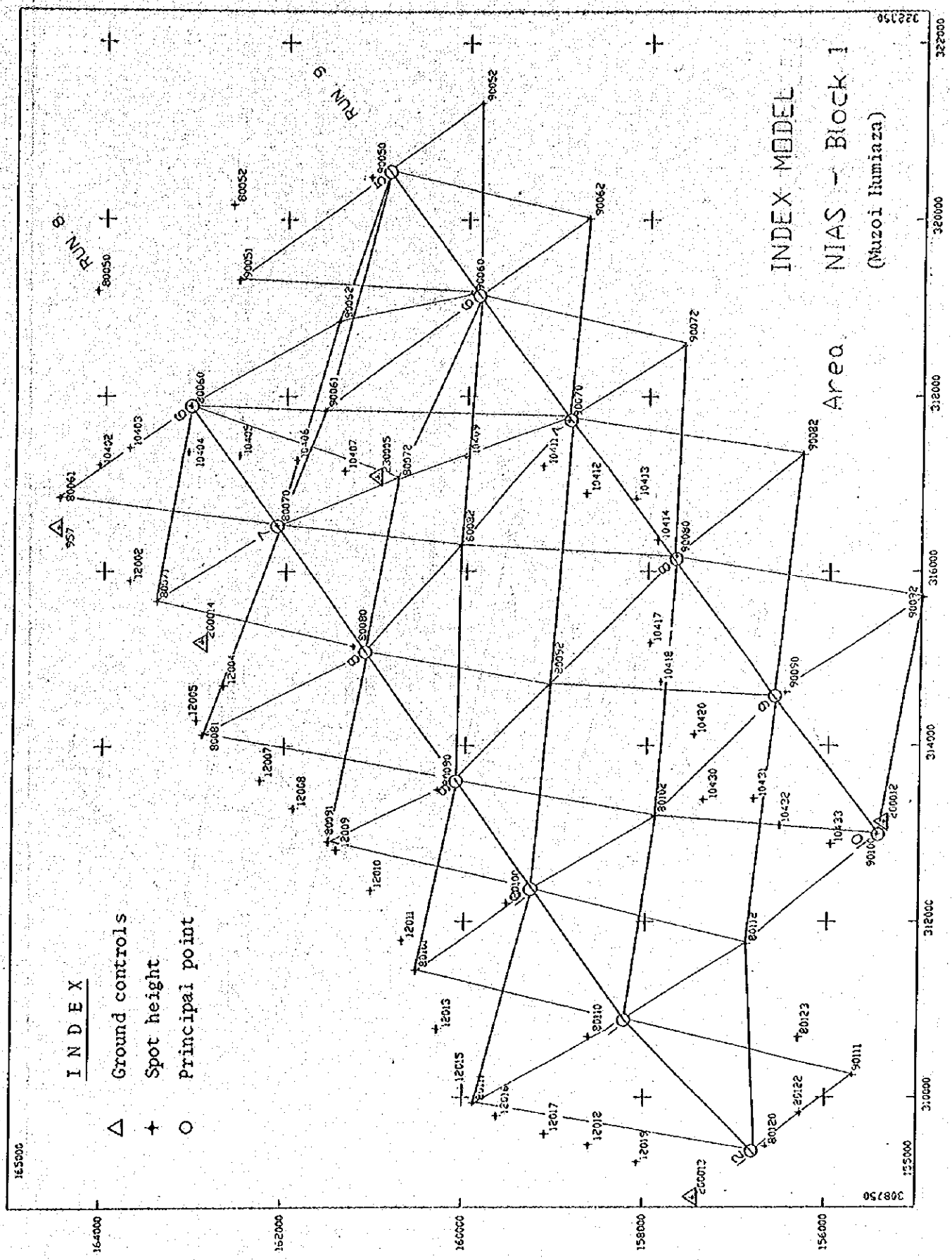
Block-I
Muzoi Humiaza

FIG. 7-a

NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT

1:5,000 SCALE TOPOGRAPHIC MAPPING

AERIAL TRIANGULATION



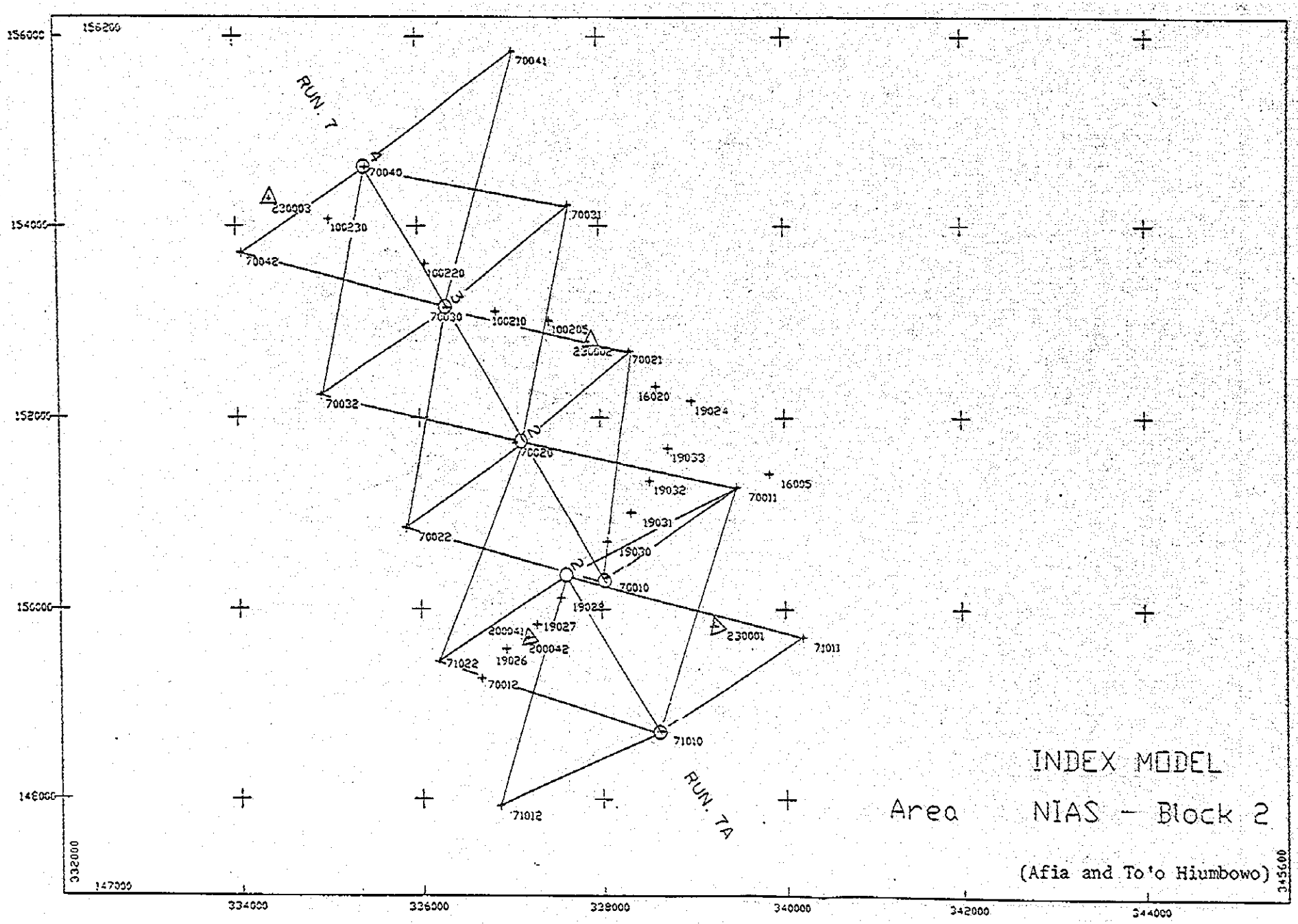

INDEX MODEL
Area NIAS – Block 2
(Afia and To'o Hiumbowo)
RUN. 7
RUN. 7A
70041
70040
230003
100230
70031
70042
100220
70030
100210
100205
230002
70021
16020
19024
70032
70020
19033
16005
19032
70011
19031
70022
19030
70010
19024
19027
200041
200042
19026
230001
71011
71022
70012
71010
71012
156000
154000
152000
150000
148000
332000
147000
334000
336000
338000
340000
342000
344000
345000

FIG. 7-b

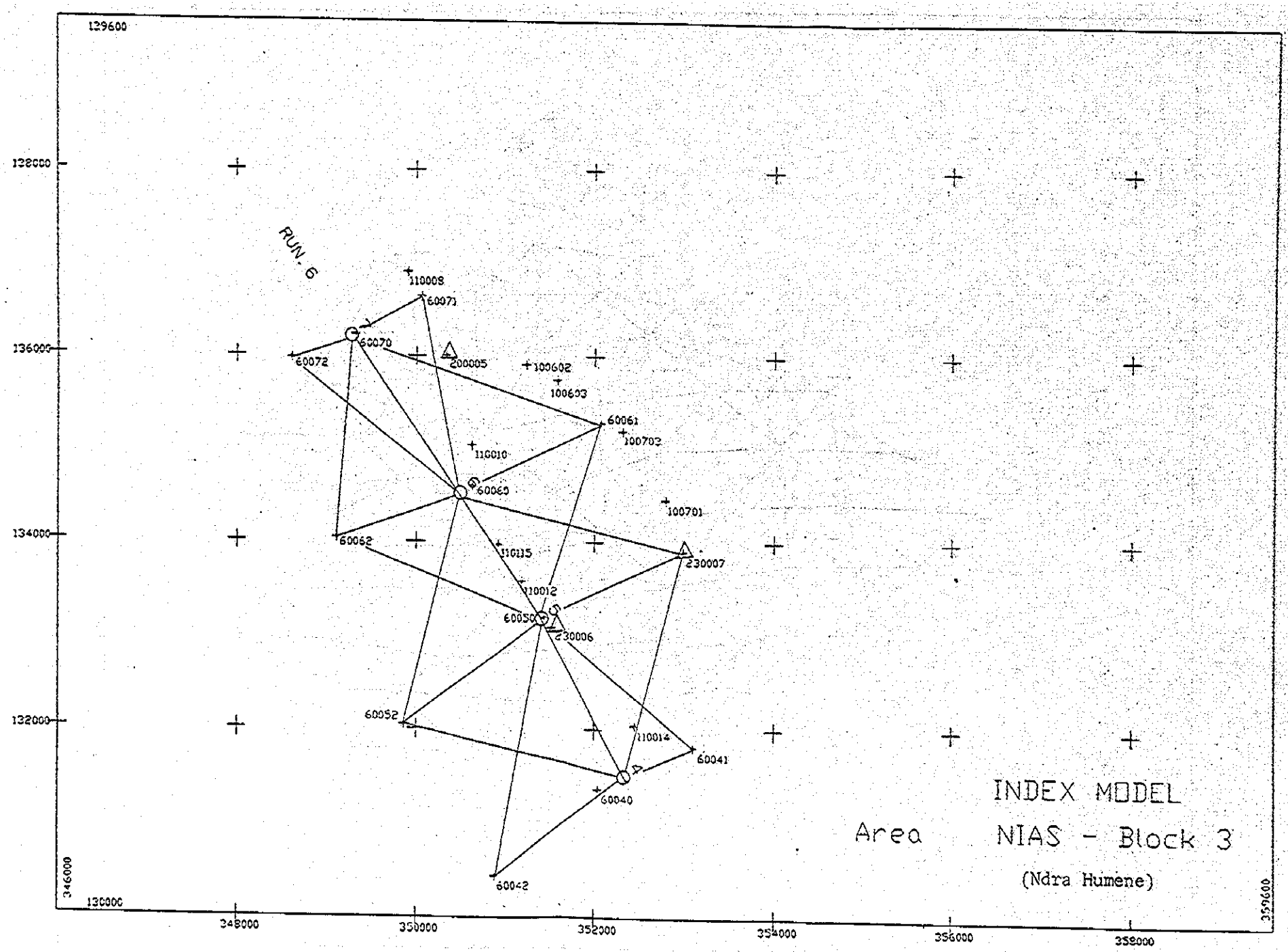

129600
128000
136000
134000
132000
130000
346000
348000
350000
352000
354000
356000
358000
359600
RUN-6
110008
60071
60070
60072
200005
100602
100603
60061
100703
110010
60060
100701
60062
110115
230007
110012
60050
230006
60052
110014
60041
60040
60042
INDEX MODEL
Area NIAS - Block 3
(Ndra Humene)

FIG. 7-c

FIG. 7-d

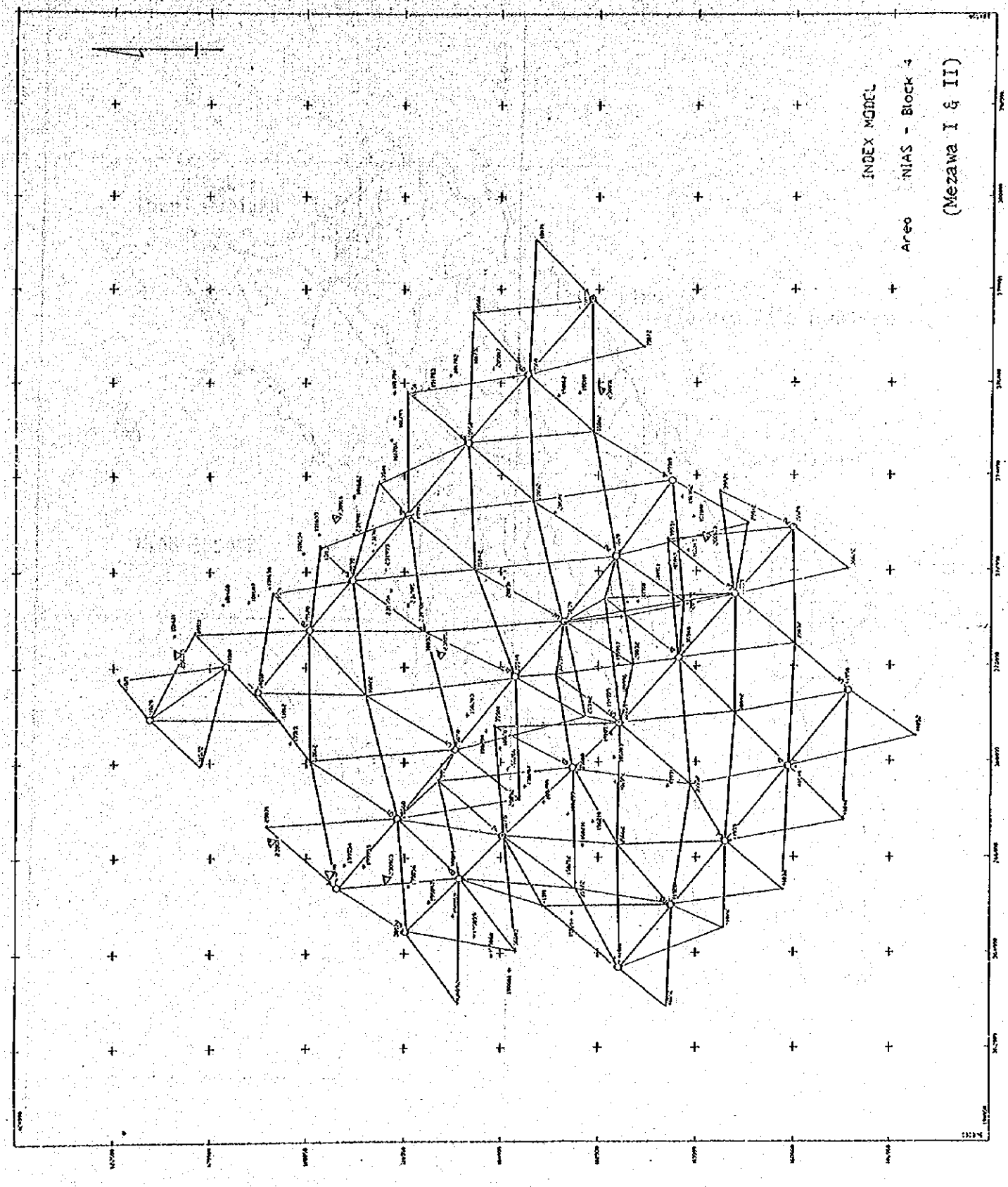
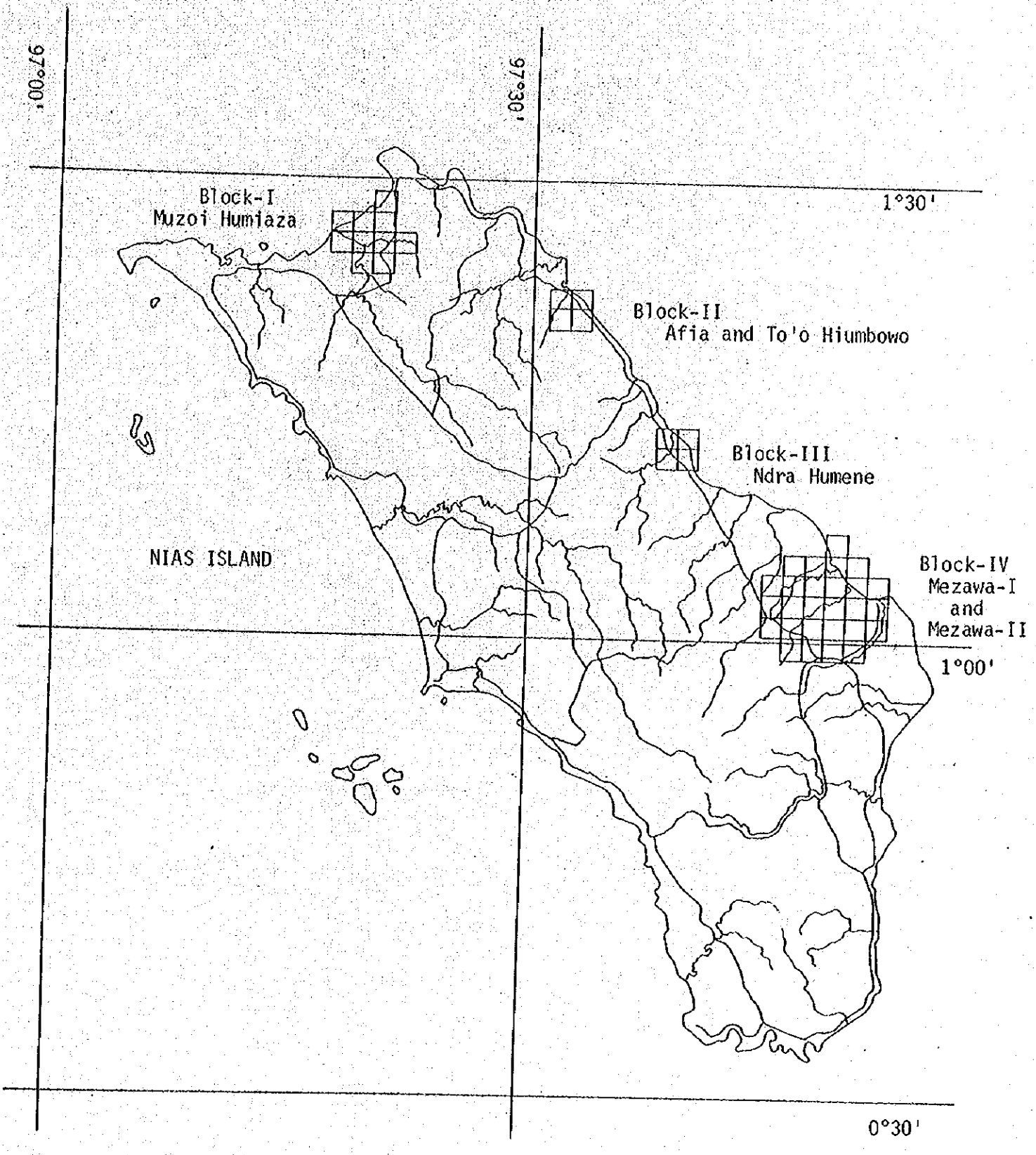


FIG. 8

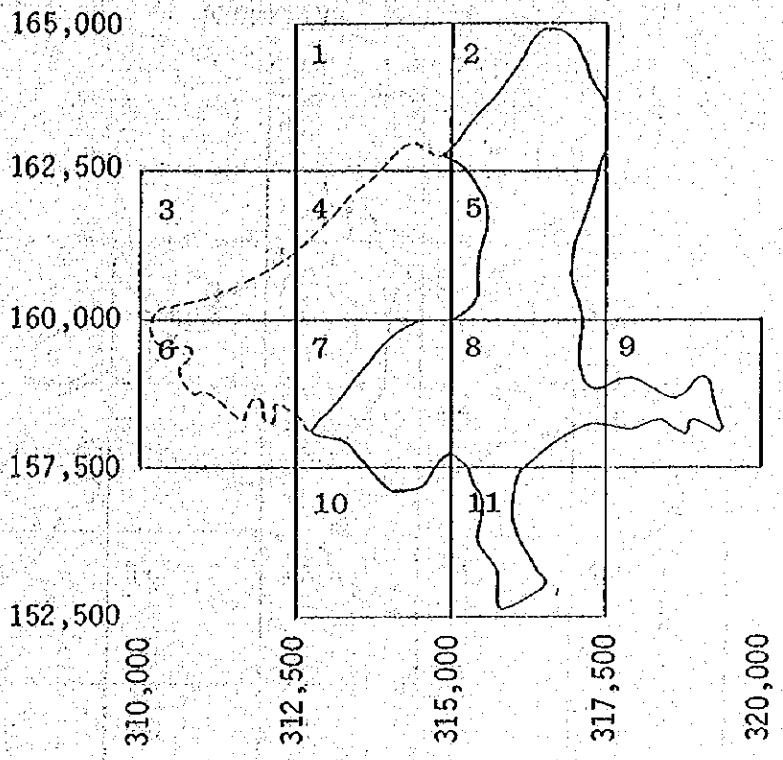
NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT
1:5,000 SCALE TOPOGRAPHIC MAPPING SHEET INDEX



NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT
1:5,000 SCALE TOPOGRAPHIC MAPPING SHEET INDEX

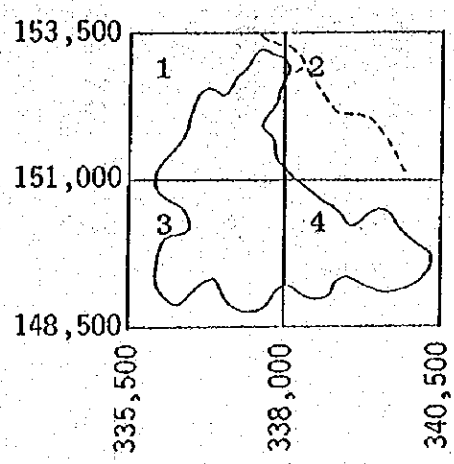
Muzoi Humiaza

BLOCK-I



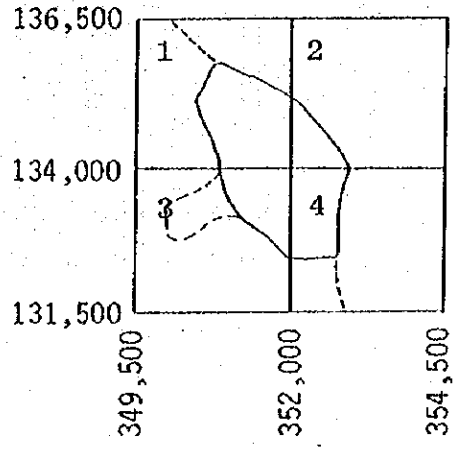
Afia and To'o Hiumbowo

BLOCK-II



Ndra Humene

BLOCK-III



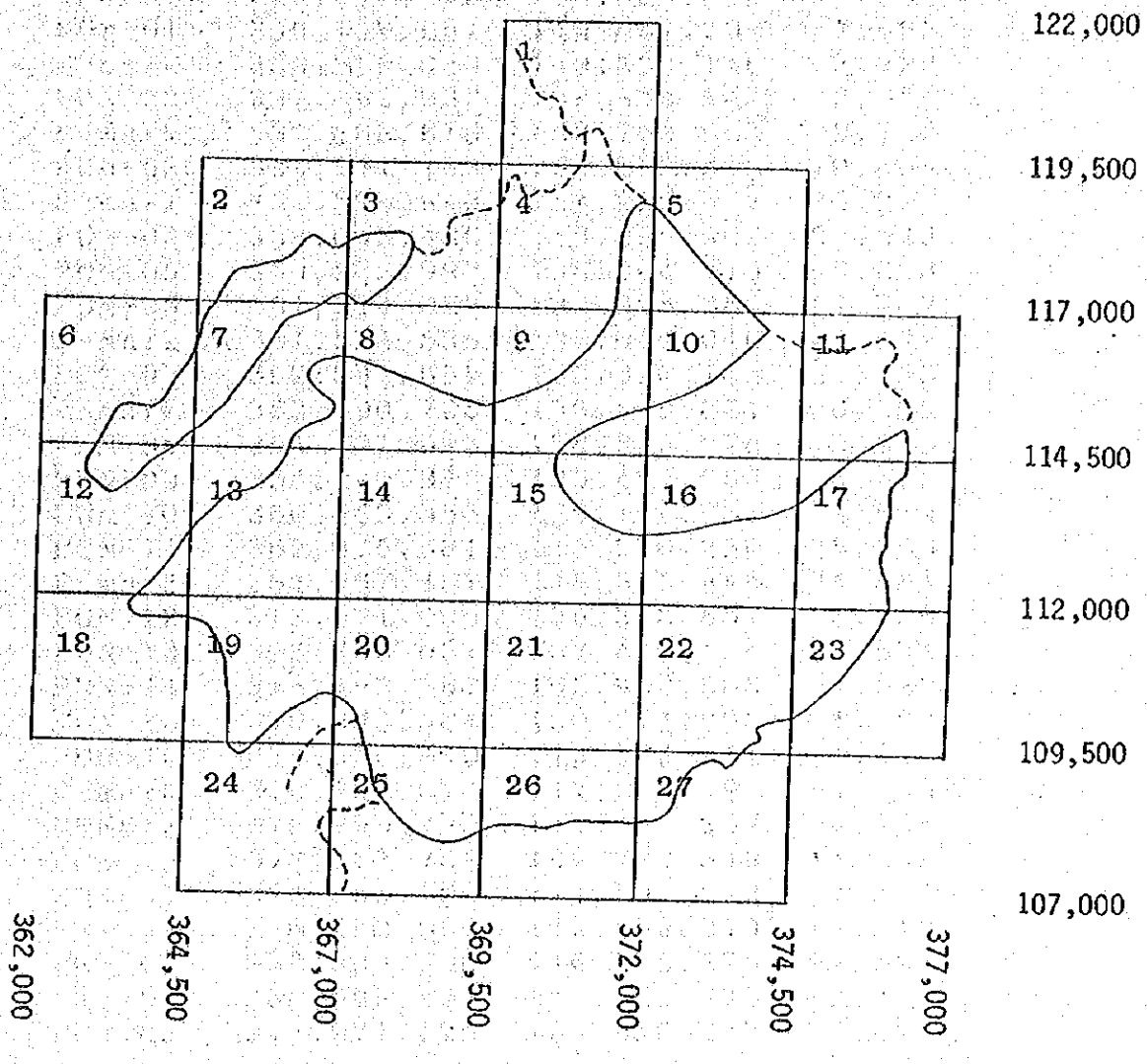
Note : ⬭ 1:5,000 scale topographic mapping area

---- Shape of river and coastal line only

NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT
1:5,000 SCALE TOPOGRAPHIC MAPPING SHEET INDEX

Mezawa I & II

BLOCK-IV



Note : ⊂⊃ 1:5,000 scale topographic mapping area

---- Shape of river, road and coastal line only

TABLE 1

BENCH MARKS IN NIAS ISLAND
Established by JICA Study Team in October 1990

The horizontal coordinates: UTM. Zoon 47, WGS.69
The elevation: MSL at Gunung Sitoli Seaport

Code No.	X(E) m	Y(N) m	H m	Remarks
PUN/BM1	345,926.493	142,652.075	5.080	
PUN-01	339,159.951	149,867.691	7.662	
P-mark	339,229.040	149,823.146	7.222	
PUN-02	337,882.032	152,844.851	3.065	
P-mark	337,868.618	152,792.954	3.163	
PUN-03	334,371.153	154,285.843	10.609	
P-mark	334,375.543	154,280.852	10.227	
PUN-04	338,045.486	146,895.992	92.542	
PUN-05	350,333.093	136,004.713	9.868	
PUN-06	351,514.077	133,095.980	11.687	
P-mark	351,524.533	133,082.010	11.572	
PUN-07	352,981.655	133,920.185	1.128	
P-mark	352,990.726	133,899.861	0.922	
PUN-08	354,791.013	128,825.378	9.578	
PUN-09	358,240.373	123,487.063	16.403	
PUN-10	360,683.856	129,104.984	1.649	
PUN-11	362,075.681	115,600.230	35.056	
P-mark	362,067.457	115,645.446	34.684	
PUN-12	313,071.605	155,378.857	3.436	
PUN-13	308,853.021	157,426.104	1.536	
PUN-14	315,197.367	162,902.068	1.629	
PUN-15	370,323.604	120,711.893	1.027	
PUN-16	374,350.649	116,373.711	1.657	
P-mark	373,132.074	117,386.491	1.569	
PUN-17	376,295.780	114,151.237	4.134	
PUN-18	372,707.768	109,772.643	14.438	
PR- 01	375,850.190	111,909.272	7.834	Premark only
PR- 02	370,288.966	115,260.919	11.213	〃
PR- 03	365,603.660	116,375.878	22.064	〃
PR- 04	366,365.596	118,740.776	12.431	〃
PR- 05	317,071.428	160,986.347	5.876	〃

Weir site bench marks: For the feasibility study in the second fase, three bench marks were established in the proposed weir sites in Idanau Gawo, Mezawa and Mola of Mezawa area.

Code Name	Location	Height m
TBM-Gawo	Gawo River	49.454
TBM-Mezawa	Mezawa River	44.148
TBM-Mola	Mola River	47.986

TABLE 2

Block and stereo models of aerial triangulation

Block No.	Name of area	No. of runs	No. of models	No. of horizontal control points	No. of vertical control points
Block-I	Muzoi Humiaza	Run-8	6 models	4 points	31 points
		Run-9	5 models		
	Sub-total	2 runs	11 models		
Block-II	Afia and	Run-7	3 models	5 points	16 points
	To'o Hiumbowo	Run-7A	1 model		
	Sub-total	2 runs	4 models		
Block-III	Ndra Humene	Run-6	3 models	3 points	10 points
	Sub-total	1 run	3 model		
Block-IV	Mezawa-I	Run-1	6 models	7 points	57 points
	and	Run-1'	1 model		
	Mezawa-II	Run-2	6 models		
		Run-3	7 models		
		Run-4'	4 models		
	Sub-total	5 runs	24 models		
Total 4 blocks		10 runs	44 models	19 points	114 points

TABLE 3

Residual of horizontal ground controls after block adjustment

Number	station	ΔX (m)	ΔY (m)	V (m)	Δ⊥ (m)
Block-I					
957	D-957	0.394	0.003	0.394	----
200013	PUN-13	0.070	- 0.206	0.218	0.086
200014	PUN-14	0.131	0.159	0.206	- 0.091
230005	PR-5	- 0.595	0.044	0.596	0.321
Block-II					
200041	PR2A-PUN-4	- 0.323	0.107	0.340	----
200042	PR-2B-PUN-4	0.118	0.057	0.131	----
230001	PR-PUN-1	0.151	- 0.021	0.152	0.121
230002	PR-PUN-2	0.114	- 0.075	0.136	0.357
230003	PR-PUN-3	- 0.060	- 0.068	0.090	0.190
Block-III					
200005	PUN-5	0.038	- 0.028	0.047	0.108
230006	PR-PUN-6	- 0.082	- 0.048	0.095	0.136
230007	PR-PUN-7	- 0.044	0.077	0.088	0.165
Block-IV					
200015	PUN-15	- 0.155	- 0.155	0.219	----
200017	PUN-17	0.125	- 0.040	0.131	0.107
200018	PUN-18	- 0.334	0.205	0.392	0.048
230001	PR-1	- 0.211	- 0.014	0.211	- 0.047
230002	PR-2	0.566	- 0.051	0.568	- 0.006
230004	PR-4	- 0.458	- 0.092	0.467	0.017
230016	PR-PUN-16	0.467	0.147	0.490	- 0.192

Note : D : Existing Doppler Station
PR : Pre-mark
PUN : Bench mark established by this project

TABLE 4

Maximum residual and standard deviation in horizontal control

Block No.	Maximum residual	Standard deviation
Block-I	0.596 m (PR-5)	0.447 m
Block-II	0.340 m (PR2A-PUN-4)	0.214 m
Block-III	0.095 m (PR-PUN-6)	0.097 m
Block-IV	0.568 m (PR-2)	0.417 m

Maximum residual and standard deviation in vertical control

Block No.	Maximum residual	Standard deviation
Block-I	- 0.487 m	0.222 m
Block-II	- 0.396 m	0.233 m
Block-III	- 0.182 m	0.124 m
Block-IV	- 0.628 m	0.194 m

TABLE 5

Residulas of vertical ground controls after block adjustment

Block-I

Number	Station	V (m)	Number	Station	V (m)	Number	Station	V (m)
10402		0.135	10414		-0.024	12007		0.216
10403		0.417	10417		-0.069	12008		-0.003
10404		-0.125	10420		0.236	12009		0.153
10405		-0.075	10430		-0.107	12010		-0.114
10406		-0.309	10431		-0.255	12011		0.011
10407		-0.487	10432		0.111	12013		-0.107
10409		-0.020	10433		0.295	12015		-0.099
10411		0.153	12002		0.466	200012	PUN-13	0.086
10412		-0.038	12004		-0.306	200014	PUN-14	-0.091
10413		-0.101	12005		-0.270	230005	PR-5	0.321

Block-II

Number	Station	V (m)	Number	Station	V (m)	Number	Station	V (m)
16005		0.241	19028		0.031	100210		-0.246
16020		0.054	19030		0.204	100220		-0.396
19024		-0.300	19031		0.210	100230		0.209
19026		-0.174	19032		-0.222	230001	PR-PUN-1	0.121
19027		-0.039	19033		-0.240	230002	PR-PUN-2	0.357
						230003	PR-PUN-3	0.190

Block-III

Number	Station	V (m)	Number	Station	V (m)	Number	Station	V (m)
100602		-0.119	110010		0.086	110115		-0.182
100603		0.034	110012		-0.009	200005	PUN-5	0.108
100703		-0.139	110014		-0.081	230006	PR-PUN-6	0.136
						230007	PR-PUN-7	0.165

Note : PR : Pre-mark

PUN : Bench mark established by this project

No mention in station means pricked poin by direct levelling.

Residuals of vertical ground controls after block adjustment

Block IV

Number	Station	V (m)	Number	Station	V (m)	Number	Station	V (m)
100101		-0.059	101010		-0.344	190055		0.146
100102		0.344	101011		-0.052	190056		-0.295
100204		-0.140	101012		-0.083	190057		0.106
100205		-0.128	101013		-0.157	190058		-0.033
100206		-0.039	101602		-0.121	190059		0.042
100207		0.180	101603		0.257	190060		-0.230
100208		0.145	101604		0.020	190061		0.312
100209		0.238	101606		-0.628	200017	PUN-17	0.107
100210		0.087	101607		0.058	200018	PUN-18	0.048
100211		-0.189	101608		0.207	230001	PR-1	-0.047
100212		-0.360	101701		-0.007	230002	PR-2	-0.006
100214		0.139	101702		-0.045	230004	PR-4	0.017
101002		-0.025	101703		-0.067	230016	PR-PUN-16	-0.192
101003		0.323	101704		0.210	231901		0.195
101004		-0.194	101705		-0.028	231902		0.083
101005		-0.138	101706		-0.138	231903		-0.001
101006		0.196	101801		0.226	231904		-0.120
101007		-0.346	101802		0.077	231905		-0.178
101009		0.247	190054		0.206	231906		0.109

9. APPENDIX

APPENDIX – 1 MINUTES OF MEETING

MINUTES OF MEETING ON THE PLAN OF OPERATION OF THE TOPOGRAPHIC MAPPING FOR THE FEASIBILITY STUDY ON THE NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT

JULY 1990

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

FEASIBILITY STUDY TEAM (TOPOGRAPHIC MAPPING)

MINUTES OF MEETING ON THE PLAN OF OPERATION OF THE TOPOGRAPHIC MAPPING FOR THE FEASIBILITY STUDY ON THE NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT

1. Date and time of the technical meetings
   July 10, 1990 14:00~16:00
   July 11, 1990 9:30~11:30

2. Places of the technical meeting
   July 10, 1990 Conference room of Sub-Directorate of Planning and Design
   July 11, 1990 Ditto

3. Attendants

3.1. Meeting on July 10, 1990

The Government of Indonesia

- Ir. Mashudi Dipl.HE	Chief, Sub-Directorate of Planning and Design DOI-I
- Ir. Fritz Hutasoit	Chief, West Region Section SDPD. DOI-I
- Ir. Bonar Sinaga	Staff, SDPD. DOI-I
- Ir. Sukarna	Staff, SDPD. DOI-I

JICA Study Team

- Mr. H. Goto	Team Leader, Topographic Mapping Team

3.2. Meeting on July 11, 1990

The Government of Indonesia

- Ir. Mashudi Dipl.HE	Chief, Sub-Directorate of Planning and Design DOI-I
- Ir. Bonar Sinaga	Staff, SDPD. DOI-I
- Ir. Sukarna	Staff, SDPD. DOI-I

JICA Expert

- Mr. Shimonomura — JICA Irrigation Expert for DOI-I

JICA Study Team

- Mr. H. Goto — Team Leader, Topographic Mapping Team

4. The Leader of the Topographic Mapping Team for the feasibility study on the Nias Island Irrigation Agricultural Development Project, Mr. H.Goto briefed the draft of Plan of Operation.

5. After every item in the draft of Plan of Operation was carefully examined, discussed, clarified, the following was agreed to be changed:
   - The size of the mapping sheets shall be 50 x 50cm and the number of map sheets will be 35. (The size was proposed 60 x 80cm and 19 map sheets in the draft of Plan of Operation).

6. Due to the change in Plan of Operation, the size and number of the map sheets shall also be changed in the Technical Specifications

7. The following matters necessary for the implementation of the Project were requested by JICA Team and DOI-I agreed:
   - To make arrangement to obtain the 1:50,000 photo mosaics covering the Nias Island from BAKOSURTANAL.
   - To make arrangement to obtain the coordinates data of GPS Stations in the Nias Island from BAKOSURTANAL.
   - To make arrangement to obtain the security clearance for the aerial photography from the SURTAABRI.

- To provide counterpart personnel for the Field Survey Team.
- To recommend some of Indonesian survey and mapping companies as the candidates for the Tender.
- To provide office space for the Tendering to the Study Team.
- To make arrangement to obtain Surat Keterangan Jalan for the Japanese members of the Field Survey Team from POLRI.

July 12, 1990

Ir. Mashudi Dipl.HE
Chief, Sub-Directorate
of Planning and Design
DOI-I

H. GOTO
Team Leader,
JICA Study Team

PLAN OF OPERATIONS FOR THE TOPOGRAPHIC MAPPING FEASIBILITY STUDY ON NIAS ISLAND IRRIGATION AGRICULTURAL DEVELOPMENT PROJECT

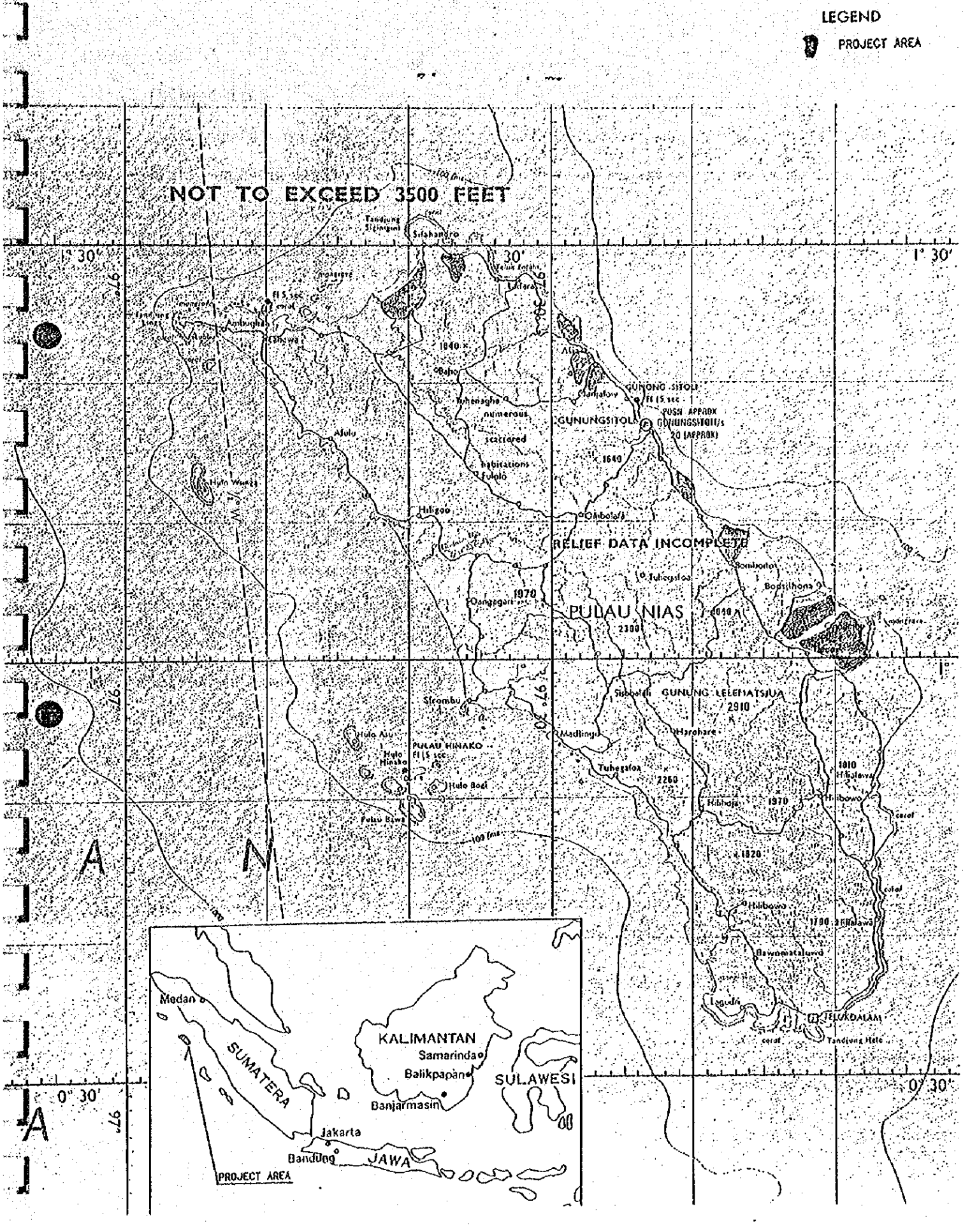
JULY, 1990

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

FIG. 1

NIAS ISLAND IRRIGATION AGRICULTURE DEVELOPMENT PROJECT (TOPOGRAPHIC MAPPING)

PROJECT AREA



CONTENTS

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1. INTRODUCTION	1
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3. TENDER AND CONTRACT	3
4. OUTLINE OF THE PLAN	4
4.1 AERIAL PHOTOGRAPHY	4
4.2 GROUND CONTROL SURVEY	4
4.3 PHOTOGRAMMETRIC MAPPING	4
5. DETAILED PLAN OF OPERATIONS	5
5.1 PROJECTION, COORDINATES AND DATUM ELEVATION	5
5.2 AERIAL PHOTOGRAPHY	5
5.3 GROUND CONTROL SURNEY	5
5.3.1 MONUMENTATION AND SIGNALIZATION	5
5.3.2 TIDAL OBSERVATION	5
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1. INTRODUCTION

In response to the request made by the Government of the Republic of Indonesia, the Govermnet of Japan has decided to conduct the feasibility Study on The Nias Island Irrigation Agricultural Development Project (hereinafter referred to as the project). For the project, topographic surveying and mapping are required. And now, the topographic surveying and-mapping work (hereinafter referred to as the Work) is going to be conducted by the Government of Japan.

The Japan International Cooperation Agency (hereinafter referred to as JICA), the official agency responsible for the implementation of international technical cooperation programs of the Government of Japan, will carry out the Project in close cooperation with the Indohesian Authorities concerned.

The Directorate General of Water Resources Development, the Ministry of Public Works, the Republic of Indonesia (hereinafter referred to as DGWRD) shall act as the counterpart agency to the JICA Survey team.

2. Objective of The Work

The objective of the Work is to carry out the following topographic surveying and mapping for the feasibility study on the Nias Island Irrigation Agricultural Development Project.

1) 1:20,000 Aerial Photography
2) Ground control surveying
3) 1:5,000 topographic mapping

These surveying and mapping work, including aerial photography, vertical and horizontal ground control survey, photogrammetric plotting and drawing shall be executed by contracting them out to a qualified Indonesian survey company.

For supervision and inspection of these work, Three (3) Japanese engineers will be sent to Indonesia.

3. Tender and Contract

The surveying and mapping work shall be contracted to a local contractor specialized in surveying and photogrammetric mapping. The procedures to make the contract will be as follows:

1) Pre-qualification of local contractors.
2) Tendering by the qualified local contractors.
3) Contract to a local contractor.

4. Outline of the Plan

4.1 Aerial photography

Aerial photographs to be used for the 1:5,000 photogrammetric mapping shall be newly photographed at a scale of 1:20,000.

Necessary reproduction such as contact prints, dia positives and enlarged photographs will be prepared from the original negatives. The areas to be covered by the aerial photographs are shown in Fig. 2.

4.2 Ground Control Survey

The ground control survey shall be carried out to provide vertical and horizontal ground controls for the photogrammetric mapping. The work will include monumentation, signalization, tidal observation, leveling, traversing, spot leveling and field identification.

4.3 Photogrammetric Mapping

The photogrammetric mapping shall be carried out to prepare 1:5,000 topographic maps with 1 meter contour line intervals covering the project areas approximately 120 km^2. The areas to be mapped are shown in Fig. 2.