6.3.2　ケニア国側の分担範囲

(1)　一般事項

1）本プロジェクトのため輸入される資機材に関し、ケニア国における荷揚げ、通関および免税手続が速かに行われるよう措置する。

2）本プロジェクトの資機材及び役務の供与に関して、ケニア国における関税，内国税その他の財政課徴金を免除すること。

3）本プロジェクトの資機材及び役務を供与する日本国民に対し、その業務の遂行のため、ケニア国への出入国ならびに同国に滞在するための必要な便宜を与えること。

4）本プロジェクトに必要とされるケニア国内法による申請，承認書等一切の行為はケニア国で処理されること。

5）本プロジェクトで使用される建設資材等で、ケニア国内にて購入するものについては、政府公定価格のものを必要な時期に購入しうるよう措置する。

6）本プロジェクト完成後、施設の運転・保守に必要な予算の確保。

(2)　敷地造成

1）地上障害物及び地中埋設物の撤去又は移設

2）切土及び盛土を含む敷地造成

(3)　設備関係

1）電　力：建設期間中の仮設電力の引込、及び敷地迄の電力線の引込みと変電設備。

2）電　話：建設期間中の仮設電話の設置、及び本設MDFまでの外線の引込み。

(4)　外　　構

1）フェンス

2）門及び守衛所

3）防風林

4）造園及び植林

(5)　家　　具

一般事務用家具，事務用機器，什器等。

(6)　下記の諸施設は本無償援助に含まれないので、もし建設あるいは購入が必要とされる場合はケニア国負担となる。

1) 農　　道

2) 職員宿舎

3) ガソリンスタンド，洗車場

4) 屋外便所

5) 駐車場及びシェルター

6) 外　　灯

7) 育苗施設以外の舗装，歩道

8) マイクロバス（１台）及びピックアップ（１台）以外の車輌

6.4 概要事業費

本センター設立に必要な概算事業費は以下のとおりである。

6.4.1 積算条件

本概算事業費は以下の条件の下に算出したものである。

(1) 積算時期：1984年2月

(2) 積算は1984年12月に工事契約が完了するものとした。

6.4.2 概算事業費

(1) 日本国側負担

1) 建設工事費	864,390,000円
2) 資機材費	53,350,000
3) コンサルタント料	128,870,000
4) 予備費	103,390,000
	合計 1,150,000,000円

(2) ケニア国側負担

敷地造成，設備，外構等　　合計　40,000,000円

（ただし本文 6.3.2(6)を含まず）

(3) 総事業費　　合計 1,190,000,000円

6.5 実施工程計画

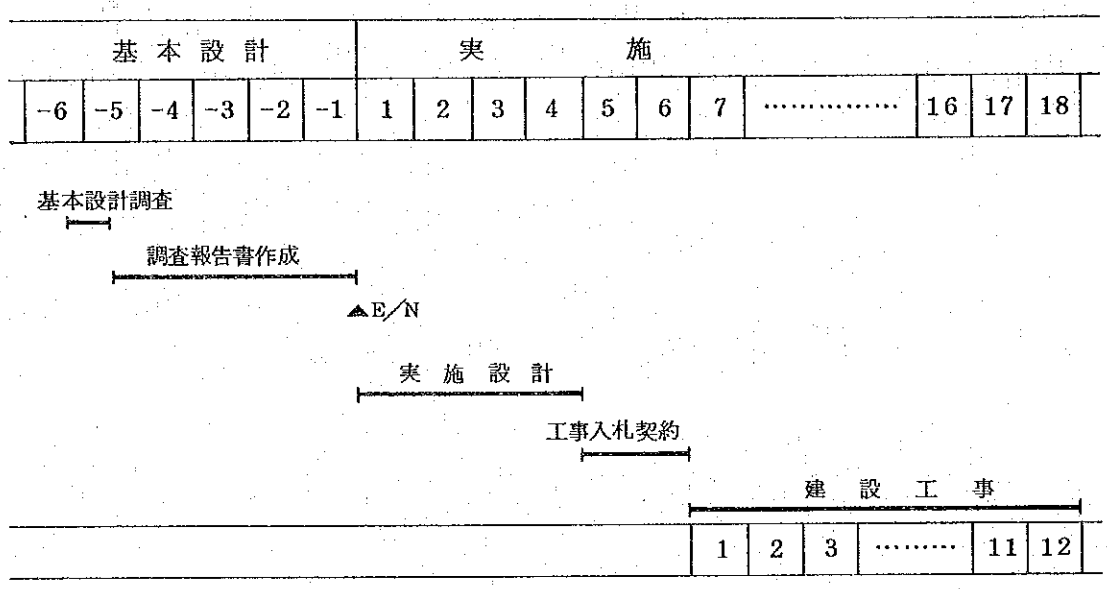
プロジェクトの全工程は、(1)技術協力による基本設計調査と、(2)無償資金協力による実施設計，建設工事及び監理業務に分けられる。

以下に示す実施工程を守るためには、次のようなケニア国側の協力が必要である。

1) 基本設計報告書，実施設計及び入札図書等の迅速な検討及び承認

2) 建設に関する諸認可，及び敷地造成，仮設電力の引込み等の建設着工以前の完了

実施工程計画


基本設計
実施
-6
-5
-4
-3
-2
-1
1
2
3
4
5
6
7
16
17
18
基本設計調査
調査報告書作成
E/N
実施設計
工事入札契約
建設工事
1
2
3
11
12

第7章　事業評価

第7章 事 業 評 価

7.1 直接的効果

マカデミアの優良系統の選抜，接木技術の改善等は、1977年以来国立園芸試験場において非常に小規模且つ不充分な設備の下で行なわれて来た。しかし最近の研究の成果によりマカデミア・ナッツは、小規模農家の換金作物として、また輸出農産物として注目を集め、政府は奨励作物として普及させようとしている。

しかし種苗の大量生産及び普及を前提として、接木・育苗技術，基本的な栽培方法を早急に確立する必要に迫られている。

これに応えるためナッツの接木増殖、基本的栽培方法の研究、またこれらの技術者の研修養成等を主目的とした本ユニットの設立は、政府の経済開発の一助として具体的、且つ直接的に貢献するものと期待される。

7.2 経済的利益

この種の計画の正確な事業評価を行うことは極めて困難である。即ち、試験研究の分野，研修の分野，苗木栽植或はその他の分野等区別することが非常に困難であり、このことは基本的に、試験研究，研修，その他の各要因が相乗作用としてユニット設置の利益をもたらすからである。また一方、本ユニットの活動は各県，各農業地帯，農家の技術レベルの相違等多岐，多方面に亘るため将来の生産や、増収の度合を推定することが極めて困難である。普及活動は現在の普及組織に従って行われようが、単位面積当り或は1戸当りのコストにすれば微々たるものである。従って普及対象地区での僅かの生産増でも可成りの利益増につながることになる。

小農家のマカデミア1本当りの平均収量はハワイ諸島の40kgに比較して僅か5kgである。現在、政府の目標は100万本の優良種を普及することであり、当面6,000トンの殻つきナッツから1,500トンの中味をとることである。この場合、輸出価格にして450万ドルの外貨を得ることになる。

本計画で予想される研究成果から考えれば、この推定は内輪に見積ったものと思われる。

7.3 技術者の研修

本計画の研修活動によると、5年間で延約750人の普及員，優良農家、その他がナッツ類特にマカデミアの栽培，接木技術の研修を受けることになる。これらの研修を受けた人々は、ナッツ類（アーモンド，ペカン，オイスターナッツ等）のみならず、他の種類の果樹類の生産や種苗生産に役立ちケニヤの農業生産に貢献することとなろう。

第８章　結論及び勧告

第8章　結論及び勧告

結　　論

1. 国立園芸試験場整備計画を通じ、ケニア政府の意図を具体化するため、ナッツ開発のユニットを設立することはケニアにおけるナッツ類開発を成功させるために欠くべからざる重要な役割を果すことになる。

   特に1977年以降、日本の技術協力により不備な現地条件にもかかわらず試験研究が実施され或程度の成果を挙げて来た。これに加えて今回、日本の無償資金協力により本計画が実施されることは、相手国の要請に応えることは勿論のこと、日本の技術協力を全面的に支え、具体的な協力の場を確保することを意味しその直接的な成果が期待される。

2. 本計画は、10年以内に100万本の高収量品種を普及させる政府の目標を達成するのに役立つと思われる。

   この結果、小規模農家はナッツを栽培することによって現金収入を増加させ、一方政府は輸出によって外貨を得ることが出来、経済開発計画の目的に沿ったものとなる。

3. 当初5カ年間に延約750人の技術関係者がナッツ類の栽培と接木技術の研修を受ける。現在、農業分野では技術者の不足に悩んでいるがこれらの人々は、ナッツ類のみならず、他の種類の果樹についても生産と種苗増殖に役立つし、全般的に見てケニアの農業生産に貢献することになる。

勧　　告

1. 本ユニットが完成した暁には、本計画を円滑且つ効果的に運営するための技術協力計画が必要である。このための専門家は育種，栽培，接木などの分野の人達であろうし、更に病虫害，土壌肥料の専門家なども必要となる。

2. 本ユニットは当初5カ年は計画の基礎を充実させる形で運営されよう。しかしナッツ類に適した気象，土壌条件を備えた普及地域は広大であるが、これに比較してセンターの活動は限られたものになる。

   従って、基礎段階の終る時、本ユニットの活動を本格的に拡大するために何カ所かの分場の設立が必要となろう。これら分場は、ナッツ類特にマカデミア栽培に適した1,200㎜以上の年間降雨量のある温暖な地域の普及対象県から選ぶ必要がある。

付　表・付　図

TABLE II-1 **CENTRAL GOVERNMENT OPERATIONS, 1978/79 - 1983/84**
(Kl. million)

	1978/79	1979/80	1980/81	1981/82	Provisional 1982/83	Budget 1983/84
Current Revenue	510.6	611.0	716.9	786.8	817.4	921.0
Current Expenditure	475.1	546.4	699.2	751.6	764.4	904.2
Current Surplus	35.5	64.6	17.7	35.2	53.0	16.8
Development Expenditure	222.5	234.9	286.6	317.5	248.4	266.5
(Cash adjustment)	(-25.0)	(27.8)	(-21.9)	(23.4)	(-39.1)	(--)
Overall Deficit	-162.0	-142.5	-290.8	-258.9	-235.2	-249.7
Financing	162.0	142.5	290.8	258.9	235.2	249.7
Grants	13.3	19.1	22.6	44.3	48.6	88.2
Foreign Borrowing	61.3	74.7	138.2	58.4	75.0	77.3
Drawings	(..)	(..)	(174.9)	(111.9)	(150.4)	(162.2)
Amortization	(..)	(..)	(-36.7)	(-56.5)	(-75.4)	(-85.0)
Domestic Borrowing	87.4	48.7	130.1	159.0	111.7	84.3
Non Bank	(32.1)	(40.6)	(51.4)	(74.4)	(63.2)	(33.2)
Bank	(55.3)	(8.1)	(78.7)	(84.7)	(48.4)	(51.1)
Memorandum Items						
(1) Tax ratio	19.4	21.0	21.6	20.8	17.8	..
(2) Total Revenue/GDP (%)	32.1	31.9	34.9	32.9	26.1	29.0
(3) Total Deficit/GDP (Bank)	7.4	5.8	10.3	8.0	6.0	6.2
(4) Total Deficit/GDP (IMF)	6.8	5.0	9.5	6.0	4.8	4.0

Source: Ministry of Finance

TABLE II-2 **CENTRAL MONETARY AUTHORITIES: FOREIGN EXCHANGE RESERVES, 1978-1982**

Unit: KŁ'000

	Central Bank of Kenya					General Account with IMF				
As at end of	SDR's	Foreign Reserves	Foreign Liabilities (other than to IMF)	Total Net Foreign Reserves of Central Bank	Total Net Foreign Reserves of Central Government	Total Net Foreign Reserves of Central Monetary Authorities	Sub Scription	IMF holding of Kenya Currency	Net use of Fund Credit	Counter-part Liability SDR Account
1978	5,293	129,909	3,294	131,908	1,420	133,328	33,327	58,583	-25,256	6,721
1979	39,821	197,766	4,877	232,710	1,829	234,538	33,327	85,636	-52,309	10,781
1980	9,730	176,362	2,224	183,868	3,097	186,965	49,991	123,565	-73,574	14,467
1981	5,615	119,180	2,297	122,498	3,933	126,431	61,842	166,494	-104,652	22,102

Source: Economic Survey 1983

Table II-3 **Major Agriculture Research Institutions and Program in Kenya**

Institution	Location	Objectives & Programmes
Kenya Agricultural Institute (KARI)	Muguga (Central)	a) Crop production plant protection and quaratine, in future, crop improvement and dryland farming; b) Animal production; dairy cattle breeding and production c) Veterinay: research and vaccine production for for vinderpest, and East Cost Fever; d) Forestry: silvicultural techniques, pest and disease control for plantation species
National Agricultural Research Station	Kitale (Rift v.)	a) Breeding and agronomy of maize and improved pastures b) Soil testing
National Plant Breeding Station	Njoro (Rift v.)	a) Breeding and agronomy of wheat, barley, tritical oats and oilseeds b) Development of technology for smallholder wheat production c) Soil testing
National Horticultural Research Station	Thika (Central)	a) Breeding and agronomy of horticultural crops (vegetables, fruits, dry beans, roots and tubes) b) Horticultural seed production; supply of plant materials c) Sericulture

Table II-3 **Major Agriculture Research Institutions and Program in Kenya**

Institution	Location	Objectives & Programmes
National Agricultural Laboratories	Kabete (Nairobe)	a) Soil chemistry and testing b) Kenya Soil Survey c) Plant protection (pathology, entomology, and pesticide analysis) d) Irrigation and drinage, water management
National Drying Farming Research Station	Katumani (Eastern)	a) Integrated farming systems for marginal areas development of adapted varieties of millet, sorghum, maize, peas, and beans; b) Integrated farm livestock, agro-forestry
Costal Agricultural Research Station	Mtwapa (Coast)	a) Crop research for coastal zone; coconut, maize, cashew, cassava, tubes, and some cotton sugarcane, grain-legume and livestock research
Coffee Research Foundation	Ruiru (Main Station) Kisii, Koru, Meru (Substation)	a) Coffee research in areas of breeding plant protection, soil fertilitz, agronomy, agricultural economics and extension work
Tea Research Foundation	Kericho (Rift v.)	a) Tea research in areas of botamy, agronomy, chemistry and all related subjects

Table II-3 **Major Agriculture Research Institutions and Program in Kenya**

Institution	Location	Objectives & Programmes
National Sugar Research Station	Kibos (Western)	a) Sugar research, selection, agronomy, irrigation and soil testing
National Potato Research Station	Tigani (Central)	a) Potato research, selection, agronomy and plant protection
International Laboratory for Research in Animal Diseases (IIRAD)	Nairobi (HQ)	a) Animal disease, primarily trypanosoniasis and East Cost Fever
International Centre for Research on Agro-Forestry (ICRAF)	Nairobi (HQ)	a) Land use systems and development of agro-forestry systems
International Centre of Insect plysiology and Ecology (ICIPE)	Nairobi (HQ)	a) Basic research on insects of agricultural and medical importance

TABLE II-4 **GOVERNMENT BUDGET FOR MACADAMIA NUTS PROJECT IN 1982/83**

Unit: K'000

Head	Sub-Head	Item	Title	Approved Estimates 1981/82	Estimates 1982/83	External Receipts 1981/82	External Receipts 1982/83	Sources of External Receipts
237	084	100	Transport Operating Expenses	3,400	3,750			
		110	Travelling and Accommodation Expenses	2,000	1,500			Japan
		153	Farm Inputs	3,000	3,000			Technical
		190	Miscellaneous Other Charges	1,500	1,500			Aid
		220	Plant and Equipment	1,500	2,000			
		250	Maintenance of Stations	1,000	1,500			
			Total 237-084 K	-	13,250			

Source: Development Estimates for the Year 1982/83

TABLE II-5 **PLANTED MACADAMIA TREES IN KENYA**

Province	District	1964	1965	1966	1967	1968	1969	1970	1971	Total
Central	Kiambu	500	1,000	1,500	9,500	12,500	14,200	15,300	8,000	62,500
	Muranga	10,000	5,000	4,000	18,000	13,200	-	49,000	38,000	137,200
	Nyeri	5,000	6,000	15,000	35,400	12,500	23,000	4,900	5,800	107,600
	Kirinyaga	-	-	-	11,400	10,000	25,000	-	-	46,400
Eastern	Embu	3,000	5,000	2,000	14,300	10,000	23,000	22,000	14,500	98,200
	Mackakos	300	500	500	-	15,000	37,000	26,800	18,100	99,300
	Kituii	-	-	-	-	-	-	1,200	-	1,200
	Meru	10,000	20,000	10,000	33,000	37,500	113,000	16,500	10,000	250,000
Rift Valley		-	-	-	10,000	-	-	-	-	10,000
Nyanza		-	-	-	-	-	-	1,000	5,000	6,000
Western		-	-	-	-	-	-	1,500	-	1,500
Total		28,800	37,500	33,000	131,600	110,700	235,200	138,200	99,400	814,400
Accum.			66,300	99,300	230,900	341,600	576,800	715,000	814,400	

Source: Ministry of Agriculture 1971

TABLE II-6 **PURCHASES OF RAW MACADAMIA NUTS**

DISTRICT/ SECTOR	1979	1980	1981	1982	1983
MURANG'A	58	49	46	50	48
NYERI	132	155	185	190	170
MERU	157	185	220	250	240
KIRINYAGA	174	204	243	265	266
EMBU	150	175	210	240	230
MACHAKOS	41	49	46	50	60
KIAMBU	25	30	35	25	36
FACTORY	91	126	175	215	195
TOTAL (ton)	828	973	1,160	1,285	1,245
PRODUCER PRICE PER KILOGRAM (shs)	1.90	2.10	2.20	2.30	2.80
EXPORT (ton)	165	160	180	240	215

Source: Kenya Nut Co. LTD. 1984

TABLE III-1 **TRAINING PROGRAM**

1. Main Area of Extension

(1) Central P.	:	Kiambu/Muranga/Nyeri/Kirinyaga
(2) Eastern P.	:	Embu/Meru/Machacos
(3) Coast P.	:	Taita-Tabeta
(4) Rift V. P.	:	Kitale
(5) Nyanza P.	:	Kisii
(6) Western P.	:	Kakamega/Bungoma
Total		12 Districts

2. Training Courses at Center

(1) A course (One week)		
- Provincial Crop Officers	(PCO)	6 x 2 = 12
- District " "	(DCO)	12 x 2 = 24
		Total 36
(2) B course (Two weeks)		
- Divisional Extension Officers	(DEO)	12 x 5-6 = 64
		Total 64
(3) C course (Three weeks)		
- Locational Extension Officers	(LEO)	12 x 10 = 120
- District Horticultural Officers	(DHO)	Total 120
(4) D course (One week)		
- Farmers Training Center Offices	(FTC)	12 x 4 = 48
		Total 48
(5) E course (Temporary)		
- Selected Farmers/Others		12 x 40 = 480
		Total 480

3. Training Schedule

		Months											Years						
		J	F	M	A	M	J	J	A	S	O	N	D	1st	2nd	3rd	4th	5th	Total	Remarks
A	PCO/DCO-												-	-	9	9	9	9	36	
B	DEO												-	-	16	16	16	16	64	
C	LEO/DHO	-												24	24	24	24	24	120	
D	FTC/D.N		-											-	12	12	12	12	48	
E	Selected Farmers	(Temporary)												96	96	96	96	96	432	Total 748

FTC: Farmers Training Center
D.N: District Nursery

TABLE III-2 ESTIMATED OPERATION AND MAINTENANCE COST (Ksh '000)

(A)	Staff Salaries	Grade	No.	Unit cost	Base cost
	Manager	(L)	1	60	60
	Researcher (AO)	(K)	7	50	350
	Asst. Res. (TO)	(G/H)	7	30	210
	Tech. Asst. (TA)	(F)	9	30	270
	Subordinate (SS)	(A/B)	20	15	300
	Excutive Asst	(G/H)	1	30	30
	Clerical Officer	(D/F)	2	16	32
	Accountant Clerk	(D/E)	2	14	28
	Copy typist	(E)	3	16	48
	Watchmen/Tel.ope/ Driver	(C)	7	15	105
	Messenger	(B)	2	8	16
	Hostel Inspector	(F)	1	20	20
	Cook	(E)	2	16	32
	Sweeper	(B)	2	8	16
	Sub-total	-	66	-	1,517
	Housing allowance	(15%)	-	-	228
	Total		-	-	1,745
(B)	Research and Experiment				
	Plant and equipment				100
	Farm and equipment				40
	Laboratory materials				100
	Fuel for machinery				50
	Books and information				30
	Total				320
(C)	Training				
	Travel allowance (100 persons)				200
	Grafting materials				30
	Teaching materials				15
	Fuel for vehicles				40
	Total				285
(D)	Operation and Maintenance				
	Electricity				120
	Travel allowance for staff				90
	Transportation/Communication				40
	Stationary (L.S.)				15
	Maintenance of Centre				80
	Miscellaneous other charges				60
	Total				405
	Grand Total				2,755

Fig. Ⅱ−1 PRESENT ORGANIZATION AGRICULTURAL RESEARCH IN KENYA

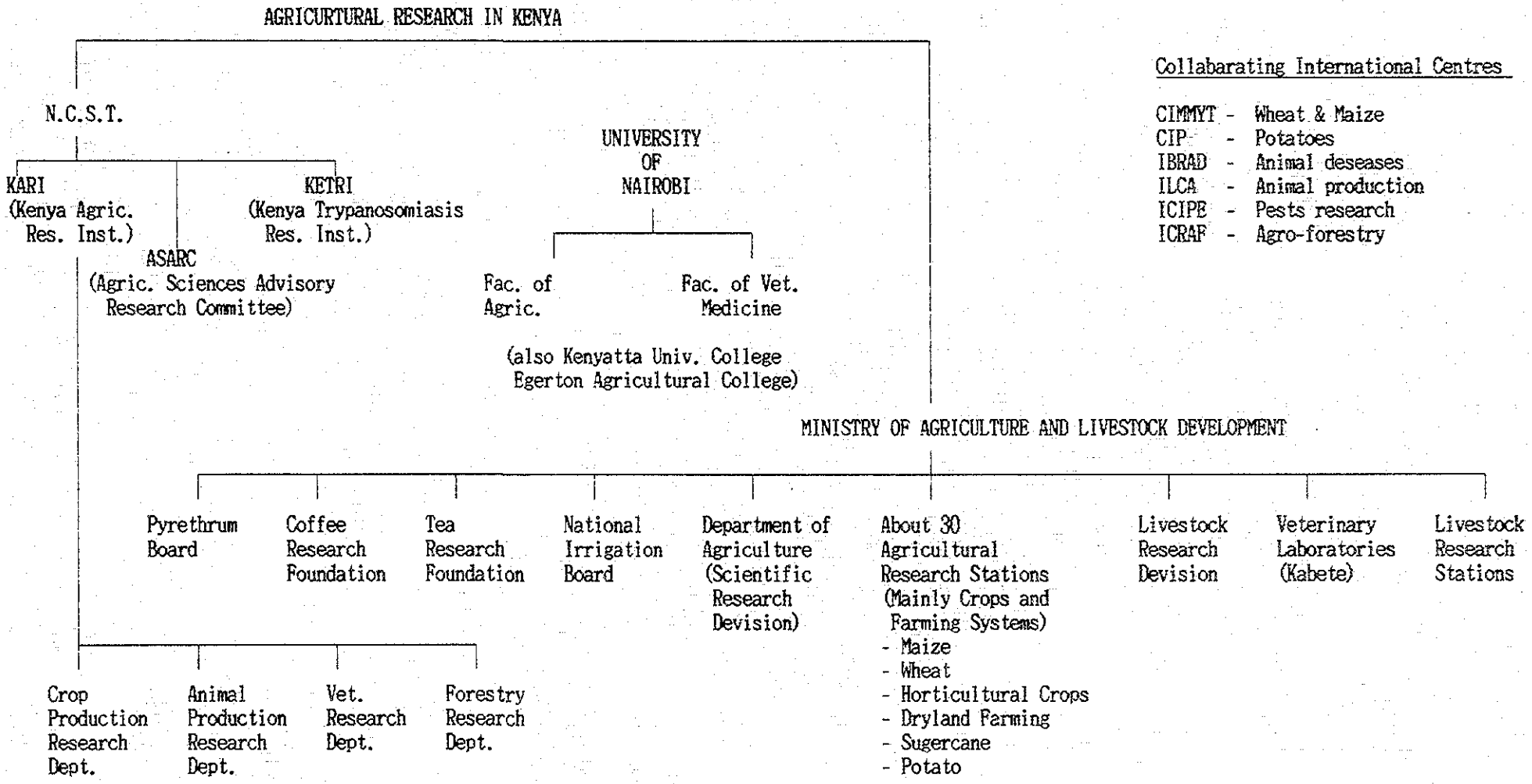


FIG. III-1 RAINFALL MAP IN SOUTHWEST KENYA

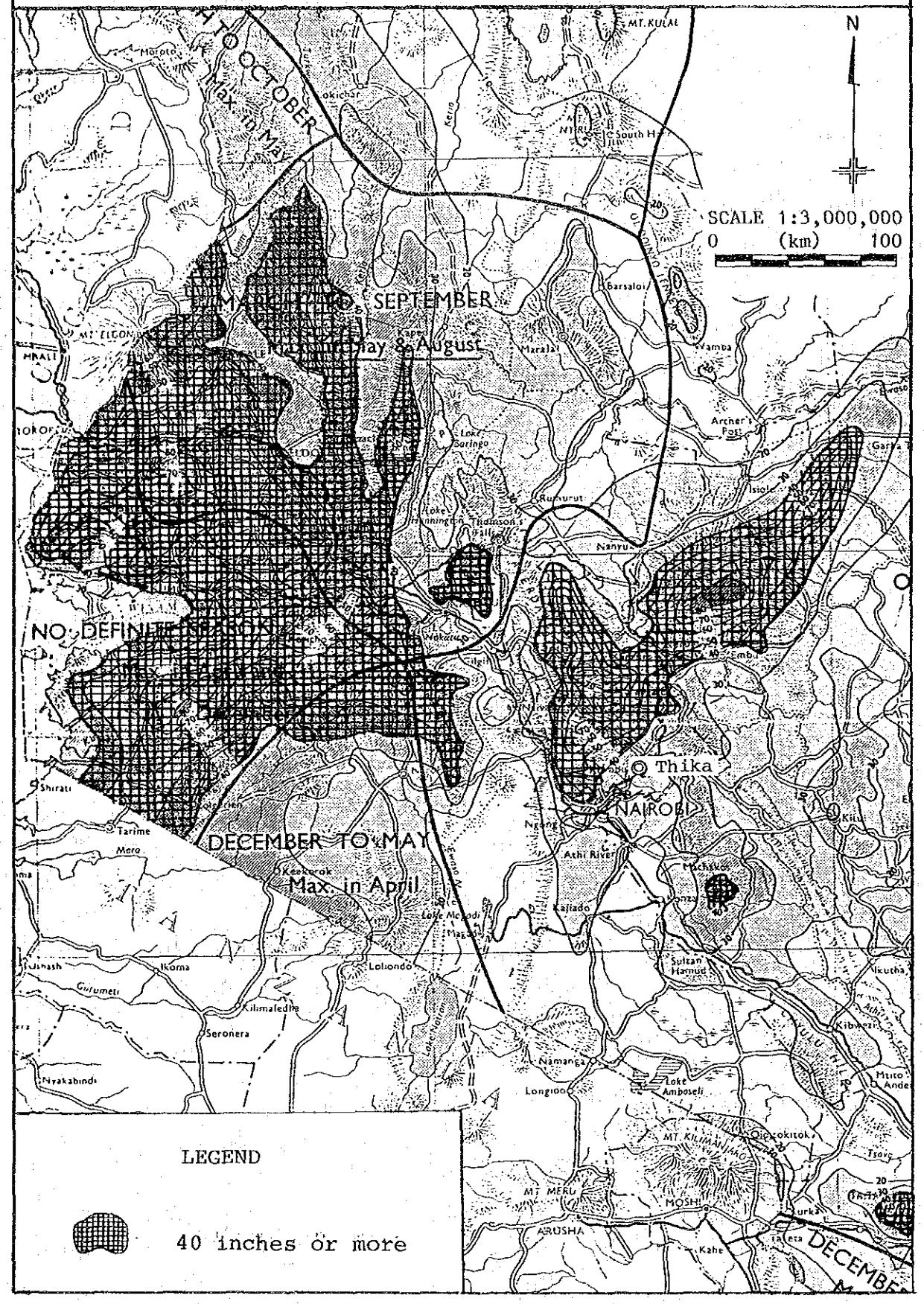


Fig. Ⅲ-2 Organization of Agricultural Department

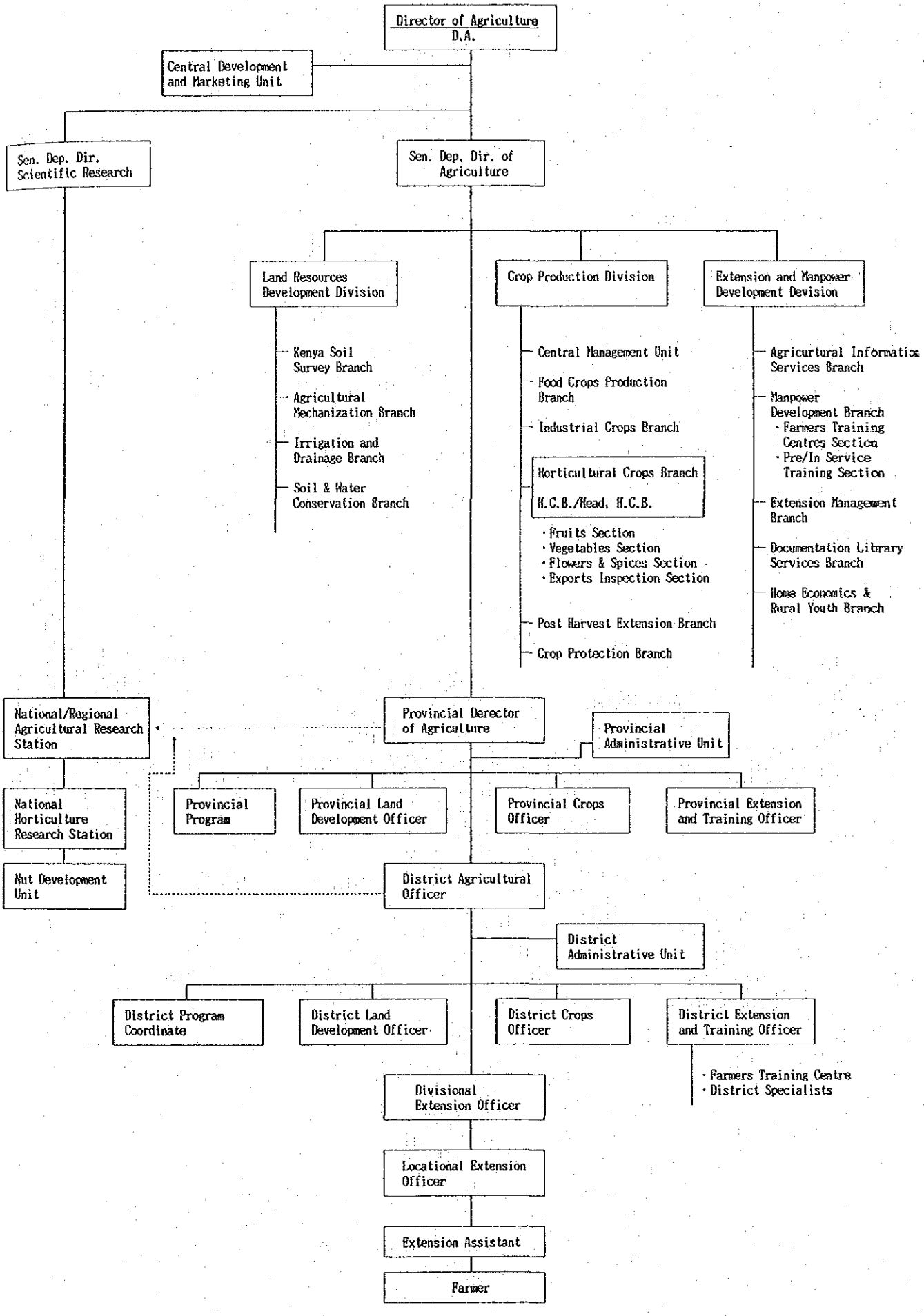
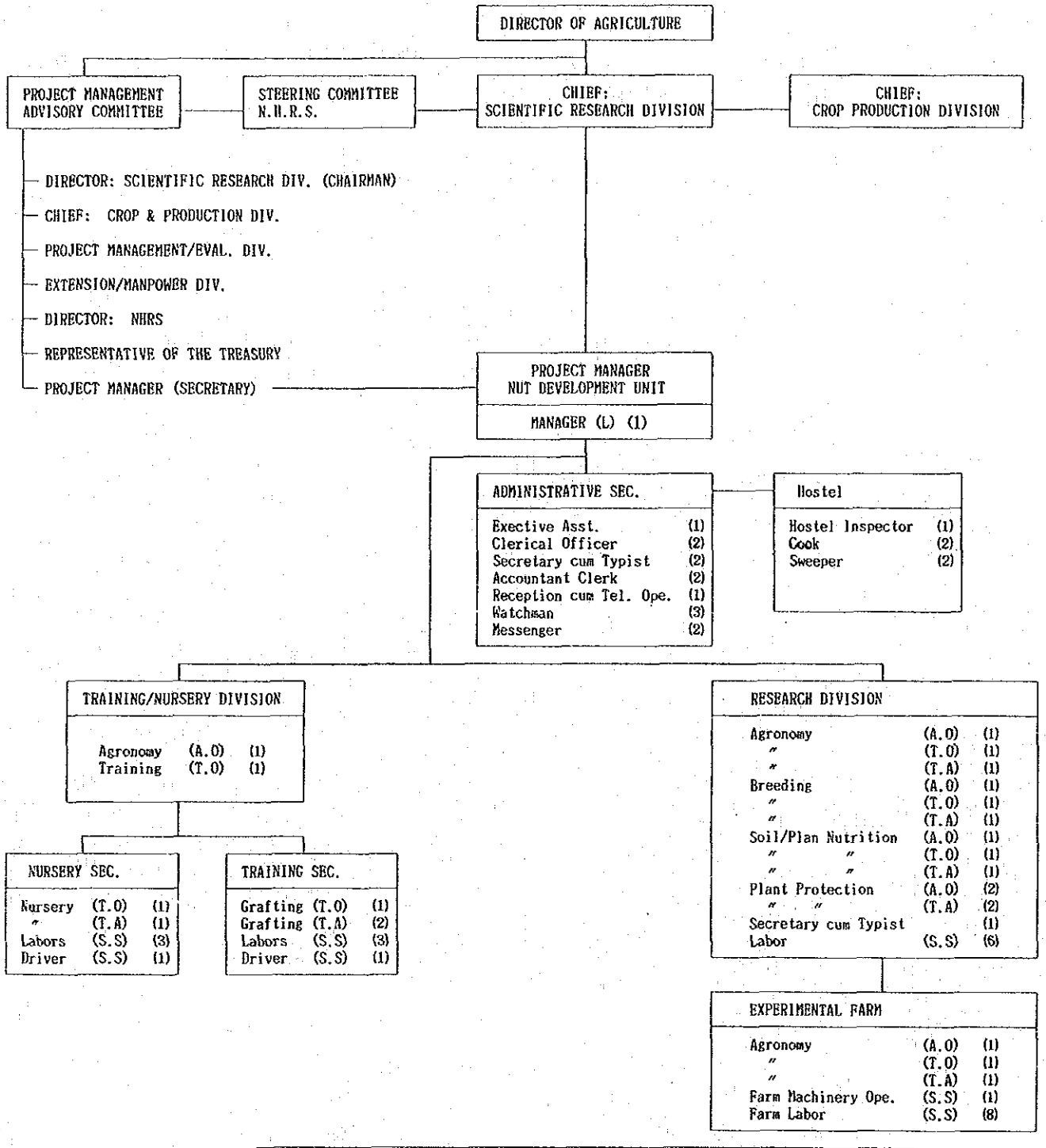


Fig. Ⅲ-3

ORGANIZATION AND MANNING

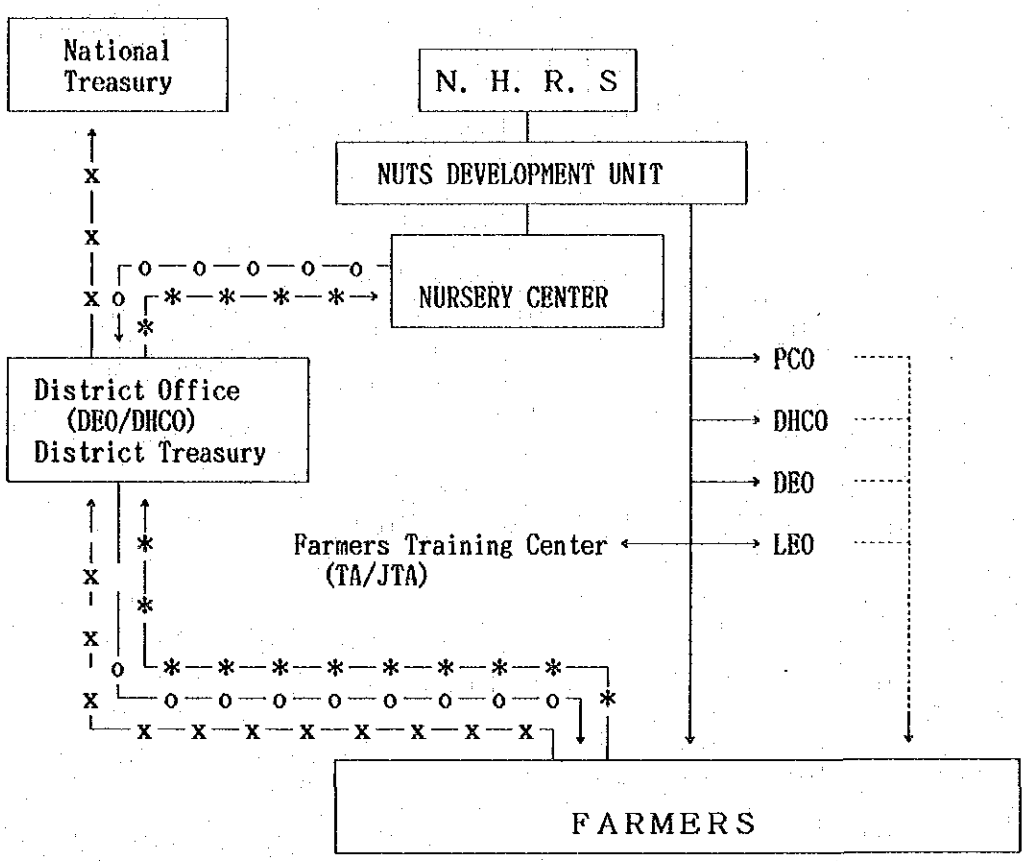


Total Number of Staff

Exective Asst.	1	Hostel Inspector	1	L.	1
Clerical Officer	2	Cook	2	A.O	7
Accountant Clerk	2	Sweepwer	2	T.O	7
Secr. cum Typist	2	Sub-total	5	T.A	9
Recep. cum Tel Ope.	1			S.S	20
Watchman	3			Driver	3
Messenger	2			Typist	1
Sub-total	13			Sub-total	48

Total 66

Fig. Ⅲ—4 TRAINING AND SEEDLING FLOW DIAGRAM



(1) ———————— Training

(2) ···· Technical Extension Services

(3) —*—*—*—*— Seedlings for Requests

(4) —o—o—o—o— Seedlings Distribution

(5) —x—x—x—x— Money Flow for Seedlings

PCO : Provincial Crop Officer

DHCO: District Horticulture Crop Officer

DEO : District Extension Officer

LEO : Locational Extension Officer

TA : Technical Assistant

JTA : Junior Technical Assistant

FIG. IV-1 TOPOGRAPHICAL SURVEY MAP

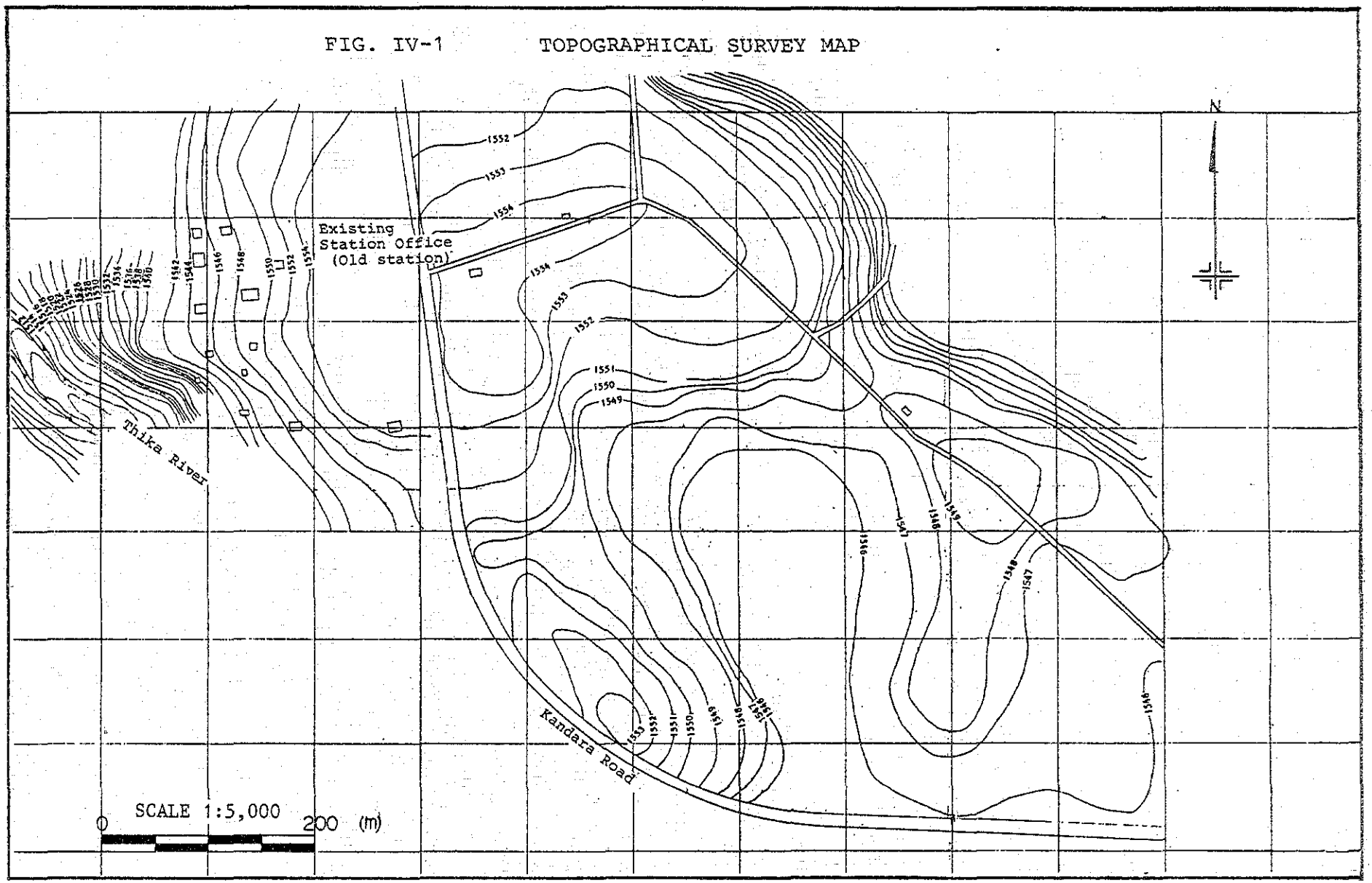


FIG. V-1

WATER SUPPLY SYSTEM

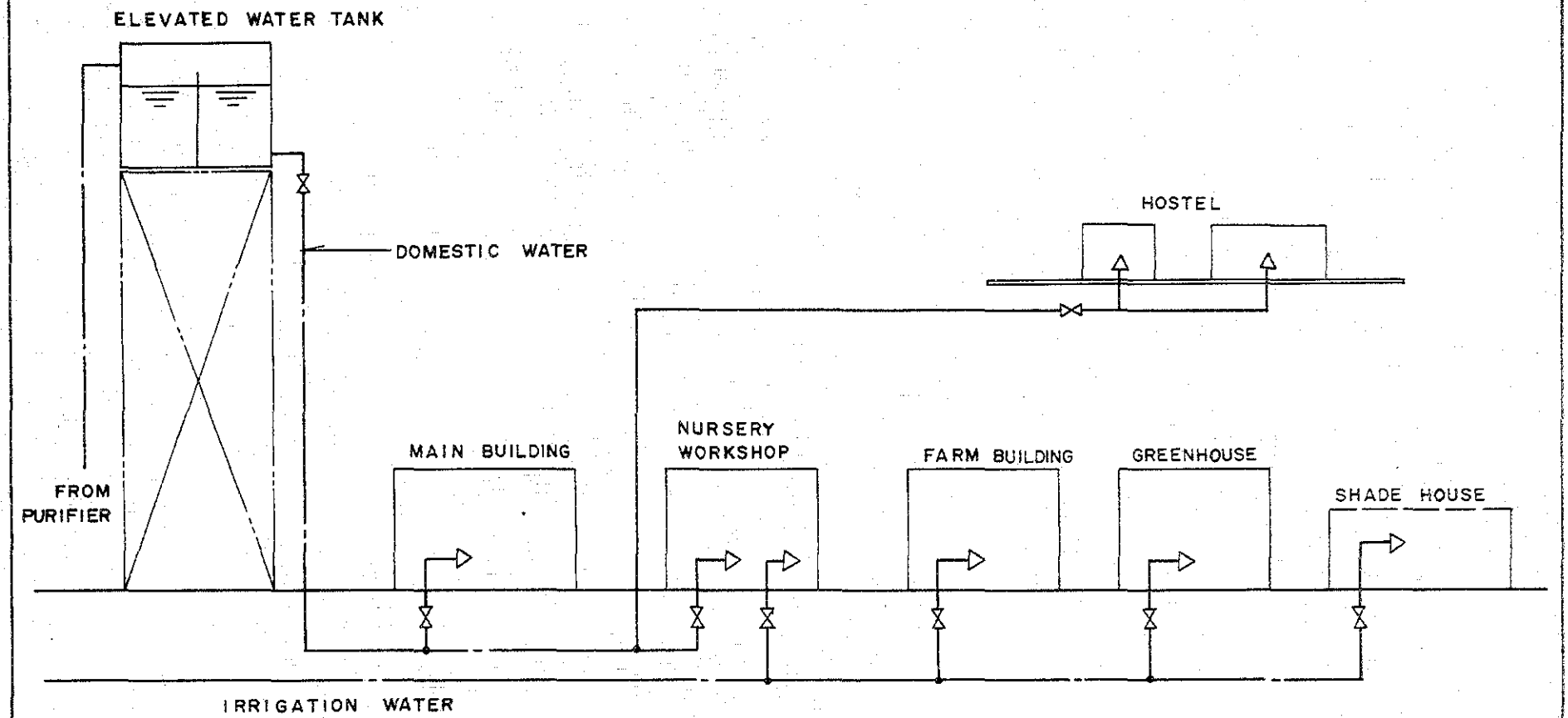


FIG. V-2

SEWAGE SYSTEM

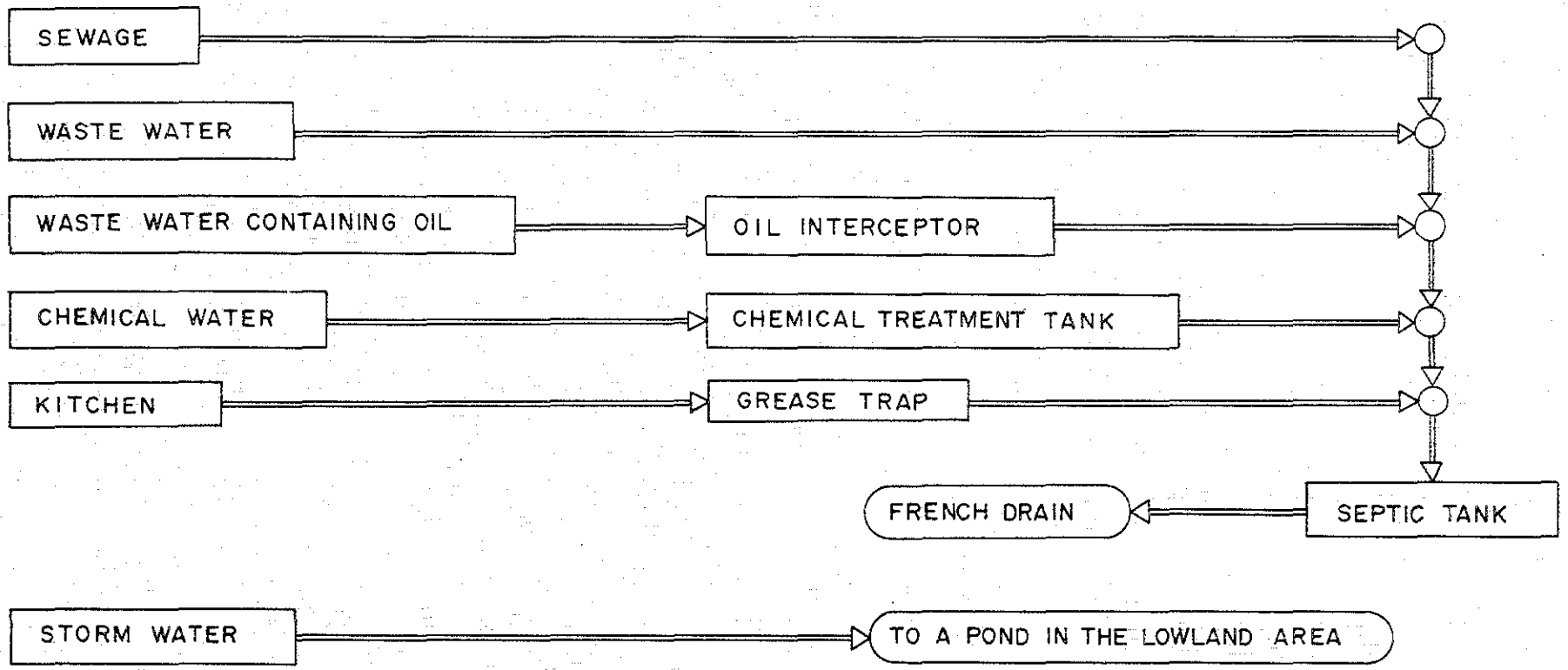
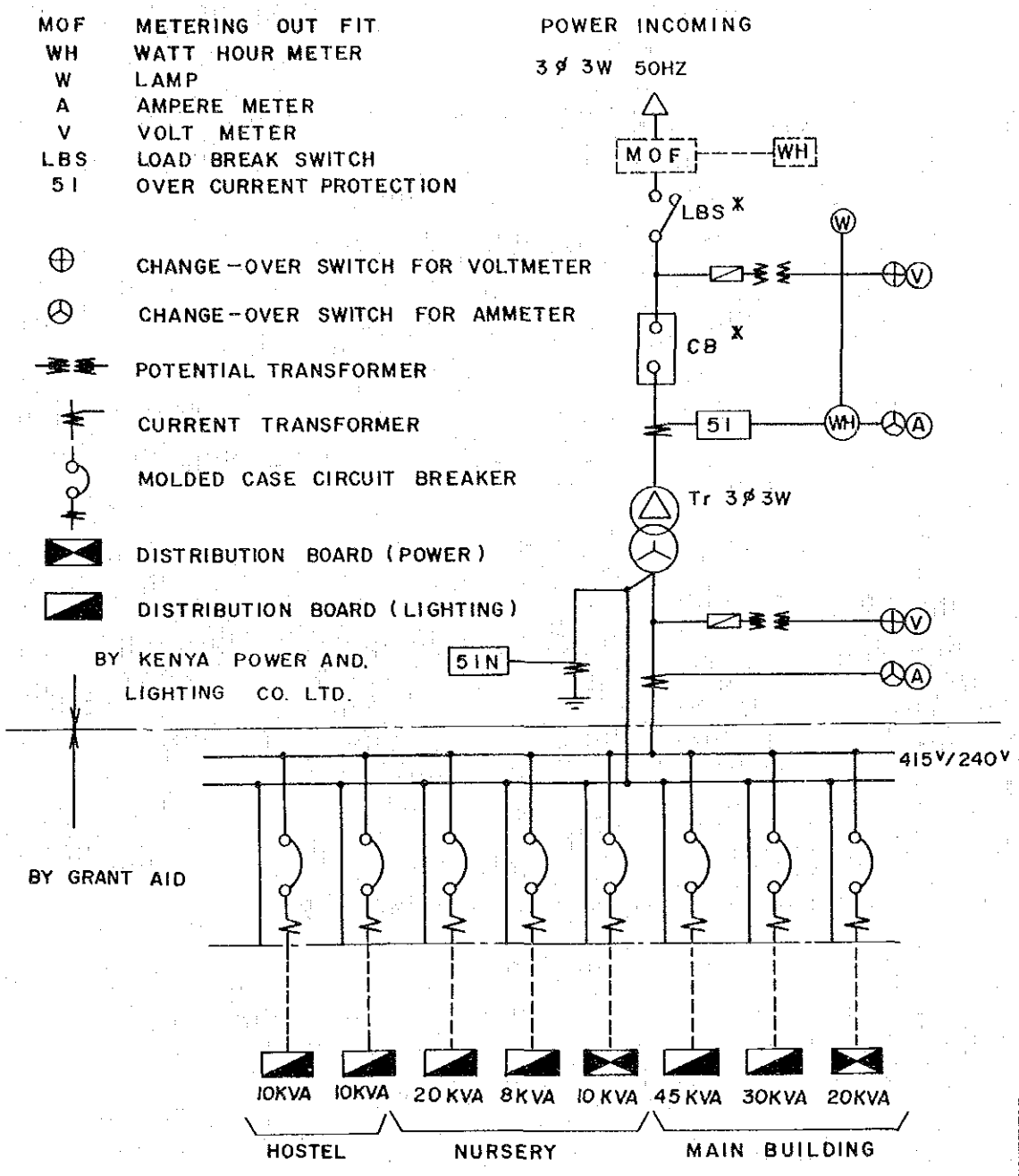


FIG. V-3

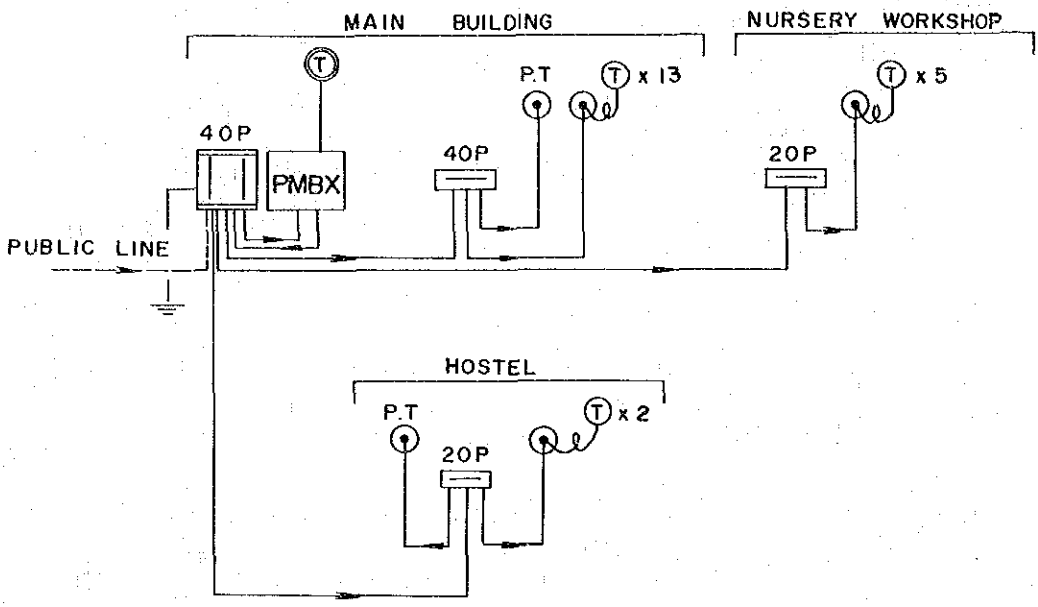
SINGLE LINE DIAGRAM



X : BY GRANT AID

FIG. V-4

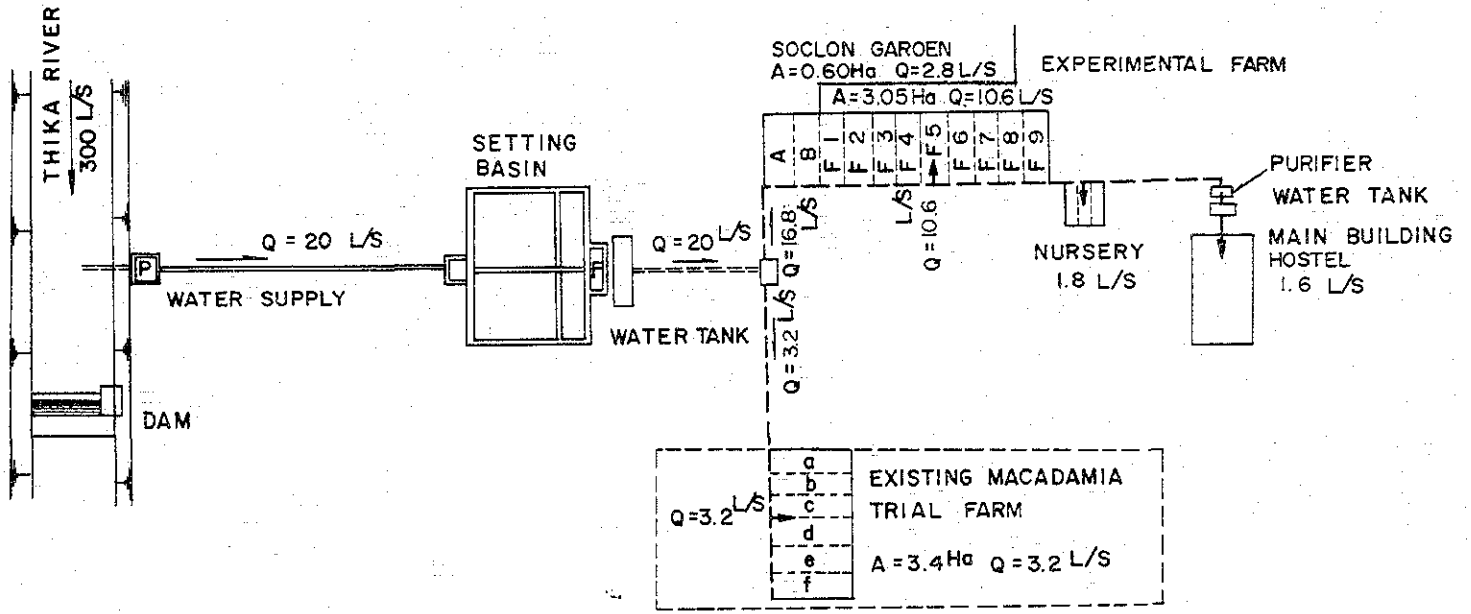
TELEPHONE WIRING AND PIPING SYSTEM



	MAIN DISTRIBUTING FRAME
	TERMINAL BOARD
PMBX	PRIVATE BRANCH EXCHANGER
⊙	OUTLET BOX (EXTENSION TELEPHONE)
⊙P.T	OUTLET BOX (PUBLIC TELEPHONE)
Ⓣ	EXTENSION TELEPHONE
Ⓣ	EXTENSION TELEPHONE (MASTER)

FIG. V-5

WATER DISTRIBUTION DIAGRAM



NAME	AREA (Ha)	IRRIGATION REQUIREMENT L/SEC	REMARKS
EXISTING MACADAMIA TRIAL FARM	3.40	3.2	
SCION GARDEN	0.60	2.8	
EXPERIMENTAL FARM	3.05	10.6	CATCH CROPS
NURSERY	0.35	1.8	
BUILDING LOTS		1.6	
TOTAL	7.40	20.0	

添付資料

MINISTRY OF AGRICULTURE AND LIVESTOCK DEVELOPMENT

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Ref. No. OFTA/76/14
and date

KILIMO HOUSE
CATHEDRAL ROAD
P.O. Box 30028, NAIROBI
25th Jan. 19 84

MINUTES OF DISCUSSIONS ON BASIC DESIGN STUDY FOR THE PROJECT FOR IMPROVEMENT OF THE NATIONAL HORTICULTURAL RESEARCH STATION IN THE REPUBLIC OF KENYA

In response to the request made by the Government of the Republic of Kenya for the Project for Improvement of the National Horticultural Research Station in Thika, in the Republic of Kenya (hereinafter referred to as " the Project"), the Government of Japan, through Japan International Cooperation Agency (JICA), has dispatched a survey team headed by Dr. Yutaka MACHIDA, Chief of Second Breeding Laboratory, Fruit Tree Research Station, Japanese Ministry of Agriculture, Forestry and Fisheries (hereinafter referred to as "the Team") to conduct the basic design study on the Project from 17th January to 16th February, in 1984.

The Team has carried out a field survey and had a series of discussions with Kenya authorities concerned of the Project.

As a result of the survey and discussions, the Team and Kenya authorities concerned have agreed to recommend to their respective Governments that the result of the survey and discussions attached herewith should be examined toward the realization of the Project.

NAIROBI 25TH JANUARY, 1984

Y. Machida

A.K. KIRIRO
for: PERMANENT SECRETARY

Dr. Yutaka Machida
Head of Japanese Survey Team.

MINISTRY OF AGRICULTURE AND LIVESTOCK DEVELOPMENT

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ATTACHMENT

1. The objective of the Japanese Grant Aid Programme is to provide necessary buildings, facilities and equipment for establishing a nut development center (hereinafter referred to as "the Center"), mainly Macadamia Nut, in the National Horticultural Research Station in Thika.

2. The purpose of the Project is to improve the activities of the National Horticultural Research Station by means of establishment of the Center.

3. The Center is directly under the Director of Agriculture in the Ministry of Agriculture and Livestock Development. The organization chart of the Center is shown in ANNEX I

4. The Executing body for the implementation of the Project in Kenyan side are the Crop Production Division and the Scientific Research Division on behalf of the Permanent Secretary, Ministry of Agriculture & Livestock Development.

5. The proposed site of the Project is the land in the National Horticultural Research Station in Thika (hereinafter referred to as "the Project Site"). The Project Site is shown in ANNEX II. The zoning plan of the Center is shown in ANNEX III.

6. The objectives of the Center are:
   6.1 To serve as a center for production and distribution of improved nut seedlings, especially Macadamia Nut.

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6.2 To serve as a training center for promoting manpower to improve and develop nuts cultivation, especially Macadamia Nut.

6.3 To serve as a research center for breeding, agronomy, soils, plant nutrition and plant protection of nut crops, mainly Macadamia Nut.

7. The Team will convey to the Government of Japan the desire of the Government of the Republic of Kenya that the former takes necessary measures to cooperate by providing the buildings and other items listed in ANNEX IV within the scope of Japanese economic cooperation programme in grant form.

8. The Team will convey to the Government of Japan the desire of the Government of the Republic of Kenya that Technical Cooperation Programme is needed for the smooth and effective operation of the Center on and after the establishment.

9. The Kenyan authorities concerned have understood and confirmed Japan's Grant Aid System explained by the Team which includes a principle of use of Japanese consultant firm and a Japanese general contractor for implementation of the Project.

10. The Kenyan authorities concerned have confirmed the Government of the Republic of Kenya will take necessary measures as listed in ANNEX V on condition that the grant aid by the Government of Japan is extended to the Project.

MINISTRY OF AGRICULTURE AND LIVESTOCK DEVELOPMENT

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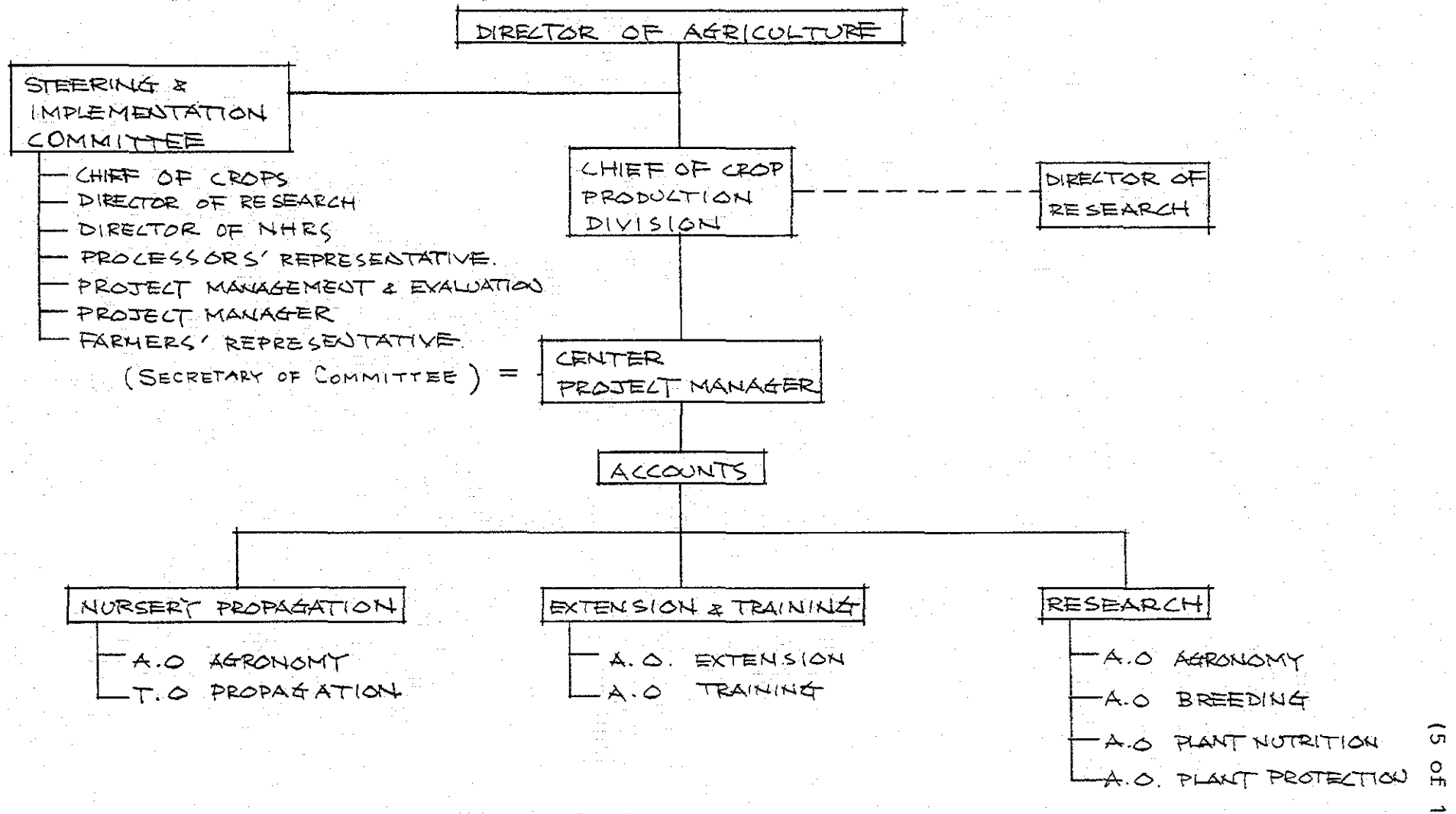
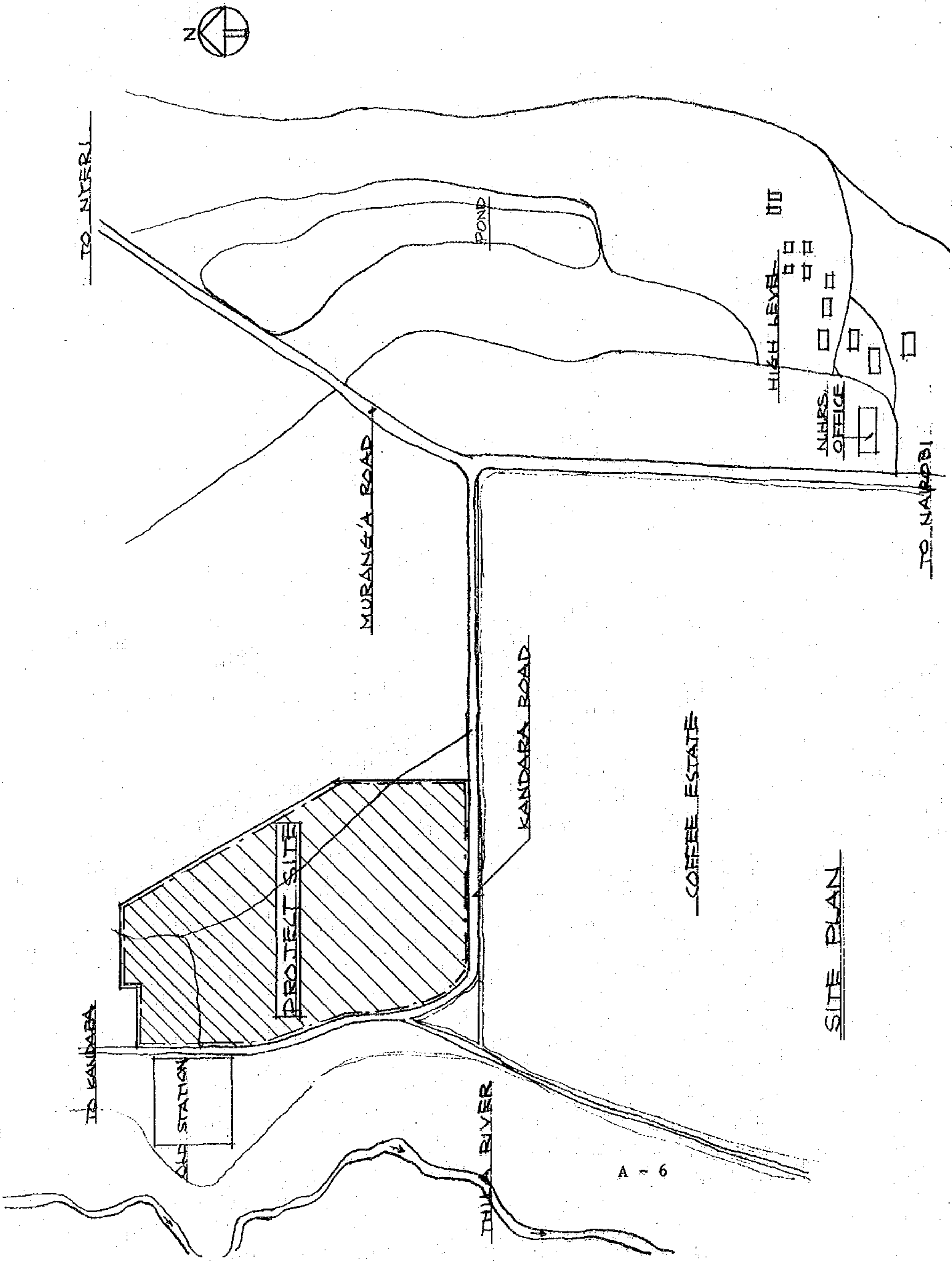
ATTACHMENT cont.

11. The Kenya Government side requests the Team to consider advising the former on the estimated local costs and external costs of the project as soon as possible.

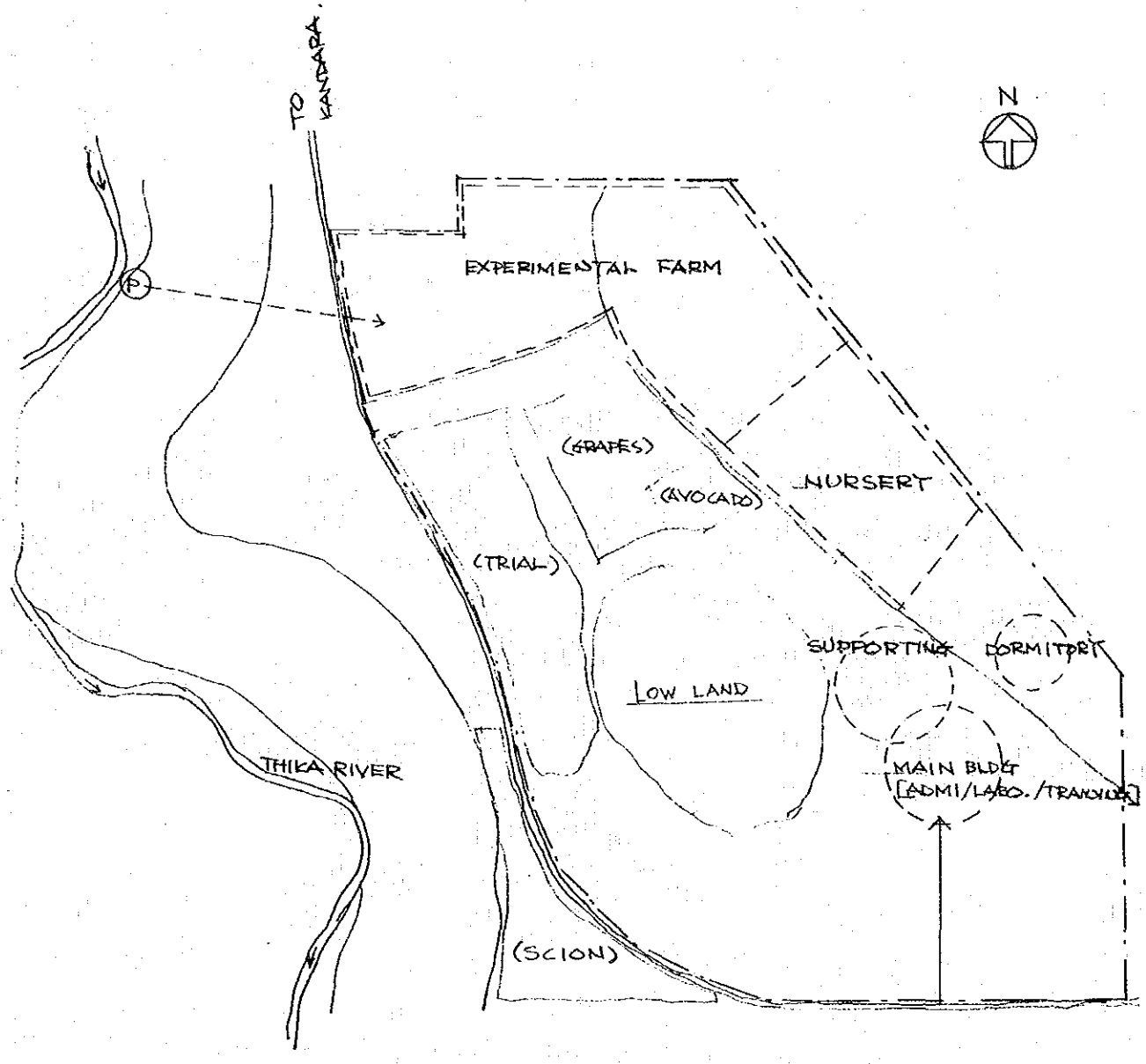
ANNEX I

ORGANIZATION OF THE CENTER




N
TO NYERI
POND
HIGH LEVEL
N.HRS. OFFICE
TO NAIROBI
MURANG'A ROAD
KANDARA ROAD
COFFEE ESTATE
PROJECT SITE
SITE PLAN
TO KANDARA
OLD STATION
RIVER

ANNEX III.



ZONING PLAN OF THE CENTER

S: 1/5,000

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ANNEX IV

Items requested by the Government of the Republic of Kenya the cost of which will be borne by the Government of Japan:-

1. Main Building
   (Administration)
   Director's room
   other offices

   (Training)
   Class room for 50 persons
   Class room for 16 persons
   Store room for teaching materials.

   (Research)
   Laboratories for
   Breeding/processing
   Agronomy
   Soils/Plant Nutrition
   Plant Protection
   Cold room
   Sample room
   [illegible]
   Small Library

2. Annex Building (supporting facility)
   Store for equipment/chemicals/fertilizers
   [illegible] Shop
   Garage for farm machinery

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ANNEX IV (conti.)

3. Nursery
   - Grafting facility
   - Green houses
   - Shed houses

4. Experimental Farm (about 4 ha)

5. Irrigation and drainage system (including Intake structure from Thika River for Experimental Farm)

6. Clean water supply system

7. Some necessary equipment

8. Special fence against wild animals.

9. Dormitory

10. Others

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ANNEX V

Following arrangements are required to be taken by the Government of the Republic of Kenya.

1. To carry out site preparation such as clearing and leveling before commencement of construction works.

2. To construct the gate and general fence in and around the site and develpp the landscape in the site. To construct wind-break.

3. To provide facilities for distribution of electricity, water supply, drainage, telephone lines and other incidental facilities to the site.

4. To furnish general furnitures (office tables and chairs, cabinet and others) except those which are laboratory and training uses.

5. To bear the commissions (Advising commission of Authority to Pay and Payment commission) to the Japanese foreign exchange bank for the banking services based upon the Banking Arrangement.

6. To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in Kenya with respect to the supply of the products and services under the verified contracts.

7. To ensure prompt unloading and customs clearance at ports of disembarkation in Kenya.

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ANNEX V (conti.)

8. To accord Japanese national whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into Kenya and stay therein for the performance of their work.

9. To maintain and use properly as effectively these facilities constructed and equipment purchased under the Grant.

10. To bear all the expenses other than those to be borne by the Grant, necessary for construction of the facilities as well as for the transportation and the installation of the equipment.

TEAM MEMBER LIST
(January 15 - February 17, 1984)

Name	Designation	Organization
MACHIDA, Yutaka	Team Leader	Fruit Tree Research Station, Ministry of Agriculture, Forestry and Fisheries, Japan
ONODA, Katsuji	Coordinator	Basic Design Division, Grant Aid Department, Japan International Cooperation Agency
KOBAYASHI, Keisaku	Consultant Team Leader, Agronomist	Chuo Kaihatsu Corporation
OCHI, Hirotaka	Irrigation Engineer	" " "
SOEJIMA, Masao	Architect	" " "
SASABE, Keiji	Hydrologist	" " "

STUDY TEAM ITINERARY
(January 15 - February 17, 1984)

A: Dr. Machida, Mr. Onoda
B: Mr. Kobayashi, Mr. Soejima
C: Mr. Ochi
D: Mr. Sasabe
MALD: Ministry of Agriculture and Livestock Development
MOW : Ministry of Works, Housing and Physical Planning

Date	Stay		
Jan. 15 (Sun)		(A)	Leave Tokyo
16 (Mon)		(B.C)	Leave Tokyo
17 (Tue)	Nairobi	(A.B.C)	Arrive Nairobi
18 (Wed)	"	(A.B.C)	Courtesy call to Embassy of Japan, JICA and Dpt. Director of Agri., Meeting w/MALD on Grant System and Inception Report
19 (Thu)	"	(A.B.C)	Meeting w/Ministry of Finance Meeting w/MALD
20 (Fri)	"	(A.B.C)	Nairobi - Thika Field survey on the Project Site
21 (Sat)	"	(A.B.C)	Nairobi-Thika Field Survey on existing facility
23 (Mon)	"	(A.B.C)	Meeting w/MALD on Project framework etc.
24 (Tue)	Nairobi Thika	(A.B) (C)	Meeting w/MALD Nairobi - Thika
25 (Wed)	"	(A.B) (C)	Preparation of minutes Land survey
26 (Thu)	"	(A.B)	Exchange of signatures on the minutes
		(C)	Land survey
27 (Fri)	 Nairobi Thika	(A) (B) (C)	Leave Nairobi Visit USAID, IBRD, MOW Land survey

Date	Stay		
28 (Sat)	Nairobi	(B)	Collect data & information
	Thika	(C)	Land survey
30 (Mon)	"		"
31 (Tue)	Nairobi	(D)	Arrive Nairobi
		(B)	Collect data & information
	Thika	(C)	Land survey
Feb. 1 (Wed)	Nairobi	(B)	Collect data & information Visit KARI (Muguga), Forest Nursery (Ngong), NDFRS (Katumani), ICRAF (Machacos), NAL, AIC and soil survey (Kabete), etc. Visit Central Province Office & District Agricultural Offices (Kiriyanga, Muranga, Nyeri, Kiambu) Meeting w/MOW
	Thika	(C.D)	Land survey, Water resource survey, Collect data on hydrology, hydraulics, meteorology and infrastructures
11 (Sat)			
13 (Mon)	Nairobi	(B.C.D)	Courtesy call to Embassy of Japan, JICA
14 (Tue)	"	(B.C.D)	Meeting w/MALD on the study
15 (Wed)	"	(B.C.D)	Farewell luncheon, Visit Kenya Nuts Co. (KNC)
16 (Thu)		(B.C.D)	Visit KNC Nursery, Leave Nairobi
17 (Fri)		(B.C.D)	Arrive Tokyo

* * * * * * *

CONTACT LIST
(January 15 - February 17, 1984)

1. Ministry of Agriculture and Livestock Development
   KILIMO HOUSE P.O BOX 30028 Nairobi TEL: 720030/1-9

A. K. KIRIRO	Deputy Secretary of Finance
G. M. KIMARI	Deputy Director of Agriculture
F. P. MUEMA	Head Officer, Horticultural Crops Branch
N. N. KAMINCHA, Mrs	Senior Agricultural Officer, Horticultural Crops Branch
J. J. ADALA	Senior Research Officer
C. N. GATHUNGU	Deputy Director, National Horticultural Research Station,
S. GACHANJA	Senior Research Officer, National Horticultural Research Station, Thika
M. M. NZUBE	Under Secretary (Administration)
J. ECHESSA	Senior Planning Officer
K. AYA, Mrs	Deputy Director, Agricultural Information Center
B. W. NGUNDO, DR.	Deputy Director, Agricultural Research Dept., Kenya Agricultural Research Institute (KARI)
DAVID N. MUNGAI	Agroclimatologist, Kenya Soil Survey
P. K. KUSEWA	Director, Katumani Dry Land Farming Research Station

2. Ministry of Finance and Planning

C. N. MWANGEMI	Senior Assistant Secretary

3. Ministry of Environment and Natural Resources

MATIRU	*Conservator of Foresty Information and Extension* Services, Forest Department
LEOPARD M. MWEKE	Forest Assistant, Forest Dept.
E.E.R. ANTAO	Forester, Forest Dept.

4. Ministry of Works, Housing and Physical Planning
   MOW P.O. Box 30260 Nairobi TEL: 721022

K. N. DUNN	Chief Architect
G. N. GITONGA	Chief Quantity Surveyor
R. BROWN	Chief Architect
J. TAYLOR	Chief Structural Engineer
J. A. LINTURIRI	Chief Plumbing Engineer
D. Q. NYAMUNGA	Chief Electrical Engineer
K. M. WANGAI	Cost Planning Officer
D. O. OMOLO	Electrical Engineer
J. OHARA	Architect

5. Other Authorities

KABAYA	Chief Engineer, Ministry of Water Development, Muranga
RUARAKA	Survey field HQ
PETER K. NJOGU	Horticultural Crops Officer, Kirinyaga District Office
C. NDUNGU MBURU	Land Development Officer, Central Province Office
J. K. KANJAGUA	District Agricultural Officer, Muranga District Office
JOHN GITHUKA	Registry In Charge, Kiambu District Office

6. Other Organisations

KEVIN CLEAVER	Section Chief, Central Agriculture Regional Mission in East Africa (R.M.E.A.) The World Bank (IBRD)
WAMBGO KURIRA	International Council for Research in Agroforestry (ICRAF)
D. K. AUDERE	Project Manager, ICRAF
T. DARNHOFER, DR	Agro-climatologist, ICRAF
P. G. VON CARLOWITZ, DR.	Senior Forestry Expert, ICRAF
A. DAVID LUNDBERG	Chief, Agriculture Division, USAID
S. MASE	Director, Japan Trade Center (JETRO)
Y. SATO	Managing Director, Kenya Nut Co. LTD.
J. SAKABE	Farm Manager, KNC.

* * * * * * *

7. Embassy of Japan

R. HAGIO	First Secretary, Embassy of Japan to Kenya

8. JICA Nairobi Office

S. YANAI	Resident Representative in Kenya
T. NAGASHIMA	Deputy Resident Representative

9. JICA Experts

S. HIRAMA	JICA Expert
T. IWASAKI	JICA Expert

* * * * * * *

MINISTRY OF AGRICULTURE AND LIVESTOCK DEVELOPMENT

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AGREED MINUTES BETWEEN MINISTRY OF AGRICULTURE AND BASIC DESIGN TEAM ON ESTABLISHMENT OF NUT DEVELOPMENT CENTRE AT NATIONAL HORTICULTURAL RESEARCH STATION, THIKA, FROM 17/7/84 TO 24/7/84

The Government of Japan has sent, through the Japan International Cooperation Agency (JICA) a team to the Republic of Kenya from July 15th to July 26th 1984 for the purpose of presenting and explaining the Draft Final Report of the Basic Design Study (the Report) on the Improvement Project of National Horticultural Research Station (the Project).

The team held meetings with the officials concerned of the Ministry of Agriculture and Livestock Development (MALD), and the National Horticultural Research Station (NHRS) to explain and to discuss the report. The main items which were discussed and confirmed by both parties at the meetings are as follows:

1. The Kenyan side principally approved the Report and appropriate alterations agreed by both sides during the discussion will be incorporated in the Final Report.

2. The Final Report (10 copies in English) on the Project will be submitted to the Government of the Republic of Kenya at the end of September, 1984.

3. Both sides confirmed that the Kenyan side understood the system of Grant Aid Programme to be extended by the Government of Japan, Especially the; arrangements to be taken by the Government of Kenya (as agreed in Minutes of Discussion on the project dated on January 25th, 1984), with the approval of the Ministry of Finance and Planning,

MINISTRY OF AGRICULTURE AND LIVESTOCK DEVELOPMENT

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NAIROBI

.....19.....

4. Through discussions, both parties confirmed and adjusted the items as per annex 1 and II

July 25th, 1984

Nairobi, Kenya.

Takeshi IMAZU

Leader,

Japanese Team, JICA

S.N. Muturi

Director of Agriculture

for: Permanent Secretary

Ministry of Agriculture &

Livestock Development

KENYAN SIDE

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ANNEX I

1. The objective of the Project is to establish the Nuts Research Unit (the Unit) at the National Horticultural Research Station for encouraging and promoting the research and development of Macadamia and other nuts with a view to strengthen Kenya's capacity for Undertaking research and development of macadamia and other nuts.

2. The Unit will also conduct training on nuts cultivation and provide high quality planting material which will be produced through research and training activities for distribution.

3. The Unit will provide the technical support for the multiplication of additional seedlings at the nursery centres to be established elsewhere by the Government of Kenya to produce the targetted number of 100,000 seedlings per year.

4. The Project Manager will be responsible for the activities of the Unit to the Director of Agriculture through the Director of National Horticultural Research Station and the Director of Scientific Research Division.

5. The Unit will give technical support to the extension and development of the nut industry under the direction of the Chief, Crop Production Division of the Ministry of Agriculture.

6. It was noted that while the Government of Kenya had requested for a hostel (dormitory) as per minutes of discussion dated 25th January

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_____ 19____

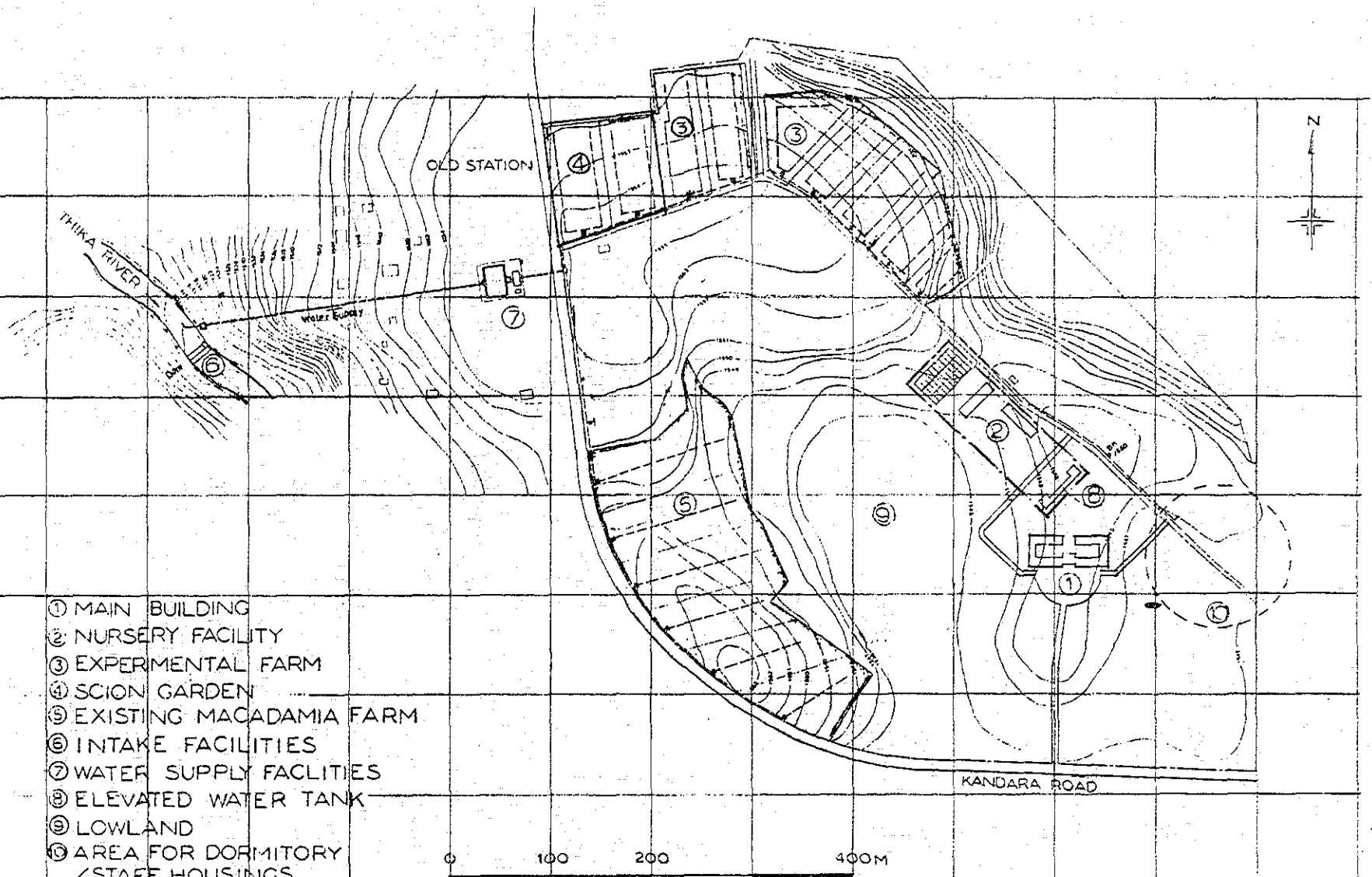
1984 (appendix 1-1 of the Draft Final Report of the Basic Design Study), it was noted that the request had not been included in the draft document.

The team explained that a hostel for trainees was considered but not allowed to be covered by the Grant Aid from the Government of Japan, but the Kenyan side requested the team strongly to convey the Kenyan desire that the Government of Japan reconsider to provide the hostel under the Grant.

The team informed the Kenyan side that the desire of the Government of Kenya will not be accepted by the Government of Japan, but they will convey the desire of the Government of Kenya to the Government of Japan.

7. The tentative development plan of the Unit site is shown in Annex II.

ANNEX II GENERAL SITE PLAN



① MAIN BUILDING
② NURSERY FACILITY
③ EXPERIMENTAL FARM
④ SCION GARDEN
⑤ EXISTING MACADAMIA FARM
⑥ INTAKE FACILITIES
⑦ WATER SUPPLY FACLITIES
⑧ ELEVATED WATER TANK
⑨ LOWLAND
⑩ AREA FOR DORMITORY /STAFF HOUSINGS

TEAM MEMBER LIST
(July 15 - July 26, 1984)

Name	Designation	Organization
IMAZU, Takeshi	Team Leader	Basic Design Division, Grant Aid Department, Japan International Cooperation Agency
KOTOBUKI, Kazuo	Technical Advisor	Fruit Tree Research Station, Ministry of Agriculture, Forestry and Fisheries, Japan
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OCHI, Hirotaka	Irrigation Engineer	Chuo Kaihatsu Corporation

STUDY TEAM ITINERARY
(July 15 - July 26, 1984)

Date	Stay	
Jul. 15 (Sun)		Leave Tokyo - Arrive Paris
16 (Mon)		Leave Paris
17 (Tue)	Nairobi	Arrive Nairobi Courtesy call to Embassy of Japan
18 (Wed)	"	Courtesy call to MALD Submission of Draft Final Report Field survey on the Project Site
19 (Thu)	"	Visit Factory and Nursery of the Kenya Nut Company Meeting w/MALD
20 (Fri)	"	Meeting w/MALD
23 (Mon)	"	Meeting w/Ministry of Finance Meeting w/MALD
24 (Tue)	"	Meeting w/MALD Preparation of minutes
25 (Wed)	"	Exchange of signatures on the minutes Leave Nairobi
26 (Thu)	"	Arrive Tokyo

CONTACT LIST
(July 15 - July 26, 1984)

1. Ministry of Agriculture and Livestock Development

D. NAMU	Permanent Secretary
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C. N. GATHUNGU	Deputy Director, NHRS

2. Ministry of Finance and Planning

C. N. MWANGEMI	Senior Assistant Secretary

3. Embassy of Japan

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4. JICA Nairobi Office

S. YANAI	Resident Representative in Kenya
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5. JICA Experts

S. HIRAMA	JICA Expert
T. IWASAKI	JICA Expert

6. Kenya Nut Company Ltd.

J. K. NJERU	General Manager
Y. SATO	Managing Director
J. SAKABE	Farm Manager

REPORT OF PROF. R.A. HAMILTON*

I. INTRODUCTION

In accordance with a request from the Government of Kenya for assistance in Macadamia nut production, the Food and Agriculture Organization of the United Nations under the United Nations Development Programme (Technical Assistance Sector) appointed Mr. R.A. Hamilton as Macadamia Nut Specialist. Mr. Hamilton served in Nairobi from 18-28 June and 15-27 July 1971. His terms of reference were: to examine the present research, field trials and expansion plans for Macadamia nut in Kenya. To advise on the most suitable areas for the crop and to advise on lines of research and requirements for such research with special reference to grafting or other ways of vegetative propagation. To advise on the establishment of processing and marketing.

With an estimated planted acreage of seven to eight hundred thousand arces of macadmia trees planted in the country, there is an urgent need for this information. In some instances young trees are starting to produce with as yet no provision for marketing and processing the nuts.

The survey part of the mission was carried out in a travel programme arranged with the advice and cooperation of the Research Section, the Planning Section and the Horticultural Crops Development Authority in the Ministry of Agriculture. Field trips were arranged to districts where macadamias were being grown or where it was considered possible that they might be grown. Processing problems and possibilities, propagation practices, the problem of which species to grow, lines of research and development for the future were studied and analysed and recommendations made. Quality determinations on representative samples of nuts were made through the cooperation of the East Industrial Research Organization.

2. BACKGROUND

There is very little research or technical information on problems of production, processing and marketing macadamia nuts in Kenya. There are still no variety trials in production in spite of the fact that seedling macadamia trees have already been planted in Kenya.

Although seedling macadamia trees grow well in highland areas where there is an excess of 55in of rainfall well distributed throughout most of the year, the present population of seedling trees planted which are relatively low in production, kernel recovery and kernel quality probably

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* Source: FAO. Report to the Government of Kenya of Macadamia Nut Growing, Marketing, Processing and Research Problems, based on the work of R.A. Hamilton, Rome, 1971, United Nations Development Programme. Report No. TA 2996.

do not provide the basis for a profitable macadamia nut growing industry in Kenya. Nuts produced in present seedling plantings are highly variable in size, shape, shell thickness and oil content compared to those from improved clonal varieties of M. intergrifolia. The average kernel weight of M. tetraphylla nuts is only about half that of kernels of selected clonal varieties of M. integrifolia.

It is considered possible that by careful and efficient handling and processing procedures, about 60 percent by weight of kernels from nuts produced by present seedling plantings could be utilized. It should however be made clear that the potential production and income from existing seedling plantings is only about 13 percent of that from comparable orchards of improved clonal varieties of M. integrifolia.

The important problem of which of the two species should be planted has not been fully investigated or resolved. Present plantings consist almost entirely of Macadamia tetraphylla seedlings with a small proportion of seedlings of Macadamia integrifolia and hybrids of the two species.

The productivity of seedling orchards and the processing quality and market acceptance of nuts produced has been investigated only superficially. Because of the large acreage and investment involved, it is important to define and study those problems in detail.

The problem of which of the two macadamia species to plant in the future needs careful study, a definite decision and wide publicity. Nuts of the two species have considerable differences in flavour, texture, composition. Their processing qualities also differ enough so that kernels of M. tetraphylla and M. integrifolia should be processed separately and at different temperatures. Storage life of the two species is also different.

A few improved clones of M. integrifolia have already been imported into Kenya but there are no variety trials of either species yet in production. Variety trials of as many improved commercial varieties as possible are important. It has been well established that production and quality of nuts from seedling trees are inferior and more variable than those obtained from selected clonal varieties.

Development in planting seedlings has preceded research in macadamia production in Kenya. Through reassessment and evaluation methods of solving problems which have become evident in attempting to market and process of problems, research priorities and macadamia nuts are now pertinent if not imperative.

3. RECOMMENDATIONS

1. If it is decided to seriously consider continuing the development and growing of macadamia nuts as a commercial crop in Kenya, it is imperative that a decision be reached as soon as possible to top or replace the major part of the highly variable seedling trees now grown. This should be with improved clonal varieties of M. integrifolia, although M. tetraphylla is presently the predominant species in Kenya. There are no proven commercial varieties of M. terraphylla since this species has

never been grown successfuly as a commercial crop. World processing of macadamia nuts is presently based almost entirely on nuts from selected clones of M. integrifolia.

2. It is believed that the choice of M. tetraphylla as a suitable species of orchard planting to establish a new commercial crop in Kenya was probably a mistake. It would be risky and perhaps disastrous to continue to rely on M. tetraphylla seedlings as a source of macadamia nuts for development of a large scale commercial processing industry.

3. It should be made clear and fully understood that the bulk of macadmia nuts presently produced in Kenya are not of the same type and species as those of commercial clones of Macadamia integrifolia grown and processed in other countries for the world market. Nuts of the two species involved are not fully comparable in uniformity, flavour, quality and oil content.

4. Planting material presently available to farmers consists mostly of hetereogeneous unselected M. tetraphylla seedlings, highly variable in productivity, growth characteristics and nut and kernel quality. These seedlings grow well enough to be satisfactory as rootstocks of selected clones of M. integrifolia. M. tetraphylla seedlings should not, however, be considered as approved nursery stock suitable for orchard planting. Size, shape, quality and shell thickness of nuts, as well as productivity of individual trees, is too variable to expect satisfactory results in an orchard or produce adequate yields of nuts suitable for commercial processing.

5. Present seedling plantings in Kenya, in addition to their considerable potential value as rootstocks for superior clones of M. integrifolia, can also provide basic information of considerable value in determining the adaptation of macadamia in Kenya. This in turn should be of considerable assistance in deciding on the most logical areas in which to locate new plantings of improved commercial varieties. Both M. integrifolia and M. tetraphylla require similar environmental conditions for optimum growth and fruiting, and the rainfall, temperature and soil requirements of both species are similar enough so that information on performance of either species could be readily interpreted in terms of climatic adaptation of the other species.

6. In order to grow macadamia successfully for commercial processing in Kenya, a comprehensive research scheme should be formulated and activated as soon as possible. The experimental programme should include variety selection and testing, propagation and nursery practices, fertilization and cultural research. The experimental programme should be supported on a long time basis and adequately staffed and financed. Variety testing and cultural research should be done in those areas of the country which appear most suitable for growing this crop.

7. At the same time, although there is definitely a calculated risk involved, grafting and topworking of existing seedling trees should be done on as large a scale as practicable, using standard commercial M. integrifolia varieties from Hawaii and Australia. This should be done rapidly as necessary scion-wood can be grown or obtained elsewhere. Seedling macadamia trees presently being planted and grown in the country

are satisfactory for use as rootstocks but nurserymen must be adequately trained in order to be able to graft and topwork macadamia on a large scale. Training of nurserymen to the rather specific techniques required in grafting macadamias successfully is absolutely necessary. Without adequately trained nurserymen who have some actual experience in grafting macadamia, any large scale attempt to graft or topwork seedling trees will probably fail.

8. Areas such as Kisii and Kitale districts have an annual rainfall of 1,500m/m or more, well distributed over most of the year, and a relatively short dry season. They are considered more suitable for growing macadamia nuts than those with less rain or a longer dry season. Areas such as Thaika and Machakos with a bimodal rainfall pattern may also be suitable for macadamia nut growing but for best results would probably require some supplemental irrigation during the driest period of the year.

9. Areas too high or too cool for successful coffee growing as well as those with mean monthly maximum temperatures above 90°F 1/, for more than two months of the year, are questionable and probably would be marginal sites for macadamia growing.

10. Of current interest and immediate importance to growers, cooperatives, Ministry of Agriculture officials and others concerned is the marketing and utilization of the current crop of nuts to the best possible advantage. There are largely M. tetraphylla nuts from many small seedling orchards planted in highland areas. In spite of their low production per tree, relatively low oil content of kernels and variability in shape, size and shell thickness of nuts, it is estimated that approximately 60 percent of the Kernels produced could be utilized as dessert nuts provided they are handled correctly. This involves several critical operations from harvesting through packing for retail and includes the following steps:

a) Nuts should be harvested weekly or at least within two weeks after they mature and fall from the trees. They should be husked within 24 hours after harvesting and air dried in shade for 10 days to two weeks before marketing.

b) Nuts should be handled rapidly enough so that they can be cracked, processed and packed not more than three to four months after harvesting. Speed in handling and marketing in-shell nuts by the farmer is necessary to avoid spoilage and/or ransidity which renders the nuts unfit for processing and human consumption. A small proportion of mouldy, rancid or spoiled nuts will make an entire stock of nuts unfit for processing. The entire lot is then fit only for use as animal food.

1/ 90°F = 32.2°C

c) Nuts received by processor or cooperative should be dried at not more than 115°F, 1/, for about 72 hours or until they contain approximately 1 1/2 percent moisture by weight.

d) The dried nuts should be cracked, roasted and vacuum sealed before they again take up additional moisture from the atmosphere.

e) Conventional macadamia nut cracking machinery and methods developed for M. integrifolia nuts will probably need considerable modification and adapting for cracking M. tetraphylla nuts, which differ considerably in size shape, shell thickness and shell consistency from those of M. integrifolia.

f) Kernels obtained should be graded to a minimum of approximately 67.5 percent oil by the floutation method, using a 1.025 specific gravity solution of sodium chloride.

g) Grade 1 kernels having a minimum oil content of about 67.5 percent should be redried, cooked in oil or dry roasted at appropriate temperatures, coated with an adhesive, salted with finely ground popcorn salt and finally vacuum sealed in attractive containers for retail marketing. As an alternative packing and marketing procedure, well dried, uncooked, grade 1 kernels with a minimum oil content of 70 percent can be marketed or successfully stored under refrigeration for at least six months depending on the storage temperature and quality of nuts involved.

11. In connection with immediate and pressing problems involved in the processing, storage and utilization of present production of M. tetraphylla nuts, an effort should be made to secure the services of the best qualified consultants available.

12. Existing seedling plantings may be looked upon as a stopgap, providing a good source of information and practical experience on cultural problems. They should not, however, be considered as improved orchards since their potential is low compared to improved clonal orchards of M. integrifolia, the preferred commercial type for production of processed nuts. It is estimated that the maximum potential production of nuts per area from seedling M. tetraphylla orchards is less than 25 percent of that expected from clonal M. integrifolia orchards of comparable age and condition. The percent kernel recovery from seedling M. tetraphylla nuts was about 29 percent by weight (Appendix I). It is estimated that about 65 percent of these kernels contained at least 67.5 percent oil and could be processed into a satisfactory dessert nut pack (Appendix I). M. integrifolia nuts of commercial varieties would be

1/ 115°F = 46°c

expected to give about 40 percent kernel recovery, about 90 percent of which contain 72 percent or more of oil. Even if a lower oil content of 67.5 instead of 72 percent is accepted in grading M. tetraphylla nuts, one acre 1/ of grafted M. integrifolias would produce a yield of usable kernels equal to that from approximately 7.3ac. of tetrapohylla seedlings of similar conditions and age. Assuming a yield per acre for mature grafted M. integrifolia trees of 4,000 pounds 2/ of in-shell nuts valued at 1.80 Sh 3/, per pound, the computed value of grade 1 kernels would be 7,200 Sh per acre. This can be compared with a computed value of 906 Sh per acre for usable grade 1 & 2 kernels from comparable M. tetraphylla seedling trees under similar conditions. Figured on a percentage basis, an acre of M. tetraphylla seedlings in full production could only be expected to produce about 15 percent or less gross income per acre as an acre of good grafted M. integrifolia trees of similar age under comparable growing conditions. Even when the comparatively low oil content of 67.5 percent is accepted for seedling M. tetraphylla kernels, the comparative advantage of planting grafted M. integrifolia trees is obvious. The implication is clear that seedling M. tetraphyllas, because of their low yields, extreme variability and comparatively low kernel quality, are not suitable for establishing commercial orchards. They should, therefore, not be planted except for home use as a fresh nut or as rootstocks for improved varieties of M. integrifolia, the preferred commercial type.

13. The relative potential return per acre from alternative crops should be considered objectively in comparison with that obtainable from macadamia nuts. This is particularly pertinent since the type of Macadamia tetraphylla seedling widely planted and now coming into production probably has a lower potential gross income per acre than some of the possible alternative crops such as pyrethrum, passion fruit, corn, avocados and coffee.

1/ 1 ac = 0.4047 ha
2/ 1 lb = 0.45369 kg
3/ 1 US$ = 7.14 Kenya Shillings

PHYSICAL CONDITIONS OF THE PROJECT SITE

1. Topography and Geology

The proposed Project site is situated at the southern end of Murang'a District, Central Province. Central Province is a mountainous area bordered by Mount Kenya on the northeast and the Aberdare Range (Nyandarua Mountains) on the west. The latter extends 70km from north to south, with an altitude range of 3,000-4,000m above sea level. Mount Oldoinyo Lesatima is situated at the northern end of the said range while Mount Elephant is located at the southern end, northwest of the Project site. It is from this mountain that the Thika River, which flows close to the Project site, originates.

The lower slope of the Aberdare Range, surrounded by the towns of Nyeri, Murang'a, Thika, Kiambu and Limuru, is a volcanic field of the Aberdares, having an altitude of 1,500-2,100m. This area presents an undulating belt with an average length of 40km, dissected by numerous parallel river valleys which include the Thika, Maragua, Mathioya and Gura rivers. The Project area is located at the lowest edge of the volcanic field where the average land slope is about 1/150.

As shown in the topographic map, the area is undulating with a maximum elevation difference of 10m. An existing non-paved road, 4m in width, passes through the said areas. Presently, the higher areas are used as experimental farms for macadamia nuts, avocados, grapes and vegatables, while the lower areas, which become swampy during the wet season, remain unutilized except to provide a windbreak forest for the existing macadamia farm.

To take advantage of the natural topography in the layout of Project facilities, the main building will preferably be located at a higher elevation along the existing road in the east of the area, while the proposed experimental farm will partially utilize existing farmland. At present, drainage canals for the experimental farm do not exist and accordingly, drainage water is conveyed to the lower swampy area utilizing the natural slopes.

Lavas of Tertiary age are exposed at the Project site and a volcanic association which is related to volcanicity in the region of the Aberdare Mountains is also present. The Trachytic Tuff Series, which includes agglomerates and claystones are exposed in the Thika riverbed. Commonly these tuffs overlie basalt agglomerates of the Simbara Series. The geological formation of the area is provided below.

Tertiary
- Lava
- Trachytic tuffs with thin basalt flows
- Welded tuffs
- Upper Thika building stone
- Lake beds
- Coarse agglomerates
- Lower Thika building stone
- Basalts and agglomerates
- Kapiti Phonolite

Precambrian
- Basement System

The sequence from trachytic tuff to lower Thika building stone is about 30m thick.

2. Soil

The soil of the Project area is classified into reddish laterite derived from pyroclastic flow of Tuffs. Although partial outcroppings of country rock occur in several areas along the Thika River, the depth of the soil layer ranges from 0-120cm. Due to topography, soil in the upland area on the left bank of the Thika is well-drained whereas soil in the bottomlands further left of the same becomes waterlogged during the wet season. From the comparatively poor drainage in the latter area it may be assumed that the effects of water logging persist into the early part of the dry season and consequently the area is generally considered unsuitable for agriculture.

The Project area can be broadly divided into 3 blocks with due consideration of soil types, land classes and topography as shown in Fig. 1 and briefly presented below;

Block 1: a narrow strip of alluvial soil along the river terrace on the left bank of the Thika

Block 2: upland area adjoining the above terrace

Block 3: poorly drained bottomland behind the upland area

Block 1: In this section the fluvisols are distributed, along the Thika River, which is relatively deep with good drainage. However, the area is also subject to frequent flooding during the wet season and consequently suffers from severe erosion.

Block 2: This section which borders the Thika can be further subdivided into 2 main topographical areas; Block 2-1 the steeply inclined (3-25°) area directly adjoining the river and river terrace, and Block 2-2 the gently sloping area further east. The soil of these 2 areas is broadly classified into 2 types, humic acrisols (U5) and dystric nitosols (U1, U2) respectively. In the steeper area, the country rock is frequently exposed and areas of thinly distributed topsoil are widespread due to erosion caused by heavy rains during the wet season.

Soil on the more gently inclined slope (Block 2-2), on the other hand, is much deeper with good drainage and is considered ideally suited for cultivation.

Block 3: This section mainly consists of humic cambisols and humic gleysols, and becomes waterlogged during the wet season. Due to the poor drainage capacity of the same, the possibility of using the area for cultivation is low.

Detailed soil properties for each area are as shown in Table-1. Alluvial and upland area soils are dark red to dark brown in color while those in the bottomlands range from dark grey to dark greyish brown. Soil pH tests revealed no great variation in the acidity of soil according to area, and overall, soils were slightly acid.

Judging from various factors such as soil depth, soil properties, and soil conditions, discussed above, soil in the upland areas, ie. dystric nitosols classfied as U1 and U2, are most suitable for cultivation.

3. Meteorology

(1) General

The seasons of Kenya are governed by the sun's movement. The sun is approximately directly overhead at the end of March, and again at the end of September, and a rainy season occurs a month after each of these respective periods in April/May and October/November. When the sun is over the Tropic of Cancer in July, the southeast trade winds are predominant and accordingly, widespread stratiform clouds frequently form on the eastern mountain slopes, while in January when the sun is over the Tropic of Capricorn, the wind is northeasterly resulting in almost cloudless conditions and high temperatures.

Although Nairobi, the capital of Kenya, is situated quite close to the Equator, its altitude of about 1,700 meters results in an equable as opposed to a tropical climate, with temperatures neither uncomfortably high during the daytime nor uncomfortably low at night. The Project area adjoining Thika Town to the north with an altitude of 1,500m, is under similar climatic conditions.

The main features of the climate are the definite wet and dry seasons, and the absence of any large seasonal changes in temperature. The year can be subdivided into 4 seasons as follows:

- Mid-December to Mid-March : Dry season; warm and sunny
- Mid-March to May : Main rainy season
- June to Mid-October : Dry season; cool, rather cloudy (especially July - August)
- Mid-October to Mid-December: Secondary rainy season

Meteorological observations were made at the objective horticultural research station from 1962 by the Kenyan Meterological Department. Based on these records, meteorological characteristics of the Project site are as described below and presented in Fig. 2.

(2) Temperature

Although the average temperature over a 24 hour period varies only from about 18°C during July and August to 21°C in March, the

daily temperature range is quite large, averaging about 10°C from April to July and 14°C in January and February. The monthly average maximum and minimum temperatures, and the average monthly temperature ranging over a 10 year period (1974-83) are tabulated below:

Unit: °C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
Mean Maximum	26.6	27.7	27.7	25.5	24.7	23.8	22.6	23.5	25.9	26.7	25.1	25.0	27.7
Mean Minimum	12.5	13.4	14.4	15.7	15.2	13.3	12.8	12.5	13.1	14.3	14.9	14.1	12.5
Mean Range	14.1	14.3	13.3	9.8	9.5	10.5	9.8	11.0	12.8	12.4	10.2	10.9	-

The maximum and minimum temperatures recorded during the past 22 years at the Project site are 33.3°C in February and 5.6°C in January and August respectively.

During the months from June to August, when the southeast monsoon prevails in the coastal regions, a cloud cap frequently forms over the uplands of Kenya immediately east of the Great Rift Valley, sometimes persisting for several days. When this phenomenon occurs, daytime temperatures remain low, the maximum temperature falling to 18°C, while temperatures at night and early morning have been recorded as low as 8°C. Low temperatures also occur at night during January and February when the sky is clear.

(3) Relative Humidity

Being some 400km from the sea, the Project site does not experience the rather high humid heat which is so characterisic of tropical coastal towns, although there is a very marked daily range of relative humidity. The monthly mean relative humidity recorded at 9:00 a.m. and at 3:00 p.m. for the past 10 years (1974-83) is tabulated as follows:

Unit: %

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
9:00a.m.	73	76	79	85	83	81	85	84	79	75	81	80	80
3:00p.m.	45	43	43	56	60	56	58	55	45	43	51	53	51
Mean	59	60	61	71	72	69	72	70	62	59	66	67	66

In the early morning the air is frequently at or very close to the saturation point, while in the afternoons the relative humidity is usually about 50% and may fall as low as 10% on clear sunny days in February and March.

(4) Sunshine

Although early mornings at the Project site are often cloudy, the sun usually breaks through by mid-morning. Throughout the year there is an average of 6.5 hours of bright sunshine per day, 30% more of which occurs in the afternoon than in the morning. The monthly mean daily sunshine observed for the past 10 years (1974-83) is shown below.

Unit: hrs.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
Daily Sunshine	9.1	9.1	7.7	6.5	5.9	4.9	3.5	3.8	5.5	7.2	6.9	8.0	6.5

There is considerably more sunshine during the 6 month period when the sun is in the southern hemisphere (Dec - May) than when it is in the north. Days with no sunshine occur only occasionally and even in the cloudiest month, July, there is an average of 3.5 hours of sunshine per day.

(5) Winds

The wind is predominantly easterly throughout the year, generally between northeast and east from October to April, and between east and southeast from May to September. The strongest winds occur during the dry season prior to the "main rainy season"

when speeds of 20-25m/hr are not uncommon from mid-morning to early afternoon. At other times of the year wind speeds are usually 10-15m/hr while at night time the wind is usually light.

The monthly mean daily wind run for the past 10 years (1974-83) is tabulated below.

Unit: km/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
Daily Wind Run	160	165	158	125	106	96	95	116	136	148	141	153	133

(6) Evaporation

Evaporation at the Project site was observed by the A-pan method. Monthly pan-evaporation varies from a high of 183mm in March to a low of 84mm in July with almost the same curve as daily sunshine, while annual pan-evaporation amounts to 1,601mm. The mean monthly pan-evaporation for the past 10 years (1974-83) is tabulated below.

Unit: mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Epan	167	171	183	127	113	96	84	102	132	158	129	139	1,601

(7) Rainfall

The average annual rainfall at the Project site is about 950mm, but the actual amount in any one year varies from less than 700mm to more than 1,200mm. As already mentioned, there are two rainy seasons, from mid-March to the end of May ("Long Rains"), and from mid-October to mid-December ("Short Rains").

Average monthly rainfall based on records for the last 10 years (1974-83) is as follows:

Unit: mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly Rainfall	30	40	128	219	110	30	21	12	18	90	188	62	948

During the rainy season, afternoon showers and thunderstorms often occur, but a large amount of rain falls after dark, sometimes persisting until early morning. Light rain or drizzle and very low cloud is quite frequent shortly after dawn, but does not commonly last beyond 10 a.m. Rain does not fall every day during the rainy season, though there are sometimes spells with four or more consecutive rainy days. The average number of days of rain in each month is shown in the table below.

Unit: Days

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainy Days	5	4	9	17	11	4	4	4	2	5	15	7	87

4. Thika River

The Thika River which flows alongside the Project site was surveyed and studied as a water source for irrigation of the proposed experimental farm and domestic use. The results of the study are presented below.

(1) River Condition

The Project site is situated in the Thika River basin. The Thika River originates from Mount Elephant (alt. 3,500m) and flows some 70km southeastward through a deeply incised valley to join its principal tributary, the Chania River, near Thika Town. Thika Falls is formed at the confluence of the two rivers and about 200m upstream from the falls there is a gaging station, "4CB4", under the jurisdiction of the Ministry of Water Development.

From there the Thika River flows generally eastward through relatively flat plateau land, though still in a well formed valley. Some 40km east of Thika Town on the right bank is a gravity intake to the Yatta Furrow. This contour canal presently takes a flow of just over one m^3/sec for irrigation and water supply.

A few kilometers downstream of the Yatta Furrow diversion, the Thika turns northward towards the Tana River. The Masinga Dam, presently under construction on the Tana, will create a reservoir extending about 20km up the Thika Valley at highest water level so that in future the Thika will flow directly into the reservoir.

The catchment area of the Thika River at gaging station "4CB4" is 324km^2, and is composed of a long and slender basin with an average width of 6km. The river gathers numerous tributaries which mainly flow southeastward, parallel to the Thika River. As most of the streams and rivers originate from the Aberdare Range and flow along the volcanic field, the Thika River is perennial. Relatively high precipitation, over 1,500mm annually, occurs in the elevated regions flanking the Aberdare Range and is retained as groundwater in volcanic rocks, while surface runoff is stabilized by forest vegetation, especially in areas above altitude 2,300m.

The proposed Project site is situated on the left bank of the Thika, 3.7km upstream from gaging station "4CB4". The site's catchment area is 292km^2. At the site, the river forms a V-shaped valley with a bottom width of 20m, and bank slopes of about 10°. The depth of the valley is 45m. The slope on the left bank is presently used for small-scale farming of corn, vegetables, etc., though the land is owned by the government. The riverbed is composed of rock, trachytic tuff, and outcroppings of rocks are evident on the left bank.

(2) Average Discharge

There are 3 gaging stations along the Thika River upstream from the confluence of the Chania River; namely, "4CB4", "4CB5" and "4CB7". As stated earlier, "4CB4" is situated just upstream of the confluence, while "4CB5" and "4CB7" are situated in the elevated regions with catchment areas of about 40km^2 or less. Consequently, the Team concentrated on the records of "4CB4".

Daily discharge has been observed at "4CB4" station by measurement of water surface level at Cipoletti weir by staff gage and automatic recorder since 1945. The observed mean average and minimum daily discharge for each month of the period from 1974-83 is tabulated below.

DAILY DISCHARGE AT "4CB4" (C.A.=324km^2)

Unit: m^3/sec

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
average	3.2	2.7	2.9	11.6	17.4	8.8	6.4	3.7	2.4	3.1	7.2	6.1	6.2
minimum	2.4	1.9	1.4	3.9	8.5	6.0	4.2	2.7	1.9	1.7	3.4	3.9	3.5

The lowest mean minimum discharge is 1.4m^3/sec in March, and the second lowest is 1.7m^3/sec. The estimated 1.4m^3/sec corresponds to 0.43m^3/s/100km^2, though actual flow for each month fluctuates considerable year by year. In contrast, the mean minimum discharge for May and December is comparatively high at 8.5 and 3.9m^3/sec respectively, representing a one month delay of the peak rainfall for the 2 annual wet seasons.

As stated earlier, the catchment area of the Thika River at the proposed Project site is 292km^2. Discharge at the Project site is estimated on the basis of the catchment area and the annual average rainfall ratio therein is as shown below.

ESTIMATED DAILY DISCHARGE AT PROJECT SITE (C.A.=292km^2)

Unit: m^3/sec

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
average	3.0	2.5	2.7	10.8	16.2	8.2	6.0	3.4	2.2	2.9	6.7	5.7	5.8
minimum	2.2	1.8	1.3	3.6	7.9	5.6	3.9	2.5	1.8	1.6	3.2	3.6	3.3

(3) *Present Water Utilization*

The Thika-Chania Basin is well developed, especially the Chania River Basin which supplies 80% of the water to the capital, Nairobi. Major demands within the catchment area of the Thika River upstream of Thika Falls are for irrigation and crop processing. Irrigation water is mainly used for coffee, while horticultural crops are grown alongside the same, typically occupying 4% of coffee estates.

Within the Thika River Basin upstream of "4CB4", including numerous tributaries, there are 167 registered water rights as of February 1984. The Ministry of Water Development is responsible

for granting the said water rights and applications for water permits must be submitted to the same Ministry in advance of development. Out of these registered water rights, only in several cases is water consumption consistently large in scale with a peak use of more than 10ℓ/sec. According to the Chania-Thika Water Resources Study prepared by Kenyan consultants for the Ministry of Water Development, in the critical dry periods of the year with the present level of development and mode of use, the resources of the catchment area are barely sufficient to meet all the demands.

As discussed in CHAPTER V the proposed peak demand for irrigation of the experimental farm and domestic use is 20ℓ/sec. Accordingly water from the above source would be sufficient to meet the requirement. An application for a water permit should be submitted to the Ministry of Water Development in the detail design stage.

(4) Water Quality

As discussed previously, the Thika River is well developed as a water source for irrigating, crop processing, and domestic, industrial and public uses. Coffee, pineapple and horticultural crops are irrigated from the Thika River and thus it may be assumed that water quality is sufficient for irrigating the experimental farm. According to the Team's survey during February 1983, the average pH of the river water was 7.7.

Hearings conducted in the vicinity revealed that the river transports a large amount of wash load during high discharge periods which could negatively affect the mechanism inside the pump. Accordingly a silting pond would be constructed to avoid this potential problem. Furthermore a purifier system would make it possible for river water to be used as domestic water.

5. Groundwater

(1) Existing Boreholes Around the Site

Numerous boreholes for groundwater have been sunk around the Project site particularly in volcanic rock on large scale coffee and pineapple farms, etc. In general, boreholes sited on volcanic

areas, i.e. agglomerates or tuffs, appear to be more successfull than those sited on Basement System rock. Volcanic rocks rest on an old bevelled land surface around the Project site, and it is probable that the weathered gneiss of that surface provides an aquifier. Based on a geological report prepared by the Ministry of Natural Resources, there are a series of buried ridges and valleys on the sub-volcanic floor in this part of the area, and it is usually found that when a borehole passes through the volcanic rock into a buried valley, the yield of water is greater than that for a borehole sunk into a ridge.

Fig. 3 shows locations of existing boreholes around the Project site, while Table-2 tabulates records of these boreholes. As these records show, all boreholes in the area are sited on volcanic rocks and lava. Rest water levels of boreholes in the area indicate a westward rise of the watertable in volcanic rock.

(2) Electric Resistivity Survey

The Team conducted an electric resistivity survey at six points in the Project site. The survey points are illustrated in Fig. 4. A Yokokawa Type 3244 resistivity survey device was utilized to identify the geological strata of the site. The presumed geological profile on the basis of the survey is presented in Fig. 5.

As shown in the geological profile, a shallow well is conceivable at the Project site, and the depth of an aquifier is assumed to be around 50m. The electric resistivity underground was surveyed to the depth of 100m. Four geological strata are assumed to exist from ground level as follows:

- wearing course of 0-1.0m stratum
- lava of 1.0-20.0m
- clay mixed rock of 20.0 to 35.0-60.0
- clay and lava

The second and third stratum may be aquifers, while the fourth stratum is comparatively impervious.

As the ideal borehole site would be where there is a deep buried valley of impervious rock, out of the six points surveyed,

No. 6 seemed the most suitable site. Further electric resistivity surveys at about 5 points around No. 6 site and test boring and pumping at a proposed point is deemed necessary to confirm the available yield, in case of utilization of groundwater for domestic water supply and for laboratory use.

(3) Application and Admission Procedure

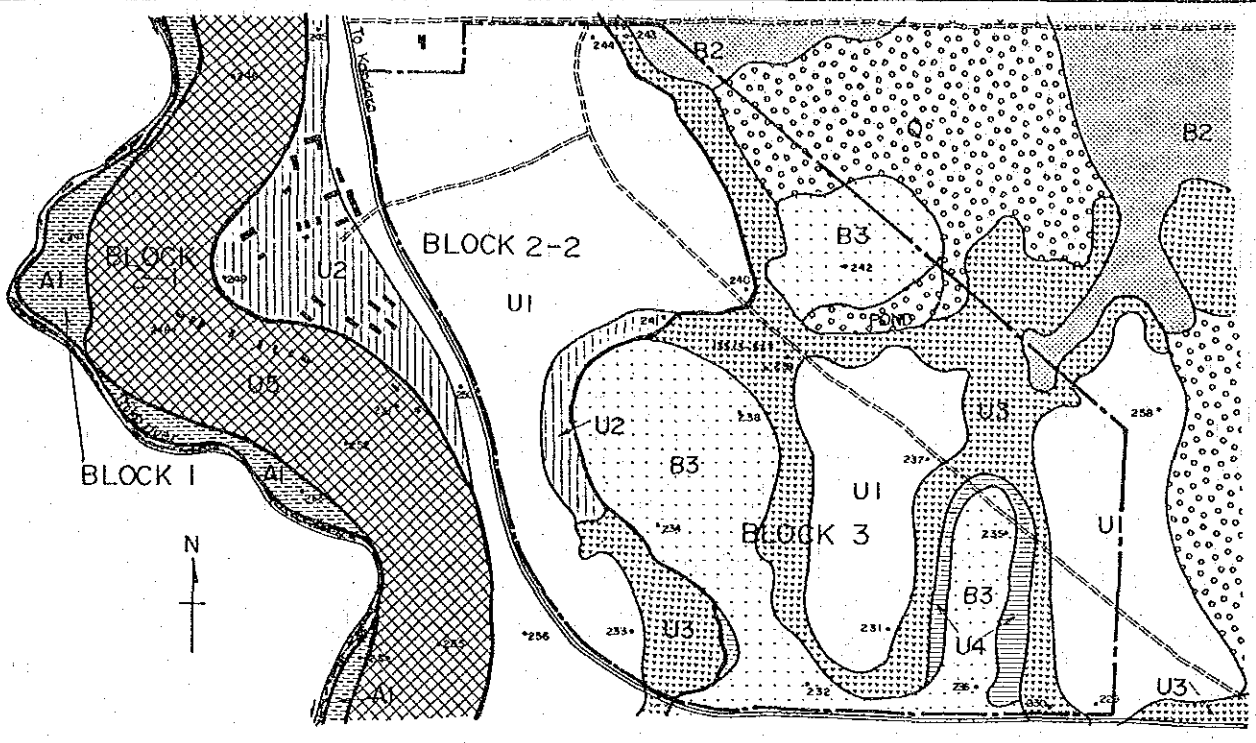
The Water Application Board under the Ministry of Water Development is responsible for granting permission to drill well-boreholes. Not less than one month prior to actual commencement, notice of intention must be submitted to the said Ministry which files well-borehole records.

Table-1 **PROPERTIES OF SOIL**

Soil	Texture of topsoil	Colour	pH	CEC	B.S. (me/ 100g)	Fertility (%)		FAO Class-ification
U1	Moderate, Medium to subungular blocky	Dark Reddish brown to dark red		5.2-6.0	23.8	50	Highly suitable	Distric NITOSOLS
U2	"	"		5.0-6.6	24.6	50	Moderately suitable	"
U3	Very fine crumbs	"		6.0-6.2	19.6-23.2	50	Variable	Humic ACRISOLS
U4	Gravelly clay to soil	Dark reddish brown to dark red		-	-	-	Permanently not suitable	LITHOSOLS
U5	"	Dark reddish brown to dark red		6.1-6.6	11.8 22.0	50	"	Humic ACRISOLS
A1	Silty clay to clay soil	Dark reddish brown to reddish brown		-	-	-	Currently not suitable	Eutric FLUVISOLS
B2	Fine clay soil	Dark grey to dark greyish brown		5.2	29.6-36.6	44-78	Currently not suitable	Fumic GREYSOLS
B3	Moderate, very fine soil	"		5.2	29.6-33.6	44-78		

Table-2 **RECORDS OF EXISTING BOREHOLES**

BOREHOLE NUMBER	TOTAL DEPTH (m)	WATER STRUCK (m)	REST LEVEL (m)	TESTED YIELD (m^3/h)	FORMATION	DATE COMPLETE
C727	60.9	27.4/39.6	-	6.8	VOLCANIC	8-9-48
C1254	193.6	91.4	25.9	3.4	VOLCANIC	22-12-50
C1326	153.0	-	-	1.9	TERT. VOLCANIC	9-5-52
C1421	132.9	115.8	28.7	13.6	TERT. VOLCANIC	11-5-51
C1457	81.7	36.3/71.6	32.3	2.1	VOLCANIC	21-5-51
C1458	111.3	18.3/120.4	7.9	5.0	VOLCANIC	28-6-51
C1547	179.5	36.6/ 131/153.9	41.2	3.2	TERT. VOLCANIC	11-8-51
C1587	124.0	35.0/ 74.7/117.3	41.2	9.0	TERT. VOLCANIC	17-11-51
C1601	243.8	18.3/134.1 170.1	14.0	3.7	TERT. VOLCANIC	23-11-51
C1616	161.5	18.3/60.4/ 110.6	32.9	6.8	TERT. VOLCANIC	18-12-51
C1660	152.4	24.4/ 48.8/149.4	40.8	9.0	TERT. VOLCANIC	6-2-52
C2002	161.5	48.8/ 85.3/152.4	61.9	13.0	LAVA	15-8-53
C2072	140.2	53.9/139.3	43.3	14.0	LAVA	16-12-53
C2418	103.6	99.9	35.4	8.0	VOLCANIC	12-7-55
C4048	161.6	51.2	17.1	5.5		24-8-74



LEGEND

U UPLANDS (slopes 1–18%)

UP Soils developed on pyroclastic rocks (trachytic tuffs)

U 1 well drained, very deep to extremely deep, dark red to dark reddish brown, friable clay (dystric NITOSOLS)

U 2 well drained, deep to very deep, dark red to dark reddish brown, friable clay; in places shallow to moderately deep over petroplinthite (murram) (dystric NITOSOLS; with ferralic CAMBISOLS, petroferric phase)

U 3 well drained to moderately well drained, shallow to moderately deep, dark red to dark reddish brown, friable, sandy clay to clay, over rock or petroplinthite (murram) (humic ACRISOLS, lithic or petroferric phase)

U 4 well drained to moderately well drained, very shallow to shallow dark reddish brown to dark brown, rocky and bouldery, gravelly clay to clay; in places over petroplinthite (murram) (LITHOSOLS)

U 5 complex of well drained, very shallow to deep, dark red to dark reddish brown, friable, rocky, gravelly clay to clay (humic ACRISOLS, partly lithic phase, with LITHOSOLS)

A RIVER TERRACE (slopes 0–2%)

AA Soils developed on alluvial deposits

A 1 moderately well drained to imperfectly drained, very deep, stratified, reddish brown to dark reddish brown, friable, silty clay to clay (eutric FLUVISOLS)

A 2 very poorly drained, deep to very deep, dark grey to very dark grey, mottled, friable to firm, clay; in places over petroferric material (murram) (humic GLEYSOLS)

(not found in this area)

B BOTTOMLANDS (slopes 0–2%)

BP Soils developed on pyroclastic rocks (trachytic tuffs)

B 1 moderately well drained to imperfectly drained, deep, dark reddish brown to dark yellowish brown, friable clay, over petroferric material (murram)

(not found in this area)

B 2 imperfectly drained to very poorly drained, shallow, dark reddish brown to dark brown, clay, over petroplinthite or petroferric material (murram) (humic CAMBISOLS, petroferric or petroferric phase)

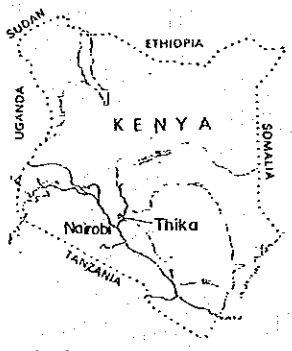
B 3 very poorly drained, deep to very deep, dark grey to dark greyish brown, mottled, firm clay, over petroplinthite (murram) (humic GLEYSOLS, partly petroferric phase)

Q Quarry

Q Broken ground with murram excavation pits, in places ponded

KEY

- soil mapping symbol
- UPrm,... depth class symbol
- C..... slope class symbol
- soil boundary
- 1353/3–47 sampled profile pit, with reference number
- B2 augerhole observation, with reference number
- 1 sq cm = 0.25 hectares
- tarmac road
- motorable track
- river
- dam and stream
- buildings
- fence (boundary of survey area)
- Boundary of the project area



= Location of surveyed area

SCALE 1:5,000

0 50 100 200 300 400 500m

FIG. 1 DETAILED SOIL MAP OF THE PROJET SITE

FIG. 2 METEOROLOGY OF THE PROJECT SITE 1974 - 83

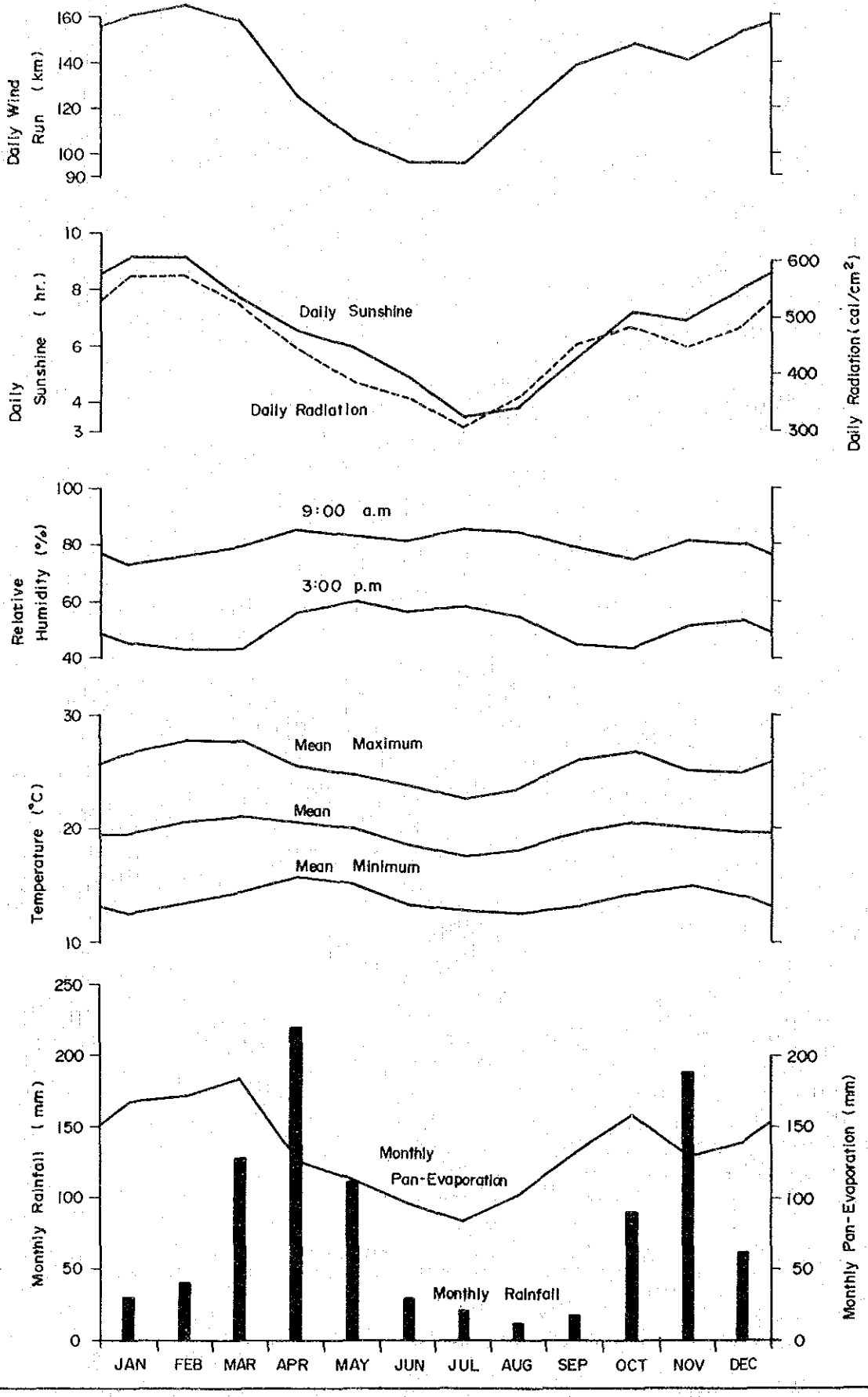


FIG. 3

LOCATION OF EXISTING BOREHOLES AROUND THE PROJECT SITE

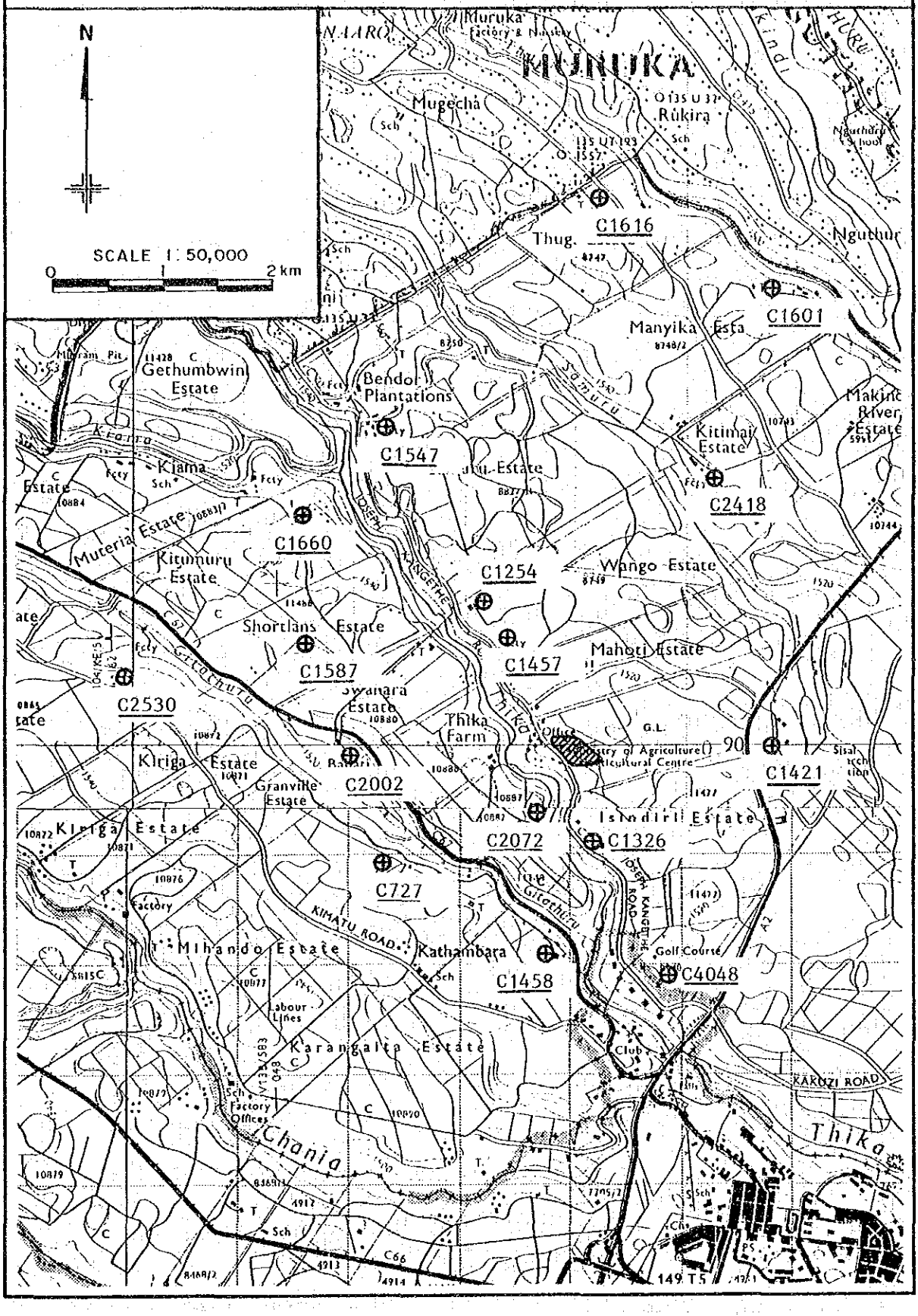


FIG. 4 LOCATION OF ELECTRIC RESISTIVITY SURVEY POINT

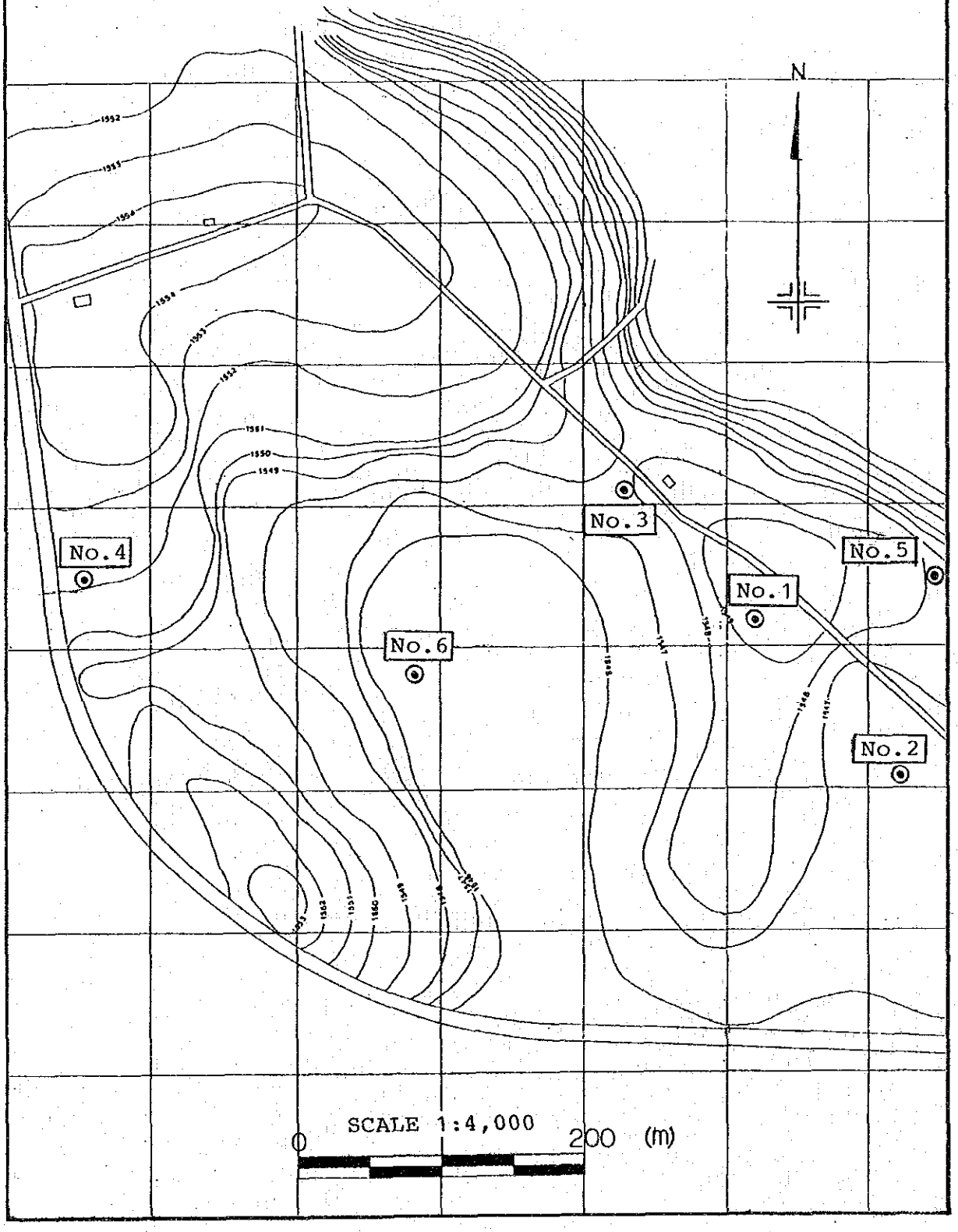
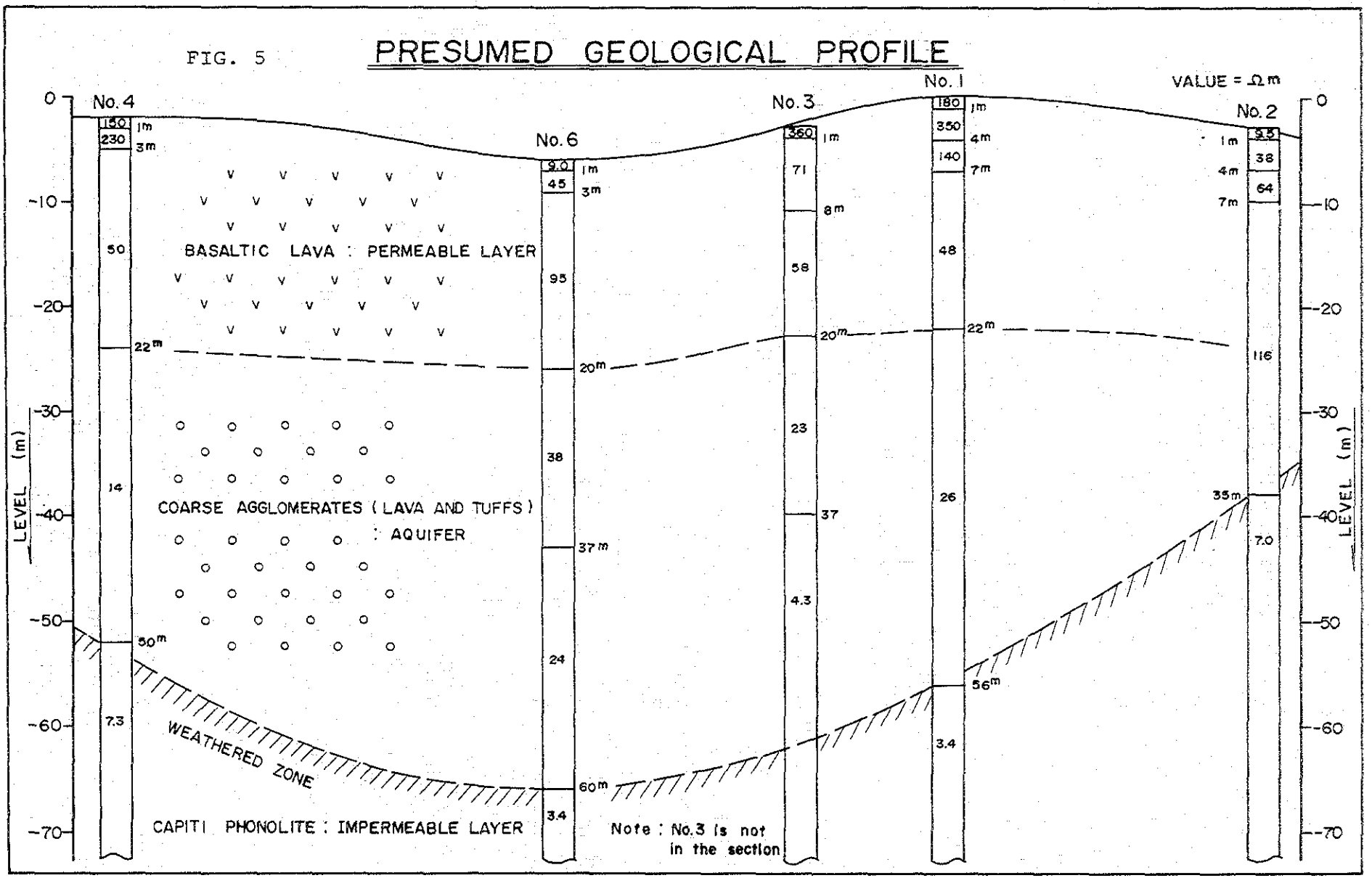


FIG. 5

PRESUMED GEOLOGICAL PROFILE



CALCULATION OF WATER REQUIREMENT

In consideration of evapotranspiration, crop coefficient, irrigation efficiency in the area, and supply for domestic water, the peak volume of water required has been determined at 20ℓ/sec. Procedures for determination of the water requirement are given in the following sections.

(1) Irrigation Plan

Procedures for determination of the irrigation water requirement is discussed below.

1) Reference crop evapotranspiration: ETo

Average monthly reference crop evapotranspiration (ETo) occuring in the Project area over a 10-year period (1974-83) was obtained from data collected by the meteorological station at the NHRS and calculated by the Modified Penman Method as presented below.

CROP EVAPOTRANSPIRATION

Unit: mm/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ETo	5.5	5.7	5.1	3.7	3.2	2.9	2.6	3.0	4.1	4.8	4.1	4.4	49.1

Note: Mean = 4.1

As shown in the table below, the evapotranspiration data indicated above can be broadly divided into 4 periods.

FOUR PERIODS OF ETo

Period	Months	Period Total ETo (mm/day)	Average ETo (mm/day)	Comparison (1st period = 1.00)
1st	Jan - Mar	16.3	5.43	1.00
2nd	Apr - Jun	9.8	3.27	0.60
3rd	Jul - Sept	9.7	3.23	0.60
4th	Oct - Dec	13.3	4.43	0.82

Accordingly, for the present Project the 1st period from January to March will be adopted as the calculation standard of irrigation water supply.

2) Crop evapotranspiration: ET crop

Crop evapotranspiration (ET crop) is defined as follows:

ETcrop = Kc · ETo

In the above formula, Kc indicates the crop coefficient which varies according to cultivated crop and growing stage. As no experimental results with regard to the crop coefficient were available in the Project area, experimental results from FAO were adopted (Table 1).

Accordingly, adopting average crop coefficient Kc = 1.10, the crop evapotranspiration during the critical period is thus calculated at Et crop = 6.0mm/day. Furthermore, consumptive use of crops during the critical period is therefore determined at 6.0mm/day.

3) Irrigation water requirement

For calculation of irrigation water requirement, the loss of irrigation water has been considered on the basis of the following factors:

Total Irrigation Efficiency	0.62 (0.65x0.95=0.6175≒0.62)
- Field efficiency	0.65
- Operation efficiency	0.95

Under these assumptions, the total irrigation efficiency was calculated at 0.62, and accordingly, the peak daily irrigation requirement has thus been calculated at 10.0mm.

6.0mm x 1/0.62 = 9.68 ≒ 10.0mm

Average daily effective rainfall during the dry season when the peak irrigation water requirement occurs is 0.6mm/day, although yearly fluctuation is very high. Accordingly for calculation of irrigation water requirement effective rainfall is neglected. On the basis of the daily irrigation requirement of 10.0mm the irrigation water requirement for each area has been estimated (Table 2).

(2) Domestic Water Plan

The working population in the Project area is estimated at 100 persons including 66 staff members and subordinates, a maximum of 20 trainees, and 14 temporary workers. According to the water supply plan in Thika Town, where the neighbouring NHRS is located, water consumption per person per day is 160ℓ. Based on this information, 160ℓ will be adopted for the Project. Therefore, the water requirement for 100 persons will be 16,000ℓ/day.

On the other hand, water requirement in the buildings for laboratories and miscellaneous water consumption including the transplanting and grafting workshop is estimated at 13,000ℓ/day.

Thus, total unit water (29,000 or 29m^3/day) requirement for domestic water with 7 hours supply is calculated as follows:

29,000ℓ ÷ (7hr x 3,600sec) x 1.4 = 1.61ℓ/sec ≒ 1.6ℓ/sec

The peak water requirement will be an increase of 40% in relation to the average water requirement.

(3) Total Water Requirement

The summary of water requirement is shown below.

WATER REQUIREMENT

Section	m^3/day	Water Requirement (ℓ/s)
Domestic Water for buildings	29.0	1.6
Nursery Facilities	35.0	1.8
Scion Garden	60.0	2.8
Proposed Experimental Farm	229.0	10.6
Existing Macadamia Farm	62.4	3.2
Total	415.4	20.0

TABLE 1 CROP COEFFICIENT

Crop	Relative Humidity (%)	over 70		less than 20		Adopted
	Wind Velocity (m/sec)	0-5	5-8	0-5	5-8	Value
	Crop Stage					
Peanut	3	0.95	1.00	1.05	1.10	1.05
	4	0.55	0.55	0.60	0.60	
Potato	3	1.05	1.10	1.15	1.20	1.15
	4	0.70	0.70	0.75	0.75	
Beans	3	1.00	1.05	1.10	1.15	1.10
	4	0.50	0.50	0.55	0.55	
Tomato	3	1.05	1.10	1.20	1.25	1.20
	4	0.60	0.60	0.65	0.65	
Cucumber	3	0.90	0.90	0.95	1.00	0.95
	4	0.70	0.70	0.75	0.80	
Onion	3	0.95	0.95	1.05	1.10	1.05
	4	0.75	0.75	0.80	0.85	
Radish	3	1.05	1.10	1.15	1.20	1.15
	4	0.90	0.95	1.00	1.00	
Pasture	3	1.05		1.15		1.15
Average	4					1.10

Note: Crop Stage 3: mid-season stage
4: last-season stage

Source: Crop Water Requirements, FAO Irrigation and Drainage Paper 24, revised 1977

TABLE 2 IRRIGATION WATER REQUIREMENT

Item / Section	Field (block)	Area (ha)	No. of Trees	Irrigation Area (m^2)	Unit Volume (mm)	Daily Irr. Requirement (m^3)	Water Supply Volume (ℓ/s)	Remarks
1. Existing Macadamia Farm								
	a.	0.65	133	1,200	10	12.0	1.2	
	b.	0.60	123	1,100	"	11.0	1.2	
	c.	0.60	123	1,100	"	11.0	1.1	
	d.	0.55	112	1,000	"	10.0	1.1	
	e.	0.50	102	920	"	9.2	0.9	
	f.	0.50	102	920	"	9.2	0.9	
Sub-total		3.40	695	6,240	10	62.4	3.2	a + c + e = 3.2 b + d + f = 3.2
2. Soion Garden								
	A	0.30	150	3,000	10	30.0	1.4	
	B	0.30	150	3,000	"	30.0	1.4	
Sub-total		0.60	300	6,000	10	60.0	2.8	
3. Experimental Farm								(Inter-crops)
	F1	0.30	47	2,200	10	22.0	3.6	Beans
	F2	0.32	50	2,350	"	23.5	3.6	Tomato
	F3	0.43	67	3,180	"	31.8	3.6	Cumcumber
	F4	0.25	39	1,880	"	18.8	3.4	Cabbage
	F5	0.35	55	2.590	"	25.9	3.4	Radish/Carrot
	F6	0.40	63	2,950	"	29.5	3.4	Potato
	F7	0.40	63	2,950	"	29.5	3.6	Onion
	F8	0.30	47	2,400	"	24.0	3.6	Peanuts
	F9	0.30	47	2,400	"	24.0	3.6	Grass
Sub-total		3.05	478	22,900	10	229.0	10.6	
4. Nursery								
Seedbed		0.02	-	200	10	2.0	0.1	
Stockyard		0.045	-	450	"	4.5	0.2	
Greenhouse		0.02	-	200	"	2.0	0.1	
Shadehouse		0.185	-	1,850	"	18.5	1.0	
Others		0.08	-	800	"	8.0	0.4	
Sub-total		0.35	-	3,500	10	35.0	1.8	
Total		7.40	1,473	38,640		386.4	18.4	