As a result of the above analysis, the Case 3 which indicates the minimm development shown in Table F-3 is selected as the optimum development plan. The result of reservoir operation study of Case 3 is shown in Fig. F-14.

(4) Mkuyu dam

Three alternative cases are selected as below.

Unit: ha

	Case 1	Case 2	Case 3
1. Irrigation are without dam development			
Rainy season	930	930	930
Dry season	180	180	180
Total	1,110	1,110	1,110
2. Irrigation area			
Rainy season	1,140	1,140	1,140
Dry season	1,140	700	180
Total	2,280	1,840	1,320
3. Incremental irrigation due to the dam	1,170	730	210
4. Construction cost (US$x10^3)	13,980	10,260	6,440
5. Development cost (US$/ha)	11,950	14,050	30,670

Based on the above, Case 1 which indicates the minimum developmet cost as shown in Table F-4 is selected as the optimum development plan. The result of reservoir operation study of Case 1 is shown in Fig. F-15.

3.3.2 Kalimawe dam

(1) Reservoir operation study

After selection of optimum development scale of the above four dams, possibility of dam heightening of the existing Kalimawe dam is examined by means of reservoir operation with the following conditions.

(a) No dam is developed on the upstream of the Kalimawe dam. Three irrigation schemes i.e. Kisiwani, Gonja and Ndungu schemes are developed without flow regulation.

(b) Igoma dam and Igoma irrigation scheme are developed additionally to the above condition (a).

(c) Hingilili dam and Yongoma dam are developed besides Igoma dam development.

The Mkuyu dam does not affect the inflow of Kalimawe dam. As a result of the reservoir operation, the relationship between irrigation area and storage requirement i.e. necessary normal water level is obtained as shown in Fig. F-16 and Table F-5. The result of the reservoir operation in condition (b) is shown in Fig. F-17.

(2) Water supply planning to the reservoir

After development of the Igoma, Hingilili and Yongoma dams, inflow of the Kalimawe dam is remarkably diminished so that the irrigation area of the Kalimawe dam will be decreased unless additional water from the upstream is supplied. A comparative study is made in order to select the most profitable means to supply the water to the Kalimawe reservoir. Two alternative plans are examined as follows:

(a) Kalimawe dam heightening

The normal water level of the reservoir is heightened up to EL. 509.0 m in order to increase the effective storage of the reservoir.

(b) Construction of diversion channel

A new open channel is proposed in order to divert the excess water of the Saseni river to the Kalimawe reservor. The length of the channel is about 7 km, however, the proposed irrigation canal in Kihurio scheme can be used as the diversion channel by increasing the flow capacity.

A comparative study of two alternatives is summarized below.

Item	Existing Kalimawe dam after optimum dam scale	Alternative(a) Kalimawe dam heightening	Alternative(b) Diversion channel construction
NHWL	EL. 505.69	EL 509.0	EL. 505.69
Effective storage capacity(10^6 m^3)	12.0	60.0	12.0
1) Annual total irrigable area (ha) of Kalimawe dam	250	1,060	1,060
- Rainy season	250	530	530
- Dry season	0	530	530
2) Annual submerged area due to dam heightening	0	820	0
3) Difference of 1) & 2)	250	240	1,060
Increased/decreased area		-10	810
Construction cost(US$ x 10^6)		3.0	0.5

As a result of the comparative study, construction of the diversion channel is justified.

4. PRELIMINARY DESIGN OF PROPOSED DAMS

The preliminary designs are conducted for the optimum development plans selected.

4.1 Criteria of design

The design criteria applied to the preliminary design of dam and related structures are as follows:

- "The Design criteria for Dam"
  (issued by Japan National Committee on Large Dam 1978)
- "The Design Criteria for Dam"
  (issued by Ministry of Agriculture, Forestry and Fishery, Japan 1981)
- "Manual for River and Sabo Works"
  (issued by Ministry of Construction, Japan 1977)

(1) Design flood

Design floods for the spillway and river diversion are determined on the following conditions:

(a) The peak flood discharge of 200-year probability of occurrence plus 20% allowance is adopted as the design flood discharge of spillway.

(b) The 20-year probability flood is adopted as the design flood discharge for the river diversion.

The design flood for each dam site is shown below.

Dam sites	Design flood (m^3/sec)	
	Spillway	River diversion
Igoma	500	208
Hingilili	225	103
Yongoma	260	131
Mkuyu	120	63

(2) Crest elevation

The crest elevation of each main dam is determined to be the flood high water surface plus a free board. The dam crest elevation is determined according to the following calculation:

$Hc = Hd + hw + hi$ or
$Hd + 2.0$ m whichever higher.

where,
Hd = flood high water level
hw = height of wave due to wind
$0.00086 \times V^{1.1} \times F^{0.45}$
(method of S.M.B)
V: wind velocity (m/s)
F: fetch (m)
hi = addition of allowance according to type of dam
hi = 1.0 m in case of fill type dam

As a result of calculation, the dam crest elevation for each dam site is determined as below together with dam height from the present river bed.

Unit: m

Dam sites	Crest elevation	River bed elevation	Dam height
Igoma	EL. 665.0	EL. 640.0	25.0
Hingilili	EL. 1,455.5	EL. 1,410.5	45.0
Yongoma	EL. 1,117.0	EL. 1,075.5	41.5
Mkuyu	EL. 1,017.0	EL. 972.0	45.0

(3) Dam type

The type of main dam in each dam site is determined from the economic view point considering the availability of construction materials and also the geological and topographical conditions. Based on the results of geological and soil mechanical investigations mentioned in ANNEX B, the type of each dam is determined as shown below.

Dam site	Dam Type
Igoma	Homogeneous earth fill
Hingilili	- do. -
Yongoma	- do. -
Mkuyu	Center core type rock fill

(4) Seismic coefficient

Seismic activity is rare in Tanzania. The maximum horizontal acceleration expected in and around the project area in the return period of 100 years is less than 10 gal., according to the seismicity data of International Seismological Centre in United Kingdom (1900-1980). The said 10 gal. is not harmful for the dam structure. Therefore an earthquake is not taken into account.

(5) Slope

Based on the stability analysis, the slope of rockfill dam is determined to be 1:2.5 for the upstream side and 1:2.0 for the downstream side. The slope of homogeneous earthfill dam is determined to be 1:3.0 for the upstream side and 1:2.5 for the downstream side. The minimum safety factor is 1.2.

(6) Foundation treatment

All top soils are stripped and the excavation reaches a depth where the foundation has a bearing strength more than 50 of the N-value. At the cutoff trench portion, the foundaton is excavated down to the durable, fresh and groutable rock. The curtain grouting is planned along dam axis and also the consolidation grouting is planned for the whole bottom area of the cutoff trench.

(7) River diversion

River diversion is to be made by a combination of coffer dam and diversion works. The type of river diversion is proposed as below.

Dam sites	Type of river diversion
Igoma	Open Channel
Hingilili	Pressure tunnel type with a circular shape of 5.0 m in diameter
Yongoma	- do. -
Saseni	- do. - 4.0 m

(8) Spillway

Uncontrolled overflow type weirs are adopted so as to automatically release water in the reservoir whenever the reservoir water level exceeds the normal high water level. A side-channel spillway is selected as the most suitable type to each dam, except Igoma dam, for the reason that this type requires relatively narrow chute-way width compared with the case of a straight center overflow spillway.

Considering that the Igoma reservoir is not often filled up to the normal water level, the causeway type is applied to Igoma dam. The right side of dam crest is lowered in order to keep the overflow depth of the design flood.

(9) Sedimentation

No valid data on sedimentation is available in and around the project area. Examination of the past records of sedimentation of many dams in Japan, shows that the annual sedimentation widely varies from less than 10 to 10,000 m^3/year/km^2 as shown in Fig. F-18. Considering that the annual rainfall in the mountains in Japan is more than 2,000 mm and surface of the earth in Japan is rather erosive than the at one in the project area, the amount of sedimentation was assumed at 100 m^3/km^2/year.

4.2 Preliminary Design of Proposed Dams

4.2.1 Igoma dam

(1) Main dam:

Normal high water level, of the proposed Igoma dam is determined at EL. 661.0 m and low water level, at EL. 650.4 m, to secure an effective storage capacity of 39.4 x 10^6 m^3 and a dead storage capacity of 7.49 x 10^6 m^3. Based on the geological conditions, main dam foundation is to be excavated about 1 m thick for removal of organic layer in the surface and earth cutoff is to be laid down 7.5 m deep below surface except for the left abutment. The proposed dam is a homogeneous earth fill type of 25 m in height and 530 m in crest length as shown in Fig. F-19. The dam volume is 392,000 m^3 will consist of 360,000 m^3 of earth fill, 20,000 m^3 of filter, and 12,000 m^3 of riprap.

(2) Spillway:

The proposed side channel spillway type is designed on the left side of the main dam. The spillway has no gate and has a overflow section 150 m wide. Its crest elevation is determined at EL. 661 m.

(3) River diversion:

The diversion open channel is located on the left side of main dam due to topographical conditions. The length of the diversion channel is about 275 m.

(4) Outlet works:

The proposed outlet works are located at the left side of main dam.

(5) Access road:

The existing Same-Tanga road is used as an access road and is relocated on the crest of main dam.

4.2.2 Hingilili dam

(1) Main dam:

Normal high water level of the proposed Hingilili dam is determined at EL. 1,451.5 m and low water level at EL. 1,419.0 m to provide an effective storage capacity of 7.8 x 10^6 m^3 and a dead storage capacity of 0.42 x 10^6 m^3. Acording to the geological conditions, the main dam foundation is to be excavated to remove a 2 m thick organic layer in the surface. Earth cutoff is to be laid down to 11 m of depth below surface. The proposed Hingilili dam is a homogeneous earth fill type 45 m in height and 214 m in crest length as shown in Fig. F-20.

The dam volume is estimated at 542,000 m^3 including 484,000 m^3 of main dam and 58,000 m^3 of two saddle dams. Its components consist of earth of 512,000 m^3, filter of 20,000 m^3 and riprap of 10,000 m^3.

(2) Spillway:

The proposed spillway is located on the right abutment of NO. 2 saddle dam. No other alternatives are conceivable because of the topographic conditions. The spillway has no gate and has a overflow section having 40 m width. Its crest elevation is determined at EL. 1,451.5 m. The stilling basin is of a horizontal apron type. Floor elevation of the stilling basin is determined at EL. 1,427.0 m to provide conjugate depths of hydraulic jump.

(3) River diversion:

A diversion tunnel is located on the left bank side due to topographical condition. The length of the tunnel is 348 m.

(4) Outlet works:

The outlet works consist of the outlet gate, the above-mentioned tunnel, water release pipes and valves, etc.

(5) Access road:

An existing road, branched from the Same-Tanga road will be used as the access road. Improvement works are needed.

4.2.3 Yongoma dam

(1) Main dam:

Normal high water level of the proposed Yongoma dam is determined at EL. 1,112.5 m and low water level at EL. 1,086 m to secure an effective storage capacity of 8.5 x 10^6 m^3 and a dead storage capacity of 0.56 x 10^6 m^3. In view of the geological condition at the site, main dam foundation is excavated about 1.5 m thick to remove organic layer in the surface and earth cutoff is to be laid down to 6 m of depth below surface. The proposed of the a homogeneous earth fill type of 41.5 m in height and 180 m in crest length as shown in Fig.F-21. The dam volume is estimated at 485,000 m^3, consisting of consist of 456,000 m^3 of earthfill, 19,000 m^3 of filter portion and, 10,000 m^3 of riprap.

(2) Spillway:

The proposed spillway is located on the left abutment of the main dam. No other alternatives are conceivable because of the topographic conditions of the dam site. The spillway has no gate and has a overflow weir section having 35 m width. Its crest elevation is determined at EL. 1,112.5 m. The stilling basin is of the ski-jump type.

(3) River diversion:

A diversion tunnel is located on the right bank side due to topographical conditions. The length of tunnel is 345 m.

(4) Outlet works:

The same outlet works as those for the Hingilili dam are to be provided.

(5) Access road

An access road of about 8 km long will newly be constructed from the Same-Tanga road.

4.2.4 Mkuyu dam

(1) Main dam:

Normal high water level of the proposed Mkuyu is determined at EL. 1,013.0 m and low water level at EL. 983.0 m to secure an effective storage capacity of 7.7 x 10^6 m^3 and dead storage capacity of 0.45 x 10^6 m^3. Main dam foundation is to be excavated about 1.5 m thick to remove organic layer in the surface and core cutoff is to be laid to 6 m of depth below surface. The proposed Mkuyu dam is of the center core rock fill type of 45 m in height and 205 m in crest length as shown in Fig. F-22. The dam volume is 510,000 m^3 consisting of 72,000 m^3 of core embankment, 40,000 m^3 of filter portion, 388,000 m^3 of rock fill and 10,000 m^3 of riprap.

(2) Spillway:

The proposed spillway is located on the right abutment of main dam. No other alternatives are conceivable because of the topographic conditions at site. The spillway has no gate and has an overflow section having 25 m width. Its crest elevation is determined at EL. 1,013.0 m. The stilling basin is of the horizontal apron type. Floor elevation of the stilling basin is determined at EL. 971.0 m to provide conjugate depths of hydraulic jump.

(3) River diversion

A diversion tunnel is located on the left bank side due to topographic conditions. The length of the tunnel is 340 m.

(4) Outlet works:

The same outlet works as those for the previous Hingilili dam are to be provided.

(5) Access road:

The existing trunk road branched from the Same-Tanga road should be improved in length of 10 km. A part of the existing road which is submerged in the reservoir should be relocated.

4.2.5 Principal features of proposed dams

The principal features and dimensions of the proposed dams are summarized as follows:

PRINCIPAL FEATURES OF THE IGOMA DAM

(1) Reservoir

Catchment area	749 Km^2
Flood high water level (FHWL)	EL. 662.4 m
Normal high water level (NHWL)	EL. 661.0 m
Low water level (LWL)	EL. 650.5 m
Gross storage capacity	46.9×10^6 m^3
Effecitive storage capacity	39.4×10^6 m^3
Dead storage capacity	7.5×10^6 m^3

(2) Dam

Type	Homogeneous earth fill dam
Crest elevation	EL. 665.0 m
Dam height above river bed	25 m
Crest length	530 m
Surface Slope Upstream	1:3
Downstream	1:2.5
Embankment volume Main dam	392,000 m^3

(3) Spillway

Type	Causeway overflow type
Design flood (1.2 times of 200 year flood)	500 m^3/sec
Weir crest length	150 m
Weir crest elevation	EL. 661.0 m

(4) Diversion tunnel

Type	Diversion open channel
Design flood (20 year flood)	208 m^3/sec
Diameter	- m
Length	275 m

(5) Outlet works

Type	Embedded steel pipe with valve

(6) Irrigable area

Location	Igoma Scheme
Annual irrigated area	1,500 ha
Rainy season	750 ha
Dry season	750 ha
Increased annual irrigated area excluding without flow regulation	1,500 ha

(7) Construction Cost * — US$$8.7 \times 10^6$

(8) Development Cost — US$5,770/ha

* No price escalation is added and the interest during the construction period is not included. Exchange rate; US$1.0 = TSh. 12.0 = ¥240

PRINCIPAL FEATURES OF THE HINGILILI DAM

(1) Reservoir

Catchment area		41.5 Km^2
Flood high water level (FHWL)	EL.	1,453.6 m
Normal high water level (NHWL)	EL.	1,451.5 m
Low water level (LWL)	EL.	1,419 m
Gross storage capacity		8,215 x 10^6 m^3
Effective storage capacity		7.8 x 10^6 m^3
Dead storage capacity		0.415 x 10^6 m^3

(2) Dam

Type	Homogeneous earth full dam	
Crest elevation	EL.	1,455.5 m
Dam height above river bed		45 m
Crest length		214 m
Surface Slope Upstream		1:3
Downstream		1:2.5
Embankment volume Main dam		484,000 m^3
Saddle dam		58,000 m^3

(3) Spillway

Type	Non gated overflow weir and horizontal stilling basin	
Design flood (1.2 times of 200 year flood)		225 m^3/sec
Weir crest lengrh		40 m
Weir crest elevation	EL.	1,451.5 m

(4) Diversion tunnel

Design flood (20 year flood)	103 m^3/sec
Diameter	5 m
Length	348 m

(5) Outlet works

Type	Concrete-lined circular tunnel and steel pipe with valve

(6) Irrigable area

Location	Gonja	Scheme
Annual irrigated area		2,000 ha
Rainy season		1,200 ha
Dry season		800 ha
Increased annual irrigated area excluding without flow regulation		1,100 ha

(7) Construction Cost * US$17.2 x 10^6

(8) Development Cost US$15,620/ha

* No price escalation is added and the interest during the construction period is not included. Exchange rate; US$1.0 = TSh. 12.0 = ¥240

PRINCIPAL FEATURES OF THE YONGOMA DAM

(1) Reservoir

Catchment area		56 Km^2
Flood high water level (FHWL)	EL.	1,115 m
Normal high water level (NHWL)	EL.	1,112.5 m
Low water level (LWL)	EL.	1,086 m
Gross storage capacity		9.06×10^6 m^3
Effective storage capacity		8.5×10^6 m^3
Dead storage capacity		0.56×10^6 m^3

(2) Dam

Type	Homogeneous earth fill dam	
Crest elevation	EL.	1,117 m
Dam height above river bed		41.5 m
Crest length		180 m
Surface slope Upstream		1:3
Downstream		1:2.5
Embankment volume Main dam		485,000 m^3

(3) Spillway

Type	Non gated overflow weir and ski jump	
Design flood (1.2 times of 200 year flood)		260 m^3/sec
Weir crest length		35 m
Weir crest elevation	EL.	1,112.5 m

(4) Diversion tunnel

Design flood (20 year flood)	131 m^3/sec
Diameter	5 m
Length	345 m

(5) Outlet works

Type	Concrete-lined circular tunnel and steel pipe with valve

(6) Irrigable area

Location	Ndungu Scheme
Annual irrigated area	1,950 ha
Rainy season	1,180 ha
Dry season	770 ha
Indreased annual irrigated area excluding without flow regulation	1,040 ha

(7) Construction Cost * US$14.1 x 10^6

(8) Development Cost US$13,560/ha

* No price escalation is added and the interest during the construction period is not included. Exchange rate; US$1.0 = TSh. 12.0 = ¥240

PRINCIPAL FEATURES OF THE MKUYU DAM

(1) Reservoir

Catchment area		45 Km^2
Flood high water level (FHWL)	EL.	1,015 m
Normal high water level (NHWL)	EL.	1,013 m
Low water level (LWL)	EL.	983 m
Gross storage capacity		8.15×10^6 m^3
Effective storage capacity		7.7×10^6 m^3
Dead storage capacity		0.45×10^6 m^3

(2) Dam

Type	Center core type rock fill dam	
Crest elevation	EL.	1,017 m
Dam height above river bed		45 m
Crest length		205 m
Surface slope		1:2.5
		1:2.0
Embankment volume Main dam		510,000 m^3

(3) Spillway

Type	Non gated over flow weir and horizontal stilling basin	
Design flood (1.2 times of 200 year flood)		120 m^3/sec
Weir crest length		25 m
Weir crest elevation	EL.	1,013 m

(4) Diversion tunnel

Design flood (20 year flood)	63 m^3/sec
Diameter	4 m
Length	340 m

(5) Outlet works

Type	Concrete-lined circular tunnel and steel pipe with valve

(6) Irrigable area

Location	Kihurio	Scheme
Annual irrigated area		2,280 ha
Rainy season		1,140 ha
Dry season		1,140 ha
Increased annual irrigated area excluding without flow regulation		1,170 ha

(7) Construction Cost * US\$13.9 x 10^6

(8) Development Cost US\$11,950/ha

* No price escalation is added and the interest during the construction period is not included. Exchange rate; US\$1.0 = TSh. 12.0 = ¥240

5. CONSTRUCTION COST

5.1 General

Construction costs of the proposed dam are estimated on the basis of the preliminary design. All the cost estimates are made at the price level of July, 1983 using exchange rates of TSh. 12.00 and ¥ 240 to US$1.00. The basic conditions applied for the cost estimate are as presented below.

(1) The civil works will be executed on the contract base. Unit prices are estimated on the basis of the information and data obtained from the Regional Development Director's Office, Ministry of Works and the Labour Office in Moshi.

(2) Prices for the mechanical equipment, including installation works, are estimated on the basis of the recent bids for similar works as well as prices in the internaitonal market.

(3) The construction costs are divided into foreign and local currency portions. The classification of local and foreign currency portions for major items is as defined below:

a. Foreign currency portion

i) Reinforcement bar
ii) Gates, valves pipes, etc.
iii) Heavy construction machinery, equipment and plants
iv) Expenses and fees of engineering services by foreign consultants
v) Fuel, oil, etc.
vi) Cement

b. Local currency portion

i) Labour
ii) Minor works
iii) Administration expanses

(4) Costs for freight, insurance and inland transportation are included in the costs of all materials, plants and equipment, which are to be imported, but import tax and duty are not included.

(5) Costs for land compensation for the submerged area is estimated tentatively.

(6) Engineering service and government administration are estimated at 20 percent of direct cost.

(7) Physical contingency amounting to 10 percent of the direct cost plus engineering service and government administration cost is added.

(8) No price escalation is considered. The interest during the construction period is not included.

5.2 Construcion cost

The construction costs for the proposed dams estimated are shown in Tables F-6 to F-9.

Table F-1 FEATURE AND CONSTRUCTION COST OF IGOMA DAM

		Case 1	Case 2	Case 3
I.	Comparative study cases	Case 1	Case 2	Case 3
II.	Annual irrigated area and dam			
	Annual irrigated area (ha)	1,500	1,250	1,000
	Rainy season	750	750	750
	Dry season	750	500	250
	Increased annual irrigable area (ha)	1,500	1,250	1,000
	Dam height (m)	26	24	21.5
	Dam crest (m)	666	664	661.5
	FHWL	664	662	659.5
	NHWL	661	659	656.5
	LWL	650.5	650.5	650.5
	Base	640	640	640
	Effective storage capacity (10^6 m^3)	39.4	27.9	16.4
III.	Construction cost (10^3 US$)			
1.	Preparatory works	340	340	340
2.	Diversion works	30	30	30
3.	Main dam	2,990	2,260	1,570
4.	Saddle dams	0	0	0
5.	Spillway	3,080	3,000	2,900
6.	Intake & outlet structure	100	100	100
	Total of Item 1 to 6	6,540	5,730	4,940
7.	Engineering and administration (20% of Item 1 to 6)	1,310	1,150	990
8.	Contingency (10% of Item 1 to 7)	783	688	593
9.	Compensation	27	22	17
	Total of Item 1 to 9	8,660	7,590	6,540
IV.	Development cost (US$/ha)			
	Construction cost/increased annual irrigable area	5,770	6,070	6,540

Table F-2 (1/2) FEATURE AND CONSTRUCTION COST OF HINGILILI DAM

(Upstream dam site)

		Case 1	Case 2	Case 3	Case 4	Case 5
I.	Comparative study cases	Case 1	Case 2	Case 3	Case 4	Case 5
II.	Annual irrigated area and dam					
	Annual irrigated area (ha)	2,170	2,050	2,000	1,950	1,500
	Rainy season	1,200	1,200	1,200	1,200	1,200
	Dry season	970	850	800	750	300
	Increased annual irrigable area (ha)	1,270	1,150	1,100	1,050	600
	Dam height (m)	50.5	46.5	45	43.5	35
	Dam crest (m)	1,461	1,457	1,455.5	1,454	1,445.5
	FHWL	1,459	1,455	1,453.5	1,452	1,443.5
	NHWL	1,457	1,453	1,451.5	1,450	1,441.5
	LWL	1,419	1,419	1,419	1,419	1,419
	Base	1,410.5	1,410.5	1,410.5	1,410.5	1,410.5
	Effective storage capacity (10^6 m^3)	10.3	8.5	7.8	7.2	4.1
III.	Construction cost (10^3 US$)					
	1. Preparatory works	1,410	1,410	1,410	1,410	1,410
	2. Diversion works	1,850	1,730	1,700	1,660	1,530
	3. Main dam	7,030	5,750	5,450	5,000	3,430
	4. Saddle dams	2,390	1,330	860	800	160
	5. Spillway	3,220	3,220	3,150	3,150	3,150
	6. Intake & outlet structure	460	440	440	440	400
	Total of Item 1 to 6	16,360	13,880	13,010	12,460	10,080
	7. Engineering and administration (20% of Item 1 to 6)	3,270	2,770	2,600	2,500	2,020
	8. Contingency (10% of Item 1 to 7)	1,969	1,669	1,569	1,499	1,209
	9. Compensation	1	1	1	1	1
	Total of Item 1 to 9	21,600	18,320	17,180	16,460	12,100
IV.	Development cost (US$/ha)					
	Construction cost/increased annual irrigable area	17,000	15,930	15,620	15,680	20,170

Table F-2 (2/2) FEATURE AND CONSTRUCTION COST OF HINGILILI DAM

(Downstream dam site)

	Case 6	Case 7	Case 8	Case 9	Case 10
I. Comparative study cases	Case 6	Case 7	Case 8	Case 9	Case 10
II. Annual irrigated areas and dam					
Annual irrigated area (ha)	2,400	2,100	2,050	2,000	1,500
Rainy season	1,200	1,200	1,200	1,200	1,200
Dry season	1,200	900	850	800	300
Increased annual irrigable area (ha)	1,500	1,200	1,150	1,100	600
Dam height (m)	58	51	50	48.5	40.5
Dam crest (m)	1,461	1,454	1,453	1,451.5	1,443.5
FHWL	1,459	1,452	1,451	1,449.5	1,441.5
NHWL	1,457	1,450	1,449	1,447.5	1,439.5
LWL	1,420	1,420	1,420	1,420	1,420
Base	1,403	1,403	1,403	1,403	1,403
Effective storage capacity (10^6 m^3)	14.7	9.2	8.5	7.8	4.1
III. Construction cost (10^3 US$)					
1. Preparatory works	1,840	1,840	1,840	1,840	1,840
2. Diversion works	2,240	1,860	1,820	1,780	1,620
3. Main dam	15,100	9,580	8,880	8,130	5,030
4. Saddle dams	2,450	760	690	610	0
5. Spillway	3,220	3,220	3,150	3,150	3,150
6. Intake & outlet structure	480	460	450	440	410
Total of Item 1 to 6	25,330	17,720	16,830	15,950	12,050
7. Engineering and administration (20% of Item 1 to 6)	5,000	3,540	3,360	3,190	2,410
8. Contingency (10% of Item 1 to 7)	3,038	2,129	2,019	1,919	1,449
9. Compensation	2	1	1	1	1
Total of Item 1 to 9	33,370	23,390	22,210	21,060	15,910
IV. Development cost (US$/ha)					
Construction cost/increased annual irrigable area	22,240	19,490	19,310	19,150	26,500

Table F-3 (1/2) FEATURE AND CONSTRUCTION COST OF YONGOMA DAM

(Upstream dam site)

		Case 1	Case 2	Case 3	Case 4	Case 5
I.	Comparative study cases	Case 1	Case 2	Case 3	Case 4	Case 5
II.	Annual irrigated area and dam					
	Annual irrigated area (ha)	2,360	2,000	1,950	1,880	1,410
	Rainy season	1,180	1,180	1,180	1,180	1,180
	Dry season	1,180	820	770	700	230
	Increased annual irrigable area (ha)	1,450	1,090	1,040	970	600
	Dam height (m)	61.5	43.5	41.5	39	32.5
	Dam crest (m)	1,137	1,119	1,117	1,114.5	1,108
	FHWL	1,135	1,117	1,115	1,112.5	1,106
	NHWL	1,132.5	1,114.5	1,112.5	1,110	1,103.5
	LWL	1,086	1,086	1,086	1,086	1,086
	Base	1,075.5	1,075.5	1,075.5	1,075.5	1,075.5
	Effective storage capacity (10^6 m^3)	23.2	9.5	8.5	7.1	4
III.	Construction cost (10^3 US$)					
1.	Preparatory works	1,500	1,500	1,500	1,500	1,500
2.	Diversion works	2,000	1,400	1,350	1,300	1,220
3.	Main dam	12,320	4,730	4,310	3,700	2,490
4.	Saddle dams	0	0	0	0	0
5.	Spillway	4,000	3,300	3,200	3,150	2,900
6.	Intake & outlet structure	370	320	310	310	300
	Total of Item 1 to 6	20,190	11,250	10,670	9,960	8,410
7.	Engineering and administration (20% of Item 1 to 6)	4,040	2,250	2,140	2,000	1,690
8.	Contingency (10% of Item 1 to 7)	2,428	1,358	1,289	1,199	1,009
9.	Compensation	2	2	1	1	1
	Total of Item 1 to 9	26,660	14,860	14,100	13,160	11,110
IV.	Development cost (US$/ha)					
	Construction cost/increased annual irrigable area	18,380	13,630	13,560	13,570	18,520

Table F-3 (2/2) FEATURE AND CONSTRUCTION COST OF YONGOMA DAM

(Downstream dam site)

I. Comparative study cases	Case 6	Case 7	Case 8	Case 9	Case 10
II. Annual irrigated area and dam					
Annual irrigated area (ha)	2,360	2,000	1,950	1,880	1,410
Rainy season	1,180	1,180	1,180	1,180	1,180
Dry season	1,180	820	770	700	230
Increased annual irrigable area (ha)	1,450	1,090	1,040	970	600
Dam height (m)	54	48	45.5	43.5	36.5
Dam crest (m)	1,122	1,116	1,113.5	1,111.5	1,104.5
FHWL	1,120	1,114	1,111.5	1,109.5	1,102.5
NHWL	1,117.5	1,111.5	1,109	1,107	1,100
LWL	1,081	1,081	1,081	1,081	1,081
Base	1,068	1,068	1,068	1,068	1,068
Effective storage capacity (10^6 m^3)	23.2	9.5	8.5	7.1	4.0
III. Construction cost (10^3 US$)					
1. Preparatory works	1,500	1,500	1,500	1,500	1,500
2. Diversion works	1,750	1,450	1,400	1,380	1,240
3. Main dam	8,530	5,530	4,920	4,410	2,950
4. Saddle dams	850	80	40	0	0
5. Spillway	3,700	3,450	3,350	3,270	3,020
6. Intake & outlet structure	330	320	310	310	300
Total of Item 1 to 6	16,660	12,330	11,520	10,870	9,010
7. Engineering and administration (20% of Item 1 to 6)	3,330	2,470	2,300	2,180	1,810
8. Contingency (10% of Item 1 to 7)	1,998	1,488	1,389	1,309	1,089
9. Compensation	2	2	1	1	1
Total of Item 1 to 9	21,990	16,290	15,210	14,360	11,910
IV. Development cost (US$/ha)					
Construction cost/increased annual irrigable area	15,170	14,940	14,630	14,800	19,850

Table F-4 FEATURE AND CONSTRUCTION COST OF MKUYU DAM

I.	Comparative study cases	Case 1	Case 2	Case 3
II.	Annual irrigated area and Dam			
	Annual irrigated area (ha)	2,280	1,840	1,320
	Rainy season	1,140	1,140	1,140
	Dry season	1,140	700	180
	Increased annual irrigable area (ha)	1,170	730	210
	Dam height (m)	45	35	19
	Dam crest (m)	1,017	1,007	991
	FHWL	1,015	1,005	989
	NHWL	1,013	1,003	987
	LWL	983	983	983
	Base	972	972	972
	Effective storage capacity (10^6 m^3)	7.7	3.3	0.3
III.	Construction cost (10^3 US$)			
1.	Preparatory works	1,450	1,450	1,450
2.	Diversion works	1,010	900	700
3.	Main dam	5,170	2,810	700
4.	Saddle dams	0	0	0
5.	Spillway	2,630	2,300	1,740
6.	Intake & Outlet structure	320	300	280
	Total of Item 1 to 6	10,580	7,760	4,870
7.	Engineering and administration (20% of Item 1 to 6)	2,120	1,560	980
8.	Contingency (10% of Item 1 to 7)	1,279	939	589
9.	Compensation	1	1	1
	Total of Item 1 to 9	13,980	10,260	6,440
IV.	Development cost (US$/ha)			
	Construction cost/increased annual irrigable area	11,950	14,050	30,670

Table F-5 IRRIGABLE AREA AND REQUIRED STORAGE OF KALIMAWE DAM

	Case A	Case B	Case C	Case D	Case E	Case E'	Case F
1. N.W.L. (El.m)	504.7	505.3	505.7	506.6	505.3	505.9	505.7
2. Effective storage ($10^6 m^3$)	5.5	8.0	12.0	21.5	8.0	14.9	8.0
3. Other dam development on upstream	-	-	-	-	Igoma	Igoma	Igoma Hingilili Yongoma
4. Irrigation area							
4.1 Ndungu scheme							
- By Yongoma river							
Dry season (ha)	230	230	230	230	230	230	770
Rainy season (ha)	680	680	680	680	680	680	1,180
Sub-total (ha)	910	910	910	910	910	910	1,950
- By Kalimawe dam							
Dry season (ha)	-	-	-	350	-	-	-
Rainy season (ha)	-	-	-	350	-	-	-
Sub-total (ha)	-	-	-	700	-	-	-
- Inundated area due to dam heightening (ha)	0	0	40	150	0	70	0
4.2 Kihurio scheme							
- By Kalimawe dam							
Dry season (ha)	740	740	740	740	740	740	530
Rainy season (ha)	440	740	740	740	740	740	530
Sub-total (ha)	1,180	1,480	1,480	1,480	1,480	1,480	1,060
- By Saseni river							
Dry season (ha)	930	930	930	930	930	930	1,140
Rainy season (ha)	180	180	580	580	180	580	1,140
Sub-total (ha)	1,110	1,110	1,510	1,510	1,110	1,510	2,280
5. Total of by Kalimawe dam (ha)	1,180	1,480	1,480	2,180	1,480	1,480	1,060
6. Total (ha)	3,200	3,500	3,900	4,600	3,500	3,900	5,290

Table F-6 CONSTRUCTION COST OF IGOMA DAM

Unit: US$$10^3$

Work item	Foreign currency	Local currency	Total
Preparatory works	253	87	340
Diversion works	23	7	30
Main dam	2,490	500	2,990
Saddle dam	0	0	0
Spillway	2,097	983	3,080
Intake & Outlet	67	33	100
Sub-total	4,930	1,610	6,540
Engineering and administration	980	330	1,310
Contingency	590	193	783
Compensation	0	27	27
Total	6,500	2,160	8,660

Table F-7 CONSTRUCTION COST OF HINGILILI DAM

Unit: US$$10^3$

Work item	Foreign currency	Local currency	Total
Preparatory works	1,000	410	1,410
Diversion works	1,017	683	1,700
Main dam	4,484	966	5,450
Saddle dam	660	200	860
Spillway	2,144	1,006	3,150
Intake & Outlet	295	145	440
Sub-total	9,600	3,410	13,010
Engineering and administration	1,920	680	2,600
Contingency	1,150	419	1,569
Compensation	0	1	1
Total	12,670	4,510	17,180

Table F-8 CONSTRUCTION COST OF YONGOMA DAM

Unit: US$$10^3$

Work item	Foreign currency	Local currency	Total
Preparatory works	1,070	430	1,500
Diversion works	807	543	1,350
Main dam	3,630	680	4,310
Saddle dam	0	0	0
Spillway	2,176	1,024	3,200
Intake & Outlet	197	113	310
Sub-total	7,880	2,790	10,670
Engineering and administration	1,576	564	2,140
Contingency	944	345	1,289
Compensation	0	1	1
Total	10,400	3,700	14,100

Table F-9 CONSTRUCTION COST OF MKUYU DAM

Work item	Foreign currency	Local currency	Total
Preparatory works	1,034	416	1,450
Diversion works	604	406	1,010
Main dam	3,516	1,654	5,170
Saddle dam	0	0	0
Spillway	1,788	842	2,630
Intake & outlet	203	117	320
Sub-total	7,145	3,435	10,580
Engineering and administration	1,429	691	2,120
Contingency	856	423	1,279
Compensation	0	1	1
Total	9,430	4,550	13,980

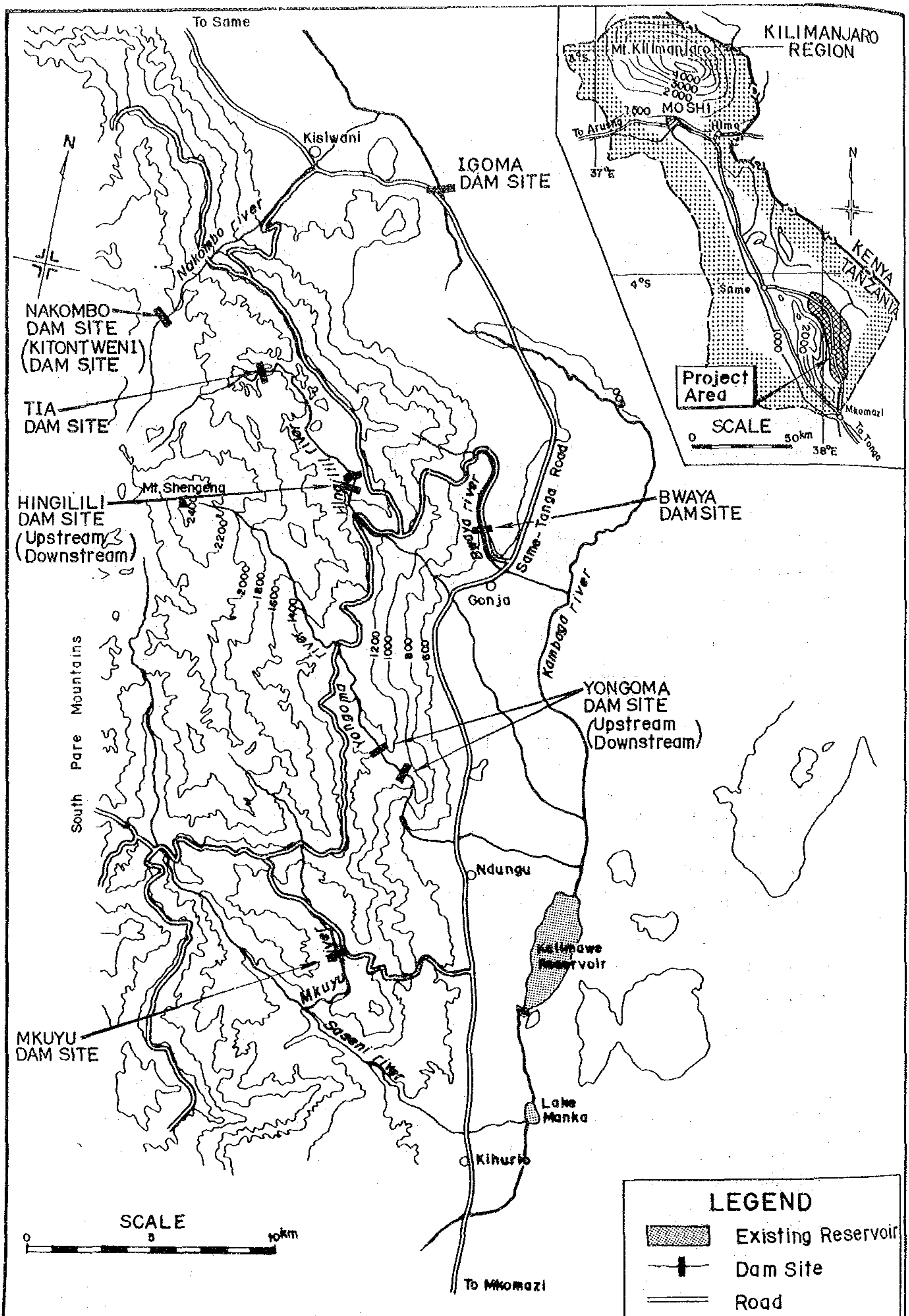
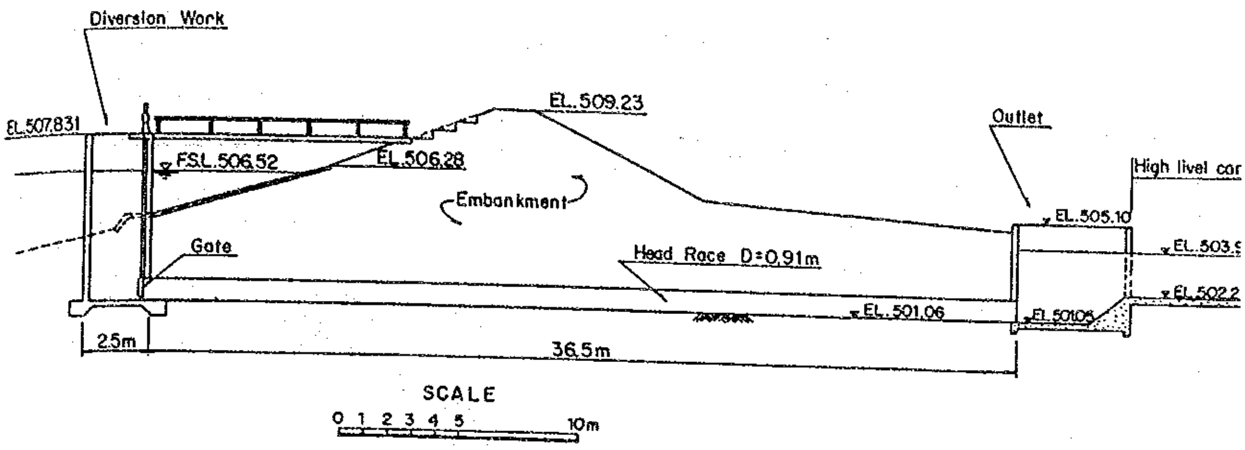


Fig. F-1 LOCATION OF DAM SITE

Typical Section of Diversion Works



Typical Section of Spillway

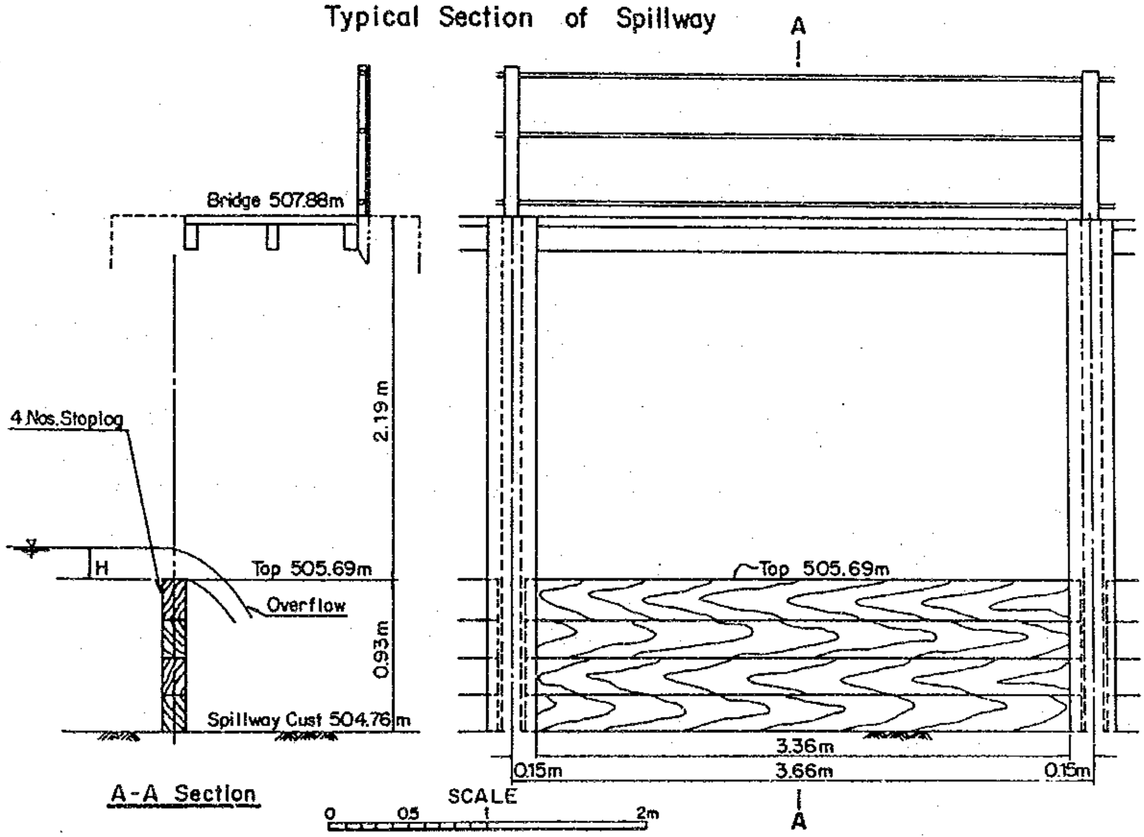


Fig. F-2 PRINCIPAL FEATURES OF KALIMAWE DAM

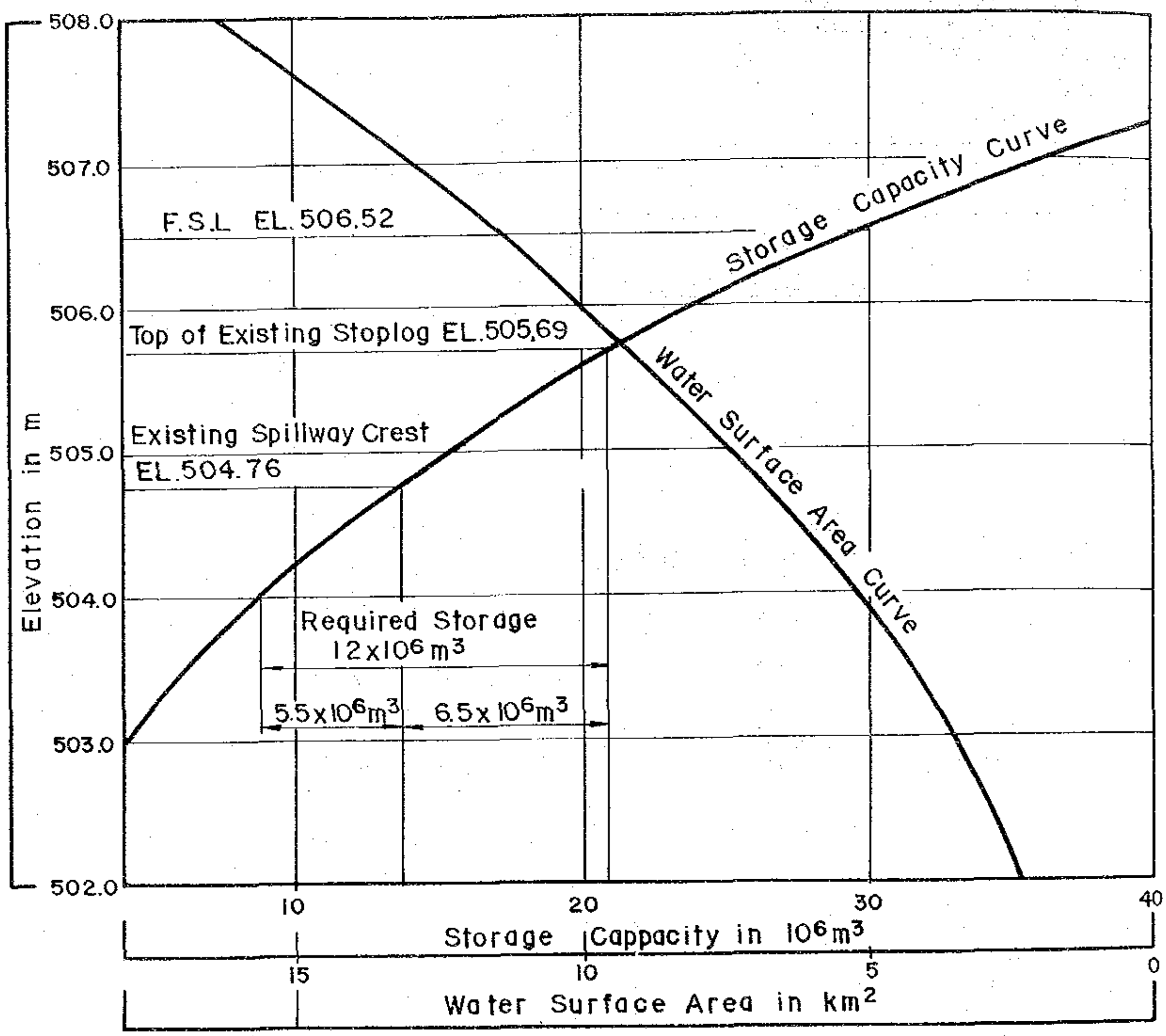


Fig. F-3 AREA-STORAGE CURVE OF KALIMAWE DAM

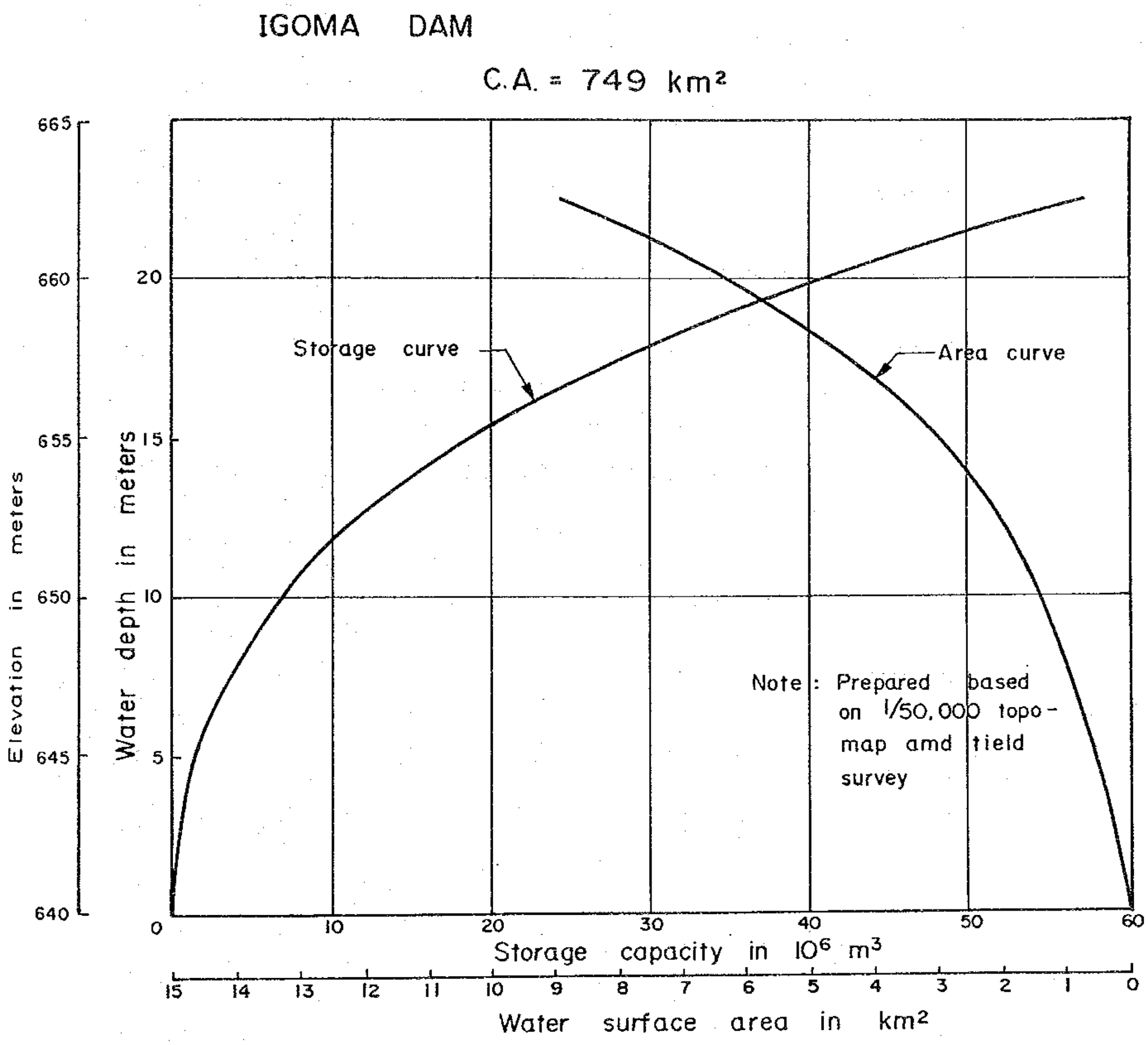


Fig. F-4 AREA-STORAGE CURVE OF IGOMA DAM

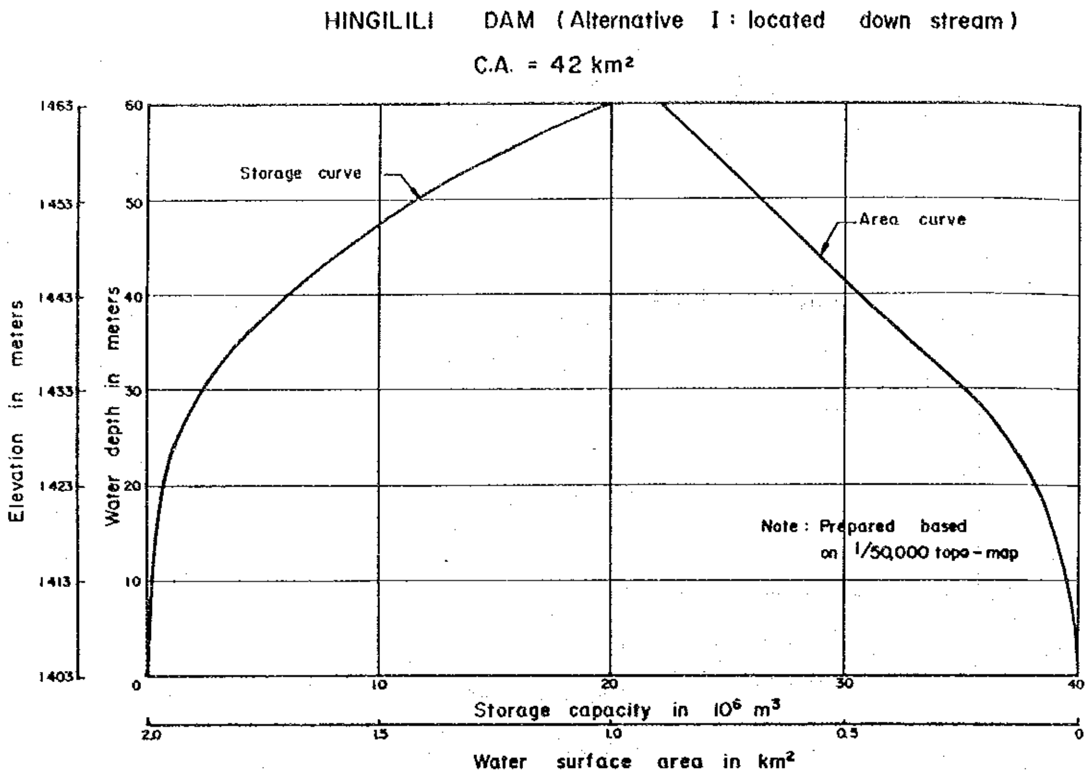


Fig. F-5 AREA-STORAGE CURVE OF HINGILILI DAM (UPSTREAM)

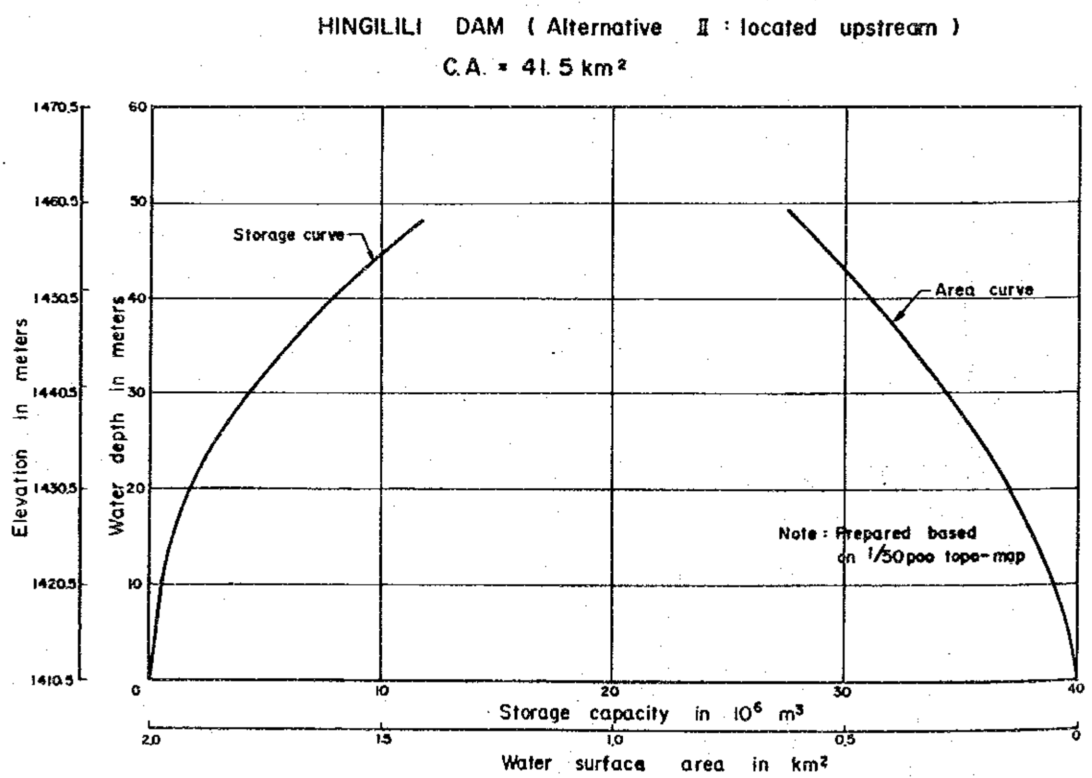


Fig. F-6 AREA-STORAGE CURVE OF HINGILILI DAM (DOWNSTREAM)

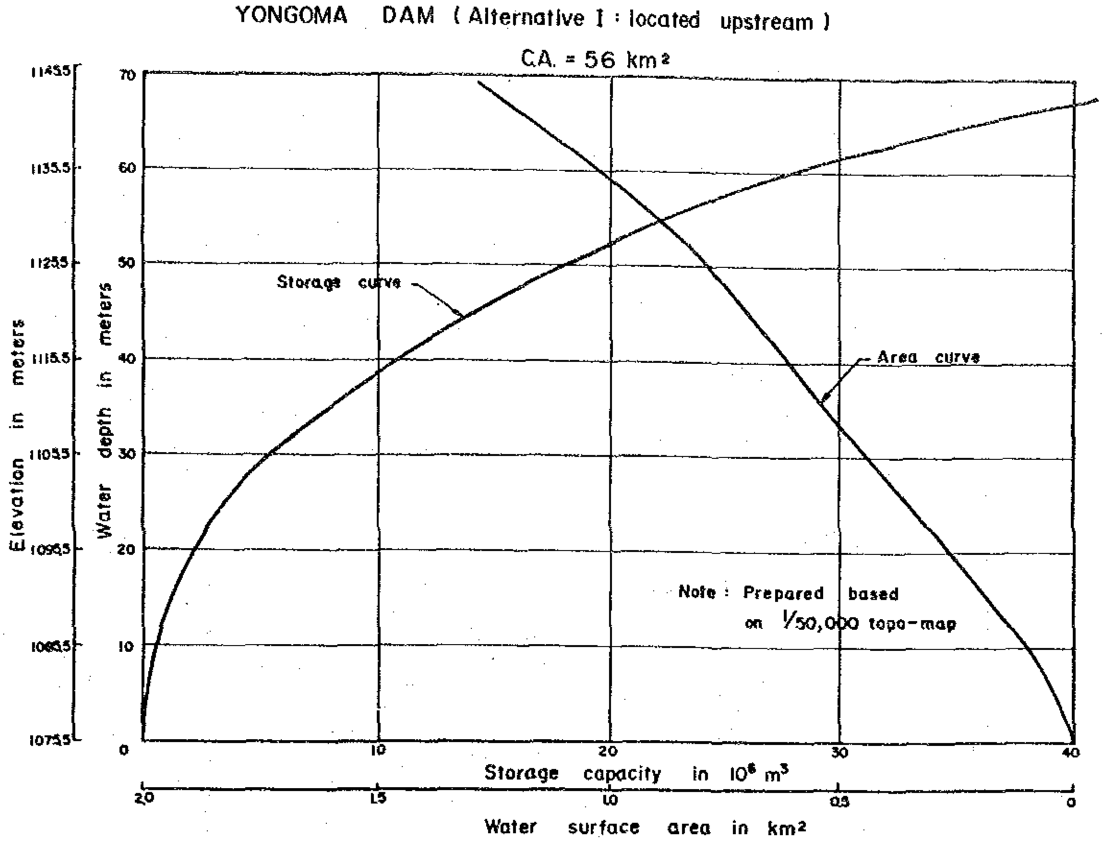


Fig. F-7 AREA-STORAGE CURVE OF YONGOMA DAM (UPSTREAM)

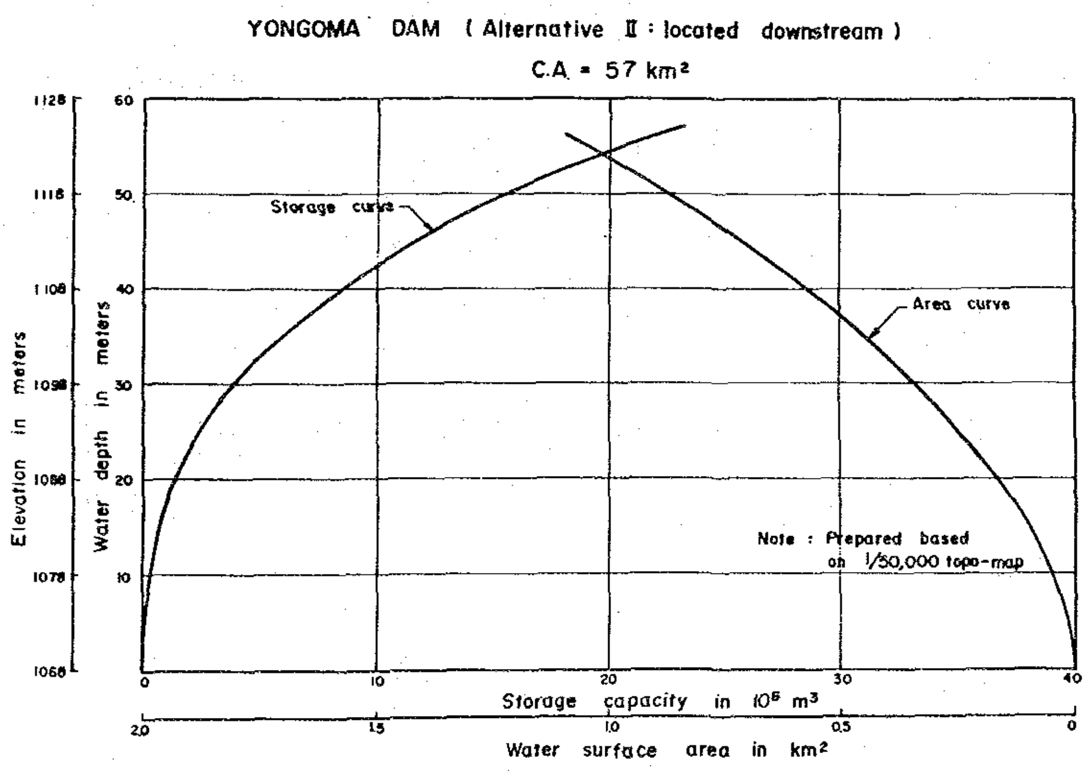


Fig. F-8 AREA-STORAGE CURVE OF YONGOMA DAM (DOWNSTREAM)

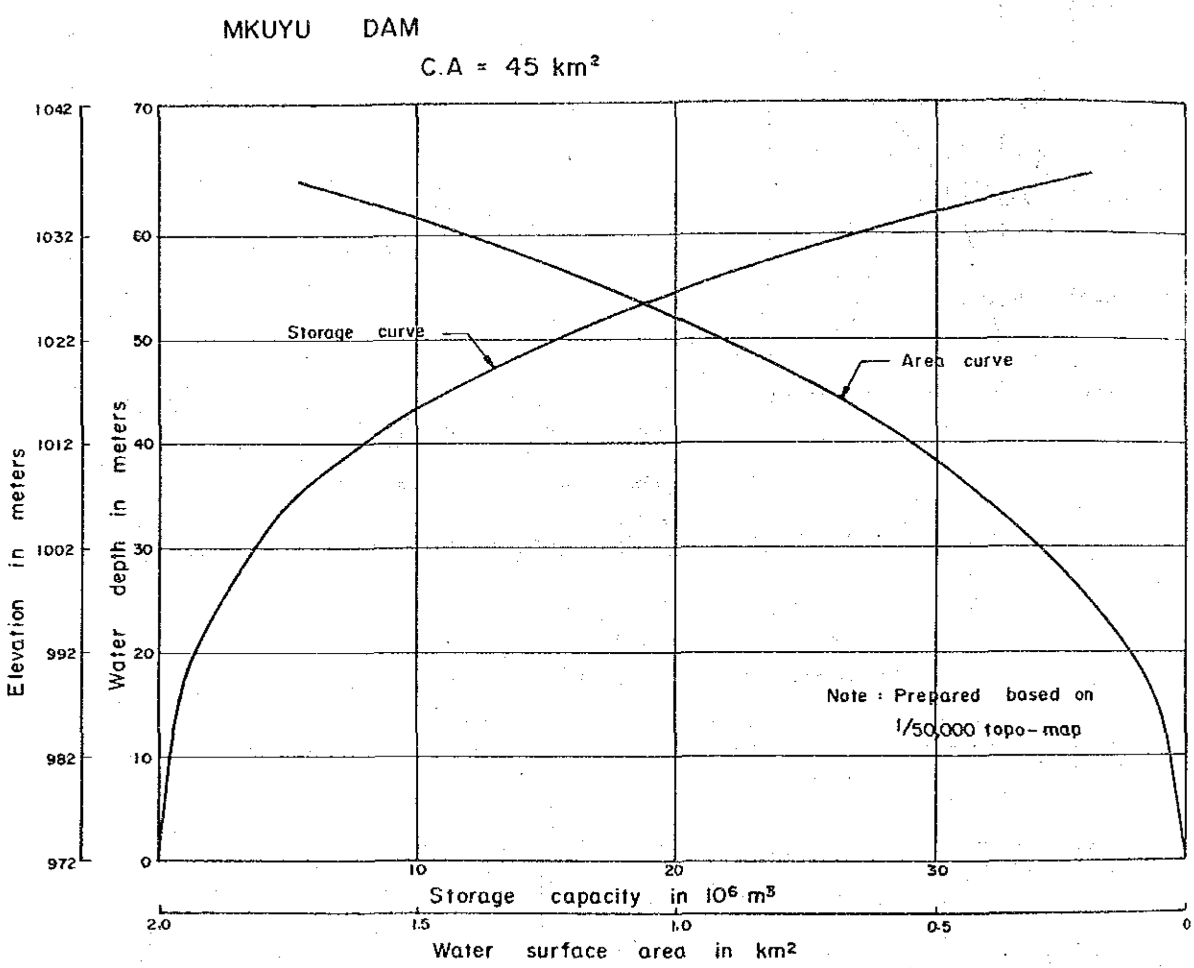


Fig. F-9 AREA-STORAGE CURVE OF MKUYU DAM

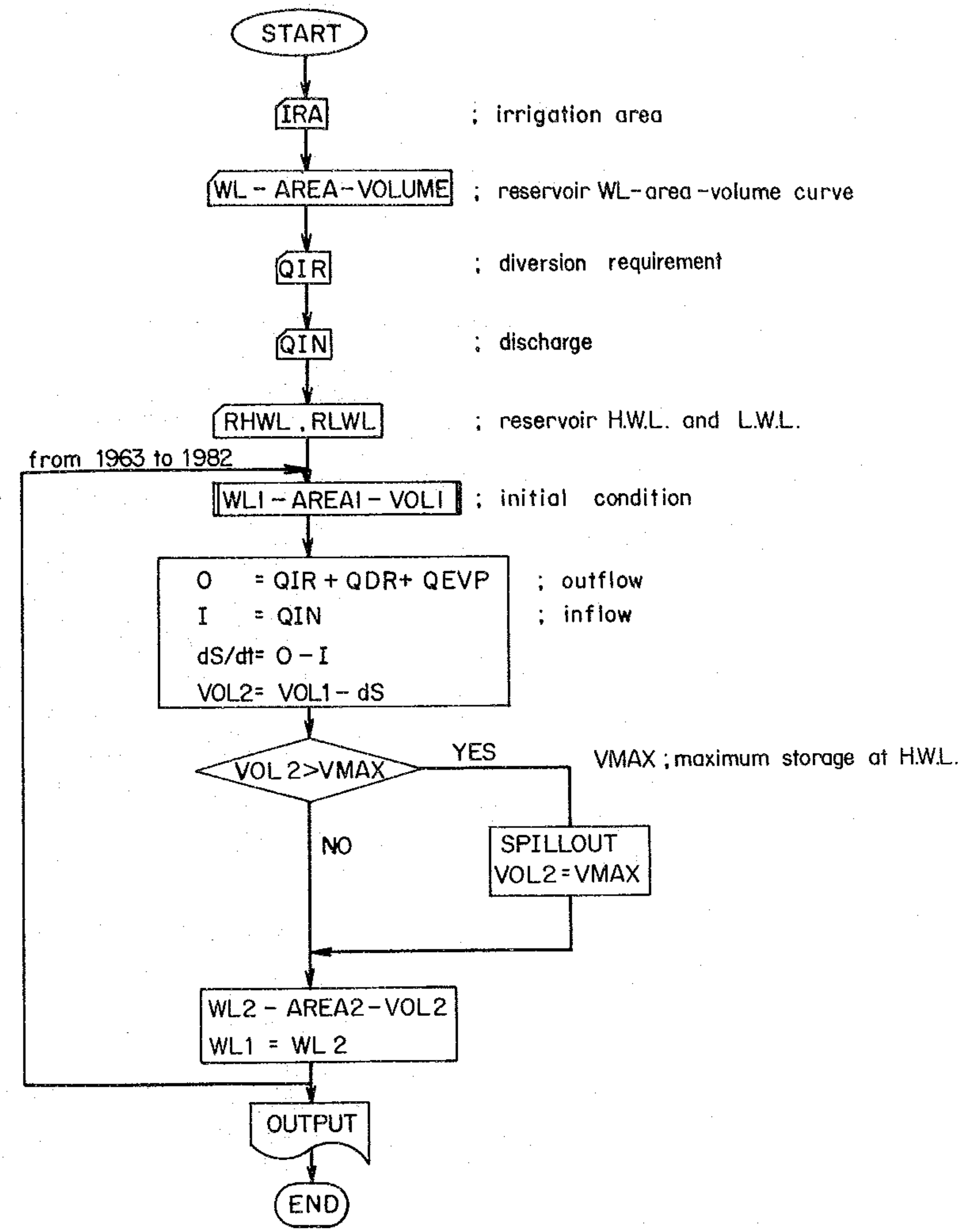


Fig. F-10 FLOW CHART OF RESERVOIR OPERATION

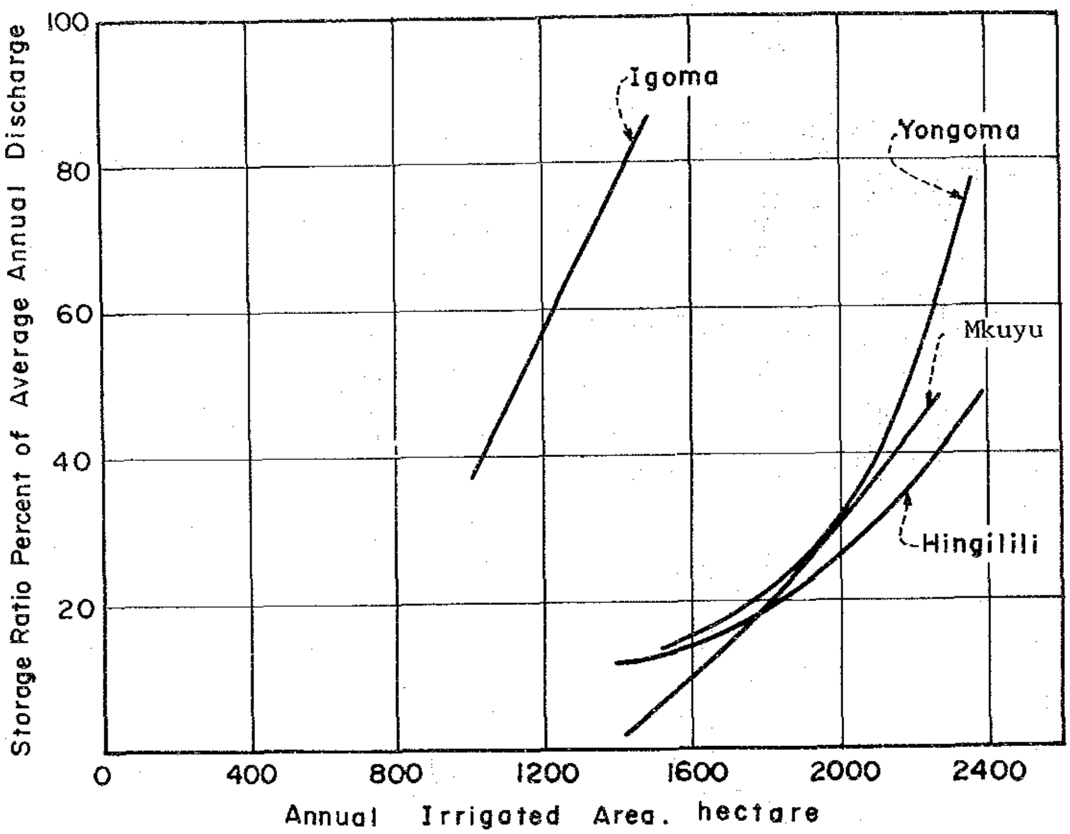


Fig. F-11 RELATIONSHIP BETWEEN IRRIGATION AREA AND EFFECTIVE STORAGE OF IGOMA, HINGILILI, YONGOMA AND MKUYU DAM

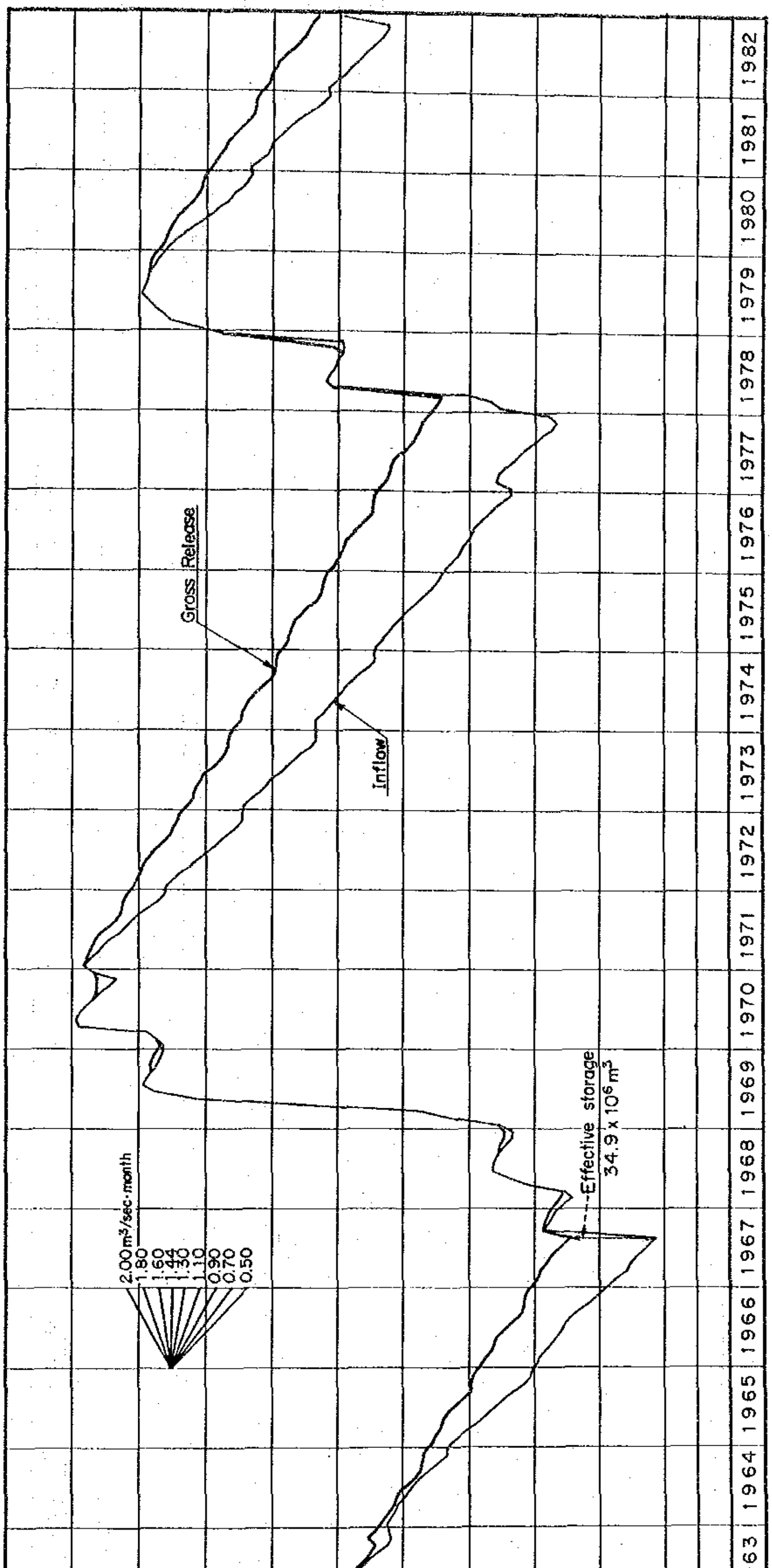


Fig. F-12 MASS CURVE OF INFLOW AND GROSS RELEASE OF IGOMA RESERVOIR

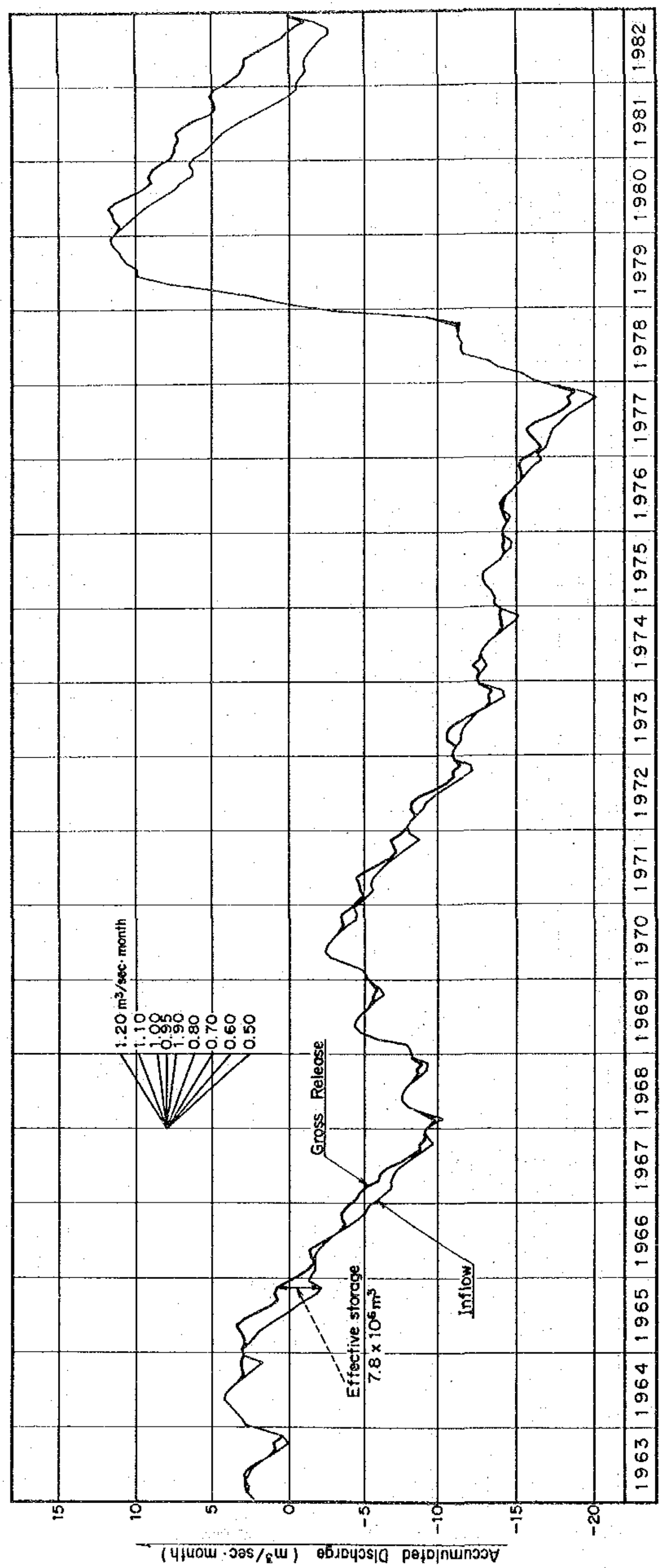


Fig. F-13 MASS CURVE OF INFLOW AND GROSS RELEASE OF HINGILILI RESERVOIR

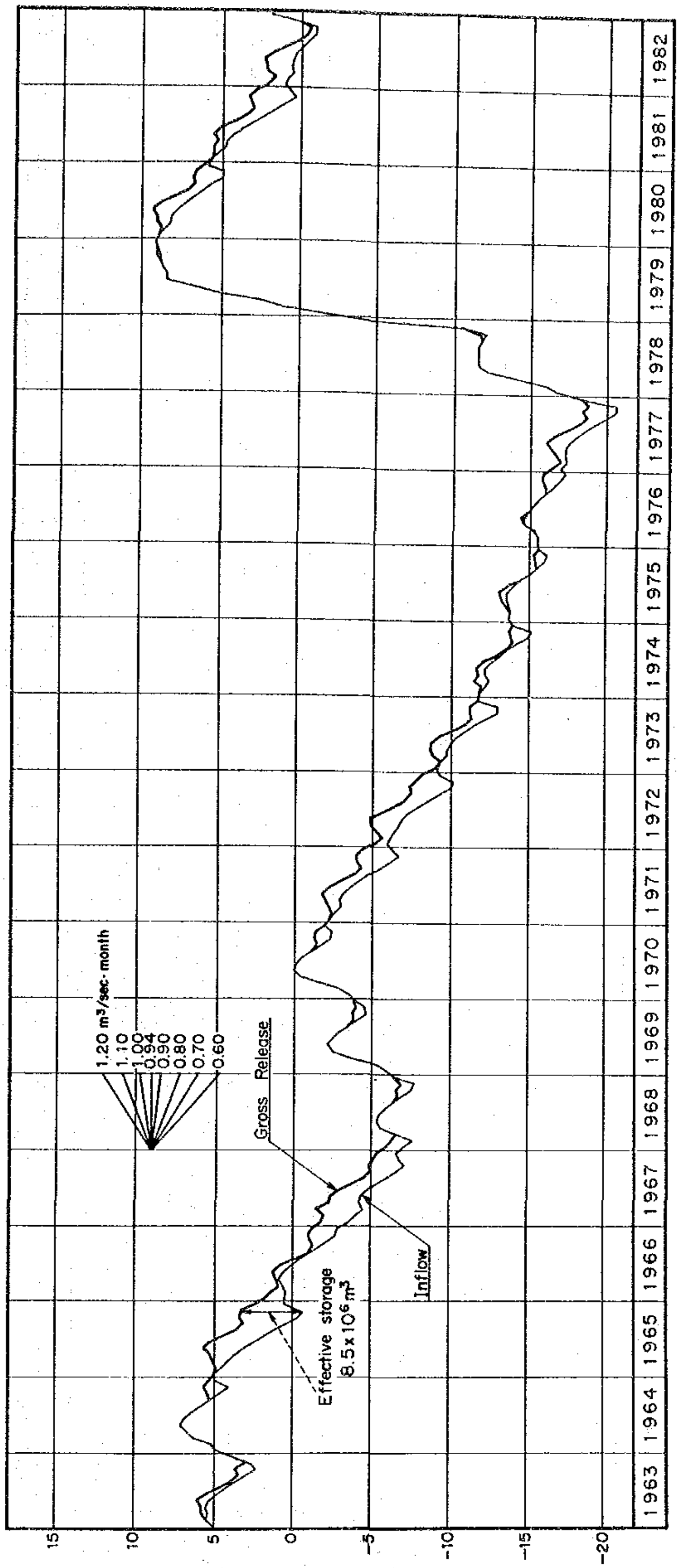


Fig. F-14 MASS CURVE OF INFLOW AND GROSS RELEASE OF YONGOMA RESERVOIR

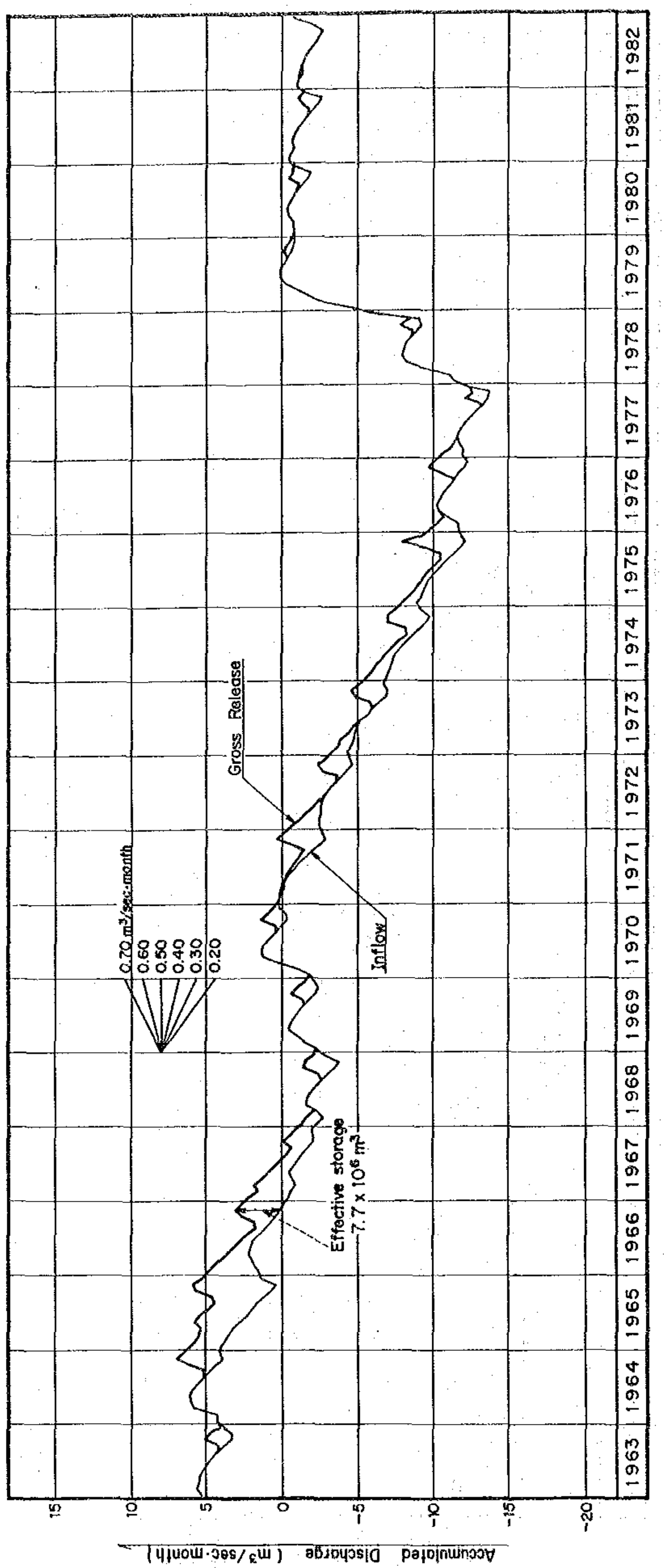


Fig. F-15 MASS CURVE OF INFLOW AND GROSS RELEASE OF MKUYU RESERVOIR

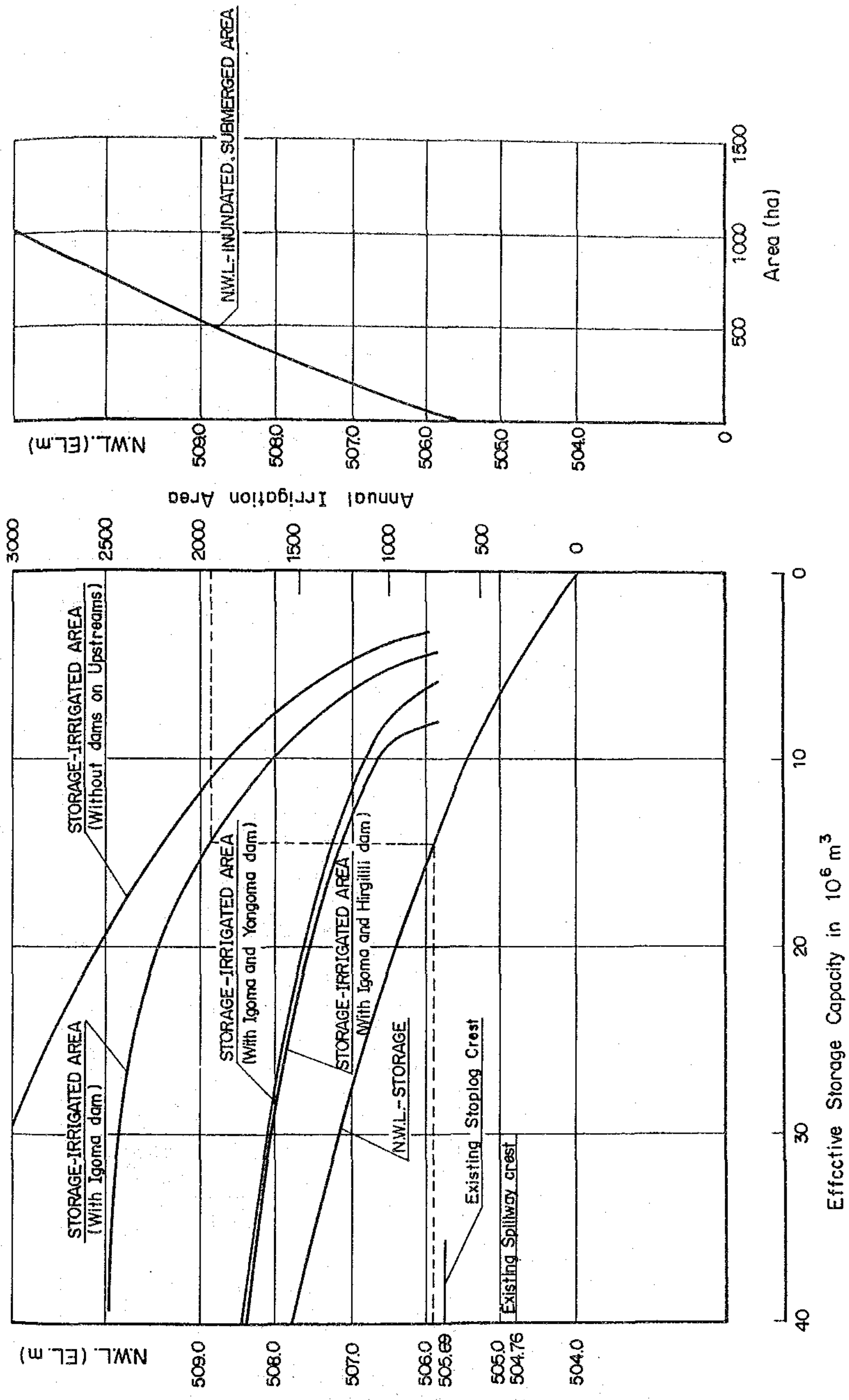


Fig. F-16 RELATIONSHIP BETWEEN IRRIGATION AREA AND EFFECTIVE STORAGE OF KALIMAWE DAM

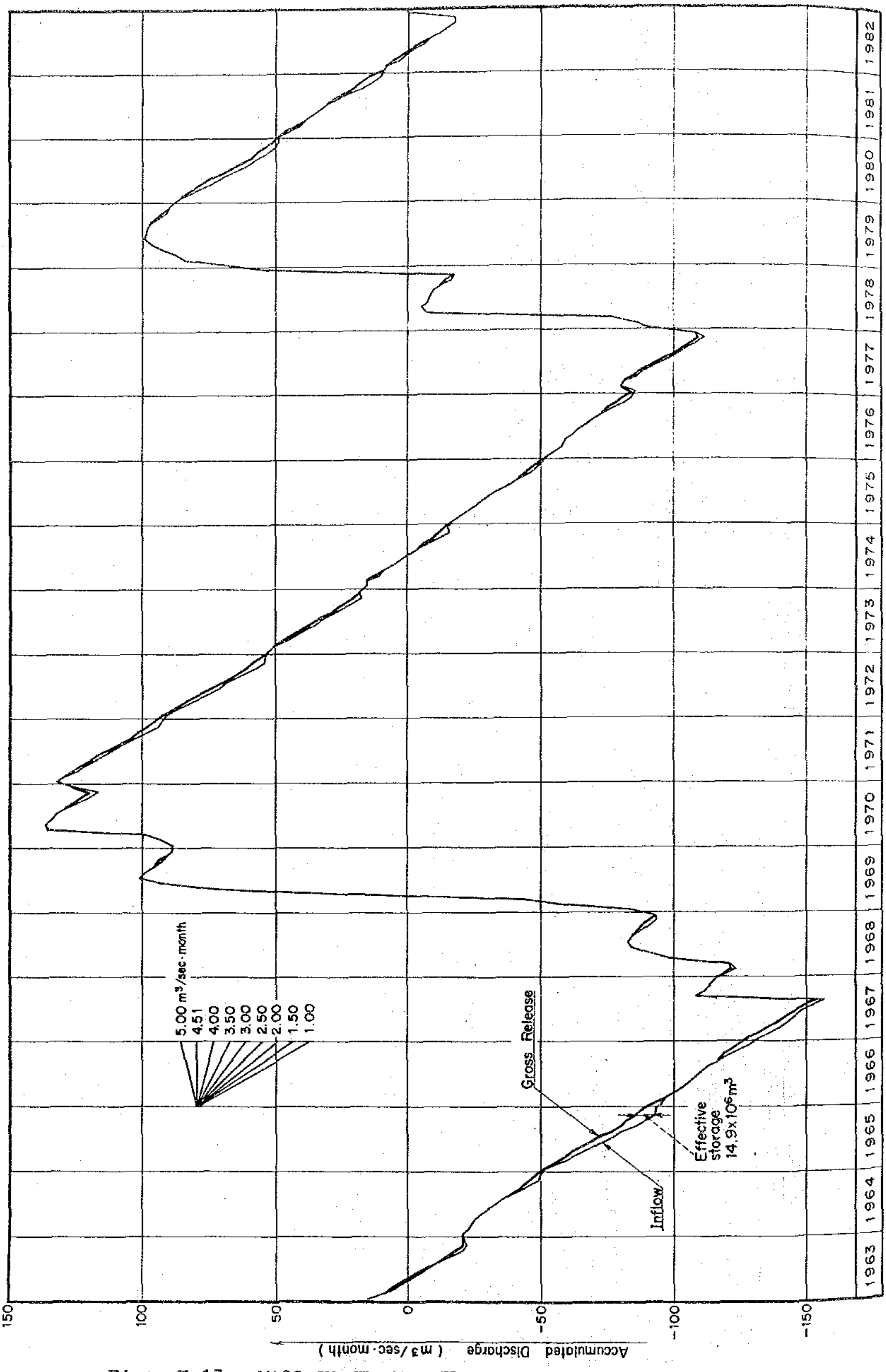


Fig. F-17 MASS CURVE OF INFLOW AND GROSS RELEASE OF KALIMAWE RESERVOIR

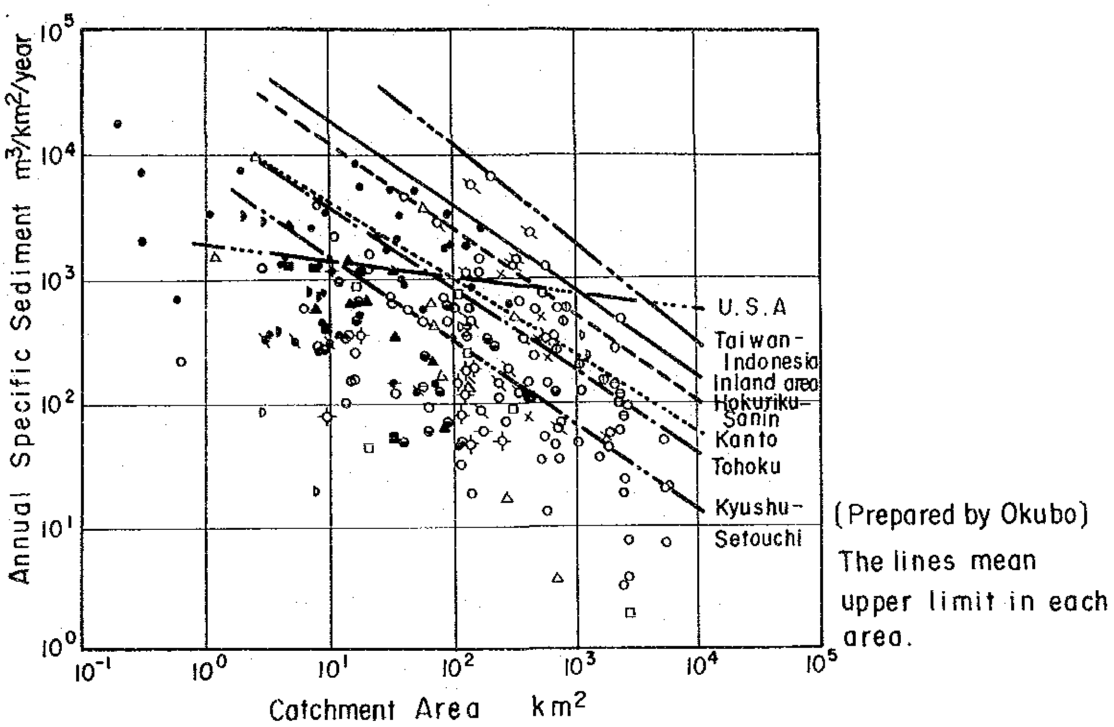


Fig. F-18 RECORDS OF SEDIMENT IN JAPAN

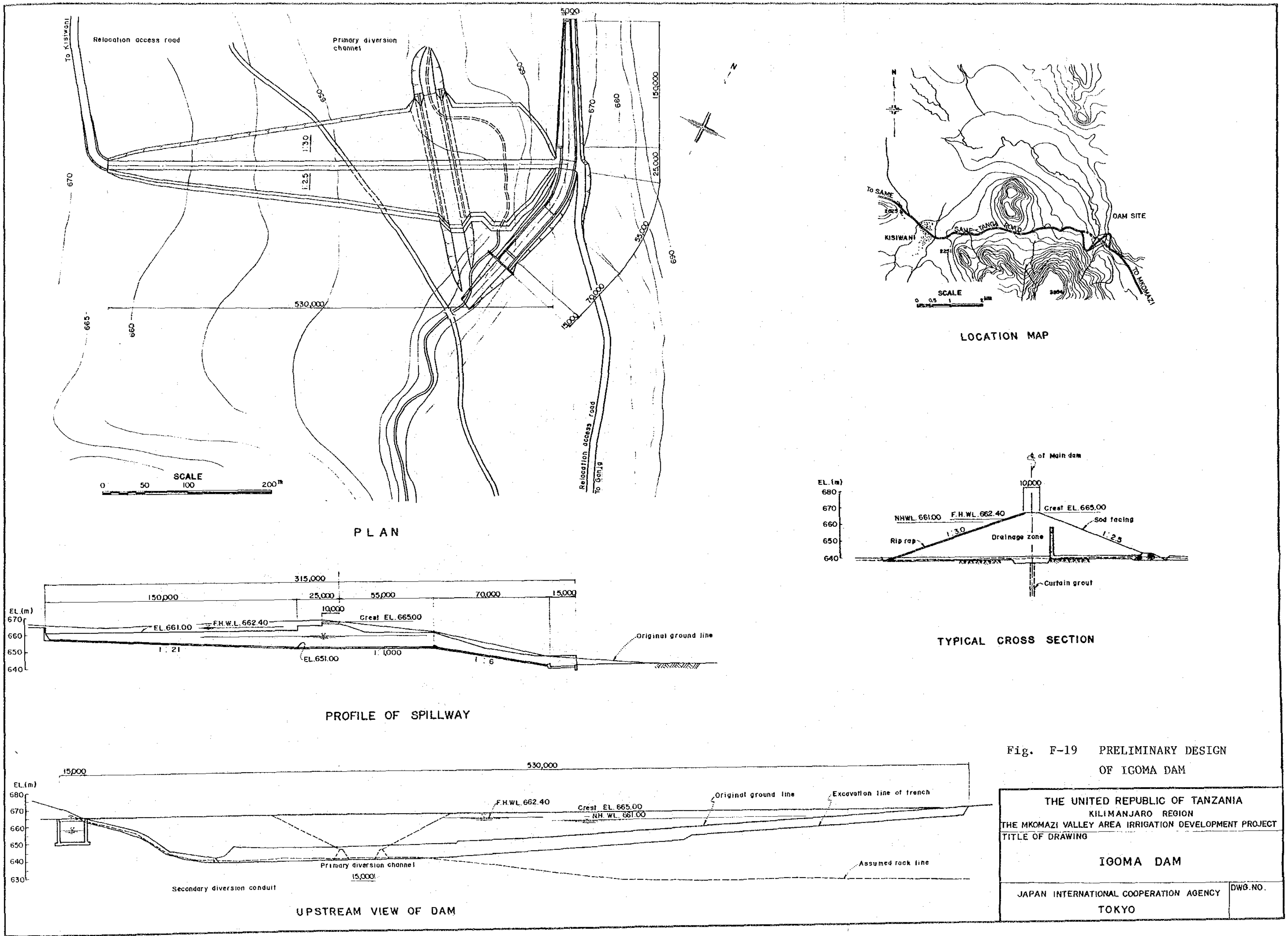
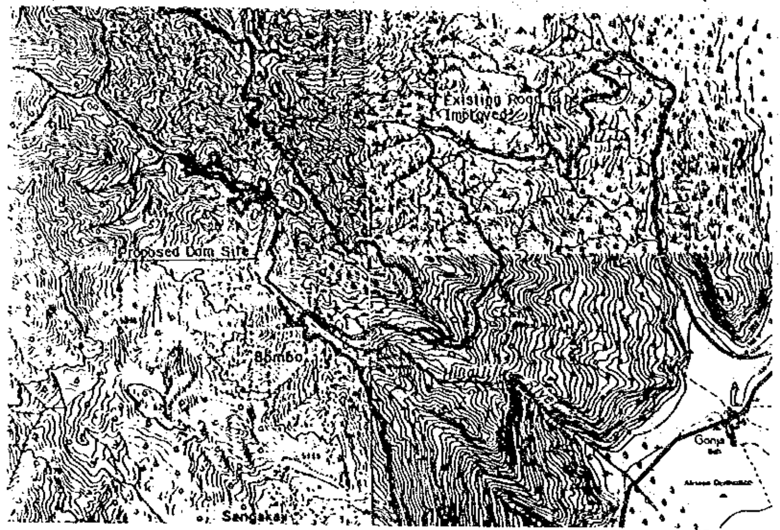
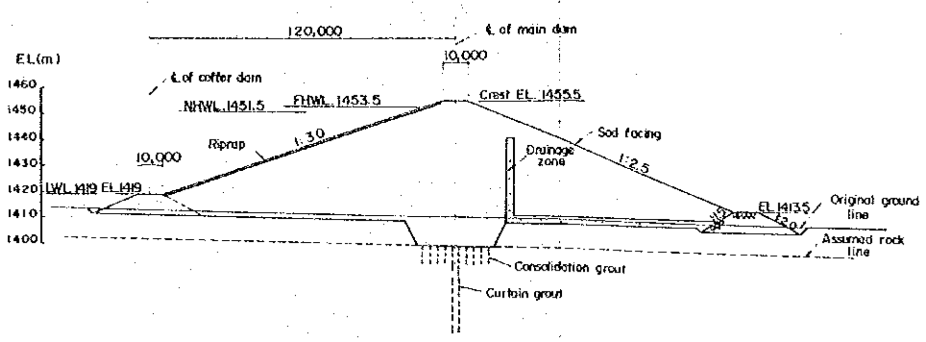


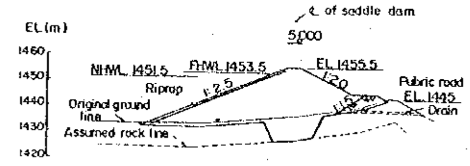
Fig. F-19 PRELIMINARY DESIGN OF IGOMA DAM



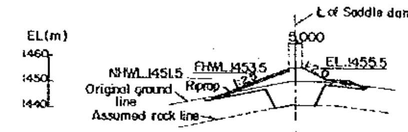
LOCATION MAP



TYPICAL CROSS SECTION

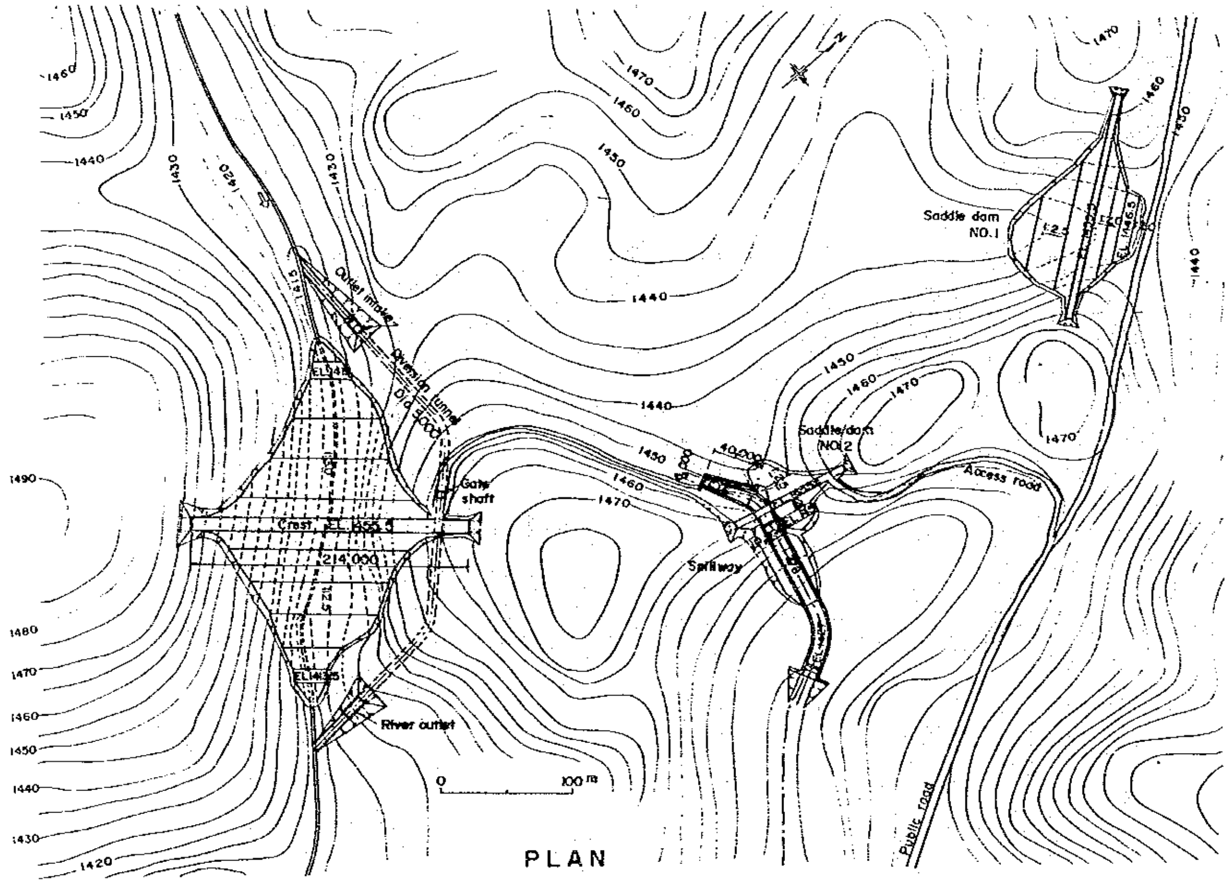


SADDLE DAM NO. 1

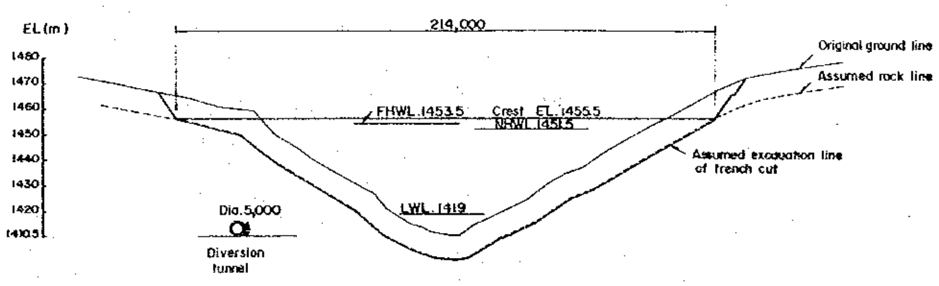


SADDLE DAM NO. 2

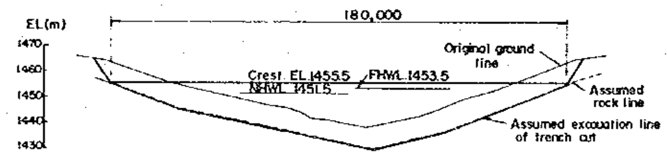
TYPICAL CROSS SECTION OF SADDLE DAMS



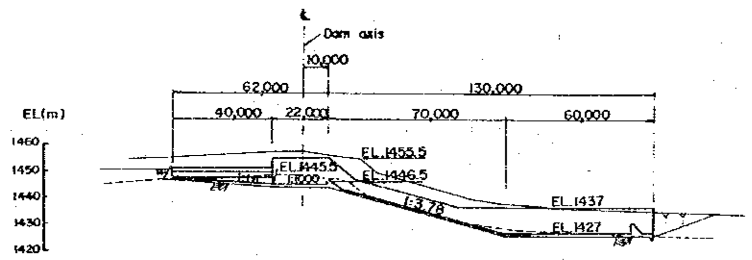
PLAN



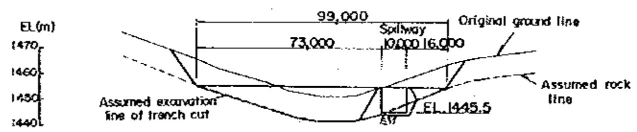
UPSTREAM VIEW OF DAM



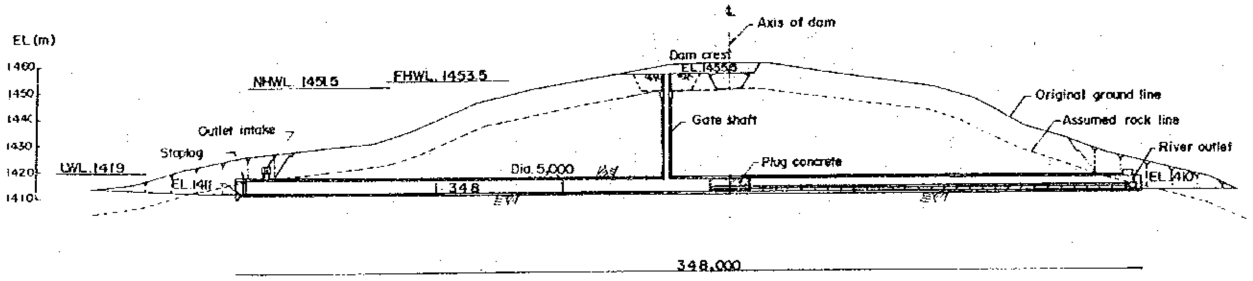
SADDLE DAM NO. 1



PROFILE OF SPILLWAY



SADDLE DAM NO. 2
UPSTREAM VIEW OF SADDLE DAMS



PROFILE OF DIVERSION TUNNEL

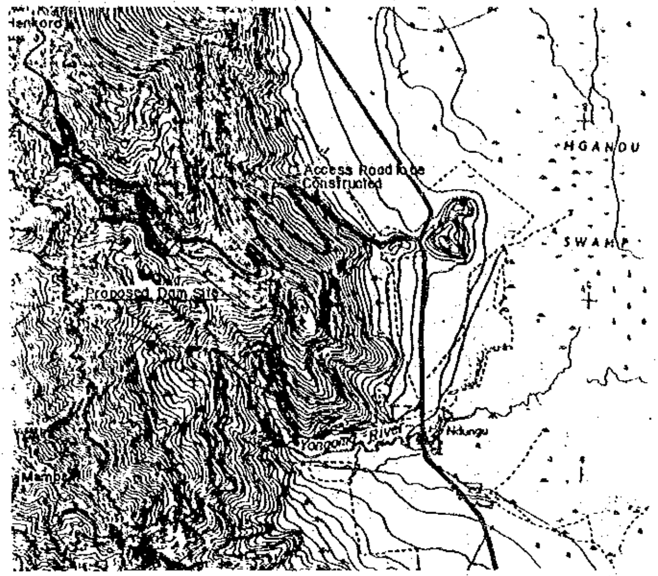
Fig. F-20 PRELIMINARY DESIGN OF HINGILILI DAM

THE UNITED REPUBLIC OF TANZANIA
KILIMANJARO REGION
THE MKOMAZI VALLEY AREA IRRIGATION DEVELOPMENT PROJECT

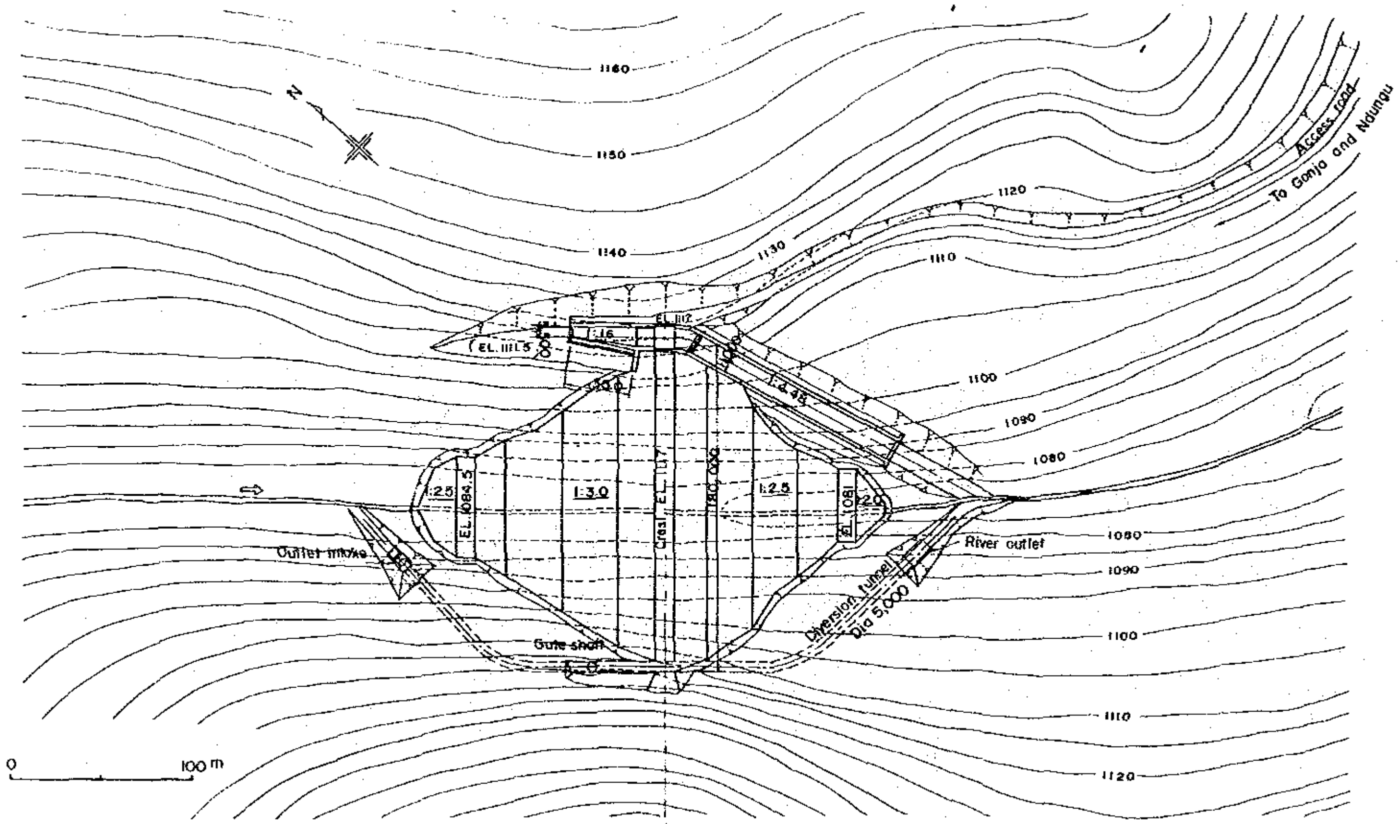
TITLE OF DRAWING
HINGILILI DAM

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO

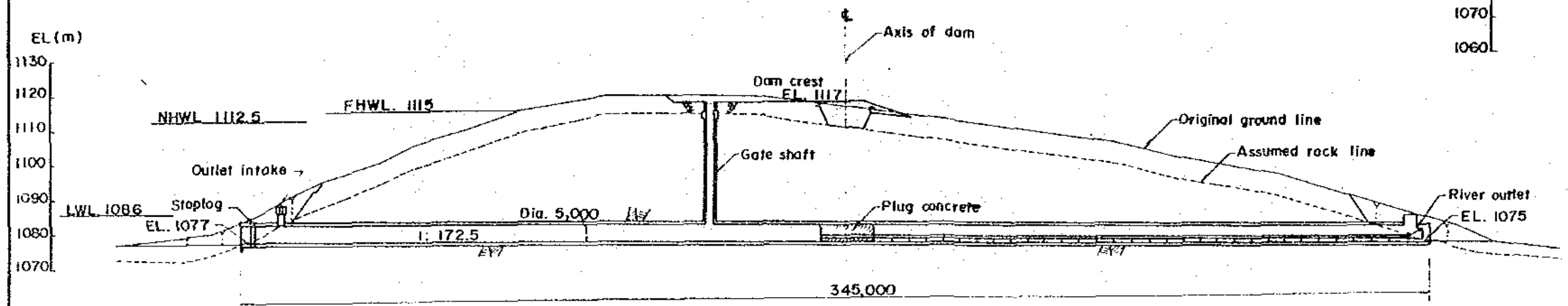
DWG. NO.



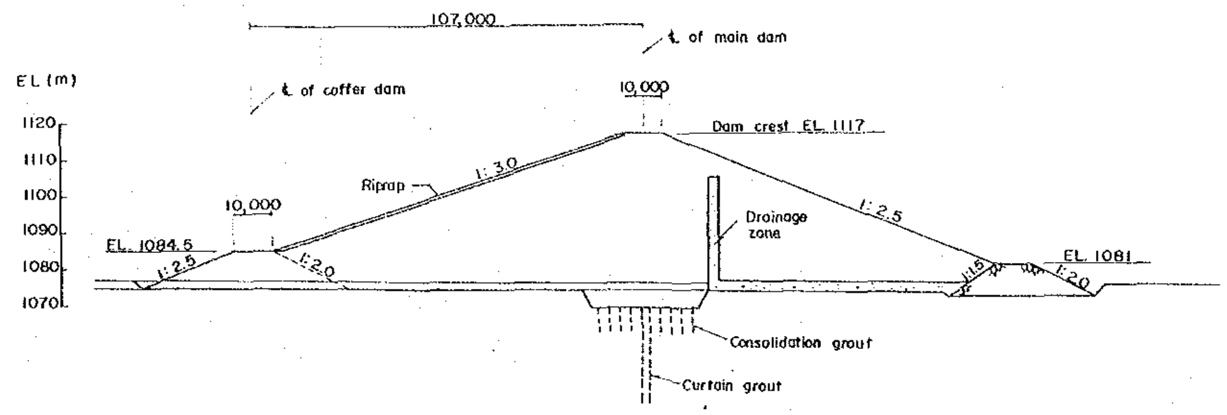
LOCATION MAP



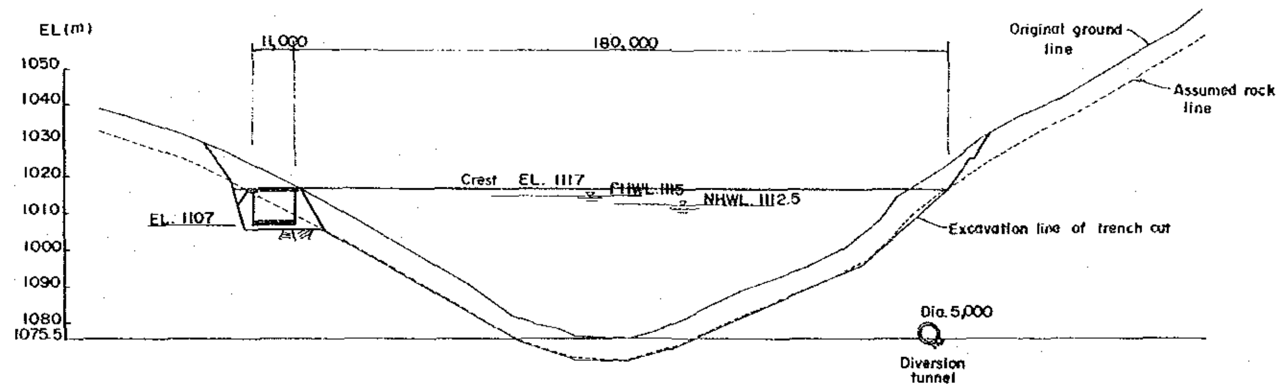
PLAN



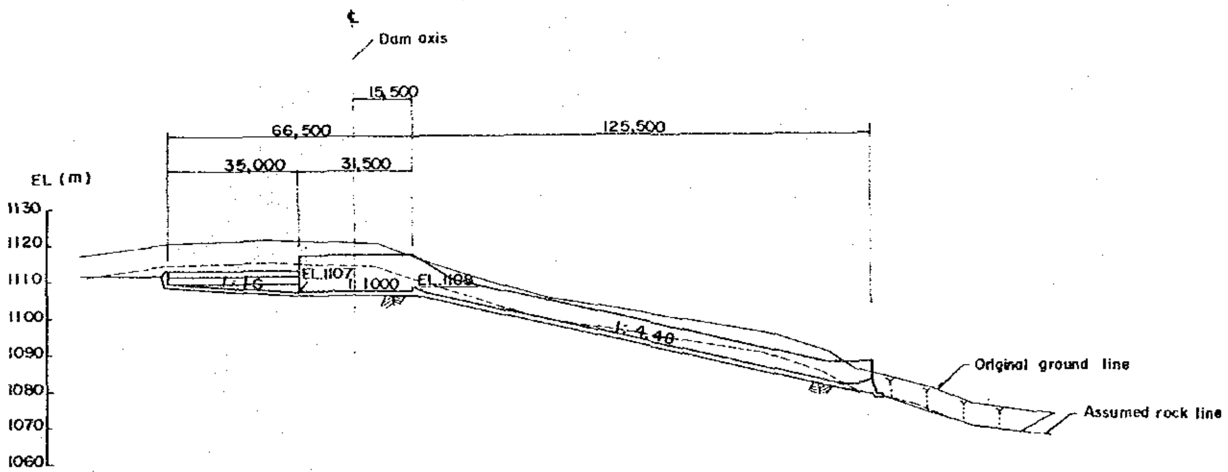
PROFILE OF DIVERSION TUNNEL



TYPICAL CROSS SECTION



UPSTREAM VIEW OF DAM



PROFILE OF SPILLWAY

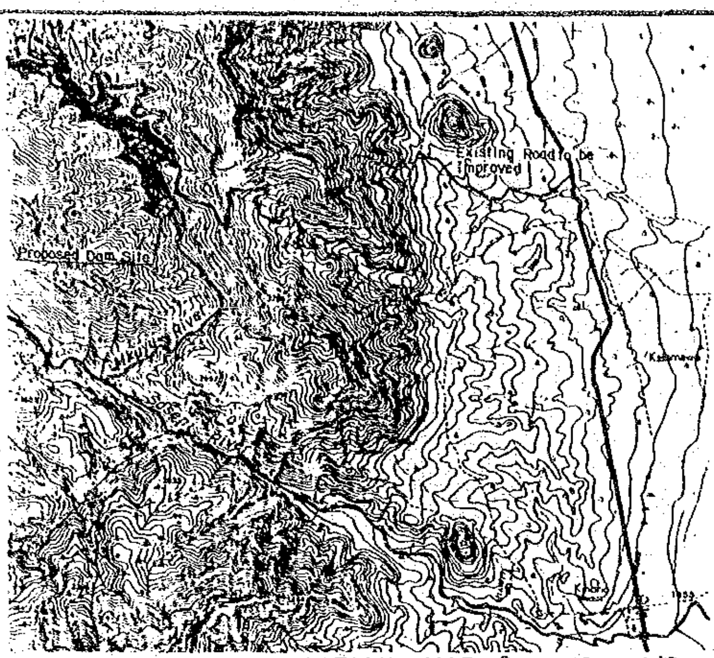
Fig. F-21 PRELIMINARY DESIGN OF YONGOMA DAM

THE UNITED REPUBLIC OF TANZANIA
KILIMANJARO REGION
THE MKOMAZI VALLEY AREA IRRIGATION DEVELOPMENT PROJECT

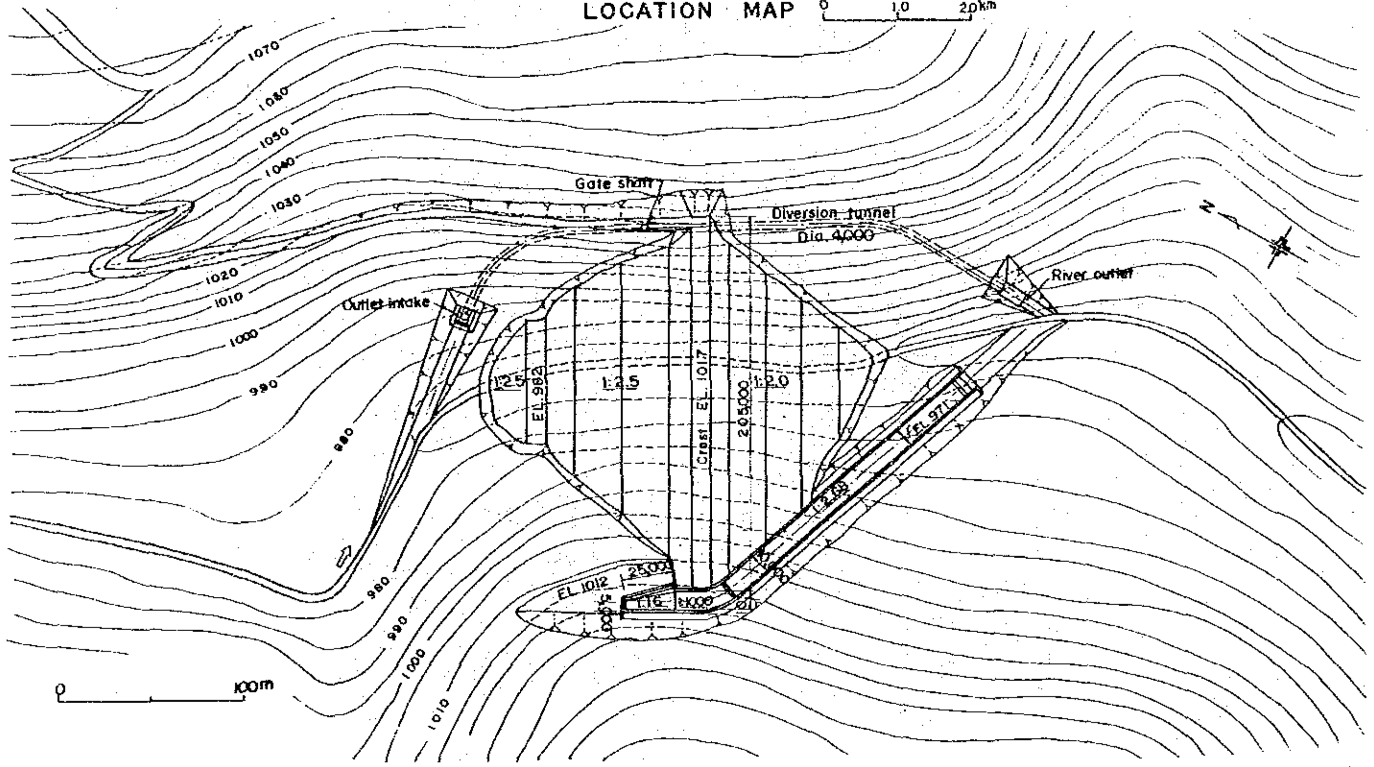
TITLE OF DRAWING
YONGOMA DAM

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO

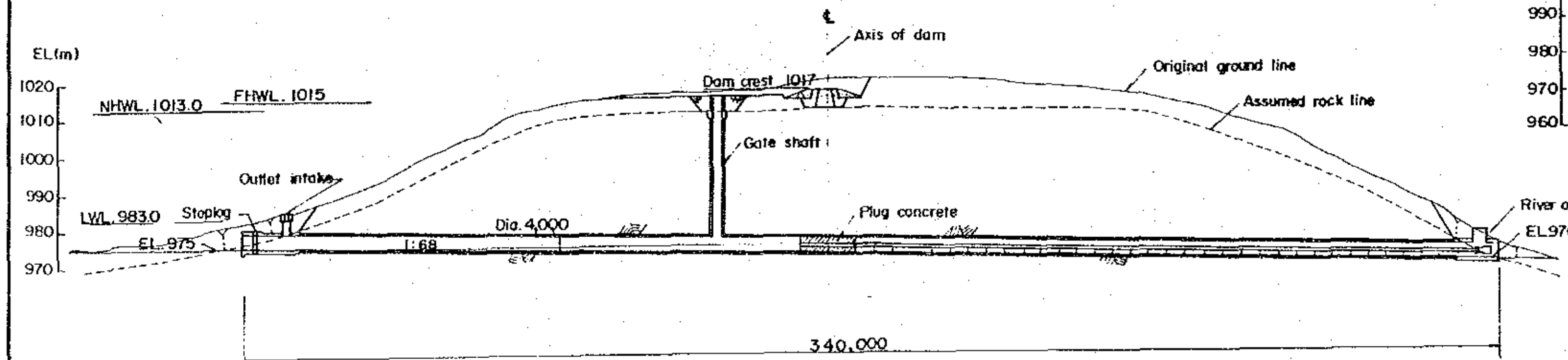
DWG. NO.



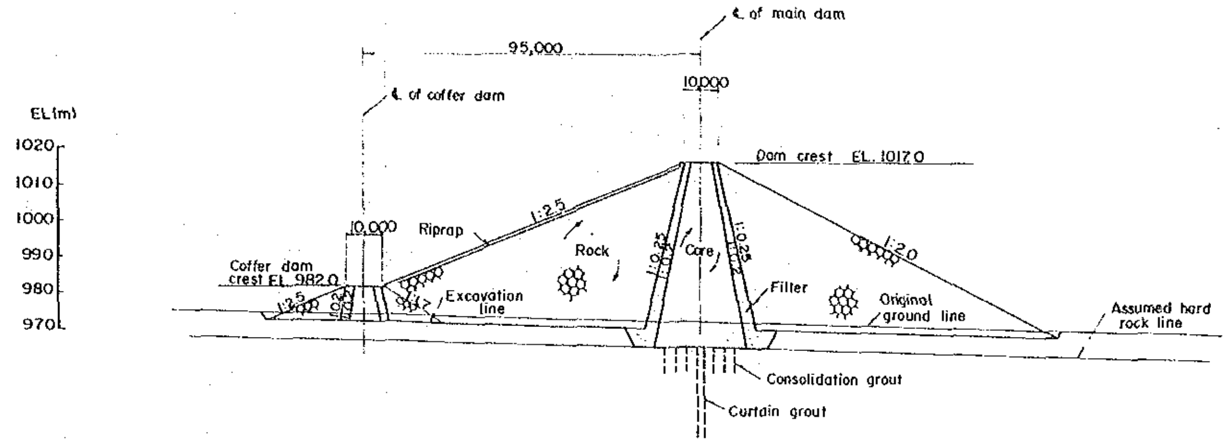
LOCATION MAP



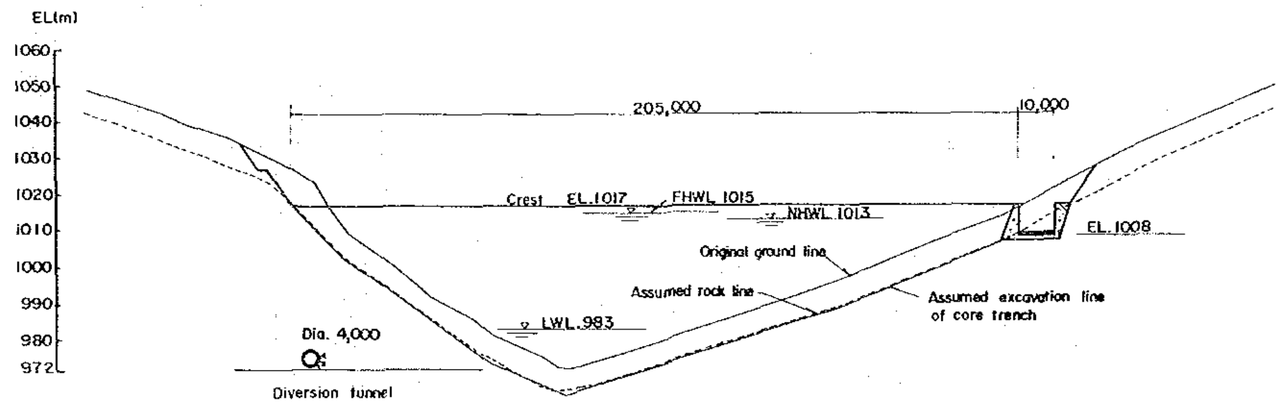
PLAN



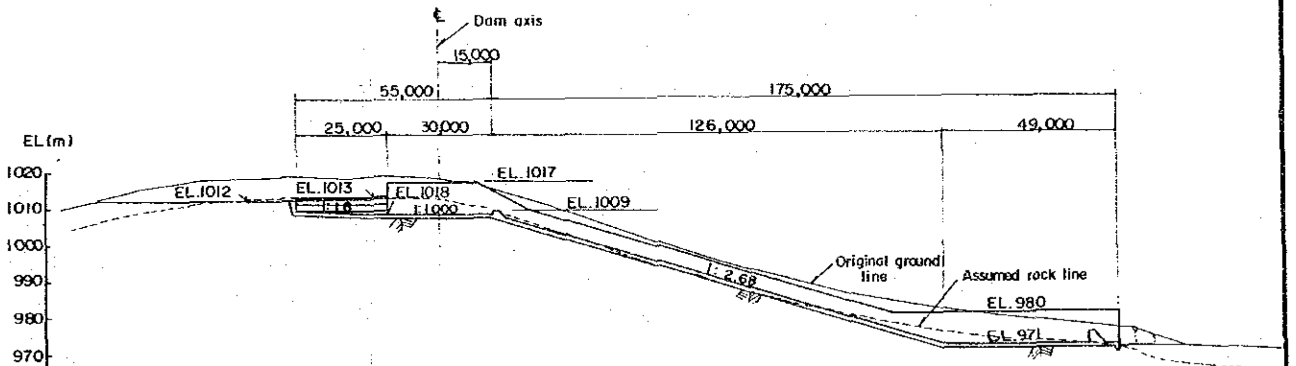
PROFILE OF DIVERSION TUNNEL



TYPICAL CROSS SECTION OF MAIN DAM



UPSTREAM VIEW OF DAM



PROFILE OF SPILLWAY

Fig. F-22 PRELIMINARY DESIGN OF MKUYU DAM

THE UNITED REPUBLIC OF TANZANIA
KILIMANJARO REGION
THE MKOMAZI VALLEY AREA IRRIGATION DEVELOPMENT PROJECT

TITLE OF DRAWING
MKUYU DAM

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO

DWG. NO.

ANNEX G

IRRIGATION AND DRAINAGE

ANNEX G

IRRIGATION AND DRAINAGE

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1. PRESENT CONDITION

1.1 Existing Irrigation System

1.1.1 Irrigation facilities

There exist a large number of small scale irrigation systems on the slope of the South Pare Mountains, in which the Mkomazi Valley area is situated. They have generally small size irrigation canals without permanent intake structures. Such irrigation systems are called "Traditinal furrows".

In the Mkomazi Valley area, nineteen(19) traditional furrows and one storage dam irrigation system are developed along the Mkomazi river and its major tributaries, of the Näkombo, Hingilili, Yongoma and Saseni rivers. In these systems, two(2) sisal estates and one sugar estate are included. The locations of the existing irrigation facilities are shown in Fig.G-1 and features including the estimated irrigation area are listed in Table G-1.

The total existing irrigation area in the Mkomazi Valley area is about 1,200ha, as shown below.

Name of Scheme	Water Source	Irrigation Area (ha)
Kisiwani	Nakombo River	150
Gonja	Bwaya River	15
	Hingilili River	140
	Talanda River	15
Ndungu	Yongoma River	290
Kihurio	Saseni River	340
	Kalimawe Reservoir	220
	Mkomazi River	30
Total		1,200ha

Out of nineteen(19) existing intake structures in the area, six(6) intakes are provided with concrete or stone masonry weirs. The other intakes are ephemeral ones made from banana leaves or logs in the lowlying area and made of boulders with pebblestones in the upper reaches of the major tributaries. All the facilities from the head works to the on-farm facilities constructed by either the Government or farmers themselves are primitive and super-annuated except for a few facilities rehabilitated recently.

Three intake facilities are provided in the Nakombo river originated from the northern slope of the South Pare Mountains. One is for the Kisiwani sisal estate commanding about 27 ha. The second one is of masonry weir for the Mkonga furrow which covers about 60 ha of farm lands in both Kisiwani and Mkonga villages. The above two intakes are located on rather steep sloped reaches of the Nakombo river at about 2 to 3 km upstream from the Same-Tanga road bridge. The last one is of concrete weir located at about 100 m downstream from the Same-Tanga road bridge. Except for a few pipe and concrete box culvert portions, all reaches of the canal are unlined. No related structures such as turnouts, drops and checks, are provided. The total irrigation area of these facilities is estimated at about 150 ha excluding the sisal estate.

In the Bwaya river, there is one traditional furrow intake. The Bwaya river often dries up during the dry season. The irrigation area is estimated at about 15 ha.

The Hingilili river which originates from the eastern slope of the South Pare Mountaines, has perennial flow. Its river course bifurcates at its debouchment and flows down through the reserved forest into the alluvial plain. At the downstream boundary of the forest reserve area, about 1.5 km from the Same-Tanga road bridge, there exists an intake structure "Mariranga weir" which has been reconstructed recently with stone masonry. Its irrigation area is about 100 ha. Other intakes on the Hingilili river are primitive and ephemeral ones made of such natural materials as boulder with pebblestones at upper reaches and banana leaves and logs at lower reaches. The Talanda and the Rika rivers originated from the eastern slope of the South Pare Mountains are non-perennial streams. These flows are used for irrigation of sugarcane in their upstream reaches and paddy or maize in downstream reaches when the river flow is available. The total irrigation area related to the Hingilili river system is about 170 ha.

The Yongoma river which originates from the eastern slope of the South Pare Mountains, possesses two perennial intake structures made of concrete or stone masonry. One is for the sisal estate. Excess water from the factory and tail water of hydropower generation in the sisal estate is used for irrigation of farm land on the left bank of the Yongoma river. The other is a concrete weir constructed for the Ndungu furrow canal (so called "Compensation canal") and for domestic water supply to both the Ndungu and Kalimawe villages. The Compensation canal diverts water to the field near the Kalimawe reservoir. In the plain, two major traditional furrows are diverted from the Yongoma river. These intakes are of non-permanent structures. The total irrigation area fed by water from the Yongoma river system is about 290 ha excluding the irrigation area in the sisal estate which is negligible small.

The Saseni river is the biggest tributary of the Mkomazi river, running from the South Pare Mountains. Parennial flow of the Saseni river is diverted into several traditional furrows through non-permanent intakes. The irrigation area fed by the Saseni river is about 340 ha in total.

The Kalimawe dam which was constructed on the Mkomazi river, has one irrigation system maintained under the control of the Regional Water Office, Ministry of Water and Energy. Water storaged in the Kalimawe reservoir is used for irrigation. The irrigation area commanded by the reservoir is about 220 ha in total, of which 180 ha are commanded by the "High Level Canal" and 40 ha by the "Low Level Canal".

In the downstream of the Lake Manka, there is a traditional furrow taking water from the Mkomazi river and its irrigable area is about 30 ha of the lowlaying area along the Mkomazi river.

The existing irrigation canals in the Mkomazi Valley area are all unlined. Most of the existing canals meander according to the topography and some of them are shapeless. A length of 11.5 km is located at the eastern boundary of the envisaged Kihurio scheme area and provided with 1 measuring device, 15 turnouts, 7 culverts, 3 syphons and 7 drops. Its lower end is connected with the Mkomazi river at just upstream of the Same-Tanga road bridge. Most of the other existing canals are entirely lacking of or very poorly provided with such canal structures as diversion structure, drainage crossing, syphons or culverts, etc. Due to the lack of canal lining and structures, these canals do not function fully and are often damaged by floods. No on-farm facilities are provided in the areas at present.

1.1.2 Irrigation practice

No systematic nor proper irrigation operations are being made in the project area at present. In case of the Kalimawe dam, irrigation water is diverted to the High Level Canal by the site operator of the dam at the request of farmers, but it is not controlled afterwards particularly at the distribution gates in the canal. In the other irrigation systems, irrigation water is taken without any control. During the low flow period, rotational irrigation practices are applied for distribution of water under the arrangement of the village council. No water charge is collected from the farmers at present.

As for on-farm irrigation practices, the flood irrigation method is prevalent but inefficient due to the unsuitable cultivation method adopted and the topographical condition of the land. The upland field is customarily ploughed by tractor and planted with crops without any harrowing and ridging. Accordingly the ground surface is so rough that no effective irrigation method seems to be applicable.

In addition, there are small undulations of the ground surface formed in the old river courses and alluvial deposit. Due to the undelations, certain areas are often either non-irrigated or over-irrigated, resulting in inefficient irrigation supply.

1.2 Water Right

The Water Utilization (control and regulation) Act was enacted in 1974 and then supplemented by a subsidiary legislation in the Government Notice No. 242 published in October, 1975. It has been mentioned in the Notice that four(4) rivers, i.e., Nakombo, Hingilili, Yongoma and Saseni, have been identified as the major water resources in the country. As regards these water sources, the control and regulation of the water utilization are dealt at the national level.

Granted water rights for irrigation schemes in the Mkomazi Valley area total about 0.34 m^3/sec (12 cusec) for the above four(4) irrigation schemes including about 0.06 m^3/sec (2 cusec) for the Gonja sugar estate which is not utilized at present. The other irrigation systems including all traditional furrows have no legitimate water right.

On the other hand, about 0.28 m^3/sec (10 cusec) is granted to 2 sisal estates and 0.03 m^3/sec (1 cusec) in total is for domestic use in the valley. Each water right is shown in Table G-2.

1.3 Drainage Conditions

The Mkomazi river is a main drain in the Mkomazi Valley area. Its river profile is shown in Fig. G-2. Two major swampy areas are formed along the Mkomazi river. One is in the Kihurio scheme area surrounding Lake Manka. The other is in lowlying areas upstream of the existing Kalimawe reservoir.

The former phenomenon results from clogging with sediment materials transported from both the Saseni river originating in the South Pare Mountains and the other rivers originated from the Usambara Mountains. The latter also is caused by sediment materials from such rivers originated from the South Pare Mountains as the Hingilili, Yongoma, Talanda and Rika, and may be under the influence of backwater of the Kalimawe reservoir.

In addition to these swampy areas, a certain extent of paddy field developed in the alluvial depression along the lower reaches of such rivers originated in the South Pare Mountains as the Nakombo, Hingilili, and Yongoma, suffers from seasonal inundation due to the lack of drainage facilities. The existing irrigation systems in the Mkomazi Valley area, excepting two systems, i.e. Kalimawe and Kisiwani, are not provided with intake gates to control water flowing into the canals or furrows. Such poor irrigation facilities often result in inundating the existing field during the flood period.

The river courses of all tributaries originated in the South Pare Mountains, except the Nakombo river, are getting narrower and shallower in the downstream after branching off into several traditional furrows, and finally flow into swamp areas. The Nakombo river forms rather a deep river course in its upper reach, surrounding the existing weir site at 100 m downstream from the Same-Tanga road bridge, then it becomes shallow in the downstream where sometimes the runoff overflows into the surrounding cultivated lands.

There exist no drainage facilities in the Mkomazi Valley area except the Kalimawe dam. The Kalimawe dam was constructed as a flood control dam and peak flood of the Kambaga river is effectively controlled by the dam. However, on the sloped areas between the Ndungu scheme and Kihurio scheme, no proper control is expected for flooding due to sheets of rain.

2. WATER RESOURCES DEVELOPMENT

2.1 Water Sources and Potential Irrigation Scheme

The water sources for irrigation in the Mkomazi Valley area are the four tributaries of the Mkomazi river, i.e. the Nakombo, the Hingilili, the Yongoma and the Saseni, and the existing Kalimawe dam. The annual mean runoff of each river for the period from 1963 to 1982 is estimated at $25x10^6m^3$ of the Nakombo, $39x10^6m3$ of the Hingilili, $37x10^6m^3$ of the Yongoma and $66x10^6m3$ of the Saseni through the hydrological analysis (See ANNEX A). The Kalimawe dam has a storage capacity of $5.5x10^6m^3$. The mean annual runoff at the dam is estimated at $166x10^6m^3$. There is no possibility of groundwater development in the Mkomazi Valley area.

Taking such factors as topography, present land use and land suitability classification, the potential irrigation schemes are preliminarily determined at 5,160 ha in total, which consist of 360 ha of the Kisiwani, 1,200 ha of the Gonja, 1,180 ha of the Ndungu, 1,670 ha of the Kihurio and 750 ha of the Igoma. These schemes are independently located along the Mkomazi river.

2.2. Irrigation Water Requirement

2.2.1 General

Based on the proposed cropping pattern as shown in Fig. G-3, the irrigation water requirement is estimated on a semi-monthly basis using monthly climatic data and daily rainfall data. The irrigation water requirements are estimated by the following procedure:

Paddy

- Estimate consumption by crop (Cu) by the product of potential evapotranspiration calculated by climatic data and crop coefficients varying with growth stage of paddy

- Estimate percolation water (Pr)

- Estimate water requirements for nursery period (Nw) and puddling works (Pw) and then, calculate total water demand (Dw)

$$DW = Cu + Pr + Nw + Pw$$

- Estimate effective rainfall (Er) by daily water balance method

- Estimate net irrigation water requirement (Nr)

$$Nr = Dw - Er$$

- Estimate diversion water requirement or gross irrigation water requirement (Gr) dividing Nr by overall irrigation efficiency

Upland crops

- Estimate consumptive use by crop (Cu) by same method as for paddy

- Estimate effective rainfall (Er) and pre-irrigation water requirement (Pi) by daily soil moisture balance method

- Estimate net irrigation water requirement (Nr)

$$Nr = Cu + Pi - Er$$

- Estimate diversion water requirement or gross irrigation water requirement (Gr) dividing Nr by overall irrigation efficiency.

2.2.2 Potential evapotranspiration

Consumption by crops is estimated based on the potential evapotranspiration (ETo) calculated from climatic data and crop coefficient (Kc) relating crop growth stages. The climatic data necessary for estimating the potential evapotranspiration in the Mkomazi Valley area are available at Kalimawe meteorological station. Based on the available climatic data, potential evapotranspiration is calculated applying four methods in FAO's Irrigation and Drainage Paper 24, Crop Water Requirements, revised in 1977. The results are shown below together with average pan-evaporation observed.

Unit: mm/day

Month	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Class-A Pan	6.4	6.6	6.3	5.7	5.5	5.8	5.6	5.5	5.7	6.1	6.0	6.1	5.9
Modified Blaney-Criddle Method	5.6	5.7	5.7	5.2	5.8	4.8	5.4	4.5	4.8	5.3	5.6	5.6	5.3
Radiation Method	6.0	6.2	5.5	4.6	4.6	3.9	4.3	4.2	4.5	6.5	6.0	6.0	5.2
Pan evaporation Method	4.9	5.1	4.9	4.4	4.0	4.2	4.0	4.2	4.4	4.7	4.6	4.7	4.5
Modified Penman Method	6.6	6.8	6.2	5.4	5.0	4.7	4.9	4.9	5.3	6.4	6.6	6.6	5.8

There are no distinct differences between them. The modified Penman method is generally accepted as the most accurate prediction method. Accordingly, the potential evapotranspiration estimated by the modified Penman method is used for estimation of the irrigation water requirements.

2.2.3. Crop coefficient and consumptive use of water

In determination of crop coefficients for the proposed crops, the crop coefficient curve shown in Fig. G-4, which were established for the Lower Moshi Irrigation Project based on the FAO's publication, is applied.

The average crop coefficient of crops are estimated for the respective growing stages as follows:

Growing Stage (%)	5	15	25	35	45	55	65	75	85	95
Paddy	1.07	1.10	1.13	1.18	1.24	1.27	1.27	1.23	1.15	1.05
Maize	0.34	0.42	0.59	0.83	1.03	1.11	1.13	1.07	0.92	0.70
Beans	0.35	0.38	0.45	0.57	0.75	0.88	0.98	1.04	1.02	0.92

The consumptive use by each crop is calculated by multiplying potential evapotranspiration by crop coefficient.

2.2.4. Percolation and other water demand

(1) Percolation

Field measurements of the percolation rate in the existing paddy field began in the middle of December, 1982, just before the end of first field survey period of the JICA survey team and finished by the Tanzanian counterpart. Judging from the results studied during inceptive period and soil conditions in the project area, the percolation rates in the paddy field in the Mkomazi Valley area are similar to those in the Lower Moshi Project area where percolation rates of 1 mm/day and 2 mm/day are adopted for the respective rainy and dry season paddy cultivation. Accordingly, the percolation rates of 1.0 mm/day in the rainy season and 2.0 m/day in the dry season are applied for the project.

(2) Puddling water requirement

The puddling water to be supplied before transplanting consists of water equivalent to the difference in soil moisture before and after the puddling, the standing water required above the soil surface and evaporation and percolation losses from paddy field during the field preparation after water supply.

The amount of puddling water is assumed as follows:

(a) Depth of soil and porosity
    Surface soil : 20 cm, 50%
    Sub soil : 10 cm, 50%
(b) Vapour phase in soil after puddling: 5%
(c) Soil moisture before water supply : 15%
(d) Water to be supplied to soil profile
    300 x (0.5 - 0.050 - 0.15) = 90 mm
(e) Standing water depth 40 mm
(f) Evaporation and percolation

Evaporations from non-crop land before water supply and after water supply are estimated based on the method of FAO's publication. Percolation is to be estimated with same rate as mentioned above. Daily rates of these evaporation and percolation in respective month are shown below:

Unit: mm/day

	J	F	M	A	M	J	J	A	S	O	N	D
Non-crop land before water supply	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2
Non-crop land after water supply	7.6	7.7	7.0	6.1	5.7	5.3	5.5	5.6	6.0	7.3	7.5	7.5
Percolation	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0

Although the puddling water requirement varies from place to place and season by season depending on the evaporation from open water surface and percolation, the maximum requirement for puddling works during 5 days is estimated at 180 mm as follows:

Water to be supplied to soil profile	90 mm
Standing water depth after puddling	40 mm
Evaporation 8 mm/day x 5 days =	40 mm
Percolation 2 mm/day x 5 days =	10 mm
Total	180 mm

(3) Nursery-water requirement

The nursery water requirements consist of water needed for preparation of nursery bed, and evapotranspiration and percolation during the nursery period. The water requirement estimated for a nursery period of 25 days is, then, increased by 50% for horizontal percolation allowances.

The nursery water requirement varies depending on the evapotranspiration and percolation rate during the nursery period. The gross requirement will as follows:

Preparation of nursery bed	130 mm
Evapotranspiration (Maximum in February)	
1.10 x 6.8 mm/day x 25 days =	187 mm
Percolation during nursery period	
2.0 mm/day x 25 days =	50 mm
Total	367 mm
Add 50% for allowance	183 mm
Total	550 mm

The area of nursery bed is 1/20 of paddy field.

A total water demand of each crop is calculated as shown in Table G-3.

2.2.5. Effective rainfall and net water requirement

The effective rainfall for paddy and upland crops is calculated based on the daily rainfall data at the Kalimawe meteorological station by daily water depth balance method on the paddy field and daily soil moisture balance method on the upland field, under the following conditions.

Paddy

- Daily rainfall less than 5 mm is considered ineffective,
- When water depth in paddy field is drawn down to 25 mm, irrigation water is supplied until water depth reached to 60 mm,

- The water storage capacity (maximum water depth) is 100 mm, and

- Daily rate of percolation and consumptive use is employed for water consumption in paddy field, while daily rate of nursery water requirement is used in nursery bed.

Upland crops in paddy field

- Daily rainfall less than 5 mm is considered ineffective

- Water holding capacity (field capacity) in the soil profile is 80 mm

- Irrigation of 40 mm is supplied when the soil profile has dried up to 40 mm.

- Daily rate of crop consumptive use is employed for water consumption from the soil profile

After deduction of effective rainfall from total water demand of each crop, net irrigation water requirement is estimated on a semi-monthly basis.

Estimated effective rainfall and net irrigation water requirements are shown on Table G-4 and G-5.

2.2.6 Irrigation efficiency and diversion water requirement

In the paddy field, where flood irrigation method is practiced, the application loss is to be estimated as low as about 5% in due consideration of surface runoff to drains during the water supply, so that the application efficiency of 95% is employed for paddy. At present, border irrigation method or furrow irrigation are usually applied for upland crops. The application efficiency of 70% is adopted for these irrigation methods.

The main and secondary canals are proposed to be lined with concrete to save conveyance losses, and the water control facilities such as intake gates, turnouts and check structures are to be provided. The conveyance efficiency of 90% and operation efficiency of 85% are adopted for estimation of irrigation requirement.

The overall irrigation efficiency are estimated as summarized below:

Unit: %

	Paddy	Upland Crops
Application efficiency	95	70
Operation efficiency	85	85
Conveyance efficiency	90	90
Overall irrigation efficiency	72	53

The gross irrigation water requirement is calculated by dividing the net water requirement by the overall irrigation efficiency. Thus, the gross irrigation water requirement of dry season paddy and rainy season paddy is estimated 1,200 mm and 1,040 mm in total depth respectively.

2.2.7 Peak diversion requirement and design water requirement

Peak diversion water requirements for respective crops are estimated as follows:

	Half monthly basis	Monthly basis
rainy season paddy	1.36 ℓ/sec/ha	1.33 ℓ/sec/ha
dry season paddy	1.60 ℓ/sec/ha	1.47 ℓ/sec/ha
dry season maize	1.59 ℓ/sec/ha	1.39 ℓ/sec/ha

The design water requirement for the irrigation system facilities is to be employed from the peak diversion requirement of the dry season paddy of 1.60ℓ/sec/ha.

2.3 Water Balance Study

2.3.1 Optimization of cropping pattern

The irrigation area, particularly that in the dry season, is largely affected by the fluctuation of natural flow. Further, the seasonal patterns of the riverflow do not always coincide with seasonal rainfall patterns in the irrigation area.

In due of such hydrological consideration, the irrigation area which can be irrigated by the riverflow is assessed by means of the water balance between the available water and the series of irrigation water requirement during the observation period. As studied in ANNEX A, the estimated riverflows of the Nakombo, Hingilili, Yongoma and Saseni and estimated inflow to the Kalimawe reservoir are quantitied for 20 years from 1963 to 1982. On the other hand, the unit diversion water requirement for paddy is estimated during the above observation period as shown on Table G-6.

In the course of the above water balance study, the cropping pattern of paddy is assessed in view point of the maximum utilization of available surface water. The irrigable areas with different cropping pattern are estimated, and relationship between cropping season and irrigable area with the dependability of 80% is shown of Figures G-5 and G-6. Taking into account the results of water balance and agricultural conditions, proposed cropping pattern are determined as shown in Figure G-3.

2.3.2 Water balance study

In order to determine the optimum development scale of the project, a water balance study is made on the basis of the monthly runoff for the period from 1963 to 1982 and the irrigation water demand.

The balance study is made for two cases, i.e. i) irrigation development without construction of new storage dam (Case-1) and ii) irrigation development with construction of new storage dam (Case-2). In Case-1 the Igoma scheme is not considered, because dependable discharge even in the rainy season cannot be exploited from the Kambaga river without construction of the storage dam. The results of the study are shown in Table G-7 and below. (See ANNEX F)

Case-1: Without Construction of New Storage Dam

Irrigation Scheme	Dam	Effective Storage Capacity ($10^6 m^3$)	Irrigable Area			Irrigation Water Req. ($10^6 m^3$)
			Dry Season (ha)	Rainy Season (ha)	Total (ha)	
Kisiwani	-	-	180	360	540	5.9
Gonja	-	-	300	600	900	9.8
Ndungu	-	-	230	680	910	9.8
Kihurio	-	-	180	930	1,110	11.8
Kihurio	Kalimawe	5.5	440	740	1,180	13.0
Total		5.5	1,330	3,310	4,640	50.3

Case-2: With Construction of New Storage Dam

Irrigation Scheme	Dam	Effective Storage Capacity ($10^6 m^3$)	Irrigable Area			Irrigation Water Req. ($10^6 m^3$)
			Dry Season (ha)	Rainy Season (ha)	Total (ha)	
Kisiwani	-	-	180	360	540	5.9
Gonja	Hingilili	7.8	800	1,200	2,000	22.1
Ndungu	Yongoma	8.5	770	1,180	1,950	21.5
Kihurio	Mkuyu	7.7	1,140	1,140	2,280	25.5
Kihurio	Kalimawe	5.5	530	530	1,060	11.9
Igoma	Igoma	39.4	750	750	1,500	16.8
Total		68.9	4,170	5,160	9,330	103.7

Since the annual runoff from the entire catchment area is estimated 234 x 10^6 m^3 in ANNEX A, the ratio of irrigation water requirement to annual runoff in Case-1 and Case-2 is calculated 21% and 44% respectively. The utilization of water resource is considerably heightened by storage dams.

2.4 Optimization of Development Scale

2.4.1 Economic comparison

(1) Economic cost

The following economic cost is used for economic comparison of two cases mentioned above.

Unit: TSh.x10^6

Scheme	Case - 1 Without Construction of New Storage Dam	Case - 2 With Construction of New Storage Dam
Kisiwani	27	27
Gonja	47	230
Ndungu	46	227
Kihurio	109	302
Igoma	-	120
Total	229	879

The preliminary construction cost of each case is estimated as shown in Table G-8.

(2) Benefit

The total benefit at full development stage is roughly estimated as shown in Tables G-9, G-10, and G-11 and summarized below.

Unit: TSh.x10^3/year

Scheme	Without Project	Case-1		Case-2	
		With Project	Incremental Benefit	With Project	Incremental Benefit
Kisiwani	1,910	10,350	8,440	10,350	8,440
Gonja	3,160	20,580	17,420	35,990	32,830
Ndungu	3,240	21,230	17,990	35,260	32,020
Kihurio	6,840	46,460	39,620	54,160	47,320
Igoma	40	-	-	24,740	24,700
Total	15,190	98,620	83,470	160,500	145,310

(3) Economic comparison

For the same cases as studied in sub-section 2.3.2, the economic viability are examined in terms of internal rate of return (IRR).

The calculated IRR are shown below.

Irrigation Scheme	Case-1 IRR (%)	Case-2 IRR (%)	Case-2 IRR 1/ (%)
Kisiwani	17.3	17.3	-
Gonja	20.2	16.3	8.2
Ndungu	20.3	11.3	8.4
Kihurio	21.6	11.1	5.2
Igoma	-	12.1	12.1

1/ = Against the incremental irrigable area by the construction of the storage dam.

The above economic study shows that the economic viabilities of the Gonja, Ndungu and Kihurio Schemes are lowered to the less feasible ranges if the irrigable areas are extended by constructing the storage dams. However, the extension of irrigable area through the construction of the storage dams would be justified, if the following secondary benefits induced by the construction of storage dams and social benefits are counted in the economic evaluation:

(1) hydro-erectric power benefit

(2) fishery benefit,

(3) more resettlement chance for the farmers living in the mountainous areas, and

(4) increase of recreational opportunities in the valley.

The Igoma scheme in Case-2 shows to provide the highest economic viabilty as well as increment of new development area.

2.4.2 Assessment of overall development plan

In order to establish the most economical overall development plan in the valley, alternative studies are made for the following three cases:

Alternative-1 : Overall development with provision of all the newly proposed storage dams.
Alternative-2 : Overall development with provision of the Igoma storage dam
Alternative-3 : Overall development without provision of any dams

For the above alternative cases, the economic viability are examined also in terms of IRR as shown in the following table.

Alternative	Irrigable Area Dry Season (ha)	Rainy Season (ha)	Total (ha)	Economic construction cost * (10^6TSh.)	IRR (%)
1	4,170	5,160	9,330	1,168	11.9
2	2,080	4,060	6,140	540	18.0
3	1,330	3,310	4,640	368	20.1

*: Ref. Table G-8

Alternative-1 has the advantage of its large annual irrigable area, but the economic viability is low and it is judged that its earlier implementation is not economical. The economic viability of Alternative-3 is the highest among three alternatives, but its social impact is lower than Alternative-2, because of no development of the new agricultural land. Alternative-2 develops the new agricultural land of 750 ha through construction of the Igoma storage dam and gives much social impacts such as provision of more resettlement area to farmers in the mountainous area and increase of employment opportunities to people in the area. Thus, Alternative-2 is recommendable for the project.

In conjunction with the Alternative-2 development plan, a further alternative study is made to determine the optimum reheightening of the existing Kalimawe dam in view of the most effective use of the Mkomazi river discharge which is regulated by the Igoma reservoir. The alternative study is made for the following three cases.

Alternative 2-1 : Present (full water level = EL. 504.70 m)

Alternative 2-2 : The full water level is changed from present EL. 504.7 m to EL. 505.3 m.

Alternative 2-3 : The full water level is changed from present EL. 504.7 m to EL. 505.9 m

The relationship between irrigation area and the effective storage requirement is obtained as shown in Fig. F-7 by means of reservois operation study described in ANNEX F.

The cost of reheightening and the benefit by means of its are estimated us shown in Table G-12, G-13, G-14, G-15 and G-16. The results of the economic comparison are as follows:

Alternative	Full Water Level (El.m)	Effective Storage Capacity (10^6m^3)	Dry Season (ha)	Rainy Season (ha)	Total (ha)	IRR (%)
2-1	504.7	5.5	2.080	4,060	6,140	18.0
2-2	505.3	8.0	2,380	4,060	6,440	18.7
2-3	505.9	14.9	2,780	4,060	6,840	19.0

The above Table shows that the Alternative 2-3 gives higher economic return and more irrigable area in the dry season than others. Then, the higher priority is given to the Alternative 2-3.

The following definite plan is selected based on the above comparative studies.

- Construction of the Igoma storage dam for development of the new agricultural land of 750 ha.

- Reheightening of the existing Kalmawe dam for 1.2 m to give the storage capacity of $14.9 \times 10^6 m^3$.

3. IRRIGATION AND DRAINAGE PLAN

3.1 Irrigation Plan

3.1.1 Irrigation development area

The irrigation area of each scheme is delineated as shown below, taking such factors as topography, present land use, land suitability classification and available water for irrigation into consideration.

Unit: ha

Scheme	Irrigation Area
Kisiwani	360
Gonja	1,040
Ndungu	940
Kihurio	1,670
Igoma	750

According to the results of water balance study, the exploited water resources limit the irrigation area for the Gonja scheme to 600 ha and for the Ndungu scheme to 680 ha. In order to fairly and effectively use the limited water, a rotational irrigation method on annual basis is introduced to both the Gonja and Ndungu schemes.

3.1.2 Irrigation canal system

Irrigation canal system in each scheme consists of main canals, secondary canals and tertiary systems. The layout planning of these canals in each scheme is made by use of 1/5,000 topographic map except Igoma scheme where no topographic map is available. The proposed canal system is shown in Figures G-8 and G-9.

(1) Kisiwani scheme

The Kisiwani scheme has a total of 360 ha. The irrigation water to the scheme is taken off by two diversion weirs on the Nakombo river, i.e. the Nakombo weir and the Kisiwani weir.

The Nakombo weir is newly constructed at the debouching point of the Nakombo river. The weir covers the area of 205 ha which extends on the left bank of the Nakombo river. The Nakombo main canal of 3.6 km branches off from the weir, and delivers the irrigation water of 0.29 m^3/sec in maximum.

The Kisiwani weir which exists 200 m downstream from the Same-Tanga road bridge, is improved under the Project. The weir commands the area of 128 ha on the left bank of the Nakombo river and the area of 27 ha on the right bank, respectively. The Kisiwani main canal of 1.4 km branches off from the weir and supplies the water of 0.21 m^3/sec in maximum. One secondary canal branches off from the weir to irrigate the area of 27 ha.

(2) Gonja scheme

The Gonja scheme has a total land of 1,040 ha. The Hingilili is the water source of the scheme. The irrigation area is limited to only 600 ha, because of available water shortage. Then, the rotational irrigation on annual basis is made for the area.

The proposed Hingilili diversion weir is constructed at the existing Maore weir site, 700 m upstream from the Same-Tanga road crossing point. The irrigation water 0.82 m^3/sec. is taken off from the intake structure provided at the left side of the weir and delivered to the service area through the Hingilili main canal of 7.6 km.

(3) Ndungu scheme

The proposed Yongoma diversion weir is provided at the debouching point of the Yongoma river. The irrigation water of 0.93 m^3/sec in maximum is taken off by the intake structure provided at the right side of the weir and supplied to the service area through the Yongoma main canal. The Yongoma main canal starts from the weir and is bifurcated into two main canals 1.4 km downstream, i.e. the Yongoma right main canal and the Yongoma left main canal. The Yongoma right main canal of 3.0 km long covers the service area of 427 ha, while the Yongoma left main canal of 3.5 km long commands the service area of 513 ha. The Yongoma right main canal is constructed by means of the rehabilitation of the existing Ndungu furrow irrigation canal.

The secondary canal is branched off from the above main canals to deliver irrigation water to a secondary block.

A tertiary block is commanded by a tertiary canal and several quartenary canals. The acreage of one tertiary unit varies from 6 ha to 29 ha.

(4) Kihurio scheme

The Khurio scheme has a total land of 1,670 ha and is irrigated from the two water sources, i.e. the Saseni river and the Kalimawe dam.

A new diversion weir is proposed at the debouching point of the Saseni river. The proposed Saseni weir commands the service area of 930 ha and has two intake structures at both sides. The Saseni left main canal with a total length of 4.5 km irrigates the service area of 214 ha which extends on the left bank of the Saseni river. The Saseni right main canal with a total length of 5 km commands the service area of 716 ha which extends on the right bank of the Saseni river. The service area of 400 ha out of 716 ha is irrigated by the water from the Kalimawe dam in the dry season.

In order to extend the irrigation service area fed by the existing Kalimawe dam, the dam is improved by means of heightening its crest under the Project. The improved dam commands the service area of 740 ha in the rainy season, while 1,140 ha in the dry season including the service area of 400 ha commanded by the Saseni weir. The irrigation water of 1.82 m^3/sec in maximum is taken from the Kalimawe right main canal and delivered to the service area by both the Kalimawe right main canal and left main canal. The Kalimawe right main canal with a total length of 2.8 km commands the service area of 210 ha in the rainy season, while 610 ha including 400 ha of the service area fed by the Saseni weir in the dry season. The Kalimawe left main canal with a total length of 4.8 km serves the area of 530 ha extended on the left bank of the Mkomazi river.

The secondary canal is branched off from the those four main canals to supply irrigation water to a secondary block.

A tertiary block is commanded by one tertiary canal and several quarternaries. The acreage of one tertiary unit ranges from 2 ha to 47 ha.

(5) Igoma scheme

A new diversion weir is proposed 1.5 km downstream from the proposed Igoma storage dam. The irrigation water exploited by the Igoma storage dam is taken by the weir to both side, 0.58 m^3/sec to left side and 0.62 m^3/sec to right side. The Igoma left main canal with a total length of 4.3 km irrigates the area of 365 ha which extends on the left bank of the Mkomazi river. The Igoma right main canal serves the area of 385 ha on the left bank of the Mkomazi river and its canal length is about 4.3 km.

The secondary canal is branched off from the main canal to deliver irrigation water to a secondary block.

A tertiary block is commanded by a tertiary canal and several quarternaries. The acreage of one tertiary unit ranges from 13 ha to 48 ha.

3.2 Drainage Plan

3.2.1 Drainage water requirement

(1) Drainage requirements from the paddy field

The drainage water requirements from the paddy field are estimated based on the following criteria.

(i) The design rainfall is two-day consecutive rainfall with a 5-year return period.

(ii) The excess water by the design rainfall is drained during two days.

The rainfall data at both the Gonja Estate station and the Kalimawe meteorological station are used for estimation of drainage water requirements. The drainage water requirements are estimated by using the following equation.

$$q = (R - S) \times 10{,}000/(3{,}600 \times 48) \quad \ldots\ldots\ldots\ldots\ldots \quad (3.1)$$

Where;
- q = unit design drainage requirement (ℓ/sec/ha)
- R = design rainfall (mm)
- S = storage capacity in paddy field (mm)

The minimum water storage capacity of 40 mm in paddy field is applied as same assumption as for estimation of effective rainfall described in Section 2.2. As studied in ANNEX A, 2-day consecutive rainfall with a 5-year return period at the Gonja Estate and Kalimawe meteorological station is 138 mm and 94 mm, respectively. Using equation (3.1), the unit drainage requirements for each irrigation scheme are calculated as shown below.

Scheme	Rainfall Station	Design Rainfall (mm)	Unit drainage requirements (ℓ/sec/ha)
Kisiwani	Gonja Estate	138	5.67
Igoma	- do. -	138	5.67
Gonja	- do. -	138	5.67
Ndungu	Kalimawe dam	94	3.13
Kihurio	- do. -	94	3.13

(2) Drainage requirement from the hinterland

The drainage requirements from hinterland which mainly consists of eastern slope of the South Pare Mountains are estimated by specific peak flood discharge as shown in Fig. A-18 in ANNEX A. Since the flood from the hinterland is hardly uncontrollable as well as other major tributaries, the peak flood discharge with a 20-year return period is adapted as the design flood discharge. The design drainage requirement is estimated by the following formula.

$$Q = q \times A$$

Where,

Q = design drainage requirement (m^3/sec)
q = specific discharge of flood ($m^3/sec/km^2$)
A = drainage area (km^2)

(3) Peak flood discharge of major tributaries

The design peak flood discharge of the Nakombo, Hingilili, Yongoma, Saseni and Kambaga river are determined based on the peak flood discharge which occurs once in 20 years return period.

River	Catchment area (km^2)	Peak flood discharge (m^3/sec)
Nakombo	48.5	77
Hingilili	55.8	127
Yongoma	70.5	127
Saseni	198.5	203
Kambaga	749.0	70 /1

/1 = peak discharge after control of the Igoma dam

3.2.2 Drainage canal system

The drainage canal system in each scheme consists of the quarternary, tertiary, secondary and main drainage canals. The quarternary drain is provided to drain out excessive water in the field and to control the subsurface water level. Tertiary drain is provided to drain out the excessive water and subsurface water collected by the quarternary drain to secondary drain. The secondary and main drains transport water from the quarternary and tertiary drains to rivers.

The route, capacity and location of drainage canals and structures should be determined to accomplish their envisaged function as much as effective and economical. The proposed drainage canal alignment in each scheme is shown in Fig. G-10. The special matters of each scheme are mentioned herein after.

(1) Kisiwani scheme

The proposed main drain of 3.7 km is provided in the middle of the service area for draining out the excess water. The secondary drains of 5.7 km in total are also provided so as to collect the excess water to the main drain.

The Nakombo river channel downstream from the Same-Tanga road bridge is improved to increase its flow capacity. The improved channel length is 2.6 km.

(2) Gonja scheme

The proposed main and secondary drains with a total length of 17.7 km are provided to collect and drain the flood water of the Talanda, the Rika and the Kisangazi rivers, the runoff discharge from the eastern slope of the South Pare mountains and the excess water from the paddy field. A floodway of 4.6 km is provided about 2.0 km downstream from the Same-Tanga road bridge to smoothly pass the flood discharge of the Hingilili river to the Kambaga river.

(3) Ndungu scheme

Only secondary drains of 15.4 km in total are proposed to collect and drain the excess water in the area. The Yongoma river channel about 1 km downstream from the Same-Tanga road bridge is proposed to be improved to increase its flow capacity. The improved channel length is 4.2 km. In order to protect the flood of the Kambaga river, a flood dike of 2.5 km is proposed north-east boundary of the scheme.

(4) Kihurio scheme

The service area of about 210 ha surrounding the Lake Manka is inundated with the flood water every year due to insufficient flow capacities of the Saseni river and the Mkomazi river. An improvement plan of the Mkomazi river is established to control the floods from the Saseni river and the Mkomazi main stem by using the storage capacity of the Lake Manka created by construction of the polder dike (See Table G-17). The length of the proposed polder dike is about 6.5 km. In this context, the Mkomazi river and the Saseni river are improved to increase their flow capacities. The improved channel length is 3.0 km of the Saseni and 6.0 km of the Mkomazi, respectively.

(5) Igoma scheme

The Kambaga river is improved to increase its flow capacity. The length of improved channel is about 5.3 km. A flood protection dike and drainage channel of 1.5 km is provided so that flood water from hinterland is drained out effectively to the Kambaga river.

3.3 Road Network

The farm road network is required to provide farm-to-market and market-to-farm access to allow transportation of project inputs and outputs, and furthermore to facilitate the operation and maintenance of the irrigation and drainage system.

The main farm roads are proposed along the main irrigation and drainage canals and their total length is 58 km. The main roads have an effective width of 4.0 m and are paved by gravells for all weather transportation.

The secondary farm roads with a effective width of 3 m are provided along the secondary irrigation and drainage canals. And the total length of the secondary roads is approximately 104 km.

Tertiary farm roads with a width of 2.0 m are also proposed along the tertiary irrigation canal.

4. PRELIMINARY DESIGN

4.1 Design Conditions

4.1.1 Irrigation system

(1) Design discharge

The design discharge for the main and secondary canals is based on the unit irrigation water requirement estimated in half monthly basis mentioned in sub-section 2.2.7.

The design discharge for the tertiary canal is based on the rotational irrigation operation. The design discharge for the tertiary canal is calculated at 1.95 ℓ/sec/ha based on the rotational operation made within a rotation block of 20 ha. The irrigation networks of the respective schemes are shown in Fig. G-9.

(2) Canal lining

The water available for irrigation in the Mkomazi Valley area is limited. Furthermore, a result of soil mechanical tests carried out so far, indicate that soils in the area have a low resistance for erosion. Consequently, the canal lining is introduced for water saving and canal protection in the main and secondary canals. The plain concrete or precast concrete blocks lining are applied. No lining on the tertiary and on-farm canals are made.

(3) Velocity and canal section

The allowable velocity of irrigation canal is as follows:

Type of canal	Maximum velocity	Minimum velocity
Concrete block lining canal	1.5 m/sec	0.3 m/sec
Unlined canal	0.9 m/sec	0.3 m/sec

The canal slope is decided as follows based on the results of soil mechanical investigation.

Main canal	:	1:1.25
Secondary canal	:	1:1.0
Tertiary canal	:	1:1.0

The typical cross section of irrigation canals are shown in Fig. G-11, and profiles are shown in the attached drawing.

4.1.2 Drainage system

(1) Design discharge

The design discharges for the main, secondary and tertiary drains are calculated by using the unit drainage requirements such as 5.67 ℓ/sec/ha for the Kisiwani, Igoma and Gonja schemes and 3.13 ℓ/sec/ha for the Ndungu and Kihurio schemes.

The drainage networks of the respective schemes are shown in Fig. G-10.

(2) Canal section

The drainage canal sections are determined by the following assumption.

Type	: Trapezoidal unlined canal
Permissible velocity	
Maximum velocity	: 0.6 m/sec
Minimum velocity	: 0.3 m/sec
Roughnes coefficient	: 0.03 for Manning formula
Side slope	
Main drain	: 1:2.0
Secondary drain	: 1:1.5
Tertiary drain	: 1:1.0

4.1.3 On-farm works

The on-farm works consist of tertiary facilities such as tertiary and quarternary irrigation canal, drain and farm road, field facilities and land levelling. The typical layout for paddy field shown on Fig. G-8 is prepared taking into consideration of future mechanized farming and economized land preparation. The size and shape of a plot is 0.3 ha (100 x 30 m) consisting of sub-field of 0.1 ha. The field plots of 0.3 ha extend on both sides of a farm ditch. Considering the average holding size of 0.8 ha, the size of a rotation irrigation block is suggested at 20 ha consisting of three "Cell" which consists of 10 farmers.

The tertiary canal is so constructed as to command at least one irrigation block of 20 ha. In general, tertiary canal of approximately 1,000 m in length will be provided for commanding two irrigation block of 40 ha.

As for quarternary facilities, quarternary canal and quarternary drain are separately provided so as to contact directly to each field plot of 0.3 ha, in view of efficient operation and maintenance and proper water management of a terminal system. Standard length of field ditch and drain will be about 450 m. No farm road along each plot is to be provided.

4.1.4 Farm road

The farm road system is provided in each irrigation scheme, which comprises main, secondary and tertiary farm roads. In principle, these roads run alongside main, secondary and tertiary irrigation canals, respectively. The main road is paved with gravel with the following width.

Main farm road	5.00 m pavement 4.0 m width
Secondary farm road	3.00 m unpaved
Tertiary farm road	2.00 m unpaved

4.1.5 Related structures

A number of related structures shown in attached drawing are required in conjunction with irrigation canals for conveyance, regulation and measurement of irrigation water and protection of canal system. The general characteristics and design criteria of those structures are briefed as follows:

(a) Culverts

Culverts are constructed to convey canal water under roads. The culverts in the proposed canal system are classified into two types depending on their discharges. The one type have box barrels and the other have pipe barrels. Design water depth in the barrel is taken to be about 80 % of barrel height, and design velocity is to be 110 % to 130% of canal water velocity.

(b) Siphons

Inverted siphons are constructed to convey canal water under rivers and drainage channels. The precast concrete pipe is provided. The maximum velocity is taken to be 1.5 to 2.0 m/sec.

(c) Crossdrains and drainage culverts

These structures are constructed across the irrigation canals at the places where the canals run across depressed lands or natural streams. Crossdrains are classified into two types depending on the design discharge. One has a pipe barrel and the other has a rectangular-shaped concrete barrel. The former is adopted for the design discharge of less than 1.8 m^3/sec and the later is for the discharge of 1.8 m^3/sec or more. The drainage culvert is provided at the place where a tertiary canal crosses a drainage canal in a tertiary unit.

(d) Drainage drops

The function of the drainage drop is to dissipate excess energy. The upstream and downstream of the structure is protected by gabion for preventing from the scouring.

(e) Drops and chutes

The function of these structures is to dissipate excess hydraulic energy in irrigation canal. The drop structures are classified into six standard size depending on the discharge. Two chute structures are proposed on Hingilili Main Canal in Gonja scheme.

(f) Turnouts

Turnouts are constructed to divert irrigation water from one to others. There are two types of turnout depending on the relations of elevations of both canals and on existing or non-existing of inspection road. A turnout is provided with one control gate and provided with one lane of pipe with a diameter of 400 mm to 800 mm.

(g) Checks

A check gate is provided at the just downstream of turnout to maintain the required water level during the period of partial flow in the canal. In case a drop structure is needed closely to a check gate, a check cum drop structure is provided.

(h) Spillways and wasteways

The spillway which has a overflow portion is proposed to drain out excess water in irrigation canals. Wasteway is provided on small irrigation canal to drain out all water in the canal.

(i) Bridge

An existing steel truss bridge on the Saseni river is improved accordingly that the Saseni river is improved. The steel truss bridge is placed to stride over the low water channel of the river. And several concrete culverts are placed on the high water channel.

4.1.6 Flood protection facilities

(1) Floodways

A shortcut or improvement of the rivers are proposed to protect from flooding of rivers. The cross section of the floodway consists of two portions. One is low water channel and the other is high water channel. Side slope of high water channel and low water channel is 1:2 and 1:4 respectively. The high water channel portion is protected by grass. The allowable maximum velocity in high water channel and low water channel is 1.5 m/sec and 2.0 m/sec, respectively. Profiles of proposed floodway are shown in attached drawing.

(2) Flood dikes

A dike construction is proposed in Kihurio scheme to enclose the Lake Manka and to protect surrounding area from inundation. The total length of the dike is about 6,500 m. Average height of the dike and width of embankment top is 2.0 m and 5.0 m, respectively. The total embankment volume is about 123,000 m^3.

4.2 Principal Features in Each Scheme

The major project facilities are designed based on the conditions described in previous section as shown in Table G-18.

4.3 Kalimawe Dam

(1) Spillway

Spillway crest is proposed to be heightened in 1.2 m (EL.505.90 m) so that effective storage of the Kalimawe dam is increased from 5.5 million to 14.9 million m^3. The overflow weir type spillway is proposed so as to select the easy operation and maintenance. The proposed overflow weir is designed on elongated line of existing dam axis and existing stoplog on the spillway and the sluice gate at the center of spillway should be removed.

Conforming to the design criteria of Japan, the design discharge of the spillway is estimated 700 m^3/sec. The length of overflow section is designed 76 m which is same with the width of existing spillway. The overflow depth is calculated about 2.7 m and design flood water level is estimated EL.508.60 m.

(2) Main dam

As a result of the above calculation, the existing dam crest (EL. 509.23 m) is not enough to keep necessary freeboard. The freeboard of the dam is calculated at 2.9 m by the following equation.

Hf = hw + hi or 2.0 m

Where, Hf = freeboard
hw = height of wave due to wind
hi = allowance according to type of dam
(fill type dam hi = 1.0 m)

The crest elevation of the dam is determined EL.511.50 m

As the existing dam is supposed to be a center core type, a new core is added to the existing one. The existing upstream side slope (1:3) is applied to the heightened portion and the downstream side slope is determined 1 to 2.5 newly. The existing concrete lining on the upstream slope is extended in 3.7 m. As the elevation of right side bank (EL.508.3) is heightened upto EL.511.50 m.

(3) Intake and Outlet

The existing intake gate is replaced for increase of flow capacity. The intake tower is heightened up to EL.510.5 m. As the existing outlet structure is buried in proposed dam body, the outlet is constructed newly at the toe of new downstream slope.

The principal feature is shown in Fig. G-12 and listed as follows:

PRINCIPAL FEATURES OF THE KALIMAWE DAM

(1) Reservoir

		Existing	Proposed
Catchment area	(km^2)	1,492	1,492
Normal high water level	(EL.m)	504.76	505.9
Effective storage	(10^6m^3)	5.5	14.9
Flood water level	(EL.m)	507.43	508.60
Surface area at N.H.W.L.	(ha)	700	950

(2) Dam

		Existing	Proposed
Type		Center core earthfill	- do. -
Crest elevation	(EL.m)	509.23	511.5
Crest length (main dam)	(EL.m)	178.0	178.0
(saddle dam)	(EL.m)	-	278.0
Height (main dam)	(m)	9.2	11.5
(saddle dam)	(m)	-	5.5
Surface slope (upstream)		1:3.0	1:3.0
(downstream)		1:2.2	1:2.5
Crest width	(m)	1.8	4.0
Top of concrete lining	(EL.m)	506.8	510.5
Embankment volume (main dam)	(10^3m^3)	58,700	74,700
(saddle dam)	(10^3m^3)	-	17,000

(3) Spillway

Type	Overflow weir type		- do. -
Crest elevation	(EL.m)	504.76	505.90
Stoplog crest	(EL.m)	505.69	removed
Elevation of scouring sluice	(EL.m)	503.25	removed
Design discharge	(m^3/sec)	500	700
Length of overflow weir	(m)	70	76

Table G-1 (1/3) EXISTING IRRIGATION SYSTEM

No.	Name of scheme/canal	Water source	Location (Village)	Water right	Irrigable area (ha)		Major structures		Major crops grown		Remarks
					Norminal	Estimated	Intake	Canal	Rainy season	Dry season	
A.	Nakombo (Kisiwani) river system				1/	2/					
A-1	Estate canal (Kisiwani sisal estate)	Nakombo R.	Kisiwani	No. 2299 Q=1cusec	(32)	-	Masonry weir (Broken)	Earth	Sisal nursery		
A-2	Mkonga furrow	Nakombo R.	Mkonga Kisiwani	Customary	90	60	Masonry weir	Earth	Paddy	Maize Beans	
A-3	Kisiwani intake	Nakombo R.	Kisiwani	Not registered			Concrete Weir		Paddy	Maize	
	Kisiwani Canal (Left bank)				120	63	2-gates	Earth 3/			
	Nakombo canal (Right bank)				90	27	1-gate	Earth 4/			Under construction 5/
	Sub-total (A)				300	150	(Excluding sisal farm)				
B.	Hingilili river system										
B-1	Kalemani furrow	Bwaya R.	Maore	Customary	80	15	Natural intake	Earth	Paddy Maize	Maize Beans	
B-2	Maore furrow	Hingilili R.	Maore	No. 798 Q=2 cusec & Customary	128	20	Natural intake	Earth 4.5 km	Paddy	Maize	
B-3	Mariranga intake Mgambo furrow	Hingilili R.	Maore Kadando Mipirani	Customary	105	100	Masonry weir without gate	Earth 5.0 km	Paddy	Maize	
B-4	Shakaka furrow	Hingilili R.	Maore	Customary	Not known	20	Natural material weir	Earth	Paddy	Maize	
B-5	Gonja Sugar Estate	Hingilili R.	Mpirani	Q=2 cusec	-	0	-	-			Water right only
		Talanda R.	Mpirani	Customary 6/	-	(500)	Natural	Earth	Sugar cane		
B-6	Talanda furrow	Talanda R.	Mpirani	Customary	104	15	Natural	Earth	Paddy	Maize	
	Sub-total (B)				417	170	(Excluding sugar cane farm)				

.... continued

Table G-1 (2/3) EXISTING IRRIGATION SYSTEM

No.	Name of scheme/canal	Water source	Location (Village)	Water right	Irrigable area (ha)		Major structures		Major crops grown		Remarks
					Norminal	Estimated	Intake	Canal	Rainy season	Dry season	
C.	Yongoma River System										
C-1	Compensation (Ndungu) canal	Yongoma R.	Ndungu	No.1178 Q=6 cusec	120	50	Concrete Weir	Earth	Maize	Maize Beans	
C-2	Msufini furrow	Yongoma R.	Msufini	No.1177 Q=2 cusec	40	0	Through si-sal estate	Earth	Paddy	Maize	
C-3	Maendeleo furrow	Yongoma R.	Ndungu	Customary	Not known	150	Natural mate-rial weir	Earth	Paddy	-	
C-4	Kazumura furrow	Yongoma R.	Ndungu Msufini	Customary	Not known	90	Natural mate-rial weir	Earth	Paddy	-	
C-5	Ndungu sisal estate	Yongoma R.	Ndungu	No.891 Q=2.7 cusec	-	-	Masonry weir	Earth	Sisal nursery		
	Sub-total (C)				160	290	(Excluding sisal farm)				
D.	Saseni River System										
D-1	Mbueni furrow	Saseni R.	Usambara Kankokoro	Customary	300	80	Natural mate-rial weir	Earth 5 km	Maize	Maize	
D-2	Mvure furrow	Saseni R.	Mvure	Customary	Not known	40	Natural mate-rial weir	Earth	Maize	Maize Beans	
D-3	Maendeleo furrow	Saseni R.	Mvure	Customary	Not known	120	Natural mate-rial intake	Earth	Paddy	Maize	
D-4	Other furrows	Saseni R.	Usambara Kankokoro Mvure	Customary	Not known	100	Natural Intake	Earth	Paddy	Maize	
E.	Mkomazi River System										
E-1	Kalimawe Dam	Kambaga R. Yongoma R.	Kalimawe	Not registered	520	(220)					

.... continued

Table G-1 (3/3) EXISTING IRRIGATION SYSTEM

No.	Name of scheme/canal	Water source	Location (Village)	Water right	Irrigable area (ha)		Major structures		Major crops grown		Remarks
					Norminal	Estimated	Intake	Canal	Rainy season	Dry season	
(a)	High level canal	Reservior	Kalimawe Mgandu		-	180	Intake 1-gate	Earth	Paddy	Maize Beans	
(b)	Low level canal	Reservior	Kalimawe		-	40	Gate from high level canal	Earth	Paddy	Maize	
E-2	Traditional Furrow	Mkomazi R.	Mgandu	Customary	Not known	30	Natural	Earth	Paddy	Maize	
	Sub-total (D & E)				820	590					
	TOTAL				1,697	1,200					

Remarks:
1/ Figures obtained from District Agricultural Office.
2/ Estimated based on the map of 1/5,000 scale and aerial photograph
3/ Including reinforced concrete pipe culvert of 60 m long (Double barrel of 0.25 m diameter)
4/ Including reinforced concrete box culvert of 60 m long (0.3 x 0.3 m)
5/ Irrigation water is supplied through sisal estate canal, at present.
6/ Non perennial

Table G-2 (1/3) WATER RIGHT

NO.	NAME OF SCHEME	LOCATION OF SCHEME	WATER SOURCE	REGISTERED NO. AND DATE	HOLDER	AMOUNT	STRUCTURES	PURPOSE	
Nakombo (Kisiwani) River System									
1.	Kisiwani Water supply	Kisiwani Village	Nakombo river	No.2540 17 Oct. 1970	Village (District)	206,00 G.P.D. (10.7 lit/sec)	Intake, Pipeline	Domestic use	
2.	Kisiwani Sisal Estate	Kisiwani Village	Bore hole No. 1	No. 351 30 Nov. 1950	Kisiwani Sisal Estate	-	Bore hole Pump Pipeline	Cooling water for Diesel engine	No use (closed)
3.	- do -	- do -	Bore hole No. 2	No. 410 applied on 27 Oct. 1955	- do -	-	Bore hole	Domestic use	No use (closed)
4.	- do -	- do -	Nakombo river	No.2299 24 Nov. 1964	- do -	1.0 cusec (28.3 lit/sec)	Portable pump	Irrigation	32 ha, Sisal nursery
5.	- do -	- do -	Nakombo	-	- do -	0.75 cusec (21.2 lit/sec)	Intake weir	Sisal factory	
6.	Njiro Water Supply	- do -	Majevu spring	No.4150 18 Jul. 1973	Village (District)	5,000 G.P.D. (0.3 lit/sec)	Intake Pipeline	Domestic use	
7.	- do -	- do -	Kisiwani spring	No.4151 18 Jul. 1973	Village (District)	10,000 G.P.D. (0.5 lit/sec)	Intake Pipeline	Domestic use	
	Sub-total					2.16 cusec (61 lit/sec			

........Continued

Table G-2 (2/3) WATER RIGHT

NO.	NAME OF SCHEME	LOCATION OF SCHEME	WATER SOURCE	REGISTERED NO. AND DATE	HOLDER	AMOUNT	STRUCTURES	PURPOSE
Hingilili River System (including Bwaya, Talanda & Rika rivers)								
1.	Gonja Water Supply	Maore, Mpirani & Kadando villages	Hingilili river	No.2514 16 Oct. 1970	Village (District)	176,600 G.D.P. (9.3 lit/sec)	Intake weir Pipeline	Domestic use
2.	Gonja Irrigation	Maore Village	Hingilili river	No. 798 -	Village	2 cusec (56.6 lit/sec)	Natural Intake	Irrigation Paddy, Maize (Area is not known)
3.	Gonja Irrigation	Maore, Mpirani & Kadando villages	Hingilili river	No.2295 applied on 24 Nov. 1964	District	-	Kiruka & Tia dams, Diversion tunnel to Bwaya river	Irrigation, 400 ha for Paddy, Maize and cotton (Planning only, not realized)
4.	Gonja Sugar Estate	Mpirani village	Hingilili river	-	Gonja sugar estate	2 cusec (56.6 lit/sec)	-	Irrigation, Approx. 500 ha of sugar cane (not used)
	Sub-total					4.34 cusec (123 lit/sec)		

........Continued

Table G-2 (3/3) WATER RIGHT

NO.	NAME OF SCHEME	LOCATION OF SCHEME	WATER SOURCE	REGISTERED NO. AND DATE	HOLDER	AMOUNT	STRUCTURES	PURPOSE
Yongoma River System								
1.	Ndungu Sisal estate	Ndungu village	Yongoma river	No.891 05 Feo. 1052	Ndungu sisal estate	2.72 cusec (77.0 lit/sec) &	Intake weir	Domestic use, sisal factory and irrigation for sisal nursery
						5.55 cusec (157.1 lit/sec)	Penstock	Hydropower to be returned
2.	Ndungu Water Supply	Ndungu Kalimawe & Mcufini Villages	Yongoma river	No.2515 02 Jul. 1969	Village (District)	76,800 G.P.D. (4.0 lit/sec)	Intake weir Pipeline	Domestic use
3.	Mroyo Furrow	Mcufini Village	Yongoma river	No.1177 Applied on -	Village (District)	2 cusec 56.6 lit/	Natural intake	Irrigation for maize, cotton (Area is not known)
4.	Kalimawe Compensation	Ndungu village	Yongoma river	No.1178 14 Nov. 1958	Village (District)	6 cusec (169.8 lit/sec)	Intake weir	Irrigation for 126 ha of Paddy, maize
	Sub-total					16.41 cusec (464.5 lit/sec)		
Saseni River System								
1.	Kihurio Water Supply	Usambara Kankokoro Mvurekongei & Mgandu Villages	Saseni river	No.2620 17 Oct. 1970	Village (District)	50,000 G.P.D. =0.09 cusec (2.5 lit/sec)	Intake weir Pipeline	Domestic use
	TOTAL					23 cusec (650 lit/sec)		

Table G-3 TOTAL DEMAND OF EACH CROP

(CONSUMATIVE USE PLUS PERCOLATION FOR PADDY)

(Unit; MM)

Growing: Stage :	Rice (Improved) 1	Rice (Improved) 1	Rice (Improved) 2	Maize
Aug. 1 :			1.	4.
Aug. 2 :		1.	8	14
Sep. 1 :		12.	41.	26.
Sep. 2 :		61.	89.	34.
Oct. 1 :		127.	130.	50.
Oct. 2 :		159.*	158.*	77.
Nov. 1 :		130.	132.	92.
Nov. 2 :		136.	137.	105.
Dec. 1 :		139.	137.	109.*
Dec. 2 :		143.	112.	94.
Jan. 1 :	1.	85.	57.	37.
Jan. 2 :	9.	17.	12.	2.
Feb. 1 :	40.			
Feb. 2 :	80.			
Mar. 1 :	120.			
Mar. 2 :	135.*			
Apr. 1 :	115.			
Apr. 2 :	113.			
May 1 :	126.			
May 2 :	90.			
June 1 :	54.			
June 2 :	18.			
Total :	901.	1,000.	1,014.	644.

Note = * means maximum

Table G-4 (1/2) EFFECTIVE RAINFALL FOR EACH CROP

(1) Rainy season paddy

AVERAGE EFFECTIVE RAINFALL OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	MEAN
JAN 1	8.	15.	11.	0.	0.	0.	0.	45.	6.	16.	
JAN 2	50.*	0.	0.	28.	0.	0.	15.	48.	23.	0.	
FEB 1	33.	17.	0.	51.	0.	0.	27.	15.	0.	50.*	
FEB 2	20.	33.	0.	12.	0.	21.	0.	58.	6.	10.	
MAR 1	24.	53.*	0.	21.	7.	28.	15.	0.	17.	13.	
MAR 2	22.	51.	83.*	116.*	0.	133.*	49.*	116.*	35.*	0.	
APR 1	41.	25.	17.	6.	94.*	67.	45.	17.	15.	0.	
APR 2	0.	44.	0.	0.	92.	6.	0.	23.	6.	24.	
MAY 1	0.	0.	0.	15.	18.	29.	0.	8.	0.	38.	
MAY 2	10.	0.	10.	4.	20.	10.	0.	0.	0.	0.	
JUN 1	0.	0.	0.	5.	0.	7.	0.	0.	6.	0.	
JUN 2	5.	0.	0.	0.	0.	0.	0.	0.	0.	0.	

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

AVERAGE EFFECTIVE RAINFALL OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	MEAN
JAN 1	0.	0.	36.*	6.	11.	0.	44.*	5.	0.	0.	10.
JAN 2	3.	17.	0.	6.	25.	49.	18.	43.*	0.	0.	16.
FEB 1	0.	0.	0.	7.	0.	0.	37.	0.	0.	6.	12.
FEB 2	16.	0.	0.	7.	49.*	24.	24.	6.	0.	17.	15.
MAR 1	6.	0.	9.	0.	0.	73.	20.	21.	0.	0.	15.
MAR 2	0.	0.	0.	35.	16.	94.*	25.	9.	100.*	0.	44.*
APR 1	30.	0.	0.	11.	0.	37.	22.	22.	73.	40.*	28.
APR 2	7.	109.*	7.	67.*	0.	43.	6.	23.	30.	8.	25.
MAY 1	45.*	0.	9.	7.	0.	7.	36.	6.	0.	22.	12.
MAY 2	0.	0.	6.	0.	0.	0.	20.	0.	8.	11.	5.
JUN 1	0.	0.	0.	0.	0.	5.	11.	0.	0.	0.	2.
JUN 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	8.	1.

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

(2) Dry season paddy (Type 1)

AVERAGE EFFECTIVE RAINFALL OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	MEAN
AUG 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
SEP 1	0.	0.	0.	0.	20.	0.	0.	0.	0.	13.	
SEP 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
OCT 1	10.	0.	7.	0.	23.	0.	18.	0.	0.	18.	
OCT 2	0.	0.	7.	5.	5.	11.	7.	0.	0.	8.	
NOV 1	48.	0.	41.	14.	9.	23.	50.	17.	0.	47.	
NOV 2	108.*	5.	0.	5.	44.*	60.*	7.	0.	0.	39.	
DEC 1	47.	0.	77.*	43.*	23.	27.	0.	91.*	0.	22.	
DEC 2	101.	7.	17.	12.	0.	0.	0.	34.	87.*	41.	
JAN 1	68.	18.*	0.	0.	0.	0.	86.*	6.	16.	70.*	
JAN 2	0.	0.	32.	0.	0.	0.	25.	29.	0.	6.	

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

AVERAGE EFFECTIVE RAINFALL OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	MEAN
AUG 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEP 1	0.	0.	12.	0.	0.	0.	6.	0.	0.	13.	3.
SEP 2	0.	0.	0.	37.*	10.	0.	0.	0.	0.	0.	2.
OCT 1	5.	0.	0.	0.	9.	0.	0.	0.	28.	73.	10.
OCT 2	0.	0.	11.	8.	0.	6.	20.	11.	11.	19.	6.
NOV 1	20.	0.	0.	0.	44.	10.	0.	42.	0.	0.	18.
NOV 2	0.	0.	0.	0.	53.	129.	8.	7.	9.	143.*	31.
DEC 1	17.	13.	76.*	0.	103.*	163.*	0.	23.	0.	100.	41.*
DEC 2	15.	7.	0.	12.	47.	56.	61.*	73.*	65.*	0.	32.
JAN 1	0.	42.*	6.	37.	0.	58.	11.	0.	7.	0.	21.
JAN 2	34.*	0.	0.	0.	86.	0.	11.	0.	0.	0.	11.

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

Table G-4 (2/2) EFFECTIVE RAINFALL FOR EACH CROP

(3) Dry season paddy (Type II)

AVERAGE EFFECTIVE RAINFALL OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	MEAN
	PLANTING YEAR										
AUG 1	0.	0.	0.	0.	7.	0.	0.	0.	0.	0.	
AUG 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
SEP 1	0.	0.	0.	0.	22.	0.	0.	0.	0.	13.	
SEP 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
OCT 1	10.	0.	7.	0.	23.	0.	18.	0.	0.	18.	
OCT 2	0.	0.	7.	5.	5.	11.	7.	0.	0.	8.	
NOV 1	48.	0.	41.	14.	9.	23.	50.	17.	0.	47.	
NOV 2	109.*	5.	0.	5.	44.*	60.*	7.	0.	0.	39.	
DEC 1	47.	0.	76.*	43.*	23.	27.	0.	85.*	0.	22.	
DEC 2	101.	7.	17.	12.	0.	0.	0.	34.	87.*	41.	
JAN 1	68.	18.*	0.	0.	0.	0.	86.*	6.	16.	70.*	
JAN 2	0.	0.	32.	0.	0.	0.	25.	29.	0.	6.	

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

AVERAGE EFFECTIVE RAINFALL OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	MEAN
	PLANTING YEAR										
AUG 1	0.	6.	0.	0.	0.	0.	0.	22.	0.	0.	2.
AUG 2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEP 1	0.	0.	12.	0.	0.	0.	7.	0.	0.	13.	3.
SEP 2	0.	0.	0.	37.*	11.	0.	0.	0.	0.	0.	2.
OCT 1	5.	0.	0.	0.	9.	0.	0.	0.	28.	73.	10.
OCT 2	0.	0.	11.	8.	0.	6.	20.	11.	11.	19.	6.
NOV 1	20.	0.	0.	0.	44.	10.	0.	42.	0.	0.	18.
NOV 2	0.	0.	0.	0.	53.	129.	8.	7.	9.	144.*	31.
DEC 1	17.	13.	76.*	0.	103.*	163.*	0.	21.	0.	100.	41.*
DEC 2	15.	7.	0.	12.	47.	56.	61.*	73.*	65.*	0.	32.
JAN 1	0.	42.*	6.	37.	0.	58.	11.	0.	7.	0.	21.
JAN 2	34.*	0.	0.	0.	86.	0.	11.	0.	0.	0.	11.

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

(4) Maize

AVERAGE EFFECTIVE RAINFALL OF MAIZE

(UNIT; MM)

GROWING STAGE	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	MEAN
	PLANTING YEAR										
AUG 1	0.	0.	6.	3.	8.	0.60	6.	0.	0.	0.40	
AUG 2	0.	2.	0.	0.	1.	0.20	2.	1.	0.	3.	
SEP 1	0.	3.	0.	0.	23.	0.	0.	2.	0.	11.	
SEP 2	5.	0.50	8.	0.80	1.	0.	0.	0.80	0.	2.	
OCT 1	11.	1.	12.	0.80	17.	0.80	21.	2.	0.	24.	
OCT 2	0.	5.	13.	6.	17.	16.	13.	0.	3.	17.	
NOV 1	31.	5.	39.	14.	22.	25.	45.*	17.	0.	49.*	
NOV 2	68.*	6.	12.	7.	46.*	67.*	14.	3.	2.	45.	
DEC 1	48.	2.	49.*	44.*	25.	44.	0.	37.*	8.	28.	
DEC 2	65.	10.	20.	10.	4.	5.	2.	35.	62.*	31.	
JAN 1	43.	20.*	0.	0.	0.	0.	31.	3.	13.	42.	
JAN 2	2.	0.	6.	0.	0.	2.	1.	14.	0.	14.	

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

AVERAGE EFFECTIVE RAINFALL OF MAIZE

(UNIT; MM)

GROWING STAGE	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	MEAN
	PLANTING YEAR										
AUG 1	0.	6.	0.	2.	11.	0.	0.50	14.	0.	2.	3.
AUG 2	0.	0.	0.	2.	0.33	0.	0.93	2.	3.	0.	1.
SEP 1	0.	0.30	14.	0.40	0.	0.	10.	0.	5.	20.	4.
SEP 2	0.	0.	0.70	23.	14.	0.	0.	0.	0.	4.	3.
OCT 1	11.	0.	0.	2.	18.	0.80	1.	0.	24.	62.	10.
OCT 2	0.	3.	12.	11.	5.	7.	18.	10.	15.	24.	10.
NOV 1	26.*	5.	0.	1.	36.	12.	6.	30.	7.	0.60	19.
NOV 2	8.	1.	3.	3.	54.	104.	10.	9.	11.	93.*	28.
DEC 1	17.	16.	61.*	9.	84.*	112.*	6.	32.	7.	54.	34.*
DEC 2	12.	16.	3.	14.	45.	45.	19.*	37.*	55.*	0.	24.
JAN 1	1.	32.*	7.	36.*	2.	51.	8.	7.	7.	0.	15.
JAN 2	19.	0.	0.70	6.	31.	4.	0.	0.	0.	0.	5.

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

Table G-5 (1/2) NET WATER REQUIREMENT PER UNIT AREA

(1) Rainy season paddy

AVERAGE WATER REQUIREMENT OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	MEAN
JAN 1 :	0.17	0.	0.03	0.67	0.67	0.67	0.67	0.	0.34	0.	
JAN 2 :	0.	9.	9.	0.59	9.	9.	3.	0.	0.94	9.	
FEB 1 :	20.	28.	40.	17.	40.	40.	22.	29.	40.	17.	
FEB 2 :	62.	54.	80.	67.	80.	58.	80.	40.	74.	70.	
MAR 1 :	96.	62.	120.	99.	113.	92.	105.	120.*	103.	107.	
MAR 2 :	113.	84.	57.	18.	135.*	14.	86.	20.	100.	135.*	
APR 1 :	74.	90.	98.	108.	21.	41.	70.	98.	100.	115.	
APR 2 :	113.	69.	113.	113.*	21.	107.*	113.	90.	108.	90.	
MAY 1 :	126.*	126.*	126.*	111.	108.	97.	126.*	118.	126.*	88.	
MAY 2 :	81.	90.	82.	86.	72.	81.	90.	90.	90.	90.	
JUN 1 :	54.	54.	54.	51.	54.	50.	54.	54.	52.	54.	
JUN 2 :	17.	18.	18.	18.	18.	18.	18.	18.	18.	18.	

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

AVERAGE WATER REQUIREMENT OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	MEAN
JAN 1 :	0.67	0.67	0.	0.29	0.01	0.67	0.	0.35	0.67	0.67	0.
JAN 2 :	8.	4.	9.	6.	2.	0.	2.	0.	9.	9.	5.
FEB 1 :	40.	40.	40.	34.	40.	40.	19.	40.	40.	36.	33.
FEB 2 :	63.	80.	80.	75.	45.	59.	56.	77.	80.	57.	67.
MAR 1 :	114.	120.	111.	120.*	120.	40.	100.	99.	120.	120.	104.
MAR 2 :	135.*	135.*	135.*	100.	119.	34.	110.*	126.*	35.	135.*	[illegible]
APR 1 :	85.	115.	115.	104.	115.	78.	93.	93.	43.	75.	87.
APR 2 :	107.	3.	106.	46.	113.	71.	108.	90.	83.	105.	89.
MAY 1 :	81.	126.	117.	118.	126.*	119.*	89.	120.	126.*	104.	114.*
MAY 2 :	90.	90.	86.	90.	90.	90.	72.	90.	83.	80.	86.
JUN 1 :	54.	54.	54.	54.	54.	51.	49.	54.	54.	54.	53.
JUN 2 :	18.	18.	18.	18.	18.	18.	18.	18.	18.	17.	18.

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

(2) Dry season paddy (Type I)

AVERAGE WATER REQUIREMENT OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	MEAN
AUG 2 :	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	
SEP 1 :	12.	12.	12.	12.	1.	12.	12.	12.	12.	5.	
SEP 2 :	61.	61.	61.	61.	61.	61.	61.	61.	61.	61.	
OCT 1 :	117.	127.	120.	127.	104.	127.	110.	127.	127.	109.	
OCT 2 :	159.*	159.*	151.*	153.*	153.*	148.*	151.*	159.*	159.*	151.*	
NOV 1 :	82.	130.	89.	116.	121.	107.	80.	113.	130.	83.	
NOV 2 :	29.	131.	136.	131.	92.	76.	129.	136.	136.	97.	
DEC 1 :	92.	139.	64.	96.	116.	112.	139.	47.	139.	117.	
DEC 2 :	42.	135.	126.	130.	143.	143.	143.	109.	56.	101.	
JAN 1 :	39.	73.	85.	85.	85.	85.	29.	82.	74.	37.	
JAN 2 :	17.	17.	12.	17.	17.	17.	13.	13.	17.	16.	

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

AVERAGE WATER REQUIREMENT OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	MEAN
AUG 2 :	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
SEP 1 :	12.	12.	5.	12.	12.	12.	9.	12.	12.	4.	10.
SEP 2 :	61.	61.	61.	33.	50.	61.	61.	61.	61.	61.	59.
OCT 1 :	122.	127.	127.	127.	119.	127.	127.	127.	100.	63.	118.
OCT 2 :	159.*	159.*	148.*	151.*	159.*	153.*	139.	148.*	148.*	140.	152.*
NOV 1 :	110.	130.	130.	130.	86.	120.	130.	88.	130.	130.	112.
NOV 2 :	136.	136.	136.	136.	83.	7.	128.	129.	127.	0.	106.
DEC 1 :	123.	126.	63.	139.	36.	0.	139.*	116.	139.	39.	99.
DEC 2 :	128.	136.	143.	131.	96.	87.	82.	69.	77.	143.*	111.
JAN 1 :	85.	57.	81.	60.	85.	45.	78.	85.	80.	85.	71.
JAN 2 :	12.	17.	17.	17.	4.	17.	16.	17.	17.	17.	16.

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

Table G-5 (2/2) NET WATER REQUIREMENT PER UNIT AREA

(3) Dry season paddy (Type II)

AVERAGE WATER REQUIREMENT OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	MEAN
AUG 1	0.59	0.59	0.59	0.59	0.15	0.59	0.59	0.59	0.59	0.59	
AUG 2	8.	8.	8.	8.	8.	8.	8.	8.	8.	8.	
SEP 1	41.	41.	41.	41.	25.	41.	41.	41.	41.	32.	
SEP 2	89.	89.	89.	89.	89.	89.	89.	89.	89.	89.	
OCT 1	119.	130.	123.	130.	106.	130.	112.	130.	130.	111.	
OCT 2	158.*	156.*	150.*	152.*	152.*	147.*	150.*	158.*	158.*	150.*	
NOV 1	84.	132.	91.	118.	124.	109.	82.	115.	132.	85.	
NOV 2	28.	132.	137.	132.	94.	78.	130.	137.	137.	98.	
DEC 1	89.	137.	61.	94.	114.	109.	137.	50.	137.	115.	
DEC 2	31.	106.	99.	102.	112.	112.	112.	85.	42.	79.	
JAN 1	26.	49.	57.	57.	57.	57.	19.	54.	49.	25.	
JAN 2	12.	12.	8.	12.	12.	12.	9.	8.	12.	11.	

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

AVERAGE WATER REQUIREMENT OF RICE (IMPROVED)

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	MEAN
AUG 1	0.59	0.22	0.59	0.59	0.59	0.59	0.59	0.	0.59	0.59	1.
AUG 2	8.	8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
SEP 1	41.	41.	32.	41.	41.	41.	35.	41.	41.	32.	38.
SEP 2	89.	89.	89.	58.	77.	89.	89.	89.	89.	89.	87.
OCT 1	125.	130.	130.	130.	121.	130.	130.	130.	102.	63.	121.
OCT 2	158.*	158.*	147.*	150.*	158.*	152.*	138.*	147.*	147.*	139.*	151.*
NOV 1	113.	132.	132.	132.	88.	123.	132.	91.	132.	132.	114.
NOV 2	137.	137.	137.	137.	84.	9.	129.	130.	128.	0.	107.
DEC 1	120.	124.	61.	137.	34.	0.	137.	115.	137.	36.	97.
DEC 2	100.	107.	112.	102.	75.	68.	64.	53.	60.	112.	87.
JAN 1	57.	38.	54.	40.	57.	30.	52.	57.	54.	57.	47.
JAN 2	8.	12.	12.	12.	2.	12.	10.	12.	12.	12.	10.

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

(4) Maize

AVERAGE WATER REQUIREMENT OF MAIZE

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	MEAN
AUG 1	4.	4.	3.	3.	2.	4.	3.	4.	4.	4.	
AUG 2	14.	12.	14.	14.	13.	14.	12.	13.	14.	11.	
SEP 1	26.	22.	26.	26.	2.	26.	26.	24.	26.	14.	
SEP 2	29.	34.	26.	33.	33.	34.	34.	33.	34.	32.	
OCT 1	38.	49.	38.	49.	36.	49.	29.	49.	50.	25.	
OCT 2	77.*	72.	64.	71.	60.	61.	64.	77.	74.	60.	
NOV 1	58.	87.	52.	78.	71.	68.	49.	75.	92.	42.	
NOV 2	40.	99.	93.*	98.*	58.	38.	91.	102.*	103.*	62.	
DEC 1	61.	107.*	58.	65.	84.	65.	109.*	72.	101.	81.*	
DEC 2	30.	84.	75.	84.	90.*	89.*	92.	61.	33.	62.	
JAN 1	16.	28.	37.	37.	37.	37.	22.	35.	31.	16.	
JAN 2	2.	2.	1.	2.	2.	2.	2.	1.	2.	1.	

NOTE; * MEANS MAXIMUM REG. IN EACH PLANTING YEAR

AVERAGE WATER REQUIREMENT OF MAIZE

(UNIT; MM)

GROWING STAGE	PLANTING YEAR 1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	MEAN
AUG 1	4.	3.	4.	4.	1.	4.	4.	0.55	4.	4.	3.
AUG 2	14.	14.	14.	12.	14.	14.	13.	12.	11.	14.	13.
SEP 1	26.	25.	11.	25.	26.	26.	15.	26.	21.	6.	21.
SEP 2	34.	34.	33.	15.	21.	34.	34.	34.	34.	30.	31.
OCT 1	39.	50.	50.	48.	32.	49.	49.	50.	28.	0.	40.
OCT 2	77.	73.	65.	66.	72.*	70.	58.	67.	62.	53.	67.
NOV 1	66.	88.	92.	91.	61.	80.*	86.	65.	85.	92.	74.
NOV 2	98.*	104.*	102.*	103.*	49.	5.	95.	96.*	94.	18.	77.*
DEC 1	91.	93.	47.	100.	22.	0.	103.*	78.	102.*	56.	75.
DEC 2	82.	79.	91.	81.	50.	51.	78.	60.	43.	94.*	70.
JAN 1	36.	22.	33.	19.	36.	12.	33.	33.	33.	37.	30.
JAN 2	0.86	2.	2.	1.	0.34	1.	2.	2.	2.	2.	1.

NOTE; * MEANS MAXIMUM REQ. IN EACH PLANTING YEAR

Table G-6 (1/2) MONTHLY GROSS IRRIGATION WATER REQUIREMENT PER UNIT AREA

(1) Rainy season paddy

********** DIVERSION REQUIREMENT UNIT DIV. REQUIRE. **********

RICE (IMPROVED) 1.00 HECTARES PLANTED FROM 2/16 IN 45 DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1963	0.00	0.49	1.07	1.00	1.07	0.35	0.00	0.00	0.00	0.00	0.00	0.00
1964	0.04	0.45	0.75	0.84	1.11	0.36	0.00	0.00	0.00	0.00	0.00	0.00
1965	0.04	0.70	0.92	1.12	1.07	0.36	0.00	0.00	0.00	0.00	0.00	0.00
1966	0.01	0.50	0.62	1.18	1.02	0.37	0.00	0.00	0.00	0.00	0.00	0.00
1967	0.05	0.70	1.27	0.22	0.93	0.36	0.00	0.00	0.00	0.00	0.00	0.00
1968	0.05	0.54	0.56	0.79	0.92	0.36	0.00	0.00	0.00	0.00	0.00	0.00
1969	0.02	0.61	0.98	0.97	1.12	0.38	0.00	0.00	0.00	0.00	0.00	0.00
1970	0.00	0.40	0.73	1.00	1.07	0.35	0.00	0.00	0.00	0.00	0.00	0.00
1971	0.01	0.67	1.04	1.10	1.12	0.37	0.00	0.00	0.00	0.00	0.00	0.00
1972	0.04	0.49	1.24	1.09	0.91	0.38	0.00	0.00	0.00	0.00	0.00	0.00
1973	0.04	0.60	1.28	1.02	0.68	0.38	0.00	0.00	0.00	0.00	0.00	0.00
1974	0.02	0.70	1.31	0.62	1.12	0.38	0.00	0.00	0.00	0.00	0.00	0.00
1975	0.04	0.70	1.26	1.17	1.05	0.38	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.03	0.61	1.13	0.80	1.08	0.38	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.01	0.48	1.23	1.21	1.12	0.38	0.00	0.00	0.00	0.00	0.00	0.00
1978	0.00	0.57	0.38	0.79	1.08	0.37	0.00	0.00	0.00	0.00	0.00	0.00
1979	0.01	0.44	1.08	1.07	0.83	0.35	0.00	0.00	0.00	0.00	0.00	0.00
1980	0.00	0.65	1.15	0.97	1.08	0.38	0.00	0.00	0.00	0.00	0.00	0.00
1981	0.05	0.70	0.81	0.67	1.08	0.36	0.00	0.00	0.00	0.00	0.00	0.00
1982	0.05	0.54	1.31	0.96	0.95	0.37	0.00	0.00	0.00	0.00	0.00	0.00

(2) Dry season paddy (Type I)

********** DIVERSION REQUIREMENT UNIT DIV. REQUIRE. **********

RICE (IMPROVED) 1.00 HECTARES PLANTED FROM 10/ 1 IN 30 DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.41	0.59	0.70
1964	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.47	1.38	1.41
1965	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.39	1.19	0.97
1966	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.44	1.31	1.16
1967	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.33	1.32	1.13	1.33
1968	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.41	0.97	1.30
1969	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.33	1.11	1.45
1970	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.47	1.32	0.79
1971	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.47	1.41	1.02
1972	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.35	1.33	0.96	1.13
1973	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.44	1.31	1.29
1974	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.47	1.41	1.35
1975	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.35	1.41	1.41	1.05
1976	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.24	1.43	1.41	1.39
1977	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.33	1.42	0.90	0.67
1978	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.44	0.67	0.43
1979	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.37	1.37	1.37	1.15
1980	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.41	1.15	0.96
1981	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	1.27	1.36	1.12
1982	0.51	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]	0.35	1.03	0.69	0.92

Table G-6 (2/2) MONTHLY GROSS IRRIGATION WATER REQUIREMENT PER UNIT AREA

(3) Dry season paddy (Type II)

********** DIVERSION REQUIREMENT UNIT DIV. REQUIRE. **********

RICE (IMPROVED) 1.00 HECTARES PLANTED FROM 9/16 IN 45 DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.42	0.60	0.63
1964	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.47	1.40	1.25
1965	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.40	1.21	0.81
1966	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.45	1.33	1.01
1967	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.60	1.32	1.15	1.16
1968	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.42	0.99	1.14
1969	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.34	1.13	1.28
1970	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.47	1.34	0.69
1971	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.47	1.43	0.94
1972	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.64	1.34	0.98	1.00
1973	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.45	1.33	1.14
1974	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.47	1.43	1.19
1975	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.64	1.42	1.43	0.88
1976	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.52	1.43	1.43	1.24
1977	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.63	1.43	0.92	0.55
1978	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.44	0.70	0.34
1979	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.66	1.38	1.39	1.04
1980	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.42	1.17	0.87
1981	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.69	1.28	1.38	1.02
1982	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.64	1.02	0.70	0.75

(4) Maize

********** DIVERSION REQUIREMENT UNIT DIV. REQUIRE. **********

MAIZE 1.00 HECTARES PLANTED FROM 8/16 IN 30 DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.39	0.80	0.70	0.64
1964	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.40	0.84	1.35	1.33
1965	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.37	0.71	1.05	0.92
1966	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.42	0.84	1.27	1.03
1967	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.25	0.67	0.92	1.21
1968	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.43	0.77	0.77	1.07
1969	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.43	0.64	1.01	1.41
1970	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.41	0.87	1.28	0.93
1971	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.43	0.86	1.41	0.95
1972	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.33	0.59	0.75	1.01
1973	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.43	0.80	1.18	1.21
1974	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.42	0.86	1.38	1.20
1975	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.32	0.80	1.40	0.95
1976	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.29	0.80	1.40	1.27
1977	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.34	0.72	0.79	0.49
1978	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.43	0.83	0.61	0.35
1979	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.36	0.75	1.31	1.27
1980	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.43	0.81	1.16	0.96
1981	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.39	0.62	1.29	1.02
1982	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.26	0.36	0.79	1.03

Table G-7 (1/4) WATER BALANCE IN RESPECTIVE SCHEME

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WATER BALANCE OF KISIWANI

****

IRRIGATED BY NAKOMBO   C.A = 48.5 SQ.KM

RICE (IMPROVED) 180.00 HECTARES PLANTED FROM 10/ 1 IN 30 DAYS
RICE (IMPROVED) 360.00 HECTARES PLANTED FROM 2/16 IN 45 DAYS

YEAR	MIN.	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	MIN.
'63/'64	0.02	0.34	0.23	0.02	1.00	1.76	1.77	0.86	0.83	0.88	0.68	0.57	0.54	0.54
'64/'65	0.09	0.44	0.27	0.09	0.13	1.58	0.80	0.22	0.12	0.10	-0.02	0.47	0.27	-0.02
'65/'66	0.01	0.25	0.14	0.01	0.37	1.29	0.54	0.44	0.61	0.46	0.24	0.35	0.39	0.24
'66/'67	-0.01	0.30	0.18	-0.01	0.19	0.42	0.16	0.17	-0.15	0.80	0.36	0.33	0.38	-0.15
'67/'68	0.07	0.29	0.23	0.07	0.90	0.70	0.37	0.22	1.57	1.28	0.72	0.69	0.60	0.22
'68/'69	0.17	0.48	0.32	0.17	0.59	1.42	0.82	0.78	2.22	1.56	0.65	0.56	0.53	0.53
'69/'70	0.11	0.44	0.28	0.11	0.83	1.09	1.00	0.88	1.07	1.39	0.68	0.57	0.54	0.54
'70/'71	0.01	0.44	0.30	0.01	0.40	0.87	0.32	0.15	0.13	0.51	0.32	0.34	0.39	0.13
'71/'72	-0.00	0.34	0.21	-0.00	0.05	1.22	0.86	0.42	0.07	-0.00	0.29	0.23	0.31	-0.00
'72/'73	0.05	0.28	0.21	0.05	0.71	1.53	0.80	0.42	0.09	0.39	0.40	0.33	0.38	0.09
'73/'74	0.00	0.35	0.22	0.00	0.68	1.94	0.73	0.29	0.09	0.83	0.52	0.48	0.50	0.09
'74/'75	0.08	0.43	0.27	0.08	0.31	1.53	1.05	0.53	0.60	0.65	0.59	0.60	0.39	0.39
'75/'76	0.28	0.35	0.48	0.28	0.57	1.06	0.68	0.38	0.29	0.89	0.39	0.52	0.53	0.29
'76/'77	0.21	0.53	0.43	0.24	0.21	0.21	0.87	0.26	0.19	0.28	0.22	0.31	0.35	0.19
'77/'78	-0.01	0.29	0.23	-0.01	0.71	2.35	1.98	1.27	1.86	1.89	0.91	0.76	0.87	0.76
'78/'79	0.46	0.97	0.77	0.46	2.55	5.73	3.18	2.42	1.69	2.86	2.49	2.04	0.86	0.86
'79/'80	0.43	1.32	1.05	0.74	0.88	0.71	0.43	0.18	-0.07	0.13	-0.01	0.15	0.25	-0.07
'80/'81	-0.08	0.22	0.45	-0.08	0.62	0.82	0.35	0.04	0.05	0.34	0.06	0.20	0.17	0.04
'81/'82	-0.05	0.12	0.12	-0.04	-0.05	0.17	0.84	0.35	0.01	0.59	0.33	0.41	0.50	0.01
'82/'83	0.41	0.45	0.41	0.65	1.45	2.01	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00

REMARK ; 999.00 MEANS NO DISCHARGE RECORD.

Table G-7 (2/4) WATER BALANCE IN RESPECTIVE SCHEME

****
WATER BALANCE OF GONJA
****

IRRIGATED BY HINGILILI C.A = 55.8 SQ.KM

RICE (IMPROVED) 300.00 HECTARES PLANTED FROM 10/ 1 IN 30 DAYS
RICE (IMPROVED) 600.00 HECTARES PLANTED FROM 2/16 IN 45 DAYS

YEAR	MIN.	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	MIN.
'63/'64	0.01	0.53	0.36	0.01	1.56	2.73	2.74	1.32	1.27	1.34	1.01	0.89	0.85	0.85
'64/'65	0.11	0.69	0.41	0.11	0.19	2.43	1.24	0.32	0.16	0.11	-0.06	0.23	0.43	-0.06
'65/'66	-0.01	0.39	0.22	-0.01	0.54	2.00	0.84	0.67	0.92	0.67	0.35	0.54	0.62	0.35
'66/'67	-0.04	0.48	0.27	-0.04	0.28	0.64	0.25	0.23	-0.26	1.25	0.52	0.51	0.60	-0.26
'67/'68	0.10	0.46	0.36	0.10	1.38	1.07	0.58	0.32	2.42	1.96	1.10	1.06	0.94	0.32
'68/'69	0.24	0.76	0.50	0.24	0.90	2.16	1.27	1.19	3.41	2.40	0.98	0.87	0.83	0.83
'69/'70	0.15	0.69	0.43	0.15	1.28	1.68	1.56	1.35	1.63	2.13	1.02	0.89	0.85	0.85
'70/'71	-0.02	0.69	0.46	-0.02	0.61	1.34	0.49	0.22	0.16	0.76	0.46	0.52	0.62	0.16
'71/'72	-0.03	0.53	0.32	-0.03	0.06	1.87	1.35	0.65	0.07	-0.03	0.42	0.35	0.50	-0.03
'72/'73	0.06	0.44	0.32	0.06	1.09	2.35	1.25	0.65	0.10	0.58	0.60	0.51	0.60	0.10
'73/'74	-0.02	0.55	0.34	-0.02	1.04	2.99	1.13	0.43	0.10	1.28	0.76	0.74	0.78	0.10
'74/'75	0.09	0.67	0.41	0.09	0.46	2.35	1.63	0.80	0.89	0.97	0.89	0.92	0.62	0.62
'75/'76	0.41	0.55	0.75	0.41	0.86	1.64	1.04	0.57	0.42	1.36	0.57	0.80	0.83	0.42
'76/'77	0.31	0.83	0.67	0.35	0.31	0.31	1.35	0.38	0.25	0.40	0.30	0.48	0.55	0.25
'77/'78	-0.04	0.46	0.36	-0.04	1.09	3.64	3.07	1.96	2.89	2.91	1.39	1.18	1.36	1.18
'78/'79	0.70	1.52	1.19	0.70	3.96	8.90	4.95	3.76	2.59	4.43	3.84	3.17	1.35	1.35
'79/'80	0.66	2.05	1.64	1.13	1.36	1.09	0.66	0.25	-0.16	0.18	-0.05	0.23	0.39	-0.16
'80/'81	-0.15	0.35	0.69	-0.15	0.95	1.25	0.55	0.04	0.04	0.50	0.06	0.30	0.27	0.04
'81/'82	-0.11	0.19	0.18	-0.08	-0.11	0.24	1.33	0.53	-0.03	0.91	0.49	0.63	0.80	-0.03
'82/'83	0.64	0.71	0.64	1.02	2.29	3.19	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00

REMARK ; 999.00 MEANS NO DISCHARGE RECORD.

Table G-7 (3/4) WATER BALANCE IN RESPECTIVE SCHEME

WATER BALANCE OF NDUNGU

IRRIGATED BY YONGOMA C.A = 70.5 SQ.KM

RICE (IMPROVED) 230.00 HECTARES PLANTED FROM 10/ 1 IN 30 DAYS
RICE (IMPROVED) 680.00 HECTARES PLANTED FROM 2/16 IN 45 DAYS

YEAR	MIN.	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	MIN.
'63/'64	0.01	0.41	0.28	0.01	1.33	2.46	2.57	1.08	2.14	1.16	0.75	0.68	0.67	0.67
'64/'65	0.09	0.51	0.32	0.09	0.12	1.96	1.13	0.14	0.03	-0.08	-0.26	0.10	0.33	-0.26
'65/'66	-0.02	0.30	0.16	-0.02	0.47	2.43	0.99	0.86	0.96	0.63	0.17	0.44	0.54	0.17
'66/'67	-0.00	0.40	0.23	-0.00	0.30	0.67	0.24	0.22	-0.34	1.29	0.56	0.42	0.51	-0.34
'67/'68	0.13	0.39	0.31	0.13	1.29	1.06	0.49	0.13	2.01	1.96	0.75	0.80	0.73	0.13
'68/'69	0.14	0.56	0.35	0.14	0.71	2.45	1.61	1.53	2.67	2.03	0.62	0.64	0.66	0.62
'69/'70	0.12	0.53	0.32	0.12	1.08	1.63	1.54	1.77	2.16	2.17	0.80	0.69	0.69	0.69
'70/'71	-0.01	0.54	0.35	-0.01	0.80	1.60	0.67	0.24	-0.01	0.51	0.17	0.35	0.48	-0.01
'71/'72	-0.04	0.40	0.24	-0.04	0.09	1.58	1.42	0.62	0.01	0.03	0.33	0.33	0.45	0.01
'72/'73	0.02	0.37	0.28	0.02	0.74	2.01	1.22	0.53	-0.08	0.40	0.38	0.36	0.48	-0.08
'73/'74	-0.02	0.41	0.25	-0.02	0.92	2.41	0.98	0.27	-0.06	0.94	0.41	0.47	0.57	-0.06
'74/'75	0.03	0.48	0.29	0.03	0.51	2.33	1.51	0.48	0.52	0.52	0.46	0.57	0.46	0.46
'75/'76	0.24	0.40	0.51	0.24	0.64	1.58	1.21	0.66	0.60	1.66	0.49	0.65	0.72	0.49
'76/'77	0.22	0.66	0.55	0.28	0.22	0.43	1.49	0.40	0.45	0.32	0.10	0.34	0.45	0.10
'77/'78	0.00	0.39	0.29	0.00	0.93	3.74	3.10	1.63	3.67	2.84	1.07	0.95	1.12	0.95
'78/'79	0.48	1.12	0.85	0.48	3.03	8.43	4.64	4.26	2.29	3.49	3.11	2.49	1.22	1.22
'79/'80	0.77	1.57	1.24	0.82	1.11	1.03	0.77	0.35	-0.02	0.46	0.07	0.32	0.47	-0.02
'80/'81	-0.06	0.41	0.55	-0.06	0.83	2.12	0.85	0.14	0.03	0.58	0.01	0.28	0.32	0.01
'81/'82	0.03	0.25	0.22	0.03	0.06	1.40	1.62	0.43	-0.15	0.75	0.35	0.68	0.67	-0.15
'82/'83	0.54	0.60	0.54	0.87	2.36	3.31	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00

REMARK ; 999.00 MEANS NO DISCHARGE RECORD.

Table G-7 (4/4) WATER BALANCE IN RESPECTIVE SCHEME

****
WATER BALANCE OF KIHURIO
****

IRRIGATED BY SASENI C.A =192.0 SQ.KM

RICE (IMPROVED) 180.00 HECTARES PLANTED FROM 10/ 1 IN 30 DAYS
RICE (IMPROVED) 930.00 HECTARES PLANTED FROM 2/16 IN 45 DAYS

YEAR	MIN.	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	MIN.
'63/'64	0.10	0.44	0.33	0.10	1.98	4.13	4.71	1.71	8.07	2.40	1.43	0.95	0.73	0.73
'64/'65	0.09	0.40	0.35	0.19	0.09	2.45	1.96	0.17	0.34	0.01	-0.46	0.06	0.32	-0.46
'65/'66	0.01	0.28	0.13	0.01	0.74	6.60	2.60	2.81	2.56	2.01	0.51	0.86	0.83	0.51
'66/'67	0.19	0.53	0.34	0.19	0.76	1.57	0.45	0.95	-0.00	2.98	1.98	0.82	0.75	-0.00
'67/'68	0.39	0.53	0.52	0.39	2.43	2.25	0.67	0.06	3.10	4.71	1.03	1.00	0.75	0.06
'68/'69	-0.01	0.46	0.22	-0.01	0.82	6.19	4.52	4.80	3.66	3.65	0.88	0.80	0.74	0.74
'69/'70	0.23	0.54	0.28	0.23	1.63	3.29	3.12	5.44	6.88	5.40	1.68	1.01	0.87	0.87
'70/'71	0.08	0.59	0.35	0.08	2.37	4.25	2.06	1.11	0.18	1.02	0.17	0.39	0.51	0.17
'71/'72	-0.00	0.34	0.22	-0.00	0.33	2.28	3.21	1.56	0.75	1.12	1.02	0.89	0.77	0.75
'72/'73	-0.03	0.52	0.46	-0.03	0.32	2.99	2.43	1.15	0.15	0.94	0.68	0.50	0.58	0.15
'73/'74	0.02	0.37	0.23	0.02	1.50	2.96	1.58	0.54	0.30	1.23	0.45	0.28	0.46	0.28
'74/'75	-0.07	0.32	0.17	-0.07	1.25	4.81	2.71	0.38	0.71	0.39	0.19	0.25	0.40	0.19
'75/'76	-0.06	0.30	0.21	-0.06	0.60	3.12	3.11	2.10	2.73	5.09	1.47	1.13	1.09	1.09
'76/'77	0.21	0.74	0.76	0.40	0.21	1.36	3.57	1.26	2.59	1.26	0.32	0.51	0.59	0.32
'77/'78	0.23	0.56	0.38	0.23	1.42	8.11	6.58	2.62	10.67	6.27	1.90	1.46	1.43	1.43
'78/'79	0.28	0.88	0.56	0.28	2.96	15.80	8.55	10.96	4.45	4.72	4.43	2.98	2.06	2.06
'79/'80	0.68	1.55	1.16	0.68	1.51	1.93	1.95	1.57	1.29	2.67	1.34	1.28	1.28	1.28
'80/'81	0.24	1.07	0.64	0.24	1.33	7.50	2.85	1.21	0.60	2.03	0.62	0.79	0.83	0.60
'81/'82	0.52	0.70	0.59	0.52	0.79	7.04	4.36	0.95	0.21	1.67	0.98	0.74	0.96	0.21
'82/'83	0.76	0.85	0.76	1.34	5.16	7.26	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00

REMARK ; 999.00 MEANS NO DISCHARGE RECORD.