but the price is decided through auctioning on the Harare or Mutare Tobacco Auction Floor which is approximatery 340 km and 170 km away from the study area, respectively. The transportation of tobacco leaves from the farm gates to the Tobacco Auction Floor is difficult for individual communal farmers because they have no long-distance transportation facilities at present. Consequently, the farmers' association in the study area should take actions to improve these transportation facilities. In addition, it should be noted that tobacco production will increase up to approximately 440 tons which is the target yield in five years after the construction of the irrigation facilities.

The price of vegetables is decided in the common markets in townships or villages. Farmers' association in the study area should organize farmer cooperation in marketing activities, especially for unifying the quality of vegetables and stabilizing vegetable prices by controlling shipments. The transportation of vegetables is also important similarly to the case for tobacco. In addition, road conditions for the shipment of farm products to the market should be improved.

4.4.5 Farm Economy

The information on farming economies provided by GMB, CMB, TMB, AGRITEX and interviews with farmers in the study area are put together and analyzed for the farming economy of the model farm in the study area. Abundant agricultural benefits are expected in the proposed irrigated model farms.

4.4.6 Agricultural support Services

(1) Farmers Association

After the irrigation facilities are constructed, it is necessary to organize an active and functional farmers' association in the new irrigation area.

The duties of the proposed farmers' association will be as follows:

1) To plan and coordinate the cropping schedules of individual farmers in the irrigation area consulting with the AGRITEX irrigation officers,

2) To plan and coordinate the operation schedule of the tractors to implement the proposed cropping schedule,

3) Perform cooperative activities for purchasing, transporting and deliverring the necessary agricultural inputs and selling output products produced by cooperative members.

It is highly desirable to cooprate with the NFAZ Clubs, village units of the National Farmers Association of Zimbabwe(NFAZ).

(2) Agricultural Extension Services

After the irrigation facilities are constructed, the farmers in the irrigated area should consult with the AGRITEX officers with regard to irrigation management, practices for planting newly introduced crops such as tobacco and onion, vegetable quality control and the operation of the tractors.

The AGRITEX Nyanga Regional Office is expected to perform a wide range of the extension activities as mentioned above to the benefited farmers.

(3) Financial Support

To implement this project, the area planted with tobacco will increase up to 204 hectares(target), or 0.3 hectares for each individual farmer. These farmers are requested to build up new tobacco barns for curing. However, some farmers lack the funds to build barns especially at the initial stage of the project. Therefore, the Agricultural Finance Corporation(AFC) is expected to provide loans to farmers who lack funds.

Table 4.4.1 FARMING PRACTICES (1)

Crops	Soil fumigation		Plough/ Harrow	Row making	Fertilizers		Planting/ Transplantig*
	Materials/Methods	Application			Materials	Application	
Maize	—	—	before planting	before planting	Compound D 300 kg/ha	before planting	E. Oct. – M. Oct.
Cotton	—	—	before planting	before planting	Compound L 350 kg/ha	before planting	M. Oct. – L. Oct.
Sugar beans	—	—	before planting	before planting	Compound D 200 kg/ha	before planting	E. Mar. – M. Mar. E. Jun. – M. Jun.
Tobacco (Nursery)	EDB 41% WM, 1:3 water 2l/90m² bed/ha, 5ml/shot 38x38cm, 30cm depth	14 days before planting			Compound S 100 kg/ha	before planting	M. Aug. – L. Aug.
Tobacco (Land)	EDB 41% WM, 1:3 water 20l/ha, 3ml/shot 30cm depth, 38cm furrow	14 days before transplanting	before transplanting	before transplanting	Compound B 1200 kg/ha	before transplanting	M. Nov. – L. Nov.
Wheat	—	—	before planting		Compound D 300 kg/ha	before planting	E. May. – M. May. E. Jun. – M. Jun.
Groundnuts	—	—	before planting	before planting	Compound L 200 kg/ha	before planting	L. Oct. – E. Nov. M. Nov. – L. Nov.
Onion (Nursery)	—	—			Compound S 60 kg/ha	before planting	E. Feb. – M. Feb.
Onion (Land)	—	—	before transplanting	before transplanting	Compound S 500 kg/ha	before transplanting	L. Mar. – E. Apr.
Cabbage ** (Nursery)	—	—			Compound S 60 kg/ha	before planting	L. Feb. – E. Mar.
Cabbage ** (Land)	—	—	before transplanting	before transplanting	Compound D 1000 kg/ha	before transplanting	E. Apr. – M. Apr.

Note: * E. = Early, M. = Middle and L. = Late, and

** Cabbage is alternative crop for future production depending on marketing requirement.

[cont.]

Table 4.4.1 FARMING PRACTICES (2)

Crops	Varieties	Plant space		Population	Seed requirement	Seed Treatment	Herbicides/ Application	Thinning
		Between rows(cm)	Within row(cm)	(plants/ha)	(/ha)			
Maize	R215 R201 SR52	80	25	50,000	30-35 kg	Treated by the Maize Seed Coop	Atrazine 80%wp 2.8 kg/ha pre-emergence	——
Cotton	K602 K502	90	30	37,000	25-30 kg	Benodanil 2.5g/kg seed	Cotoran 80%wp 3.2 kg/ha pre-emergence	2-3 weeks after germination
Sugar beans	Natal sugar	70	20	71,000	80-100 kg	Thiram 2g/kg seed	——	2-3 weeks after germination
Tobacco (Nursery)	Banket A1 Banket 21 Banket 102	Seedbed 120m²/ha			8-10g/Seedbed		——	If needed
Tobacco (Land)	do	120	55-60	14,500	——	——	——	——
Wheat	Torim 73 Angwa	Broadcast			80-100 kg	——	——	——
Groundnuts	Valencia R1 & R2 Natal common Makulu red	45	15	148,000	80-120 kg	Thiram 1.7g/kg seed	——	——
Onion (Nursery)	Dessex hybrid de Wildt Pyamid	Seedbed 300m²/ha			3 kg/Seedbed		——	If needed
Onion (Land)	do	25	12	333,000	——	——	——	——
Cabbage ** (Nursery)	Golden acre Cape spitz	Seedbed 300m²/ha			250g/Seedbed	Thiram 2g/kg seed	——	If needed
Cabbage ** (Land)	do	50	45	44,000	——	——	——	——

Note: *** 1) A.N. = Ammonium Nitrate, and 2) Applying weeks after germination or transplanting.

[cont.]

Table 4.4.1 FARMING PRACTICES (3)

Crops	Topdress *** fertilizers	Interculture Re-ridging	Weeding	Irrigation	Pests/Diseases	Applications	Interval
Maize	A.N. 150 kg/ha 4-6 weeks	5-7 weeks after germination	2 times, 4-6 weeks after germination	If needed	Stalk borer Streak virus	Corbaryl 85%wp 200g/100lwaterx5/ha	If needed
Cotton	A.N. 125 kg/ha 2 times 4-10 weeks	5-10 weeks after germination	5 times, 5-17 weeks after germination	do	Red bollworm Helio this bollworm	Thiodan 50%wp 500g/ha Carbaryl 85%wp 500g/ha	Weekly spray 5-8 times
Sugar beans	A.N. 100 kg/ha after flowering	——	2 times, 2-8 weeks after germination	do	Helio this bollworm Red bollworm Rust	Carbaryl 85%wp 200g/100lwaterx4/ha Mancozeb 80%wp 300g/100lwaterx4/ha	If needed
Tobacco (Nursery)	A.N. if needed	——	If needed	do	Aphids	Cypermethrim 20%ec 50ml/100lwaterx4/ha Decamethrin 2.5%ec 120ml/100lwaterx4/ha	Every
Tobacco (Land)	A.N. 100 kg/ha 3 times 3-12 weeks	4-8 weeks after transplanting	2 times, 2-6 weeks after transplanting	do	Alteroraria	Anilirine 100g/a00lwaterx4/ha	2 weeks
Wheat	A.N. 150 kg/ha 4-6 weeks	——	2 times, 2-6 weeks after germination	do			
Groundnuts	Gypsum 100 kg/ha 2 times 8-12 weeks	——	3 times, 2-10 weeks after germination	do	Leaf spot	Copper oxychloride 85%wp 500g/400lwater/ha	Every 2 weeks
Onion (Nursery)	A.N. 350 g/m² 2-3 weeks	——	If needed	do	Thrips Purple blotch fungus Downy mildew	Endosulfan 50%wp 100g/100lwaterx3/ha	If needed
Onion (Land)	A.N. 100 kg/ha 4-6 weeks	——	4 times, 2-14 weeks after transplanting	do		Dithane M45 200g/100lwaterx3/ha	
Cabbage ** (Nursery)	A.N. if needed	——	If needed	do	Diamond block moth Downy mildew	Endosulfan 35%ec 140ml/100lwaterx4/ha	If needed
Cabbage ** (Land)	A.N. 100 kg/ha 2 times 3-6 weeks	——	2 times, 2-6 weeks after transplanting	do		Dithane M45 200g/100lwaterx4/ha	

[cont.]

Table 4.4.1 FARMING PRACTICES (4)

Crops	Harvesting *	Growth duration (days)	Threshing/ Picking Shelling	Drying/ Curing	Bagging	Marketing	Remarks
Maize	L.Feb.- E.Mar.	140	Shelling	Drying	91kg/bag	Grain Marketing board	
Cotton	E.May- M.May	200	Picking 4-6weeks		180kg/bale	Cotton Marketing Board	
Sugar beans	E.May- M.May E.Sep.-M.Sep.	90 90	Threshing	Drying	91kg/bag	Grain Marketing Board	
Tobacco (Nursery)	M.Nov.-L.Nov.	75	—	—	—	—	
Tobacco (Land)	L.Mar.-E.Apr.	130	—	Curing 5-6weeks	45-70 kg/bale	Tobacco Marketing Board	Topping 10% flowering, suckering 15cm long 2times
Wheat	E.Sep.-M.Sep. E.Oct.-M.Oct.	120 120	Threshing	Drying	91kg/bag	Grain Marketin Board	
Groundnuts	L.Feb.-E.Mar.	120	Picking at 10% moisturere Shelling foror seed use only	Drying	Unshelled 40kg/bag Shelled 80kg/bag	Grain Marketing Board	
Onion (Nursery)	L.Mar.-E.Apr.	50	—	—	—	—	
Onion (Land)	L.Sep.-E.Oct.	180	—	—	12.5 kg/pocket	Free Market	
Caggage (Nursery)	E.Apr.-M.Apr.	40	—	—	—	—	
Caggage (Land)	L.Jul.-E.Aug.	110	—	—	15kg/bale	Free Market	

Note: * E.= Early, M.= Middle and L.= Late.

Table 4.4.2 PRESENT AND TARGET YIELDS

Type of Cropping System	Crops	Target Area (ha)	Present Unit Yield (t/ha)	Target Unit Yield (t/ha)	Target Total Yield (t/year)
Type I	(Summer crops)				
	Maize	204	2.80	6.00	1,224
	Cotton	204	1.46	2.80	571
	Tobacco	204	0.94	2.40	490
	(Late Summer crop)				
	Sugar beans 1	204	1.08	1.60	326
	(Winter crop)				
	Sugar beans 2	204	-	1.70	346
	Wheat 1	204	-	3.50	714
	Wheat 2	204	-	3.50	714
Type II	(Summer crops)				
	Groundnuts	34	-	3.00	102
	Maize	34	2.80	6.00	204
	(Late Summer crop)				
	Sugar-beans 1	34	1.08	1.60	54
	(Winter crops)				
	Onion	34	-	20.00	680
	Wheat 2	34	-	3.50	119

Note: 1)Tobacco = Air-cared tobacco, and
2)Groundnuts yield = Unshelled.

4.5 Land Consolidation Plan

4.5.1 Farm Plot Plan

The setting up the size for a farm plot mainly depends on the scale of the land holding per farmer and the scheduled cropping system.

In the project land use plan, a scale of irrigated land holding per farmer was scheduled at one hectare on average. The proposed cropping systems were scheduled as types of type I and type II as described in 4.4.1. Type I is divided into three cropping patterns, pattern a, b and c,and these patterns are to be rotated year by year and type II divided into two cropping patterns, pattern d and e,also these patterns are to be rotated year by year. Accordingly,three plots for cropping system type I and two plots for type II are required, therefore five plots in total per farmer are required on the assumption that all farmers follow the proposed cropping system.

The cropping ratios for each type have been scheduled to be thirty percent each for patterns a,b and c in cropping system type I and five percent each for patterns d and e in cropping system type II. Thus, the unit plot sizes are required to be 0.3 ha each for patterns a, b and c in system type I and 0.05 ha each for the pattern d and e in the system type II, because the scale of the irrigated land holding per farmer is scheduled to be one hectare.

It should be considered that after the implemetation of the project, smooth and effective irrigation practices in each irrigation block are expected, and easy irrigation water management is to be implemented, the cropping patterns which are controled to be irrigated under each tertiary canal will be unified in the cropping rotation.

Taking into consideration the above mentioned a cropping zone consisting of the same cropping plots have been scheduled , that is ,three zones a,b, and c for cropping system I and two zones d and e for system II, and the cropping rotations are carried out in each system respectively.

The allocation of these plots per farmer is expected to each be one plot from a,b,c,d,and e zones respectively. Thus , each farmer will be able to hold five plots and the irrigated land of one hectare in total. Moreover,irrigation practices are expected to be easy in each irrigation block.

The layout of the irrigation zones in each irrigation block is followed by conditions such as topography, the scale and shape of the block and so on. A standardized layout of the applied farm plot plan is determined and shown in Table 4.5.1 and Fig.4.5.1 respectively.

4.5.2 Land Grading Work

For each farm plot in the irrigation block land leveling work will only be carried out based on the plot re-arranging plan in this scheme. Therefore , the movement of soil beyond the plot boundary will not be fulfilled.

Based on the soil survey, the depth of the plow layer is between ten and fifteen centimeters, so in the case where removing a soil depth of more than ten centimeters, the surface soil handling work will be done during the levelling work. The work to be carried out is twenty percent of the total irrigation area.

4.5.3 Irrigation and Drainage Canal Network Plan

(1) Irrigation Canal Network Plan

For the purpose of distributing irrigation water sent to each night storage dam, an irrigation canal network plan is required in each block. The canal will be constructed along the higher parts of each block as a type of an arborescene system.

The type of canal adopted has a concrete lined section aiming to cut off seapage water and for easy maintenance. The method of distributing water to the field is through a syphone system, therefore the water surface level in the canal is to be keep at more than 20 ~ 30cm higher than adjoining fields plot levels or at the same level of the road's surface.

According to necessity, drop work and soil pits will be installed in the canal network. The end of the canal concects to same drainage canal or a natural drain aiming at taking out surplus water and the remaining water in the canal.

(2) Drainage Canal Network Plan

For the purpose of displacing rainwater in the irrigation block, a drainage canal network will be in each block. The canal route is sellected to be along lower place much like a natural drain or a small stream.

The canal will be an earth canal with a 50cm depth width and 1:1.0 side slope. The canal's height is between 80cm and 100cm with the canal discharge.

The slope of the long section will be less than 1:500 for the protection of soil erosion. According to necessity, drop work and soil pits will be installed in the canal network.

4.5.4 Farm Road Plan

The trunk road plans between the national road and each pump station and between the national road and marketing facilities in each block is to be used transport by trucks. on the other hand, the farm road plans are also transport to the blocks, collection and the sending of crops and the carring of farm machinary. The farm road will be placed higher in each block.

The road widths are 5.0m for trunk roads and 3.0m for farm roads. The soil embankment heights will be between 30 ~40cm. The pavement will be gravel with 10cm depth for 4.0m widths and 2.5m widths for trunk roads and farm roads respectively.

Table 4.5.1 LAYOUT OF FARM PLOTN BLOCK

Irrigation Area	Irrigation Zone	Size of Irrigation Unit	Nos. of Unit	Others	Rotation
A 115 ha	a (30%)	300m x 570m = 17.1ha	2 nos.	0.3 ha	0.3 ha-0.3 ha-0.3 ha
(A-1 10 ha)	b (30%)	-do-	2 nos.	0.3 ha	0.3 ha-0.3 ha-0.3 ha
(A-2 105 ha)	C (30%)	-do-	2 nos.	0.3 ha	0.3 ha-0.3 ha-0.3 ha
	d+e (10%)	33.3m x 330m= 1.1ha	10 nos.	0.8 ha	0.4 ha-0.4 ha
B 128 ha	a (30%)	300 m x 630m= 18.9ha	2 nos.	0.6 ha	0.6 ha-0.6 ha-0.6 ha
(B-1 38 ha)	b (30%)	-do-		0.6 ha	
(B-2 19 ha)	c (30%)	-do-		0.6 ha	
(B-3 71 ha)	d+e (10%)	33.3m x 360m= 18.9ha		0.1 ha	0.4 ha-0.4 ha
C 140 ha	a (30%)	300 m x 690 m= 20.7ha	2 nos.	0.6 ha	0.6 ha-0.6 ha-0.6 ha
(C-1 46 ha)	b (30%)	-do-		0.6 ha	
(C-2 47 ha)	c (30%)	-do-		0.6 ha	
(c-3 47 HA)	d+e (10%)	33.3m x 600m= 1.988ha	7 nos.	0.1 ha	0.05 ha-0.05 ha
D 203 ha	a (30%)	300 m x 600 m= 1.98ha	3 nos.	1.5 ha	1.5 ha-1.5 ha-1.5 ha
(D-1 122 ha)	b (30%)	-do-		1.5 ha	
(D-2 81 ha)	c (30%)	-do-		1.5 ha	
	d+e (10%)	33.3m x 600m= 1.998ha	10 nos.	1.32ha	0.16 ha-0.16 ha
E 94 ha	a (30%)	300 m x 450m= 13.5 ha	2 nos.	1.8 ha	1.8 ha-1.8ha-1.8 ha
(E-1 43 ha)	b (30%)	-do-			
(E-2 51 ha)	c (30%)	-do-			
	d+e (10%)	33.3m x 540m= 1.782ha	5 nos.	0.31ha	0.155ha-0.155ha

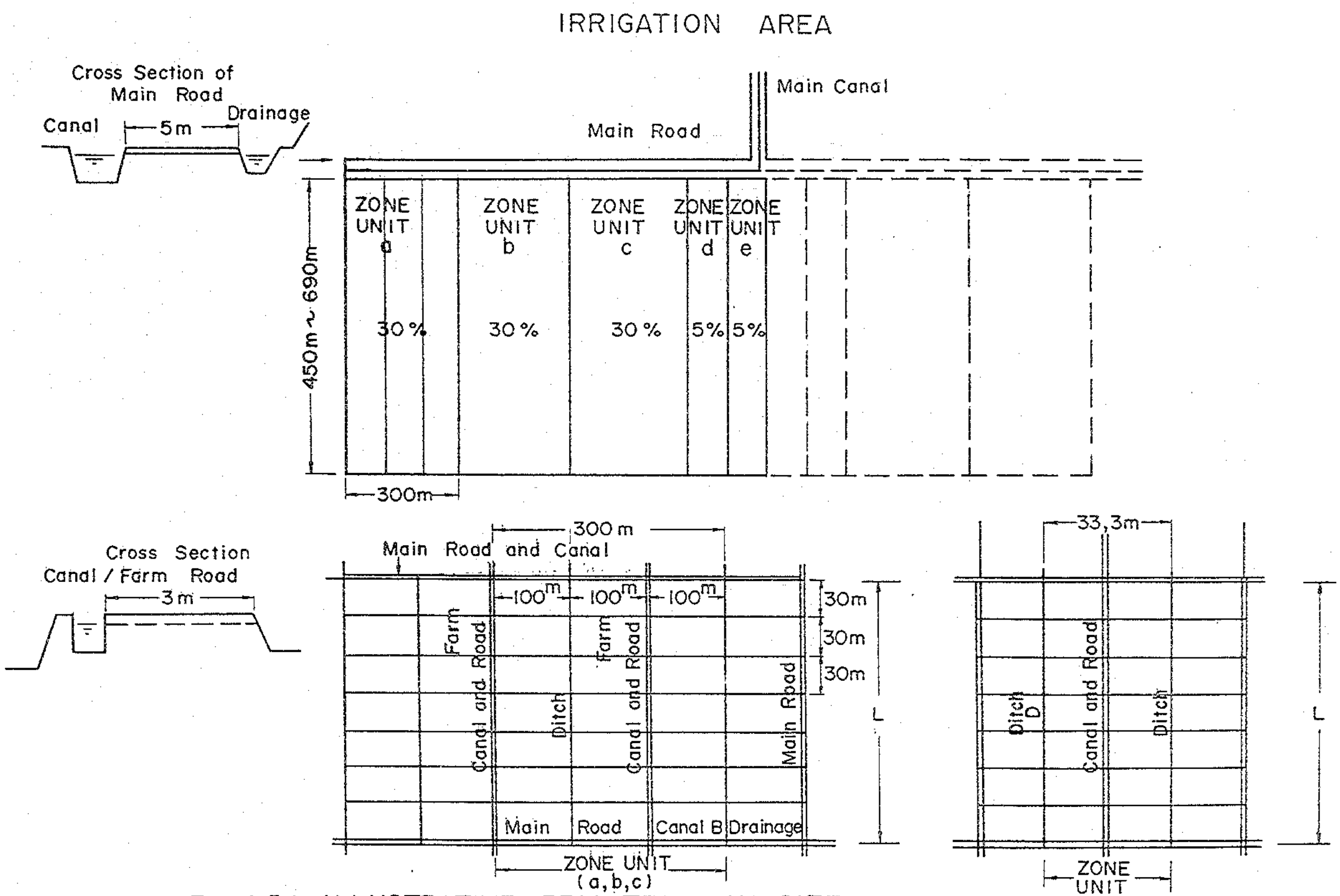


Fig.4·5·1 ILLUSTRATIVE IRRIGATED LAND SIZE

4.6 Irrigation and Drainage Plan

4.6.1 Irrigation Water Requirements

(1) Irrigation Area

The irrigation areas have been scheduled on the portions of land with capability ranking classes I and II, based on the soil survey results in consideration with the topographic conditions and the easy access to water sources. The total net irrigation area is 680 ha and it consits of five irrigation blocks from A to E. These irrigation blocks are divided into twelve sub-blocks. The irrigation areas are as follows.

Irrigation Block	Area (ha)	Irrigation Block	Area (ha)
A	115	D	203
A-1	10	D-1	122
A-2	105	D-2	81
B	128	E	94
B-1	38	E-1	43
B-2	19	E-2	51
B-3	71		
C	140	Total	680
C-1	46		
C-2	47		
C-3	47		

(2) Crop Water Requirements

The crop water requirements for the scheduled cropping systems are basically estimated with the Modified Penman Method.

The net crop water requirements ETC are expressed;

$ET_c = ET_0 \times k_c$ Where ET_0 = reference crop evapotranspiration,
k_c = crop coefficient.

The values of monthly mean reference crop evapotranspiration ET_0 have been estimated using the Reference Crop Evapotranspiration Maps(ET_0 Maps) which are generally used for irrigation planning in ZIMBABWE. The maps are shown in Annex

Fig. E.4.6.1.

The crop coeficients of the scheduled crops kc are derived from "Table 21 FAO IRRIGATION AND DRAINAGE PAPER 24, Revised 1977 (FAO Paper)" and the kc values of crops applied to the project are shown in Table E.4.6.2 and Fig. E.4.6.2 in ANNEX.

The monthly mean ETOs which are given graphically from Fig. E.4.6.1 are shown in Table E.4.6.1. Moreover, coefficients of corrected ETOs for the peak demand are given with Fig.10 of the FAO Paper. The coefficient values are shown in ANNEX Table E.4.6.3.

Crop coefficient monthly mean values per crops are given graphically in ANNEX Fig. E.4.6.2 and the kc values per crop are shown in ANNEX Table E.4.6.5. Monthly mean crop water requirements of the schduled crops are also shown in the Table.

(3) Effective Dependable Rainfall

The crop water and irrigation requirements for irrigation planning have been calculated using the effective dependable rainfall at an 80 percent exceedance also the crop and irrigation requirements for operation and maintenance of the irrigation have been calculated.

The irrigation requirement values which shall be applied for estimating the operation and maintenance costs of the project are calculated using the effective dependable rainfall at a 50 percent exceedance.

The effective dependable rainfalls both at 80 percent and 50 percent exceedance are calculated using monthly rainfall records for eighteen years from 1971/72 till 1988/89 at the Namaropa Irrigation Station, and these results are shown in Table E.4.6.6,Table E.4.6.7 and Fig. E.4.6.3 in ANNEX respectively.

(4) Crop Water and Irrigation Requirements

Using the factors mentiond above, the water and irrigation requirements of the scheduled crops have been estimated and these results are shown in Table 4.6.1 and Table 4.6.2 respectively.

Table 4.6.1 shows that the irrigation requirements at field level is 8,928,800 m^3 per year. While the irrigation requirements at a 50 percent exceedance of effective dependable rainfall are counted to be 6,623.300 m^3 per year. The peak water demands occur in July and August respectively.

4.6.2 Field Irrigation Schedules

(1) Depth of Irrigation Application

The depth of irrigation application is the depth of water that can be stored within the root zone between the so-called field capacity (sfc) and the allowance level of the soil's water that can be depleted for a given crop soil and climate.

The Depth of irrigation application including application losses is

$d = (p \times S)D/Ea$ mm and frequency of irrigation expressed as irrigation intervals for individual field (i) is:

$i = (P.Sa)D/ETC$ days

where: P : Fraction of availavle soil water permitting unrestricted evapotranspiration, (fraction)

Sa: Total availavle soil water, (mm/m in soil depth)

D : Rooting depth, (m)

Ea: Application efficiency, (fraction)

For the design and operation of the water distribution system, the supply requirements of the individual fields are expressed in flow rates or stream size (q in m³/sec) and supply duration (t in seconds hours or days).

The field supply (q.t) is :

$$q.t = 10\,(P.Sa)D.A / Ea, \ (m^3)$$

where q : Stream size, (m^3/sec)

t : Supply duration, (sec)

Ea: Application efficiency, (fraction)

P : Fraction of available soil water permitting unrestricted evapotranspiration, (fraction)

Sa: Total available soil water, (mm/m in soil depth)

D : Rooting depth (m)

A : Acreage, (ha)

The capacity of the distribution system is based on the supply requirements during the peak water use months.

(2) Calculation of (d) and (i)

1) Depth of irrigation Application (d)

The depth of irrigation applications during the peak water use months per crop are calculated and shown in ANNEX Table E.4.6.3.

2) Irrigation application interval (i)

The irrigation interval is determind from : i = (P.Sa)D/ETC and the results are shown in Table 4.6.4.

Table 4.6.1 IRRIGATION APPLICATION INTERVAL PER CROPS

Crop	Month	P	Sa	(P.Sa)	D	(P.Sa)D	ETC	i
			mm/m	mm/m	m	mm	mm/day	day
Sugar	Jul.	0.45	160	72.0	0.6	43.2	4.2	10.3=10
beens 2	Aug.	0.45	-do-	-do-	-do-	-do-	5.5	7.9= 8
Wheat 2	Jul.	0.55	-do-	88.0	1.2	105.6	4.0	26.4=26
	Aug.	0.55	160	88.0	1.2	105.6	5.2	20.3=20
Wheat 1	Jul.	-do-	-do-	-do-	-do-	-do-	4.0	26.4=26
	Aug.	-do-	-do-	-do-	-do-	-do-	5.2	20.3=20
Onion	Jul.	0.25	-do-	40.0	0.5	20.0	3.4	5.9= 6
	Aug.	-do-	-do-	-do-	-do-	-do-	5.1	3.9= 4

(3) Field Irrigation Supply Schedule

Field irrigation supply has been calculated as follows.

$$q.t = 10\ (P.Sa).D.A\ /\ Ea\ (m^3)$$

Field irrigation supply per hectare for each crop is shown in Table 4.6.2.

Table 4.6.2 FIELD IRRIGATION SUPPLY PER CROP

Crop	Month	Soil Texture	(P.Sa)D	Ea	A	q.t
			mm		ha	m³
Sugar	Jul.	Fine textured	43.2*	0.65	1.0	665
beans 2	Aug.	soil	43.2*	0.65		665
Wheat 2	Jul.		105.6*	0.65		1,625
	Aug.		105.6*	0.65		1,625
Wheat 1	Jul.		105.6*	0.65		1,625
	Aug.		105.6*	0.65		1,625
Onion	Jul.		20.0*	0.65		308
	Aug.		20.0*	0.65		308

Note : * Numerics are derived from Table 4.6.4.

In surface irrigation, the stream size depends mainly on the type of soil or infiltration rate, on the method of surface irrigation and the number and size of furrows or basins that can be irrigated simultaneously.

In the case of the furrow method, to attain uniform water distribution the flow of water to each furrow should be at least two times or more of that required for the average soil intake rate, i.e. the water should be applied between 0.2 and 0.4 of the time necessary for the required depth of water to enter the soil. In the case of furrow irrigation, the flow of water per furow should be large enough to reach the end of the run, and small enough not to cause erosion, flood and tail losses.

In this irrigation plan, the average size of a plot is to be 30 meters by 100 meters, the acreage is 0.3 hectares, to make the land surface familiar with present topographic conditions, from the point of view of protection from surface erosion.

Based on these considerations mentioned above, the scheduled peak stream size and irrigation supply of water are calculated. The results of these calculations are shown in Table E.4.6.11 in ANNEX.

(4) Maximum Water Supply Demends at the Pumping Station

1) Peak Irrigation Supply Demand

In each irrigation block, peak irrigation supply demands occur in June and August. These peak irrigation supply demands for each irrigation block at field level are shown in Table 4.6.6 in ANNEX. Taking into consideration of the conveyance loss in the canals, the peak irrigation supply demands at the pumping stations are estimated as below.

Table 4.6.3 Peak irrigation supply demands of pumping stations

Irrigation block	Area	Peak demand at field level	Conveyance efficience	Peak demand at pumping sta.
	(ha)	(l/sec)		(m^3/sec)
A	115	230	0.85	0.271
A-1	10	20		0.024
A-2	105	210		0.347
B	128	256	0.85	0.302
B-1	38	76		0.090
B-2	19	38		0.045
B-3	71	142		0.167
C	140	281	0.85	0.329
C-1	46	92.4		0.109
C-2	47	94.3		0.110
C-3	47	94.3		0.110
D	203	407	0.85	0.479
D-1	122	245		0.288
D-2	81	162		0.191
E	94	189	0.85	0.223
E-1	43	86.5		0.102
E-2	51	102.5		0.121
Total	680	1,363		1.604

2) Maximal Water Supply Demands at Pumping Stations

Maximal supply demans at pumping stations are the total of the peak irrigation supplies and the domestic water supplies. The supply demands for designing sizes of pumps are shown as follows.

Table 4.6.4 Supply demands for designing sizes of pumps

Irrigation block	Peak irrigation demand (m^3/sec)	Domestic supply * (m^3/sec)	Total (m^3/sec)
A	0.271	0.0019	0.273
B	0.302	0.0021	0.304
C	0.329	0.0023	0.331
D	0.479	0.0032	0.482
E	0.223	0.0015	0.225
Total	1.604	0.0110	1.615

Note) * : Values of domestic water supply are derived from 4.7.3.

(5) Water Supply Demands for Estimating Operation Costs of Pumps

Water supply demands for estimating the operation costs of pumps are based on the irrigation supply demands with effective dependable rainfall of fifty percent probability, (Criteria in ZIMBABWE) and the the domestic supply demands.

The water demands are estimated as follows.

Table 4.6.5 Estimated Supplied Demand by Pump

Irrigation area (Pumping station)	Irrigation supply demand (m^3)	Domestic supply demand (m^3)	Total (m^3)
A	1,317,900	29,300	1,347,200
B	1,466,600	32,800	1,499,400
C	1,604,000	36,200	1,640,200
D	2,326,400	50,000	2,376,400
E	1,033,300	24,200	1,057,500
Total	7,748,200	172,500	7,920,700

Note: - Corrected irrigation supply demand = Irrigation supply demand ÷ 0.85

- Irrigation supply demand is shown in Table 4.6.2.
- Conveyence efficiency of canal is applied at 0.85.

4.6.3 Irrigation System Plan

(1) Location of Irrigation Area

The irrigation blocks are dispersed in oder of blocks A,B,C,D and E from the upper stream to the down stream along the Gairezi river, and the elevations of the irrigation areas are higher at about 10 to 40 meters higher than the water surface of the Gairezi river. Accordingly, the irrigation water supply system in each irrigation block was scheduled to be a pump up system from the Gairezi river. The irrigation areas have been stated in 4.6.1, the locations are shown on the general map.

(2) Selection of Pump Stations

One pumping station for each irrigation block from block A to E, therefore five pumping stations in total have been scheduled, in consideration of easy water supply operations.

The locations of pumping stations are selected to be at the top of the Gairezi river bank where there is good access with a pump head from each irrigation block, also to be on a steady river stream site and where pumps suction will not be affected with sedimentation.

(3) Pumping Discharge

Pumping discharge for each station is designed based on water supply demands which are derived from Table 4.6.4, and the factors are as follws.

- Pumping hours 12 hours/day
- irrigation hours 1.44 to 11 hours

Maximum pumping discharge at each pumping station is shown below.

Pumping Station Area (ha)		Max.Water Demand (m^3/sec)	Designed Pumping Discharge (m^3/min)
A	115	0.273	16.4
B	128	0.304	18.2
C	140	0.331	19.9
D	203	0.482	28.9
E	94	0.225	13.5
Total	680	1.615	96.9

(4) Night Storage Dam (NSD)

After the establishment of irrigation system networks in each irrigation block, the system should operate smoothly and effectively for the field irrigation scheduled for each block.

Taking into consideràtion these matters, the followings should be solved in the irrigation system plan;

- Field irrigation hours per day vary from 1.44 hours to 11 hours according to the scheduled crropping systems.
- The dissolution of a time lag that is a passage time until the irrigation water reaches each block after being discharged from each pumping station should be considered.
- Domestic water supply has been scheduled using the irrigation system.

These matters will cause fluctuations in the stream size of the field irrigation supply. To avoid and to steady supply to the irrigation water field, night storage dams are scheduled in the irrigation systems. And the night storage dams scheduled in each irrigation block are as follows.

Irrigation Block	Night Storage Dam	
A	2 dams	NSD A-1, NSD A-2
B	3 dams	NSD B-1, NSD B-2, NSD B-3
C	3 dams	NSD C-2, NSD C-2, NSD C-3
D	2 dams	NSD D-1, NSD D-2
E	2 dams	NSD E-1, NSD E-2
Total 5	12 dams	

The night storage dam capacity is decided according to a one hour volume pumping discharge and surplus volume. The former is set up to cover the volume caused by time lag that is assumed to be between 20 minutes and 40minutes,and the latter is the equivalent volume which is assumed to be twenty percent of the original volume that was cause by other factors. The night storage dam capacities are estimated as follows.

NSD	Irrigation Area	One Hour Volume(A)	Design Volume(B)
	(ha)	(m^3)	(A) × 1.2 (m^3)
A-1	10	86.4	103.7
A-2	105	899.2	1,067.0
B-1	38	324.0	388.8
B-2	71	162.0	184.4
B-3	19	608.4	370.1
C-1	46	396.0	475.2
C-2	47	396.6	479.5
C-3	47	396.6	479.5
D-1	122	1,044.0	1,252.8
D-2	81	691.2	829.4
E-1	43	370.8	445.0
E-2	51	439.2	527.0

(5) Irrigation System Networks

The irrigation system networks are scheduled independently per irrigation block. The water supply is sent from the pumping station to the night storage dam (NSD) by a pipeline and from the NSD to the irrigation fields by an open canal system. The water head in the tertiary canal field plots is kept at a head of 0.5 meters to easily irrigated the field from the canal. All irrigation canals are paved with concrete to save water loss and to make easy the operation and maintenance of the irrigation system.

The irrigation system networks are shown in Fig. 4.6.1.

(6) Domestic Water Supply

As described in 4.7.3, the domestic water is counted in the supply with the irrigation system networks. This water shall be supplied at the open canal after the NSD, but no facilities are scheduled in this project.

4.6.4 Drainage Plan

(1) Conseption of Drainage Plan

On assumption that drainage systems have been covered with naturally originated draine in the area, a drainage canals are arranged in each irrigation block aiming to drain any surplus rainwater.

The canals are to be placed in same lower strips which are presently being used as natural drains.

The drainage canals are principallu designed with earth canal and drops, sedimentation tanks and protection weirs are considered to install in each canal to protect the occuring erosion in accordance with needs.

(2) Unit Area Drainage Discharge

The unit area drainage discharge are estimated using a rainfall at the time of concentration for two hours for the mountain area and the rainfall at the time of concentration for four hours, for the irrigation area.

The calculation methods are as follows.

$$R_t = R_{24}(t/24)^k$$

Where R_t : Rainfall at the time of concentration for t hour(mm)

R_{24} : Rainfall per day at ten year probability (mm)

k : 1/2

The rainfall per day (R_{24}) is culculated to be 123.2mm (refer to 4.2.1), and

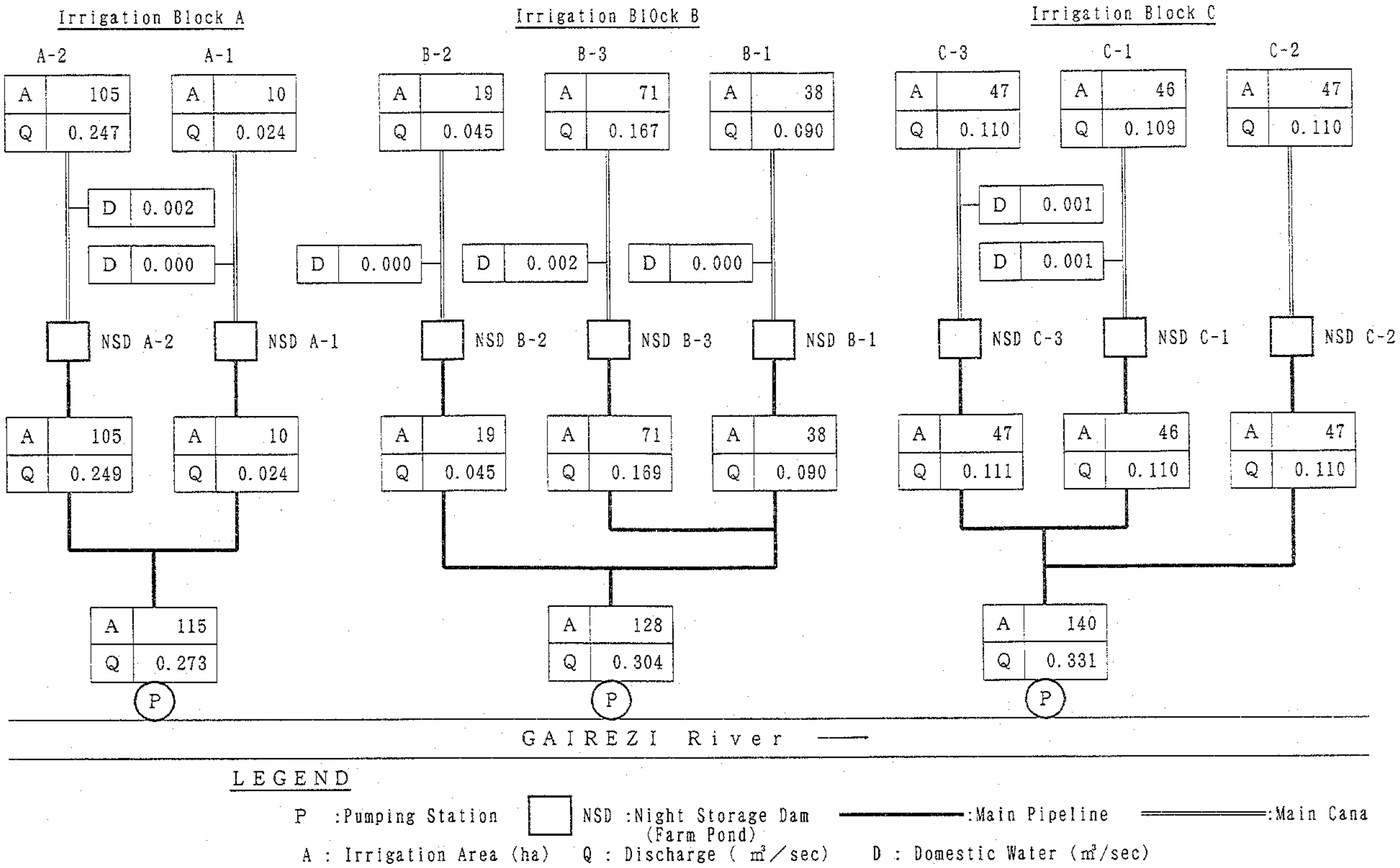


Fig. 4.6.1 SCHEMATIC IRRIGATION SYSTEM NETWORKS (1/2)

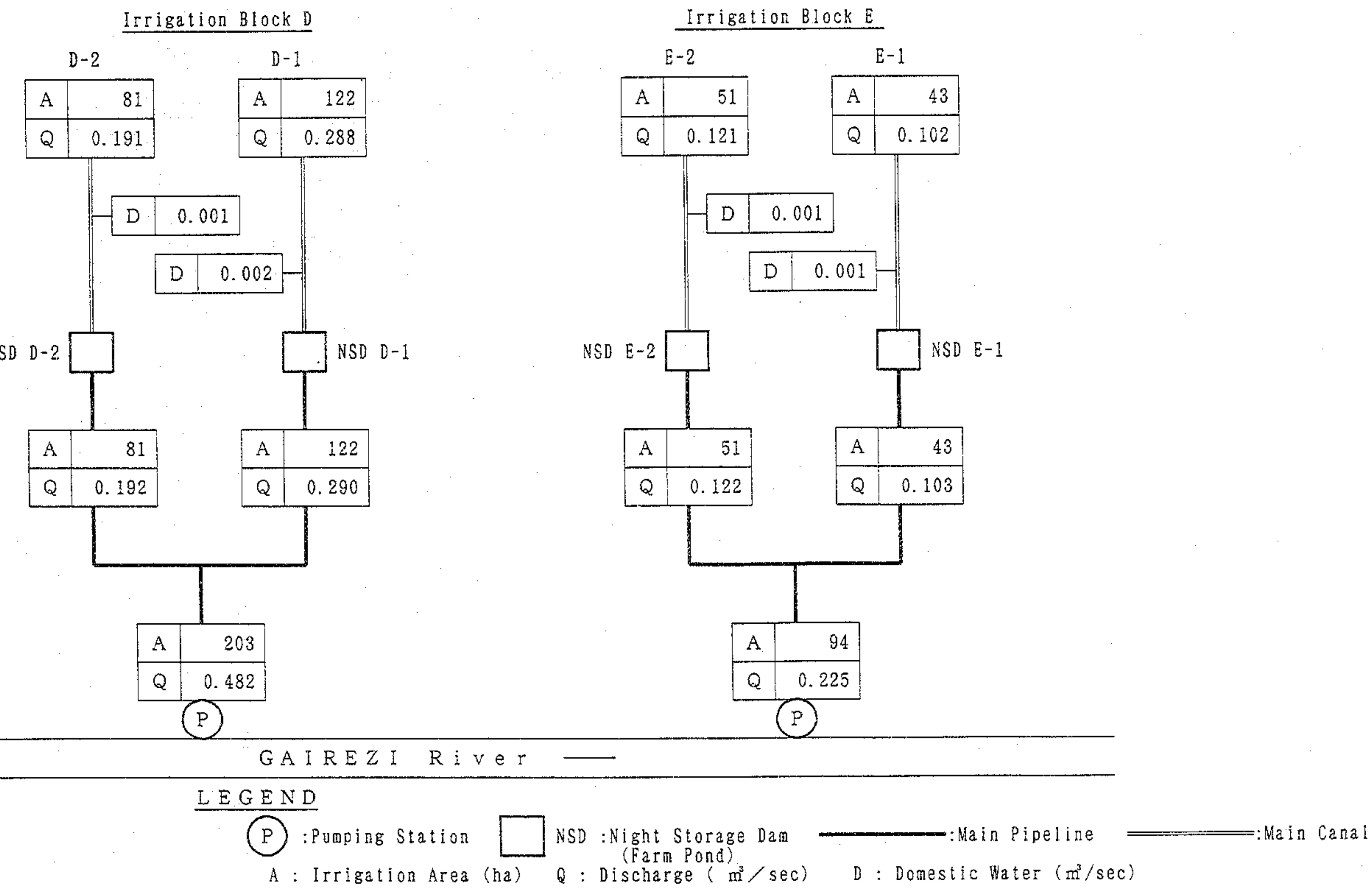


Fig. 4.6.1 SCHEMATIC IRRIGATION SYSTEM NETWORKS (2/2)

R_t are calculated to be, R_t = 24hrs is 35.6mm and R_t = 4 is 50.3mm respectively.

The unit area drainage discharge (q) is calculated using the value of R_t calculated above, as follows.

$$q = 10 \cdot R_t \cdot f / 3.600 \cdot t$$

Where q : Unit area drainage discharge (m^3/sec/ha)

f : Run off coefficient

field : 0.52 (0.45 ~ 0.60)

mountain area : 0.82 (0.72 ~ 0.90)

The values of f are adopted to be 0.52 for the field and 0.82 for the maoutain area respectively.

Then q_t are calculated to be :

$$q_{t=2} = 10 \times 35.6 \times 0.82 / 3.600 \times 2 = 0.0405 \ m^3/sec/ha$$
$$q_{t=4} = 10 \times 50.3 \times 0.52 / 3.600 \times 4 = 0.0182 \ m^3/sec/ha$$

respectively.

4.7. Supplemental Component Plan

4.7.1 Rural Road Improvement

The rural road improvements are classified as trunk roads which aim to connect the national road (route 269) and each village and a secondry road which aims to facilitate the easy movement of vehicles and other transportion vehicules etc. at the harvesting time and for maintenance work.

The structure of these roads is scheduled to be five meters in width for the trunk road with gravel pavement and three meters in width of secondary road with gravel pavement. Also pipe culvert work is to be installed at road and canal crossings.

The road lengths and the number of canal crossings in each irrigation block are as follows.

Block	Trunk Road: Out of irrigation block	Trunk Road: In side of irrigation block	Farm Road
A	—	540 m	2.980m
B	—	240 m	4,880m
C	—	220 m	4,240m
D	3,280 m	—	7,260m
E	3,640 m	—	3,900m
Total	6,920 m	1,000 m	23,000m
	5.0m width		3.0 m width

4.7.2 Land Conservation Plan

The land conservation plan in this project is considered as a countermeasure soil erosion on the farm land and natural drainage within the confines of the proposed irrigation areas and other related plans.

Soil erosion caused by rainfall in the irrigation areas are protected by counter farming practices with smooth and systematicl drainage run-off through furrows and ditches which are scheduled in the land consolidation plan.

Also small check dams and other protection work are scheduled to control soil erosion which have occured with natural drainage.

4.7.3 Domestic Water Supply

Domestic water for farm households such as for the farmer's living use, livestock drinking water and water for miscellaneous farm uses are scheduled to be supplied together with irrigation water through the irrigation facilities to improve the living conditions of the farmers.

The domestic water supply per household is estimated as follows:

	Unit requirement(1)	Size of family	Total(1)
Family use	50/oerson/day	6 persons	300 per day
Bull	50/head/day	5 heads	250 per day
Others			100 per day
Total			650 per day

Note: (1) Unit requirements are derived from standards in Japan.
(2) The average family size is derived from the Ward Development Plan AGRITEX 1989.

The total water requirements for the 618 farm households in the project area are estimated as 618 × 650 l/day = 401,700 l/day.

The total domestic water supply is allocated to five pumping stations as follows:

Irrigation block	Irrigation Area	Ratio of area	Supply demand	
	(ha)	(%)	(ℓ/day)	(ℓ/sec)
A	115	17	80,340	1.9
B	128	19	89,792	2.1
C	140	21	99,244	2.3
D	203	29	137,051	3.2
E	94	14	66,162	1.5
Total	680	100	472,589	11.0

Note: (1) Operation time of pumps are 12 hours per day.
(2) Conveyance efficiency in the canal is upplied as 0.85.

Gross domestic water supplies at pumping stations through a year are estimated as follows.

Pumping station	Water supplies		
	Per day (ℓ)	Operation days	Per year(m^3)
A	80,300	365	29,300
B	89,800	365	32,800
C	99,200	365	36,200
D	137,100	365	50,000
E	66,200	365	24,200
Total	472,600	365	172,500

5. FACILITY PLANNING

5 Facilities Planning

5.1 Pumping Station

As water resources for the irrigable area are planned two comparative plans which are "Pumped water from the Gairezi river" and a "Storage water dam at the Nyakomba river".

The Dam plan has been exculded from the plan due to it's inefficiency being that the dam volume is too large in proportion to the storage volume, and the construction cost is three times as expensive as the pump stations' cost at a rough estimate.

Therefore, the selected the water resources in this plan are the pump up system.

5.1.1 Pump Site

Each irrigation block will have one pump station. The locations of each pump station are to be selected at the top of the Gairezi river bank where there is good site access and a pump head from each irrigation block, and pump's suction will not be affected with sedimentation.

5.1.2 Pumping Discharge

Each irrigation block pump dischage will use an estimated peak consumption of crop water requirements. Based on the "The Peak Irrigation Supply Demand (Chapter 4.6.1)" the maximum pumping discharge of each block are shown below.

Table 5.1.1 MAXIMUM PUMP DISCHARGES

Block	Irrigation Area	Peak Irr. Demand	Max. Pump Discharge
	(ha)	(m^3/min)	(m^3/sec)
A	115	16.3	0.271
B	128	18.1	0.302
C	140	19.7	0.329
D	203	28.7	0.479
E	94	13.4	0.223

5.1.3 Pump Plan

(1) Pump Type

Each pump type is chosen according to the pumping discharge and the water lifting head. All proposed pumps require a pump head of more than fifty meters, therefore, volute pumps were selected.

(2) Outlet Diameter and the Number of Pumps

The outlet diameter of a pump should be the size required to maintain it's own staff after the completion of every pump station in this country. Therefore, the pump outlet size is selected between ϕ200mm and ϕ300mm based on the introduced experience of pumps so far.

The number of pumps are to be divided into three units faking into consideration the corresponding seasonal fluctuations of crop water requirements. The pump's diameter and the pump units for every irrigation block are as follows. Each pump station has one standby unit of the same size for the effective running ofthe pump and for maintenance.

Table 5.1.2 PUMP DIMENSION

Block	Total Pump Discharge	Pump Outlet Diameter	Pump Discharge	Number of units
	(m^3/min)	(mm)	(m^3/min)	
A	16.3	ϕ250	5.43	4
B	18.1	ϕ250	6.03	4
C	19.7	ϕ250	6.57	4
D	28.7	ϕ300	9.57	4
E	13.4	ϕ200	4.47	4

Note: Each pump station includes one standby unit.

(3) Pumping up Water Head

The Water head to be lifted by each pump is decided according to the difference in elevation between the suction water level at the pump site and the discharge water level in the night storage dam and the conveyed pipe head loss.

The lowest water suction level that is the designed water level for the pumps suction level is half the depth of the observed lowest water level in the dry season study. The highest water discharge level used is the full water level of the night storage dam in each block.

The designed water level and pump heads of each pump station are shown below.

Table 5.1.3 PUMP HEAD

Block	Suctioned Water Level	Discharged Water Level	Actual Pump Head	Total Pump Head
A	EL 808.30m	EL 853.00m	44.70m	52m
B	802.50	861.00	58.50	69
C	801.67	860.00	58.33	77
D	800.54	862.00	61.46	69
E	794.13	836.00	41.87	52

5.1.4 Related Facilities Plan

(1) Power Sources Plan

The power sources for the pumps considered in this project are an electric motor or a diesel engine. In the study area electricity is notset supplied, butZESA recently has started a F/S study for laying out electrical wiring to the project site in the north, then ZESA will put forward this future plan.

Therefore, in this project electric moters and generator systems are selected as the power sources.

The designed output of the power sources are estimated with the following formula.

$$P = \frac{K \times \gamma \times Q \times H}{\eta_p} (1 + R)$$

Where

- P : Output of Power Sources (kw)
- K : Constant (0.163)
- R : Specific Gravity of Water (1.0)
- Q : Pump Discharge (Cu.m/min)
- H : Total Pump Head (m)
- η_p : Pump Efficiency (ϕ200/0.65, ϕ250/0.68, ϕ300/0.71)
- R : Reserved Ration (0.15)

The estimated power requirement are shown in the following.

Table 5.1.4 PUMP POWER REQUIREMENTS

Block	Total Pump Head	Pump Discharge	Power of Motor	Generator
	(m)	(m^3/min)	(kw)	(KVA)
A	52	5.43	78	400
B	69	6.03	115	575
C	77	6.57	140	700
D	69	9.57	175	850
E	52	4.47	67	325

(2) Other Facilities

Other facilities required for pump working are electric boards that are power boards, distribution boards, potential transformers control boards and others will be arranged. These facilities can be used both with a generator and with supplied electricity to the study area by ZESA.

The pump dimension is shown in Table F.5.1.1 of ANNEX.

5.1.5 Pump House Plan

The structures of each pump house will have two floors due to the fluctuating water leves. The operation board and related facilities are to be installed on the upper floor which is not beyond the flood water, and the pump and the motor are to be placed on the lower floor.

(1) Pump House Dimensions

Pump House dimensions will be decided according to the pump arrangement motor and related facilities.

Dimensions of each pump house are shown below.

Table 5.1.5 PUMP HOUSE DIMENSIONS

Block	Length	Width	Height
A	23.0m	8.8m	7.3m
B	23.5	8.4	9.2
C	23.5	8.4	9.3
D	25.0	8.9	6.2
E	22.0	8.1	8.2

Note: Dimensions show inside wall distance

(2) Pomp House Structures

The Pump houses will be constructed as rigid frame structures using concretepillars and concrete beams. The walls will be made of a concrete brick layer and the roofs are to be asbestos slates. The entrances of these houses will be one big door to accomodate pump facilities and two side doors will be placed on the either side.

The layout of the Block A pump house is shown in Fig. 5.1.1.

(3) Generator House

The Generator house will be separate from the pump house as to reduce the noise of the working generator and the need to install a fuel tank.

The dimensions of the generator house are as follows. The structure will be constructed as a brick layer house.

Table 5.1.6 LAYOUT OF GENERATOR HOUSE

Block	Length	Width	Height
A	8.0m	6.0m	5.0m
B	8.0	6.0	5.0
C	9.0	7.0	5.0
D	9.0	7.0	5.0
E	8.0	6.0	5.0

The layout of the Block A generator house is shown in Fig. 5.1.1.

5.1.6 Sump Pomp Suction

Sump Pump suction is a structure aiming at lifting water by suction. In this plan, the pump selected is a suction type, therefore the sump pump will be separated from the pumphouse.

The sump pumps are designed to distinguish between a part of a culvert and apart of suction pit.

(1) Culvert Parts

The culvert will be constructed to carry a water supply from the river to the sump and to protect the water from rubbish inflow to the sump. Considering the effects of sedimentation by a slow flow of less than 0.5m/s, the dimension of the culvert is designed at 2.0m ×2.0m×2 lines box culvert, and screens and gates for maintenance will be installed at the inlet and the outlet.

(2) Suction Sump Parts

The suction sump consists of transition and sump sections. In the sump section the slope of a 50cm drop and portions of a 1.5m length in center of two suction pipes are placed side by side aiming to stabilize the water flow.

5.2 Head Race (Main Supply Pipe Line)

The head race from the pump station to the night storage dam is to be a pipeline due to the water being lifted and high place conveyance.

5.2.1 Pipe Length and Pipe Diameter

The pipe length of each block is between 1,410m and 3,910m, and the discharge is between 0.024m^3/s and 0.018m^3/s. The selection of pipe diameters are decided following the criterion that is an economical pump working belocity.

Diameter (mm)	Economic Velocity
φ 75 ～φ150	0.7 ～ 1.0m/s
φ200 ～φ400	0.9 ～ 1.6
φ450 ～φ800	1.2 ～ 1.8

The selected diameter and length based on hydraulic examinations are shown below.

Table 5.2.1 HEAD RACE DIMENSION

Block	Discharge	Length	Pipe Diameter
	(m^3/s)	(m)	(mm)
A	0.272 ～ 0.024	3,460	φ500 ～φ200
B	0.303 ～ 0.045	3,910	500 ～ 250
C	0.332 ～ 0.110	3,340	500 ～ 350
D	0.481 ～ 0.191	2,200	700 ～ 450
E	0.223 ～ 0.103	1,410	450 ～ 350

The head race network is shown in Fig. 5.2.3 ～ Fig. 5.2.5.

5.2.2 Pipe Material

The selection of pipe material will be decided based on the water pressure on the water head in the pipe. The elevation differences among each pump station and each night storage dam are between 45m and 62m. These water heads need a high pressure pipe made of Iron pipes, Asbestos pipes Pvc pipes etc.

There are many rocks around the proposed pump station sites and night storage dams. Therefore according to the pipe laying work, iron pipes are selected in this head race.

5.2.3 Hydraulic Calculations

The head losses of the pipe line are estimated with the following formula.

$$h_f = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$

Where h_f : friction loss of head (m)
C : coefficient of velocity (iron pipe / 100)
D : pipe diameter (m)
Q : discharge (m^3/sec)
L : pipe length (m)

The head losses of each pipe line are as follows.

Table 5.2.2 HEAD LOSSES

Block	Period	Pipe Diameter	Head Loss
A	P.S. → NSD-2	φ500 ～ φ200mm	6.8m
B	P.S. → NSD-1	φ500 ～ φ350mm	9.8m
C	P.S. → NSD-1	φ500 ～ φ350mm	15.5m
D	P.S. → NSD-2	φ500 ～ φ450mm	6.7m
E	P.S. → NSD-1	φ500 ～ φ350mm	9.8m

The results of hydraulic calculation is shown in Table F.5.2.1 of ANNEX.

5.2.4 Related Facilities

For the purpose of maintenace, suluice valves will be installed every 400m or 500m and at bifurcation point of each pipeline. Furthermore air-valves will be installed every 400m or 500m and peaked places of pipe lines. Brow off valves will be installed at bottum places of pipe long section and at siphon places of pipe lines.

5.3 Night Storage Dam

The main purpose of a night storage dam in the irrigation network, is for the dissolution of a time lag that is a passage time until the irrigation water reaches each block after being discharged from each pump station.

5.3.1 Location

Location of night storage dams are selected in the area which are 3 ～ 5m higher than the highest plot of each block. Considering to the domestic water use, the sites are near villages where are foot of the mountain.

The formation height of each night storage dam and the highest plot elevation are shown in Table F.5.3.1 of ANNEX.

5.3.2 Dam Capacity

The night storage dam capacity is decided according to a one hour volume of pump discharge and surplus volume. The first volume is the quantity of the time lag from each pump station to each night storage dam. As for the volume, a one hour discharge volume was set up because of the times are between 20 minutes and 40 minutes. And, the second volume is equivalent to the conveyance loss and the flexible water volume which is estimated to be twenty percent of the original volume.

Each night storage dam capacity is as below.

Table 5.3.1 NIGHT STORAGE DAM CAPACITIES

Block	Controlled Irrigation Area	(A) One hour Dam Volume	(B)=(A)×1.2 Design Dam Volume	No. of Dams
	(ha)	(m^3)	(m^3)	(placess)
A	10 ~ 105	85 ~ 893	110 ~1080	2
B	19 ~ 71	162 ~ 605	200 ~ 700	3
C	46 ~ 47	397 ~ 400	480	3
D	81 ~ 122	688 ~1044	830 ~1260	2
E	48 ~ 56	371 ~ 432	450 ~ 520	2

The allocation of the night storage dam capacity for every block will be decided by the irrigable coverage of every sub dam.

The dimension of each night storage dam is shown in Table F.5.3.2 of ANNEX.

5.3.3 Dam Structure

The night storage dam structure is selected as a concrete lining type aimed at cutting down on water loss and for easy maintenance.

The effective water depth is two meters and the free board is one meter in height.

5.4 Irrigation and Drainage Canals Plan

5.4.1 Irrigation Canal Plan

For the purpose of water distribution from each night storage dam to each irrigation area, an irrigation canal will be constructed.

In principle the canal route is stationed at a higher than each irrigation block.

The covered area of each canal is between 10ha and 30ha, and the canal discharge is between 0.020 m^3/s and 0.060 m^3/s.

(1) Canal Dimensions

Canal sections are decided based on velocities of 0.5m/s ~ 1.0m/s. And the trapezoid section which is the invert width of 30cm and a free board of five cm is selected. The examination of the velocities are carried out the following formula.

$$V = \frac{1}{n} \cdot R^{2/3} \cdot I^{1/2}$$

where V : Average Velocity (m/s)

n : Coefficient of Roughness

$R^{2/3}$: Hydraulic Mean Depth

$I^{1/2}$: Canal Bed Slope

The dimensions of each canal are below.

Table 5.4.1 IRRIGATION CANA DIMENSIONS

Block	Total Length	No. of Infield Canal	Section (B×H)
A	7,060m	7 lines	300mm×(300~500)mm
B	7,020	8	300×(300~500)
C	9,560	15	300×(250~400)
D	9,820	7	300×(300~500)
E	4,920	7	300×(250~400)

Note: Canals include a freeboard of 50mm (2").

The canal list of each block is shown in Table F.5.4.1 of ANNEX.

(2) Canal Structure

The selected structure is a concrete trapezoid canal with the sides sloping at 60 degrees aimed at cutting down on water loss and for easy maintenance.

According to needs, droop work, a sedimentation tank and road crossing will be installed in each canal.

5.4.2 Drainage Canal Plan

A drainage canal will be arranged in each irrigation block aiming to drain any surplus rainwater.

The canals are to be placed in some lower strips which are presently being used as natural drains. The darin canal section will be a trapezoid earth canal with the invert width of 50cm and a side slope of 1:1.0.

According to needs, drop work, sedimentation tanks and protection weirs for soil erosion will be installed in each canal.
The drainage canal list of each block is shown in Table F.5.4.2 of ANNEX.

5.5 Farm Roads Plan

Farm roads are classified as trunk roads which aim to connect the national road (Route 269) and each village and a secondary road which aims to facilitate the easy movement of vehicles of harvesting time and maintenance work.

5.5.1 Rout Plan

Trunk roads plan between the national road and each pump station and between the national road and each marketing facilities place in order to transport of machinaries, crops and others.
Farm roads plan along higher place with irrigation canal for the purpose of farming traffic and a patrol of irrigation facilities in each block.

5.5.2 Road Structure

The roads structure is five meters in width of trank road with gravel pavement and three meters in width of secondary road with ten centimeters of gravel pavement.

Pipe culvert as canal crossing work are installed at crossing points of the road and canal.

The road lengths and number of canal crossings in each block are as follows.

Table 5.5.1 FARM ROAD DIMENSIONS

Block	Length of Trunk Road	Length of Farm Road	No. of Canal Crossing
	(m)	(m)	(places)
A	540	2,980	0
B	240	4,880	1
C	220	4,240	0
D	3,280	7,260	2
E	3,640	3,900	1

The road list of each block is shown in Table F.5.5.1 of ANNEX.

5.6 Nyakomba Project Management Office (NPMO)

The Nyakomba Project Management Office (NPMO) will be constructed adjacent to block C will have the following main facilities.

① Office Building
- Area : 252 m² for two houses
- Structure : Concrete pillars, brick walls and asbestos roof

② Ware House
- Area : 300 m²
- Structure : Concrete pillars, brick walls and asbestos roof

③ Garage
- Area : 308 m² for 3 houses
- Structure : Concrete pillars, brick walls and asbestos roof

④ Multi-purpose hall (Meeting Room)
- Area : 130 m² for 2 rooms
- Structure : Concrete pillars, brick walls and asbestos roof

⑤ Work Shop

- Area : 210 m²
- Structure : Concrete pillars, brick walls and asbestos roof

⑥ Fuel Station

⑦ Motor Pool

⑧ Staff Quarter
- Area : 360 m² for 6 houses
- Structure : Concrete pillars, brick walls and asbestos roof

5.7 Marketing Facilities

Marketing facilities will be constructed in each irrigation block. The main facilities are as follows.

① Office Building
- Area : 60 m²
- Structure : Concrete pillars, brick walls and asbestos roof

② Warehouses for general crops
- Area : 120 m²
- Structure : Concrete pillars, brick walls and asbestos roof

③ Warehouses for tobacco
- Area : 400 m² for two houses
- Structure : Concrete pillars, brick walls and asbestos roof

④ Garage
- Area : 30 m²
- Structure : Concrete pillars, brick walls and asbestos roof

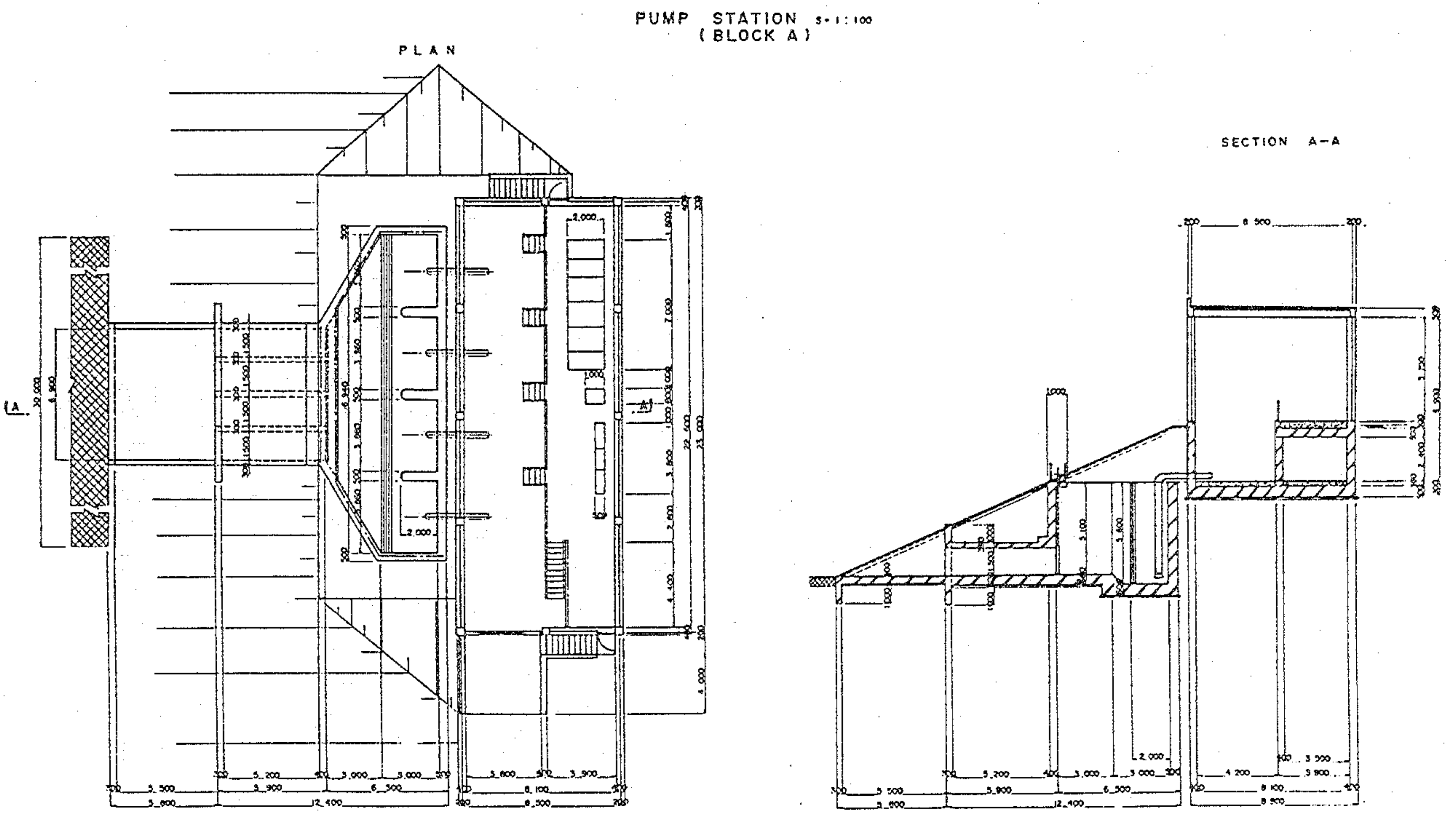


Figure 5.1.1 LAYOUT OF PUMP STATION (BLOCK A)

GENERATOR HOUSE

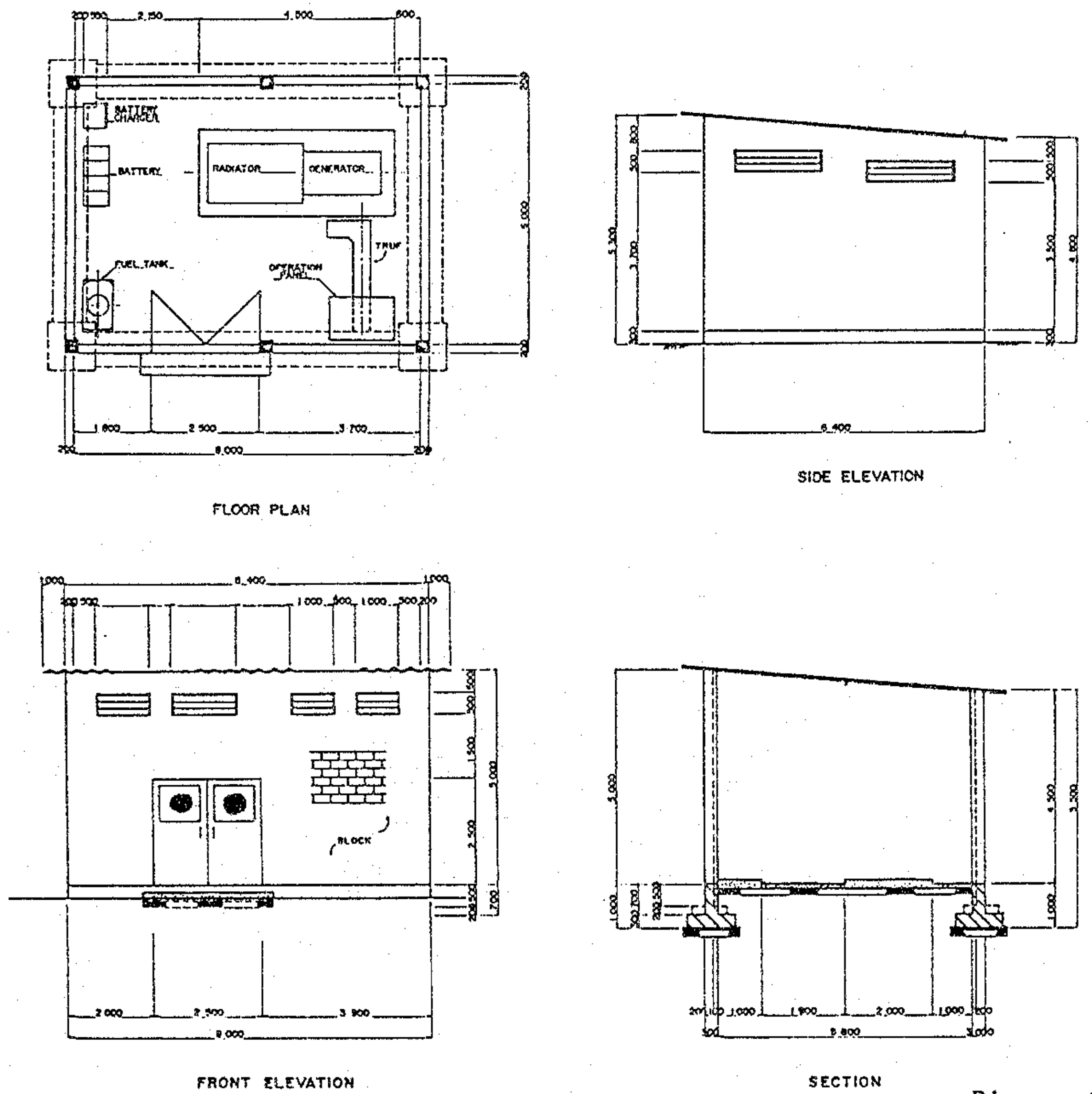


Figure 5.1.2 LAYOUT OF GENERATOR HOUSE

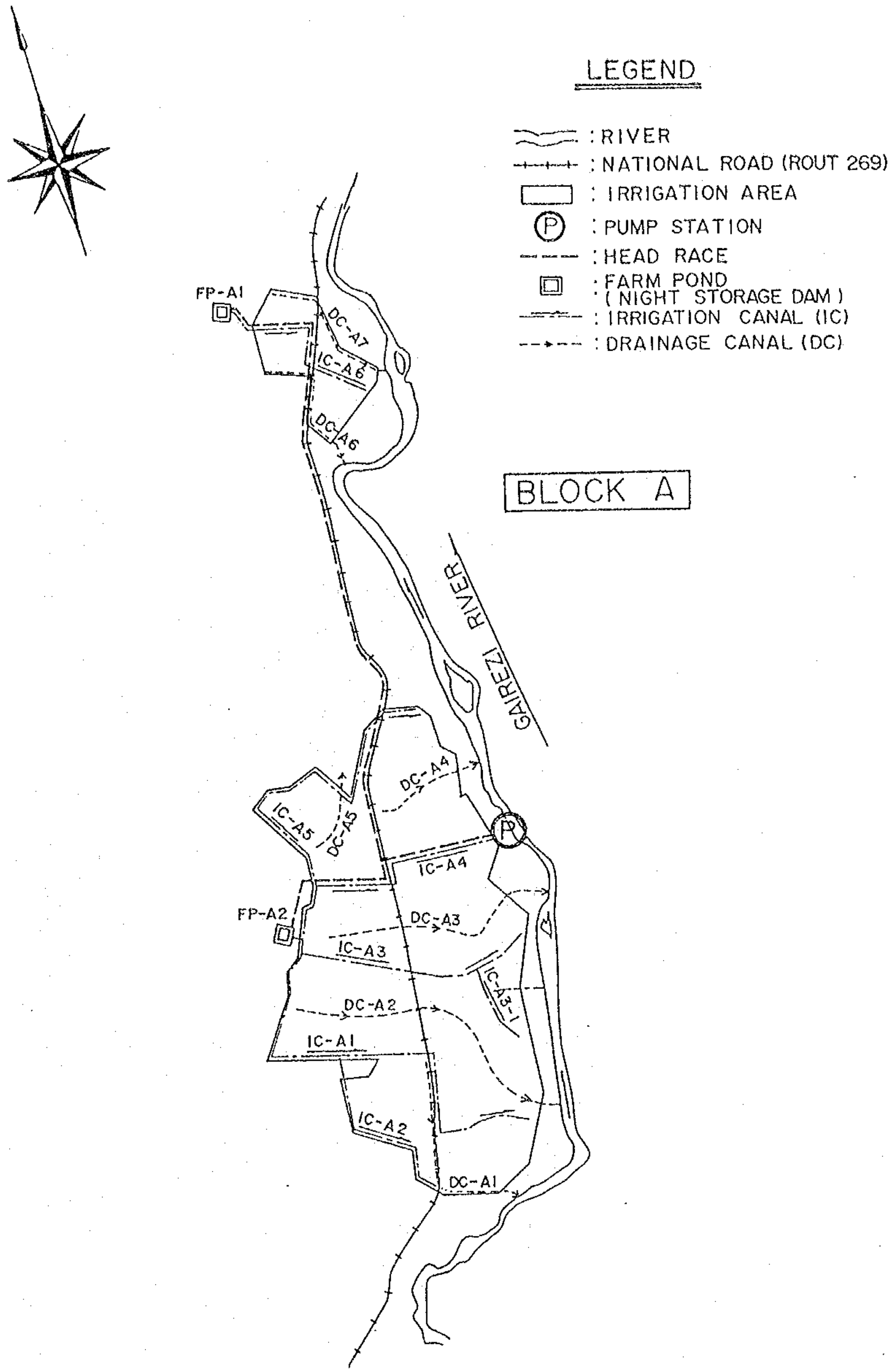


Figure 5.1.3 HEAD RACE, IRRIGATION CANAL AND DRAINAGE CANAL NETWORK (1)

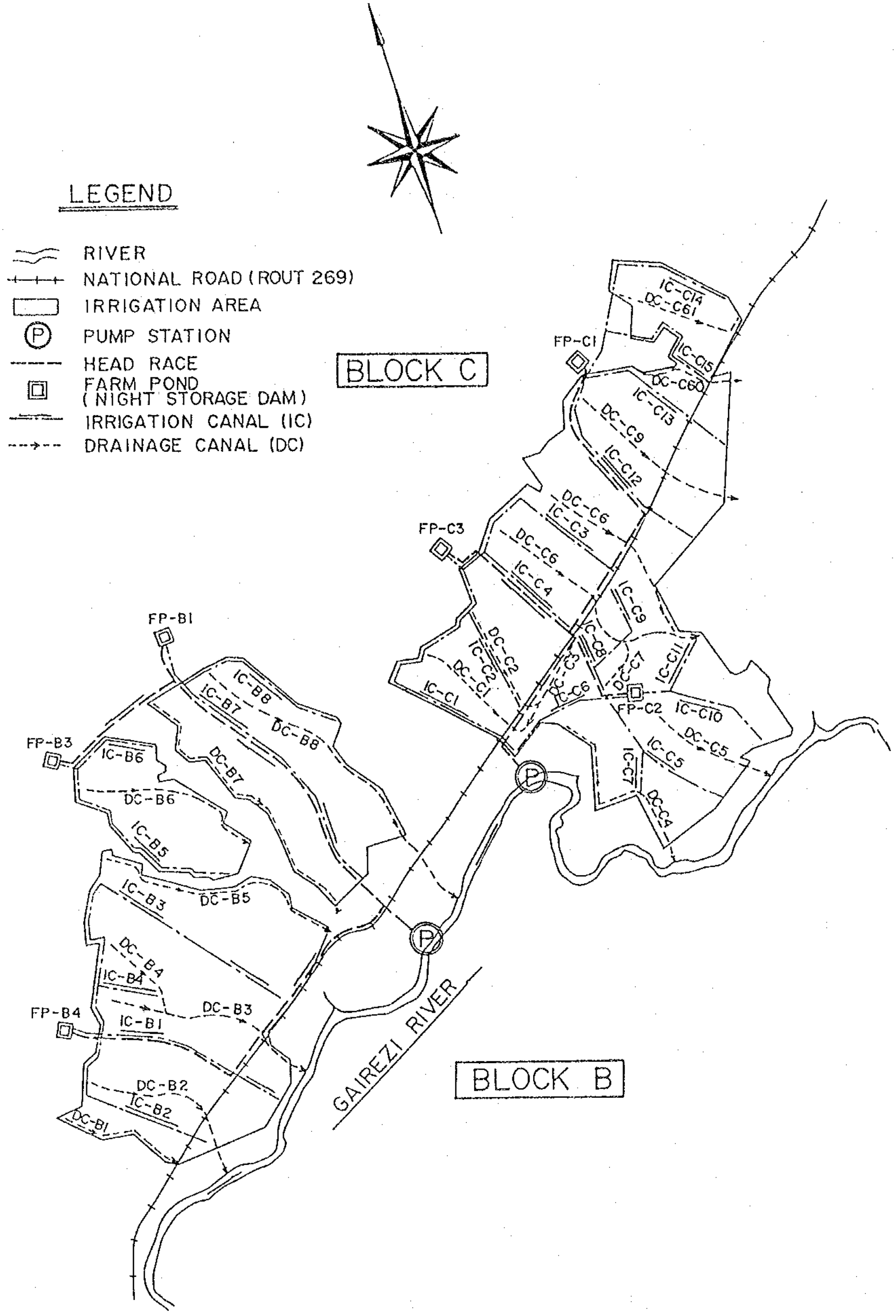


Figure 5.1.4 HEAD RACE, IRRIGATION CANAL AND DRAINAGE CANAL NETWORK (2)

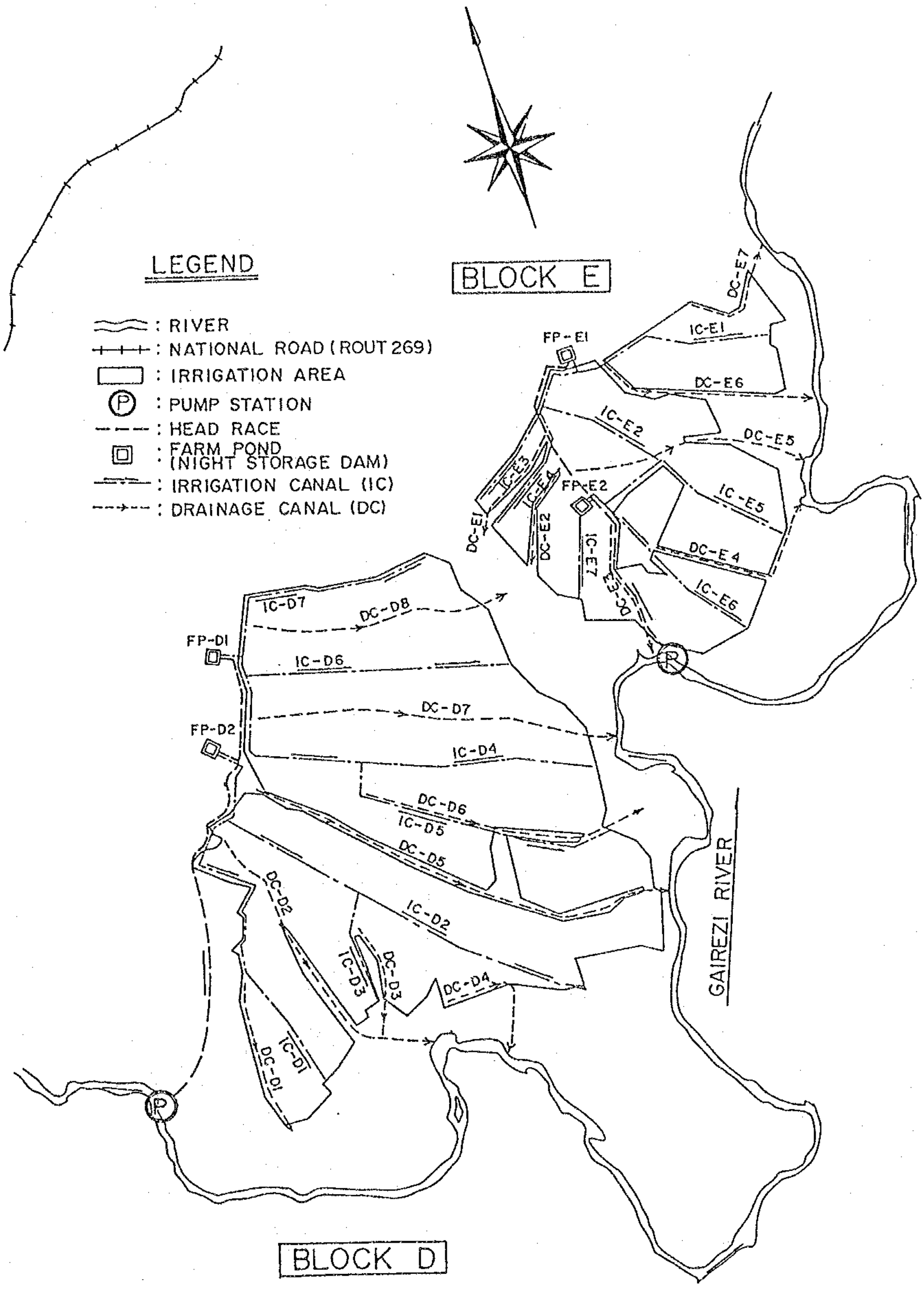


Figure 5.1.5 HEAD RACE, IRRIGATION CANAL AND DRAINAGE CANAL NETWORK (3)

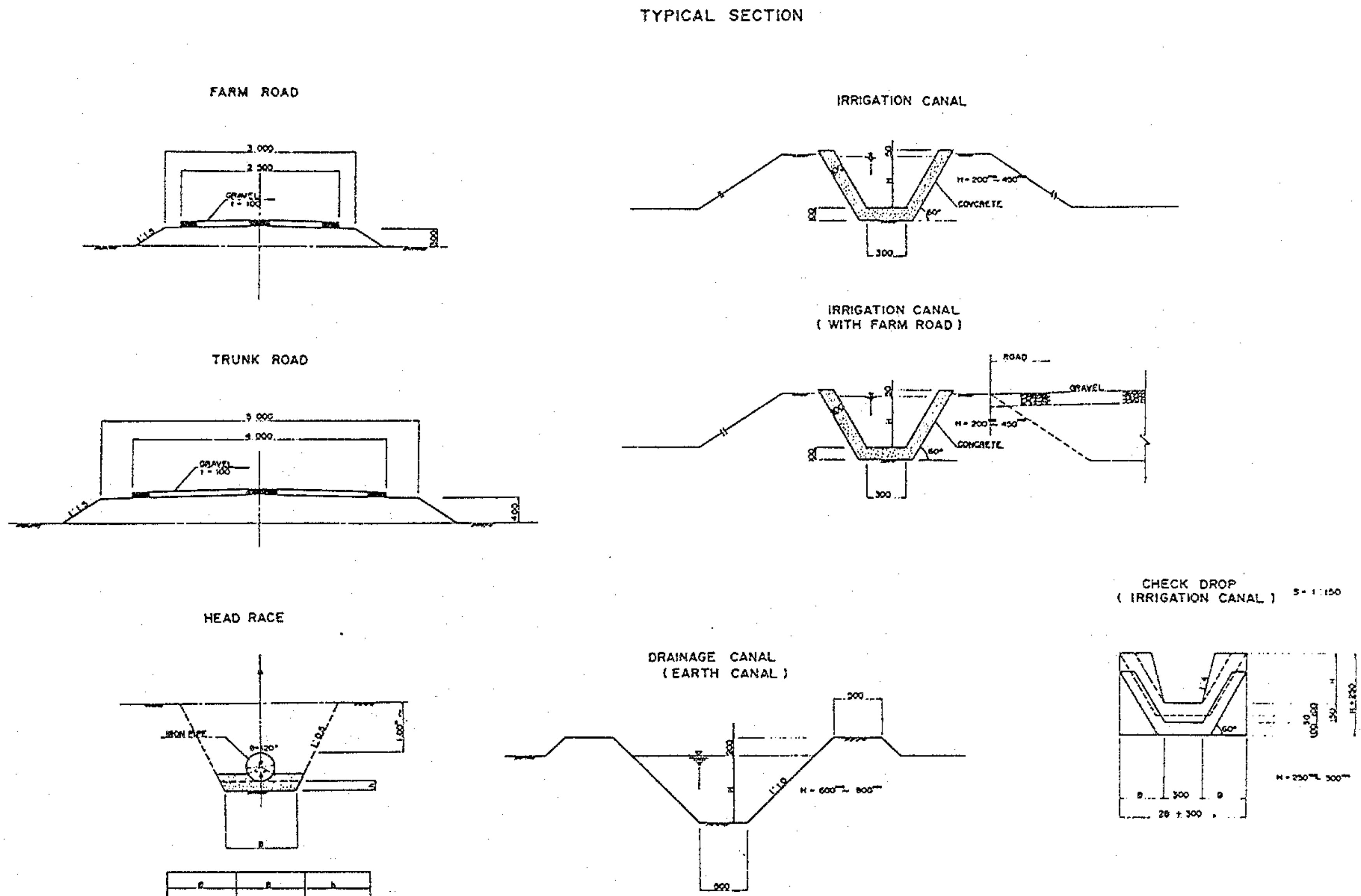


Figure 5.1.6 TYPICAL SECTION (CANAL AND ROAD)

φ	B	h
700	1.40	0.20
500	1.20	0.20
450	1.10	0.15
400	1.10	0.15
350	1.00	0.10
250	1.00	0.15
200	1.00	0.10

6. ORGANIZATION AND MANAGEMENT

6. ORGANIZATION AND MANAGEMENT

6.1 Project Implementation

6.1.1 Executing Agency

Based on the administrative jurisdiction of Zimbabwe Government, two agencies would undertake the implementation of the Project from the detailed design stage up to the completion of construction. The works to be executed by each agency have been divided at particular structure point in the whole irrigation system so called "field edge". It is understood that the field edge in this project is outlet gate of the night storage dam.

Ministry of Energy, Water Resources and Development (MEWRD) which controls all surface water supplies would execute intake pumping stations, water conveyance facilities and night storage dam. While Agricultural, Technical and Extension Services (AGRITEX), under the Ministry of Lands, Agriculture, and Rural Resettlement, would execute in-field works and construction of the projectmanagement office and marketing facilities. (Refer to FIGURE 6.1.1)

Both the agencies have sufficient experiences in the implementation of various irrigation development projects. They have their own provincial office in Mutare, Manicaland which would handle actual implementation with assistance of the engineering consultants and hiring general contractors.

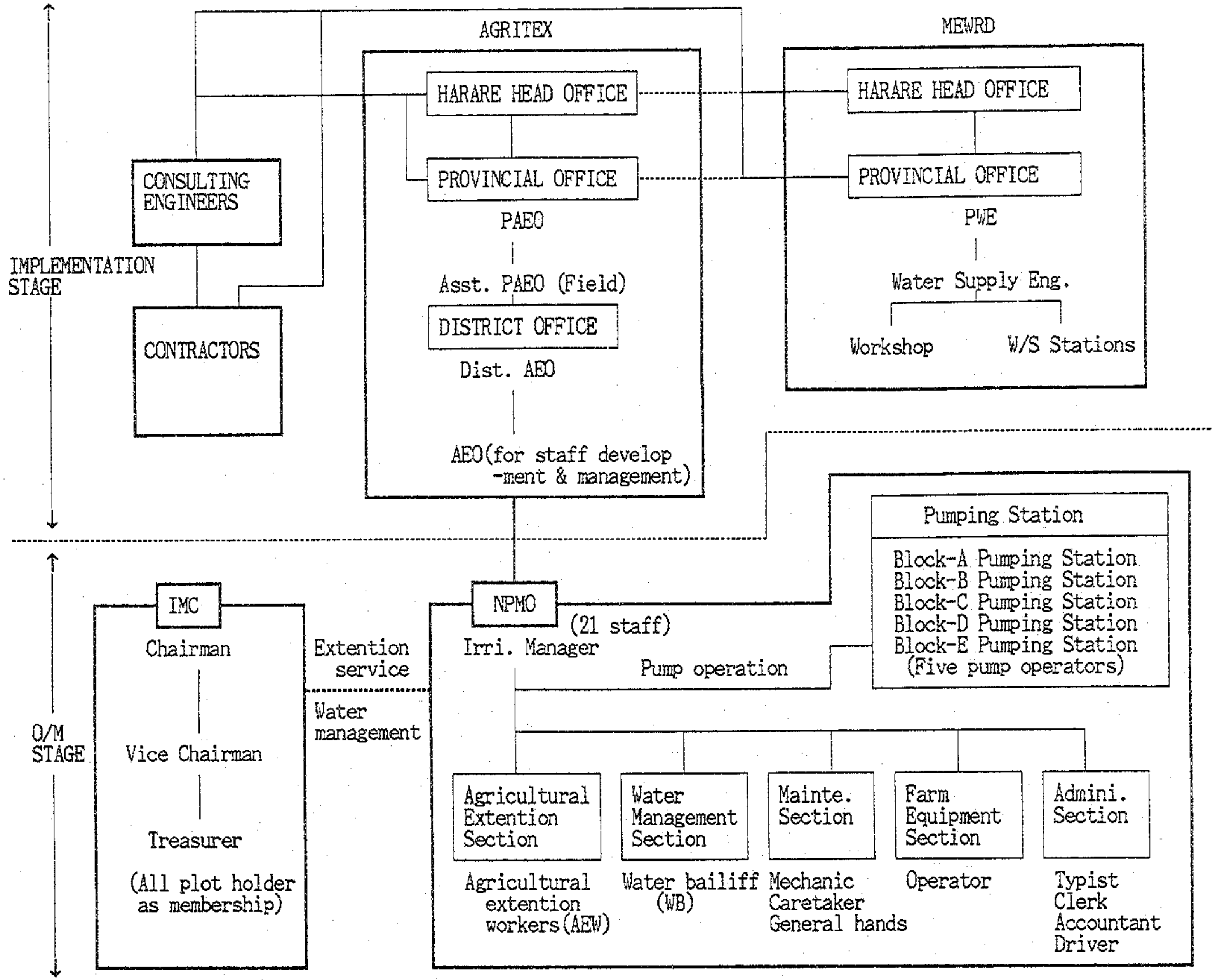
6.1.2 Financing

Since huge amount of the project cost is required for the implementation, it would be necessary to obtain fund from foreign governments and/or international financing agencies in order to complete the construction on schedule. In this case, foreign currency portion of the project cost would be financed by such foreign funds while local currency portion would be provided by the government of Zimbabwe.

6.1.3 Construction Mode

Procurement for implementation of the project must be managed to serve three objectives. First, it must help and ensure the efficient and economical

FIGURE 6.1.1 ORGANIZATIONAL STRUCTURE FOR IMPLEMENTATION AND O/M



execution of the project. Second, procurement in the public sector can be used to promote national goal for the development of domestic industry or for expansion of small-scale enterprise. Third, procurement must comply with the requirement of any external agencies assisting with the project.

In consideration of three objectives stated above as well as the project size, nature and proposed funding arrangement, construction works shall be undertaken by contractors. Such contractors whould be procured through international competitive bidding (ICB) that has widely proved to be the best means of procurement.

6.1.4 Consulting Services

Procurement of consulting services is an important factor to attain satisfied outcome of the project. In this regard, for certain large size of project which is implemented by contract through international bidding, it is essentially necessary to use consultants for smooth implementation and successful completion of the project.

In this project case, assuming that foreign funds are procured for implementation, well-experienced consulting firms would be required to undertake detailed design works, tendering procedure and construction supervision under overall management of the executing agencies particularly taking into account the procurement conditions and regulation of lending agencies. In addition to the above, it is pointed out that all works at every stage of the implementation shall intensively be carried out, because the work schedule is tight even though the Project is divided into two phases.

The consulting services to be undertaken by the consultants are composed of three stages, i.e. detailed design stage, tendering stage and supervision stage. These tasks include project management, inspection and expediting, certification of invoice submitted by contractors and suppliers, technical services connected with the interpretation of contract documents, and the start-up of facilities and their operation for an initial period. Such services shall be rendered to the executing agencies and/or lending agencies with respect of their provision, standard and conditions on regarding works.

A total man-month of consultants to be engaged in the project implementationwould be 53 man-months for each phase that include 15 man-months of local consultants. (Refer to Annex G)

6.2 Implementation Schedule

Since the Project is quite large size which requires the big number of construction inputs in a short time, it is recommended to divide whole project into two phases for smooth implementation. Such phasing of the Project, named phase-1 and phase-2, is carefully studied and set taking account of the construction cost, work volume of each block and advantageous location to the construction works.

The implementation of Phase-1 would be for block-B and block-C including project management office and marketing facilities being attached to block-B and block-C. While Phase-2 would be for block-A, block-D, block-E and marketing facilities in these blocks. Thus, the project size of each phase would become favorably appropriate to be implemented in one time.

Whole project works, i.e. phase 1 and phase 2 works, could complete in three years and six months after commencement of the detailed design. Civil works for intake pumping stations and in-field works shall be carried out during dry season, six months from April to September. (Refer to Figure 6.2.1 and Annex G for detailed construction time schedule)

Investment schedule of the project cost based on the above implementation schedule is shown in Table 6.2.1.

6.3 Organization for Operation and Maintenance

6.3.1 Operation and Maintenance Body

Most essential factor to secure fully operational irrigation system for successful reallocation of the Project area would be water management and pump operation. Pump operation shall be carried out steadily according to the water management plan. In this regard, whole irrigation system from pumping station to the field shall be managed and handled by one excuting body. If pump operation and field water management are undertaken by different agencies as

Figure 6.2.1 OVERALL TIME SCHEDULE

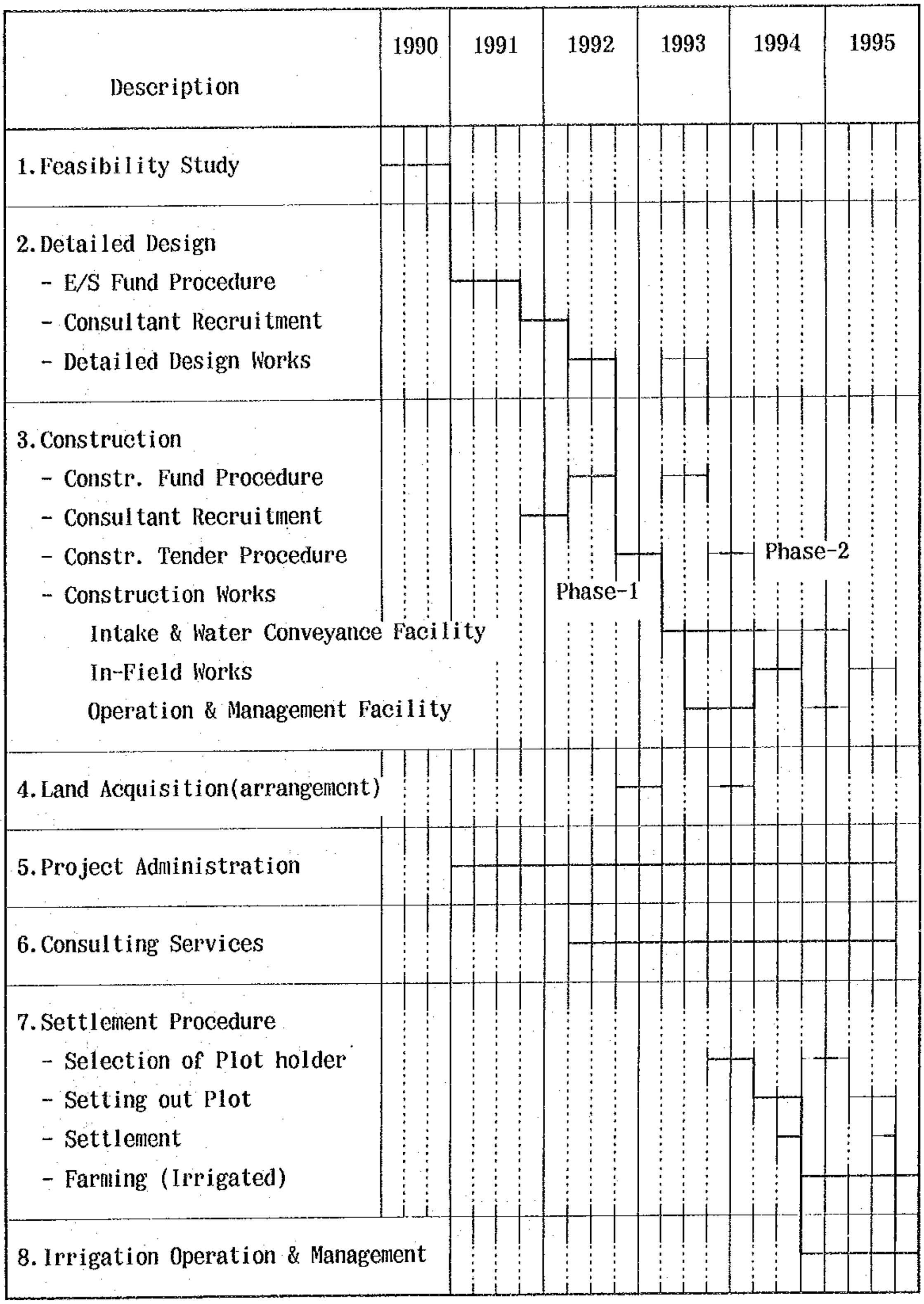


Table 6.2.1 INVESTMENT SCHEDULE

(Unit: 1,000 Z$)

Year		Block-A	Block-B	Block-C	Block-D	Block-E	Total
1991	F/C	--	92	94	--	--	186
	L/C	--	75	96	--	--	171
	Total	--	167	190	--	--	357
1992	F/C	--	91	94	--	--	185
	L/C	--	76	96	--	--	172
	Total	--	167	190	--	--	357
1993	F/C	84	1,073	1,586	86	83	2,912
	L/C	83	571	903	96	73	1,726
	Total	167	1,644	2,489	182	156	4,638
1994	F/C	1,022	3,221	4,755	1,224	743	10,965
	L/C	542	1,684	2,679	688	462	6,055
	Total	1,564	4,905	7,434	1,912	1,205	17,020
1995	F/C	3,066	--	--	3,673	2,228	8,967
	L/C	1,603	--	--	2,018	1,366	4,987
	Total	4,669	--	--	5,691	3,594	13,954
Total	F/C	4,172	4,477	6,529	4,983	3,054	23,215
	L/C	2,228	2,406	3,774	2,802	1,901	13,111
	Total	6,400	6,883	10,303	7,785	4,955	36,326

usually exercised in the most previous pump irrigation schemes in Zimbabwe, smooth and efficient pump operation based on the required field water management could hardly be achieved due to miss-coordination, lack of information or jurisdictional irregularity between two agencies.

In consideration of above aspect, whole irrigatioon system shall be operated and maintained by AGRITEX since AGRITEX is only agency responsible for the field water management to farmers in accordance with the provisions of Government of Zimbabwe. For smooth pump operation, pump operators shall be stationed at each pumping station site.

AGRITEX shall then, to carry out smooth and efficient operation and maintenance works, establish the Nyakomba Project Management Office (NPMO) which undertakes actual all activities under management of District Office with assistance of Mutare Provincial Office. Six major organizational functions to be attached to NPMO are considered below.

(1) Irrigation Manager: To manage overall activities and to coordinate with AGRITEX District Office, MEWRD and Irrigation Management Committee (IMC).
(2) Pump Operation Section: To operate pumps and generators according to requirement of watermanagement.
(3) Water Management Section: To undertake water distribution control, gate operation and monitoring the water management.
(4) Agricultural Extension Section: To undertake consultation and guidance to plot holders on various matters such as farming technologies, crop selection, marketing, farm economy, etc .
(5) Maintenance Section: To undertake repairs and maintenance of infrastructures, facilities, buildings and equipment. However major repaires of vehicles and farming/maintenance equipment would be handled to the Central Mechanical Equipment Department (CMED).
(6) Farm Equipment Section: To manage and operate farming equipment and marketing facilities for rent to plot holders.
(7) Administrative Section: To undertake general office routine works, collection of irrigation fee, etc.

Besides NPMO, the Irrigation Management Committee (IMC) would also be organized by all plot holders as a committee member in the project area according to the provision of the government policy. IMC headed by a chairman would be one of the key organization to attain smooth resettlement in the project area. Major functions of IMC are described below.

- To act on water management and crop selection under consultation and guidance of NPMO.
- To encourage plot holders on their farming in co-operation with agricultural extension workers of NPMO.
- To coordinate with plot holders and NPMO in terms of collection of irrigation fee, farm machine hiring and use of marketing facilities.
- To coordinate among plot holders on the organized procurement of farm inputs, finance, transport and marketing.

In order to provide fully functional irrigation system based on the water management as designed, it is insisted that close cooperation and effective coordination be attained among executing bodies, i.e. between MEWRD and AGRITEX/NPMO in regard to pump operation, and between NPMO/AGRITEX and IMC concerning the water management, collection of irrigation fee, farming system, extension services etc. (Refer to Figure 6.1.1)

6.3.2 Operation and Maintenance Activities

General operation and maintenance activities to be carried out by AGRITEX are detailed below.

- Intake Pumping Station :Daily operation of pumps as required by NPMO, periodic maintenance and replacement.
- Water Conveyance Pipeline :Periodic and routine maintenance, repair of water leakage.
- Night Storage Reservoir :Weeding, refilling slope, etc.
- Canal and Drainage :Daily operation of check gate, turn-out, etc. Replacing broken lining concrete, repair and painting of gates, boxes, weeding, and canal bank repair.

- Farm Road : Periodic and routine maintenance, regraveling, weeding and clearing road shoulder, filling potholes.
- Project Management Office : Routine works on general project operation, repair of facility and equipment, regular cleaning.
- Marketing Facilities : Repair of facility, regular cleaning.

7. COST ESTIMATE

7. COST ESTIMATE

7.1 Project Cost Component

Project costs are composed of the following major work items and cost categories. (Refer to Figure 7.1.1)

1) Preliminary and General (P & Gs)

This item covers following works to be carried out by the contractor, and general overhead necessary at the site office and their head office.

- mobilisation, insurance and bonds
- site office and workers' camp with necessary facilities
- material stockyard and equipment pool
- material testing
- access road, temporary road and dewatering works
- safety and protection works
- administrative expenses including staff salary at the site and hea d office.

2) Intake Pumping Station

The works consist of river diversion works (cofferdaming works), supply and installation of pump equipment and generators, construction of pump houses and operator's quarters, and civil works for suction pit. The river diversion works as well as construction of suction pit shall be executed during dry season.

3) Water Conveyance Pipeline

This item covers supply of pipe material (steel pipes) and pipelaying works which include clearing and grubbing along pipeline alignment, excavation and back-filling of pipe trench, and installation of pipes.

4) Night Storage Dam

Major works in this item are excavation, embankment, concrete lining, sodding and construction of inlet/outlet structures.

5) Irrigation Canal

Irrigation canal would be by concrete lining in order to minimise the

Figure 7.1.1 PROJECT COST COMPONENT

- Project Cost
  - Construction of Intake and Water Conveyance Facility (MEWRD)
    - (1) Preliminary and General
    - (2) Intake Pumping Station
    - (3) Water Conveyance Pipeline
    - (4) Night Storage Dam
  - In-Field Works (AGRITEX)
    - (1) Preliminary and General
    - (2) Irrigation Canal
    - (3) Drainage Canal
    - (4) Farm Road
    - (5) Land Grading Works
  - Construction of Operation and Management Facility (AGRITEX)
    - (1) Preliminary and General
    - (2) Project Management Office
    - (3) Marketing Facility
  - Engineering and Administration Cost
    - (1) Administration Cost
    - (2) Engineering Services
    - (3) Investigation Works for Detailed Design
  - Physical Contingency
  - Compensation

Figure 7.4.1 OPERATION AND MAINTENANCE COST COMPONENT

- Operation and Maintenanance Cost
  - Salary and Wages
    - (1) For Pump Station
    - (2) For Project Management Office
  - Equipment and Material
    - (1) Fuel and Oil
    - (2) Spare Parts and Material
  - General Expenses for Project Management Office
  - Replacement Cost
    - (1) Equipment for Pumping Station
    - (2) Equipment for PMO

construction period and to reduce water rosses from the canal. Small structures such as drops, road crossings, turn-outs and farm inlets are also constructed.

6) Drainage Canal

Drainage canal is just earth canal which would be excavated by back-hoe. Erosion protection weir would be necessary at some places along natural drainagecourse way.

7) Farm Road

Farm roads are divided into two types, i.e. trunk farm road and secondary farm road. Both roads shall be all-weathered road with gravel pavement. Construction would be carried out during dry season as well as canal works and land grading works.

8) Land Grading Works

Since contour ditch irrigation method is proposed to the project area where present land slope is in the range of 2 ~5%, the present natural land slope would be reserved. Thus, land grading works would be minimized.

9) Project Management Office (PMO)

The works under this item consist of the following two categories.

- Construction of facilities such as office buildings, warehouse, workshop, garage, multi-purpose hall and staff quarters.
- Supply of workshop equipment, generator, vehicles, farm machines and maintanance equipment.

10) Marketing Facilities

Two types of warehouse as marketing facility are constructed in every village. One type is for general crops and the other is for tobacco crop. They would also be used for drying purpose.

11) Administration Cost

This is the cost necessary for administrative promotion and setting-up of the Project and to be allocated to the executing agencies.

12) Engineering Services

Engineering services by the consultants would be required for detailed design, tendering procedure and construction supervision, as the Project is approprcately large size.

13) Investigation Works

Investigation works consist of topo-survey for the pumping station, night storage reservoir and PMO, route survey for the pipeline and trunk farm roads, and boring survey for the pumping station. The investigation shall be conductedduring detailed design stage.

14) Physical Contingency

Physical contingency is considered since estimated work volume would be changed during detailed design stage due to unforeseenable site and geological conditions.

15) Compensation

Compensation to farmars is required for their cropping interruption during construction works. No compensation for housing is considered because all existing houses are reserved according to the land use plan.

7.2 Quantity of Project Works

Project work volume is carefully quantified by basic work item for civil and building works, and by each equipment item for equipment procurement.

7.3 Project Cost

7.3.1 Estimate Conditions

1) Construction Method

Since the project with a total irrigation area of 680 ha is appropriately large to be undertaken by civil engineering contractors, the construction cost is estimated on the contract basis.

2) Price Year and Exchange Rate

Current price as of February 1990 is applied to cost estimates.
The exchange rate between US Dollar and Zimbabwe Dollar is, 1 US$ = 2.304 Z$.

3) Unit Construction Rate

The unit construction rates obtained from the recent similar projects are well examined. Then appropriate unit construction rates to be applied to the Project are taken as detailed in Annex H. These unit construction rates are further split into foreign and local currency portions for the purpose of economic evaluation and possible foreign fund procurement.

4) Engineering and Administration Cost

The administration cost is set as 3% of direct construction cost. The engineering costs for the consulting services are estimated on the man-monthbasis required during detailed design, international bidding and construction supervision stages.

The unit rates of the consulting services and investigation works are detailed in Annex H. The expenses for land acquisition are not considered in accordance with the national policy, while compensation for cropping interruption due to construction workes is based on the present farming income.

5) Physical Contingency

The physical contingency is set as 10% of direct construction cost.

7.3.2 Project Cost

Based on the work volume and unit construction rates as described above, the total project cost at current price (as of February 1990) amounts to 36.3 million Zimbabwe Dollar composing 23.2 MZ$ for foreign currency portion and 13.1 MZ$ for local currency portion. (Refer to Table 7.3.1 and Annex H)

7.4 Operation and Maintenance Cost

7.4.1 Cost Component

Major components of the operation and maintenance cost are described below and shown in Figure 7.4.1.

Table 7.3.1 SUMMARY OF PROJECT COST
(As of Feb 1990)

(Unit: 1000 Z$)

Block	Service Area (ha)	Project Cost F/C	Project Cost L/C	Project Cost Total	Cost per ha
Block A	115	4,172	2,228	6,400	55.6
Block B	128	4,477	2,406	6,883	53.7
Block C	140	6,529	3,774	10,303	73.6
Block D	203	4,983	2,802	7,785	38.3
Block E	94	3,054	1,901	4,955	52.7
Total	680	23,215	13,111	36,326	53.4
		64%	36%	100%	

NOTE: Construction cost of NPMO is included in Block C

Table 7.4.1 SUMMARY OF ANNUAL OPERATION AND MAINTENANCE COST
(As of Feb 1990)

(Unit: 1000 Z$)

Block	Service Area (ha)	Annual O/M Cost F/C	Annual O/M Cost L/C	Annual O/M Cost Total	Cost per ha
Block A	115	45.3	47.7	93.0	0.808
Block B	128	57.6	56.8	114.4	0.893
Block C	140	87.7	299.7	387.4	2.767
Block D	203	80.0	73.8	153.8	0.757
Block E	94	34.5	41.9	76.4	0.812
Total	680	305.1	519.9	825.0	1.213

NOTE: 1) Operation & maintenance cost for NPMO is included in Block C.
2) Replacement cost is not included in the Table.

1) Salary and Wages

This is salary and wages for staff and personnel who are engaged with operation and maintenance works in the Project. Such personnel is divided into two categories, ie. intake pump operator and project management office staff.

2) Equipment and Material

The equipment and material costs are composed of fuel and oil costs to operate pump and generator, and costs of spare parts and maintenance materials for equipment and facilities.

3) General Expenses

This is the costs to manage the project management office. General administrative expenditure for the various office and field activities is required.

4) Replacement Cost

All equipment procured by the Project shall be replaced after use of economic durable year. Economic life span years for each equipment are listed below.

Pumps and generators	------------------	20 years
Pipes and valves	------------------	50 years
Vehicles	------------------	7 years
Farm machines	------------------	7 years
Maintenance machines	------------------	10 years

7.4.2 Unit Rate for O/M

Salary and wages for staff and personnel are based on the current budget figures (as of February, 1990) used by AGRITEX and MEWRD.

Fuel and oil costs is based on the current market price, while costs of spare parts and materials are estimated as a percentage of the initial construction costs. General expenses for PMO are also based on the percentage basis. 0.3 percent for spare parts and materials, and 10% for general expenses would be applied. (Refer to Annex H)

For the replacement costs of various equipment, original procurement costs could be adopted.

7.4.3 Operation and Maintenance Cost

Based on the unit rates and work quantities, annual operation and maintenance cost at current price (as of February 1990) at full development stage was estimated.

The annual operation and maintenance cost amounts to 578.6 thousand ZimbabweDollar. (Refer to Table 7.4.1 and Annex H)

8. PROJECT JUSTIFICATION

8. PROJECT JUSTIFICATION

8.1 Basic Concept

8.1.1 Objective

The objectives of the Project are;

(i) To significantly improve agricultural productivity in the project area through irrigation development project

(ii)To establish an irrigation development model for the development of other communal lands.

Thereby, achieving the ultimate goal of rural development, especially, the enhancement of living standards of communal land farmers of the lower income class, which the Five-year National Development Plan accords a top priority.

Therefore, the Project has a model and pilot role for other irrigated agriculture on Communal Lands, and for border stabilization with commercialized agriculture. The Project is not only included the simple irrigation development category but there is also construction work which should be executed as another projects.

In general an irrigation development project is, at least, fromed with pumping stations for water source work, pipelines for water conveyance work, farm-ponds for control work and on-farm facilities.

As for this, so many other facilities are required, which should be excuted in other of projects, such as office buildings and staffing, warehouses, workshop and staffing, garages, halls, marketing facilities and staffing, machinary, staff quarters, etc.. These should be already already be constructed for social infrastructures when the farmers are carrying out agriculture in the area. There are, however, no such facilities in the Project area, therefore the Project delineates these facilities.

In the economic evaluation of this Project, there are two categories one including and another excluding the social infrastructures which are comparatively investigated .

Furthermore, the Social Internal Rate of Return (SIRR) study shall be tried as new method of project justification, because the target of the Project is poverty eradication for Communal Land farmers and the mitigation of income disparity with urban workers.

To investigate the projected financial independence of Communal Land farmers and the irrigation development model on Communal Land, farm budget analysis and government budget analysis were carried out as well as the Financial Internal Rate of Return (FIRR) for the financial evaluation.

8.1.2 Methodology

(1) Economic Evaluation

The economic evaluation judges the project viability in terms of direct contribution to the national economy. In general, there are 3 judging criteria for the project's viability for development; (i) benefit-cost ratio (B/C ratio), (ii) net present value (NPV) and (iii) Economic internal rate of return (EIRR). In this economic evaluation, the EIRR method is employed.

(2) Social Evaluation

The traditional economic evaluation judges the project's viability by the EIRR meth computed from "Efficient Price" which justy measures national benefits through the optimum allocation of scare resources. Under the EIRR method, a development project for rural poverty is not promoted, when the EIRR is lower than the opportunity cost of capital. In recent years, in order to avoid such situations, international funding agencies such as the World Bank has introduced the Social Internal Rate of Return method (SIRR) computed from "Social Price" which puts a shadow weight on project benefits.

The basic concept of the SIRR method is to put more value on one dollar for low income brackets than one dollar for high income brackets. This project's justification, with the project benefits clearly beloning to the low income brackets, the SIRR is caluculated.

In general, the Social Internal Rate of Return (SIRR) is computed through the following process.

(i) Application of Shadow Wage Rate (SWR) for Unskilled Labour,

(ii) Application of Shadow Consumption Weight (SCW) for Each Income Bracket,

$$SCW(n) = [TE/I(n)]^e$$

where

SCW(n) ; Shadow Consumption Weight of Income Bracket n,

TE ; Income on Tax-Exempt Line,

I(n) ; Income on Income Bracket n,

e ; Elasticity of Marginal Unity ($0.5 \leq e \leq 2.0$).

(iii) Application of Shadow Income Weight (SIW) of Each Income Bracket,

$$SIW(n) = [MST(n) \times SP + MCT(n) \times 1.0] \times SCW(n)$$

where

SIW(n) ; Shadow Income Weight of Income Bracket n,

MST(n) ; Marginal Savings Tendency of Income Bracket n,

SP ; Savings Premium,

MCT(n) ; Marginal Consumption Tendency of Income Bracket n,

SCW(n) ; Shadow Consumption Weight of Income Bracket n.

(iv) Conversion of Benefits to Social Prices,

$$TSB = \sum_{n=1}^{10} EP(n) \times SIW(n)$$

where

TSB ; Total Social Benefits,

EP(n) ; Economic Benefits for Income Bracket n,

SIW(n) ; Shadow Income Weight of Income Bracket n.

(v) Calculation of Social Internal Rate of Return

In this project's evaluation, the SIRR is computed from the above costs and benefits for the purpose of eradicating poverty and mitigating the income disparity on the lowest income earners bracket, thereby quantifying the income redistributional function of the Project.

(3) Financial Evaluation

The following three analysis methods are employed to identify the financial viability of the Project;

(i) FIRR
(ii) Farm Budget Analysis
(iii) Government Budget Analysis
(iv) Foregin Reserve Position Analysis

8.1.3 Parameters

The following parameters for economic, financial and social evaluation are employed.

(1) Project Life

In line with the durable life of irrigation facilities, the project's life span is fixed at 50 years including the construction period. Therefore, facilities and equipment whose durable lives are within 50 years must be replaced within the replacement cost.

(2) Without Case

Although the present non-irrigated agriculture in the project area will result in a slight yield increase, the future without-case is fixed on to the present situation.

(3) Opportunity Cost of Capital

The application scope for security schemes in Zimbabwe is EIRR = 2.80%. Irrigation development projects executed on Communal Lands are included in the food security scheme. Therefore, this rate of 2.80% is regarded as the opportunity cost of capital which would be the cut-off rate of the Project suitability.

(4) Exchange Rate

The relevant exchange rate or Zimbabwean dollar (Z$) to US dollar (US$), as of the end of February 1990, is US$1 = Z$2.304.

(5) Price Level

All financial prices are expressed in the market prices, as of February 1990.

(6) Conversion Factor

The conversion factors from financial price to economic price are tabulated below.

Item	Conversion Factor	Basis	Table
Standard	0.852	Trade Statistics	I.1
Consumption	0.817	Trade Statistics	I.2
Transportation (Truck)	0.680	World Bank	I.7
Transportation (Train)	0.730	World Bank	I.7
Energy	0.620	World Bank	I.3
Shadow Wage Rate	0.300	World Bank	I.3

(7) Financial and Economic Prices

All financial and economic prices of farm inputs and outputs are fixed in standard internationally accepted methods, and shown in the Table I.4 to I.10 of Annex I.

(8) Residual Value

The residual values at the end of the project's life are not taken into account.

(9) Sunk Cost

i) The sunk cost of existing facilities are not taken into account, because these are negligible values.

ii) In Zimbabwe project evaluation is sometimes carried out under the condition that the costs of social infrastructures or governmental public survices are excepted from project cost, ragarding the sunk cost. As for project evaluation this methodology was adopted.

8.2 Project Cost

The project's cost is composed of investment cost, operation and maintenance cost and replacement cost. The financial project's costs expressed in market prices are converted to economic project costs for the purpose of performing the economic evaluation. (Table I.11,12 and 13 of Annex I)

(1) Investment Cost

The investment cost includes (i) Construction Cost, (ii) Engineering and Administration Cost, (iii) Compensation Cost and (iv) Physical Contingency.

The financial investment cost is 36,326 thousand Z$ and the economic one is 29, 435 thousand Z$. The investment cost flow except for physical contingency is as follows.

Table 8.2.1 INVESTMENT COST

(Unit: Thousand Z$)

Calender Year	Financial			Economical		
	Total	F/C	L/C	Total	F/C	L/C
1991	327	170	157	262	136	126
1992	327	169	158	263	136	127
1993	4,252	2,665	1,587	3,417	2,141	1,276
1994	15,606	10,032	5,574	12,538	8,060	4,478
1995	12,795	8,205	4,590	10,280	6,592	3,688
Total	33,307	21,241	12,066	26,760	17,065	9,695

(2) Operation and Maintenance Cost

The operation and maintenance cost includes (i) salary and wages, (ii) equipment and materials such as fuel/oil and spare parts and (iii) general expences. The financial cost and economical cost of those are estimated as 579 thousand Z$ and 461 thousand Z$, respectively. The details of operation and maintenance cost at full development is as follows.

Table 8.2.2 OPERATION AND MAINTENANCE COST

(Unit: Thousand Z$)

Item	Financial			Economical		
	Total	F/C	L/C	Total	F/C	L/C
Salary and Wages	155	0	155	117	0	117
Fuel and Oil	285	157	128	223	123	100
Spare parts	127	78	49	111	68	43
General Expences	12	0	12	10	0	10
Total	579	235	344	461	191	270

(3) Replacement Cost

The replacement cost includes costs for the replacement of equipment. The details of replacement cost is as follows.

Table 8.2.3 REPLACEMENT COST

(Unit: Thousand Z$)

Item	Economic Durable Yr	Financial Total	Financial F/C	Financial L/C	Economical Total	Economical F/C	Economical L/C
Pump and generator at pump station	20 years	5,336	4,813	523	4,909	4,428	481
Generator at project management office	20 years	59	53	6	54	49	5
Farming and maintenance machines	10 years	1,500	1,350	150	1,380	1,242	138
Vehicles and other equipment	7 years	187	156	31	170	147	23

8.3 Project Benefits

8.3.1 Definition of Benefits

The project's benefits accrued from irrigation facilities, rural roads and other components are divided into tangible benefits and intangible benefits (non-quantified benefits and non-quantifiable benefits). The intangible benefits are not mentioned in economic and financial evaluations but mentioned qualitatively in social evaluations. The tangible benefits are subdivided into agricultural output increase benefits, road benefit and domestic water benefits.

8.3.2 Beneficiaries

The beneficiaries for tangible benefits are 3,559 communal farmers in 618 households living in five villages with in the project area. In addition to these beneficiaries, the beneficiaries for intangible benefits are producers/dealers of forward-related and backward-related industries and neighbouring communal farmers who are able to learn irrigated agricultural technology.

8.3.3 Development of Benefit Accrual

The agricultural output increase benefit is subject to change in relation with irrigated service area and yield. The gestation period between the completion of on-farm work and the full development accrual is estimated at 4 years as shown in Table 8.3.1.

Table 8.3.1 DEVELOPMENT OF BENEFIT ACCRUAL THE GESTATION PERIOD

(Unit: percent)

Year in order	1	2	3	4	5	6	7	8	9
Irrigation Area	0	0	0	0	40	100	100	100	100
Yield	0	0	0	0	80	90	90	100	100
Benefit Accrual	0	0	0	0	32	90	90	100	100

8.3.4 Agricultural Output Increase Benefit

The agricultural output increase benefit is accrued from increases in cropping intensity through irrigated agriculture and from increases in yields through the ample supply of fertilizers, chemicals, high-yield variety seeds and tractors.

In this case, the benefit is quantified by a net increase in production value from a without-project case to a with-project case.

As shown in Table I.14 and 15 of Annex I, the benefit on an average-production-year basis is financially 2,642 thousand Z$ per annum and is economically 2,477 thousand Z$ per annum. And the crop budget on which the benefit calculation is based as shown in Table I.16 and 17 Annex I.

8.3.5 Road Benefit

The project includes the component of the improvement of non-paved rural roads which are 2 - 3m in width and 500 - 600m in length, connecting the five villages to the Nyamaropa-Elmi main road accross the project area.

The present non-paved rural roads, practically only permit scotch carts with oxen. It takes apt of time for scotchcarts with oxen and man power to transport agricultural output products and input materials.

In general, the road benefits are quantified by running cost saving benefits. In this case, the following formula is applied to quantify the transport labour time saving benefit.

FB = HH x TS x MWD

EB = FB x CCF x SWR

where

FB ; Annual transport labour time saving benefit (Z$, Financial price)

EB ; Annual transport labour time saving benefit (Z$, Economic price)

HH ; Number of households in the service area

TS ; Average annual transport labour time saving per household (Man-day)

MWD ; Unskilled labour wage rate per day (2.0Z$ per day)

CCF ; Consumption Conversion Factor (0.817)

SWR ; Shadow Wage Rate (0.300)

As a result, the benefit is financially 7,278Z$ per annum and economically 1,783Z$ per annum as shown in the Table I.18 of Annex I.

Although the monetary value of the benefit is small, the average annual labour saving per household is approximately 10 man-days, and the potential value is rather large.

8.3.6 Domestic Water (Except Drinking Water) Benefit

Since the irrigation facilities are able to sufficiently supply irrigation water, the surplus can be used for cattle and domestic use except for drinking water. Under the present situation, this kind of water is almost all from the Gairezi River.

In general, the water benefit is quantified by a willingness-to-pay for drinking water. In this case, the following formula is applied to quantify the water supply labour time saving benefit.

$$FB = HH \times (TSC \times TSA) \times MWD$$
$$EB = FB \times CCF \times SWR$$

where FB ; Annual water supply labour time saving benefit (Z$, Financial price)

EB ; Annual water supply labour time saving benefit (Z$, Economic price)

HH ; Number of households in the service area

TSC ; Average annual water supply labour time saving for cattles per household (man-day)

TSA ; Average annual water supply labour time saving for domestic water per household (man-day)

MWD ; Unskilled labour wage rate per day (2.0Z$ per day)

CCF ; Consumption conversion Factor (0.817)

SWR ; Shadow wage rate (0.300)

As a result, the domestic water benefit is financially 27,256Z$ per annum and economically 6,678Z$ per annum as shown in Table I.19 of Annex I.

Although the monetary value of the benefits are small, the average annual labour saving per household is approximately 37 man-days and the potential values are rather large. Especially, it contributes to decrease the heavy burden of women's domestic daily work.

8.4 Economic Evaluation

8.4.1 Economic Internal Rate of Return (EIRR)

The cut-off rate, which equals the tatal present values of the cost and benefit or B/C Ratio = 1.00, is called the Economic Internal Rate of Return. EIRRs are calculated for each cases nd are shown as follows, with the calculation basis also shown in Table I.20 of ANNEX report.

	CASE	EIRR
Case-1	Total project cost, including social infrastructures, public services and others.	5.50%
Case-2	Simple irrigation project cost, excluding consultant survices, social infrastructures and public services. To execute with an international fund.	8.28%
Case-3	Total project cost. To be executed with the Zimbabwean Government fund.	6.75%
Case-4	Simple irrigation project cost. To be executed with the Zimbabwean Government fund.	9.29%

Where the Project is regarded as a simple irrigation development, and to be executed with international funds, the Project becomes quite feasible because of on EIRR of 8.28%. Furthermore, when the Project is executed with a domestic fund, the EIRR rises up to 9.29%.

Even when the Project is executed totaly with an international fund, the EIRR shows 5.50%. And when the Project is executed with a domestic fund the EIRR rises up to 6.75%.

As a result which ever method is used the Project, with a model and pilot project role for Communal Lands, is quite feasible, because each case the EIRR exceeds the opportunity cost of capital by 2.80%.

8.4.2 Sensitivity Analysis on EIRR

The sensitivity analysis highlighted the effect of changes in parameters as shown in the following table.

Table 8.4.1 SENSITIVITY ANALYSIS OF EIRR

Risk Item	EIIR (%)
Two-Year Delay in Benefit Accrual	4.47
Five-Year Delay in Benefit Accrual	3.32
Benefit Minus 10%	4.44
Cost Plus 10%	4.54
Two-Year Delay in Project Commencement	5.41
Five-Year Delay in Project Commencement	5.23
Base Case	5.50

The project's EIRR is the most sensitive in delaing in the accrual of benefits. The EIRR declines from 5.5% in the lowest case to 4.47% in a two-year delay and even to 3.32% in a five-year delay 10% decline and an increase in benefits and costs both result in approximately 1.0% of the falling EIRR. Delay in project commencement has a little impact on the EIRR.

8.5 Social Evaluation

8.5.1 Social Internal Rate of Return (SIRR)

The social internal rate of return (SIRR) of the Project is calculated based on the foregoing methods.

(1) Premises

(i) Number of households per income bracket in Zimbabwe;

* To be based on "The Economy of Households in Zimbabwe" surveyed by the Central Stastical Office (CSO) in 1985,
* The income bracket composition in 1990 to remain unchanged compared with 1985,
* The income level in each income bracket in 1985 is to be inflated by the consumer price index of 141.0 in 1990 against 1985.

(ii) Tax-exempt income level;

2,050Z$ per annum, as of February 1990.

(iii) Elasticity of marginal utility;

To be fixed at e = 1.0 which is the average level of developing countries.

(iv) Saving Premium;

To be neglected due to uncertainty, therefore, the shadow consumption weight is equal to shadow income weight.

(2) Calculation of Social Internal Rate of Return (SIRR)

(i) The Application of shadow wage rate to unskilled labour;

0.300, based on the World Bank estimation is used.

(ii) The Application of shadow consumption weight on each income bracket;

The shadow consumption weight is computed by dividing the tax-exempt line income by respective income.

$SCW = (2,050/1,268)^{1.0} = 1.62$

(iii) Application of shadow income weight to each income bracket;

As the saving premium is neglected, SIW = SCW =1.62

For reference, the shadow income weight in each income bracket is shown in Table I.21 of ANNEX I.

(iv) Calculation of social prices;

The economic prices of the project's benefits at full development are converted to social prices.

TSB = 2,485 thousand Z$ x 1.62 = 4,026 thousand Z$

(v) The Social Internal Rate of Return for the Project, which takes income disparity into account, is calculated as follows.%

CASE			SIRR
Case-1	Elasticity of marginal utility	; e = 0.5	8.09%
Case-2	〃 〃	; e = 1.0	11.05%

It is proper to note that Case-1 with e = 0.5 is for the higher level developing countries and Case-2 with e = 1.0 is for the average level developing countries. It might be proper to apply Case-1 for Zimbabwe especially for an irrigation project in Communal Land. In this case, SIRR is 11.05% which exceed the opportunity cost of capital by 2.80%, then the Project becomes highly feasible.

8.5.2 Sensitivity Analysis on SIRR

The sensitivity analysis on SIRR is performed under the same conditions for EIRR. In addition, the sensitivivity analysis at the elasticity of marginal utility of 0.5 which is the lowest level of developing countries is also computed.

Table 8.5.1 SENSITIVITY ANALYSIS OF SIRR

Risk Item	SIRR (%) e = 0.5	SIRR (%) e = 1.0
Two-Year Delay in Benefit Accrual	6.59	8.88
Five-Year Delay in Benefit Accrual	5.06	6.86
Benefit Minus 10%	6.91	9.71
Cost Plus 10%	7.02	9.84
Two-Year Delay in Project Commencement	8.02	11.03
Five-Year Delay in Project Commencement	7.93	10.98
Base Case	8.09	11.05

Note: "e" stands for elasticity of marginal utility

The Project's SIRR is the most sensitive for delaing in the accrual of benefits. The SIRR declines from 11.05% in the lowest case to 8.88% in a two-year delay and even to 6.86% in a five-year delay. Although a 10% decline and an increase in benefits and costs both have a slight impact on the SIRR, these are almost the same as or more than 9.75% of the oppotunity cost of capital. A Delay in project commencement hasa little impact on the SIRR.

8.5.3 Intangible Benefit

In addition to tangible benefits, the following intangible benefits (non-quantified and non-quantifiable benefits) are accrued from the Project.

(1) Foreign Currency Saving Effect

Since tobacco, cotton, maize and wheat are export and/or import-substitute products, the maximum annual foreign currency saving is 1,113 thousand Z$ as shown in Table I.27 of ANNEX I on the condition that 50% of tabacco, and cotton with 30% of maize and wheat are exported and/or import-substituted.

(2) Forward and Backward Linkage Effect

The increase in agricultural output brings about an increase in production and employment of the forward-related industries such as machinery, seeds, fertilizers and chemicals and the backward-related industries such as agricultural product marketing.

(3) Multiplier Effect

Since the Project includes approximately 36.2% of the local currency portion, the considerable amount of this local currency is expected to finance the procurement of local construction materials and the providing of employment to the construction labour force which strengthens the purchasing power for consumer goods. This result in the creation of additional income and employment which is stimulated by the secondary and tectiary production activities.

(4) Stable Supply of Food

Stable supply of food around the project area is secured by a production increase in basic food crops such as maize and wheat.

(5) Irrigated Agricultural Technology Extension Effect

The neighbouring communal farmers around Nyakomba are expected to effectively learn the water management technique.

(6) Improvement of Living Standards

An increase of farm economic surpluses will bring forth the improvement of living circumstances of the households in the project area.

8.6 Financial Evaluation

The financial feasibility of the Project is investigated on the basis of Financila Internal Rate of Return (FIRR), farm budget analysis, the government expenditure analysis, foreig reserve position analysis.

8.6.1 Financial Internal Rate of Return (FIRR)

For the Financial Internal Rate of Return, it was studied that the Government pays subsidies to the Project on operation and maintenance costs.

	CASE				FIRR
Case-1	Governmental subsidy rate	is	0%	for O&M cost	4.25%
Case-2	〃 〃	is	20%	〃	4.91%
Case-3	〃 〃	is	40%	〃	5.52%

Each cut-off rate of B/C ratio = 1.00 are investigated. The FIRR is 4.25% when the subsidy rate is 0%. To gain the cut-off rate of 5.50% which is equivalent to Case-1 of the EIRR, it is required that the Government pays the subsidy of 40%. Even when the FIRR exceeds 2.80% of the opportunity cost of capital.

8.6.2 Farm Budget Analysis

(1) Definition of Farm Model

The typical farm model in the project area is estimated based on statistical data and the farm economic survey. The size of land holdings per typical household in the planning stage was suggested in the reallocation plan. 1.89ha of land holdings at present (without-project) and 1.75ha of landholding including 1.0ha of irrigated land during the projected (with-project) are employed for the farm budget analysis for the typical household. The physical parameters for the farm model is shown in Table 8.6.1.

(2) Farm Economic Surplus

By utilizing the crop budget and the above physical parameters, the farm economic surplus (disposable income) for the model household will increase by 1,344.6Z$ per annum as shown in Table I.24 of Annex I.

(3) Water Charge

In Zimbabwe, the water charges is levied for communal land farmers in the national irrigation scheme as part of the operation and maintenance (O&M) cost of irrigation facilities. The O & M cost of the Project per hectare is approximately 851.5Z$ per annum. The World Bank reports that the cost recovery rates which are dealt with by the Bank in several projects averaged only 30% of the total project costs including costruction cost, O & M cost and replacement cost. 30% of the total project cost is equivalent to 52.9% of the O & M cost in this project. Consequently, maximum water charge to be levied per model household is,

851.5Z$/ha × 1.00ha (irrigation area) × 52.9% = 450.4Z$.

This water charge shows a 15.3% increase of farm economic surplus which is less by 40% (affordability-to-pay).

Table 8.6.1 PHYSICAL PARAMETERS FOR THE FARM MODEL

Item	Unit	Without-Project	With-Project
Total Number of Family	Person	7	7
Family compsition	Person	2	2
Non-faeming adult	Person	1	1
Children	Person	4	4
Total area	ha	1.89	1.75
Dryland farming	ha	1.89	0.75
Maize	ha	1.04	0.41
Cotton	ha	0.76	0.34
Sunflower	ha	0.09	0
Irrigated farming	ha	-	1.00
Maize	ha	-	0.75
Cotton	ha	-	0.35
Tobacco	ha	-	0.30
Sugar beans 1	ha	-	0.35
Sugar beans 2	ha	-	0.30
Wheat	ha	-	0.65
Groundnuts	ha	-	0.05
Onion	ha	-	0.05
Item	Unit	Without-Project	With-Project
Total food retention	ton/year	1.88	1.88
maize	ton/year	1.66	1.66
Sugarbean	ton/year	0.11	0.11
Groundnuts	ton/year	0.11	0.11

Note: from Farm Economy Survey by the Study Team.

8.6.3 Government Budget Analysis

In addition to the farm budget analysis, a foreign loan repayment plan and the impact on government expenditures are investigated in the govenment budget analysis.

(1) Foreign Loan Repayment Plan

Assuming that the foreign currency portion of the project's cost will be financed from an international funding agency under the following interest rates and term of repayment, the foreign loan repayment plan is shown in Table I. 25 of Annex I.

Item	Period
Interest Rate	3% per annum
Grace Period	10 years
Loan Period	30 years

As a result, the maximum annual capital and interest payment is approximately 1,668 thousand Z$ in the 11th year and this amount is equivalent to 0.033% and 0.757% of the national budget and the budget for the agricultural sector in the 1988-1989 fiscal year, respectively.

(2) Impact on Government Expenditures

Furthermore, in addition to foregin loan repayments, the government's budgetary position is forecasted considering local currency portions and revenues from the water charge and marketing board sales as shown in Table I.26 of Annex I.

As a result, the maximum annual net budget requirement is approximately 6,196 thousand Z$ in 4th year, and this amount is equivalent to 0.124% and 2.812% in the national budget and the budget for the agricultural sector in the 1988-1989 fiscal year, respectively.

8.6.4 Foregin Reserve Position Analysis

The Project will have substancial impact on the foreign reserve position through (i) foreign exchange requirement of the foreign loan repayment and O & M and replacement cost and (ii) the foreign exchange contribution of foreign loan disbursement and trade outputs. Table I.27 clearly shows that there are no drastic fluctuations in the Foreign Reserve Position.

8.7 Overall Evaluation

[Opportunity Cost of Capital] As previously mentioned,as a National standard, there are Food Security Scheme in Zimbabwe, and their application scope is EIRR = 2.80%. For the project evaluation this standard of EIRR = 2.80% was adopted as the Opportunity Cost of Capital.

[Economic Evaluation] Economic evaluation was carried out in four cases, according to the EIRR method. The calculation result was 5.50% in the lowest case which exceeded the Opportunity Cost of Capital. Therefore, it can be said that Project is quite viable.

[Social Evaluation] The cut-off rate of the SIRR exceeds the EIRR theoretically. In this Project the SIRR was quite higher by 11.05%. Therefore, it can be said that the Project is highly social.

[Financial Evaluation] The financial evaluation was studied for four times.

Firstly is the FIRR method. Even in the case where the governmental subsidy is 0% for O/M cost, the FIRR was 4.25%, therefore the Project is financially viable.

Secondly farm budget analysis. The farm economic surplus increases by Z$ 1,344.6, therefore, farmers' income are significantly improved. Farmers water payment charges will also be easy.

Thirdly is the impact on Government Expenditures. The maximum annual net budget requirment is Z$ 6,196 thousand in the 4th year, and this is equivalent to 2.81% of the budget for the agricultural sector in the 1988/1989 fiscal year.

Fourth is foreign Reserve Position Analysis. The analysis clearly shows that there are no drastic fluctuations in the foreign Reserve Position.

[Other Evaluations] Minor and intangible benefits are explained in this part. Road and domestic water benefits were studied as mjnor benefits. Both are not financially large yet are high in terms of local potentiality, namely the roads make labour saving of 10 man-days per year per houschold, and a domestic water supply makes same 37 man-days labour saving.

As intangible benefits, the following items are accrued from the Project, namely foreign currency saving effect, forward and backward linkage effect, multiplier effect, stable supply of food effect, irrigated agricultural technology extension efect and improvement of living standard effect are expected.

[Overall Evaluation] The most important governmental policies to improve the agricultural productivity and living standard of communal land farmers which occupy 55% of the National population.

The Project, which planed under this governmental policy, has not only economical and financial viabilities, but also as model and pilot roles for future irrigation development projects on other Communal Lands.

As mentioned above, the viability and significance of the Project were confirmed, and then Zimbabwean Government strongly recommended to commence the construction work of the Project.

ANNEX

ANNEX-1 Member List of JICA Team and AGRITEX

NAME	TITLE
JICA Official	
- Mr. Sigemitu Tukamoto	JICA Cordinator (Phase Ⅰ)
- Mr. Kazushige Aragaki	JICA Cordinator (Phase Ⅱ)
JICA Study Team	
- Dr. Mochizuki Yoshizo	Team Leader, Rural Development Planning
- Mr. Jimpei Ishizaka	Sub Team Leader, Irrigation and Drainage
- Mr. Ryosuke Sakanashi	Facilities Planning
- Dr. Yoshio Yoshida	Agriculture (Phase Ⅰ)
- Mr. Takeshi Ohmori	Agriculture (Phase Ⅱ)
- Mr. Akira Iwamoto	Hydrology and Meteorology
- Mr. Masahiro Isomura	Land Use Planning
- Mr. Takehiko Ogawa	Economic Evaluation
- Mr. Shunichi Hosono	Design and Cost Estimation
ZIMBABWE Officials Concerned	
(AGRITEX Counterparts)	
- Mr. J. C. Nduna	District Agricultural & Extension Officer (D.A.E.O.)
- Mr. A. F. Mtetwa	Agricultural & Extension Officer (A.E.O.)
- Mr. B. Jenah	Agricultural & Extension Officer (A.E.O.)
- Mr. S. Tauro	Agricultural & Extension Officer (A.E.O.)
- Mr. F. Dzvatsva	Senior Agricultural & Extension Supervisor (S.A.E.S.)

- Mr. A. D. Sondo	Extension Worker Cartographic (E.W.Carto)
- Mr. A. O. Runganga	Agricultural & Extention Supervisor (S.A.E.S.)
- Mr. P. Samusodza	Extension Worker
- Mr. G. Mandimutsira	Irrigation Manager

(Another Officials Conserned)

- Mr. J. Makado	Acting Director, AGRITEX
- Mr. R. J. Chitsiko	Chief Irrigation Officer, AGRITEX
- Mr. B. Madondo	Provincial A.E.Officer, AGRITEX
- Mr. D. Chipatiso	Assistant P.A.E.Officer, AGRITEX
- Mrs. G. H. Mudiwa	Under Secretary, MLARR
- Mr. B. Marowa	Desk Officer Japan, Ministry of Foreign Affairs
- Mrs. M. A. Bamu	Assistant Secretary, Ministry of Finance

Note

JICA : Japan International Cooperation Agency

AGRITEX : Department of Agricultural Technical and Extension Services

MLARR : Ministry of Lands, Agriculture and Rural Resettlement

JICA