CHAPTER 3. THE DEVELOPMENT PLAN

3.1. Basic Concept of Development Plan

3.1.1. General

Of the total land reclamation area (254,700 feddan) proposed in the M/P Study, the area centering on Rabaa/Qatia (53,400 feddan) was selected as the priority subproject of land reclamation to be conducted the feasibility study (the F/S Area), adjacent to the South Tina Plain area (60,000 feddan) for which feasibility study has been completed by PPU/GARPAD. For the land reclamation areas, the El Salam Canal extension from Suez Canal to El Khirba was studied.

The F/S Area is located at the starting point of the El Salam Canal extension next to the Tina Plain so that it could act as a pilot project for the whole M/P land reclamation of North Sinai. The area consists of a variety of landforms and soils, therefore, it could also serve as a model for the development of North Sinai. Unlike conditions in the Nile Delta, sandy soils occupy most of the area; accordingly, the farm management pattern should be different from those of the Delta.

3.1.2. Land Classification for Reclamation

Based on the results of soil survey, land classification has been made in order to evaluate land reclaimability. The F/S Area can be separated into two physiographical units, that is, clay flats where surface irrigation can be performed and sandy terrain where sprinkler and drip irrigation will be introduced. Because the limitations of land conditions regarding each irrigation method are different, two land classification specifications for respective irrigation methods are required.

As shown in Table 3.1-1, land classes are separated into "arable", that is, Class-1 to Class-4 and "nonarable", namely Class-6. The most suitable land is Class-1 land which does not have any limitations as to reclamation. The limitations are categorized into soil condition (s), topographic condition (t), and drainage condition (d). According to the severity of single or combined limitations, arable land is classified into Class-2 to Class-4 land. Class-6 land is non-arable land including mobile sand dunes and Sabkha.

Land classification specifications for surface irrigation and for sprinkler/drip irrigation were prepared for the North Sinai region in accordance with the system of the U.S. Bureau of Reclamation and are shown in Table 3.1-2. Using the specifications, a land classification map was drawn up (Figure 3.1-1).

Class-1 land is not found in the F/S Area. Class-2 land (2s) is located near Rabaa/Qatia area and occupies 8.3 percent of the total area. Gently undulating sandy terrain, Class-3 land (3st) occupies about a half of the F/S Area, followed by undulating sandy terrain, Class-4 land (4st). Both Class-3 and Class-4 lands comprise about 3/4 of the F/S Area. Class-6 land consists of mobile sand dunes and Sabkha occupies about 2 percent of the total area and should be excluded from the land reclamation area. Moreover, miscellaneous land consisting of ruin and military space in addition to existing town and village, which occupy about one percent of the total area will also be excluded from the land reclamation area.

Consequently, 51,750 feddan of land is considered to be reclaimable for irrigated agriculture, as shown in Table 3.1-3.

Table 3.1-1 Land Classification for Irrigated Agriculture (Sprinkler/Drip Irrigation or Surface Irrigation)

Class 1 - Arable: Land that is highly suitable for irrigated farming, being capable of producing a sustained and relatively high yield of climatically adapted crops at reasonable cost. This land has a relatively high payment potential.

Class 2 - Arable: Land that has moderate suitability for irrigation. These are usually either adaptable to a narrower range of crops more expensive to develop for irrigation, or less productive than Class 1. Potentially this land has only intermediate payment potential.

Class 3 - Arable: Land that has only marginal suitability for irrigation. It is less suitable than Class 2 land and usually has either a serious single deficiency or a combination of several moderate deficiencies in soil, topography, or drainage properties. Although greater risk may be involved in farming this land than that of Classes 1 and 2, it is expected to have adequate payment potential under the proper management.

Class 4 - Limited Arable: Land that is adaptable to only a very limited range of crops. For example, land suited only to such single crops as rice, pasture, or fruit.

Class 6 - Nonarable: Land that is nonarable under the existing or projected economic conditions associated with the proposed project development. Generally, Class 6 comprises steep, rough, broken, rocky, or badly eroded land, or land with inadequate drainage, or other marked deficiencies.

Table 3.1-2 Land Classification Specifications

(1) For Sprinkler and Drip Irrigation

Limitation	1	2	3	4	6
Soil (s)					
Texture	loam to clay loam	sandy loam to fine sand	loamy sand to medium sand	coarse sand	loose coarse sand
Depth (cm)	> 200	> 200	> 100	> 100	< 100
Available moisture (cm/m)	> 15	> 15	5 - 10	2 - 5	< 2
Salinity	none	none to slight	slight	strong	very strong
Sodicity	none	none	slight	strong	very strong
Topography (t)					
Slope (%)	0 - 3	0 - 3	3 - 8	8 - 15	> 15
Relief	flat	flat - gently undulating	gently undulating - undulating	undulating - rolling	hilly
Erosion hazard	none	none	slight	moderate to severe	severe
Drainage (d)					
Drainability	good	good to moderate	moderate	excessive or poor	very excessive or very poor
Permeability	moderate	moderate	moderate to high	high to very high	very high
Water table (cm)	> 150	100 - 150	100 - 150	60 - 100	< 60

(2) For Surface Irrigation

Limitation	1	2	3	4	6
Soil (s)					
Texture	loam to clay loam	clay loam to light clay	light clay to clay	clay	heavy clay, soft immatured
Depth (cm)	> 200	> 200	> 100	> 100	< 100
Salinity	none to slight	slight to strong without salt crust	strong without salt crust	very strong with salt crust	extremely strong with thick salt crust
Sodicity	none	none-slight	slight	strong	very strong
Carbonate (%)	0 - 10	0 - 10	> 10	> 10	> 10
Gypsum (%)	0 - 5	0 - 5	5 - 10	10 - 15	> 15
Topography (t)					
Slope (%)	0 - 2	0 - 2	2 - 5	2 - 5	> 5
Relief	flat	flat - very gently undulating	flat - gently undulating	flat - gently undulating	flat - undulating (depression, EL 0 m)
Erosion hazard	none	none	none	slight	severe
Drainage (d)					
Drainability	good	slightly poor	poor	poor to very poor	very poor
Permeability	moderate	low	low	low to very low	impermeable
Water table (cm)	> 150	100 - 150	60 - 100	30 - 60 periodically water logging	30 permanently water logging

Figure 3.1-1 Land Classification Map

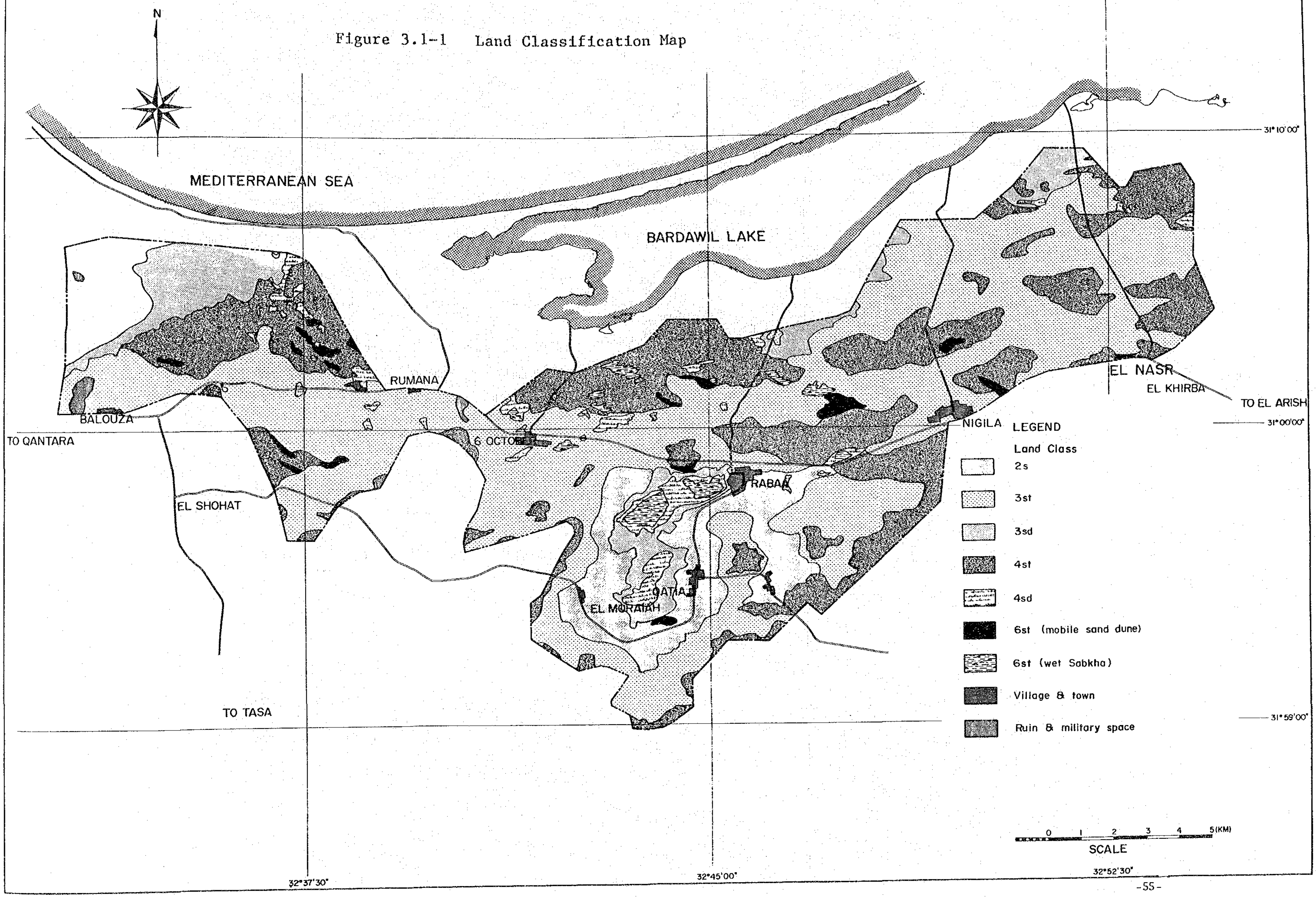


Table 3.1-3 Land Classification of F/S Area

Land Class		Area (feddan)	(%)
Class-2 (arable)	2s	4,400	8.3
Class-3 (arable)		29,200	54.7
	3st	(25,150)	
	3sd	(4,050)	
Class-4 (arable)		18,150	34.0
	4st	(15,050)	
	4sd	(3,100)	
Sub-Total		51,750	97.0
Class-6 (nonarable)		1,650	3.0
	6st (sand dune)	(550)	
	6sd (wet Sabkha)	(550)	
	Ruin & military	(150)	
	Town & village	(400)	
Total		53,400	100.0

3.1.3. Land Use Plan

The land use plan in the F/S Area was drawn up based on the land classification map, with consideration for the following points;

Firstly, non-arable Class-6 land (mobile sand dune and Sabkha) was excluded from the land reclamation area. Meanwhile, existing roads, villages and towns, ruins and military areas were to be left as they were or expanded in the future.

Secondly, arable land (Class-2 to Class-4 land) was proposed to be reclaimed after reducing the areas for newly built settlement villages, livestock shelters and investor's complex, etc. Accordingly, 49,200 feddan (gross) of land was determined to be reclaimed for farmland and allocated to settlers in different categories as below:

Settlement Category	Farm Size (feddan/family)	Ratio in Total Area (%)
Smallholders	5	50 - 65
Graduates	10	10 - 15
Investors	80/unit	25 - 35

Finally, the proposed land reclamation area was divided by existing roads and the planned El Salam Canal alignment in accordance with the following five farming types:

CP-1	Smallholders, sand flats
CP-2	Smallholders, clay flats
CP-3	Graduates, sandy undulating
CP-4	Investors, sand undulating, livestock
CP-5	Investors, sand undulating, fruits

The land use plan is shown in Figure 3.1-2 and Table 3.1-4. Comparison between present and proposed land use is given in Table 3.1-5.

Sand flats where partly settled Bedouin farmers cultivate crops under drip irrigation, were determined to be allocated to smallholders including Bedouin. Sandy terrain with gentle undulation (sand undulating) was to be allocated to graduates or investors. A somewhat steeper portion of sand undulating was to be allocated to the investors who will grow fruit trees. Clay flats were planned for allocation to smallholders migrating from the Delta region.

Exploring the groundwater, farmland with drip irrigation system have been expanded by Bedouin settlers in El Moraiah, Rabaa and Qatia, however, the groundwater quality is saline. Therefore, the existing farmlands will also be included in the on-farm development plan when the Nile water becomes available through the El Salam Canal extension. The current landownership will be assured or compensated after the project implementation.

The reclaimed land will be distributed to smallholders, graduates and investors, in addition to Bedouin. The total number of farming families is estimated at 6,500 households. On their farmland in sandy terrain, fruits, vegetables, oil crops, food crops and fodder crops will be cropped under sprinkler or drip irrigation systems. Livestock production mainly of sheep, goats and beef cattle will also be practised.

An oil extraction plant and a slaughterhouse with cut meat plants will be established for agro-industrial development. Two sites of investor's complex were proposed to be established in Rabaa and Rumana. The following facilities will be constructed in these sites:

- Farm machinery shed
- Slaughtering and cut meat plant
- Oil extraction and refinery plant
- Fruit and vegetables marketing center

In addition, Agricultural Development Center will be built along the highway near Rabaa in order to give technical support to the farmers.

New-communities (settlement villages) for settlers, namely, smallholders and graduates were planned to be distributed with a distance between house and farm of 2.5 and 3.0 km. The settlement villages are divided into 3 levels according to population, that is, large, medium and small. Livestock shelters will be set up adjoining the settlement village. Twelve new-communities for settlers will be constructed and 4 existing villages will be rehabilitated in the F/S Area.

Table 3.1-4 Land Use Plan

Land Use	Area (feddan) (gross)	(net)
Cultivated Land		
Smallholders (sand flat)	27,700	23,500
" (clay flat)	2,400	1,800
Graduates	5,400	4,600
Investors (livestock)	7,000	6,000
" (fruits)	6,700	5,700
(Sub-total)	(49,200)	(41,600)
Livestock Shelter	1,400	
Investors Complex	50	
Agricultural Development Center	50	
Existing Town & Village	400	
Settlement Village	1,050	
Ruins & Military Areas	150	
Mobile Sand Dune	550	
Wet Sabkha	550	
(Sub-total)	(4,200)	
Total	53,400	

Figure 3.1-2 Land Use Plan

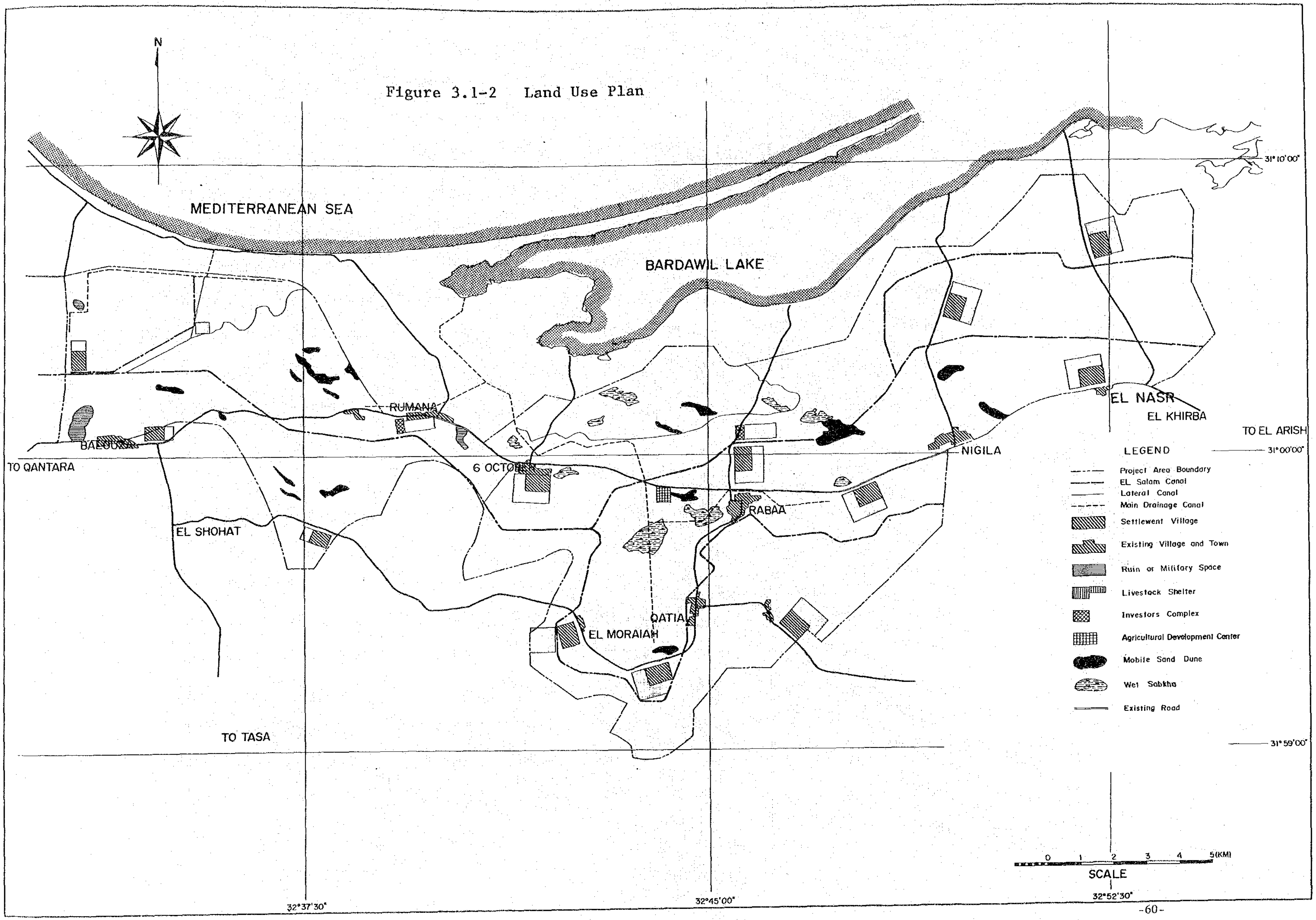


Table 3.1-5 Comparison between Present and Proposed Land Use

(Unit: feddan, gross)

Proposed Land Use	Present Land Use by Landforms: Sand Flat: Cultivated Land	Sand Flat: Town & Village	Sand Flat: Desert	Sand Undulating: Military Space	Sand Undulating: Desert	Clay Flat: Ruin	Clay Flat: Desert	Mobile Sand Dune	Sabkha	Total
Cultivated Land										
Small Holders	1,300		26,400				2,400			30,100
Graduates					5,400					5,400
Investors					13,700					13,700
Livestock Shelter			1,200		160		40			1,400
Investors Complex					50					50
Irrig. Agric. Extension Center			50							50
Existing Town & Village		400								400
Settlement Village			900		80		70			1,050
Ruin & Military Space				140		10				150
Mobile Sand Dune								550		550
Sabkha									550	550
Total	1,300	400	28,550	140	19,390	10	2,510	550	550	53,400

3.2. Land Settlement Plan

3.2.1. Premise for the Settlement

One of the factors which can determine the project's success is the settlement plan. For the purpose, it is necessary to consolidate the environment in order to settle the farmers in the F/S Area and to make them self-supporting in agricultural management.

It is anticipated that many people who belong to various categories including the Bedouin will come to settle from many different locations. Therefore, the main premises for the settlement are as follows;

- To act in harmony with each other
- To realize highly productive agriculture
- To achieve self-supporting agricultural management

There are 3 categories for settlement, that is, smallholders, graduates and investors. Generally, farm size for settlers are considered as follows;

Smallholder	5 feddan
Graduate	10 feddan
Investor	80 feddan/unit

As for the distribution ratio for each category, land conditions and balance for farm labour in the F/S Area should be studied. However, considering the increases in employment opportunities and the supply of farm labour in the Area, it is recommended to promote the settlement of smallholders including the Bedouin.

3.2.2. Settlement Plan

Based on the premise mentioned in the previous paragraphs, the land settlement plan in the F/S Area was prepared as shown in Tables 3.2-1 and 3.2-2. As the results, 61.2 percent of reclaimable land is distributed for smallholders, 11.0 percent for graduates and 27.8 percent for investors, respectively.

It is considered that harmony among the settlers is very important for farming and maintaining irrigation facilities etc. in the rural society; therefore, each category was planned to be distributed as shown in Figure 3.2-1. And the procedure of land settlement is given in Figure 3.2-2.

1) Target Farm Income and Form of Settlement

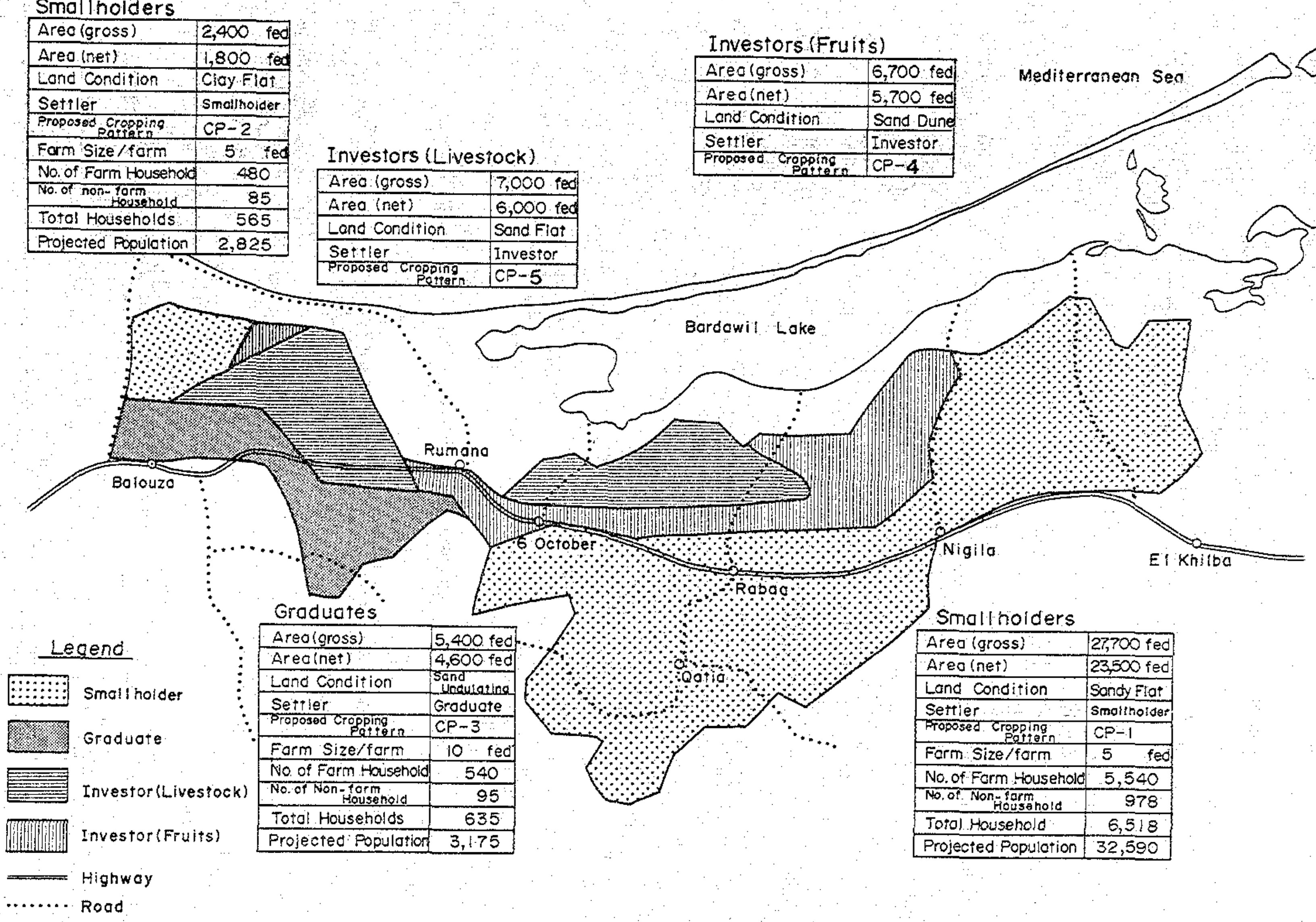
Based on the proposed cropping pattern, target farm income will be accounted for in each farming type taking into consideration an annual household expenditure of 2,000 - 3,500 LE/farm.

As mentioned before, many different kinds of people will come to settle in the F/S Area from various locations. In order to establish a rural communities with favourable cooperation among residents, and also to promote productive agriculture, it is recommended to form the settlements with farmers who belong to the same category or whose places of origin are the same. Organization of settlers will be necessary for the efficient use of irrigation and for marketing and supply of agricultural products and inputs. Considering the necessity for organization and cooperation among settlers, it is deemed more effective to form rural communities according to the settlers' categories and native places. Organization of settlers is described in Section 3.9.

2) Strategy for the Bedouin

There are 2,700 households in the F/S Area, of which 1,950 households (72%) are Bedouin. The Study Team conducted interviews with Bedouin in parallel with the farm economic survey. As a result, Bedouin who are nomadic or semi-nomadic are willing to settle, and they require housing, farmland (5 feddan), livestock and financial loans.

Figure 3.2-1 Land Settlement Plan in F/S Area



Smallholders

Area (gross)	2,400 fed
Area (net)	1,800 fed
Land Condition	Clay Flat
Settler	Smallholder
Proposed Cropping Pattern	CP-2
Farm Size/farm	5 fed
No. of Farm Household	480
No. of non-farm Household	85
Total Households	565
Projected Population	2,825

Investors (Livestock)

Area (gross)	7,000 fed
Area (net)	6,000 fed
Land Condition	Sand Flat
Settler	Investor
Proposed Cropping Pattern	CP-5

Investors (Fruits)

Area (gross)	6,700 fed
Area (net)	5,700 fed
Land Condition	Sand Dune
Settler	Investor
Proposed Cropping Pattern	CP-4

Graduates

Area (gross)	5,400 fed
Area (net)	4,600 fed
Land Condition	Sand Undulating
Settler	Graduate
Proposed Cropping Pattern	CP-3
Farm Size/farm	10 fed
No. of Farm Household	540
No. of Non-farm Household	95
Total Households	635
Projected Population	3,175

Smallholders

Area (gross)	27,700 fed
Area (net)	23,500 fed
Land Condition	Sandy Flat
Settler	Smallholder
Proposed Cropping Pattern	CP-1
Farm Size/farm	5 fed
No. of Farm Household	5,540
No. of Non-farm Household	978
Total Household	6,518
Projected Population	32,590

Table 3.2-1 Land Settlement Plan in F/S Area

Settlement Category	Farm Size (feddan/family)	Area (gross) (feddan)	(%)
Smallholders			
Sand flat	5	27,700	
Clay flat	5	2,400	
(Sub-total)		(30,100)	61.2
Graduates	10	5,400	11.0
Investors			
livestock	80*/	7,000	
fruits	80*/	6,700	
(Sub-total)		(13,700)	27.8
Total cultivated land		49,200	100.0
Non-cultivated land		4,200	
Grand Total		53,400	

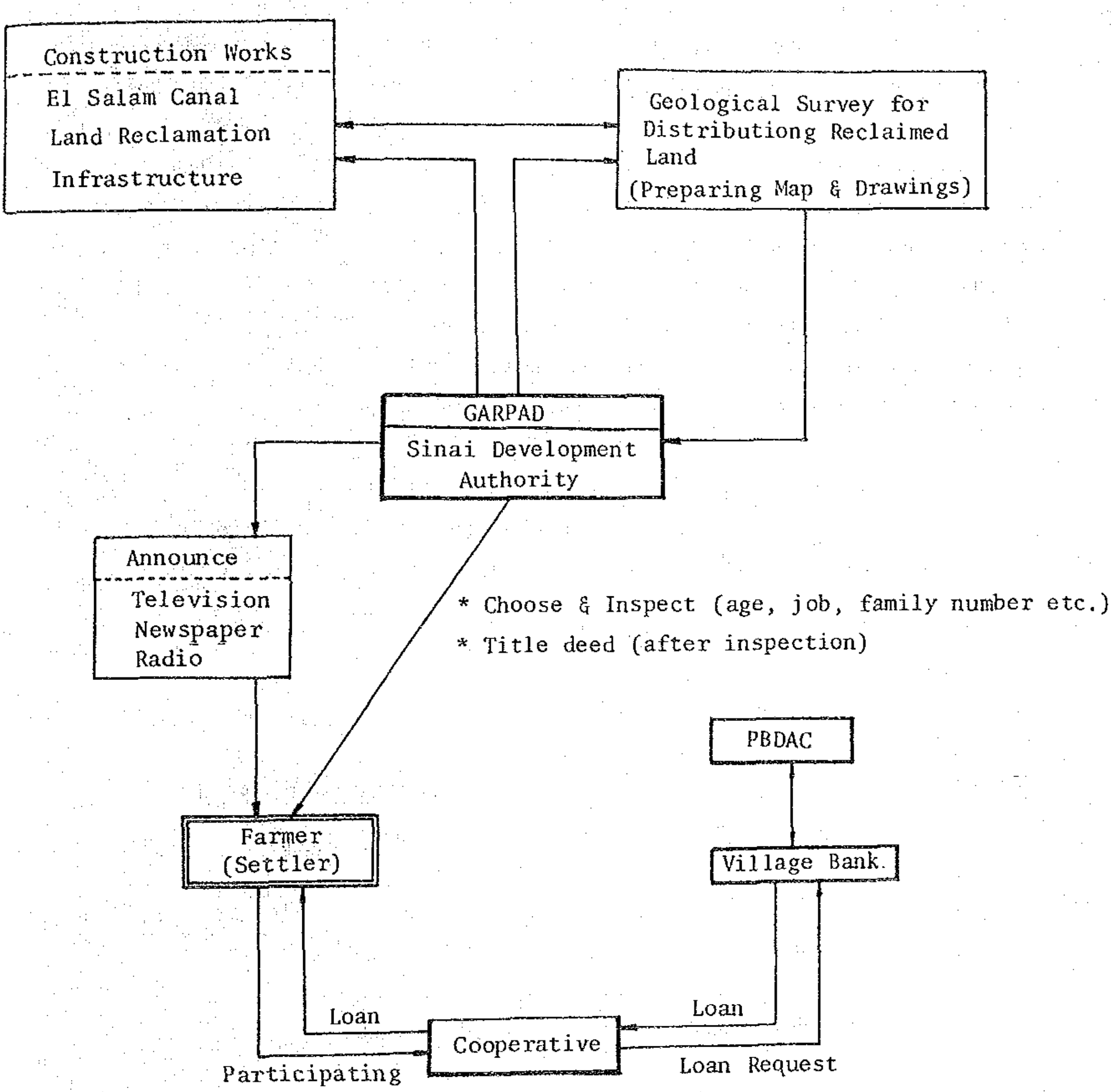
*/ Per unit

Table 3.2-2 Number of Settlement Farmers in F/S Area

Settlement Category	No. of families	Population
Smallholders		
Sand Flat	5,540	27,700
Clay Flat	480	2,400
(Sub-total)	(6,020)	(30,100)
Graduates	540	2,700
Total	6,560	32,800
Non-farming families*/	1,160	5,800
Grand Total	7,720	38,600

*/ 15% of total families

Figure 3.2-2 Procedure of Land Settlement



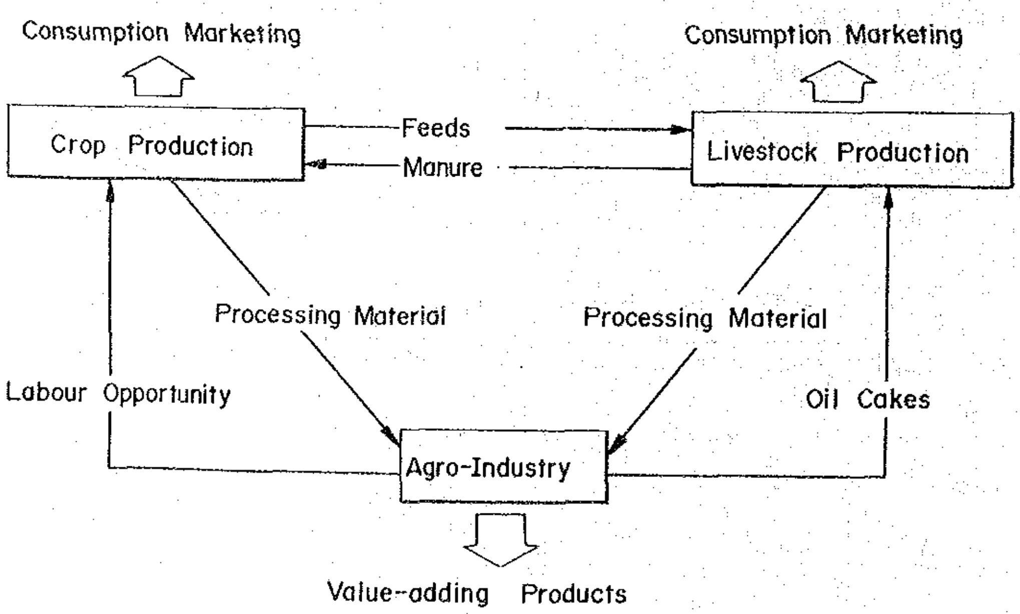
3.3. Crop and Livestock Production Plan

3.3.1. General

It is imperative to establish and maintain stabilized productivity by improving soil water-holding capacity and nutrient retention capacity in any desert area agricultural development.

This can only be realized by coupling crop production with a livestock sector, in terms of the following aspects. Firstly, crop diversification is necessary to prevent continuous mono-cropping hazards, and at the same time to increase vegetative coverage on the reclaimed land, protecting them from wind erosion. Secondly, livestock by-products should be effectively utilized to supply manure to farmland and crop by-products to livestock feeding.

Such a typical linkage among crop, livestock and agro-industrial subsectors enables development to be amplified in value-adding products from the projects, as shown in the following figure.



3.3.2. Crop Production Plan

Selection of crops was made from among those which are currently cropped in the proposed area, already introduced in surrounding areas or tested at nearby agricultural experimental stations and which have shown promising results. The selection process was based on a numerical evaluation for various environmental, physiological and economic factors, covering (1) food crops, (2) fodder crops, (3) oil crops, (4) vegetables, and (5) fruits, as shown in Table 3.3-1 (refer to APPENDIX-F).

Three types of farmers will be settled, namely, smallholders, graduates and investors. And three types of locational conditions, i.e., sand flats, clay flats and undulating sand areas, in combination, give the following five proposed farming types (Table 3.3-2):

CP-1	Sand Flats,	Smallholders including Bedouin
CP-2	Clay Flats,	Smallholders
CP-3	Undulating Sand,	Graduates
CP-4	Undulating Sand,	Investors (Livestock)
CP-5	Undulating Sand,	Investors (Fruits)

3.3.3. Cropping Patterns

Characteristics and crop composition of the proposed patterns are shown in Figure 3.3-1. Crop diversification is indispensable for efficient cropping and marketing. From various crops, crop combinations and crop calendars are formulated with consideration to locational conditions of applying areas, degree of coupling with livestock sector, extent of demand for products, balance in labour and other inputs and measures to cope with current issues (Figure 3.3-2).

Table 3.3-1. Crop Selection Procedure

Characteristics	Description		Score
Adaptability to Desert	Drought resistance, sand adaptability	Sand preference	2
		Moderately susceptible,	1
		Poor growth on sand	0
Demand Situation	Supply tightness, tendency of price hike	Infinite demand	3
		Estimated, 10,000-ton	2
		Estimated, 10,000-ton	1
		Demand saturated	0
Export/Import	Exportable or import substitutable	Import substitutable	3
		Currently exporting	2
		Overseas market aspect	1
		No trade expected	0
Crop Economy	Gross margin/feddan	Over LE 1,000	3
		500 - 1,000	2
		200 - 500	1
		Below LE 200	0
Current Existence	Observed in ...	Farms in North Sinai	2
		Trials plot	1
		None	0
Processibility	Storable by processing	Valuable material	2
		Low profit if processed	1
		Not processable	0
By-product Utilization	Value of by-products	Useful by-product	2
		Conditionally useful	1
		Not usable	0
Water Requirement	Daily consumption in June/July (in mm)	No crop in summer	3
		0 - 3 mm/day	2
		3 - 10 mm/day	1
		More than 10 mm/day	0
Labour Utilization	Return to labour input (LE/manday)	Higher than LE 10	3
		LE 5 - LE 10	2
		LE 2 - LE 5	1
		Not labour intensive	0
Salinity Tolerance	ECe level causing yield drop (to a half)	ECe 16	3
		12 - 16	2
		8 - 12	1
		8	0

Table 3.3-2. Proposed Farming Types

Type of Farming	CP-1	CP-2	CP-3	CP-4	CP-5
Locational Situation	Sand Flat	Clay Flat	Sand Undulating	Sand Undulating	Sand Undulating
Project area (Gross) (feddan) (Net)	27,700 23,500	2,400 1,800	5,400 4,600	7,000 6,000	6,700 5,700
Settlers	smallholder	smallholder	graduate	investor	investor
Holding size (feddan)	5	5	10	80	80
Type of farming	combined, oil crop with sheep/goats	combined, field crop with cattle	combined, crop, orchard with cattle	livestock, specialized	orchard, specialized
Role of animal husbandry	Major role	auxiliary role	auxiliary role	specialized	not combined manure purchased
Labour Supply / mechanization	labour intensive, suppliable to other types	mechanizing paddy only labour intensive	self supplied labour, no typical mechanization	hired labour, mechanized	hired labour, mechanized

The type of cropping pattern applied to smallholders and graduates must pay particular attention to the preventive measures for degradation of productivity, as well as selecting crops and cropping periods to ensure that water consumption in June and July does not exceed the critical level.

As for cash crops, vegetables are planned to give priority to nily-winter season, according to the rise in demand during this season. Rate of fruit planting was determined within a predictable range of securing outlets to correspond with projected demand in the target marketing areas. A wide-ranging harvesting period for labour requirements and machinery use was reflected in determining the share of planting areas for individual fruit species.

Furthermore, crop species well-adapted to the ambient conditions during the initial stages of reclamation were provisionally employed prior to establishment of a permanent rotation cycles. Additionally, orchard space with immature fruit seedlings, under smallholder and graduate patterns, is to be intercropped for short duration crops, thus maximizing land use and cropping intensity.

For the formulation of patterns, attention was also paid to crop rotation. Crops that are liable to exhaust soil fertility should be dispersed evenly over a cropping pattern. General efforts to maximize crop intensity should be made. As a means of wind erosion control, a higher percentage of land should be given to perennial crops such as orchards or alfalfa.

Manure requirement for each pattern formulated in this way was assessed as slightly less than the supply from planned livestock herds, therefore it would be sustainable with self-supplied feeds.

The typical cropping pattern for each farming type is proposed as follows;

1) Cropping Pattern CP-1

This pattern is applied on sandy flat areas, where immediate cropping is available after the completion of land consolidation work. Twenty percent of the area under this pattern is planted with olive trees (for oil production), where a rotation is introduced covering fodder crops, oil crops, and vegetables.

The sandy soils under this pattern have low water holding capacity and poor nutrient retention capacity. These constraints can be improved by heavy application of manure or crop residues. This is why livestock is emphasized in this pattern to which fodder crops are heavily devoted. For example, successive cuttings of alfalfa for two years, can be incorporated with fodder beet as a winter crop and sordan and napiergrass as summer forages so that seasonal fluctuations in feeds supply can be minimized. As a whole, the important roles of fodder crops in the protection of farmlands from wind erosion as well as in the supply of soil organic matter are fully realized in the cropping patterns.

Vegetables are grown principally during nily and winter season. In addition, vegetables share of the total cropping was limited to less than 15 percent with a great diversity of species to avoid over production.

As regards oil seeds, high-yield oil bearing species which produce oil cakes with high nutritional value were chosen. Olive oil is harvested in the fifth year after planting, but during the growing period prior to the first harvesting other short season crops can be intercropped. Goats and sheep constitute the livestock sector because they are suitable for smallholders.

2) Cropping Pattern CP-2

This pattern is applied on saline clay flat area. After leaching, salt-tolerant amshoot (Echinochiloa crassicarum) is sown as a fodder crop followed by paddy. Rice is used as a regular rotation crop because periodical leaching under submerged conditions with paddy rice every three years is desirable to facilitate desalinization.

Vegetables are grown as nily and spring crops. Frenchbeans and tomatoes are planned as export crops. An equal share was given to cereals and fodder crops. Maize, alfalfa, and other salt-susceptible crops are excluded. Beef cattle constitutes the livestock species. Mechanization is only applied to paddy cropping.

3) Cropping Pattern CP-3

Because this pattern is applied on fairly undulating sandy terrain, 40 percent of the arable area is devoted to orchards. The rest is cropped in a way such that fodder crops and others (field crops, oil seeds, and vegetables) have roughly equal shares. Beef cattle constitute the livestock sector. This pattern, with a holding size roughly twice that of CP-1. It should be managed by family labour and through minimum initial investment. To meet this requirement, the share of vegetable cropping was set at under 15 percent. Plastic tunnels are used for some species of winter vegetables. Groundnut is planned only for confectionary usage but no oil varieties are introduced due to low returns for processing materials.

As for orchard trees, minor species which have been planted in existing orchards, i.e., apples, oranges, grapes and figs, are adopted to avert possible competition or oversupply.

4) Cropping Pattern CP-4

This is applied to undulating sandy terrain but comparatively flat sand deposits, devoted to feed crop production through which investors keep a large size herds of beef cattle or goats/sheep. Less than 20 percent of cropping share is given to early summer oil crop (sunflower). Fodder maize is to be introduced as a nily crop, so that its growing season would be in late summer to mid autumn.

As major fodder crops, alfalfa is to be grown for three consecutive years, fodder beet and barley are cropped for winter feed crops, with sordan (a gramineae species genetically closer to sorghum) and fodder maize as summer fodders. In this pattern either beef cattle or sheep/goats are employed on a commercial basis, i.e. in large herds or flocks, depending on the profitability (though the latter require more labour). Hired labour and mechanization are essential for the investors to manage their farms under this pattern, and livestock rearing also requires hired labour according to the herd size being kept. Investors rely on to smallholders to meet their labour requirements.

5) Cropping Pattern CP-5

This is applied to areas which are undulating sand and subject to wind erosion. The land is reclaimed with limited cutting or filling into orchard plots. The reclaimed land is irrigated with drip pipes. Consequently, the area under such conditions can only be developed as orchards. Such a pattern has no room for combining a livestock sector due to lack of self-supplied feed production, and manure will be purchased from neighbouring farms under other patterns.

Fruit species were selected in order to avoid competing with existing fruit producing areas in and around the governorate. A larger planting share, namely 40 percent, was allotted to apples because of their relatively limited planting throughout Egypt and within the North Sinai Governorate. This is followed by grapes and figs each of which have 20 percent of the orchard area. Various minor fruit species, such as oranges and guavas are planted in the orchard area. Planting density is initially set at 250 seedlings per feddan for maximizing yields at an early stage of maturity, but thinning should be practised as soon as they develop to form a broad canopy, eventually leaving only two thirds of the original population at the matured stage.

Labour supply from smallholders is fully utilized to manage orchards, but the selected species will provide broadly dispersed peaks of harvesting ranging from June to November. Harvesting quantities are then evenly distributed during the proposed harvesting season, so that hired labour may be economized. Harvested fruits are sent to a fruit grading and packing facilities for fresh marketing. Processed fruit such as juice, canned fruits, and dry fruits still have a low level of domestic consumption, and only a few percent of fruits are exported in a processed form.

Finally, crop rotation and cropping intensity of each cropping pattern were determined as follows:

	Crop Rotation	Cropping Intensity (%)
CP-1	4 years	200 (perennial 20%)
CP-2	3 "	200
CP-3	3 "	200 (perennial 40%)
CP-4	5 "	200
CP-5	-	all perennial crops

Figure 3.3-1 Crop Composition

Cropping Pattern			Characteristics	Crop Composition (10 20 30 40 50 60 70 80 90 (%))
CP-1	Small holders	Sand flat	labour-intensive, diversified crops, labour-supply sources for Investors.	fodder crops / oil crops / vegetable / oil olive
-2	-do-	Clay flat	Flood irrigation for periodical salt leaching, Shallow water table.	Field crops / fodder crops / vegetable
-3	Graduates	Sand undulating	Soil Conservation, Diversified Cropping	field crops / fodder crops / oil crops / vegetable / orchard fruits
-4	Investors	-do-	Sand erosion preventing measures, oriented to fodder crop & pasture grasses	oil crops / fodder crops
-5	-do-	-do-	Soil Conservation, perennial tree crops Contour-line planting.	orchard fruits

Figure 3.3-2 Proposed Cropping Pattern

CP-1 : Smallholders (Sand Flat)

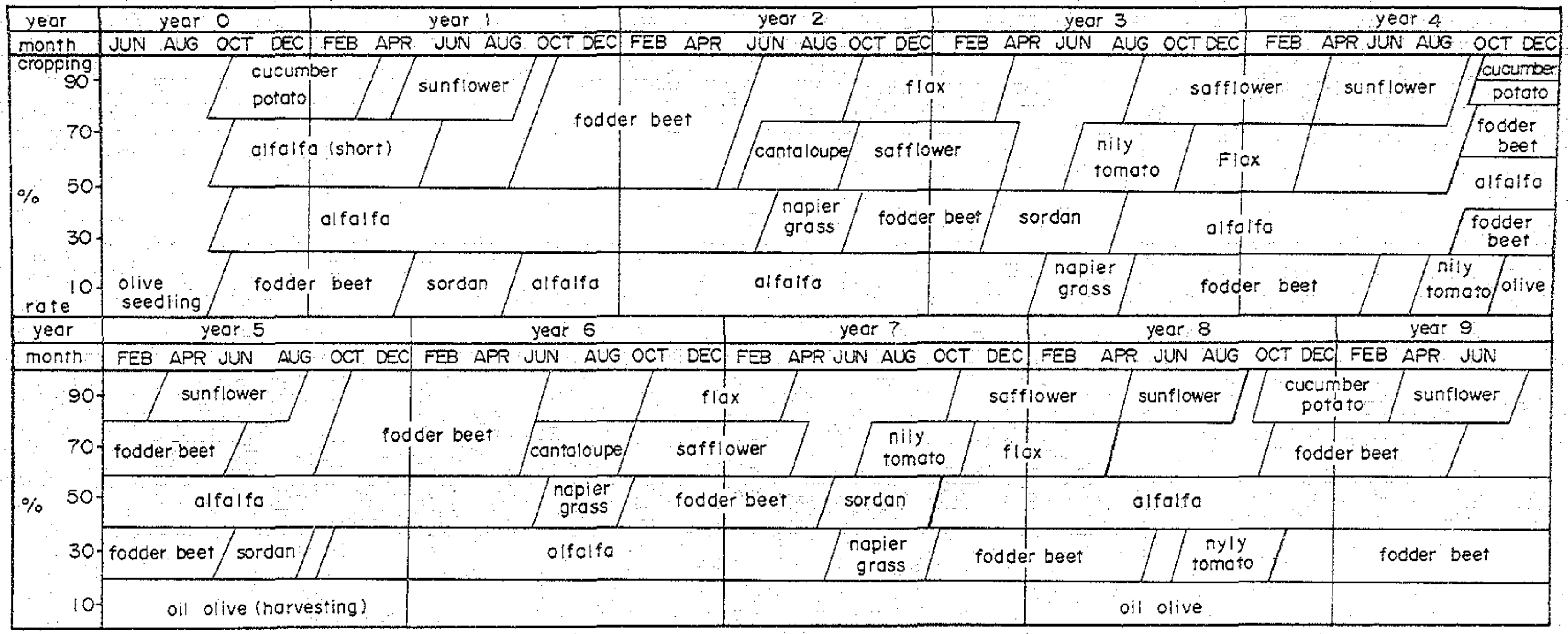
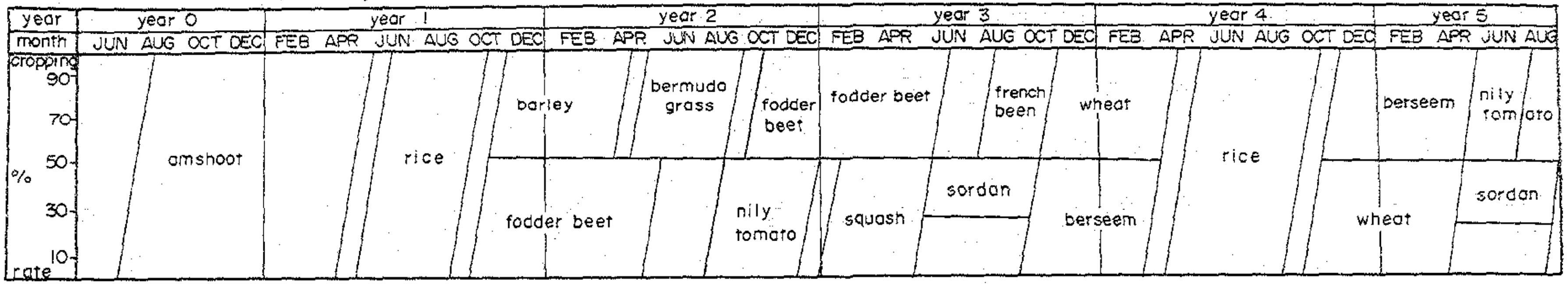


Figure 3.3-2 Proposed Cropping Pattern

CP-2 : Smallholders (Clay Flat)



CP-3 : Graduates (Sand Undulating)

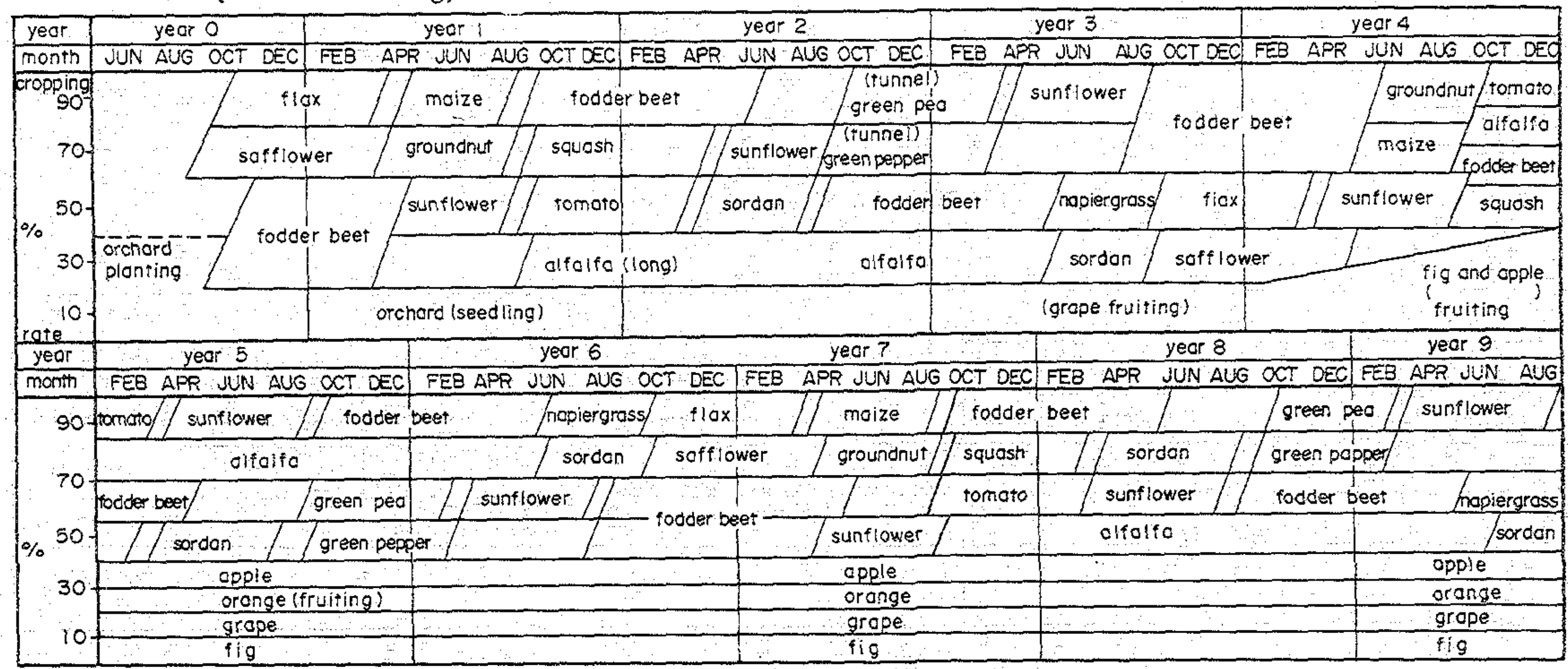
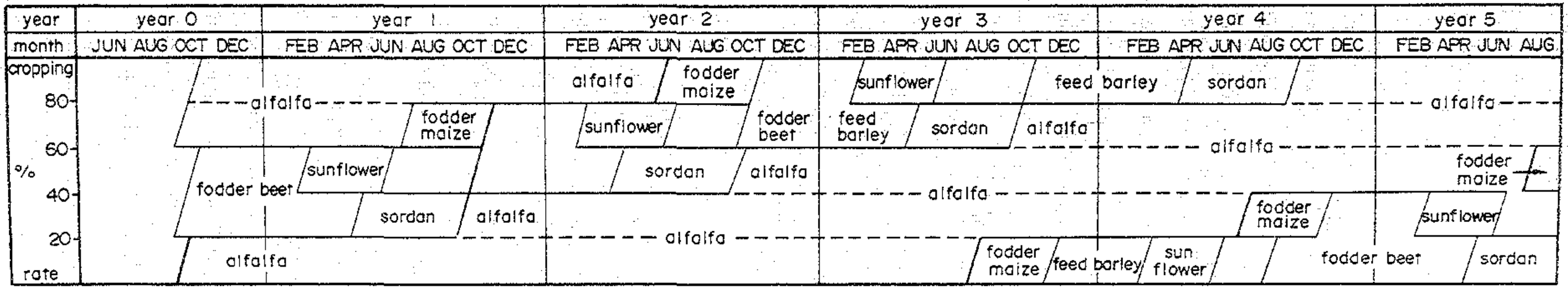
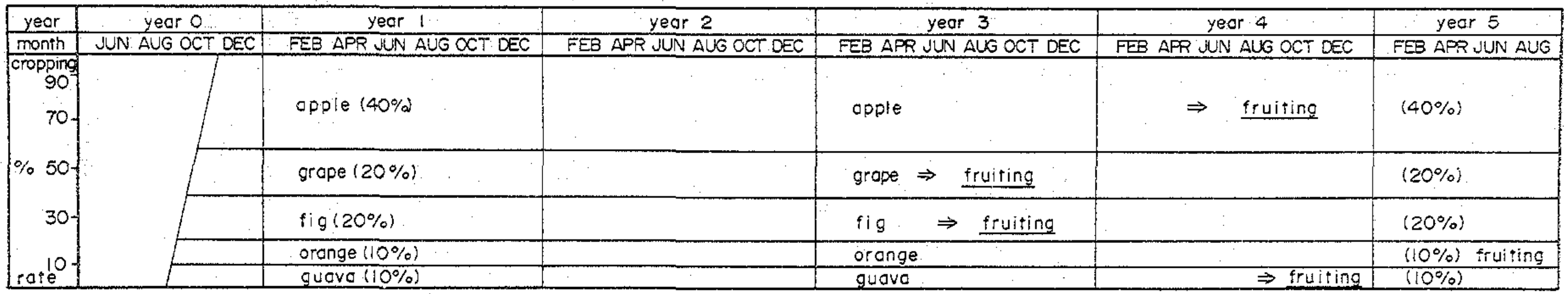


Figure 3.3-2 Proposed Cropping Pattern

CP-4 : Investors (Livestock)



CP-5 : Investors (Fruits)



3.3.4. Target Yields and Total Production

Target yields were determined based on current levels in and around the F/S Area, and results of trials obtained in adjacent experimental stations, as well as agricultural statistics related to the F/S Area etc. Judging from the present cropping conditions, the crop yield except for fodder crops would not reach the country's average level at the stabilized stage. The fodder crops can be expected to attain a fairly high yield level owing to irrigation and fertilizer use. Similarly, maturing ages of orchard fruit trees were estimated from the results of an interview survey and statistical data (refer to APPENDIX-F).

Consequently, target yield and total production of crops and livestock in the F/S Area at the stabilized stage are shown in Table 3.3-3; moreover, total crop production by farm types is given in Table 3.3-4.

3.3.5. Agricultural Input and Labour Requirement

To attain the target yield as mentioned above, agricultural inputs such as seed, fertilizers, chemicals, feeds, animal stocks, etc., should be properly applied. The necessary amounts of inputs for respective cropping patterns at the stabilized stage are shown in Table 3.3-5.

Labour requirement for each pattern was calculated on an annual basis to include farm practice and irrigation (Table 3.3-6). The result shows that almost all practices throughout the year can be accommodated by family labour, i.e., three man-days/family for the patterns devoted to smallholders and graduates. Moreover, smallholders can offer a part of their surplus manpower to serve as off-farm labour to meet investors' labour demand, in other words, as a source of off-farm income.

Table 3.3-3 Projected Crop and Livestock Production
(At Stabilized Year)

Crop	Planted Area (feddan)	Target Yield (ton/feddan)	Production (1,000 ton)
Alfalfa	14,380	30	431.4
Berseem	450	28	12.6
Fodder beet	10,540	32 - 35	338.7
Sordan	4,740	"	152.5
Napier Grass	2,990	27	80.4
Fodder maize	1,200	25	30.0
Feed barley	1,200	1	1.2
Sunflower	4,930	0.9	4.5
Safflower	2,810	0.5	1.5
Flax(grain)	2,810	0.5	1.5
Flax(stalk)	-	2.3	6.5
Groundnut	460	0.8	0.4
Rice	630	2	1.2
Wheat	450	1.3	0.6
Maize	460	1.5	0.7
Tomato	3,080	7 - 8	21.9
Cucumber	590	5	3.0
Squash	730	7	5.4
Green pepper	460	5	2.3
Green peas	460	4	1.8
French bean	270	5	1.4
Cantaloupe	1,180	6	7.1
Potato	590	6	3.5
Oil olive	4,700	3	14.1
Apple	3,200	2	6.4
Orange	1,490	8	12.0
Grape	2,060	6	12.3
Fig	2,060	5	10.3
Guava	570	7	4.0
Sheep meat	18,800 head	0.03	0.5
Goat meat	122,000 "	0.03	3.0
Cattle meat	7,900 "	2.2	1.7

Table 3.3-4. Total Crop Production by Farming Types

Farm Type	Crop	Production (1,000 ton)
C.P-1	Alfalfa	282
	Fodder beet	226
	Sordan	75
	Naper grass	63
	Safflower	1
	Flax Grain	2
	Flax Stalk	5
	Sunflower	4
	Cucumber	3
	Tomato	16
	Cantaloupe	7
	Potato	4
	Oil olive	14
C.P-2	Berseem	13
	Fodder beet	17
	Sordan	10
	Napier grass	4
	Bermuda grass	-
	Amshoot	-
	Rice	1
	Wheat	1
	Barley	-
	Squash	2
	Tomato	2
	French bean	1
C.P-3	Alfalfa	21
	Fodder beet	29
	Sordan	15
	Napier grass	6
	Maize	0
	Groundnut	0
	Green peas	1
	Green pepper	1
	Tomato	2
	Squash	2
	Sunflower	1
	Safflower	0
	Flax Grain	0
	Flax Stalk	1
	Apple	1
	Orange	4
	Grape	3
	Fig	2
C.P-4	Alfalfa	108
	Fodder beet	38
	Feed barley(grain)	1
	Feed barley(stalk)	2
	Fodder maize	30
	Sordan	38
	Sunflower	1
C.P-5	Apple	5
	Orange	5
	Grape	7
	Fig	6
	Guava	4

Table 3.3-5. Agricultural Inputs at Stabilized Stage

Inputs	Unit	Cropping Pattern CP-1	CP-2	CP-3	CP-4	CP-5
Net Cropping Area	feddan	23,500	1,800	4,600	6,000	5,700
Seed	ton	272*	39	53**	120	0
Manure	1,000 ton	301	16	62	41	95
Fertilizer (N)	ton	4,780	340	1,005	945	1,650
" (P_2O_5)	"	3,615	395	1,740	795	680
" (K_2O)	"	2,505	135	515	630	680
Chemicals	"	108	11	28	14	45
Machinery hours	1,000 hours	-	19.6	-	66.9	108.9
Agricultural labor	1,000 manday	2,605	207	408	184	274
Self-supplied feeds	1,000 ton	647	44	71	119	0
Purchased feeds	1,000 ton	0	0	-	5	0
Replacement stock	heads	7,050	54	92	375	0

Notes: * --- except potatoes.
** --- thousand seedlings.

Table 3.3-6 Labour Requirement per Farm at Stabilized Stage

(Unit : Man-day)

Cropping Pattern	Annual Labour Requirement (Crop)	(Livestock)	(Total)	Labour Requirement at Peak Month (Crop)	(Livestock)	(Total)	(Month)	Annual Labour Requirement (per feddan)
CP-1	247	223	470	45	24	69	October	58
CP-2	272	160	432	44	8	52	September	73
CP-3	556	200	756	69	10	79	August	65
CP-4	656	1,792	2,448	96	225	321	May	8
CP-5	3,814	-	3,814	596	-	596	September	48

3.3.6. Livestock Production

Livestock production following a collective rearing system is suggested combination with smallholders, graduates and investors' crop production. Settlers should be induced to establishing a collectively utilized livestock yard in the vicinity of their villages, while individual settlers keep their livestock in enclosed lots surrounded by reed screens and barbed wire fences where they feed the livestock with self-supplied feeds harvested from their plots.

Regarding livestock species selection, traditional, local species and other varieties are considered. As to new species, beef cattle and improved goats/sheep are considered, taking into account the availability and economic aspects of self-supplied fodders, production efficiency and labour requirement, production risk and adaptability to ambient conditions.

Various feeding methods have been studied. The most economical method, best-suited to local conditions, is rearing in an enclosed shaded yard. This way of husbandry requires the least land, labour and facility expenses and can raise the extent of feeding efficiency.

Diversification is also necessary for the livestock sector, for the risk is greater if the sector merely resorts to a single species regardless of farming types, because such a vulnerable structure could not respond to changes in the demand/supply situation or feed utilization efficiency. So different species should be employed in compliance with the characteristics of the cropping patterns.

Of the species studied, smaller ones such as poultry and rabbits not only require processed or purchased feeds, but also incur heavy expenses for the installation of cages, ventilation, and other facilities. As the results of survey on existing poultry farm, the facilities are idle due to the price hike of feed, i.e., they input 4 LE to produce one kg of chicken meat (3 LE/kg). Rabbit is reared by only automated rearing farm at present and considered to be viable for a large-scale commercial farm but for smallholders because it requires high level of technology. Because demand for dairy products remains low and future prospects in and around the F/S Area are uncertain, dairy farming is highly risky not only from the aspect of poor demand, but also from the heavy initial investment for milk collection and processing, bulky concentrates requirement, and shortage of technical experience.

Goats and sheep can be fed with either high-protein, self-supplied fodders such as alfalfa, or olive oil cake which is difficult to apply to other species of livestock. They are thus identified as the most remunerative species for desert conditions. Nevertheless, goats/sheep feeding was restricted to the combination of sand flats and smallholders (CP-1) owing to the higher labour and feed protein requirement for maintaining flocks.

The results from the study as mentioned above led to the conclusion that species to be employed in the F/S Area should be beef cattle and goats/sheep. In the initial stage, local varieties will be adequate for stocks. A part of the beef cattle herd can later be replaced by hybrids with foreign varieties, or other heavier but purely indigenous ones. Damascus goats, Rafmanii and Awassi varieties of sheep will be able to replace indigenous Sinai varieties.

3.3.7. Livestock Feeding Methods and Livestock Herd-Building

Maximum utilization of surplus labour and ample self-supplied fodders is realized through multiple rearing in enclosures coupled with the labour intensive daily harvests, and carrying and feeding of fodder crops. Such enclosures (livestock shelters), providing more efficient feed utilization than grazing, can be installed under shade in public livestock yards on the village periphery (Figure 3.3-3).

Fresh fodder/tubers, stored hay prepared during the summer, olive oil cakes as by-products, grain straw, or bean stalks can be used as feed. In addition, investors and graduates require some purchase of rice straw from the Nile Delta region to supplement gaps in supply of total digestible nutrients. The feed supply plan is given in APPENDIX-F. In this connection, use of concentrates for finish-fattening can be an option depending on their price levels, at the stabilized stage of farm management.

Stock supply at the initial stage is planned as home-breeding for goats and sheep rearing, and only calves are imported from outside the F/S Area. A livestock service center, when established in the Area, is to provide a mating service for farmers by keeping registered breeding stocks (bulls, male goats, etc.).

Herd-building patterns for beef cattle, goats/sheep mixed-flocks, fattening plan, nutrition requirement, dressing rate as well as mortality, fertility, culling rate, and average litter size, as indices for herd-building were determined as shown in Tables 3.3-7 and 3.3-8. Planned livestock production is based on the calculated numbers of head slaughtered according to the given herd-building schedules (refer to APPENDIX-F).

Finally, about 27,000 heads of beef cattle, 130,000 heads of goat, and 65,000 heads of sheep will be kept in the F/S Area at the stabilized stage.

Figure 3.3-3 Livestock Rearing Facilities

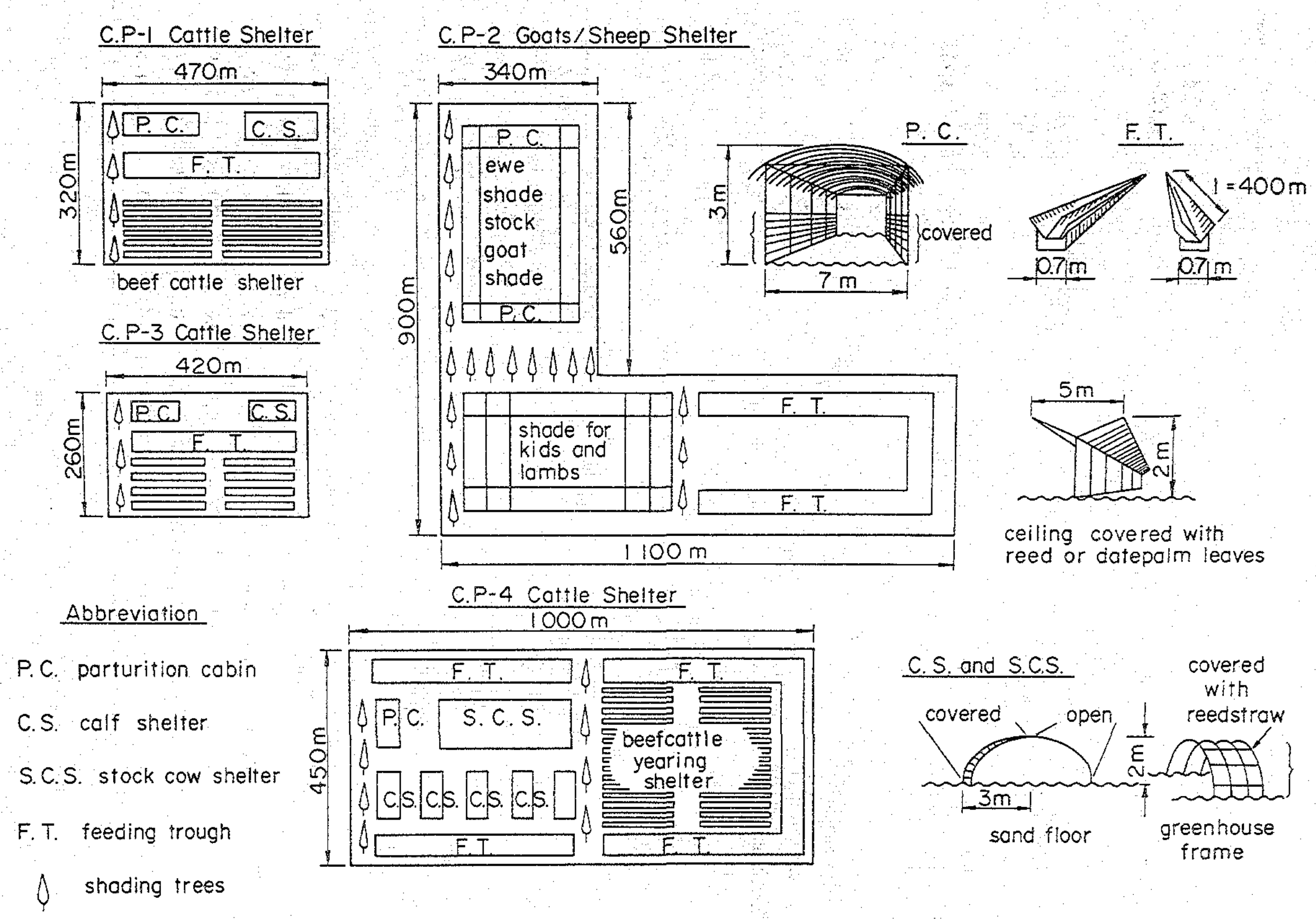


Table 3.3-7 Livesock Herd Composition and Slaughter

(Unit: head, carcase ton)

Livestock Specy	CP-1 Sheep and Goat		CP-2 Beef Cattle		CP-3 Beef Cattle		CP-4 Beef Catle	
	Head	Meat	Head	Meat	Head	Meat	Head	Meat
Calf. Kid or Lamb	131,600		1,080		1,840		6,380	
Yearling	0		720		920		5,400	
Stock lactating	65,800		1,080		1,840		7,500	
Culled/Slaughtered	141,000	3,878	720	159	1,380	329	5,850	1,333
Mortality (%)		5		3		3		3
Conception Ratio (%)		80		85		85		85
Standard Culling (%)		20		15		15		15
Litter Size (head)		2		1		1		1

Table 3.3-8. Nutrition Availability and Carrying Capacity

	Farming Type			
	CP-1	CP-2	CP-3	CP-4
Nutritional output:				
D.C.P basis ('000 ton)	12.2	0.5	1.0	3.5
T.D.N " ('000 ton)	61.1	4.0	6.6	23.8
Carrying capacity*:				
Beef cattle (DCP basis)	2.2	1.2	0.9	2.5
" (TDN ")	0.9	0.8	0.5	1.4
Goats/sheep (DCP basis)	23.6	12.7	9.5	26.8
" (TDN ")	19.0	16.2	10.5	28.9
Dairy cow (DCP basis)	0.9	0.5	0.4	1.1
" (TDN ")	0.4	0.3	0.2	0.5

* --- adult heads/feddan.

3.4. Land Reclamation Plan

3.4.1. Selection of Standard Farm Blocks

Prior to land reclamation plan, standard farm blocks were designed to each farm type, which will form the basis of cost estimate of land reclamation. Selection on standard farm blocks are as follows:

1) El Moraiah Block

This block is geographically favoured and situated on sand flats that have gentle sloping terrain. Some cultivated areas are found, where irrigated farming by groundwater are practiced. This block is located in the neutral zone protected from both land and sea-ward wind. Wind direction is variable but not strong, therefore, modernized farm management can be anticipated in future.

2) Nigila/El Nasr Block

This block is situated on undulating sand terrain formed of small-scale dunes. If windbreaks are provided against the prevailing wind from the sea, this block will be transformed into fair farmland after reclamation.

Situated next to the lateral road to the Bardawil Lake, the prevailing northeast wind from the Mediterranean Sea has formed the shape of the land. There are dune areas of 25 to 30 m high above sea level on the east side. On the west side, the northwest wind is prevailing, and the land is comparatively gently sloping in the direction of the Bardawil Lake. This block is intended as a model for the undulating sand.

3) Tina Plain Block

This block is located in the extreme east of the Nile Delta, belonging to the clay flat of the northwest part of the F/S Area. Salinization of soil is in progress, therefore, land reclamation will be put into practice ordinarily found in the Delta after leaching for saline soil.

3.4.2. Features of Sand Dunes and Windbreak

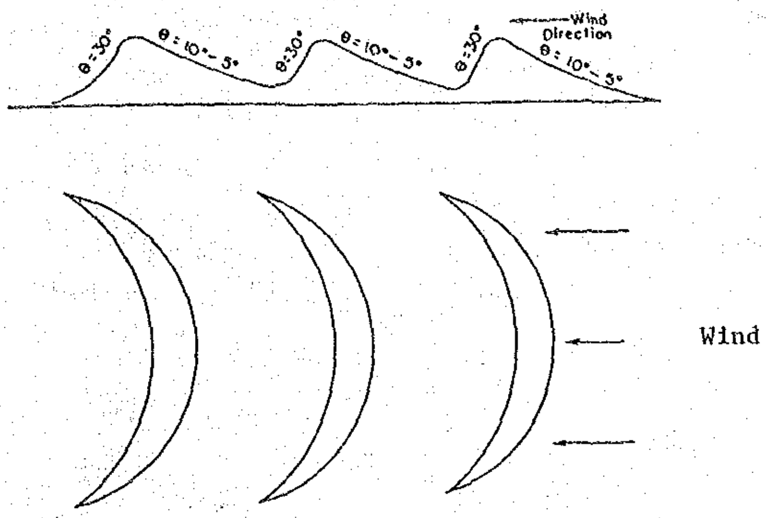
1) Features of Sand Dunes

It has been pointed out that sand dunes are formed parallel to the prevailing wind under very strong and constant winds. The study on features of sand dunes is very important for the design of windbreaks.

The typical sand dune has a gentle slope from 5 to 10 degree to the wind facing direction and has a very steep slope of perhaps 30 degree to the backward. This explains that the wind tends to push or jostle the individual particles onwards and upwards until the dune tip. The height of dunes tends to be constant for any particular area, depending upon the strength of the prevailing wind, the average size of sand grain, the amount of moisture available and the presence or absence of vegetation.

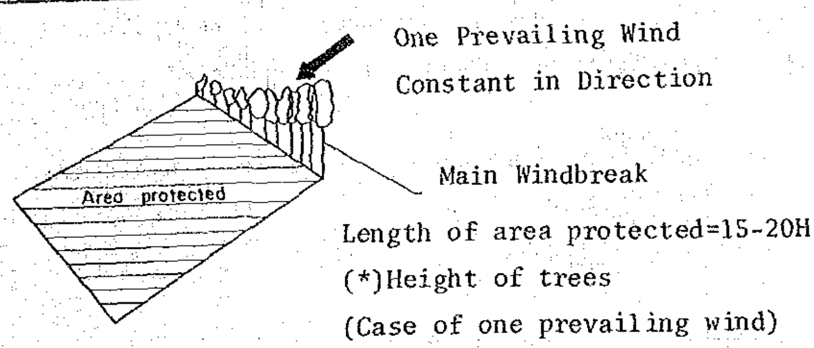
From the abovementioned standpoint, the establishment of windbreaks is necessary to prevent the farm land from the movement of individual sand particles by the wind.

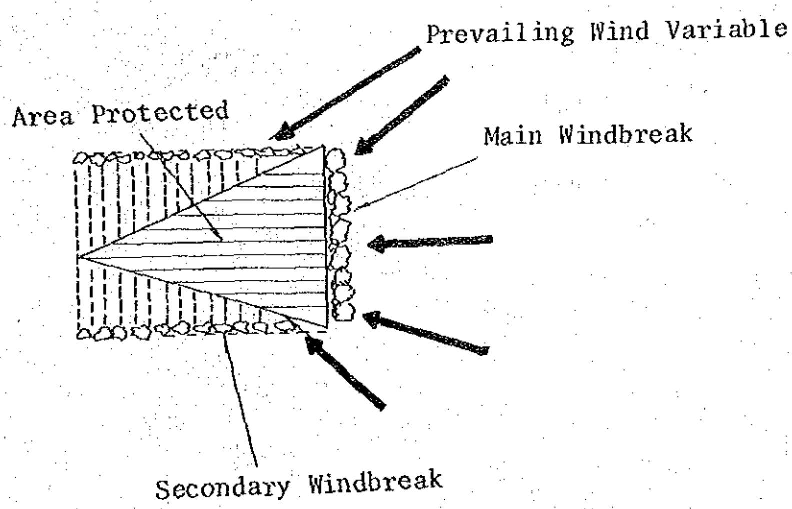
Shape of Typical Sand Dune



2) Effect of Windbreaks and Wind Direction

Type of area protected by windbreak trees





In the F/S Area, the size of area protected by windbreak is planned as follows;

(Farming types : CP-1, CP-2 and CP-3)

Main windbreak intervals	:	100 m
Secondary windbreak intervals	:	210 m

(Farming types : CP-4 and CP-5)

Main windbreak intervals	:	200 m
Secondary windbreak intervals	:	420 m

3.4.3. Basic Items on Land Reclamation

1) Standard Farm Block

This standard farm block is designed under the plan of irrigation and drainage.

After the study on topographic and soil conditions in the F/S Area, land reclamation method is planned by farming type blocks.

Standard farm block classification	:	3 types (A, B, C)
Field block (lot)	:	5 feddan (gross)
Land gradient limit	:	5%

2) Applicable Block by Standard Farm Block (Figure 3.4-1)

Farming Type		Standard Farm Block
CP-1:	Sand flats	A Type (B Type)
CP-2:	Clay flats	C Type
CP-3:	Undulating sand	A Type
CP-4:	"	A Type (B Type)
CP-5:	"	-

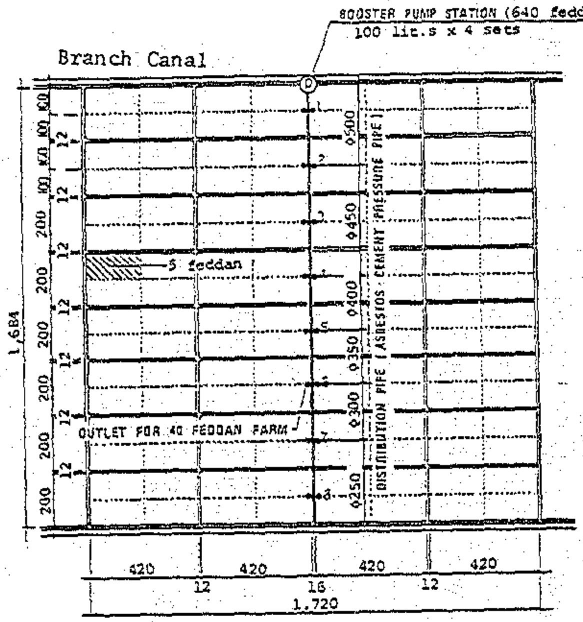
3) Hauling Soil Quantity per Unit Area by Farming Type Block

Based on the study of the standard farm blocks, the hauling soil quantities per unit area were estimated by farming types as below;

1. Farming Type CP-1 : about 200 m^3/feddan
2. Farming Type CP-2(*) : about 100 m^3/feddan
3. Farming Type CP-3 : about 300 m^3/feddan
4. Farming Type CP-4 : about 600 m^3/feddan
5. Farming Type CP-5 : about 200 m^3/feddan

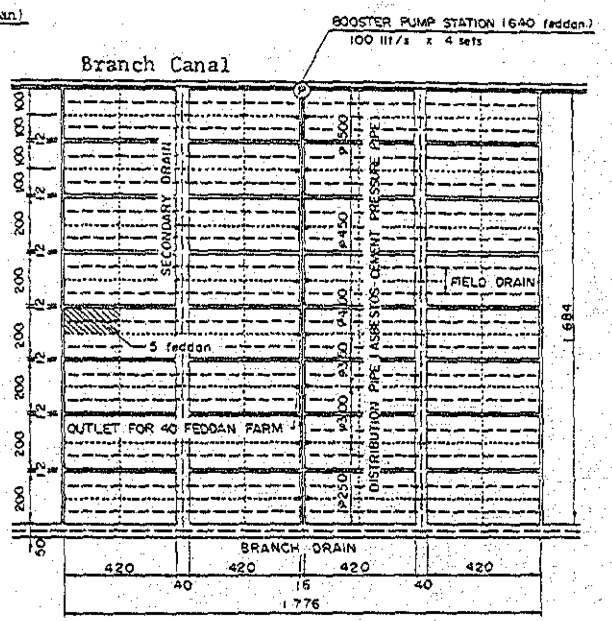
(*) Note : Including the initial leaching

Figure 3.4-1 Standard Farm Blocks

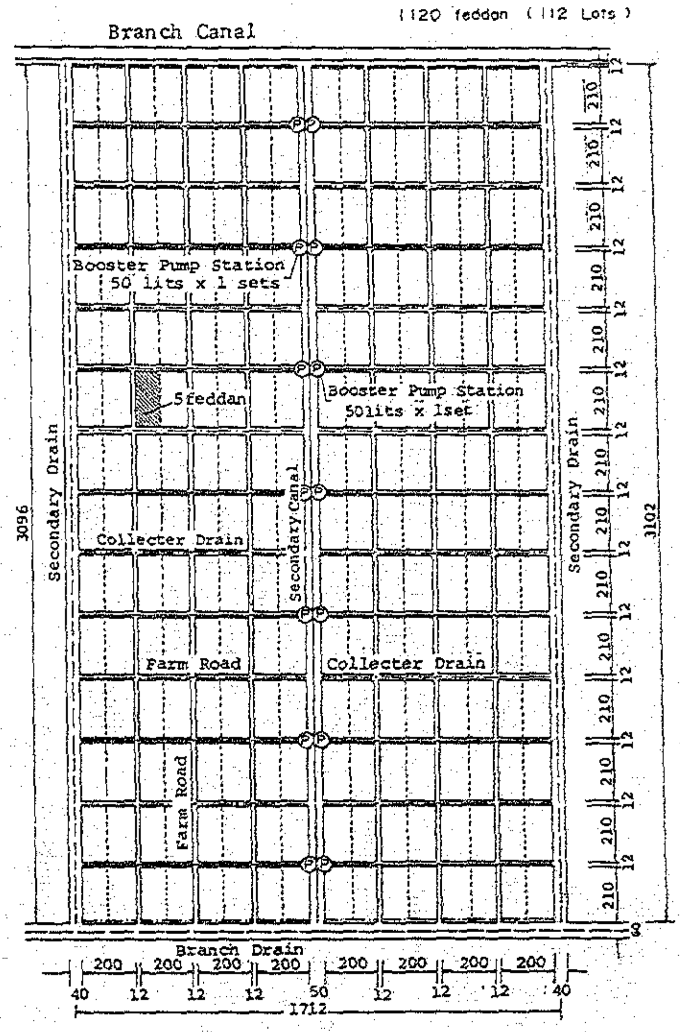


NOTE :
- BRANCH DRAIN : OPEN CANAL
- SECONDARY DRAIN : OPEN CANAL
- FIELD DRAIN : PVC CORRUGATED PERFORATE PIPE 80mm dia. SPACING : 100m

Standard Farm Block A Type



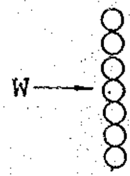
Standard Farm Block B Type



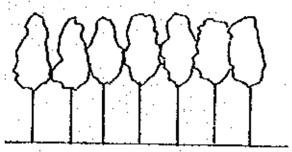
Standard Farm Block C Type

3.4.4. Design of Windbreak Trees

1) On the arrangement of windbreak, four types of windbreak trees were considered:

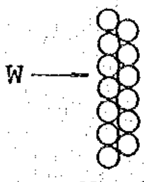


No.1

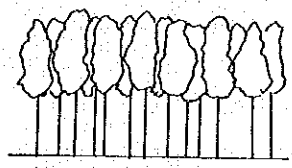


Single Row

Single row is too sparse, wind blows through.

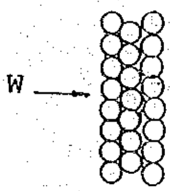


No.2

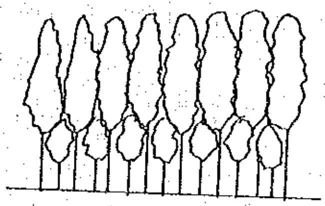


Two Rows

Two rows are put into practice at FAO Agricultural Experiment Station in Ismalia; however, shielding effectiveness is not so much, wind blows through.

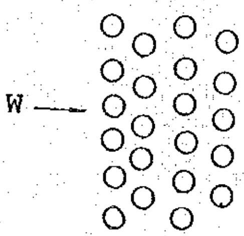


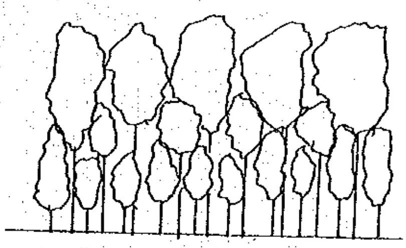
No.3



Three Rows

Three rows were not found in Ismailia and North Sinai region.





Four Rows

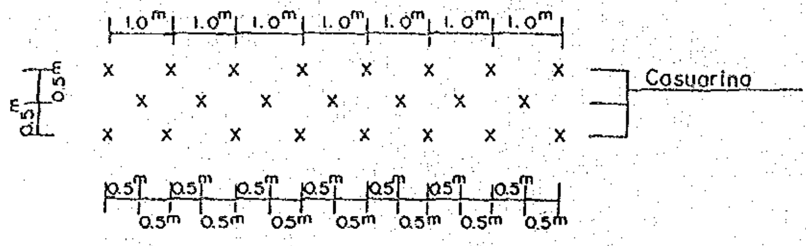
This type forms a solid wind-wall, however, it's cost is very high.

Wind shelter belts with from 3 to 8 rows of trees are recommended by American worker in 1935 (U.S. Forest Service Division).

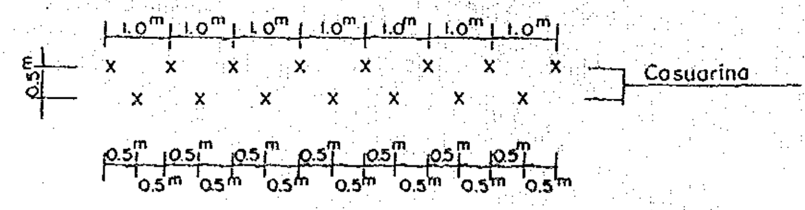
2) Design of Windbreak Trees

It is thought that three rows of windbreak trees are geographically and economically most profitable as main windbreak for the F/S Area.

(1) Case of Main Windbreak



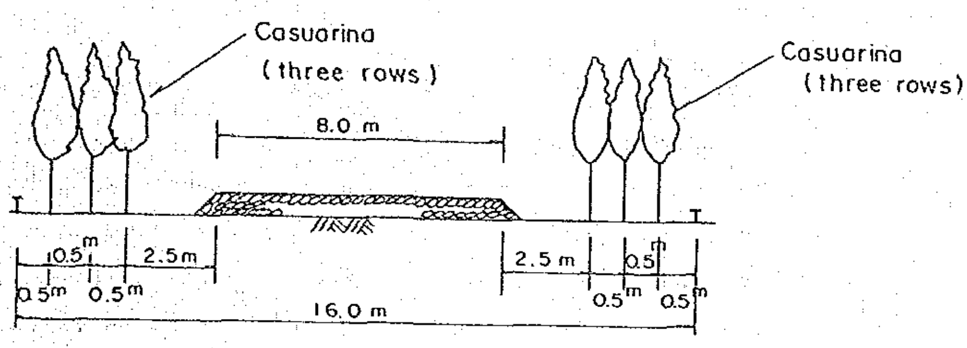
(2) Case of Secondary Windbreak



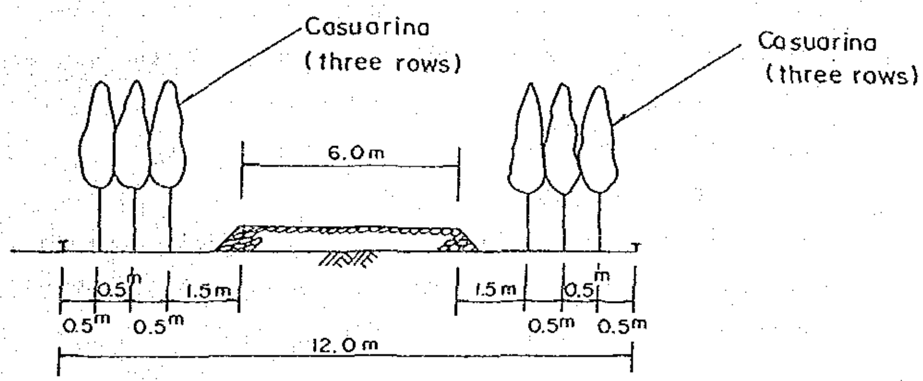
3.4.5. Standard Farm Road

Standard farm road are classified into two types. Type A road is a main farm road and connects villages or towns. Type B road is a farm road for farming purposes.

Standard Farm Roads



Type-A



Type-B

3.5. Irrigation and Drainage Plan

3.5.1. Irrigation Plan

1) Physical Conditions

The main physical factors affecting the layout of irrigation and drainage systems are climate, topography, and soil conditions.

Climate

The annual average windspeed is around 14 km/hr and the prevailing directions of wind are north, northwest and northeast. During the spring, the "Khamseen wind" blows from the south and southeast. These winds affect the water application efficiency of the sprinkler and sometimes erode the farmland. Therefore, provision of windbreaks is essential in the F/S Area.

Topography

The greater part of the F/S Area is covered with undulating sand terrain of aeolian origin. Sand flats developed around the lowland including Sabkha, are found in the vicinity of Rumana, Six October, and Rabaa/Qatia. Clay flats are only found in the northwest corner of the F/S Area. In the areas of sand flats and clay flats, problems of waterlogging and salinity due to the initiation of irrigation are anticipated. Therefore, the field drainage system should be provided for water-table control in these areas.

Soil Texture

The results of the field tests of basic intake rate and hydraulic conductivity are summarized as follows:

Basic Intake Rate and Hydraulic Conductivity

	Clay Flats	Aeolian Sand Terrain (Uncultivated)	Aeolian Sand Terrain (Cultivated Land)
Basic intake rate (mm/hr)	10 - 20	200 - 1,100 (Ave. 700)	300 - 400
Field moisture (%)	-	5 - 11	10 - 14
Hydraulic conductivity (m/day)	0.7	3 - 23	-

In the cultivated land, which has been irrigated by drip irrigation system for 6 - 7 years, organic manure (poultry manure) has been applied, which seems to be effective in improving the water-holding capacity of sandy soils.

2) Limits of Irrigation Water Supply

The upper limits of irrigation water available for the M/P land reclamation area in North Sinai through the El Salam Canal are as follows:

Limits of Irrigation Water Supply

Maximum amount of water available for the M/P land reclamation area .... 2,714 MCM/annum

Peak project irrigation supply per gross feddan .... 30 cu.m/day

These limits were decided based on the results of the meetings with the Steering Committee and MPWWR.

3) Project Irrigation Supply and Design Requirements of Irrigation Canal

Project irrigation supply for the M/P land reclamation area is shown in Table 3.5-5. Project irrigation supply per net cultivable area of one feddan is 8,900 cu.m/annum. The peak project irrigation supply of 37.6 cu.m/day/net feddan (or 30 cu.m/day/gross feddan) occurs in July (For detailed calculation of the project irrigation supply, refer to APPENDIX-D).

Table 3.5-1. Project Irrigation Supply in M/P Area

Subarea 1/	Cultivable Area Gross (feddan)	Cultivable Area Net (feddan)	Project Irrigation Supply 2/ Annual (MCM)	Project Irrigation Supply 2/ Peak (cu.m/sec)
Western Area of F/S Area	130,400	105,800	970.8	48.61
F/S Area (Rabaa/Qatia)	53,400	41,600	341.3	17.21
Hod Abu Samara	14,000	11,200	111.2	4.38
Eastern Area of F/S Area	56,900	45,200	389.8	18.46
Total	254,700	203,800	1,813.1	88.66

1/ ... For location of subarea, see Figure 3.5-2(1).
2/ ... including irrigation water for windbreak.

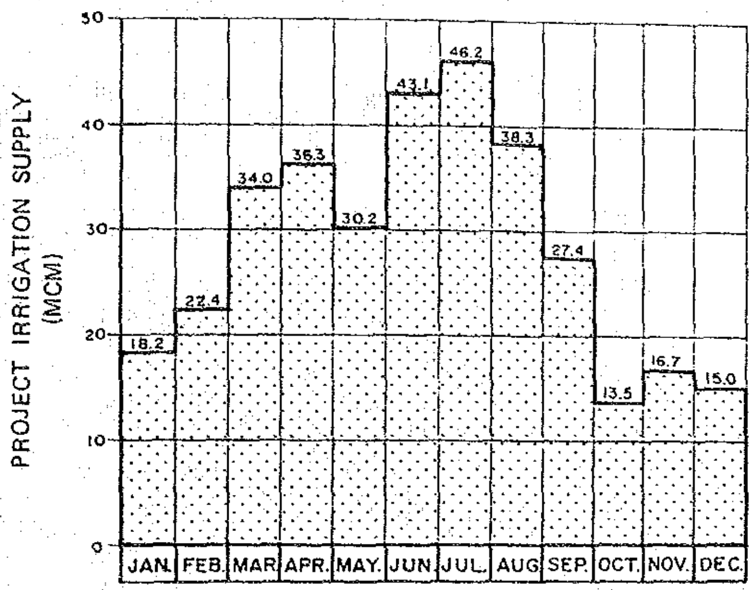
The project irrigation supply for each cropping pattern is shown in Table 3.5-2 and monthly project irrigation supply is shown in Figure 3.5-1.

Table 3.5-2. Project Irrigation Supply for Each Cropping Pattern in F/S Area

Cropping Pattern	Project Irrigation Supply (Peak) (lit/s/fedd.)	Project Irrigation Supply (Annual) (cu.m/fedd.)	Net Cultivable Area (feddan)	Project Irrigation Supply (MCM)
CP-1 (smallholders, sand flat)	0.421 (0.379) 1/	8,190	23,500	192.4
CP-2 (smallholders, clay flat)	0.634 (0.571)	10,830	1,800	19.5
CP-3 (graduates)	0.383 (0.345)	7,100	4,600	32.7
CP-4 (investors, livestock)	0.391 (0.352)	9,930	6,000	59.6
CP-5 (investors, fruit)	0.364 (0.328)	6,510	5,700	37.1
Total			41,600	341.3

1/ ... Values at entrance of irrigation block; not including water losses in main irrigation canal system

Figure 3.5-1 Monthly Project Irrigation Supply for F/S Area



CROPPING PATTERN	NET CULTIVABLE AREA (FEDDAN)	PROJECT IRRIGATION SUPPLY (1000 CU.M) JAN	FEB	MAR	APR	MAY	JUN
CP - 1	23500.0	11905.7	14328.8	19083.6	19567.3	15157.9	23572.7
CP - 2	1800.0	872.2	1158.2	2092.6	1455.3	2266.1	2622.0
CP - 3	4600.0	1757.2	1893.8	2917.8	3137.1	2533.3	4129.2
CP - 4	6000.0	3309.4	4599.0	6999.3*	8186.2	5336.1	7321.9
CP - 5	5700.0	380.0	425.5	2873.4	3911.8	4904.7	5505.6
TOTAL	41600.0	18224.5	22405.3	33966.7	36257.7	30198.1	43101.3
	(CU.M/SEC)	6.8	9.3	12.7	14.0	11.3	16.6

CROPPING PATTERN	NET CULTIVABLE AREA (FEDDAN)	PROJECT IRRIGATION SUPPLY (1000 CU.M) JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
CP - 1	23500.0	26533.0	21889.2	14104.2	6669.7	9867.5	9783.6	192412.9
CP - 2	1800.0	3055.4	2645.8	2018.5	337.4	404.8	562.7	19491.0
CP - 3	4600.0	4728.1	4183.3	2853.6	1437.4	1691.9	1392.0	32654.6
CP - 4	6000.0	6274.8	4777.9	4574.4	2239.0	3080.7	2874.1	59572.8
CP - 5	5700.0	5564.9	4813.7	3892.0	2823.7	1695.5	339.3	37130.3
TOTAL	41600.0	46156.1	38309.9	27442.8	13507.2	16740.6	14951.7	341263.5
	(CU.M/SEC)	17.2	14.3	10.6	5.0	6.5	5.6	

Table 3.5-3 Peak Project Irrigation Supply

Subarea		CP-1	CP-2	CP-3	CP-4	CP-5	Total	Accumulated
Peak project irrigation sypply in ℓ/sec/feddan :		0.421	0.634	0.383	0.391	0.364		
Western Area of F/S Area								
	A	10,100	29,500	31,300	34,900	-	105,800	203,800
	Q	4.26	18.71	11.99	13.65		48.61	88.66
F/S Area								
I Balouza	A	-	1,800	-	760	-	2,560	98,000
	Q	-	1.14	-	0.30		1.44	40.05
II Rumana N.	A	-	-	1,660	-	2,940	4,600	95,440
	Q	-	-	0.64	-	1.07	1.71	38.61
III Rumana S.	A	-	-	2,700	-	-	2,700	90,840
	Q	-	-	1.03	-	-	1.03	36.90
IV Six October	A	1,780	-	240	670	80	2,770	88,140
	Q	0.75	-	0.09	0.27	0.03	1.14	35.87
V Rabaa/Qatia	A	10,480	-	-	-	-	10,480	85,370
	Q	4.41	-	-	-	-	4.41	34.73
Hod Abu Samara								
	A	-	-	-	11,200	-	11,200	74,890
	Q	-	-	-	4.38	-	4.38	30.32
F/S Area								
VI Rabaa N.	A	2,770	-	-	-	-	2,770	63,690
	Q	1.17	-	-	-	-	1.17	25.94
VII El Tina	A	-	-	-	1,780	2,680	4,460	60,920
	Q	-	-	-	0.70	0.97	1.67	24.77
VIII El Haswa	A	-	-	-	1,130	-	1,130	56,460
	Q	-	-	-	0.44	-	0.44	23.10
IX El Nasr	A	2,520	-	-	-	-	2,520	55,330
	Q	1.06	-	-	-	-	1.06	22.66
X Nigila	A	5,950	-	-	1,660	-	7,610	52,810
	Q	2.50	-	-	0.64	-	3.14	21.60
Total (F/S Area)	A	23,500	1,800	4,600	6,000	5,700	41,600	
	Q	9.89	1.14	1.76	2.35	2.07	17.21	
Eastern Area of F/S Area								
	A	27,400	-	4,000	13,800	-	45,200	45,200
	Q	11.53	-	1.53	5.40	-	18.46	18.46

Note : A .... Net cultivable area in feddan
Q .... Peak project irrigation supply in cu.m/sec

Concerning the required canal capacity for calculation purposes, the F/S Area is divided into ten subareas, as shown in Figure 3.5-2(1). Peak project irrigation supply for each subarea is calculated as shown in Table 3.5-3 and then the required canal capacities of the El Salam Canal and branch canals are determined, as shown in Figure 3.5-2(2).

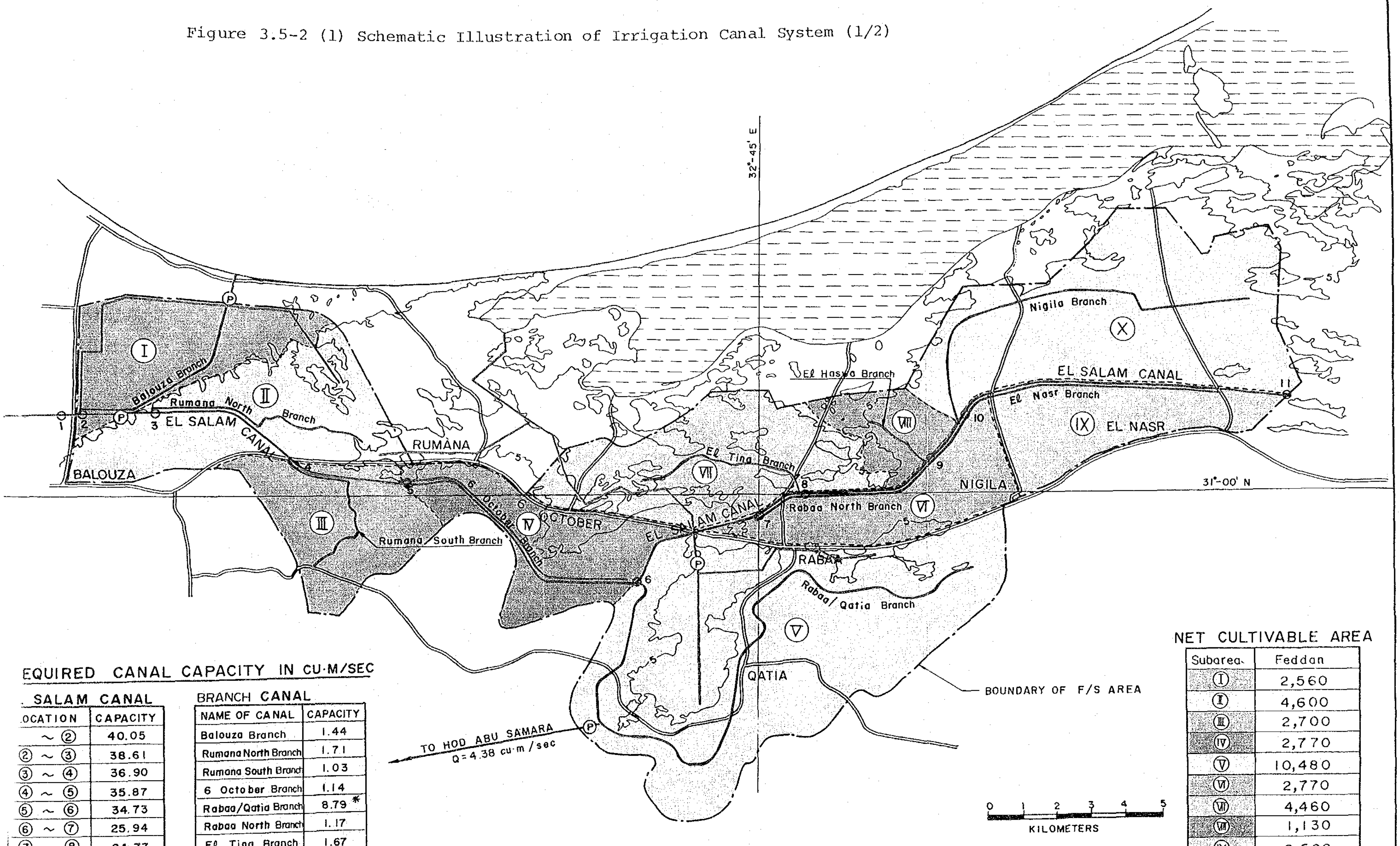
The maximum irrigation hours per day is planned to be 20 hours while the El Salam Canal has been designed for continuous operation. The gap of 4-hours operation between the supply of El Salam Canal and the field irrigation should be controlled. The facilities functioning water storage in irrigation system are reservoir, farm pond, main and branch canals etc. In Egypt, storage in branch canals, which has the lowest cost among these storage facilities, is usually selected. Accordingly, 4-hours supply is planned to be stored in the branch canal. Required storage capacity is shown below:

Table 3.5-4. Required Storage Capacities of Branch Canals

Subarea	Location of Storage	Peak Project Irrigation Supply (cu.m/sec)	Required Storage Capacity (cu.m)
I	Balouza Branch Canal	1.44	20,700
II	Rumana North Branch Canal	1.71	24,600
III	Rumana South Branch Canal	1.03	14,800
IV	Six October Branch Canal	1.14	16,400
V	Rabaa/Qatia Branch Canal	4.41 (*)	63,500
VI	Rabaa North Branch Canal	1.17	16,800
VII	El Tina Branch Canal	1.67	24,000
VIII	El Haswa Branch Canal	0.44	6,300
IX	El Nasr Branch Canal	1.06	15,300
X	Nigila Branch Canal	3.14	45,200

(*) Excluding the supply to Hod Abu Samara (4.38 cu.m/sec)

Figure 3.5-2 (1) Schematic Illustration of Irrigation Canal System (1/2)



EQUIRED CANAL CAPACITY IN CU·M/SEC

. SALAM CANAL

.OCATION	CAPACITY
~ ②	40.05
② ~ ③	38.61
③ ~ ④	36.90
④ ~ ⑤	35.87
⑤ ~ ⑥	34.73
⑥ ~ ⑦	25.94
⑦ ~ ⑧	24.77
⑧ ~ ⑨	23.10
⑨ ~ ⑩	22.66
⑩ ~ ⑪	18.46

BRANCH CANAL

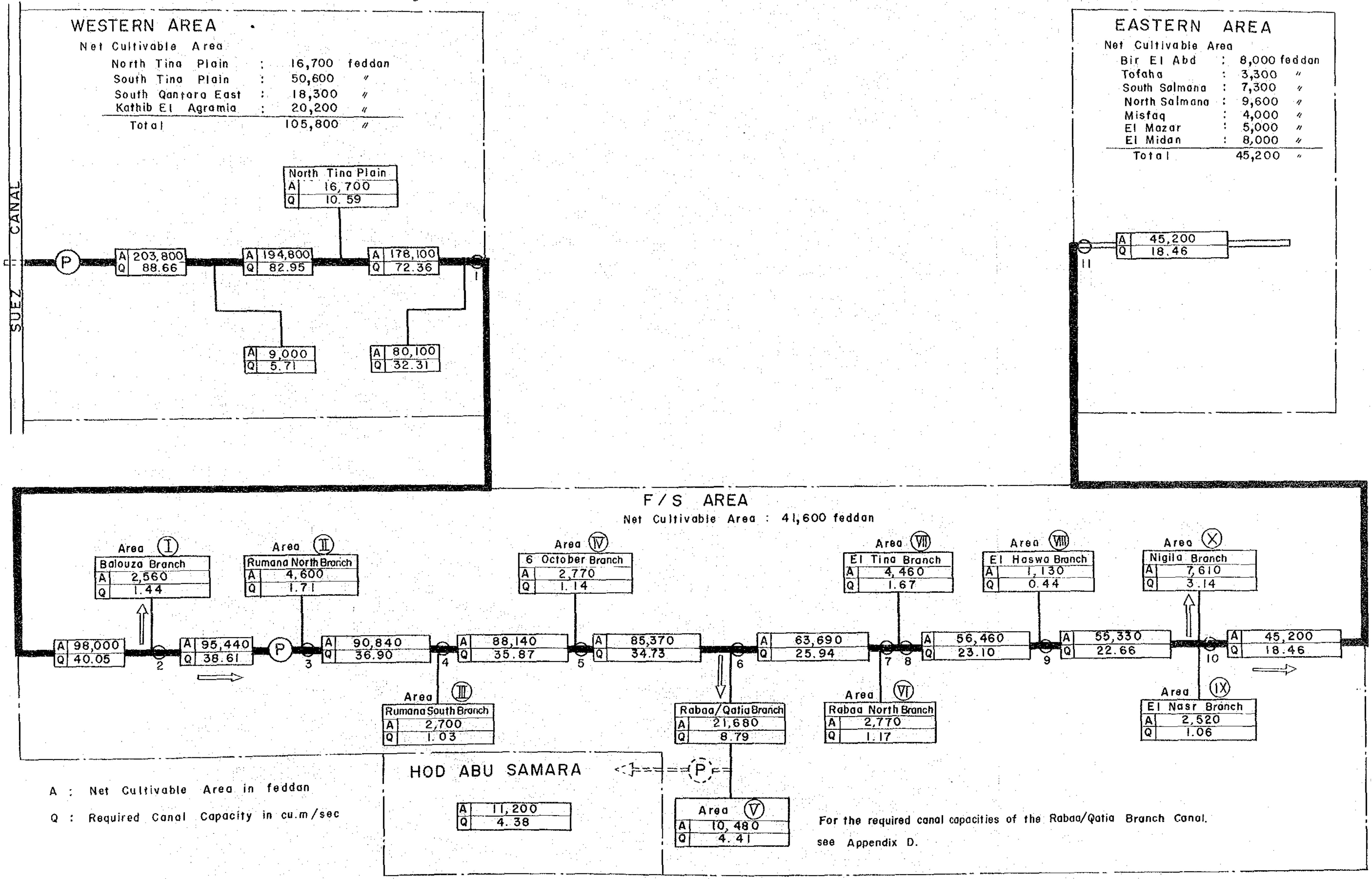
NAME OF CANAL	CAPACITY
Balouza Branch	1.44
Rumana North Branch	1.71
Rumana South Branch	1.03
6 October Branch	1.14
Rabaa/Qatia Branch	8.79 *
Rabaa North Branch	1.17
El Tina Branch	1.67
El Haswa Branch	0.44
El Nasr Branch	1.06
Nigila Branch	3.14

* including the required canal capacity for the area of Hod Abu Samara (Q=4.38 cu·m/sec).

NET CULTIVABLE AREA

Subarea	Feddan
Ⅰ	2,560
Ⅱ	4,600
Ⅲ	2,700
Ⅳ	2,770
Ⅴ	10,480
Ⅵ	2,770
Ⅶ	4,460
Ⅷ	1,130
Ⅸ	2,520
Ⅹ	7,610
TOTAL	41,600

Figure 3.5-2 (2) Schematic Illustration of Irrigation Canal System (2/2)



4) Selection of Field Irrigation System

The clay flats area, which is found in the northwest corner of the F/S Area, has a low basic intake rate of 10 - 20 mm/hour, so that surface irrigation is applied in the area. The irrigation intervals of 7 - 10 days are adoptable. A four-day rotation is recommended because it provides more flexibility to farmers in operating their field irrigation systems.

Total available moisture of aeolian sand in the F/S Area is estimated approximately at 5 percent, although it may be improved after land reclamation. Readily available moisture will be 33 mm/m equivalent to two thirds of the total available moisture. For a rooting depth of 0.7 - 1.0 m and crop water requirement of 8 mm/day, the irrigation interval will be 2 - 6 days. Such a high frequency of irrigation will require much labour where hand-move sprinkler system or side roll sprinkler system is applied. Drip irrigation system, which is widely in use in Egypt, is applied for irrigation of orchards. The recommendable field irrigation system for the farmland, excluding orchards, are as follows;

- Smallholders

  Hand-move sprinkler systems are recommended because of their low initial cost, although solid set sprinklers are much more suitable for the sandy terrain where highly frequent irrigation is required. One lateral is planned to be supplied to each farmer. In future, numbers of lateral for each farmer should be increased to provide greater freedom in operating his field irrigation system.

- Graduates & Investors

  Solid-set sprinkler systems which are labour-saving field irrigation systems are recommended for farms of graduates and investors where labour is relatively scarce. Side-roll sprinklers are not recommended for the F/S Area due to necessity of highly frequency of irrigation and strong winds in the F/S Area.

5) Layout of Irrigation Blocks

Typical irrigation blocks in the F/S Area are as follows;

Area of Surface Irrigation

Typical surface irrigation block of 560 feddan net cultivable area is shown in Figure 3.5-3. As shown in Figures 3.5-3 and 3.5-4, irrigation water supply from the secondary canal to the tertiary canal will be made by booster pump. One booster pump will supply irrigation water for 80 feddan of net cultivable area.

Required flow rate of the booster pump is as follows;

Q = 0.571 lit/s/feddan x 80 feddan x 24/20 = 55 lit/sec

Required capacities of secondary canal, tertiary canal and farm ditch are as follows;

Secondary Canals

Q = 0.571 lit/s/feddan x 560 feddan x 2 = 640 lit/sec

Tertiary Canals

Same as the flow rate of the booster pump: Q = 55 lit/sec

Farm Ditches

Required capacity of farm ditches is estimated, based on a peak crop water requirement for rice, with a value of 9.3 mm/day in June. An application efficiency of 70 percent given a peak water requirement of 0.65 lit/s/feddan. Required capacity of the farm ditches is as follows;

Q = 0.65 lit/s/feddan x 2.5 feddan x 24/20 = 2 lit/sec

Typical sections of the secondary and tertiary canals and farm ditches in the Tina Plain are shown in Figure 3.5-5.

Figure 3.5-3 Typical On-Farm Irrigation System (Tina Plain)

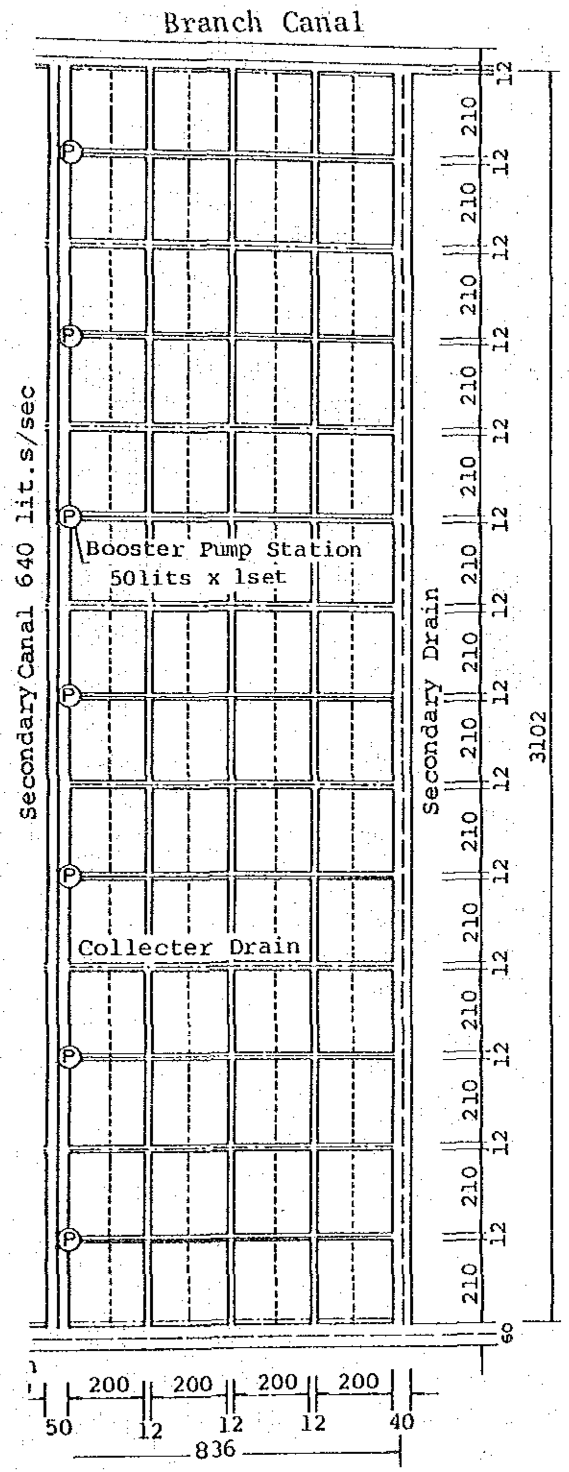
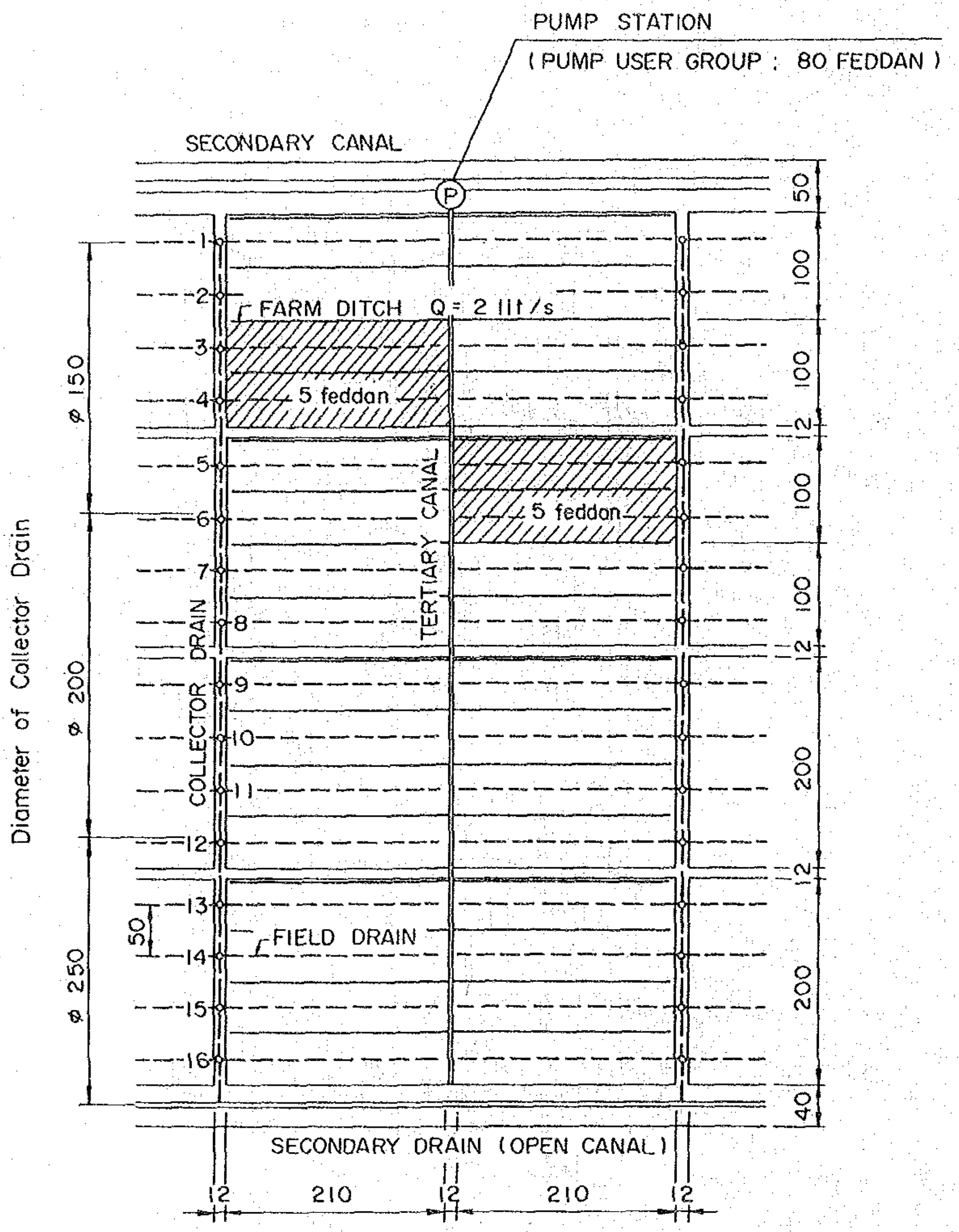


Figure 3.5-4 Detail of Typical On-Farm Irrigation System (Tina Plain)



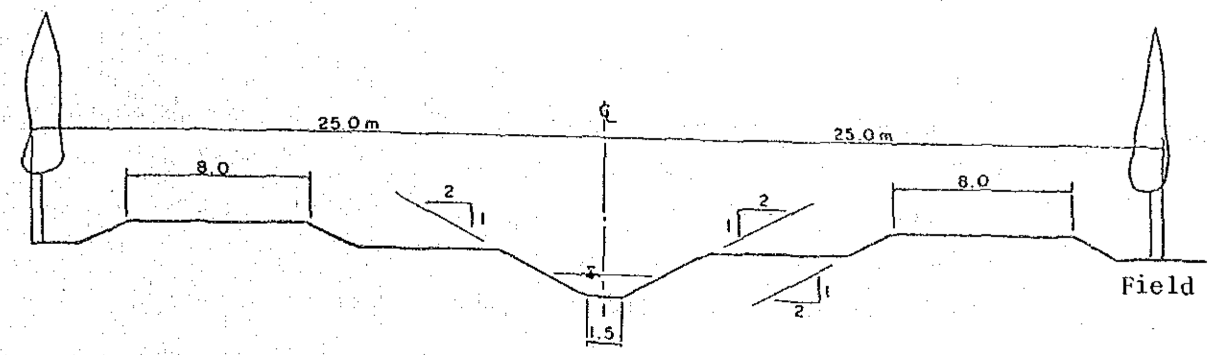
NOTE :

—o—o— COLLECTOR DRAIN : NON-REINFORCED CONCRETE PIPE

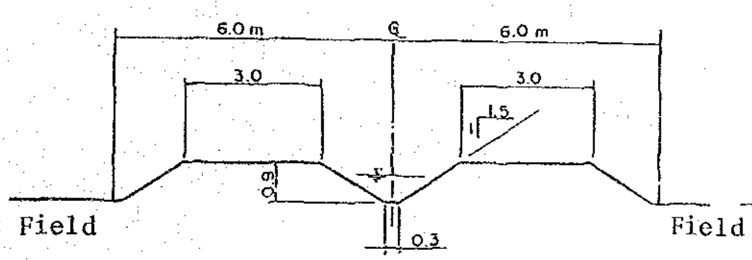
----- FIELD DRAIN : PVC CORRUGATED PERFORATE PIPE
80mm dia. SPACING : 50 m

For computation of the required pipe diameters of the collector drain, presented in Appendix D.

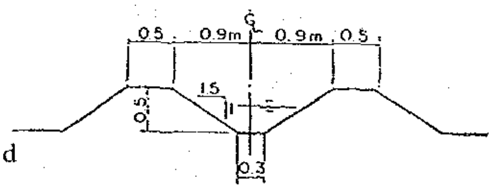
Figure 3.5-5 Typical Sections of Irrigation Canals in Typical Irrigation Block (Tina Plain)



SECONDARY CANAL



TERTIARY CANAL



FARM DITCH

Area of Drip or Sprinkler Irrigation

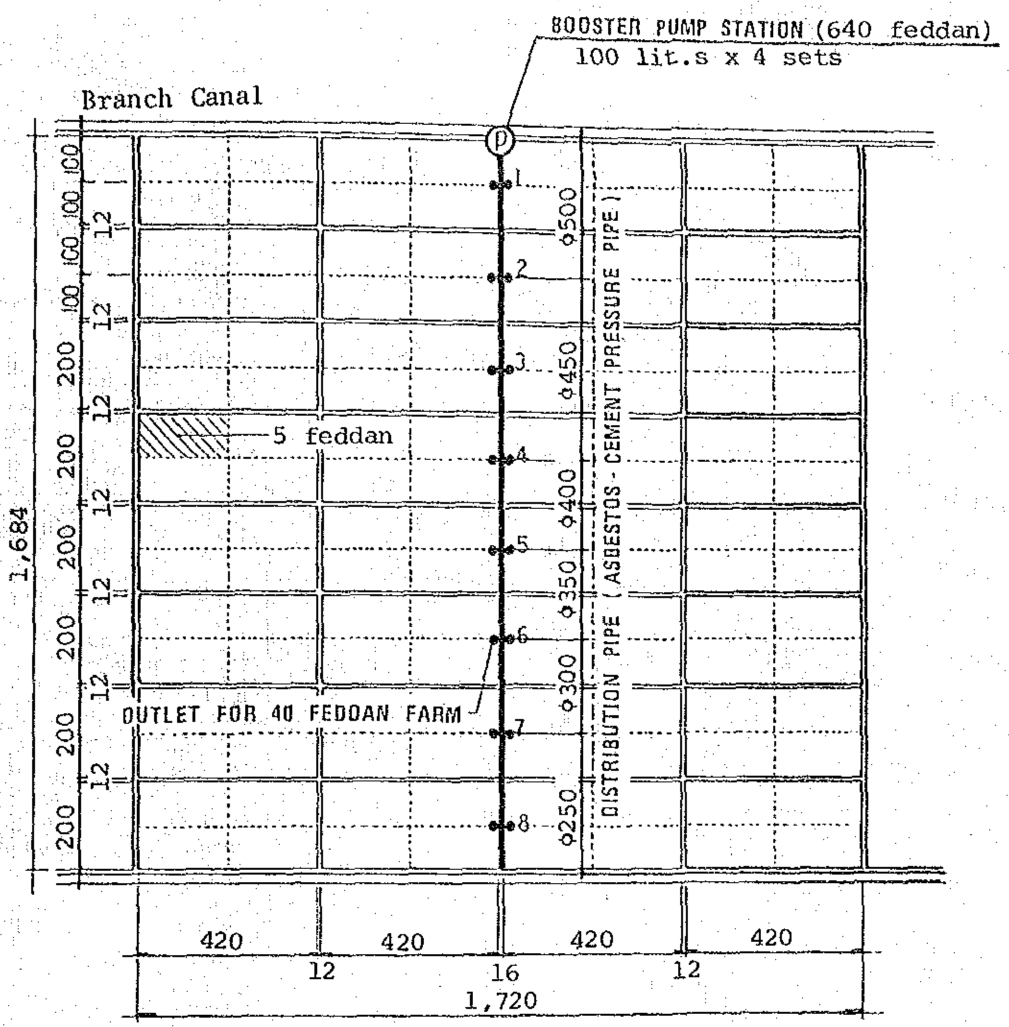
Typical irrigation blocks in the areas where drip or sprinkler systems will be applied have a 640 feddan net cultivable area as shown in Figures 3.5-6 and 3.5-7. The peak water requirement for this type of irrigation block is as follows;

$$Q = 0.379 \text{ lit/s/feddan} \times 640 \text{ feddan} \times 24/20 = 300 \text{ lit/sec}$$

Four sets of booster pumps, including one stand-by, are planned to be provided. The flow rate of each pump is 100 lit/sec. As shown in Figures 3.5-6 and 3.5-7, asbestos cement pipes of 500 - 250 mm diameter are selected as distribution pipes. Small pipes to be installed in the field will in principle be PVC pipe.

The layout of drip and solid set sprinkler systems in a typical field is shown in Figures 3.5-8 and 3.5-9 respectively. A booster pump station is shown in Figure 3.5-10.

Figure 3.5-6 Typical On-Farm Irrigation System (Sand Terrain) -Without Field Drainage System



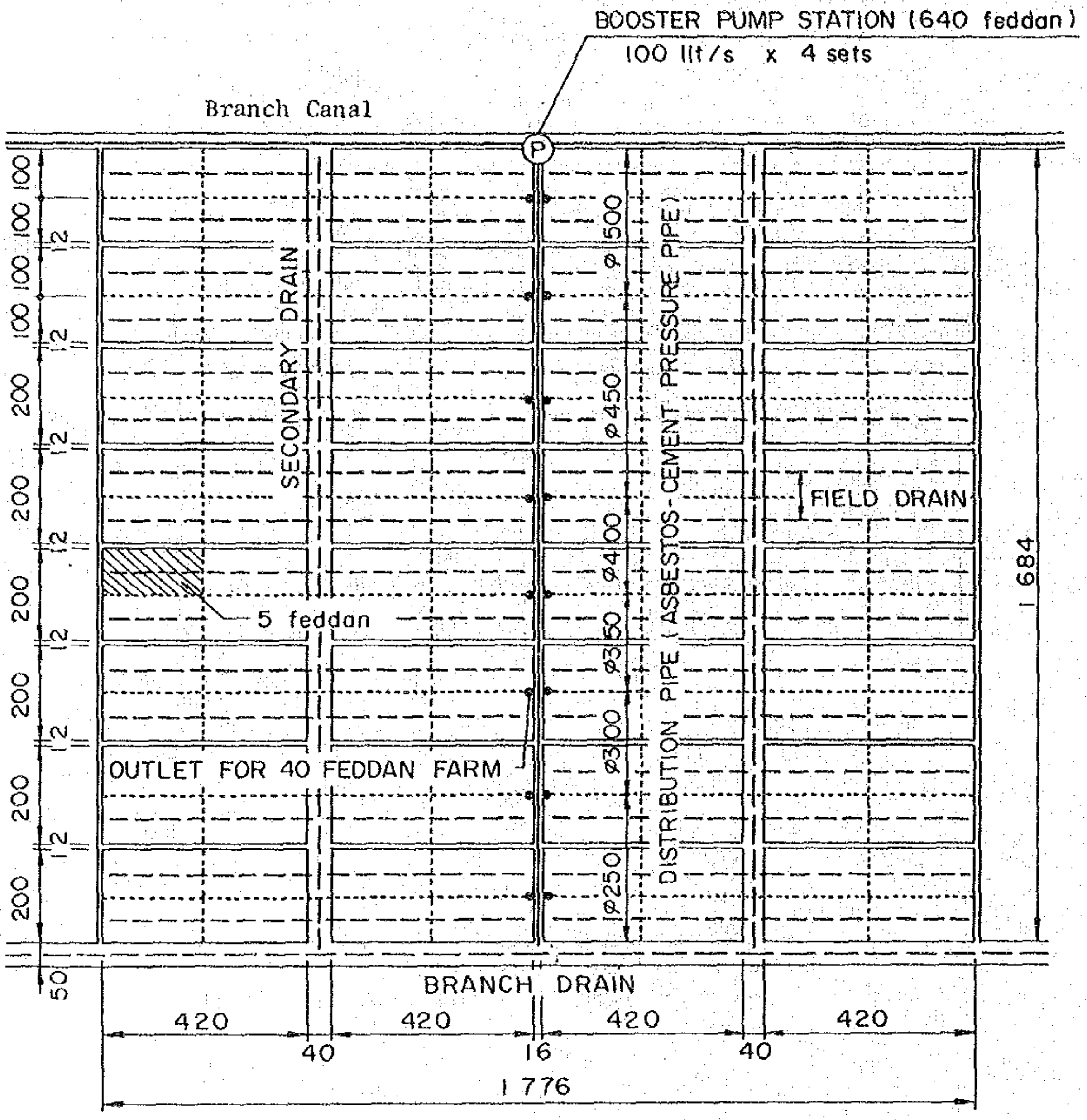
REQUIRED CAPACITY OF DISTRIBUTION PIPE

Location	Accumulated Net Cultivable Area (feddan)	Required Capacity (lit/sec)	Dia. of Pipe (mm)	Velocity (m/sec)
Ⓟ - 1	640	290	500	1.49
1 - 2	560	255	500	1.30
2 - 3	480	219	450	1.38
3 - 4	400	182	450	1.14
4 - 5	320	146	400	1.16
5 - 6	240	110	350	1.14
6 - 7	160	73	300	1.03
7 - 8	80	37	250	0.75

Peak project irrigation supply :

q = 0.379 lit/sec/feddan x 24/20 hr = 0.455 lit/sec/feddan

Figure 3.5-7 Typical On-Farm Irrigation System (Sand Terrain) -With Field Drainage System



NOTE :

- BRANCH DRAIN : OPEN CANAL
- SECONDARY DRAIN : OPEN CANAL
- FIELD DRAIN : PVC CORRUGATED PERFORATE PIPE 80mm dia. SPACING : 100m

Figure 3.5-8 Typical Drip Irrigation System

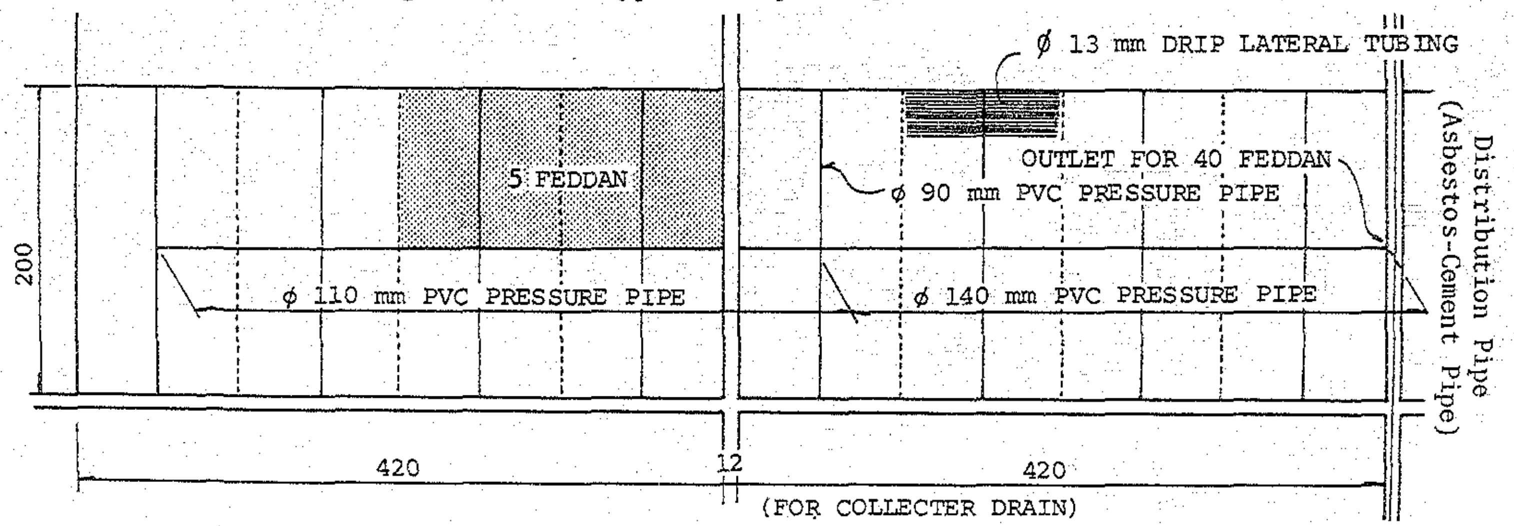


Figure 3.5-9 Typical Sprinkler Irrigation System

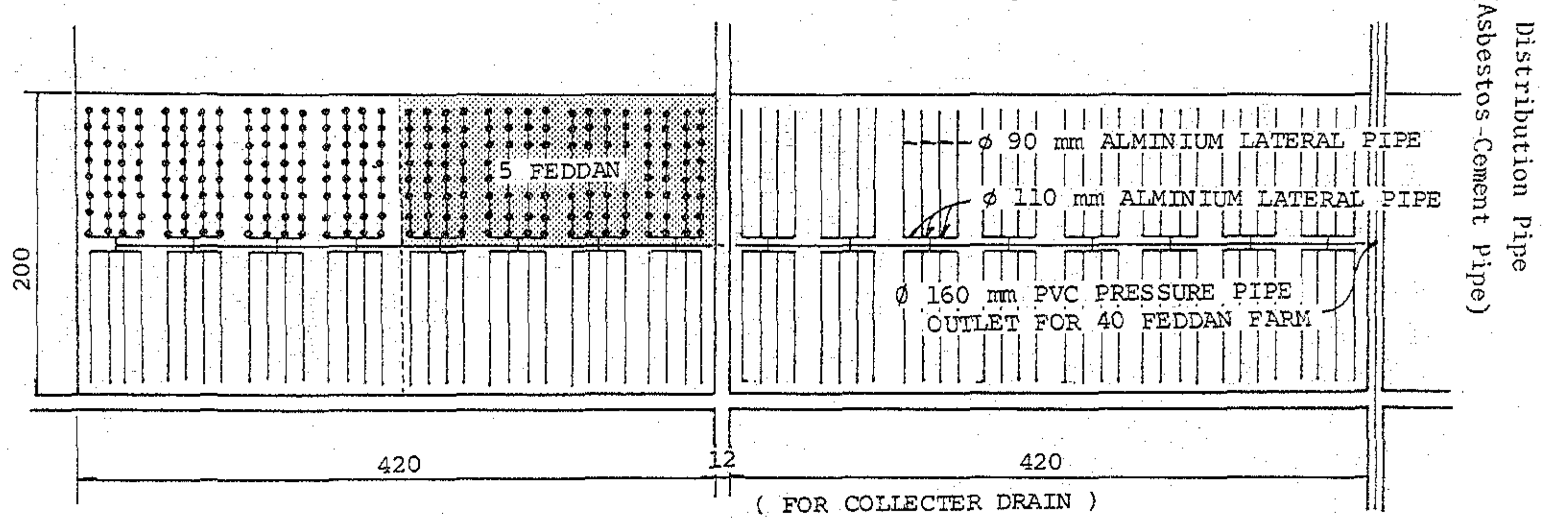
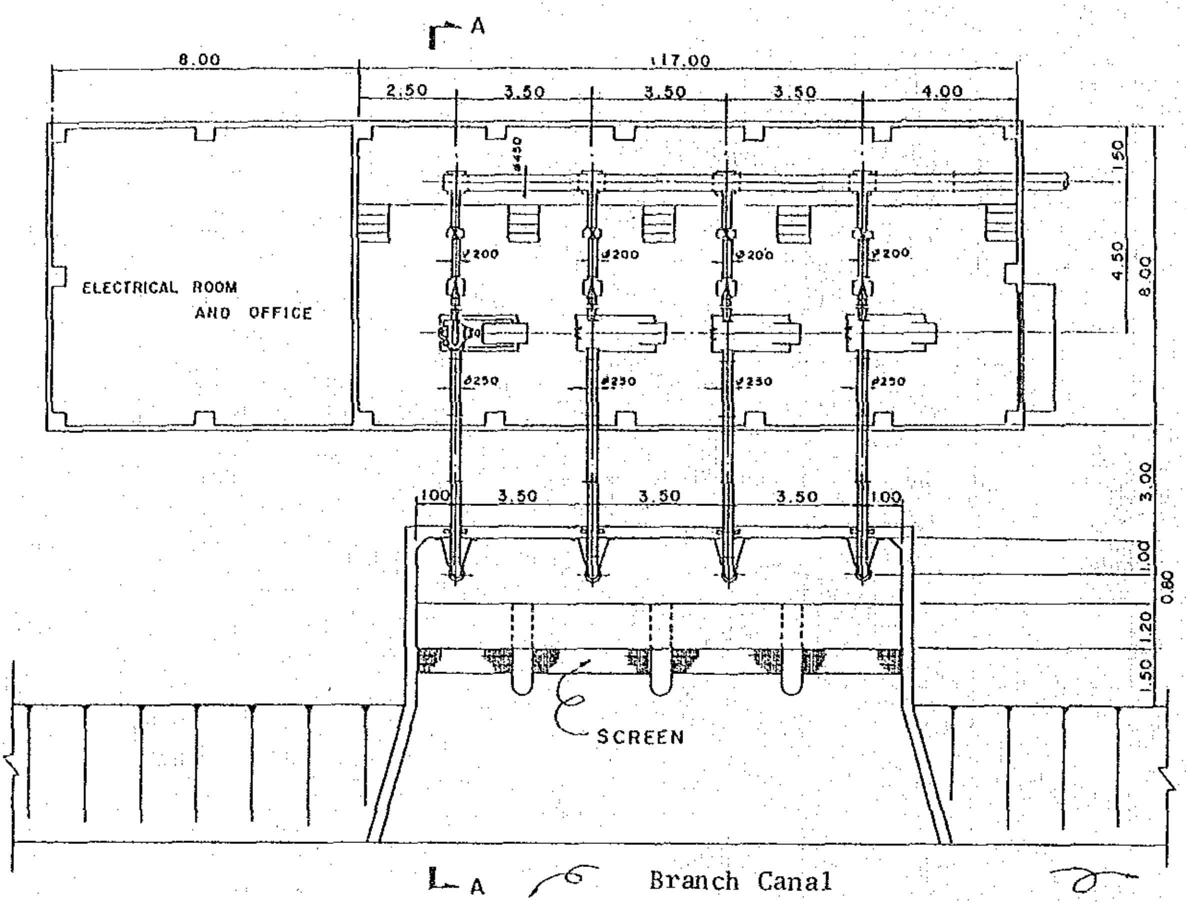
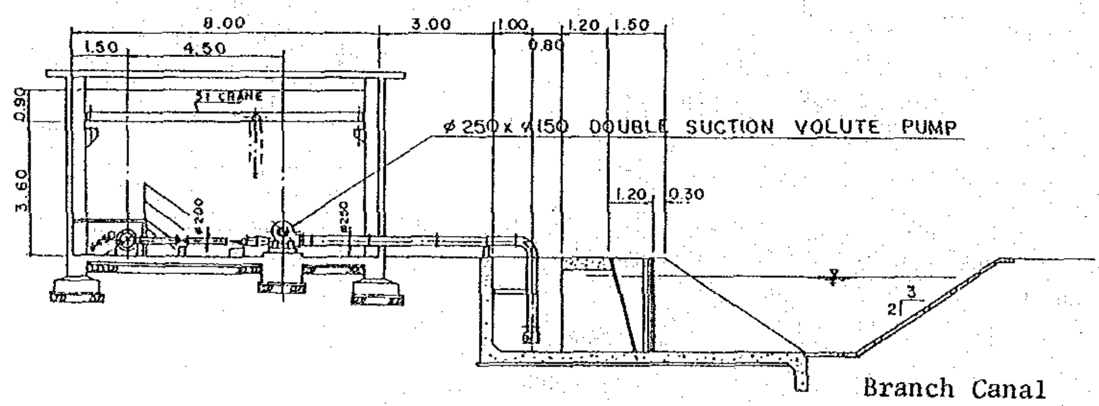


Figure 3.5-10 Layout of Pump Station for Booster



PLAN



SECTION A-A

SCALE

0 1 2 3 4 m

3.5.2. Drainage Plan

1) General

As shown in Figure 3.5-11, the following areas in the F/S Area will require the provision of field drainage systems.

- Clay flats : north of Balouza
- Sand flats : Rumana, Six October and Rabaa/Qatia

Net cultivable area which require field drainage systems is estimated to be 9,720 feddan, equivalent to 23.4 percent of the total net cultivable area in the F/S Area.

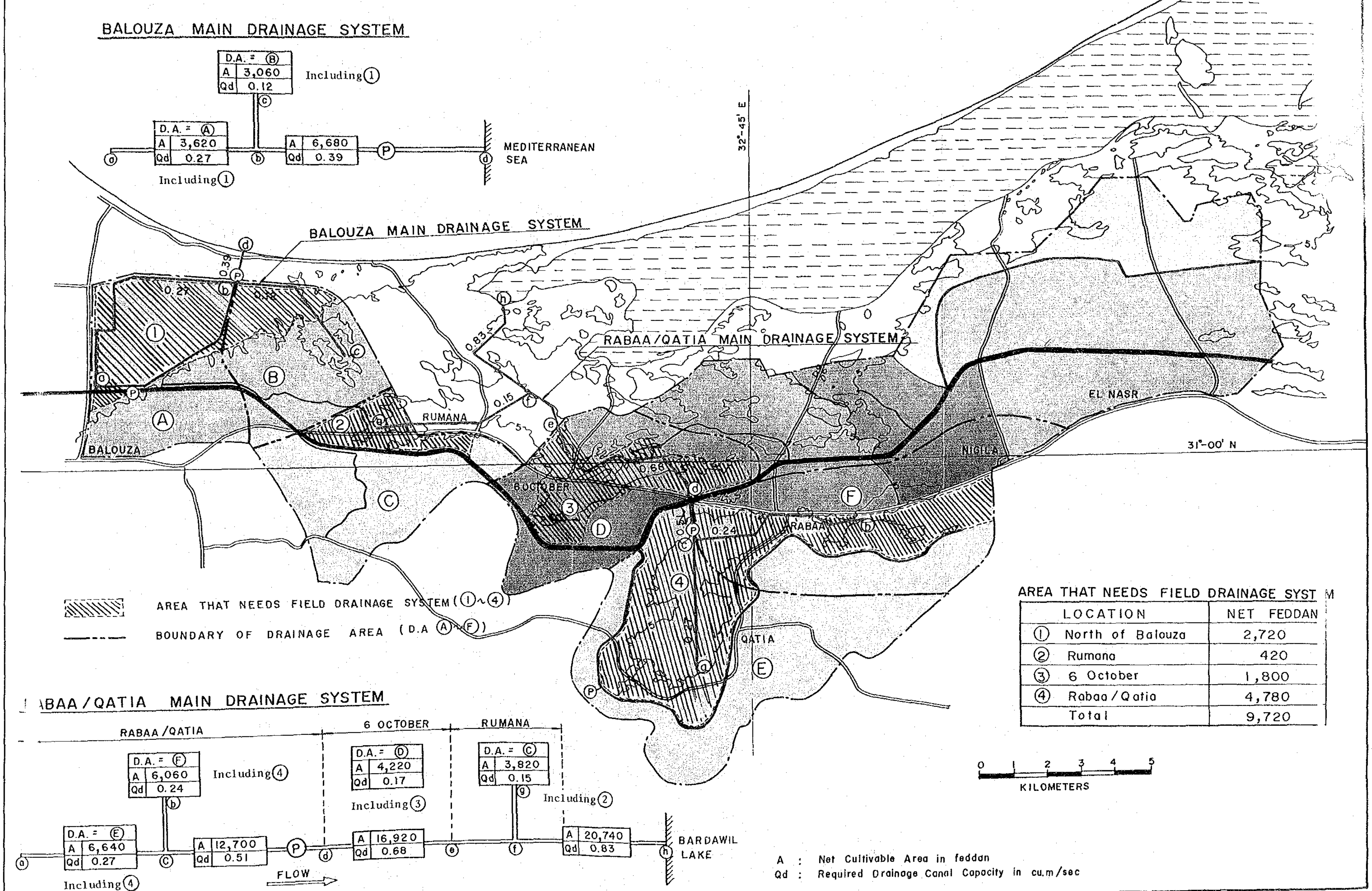
For cost estimation purposes, the field drainage systems in the sand flat areas developed around Sabkha are planned only for areas lower than 10 m elevation. It is difficult to decide exactly the limits of the area that requires field drainage systems before the initiation of irrigation. Therefore installation of the field drainage system could be done after the initiation of irrigation.

For designing drainage facilities, the following drainage rates are adopted with due consideration for permanent leaching requirements.

- Clay flats: 20 percent of peak block water requirement Cropping Pattern CP-2;
  q = 0.571 lit/s/feddan x 0.2 = 0.11 lit/s/feddan
  = 2.3 mm/day
- Sand flats: 10 percent of peak block water requirement Cropping Pattern CP-1;
  q = 0.379 lit/s/feddan x 0.1 = 0.04 lit/s/feddan
  = 0.8 mm/day

Drainage surplus from the clay flats and the sand flats will be conveyed from the F/S Area by the Balouza main drainage system and Rabaa/Qatia main drainage system, respectively.

Figure 3.5-11 Drainage System in F/S Area



AREA THAT NEEDS FIELD DRAINAGE SYSTEM

LOCATION	NET FEDDAN
(1) North of Balouza	2,720
(2) Rumana	420
(3) 6 October	1,800
(4) Rabaa / Qatia	4,780
Total	9,720

2) Field Drainage System

In the F/S Area, the field drainage system aims mainly to control the water level to prevent problems of waterlogging and salinity, rather than to eliminate surface runoff which takes place very rarely because rainfall is only 80 mm per annum. The pipe drain system is adopted as the field drainage system in the F/S Area because of its low land space requirement and its low maintenance costs. Spacing of the field pipe drain is calculated by Hooghoudt's and Donan's formulae, and the results are shown in the following table (for detail of the calculations, refer to APPENDIX-D.)

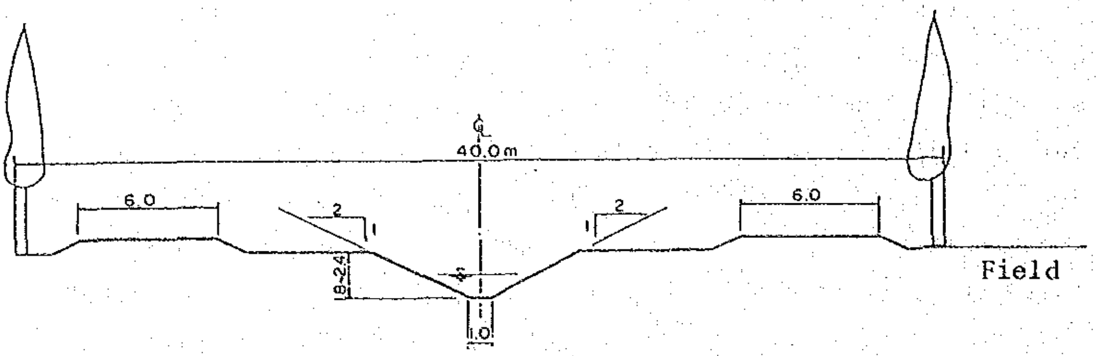
Table 3.5-5. Spacing of Field Pipe Drain

Items	Clay Flats	Sand Flats
- Drainage rate	2.3 mm/day	0.8 mm/day
- Hydraulic conductivity	0.7 m/day	3.0 m/day
- Distance between the water level and drain	0.5 m	0.3 m
- Depth of drain (minimum)	1.5 m	1.5 m
- Spacing		
by Hooghoudt's formula	51 m	138 m
by Donan's formula	52 m	139 m
Adopted	50 m	100 m

The drainage pipe will be corrugated and perforated PVC pipe with 80 mm diameter.

3) Main Drainage Systems

The main drainage systems are installed to collect drainage water and tail escape discharge and to convey this surplus water out of the F/S Area. The main drainage system consists of main drain and secondary drain as an open canal type, and includes drainage pumping stations.



SECONDARY DRAIN

Two main drainage systems, the Balouza main drainage system and the Rabaa/Qatia main drainage system, are necessary in the F/S Area.

Balouza main drainage system will discharge the drainage surplus from the clay flats in the north of Balouza, of which ground elevation is 0 - 3 m, to the Mediterranean Sea. Because the water level in the drainage canal is lower than that of sea level, natural drainage is impossible. Therefore, a drainage pump will be provided.

Meanwhile, the Rabaa main drainage system will discharge the drainage surplus from the sand flats and farmland near the Sabkha to the Bardawil Lake. The sand flats near Rabaa/Qatia extends in the vicinity of the Sabkha located in the midst of the depression of which elevation is below one meter. The Sabkha is bordered by the highway at the north, of which surrounding area has higher elevation. Accordingly, a drainage pump will be required to cross beyond this elevated portion to the Bardawil Lake (refer to Figure 2.1-1 Elevation Classification Map).

The F/S Area is subdivided as shown in Figure 3.5-11. The required capacities of the main and secondary drains are calculated and the results are shown in the following tables.

Table 3.5-6. Design Criteria of Main Drainage System

Main Drainage System	Required Capacity of Drainage Canal (Max.) (cu.m/sec)	Required Flow Rate of Drainage Pump (cu.m/sec)
Balouza Main Drainage System	0.39	0.39
Rabaa/Qatia Main Drainage System	0.83	0.51

Table 3.5-7 Calculation of Drainage Surplus

Subarea	Net Cultivable Area			Drainage Surplus
	CP-2 (feddan)	Other than CP-2 (feddan)	Total (feddan)	(cu.m/sec)
Balouza Main Drainage System				
A	1,800	1,820	3,620	0.27
B	-	3,060	3,060	0.12
Total	1,800	4,880	6,680	0.39
Rabaa/Qatia Main Drainage System				
C	-	3,820	3,820	0.15
D	-	4,220	4,220	0.17
E	-	6,640	6,640	0.27
F	-	6,060	6,060	0.24
Total		20,740	20,740	0.24

Drainage Rate : CP-2 : 0.11 lit/sec/feddan
other than CP-2: 0.04 lit/sec/feddan

Table 3.5-8 Area That Needs Field Drainage System (Tentative)

Location	Net Cultivable Area in Feddan					
	CP-1	CP-2	CP-3	CP-4	CP-5	Total
1 North of Balouza	-	1,800	160	760	-	2,720
2 Rumana	-	-	-	110	310	420
3 Six October	500	-	-	1,200	100	1,800
4 Rabaa/Qatia	4,780	-	-	-	-	4,780
Total	5,280	1,800	160	2,070	410	9,720

Two pumping stations will be constructed for main drainage systems, of which location and capacity are as shown below;

Pumping Station	Location	Discharge (cu.m/sec)	Head (m)
Balouza Drain. St.	Balouza Main Drain. Canal	0.39	3.0
Rabaa Drain. St.	Rabaa Main Drain. Canal	0.51	3.0

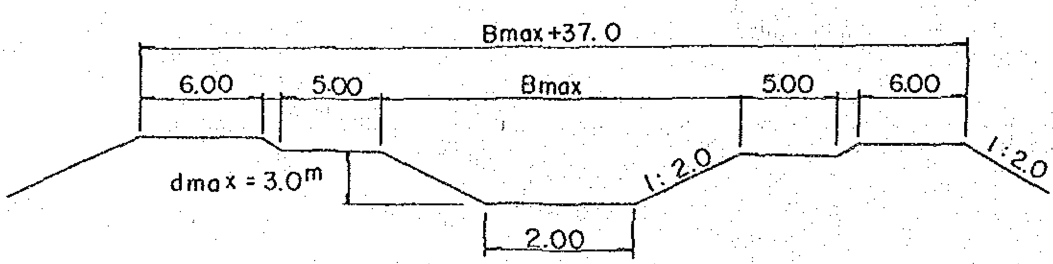
The main drainage canals were designed as follows:

- To construct no special lining for the drainage canals, and to place two rows of reinforced concrete pipes for those sections where the drainage canal bed is lower than 3.0 m from the original ground level.

- To construct the drainage canal bed slope : 1/10,000

- To adopt the side slope gradient : 1 : 2.0

The dimension of the cross section of main drainage canals are shown below:



(Main Drainage Canal)

3.6. Water Conveyance Plan by the El Salam Canal

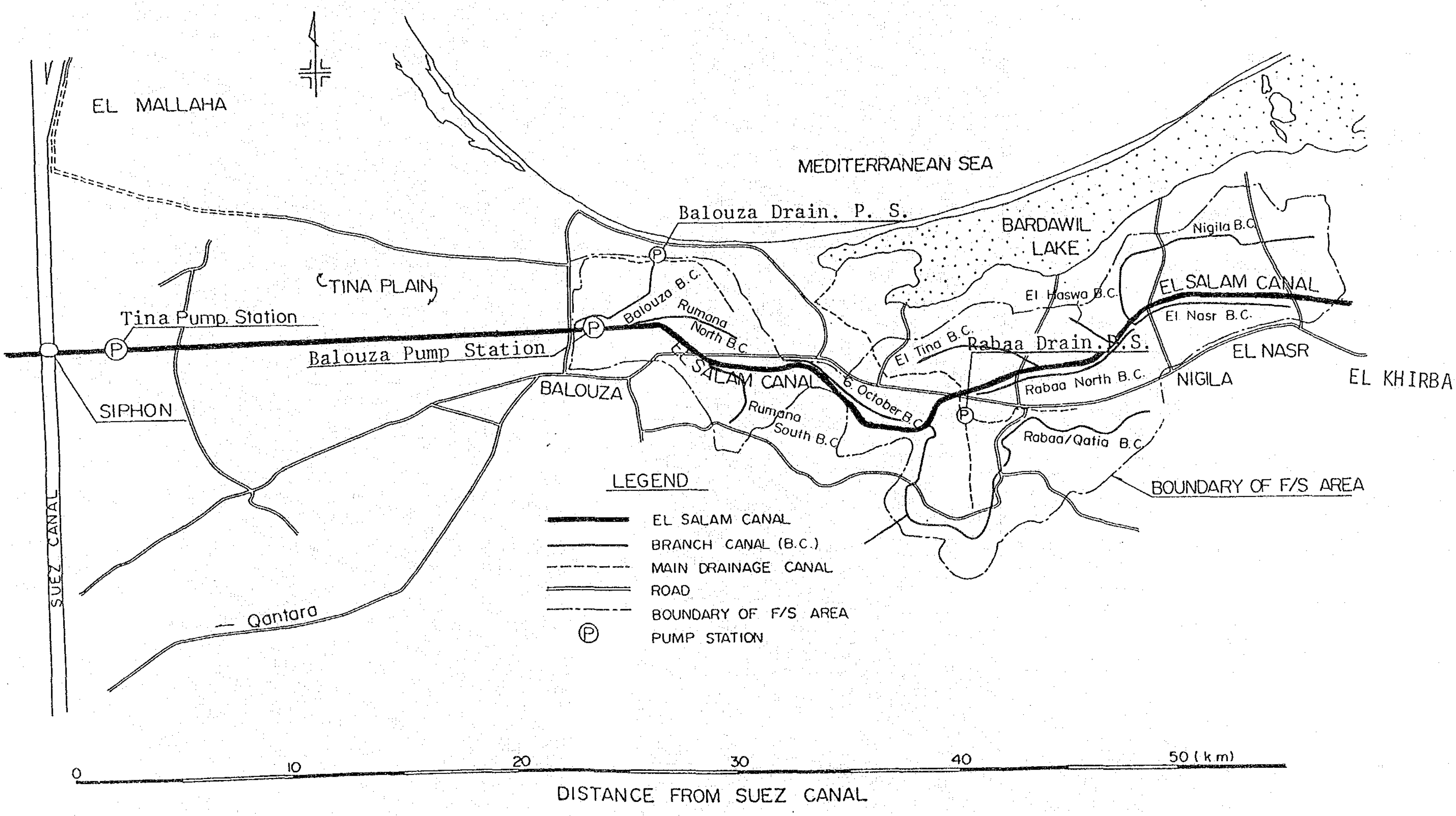
3.6.1. General

El Salam Canal planned in the northern area of Sinai is intended to supply enough irrigation water for 254,700 feddans (gross) delineated as potential areas for agricultural development under the M/P. So, the capacities of the water conveyance facilities such as the siphon under the Suez Canal, pump stations and El Salam Canal and its branches are designed based on the amount of the irrigation water demand for the M/P Area covering 203,800 feddan (net) of irrigable land.

Water conveyance facilities of the El Salam Canal have been extended up to a point 300 m west of the Suez Canal as the Phase I Project. The El Salam Canal Extension is planned to cross the Suez Canal and to irrigate the Tina Plain and far eastern sandy area in North Sinai region (Figure 3.6-1). Designing of the following facilities was carried out from both engineering and economic viewpoints.

- The siphon under the Suez Canal: the length of 1,350 m to meet the future widening plan of the Suez Canal specified by the Suez Canal Authority.
- The pumping stations: the Tina Station, (Q = 88.7 cu.m/s) located 2 km downstream from the siphon outlet to lift the water to cross the Tina Plain (23.8 km) without intrusion of the saline groundwater into the canal; the Balouza Station, (Q = 38.6 cu.m) located at the eastern end of the Tina Plain to lift the water 11 m to enable gravity conveyance of water to the far eastern sandy area.
- The El Salam Canal: both in the Tina Plain for 23.8 km long, and in the sandy area for 36.9 km long to the eastern end of the F/S Area near El-Khirba.
- The branch canals: ten branch irrigation canals branched from the El Salam Canal, i.e., Balouza, Rumana North, Rumana South, Six October, Rabaa/Qatia, Rabaa North, El Tina, El Haswa, El Nasr and Nigila.
- Water control systems: to manage water distribution and to enhance the efficiency of water conveyance of El Salam Canal.

Figure 3.6-1 El Salam Canal Plan



3.6.2. Canal Alignment

The canal alignment was investigated during the field survey based on the topographic maps scaled 1/10,000 and 1/5,000. Simultaneously, the topographic survey of the longitudinal section from the Suez Canal up to the El Khirba was conducted.

The basic concepts to determine the canal alignment are as follows:

(1) to avoid the windblown sand deposits into canal

(2) to minimize the embankment section in the sandy area

(3) to minimize the construction and maintenance costs

Followings are the points to determine the canal alignment in the Tina Plain and the sandy area, respectively.

- The proposed alignment in Tina Plain was adjusted with the existing canal alignment on the west bank of the Suez Canal. It was selected carefully to avoid wet Sabkha and two historial ruins and to traverse the Tina Plain in the shortest distance (23.8 km). As for the ruins of Tell El Louli, the selected canal route was approved by the Archaeology Authority in response to the letter submitted from the Study Team through MOD at the beginning of November 1988.

- The alignment in the sandy area after passing the Tina Plain, was carefully studied not to generate an excessive water head for pumping facilities. The water will be distributed by gravity after Balouza pump station for the areas up to Tulul. It is necessary to place another pumping station at Tulul in case of the canal extends further east.

- The canal alignment in the sandy area was also checked on the ground elevation using the elevation classification of every 5.0 m intervals on the map scaled 1/25,000.

- It was observed during the field survey that the elevation belt between EL. 10 m to 15 m was covered with stable vegetation without trace of mobile sand dunes so that the canal alignment was made within this belt. It virtually coincides with the proposed alignment prepared by GARPAD.

- The operation of El Salam Canal is designed for 24 hours in a day. Nine branch irrigation canals located downstream of the Balouza Pump Station in the sandy areas have a function to store the water inbalanced between the 24 hours El Salam Canal conveyance and 20 hours operation of booster pumping stations at downstream of branch canals. The Balouza branch canal is designed by the same criteria as the El Salam Canal in the Tina Plain without special linings, while concrete lining will be applied for the branch canals in the sandy area.

As a result of the alternative study, the canal alignment was determined in the elevation belt between EL. 10 m to 15 m, which runs in the midst of the F/S area. The alternative routes shown in the Figure 3.6-2 were eliminated by the comparison of the following points:

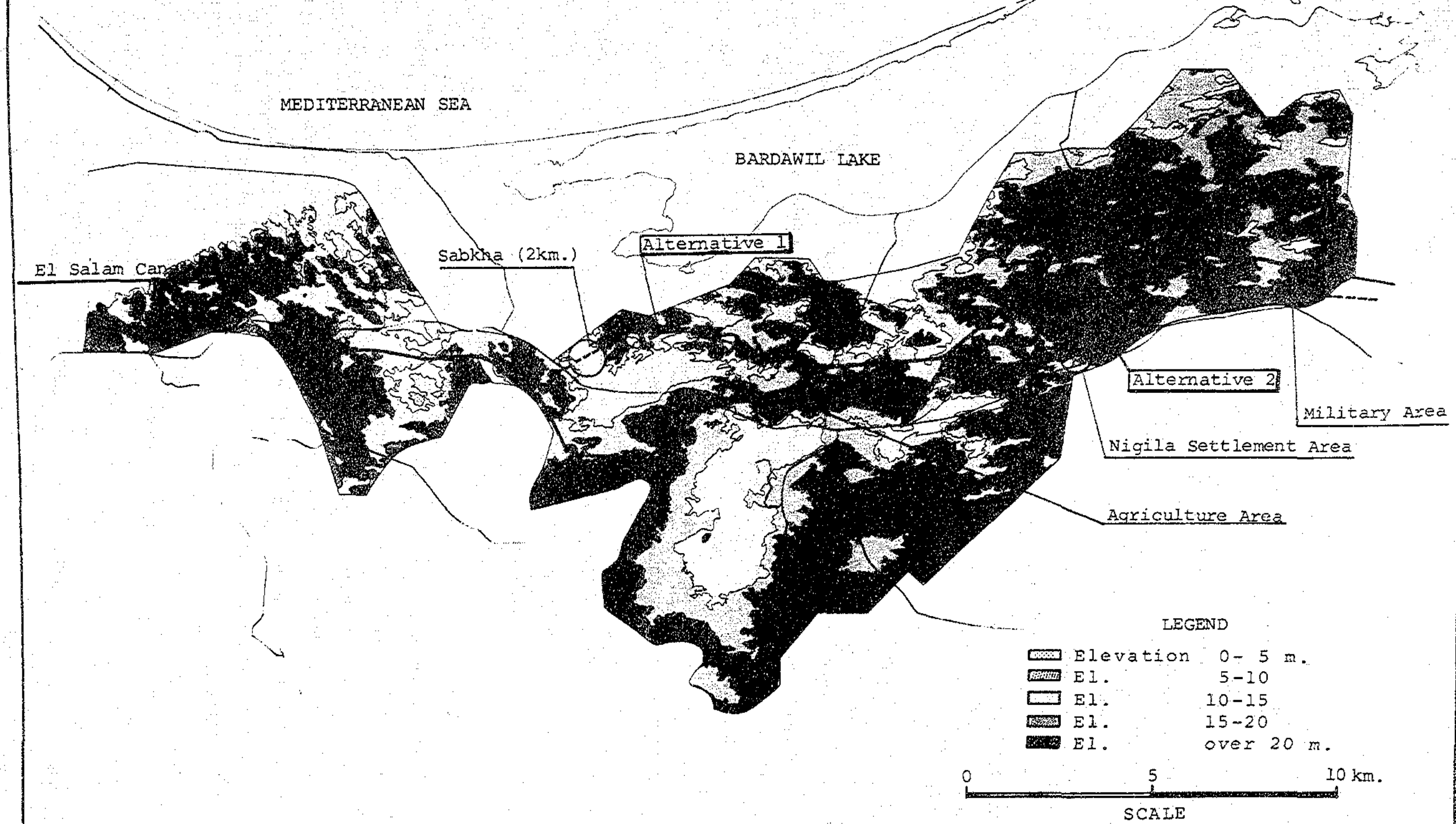
- To shorten the canal reach
- To escape from the Sabkha below EL. 5 m
- To minimize the highway crossing
- To be free from the disturbance for the existing social facilities

3.6.3. Siphon under the Suez Canal

The El Salam Canal, which has reached within 300 m of the west bank of Suez Canal, will cross the Suez Canal and other important infrastructures in a minimum distance of 1,350 m (1,050 m to cross the Suez Canal Section and its future widening, and other 300 m for crossing the section which contains important infrastructures such as highways, railways and irrigation channels). The siphon capacity is determined by the siphon diameter and the difference in the water head between the inlet and outlet.

The water surface elevation at the end of the existing El Salam Canal is fixed as EL. 1.50 m at peak discharge period.

Figire 3.6-2 Alternative Route of El Salam Canal



The tidal record over the last 10 years showed the highest tidal elevation was EL. 0.50 m in June and July. This period is the peak discharge period of the El Salam Canal. Accordingly, it is necessary to keep the water level of El Salam Canal higher than EL. 0.5 m to avoid the seawater intrusion to the Canal. Consequently, the available range of water head for the siphon to cross the Suez Canal is from EL. 1.50 to 0.50 m (Figure 3.6-3).

In addition, according to the instruction of the Suez Canal Authority, it is necessary to place a pumping station far two km from the siphon outlet to leave the space for sediment which will be dredged from Suez Canal widening.

1) The Number of Siphons

Considering the available water head to cross the Suez Canal and its connection canal to pumping station, a total water head of 1.0 m from EL. 0.50 to 1.50 m is defined for a distance of 1,350 m of siphon and 2,000 m length of canal. Three different projections for costs and construction periods were compared using different number of siphon rows, based on the following hydraulic assumptions

- Siphon Discharge .... 88.7 cu.m/s
- Hydraulic Gradient .... 0.60 m/1,350 m
- Friction Loss .... Hazen Williams (C = 130)

Results of comparison are shown in Table 3.6-1. Assuming the maximum construction period of siphon is 48 months in which six months is possible to be shorten by minimizing the preparatory works, the same number of drilling machines as number of siphon rows will be required and the drilling of siphon should be done simultaneously by using all drilling machines. For reference, construction schedule of siphon by two rows (Case-1) is shown in APPENDIX-K.

Figure 3.6-3 Siphon crossing Suez Canal

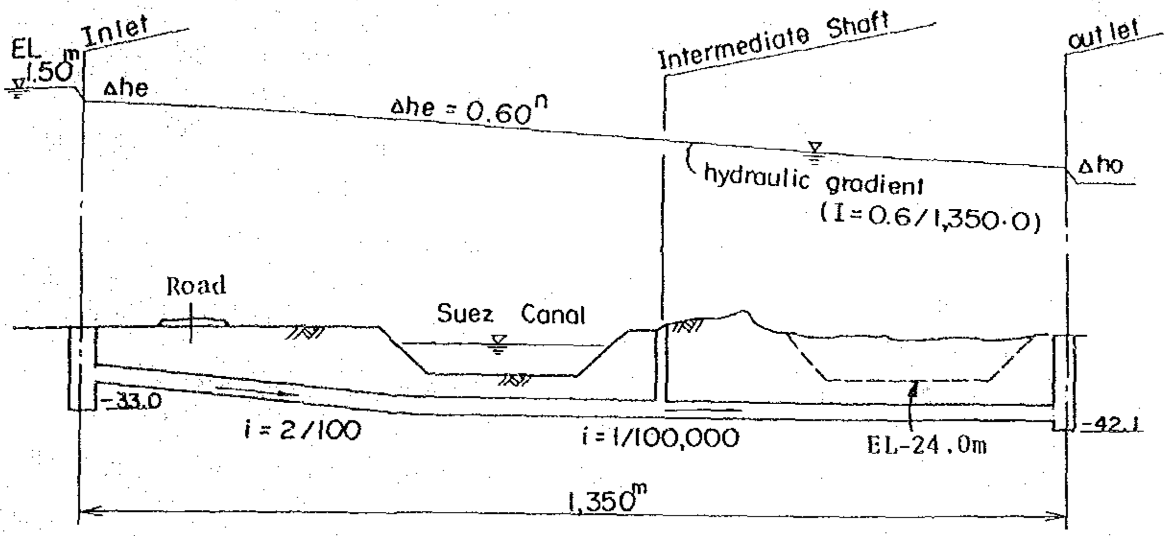


Table 3.6-1 Alternative Study on Siphon

Item	Unit	Case-1	Case-2	Case-3
Number of rows	No.s	2	3	4
Diameter	m	5.3	4.6	4.1
Velocity	m/s	2.0	1.8	1.7
(Siphon Work)				
Excavation	cu.m	90,700	108,500	120,900
R.C. & Segment	ton	40,400	53,600	64,800
Lining	cu.m	11,800	15,400	18,400
(Shaft Work)				
Excavation	cu.m	25,100	30,400	36,400
Diaphragm wall	sq.m	9,700	11,900	14,000
Waling/Strut	ton	1,050	1,380	1,720
Bottom Slab Conc.	cu.m	590	780	930
Construction Cost	mil. LE	174 (100)	250 (118)	218(125)
Construct. Period	month	45	47	47
		Adopted		

The construction costs increase proportionally by the number of siphon rows. The indices of construction costs for alternative plans of three and four rows show 118 and 125 respectively, when compared to the base index of 100 for the alternatives of two rows (Table 3.6-1). Consequently, the siphon of two rows is recommended, both from viewpoint of the construction costs and the period of construction.

The design velocity during the peak discharge period of June and July shows a maximum value of 2.0 m/s. The head loss of the siphon section is a total of 0.90 m including 0.60 m of friction loss and 0.30 m of other losses for inlet and outlet. In winter, total head loss decreases to only 0.30 m. The difference in the water levels between inlet and outlet is to be maintained from 0.30 m to 0.90 m annually, by operating the Tina Pumping Station. Remaining 0.10 m of available water head will be used for the flow energy between outlet of canal and pumping station at 2.0 km distance.

2) Siphon Structure

The siphon structure is designed in relation to the following aspects, based on the instruction by the Suez Canal Authority and the determination for efficient operation and maintenance.

- To keep at least 5.0 m depth between the top of siphon structure and the bottom of Suez Canal which has specified EL.-24.0 m as the future plan of the Canal expansion.
- To employ a siphon gradient of 2/100 for the beginning of the 300 m section in order to minimize the depth of entrance shaft.
- To employ a siphon gradient of 1/10,000 for the 1,050 m section up to the outlet shaft in order to drain and to minimize the depth of the outlet shaft.
- To provide intermediate shaft to maintain safe hydraulic function along with the ventilation necessary during the transition from free surface flow to surging pipe flows, this shaft will be used for the maintenance of the drilling machine during construction period.

- To have the lining thickness both for the first layer of 0.30 m and for the second layer of 0.25 m in consideration of the safety for the uplift when the siphon is vacant.
- To design the distance between two rows of siphon center as two times of the siphon diameter to enable the safety drilling without affecting another row.

3) Construction Method

The construction method of the siphon drilling was studied based on the results of a geological survey carried out on both banks of the Suez Canal by the MPWWR (formerly Ministry of Irrigation) in 1980.

As a result, the shield driven method was selected since it is the only possible method for the construction without disturbing the functions of the existing infrastructure of highway, railway and irrigation canal on the west bank of the Suez Canal.

Potentially, three kinds of shield driven method are adoptable in this condition;

(1) Open-face with auxiliary pneumatic shield method
(2) Slurry shield method
(3) Earth pressure-balanced shield method

Among these three methods, the earth pressure-balanced shield driven method is proposed. The reasons for recommending this method are as follows;

- Shield driving avoiding a collapse of the cutting surface could be achieved.
- Least auxiliary works are required.
- Excavated material could be disposed of without any treatment.

3.6.4. El Salam Canal in the Tina Plain

The El Salam Canal in the Tina Plain is to be lifted by the Tina Pumping Station located at two kilometers downstream from the siphon outlet and crosses the next 22 km of plain by gravity flow up to Balouza Pumping Station.

The soil condition in the Tina Plain is generally same as the 87 km of canal alignment already constructed on the west bank of the Suez Canal. On the west bank of the Suez Canal, the canal bed slope varies from 3.5 to 6.0 cm per 1.0 km length.

The discharge of the El Salam Canal in the Tina Plain varies from 88.7 to 38.6 cu.m/s. It is important to employ the uniform bed slope for the canal reach sectioned by the Tina and Balouza Pumping Stations in the Tina Plain and to determine the most economical bed slope.

1) Canal Bed Slope

The longitudinal section in the Tina Plain is designed taking into consideration of the followings;

- To ensure the Canal water surface at 0.5 m above the ground elevation surrounding.
- To get EL. 2.0 m of the water surface at the Balouza Pumping Station distant 22 km from the Tina Pumping Station.
- To consider the soil on the Canal reach varying from silt to clay.
- To employ 4.0 m of the Canal water depth and 0.5 m of the free board height to maintain the slope stability and construction efficiency.

In addition, 0.7 m/s of the maximum velocity is uniformly adopted in the 23.8 km distance of the Tina Plain section according to the Kennedy formula ($Vs = C.D^{0.5}$) based on the design criteria of USBR.

The following assumptions are adopted to estimate the maximum velocity in the Tina Plain.

- Sediment and erosion on the canal bed are potentially occurred at the point where the velocity changes, that the uniform velocity in the Plain Section is recommended.
- The criteria of maximum velocity varies in accordance with the soil classification from silt to clay in the canal reach, that the silt (C = 0.35) is employed conservatively.

The annual cost comparison in terms of the construction and maintenance with pumping operation is listed in the Table 3.6-2 by varing the canal bed slope from 2/100,000 to 6/100,000 and using the maximum discharge (88.7 cu.m/s) of the section 8 km distance. As a result, a bed slope with a gradient of more than 6/100,000 exceeds the maximum velocity. In the range of bed slope from 2/100,000 to 5/100,000, the cost reduction of canal work is more prominent than the increase of the pumping cost, so that a canal bed slope of 5/100,000 is to be employed in the Tina Plain section.

Dimensions of the cross section of the Canal are shown in Figure 3.6-4.

The lifting height at the Tina Pumping Station is from EL. 0.50 to 3.05 m as illustrated below (refer to Figure 3.6-5):

Hydraulic Profile in Tina Plain

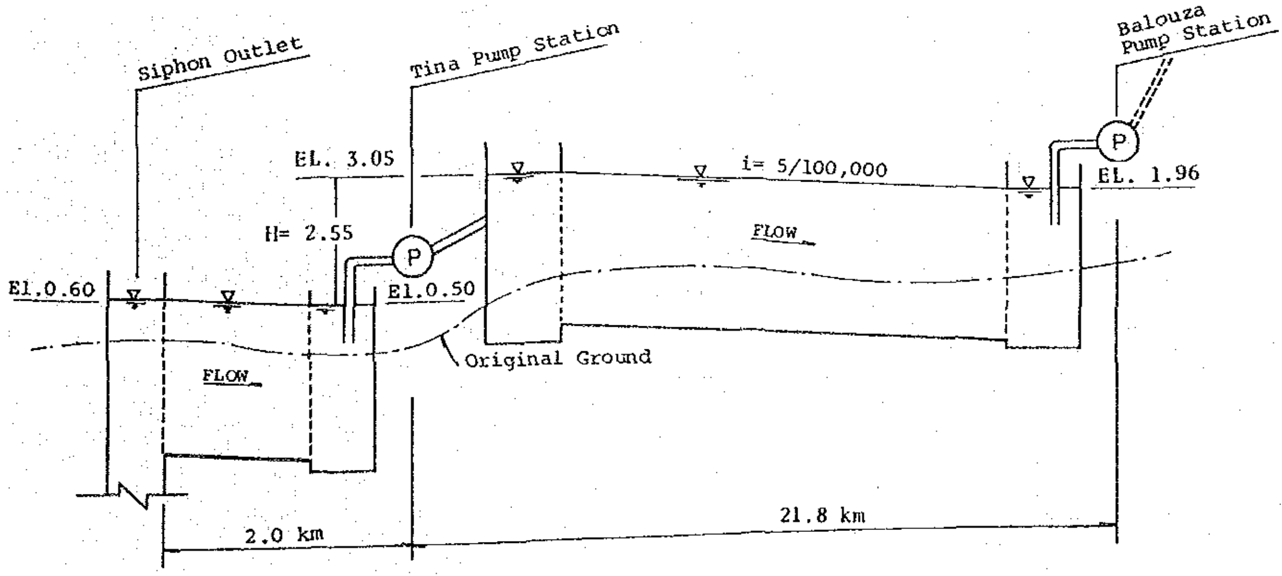
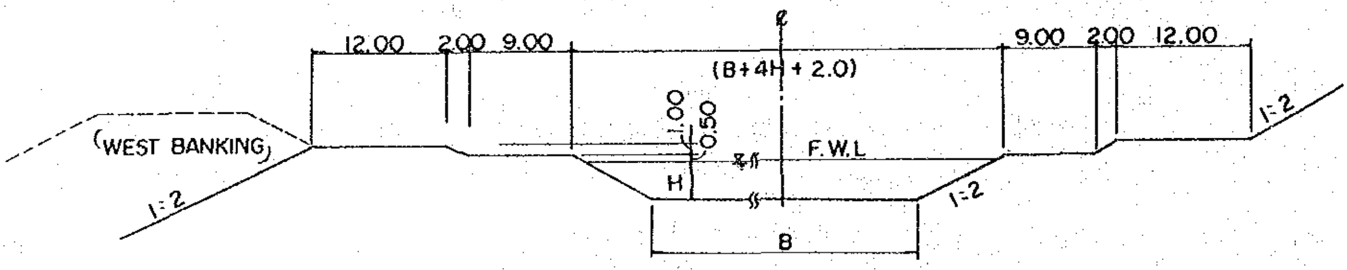


Table 3.6-2 Gradient of El Salam Canal (Tina Plain)

Canal Section (m)			Velocity (m/s)		Annual Cost ('000LE)		
Slope	Width	Depth	Q=88.7m³/s	Q=23.5m³/s	Canal	Mainte.	Total
2/100,000	40	4	0.45	0.28	942	42	984(150)
3/100,000	33	4	0.54	0.37	807	63	870(134)
4/100,000	27	4	0.62	0.43	691	85	776(121)
5/100,000	25	4	0.68	0.45	653	106	759(100)
6/100,000	22	4	0.73	0.48	-	-	-

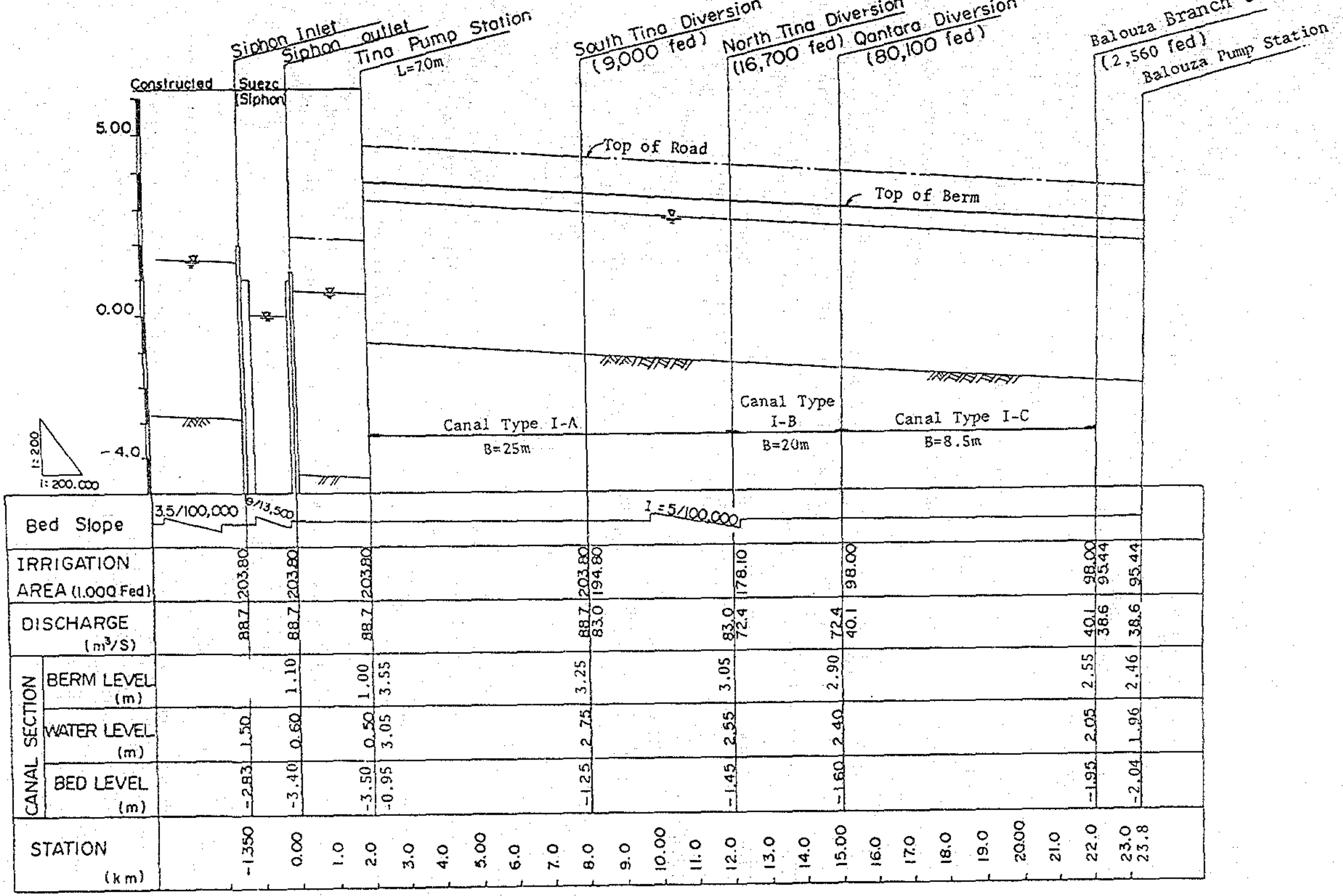
Note: Canal --- Canal Work Cost
Mainte. --- Maintenance Cost (Electricity Charge)

Figure 3.6-4 Cross Section of El Salam Canal (Tina Plain)



Canal Type	Section	Length km	Discharge cu.m/s	Bed Width m	W. Depth m
I-A	0.00 - 12.00	12.0	88.7-83.0	25.0	4.0
I-B	12.00 - 15.00	3.0	72.4	20.0	4.0
I-C	15.00 - 23.80	8.8	40.1-38.6	8.5	4.0

Figure 3.6-5 Longitudinal Profile of El Salam Canal (Tina Plain)



3.6.5. El Salam Canal in the Sandy Area

The El Salam Canal in the sandy area runs a distance of 37 km from the Balouza Pumping Station to the eastern boundary of the F/S Area. It is necessary to determine the most economical pumping head and canal bed slope in relation to the costs of canal construction and annual cost of maintenance. The canal bed slope should be taken into consideration of the future extensions further east of the sandy area. The canal section is to be designed considering of the hydraulic efficiencies under conditions of the concrete lining which has a side slope of 1:1.5.

The most economical canal bed slope, pumping head and cross section were determined as follows:

1) Canal Bed Slope and Pumping Hight (Balouza Station)

The hydraulic profile in sandy area is designed aiming at the Canal extention up to the further eastern part for Misfaq (Tulul) and El Arish beyond the F/S boundary. The basic concepts of the Canal extension was consulted with MPWWR and confirmed as below:

- The Canal is able to run in the midst of the North Sinai Rural Development area up to Misfaq, although the project area is isoloated in its eastern part from Misfaq to El Arish, where the water conveyance is to be dependent on the pipeline to link those scattered areas.
- In the downstream of the Balouza Pumping Station, the Canal water is conveyed 55 km by gravity up to Misfaq, where the water is boosted again to be conveyed by pipeline for the further eastern area.

Considering those points, it is targeted to get the Canal water surface of EL 6.0 m based on the average ground elevation around Misfaq.

A comparison of annual costs on the Canal construction and pumping operation (Balouza Station) at the maximum discharge of Q = 38.6 cu.m/s varying the canal bed slope from 1/5,000 to 1/10,000 is shown in the Table 3.6-3. The construction cost consists of both the earth work and canal lining of the canal reach of 37 km length in the F/S area.

Consequently, the adoption of a bed slope of 1/8,000 in its longitudinal section is recommended due to the economic advantages in annual cost comparison.

The pumping height at Balouza Station is about 11.0 m from EL 1.96 m (Tina Plain) to EL 13.0 m (sandy area) as illustrated below (refer to Figure 3.6-6):

Hydraulic Profile in Sandy Area

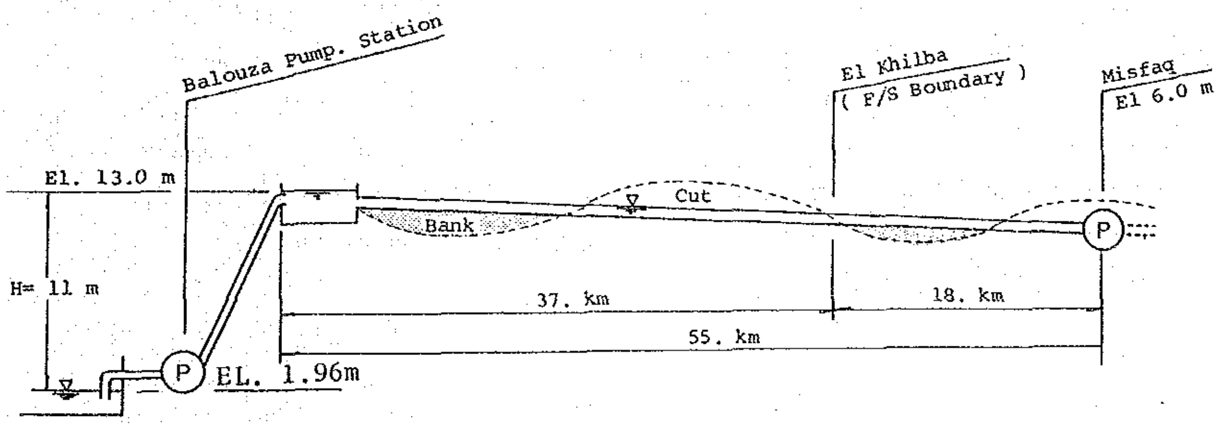


Table 3.6-3. Bed Slope and Annual Cost in Sandy Area

Bed Slope	h (m)	Investment Initial	Investment Annual	Investment Maintain	Investment Total	Operation Electricity	Total
1/10,000	0.100	648	53.1	6.5	59.6	10.2	69.8
1/9,000	0.111	634	52.0	6.3	58.3	11.3	69.6
1/8,000	0.125	615	50.4	6.2	56.6	12.7	69.3 *
1/7,000	0.142	597	49.0	6.0	55.0	14.6	69.5
1/6,000	0.166	578	47.4	5.8	53.2	16.9	70.1
1/5,000	0.200	553	45.3	5.5	50.8	20.4	71.2

Note: h = Pump head for 1.0 km of Canal * adopted

2) Canal Section

The side slope of 1 : 1.5 in the canal section has proved its stability with a safety ratio of 1.59 after a slope stability analysis of the canal embankment with assumption of the embankment height of 4.5 m and a soil classification of SP (poorly graded sand). In case that saturation occurs at behind the canal lining due to leakage, the safety ratio decreases to below 1.0 and it causes sliding of canal dike at the foot of the embankment. It is essential that the canal lining should be executed with the highest construction standards in the sandy area. The canal design, with respect to its longitude and cross-section, has to be on the following considerations:

- To select the canal route which has a height of embankment less than 3.0 m at the canal bed from the original ground.
- To use a plain concrete lining with a thickness of 12 cm, which has been successfully used in and has proved its reliability in Egypt for the equivalent capacity of canal.
- Not to use a membrane lining by polyethylene or rubber sheet due to its lack of satisfactory results from the viewpoint of durability and economy.
- To maintain the same canal section within 10 percent of the difference in designed discharge.

Figure 3.6–6 Longitudinal Profile of El Salam Canal (Sandy Area)

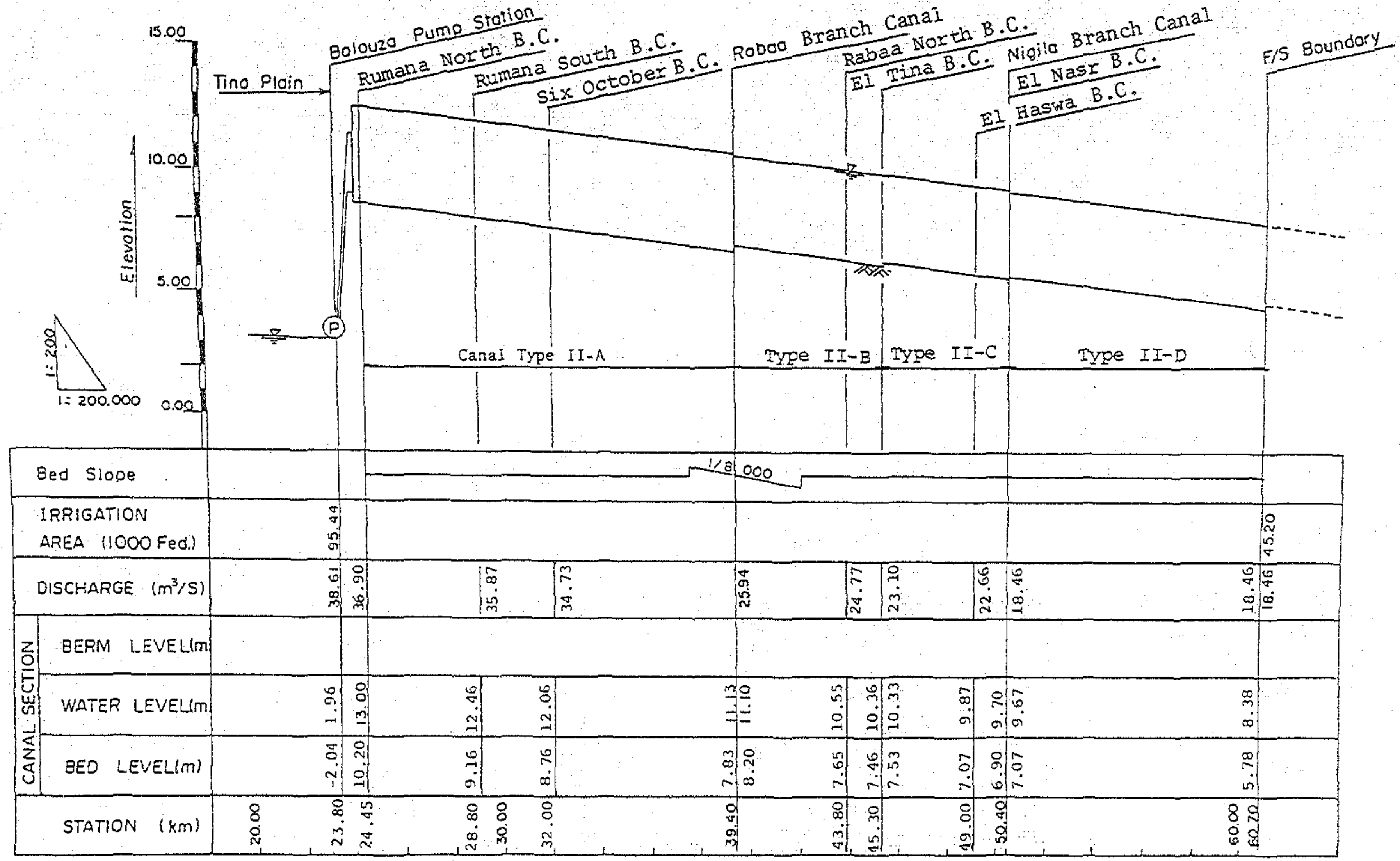
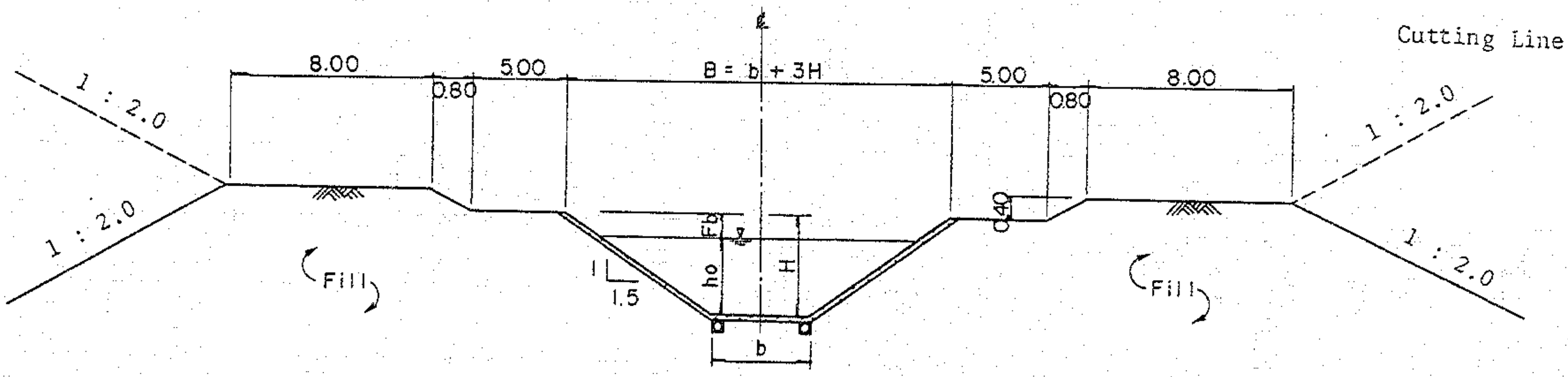


Figure 3.6-7 Cross Section of El Salam Canal (Sandy Area)



° Side Slope 1 : 1.5 (Canal) 1 : 2.0 (Bank)
° Coefficient of Manning Formula
n = 0.015

Canal Type	Section Point in km	Design Capacity cu.m/sec	Length km	Canal Dimension (m) b	ho	Fb	H	B	Branch Canal Diverted
II-A	24.45 –39.40	36.90 - 34.73	14.95	5.00	3.30	0.40	3.70	16.10	Rumana South B.C. Six October B.C. Rabaa/Qatia B.C.
II-B	39.40 -45.30	25.94 - 24.77	5.90	4.00	2.90	0.40	3.30	13.90	El Tina B.C. Rabaa North B.C.
II-C	45.30 -50.40	23.10 - 22.66	5.10	4.00	2.80	0.35	3.15	13.45	Nigila B.C. El Nasr B.C. El Haswa B.C.
II-D	50.40 -60.70	18.46	10.30	3.50	2.60	0.30	2.90	12.20	F/S Boundary

Note : ho = Uniform flow depth
b = Canal bed width
Fb = Free boad height

- To provide a drain filter on both sides of the canal bed with a depth of 0.40 m.

The dimensions of the cross section of the El Salam Canal are shown in Figure 3.6-7.

3.6.6. Pumping Station

The location and capacity of pumping stations to be placed along the El Salam Canal are given in the following table.

Table 3.6-4. Design Criteria of Pumping Stations

Name	Location	Discharge (cu.m/sec)	Head (m)
1. Tina Station	2.0 km on El Salam Canal	88.7	2.6
2. Balouza Station	23.8 km "	38.6	11.0
3. Hod Abu Samara Station	5.3 km on Rabaa/Qatia B.C.	4.4	15.0

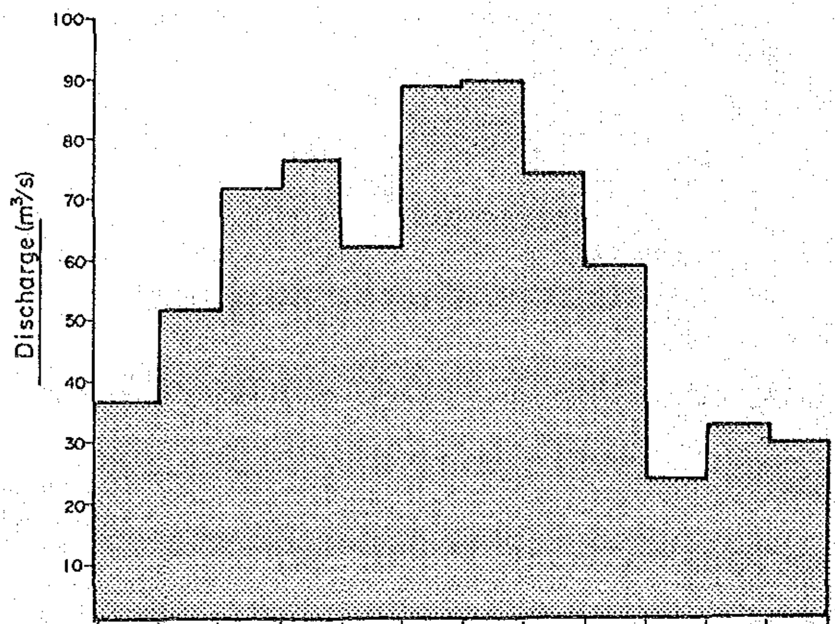
The pump type is determined by its total required head, in general. The relationship between pump type and required head can be summarized as below:

Pump Type	Horizontal Axis (m)	Vertical Axis (m)
Volute Flow	15.0 - more	15.0 - more
Vertical Mixed Flow	2.0 - 9.0	9.0 - 20.0
Axial Flow	1.5 - 5.0	1.5 - 5.0

1) Tina Station

After crossing the Suez Canal by siphon, the actual head of the El Salam Canal to be lifted at the Tina Station is 2.55 m.

Figure 3.6-8. Monthly Fluctuation of Discharge at Tina Station



Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q (m^3/s)	36.6	51.5	71.3	76.1	61.3	88.1	88.7	73.3	58.1	23.5	32.0	29.6

Operation Period	Discharge (cu.m)	Suction (El.m)	Discharge (El.m)	Head (m)
Peak (July)	88.7	0.50	3.10	2.60

The pump type is selected in respect of the following physical constraints of the Tina Station.

- To enable to adapt to low up-lift and a wide range of discharge variations during the continuous pump operation.

- To facilitate efficient pumping operations without cavitation or loss of motor power.

- To adjust with the design of three existing pumping stations located on the reaches of the El Salam Canal already constructed on the west bank of the Suez Canal.

Consequently, a vertical axial flow with movable blade is recommended.

Alternative plans for the pump units were studied and listed in Table 3.6-5.

Case-1 ...... 2,800 mm pump x 6 units
Case-2 ...... 2,600 mm pump x 7 units
Case-3 ...... 2,200 mm pump x 4 + 2,500 mm pump x 5 units

Each case includes one unit of pump for stand-by on the respective capacity. Comparing the three cases, Case-1 equipped with five units and one stand-by of 2,800 mm pumps has economic advantages both in costs of pumping equipment and civil works (refer to Table 3.6-6). Case-1 is therefore to be adopted.

Comparing the capacity of a stand-by pump with five regular units, it becomes the value of 20% up on the design discharge (Q = 88.7 cu.m/s) in respect of the pump number. However, the design discharge is recorded only within two months of June and July, that the capacity of a stand-by pump is estimated to 25% in terms of the usage during the high discharge period for six months from March to September. Furthermore, it has an allowance owing to the design value of the pump efficiency (85%) and its mechanical characteristic of a movable blade type.

Table 3.6-5 Alternative Study on Tina Pumping Station

Item	(Unit)	Case-1	Case-2	Case-3	
Pump Type		Axial Flow (Movable blade)			
Water Requirement	(cu.m/s)	88.7 cu.m/s			
Pump Capacity/unit	(cu.m/m)	1,064	887	642	852
Pump Bore	(mm)	2,800	2,600	2,200	2,500
Actual Head	(m)	2.55 m			
Total Head	(m)	3 m			
Pump Efficiency	(%)	85.5	85	84	84.5
Motor Power	(kw)	870	730	540	680
Pump Nos. including stand-by unit		6	7	4	5
Total Motor Power (kw)		4,350	4,380	4,340	
		Adopted			

Table 3.6-6 Cost of Alternative Study on Tina Pumping Station

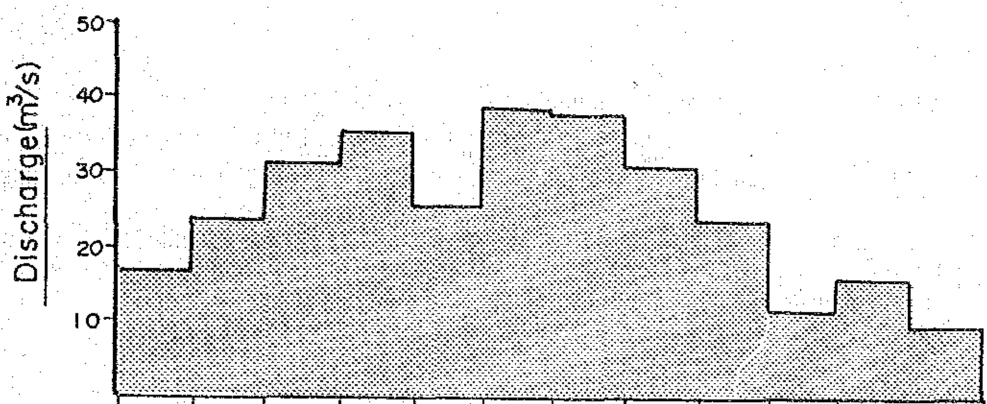
(Unit: 1000LE)

I. Facilities	Case-1 ø2800 + (5+1)	Case-2 ø2600 x (6+1)	Case-3 ø2200 x (3 + 1)	Case-3 ø2500 x (4+1)
1. Vertical Axial Flow Pump	21,990 (1064 cum/m)	21,420 (887 cum/m)	8,620 (642 cum/m)	13,840 (852 cum/m)
2. Speed Reduction Gear	3,840 (590/130 rpm)	4,500 (735/140 rpm)	1,360 (735/170 rpm)	3,210 (735/150 rpm)
3. Motor	1,890 (870kw-10p)	1,720 (730kw-8p)	750 (540kw-8p)	1,170 (680kw-8p)
4. Pipe in Pump Station	5,150	5,090	1,670	2,740
5. Flap Value	1,230	1,190	490	760
6. Screen Equipment	3,540	3,830	4,290	
7. Bar Screen	420	410	530	
8. Electrical Equipment	4,970	4,990	5,050	
9. Auxiliary Equipment	580	580	580	
10. Cable and Earthing Material	1,230	1,460	1,460	
Total	44,900	45,190	46,520	
II. Civil Work	6,180	6,350	6,500	
Total	51,080	51,540	53,020	
III. Running Cost /year	825	831	823	

2) Balouza Station

Balouza Station located at the eastern end of the Tina Plain is to lift the El Salam Canal water up to the sandy area with the actual pump head of 11.0 m.

Figure 3.6-9. Monthly Fluctuation of Discharge at Balouza Station



Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q(m^3/s)	17.2	24.0	31.7	36.0	25.9	39.0	38.6	31.4	24.2	11.7	16.1	14.4

Period	Discharge (cu.m/s)	Suction (El.m)	Discharge (El.m)	Head (m)
Peak (Jul.)	39.0	2.0	13.0	11.0

The vertical mixed flow pump, of which discharge is controlled by the number of operation units, is selected in accordance with the general design criteria.

The alternative study to select the size of pump bore and the number of units was conducted in the following four cases (Table 3.6-7) and are summarized as follows;

Case 1 ..... 1,500 mm x 4 + 2,000 mm x 4 units
Case 2 ..... 1,600 mm x 5 + 1,800 mm x 3 units
Case 3 ..... 1,500 mm x 6 + 1,800 mm x 3 units
Case 4 ..... 1,350 mm x 7 + 1,800 mm x 3 units

Table 3.6-7 Alternative Study on Balouza Pumping Station

Item	(Unit)	Case-1		Case-2		Case-3		Case-4	
Pump Type		Vertical Mixed Flow							
Water Requirement	(cu.m/s)	39.0 cu.m/s (2,340 cu.m/m)							
Pump Capacity	(cu.m/m)	300	480	360	450	288	450	240	450
Pump Bore	(mm)	1,500	2,000	1,650	1,800	1,500	1,800	1,350	1,800
Actual Head	(m)	11 m							
Total Head	(m)	15 m							
Pump Efficiency	(%)	85	85.5	85	85.5	85	85.5	85	85.5
Motor Power	(kw)	1,010	1,590	1,210	1,500	970	1,500	820	1,500
Pump Nos. including stand-by unit		4	4	5	3	6	3	7	3
Total Motor Power	(kw)	7,800		7,840		7,850		7,920	
						Adopted			

Table 3.6-8 Cost of Alternative Study on Balouza Pumping Station

(Unit: 1000LE)

	Case 1		Case 2		Case 3		Case 4	
I. *Facilities*	*ϕ1500x4*	*ϕ2000x4*	*ϕ1650x5*	*ϕ1800x3*	*ϕ1500x6*	*ϕ1800x3*	*ϕ1350x7*	*ϕ1800x3*
1. Mixed Flow Pump (cu.m/s.)	2,430 (300)	4,770 (480)	3,910 (360)	2,870 (450)	3,480 (288)	2,870 (450)	3,720 (240)	2,870 (450)
2. Motor (kw-p)	2,220 (1010-14)	4,440 (1590-18)	3,940 (1210-16)	3,240 (1500-18)	3,240 (970-14)	3,240 (1500-18)	3,070 (820-14)	3,240 (1500-18)
3. Check Valve	1,290	3,150	2,040	1,840	1,920	1,830	1,640	1,840
4. Butterfly Valve	350	550	540	360	540	360	510	360
5. Pipe in Station	5,270		4,940		5,290		5,780	
6. Screen Equipment	3,630		3,590		3,780		3,970	
7. Bar Screen	420		370		405		470	
8. Electric Equipment	7,360		7,360		7,480		7,590	
9. Crane (ton)	880 (20)		640 (15)		670 (15)		700 (15)	
10. Auxialiary Equipment	150		150		150		150	
11. Cable & Earthing Material	1,750		1,750		1,900		1,990	
Total	38,660 (104)		37,540 (101)		37,155 (100)		37,900 (102)	
II. Civil Work	5,770		5,580		5,870		6,700	
Total	44,430		43,120		43,035		44,600	
III. Running Cost /year	1,480		1,487		1,489		1,502	

Each case is combined with a different capacity of pumps due to the stable adaptability to the discharge variation and is also equipped with a stand-by unit for the respective pump capacity.

Consequently, Case-3 equipped with 6 units of 1,500 mm pumps and 3 units of 1,800 mm pumps has an economic advantage for the total pumping equipment and civil works (Table 3.6-8). Thus, the plan of Case-3 was selected.

3.6.7. Branch Canals

The capacity and location of ten branch irrigation canals are designed.

- To provide a branch canal, secondary canals, tertiary canals and farm ditches for distribution of irrigation water in the clay flats at the north of Balouza where surface irrigation will be applied.

- To provide branch canals and pipelines for distributing the irrigation water in the flat and undulating sand terrains where sprinkler or drip irrigation will be used. Because the construction cost of canal per unit length will become high, it is more economical to avoid the dense branch canal but to enlarge the command area of one booster pump. The branch canals will be provided to make the pipeline length with 3 km. The branch canal will be constructed in parallel with the contour lines to save the construction cost.

- To store the conveyed water, imbalanced between the El Salam Canal conveyance and the field usage, in branch irrigation canals located in sandy area.

- To alter the branch canal dimensions for the Rabaa/Qatia branch canal at the point diverted to the Hod Abu Samara area, 5.0 km from the intake at the El Salam Canal.

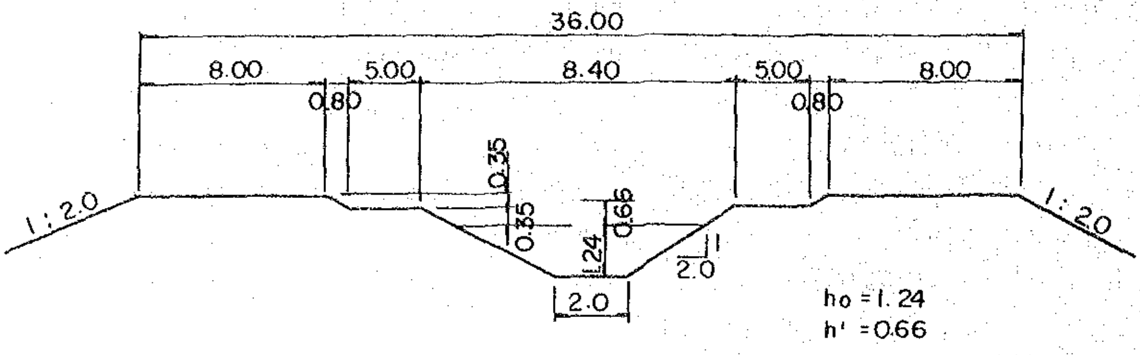
- To construct the canal bed slope : 1/8,000

- To adopt a side slope gradient : 1 : 1.5 (with lining)

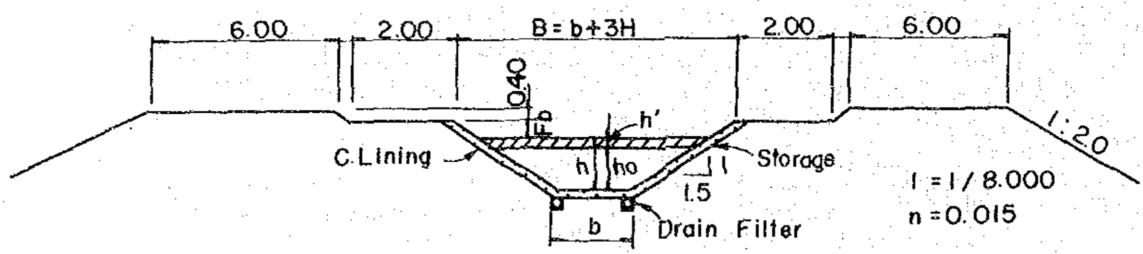
The dimension of the cross section for branch canals are shown in Figure 3.6-10.

Figure 3.6-10 Typical Cross Section of Branch Canal

Balouza Branch Canal



Other Branch Canal



Name of Branch Canal	Discharge Q (cu.m)	Length L (km)	Dimension b (m)	ho (m)	h' (m)	h (m)	F.b (m)	H (m)	B (m)
Rumana North	1.71	7.0	2.00	1.00	0.85	1.85	0.50	2.35	9.05
Rumana South	1.03	5.0	1.70	0.75	0.85	1.60	0.50	2.10	8.00
6 October	1.14	6.5	1.50	0.75	0.65	1.40	0.50	1.90	7.20
Rabaa / Qatia (I)	8.79	5.3	3.00	1.85	0.60	2.45	0.50	2.95	11.85
(II)	4.41	17.0	2.00	1.30	0.60	1.90	0.50	2.40	9.20
Rabaa North	1.17	6.0	1.70	0.80	0.80	1.60	0.50	2.10	8.00
El Tina	1.67	6.0	2.00	0.90	0.90	1.80	0.50	2.30	8.90
El Haswa	0.44	2.0	1.60	0.50	1.10	1.60	0.50	2.10	7.90
El Nasr	1.06	7.5	1.50	0.80	0.65	1.45	0.50	1.95	7.35
Nigila	3.14	12.1	2.00	1.30	0.60	1.90	0.50	2.40	9.20

3.6.8. Remote Control System

For the efficient and stable operation of the El Salam Canal, it is recommended to install a remote control system to regulate the canal water flow at the siphon, pumping stations and diversions.

The concentrated control center is planned to be located along the El Salam Canal at Balouza. The concept of system are shown in Figure 3.6-11 and the installed devices are shown in APPENDIX-K.

Figure 3.6-11 Control System of Irrigation and Drainage Canals