7.2.3 Hydrology

1) Priority Development Area

a) Rainfall

The rainfall gauging station that may represent the Project Area is Alexandria (Nohza, No.318). A review of 20 years of data (1973-94) reveals that the amounts of maximum annual, monthly and daily rainfall are 405 mm(1991), 167 mm (1991) and 54.3 mm (1974) respectively. The average annual rainfall is 200 mm. A probability analysis for rainfall is performed and presented below;

Probability of Rainfall

(unit : mm)

Return Period	Daily Maximum	2-Days Consecutive	3-Days Consecutive	Annual
2	27.0	34.0	38.0	179.5
5	35.0	49.0	54.0	253.0
7	37.0	54.0	59.0	277.7
10	39.0	59.0	65.0	303.4
15	41.0	65.0	71.0	332.0
20	42.0	68.0	75.0	352.5
25	43.0	72.0	79.0	368.4
40	45.0	79.0	86.0	402.0

b) Drainage Discharge

The main hydrological features surrounding the Project Area are the Nubariya canal which flows along the northwestern side, Omoum main drain along the northeast and the Mariut Lake in the north. Following the irrigation, the excess water from the field is collected by a drainage network system and carried to the Hares main drain. Finally through the Hares pumping station water is pumped into the Omoum main drain/Mariut Lake. Monthly average discharge of the Hares pumping station is as follows;

Monthly Average Drainage Discharge (1991-94)

(unit : MCM)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
49	39	41	43	48	46	50	57	60	60	55	52	600

c) Reuse of Drainage Water

During the field survey it was observed that water of Omoum main drain is being reused in the area. The estimated daily average amount is 0.26 MCM.

2) Priority Development Project

a) Current Conditions of Mariut Lake

The main hydrological elements that are related to the Priority Development Project are Omoum main drain, Nubariya canal and the Mariut Lake with a total water surface area of 13,000 feddan (5,460 ha). Originally, Omoum main drain used to carry drainage discharge from seven upstream drainage blocks to the El-Max pumping station and through this station water is discharged into the Mediterranean Sea. The average annual discharge from the El-Max pumping station is about 2,440 MCM.

Recently, to conserve the deteriorating water quality and to maintain a reasonable water level of the Lake, local fishermen have cut the embankments of Omoum main drain and Nubariya canal. Due to these cuts, Mariut Lake is playing a role as a large reservoir. On the other hand, these activities have increased the design water level of Omoum main drain, adversely affecting the upstream drainage. Presently suction water level at the El-Max pumping station is maintained between (-)2.70 and (-)2.80 m.MSL.

b) Inflow to the El-Max Pumping Station

The inflow sources for the El-Max pumping station may be broadly classified into three, i.e., Omoum main drain, Nubariya canal and Mariut Lake. Mariut Lake receives sewage water from Alexandria city and rainfall runoff from its surroundings, and Nubariya canal receives sewage water from Ameriya city, Nubariya drain escape water, navigation lock water etc. For the year 1994, the amount of inflow and outflow of the El-Max pumping station could be summarized as follows;

Inflow and Outflow of El-Max Pumping Station (1994)

(Unit: MCM)

Month	Inflow	Outflow	Month	Inflow	Outflow
Jan.	211	231	Jul.	215	210
Feb.	135	156	Aug.	216	200
Mar.	202	212	Sep.	236	242
Apr.	201	214	Oct.	219	233
May	198	216	Nov.	281	246
Jun.	172	164	Dec.	215	245
			Total	2,501	2,569

Note: Assuming 80 percent of recorded discharge of upstream blocks

According to the collected information, in December 1991 and November 1994, the water level of Mariut Lake went up to a dangerous level due to heavy rainfall in the area and a shortage of pump capacity at the El-Max pumping station.

3) Water Level

The design suction water level of the El-Max pumping station is (-)3.25 m.MSL, but at present it is maintained between (-)2.70 and (-)2.80 m.MSL. The data reveals that in December 1991 water level increased to a level of (-)1.86 m.MSL. The present water level of Omoum main drain has an adverse effect on the drainage from upstream blocks.

The Study Team installed one automatic water level recorder at Mariut Lake (upstream of Nubariya siphon) and another upstream of Omoum main drain (delivery side of Abu Hommos pumping station) in order to know the fluctuations of water levels. The analysis of the collected data shows that the Mariut Lake water level fluctuates within a range of 30~40 cm. These fluctuations are related to the inflow of drainage of excess water and rainfall (refer to Figure B-2-5 and B-2-6, Annex B).

4) Reuse of Drainage Water

At present, reuse of drainage water is taking place at a variety of locations in the area. But there is a large-scale future plan for using Omoum main drain water, the called "Omoum Drain Project". According to this plan about 1,000 MCM of Omoum drain-water will be reused annually in the development of West Nubariya desert area, and this water will come from the three upstream blocks, namely, Abu Hommos, Shereshera and Truga.

In the table below the monthly amount of reuse water (planned) and available water from the three blocks during a normal year (1985) is shown. As can be seen from the table that in the month of October available water is less than the planned amount. Therefore, it is very important to formulate a plan which not only takeing into account the water quality but also the amount actually available.

Amounts of Reuse and Available Water (Normal Year, 1985)

Month	Planned Reuse Water /1	Available Amount /2	Month	Planned Reuse Water	Available Amount
	(MCM)	(MCM)		(MCM)	(MCM)
Jan.	44	100	Jul.	85	224
Feb.	33	101	Aug.	111	204
Mar.	92	98	Sep.	125	128
Apr.	91	108	Oct.	127	77
May	79	117	Nov.	57	99
Jun.	92	136	Dec.	62	136
			Total	996	1,528

Note; /1: Derived from Omoum Drain Project
/2: Estimated design discharge

7.2.4 Soils and Land Classification

1) Soils

a) Objectives and Methods of Soil Survey

The soil survey was carried out during the field survey during the Phase II Study to obtain sufficient information on the possible crop production development in relation to the drainage project. However, because of the short duration of the survey, the soil survey has a limited number of soil samples, where one sample site for auger boring was distributed in 125 ha. But a comprehensive survey was done for only 24 soil pits. As for the detailed design study, it may require a more detailed soil survey. The soil survey is composed of the following items. (refer to Figure C-2-2, Annex C);

- Soil profile investigation
- Soil physical and chemical analysis
  (applying the method in the "Soils Bulletins No.10, FAO")
- Land classification

b) Geomorphological Division

The climate of the Project Area is characterized by its hot and dry summers with temperate and fairly wet winters according to the climatic divisions in Egypt. About 67percent of the Project Area has an elevation below mean sea level (MSL), comprised of two categories of land, the lacustrine deposits and a part of transitional land from the lacustrine deposits to the Pleistocene marine deposits. There is very flat and low-lying land with an elevation of (-)2.5 m.MSL in the category of land. The remaining 37 percent of the Project Area is covered by Pleistocene marine deposits and also partially by the remaining transitional land, which has a slope from 1/300 to 1/1,000(refer to Table C-2-2 and Figure C-2-3, Annex C).

c) Soil Classification

In the soil survey, soils in the Project Area are classified in accordance with the USDA Soil Taxonomy, which is applied to the "Soil Map of Egypt, prepared by the Academy of Scientific Research and Technology in 1986". The units of soil classification (soil orders and great group) with the area coverage in the soil survey are as follows;

Unit of Soil Classification

Soil Unit	Area Coverage		
(Order/Great Group)	(ha)	(feddan)	(%)
Entisol	8,450	(20,130)	31.8
Fluvaquents	2,060	(4,900)	7.7
Torrifluvents	7,610	(18,120)	28.6
Torriorthids			
Aridsols	3,550	(8,450)	13.3
Gypsiorthids	2,940	(7,000)	11.1
Salorthids	1,990	(4,740)	7.5
Calciorthids	26,600	(63,330)	100.0

Three units of Calciorthids, Gypsiorthids, and Torriorthids could be found on the elevated land, namely Pleistocene marine deposits and the transitional land between Pleistocene marine deposits and lacustrine deposits. Most of the soil units have rather a deep groundwater table, more than 80 cm below the ground surface. The soil texture of sandy to clayey soils varies from one point to another. The soils of the other three soil units are of lacustrine deposits with elevations below the mean sea level. The groundwater table is as shallow as 80 cm to 50 cm below ground surface. The soil texture of these soils also varies from sandy clayey to clayey soils. Particularly, the soils in land with elevation below (-) 2.5 m.MSL have shell layers of about 20 cm depth (see Table C-2-3 and Figure C-2-4, Annex C).

d) Soil Salinity and Alkalinity

According to the "US Salinity Laboratory's Classification", soils in the Project Area are characterized by their saline and alkaline soils as shown below;

Soil Salinity and Alkalinity Classification

Item	ECe	ESP	pH	Area	Great Group
	(mS/cm)	(%)		(%)	
1. None Saline-None Alkaline	<4	<15	<8.5	20.3	Torriorhids (partial)
2. Saline	>4	<15	<8.5	-	
3. Alkaline	<4	>15	>8.5	-	
4. Saline-Alkaline	>4	>15	>8.5	79.7	Other groups
Total				100.0	

The soil salinity in terms of ECe range from 4 mS/cm to 8 mS/cm, covering about 72.2 percent of the Project Area according to the results of the soil survey. In 11.0 percent of the Project Area out of the said Area, the soil salt content is as high as 30 mS/cm at the maximum, where the elevation is the lowest with very poor drainage conditions. (refer to Table C-2-5 and C-2-6, Annex C).

The result of the soil survey reveals that almost all the soils contain very high amounts of exchangeable sodium and magnesium with high values of Sodium Absorption Ratio (SAR) as well as Exchangeable Magnesium Rate

(EMR). Soil alkalinity causes severe soil permeability problems as well as the toxicity problems of sodium and magnesium. High exchangeable sodium induces the dispersion of clay fractions. Thereby, the soil structure is degraded and soil permeability is considerably reduced.

2) Land Classification

a) Land Classification

The land in the Project Area is classified into five classes on the basis of irrigation suitability criteria in nine items inclusive of groundwater table and soil salinity. Major criteria in the soil classification are groundwater table and soil salinity, and which are indicated together with the area coverage by soil class in the following;

Land Classification

Class	Groundwater Table	Soil Salinity	Area Coverage
	(cm)	(ECe mS/cm)	(%)
1	> 100	< 4	27.8
2	80 - 100	4 - 8	30.5
3	50 - 80	8 - 16	30.7
4	25 - 50	16 - 30	11.0
5	< 25	> 30	-
Total			100.0

The first, second and third class land amounts are 27.8, 30.5, and 30.7 percent of the Project Area respectively . The remaining area, 11.0 percent of the Area is covered by fourth class land, which is mostly covered by cultivable waste-land or fishponds. This land was severely flooded in December 1991 for a long period, where the drainage improvements to lower groundwater table are urgently required (refer to Table C-2-6 and Figure C-2-5, Annex C).

b) Soil Improvement

It is necessary to apply gypsum to amend the soils containing high amounts of exchangeable sodium and magnesium. The required soil improvement works are as follows;

Application of Gypsum

The gypsum requirement is estimated based on the SAR value, and 2 to 13 tons/ha of gypsum are required to improve the soils, depending on the soil types. Taking into account a probable limit of gypsum application of 4.8 ton/ha per year, the required period of gypsum application will be three to five years (refer to Annex I).

Subsoiling

Subsoiling with the depth at 40 cm is also required besides the gypsum application, and it is incorporated with the proposed land improvement plan.

These soil improvement works have been undertaken by Executive Authority for Land Improvement Project (EALIP) under the MOALR.

7.3 Present Irrigation and Drainage Conditions

7.3.1 Irrigation Water Supply and Its Use

Irrigation water for the Project Area is supplied through the Nubariya canal. The irrigated areas of the Nubariya canal are spread from the western part of the Nile Delta to the West Nubariya New Reclamation Land, and the Project Area is located at the extreme end of the right side of the canal.

Irrigation water for the Project Area is taken through the canals of Hares No.1 to Hares No.4, Hares EL Omoumy, EL-Moshtarak, EL-Hager Extension canals and six direct intake works from the Nubariya canal. On the other hand, there are two canals that run across the center of the Project Area. One is the Tameer Sahary canal which draws reuse water from the Omoum main drain and diverts it to the Nubariya canal and the other is EL-Hager Feeding canal which conveys irrigation water to the EL-Hager Extension canal.

The cultivable area in the Project Area is 53,920 feddan (22,650 ha) and the present irrigated area is 47,190 feddan (19,820 ha), 88 percent of the cultivable area (refer to Table 7-1.).

Irrigation Area in Project Area

Area	Cultivable Area		Present Irrigated Area	Rate
	(ha)	(feddan)	(feddan)	(%)
El-Hager Extension	6,230	14830	11,260	76
Nahda	9,300	22,140	21,350	96
El-Moshtarak	7,120	16,950	14,580	86
Total	22,650	53,920	47,190	88

2) Irrigation Water Supply

The areas served by the Nubariya canal are on a rotation of 5-days irrigation and 10-days pause, and irrigation water supply for all branches is distributed by the following rotation rules of "A","B" and "C".

Irrigation Rotation

Irrigation Ration		Area		Rate
First 5-days	Rule-A	5,690 ha	(13,550 feddan)	29%
Second 5-days	Rule-B	6,440	(15,330 feddan)	32%
Third 5-days	Rule-C	7,690	(18,310 feddan)	39%
Total		19,820	(47,190 feddan)	100%

All irrigation canals are operated/maintained by the related engineers of the Nubariya Irrigation Directorate and basically controlled at the proposed water level. However, it is difficult to grasp actual intake discharges in the Area. The gate operations are standardized and can not reduce any excess intake discharge in the upper areas. This situation causes water shortage and contributes to the poor drainage conditions in the lower area.

3) Water Balance and Intake Pattern

The present annual water requirement and the actual water intake for the Project Area are calculated at 586 MCM and 408 MCM, respectively, and the scale of water shortage is about 30 percent. The annual designed intake of water is 497 MCM, which is almost equal to the annual intake water.

Table 7-1 Irrigation Blocks in Project Area

Irrigation Area	Block Area (ha)	Irrigable Area (ha)	Irrigated Area (ha)	Irrigated Area (fed)	Irrigation Rotation Rule A	Irrigation Rotation Rule B	Irrigation Rotation Rule C
from Nubariya Canal							
Hares Canal No.1	4,430	3,800	3,630	8,640	○	○	
Hares Canal No.2	1,770	1,500	1,450	3,450		○	
Hares Canal No.3	2,790	2,360	2,290	5,450			○
Hares Canal No.4	1,950	1,640	1,600	3,810	○		
Hares El-Omoumy Canal	1,820	1,550	1,330	3,170		○	
El Moshtarak Canal	2,940	2,500	2,150	5,120	○	○	
El Hager Feeding Canal							
Sub-total	15,700	13,350	12,450	29,640			
Direct Intake from Nubariya Canal							
Sadnauy	1,040	880	760	1,810	○		
Hammad	600	510	440	1,050	○		
Abu El-Wafa	520	440	380	900		○	
Abu El-Kader	540	460	390	930		○	○
Moh. El Serafy	520	440	380	900			○
Karam	400	340	290	700			
Sub-total	3,620	3,070	2,640	6,290			
from El-Hager Extension Canal							
Left Branch No.1	1,090	1,050	710	1,690			○
Left Branch No.2	1,270	1,060	820	1,950			○
Left Branch No.3	950	790	620	1,480			○
Right Branch No.1	1,150	960	750	1,780			○
Right Branch No.2	1,400	1,170	910	2,170			○
Right Branch No.3	1,420	1,200	920	2,190			○
Sub-total	7,280	6,230	4,730	11,260			○
Total	26,600	22,650	19,820	47,180			○

Note; All figures in this table are modified with planimeter measurement by the Study Team on the basis of the data given by Nubariya Irrigation Directorate.

Table 7-2 Drainage Blocks in Project Area

Drainage Area	Gross Area (ha)	Gross Area (fed)	Irrigable Area (ha)	Irrigable Area (fed)	Area with Subsurface Tile Drain (ha)	Area with Subsurface Tile Drain (%)
1.Omoum Left-1	1,550	3,690	1,320	3,140	0	0.0
2. Omoum Left-2	1,780	4,240	1,550	3,690	0	0.0
3. Hares Area-1	2,070	4,930	1,760	4,190	0	0.0
4. Hares Area-2	1,880	4,480	1,600	3,810	0	0.0
5. El Saaida Area-1	3,000	7,140	2,550	6,070	0	0.0
6. El Saaida Area-2	1,980	4,710	1,680	4,000	0	0.0
7. Hares Area-3	2,970	7,070	2,520	6,010	0	0.0
8. Hares Area-4	2,500	5,950	2,130	5,060	210	0.9
9. Hares Area-5	2,120	5,050	1,800	4,290	0	0.0
10. Hares Area-6	2,590	6,170	2,200	5,240	0	0.0
11. Hares Area-7	760	1,810	650	1,540	0	0.0
12. Abdel hadi-1	2,300	5,470	1,950	4,650	0	0.0
13. Abdel hadi-2	1,100	2,620	940	2,230	0	0.0
Total	26,600	63,330	22,650	53,920	210	0.9

Source; Nubariya Drainage Directorate

However, the monthly designed intake water from March to October is constant and does not meet the water requirement pattern in the same period. Namely, the monthly peak water requirement in July and August is about 100 MCM, whereas the actual intake water that is controlled by the designed intake water pattern is about 50 MCM. In this situation, the water shortage in summer season become a serious problem in the Area. Accordingly the designed intake water should be planned on the basis of water requirement pattern (refer to Figure D-3-1, Annex D).

7.3.2 Drainage Systems and Conditions

1) Present Drainage Systems

The Project Area is divided into 13 drainage areas. Eleven are located in the area of the Hares main drain and other two are on the left of the Omoum drain. These two main drains join each other at the downstream end and the drain-water is lifted to the Omoum main drain by the Hares pumping station. At the extreme downstream portion of the Omoum main drain, the EL-Max pumping station drains all discharge, including an other six pumping stations, to the Mediterranean Sea. Table 7-2 shows the drainage areas by drainage systems.

An annual discharge from the Hares pumping station for the years, 1991-1994, is about 600 MCM as shown in the following table. These discharge records are calculated by DRI using pump capacity and the running hours of the pumps. Since in the case of the Hares pumping station, which has worn out facilities, it can be considered to modify its data. The reduction rate of the Hares pumping station is calculated to be 20 percent according to an actual discharge measurement in August 1994. Therefore, present pump capacity of Hares pumping station corresponds to 80 percent of its designed capacity.

Discharge Records of Hares Pumping Station

Year	Drainage Area	Drainage Discharge	
	(ha)	(MCM)	(mm.day)
1991	26,600	573.8	5.9
1992	26,600	595.9	6.1
1993	26,600	608.6	6.2
1994	26,600	623.4	6.4
Mean		600.4	6.2

Source: Drainage Research Institute (DRI)

2) Flood Damages

Regarding flood damage caused by the December 1991 flood, verbal information at fields was collected from the farmers in the Project Area. According to their information, it was found that the lower parts of the Project Area suffered from a large-scale inundation and resulting damage. The inundation period was lasted for one to two weeks and the maximum water depth was over 50 cm on the fields. The maximum suction water level of the Hares pumping station was observed at (-)2.90 m.MSL. The maximum water depth on the fields could be estimated at 0.5 m using the flood water slope.

On the other hand, the inundation period was analyzed at 11 days through hydrological study. These estimated results are similar to the farmers' information. As a results, inundation area is estimated at about 30 percent of the Project Area (refer to Figure 3-9).

Drainage capacity in the Project Area is 8 mm/day for the Hares pump, 8 mm/day for Hares main drain, 4 mm/day for collector drains, and 1.5 mm/day for lateral drains, respectively. Under the situation of drainage capacity, frequent observation of daily rainfall more than 10 mm/day during the winter season causes periodical drainage problems in the season. These facts lead to the potential problem of inundation damages in the low-lying areas below mean sea level.

3) Subsurface Tile Drains

Subsurface tile drains are only implemented in the Hares Pilot Area of 500 feddan (210 ha) in the Project Area. At present EPADP has finished the design of tile drain in the Omoum Left No.1, No.2 and the Hares No.1 and No.2 areas, as shown below;

Tile Drain Area Designed in Hares Area

Area	Tile Drain Designed Area		Lateral Spacing
	(ha)	(feddan)	(m)
Omoum Left No.1	940	2,240	75
Omoum Left No.2	1,850	4,400	71
Hares No.1	1,550	3,700	77
Hares No.2	1,890	4,500	79
Total	6,230	14,840	75 (mean)

These areas correspond to 23 percent of the Project Area. According to the data, the designed average spacing of laterals is 75 m, considering the soil texture of sandy silt or loamy in the area. This spacing seems to be inadequate from the viewpoint of effective functioning of subsurface tile drain. Additionally, EPADP is discussing with DRI about problems of collector joint and procedures of construction works. The implementation of a subsurface tile drain in the Project Area is to be started in 1995.

7.3.3 Reuse Plan of Drainage Water

Since the Project Area is located at the tail end of the Nubariya canal, there is a general shortage of irrigation water. In the Project Area there are many drainage reuse systems from the drainage ditches using small portable pumps. Through the results of the present water balance in the Project Area, these reuse volumes are estimated at 83 MCM per annum on average.

And also, the left side areas of the EL-Hager Extension canal, which is surrounded by the Hares main drain, the Omoum main drain and EL Sahery canal, periodically suffer from serious water shortages. Therefore, many farmers in this area are taking the drain water from the lateral drains through numerous pipes (diameter of 200 to 1,000 mm) and using it for irrigation after mixing it with freshwater from EL-Hager Extension canal. This reuse water volume is estimated at 95 MCM per annum on an average. These reuse amounts total 178 MCM per annum and the reuse rate to the water requirement is calculated at 30 percent (refer to Figure D-3-1, Annex D).

7.4 Present Agriculture

7.4.1 Land-Use

The Project Area is divided into the following three drainage areas, and the present land-use in the areas is shown below;

Present Land-Use

Items	Drainage Area				
	El-Hager Extension	Nahda	El Moshtarak	Total	
	(ha)	(ha)	(ha)	(ha)	(%)
Cultivable Land					
- Actual Cultivated	4,730	8,970	6,120	19,820	74.5
- Cultivable Waste	1,500	330	1,000	2,830	10.6
Sub-total	6,230	9,300	7,120	22,650	85.1
Non-Farmland	1,050	1,640	1,260	3,950	14.9
Grand Total	7,280	10,940	8,380	26,600	100.0

The rate of cultivated area to the total cultivable area (cultivated area exclusive of temporary fallow area/the total cultivable area) is estimated at 88 percent. The remaining 12 percent of the total cultivable area is left as cultivable waste mainly due to the high level of groundwater table and soil salt content. The cultivable waste is located in the downstream areas of El-Hager Extension and the Moshtarak areas, which are situated below mean sea level. This land is classified into fourth class land and has not yet been cultivated because of the marginal returns.

Aside from the said cultivable waste-land, 31 percent of the Project Area are classified into third class land according to the criteria including the content of exchangeable sodium and magnesium. The farm management is rather unstable due to narrow soil suitability to crops with low land productivity.

7.4.2 Population, Farm Household and Farm Labor Force

The total population in the Project Area as of 1993 is estimated at about 95 thousand with a population density of 360/sq.m. This density is less than the average density in the Study Area as well as in Behera Governorate. The total number of farm households, landless farm laborer households as well as non-farm households in the Area are indicated as follows (refer to Table F-2-1 and F-2-2, Annex F);

- Total population	:	95,840
- Total households	:	16,900
- Total farm households	:	11,100
- Total land owners	:	9,590
- Total landless farm labor households	:	1,080
- Total non-farm households	:	4,720

Source; Agricultural Statistic Zone Office in Behera and Alexandria.

Note: Non-farm households = Households - (Farm households + Farm laborer household)

7.4.3 Land Ownership and Typical Farm Management

1) Land Ownership

Generally, there exist only owner-farm households in the Project Area excluding the Moshtarak area, because the Area is newly reclaimed and has been distributed to the settled farmers. Then the number of owner-farm households in the Area amount to 91 percent of the total farm households. There are no landless farm laborer households outside the Moshtarak area.

The holding sizes by landownership type in the Project Area are estimated as follows;

Landownership Type and Average Holding Size

Type of Farmer	Number of Household	Average Land Holding Size	
		(ha)	(feddan)
Farm Household	11,100 (100%)	1.8	4.2
Owner	9,590 (86)		
Tenant	1,510 (14)		

Source: Agricultural Statistics Zone Office, Behera
For the further detail, refer to Table F-2-2, Annex F.

The above farmland holding size in the Project Area is 1.4 times of the Study Area (refer to Table F-2-2, Annex F). On the other hand, the data on distribution of the owner-farm households by size in the Area show that the average farm size is 5.4 feddan (2.3 ha), where about 46 percent of the owner-farmers have a farm size of more than five feddan.

2) Typical Farm Management

Farm management scale of the typical owner-farm household is estimated as shown below, based on the above mentioned average farm size of 4.2 feddan (1.8 ha);

Typical Farm Management Scale

Items	Area	
	(ha)	(feddan)
Cultivated Area (owned land)	1.8	4.2
Crop and Cropped Area		
(1) Winter Crops		
- Berseem	0.7	1.7
- Wheat	0.6	1.4
- Beans	0.2	0.5
- Vegetables	0.2	0.5
Sub-total	1.7	4.1
(2) Summer Crops		
- Vegetables	0.7	1.7
- Maize	0.6	1.4
- Cotton	0.3	0.7
- Sunflower	0.1	0.2
Sub-total	1.7	4.1
Total	3.4	8.2

The farm operation of land preparation and threshing of wheat and rice is mechanized throughout whole Project Area. Use of portable pumps for pumping-up irrigation water instead of Sakhiya operation has become popular among the farmers. Moreover, mechanized sprayers are used together with hand sprayers. There are many fields, where the standing crops are contaminated with irregular type plants because most seeds are supplied from the producer by local farmers.

Comparatively heavy chemical fertilizer dosage for nitrogen and phosphate seems to be common in the cultivation of cotton, where the nitrogen application is as heavy as 190 kg/ha. On the other hand, about 150 kg of nitrogen are used for wheat, maize and vegetables. The input of farm material inputs, manpower and animal power per feddan is estimated as shown in Table F-2-10, Annex F.

7. 4. 4 Cropping Pattern and Crop Production

1) Cropping Pattern

The following two types of proposed cropping patterns are employed with cropping intensity of 97 and 98 percent of the total cultivated area for summer and winter seasons (refer to Figure 7-1).

- Three years rotation
  Beans - Maize - Berseem - Cotton - Vegetables - Sunflower
- Two years rotation
  Wheat - Maize - Berseem - Vegetables

The principal crops in the Project Area are wheat, berseem, beans and vegetables in the winter season, and vegetables, maize, cotton, and sunflower in the summer season.

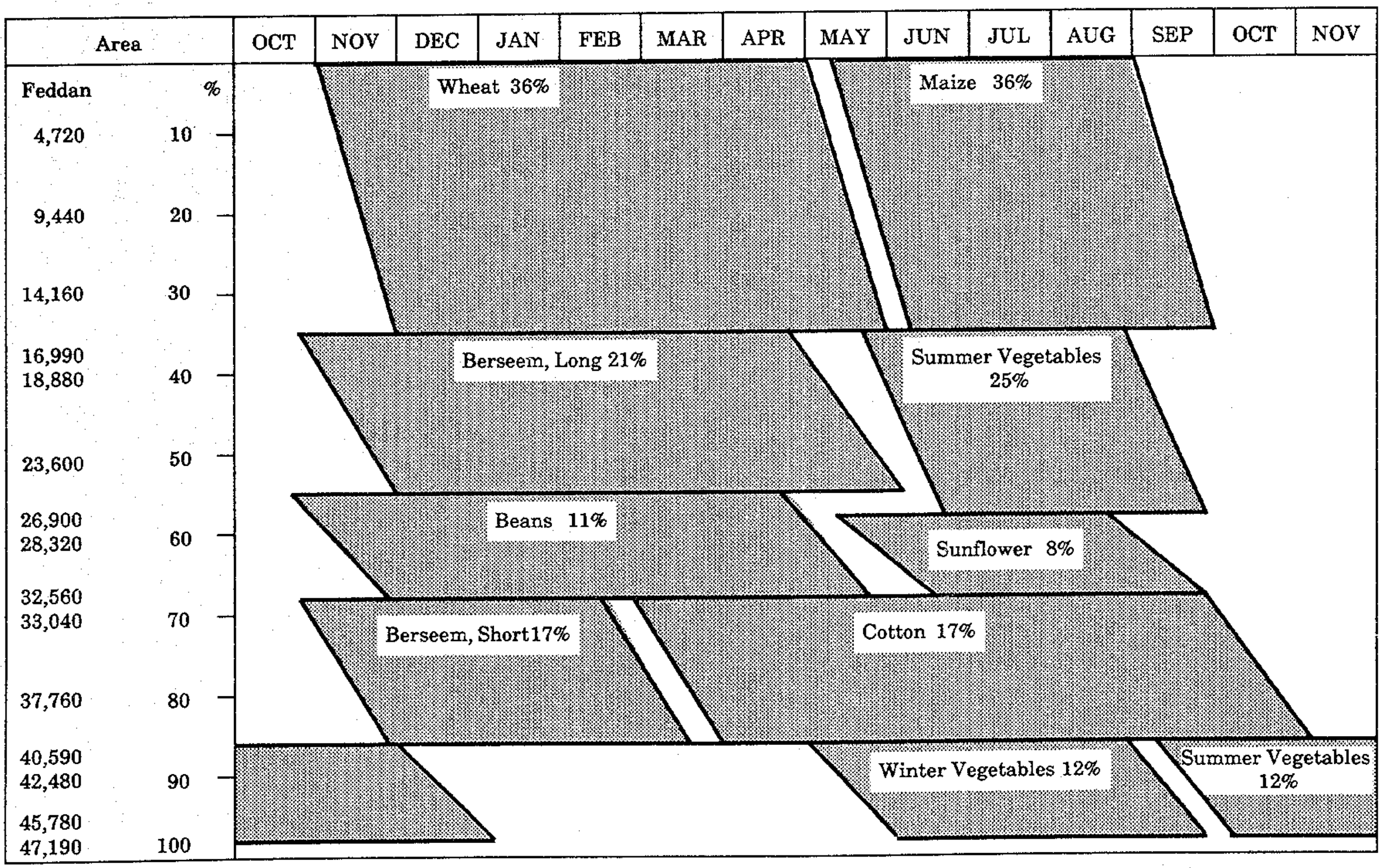
2) Crop Damage by Flood and Poor Drainage

Floods occurred in December 1991 completely ruining the farmland of 9,500 feddan (4,000 ha), and about 1.5 million LE was paid by the government as compensation for crop damages to the farmers. In the low-lying area below mean sea level, the crop damage from floods or poor drainage occurs almost every winter season. Agricultural activities as well as daily life are severely disturbed every winter and aggravated by poor transportation conditions.

3) Crop Production

According to the collected data from the Department of Agricultural Statistics, MALRF, inclusive of District and village-wise crop production data and also the data in study report on the Mohamodia Irrigation Improvement Project, the total crop production is estimated as shown below (refer to Table F-2-6, Annex F).

FIGURE 7-1 PRESENT CROPPING PATTERN



Crop Production in Project Area

(unit: ton/ha)

Crops	Cropping Area	Cropped Yield	Unit	Production
	(%)	(ha)	(ton/ha)	(ton)
Cultivated Area = 19,820 ha	100			
Winter				
Wheat	36	7,140	4.42	31,559
Beans	11	2,180	1.99	4,338
Berseem, Long	21	4,160	53.57	222,851
Berseem, Sort	17	3,370	23.57	79,431
Vegetables	12	2,380	19.05	45,339
Sub-total	97	19,230		385,518
Summer				
Cotton (raw)	17	3,370	2.63	8,863
Maize	36	7,140	4.97	35,489
Sunflower	8	1,590	1.79	2,846
Vegetables	37	7,330	28.57	209,418
Sub-total	98	19,430		256,613
Total	195	38,660		642,131

Source: MALRF(refer to Table F-2-9, Annex F)

The above yields for major crops in the Project Area are lower than the level for the whole of Egypt, Behera and Alexandria Governorate and Study Area. Following facts are observed regarding the relationship between crop production and drainage conditions;

- The low level of unit yields for major crops are obtained in the lower-stream of drainage areas, particularly in the El-Hager Extension area,
- The significantly poor standing crop features are found in the fourth class land.

7.4.5 Animal Husbandry

There are a limited numbers of farm households raising animals with the advantage of large vegetable market adjacent to the Project Area. About 60 percent of farm households employing crop husbandry also raise cattle and water buffaloes not only for draft but also for meat and milking purposes, as shown below. The cropping area with forage crops of berseem and corn amount to about 30 to 40 percent of the total cropped area in winter and summer seasons for feeding the animals. Besides these crops, both wheat and rice straw are also another important feed source.

Average Number of Livestock and Poultry per Farm Household

Livestock/Poultry	No. of Farm Households Raising Animals 1/	No. of Animal per Farm Household
	(%)	
Cattle	62.6	2.6
Buffaloes	55.1	2.1
Sheep	35.0	4.8
Goat	29.1	3.7
Donkey	65.1	1.1

Note: 1/ ; The percentage of farm households to total farm households with land in two Districts and a Square in the project.
Source ; Agricultural Census, 1989/90(refer to Table F-2-10, Annex F)

7. 4. 6 Marketing of Agricultural Products

Marketing is an important aspect of the cooperatives, assisting farmers to ship their products to the area, where demand exceeds supply. Most farmers sell their products to the nearest cooperatives and local markets. Products for export are organized by commercial traders. However, domestic products are not well organized in the Project Area due to the lack of institutional organization.

The legacy of the long-dominant state-controlled farm policy hinders implementation of marketing cooperatives in a free economy. Institutional setup and dissemination of marketing information among farmers will be prerequisites for future marketing.

International marketing deserves attention. Tomatoes, watermelons, potatoes and oranges are major export items from the Project Area to Europe and Middle Eastern countries through traders. A local cooperative could compete with to commercial traders, so that they should be well equipped with basic minimum equipment such as selectors, sorters, automated packing and labeling machines. Institutional arrangements with local shippers and international traders must be made available for efficient handling and marketing abroad.

7. 4. 7 Agricultural Supporting Services and Farmers' Organization

1) Agricultural Supporting Services

There are two agency channels providing agricultural supporting services, namely the Agriculture Offices at Governorate to District level, and the Control Offices for Cooperative and Development, the General Authority for Project and Development under the Ministry of Agriculture, Land Reclamation, and Fishery (MALRF). The agricultural supporting services are extended to the farmers through village agricultural cooperatives by both agencies.

The agricultural supporting services in the reclamation areas include supply of agricultural input materials with subsidized price and marketing of major crop products. Almost similar services are provided to the farmers by the Agriculture Office at the District level.

The above agricultural supporting services are not adequately rendered to the farmers where the following constraints have been identified;

- Adequate agricultural technology has not been developed and applied for the prevailing area suffered from high alkaline and saline content soils, poor drainage, and shortage of irrigation water,
- The activities of agricultural supporting services are hampered by poor transportation.
- The effective agricultural extension services which are properly linked with irrigation and drainage managements are not provided because no adequate training on this matter is available for the agricultural extension staff of Agriculture Offices.

2) Farmers' Organization

As described above, the general village agricultural cooperatives are organized in every village in the Moshtarak area, and ten agricultural cooperatives in the land reclamation areas are organized in the Project Area. However, no special typed cooperatives such as vegetable cooperative are organized in the Project Area.

Regarding the farmers' organization for operation and maintenance of irrigation and drainage facilities, no Water User' Association or Drainage Users' Association are organized in the Project Area by the Irrigation Department (ID) and EPADP. The farmers, on the other hand, hardly seem to promote the operation, maintenance, and development of the related facilities from their side, either.

7.4.8 Farm Household Economy

1) Farm Economic Conditions

Farm household income was estimated from the sample survey of 30 farm households, 1995. 15 farmers came from productive areas with good irrigation and drainage, while the remaining 15 farmers represented poor areas, where irrigation and drainage are deficient. The objective of the survey was to make sure whether there exist differences in family size, working conditions, income and expenditures, diffusion of farm machinery and equipment. Survey results are shown below and in Table 7-3.

- Farmers representing the poor areas had an average of 12.5 family members, substantially larger than the average household family size of 5.7 in the Project Area. This large figure includes not only direct nucleus family but also related / extended family member from the same family tree. Comparable figure of good area was 15.3.
- On the basis of household expenditures adjusted to family size of 5.7 household expenditures were LE.2,964 in poor area compared with LE.3,095 in the good area. Hares area household expenditures were lower than the national average of LE.3,351 for all rural areas.
- Income calculated from the farmers' survey was estimated on the basis of per capita income LE.560 in the poor area and LE.588 in the good area. It was found that adjusted family income of 5.7 family size was LE.3, 192 in the poor area and LE.3,351 in the good area.
- Carts are widely owned by farmers both in poor and good areas. However, there exist differences in machinery and equipment ownership between poor and good areas. Automobile transport, milling blowers, diesel pumps are owned in the good area, compared with limited ownership of tractors, sprayers and threshers.

- The average bank loan was LE.880 in the poor areas compared with LE.395 in the good area.
- The most pressing needs for the area's improvement include ways to alleviate the water shortage, drainage and communication facilities.

Table 7-3 Summary of Household Survey of 30 Farmers in Project Area

		Poor Area			Good Area		
Items	Unit	Ave.	Max.	Mini.	Ave.	Max.	Mini.
Average Household (6.7 person/household)							
Bank Loan	LE	880	6,500	200	395	1,000	300
Food	LE (%)	4,626	(72.0%)		5,446	(65.6%)	
Non food	LE (%)	1,874	(28.0%)		2,869	(34.4%)	
Total Expense	LE (%)	6,500	(100.0%)		8,315	(100.0%)	
Per Capita Expense		520			543		
Per Capita Income		560			588		
Adjusted Household (5.7 person/household)							
Income	LE	3,192	(=5.7×560)		3,351	(=5.7×588)	
Expenses	LE	2,964	(=5.7×520)		3,095	(=5.7×543)	
National Rural Average Adjusted to 1995 Level							
Income	LE	3,850					
Expenses	LE	3,580					
Major Problems (1=most important, 2=next, 3=third)							
Response Share in Percent							
Ranking	Response	Share			Ranking	Response	Share
1=Water	1=100%	3=40%			1= Water	1 = 73%	2=27%
2= Drain	2=60%	2=40%			2= Drain	2= 47%	1=40%
3=Comm.	3=60%				3= Comm.	3= 100%	
Water=Water shortage, Drain= Drainage, Comm=Communication facilities							

Survey conducted in February, 1995
Poor Area = Hares, M. Amer & Ycenyah villages
Good Area = Tieb, Wastanya & Komelfarage village
National Income and Expenditures Survey 1990/91, Cairo
Adjusted to 10 percent increase of income and expenditures between 1990 and 1995.

2) Affordability and Drainage Improvement Costs

Drainage improvement costs include initial investment costs of drainage improvement works. Tile drainage costs of LE.600 per feddan will be expected to be borne by farmers with loans of 20 years without interest. The EPADP in Cairo has surveyed farmer's ability to repay loan within 20 years regarding tile drainage installation. It has been found that over two thirds of farmers can afford to pay back the loan for tile drainage installation without interest. With eight percent interest on the loan for tile drainage, this ability was drastically reduced to one third. To be specific, 71 percent of farmers surveyed could afford to pay back the annual loan of LE.51 for 20 years should there be no interest charge. On the other hand, only 35 percent of farmers could afford to pay back LE.153 should interest be charged at eight percent per annum. Operation and maintenance costs would be borne by the farmers.

3) Benefits from Drainage Improvement

National drainage project evaluated the effect of tile drainage upon crop yield increase. Three areas, i.e., West Delta, Central Delta, and East Delta were selected to gather data. After installing tile drainage network, crop yield data has been collected for six years from each of the three areas. A summary of the results clearly indicates that an average increase of 20 percent higher yield has been obtained for wheat, cotton, rice, and maize.

7. 5 Drainage Facilities

7. 5. 1 Drains and Roads

1) Hares Main Drain

Hares main drain flows through the middle of the Project Area from southeast to northwest. While traverses, it crosses El-Hager canal and Khalt drain, and ends at the Hares pumping station. The total length is about 24 km.

This is an unlined drain. The width varies from 2 m to 18 m with a side slope of 3 : 2. The longitudinal slope varies from 10 to 25 cm/km (1/10,000 to 1/40,000).

The existing conditions of this drain can be outlined as follows;

- There are many places where side slopes have been damaged which has contributed to deposition of sand,at the drain bottom, affecting the flow capacity.

- The survey results indicate that there are some parts where depth of deposition is one to two meters which have covered 50 percent of the design cross section.
- The design capacity of this drain was calculated on the basis of unit drainage discharge of 33 cu.m/feddan/day, considering the maximum as 26 cu.m/sec. The capacity has become insufficient due to the changed circumstances such as increased drainage discharge, and installation of subsurface tile drain system etc.
- At a distance of 18 km from Hares pumping station there are two siphons. The siphon at the inter-section of EL-Hager canal needs improvement/replacement to recover its capacity that has been lost due to siltation inside the siphon. The dimensions of these two siphons are given below;

Item	El-Hager Siphon	Khalt Siphon
Structure	Concrete Box	Steel Pipe
Cross Section	1.5 m×1.5 m×2 nos.	D=1,800 mm×3 nos
Length	57 m	63 m
Design Capacity	8.25 cu.m/sec	8.4 cu.m/sec
Year of Construction	1972	1993

2) Branch Drains

There are 17 branch drains connected to the Hares main drain. These branch drains have 25 sub-drains. Total length of the network is 113km. The bed widths of these drains ranges from one to four meters with a side slope of 3 : 2. The longitudinal slope is 10 - 40 cm/km(1/10,000 to 1/2,500).

The existing conditions of these drains are described below;

- With the main drain, branch drain beds are covered by a deposition of sand resulting from damaged side slopes.
- To substitute bridges, local people have put concrete pipes in the drain bed for crossing the drains. This has decreased the capacity of drains substantially and leads to inefficient drainage, especially during the winter season.
- The unit drainage discharge for these drains are also the same as the main drain i.e. 33 cu.m/feddan/day and suffers from a shortage of capacity. Density of drains may be estimated as 2.2 m/feddan. In other blocks the density ranges from 1.0 to 3.0 m/feddan, which means Project Area has an average density of 2.0 m/feddan.

3) Maintenance Roads

Although with few exceptions, maintenance roads are exist on only one side of the drains or canals, the conditions of these roads are very bad due to lack of maintenance. In the winter season the surface turns very muddy and access to the area becomes difficult. Also when routine maintenance works for drains and canals take place, excavated bed materials are deposited on the roads which create obstacles. On the other hand when rainfall occurs these materials are washed away and enter the drains/canals again.

7. 5. 2 On-farm Facilities and Subsurface Tile Drains

1) On-farm Facilities and Subsurface Tile Drain

The drainage from the fields takes place with the help of small drains, locally called 'Zaruk' constructed along the boarders of the fields with a pitch of 30 - 35 m. In general, the bed width is 0.5m.

In the Project Area, subsurface tile drains are not in use except in a Pilot project covering 500 feddan (210 ha). Therefore, groundwater level in this area is relatively high, which is about 0.2 - 1.2 m below the ground surface. This high groundwater level is causing salinity problems in the area.

2) Other Related Facilities

According to the collected information, the downstream area is suffering from a shortage of irrigation water. This happens due to the over-withdrawal (or withdrawal without concern for downstream farmers) using small pumps by the upstream farmers. To overcome the shortage of irrigation water in El-Hager Extension area, reuse of Omoum main drain water is taking place.

7. 5. 3 Drainage Pump Facilities

As a result of the Master Plan Study, the El-Max (1) pumping station is selected as a first priority development project in the overall Study Area, while the Hares pumping station is selected as a facility in the priority development area for emergency countermeasures. As mentioned in the Master Plan Study, both pumping stations have serious problems due to time-worn facilities, the shortage of pump capacity and the decreased pump capacity due to the old pump facility.

1) Outline of Existing Pump Facilities

The outline of the existing El-Max and Hares pump facilities are shown in Table 7-4:

Table 7 - 4 Outline of Existing El-Max and Hares Pump Facilities

Description	Unit	El-Max Pumping Station (1)	El-Max Pumping Station (2)	Hares Pumping Station
Design Dimensions				
Station Code No.		111101	111102	111302
Drainage Area	feddan	430,260		63,330
Drainage Discharge	cu.m/sec	62.5	62.5	24.0
Suction Water Level	m.MSL	(-)3.25	(-)3.25	(-)6.00
Delivery Water Level	m.MSL	(+)0.75	(+)0.75	(-)2.80
Main Pump				
Year Operation Started		Aug. 1963	Mar. 1983	Jun. 1968
No. of Pumps	unit	6	6	4
(Stand-by)	〃	(1)	(1)	(1)
Unit Discharge	cu.m/s/unit	12.5	12.5	8.0
Static Head	m	4.0	4.25	3.2
Type	-	Inclined Shaft Type Axial Flow Pump		
Revolution	rpm	160	190	180
Diameter	mm	2,300	1,900	1,800
Prime Mover		Electric Motor		
Reduction Gear				
Type		Double-Helical Reduction Glear		
Ratio	-	160/980	194/987	6/49
Main Motor				
Power	kw	662	800	353
Revolution	rpm	1,000	983	1,470
Type	-	Three Phase Wound Rotor Type Induction Motor		
Frequency/Voltage	Hz/v	50/6,000		
Flap Valve		Hydraulic Drive		
Overhead Crane	ton	8, Manual	10, Manual	7.5, Manual
Trashrack		Automatic/Bar Screen Type		
Produced Country		Japan	Germany	Japan
Manufacturer		Hitachi	Foyet	Hitachi

2) Maximum Discharge and Water Level

According to the obtained data on discharge and water level in the El-Max and Hares pumping stations, the maximum discharge and water levels at suction and delivery sides are observed in December 1991 and November 1994, as shown below;

Maximum Discharge and Water Level

Pumping Station	Date	Discharge	Water Level		Increment to the Original	
			Suction	Delivery	Suction	Delivery
		(cu.m/s)	(m.MSL)	(m.MSL)	(m)	(m)
El-Max	December, 1991	115.0	(-)1.86	(+)0.95	(+)1.39	(+)0.20
	November, 1994	120.8	(-)2.54	(+)1.15	(+)0.71	(+)0.40
Hares	December, 1991	24.0	(-)2.90	(-)1.40	(+)3.10	(+)1.40
	November, 1994	32.0	(-)3.60	(-)1.85	(+)2.40	(+)0.95

Note: Monthly fluctuation is given in Figure 7-2 and 7-3.

The damage in the 1991 flood was greater than that in 1994. According to the pump operation records, the maximum numbers of operated pumps in case of December 1991 flood, were nine units in the El-Max pumping station and three units in the Hares pumping station respectively. On the other hand, in case of November 1994 flood, all Hares pumps including one stand-by pump were operated, so that suction water level did not increase to the December 1991 level as a result of better operation following the actual run-off conditions. However, a rather big increase in water level during floods suggests a shortage of pump capacity and the needs for more precise pump operation.

3) Decreased Pump Capacity

Flow measurement has been carried out both upstream and downstream of pumping stations in order to investigate the decreased pump capacity under the cooperation of EPADP and DOI. The result shows that the pump capacity in the El-Max (1) and Hares pumping stations seems to have decreased at the rate of around 15 to 20 percent of that of the original design, although the pump capacity in the El-Max (2) pumping station seems normal. Flow measurement results are shown in Table 7-5.

FIGURE 7-2 DISCHARGE AND WATER LEVEL AT EL-MAX PUMPING STATION

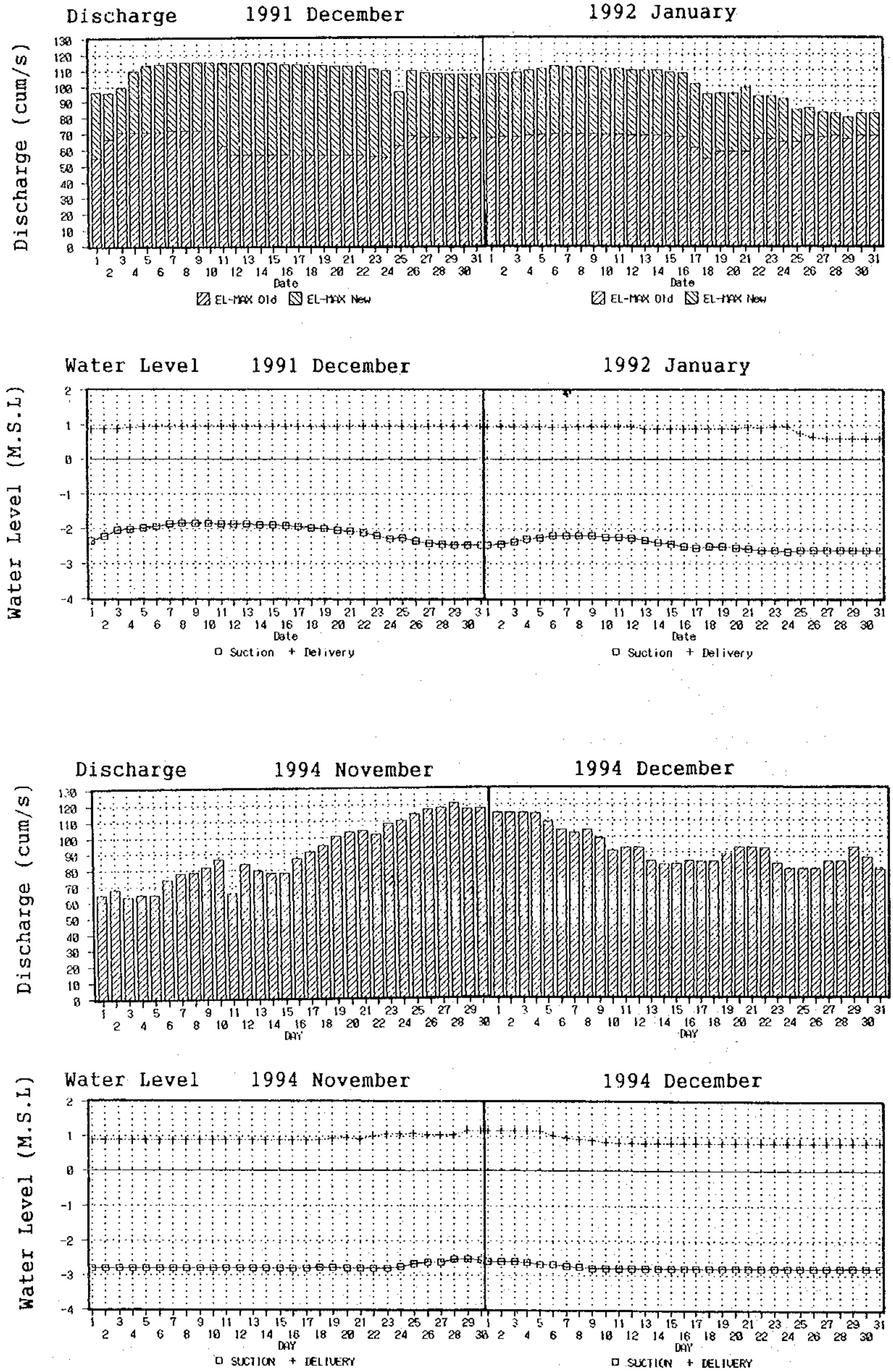
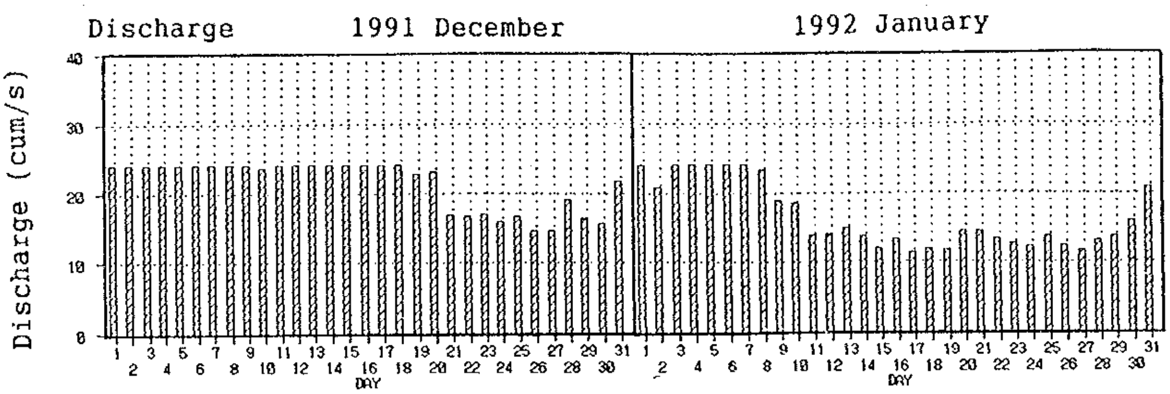
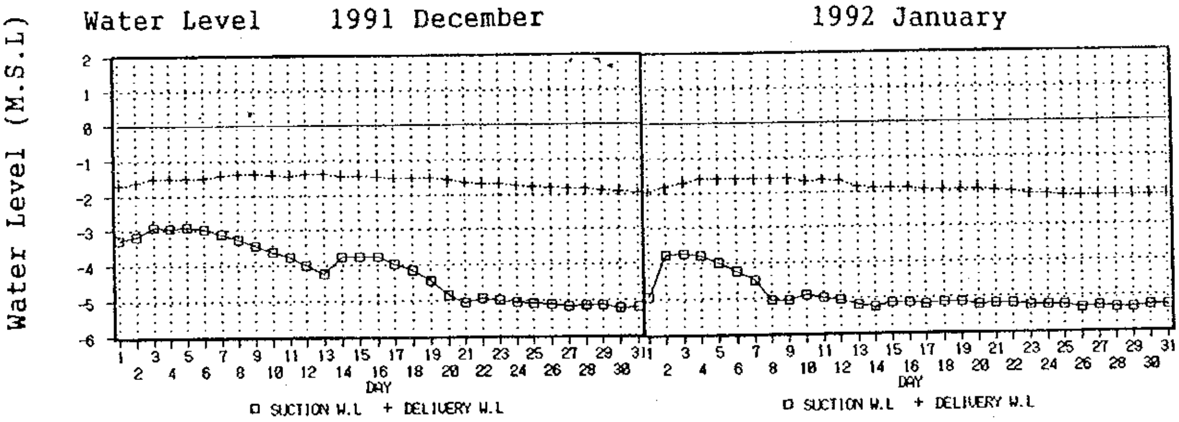
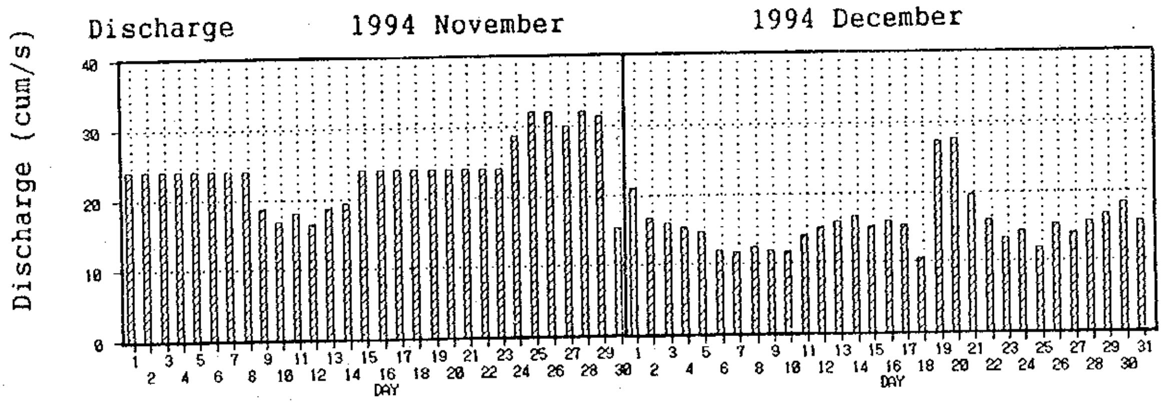


FIGURE 7-3 DISCHARGE AND WATER LEVEL AT HARES PUMPING STATION







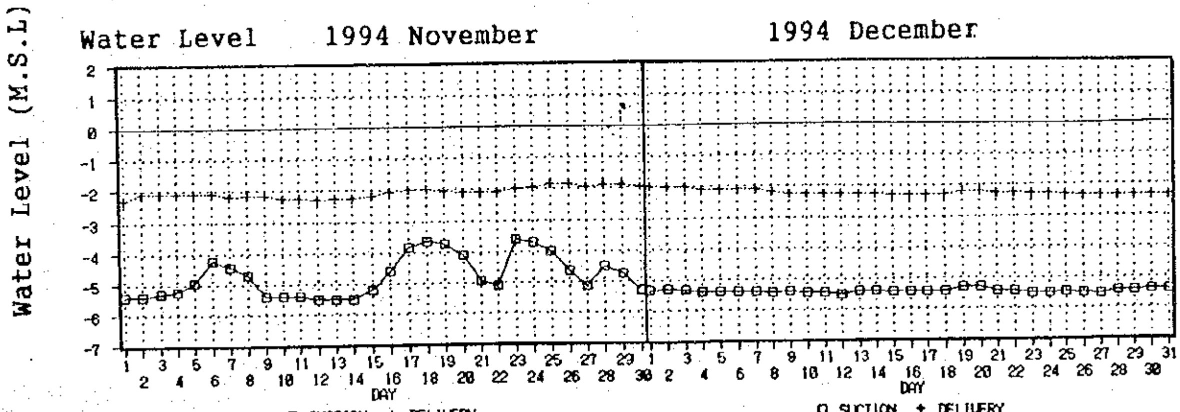


Table 7-5 Present El-Max and Hares Pump Capacities

Pumping Station	Date	Location	No. of Pump operated	Total Discharge (cu.m/s)		Total Head (m)		Ratio of Decrease (%)	
				Design	Observed	Design	Observed	Appeared	Actual
El-Max (1)	1994. 8. 17	Suction	1	12.5	11.03	4.00	3.25	88.2	80.2
	1995. 3. 07	Delivery	5	62.5	58.25	4.00	3.40	93.2	86.3
El-Max (2)	1994. 8. 17	Suction	1	12.5	11.03	4.00	3.35	111.7	102.5
Hares	1994. 8. 14	Delivery	3	24.0	15.20	3.20	3.15	63.3	-
	1994. 8. 17	Suction	1	8.0	6.19	3.20	3.00	77.3	76.6
	1995. 3. 07	Delivery	2	16.0	13.99	3.20	3.00	86.7	85.9

Note: 1. Appeared ratio of decrease are estimated dividing the observed total discharge by the design one, while actual ratio of decrease are the value based upon the characteristic curve of each pump (see Table G-2-2, Annex G).

4) Civil/Architectural Structures

A technical report regarding the El-Max pumping station has been submitted by local consultants from the Engineering Design & Irrigation Projects Consulting Office (EDIPCO) to MED in February, 1994. This report has dealt with the current problems of the civil/architectural structures and discharge channel to the Mediterranean Sea. The report has pointed out there were partial concrete cracks in some walls and exposed reinforcing bars in some columns and walls of El-Max (1) pumping station. The present structures could still be utilized if adequate repairs were carried out.

However, no effective measures and actions have not yet been taken till now and it is expected that the situation has grown worse. Concrete cracks and peeling can be observed at the front surfaces of walls and columns of the suction side in the El-Max (1) pumping station. It can be considered that these cracks and peeling have been caused by poor workmanship, insufficient coverage of reinforcing bars, corrosion due to chemical action and overload in some places and not by drying shrinkage on the mortar surface, so that it can be considered that the existing structures are laid in an extremely dangerous situation.

On the other hand, the situation in the Hares pumping station is the same as that in the El-Max (1) pumping station although the reinforcement work in some columns has been carried out.

5) Head Loss around the El-Max (1) Pumping Station

It is observed that the water level at Mariut Lake and the Omoum main drain are controlled by the El-Max pumping station. It is very difficult to lower the water level, even though full operations are performed. The head between the El-Max pumping station and Hares pumping station was about 80 cm in February 1995 which has had a tendency to become wider in recent years. This phenomena is caused by inadequate maintenance and management of the drains, resulting in the increase of pump head and motor output. The proper maintenance and management such as the removal of trash, etc. are carried out around the pumping station and also in the approach canal.

The following head losses are observed:

- Inlet canal	Good condition	:	0 to 2 cm
(Bar Screen)	Bad condition	:	10 to 15 cm
- Omoum main drain	Railway bridge	:	24 cm
	Floating screen	:	6 cm

The following head losses between the El-Max pumping station and Hares pumping stations have been observed.

Head Loss between El-Max and Hares Pumping Stations

Year	Average Suction Water Level at El-Max P.S.	Average Delivery Water Level at Hares P.S.	Head Losses
	(m.MSL)	(m.MSL)	(m)
1991	(-) 2.35	(-) 1.95	0.40
1992	(-) 2.71	(-) 2.25	0.46
1993	(-) 2.77	(-) 2.37	0.40
1994	(-) 2.78	(-) 2.20	0.58

6) Hourly Pump Running Records

According to hourly pump running records in the Hares pumping station for a period of 10 days from September 25 to October 5, 1994, which corresponds to a rather large discharge, there were no particular changes of the pump operation and suction water level in either day and night.

7. 5. 4 Operation and Maintenance of Drainage Facilities

1) Drains and Roads

Major operation and maintenance (O&M) work for Omoum main drain, main and lateral drains in the Project Area are the excavation of soils deposited in the drains and reshaping the drain section inclusive of grass cutting on the side slope. These works are carried out by heavy equipment such as back hoe and clamshell. The annual O&M costs of drains, which averaged over the past three years are reported to be about 5,000 LE/km.

The operation and maintenance works for Nubariya siphon and discharge-channel are not being done well, and a situation which causes an obstruction of water flow in the facilities due to soil sedimentation and growth of aquatic plants.

Regarding drainage facilities in the Project Area, necessary O&M works are implemented by related government staff member after inspection of drainage facilities, paying special attention to deposited soils and aquatic plants in the drains. In addition to these routine O&M works, careful maintenance and inspection for pipe-structured bridges crossing drains will be important. However, due to shortages of necessary budget, staff, and little understanding of O&M works, inadequate O&M works are undertaken at present.

Furthermore, in the Project Area, O&M roads provided along the drains cause severe problems from the viewpoint of engineering and socio-economic conditions in the Area. Namely, no vehicle can pass during winter seasons due to heavy rainfall, in order to carry out O&M works and also rehabilitation works for the facilities damaged by flood, because road surface is muddy and without pavement. At present some rehabilitation work of the roads has began in some parts by adding gravel pavement.

2) Hares and El-Max Pumping Stations

The office of the El-Max Directorate under MED has three branch offices in El-Max, Dishudi and Tabia pumping stations, and each branch office manages two to five pumping stations. El-Max pumping station belongs to El-Max branch office and Hares pumping station belongs to Dishudi branch office, respectively.

In each branch office, mechanic, electric and civil engineers are permanently appointed, and a workshop equipped with the necessary equipment and tools is stationed to conduct normal repairing, inspection, manufacturing of parts, overhaul of pump facilities. Pump operation is recorded on an hourly basis in the items of operation time, suction and delivery water levels, voltage, electricity and pump conditions.

Communication among El-Max pumping station and the other six pumping stations is performed by means of telephone, but communicated pump operation systems are not yet introduced. Therefore, each pump is independently operated depending upon the suction water level of the pumping station, which is made by control of the pump unit.

CHAPTER VIII. DEVELOPMENT PLAN

CHAPTER VIII. DEVELOPMENT PLAN

8.1 Objectives and Components of the Project

8.1.1 Objectives of the Project

As described in the Basic Development Plan for drainage improvement in the Study Area, the factors impeding development in the Priority Development Area and in its vicinity as well as causing rural poverty are as follows;

Deterioration and Changes in Land and Water Resources

- Change for the worse of soil water-logging and salinization of farmland, due to flat and low-lying topography, heavy soils with low permeability, inadequate drainage management at the farm level, etc.,
- Deterioration of water quality in the Omoum main drain and Mariut Lake, in accordance with high salinity drainages discharges from farmland and waste water from Alexandria city,
- Shortage of irrigation water sources and an increase in reuse amounts of drainage water to cope with the shortage of irrigation water, and
- Increase in flood damage to agricultural crops and public facilities, due to recent changes in rainfall magnitude, land-use pattern and runoff mechanism, etc.

Deterioration of Rural Living Environment

- Potential of periodical flood damage to local people living in low-lying areas, for which drainage requires pump operations,
- Ill effects on local peoples' health and sanitation, due to lack of sewerage facilities in the area,
- Water quality pollution for drinking and living purposes, and spread of water-borne communicable diseases such as diarrhea, paratyphoid and skaris, and

- Decrease in fish production resulting from water quality pollution of the Mariut Lake.

Low Agricultural Productivity

- Low agricultural productivity related to high soil salinity, and groundwater table caused by poor drainage, flooding, shortage of irrigation water, and some coarse and less fertile soils,
- Poor cultivation technique of farmers and insufficient utilization of agricultural production materials, and
- No agricultural extension services and farmers' organizations such as drainage users' organizations.

Inadequate Function of Agricultural and Rural Infrastructure

- Shortage of drainage capacity for major drainage facilities such as El-Max pumping station, Omoum main drain and drains, due to timeworn and insufficient operation and maintenance of the related facilities,
- Poor drainage conditions due to lack of subsurface drainage facilities,
- Insufficient operation and maintenance of irrigation and drainage facilities, and lack of knowledge and experience regarding water management in terms of irrigation and drainage at on-farm level, and
- Obstruction for transportation of production materials and for rural communication among villages, due to lack of functional roads even in winter season.

Accordingly, the objectives of the farmland environmental improvement project in Omoum area emphasizing on drainage improvement are to formulate development plan mentioned below, in order to eliminate the above-stated factors impeding development and to improve the existing conditions.

- Drainage improvement plan should be established aiming at alleviation of flood damage for agricultural crops and increase in agricultural production by means of improvement of drainage facilities of El-Max and Hares pumping stations, Omoum main drain, branch drains, subsurface tile drain facilities, and roads.

- Living standard of local people and living environment in the rural area should be raised and improved through increased agricultural production mentioned in the above.

- Water management techniques for both irrigation and drainage up to the on-farm level should be improved, in order to execute smooth and effective works for land-use, crop husbandry, water distribution and pump operation, and so on.

- Scarce water resources inclusive of reuse of drainage water should be utilized effectively, which will be achieved through improvement of water management mentioned above.

- Water quality conservation of the Omoum main drain and Mariut Lake should be undertaken through adequate water management and monitoring on water quality and quantity.

8. 1. 2 Components of the Project

The project components will be made with the following development concept to achieve the development objectives mentioned above.

i) Improvement of Major Drainage Facilities

In order to improve the drainage conditions in the lower reaches of the Omoum area, major drainage facilities of El-Max pumping station and Omoum main drain, inclusive of Nubariya siphon and other related facilities in Mariut Lake, which principally govern the drainage mechanism in the vicinity of the Study Area, should be replaced or upgrade to meet adequate drainage systems and increased drainage capacity, after due considerations of alternative plans.

Together with these facilities improvement, an adequate water management plan should be undertaken by the relevant Government agencies, emphasizing the water level of Omoum main drain as well as Mariut Lake, that is, (-) 3.25 m.MSL in Omoum main drain and (-) 2.40 m.MSL in Mariut Lake, respectively.

ii) Improvement of Agricultural and Rural Infrastructure

The Project Area with total drainage area of 63,300 feddan (26,600 ha), which is located downstream from the Study Area, is beset with depressed conditions from the viewpoint of socio-economy, due to newly reclaimed land with a low elevation and scarce agricultural and rural infrastructure such as drains, subsurface tile drains, on-farm facilities, rural roads, which causes soil water-logging and salinization at the farm level.

Especially, the deterioration of Hares pumping station causes severe drainage problems not only for agricultural production, but also the local people's living in the Area. Therefore, these agricultural and rural infrastructure, especially Hares pumping station, subsurface tile drains and roads should be installed and/or improved at an early stage.

iii) Water Source Development and Improvement of Irrigation and Drainage Water Management

Water source development by means of reuse of drainage water in the Project Area should be promoted considering the shortage of water resources in the vicinity of the West Delta Region and newly developed desert area. And an adequate distribution plan in terms of quality and quantity management should be formulated to achieve effective utilization of water resources.

iv) Agricultural Development Plan

In order to achieve more productive farming, adequate plans of land-use, cropping pattern, farming management, animal husbandry, agricultural supporting services, farmer's organization, and so on should be formulated for the Area.

v) Mariut Lake Environmental Conservation Plan

Water quality of Mariut Lake, which will be separated from the Omoum main drain in the Project should be strictly controlled and monitored to a suitable water level and water supply to the Lake, to expect water quality conservation of the Lake, and adequate countermeasures by laws and regulations should be recommended to preserve the Lake's natural environment.

8.2 Formulation of Optimum Project Planning

8.2.1 Purpose and Concept of the Study

As described in paragraph 5.3 (Area-Wide Drainage Improvement Plan) that Omoum main drain will be separated from Mariut Lake(Case-3) and gates and weirs will be provided on the embankments of the Omoum main drain. Owing to this development plan, it is very important to know the optimum size and operation methods of the gates, weirs and the El-Max pumping station, in order to formulate an appropriate water management plan for both Omoum main drain and Mariut Lake.

Preconditions:

- Basic operating water levels of Mariut Lake and Omoum main drain are as follows;
  - Water level of Mariut Lake : (-)2.40m.MSL
  - Water level of Omoum main drain : (-)3.25m.MSL (Suction water level of El-Max pumping station)

- According to the plan, all discharge from Hares and Abis pumping stations will be drained into the Mariut Lake to maintain the water quality. Their rates are as follows;
  - Hares pumping station : Qmax = 30.0 cu.m/sec
  - Abis pumping station : Qmax = 5.6 cu.m/sec

- Some water from Mariut Lake (through gates and over the weir) will constantly flow to Omoum main drain.

Items for Comparative Study

- Inflow to Mariut Lake (with and without reuse water)
- Size and improvement plan for El-Max pumping station
- Size of Omoum main drain (part within Mariut Lake)
- Appropriate size, number and construction sites for gates and weirs
- Operation procedure of gates

8. 2. 2 Proposed Drainage Area and Discharge

a) Drainage Area

The drainage areas that will be covered by El-Max pumping station are given below;

- Area covered by Omoum main drain : 335,530 feddan(140,920ha)
- Area covered by Mariut Lake
  - Hares and Abis blocks : 72,330 feddan (30,380 ha)
  - Mariut Lake and its surroundings : 22,400 feddan (9,410 ha)

  Total : 430,260 feddan(180,710ha)

b) Inflow to Mariut Lake

There are three sources of inflow coming to El-Max pumping station; agricultural drainage water carried by Omoum main drain; navigation by-pass and escape water carried by Nubariya canal; and sewage water from Alexandria city from WTP. However, total amount of inflow at El-Max pumping station during normal and design years considering the future plan for the reuse of drainage water are presented below;

Inflow to El-Max Pumping Station

Item	Without Reuse		With Reuse	
	Normal Year /1	Design Year /2	Normal Year	Design Year
	(MCM)	(MCM)	(MCM)	(MCM)
Inflow to Mariut Lake	961	986	961	986
Inflow from Omoum main drain	1,746	1,794	789	843
Total	2,707	2,780	1,750	1,829

Note; 1/ : Normal year(1985) with 1/2 probability,
2/ : Design year(1994) with 1/7 probability
Details are presented in Table 8-1

Table 8-1 Monthly Runoff Discharge into El-Max Pumping Station (in Cases of Without and With Reuse)

(Unit: MCM)

Month	Without Reuse						With Reuse						
	Normal Year			Design Year			Reuse	Normal Year			Design Year		
	Mariut Lake (1)	Omoum Main Drain (2)	Total (3)	Mariut Lake (4)	Omoum Main Drain (5)	Total (6)	Amount (7)	Mariut Lake (8)	Omoum Main Drain (9)=(2)-(7)	Total (10)	Mariut Lake (11)	Omoum Main Drain (12)=(5)-(7)	Total (13)
1	79	116	196	84	125	209	44	79	72	151	84	81	165
2	74	117	191	62	89	151	33	74	84	158	62	56	118
3	65	111	176	75	132	207	92	65	19	84	75	40	115
4	67	123	190	66	120	186	91	67	32	99	66	29	95
5	75	134	209	75	134	209	79	75	55	130	75	55	130
6	77	156	233	77	156	233	92	77	64	141	77	64	141
7	101	256	357	101	256	357	85	101	171	272	101	171	272
8	92	233	325	92	233	325	111	92	122	214	92	122	214
9	61	146	207	61	146	207	125	61	21	82	61	21	82
10	44	88	132	42	82	124	127	44	0	44	42	0	42
11	106	112	218	136	182	318	56	106	56	162	136	126	262
12	120	154	274	115	139	254	61	120	93	213	115	78	193
Total	961	1,746	2,707	986	1,794	2,780	996	961	789	1,750	986	843	1,829

Note: Amount of reuse water by Omoum Drain Project was derived from EPADP Plan.
(1), (2) : see Table E-2-1, Annex E
(4), (5) : see Table E-2-2, Annex E
(7) : see Table D-1-14, Annex D

8. 2. 3 Water Balance for Mariut Lake

On the basis of inflow and outflow, two case studies of water balance are performed. Namely, one is for present condition and the other is for the proposed plan (Case-3 of development plan, i.e. separation of Omoum main drain from Mariut Lake). Details of these case studies are presented below;

1) Water Balance for Present Conditions

The purpose of this study is to review the behavior of actual water levels of Mariut Lake (recorded by the JICA Study Team at Nubariya Siphon site) and the analyzed water levels. It is worth mentioning that due to the cuts in the embankments of Omoum main drain and Nubariya canal, Mariut Lake plays the role of one big reservoir with a storage capacity of 54.6 MCM. The inflow and outflow sources that are used in the calculation are given below;

Inflow Sources	Outflow Sources
· Drainage discharge from seven upstream blocks · Rainfall runoff · Sewage water from WTP · Spilled water from west Nubariya drain escape · Water from Nubariya canal by-pass · Navigation lock water · Discharge from Ameriya drain · Intrusion of sea water	· Discharge through El-Max pumping station · Evaporation from Mariut Lake · Reuse water through Mariut No.1 pumping station · Evaporation from Omoum main drain

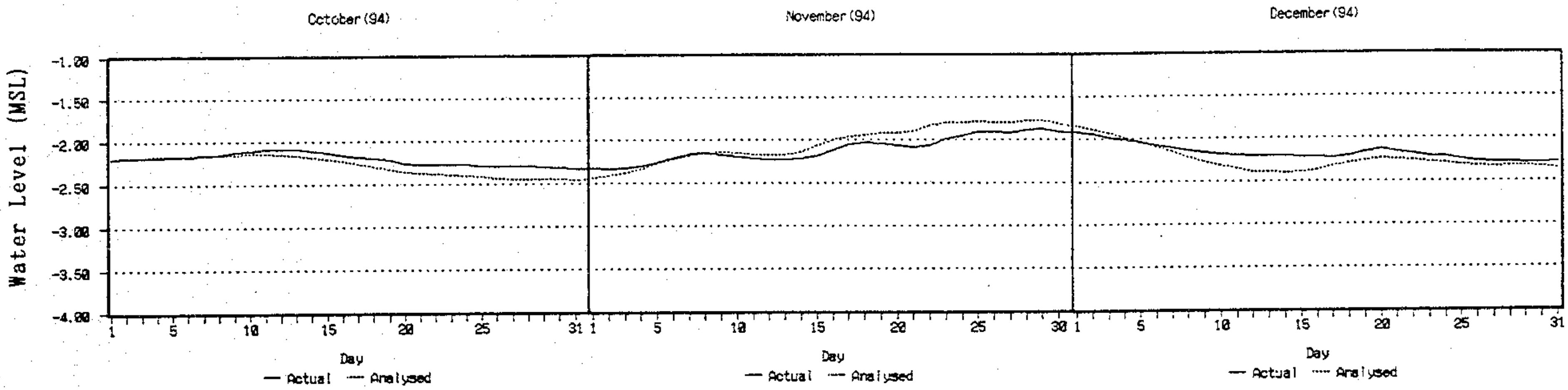
The study is performed on the daily basis in case of 1994. The main results of the study for the three months of October, November and December are presented in the table below and a comparison of analyzed and actual water levels at the siphon site is presented in Figure 8-1.

Main Outcome of Water Balance Study

Description	October	November	December
Rainfall (mm)	5.0	112.6	67.5
Inflow to Mariut Lake (MCM)			
Drainage discharge from seven blocks	198.7	205.7	148.9
Inflow from other sources	20.3	75.2	65.7
Total	219.0	280.9	214.6
Outflow (MCM)			
(El-Max P.S., evaporation, reuse etc.)	233.0	245.5	244.6

Note : For discharge from upstream pumps, decline rate of pump capacity is assumed at 20 percent, i.e. 80 percent of recorded discharge is used. Detail of the calculation is presented in the Tables E-2-4, E-2-5 and E-2-6, Annex E.

FIGURE 8-1 COMPARISON OF ANALYZED AND ACTUAL WATER LEVEL AT SIPHON SITE (OCTOBER - DECEMBER, 1994)



As can be seen in Figure 8-1 that the recorded and analyzed water levels are relatively close to each other which helps to draw the conclusion that the model and parameters that are used in the calculation are reasonable.

2) Water Balance for Proposed Plan

The basis of this study is Case-3 of the development plan in which the separation of the Omoum main drain from Mariut Lake is proposed. In the water balance study, six case studies were made, namely, for a normal year, design year and flood year considered with and without the reuse of drainage water.

Selection of Rainfall and Runoff

From a probability analysis of fifteen years' data (1980-94) recorded in Alexandria, the following years are selected for this study.

- Normal year (1985) : 202 mm/year
- Design year (1994) : 273 mm/year
- Flood year(1991) : 405 mm/year

Review of rainfall data reveals that rainfall occurs only during the months from October through March, and considering the Study Area as a low-lying flat area, daily runoff from Mariut Lake surroundings is calculated. Drainage discharge from Hares and Abis blocks are also calculated on a daily basis. (Refer to Table D-4-2, Annex D). Discharge from the rest of the five drainage blocks are calculated on a monthly basis (Refer to Table D-2-12~14, Annex D).

Table below represents the calculated monthly rainfall runoff from Mariut Lake (direct) and its surroundings (indirect).

Monthly Rainfall Runoff

(unit : MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Normal (1985)	2.15	2.50	0.14	0	0	0	0	0	0	0.67	0.58	5.95
Design (1994)	2.95	0.19	2.00	0	0	0	0	0	0	0.27	7.16	4.67
Flood (1991)	4.94	1.88	1.95	0	0	0	0	0	0	0	4.19	9.12

Note : Details are presented in Figures B-2-1 to B-2-4, Annex B

Concept and Structure of the Model

Separation of Omoum main drain will make it possible to construct a model with three blocks, i.e., Omoum main drain, Mariut Lake and the Mediterranean Sea. These blocks are somehow interconnected by drainage facilities namely, gates, weir and El-Max pumping station. Therefore, from the structure of the model, it may be termed a continuous reservoir model.

The first two blocks will receive inflow separately from different sources and some amount of flow will go to the Omoum drain through the gates and weirs, and finally the pumps at El-Max will drain to the Sea. The schematic diagram of the model is presented in Figure 8-2. The blocks in the model are designated with numbers like Mediterranean Sea as block 1, Omoum main drain as block 2 and Mariut Lake as block 3, respectively. The dimensions of the drainage facilities and operation water levels are described below.

Dimension and Operation Water Level of Drainage Facilities

Item	Dimensions	Operation Water Level (MSL)	Facility No.
Mariut Lake	5,460 ha (13,000 feddan)	(-) 2.40 to (-) 2.50 m	
El-Max Pump (new)	14.6 cu.m/s×6 units	(-) 3.25 to (-) 3.30 m	1
El-Max Pump (old)	12.5 cu.m/s×4 units	(-) 3.25 to (-) 3.30 m	2
El-Max Pump (old)	12.5 cu.m/s×2 units	(-) 3.15 to (-) 3.25 m	3
Gate	B 3.0×H 2.0 m		4
Gate opening	H=0.30 m		
Weir elevation	(-) 2.50 m.MSL		5

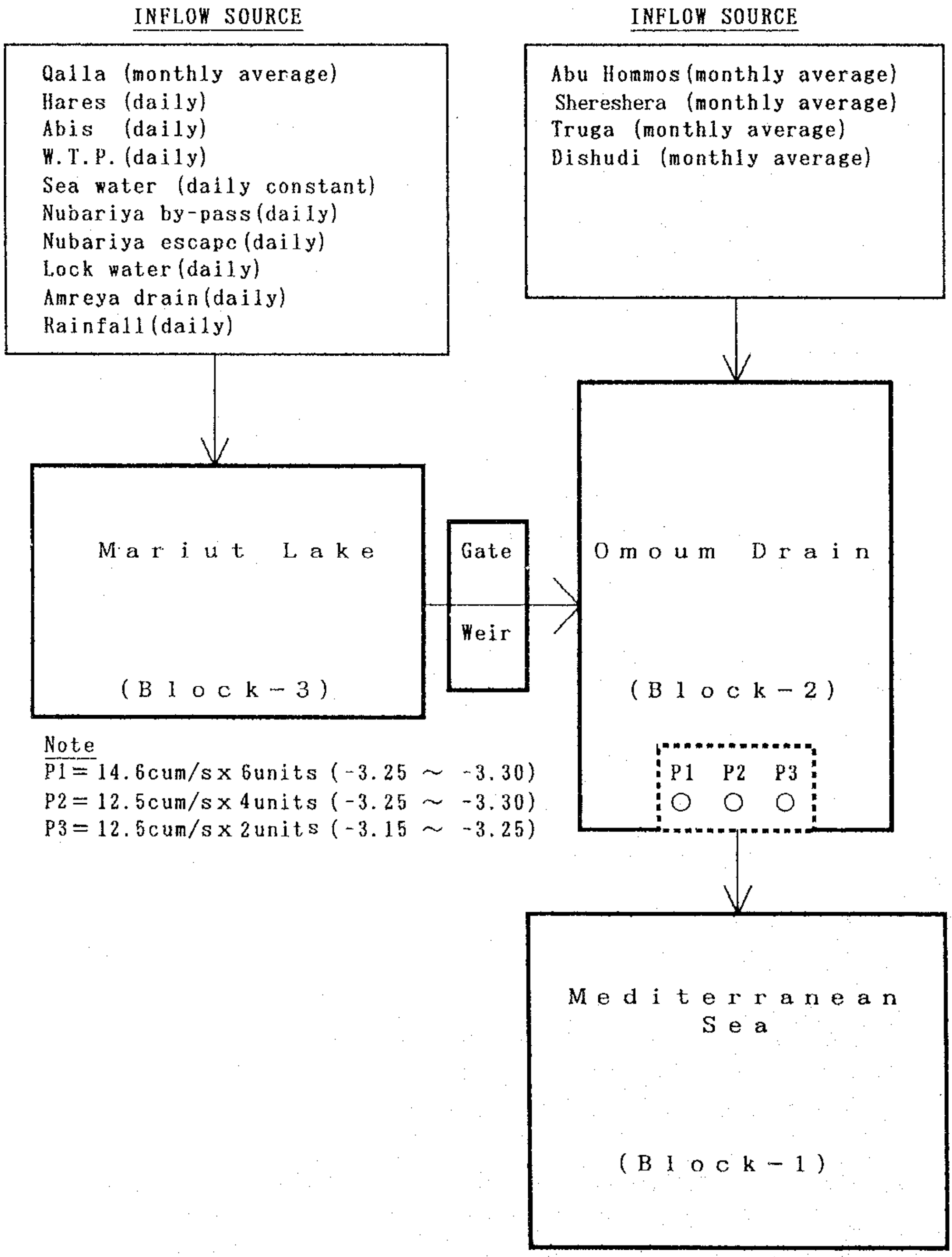
Refer to Figure E-2-6, Annex E

3) Result of Water Balance Study

Computer aided analyses for the above mentioned cases were performed changing the variables such as number of gates, length and elevation of the weir, and pump operation water levels, in order to maintain the design water levels of Mariut Lake and Omoum main drain.

Case study (without considering reuse) shows that fixing the gate opening at 0.30 m, weir length as 100 m at an elevation of (-)2.50 m.MSL and allowing a certain amount of constant flow over the weir into Omoum main drain for all time, a monthly basis for gate operation is possible. In general, the number of gates will vary from four to ten. In fact, in some months

FIGURE 8-2 SCHEMATIC DIAGRAM OF CONTINUOUS RESERVOIR MODEL



weekly/fortnightly operations may be needed when the Mariut Lake water level decreases/increases beyond the desired level.

On the other hand, when the future withdrawal of reuse water from Omoum upstream is considered, operation hours of El-Max pumps become reasonably short without affecting Lake or Omoum main drain water levels.

4) Operation Procedures of Drainage Facilities

From the viewpoints of geography and objectives, it seems that construction sites of gates and weirs are located far away from the El-Max pumping station. Owing to this fact and from a practical point of view frequent operation of gates should be avoided, and consideration should be given on a seasonal/monthly operation procedures. Therefore, according to the result of the water balance study, a seasonal operation ranging from four to ten gates is recommended. For normal years, from December to February ten gates, March to June six gates, July to August eight gates, September to October four gates and for November six gates.

Analysis of daily water level of Mariut Lake is presented in Figures 8-3 and 8-4. Monthly pump operation hours for El-Max pumping station corresponding to the proposed number of gates are tabulated below;

Gate Operation Procedure and Pump Operation Hour

Month	Normal Year			Design Year		
	Gate No.	Pump Operation Hour		Gate No.	Pump Operation Hour	
		W/out Reuse	With Reuse		W/out Reuse	With Reuse
Jan.	10	791	613	8	800	622
Feb.	10	793	660	6	630	451
Mar.	6	678	306	6	795	423
Apr.	6	724	478	6	712	345
May	6	796	478	6	796	478
Jun.	6	879	508	6	879	508
Jul.	8	1,385	1,042	8	1,385	1,042
Aug.	8	1,252	804	8	1,252	804
Sep.	4	778	273	4	778	273
Oct.	4	523	201	4	486	186
Nov.	6	653	431	8	1,027	804
Dec.	10	947	701	8	839	593
Total		10,199	6,495		10,379	6,529

Note: Details are presented in the Tables E-2-7 to E-2-10, Annex E

FIGURE 8-3 ANALYZED DAILY WATER LEVEL OF MARIUT LAKE (NORMAL YEAR)

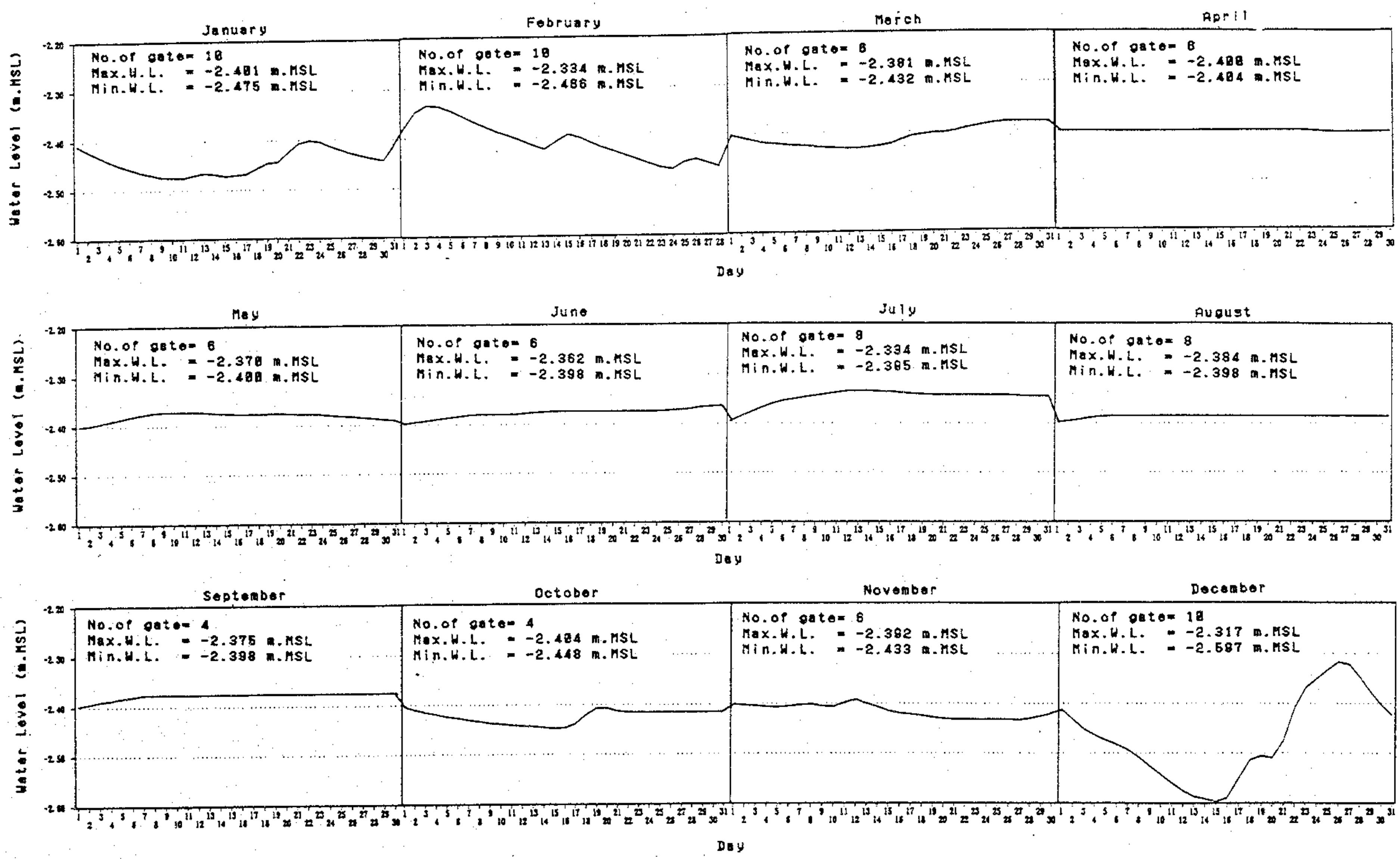
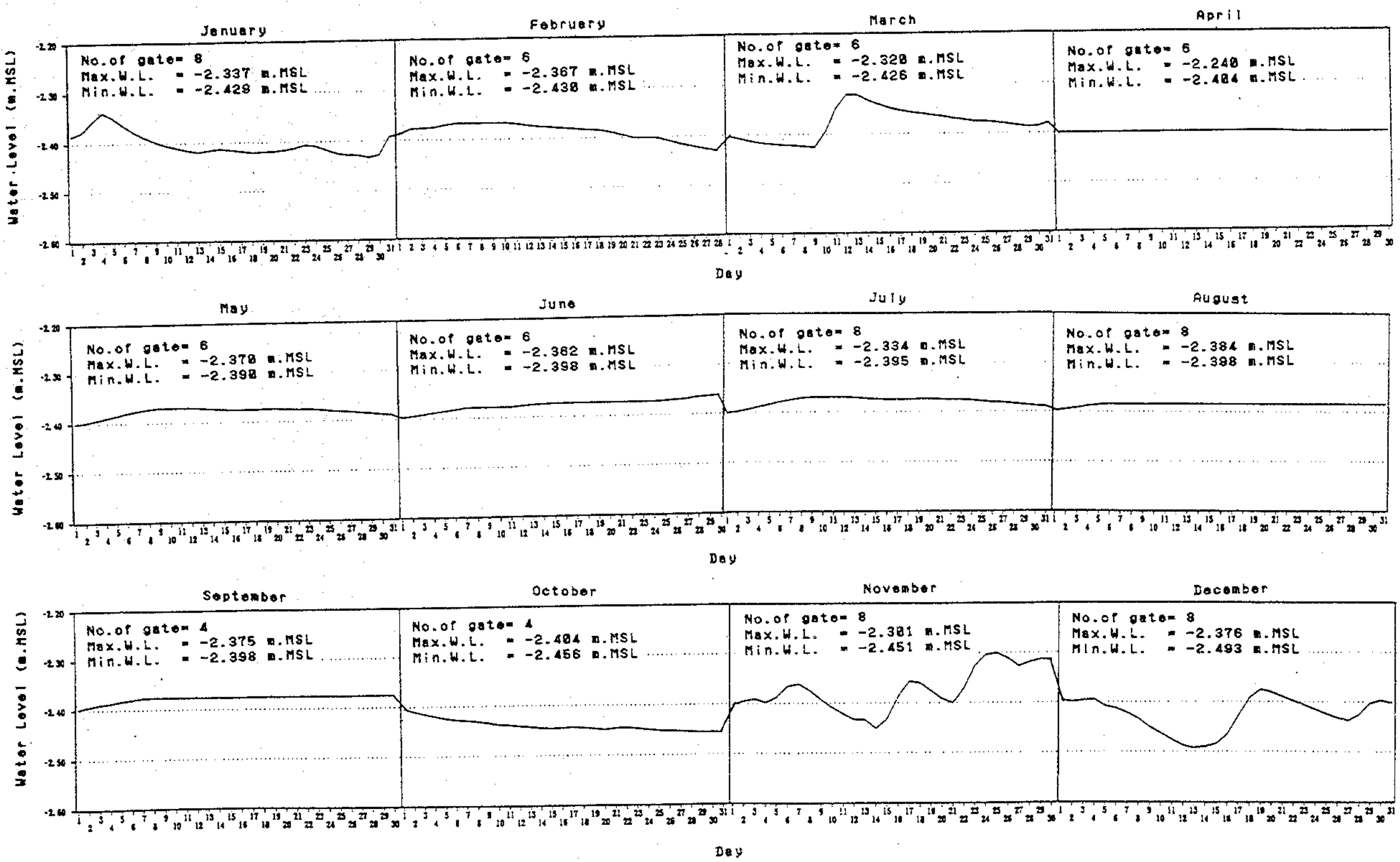


FIGURE 8-4 ANALYZED DAILY WATER LEVEL OF MARIUT LAKE (DESIGN YEAR)



8.2.4 Proposed Project Size

As discussed above, for an efficient, safe and environmentally friendly drainage system for the Omoum main drain and Mariut Lake, the following dimensions for the drainage facilities are proposed.

- El-Max pumping station
  - Total discharge : Q= 150.0 cu.m/sec
  - New pump capacity : Q= 87.6 cu.m/sec (14.6cu.m/s×6 units)

- Omoum main drain (the part within Mariut Lake)
  - Improvement method : Separation from Mariut Lake
  - Design discharge : Q = 150.0 cu.m/sec

- Gates and Weirs (Set)
  - Location and number : seven places (Figure 5-4)
    Gate size : width = 3.0 m, height = 2.0 m
    Gate opening : H = 0.30 m
    Weir elevation : (-)2.50 m.MSL
    Weir length(total) : L = 140 m

8.3 Land-Use Plan

8.3.1 Basic Concept of Land-Use Plan

There are 53,930 feddan (22,650 ha) of cultivable land in the Project Area. Of the total cultivable area, 47,190 feddan (19,820 ha) are presently cultivated. The remaining area of 6,740 feddan (2,830 ha) is almost covered by fourth class land, which needs to be improved, in terms of drainage and soils. The second class and third class land will be able to be cultivated in the same way to that in the first class land, having a wider range in crop selection.

8. 3. 2 Land-Use Plan

The proposed land-use for the Project Area of 63,330 feddan (26,600 ha) is formulated as shown below, taking into account the possible drainage and soil improvements;

Land-Use Plan

Item	Area	
	(ha)	(%)
Cultivated Land	22,650	85.1
Non-farm Land	3,950	14.9
Total	26,600	100.0

As shown in the above, the following soil improvement is necessary for all the cultivable land in this project;

Soil Improvement Plan

Item	Area	Description
	(ha)	(%)
Gypsum application	22,650	2.4~4.8 tons/ha×3~5years
Subsoiling	22,650	40 cm depth

Note: The gypsum requirement is estimated on the ESP value for the average soils for first to fourth class land (refer to Table C-2-10, Annex C).

8. 4 Irrigation and Drainage Plan

8. 4. 1 Irrigation Plan

Regarding the estimation of irrigation water requirements, the Department of Irrigation (DOI), MPWWR has a criterion on the regional unit of crop water requirements for areas of Upper Egypt, Lower Egypt and the Nile Delta, which has been described in the Technical Report No.17 (Water Master Plan) published in 1973. Its calculation method is based on the FAO Irrigation Report (No.24).

Monthly irrigation water requirements can be estimated by adding planting water requirements to crop water requirements estimated applying the above method. Since the Delta region has very little rainfall during the winter season, and also Egypt is located in the arid region, no effective rainfall is considered in the calculation of irrigation water requirements.

The estimation of irrigation water requirements for the Project Area was made taking into account unit crop water requirements mentioned above, proposed cropping pattern and irrigation efficiency.

Overall irrigation efficiency in Egypt is generally around the scale of 0.60 as indicated below. But when the FAO standard is applied, irrigation efficiency for the Project is estimated at 0.49, and furthermore according to the actual rate of field measurements in the Integrated Soil and Water Improvement Project (ISAWIP), overall irrigation efficiency of 0.47 is indicated. Considering these figures, the proposed irrigation efficiency is set at 0.50 for both Project and Study Areas.

Irrigation Efficiency

Project Name	Present	Proposed
Mahmoudia Irrigation Improvement Project (Mar. 1994)	0.44	0.66
Irrigation Improvement Project (World Bank, Dec. 1994)	0.50	0.60
Integrated Soil and Water Improvement Project (Apr. 1994)	0.37	0.47
FAO Standard ($Ep = Ea \times Ed$)	0.35	0.49
Farmland Environmental Improvement Project in Omoum Area	0.35	0.50

Note ; EP (project irrigation efficiency), Ea (application efficiency), Ed (distribution efficiency)

Annual Irrigation Water Requirement in Project Area

Item	Irrigable Area	Cropped Area	Cropping Intensity	Net Water Req.	Irrigation Effi.	Gross Water Req.
	(feddan)	(feddan)	(%)	(MCM)		(MCM)
Present	47,190	92,020	195	205	0.35	586
Proposed	53,920	107,840	200	240	0.50	480

Monthly Irrigation Water Requirement in Project Area

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
(day)	(19)	(23)	(31)	(30)	(31)	(30)	(31)	(31)	(30)	(31)	(30)	(31)	(348)
Present													
MCM	29	31	43	46	60	71	106	94	37	6	34	29	586
cu.m/s	17.7	15.6	16.1	17.7	22.4	27.4	39.6	35.1	14.3	2.2	13.1	10.8	19.5
Proposed													
MCM	24	22	30	36	48	60	86	78	36	6	30	24	480
cu.m/s	14.6	11.1	11.2	13.9	17.9	23.1	32.1	29.1	13.9	2.2	11.6	9.0	16.0

In the Nubariya irrigation area, the major components of West Nubariya Agricultural Intensification Project are canal linings and improvement of lateral canals, which are proposed by the Department of Irrigation to increase the irrigation efficiency. Therefore, early implementation of the project along with this drainage improvement project is desired.

8.4.2 Drainage Plan

1) Proposed Drainage Discharge

The proposed drainage discharge for the Project is calculated based on the following procedures;

a) Design Year and Rainfall

In general, a drainage project emphasizing agricultural development uses the rainfall of 10-year probability (w = 1/10) as its design year, considering the economy of the project. However, in case of drainage projects involving river improvement or flood protection for the residential areas, rainfall of 30 to 50 probability is generally used. Since this Project aims at the farmland drainage improvement in the Omoum Area, a probability of 10-year is adopted.

The Project aims to halve the inundation period, considering the existing field conditions. The estimated flood discharge in the area will be drained within the flood concentration time. A design rainfall with consecutive 7-days rainfall during the flood in December 1991 is applied. Through the probability analysis of annual rainfall, design and normal years are selected as 1994 and 1985, respectively.

- Design rainfall (W = 1/10) : 11.5 mm/day
- Design year (W = 1/7) : 1994
- Normal year : 1985
- Flood year (W = 1/40) : 1991

b) Proposed Drainage Area

The proposed drainage area is shown below;

- Drainage area : 63,330 feddan (26,600 ha)
- Cultivable land : 53,920 feddan (22,650 ha)

c) Calculation of Design Discharge

The drainage discharges in the Project Area can be categorized into two types, that is, normal discharges originating from excess irrigation water and flood runoff caused by rainfall in the winter season. In determining design drainage discharge, the larger discharges will be adopted. As a result, maximum discharge by normal drainage is estimated at 21 cu.m/sec in July, while that caused by rainfall with a probability of 10-year is 30 cu.m/sec. Accordingly, the design discharge for the Project Area is determined at 30 cu.m/sec, equivalent to a unit area discharge of 41 cu.m/sec/ feddan/day.

The design discharges are summarized as follows;

- Pump drainage discharge : 30 cu.m/sec
- Unit area drainage discharge : 41 cu.m/feddan/day
- Subsurface tile drain
  Lateral drain : 1.5 mm/day (EPADP standard)
  Collector drain : 4.0 mm/day (EPADP standard)
  Spacing of lateral drains is calculated as shown below applying mean permeability of soil (K);

  $L \times L = 8 \times K \times M \times D / Q$
  where; L : lateral spacing of drain (m)

K : soil permeability = 10^{-4} cm/sec = 0.086 m/day
M : elevation of water table at midway between laterals = 0.4 m (EPADP)
D : thickness of permeable layer = 5.0 m (assumed)
Q : design discharge = 0.0015 m/day

L x L = 8 x 0.086 x 0.4 x 5 / 0.0015 = 917
L = 30 m (average)

Diagram of irrigation and drainage systems of the Project Area is shown in Figure 8-5.

2) Inundation Analysis

Two cases of inundation analyses for the Project, that is, firstly the design year with a probability of once every 10-year and secondary flood year with probability of once every 40-year were made by applying the graphic method with accumulated inflow-drainage discharge curve. Because the water level of Omoum main drain is always higher than the water level in the Project Area, it has to rely at all time on pumping drainage.

According to the hydrological analyses using consecutive three-days rainfall with the probability of 1/10-year, the proposed inundation period is analyzed for five days in comparison with the present period of 11 days, and also inundation areas will be reduced to half. The maximum water depth in fields will be reduced from the present level of 0.29 m to 0.22 m in future. In the case of the December 1991 flood, of which a consecutive rainfall is equivalent to about a 10-year probability, the present inundation period will be reduced to three days in the project from the present 11 days (refer to Figure 8-6 and Figure 8-7).

8.4.3 Reuse Plan of Drainage Water

The proposed irrigation water requirements for the Project Area are 480 MCM per annum as mentioned previously, an amount which is almost equal to the design delivery discharge of 497 MCM. But the present actual intake discharge is 80 percent of the design delivery discharge, so that water

FIGURE 8-5 PROPOSED IRRIGATION AND DRAINAGE DIAGRAM IN PROJECT AREA

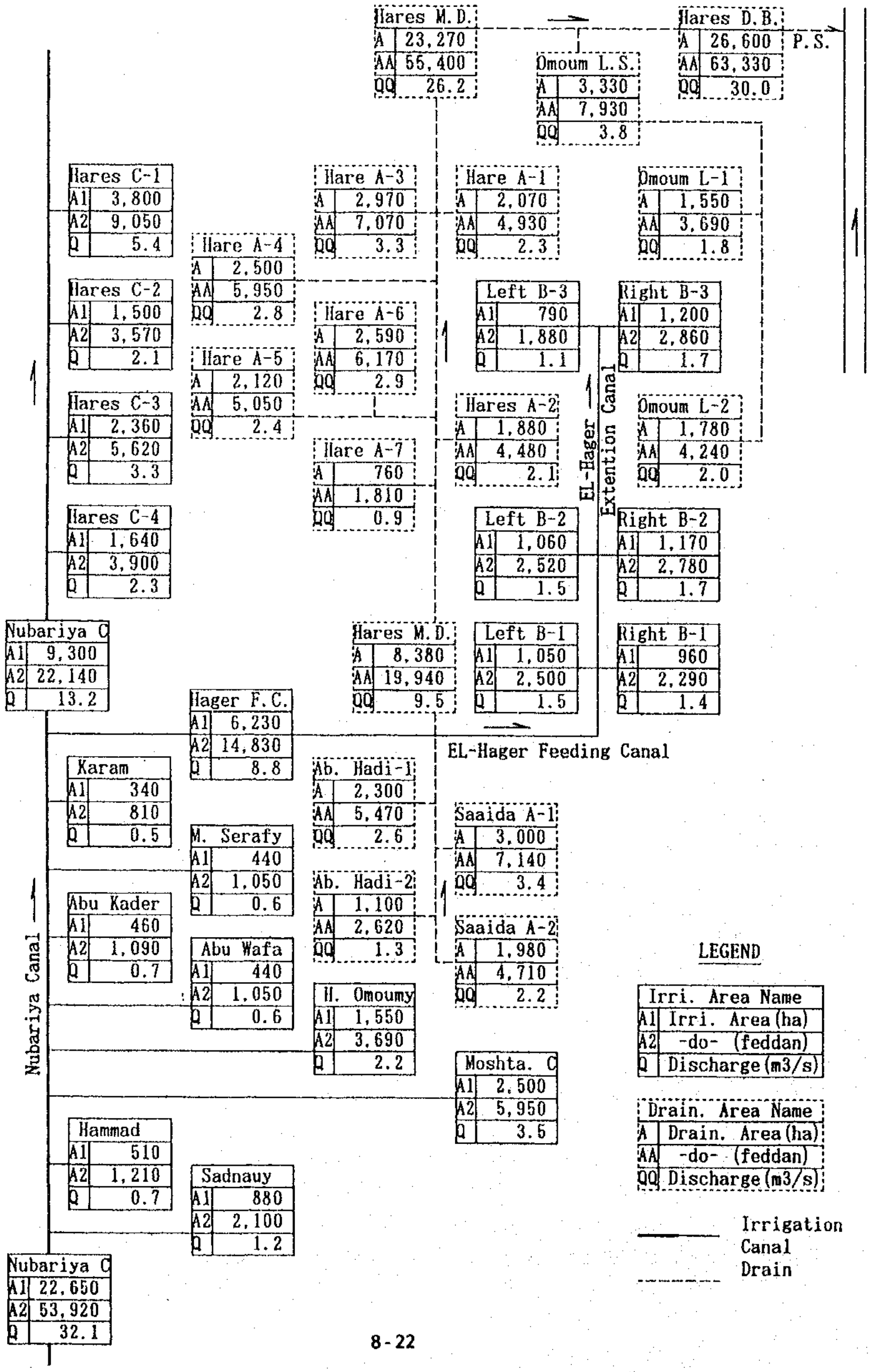
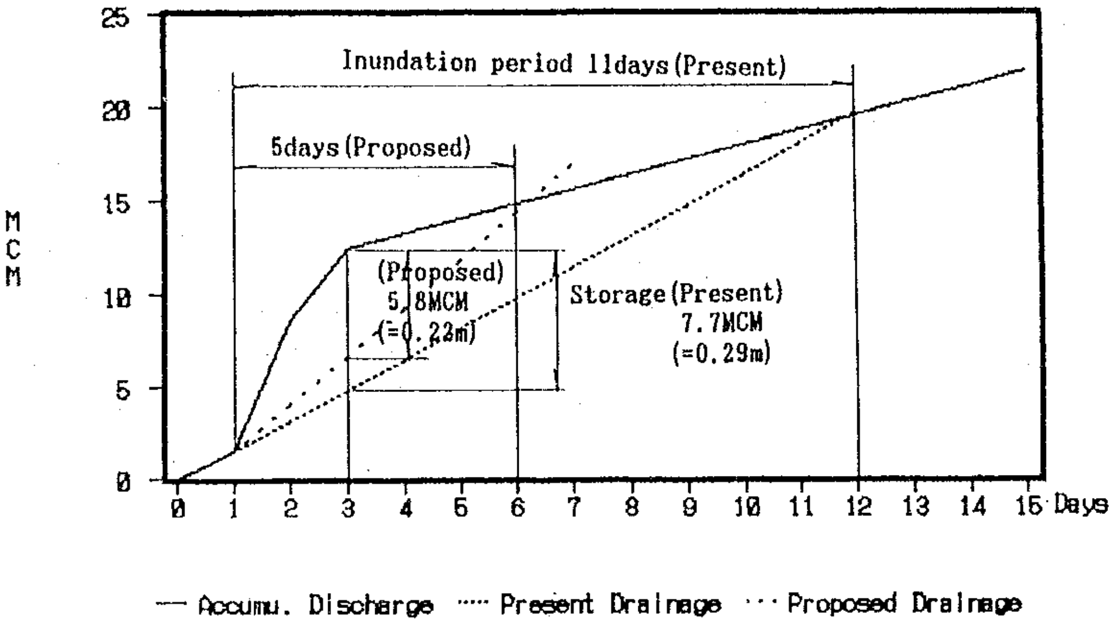
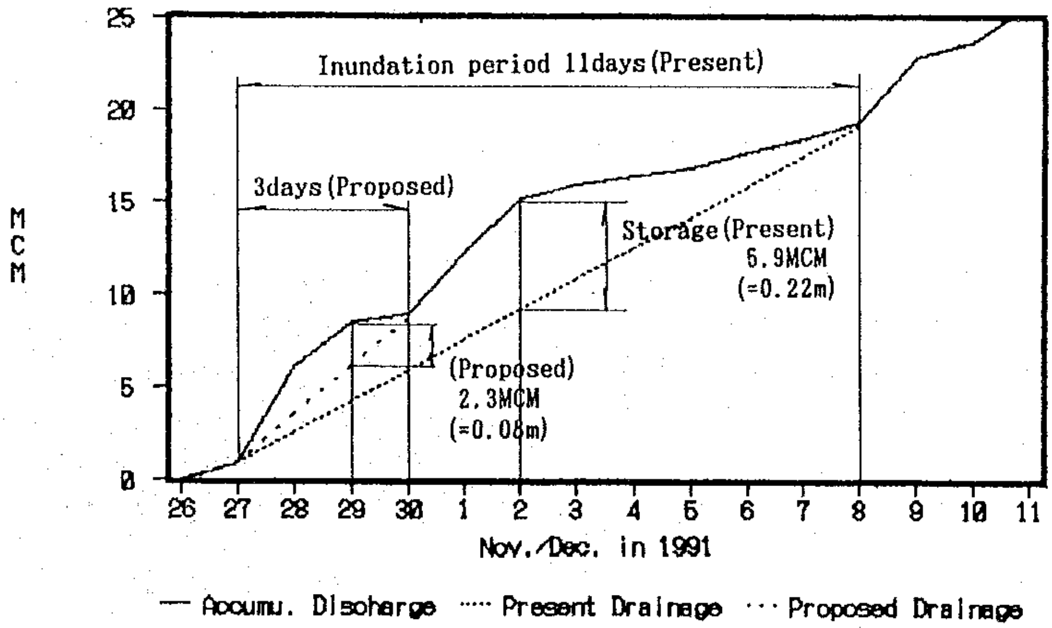


FIGURE 8-6 INUNDATION ANALYSIS IN PROJECT AREA

(W = 1/10 RAINFALL)



(DEC. 1991 FLOOD)



shortages have periodically occurred, due to inadequate water management such as over-irrigation at the upstream areas.

Under this situation, the Project Area has to rely on the reuse of drainage water from the Omoum main drain or reuse within the area to overcome water shortages. However, since the Omoum Drain Project (see Table 8-1) will start its operation in the near future, these water shortages will be dissolved by the Project. In this Project, drainage water of Omoum main drain with high salinity will be mixed with fresh-water from the Nubariya canal, and water quality after mixing will be about 700 ppm (1.1 mS/cm) in salinity. Although this water quality has no special restriction to crop cultivation, the mixed water quality should be monitored sufficiently from the viewpoint of water quality.

8.5 Agricultural Development Plan

8.5.1 Crop Selection

Crop selection for the Project was made taking into consideration the following items;

- Drainage conditions
- Soil conditions
- Quality of irrigation water
- Marketability and return

The drainage and soil improvement as well as flood control will make it possible to select a wider range of crops. The irrigation water source is a mixture of drainage water with fresh water, according to the irrigation plan. The data on reuse water quality show that the salt content in irrigation water will be kept below 1 mS/cm (700 ppm) so as to avoid any crop damages caused by the salt content. The expected value of SAR is about 7.4 as indicated below;

Quality of Irrigation Water

Item	Water Quality	Minimum Permissible Limit 1/
EC	696 ppm	750 ppm (general crops)
SAR	7.4	less than 8.0

Note: 1/ : refer to "Land Master Plan, Annex B, Irrigation and Drainage 1985, Euroconsult-Pacer" and "Guidelines: Land Evaluation for Irrigated Agriculture, FAO"

As shown in the above, there is no limitation to crop selection when the reuse water is planned. Considering the domestic market for vegetables in Alexandria as well as expant potential for vegetables to the European market, it should be possible to increase vegetable growing area with the Project.

To develop vegetable production in the Project Area, it is important to establish proper crop rotation to avoid crop damage caused by intensive cropping of vegetables. Such major crops as wheat, beans, cotton and sunflower in the present cropping pattern will be maintained to keep the necessary crop rotation. Moreover, the forage crops will be maintained as principal crops to take advantage in maintaining the soil fertility from animal husbandry.

8. 5. 2 Reduction of Flood Damage and Yield Increase

1) Reduction of Flood Damage

The proposed drainage project will reduce flood damage to crops. It will be expected that such a scale of flood damage of crops caused by the floods of December 1991 will be decreased to one third of the flood scale as shown below. Accordingly, flood damage reduction on crops by the project could be estimated at two thirds of the crop flood damage in December 1991.

It could be estimated that a flood on the scale of the December 1991 could appear every ten years when probability of consecutive rainfall is considered. Then the annual average flood reduction is calculated at 4,100 ton as shown below;

Reduction in Flood Damage

Item	Without Project	With Project	Reduction per Year
	(1)	(2)	(1-2)/10 year
Submerged Area	4,010 ha	1,340 ha	
Duration	11 days	3 days	
Crop Damage	61,579 ton	20,526 ton	4,100 ton/year

2) Increase in Unit Yield

To estimate the degree of yield improvement resulting from the drainage project, data on the yield-related groundwater table and soil salinity by type of soils is required. However, adequate data are not available, although the research work on this matter has been initiated only recently by the Drainage Research Institute (DRI). The average yield increases under the project are estimated at 5-25 percent, based on the existing data on the average yield increases attributable to subsurface tile drainage alone (refer following table). The full benefits will be attained in the fourth year as shown in Table F-2-11, Annex F.

Increase in Crop Yield

Crops	Without Project		With Project		
	Main	Second	Main	Second	Increase Rate 1/
	(ton/ha)	(ton/ha)	(ton/ha)	(ton/ha)	(%)
Winter Crops					
Wheat	4.42	3.50	5.09	4.03	15
Beans	1.99	1.46	2.39	1.75	20
Berseem, Long	53.57	-	64.29	-	20
Berseem, Short	23.57	-	28.29	-	20
Vegetables	19.05	-	23.81	-	25
Summer Crops					
Cotton	2.63	3.28	3.28	2.86	25
Maize	2.09	2.98	5.71	3.43	15
Sunflower	1.79	-	2.05	-	15
Vegetables	28.57	-	35.71	-	25

Source: 1/ : Abel-Dayem Al-saftiy, 1992, FAO/UN/World Bank, 1984 and 1991(refer to Table F-2-11, Annex F)

8.5.3 Proposed Crop Production

1) Proposed Cropping Pattern

The proposed cropping intensities in both the winter and summer seasons will increase to 100 percent, reaching an annual total intensity of 200 percent. The cropping areas of the winter and summer season vegetables will be raised to 150 percent of the present cropping area, as shown in Figure 8-8, considering the expected marketing conditions for vegetables.

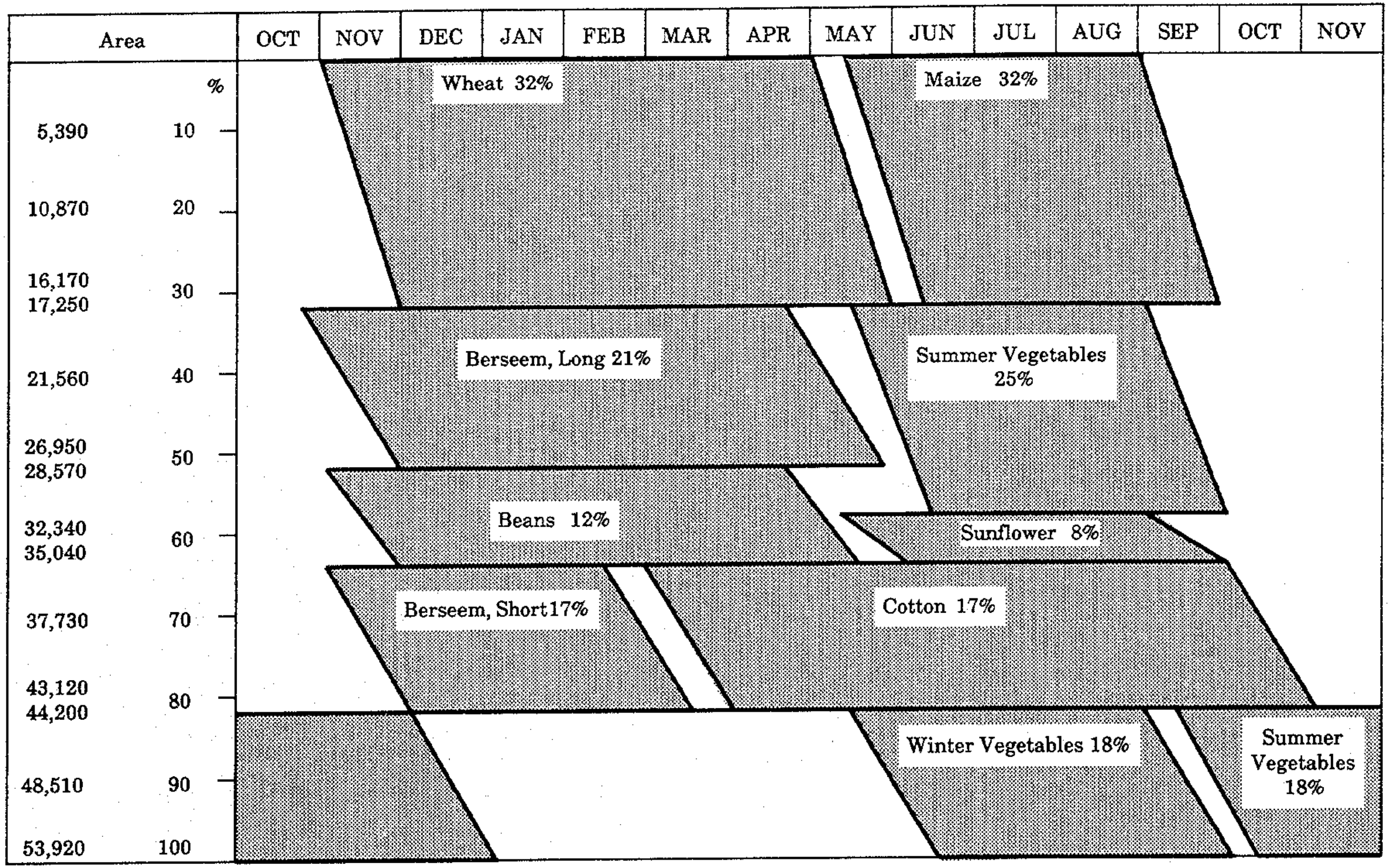
2) Crop Production

Following the proposed cropping pattern and the expected yield increase, it could be estimated that about 956,400 ton of crops will be produced on an expanded cropping area of about 107,860 feddan (45,300 ha), which represents an increase of about 50 percent compared with the present area as shown below;

Crop Production in Project Area

Crops	Cropping Rate	Cropped Area	Unit	Production
	(%)	(ha)	(ton/ha)	(ton)
Cultivated Area = 22,650 ha	100			
Winter Crops				
Wheat	32	7,250	5.09	36,958
Beans	12	2,720	2.39	6,289
Berseem, Long	21	4,750	64.29	305,640
Berseem, Short	17	3,850	28.29	108,821
Vegetables	18	4,080	23.81	97,145
Sub-total	100	22,650		550,853
Summer Crops				
Cotton (raw)	17	3,850	3.28	12,624
Maize	32	7,250	5.71	41,393
Sunflower	8	1,810	2.05	3,707
Vegetables	43	9,740	35.71	347,815
Sub-total	100	22,650		405,539
Total	200	45,300		956,392

FIGURE 8-7 PROPOSED CROPPING PATTERNS IN PROJECT AREA



8.5.4 Farm Management Plan

The farm management scale for a typical owner-farm household is estimated as follows, based on the average farm size of 4.2 feddan(1.8 ha);

Typical Scale of Farm Management

Items	Area (ha)	Area (feddan)
Cultivated Area (owned land)	1.8	4.2
Crop and Cropped Area		
(1) Winter Crops		
- Wheat	0.6	1.3
- Beans	0.2	0.5
- Berseem, Long	0.4	0.9
- Berseem, Short	0.3	0.7
- Vegetables	0.3	0.8
Sub-total	1.8	4.2
(2) Summer Crops		
- Cotton	0.3	0.7
- Maize	0.6	1.4
- Sunflower	0.1	0.3
- Vegetables	0.8	1.8
Sub-total	1.8	4.2
Total	3.6	8.4

8.5.5 Agricultural Supporting Service Plan

It is indispensable to have proper on-farm irrigation and drainage development as well as effective operation and maintenance. In this connection, it is important for the farmers to organize functional farmers' organization for operation and maintenance of on-farm irrigation and drainage systems prior to the implementing stage.

To cope with the requirement mentioned above, the agricultural extension activities provided by the MALRF agricultural offices should be extended to farmers in close coordination with the activities of the Drainage Advisory Unit. Then, it is proposed to implement MALRF agricultural extension staff training on soil and drainage improvement in the project.

In connection with the on-farm facility improvement, which is under the responsibility of farmer's groups, if no realization of farmers' organization to participate the improvement works for drainage facilities and operation and maintenance, and also of raising of management ability of the organization were taken place in the Project, the objectives of the drainage improvement will not be achieved. Furthermore, if sufficient agricultural supporting services for agricultural extension and agricultural marketing for the increased crop production were not extended to the farmers, the Project will not also attain the objectives of the Project.

There will be the following two items of risk due to inadequate agricultural supporting services;

- Difficulty in attainment of target yields due to poor operation and maintenance for on-farm facilities

  The groundwater table will not be adequately controlled with a depth deeper than 120 cm below ground surface, when the operation and maintenance of on-farm facilities such as subsurface tile drains will not be well undertaken by Drainage Users' Groups and/or Association. Under the situation, drainage conditions at on-farm level as well as sodic and saline soils would not be maintained adequately to attain the proposed target yield of crops.

- Lower farm gate price under the current marketing systems

  If current marketing systems relying upon private shipping of crops to the markets or selling the products to middlemen with lower price would not be improved, the selling price of agricultural crops will be kept to be low level. Especially, the products to be exported will not be sold at a reasonable price without setting up quality standardization for the export, if the prevailing marketing systems for export would not be improved substantially.

Although it will be difficult to analyze the risk quantitatively for attainment of target yield, it could be said that the crop production profits would be reduced significantly, if the above two items will occur at the same time.

8.5.6 Marketing Plan

Project implementation will contribute to increasing the production of vegetables (both the summer and winter season crops). At the end of the 9th year, the targeted production will increase from 255,000 ton to 445,000 ton, an increase of 75 percent. Since the Project Area is close to Alexandria, the second largest city for shipping vegetables, it can be expected to export some vegetables to Europe and the neighboring Middle Eastern countries, and to further increase its share of future exports.

The problem of vegetable marketing abroad lies in the marketing system itself. At present traders buy vegetables at substantially lower prices from farmers. In order to increase the distributional share of profits for farmers cooperatives, farmers must share export profits.

No cooperatives are organized to handle the export of vegetables. It is strongly recommended that for cooperatives specializing in network of sales and exports with farmers, as seen in other areas, some existing specializing cooperatives are organized under the guidance of MALRF. The objectives of cooperatives are to set up quality standardization for exports, price shares, financial arrangements and advice to farmers.

CHAPTER IX. PROJECT ENGINEERING

CHAPTER IX. PROJECT ENGINEERING

9.1 Open Drains and Roads

9.1.1 Drains and Related Facilities in the Area

1) Project Facilities

The following facilities are proposed in the Project Area.

i) Improvement of Hares main drain (including El-Hager Siphon)
ii) Improvement of branch drains
iii) Improvement/construction of maintenance roads and bridges

The necessity of improvement and planning of the above mentioned facilities are described below.

2) Necessity of Improvement

a) Difference of Design Discharges

The Hares main drain and other branch drains in the Area were constructed for a maximum discharge of 26 cu.m/sec (on the basis of an unit discharge of 33 cu.m/feddan/day). The Project has proposed a new maximum discharge of 30 cu.m/sec (41 cu.m/s/feddan/day) and for smooth operation of future subsurface drainage, lower water levels in the main and branch drains will be a prerequisite. Therefore, improvement of drains will be essential.

b) Safe Passage for Drainage Discharge

There are two structures in the Hares main drain, namely, El-Hager siphon and Khalt siphon. Khalt siphon is relatively new and capable of handling the proposed discharge. But El-Hager siphon is about 20 years old and lack of maintenance has caused sedimentation in the siphon and loss of design capacity. Therefore, replacement of this siphon has become essential for a smooth discharge in Hares main drain.

Also, for proper maintenance of the facilities, provision of maintenance roads and bridges is essential.

3) Hydraulic Conditions for Design

- Drain Type and Shape : Unlined trapezoidal with a side slope of 1 : 1.5
- Permissible velocity : 0.7 m/sec - 0.3 m/sec
- Roughness coefficient : 0.025
- Free board : Considering subsurface tile drain, the range will be 2.5 m - 1.65 m.

4) Hares Main Drain

a) Basic Criteria for Planning

- With a design unit discharge of 41 cu.m/feddan/day, maximum design discharge would be 30 cu.m/sec.
- Suction water level of Hares pumping station would be (-) 6.0 m.MSL.
- Head losses due to Khalt and El-Hager siphons would be increased to 0.15 m each from their present losses of 0.12 m.
- In principle, improvement works will be limited only to deepening the drain bed, if unavoidable, expansion only within the presently available land may be taken place.

b) Design Drainage Discharge and Cross-Sections

According to the design drainage discharges, appropriate cross sections are selected and presented below (refer to Table G-3-1, AnnexG).

Proposed Longitudinal and Cross Sections of Hares Main Drain

Drain Type	Distance	Length	Catchment Area	Design Discharge	Bed Width	Slope	Flow Depth	Flow Velocity
	(km)	(km)	(feddan)	(cu.m/sec)	(m)	(cm/km)	(m)	(m/sec)
1	0~0.5	0.5	63,300	30.0	18	8	2.45	0.564
2	0.5~7.0	6.5	55,400	26.3	16	8	2.43	0.553
3	7.0~10.0	3.0	51,330	24.4	13	10	2.43	0.604
4	10.0~12.5	2.5	45,400	21.5	10	12	2.43	0.643
5	12.5~14.5	2.0	32,400	15.4	9	13	2.09	0.607
6	14.5~18.0	3.5	21,770	10.3	6	15	1.95	0.594
7	18.0~20.0	2.0	19,940	9.5	6	15	1.86	0.580
8	20.0~21.0	1.0	12,800	6.1	4	15	1.74	0.529
9	21.0~24.0	3.0	4,710	2.2	2	15	1.33	0.415

Note: See Figure 9-1.

5) Branch Drains

a) Basic Criteria for Planning

- As the outlets of the future subsurface tile drains will be designed in the range of 2.50 - 1.65 m below the ground surface, therefore, for an effective drainage system, the water level of branch drains should be below that range.
- In principle, improvement of cross sections of the drain should be done giving preference to the existing shape, and expansion work should be limited to the deepening of drain beds.

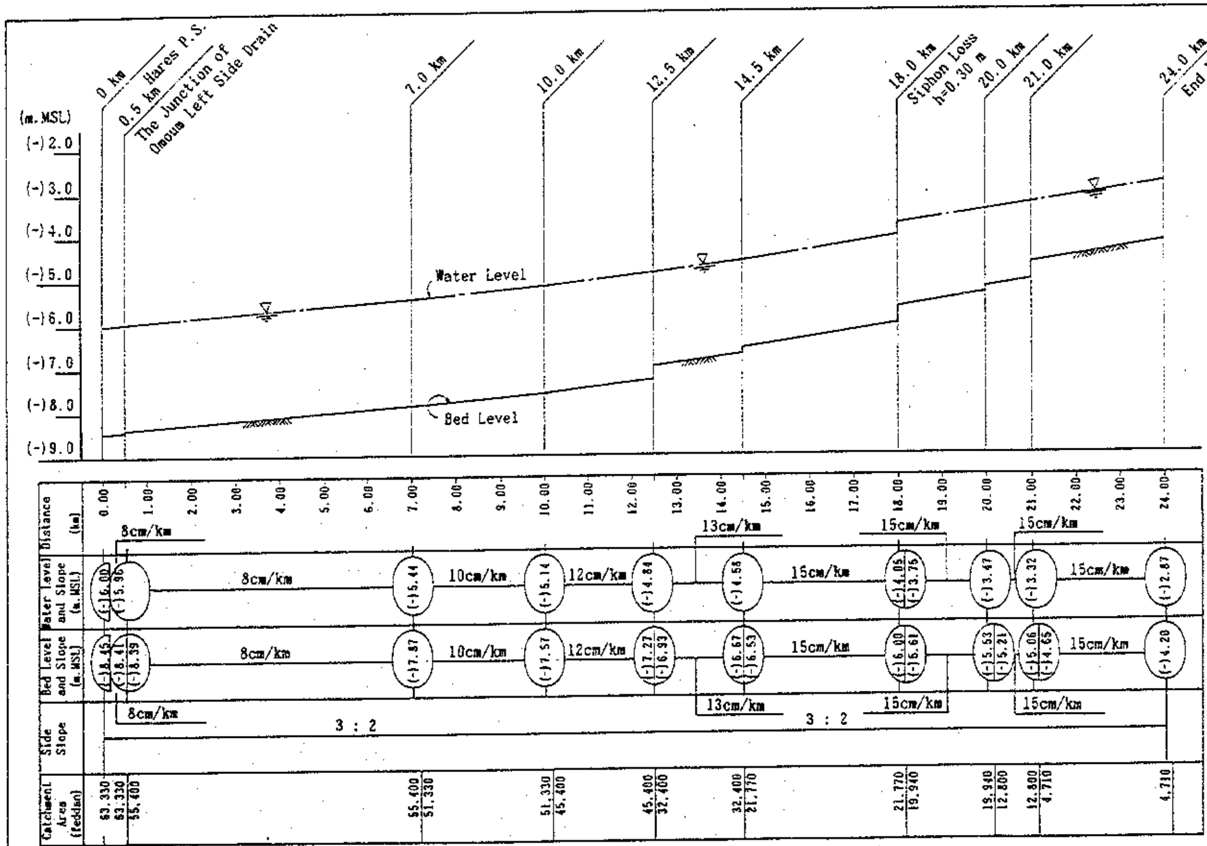
b) Design Drainage Discharge and Cross Sections

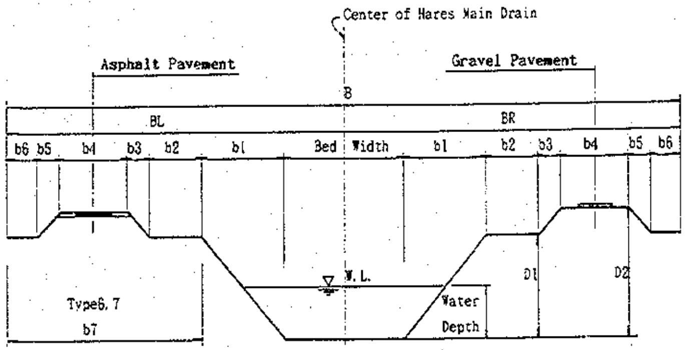
Required branch drain cross sections according to the design discharge are presented below;

Proposed Longitudinal and Cross Sections of Branch Drains

No. and Total Length	Catchment Area	Design Discharge	Bed Width	Slope	Flow Depth	Flow Velocity
	(feddan)	(cu.m/sec)	(m)	(cm/km)	(m)	(m/sec)
24, L=113 km	900-11,000	0.4-5.2	1.0-4.0	5-30	0.63-1.79	0.30-0.68

Note: Details are presented in Table G-3-2, Annex G.





DIMENSION TABLE of HARES MAIN DRAIN

Type	Discharge (cum/sec)	Bed Width (m)	Side Slope	Bed Slope	Water Depth (m)	Velocity (m/sec)
Type-1	33.0	13	1:1.5	8cm/km	2.45	0.564
Type-2	26.3	16	1:1.5	8cm/km	2.43	0.553
Type-3	24.4	13	1:1.5	10cm/km	2.43	0.604
Type-4	21.5	10	1:1.5	12cm/km	2.43	0.643
Type-5	15.4	9	1:1.5	13cm/km	2.09	0.607
Type-6	10.3	6	1:1.5	15cm/km	1.95	0.594
Type-7	9.5	6	1:1.5	15cm/km	1.86	0.580
Type-8	6.1	4	1:1.5	15cm/km	1.74	0.529
Type-9	2.2	2	1:1.5	15cm/km	1.33	0.415

0 — 5 m
Vert. 1/100

0 — 5 Km
Hori. 1/100.000

Scale of Longitudinal Section

Type	B (m)	BR (m)	BL (m)	b1 (m)	b2 (m)	b3 (m)	b4 (m)	b5 (m)	b6 (m)	b7 (m)	D1 (m)	D2 (m)
Type-1	68.0	34.0	34.0	8.55	5.00	1.50	6.00	1.50	2.45	—	5.70	6.80
Type-2	64.0	32.0	32.0	8.10	5.00	1.50	6.00	1.50	1.90	—	5.40	6.40
Type-3	62.0	31.0	31.0	7.80	5.00	1.50	6.00	1.50	2.70	—	5.20	6.20
Type-4	56.0	28.0	28.0	7.30	5.00	1.50	6.00	1.50	1.70	—	4.85	5.85
Type-5	52.0	26.0	26.0	6.50	5.00	1.50	6.00	1.50	2.50	—	4.35	5.35
Type-6, 7	54.0	27.0	27.0	7.70	5.00	1.50	6.00	1.50	2.30	—	5.15	6.15
Type-8	39.0	23.0	16.0	6.30	5.00	1.50	6.00	1.50	2.70	2.75	4.20	5.20
Type-9	39.0	22.5	16.5	6.45	5.00	1.50	6.00	1.50	3.05	4.05	4.30	5.30

ARAB REPUBLIC OF EGYPT
MINISTRY OF PUBLIC WORKS AND WATER RESOURCES

FARMLAND ENVIRONMENTAL IMPROVEMENT PROJECT IN OMOUM AREA

HARES MAIN DRAIN
PROPOSED LONGITUDINAL AND CROSS SECTION

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE 9-1 PROPOSED LONGITUDINAL SECTION OF HARES MAIN DRAIN

6) El-Hager Siphon

As was previously described, replacement of this siphon is proposed.

a) Design Drainage Discharge

On the basis of proposed unit drainage discharge, design discharge at the siphon is calculated as follows.

Location	Catchment Area	Design Discharge
(distance from Hares P.S.)	(feddan)	(cu.m/sec)
18.09-18.15 km	19,940	9.5

b) Structure and Size

- The structure of this siphon will be of the reinforced concrete type the same as the Khalt siphon.
- On the basis of hydraulic analysis, the proposed diameter is 1,800 mm with three lanes. Considering existing conditions, length has been fixed at 58 m with a head loss of 15 cm (refer to Table G-3-3, Annex G).

9. 1. 2 Maintenance Roads

At present maintenance roads in the area are inadequate. With some exceptions they are provided only on one side of the canals/drains. Moreover, lack of maintenance has caused the surfaces of these roads to deteriorate. Local people have no alternative but to use them. Therefore, an improvement plan for old roads, construction of new roads and necessary connecting bridges is proposed.

1) Maintenance Roads

a) Functions

- Maintenance : These roads will be used for such maintenance work as cleaning of weeds from the canals/drains, and as access to check other facilities.

- Others : Also they will be used as connecting roads between the villages for inhabitant's daily or agricultural needs.

b) Pavement and Proposed Length

- Width : 6 m (effective width 5 m)
- Pavement (gravel) : 20 cm thickness

  (asphalt) : 15 cm thickness for lower course (mixed with gravel), 10 cm thickness for upper course (grading controlled with crushed stone) and 5 cm thickness of only asphalt

Pavement Type	Location	Length
		(km)
Gravel	along the Hares main drain	24.00
	along the branch drains	74.95
	Total	98.95
Asphalt	along the Hares main drain	24.00
	along the Hares branch drain (No.3)	2.00
	Total	26.00

Details are presented in Table G-3-4, Annex-G.

2) Bridges

a) Bridge Type and Required Numbers

Bride width would be six meter with concrete structure. According to the span length, they have been divided into four groups considering the local environment. Selection has been made as follows;

Type	Bridge Length	Length (Spans)	Required Number
	(m)	(m)	
A	14	3-8-3=14	1
B	16	3-10-3=16	2
C	18	3-12-3=18	2
D	8	single span	17

Details are presented in Table G-3-5, Annex G.

9. 2 On-Farm Facilities and Subsurface Tile Drains

Except for a few scattered areas there are no on-farm drainage facilities. Therefore, to facilitate drainage at the on-farm level more field drains should be constructed. The size would be the same as the existing ones, that is unlined ditches with 30 cm bed width and 60 cm depth.

There are no subsurface tile drains in the Area, but in a pilot area various experiments are taking place. Considering the future implementation plan a sample area for new lateral spacing is proposed with the following details.

- Sample area : Omoum No.2 area
- Branch drain : Branch drain No.2
- Position of collector outlet : 2.985 km from Omoum left side drain
- Catchment area of sample area : 151 feddan
- Lateral spacing : 30 m (ref. to paragraph 8.4.2)
- Collector diameter, slope and area : EPADP standard will be followed. (refer to Table G-3-6, Annex G)

9. 3 Hares Pump Facilities

1) Design Policy

Four units of inclined shaft axial flow pump with diameters of 1,800 mm with a total pump capacity of 24 cu.m/sec, are in operation in the existing Hares pumping station. However, the existing pumping station is facing a shortage of pump capacity resulting from the decreased pump capacity due to overage (27 years have been passed since operations started) and the increase of drainage discharge due to new area development in the drainage block.

The new pumping station with a total capacity of 30 cu.m/sec, is to be constructed considering the present design standards on drainage development in the concerned block. The existing pumping station is to be demolished. Meanwhile, the Hares pumping station drains some of its water into Mariut

Lake in order to maintain its water level and to conserve water quality. However, according to the proposed plan, all water has to be drained into Mariut Lake as requested by the EPADP.

2) Design Dimension and Design Criteria

a) Design Dimension

Drainage Area	:	A=63,330 feddans (26,600 ha)
Design Discharge	:	Q=30.00 cu.m/sec
Design Suction Water Level	:	NWL. (-)5.75 m.MSL
	:	LWL. (-)6.00 m.MSL
Design Delivery Water Level (Mariut Lake)	:	NWL. (-)2.40 m.MSL
Location of Pumping Station	:	Just upstream of the existing pumping station

b) Number of Pumps

Generally, the number of pumps is fixed, considering the design conditions like discharge, discharge characteristics, capacity of drainage channels, etc., economy (construction costs and O/M costs) and operation/ maintenance. Moreover, generally, the smaller the number of pumps is, the cheeper the construction cost. On the other hand, it is obliged to adjust the pump operation hours must be adjusted following the fluctuation of flow in the case of smaller number of pumps are fixed. Although the same pump size with the pump per unit capacity of eight cu.m/sec is employed in the existing pumps, EPADP requested the introduction of the combination of different pump sizes. The same pump size are used for the selection of the number of pumps by MED bor the convenience in procurement of equipment parts and the management.

The comparative studies are carried out for four to seven unit plans including the different combinations of pump sizes, although two to four units with same pump size are generally adopted in Egypt in cases where the design discharge is less than 30 cu.m/sec.

c) Pump Type

The pump type will be fixed, considering the design discharge, the total head, the suction head and the revolution. The vertical shaft (inclined shaft) axial flow or mixed flow pump will be adopted from the viewpoint of the cavitation in the case of a rather large pump capacity, the low head (less than 5.0 m) and large suction head.

The inclined shaft axial flow pump is adopted as it is the most often employed as a drainage pump under similar design conditions in the Nile Delta, although the vertical shaft mixed flow pump has greater advantage in operation and the required pump house area. On the other hand, the vertical types have recently become more popular in the Project by the Irrigation Department.

d) Pump Diameter

Pumps with same pump size and type have more advantage from the viewpoint of economy and operation/maintenance. The stand-by unit will be provided for diversification of risks depending upon the importance of facilities. One stand-by unit is to be provided, following the current practice whereby each pumping station has one stand-by unit from the viewpoint of the procurement of main pump equipment parts and the operation/maintenance because they are foreign-made. The following pump diameter will be adopted depending on the current practice in the Study Area.

Pump Discharge and Diameter

Discharge (cu.m/sec)	Diameter (mm)	Velocity (m/sec)	Discharge (cu.m/sec)	Diameter (mm)	Velocity (m/sec)
2.00~2.50	1,000	2.55~3.18	6.00~7.50	1,650	2.81~3.51
2.50~4.00	1,200	2.21~3.54	7.50~9.00	1,800	2.95~3.54
4.00~5.00	1,350	2.79~3.49	9.00~11.00	2,000	2.86~3.50
5.00~6.00	1,500	2.83~3.40	11.00~15.00	2,300	2.65~3.61

3) Selection of Required Numbers of Pumps and Their Diameters

The following cases are examined in the maximum drainage discharge, the characteristics of drainage discharge and drainage canal, the size of pump house and other structures including the construction costs and the O/M costs. (refer to Annex G2)

a) Comparative Study

Case	Pump Capacity	Number of Pumps
	(cu.m/sec/unit)	(unit)
1-1	10.0	4 (including 1 stand-by)
1-2	7.5	5 (including 1 stand-by)
1-3	6.0	6 (including 1 stand-by)
2-1	10.0	3 (including 1 stand-by)
	5.0	2
2-2	7.5	4 (including 1 stand-by)
	3.75	2
2-3	6.0	5 (including 1 stand-by)
	3.0	2
2-4	10.0	1
	7.0	4 (including 1 stand-by)

b) Design Discharge

The discharge in the Hares pumping station is mainly the normal discharge from excess irrigation water, except during the rainy season in winter. The maximum design discharge of 30 cu.m/sec with a probability of once every ten years, while in a normal year the maximum discharge is 20.9 cu.m/sec (in July) with a probability of once every two years. The difference between the discharges is 9.1 cu.m/sec and about 30 percent of the design discharge. The maximum discharge is taken into consideration for the selection of the number of pumps with the same pump diameter. Case 2-4 represents a plan for the exclusive case of flood occurrence.

c) Discharge Characteristics

The maximum and minimum monthly discharges are 20.9 cu.m/sec for July and 6.7 cu.m/sec for October respectively as shown below;

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Design Flood
Discharge (cu.m/sec)	11.6	12.4	10.5	12.0	13.8	16.2	20.9	19.4	11.6	6.7	11.2	15.3	30.0

The minimum discharge is 23 percent of the maximum discharge and it is therefore the four unit plan which is the most advantage one. The effectiveness for each plan is examined in relation to the operating costs as shown in the table of item g). The higher value in the table shows the greater saving in relation to the power tariff.

d) Drain Characteristics

The Hares main drain is connected directly to the pump house without the flood storage basin. Moreover, the bottom elevation of the existing inlet canal equals that of the inlet of suction pit, so that it is necessary to deepen the inlet canal. Problems arise in the improvement of the existing approach canal and the maintenance of sedimentation in which case a larger pump size will be adopted. Accordingly, it is desirable that the new pump has the same pump size as the existing one.

e) Structure Size

Width of Inlet Canal

The cross sectional area of the inlet canal is fixed, considering the standard flow velocity of the canal (0.75 m/sec in front of the trashrack), the required submerged depth of suction mouth (2×pump diameter) and the required width occupied by a pump. The standard widths of the inlet canal are as follows:

Pump Diameter (mm)	Width (m)	Pump Diameter (mm)	Width (m)
1,100~1,650	3.00	2,300	4.00
1,800	3.30	2,500	4.50
2,000	3.50		

Length of Each Structure

The length of each structure is fixed, considering the required space for equipment, the required length of transition and allowances for maintenance.

Inlet Canal	:	Min. 3.00 m for the trash racks and min. 5.5 m for the stop-log
Pump Room	:	Spaces for the mechanical and electrical equipment and the operation/maintenance
Outlet basin	:	9.5 m in total consisting of 5.0 m for the flap valve, 3.0 m for the stop-log and 1.5 m for the operation/ maintenance platform

Elevation

The floor elevation of the pumping room is fixed at EL (-) 1.20 m.MSL considering the ground level of surrounding area (EL (-)2.00 m.MSL: the existing, EL (-) 2.40 m.MSL: Mariut water level), while the top elevation of the concrete wall in the inlet canal is fixed at EL (-) 4.75 m.MSL (EL (-) 5.25 m.MSL : the existing, EL (-) 5.75 m.MSL : design suction water level).

Pump Building

The space for the entrance and the disassembly/repair with a span of four meters is provided on both sides of the pump room.

f) Construction Cost

The construction costs of civil/architectural structures for each case are roughly estimated based on estimates of quantities such as earth-works and concrete works. The results are shown in the table of item g).

The unit prices are the same as those applied for the project cost estimates, while the percentage to the direct construction costs are applied for the estimates of temporary works and appurtenant works.

g) Comparison Results

Results of Comparison Study

Case	Pumps Diameter	Pumps Discharge	Pumps No. of Pumps	Pump Room Width	Pump Room Length	Pump Room Height	Efficiency of Pump	Construction Cost
	(mm)	(cum/s/unit)	(Unit)	(m)	(m)	(m)		('1000LE)
1-1	ø2,000	10.0	4(1)	16.7	14.9	9.9	0.67	32,100
1-2	ø1,650	7.5	5(1)	18.2	14.3	9.4	0.80	32,800
1-3	ø1,500	6.0	6(1)	21.7	13.8	8.8	0.85	34,200
2-1	ø2,000	10.0	3(1)	19.7	14.9	9.9	0.81	34,200
	ø1,350	5.0	2					
2-2	ø1,650	7.5	3(1)	21.7	14.3	9.4	0.85	35,000
	ø1,200	3.75	2					
2-3	ø1,500	6.0	5(1)	25.2	13.5	8.7	0.91	37,400
	ø1,200	3.0	2					
2-4	ø2,000	9.0	1	18.5	15.6	9.5	0.88	31,300
	ø1,650	7.0	4(1)					

From the above table, the following can be ascertained:

- The greater the numbers of pumps, the greater the efficiency of the pumps.
- The smaller the numbers of pumps, the cheaper the construction costs.
- The difference of construction cost for each case is within 10 percent except Case 2-1.
- Regarding the selection of the number of pumps with differing pump diameters, there is not much difference in the efficiency of pumps from case to case because the minimum discharge is 6.7 cu.m/sec and about 20 percent difference on the construction cost between Case 2-4 (the maximum) and Case 2-3 (the minimum).
- Case 2-3 has the biggest advantage in terms of the effectiveness of pump, while Case 2-4 has the biggest advantage in terms of the construction cost.
- Case 2-4, 1-2 and 1-3 have the advantage of both effectiveness of pumps and construction costs.

From these cases, Case 1-2 is the most suitable for selection, considering that Case 2-4 has a problem about a stand-by unit.

4) Specification of the Selected Pump

- Pump
  - Type/Number : Inclined shaft axial flow pump/four units
  - Design Capacity : 7.50 cu.m/s/unit
  - Static Head : 3.55 m
  - Total Head : 4.00 m

- Motor
  - Output/Number : 430kw/unit×4 units

- Ancillary Equipment : Overhead crane, flap valve, trash racks, stop-log, floor drainage pump etc..

- Electrical Facilities : Equivalent or more than existing facilities

CHAPTER X. PROJECT IMPLEMENTATION AND OPERATION

CHAPTER X. PROJECT IMPLEMENTATION AND OPERATION

10. 1 Project Implementation

10. 1. 1 Executing Agencies of the Project

The main executing agencies of the project will be EPADP and MED under the Ministry of Public Works and Water Resources, which have sufficient capability and long experience in carrying out detailed design, construction of civil works and operation and maintenance (O&M) of the completed facilities of the project. EPADP deals with drain and subsurface tile drain works and, on the other hand, MED is responsible for drainage pump-works, respectively.

These executing agencies will implement the detailed design for major project facilities recruiting a consulting firm, the construction contracting with a competing contractor and the operation and maintenance guiding drainage user' association.

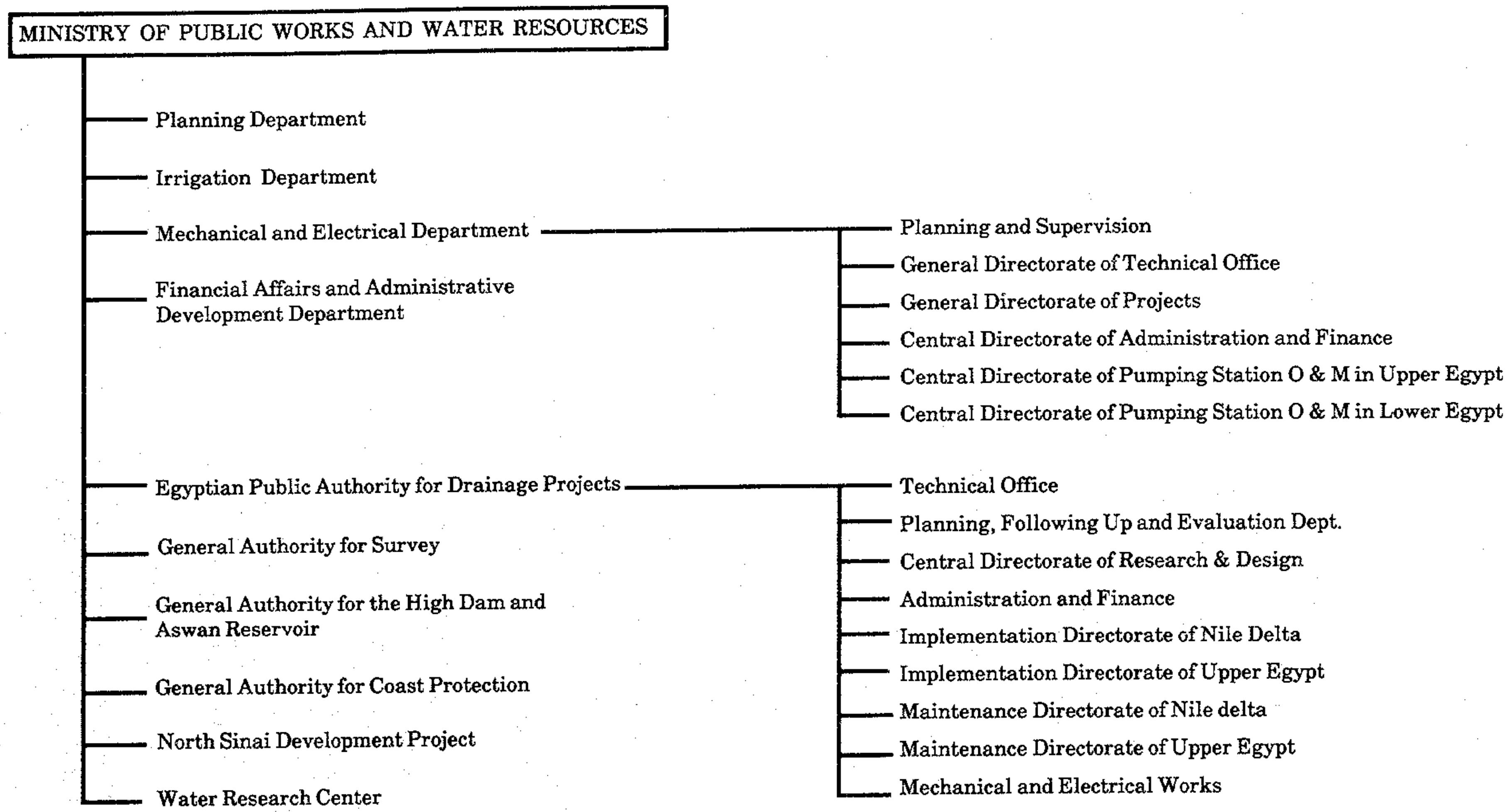
The organization of EPADP and MED is shown in Figure 10-1. Among these organizations, detailed design, implementation and O & M of drain and subsurface tile drain works will be undertaken by the Central Directorate of Research and Design, Implementation Directorate of Nile Delta and Maintenance Directorate of Nile Delta, respectively. Regarding pump works, Central Directorate of Project will undertake the detailed design and implementation, while Central Directorate of Pumping Station O & M in Lower Egypt will implement O & M works of the pump facilities.

Agricultural supporting services for the farmers and soil improvement works are currently being undertaken by the Ministry of Agriculture, Land Reclamation and Fishery (MALRF), so that close coordination with the MALRF will be essential.

10. 1. 2 Financing

The foreign currency portion of the project costs will be financed by an international financing agency, while the local currency portion will be provided by the Egyptian Government.

FIGURE 10 - 1 ORGANIZATION CHART FOR MINISTRY OF PUBLIC WORKS AND WATER RESOURCES



10. 1. 3 Construction Mode

A qualified contractor to construct the project's civil work will be selected by international competitive bidding. Although operation and maintenance works of on-farm facilities and subsurface tile drain in the Project Area will be the responsibility of farmers' group to be newly established in the Project Area, with technical guidance by EPADP and other government agencies concerned, the EPADP will provide these facilities.

10. 1. 4 Preparatory Works

The preparatory work for the project is composed of site facilities for administration of project implementation and additional survey and investigation work for the detailed design stage. The detailed descriptions of additional survey and investigation are given in subsequent paragraphs.

The site facilities for the project administration will be furnished by EPADP, before commencement of project construction.

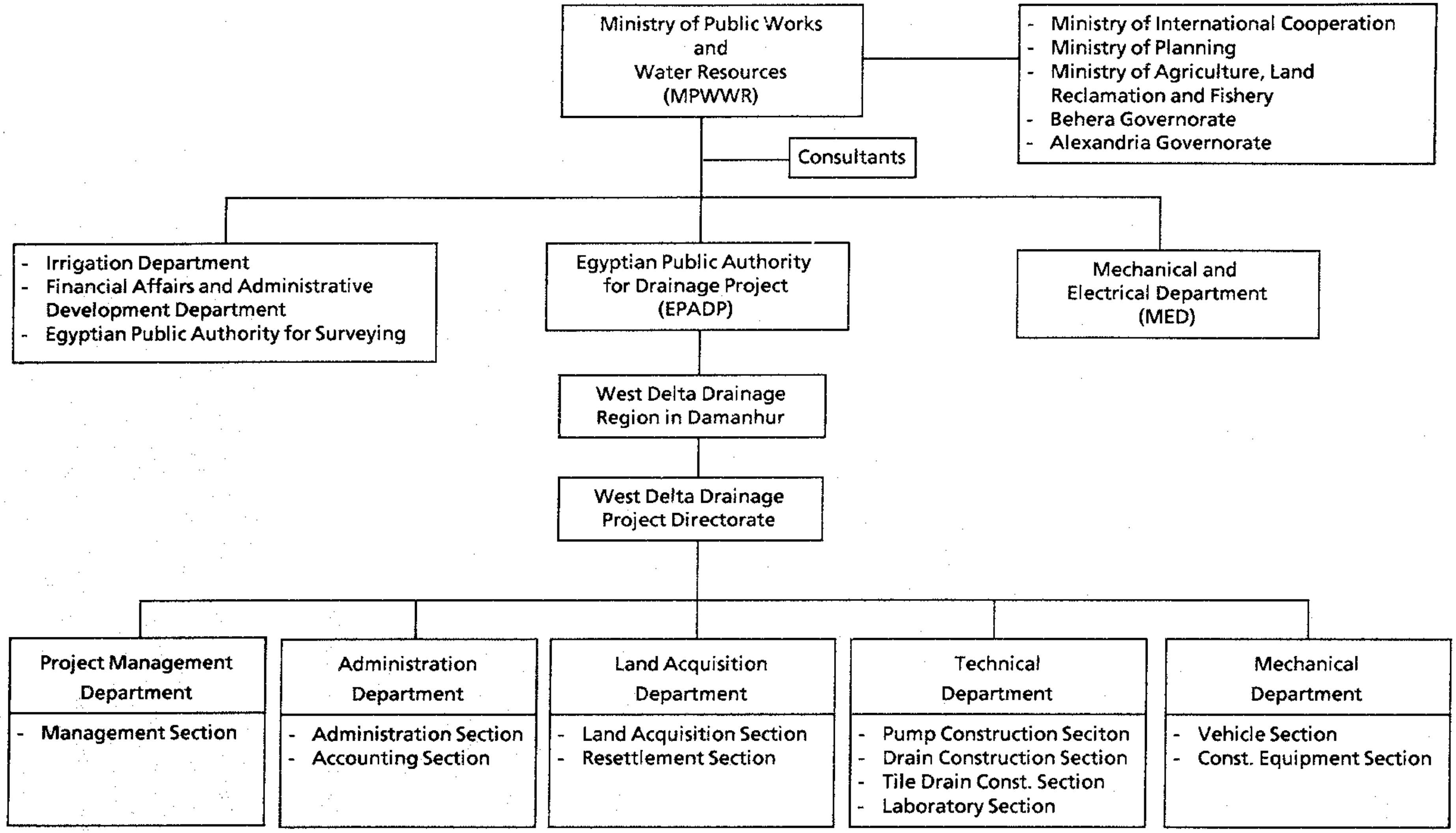
10. 1. 5 Administration Office

The proposed organization of EPADP project implementation office (West Delta Project Directorate) is proposed as shown in Figure 10-2, taking into consideration administrative and engineering works at the project site during the construction period.

10. 1. 6 Consulting Services

The EPADP, the main executive agency of the project, will employ consultants in the fields of hydrology, irrigation and drainage, geology, soil mechanics, pump, drain and structure, civil works, machinery, construction planning, bidding, project economy, and environment. The consultants will assist EPADP and MED to review the project planning, detail design of pump and drains, cost estimate, preparation of bid documents, tendering and

FIGURE 10 - 2 PROPOSED ORGANIZATION CHART FOR PROJECT IMPLEMENTATION



contracting, quality control of construction works and general supervision of the project implementation.

10.1.7 Land Acquisition and Compensation

Land acquisition and compensation for the project will be undertaken by the EPADP and MED, before the construction works are started. The following gives the estimated land acquisition and compensation areas.

Site	Area	
	Land Acquisition	Land Compensation
	(ha)	(ha)
Drain and Road Improvement	-	30.0
Pump Improvement	1.0	-
Others	-	-
Total	1.0	30.1

Since the construction site of new the Hares pumping station is located in the area surrounded by Hares main drain and Mariut Lake and without any houses, no special attention will be needed for the acquisition of land. On the other hand, improvement of drains and roads will be implemented with a temporary placement of excavated materials on the adjacent fields, so that only a minimum compensation for using the fields should be taken into consideration.

10.2 Construction Plan

10.2.1 Drains and Roads

1) Outline of the Construction Works

The construction works proposed for the Project Area are as follows.

- Improvement of Hares main drain including El-Hager siphon
- Pavement of O&M roads, and construction/improvement of the bridges

The O&M roads of these drains will be used as access roads to the respective construction sites, but careful attention should be paid to safety during the construction work, since the surface of the roads is very muddy due to lack of maintenance.

The major quantity of construction works are given below;

<u>Hares Main Drain</u>

- Civil Works

Excavation	:	1,308,000 cu.m
Embankment	:	45,000 cu.m

<u>Branch Drains</u>

- Civil Works

Excavation	:	977,000 cu.m
Embankment	:	385,000 cu.m
Revetments	:	15,500 cu.m

<u>El-Hager Siphon</u>

- Civil Works

Excavation	:	9,800 cu.m
Back filling	:	5,800 cu.m
Temporary work	:	2,300 cu.m
Reinforced concrete	:	1,300 cu.m
Revetments	:	900 cu.m

- Pipe Material

Steel pipe (dia.= 1,800 mm)	:	125 ton

<u>Operation and Maintenance Road</u>

- Gravel pavement	:	495,000 sq.m
- Asphalt pavement	:	130,000 sq.m

<u>Bridges</u>

- Civil Works

Excavation	:	17,400 cu.m
Back filling	:	15,500 cu.m
Temporary works	:	154,000 cu.m
Reinforced concrete	:	2,900 cu.m
Revetments	:	2,800 cu.m

2) Construction Methods

- Improvement works of Hares main drain will not include construction of any diversion channel considering the work scale and site conditions. The excavation work will be done with the use of back hoe and pump dredger.

- Improvement of branch drains will be done by applying the local method and back hoe.

- Excavated material shall be transported from the construction sites by dump trucks.

- Materials obtained from dredging of Hares main drain will be dried up and used as embankment materials. O/M road body works shall be done in the same way with sufficient compaction.

- Pavement of O/M roads and construction of bridges will be given priority from the viewpoints of i) O/M services for drains and related facilities, ii) farm management, iii) road network in the area, in particular, pipe bridges will be taken up urgently.

- The construction of El-Hager siphon and bridge will require a diversion channel and a coffer-dam dewatering shall be done by using shallow pumps.

10. 2. 2 On-Farm Facilities and Subsurface Tile Drains

- To facilitate field drainage, drainage ditches with 60 cm depth, 30 cm width and with a 1:1 side slope shall be provided in the field. The density would be 1,680 m/feddan(4,000 m/ha) taking into consideration that one block is about 600 m x100 m and average farm holdings are 4.3 feddan (1.8ha).

- Construction of subsurface tile drain facilities is done mainly by the local contractors. A machine called "Inter Drain" has been imported from Holland by EPADP for laying laterals/collectors. According to the information obtained, the machine can operate 200 days per year, and has a pipe placing speed of 2,000 m/day and 800 m/day for lateral and collector, respectively. In other words the machine is able to place 400 km of laterals and 160 km of collectors per year.

10. 2. 3 Hares Pump Facilities

1) Outline of Construction Work

The new Hares pumping station is located on the left bank of Omoum main drain and just upstream from the existing pumping station. Accordingly, the new pumping station faces the Omoum main drain in the front side and Mariut Lake to the rear side. There are no problems in terms of noise and vibration during the construction because no private houses are near. However, considerable safety measures shall be taken during the construction because the left bank of the Omoum main drain plays a role as an quasi-trunk road. The village road or both banks of the Omoum main drain will be utilized as the access road to the construction site across the so-called Desert Road.

The main items of the works are as follows;

- Mechanical works : ø1,650 mm, inclined shaft axial flow pump, 5 units
- Electrical works : 430 kw, three phase wound rotor type induction motor, 5 units
- Civil/Architectural works

Dimensions of sub-structures:		Width 18.4 m, Length 38.0 m, Height 9.4 m in maximum
Ground level	:	The existing = EL (-) 1.20 m. MSL The excavated = EL (-) 10.30 m. MSL
Groundwater level	:	Mariut Lake = WL (-) 2.00 m. MSL Omoum Main Drain = WL (-) 5.30 m. MSL
Foundation works	:	R.C pile, ø 500 mm, L = 10 m/13 m, 120 piles
Excavation volumes	:	17,000 cu. m
Back fill	:	10,500 cu. m
Concrete	:	2,300 cu. m
Dimensions of superstructure	:	26.2 m × 14.3 m = 374 sq. m

The construction of substructures is an important issue in the execution of the above-mentioned works. So, the construction methods for substructures are described below.

2) Construction Methods and Sequence for Substructure

The high groundwater level is the most serious problem to be dealt with during construction work. The soils involved are silty clay with fine sand or clayey silt with a N-value ranges from five to ten. The sheet pile method will be introduced as countermeasures against groundwater and earth sheathing (top elevation of sheet pile: EL (-) 1.20 m. MSL length of sheet pile : 15.0 m). The dewatering pump with pits will be employed as a temporary drain. The hydraulic type vibro-hammer will be employed for pile-driving.

The temporary coffer dam, which will also play a role of the temporary road will be provided at Mariut Lake preceding the excavation works. The embankment materials will be borrowed from the existing soil deposits along the Omoum main drain or from the nearby area. The back-hoe will be employed for upper layer excavation, while the dragline will be used for the lower layer excavation. The excavated materials will be transported to the designated spoil bank by dump trucks. The foundation pile (ø500 mm, L = 10/13 m) will be driven at the required depth by diesel hammer. The truck mixer will be employed for the concrete mixing because of the unavailability of ready-mixed concrete in the area. The concrete will be poured by the truck crane with buckets.

3) Construction Schedule

The overall construction period will be about 18 months. The primary estimation of required time for each activities are as follows:

Site preparation work	:	1 month	
Sheet piling work	:	1 month	
Foundation piling work	:	1 month	(120 piles ÷ 11 piles/day)
Excavation work	:	3 months	(27,500 cu.m ÷ 500 cu.m/day)
Concrete work	:	4 months	(2,300 cu.m ÷ 25 cu.m/day)
Appurtenant work	:	1 month	
Super-structure work	:	4 months	
Equipment installation work	:	2 months	
Site cleaning/removal	:	1 month	
Total	:	18 months	

10.3 Implementation Schedule of the Project

The project will be implemented over seven years from 1996 to 2002, consisting of such works as the evaluation of the project by the Egyptian Government including environmental aspects, economic viability, loan procedures, detailed design and construction of civil works.

EPADP and MED will commence the detailed topographic survey and geological investigation of pumping station, drain and related works during the year 1997, after the evaluation and approval of Egyptian Government in 1996. The detailed design will be completed during the year 1998 by employing Consultants.

The construction of civil work such as the pumping station, drains and on-farm and subsurface tile drain facilities is scheduled to start in early 2000 with a construction period of three years. The construction of the pumping station will commence one-and-a half years before the completion of other major civil work.

In accordance with the above mentioned schedule, construction works will be completed by the end of 2002. Figure 10-3 shows the implementation schedule of the project.

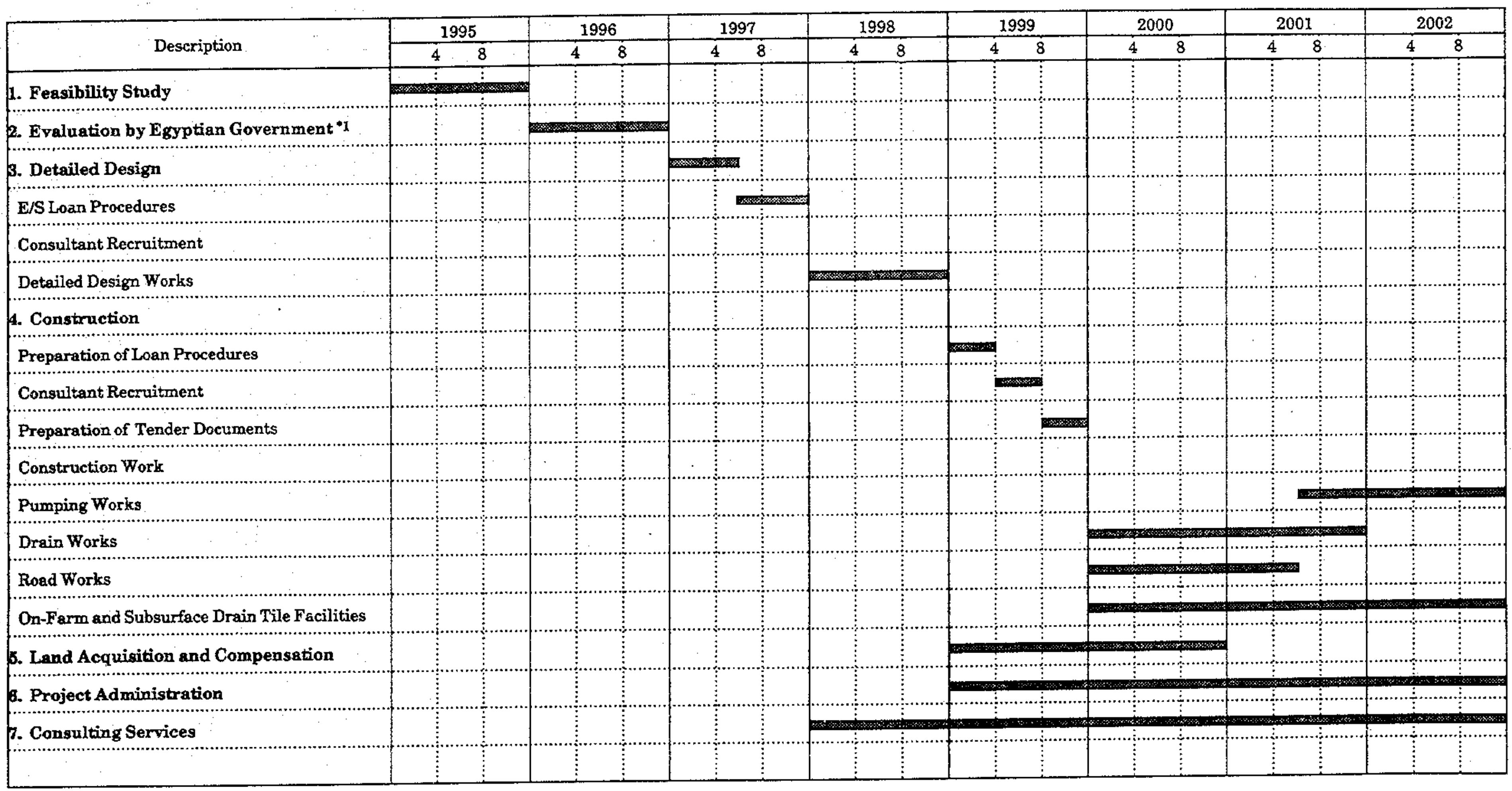
10.4 Operation and Maintenance Plan

10.4.1 Operation and Maintenance Organization

1) Organization of Government O & M Office

Operation and maintenance (O & M) of the project facilities will be the responsibility of two government agencies of EPADP and MED. Namely, O & M works of the farm facilities such as drains and roads will be carried out by the Nubariya Drainage Directorate under the jurisdiction of General Directorate for West Delta Drainage Region, EPADP, and on the other hand the O & M works of the pump facilities will be by the El-Max Directorate under the General Directorate for North West Delta, MED in Damanhur, respectively.

FIGURE 10-3 IMPLEMENTATION PROGRAM FOR THE PROJECT (PRIORITY DEVELOPMENT AREA)



*1 Including environmental aspects and economic viability

The proposed organization chart for O&M of project facilities is shown in Figure 10-4. The O&M Project Office headed by Director General consists of four Departments; Financial & Administration Affairs, Technical Office, Drainage Advisory, and Tile Drain Pipe Factory Departments. Under the O & M Project Office, three Centers headed by the Nubariya Drainage Directorate, which has the actual responsibility of operation and maintenance work, will be set up in each area averaging about 16,670 to 23,810 feddan (7,000 to 10,000 ha).

2) Organization of Farmers

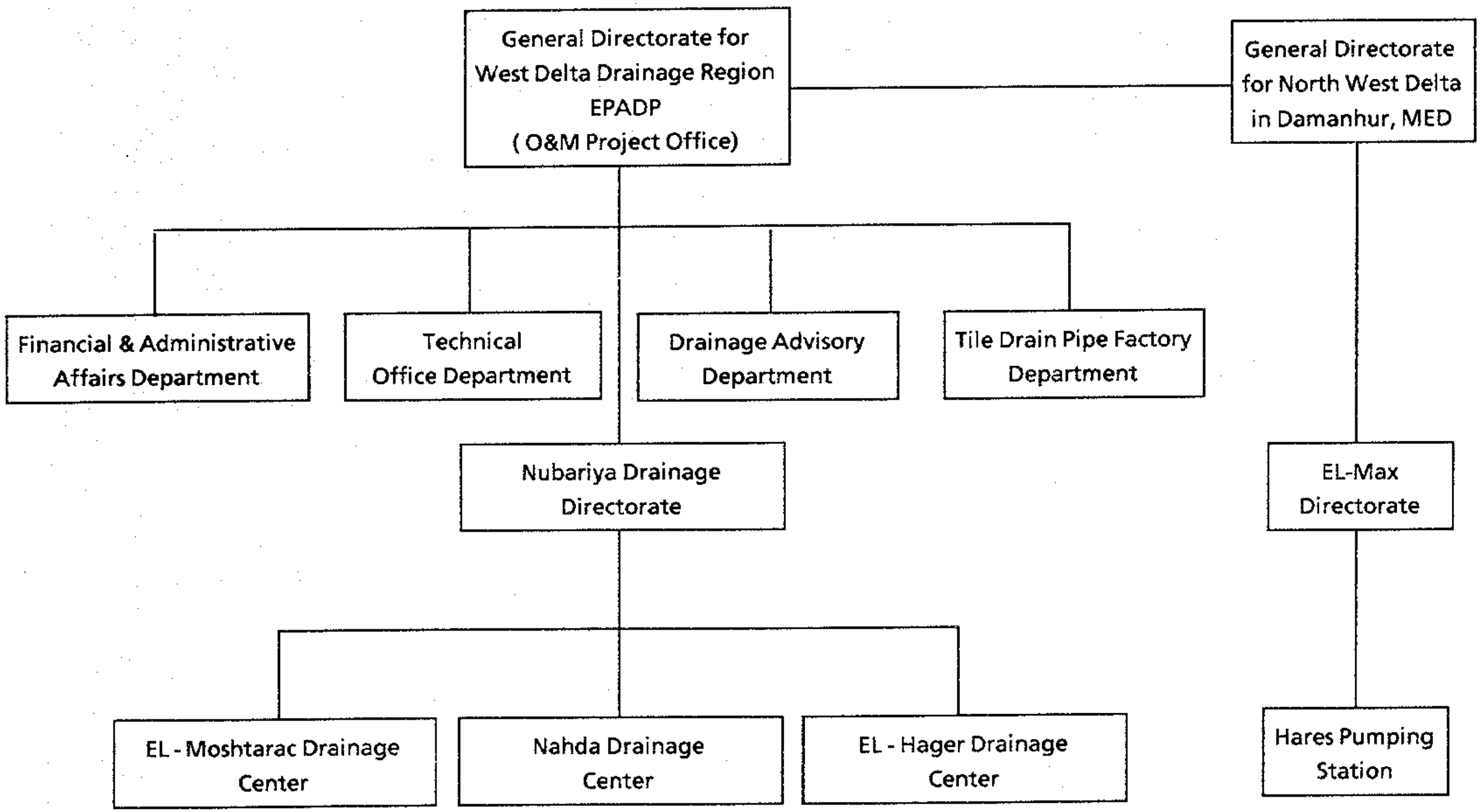
As for drainage improvement project, the farmers should actively participate in the development project of subsurface tile drain installation, and in operation and maintenance of the drainage systems at the on-farm level, as follows;

- The farmers who will benefit will organize drainage users' association at the planning stage,
- The content of the subsurface tile drain development plan will be explained sufficiently to the farmers of the association,
- The plan including location of collectors and laterals has to be approved by more than 80 percent of beneficiaries,
- The construction work will be checked by the drainage users' association, if necessary,
- The necessary data for operation and maintenance have to be recorded and maintained, namely list of constructed facilities with location map, beneficial land and farmers and so on.

During the implementation stage of the project, beneficial farmers at farm level having an average drainage area of 70 to 90 feddan (30 to 40 ha), which will correspond to one collector system in subsurface tile drain, will be organized into a Farmers' Group on the initiative and assistance by EPADP and other governmental agencies concerned. Three Farmers' Groups will be integrated into a Drainage Users' Association.

Possible close cooperation between Farmers' Groups and O&M Project Office is essential for successful day-to-day water management.

FIGURE 10 - 4 PROPOSED ORGANIZATION CHART FOR O & M OF PROJECT FACILITIES



10.4.2 Operation and Maintenance Plan

1) Planning of Seasonal Drainage

The O&M Project Office will prepare a drainage plan for each cropping season along with the proposed cropping pattern to be introduced in the area and also plan for water supply to be established by the Central Government, and will instruct them to each Drainage Center.

In the case of rainfall during the winter season, the drainage plan inclusive of pump operations for the following week will be adjusted taking into account the total amount of rainfall.

2) Maintenance Work

Periodic maintenance work for open drains is a prerequisite for satisfactory performance of both the drain and sub-surface tile drains.

Removing of silt deposit and weed cutting are the main problems in the open drain, so that these works should be done by manual or machines using draglines and excavators. These maintenance works will be carried out twice a year before summer and winter season cropping, in which maintenance works of the main systems will be carried out under the responsibility of the O&M Project Office.

Project facilities at the farm level will be done by the Drainage Users' Association to be established under the supervision of the O&M Project Office.

10.4.3 Operation and Maintenance Costs

Office and facilities provided during the construction stage will be utilized for operation and maintenance purposes. The operation and maintenance equipment will be newly provided, because the construction work will be done on a contract basis, and repair and maintenance costs will be needed.

Operation and Maintenance costs are estimated at about 1.87 million Pound (LE) per annum, and are summarized as follows;

Operation and Maintenance Costs

Description	Annual O & M Costs ('000 LE)
Salary and Wages	451.2
Administration and General Expenditure	45.1
Pump Operation Cost	291.9
Equipment Repair and Maintenance Cost	611.5
Fuel Cost	28.7
Drain Maintenance Cost	420.6
Office Maintenance Cost	20.1
Total	1,869.1

Regarding operation and maintenance (O&M) of on-farm irrigation and drainage facilities, Ministry of Public Works and Water Resources (MPWWR) will amend the legislation on recoveries of the costs for on-farm facilities. It is expected that the executive regulations will be issued before the end of January 1995. According to this amendment of the legislation, operation and maintenance costs of on-farm facilities will be burden by the farmers.

On the other hand, the construction costs of these on-farm facilities have been repaid by farmers with installment periods of 20 years. Therefore, all the required costs concerning on-farm facilities will be paid by farmers.

O & M costs for on-farm facilities will be paid by farmers directly to the Water User's Association, while the construction costs for on-farm facilities will be paid to EPADP without interest.

10.5 Additional Survey and Investigations

Additional survey and investigation for the following items are proposed to be undertaken during the detailed design stage;