however, before 1974 a movable system of a diesel engine was operated. Necessary motor power ranges from 50 to 200 kw per unit.

This pump equipment has no problems due to application of mainly local made mechanical spare-parts. However, since it is rather difficult to secure electrical spare-parts, the drainage pump is sometimes halted. During this suspensive period of the pump, a stand-by pump was operated instead of the pump to keep the function. Ordinary maintenance of equipment is carried out during the winter closure period of about three weeks in January. However, a part of pumps must be operated even during this period, because the drainage pump stations, excepting the Abu Raheb drainage pump station, have no by-pass drainage canal around the pump stations (refer to Appendix F, Table F-3-10).

The Faiyum area has a steep land slope, therefore, drainage pumps are not so important because a gravity drainage system is available. Tamia and Tagen drainage pump stations now only operated for the reuse of drainage water. The Tamia drainage pump station is now under construction by the Dutch assistance and construction works will be finished in the near future.

2) Drainage Canal

All drainage canals with side slope of 1 : 1 are unlined and bottom widths of the canals are determined based on the drainage area. In order to keep low water level for a tile drainage system, a canal depth is about four to five meters from a field surface. By using actual observed discharge data and drainage area of drainage pump stations, unit drainage discharge is analysed to range from 1.1 to 1.5 mm/day (0.12 to 0.17 lit/sec/ha) at large scale drainage pump stations and 0.3 to 2.0 mm/day (0.03 to 0.23 lit/sec/ha) at small scale drainage pump stations. The rate is low during the summer season and high in winter; it rises from 120 to 170% of the summer one in winter season. One of the reasons for this is due to poor management of water distribution.

3.3.5 *Drainage and Irrigation Pump Stations*

In the Project Area, there are nine drainage and eight irrigation pump stations. Electric motors are the mover of all the pump equipment, MED, MPWWR has been fully responsible for operation and maintenance of the pump stations. The study has been made on the basis of the data and records of pump equipment/facilities on repair/improvement history, which are kept in MED, and furthermore, hearing survey has been carried out to supplement the data and information for all the pumping stations (refer to Table F-1-17 and -18 in Appendix F).

1) Drainage Pump Stations

Although two pump stations of nine stations, El Badraman and Tona El Gabel, provide the horizontal shaft type pump units, other seven stations provide 45 degree inclined shaft type pump units. Fifty-five years have elapsed since the pump units were installed at El Badraman, and the lifting efficiency has become extremely low for total renewal of all the equipment.

After installation of the pump units at other eight stations, only 6 to 19 years have elapsed and all the equipment is expected to function successfully and sufficiently. The hearing survey conducted, however, has clarified that lifting efficiency of the horizontal shaft pumps at Tona El Gabel has become low.

Each station provides on stand-by unit of pump. The side canal for gravity drainage for maintenance services of the pumping facilities is provided at only Abu Raheb Station, and other eight stations have not provided the side canals.

2) Irrigation Pump Stations

The pump type of two pump stations of Arab Beni Khalid and Beni Khalid is the horizontal shaft type and installed in open field. The operation of these stations is carried out during the low water level period from October to May. Six irrigation pump stations except for the above two, provide the vertical shaft type pumps.

All eight pump stations are operated throughout the year except the winter closure period in January, and among them, the Terfa New No.1 and Mazoura New No.1 are newly construction in 1984, while, for other six, 19 to 25 years have passed since construction. Consequently, the pumps and other equipment are time-worn to reduce the lifting efficiency. The Terfa No.1 provides two stand-by pumps, while the others provide one each.

According to information clarifying that the Kamadir station is operated to lift water from a canal in difficulty of pumping water from the Bahr Yusef canal due to lowering of water level, it is quite necessary to establish a permanent plan to make any adequate countermeasures.

3.3.6 Pilot Irrigation Area

1) Pilot Area

The purpose of pilot irrigation area study is to clarify present problems and constraints on the existing on-farm irrigation system, and to contribute to formulation of feasible on-farm improvement plan. The study and analysis are focused firstly on the irrigation efficiency which is the most essential factor in the on-farm water management, and secondary on the on-farm delivery canal system including sub-branch canals. Various field measurement, monitoring and tests as well as field and canal survey were carried out in the sample pilot irrigation areas.

Three pilot areas, namely Kom El Hasel, Nazlet Ramadan and El Baghour, as a representative sample area for study were selected in the Harika canal command area located at El Edwa district in Minia governorate (refer to Appendix G, Figures G-1-1 to G-1-3).

Principal profiles of these three pilot areas are shown as follows (refer to Appendix G, Tables G-1-1 to G-1-4 for further details).

Item		Kom El Hasel	Nazlet Ramadan	El Baghour	Total
Command area	(fed) :	550	780	1,800	3,130
Net irrigated area	(fed) :	421	645	1,388	2,454
1) From sub-branch canal	:	(315)	(456)	(1,007)	(1,778)
2) From Harika direct	:	(106)	(189)	(381)	(676)
Canal length	(m) :	2,300	2,400	6,400	11,100
Branch length	(m) :	-	-	2,560	2,560
No of meskas	(No) :	10	8	25	43
Meska length	(m) :	4,980	3,700	12,950	21,630
No of intake pumps	(No) :	27	54	84	165

Kom El Hasel pilot area is located at the upper reaches (5.140 km) of the Harika canal, while Nazlet Ramadan (15. 750 km) and El Baghour (13.750 km) are at the middle reaches. The land is flat with field elevation ranging between El. 32.8 m and El.33.7 m, El. 31.0 m and 32.1 m, and El. 31.1 m and El. 32.5 m, respectively. Sub-surface drainage have been laid at most crop fields. Major crops being cultivated in the pilot areas are cotton and maize in summer and wheat, beans and berseem in winter. Soil texture originated from the Nile River deposit is silty clay.

Irrigation network is quite complicated particularly at the lower reaches of sub-branch canal. When water is not available in the sub-branch canal due to water shortage, farmers can not avoid to get water from drains or from another sub-branch canals. Thus, many meskas and marwas are connected each other to secure the crops against water shortage, resulting complicated on-farm ditch network and water use (refer to Appendix G, Figures G-1-4 to G-1-6).

2) On-farm Irrigation

a) On-farm Irrigation System

Canals/ditches which are concerned in the on-farm irrigation system are sub-branch canals, Meskas (elevated) and Marwas. Sub-branch canal is the last unit of the delivery water system operated by the Irrigation Department, while Meska and Marwa are on-farm delivery ditches operated and maintained by farmers. Meska is usually owned by several farmers, at least more than two farmers, while Marwa is owned by one or two farmers. In the Harika command area, sub-branch canal covers irrigation area of 500 to 2,400 feddan, Meska covers 10 to 120 feddan and Marwa covers less than 10 feddan.

Since three-turn rotation, 5 days-on and 10 days-off, has been applied in the Harika canal, irrigation water is available only for 5 days as a rule. Irrigation water is pumped up from the sub-branch canals at Meska intake point, then conveyed by gravity method to each plot through elevated Meskas and Marwas. Usually one or two pumps, sometimes several pumps are engaged at each Meska intake. However, direct pumping from Harika/sub-branch canals to Marwas is widely practiced by farmers for more convenient and safety irrigation.

For reference to irrigation intervals which are the key factor to determine the appropriate irrigation rotation system, soil moisture was measured by laboratory test taking undisturbed sample soils from the pilot areas. As the result of analysis, irrigation intervals are calculated as 15 days based on 14% effective soil moisture in summer, while 16 days are stated by Irrigation Department calculation. Anyhow 15 days irrigation intervals presently applied on the three-turn rotation system will be adequate (refer to Appendix G, Table G-1-8).

b) Irrigation Method

Common irrigation methods are furrow and basin irrigation depending on crops. Cotton and beans are by furrow and maize, wheat and berseem are by basin irrigation. Irrigation time is usually for about 16 hours from 6:00 to 22:00 in summer, and 12 hours from

7:00 to 19:00 in winter. In peak demand period of June, July and August, night time irrigation is partly performed. Intake rates were measured at the field using double ring infiltrometer, and its result shows quite low basic intake rates ranging between 0.56 and 1.31 mm/hr which would allow rather wide range of irrigation intensity (refer to Appendix G, Table G-1-5).

c) Water Distribution

Water distribution from sub-branch canals to Meskas/Marwas is performed by farmers using small pumps with diameter of five to six inches. Such water pumped up to Meskas is then distributed to Marwas by gravity which is the last unit of the on-farm irrigation system. Irrigation rotation among Marwas and in plots is executed by farmers based on their own experiences.

Distribution control downstream of sub-branch canals is totally left in individual farmer's hand, therefore proper distribution management could hardly be expected particularly on the water saving point of view. Major factors by which farmers control their performance of pumping up water from sub-branch canals would only be the pumping cost and sufficiency of water for their crops in consideration of the rotation system and hard experiences of water shortage.

d) Drain Water Reuse

As observed at the pilot areas, drain water reuse for on-farm irrigation is commonly and unavoidably practiced without mixing with fresh water, when water is short in the sub-branch canals. An analysis is tried in order to estimate how much drain water is taken for irrigation, based on on-farm water balance analysis as described later. From the result of analysis in Nazlet Ramadan pilot area in the period from August 3 to August 17, nearly 10% of total supplied water to overall net irrigated area of 456 feddan is taken from the drains. This ratio, however, would be presented for reference only. Drain water reuse was not observed in winter (refer to Appendix G, Table G-1-6).

3) On-farm Irrigation Facilities

a) Sub-branch Canals

Among three sub-branch canals, Kom El Hasel and Nazlet Ramadan sub-branch canals are 2.3 to 2.4 km long, while El Baghour sub-branch canal is 6.4 km long that seems to be rather long as a sub-branch canal. Profiles of three sub-branch canals were surveyed and water level monitoring was conducted at three to four places on each canal.

The sub-branch is low level earth canal, and canal bed is generally 1.0 m to 2.0 m lower than the field level. Water plants and weeds which affect water flow are found at many places, and canal bed has been disturbed by accumulation of previous maintenances. Bed gradient is gentle, 1/10,000 for Kom El Hasel, 1/3,000 for Nazlet Ramadan and 1/7,000 for El Baghour sub-branch canals. Gates for intakes, regulators and tail escapes are all steel made sluice gate, however they have not been operated for long time due to probably unnecessity in the present irrigation system. Much leaking water from tail escapes due to improper gate installation was found when water reached to the tail escapes. RC pipe culverts and steel pipe aqueducts are found in the sub-branch canals.

During water level monitoring, particularly in the high water demand period from June to September, farmers who are located at the lower reaches of the canal have been frequently suffered from water shortage. The worst case was observed in early August at Nazlet Ramadan, that is canal water reached to the canal end only for half day during eight days actual irrigation working period. On the other hand, in winter period from February to March, water shortage at the canal tail was not found except immediately after breaking of four weeks water closure period. On the contrary, water level became so high that downstream farmers could irrigate by gravity, and canal water remained in the canal even after closing the Harika head gate. This is because that the Harika canal is used as a spillway of the Bahr Yusef main canal when water level upstream the Sakoula regulator becomes higher than the certain critical level. Accordingly much ineffetive outflow from the canal tail escapes to the drains would be unavoidable. Water levels in winter are generally a little higher than the water levels in summer.

In general daily trend, water level is recovered during night time, however after starting pump operation in the morning, water level goes down sharply. Water levels at sub-branch canal intakes by rotation period fluctuated during summer season from May to September. Particularly water levels in early June and early August, during when severe tail shortage occurred, were very low by around 40 to 60 cm from water levels at other period. Such periodical and daily fluctuation, water shortage in summer and water excess in winter mean that both water level and discharge quantity have not been satisfactorily managed, and would be mainly due to the followings (refer to Appendix G, Figures G-1-7 to G-1-9);

- Shortage of canal flow capacity under present rotation system,

- Over intaking water (by pumps) to Meskas which resulted downstream or tail shortage,
- Shortage of night storage capacity at Harika and sub-branch canals,
- Improper water level control at Harika intake or at upstream barrages/regulators, and
- Water level at Harika intake does not meet design discharge, or design discharge does not meet actual crop water consumption.

b) Meskas, Marwas and Plots

Meskas and Marwas are open raised on-farm earth ditches. One Meska with average length of 500 m covers irrigation area of 10 to 120 feddan, average of 30 feddan in the pilot areas. Meska bed level is 20 to 40 cm low from the field level, and its slope is generally in the range of 1/3,000 to 1/10,000.

The plot size is narrow as 5 to 10 m and long as 300 to 400 m. For example, 5 m width × 250 m length (0.3 feddan) plots are often found. Marwas, therefore, is also long as plot length. Such narrow plots which are obviously disadvantageous on crop cultivation are due to equal inheritance by the Islamic Law. Grouping of farmland by exchange or substitution would also be difficult because of Islamic custom. Land levelling seems to be fairly good, even around 10 cm height differences in some 100 m distance are observed at some places.

c) Operation and Maintenance

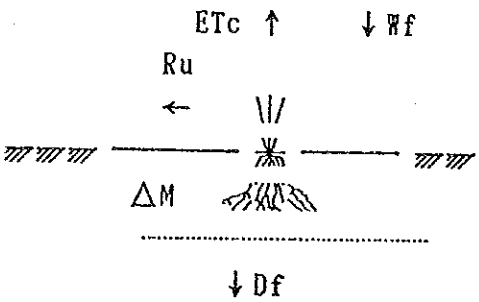
Irrigation Department is responsible for operation and maintenance of the sub-branch canals, and actual O/M activities are undertaken by the District office. Major activities are gate operation at intakes, regulators and tail escapes, repair of structures and canals, and regular canal cleanings. However, operation and maintenance seem not to be executed properly, particularly thickly growing of water plants and weeds and water leakage from tail escapes are often observed. Meskas and Marwas, on the other hand, are under farmers' responsibility. Their O/M activities are pump operation at Meska/Marwa intakes as main works, and ditch repair and cleanings as occasionally needed.

4) On-farm Water Balance

a) Method of Analysis

On-farm water balance at certain period in the effective soil layer can be explained as, $Wf = ETc + Ru + Df \pm \triangle M$ as shown in the figure below.

If much irrigation water is supplied to the field, some water would be lost as runoff water and some other water would percolate into soil. When soil moisture in effective soil layer becomes more than field capacity, excess water starts to percolate to deeper soil layer as deep percolation loss which is not used for crop growth. The rule of irrigation is, therefore, to minimize those losses. Runoff losses, so called management losses, can be avoided by appropriate water management. Deep percolation losses, on the other hand, could hardly be avoided but could be minimized by improvement of irrigation method and water management.



Where,

ETc	:	Evapotranspiration by crop
Wf	:	Irrigation water into field
Ru	:	Runoff water
Df	:	Percolation water
$\triangle M$	:	Soil moisture change in effective soil layer

Actual water application efficiency (Ea) which is one of the principal factors in evaluation of present on-farm water management, could be obtained from on-farm water balance analysis. Assuming that $\triangle M$ is almost the same at the time immediately before every irrigation, Ea is explained as;

$$Ea = ETc / Wf \times 100\ (\%)$$

On-farm water balance analysis was arranged at Kom El Hasel and Nazlet Ramadan pilot areas by irrigation rotation periods as follows;

- From June 4 to July 3, 1991 (30 days)
- From July 4 to Aug. 2, 1991 (30 days)
- From Aug. 3 to Aug. 17, 1991 (15 days)
- From Aug. 18 to Sept. 1, 1991 (15 days)

- From Sep. 2 to Sep. 16, 1991 (15 days)
- From Feb. 5 to Mar. 5, 1992 (30 days)

Since irrigation water into the field is taken only by pumps by farmers themselves, daily pump operation time was recorded in order to estimate amount of irrigation water into each block. There are 84 pumps in two pilot areas, Kom El Hasel and Nazlet Ramadan, mostly five or six inches in pump diameter. Actual pump capacity was also measured by field pumping test using triangular or rectangular measuring notches, and determined as 26.0 lit/sec for five inch pumps, 34.0 lit/sec for ordinary six inch pumps and 46.0 lit/sec for large power six inch pumps (refer to Appendix G, Table G-1-7).

On the other hand, crop water consumption during each analysis period was estimated basing on the water requirement which is presently applied by the Irrigation Sector, MPWWR. Particular surface runoff water was not observed. Permeability measurement by auger-hole method, soil mechanical analysis and Meska conveyance loss measurement by using V-notch weir were carried out for reference. Actual cultivated area by crop and by irrigation block was also surveyed.

b) On-farm Water Balance

On-farm water balance analysis was conducted at two pilot areas. Efficiencies at some irrigation blocks where water balance becomes negative are to be neglected due to mainly obvious lack of pump operation records. It is also noted that these efficiencies include Meska and Marwa losses which however seem to be small considering silty clay soil with low permeability of 0.14 to 0.36 m/day. Meska conveyance loss including evaporation was 6.0 ~ 8.1% for 430 m Meska length according to the actual measurement, while Meska seepage loss was around 2.3% by estimation from measured permeability value (refer to Appendix G, Table G-1-9 and G-1-10).

As the result of analysis, it could be stated that field efficiencies are generally high at downstream and low at upstream. Such high efficiencies, average 80.1% and 90 to 110% as major range at the downstream area, would be due to unavoidable condition considerably frequent tail shortage. On the other hand, low efficiencies at the upstream area, 60 to 70% as major range with average of 65.6%, would be possible actual field efficiency in consideration of the present on-farm water distribution management particularly pump works by farmers as stated before. Possible causes of the above difference of field efficiencies would be; (refer to Appendix G, Figure G-1-10 and Tables G-1-11 and G-1-12).

- Inadequate water management particularly pump operation which resulted upstream priority in water intaking and inequitable water distribution,
- Low level of Meska which resulted on-farm delivery inconveniency,
- Present irrigation water rotation system in which farmers intend to execute over irrigation and
- Poor land leveling partily.

5) Water User's Association (WUA)

Irrigation charge is free in all over Egypt and there was no publicly organized water user's association till quite recently. Since around 1985, however, Water User's Associations (WUAs) have been established at several areas as Irrigation Improvement Projects (IIP) were implemented. Actual activities to organize, establish and maintain the WUAs are undertaken by Irrigation Advisory Service (IAS) under supervision of IIP. Their major tasks are preparation, explanation and meeting with farmers, organizing WUAs, farmers participation in improvement, Meska rotation scheduling, monitoring and evaluation, and so on. A WUA to be established by one Meska is classified to seven phases by organizing stage. Over 1200 WUAs have been established or under organized at six governorates. They are mostly in the Entry Phase (Phase 1 level), and only small numbers have been organized up to the Regular WUA Operation Phase (Phase 5 level) (refer to Appendix J-2).

In the Bahr Yusef command area, however, WUAs have not been set up except some areas in Faiyum. Thus farmers can take water from canals by self-owned or group-owned pumps whenever they deem necessary to crops. Such individual farmer's pump operation practices must be organized and managed in order to achieve equitable water distribution and proper pumping-up at Meska intake. Direct intaking water by pumps from canals to marwas shall be avoided. It is, therefore, essentially necessary to set up WUA for appropriate on-farm water management in the improved irrigation water delivery system.

3.3.7 Road and Transportation System

1) Road System

There are 15 existing bridges across the Bahr Yusef canal between Dairout barrage and Lahoun regulator. A road width of more than six meters of an existing bridge has been proposed, designed and constructed and concrete and truss structures are applied. One connection road is paved by asphalt. Due to a small number of existing bridges for daily life of inhabitants, operation and maintenance bridges on existing five regulators are used for inhabitants in the Project Area as a common bridge.

Due to heavy load of traffic and superannuation of the facilities, hair pin cracks are found on the operation and maintenance bridge. Because when it was constructed (about 90 to 120 years ago), heavy vehicles, especially big ones, were not taken into consideration, only light vehicles such as horses or bull carts were considered. The four meter road-way width of the existing bridge is not sufficient for vehicles to pass each other on the bridge. The daily operation of gates of a regulator is done manually. However, unexpected maintenance of the gates by machines are executing to stop daily traffic of inhabitants in the rural area (refer to Appendix F, Table F-1-19).

The Dairout barrage and Lahoun regulator are located on the boundaries of governorates and districts, and the national road runs across the barrage/regulator. The present traffic volume is quite big and large vehicles often pass on the bridge. The operation and maintenance bridge of other three regulators, Mansht El Dahab, Sakoula and Mazoura regulators, is used for the daily lives of people that drive pick-up trucks or heavy traffics that are often passed on bridges since they transport sand and gravel from quarry site in the western desert. This type of traffic will affect the bridge body. People in those areas hope to expand the width of the existing operation and maintenance bridge or hope to construct a new bridge near the regulators

2) Navigation System

During the ancient time without automobile traffic, navigation at the Bahr Yusef canal was only a convenient measure of transport for inhabitants which were living in rural areas along the canal. All facilities constructed in the canal, therefore, have a lock with enough width for those navigation. However, presently, the traffic navigation system changed to automobile traffic. On the canal, a navigation lock is only used once or twice a year for passing dredgers. Only small boat navigation is found now, however, this navigation will decrease year by year.

3.4 Present Agriculture

3.4.1 Land Use and Productivity

1) Command Area and Ratio of Cultivable Land

The beneficiary area of Bahr Yusef canal, 770 thousand feddan, extended over four related governorates, consists of old lands (87%) and new lands 13% (inclusive of planned expansion area but currently desert land). Cultivable land is totaled at 651 thousand feddan, equivalent to 84.5% of gross beneficiary area, including planned expansion, 86.8% of which, or 565 thousand feddan has been cropped in 1991, where the old lands account for over 95%. Annual cropping acreage on this cropped lands comes to 1,047 thousand feddan as recent five-year average of which 1,010 thousand feddan has been cropped to the old lands, and the rest 37 thousand feddan to the new lands (refer to Table H-1-1, Appendix H).

2) Crop Composition

Crop composition is different from governorate to governorate and that in Bahr Yusef command area is also different from overall composition in each governorate, reflecting local conditions and policy orientation. As a whole maize is by far the dominant crop as summer and Nili cropping, as compared with other summer and Nili crops, while its share tends to be declining in northern governorates. Berseem and wheat predominate in winter cropping (refer to Appendix H, Table H-1-2).

Cotton represents important export crop whose share in crop composition is higher in three governorates except Giza. Acreage under cotton in command area has comparative or even higher share than governorate average in these areas. Minia governorate is one of major cotton producing areas in Egypt.

Traditional Nili cropping allows to disperse peak water consumption during mid-summer, and it has a significant share in Beni Suef and Faiyum, but in Minia its relative share is smaller both on governorate and command area basis.

As to winter crop, acreages under wheat and long berseem are grown after cotton. The former food crop is as important as summer maize, and the latter sustains livestock herds during winter, mainly cropped as long berseem whose cropping period extends 7 - 8 months. Broadbean follows these two crops (refer to Appendix H, Table H-1-3 to Table H-1-7).

3) Geographical Crop Distribution

A remarkable feature in crop composition lies in horticulture oriented cropping in Faiyum and Giza where share of fruit and vegetable on total acreage is higher than that in Minia and Beni Suef, *reflecting locational advantage or better market access.* Especially, vegetable supply in winter becomes more important as urban demand has been risen in parallel with population pressure in these governorates and adjacent Cairo Metropolitan Area.

Besides, command area in these governorates plays a key role in supplying livestock products for these consumption areas, sustained by acreage under fodder crop, though it is insufficient to meet the whole feed requirement (refer to Appendix H, Table H-1-8).

In contrast with northern part, cropping in southern governorates has been traditionally characterized by cereal-cotton combination, though specialty crops like sugarcane are existing in Minia (out of command area).

As stated in 3.1.5, somewhat different soil-water conditions in Faiyum has led to cropping of different crop types adaptable to them that are not popular in other parts of command area or in other governorates. Geographical distribution thereof is closely related with irrigation water regime (refer to Appendix H, Table H-1-9).

4) Current Crop Composition and Local Farming Conditions

a) Southern Part of the Command

In Minia and Beni Suef cropping patterns show a typical dependence on grains (with beans as major source of plant-protein) and fodder feeds, because basic objective of agriculture is to be self sufficient in staple foods and to sustain livestock herd which provides local population with convenience of draught works, farm practices and transport, source of animal protein and also means of keeping property or savings. A typical farm holding with only 1 - 2 feddan can hardly pay for hiring machinery to cover all farm practices or to keep a car for means of transport for those who live remote areas away from major markets they depend on, or to pay for value-added dairy or livestock or poultry products instead of producing by themselves. This is the reason why farmers in command area (in general located in more remote or desert areas than those in Nile River banks or along Ibrahimia canal) have been living with domestic animals and farming activities cannot be independent of animal husbandry.

Therefore, unless local industry patterns undergo radical changes or drastic industrialization takes place in these local areas, the existing patterns would hardly be replaced by new ones less linked with livestock sector. In this sector the herd size has already reached an equilibrium with self feed supply, as is shown in feed balance in Table H-1-28, where the command in Minia sells a part of feed surplus to outside markets and some of feed deficit in the command in Beni Suef depends on it or offsets it to some extent with natural grass feeding.

However, natural grass could not be relied upon because urban herd keepers whose herds always remain out of livestock statistics also compete with farmers for feeding their sheep/goats. Grains produced in the area used to be sold or domestically consumed and only a part is fed (mostly sorghum and its production is negligible in this area) to poultry/geese rather to mammals.

Dairy or fattening activities in commercial scales are not likely active in this area in contrast with northern part of the command. Concentrate feeds are available through PBDAC loans but they are too expensive to feed common draught herds. Even if feeds are positively balanced throughout the year, they are often scarce during summer time since fresh berseem is not available.

As to gardening or perennial cropping, acreage under orchard trees is quite limited in this area because of small holding, and such cash crops as sugarcane in Minia or seed onion in Beni Suef are almost exclusively produced by rich farmers in Ibrahimia command. These crops often need hired labor and high rate of inputs which small peasants can hardly afford to provide for.

b) *Northern Part of the Command*

Cropping intensity in this area has been much higher than the above cited area, especially in Giza. Land use has become so intensive that there remains little room for further intensification, unless degraded or desert land is either restored or reclaimed. As a matter of course, dependence on staple grains has been declined and cropping has been more oriented to cash crops like winter vegetables/tree fruits whose profits are higher due to scarcity, though production costs of which tend to be higher owing to heavier investment for vinyl covering. In this connection, green house farming is as a rule banned in old land and only allowed in the reclaimed, new land.

With regard to animal husbandry, a part of farm has been specialized in fattening and dairy production especially in Giza, one of the highly ranked livestock producing governorates in Egypt, and also in Faiyum where commercial scale milk and meat production sector is now developing as a timely response to growing demand in its urbanized area and in greater Cairo. Besides winter berseem, summer and Nili fodder crops have been cropped, though feed balance shows a considerable annual deficit, that is met partly with straw from delta areas or partly with concentrates to which PBDAC credits are applied. Prices of meat and dairy products have been attractive to farmers, but input costs including concentrates tend to be bullish, limiting further expansion of herd size and livestock production.

Vegetable production is so to speak a specialty sector of this area, but it has been facing to plant protection problems like onion nematoda and aphids damage suffered by solanaceae vegetables, and soil fertility problems.

Strict pursuance of established rotation programs is one of measures to avoid or mitigate these problems, and for maintaining soil fertility in order to keep yield/quality levels, rotation with leguminous food/forage crops has been most effective along with application of livestock manure/compost.

Fertility problems have now become serious as cropping intensity rises, and nutrient holding capacity of soils can only be sustained through these practices for soil sedimentation with high CEC suspended solid has not been carried by annual Nile flooding any more since the construction of High Dam.

The reason why winter berseem still shares fairly large part of cultivated area in Faiyum and Giza which actually need more acreage for more profitable crops lies in this point, for farmers are fully aware of the importance of berseem planting to this end.

5) Cropping Pattern and Cropping Practices

Cropping intensity tends to be higher in northern part of command area. Cropping period of a particular crop varies to some extent with areas according to maturity of varieties adopted or to cropping season of precedent crops. Cropping pattern is based on quota crops, or cotton in command area (although no quota is allocated to Giza because of relative importance of perishable products), and the preceding crops are harvested in early spring for better field preparation. Since cotton has longer flowering/ripening period, retarded harvesting often results in mixed cropping with following winter crops. Nili crops often follow after long berseem is harvested, with lower yield levels due to shortened cropping period as compared with summer cropping as a rule. Crop rotation often has two year-cycle for old land but three year cycle for new, reclaimed land that has less fertility and require fallow period or longer-interval crop rotation than old land does.

Furrow irrigation is generally applied to cotton, maize and many other crops planted in lines, while basin irrigation is done to berseem, rice and other crops with spread sowing or random planting, for which enough levelling is needed to irrigate homogeneously. As to watering practice, a major part of command area in Nile valley is covered with thick layer of Vertisols in which water table generally fluctuates at the depth deeper than two meters from land surface, though depending on season and distance from fluvial basin. On these soils irrigation intervals of 15 days (5 day irrigating and 10 day off) is allowed during growth and of 20 days or more between sowing and germinating is applied because of high water retentive capacity of soils with high percentage of capillary pore (porosity often exceeds 60%) derived from soil structures and component soil clay minerals.

On the other hand, in new, reclaimed areas where Aridisols are distributed, as well as in western edge of Nile valley where soils influenced by desertification, or Entisols are distributed, soil physical nature gives much less effective porosity than Vertisols, soil water tends to deplete in spite of prevailing tendency of higher water table in areas where buried clayey fluvial deposits lie underneath surface layers, often entails in formation of surface salt accumulation (crust), which often affects plant growth. To cope with these detrimental effect of poor water retention capacity, leguminous crops like berseem and alfalfa are incorporated into crop rotation, manure and compost application or soil aggregate formation by leaching/gypsum application is recommended, and irrigation interval is also mitigated up to 14 days (7 day watering, 7 day off). Nevertheless, such drought resistant crops as sesame or barley sometimes wilt.

In command area on the whole, water uptake by crops can take place throughout thickly developed rhizosphere, where vertical soil structures and thick profile of Vertisols give favourable conditions for water uptake of crops like cotton, maize, sorghum, wheat and sunflower that are able to develop rather deep rhizoshere (refer to Appendix H, H-1-10).

6) Limiting Factors Affecting Crop Development

Winter temperature is an influential factor that limits productivity of crops of tropical origin, like sugarcane, while summer temperature also limits that of temperate origin, like some orchard crops, flax, sugarbeet etc.

Soil textures are also confining factors which decide crop suitability, particularly in new land where sandy soils predominate which have poorer water holding or cation holding capacity and hence are not suitable for water consuming or nutrient consuming crops like cotton, and water consuming crops like rice etc. Even in Bahr Yusef command there intervene some sandy areas in Faiyum, Beni Suef and Minia where more drought resistant crops like sesame, sunflower, sorghum, watermelon account for larger acreages than in areas with finer textures.

Water table is another, influential limiting factor ever since reclaiming activity in desert area near Nile valley border has created within Nile valley. High water table often results in higher salt content of surface soil layers, on which only a few tolerant crops can give acceptable yields unless radical drainage improvement is applied to. On the other hand, insufficient irrigation is a potential limiting factor, and areas covered by the tail part of canals and of course in new, reclaimed land often suffer water shortage especially during summer, entailing to disappointed yield levels of summer crops. Even in winter period, soil water depletion can reduce wheat yield by 20 - 30%, according to the report by Soil and Water Research Institute.

In addition to these plant physiological factors cited above, there are a number of socio-economic ones.

7) Crop Productivity and Current Improvement Measures

Crop yield levels of staple food crops have reached considerably high levels and comparable to national averages, while cotton yield has a declining tendency, due chiefly to insect damages, though the control measures including airplane spraying have been taken for more than a decade (refer to Appendix h, Tables H-1-11 to 1-16).

Efforts of rising yield levels have been made through various measures, e.g. land improvement by MALR, loan systems by PBDAC for acquisition of better inputs, government pest-disease control programs.

High yielding variety seed, especially for cotton, chemical fertilizers and pesticides have been popular among farmers to maintain their crop yields, but soil fertility is hardly sustained after the construction of High Dam which intercepts fertile soil colloid carried by annual flood allowing very little to reach cultivated area. To cope with this problem of fertility maintenance, especially in the periphery of urban areas (Faiyum and Giza), farmers use manure and compost for supply of soil organic matter on one hand, and adopt berseem as component of crop rotation on the other, since crop residue is deprived from farmland for livestock feed and so replenishing organic matter is required (refer to Appendix H, Table H-1-11 and Table H-1-19).

Horizontal expansion by reclaiming new agricultural land in the periphery areas along Nile valley, along with increasing cropping intensity has led to insufficient water supply to old land and drained water from new land also created higher water table which sometimes affects crop yields.

8) Changes in Farming and Horizontal Expansion

Rapid mechanization has become a conspicuous focal point recently in farm practice in old land. The change is triggered either by acute requirement of fast irrigation by pumps to procure necessary amount of water under competitive water use conditions especially during peak water consuming period or by prompting efficiency of farm practices like post-harvest threshing and land preparation for the following sowing, responding to intensification of land use and its aftermath of shortened idle period in between cropping schedule, rather than by the measures to meet farm labour shortage.

On the other hand, land reclamation projects as horizontal expansion have been promoted by GARPAD, in desert areas along the fringe of old land developed in Nile valley. To supplement settlers labour force, a large quantity (2.3 man-day/feddan/year, in 87,000 feddan) of casual farm labour has been put into this new land from adjacent old land in command area. Diversion of water from old land to new land means reduction of available water in traditional old land which could aggregate seasonal water shortage in peak consuming period when water supply from Nile is affected. Further, water drained from new land could percolate into old land causing elevation of groundwater level and could affect crop growth. This has become a long term and wide-spread issue, to which afore-mentioned land improvement project by MALR has been applied not only in four related governorates but throughout Egypt as one of the means to retrieve crop productivity. This project consists of deep plowing/pan breaking, farm drainage channel cleaning and rectifying soil reaction through mechanical gypsum mixing, thus contributing to improvement in crop productivity in the areas covered with alluvial clay deposits (refer to Appendix H, Table H-1-18).

9) Present Agriculture in the Command Area of Harika Canal

The command area of Harika canal extends from Maghagha district through Edwa district in Minia governorate to Fashn district in Beni Suef, covering 32 villages, around

18,800 feddan. Land holding size of this area lies in predominance of small scale farm engaged in typical cereal-cotton type farming.

Major crop composition shows higher dependency on cotton as compared with the whole governorate base. 5-year averaged yield levels in recent years show cotton yield follows a declining trends as is observed in the whole country. But those for other crops seem to be quite stable in these years, and their levels are slightly lower than those of total command in Minia or governorate levels (refer to Tables H-1-20 to H-1-22 in Appendix H).

Currently prevailing cropping pattern has relative share of 27 percent by wheat in winter crops, while cotton and maize share 53 percent of total acreage, respectively in summer crop, with low intensity in Nili crop, leading to the total annual cropping intensity of 175%. In this pattern, three year crop rotation with double wheat cropping is common. Cotton is the most important crop and its retarded sowing will result in lower yield and mixed sowing in the beginning is not allowed. However, mixed cropping in the harvesting period is a traditional custom in order that longer harvesting and early winter planting be at the same time met. Continuous cropping of cotton on the same plot is avoided to minimize yield declining therefrom.

Cotton is cropped on as widely grouped tract of land as possible within the same village so that farm practice like irrigation and spraying by airplane can more efficiently be applied to. Summer irrigation is primarily focused on cotton, but it is as a principle to terminate as of August 15, because it fosters outbreak of insect/disease attack if continued later. Recently farmers are inclined to reinforce early planting of cotton, leading to early harvesting and avoiding mixed cropping with winter crop, though traditional practice is still remaining (refer to Appendix H, Fig. H-1-6).

Typical crop rotation types in three villages in the Pilot Area could be summarized as follows:

- Feed fodders and long/short berseem often planted in fields which surround the villages for the convenience of feeding
- Long berseem often followed by Nili maize or other Nili crops
- Cotton is followed by mixed planted crops like broadbeans or berseem which never followed by cotton again but by summer or Nili maize

- Winter crops are often early-harvested in green , unripened stage to facilitate early land preparation for cotton

- Cotton's share is about one third while that of maize approaches a half, and wheat's share lies between one third and a half

- As cropping intensity is raised, share of berseem tends to be sacrificed to less than 10 % of cropping acreage

- Some other catch crops which are not scheduled in the cooperative planting program are grown by farmers, for example farales in place of wheat or banco instead of maize (both for canary feed with less water requirement than the scheduled crops)

Major soil type found in this area is that derived from fluvial deposits, with soil texture of clay to heavy clay in soil surface, but subsoil texture tends to shift sandy in the west side of Sakoula Drain, influenced by desert. Share of land class III seems to be dominant according to the results of land classification survey, however overall physicochemical characters of soils are favorable to cropping. Occasionally, farm plots covered with salt crust are found, but salt concentration is within the tolerable range for most crops, according to field measurement. As a whole, drainage conditions are also favorable, and it is able to keep groundwater level deeper than two meters from soil surface during summer through drainage management. This allows soil salts to leach out of soil and help formation of vertical crack during off season. In the part near sand dunes in desert fringe, however, abandoned farmland with heavy salt accumulation resulted from staggering high groundwater table (refer to Table H-1-21, in Appendix H).

In Maghagha and Edwa drains have been excavated in early eighties through the land improvement project as cited above, and also culverts/farm drainage channels have been consolidated since then. These improvement measures have significant effects on physico-chemical properties of surface soils in this area, leading to less carbonate accumulation and lower EC/pH of soil solution. Besides, tillage pan is not yet formed owing to rare chance to receive machinery tillage, and dependence on manure rather than chemical fertilizer, or high rate of berseem cropping has positive effect on the formation of soil aggregates for higher rate of effective or capillary pore formation. These create higher water permeability and hence favorable drainage and salt leaching than ordinarily expected for clayey soils (refer to Figure D-1 in Appendix D).

10) Supply and Use of Farm Inputs

a) Seed and Fertilizers

In most cases small holders use self-supplied seed taken from their own fields for most food crops. However, production often tends to drop unless qualified or certified seed of HYV is used for the renewal of self-supplied one. Traditional farming with only livestock manure does not require HYV seed and if it is used without modern inputs like chemical fertilizers it will lead to unsatisfiable yields. According to PBDAC, small holders in the related governorates use HYV seed covering only 25 ~ 30% of the total cropping acreage. However, as far as chemical fertilizers are concerned, almost all the crop requirement has been met by official supply, though the coverage falls down to 70% this year due to transient stage of privatisation policy.

Seed is provided by a few private companies but each governorate has its own official seed distributing system. When promising new varieties are exploited in the government research institutes like Giza, Sakha, Beni Suef, Assiut University etc., the foundation seed can be multiplied through these companies to supply HYV seed to the distributing system.

Fertilizers are purchased by the bank referred to above from factories and carried up to village bank where farmers can receive them according to the government direction in which dozes are fixed for all crops, through the bank loans, and the repayment is scheduled at harvest time. Among fertilizers, nitrogen, chiefly in the form of ammonium nitrate and sulfate is consumed by far in greater amount than other kinds, followed by phosphatic like SSP and TSP, but potassium is rarely applied to, except for grape and other orchard trees, sugarcane and potatoes. Cattle manure is widely used in the command area because it improves soil fertility and price is cheaper. Cattle manure is also extensively used along with green manure, such as berseem and alfalfa in new land where infertile sandy soils predominate.

b) Agricultural Chemicals

Old land in the Nile valley is so to speak paradise of pests and diseases because farming in this area has been continuing for thousands of years and farmers are apt to grow the same crop continuously on the same plots, and this fosters prevalence of insects or fungal diseases. However, extension activities succeeded in improving cropping tradition by introducing better rotation system to avoid continuous planting of a particular crop. Insecticides, pesticides and herbicides are virtually all imported and costly. They are generally not used for berseem, sugarcane, barley and minor winter crops because they are fairly resistant or of little value and abundant in season, except special cases.

Chemicals are usually heavily used for orchard trees, vegetables and cotton because of their susceptibility to pests and diseases. They are also frequently applied to rice, soybean and broadbean. Major pests in the command are aphids, whitefly, ball worm, while as to diseases virus to solanaceae and mildew to gramineae sometimes occur, and yellow dying of broadbean is epidemically spread in Beni Suef and Faiyum this winter. White rot of onions is contagious, fastly spread in onion producing areas of northern Minia and Beni Suef, leading to sharp decrease of cropping acreage because once this disease prevails, the infected plot cannot be used for onion planting for at least fifteen years.

c) Machinery and Labor Force

Use of agricultural machinery was rapidly popularized during the period of labor exodus to gulf countries especially in Minia, but their utilization needs tariff payment for hire and hence it is mainly used in orchards, large tracts of privately owned plots, sugarcane fields etc. However, use of portable pumps are widely common in all areas, irrespective of crops or economic ability.

Multitude of small holders, especially those in the command area do not own tractors and other big size machinery, therefore only hours of machinery hire is to be accounted for the production inputs. Other than frequently used tractors, threshers and pumps, knapsack sprayers are becoming popular.

As regards labor force, the command area has enough manpower to be engaged in farming, because of small holdingness and repatriation of workers from gulf countries, even if cropping intensity is raised. This is indirectly proved by the fact that around 200 thousand man-days have been offered from farm population to work for new land development/farming and daily wage levels are quite low as compared with those paid by delta and coastal areas. Labor supply in northern part of command tends to become tight seasonally.

d) Other Input Materials

Recently, polymerized film coverage for protecting coldness in winter period has rapidly become popular in new land in Beni Suef, Minia and sandy area in Faiyum.

Two types of covering, i.e., low covering and tall (green house covering are found and the latter is only allowed in the new land. Usually, tomatoes, capsicum chilli or cucumber or zucchini marrow are grown. This incurs additional cost and should be added in prospect of future costs. Besides, vegetables require marketing costs for container cages and special transportation.

e) Livestock Feeds and Breedstocks

As mentioned above, livestock feeds tends to be deficient in the command, and the deficit is met by purchased feeds like dried berseem, straws and concentrates. In Minia, a private feed factory produces concentrates whose supply covers not only Minia but Beni Suef and Assiut. There is another feed factory in Badraseen, Giza which supplies feeds to Giza and Faiyum. Breedstocks are distributed from government livestock breeding stations to livestock holders, or artificial insemination is also available to them.

In Giza where feed consumption is greatest in command area, four feedmills have so far been established, but most of them at present meet only the requirements for poultry sector, because concentrate prices are too dear for giving to cattle or buffaloes.

11) Livestock Production

Farmers in command area still rely on livestock as draught animals for daily living/production activities, though motorization and farm mechanization have partly developed. Domestic animals are important for local population living in the areas distant from trunk roads, because they provide means of transport (especially input and harvest carrying), manures to apply to farm, livestock products like eggs, milk and meat as well as serve as a form of property saving. For these reasons almost every farm family in command area used to keep cattle and other kinds of livestock.

A large livestock herd, consisting of both large and small types, has been fed within command area. As regards feeding type, it is generally utilized for draught power/manure supplying in Minia and Beni Suef, whereas it is not only important for these purposes but for commercial production to provide milk/meat along with large scale poultry industry in Faiyum and Giza. Concentrate feeding processed from imported feedstuff is also practised in the latter area for commercial livestock production, but it costs too expensive and hence majority of livestock keepers use only self-supplied feeds. Such heavy dependence upon locally available feeds as a whole limits herd size depending on capacity of roughage feed supply within the areas (refer to Appendix H, Table H-1-25).

Major self-supplied feeds in command area are confined to berseem that is available to feed during winter to early summer, such fodder crop as sordan and sorghum from summer or Nili crop available during these periods, such crop residue as maize or sorghum stover, stalk of leguminous crops, straw of cereal crops that is storable throughout the year and sugarcane bagasse etc. Therefore, fluctuations of berseem cropping acreage has been practically small provided that current size of herd is maintained. In other words, current herd size remains stable if cropping pattern does not change much from present one (refer to Table H-1-26 in Appendix H).

Results from the comparison of feed requirement for current herd size, comprising feed component for maintenance, growth and production, with the quantities of local feed supply show that self-sufficiency of feed would often fail within command area, implying that the herd is dependent on feed supply from outside. Breakdown by governorate implies that as far as command area is concerned some surplus is estimated in Minia while slight shortage is identified in Beni Suef, and it is roughly self supplied in Faiyum but there is fairly large deficient gap in Giza where cereal production is comparatively small in comparison with relatively big size commercial herd (refer to Appendix H, Table H-1-27 to Table H-1-28).

In command area as a whole, present type of self-sustenance feeding does not likely change for the time being where major component of total herd is represented by baladi cattle, sheep/goats with minor one represented by buffaloes (as draught as well as meat cattle for source of red meat), camels and asses (for transport).

3.4.2 Agricultural Research

The Command area falls in the jurisdiction of three different research stations, i.e., of Mallawi Agricultural Research Station covering Minia, Sids Agricultural Research and Seed Supply Station covering Beni Suef and ARC (Agriculture Research Center) covering two other governorates, with a branch station in Tamia in Faiyum handling research on fruit tree as a specialty crop of the said governorate.

<u>Mallawi Agricultural Research Station</u>

Supervisory body	:	Agricultural Research Stations Dept.
Objectives	:	To promote agricultural development of the region; Medium staple cotton development

Structure : Wheat reseach section; Barley research section; Maize research section; Oil crops, research section; Onion research section; Legume crops research section; Sugar crops research section; Cotton, maintenance research section; Cotton cultivation research section; Plant protection research section; Plant diseases research section; Plant nutrition; Water requirements Soils research section

Activities : Applied and developmental research; training; advisory; library services

History and development: Established in 1965

Sids Agricultural Research Station,

Supervisory body : Agricultural Research Stations Dept.

Objectives : To promote agricultural development in Middle Egypt; Wheat production development; developing new varieties; Supplying farmers with improved, seeds

Structure : Wheat and barley research section; Forage crops research section; Onions research section; Legume crops research section; Cotton cultivation and maintenance research section; Herbicides research section; Plant protection research section; Plant diseases research section; Plant nutrition research section; Soils and water requirements research section

Activities : Applied and developmental research; training; advisory; library services

History and Development: Established in 1962, to represent the optimal cultivation conditions of the Middle Egypt region

3.4.3 Agricultural Extension

Agricultural extension has a well-organized network system from the governorate level through district agricultural offices to village levels where an agricultural supervisor is generally responsible for extension covering 500 to 1,000 feddan, giving farmers necessary advice and making efforts to solve crop problems they face like pest/disease control, participation in formulation of yearly cropping program (particularly for quota crops) including farm input distribution logistics to fulfill the program.

Extension staff take part in administration in governorate agricultural offices or in their research stations, by presenting field issues they are facing. They are also regularly trained in agricultural research stations so that they can absorb up-dated techniques to cope with more difficult problems. Farmers also have opportunities to join training programs offered by governorate and district agricultural offices, and by research stations.

Figures J-3 to J-5 in Appendix J show the organization chart and procedure of agricultural extension services.

3.4.4 Input Supply

Cotton, sugarcane and all other high yielding crops require seed supply and quite high doses of chemical fertilizers. They also need plant protection management by insecticide/fungicide spray. So far, the government has supported farmers in supplying these agricultural inputs at a subsidized price. However, hereafter, farmer has to buy inputs at market price with the implementation of structural adjustment policy.

3.4.5 Agricultural Credit

Farmers usually utilize loans through their village banks, and various kinds of loans from the mentioned bank are provided according to borrowing purposes as shown below;

Loans	Subject	Interest (%)	Repayment Period
Seasonal loan	Seasonal crops	16	6 ~ 14 months
Short-term loan	Livestock	19	1 year
Middle-term loan	Machinery, facilities for livestock	19	5 years
Long-term loan	Land reclamation, horticulture	18	More than 5 years

Other than credit services, PBDAC serves for deposit as same as city banks at the rate of 16.5% for 1 ~ 2 years deposit and 18% for 7 years deposit.

3.4.6 Agricultural Processing

As for processing in the Bahr Yusef command area, only a private essence extraction factory is found in Bascalon, Edwa district. It processes garlic and other various crops for providing materials for pharmaceutical industry. The materials to be processed are delivered from both old land and new land located around the factory. Another dry onion producing factory is located in Maghagha in which material is supplied from the same source as described above. In Faiyum, cotton ginnery and cereal mills are located.

3.4.7 Farm Economy

1) Crop Budget

Crop budget of the major crops in 1989 is estimated as follows based on the data of Ministry of Agriculture;

Crop	Yield (t/fed)	Gross Income (LE/fed)	Production Cost (LE/fed)	Net Income (LE/fed)	Ranking in Income	Ratio of Net Income (%)
Winter Crops						
Wheat	2.11	979.04	524.02	455.02	5	46.5
Broadbeans	1.16	780.68	484.97	295.71	10	37.9
Barley	1.34	376.54	335.54	41.00	17	10.8
Fenugreek	0.88	738.32	340.00	398.32	8	53.9
Lupine	0.86	1,165.30	428.71	736.59	1	63.2
Berseem (S)	8.99	224.75	229.41	- 4.66	18	-
Berseem (L)	25.39	648.25	391.40	256.85	13	39.6
Onion	9.60	1,699.20	1,002.97	696.23	2	41.0
Garlic	10.39	1,423.43	903.67	519.76	4	36.5
Summer Crops						
Cotton	0.76	1,004.72	699.61	305.11	9	30.4
Paddy	2.58	565.02	465.32	99.70	16	17.6
Maize	2.34	931.32	485.10	446.22	7	47.9
Sorghum	1.67	619.57	382.27	237.27	15	38.3
Soybean	0.97	776.00	484.20	291.80	11	37.6
Sugarcane	40.82	2,041.00	1,425.16	615.84	3	30.2
Sesame	0.49	672.77	432.80	239.97	14	35.7
Groundnut	0.94	940.00	493.24	446.76	6	47.5
Nili Crops						
Maize	1.75	696.50	428.32	268.18	12	38.5

Production costs and farm-gate prices mentioned above would be changed by enforcement of the economic reform policy, so the ranking in income would also be changed.

2) Crop Incomes Based on Unit Water Requirement

Crop incomes per unit water requirement was also compared;

Crop	1/ Net Income (LE/fed)	Ranking in Income	Gross Water 2/ Requirement (m^3/fed)	Net Income (LE/m^3)	Ranking
Winter Crops					
Wheat	455.02	5	2,690	0.169	6
Broadbeans	295.71	10	1,501	0.197	4
Barley	41.00	17	2,690	0.015	16
Fenugreek	398.32	8	2,144	0.186	5
Lupine	736.59	1	2,144	0.344	2
Berseem (S)	- 4.66	18	2,417	-0.002	18
Berseem (L)	256.85	13	2,802	0.092	12
Onion	696.23	2	1,637	0.425	1
Garlic	519.76	4	2,144	0.242	3
Summer Crops					
Cotton	305.11	9	5,455	0.056	15
Paddy	99.70	16	6,730	0.015	17
Maize	446.22	7	3,683	0.121	8
Sorghum	237.27	15	2,999	0.079	13
Soybean	291.80	11	2,835	0.103	11
Sugarcane	615.84	3	5,946	0.104	10
Sesame	239.97	14	3,711	0.065	14
Groundnut	446.76	6	2,792	0.160	7
Nili Crops					
Maize	268.18	12	2,394	0.112	9

Note: 1. Source: MALR 2. Source: ID, MPWWR

Sugarcane is ranked at 3rd in income per feddan but at 10th in income per m^3 due to large water requirement. Generally, beans are profitable from the viewpoint of income per unit water requirement.

3) Income of Farm Household

Averaged annual gross income of the farm households in the four governorates concerned to Bahr Yusef canal are estimated based on the statistics of CAPMAS and agricultural office's data. There is not notable difference in the composition of net income among four governorates, however, big difference in income itself such that Giza has highest income of 4,484 LE/year and lowest in Minia of 1,790 LE/year (for detail refer to Table L-1 Appendix L);

Governorate	Net Income (LE/year)	Item (%)	
		Crop	Livestock
Minia	1,790	75	25
Beni Suef	2,110	75	25
Faiyum	3,190	80	20
Giza	4,484	67	33

4) Economic Reform Policy and Agricultural Production

Economic reform policy announced by the government has already influenced agricultural management in prices of gasoline, fertilizer and so on. In case of enforcement of policies such as abolition of crop control and subsidy system, and liberalization of crop prices, influences on farm management will be considered serious, particular for the small-scale farmers.

However, it is difficult to forecast how the pricing system will be changed in the near future. Farm management would be developed along with farmer's intentions and fluctuation in domestic and international market, so supporting services on agricultural extension and credit have to be strengthened more than previous ones.

3.5 Farm Economic Survey

3.5.1 Survey Method

The survey was conducted for 31 farmers using prepared forms in the four governorates. In Minia, 23 farmers in the command area of Harika canal were interviewed to know a economic and irrigation conditions in detail. Agricultural technicians of agricultural office in each governorate attended with the Survey Team to interview to farmers at the cooperative society offices. The major components of the forms are as follows;

- Land tenure and farm size
- Land use, crop production, cropping calendar
- Marketing
- Livestock
- Farm labour supply
- Agricultural machinery
- Agricultural inputs
- Agricultural income and living expenses
- Irrigation water use
- Others

3.5.2 Results of the Survey

1) Land Tenure

Most of the interviewed farmers are landowner and some of them rent farmland from or to other farmers at a rate of 200 ~ 300 LE/feddan/year. One landless farmer who is hired by other farmers at daily wage basis is included.

2) Farm Size

There is big difference in farm size from 10 kirat (0.42 fed) to 29 fed., however, about 50% of the farmers have only less than one feddan on the basis of statistics.

3) Family Size

There is big difference in family size among interviewed farmers from 4 to 22 persons.

4) Agricultural Income

There exists big difference in agricultural income among farmers interviewed in the economic survey from 1,250 LE/year to 30,000 LE/year. It is considered that this big difference is caused by farm size, cropping intensity and composition of the planted crops.

5) Living Expense

As well as the agricultural income, there is big difference in living expenses among farmers from 2,100 LE/year to 19,330/year, this is due to family size, composition of family and location of the farms.

6) Off-farm Income

As far as interviewed farmers, off-farm income is very rare. However, it is popularly observed that one farmer gets income by working for other farms at daily wage basis.

7) Land Use

Two-year or three-year rotations are applied in the command area, however, the former is popular in Minia and the latter in other three governorates. Giza has the highest cropping intensity of about 300%.

8) Major Crops

Maize and cotton are the main crops in summer, and wheat, berseem in winter, however, crops are diversified in Giza to produce vegetables such as cabbage, squash etc., resulting in higher cropping intensity than other three governorates.

9) Marketing

Field crops are generally sold to cooperative society, however, vegetables and fruits are marketed to merchant. All of cotton is delivered to the cooperative society as a quota crop.

But, hereafter, these marketing system will be changed according to the structural adjustment policy of economy by the government.

10) Input Supply

Most of the agricultural input such as fertilizer, seeds, agro-chemicals have been supplied through village bank at subsidized prices but this system has been abolished along with the structural adjustment policy, therefore, those kinds of inputs will be supplied to farmers at market prices.

11) Farm Labour

Hired labour are popularly used for planting, weeding, harvesting at 4 ~ 8 LE/man-day and 2 ~ 2.5 LE/child-day. This system has supplied employment opportunities for landless farmer and children.

12) Machinery

Plowing, harrowing and threshing are mostly mechanized using rented tractor at a rate of 40 ~ 50 LE/fed, and some big owners of farmland have their own tractors. Excluding Faiyum area in which gravity irrigation is applied, water pumps with 5 ~ 6 inches diameter are popularly used for irrigation.

13) Livestock

Buffalo, baladi cow and chicken are popularly bred for mainly family use. Some of farmer sells milk products such as cheese, milk, butter, and donkey are also popularly kept for transportation and communication. Income from livestock is estimated occupying about 20 ~30% of agricultural income.

14) Animal Feed

Berseem is the main animal feed in winter, and some by-products such as wheat straw, broadbean straw etc. are used in summer.

15) Land Tax

Rate of land tax is not same in the area, changing from 20 ~ 40 LE/fed/year, and 35 LE/fed/year is additionally imposed to the farmland for which underdrain is consolidated.

16) Present and Expected Irrigation Rotation

Currently irrigation rotation of 5 day-on and 10 day-off has been applied in the command area of Bahr Yusef canal, however, farmer expects to change this rotation to 7 day-on and 7 day-off which had been applied in the area 15 years ago.

17) Irrigation Water Supply

In winter, irrigation water is generally supplied enough excluding some farmers in Faiyum area, however, water shortage is observed in summer particularly in middle and downstream of meska in which some drained water of drainage canal are re-used for irrigation, resulting in salinity damage for crops and lower income compared with upstream farmers.

18) Irrigation Hour

In parallel with farm economic survey, current irrigation hour of crops was also surveyed, as the results, some over-irrigation was observed compared with unit water requirement.

19) Meska Cleaning

Meska is generally cleaned three times in a year by farmers group, but one to two times in some places.

For detail, refer to Appendix L.

3.6 Problems and Constraint of the Present Delivery Water System

Problems and constraint of the present delivery water system on Bahr Yusef canal are carefully analyzed and studied for a formulation of the rehabilitation and improvement plan, and discussed on the physical and institutional bases.

3.6.1 Physical Problems and Constraint

1) Water Resources for Irrigation in Bahr Yusef Command Area

Increase of water supply for irrigation is eagerly required from the agriculture sector for expanding the production in horizontal and vertical development. However, water resources available for the command area of Bahr Yusef canal will be limited by the condition of release flow from Lake Nasser, which is only an irrigation water resources. Recent serious situation of live storage in Lake Nasser will be hardly solved due to the widespread Sahalian drought. Under the circumstances, water resources available for the command area of Bahr Yusef canal will be considered a flow of 19.5 MCM per day at a peak period.

The present condition of agricultural productivity in the Bahr Yusef canal command area should be improved through a produce of spare water resources in the system by effective utilization of the limited water resources. The effective utilization of water resources will be realized in improving irrigation efficiency as well as decrease in losses in conveyance, operation and on-farm application by providing improved facilities and proper management of the distribution system.

2) Facilities of Delivery Water System

Problems and constraint of the delivery water system are mainly caused by overage of the facilities, especially barrage and regulators as major structures which were constructed in the late 19th or the early 20th century. Major facilities are not sufficiently operational, especially gates and bridge. Gates of barrage and regulators were partially being opened and closed, which brought about irregular flow and eddy current of the canal in providing deep scouring of the canal bed at the immediate downstream of the regulators and erosion of the canal side slope.

Aside from the above-mentioned major facilities, since Bahr Yusef canal is an earth and non-lined meandered canal, erosion and sediment of the canal cross sections were frequently occurred. As far as the right-of-way of the canal is acquirable and also dwellers in the area are acceptable, the canal alignment shall be made straight line by the shortcut of the meandered canal course. Concerning the existing canal section of Bahr Yusef canal, it was originally designed in hydraulics based on Manning's equation in applying the roughness coefficient of $n = 0.025$ instead of reasonable value of $n = 0.030$, which provided an insufficient flow capacity of the canal.

Bahr Yusef canal has about 40 intake structures to be diverted water to the branch canals which can be classified into a few classes by a viewpoint of the structural quality and operational conditions. Civil works of about 60 percent of the intake structures were deteriorated by overage structure and hardly operated. These intake structures shall be improved by reconstruction of the civil works and replacement by the recommendable new gates. Among the remaining intake structures, Fahmy Henen gate widely being used shall be necessary to strengthen the support member of the gate by supplementing the steel frame, while some of Fahmy Henen gates shall be improved on the fixation of the gate lift to the structure, which was often loosened and then deteriorated the lifting facilities.

The system of Bahr Yusef canal is being operated at every barrage and regulators by observations / records and control of water level based on the instruction of the Irrigation Directorate concerned. These observation and records of water level is being made manually. There is a need to improve the facilities with automatic record of the data for more effective operation of the system.

3) Communication and Management System

Operation and maintenance of the delivery water system on Bahr Yusef canal is being manually handled by the District Engineers of the Irrigation Directorate in governorate concerned. The present operation is mainly concentrated in observations and records of water level at regulators and intake structures of the branch canals and then operated the control facilities.

Communication between the offices of the Irrigation Directorate and District Engineers is connected by telephone, however, the such between the District Engineers office and the sites of the observations has no telephone, and someone has to bring the information by motorcycle.

Proper operation and maintenance of the system can be made not only by the proper operation, but it is significantly necessary to introduce monitoring system. The monitoring system will be processed several observations and information and reflected with the results of the analyses immediately to the operation of the system.

Aside from the above-mentioned communication system, a processing and analyses facilities with adequate processing speed and reasonable accuracy shall be required.

4) Implementing Programme of the Improvement Project

Major structures along the Bahr Yusef canal are mainly overage of the facilities, some of which, Dairout barrage and Lahoun regulator, were strengthened by grouting. The strengthening of the structures by grouting will be effective as a temporary countermeasure for extending a durability of the superannuated structure, however, the extended durability will be quite limited for about ten years or less.

Reconstruction of the facilities and improvement of the some structures shall be programmed according to a consideration of the structure's durability and priority among the project components.

3. 6. 2 Institutional Problems and Constraint

1) Government Organization and Water User's Association

Operation and maintenance of major facilities in the delivery water system are handled by the Irrigation Directorate of MPWWR, while the on-farm facilities after Meska are by the water user's association (WUA).

Distribution programme of irrigation water is provided by the MPWWR based on the proposed cropping pattern in consultation with the MALR and the distributed water are recorded at the head of the branch canals by the District concerned. Analysis and evaluation of the records shall be necessary for planning the programme on improvement of the total irrigation efficiency.

The monitoring system on the irrigation water distribution shall be set up in the Irrigation Directorate and carried out the analyses and evaluation on the records in close cooperation with the WUA.

2) Rules and Regulations on O/M of the System

The present O/M of the system is handled by the MPWWR as a rule and regulations of the MPWWR enacted based on the capacity and function of the existing delivery water system. The said rules and regulations shall be revised to suitable one with improved and modernized facilities of the system for effective and proper O/M of the system.

3) Training and Education for O/M Staff and Water Users

Effective and proper O/M of the system would be required some training and education of the O/M staff and water users on the knowledge of water management and function of the delivery water system. Taking account into consideration an importance of this matter, the training and education facilities shall be provided at every Irrigation Directorate and the training programme including schedule, curriculum, etc. shall be planned in considering classes of trainee and course of training. The training shall be conducted continuously and periodically.

3.6.3 Administrative Aspect

Since the delivery water system on Bahr Yusef canal has long canal length and numbers of canal structures servicing so wide command area, long-term development programme on the rehabilitation and improvement of the system shall be set up by supporting the available budgetary source and the works shall be systematically implemented.

According to the organization for O/M of the system, personnel arrangement shall be necessary, particularly on the communication of the O/M between the MPWWR and WUA and monitoring of the water distribution

CHAPTER 4. THE PROJECT

CHAPTER 4. THE PROJECT

4.1 Objectives and Project Formulation

4.1.1 Objectives

Rehabilitation and Improvement Project of Bahr Yusef canal (hereinafter referred to as "The Project" or "RIPBY") aims at eliminating the present problems and constraint of the existing delivery water system on the basis of equitable supply of water, improving the overall efficiency of water use by reduction of water losses, and improving the irrigation application to achieve the optimum crop production and contribution to the revitalization of the regional economy as well as sharing a part of the national strategy on the adjustment of economic structure of the country.

Agricultural sector is the major sector under the Five-Year Plan, supplying foods, providing employment opportunity of 36 percent of the labour force and contributing foreign exchange earnings through exports of agricultural production. However, small agricultural lands, occupying 3.4 percent of the country or 6.12 million feddan, is the major constraint for the Egyptian agriculture. Agriculture in Egypt depends upon irrigation by the limited water resources of Lake Nasser supplied through Nile River. Available annual water resources of 55.5 milliard cubic meters is allocated to Egypt by 1959 Water Agreement, however, due to prolonged Sahalian drought, inflows to Lake Nasser will be reduced and it will be difficult to gain the allocated water resources to Egypt.

MPWWR aims at immediate implementation of the rehabilitation and improvement of the existing water distribution systems covering about 6.0 million feddan in the old lands, and has a schedule for 1.0 million feddan within the Second Five-Year Plan (1987/88 - 1991/92). It, however, will need 30 years, if a progress will be so, to improve all irrigation systems in old lands. MPWWR desires to accelerate the execution of the rehabilitation and improvement project by seeking engineering and financial cooperation from international agencies and developed countries on a bilateral basis. Also MPWWR requested Japanese Government the feasibility study for the Bahr Yusef canal and the command area, where are the major cultivated lands in the middle Egypt and needed the urgent rehabilitation and improvement of the irrigation system with top priority.

Command area of Bahr Yusef canal is served solely by Bahr Yusef canal diverted at Dairout from Ibrahimia canal which started at Asiout and diverted from Nile River. Agriculture in this area depends upon proper and timely irrigation water distribution in keeping high agricultural productivity. The irrigation command area of Bahr Yusef canal, which is about 770 thousand feddan and extends four governorates, shares significant roles covering about 13 percent of the total agricultural lands of the country and one of the biggest irrigation systems in Egypt.

There exist various problems and constraint of the existing facilities on Bahr Yusef canal to be solved and improved. Major subjects in which are low structural stability of the superannuated structures, insufficient function of the facilities in operation on control of irrigation water distribution, and poor maintenance and its rules and regulation of the operation and maintenance of the facilities. Most of the facilities are already obsolete giving rather low irrigation efficiency and unequal water distribution.

Aside from the distribution of irrigation water at the principal and branch canals, improvement of irrigation method at on-farm level is an important task in this regards. Operation and maintenance of the on-farm facilities handles by farmers themselves. Improvement of irrigation method in on-farm level should be started from establishment of Water User's Association (WUA).

4.1.2 Project Formulation

The Project of the rehabilitation and improvement of Bahr Yusef canal is formulated to fulfill the objectives of the Project, namely equitable water supply, effective water use and improved irrigation application the following:

(1) Rehabilitation and improvement of the existing facilities is planned to provide facilities by less initial investment in minimum extent and link it to the on-going modern management system of the Main System Management Project (MSM) after its completion.

(2) Major superannuated structures such as Dairout barrage, and four regulators of Manshat El Dahab, Sakoula, Mazoura and Lahoun, will be reconstructed nearby the existing site. Improvement of these structures will be the major works of the Project and in this regard modern facilities of remote operation system will be provided.

(3) Works on excavation and trimming of the cross section and shortcut of the canal course is scheduled in minimum extent. The Project provided design consideration and criteria for these works to save the project cost. These works are rather easy and non-technical and will be executed together with maintenance works during the operation period.

(4) Aged pump equipment of drainage and irrigation pump stations are to be replaced and spare parts/accessories of equipment and operation panel are to be procured for improvement of the operation. Pump buildings and civil works are to be improved by renovation and minor rehabilitation.

(5) Design procedures and criteria for rehabilitation and improvement of the branch canals are to be provided through study of Harika branch canal which is a representative of the branch canals. The results of the study will be applied for the planning and design of the whole branch canals along Bahr Yusef canal.

(6) There exist a potential hydropower generation only at the site of Lahoun Regulator which has about 2.0 meters head on an average, and about 40 to 50 m^3/sec discharge, producing a generating capacity of 640 KW. Therefore it is confirmed that the hydropower generation along Bahr Yusef canal is not economically viable and socially unacceptable at present, therefore the hydropower plan is not included in the Project.

(7) The Project is formulated by the project components of rehabilitation and improvement of major facilities along the principal canal and branch canals administrated under MPWWR, while the project components of on-farm facilities after Meska maintained by farmers themselves is not included in the Project, however, the cost for the on-farm facilities are to be included in the project evaluation, and planning procedures and design criteria on the said works are recommended in the report.

4.1.3 Project Components

The project components are planned based on the concept of the project formulation and each component is finally proposed through several alternative studies. Rehabilitation and improvement of major facilities are proposed as follows;

(1) Delivery water system of Bahr Yusef canal is recommended by a combination of continuous flow system at the principal canal and branch canals and three-turn rotation at on-farm level. Several alternative studies are made about distribution systems including the present distribution method of three-turn rotation after branch canals.

(2) Rehabilitation and improvement of the cross sections of Bahr Yusef canal is proposed by digging about 0.70 meters deep of the canal bed based on the results of alternative studies taking into consideration possibility on acquisition of additional Right-of-Way and planned water level. As a result of engineering and environmental study and consideration, four portions of shortcut canal course, out of 17 surveyed sites, are recommended and scheduled in the project components.

(3) Major structures along Bahr Yusef canal, particularly five barrage and regulators were already aged over 90 years and superannuated structures. These five structures are proposed to be replaced by new structure based on a result of several alternative studies including a study on partial rehabilitation/improvement of the existing structure.

(4) Most of large scale intake structures for branch canals are made by red brick with Fahmy Henen gates and superannuated structures. Out of many intakes, Hassan Wasef and Giza branch canals are special large scale covering quite wide command areas, 118 thousand feddan in Hassan Wasef and 153 thousand feddan in Giza, and planned to be replaced with new gates. The middle scale about 16 intakes with 2.0 to 3.0 meters vent have several size of Fahmy Henen gates, which are mostly destroyed or not operational and need to replace with re-construction of the relevant civil works. Other 28 intakes of small scale structures, 1.50 meters or smaller vent, are to be improved Fahmy Henen gates by strengthening the gate frame and renovated the civil works.

(5) Pump equipment with over 10 years age on the drainage and irrigation pump stations need to be replaced for improvement of the operation efficiency, because spare parts of these equipment are not available and improvement of efficiency are difficult. Out of nine drainage pump stations, pump equipment and operation panels of five drainage pump stations with low efficiency equipment including Old El Badraman Pump Station are to be replaced, and operation panels and electric parts of other four drainage pump stations are improved. Mechanical weed screen cleaning machine is provided and civil works of gravity by-pass are constructed for all nine drainage pump stations.

(6) In eight irrigation pump stations, a pump station in combination of two pump stations of Arab Beni Khalid and Beni Khalid is constructed newly. For Kamadir and Terfa (1) irrigation pump stations, pump equipment are replaced and civil works of intakes are re-constructed. Pump equipment of Sakoula and Mazoura (0) irrigation pump stations are replaced while Terfa (1) new and Mazoura (0) new are not improved due to rather new facilities.

(7) Harika canal is studied and planned as a representative for rehabilitation and improvement of 45 branch canals. The existing canal section has a sufficient capacity for continuous flow distribution discharge to be recommended, however, insufficient capacity for presently practiced three-turn rotation method. It is proposed to construct a new regulator and improvement of the existing regulators along the canal for proper control of intake water level on subbranch canals or Meskas. The design procedures and criteria and also project cost for Harika branch canal are applied for planning rehabilitation and improvement of all over the branch canals in the command area of Bahr Yusef canal.

(8) Planning procedures and criteria and necessary investment fund are derived from the results of research in the pilot areas conducted in the command area of Harika branch

canal. These improvement works will be implemented by the members of the WUA to be established among farmers concerned under the assistance of the MPWWR and MALR. The cost of these works is not involved in the project cost, however, it is considered for the project evaluation.

4. 2 Irrigation Planning

4. 2. 1 Proposed Water Requirement

1) Water Requirement and Irrigation Efficiency

As mentioned in the section 4. 5,various cropping periods are considered for irrigation planning based on proposed cropping pattern for several areas of the command area of the Bahr Yusef canal, such as the old lands in four governorate areas, the reclaimed area and the expansion planned area. Evapotranspiration by crop and cropping period, would be estimated by applying the Modified Penman method. Since the cropping periods for the old lands are the same as the present one, the present monthly unit water requirements are applied for the following analysis (refer to Table E-3-1, Appendix E).

The proposed net irrigation area is about 770 thousand feddan of the Bahr Yusef canal command area including expansion area of about 56 thousand feddan, while the total cropped area is about 1,100 thousand feddan. The command area of each barrage / regulator is applied an acreage determined by the MPWWR (refer to Table E-3-2, Appendix E).

The proposed monthly net water requirements are calculated based on the above unit water requirement and net cropped area. According to the results of the study, the monthly maximum net water requirement is 429.17 MCM (160.23 m^3/sec) in July and followed by 376.62 MCM (140.62 m^3/sec) in August. On the other hand, the monthly minimum one of 83.14 MCM (31.04 m^3/sec) appears in October when a little crops are planted on fields in a transition period between summer and winter seasons.

Taking into consideration population increase in the future, the water requirement for drinking water for inhabitants and animals is estimated at twice of the present water requirement of 467 thousand m^3/day including about 30 thousand m^3/day of water for animal use. When the annual population increase rate of 2.8% is continued in the future, necessary amount of water for the future population will reach to the proposed amount after 26 years. An assumption of 50% of the proposed amount of drinking water, is applied for future industrial water. The total amount of water for this purpose, therefore, would reach to 1.4 MCM/day (16. 21 m^3/sec) (refer to Table E-3-3, Appendix E).

Water requirement for the reclaimed area of about 43.8 thousand feddan which exists at the west hill of Minia and Beni Suef governorates, is calculated as procedure of the said old lands by using the unit water requirement and cropped area based on the proposed cropping pattern for the reclaimed area. The monthly maximum net water requirement of 25.04 MCM occurs in July followed by 17.78 MCM in August. The minimum one is at 4.03 MCM in October. Leaching water which equivalents to 2 to 14% of the net water requirement by assumption of expected electric conductivity value of 0.6 mmhos/cm of supplied water, is applied for the study (refer to Table E-3-4, Appendix E).

Water requirement for the expansion planned area of about 56 thousand feddan is calculated by cropped areas and unit water requirement by the modified Penman method as the same procedure of above one. The maximum net water requirement of 24.91 MCM occurs in July and the minimum one of 6.96 MCM in October. The leaching water is also counted in the above calculation (refer to Tables E-3-5 and -6, Appendix E).

Conveyance and application efficiencies are considered at 80% each. The present application efficiency of 70% will be improved to 80%, because water management will be improved by organizing "Water User's Association (WUA)". It is presumed that in the old lands, new irrigation system such as sprinkler or drip irrigation will not be introduced to save water for agriculture in the near future, and the basin irrigation system presently practiced will be continuously followed by farmers. Since in a part of the reclaimed and expansion planned areas, new irrigation system is and / or will be introduced for the same purpose, the application efficiency of 85% is applied.

2) Proposed Available Water Resources

As mentioned at the present conditions, the proposed available water resources consists of Nile water, groundwater contribution, reuse water by drainage pump stations and gravity intake water in Faiyum.

The groundwater contribution rate of 10% against net water requirement would be assumed because of no change of the existing field conditions. The amount of reuse water by drainage pump stations would be also counted the same as the present one.

At present in fields located near a drainage canal, many farmers utilized drain water to be lifted by a small pump to irrigate their fields during the water shortage period from June to August. It is easy to arise salt accumulation from the reuse water with high contents of salinity. It is proposed that drain water is lifted to the Bahr Yusef canal by drainage pump stations and mixed with fresh water for irrigation in their fields through Meska and Marwa after organized water management is improved by organized WUAs. The present capacity of drainage pump stations in the Bahr Yusef command area is calculated at 56.7 m^3/sec excluding the capacity of standby pumps. The present drainage pump stations have adequate capacity to drain excess water of 41.74 m^3/sec (drain water of 23.85 m^3/sec in July and the additional drain amount of 17.89 m^3/sec) (refer to Table E-3-7, Appendix E).

The existing reclaimed and expansion planned areas are proposed at high elevation desert areas. On geographical condition, some amount of water to irrigate those areas, which will be drained to a drainage canal located in the old lands, is one of the proposed water resources. Based on existing records of drain water by drainage pump stations, the amount of 1.5 mm/day is expected as proposed water resources. The amount of reuse water by gravity intake from drains in Faiyum is the same as the present amount due to no change of the present condition of intake facilities.

Since the necessary amount of the Nile water will be calculated as supplemental water to solve water shortage in the Bahr Yusef command area, the amount of Nile water is seasonally fluctuated. However, the maximum water is fixed at 19.5 MCM/day.

Considering the above items, the water balance study are carried out at each barrage /regulator on the Bahr Yusef canal. The monthly available water resource is fluctuated between 763.3 MCM in July at maximum, followed by 664.6 MCM in August and 184.8 MCM in October at minimum (refer to Table E-3-8, Appendix E).

3) Overall Irrigation Efficiency

After the Bahr Yusef command area of about 770 thousand feddan is perfectly developed, the overall irrigation efficiency can be expected at 69.8% based on the study of the net water requirement and total available water resource, which is higher than 60.5% of the present one. The major reasons of improvement of the irrigation efficiency are reduction of seasonal water distribution and on-farm water management losses (refer to Table E-3-8, Appendix E).

4. 2. 2 Proposed Design Discharge

The Bahr Yusef canal is divided into four sections by five barrage/regulators. Each section has a length between 50 to 100 km and has many intakes of branch canals, irrigation pump stations and outlet of drainage pump stations. Within a section, sectional water balance study in water intakes and gains are conducted. The sectional water balance on the maximum and minimum discharge stages determine the design discharge of each section. The

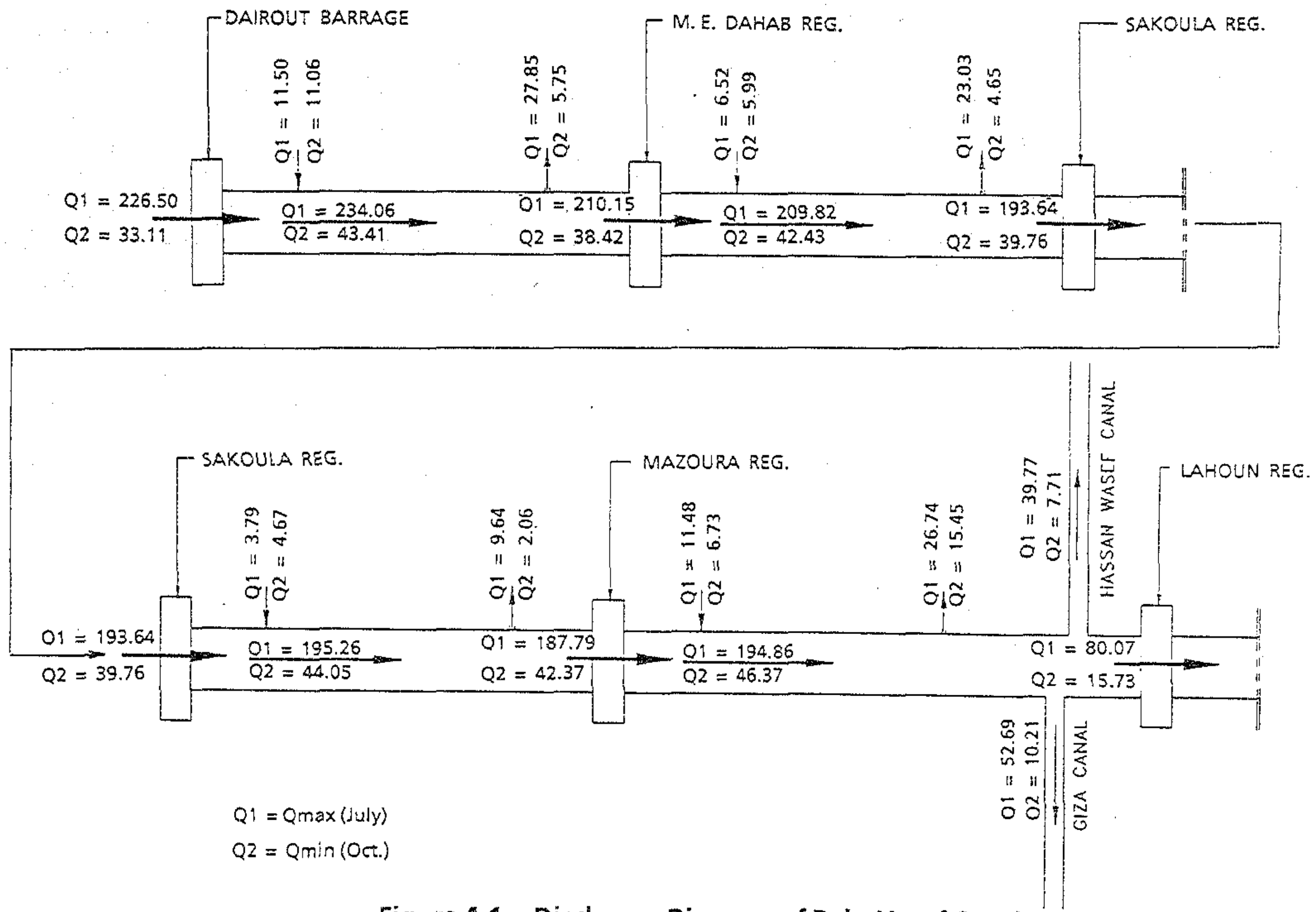


Figure 4-1 Discharge Diagram of Bahr Yusef Canal

maximum discharge determines the proposed canal cross section and the minimum discharge is used to check the water level for availability of gravity intake of branch canals. And also water balance shows the design discharge at the barrage and regulators (refer to Figure 4-1 and Table E-3-9 to -19 of Appendix E).

4. 2. 3 Irrigation Rotation System

Major problems and constraints caused by the existing irrigation system, particularly three-turn rotation at branch canals, are summarized below;

Problems:
- frequent occurrence of water shortage at the tail that resulted inequitable water distribution,
- ineffective outflow partly due to the present rotation system, and
- low irrigation efficiency caused by the rotation system.

Constraint:
- 16 hrs/day irrigation time, thus night time flow shall be considered as primary factor.
- canal check (regulator) is operated by the fixed water level at downstream, and
- unfamiliarity of cooperative water use due to farmers' traditional custom of water use.

Study on four alternatives of the improvement for the irrigation rotation system including the present rotation system is conducted as characterized below;

Canal Category	Case-1	Case-2	Case-3	Case-4
Bahr Yusef main	24 hrs	24 hrs	24 hrs	24 hrs
Branch canals	Three-turn (5/10)	24 hrs	24 hrs	24 hrs
Sub-branch canals	←—	Three-turn (5/10) (*1)	Three-turn (5/10) (*2) —→	24 hrs
Meskas	←—	Pump rotation (16 hrs/day)		—→

Note: *1 : Rotation block is set at the upper, middle and lower reaches.
*2 : Rotation block is set at 1/3 area from three reaches.

Several comparable factors were taken into consideration, such as required canal capacity, number of control points, operation and maintenance, night storage capacity, relation to WUAs, environmental aspect and so on. However, since these factors are not quantifiable, expected system functions by each alternative to solve the problems are taken into account for selection of the most recommendable rotation system.

As a result of comparison of four alternatives, case-3 would be the most recommendable, particularly from the viewpoint of water control and utilization conveniency. This case-3 could be stated as a middle level improved system but highly realizable for both water supplier and users. Case-4 system would be the most desirable for users but risky for supplier compared with the present system (refer to Table G-2-1 in Appendix G).

4.2.4 Water Distribution Control System

Irrigation water distribution system is divided into two parts, i.e. a main irrigation system which covers from the main canal till sub-branch canals and the other is an on-farm irrigation system. The main system belongs to MPWWR and the Irrigation Department (ID) is responsible for distribution control. On the other hand, the on-farm irrigation system belongs to farmers.

1) Main Irrigation System

Major problems on the present distribution control system are stated as follows;

- distribution water levels to be controlled have been determined by empirical water levels,
- water levels at regulators/intakes are recorded but not used for readjustment / checking purposes,
- in case water levels are not satisfactorily maintained, control function by which such irregularity can be quickly adjusted as a whole canal system not exist, and
- poor operational gate condition causes low accurate water level adjustment.

Duties of the water distribution control in the main system are to maximize operational capability as to a whole irrigation system, and to distribute irrigation water equitably and timely with minimum losses. The main point of distribution control is to maintain required distribution water levels with necessary discharge volume at every distribution control point. In order to achieve such duties, therefore, the system shall be accommodated with the following three essential functions. Namely, the first is to adjust water levels as required by adequate gate operations. The second is to convert water level data into discharge volume. The third is monitoring, evaluation and feedback functions for readjustment of water levels with real-time communication.

Since Bahr Yusef canal which begins its flow at Dairout barrage covers four Irrigation Directorates of Minia, Beni Suef, Faiyum and Giza, an integrated water distribution control system shall be established to provide functional distribution control as one completed system.

Among water distribution control systems to be considered in the Project, the most conventional one would be the existing system. The middle level developed system would be by introduction of more functional equipment including computer processing system. The most advanced system would be a telemetry and remote control system as full automatic system. For selection of the system level in the Project, local conditions shall be taken into account such as technology acceptability and O/M availability of the new system. In consideration of local conditions in Egypt, the most advanced system would not be economically and technologically suitable at present, thus the middle level system would be recommended in the Project.

For operation and management of the integrated water distribution control system, it is recommended to establish an operation center, sub-centers and remote stations. The operation center shall undertake distribution operation and management of the whole Bahr Yusef command area. Sub-centers shall be located at each Directorate, and remote stations shall be at five regulators, irrigation pump stations, drainage pump stations and major branch canal intakes. All data and information concerning with distribution control which are taken at the remote stations shall be sent to the operation center through sub-centers for data base, processing and analysis. Any instructions necessary for distribution control shall be transmitted promptly as possible to the remote stations. Telephones as presently used and radio-telephones or mobile telephones for emergency shall be installed at stations. Electric operated gates for water level adjustment, automatic water level recorders for monitoring and concrete lining canal sections for discharge calibration, shall be provided to the stations (refer to Figures G-2-1 and G-2-2 in Appendix G).

On the other hand, a telemetry system throughout Egypt, named the Main System Management (MSM) Project, is being developed by MPWWR. The MSM Project consists of the data collection system, data development system and remote control capability. Stations for the data collection system are partly under construction, and data base software development for data management system has just started. Meteor Burst and VHF radio system are used for communication. It will take long time to become operational condition, however when completed, the Bahr Yusef irrigation system will be covered by the integrated telemetry system of the MSM Project as one of the main canal systems. Therefore it is necessary that facilities and equipment to be provided by this Project shall be convertible to the advanced MSM Project.

2) On-farm Irrigation System

The on-farm irrigation system is the facilities downstream Meska, and has been managed by farmers individually. For improvement of the on-farm irrigation system, water distribution control at Meskas is particularly essential and a matter of urgency.

As stated in Chapter 3, recently in Egypt, Water User's Associations (WUAs) have been established under the guidance of the Irrigation Department on the project basis. In this Project, therefore, it is recommended to establish WUAs for distribution control system improvement at on-farm level. It could be stated that successful organizing WUAs could hardly be materialized unless the improvement of distribution control at the main irrigation system and benefit by the on-farm distribution improvement are clearly presented and accepted by farmers.

Minimum unit of WUA is one Meska and then Meska union will be formed at sub-branch and branch canal levels. Strong support, guidance and training shall be extended by the Irrigation Advisory Services (IAS) of the Irrigation Department to farmers before, during and after establishment, in order to promote the functional and sustainable WUAs. WUA, a private organization composed of farmers as a membership, will have a Meska leader, section leaders, Marwa leaders and pump operators. Major activities are pump operations according to the guidance and irrigation scheduling given by IAS, and maintenance of pumps and Meska ditches. IAS shall also undertake monitoring and evaluation of Meska distribution control operations (refer to Figure G-2-2 in Appendix G, and Appendix J-2).

4.3 Alternative Study of Rehabilitation and Improvement of the Facilities

4.3.1 Bahr Yusef Canal

1) Basic Conditions for Rehabilitation and Improvement Works

The work plan has to be so made as to minimize the work volume in utilizing the existing facilities as much as possible for successful achievement of the Project.

The profile plan of the canal should be prepared to meet the original design conditions as much as possible. The Manning's formula with n-value of 0.030 for roughness coefficient has been applied to the necessary hydraulic design.

For determination of the design discharge, the design intake discharge at the Dairout barrage is planned at 19.50 m^3/sec according to the decision of the MPWWR. The design discharge for the canal sections between the barrages were determined taking into consideration water amount lifted at each pumping station as follows (refer to Table E-3-16 in Appendix E):

Canal Section between Barrages	Design Discharge	Low Level Discharge
Dairout - Manshat El Dahab	234.06 m^3/sec	43.41 m^3/sec
Manshat El Dahab - Sakoula	209.82	42.43
Sakoula - Mazoura	195.26	44.05
Mazoura - Lahoun	194.86	46.37

2) Study of Designed Canal Section

The canal sections to be improved shall be determined through the following alternative studies to select the best available.

Case-1 : Canal widening without changing water level
Case-2 : Lowering canal bed elevation without changing water level
Case-3 : Raising water level without changing canal sections

There are two types of canal bed width (46 m and 44 m) in the canal from Dairout barrage to Lahoun regulator. The canal with 46 m bottom width is applied to the upstream portion from the Dairout barrage to the Manshat El Dahab regulator, while that with 44 m in the downstream portion from the Mazoura regulator to Lahoun regulator for studying the hydraulical canal sections (refer to Table F-2-1 in Appendix F).

In hydraulical study, for case-1 where the same trend is learned in the upstream and downstream, the bottom widening width is 10 m, for case-2, the depth to be lowered is about 70 cm and for case-3, the water level to be raised is about 60 cm. The works for rehabilitation and improvement are determined for the respective cases as follows:

Case-1 : The canal bottom shall be widened by 10 m. For the total 288.7 km, farm land of 690 feddan is needed and this plan is not applicable due to difficulty in land acquisition for the works.

Case-2 : New land acquisition is not required, and since neither change in water level nor adverse effects are expected, it is highly realistic to be implemented.

Case-3 : Due to rising of water level, it is impossible to realize the plan in considering the fact that there are some farm land extending under the present water level.

According to the result of the above alternative study, the case-2, the canal bottom to be lowered by about 70 cm shall be taken up for design of the canal sections. The designed typical canal section are as follows:

Canal Section	Bottom Width	Side Slope
Dairout Barr. - Sakoula Reg.	43.9 m	1 : 1.5
Sakoula Reg. - Lahoun Reg.	41.9	1 : 1.5

3) Study on Canal Profile

The controlled water level at the upstream of the barrages/regulators has been determined in consideration of such conditions as present water level observed, restrictive conditions on water control, intake water level at the branch canals, relations between water level and farm land elevation, etc. (refer to Table F-2-2 in Appendix F).

Regulator	Control Water Level
Manshat El Dahab	40.40 m
Sakoula	33.70
Mazoura	29.70
Lahoun	26.60

On the basis of these water levels, non-uniform flow analysis has been made for design discharge and low discharge. The conditions of hydraulic calculation are that the canal bed slopes between barrage / regulators are the same as those used in the original design, all canal bottom elevations are about 70 cm lower than the original designed level, and the other hydraulical conditions depend upon the basic concept of the Project planning.

The hydraulic profile study has resulted in that the designed discharge will cause little effect by back water, while the low discharge will give considerably large effect up to about 70 km upstream from the regulators of Manshat El Dahab and Sakoula and about 50 km at Mazoura and Lahoun regulators where the water level will rise by 0.50 m. Difference between designed water level and low water level at the immediate downstream of the barrage is 3.53 m at Dairout, 3.36 m at Manshat El Dahab, 2.59 m at Sakoula, and 2.32 at Mazoura, respectively (refer to Tables E-3-20 and E-3-21 in Appendix E, and Figure F-2-2 in Appendix F).

A study was made on the effect of low water level to the water intake for the branch canal between the Dairout barrage and Manshat El Dahab regulator. The water depth for intaking at Mossa to the branch canal and neither troubles are expected for water intake at Mossa nor at further downstream regulators.

It is impossible however to make gravity intake at Arab Beni Khalid and Beni Khalid intakes in the upstream in the low water level. Improvement in intake level and lowering the canal bottom will be necessary to make gravity intake possible in the low water level. Such improvement works, however, will not be realized due to unfavourable topographical conditions and other natural conditions. Under the conditions, the existing pumping facilities shall be improved to lift water during the low water level period.

There will be no adverse effect for gravity water intake to the branch canal between Manshat El Dahab and Sakoula regulators even in low water level period. Renewal and improvement of the pump and intake facilities of Kamadir No. 5 and Terfa No. 1 pump stations are required because the low water level at their intakes is lower than that of the existing water supply point.

Neither adverse effects are given to gravity intake for the branch canals between the Sakoula and Lahoun via Mazoura regulators even in the low water level, nor to intake for water lifting at the pump stations. Renewal of the facilities of the both pump stations and improvement of the water supply facilities are necessary, although the designed profiles and cross sections have clarified that there are no adverse effects to the for gravity intakes even in the low water level.

4) Improvement of Meandering Portions of Canals

Shortcut of the meandering portions, which will bring about shortening and reformation of the canal alignment, will result in at least, hydraulical advantages and easiness of operation and maintenance of the facilities. Shortcut of the meandering portions, however, will require land acquisition of the existing farmland for civil works, which will bring about considerable change in living environment of the local people. Prudent study is necessary because there are such many serious problems concerning with daily life of the inhabitants, as irrigation, other farming works, traffic, etc.

The candidate sites for realignment of the meandering parts have been made in location hunting on the topographical maps at the first stage and then, the field survey has been made for confirmation. And finally, 17 sites are selected as promising sites for alignment of the meandering portions (refer to Figure 2-3 in Appendix F).

Particular attention was paid to the following points that there would be no problems on relocation of houses in villages, daily life as washing places of the local people, social infrastructures like irrigation facilities and bridges, etc. In the above view, six promising candidates are screened on the 1/2,500 topo-map to carry out the detailed field investigation. Out of the above six, the following four sites are decided as the objective areas for development with realignment of the meandering portions; they are km 20.5 point (No.4 area), km 30.5 point (No.5 area), km 80.5 point (No.7 area), and km 193.5 point (No.15 area) (refer to Figure F-2-4 in Appendix F).

4. 3. 2 Barrage and Regulators

1) Outline of Rehabilitation Plan

The barrages and regulators are the time-worn facilities as old as more 90 years after construction. There are two ways of implementation considered for rehabilitation and improvement; the partial rehabilitation and improvement that only heavily deteriorated parts shall be so rehabilitated as to make best use of the remaining parts as much as possible, while the total rehabilitation that some structures as a whole shall be totally rehabilitated in considering them out of their life span.

The partial rehabilitation aim to alleviate the burden of initial stage and renew the gates which are the obstacles to efficient operation and maintenance and the related piers will be rehabilitated. Consequently, the structure for the partial rehabilitation shall cover the above items only and be provided in connection with the upstream side in considering the relationship with the rest structure such as arches and their related structures. In view of space for the works, the old bulge portions of the piers shall be removed and the necessary structures shall be independently provided at there.

The Manshat El Dahab regulator with a long length of the regulator's body is picked out as a model in order to study various alternative plans to improve and rehabilitate of existing barrage and regulators. The gate width of 3.0 m shall be the minimum length, and a comparative study shall be made in considering the widening of the width. The superstructure shall be made in considering the widening of the width. The superstructure shall be planned taking into consideration the easiness of operation and maintenance.

On the other hand, the total rehabilitation shall aim to make a total rehabilitation or improvement for the whole structures which have already been so deteriorated as to unable the partial rehabilitation to expand the remaining life span any longer. And the total renewal of such facilities shall be planned. For the new construction of the facilities, the present location of three upstream regulators except for the Dairout barrage and Lahoun regulator is deemed suitable for water diversion to the branch canals judging from the results of the canal profile study (refer to Figure F-2-2 in Appendix).

The new facilities shall be constructed possibly close to the present location so as to keep the same functions of securing water level as that in the past, taking into consideration easiness in operation and maintenance of the superstructures and in construction works as well. The gate scale shall meet the designed canal width and satisfy the hydraulical conditions of the relevant barrage/regulators to secure sufficient capacity. The alternative study has been made on the gate types and span length taking into consideration the control function, operability, safety as well as easiness of operation and maintenance of superstructures.

2) Study on Gate Types and Scale

a) Gate Types

Gates are important facilities to control the water level for better water utilization by barrage/regulators. The gates facilities have to provide such functions as securing a stable water level, and controlling the water level and discharges as well as holding necessary water tightness.

The gate types to be taken up for the study are wheel gates, slide gates, radial gates, etc. which are to be studied on their applicability. The wheel gates type is a representative type of gates, which is suitable to the gates with span length less than 15 m. And girder type of leaves is commonly employed in the case that the rate of leaf height to length (H/L) is more than 1/5, and a shape and its mechanics are simple with smaller winding load than that of slide gates and high reliability in operation. The high single leaf gates of this type, however, will require high piers to result in large winding load.

Double leaf gates are easy in discharge control and in permitting floating materials to flow down. It is also advantageous to lower the pier height, but the mechanism will become complicated with water tightening, leaf guiding, and winding. This gate has two types of structure as double leaf wheel and hook type. The double leaf wheel type employs girders in combination. And special attention should be paid to the structural stability of the gates, when the height-length rate (H/L) of a single leaf of the gate is too small. The hook type gate is the gate with the upper leaf with ⌈ shape. The gate is used in combination with the lower wheel gate and is suitable to the conditions that there is some difference in water levels at up and downstream with water level and discharge controlled properly.

The slide gate is employed in the case that the span length and water level difference are comparatively small. The structure is simple with steel plate at supports. Winding load become large due to friction of guide rails with supports, when the gates are operated with high water pressure.

Radial gates are hydraulically advantageous in operation without receiving effects of flow because of providing no guide rails. The piers will become longer because there is a center of trunnion shaft located at the downstream side, while the piers' width can be smaller than that of wheel gates. Winding load can be smaller than that of wheel gates because of very small friction by little water pressure. Weight of the gate leaves can be smaller than those of wheel gate when the scale becomes larger, which will allow comparatively smaller motor powers. The structure is more complicated than that of the wheel gate, and also is not so strong in considering that there are very few steel members used.

As a result of comparison of the characteristic features of the respective gates, the proposed gates have been studied on the double leaf wheel gate and the radial gate in view of the scale and operability.

b) Span Length

The partial rehabilitation plan is proposed to construct new gate facilities at immediate upstream of the existing regulator, that is, proposed new gate facilities connect with the existing one. As mentioned in section 3.3, an existing gate facility between existing 2 m width piers (big piers), total width of 20 m, is composed of five, 3 m width vents and four, 1.25 m piers (small piers). Taking into consideration those present conditions, following two case studies of span length are carried out as one of the alternative plans to avoid an interruption of smooth flow of discharge. In Plan-A, the proposed gate width is the same of the existing vents width of 3m. In Plan-B, two gates with a span length of 6.5 m, one gate of a span length and new two 2 m pier would be proposed for the 20 m span length between big piers.

The total rehabilitation plan shall be made in the conditions of better consistency with designed cross sections of the canals and having the total effective span length by 40 m in terms of hydraulical conditions of the up- and downstream of the gates.

On the basis that the double leaf wheel gates shall have the leaf height by 3.1 m and the radial gates by 6.0 m, the leaf weight of the wheel gates will proportionally increase up to 10 m in span length in view economy and operability, but for more than 10 m in span length, the weight increasing rate will become larger.

For the radial gates, with more complicated structure with leaves than the wheel gates, longer span length can not be recommended. And furthermore, the operation shall be made originally by electric motor, but manual operation system should be provided in considering the local conditions and longer span length should be avoided.

Economy of the works shall be considered together with that of the civil works. As a result of the aforesaid comparative study, the gate size to be taken is recommended as follows. For the wheel gates, the span length shall be 8.0 m and 13.4 m, while for the radial gates, be 6.6 m, respectively.

c) Selection of Operation Devices

The operation mechanism of gates has to secure safety, and stable operation speed required against operation load and the mechanism should be as simple as possible. The operation devices for the respective gate types shall be selected on the basis of the following suitability.

Type and Applicability of Operation Device

Type of Gate	Size	Hoisting Equipment: Wire Rope Winch Type	Hoisting Equipment: Spindle Type	Hoisting Equipment: Rack Type
Wheel Type Gate	Large	○	×	×
	Medium	○	△	△
	Small	○	○	○
Radial Gate		○	△	△

Notes: Symbols and Words

	○	:	Most applicable
	△	:	Applicable in cases
	×	:	Unsuitable
Small size leaf		:	Leaf area less than 10 m^2
Medium size leaf		:	Leaf area between 10 and 50 m^2
Large size		:	Leaf excepting for the above

Selection of operation devices for the existing gates with span length by 3.0 m shall be made taking into consideration the following four types as applicable ones: Roller Chain, Spindle, Rack, and Wire Rope Winch. In reference to the above suitability and characteristic features, the comparative study on the operation devices shall be made in the following paragraphs (refer to Table F-2-3, Appendix F).

Wheel gates:	Medium size gate	-	Wire rope winch type
	Small size gate	-	Rack type
Radial gate:		-	Wire rope winch type

3) Alternatives of the Rehabilitation and Improvement Works

The partial rehabilitation will have new facilities in connection with the existing ones at immediate upstream of the remaining facilities. Alternative-A shall be that the span length of the new gates is 3.0 m which are the same as that of the existing vents. Alternative-B shall be that a span length is 6.5 m (equal to two spans of the old vents) and the other 3.0 m (equal to one old span) in their combination. The two plans are further specified into five sub-plans as follows from the viewpoint of utilization extent of the existing facilities, easiness of operation, and contents of rehabilitation works for the superstructures; Alternative-A is specified into three sub-plans, while Alternative-B into two sub-plans. The total rehabilitation has been specified as Alternative-C. The plan is specified into three sub-plans by combination of gate types and span length (refer to Table 4-1 and Figures F 2-5 to -7 in Appendix F).

TABLE 4-1 ALTERNATIVES OF CASE STUDY ON REGULATOR

Alternatives		Scheme of Rehabilitation / Improvement: Weir's Body / Pier	Pier Superstructure	Gate
Alternative - A (Partial Improvement)	A-1	- Newly construct piers for gates' installation at just front of the existing piers. - Span length takes the same as the existing one. - Spans length: 3.0 m × 15 spc - Piers : 1.25m × 12 pcs 2.00m × 4 pcs - Total length of weir : 64.0 m which reduced 24m from the present 88m.	- Strengthen the existing pier superstructure	- Newly install Double-leaf wheel type gate. - 3.0 m× 3.1 m × 2 leaves 15 spans
	A-2	- The same scheme as A-1. - Total length of weir : 64.0 m	- Newly construct pier superstructure of 4.0 m width at the immediate downstream of the existing structure.	- The same scheme as A-1.
	A-3	- The same scheme as A-1. - Total length of weir : 64.0 m	- Newly construct pier superstructure of 6.0 m width at the immediate downstream of the existing structure.	- The same scheme as A-1.
Alternative - B (Partial Improvement)	B-1	- Newly construct piers for gates' installation at just front of the existing piers. - Span length partially expand. Span length : 3.0 m × 3 sps 6.5 m × 6 sps Pier : 2.0 m × 10 pcs - Total length of weir : 64.0 M	- Newly construct pier superstructure of 4.0 m width connecting to new piers.	- Newly install Double-leaf wheel type gate. - 3.0 m × 3.1 m 2 leaves 3 spans - 6.5 m × 3.1 m × 2 leaves 6 spans
	B-2	- The same scheme as B-1	- Newly construct pier superstructure of 6.0 m width connecting to new piers.	- The same scheme as B-1.
Alternative - C (New Construction)	C-1	- Span length : 6.6 m × 6 sps Pier : 1.5 m × 7 pcs - Total length of weir : 64.0 m - The same scheme as B-1	- Pier superstructure of 6.0 m width.	- Radial gate 6.6 m × 6.0 m 6 spans
	C-2	- Span length : 8.0 m × 5 sps Pier : 2.0 m × 6 pcs - Total length of weir : 48.0 m	- The same scheme as C-1.	- Double-leaf wheel type gate 8.0 m × 3.1 m × 2 leaves 5 spans
	C-3	- Span length :13.4 m × 3 sps Pier : 2.5 m × 4 pcs - Total length of weir : 45.2 m	- The same scheme as C-1.	- Double-leaf wheel type gate 13.4 m 3.1 m × 2 leaves 3 spans

Notes: 1. The aforesaid plans of rehabilitation for regulators have been carefully studied on the comparison of various figures with several kinds of plans.
2. The dimensions of the Manshat El Dahab have been selected as representative values for comparative study of the major five barrages and regulators along the Bahr Yusef canal.

a) Alternative-A

The piers at upstream shall be removed, where the new gate facilities shall be constructed in connecting with remaining facilities. The new beds shall be extended to the upstream from the existing one. The span length of the new gates shall be 3.0 m, the same length as the existing one. Consequently, the pier width will become 1.25 m and 2.0 m which are the same width as those of the existing ones. Double leaf wheel gates shall be employed for the new gates from the view of advantage in operability and low piers adoptable in structure because of high leaf height of 6.0 m. The rack type devices shall be employed in consideration of high mechanical efficiency and simple mechanism suitable to small size gates. The structure of the regulator's bodies is same as each other, but the plan is further classified into the following three alternative plans from the viewpoint of the contents of the rehabilitation works.

Alternative A-1	:	Reinforcement of the existing facilities
Alternative A-2	:	Providing at immediate downstream of the existing facilities, road width 4.0 m
Alternative A-3	:	Providing at immediate downstream of the existing facilities, road width by 6.0 m

b) Alternative-B

The existing upstream piers shall be removed, and the new gates shall be constructed in connection with the remaining facilities at the places where the old facilities will be removed. The new facility beds shall be extended to the upstream in contracting the existing ones.

The new span length shall be in combination of 6.5 m (two spans of the old span) in taking the existing large spans of 2.0 m as one unit, and 3.0 m (one unit of the old one). The double leaf gates shall be employed in consideration of the advantages in operability and availability of lower pier height for the piers as high as 6.0 m. The rack type devices shall be provided for the gate operation in view of high mechanical efficiency and simplicity. The plan is specified into two in terms of the facility scales, although having the same structure.

Alternative B-1	:	Existing facilities with additional road width by 4.0 m
Alternative B-2	:	Existing facilities with additional road width by 6.0 m

c) Alternative-C

This plan aims to provide totally new facilities. The plan is prepared with the concept that the gate width shall meet consistently the designed cross section and the total effective vent width shall be 40 m to satisfy the hydraulical conditions of the facilities. The conditions to determine the details of the plan are based on the combination of the gate types and the span length. Two types, radial gates and double-leaf wheel gates, are selected from the viewpoints of superiority in water level control, operability, safetiness, etc. The latter plan is further specified into two by span length to result in three plans in total.

Alternative C-1 :	Radial gates with 6.6 m of span length and 3.0 m of leaf height, 6 gates
Alternative C-2 :	Double leaf wheel gates with span length of 8.0 m and leaf height 3.1 m × 2 leaves, 5 gates
Alternative C-3 :	Double leaf wheel gates with 13.4 m span length and 3.1 m leaf height × 2 leaves, 3 gates

4) Alternative Study

Comparative study of the construction costs in taking Alternative-A by 1.00 has clarified that the Alternative-B will be in a range from 1.08 to 1.10 and Alternative-C for total new construction from 1.10 to 1.15 (refer to Tables K 2-1 to -3 in Appendix K).

Alternatives A and B as partial rehabilitation will not be expected to keep longer life of the structures because there existing major parts of existing structures will be remained intact. And deterioration and abrasion of the old structures will give fear for instability of the structures. On top of the above, there will be much trouble some work caused from operation of a number of small size gates. And for rehabilitation works it will be rather difficult implement the works for such short period of about three weeks of the winter closure period and the works will require temporary works for deep water.

Alternative C-1 is the plan that radial gates are provided, which will result in a large scale civil work due to longer trunnion shaft with more complicated structures than those with wheel type gates. And, as a result, the structure itself will become weak. Besides, single-leaf structure will be unfavorably function for letting floating matters smoothly flow down.

On the other hand, Alternatives C-2 and C-3 will employ wheel type gates, which have comparatively simple structure in double leaf wheel gates as well as rigidity. The double leaf wheel gates are easy in discharge control and letting floating matters flow down. In the case of the span length will be 13.4 m, larger winding load, however, prevents operators from manual operation.

As the results of comparative study of the above alternatives on their economy, operationability safety and life longevity, the new construction in Alternative-C shall provide double leaf wheel gates as recommendable gates with many good results and high reliability in structure. The span length shall be 8.0 m at the longest in consideration of the operability by manual works and Alternative-C-2 of the above three is recommended for the project.

5) Construction Sites for Proposed Facilities

The locations of proposed facilities have been studied in view of relations to the traffic networks and the intake facilities for branch canals to be selected at the places as close to the existing facilities as possible. The dry work sites should be considered primarily from the viewpoints of economy and easiness in construction works. The existing lock facilities, which have been constructed rather recently, shall be used by themselves taking into consideration the rare frequency in their use. The better canal alignment shall be selected. For new construction works, the locations should be so selected to minimize the land for acquisition. The above conditions are taken into consideration as the base for selection of the proposed new construction sites. For each regulator, two to four alternative plans have been prepared for comparative study.

a) Dairout Barrage

Since it is difficult to secure the dry works with wide space unavailable, the right bank site about 100 m downstream thereof, which is shown in Alternative D-1, shall be recommended to be suitable in terms of easiness in construction works as well as economy in making best use of the existing lock facility (refer to Figure F-2-8 and Table F-2-24 in Appendix F).

b) Manshat El Dahab Regulator

The site in a cultivated land, which is located at about 120 m upstream left bank from the present site, is recommended as Alternative A-1 in consideration of advantages in local conditions with road networks and minimum land loss as well as economy in utilizing the existing lock facility (refer to Figure F-2-9 and Table F-2-4 in Appendix F).

c) Sakoula Regulator

The site in upland fields, as Alternative S-1 located at about 320 m upstream left bank from the present site, is recommended in considering advantages in minimum land loss and economy in utilizing the existing lock facility (refer to Figure F-2-10 and Table 2-4 in Appendix F).

d) Mazoura Regulator

The site in the upland field about 200 m upstream right bank as Alternative M-1 is recommend in considering advantages in minimum land loss and economy in utilizing the existing lock facility (refer to Figure F-2-11 and Table F-2-4 in Appendix).

e) Lahoun Regulator

The Gezirah site (shoal island site) located between the present facilities and lock facility is proposed as Alternative L-1 considering advantages in minimum land loss and easiness in construction works (refer to Figure F 2-12 and Table F 2-4 in Appendix F).

In addition to the above plans, in a case that it is difficult to secure land acquisition for the proposed facility on the above plans, the other proposed plans which has a proposed site in the Bahr Yusef canal, even with longer construction period, hard constructionability and higher cost, would be recommended.

4.3.3 Branch Canal Intake Facilities

1) Outline of Improvement Plan

The branch canal intake facilities provided cover many types and sizes from 1.0 m span length on a simple sluice gate to a number of large size gates, and also a variety of gate ages from those more than 90 years old and those constructed/rehabilitated recently. For these various facilities, partial repairmen/rehabilitation and total improvement shall be made for the plan.

The intake facility with small-size sluice gates, which are with comparatively time-worn structure on both gates and bodies, shall be replaced completely with new gates and bodies.

The intake facilities with F.H gates, some partial rehabilitation/improvement will permit their functions greatly improved. The broken gates and winding devices, however, will have to be replaced with their gate leaves and improve the gate bodies partially.

Most of plural number of large-size gates are so heavily deteriorated with both civil works parts and mechanical parts like gates, screens, etc. that there have been some gates found inoperative. These gates in troubles are mostly made of bricks, and deemed as old as 90 years. As life-span of these bodies is considered to have exhausted and to require total rehabilitation and improvement. Consequently, the gate type, which is superior in operability and safety, shall be proposed.

2) Types and Sizes of the Gates

The F.H gates, which have been long and popularly used and economical, shall be proposed for medium-scale intake facilities with single and plural number gates type; while the wheel type shall be proposed for the large-scale intake facility in plural number gates type in considering advantages in intake control and operability. And the large leaf height gates shall be of double leaf type with advantage in civil work structure and operability.

Wire-rope winch type winding devices shall be proposed for those medium-scale intake gates in plural number gates with a span length of 3.0 to 5.0 m.

4. 3. 4 Branch Canals

Harika branch canal had been selected and studied as representative of 45 branch canals to formulate the rehabilitation and improvement plan. The manner of planning and design standard and the estimation of project cost would be applied to the rehabilitation and improvement plan of the other branch canals.

1) Analysis of the Existing Condition

Harika branch canal has been studied by the mathematical model that the pursuit of water level has been analyzed as non-uniform flow based on the survey of vertical alignment and cross sections and the investigations of the present water level and discharge at Harika branch intake. The existing facilities are studied based on the following conditions.

- The command area of Harika canal is 18,800 feddan and the cultivated area is 12,600 feddan which covered 67% of the command area.
- The discharge of sub-branch canal at the each intake were calculated by the maximum unit water requirement of 0.383 ℓ/sec/feddan which is based on the standard unit water requirement of MPWWR and the present cropping pattern.
- The water level at the tail escape of Harika branch canal is regarded as EL30.10 m
- The coefficient of roughness in Manning's equation is $n = 0.030$
- The cross sections of every 1 km are coordinated to X and Y axis for the mathematical model.

The present water requirement of Harika branch canal has been estimated at Q = 19.3 MCM/month by the manner of MPWWR which is multiplied the unit water requirement by the command area of Harika branch canal. The other hand, the actual amount of water use based on the observation discharge of Q = 9.6 m^3/sec at the downstream of Harika intake on July 7th in 1991 surveyed by the JICA study team and the operation record of Harika intake gate from June to August in 1991 is estimated at Q = 13.1 MCM/month which covers 68% of the calculated water requirement by MPWWR. According to the survey for water reuse at the pilot area by the JICA study team, the amount of water reuse which has been provided by drainages and groundwater is estimated at 10% of the peak water requirement. Therefore, the command area of Harika canal has been provided the amount of water which covered 78% of the water requirement at the period of the peak water requirement.

Taking into account of the similarity between the observation discharge of Q = 9.6 m^3/sec and the water requirement of Q = 9.65 m^3/sec estimated by the manner of MPWWR in case of two turn rotation system, and the operation record of Harika intake gate during the summer season, it's possible that the existing irrigation system is regarded as two turn rotation system actually. The analysis of the water level has been carried out as the condition of two turn rotation system. Even disregarding the five existing regulators, the water level at the point of No.13, No.20 and No.25 were very close to the field elevation so that there was no freeboard in case of two turn rotation system. In other words, the capacity of Harika branch canal has been adapted to two turn rotation system.

2) Rehabilitation and Improvement Plan

Rehabilitation and improvement plan of irrigation facilities has been formulated based on the continuous system for branch canals and three turn rotation system for sub-branch canals and the following conditions.

- The cultivated area of Harika canal is the same as the existing area of 12,600 feddan.
- The discharge of sub-branch canal at the each intake was calculated by the maximum unit water requirement of 0.545 ℓ/sec/feddan which is based on the design unit water requirement, the design losses of transportation and on-farm and the cropping pattern.
- The restriction water levels for planning are the design diversion water level of three pilot areas and the taking over water level to Beni Suef governorate at the second existing regulator.

Kom El Hasel sub-branch	:	EL 32.06 m
El Baghour sub-branch	:	EL 31.63 m
Nazlet Ramadan sub-branch	:	EL 31.34 m
Downstream of the Second existing regulator	:	EL 31.10 m

- The water level at the tail escape of Harika branch is EL 30.10 m and the coefficient of roughness is n = 0.030.

The necessity of rehabilitation and improvement plan for facilities such as canals and regulators has been studied by the manner of pursuing the water level at the following each case.

Case 1 - The study has been carried out as uniform flow with the proposed trapezoid cross section and the design discharge of 6.926 m^3/sec at Harika intake.

Case 2 - The study has been carried out as non-uniform flow with the existing cross section and the design discharge.

Case 3 - The study has been carried out as non-uniform flow with the existing cross section and a half of the design discharge of 3,463 m^3/sec at Harika intake.

Case 4 - The study has been carried out as non-uniform flow with the existing cross section. The discharge has been applied the discharge at the top of the block which was divided Harika canal into three blocks based on the reaching distance during night time. The first block has the range from Harika intake to the existing first regulator and the discharge of 6.926 m^3/sec, the second block has the range from the existing first regulator to the exiting second regulator and the discharge of 5.169 m^3/sec and the third block has the range from the existing second regulator to the end of Harika canal and the discharge of 2.631 m^3/sec.

According to the study of the case 1, the canal bed shall be set on the cut portion from the viewpoint of the implementation and be arranged the proper gradient of 6 ~ 8 cm/km, the cross sections much smaller than the existing cross sections make farmers anxious, taking the above into consideration the water level should be regulated at proper points anyhow.

According to the study of the case 2, the water level should be regulated at the existing fourth regulator and the proposed new regulator which would be installed at the immediate downstream of Nazlet Ramadan intake to keep the restriction water level. The existing cross section has an enough capacity to convey the design discharge so that the existing cross section needs the minimum rehabilitation such as trimming the particular portion where has restricted on the water flow.

Considering the case of the minimum discharge during the winter season, the case 3 has been studied. The existing first and fourth regulator and the proposed new regulator control the water level in this case.

Considering the night storage capacity, the case 4 has been studied. The existing first regulator and the tail escape of Harika canal dam up 24 and 20 cm, consequently the water level has increased 30 cm on the average higher than the water level of the design discharge.

The water levels (EL. m) at each regulator which are proposed the rehabilitation and improvement or the new construction and at Harika intake in case 2, 3 and 4 are shown as below.

Consequently the rehabilitation and improvement plan for branch canal has been formulated as reconstructing the three existing regulators and tail escape, constructing a new regulator proposed and trimming the cross section which restricted the water flow based on the continuous system.

	Case 2	Case 3	Case 4
Harika intake	32.54	32.22	32.73
The first regulator			
Upstream	31.75	31.98	32.15
Downstream	31.75	31.68	31.91
The proposed new regulator			
Upstream	31.59	31.64	31.75
Downstream	31.30	31.16	31.75
The second regulator			
Upstream	31.10	31.10	31.50
Downstream	31.10	31.10	31.50
The Fourth regulator			
Upstream	31.00	31.08	31.36
Downstream	30.29	30.17	31.36

4.3.5 Mini-hydropower Generation

Water head of about 2 m between upstream and downstream of the Lahoun regulator and stable discharge of about 40 to 50 m^3/sec are observed throughout the year. Under these conditions, the potentiality of hydropower generation at the Lahoun regulator is higher than that of other regulators. At the other regulators, a water head of less than 50 cm during a period of higher water level and 1 to 2 m during the period of lower water level were observed between upstream and downstream of the regulators. Under this situation, potentiality of hydropower generation at the other regulators is lower than that of the Lahoun regulator due to seasonal big fluctuations of heads and discharges.

Based on the past five years records of water level and discharge at the Lahoun regulator, potentiality of hydropower generation was theoretically and hydraulically calculated as having a 640 kw of hydropower generation capacity and a 4.72 GWH of annual hydropower generation for 10 months from February to December. However, at present, a hydropower generator is technically and economically not feasible. Development of this potentiality will need more technical progress for equipment in the future (refer to Table E-3-22 in Appendix E).

4.3.6 Drainage and Irrigation Pump Stations

Pump stations relating to the Bahr Yusef canal are nine drainage pump stations and eight irrigation pump stations for six command areas. The rehabilitation plan of the related pump station has been prepared on the basis of history of each facility, MED's records, and field survey.

1) Rehabilitation of Drainage Pump Stations

The pump houses, for which considerably long time has passed since their last rehabilitation, shall be reconstructed. Total renewal of pump equipment, including motors, shall be made for those machines and devices with pump efficiency lowered by old ages more than 19 years, while those older than 12 years in use shall be partially renewed and repaired. Possibly many spare parts shall be supplied to make troubled equipment operative. Removal of water hyacinth and trash treatment has been a problem and a mechanical weed screen cleaning machine shall be provided at adequate places. Since eight drainage pump stations, excepting one pump station, have problems on operation and maintenance due to no gravity by-pass way. For the plan of a complete new pump station, a gravity spill way and/or a by-pass canal would be proposed and for other plan such as replacement of pump equipment, a by-pass canal would be proposed around the existing pump station.

2) Rehabilitation of Irrigation Pump Stations

The irrigation pump stations except Mazoura (0) new are as old as 19 to 25 years, and total equipment shall be renewed with seven stations, six of which are low in pump efficiency and one of which, Terfa (1) new is in sufficient in lift.

Arab Beni Khalid and Beni Khalid pump stations are located closely each other, and at this opportunity of renewal, a combined irrigation pump station is studied from the viewpoints of economy and advantages in O/M works.

For rehabilitation of the Kamadir station where water intake is impossible directly from the Bahr Yusef canal, the three alternative rehabilitation plans have been studied including that of intaking from Manshat El Dahab branch canal.

Since, in general, short supply with spare parts has caused much difficulty in O/M of the facilities, needed spare parts shall be supplemented to meet the local requirements. A mechanical weed screen cleaning machine shall be provided to solve the long suspended problem.

3) Study on Combined Plan of Arab Beni Khalid and Beni Khalid

A plan is prepared to combine the above two pump stations to one new station. The location for the new station is proposed to the site of the existing Arab Beni Khalid station, and four units of pumps with capacity of 0.8 m^3/sec/unit. The total capacity is 3.2 m^3/sec, and one stand-by unit is provided. The total number of the units is five. Other devices and facilities like transformers, transmission lines, etc. shall be included in the new combined irrigation pump station. A feeder canal between two stations shall be provided with checks, bridge, intake works, and other necessary appurtenant structures. The section required for the canal shall be 1.62 m^3/sec with total length of about 3.3 km.

Canal types are studied on two types of open canals and pipelines. In considering the fact that the topographic slope around the pump stations is so flat by 9 cm/km as for pipeline to require diameters more than 2,000 mm, the open canal is employed with a bottom width by 1.0 m, side slope by 1 : 1, water depth by 1.4 m, side and in concrete lining with 0.2 m thickness. Finally, open canal type would be chosen according to availability of the materials in the field (refer to Figure F-2-15 in Appendix).

4) Alternative Study on Kamadir Station

This pump station was constructed to take water from Bahr Yusef canal, but the lower water level at the Bahr Yusef canal has not allowed the water intake available at present. Consequently, presently, water pumped from the Manshat El Dahab branch canal has been taken in. This branch canal, however, is insufficient in section to convey water in the amount including the above amount to be lifted, and the local farmers in the downstream areas have been suffering from water shortage. The following alternative plans, therefore, have been studied to improve the present unfavourable conditions.

a) Irrigation water shall be taken from Manshat El Dahab branch canal by gravity method and the pump station shall be abolished (to save O/M costs).

The study on the supply water level of 37.98 m at Manshat El Dahab branch canal and delivery water level of 38.70 m has clarified impossibility by gravity intake (refer to Figure F-2-16 in Appendix F).

b) Irrigation water shall be taken from Manshat El Dahab branch canal

The branch canal shall be improved in widening to meet the necessary maximum discharge. The both are, however, farm lands extending along the both bank areas of the branch canal, and land acquisition will be extremely difficult. The necessary farm land width is 4.0 m, and about 70 feddan of the farm lands will become land loss for the total 19.1 km of the canal. This plan, therefore, has not been proposed in terms of difficulty of land acquisition.

c) Irrigation water shall be taken directly from the Bahr Yusef canal, and two alternative plans are considered for the study as follows:

Case-a: The existing pump station shall be improved. The pump facilities shall be improved so as to meet the low water level. Total improvement shall be made including all equipment and devices.

Case-b: The pump station shall remain unchanged and a new regulator shall be constructed so as to rise the water level in the Bahr Yusef canal. This plan, however, requires more costs than the above.

As a result of the study, the alternative Case-a is proposed for rehabilitation of the Kamadir pump station.

4.3.7 On-farm Facilities

As clarified in Chapter 3, for improvement of the on-farm irrigation system, it is indispensable to improve not only facilities but farmers' cooperation on operation and maintenance of the system. Therefore, in consideration of equitable distribution and stable irrigation water supply, the objectives of on-farm irrigation facility improvement could be stated as follows;

- to remove water shortage at canal tail,
- to improve on-farm irrigation efficiency, and
- to reduce ineffective outflow caused by improper structure.

1) Sub-branch Canal Improvement

From hydraulic analysis of the sub-branch canals at the pilot irrigation areas, canal flow capacity at the peak period in the proposed rotation system (5 days-on, 10 days-off) is found generally satisfied even taking night storage volume into consideration. Improvement requirement, therefore, will be the minimum, such as canal bank trimming, weeding of canal bed and banks, and maintaining necessary intake water levels. Improvement with canal concrete lining, blocks/stones or canal widening would not be required and sub-branch canals shall remain with an low level earth canal as existing. Even in a long length canal of El Baghour sub-branch, canal flow capacity can be secured by means of canal trimming and partly heightening canal banks.

For intake structures of sub-branch canals, existing intake gates, mostly one steel sluice gate, shall be rehabilitated to be in operational condition, since branch canals are planned to change to the continuous flow system and sub-branch canals remain with the present three-turn rotation system. Operation works of sub-branch canal intake gates can be undertaken by present staff of the District office after training on gate operations.

Tail escapes shall also be rehabilitated as much water leakage was observed at the most of spill gates. Small regulators found in the long sub-branch canals like El Baghour sub-branch will remain in the improved system. Other canal structures, such as RC pipe culverts and SP pipe aqueducts are also necessary to rehabilitate or replace at some places.

Proposed pilot area maps, irrigation networks and longitudinal profiles of the sub-branch canals are presented herein (refer to Appendix G, Figures G-2-3 to G-2-13).

2) Meskas

Improvement of Meskas as major on-farm ditches operated by farmers is principal works for upgrading of the on-farm water distribution system. Meska improvement plans shall be formulated under following principles;

- to regulate one-point lifting at Meska intakes in order to avoid direct and individual intakes,
- to improve Meskas for convenient and quick delivery water system by which WUAs can be functioned, and
- to improve on-farm irrigation efficiencies.

Seven alternatives for Meska ditch improvement were studied as follows.

Alternative-1	Open low level Meska	, Earth,
Alternative-2	- do -	, Lined,
Alternative-3	Open raised Meska	, Earth,

Alternative-4	- do -	, RC flume,
Alternative-5	- do -	, Trapezoid section,
Alternative-6	Closed pipeline Meska	, PVC pipe,
Alternative-7	- do -	, RC pipe

Many factors were taken into account, such as water losses, construction easiness, land requirement, operation and maintenance, and so on. Among these factors in comparison, two factors were particularly considered for selection of the most recommendable alternative. One is contributability to the distribution control improvement, and the other is acceptability for farmers or adaptability to WUAs. As the result of comparative study, alternative-5, raised-lined Meska with trapezoid section, would be the first recommendable improvement, and followed by alternative-3, raised earth Meska, particularly from the viewpoint of construction cost (refer to Appendix G, Table G-2-3).

Small pump station shall be constructed at Meska intake to regulate one point lifting system. Pumps for Meska intakes are determined either ø6 or ø8 inches depending on the area served. Other intake structures are RC pipe culvert, pump sump and delivery basin. Intake pump operations at Meska shall be executed by WUAs according to the irrigation scheduling given by the IAS (refer to Appendix G, Figure G-2-14).

Proposed longitudinal profiles of five sample Meskas were prepared. Number of Meskas will increase because of construction of some new Meskas to replace the existing direct intakes. However, number of pumps working at sub-branch canals shall considerably be decreased in the proposed irrigation networks. Meska rotation scheduling was also prepared for reference (refer to Figures G-2-15 to G-2-18 and Tables G-2-4 to G-2-6).

Meska improvement plans are formulated above, however it is insisted that the on-farm distribution system improvement is a matter of urgency to be achieved through establishment of WUAs. Moreover Meska improvement with concrete lining shall require large construction cost which shall be borne by farmers in principle. In this regard, therefore, it could be stated that raised earth Meska (alternative 3) would be the practical way of the Meska improvement for the moment.

3) Marwas and Plots

No improvement plans will be set up for Marwas which belong to individual farmers. This is because particular problems are not found except long ditch length at some areas, and on-farm water distribution improvement could be attained through Meska improvement plans. Since Meskas are improved to a raised-lined ditch, location of Marwa intakes is to be fixed providing small sluice gate for more convenient distribution.

For land leveling, plots are generally in the fair condition taking account of comparatively small size of in-field rotation block, field crop cultivation by furrow or basin irrigation method unlike paddy, and small infiltration rate. However, since poor land leveling condition was observed at some places, land leveling improvement at some places will be planned in the Project. As to plot size and shape, it seems to be difficult to reform land size and shape through land exchanges due to land inheritance system in Egypt.

4.4 Physical Planning

4.4.1 Bahr Yusef Canal

The cross sections of the Bahr Yusef canal have been deformed by erosion and sediment to result in shortage of the capacity. The alternative study of the canal section improvement has concluded that the present canal width shall be unchanged but the depth shall be deepened by 0.7 m evenly in keeping the designed water level unchanged.

The field survey on the local conditions has resulted in the rehabilitation plans to carry out shortcut of the following four meandering sections of the canal. The alignment of the proposed shortcut has been selected in considering that the local conditions for shortcut are favourable and the connection with the existing canal is to be made smoothly. For the cross sections of the shortcut portions at km 20.5, km 30.5, and km 80.5, respectively, the bottom width shall be 43.9 m and side slope 1 : 1.5, while at the point of km 193.5, the bottom width shall be 41.9 m and side slope 1: 1.5. The total canal length of shortcut improvement and the effects resulting from the said improvement are shown as follows: (refer to Figures F-3-1 to -4 in Appendix).

Location (km)	Length (km)	Reduced Length (km)
20.5	1.1	1.8
30.5	1.0	1.6
80.5	0.9	0.6
193.5	2.3	2.5

4.4.2 Barrage and Regulators

1) Basic Design Concept

The scale of the barrage/regulators is so determined as to maintain a flow width for stable flow in the canal even when the water level difference can be rather large between upstream and downstream of the barrage/regulators and the canal section can be secured hydraulically large. The unit discharge throughout barrage/regulators is limited in view of hydraulical stability in gate operation as well as O/M work for bed protection works. And since the plan employs double leaf gates because of high leaf height, the gate opening degree shall be in medium degree and over in peak discharge operation in consideration of less gate vibration. Besides, such gates shall be in a submerged condition for keeping advantages in discharge and water level control. The effective gate width of the barrage/regulators is determined in taking into account that the peak discharge should be 8.0 m^3/sec for the Dairout barrage and Lahoun regulator which are restricted in local conditions, while 6.0 m^3/sec for the other three. The gate arrangement is made with the largest span length by 8.0 m and shall have plural number of gates with even span length (refer to Table F-3-1 in Appendix F).

The barrage/regulator foundation shall be of spread and continuous foundation from the viewpoint of the extremely stiff sandy foundation layers of the canals. The gate sill elevation is designed to be 0.5 m higher than apron elevation in terms of effects for sediment control and flushing. The Bligh's empirical formula was applied to the designed length of the apron, riprap, piping works for water interception, etc. The riprap is to tie the concrete apron with very fine sand material canal beds (refer to Tables F-3-2 & -3 in Appendix F).

Since an average velocity of discharge is as gentle as about 0.7 m/sec, the riprap is consisted of stone rubble of about 60 cm thickness and of concrete blocks with 60 cm thickness, 1.2 m length and 1.2 m width arranged by 6 m mesh. And the riprap is placed over a gravel filter of 30 cm thickness to protect sucking up fine sand foundation materials.

2) Dairout Barrage

The alternative study has concluded that the location is at the major bed point about 100 m downstream right bank from the existing facilities. The designed discharge at the proposed site is 226.5 m^3/sec and the effective flow width is 28.0 m. Therefore, the designed discharge for the unit width is 8.09 m^3/sec. The gate arrangement is determined in the plural number of gates with even span length, 8.0 m at the longest (refer to Figure F-3-5, Appendix F).

Scale	:	Span length of 7.0 m × 4 nos. piers width of 2.0 m × 3 nos., 1.8 m × 2 nos., barrage length of 34.0 m (total length 38.0 m)
Barrage body	:	Concrete structure with spread foundation, pier height of 12.15 m, apron length (incl. bed) of 48.0 m
Superstructures	:	O/M Bridge of 4.0 m width
Gates	:	Double leaf wheel gates, wire-rope winch type, span length of 7.0 m, leaf height of 3.3 m × 2 leaves × 4 gates

3) Manshat El Dahab Regulator

The alternative study has concluded that the location is selected at the point in the field about 120 m upstream left bank from the exiting facilities. The designed discharge at the regulator is 210.15 m^3/sec, and the effective flow width is 35 m. Therefore, the designed discharge for the unit width is 6.0 m^3/sec. The gates arrangement shall be made in even span length (8.0 m at the longest) with plural number of gates (refer to Figure F-3-6, Appendix F).

Scale	:	Span length of 7.0 m × 5 nos. piers width of 2.0 m × 4 nos., 1.8 m × 2 nos., regulator length of 43.0 m (total length 46.6 m)
Regulator body	:	Concrete structure with spread foundation, pier height of 12.05 m, apron length (incl. bed) of 48.0 m
Superstructures	:	O/M Bridge of 8.0 m width
Gates	:	Double leaf wheel gates, wire-rope winch type, span length of 7.0 m, leaf height of 3.25 m × 2 leaves × 5 gates

4) Sakoula Regulator

The alternative study has concluded that the location is selected at the point in the field about 320 m upstream left bank from the present facilities. The designed discharge is 139.64 m^3/sec. The effective section is 32.0 m in its width. Therefore, the designed discharge for the unit width is 6.05 m^3/sec. The gate arrangement is made in even span length (8.0 m at the longest) with plural number (refer to Figure F-3-7, Appendix F).

Scale	:	Span length of 8.0 m × 3 nos. piers width of 2.0 m × 3 nos., 1.8 m × 2 nos., regulator length of 38.0 m (total length 41.6 m)
Regulator body	:	Concrete structure with spread foundation, pier height of 11.45 m, apron length (incl. bed) of 42.0 m
Superstructures	:	O/M Bridge of 4.0 m width
Gates	:	Double leaf wheel gates, wire-rope winch type, span length of 8.0 m, leaf height of 3.2 m × 2 leaves × 4 gates

5) Mazoura Regulator

The alternative study has concluded that the location is selected at the point in the field about 200 m upstream right bank from the present facilities. The designed discharge at the regulator is 187.79 m^3/sec, and the effective flow width is 32.0 m. Therefore, the designed discharge for the unit width is 5.87 m^3/sec. The gate arrangement is made in even span length (8.0 m at the longest) with plural number (refer to Figure F-3-8, Appendix F).

Scale	:	Span length of 8.0 m × 4 nos. piers width of 2.0 m × 3 nos., 1.8 m × 2 nos., regulator length of 38.0 m (total length 41.6 m)
Regulator body	:	Concrete structure with spread foundation, pier height of 11.45 m, apron length (incl. bed) of 42.0 m
Superstructures	:	O/M Bridge of 4.0 m width
Gates	:	Double leaf wheel gates, wire-rope winch type, span length of 8.0 m, leaf height of 3.05 m × 2 leaves

6) Lahoun Regulator

The alternative study has concluded that the location is selected at the Gezirah (shoal island) between the existing facilities and the present lock gate. The designed discharge at the barrage is 80.06 m^3/sec. The effective flow width is 11.0 m. Therefore, the designed discharge for the unit width is 7.28 m^3/sec. The gate arrangement is made in even span length (8.0 m at the longest) with plural number.

When the design discharge flows down throughout the regulator under bigger head of 1.8 m between downstream water level (WL) of 24.8 m and the controlled upstream WL of 26.6 m, the velocity of the discharge at the gates will be bigger and the discharge control by the gates will be unstable. In order to prevent those phenomenons, the head between up- and downstream would be limited at 1.0 m to dam up downstream water level by proposing a sub-dam at downstream of the proposed regulator (refer to Figure F-3-9, Appendix F).

Scale	:	Span length of 5.5m × 2 nos. piers width of 1.8 m × 1 nos., 1.5 m × 2 nos., regulator length of 12.8 m (total length 15.8 m)
Regulator body	:	Concrete structure with spread foundation, pier height of 11.75 m, apron length (incl. bed) of 8.0 m
Superstructures	:	O/M Bridge 8.0 m width
Gates	:	Double leaf wheel gates, wire-rope winch type, span length of 5.5 m, leaf height of 3.15 m × 2 leaves × 2 gates
Canal	:	Concrete structures with spread foundation, sub-dam with a height of 3.0 m, canal length of 60.0 m including regulator length