No. 2

ARAB REPUBLIC OF EGYPT

MINISTRY OF PUBLIC WORKS AND WATER RESOURCES

FEASIBILITY STUDY
FOR
REHABILITATION AND IMPROVEMENT OF DELIVERY WATER SYSTEM
ON
BAHR YUSEF CANAL

MAIN REPORT

NOVEMBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request of the Government of The Arab Republic of Egypt, the Government of Japan decided to conduct a feasibility study on Rehabilitation and Improvement of Delivery Water System on Bahr Yusef Canal and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to The Arab Republic of Egypt a study team headed by Mr. Yoshio Arai, Sanyu Consultants Inc., four (4) times between April, 1991 and September, 1992.

The team held discussions with the officials concerned of the Government of The Arab Republic of Egypt, and conducted a field survey at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

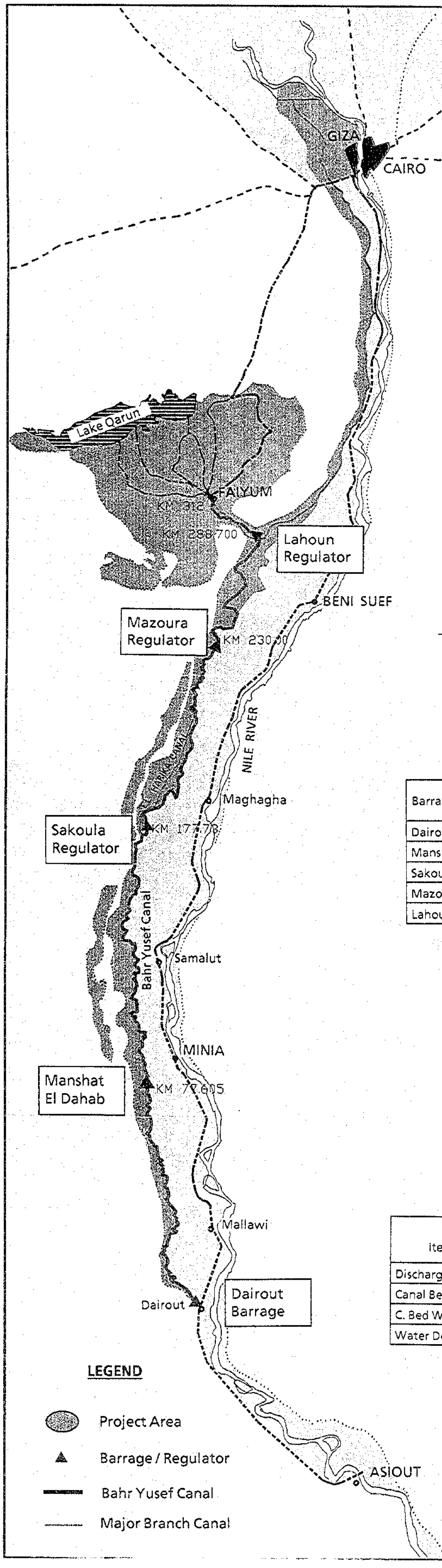
I wish to express my sincere appreciation to the officials concerned of the Government of The Arab Republic of Egypt for their close cooperation extended to the team.

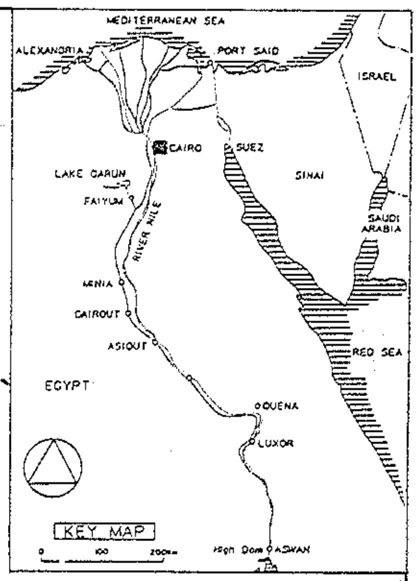
November, 1992

Kensuke Yanagiya

KENSUKE YANAGIYA
President
Japan International Cooperation Agency

GENERAL PLAN MAP

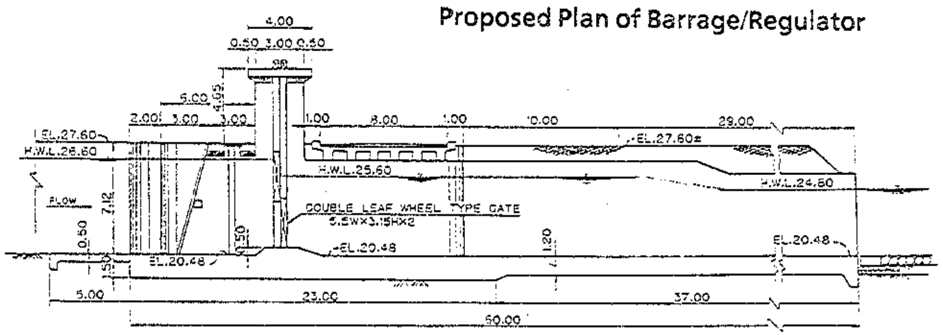




Command Area

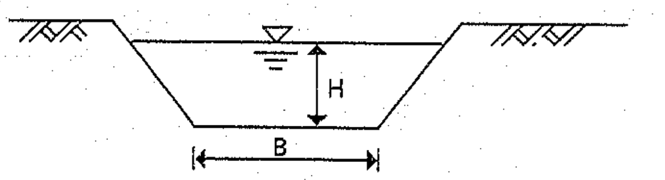
	Minia	Beni Suef	Faiyum	Giza	Total
Valley(Old Land)	114,101	57,295	361,589	137,300	670,285
Reclaimed Area	32,999	10,850	-	-	43,849
Expansion Planned	-	5,000	40,000	11,000	56,000
Total in feddan	147,100	73,145	401,489	148,300	770,134
(ha)	(61,800)	(30,700)	(168,600)	(62,300)	(323,400)

Proposed Plan of Barrage/Regulator



Dimensions of Proposed Barrage/Regulator

Barrage / Regulator	Weir Width	Vent		Gate	
		No.	Span	Type	Size (W × H × Leaves)
Dairout	34.0 m	4	7.0 m	Double Leaf Wheel Type	7.0 m × 3.30 m × 2
Manshat El. Dahab	43.0	5	7.0		7.0 × 3.25 × 2
Sakoula	38.0	4	8.0		8.0 × 3.20 × 2
Mazoura	38.0	4	8.0		8.0 × 3.05 × 2
Lahoun	12.8	2	5.5		5.5 × 3.15 × 2



Proposed Typical Cross Section

Dimensions of Proposed Canal

Item		Dairout to Manshat Dahab	M.E. Dahab to Sakoula	Sakoula to Mazoura	Mazoura to Lahoun
Discharge	(m^3/sec)	234.06	209.82	195.26	194.86
Canal Bed Slope	(cm/km)	7.15	6.50	7.00	5.00
C. Bed Width (B)	(m)	43.90	43.9	41.9	41.9
Water Depth (H)	(m)	5.70	5.50	5.29	5.83

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ABBREVIATION AND GLOSSARY

Abbreviation

ARC	Agricultural Research Center
ARE	Arab Republic of Egypt
CAPMAS	Central Agency for Public Mobilization and Statistics
EALIP	Egyptian Agriculture and Land Improvement Project
EIRR	Economic Internal Rate of Return
EPADP	Egyptian Public Authority for Drainage Projects
EWUP	Egypt Water Use and Management Project
FAO	Food and Agriculture Organization
F/S	Feasibility Study
GARPAD	General Authority for Rehabilitation Projects and Agricultural Development
GNP	Gross National Product
GDP	Gross Domestic Product
IAS	Irrigation Advisory Services
ID	Irrigation Directorate
IIP	Irrigation Improvement Project
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
MED	Mechanical and Electrical Department
MALR	Ministry of Agriculture and Land Reclamation
M/P	Master Plan
MPWWR	Ministry of Public Works and Water Resources
O & M	Operation and Maintenance
PBDAC	Principal Bank for Development and Agricultural Credit
RIPBY	Rehabilitation and Improvement Project of Bahr Yusef Canal
SCF	Standard Conversion Factor
S/W	Scope of Work
WRC	Water Research Center
WUA	Water User's Association

Conversion

cm	centimeter
°C	centigrade
cu.m	cubic meter

m^3/sec (cms)	cubic meter per second
fed.	feddan = 0.42 ha
ha	hectare = 2.38 fed.
hr	hour
kg	kilogram = 1,000 g
km	kilometer = 1,000 m
km^2	square kilometer
lit./sec	liter per second
m	meter
MCM	million cubic meter
m/sec	meter per second
okta	cloudiness
%	percent
ppm	parts per million
t	ton = 1,000 kg

Currency

LE	Egyptian Pound
Pt	Egyptian Piaster
Yen (¥)	Japanese Yen
US$	US Dollar(s)

Exchange Rate (1991)

LE	= 100 Pt
LE	= ¥42
LE	= US$0.30
US$	= LE3.30
US$	= ¥140

Glossary

Marwa	Small distributor, irrigation ditch
Meska (Mesqa)	Private ditch serving from 10 to 300 feddans and 10 to 200 farmers
Sakia (Saqia)	Water wheel to lift water

SUMMARY, CONCLUSION AND RECOMMENDATION

SUMMARY

CHAPTER 1. INTRODUCTION

1.01 In response to the request of the Government of the Arab Republic of Egypt, the Government of Japan has decided to conduct the Feasibility Study for Rehabilitation and Improvement of Delivery Water System on Bahr Yusef canal (hereinafter referred to as "the Study"), within the framework of the Agreement of Technical Cooperation between the Government of Japan and the Government of the Arab Republic of Egypt (ARE) signed on June 15th, 1983. The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programmes of the Government of Japan, has dispatched a preliminary survey team and concluded the S/W of the Study between the Ministry of Public Works and Water Resources (hereinafter referred to as "MPWWR") and the JICA on October 22, 1990.

1.02 The field work of Phase-I for the Study has been conducted from April 21 to June 2, 1991 and from July 15 to September 17, 1991, while the field work of Phase-II has been successively performed from January 9 to March 17, 1992, by the Study Team in compliance with the S/W. The Study Team has conducted the field work to grasp the present problems and constraint of the existing delivery water system for planning the rehabilitation and improvement of the said facilities for effective and equitable distribution of irrigation water in the command area of Bahr Yusef canal. The home office work has been subsequently conducted in Japan. This work comprises observations and findings of the field work as well as various alternative studies undertaken in the formulation of plans for the rehabilitation and improvement of the said system. Draft Final Report has been submitted and discussed with officials of MPWWR from August 27 to September 2, 1992.

1.03 The objectives of the Study is to evaluate the feasibility of the rehabilitation and improvement of delivery water system on Bahr Yusef canal in order to improve the overall efficiency of water use thus contributing optimum crop production in the area. The plan shall be formulated to be technically sound, economically viable and socially acceptable.

1.04 This Report incorporates the results of the analyses, observations and findings and alternative studies on the proposed rehabilitation and improvement plan as well as the results of various studies and discussions conducted by the officials of MPWWR on the Progress Reports I and II, Interim Report and Draft Final Report.

CHAPTER 2. BACKGROUND

2.01 Egypt is an agricultural country having a total area of some one million square kilometers or 238 million feddan and located in the north east Africa. About 96 percent of the nation is desert, and the remaining four percent is concentrated mostly in the valley of the Nile and its delta, which are densely populated and agriculturally productive. The arable area with about 6.4 million feddan covers only 0.12 feddan per capita, the lowest level in the world.

2.02 Egyptian economy has been seriously affected situation by financial and trade deficits,, cumulative external debt, etc. GDP showed the growth of 5.0 percent in 1988/1989 and GDP per capita in 1990 is 630 US dollars. Share of the agricultural sector in GDP has been reduced, but contributing labour force participation rate to 36 percent and earning foreign exchange by exports of agricultural products.

2.03 The productivity of agriculture depends upon irrigation. Virtually all the water available for the irrigation use comes from the Nile river which passes through Lake Nasser. A reservoir is now utilized after the construction of the High Aswan Dam (HAD). Following completion of the HAD and the consequent provision of perennial water supplies from 1968 to all irrigated areas, the cropping intensity, yields and water use per unit of area have sharply increased resulting to drastic changes of agriculture and irrigation system in the country.

2.04 In the past 20 years, whilst much of Africa has suffered as a result of the widespread Sahalian drought, Egypt has been insulated against its effects by the water storage provided by Lake Nasser. The reduced Nile flow has resulted falling substantially of the volume of water stored in reserve in Lake Nasser. There was critically little reserve storage before the 1988 flood. If the prolonged Sahalian drought will persist, inflow of 84 milliard at Aswan would be reduced to some 70 milliard and the secure yield available to Egypt would reduce to some 49 milliard against the allocated 55.5 milliard.

2.05 MPWWR aims at immediate implementation of the rehabilitation and improvement for the existing water distribution systems covering about 6.0 million feddan in old lands. It was projected to reach to 1.0 million feddan within present Five-Year Plan for Socio-economic Development. 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 for rehabilitation and improvement project after obtaining economic and technical cooperation from the Japanese Government and other developed countries. Toward this end, MPWWR requested the Japanese Government to conduct the feasibility study the Rehabilitation and Improvement of Delivery Water System on Bahr Yusef Canal for the urgent rehabilitation and improvement of the said system.

CHAPTER 3. THE PROJECT AREA

(Location and General Features)

3.01 The whole country of Egypt lies in the temperate zone between 22 degrees and 32 degrees of north latitude. The Project Area is between 27 degrees and 30 degrees north latitude, therefore, the climate in the Project Area belongs to desert or Sahalian climate. Average annual rainfall was recorded only 9.2 mm in Faiyum and 5.0 mm in Minia, therefore, rainfall is not of any value for irrigation use.

(Project Area)

3.02 Bahr Yusef canal serves the command area of about 770 thousand feddan, which are spread over 147 thousand feddan in Minia governorate, 73 thousand feddan in Beni Suef governorate, 402 thousand feddan in Faiyum governorate, and 148 thousand feddan in Giza governorate.

(Present Agriculture)

3.03 Crop composition and cropping pattern differ from governorate to governorate and those in Bahr Yusef canal command area are also different, reflecting local conditions. As a whole, maize, cotton, sorghum and vegetables are the dominant crops in summer, meanwhile, wheat, broadbean, berseem and vegetables in winter, maize and vegetables in Nili season, respectively. The present cropping intensity in the command area of Bahr Yusef canal are 171 percent in Minia, 187 percent in Beni Suef, 179 percent in Faiyum and 225 percent in Giza.

(Bahr Yusef Canal)

3.04 Bahr Yusef canal, branched off from Ibrahimia principal canal at Dairout barrage, is a main canal with a length of 312.7 kilometers and ends at Faiyum town. The unlined meandering canal has certain cross sections to meet required discharge and has many facilities such as regulators, intake structures of branch canals and pump stations. Regulators of Sakoula and Lahoun control discharges by a downstream water level, while Manshat El Dahab and Mazoura regulators control upstream water level.

3.05 Discharge measurement of Bahr Yusef and Ibrahimia canals were carried out. Accordingly, the maximum daily intake discharge for the past five years was recorded at 18.8 MCM/day which is smaller than 19.5 MCM/day of the maximum design discharge. It is confirmed based on the observed data that the existing canal capacity of Bahr Yusef canal equals to about 80 percent of the original design capacity. It is presumed that will be due to the limited water resources and application error of "n" value of roughness coefficient on the Manning's formula.

(Present Problems and Constraint of Irrigation Water Distribution)

3.06 According to the review of problems and constraint on the existing water delivery system, the following conclusions are summarized;

(1) The water management in Egypt is conducted by governorate basis. The water control facilities located near governorate boundary have an important role as same as the intake facility. Water level and discharge of Bahr Yusef canal are controlled at Dairout barrage as an intake, and Sakoula and Lahoun regulators near the governorate boundary by using rating tables. Other two regulators, Manshat El Dahab and Mazoura, have function of water level control.

(2) The gate operation of those barrage/regulators is carried out based on water level instructed by the Irrigation Directorate. The gate is manually operated by several labourers. Leakage water from the gate of barrage/regulators is observed and is effectively utilized at the downstream command area, thus it is not a loss.

(3) Irrigation water of Bahr Yusef canal system is delivered from the Nile River based on the calculated amount of water by application of the standard unit water requirement of MPWWR and scheduled cropping area of MALR. Irrigation water of the principal canal is distributed to the branch canals on the proportional basis of the command area. In a period of low irrigation efficiency in April and October, some excess water is observed. At Sakoula regulator, branch canals are used as spillway to drain the excess water. Such ineffective operation will be caused that an application of standard unit water requirement for a wide command area does not

meet the actual demand and also cropping pattern does not agree the proposed cropping.

(4) The studies and analysis of the present water requirement are conducted by applying the modified Penman method, which shows the middle value of evapotranspiration with observed meteorological data of concerned stations in comparing with Blaney-Criddle and Radiation methods. In this study, investigated crop area and cropping pattern were prepared by governorate. It is estimated the annual net water requirement of 3,053 MCM. Considering amount of intake water, reuse water and contribution of groundwater, the present overall irrigation efficiency is observed at 60.5 percent. The irrigation efficiency is fluctuated by season. Maximum monthly efficiency of 76.9 percent is appeared in July, while the minimum monthly efficiency of 28.3 percent in October. The present water shortage in summer season and excess water in winter season meet the above efficiencies. For reference, the net water requirement based on the present standard unit water requirement of MPWWR equals to 3,179 MCM, about 104 percent of the above calculation.

(5) The drain water with salinity contents of 2,000 to 3,000 ppm is utilized as irrigation water during the peak water demand period. To prevent salt accumulation at the surface layer of the old lands, tile drain projects with about 127,000 feddan were implemented, and these projects for about 55,000 feddan of the old lands will be executed in the future.

(Pilot Irrigation Area)

3.07 The pilot areas, namely Kom El Hasel, Nazlet Ramadan and El Baghour, with total command area of 3,130 feddan were selected in the Harika branch canal command area, then various field measurement, monitoring and tests were carried out.

(1) The on-farm irrigation system consists of sub-branch canals, Meskas and Marwas. Sub-branch canals belong to MPWWR and Meskas/Marwas are to farmers. One meska covers 10 to 120 feddan and irrigation water is taken from sub-branch canals by farmers' individual pumps.

(2) According to water level observation, water shortage at sub-branch canal tail was frequently occurred in summer period, thus irrigation from drainage canals by pump was widely practiced. However, water shortage was not found in winter, on the contrary water levels became so high that downstream farmers could irrigate by gravity sometimes. As the result of on-farm water balance analysis, on-farm

irrigation efficiency was 70 percent on an average, 65 percent at upstream and 80 percent at downstream.

(3) Major problems on the present on-farm irrigation system are summarized below:

- tail water shortage due to over irrigation at the upstream,
- farmers' trend of over irrigation caused by the present rotation,
- shortage of night storage capacity and much ineffective outflow, and
- inadequate water level control at the branch canal intake or regulator of the principal canal.

(Existing Principal Canal)

3.08 Bahr Yusef canal is a meandering, rather flat and unlined earth canal forming like a natural river. A meandering form of the canal gives not so serious hydraulic conditions in flowing discharge, hydraulic lost head, etc. due to slow velocity of about 0.60 to 0.80 meters per second. However, this meandering course provides non-uniform flow in the canal section and it will foster erosion of the canal side slope and scouring of the canal bed. The existing trapezoidal design section of the canal was changed to nearly an elliptic section by erosion of the canal side slope and sediment occurred at the foot of the side slope, but most of the canal sections are being kept the flow area as same as the original designed area.

(Existing Major Facilities)

3.09 The structure's body of the existing barrage and regulators of Bahr Yusef canal seems to be already overage according to the investigation report for Dairout barrage and Lahoun regulator made by the MPWWR and the results of drilling investigation on Manshat El Dahab, Sakoula and Mazoura regulators conducted by the JICA Study Team. Most of gates installed with barrage/regulators are hardly operated or deteriorated and would be replaced by the new type for proper operation and management of the delivery water system. Large scale scouring at the downstream of the barrage/regulators were found which is presumed to be occurred by the turbulent flow or non-uniform flow to be provided improper gate operation or closure of the gates. The downstream of the barrage/regulator would be protected by construction of a riprap with concrete blocks instead of the present boulder riprap.

CHAPTER 4. THE PROJECT

(Objectives of the Project)

4.01 The 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 regional economy as well as sharing a part of the national strategy on the adjustment of economic structure of the country.

4.02 Agriculture is the most important sector in Egypt supplying foods and creating employment opportunity with 36 percent of the labour force as well as contributing the country in terms of foreign exchange earnings by export. Agriculture in Egypt depends only on the limited water resources of Lake Nasser supplied through the Nile River. The available annual water resources of 55.5 milliard cubic meters is allocated to Egypt under the Nile Water Agreement 1959, however, due to prolonged Sahalian drought, inflows to Lake Nasser will be reduced and thus be difficult to get the allocated water resources for Egypt.

4.03 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 improving 1.0 million feddan within five years. 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 projects. The command area of Bahr Yusef Canal, covers about 770 thousand feddan and extends over the four governorates, shares about 13 percent of the total agricultural lands and one of the biggest irrigation system in Egypt.

4.04 There exist various problems and constraint of the existing facilities on Bahr Yusef canal to be solved and improved. Major problems are low structural stability due to superannuated structures, lack of irrigation water distribution facilities, and poor maintenance of canal 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 on-farm irrigation method is an important task in this regard.

(Project Formulation)

4.05 RIPBY is formulated to fulfill the objectives of the Project: namely, equitable water supply, effective water use and improved irrigation application for following:

(1) Rehabilitation and improvement of the existing facilities is planned to provide facilities by less initial investment 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 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 at minimum extent. The Project provide design consideration and criteria for these works to save the project cost. These works are rather easy and non-technical and will be executed in parallel with maintenance works during the operation period.

(4) Aged pump equipment of drainage and irrigation pump stations are to be replaced and spareparts/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 the study of Harika 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 cubic meters per second discharge, producing a generating capacity of 640 kilowatts. It is confirmed that the hydropower generation along Bahr Yusef canal is not economically viable and socially unacceptable at present in Egypt and thus the hypro-power plan is not included in the Project.

(7) The improvement plan under the Project is composed of rehabilitation and improvement of the major facilities on the main irrigation system operated and

managed by MPWWR. For the on-farm facilities operated by farmers, standard plan for improvement is presented based on the study of the pilot area, however, the improvement cost is not included in the project cost but is included in the project evaluation. It shall be noted that the Water Users Association (WUA) plays a major role in the improvement of the on-farm water management.

(Irrigation Water Requirement)

4.06 The proposed water requirement for about 670 thousand feddan of the old lands, about 44 thousand feddan of the reclaimed lands and about 56 thousand feddan of the expansion area, is calculated by the Modified Penman method along with the proposed cropping pattern and cropped area by crop. At present, the MPWWR and MALR have no development plan for the expansion area, therefore, the water requirement including leaching water in the expansion area is estimated taking into account the data of the neighbouring area reclaimed. Considering reuse water of 38.3 cubic meters per second of the nine drainage pump stations, reuse water in Faiyum and the groundwater contribution, the intake of 19.5 MCM/day for Bahr Yusef canal are considered sufficient for the Project. According to the results of analysis, the overall irrigation efficiency rate accounts to 69.8 percent by counting the annual net water requirement of 3,355 MCM and annual total water supply of 4,804 MCM. *It is proposed that the reuse water lifted by small pumps of farmers* from the drainage will be changed to the reused water to be lifted by drainage pump stations. The existing drainage pump stations have sufficient capacity for such changes.

(Proposed Improvement of Principal Canal)

4.07 The maximum and minimum water requirement are occurred in July and October, respectively. Based on the results of the water balance study in the principal canal, *the flow capacity of the canal section for the design discharge is comparatively* studied for the improvement. On the improvement plan of the canal section, the alternative-2 is proposed based on the following alternative studies:

Alternative-1: Widening water surface width by about 10 meters, keeping the present water level and water depth of about five meters, requiring Right-of-Way acquisition.

Alternative-2: Deepening water depth by about 0.70 meters, keeping the present water surface width of about 61 meters and the present water level, resulting no Right-of-Way acquisition.

Alternative-3: Raising water level by about 0.60 meters, keeping the existing canal bed width of 46 meters, resulting problems to be happened by too high water level at certain area.

According to the hydraulic analysis at the peak and low water demand periods, there is no problem on the intake of the branch canals, because most of the branch canal intakes are located at the upstream closed to the regulator. However, irrigation pump stations of Kamadir and Terfa are required to improve due to low water level both in the present and future.

(Irrigation Rotation System)

4.08 Irrigation rotation system as a principal factor of the irrigation system operation was studied taking into consideration the adequate combination between the continuous flow at the principal canal and the rotational irrigation at on-farm level. As a result of the alternative study, it is proposed the continuous flow up to the branch canals and three-turn rotation at sub-branch canals.

(Distribution Control System)

4.09 For the water distribution control system improvement, control and communication function for water level adjustment and monitoring, evaluation and feedback shall be established. An operation center shall also be established to undertake the distribution operation of the integrated Bahr Yusef canal irrigation system. On-farm water distribution control, on the other hand, shall be improved by establishing Water User's Associations (WUAs) which shall manage pump operations at Meska intakes. The Irrigation Advisory Services (IAS) shall provide strong support, guidance, training and monitoring to the farmers.

(Improvement Plan of Principal Canal)

4.10 Some reaches of Bahr Yusef canal have an insufficient flow capacity of the canal cross sections in changing the original trapezoidal section to nearly elliptical section by erosion and sediment of the flow. The improvement plan of the canal sections are recommended by deepening the canal bed and keeping the present total surface width to avoid an additional acquisition of Right-of-Way. For the improvement of the canal course to be straightened by the shortcut, it is proposed the improvement of four places out of 17 candidate sites according to the results of the detailed survey on the candidate sites in engineering and also environment of the villages concerned and livings.

(Improvement of Barrage/Regulator)

4.11 Major facilities of Bahr Yusef canal like barrage/regulators are mostly over durable aged structures of more than 90 years after it's construction. It is proposed to reconstruct such superannuated barrage/regulators near the existing site through several alternatives study including a partial improvement plan.

(Improvement of Branch Canal Intakes)

4.12 Most of intake structures of the branch canals are over durable age and made mainly of bricks and equipped with Fahmy Henen Gate (FH). Giza and Hassan Wasef intakes are quite large scale structures covering a wide command area of 153 thousand feddan and 118 thousand feddan, respectively. These intakes play significant roles for the command area and are proposed to reconstruct with a new type structure. Likewise, 14 intakes of 3.0 to 2.0 meters vent with the FH gate are proposed to replace, while the small scale intake structures smaller than 1.5 meters vent with the FH gate are partially rehabilitated and strengthened the support of the gate frame with improvement of the partial civil works concerned.

(Drainage Pump Station)

4.13 Since the existing pump stations aged more than ten or more years have low efficiency and it is rather difficult to secure the needed spareparts, pump equipment shall be replaced. The aged building are reconstructed and a by-pass canal in and around the drainage pump stations including El Badraman pump station out of nine stations, pump equipment and operation panels shall be replaced and needed spareparts for other four drainage pump stations shall be supplied. Furthermore, mechanical weed screen cleaning machine and a by-pass canal shall be provided.

(Irrigation Pump Station)

4.14 A new pump station combined with two irrigation pump stations of Arab Beni Khalid and Beni Khalid shall be advantageous for improvement of these stations. Pump equipment of Kamadir and Terfa No.1 irrigation pump stations shall be replaced and civil works of intake structures will be partially improved. On the improvement of Sakoula and Mazoura irrigation pump stations, only pump equipment shall be replaced. The above six pump stations shall be provided with weed screen cleaning machine. Terfa No.1 and Mazoura pump stations are comparatively new stations and no necessity for any improvement.

(Improvement of Branch Canals)

4.15 Harika branch canal is selected and studied as representative of a lot of branch canals to formulate the rehabilitation and improvement plan of the branch canals.The capacity of the existing canal is good for the discharge of the two-turn rotation system, therefore, the present capacity is not applicable for the three-turn rotation system recently practiced. However, the proposed irrigation system is a combined system of the continuous flow in the principal and branch canals and the three-turn rotation system in the on-farm level, resulting the capacity of the existing canal has enough capacity for the proposed system, and the canal sections will be improved partially at the minimum extent. For proper water management by control of water level, it is proposed to construct a regulator, improvement with replacement of gates of two existing regulators and construction of a tail wasteways. Planning and design criteria on these improvement on the Harika canal shall be applied for improvement of all branch canals in the Bahr Yusef canal command area and projected the improvement cost of the branch canals.

(Improvement of On-farm Facilities)

4.16 Improvement of the on-farm facilities are studied in the three pilot areas and formulated a standard on the improvement of the whole Bahr Yusef canal command area. Major works are improvement/construction of Meska, construction of Meska intake and rehabilitation/construction of farm road. Such works shall be undertaken by WUAs under technical assistance and support to be extended by MPWWR.

(Improvement of Cropping Pattern)

4.17 Increase in crop yield and cropping intensity can be expected by efficient water use, equitable water distribution, and timely and appropriate irrigation in the command area of Bahr Yusef canal, particular in summer season, in which water shortage often occurs. Target yield is derived by using the average of the best five crop yield in each governorate, and data on yield before and after establishment of WUAs surveyed by IIP under assistance of USAID are also considered.

Crop composition in case of with-project is studied based on 1) ecological / physiological, 2) strategic/political, 3) economic, 4) demand-supply of view. Particularly, berseem, which is the main animal feed in winter, occupying the largest area in crops, is indispensable for maintain soil fertility of farm land. As the result of study on feed balance, a part of berseem area is planned to be converted to more strategic crops such as wheat, maize, broadbean in Minia and Faiyum.

4.18 Since cropping intensity in each governorate reaches more than 170 percent, remarkable increase might be limited, however, possible improvement of cropping intensity is studied along with improved water management excepting Giza governorate which has reached leveled off. Consequently, improved cropping intensity are 217 percent from the current 171 percent in Minia, 196 percent from 187 percent in Beni Suef, 195 percent from 179 percent in Faiyum and 225 percent in Giza. Moreover, the cropping intensity in the reclaimed area and the expansion area are planned at 145.2 percent and 136.9 percent, respectively.

(Project Cost)

4.19 The project cost at current price is estimated at 850.1 million Egyptian Pound, of which 274.5 million, 291.3 million and 284.3 million Egyptian Pound are scheduled for the Phase-1 project, Phase-II project and Phase-III project, respectively.

CHAPTER 5. PROJECT IMPLEMENTATION AND OPERATION

(Executing Agency)

5.01 The executing agency of the Project shall be MPWWR in close coordination with the WUAs which will be organized among the farmers concerned and also other government agencies concerned led by the MALR. Under the MPWWR, Rehabilitation and Improvement Project of Bahr Yusef Canal (RIPBY) will be headed by the General Director (GD), who shall also act as the manager of the Project.

(Implementation Schedule)

5.02 Implementation of the RIPBY will be done into three phases, and each phase will be implemented in four years. The Project is expected to be completed within a period of 12 years.

(Engineering Services)

5.03 Engineering services shall be provided during the final design of the Project as well as in the supervision of the Project implementation in order to introduce modern engineering on design and construction management. The schedule of the engineering services will be made based on the implementing schedule of the Project.

(Operation and Maintenance)

5.04 After completion of the construction of the Project, all the facilities and equipment provided by the Project shall be turned over to the Irrigation Directorate concerned for the operation and maintenance of the system.

CHAPTER 6. PROJECT EVALUATION

(Evaluation Method)

6.01 Project evaluation is conducted from the viewpoint of national economy as the economic analysis and private economy as the financial analysis. Economic internal rate of return (EIRR) is used for judging economic feasibility of the Project. Result of the project evaluation shows 13.1 percent of EIRR, which is over 12 percent of the opportunity cost of capital applied by the Ministry of Planning. Therefore, the Project can be considered economically viable.

6.02 The existing barrage/regulators were maintained by strengthening the structures by grouting and repairing the gates to keep the function. Considering the durable age of the structures, more than 90 years after construction, it can be judged that the existing facilities have no any economic value.

(Economic Project Cost)

6.03 Economic project cost is composed of foreign currency portion, and local currency portion which is converted by multiplied by the standard conversion factor (SCF) of 0.877. SCF is accounted based on the data of trade statistics in the past six years.

(Project Benefit)

6.04 Agricultural benefits from the Project are derived from the increase in crop yield, cropping intensity and agricultural production in the command area of the Project.

(Economic Sensitivity Analysis)

6.05 Taking into consideration the influence on the project evaluation, which may occur by unexpected factors in the future, sensitivity analysis is conducted as follows:

Conditions of Analysis	EIRR (%)
1) 10% increase of project cost	12.2
2) 20% increase of project cost	11.5
3) 10% reduction of benefit	12.0
4) 20% reduction of benefit	10.8
5) combination of ① and ③	11.2
6) combination of ② and ④	9.4

(Farm Income Analysis)

6.06 Farm income of with-project and without-project are analyzed as a financial analysis. As the result, farm income of the average farm household in governorate will be improved as follows:

	Minia	Beni Suef	Faiyum	Giza
Averaged farm size (fed/farm household)	1.38	1.58	2.45	1.43
Farm income (LE/farm household/year)				
without project	1,470	1,760	3,240	4,740
with project	1,970	2,090	4,280	5,130

(Socio-economic Impact)

6.07 Not only tangible benefit, but also intangible benefit from the Project can be expected. They are improvement of living conditions, and correction of economic disparity in the region. Further, the Project will be a model for improvement of the water management through the rehabilitation and improvement of the major structures and on-farm facilities.

Moreover, water level of the Lake Qarun, where located at western part of the Project Area in Faiyum governorate, is extremely influenced by the water management of Bahr Yusef canal due to keeping the water level of the Lake by a balance of runoff into the Lake and evaporation from the Lake surface. Once the water level of the Lake rises by an unbalance of the above two factors, a wide area of lands and a lot of houses along the coast of the Lake will be inundated.

CHAPTER 7. DEVELOPMENT PRIORITY PROJECT

(Identification of Priority Components)

7.01 Rehabilitation and Improvement of Bahr Yusef Canal Project (RIPBY) comprises various project components with a large volume of works. Implementation of the Project is scheduled based on the identification of the project components in engineering and socio-economic priority. In developing the framework in the ranking of the project components for rehabilitation and improvement project prioritization, the following basic assumptions are made:

- Avoiding risks of failure on the existing facilities among the various project components is a primary concern during the planning stage. Hence, priority in the implementation of the project components should be given to the existing facilities with high risk of failure.

- Planning is considered a magnitude of the command area controlled and influenced by the facilities concerned as a beneficiary from the project components due to the irrigation facilities.

- Conveniency in the construction site, access to the site, availability of acquisition of the Right-of-Way for the construction and also impact to the agriculture, socio-economy and environmental aspects.

(Indicators of Project Components Ranking)

7.02 The following is the proposed indicators in the ranking of project components:

Indicators of the Existing Facilities:	- Durability - Function - Operation - Risk of failure
Indicators of the Beneficiary:	- Command area - Water resources - Efficiency of water
Indicators of the Implementation:	- Conveniency of construction - Accessibility - Right-of-Way - Impact

(Ranking of Project Components)

7.03 The observed values for the project formulation are finally grouped into four class intervals, namely A, B, C and D. The priority of the project components is determined taking into consideration such other conditions as administrative and regional matters. According to the results of the ranking of the project components in respect of formulation of the implementation programme for the project, five barrage/regulators are placed in the high rank of Class-A, followed by drainage and irrigation pump stations. All major facilities of the project components are ranked as Class-A, which just coincide with the objectives of the Project. Both large and small scale intake structures are placed in Class-B, while improvement and trimming of canal sections and straightening the canal course are placed in rather low rank of Classes-C and D, respectively.

(Implementation Programme of Priority Components)

7.04 The implementation programme of the Project are scheduled based on the ranking rate of the project components. Lahoun regulator together with intake structures of Hassan Wasef and Giza are to be implement in the first half of the Phase-I Project, while the Sakoula regulator and the related structures ranked as second priority in Class-A are to be implemented in the second half of the Phase-I Project.

(Project Components of Priority Project)

7.05 The project components to be implemented in the first half of the Phase-I project as a top priority are as follows:

1. Preparatory Works for Construction of Major Facilities

1.1	Construction Equipment	:	Bulldozer, Shovel, Crawler Crane, Vibro Hummer, Diesel Generator, others	
1.2	Construction Materials	:	Steel Sheet Pile, H-Shape Steel, Channel Steel, Sheet Pile Cap, Tie-Rod, Steel Foot Plate, Steel Stage, others	

2. Construction of Canal Structures

2.1	Lahoun Regulator	:	Intake :	Vent 5.50 m × 2
			Gate :	Double Wheel Gate 5.50 m × 3.15 m × 2, 2 sets
			Accessory:	Screen, Handrail, others
			Detour :	Bridge 30 m length 8 m width Access road150 m
2.2	Giza Intake	:	Intake :	Vent 4.00 m × 4
			Gate :	Double Wheel Gate 4.00 m × 2.40 m × 2, 4 sets
			Accessory:	Screen, others
2.3	Hassan Wasef Intake	:	Intake :	Vent 4.00 m × 3
			Gate :	Double Wheel Gate 4.00 m × 2.65 m × 2, 4 sets
			Accessory:	Screen, others

CONCLUSION

1. Achievement of optimum crop production by improvement of overall irrigation efficiency is a primary objective under the Agricultural Program of the Egypt's Five-Year Plan. Agricultural sector is the major sector under the Plan, supplying foods, providing employment opportunity of 36 percent of the labour force, and contributing foreign exchange earnings through exports of agricultural production. Agriculture in Egypt depends upon irrigation through the limited water resources of Lake Nasser, which is now seriously affected by the prolonged Sahalian drought. Therefore, improvement of this situation should be given priority.

   MPWWR desires to accelerate the execution of the rehabilitation and improvement project of the country by seeking engineering and financial cooperation from international agencies and developed countries on a bilateral basis.

   Toward this end, Bahr Yusef canal is important source of irrigation. It covers about 13 percent of the whole agricultural lands in Egypt. Based on the Study, this rehabilitation and improvement project of Bahr Yusef canal is technically sound, economically viable and socially acceptable.

2. Bahr Yusef canal is a meandering, flat and unlined earth canal forming like a natural river. The major facilities along the canal are already deteriorated and outdated, with age 90 years since its construction. Low irrigation efficiency exist in the canal due to superannuated structures of the said facilities. Therefore, such major facilities as barrage/regulators and intakes of the branch canals should be reconstructed and pump equipment of the drainage and irrigation pump station should be replaced in order to conduct a modernized water distribution and management and thus increase the irrigation efficiency in the irrigation system.

3. The executing agency of the Project will be MPWWR. Implementation of the Project shall be conducted into three phases for a period of four years each. In the first half of the Phase-I project, large scale construction equipment and materials shall be procured and utilized for the construction of all major structures on rotational basis. During the construction of the major structures, the irrigation system shall not be allowed to stop the operation, therefore it is needed to provide particular construction equipment and materials.

4. In conclusion, the proposed major components of the Project are as follows:

MAJOR PROJECT COMPONENTS

Description	Unit	Total	Phase-I	Phase-II	Phase-III
1. Improvement of Bahr Yusef Canal					
1.1 Remodeling & Trimming of Canal					
Improvement of Canal Sections	km	311.0	70.0	140.0	101.0
Improvement of Canal Course	km	4.8	-	-	4.8
1.2 Improvement of Barrage/Regulators					
Preparatory Works for Construction		LS	LS	-	-
Dairout Barrage	place	1	-	-	1
Manshat El Dahab Regulator	place	1	-	1	-
Sakoula Regulator	place	1	1	-	-
Mazoura Regulator	place	1	-	1	-
Lahoun Regulator	place	1	1	-	-
1.3 Improvement of Canal Structures					
Intake of Manshat El Dahab B.C.	place	1	-	1	-
Intake of Harika Branch Canal (B.C.)	place	1	1	-	-
Intake of Saab B.C.	place	1	1	-	-
Intake of Hassan Wasef B.C.	place	1	1	-	-
Intake of Giza B.C.	place	1	1	-	-
Large Scale Intake (3.m vent)	place	3	2	1	-
Median Scale Intake (2.5 m vent)	place	3	-	3	-
Median Scale Intake (2.0 m vent)	place	5	-	1	4
Small Scale Intake (1.5 m vent)	place	8	1	1	6
Small Scale Intake (1.2 m below)	place	21	7	6	8
2. Improvement of Branch Canals					
Branch Canals Command Area	1,000fed	670	200	200	270
3. Improvement of Pump Station					
3.1 Drainage Pump Station (D.P.S.)					
El Badraman D.P.S.	place	1	1	-	-
Other 8 D.P.S.	place	8	-	4	4

Description	Unit	Total	Phase-I	Phase-II	Phase-III
3.2 Irrigation Pump Station (I.P.S.)					
Arab Beni Khalid I.P.S.	place	1	1	-	-
Beni Khalid I.P.S.	place	1	1	-	-
Kamadir I.P.S.	place	1	-	1	-
Terfa I.P.S.	place	1	-	1	-
Sakoula I.P.S.	place	1	-	-	1
Mazoura I.P.S.	place	1	-	-	1
4. Operation and Maintenance of Bahr Yusef Canal					
4.1 Operation and Maintenance Facilities					
Hydraulic Observation Facilities	place	68	21	27	20
Communication Data Processing	place	61	18	25	18
4.2 Enhancement of Operation and Maintenance		LS	LS	-	-
4.3 Water Management		LS	LS	LS	LS
4.4 Training & Education		LS	LS	LS	LS
5. Project Cost					
Phase-I Project	274,500,000 LE				
Phase-II Project	291,500,000 LE				
Phase-III Project	284,300,000 LE				
Total Cost	850,100,000 LE				

RECOMMENDATION

1. Establishment of the Rehabilitation and Improvement Project of Bahr Yusef canal (RIPBY) headed by General Director (GD) under the administration of MPWWR Headquarters is a significant strategy for the successful implementation of the Project taking into consideration the large volume of the construction works and wide command area spread over the four governorates of Minia, Beni Suef, Faiyum and Giza.

2. It is recommended to provide a training and education to the farmers in the Bahr Yusef canal command area during the early stage of the Project implementation. It should be noted that proper water management at the on-farm level in cooperation with the field staff of MPWWR is a key to utilize limited water resources effectively for the realization of the desired crop production, and in this case, the water management shall be conducted by the Water User's Association (WUA) to be organized among the farmers concerned on the basis of the rotational irrigation system. Whilst the IIP, which is under the MPWWR cover the activities of the on-farm water management including establishment and operation of the WUA in the IIP area. These activities shall also be applied for RIPBY.

3. In carrying out the final design of the major structures such as barrage/regulator, large scale intake structure, etc., geological investigation on its foundation shall be conducted by boring and laboratory soil test to ensure a strong structural foundation.

4. During the implementation of the Project, training and education on the operation and maintenance of the modernized facilities shall be provided to the staff of MPWWR.

CHAPTER I. INTRODUCTION

CHAPTER 1. INTRODUCTION

1.1 Background of the Study

The Arab Republic of Egypt has formulated the Five-Year Plan to promote social and economic development of the country. Currently, the Third Five-Year Plan (1992/93 - 1996/97) is being launched aiming at realizing the targeted economic growth through promotion of horizontal expansion, increase of wheat production and expansion of employment opportunity as well as restructuring of the country's economic structure.

Agricultural sector plays a dominant role under the Five-Year Plan. According to the Plan, this sector, shall be supported by limited irrigation water resources through Nile river system. However, due to recent continuous drought and desertification in Africa, a 55.5 milliard cubic meter allocated to Egypt by the Nile Water Agreement cannot be attained, therefore, the Government should take necessary step to improve the present situation.

The Project calls for effective and immediate countermeasures to develop water resources in the Bahr Yusef canal, and in this concern, the Ministry of Public Works and Water Resources (MPWWR) plans to execute the rehabilitation and improvement projects as soon as possible after obtaining technical and economic cooperation from the donor countries, viz. Japanese Government and other developed countries and international financing institutions.

In response to the request of the Government of the Arab Republic of Egypt, the Government of Japan dispatched a Preliminary Study Team headed by Mr. Kenji Yoshinaga to Egypt through the Japan International Cooperation Agency (JICA) and concluded the Scope of Work (hereinafter referred to as "the S/W") between JICA and MPWWR for the Feasibility Study for Rehabilitation and Improvement of Delivery Water System on Bahr Yusef Canal (hereinafter referred to as "the Study") on October 22, 1990, within the framework of the agreement of technical cooperation between the Government of Japan and the Government of the Arab Republic of Egypt, signed on June 15, 1983.

The Study aims to evaluate the technical and economic soundness of the Project in order to improve the overall efficiency of water use and thus contribute to the optimum crop production in the area.

1.2 Implementation of the Study

The Study was divided into two phases; namely Phase I and Phase II. The field work of Phase I Study was conducted from April 21 to June 2, 1991 and July 15 to September 17, 1991, while the field work of Phase II Study was performed from January 9 to March 17, 1992 by the JICA Study Team, in cooperation with the staff of the MPWWR in the command area of Bahr Yusef canal in the governorates of Minia, Beni Suef, Faiyum and Giza.

Phase I Study aims to grasp the present conditions, particularly the problems and constraint of the existing delivery water system and formulate an overall plan for the rehabilitation and improvement project in order to obtain an effective and equitable distribution of irrigation water. Phase I Home Office Work covers the detailed study on the overall rehabilitation and improvement project plan. The results of the Phase I Study were compiled in the Interim Report.

Phase II Study aims at conducting supplemental field work and detailed survey on the high-ranked priority project components and formulating a final overall rehabilitation and improvement project plan as well as the semi-detailed design of the prioritized components. The concept of the plan has been formulated based on studies and various discussions on the Field Report, Progress Reports (1) and (2) and Interim Report and Draft Final Report prepared by the JICA Study Team. The results of the studies and discussions had been incorporated in this Final Report.

Members of the JICA Study Team assigned to the Study and the related offices of the Government of Egypt are listed below:

<u>JICA Study Team</u>

1.	Mr. Yoshio ARAI	Team Leader
2.	Mr. Masahiro IIDA	Irrigation & Drainage / Ass. Leader
3.	Mr. Keiichi SAKAEBARA	Meteorology & Hydrology
4.	Mr. Shunichi HOSONO	O/M of System & Water Management
5.	Mr. Yasumi KINOSHITA	Irrigation Facilities & Canal Structure
6.	Mr. Yasuhiro AMATSUJI	Design, Construction Planning & Cost
7.	Mr. Toshihide SHIBATA	Agriculture & Soil
8.	Mr. Kensuke IRIYA	Agro-economy & Project Evaluation

Related Offices of Government of Egypt

1. Planning Department of MPWWR
2. Irrigation Department of MPWWR
3. Mechanical and Electrical Department of MPWWR
4. Egyptian Public Authority for Drainage Projects of MPWWR
5. Water Research Center of MPWWR
6. Minia Irrigation Improvement Directorate of MPWWR
7. Faiyum Irrigation Improvement Directorate of MPWWR
8. East Minia Irrigation Directorate of MPWWR
9. West Minia Irrigation Directorate of MPWWR
10. Beni Suef Irrigation Directorate of MPWWR
11. Faiyum Irrigation Directorate of MPWWR
12. Giza Irrigation Directorate of MPWWR
13. Ministry of Agriculture and Land Reclamation, and Agricultural Offices
14. Agricultural Research Center

CHAPTER 2. BACKGROUND

CHAPTER 2. BACKGROUND

2.1 The National Economy and Agricultural Sector

The Arab Republic of Egypt is an agricultural country with an area of about one million km^2. However, the cultivable area is only 3.4% of the national land which has been distributed in the Nile Valley and the Nile Delta. The mid-year population of 1990 was about 55.5 million and has increased at a rate of 2.8% per year since 1979. Food supply for the people, transmigration to urban areas and unemployment are the major social problems in the country.

The Egyptian economy has been seriously affected situation by financial and trade deficits, cumulative external debt, etc. The Gross Domestic Product (GDP) showed a growth of 5.0% in 1988 / 1989 and shares of the agricultural sector in GDP have been reduced. The GDP per capita in 1990 was US$ 630.

At present staple foods such as wheat, fertilizer, agro-chemicals, are supplied by the Government at a subsidized price to support low-income groups. This subsidy system also includes public utility costs. However, this systems has been considered to be the cause of financial deficit and production efficiency reduced, therefore, the International Monetary Fund (IMF) has requested the government of Egypt to remove this system immediately.

Under the above situation as, the Government has launched policies aiming to improve the current economic conditions of the country. These policies are the following ;

- Removal of crop control (excluding cotton, paddy, sugarcane)
- Liberalization of crop prices
- Abolition of subsidy system for foods, fertilizers, agri-chemicals, and public utility charges
- Transfer of public sector to private sector
- Introduction of the new sales tax
- Increase of interest rate

The current Five-Year Plan (1987/88 ~ 1991/92) aims at promoting the following targets and goals ; ① expansion of production, ② increase of investment for transfer of economic structure, ③ importance of the private sectors, ④ appropriate redistribution of population, ⑤ expansion of economic cooperation and trade, ⑥ economic growth of 5.8% annually.

Agricultural sector is the most important sector in Egypt. This sector supplies not only foods but also contributes 36% (1986/87) of all employment opportunity for the occupational people as well as foreign exchange earnings through exports of the agricultural production. However, small agricultural lands, occupies only 3.4% of national land or 6.12 million feddans. The Egyptian government has also adopted a policy, by to developing new land (horizontal expansion) and increasing the yield (vertical expansion). Since 1952, 1.6 million feddans of new land had been reclaimed, however, newly reclaimed areas, which are mostly desert areas, need irrigation facilities to be consolidated.

From the viewpoint of national economy, self-sufficiency of wheat must be increased from the present 33% (1987/88). For this purpose, study shall be made whether the area for berseem can be reduced and converted to wheat.

Egypt is obtains 55.5 billion m^3 of Nile water annually under the Nile Water Agreement. However, the continuous droughts during the last 10 years, caused desertification in Africa, and attacked the riverhead of Nile River, resulting in the reduction of water level in the High Aswan Dam. In view of this Egypt was forced to stop power generation at High Dam to save drinking and industrial waters in 1988. Recently, discharge of the Nile River from 1978 to 1987 was reduced to 72.2 billion m^3 on an average, but the water level of the High Dam increased during the flood that occurred in 1988. Based on these facts, a drought may also occur in the future.

Toward this end, the Government of Egypt has promoted horizontal and vertical expansion to increase food production. Efficient use of the limited water resources was thereby requested. But the existing barrages and regulators now aged more than 90 years are already deteriorated, so efficient water control can not be expected due to these outdated facilities.

On a farm level, rotational irrigation system has been done but farmers are apt to take more water than they need because of the soil moisture during of non-irrigation period. To cope with the above situations, survey and improvement projects for efficient water use have been carried out under the multilateral and bilateral aids.

2.2 Structural Adjustment Programme and Agriculture

2.2.1 Crop Selection

As of March 1992, cotton and sugarcane are listed as quota crops, however, farmers can choose their own crops after two years when all crop control policy has been completely removed. It was observed on the field level, that many farmers planted broadbean this winter due to its high price in the last season. But agricultural office forecasts that the broadbean price will fall this season. According to field observation, there has been no remarkable change in planted crops as compared to the previous cropping patterns. On the contrary, berseem occupies bigger areas. Wheat ranks second and broadbean third.

Crop selection is free, however, production of cotton and sugarcane shall be secured to earn foreign exchange. Therefore, the government should insure the planted area, and production of those two crops should raise their prices to maintain farmer's willingness.

2.2.2 Privatisation

Currently, privatisation of the governmental companies is being promoted excluding some superior companies. The reclaimed area managed by land reclamation companies will be sold, and this also aims at not only promoting land reclamation by private sectors and ordinary farmers but also at reducing the present high unemployment rate of 12.3% through creating of job opportunity.

2.2.3 Role of Cooperative Society and Village Bank

The present roles of cooperative society and village bank are to implement the crop control policy by supplying agricultural inputs to farmers at a subsidized price, although those two organizations function separately as well as relating to the matters to the removal of crop control and subsidy systems. Village bank will take charge of credit and deposit of the villagers while the cooperative society supplies inputs at a market price and extension services to the villagers.

2.2.4 The Third Five-Year Plan

The Second Five-Year Plan was completed on 30th June 1992, but as of February 1992 the Third Five-Year Plan (1992 ~1997) has not yet been published by the Ministry of Planning. The third Fiva-Year Plan, as published in the newspapers, embodies the following goals:

- Abolition of financial investment in commodities and services
- Adopting a clear-cut policy of privatisation
- Putting an end to imbalances in Egyptian economy
- Promotion of horizontal expansion
- Increase of wheat production
- Promotion of land privatisation
- Expansion of employment opportunities

2.3 Regional Economy

Agricultural production in the four governorates contributes 20% (1985) in gross production value (GPV) of the whole Egypt.

The command area of Bahr Yusef canal occupies about 12% of the total cultivable lands of Egypt. Excluding Giza with 20.2%, 61 to 65% of the labour force is engaged in agriculture, and the economic structures of the other three governorates are similar.

The GPV of vegetables and fruits is high in Giza and Faiyum due to proximity to Cairo. On the other hand, the main crops in Minia and Beni Suef are maize, berseem, wheat etc. and the growing periods for these crops are relatively long, resulting to low cropping intensity as compared to Giza and Faiyum. As to actual crop intensity at governorate level, Giza is highest with a rate of 225%; then Faiyum, 179%; Beni Suef, 187%; and Minia, 171%.

As to GPV of livestock production, 20 ~25% of the total GPV accounted in the three governorates but excluded Giza, whose growth rate accounts to 33%.

Water resources in the Project Area depend on Bahr Yusef canal including some reuse water from drainage canals. Rotation irrigation of 5 days-on and 10 days-off have been applied, but farmers are apt to take use much more water than what the crops required during the 10 days-off. In particular, water shortage in the middle and downstream areas of the canals was observed during summer season, forcing farmers to use drained water. In view of this, farm income varies due to differences in crop yields even in beneficial areas of the canal. In order to correct these differences and maintain the regions as the agricultural producing areas, water sources of Bahr Yusef canal should be used more efficiently. However, the existing barrages/regulators have been already deteriorated, so these facilities should be rehabilitated. A need for efficient water management throughout the main irrigation facilities and on-farm facilities is therefore indispensable (refer to Appendix B-2).

CHAPTER 3. THE PROJECT AREA

CHAPTER 3. THE PROJECT AREA

3.1 Location and General Features

3.1.1 Location

The Bahr Yusef canal covers an agricultural land of about 770,000 feddan (about 323,400 ha) in the areas of Minia, Beni Suef, Faiyum and Giza governorates, and located on the left bank of the Nile River. The irrigation water diverted at the Asiout barrage (about 330 km south from Cairo) from Ibrahimia principal canal, 60 km downstream, and reaches at the Dairout barrage, where is the beginning point of the Bahr Yusef canal.

The Bahr Yusef canal is naturally meandering canal with 312.7 km length and ends at the Faiyum town, the capital of Faiyum governorate. The canal course traces the old river course to supply water to the depressed Faiyum area developed since the ancient era. The canal diverts irrigation water both to the Faiyum depression, having about 401,500 feddan of the command area and to the Giza canal, having about 153,100 feddan at the Lahoun regulator located at some 288.7 km downstream. The canal course reaches the end point, after 24 km flow down from the Lahoun regulator.

The narrow Nile valley, about 20 km width, from Asiout to Cairo is irrigated by the Ibrahimia and Bahr Yusef canals. The command area of the Bahr Yusef canal is located at the west side of the Nile valley. The command area, excluding the Faiyum depression, shows a strip shape area having an average width of 4 km, (wide width of about seven to eight km and narrow one of about one to two km).

3.1.2 Geographical Conditions

The command area of the Bahr Yusef canal is categorized at the old land, reclaimed land and expansion area. The old land is mainly classified into two categories: an alluvium plain with a belt shaped area extended on the left bank of the canal, and a Faiyum depression with 401,500 feddan. There is a quite big difference in the land slope of each area. The former one, located on the left bank of the Nile River, has a gentle slope of about 1:15,000 and the latter one has a steep slope facing to Lake Qarun, located at the northwest of the Faiyum depression.

Description	Minia	Beni Suef	Faiyum	Giza	Total
	fed	fed	fed	fed	fed
Old Land	114,101	57,295	361,589	137,300	670,285
Reclaimed Land	32,999	10,850	-	-	43,849
Expansion Planned	-	5,000	40,000	11,000	56,000
Total fed	147,100	73,145	401,589	148,300	770,134
(ha)	(61,800)	(30,700)	(168,600)	(62,300)	(323,400)

The command area of the Bahr Yusef canal is mostly located at the left bank of the canal. During the period of the peak water demand in summer, a part of the command area on the right bank is irrigated by the canal. The command area of the canal begins at the Arab Beni Khalid branch canal branched off at 39.3 km from the beginning point. The two boundaries of the downstream end of the command area exist at difference points. One is the shore of Lake Qarun in Faiyum and another is the boundary of the Giza branch canal.

The command area has elevation from 42.5 to 15.5 m above the mean sea level excluding the Faiyum depression. Since elevation of the Faiyum depression ranges from +25 m to -45 m facing to the Lake Qarun with five km width and 40 km length, located at the northwest of the depression, the land slope of the depression is steep, about 1:500.

On the other hand, there is the command area of about 43,000 feddan reclaimed on a desert area. This reclamation project was planned in 1965 and implemented in 1978. The large scale irrigation lifting was began in the reclaimed area in 1983. However, a part of the project area is still under ongoing reclamation. This reclaimed area also shows a strip shaped area divided into two parts in southern and northern parts. The southern part, with three km width and 45 km length is mostly in the Minia governorate, and northern part with three km width and 30 km length is mostly in the Beni Suef governorate.

Since these reclaimed areas have higher elevation of about 40 to 50 m than that of the old land, the Bahr Yusef canal can not irrigate the land by gravity. Four pump stations intake water from the Bahr Yusef canal,and additional booster pump stations lift water up to the command area with higher elevation in the reclaimed land. Since there is no water source in the area, the drinking water for animals and other inhabitants is to be supplied from the canal. The deep wells are only operated to supply water during the winter closure time and water shortage period.

3.1.3 Climate

The entire country of Egypt lies in the temperate zone between 22° and 32° north latitude. The Project Area is between 27 and 30 degree north latitude, therefore, the climate belongs to Type 2 distinguished by Hurst, H.E. and Philips, P., that is, desert or Saharan climate. The Nile River, flowing from the southern region to the Mediterranean, forms the ribbon of life for the country. The Project Area belongs to this ribbon with subtropical temperature prevailing through the land. This strip of water confines people and crops to the eastern and western edges. The desert on both sides of the Nile valley provide a warm and rainless climate with pronounced diurnal changes (refer to Figure C-1-1 in Appendix C).

The monthly mean temperature ranges from 12.3°C in January to 27.75°C in July. On the average, the temperature ranges around 15° to 20°C. The mean annual relative humidity usually decreases from the north at Giza where it is 68% to the south at Minia where it is 54%. In the Project Area, December is the month with the highest mean relative humidity, reaching 67.5%, while the lowest, 41.3% in May. The monthly cloudiness in December is the maximum with 2.87 oktas, and decrease to 0.67 oktas in July. The cloudiness usually decreases from the north in Giza to the south in Beni Suef. The wind velocity in September is weak with 1.08 m/sec, and become strong in summer, especially in May with 1.59 m/sec. In Minia, the mean monthly evaporation reaches its maximum in June, about 16.4 mm/day, while its minimum in December, 4.6 mm/day. On the other hand, evapotranspiration rate of the reference crop is the minimum with 2.35 mm/day in December, and increase to 8.32 mm/day in June (refer to Figure C-1-2 in Appendix C).

There is almost no rainfall in the Project Area due to the above-mentioned climate. The average rainfall in the northern part of the Project Area is the highest . Annual rainfall averages about 9, 11.3 and 5.1 mm in Faiyum, Beni Suef and Minia respectively, most of which comes in the winter period. Rainfall in the Project Area is not of any value for irrigation use, therefore, the irrigation water should depend on the Nile River (refer to Table C-1-6 in Appendix C).

3.1.4 Hydrology

The Nile River is the only the source used for irrigation in the Project Area. The water is supplied by the old Bahr Yusef canal, which is fed from the Ibrahimia canal, the largest fresh water canal in Middle Egypt. The Ibrahimia canal gets its water directly from the Nile River through a head regulator upstream of Asiout barrage.

The maximum mean monthly releases from Aswan Dam recorded as 6.9 milliards m^3 in July, and was reduced as the minimum 3.37 milliard m^3 in January. In recent years, Aswan releases from October to January tend to be less than the long-term (10-year, 20-year and 23-year) average based on the past release records. Particularly, the annual release in 1988 is the lowest one after the construction of High Aswan Dam (refer to Table C-2-3 in Appendix C).

The average intake water by Bahr Yusef canal is 20 million m^3 per day in summer season and 10 million m^3 per day in winter season. The actual discharge cannot meet the water requirement in summer season. On the other hand, water closure is scheduled for a period of 9th January to 1st February in Upper Egypt area and 10th January to 10th February in Delta area, Bahr Yusef command area is closed as irrigation water as a category of Upper Egypt area. Subject of water closure is maintenance of canal and its facilities (refer to Tables C-2-3 and C-2-5 and Figure C-2-3 in Appendix C).

3.1.5 Soil

Soils distributed within old land in the command area of Bahr Yusef canal are divided into two major categories, i.e., fluvial deposits derived form Nile silt without any significant influence of desert aeolian deposits, and those significantly influenced. The former, mainly classified as Vertisol (suborder: Uderts) without any key diagnostic horizon but cracks are deeply formed when they are kept dry during off-time of irrigation rotation, is distributed along Bahr Yusef basin, Nile River and other canals branched from Nile.

The latter, typical Entisol (suborder Fluvents and Psamments) influenced by aeolian deposits (Aridisol, suborder Orthids), are generally found around Lake Qarun depression of Faiyum Governorate surrounded by desert plateaus and wadis, but also narrowly distributed in between Nile valley and sand dune (only 5 to 10 m higher than Nile valley level) at the western desert edge. The width of command area between Bahr Yusef canal and sand dune deposits ranges from a half to ten kilometers along Bahr Yusef basin, and narrow parts are found in Abu Qurqas and Beni Mazar in Minia governorate, Somosta and areas under Koftan canal command in Beni Suef where the latter soil groups intervene. The latter is also distributed in Giza governorate.

The major differences in physico-chemical characteristics between these two soil groups are: drainability/water holding capacity (the former showing poorer drainage but higher water retentive capacity), fertility (the former is more fertile because of higher CEC richer cation content etc.) and soil reaction (the former is non-calcareous but the latter is more calcareous and often alkaline).

Soil found in new land (including expansion area) irrigated from Bahr Yusef canal are mostly Aridisols with patchy Entisols. Their predominant suborders are identified as Calciorthids, Durorthids and Salorthids accompanied with patchy Quartzipsamments, Torripsamments or Xeropsamments, mostly calcareous with sandy or loamy textures. They are developed on lower plateaus along with fluvial terraces formed by Nile River. These desert soils are usually alkaline (pH 7.9 ~ 8.8), but their sodium content is mostly low.

General observation results of soils in four governorates in Bahr Yusef command area are as follows:

1) Minia Governorate

Majority of soil types have heavy clay textures, but those found in the edge of Nile valley have lighter textures or sandy, whose depth sometimes reaches more than 1.5 m. Calcium carbonate content of these soils ranges 7 to 23% of total salt contents, referred to as sandy calcareous soils. If the content exceeds 10% it entails some nutritional problems such as phosphorus availability for crops or heavier tillage practice. Except Maghagha district, heavy clay soils are predominant with common clay minerals like montmorillonite representing three fourths of total clay minerals and illite or hydrous mica and less kaolinite. Sand dunes often supply sandy material in the extreme western edge of Nile valley, forming patches of sandy soils (Psamment).

General content of suspended matter (S.S.), considered as supplier of soil fertility, in canal water has been reduced from over 2,000 ppm to only 12 to 16 ppm feeding much less deposit on farm plots as compared with S.S. supply during old period before the construction of High Aswan Dam. Normally, less saline soils are found in Minia, however, some medium saline soils exist in western extreme of command area. Normal saline soils with EC less than 4 mmho per cm also predominate from the northern most boundary of Minia to southern Beni Suef. Very limited areas have medium to high saline soils for example in Mataai district. For the most cases, groundwater level stays at 1.5 m or deeper from the ground surface, except for farm plots in depressions.

Soils distributed in new land form sand dunes (1 - 3 km in width) along the border of Nile valley (old land), which is filled by Bajada Plain without dunes (4 - 10 km in width), bounded with longitudinal dune areas in the west. They are observed as Torripsamments/Quartzipsamments. They are derived from old Nile fluvial deposits and hence less calcareous/alkaline.

2) Beni Suef Governorate

In the western strip of Beni Suef including Fashn, Somosta, Ehenesia and Wasta districts, where Koftan canal feeds water, different types of soils are observed and typical sandy soils with coarse sand content of 73 to 90% are distributed at the western extreme of command area. These soils do not have any structural change throughout the thick sandy profile. Water table in these soils fluctuates variably with irrigation practices and other underground water conditions.

Soils in Somosta district, or in the extreme west of Nile valley, have higher calcium carbonate content, sometimes exceeding 5% level, as compared with those found in wadis or in Nile valley/delta. Whereas in the eastern part of this strip light textured soils are often found with clayey surface textures but below them up to deeper sola, sandy horizons with coarse sand of looser structure than Nile silt deposits are dominant (sand shares 73 to 90% of soil weight) except for southern part of the governorate like Somosta district where more calcareous soils with carbonate content of 5% or higher are generally found. In the command area, soil textures always fall in the category of heavy to very heavy clay both in the western and central districts, up to the depth of 60 cm from the ground surface, but underneath are found sandy or silty layers or sometimes loamy horizons, some of which contain less than 5% calcium carbonate.

Soils in new land and expansion area in Beni Suef are similar to those found in Minia governorate.

3) Faiyum Governorate

Soils found in Faiyum have alluvial origin but to a fairly extent they have been under the influence of surrounding desert areas. Light and heavy textures are often found in the same soil profile, but in many cases texture changes from light to heavy as depth increases. Likewise, often soils with medium texture accompany light-clay subsoil or underneath it heavy-clay soil. Ground surface may be covered by clay loam, sandy loam or other sandy soils that are generally found in eastern, and south-eastern parts of the governorate. Heavy clay soils with higher calcium carbonate content than 10% and stony soils are often not cultivable, which are distributed in both southern and eastern extreme parts of Faiyum. Sandy soils found in these parts of the governorate contain duripan, or gypsum concretion or it may sometimes form very friable crystals diffused all over profiles. They are classified as Torrifluvents or Quartzipsamments according to soil formation processes, however some derived from desert deposits are under Durorthids or Salorthids, according to profile nature.

As to soil salinity, Faiyum has a saline lake, or Qarun, which has influenced crop land around it. Normal saline soils are located in the middle-eastern parts of Faiyum, as enough productive soils. Medium saline soils with EC ranging 4 to 8 mmho/cm are chiefly distributed in the west or south of the governorate, which need amending improvement with leaching/gypsum application subsidized by the Government at the rate of 6 LE per feddan. Standard doze of gypsum averages 3 tons/feddan with its cost 12 LE/ton of which 7.5 LE/ton for transportation cost and the rest 4.5 LE for gypsum itself. This amendment for soil alkalinity proves more effective if it accompanies with drainage to lower water table staying high as a result of recent water balance changes. Affected soils can only allow winter grain crops with higher tolerance to soil salinity. Soil characters confine crop selection in Faiyum to a greater extent than in any other governorates in Middle Egypt.

Soils prevailing over the expansion area (around Lake Qarun and near Hawaret El Maktah pyramid) are finely alkaline and calcareous (carbonate nodules/concretions are often recognized in subsoil) with their textures ranging from loamy sand to sandy clay loam. Salty crust is often found whenever water is applied to, whereas carbonate content ranges 1 - 15%, with alkalinity order (ESP $<$ 11). Soil distribution from the lowest elevation (Lake Qarun) to higher western desert tableland in the order: Salorthids (clay) - Durorthids (loamy sand) - Torrifluvents (sandy clay loam) or Quartzipsamments (sand) - Calciorthids (loamy sand - sand). All these except Calciorthids are said to be formed by the influence of old greater Lake Qarun.

4) Giza Governorate

Nile silt is also the basic material from which soils in Giza governorate have been developed. They are mostly non-calcareous with neutral to slightly alkaline pH with high range of CEC and hence agriculturally productive. They are also fertile in terms of water holding nature, or field capacity. Their textures range from clay to sandy loam but clay loam may be a representative texture. Calcium carbonate content seldom exceeds 5% and organic matter content sometimes reach 3%. Desert influences in a similar way to those observed in Beni Suef.

Desert soils found in the expansion area for reclamation, to be irrigated from Bahr Yusef branch canal are also alkaline with high pH range, the textures of which ranges from loamy sand to sand. However, they are less calcareous and hence not so alkaline as found in Faiyum, with calcium content around 1%. These characteristics are presumably derived from their fluvial origin rather than pure aeolian sand formation.

5) Harika Canal Command Area

Soil in this area can also be divided into two categories as already described, effect of sand dunes give influence to soil profiles distributed in the west side of Sakoula Drain beneficiary. Textures of Vertisols found in the command area range heavy clay to loamy sand but mostly silty clay, some of which contain fine gravels in surface soil. Soil reaction ranges neutral to slightly alkaline, sometimes salt crust is formed over soil surface. Field observation result is given in the Appendix D.

3.2 Socio-Economic Conditions

3.2.1 Population

About 4.37 million people are living in the command area of Bahr Yusef canal out of about 9.34 million people in the four governorates in 1986.

(Unit : 1,000 persons)

Area	Minia	Beni Suef	Faiyum	Giza	Total
Governorate	2,648	1,443	1,544	3,700	9,335
Command Area of Bahr Yusef Canal	285	197	1,544	2,330	4,366

3.2.2 Number of Farm Household

The number of farm households in the command area of Bahr Yusef canal is about 244,000 in 1990 as shown below;

(Number of Farm Household)

Area	Minia	Beni Suef	Faiyum	Giza	Total
Governorate	266,029	150,090	125,848	108,403	650,370
Command Area	29,530	20,410	125,848	68,290	244,078

3.2.3 Land Tenure Status

Though land tenure status in the command area of Bahr Yusef canal can't be described accurately, it can be estimated based on the data for the whole governorate, thus, about 50% of the farm households manage less than one feddan and about 45% of the farm households manage 1 ~ 5 feddans as well. Ratio of land owner is the highest in Giza at about 64% and lowest in Beni Suef at 53%. Averaged farm sizes are as follows; (refer to Figure L-1 in Appendix L)

Description	Minia	Beni Suef	Faiyum	Giza	Average
Average Farm Size (fed)	1.38	1.58	2.45	1.43	1.64

Excluding these farm households, it is considered that there are considerable numbers of landless farmer whose numbers are not statistically clear.

3.2.4 Living Conditions

1) Commodity Price

Commodity price in the command area of Bahr Yusef canal can't be described due to the lack of statistics, however, CAPMAS shows the consumer price index in rural area. Price escalation ratio in the rural area is generally higher than that in the urban area.

Year	1984/85	1985/86	1986/87	1987/88	1988/89
Escalation Ratio (%)	11.7	22.8	13.4	20.7	23.6

2) Agricultural Income and Expenditure of Farm Household

Following shows the agricultural income of farm household in each governorate. In spite of smaller farm size, average income per farm household in Giza is the highest among four governorates and the lowest in Minia. The reason for the highest income in Giza is considered that land use is more efficient than other three governorates for supplying vegetables and fruits to Cairo metropolis. Contrary to this, the lowest income in Minia is due to the lowest crop intensity caused by planting crops with long growing periods.

(LE/farm household/year)

Description	Minia	Beni Suef	Faiyum	Giza
Agricultural Income	1,790	2,110	3,190	4,484

3) Family Size

According to the statistics of CAPMAS, average family size in the four governorates is as follows, and it shows that rural areas have generally bigger family size than that in urban area.

(Person/family)

Area	Minia	Beni Suef	Faiyum	Giza
Urban	4.7	5.0	5.0	4.5
Rural	4.9	5.2	5.4	5.1
Average	4.9	5.1	5.3	4.7

4) Farm Labour per Farm Household

Farm labour available in a farm household can be estimated based on the statistics of CAPMAS and number of farm household collected from agricultural office in each governorate.

Description	Minia	Beni Suef	Faiyum	Giza
Occupational population working in agri. sector (more than 6 years old)	433,785	219,765	255,940	192,800
No. of farm household	266,029	150,090	125,848	108,403
Farm labour (person/family)	1.63	1.46	2.03	1.78

3.2.5 Infrastructure

1) Electricity Supply

Electricity is supplied to 100% of the villages in three governorates and 98% in Giza.

2) Number of Hospitals

Hospitals are mainly distributed in urban area more than rural area.

(Unit: place)

Area	Minia	Beni Suef	Faiyum	Giza
Urban	11	9	15	43
Rural	3	1	3	1

3) Length of Roads

Density of roads per square kilometer is the highest in Minia, secondly in Giza. However, there are big difference in ratio of desert road between Minia and Giza at 53% and 14%, respectively (refer to Appendix B-2).

4) Drinking Water

In rural area, drinking water is generally supplied in each village for public use.

3.2.6 Farmer's Organization

1) Cooperative Society

Farmer's representative organization is a cooperative society. There are two types of cooperatives; one is established by governmental instruction and the other is set up by the farmers as a special cooperative. The organization of the cooperative can be divided into three levels, national, governorate and district; in principle each village has one cooperative in which a farmer has to be a member as a duty (refer to Appendix J-2).

2) Village Bank

Village bank is the terminal organization of PBDAC which is the main agency for agricultural finance and distributed to each village as well as a cooperative society. Organization chart of village bank is shown in Appendix J-2.

3) Water User's Organization

IIP (Irrigation Improvement Project) is promoting in six governorates to improve the main irrigation system and Meskas by MPWWR since 1988. One of the main activities of IIP is to build up a water user's association (WUA) to improve water delivery and on-farm water use.

WUA is existing in a part of Minia and Faiyum governorates. Since the idea of WUA recently started, this conception has not expanded into national and governorate levels.

Micro system is composed of Meska and Marwa, which irrigate 10 ~ 300 feddans and about 20 feddans, respectively. Generally, Meska distributes water to several Marwa.

The members of WUA select their own leader and establish their own local rules on water distribution which they will enforce.

Any water charge for maintaining the canal and structures has not been collected. Repair and improvement of Meska are done by farmers and the group cleans Meska by cutting grass along the canal and dredging.

The conception of WUA is to establish one WUA at Meska level (refer to Appendix J-2).

3.3 Irrigation and Drainage

3.3.1 Irrigation Conditions

1) Irrigation System

a) Present Water Distribution

The water distribution system at principal and main canals under operation of MPWWR is applied the 24 hours continuous flow. Branch canals, which branch off from the main canal (Bahr Yusef canal in the Project Area), is used the three-turn rotation system (5 days-on, 10 days-off) in the governorates of Minia, Beni Suef and Giz, while branch canals in Faiyum governorate are applied the 24 hours continuous flow system, where the gravity ittigation method is practiced.

Water distribution at regulators and intakes along the Bahr Yusef canal is conducted by controlling the downstream water level. Water level and discharge conversion tables (H-Q curve) have been provided at Dairout, Sakoula and Lahoun barrage/regulators. H-Q curve is utilized to control downstream discharge at the barrage and regulators. At branch canal intakes, there is no H-Q curve, therefore water distribution is controlled with empirical downstream water levels. In any case, the empirical water levels presently applied for distribution control might have originated at the initial time of canal operation and developed during many years of distribution practice.

Considering cropping area on governorate basis provided by MALR, amount of distribution water from the Nile River to the principal canal is annually / monthly and / or 10-days basis estimated based on the unit water requirement provided by Irrigation Department, MPWWR. Reused drainage water, groundwater use, and drinking use and industry use are also taken into consideration.

b) Water Distribution Organization

Water distribution for irrigation use from the Nile River to the sub-branch canal has been controlled by the Irrigation Sector of MPWWR. In the organization chart, distribution from the Nile River, such as at the Asiout barrage, is controlled by the office of Water Distribution under the Irrigation Sector. Water distribution downstream the Asiout barrage is controlled by the office of Upper Egypt. Then each directorate is responsible for water distribution at irrigation canals from the main canal to the sub-branch canal in the directorate.

Under the General Director of each directorate, there are usually two Inspectors who give daily instruction on water levels at barrages, regulators and intakes to district engineers. The district engineer gives instruction to gate operators who watch and record water levels at upstream and downstream of barrage / regulator or intakes, and report water levels to the Inspector four times a day (refer to Appendix E-1).

2) Available Water Resources

a) Nile Water

The annual amount of water to be diverted into the Bahr Yusef canal at the Dairout barrage recorded at 4,034.7 MCM on an average from 1986 to 1990. In 1987, the intake discharge was reduced to 3,761.5 MCM (equivalent to 93.2% of the averaged one) due to less inflow into the High Aswan dam. In 1990, the amount of 4,424.8 MCM (109.7% of averaged one) was observed. Monthly average amount of 363.5 MCM was taken into the Bahr Yusef canal except in January because of winter closure period. Maximum intake volume of 571.3 MCM was observed in July, 1990. The daily discharge changed within three to five days. When the amount was gradually increased, the discharge reached a maximum in a period from June to August, after that, the discharge was gradually decreased. The maximum discharge of 18.8 MCM/day (217.3 m^3/sec) was recorded on August 1 and 2, 1990. For 20 days in winter, water delivery was stopped for canal and facilities maintenance. The daily maximum discharge will be increased to 19.5 MCM, when the command area of Bahr Yusef canal will be fully developed in the future (refer to Appendix E, Table E-2-1 and Figure E-2-1).

b) Reuse Water

In Minia and Beni Suef areas, there are nine large scale drainage pump stations (DPS), namely, El Badraman, Kabkab, Tona El Gabel, Monshat, Beni Mazar, Dier El Sankuria, Abu Raheb, Sakoula and Mazoura, to lift drainage water to the Bahr Yusef canal. Drainage areas of about 404,000 feddan extends on both banks of the canal. Of which, the Abu Raheb DPS can drain water to the Nile River during the high water period of the Bahr Yusef canal. In the past five year from 1986 to 1990, mean drainage discharge of the nine pump stations is recorded at 735.0 MCM (equivalent to 23.3 m^3/sec) and the maximum discharge of 897.7 MCM (28.5 m^3/sec) was in 1987. The minimum of 614.0 MCM (19.5 m^3/sec) occurred in 1988. The mean monthly discharges from February to June were lower than those of other months and the discharge increases by the end of the year. In December, the mean maximum monthly discharge of 86.59 MCM (32.33 m^3/sec) was shown and the minimum monthly discharge of 31.66 MCM (13.09 m^3/sec) in February, 1990. The winter closure period in

January may affect the drainage discharge in February at minimum mean monthly discharge, 31.66 MCM (refer to Appendix E, Table E-2-2 and Figure E-2-2).

The Giza branch canal irrigating a part of the Giza governorate area is one of the biggest branch canals of the Bahr Yusef canal. Within the command area of its canal, there is no drainage pump stations and no facilities for the reuse of drain water.

There were 28 drainage pump stations for the reuse of drain water in Faiyum area, of which two drainage pump stations are large scale. Those two pump stations are operated and maintained by MED, MPWWR. The annual drain discharge amounts of 51.6 MCM (1.64 m^3/sec) and the monthly mean discharge is 4.33 MCM (1.66 m^3/sec). The Tamia pump station is under construction now. The remaining 26 pump stations are maintained by Faiyum ID. The pumps operate based on request from farmers, and operating hours are not recorded now. The 15 pump stations out of 26 pump stations were no longer operational due to the change in drain courses and/or no supply of spareparts. The annual mean of the lifted amount by 11 pump stations are estimated at 8.7 MCM (0.28 m^3/sec) based on the daily operation of 10 to 12 hours a day and the lifting capacity from 0.14 to 0.23 m^3/sec (refer to Appendix E).

c) Reuse Water of Drain Water by Gravity Intake (Mixed Water)

Only in Faiyum area, the reuse of drain water is practiced by gravity due to a topography of steep slope of land. Since nine intake facilities have no discharge records, intake discharge of 23.3 MCM (0.74 m^3/sec) is estimated based on the size of those facilities.

d) Deep Wells

There are some private deep wells in the command area of the Bahr Yusef canal, however, the lifted amount of water is negligible small as compared to the above mentioned water resources.

e) Drain Water by Private Farmer's Pump

Aside from the above-mentioned reuse water, in the water shortage period of the summer season from June to August, farmers in the command area the Bahr Yusef canal takes individually drain water from a neighboring drainage to irrigate their fields. Its amount measured at the Pilot area in the Harika command area meets eight % of the water requirement.

f) Annual Mean Water Resources Available

According to the above records and estimations, the total available water in the command area of the Bahr Yusef canal are summarized as follows.

Item	Available Water		Ratio
	(MCM)	(m^3/sec)	(%)
Nile Water	4,034.7	127.9	83.1
Reuse of Drain Water	735.0	23.3	15.1
Reuse of Drain Water by Large Pumps in Faiyum	51.6	1.6	1.1
Reuse of Drain Water by Small Pumps in Faiyum	8.7	0.3	0.2
Reuse of Drain Water by Gravity Intake	23.2	0.7	0.5
Total	4,853.2	153.8	100.0

3) Present Water Requirement

a) Present Water Requirement/Water Management

The water management in Egypt is carried out by governorate unit. The facilities near the boundaries of governorates and districts have an important role as water level and discharge control of an intake facility. The discharge of the Bahr Yusef canal is contralled at the Dairout barrage and Sakoula and Lahoun regulators located near governorate boundaries. The gate keeper received an instruction on the water level control which is determined based on the proposed discharge by using the Q-H curve. Another two regulators, Manshat El Dahab and Mazoura, have only a function of water level control. Based on the field investigation of the Q-H curve, it is confirmed its accuracy (refer to Table E-2-3, Appendix E).

The gate operation is carried out based on the water level instructed by Irrigation Directorate on the telephone. After receiving an instruction of water level, the gate keeper operate the gate(s) to meet the requested water level by five to six laboures. According to the visual investigation on the barrage/regulator, there are some leakage water through the gate(s), however, its discharge measurement is rather difficult due to no water stop at the regulator, and even during the winter closure period, the water level at up- and downstream of the regulator is not so low. Since the water control is conducted based on the downstream water level, the leakage water is used for downstream irrigation as a part of the distributed discharge, therefore those leakage water is not defined as a loss at the regulator.

The water distribution to the command area of the branch canal through the major intake facilities is made based on the amount of water calculated by using the cropped area planned by the MALR and MPWWR standard unit water requirement for crop in middle Egypt. In the branch canal at the downstream of the intake, the water distribution is carried out by due proportion of the acreage of the command area. The water requirement is comparatively studied on the consumptive use applied by the Modified Penman method and actual cropping calendar. According to the results of the analysis, irrigation efficiency in April and October was remarkably lower than that of other months and the emergency flux was observed through the branch canal at the Sakoula regulator during this period. It is pointed out some reasons that the MPWWR standard unit water requirement in the middle Egypt is applied over the large area, about 300 km length along the Nile River, and the actual cropped acreage and cropping period are not same as the planned one (refer to Table E-2-4 and Figure E-2-3, appendix E).

b) Evapotranspiration (ETo)

Crop evapotranspiration is calculated based on the FAO Technical Paper of Irrigation and Drainage "Crop Water Requirement" #24. The basic climate data such as mean temperature, relative humidity, wind speed and cloudiness at four stations, namely Minia, Beni Suef, Faiyum and Giza stations for four years from 1986 to 1989 were applied to calculate crop evapotranspiration.

Three prevailing equations of Modified Penman method, Blaney-Criddle method and Radiation method were employed for the study. The Radiation method shows the highest values of 9.4 mm/day (29.1 mm/month) in July. On the other hand, the Blaney-Criddle shows the lowest value of 8.7 mm/day (27.0 mm/month) in this period. The Modified Penman method almost shows almost middle value among them. As a result of study, the values of evapotranspiration calculated by the Modified Penman method would be applied for planning the Project as shown below (refer to Table E-2-5 and Figures E-2-4 to -8 in Appendix E).

(unit: mm/day)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
ETo	2.5	3.5	5.1	7.1	7.9	8.8	8.9	7.7	7.2	5.3	3.2	2.4

c) Consumptive Use

Many kinds of crops are planted and the following some characteristics of crop cultivation were identified in the command area of the Bahr Yusef canal. The planted acreage of sugarcane is negligibly small, and paddy is cultivated only in the Faiyum area. The dominant crops in the command area are cotton, summer maize, sorghum, sunflower and vegetables in summer, Nili maize and sorghum as Nili crops, and wheat, beans and berseem in winter. In Giza, no cotton is planted. Fruit gardens are also observed in all governorates. According to cropping calendar, cotton is broadcasted in March and maize and sorghum in April.

Crop coefficient (kc) are calculated based on the FAO Technical Paper as mentioned before. The irrigation period and crop evapotranspiration of major crops are listed below. The irrigation period is determined by considering the ripening period of two to four weeks before harvesting without irrigation. However, after August 15, no irrigation water is applied regardless of cotton cultivation (refer to Table E-2-6 and Figure E-2-9, -10 in Appendix E).

Name of Crop	Irri. Period	Net Water Requirement	Name of Crop	Irri. Period	Net Water Requirement
	(day)	(mm)		(days).	(mm)
Wheat	149	545.7	S. Maize	89	598.0
L. Berseem	173	623.7	Sunflower	102	665.5
Beans	123	344.3	S. Sorghum	90	571.2
Cotton	144	963.6	W. Vegetables	135	340.3

Note: Above figures do not include percolation loss.

4) Present Water Balance Study

Considering the cropped area and consumptive use of crops, the present water balance study is carried out. Based on the results of study the overall irrigation efficiency is analized.

a) Water for Reclaimed Area

As mentioned before, the irrigation area of the Bahr Yusef canal is classified into two categories, that is, old lands and reclaimed lands. In the old lands, cropping calendars are almost fixed and statistical data of cropped area, etc. are available. However, in the reclaimed lands with about 43,000 feddan, construction works is still carried out and its reclaimed area has not been established yet. Therefore, water requirements for this lands have been determined based on the records of actual amounts of four irrigation pump stations of Terfa, Kamadir, Sakoula and Mazoura. According to the field office of the reclaimed lands, the Irrigation Department has not permitted to use additional water, therefore, improvement in irrigation methods, like sprinkler irrigation, drip irrigation, and a lining of irrigation canals are being introduced to the area in order to save water losses. The annual mean water requirement of the lands for the past five years is analyzed at 297.5 MCM (9.43 m^3/sec) based on the actual discharge records of those pump stations and the monthly mean water requirement is confirmed at 24.8 MCM. A fluctuation of the monthly water requirement in each month is a little (refer to Table E-2-7 and Figure E-2-11, Appendix E).

b) Contribution of Groundwater

According to the past research, in case that groundwater table is within two meters from the field surface, the groundwater contribution rates will be ranged at 5 to 10%, where the irrigation efficiencies is high. Also EWUP Report No. TR-61 reported that groundwater contribution rate to evapotranspiration are 19% to 53% depend on the sites. Since groundwater tables are usually observed at about one meter in the Project Area, the groundwater contribution rate would be applied at 10% for the study.

c) Reuse of Drain Water by Farmer's Small Pumps

As mentioned before, eight percent of the net water requirement would be applied for the study on the reuse of the drain water to be lifted by farmer's small pumps.

d) Other Water Requirement

In the command area, there is no water source other than the Nile water. Drinking water and other types of water for inhabitants' life and livestock's life depends on the Nile water resource. This water amount can be estimated by using a population of 4.37 million inhabitants and 1.17 million heads of livestock in 1990 within the command area of the Bahr Yusef canal. Proposed water consunption equals to 100 lit/day/person for inhabitants and 3 to 65 lit/head for livestock, respectively. The total annual water requirement would be 170.4 MCM. Other water requirement, industrial water, etc. would be assumed at 50% of the above water requirement. Finally, water requirements of this category amounts to 255.6 MCM (refer to Table E-2-8, Appendix E).

e) Present Water Balance Study

Considering he above items, the water balance study would be carried out. According to the results of the study, the overall irrigation efficiency is 60.5%. By month, the efficiency of 76.9% in July is the highest except January and February and 28.3% in October is the lowest. However, since this analysis was carried out based on the short period data, therefore more research and studies will be required for an accurate result of the study (refer to Tables E-2-9 and -10, Appendix E).

5) Hydraulic Analysis on Irrigation System

Based on the of observed data of discharge and water level on barrage and regulators for five years from 1986 to 1990, two cases of hydraulic analysis of the Bahr Yusef canal during peak water discharge time from June to September and during low discharge time in December, were carried out. In the section of downstream of the Mazoura regulator, hydraulic analysis could not be carried out due to no available discharge data.

The hydraulic conditions and present profiles and cross sections of the Bahr Yusef canal prepared by Irrigation Directorate were employed for the analysis. The "n" value of 0.030 of the Manning equation was applied. Discharge passed throughout the regulator is determined by considering the discharge the of pump stations operated at each section as follows:

Section	Jun. to Aug.	Dec.
	(cu.m/sec)	(cu.m/sec)
Dairout and Manshat El Dahab Reg.	198	91
Manshat El Dahab and Sakoula Reg.	153	81
Sakoula and Mazoura Reg.	158	83

The actual high water level is applied as for the starting water level of the analysis as follows ;

Manshat El Dahab Regulator	40.40 m
Sakoula Regulator	33.70 m
Mazoura Regulator	29.70 m

According to the results of analysis, during the high water period, backwater caused by the regulator only influences a little reaches of the upstream section. However, during the low discharge time, backwater influences by about 60 to 70 km upstream of the regulator. At the influential points, 30 to 40 km upstream of the regulator, influential water levels rises by about 60 cm. Downstream of the regulator, water levels at peak discharge and low discharge times are almost equal to the observed one. Differences in water levels between both times of peak discharge and low discharge is 1.3 to 1.8 m (refer to Figure 3-1).

3. 3. 2 Drainage Conditions

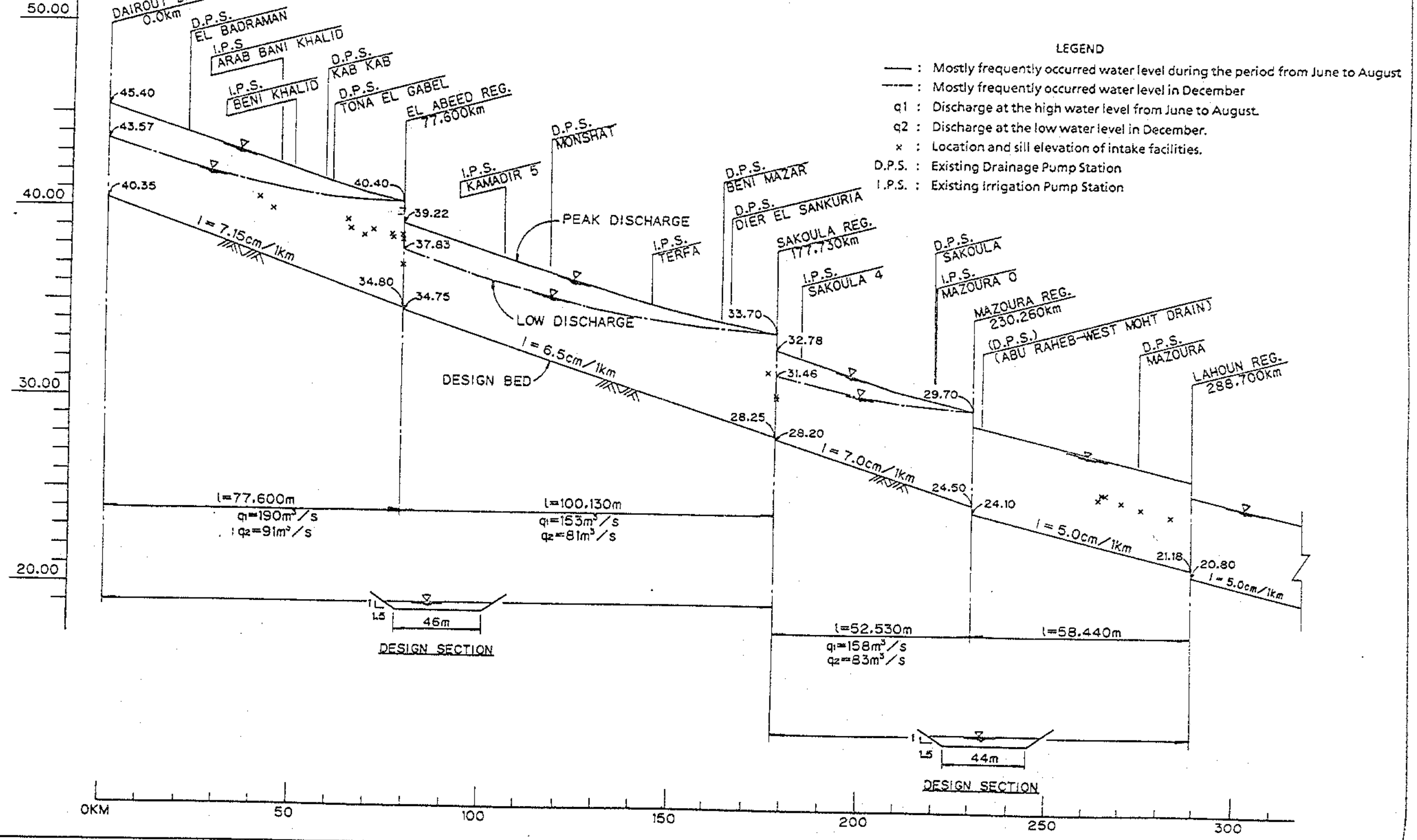
Since there is almost no rainfall in the Project Area as mentioned before, drainage problem caused by rainfall is not occurred. The salt accumulation on top soil is brought about by high groundwater tables (water logging) to be caused by irrigation water and results to reduce the production of farm output and to increase the uncultivable area. MPWWR and MALR are implementing tile drainage projects and improvement of drainage canal projects in order to control groundwater table.

MPWWR is managing and operating several large scale pump stations to control groundwater tables. One of the subjects in the operation manual of those pump stations is to keep water level of the drainage canal below 50 cm under an invert of a collector pipe of the tile drainage system. Judging from soil analysis and observation of groundwater table, necessity of the tile drainage system is analyzed and a tile drainage project is implemented. The total tile drainage area is about 127,000 feddan in the Project Area so far, however, the area of about 55,000 feddan will be expanded in the future (refer to Table E-2-11, Appendix E).

The drain water is one of valuable water resources in Egypt. The above mentioned nine pump stations are operating to lift the drainage water to the Bahr Yusef canal as reuse water for irrigation etc. The annual discharge of lifting water to the Bahr Yusef canal by large scaled pump stations including two pump stations in Faiyum amounts to about 703 MCM, which is equivalent to 17% of the annual discharge of the Bahr Yusef intake water of 4,035 MCM at the Dairout regulator for the past five years. Farmers are individually lifting drain water to their field during the water shortage period in summer. Since the farmers can not mix drainage water with fresh water, some damaged areas from the salt accumulation are found in the Project Area.

Based on the results of electric conductivity test in the Project Area, EC of water in drainage canals is ranging from 2,300 to 3,310 micro S/cm, however, EC of water in a irrigation canal from 400 to 470 micro S/cm. During the water closure period of the canal, EC value raises up to about 1,000 micro S/cm (refer to Table E-2-12, Appendix E).

FIGURE 3-1 Hydraulic Profile of Bahr Yusef Canal



3.3.3 Irrigation Facilities

1) Bahr Yusef Main Canal

a) *General Conditions*

The Bahr Yusef canal, which branches off from the Ibrahimia principal canal at the Dairout barrage, finally reaches Faiyum city after running 312.7 km, and is the heavily meandering earth canal irrigating about 770 thousand feddans of agricultural lands. Canal cross sections varied on its course due to erosion on the canal side walls, sand sediment on the canal bed, etc. There are barrages, regulators, intake facilities, irrigation and drainage pump stations, and other structures along the canal. Each regulator controls the water level in the canal.

The average canal width for 288.7 km of the main canal with a length of 288.7 km between Dairout barrage and Lahoun regulator is about 60 meters width on an average and canal bed slope of 1/15,000, which results in a gentle flow at velocity of 0.8 m/sec at maximum in the meandering earth canal. The profiles and cross sections of the Bahr Yusef canal have been prepared in supplementing those made by the Irrigation Directorates of Minia, Beni Suef and Faiyum through additional surveying and studying; especially, the additional detailed works on the upstream and downstream portions of the five barrage and regulators to grasp the present conditions clearly (refer to Figures F-1-1 to F-1-4 in Appendix F).

Although all the canal cross sections has remained in nearly same hydraulic conditions originally designed, some canal portions have wider canal width than the designed width and the others have scoured sectionas pertioularly at canal bottom. Increase of the cross-sectional area of flow, however, is a little, so that there is no adverse effect to water conveyance in view of hydraulics for short canal length. At the canal beds in immediate downstream of the barrage and regulators, unsteady flow has caused scouring and erosion of the canal bed and side slope.

b) Sediment in the Canals

Since the Bahr Yusef canal is unlined and heavily meandering earth canal, erosion of the side slopes and sedimentations on canal beds are unavoidable. MPWWR is rendering maintenance services for the canal. The canal maintenance works usually practised include dredging, sweeping aquatic plants like reeds and water hyacinth, etc. for clearance.

The conditions of sediment have been analyzed from the viewpoint of the past maintenance records of the canals. Reformation of the canal sections by dredging between 1986 and 1991 was carried out by Irrigation Directorates of Minia and Beni Suef. According to the records of the reformation works, the dredged volume of the canals cross sections at the upstream and downstream portions ranges between 40 to 60 m^3 per linear meter of the canal, while about 100 m^3 in the mid-stream portion (refer to Table F-1-1 in Appendix F).

c) Water Level in the Canal

The following are the analyzed results on the water level and discharge recorded for five years from 1986 to 1990. The water levels are shown on their range which appeared most frequently for peak months from June to August at respective barrage and regulators together with their maximum values.

Barrage / Regulators

Barr. /Reg.	Most Frequented Water Level from June to August		Max. Water Level	
	Upstream	Downstream	Upstream	Downstream
Dairout barrage	46.20 ~ 45.90	45.60 ~ 45.30	46.20	45.55
Manshat El Dahab reg.	39.80 ~ 39.50	39.80 ~ 39.50	40.50	39.86
Sakoula reg.	33.10 ~ 32.80	32.80~ 32.50	33.95	32.90
Mazoura reg.	29.40 ~ 29.10	29.10 ~ 28.80	29.88	29.15
Lahoun reg.	26.40 ~ 26.10	24.90 ~ 24.60	26.70	25.20

A water surface tracing was made under the present conditions for each regulator on the basis of annual average discharge in December as the low water level period. And the results have suggested that gravity water intake in low water level would become difficult at the intakes of Arab Beni Khalid and Beni Khalid branch canals, and these two regulators have ready provided the pump facilities for supplementing water, respectively (refer to Figure 3-1).

d) Hydraulical Observation of the Canals

The daily discharge analysis for the Bahr Yusef canal at Dairout barrage resulted as follows;

- The monthly average amount of intake water through Dairout barrage to the canal for three months from June to August was estimated at 497.7 MCM (187.8 cu.m/sec) for five years from 1986 to 1990. The water drained out for that period by three drainage pump stations located between the Dairout and Manshat El Dahab regulators amounted to 25.8 MCM (9.7 cu.m/sec). The present discharge of the Bahr Yusef canal is estimated at 523.5 MCM/day

(197.5 cu.m/sec), which is equivalent to about 80% of the designed maximum discharge of 248.8 cu.m/sec.

- According to the data prepared by Minia Irrigation Directorate, the discharge of this canal was computed with Manning's formula taking n-value as 0.025, which will be small n-value of Manning's formula for applying very gently sloped and heavily meandering earth canal with thick weed. The discharge computed at 2.45 km point of the canal was 195.5 cu.m/sec, which can be obtained with the above formula taking n-value of 0.029. The n-value of 0.030 is deemed reasonable to estimate the discharge of this canal, and the result of estimation with n-value of 0.030 is equivalent to about 80% of the discharge estimated with n-value of 0.025.

2) Barrage and Regulators

There are many microfilms of old facilities and structures kept in the data room of the Irrigation Meseum, MPWWR, but reappearance to these data and records has failed to find those necessary for the study. The surveys have been made for these five barrage/regulators of Dairout, Manshat El Dahab, Sakoula, Mazoura, and Lahoun on their structures, repair history, regulator's body conditions, gate conditions together with operational conditions, and canal bed conditions at the immediate upstream and downstream of the structures (refer to Table 3-1).

a) General Conditions

The memorial plates embedded in each structure have suggested that the stractures were constructed about 120 years or 90 years ago even at the latest, although some have no records of their history.

In appearance, some bricks of the surface exposed to the air have fallen; especially arch portions with cracks. And abrasion and scourings are observed at some water contacting parts of the gate piers. As a whole, the structures have been considerably time-worn. For three regulators of Manshat El Dahab, Sakoula and Mazoura, surface strength survey with concrete Schmidt test hammer was carried out on the brick surfaces at front walls of each gate above water level. The base of the arches have been suffering from remarkable cracks and brick peeling with aging, and the strength surveyed has a wide range from 120 to 200 kg/cm^2 (refer to Table F-1-2 in Appendix F).

The test results of core samples taken by borehole drilling of the structures have made confirmation on the construction materials and their quality. In 1988, MPWWR carried out borehole drilling by 71 holes at Dairout barrage and 200 holes at New Lahoun regulator together with grouting by 65 holes for the former and 176 holes for the latter. In addition to the above, the results of permeability tests have been used for analyzing the structure bodies.

TABLE 3-1 GENERAL DESCRIPTION OF BARRAGE AND REGULATORS.

Classification	Name of Barr./Reg.	Dairout Barrage	Manshat El Dahab Regulator	Sakoula Regulator	Mazoura Regulator	New Lahoun Regulator
Location	KM	0.0	77.600	177.730	230.260	288.700
Scale	Total Length	26.4 m	88.0 m	88.0 m	110.0 m	15.8 m
	Gate	Span 3.0m × 5 sps	Span 3.0m × 20 sps	Span 3.0m × 20 sps	Span 3.0m × 25 sps	Span 3.0m × 2 sps, Span 3.2m × 1 sps
Barr./ Reg. Body	Year of Completion	1869 ~ 1872	1899 ~ 1900	Estimated 1900 more or less	Estimated 1900 more or less	Estimated 1800
	History of Repair	1900~1907, 1962, 1988 (Barr. Reinforcement by Grouting)	1917, 1951 , 2 Trace of a Boring Test on each pier	Trace of a Boring Test on each pier in estimated 1951 or 52	Trace of a Boring Test on each pier in estimated 1951 or 52	1988 (Reg. Reinforcement by Grouting)
	Structure of Barr./Reg	Brick - made	Brick - made	Brick - made	Brick - made	Stone - made
	Apron Structure	Ripap, Raised Gate Sill	Riprap, Raised Gate Sill	Riprap, Raised Gate Sill	Riprap, Raised Gate Sill	Riprap, Raised Gate Sill
	Co-provided Bridge	Brick Arch Structure, Width 10.0 m	Brick Arch Structure, Width 4.0 m	Brick Arch Structure, Width 4.0 m	Brick Arch Structure, Width 4.0 m	Stone Arch Structure、Width 6.0 m
Gate	Gate Type	Triple Leaves Steel Sluice Gate	Double Leaves Steel Sluice Gate	Double Leaves Steel Sluice Gate	Double Leaves Steel Sluice Gate	Worm gear gate (Fahmy Type)
	Operating System	Movable Type with single point hanging	Movable Type with single point hanging	Movable Type with single point hanging	Movable Type with single point hanging	Wheel Rack
Lock		co - provided at left end, width 8.0m	Relocated apart to the left end (1967), width 8.0m	Relocated apart to the right end (estimated about 1960) width 8.0m	Relocated apart to the right end (1965), width 8.0m	Relocated apart to the left end (estimated about 1960), width 8.0m
Special Descriptions						Old Lahoun Reg. exists abt. 8.5 m downstream (Bent width 2.75m×3, without leaves)
General Map	Appendix	Fig.F-1-2	Fig.F-1-3	Fig.F-1-4	Fig.F-1-5	Fig.F-1-6

From those record and data of the survey, some of the core sampling rates are found lower than 50%, the fact of which would not only come from the quality of the construction materials, but also low efficiency of the drilling machines used and ineffective survey methodology (refer to Tables F-1-3 to -8 in Appendix F).

For two months of January and February, 1992, during the winter closure period, three regulators of Manshat El Dahab, Sakoula, and Mazoura, were surveyed by borehole drilling for core sampling with six holes for each and 42 m long in total depth. Compaction tests for 36 samples each, standard penetration tests together with foundation boring were made so as to secure fundamental information on the quality of the respective structure bodies and foundation conditions. According to the surveyed data, the gate bodies are constructed with bricks with cement mortar filled, and stone layers were placed below the beds. Core sampling efficiency for the case has been so high as over 95% on an average, and the specific weight has been measured by 1.92g/cu.cm in saturation. The foundation survey has resulted in the sufficiently hard foundation of sand layer with n-value by over 50, which can be a successful supporter of the structures (refer to Tables F-1-9 to -12 in Appendix F).

The bridges provided as superstructures of the barrages/regulators have heavy traffic as major transportation facilities for Dairout barrage and Lahoun regulator, while there is not so much traffic in Manshat El Dahab, Sakoula and Mazoura at the mid-stream of the Bahr Yusef canal as that in the above two. And a traffic survey has been conducted for these three bridges on pedestrians and vehicles for getting the accurate information of the bridges, although for very short time. Although located in rural areas, these bridges have more frequent traffic than expected by 30 to 70 vehicles of tractors, pick-up tracks, etc. per one hour. In view of transported items, the bridges have been used with multiple purposes in transporting not only farming materials but construction materials like stone materials and others (refer to Table F-1-13 in Appendix F).

The gate type, excepting Lahoun regulator of Fahmy Henen, is of garter type with double leaf slide gate by chain block operation with single chain hanging. And the gate operation has been usually made with the lower leaves closed and the upper ones opened. The number of the upper gate opened can control the water level at the upstream. This method is different from the under flow discharge with lower leaf operation practiced by Asiout barrage. Many lower leaves are in trouble with winding chains and gate hooks to be closed. These troubles have caused gate operation impossible from heavy sand sediment and clogging the leaf guides.

Riprap work with 500 to 1,000 m^3 stone materials at immediate downstream of the aprons or canal bed protection works at each barrage/regulators so as to prevent scouring. Such riprap works have been made temporarily for supplementing stones buried in sand or washed away, but no made as fundamental countermeasures for prevention of scouring.

The present conditions of the scouring and erosion have been grasped through the canal profile and cross section survey made additionally for the canal portions of 1.0 km up- and downstream from the barrage or regulator. In 1992, the survey was carried out, but there was a considerably deep water ponding at the immediate upstream of the barrages for canal base flow even in the winter closure period in January and February. The ponding water depth was measured by 1.5 to 2.0 m at the upstream barrage and 4.5 to 5.0 m at Lahoun regulator at the down most. Under the circumstances, visual inspection from boat was carried out for gate structures. The visual inspection have been resulted to classify into four classes; A for no need to repair or improvement, B for partial repair needed, C for total repair or improvement needed and no operational at present, and D for destructed and total reconstruction needed (refer to F-1-14 in Appendix F).

b) Dairout Barrage

About 120 years have passed since construction of this barrage, counting from the figures written on the memorial plate. Located at the important point in traffic, the bridge provided with the barrage is used for much traffic, and the barrage body as well as bridge are considerably weakened as a whole.

MPWWR carried out improvement of strength by grouting works for the body in 1988. The records of the improvement works can read bricks used as construction materials, 65 points for grout hole drilling with cement milk by 20 kg/m on an average (over 10 tons of cement used in total).

Around the thalweg immediately downstream the existing apron, a large scale scouring is found by 6.0 m deep at the deepest. Turbulent flow has based heavy erosion on the both banks to result in an extremely wide canal width. Such being the case, the canal in the downstream from the barrage is heavily devastated.

The gates provided are in the triple leaf type because of higher gate structures, and the leaf size is 3.0 m width by 3.25 m height with rather thick skin plate. With nut tight system, the leaf dead weight is large and friction of guide metal with leaf plate is so large by sluice gate type, that winding load is considerably large. As a result, operation of the gate has become difficult. On top of the above, the single point chain hanging in the center of 3.0 m wide plate is obstructed to make smooth operation in imbalance.

Since this barrage is not a regulator but an intake facility, no gates are left in trouble in the flow but all maintained in full operation. Due to difficulty in operation including chain breakage, the lowest leaves are usually kept closed and the upper leaves are operated for the purpose so as to make water level control in submerged overflow weir type. Consequently, the water level control has unavoidably become irregular and unstable.

c) Manshat El Dahab Regulator

The memorial plate of the structure shows that amount 90 years has passed since construction of the regulator. And the records suggest that crack repair on the front wall of the body was made in 1917, 1951 and 1952, but no direct effects on the body are observed.

Visual inspection made so far has clarified that there are some bricks defected on the surface, especially at the base of arches, scouring holes at the water contracting portions as well as hydraulic abrasion of the piers by No.1 to No.10 from the left bank. The attached bridge as well as these piers have been considerably time-worn.

At the upstream from the regulator, sand sediment in the canal has become heavy more closely to the regulator and the sediment thickness is measured by about 1.0 m at the immediate upstream of the barrage. The usual closing of the lower leaves is deemed to cause such heavy sediment. At about 80 m downstream of the barrage, there has been a scour with 5.0 m depth found around the thalweg. Furthermore, the both banks have been eroded to result in heavy devastation of the canal.

The gate leaf size is 3.0 m in width and 2.8 m in height. With rather thick skin plates and nut tightening structure, the dead weight of a plate is as heavy as about 6.0 tons, and friction of leaves with guide metals is large and a heavy winding load makes operation not smooth due to being the sluice gate. Under such conditions, there have been many chain breakage accidents that lower gate leaves have been left in the flow. The case being as such, usually the closed lower leaves are kept in the flow, and the water level control has been made by operation of the upper gate leaves as submerged overflow weir type. The water level control has been carried out irregularly and unstably.

d) Sakoula Regulator

The accurate construction year of this regulator is not known, but judging from the type, aging extent, etc., this regulator seems to be constructed almost at the seems to be constructed almost at the same year as those of Manshat El Dahab and Mazoura regulators, and about 90 years are considered to have passed.

Visual inspection made so far has clarified that there are some brick aging and fallen at the base of arches of the superstructure, and scoured holes and hydraulic abrasion on the water contacting part of the piers by No.16 to No.20 from the right bank. The attached bridge as well has been time-worn considerably.

At immediate upstream of the regulator, there is about 1.0 m thick sand sediment observed, while at about 50 m downstream from the structure, about 2.0 m deep scour observed, which has not been much progressed because of additional riprap works made annually.

The existing lock gate with 8.0 m width has been relocated at the right bank from the left bank due to widening from 6.0 m, but actually there are only two or three times of navigation through the lock gate every year for carrying heavy construction machines for canal dredging.

The gate size is quite the same as that of Manshat El Dahab regulator, and since the winding load is large, chain breakage has taken place frequently. The water level difference of 60 cm between up- and downstream water is taken as empirical standard for gate operation. Chain breakage, which frequently takes place, has caused many leaves left in the flow, and about 20% of the gate leaves are found defected or in trouble.

e) Mazoura Regulator

The accurate construction year is unknown, but judging from the type and degradation extent of the structure, the regulator appears to have been constructed around the same period as those of Manshat El Dahab and Sakoula regulators; therefore, the Mazoura regulator is as old as about 90 years in construction. Different from the above two regulators, this is longest of the three with 25 gates, although other two with 20 gates.

The attached bridge has recently become used so frequently by heavy traffic of 17 to 20 ton large trucks for construction stone material transportation from the western quarry sites of the area. Such heavy traffic load has resulted in making cracks on the arches to endanger destruction the body. There have been some signs appearing on the arch of the No.20 gate in particular. Visual inspection has allowed to confirm many cracks and defects on the surface bricks as well as scoured holes and hydraulical abrasion on the piers placed in the thalweg of the canal. The structure body together with attached bridge have been time-worn remarkably. Since the narrow bridge has caused heavy traffic jam, the users and local people have made a request for widening the bridge width.

There is about 0.8 m thick sediment observed at the immediate upstream of the regulator, while no remarkable devastation like scouring observed but some lowering of the canal bed in its level at the immediate downstream of the structure.

The gate size is the same as that of the Manshat El Dahab regulator, and the large winding load has caused difficulty in the gate operation. This has brought about frequent chain breakage to leave many lower gate leaves in the flow.

Above all ten gates of the total 25 gates (No. 16 - No.25) from the right bank have remained in no operational condition due to about 1.5 m sediment at the immediate upstream of the gates. At present, only about 46% of the total gates is operative.

Difficulty in operation (including chain breakage) has caused the lower closed leaves left in the flow, and the water level control has been practised through upper leaf operation only, and this is just like submerged overflow type weir for water level control, which will become irregular and unstable. Presently, the control has been successfully made by operation of 15 gates only and with the rest kept closed. This means that the idea of the original design of the gates is not clear as a whole, and it can be guessed only that the designer took inflow of runoff discharge before construction of High Aswan Dam into consideration.

f) New Lahoun Regulator

The construction year of the regulator is not known, but presumed that almost 120 years passed from the latter part of the 1800s, judging from the materials used as members and the degradation of their quality. The structure surface is made with cut stones in arches, and the stone materials used are of sandy stones which have been heavily weathered together with considerable defects on the joint materials. The brick piers at the upstream have been also deteriorated heavily.

In 1988, MPWWR made grout works so as to reinforce the regulator body, and the records of the related works explain that the relevant works covered brick works, and grout works for 170 holes with pouring cement milk of 30 kg/m on an average, and total cement of about 40 tons.

With heavy traffic as the important facilities, the structures together with the bridge have been remarkably deteriorated. The canal bed immediately downstream of the regulator is comparatively stable in its condition because of hydraulical dissipation effect by relatively high elevation at the sill of the old regulator.

This is the only regulator, among all the regulators, that is of the Fahmy Henen type. This gate type is applied mostly to the small scale gates. Since, however, the leaf is rather large in size, the leaves are pushed over the piers when operated. This causes the gear operating system tends to be broken. The gate is a large size gate with 5.2 m height, which has brought about troubles in operation and maintenance. Deterioration of the leaves has been greatly advanced.

g) Old Lahoun Regulator

The regulator is presumed to have been constructed in the early 1800s and the regulator is of arch structure with and stone material surface. The surface has been heavily weathered, and the attached bridge as superstructures (width of 18 m) has not already been used. Deterioration of the structure has been badly advanced. About 70 m downstream from the structure, there is a large size scouring with 15 m depth in maximum, which is assumed to give adverse effects to the structure body.

3) Intake Structures for Branch Canals

The existing intake structures for the branch canals were equipped with steel regulating gates. The gates can be classified into three types by canal scales; For small scale gates with less than 1.20 m vent, spindle winding sluice gates were used, while for medium and large scale gates with 2.0 to 3.0 m vent, gear winding Fahmy Henen gates were equipped. For large scale gates with 3.0 m vent and large leaf height, chain winding double leaf gate was commonly used. The Fahmy Henen gates for medium and large scale intake structures were used generally in Egypt.

The winding mechanism of this gate type, however, is that the gate leaves are lifted up by gears put on both ends of the rounding shaft, so that the large size gate leaves tend to incline when lifted to make disengagement of the gears or make mislead of the gate leaves out of guide metals. Such troubles often result in defects of the gears and difficulty in operation.

With this mechanism, one man operation is possible when newly installed, but two or three staff operation will become rather difficult as time goes by.

The large scale intake facilities of Giza and Hassan Wasef canals are equipped with double leaf chain winding mechanism, which has the same difficulty in operation with chain breakage, clogging with guide metals, imbalance in single chain hanging system, etc. as those of the regulator at the Bahr Yusef canal. Under the situation, there have been the lower gate leaves left closed in the flow. The medium or large scale intake facilities made with bricks have been deteriorated heavily.

The survey of the intake facilities for the branch canal of Bahr Yusef canal has been made on the data available by related Irrigation Directorates in supplementing by field survey. In addition, the field survey has been carried out for 16 medium and large scale intake facilities. The visual survey criteria were decided in the same as those of the barrage and regulators. The major structures have been surveyed for the main intake facilities (refer to Tables F-1-15 and -16, and Figure F-1-9 in Appendix F).

4) Branch Canals

Among many branch canals of the Bahr Yusef canal, the Harika branch canal has been taken up as a representative of the canals for planning the improvement of water distribution system. The Harika branch canal, an earth canal, branches off at km 177.23 point of Bahr Yusef canal, in the immediate upstream of the Sakoula regulator.

The Harika canal runs about 32.8 km in total to cover about 18,800 feddan of the farm land. Most part of the canal is of unlined canal excepting only few meandering portions with stone masonry protection works. The most part of the canal runs straight along the road, having the average canal slope by 1/16,700 in very gentle flow. The canal width is about 13.0 m at the upstream and about 5.0 m at the downstream, and side slope is 1 : 1, and the water depth ranges from about 1.5 m to 2.0 m (refer to Figure F-1-8 in Appendix F).

The canal provide the intake facilities and five regulators, one each at upper reach and middle reach, and three at lower reach, respectively. These five regulators play a role to control the intake water level in the related small branch canals. The regulating gates at No.1, 2 and 5 are of Fahmy Henen type, and other two provide the stop-log system. The No.2 regulating gate was rehabilitated in 1989 and the No.5 in 1990. The No.2 regulator is located on the boundary of the operation and maintenance service area by the Minia and the Beni Suef

Irrigation Directorates so as to control the water level in a range from 31.40 m at the highest to 31.10 m at the lowest.

Along the canal, there are two spillway facilities to the Bahr Yusef canal. The one at the mid-stream is located at the upstream of the No.2 regulating gate, and the restrictive section is 1,000 mm dia., while that at the downstream is located at the point of the No.5 regulating gate, having gate width of 1.5 m. The said spillway has a role as emergency spillway of the Bahr Yusef canal at the Sakoula regulator in non-irrigation season. At the terminal point of the canal, there is a cylindrical overflow drain provided to link with a drainage canal.

A survey has been made for the structures of the major barrages. For planning a rehabilitation of the facilities, the Minia Irrigation Directorate was requested to make profile and cross section surveying to confirm the present conditions of the facilities. Besides, discharge measurements were carried out and and water level gauges were also provided to keep water level measurement for grasping the accurate information of the hydraulic conditions in the peak time of irrigation season (refer to Figures F-1-9 in Appendix F).

3.3.4 Drainage Facilities

1) Drainage Pump Station

The major drainage facilities consist of drainage pump stations and drainage canals connecting with drainage pump stations. The nine drainage pump stations along the Bahr Yusef canal, which drain excess water to the Bahr Yusef canal, were constructed in order to drain excess groundwater from the irrigated fields of about 404,000 feddan located at both right and left banks of the canal. The oldest El Badraman drainage pump station was constructed in 1937 and other eight drainage pump stations were constructed from 1978 to 1986.

Inclined axis mixed flow pumps, excepting two drainage pump stations of El Badraman and Tona El Gabel, are installed in seven other pump stations. Diameters of the pumps are 500 mm in minimum at the Tona El Gabel drainage pump station and 1,500 mm in maximum at the Beni Mazar drainage pump station. The mean diameter of the drainage pumps is about 1,000 mm. A lifting capacity of a pump usually ranges from 2 to 3 m^3/sec. The maximum lifting capacity is 4.36 m^3/sec in the Kabkab drainage pump station. The average number of pumps is four, of which one stand-by pump is prepared. The actual lifting head is less than about four meters. A movable system with electric motors is operating at present,