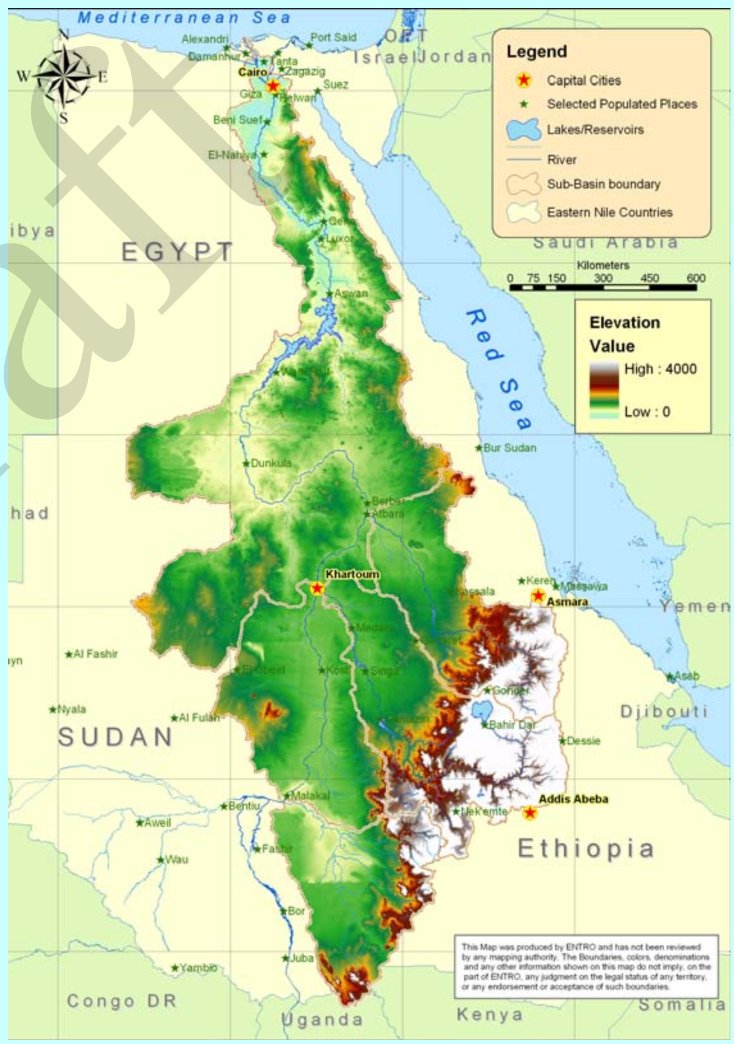
Multipurpose Development of the Eastern Nile, One–System inventory report on water resource related Data and information
EGYPT



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ENTRO
(Eastern Nile Technical Regional Office)

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LIST OF ACRONYMS

AHD	Aswan High Dam
AHDA	Aswan High Dam Authority
AHDL	Aswan High Dam Lake
AMSL	Above Mean Sea Level
BCM	Billion Cubic Meter
CMPS	Cubic Meter Per Second
DWT	Depth-Weight-Tonnage
EN	Eastern Nile
ENSAPT	Eastern Nile Subsidiary Action Program
ENTRO	Eastern Nile Technical Regional Office
FAO	Food and Agriculture Organization
Feddan	Area Unit equal to 4200 m^2 = 1.038 acre.
ha	hectare
JMP	Joint Multipurpose Projects
LN	Lake Nasser
MCM	Million cubic meter
MWRI	Ministry of Water Resources and Irrigation
NBI	Nile Basin Initiative
NFP	National Focal Person/Point
NRI	Nile Research Institute, NWRC
NWRC	National Water Resources Center, MWRI
NWS	Nile Water Sector
OSI	One System Inventory
PJTC	Permanent Joint Technical Commission for Nile waters
ppm	Part per million
RTA	River Transport Authority
SAP	Subsidiary Action Program
SVP	Shared Vision Program
SWECO	Swedish commission for Technical Cooperation

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EXECUTIVE SUMMARY

Under the Eastern Nile Subsidiary Action Program (ENSAP), planning is underway for the multipurpose development of the region. As part of the initial activities in this exercise, the Eastern Nile Technical Regional Office (ENTRO), a joint establishment of the three Eastern Nile (EA) countries, Egypt, Ethiopia and Sudan, is interested to conduct a preliminary assessment of the Nile Basin resources and development opportunities. The assessment, which is known as ‘One-System Inventory’ has three components dealing with Water Resources, Environment and Socio-economy.

The objective of this consultancy report is to compile essential information on water and related resources of Egypt that can be used for proper planning of the initial activities in the Eastern Nile Sub-basin under the EN Multipurpose Development Program. The work also includes data compilation and report preparation, including comments on data quality, and annotated list of references.

The main sources of the River Nile are found in the Ethiopian plateau and the Equatorial Lakes region. All along the Nile, people are affected to some extent by the river or its water. With a few exceptions, the water resources in the headwater areas of the system are not yet developed. The hydrographic and hydrological characteristics vary greatly over the basin. Rainfall in the headwater areas is abundant though it is seasonal. On the other hand, from north Sudan the river runs through arid countries.

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The dependence of Egypt and Sudan on the Nile has led to intensive studies of quantities of water carried by the main stream and its tributaries throughout the year. The annual average natural discharge of the River Nile at Aswan was estimated 84 BCM for the period 1900/1901- 1954/1955). Although, the average annual amount of the rainfall over the basin reaches about 1700 billion cubic meters (BCM), the amount of water that reaches Egypt at Aswan represents less than 6% of that amount. The annual water flow at Aswan was the basis of design for the over year storage at the Aswan High Dam. The construction of AHD in 1964 created a huge man-made lake, Aswan High Dam Lake, which resulted in modifying the hydrological regime of the River Nile. The Lake of high Dam is about 500 kilometer long, of which 350 km is in Egyptian territory, comprising Lake Nasser, and 150 kilometer in the Sudan comprising Lake Nubia. Lake Nasser has an area of about 6000 km^2, mean depth of 25.5 m (maximum 90 m), and a width of 12 km at 182 meter Above Mean Sea Level (AMSL).

Water Resources data which include Main Nile in Egypt has physical features, hydrology and climate, existing water infrastructure, hydropower, irrigation schemes, navigation, water resources opportunities, and major issues in water resources development and managements where they have been compiled. Data quality has been assessed and gaps of information with respect to water resources development and managements are noted.

In general, analysis of water resources data indicates the following.

- River Nile is the main source of fresh water for Egypt and represents more than 95 % of its water supply.
- The fast growth of Egypt’s population creates an argent need to expand

agriculture land area and increase the cropping intensity. The major obstacle to the achievement of these goals is the shortage of irrigation water. Therefore, several steps have been taken to utilize the use of water in Egypt, some of these steps are: -

- Reuse of Drainage water;
- Implementing new methods of irrigation (i.e. drip, and spray methods);
- Sea water desalinization;
- Use of deep ground water; and
- Rain water harvesting.

* The conservation, control and regulation of the Nile and its tributaries, therefore, have a strong direct bearing on the economic development in Egypt and EN countries.

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ONE SYSTEM INVENTORY
WATER RESOURCES THEME REPORT

1- INTRODUCTION

1-1 General

Nile Basin Initiative (NBI) is a partnership of the riparian states of the Nile : Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. The NBI seeks to develop the river in a cooperative manner, share substantial socio-economic benefits, and promote regional peace and security. The NBI started with a participatory process of dialogue among the riparians that resulted in their agreeing on a shared vision: to "achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources," and a Strategic Action Program to translate this vision into concrete activities and projects. The NBI's Stragetic Action Program is made up of two complementary programs: the basin wide Shared Vision Program to build confidence and capacity across the basin, and Subsidiary Action Programs to initiate concrete investments and action on the ground at sub-basin levels.

The programs are reinforcing in nature. The Shared Vision Program, which focuses on building regional institutions, capacity, and trust, lays the foundation for unlocking the development potential of the Nile, which can be realized through the subsidiary action programs. These investment-oriented programs are currently under preparation in the Eastern Nile and the Nile Equatorial Lakes Regions

The Eastern Nile includes the countries Egypt, Sudan and Ethiopia1 and encompasses the sub-basins Baro-Akobo-Sobat, Bue Nile, Tekezze-Settit-Atbara, portions of the White Nile in Sudan, and the Main Nile. The EN countries are pursuing cooperative development at the sub-basin level through the investment oriented Eastern Nile Subsidiary Action Program (ENSAP). The Eastern Nile Technical Regional Office (ENTRO) is an institution established by the three EN countries to advance the implementation of ENSAP .

ENSAP seeks to realize the NBI Shared Vision for the Eastern Nile region, and is aimed at the reduction of poverty in the region, economic growth, and the reversal of environmental degradation. Towards this end, the EN countries have identified their first joint project, the Integrated Development of the Eastern Nile (IDEN), which consists of a series of sub-projects addressing issues related to flood preparedness and early warning, power development and interconnection, irrigation and drainage, watershed management, multi-purpose water resources development, and modeling in the Eastern Nile. Considerable progress has been made in the preparation of most of the IDEN projects since their inception. As the cooperation among the countries continued to grow, the riparians are now launching a multipurpose program, which involves more complex, regional, joint win-win projects.

The Eastern Nile region is characterized by highly variable climate and river flows, making it prone to consequences of extremes of droughts and floods. A significant

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proportion of the annual runoff volume occurs during a few high rainfall months in the year, thus, requiring adequate regulation to maintain required flow during dry periods. During high rainfall periods major rivers in the region often give rise to large scale riverine flooding, particularly in floodplain areas in Sudan and Ethiopia. The sub-basins of the EN are endowed with water and other related resources with tremendous development potentials. The proper development and management of these resources calls for an integrated approach within the framework of multi-country joint development program, which will address the opportunities, and challenges within the basin in a unified manner. The EN Multipurpose Development Program seeks to advance the development of multi-country joint projects that benefits all riparian countries.

To promote the Eastern Nile Joint Multi Purpose Projects (JMP), a new cooperative mandate is proposed to prepare inventories containing information on the Water Resources, Environmental and Socio-economic issues for the Eastern Nile. These inventories are being prepared to provide a comprehensive overview of the current knowledge base associated with this River Basin. The inventories will be based on information available within each country it will be compiled to "one system inventory" providing an overview of the river basin of Eastern Nile without political boundaries. The "one system inventories" will be available to inform the ongoing strategic discussions between countries. All countries have indicated their willingness to cooperate in providing the necessary data.

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1-2 Objectives

The objective of this consultancy is to compile essential information on water and related resources of Egypt that can be used for proper planning of the initial activities in the Eastern Nile Sub-basin under the EN Multipurpose Development Program. The work also includes data compilation and report preparation, including comments on data quality, and annotated list of references.

1-3 Outlines

This report presents the water resources information of the Main Nile Sub-basin in Egypt, in the following arrangements:

- Basin Physical Features that includes river network and the longitudinal profile of the main river in Egypt and its major two tributaries; Rosetta and Damietta;
- Hydrology and Climate;
- Sediment transport;
- Water Infrastructure;
- Water resources opportunities Based on Egyptian Master Plan;
- Major issues in water resources development and management;
- List of annotated references; and
- List of Annexes that includes: maps, drawings, data, and information

2- BASIN PHYSICAL FEATURES

2-1 General

The conventional water resources in Egypt are limited to the River Nile, groundwater in the Delta originated from the Nile waters, deep groundwater in Western deserts and Sinai, limited rainfall and flash flood in northern coast and red sea coast. Each resource has its limitations on use. These limitations relate to quantity, quality, location, time, and cost of development.

The River Nile is predominant source of fresh water in Egypt. Presently, it's flow rate relies on the available water stored in Lake Nasser in the flood season (July-October) and in the wet years to meet needs in the rest of the year and in the dry years within Egypt's annual share of water.

2-2 Basin Physical Features: River Network Related

a) Major rivers, lakes and wetlands, and their basic features

The River Nile has a total length of about 1532 km inside Egypt, starting from Egypt-Sudan border in the south and ending at the Mediterranean Sea in the North. The construction of AHD, nearly 350 km north of the Egypt-Sudan border, created lake Nasser, which is the largest man-made lake in the world. Lake Nasser has a length of 350 km inside Egypt and 150 km inside Sudan. The lake has an average width of 12 km and surface area of 6000 km^2 at the highest water level. (Annex A-1 **Figure 1** ***map of Lake Nasser)***

The River Nile provides Egypt with a gently sloping water path 1428-Km in length divided into three major parts. The first part is 946 Km long extending between Aswan and Delta Barrages. This part is segregated into four reaches separated by the historic barrages, Isna, Nag Hammadi, and Asyut barrages. At the apex of the delta, the Nile bifurcated into two parts, Damietta and Rosetta branches. The length of Damietta branch is 246 Km while Rosetta branch reaches 236 Km long.

The width of the Nile differs from Aswan to Delta Barrages. Wherever Nile has one channel, its width varies between 300 m and 650 m, but it varies between 1200 and 1500 m or more, along reaches, where the river flows in two or more channels, with central islands. In plan, the Nile is relatively straight with some sinuous reaches over short distances which are related to a steeper valley slope. The increase in sinuosity appears to occur with a valley slope in excess of 7 -10 cm/km.

There are about 356 islands in the Nile channel between Aswan and Cairo with an average of one island every 3 Km. This number includes all type of islands, permanent ones (defined as having permanent vegetation and are distinct from sand bars), the submerged islands which appear only in low flow seasons, sand bar islands, and weed islands. Many islands are attached to the main bank of the river and the secondary channels are blocked in many parts of the river. (Annex A-4 ***Figure 14 shows schematic Network of main inland water ways***)

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It may seem possible to classify wetlands in Egypt in a systematic pattern (salt water and freshwater wetlands, etc…..) or in a geographical pattern (Mediterranean, Red sea coastlands, inland wetlands, etc). But environmental management and conservation make this taxonomy difficult. We note here different types of wetlands in the catchments of the River Nile in the Egyptian borders, as shown in ***map 1***. (***Map 1 Egypt wetlands in the catchments of the river Nile***)

1. The Manzala- Burullus, -Idku-, Mareot lakes of north Egypt. These are lakes of different origin and different ecology. They all have access, natural or artificial, to the Mediterranean; even natural outlets (Bughaz) require maintenance. They all are important bird sites due to their habitat and their geographical position along the migration routes. In their pristine state, these lakes received agriculture drainage water and sea water. The Mallaha of Port Fouad with its extensive salt mudflats may be added to this group. All are among the Egyptian fisheries.

2. The Qarun – Wadi Rayyan lakes. These are two of the depressions of the West desert. Lake Qarun is the lowest part (bottom at 45 m. below sea level) of the larger depression that is now the farmlands of the Governorate of Faiyum. Lake Qarun receives drainage water of the Faiyum. Evaporation makes it hyper –saline. Wadi Rayyan was a dry un-inhabited depression (60m. below sea level) with a few fresh water springs that formed small patches of reed swamps. In 1970s the Rayyan depression was connected to the agriculture drainage system of the Faiyum Governorate. Two lakes were formed in the area, these are man-made brackish lakes.

3. A number of small lakes scatter in the Delta and its outskirts, mostly formed as drainage water collected in depressions. Two lakes were made famous as fowl shooting sites (winter sport): Abasa in the eastern outskirts of Delta, and Dahshoor in the western outskirts of the Delta. Abasa is a body of fresh water; it maintains its original function and accommodates fish-farming research and training center. Dahshoor has dried, its fringes afforested and it retains relicts of reed swamps.

4. The main channel of the Nile between Aswan and Cairo embraces numerous islands. Shores of these islands and the riverbanks provide strips of wetland habitat and vegetation including floating reed growth. In Aswan reaches there is a group of granite islands (First Cataract Islands) that have relicts of riverine forests. The islands of the rest of the Nile are alluvial and a few of them may be seasonally inundated.

5. Lake Nasser is the Egyptian part of the Aswan High Dam reservoir-lake. This is an extensive freshwater body, one of the larger man-made lakes in the world: 500 km long (350 km in Egypt and 150 km in the Sudan, total area catchment 6000 km^2). Its position in an area of extreme aridity provides stark contrast between desert and water with interesting acetone transitions. The western part of Lake Nasser comprises a number of shallow lobes, the eastern part includes the mouth parts of wadis. All are wetland habitats.

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6. The depressions of Tushka spillway: a number of freshwater lakes formed in depressions of the western Nubian Desert as excess of Lake Nasser water flowed into them. These are temporary freshwater bodies formed in an extremely arid desert. Wetland habitats prevail including reed swamps. These depressions will eventually receive drainage of the Tushka agricultural lands and will become permanent.

Map 3 **Egypt Wetlands in the Catchments of the River Nile**

b) River Network maps (scale 1:2,000,000)

The River Network map is attached with the report. (***map 2***)

c) Longitudinal Profile of major Rivers (Scale 1:10,000,000)

The longitudinal Profile of Major Rivers is attached at (Annex A-1 ***Figures 2&3***)

3-HYDROLOGY AND CLIMATE

3-1 Climate

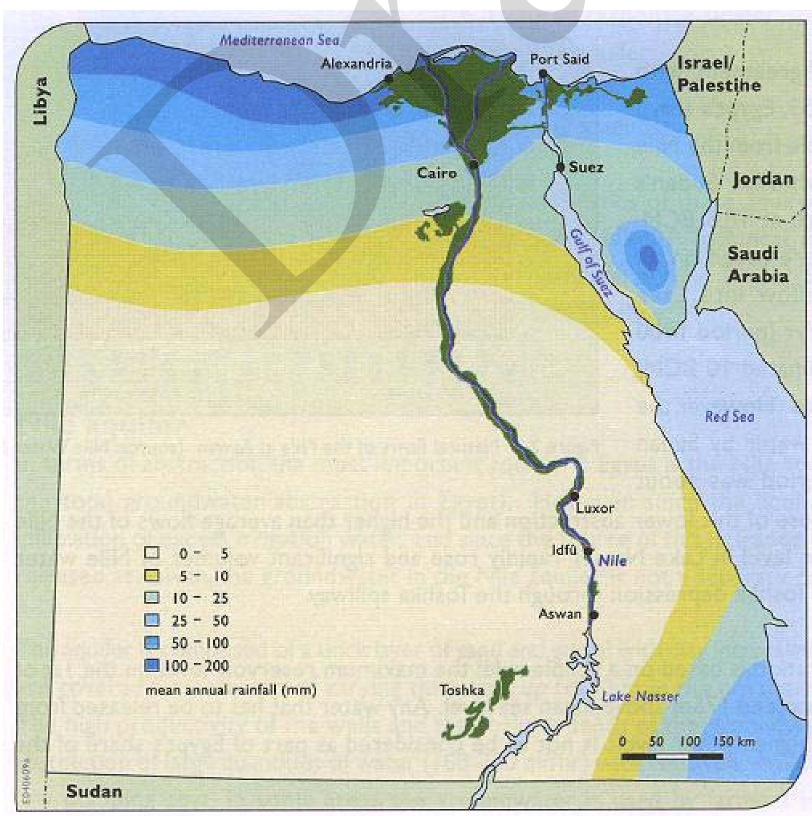
a) Mean Annual Rainfall patterns and its variability

Egypt is a very arid country where rainfall over most of the country is virtually non-existent. Rain in Egypt falls in the winter in the form of scattered showers and its amount may vary considerably from year to year in the same places and may also differ widely in two neighboring localities in the same season or year. Therefore, it cannot be considered a dependable source of water. Nevertheless, some seasonal rain-fed agriculture is practiced in the northern coast to the west of Alexandria and in Sinai utilizing these small amounts of water.

Rainfall on the Mediterranean coastal strip decreases eastward from 200 mm/year at Alexandria to 75 mm/year at Port Said. In the whole of Upper Egypt, i.e. south of Cairo, the rains are very scarce and in this connection, it is considered negligible. The average yearly rains vary from less 5 mm at Aswan to about 25 mm near Cairo. Floods occurring due to short period, high intensity storms are a source of environmental damage, especially in the Red Sea area and southern Sinai.

The average rainfall over the whole Delta can be estimated at one billion m3 per year. This quantity corresponds to about 3 percent of the waters at present brought to the Delta by the Nile.

Annex (B-1 ***Tables 1, 2, 3, and 4***) represent the mean monthly precipitation for four main stations in Egypt namely Alexandria, Port Said, Cairo, and Aswan.



Map 4 **Mean annual Rainfall pattern in mm**

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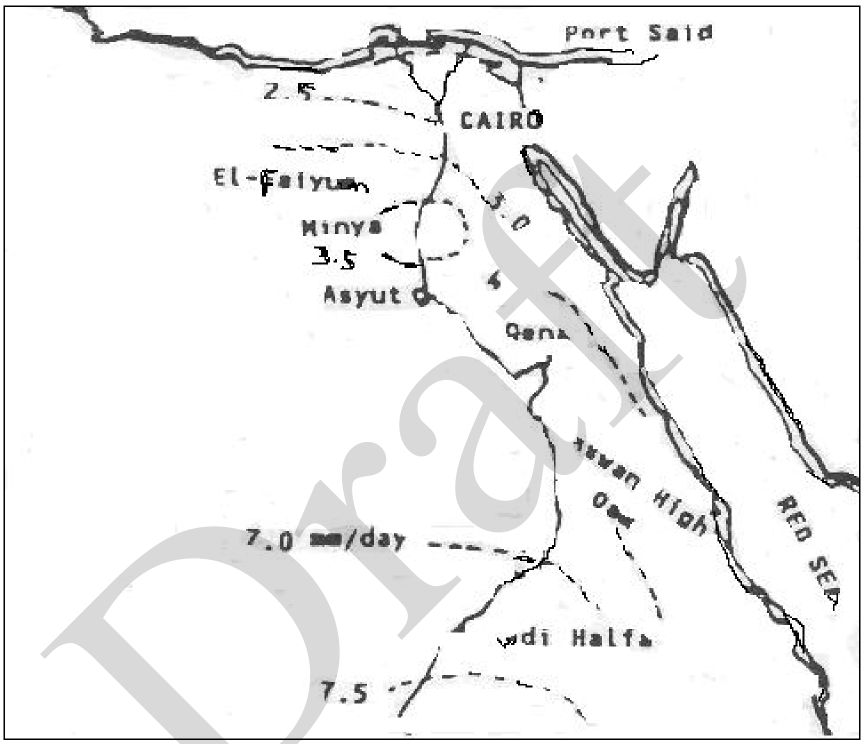
b) Annual Rainfall Trends

Annex A-2 ***figures 4,*** *and* ***5*** represents the annual trend of annual total rainfall for the main four rainfall stations. Its total annual rainfall data show positive trend for Alexandria, Port Said, and Aswan Stations, while data for Cairo shows negative trend.

c) Mean Annual Evaporation Rates

Mean Annual Evaporation rates map is attached in ***map 3***



Map 4 **The mean annual evaporation rates in mm/ day**

Annex B-2 ***Table 5*** presents the mean monthly amount of evaporation; ***Table 6*** presents the highest daily amount of evaporation.

d) Evaporation Rates at Lake Nasser

Lake Nasser lies in a hot and extremely arid climate, and is surrounded by desert and hilly land. The first meteorological station at Aswan was constructed south of the old town near the river in 1931 at altitude 110 m AMSL. In the planning stage for constructing AHD, a new airport was constructed in the western side of the Dam area at the end of 1959, at altitude of about 193 m AMSL.

A new meteorological station was installed in the airport instead of the other one downtown. After the construction of the dam, no regular daily meteorological measurements have been recorded along the lake. As a result of close co-operation among the Permanent joint Technical Commission for Nile Waters (PJTC), The High Dam and Aswan Reservoir Authority, and the

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Egyptian Meteorological Authority in 1973, hydro meteorological network stations were planned to be installed sequentially along and around the lake for measuring the meteorological parameters to estimate the rate of evaporation from the lake.

The lake area is located just south of latitude 24 N which is classified as subtropical, hot, very dry desert climate. Rainfall is extremely scarce during winter season but sometimes occurs in very small amounts when the area is affected by active cold fronts of the Mediterranean depressions. It is also rare in tangible amount during transitional seasons due to the effect of the north oscillation of the Inter Tropical Convergence Zone.The following table presents the Mean Monthly rate of evaporation estimated in mm/day for the whole lake.

Table of the Mean Monthly rate of evaporation mm/day for Lake Nasser.

Month	Lake evaporation (mm/day)
Jan.	4.82
Feb.	5.03
Mar.	5.35
Apr.	5.69
May	6.91
June	8.04
July	8.68
Aug.	9.06
Sep.	9.59
Oct.	8.68
Nov.	6.70
Dec.	5.72

3-2 Flow Characteristics

Annex B-3 ***Table 7*** represents the mean monthly flow characteristics at main points at River Nile network for the period 1980-2000.Mail flow measurement points are represented in Annex 10 ***figures 20-22***.

3-3 Sediment Transport

a) Historical reservoir sedimentation rates

The sediment load of the Nile generally depends on the volume of the flood. About 95% of the total sediment load is received during the flood season and originates in the Ethiopian Plateau. At Wadi Halfa on the border between Egypt and Sudan, the annual sediment load varied from 50 million tons to 228 million tons per year with a mean annual load of 134 million tons for the period 1929-1955.

The coarser sediments (sands and very little gravel size material coming from the Blue Nile and River Atbara) are found near the bed while the finer sediments (silts and clays) are found in suspension. The concentration of the flood water suspended sediments proportion of the constituents is roughly:

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30% clay size, 40% silt size, and 30% fine sand. (Annex B-4 ***Table 8*** shows the total suspended solid in flood water)

b) Lake Nasser Sedimentation

The construction of AHD has caused modifications in the hydrological regime of the River Nile. Flow control by AHD eliminated the Nile flood that used to flush and clean the river once a year. Meanwhile, the impoundment of water upstream of the dam has caused some environmental changes with regard to its physico-chemical and biological properties. On the other hand, with the increasing water demands for domestic, agricultural and industrial uses, the quantities of domestic and urban wastewater effluents requiring treatment and/or disposal are rising rapidly. The complexities of wastewater treatment, under some circumstances, are demanding the use of advanced techniques and requiring increasing expenditures.

During the reservoir filling process, the distribution of siltation used to cover wider areas depending on the size of the flood. More recently, siltation has been confined to the most southern part of the reservoir. Particularly, heavy siltation occurs in the area between 360 km and 430 km south of the dam site. In this region, siltation beds have already emerged in the life storage zone as shown in ***figure***. Nevertheless, sediment transport phenomena tend to be in a northerly direction.

Following ***figure*** shows the longitudinal section for AHD reservoir. This part illustrates the sedimentation process for the lowest points along the lake. This estimation is updated annually during the hydrographic survey missions performed by the NRI (National Research Institute) and the AHDA. Measurements indicate that sedimentation depth increases with time. It has to be mentioned here that the total deposited sediment volume is 2477.042 MCM in the time interval 1964-1995. Based on, one of the study the mathematical model and the annual sedimentation rate the total reservoir life is about 408 years. (Annex B-4 ***Table 9***)

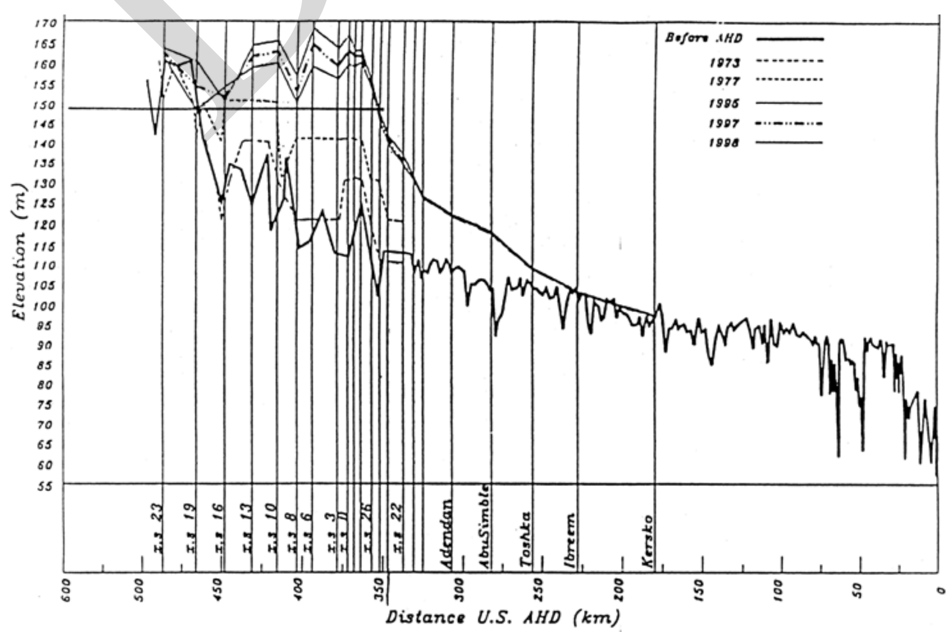

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Figure **The longitudinal section for AHD reservoir**

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c) Compilation of Sediment problem

One of the major problems encountered in operation of AHDL is the sediment deposition. Continuous deposition of sediment decreases the reservoir capacity; increases bed levels at the reservoir entrance; and has formed an internal delta. The progress of delta formation and the change in its properties in all directions have not been analyzed comprehensively. Although several endeavors have been practiced, an accurate approach needs to be designed to analyze the main properties of the delta formation, and its progress in Lake Nasser/ Nubia, and to estimate the time for filling the dead zone buffer of the Lake, which defines the lifetime of the reservoir.

Average bed levels have been monitored for different years and analyzed, in the longitudinal direction. The results show that deposition is still carrying on in the Lake and the delta is expanding in vertical, longitudinal and transverse directions as interpreted from the cross sections profiles .

A complete hydrographic survey has to be executed, for the whole Lake area to have a complete bathymetric map with suitable contour intervals. Consequently, better and accurate estimation of sediment deposition volumes and their distributions will be easily obtained. Moreover, the Lake water levels versus Lake surface area and Lake Volume curves require updating especially under different operation scenarios of Aswan High Dam. Furthermore, lakebed materials in addition to deep borings have to be obtained through specific sediment quality and sediment deposition monitoring program. Physicochemical and biochemical analyses have to be applied on lakebed materials and sediment deposition borings to study the organic matters contents and the degree of contaminants in the deposited sediments, particularly clay soils.

d) AHD operation Strategy

The AHD operation Strategy depends mainly on Agriculture Demand, where it consumes around 78% of available total water demands. Other water uses are municipal 6%, Industrial 4%, Environmental and navigation 12%. Although, sediment problems were not considered when dealing with AHD operation Strategy, many studies have been carried on monitoring of sediment transport, and its management.

The torrential rainfall on the Ethiopian Plateau washes down large quantities of silt which are carried by the Nile during flood. The sediments are transported both in suspension and as bed load. After constructing the AHD these sediments would be deposited in the reservoir, which should include a sufficient capacity to hold it for an adequate period of time before the volume of the live storage is affected. The average quantity of suspended matter in the Nile at Wadi Halfa (350 km upstream AHD) is estimated at 134 million tons per annum. Most of it is carried by the flood during the months August to October. After consolidation under water the accumulated volume of sediments is estimated to be about 60 million m^3. The dead storage capacity is designed at 30 BCM to be used as a silt trap for about 500 years. The dead storage capacity occupied the range up to elevation 147 meter.

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e) Mitigation/ corrective measures

Many mitigation and corrective measures have been implemented of those:

- Annual hydrographic monitoring mission for sediment and water quality
- Studies concerning the use of sediments

3-4 Flood Peaks

a) Flood Management Prior To AHD

The incidents of high floods have been one of the most destructive hazards facing the people of Egypt. Since the earliest times, Egyptians have been subject to the dangers of the Nile during high floods especially at the peaks. Great disasters in the second half of the 19^{th} century, involving the losses of thousands of lives, happened because the protection embankments, intervening between the annual floods and the land which everywhere is lower than the level of a high flood, burst at some points.

These embankments were erected long time ago on both sides and along the whole length of the River between Aswan and the Sea, a distance of about 1100 Kilometers. The people lived under the protection of embankments, which act as a barrier for protection of crops and human settlements from inundation. The maintenance of the banks were in ancient times regarded as vital importance that the system known as the Corvee, or compulsory labor, was imposed by Decree in case of threatening flood. Only in recent times was the Corvee abolished and labor engaged in the normal manner for service at dangerous points. Tens of millions of Egyptian pounds were spent annually to maintain the banks. During floods the Nile banks were covered by booths at intervals of 50 to 150 m, according to the degree of risk incurred. Watchmen day and night parade the whole length, in the weak spots; men and material in great quantities were held ready to prevent any possible disaster. The policy in the 19^{th} century was to spread the flood waters among many channels and protect them with tens of thousands of Corvee. This policy was changed later and efforts were concentrated on Rosetta and Damietta branches.

The first half of the 20^{th} century witnessed tremendous efforts to lessen the threat of high floods. Aswan Dam, was completed in 1902 and heightened twice in 1912 and 1933, and was also used as a flood escape by holding up some flood water in the reservoir, which could help in reducing the flood by, about 100 MCM/day for a month duration.

Before the construction of AHD, the data available for the flood management past Cairo was limited to:

- Using the old Aswan Dam as flood escape. The total available capacity of the reservoir during floods was only about 3 BCM and this could help to reduce the flood flow by 100 MCM/day in month duration. The annual storage was only a partial solution to the problem of harnessing Nile waters.
- Ministry of Public Works (MPW) had concentrated on formulating a vigorous defense policy, by establishing in 1938 special Nile Banks

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administration in Lower Egypt to be in charge of strengthening and remodeling of banks to approved type, throughout their length, and to focus on training works of the channel, and making necessary diversions according to experiments made on models in the hydraulic research laboratory.

In 1946 MPW, following this policy adopted in Lower Egypt, established a Nile bank administration in Upper Egypt. After the completion of AHD the danger of high floods has been considerably reduced and the present Nile banks are mainly served as main roads linking towns and all sites of strategic importance that now stand on both sides of the Nile River.

- MPW directed the attention, since the flood of 1938, to the policy of suspending the conversion of the remaining areas of basin lands in Upper Egypt until a protection scheme to be constructed, and decided to maintain these basins so as to serve as a big flood escape into which some 200 MCM can flow daily, that is about 8 BCM of excess flood waters.

Due to this policy, the country was saved from the ravages of the 1946, 1954 and 1957 floods

AHD, completed in 1968, is considered the major project and the main link of a series of projects for Nile control and development of its water resources. For first time in history of Egypt, the gigantic floods of 1964, 1975, 1988, 1998 and 1999 did not bring any kind of damage or harm to the country. If AHD was not firmly established and in full operation, the destruction and damage would have been far more serious and loss of life would be truly appalling. A total volume of about 41 BCM of the reservoir capacity is effective for full protection against floods.

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4- WATER INFRASTRUCTURE

4-1 Water Utilization Overview

The following figure (***figure 5***) presents the current water utilization infrastructure and their locations.

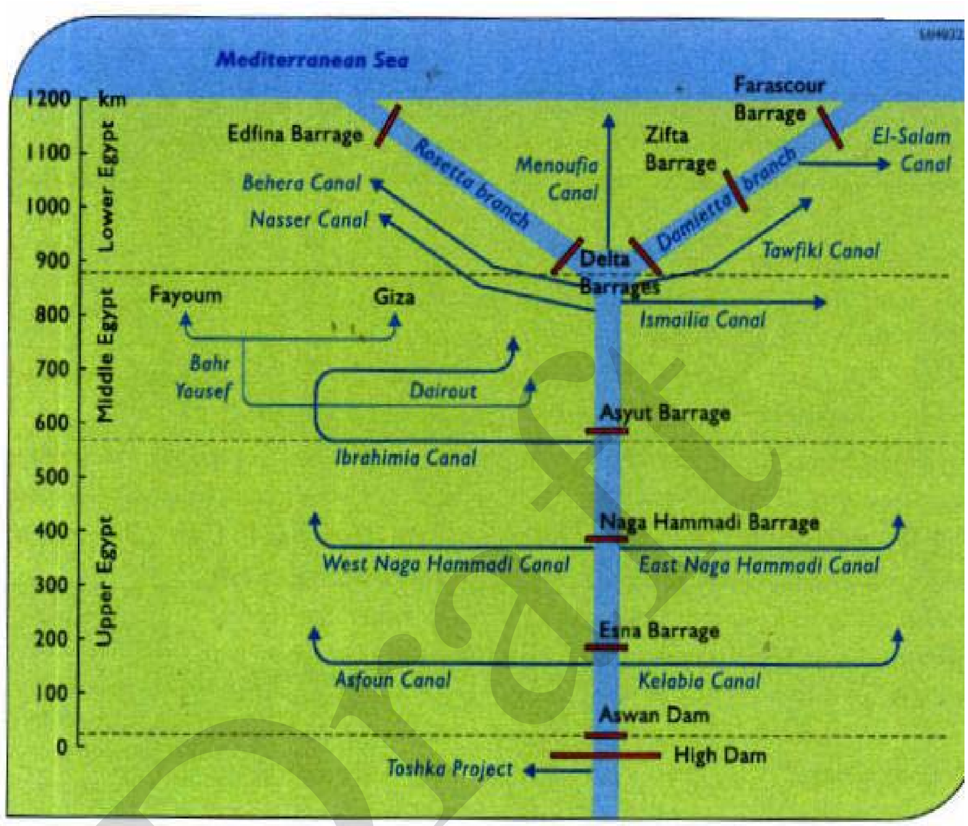

Figure 5 **The current water utilization infrastructure and their locations**.

The main irrigation systems, Directorates and canals are shown schematically in Annex A-3, where Figures 6, 7 and 8 show the West, Middle and East Section of the Delta, while Figures 9 to 12 show the four reaches of the Nile between the major control structures.

4-2 Hydropower

a) Existing hydropower schemes

The utilization of electric energy in Egypt has begun in 1893 in Cairo and Alexandria to feed homes and some streets with electric energy, direct current and low voltages. Utilization of Aswan Dam for electricity generation was suggested as early as 1912 after the first heightening, but the idea was not given any serious consideration until 1920. With the completion of the second heightening in 1933 and the consequence increase in water head and potential sources of electric energy, the Government of Egypt became more interested in the scheme. The prevailing economic circumstances and the political and party factors delayed the actual commencement of execution.

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Al Azab mini hydropower station lies 5 km south of Faiyum city and was constructed in 1925 as a diversion power station on Bahr El-Nazla. It is the first mini hydropower plant in Egypt and it was retired in 1983. It was renovated in 1983 – 1991.The total annual energy production is 4.75 Million KWh.

Nag Hammadi mini-power plant is situated on a diversion canal and is utilizing the head created by Nag Hammadi Barrage. It was constructed during the years 1939 – 1942. The operation of the plant ceases in 1971. In 1991, the Ministry of Electricity and Energy in collaboration with **SWECO** concluded a feasibility study for the renovation of the power plant. The study found that it is economically feasible to rehabilitate the plant for a total output of 3 × 1.5 MW, while the original was 3 × 1 MW.

Until the year 1960, the main source of power in Egypt was petroleum. Of the total annual energy consumed, which amounted to 2600 million kilowatt hours, 99٪ was generated by thermal stations. The picture was changed in 1961 due to the completion of Aswan hydro-power plant, Aswan I. It was constructed in (1953 – 1960) and designed for a head varying between 32 to 10 meters of a total output 345 MW.

The AHD hydro-electric power station is built at the outlets of tunnels. It contains twelve generating units of 175000 kw each. The total generating capacity is 2.100.000 kw producing 10 milliard K.W.H. annually. The station building is provided with two cranes, each of a capacity of 400/32/3.2 tons. On the right side of the station an assembly ground was prepared for the anchorage of the floating transport units to the station during the construction operation. Below the assembly ground, there is a plant which contains four pumping units, each of 1CM/sec. capacity. These pumps are to be used in pumping out the water from the electric power station and the tunnels during maintenance and installation operation. At the top of the electric power station at a level of 126 m AMSL, 12 power transformers were installed to step up the voltage form 15.75 kv to 500 kv for transmission to Cairo. The first unit has been put in commercial operation on 15th of October, 1967.

In 1986, Aswan II power plant was installed with a total capacity of 270 MW. It is noticed that the main water control structures across the Nile in Egypt have been utilized satisfactorily for power generation. However, there are still some barrages and many other small to medium hydraulic structures which can be used for the same purpose. New Isna barrage power station was constructed in 1994 with a total capacity of 90 MW. The results of the studies proved the economic profitability of the installed capacity at Nag Hammadi and Asyut barrages with the normal headwater level up to the limit 52 and 48 MW, respectively. There are possible sites for mini-hydropower installations, when added together shall contribute favorably to Egypt's energy balance. Mini hydropower refers to installations having a capacity ranging between 100 and 1500 kw.

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b) Electric Transmission Network

The erection of the power network began in 1928, the maximum voltage was 33 KV and 66 KV in 1955. Due to the development of the electric loads over the years, the ultra HV of 500 KV transmission lines is used to connect Aswan to Cairo, HV of 220 KV & 132 KV transmission lines in upper Egypt. These networks are mainly constructed to connect power stations and facilitate power flow to the load centers.

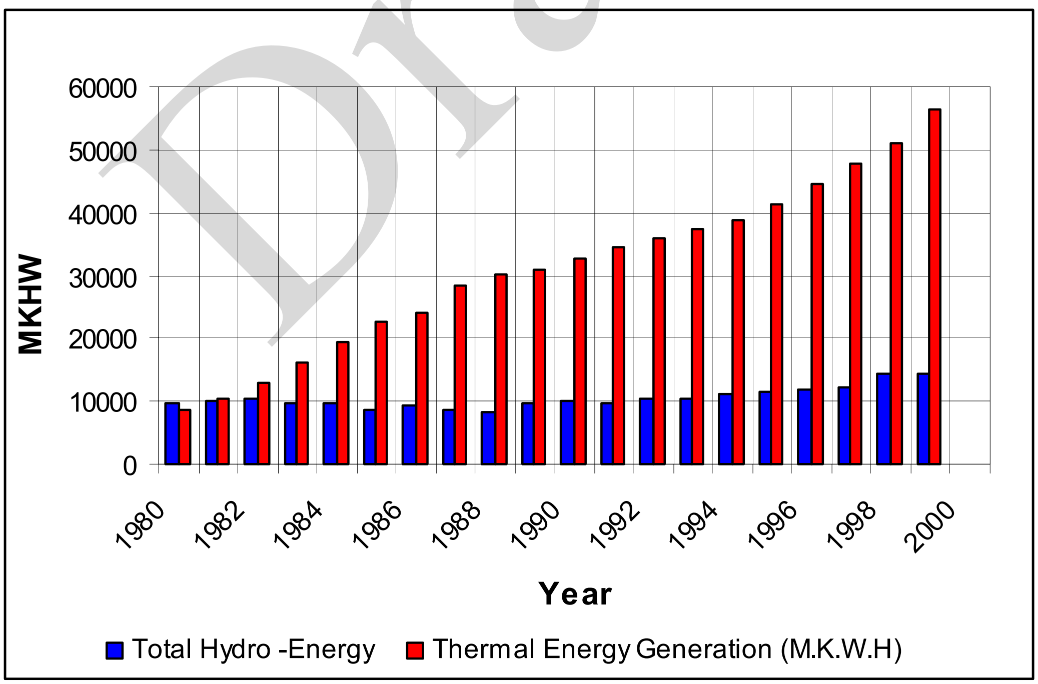
Since 1967, the years of commissioning the High Dam Hydro-Power Station, the operation of the unified power system has begun to connect power stations and to transfer Hydro-Energy from Upper Egypt to Lower Egypt across double circuits, over head 500 KV transmission line, passing Nag Hammadi, Asyut and Samalut substations 500/132 and KV finally Cairo 500 and Bassos substations 500/220 KV. The distribution network is fed from step down transformers 132/33 KV and 220/66 KV.

c) Characteristics of Installed Hydropower Stations

Annex B-5 ***Table 10*** presents the characteristics of the installed hydropower stations.

d) Total annual energy generated from existing schemes

The following figure presents the development of Total generated hydropower energy in comparison with the thermal generated energy.



The Development of Total Generated Energy

***Figure T**he development of Total generated hydropower energy in comparison with the thermal generated energy.*

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Annex B-5, ***Table 11, and 12*** present the annual development of hydropower generated energy and the thermal energy.

e) Value of power generated

Annex B-5, ***Table 13*** presents the 1992 energy tariff structure.

f) Impact of low flows

The hydropower generated from AHD is affected by AHDL levels. However, the AHD operation roles depend only on Water demand DS AHD. All the hydropower station downstream AHD is affected by AHD releases.

4-3 Irrigation Schemes

a) Historical Overview

For thousands of years, irrigation in Egypt depended on the annual flow of the Nile. Perennial irrigation began on a significant scale after 1840's, when the irrigated area was gradually extended by a canal system. The Aswan High Dam presently ensures Egypt's annual quota of 55.5 billion cubic meters of water for irrigation and other purposes. The discharge of water from the Aswan High Dam is under full control. The release of water for irrigation is adjusted throughout the year to provide all agricultural areas with sufficient water for crop needs.

Till the beginning of 19^{the} century, direct irrigation system was adapted in Egypt. In this system water supplies are drawn under controlled conditions directly from the River Nile without any intervention of any storage work. After the construction of Old Aswan Dam in 1902, direct irrigation was practiced during flood time, while the annual storage of the dam has been used during low water levels in winter and spring. Since 1971, storage irrigation system is being used in Egypt in which stored water is drawn from the reservoir of the Aswan High Dam and supplied to the fields by the canal network.

The River Nile from AHD to Mediterranean Sea is shown in ***figure 13*** where the Location of the irrigation diversion at the Delta barrages, the Nile divides into two branches, The Rosetta branch to the west and the Damietta branch to the east. Both branches have barrages near their out-falls that are normally closed to prevent discharge to the Mediterranean Sea. A1l of the barrages on the Nile are equipped with navigation locks to serve the river traffic. During the winter months, when irrigation demands are low, extra water is needed in the Nile to maintain the draft required for navigation.

Distributary's canal cross sections are designed to serve command areas according to specified water duties. Misqas (Private canals) are served from distributary's canals which are on a two or three-turn rotation. The time interval between periods when water is turned off and when it is later turned on depends on the cropping patterns and seasonal climatic conditions. The on-day of a canal rotation is considered 24-hour periods (starting at sundown) without any adjustments between daytime and nighttime use. The number of on-days in a turn is sometimes modified to meet farmers' requests for more irrigation water.

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Good on-farm water management requires level fields, appropriately designed on-farm distribution systems, and knowledge of when to irrigate and how much water apply. Consequently, there must be close communication and interaction among all farmers served by a misqa and with the district irrigation engineer who regulates the water upstream from the misqa intakes. The potential for achieving benefits from better water management is substantial.

b) Irrigation Improvement

Actually, water is being a severe constraint to Egypt's economic development and food self-sufficiency. This will call in increasing the water use efficiency by improving irrigation management practice, as the agriculture sector is the main user of water resources. The irrigation improvement program is one of the large-scale projects to help Egypt in the 21st century in order to sustain its ambitious development plan.

To achieve the above-mentioned aims and objectives, the program uses the following physical and organization means: continuous flow, high-level mesqa, single point lifting, and demand irrigation advisory service. The government of Egypt is now committed to a long-term irrigation improvement program, which will continue for the next 15 years.

c) Locations and Features of existing Irrigation schemes

Annex B-6 ***Table 14& Table 15*** present the location and main features (mean monthly discharges- crops types on main canals) of irrigation schemes. However, these features are dynamic and depend on available water supply. During the dry years, crops that consume more water like rice and sugarcane are reduced to the minimum. While in the wet year and in the case that the live storage of AHD at its maximum in the beginning of the water year (i.e. July), the government permit additional areas for rice and sugarcane as a precaution method of AHD.

d) Diversion requirements for the schemes

Long term water budgets in Egypt are depending on two major strategies:

- The first is related to the management of existing available water resources.
- The second one is related to management of the new potential water resources in cooperation with other Nile River Basin countries.

One of the major challenges facing Egypt these days is the fixed Egypt annual water share by 1959 treaty with the Sudan which determines this share by 55.5 BCM per year. This share has not changed since the construction of the High Aswan Dam in 1968 in spite of the increasing population in Egypt. More over, the under going mega Projects such as South Valley and El-Salam Canal projects require more water demands to continue the economical development where those projects will open new fields and opportunities to convey the increase in population.

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The total area of irrigated land in the year 2000 was approximately 7.7 million feddans (3.25 million hectares) and expected to be 11 million feddans (4.6 million hectares) by the year 2017 due to horizontal expansion and the implementation of the two mega projects of El-Salam Canal at North Sinai and Tushka at south valley. Consequently, the agriculture demand is expected to increase from 53.9 to 63.6 BCM (next figure) taking into consideration the rising of irrigation efficiency by extending the irrigation improvement projects to cover most of the old lands, and applying modern irrigation techniques, e.g., Sprinkler and drip irrigation, in the new reclamation lands.

Figure shows development of Egypt water demand

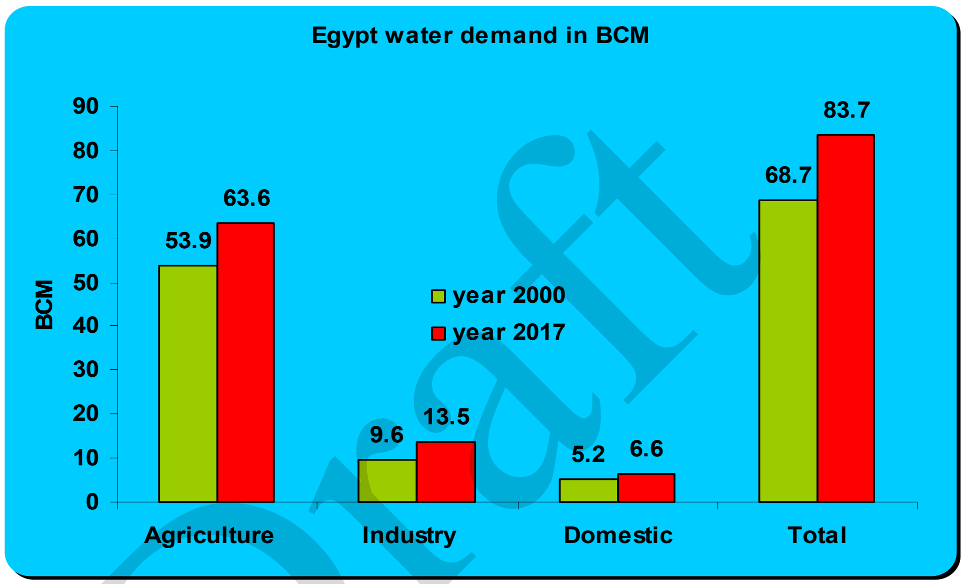

Figure 14 **Egypt Water Demand in BCM**

e) Flow variability and associated impact on irrigation schemes

AHD is designed and built to supply Egypt with its water demand all over the year. Therefore, flow variability has no impacts on irrigation schemes. However, in the case of severe drought like the one of 1980's, there will be a shortage of water and the irrigation schemes will be affected.

Annual agriculture planning in Egypt depend on the Egypt water share in the Nile waters which is safeguarded by the amount of water stored in AHDL in the wet years. Therefore, it is difficult to point the value of production lost due to water shortages.

Egypt is now applying very modern irrigation techniques, and applying modern agriculture methods and biological fertilization which increase the economic value of agro-products. Additionally, there are a lot of studies concerning marketing in different places in the world. The products are timely produced to have an economic value in export markets, which is also increase the products value of the additional irrigation water.

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4-4 Navigation

The inland waterway transport in Egypt is an important element in the development of tourism infrastructure, both in terms of navigation safety as well as economic growth due to:

- Waterway transport units are more efficient and economical than railways, airplanes and roads
- Waterway transport has the capability of transporting loads exceeding 30 m in length and 400 tones in weight.
- Waterway transport units can be built up locally in Egypt, thus a limited foreign currency investment is needed.
- Waterways transport requires less investment than other methods.
- Less energy and fuel consumption are needed to operate ship units.
- Low depreciation due to long life period for the waterway transport units.
- Clean and appropriate environmental conditions than other transportation.
- Cheapest method of transport especially for long distances.
- River transportation is a major tourism object in Egypt.

a) River reaches

The River Nile has a total length of about 1532 km inside Egypt, starting from Egypt-Sudan border in the south and ending at the Mediterranean Sea in the North. The Nile has played an important role since ancient times as a major navigational artery for transporting people and goods in Egypt. As most Egyptians have been living along the Nile, it is necessary to utilize it as navigational and recreational asset.

Lake Nasser provides a good opportunity for providing a navigable path between Egypt and Sudan in addition to tourist attractions. Downstream of AHD, the Nile flow is regulated and controlled maintaining enough water depths for navigation all over the year. Navigation and tourism in Lake Nasser and the River Nile downstream the dam has been considerably enhanced.

As with any Barrages built across a river, changes in river regime usually occur that might cause local navigational problems. AHD flattened the pre-dam peak flood discharges that occur in the summer period. Before the dam, navigation was very difficult and risky during the flood season due to high flood, intensive sediment movements and channel shifting. The dam has regulated the flow on the Nile so that the river channel is converging to a stable regime. This provides adequate conditions for a stable navigational channel within the Nile Annex A-4 ***figure 14*** show Schematic Network of Main Inland waterway.

Annex B-8 ***Table 17*** presents the main characteristics of the navigational river reaches.

***b**) Vessel size, type, and classification*

The total registered DWT (dead weight tonnage), according to the ships' licenses as issued by RTA is:

- 288 twin units fleet; total registered tonnage 99,043

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- 1643 units self propelled barges; total registered tonnage 185,622
- 473 rugs total horse power 50,922 HP; total registered tonnage 2,372

Annex B-8 ***Table 18*** presents vessel classification and dimensions, while ***Table 19*** presents type and number of the navigable units in the Nile (year 1995)

c) Navigation constrains

Navigation constraints mean that flowing water is not sufficient to maintain enough water depths for navigation. As a result, some locations along the river have water depths less than the permissible minimum depth for navigational units. Such locations are called bottlenecks. Many factors might create bottlenecks in rivers. These factors can be divided into categories related to hydrology, channel geometry, traffic, vessel specifications, weather, and human interference to rivers.

Bottlenecks often occur between bends where the river is shallow. The meandering channel is usually shifting and unstable causing some navigational problems. Construction of AHD caused drop in water levels, which badly affected navigation at the locks of the Nile barrages due to high apron levels of these locks.

In the reach below Aswan (approximately 40 Km) wind blown sands from the western desert deposit on the Nile bed causing navigational problems. MWRI has dealt with these bottlenecks by periodic dredging. Navigation can be made possible during the low flow season by using experienced pilots who follow a path along the deepest parts of the river.

NRI made an analysis of water depths in the Nile, based on water levels at the existing gauging stations for a discharge of 75 MCM/day. Between 16 to 18 bottlenecks were found along the river Nile reaches from Aswan to Cairo for released discharge at AHD less than 75 MCM/day.

Annex B-8 ***Table 19*** presents the location of navigation bottlenecks along the River Nile, while ***Table 20*** presents the navigation depth along the River Nile.

In the framework of cooperation between NRI the RTA, NRI is technically responsible for execution of required survey and solution procedure for any navigational bottleneck along the Nile. About 60 sites were surveyed and solution procedures and dredging amounts were computed for about 24 sites.

Recently, thirty sites in the reach between Asyut and Cairo were surveyed (NRI, 2002) within the agreement between the Pacific Consultants International “PCI” of Japan (engaged by Japan International Cooperation Agency “JICA”) and NRI. The main task of the study was to undertake the Development Study on Inland Waterway Transport System in Egypt

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4-5 Storage and Diversion Schemes

The annual flow of the Nile varies considerably from year to year and from one season to another. This variable supply may be short to meet the irrigation requirements, threatening the country with famine, as happened in year (1913/1914), when the annual supply did not exceed 42 BCM. On the other hand, the supply may be so high, exposing the country to destructive inundations, as happened in year (1878 / 1879), when the supply was 150 BCM. Regulation of the varying natural flow of the river to reasonable limits has been the major problem facing Egyptians since time immemorial.

The solution of this problem has been achieved in consecutive steps. Barrages have been constructed to bring the water to command levels. Later on, reservoirs of limited capacities had been built for annual storage i.e. to store part of the late flood waters to supplement the deficient supply of the following season. These reservoirs offered partial protection against dangers of high floods, but did not offer complete control of the Nile waters. The Nile's average annual discharge amounts to 84 BCM (1901 / 1902 – 1953 / 1954) out of which 52 BCM were used for irrigation purpose in Egypt and the Sudan. This means that in a normal year, the wasted amount that has been discharged into the Mediterranean Sea was as high as 32 BCM, a little over a third of the total average yearly supply.

The total annual "River Supply" varies from 42 to 150 BCM. The "natural river" during the summer months, ie. 1^{st} of February to end of June, varies from 5 to 26 BCM. The Ministry of Public Works, issued volume VII of the Nile Basin, in which the idea of over-year storage was fully studied and established on scientific basis.Thus, in order to safeguard against individual low years and a succession, of low years as well, over-year storage was found to be the best solution.

The following table (***Table 21***) presents the main features of AHD:

Major Features	**Water Levels *(m)***
Maximum level of the storage	182
Normal storage level (annual level before flood)	175
Minimum storage level	147
Mean storage level at which the capacity of the power station is calculated	168-170
Normal downstream level by Aswan Dam	108
Minimum downstream level by Aswan Dam	105
Variation of downstream level due to daily regulation from normal level	± 3
Minimum gross head at which the turbines generate the installed capacity	56-59

a) Storage Capacity

The following ***figure (15)*** represents the main storage characteristics of AHD. The capacity of the reservoir was divided into three parts:

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- Dead storage capacity.
- Live or working storage capacity.
- Flood control storage capacity.

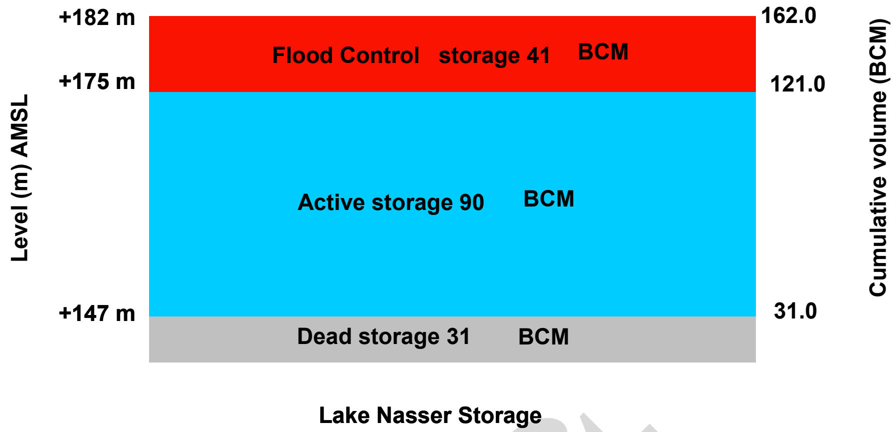

Figure 15 Lake Nasser Storage capacities

Dead Storage Capacity

The dead storage capacity is designed at 31 BCM to be used as a silt trap for about 500 years. The dead storage capacity occupied the range up to elevation 147-meter, which is the minimum design water level for operating the hydro-electric power station.

Optimum Size of the Live Storage Capacity

The average of the Nile discharge at the present century till the year 1959 (84 BCM), represents the guaranteed discharge. The necessary storage capacity was calculated to be 90 BCM. This live capacity falls in the range between elevation 147 & 175 m.

Flood Control Capacity

A flood control capacity of 41 BCM is designed to be contained between elevations 175 m and 182 m. It is estimated to receive and store the water of high flood years. The upstream level should be kept at elevation 175 m before the arrival of the next flood i.e. at the beginning of August.

For protecting the Nile course downstream Aswan against unfavorable degradation due to released aggressive discharges, Tushka spillway was executed in 1982 which added extra 120 MCM/day to the flood control capacity.

Annex B-9 ***Table 22***, and ***Figure*** 14 present AHDL level-area-content. The data are checked and used for dam operations.

Annex B-10 ***Table 23*** presents reservoir water levels for a typical dry year of 1984-1985 for the study period 1980-2000, whereas, ***Table 24*** presents reservoir water level for a typical wet year of 1999-2000 for the same study period.

b) Major off-take (diversion) infrastructure and their main features

The only proposed off-take diversion of AHD is Tushka spillway. The capacity of the channel is designed to carry 120 MCM/day. However, after the successive of high floods of 1998-2001, the channel capacity is redesigned to carry 250 MCM/day. Channel Inlet regulator is also proposed to have full control of Tushka spillway channel.

c) Other diversion schemes

For full control of the river networks, several regulators and barrages are in operation. The barrages control the water supply distribution to the farmers through very sophisticated irrigation engineering systems. A telemetry system have been developed and used in early 1990's for water distribution management. Canals discharges are measured and calibrated with the upstream and downstream levels of the barrages for full automated control of barrages and flows in the canals.

See Aannex B-7 ***Table 15*** presents the average monthly discharges of the main canals in Egypt for the period 1980-2000.

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5- WATER RESOURCES OPPORTUNITIES

5-1 Hydropower Potentials

It is seen that the main water control structures across the Nile in Egypt have been utilized satisfactory for power generation. However, there are still some barrages and many other small to medium hydraulic structures which can be used for the same purpose. Mini hydropower generation constitutes a readily accessible source of renewable energy.

a) The Planned Hydropower plants on the Nile Barrages:

Some preliminary studies have been conducted to identify the need and location for hydropower development for intermediate barrages on the River Nile. Some sites have been identified, but it was decided to rehabilitate or replace the existing barrages at Nag Hammadi, Asyut and Damietta with add on hydropower.

- A study was done by the HYDROPROJECT, MOSCOW in 1977 for the power utilization of Nag Hammadi and Asyut Barrages. The results of the study proved the economic profitability of increment of the installed capacity at the above hydroelectric stations with the normal headwater level to the following limits:
  - Nag Hammadi up to 52.5 MW
  - Asyut up to 48 MW
- A study was conducted by the Swedish commission for Technical Cooperation (SWECO) in cooperation with the Reservoirs and Ground Barrages sector, MWRI, during the period 1982-1986. The study covered five sites that seemed promising for power production. They are the barrages at Damietta, Rosseta, Zifta and Dairout drain in addition to the head regulator at the Nassery canal.

Annex B-11 ***Table 25*** shows the potential sites suitable for medium hydropower generation as planned by the Hydropower Plant Authority in cooperation with the MWRI.

b) Possible Sites for Mini-Hydropower Installation:

Mini Hydropower refers to installations of units having a capacity ranging between 100 and 1500 KW. Several studies have been conducted to investigate mini-hydropower potentials as follows:

1. Annex B-11 ***Table 26*** presents available Flows, Head and Power at the Proposed Sites of the proposed Sites of Power generation at El-Faiyum.
2. An inventory of possible sites for hydroelectric mini-power development in a study of SWECO is shown in Annex B-11 ***Table 27***
3. Twenty eight hydraulic structures were investigated. Eleven sites were found to be most promising for hydropower development. The results are shown in Annex B-11 ***Table 28***.
4. The main goal of the work was to evaluate the potential for hydropower generation using mini stations along the existing irrigation system. 46 sites were considered in the study. It was found that the utilization of these sites for power generation will be possible.

5-2 Irrigation Potentials

The aim of the horizontal expansion in Egypt is to add around 4.6 million feddans by the year 2017 to be added to the current irrigated land which is estimated in year 2000 by approximately 7.7 million feddans (3.25 million hectares). This will be done through the implementation of the two mega

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projects of El-Salam Canal at North Sinai and Tushka at south valley. Consequently, the agriculture demand is expected to increase from 53.9 to 63.6 BCM taking into consideration the rising of irrigation efficiency by extending the irrigation improvement projects to cover most of the old lands, reuse of drainage and waste water, rainfall harvesting, and applying modern irrigation techniques, e.g., Sprinkler and drip irrigation, in the new reclamation lands.

☒ ***SOUTH EGYPT DEVELOPMENT PROJECT:*** The high density of population in the Nile Valley and Delta made the expansion and redeployment of Egyptian communities a necessity. Delay in spreading out this density on a wider space of land could in the future lead to national catastrophes. Tushka Project is a strategic vision covering activities in the field of agriculture, industry, transport, communication and roads, as well as social aspects and services. The new communities to be set up in South Egypt will not be merely urban communities that activate the civil sector, but shall be projects that absorb part of excessive employment and held overcome the problem of unemployment.

The Tushka project area occupies a large part of Egypt's desert whose vegetation and animal wealth can be utilized in many pharmaceutical industries. ***Map 8 s***hows layout of the project including Sheikh Zayed main canal.

Objectives of the Project

- Establishment of agricultural and industrial communities based on the exploitation of the agricultural raw material available in this new land.
- Establishment of new expected communities to attract work force, hence gradually alleviating the problem of overpopulation in the old valley.
- Establishment of a network of main and side roads in accordance with the development objectives and plans.
- Promotion of tourist activities in such regions rich in ancient monuments.

Arable Land and Water Requirements:

Several studies were made on the project land to classify the soil in the vast west desert areas. The lands in the area were classified according to their possible degree of reclamation and the specifications of the Food and Agriculture Organization (FAO).

The proposed cropping pattern includes kinds of fruits, which would have a priority due to the climate conditions such as palm trees, mango, papaya, leecci, supodela and banana. It is also possible to grow medicinal and aroma herbs that grow naturally in the area such as sanamchi, hisbiscus, tamarind and cactus. Moreover experts confirmed the possibility of cultivating certain kinds of timber trees and bamboo. Due to the specific climate, the region is suitable for cultivation of some kinds of citrus plants, and olives. Vegetable crops are appropriate such as tomato, string beans, cucumber, okra, potato, onion and sweet potato.

The annual water requirements for the project area depend on the water demands for agricultural, domestic and industrial uses.

The annual water demand for each feddan within the area is estimated to be within the range of 8000 to 11000 m^3, including leaching requirement. This

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amount depends on the kind of crop, soil, and irrigation method. Total annual water requirements for the project area is estimated at about 5 BCM, considering a cultivated area of 540,000 feddans, along with all other activities of industry, mining, commerce, tourism and domestic uses.

Key Elements of the Project

Sheikh Zayed main canal is the corner stone of the project ***(Map 8***). It is 70-Km long and is designed to convey water to the following:

- 1st branch canal is 42 km long serving an area of 120,000 feddans.
- 2nd branch canal is 35 km long serving an area of 120,000 feddans.
- 3rd branch canal is 20 km long serving an area of 100,000 feddans.
- 4th branch canal is 60 km long serving an area of 200,000 feddans.

The main canal is lined to prevent water leakage. It has a bed width of 30 m, water depth of 6 m, one meter free board. The upper width is 54 m with platforms on the two sides 8 m wide, and 20 m-wide banks. The cross section of the main canal is designed for a daily discharge of 25 MCM of water during the peak demand period (July & August), and 8 MCM during the low demand period (December & January).

The main canal starts with a major pumping station on the left bank of Lake Nasser 8 km north of Khor Tushka. The station is designed to have a maximum static lifting of about 52.5m to guarantee operation for the lowest water level of storage in Lake Nasser. 21 pumps, each with a discharge capacity of 16.7 CMPS, will be housed inside the pumping station, 18 units of which will be on duty while the rest will be standby.

☒ ***West Delta Project in Egypt:*** The Government of Egypt has the policy to intensify the cropping pattern in the old irrigated lands of the Nile Valley and Delta (vertical expansion), and to expand irrigated agriculture on new land in several oasis, the fringes of the Nile Valley, and on the desert plains west and east of the delta (horizontal expansion). ***Map 9, 10*** show the proposed West Delta Project.

The required water for this newly irrigated land has to come from:

- more efficient use of irrigation water in the old lands, including reuse of drainage water;
- a bigger share of the Nile water available that could be made available by implementation of the proposed water conservation projects; and
- Development of groundwater for irrigation.

Agriculture on the west desert plains started to developed in 1989 on basis of groundwater pumping for irrigation. After less than 20 years of pumping it is now clear that the existing practice is unsustainable.

In order to reverse the situation of rapidly decreasing water tables and deteriorating groundwater quality in the West Delta project area, the Government is seeking to achieve full cost recovery and to identify practical

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ways of involving the private sector in the design, operation and even financing of new surface[1] water for irrigation systems.

The Government has identified an initial area involving 255,000 feddans in the West Delta for investment under this new philosophy of full cost recovery.

The conceptual study defines the following:

- Pumping of 1.6 BCM per year from Rosetta branch into Nasseri Rayah and from three sites along this canal into the project area.
- The construction of the water conveyance infrastructure, (open canals or closed conduits).
- Distribution of the surface water to individual farms or blocks of farms with a total area not less than 100 feddans.

Total concession Nile water is 1.6 BCM. The net cultivable area is: 1.6 BCM/6275m^3/fed = 255,000 fed.

The canal capacities were calculated for the average required flow to meet 3.2 mm/day water supply. This corresponds with 40m^3/sec. This procedure leads to the most cost-effective design. The maximum capacity however is based on a maximum net supply of 4.5mm/day.

☒ ***El-Salam Canal:*** It is necessary to have an integrated vision that connects between east of Suez Canal, Sinai, and west of Suez Canal regarding the development projects. Bearing in mind that this transported water must not be taken at the expense of any other lands in Delta or Valley. Therefore, the main philosophy of using water resources of marginal quality, i.e. agricultural drainage water, as a base for the main water supply to the canal and mixing it with Nile Water.

The canal's intake was constructed at km 219 on the Damietta Branch in front of Damietta Dam. ***Map 11*** shows layout of the project.

The Canal will serve an area of 620,000 feddans of which 220,000 feddans at the west of Suez Canal representing the first stage, while the second stage serves an area of 400,000 feddans east of Suez Canal. The volume of water needed to serve the two phases is about 4.45 BCM of which 2.11 BCM from the Nile and 2.34 BCM from El-Serw and Hadus Drains.

The average salinity of the water is:

- 300 ppm for Nile water
- 900 – 1900 ppm for El. Serw drainage water
- 1150-1800 ppm for Hadus drainage water

After blending the general average salinity ranges from 700 to 825 ppm.

The proposed crop pattern, in percent of the total area: farm crops 37%; pasture crops 22%; fruits 15%; vegetables; 14%; olives 6%; oily crops 6%.

The following earth and civil works were completed in 1995:

- Total earth works of 58 MCM.

[1] Net cultivable land area estimated of 255,000, of which gross area is estimated between 289,000 and 291,000, depending on source.

- A head regulator of El-Salaam Canal at km 219 of Damietta Branch to pass 12 million CMPD.
- Construction of the canal with a length of 87 km from its head at Damietta Branch to Suez Canal.
- Three main pumping stations.
- 22 head regulators to control water released to the branches of El-Salaam Canal.
- Twelve syphons and 17 bridges at the crossings of water ways and road ways with El-Salaam Canal.

The second stage of El-Salaam Canal:
The second stage of El-Salaam Canal, called El-Sheikh Gaber El-Sabah, serves 400,000 feddans and extends in the area of north Sinai and Wadi El-Arish. The area served is divided into five regions: Tina Plain area, South Eastern Kantara area, Rabaa area, Bier El Abd and El Ser and El Kawareer

The main components of the second phase of the project are:
- The syphon at km 127.8 below Suez Canal, south of Port Said.
- Four main pumping stations along El Sheikh Gaber Canal.
- Four head regulators at km 14.7, 34.5, 85.7 and 73

Brief Description of El Sheikh Gaber El Sabbah Canal
- It extends for 175 Km downstream the syphon east of Suez Canal until its end west of Al Arish Valley (south of Al Arish city).
- Some parts of the canal and its subsidiaries are lined.
- The canal is aiming at reclamation of lands of sedimentary formation from ancient Nile branches (east of the old delta).
- The water level of canals in Tina plain is designed to be at least 0.5 m AMSL.

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6- MAJOR ISSUES IN WATER RESOURCES DEVELOPMENT AND MANAGEMENT IN THE EASTERN NILE

6-1 Floods, Droughts, and Sea Intrusion

The incidents of high floods have been one of the most destructive hazards facing the people of Egypt. Since the earliest times, Egyptians have been subject to the dangers of the Nile during high floods especially at the peaks.

Great disasters in the second half of the 19th century, involving the losses of thousands of lives, happened because of the breaches of the protection embankments, intervening between annual floods and the low land behind. These embankments were erected long time ago on both sides and along the whole length of the River between Aswan and the Sea, a distance nearly about 1100 Kilometers. The people lived under the protection of embankments, which act as a barrier for protection of crops and human settlements from inundation.

Efforts to control the river Nile date back well to the 19th century. The first half of the 20th century witnessed tremendous efforts to lessen the threat of high floods. Aswan Reservoir, completed in 1902 and heightened twice in 1912 and 1933, was also used as a flood escape by holding up some flood water in the reservoir, which could help in reducing the flood by, about 100 MCM/day for a month duration.

AHD, completed in 1968, is considered the major project and the main link of a series of projects for Nile control and development of its water resources. For first time in history of Egypt, the gigantic floods of 1975, 1988, 1998 and 1999 did not bring any kind of damage or harm to the country.

AHD is considered the latest, but not the last, link of a series of projects constructed on the Nile River for flood management. A total volume of about 41 BCM of the reservoir capacity is effective for full protection against floods. The high floods of 1964, 1975, 1998, and 1999 caused no losses to Egypt. The Nile has been tamed in Egypt, and practically there will be no more floods, which means that troubles of floods have virtually come to an end.

a) Major floods and damage assessment

Usually, floods attaining the level of 20.05 m at Roda gauge (Cairo) caused disastrous inundations. There are only 14 years with annual discharge exceeding 100 BCM during the 20th century compared to 19 years in the last three decades of the 19th century. The breaches that occurred in 1861, 1863, 1868, 1874, and 1878 on the Damietta branch and that of 1863 on the Rosetta branch, when the whole western half of the Delta was swept by the river. Canals there had no enough high banks, people had no place of shelter to flee and they drowned in great numbers. When the maximum level at Aswan and Roda was above 93.00 and 20.05 m respectively, there would be floods, inundation, and destruction. It was not only harmful to agriculture but also to the health of the country, by the long continued seepage and stagnant pools behind the Nile banks. Annex B-12 ***Tables 29 and 30*** gives the maximum-recorded levels for high years at Aswan and Roda (above 93.00 and 20.05 m) and their duration.

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The 1946 flood was extremely high. The maximum level at Aswan reached on 8, 12 September 1946 (93.6 m). The highest level at Roda was 20.34 m on 11, 12 September 1946 and the duration above that level was 36 day. The maximum 5 days measured quantity of water flowing at the peak of flood was 777 MCM/day. During the flood the Minister of irrigation, took up his quarters at the barrage along with his staff, and from there he was able to estimate the position and move quickly to any threatened point. Engineers and tens of thousands workers all over the country traveling day and night, along the Nile banks to protect its banks using different facilities and equipments. Although Aswan Reservoir was used to hold back floodwater and reduce the high peak of flood, flooding of about 70,000 feddans on the shores and island lands had occurred. Two sites at Khatatba and Beni Salaama on the Rosetta branch were breached.

The Nile flood in 1964 was a very high one. The maximum 5-day observed discharge reached 780 MCM/day. For the first time in the history of Egypt, the 1964 flood did not bring any damage or harm to the country because of the construction of the 1st stage of AHD. During the flood the water level upstream AHD was raised up to 127.64m. The volume of water accumulated during 1964 was 9 BCM, which is 1.8 times of the old Dam Reservoir. The Nile levels at Roda gauge reached their maximum, amounting to 20.47 m, on 16-21 September 1964, which the country could withstand.

Gigantic floods of 1975, 1988, and 1998 had natural annual flow at Aswan 101, 108 and 127 BCM, respectively, caused no harmful effects. AHD provided a full protection against floods in Egypt. (Annex B-13 ***Table 31***) shows that some of Historical Flooding Damages on the Nile Valley, where (Annex B-14 ***Table 32)*** presents list of Torrents for the River Nile from (Aswan to Cairo). ***Map 12*** shows Torrents for the River Nile from Aswan to Cairo.

However due to the successive floods in the period 1998-2001, the capacity of AHD reached its maximum exceeding 181.6 meter Level. Intensive studies have been done to protect AHD from danger. A discharge of 270 MCM was to be released from AHD that cased some problems in DS areas which includes scouring at regulators and bridges, flooding of some populated islands, flooding of some cultivated areas near to the river.

b) Droughts

In Egypt, drought is believed to have exited at one time or another for time immemorial, and certainly was known to be experienced during the Pharaohnic era. That was the time, according to written religious records. Now food preservation and storage is a matter of great strategic importance. Every nation is doing her best to have strategic food stock as a protective measure against events like drought.

Since time immemorial the people of Egypt have been subject to the danger of drought due to very low levels of the Blue Nile and Atbara. Though many droughts and famine years hit Egypt, the historians were only interested to describe the impact of the worst two droughts occurred in (1067-1072) and (1199-1202). The (1067-1072) drought was very severe. The (1199-1202) drought was also referred to as “the years of starvation” and was due to the very low Nile levels. About 2/3 of the population perished. Thousands of

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people starved to death and immigrated to Yemen, Hijaz and Morocco in search of live hood, and problem of hygiene.

The beginning of the 20th century witnessed a prolonged drought following the years 1913/1914 and around the years 1940-1942. The years 1972 /1973 were dry and that period (1979/1980- 1987- 1988) coincided with the drought in the Sahel that extended to Ethiopia and the Sudan.

In 1913/ 1914, Egypt suffered one of its worst drought in recorded history (since 1695). The natural yield of the river at Aswan was 42 BCM. The available storage water plus the natural summer flow were too small to fulfill the irrigation requirements at that time. The area under basin irrigation (1.225 million feddans) was scarcely irrigated. This was real harm to cereals agriculture and badly affected the crops. Had not the heightening of Aswan Dam occurred in 1912, the disaster would have been greater.

The 1972/ 1973 flood was very low. Has it not been for the existence of AHD, by then fully-established, land would have been barren and poverty and drought would have prevailed. Next table presents a comparison between summer yield and actual water requirements in this period.

Table 33 Comparison between Summer Yield and Actual Water Requirements in 1972/1973

Month	**Total Natural Yield BCM**	**Water Requirements BCM**
February	1.72	3.7
March	1.52	4.0
April	2.00	3.8
May	2.52	4.9
June	2.44	6.4
July	3.47	6.8
Total	**13.67**	**29.6**

If this yield is added to what the annual storage reservoirs (Aswan and Gebel Aulia Reservoirs) would have provided, amounting 7.5 BCM the total summer water available would have been approximately 21.2 BCM. This amount is 8.4 BCM less than the actual requirements during this period; a fact could have the following losses:

- Reduction of the rice planted area from 1.143 million feddan to only 200,000 feddans.
- Complete incapability of meeting the water requirements needed to plant about 700,000 feddans of millet, which would have caused the area to become fallow.
- Assuming the AHD was not built, and basin irrigation continued, the river during 1972/ 1973 flood season would not have reached sufficient levels to submerge a large part of the basin between Nag Hammadi and Asyut barrages. This is due to the fact that the levels required for basin irrigation in this reach, need a discharge of at least 750-million m3/ day at Aswan and a period of not less than 10 days, requirements which the 1972 flood was not able to fulfill.

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c) Sea Water Intrusion

Egypt has a relatively long coast line, including:

- more than 950 km along the Mediterranean sea in the north;
- 200 km along the Gulf of Aqaba;
- 400 km along the Gulf of Suez; and
- 1200 km along the Red Sea in the east.

The coastal area of the Nile Delta is one of the most populated regions in Egypt and is still attracting more population and a variety of development activities. One of the major constraints facing the developments is the effect of sea level rise on the Nile Delta Aquifer system.

The Nile Delta comprises the most important coast lowland along the Mediterranean Sea. It covers an area of about 22000 km2. There is possibility of hydraulic contact between the Nile Delta aquifer system and underlying the formations directly by embedded faults. The fresh groundwater thickness increases with time, most probably due to the increasing surface water diversions and also as an effect of the construction of the Aswan High Dam.

The Nile branches and the main canals act as drains, also the increasing amount of the groundwater seeps to the drainage network. High water table at that South of the Delta causes many problems to buildings, increases the amount seeps to sewage systems. Observations indicated that the artisan pressure exists at some locations and not everywhere in the northern part of the Delta. Also, it has been observed that the salinity increases with depth at most of locations observed.

The impact of the geological evolution on both the development of the salinity distribution of the transition zone of the Nile Delta and its behavior under different pumping schemes has not been covered yet. The movement of seawater intrusion (at present) is a natural response to geological change in past times. The most representative area for the Nile Delta is the Northern part of the Nile Delta. It is affected by high land subsidence and a severe shore line retreat.

Previous studies predicted that relative rise in sea level on the Mediterranean Coast could lead to increased flooding and saltwater intrusion. The current simulation of the compaction phenomena has provided understandable view about the saline water near the base of the Nile Delta aquifer within the fresh water part at south of Delta as a geologic evolution is the main sources of the salt in groundwater aquifer system.

Also, it is interesting to know that the calculation shows that the drainage water used to collect more than 2.0 BCM/year for the sea water intrusion to get them back with the drainage water to the sea.

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Annex A

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Map No: (1) shows Lake Nasser (AHD Lake)

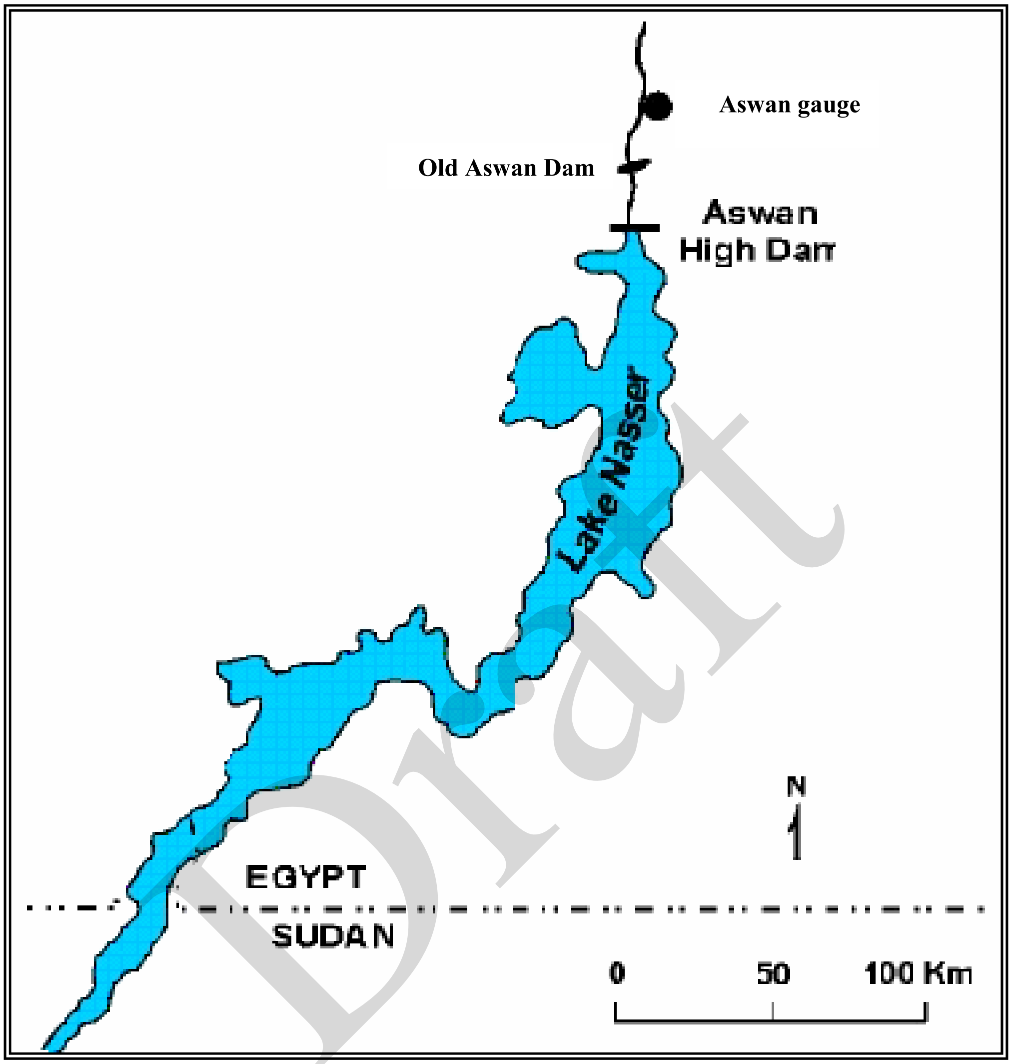

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FIG NO: (1) shows The Shallow Navigation Bottlenecks according to TRA

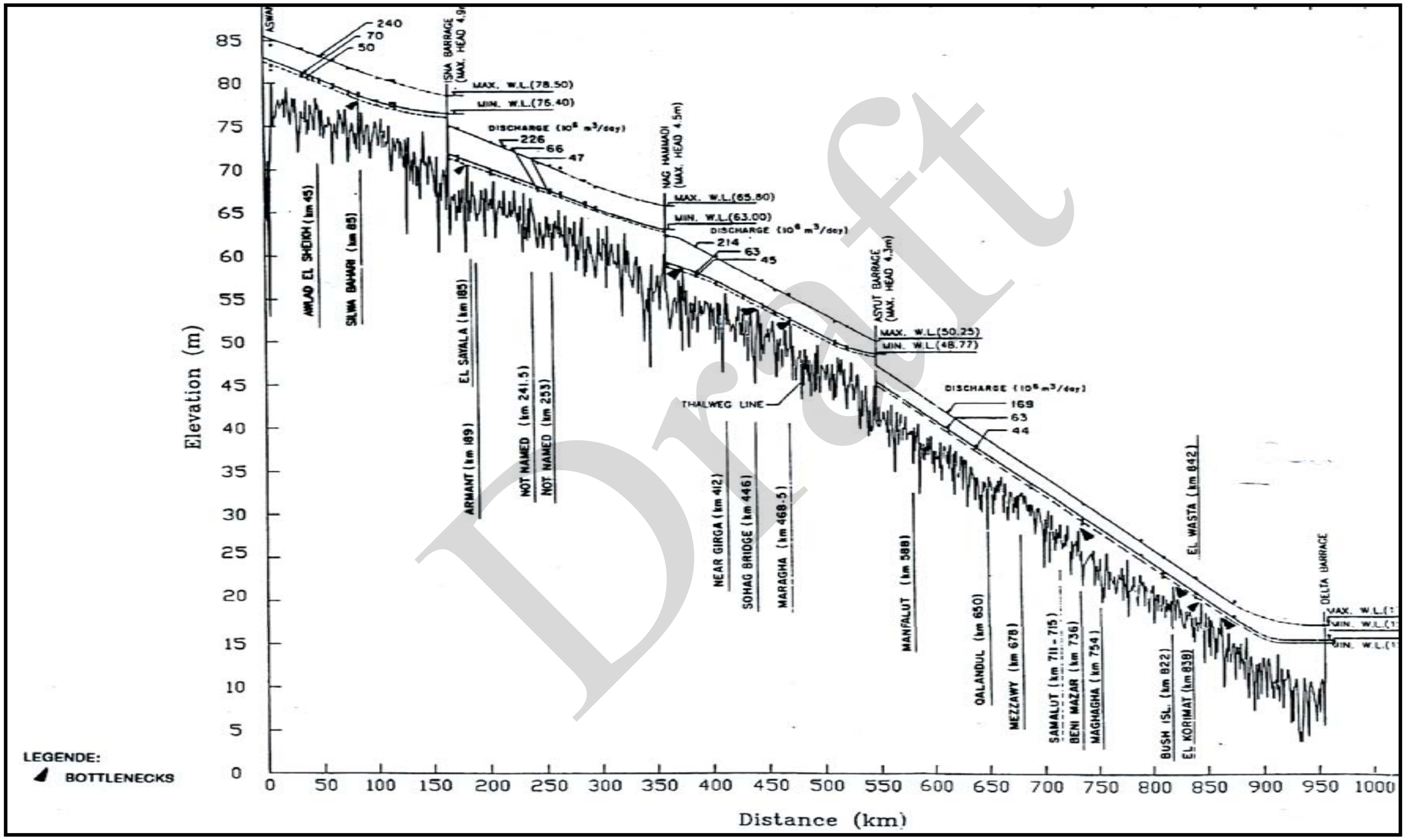

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FIG NO: (2) Shows the River Nile Level Profiles For High and Low Flows

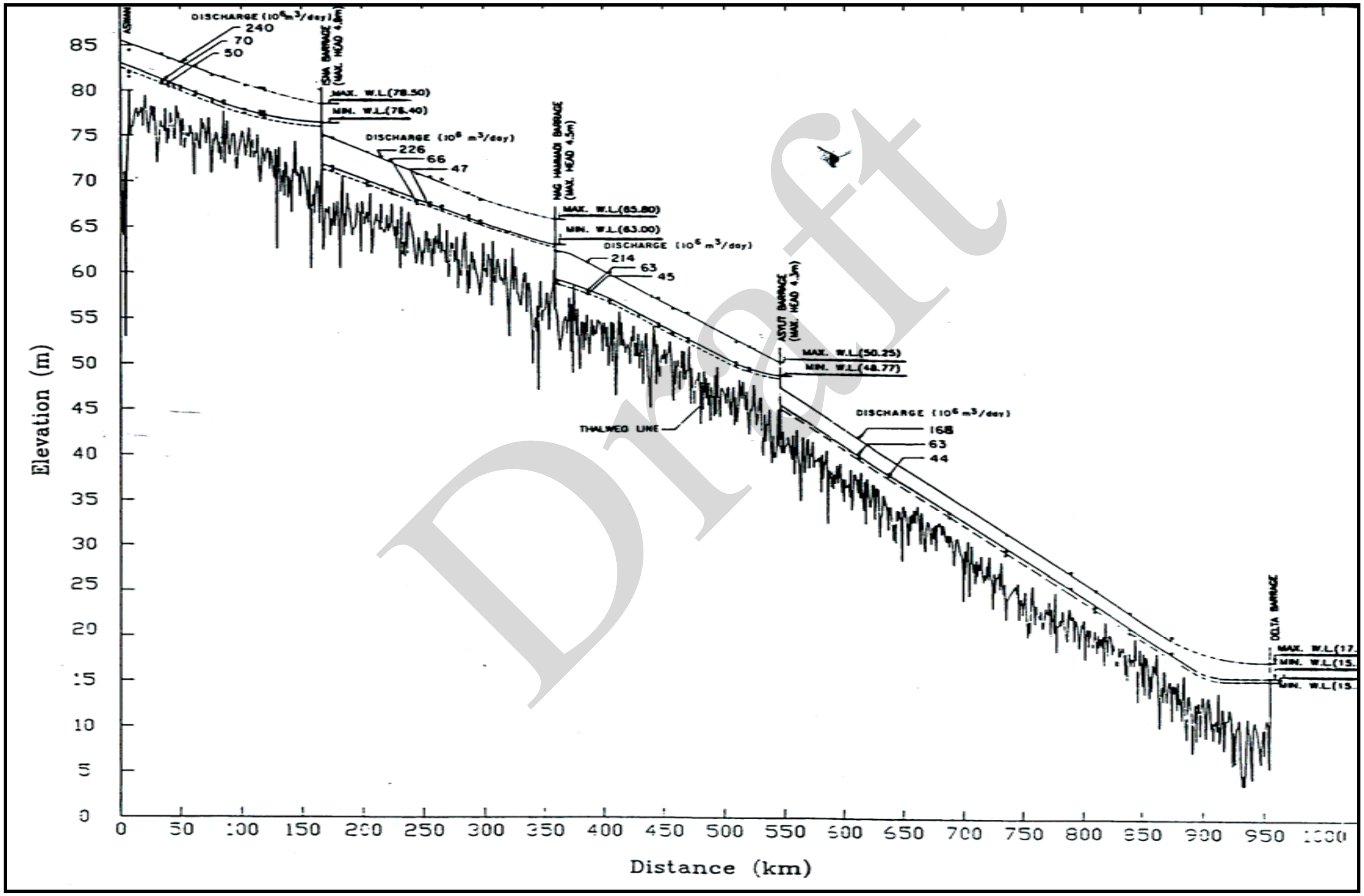

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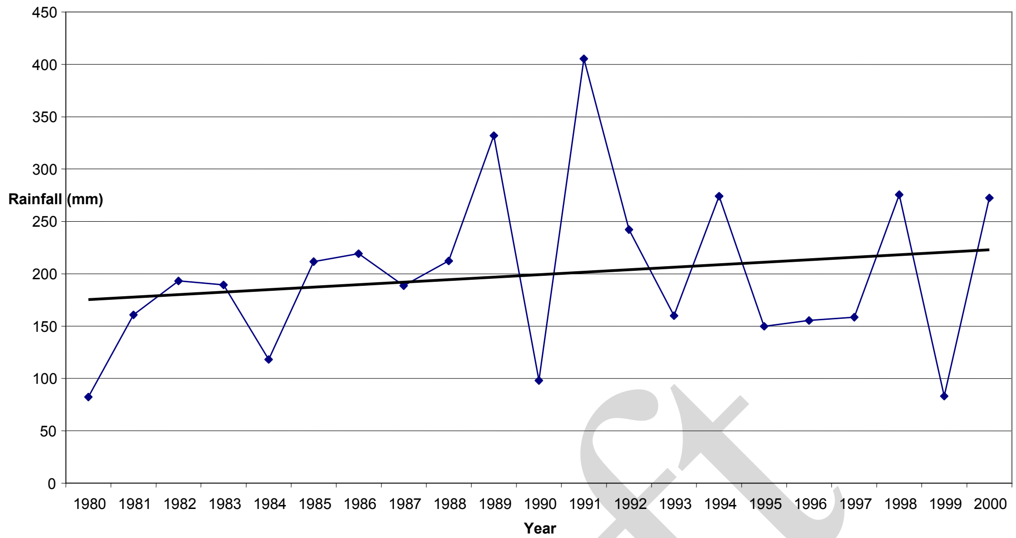
Fig (3) Rainfall Trend for

Alexandria Station



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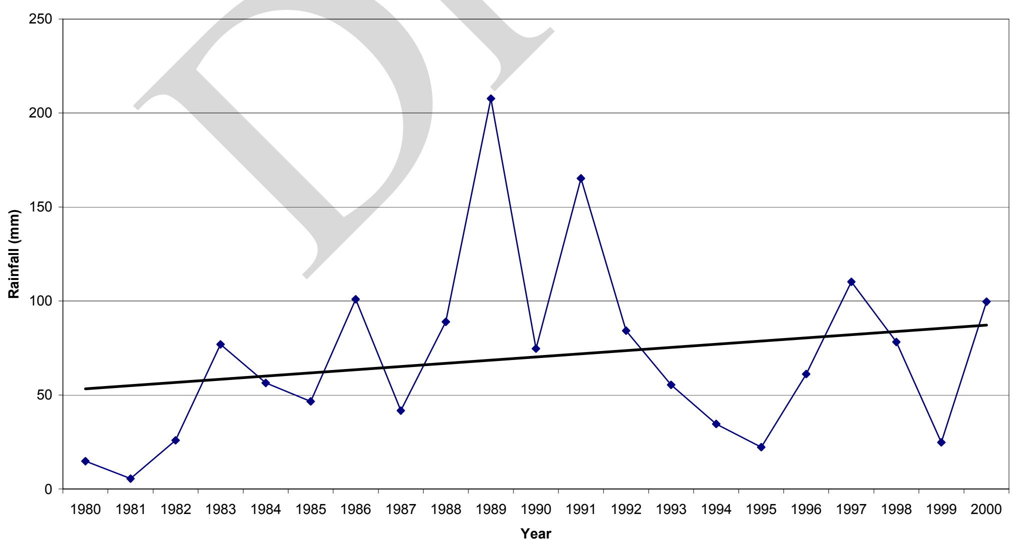
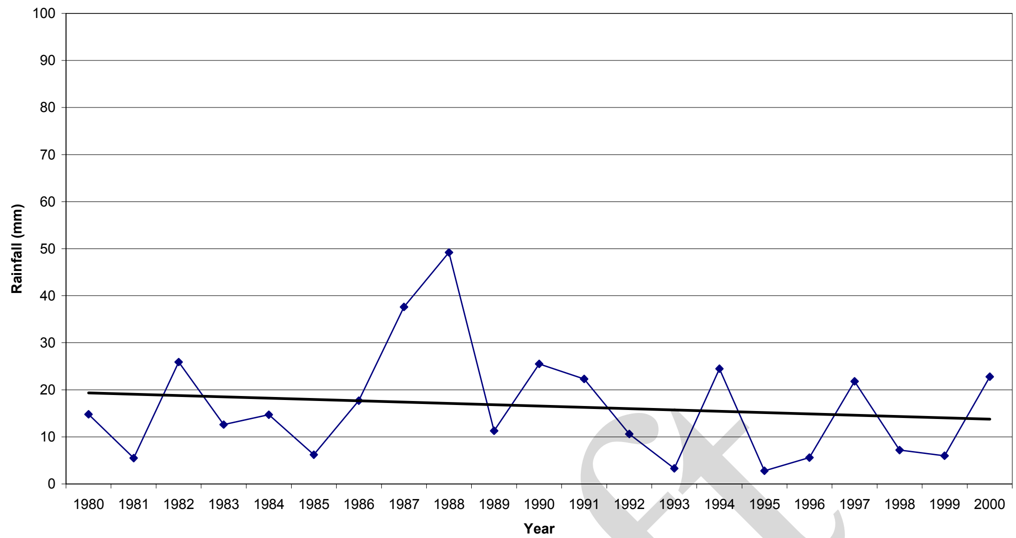
Rainfall Trend for Port Said Station



Rainfall Trend For Cairo Station



Rainfall Trend For Aswan Station

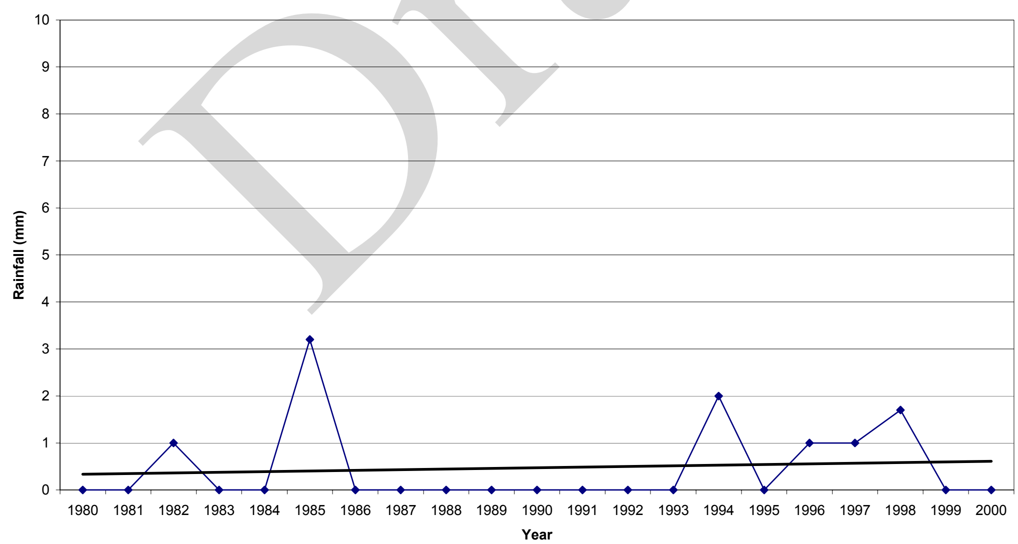


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FIG No: (6) shows The Schematic location of diversion and canals for West Delta

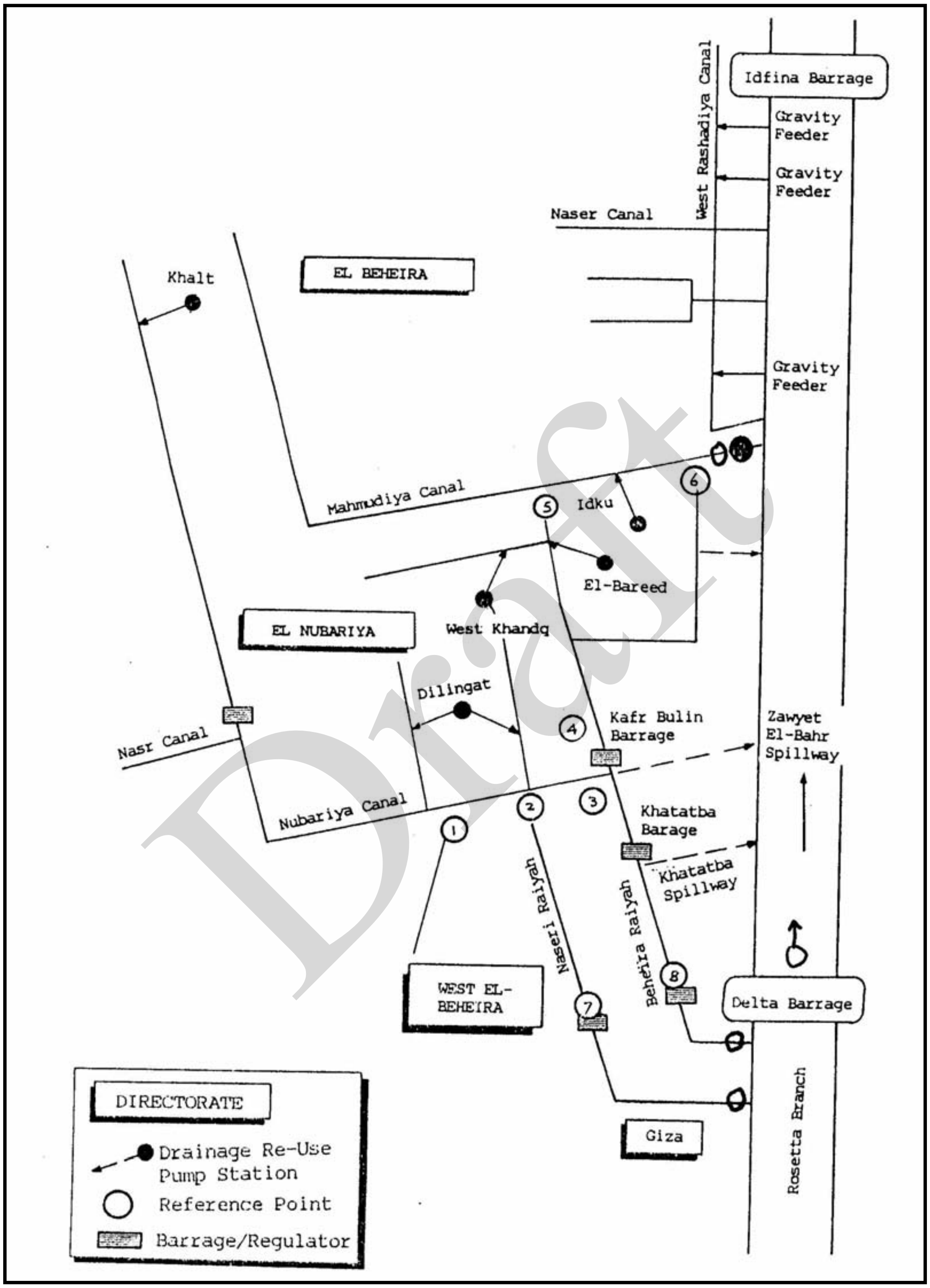

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FIG No: (7) shows The Schematic location of diversions and canals for Middle Delta

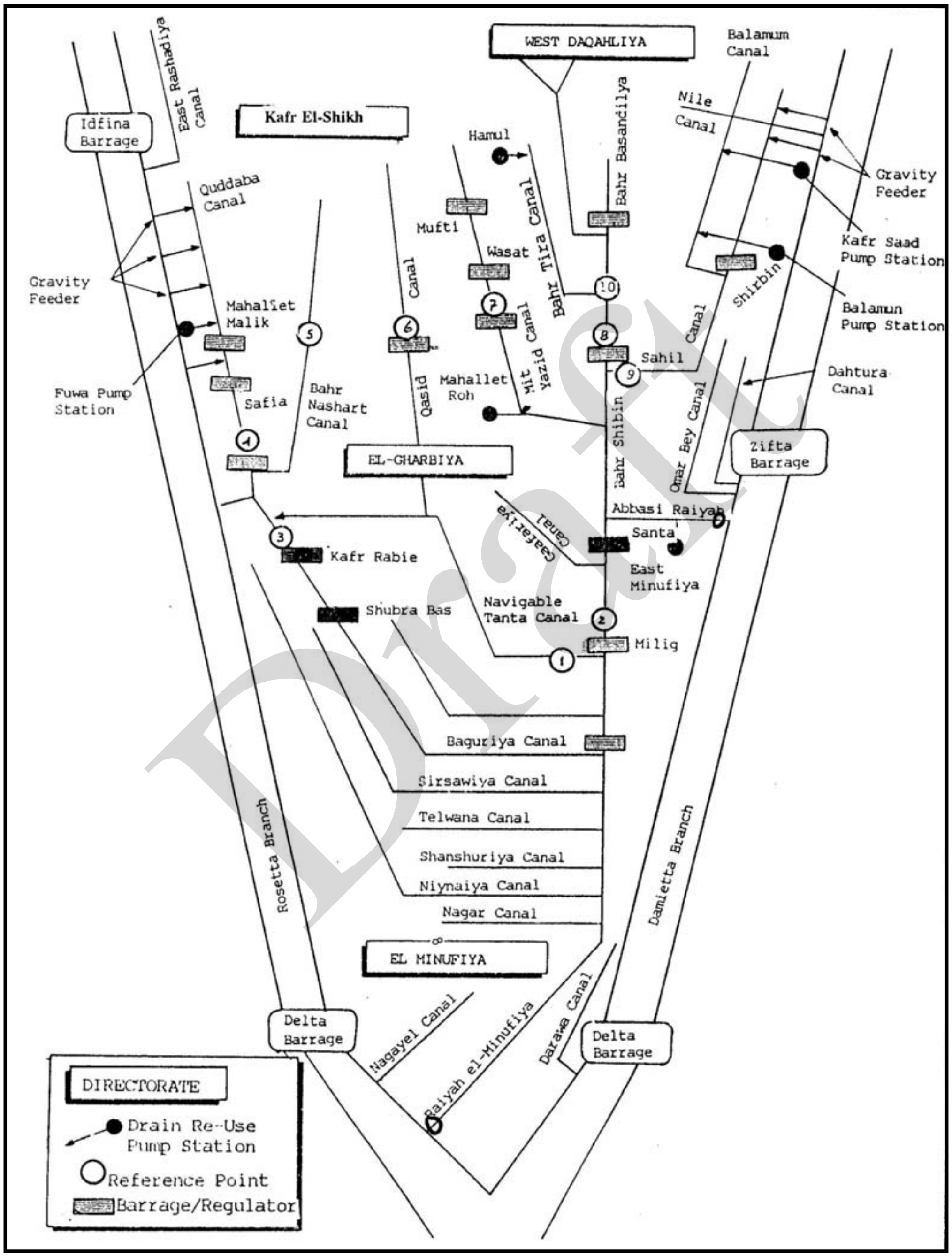

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FIG No: (8) shows The Schematic location of diversions and canals for East Delta

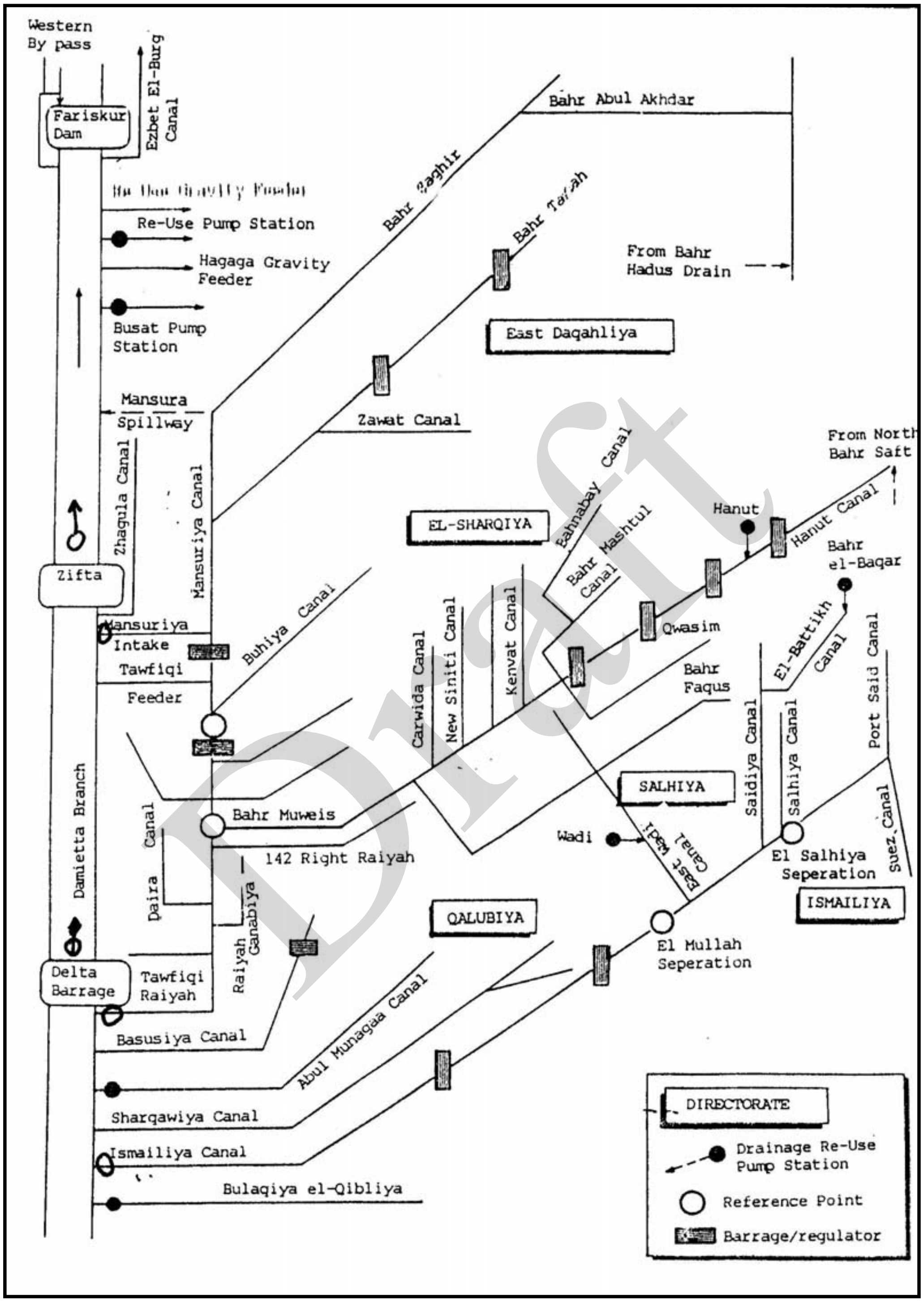

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FIG No: (9) shows The Schematic location of diversions and canals between Asyut and Delta

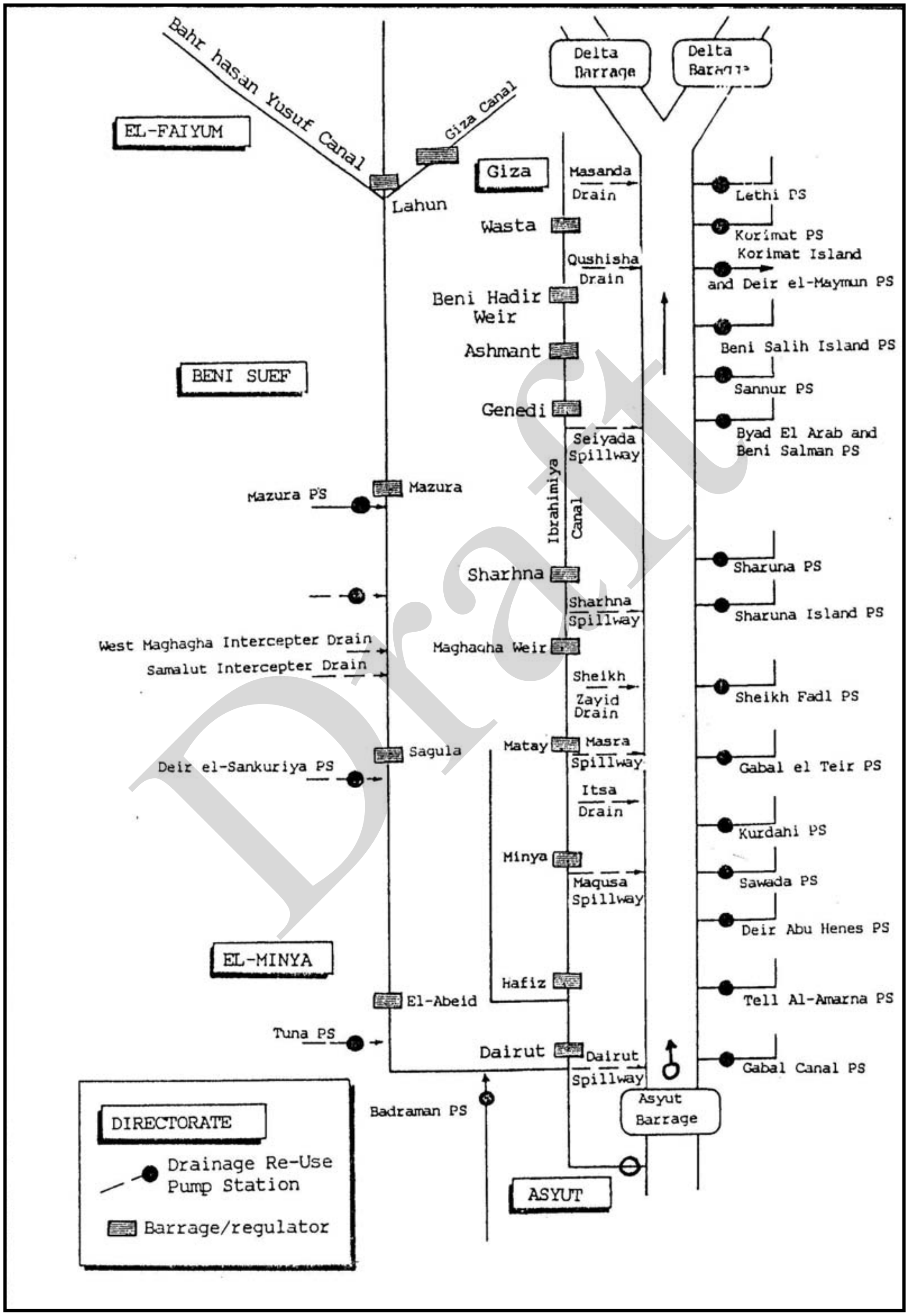

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FIG No: (10) shows The Schematic location of diversions and canals between Nag Hamadi and Asyut

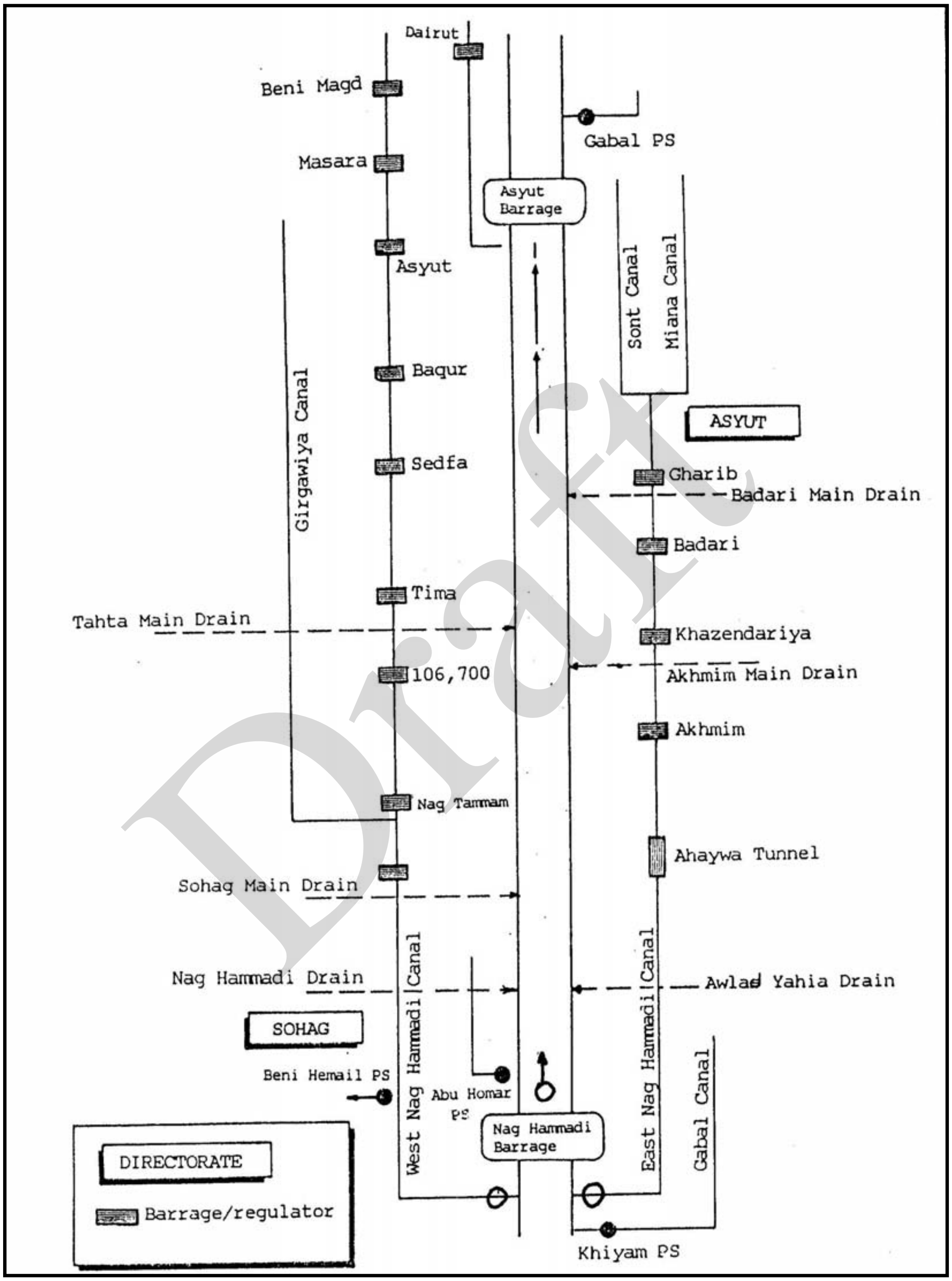

FIG No: (11) shows The Schematic location of diversions and canals between Isna and Nag Hamadi

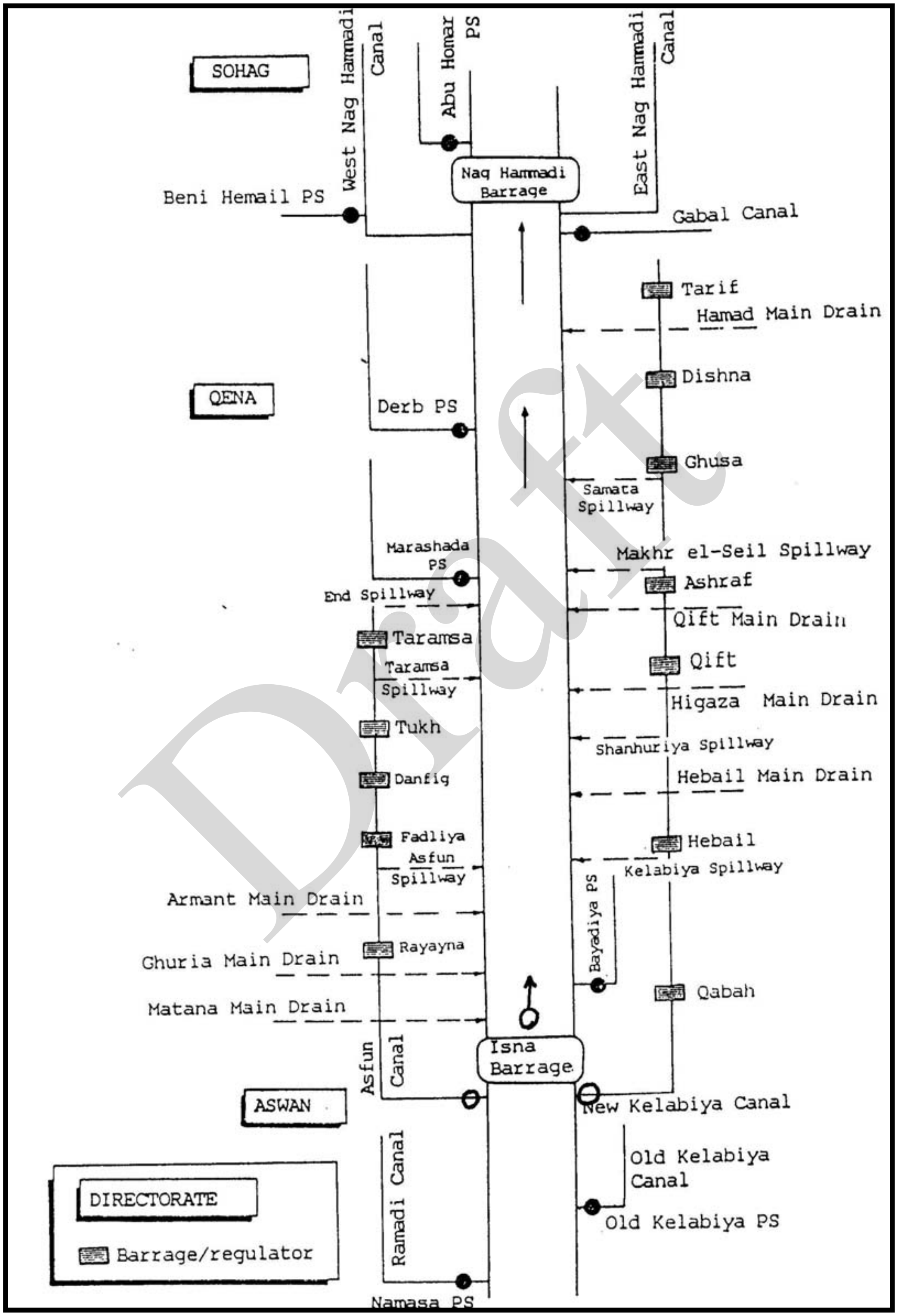

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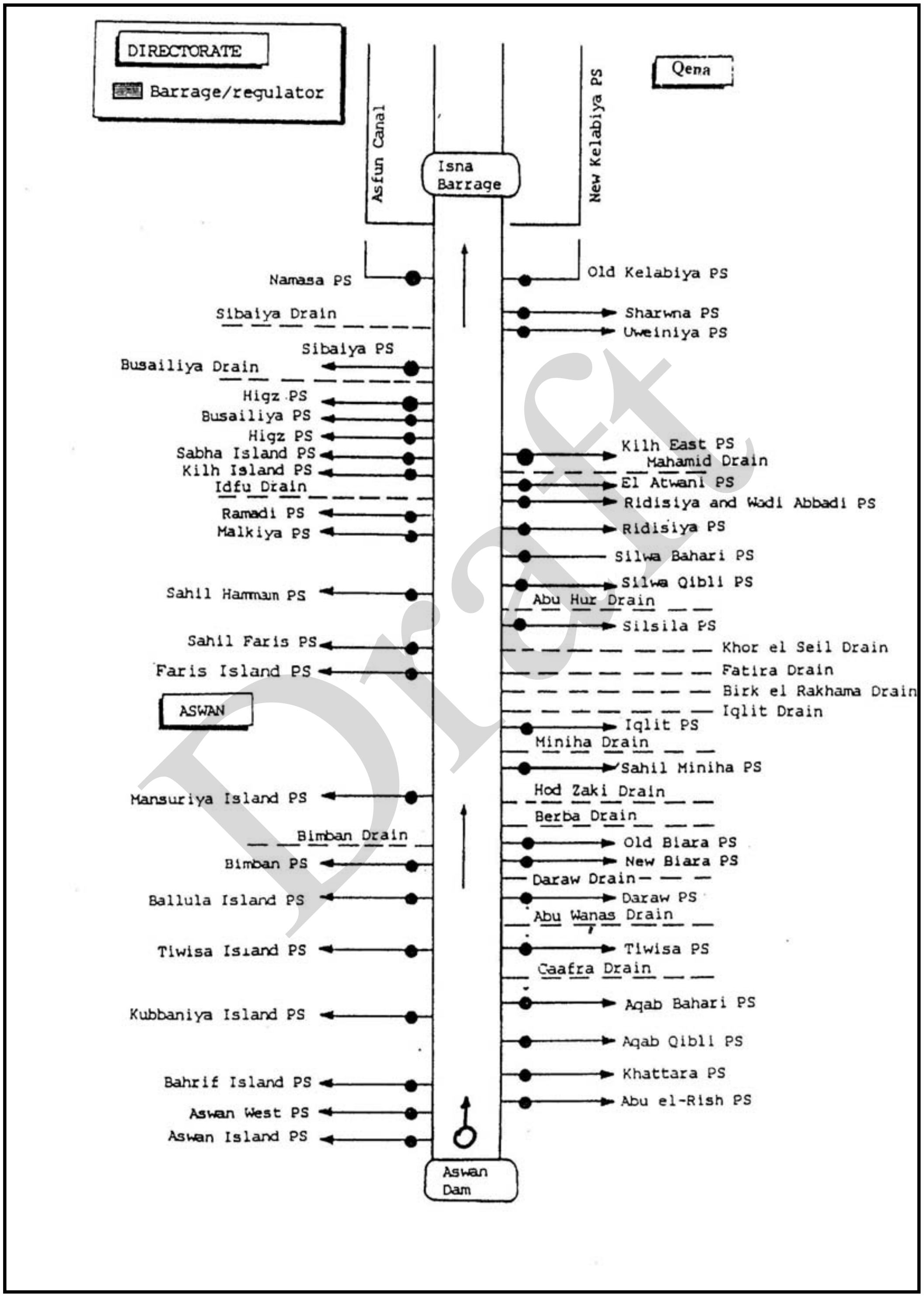
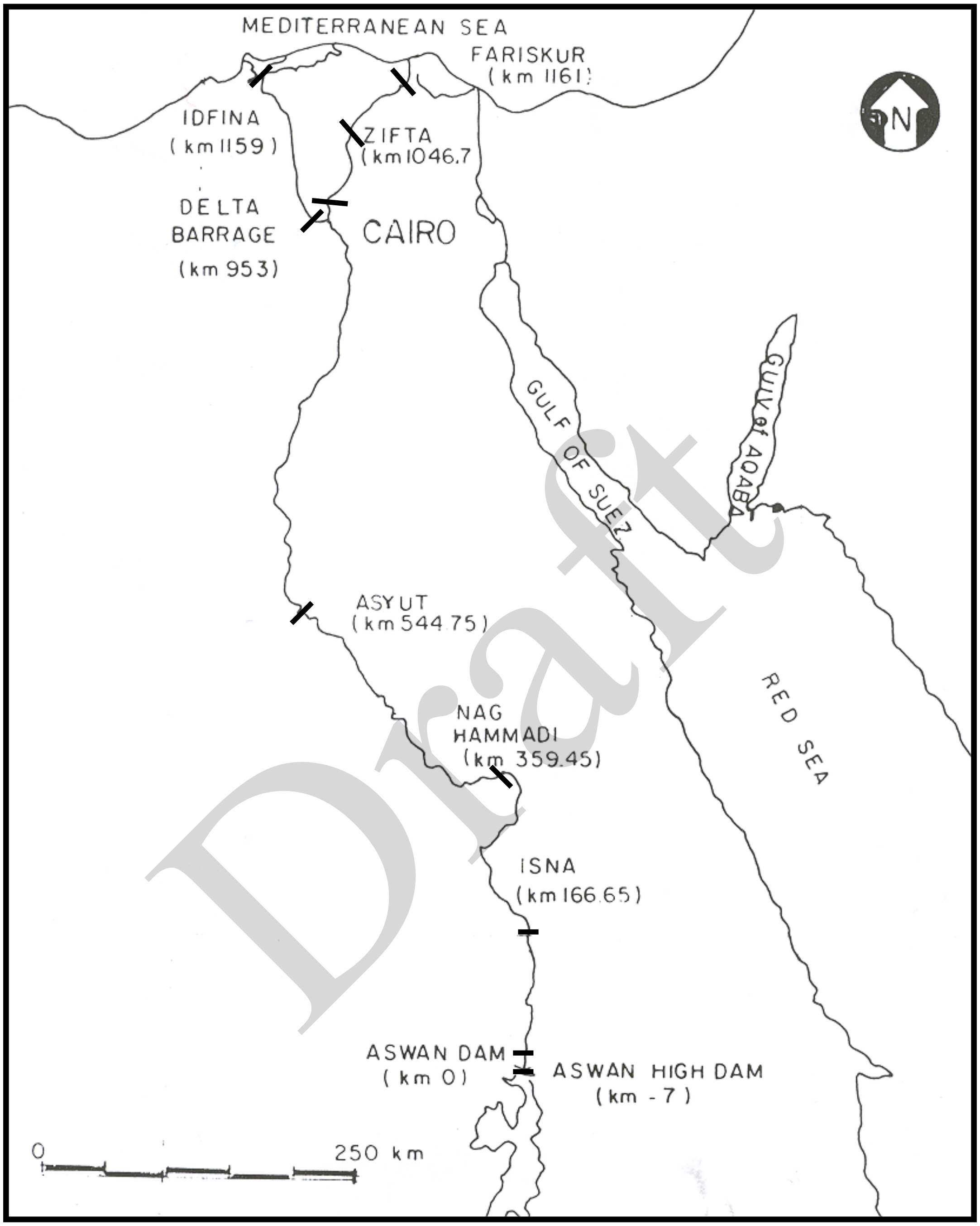
FIG No: (12) shows The Schematic location of diversions and canals between Aswan and Isna



Map No: (6) show Location of Barrages and Dams



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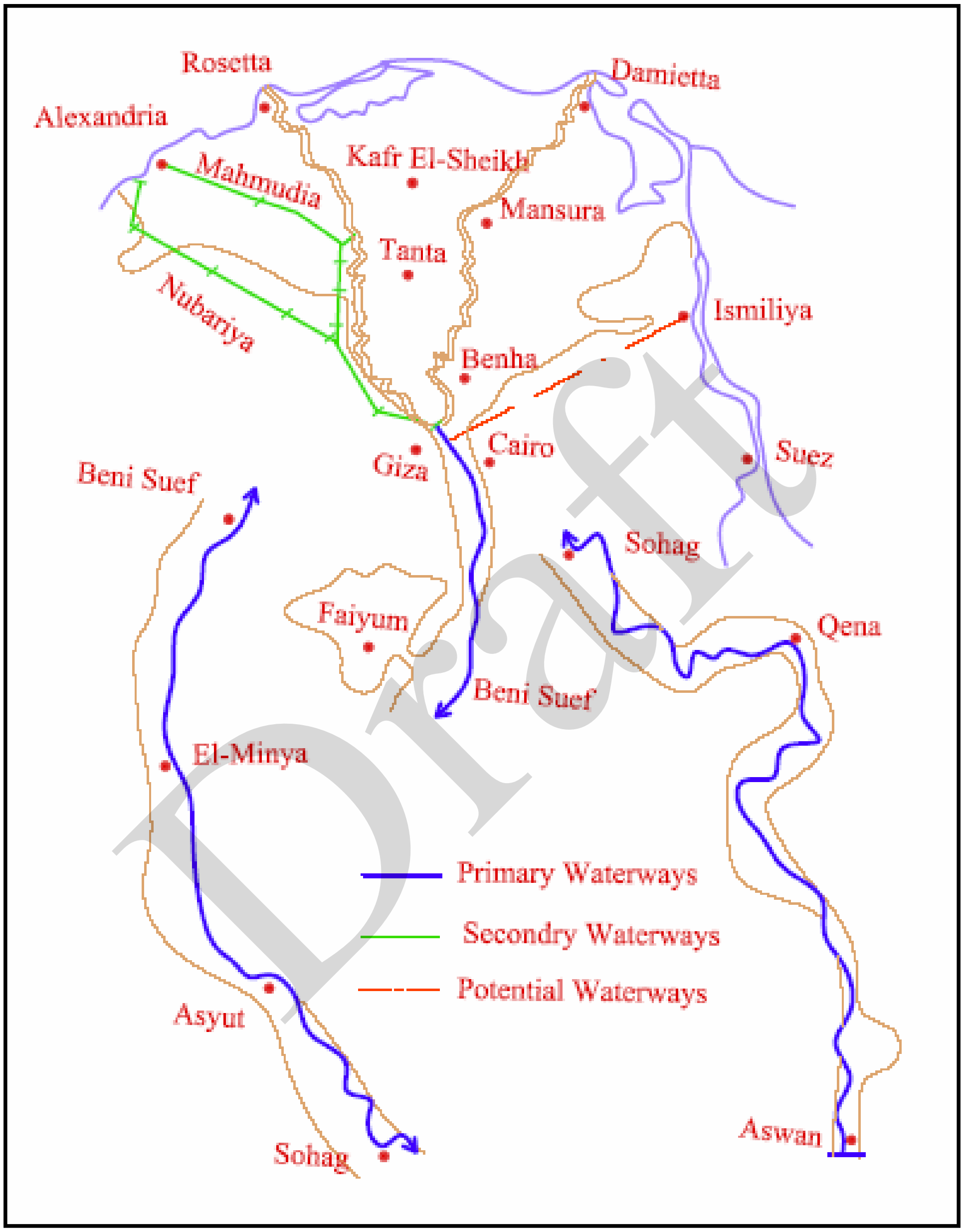
Map No: (7) show Schematic Network of Main Inland waterways



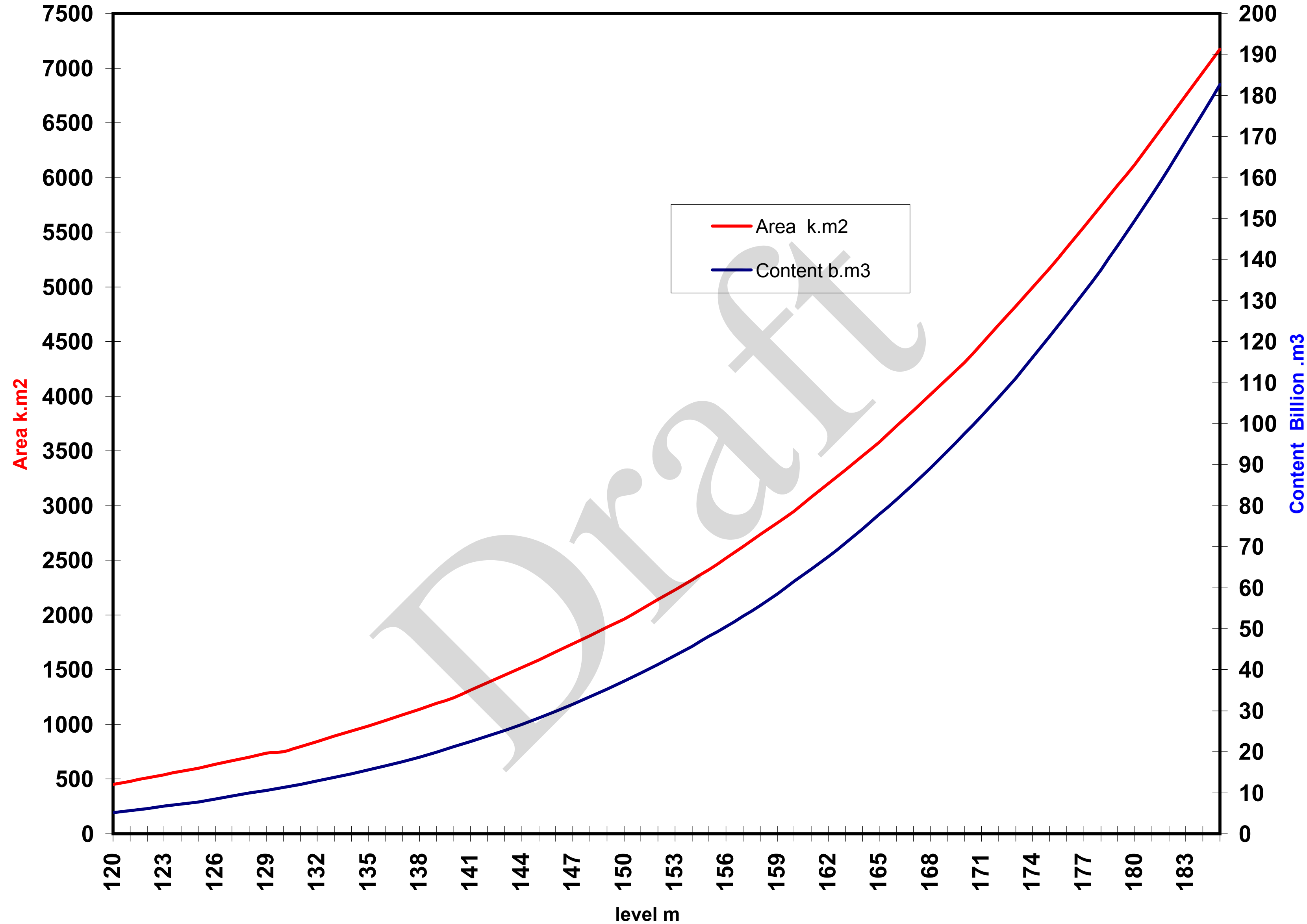
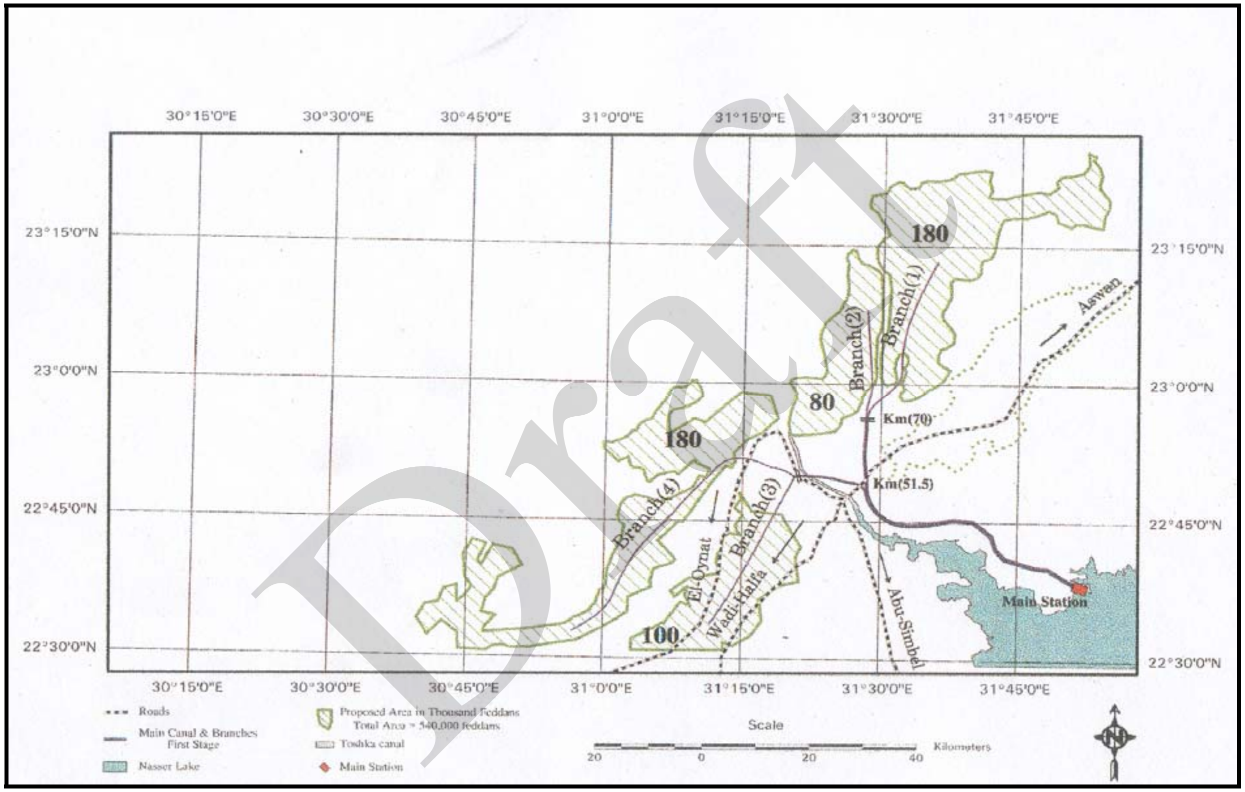


FIG 14 Lake nasser leve - area- content

Map No :(8) shows Tushka Project



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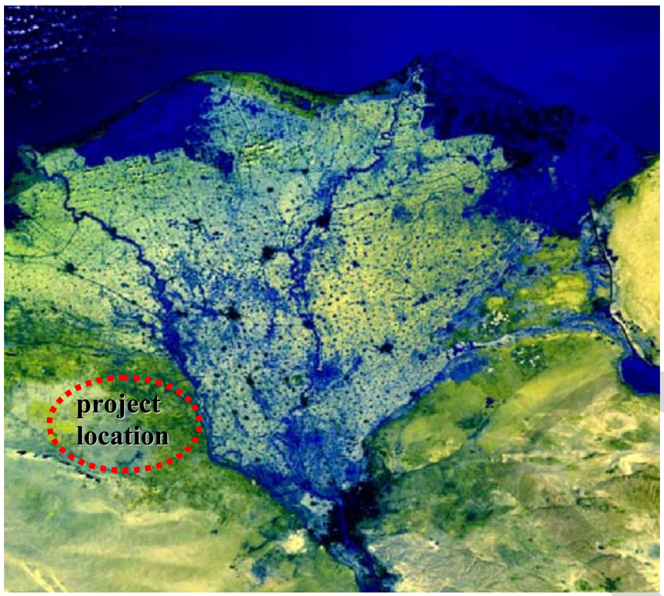
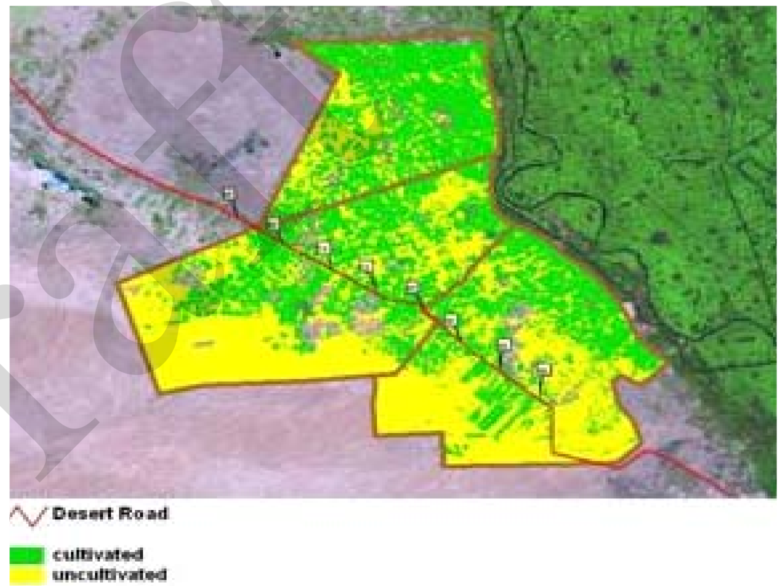
Map No: (9, 10) shows Horizontal Expansion in Western Delta





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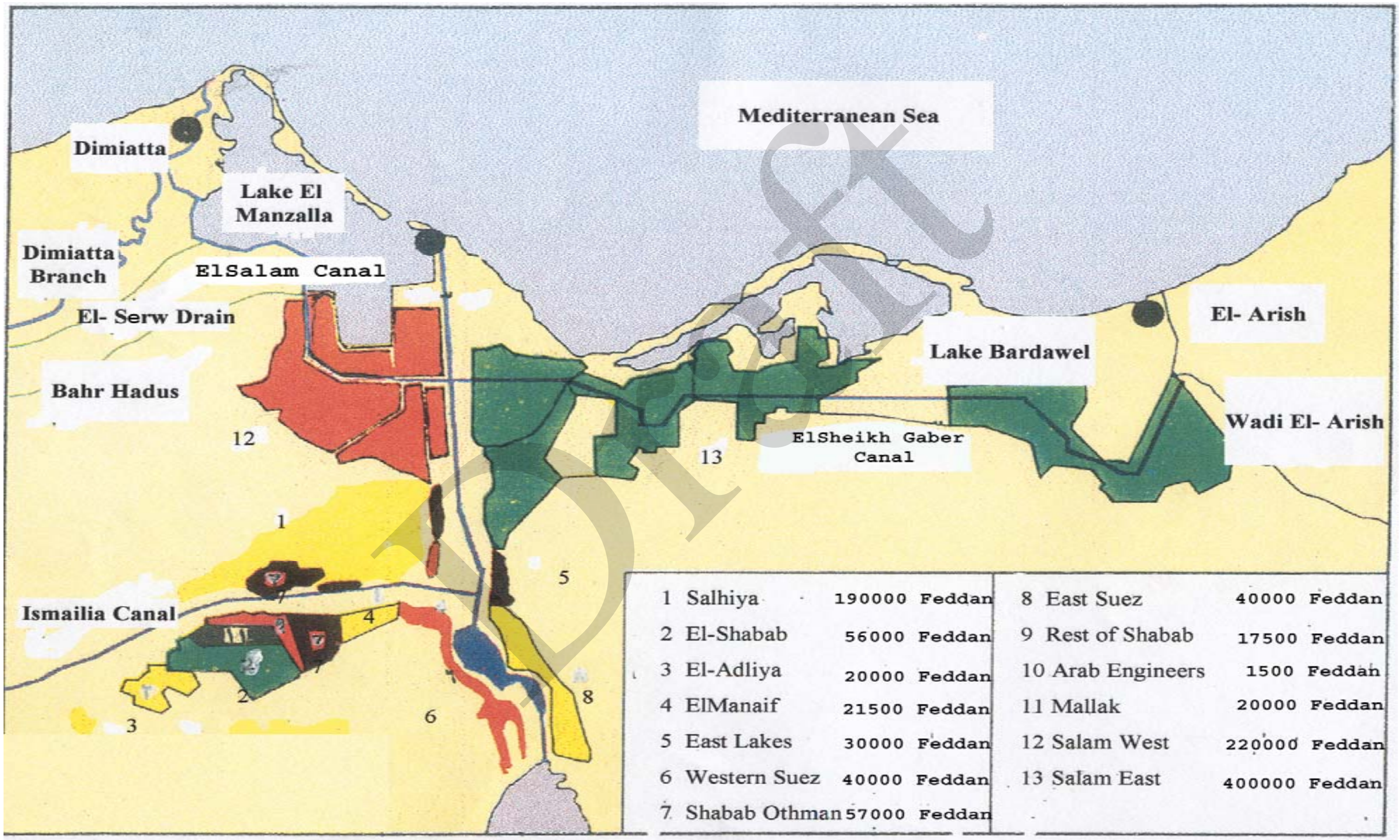
Map No: (11) shows Horizontal Expansion in Eastern Delta



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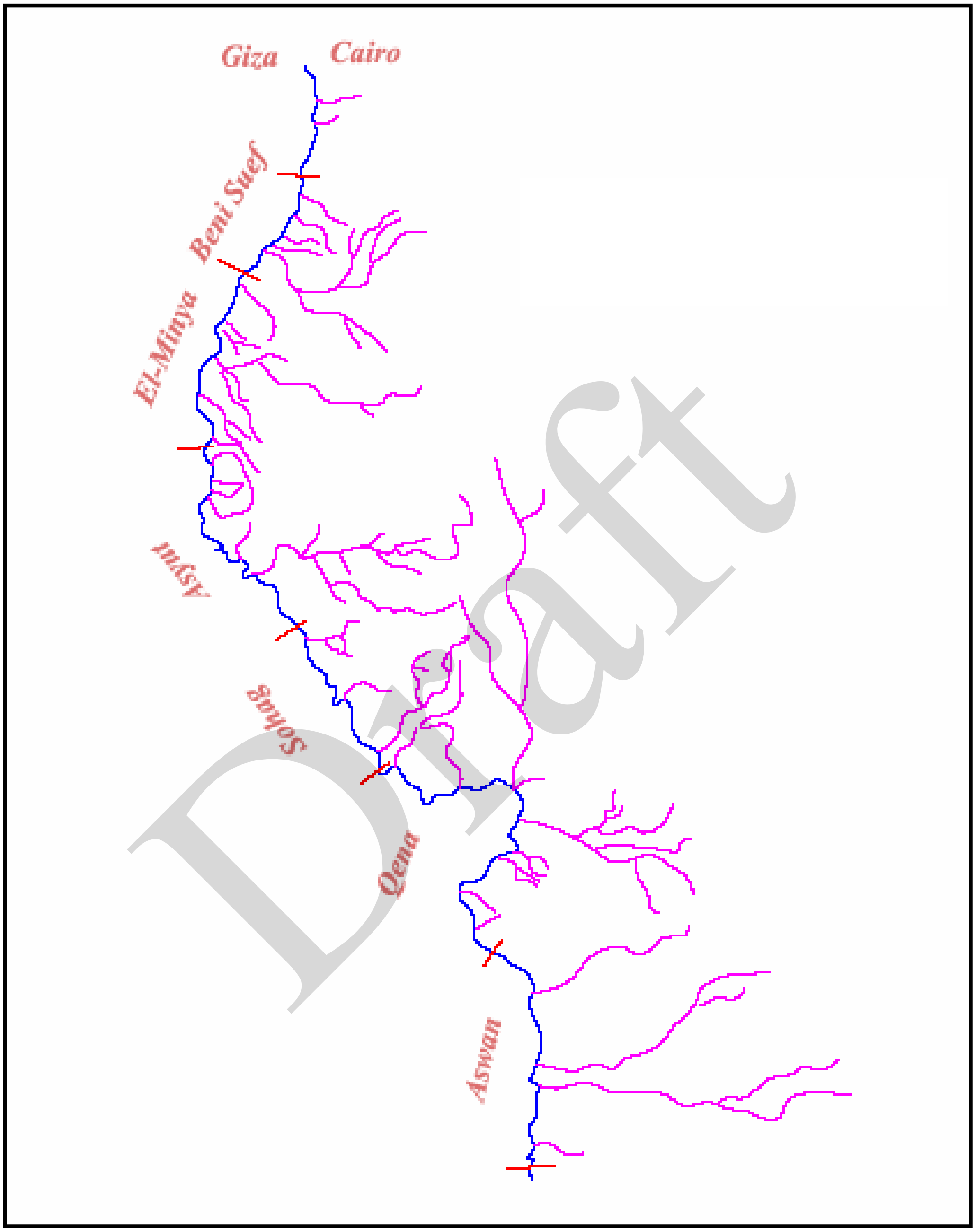
Map No: (12) shows Torrents for River Nile from Aswan to Cairo



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Annex B

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Tabl No: 1

Mediterranean Sea Coast District

Alexandria

Period of observation **1980 - 2000**
Latitude ° N / **31 12**
Longitude ° E / **29 53**
Altitude Meters **32.00**

Rainfall Totals(mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Yearly
1980	20.2	41.5	6.9	1.8	0	0	0	0	0	0.1	0.2	11.5	**82.2**
1981	109.6	14.7	6	1	0.1	0	0	0	0	0	29	0.3	**160.7**
1982	32	66.2	36	2.7	0	0	0	0	0	0.6	14	41.6	**193.1**
1983	74.9	65.2	17.5	0.8	0.2	0	0	0	0	3.4	19.9	7.4	**189.3**
1984	19.2	3	2	3.1	0	0	0	0	0	11.6	17	62.2	**118.1**
1985	35.8	44.1	2.6	5.7	0.1	0	0	0	tr.	21.1	10.7	91.5	**211.6**
1986	18.6	18.6	7.9	4.8	7.9	0.1	0	0	0.4	0.2	98	62.6	**219.1**
1987	31.4	17	31.7	7.8	0.2	0	0	0	0	10.4	1.1	89	**188.6**
1988	35.7	45.8	20.1	1.3	0	0	0	0	0	15.2	33.1	61	**212.2**
1989	174.4	41.3	23.1	0	0	0	0	0	0	49.7	20.2	23.3	**332**
1990	49.1	28.7	13.8	0.1	0.2	0	0	0	0	0.2	5	0.8	**97.9**
1991	82.5	33.8	33.8	11.2	0.1	0	0	0	0	0	76.9	167	**405.3**
1992	84.8	82.8	0.8	0.9	0.4	0	0	0	0	0	4	68.4	**242.1**
1993	51.3	60.2	10.3	0.0	3.8	0.0	0.0	0.0	0.0	7.0	6.8	20.5	**159.9**
1994	51.4	3.5	34.1	0.0	0.0	0.0	0.0	0.0	0.0	5.0	112.6	67.5	**274.1**
1995	16.7	57.1	7.3	5.3	0.0	0.0	0.0	0.0	0.0	0.3	46.4	16.7	**149.8**
1996	61.0	11.6	30.4	5.3	0.0	0.0	0.0	0.0	0.0	7.9	14.3	24.9	**155.4**
1997	23.2	50.8	20.4	7.6	0.6	0.0	0.0	0.0	3.4	4.8	8.4	39.2	**158.4**
1998	100.2	50.5	40.4	0.7	2.5	0.0	0.0	0.0	0.0	0.6	62.2	18.4	**275.5**
1999	25.1	6.7	3.2	1.2	0.0	0.0	0.0	0.0	0.0	0.4	6.1	40.3	**83**
2000	108.1	19.6	7.4	0.1	4.0	0.0	0.0	0.0	8.3	50.3	34.3	40.4	**272.5**
Ave	**57.4**	**36.3**	**16.9**	**2.9**	**1.0**	**0.0**	**0.0**	**0.0**	**0.6**	**9.0**	**29.5**	**45.5**	**199.1**

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Table No: 2

Port Said Station(mm)

Period of observation 1980 - 2000
Latitude ° N ′ 31 16
Longitude ° E ′ 32 19
Altitude Meters 4.00

Rainfall Totals (mm)

	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
1978	11.7	1.5	3.4	tr.	0	0.1	0	0	0	0	tr.	5.2	**21.9**
1979	0.3	9.6	3.9	0	0	0.6	0	0	0	0	1.1	13.3	**28.8**
1980	0.1	11.3	1.2	0	0	0	0	0	0	tr.	0	2.2	**14.8**
1981	1.6	0.1	1.9	0.7	0	0	0	0	0	0	1.2	0	**5.5**
1982	8.3	9.7	1.2	1.5	tr.	0	0	0	0	0	5.2	tr.	**25.9**
1983	38.1	9.2	19.5		1.6	0	0	0	0	tr.	1.4	7.1	**76.9**
1984	16.1	2.9	8.9	1.6	0	0	0	0	0	0	6.8	20.1	**56.4**
1985	2.6	15	3.2	11.6	1.2	0	0	0	0	1.1	0	11.9	**46.6**
1986	4.2	12.3	15.4	14.3	7.8	0	0	0	0.4	2.5	25.1	18.9	**100.9**
1987	7.2	13.7	8.7	0	0	0	0	0	0	7.8	0	4.3	**41.7**
1988	44.2	21.7	6	3.4	0	0	0	0	0	0	2.2	11.4	**88.9**
1989	65.6	111.4	11.5	0	0	0	0	0	0	0	0.4	18.8	**207.7**
1990	43.6	15.6	13.3	1.5	0	0	0	0	0	0.1	0	0.6	**74.7**
1991	31.6	12.7	96.3	5.3	0	0	0	0	0	0	1.8	17.5	**165.2**
1992	16.1	48.5	3.9	0.5	0	0	0	0	0	0	4.1	11.1	**84.2**
1993	20.0	13.1	4.5	0.0	9.7	0.0	0.0	0.0	0.0	0.0	1.4	6.7	**55.4**
1994	7.0	8.5	5.6	Tr	Tr	0.0	0.0	0.0	0.0	0.0	2.7	10.8	**34.6**
1995	0.2	11.8	1.1	5.8	0.0	0.0	0.2	0.0	Tr	Tr	1.8	1.4	**22.3**
1996	17.3	6.1	23.2	7.7	0.0	0.0	0.0	0.0	0.0	4.4	0.0	2.4	**61.1**
1997	59.8	13.1	17.7	7.6	0.6	0.0	0.0	0.0	0.0	0.2	3.0	8.2	**110.2**
1998	3.1	51.1	12.9	0.5	5.0	0.0	0.0	0.0	0.2	TR	0.3	5.1	**78.2**
1999	2.3	6.3	7.3	5.7	0.0	0.0	0.0	0.0	0.0	TR	2.0	1.2	**24.8**
2000	23.4	6.3	12.9	tr	0.0	0.0	0.0	0.0	0.7	23.0	6.4	27.0	**99.7**
Ave	**18.5**	**17.9**	**12.3**	**3.6**	**1.2**	**0.0**	**0.0**	**0.0**	**0.1**	**2.2**	**3.0**	**9.3**	**66.4**

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Table No:3

Middle Egypt District

CAIRO

Period of observation **1980 - 2000**
Latitude ° N ′ 30 05
Longitude ° E ′ 31 17
Altitude Meters 30.00

Rainfall Totals (mm)

	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	yearly
1980	0.1	11.3	1.2	0	0	0	0	0	0	tr.	0	2.2	**14.8**
1981	1.6	0.1	1.9	0.7	0	0	0	0	0	0	1.2	0	**5.5**
1982	8.3	9.7	1.2	1.5	tr.	0	0	0	0	0	5.2	tr.	**25.9**
1983	8.3	0.8	3.5	0	0	0	0	0	0	0	0	0	**12.6**
1984	10.6	0	0.5	0	0	0	0	0	0	0	3.4	0.2	**14.7**
1985	0.2	2.7	2.3	0	0	0	0	0	0	0	tr.	1	**6.2**
1986	0	0.6	0.2	0.6	5	0	0	0	0	0	11.1	0.2	**17.7**
1987	0	0.8	2.1	0	0	0	0	0	0	0	0	34.7	**37.6**
1988	7.3	4.1	8.1	0.8	0	0	0	0	0	0	0	28.9	**49.2**
1989	8.6	0.3	0.2	0	0	0	0	0	0	1.9	0	0.3	**11.3**
1990	11.3	9.7	1.2	3.3	0	0	0	0	0	0	0	0	**25.5**
1991	6.7	1.2	7.8	1.1	0.1	0	0	0	0	0	3.1	2.3	**22.3**
1992	4.3	2.1	0	0	0	0	0	0	0	0	0	4.2	**10.6**
1993	2.1	0.3	Tr	0.0	0.9	0.0	0.0	0.0	0.0	0.0	Tr	Tr	**3.3**
1994	5.3	0.0	4.9	0.1	0.0	0.0	0.0	0.0	0.0	0.2	6.0	8.0	**24.5**
1995	Tr	2.8	Tr	Tr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**2.8**
1996	1.1	0.4	2.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**5.6**
1997	2.4	0.6	17.6	0.0	0.2	0.0	0.0	0.0	0.0	0.4	0.2	0.4	**21.8**
1998	0.1	0.8	0.2	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	4.8	**7.2**
1999	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**6.0**
2000	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	9.1	12.7	**22.8**
Ave	**3.9**	**2.6**	**2.9**	**0.5**	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**2.1**	**5.3**	**17.8**

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Table No: 4

Upper Egypt District

Aswan Station

Period of observation **1980 - 2000**
Latitude ° N ′ 24 02
Longitude ° E ′ 32 53
Altitude Meters 111.0

Rainfall Totals (mm)

	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
1980	0	0	0	0	0	0	0	0	tr.	0	0	tr.	**0**
1981	0	0	0	tr.	tr.	0	0	0	0	0	0	tr.	**0**
1982	0.1	0	tr.	0	0.4	0	0	0	0	0	0	0.5	**1**
1983	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1984	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1985	0	0	0	tr.	0	0	0	0	0	0	1.6	1.6	**3.2**
1986	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1987	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1988	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1989	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1990	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1991	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1992	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1993	–	–	–	0	0	0	0	0	0	0	0	0	**0**
1994	0	0	0	0	0	0	0	0	0	2	0	0	**2**
1995	0	0	0	0	0	0	0	0	0	0	0	0	**0**
1996	0	0	1	0	0	0	0	0	0	0	0	0	**1**
1997	0	0	0	0	0	0	0	0	0	1	0	0	**1**
1998	0.0	0.0	tr	tr	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.7**
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Ave	**0.0**	**0.0**	**0.1**	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.1**	**0.5**

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Table No: 5-1

Mean Daily Amount of Evaporation (mm)

Station	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alexandria	4.2	4.6	5.2	5.4	5.8	5.7	5.5	5.6	5.8	5.4	4.4	3.8
Port Said	4.7	5.4	6.5	6.4	6.8	7.4	7.5	7.3	7.8	7.9	5.9	4.5
Cairo	5.6	7	8.7	10.6	13.1	13	11.2	10	8.9	8.5	6.6	5.5
Aswan	8.9	10.9	15.3	17.5	18	22.2	20.6	20.5	19.4	17.4	12.1	9.6

Table No: 5-2

Highest Daily Amount of Evaporation (mm)

Station	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alexandria	12.7	12.2	15	14.7	17	16.4	11.2	9.3	9.5	10	11.3	12
Port Said	5.4	16.6	16.4	15.4	13.5	15.5	14.5	14.5	12.8	10.5	12.9	19.3
Cairo	21.3	23.9	27.7	32.2	42.5	41	23.9	32.6	28.3	29	23.8	29.6
Aswan	21.8	25.5	38.3	34.7	34.5	40.5	32.4	32.5	32.7	38	24.5	20.2

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Table No: 7

Mean Monthly Flow characteristics at selected points (1980 - 2000) in M.m3

Flow at Selected points	January	February	March	April	May	June	July	August	September	October	November	December	Total
High Aswan Dam	2874	3594	4398	4394	5505	6928	7148	6380	4698	3919	3604	3036	* 56478
Kalbia Canal	39	100	97	103	268	1261	155	154	132	115	114	86	2624
Asfon Canal	19	38	42	43	111	57	63	66	58	50	53	32	631
Esna Barrages	2292	3200	3947	4048	4994	6557	6196	5834	4319	3496	2734	2549	50166
West Nagaa Hamady canal	89	210	218	226	238	284	329	315	357	205	232	176	2878
East Nagaa Hamady Canal	32	88	88	89	95	105	121	117	100	87	103	72	1098
Nagaa Hamady Barrages	2227	2636	3440	3449	4260	5846	5861	5277	3862	3014	2652	2216	44741
Ebrahimya Canal	216	679	735	799	831	1004	1160	1097	852	745	709	592	9420
Assiut Barrages	2068	1789	2346	2601	3155	4719	4713	4330	3019	2353	2066	1798	34958
Delta Barrages	2822	2259	2805	3405	3235	4706	5095	4347	3517	2754	2596	2458	40000
Esmaillya Canal	214	222	307	426	339	422	444	413	369	309	284	255	4003
Tawfeky Rayah	184	203	313	322	341	529	583	485	390	282	270	257	4159
Dammeitta Branch	406	446	659	740	841	1408	1561	1221	919	553	584	546	9884
Menofy Rayah	256	254	405	449	433	670	756	665	463	374	362	319	5406
Rosetta Branch	1212	656	320	277	350	555	457	378	366	364	328	492	5755
Behery Rayah	359	317	538	570	588	720	753	722	659	546	487	450	6710
Nasri Rayah	83	86	153	150	156	216	243	234	206	177	147	118	1968
El-Mansoriya Canal	98	104	159	166	193	373	414	342	257	122	141	107	2477
et Ghamir Feeder to Mansoriy	29	27	45	36	41	33	74	2	16	51	49	53	458
Abasi Rayah	185	171	302	352	375	649	739	576	437	270	277	229	4563
Zefta Barrages	130	124	171	205	229	306	302	241	219	159	150	124	2360
Farskor Dam	400	207	222	127	57	29	82	6	44	325	173	409	2080
Edfina Barrages	996	579	199	81	64	41	12	6	119	215	207	433	2952

* This Increase in D.S discharge of the AHD from the specified quota (55.5) B.m^3 is due to the high floods and for the safety o

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Table NO: 8

Total Solids in Suspension Passing Wadi Halfa (1929-1955)

millions of metric tons

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Dis Wad-Half	Natural Flow
1929	0.27	0.11	0.06	0.04	0.07	0.38	10.7	62.1	43.1	16.1	3.5	0.8	137.23	108.99	103.78
1930	0.47	0.21	0.12	0.07	0.07	0.07	1.41	43.77	30.58	6.08	0.91	0.32	84	79.04	75.81
1931	0.16	0.06	0.03	0.03	0.03	0.03	0.32	48.89	53.85	13.67	2.57	2.57	120	78.52	78.1
1932	0.27	0.09	0.06	0.03	0.04	0.08	1.09	52.33	66.71	20.55	2.33	0.61	144	88.44	86.55
1933	0.44	0.31	0.15	0.06	0.06	0.08	0.39	22.37	62.6	16.72	3.72	1.06	108	86.02	84.44
1934	0.45	0.2	0.08	0.06	0.06	0.06	4.28	66.72	79.04	22.5	2.34	0.76	177	97.08	94.37
1935	0.46	0.25	0.1	0.06	0.07	0.16	4.4	71.03	44.7	17.85	2.5	0.72	142	100.16	98.33
1936	0.4	0.18	0.12	0.07	0.06	0.08	2.67	51.68	92.82	19.97	1.95	0.46	170	92.67	89.68
1937	0.25	0.1	0.06	0.03	0.04	0.07	0.94	65.59	56.45	14.56	1.19	0.52	140	85.18	82.27031
1938	0.27	0.12	0.12	0.06	0.03	0.05	0.73	69.77	55.2	23.4	3.7	0.8	154	101.56	101.8173
1939	0.46	0.27	0.13	0.11	0.11	0.11	0.51	17.73	33.33	10.88	2.08	0.51	66	77.05	77.88898
1940	0.22	0.1	0.15	0.07	0.04	0.04	0.32	30.79	34.49	4.93	0.55	0.21	72	67.33	68.88801
1941	0.09	0.08	0.09	0.07	0.03	0.09	0.91	31.13	30.29	5.96	2.75	0.41	72	66.12	66.42523
1942	0.2	0.11	0.14	0.15	0.09	0.09	1.46	87.53	57.12	13.93	1.34	0.38	163	86.49	86.34794
1943	0.23	0.1	0.15	0.12	0.07	0.06	0.45	35.99	81.66	12.33	1.41	0.36	133	79.85	83.524
1944	0.19	0.08	0.14	6.18	0.09	0.1	1.3	61.18	49.82	12.1	1.03	0.36	127	76.05	76.574
1945	0.17	0.1	0.17	0.13	0.04	0.08	0.41	25.59	44.58	20.16	2.83	0.71	95	81.39	82.274
1946	0.37	0.14	0.14	0.18	0.08	0.05	3.51	111.41	86.33	14.67	2.73	0.78	220	104.73	106.734
1947	0.43	0.29	0.25	0.18	0.18	0.18	0.33	37.49	66.06	15.1	1.28	0.48	122	84.97	88.284
1948	0.27	0.17	0.13	0.14	0.11	0.08	1.14	47.87	45.5	15.64	4.23	0.6	116	86.55	91.414
1949	0.31	0.16	0.13	0.15	0.15	0.08	0.65	54.98	44.1	17.25	1.89	0.52	120	83.27	87.204
1950	0.37	0.22	0.17	0.15	0.16	0.14	1.29	62.86	66.97	16.1	1.37	0.38	150	91.49	92.504
1951	0.24	0.11	0.14	0.18	0.1	0.04	0.42	48.55	56.53	7.96	2.88	0.55	118	75.11	76.654
1952	0.21	0.12	0.2	0.14	0.05	0.05	0.59	58.93	59.45	9.14	1.09	0.33	130	73.6	77.304
1953	0.15	0.09	0.12	0.15	0.04	0.08	1.48	73.74	48.5	12.13	1.05	0.31	138	82.69	85.644
1954	0.17	0.1	0.15	0.12	0.08	0.07	6.15	102	69	31	2.6	0.57	212	102.85	106.8356
1955	0.3	0.19	0.1	0.15	0.15	0.15	0.95	76	70.5	29.3	2.3	0.43	180	91.12	91.77

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TableNo: 9

Lake Nasser Deposeted Sediment
Yearly Totals In millions of metric tons

Year	Sediment	Commul.	Year	Sediment	Commul.
1964	183.1	183.1			1723.8
1965	133.8	316.9	1983	30.3	1754.1
1966	66.5	383.4	1984	12.4	1766.5
1967	154.2	537.6	1985	49.8	1816.3
1968	75.7	613.3	1986	30.7	1847
1969	77.2	690.5	1987	17.6	1864.6
1970	93.2	783.7	1988	167.6	2032.2
1971	106.3	890	1989	51.3	2083.5
1972	32.8	922.8	1990	28.4	2111.9
1973	60.4	983.2	1991	182	2140.3
1974	129.6	1112.8	1992	182	2322.3
1975	198.2	1311	1993	163	2504.3
1976	76.6	1387.6	1994	140.06	2667.3
1977	79.9	1467.5	1995	129	2807.36
1978	74.7	1542.2	1996	129	2936.36
1979	37	1579.2	1997	155	3065.36
1980	54.7	1633.9	1998	168	3220.36
1981	63.6	1697.5	1999	182	3388.36
1982	26.3	1723.8	2000	160	3570.36

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Table NO: (10) Installed capacity of hydropower generation and characteristics of turbines.

	UNIT	AHD	ASWAN DAM I	ASWAN DAM II	ESNA	NAG HAMMADI
Capacity	MW	2.100	345	270	90	5
Commissioned in	Year	1967	1960	1986	1995	1998
Discharge	BCM/Y	57	57	57	51	52
Discharge rate	M3/kWh	6	21	18	81	103
Average Head	m	70	22	22	5	4
U/S water Level	M(+MSL)	175	111	111	79	65
D/S water level	M(+MSL)	110	90	90	75	62
Efficiency	%	85	78	90	82	83
Maximum Load	MW	1.980	265	270	79	5
Generated energy	GWH	8.949	1.196	1.673	394	9
Max. gen.energy	GWH/d	44	6	7	2	0
Min. gen. energy	GWH/d	7	1	2	0	0
Distance from old Aswan dam	K.M	7 U.S Aswan Dam	0	0	167	359.45

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Table NO: (11) The development of generated energy

Year	AHD Generation (M.K.W.H)	Thermal Generation	Total Generation (M.K.W.H)	Percentage AHD/Total %
1980	8071.31	8628.8	18425	43.81
1981	8336.18	10532.4	20747	40.18
1982	8631.9	12868.6	23353	36.96
1983	7936.88	16062.8	25867	30.68
1984	7629.45	19416.48	29049	26.26
1985	6581.21	22777.49	31458	20.92
1986	6511.78	24183.17	33464	19.46
1987	5962.05	28234.16	36909	16.15
1988	5769.05	30156.92	38569	14.96
1989	7098.43	31058.34	40857	17.37
1990	7151.46	32561.9	42470.1	16.84
1991	7092.68	34581.8	44447.84	15.96
1992	7568.67	36045.6	46429.74	16.3
1993	7772.87	37338.8	47927.04	16.22
1994	8029.1	38731.4	49827.21	16.11
1995	8439.97	41269.7	52862.72	15.97
1996	8522.98	44389	56066.32	15.2
1997	8915.38	47683.7	59905.4	14.88
1998	10686.91	51162.9	65447.26	16.33
1999	10701.01	56269.5	70695.11	15.14
2000				

Table NO: (12) Development of hydro-energy and thermal energy in Egypt from 1980 to 2000

Year	AHD Generation (M.K.W.H)	Aswan I M.K.W.H	Aswan II M.K.W.H	Isna M.K.W.H	Nag Hammadi M.K.W.H	Total Hydro - Energy	Thermal Energy M.K.W.H	Total Energy
1980	8071.31	1730.93	-	-	-	9802.24	8628.8	18425
1981	8336.18	1878.87	-	-	-	10215.05	10532.4	20747
1982	8631.9	1852.29	-	-	-	10484.2	12868.6	23353
1983	7936.88	1879.62	-	-	-	9816.501	16062.8	25867
1984	7629.45	2003.06	-	-	-	9632.519	19416.48	29049
1985	6581.21	1785.01	314.09	-	-	8680.31	22777.49	31458
1986	6511.78	1196.08	1572.78	-	-	9280.645	24183.17	33464
1987	5962.05	1222.04	1476.35	-	-	8660.44	28234.16	36909
1988	5769.05	1247.39	1396.13	-	-	8412.57	30156.92	38569
1989	7098.43	1216.25	1514.29	-	-	9828.97	31058.34	40857
1990	7151.46	1226.95	1529.79	-	-	9908.2	32561.9	42470.1
1991	7092.68	1200.91	1572.45	-	-	9866.04	34581.8	44447.84
1992	7568.67	1183.31	1632.16	-	-	10384.14	36045.6	46429.74
1993	7772.87	990.5	1776.97	47.9	-	10588.24	37338.8	47927.04
1994	8029.1	923	1808.206	335.5	-	11095.81	38731.4	49827.21
1995	8439.97	1018.506	1789.141	345.4	-	11593.02	41269.7	52862.72
1996	8522.98	1085.68	1716.364	352.3	-	11677.32	44389	56066.32
1997	8915.38	1216.76	1649.658	439.9	-	12221.7	47683.7	59905.4
1998	10686.91	1420.711	1851.834	310.5	14.4	14284.36	51162.9	65447.26
1999	10701.01	1482.803	1909.398	318.3	14.1	14425.61	56269.5	70695.11
2000								

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Table NO: (13) Amounts of tariff rate

Item	Description	Price (Pt/KWH)	Anecdotal Comment
	June 2005		
1	Power service on Ultra – high Voltage		
-	KIMA COMPANY	4.70	
-	All Consumers	6.80	
2	Power service on high voltage		
-	All Consumers	11.34	
3	Housing Companies	10.70	
4	Power service on Medium& Low		
-	More than 500 KW	7.30	
-	Demand charge (LE / KW – Month)	15.35	
	Energy Rates		
-	Up to 500 Kw	7.00	
-	Agriculture &and Reclamation	18.00	
	Other Purposes		
5	Residential		
-	First 50 KWH monthly	5.00	
-	51-350 KWH monthly	8.30	
-	351-650 KWH monthly	11.00	For consumption average about 280 kwh/ month a rate paid
-	651-1000 KWH monthly	15.00	In jan. 2004 was 0.084 and
-	More than1000 KWH monthly	21.00	In jan . 2005 was 0.084 and
		25.00	In jan . 2004 was 0.084 and
	6 Commercial		
	First 100 KWH monthly	18.00	A rate paid in jan 2004 was 0.180
	101-250 KWH monthly	26.00	And in jan. 2005 was 0.189
	251-600 KWH monthly	33.00	
	601-1000 KWH monthly	41.00	
	More than 1000 KWH monthly	43.00	
	7 Public Lighting	30.00	

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Ministry of Water Resources and Irrigation
Table NO: (14) Irrigated Area Served from River Nile

1- Area Served form the Main Canals/Nile in Upper Egypt (Acre)

No.	Canal	Area Served
1	El-Ibrahimiya	1535152
2	Naga Hamadi El-Sharkia	103175
3	Naga Hamadi El-Gharbia	425638
4	El-Kalabia	172100
5	Asfun	69390
6	Direct Intakes	414725
Total		**2720180**

2- Area Served form the Main Canals/Nile in Delta (Acre)

A) US of Delta Barrages		B) Domiatta Branch		C) Rosetta Branch	
Canal	Area Served	Canal	Area Served	Canal	Area Served
El-Raiyah El-Monofi	736165	El-Rayah El-Abasi	783393	Mahmoudia Pump Sta.	285000
El-Raiyah El-Bihiri	1195157	El-Mansoria	324546	Direct Intakes	107754
El-Raiyah El-Nasri	75823	Direct Intakes	184060		
El-Raiyah El-Tawfiki	672131				
Ismailiya Canal	580000				
Direct Intakes	302546				
Total	**3561822**	**Total**	**1291999**	**Total**	**392754**
Total	**5246575**				

Total Area Served from River Nile = 7966755 feddan

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Table NO:(14)

Cropped Areas for All Egypt (feddans)

Mahmoudia	Menoufi Ra	Abassi Ray	Ismailiya	awfiki Raya	Mansouria	Busat P.S.	ehera Raya	aseri Raya	Ibrahimiya	Asfoun	Kelabia
wheat	wheat	wheat	wheat	wheat	wheat	wheat	wheat	wheat	wheat	wheat	wheat
horse beans	horse beans	horse beans	horse beans	horse beans	horse beans	horse beans	horse beans	horse beans	horse beans	horse beans	horse beans
barley	barley	barley	barley	barley	barley	barley	barley	barley	barley	barley	barley
clover c	lentiles	lentiles	fenugreek	lentiles	lentiles	lentiles	fenugreek	0	fenugreek	chickpeas	fenugreek
clover f	clover c	clover c	lupins	clover c	clover c	clover c	lupins	lupins	lupins	lentiles	lentiles
flax	clover f	clover f	lentiles	clover f	clover f	clover f	chickpeas	clover f	chickpeas	clover f	onion w
vegetables w	flax	flax	clover c	flax	flax	flax	clover c	vegetables w	lentiles	0	garlic w
others w	onion w	onion w	clover f	onion w	onion w	garlic w	clover f	others w	clover c	onion w	vegetables w
cotton	garlic w	garlic w	flax	garlic w	garlic w	vegetables w	flax	maize s	clover f	garlic w	others w
rice	vegetables w	vegetables w	onion w	vegetables w	vegetables w	cotton	onion w	ground nuts	flax	vegetables w	0
maize s	others w	others w	garlic w	others w	others w	rice	garlic w	onion s	onion w	maize s	maize s
soya beans	cotton	cotton	vegetables w	soya beans	cotton	maize s	vegetables w	vegetabless	garlic w		
vegetabless	rice	rice	others w	sugar cane	rice		others w	others s	vegetables w		
	maize s	maize s	cotton	maize s	maize s		cotton		others w		
	soya beans	soya beans	rice		soya beans		rice		sugar beat		
	sugar cane		maize s				maize s		cotton		
	ground nuts		sugar cane						rice		
			sesame						maize s		
			ground nuts								

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TableNo: (15)

Monthly Mean Discharges of Main Canals in Egypt (1980-2000) in M.m^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Aswan High Dam	2874	3594	4398	4394	5505	6928	7148	6380	4698	3919	3604	3036	* 56478
Kalbiya Canal	39	100	97	103	268	1261	155	154	132	115	114	86	2624
Asfun Canal	19	38	42	43	111	57	63	66	58	50	53	32	631
Isna Barrages	2292	3200	3947	4048	4994	6557	6196	5834	4319	3496	2734	2549	50166
West Naga Hamadi canal	89	210	218	226	238	284	329	315	357	205	232	176	2878
East Naga Hamadi Canal	32	88	88	89	95	105	121	117	100	87	103	72	1098
NagaHamadiBarrages	2227	2636	3440	3449	4260	5846	5861	5277	3862	3014	2652	2216	44741
Ibrahimiya Canal	216	679	735	799	831	1004	1160	1097	852	745	709	592	9420
Asyut Barrages	2068	1789	2346	2601	3155	4719	4713	4330	3019	2353	2066	1798	34958
Delta Barrages	2822	2259	2805	3405	3235	4706	5095	4347	3517	2754	2596	2458	40000
Ismailiya Canal	214	222	307	426	339	422	444	413	369	309	284	255	4003
Tawfiki Rayah	184	203	313	322	341	529	583	485	390	282	270	257	4159
Damietta Branch	406	446	659	740	841	1408	1561	1221	919	553	584	546	9884
Minufy Rayah	256	254	405	449	433	670	756	665	463	374	362	319	5406
Rosetta Branch	1212	656	320	277	350	555	457	378	366	364	328	492	5755
Behery Rayah	359	317	538	570	588	720	753	722	659	546	487	450	6710
Nasri Rayah	83	86	153	150	156	216	243	234	206	177	147	118	1968
El-Mansoriya Canal	98	104	159	166	193	373	414	342	257	122	141	107	2477
Mit Ghamr Feeder to Mansoriya	29	27	45	36	41	33	74	2	16	51	49	53	458
Abbasi Rayah	185	171	302	352	375	649	739	576	437	270	277	229	4563
Zefta Barrages	130	124	171	205	229	306	302	241	219	159	150	124	2360
Fariskur Dam	400	207	222	127	57	29	82	6	44	325	173	409	2080
Idfina Barrages	996	579	199	81	64	41	12	6	119	215	207	433	2952

* This Increase in D.S discharge of the AHD from the specified quota (55.5) B.m^3 is due to the high floods and for the safety of the Dam

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Table NO: (16) Nile River Reaches from Aswan to Mediterranean Sea

Reach	Location	Length (km)	Average width (m)
	Part 1(Aswan to Cairo)		640
1	Aswan Dam to Isna Barrage	167	570
2	Isna Barrage to Nag Hammadi Barrage	186	1060
3	Nag Hammadi Barrage to Asyut Barrage	187	548
4	Asyut Barrage to Delta Barrages	410	
	Part 2		
	Damietta branch	246	217
	Part 3		
	Rosetta branch	236	331

Source: River Nile bank erosion and protection methods, Working Paper 200-7, NRI, 1989

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Table NO: (17) Vessel Classification and Dimensions

Vessel class	Length (m)	Beam (m)	Maximum Draft (m)
I	12-16	3-4	1.4
II	44-49	7-8	1.9
III	50-64	9-10	2.1

Table NO: (18) Type and Number of the Navigable units in the Nile (1995)

Type	Number of Units
Tourist Boats	200
Transportation, public and privet recreations	2161
Cargo transportation	1736
Towing boats	200

Table (19) Bottlenecks along the Nile (minimum water depth 1.45 m).

Reach	**Distance D.S. Old Aswan Dam (Km)**	**Total bottlenecks**
1	**None**	0
2	183	1
3	410, 439, 433, 465, and 471	5
4A	572, 584, 613, 664, 677, 684, and 707	7
4B	777, 845, and 862	3
SUM		16

Table NO: (20) Navigation Levels Along the River Nile

Construction Name	**Lock Level (m)**	**Average Water Depth (m)**
Esna Lock	**70.00**	2.00
Nagaa Hamadi Lock	**58.50**	2.00
Asyut Lock	**43.25**	2.00
Ibrahimia Intake Lock	**44.15**	2.00
El-yousfi Intake Lock	**--.--**	2.00
Ibrahimia Lock (Dirot)	**--.--**	2.00
Navigation Line Locks	**--.--**	1.80

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Table No: 22

Lake Naser Level - area - content

Level m	Area k.m2	Content Billion .m3	Level m	Area k.m2	Content Billion .m3
120	450	5.2	153	2232	43.5
121	480	5.7	154	2323	45.7
122	510	6.2	155	2414	48.1
123	540	6.8	156	2521	50.5
124	570	7.3	157	2628	53.1
125	600	7.8	158	2735	55.7
126	634	8.5	159	2842	58.5
127	668	9.2	160	2950	61.5
128	702	9.9	161	3076	64.5
129	736	10.6	162	3202	67.6
130	749	11.3	163	3328	70.9
131	796	12.1	164	3454	74.3
132	844	12.9	165	3581	77.9
133	892	13.7	166	3726	81.5
134	940	14.6	167	3871	85.3
135	988	15.6	168	4016	89.2
136	1038	16.6	169	4162	93.3
137	1089	17.6	170	4308	97.6
138	1140	18.7	171	4480	101.9
139	1191	19.9	172	4652	106.4
140	1242	21.2	173	4824	111.1
141	1311	22.5	174	4996	116.1
142	1380	23.8	175	5168	121.3
143	1449	25.2	176	5358	126.5
144	1519	26.7	177	5548	131.9
145	1589	28.3	178	5738	137.5
146	1663	29.9	179	5928	143.4
147	1737	31.6	180	6118	149.5
148	1812	33.4	181	6329	155.8
149	1887	35.3	182	6540	162.3
150	1962	37.2	183	6751	168.9
151	2052	39.2	184	6962	175.7
152	2142	41.3	185	7174	182.7

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Table No:23 Daily High Dam U.S. Level in (ms) Low Year 1987-1988

Day	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FAB.	MAR	APR.	MAY.	JUN.	JUL.
1	154.62	156.10	158.16	158.37	158.41	157.92	157.68	156.90	155.93	155.30	154.06	151.60
2	154.59	156.24	158.15	158.40	158.40	157.92	157.67	156.87	155.90	155.27	153.96	151.54
3	154.58	156.38	158.13	158.40	158.39	157.90	157.63	156.85	155.88	155.24	153.91	151.47
4	154.57	156.52	158.11	158.42	158.37	157.90	157.58	156.82	155.86	155.22	153.83	151.40
5	154.54	156.65	158.10	158.44	158.34	157.90	157.56	156.81	155.85	155.19	153.75	151.35
6	154.52	156.77	158.10	158.48	158.32	157.90	157.55	156.75	155.82	155.15	153.71	151.31
7	154.50	156.92	158.09	158.44	158.30	157.88	157.54	156.74	155.80	155.13	153.58	151.27
8	154.50	157.07	158.08	158.47	158.30	157.86	157.50	156.72	155.76	155.11	153.50	151.17
9	154.50	157.20	158.09	158.47	158.29	157.86	157.48	156.69	155.75	155.06	153.44	151.12
10	154.50	157.32	158.08	158.46	158.28	157.85	157.48	156.65	155.74	155.02	153.38	151.06
11	154.50	157.45	158.07	158.47	158.29	157.85	157.45	156.60	155.72	154.98	153.26	151.00
12	154.50	157.57	158.08	158.48	158.28	157.86	157.42	156.55	155.70	154.95	153.18	150.93
13	154.52	157.68	158.06	158.49	158.24	157.86	157.36	156.49	155.67	154.91	153.10	150.86
14	154.53	157.78	158.08	158.48	158.22	157.84	157.33	156.47	155.65	154.87	153.01	150.85
15	154.56	157.84	158.08	158.46	158.21	157.84	157.31	156.43	155.63	154.83	152.91	150.80
16	154.61	157.92	158.09	158.46	158.20	157.84	157.30	156.42	155.63	154.77	152.79	150.75
17	154.64	157.97	158.10	158.46	158.21	157.83	157.26	156.39	155.60	154.74	152.70	150.70
18	154.66	158.04	158.10	158.46	158.20	157.82	157.24	156.37	155.57	154.71	152.60	150.65
19	154.70	158.07	158.14	158.44	158.20	157.80	157.22	156.35	155.56	154.67	152.54	150.65
20	154.75	158.12	158.12	158.44	158.18	157.80	157.17	156.32	155.54	154.65	152.49	150.63
21	154.82	158.14	158.14	158.46	158.16	157.80	157.16	156.29	155.50	154.61	152.43	150.62
22	154.87	158.18	158.14	158.46	158.13	157.80	157.11	156.25	155.47	154.55	152.32	150.65
23	154.96	158.19	158.14	158.44	158.13	157.79	157.07	156.22	155.44	154.51	152.26	150.68
24	155.05	158.20	158.15	158.43	158.10	157.79	157.04	156.17	155.41	154.46	152.18	150.76
25	155.12	158.20	158.20	158.43	158.08	157.79	157.00	156.14	155.37	154.41	152.09	150.85
26	155.18	158.20	158.23	158.43	158.07	157.77	156.96	156.10	155.34	154.36	152.00	150.95
27	155.28	158.20	158.26	158.43	158.05	157.76	156.92	156.06	155.30	154.31	151.91	151.14
28	155.40	158.20	158.27	158.43	158.02	157.74	156.91	156.03	155.30	154.25	151.81	151.33
29	155.55	158.20	158.31	158.42	157.99	157.72	156.90	156.00	155.30	154.20	151.75	151.43
30	155.75	158.18	158.33	158.41	157.97	157.70		155.96	155.30	154.17	151.66	151.57
31	155.95		158.35	158.35	157.95	157.70		155.95		154.13		151.70

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Table No: 24 **Daily High Dam U.S. Level in (ms) High Year 1999 -2000**

Day	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FAB.	MAR	APR.	MAY.	JUN.	JUL.
1	175.72	178.27	180.56	181.44	181.38	180.93	180.25	179.66	178.90	178.41	177.52	176.45
2	175.85	178.37	180.56	181.48	181.37	180.91	180.27	179.64	178.89	178.40	177.50	176.42
3	175.88	178.47	180.56	181.52	181.36	180.90	180.21	179.62	178.88	178.38	177.47	176.38
4	175.92	178.57	180.56	181.56	181.34	180.88	180.20	179.60	178.86	178.36	177.42	176.34
5	176.00	178.67	180.56	181.56	181.32	180.88	180.19	179.58	178.84	178.34	177.37	176.31
6	176.07	178.77	180.55	181.56	181.31	180.87	180.17	179.55	178.83	178.30	177.32	176.27
7	176.14	178.87	180.54	181.57	181.30	180.84	180.14	179.52	178.82	178.26	177.29	176.24
8	176.19	178.97	180.54	181.58	181.29	180.83	180.12	179.49	178.79	178.22	177.26	176.22
9	176.24	179.07	180.53	181.59	181.28	180.79	180.10	179.46	178.75	178.19	177.24	176.20
10	176.31	179.19	180.53	181.60	181.27	180.74	180.09	179.44	178.72	178.17	177.21	176.17
11	176.39	179.33	180.53	181.60	181.26	180.70	180.07	179.41	178.69	178.15	177.19	176.14
12	176.49	179.43	180.53	181.60	181.25	180.67	180.06	179.38	178.68	178.13	177.16	176.12
13	176.54	179.53	180.53	181.60	181.23	180.65	180.05	179.35	178.67	178.10	177.13	176.10
14	176.60	179.63	180.55	181.60	181.22	180.62	180.02	179.32	178.66	178.08	177.09	176.08
15	176.68	179.73	180.58	181.59	181.20	180.60	179.99	179.30	178.65	178.06	177.07	176.05
16	176.75	179.83	180.62	181.56	181.19	180.58	179.96	179.28	178.64	178.04	177.05	176.02
17	176.82	179.92	180.64	181.54	181.17	180.56	179.93	179.27	178.63	178.02	177.02	176.00
18	176.89	179.99	180.66	181.53	181.15	180.54	179.91	179.26	178.62	178.00	176.98	175.97
19	176.99	180.07	180.71	181.53	181.14	180.52	179.89	179.24	178.61	177.98	176.93	175.95
20	177.09	180.15	180.79	181.53	181.13	180.50	179.88	179.24	178.59	177.95	176.87	175.94
21	177.19	180.23	180.86	181.53	181.11	180.49	179.87	179.18	178.55	177.91	176.80	175.93
22	177.28	180.27	180.94	181.52	181.10	180.47	179.85	179.15	178.53	177.87	176.75	175.92
23	177.37	180.30	181.02	181.51	181.09	180.45	179.83	179.12	178.51	177.82	176.72	175.91
24	177.46	180.35	181.07	181.50	181.09	180.43	179.80	179.09	178.50	177.77	176.69	175.89
25	177.55	180.38	181.12	181.49	181.08	180.40	179.78	179.06	178.49	177.74	176.66	175.87
26	177.64	180.41	181.15	181.47	181.07	180.38	179.76	179.04	178.47	177.73	176.62	175.85
27	177.73	180.44	181.20	181.43	181.06	180.36	179.73	179.01	178.45	177.70	176.57	175.84
28	177.83	180.48	181.26	181.41	181.04	180.34	179.71	178.99	178.44	177.66	176.54	175.84
29	177.94	180.52	181.32	181.40	181.01	180.32	179.68	179.96	178.43	177.61	176.51	175.84
30	178.06	180.54	181.34	181.39	180.98	180.29		179.94	178.42	177.58	176.48	175.84
31	178.16		181.39		180.95	180.27		179.92		177.55		175.85

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Table NO: (25) Potential Sites Suitable for Medium Power Generation

Site Location	Head (m)	Discharge (m3/s)	Capacity to be installed (MW)	Energy produced GW-hr/year	No. of units	Type of Turbine	Study Conducted by
Nag-Hammadi	4.5	1,500	56.5	412	5	Bulbe	BONIFICA
Asyut	4	1,200	40	262	4	Bulbe	BONIFICA
Damietta branch	4.4	280	12	53.8	2	Semi Kaplan Gear Siphon	SWECO
Rosetta branch	5.3	60	3.1	18.5	1	Kaplan W. Gear	SWECO
Zefta	3.5	90	3.1	17.4	1	Semi Kaplan Gear Siphon	SWECO
Dairout	51	60	3	13.49	1	Kaplan W. Gear	SWECO

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Table (26) Available Flows, Head and Power at the Proposed Sites of the proposed Sites of Power generation at El-Faiyum.

Site	**Head (m)**	**Flow (m^3/sec)**	**Capacity (KW)**
Tamia	6	8.7	430
El Azab	5.5	11.6	540
El Mokhtalat	25	5.8	1,220
Wadi El Rayan	6	5.8	290
Lahun Barrage	2	52	873
Bahr Wasef	1.4	30	352
Hagz Wahbi	2	11.6	194

Table (27) Potential Sites for Water Wheels Installations

Site	H (m)	Q (m^3/s)	No. of Wheels	Capacity to be installed	Energy Produced GW.hr/year
Mansouria canal	1.37	73	3	500	2.5
Abassy canal	1.53	150	6	1,000	5
Menoufia canal	1.3	201	6	1,000	4.5
Nassery canal	1.77	31	2	380	2
Bagouria canal	1.84	42	2	400	2
Karenein canal	1.31	92	4	750	3.8
Tawfiki canal	2.25	155	6	1,200	7
Gamgara canal	2.06	61	4	750	3.8
Yousef canal	1.67	138	6	1,200	6
Ibrahimia canal	1.67	133	6	1,200	6
Lahoun canal	1.85	49	3	600	3
Hebab weir	2.55	13	1	180	0.9
Sikka	1.88	12	1	150	0.8
Asfoun canal	2	16	1	150	0.8
Kellabia canal	2.08	39	2	380	1.5
Edfina Barrage			7	1,000	4
Total			60	10,840	53.6

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Table (28) Most Promising Sites for Power Development as reported by the Study for Academy of Science

Site	**Head (m)**	**Flow (m^3/sec)**	**Capacity (KW)**
Damietta Barrage	3.12	293	7,645
Damietta Barrage connected with the downstream weir	4	293	9,328
Rosetta Barrage	3.3	268	6,025
Rosetta Barrage connected with the downstream weir	6	268	10,690
Zefta Barrage	3.5	61	1,781
Zefta Barrage with the downstream weir	5	61	2,479
El Mansouria Barrage	1.37	73.5	691
El Rayah El Abbasy Barrage	1.53	150.5	1,625
El Rayah El Nassery Barrage	1.77	31	458
El Rayah El Abbasy Barrage	1.3	201	1,898
El Rayah El Menoufy Barrage	1.32	93	1,057
Gamgara Barrage	2	61	1,089
El Rayah El Tawfiky Barrage	2.25	156	2,732
El Bagouria Barrage	1.84	42	706

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Table NO: (29) Maximum Recorded Levels at D/S Old Aswan Dam and the Duration above level (93.00) m

Year	Max. Levels at Aswan, m AMSL		Levels above (93.00) m AMSL	
	Level	Date	Duration	No. of Days
1874	93.97	6 Sep.	12Aug.- 3 Oct.	53
1878	94.15	1 Oct.	24 - 26 Aug.,4 Sep.- 14 Oct.	44
1887	93.81	1 Sep.	10 Aug.- 27 Sep.	49
1892	93.88	20 Sep.	23 Aug.- 6 Oct.	45
1908	93.30	10 Sep.	23- 26 Aug., 7- 22 Sep.	20
1916	93.20	25 Aug., 15-16 Sep.	22- 29 Aug., 3- 8 Sep., 13-24 Sep.	26
1917	93.17	14 Sep.	13- 22 Sep., 27 Sep.- 2 Oct.	16
1929	93.11	8 Sep.	6- 9 Sep.	4
1934*	93.24	4 Sep.	30 Aug.- 10 Sep.	12
1934**	93.37	6 Sep.	30 Aug.- 11 Sep.	13
1938*	93.32	19- 25 Sep.	2- 27 Sep.	26
1938**	93.17	17-18 Sep.	31 Aug.- 21 Sep.	22
1946*	93.60	8-21 Sep.	26 Aug.- 29 Sep.	35
1946**	94.07	31 Aug., 2 Sep.	18 Aug.- 24 Sep.	38
1954*	93.60	8-12 Sep.	1 Sep.- 3 Oct.	33
1954**	93.88	3-5 Sep.	26 Aug.- 3 Oct.	38
1958*	93.15	6- 9 Sep.	4 Sep.- 15 Sep.	12
1958**	93.77	1 Sep.	23 Aug.- 15 Sep.	24
1961*	93.40	18-26 Sep.	28 Aug.- 28 Sep.	32
1962**	94.13	8 Sep.	28 Aug.- 24 Sep.	28
1964*	93.51	31 Aug.	25 Aug.- 19 Sep.	26
1964**	94.25	4 Sep.	23 Aug.- 26 Sep.	35

* With influence of regulations of Aswan Dam
** Without influence of regulations of Aswan Dam

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Table NO: (30) Maximum Recorded Levels at Roda Gauge and the Duration Above Level (20.05) m.

Year	Max. Levels at Roda, m AMSL		Levels above (20.05m) AMSL		Max. Levels m (Ave. 5 days)
	Level	Date	Duration	Number of days	
1874	21.40	5-6 Oct.	9 Sep.- 23 Oct.	45	21.33
1878	21.26	12 Oct.	22 Sep.- 31 Oct.	39	21.04
1887	20.63	25 Sep.	11 Sep.- 12 Oct.	32	20.60
1892	20.63	2-5, 7 Oct.	19 Sep.- 30 Oct.	41	20.62
1908	20.14	18-30 Sep.	27 Sep.- 1Oct.	5	20.12
1916	20.23	29 Sep.	18 Sep.- 2 Oct. 19 Sep.- 31 Oct.	28	20.19
1917	20.47	24 Oct.	21 Sep.- 15 Oct. 20 Sep.- 28 Oct.	34	20.38
1929	20.11	14 Sep.	13- 15 Sep.	3	20.07
1934*	20.16	9 Sep.	7- 10 Sep.	4	20.06
1934**	20.09	8-9 Sep.	8- 10 Sep.	3	
1938*	20.54	12 Sep.	4- 20 Sep.	17	20.27
1938**	20.29	10-12 Sep.	2- 23 Sep.	22	
1946*	20.99	8,9,11,12 Sep.	24 Aug.- 23 Sep.	32	20.32
1946**	20.34	11-12 Sep.	25 Aug.- 29 Sep.	36	
1954*	20.76	8 Sep.	29 Aug.- 28 Sep.	31	20.45
1954**	20.48	17 Sep.	5- 29 Sep.	25	
1958*	20.9	6 Sep.	26 Aug.- 20 Sep.	26	20.29
1958**	20.31	7-8 Sep.	27 Aug.- 20 Sep.	25	
1961*	20.93	13 Sep.	29 Aug.- 27 Sep.	30	20.38
1961**	20.40	8-11 Sep.	30 Aug.- 25 Sep.	27	
1964*	21.14	9 Sep.	26 Aug.- 4 Oct.	40	20.45
1964**	20.47	16-21 Sep.	30 Aug.- 2 Oct.	34	

* Without influence of regulations of Aswan Dam
** With influence of regulations of Aswan Dam

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Table NO: (31)

Some of Historical Flooding Damages on the Nile Valley

No.	Date	Location	Damages
1	23 February 1975	Sohag-Assuit-Minea-Beni-Sweif	23 Villages, Failure of Bahr Yousif Canal Embankment and Problems of supplying of Drinking Water
2	4/5 May 1979	Aswan-Qena	Some Railways, Main Road of the upper Egypt, 200 Houses and 300 Families
3	18 October 1979	Aswan	300 Houses, Main Road and Railways
4	20 October 1979	Qena-Sohag-Red Sea	Death of 37 persons, Failure of 1331 Houses, Flooding of 10000 acres
5	7 December 1980	Aswan	Failure of 100 Houses, Failure of Embankments and Flooding of some Irrigated lands, Problems in the City of Edfo
6	30 December 1980	Qena-Sohag	Failed of 23 Houses, the need to implement diverting dam in front of Qena University
7	21 April 1981	Aswan	Closing of Aswan AirPort, Problems on the Railways, Closing the Main Road and Sinking of A tourist Ship
8	13 February 1981	Giza	180 Houses Failed in Qenayat village and Displacing of 1500 Person
9	1 April 1985	Qena	Death of 32 Person because of the failure of Khuzam Dam
10	25 December 1987	Giza	Damages of Many Farms and Houses along El-Saaf Road
11	2-15 November 1994	Allover Egypt	Flooding Many Farms and a large number of Houses
12	16-18 November 1996	Aswan-Qena-Sohag-Assyut-Menia	Limited Damages

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Table NO :(32) List of Torrents for the River Nile from Aswan to Cairo
(Record of November 1996)

No.	Name of Spillway	Location	Side	Discharge (M.m^3)
Aswan				
1	El-Kasara Branch	10.500	Right	3.00
2	Abo-Sabira Village	33.360	Right	3.00
3	Fadira Drain	7.00	Right	60.00
4	El-Dadida and Helal	138.750	Right	1.00
Qena				
1	Zarnigh	156.00	Right	2.00
2	Ghazam	216.00	Right	5.00
3	Main Kaft	278.00	Right	0.50
4	Main Qena	288.00	Right	40.00
Sohag				
1	Mazin	519.80	Right	25.00
Assuit				
1	El-Osmania and El-Shiekh Valley	530.00	Right	4.00
2	El-Asyuty Valley	530.00	Right	3.00
3	Arab Matir	589.00	Right	1.00
El-Minya				
1	Tal Beni Omran	619.50	Right	1.50
2	El-Bershay	628.50	Right	1.50
3	El-Nowirat	688.00	Right	2.00
4	Awlad Younis	740.00	Right	2.50
5	El-Shiekh Valley	777.00	Right	2.50
Beni Suef				
1	Lisab Valley	800.00	Right	1.50
Giza				
	none			

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Total Torrents for the River Nile in the Upper Region of Egypt:

1. Aswan 67.00 M.m^3
2. Qena 43.00 M.m^3
3. Sohag 25.00 M.m^3
4. Asyut 08.00 M.m^3
5. El-Minya 10.00 M.m^3
6. Beni Suef 01.50 M.m^3
7. Giza 00.00 M.m^3

Total 154.50 M.m^3