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Project in Development and the Environment

Egypt Water Quality Impact Assessment: Phase I

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The objective of the Project in Development and the Environment (PRIDE) is to help the U.S. Agency for International Development (AID) design and implement programs that foster the agency's environmental and natural resources strategy for sustainable economic growth in the Near East and Eastern Europe.

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Egypt Water Quality Impact Assessment: Phase I

PRIDE Technical Report #3

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LIST OF ACRONYMS

ASRT	Academy of Scientific Research and Technology
bcm/yr	Billion cubic meters per year
BOD	Biochemical oxygen demand
CEA	Central Environmental Agency
DO	Dissolved Oxygen
DRI	Drainage Research Institute
EEAA	Egyptian Environmental Affairs Agency
EHD	Environmental Health Department
EOHC	Environmental and Occupational Health Center
ESG	Environmental Studies Group
GOE	Government of Egypt
GOFI	General Organization for Industry
IMS	Irrigation Management Systems (USAID-funded project)
LE	Egyptian pound (currency)
MA	Ministry of Agriculture
MALR	Ministry of Agriculture and Land Reclamation
mcm	Million cubic meters
mg/l	Milligrams per liter
MH	Ministry of Health
MHRANC	Ministry of Housing, Reconstruction, and New Communities
MI	Ministry of Interior
MPN	Most Probable Number
MPWWR	Ministry of Public Works and Water Resources
ng/l	nanograms per liter
NOPWASD	National Organization for Potable Water and Sanitary Drainage
NRC	National Research Center
NRI	Nile Research Institute
ppm	Parts per million
PRIDE	Project in Development and the Environment
RNPD	River Nile Protection and Development project
TDS	Total dissolved solids
TOC	Total organic carbon
TSS	Total suspended solids
UNEP	United Nations Environmental Programme
USEPA	U.S. Environmental Protection Agency
USFDA	U.S. Food and Drug Administration
WHO	World Health Organization
WRC	Water Research Center

PREFACE

The U.S. Agency for International Development (AID) commissioned this environmental water quality impact assessment in response to a request from the Government of Egypt through its Ministry of Public Works and Water Resources (MPWWR). The results of this activity, Phase I of a two-phased assignment, will serve as the basis for the design of a Water Management Action Plan under Phase II. Both phases are funded by the AID Mission in Egypt, through the Project in Development and the Environment (PRIDE), and by the MPPWR's Water Research Center (WRC). PRIDE is a centrally funded project that provides technical assistance in environmental and natural resource management to AID's Near East (NE) Bureau, missions, and host-country institutions.

PRIDE is being implemented by a consortium led by Chemonics International and including RCG/Hagler, Bailly, Inc.; Science Applications International Corporation (SAIC); Capital Systems Group, Inc.; Industrial Economics, Inc.; Environomics, Inc.; Resource Management International (RMI), Inc.; and Lincoln University.

James L. Welsh, an engineer with over 40 years of experience in water resource planning and water quality evaluation, served as the team leader/water quality assessment specialist for this assignment. Mr. Welsh is a senior consultant with RMI/Bookman-Edmonston Engineering, Inc., Sacramento, California. Dr. Khalil H. Mancy, chairman of the Department of Environmental and Industrial Health of the University of Michigan School of Public Health, served as water quality specialist on this activity. Dr. Mancy, a water quality and environmental health specialist, has studied Egypt's water resources throughout his career. He advised Mr. Welsh on data availability and analysis and the identification and prioritization of water quality issues, and helped write this report.

Mr. Welsh arrived in Egypt to begin his eight-week assignment on February 2, 1992. Dr. Mancy participated in the assessment for a two-week period beginning on February 12 and again in early April when he finalized the report in the United States with Mr. Welsh. While in Egypt, the team was assisted by specialists from the MPWWR's Water Research Center, under the direction of Dr. Mahmoud Abu Zeid, director of the WRC. The WRC specialists include Dr. Fatma El-Gohary, water pollution control specialist, and Drs. Soheir Abu-Elela and Rifaat Abdel Wahab, assistant water pollution control specialists for this activity.

PRIDE appreciates the continuous and active support and participation of Dr. Abu Zeid and his staff. The PRIDE team also expresses its appreciation to the following individuals at USAID/Egypt: Glenn Rutanen-Whaley, mission environmental officer; Richard Rhoda, director of the Office of the Environment; Flynn Fuller, agricultural development officer, Office of Water and Irrigation, Directorate of Agriculture; Clem Webber, director, Office of Irrigation and Land Development; and Chris Crowley, associate mission director for program development and support.

EXECUTIVE SUMMARY

This project has two major purposes and has been divided into two phases. The first goal and the project's first phase assess water quality and water pollution in Egypt and describe their environmental and health impacts. The second phase of the project is presented in a separate report, "Egypt Water Management Action Plan: Phase II," that develops a water management action plan for environmentally sound water use and development in Egypt. Both phases rely on existing data and information from knowledgeable policy and technical experts, and both documents are intended for policy officials and decisionmakers who are responsible for Egypt's water resources management.

This Phase I report covers historical patterns of water quality in the Nile River, canals, and drains; the current quality of groundwater and surface water; municipal, domestic, and industrial wastes; agricultural drainage water; health impacts of the water quality situation; water quality monitoring; and capacity building and water quality management recommendations.

All these issues are vital to Egypt. The Nile River is the sole water supply for nearly 56 million people, a burgeoning industrial base, and over 7 million acres of highly productive irrigated lands. Nevertheless, a number of trends threaten the country's capacity to supply good quality water, maintain its fisheries, and preserve the Nile's environmental quality. Among these patterns are intensive water use, growing amounts of untreated wastes, and an expanding population's increasing water needs. Appropriate management of the Nile's water resources is central to Egypt's continued prosperity and its leading role in the Arab world.

Under 1990 conditions, Egypt has sufficient water of adequate quality in the Nile system to meet current water needs. That will still be true in the year 2000 if Nile supplies increase and irrigation efficiency improves, and, most importantly, if adequate water quality is maintained. Agriculture diverts water from other uses and produces more wastewater than any other use in Egypt. Domestic and industrial water usages are much smaller but often produce inadequately treated wastewater. The quality of industrial waste discharges is generally very poor; heavy metal discharges pose the greatest concern, followed by toxic organic discharges.

Shortcomings in the available data constrain efforts to describe current water quality and predict future trends. Nevertheless, it is clear the Nile's water quality generally declines and biological productivity increases as the river travels north. The causes include major withdrawals for irrigation, minor municipal and industrial withdrawals, large agricultural drainage returns to the river, and discharges of municipal and industrial wastes. These changes in the river are most obvious in the vicinity of Cairo. In addition, within the Delta, salinity and organic loading substantially increase particularly in the drains.

Municipal and domestic wastes are a problem especially for Egypt's rural population. Currently, an estimated 95 percent of these 31 million persons have no access to sewer systems or wastewater treatment facilities. Instead, they rely on onsite disposal using a leaching pit adjacent to the house or direct discharge of raw sewage into drains and canals. This situation poses major hazards for domestic water supplies in the villages and exposes edible crops and agricultural workers to domestic waste discharges. The lack of rural sanitation is the major health-related water-quality problem in Egypt.

The number of sewage treatment facilities for urban populations will increase by the year 2000, but the present undersupply of rural wastewater treatment facilities will remain largely unchanged. In addition, between 2000 and 2020 urban treatment capacity is expected to fall behind demand.

Egypt has three major water quality monitoring programs, but they suffer from a variety of shortcomings. The basic program, which is on the Nile River and Delta, develops little diversity of data, has inadequate funding and staffing, and needs upgrading for its laboratory facilities to accommodate the number and type of analyses needed. The program has minimal data storage and evaluation capability and does little to disseminate data to concerned users. The second program, for drainage monitoring, is limited mainly to drainage salinity. The third program, for groundwater monitoring, has focused mostly on specific investigations, although some meaningful data have been compiled.

For Egypt to meet its water planning, pollution control, and research needs, the country urgently needs a comprehensive water quality data program. It should be accompanied by adequate funds, effective laboratory facilities, competent professional staff, and effective data storage and retrieval systems. Such water quality management planning must integrate water quantity and quality concerns. Egypt's water quality information efforts should be centered in the Ministry of Public Works and Water Resources, and they should be supported by the Ministry of Public Health and other concerned agencies. Egypt should identify the pollutants that will pose the greatest future threats to its water resources. The country should better control agricultural, municipal, and industrial wastes. Egypt should move forward on the second phase of this environmental water quality assessment. That will provide significant guidance for revising and implementing the preliminary recommendations of this first phase of the study. Finally, Egypt should develop a water and waste disposal cost recovery plan that could create an adequate financial base and provide an equitable distribution of costs for the country's water use and waste disposal systems.

SECTION I
INTRODUCTION

The River Nile, the life blood of Egypt, is the sole water supply for nearly 56 million people, a burgeoning industrial base, and over 7 million acres of highly productive irrigated lands. Intensive water use, disposal of largely untreated wastes, and continuing demands for even more water by a rapidly expanding population are stretching the country's capacity to supply good quality water, maintain fisheries, and preserve the environmental quality of this magnificent river. While the traditional concern with securing sufficient Nile water for Egypt's survival and economic development cannot be overemphasized, unchecked water quality deterioration significantly threatens the country's aquatic resources, public health, environmental well-being, and economic growth. Bold changes are needed in the management of the nation's aquatic resources.

Despite the rapid economic growth, the resources required to cope with water quality management problems are lagging behind real needs. Only recently has there been significant pollution control in new factories. Progress in retrofitting of old factories with waste treatment equipment has been slow. In rural areas domestic wastes are generally not treated, and in major cities they are treated only with massive assistance from donors. The Cairo population is growing so fast that even the current plant construction program for massive sewage treatment may not keep pace with the need. Intensive reuse of agricultural drainage water, which contains high proportions of municipal and industrial waste, requires careful planning and vigilance to maintain crop production, protect the Delta resources from lasting damage, and maximize water supplies.

Egypt can continue its lead role in the Near East only by carefully managing the environment. A decline in crop production, wide-spread water-related disease, and the destruction of productive fisheries will increase Egypt's reliance on the outside world at a time when resources to pay for foreign goods and services are diminishing. Learning to manage a valuable and unique resource, the River Nile, is central to Egypt's continued prosperity.

SECTION II
BACKGROUND

A. Objectives and Scope of the Study

This study was initiated to assess water quality and water pollution in Egypt and its environmental and health impacts (Phase I) and develop a water management action plan for environmentally sound water use and development (Phase II). This report presents an assessment of the environmental water quality in Egypt and the basic requirements for management programs.

The study relies on existing data and information from knowledgeable policy and technical experts. The report is aimed at policy and decision makers who are responsible for formulating, financing, implementing, and administering plans for water resources management in Egypt.

B. Study Methodology

The study was carried out by a group of international and local water resource experts who were asked to provide as much information as they could on the following topics:

- Historical patterns of water quality in the River Nile and canals
- Historical patterns of water quality in agricultural drains
- Current patterns of water quality in groundwater
- Current industrial and municipal discharges to the Nile, canals, and drains

These topics were documented in four working papers (Annexes A, B, C, and D) that describe what is known about the Nile basin water quality and the factors affecting it. This report summarizes the most significant factors and provides additional information on current and projected population, agricultural and industrial development, and water supply and use.

C. Availability of Water Quality Information

Water quality data and information in Egypt are scarce and cannot be accessed easily. Scattered water quality information was found in government offices, universities, and research institutes in various reports but they were often not available in a form suitable for analysis. The utility of this information is further limited by frequent restrictions on accessibility. The data that were available in reports were presented in different formats, generated by different measurement techniques, and were often not subjected to quality assurance programs.

One of the most useful data sets available was the comprehensive water quality information system that was developed through a joint project of the University of Michigan

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and the Academy of Scientific Research & Technology (ASRT) in 1978. The Water Quality Data Bank was housed at the National Research Center, equipped with modern computer facilities, and staffed with qualified, experienced personnel. This center no longer exists. All activities were terminated after external funding was exhausted. A complete set of the collected data can be found only at the University of Michigan in the United States.

Water quality data, and information on associated surveillance and monitoring programs were found at several institutes. These institutes were visited and the responsible persons were interviewed.

D. The Ministry of Public Works and Water Resources

The Ministry of Public Works and Water Resources (MPWWR), formerly the Ministry of Irrigation, has traditionally been in charge of Nile flow control. It focuses principally on irrigation water service and management of the complex system of dams, barrages, canals, drains, and pumping stations. In collaboration with corresponding agencies in Sudan, and to a lesser extent with other riparian countries, MPWWR was instrumental in developing and implementing River Basin Agreements defining Egypt's share of the River Nile flow. As the only government agency concerned solely with water resources in Egypt, responsibilities of MPWWR include water planning and management, water allocations, and the development, operation, and maintenance of the irrigation and drainage systems.

The construction of the Aswan High Dam, completed in 1968, was one of the MPWWR's great achievements. This major hydraulic intervention significantly changed both upstream and downstream river conditions. Subsequently, campaigns against the Aswan High Dam generated controversy about the effects of these changes and policy and decision makers became interested in Nile River water characteristics and changes brought about by the High Dam. By authority of Presidential Decree No. 830 issued in 1975, the MPWWR established the Water Research Center (WRC), which includes four general departments and 12 research institutes, to address these issues and to more effectively manage Egypt's water resources.

WRC has developed general water resource plans and undertaken numerous specific studies relating to the management of Nile resources. Highly qualified professionals have conducted these activities, aided by international organizations providing strong technical expertise, and impressive results have been achieved in specific areas.

Water quality studies have been undertaken in connection with agricultural development, particularly in reuse of agricultural drainage water. Water quality monitoring programs have developed information on the Nile and on drainage and point source discharges from industrial plants. Groundwater quality data have been collected as part of specific studies. However, budget uncertainties, lack of technical personnel, ineffective communications, and organizational constraints within both MPWWR and other governmental organizations hamper effective management, integration, and implementation of water-related programs.

While MPWWR allocates irrigation supplies, it does not allocate water for municipal, domestic, or industrial use. These supplies are taken as required, based on municipal needs as determined by the constructing agency, by individual domestic users, and by villages and industries as needed.

MPWWR is responsible for establishing and enforcing waste discharge requirements under Law 48, the Water Pollution Control Act of 1982, through a committee comprising concerned agencies. However, since the law sets standards which are essentially unenforceable, little action has been taken. Many industries are in violation of discharge requirements.

SECTION III
WATER SUPPLY AND USE

A. Present Conditions

Egypt, at the lower end of the Nile Basin, is entirely dependent on waters originating outside the country. Egypt achieved relative water supply stability through the 1959 Nile Water Agreement with Sudan, which allocated 55.5 billion cubic meters per year (bcm/yr) to Egypt with completion of the High Aswan Dam in 1968. The active storage capacity of 130 bcm in the Aswan Dam Reservoir provides multiple year carryover to meet Egypt's allocation and Sudan's allocation of 18.5 bcm, and absorb the estimated annual evaporation loss of 10 bcm. The dam gives complete control of the Nile below Aswan. However, fluctuations in annual inflow created by climatic variations over several years have already reduced yields. Similarly, Egypt's share of the Nile may be subject to potential actions by upstream riparian countries.

The current and projected water supply use and disposal of the Nile Valley, Delta, and associated groundwater resources is shown in Table 1 for conditions in 1990 and the year 2000. These values are based on "Egypt's Water Resources Management and Policies" presented to the World Bank on June 24-28, 1991, by the MPWWR.

It must be stressed that values of current supply and demand, with the exception of Aswan Dam releases, drainage quantities reused, and outflow to the Northern Lakes, are estimates based on limited data. These estimates are limited to major water use categories such as irrigated area, agricultural diversions, groundwater pumpage, and municipal and industrial diversions. The values have been reoriented and interpreted to reflect common categories of supply, use, and disposal, and to permit identification of items particularly significant for environmental and water quality management for 1990 and projections for the year 2000. They represent the latest figures which could be found, to the extent possible, reflecting official Egypt water policies.

The 1990 population of Egypt was 56 million people, 95 percent of whom occupy the Nile Valley and Delta which comprise only 3.4 percent of the land area of Egypt. The net water supply to this area, which is the agricultural and industrial base of Egypt, is 54.0 bcm, the present normal release from the dam. The current ground water pumpage of 4.5 bcm is recharged from the River Nile and from infiltration of diversions and water applications. Minimal groundwater is exchanged with the surrounding deep aquifers. Rainfall, declining from a maximum of 200 mm/yr at the coast to about 20 mm/yr near Cairo and to less than 5 mm/yr in Upper Egypt, is an insignificant water source in the Nile Valley and Delta.

TABLE 1
RIVER NILE WATER SUPPLY USE AND DISPOSAL
BCM/YR

ITEM	1990 ACTUAL	2000 PROJECTED	2000 PROBABLE
NET WATER SUPPLY-River Nile at Aswan	54.0	57.5	55.5
WATER DIVERSIONS-EXTRACTIONS			
Agriculture	66.8	66.7	67.9
River Nile and Canals	59.1	56.3	58.5
Groundwater	3.0	3.4	3.4
Planned Drainage Reuse	4.7	7.0	6.0
Unofficial Reuse	2.0	2.0	2.0
Municipal-Domestic	3.7	4.4	4.4
Surface Water	2.2	2.9	2.9
Groundwater	1.5	1.5	1.5
Industrial	4.6	7.9	7.9
Evaporation	2.0	2.0	2.0
Navigation	1.8	0.3	0.5
TOTAL	78.9	81.3	82.7
DRAINAGE AND WASTE DISCHARGES			
Agricultural Drainage	19.0	17.6	20.0
Municipal-Domestic Discharge	1.5	1.8	1.8
Industrial Discharges	4.4	5.4	5.4
Cooling Water	2.9	3.3	3.3
Industrial Process Waste	1.5	2.1	2.1
TOTAL	24.9	24.8	27.2
CONSUMPTIVE WATER USE AND DISPOSAL			
Agriculture	34.5	42.2	38.5
Municipal-Domestic	2.2	2.6	2.6
Industrial	0.2	0.4	0.4
Drainage Outflow	12.8	8.5	11.0
Evaporation	2.0	2.0	2.0
Navigation	1.8	0.3	0.5
Fayoum Sink	0.5	0.5	0.5
TOTAL	54.0	56.5	55.5

Source: MPWWR

At the Delta Barrage below Cairo the average annual flow is about 33 bcm, a net reduction of about 21 bcm from Aswan, reflecting the extensive agricultural diversions, and return flows in the Nile Valley, the export diversions and the municipal and industrial use in and above Cairo. At Cairo, flows range from about 70 million cubic meters per day (mcm/dy) during the closure period to 160 million mcm/dy in summer, averaging 90 million mcm/dy, compared to the peak releases at Aswan of about 240 bcm.

The following tabulation shows proportionate consumptive water uses and disposal and forecasts for the year 2000.

USE	PERCENT OF USE	
	1990	2000
Irrigated agriculture	64	75
Municipal-domestic	4	5
Industrial	<1	<1
Navigation	3	<1
System evaporation	4	4
Drainage outflow	25	16

In 1990 nearly 93 percent of the Nile's net water use was for agriculture, including 64 percent consumptively used by crops, with another 29 percent indirectly allocatable to agriculture for drainage outflow and evaporation, irrigation distribution channels, and drains. Only 7 percent is used for municipal, domestic, industrial, and navigation needs combined.

Nearly 79 bcm of water is diverted from the Nile system or pumped from groundwater compared to the net supply of 54 bcm, showing that more than 46 percent of the Nile supply is used at least twice in the more than 1,150 km journey from Aswan to the Mediterranean Sea. Presently, irrigation on 7.4 million acres of land requires a gross supply of 66.8 bcm; municipal and domestic use, 3.7 bcm; and industrial use, 4.6 bcm. Navigation needs from October to January require a 1.8 bcm release from the Aswan Dam. Estimated evaporation losses from waterways, lakes, distribution channels and drains are 2.0 bcm. Agriculture diverts 85 percent of the total water; municipal and domestic use, 5 percent; industrial use, 6 percent; navigation, 2 percent; and evaporation, about 3 percent. However, agriculture consumes 34.5 bcm or 64 percent of the net water supply while domestic and industrial municipal consume 4 percent and less than 1 percent, respectively. Drainage outflow, which comprises about two-thirds drainage from irrigated lands and one-third from municipal and industrial waste discharges, makes up 25 percent of the consumptive water use and disposal. Thus, 38.9 bcm or 72 percent of the net supply is consumptively used.

An estimated 24.9 bcm of agricultural drainage and municipal and industrial waste discharges, which have been used at least once and degraded by that use, are returned annually to the system, generally untreated, to remove or neutralize pollutants.

Currently Egypt has an adequate supply of water. However, present levels of reuse and lack of waste treatment suggest the usability of this supply is diminishing.

B. Future Requirements

The Government of Egypt has established policies and actions to the year 2000 covering water resource requirements and proposals for supplying those requirements. Water supply, use, and disposal estimates are shown in Table 1.

By the year 2000, Egypt's population is expected to be 70 million people if the net growth rate of 2.4 percent and active efforts to reduce disease and improve health standards continue. The population will continue to be concentrated in the Nile Valley and Delta. The plan is to increase acres under irrigation by 1.6 million to a total of 8.8 million. Extensive irrigation distribution, drainage, and farm management improvements are also planned.

Egypt water plans include resumption of construction and implementation of the first phase of the Jonglei project in the Sudd Region of Sudan to channelize the Nile and drain extensive swamps, saving 4.0 bcm of water each year, of which 2.0 bcm would accrue to Egypt, providing a firm water supply of 57.5 bcm. Planned reuse of drainage flows would increase from 4.7 to 7.0 bcm.

Irrigation diversions would decrease to 66.7 bcm, reflecting the increased water needs of the additional land, which would be offset by reduced diversion needs from improved irrigation efficiency. Municipal-domestic and industrial needs would increase by 19 and 72 percent, respectively. Navigation requirements would be decreased to 0.3 bcm through improvements to the Esna Barrage and other measures to improve water level control and provide for water storage in Lake Burullus for later use. Total diversions and extractions from the Nile system would increase by 3 percent while the supply would increase by 6 percent. The amount of water used at least twice would increase by 5 percent.

The amount of waste discharges and drainage would remain about the same, because of increased irrigation efficiency and less agricultural drainage from existing land, offsetting drainage from new irrigated lands. The drainage would contain a measurably higher concentration of salts, pesticides, and nutrients. Significantly, the municipal and industrial process discharges will stress the ability to maintain adequate quality. If untreated, pollution in the river system would greatly increase, posing substantial risks to the water environment.

In the year 2000, 93 percent of the water would be used for agriculture, with a net increase of 12 percent for consumptive use and a decrease in drainage outflow of 11 per cent, leaving 7 percent for municipal, domestic industrial, and navigation combined.

The data in Table 1 demonstrate that Egypt would have an adequate water supply under development proposed in the year 2000 if the additional supplies and increases in irrigation efficiency are realized and, most importantly, if adequate water quality is maintained.

However, the water supply available to Egypt by the year 2000 is not expected to include increased supply from the Jonglei project. While Egypt is anxious to restart construction, political conditions in Sudan remain unfavorable. Moreover, environmental

consequences of channelization have not been thoroughly reviewed and may further impede implementation.

While Egypt has embarked on an ambitious program to increase irrigated lands, progress to date suggests that considerably less land than planned will be put into cultivation by the year 2000. Currently about 100,000 acres of the 1.6 million acres of new land planned has been put into production since 1990. About 700,000 acres of new irrigated lands, a very sizable increase, may be realized by the year 2000. Increases in average irrigation efficiency to about 70 percent are sought, but experience to date suggests that hopes of raising the average efficiency above 60 to 65 percent are optimistic.

The combination of these factors results in the water supply and use evaluation shown in Table 1, year 2000. Under these conditions, Egypt is unlikely to have sufficient water of adequate quality. Diversions for irrigation would remain high due to increased irrigated lands and continued low water-use efficiency.

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SECTION IV
WATER QUALITY

This section of the report is a summary of water quality and the status of pollution of surface and groundwaters in Egypt. It includes an overview of sources of pollution and projections of future trends.

A. Surface Water

A1. The Aswan High Dam Reservoir

Since the construction of the Aswan High Dam, the river quality in Egypt has had to depend primarily on the water quality and ecosystem characteristics of the Aswan High Dam Reservoir and less on water quality of the upper reaches of the Nile. Since 1964, the source of the Nile in Egypt has been the reservoir, which has an area of about 5,000 km^2, a total capacity of approximately 164 bcm and a residence time of about two years. The water released from the dam generally exhibits the same seasonal variations and the same overall characteristics from one year to the next.

Water quality management of the Aswan High Dam Reservoir should be an integral part of a comprehensive river management program in Egypt. This should include monitoring of the water quality and ecosystem characteristics of the reservoir at different locations south of the dam.

The quality of water released from Aswan High Dam Reservoir reflects the combined effects of the watershed area, upstream uses, pollution loads, multi-year storage, and mixing and evaporation in the reservoir. There is little current development around the reservoir. Water quality data for the reservoir are almost totally lacking, except for a few analyses of mineral and biological quality. The mineral quality is remarkably good with a Total Dissolved Solids (TDS) of less than 200 parts per million (ppm). TDS appears, as expected, to have increased slightly from 1977 to 1986 with a decline in inflow and storage. From 1986 to 1991 the change was more than reversed with an increase in inflow and storage. Biological production is low. Stratification occurs as demonstrated by low dissolved oxygen levels sometimes recorded in water discharged from Aswan from the low level outlets. Development around the lake would contribute to organic loading, would likely increase biological productivity, and would expand the zone of low oxygen levels.

A2. River Nile-Aswan to Delta Barrage

Only limited water quality data exist for the River Nile from Aswan to Cairo. Mineral quality, BOD, suspended material, coliform data, and nutrients are available for some locations along the Nile, for a few municipal and industrial discharges to the Nile, and for most drains discharging into the Nile. These data are available for some locations for

one or more times during the years from 1975 to 1991. Table 2 lists 34 water quality monitoring sites from the Aswan High Dam to the Nile Delta that were used to summarize available information on river water quality during this time period. Insufficient data are available to effectively define temporal or spatial relations, pollution loading, or specific problems.

Since the construction of the High Aswan Dam, the quality of the River Nile below Aswan has reflected the uniform quality of stored water and of managed releases, both seasonally and from year to year. The releases exhibit occasional low dissolved oxygen. Figures 1-4 show typical past and present quality in the River Nile.

Downstream changes occur in river water quality and hydrobiology. Water quality generally declines and primary productivity increases as the river travels north. The changes result from the major diversions, mostly for irrigation, the resulting irrigation return flows, treated and untreated municipal waste discharges, untreated industrial waste discharges, and different hydrodynamic conditions regulated by six Nile barrages in the 960-km, 10- to 12-day river journey from Aswan to Cairo. The changes are more pronounced as the river passes the densely populated urban and industrial centers at Cairo and in the Delta.

Between Aswan and El Khassas, 40 km south of Roda Island in Cairo, an estimated 21 bcm of water are diverted from the river directly or by main canals or groundwater pumping. About 4 bcm of irrigation drainage, industrial, and municipal waste is returned through the 72 major drains or directly to the river. The present TDS increases on the order of 40 ppm suggest some storage of dissolved salts in the system, probably into storage in waterlogged areas, which have increased since regulation of the Nile by the dam, and infiltration into shallow groundwater. Dissolved oxygen levels are at or near saturation in much of the river. BOD loading in the river from industrial waste discharges, particularly the sugar refineries, and from major cities creates high peaks immediately downstream with some reduction in dissolved oxygen, but assimilative capacity is sufficient for dissolved oxygen to recover within a few kilometers. Fecal coliform peaks increase up to 5,000 MPN/100 ml or more downstream from major municipal waste discharges and some drains and decline to levels of 200 to 1,000 mpn/100 ml in intervening reaches. These levels indicate a relatively high degree of bacterial contamination. Recent benthos data (1991) indicate some heavy metals, including chromium, in the reach between Nag Hammadi and Assuit.

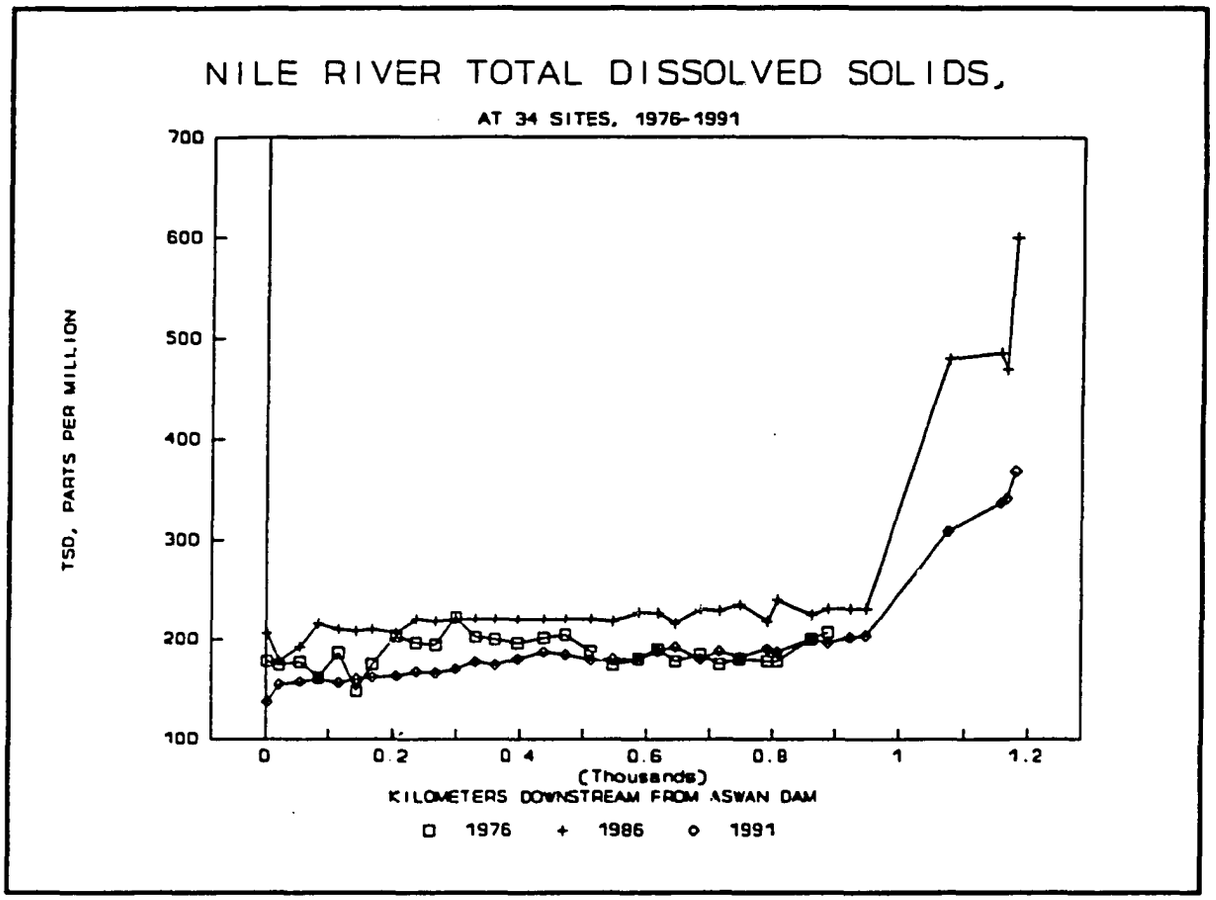
A comparison of water quality data and an evaluation of waste loadings in 1977, 1986, and 1991 suggest that while quality has slightly deteriorated, the river from Aswan to Cairo remains healthy and suitable for present beneficial uses, with some exceptions. The high fecal coliform counts should restrict water contact and suggest careful treatment for domestic use.

The TDS at Aswan was less in 1991 than in 1977, but it remained the same at El Khassas, reflecting increased irrigation use and waste disposal. Dissolved oxygen levels

TABLE 2
NILE RIVER WATER QUALITY MONITORING SITE LOCATIONS

Site No.	KM. from Aswan	Location
1	1.40	ASWAN
2	21.00	
3	53.80	
4	83.40	
5	114.50	IDFU
6	143.05	
7	167.65	ESNA BARRAGE
8	206.90	
9	236.80	
10	268.15	NAGA HAMMADI BARRAGE
11	299.20	
12	331.10	
13	361.00	
14	397.00	
15	438.55	SOHAG
16	472.00	
17	512.00	
18	547.40	ASSIUT BARRAGE
19	587.00	
20	618.65	
21	646.00	
22	686.05	MINYA
23	716.60	
24	748.00	
25	792.40	
26	807.80	BENI SUEF
27	862.00	
28	887.95	
29	921.80	CAIRO
30	947.00	
31-Rosetta	1075.00	
32-Rosetta	1156.50	EDFINA
33-Damietta	1166.00	
34-Damietta	1180.00	DAMIETTA

Figure 1



declined about two ppm from 1977 to 1991, while total BOD loading increased from around 500 tons per day in 1977 to possibly 1,000 tons per day or more in 1991. There were similar increases in nutrients.

Between 1990 and the year 2000 the river's TDS is expected to rise slightly with increased irrigation use and efficiency. Increased population and need for municipal water supply and waste disposal will cause an increase in BOD loading and an attendant decrease in dissolved oxygen unless advanced waste treatment facilities, now planned but unfunded, are constructed. Industrial water use and untreated waste discharges will increase unless measures are taken soon to treat critical discharges. A 50 percent increase in BOD loading, further reducing dissolved oxygen levels, may be anticipated in the absence of additional treatment. Nutrient levels and biological productivity would increase, tending to decrease the diversity of species. Under these conditions this stretch of the river would still be usable for most beneficial uses, but would be a less suitable supply for downstream users. Quality may be poor near major waste discharges.

In the strech from El Khassas to the Delta Barrage, there are major changes in both quantity and quality. There are diversions for export to Ismailia and the Suez area, for

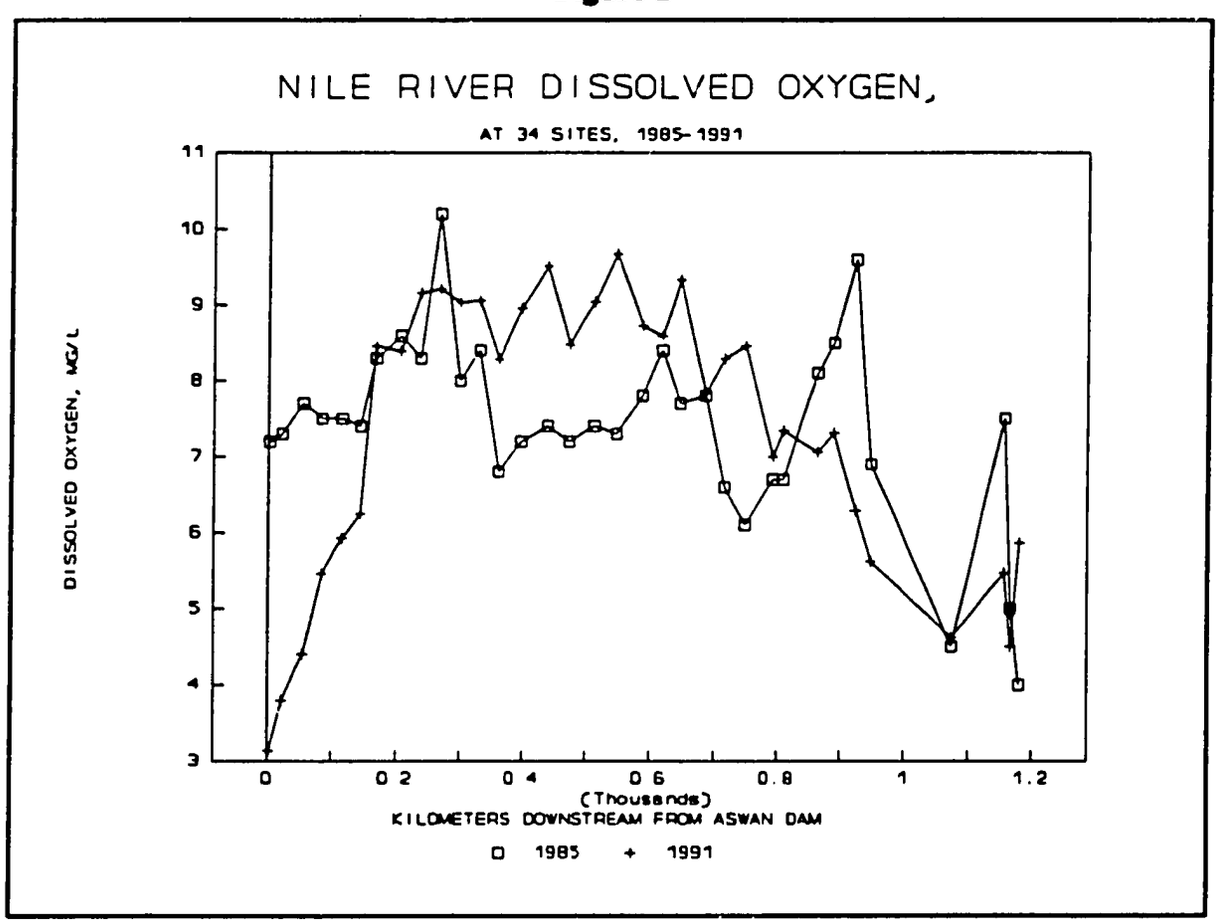
municipal use in Cairo, and for downstream irrigation. The partially treated municipal wastes from Cairo and generally untreated industrial wastes from the Cairo area, including Helwan and Shoubra El Kheima, reach the river or are discharged to Bahr el Baqar and other drains to the Delta.

Waste discharged to the river from Khassas to the Delta Barrage is readily diluted and usually accompanied by water quality deterioration immediately downstream from the waste outfall. The accumulation of toxic substances like heavy metals in sediments near industrial outfalls is also prevalent. High sediment concentrations have been reported at the beginning of the Ismailia Canal and at Kafr El Zayat.

The river in this stretch demonstrates the effect of the increased diversion and urbanization and industrial activity. Salinity increases by about 30 ppm. However, dissolved oxygen remains near the saturation level. Nutrients increase, as do fecal coliforms. Significantly, limited data show high levels for chromium and manganese and lower levels for copper and lead, reflecting the untreated discharges from chemical plants, tanneries, and possibly textile plants. Other toxic materials are probably present but they have not been analyzed.

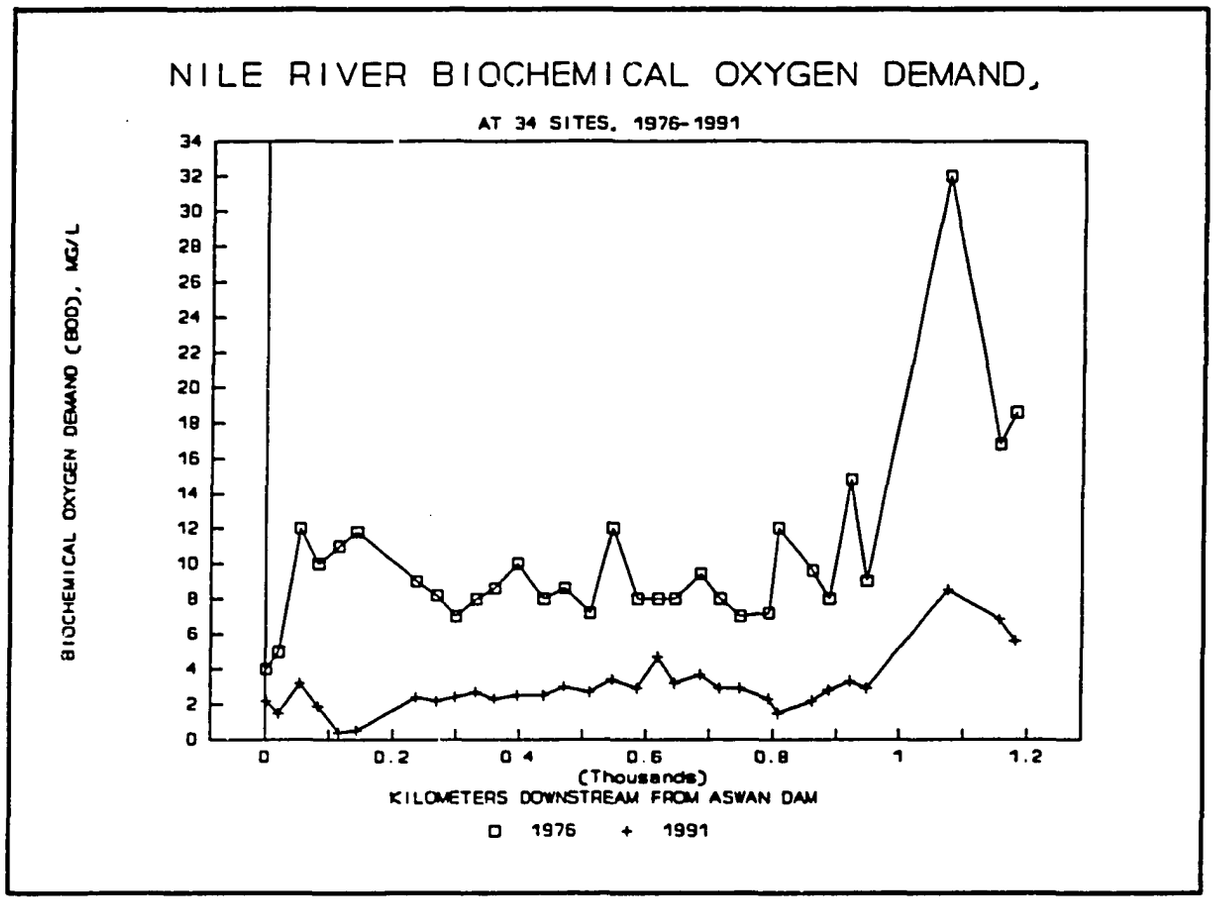
By 1996, Cairo is scheduled to have secondary treatment in place for all municipal wastes, including pretreatment of industrial wastes. Nile water quality should benefit

Figure 2



20

Figure 3

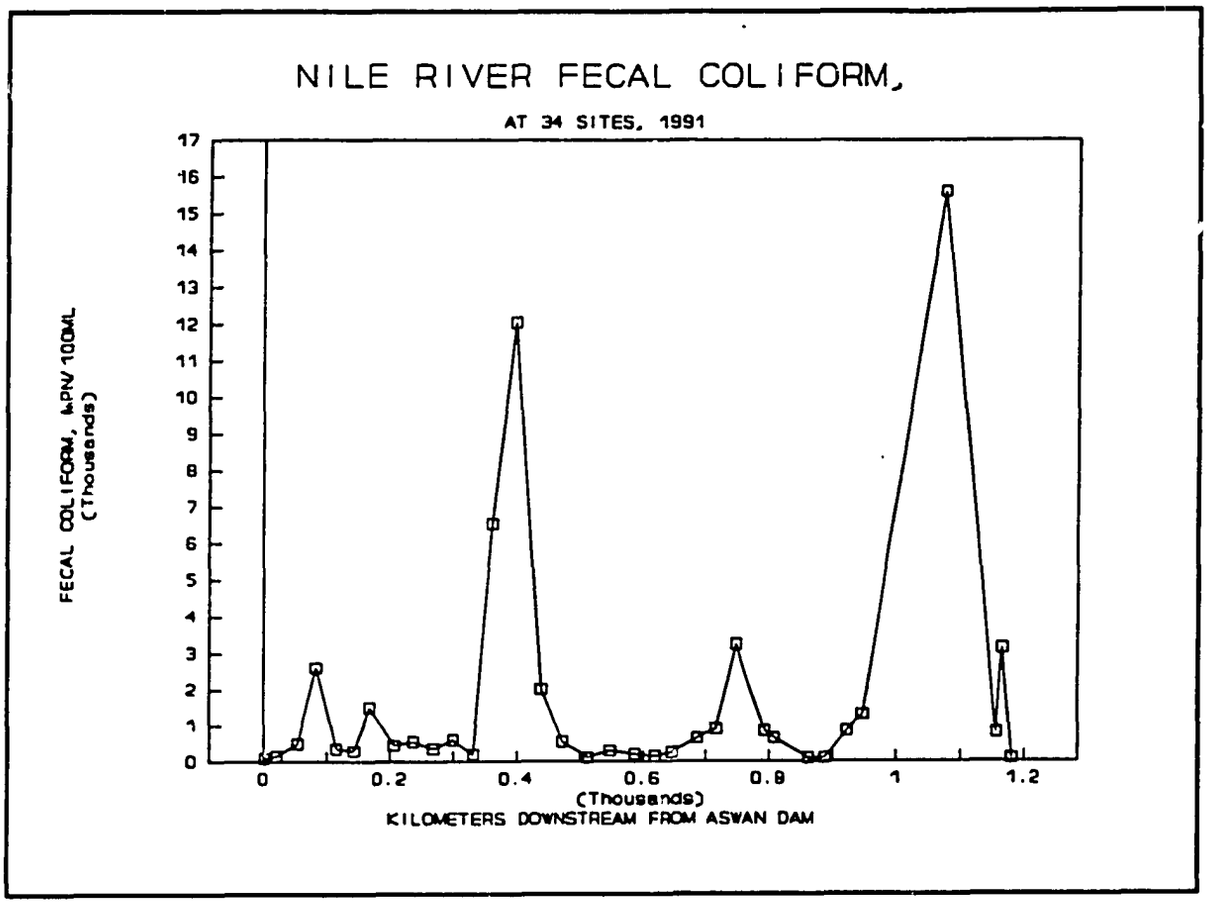


significantly from that action. However, the heavy metals previously deposited will remain for long periods in the sediments, continuing to accumulate in fish and threatening the health of humans who consume the fish. Furthermore, continued discharge to the drains will continue to degrade conditions there and in Lake Manzala, which receives the discharge from Bahr El Baqar.

A3. Nile Delta

The Nile Delta quality reflects the effects of upstream depletion, return flows, and waste discharges. At the Delta Barrage, the water supply of about 33 bcm with an average salinity of about 225 ppm is distributed to the Damietta and Rosetta Branches for distribution throughout the Delta, primarily for irrigation. About 3.4 bcm with an average salinity of 1,168 ppm of the estimated 18 bcm of drainage water produced is officially reused and farmers unofficially pump some 2 bcm from drains. About 12.8 bcm of water with an average salinity of 3,000 ppm is discharged to the Northern Lakes and to the sea. Another 1.8 bcm of water released for navigation discharges directly to the sea. The drains receive treated and untreated domestic wastes from Cairo and Delta cities and towns and untreated industrial waste from within the Delta. Drainage water adds nutrients which promote algal and hydrophyte production. Pesticide residues, depending on persistence and concentration, accumulate in fish.

Figure 4



Limited samples indicate wide ranges of pollutant concentrations in the branches and a few canals that are monitored. BOD levels up to 100 mg/l and fecal coliform mpn of 1,500/100 ml have commonly been observed.

There is a general increase in primary production as the river travels north due to the cumulative effects of agricultural and human waste inputs. Eutrophic conditions occur in the northern Delta as the river velocity is greatly reduced, and bottom anaerobic conditions sometimes occur during the summer at Edfina and Faraskour.

The Rosetta Branch has generally higher algal counts than the Damietta Branch, where hydrophytes predominate during spring and summer. Total algal counts range from 10^4 to 10^5 organisms per liter and may reach 10^6 organisms per liter in the northern Delta. The predominant species are diatoms, except at the ends of the Rosetta and Damietta Branches, where blue-green algal blooms flourish occasionally.

Hydrophytes proliferation in the spring and summer in locations of low river velocity and high nutrient content. Typical examples are found in the river stretch between Mansoura and Faraskour on the Damietta Branch. The main impacts on river use are (a) reduction in commercial fishery, (b) interference with river navigation, (c) mechanical plugging of water intakes and canals, and (d) depreciation of the river's aesthetic quality.

It is believed that some chemicals are still being used to control hydrophytes. However, mechanical removal is widely used and will soon completely replace herbicides.

The riverine fishery throughout the Nile system has been adversely affected following the construction of the Aswan High Dam and downstream ecological perturbations. A reduction in the number of commercially desirable fish species has been recorded in places where river conditions deteriorated (e.g., the northern Delta). Out of the 47 commercial Nile fish species recorded in 1948, only 17 remain. The other species have not necessarily disappeared, but were not found in sufficient quantity to appear in the commercial catch.

Among the various riverine species, Tilapia nilotica constitutes the main commercial fish catch in the Nile. Beginning from Assyut, only 14 species were present, and Tilapia nilotica constituted 60 percent of the total catch. At Cairo, only 13 species were present and Tilapia nilotica constituted 66 percent of total catch. The quantities of Tilapia in the catch did not increase. Rather, other species, such as Schilbe mystus, decreased. In the Damietta Branch, 11 species were recorded and Tilapia nilotica decreased to 10 percent of the total catch. In the Rosetta Branch, 11 species were found and Tilapia nilotica constituted 71 percent of the catch.

Under year 2000 projected conditions, it is expected that inflow to the Delta will decrease to about 30 bcm, Delta use and reuse of drainage water will increase to 7.0 bcm, and the pollution load from domestic and industrial wastes will increase by nearly 40 percent. This would result in a Delta outflow of about 9.0 bcm with a salinity approaching 4,000 ppm and significantly increased pollution loads to the Northern Lakes. If expected water development is realized, more Delta outflow would decrease salinity to about 3,500 ppm.

The Northern Lakes are the sink for Nile drainage and wastes prior to outflow of some wastes to the sea. The lakes receive the drainage water from the Nile Delta and major inputs of municipal and industrial waste from Cairo, Alexandria, and other areas.

Lake Maryut receives sewage from Alexandria, drainage and domestic and industrial waste from four major Delta drains, and wastes directly from about 40 industrial plants in addition to 22 identified plants discharging to the drains. Mercury levels of 1,295 ppm have been reported in fish from the lake although the circumstances are not clear. BOD levels of 2000 mg/l and oil and grease levels of 2000 mg/l have been found in the waters and mercury levels of 30-90 mg/l and chromium levels of 50 to 200 mg/l have been found in bottom sediments.

Lake Manzala receives the drainage and wastes from Cairo via Bahr El Baqar, from Hadous and Ramses Drains, and from Port Said and Damietta. The lake remains aerobic except near discharges and supports an extensive commercial fishery. Heavy metal concentrations including cadmium, copper, and zinc are reported to be high.

Studies are underway now to develop means to improve lake quality. However, future decreased inflow, increased salinity, and more discharge of industrial and municipal wastes, although some may be treated, will continue to tax the quality of these resources.

Furthermore, existing heavy metals in the sediments will remain for long periods, threatening the fishery.

B. Groundwater

Groundwater in the Nile Valley and Delta is an important resource for both irrigation and domestic water supply, particularly for villages.

The Nile alluvium is in direct hydraulic contact with the River Nile. It is replenished from the River Nile, by excess irrigation water (subsurface drainage) and seepage from the irrigation distribution system and from drains. Rainfall is insignificant except for recharge that occurs in the northern sand dunes along the coast. The main sources of discharge from the alluvium are the seepage to the river, upward saline water flow to the clay-silt (north Delta), and groundwater abstraction for various purposes.

The aquifer transmissivity ranges from 5,000 to 25,000 m^2/day in the Valley and from 10,000 to 50,000 m^2/day in the Delta. Aquifer storativity varies greatly according to the type of aquifer (from 0.1 for unconfined conditions to about 0.001 for semi-confined conditions). The hydraulic resistance of the top silt-clay layer to vertical flow also varies greatly, with averages of about 800 days in the valley to 1,500 days in the southern part of the Delta. Groundwater flows mainly in the south-north direction and toward the river in the area close to the river.

The main pollutants involved in groundwater contamination are pathogens, nitrogen compounds, and dissolved salts. The salinity of the groundwater in the Delta increases from Cairo to the Mediterranean Sea. Salinity in this region ranges from 500 ppm near Cairo to 30,000 ppm close to the sea. In general total dissolved salt levels increase from south to north and also with respect to the depth of the water. The dissolved salt levels found in groundwater differ slightly from concentrations found in irrigation water. Decreases in Ca and Mg with respect to Na and K and an increase of SO4 and Cl with respect to HCO3 are observed.

Pollutants of concern, in addition to total dissolved salts, are nitrogen compounds (nitrates, nitrites, ammonia, etc). Nitrogen enters the groundwater when it is leached from agricultural fields in the drainage water. The level of contamination depends on the hydrogeologic conditions and vulnerability of groundwater to pollution.

Groundwater quality in the old land is not characterized by excessive levels of nitrates or ammonium. Groundwater in the northern Delta is not suitable for use due to its high salinity. Iron and manganese are randomly distributed in the groundwater of the old land. The WHO guideline for manganese is often exceeded, particularly at shallow depths. Most of the free iron concentrations are below WHO guidelines. Release of iron from clay sediments may be the source of this contaminant.

The reclaimed lands are noted for their sandy soils. Groundwater from sandy areas typically has high nitrate concentrations and lacks ammonium. The manganese

concentrations are lower than those in the old lands. Free iron concentrations generally do not exceed WHO guidelines but are higher than those in the old lands.

Most Egyptian villages have neither wastewater collection nor treatment systems. Onsite disposal, which relies on the dissipation of the domestic wastewater through a leaching pit, is the most common practice. Recently, the Egyptian Government provided a large number of villages with piped drinking water, without providing for the collection and the disposal of the wastewater. The generated wastewater commonly exceeds the capacity of the onsite disposal facilities. The outcome is that a large number of villages are chronically flooded with sewage effluent, causing contamination of groundwater and surface water. Results of recent surveillance programs indicate widespread fecal contamination of groundwater in the Delta.

Domestic sewage may also contaminate groundwater in urban areas. This is more likely to occur in urban areas with sandy or thin upper soils. In areas with sewage penetration of groundwater, there is a corresponding increase in nitrate concentrations. Groundwater in urban areas where a thick clay-silt layer protects the aquifer has low nitrogen levels.

Pesticides have been noted in several agricultural areas. Even though polychlorinated pesticides have been banned for more than 20 years, they can still be detected in the groundwater. Organo-phosphates have also been detected in the groundwater.

The groundwater in the area near Mansuriya contains high concentrations of both nutrients and pesticides, probably due to a combination of long-term cultivation and sandy soils. Human activities already affect the nitrate and organo-phosphate concentrations, which are on the same order of magnitude as in the Mansuriya area.

The higher concentrations of ammonium in deeper groundwater indicate denitrification. Total phosphate concentrations remain low in all situations, probably due to strong adsorption by the soil. The thick layers of clay prevent a serious migration of pollutants to the aquifer near Benha, with probable adsorption and cation exchange being the responsible processes.

The type and extent of pollution from agricultural activities is typical of aquifers in the Nile floodplain.

- High levels of fecal coliform in much of the shallow groundwater, the main domestic water supply in the Delta area.

- High levels of fecal coliform in the urban areas with sandy or thin upper soils (Beni Suef, Abu Rawash, Giza) and slightly higher nitrate concentrations in these locations.

- Low to medium levels of fecal coliforms in sandy areas with wastewater drains and wastewater irrigation (Belbeis and El Gabal El Asfar). High nitrate concentration in these areas.

- Low levels of contamination with both fecal coliform and nitrate in urban areas with a thick covering clay-silt layer and extraction from greater depths (Shibin El Kanater and Imbaba).

Previous investigations in Egypt by the Research Institute for Groundwater show similar results in groundwater quality in urban areas. Most of these investigations indicated a sharp decrease in fecal coliform with depth in both unconfined and semi-confined aquifers. Fecal coliform generally survives for less than a year in groundwater due to the low velocity of groundwater flow. Under phreatic (unconfined) conditions, the travel time to the aquifer is shorter, but the relatively long exposure to air increases die-off rates.

SECTION V
MUNICIPAL AND DOMESTIC WASTES

A. Present Conditions

In addition to greater Cairo with an estimated population of 16 million, about 60 cities lie within the Nile system in Egypt with a total population of about 13 million and individual populations of 50,000 to 1 million. About 40 of them have sewer systems and primary or secondary treatment plants existing or under construction. The current discharge from these cities, excluding Cairo, is about 0.5 bcm. A number of these plants are reportedly not operating or operating poorly because of overloading, shortage of parts and equipment, or lack of trained operating personnel. The reported capacity of the existing and planned plants, excluding Cairo, is about 2.8 mcm/day. Most of these plants discharge to lakes or to drains whose water flows directly or indirectly to the River Nile and distribution channels or the drainwater is reused for irrigation.

Cairo has six treatment plants operating or under construction with a design capacity reported to be about 2,850 mcm/day. Currently three secondary treatment plants are operating and three primary plants are being upgraded to secondary treatment with completion scheduled for 1996. Because of plant overloads and other operational problems, raw and partially treated wastes are discharged. These plants, when completed, will accept industrial wastes. Discharge totalling about 1 bcm flows to Mohit Drain, to drains leading to the Nile River or to Bahr El Baqar, and is used for irrigation.

Egypt's rural population of about 31 million people live in an estimated 4,300 villages with populations ranging up to 30,000. The majority of these are in the Nile Valley and the Delta. An estimated 95 percent have access to neither sewer systems nor treatment facilities. The population depends on onsite disposal using a leaching pit adjacent to the house or on direct discharge of raw sewage to drains and canals using buckets. The pits are periodically emptied and the contents commonly dumped into nearby drains or canals. Presently an estimated 0.3 bcm of high strength raw sewage and pit sludge infiltrates to shallow groundwater, and is discharged to drains or canals or directly to the Nile. Since the early 1980s, a program to develop viable village waste treatment facilities has been underway through NOPWASD with USAID sponsorship.

Domestic water in larger villages is supplied by deep wells and in some cases by surface water. Most smaller villages derive their supply from shallow wells. The water receives little or no treatment and is subject to contamination from seepage of raw sewage and sullage water discharged near the house, by infiltration from leaching pits, or by direct hydraulic contact with shallow groundwater, particularly in the Delta. In the Nile Valley about 100 mcm/yr is extracted from shallow wells and about 190 mcm/yr from deep wells for domestic use. Within the Delta the corresponding quantities are 275 and 415 mcm/yr, respectively.

Equally significant is the exposure of edible crops and agricultural workers to the domestic wastes discharged to canals and drains through projects where the drainwater is generally diluted, but particularly for unofficial use where the water is directly used.

Little information is available concerning the quality of the 1.8 bcm of treated and untreated domestic waste discharged within the Nile system. TDS levels of the sanitary sewage range from about 250 to 500 ppm. BOD concentrations of raw sewage are on the order of 900 to 1,000 mg/l while concentrated sludge from pits may range up to 5000 mg/l. Since many treatment plants produce inadequately treated and disinfected wastes, the quality of waters reaching groundwater, the drains, and the Nile is poor. Fecal coliform counts up to 20,000/100 ml may be detected in drains receiving domestic wastes signifying high levels of viral and bacterial infectious agents and parasites. Within Upper Egypt, an estimated BOD loading of 500 tons per day from domestic wastes from cities, towns, and villages reaches the River Nile, while in the Delta the loading may also reach 500 tons per day, excluding Cairo discharge to Bahr El Baqar which is about 300 tons per day.

In the stretch from Aswan to Delta Barrage much of the domestic waste water from cities, villages, and individual houses reaches the river directly or through drains. Much of Cairo's wastewater is discharged to tributaries of Bahr El Baqar, where it reaches the Northern Lakes after a 170-km journey. The remainder is used directly for irrigation or is discharged to Mohit Drain and thence to the Nile. Cities within the Delta discharge to the drains, where the waste is reused in irrigation projects, reaches the Damietta and Rosetta Branches of the Nile, or is discharged to the Northern Lakes. Rural wastes in the Delta are discharged to the shallow groundwater via leaching pits or direct disposal to the ground, or are discharged directly or as concentrated sewage sludge from leaching pits to the drains or to the canals.

Currently, dissolved oxygen levels in the Nile and major drains, based on limited information, remain at or above 5 mg/l during much of the year, indicating that the assimilative capacity is generally adequate under present conditions. However, during the annual winter closure, dissolved oxygen levels in some drains and in the Damietta and Rosetta Branches may dip below 4 mg/l for short periods.

B. Future Needs

By the year 2000 when the population is expected to reach 70 million, with urban area population estimated at 34 million or 49 per cent of the total, secondary sewage treatment is expected to operate in the major cities, including Cairo. Some 116 treatment plants for cities and towns are projected for construction by NOPWASD. The urban areas within the Nile system may reach a population of 31 million. With increasing capability in the operation and management of treatment facilities, many of the plants are expected to produce effluent meeting secondary standards, including BOD removal and disinfection, although some primary treated water and discharges from inoperative or poorly operating plants are expected to reach the Nile.

However, the rural areas, including villages and small towns, are still expected to rely heavily on household systems with attendant disposal to shallow groundwater and to both canals and drains with little BOD removal or disinfection. BOD loading is expected to be about 800 tons per day divided equally between Upper Egypt and the Delta.

Domestic wastewater, as the carrier of pathogens and parasites, is the primary source of most of Egypt's water quality problems. However, the long-term prospects for adequate domestic wastewater treatment capacity are very discouraging. The situation is summarized on the next page in Table 3, where domestic wastewater treatment demand and capacity are projected to 1990-2020, using 1986 as the base year. These projections indicate slight excess urban treatment capacity during 1990-2000, with severe rural excess demand, i.e., a serious sewage-borne water quality threat, during the same period. Beyond the year 2000, even urban treatment capacity falls well behind demand. Overall, during the 2010-2020 period, treatment capacity is projected to fall to about two-thirds of treatment demand.

Table 3. Projected Egypt Domestic Wastewater Treatment Demand and Capacity, 1990-2020

		1986	1990	2000	2010	2020
Population Assumptions		Millions (Assuming Annual Growth Rate of 2.7%)				
	Urban	21.2	23.6	30.8	40.2	52.5
	Rural	27.0	30.1	39.3	51.2	66.9
	Total	48.3	53.7	70.1	91.5	119.4
WATER CONSUMPTION						
	Per Capita Assumptions	Liters Per Capita Per Day				
	Urban	165.0	172.0	190.0	208.0	232.0
	Rural	82.5	86.0	95.0	104.0	116.0
	Annual Consumption	1,000 Cubic Meters Per Day				
	Urban	3,501	4,059	5,853	8,364	12,177
	Rural	2,231	2,587	3,730	5,330	7,760
	Total	5,731	6,646	9,583	13.694	19,936
SEWAGE FLOW (Treatment Demand)						
	Per Capita Assumptions	Liters Per Capita Per Day				
	Urban (80% of Water Consumption)	132	137.6	152	166.4	185.6
	Rural (60% of Water Consumption)	49.5	51.6	57	62.4	69.6
		1,000 Cubic Meters of Waste Water Per Day				
	Urban	2,800	3,248	4,683	6,691	9,742
	Rural	1,338	1,552	2,238	3,198	4,656
	Total	4,139	4,800	6,920	9,889	14,397
SEWAGE TREATMENT CAPACITY (Existing and Planned)		1,000 Cubic Meters of Waste Water Per Day				
	Urban	1,147	4,018	5,192	5,738	7,088
	Rural	42	68	118	418	1,518
	Total	1,189	4,086	5,310	6,156	8,606
BALANCE: DEMAND - CAPACITY		1,000 Cubic Meters of Waste Water Per Day				
	Urban	1,653	(771)	(509)	953	2,654
	Rural	1,296	1,484	2,120	2,780	3,138
	Total	2,950	713	1,610	3,733	5,791

2,0

SECTION VI
INDUSTRIAL WASTES

About 650 of the 20,000 industrial facilities in Egypt are major industrial facilities. The great majority of them are publicly owned, with 330 managed by the Ministry of Industry and 120 by other ministries (GOFI, 1992, personal communication). Many publicly owned facilities remove water from the River Nile and discharge liquid waste back into the river or drains that enter the river. In major cities, most industries discharge to sewers, and the treated sewage is returned to the Nile. In western Cairo, a major industrial center, the treated sewage is discharged to Bahr el Baqar, which ultimately enters Lake Manzalla. Most private facilities are located in the new cities away from the Nile and discharge liquid wastes to land. Many others, however, are located in the larger towns and cities and discharge primarily to sewers.

A recent National Research Center study using data in part from GOFI listed 367 facilities in 34 categories. The most numerous facilities were in the following categories:

- Spinning and weaving (80 plants)
- Cotton ginning (30) plants
- Flour mills (25 plants)
- Oil and soap (24 plants)

Over 63 percent of the industries could be categorized as either food-related (grain mills; dehydration plants; macaroni, sugar, milk, and canning facilities) textile-related (textile, spinning and weaving, cotton ginning), or chemical-related (oil and soap, fertilizer, plastics and rubber, pesticides, general chemical). The remaining facilities are heavy manufacturing plants making vehicles, defense products, and other iron and steel products, and plants providing other goods or services such as cement or power.

Excluding cooling water, it has been estimated that public industries have gross water withdrawals of 636 mm3/yr, of which a large percentage is returned to the waterways via effluents (550 mm3/yr). Consumptive water use by industry is thus about 86 mm3/yr, an insignificant amount compared with municipal and agricultural uses. The largest volumes of water use were found in the food industry, with the smallest volumes used in the engineering industries. About 33 percent of the industrial water use occurs in Upper Egypt with the Greater Cairo Area also consuming a major share (25 percent). Industrial facilities in Lower Egypt (excluding Alexandria) use 25 percent of the industrially withdrawn water, and Alexandria industries use 23 percent.

Despite a strongly worded law requiring treatment of all industrial wastes entering the Nile, and its canals, drains, and groundwater (Law 48/1982), the great majority of industries have not yet installed wastewater treatment. Indeed, very little information is available on the concentrations and loads of pollutants from individual facilities. Recent estimates for

public industries managed by the Ministry of Industry suggest that the average concentration of metals in chemical industrial discharges is about 1 mg/l, the standard specified in Decree 8/1983. Since the chemical plant category includes many plants that do not discharge heavy metals, this high average indicates a large number of heavy metal facilities are discharging significantly more concentrated wastes than allowed. This evidence, combined with the fact that more that 74 percent of the metals, 72 percent of the BOD, and 75 percent of the suspended solids are discharged from Cairo north, indicates that industrial facilities are probably substantially affecting the quality of the Nile and its canals in the Delta.

SECTION VII
AGRICULTURAL DRAINAGE WATER

A. Present Conditions

Agricultural drainage constitutes an important and substantial portion of Egypt's water resources. About 30,000 km of irrigation canals and 17,500 km of agricultural drains serve the estimated 7.2 million acres of irrigated land. The drains largely control groundwater levels, particularly in the Delta. At the 1990 level of development, about 28 bcm of drain water, comprising runoff of applied water, water leached through the soil, groundwater, and industrial and domestic wastes, reaches the drains or is discharged to the Nile. About 19 bcm is agricultural drainage.

Most Upper Egypt drains discharge their water into the Nile by gravity. The areas served by these drains are relatively small due to the narrow width of the Nile Valley. Information about these drains is limited. In Upper Egypt about 10 bcm of drainage and waste augment Nile flows and are available for use in the Nile Valley or Delta.

All Middle Egypt drains discharge into the irrigation system (Nile, Bahr Youssef, or Rosetta branch). The main drains are:

- Mohit, extending the total length of middle Egypt, with several outlets to the Nile, ending at Rosetta branch;
- Ben Khaled, serving 11,400 feddans, discharges into Bahr Youssef by gravity;
- Menshat El-Dahan, serving 21,000 feddans, discharges to Bahr Youssef by gravity;
- Dir Tanhoria, serving 50,000 feddans, discharges to Bahr Youssef by a pump station;
- Sakoula, serving 65,000 feddans, discharges to Bahr Youssef by a pump station;
- Mazoura, serving 30,000 feddans, discharges to Bahr Youssef by a pump station;
- Wadi and Batts in Fayoum discharge to Lake Qarun. Drainage in Fayoum does not return to the Nile.

Information regarding the quality of water in these drains is limited.

In the Delta, drainage from 22 catchment areas flows by gravity to drains where it discharges to the Northern Lakes or is pumped by 21 existing reuse stations to canals, mixed with fresh water, and reused.

Nile Delta activities generate an estimated 17.7 bcm of flows to agricultural drains, mixed in varying proportions with domestic and industrial wastes. Under 1990 conditions, nearly 3.37 bcm with an average salinity of 1,167 ppm was reused after mixing with fresh water, while 12.8 bcm was discharged to the Northern Lakes and the sea. Mixing increases the amount of water available by diluting the less saline drainage water, making it suitable for irrigation use. A mixing ratio of about 1:1 is sought with a final quality of 600 to 800 ppm, although in most cases a larger proportion of fresh water is required.

Based on field observations, a conservative estimate of 2 bcm was unofficially reused by farmers withdrawing directly from the drains. This unofficial reuse increases the salinity of the drainage and directly affects the quality of water discharged and reused.

Salinity of the drain water in Upper Egypt exceeds diversion salinity by 150 ppm caused by concentration due to about consumptive use between Aswan and Cairo, soil leaching, groundwater inflow, and municipal and industrial waste discharges. The salinity of 160 to 180 ppm at Aswan increases to about 230 ppm at Cairo. While the salinity increase from Aswan to Cairo is well within acceptable limits, the higher salinity will increasingly limit reuse in the Delta.

Throughout the Nile Delta, the groundwater levels are controlled by drains and some tile drainage. Consequently, the drain flows are a mixture of applied irrigation water, water leached through the root zone, and groundwater reaching the drains by lateral and upward movement. In the northern part of the Delta, the groundwater is saline, resulting in highly saline drainwater, which limits its reuse in these areas.

Salinity of the 12.8 bcm of discharged drainage in the Delta averaged 3,000 ppm, varying from 1,840 ppm in the Eastern Delta, to 2,670 ppm in the Middle Delta, to 4,210 ppm in the Western Delta, where saline groundwater contributes highly saline water. Nearly 7.0 bcm of the remaining unused drainage water is less than 2,000 ppm and is potentially available for reuse under the present level of development after mixing with fresh water. However, the hydrologic, agronomic, and salinity interrelations are complex. A drainage system model has been developed at the Water Research Center that will be essential in forecasting water management and reuse options.

Both unused and reused drain water has become steadily more saline since 1984. In 1984 the reused portions of the drain water had a salinity of 867 ppm; by 1990 the reused portion had a salinity of 1,167 ppm. This trend is also seen in the salinity of the unused drain water.

The drainage system receives untreated domestic wastes from rural systems that illegally dump into the drains, from seepage from contaminated groundwater, or from direct discharge of fecal material and urine. Limited bacteriological tests consistently show fecal coliform counts up to 1,500 mpn/100ml.

Agricultural drainage carries nutrients and pesticide residues. Industrial and domestic waste discharges to the Delta drains contribute organic material, heavy metals, and toxicants.

Nutrients in the drains largely reflect fertilizer application with the unused portions passing through the soil column or as surface runoff from the ends of the fields. Nutrients contribute to eutrophication of drain and River Nile water, while nitrates, particularly in groundwater, may reach concentrations that cause health problems in infants. Nutrient levels in drains currently range from about 0.05 mg/l to 0.5 for PO4 and 0.8 to about 6.0 mg/l for No.3. Values appear to have about doubled since 1977, reflecting increased use of fertilizers and more irrigated land.

In Egypt a wide variety of pesticides are used on agricultural crops, with about 620,000 tons of 200 different types reportedly used since 1960. The persistent organochlorine compounds, while banned in the late 1960s, are still detected in Nile branches and Delta drains. A sample collected in early 1991 after the winter closure period showed DDT compounds of 4.6ng/l. Other samples collected before, during, and after the closure period in a number of drains had DDT compounds of up to 1.5 ng/l, although most were about 3 to 5 ng/l, and in several samples none were detected. Earlier samples in 1979 detected concentrations of 8 ng/l at Cairo and above and 18 ng/l at Kafr El Zlat. Concentrations of 4 to 18 ng/l of various organochlorine compounds were found in Bar Hadous Drain, also in 1979. In 1991 the use of ametryn to control water hyacinths in drains was discontinued and Ametryn to control rooted aquatics will be discontinued soon, after which only physical or biological means will be used.

Organophosphorus compounds are increasingly used, although data on their concentration in receiving waters are sparse. In 1979 concentrations of 0.1ng/l to 28 ng/l were found in the River Nile. Lower concentrations were found in April upstream at Assuit, while the higher concentrations were found in the Delta at Kafr El Zlat in August. In Bar Hadous Drain, also in 1979, concentrations ranging from 10 to 80 ng/l were detected. Although they are much shorter lived in the environment, the presence of these compounds indicates lack of adequate application control and threatens aquatic life.

Few studies have been carried out to monitor the water quality in the drainage systems for anything other than salinity. Simple tests have been done to check water pollution such as BOD, COD, and some micro-biological examinations. Traditionally, coliform bacteria have been the principal indicator of the sanitary quality of water.

Various sites throughout the Delta have been monitored; ammonium concentrations range from 0.0 to 3.9 mg/l; nitrate, from 0.0 to 49.0 mg/l; BOD, from 0 to 160 mg/l; COD 0 to 952 mg/l; and coliforms, as high as 24 x 10^6/100 ml. Although iron, zinc, manganese, and copper elements were found at low levels, their cumulative effects and bioaccumulation in the food chain are a concern.

From the existing monitoring programs and studies carried out by different organizations, the drains and lakes identified as the most polluted are as follows:

A1. Lake Mariut, Alexandria

The lake receives agricultural drainage, and domestic and industrial wastes from the following drains:

- Omoum Drain (agricultural drainage, industrial and domestic wastes)
- Kalaa Drain (agricultural drainage, domestic wastes)
- Drain of collective factories (industrial wastes)
- Gheit El-Enab Drain (agricultural drainage)
- Kabbari Drain (agricultural drainage, industrial wastes)

The Drainage Research Institute of the Water Research Center found the following in a survey of the lake:

- Seventeen factories discharge directly into the lake through pipelines.
- Four factories direct their wastewater to the lake in trenches which are desludged by tractors.
- Nineteen factories lie in the vicinity of the collecting point of the treatment plant.
- Ten factories discharge to El-Kabbary Drain which discharges to the lake.
- Five factories discharge to Smouhe Drain and then to the lake.
- Seven factories discharge to Gheit El-Enab Drain, which discharges into the lake.

The Egyptian Environmental Affairs Agency (EEAA) has reported that high concentrations of pollutants directly affect fisheries. The measured parameters revealed the following, although the sampling details are unknown:

BOD	2,000 mg/l
Oil and grease	2,000 mg/l
Hg	30-90 mg/l
Cr	50-200 mg/l

The Drainage Research Institute is carrying out a program to monitor effluent quality and a study to improve the quality of flow reaching El-Max pump station.

A2. Lake Manzala

Sources of pollution:

- Sewage drainage from El-Gabel Asfar sewer ("East Cairo")
- Agricultural drainage and sewage wastes via Bahr El-Baqar Drain
- Sewage drainage from Port Said and Damietta
- Industrial wastes
- Closing of the lake openings to the Mediterranean Sea and the Suez Canal

The EEAA and Suez Canal University are developing an action plan to rehabilitate Lake Manzala and develop its fisheries resources.

A3. Bahr El-Baqar Drain

The drain originates at the confluence of two drains, namely Bilbeis Drain and Qalyubia Drain. Both drains receive extensive industrial wastes from Shubra El-Kheima and domestic sewage water from Greater Cairo. The two drains discharge approximately equal quantities of drainage water annually, but the main quantity of Qalyubia Drain was pumped by Wadi P.S., now shut down because of pollution.

Bahr El-Baqar Drain discharges about 1 bcm of drainage water with a salinity of about 2,400 ppm to Lake Manzala. Anaerobic conditions have been reported through part of the drain. This water is very polluted and unsuitable for reuse.

A4. Mohit Drain (West of Cairo)

The drain receives wastewater from Zenein and Abu-Rawash plants together with agricultural drainage.

A5. Gharbia Drain

The Gharbia Drain system consists of 10 pumping stations, three of which lift water to irrigation canals. Both official and unofficial reuse intakes are found along the main part of the drain. All the generated drainage water is either reused by Hamul P.A. or unofficially by the farmers. Domestic wastewaters from villages and towns along the drain are deposited into the drain. It also receives extensive amounts of industrial wastes from oil and textile factories.

An estimated 2 bcm of agricultural drainage water mixed with industrial and domestic wastes receiving little or no treatment and unsuitable for further use is discharged to the Northern Lakes from Gharbia, Mohit, and Bahr El Baqer Drains.

Several Delta drains receive a preponderance of industrial and domestic wastes. Bahr El Baqar receives extensive industrial waste from Shubra El-Kheima and treated and untreated domestic and industrial waste from Greater Cairo. It discharges about 1 bcm of highly polluted saline water to Lake Manzala. Mohit Drain west of Cairo, which discharges at several points to the Nile before terminating at Rosetta Branch, receives domestic wastewater in its lower reach from Zenein and Abu-Rawash primary treatment plants serving Cairo together with agricultural drainage along its entire length. In some areas solid waste also contributes to the pollution load of the water. In many urban and rural areas solid waste, including garbage and material of sewage and industrial waste origin is dumped directly into canals, ditches, and the River Nile.

The Wadi Pumping Station cannot operate currently because of polluted drain water.

B. Future Needs

Planning for reuse projects in the early 1980s was marked by the desire to use as much drain water as possible, especially to irrigate large land reclamation projects in the eastern and western parts of the Delta and in Fayoum.

Four projects of this kind were designed and are now under construction:

B1. Al-Salam Canal Project (Eastern Part)

Al-Salam Canal is designed to be fed with fresh water from the Damietta Branch upstream of Faraskour Dam supplemented with drainage water from the Lower Serw P.S. and Bahr Hadus Drain near its outfall.

The average yearly discharge of the Lower Serw P.S. is about 0.6 x bcm and that of Bahr Hadus Drain is about 2 bcm, bringing the total to 2.6 bcm/year.

The average salinities measured at both locations are 1,000 and 1,400 ppm respectively. The weighted average of both waters is then 1,300 ppm. When this is mixed with fresh water at a ratio of 1:1, the expected salinity is 800 ppm.

It is planned to use 1.5 bcm of this quantity in the first and second phases of the project in addition to a similar quantity of Nile water.

B2. Omoum Drain Project (Western Part)

The objective of the project is to collect drain water from these catchments of Omoum Drain, Shereishra, and Truga and mix it with the fresh water of Nubaria Canal. The quantity of drainage water to be used in the project is about 1.0 x 109 m3/year with average salinity of 1,800 ppm. The expected salinity after mixing will be 800 ppm.

B3. Botita Pumping Station (Middle Part)

This station, which pumps part of the water delivered by Samatay P.S. and Segaiya P.S. to Zawia Canal, is located on the Main Gharbia Drain. A total of 0.25 bcm/year is planned for use with average salinity of 900 ppm. The salinity of blended water after mixing will be 600 ppm.

Following the completion of the construction of the above three projects, an extra quantity of 2.75 bcm of drainage water will be used for irrigation.

B4. Fayoum Governorate

The MPWWR is planning for a fourth project consisting of three pumping stations for reuse of drainage water in the Fayoum Depression.

The Tagen pump station will lift 0.135 bcm/year of drainage water from Tagen Drain into Bahr Nazle Canal. Construction of a second major reuse pump station started in 1988. A pump station at Tamya will lift 0.13 bcm/year from the Batts Drain to Bahr Wahbi Canal.

A third major pumping station is being planned. About 0.13 bcm/year will be diverted from Wadi Rayan Drain to Bahr Nazle tail-end section. An extra 0.4 x 109 m3 of drainage water will be used to supply the main canals.

Planned reuse of agricultural drainage will be increased by about 3.0 bcm with the scheduled completion of the four reuse projects by the end of 1992 or early 1993.

By the end of 1992, there will be nearly 6.4 bcm of planned reuse in the Delta, reducing outflow to the Northern Lakes to an estimated 10.0 bcm with an average salinity of about 3,500 ppm.

Under year 2000 level of development with the addition of 1.6 million acres, an increase in irrigation efficiency as planned by the Government of Egypt, and corresponding increases in domestic and industrial water use and discharges to reflect a population growth of 70 million, the drainage outflow is expected to decline to about 8.5 bcm with a TDS of nearly 4,000 ppm. This level of outflow salinity will require application of up to 1,400 ppm salinity water to some lands, possibly causing yield reduction in sensitive crops. This scenario represents about the maximum usability of the River Nile from a salinity standpoint. It requires that municipal and industrial wastes from Cairo be disposed of separately as part of an isolated drain system as they are now, or treated so that the wastewater discharged will be usable for agriculture, when diluted in the Nile system. It is expected that nutrient and pesticide residues are also expected to increase, although data are insufficient to suggest the amounts.

SECTION VIII
HEALTH IMPACTS

Disease-causing organisms originating in sewage (e.g., viruses, bacteria, parasites) are the biggest problem in Egypt because of fecal contamination of surface and groundwaters. Data are too limited to accurately assess health risk from exposure to chemical contaminants in water (e.g., from industrial waste origin). Heavy metals from industrial waste discharges are believed to be a serious problem, although confirming data are limited.

Water-related diseases, such as infant and child diarrhea, are completely manageable in countries with adequate water pollution control programs. In Egypt, despite significant improvements in health services, infant mortality (first year of life) remains at the high level of 60 per thousand. Similarly, child mortality (1-4 years age group) has been 7.4 per thousand and the survival rate is 87.1. Diarrhea and other enteric water-borne diseases amount to about half of infant and child mortality in Egypt.

Water quality deterioration in Egypt can be also assessed in terms of water-related diseases, such as typhoid, paratyphoid, infectious hepatitis, and infant and child diarrhea. These diseases are still considered endemic in Egypt with 90,000 deaths estimated by WHO in 1987.

Human waste contamination of surface waters (i.e., urine and feces) is still prevalent in rural Egypt. This is manifested in the prevalence of schistosomiasis (Bilharzia) which remains endemic despite the continuous control efforts. The prevalence rate for Schistoma mansoni in Kafr El Sheikh has reportedly reached 30 to 40 percent.

Most Egyptian villages have neither wastewater collection nor treatment systems. Onsite disposal of the domestic wastewater through a leaching pit is the most common practice. Recently, the Egyptian Government provided a large number of villages with piped drinking water without providing for the collection and the disposal of the wastewater. The generated wastewater commonly exceeds the capacity of the onsite disposal facilities. As a result, many villages are chronically flooded with sewage effluent, contaminating groundwater as well as surface water. Results of recent surveillance programs indicate the widespread fecal contamination of groundwater in the Delta.

The unregulated discharge of sewage and industrial waste effluents in Egypt has created a significant pollution problem with serious health implications. WHO has indicated that the contamination of water resources and the lack of adequate water supply and sanitation facilities constitute the most common health problem in Egypt. Furthermore, a recent World Bank socioeconomic assessment determined that "Although access to water resources has improved significantly over the last decade, the lack of access to safe water for many households and the poor quality of the services at times pose a considerable, if not the most important, threat to the welfare of Egypt's population."

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SECTION IX
WATER QUALITY MONITORING/INFORMATION SYSTEM

A. Existing Systems

Three programs monitor the quality of Nile River water and associated groundwater.

In 1976 a monitoring program was established by the Nile Research Institute with the Ministry of Health in collaboration with local governorates and research institutions. On the River Nile from Aswan to the sea, 390 stations were identified, including major drains to the Nile, industrial and municipal discharges directly to the river, and stations along the river at approximately 10-km intervals. Constituents included salinity, major minerals, temperature, pH, suspended solids, oil and grease, biological analyses including DO, BOD, and COD, coliform, and limited nutrients. Eight sampling runs were made at various times from 1976 to 1986, never at all stations, and some were sampled only once during the eight-year period. Four additional sampling runs were made on the Rosetta and Damietta Branches between 1984 and 1987. The Ministry of Health designed a comprehensive program in 1988, but collected only a few samples and curtailed the program in 1990 due to a lack of funds. The Nile Research Institute redesigned its monitoring program in 1989 to include:

- 13 major sites on the river
- 22 minor sites
- Drains and industrial discharges to the Nile

The WRC maintains two laboratories at Qanater. The Nile Research Laboratory is equipped to analyze major ions, nutrients, biological parameters, and heavy metals. It analyzes the Nile system monitoring samples, except for specialized pesticides. The Drainage Research Institute Laboratory analyzes the Delta drainage monitoring samples for major minerals, nutrients, and biological parameters.

The sampling frequency was to be at varying intervals: monthly at five major river sites, four times a year at all river sites and major pollution sources, and twice a year at minor pollution sources. Analyses cover a range of constituents, depending on source, include standard field measurements, nutrients, organic pollutants, major ions, trace metals, organic micro pollutants, and bacteriological and minimal biological parameters. Runs were made on the Rosetta and Damietta Branch in 1990 and 1991. Samples from all stations were made in July 1991 and April 1992. The samples are analyzed in the Nile Research Institute laboratory, or when special analyses are needed, under contract at the Ministries of Health or Agriculture. Most of the data are maintained in a Lotus 1-2-3 file.

The WRC Drainage Research Institute developed a network of measuring stations on the key points of main drains in the Nile Delta and Fayoum in the late 1970s. Currently there are 102 measuring locations, 68 at pump stations and 34 at open drain locations.

Conductivity is measured continuously and water samples are taken every three weeks to determine major ions. Samples are collected from some locations where domestic and industrial wastes occur for BOD and biological and bacterial analyses. Analyses are conducted in the institute's laboratory. The data are maintained on a computerized database and analyzed and published annually.

The Drainage Research Institute, which is conducting a study of drain discharges that contain high amounts of municipal and industrial waste to Lake Maryut, is deeply concerned with polluted drainage, which impedes the reuse of drain water. A proposed analysis of a broader range of constituents in drains would assess the seriousness of this problem.

The WRC Research Institute for Groundwater has a long-established monitoring network of 500 observation wells in the Nile floodplain and desert fringes. Most tap the main aquifer. Samples for water quality analyses, primarily for mineral constituents and nutrients, are collected periodically at a few wells. In a special study on groundwater pollution jointly funded by the Dutch Government, analyses of groundwater from a number of wells was utilized to conduct special studies on groundwater pollution. Limited pesticide data have been compiled. The analyses are stored in investigation files.

In addition to the two laboratories in the Water Research Center capable of routine mineral analyses and minor biological and bacterial analyses, the government has several other laboratories. The Environmental and Occupational Health Center has a central laboratory and nine regional laboratories that analyze municipal water supplies, sewage, and industrial discharges. The Ministry of Agriculture supports two research laboratories, one concerned primarily with fertilizers and pesticide applications and quality of soil water and drainage, the other with pesticide residues in crops, soil, and drainage water. The National Research Institute has two well-equipped and maintained research laboratories. One, the water pollution control laboratory, is equipped to analyze domestic and industrial waste, toxic substances, oil and degradation products, plankton, and aquatic plants, bacteriology, virology, and other pathogens. The second is the National Laboratory of Environmental Toxins, which analyzes toxic substances in food, plants, and fish. The National Institute of Oceanography and Fisheries laboratory supports research on the Nile and lakes.

The data from these laboratories were not readily available except in published papers and sometimes in the institute files. No specific data banks or computerized filing systems are maintained. In some cases, historic data cannot be easily located. Scattered water quality data may sometimes be obtained from governmental files or individual researchers. In some cases, data found in reports or in the literature has gone through several hands and is not reliable. Since little information is available about much of the data, validation is often difficult.

The water quality monitoring program can be generally summarized as follows:

- There is no national environmental policy framework to coordinate existing monitoring resources and support national environmental quality objectives.

- The WRC has made laudable progress in building a national water quality monitoring capacity, but faces severe financial, legislative, and institutional constraints in accomplishing the functions of an effective water quality monitoring program.

- The data management system limits overall effectiveness of the water quality monitoring program because:

  - data and information are not widely shared among the many relevant water quality interest groups;
  - data are not stored in formats that are meaningful for identifying critical water quality problems and solutions; and
  - data storage and retrieval procedures are not standardized to allow ease of analysis, interpretation, and dissemination.

- There are no criteria, based on practical risk assessment methods, for determining the priority water quality problems and thus critical areas for scarce monitoring resources.

- The monitoring program is hampered by a weak water quality standards enforcement system. The enforcement system is largely disconnected from efforts to identify critical problems and coordinate water quality management across diverse water user groups and government agencies.

With regard to an effective water quality program for Egypt, the following critical conclusions can be drawn:

Adequacy of Sampling Sites. The reduction in the number of Nile River sites has concentrated resources on critical pollution sources and ensured more regularity in sampling and timely analysis of all sites. The shift in the Ministry of Health Program of river sampling from 83 to 35 sites in the Canadian projects brought needed focus to the monitoring system. While the program was curtailed due to a lack of funds, the Nile Research Institute's new monitoring program for 13 major and 22 minor river sites is an important foundation. Now, the challenge is to develop trend analyses from regular sampling of each of these sites to measure overall changes in river water quality and to indicate where additional sampling is needed to pinpoint "hot spots" of localized pollution that present serious environmental risks. Lakes are not sampled regularly, nor are many drainage and ground water sites. A greater contribution to trend analysis will come from regular sampling of a smaller number of drainage and groundwater sites, rather than an irregular pattern of samples drawn from different sites at different intervals.

Placement of Sampling Sites. The location of the 35 river sampling stations is appropriate for a permanent network to establish trends in river water quality. The placement of groundwater and drainage sampling sites has not been analyzed well enough to determine their effectiveness in identifying local and regional pollution problems.

Frequency of Samples. The frequency of samples has varied, largely according to the availability of funds. Except in the case of the Nile River, most sites have been sampled less than once a year.

Adequacy of Sampling Techniques. The Nile River sampling techniques have been established and maintained according to international standards for representativeness and accuracy.

Adequacy of Analysis of Samples. The Nile River samples are analyzed under laboratory protocols developed by the WRC according to international standards. Tests for TDS, dissolved oxygen, BOD, and fecal coliform are routinely performed. Tests for heavy metals and pesticides are not performed regularly.

Adequacy of Institutional Capacity. At least 17 laboratories in the WRC, Environmental and Occupational Health Center, Ministry of Agriculture, and National Research Institute monitor water quality. Considerable GOE and donor funding has resulted in a significant national capacity to analyze any specific water pollutant. However, there are insufficient staff, equipment, and operating and maintenance funds for regular operation of the sampling and analysis operations to support the expanded monitoring program these institutions would prefer. Without a comprehensive framework for setting monitoring priorities, there is likely to be some misallocation of current monitoring resources. For example, drawing fewer samples well is more likely to produce effective monitoring results than a more extensive sampling system that fails to pinpoint critical pollution problems.

B. Required System

The successful implementation of a national water quality management program will depend on the simplification of complex physiochemical and biological phenomena in models that will enable planners to develop management strategies. Furthermore, these models should also help to identify missing or redundant information, thus helping to create an optimal monitoring/information system.

Because of limited funds and human resources, only information that is essential to the implementation of a management program should be collected. This will ensure that decision models are kept within manageable proportions. While these models should be simple enough to be readily understood, they should also be realistic enough to accurately describe current and future water quality characteristics.

The environmental water quality information system will assimilate and synthesize data from various sources, providing valuable information on temporal and spatial scales. Independently, data from the different sources has limited utility in comprehensively assessing environmental water quality. The assimilation of data from physical, chemical, and biological measurements will provide a picture of the interdependent characteristics of water resources in Egypt.

The Environmental Water Quality Information System will collect data from various sources (e.g., satellite images, meteorological information, physicochemical, biological, health effects, agricultural production, socioeconomics, and demographic data). In addition, the MPWWR surveillance and monitoring programs will generate data.

The proposed water quality monitoring program will have two essential components: the first, a quality assurance program that includes intralaboratory and interlaboratory calibration; the second, a water quality data bank and associated information/reference center.

The bottom line for any new monitoring program is affordability, simplicity of operation, and sustainability with local government resources.

At present, information in general is not necessarily accessible and reliable. Researchers and national and international agencies continuously generate data. Too often these data are believed to have served their purpose once they become part of a specific study or program and frequently appear in the appendices of progress reports. A large body of valuable data remains buried in inaccessible files and agency reports until they are discarded or lost. Agency reports in Egypt are frequently viewed as privileged information, generally unavailable in university libraries, and difficult to obtain.

Another important concern is the reliability and validity of the data. In view of the lack of uniformity among the various measurement programs, available data exhibit both random and systematic errors. It is therefore imperative to provide the Environmental Water Quality Monitoring Program with data quality control and validation programs. The proposed information system should be able to retrieve relevant data and provide the user with applicable information.

Establishing the information system should have a higher priority than starting any monitoring or surveillance programs.

SECTION X
CAPACITY BUILDING

The evidence is compelling that the major constraint on Egypt's water sector is capacity building, that is, the ability to develop, utilize, and sustain available resources. Capacity building, basically a social-political process, must come from within. Technocratic and econocratic, financially induced development, does not succeed without the capacity to absorb.

Capacity building for water resources is broadly conceived to include the establishment of a favorable policy environment and appropriate institutional development. The latter includes sound management systems, incentive structures, and the human resources development needed to sustain water-related programs. In this context, capacity building seeks to integrate the management of the several subsectors in the water resources sector.

A. Donor Support

Over the past two decades, there has been substantial donor support for Egypt's water quality management program. In 1975, the River Nile Project began as a joint study between the Egyptian Academy of Scientific Research and Technology and the University of Michigan. The project made an important contribution to water management research resources. The Nile Environmental Information Center was established by the project in the National Research Center to house an advanced water quality data bank.

In 1977, Cairo University and the Massachusetts Institute of Technology began a Technology Planning Program with interim funding from USAID. The program focused on water resources planning and included a substantial emphasis on water quality issues.

In 1977, the Ministry of Irrigation and the UNDP began joint funding of the Egyptian Water Master Plan. Work initiated under the master plan project laid many of the foundations for the country's present water quality management program.

The USAID-funded Irrigation Management Systems (IMS) project has made an important contribution to water quality management. A 1985 study of the North Zifta Irrigation System, supported by the project and the Ministry of Public Works and Water Resources, analyzed the environmental effects of using herbicides to control aquatic weeds. In 1987, the project assisted the MPWWR in an environmental assessment of the project's impact on Egypt's irrigation system.

In 1986, the Canadian International Development Agency began collaboration with the MPWWR on the River Nile Protection and Development (RNPD) project, with the WRC acting as the executing agency through the High Aswan Dam Side Effects Institute. The project has focused on the rational utilization of the Nile waters, mitigation of negative side

effects, improvement of present river use, and definition and evaluation of protection and development options. This project has provided a critical degree of momentum to the water quality management capacity building process begun under the Egypt Water Master Plan project. Key RNPD activities have included institutional upgrading, river studies, and water quality pollution control studies.

The Netherlands and the UNDP are assisting the WRC Research Institute for Groundwater and the Egyptian Academy of Science and Technology in developing hydrogeological maps of the Nile Valley, the Nile Delta, and deserts.

The Netherlands is funding groundwater management plans for selected areas under the Management and Development of Groundwater in the Nile Valley and Delta project. The Netherlands also supported assessments of groundwater quality during 1990-1991 under this project. These activities have also been supported by the USAID IMS project.

B. Future Requirements

If Egypt is to address its growing water quality problems, the water quality monitoring program will have to develop a number of managerial and institutional capabilities. Among these are determining whether water quality is improving or not, that is, trend analysis; determining where water quality most needs improvement, that is, problem analysis; determining compliance of discharges with license conditions or standards; locating discharges that are not licensed or violate license conditions; identifying the nature and extend of specific pollution problems; and determining whether suspected problems exist or not. Other key elements of capacity building in any country include policy environment identification; adequate institutional resources; water resources availability, quality, and demand; and human, educational, and financial resources.

In the future, there should be a more effective and less fragmented institutional structure for Egypt's water sector. This should go beyond a concern for water availability and incorporate sound management of water quality for all purposes, including agriculture, industry, fisheries, and inland navigation. An integrated water management plan that addresses the water resources sector as a whole is needed. Urban population growth, expansion of housing projects, and rapidly rising per capita water use all exacerbate the competition for water from irrigation and other uses.

There is a pressing need to re-examine the institutional structure in Egypt. The MPWWR has traditionally been a strong, effective institution. While it is a logical choice to take charge of integrated water management for Egypt, other options should be considered. The essential ingredient in capacity building is institutional development, including human resources. Most failures, whether managerial, technical, or financial, can be traced to institutional inadequacies, which in turn can be blamed on the quality of their personnel.

Many types of institutions have been successful; no model is universally suitable. Institutions are products of a country's history and social and economic structure; the choice is a local prerogative. The major problem is that there are too many institutions with

overlapping authority. The intention is not necessarily to add new institutions, but to use those that exist and consider other appropriate models.

The capacity building process needs a strong commitment from the GOE to support a comprehensive strategic planning program that will:

- Determine a unified government assignment of water quality monitoring responsibility and authority to a specific agency or ministry
- Establish water quality program goals and action plans for those objectives
- Oversee action plans and monitor program objectives
- Revise program objectives or action plans as required to support the national environmental strategy

Along with the strategic planning process, major efforts are needed to improve water quality data management so as to ensure widespread sharing of data and information; maintain meaningful data for water quality decisionmaking; and standardize data storage and retrieval.

Legislative reform is required to streamline Law 48/1982 and Decree 8/1983 and remove current technical and administrative barriers to enforcement of water quality standards.

Finally, any capacity building process must address human resource development. Egypt has an adequate pool of scientists to support the basic water quality monitoring functions. However, water quality program managers and supervisors have little experience in environmental science. Substantial short-term, non-degree training is needed in this emerging area to strengthen the skills of the existing staff. In the long run, Egyptian universities and colleges will need to develop undergraduate and graduate degree programs in environmental sciences.

SECTION XI
WATER QUALITY MANAGEMENT

Egypt has long been in the forefront of the 10 riparian Nile nations in planning for the future of the Nile supplies. The region continues to review water needs for consumption and water-related development for hydroelectric power, navigation, fishing and tourism. Fulfillment of these demands will affect not only the quantity of water available to the downstream riparians, but also the quality, including potential impacts on the Aswan High Dam Reservoir.

It is essential that Egypt prepare to negotiate pacts to manage upstream resources, projects that will use water and affect the quality, but also schemes to conserve water for downstream uses in a manner that benefits both Egypt and the upstream interests. Egypt must define its needs and expectations for water quantity and quality so as to establish an international water quality agreement with upstream riparians. While Egypt has information on existing and future water supplies and needs, insufficient data and analysis about the quality and quantity impacts on the reservoir and downstream uses.

A water plan to define water supplies and needs, including further reuse of drain water, suggests that Egypt has sufficient water to meet its needs through the year 2000 if it taps scheduled additional water supplies of the Nile and groundwater, and if irrigation efficiencies are realized and municipal water distribution losses are minimized. That plan does not address the impacts of looming water quality problems resulting from increased municipal and industrial waste discharges on the availability and usability of future water supplies and the impact on supplies of failing to effectively treat and dispose of those wastes. Likewise, current planning does not incorporate the potential impairment of Delta water quality due to upstream Nile uses, both within and outside Egypt. Rational planning should carefully consider the impact of municipal and industrial wastes on the quality of drain waters, on existing reuse of drain waters, and on potential reuse of those waters for irrigation.

In summary, Egypt must integrate water quantity and quality planning and take immediate steps to undertake and sustain the effort. These steps include securing the necessary data and information and developing expertise, institutional capacity, and financial resources.

Specific areas that need management strengthening include water quality databases, training programs so staff understand and apply modern environmental science methods, strategic planning for the water quality monitoring program, and risk assessment methods to identify and choose strategic options for water quality problems.

SECTION XII
CONCLUSIONS

A. Water Supply and Use

1. Egypt has sufficient water of adequate quality in the Nile system to meet current water needs under 1990 conditions from river supplies, groundwater, agricultural drainage, and wastewater.

2. Egypt will have an adequate water supply under development proposed in the year 2000 if the additional Nile supplies and increases in irrigation efficiency are realized and most importantly, if adequate water quality is maintained.

3. If the Jonglei project is not completed by 2000 and if irrigation efficiency is not substantially improved, available water supplies may not match water demands. Water quality in the Delta will deteriorate. Salinity of Delta Drains will sharply increase, coupled with increasing discharge of domestic and industrial wastes to the drains. If insufficient water is available, water levels in some canals and drains will decline as occurred in the late 1980s. Less inflow of higher salinity will discharge to the Northern Lakes, which will decrease water levels and increase sea water intrusion and salinity. Continued attention to waste treatment will be necessary to reduce the load on the drains and Northern Lakes with attendant salinity management necessary. Some control of unofficial use may be indicated.

4. Agriculture diverts water from other uses and produces more wastewater than any other use in Egypt.

5. While both diversions and consumptive domestic and industrial water use consume small quantities of water compared to irrigation, the wastewater they produce has a major impact on beneficial uses.

6. While agricultural drainage water overshadows domestic and industrial wastewater, quantities of the latter are important. With treatment and management, these wastewaters can remain part of the usable supply rather than degrading and rendering existing supplies unsuitable for use.

B. Water Quality

1. Water quality data are insufficient to make possible effective evaluation of the quality of water in the Nile system and associated groundwater supplies, past or present, or to effectively forecast future quality.

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2. The quality of water released from Aswan Dam is relatively uniform throughout the year and from year to year, reflecting the uniform quality of stored water and managed releases. The quality is excellent, with low TDS, and relatively low biological productivity.

3. Water quality generally declines and biological productivity increases as the river travels north due to major withdrawals for irrigation use, minor municipal and industrial withdrawals, large agricultural drainage returns to the river, and discharge of largely untreated municipal and industrial wastes.

4. While quality has declined since early measurements in 1977, the quality remains good in the stretch from Aswan to Cairo. With the exception of stretches immediately below major waste discharges, the river effectively assimilates wastes discharged. Quality is expected to remain good through the year 2000 in this stretch.

5. In the vicinity of Cairo, the river undergoes major changes with large diversions and major discharge of partially treated municipal wastes and untreated industrial wastes.

6. Within the Delta, large diversions of water and irrigation drainage, along with municipal and industrial wastes, substantially increase salinity and organic loading, particularly in the drains. Some drainage water is rendered unusable by these wastes. Significant reuse of drain water and dilution with canal water takes place. Sea water has intruded in the Northern Delta in historic times, creating highly saline drainage in this area. The remaining highly saline water is discharged to the Northern Lakes and to the sea. This outflow maintains salt balance.

7. Delta drainage water will become increasingly saline as reuse increases. Under year 2000 level conditions, most drainage water will remain usable if increased supplies and increased irrigation efficiency are realized to supply planned agricultural development and added water for municipal and industrial use. Absent additional supplies and efficiency, quality in the Delta will decrease markedly, with higher salinity drainage, decreased water levels, increased saline intrusion in the Northern Lakes, and general decline of drainage water suitable for reuse because of increased salinity and additional waste loads.

8. Shallow groundwater quality reflects recharge from the river, discharge to the river, and return flows from irrigation. Significantly, infiltration of contaminated wastes from rural domestic disposal contaminates water widely withdrawn for domestic use throughout the Nile alluvium, particularly in the Delta.

C. Municipal and Domestic Wastes

1. Data are inadequate to effectively evaluate the quantity or quality of domestic wastes in Egypt, types and levels of treatment, or the quantity, quality, or location of domestic waste discharges or their impact on receiving waters

2. The main stem of the Nile from Aswan to Cairo can assimilate the BOD loads during most of the year from the present domestic and industrial wastes discharged to the

Nile and to drains. Exceptions are immediately downstream of large discharges such as the sugar factories and from km 0 to about km 150 below Aswan. There, dissolved oxygen levels are very low due to discharge of oxygen-deficient water from lower stratified levels of the Nasser Reservoir.

3. The main stem of the Nile and most drains in populated areas have high levels of fecal coliform, and it is assumed, correspondingly high levels of infectious agents. Fecal coliform levels in the Nile main stem sometimes exceed criteria for raw drinking water supplies.

4. Many drains in the Delta receive large quantities of inadequately treated domestic and industrial wastes, rendering the drain water unsuitable for agricultural reuse, although in many cases the water is currently reused both officially and unofficially, exposing edible crops and local workers to untreated wastewater.

5. In Egypt, and particularly in the Delta, the common practice of disposal of domestic waste directly to the ground, drains, and canals, or to shallow pits with subsequent discharge to drains and canals, creates potential health problems for persons in contact with these wastes or for those using or in contact with the surface water or shallow groundwater.

D. Industrial Wastes

1. Consumptive water use in industry is insignificant compared to agricultural use.

2. The known quality of waste discharges is generally very poor, and there are few data that allow adequate evaluation of most discharges.

3. Of the known discharges, heavy metals pose the greatest concern. High levels of toxic organic discharges are also suspected.

4. The concentration of industrial plants in the Helwan and Shoubra El Khiema areas, along with those near Alexandria, pose particular problems to water quality.

E. Agricultural Drainage

1. Salinity of drainage water in the Delta is the worst water quality problem affecting the Nile system because it controls the amount of water available for reuse.

2. Pollution of the drain system by inadequately treated municipal and industrial wastes effectively reduces the amount of water available for reuse from agricultural drainage.

3. Several drains in the Delta are polluted by domestic and industrial wastes. Notable examples are Bahr El Baqar, Belbis Mohit, and Gharbia.

4. Under year 2000 level conditions with planned increases in irrigated acreage and reuse of drainage water, increase in irrigation efficiency and added municipal and industrial

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water use and waste production, the outflow salinity will reach maximum levels. Yields of salt-sensitive crops may be reduced due to higher water supply salinities. Water supplies to meet projected needs will be sufficient only if municipal and industrial waste treatment and disposal practices provide a wastewater which, when diluted in the Nile system, would meet requirements for agricultural, municipal, and industrial uses.

5. Limited data on pesticide levels in the drain water, particularly drain water which results from reuse of mixtures of drain water and fresh water, appear to reflect inappropriate use of pesticides on crops. Data were insufficient to demonstrate pesticide levels in the Nile River.

6. Limited data on nutrient levels in the drains indicate phosphorous and nitrate levels have about doubled since 1977, suggesting some increased eutrophication in the drains and the Nile River.

7. The Nile system drains receive untreated domestic wastes highly contaminated with fecal coliform and infectious agents and parasites which create health hazards for the rural population in direct contact with drain waters or with drain waters used for irrigation or domestic purposes.

8. Production and reuse of agricultural drainage water is a main cause of water pollution in Egypt. The agricultural drainage water, along with the domestic and industrial wastes discharged to the drains and the River Nile, are major resources. Egypt cannot afford to not use this supply most effectively. Additional reuse of this supply requires effective management and economic treatment of industrial and domestic wastes to ensure that supply meets demand.

F. Health Impacts

1. Lack of rural sanitation is the major health-related water-quality problem in Egypt. An estimated 95 percent of the rural population lacks community water supply or effective waste disposal. Contamination of shallow groundwater, the major supply of rural Egypt, occurs by surface or pit disposal of wastes. Direct discharge of rural wastes into drains and canals, which are used for laundry and other washing, and into water used for irrigation contributes to infectious diseases.

2. Heavy metal accumulation in fish from industrial wastes, and toxic wastes from industry and untreated or partially treated municipal wastes are believed to contribute to public health problems.

G. Water Quality Monitoring/Information Systems

1. WRC has three water quality monitoring programs. The basic program on the Nile River and Delta, while focused on generating baseline and general water pollution data, develops little diversity of data. Its funding and staffing are inadequate to operate the monitoring program. Laboratory facilities need upgrading to accommodate the number and

Cb

type of analyses needed. The program has minimal data storage and evaluation capability, and significantly, plays no role in dissemination of data to concerned users. The drainage program has compiled, used, and published valuable data, but its activities have been limited mostly to drainage salinity. The third program, groundwater monitoring, has been limited mostly to specific investigations, although some meaningful data have been compiled.

2. A water quality data program designed to meet planning, pollution control, and identified research needs is urgently needed to begin compiling critical information. The program must have adequate funds, effective laboratory facilities, competent professional staff, and effective data storage and retrieval systems. These data must be available where needed for effective management of the Nile system.

H. Water Quality Management Planning

1. Egypt must integrate water quantity and quality planning and take immediate steps to secure the necessary data and information, including development of expertise and institutional capacity and financial resources to undertake and sustain the effort.

2. Careful planning and management of agricultural drainage in conjunction with other water and environmental needs is necessary to attain a safe, dependable, effective water supply.

I. Implementation

1. Action should begin immediately to identify those industries likely to discharge heavy metals and toxins. Immediate measures should be taken to reduce such discharges.

2. Priority should be given to identifying and upgrading municipal waste treatment plants that are not operating properly.

3. Attention should be given to improving rural sanitation through public education on how to properly dispose of wastes, develop and maintain a safe drinking water supply, and eliminate dangerous contact with drain and canal water.

4. A national campaign to improve rural wells and waste disposal methods should be inaugurated.

SECTION XIII
RECOMMENDATIONS

A. Develop an Integrated Water Quantity/Quality Management Program

A comprehensive, flexible master plan to guide use and management of the Nile waters and associated groundwater is urgently needed. Action should be initiated now to begin correction of existing problems and to ensure the future health of the Nile system. The Water Management Action Plan to be developed in Phase II of this study will serve as a base to begin establishment of the budgetary elements, institutional and legal framework, information support, and analytical methodology needed to expand the elements described in Phase I. Most importantly, implementation of the critical elements of the Water Management Action Plan to be developed in Phase II should begin concurrently with development of a water quality management plan.

The planning process should be carried out with the direct involvement of agencies whose responsibilities and authorities affect water management.

The purpose of this plan will be to provide a flexible framework for budgetary decisions and implementation of actions to facilitate effective water development, allocation, and use decisions and waste discharge regulation. The plan should generate maximum usable water supplies, optimize water quality among competing uses, minimize water pollution control costs, and provide for an environmental setting that will protect fisheries and aesthetic values. Plan elements include:

- Water supply
- Water demand
- Water allocation
- Water management
- Waste water regulation
- Critical pollutants
- Environmental assessment
- Quality criteria
- Action programs

Key principles are:

1. Integration of water quality and water quality elements in all analytical and policy considerations.

2. Institutionally viable, affordable, achievable within identified timeframes, and enforceable plan elements that include implementation plans and schedules. Adequate long-term financing to implement priority elements of the program developed concurrently with

the planning process. A realistic reflection of the available financing, staff support capabilities, and institutional framework in Egypt.

3. Multi-year budget commitments to provide for continuity of the planning process.

4. A planning framework encompassing interrelationships of water supply, water diversions, competing uses, waste disposal, and reuse through analytical procedures to assess damages, benefits, costs, and risks.

5. Flexibility to adjust to continually changing conditions.

6. Long-term and short-term objectives with updates scheduled at intervals of not more than two years.

7. A wide range of expertise on the planning staff including engineers, planners, geologists, economists, biologists, and other professionals and access to supplementary expertise from other organizations and through agreements with international groups.

8. A wide range of readily available and continually updated resource, technical, and economic information to support the planning process.

B. Establish a Comprehensive Water Quality Information Program in the Ministry of Public Works and Water Resources, Jointly Supported by the Ministry of Public Health and in Cooperation with Other Concerned Agencies

Specific water quality data and information and access to a wide range of information is needed to support the development of a water quality management plan. The elements of a data/information program include the system design, collection, analysis and validation of water-related data, data evaluation and storage, retrieval and dissemination of information to planners, regulators, decision makers and importantly, the public. Priority water quality data needs may be defined as:

1. Routine intensive monitoring at a few key points to evaluate the state of the resource, detect possible quality problems, and provide spatial and temporal base data for planning, regulation, and public dissemination.

2. Specific data to evaluate an identified problem.

3. Screening to determine whether a suspected problem exists.

4. Effluent monitoring.

Monitoring program design and implementation should be initially guided by relating priority pollutants identified in this study to specific areas of concern.

A monitoring program must include adequate equipment for sampling and monitoring; laboratory facilities; validation and evaluation procedures; a storage, processing and retrieval system; and most importantly, adequately trained professional and support staff.

The monitoring program must have continuity of budgeting and staffing, provision for professional advancement, and adequate staff training.

To conduct, direct, and coordinate the development and implementation of a water quality program and a water information system, an effective institutional setting must be provided.

It is recommended that the monitoring programs be within the Ministry of Public Works and Water Resources, supported by the Ministry of Health, to meet specific responsibilities. Interfaces, responsibilities, and authorities among concerned ministries should be established with direct support from other agencies according to identified needs. The monitoring and information systems should be guided and advised by steering committees from concerned agencies responsible for water-related matters. A detailed evaluation of the institutional framework and legal requirements for a monitoring/information system will be conducted in Phase II of this study.

C. Initiate a Program to Identify Priority Pollutants

A program should be developed to focus on priority pollutants defined as those which under future water use and waste production will pose the greatest threats to beneficial uses and the aquatic environment. The priority pollutant program would be conducted in conjunction with the water quality management plan and data monitoring programs. This program would prioritize pollutants most affecting water uses of the system in specific areas, as defined by water quality criteria for beneficial water uses; control measures would be developed. Current priority pollutants are:

- Pathogens/parasites
- Heavy metals
- Salinity
- Pesticides
- Nutrients

The human health aspects of pathogens and parasites in surface and ground water supplies, particularly in rural settings, are especially significant. Major efforts to improve rural sanitation, to develop safe water supplies, and to provide effective waste disposal are critical.

D. Initiate Programs to Control Agricultural, Municipal and Industrial Wastes in Identified Problem Areas

1. Develop a specific program to compile pesticide and nutrient data on agricultural drainage for assessing the potential problems and developing control and management

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measures. A screening program should initially focus on the discharge of drainage water to the canal and drain system. The system design and initial results should be related to the service area, cropping patterns, and applications of pesticides and fertilizers.

2. Survey municipal waste discharges to the system and develop screening analyses for those sources likely to significantly impact the aquatic system. Review industrial wastes discharged to the sewer systems, review industrial pre-treatment requirements and results, and review potential toxic constituents and priority pollutants.

3. Survey industrial plants to define those which are likely to discharge priority or other significant pollutants to the system. Develop discharge data and priority pollutant information initially for selected industries most likely to create water quality problems as the initial phase of an action program.

E. Conduct Phase II of Environmental Water Quality Assessment

Phase II of this program will provide significant guidance to revise and implement the preliminary recommendations of this Phase I study, particularly related to identification of water quality problems, water quality monitoring and management, and the institutional framework.

F. Develop a Water and Waste Disposal Cost Recovery Plan

Focus on possible charges for water-related services as a means to equitably develop a financial base and distribute costs of water use and waste disposal and to generate user recognition of the cost of service and responsibility for effective use and disposal.

While water is a renewable natural resource, the costs associated with supplying the resource to the user, including procuring and maintaining the supply, storage in Aswan, and operating and maintaining the River Nile, barrages, canals, and other distribution facilities is significant. In addition, the costs of drainage and waste disposal, including damage to the resource and other users, need recognition.

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ANNEX A

SOURCES OF WATER POLLUTION

by

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ANNEX A
SOURCES OF WATER POLLUTION

Egypt's water pollution problem is closely tied to the Nile, the longest river in the world, extending for approximately 6,800 km from its most remote source in the East African Plateau to the Mediterranean and thus traversing approximately half of the African continent, as shown in Figure 1. The Nile drainage basin, an area of nearly 3.1 million km^2, occupies one tenth of the African continent and is unique among major rivers of the world in that it includes three climatic zones: tropical, sub-tropical, and arid desert. The Nile basin extends over 10 riparian countries: Burundi, Rwanda, Tanzania, Zaire, Uganda, Kenya, Central African Republic, Ethiopia, Sudan, and Egypt.

The Nile receives its water from two main watershed areas, the equatorial East African Plateau which feeds the White Nile, and the Ethiopian Highlands which feed the Sobat, Atbara, and the Blue Nile. The Blue Nile represents the major supply source, as 86 percent of the main Nile's annual discharge is derived from the Ethiopian Highlands, and only 41 percent from the Equatorial Lakes. Furthermore, the silt carried by the main Nile, which forms the fertile Nile Delta, originates exclusively in the Ethiopian Highlands and is carried by the Blue Nile. The Victoria Nile and the Bah El Jebel carry much smaller amounts of silt, which is largely lost as the river flows through Lake Mobutu and the Sudd region. The annual silt load of the main Nile at Aswan varies between 60 and 110 million tons.

Hydrological observations of the Nile date back to the ancient Egyptian who installed river gauges, known as nilometers, to determine the arrival and height of flood waters. Although not continuous, the Nile has the longest and most extensive hydrological record of any river in the world.

Annual discharges may vary dramatically from one year to another. During the 1971-75 period, the annual discharge of the main Nile at the entrance of the Aswan High Dam reservoir varied from a low of 53.102 mcm in 1972 to a high of 100.045 bcm in 1975.

Seasonal variations of the main Nile flow rate are even more dramatic. More than 80 percent of the river's total discharge occurs during the flood period, from August to October, and used to be directly discharged into the sea prior to the Aswan High Dam. During the remaining nine months the river carried only 20 percent of the annual discharge.

The Nile constitutes over 90 percent of Egypt's fresh water resources, the remaining 10 percent being largely groundwaters recharged from the river. Egypt's share of water according to the 1959 Nile Waters Agreement is 55.5 bcm/yr at Aswan.

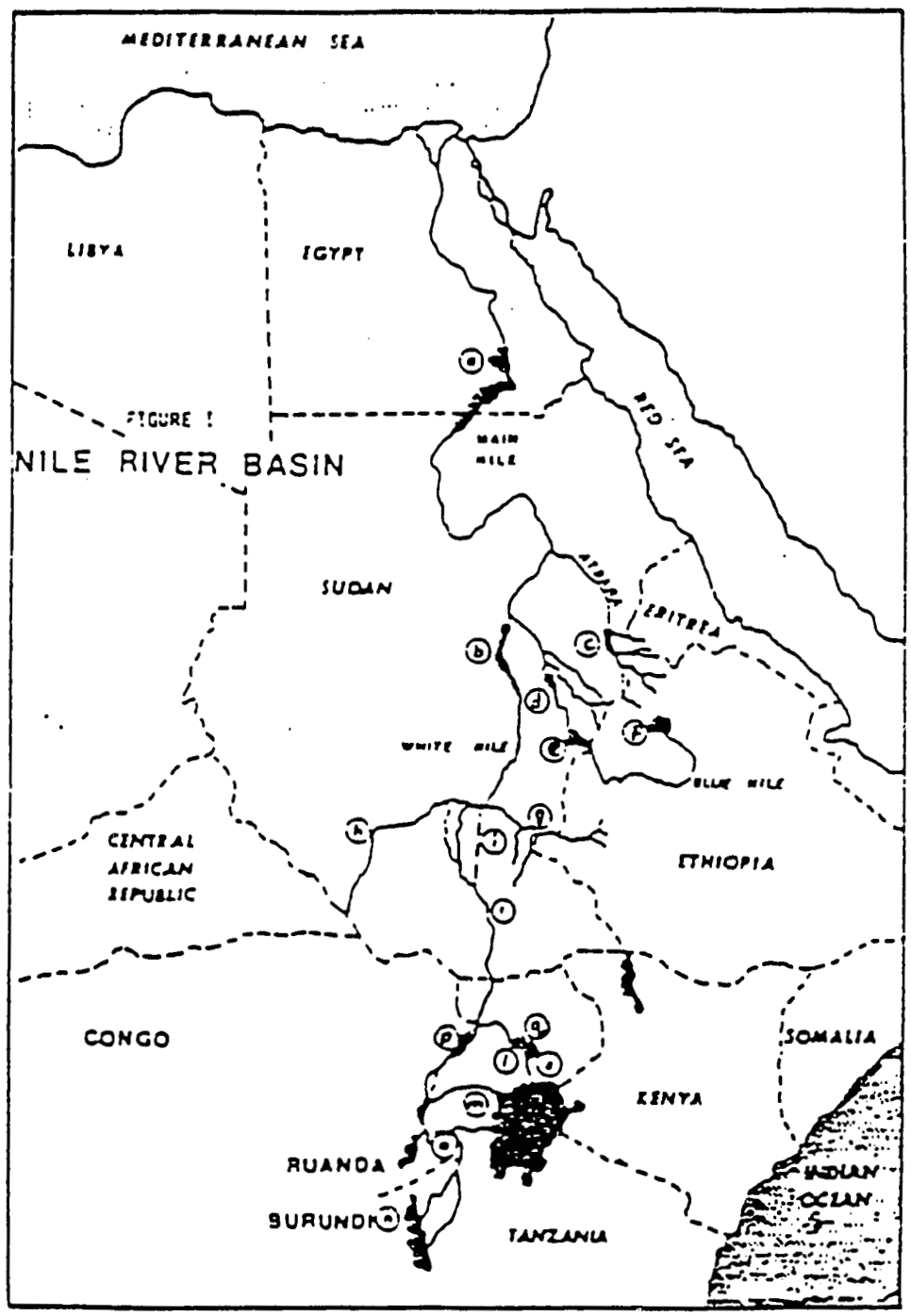

Figure 1:Nile River Basin

a-Aswan High Dam Reservoir
b-Jebel El aulia Dam
c-Khashm El Girba Dam
d-Sennar Dam
e-Roseires Dam
f-Lake Tana
g-River Sobat
h-Bahr El Ghazal
i-Jonglei Canal
j-Bahr El Bebel
k-Lake Victoria
l-Victoria Nile
m-River Katonga
n-Upper Kagera Lakes and Swamp
0-River Kagera
p-Lake Mobuta(Lake Albert)
q-Lake Kioga

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The Nile, more than any other river in the world, has been subjected to various controls by its human beneficiaries. Menes, the first pharaoh of united Egypt, dammed the river over 5,000 years ago to build the city of Memphis (reported by Herodotus in 440 BC). Later, the pharaoh Om Hotep used Lake Karoun at Fayoum for the storage of flood waters and low-flow augmentation. More recently, with the construction of the Aswan High Dam, the Nile has become totally controlled and fully utilized. The diversion of the river channel took place on May 15, 1964, and the High Dam was completed in 1968. The reservoir reached its operating level of 175 m in 1975 with a total of 121.3 bcm of stored water.

The Aswan High Dam reservoir extends over an area of 5,000 km^3 with its northern two-thirds in Egypt (known as Lake Nasser) and its southern third in Sudan (known as Lake Nuba). At Aswan, the Nile is only 87 m above sea level and 1,180 km away from the Mediterranean. By the time the river reaches Cairo, it has dropped 74 m in 960 km. North of Cairo, the Rosetta and Damietta branches of the Nile Delta empty directly into the Mediterranean. The river slope in the Delta is very low, estimated at only 12 m over approximately 240 km.

A. General Sources of Water Pollution

A1. Municipal and Rural Domestic Wastes

Many canals and drains are suffering from an alarming increase in the discharge rates of municipal and rural domestic wastes. The expansion of water supply networks in villages, towns, and cities without the parallel construction of new sewer systems or the rehabilitation of existing systems has led to serious water pollution problems.

Twenty cities in Egypt have sewer systems and wastewater treatment plants. Very few treatment plants operate efficiently.

Most Egyptian villages, on the other hand, have neither wastewater collection systems nor wastewater treatment facilities. There are, however, some pilot projects for the treatment of domestic wastewater in three governorates, covering a total of 24 villages: 20 in Damietta Governorate, two in Menufeya Governorate, one in Dakahleya Governorate, and one village in Sharkeya Governorate (Environmental Studies Group, 1989).

To appreciate the potential of pollution from municipal sources along the main river channel, a review has been made of the distribution of the most important communities between Aswan and Cairo. Forty-three important towns were identified and their distribution is shown in Figure 2. The population of these towns ranges between 50,000 and 1 million inhabitants so they represent significant sources of municipal effluent.

Tables 1-5 represent available information about existing sewage treatment works in Egypt. The quality of the treated effluent and points of discharge are identified.

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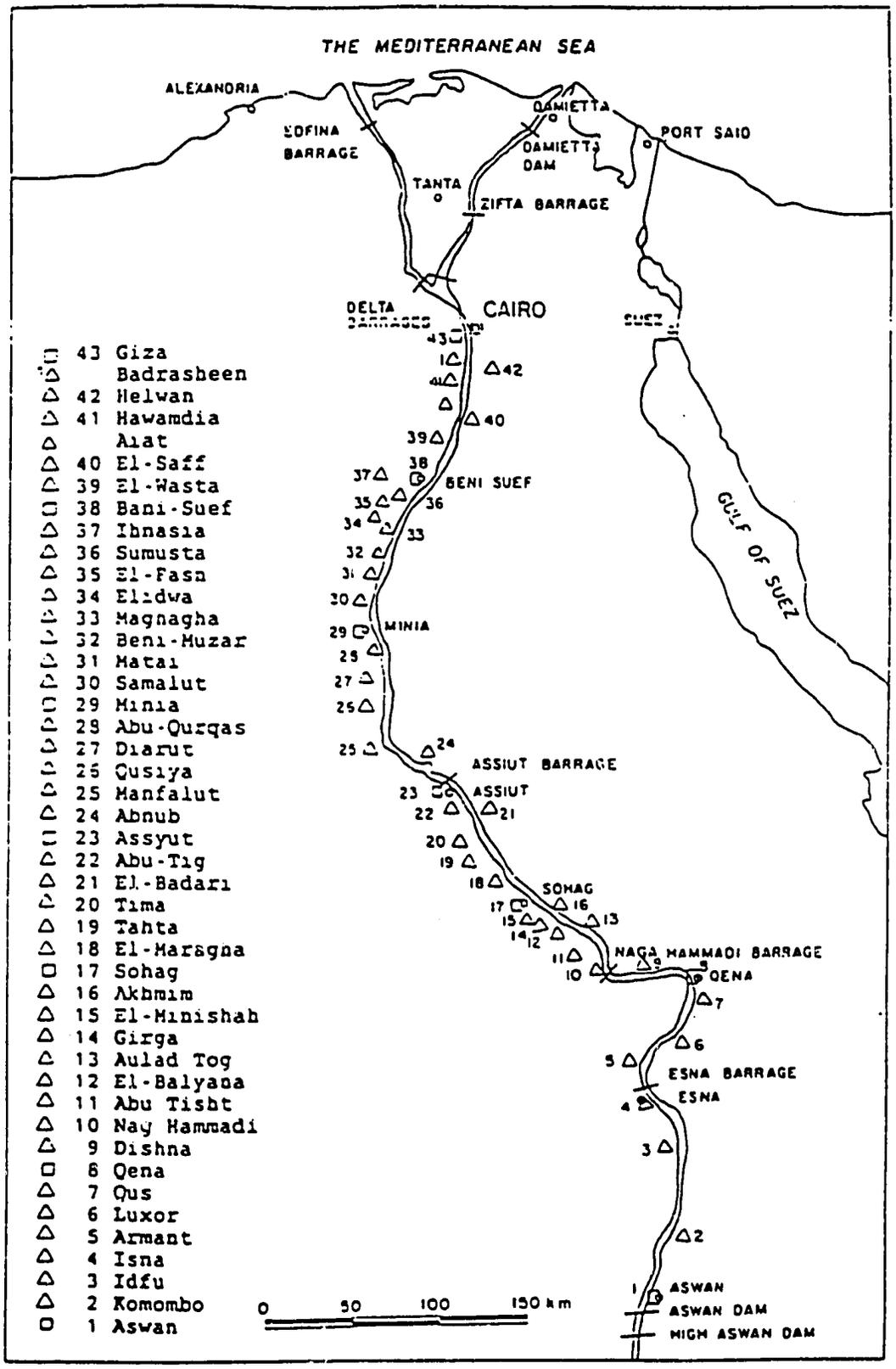

RIVER NILE
PROTECTION AND DEVELOPMENT PROJECT

N.B
Δ. Towns
□. Capital Of Governate

Figure 2. Towns and Cities Along the River Nile from Aswan to Cairo

Existing wastewater treatment facilities

(Upper Egypt)

Table 1

Govern. Name	Discharge 1000m³/day	Point of Discharge	Type of Treatment	Load Kg/day				
				COD	BOD/5	SS.	P.	NH3-N
ASWAN	21	EL-SIL DRAIN	AERATED OXIDATION POND	5943	3570	8505	-	126
QENA	30	L.R.	TRICKLING FILTER	6000	3750	1590	-	1200
AL-OKSOR	30	L R.	TRICKLING FILTER	5250	-	720	900	540
SOHAG	50	SOHAG DRAIN	TRICKLING FILTER	9000	4750	19850	300	1500
ASSIUT	60	L.R.	TRICKLING FILTER	-	-	-	-	-
EL-MENIA	20	EL-MOHEET EL-GARBY DRAIN	TRICKLING FILTER	4800	3000	8620	84	300
BENI SEWIF	40	MOHIE EL-DEEN DRAIN	TRICKLING FILTER	-	-	-	-	-
EL-FAYOUM	40	EL-BAST DRAIN	TRICKLING FILTER	7520	4960	-	-	-

Existing wastewater treatment facilities

(Delta region)

Table 2

Govern. Name	Discharge 1000m³/day	Point of Discharge	Type of Treatment	Load Kg/day				
				COD	BOD/5	SS.	P.	NH3-N
EL-KALUBIYA								
BANHA	42	AGR. DRAIN	TRICKLING FILTER	7560	4620	25200	-	-
EL-SHARKIYA								
ZAGAZEEG	90	AGR. DRAIN	TRICKLING FILTER	36000	22500	44010	36	495
EL-DAQAHLIYA								
EL-MANSOURA	120	AGR. DRAIN TO EL-MANSOURIA	TRICKLING FILTER	The facility is not operating				
MIT MAZAH	1	AGR. DRAIN TO EL-MANSOURIA	AERATED OXIDATION POND	99	32	67	50	7.7
DEIETTA	60	AGR. DRAIN TO LAKE MANZALA	TRICKLING FILTER	-	-	-	-	-
KAFR EL-BATEK	2.7	KAFR EL-BATEK DRAIN	AERATED OXIDATION POND	257	84	162	-	NIL
EL-KAITA	1.4	LAKE MANZALA	AERATED OXIDATION POND	-	-	-	-	-
ADLIYA	0.4	ADLIYA DRAIN	AERATED OXIDATION POND	-	27	32	-	-
FARASKOR								
EL-RODA	1	FARASKOR DRAIN	Extended Aeration	-	-	-	-	-
EL-GONAIMIA	0.5	EL-GONAIMIA DRAIN	Extended Aeration	-	-	-	-	-
SHARBAWS	0.5	SHARBAWS DRAIN	Extended Aeration	-	-	-	-	-
KAFR EL-ARAB	0.5	KAFR EL-ARAB DRAIN	Extended Aeration	-	-	-	-	-
EL-BAISHHIA	0.6	EL-BAISHHIA DRAIN	AQUALIFE	-	13	8	-	-
EL-RAHMANIA	1.4	EL-RAHMANIA DRAIN	AERATED OXIDATION POND	-	-	-	-	-
AL-ZARKA								
EL-SERW	1.1	EL-SERW DRAIN	Extended Aeration	-	31	61	-	-
MIT EL-KOHLY	0.6	MIT EL-KOHLY DRAIN	Extended Aeration	-	19	19	-	-
DAKHLA	0.6	BAHAR ELGAT DRAIN	AERATED OXIDATION POND	-	21	17	-	-
KAFR SAAD								
KAFR SAAD	0.6	KAFR SAAD DRAIN	AQUALIFE	-	16	17	-	-
KOFOR EL-GAB	2.2	DRAIN NO 10	AQUALIFE	-	-	-	-	-
KAFR SELIMAN	1.3	EL-BORAY DRAIN	AERATED OXIDATION POND	-	42	34	-	-
MIT ABO GALEB	0.6	MIT ABO GALEB DRAIN	Extended Aeration	-	-	-	-	-
AL-WASTANY	0.6	AL-WSATANY DRAIN	Extended Aeration	-	-	-	-	-
RAS EL-BAR	50	DUMPED IN DEPRESSION		-	-	-	-	-

Existing wastewater treatment facilities

(Delta region)

Table 2 (Cont'd)

Govern. Name	Discharge 1000m³/day	Point of Discharge	Type of Treatment	Load Kg/day				
				COD	BOD/5	SS.	P.	NH3-N
EL-MONOFIA								
SHBEN EL-KOM	40	AGR. DRAIN	TRICKLING FILTER	19600	14000	8080	-	1600
MENOF	24	MENOF DRAIN	ACTIVATED SLUDGE	960	480	1752	192	NIL
EL-KOM ELAKDA	0.7	EL-HERF DRAIN	AQUALIFE	-	91	92	-	-
SAHEL GWABER	0.7	EL-SHOHADA DRAIN	AQUALIFE	-	103	132	-	-
EL-GHARBIYA								
KAFR EL-ZIAT	90	GANAG DRAIN	TRICKLING FILTER	The facility is not operating				
SAMANOD	15	AGR. DRAIN	TRICKLING FILTER	The facility is not operating				
TANTA	60	???						
MAHLA KOBRA	60	AGR DRAIN	TRICKLING FILTER	29400	16800	36660	480	2400
KAFR EL-SHAK	20	AGR DRAIN	TRICKLING FILTER	4600	3000	3920	50	500
EL-BEHARA								
DAMANHOR	110	DAMANHOR DRAIN	TRICKLING FILTER	The facility is not operating				
SHOBRAKEET	8	AGR DRAIN RIVER NILE	TRICKLING FILTER	1120	760	1840	60	240

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EXISTING WASTEWATER TREATMENT FACILITIES

(GREAT CAIRO)

TABLE(3)

Govern. Name	Discharge 1000m³/day	Point of Discharge	Type of Treatment	Load Kg/day				
				COD	BOD/5	SS.	P.	NH3-N
(a)EAST								
EL-BERKAH	600	BILBEES DRAIN	ACTIVATED SLUDGE					
EL-GABAL EL-ASFAR	1200	..	..					
SHOBRA EL-KAMAH	600	SHEBEEN EL-KOM D	..					
(b)WAST:								
ZENIN	330	NAHIA DRAIN	ACTIVATED SLUDGE & TRICKLING FILTER					
ABO RWASH	720	EL-MOHET DRAIN	PRIMERY TREATMENT ONLY.					
(C)HELWAN	350	L.R.	ACTIVATED SLUDGE					

EXISTING WASTEWATER TREATMENT FACILITIES

(ALEXANDRIA)

TABLE (4)

Govern. Name	Discharge 1000m³/day	Point of Discharge	Type of Treatment	Load Kg/day				
				COD	BOD/5	SS.	P.	NH3-N
EAST &								
MIDDLE	475	SEWERAGE SYSTEM	MECHANICAL					
WAST BORG	175	..	..					
EL-ARAB	10	OXID P.						

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EXISTING WASTEWATER TREATMENT FACILITIES

(CANAL CITIES)

TABLE(5)

Govern. Name	Discharge 1000m³/day	Point of Discharge	Type of Treatment	Load Kg/day				
				COD	BOD/5	SS.	P.	NH3-N
EL-ESMAELIA	90	DRAIN	TRICKLING FILTER	28620	13500	16380	-	-
PORT SAID	150	LAKE MANZALA	PRIMERY TREATMENT	42900	24000	106800	-	-
EL-SUIZ	200	DRAIN	OXID.P.	76000	45200	44000	-	-

In Egypt, villages represent a significant source of pollution into the River Nile system. There are approximately 4,300 villages in rural Egypt, whose average population is 10,000 but may be as high as 30,000 (USAID, 1983).

The number of villages located in the relatively narrow strip of irrigated land along the River Nile between Aswan and Cairo is approximately 1,500.

Number of Villages per Governorate in Upper Egypt

Governorate	Number of Villages
Aswan	75 (2)
Qena	240
Sohag	217
Assiut	125 (2)
El Minya	377
Seni-Suef	175 (2)
Giza	237
Total	1,446

(1) Villages participating in the USAID BVS project (USAID, 1982)
(2) Estimated number

At present most of the rural population depends on on-site disposal of wastewater. The most common on-site disposal facility is a kind of leaching pit without ground floor, built inside or in front of the houses. The walls of the pit are made of brickwork with a rather open structure. This pit serves to collect excreta and a limited amount of sullage water. After biological digestion, wastewater and soluble compounds of the digested excreta leach into the soil surrounding the pit. The solid elements are accumulated in the pit at a rate of circa 25 liters per person per year. A significant proportion of the households, however, lack such a facility.

The pits have to be emptied regularly by means of vacuum truck. The leaching pits are sometimes emptied by hand, which requires people to enter the facilities with buckets. The vacuum trucks are generally discharged into nearby drainage canals.

In many villages in the Delta, the amount of sullage water discharged into the pit is limited due to the high level of the groundwater table, which seriously affects the infiltration capacity of the surrounding soil. Houses near streams or drains often have drainage pipes for wastewater discharge into these streams.

BOD LOAD OF WASTEWATER DISCHARGING TO THE RIVER NILE
TABLE(6)

GOVERN. NAME	DOMESTIC Q m³/day	DOMESTIC BOD kg/day	INDUSTRIAL Q m³/day	INDUSTRIAL BOD kg/day	AGRICULTUR Q m³/day	AGRICULTUR BOD kg/day
ASWAN						
STP	21000	3570			88000	46240
KOM OMBU (SUGAR)			114000	45600	643000	335722
EDFU (SUGAR)			76800	21888	1972000	502510
EDFU (SUGAR)			13200	6336		
TOTAL	21000	3570	204000	73824	2703000	884472
QENA					2358000	1211920
STP	30000	L.R.				
LOUXOR	30000	-				
ARMANT 1 (SUGAR)			84000	44520		
ARMANT 2	?					
ARMANT 3	?					
QUS (SUGAR)			169200	36548		
DESHNA (SUGAR)			14400	1642		
NAGA HAMM. (SUGAR)			16800	76440		
NAGA HAMM. (ALUMENIUM)	?					
TOTAL	60000		284400	159150	2358000	1211920
SOHAG					973000	322620
STP	50000	4750				
OIL&SOAP CO.			14580	875		
SPINNING CO.	?					
COCACOLA CO.	?					
TOTAL	50000	4750	14580	875	973000	322620

BOD LOAD OF WASTEWATER DISCHARGING TO THE RIVER

TABLE(6)

GOVERN. NAME	DOMESTIC Q m³/day	DOMESTIC BOD kg/day	INDUSTRIAL Q m³/day	INDUSTRIAL BOD kg/day	AGRICULTURE Q m³/day	AGRICULTURE BOD kg/day
ASSIUT					509000	115069
STP	60000	L.R.				
PHOSPHATE CO.			1000	14		
ABU HOL (CARPET)			14	2.66		
POWER GENERATION	?					
OIL&SOAP CO. (TO IBRAHIMIA CANAL)			360			
SPINNING CO.			1200	L.R.		
TOTAL	60000		2574	16.66	509000	115069
MINYA:					2193000	406790
STP	20000 (IBRAHIMIA CANAL)					
FLOUR CO. (5 FACTORIES)			2580 (IBRAHIMIA CANAL)			
COTTON SPINNING			1200 (IBRAHIMIA CANAL)			
OIL&SOAP AND COTTON GINNING			24000			
TOTAL	20000		27780		2193000	406790
BEN SUIF:				1219000	876320	
STP	40000					
COTTON GINNING CO.			1200 (IBRAHIMIA CANAL)			
SPINNING&WEAVING CO.			1200 (LAND)			
TOTAL	40000		2400	1219000	876320	
FAYOUM:						
STP	40000	4960				
TOTAL	40000	4960				

A2. Industrial Wastewater

Although modern industry has existed in Egypt since the early 19th century, industrial exploitation of natural resources increased after World War I. Food processing, textile manufacturing, and cement and fertilizer production were the main industries. Industrial development in the early 1950s took a new course, shifting away from the traditional agrarian base to heavy industries such as steel, machinery, and chemicals. An important feature of Egypt's industrialization at the time was the concentration of new industries in the metropolitan areas along the Nile Delta: north and south of Cairo, particularly in Helwan and Shoubra El Keima, Kafr El Zayyat, and Talkha, and in the Alexandria metropolitan area.

Because the trend during that period was to support industrial development and attain rapid returns on investment, inadequate attention was paid to the long-term issue of environmental deterioration. An added problem was that most new industries were state-owned, making enforcement of government regulations almost impossible. Although Law "93" on wastewater disposal was promulgated in 1962, its regulations and standards were not applied to public sector industries, inspection was discouraged, and rules not enforced. Out of fear of hindering industrial development, no industry was ever prosecuted under this law. As a result, untreated wastewaters have been discharged ever since into the Nile, lakes, drains, and the Mediterranean.

In 1983, the Ministry of Industry's General Organization for Industrialization (GOFI) scheduled an urgent action plan to control pollution of the Nile from the liquid wastes discharged by 25 industrial plants belonging to the Ministry. This plan was modified in 1985 to include 188 industries classified into three categories, according to their effluent discharge points. Priority was given to industries discharging into the Nile, followed by those discharging into canals, drains and sewer systems, in that order. Apart from the Egyptian coke company (Tibeen), which installed a facility for treatment of phenolic waters, very little has been implemented.

The nature of industrial wastes depends upon the processes in which they originate. Industrial wastewaters vary in nature from relatively clean cooling water to waste liquids that are heavily laden with organic or mineral matter, or with corrosive, poisonous, or explosive substances.

Discharge of untreated or partially treated wastewater is a major cause of water pollution. The principal hazard to public health caused by industrial wastes is toxic pollution, which may enter a municipal water supply or a stream used for recreational purposes. Polluted waters endanger public health not only from direct use of the water but through food fish that live in the polluted stream.

The Government of Egypt reportedly owns and operates 367 industrial facilities. Table 7 lists government-owned industries and the ministries responsible for each. This is important information when considering the implementation of industrial pollution control programs.

Table (7)

Public Industries in Egypt

Ministry	Industrial Sector	Number of Plants
Ministry of Industry	Oil & Soap	24
Ministry of Industry	Starch & Glucose	6
Ministry of Industry	Sugar & Distillation	9
Ministry of Industry	Milk Products	9
Ministry of Industry	Canning Food	5
Ministry of Industry	Soft Drinks	10
Ministry of Industry	Beer	2
Ministry of Industry	Macaroni	8
Ministry of Industry	Leather & Tanneries	3
Ministry of Industry	Tobacco	6
Ministry of Industry	Fertilizer	7
Ministry of Industry	Plastic & Rubber	5
Ministry of Industry	Pesticide	2
Ministry of Industry	General Chemical	12
Ministry of Industry	Matches	3
Ministry of Industry	Pulp & Paper	16
Ministry of Industry	Textile, Spinning & Weaving	80
Ministry of Industry	Jute	4
Ministry of Industry	Non Metallurgical Mining	11
Ministry of Industry	Heavy Industries	15
Ministry of Industry	ALUMINUM	1
Ministry of Industry	Transportation Industry	5
Ministry of Defense	Heavy Industries	1
Ministry of Defense	Transportation Industry	1
Ministry of Industry	MISCELLANEOUS	22
Ministry of Economics	Ginning of Cotton	33
Ministry of Agriculture	Wine	2
Ministry of Agriculture	Onion & Vegetables Dehydrating	5
Ministry of Supplies	Rice Mill	5
Ministry of Supplies	Flower Mill	25
Ministry of Petroleum	Petrochemical	3
Ministry of Health	Pharmaceutical	6
Ministry of Housing	Cement	8
Ministry of Electricity	Power Station	13
Total		367

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The Ministry of Industry, however, is the major owner of governmental facilities. It owns 72 percent of the 367 public industries, followed by the Ministry of Economics with 9 percent, and the Ministry of Supplies with 8 percent. Ownership of the remaining 11 percent is split between the Ministries of Defense, Electricity, Agriculture, Housing, and Health (RNPD, 1989).

Most of these industries are discharging their wastewater without treatment into the River Nile, coastal lakes, agricultural drains, and canals. The government factories at Helwan and Hawamdia are listed in Table 8.

At present, industrial use of Egypt's water is estimated to amount to 3.7 bcm/year. Out of this total, 2.1 bcm/yr is used as cooling water (e.g., power plants) and 0.6 bcm/yr is used as process water. By the year 2000, the industrial use of water is estimated to increase from 2.1 to 6.7 bcm/yr for cooling water and from 0.6 to 3 bcm/yr for process water (GOFI, 1985a). Under such projections, nearly five times the current quantity of industrial effluent (process water) will have to be treated and discharged into the various aquatic components of the Nile system. Whether or not these projections are reached, it is clear, that growing industrialization is taking place in the short term, resulting in an increase in the volume of effluents and toxic wastes and in the variety of toxic contaminants discharged into the river system. The situation calls for the implementation of pollution control measures for the existing industries and information and monitoring systems for this growing industrialization.

B. Greater Cairo Sources of Water Pollution

Greater Cairo and Helwan has a population of some 15 million and includes areas that are industrial, commercial, residential, or mixed. Heavy industry is generally located around Helwan and Shoubra El Kheima with various large individual factories located throughout the city.

Many small industries are spread throughout the city; wastewater discharges from these industries are generally low in volume. However, short discharges of highly toxic material may cause problems.

Some districts are also centers for specific types of industry, such as tanning (Ein Sierra), and the combined discharges from such areas can present a problem.

Industry in Greater Cairo comprises 75 percent public and 25 percent private sector factories. Of the public sector factories, GOFI monitors some 80 percent. The other 20 percent are under different ministries such as Health and Housing.

The 127 public sector factories under GOFI control (December 91) are classified as follows:

- 23 chemical industries
- 27 textile and spinning industries

Table 8. Factories at Helwan and Hawamdia

FACTORIES AT NORTH HELWAN

1 . EGYPTIAN STARCH AND GLUCOSE COMPANY
2 . TOURA PORTLAND CEMENT COMPANY
3 . THE EGYPTIAN TELEPHONE COMPANY
4 . MILITARY FACTORY NO 45 (MAASARA CO. FOR ENG. INDUST.)
5 . THE EGYPTIAN COMPANY FOR PIPES AND CEMENT PRODUCTS
6 . E-NASR AUTOMOBILE MANUFACTURING COMPANY.
7 . THE EGYPTIAN TRANSPORTATION
8 . CAIRO SOUTH POEWR STATION.
9 . EL-NASR STEEL PIPES AND FITTINGS COMPANY.
10. LASOCIETE CENERAL EGYPTIENNE DE MATERIAL DE CHEMINS DE FER (SEMAF)
11. MILITARY FACTORY NO 99
12. MILITARY FACTORY NO 9 (HELWAN IRON FOUNDRIES)
13. MILITARY FACTORY NO 999 (MACHINE TOOLS)
14. MILITARY FACTORY NO 909 (HELWAN DIESEL ENGINE CO.)
15. MILITARY FACTORY NO 63 (NO FERROUS METAL CO.)
16. GALVANIZING FACTORY (ZINC COATING)

FACTORIES AT SOUTH HELWAN

17. MISR COMPANY FOR EQUIPMENT OF SPINNING AND WEAVING
18. HELWAN SPINNING AND WEAVING CO
19. STELCO COMPANY.
20. HELWAN PORTLAND CEMENT COMPANY.
21. MILITRARY FACTORY NO 360
22. MILITARY FACTORY NO 36 (AIRCRAFT FACTORY)
23. MILITARY FACTORY NO 135 (ENGINE FACTORY)
24. CEMENT FACTORY OF EL-TEBEEN.
25. NATIONAL CEMENT COMPANY.
26. EGYPTIAN IRON & STEEL COMPANY.
27. EL-TEBEEN POWER STATION
28. PREFABRICATED HOUSES COMPANY.
29. EGYCO.
30. SOUTH CAIRO FLOUR MILL.
31. EGYPAC
32. GENERAL METAL COMPANY
33. (CHEMICAL FERTILIZER PLANT)
34. (EL NASR CO. FOR COKE AND CHEMICALS) COMBINED
35. EL-NASR FORGING INDUSTRY

FACTORIES AT HAWAMDIA

36. SUGAR REFINERY OF HAWAMDIA
37. SUGAR AND DISTILLATION COMPANY
38. FACTORY OF ORGANIC CHEMICAL INDUSTRY

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- 7 metal industries
- 32 food industries
- 29 engineering industries
- 9 mining and refractories industries

These industries consume some 162 million m^3/year of water and discharge some 127.5 mcm/yr of effluent.

- 55.5 M.m^3/year discharge to the sewers
- 6.5 M.m^3/year to underground and superficial drains
- 24.5 M m^3/year to canals
- 21.0 M.m^3/year to drains
- 20.0 M.m^3/year unidentified

To date the major polluted areas in Greater Cairo have been identified as Shoubra El-Kheima and Helwan. Industries in Greater Cairo can be classified as follows:

Industrial zone located between **south Maadi and Helwan:**

- El Nasr factory for the production of automobiles
- Factory No. 9 cast iron works
- Factory No. 63 casting for non-ferrous metals
- Factory No. 909 diesel engine manufacturers
- Steel pipe manufacturer
- Cement factory

These factories are not connected to the sewerage network and some discharge their wastewater into lagoons.

South Helwan. This zone contains the iron and steel complex aeroplane manufacturer plus Helwan textiles. Figure 3 shows the location of industries in Helwan, with the respective names listed in Table 8.

Shoubra El Kheima. Various factories are located in this zone and include:

- Spinning, weaving, and dyeing
- Glass manufacture
- Cable manufacture
- Electric appliance
- Cement pipes
- Metal foundries

The results of a comprehensive study carried out by the WPCD of the NRC are presented in Figures 4, 5, 6, and Table 9.

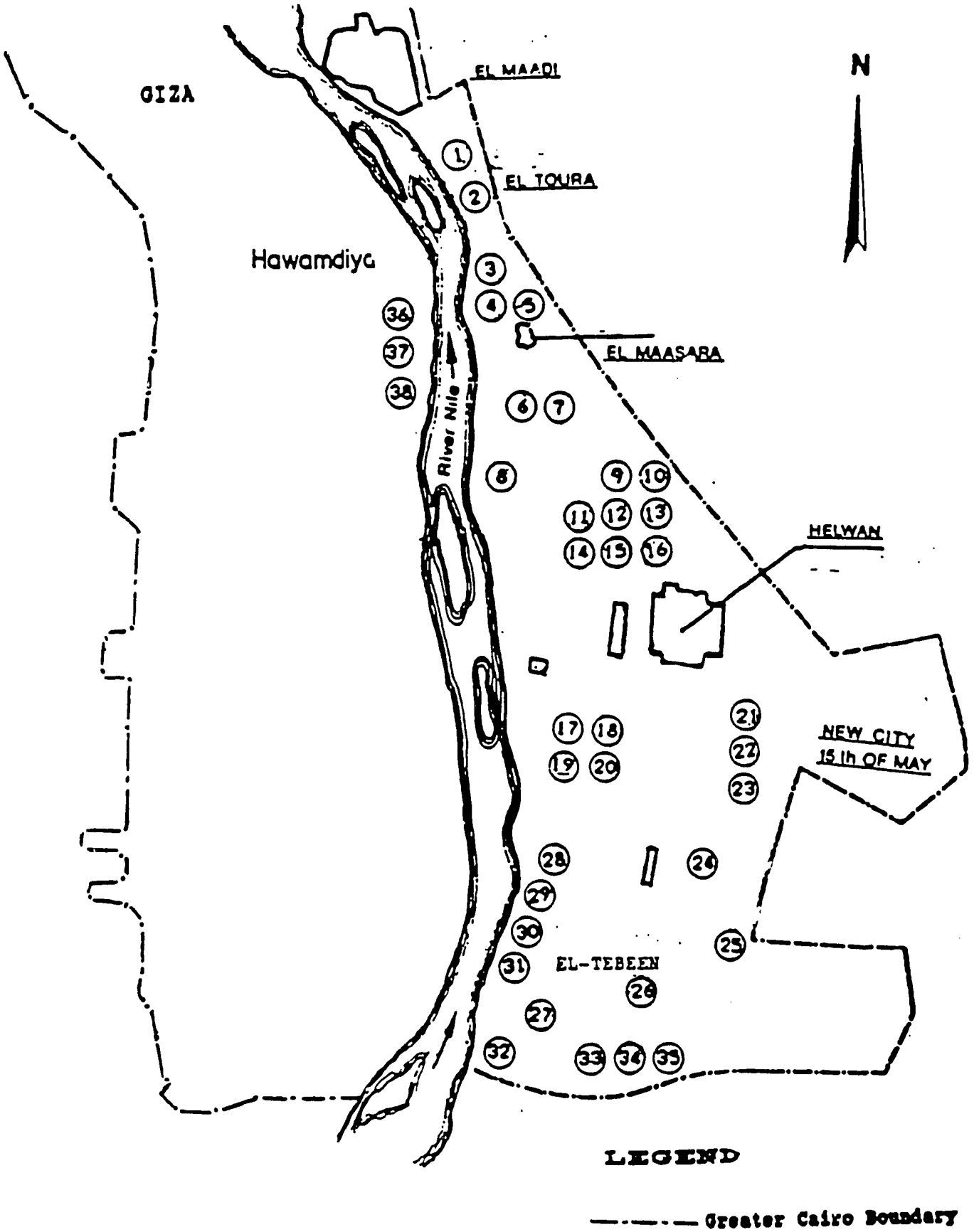

Figure 3. Greater Cairo Area
Factories at Helwan and Hawamdia

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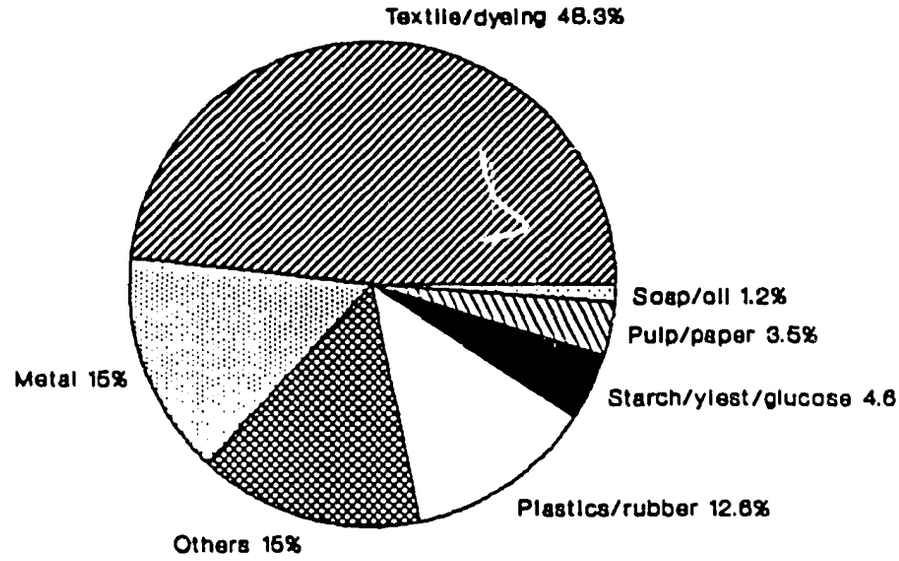
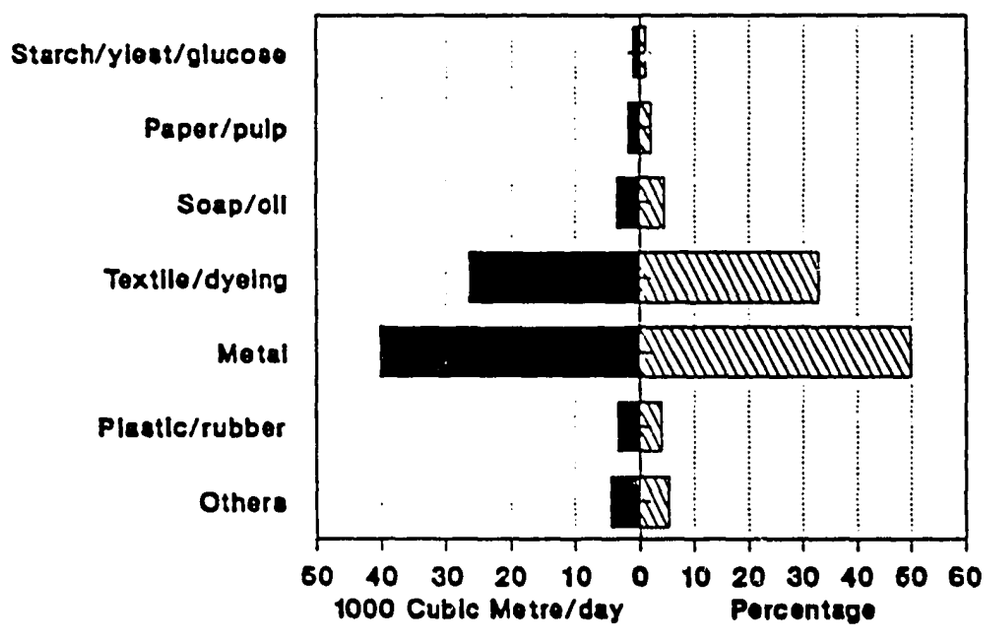
Figure 4
PERCENTAGE DISTRIBUTION OF INDUSTRIES



Source: WPCD of NRC

Figure 5
WASTEWATER DISCHARGED FROM DIFFERENT INDUSTRIAL SECTORS



Source: WPCD of NRC

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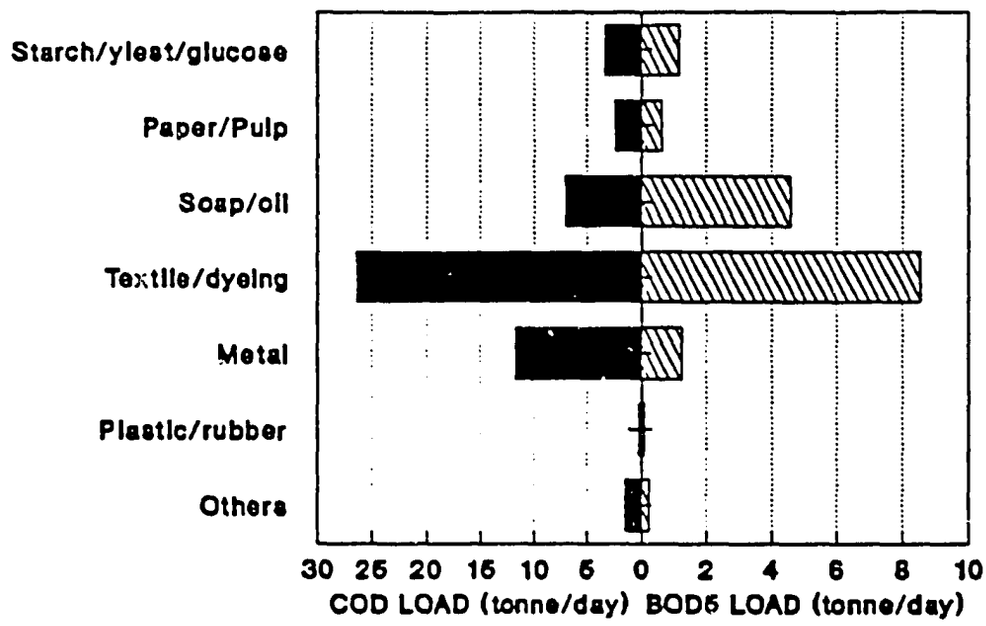
Figure 6
LOADS OF POLLUTION CONTRIBUTED FROM DIFFERENT INDUSTRIAL SECTORS



Source: WPCD of NRC

Table 9. Organic Load Contributed by the Different Industrial Sectors in Shoubra El-Khema

Type of Industry	Miscell-anecus	Oil & Soap	Starch Yiest glucose	Pulp & paper	Metal Ind.	Plastic & Rubber	Textile & Dyeing	Total Load
COD Load (Kg/day)	1366.9	7006	3239.4	2322.3	11676.3	236.7	26372.3	52219.9
BOD_5 Load (Kg/day)	244.9	4568	1148	661.7	1257.7	77.9	8533.9	16492.1

Source: National Research Center (NRC) and WPCD

Imbaba Industrial Zone. This zone contains many large factories that drain their effluent into the Giza sewerage system. These factories include textile and metal producers, printshops, and shipyard workshops.

Diffuse Factories. The second category is diffuse industrial units, often with small work forces and located within the residual areas.

Tanneries. Cairo has approximately 52 tanneries, all in one area south of the city. They discharge acids, chrome salts, and animal residues (including blood, hair, intestinal contents, and fat).

In general, industrial wastewater in Greater Cairo represents 23 percent of total industrial wastes in Egypt (December 91).

It should be mentioned, however, that projects being undertaken by CWO and GOSD involve the construction of an extensive sewerage network and six major treatment plants. Three will be located on the East Bank, two on the West Bank, and one at Helwan. These plants will significantly reduce pollution within the city and provide the potential for effluent and sludge reuse in agriculture.

Three of the treatment plants (Zenein, Helwan, and Berka) are already in operation and the others are under construction at Gabal El Asfar, Shoubra El Kheima and Abu Rawash. By 1995, total treatment capacity should be 3,280,000 m^3/dy (Table 10).

C. Agriculture as a Source of Water Pollution

Egypt is one of the few countries in the world where agricultural production depends almost entirely on artificial irrigation. The main source is the Nile, which provides irrigation water for 7.2 million feddans (El Goweily, 1991).

The water is transferred from the Nile to the fields through a system of main canals and rayahs, secondary canals, third order canals, and Meskas. The length of the irrigation system is about 30,309 km.

The cultivated area is covered with a network of drains starting from the collectors and ending with the main drains. The total length of the drainage system in Egypt is about 17,497 km. Most of the drainage system of Upper Egypt discharges wastes into the River Nile, while most of the Nile Delta discharges into the northern lakes or directly into the sea.

The major impacts of agricultural activities on water quality are the following:

- Changes in salinity due to agricultural activities
- Increasing water quality deterioration due to chemical fertilizers and pesticides
- Possible eutrophication of water bodies due to leaching of fertilizers

c 6

Table (10)

Treatment Plant Capacity within the CWO project Area

Name	Location	Treatment	Capacity m^3/day
Gbal El Asfar	East Bank	P+S	1,000,000
Berka	East Bank	P*	600,000
Shoubra El Kheima	East Bank	P*	600,000
Helwan	East Bank	P+S	350,000
Abu Rawash	East Bank	P	400,000
Zenein	East Bank	P+S	330,000
Total Capacity			3,280,000

* Commissioned as primary treatment plants, secondary treatment units under construction.

P= Primary treatment

S= Secondary treatment

The impacts of the above factors vary from place to place depending on a variety of factors, which fluctuate due to many variables, including management activities.

C1. Irrigation and Salinity

The increased salinity arising from irrigated agriculture is considered to be an acute problem in the arid and semi-arid areas of the world. Some countries that are particularly affected are listed in Table 11. It is estimated that 60 to 80 million of the 270 million hectares presently irrigated worldwide are affected to some extent and another 20 to 30 million hectares are severely affected (UNEP and WHO, 1988).

It is estimated that because of irrigation in Upper Egypt, nearly 2.3 billion m^3 of drainage water is returned to the Nile annually, either directly or indirectly. This means that total soluble salt concentration of the Nile is higher in lower Egypt (250 ppm) as compared to Upper Egypt (180-200 ppm) (Abu zeid, 1988). Fortunately, because of the high dilution effect of the Nile, this increase in salt concentrations is not significant in terms of any type of possible water use.

However, the salinity of drainage water in Egypt is, of course, much higher than that of river water. The salt concentrations vary from location to location, depending on soil type, texture, irrigation practices, cropping patterns, and other special factors such as seawater intrusion. Even at each individual location, salinity of drainage water varies every month, with the highest observed values in January and February when the irrigation system is closed for annual maintenance, and during June to August when crop-water requirements reach peak values due to maximum evapotranspiration losses. The average salinity of drainage water in the Middle Delta during 1980 to 1983 and 1988 are shown in figures 7 and 8. Comparison of the available data indicates the tremendous increase in salinity during this period.

It should be mentioned, however, that with the continuity of the ongoing projects of rationalization of irrigation water use, improvement of the irrigation networks (lining of canals and modification of gates) and promotion of night irrigation, tail-end losses will decrease, thus reducing the quantity of drainage water. This may lead to higher concentrations of salt, residual pesticides, and other pollutants.

Effective management of waterlogging and salinity requires highly developed institutional arrangement and enormous financial resources, if irrigated agriculture is to be sustained at the required levels.

C2. Fertilizer Application and Nutrients

The exponential increase in fertilizer use in countries throughout the world is well documented. Egypt is no exception.

The heavy reliance on fertilizer and herbicides is directly related to the construction of the Aswan High Dam. Prior to the construction of the dam in 1964, 24 million tons of

Table 11. Countries Affected by High Salinity and Waterlogging from Irrigation

Country	Total Irrigated Area		Area Affected by Salinity		Notes
	(million ha)	(year)	(million ha)	(year)	
India	50	1985	12	1977	
U.S.A.	21.5	1982	4	1985	
USSR	12.7	1982	na	–	
Pakistan	12.4	1982	3	1987	80% of irrigated land is affected in Punjab
Iran	5.2	1982	1	1977	
Iraq	4	1982	0.15	1977	More than 50% of the irrigated land in the Lower Rafidain Plain is affected
Egypt	2.9	1982	0.8	1970	Mostly in north part on Nile Delta

Source: UNDP & WHO Report (1988)
Assessment Of Freshwater Quality

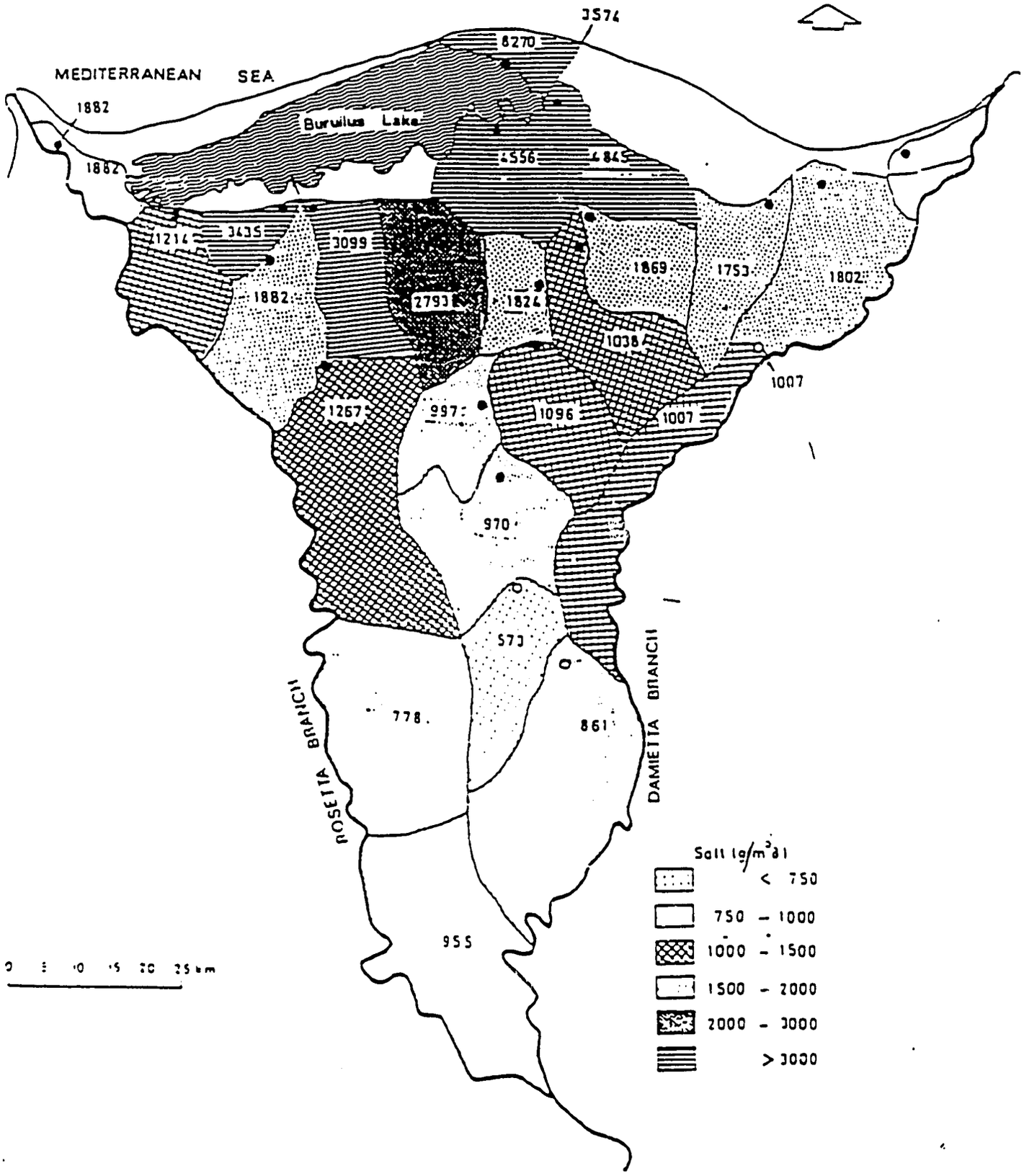


FIG. (7) Average salinity of the drainage water in the Middle Delta in g/m3 during 1988.
Source: Abu-Zeid M. & Biswas,A.K.

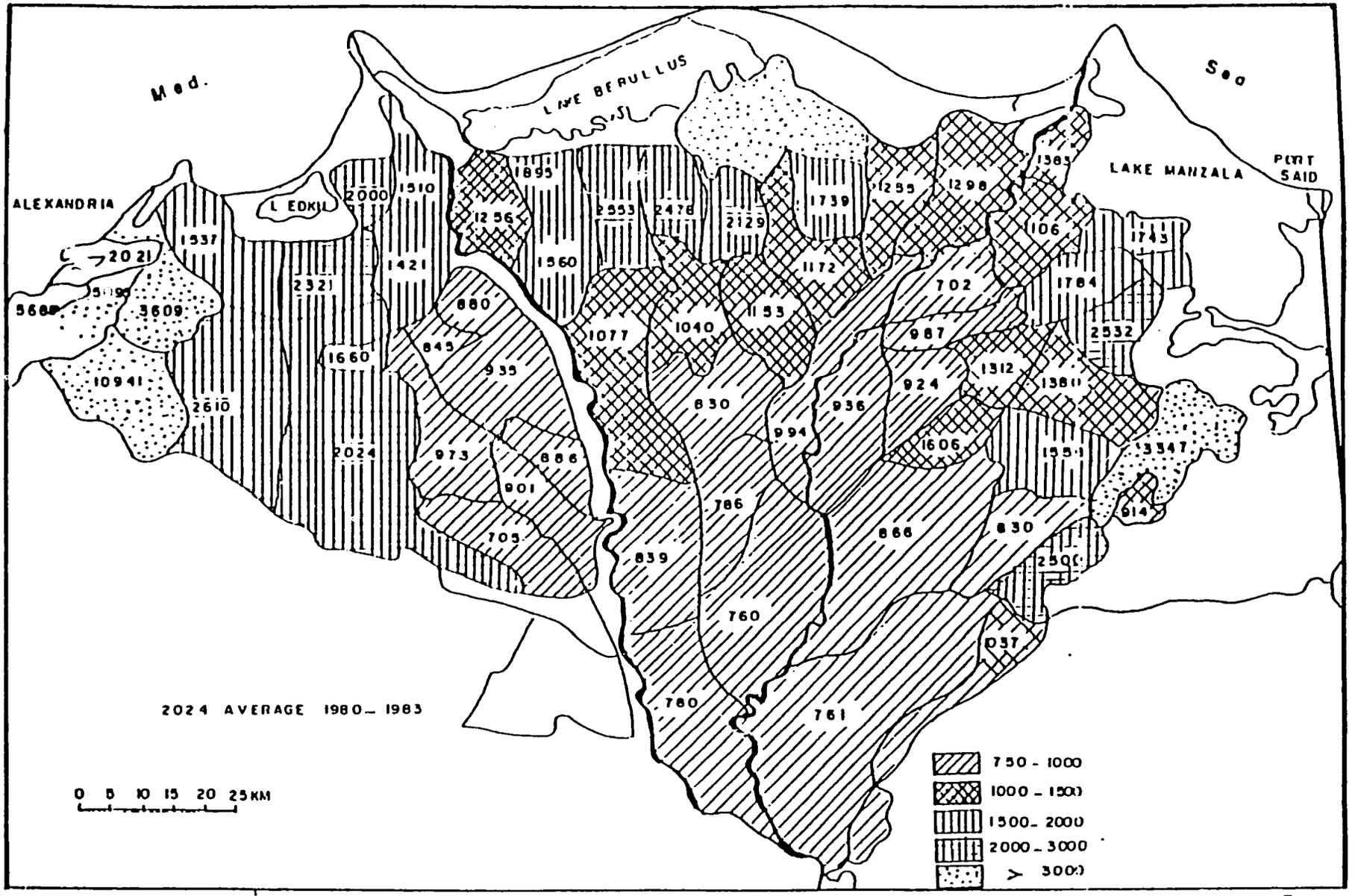


Fig.(8) AVERAGE SALINITY 1980 - 1983 OF DRAINAGE WATER IN THE MIDDLE DELTA IN GM^{-3}

Source: Environmental & Health Impacts of Irrigation & Drainage systems in Egypt (E.S.G.,),1989.

silt were deposited on the Egyptian flood plains per year. This amount has decreased to 2.1 million tons per year, with the remainder settling in southern Lake Nasser (Figure 9). The loss in nitrogen (Sediment N) and phosphorus (Soluble P) is estimated to be 12,000 and 6,000 tons, respectively. This loss has required a significant increase in the use of fertilizers, which in turn has resulted in increased values of nutrients and phosphorus in the soil, canals and drains (Environmental Studies Group, 1989). Table 12 presents the amount of fertilizers used in agriculture between 1952 and 1989.

The increase in nutrients from fertilizer seepage, coupled with clearer waters resulting from the elimination of silt have greatly stimulated weed growth. About 4 percent of the GOE's waterway maintenance program has been devoted to using herbicides. To combat the Bilharzia (snail) problem, canals and drains are also sprayed with Bayluscide (Baldwin, Ferguson, et al., 1988).

C3. Pesticides

Only limited attention has been given to the leaching of pesticides from cultivated land, despite the fact that use of these compounds has increased greatly in recent years and new compounds have been introduced particularly since the DDT ban in the late 1960s (Figure 10).

Among the many factors that affect the leaching of pesticides to water bodies are properties of individual pesticides, soil characteristics, hydrogeological conditions, climatic factors, and cropping patterns which dictate type, rate, and timing of pesticide application. Because of so many variables, it is not possible to generalize on the extent of pesticide leachings to water bodies or their concentration levels.

Presently, not enough is known on the impacts of pesticides on human and animal health. This is because toxicological research on all the currently approved pesticides has been grossly inadequate. WHO guideline limits for selected pesticides in drinking water are shown in Table 13.

About 620,000 tons of about 200 different types of pesticides have been used in the Egyptian environment over the last 30 years. Table 12 presents the annual consumption of pesticides in Egypt (1952-1989).

Egypt's heavy reliance on pesticides to increase food production and protect its crops, as in the case of cotton, a primary export commodity, poses a serious environmental risk. It has been estimated that every square meter of the Delta has received 30 grams of pesticide since 1952 (Baldwin, Ferguson, et al., 1988).

The uncontrolled use of pesticides, which results in residues seeping from the soil to the irrigation water, into the drains, and finally into the Nile, poses serious environmental and health risks.

Table 12. Insecticides and Chemical Fertilizer Use in Agriculture

Year	Insecti-cides (Tons)	Azot and Ammonia Fertilizers (1000 Tons)	Phosphatics Fertilizers (1000 Tons)	Potassium Fertilizers (Tons)
1952	2143	648	92	-
83/84	16316	4815	1064	36400
84/85	16371	4123	1094	50506
85/86	23461	4999	1223	50767
86/87	20718	5013	1236	60177
87/88	17152	5104	1272	61441
88/89	17997	4983	1204	56322

Source: CAMPS (1990)

Table (13)

WHO recommended guideline limits

for pesticides in drinking water

pesticide	WHO Guideline (mg/l)
Atrazine	2
Bentazone	25
2,4-D	100
Lindane	3
MCPA	0.5
Methoxychlor	30
Metolachlor	5
Pendimethalin	17
Pyridate	60
Simazine	17
Trifluralin	170

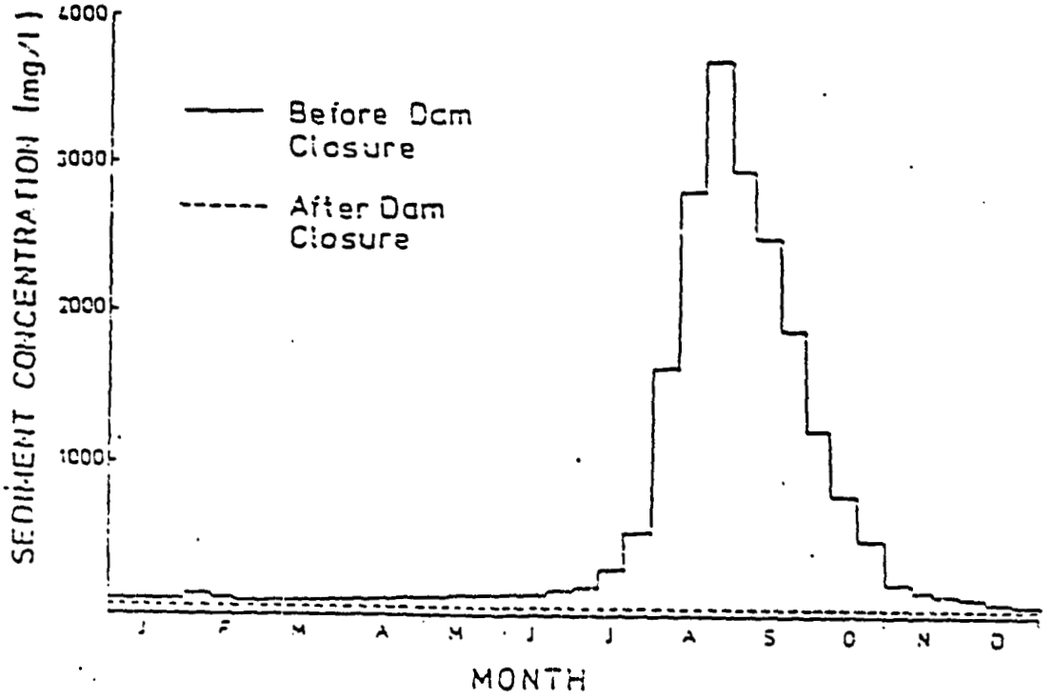


Figure (9) Sediment concentrations in the Nile before and after the closure of the High Dam at Gaafra, 35 km below Aswan

Source: Scamp (1983)

UNEP & WHO (1988)

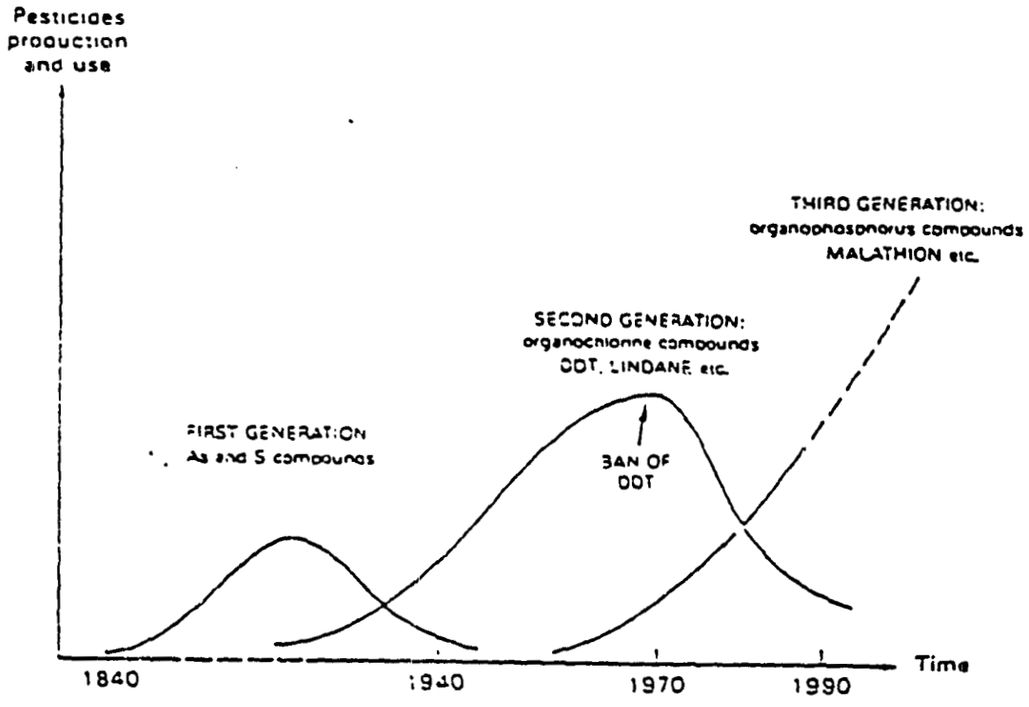


Figure (10) Historic trends in pesticide use

Source: UNEP & WHO (1988)

In a study conducted between August and October 1979, in three selected agricultural areas, Lindane, Endrin, DDT, and its degradation product (DDD) were detected in all soil and water samples collected, the highest concentration being that of DDT. Figures 11 and 12 present the different concentrations of organophosphorus and organochlorine pesticide in Nile water, fish, and soil.

Concentrations of selected organo-phosphorus and organochlorine pesticides in Hadous Drain during August and October 1979 are shown in Figures 12 and 13.

Contamination of groundwater by pesticides has become an important cause for concern primarily in Europe and North America. Little information is available on groundwater contamination with micro-pollutants.

D. Northern Lakes

Three major environmental problems impact inland lakes: land reclamation, runoff from surrounding areas, direct discharge of untreated wastewater, and discharge of irrigation water from drainage canals. Collectively, these problems have contributed to a significant deterioration of water quality and the disappearance of several important species of fish.

Land reclamation by indiscriminate filling of inland lakes and marshlands has a detrimental effect on the entire ecosystem, diminishing fishery resources, destroying the habitat for migratory water fowl, and frequently causing significant changes in water table levels in the surrounding area. Runoff, particularly in proximity to agricultural areas, may lead to serious contamination from herbicides, pesticides, and fertilizers, often misused and over applied. Discharge of untreated wastewater and irrigation water from drainage canals into inland lakes is a major source of contamination, introducing persistent materials such as heavy metals, carcinogens, and other toxic wastes.

According to 1990 estimates, about 13 billion cubic meters of agricultural drainage water are discharged annually into the Mediterranean and the Delta lakes (El Khordagui and Mancy, 1981). Three of the four major Eastern Delta drains discharge into Lake Manzala, most of the 11 Middle Delta drains discharge into Lake Burullus, one of the two main Western Delta drains discharges into Lake Edku, with the other discharging into Lake Maryut, and two of the eight Middle Egypt drains discharge into Lake Qaroon (Environmental Studies Group-ESG, 1989) (Figure 18).

The most important northern lakes are Manzala, Maryut, Idku, Burullus, Malaha, and Bardawil.

D1. Lake Manzala

Lake Manzala is located on the northeastern edge of the Nile Delta, between Damietta and Port Said. It is separated from the Mediterranean Sea by a sandy beach ridge which has three open connections (bugaz) between the lake and the sea.

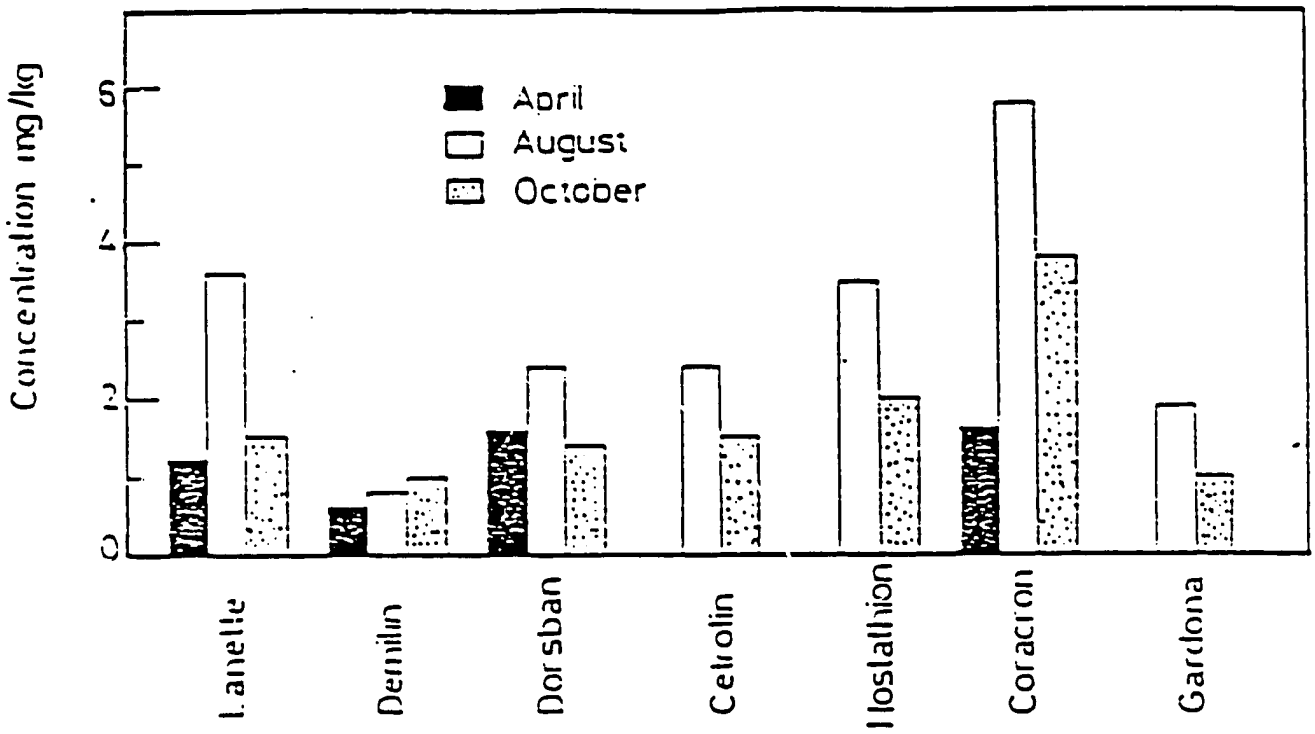


Figure 11. Concentration of Pesticides (Organo-phosphorus) in Soil Samples Collected from El-Mansora Province

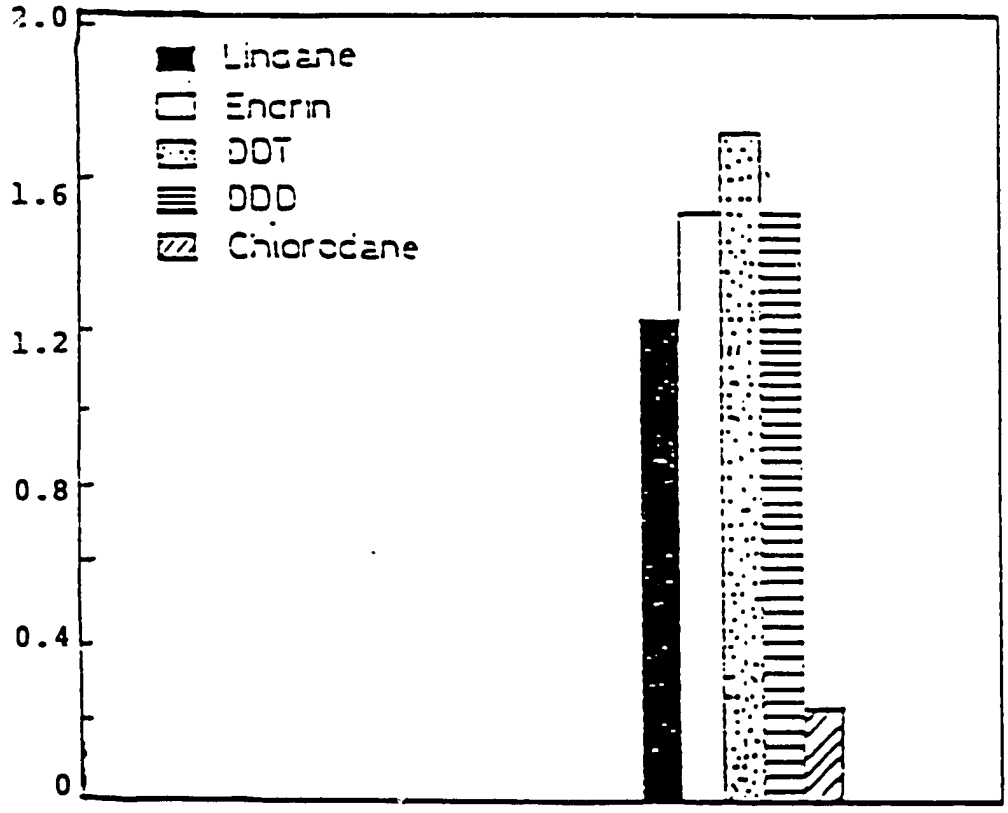
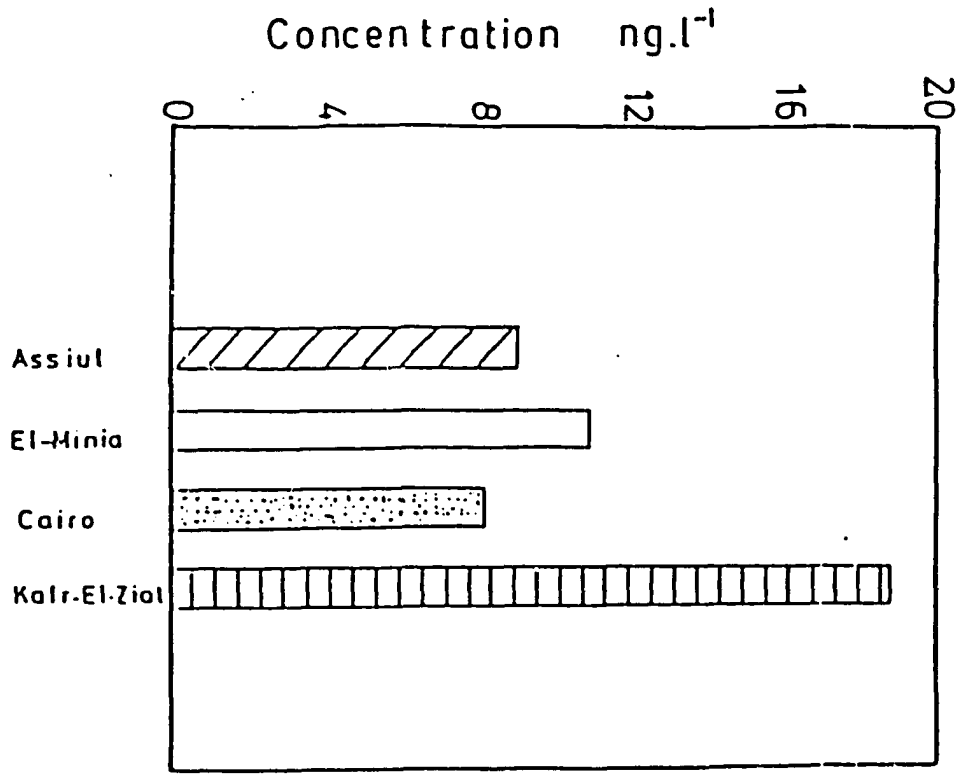


Figure 12. Concentration of Organochlorine Insecticides in Soil (Samples Collected from El-Mansoura Province during August 1979)



Source: Badawy, M. Internal Report, River Nile & Lake Nasser Research Project. The Egyptian Academy of Scientific Research and Technology, Cairo, 1982.

Figure 13. Concentration of Total Organochlorine Insecticides in River Nile Waters (1979)

98

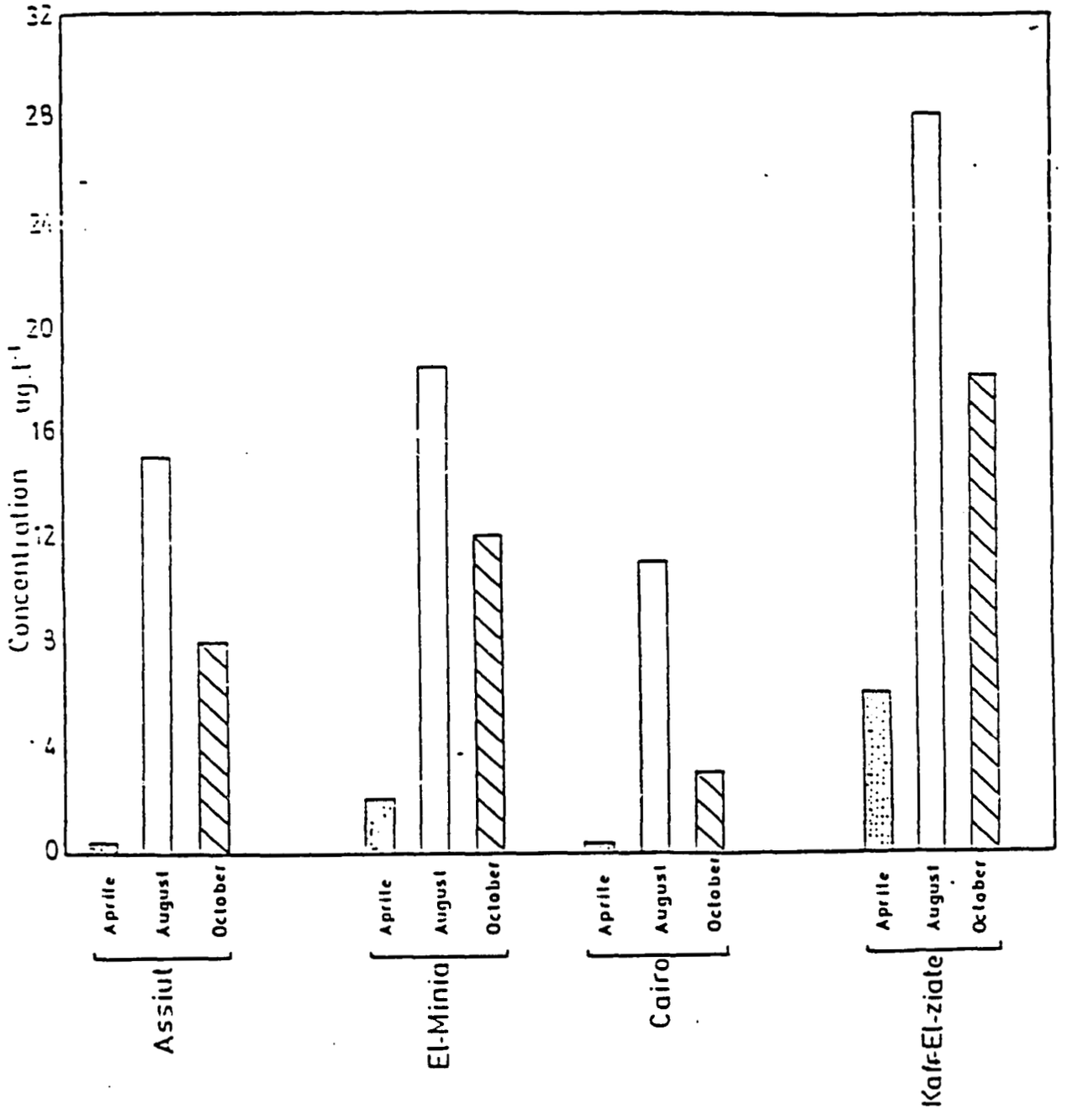
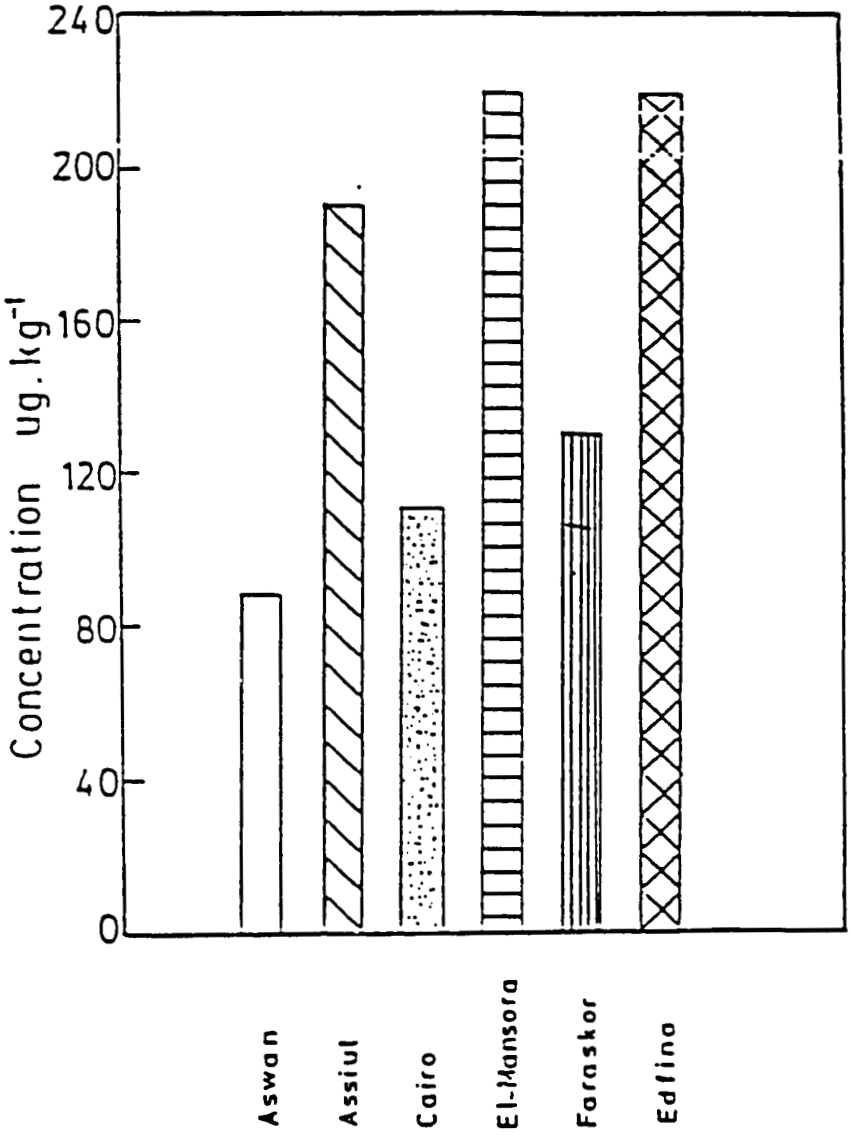


Figure 14. Concentration of Organophosphorus Insecticides in River Nile Waters During 1979.



Source: Badawy, M. Internal Report, River Nile & Lake Nasser Research Project. The Egyptian Academy of Scientific Research and Technology, Cairo, 1982.

Figure 15. Concentration of Organochlorine Insecticides in Fish Samples Collected from River Nile

60

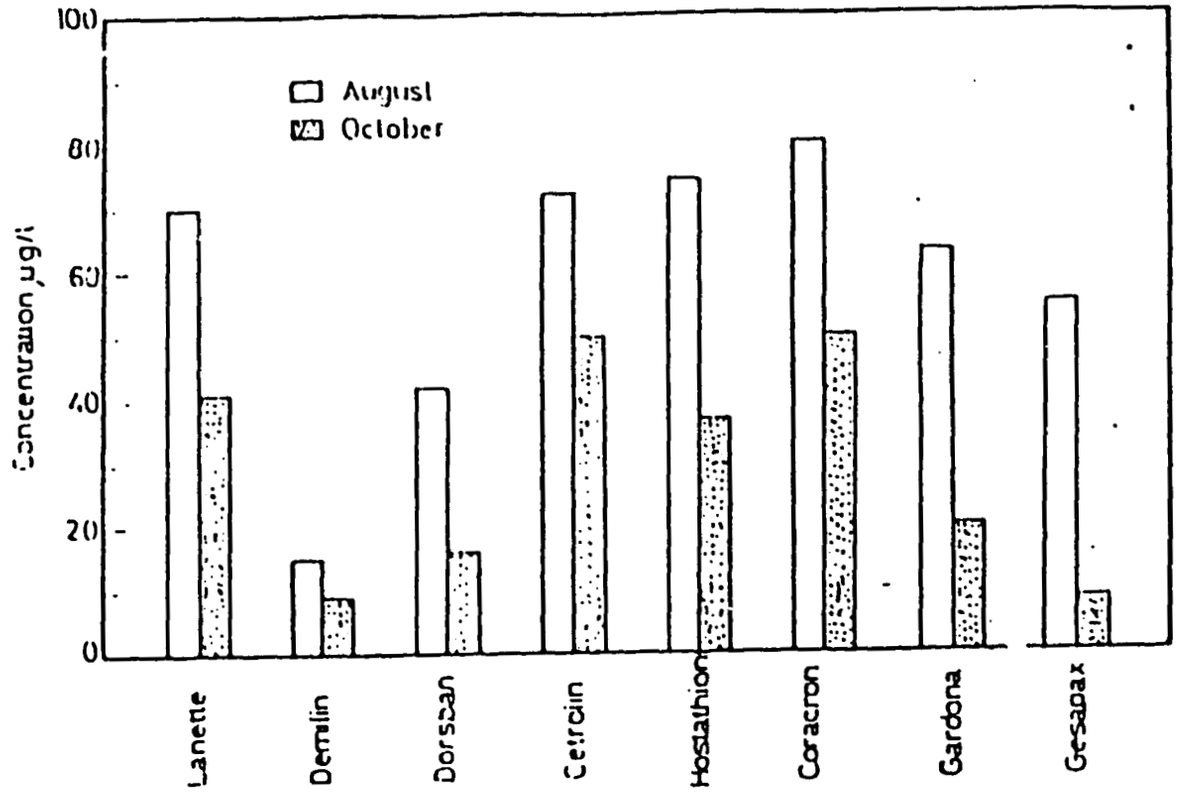


Figure 16. Concentrations of Pesticides (organo-phosphorus) in Bahr Hadous Drain During August & October 1979.

Source: Aly and Badawy, 1981.

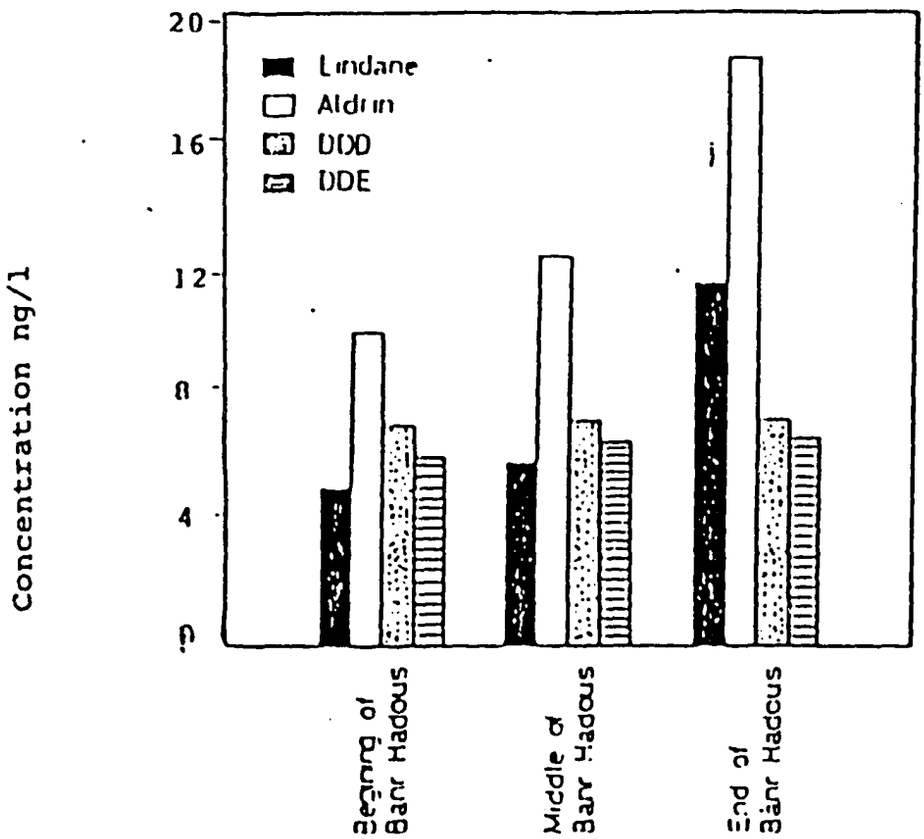
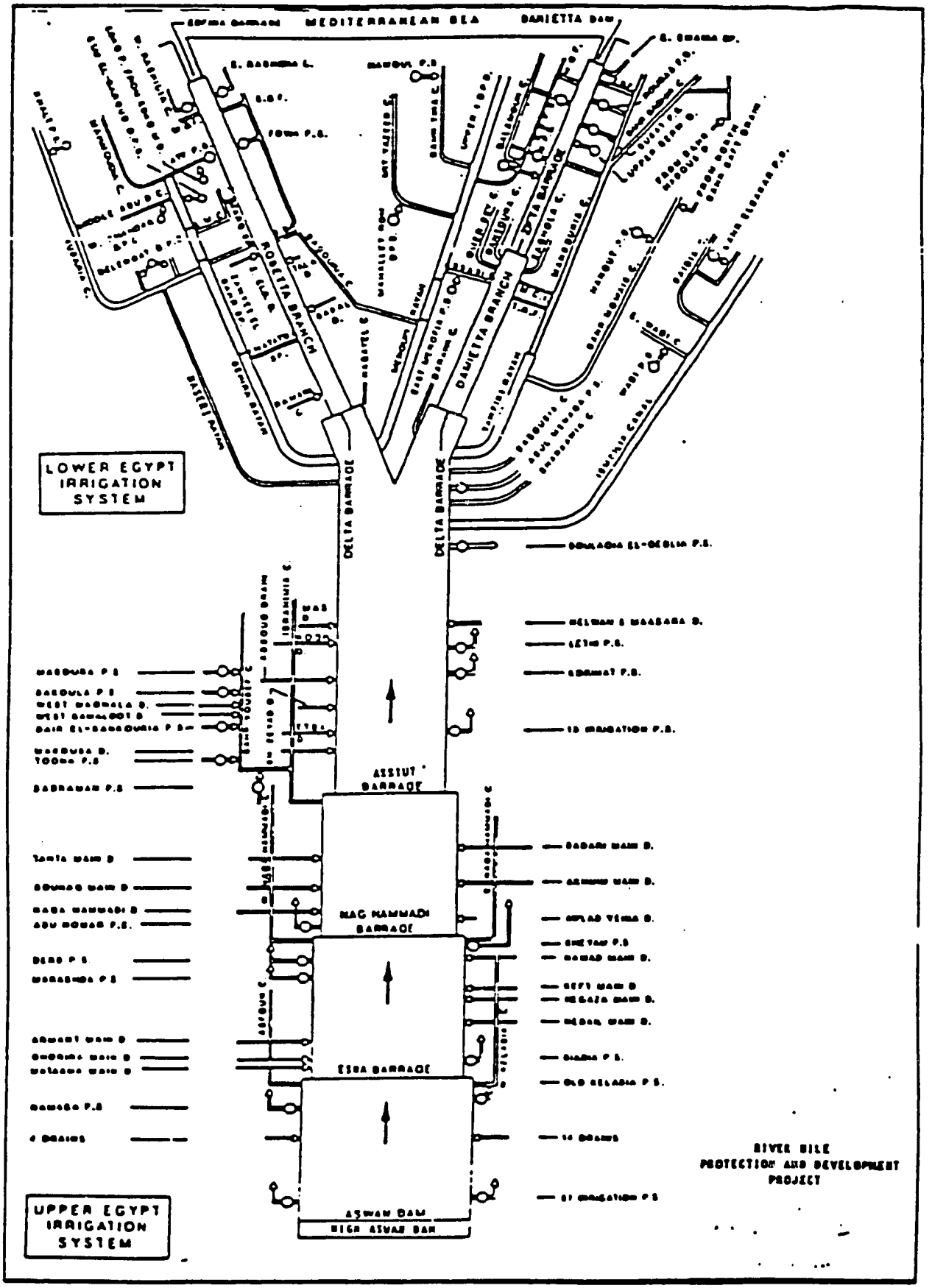


Figure 17. Concentration of Organochlorine Insecticides in Bahr Hadous Drain During October 1979

Source: Aly and Badawy, 1981



Source: Environmental Studies Group

Figure 18. Nile River System Barrages, Canals and Drains

Lake Manzala used to include 1,698 sq km. However, continuous land reclamation projects set up to meet a rapidly growing population have significantly decreased the size of the lake, which reached 769 sq. km, in 1988.

According to a USAID-funded study on Egypt's biological resources, "existing plans will reduce it to 469 sq. km" (Baldwin, Ferguson, et al., 1988). Land reclamation for agriculture together with the introduction of perennial irrigation, the construction of canals and drains, and the discharge of nutrients have greatly modified Lake Manzala.

Today, the lake is characterized by low saline levels near drain and canal outlets in the south and west, saline waters in the extreme northwest, and brackish waters over most of the remaining areas. Table 14 presents the nutrient load discharging into Lake Manzala in 1982 (Maclaren Engineers, Planners and Scientists Inc., 1982). The data suggests that there are several sources contributing to the contamination of the lake, including wastewater from Cairo discharged through Bahr El Baqar, Hadous, and El Sirw drains.

Nutrients from the major drains have modified the aquatic life, resulting in a less diverse but highly productive system, which supports a large commercial fishery. In the El Genki region in the south, fish standing stock densities are the highest in the lake, reaching 700-1,300 kg/feddan. In addition, El Genki also enjoys the highest average yield of 850 kg/feddan for open fishing and 2,000 kg/feddan for closed fishing (Maclaren Engineers, Planners and Scientists Inc., 1982).

The lake is of international importance as a wintering area for water birds, mainly ducks (100,000) and coots (150,000), and is used in the summer by many migrating species. In addition, aquatic birds are an important resource both locally and internationally. According to a 1982 estimate, 135,000 birds are sold on the local markets annually for a value of approximately LE 100,000 (Maclaren Engineers, Planners and Scientists Inc., 1982). In June 1988, approximately 1,200 hectares in the eastern part of Lake Manzala in the Port Said Governorate were declared a natural protectorate (Baldwin, Ferguson, et al., 1988).

The lake is very shallow, with an average depth of 1.3 m. The water in the lake is not mixed uniformly, due to the islands. The lake can be divided into five basins, which each have a different salinity regime (Figure 19).

It is worth mentioning however, that the implementation of the Northern Sinai Agricultural Development project will involve the diversion of 1,270 million m^3/year of drainage water through El-Salam Canal for land reclamation in Sinai. The reduced flow toward Lake Manzala will increase the salinity of the lake, especially in the southern part.

This will affect the fisheries in the lake. The yield of freshwater species might decline, while yields of marine species will increase.

Table 14. Nutrient Load Discharging into Lake Manzala Under Existing Conditions

	Flow (10^6 m^3/year)	Percent of Total Flow	Nitrogen Concentration (mg/L-N)	Nitrogen Load (T/Y-N)	Phosphorus concentration (mg/L-P)	Phosphorus Load (T/Y-P)	Nutrient Load (T/Y)	Percent Total Nutrient Load
Bahr El Baqar Drain	1 678	25	3.683	6.180	1.013	1 700	7 880	60
Hadous Drain	3 276	49	0.730	2.391	0.192	629	3 020	23
Ramsis Drain	252	4	0.633	160	0.143	36	196	1
El Siru Pumping Station	847	13	1.144	969	0.181	153	1 122	8
Materiya pumping Station	154	2	0.381	59	0.18	28	87	1
Fariskur pumping Station	292	4	0.45	131	0.138	40	171	1
Port said sewage Treatment plant	40	1	14.888	596	4.128	165	761	6
Inaniya Canal	156	2	Nutrient Load has been neglected					
TOTAL	6 695	100	N/A	10.486	N/A	2 751	13 237	100

Source: Machlaren Engineers, Panners & Scientists Inc., 1982

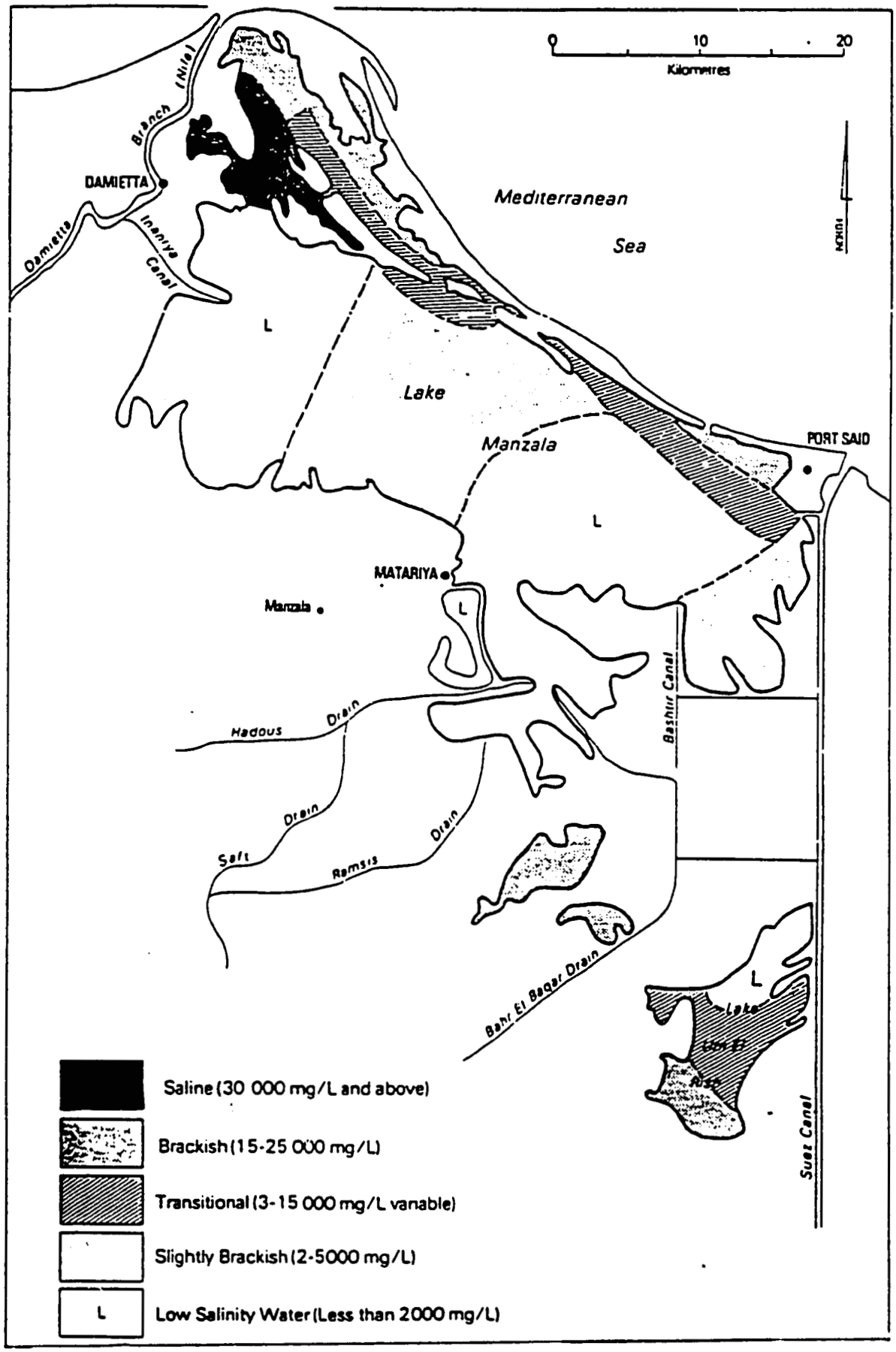


Figure 19. Salinity Regime of Lake Manzala

D2. Lake Maryut

Lake Maryut, which is located south of Alexandria, consists of a series of shallow, brackish, interconnected basins that are used extensively as discharge sites for heavy industrial and domestic wastewater. Little information has been published on conditions of the lake in the last 10 years, but several environmentalists have expressed concern about the alarming conditions prevailing in the lake.

According to a study on industrial waste disposal in Alexandria, the effluent from the city's eastern sewage treatment plant, which handles a discharge of about 100,000 cubic meters per day, is discharged into Lake Maryut, now considered to be an enormous waste disposal oxidation pond covering as area exceeding 3,000 hectares. In addition, an average of 100,000 cubic meters of wastewater from the city's southern industrial area is discharged daily into the lake. Lake Maryut also receives the agricultural drainage water from the west bank of lower Egypt, which ranges from 6 to 7.5 million cubic meters a day (Mitwally, 1981).

The Moharrem Bey Industrial Complex, in Alexandria's southern area, comprises paper reprocessing, textile finishing, yeast and starch production, and edible oil refining plants, as well as a foundry and several small plants for production of matches and macaroni. The effluent of all plants, except that of textile finishing, is discharged into the lake at an approximate rate of 12 million cubic meters per year. The heavily polluted effluent from the textile finishing plant is discharged into the lake through a separate outfall at an annual rate of approximately 5 million cubic meters (Hamza, 1981).

The high eutrophication resulting from industrial and agricultural runoff threatens Lake Maryut's biological and economic productivity. Over the past 10 years, fish production has dropped by approximately 80 percent. Moreover, even the few species of commercially utilized fish it produces are threatened. According to the Baldwin study on Egypt's biological resources, the lake has experienced severe fish kills from heavy concentrations of DDT, DDE, and Lindane (Baldwin, Ferguson, et al., 1988). Current conditions of the lake can, for all practical purposes, be regarded as an ecological disaster, with significant potential for long-term damage to the surrounding environment and health of the general public.

D3. Lake Idku

Lake Idku is a shallow marine lagoon located east of Alexandria and connected to the Abu Kir Bay. The lake makes an important contribution to Egypt's economy. It supports a commercial fishery and supplies the brackish water to Abu Kir Bay that is necessary to nurture its shrimp fishery. Lake Idku also supports regular bird catching activities (Baldwin, Ferguson, et al., 1988). However, agricultural drainage and industrial wastes dumped into the Abu Kir Bay are negatively affecting the lake.

D4. Lake Burullus

Lake Burullus lies midway between the Nile's two branches. It is internationally important as a sanctuary for wintering birds. Connected to the Mediterranean, its waters are shallow and brackish. "It supports a commercial fishery and its southern shores are used for enclosing shallow basins to capture or rear fish" (Baldwin, Ferguson, et al., 1988).

D5. Lake Qarun

Lake Qarun is situated in Fayoum, southwest of Cairo in the western desert. It covers approximately 214.4 sq. km, stretches 45 km from east to west, and about 9 km from north to south at its widest point, with no outlet. The average depth of the lake is 4.5 m, and it is 44 m below sea level.

The two principal drains entering Lake Qarun are El Bats and Wadi. A third drain also enters the lake at the southeast edge, El Bashma Drain. Of the three drains, El Bats is the largest, contributing about 10 times more flow to the lake than the Wadi Drain and about 30 times more flow than the El Bashma Drain.

The constant inflow from the drains with no outlet except largely through evaporative losses has resulted in substantial increase in the salt content of the lake (3.3 percent). At the current rate of salinity increase, the total dissolved solids concentration could reach 50,000 mg/l or more by the year 2000. This will affect fish production and the available fish species.

D6. El Malaha and Bardawil Lakes are both located in northern Sinai, El Malaha bordered by the Suez Canal, and Bardaweil situated west of Al Arish. They are both shallow and hyper-saline, and have several outlets to the Mediterranean. Commercial fishing is well established at both lakes.

El Malaha is a particularly important habitat for breeding, migrating, and wintering aquatic birds. It serves as a nesting ground for flamingoes and slender billed gulls (Maclaren Engineers, Planners and Scientists Inc., 1982).

Baradwil, on the other hand, attracts bird hunting, especially for quail, for market purposes (Baldwin, Ferguson, et al., 1988).

E. Assessment of Water Pollution Effects

Assessment of available information shows that the Nile and its waterways in Egypt currently suffer from increasing pollution caused by the discharge of untreated industrial and domestic wastewater, contaminated agricultural drainage water, and oil and grease from navigation.

River Nile Research Institute (RNI) has reported that 63 discharge points along the Nile are from industrial effluent, power stations, and domestic wastes and 79 discharge points are mainly from agricultural drains (Table 15).

The industrial wastes are considered a main source of water pollution, because of their toxic chemicals and organic loading. It is estimated that wastewater from 350 industries are discharged directly into the Nile or through municipal systems which discharge into the Nile. Table (16) shows the overall volume and polluting loads for the various regions of Egypt and Table (17) presents the main polluting industries.

Studies of special and seasonal distribution of trace metals in river water and sediments reveal the presence of higher concentrations of chromium and manganese in all sediments. In most examined samples, however, concentrations of copper and lead were found to the lowest. Profiles of metals in sediments also indicates differences in concentrations, and demonstrates contamination from wastewater discharges. High concentrations were found at Helwan, Kafr El Zayat, and Talkha (Ragaaei, 1982).

In Helwan, the Iron and Steel Factory and the Nasr Automobile Company discharge large quantities of toxic wastes. According to the Helwan Wastewater Master Plan (1987), the industrial wastewater discharged from the Helwan area amounts to 42,314,000 cubic meters per annum. In Talkha, a study of the El Nasr company for Fertilizers and Chemicals (SEMADCO) reveals that until 1982, untreated process wastewater was discharged into the Tawila Drainage canal and into the Nile at rates of 1,000 cubic meters per hour (Weston, 1982).

In Shoubra El Kheima, which represents one of the highest concentrations of industry in Egypt, industrial activities range from metal production, food processing, detergent and soap manufacturing, to textile finishing and paper production. Huge volumes of untreated wastewater are discharged into agricultural drains daily. Water Pollution Control Department, 1984-1989 industries were identified as being the major sources of water pollution in the area. The textile industries representing 48.3 percent of the total number are the main contributors to organic load, at almost 52 percent (26,372 kg/day).

The metal industry, on the other hand, which represents only 15 percent of the total number, discharges almost 50 percent (49.8) of total wastewaters discharged and contributes 7.6 percent of the total BOD_5 load (El-Gohary et al., 1990).

The Nile and its waterways also suffer from an alarming increase in the discharge rates of municipal and rural domestic waste. The expansion of water supply networks in villages, towns, and cities without the parallel construction of new sewer systems or the rehabilitation of existing systems has led to serious water pollution problems. A limited number of cities and towns in Egypt have sewer systems and wastewater treatment facilities. The effluent of these plants, in many cases, is not complying with the standards. The plants are receiving wastewater exceeding their designed capacity in addition to not being operated and maintained properly.

Table 15. List of Drains & Industrial Effluents

Serial No.	Km From Aswan	Name	Description
1	6.000	Aswan SewerageDrain	Sewarage Drain
2	9.900	Khour El Sail Drain	Agricultural Excess Water R.B.
3	37.250	El Tawansa Drain	Agricultural Excess Water R.B.
4	42.500	El Sheikh Ibrahem Drain	Agricultural Excess Water R.B.
5	46.550	El Ghaba Drain	Agricultural Excess Water R.B.
6	47.150	Abu Wanas Drain	Agricultural Excess Water R.B.
	47.500	G.B.Drain *	Agricultural Excess Water R.B.
7	48.000	El Shatb Drain	Agricultural Over Flow From Canal R.B.
8	48.850	Main Draw Drain	Agricultural Excess Water R.B.
9	49.100	EL Berba Drain	Agricultural Excess Water R.B.
10	50.000	Kom Ombu Sugar Ind.	Industrial Effluent R.B.
11	51.000	Kom Ombu Drain *	Agricultural Excess Water R.B.
12	53.000	Benban Drain	Agricultural Excess Water L.B.
13	55.000	Meneha Drain *	Agricultural Excess Water R.B.
14	57.650	Main Ekleet Drain	Agricultural Excess Water R.B.
15	63.600	Ekleet Power Station	Power Station
16	64.650	Berak El Raghama Drain	Agricultural Excess Water R.B.
17	70.450	Fatera Drain	Agricultural Excess Water R.B.
18	70.750	Khour El Sail Drain	Mixed From Water & Ind. R.B.
19	73.850	Selesla Drain	Agricultural Excess Water R.B.
20	75.750	Kagouk Drain *	Agricultural Excess Water R.B.
21	76.000	Awarta Drain *	Agricultural Excess Water R.B.
22	99.850	Radisia Drain	Agricultural Excess Water R.B.
23	101.750	Hasia Drain *	Agricultural Excess Water L.B.
24	109.250	Hager Drain *	Agricultural Excess Water L.B.
25	116.200	Edfu Drain *	Agricultural Excess Water R.B.
26	119.600	Kalh Power Station	Power Station
27	122.450	Edfu Paper Pulp A.	Industrial Effluent L.B.
28	122.500	Edfu Paper Pulp B.	Industrial Effluent L.B.
29	123.000	Edfu Sugar Ind.	Industrial Effluent L.B.
30	135.600	El Mahameed Drair	Agricultural Excess Water R.B.
31	139.500	Houd El Sabaia	Agricultural Excess Water L.B.
32	143.100	Hagz El Bahary Drain	Agricultural Excess Water R.B.
33	147.000	Seba Phosphate drain	Industrial Effluent R.B.
34	149.100	Hagar El Sebia	Agricultural Excess Water L.B.
35	187.700	Mataana Drain *	Agricultural Excess Water L.B.
36	196.700	Shoreara Drain	Agricultural Excess Water L.B.
37	204.500	Armant Sugar Ind.1	Industrial Effluent L.B.
38	204.505	Armant Sugar Ind.2	Industrial Effluent L.B.
39	204.510	Armant Sugar Ind.3	Industrial Effluent L.B.

Table 15. List of Drains & Industrial Effluents (continued)

Serial No.	Km From Aswan	Name	Description
40	209.000	El Salamia Drain *	Agricultural Excess Water R.B.
41	220.800	El Mraibia Drain *	Agricult.Excess Water From Canal L.B.
42	220.850	El Rayayna Drain	Agricultural Excess Water L.B.
43	224.500	Outlet Louxor Water Treatment *	Industrial Effluent
44	236.000	El Zeinia Drain	Agricultural Excess water R.B.
45	237.700	Habail El Sharky Drain	Agricultural Excess Water R.B.
46	245.100	El Shanhoria Drain	Agricult.Excess Water From Canal R.B.
	246.850	Ques Sugar Ind. *	Industrial Effluent R.B.
47	251.550	Danfik Drain	Agricultural Excess Water L.B.
48	265.300	Sheikhia(El Hagaza) Drain *	Agricultural Excess Water R.B.
49	265.400	Grinding Mill *	Industrial Effluent L.B.
50	270.700	El Ballas Drain	Agricultural Excess Water L.B.
51	275.900	Kaft (Qift) Drain	Agricultural Excess Water R.B.
52	286.750	El Tramasa Drain	Agricultural Excess Water L.B.
53	288.800	Khour El Sail Qena *	Mixed From Agr.& Ind. R.B.
54	299.750	Bahari Dandra Drain *	Agricult.Excess Water From Canal R.B.
55	314.000	Deshna Sugar Ind.	Industrial Effluent R.B.
56	331.200	Hamad Drain *	Agricultural Excess Water R.B.
57	333.500	Salamia Drain *	Agricultural Excess Water R.B.
58	337.500	Alumenium Ind. *	Industrial Effluent
59	340.350	Magrour Hoe Drain	Agricultural Excess Water L.B.
60	343.200	Naga Hammadi Sugar Ind.A.	Industrial Effluent L.B.
61	343.250	Naga Hammadi Sugar Ind.B.	Industrial Effluent L.B.
62	363.000	Abu Homar Power Station	Power Station
63	377.800	Naga Hamadi Drain	Agricultural Excess Water L.B.
64	384.000	Abu Shousha Drain *	Agricult.Excess Water From Canal L.B.
65	392.750	Mazata Drain	Agricultural Excess Water R.B.
66	432.700	Essawia Drain *	Agricult.Excess Water From Canal L.B.
67	443.200	Onion Ind.	Industrial Effluent L.B.
68	444.550	Souhag Drain	Agricultural Excess Water L.B.
69	445.600	Souhag Oil Ind.	Industrial Effluent L.B.
70	445.605	Cocacola Ind.	Industrial Eff' 'n
71	454.700	Seflak Drain	Agricultural Excess Water R.B.
72	473.850	Ekheem Drain	Agricultural Excess Water R.B.
73	486.400	Raaina Drain *	Agricult.Excess Water From Canal R.B.
74	486.700	Tahta Drain	Agricultural Excess Water L.B.

Source: River Nile Research Institute

Table 15. List of Drains & Industrial Effluents (continued)

Serial No.	Km From Aswan	Name	Description
75	520.800	Abu Teeg Drain	Agricultural Excess Water L.B.
76	525.400	El Badary Drain	Agricultural Excess Water R.B.
77	525.850	El Metmar Drain	Agricult.Excess Water From Canal R.B.
78	536.000	Assuit Power Station *	Power Station
	537.000	Assuit Water Treatment Plant *	Industrial Effluent
79	541.600	Selim Drain *	Agricultural Excess Water L.B.
80	544.250	Marawana Drain *	Agricultural Excess Water R.B.
81	550.200	El Zenar Drain	Agricultural Excess Water L.B.
82	552.200	Mankabad Pipe 1	Industrial Effluent L.B.
83	552.205	Mankabad Pipe 2	Industrial Effluent L.B.
84	552.210	Mankabad Pipe 3	Industrial Effluent L.B.
85	588.600	Bany Shaker Drain *	Agricultural Excess Water L.B.
86	637.400	El Rayamoun Drain	Agricultural Excess Water L.B.
87	642.750	Abu Henis Drain	Agricultural Excess Water R.B.
88	682.000	Minia Water Treatment Plant *	Industrial Effluent
89	682.500	Makoussa Drain	Agricultural Excess Water L.B.
90	701.100	Etsa Drain	Agricultural Excess Water L.B.
91	752.150	El Sheikh Zied Drain	Agricultural Excess Water L.B.
92	780.500	Ebsig Drain *	Agricultural Excess Water L.B.
93	807.000	Beni Suif Water Plant *	Industrial Effluent
94	807.200	Ahnasia Drain	Agricultural Excess Water L.B.
95	808.000	El Saayda Drain	Agricultural Excess Water L.B.
96	841.000	El Zawia Drain	Agricultural Excess Water L.B.
97	848.900	Khour El Sail Atfih Drain	Agricultural Excess Water R.B.
98	865.200	El Dessamy Drain *	Agricultural Excess Water R.B.
99	871.300	kafr Gazara (El Saaf) Drain	Agricultural Excess Water R.B.
100	879.500	El Masanda Drain	Agricultural Excess Water R.B.
101	884.500	Ghamaza El Soghra Drain	Agricultural Excess Water R.B.
102	888.950	Ghamaza El Kobra Drain	Agricultural Excess Water R.B.
103	898.100	El Tibeen Drain	Mixed From Agricultural & Ind.R.B.
104	901.000	Tibeen Power Station *	Power Station
105	904.000	Hawamdia Chemical 1 *	Industrial Effluent L.B.
106	904.080	Hawamdia Chemical 2 *	Industrial Effluent L.B.
107	904.300	Hawamdia Chemical 3 *	Industrial Effluent L.B.
108	904.350	Hawamdia Chemical 4 *	Industrial Effluent L.B.
109	909.200	Helwan Power Station *	Power Station
110	910.150	Khour Sail El Badrashin	Mixed From Agricultural & Ind.R.B.

Source: River Nile Research Institute

Table 15. List of Drains & Industrial Effluents (continued)

Senal No.	Km From Aswan	Name	Description
111	911.400	Chemical Ind.	Industrial Effluent L.B.
112	911.900	Hawamdia Sugar Maulas	Industrial Effluent L.B.
113	912.100	Hawamdia Sugar Pipe 1	Industrial Effluent L.B.
114	912.105	Hawamdia Sugar Pipe 2	Industrial Effluent L.B.
115	912.115	Hawamdia Sugar Pipe 3	Industrial Effluent L.B.
116	912.120	Hawamdia Sugar Pipe 4	Industrial Effluent L.B.
117	912.125	Hawamdia Sugar Pipe 5	Industrial Effluent L.B.
118	912.130	Hawamdia Sugar Pipe 6	Industrial Effluent L.B.
119	912.900	Khour Sail El Masara Drain	Mixed From Agricultural & Ind.R.B.
120	916.550	Kotsica Starch&Glucose Dr.	Industrial Effluent R.B.
121	916.551	Kotsica Starch&Glucose Dr.	Industrial Effluent R.B.
122	939.600	El Nasr Glass tube 1	Industrial Effluent R.B.
123	939.605	El Nasr Glass tube 2	Industrial Effluent R.B.
124	939.610	El Nasr Glass tube 3	Industrial Effluent R.B.
125	939.615	El Nasr Glass tube 4	Industrial Effluent R.B.
126	939.620	El Nasr Glass tube 5	Industrial Effluent R.B.
127	946.250	Sakeel Power Station	Power Station
128	947.900	Delta Cotton at Kanater	Industrial Effluent
R1	962.850	El Rahawy Drain	Mixed From Agricultural & Ind.R.B.
R2	1024.400	Sabal Drain	Agricultural Excess Water R.B.
R3	1039.500	El Tahreer Drain	Agricultural Excess Water L.B.
R4	1053.700	Zaweit El Bahr Drain	Agricultural Excess Water L.B.
R5	1073.400	Tala Drain	Agricultural Excess Water R.B.
R6	1074.500	Pesticides Company	Industrial Effluent R.B.
R7	1074.505	El Malaya Company	Industrial Effluent R.B.
R8	1074.510	Salt&Soda Company	Industrial Effluent R.B.
D1	1098.000	Talkha 1 Fertilizers	Industrial Effluent L.B.
D2	1098.120	Talkha 2 Fertilizers	Industrial Effluent L.B.
D3	1124.500	Batra Drain	Agricultural Excess Water R.B.
D4	1125.200	High Serw1	Agricultural Excess Water L.B.
D5	1135.300	High Serw Power Station	Power Station R.B.
D6	1166.000	Faraskour	Industrial Effluent R.B.

Source: River Nile Research Institute

TABLE 16 : "Yearly Water Consumption, Effluent Volumes, and Polluting Loads - Regions

DATA	No.	Water Mill. m^3 /year Pollution Loads (t/day)						
Region		Use	Eff	BOD	COD	Oil	SS	Metals
Greater Cairo	127	162	128	71	120	93	97	0.75
Alexandria	85	110	88	91	186	43	40	0.17
Lower Egypt	60	146	125	34	42	24	86	0.5
Upper Egypt	35	211	204	72	37	5	68	0.2
The Canal & Remote Government	24	7	5	2	3	3	5	0.3
TOTAL	330	636	550	270	388	388	296	1.92

Source: River Nile Research Institute

TABLE 17: Average Water Consumption, Effluent Volumes and Polluting Loads for Industry throughout Egypt

DATA	Nos	Water	Eff	Pollution Loads (t/day)				
Industry		Use mill. m^3/yr	mill. m^3/yr	BOD	COD	Oil	SS	Metals
Chemical	53	127	98	26	178	23	33	0.94
Food	119	296	227	182	142	110	168	0.17
Spinning & Weaving	75	114	88	39	47	24	64	0.3
Engineering	39	13	12	5	6.6	2	3	0.03
Metal/Metallurgy.	11	69	60	15	14	8	24	0.2
Mining	33	19	14	3	1	1	4	0.01
TOTAL	330	638	499	270	389	168	296	1.65

Source: River Nile Research Institute

Discharge of untreated or partially treated sewage into streams upsets the natural cycle. Excessive pollution usually places too much unstable organic matter in the streams. The consequence is the flourishment of anaerobic organisms with the resulting odor and other health and environmental nuisances.

Pathogenic organisms discharged by persons harboring intestinal parasites or suffering from infectious diseases, particularly typhoid, paratyphoid, the dysenteries, and other gastrointestinal infections, or excreted by carriers of these diseases, are always potentially present in domestic sewage and render it dangerous.

An increase in incidence of infectious diseases and the exposure of people to potential hazardous chemicals is therefore to be expected.

Livestock using contaminated water for drinking will suffer from diseases that could be transmitted to the consumer. Fish caught from contaminated sources will be an intermediate host for some of the infections and diseases, and will transfer accumulated toxicants to the human consumer.

With regard to contamination from agricultural and drainage water, relatively high concentrations up to 220 ug/kg 1 of organochlorine insecticides were found in collected fish samples (Badawy, 1982). In a study conducted between August and October 1979 in three selected agricultural areas in Egypt, Lindane, Endrin, DDT, and its degradation product DD were detected in all soil and water samples collected, the highest concentration being that of DDT (Aly and Badawy 1981). Available data on oil and grease reveal that the highest concentrations are found in areas where most of the shipyards, docking facilities, and oil refineries are located. The concentration decreases downstream from these areas, which may be attributed to dilution, vaporization, biodegradation, and/or sedimentation. The concentration of total oil and grease in water samples collected from midstream around Cairo was found to be around 2.5 mg/l (Moursy, 1983). The most polluted areas in the Cairo region are around the iron and steel factory, boat docks, and electric power stations (Moursy, 1981). At the port of Lake Nasser, on the other hand, oil and grease concentrations of up to 15.2 mg/l were detected. This is probably due to the presence of docking facilities and oil spills from ships (Moursy, 1983).

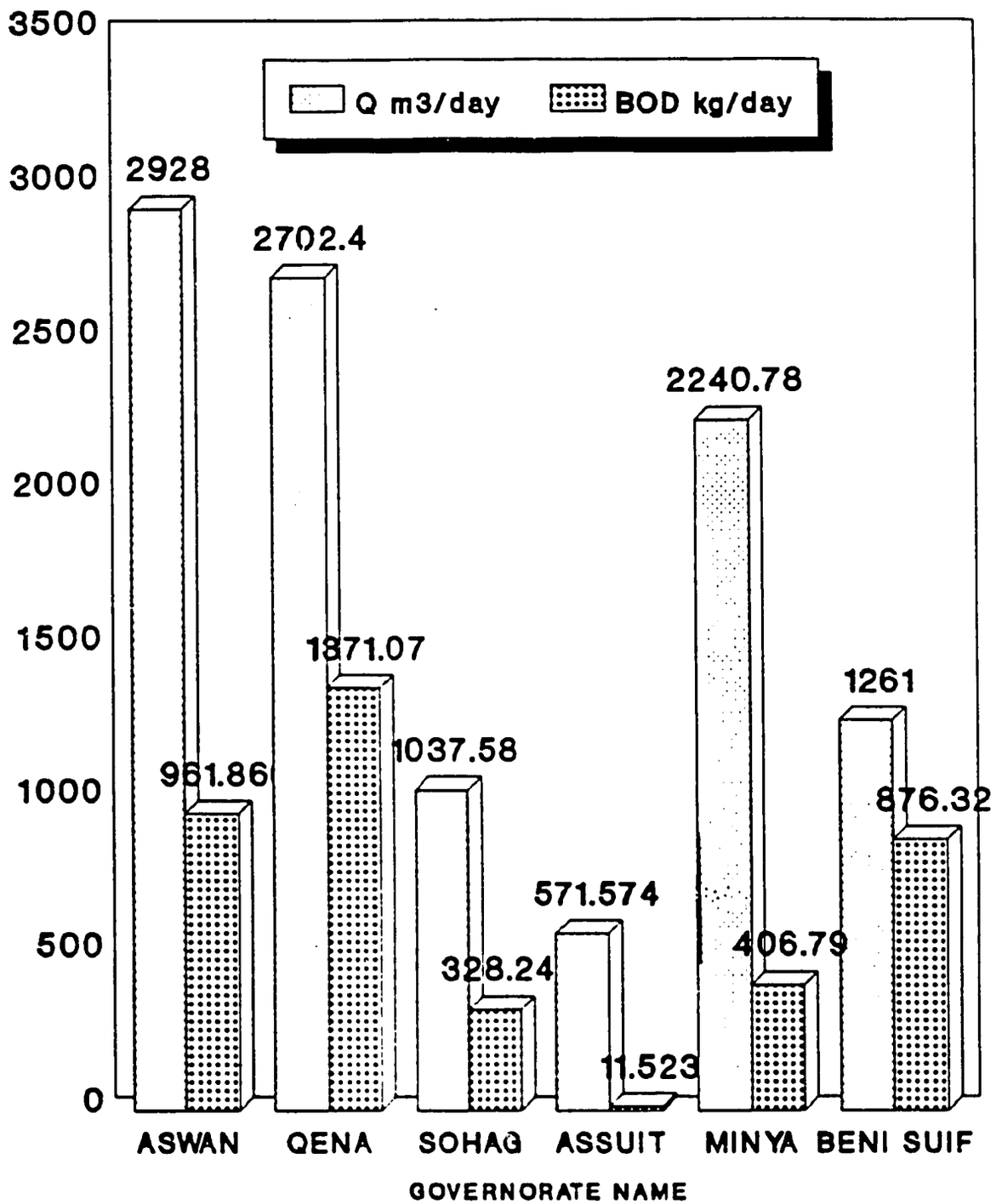
Table 18 and Figures 20-22 show the total hydraulic and BOD loads discharge into the River from Aswan to Beni-Suef. Figures from 23 to 27 present the variation of BOD and COD values along the river and its two branches.

F. Water Quality Management

The success of a nationwide Water Management Program largely depends on policies and programs, legislation, and an appropriate institutional framework for implementation. Public awareness of water quality issues and the ingredients for programming and implementing effective control measures are also vital.

Table 18. Hydraulic and BOD Loads Discharging into the River Nile from Point Sources of Pollution

GOVERNORATE NAME	$Q\ m^3$ X1000 /DAY	BOD KG X 1000/DAY
ASWAN	2928	961.366
QENA	2702.4	1371.07
SOHAG	1037.58	328.245
ASSIUT	571.574	11.523
MINYA	2240.78	406.79
BENI SUIF	1261	876.32



HYDRULIC AND BOD LOADS DISCHARGING INTO THE RIVER NILE FROM POINT OF SOURCES OF POLLUTION.

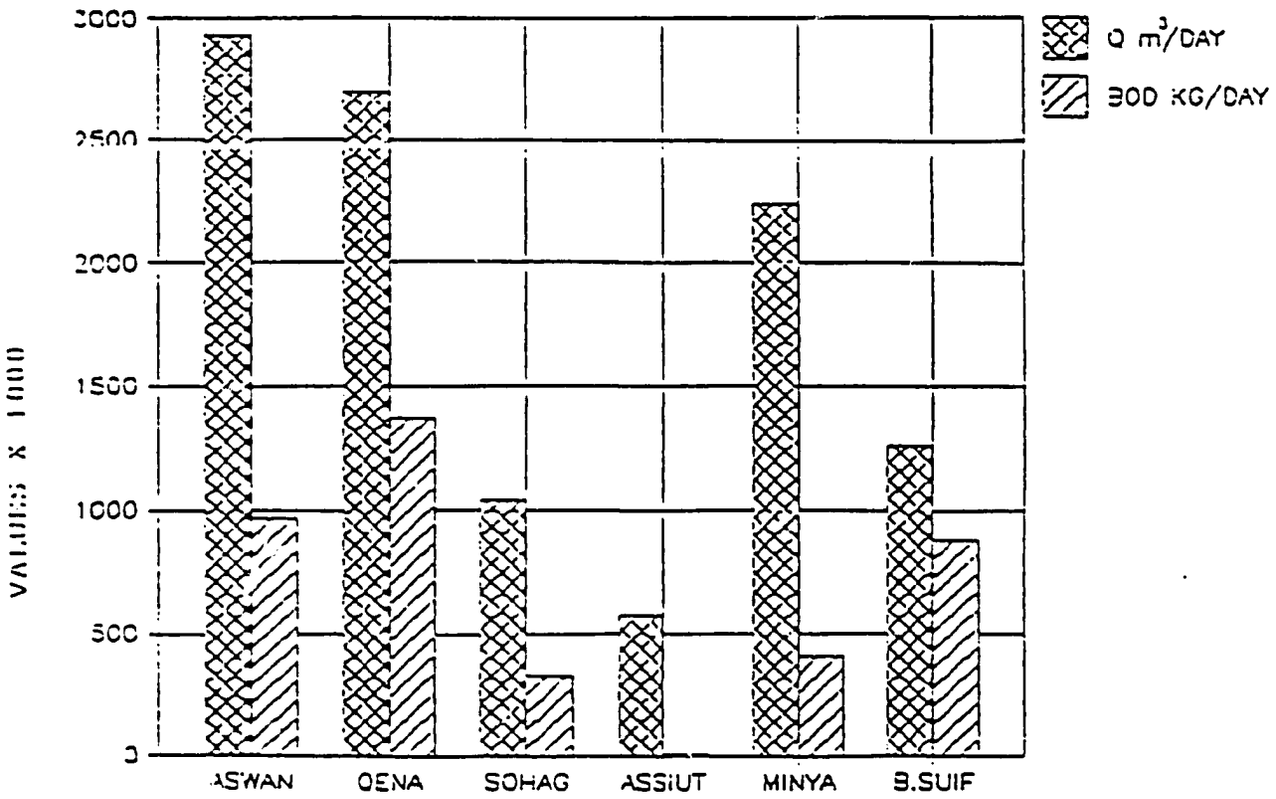


Figure 20. Hydraulic and BOD Loads Discharge Into River by Governorate

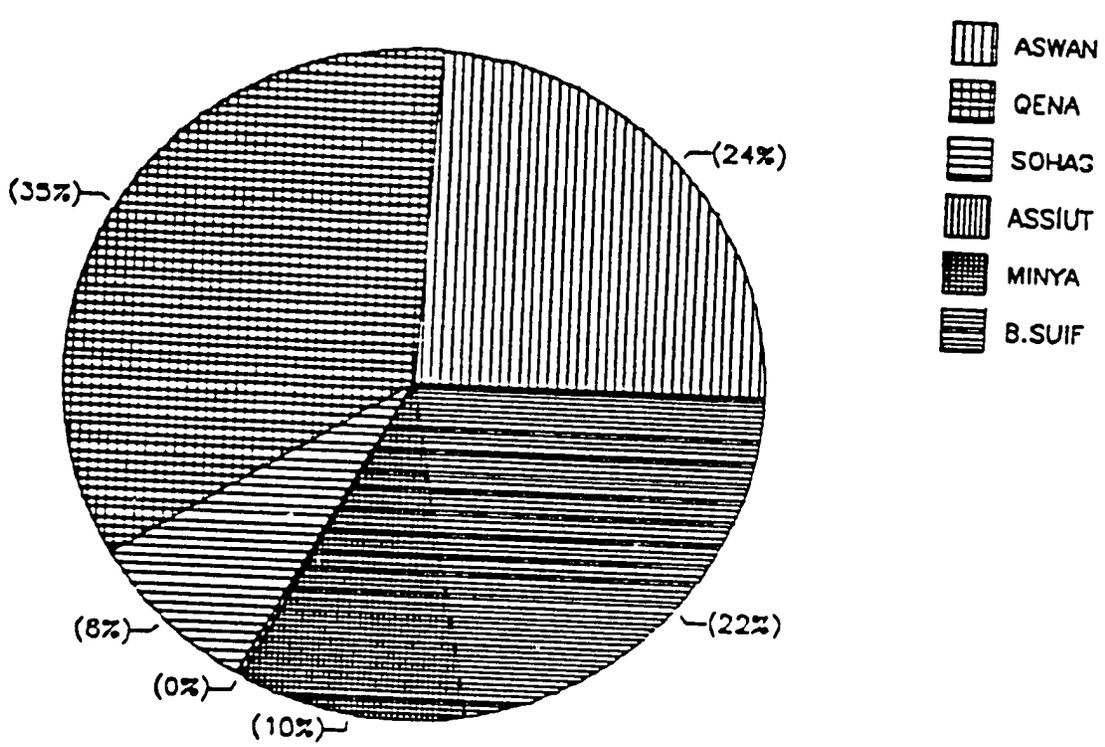


Figure 21. BOD Loads Percentage Distribution of Point Sources of Pollution Along the River Nile in Upper Egypt

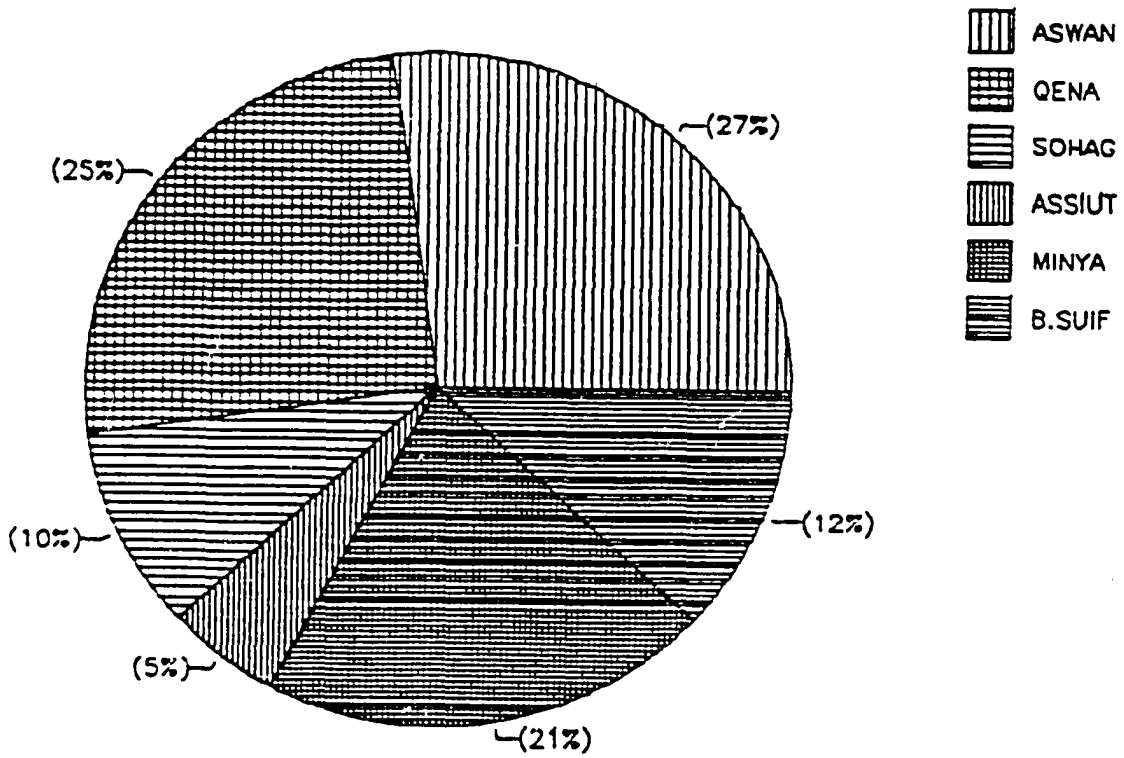


Figure 22. Hydraulic Percentage Distribution of Point Sources of Pollution Along the River Nile in Upper Egypt

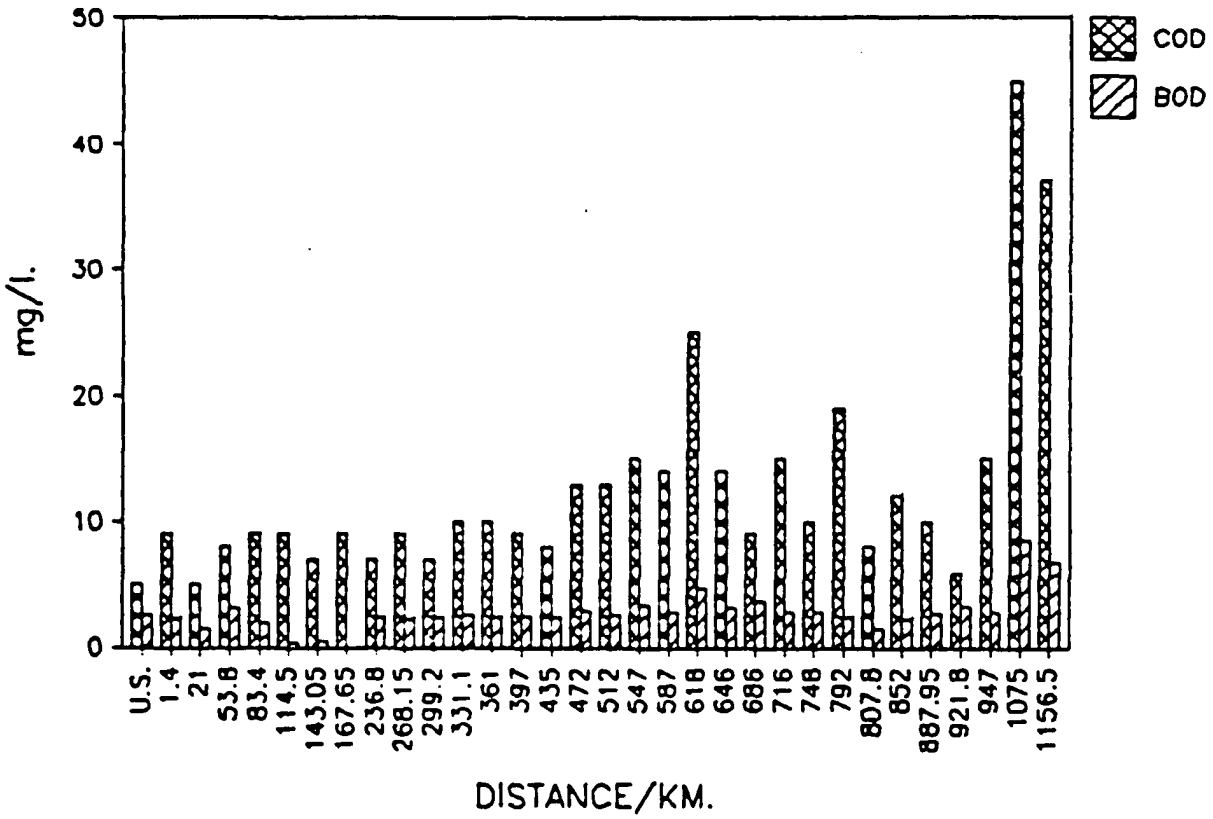


Figure 23. Variation in COD and BOD of River Nile Water from Aswan to Damietta

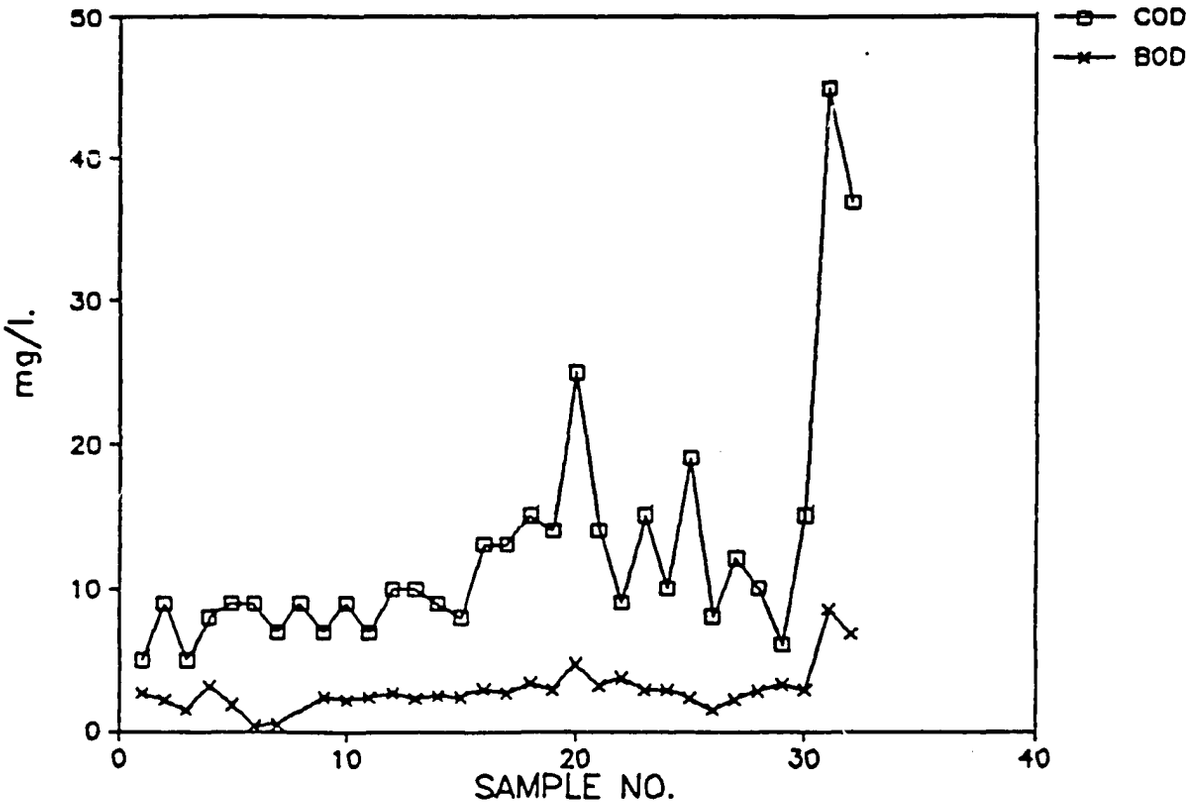


Figure 24. Variation in COD and BOD of River Nile Water from Aswan to Damietta.

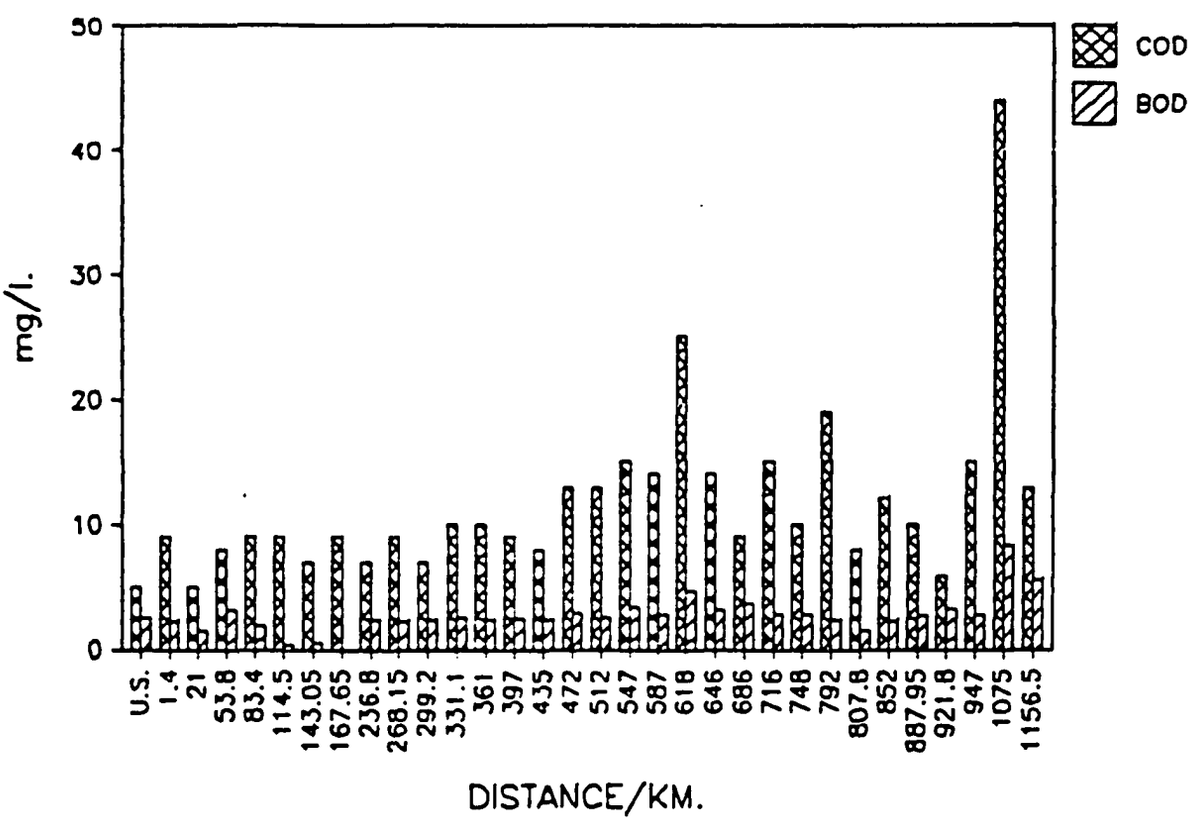


Figure 25. Variation of COD and BOD of River Nile Water from Aswan to Rosetta

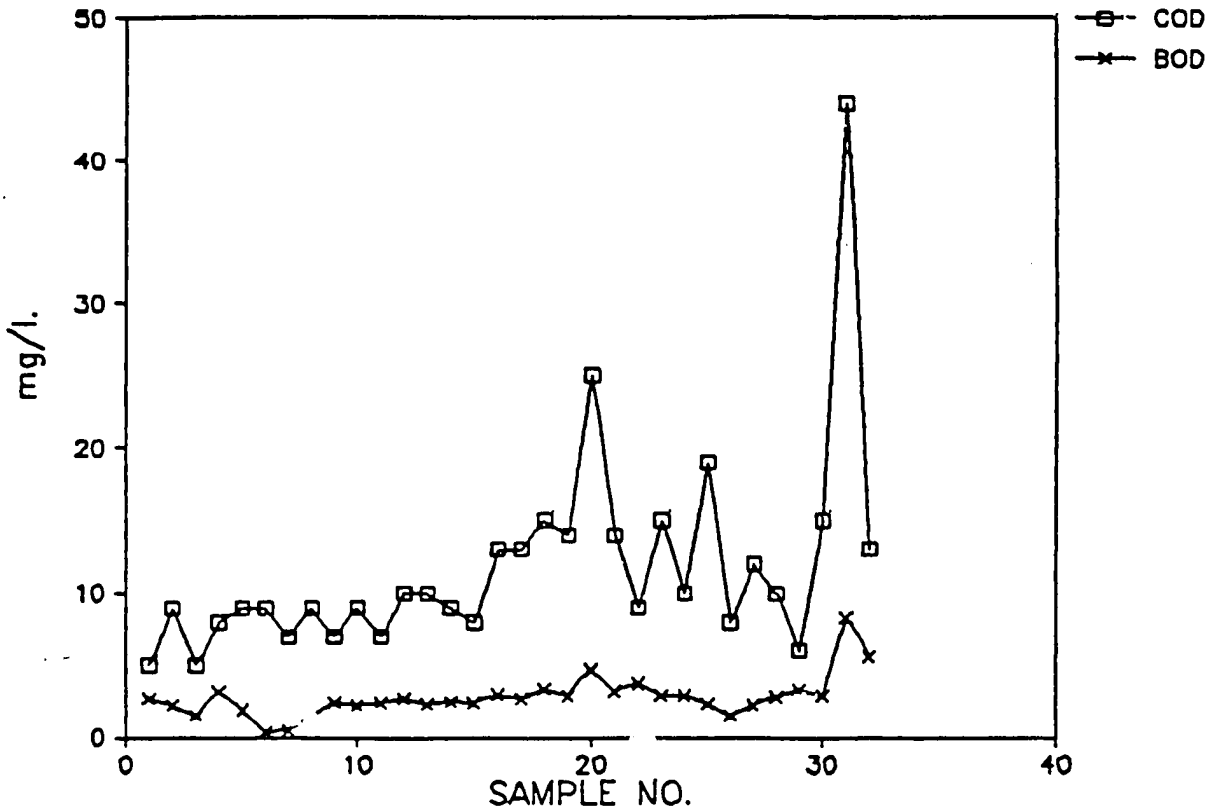


Figure 26. Variation of COD and BOD of River Nile Water from Aswan to Rosetta

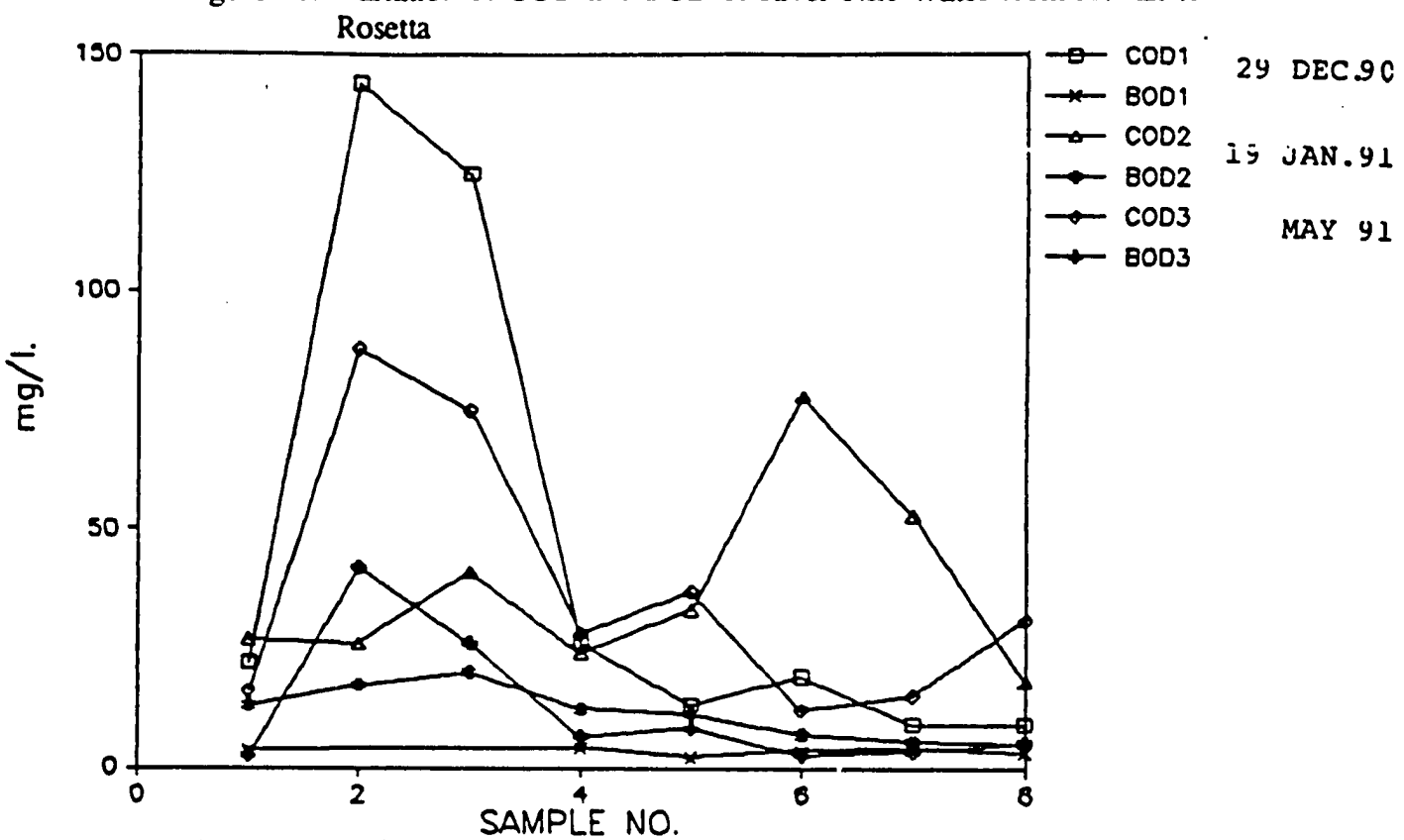


Figure 27. Variation in COD and BOD Along Rosetta Branch During and After the Winter Closure Period

F1. Control Strategy

Restoring and maintaining the quality of our water resources should be a national priority. To date, investment in water supply in both urban and rural areas has by far exceeded investment in sanitation. As a result, construction and operation and maintenance of wastewater systems has emerged as a major environmental challenge for the next decade.

Wide-scale construction and operation of low-cost sanitation systems should be an integral part of any rural or urban environmental management plan. Special effort should be devoted to developing appropriate treatment systems. Although these systems may differ between urban and rural areas and among rural settlements in the Delta and Upper Egypt, their replicability potential is bound to be significant.

To date, most studies have focused on end-of-pipe treatment of industrial wastes. Very little attention has been given to in-plant control measures. Concurrently, the immediate institution of improved housekeeping measures and operation and maintenance procedures could potentially reduce environmental risks significantly. Simple management practices such as cleaning oil traps, leakage control, and separation of cooling waters complemented by sedimentation and neutralization processes, as necessary, may bring about a considerable reduction in pollution.

Special attention must be focused on the deteriorating water quality conditions resulting from the uncontrolled use of pesticides, herbicides, and fertilizers. A national program for minimizing nutrient discharge into canals and waterways and for developing alternative approaches to weed control is urgently needed.

Environmental impact assessment has to be mandatory for proposed development projects to be able to develop a water management action plan (immediate, midterm, and long term). This will ensure the availability of an adequate quantity of water of the right quality. Also, water-quality data collection and monitoring are essential.

F2. Legal Aspects

To date, legislative inputs for pollution control have been largely fragmented, cutting across different line ministries and specialized government agencies with no clear responsibility for enforcement. A notable exception is Law 48/1982.

Although the promulgation of this law reveals a commitment on the part of legislators to protecting the principal water resource, some 10 years of application have shown many areas where amendment and modifications are required.

Legislative reform is necessary to protect Egypt's natural resources and improve environmental and living conditions. An Environmental Act, covering all aspects of risk to man and the environment is under preparation.

It should be noted that the Act will need to be supplemented by a large body of regulatory standards and enforcement techniques directed at specific environmental concerns. A substantial amount of in-depth research will be required to establish guidelines and set standards that are commensurate with local conditions and priorities.

F3. Institutional Aspects

The Ministry of Public Works and Water Resources is responsible for issuing permits to commercial, industrial, and tourist establishments for the discharge of liquid wastes into Egyptian waterways, including the Nile, canals, lakes, and groundwater reservoirs—in compliance with Law 48/1982. The Ministry is responsible, in accordance with its Decree 8/1983, for setting the regulations, standards, and specifications for treated wastewaters and receiving water bodies before discharge into surface waters. In addition, the Ministry is solely responsible for issuing permits for new floating vessels and may cancel licenses and seek removal or correction of polluting facilities. The Ministry is also solely responsible for licensing the construction of any establishment that produces waste to be discharged into waterways. The Ministry's irrigation engineers are responsible for the required inspection—at least once every three months—and technical studies of establishments located within their areas of jurisdiction. Law 48/1982 empowers water resources police with the authority to arrest violators.

Finally, Law 48 stipulates that it is the Ministry's responsibility not to pollute waterways when selecting and using chemical herbicides for aquatic weed eradication. The Law stipulates that the Ministry take the necessary precautions, in all cases, prior to, during, and after herbicide treatment to prohibit use of the treated waterway until it has ensured that the adverse impact of herbicides on water quality has been eliminated and that the water is suitable for use.

The Ministry of Health is responsible according to Law 27/1978 (on public water sources for drinking and domestic use) for meeting specifications and standards for water sources and drinking water, as well as for collecting and analyzing, at least every three months, treated liquid effluents from establishments licensed to discharge into waterways.

The Ministry of Reconstruction, Housing, and Development has several agencies responsible for the control of water quality, to be discharged into sewers. These are :

- The National Organization for Potable Water and Sanitary Drainage (NOPWASD) established by Presidential Decree 1971-1981)
- The Greater Cairo Organization for Sanitary Drainage
- The Greater Cairo Water Authority
- The Alexandria Water Authority
- The Alexandria Sanitary Drainage Authority
- Several companies for potable water and sanitary drainage in Damietta, Kafr El Sheikh, and Beheira

According to its Decree 643/1962, implementing Law 93/1962, the Ministry sets specifications and standards for wastewater discharged into public sewers and specifications for its disposal into the sea and on land.

The Ministry of Agriculture is responsible, in its choice and use of pesticides, not to pollute waterways whether by direct spraying or by mixing pesticides with drainage water from agricultural lands, or by washing machinery, spraying equipment, or pesticide containers in waterways, in accordance with standards agreed upon by the Ministries of Agriculture, Water Resources, and Health in compliance with Law 48/1982.

The Ministry of Interior's Waterways Police plays a role in the control of pollution of the Nile and its waterways according to Law 48/1982. The Waterways Police is responsible for conducting continuous inspection patrols all along the waterways and for apprehending floating and river units that discharge their wastes into waterways, or that suffer from fuel leaks.

G. Water Quality Monitoring

G1. Concerned Institution

The responsibility of water quality monitoring is not entrusted by law to any ministry. However, the legal framework for the control and protection of the water resources is laid down in law 27 and law 48. In Law 27 the standards and codes for drinking water are given. The Ministry of Public Health (MOH) is responsible for the execution of Law 27. Law 48 provides standards and codes for discharge of wastewater effluents in the receiving fresh water bodies. The Ministry of Public Works and Water Resources (MPWWR) is responsible for the implementation of Law 48.

In executing its tasks, the MPWWR cooperates with the MOH and the Ministry of Interior. The MOH carries out the regular sampling and analysis of industrial and domestic effluents.

Since it is the responsibility of MOH to care for the health of the people, it has the authority to do the following activity through its specific departments:

- Sampling and analysis of intake of drinking water treatment plants
- Sampling and analysis of effluents of drinking water works (surface and ground)
- Sampling and analysis of sewage treatment plants effluents

These activities are carried out on a regular basis by members of the central laboratory in Cairo and the regional laboratories in the governorates. The drinking water authorities are also analyzing the intake and treated water within the premises of the drinking water facilities.

The laboratories in the sewage treatment works are responsible for analyzing the influent and effluents of the waste water treatment plants.

G2. Monitoring Activities

Although water resources management has been emphasized, water quality management has been given little attention. There are however, a variety of sources of water quality data in Egypt. Historical data exist primarily for agriculture and irrigation, and are maintained by the two ministries. These data are concerned with the major anions and cations and other basic water quality parameters such as: Ph, total dissolved solids, total suspended solids, conductivity, and temperature. Another prime source of data is the Institute of Oceanography and Fisheries, which conducted a series of investigations in the lakes of the Nile Delta. Many basic physical and chemical parameters, in addition to limnological factors, have been studied by the Institute, often in conjunction with the University of Alexandria. These data may be found in graduate theses and various publications of the Institute. The Institute of Oceanography and Fisheries in Cairo has conducted some water quality investigations as part of broader limnological studies on various waters in the country. Results of these studies may be found in reports of the Institute and relevant scientific publications.

Another principal source of data is the records of the various water authorities in Egypt.

The first comprehensive monitoring program was carried out in 1975 as part of a joint Egyptian/U.S. project, sponsored by the Egyptian Academy for Scientific Research and Technology and the University of Michigan, Ann Arbor. The monitoring has been conducted using local groups in Aswan, Assuit, Cairo, and Alexandria. No interlaboratory calibration program exercise has been carried out. By the end of 1978, the research team of the Water Pollution Control Department of the National Research Center took over the whole responsibility.

The river was divided into segments, taking into account: (a) geographical features, (b) administrative boundaries, and (c) human activities. The segments were identified as follows :

- Lake Nasser and Aswan Reservoir
- Aswan segment
- Assuit segment
- Cairo segment
- Zefta segment
- Faraskur segment
- Rosetta segment

Sampling sites for each segment were assigned to enable reliable characterization of water quality. The survey also covered point sources of pollution ar ultimate sink.

During 1975-1976, the survey was carried out monthly, after which it was conducted quarterly until the end of 1980. The analysis covered a broad range of water quality parameters in addition to a variety of biotic factors. This survey has provided the most

comprehensive body of data regarding the status of the river. In 1981 and 1982 one survey was done each year.

The same project has developed a central computerized data storage and retrieval system, into which all the data generated by the study were deposited. Also, all historical data made available to the project regarding water quality in the river, the canals, and the drains were stored in the system.

Since the objective of this project was to assess the impact of the Aswan High Dam, consequently the creation of a huge man-made water impoundment on the water quality of the river, the project terminated after fulfilling its objectives.

In 1979, the High Aswan Dam Side Effects Research Institute, HADSERI, started a monitoring program with the assistance of the MOH. The program stopped from 1980-83 and then continued again in March 1984, November 1984, 1985, and 1986. The sampling program was carried out from Aswan in stretches of about 10 km. Sampling was also carried out for point sources. The analysis covered almost all physico-chemical parameters of the water quality. However, the results were of limited utility as they were not continuous and also they represent a single point in time over the course of each year. This discontinuity may be due to lack of funds required for the monitoring activity.

The Drainage Research Institute (DRI) established a measurement program for the quantity and quality of drainage water (approximately 90 locations). The objective of this program is to assess the potentialities of reusing drainage water for agriculture. Electric conductivity and Ph are measured bi-weekly. Other samples are analyzed every two months. The analysis are limited to: total soluble salts, sodium, calcium, magnesium, boron, chlorides, and nitrates. Recently, bacteriological examinations of drainage water has been added to the program. Data are stored in a computerized database and published annually in data books.

The Research Institute for Ground Water (RIGW) is the authorized research body within the MOPWWR in the field of ground water for agricultural, domestic, and industrial uses. The RIGW operates, since 1953, an observation well network in the Nile Valley and Delta. Since 1958, water levels are recorded monthly by locally employed observers. Water samples are taken once every year by the staff of the hydrochemical unit and analyzed in the RIGW. Analysis covers: electric conductivity, Ph, cations (Ca, Mg, Na, K), and anions (HCO_3, CO_3, Cl, SO_4).

In February 1988, the Water Laboratories of the Environmental and Occupation Health Center (MOH), with financial support from the Egyptian Environmental Affairs Agency, established a monitoring program for surface water. The monitoring network includes:

- Nine water analyses laboratories in Greater Cairo (Environmental Health Center in Embaba), and regional Laboratories in Alexandria, Daquahlia, Damietta, Ghrbia, Beni Suef, Minia, Assuit, and Aswan.

- One hundred and seventy-one fixed sampling sites on the River Nile, its town branches, together with 10 of the main irrigation canals and agriculture drains.

The main sources of pollution are identified and included in the sampling points. Analysis is done for 24 parameters determining water quality: pH, alkalinity, hardness, DO, BOD, COD, TDS, TSS, conductivity, SO_4, Cl, SiO_2, No_2, No_3, Na, K, Ca, g, Fe, n, and Faecal Coliform.

The data are being tabulated and will probably be processed and published in a quarterly newsletter.

H. Summary and Conclusions

Egypt is a predominantly urban country, the majority of its population being concentrated on 4 percent of the land, primarily along the banks of the Nile and its Delta. Urbanization continues at a rapid pace; the urban population is growing at 3.2 percent annually, as compared with the country's overall 2.4 percent growth. Recent estimates suggest that by the year 2000, Egypt's population will increase from its present level of 55 million to 70 million, with the urban population expected to grow to about 37 million at an estimated growth rate of 5.9 percent

To satisfy the needs of its growing population, Egypt has been engaged in an intensive program of economic development. New towns were built, modern industrial and agricultural protects were introduced, water resources were tapped, and roads were constructed.

The combined impact of urbanization and industrial production has created acute environmental problems. The compulsion for economic growth and lack of understanding of the long-term damage potential of pollution have resulted in the manifest deterioration of Egypt's natural resources. The Egyptian Government has recently become increasingly aware of the importance of environmental risk management on economic development, health, and quality of life. This report assesses the challenges facing the country in implementing a nationwide program to improve the quality of the Egyptian water resources for generations to come.

Available information indicates that the River Nile is subjected to several sources of pollution. Most of the towns and many of the industries are discharging wastewater into drains which ultimately discharge into the Nile. Aside from the drains, there are also industries discharging effluent directly into the River.

Another serious source of water pollution in Egypt is the uncontrolled use of pesticides and fertilizers, which results in residues seeping from the soil to the irrigation water, into the drains, and finally into the Nile.

Existing data concerning water quality of the drains, industrial wastewater, and effluents of sewage treatment facilities is very limited. This report's assessment of the water

quality is based on existing data, which is incomplete and in some cases not reliable, creating a situation that supports the need for developing a more adequate database on agricultural drains and pollution sources.

The following conclusions can be made:

- High levels of toxic material is discharged into the River and the Northern lakes.
- The main polluted areas of the River are at Aswan, Kafr El-Zayat, and Talka.
- A database of polluting sources does not yet exist and legislative controls, although in place, are not enacted.
- A water quality map for the River Nile system does not exist.

I. Recommendations

- Restoring and maintaining the quality of the environment, including air, water, and soil, should be a national priority.

- Implementation of low-cost sanitation systems should be an integral part of any rural or urban environmental management plan. Special effort should be devoted to developing appropriate models and raising awareness among the general public to maximize public participation in sustaining operations. While models may differ between urban and rural areas and among rural settlements in the Delta and Upper Egypt, their replicability potential is bound to be significant. Demonstration programs for the above-mentioned systems and technologies should be adopted as a priority to mitigate against the proliferation of expensive, inappropriate technologies. An equally important element of wastewater management systems is the development of an integrated program for sludge reuse and disposal. The development of such a program is essential given the increasing burden of sludge generated from current and future plans for wastewater treatment.

- Controlling environmental pollution from industrial sources is best achieved by controlling pollutants emission. Experience gained during the last two decades suggests that in many circumstances it is more efficient and less expensive to incorporate pollution preventive measures than corrective techniques. Consequently, the immediate institution of improved housekeeping measures and operations and maintenance procedures could potentially reduce environmental risks significantly. It has been suggested that simple environmental management practices such as cleaning oil traps, controlling leakage, and separating cooling water as complemented by basic sedimentation and neutralization processes, as necessary, may considerably reduce pollution.

- Special attention must be focused on the deteriorating water quality resulting from the uncontrolled use of pesticides, herbicides, and fertilizers. A national program for minimizing nutrient discharge into canals and waterways and for developing alternative approaches to weed control is urgently needed.

- Solid waste alongside wastewater management should be part and parcel of an integrated approach to environmental management in rural and urban areas. Waste management plans covering both urban and rural settlements need to be developed. These plans should be guided by the use of simple collection, transfer, and resource recovery technologies. They should focus on maximizing the involvement of the private sector in service delivery, capitalizing on its resources and traditional interest in the business.

- Assessments of waste processing and disposal alternatives conducted for several governorates suggest that comporting, supplemented by sanitary landfilling for ultimate disposal of noncompostable waste, offers a cost-effective and environmentally sound option.

- Environmental concerns should be integrated into the basic educational system. Communication networks should work on raising consciousness and converting the general public into environmental advocates. The government and businesses should begin training their staffs to account for the environment in their respective professional disciplines. This is necessary to introduce and sustain the concept of sound management of water resources at all levels.

- A biological map for the River Nile and its major branches should be prepared and should be updated every five years.

- To effect control of point sources of pollution, it is necessary to monitor the volume and quality of the discharge from theses sources. Since sampling and analysis is by far the most costly part of any monitoring program, it is important to make use of existing monitoring activities carried out by various institutions (organization for potable water, general organization for sanitary drainage, and national organization for water and sanitary drainage).

ANNEX B

DRAINAGE WATER QUALITY

by

Shaden Tawfik Abdel-Gawad

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ANNEX B
DRAINAGE WATER QUALITY

A. Introduction

The fast growth of Egypt's population creates an urgent need to expand agricultural land area and increase the cropping intensity. The major obstacle to the achievement of these goals is the shortage of irrigation water.

The Egyptian water budget consists mainly of the country's share of the Nile water which is fixed according to international agreements at 54 bcm/yr, minor quantities of groundwater, and negligible rainfall over the northeast and northwest coastal areas.

Reuse of drainage water is one of the most promising means of promoting water resources and increasing water use efficiency.

At present, about 13 bcm/yr of drainage water flows unused to the Mediterranean Sea and the coastal lakes. Fifty-five percent of this water (about 7 bcm/yr) falls in the salinity class of 2,000 ppm or less. In addition, approximately 3.4 bcm/yr of drainage water mixed with fresh water in canals is reused for agricultural purposes.

To date, the only water quality parameters used in designing drainage water reuse projects have been salinity levels. However, other water quality parameters and environmental concerns must be considered.

B. General Description of the Drainage System in Egypt

The cultivated area is covered with a network of drains starting with the collectors and ending with the main drains. The drainage network is about 17,500 km long.

B1. Upper Egypt Drains

Most Upper Egypt drains discharge their water into the Nile by gravity. The areas served by these drains are relatively small due to the narrow width of the Nile Valley in this area. The main drains are Nagaa Hammadi Drain (57,000 feddans), Souhag Main Drain (56,500 feddans) and Abou-Teeg Drain (75,800 feddans).

B2. Middle Egypt Drains

All drains discharge into the irrigation system (Nile, Bahr Youssef, or Rosetta Branch). The main drains are:

- Mohit Drain extends the total length of Middle Egypt. It has several outlets to the Nile and ends at Rosetta Branch.

- Ben Khaled Drain serves 11,400 feddans and discharges into Bahr Youssef by gravity.

- Menshat El-Dahan serves 21,000 feddans and discharges to Bahr Youssef by gravity.

- Dir Tanhoria serves 50,000 feddans and discharges to Bahr Youssef by a pump station.

- Sakoula Drain serves 65,000 feddans and discharges to Bahr Youssef by a pump station.

- Mazoura Drain serves 30,000 feddans and discharges to Bahr Youssef by a pump station.

- Wadi and Batts Drains discharge to Lake Karoun.

B3. Nile Delta Drains

The drainage system in the Nile Delta comprises 22 drain catchments, each of which consists of a single or a multiple drainage zone as shown in Figure 1. These drain catchments can be classified as follows:

Region	Single zone drains		Multiple zone drains	
Eastern Delta	Upper serw	(3)	Bahr El Baqar	(1)
	Lower Serw	(4)	Bahr Hadous	(2)
	Mataria	(5)		
	Farskour	(6)		
Middle Delta	Sabal	(7)	Gharbia Main Drain	(9)
	Tala	(8)	Drain No. 1	(10)
	Burullus	(11)	Nashart Drain	(15)
	Tira	(12)		
	No. 7	(13)		
	Lower no. 8	(14)		
	No. 11	(16)		
	Zaghloul	(17)		
Western Delta	Barsiq	(19)	Edku Drain	(18)
	Tabia	(20)	Omoum Drain	(22)
	Qalaa	(21)		

The above classification shows that the number of single zone drains is 15. They all end with pumping stations except the Sabal and Tala zones, which flow by gravity to the Rosetta Branch. Each multiple zone drain includes several drainage catchments, which are drained by gravity or by lifting.

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Table 1 on page 4 shows the general characteristics of the drainage system in the Nile Delta.

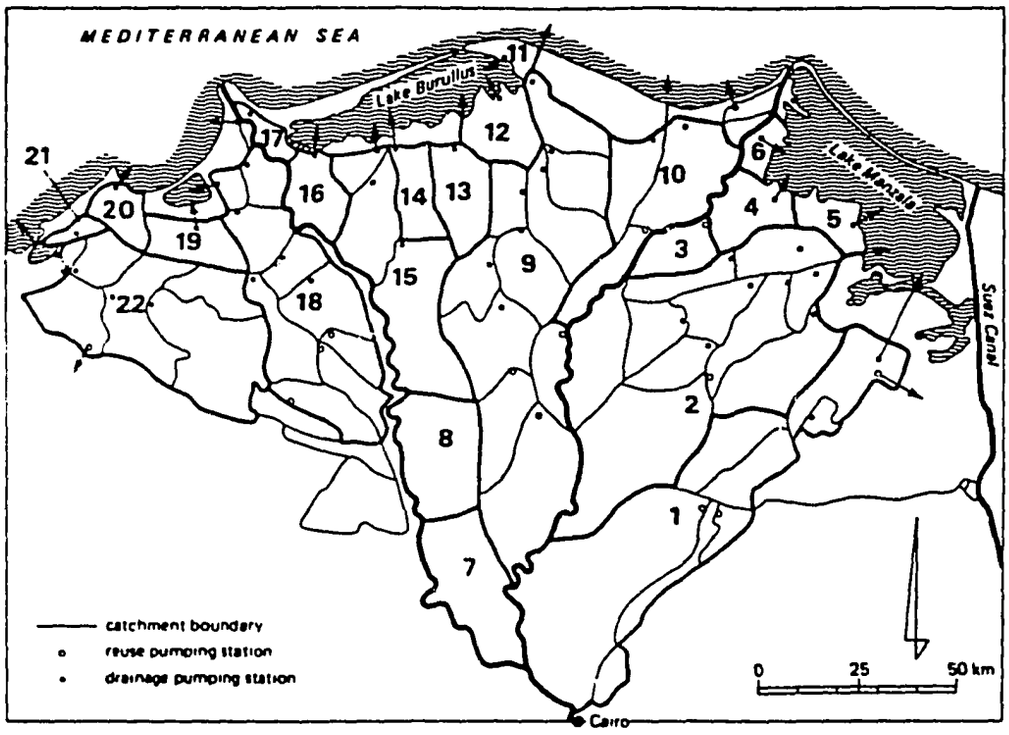


Figure 1. Drainage Catchments in the Nile Delta

C. Drainage Water Monitoring Network in the Nile Delta and Fayoum

C1. General Description

The Drainage Research Institute (DRI) of the Water Research Center took the lead in establishing a network of measuring stations on the key points of main drains in the Nile Delta and Fayoum in the late 1970s. The ultimate goal of the monitoring program is to obtain knowledge about the accurate values of the quantity and quality of drainage water at the outlet of each single zone catchment and at different locations on the main drains where significant changes take place due to the addition or withdrawal of water to or from the drain.

A complete description of the measurement network in the Delta is presented in Reuse Report No. 20.

Table 1. General Characteristics of the Drainage System.

Description	Eastern Delta	Middle Delta	Western Delta	Whole Delta
Gross area }	1.64	1.76	1.32	4.72
Net drained area }	1.31	1.41	1.10	3.82
Net area drained by gravity }	0.63	0.23	0.34	1.20
Net area drained by lifting } x 10^6 feddan	0.68	1.18	0.76	2.62
Net area from which drainage water is reused }	0.53	0.52	0.16	1.21
Number of outlets to sea	-	3	3	6
Number of outlets to coastal lakes	5	6	2	13
Number of reuse locations	8	7	6	21
Number of pumping stations	24	24	22	70
Number of pump units	96	97	92	285
Range of pump station discharges (m^3/s)	1-20	2-26	2-73	
Range of lifting head (m)	1.2-3.7	0.25-3.6	1.1-6.5	
Average of lifting head (m)	2.3	2.3	3.0	
Number of open locations	11	8	11	
Range of drain discharges at open locations (m^3/s)	7-51	10-43	21-40	
Approximate total length of main drains (km)	500	700	400	1600
Range of bed width (m)	10-40	10-40	20-30	

The measurement locations are shown in Figure 2 for the Delta area and Fayoum. Their distribution is arranged in Table 2.

Table 2. Distribution of Measurement Locations in the Nile Delta and Fayoum.

	Eastern Delta	Middle Delta	Western Delta	Fayoum
Pumping station	21	24	22	1
Open drain locations	13	4	7	10
Total	34	28	29	11

Source of Tables 1 and 2: Drainage Research Institute, WRC

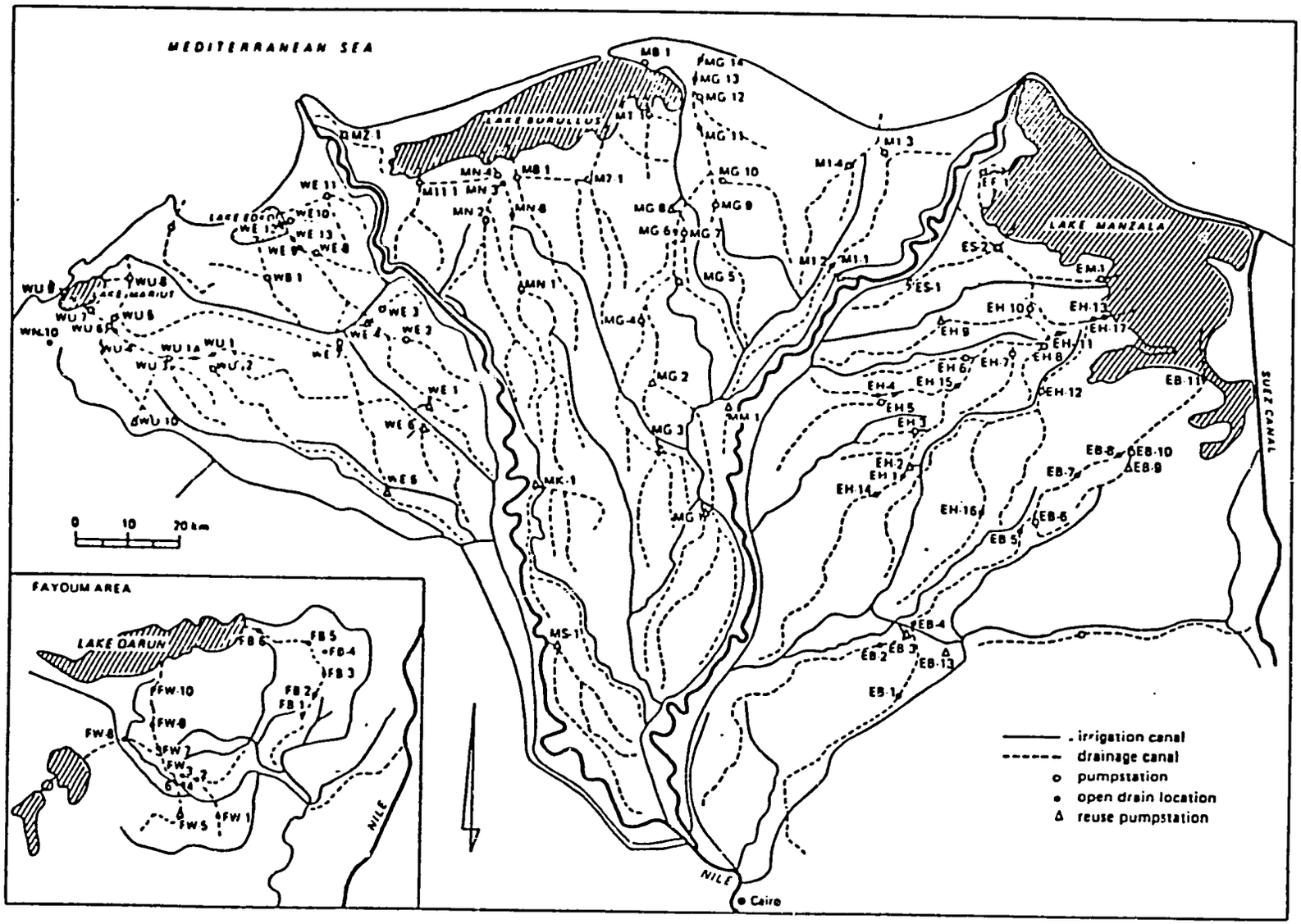


Figure 2 Measurements locations at pumping stations and open drains in the Delta and Fayoum.

Source: Drainage Research Institute, WRC

Figures 3, 4, and 5 show the schematic diagrams of the main drains and the measuring stations in the Eastern, Middle, and Western Deltas, respectively. Single zone catchments as well as these locations on the main drains are divided into pumping stations or open locations depending upon whether water is lifted or flows by gravity.

Figure 6 shows a schematic diagram of all activities included in the monitoring program. These activities are divided into the measurement of water quantity and quality at pumping stations or open locations, as explained in the following sections.

C2. Water Quantity Measurements

Flows lifted by pumping stations or passing through open drains are measured by the establishment of rating curves which relate discharges to the lifting head in the case of pumping stations and to the water depth in the case of open locations. Operators of the pumping stations keep continuous daily records of lifting heads. Water level recorders are installed in open drain locations to give the variation in water levels.

Stage/discharge relations are valid only when the flow is steady and uniform. This is not the case in locations where addition or abstraction of water takes place close to the measuring station. These relations cannot be obtained at or near the drain outfalls to the sea or a lake. In such cases, a velocity/discharge relation is established and continuous records of velocities are necessary. Such records are obtained by means of velocity recording devices.

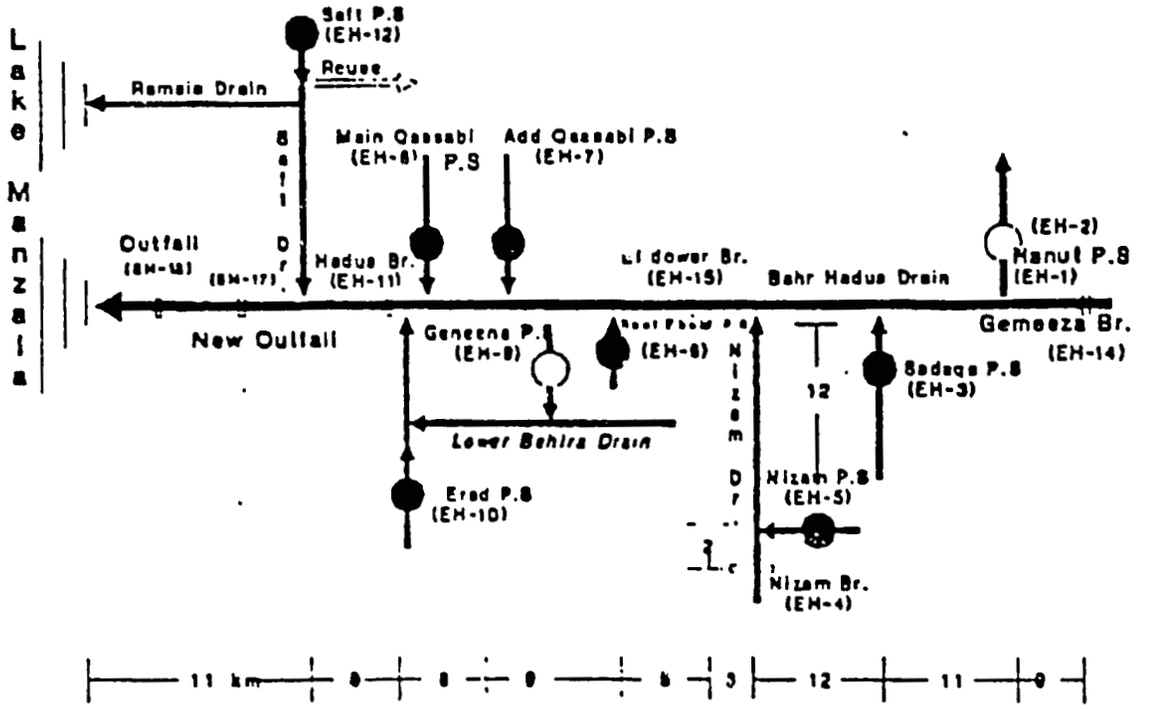
Discharges per unit time are multiplied by the actual operation time of each unit in the pumping stations to calculate the daily discharge lifted.

In the case of open drain locations, the average daily water level is introduced to the stage/discharge relation to obtain the corresponding daily flow. For locations subject to back water effect the recorded velocity is substituted in the appropriate velocity/discharge relation to get the daily discharge.

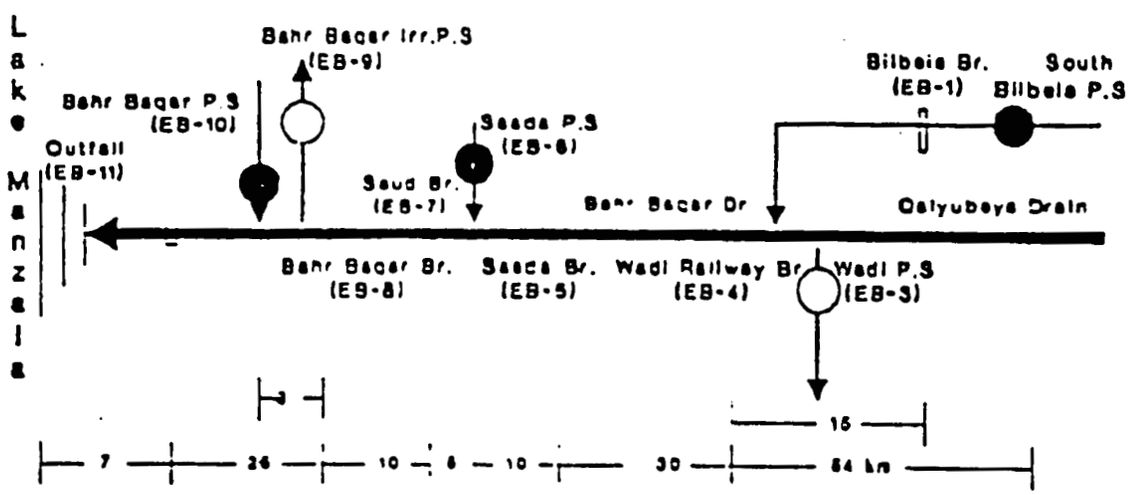
C3. Water Quality Measurements

Water quality is measured in-situ with simple Electrical Conductivity (EC) and Concentration of Hydrogen Ion (Ph) meters in pumping stations, and with continuously recording devices (EC Recorders) in open locations. This guarantees daily records of these parameters.

Water samples are taken routinely once every three weeks and brought to the DRI laboratory for a complete chemical analysis, performed according to established and well-known methods and procedures. The laboratory analyses are shown in Table 3.



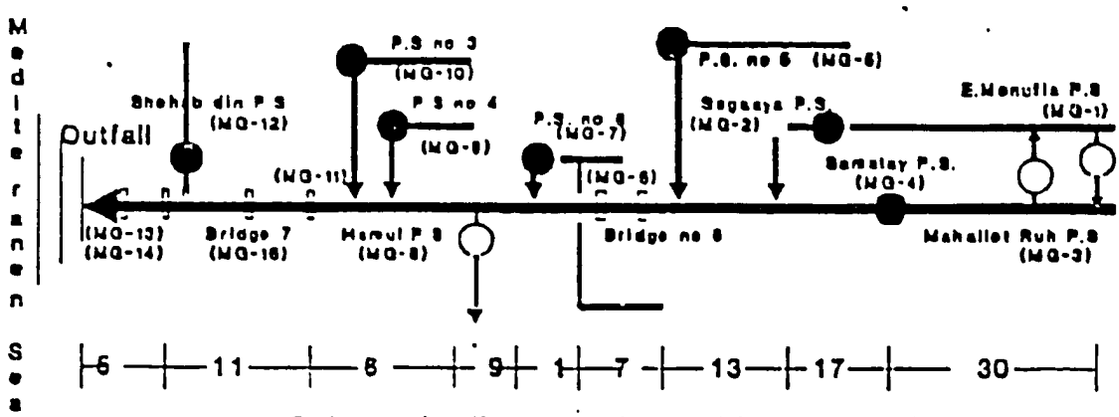
Schematic Diagram of Bahr Hadus Drain



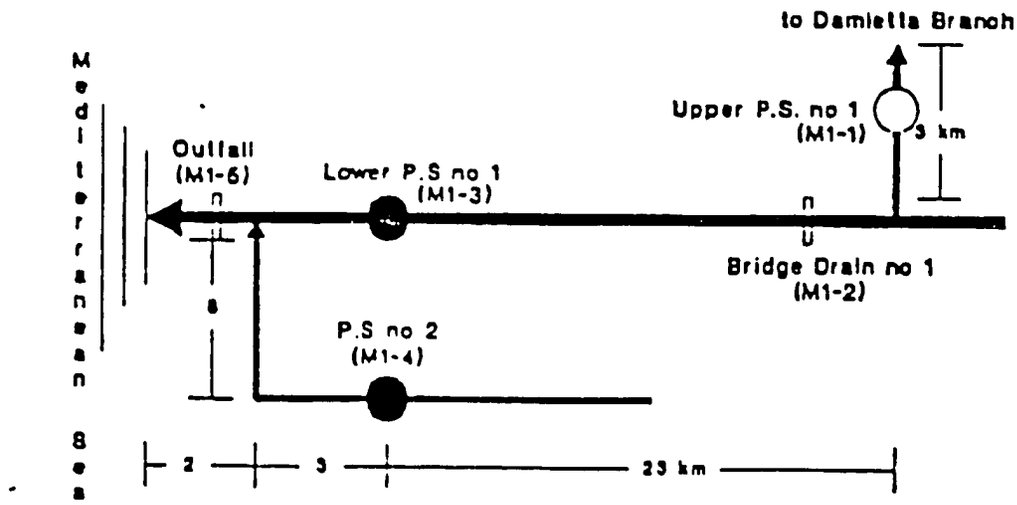
Schematic Diagram of Bahr Baqar Drain

Source: DRI

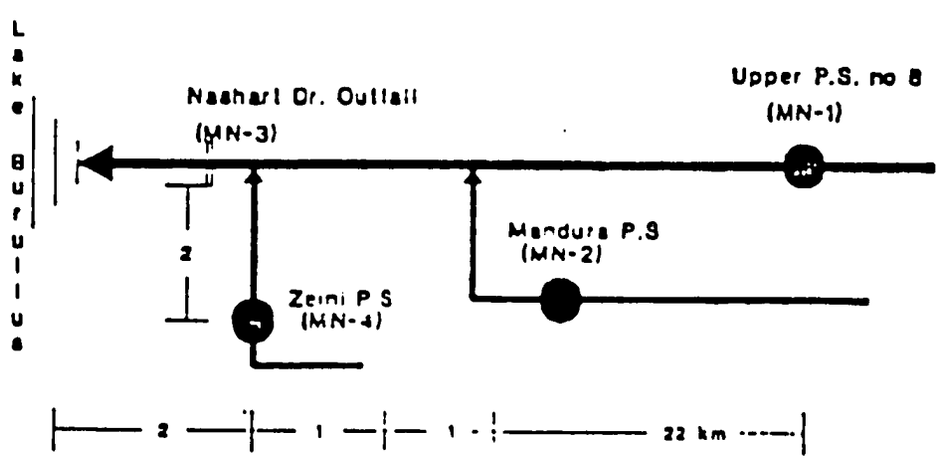
Fig. 3 Schematic Diagrams of Main Drains in Eastern Delta.



Schematic diagram of Gharbia main Drain



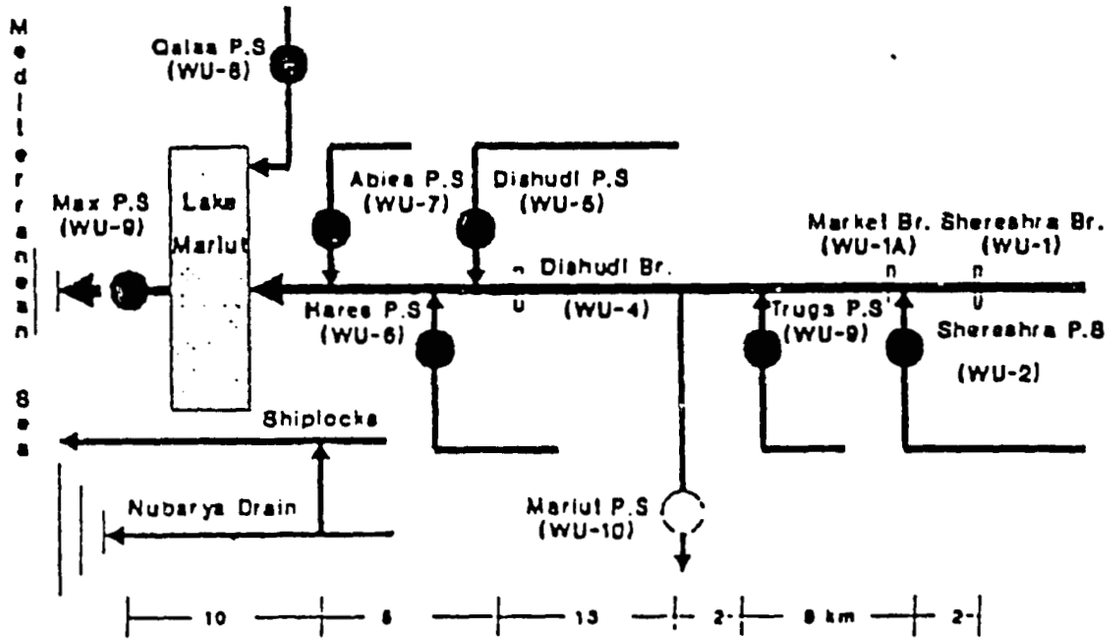
Schematic Diagram Of Drain No. 1



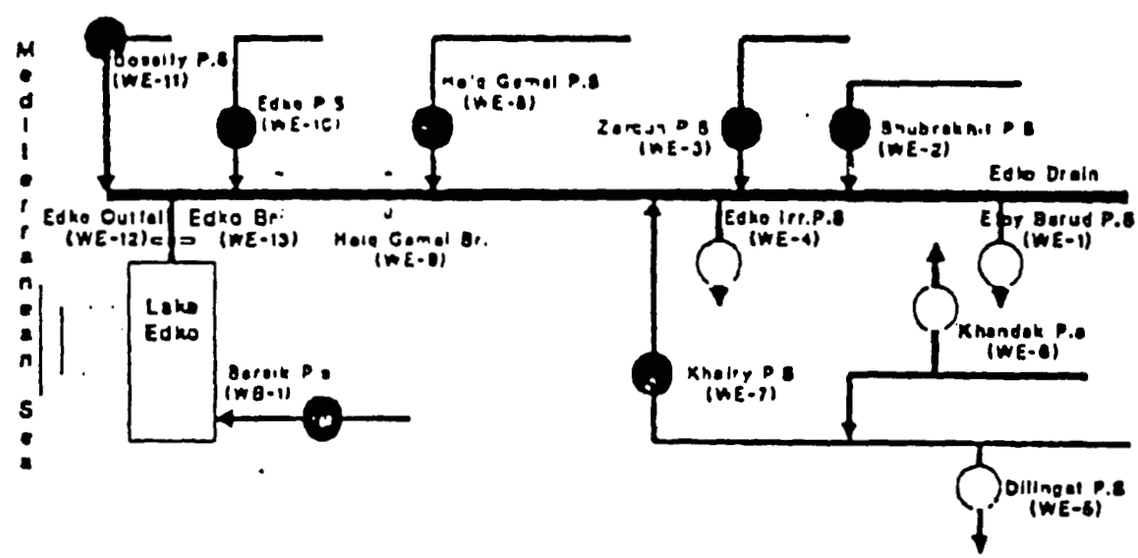
Schematic Digram of Nashart Drain

Fig. 4 Schematic Diagrams of Main Drains in Middle Delta

Source: DRI



Schematic Diagram of Umun Drain



Schematic Diagram of Edko Drain

Source: DRI

Fig. 5 Schematic Diagrams of Main Drains in Western Delta

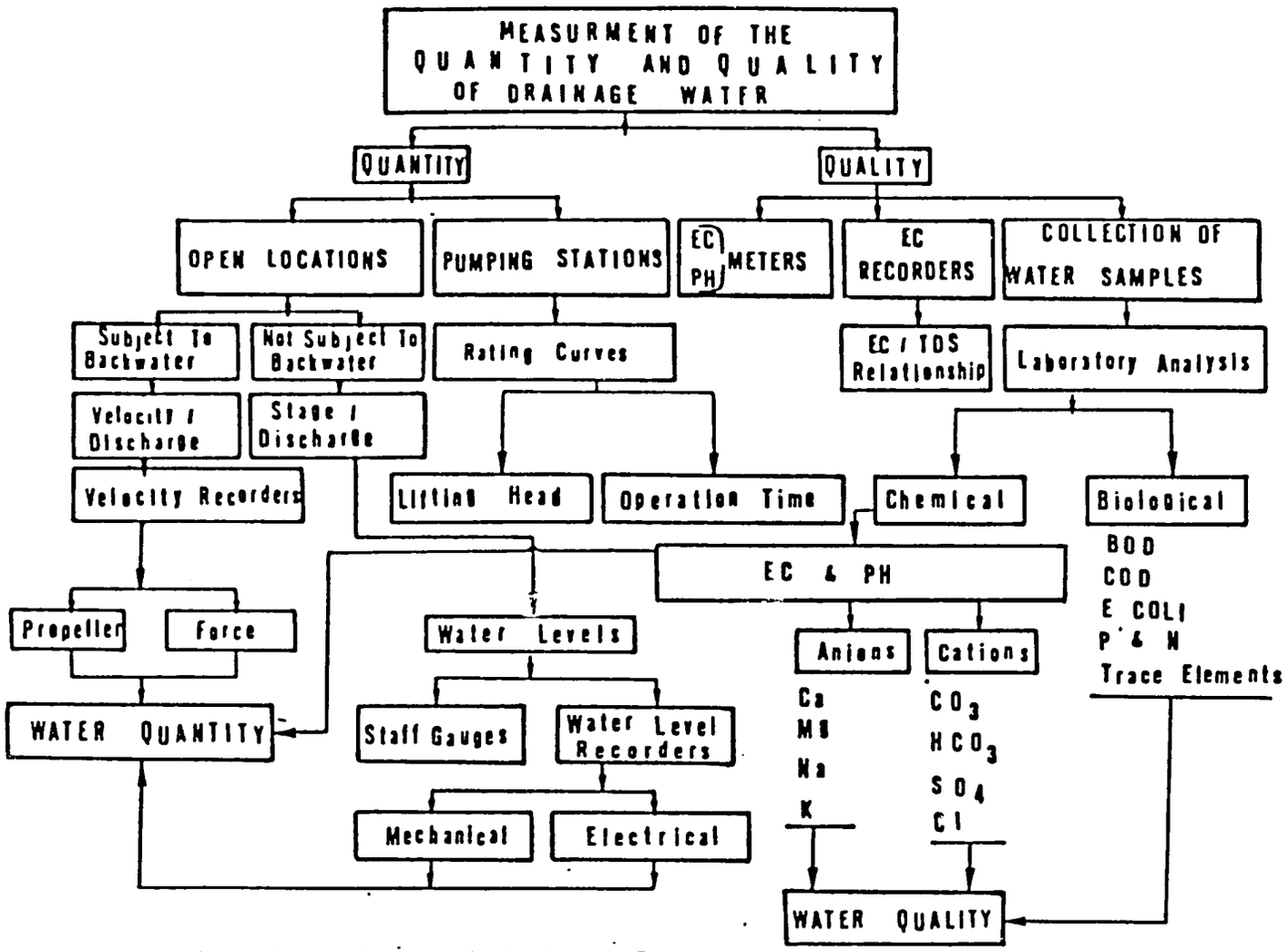


Fig. 6. Main Activities of Measurement Programme.

Source: DRI

Since sewage and industrial systems discharge their wastes into the drains and thus pollute their water to varying degrees, samples are collected from certain locations for the following biological analysis:

- The biological oxygen demand (BOD)
- The chemical oxygen demand (COD)
- Quantitative determination of E.Coli and coliform bacteria in terms of the most probable number (MPN)

The biological analysis is carried out upon request.

Table 3. Laboratory Analysis of Drainage Waters

Routine item	Symbol	Units *	Equivalent weight
a. For Routine Analysis (all samples)			
Electrical conductivity	EC_w	mmhos / cm	-
Calcium	Ca	meq / l	20
Magnesium	Mg	meq / l	12.2
Sodium	Na	meq / l	23
Carbonate	CO_3	meq / l	30
Bicarbonate	HCO_3	meq / l	61
Chloride	Cl	meq / l	35.4
Sulphate	SO_4	meq / l	48
Acidity-Alkalinity	pH	pH	-
Potassium	K	meq / l	39.1
Boron	B	mg / l	
Copper	Cu	mg / l	
Manganese	Mn	mg / l	
Iron	Fe	mg / l	
Zinc	Zn	mg / l	

* mmhos / cm = millimhos cm at 25°C. (mmhos / cm x 640 = mg /l)
meq/l = milliequivalents per litre.
mg/l = milligrams per litre

Source: DRI

It should be mentioned that in less than 10 years, DRI has carried out the following activities:

- Maintenance of a semi-automated network
- Development of regulatory measurements
- Updates of rating curves for each location
- Installation and periodic maintenance of measuring equipment

- Storage of measured and collected data in a database system
- Publication of fully detailed yearbooks

D. Quantitative and Qualitative Analysis of Drainage Water

The ultimate goal of the measurement network established in the Delta is to provide MPWWR with the required information on the quantity, quality, and location of drainage water for the present situation. The results obtained from the regular monitoring are satisfactory. The major output of this program is the publication of yearbooks covering the 1984-90 period, which include the average monthly discharges and complete chemical analysis of drainage water at each measuring location (Reuse Reports No. 13, 14, 15, 31, 32, 33, 34). Tables 4 and 5 summarize the results of the measurement program published in those reports. In Figure 7, the total drainage water that flows unused to the sea and the drainage water that is officially reused are presented, together with their salinities, for the 1984-90 period.

Further analysis reveals the quantity of drainage water produced in each part of the Delta divided into salinity classes. This gives an idea of the potential drainage water that can be made available for irrigation according to any prespecified criteria of suitability. Figure 8 shows the distribution of unused drainage water among the three Delta regions (East, Middle and Western) for the year 1990 according to the salinity levels in each region. The data in this figure indicate the following:

- About 55 percent of the drainage water discharged to the sea is below 2,000 gm/m^3.

- A quantity of 0.756, 0.172 and 0.157 x 10^9 m^3 can be made available for irrigation from the East, Middle and Western Delta, respectively, with a salinity of less than 1,000 gm/m^3.

- If water of salinity up to 1,500 gm/m^3 is to be used, a quantity of 3.11 x 10^9 m^3 can be made available. If the maximum salinity limit is taken at 2,000 gm/m^3, a quantity of 6.885 x 10^9 m^3 can then be made available.

- The above figures comply, more or less, with the short- and long-term plans of MPWWR, which call for the use of further 4 x 10^9 m^3 of drainage water by the year 2000.

Regular monitoring of the drainage water enables investigation of the changes in quality that occur with space and time. Spatial and temporal variations are functions of several factors including:

- Irrigation water quantity and quality
- Cropping patterns
- Climatic conditions
- Soil types

Table 4
Quantity and Salinity of drainage water flows unused to the Mediterranean Sea and the Coastal Lakes

	1984		1985		1986		1987		1988		1989		1990	
	Quantity	Salinity	Quantity	Salinity	Quantity	Salinity	Quantity	Salinity	Quantity	Salinity	Quantity	Salinity	Quantity	Salinity
Eastern Delta	4516	1333	4272	1456	4016	1550	3779	1560	3182	1827	3317	1831	3621	1842
Middle Delta	5064	1448	5057	2281	5264	2280	5080	2280	4361	2430	4546	2410	4476	2671
Western Delta	4351	3439	4313	3699	4226	2925	4376	3320	4437	3387	4425	3793	4723	4212
Total	13931	2033	13642	2471	13506	2265	13235	2418	11980	2624	12288	2752	12820	3005

Table 5
Quantity and Salinity of drainage water reused in the Delta

	1984		1985		1986		1987		1988		1989		1990	
	Quantity	Salinity	Quantity	Salinity	Quantity	Salinity	Quantity	Salinity	Quantity	Salinity	Quantity	Salinity	Quantity	Salinity
Eastern Delta	1333	819	1284	856	1413	870	1350	927	1130	1035	1412	1077	1527	1094
Middle Delta	737	813	777	888	721	853	719	886	686	957	673	1024	1236	1272
Western Delta	858	955	794	1035	765	994	765	1033	554	1148	587	1023	607	1139
Total	2928	857	2855	915	2899	898	2834	945	2370	1039	2672	1051	3370	1167

Quantity : million m^3/year
Salinity : ppm

Source of Tables 4 and 5: Drainage Research Institute, WRC

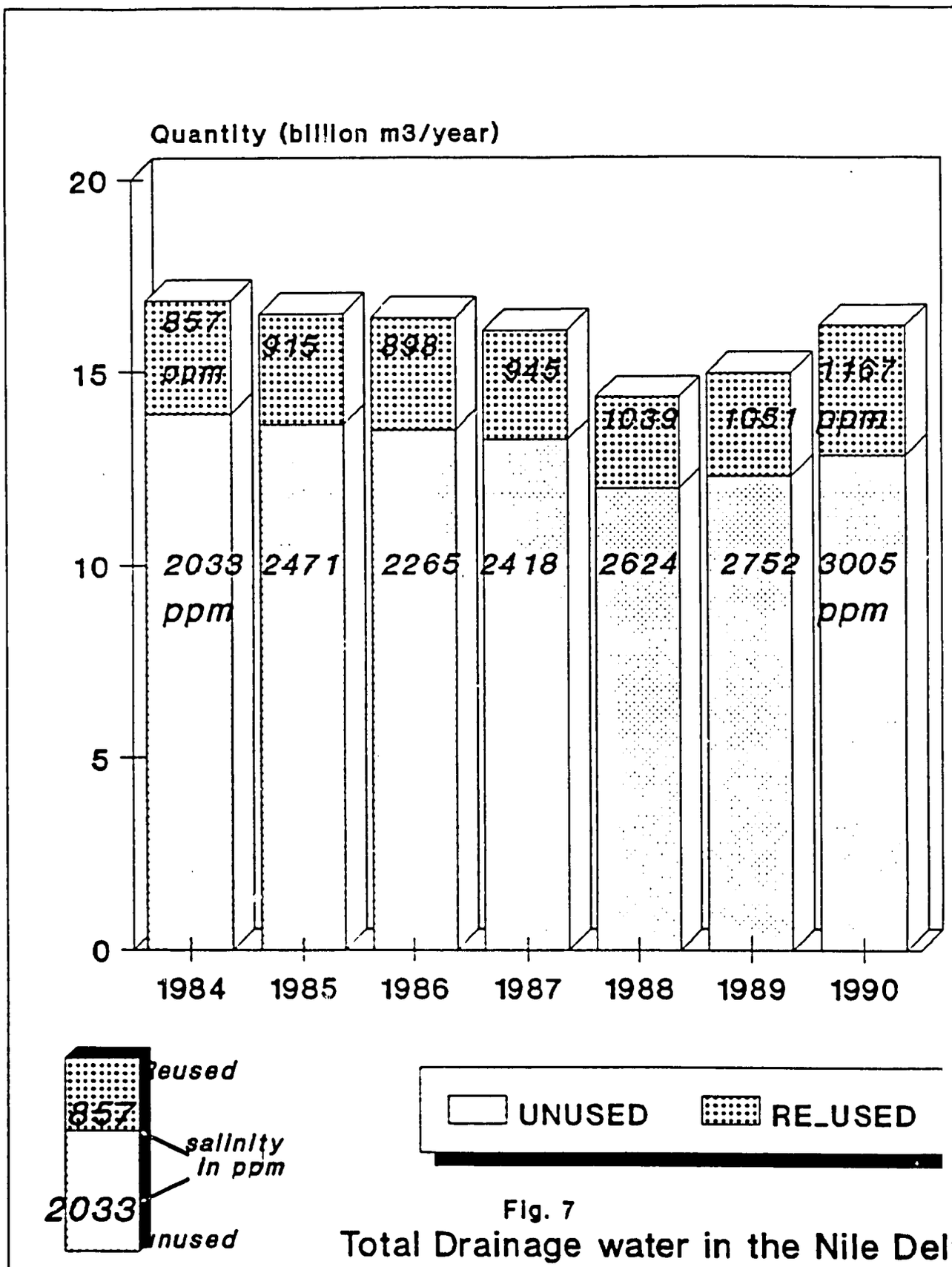
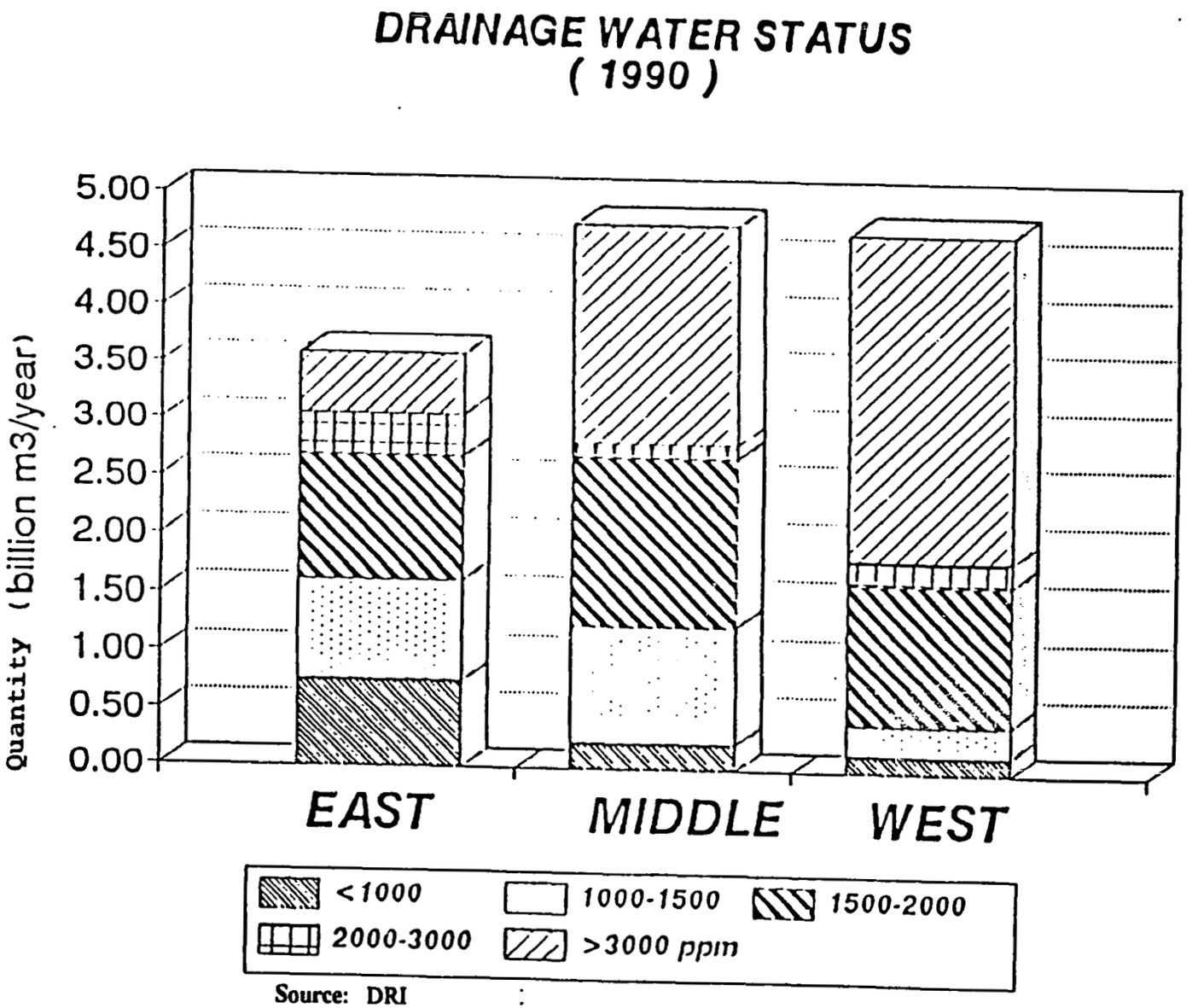


Fig. 7
Total Drainage water in the Nile Delta

Source: DRI



Source: DRI

Fig. 8 Unused Drainage Water Status

- Groundwater conditions
- Seawater intrusion into areas close to the Mediterranean Sea

Figure 9 illustrates the yearly average drainage water salinity at various parts of the Delta for the year 1990. Differences are found between the various parts.

- In the southern part of the Delta, the drainage water salinity is affected only by irrigation water salinity. It ranges between 750 and 1,000 ppm.

- In the middle part of the Delta, where soil salinity is considered moderate, the drainage water salinity ranges from 1,000 to 2,000 ppm. This rise in drainage water salinity could be attributed to:

  - The salt originating from seepage of saline groundwater, particularly in those parts of the Delta that are below mean sea level;
  - The salt originating from desalinization of soils through subsurface drainage; and
  - The salt accumulated in the soil cultivated with field crops, during periods of high demand for water. These salts leach into the drains during the period of low water demand.

However, in the most northern part of the Delta parallel to the seacoast, drainage water salinity is considered high and reaches more than 3,000 ppm in some locations. This could be due to the following causes:

- The non-official reuse of drainage water which causes a corresponding increase in drainage water salinity reaching from 3,500 to 7,000 ppm in the various parts of the Delta;

- The seepage of seawater inland coupled with the normal subsoil water, which should have already acquired some salinity during its flow with the generally descending gradient of land surface northward. Thus, the salinity of subsoil water at those parts of the Delta increases greatly. In this case, where the groundwater table is high, it will contribute to the salinity of the drainage water; and

- High soil salinity at this part of the Delta.

The composition of the soil solution and, consequently, drainage water varies greatly depending on place and time as a result of changes in soil salinity, temperature, and the preferential solubility of different salts at different temperatures. Figure 10 shows the dominant salts in the drainage water at various parts of the Delta (El-Guindy, 1989).

- In the southern part of the Delta, where the soil salinity is low, the main source of salts in the drainage water is the irrigation water delivered to the fields. The dominant salts in the irrigation water are Ca and Mg HCO_3.

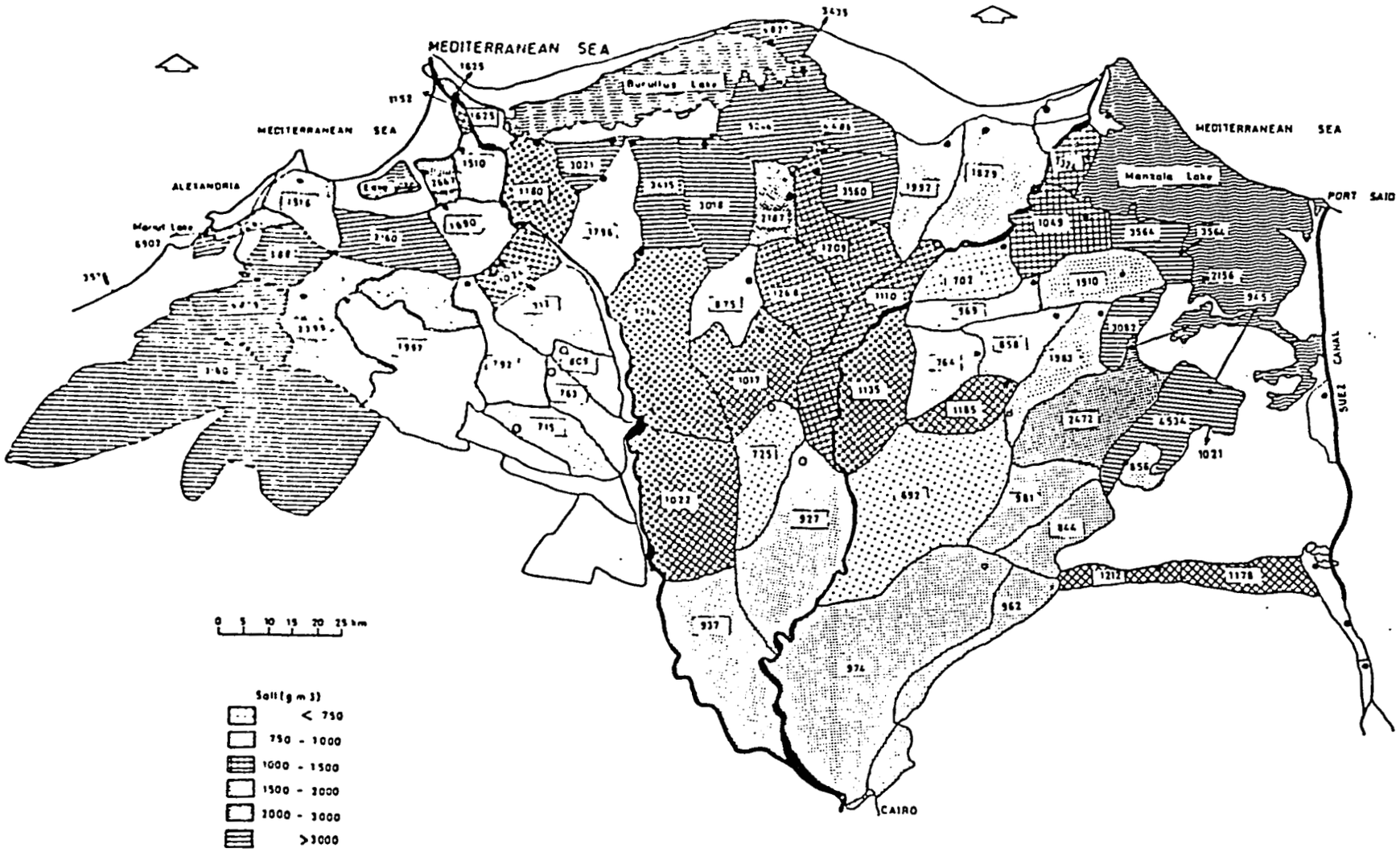


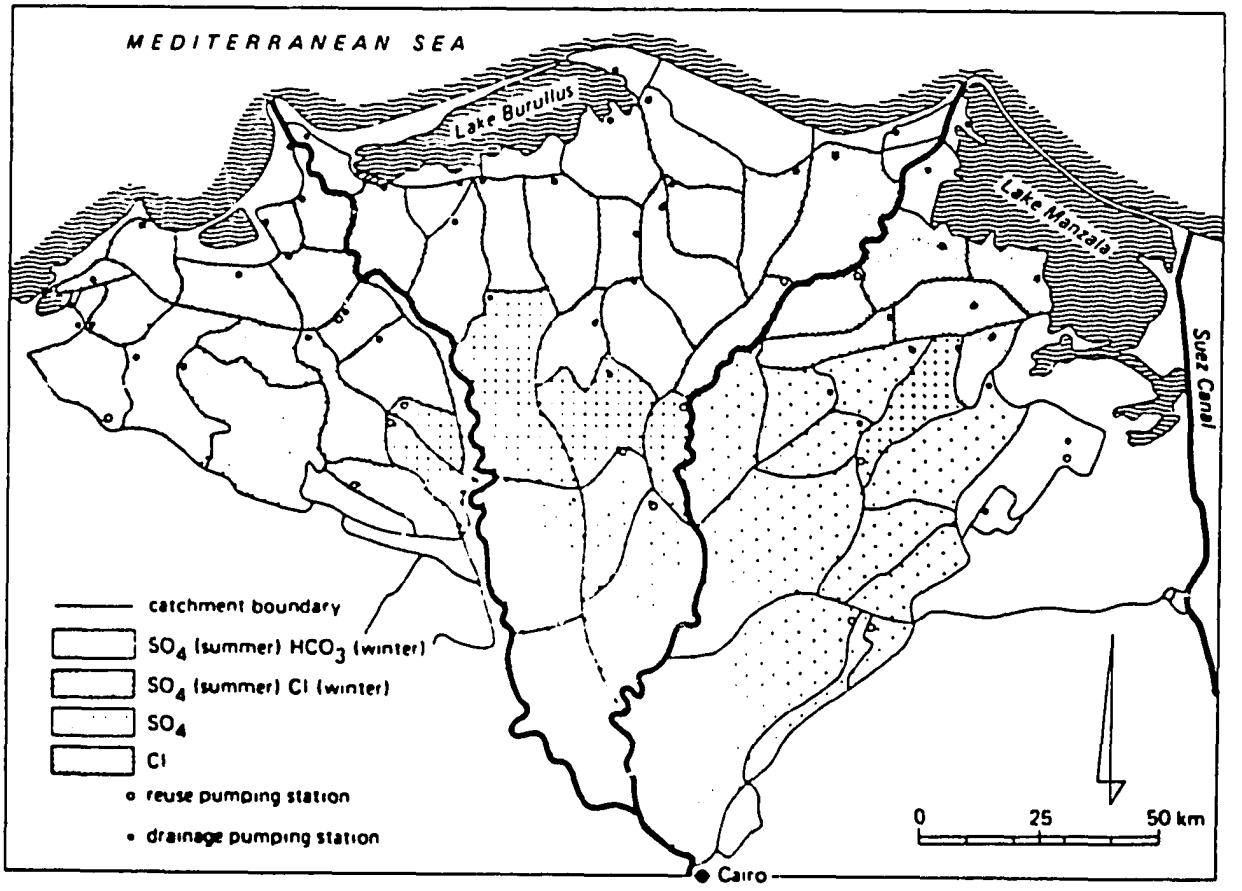
Fig. 9 Average Drainage Water Salinity for the Year 1990

Source: DRI

During the winter months, the predominant anion in the drainage water in this part of the Delta is bicarbonate, while high summer temperatures increase the solubility of SO_4 making this the dominant anion. In summer, the prevalent action in the drainage water in this part of the Delta was sodium, which is the dominant cation in the soil also.

- Toward the north, the salt content of the soil greatly modifies the composition of the drainage water. Since natural salts present in soil and irrigation water have different solubilities, some of them ($Ca\ CO_3$, $Mg\ CO_3$ and $Ca\ SO_4$) may precipitate in the soil as the concentration increases. The more soluble salts, such as Na Cl and $Na_2\ SO_4$, remain in soil solution, moving toward the drains.

- In the north, northwest, and east of the Delta, where the soil salinity is very high and consists mainly of Na Cl and $Na_2\ SO_4$, the dominant salt in drainage water is Na Cl. This could be attributed to the fact that chlorides usually move downward faster than sulphates, which leads to the difference in distribution of salt composition between the soil and drainage water.



Source: DRI

Figure 10 Dominant salts in drainage water

E. Reuse of Drainage Water in The Nile Delta

Drains between Aswan and Cairo receive runoff from agricultural lands and are discharged back into the River Nile. This slightly affects the quality of the Nile water as its salinity increases from 250 ppm at Aswan to 350 ppm at Cairo. Drains in the Delta vary dramatically in quality. Most Delta drains receive municipal and industrial waters in addition to agricultural return flows, and discharge to the coastal lakes and the Mediterranean Sea.

The total amount of drainage water discharged to the sea depends on many factors including amount of water released at Aswan, cropping patterns, and irrigation efficiency. The total amount of drainage water discharged annually has varied from 14 bcm in 1984 to 12.8 bcm in 1990. Surveys and monitoring of the quantity and quality of drainage water in the Nile Delta have shown that it is possible to reuse part of this water in irrigation.

The effect of reducing the quantity of water released from the High Aswan Dam on the quantity and salinity of drainage water is indicated in Table 6. MPWWR is imposing strict policies for releases of the Nile water downstream of the High Aswan Dam.

Table 6. River Nile Flow D/S High Aswan Dam and the Drainage Water Flowing to the Sea

Year	River Nile Flow x 10^9 m^3		Drainage Water	
	Below HAD	U/S Cairo	Quantity 10^9 m^3	Salinity gm/m^3
84	57.31	36.10	13.93	2214
85	55.84	34.51	13.64	2471
86	55.23	34.93	13.52	2265
87	54.41	34.45	13.24	2415
88	52.15	33.08	11.98	2624
89	53.24	33.22	12.29	2678
90	54.05	33.77	12.82	2744

Source: DRI

E1. Locations of Existing Reuse Pump Stations

Delta Area. As a result of the pressing need to increase the availability of irrigation water and to improve the efficiency of its use, more and more drainage water was

mixed with fresh water from the Nile branches and main irrigation canals. At present, 21 reuse pumping stations are operating in the Delta (Table 7).

Of the existing reuse locations, only two, the Sabal Drain Outfall (MS-1) and Tala Drain Outfall (MK-1) in Middle Delta, allow water to flow by gravity to Rosetta Branch. For the others, water is lifted by pumping.

Fayoum Area. The sloping lands in Fayoum make natural reuse by gravity feasible. This feature was used in the original design of the present irrigation and drainage network.

At other locations, small pumps were installed along the drains. Recently, large pumping stations have been constructed or are planned by the Fayoum Irrigation Department (Figure 11). These stations will deliver their discharge to existing irrigation canals. By this mixing, water salinity can be kept within tolerable levels.

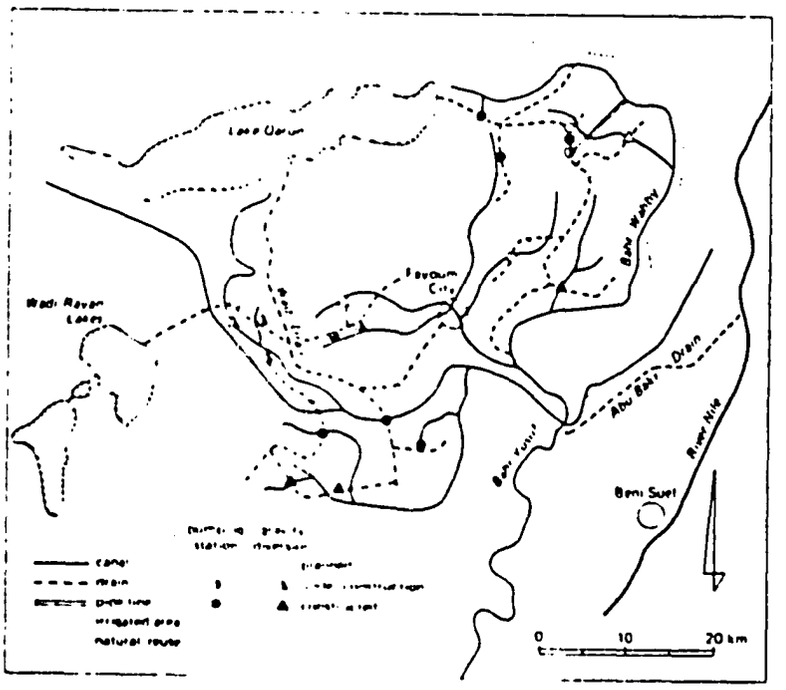


Figure 11 Re-use locations in the Fayoum

Source: Fayoum Irrigation Department

Table 7. Locations of Reuse Pumping Stations in Delta

Pumping Station	No. of Unit	Q/Unit m^3/sec	Suction	Delivery	Directorate
Eastern Delta					
Wadi P.S.	5 + 2	6	El-Qalubeya Drain	Wadi El-Sharki Canal	Sharkia
Genena P.S.	4	5	Upper Erad Drain	Bahr Tanah + Bahr Saghir Canal	East Dakahlia
Hanut P.S.	3	5	Bahr Hadus Drain	Hanut Canal	Sharkia
Saft P.S.	6	7.5	Saft Drain	Daffan Canal	Sharkia
Upper Serwa P.S.	3	8	Garga Fargas Drain	Damietta E. Branch	Dakahlia-Damietta
B. Baqar Irr. P.S.	8	0.83	Bahr El-Baqar Drain	Main Canal	Sharkia
Blad El-Ayed P.S.	4	3.5	Blad El-Ayed Drain	Wadi El-Sharki Canal	Sharkia
Mahsama P.S.	4	3.5	Mahsama Drain	Ismailia Canal	Ismailia
Middle Delta					
East Menufia P.S.	2 + 3	2.5 + 5.0	Arineen Drain	Abbasi Rayah	Gharbia
Mahallet Ruh P.S.	4	2.5	Tuca Drain	Meet Yazid Canal	Gharbia
Hamul P.S.	3	10.0	Gharbia Drain	Bahr Teara Canal	Kafr El-Sheikh
Upper No. 1 P.S.	3	5.0	Drain No. 1	Damietta Branch	Kafr El-Sheikh + W. Dakahlia
Tala Drain			Tala Drain	Rosetta Branch	Menufia
Sabal Drain			Sabal Drain	Rosetta Branch	Menufia
Mahalla El-Koubra P.S.	4	3.0	Nasseria Drain	Damietta Branch	Gharbia
Western Delta					
Etay El-Baroud P.S.	3	2.60	Etay El-Barud Drain	Khandak El-Sh. Canal	West Behaira
Delingat P.S.	3	5.79	Dilingat Drain	El-Hagir Canal	Nubaria
Khandak El-Gharbi P.S.	4	2.65	Khandak El-Gharbi Drain	Abu-Diab El-Awsat Canal	West Behaira
Edku Irr. P.S.	3	6.36	Edko Drain	Mahmudeya Canal	Nubaria
Mariut No. 1 P.S.	3	6.0	Umum Drain	Nubaria Canal	Nubaria
Bustan P.S.	3		Bustan Drain	Nubaria Canal	Nubaria

E2. Quantity and Salinity of Drainage Water Reused

Delta Area. Tables 8 and 9 give the annual discharges and salinities of the reuse locations in the Nile Delta for the 1984-90 period.

It may be noted that the amount of drainage water presently reused in irrigation in the Nile Delta is 3.37 bcm/yr and the overall weighted salinity is about 1,167 ppm (gm/m^3). If the mixing ratio is 1:1 (the portion of fresh-water in most cases is more than that of drainage

Table 8

Quantity of reused drainage water in the Nile Delta (all data in million m³)

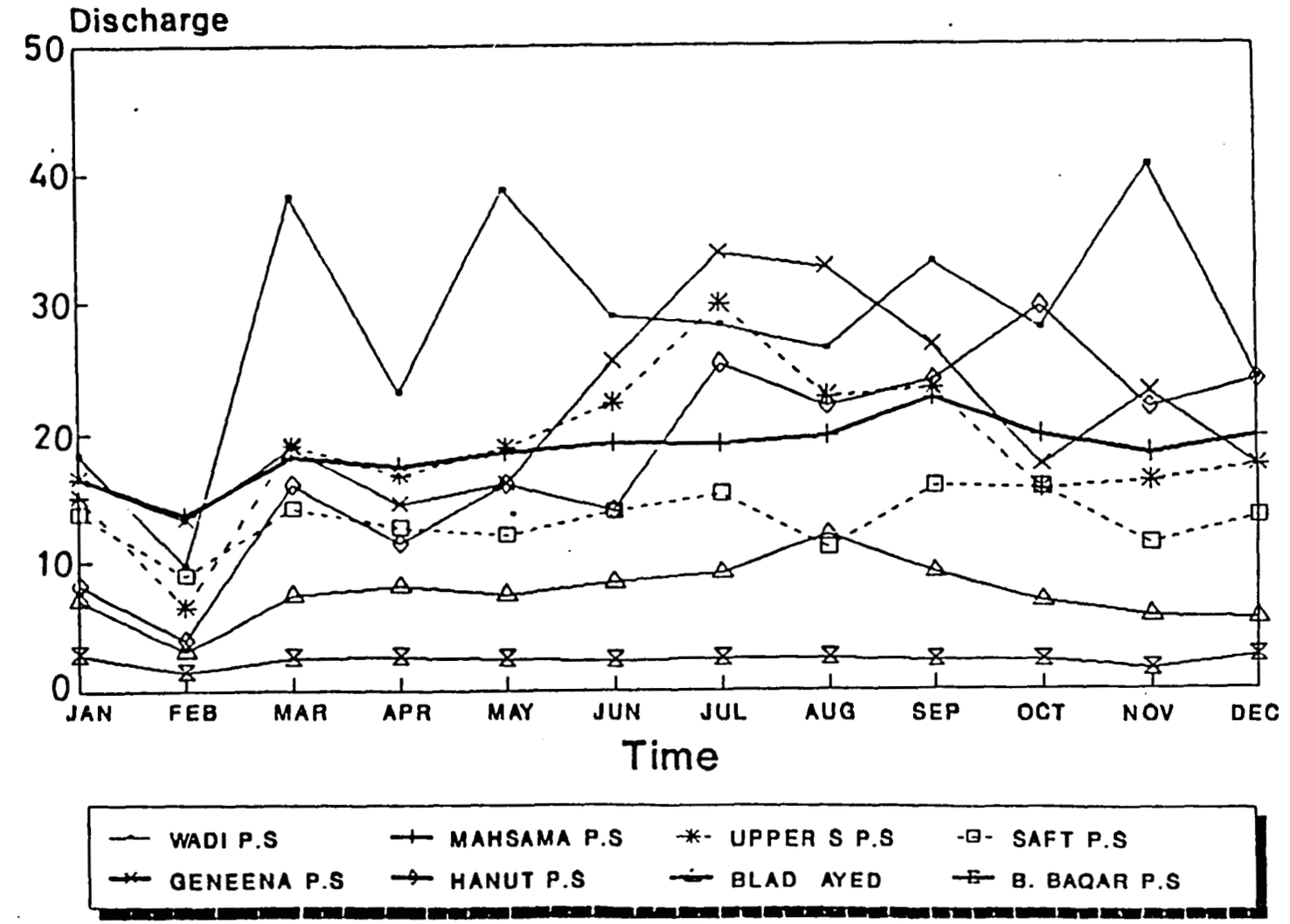
* Estimated quantity

Drains or Pumping stations	code	1984	1985	1986	1987	1988	1989	1990	Delivery
Eastern Delta									
Wadi P.S.	EB-3	396	357	337	270	229	257	337	To Wadi El Sharky Canal
Geneena P.S.	EH-9	225	197	210	262	220	261	255	Unofficial reuse
Hanut P.S.	EH-2	238	284	309	271	188	208	216	To Hanut Canal
Salt P.S. (30%)	EH-12	169	163	160	152	133	136	157	Part to Daffan Canal
Upper Serw P.S.	ES-1	261	244	239	242	222	221	223	To Damietta Branch
B.Baqar Irr. P.S.	EB-9	44	39	40	37	34	31	28	To Battikh Canal
Blad El Ayed P.S.	EB-13	*In operation since Aug 85*		118	116	104	87	89	To Wadi El Sharki Canal
Mahsama P.S.	ET-2	*In operation since April 87*					211	222	To Ismailia Canal
Subtotal		1333	1284	1413	1350	1130	1412	1527	
Middle Delta									
East Menufia P.S.	MG-1	117	105	89	87	87	73	36	To Abbasi Rayah
Mahallet Ruh P.S.	MG-3	67	80	70	59	47	37	44	To Meet Yazid Canal
Hamul P.S.	MG-8	252	257	243	271	230	233	257	To Bahr Teera Canal
Upper no. 1 P.S.	MI-1	72	63	96	73	95	115	116	To Damietta Branch
Tala Drain	MK-1	129 *	152	134	126	112	97	120	To Rosetta Branch
Sabal Drain	MS-1	100 *	120	89	103	87	87	77	To Rosetta Branch
Mahalla El Koubra P.S.	MM-1	*In operation since April 87*				28	31	63	To Damietta Branch
								523	Extra reuse locations
Subtotal		737	777	721	719	686	673	1236	
Western Delta									
Etay El Baroud P.S.	WE-1	78	84	78	71	56	59	46	To Khandak El Gharby Canal
Delingat P.S.	WE-5	188	201	214	194	162	157	166	To Fernash & Hager Canal
Khandak El Gharby P.S.	WE-6	96	66	74	81	55	62	51	To Abu Diab Canal
Edku Irr. P.S.	WE-4	335	302	272	270	146	167	192	To Mahmoudia Canal
MArriut No. 1 P.S.	WU-10	161	141	127	112	99	102	103	To Nubaria Canal
Bustan P.S.	WB-1	*In operation since Oct. 86*			37	36	40	49	To Nubaria Canal
Subtotal		858	794	765	765	554	587	607	
Total		2928	2855	2899	2834	2370	2672	3370	

Table 9
Salinity of reused drainage water in the Nile Delta (all data in mg/l)

Drains or Pumping stations	code	1984	1985	1986	1987	1988	1989	1990	Delivery
Eastern Delta									
Wadi P.S.	EB-3	734	787	768	824	910	947	974	*To Wadi El Sharky Canal*
Geneena P.S.	EH-9	749	791	949	1011	1164	1149	969	*Unofficial reuse*
Hanut P.S.	EH-2	796	786	794	828	992	990	936	*To Hanut Canal*
Saft P.S. (30%)	EH-12	1659	1643	1829	1985	2253	2347	2472	*Part to Daffan Canal*
Upper Serw P.S.	ES-1	518	593	581	608	579	655	737	*To Damietta Branch*
B.Baqar Irr. P.S.	EB-9	630	696	671	793	980	1075	1021	*To Battikh Canal*
Blad El Ayed P.S.	EB-13	*In operation since Aug 85*		571	527	550	559	563	*To Wadi El Sharki Canal*
Mahsama P.S.	ET-2	*In operation since April 87*					1067	1178	*To Ismailia Canal*
Salinity weighted average		819	856	870	927	1035	1077	1094	
Middle Delta									
East Menufia P.S.	MG-1	620	865	766	777	861	911	927	*To Abbasi Rayah*
Mahallet Ruh P.S.	MG-3	650	692	539	625	573	648	645	*To Meet Yazid Canal*
Hamul P.S.	MG-8	1002	1052	1018	1048	1143	1050	1081	*To Bahr Teera Canal*
Upper no. 1 P.S.	MI-1	896	954	860	863	1007	1167	1110	*To Damietta Branch*
Tala Drain	MK-1	705	770	760	778	778	1095	1022	*To Rosetta Branch*
Sabal Drain	MS-1	750	800	865	847	955	955	937	*To Rosetta Branch*
Mahalla El Koubra P.S.	MM-1	*In operation since April 87*				923	979	907	*To Damietta Branch*
								1629	*Extra reuse locations*
Salinity weighted average		813	888	853	886	957	1024	1272	
Western Delta									
Etay El Baroud P.S.	WE-1	715	731	611	615	688	626	809	*To Khandak El Gharby Canal*
Delingat P.S.	WE-5	656	753	692	708	677	675	715	*To Fernash & Hager Canal*
Khandak El Gharby P.S.	WE-6	721	775	709	624	689	778	763	*To Abu Diab Canal*
Edku Irr. P.S.	WE-4	682	791	762	726	971	765	862	*To Mahmoudia Canal*
MArriut No. 1 P.S.	WU-10	2127	2261	2402	2939	2776	2409	2672	*To Nubaria Canal*
Bustan P.S.	WB-1	*In operation since Oct. 86*			900	927	892	1145	*To Nubaria Canal*
Salinity weighted average		955	1035	994	1033	1148	1023	1139	
elta salinity weighted average		857	915	898	945	1039	1051	1167	

Fig. 12 Quantity of reused drainage water Eastern Delta (1990)



All Data In (10^6 cubic meter)

Fig. 13 Quantity of reused drainage water
Middle Delta (1990)

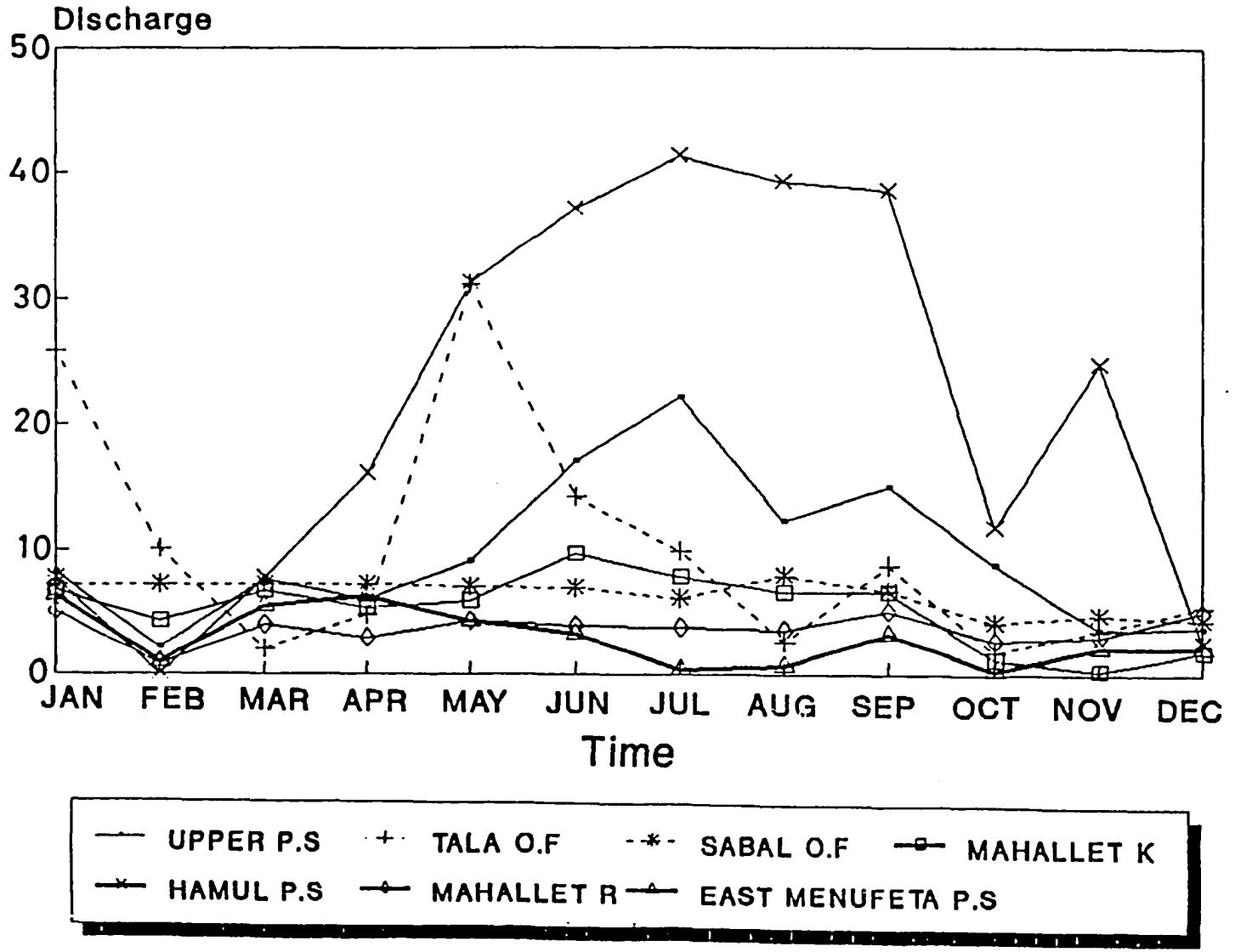


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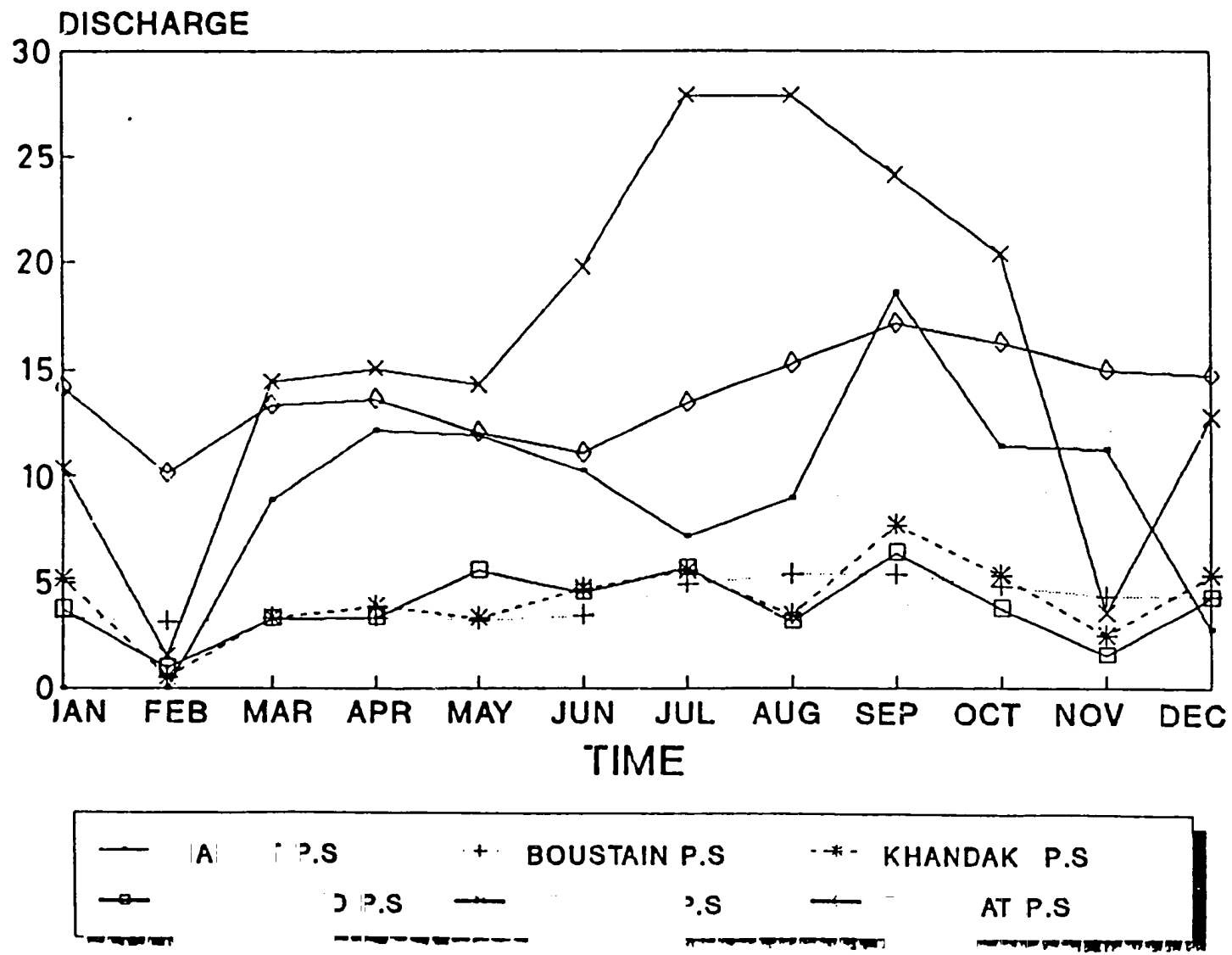
Fig. 14 QUANTITY OF REUSED DRAINGE WATER
WESTERN DELTA (1990)



water), then the expected salinity of the mixture ranges from 600-700 ppm. This explains why this mixture can be used for such an extended period of time without serious problems.

The monthly changes of reuse discharges for the different locations are presented in Figures 12, 13, and 14 for East, Middle, and Western Delta, respectively. It is clear that the maximum discharges occur between May and September.

Fayoum Area. The present annual drainage flow of the irrigated lands in the Fayoum amounts to 714 x 10^6 m^3. Only part of this water is reused because of the following limitations:

- To maintain Lake Qarun's average level at -43.80 m.MSL, an annual inflow of 426 x 10^6 m^3 is required.
- To maintain a favorable salt balance in the first lake of Wadi Rayan, an annual inflow of 120 x 10^6 m^3 is required.
- In the lower reaches of the drains, the salinity of the waters is high and can be only a minor component in a mixture of drainage and irrigation water.

The present reuse of drainage water is about 180 x 10^6 cm/yr by lifting, and an estimated 150 x 10^6 cm/yr by gravity. Drainage water has to be mixed with fresh irrigation water to ensure a good water quality. In the Fayoum, a mixing ratio of 1:1 results in a salinity of 600-800 ppm.

E3. Unofficial Reuse

Besides the above reuse pumping stations, unofficial reuse is taking place in many locations. Details of such activities cannot be given because of the great number of gravity intakes and pumping points involved. However, field observations show that drainage water is intensively reused from south toward the north and then toward the fringes of the Delta. It is believed that a quantity as high as (1.5-2.0) x 10^9 cm/yr is being reused unofficially.

E4. Reuse Projects Under Construction

Planning for reuse projects in the early 1980s was marked by the desire to use the water of drain catchments. The purpose was to use as much drainage water as possible, especially to irrigate large land reclamation projects in the eastern and western parts of the Delta and in Fayoum. Four projects of this kind were designed and are now under construction:

E4a. Al-Salam Canal Project (Eastern Part)

Al-Salam Canal is designed to be fed with fresh water from the Damietta Branch upstream of Faraskour Dam supplemented with drainage water from the Lower Serw P.S. and Bahr Hadus Drain near its outfall.

The average yearly discharge of the Lower Serw P.S. is about 0.6 x 10^9 m^3 and that of Bahr Hadus Drain is about 2 x 10^9 m^3. These bring the total to 2.6 x 10^9 cm/yr.

The average salinities measured at both locations are 1,000 and 1,400 ppm, respectively. The weighted average of both waters is then 1,300 ppm. When this is mixed with fresh-water at a ratio of 1:1, the expected salinity is 800 ppm.

The plan is to use 1.5 x 10^9 cm/yr of this quantity in the first and second phases of the project in addition to a similar quantity of fresh Nile water.

E4b. Omoum Drain Project (Western Part)

The objective of the project is to collect drainage water from these catchments of Omoum Drain, Shereishra, and Truga, and mix it with the fresh water of Nubaria Canal. The quantity of drainage water to be used in the project is about 1.0 x 10^9 cm/yr with average salinity of 1,800 ppm. The expected salinity after mixing will be 800 ppm.

E4c. Botita Pumping Station (Middle Part)

This pumping station is located on the Main Gharbia Drain. The plan is to pump part of the water delivered by Samatay P.S. and Segaiya P.S. to Zawia Canal. The plan is to use 0.25 x 10^9 cm/yr with average salinity of 900 ppm. The salinity of blended water after mixing will be 600 ppm.

Following the completion of the construction of the above three projects, an extra quantity of 2.75 x 10^9 cm of drainage water will be used for irrigation.

E4d. Fayoum Governorate

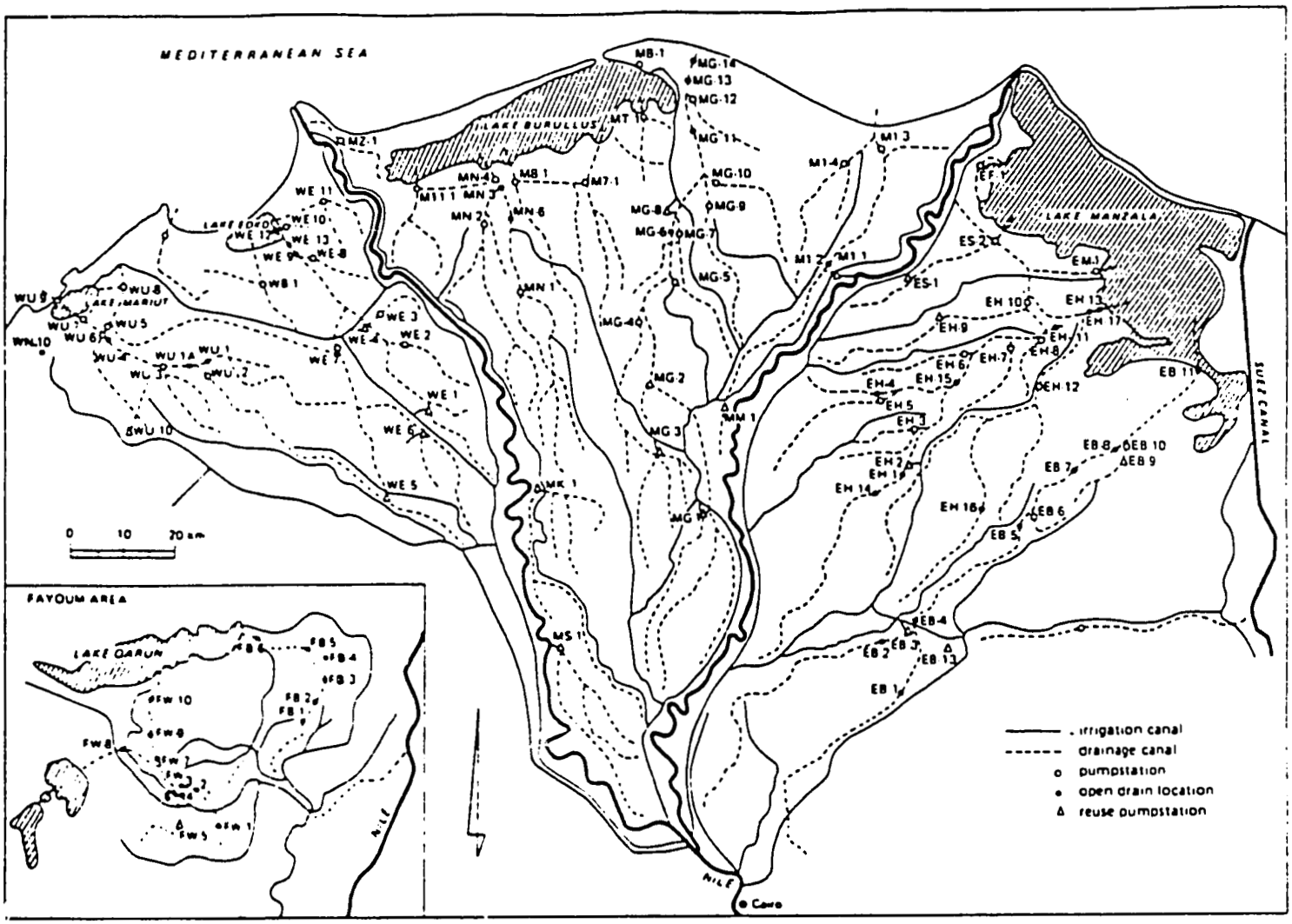
The MPWWR is planning three projects for the reuse of drainage water in the Fayoum Depression.

Of the present series of reuse pumping stations (Figure 15), the Tagen Pump Station is the first major reuse project. This station will lift 0.135 x 10^9 cm/yr of drainage water from Tagen Drain into Bahr Nazle Canal.

Execution of a second major reuse project started in 1988. A pump station at Tamya will lift 0.13 x 10^9 cm/yr from the Batts Drain to Bahr Wahbi Canal.

A third major project being planned will divert about 0.13 x 10^9 m^3/year from Wadi Rayan Drain to Bahr Nazle tail end section.

Therefore, an extra quantity of 0.4 x 10^9 cm of drainage water will be used to supply the main canals.



Source: MPWWR

Figure 15. Measurements Locations at Pumping Stations and Open Drains in the Delta and Fayoum.

F. Water and Salt Balance

Long-term planning of reuse projects should take account of the overall water and salt balances of the country. However, the existing situation indicates those balances:

- The quantity of water passing the Aswan High Dam is approximately 54 x 19^9 cm/yr. The salinity of this water is 250 gm/m^3 which results in a salt load of 13.5 x 10^9 kg.

- The quantity of water upstream from the Delta Barrages is approximately 33.5 x 10^9 cm/yr at a salinity of 350 gm/m^3. The salt load is then 12 x 10^9 kg.

- The two salt loads are almost the same, which means that no accumulation of salts is taking place.

- The quantity of drainage water leaving the Delta is 13 x 10^9 cm/yr at a salinity of about 3,000 gm/m^3. The salt load is then 38 x 10^9 kg.

- The difference in salt load between the water coming into the Delta and that going out is too great to be attributed to the leaching of agricultural lands. This difference might be due to upward saline seepage and seawater intrusion.

- When the locations where drainage water salinity is 2,000 gm/m^3 or more are separated from other points in the system, the salt load falls from 38 x 10^9 kg to 11 x 10^9 kg and the quantity is reduced to 7 x 10^9 m^3 (Table 10). This means that the separated locations are responsible for the major part of the saline seepage and seawater intrusion. This can be justified since these locations lie close to the coast as shown in Figure 16.

Table 10. Simple Water and Salt Balance of the Delta for the Year 1990.

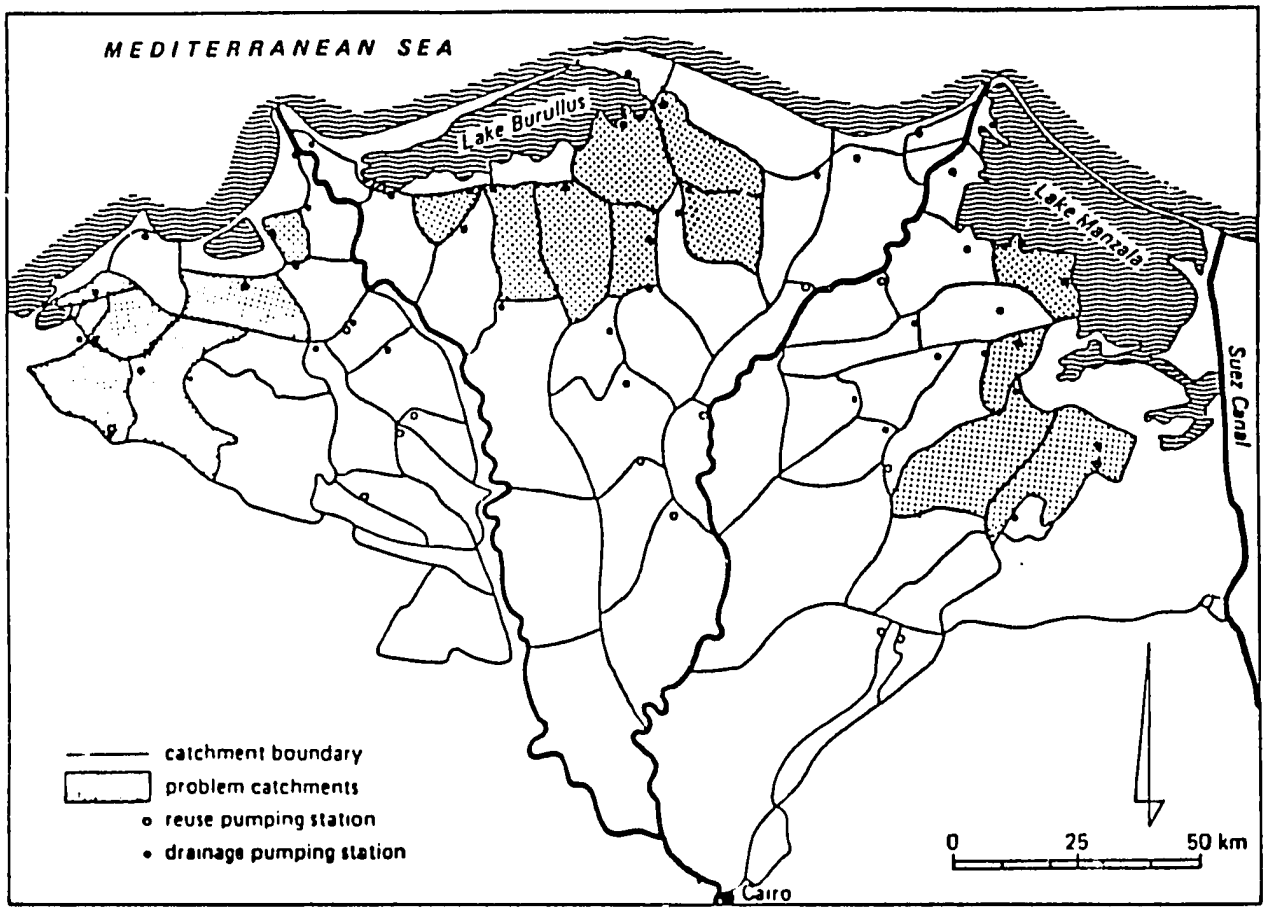
				Excluding Salinities Above 2000 ppm		
	Discharge $10^6 m^3$	Salinity gm/m^3	Salt Load 10^9 kg	Discharge 10^6 m^3	Salinity gm/m^3	Salt Load 10^9 kg
East	3621	1842	6.670	2709	1385	3.75
Middle	4476	2671	11.955	2515	1690	4.25
West	4723	4212	19.900	1660	1980	3.30
	---	---	---	---	---	---
	12820	3004	38.525	6884	1639	11.30

- The above argument is made to show that about 7 x 10^9 m^3 of water of salinity of 2,000 gm/m^3 or less can be made available for reuse provided that the supply and demand remain the same, and that the locations and water elevation are suitable. However, the consequences of using such water have to be considered, which can be done only through the use of mathematical modeling and field experiments.

G. Predicting the Quantity and Quality of Drainage Water through Mathematical Modeling

The fundamental limitation in planning to reuse drainage water for irrigation is the uncertainty about the quantity and salinity of the water resulting from changes in water management in the corresponding catchment. Also, the uncertain consequences for agricultural production in the area receiving mixed drainage water limits this planning.

To predict future results of changes in water management, agronomy, or hydraulic conditions, a mathematical model named SIWARE (Simulation of Water Management in the Arab Republic of Egypt) was developed jointly by the Land and Water Research Institute of The Netherlands and the Drainage Research Institute of Egypt. In this simulation model for the Nile Delta, all relevant physical and functional relationships have been combined in a simplified and schematized way.



Source: MPWWR

Figure 16. Drainage Catchments Excluded in Table 10

Following the path of irrigation water from the Nile Delta Barrages, where it enters the Nile Delta to the points where it leaves the area, numerous subsystems can be distinguished (Figure 16):

- The water allocation to the intakes of the major irrigation command canals is treated in the model DESIGN.
- The estimation of the water requirement at farm level, taking into account the hydrological and climatic circumstances, as well as the moisture and salinity status of the soil, is treated in the model WDUTY.
- The water distribution within the irrigation command areas, resulting in a supply to the agricultural fields and operational losses to the drainage system, is treated in the model WATDIS.

- The Nile Delta's water losses to the atmosphere through evaporation and transpiration, to the aquifer through leakage and seepage, and to the Mediterranean Sea and coastal lakes through the drainage system, are treated in the model REUSE.

Three clusters of water management scenarios have been analyzed with the SIWARE model:

- Water-saving strategies by replacing rice with maize in the cropping pattern and/or reducing the rice allocation duty.

- Extension of agricultural area in the eastern deserts in yearly increments of 44,000 feddans, starting with the 1988 water management and cropping pattern situation.

- Improvement of the local water management situation by prohibiting the use of movable irrigation pumps and/or prohibiting the unofficial reuse of drainage water by farmers.

For each strategy, the SIWARE model package has been used to estimate the quantity and salinity of drainage, the amount of available official reuse of drainage water, the evapotranspiration, and crop yields. A distinction has been made between the short (one year) and long-term effects (50 years) caused by a salinization or desalinization of the top soil. A specimen of the model results is shown in Figure 17, which illustrates the long-term effect of reducing the rice area in the Eastern Delta on the average drainage salinity, soil salinity, and relative evapotranspiration (Abdel-Gawad et al. 1991).

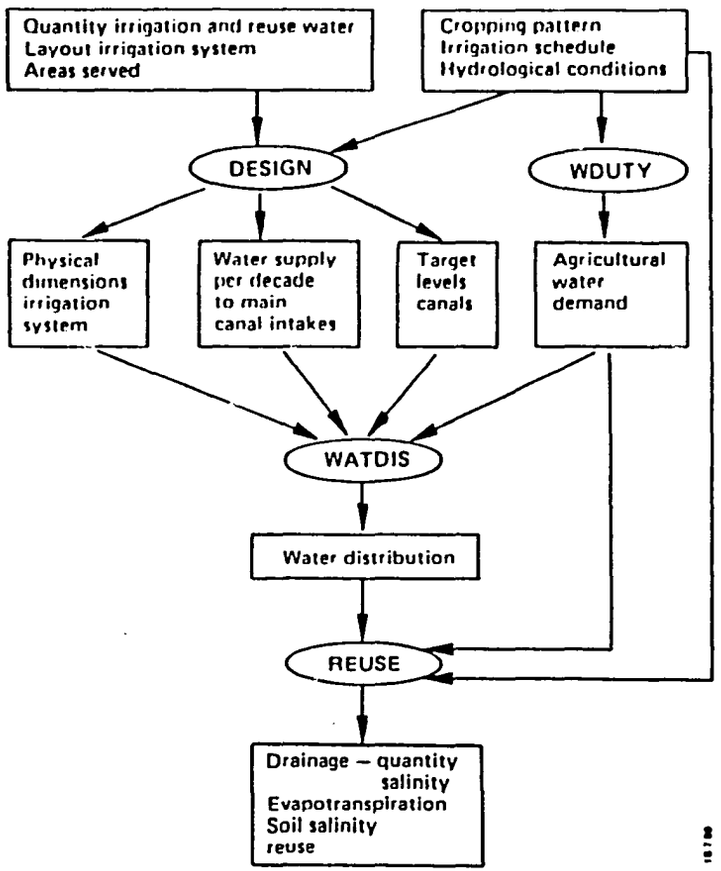
The model has been applied to the Eastern Delta; its application to the other Delta regions is under way with completion expected by 1994.

H. Pollution of Drainage Water

Agricultural drains are designed to collect and transport agricultural drainage water. Conventionally, higher salt levels are the expected type of water pollution. However, with the application of agricultural chemicals to land, these chemicals also appear in the drainage system. Moreover, domestic wastewaters from villages, towns, and even cities, and industrial wastes reach these drains either directly or indirectly. This produces water quality problems in some drains.

H1. Sources of Pollution to Drainage System

Municipal and Rural Domestic Wastes. The present expansion in water networks in several cities without a parallel construction of new sewerage systems leads to pollution of the waterways with consequent public health hazards.



Source: MPWWR

Figure 17. Schematization of the SIWARE Simulation Model, its Sub-Models, and Required In- and Output

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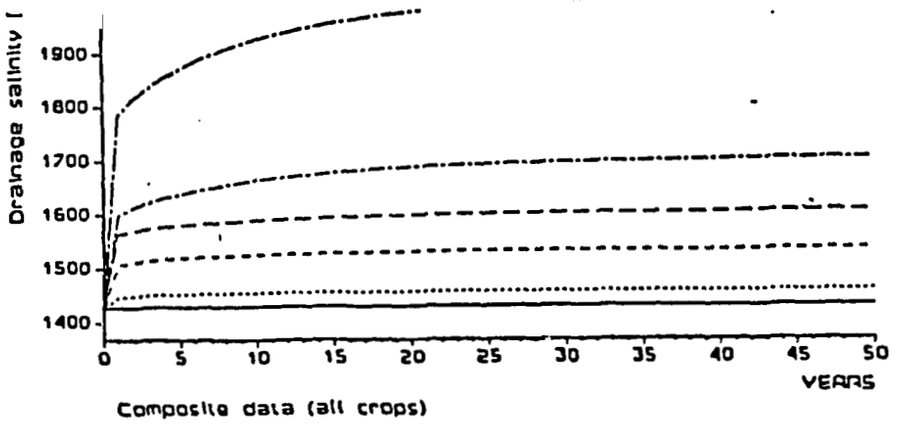

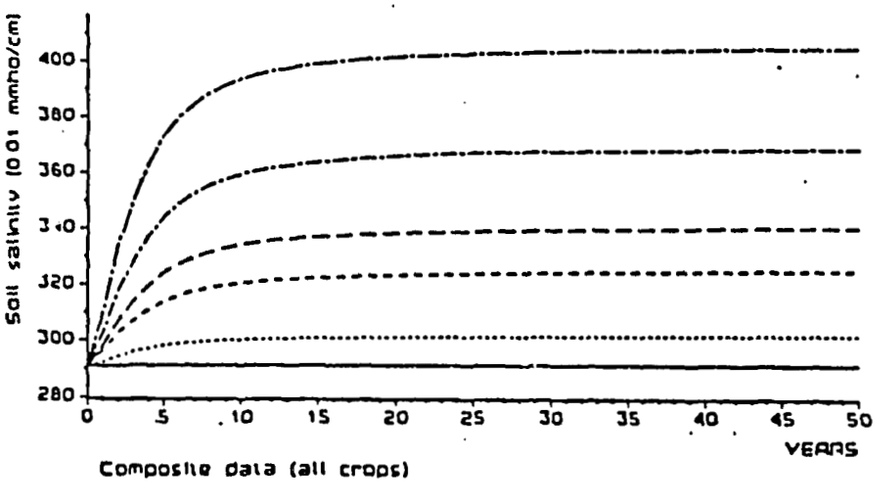

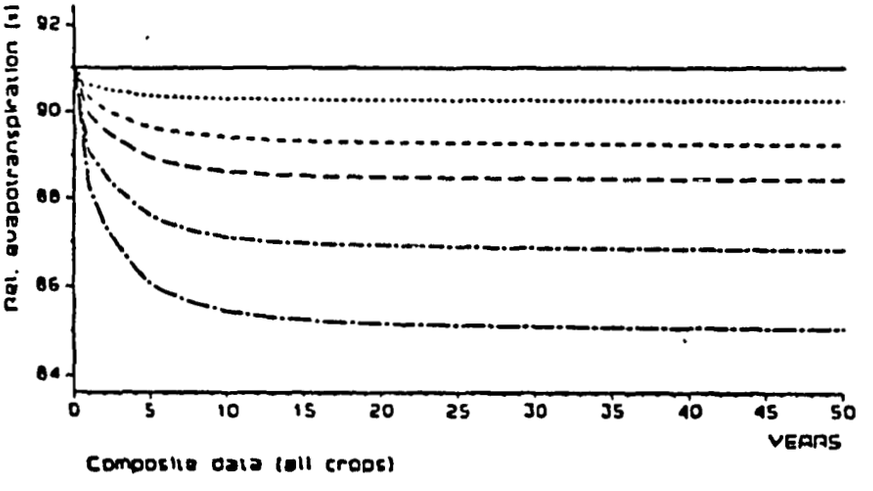

Source: MPWWR

27: RICE SOV, duty 8800, 510 000 feddan
53: RICE SOV, duty 8800, 468 000 feddan
54: RICE SOV, duty 8800, 375 000 feddan
55: RICE SOV, duty 8800, 309 000 feddan
28: RICE SOV, duty 8800, 210 000 feddan
71: RICE SOV, no rice

Figure 18. Long-term Effect (50 years) of Reducing the Rice Area on the Average Drainage Salinity, Soil Salinity, and Relative Evapotranspiration in Eastern Delta.

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The present state of municipal wastewater treatment facilities in Egypt is given in Tables 11 and 12 for Upper Egypt and the Delta area, respectively.

Most villages and rural areas lack any system of wastewater collection or treatment. Raw sewage from about 5,000 rural agglomerations, semi-treated or untreated wastewater from Cairo and other urban centers, and mostly raw sewage from the rapidly growing, unserviced, peri-urban areas are discharged into the agricultural drains.

Industrial Wastewater. Industrial wastes are considered a major source of environmental pollution for the water systems, because of their toxic chemicals, organic loading, dissolved oxygen, and nutrients.

An estimated 350 industrial plants discharge directly into the Nile or through municipal systems which discharge into the Nile, and 227 are identified as releasing hazardous and toxic materials.

It is reported that one mcm/dy of effluent, which discharges directly from all the industries located along the River Nile, canals, and drains, contains a high load of organic matter, oil and grease, heavy metals, and toxic chemicals (RNDP, 1991).

River Nile Research Institute (RNRI) has reported that 63 discharge points along the Nile are from industrial effluent, power stations, and domestic wastes, and 79 discharge points are mainly from agricultural drains (Table 13).

Salinity. Drainage water contains high salt concentrations as plants evapotranspirate irrigation water leaving its salt load behind. Thus, excess irrigation water leaches these salts, as well as some salts already in the soil formation, to the drainage system.

Pesticides and Herbicides. Pesticides and herbicides have been used recently on a large scale for crop protection, pest control, and weed control. The pesticide and herbicide residues pass through the soil into the drains via the irrigation water. About 620,000 tons of 200 different types of pesticide have been used in the Egyptian environment over the last 30 years (El-Assiouti et al., 1989). Table 14 presents the annual consumption of pesticides in Egypt between 1962 and 1982. It is worth mentioning that data and research in this field are limited.

In early 1991, use of herbicides to control aquatic weeds became an important media and political concern. Acrolein was used in canals to control submerged weeds, and ametryn to control water hyacinths in drains. Aquatic weeds are a major concern for efficient water management. In 1990, an estimated 13,000 km of canals and drains were infested by submerged aquatic weeds, and another 1,900 km were covered by water hyacinths. Because of the political and public concern, use of ametryn was cancelled for 1991. Also, acrolein will be used for only another two to three years, after which only manual, mechanical, and biological means will be used for weed control.

Existing wastewater treatment facilities

(Upper Egypt)

Table 11

Govern. Name	Discharge 1000m³/day	Point of Discharge	Type of Treatment	Load Kg/day				
				COD	BOD/5	SS.	P.	NH3-N
ASWAN	21	EL-SIL DRAIN	AERATED OXIDATION POND	5943	3570	8505	-	126
QENA	30	L R	TRICKLING FILTER	6000	3750	1590	-	1200
AL-OKSOR	30	L R	TRICKLING FILTER	5250	-	720	900	540
SOHAG	50	SOHAG DRAIN	TRICKLING FILTER	9000	4750	19850	300	1500
ASSIUT	60	L R	TRICKLING FILTER	-	-	-	-	-
EL-MENIA	20	EL-MOHEET EL-GARBY DRAIN	TRICKLING FILTER	4800	3000	8620	84	300
BENI SEWIF	40	MOHIE EL-DEEN DRAIN	TRICKLING FILTER	-	-	-	-	-
EL-FAYOUM	40	EL-BAST DRAIN	TRICKLING FILTER	7520	4960	-	-	-

Source: MPWWR

(Delta region)
Table 12

Govern. Name	Discharge 1000m³/day	Point of Discharge	Type of Treatment	Load Kg/day				
				COD	BOD/5	SS.	P.	NH3-N
EL-KALUBIYA								
BANHA	42	AGR. DRAIN	TRICKLING FILTER	7560	4620	25200	-	-
EL-SHARKIYA								
ZAGAZEEG	90	AGR. DRAIN	TRICKLING FILTER	36000	22500	44010	36	495
EL-DAQAHLIYA								
EL-MANSOURA	120	AGR. DRAIN TO EL-MANSOURIA	TRICKLING FILTER	The facility is not operating				
MIT MAZAH	1	AGR. DRAIN TO EL-MANSOURIA	AERATED OXIDATION POND	99	32	67	50	7.7
DEIETTA	60	AGR. DRAIN TO LAKE MANZALA	TRICKLING FILTER	-	-	-	-	-
KAFR EL-BATEK	2.7	KAFR EL-BATEK DRAIN	AERATED OXIDATION POND	257	84	162	-	NIL
EL-KAITA	1.4	LAKE MANZALA	AERATED OXIDATION POND	-	-	-	-	-
ADLIYA	0.4	ADLIYA DRAIN	AERATED OXIDATION POND	-	27	32	-	-
FARASKOR								
EL-RODA	1	FARASKOR DRAIN	Extended Aeration	-	-	-	-	-
EL-GONAIMIA	0.5	EL-GONAIMIA DRAIN	Extended Aeration	-	-	-	-	-
SHARBAWS	0.5	SHARBAWS DRAIN	Extended Aeration	-	-	-	-	-
KAFR EL-ARAB	0.5	KAFR EL-ARAB DRAIN	Extended Aeration	-	-	-	-	-
EL-BAISHHIA	0.6	EL-BAISHHIA DRAIN	AQUALIFE	-	13	8	-	-
EL-RAHMANIA	1.4	EL-RAHMANIA DRAIN	AERATED OXIDATION POND	-	-	-	-	-
AL-ZARKA								
EL-SERW	1.1	EL-SERW DRAIN	Extended Aeration	-	31	61	-	-
MIT EL-KOHLY	0.6	MIT EL-KOHLY DRAIN	Extended Aeration	-	19	19	-	-
DAKHLA	0.6	BAHAR ELGAT DRAIN	AERATED OXIDATION POND	-	21	17	-	-
KAFR SAAD								
KAFR SAAD	0.6	KAFR SAAD DRAIN	AQUALIFE	-	16	17	-	-
KOFOR EL-GAB	2.2	DRAIN NO 10	AQUALIFE	-	-	-	-	-
KAFR SELIMAN	1.3	EL-BORAY DRAIN	AERATED OXIDATION POND	-	42	34	-	-
MIT ABO GALEB	0.6	MIT ABO GALEB DRAIN	Extended Aeration	-	-	-	-	-
AL-WASTANY	0.6	AL-WSATANY DRAIN	Extended Aeration	-	-	-	-	-
RAS EL-BAR	50	DUMPED IN DEPRESSION		-	-	-	-	-

Existing wastewater treatment facilities

(Delta region)

Table 12(Cont'd)

Govern. Name	Discharge 1000m³/day	Point of Discharge	Type of Treatment	Load Kg/day				
				COD	BOD/5	SS.	P.	NH3-N
EL-MONOFIA								
SHBEN EL-KOM	40	AGR. DRAIN	TRICKLING FILTER	19600	14000	8080	-	1600
MENOF	24	MENOF DRAIN	ACTIVATED SLUDGE	960	480	1752	192	NIL
EL-KOM ELAKDA	0.7	EL-HERF DRAIN	AQUALIFE	-	91	92	-	-
SAHEL GWABER	0.7	EL-SHOHADA DRAIN	AQUALIFE	-	103	132	-	-
EL-GHARBIYA								
KAFR EL-ZIAT	90	GANAG DRAIN	TRICKLING FILTER	The facility is not operating				
SAMANOD	15	AGR. DRAIN	TRICKLING FILTER	The facility is not operating				
TANTA	60	????						
MAHLA KOBRA	60	AGR. DRAIN	TRICKLING FILTER	29400	16800	36660	480	2400
KAFR EL-SHAK	20	AGR DRAIN	TRICKLING FILTER	4600	3000	3920	50	500
EL-BEHARA								
DAMANHOR	110	DAMANHOR DRAIN	TRICKLING FILTER	The facility is not operating				
SHOBRAKEET	8	AGR. DRAIN RIVER NILE	TRICKLING FILTER	1120	760	1840	60	240

Source: MPWWR

Table (13) **List of Drains & Industrial Effluents**

Serial No.	Km From Aswan	Name	Description
1	6.000	Aswan SewerageDrain	Sewarage Drain
2	9.900	Khour El Sail Drain	Agricultural Excess Water R.B.
3	37.250	El Tawansa Drain	Agricultural Excess Water R.B.
4	42.500	El Sheikh Ibrahem Drain	Agricultural Excess Water R.B.
5	46.550	El Ghaba Drain	Agricultural Excess Water R.B.
6	47.150	Abu Wanas Drain	Agricultural Excess Water R.B.
	47.500	G.B.Drain *	Agricultural Excess Water R.B.
7	48.000	El Shatb Drain	Agricultural Over Flow From Canal R.B.
8	48.850	Main Draw Drain	Agricultural Excess Water R.B.
9	49.100	EL Berba Drain	Agricultural Excess Water R.B.
10	50.000	Kom Ombu Sugar Ind.	Industrial Effluent R.B.
11	51.000	Kom Ombu Drain *	Agricultural Excess Water R.B.
12	53.000	Benban Drain	Agricultural Excess Water L.B.
13	55.000	Meneha Drain *	Agricultural Excess Water R.B.
14	57.650	Main Ekleet Drain	Agricultural Excess Water R.B.
15	63.600	Ekleet Power Station	Power Station
16	64.650	Berak El Raghama Drain	Agricultural Excess Water R.B.
17	70.450	Fatera Drain	Agricultural Excess Water R.B.
18	70.750	Khour El Sail Drain	Mixed From Water & Ind. R.B.
19	73.850	Selesla Drain	Agricultural Excess Water R.B.
20	75.750	Kagouk Drain *	Agricultural Excess Water R.B.
21	76.000	Awarta Drain *	Agricultural Excess Water R.B.
22	99.850	Radisia Drain	Agricultural Excess Water R.B.
23	101.750	Hasia Drain *	Agricultural Excess Water L.B.
24	109.250	Hager Drain *	Agricultural Excess Water L.B.
25	116.200	Edfu Drain *	Agricultural Excess Water R.B.
26	119.600	Kalh Power Station	Power Station
27	122.450	Edfu Paper Pulp A.	Industrial Effluent L.B.
28	122.500	Edfu Paper Pulp B.	Industrial Effluent L.B.
29	123.000	Edfu Sugar Ind.	Industrial Effluent L.B.
30	135.600	El Mahameed Drain	Agricultural Excess Water R.B.
31	139.500	Houd El Sabaia	Agricultural Excess Water L.B.
32	143.100	Hagz El Bahary Drain	Agricultural Excess Water R.B.
33	147.000	Seba Phosphate drain	Industrial Effluent R.B.
34	149.100	Hagar El Sebia	Agricultural Excess Water L.B.
35	187.700	Mataana Drain *	Agricultural Excess Water L.B.
36	196.700	Ghoreara Drain	Agricultural Excess Water L.B.
37	204.500	Armant Sugar Ind.1	Industrial Effluent L.B.
38	204.505	Armant Sugar Ind.2	Industrial Effluent L.B.
39	204.510	Armant Sugar Ind.3	Industrial Effluent L.B.

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Cont.

List of Drains & Industrial Effluents

Serial No.	Km From Aswan	Name	Description
40	209.000	El Salamia Drain *	Agricultural Excess Water R.B.
41	220.800	El Mraibia Drain *	Agricult.Excess Water From Canal L.B.
42	220.850	El Rayayna Drain	Agricultural Excess Water L.B.
43	224.500	Outlet Louxor Water Treatment *	Industrial Effluent
44	236.000	El Zeinia Drain	Agricultural Excess Water R.B.
45	237.700	Habail El Sharky Drain	Agricultural Excess Water R.B.
46	245.100	El Shanhoria Drain	Agricult.Excess Water From Canal R.B.
	246.850	Ques Sugar Ind. *	Industrial Effluent R.B.
47	251.550	Danfik Drain	Agricultural Excess Water L.B.
48	265.300	Sheikhia(El Hagaza) Drain *	Agricultural Excess Water R.B.
49	265.400	Grinding Mill *	Industrial Effluent L.B.
50	270.700	El Ballas Drain	Agricultural Excess Water L.B.
51	275.900	Kaft (Qift) Drain	Agricultural Excess Water R.B.
52	286.750	El Tramasa Drain	Agricultural Excess Water L.B.
53	288.800	Khour El Sail Qena *	Mixed From Agr.& Ind. R.B.
54	299.750	Bahari Dandra Drain *	Agricult.Excess Water From Canal R.B.
55	314.000	Deshna Sugar Ind.	Industrial Effluent R.B.
56	331.200	Hamad Drain *	Agricultural Excess Water R.B.
57	333.500	Salamia Drain *	Agricultural Excess Water R.B.
58	337.500	Alumenium Ind. *	Industrial Effluent
59	340.350	Magrour Hoe Drain	Agricultural Excess Water L.B.
60	343.200	Naga Hammadi Sugar Ind.A.	Industrial Effluent L.B.
61	343.250	Naga Hammadi Sugar Ind.B.	Industrial Effluent L.B.
62	363.000	Abu Homar Power Station	Power Station
63	377.800	Naga Hamadi Drain	Agricultural Excess Water L.B.
64	384.000	Abu Shousha Drain *	Agricult.Excess Water From Canal L.B.
65	392.750	Mazata Drain	Agricultural Excess Water R.B.
66	432.700	Essawia Drain *	Agricult.Excess Water From Canal L.B.
67	443.200	Onion Ind.	Industrial Effluent L.B.
68	444.550	Souhag Drain	Agricultural Excess Water L.B.
69	445.600	Souhag Oil Ind	Industrial Effluent L.B.
70	445.605	Cocacola Ind	Industrial Effluent L.B.
71	454.700	Seflak Drain	Agricultural Excess Water R.B.
72	473.850	Ekheem Drain	Agricultural Excess Water R.B.
73	486.400	Raaina Drain *	Agricult.Excess Water From Canal R.B.
74	486.700	Tahta Drain	Agricultural Excess Water L.B.

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List of Drains & Industrial Effluents

Serial No.	Km From Aswan	Name	Description
75	520.800	Abu Teeg Drain	Agricultural Excess Water L.B.
76	525.400	El Badary Drain	Agricultural Excess Water R.B.
77	525.850	El Metmar Drain	Agricult.Excess Water From Canal R.B.
78	536.000	Assuit Power Station *	Power Station
	537.000	Assuit Water Treatment Plant *	Industrial Effluent
79	541.600	Selim Drain *	Agricultural Excess Water L.B.
80	544.250	Marawana Drain *	Agricultural Excess Water R.B.
81	550.200	El Zenar Drain	Agricultural Excess Water L.B.
82	552.200	Mankabad Pipe 1	Industrial Effluent L.B.
83	552.205	Mankabad Pipe 2	Industrial Effluent L.B.
84	552.210	Mankabad Pipe 3	Industrial Effluent L.B.
85	588.600	Bany Shaker Drain *	Agricultural Excess Water L.B.
86	637.400	El Rayamoun Drain	Agricultural Excess Water L.B.
37	642.750	Abu Henis Drain	Agricultural Excess Water R.B.
88	682.000	Minia Water Treatment Plant *	Industrial Effluent
89	682.500	Makoussa Drain	Agricultural Excess Water L.B.
90	701.100	Etsa Drain	Agricultural Excess Water L.B.
91	752.150	El Sheikh Zied Drain	Agricultural Excess Water L.B.
92	780.500	Ebsug Drain *	Agricultural Excess Water L.B.
93	807.000	Beni Suif Water Plant *	Industrial Effluent
94	807.200	Ahnasia Drain	Agricultural Excess Water L.B.
95	808.000	El Saayda Drain	Agricultural Excess Water L.B.
96	841.000	El Zawia Drain	Agricultural Excess Water L.B.
97	848.900	Khour El Sail Atfih Drain	Agricultural Excess Water R.B.
98	865.200	El Dessamy Drain *	Agricultural Excess Water R.B.
99	871.300	kafr Gazara (El Saaf) Drain	Agricultural Excess Water R.B.
100	879.600	El Masanda Drain	Agricultural Excess Water R.B.
101	884.500	Ghamaza El Soghra Drain	Agricultural Excess Water R.B.
102	888.950	Ghamaza El Kobra Drain	Agricultural Excess Water R.B.
103	898.100	El Tibeen Drain	Mixed From Agricultural & Ind.R.B.
104	901.000	Tibeen Power Station *	Power Station
105	904.000	Hawamdia Chemical 1 *	Industrial Effluent L.B.
106	904.080	Hawamdia Chemical 2 *	Industrial Effluent L.B.
107	904.300	Hawamdia Chemical 3 *	Industrial Effluent L.B.
108	904.350	Hawamdia Chemical 4 *	Industrial Effluent L.B.
109	909.200	Helwan Power Station *	Power Station
110	910.150	Khour Sail El Badrashin	Mixed From Agricultural & Ind.R.B.

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List of Drains & Industrial Effluents

Serial No.	Km From Aswan	Name	Description
111	911.400	Chemical Ind.	Industrial Effluent L.B.
112	911.900	Hawamdia Sugar Maulas	Industrial Effluent L.B.
113	912.100	Hawamdia Sugar Pipe 1	Industrial Effluent L.B.
114	912.105	Hawamdia Sugar Pipe 2	Industrial Effluent L.B.
115	912.115	Hawamdia Sugar Pipe 3	Industrial Effluent L.B.
116	912.120	Hawamdia Sugar Pipe 4	Industrial Effluent L.B.
117	912.125	Hawamdia Sugar Pipe 5	Industrial Effluent L.B.
118	912.130	Hawamdia Sugar Pipe 6	Industrial Effluent L.B.
119	912.900	Khour Sail El Masara Drain	Mixed From Agricultural & Ind.R.B.
120	916.550	Kotsica Starch&Glucose Dr.	Industrial Effluent R.B.
121	916.551	Kotsica Starch&Glucose Dr.	Industrial Effluent R.B.
122	939.600	El Nasr Glass tube 1	Industrial Effluent R.B.
123	939.605	El Nasr Glass tube 2	Industrial Effluent R.B.
124	939.610	El Nasr Glass tube 3	Industrial Effluent R.B.
125	939.615	El Nasr Glass tube 4	Industrial Effluent R.B.
126	939.620	El Nasr Glass tube 5	Industrial Effluent R.B.
127	946.250	Sakeel Power Station	Power Station
128	947.900	Delta Cotton at Kanater	Industrial Effluent
R1	962.850	El Rahawy Drain	Mixed From Agricultural & Ind.R.B.
R2	1024.400	Sabal Drain	Agricultural Excess Water R.B.
R3	1039.500	El Tahreer Drain	Agricultural Excess Water L.B.
R4	1053.700	Zaweit El Bahr Drain	Agricultural Excess Water L.B.
R5	1073.400	Tala Drain	Agricultural Excess Water R.B.
R6	1074.500	Pesticides Company	Industrial Effluent R.B.
R7	1074.505	El Malaya Company	Industrial Effluent R.B.
R8	1074.510	Salt&Soda Company	Industrial Effluent R.B.
D1	1098.000	Talkha 1 Fertilizers	Industrial Effluent L.B.
D2	1098.120	Talkha 2 Fertilizers	Industrial Effluent L.B.
D3	1124.500	Batra Drain	Agricultural Excess Water R.B.
D4	1125.200	High Serw1	Agricultural Excess Water L.B.
D5	1135.300	High Serw Power Station	Power Station R.B.
D6	1166.000	Faraskour	Industrial Effluent R.B.

Source: MPWWR

Table 14 : The Annual Consumption of Pesticides In Metric Tons In Egypt

YEAR	TOTAL AMOUNT OF PESTICIDES
1962	16,924
1963	20,483
1964	20,471
1965	25,082
1966	36,071
1967	24,201
1968	24,740
1969	24,455
1970	25,619
1971	24,652
1972	26,976
1973	28,691
1974	30,070
1975	27,429
1976	29,013
1977	27,152
1978	23,485
1979	22,552
1980	20,487
1981	18,629
1982	16,784

Source: MALR

Fertilizers. Inefficient use of nitrogen fertilizers results in nitrates being leached from the soil, thus contaminating surface water and groundwater. The increases in average concentrations of nitrogen compounds in drains was found to roughly correspond with the growth in application of nitrogen fertilizers.

Before the Aswan High Dam was constructed, 24 million tons/year of solids were deposited on the Egyptian flood plains. After the High Dam construction, this amount decreased to 2.1 million tons/year. The remainder settled in Lake Nasser. The loss of sediment N and soluble P is estimated to be 12,000 and 6,000 tons/year, respectively. This required a significant increase in fertilizers, which caused an increase in nutrient and phosphorous in soil, canals, and drains. Tables 15 and 16 present the amount of fertilizers introduced and imported to Egypt. Table 15 shows that the application of fertilizers in Egyptian agricultural lands increased nearly fourfold in the 1960-88 period.

Nitrate contamination of groundwater from agricultural activities has been a major environmental concern in many developed countries.

Water Weeds, Especially Water Hyacinth. These weeds grow in clear water as a side effect of the High Dam. The Weed Control Institute of MPWWR has planned a control program using herbicides to reduce the infestation by water weeds and hyacinth. Manual control also proved to be practical at some locations.

Solid Wastes (Refuse). Low quantities of refuse are discharged into the waterways along drains passing through villages and towns.

H2. Polluted Drains in the Delta and Fayoum

Almost all drains in Egypt receive domestic and industrial wastes. Table 17 lists the polluted drains in the Delta and Fayoum.

The MPWWR has conducted few studies for monitoring the water quality in the drainage systems. The DRI laboratory has done simple tests to check the pollution of the water and its degree such as biochemical oxygen demand, chemical oxygen demand, and some micro-biological examinations (El-Guindy, 1984). Traditionally, the Coliform group of bacteria has been the principal indicator of the sanitary quality of water. It is convenient to express the results of the examinations in terms of the most probable number (MPN). If MPN exceeds $10 * 10^3/100$ ml, this means that the water is polluted.

Table 15 : Amount of Fertilizers Introduced (1952-1987)
(1000 tons)

Year	1951/52	1960	1965/66	1970	1977/78	1980/81	1983/84	1987/88
Tot.	881	1372	2150	2452	3625	4545	5628	6193

Source: MALR

Table 16 : Amount of Fertilizers Imported (1977-1987)
(1000 tons)

Year	Uria	Amonium Nit. NH_4NO_3	Amonium Sulph. $(NH_4)_2SO_4$	K_3PO_4	Potas. Sulph. K_2SO_4
77/78	399.5	270.0	153.0	20.0	---
78/79	395.0	194.0	288.0	39.0	10.0
79/80	250.0	190.0	202.0	41.0	20.0
80/81	173.2	315.0	90.0	106.0	15.5
81/82	63.3	59.5	110.0	155.0	25.0
82/83	---	---	120.0	140.0	55.0
83/84	---	---	70.0	71.0	55.0
84/85	24.0	145.0	313.0	51.0	35.0
85/86	68.0	101.0	362.0	---	50.0
86/87	---	60.0	216.0	---	60.0

Source: MALR

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Table 17. Summary of Polluted Drains in the Delta and Fayoum

Governorate	Polluted Drain	Source of Pollution
1. Sharkia	Qalubia Drain	Sewage + Industry
	Belbeis Drain	Sewage + Industry
	Bahr Baqar Drain	Sewage
	Bahr Saft Drain	Sewage
	Bahr Faqus Drain	Sewage
2. East Dakahlia	Bahr Hadus Drain	Sewage + Industry
3. West Dakahlia	Upper No. 1 Drain	Fertilizer Industry
4. Kafr El-Sheikh	Gharbia Drain	Sewage + Oil and Textile Industries
5. Gharbia	Mahallet Ruh Drain	Oil and Textile Industries
6. Alexandria	Umoum Drain	Sewage
	Abu-Keer Drain	Sewage + Industry
7. Behaira	Etay El-Baroud Drain	Sewage
8. Fayoum	Batts Drain	Sewage

Table 18 shows sources and degrees of pollution in some polluted locations in the Delta. Iron, zinc, manganese, and copper elements are under the toxicity limits in all the measurement locations. Table 19 shows the measurement locations which have higher boron concentrations than the toxicity limits for plants (limit < 2 ppm).

Table 20 presents water quality measurements carried out by NRI at the outfalls of the major drains and industries along the River Nile in Upper Egypt.

H3. Identified Polluted Areas

Monitoring programs and research carried out by different organizations identify the following drainage areas as the most polluted:

H3a. Lake Mariut, Alexandria. The lake receives agricultural drainage and domestic and industrial wastes from the following drains:

- Omoum (agricultural drainage, industrial and domestic wastes)
- Kalaa (agricultural drainage, domestic wastes)

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Table 18 : Results of some pollution examinations

LOCATION	CODE No.	SOURCE OF POLLUTION	NH_4 mg/l	NO_3 mg/l	BOD mg/l	COD mg/l	No. Coliform Bacteria/100 ml
Eastern Delta:							
Belbis drain	E.B.1	Sewage + Industry	3.9	45.0	-	-	-
Wdi P.S.	E.B.3	Sewage	3.9	49.0	50	336	11×10^6
Bahr Bagar		Sewage	3.7	46.5	160	952	24×10^6
Miaza P.S.	E.H.5		2.6	31.0	100	660	24×10^6
Middle Delta:							
Segaaia P.S.	M.G.2	Textil Indu. + Sewage	1.2	13.0	50	336	24×10^5
Senatay P.S.	M.G.4	,,	3.0	30.0	-	-	-
P.S. No. 5	M.G.5	,,	2.7	29.0	-	-	-
Hamul in P.S.	M.G.8	,,	1.2	11.8	-	-	-
Bridge drain 1	M.1.2	Fertilizer Industry	1.2	13.0	-	-	-
Western Delta:							
Etay Baroud P.S.	W.E.1	Sewage influent	-	-	85	542	24×10^6
Khandaq P.S.	W.E.6	,,	-	-	70	282	43×10^5
Khairy P.S.	W.E.7	,,	1.6	22.0	-	-	-
Tabia P.S.	W.T.1	Sewage + Industry	2.6	32.0	30	56	21×10^3
Dushudi P.S.	W.U.5	Sewage	1.2	11.8	40	56	15×10^3
Max P.S.	W.U.7	Oil industry	2.8	28.0	80	306	23×10^6
Qalaa P.S.	W.U.8	Sewage	-	-	-	-	-

Source: DRI

Table 19 : Locations With High Concentrations of Boron

Eastern Delta		Middle delta		Western Delta	
Location	Code	Location	Code	Location	Code
Belbis Drain	E.B.1	Drain 2	M.1.4	Khairy P. S.	W.E.7
Bahr Bagar	E.B.11	Drain 3	M.G.10	Idko P. S.	W.E.10
		Drain 4	M.G.9	Sherishara P. S.	W.U.2
		Gharbia outfall	M.G.13	Dushudi P. S.	W.U.5
		Hafir S. El-Din	M.G.12	Max P. S.	W.U.9

Source: DRI

Table 20 : Water Quality Measurements at the Outfalls of Major drains and industries along the River Nile in the Upper Egypt.

	Name of Point Sources of Pollution	Location From Aswan K m	Discharg mm3/day	TDS mg/l	TDS Ton/day	PO4-P mg/l	PO4-P Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
1	Khour El Sail Drain (Aswan)	009 900	0 0657	501	32 9157	0 252	0 0166	59 000	3 8763	6 000	0.3942	84.00	5.5188
2	El Twansa Drain.	037 250	0 0192	1174	77.1318	0 017	0 0011	0 030	0 00197	0 023	0.0015	5.00	0.3285
3	El Ghaba Drain.	046 550	0 2864	667	43 8219	0 023	0 0015	0 010	0 00065	0 030	0.0020	34.00	2.2338
4	Main Draw Drain.	048 850	0.0936	504	33.1128	0 252	0 0166	0 010	0 00065	0.040	0.0026	14.00	0.9198
5	Komombu Sugar Ind.	050 000	0 0422	628	41.2596	0 130	0 0085	0 610	0 04007	0 350	0 0230	9 00	0.5913
6	Fatera Drain.	070 450	1.0439	567	37.2519	0 097	0 0064	0 300	0.01971	0.065	0.0043	28.00	1.8396
7	Khour El Sail Drain (Komombu)	070 750	0.3099	477	31 3389	0 037	0 0024	0.030	0 00197	0.055	0.0036	12.00	0.7884
8	Edfu Drain.	116 200	0 2459	269	17.6733		0 0000	0.100	0.00657	0.067	0.0044	26.00	1.7082
9	Edfu Paper Pulp A.	122 500		580		0.154		0.100		1.100		2.20	
10	Edfu Sugar Ind.	123 000	0 0002	123	8 0811	0 161	0.0106	0.010	0.00065	0.010	0.0007	0.80	0.05256
11	El Mahameed Drain.	135 600		>1980		0 073		0.170		1.300		21.00	
12	Matasna Drain	187 700	0 3175	600	39 42	0 200	0 0131	0.850	0 05584	0.260	0.0171	5.80	0.38106
13	Armant Sugar Ind 1	204 500	0 0004	166	10 9062	0 008	0.0005	1.100	0.07227	0.150	0.0099	1.85	0.12154
14	Armant Sugar ind 2	204 505	0 0002	138	9 0666	0 009	0 0006	1.200	0.07884	0.120	0.0079	1.60	0.10512
15	Armant Sugar ind 3	204 510	0 0002	160	10.512	0 016	0.0011	1.000	0.0657	0.180	0.0118	1.50	0.09855
16	Oues Sugar Ind.	246 850		167		0 042		1.300		0.200		1.80	
17	Khour El sail Qena Drain	288 800		196		0.029		0.650		<0.01		2.00	
18	Deshna Sugar	314 000		189		0.042		<0.01		0.250		1.20	
19	Naga Hammadi Drain.	377.800	0 7620	332	21.8124	0.049	0.0032	0.020	0.00131	0.150	0.0099	8.00	0.5256
20	Souhag Drain.	444 550	0 6940	377	24.7689	0.148	0.0097	0.013	0.00085	0.600	0.0394	2.20	0.14454
21	Souhag Oil Ind.	445.600	0 0002	895	58.8015	0.025	0.0016	0.01	0.00065	0.500	0.0329	4.00	0.2628
22	EL Badary Drain.	525 400	0.6321	301	19.7757	0.088	0.0058	0.017	0.00111	0.560	0.0368	4.20	0.27594
23	ManKabad Pipe 1.	552.200	0.0002	244	16.0308	0.396	0.0260	0.030	0.00197	0.720	0.0473	0.90	0.05913
24	Etsa Drain.	701.100	0.8837	290	19.053	0.332	0.0218	0.020	0.00131	0.086	0.0057	4.00	0.2628
25	Ahnasia Drain.	807.200	0.8380	564	37.0548	0.400	0.0263	0.800	0.05256	0.088	0.0058	6.20	0.40734
26	EL Zawia Drain.	841.000	0.1160	927	60.9039	0.086	0.0057	0.300	0.01971	0.118	0.0078	22.00	1.4454
27	EL Dessamy Drain.	865.200	0.0272	201	13.2057	0.052	0.0034	0.015	0.00098	0.018	0.0012	2.00	0.1314
28	EL Tebeen Drain	898.100	0.1590	750	49.275	0.444	0.0292	0.100	0.00657	0.180	0.0118	15.00	0.9855
29	EL Hawamdia Chemicals Ind.1	904.040		483		0.123		0.180		0.020		1.50	
30	Chemical Ind	911.400		5724		0.218		1.800		0.500		35.00	
31	Hawamdia Sugar Maulas	911.900		335		4.400		0.018		1.000		2.30	
32	Khour Sail El Maasara	912.900	0.0130	921	60.5097	1.160	0.0762	0.020	0.00131	0.010	0.0007	30.00	1.971
33	kotsica Starch & Glucose Ind.	916.550		208		0.062		0.030		0.010		2.60	
34	kotsica Starch & Glucose Ind.	916.555		438		2.620		1.000		0.012		2.50	
35	kotsica Starch & Glucose Ind.	916.560		399		2.380		0.950		0.022		3.20	
36	EL Nasr Glass 1.	939.600		233		0.098		0.350		0.018		8.00	
37	EL Nasr Glass 5.	939.605		310		0.099		0.600		0.015		7.00	
38	EL Rahawy Drain (Rosetta Br.	962 850	2.4580		0	1.250	0.0848	2.000	0.1314	0.038	0.0025	6.00	0.3942

Source: River Nile Research Institute

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- Drain of collective factories (industrial wastes)
- Gheit El-Enab (agricultural drainage)
- Kabbari (agricultural drainage, industrial wastes)

A Drainage Research Institute (DRI) survey of the areas surrounding the lake found the following:

- Seventeen factories discharge directly to the lake through pipelines.
- Four factories collect their wastewater in trenches which are desludged by tractors to the lake.
- Nineteen factories lie in the vicinity of the collecting point of the treatment plant.
- Ten factories discharge to El-Kabbary Drain which goes into the lake.
- Five factories discharge to Smouhe Drain and then to the lake.
- Seven factories discharge to Gheit El-Enab Drain and then to the lake.

The Egyptian Environmental Affairs Agency (EEAA) has reported high concentrations of pollutants that directly affect the fisheries. The measured parameters revealed the following:

• BOD	2000 mg/l
• Oil and grease	2000 mg/l
• Hg	30-90 mg/l
• Cr	50-200 mg/l

The DRI is carrying out a program to monitor effluent quality and a study to improve the quality of flow reaching the El-Max Pump Station.

H3b. Lake Manzala. Sources of pollution:

- Sewage drainage from El-Gabel Asfar sewer in "East Cairo"
- Agricultural drainage and sewage wastes via Bahr El-Baqar Drain
- Sewage drainage from Port Said and Damietta
- Industrial wastes
- Closing of different openings of the lake to the sea and the Suez Canal

The EEAA and Suez Canal University are developing an action plan to rehabilitate Lake Manzala and develop its fisheries.

H3c. Bahr El-Baqar Drain. The drain originates at the confluence of two drains, Bilbeis and Qalyubia (Figure 19). Both drains receive extensive industrial wastes from Shubra El-Kheima and domestic sewage water from Greater Cairo. The two drains discharge approximately equal quantities of drainage water annually, but the main quantity of Qalyubia Drain is pumped by Wadi P.S. (reused station). It is worth mentioning that this station has not operated since November 1991 because of several reported kidney failures in the neighborhood.

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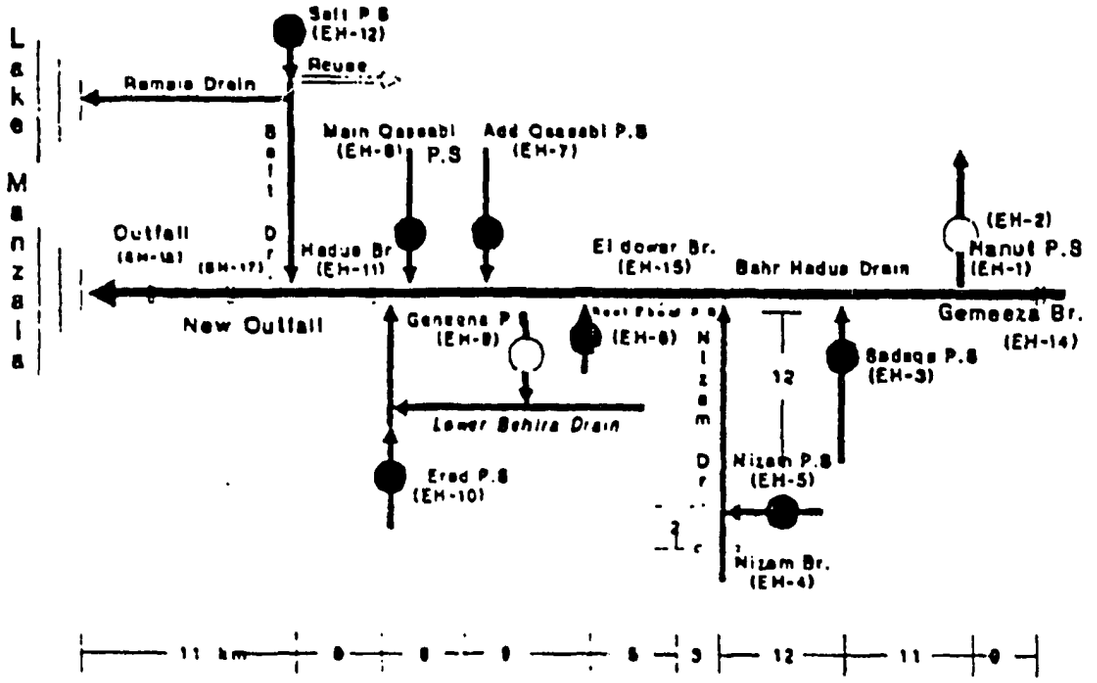
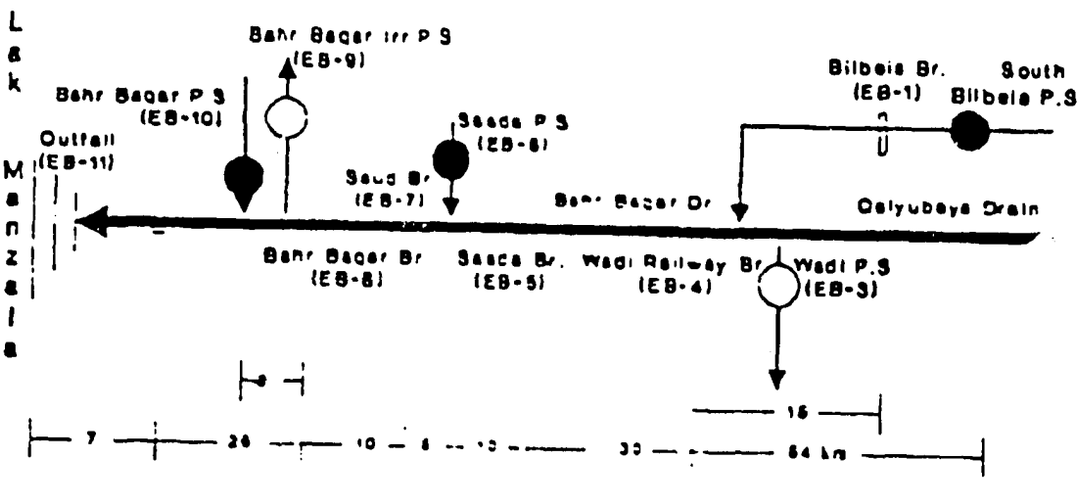


Schematic Diagram of Bahr Hadus Drain



Schematic Diagram of Bahr Baqar Drain

Figure 19. Schematic Diagrams of Bahr Madus and Bahr Baqar Drains

Bahr El-Baqar Drain discharges about 1 bcm of drainage water with a salinity of about 2,400 ppm to Lake Manzala. This water is very polluted and unsuitable for reuse.

H3d. Mohit Drain (West of Cairo). The drain receives wastewater from Zenein and Abu-Rawash plants, together with agricultural drainage.

H3e. Gharbia Drain. The Gharbia Drain system consists of 10 pumping stations, three of which lift water to irrigation canals (Figure 19). Both official and unofficial reuse intakes are found along the main part of the drain. All the generated drainage water is either reused by Hamul P.S. or unofficially by the farmers. Domestic wastewaters from villages and towns along the drain are deposited into the drain. It also receives extensive amounts of industrial waste from oil and textile factories.

I. Impact of Drainage System on Health

The drainage system has an adverse effect on the health environment of the Egyptian farmers due to the chemical and biological pollution of their water.

I1. Impact of Biological Pollution of the Drainage System

The biological pollution of drainage water has affected the health environment in rural Egypt, causing water-related diseases that can be classified into three categories:

- Water-borne (diarrhea, dysentery)
- Water-hygiene (typhus, eye and skin diseases)
- Water-habitat (bilharzia)

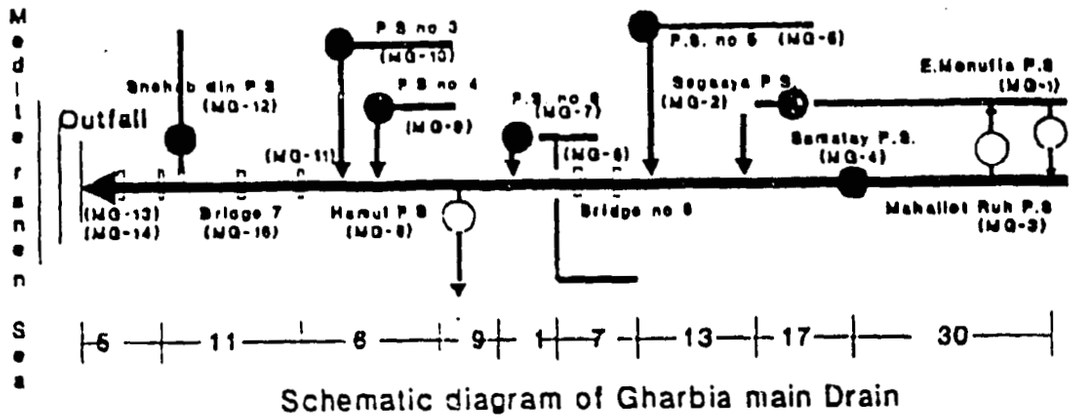
I2. Impact of Agriculture-Related Chemical Pollution

Pesticides. Pesticides have a negative impact on food chain organisms. A large variety of chemicals has been used, such as DDT, aldrin, and dieldrin.

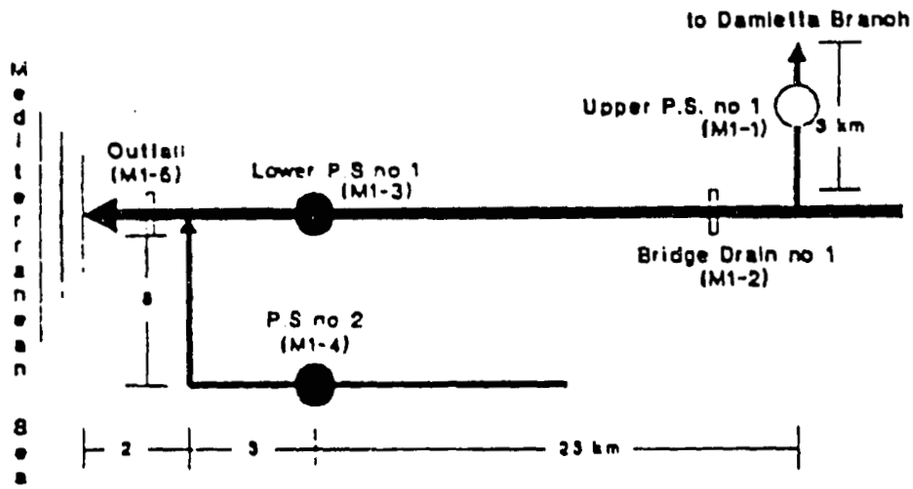
Despite the ever-growing use of agricultural chemicals for plant protection, crop losses have increased over the last decade. Soil fertility has reportedly deteriorated due to the use of pesticides.

The toxicity of some drain water exceeds the toxicity limits for plants (2 ppm). Table 19 summarizes some locations in the Delta with higher concentrations of Boron.

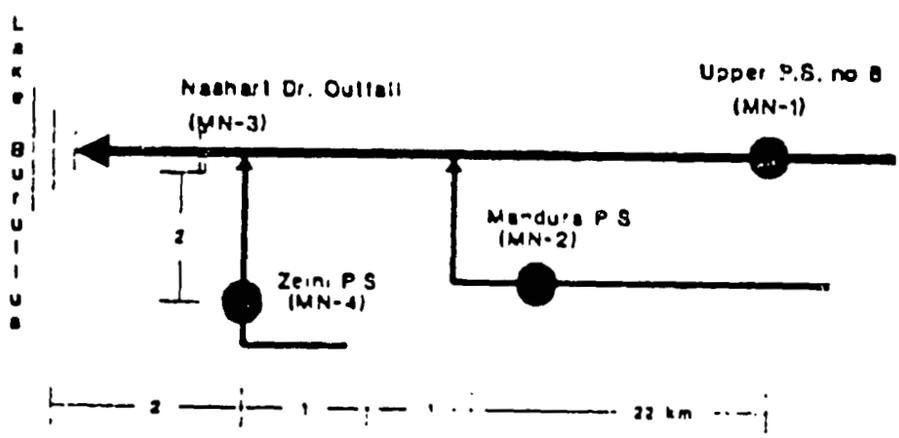
Fertilizers. Fertilizers negatively affect soil, drain water, and groundwater. Inefficient use of nitrogen fertilizers results in losses of nitrate that leaches out from the soil, contaminating surface water and groundwater. The increase in the average concentrations of nitrogen compound in drains corresponds roughly to increased application rates of nitrogen fertilizers.



Schematic diagram of Gharbia main Drain

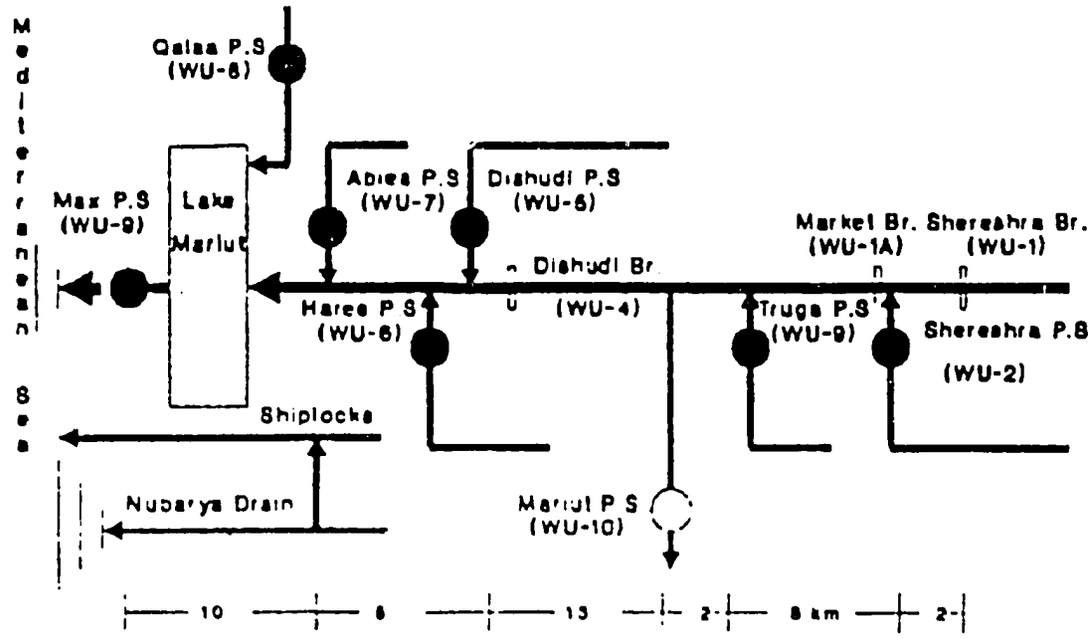


Schematic Diagram Of Drain No. 1

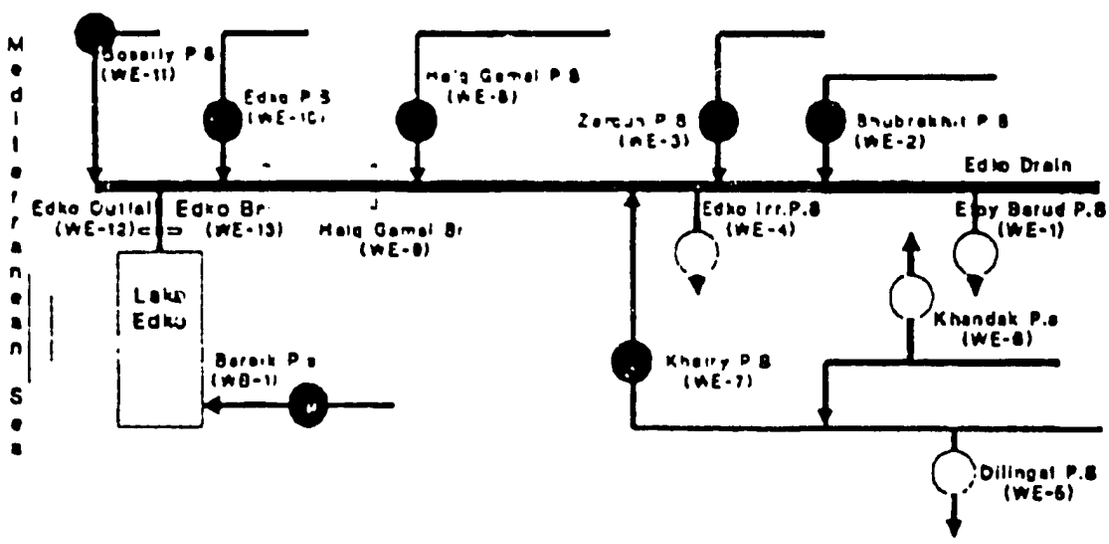


Schematic Digram of Nashart Drain

Figure 20. Schematic Diagram of Gharbia and Nashart Drains



Schematic Diagram of Umun Drain



Schematic Diagram of Edko Drain

Figure 21. Schematic Diagram of Umun and Edko Drains

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J. Conclusions and Recommendations

J1. Existing Problems of Drainage Water Pollution

In the past, the quantity of water available received more attention than the quality, because quality had not been a constraint. With increases in population; industrialization; use of fertilizers, pesticides, and other agricultural chemicals; in addition to domestic water discharges and awareness of the importance of water quality and its effects on public health, research on water quality has become a major concern. Monitoring is the first step in water quality assessment and pollution control.

At present, pollution in the drains and the Northern Delta Lakes (Lake Mariut and Lake Manzala) is very serious and worsening each year. While the salinity of drainage water is reasonably clear, usable information on other water quality parameters is very limited. Temporal changes in drainage water quality are nonexistent. The pollution problem in the drains affects the natural habitat of the environment and threatens human health.

Reuse of drainage water, either officially or unofficially, is a common practice and is very important to the country. Currently, 3.4×10^9 cm/yr of drainage water in the Nile Delta is mixed with fresh-water in the canals, and MPWWR plans to mix 7×10^9 m^3 by the year 2000. To date, the only water quality parameter used in designing drainage water reuse projects has been the salinity; however, other water quality parameters and environmental concerns must be considered.

J2. Gaps of Information

Many organizations and authorities in Egypt deal with the environmental measures and impacts, but they lack the master plan to monitor and coordinate activities. Policies of the different sectors have to be directed toward the main goal of achieving clean water, which would help maintain a clear environment and minimize health hazards.

The existing monitoring network provides a clear picture of the salinity levels in Delta drainage water but virtually nothing is known about the presence of toxic and hazardous pollutants.

J3. Strategies for Drainage Water Protection

J3a. Monitoring Programs

- Drainage water quality should be adequately monitored and provided with human and financial resources. Monitoring should put much emphasis on pertinent water quality parameters. Sampling sites, techniques, frequency, and facilities of analysis should be thoroughly studied. The monitoring should be expanded to cover Upper and Middle Egypt drains.

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- Since the agricultural chemicals (fertilizers, pesticides, herbicides, etc.) threaten the environment, their use in terms of types, rates, and loads should be reviewed from an environmental point of view.

- All discharge points from municipalities and industries should be carefully examined. Treatment before discharging to drains should be provided. A careful program to monitor these outfalls is extremely important.

- The practice of drainage water reuse should be carefully reviewed and all water quality parameters should be considered.

- The need to monitor soil variables and other ecosystem components before drainage construction and over the long term cannot be over emphasized. The information generated by this process will ensure that environmental issues are corrected before large-scale damage occurs.

- Establishment of a computerized environmental data bank for information about water resources and their quality is needed. Coordination among all concerned authorities is extremely important.

J3b. Training Programs

- Educational programs for farmers on public health, personal hygiene, and sanitation are suggested to reduce the health risk from contact with contaminated water.

- Training of personnel in charge of sampling and analysis is required.

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ANNEX C

GROUNDWATER QUALITY HYDROLOGIC BALANCE

by

Fatma Abdel Rahman Attia

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ANNEX C
GROUNDWATER QUALITY HYDROLOGIC BALANCE

A. Introduction

The available water resources in Egypt includes the country's share from the River Nile, and the reused subsurface drainage surplus that includes groundwater and drainage water. The quantity of water available from each source is well defined for the present and future. The quality is the main constraint affecting the available water.

The main body responsible for Egypt's water is the Ministry of Public Works and Water Resources (MPWWR). The MPWWR needs highly specialized technical assistance to perform an environmental water impact assessment (Phase I) and to assist in the development of a water management action plan for environmentally sound water use and development (Phase II). For this reason a project has been initiated consisting of the two phases. Phase I results will be applied in the development of Phase II.

This annex covers groundwater quality, an activity of Phase I. Groundwater quality depends on the initial and boundary conditions of the system, sources of recharge and discharge, and surface activities.

The Nile alluvium is in direct hydraulic contact with the River Nile. It is replenished essentially from the excess irrigation water (subsurface drainage) and seepage from the irrigation distribution system. The main sources of discharge from the alluvium are the seepage to the river (1.91 mcm/yr) and groundwater abstraction for various purposes (2.66 mcm/yr). Accordingly, the groundwater quality depends largely on the quality of the subsurface drainage water.

There is no specific quality monitoring network in the flood plain. The regular quality monitoring is carried out with the help of the groundwater heads monitoring network. In general, groundwater quality analyses are carried out for the main ions; while biological analyses are carried out at only selected sites.

The Research Institute for Groundwater has recently started a quality monitoring program to define the type and extent of groundwater pollution from the various sectors. The program includes sites that are affected by agricultural and domestic sewage. Industrial pollution was included in a regional survey carried out in the Delta region.

Results of these investigations indicated that the main source of groundwater pollution is agriculture (mainly nitrogen), since most of the flood plain floor is occupied by agriculture; iron and manganese are of secondary importance.

Groundwater pollution from nitrogen can be controlled mainly through its source, fertilizer. A fertilizer surplus should be avoided to prevent the excess nitrogen from seeping down to the aquifer. It is thus necessary to formulate guidelines and restrictions for fertilizer use and to include them in the fertilizer extension programs for the farmers. On the other hand, wherever nitrate pollution exists, groundwater abstractions for drinking water purposes should be carried out from the deeper layers of the aquifer. Groundwater use for irrigation in the areas where nitrate is highly concentrated should be allocated to less sensitive crops (for nitrogen).

To prevent additional pollution of groundwater, the groundwater quality should be monitored. This dictates the initiation of a reference quality monitoring network in the flood plain and the reclaimed areas. With the help of this network, monitoring should be conducted periodically. Moreover, the survey should follow a proper sampling method. Field and laboratory analyses should include thorough checks for the analysis method. Monitoring of nitrogen pollution should be emphasized. The path of nitrogen through the soil should be monitored to detect the specific behavior of the different kinds of nitrogen which are considered to be sources of pollution (organic nitrogen, ammonium, nitrite and nitrate). To quantify the process involved, pilot studies should be implemented to assess the mass balance of nitrogen. They should include the effect of fertilizer applications on the composition of the top clay silt formation and the vertical travel velocity of nitrate/ ammonium to obtain reliable information for development of policy guidelines.

B. Description of The Groundwater System

B1. Geology

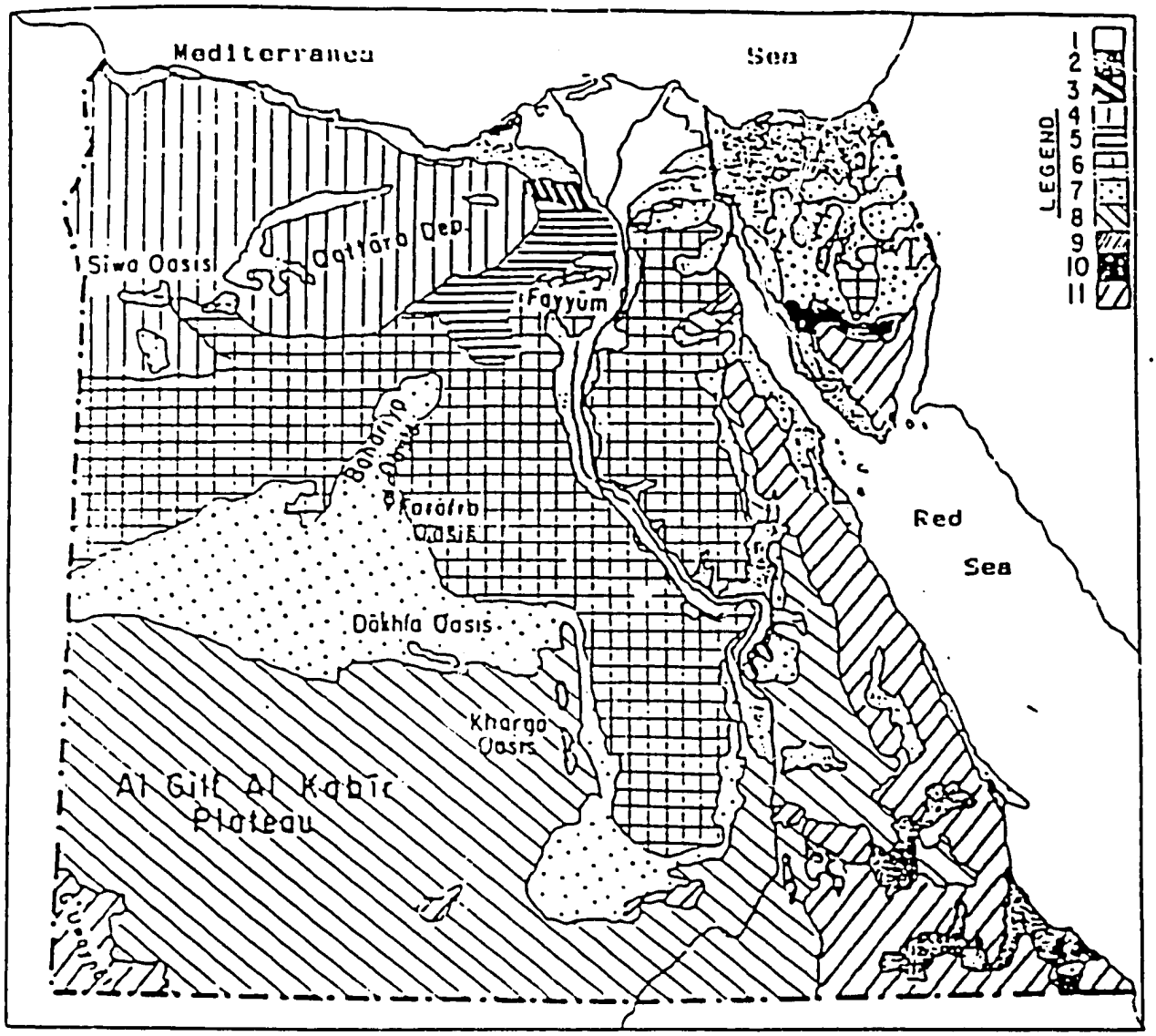
Figure 1 is a simplified geological map of Egypt in which the following formations can be distinguished:

- The Nile alluvium is composed of valley fill deposits of Pliocene, Pleistocene, and Holocene age, in contact with older formations.

- Between Esna and Cairo, the Valley is bordered with Tertiary deposits of the Eocene period. These deposits are generally composed of limestone and shales, with some sandstone and gravel in the upper part of the sequence.

- In the Kom Ombo plain, the Valley is bordered with limestone; giving way to Nubian sandstone south of Kom Ombo. The Nubian sandstone extends to underlay the valley deposits between Idfu and Aswan.

- The Nile Delta occupies a tectonic depression formed during the Pliocene and Pleistocene periods. Near Cairo it is bounded on the southwest by Eocene and Oligocene plain deposits and on the southeast side, by Eocene limestone covered with Oligocene sand and gravel.



Legend

1. Nile Alluvium
2. Pleistocene &Holocene
3. Pliecene
4. Miocene
5. Oligocene
6. Eocene
7. Cretaceous
8. Nubian Sandstone
9. Jurassic
10. Carboniferous
11. Pre-Cambrian & Paleozoic

Figure 1. Simplified Geological Map of Egypt

- In the region between Cairo and Suez, the geology is complex in structure, consisting of Oligocene, Miocene, and Eocene formations.

- To the west and northwest are plains of gravel and pebbles of Oligocene, Pliocene, and Pleistocene origin.

- To the north, plains of gravel and sand of Plio-Pleistocene origin dominate.

B2. Lithology

The Nile alluvium, which constitutes the main aquifer in the Nile flood plain consists of graded sand and gravel overlain by a clay-silt formation over most of the area. The aquifer system is generally in contact with older formations either of limestone or sandstone. These formations constitute the lateral boundaries of the aquifer. From the bottom, the aquifer system is generally bounded by clay sediments. Figure 2 and 3 are typical lithological cross sections in the Valley and Delta, respectively.

In the Nile Valley, the width of the alluvium varies from 2 km at Aswan and increases northward reaching its maximum width at Minia (about 20 km). Its average width all over the Valley is about 10 km. The thickness of the graded sand and gravel member constituting the water bearing formation ranges from 20 to 300 m; while the thickness of the overlying clay-silt member varies from zero (near the fringes where the aquifer is phreatic) to a maximum of 20 m (in the central part of the valley). The River Nile runs more or less close to the eastern boundary, cutting into the top clay-silt formation down to the aquifer.

In the Delta, the thickness of the graded sand and gravel ranges from 150 to 900 m (maximum thickness is in the north and minimum toward the edges). The thickness of the clay-silt deposits ranges from 5 to 25 m in the south, and exceeds 60 m in the north. In the Delta, starting at the Delta barrage, the River Nile branches into two main branches, the Damietta and the Rashid, which end at the Mediterranean Sea.

B3. Hydrogeology

B3a. Boundary Conditions

In about 70 percent of the Valley, the aquifer is overlain with a clay-silt semi-confining layer. In the remaining area (near the fringes) the aquifer is unconfined. The aquifer bed is made up of thick deposits of Pliocene clays which are almost impervious. The lateral boundaries are generally of fissured limestone, which may be considered impervious. Due to the significant decrease in aquifer thickness and extent at Aswan and Cairo, the northern and southern boundaries have little effect on the groundwater flow.

The Nile Delta aquifer is semi-confined in the middle, changing gradually to unconfined conditions in the east and west. The western boundary of the aquifer (West Beheira) is at present considered a recharge boundary due to desert reclamation with surface

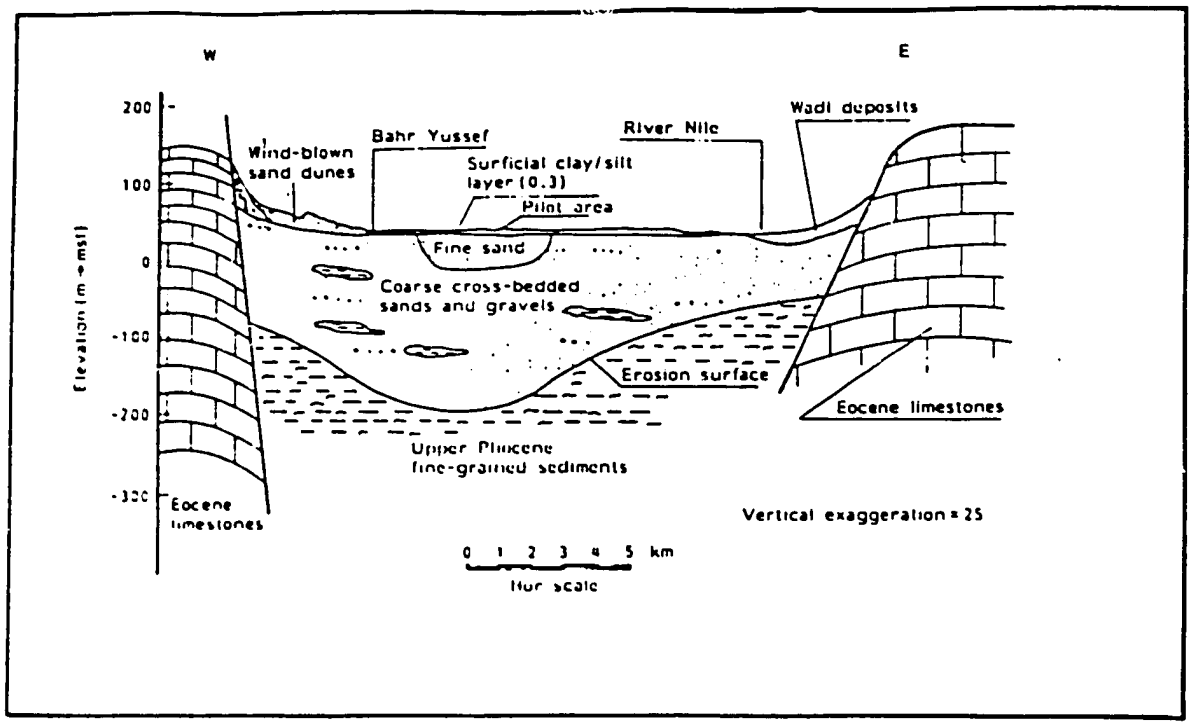


Figure 2. A Typical Lithological Cross Section in the Valley

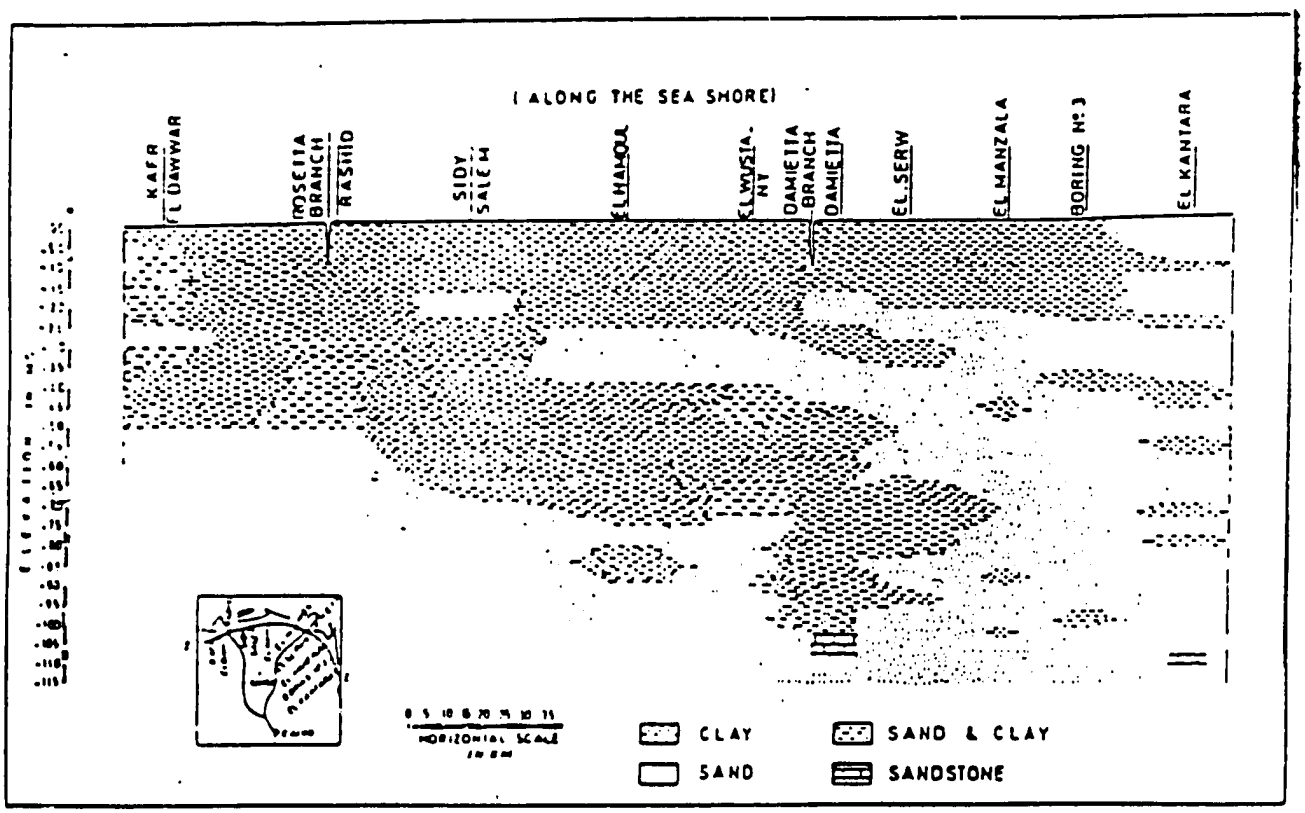


Figure 3. A Typical Lithological Cross Section in the Delta

water. Wadi El Natrun depression is considered a discharge area due to its low topography. Toward the northeast, the Suez Canal forms a discharge boundary. Along the coast, the fresh/saline water interface forms another discharge boundary.

B3b. Hydraulic Characteristics

The key parameters are the transmissivity and storativity of the aquifer; and the vertical hydraulic resistance and storativity of the top clay-silt layer (for the semi-confined part of the aquifer). The aquifer transmissivity in the Nile Valley ranges between 5,000 and 25,000 cm/dy, varying between 10,000 and 50,000 cm/dy in the Delta. Aquifer storativity varies greatly according to the type of aquifer (.1 for unconfined conditions and about .001 for semi-confined conditions). The hydraulic resistance of the top silt-clay layer to vertical flow varies considerably from one location to another. Its average value for the Valley is about 800 days, but it rises to about 1,500 days in the southern part of the Delta.

B3c. Recharge-Discharge

The groundwater in the alluvial aquifer is generally recharged from the irrigation application water and partly from the seepage from the distribution system. Recharge from rainfall is generally neglected, except for the recharging of the northern sand dunes along the coast. On the other hand, the main discharge components are through groundwater flow to the Nile (main), groundwater abstraction, and upward flow to the clay-silt (North Delta). Figure 4 shows the areas of upward and downward leakage in the Delta.

B3d. Fresh/Salt Water

In the northern part of the Delta the characteristics of flow in the aquifer system are distinctly different from those prevailing in the Nile Valley and southern part of the Delta. The difference is caused by a saline water zone underlying the fresh-water zone. Figure 5 shows the estimated thickness of the fresh-water zone in the Delta.

B4. Piezometry

Aquifer piezometry and water table elevation are strongly controlled by the ground surface elevations. The natural drainage capacity of the aquifer is certainly not sufficient to absorb the deep percolation from applied irrigation. A situation is then reached where the surplus deep percolation is discharged from the system through upward capillary flux or flow to the shallow drainage system. The only area where natural drainage is sufficient and where consequently water levels are not controlled by ground surface are located along the river course and its tributaries.

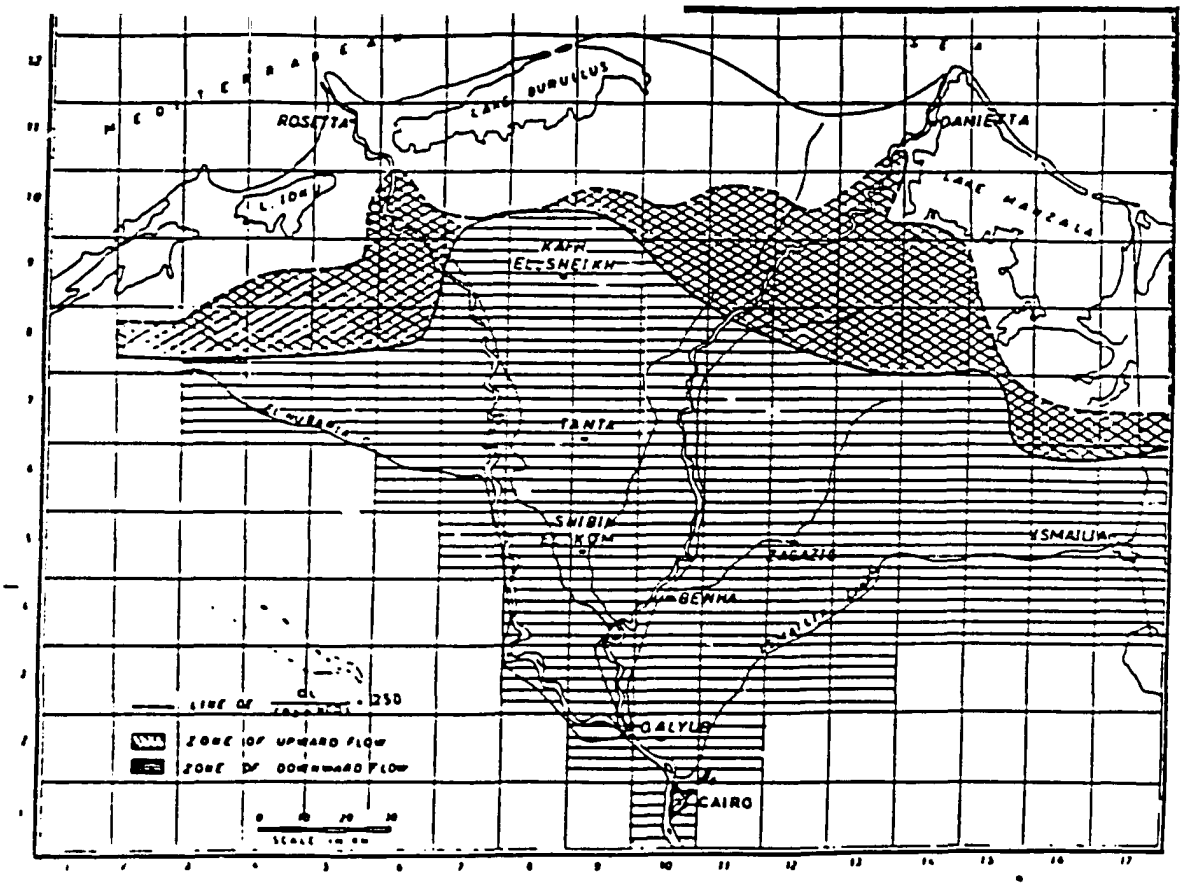


Figure 4. Areas of Upward and Downward Leakage in the Delta

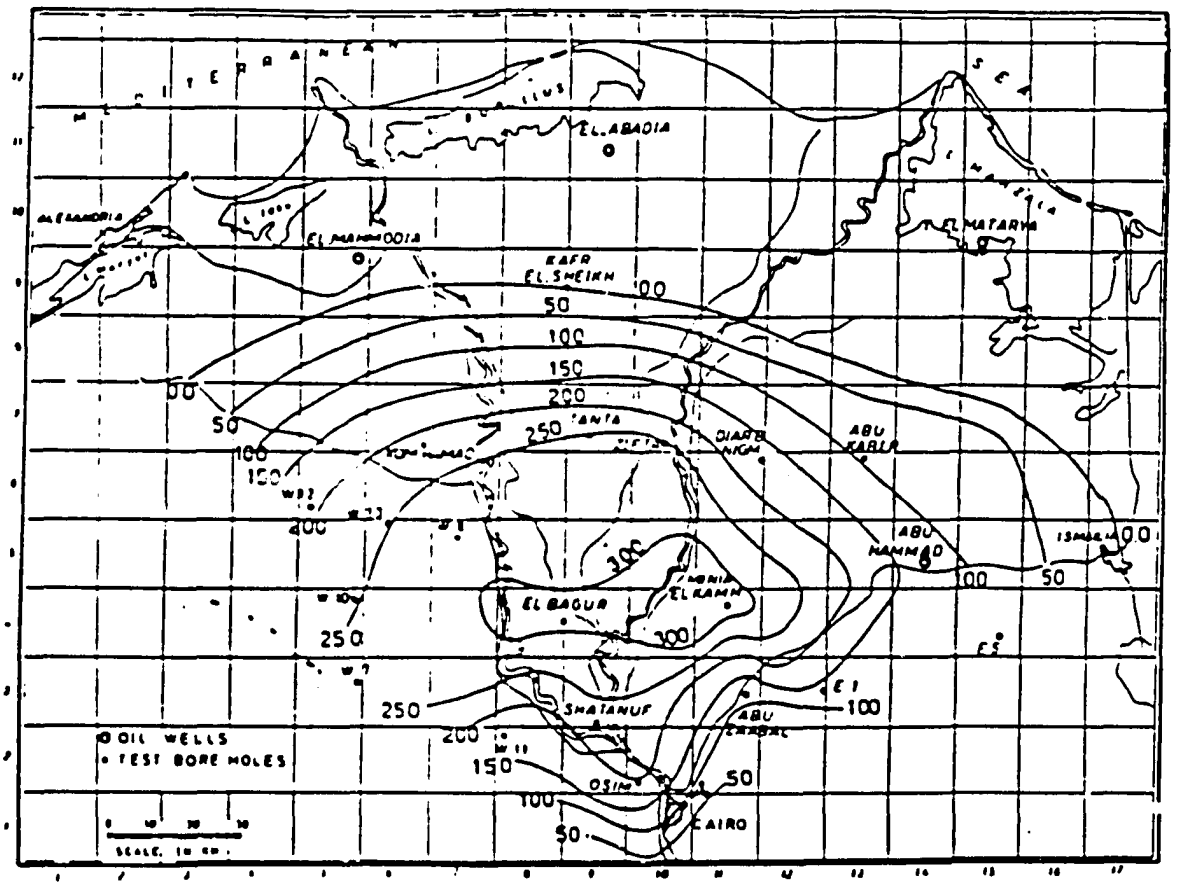


Figure 5. Thickness of the Fresh Water in the Delta

Figures 6 and 7 show the hydrographs of the groundwater, water table and Nile stages at some locations in the Nile Valley.

Groundwater Flow. The main direction of groundwater flow is in the longitudinal direction (south-north), and toward the river in the area close to the river course (see Figure 8).

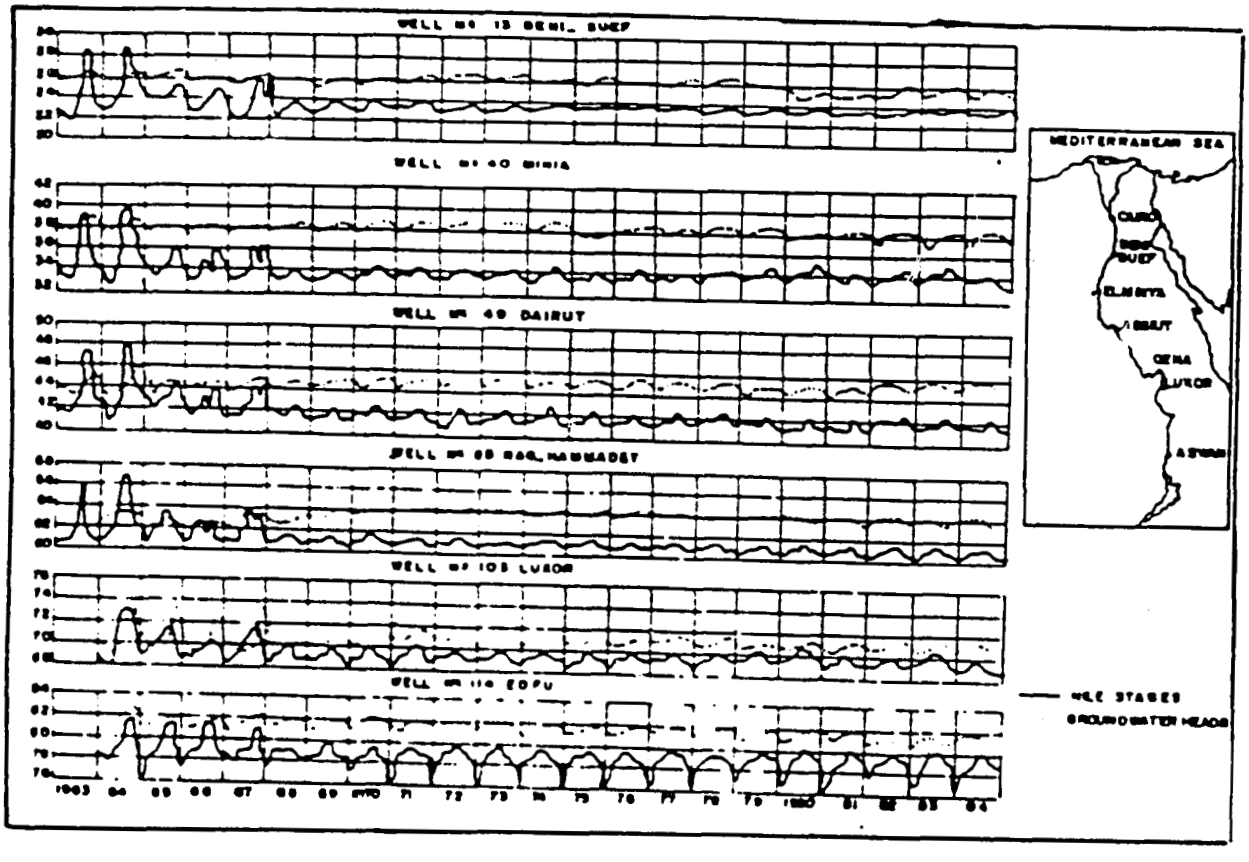


Figure 6. Groundwater Levels and Opposite Nile Stages in the Nile Valley

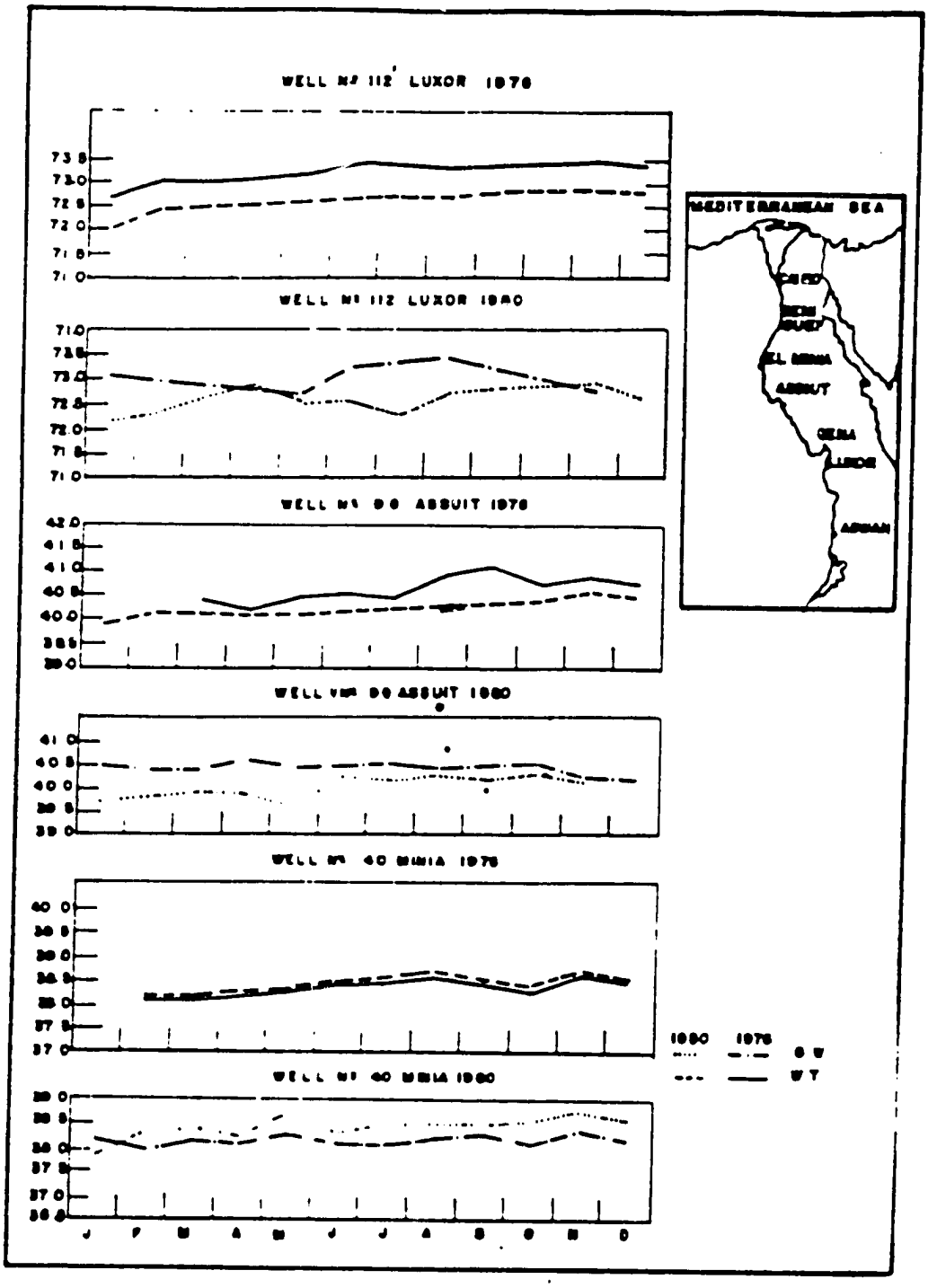


Figure 7. Groundwater and Water Table Hydrographs

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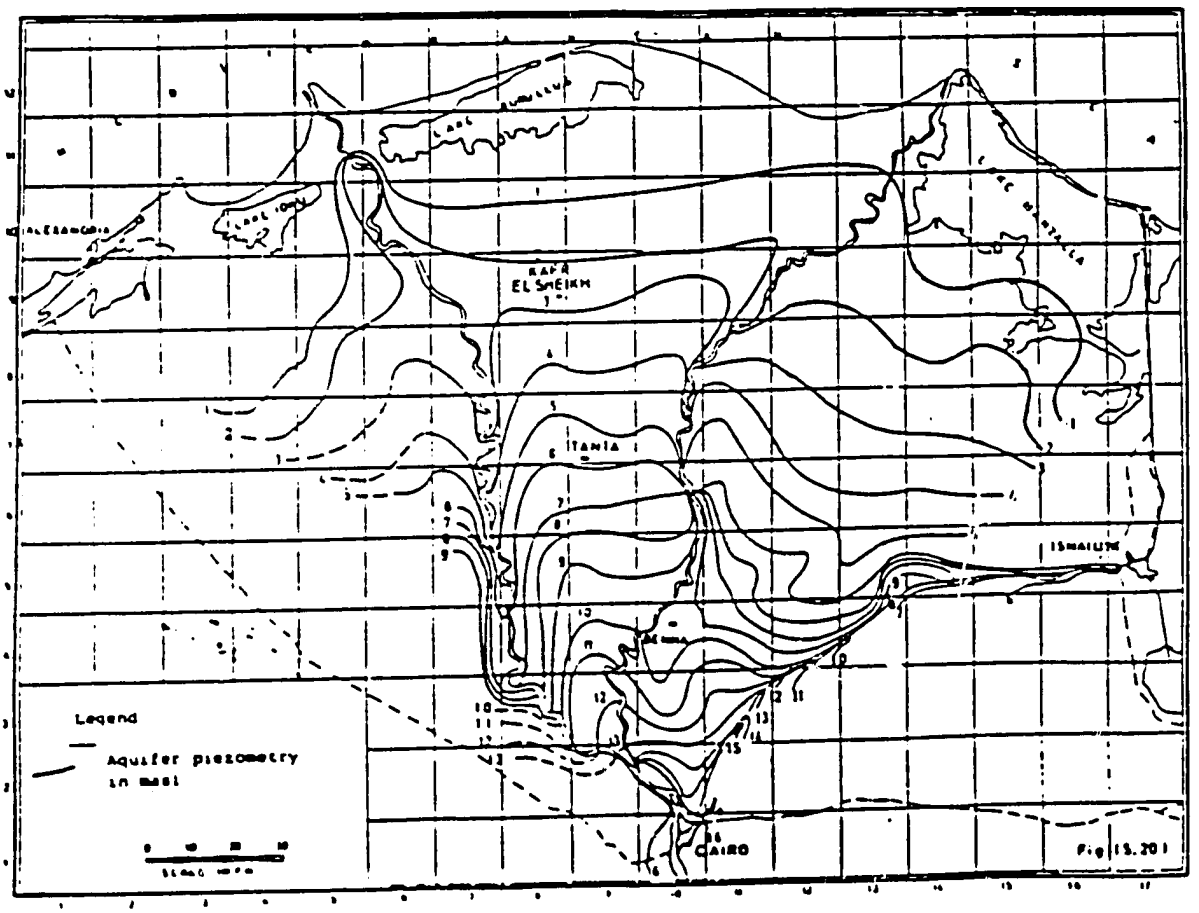

Figure 8. Average Groundwater Contour Map for the Delta

B5. Groundwater Utilization

Groundwater is mainly abstracted for domestic and agricultural uses. Abstractions by industries probably cover a minor portion of the total abstraction. Table 1 presents the overall magnitude of groundwater abstraction from the Valley, Delta, and Cairo regions.

Deep wells feed a piped drinking water supply system (serving a municipality or a rural unit) or irrigation canal. They generally have depths of up to 70 m with a screened section of 20-30 m.

Shallow wells operated by hand pumps are still extensively used for domestic purposes, especially in the rural areas of the Nile Delta. Shallow wells are usually drilled until sandy or gravelly sediments are reached, which often coincides with the top of the aquifer. Intercalated sandy layers within the top layer may also be pumped by hand pumps.

Table 1. Total Groundwater Abstractions (mcm/yr)

	DRINK.DEEP WELLS	DRINK.HAND PUMPS	TOTAL DRINKING	IRRIGATION	TOTAL ABSTRA.
NILE DELTA	415	275	690	600	1290
CAIRO	330	-	330	0	330
NILE VALLEY	190	100	290	750	1040
TOTAL	935	375	1310	1350	2660

C. Groundwater Balance in The Nile Valley and Delta

C1. Balance Along the Nile

The Nile river from Aswan to the Mediterranean Sea cuts into the Nile alluvium and generally reaches the aquifer. This results in a hydraulic contact between the water in the river and the groundwater. On the other hand, most of the canals and drains cut only in the surfacial layers, which renders the hydraulic contact between their water and the aquifer indirect (through the top clay-silt formation).

The relationship between the inflow-outflow components along the River Nile from Aswan to the Mediterranean (see Figure 9) can be represented by the following equation:

$$I - O = DV + SE - Gw - Dr \qquad (1)$$

where:

I = water released downstream Aswan Barrage
O = water leaving Edfina Barrage to the sea
DV = water diverted from the Nile for the various purposes
SE = surface evaporation from the river
Dr = drainage water disposed into the river
Gw = net groundwater seepage to the river (residual)

(all components are in L^3/T)

SE is calculated as: SE = dWL, where d is estimated at 1.5 m/year as the equivalent depth of evaporated water (Attia et al, 1986); W is the average surface water width (830 m) and L is the length of the river course (950 km from Aswan to the Delta Barrage, and 650 km for the Damietta and Rashid branches).

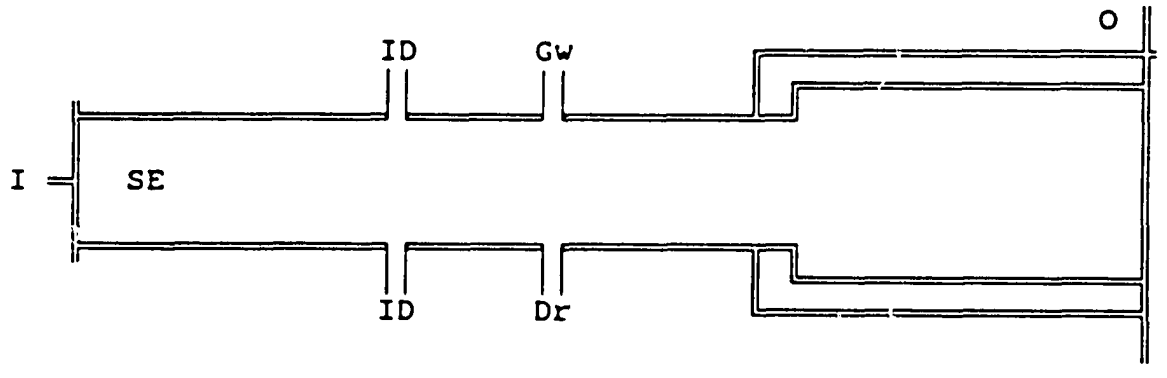

Figure 9. A Schematic Presentation of the Water Balance Along the Nile

(Attia, 1984; and Farid, 1980) indicated that the net groundwater return flow to the River Nile amounts to about 1,700 mcm/yr in the Nile Valley region, and about 212 mcm/yr in the Delta region (mainly to Rashid Branch).

C2. Balance on the Groundwater System

The alluvial groundwater system may generally be considered a closed system, except at very few locations in the North Delta (groundwater flow to the sea) and in the West (flow to Wadi El Natrun). The amounts of flow that the system gains or loses is minimal compared to the main flow components appearing in equation 2. Accordingly, the water balance on the groundwater system (Figure 10) may be represented as follows:

$$ID + Dru + Drv + Qi = EV + ET + (Dru+Drv+Drs) + (Qi+Qm+Gw) + S \quad (2)$$

where:

- ID = irrigation water diversions
- Drv = drainage water disposed in the river
- Dru = drainage water reused in the Delta
- Drs = drainage water disposed in the sea and lakes
- EV = evaporation from the capillary fringe of the aquifer (unconfined aquifer)
- ET = evapotranspiration by crops
- Qm = groundwater withdrawals for municipal and industrial purposes
- Qi = groundwater withdrawals for irrigation
- S = $S_w + S_g$
- S_w = change in storage in the clay-silt
- S_g = change in storage in the aquifer
- Gw = net groundwater gained into the aquifer

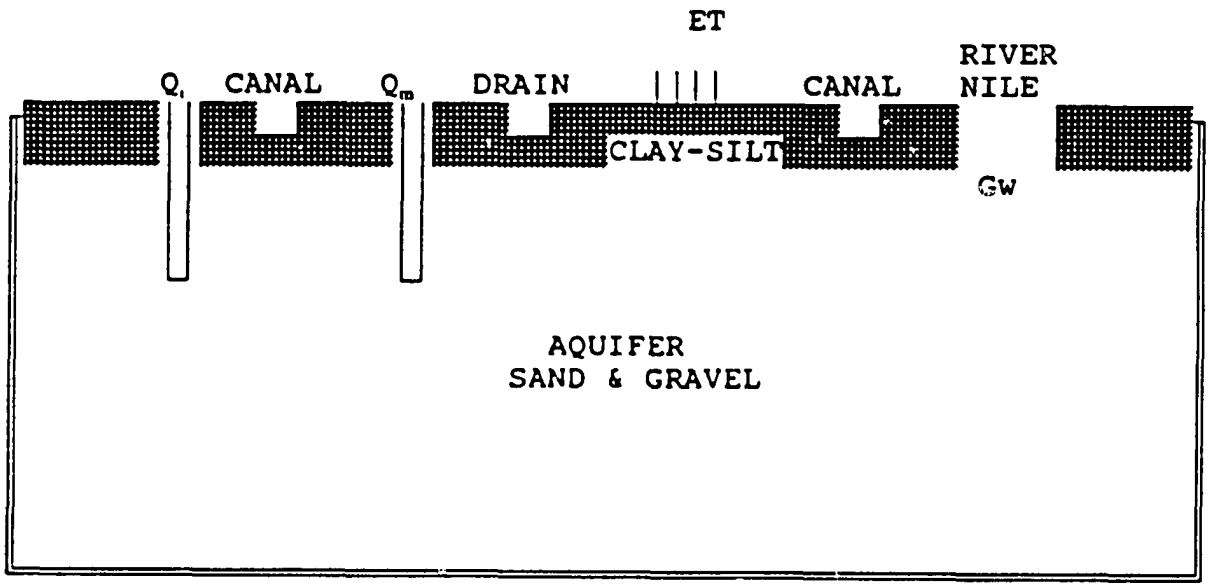

Figure 10. A Schematic Representation of the Water Balance on the Aquifer

In equation 2, ID represents the surface water diverted from the Nile to the main canals for irrigation; Drv is the drainage water disposed into the Nile mainly in the Valley; Drs is that disposed into the sea or northern lakes (see Annex I); and Dru that reused in the Delta. Groundwater withdrawals for irrigation and drainage water reused are eliminated in the balance, as they are directly used by crops and stay within the system.

Groundwater withdrawals for municipal and industrial uses leave the system. These are estimated from a recent well inventory carried out by the RIGW (1990-91).

The change in storage in both the clay-silt and the graded sand formations is estimated as being equivalent to the amount of upward groundwater leakage in the northern Delta (see Figure 4). ET is estimated from available data on crop pattern and cultivated areas for the year 1978 (WMP) (see Annex C-II). Evaporation from the capillary fringe occurs at some spots of the Valley and Delta fringes where no drainage network has yet been established. Those areas cover about 500 km^2 (MOI) located on the fringes of the flood plain. Estimating an equivalent annual depth of 1 m of evaporated water through the capillary fringe, the annual EV value is estimated at 500 million cum/year.

Due to the lack of some basic data, the estimation of the groundwater component is adapted from previous studies. These studies indicate that the groundwater component amounts to about 1,700 mcm/yr in the valley region, and about 212 mcm/yr in the Delta region.

Results obtained from both types of water balance indicate that the groundwater in the flood plain is affected and affecting both the quantity and quality of the water in the River Nile. It is recommended that a salt balance be carried out on the river to determine the effect of the seeping groundwater on the quality of the river water.

D. Existing Groundwater Quality Program

D1. The Groundwater Quality Monitoring Network

The Research Institute for Groundwater (RIGW) has implemented a groundwater monitoring network consisting of about 500 observation wells in the Nile flood plain and desert fringes. The main aim of the observation wells was to monitor the groundwater fluctuations. The network is operational for more than 25 years. Moreover, groundwater samples were extracted periodically for chemical analysis. Most of the observation wells are screened (3m) in the main aquifer, and very few tap the upper clay-silt layer. No special network has yet been implemented for quality monitoring.

Data concerning the location and characteristics of the observation wells are available in the data bank of the RIGW. The files also contain historic data on groundwater heads and main chemical constituents. Annex C-III contains samples of the available data as stored in the RIGW database.

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D2. The Groundwater Quality Monitoring Program

During the past years, some observation wells were selected for periodic sampling and chemical analysis (every three months). In addition, during the implementation of groundwater research programs, wells located in the study areas were sampled and analyzed (see Annex C-III).

Recently, the RIGW has started a research program on groundwater pollution (jointly funded by the Dutch government). Groundwater samples were extracted from the existing observation wells and the private production wells at some locations. The program includes various activities, and achieved the following tasks:

- Assessment of groundwater vulnerability to pollution in some spots of the Nile alluvium (TN 70.130-89-02).
- Assessment of groundwater pollution from domestic activities at some locations in Cairo and the Delta (TN 77.01300-89-05).
- Assessment of groundwater pollution from agricultural activities at some locations in Cairo and the Delta (TN 77.01300-90-03).
- Assessment of groundwater pollution from industrial activities at some locations in Cairo and the Delta (TN 77.01300-90-05).
- Monitoring and control of groundwater pollution, Strategy Report (TN 77.01300-90-06).
- Monitoring and control of groundwater pollution, design of a monitoring network for groundwater quality in the Cairo map sheet area.

Most of the studies are site specific except those on the impact of agricultural activities. The available sampling facility (the observation wells) have restricted the type of information required for analysis. For most of the samples, chemical nitrate analysis was carried out. Trace element and other biological elements are few.

These reports are available in the RIGW library. A summary of the results of these programs is included in Section F.

E. Changes in Groundwater Quality

E1. General Trends

In the Nile Valley there are no regional patterns for water quality. Total dissolved salt values average 500 ppm with a range of 160 to 1,700 ppm. Locally, especially in areas where upward leakage occurs or where drainage is restricted, values in excess of 2,000 ppm have been recorded. In the Nile Delta a gradual increase in TDS is observed in the fresh

water zone from South to North. It is also observed that salinity increases gradually with respect to depth. Figures 11 and 12 show the salinity of the groundwater in terms of TDS in the Delta and Valley, respectively.

In general terms, the groundwater has originated from the Nile (irrigation) and infiltrated through the soil. Changes in ion concentration are expected, due to evaporation and chemical reactions in the unsaturated and saturated parts of the soil. Figure 13 shows the prevailing water groups of the irrigation water, soil water, drainage water, and groundwater.

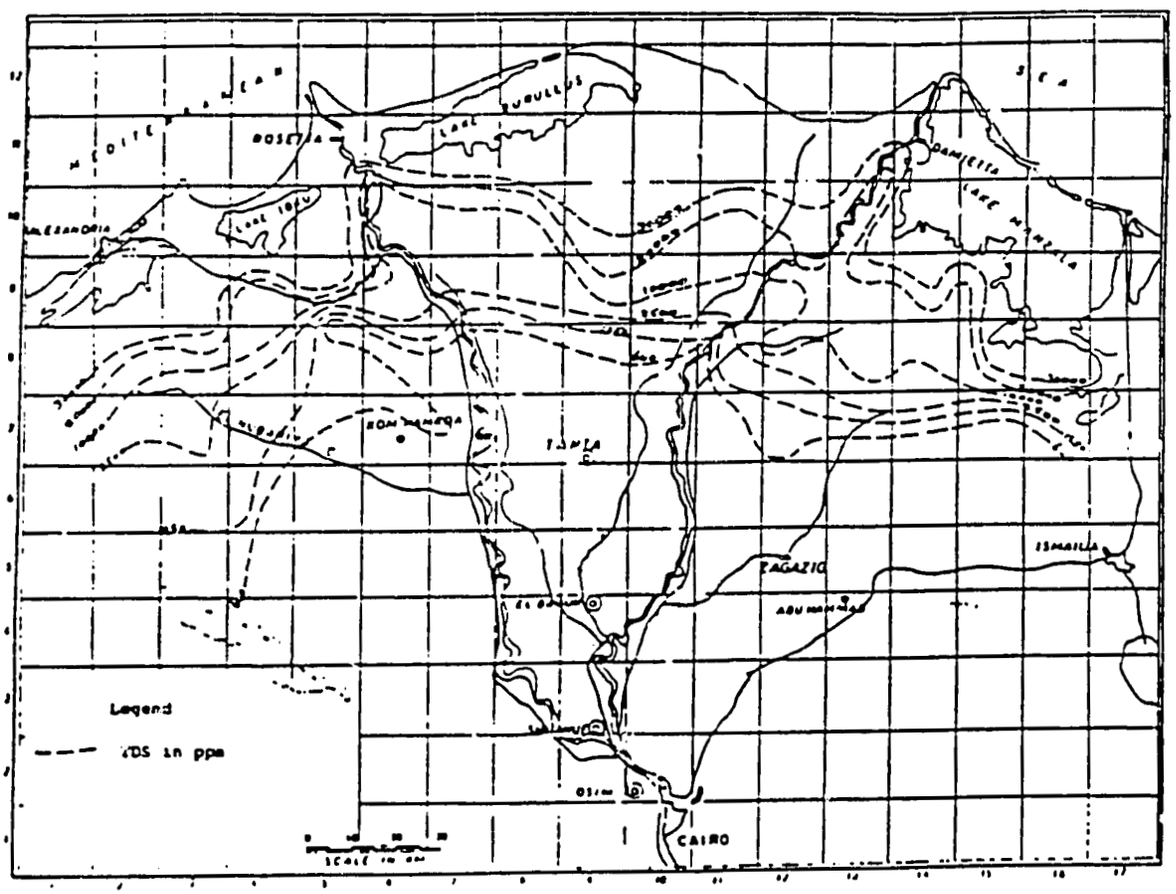

Figure 11. Average Salinity of Groundwater in the Delta

From the figure the following can be observed:

- There is a small difference between the chemical constituents of the irrigation water and the drainage water of open drains. This supports field observations of direct tail end losses from the irrigation system to the open drains.

- There is a significant difference between groundwater and irrigation water in the chemical constituents.

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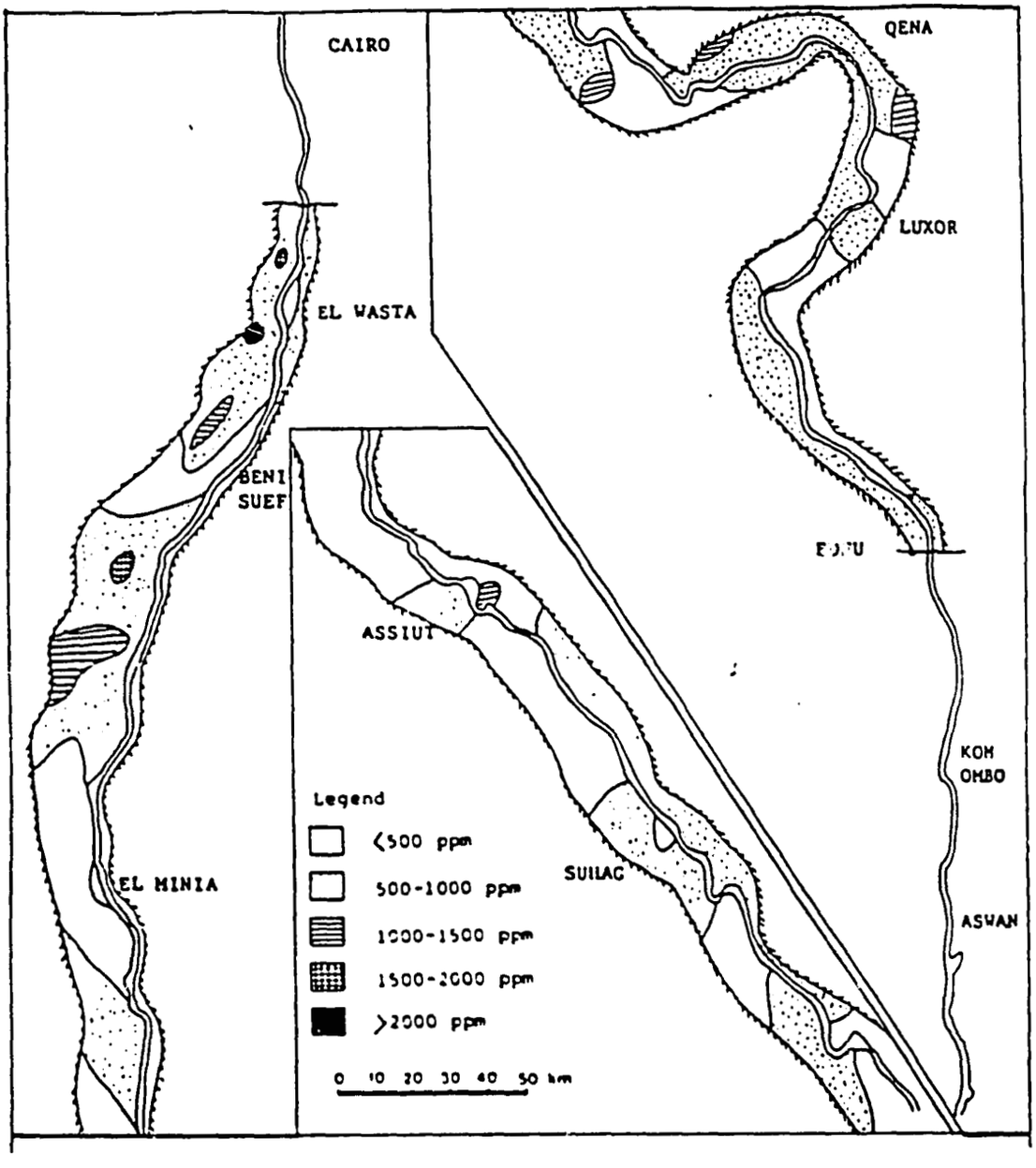

Figure 12. Average Salinity of Groundwater in the Valley

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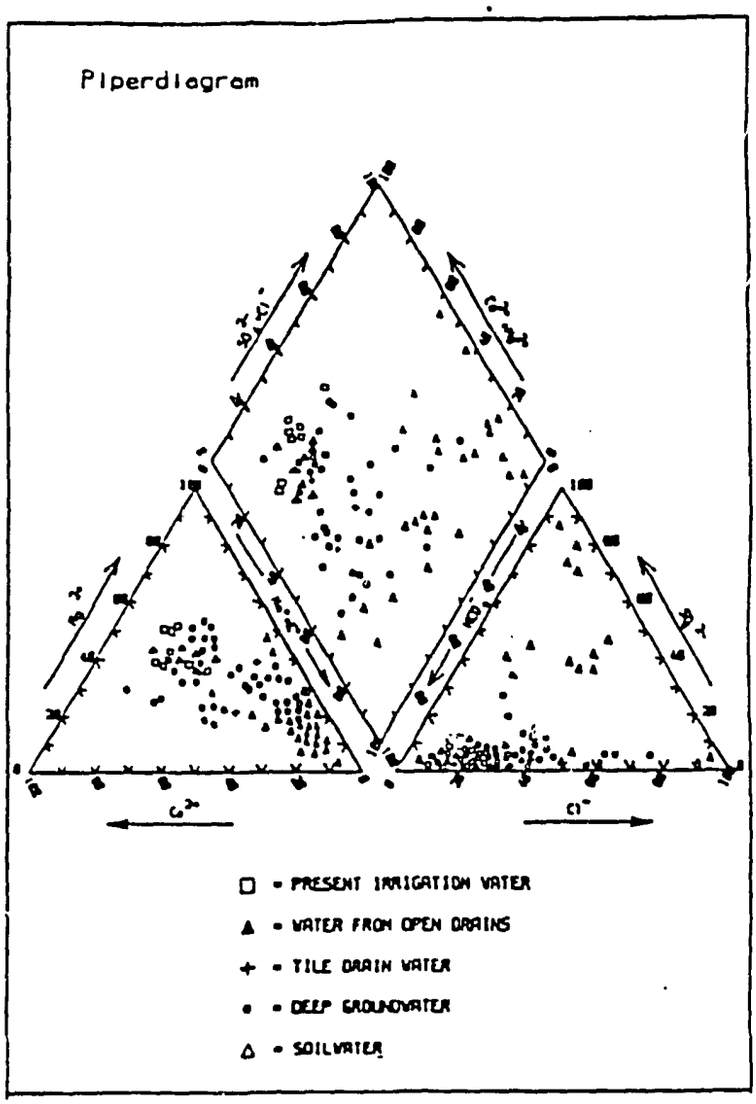

Figure 13. Piper Diagram of the Prevailing Water Groups

- From irrigation water to groundwater, a decrease in Ca and Mg with respect to Na and K and an increase of SO_4 and Cl with respect to HCO_3 are observed.

E2. Site-specific Trends

The trend in the groundwater quality presented in the previous section represents that prevailing in the Nile Valley and Delta regions. Localized trends in groundwater quality are generally a result of local surface activities or local changes in the formations comprising the aquifer. The major trends resulting from surface activities are discussed in Section F of this report. On the other hand, no internal effects are observed unless one considers the seawater intrusion in the coastal aquifer and water enriched with calcium carbonates near the fringes of the flood plain as internal effects.

F. Sources of Groundwater Pollution

Three main sources of pollution originating from human activities can be distinguished as indicated in Figure 14. Surface water can also be regarded as a source of groundwater pollution, particularly in case of relatively high surface water levels.

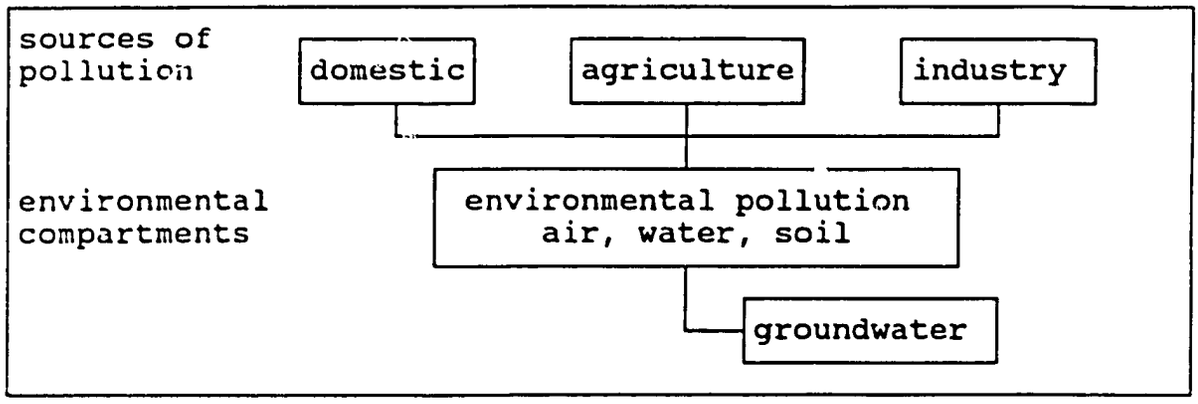

Figure 14. Main Sources of Pollution

Moreover, the groundwater itself may represent a source of pollution to the surrounding environment. An example is in the Northern Delta where saline groundwater is seeping upward to the soil and to the water distribution and drainage systems (see Figure 4 on page C-7).

F1. Pollution from Agriculture

The majority of the Nile flood plain floor is occupied by agricultural activities. Nitrogen fertilizers are mainly applied to rice, wheat, and maize. Urea is the most common fertilizer and it constitutes 45 percent nitrogen. Other main crops like cotton and berseem are provided only with nitrogen fertilizer in lower quantities. In Table 2 the cropping pattern and the applied urea rates for the concerned crops in the Nile Delta are presented.

Table 2. Cropping Pattern and Fertilizer Application

	East Delta	Middle Delta	West Delta	Urea kg/ha/yr
Rice	44	43	35	500
Wheat	28	33	31	600
Maize	20	12	26	350

CROPPING PATTERN IN% OF CULTIVATED LAND
(AMER AND DE RIDDER, 1989; AND PULSKENS, 1991)

The fertilizer not used by the crop leaches into the soil. With the application of irrigation water, these fertilizers can reach the aquifer where the soil permits infiltration.

The amounts of fertilizer reaching the groundwater depends on many factors, especially, the vulnerability of groundwater to pollution, and the existence and functioning of the drainage system.

Sources of agricultural pollution generally have a diffuse character; and due to the high mobility of nitrate, the nitrate from agriculture may be considered as the main pollution source for groundwater.

Annex C-III presents the results of the survey carried out by the RIGW at some locations in the Delta.

F2. Pollution from Domestic Sewage

Domestic sewage could be considered a diffuse source or a point source. The main sources of groundwater pollution from domestic origin comprise leakage from municipal sewerage or septic tanks; sewage sludge or land disposal of solid waste; and land disposal of sewage water (see Annex C-III).

Migration of pollutants from these sources strongly depends on the volume of discharged wastewater, which determines the infiltration rate.

Surface water may also function as a pollution source for groundwater. However, water in drainage canals, which are basically most polluted, cannot infiltrate into the soil as water tables in these drains are low compared to surrounding groundwater. Irrigation canals in the southeast part of the Nile Delta have high infiltrating capacities and may affect the quality of groundwater.

Domestic wastewater may contain considerable amounts of nitrogen, particularly in the form of ammonium and organic nitrogen. Phosphates may also be present, depending, primarily on the application of phosphate-containing washing powders.

F3. Pollution from Industrial Activities

Industries or industrial activities are mainly distinguished according to the materials used or those resulting during the production process. Materials are released as solids or liquids. Pollution from solid materials generally reaches the groundwater through percolation due to rain or irrigation. This threat is small in Egypt as rainfall is limited and disposal areas are far from agricultural activities. On the other hand, industrial liquids might seriously threaten the groundwater quality.

In general, no direct recharge of industrial effluent is taking place to the aquifer system in Egypt. Industrial effluent are disposed either into the surface water conveyors or to the drains. The risk that pollutants reach the groundwater depends on the hydrogeologic conditions and the vulnerability of groundwater to pollution.

Although industrial groundwater pollution can be very serious on a local scale, the impact on the composition of the main aquifer is far less than the effect on agriculture. Industrial sites cover less than 1 percent of the total Delta area, while agricultural activities are widely spread and are the dominant polluting agent in Egypt.

F4. Factors Affecting Groundwater Pollution

F4a. Groundwater Vulnerability

The following aspects are important with respect to groundwater vulnerability:

Precipitation and Evaporation. Recharge to the aquifer from rainfall is extremely low, except in the area adjacent to the coast. Migration of pollutants occurs if considerable wastewater is drained into the soil. Infiltration from polluted drains depend on the water table position with respect to the groundwater head. The entrance resistance of the drain plays an important role in that respect.

Thickness and Lithology of the Top Clay Layer. The thickness of the top clay layer in the flood plain changes from nil on the fringes to more than 20 m in the central regions. Locally, this clay layer is intercalated with sand. The clay layer plays an important role in protecting the groundwater. Cation exchange and adsorption of organic matter are the main processes responsible for the retention of pollutants. The phreatic aquifer is thus more subject to pollution.

Vertical Flow of Groundwater. The potential for groundwater pollution primarily depends on the vertical groundwater flow. Groundwater pollution is normally impossible under upward groundwater flow (north Delta and fringes).

Horizontal Flow of Groundwater. The horizontal groundwater flow in the alluvium is generally about 25 m/year. The horizontal migration of pollutants may also depend on local homogenities of the soil. Groundwater movement and also pollutants follow the layers of higher permeability. However, concentrations are reduced through dispersion in highly permeable formations. On the other hand, low permeable formations located near pollution sources may locally contain higher concentrations due to the low dispersion.

F4b. Pollutants' Properties

Besides the vulnerability of the groundwater, the properties of the pollutants affect greatly their migration through the soil. The specific weight of pollutants may show specific migration patterns. Light substances such as mineral oils and aromatic hydrocarbons (specific weights approximately 0.9 and 0.95, respectively) will remain above the water table. Heavy substances as volatile chlorinated hydrocarbons (specific weight about 1.5) may reach deeper strata by specific vertical migration.

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Absorption is the main regulating process for migration of pollutants in soils. Its effect is primarily determined by the solubility of the pollutant in water and the original organic matter content of the soil. Table 3 summarizes the grouping of pollutants according to their adsorption to sand (low organic matter) and clay (relatively high organic matter).

Table 3. Relative Mobility of Pollutants in Soils

Group of Pollutants	Mobility through	
	Sand	Clay
anions (Cl, NO3)	***	**
aliphatic chlorinated hydrocarbons	**	*
aromatic hydrocarbons	**	*
aliphatic hydrocarbons	*	0
heavy metals (Zi, Ni, A)	*	0
herbicides	*	-
heavy metals (Hg, Pb)	0	--
insecticides	0	--

*, 0, - : RESPECTIVELY, HIGH, MODERATE, AND LOW

Heavy metals such as lead, copper, and chloro-pesticides are usually strongly retained by the clay and organic matter of the topsoil. Chlorinated hydrocarbons such as ethylene are more soluble and adsorb less to the solids.

Some pollutants show decay, especially in the unsaturated zone and near the water table. In the groundwater itself decay is a very slow process and is therefore often neglected. Decay of non-chemical substances is probably substantial, also due to relatively high temperatures in Egypt. Ammonium is often at least partly nitrified to nitrate.

F5. Extent of Groundwater Pollution in the Nile Delta

Previous investigations carried out by the RIGW indicated that the main pollutant threatening groundwater quality in the flood plain is the nitrate. As a start of a country survey, the Delta was selected for a regional survey on the extent of groundwater pollution from nitrate.

F5a. Area Classification

For the purpose of the survey, the Delta has been divided into subregions according to: (a) salinity of the groundwater; (b) land use; and (c) vulnerability of groundwater to pollution. Each of these parameters has a major impact on the quality of groundwater. The distribution of these subregions is indicated in Figure 15 with a summary of their classification presented in Table 4.

- Salinity of groundwater: The groundwater in the Nile Delta is divided into fresh and non-fresh areas according to an iso-TDS-line of 1,000 ppm (see Figure 11). In the areas adjacent to the Mediterranean, the Red Sea, and the lakes, the

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groundwater is fresh on the top, becoming brackish downward due to the seawater intrusion. In these areas a clear distinction between fresh and brackish zones is generally difficult. The division is thus made according to the TDS of the observation wells.

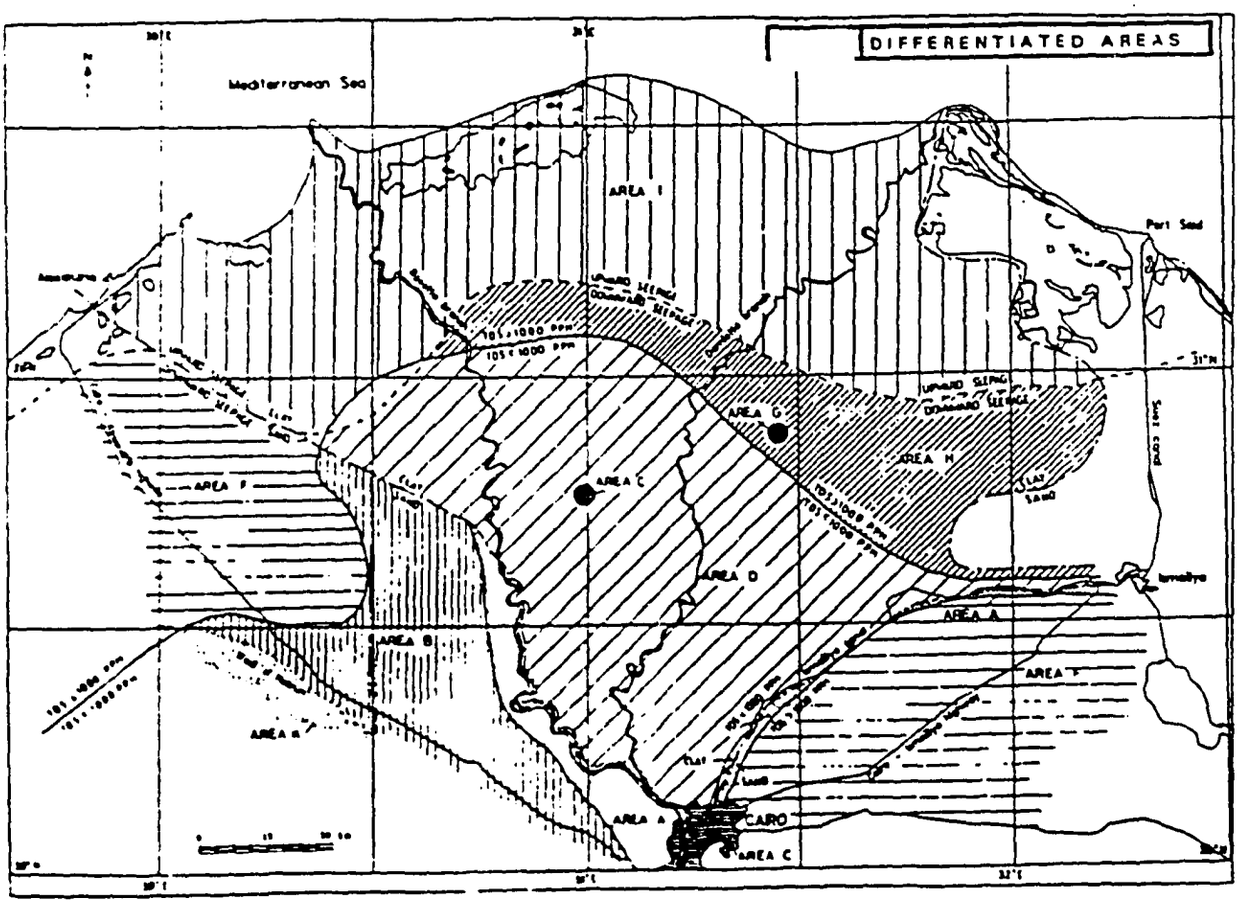

Figure 15. Differentiated Homogeneous Subareas

Table 4. Summary of Area Coding and Classification

AREA CODE	SALINITY 1000 PPM	VULNERABILITY TO POLLUTION	LAND USE	NUMBER OF WELLS
A	NO	HIGH	TRADITIONAL	7
B	NO	HIGH	RECLAIMED	4
C	NO	MEDIUM	URBAN	3
D	NO	MEDIUM	TRADITIONAL	14
F	YES	HIGH	RECLAIMED	6
G	YES	MEDIUM	URBAN	1
H	YES	MEDIUM	TRADITIONAL	3
I	YES	LOW	TRADITIONAL	7
K	NO	LOW	TRADITIONAL	1

Land use. Three categories of land use have been distinguished: urban, industrial, and agricultural.

The agricultural category is subdivided into traditional agriculture and agriculture in the reclaimed areas. The reclaimed areas are located on the east and west fringes of the Delta. Obviously the Nile Delta is characterized by its agricultural use, since over 90 percent of the area can be classified as agricultural.

If an observation well is located in a small town where surroundings are dominated by agricultural use, the area classified as agricultural. Industrial areas are not sampled due to their minor areal importance to groundwater pollution. Moreover, pollution from industries originate from point sources, which requires more specific monitoring.

Vulnerability of groundwater. According to a previous study on the vulnerability of groundwater to pollution in the Nile Delta, the vulnerability of areas in the Delta can be roughly classified as high, moderate, and low. Due to high infiltration rates and low absorption capacity of the soil, the sandy areas are classified as highly vulnerable. Low infiltration rates within the clay areas determine the groundwater as medium vulnerable. Only in the areas where upward seepage occurs is the groundwater vulnerability low. Upward seepage can be found in the northern part of the Nile Delta and near fringes of the Nile Delta where waterlogging problems occur.

F5b. Area Coding

Based on the above parameters, 12 sub-areas, each with different characteristics, are distinguished in the Nile Delta. Selection of the observation wells throughout the Delta is based on an effort to get an evenly distributed network over the nine areas, excluding three with industrial land use. The areas are indicated in Figure 15.

In Table 4 the nine areas are presented, their distinguishing features summarized, and the number of selected wells given.

F5c. Sampling

Approximately 60 RIGW observation wells were selected for this survey. Most of them were visited and cleaned before the survey. If no observation wells were available, an

irrigation and/or drinking water well substitutes for the observation well (e.g., D202.X, WADN.3 and DINA.3). Figure 16 shows the locations of the sampled observation wells.

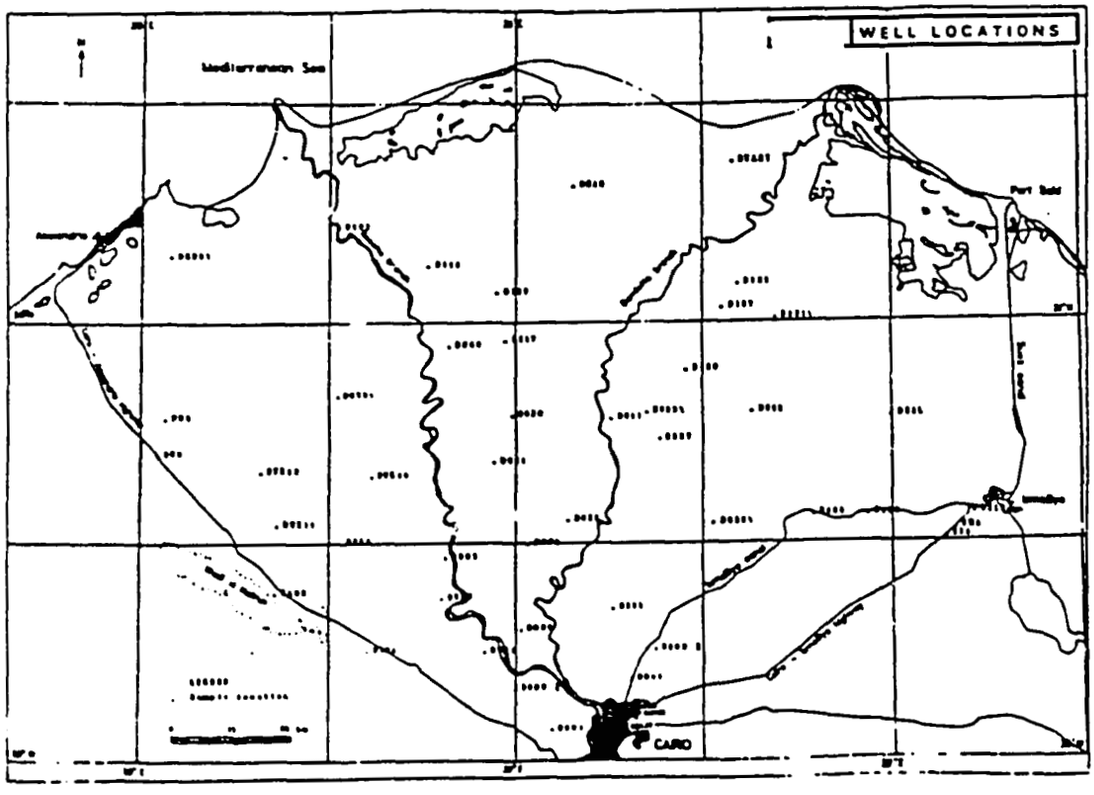

Figure 16. Location of Sampled Wells

To obtain a three-dimensional insight into the occurrence of nitrogen in the Delta's groundwater, one needs data from various depths. For this reason, at each observation location efforts were made to take additional samples from nearby wells. (Shallow handpumps tapped the top layer of the aquifer.) Generally, two samples were taken from shallow wells to compensate for the great variations expected. Sampled shallow handpumps were generally within a radius of 250 m from the observation well. The two shallow handpumps are always less than 100 m away from each other.

Irrigation production and drinking wells (near water towers) usually have depths of 50 to 150 m below ground level. Samples taken from these wells represent the deeper layers of the aquifer. An advantage of those wells is that they are very well maintained, highly productive, and they give direct fresh-water from the aquifer. A disadvantage is that they have screens over extended lengths and thus provide water from a wide range of the aquifer.

Irrigation and drinking water wells were chosen within a radius of 1,000 m from the observation well. A total of 117 wells were sampled, as shown in Table 5.

Table 5. Number and Type of Sampled Wells

Total observation locations	(46)
Observation wells	42
Shallow hand pumps	44
Irrigation wells	18
Drinking water pumps	13
Total	117

All samples were collected following standard procedures.

Observation Wells. The observation wells are sampled with an electric submersible pump. The pump is lowered into the pipe of the well as deep as possible. The maximum depth which the pump can reach is determined by the length of its hose/electric wire, which is 30 m. Observation wells usually have a 4-inch diameter for at least the first 10 m-GL. Sometimes the rest of the pipe is only 2 inches. In this case the pump can be lowered only to this depth. Many wells have a 4-inch diameter over the whole length. Sampling from observation wells required more pumping, as water does not flow continuously as with production wells (irrigation/drinking). If a sample is taken from the upper part of the water column or after too little pumping time, the sample may not represent the aquifer and is thus useless for a scientific survey. The quality of the water in observation wells may also be affected by evaporation and corrosion of the well, which causes an increased iron (Fe) load in the water. Prior to sampling, the stagnant water in the observation well is replaced by fresh-water coming directly from the aquifer. This is checked by the temperature of the pumped water.

Directly after taking the sample, EC, temperature, and pH are measured. Analysis of NH_4^+, NO_3^-, NO_2, Fe, and Mn are carried out later the same day. One of the bottles is acidified, to prevent heavy metals from precipitating. The sample is analyzed on pH, EC, cations, and anions in the RIGW laboratory. The acidified sample is analyzed on NH_4^+, NO_3^-, B, PO_4^{3+}, and COD in the DRI laboratory. All samples are delivered to the laboratory within five days.

Characteristics of the direct surroundings of the observation well are written on the survey form. Special attention is paid to possible pollution sources such as drains, latrines, and (minor) industrial activities. The land use, the soil condition, and the drainage method are taken into account. Non-visible characteristics, such as depth of water table or placements of septic tanks, are obtained by interviewing local farmers.

Shallow Handpumps. Within a range of 250 m from the observation well, two shallow handpumps (5-20 m depth) are selected to be sampled. Here only one bottle of sample is taken because only field analyses are carried out. Attention is paid to obtaining

original groundwater; after five minutes of pumping, the water is then considered to be water from the aquifer and a sample is taken. A new survey form is filled out.

Irrigation and Drinking Water Production Wells. In a range of 1,000 m from the observation well, two deep wells are selected to obtain samples of deeper groundwater (50-150 m depth). One sample is taken; most of the time these pumps are constantly running so a sample can be tapped directly from the pumping installation. In this situation a survey form is also filled out. The locations of all visited wells are indicated on maps with a scale of 1:25,000.

F5d. Analysis

Field Analysis. A field colorimeter is applied for a quick and easy determination of the concentrations of NH_4^+, NO_3^-, NO_2^-, Fe, and Mn in the sample. For all three nitrogen-related parameters, two tests are carried out, one for the lower range of concentrations and one for the higher range of concentrations.

Prior to determining the total iron and manganese concentrations, a digestion procedure is carried out. This could not be executed in the field and was not applied during this survey. The concentrations of Fe and Mn to be found in this report are therefore not the total concentrations; they indicate a tendency in the occurrence of those components in the groundwater at a lower concentration level.

Reliability Check Colorimeter. Pre-survey checks with the colorimeter were executed with standard solutions for all concerned parameters, which gave good results. Previous RIGW/IWACO analyses with the colorimeter in other project areas were counter checked with data from other laboratories; only very slight differences appeared.

Laboratory Analysis. Chemical analyses in both RIGW and DRI laboratories are conducted according to the 'Standard Methods 1985.' Basically, the RIGW laboratory provided this study with concentrations of the major cations and anions, the DRI laboratory provided some miscellaneous data such as ammonium, phosphate total, boron and chemical oxygen demand. Both laboratories determined nitrate concentrations, which offered the possibility of comparing the laboratory concentrations with the field analyses data. The standard methods, however, prescribe a cool storage (4°C) and a storage time of not more than seven days for samples which are analyzed for nitrate. Both conditions were not always met in either laboratory. A thorough comparison of the nitrate concentrations could therefore not be conducted.

F5e. Results

All individual data are available in a data book, which also contains a full description of procedures.

The results of the survey for each subarea are presented in a report (TN 77.01300.91.12). A summary of the results follows.

Figures 17 and 18 present an overview of the occurring concentrations of the three nitrogen parameters in the nine distinguished areas. The quality data for each subarea is included in Annex C-IV.

The Old Land. An extended period of fertilizer use in the old land brought a huge amount of nitrogen during the last decades. However, the implementation of tile drainage in large areas of the Delta transported a considerable amount of nitrogen pollution to surface waters protecting the aquifer from downward movement of nitrogen to the groundwater. This may be the main reason for an overall low load of nitrogen in the groundwater in the semi-confined aquifer. Adsorption of ammonium to the thick top clay layer probably plays an important role in that respect.

The groundwater in the north is not suitable for any sector due to its high salinity. The ammonium concentrations detected in the groundwater also reach high values. The ammonium may possibly originate from the intrusion of seawater and/or from marine sediments.

Iron and manganese seem randomly distributed. The WHO guideline for manganese is often exceeded, particularly at low depths. Most of the free iron concentrations are below WHO guidelines. However, the total iron concentrations are higher due to the applied analyses methods. Release of iron from clay sediments is confirmed in this survey, since iron and manganese concentrations in groundwater of sandy desert areas are much lower.

The Reclaimed Areas. A common feature in groundwater of all sandy areas, both reclaimed and traditionally cultivated, is the presence of a relatively high concentration of nitrate. Another striking feature is the almost total absence of ammonium in the groundwater. The thick unsaturated sandy subsurface creates good conditions to convert ammonium into nitrate. This makes unconfined aquifers more vulnerable to pollution (with nitrate) than semi-confined and confined aquifers. Even with shallow groundwater tables (areas A and F), the detected amounts of nitrate in groundwater are considerable.

In sandy areas (unconfined aquifers), no relation between the type of agriculture, groundwater depth and salinity, on the one hand, and the concentration of nitrate (at 50m depth), on the other, seems to exist.

The manganese concentration is quite low compared with that in confined and leaky aquifers (old land). The free iron concentrations tend to be lower; but this may depend on the form in which the iron is analyzed. WHO guidelines are not exceeded, but the actual total iron concentrations are definitively at a higher level.

The Urban Areas. The influence of urban activities on the groundwater quality is difficult to determine as the areas covered by urban and industrial activities are minor compared with those occupied by agricultural activities. Nevertheless, the impact of

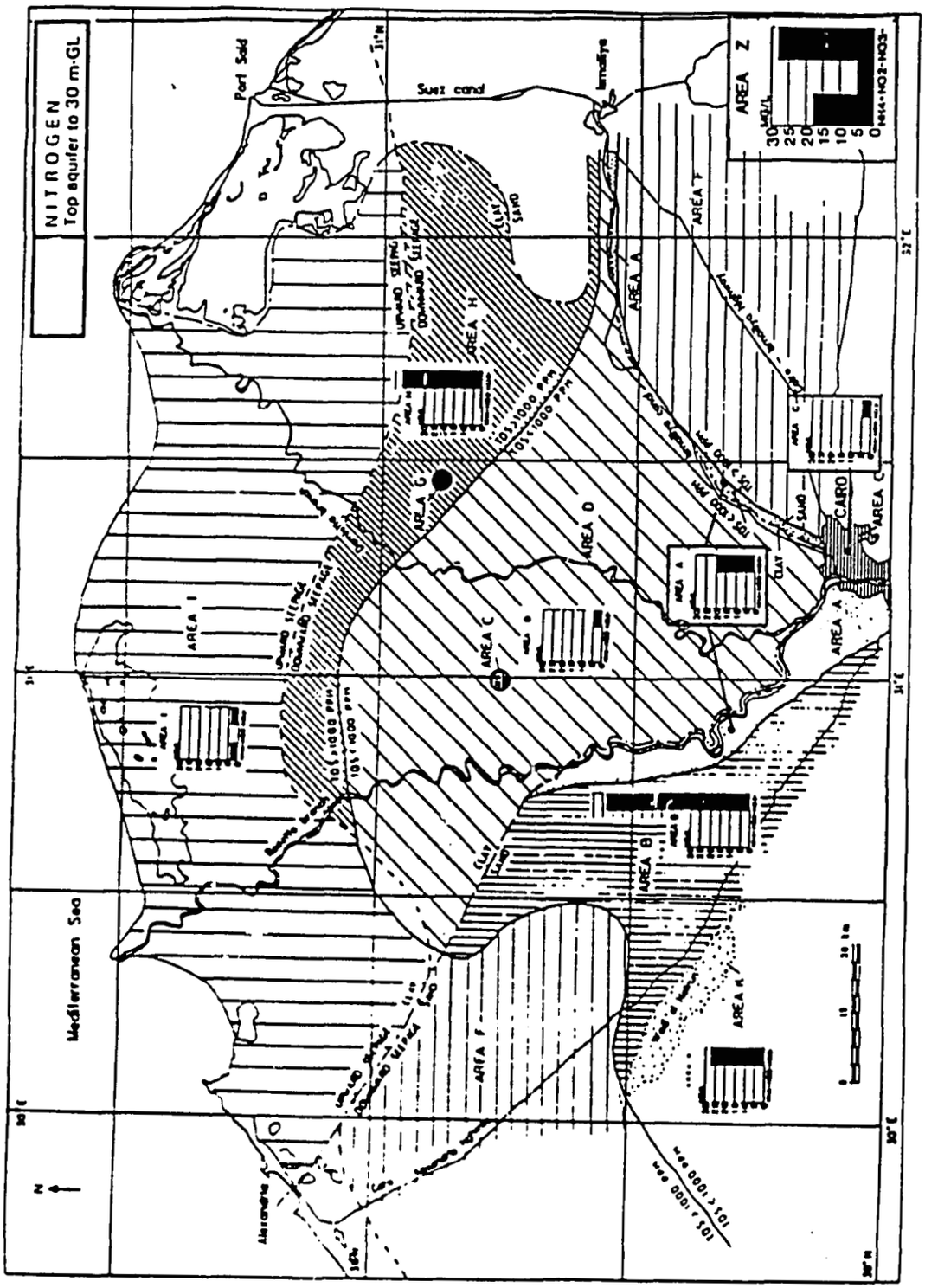

Figure 17. Presence of Nitrogen up to 30m Below G.S.

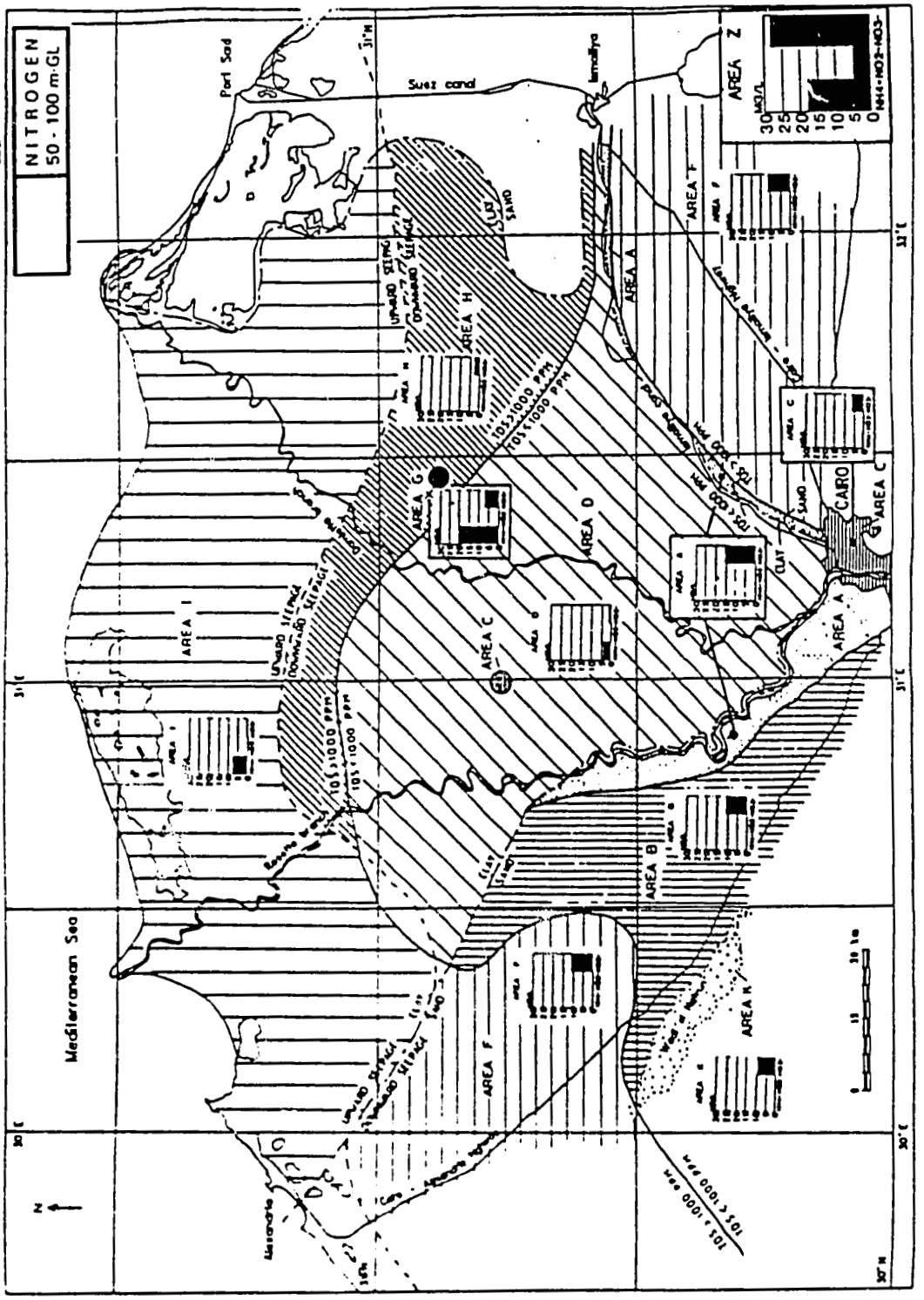

Figure 18. Presence of Nitrogen at 50-100m below G.S.

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domestic activities in areas of cities having no sewage systems (or with a leaching sewage system) should be reflected by the quality of groundwater just downstream from these locations.

The samples from urban area C, which is underlain by a semi-confined aquifer, show a low overall nitrogen content. Nitrate is clearly present in higher concentrations than ammonium, but the nitrate concentrations still remain below the FAO and WHO guidelines. The high ammonium concentrations in area H depend on only one observation and might not be representative.

G. Conclusions and Recommendations

G1. Potential Sources of Groundwater Pollution

The groundwater in the Nile Valley and Delta is mainly recharged from drainage surplus. Accordingly, one can expect the main source of groundwater pollution is agricultural activity. Pollution from domestic sources exists on a local scale, except in those areas where domestic effluent is used directly for irrigation (El Gabal, El Asfar) or where domestic sewage is disposed into a drain (Belbeis). Pollution from industrial sources is very limited as it is very rarely disposed on the land and never injected to the aquifer.

Nitrogen is likely to represent the main pollutant in groundwater, followed by iron and manganese.

The extent of groundwater pollution by nitrate depends mainly on the groundwater vulnerability. Under the old land, the groundwater is less vulnerable than in the newly reclaimed areas. This is due to the existence of the clay-silt top formation over most of the old land and its absence in the new land. The groundwater in the transition area between the old land and the new land is highly vulnerable. This is due to the shallow water table and thin or no clay-silt top layer.

Iron and manganese are found at higher concentrations in the old land than in the reclaimed areas. The figures found, however, that irregular and standard deviations are high. There is a tendency for iron and manganese to appear in higher concentrations in areas with a clay cap. A natural source of iron and manganese within this clay cap is the most probable explanation for the increased concentrations.

G2. Gaps of Information

Due to the lack of a quality monitoring network, the information obtained until now may not be accurate to the extent that would enable MPWWR to draw concrete conclusions on the type and extent of groundwater pollution; and, thus develop strategies to protect it. The existing monitoring network (groundwater heads monitoring) is not convenient for the survey of groundwater quality. The corrosion of the old steel pipes affects the groundwater extracted from the wells.

Moreover, the available information comes from one overall survey carried out in the Delta region (for nitrate mainly) and some selected sites for local (point sources).

G3. Strategies for Groundwater Protection

From the little information obtained from the studies carried out so far, it can be concluded that nitrate pollution in the soil can only be prevented by directly controlling the input. Fertilizer, the main source of nitrate on a national scale, should be critically regarded for its efficiency, need, and application. Surpluses of fertilizer should be avoided to prevent the excess nitrogen from seeping down to the aquifer.

It is necessary to formulate guidelines and restrictions for fertilizer use and to include them in the fertilizer extension programs for farmers.

G3a. Groundwater Use

Groundwater abstractions for drinking water purposes in the reclaimed desert fringes of the flood plain should be carried out from the deeper layers of the aquifer to avoid high nitrate concentrations. The same holds for some locations near the fringes of the flood plain.

Groundwater use for irrigation purposes in the areas where nitrate is present in high concentrations should be allocated to less sensitive crops (for nitrogen).

A solution to the high iron and manganese concentrations in drinking water supplies in the flood plain may be approached along two lines:

- Treatment of groundwater (coagulation), which is expensive
- Emphasis on abstraction of groundwater from surrounding areas or different depths with lower concentrations, if possible

G3b. Groundwater Quality Monitoring

To monitor the groundwater quality, a reference quality monitoring network should be implemented in the flood plain and the reclaimed areas. With the help of this network, monitoring should be conducted periodically. Moreover, a proper sampling method should be followed in the survey. Field and laboratory analyses should include thorough checks for the analysis method.

Monitoring should put much emphasis on nitrogen pollution. This dictates monitoring the path of nitrogen through the soil to detect the specific behavior of the different kinds of nitrogen which are considered as sources of pollution (organic nitrogen, ammonium, nitrite and nitrate). To quantify the process, pilot studies should be implemented to assess the m

balance of nitrogen. These studies should include the effect of fertilizer applications on the composition of the top clay-silt formation and the vertical travel velocity of nitrate/ammonium to obtain reliable information to develop policy guidelines.

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SUPPLEMENTARY ANNEX C-I

ANNUAL DISCHARGES OF MAIN CANALS AND MAIN DRAINS

TABLE I.1 DISCHARGES OF THE RIVER NILE AT SOME MAIN LOCATIONS (MILLION CUBIC METERS/YEAR)

LOCATION	DISCHARGE					
	1984	1985	1988	1989	1990	1991
DS ASSWAN	57,310	55,840	52,149	53,283	53,996	53,750
DS ESNA			46,238	46,954	49,025	
DS N.HAMADI			41,534	42,707	42,891	
DS ASSIUT			30,310	31,960	31,010	
US DELTA	36,096	34,505	33,084	33,217	33,769	
US DAMIETTA			8,100	8,982	9,159	10,115
US RASHID			4,374	7,135	4,069	4,280
DS EDFINA	5,220	3,580	2,753	2,517	2,399	2,200

TABLE I.2 ANNUAL DISCHARGE OF MAIN CANALS

CANAL	DISTANCE ON THE NILE(Km)	DISCHARGE(million cubic meter/year)			
		1988	1989	1990	1991
ASFOUN	167.000	550.52	483.72	502.96	554.13
EL KALLABEYA	156.000	1176.41	1044.13	954.25	1211.39
NAG HAMMADI EL SHARQUEYA	345.000	1134.22	1658.83	1058.61	1065.18
NAG HAMMADI EL GHARBEYA	345.000	2414.60	2459.75	2465.05	2461.00
EL IBRHIMEYA	538.000	9021.05	10038.98	8157.74	9307.05
TOTAL VALLEY		14284.13	14670.88	13148.51	14761
EL ISMAILEYA	929.000	3136.95	3335.95	2524.05	3610.00
EL SHARQUAWEYA	932.500	675.20	660.45	824.35	662.85
RAYAH BEHERI		6689.80	6473.85	6330.55	5625.25
RAYAH NASERI		1497.85	1892.00	2036.00	2369.30
RAYAH MENUFI		5095.87	4972.25	5144.56	4939.25
RAYAH TAWFIQUI		3838.50	3834.85	3871.48	3801.15
TOTAL		20934.17	21098.25	21592.75	19843.60
TOTAL		35218.30	35769.13	34741.26	34604.60

TABLE I.3 ANNUAL DISCHARGES OF MAIN DRAINS INTO THE RIVER BETWEEN ASWAN AND DELTA

YEAR	MONTH	MEASURED DISCHARGE million cum/day
1977	OCTOBER	10.398
1979	MARCH	5.088
1984	MARCH	5.145
1985	JULY	11.885
1986	SEPTEMBER	11.101
1991	JULY	9.300

TABLE I.4 ANNUAL DISCHARGES OF MAIN DRAINS INTO THE RIVER IN THE DELTA (MILLION CUBIC METERS/YEAR)

YEAR	NILE DISCHARGE U.S. DELTA BARRAGE	DRAINAGE WATER REUSED			TOTAL REUSED DRAINAGE	DRAINAGE WATER FLOWING TO SEA			TOTAL DRAINAGE NOT USED
		EAST	MIDDLE	WEST		EAST	MIDDLE	WEST	
1984	36,096	1,333	737	858	2,928	4,516	5,064	4,350	13,930
1985	34,505	1,284	777	794	2,855	4,272	5,057	4,313	13,642
1986	34,929	1,413	721	765	2,899	4,016	5,264	4,226	13,516
1987	34,449	1,350	719	765	2,834	3,779	5,080	4,376	13,235
1988	33,084	1,130	686	554	2,370	3,182	4,361	4,437	11,980
1989	33,217	1,412	673	587	2,672	3,317	4,546	4,425	12,288
1990	33,769	1,527	1,236	607	3,370	3,621	4,476	4,723	12,820

ESTIMATED DRAINAGE WATER DISPOSED INTO THE RIVER IN THE ASWAN-CAIRO REACH

The amounts of drainage water discharging into the river in the Nile Valley can be estimated as follows:

1. The measured discharges as appearing in Table I.3, which provides daily discharges during certain months

2. Comparing these discharges with the monthly discharges to sea of the year 1984 (second interim report of the project RIWDS, N. EGY/85/012 of the MPWWR), shown below (million cubic meters/month):

month	january	februa.	march	april	may	june	july	august	septemb	october	novemb.	decemb.
disch.	1,030	650	1,000	1,020	1,070	1,150	1,370	1,420	1,470	1,380	1,170	1,140
%	7.4	4.7	7.2	7.4	7.7	8.3	9.9	10.2	10.6	10.0	8.4	8.2

THE ANNUAL TOTAL DRAINAGE TO THE SEA WAS 13,860 MILLION CUBIC METERS

3. The figures in the previous table could be used as percentages for monthly drainage for any year for both the Valley and Delta (i.e., the percent of the drainage during July is 9.9 percent of the annual drainage).

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4. Accordingly, the annual drainage water discharged in the Nile in the Valley reach is estimated at about 2,919 million cubic meters. This amount represents about 20 percent of the irrigation water diverted to the Valley during the same year (see Table I.2)

5. Applying the same percentage to the previous years, the drainage water disposed into the river in the Valley reach is as follows (million cubic meters/year):

YEAR	1988	1989	1990	1991
DISCHARGE	2,857	2,934	2,630	2,919

SUPPLEMENTARY ANNEX C-II

CROP WATER USE DATA

Table II.1. Consumptive Use by Major Crops in Egypt
(WMP report No. 17)

CROP \ LOCATION	WATER USE (cum/fed./day)		
	DELTA	MID.EGYPT	UPPER EGYPT
COTTON	67.10	84.62	92.44
RICE	108.15		
MAIZE (SUMMER)	57.86	62.19	66.71
MAIZE (NILI)	53.55	55.11	58.87
SORGHUM			65.56
SUGAR CANE		170.66	216.89
WHEAT	38.31	47.54	52.27
BERSEEM	56.15	67.68	74.30
FUL	30.48	37.34	43.50

Table II.2. Cropped Areas in Feddans

CROP	LOCATION			
	DELTA	MID.EGYPT	UP.EGYPT	TOTAL
COTTON	619,116	199,303	179,648	998,067
RICE	914,242	9,729		923,971
MAIZE	1,118,483	579,640	216,310	1,914,433
SUGAR CANE	9,193	30,474	204,717	244,384
WHEAT	681,549	201,578	296,796	1,179,923
BERSEEM	1,344,947	356,954	207,343	1,909,244
TOMATOES	210,941	85,600	25,544	322,085
POTATOES	117,828	28,638	1,661	148,127
ONIONS	272,332	70,050	30,809	373,191
WATER MELON	82,962	31,199	8,004	122,165
FRUIT TREES	226,357	67,988	32,239	326,584
TOTAL	5,597,950	1,661,157	1,203,071	8,462,174

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SUPPLEMENTARY ANNEX C-III

SITE INVESTIGATIONS ON GROUNDWATER POLLUTION

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C-III.1 Agriculture Activities

The RIGW carried out field investigations to determine the type and extent of groundwater pollution from domestic and agricultural activities. Locations were selected to include areas with various degrees of vulnerability to pollution. The main characteristics affecting the vulnerability of the groundwater to pollution are the type and thickness of the upper soil and the depth to groundwater (RIGW/IWACO, 1989).

Three agricultural areas, Mansuriya, Tahrir/Bustan, and Benha have been investigated for possible pollution from agricultural activities during the period from March to June, 1990. The main crops as well as the main chemicals which have been used during the investigation period are shown in Table III.1. Figure III.1 shows the investigated locations; while Table III.2 summarizes their characteristics.

Table III.1. Cropping Pattern and Use of Chemicals

AREA	CROPS		CHEMICALS	
	SUMMER	WINTER	PESTICIDES	FERTILIZERS
MANSURIYA	ONION FAVA BEANS MAIZE	CLOVER VEGETABLES	MALATHION LANITE OXICHLOR	UREA, SUPERPHOSPHATE AMMONIUM - NITRATE SULPHATE
TAHRIR/BUSTAN	MAIZE FAVA BEANS FRUITS	CLOVER CITRUS	MALATHION LANITE TEMEK	UREA, SUPERPHOSPHATE AMMONIUM - NITRATE POTASSIUM SULPHATE
BENHA	MAIZE SOYA BEANS COTTON	WHEAT, CLOVER FAVA BEANS VEGETABLES	MALATHION ACTELIC OXYCHLOR	UREA, SUPERPHOSPHATE AMMONIUM - NITRATE SULPHATE

Table III.2 Characteristics of the Study Areas

AREA	COVERING LAYER			DISTANCE POLLUTION SOURCE	WELL DEPTH (m)
	LAND USE	TYPE OF SOIL	THICKNESS		
1. BELBEIS	WASTE WATER D	CLAYEY SAND	4 - 11 m	3 - 100 m	5 - 12 m
2. SHEBIN EL KANATER	URBAN	CLAY		5 - 20 m	19 - 20 m
3. BENI SUEF	URBAN	SAND, CLAY	5 - 16 m	3 - 15 m	4 - 15 m
4. IMBABA, CAIRO	URBAN	CLAY	10 - 22 m	2 - 20 m	9 - 21 m
5. ABU RAWASH	URBAN	CLAYEY SAND	0 - 4 m	2 - 5 m	7 - 22 m
6. EL GABAL EL ASFAR	WASTE WATER	SAND	0	diffuse	5 - 12 m
7. GIZA	URBAN	CLAY	2 - 3 m	2 - 3 m	11 - 14 m
8. EL MANSURIYA	AGRICULTURE	CLAYEY SAND	0 - 2 m	diffuse	5 m, 33 m
9. EL TAHRIR/EL BUSTAN	AGRICULTURE	CLAY	15 - 20 m	diffuse	28 m, 62 m
10. BENHA	AGRICULTURE	SAND	0	diffuse	25 m, 51 m

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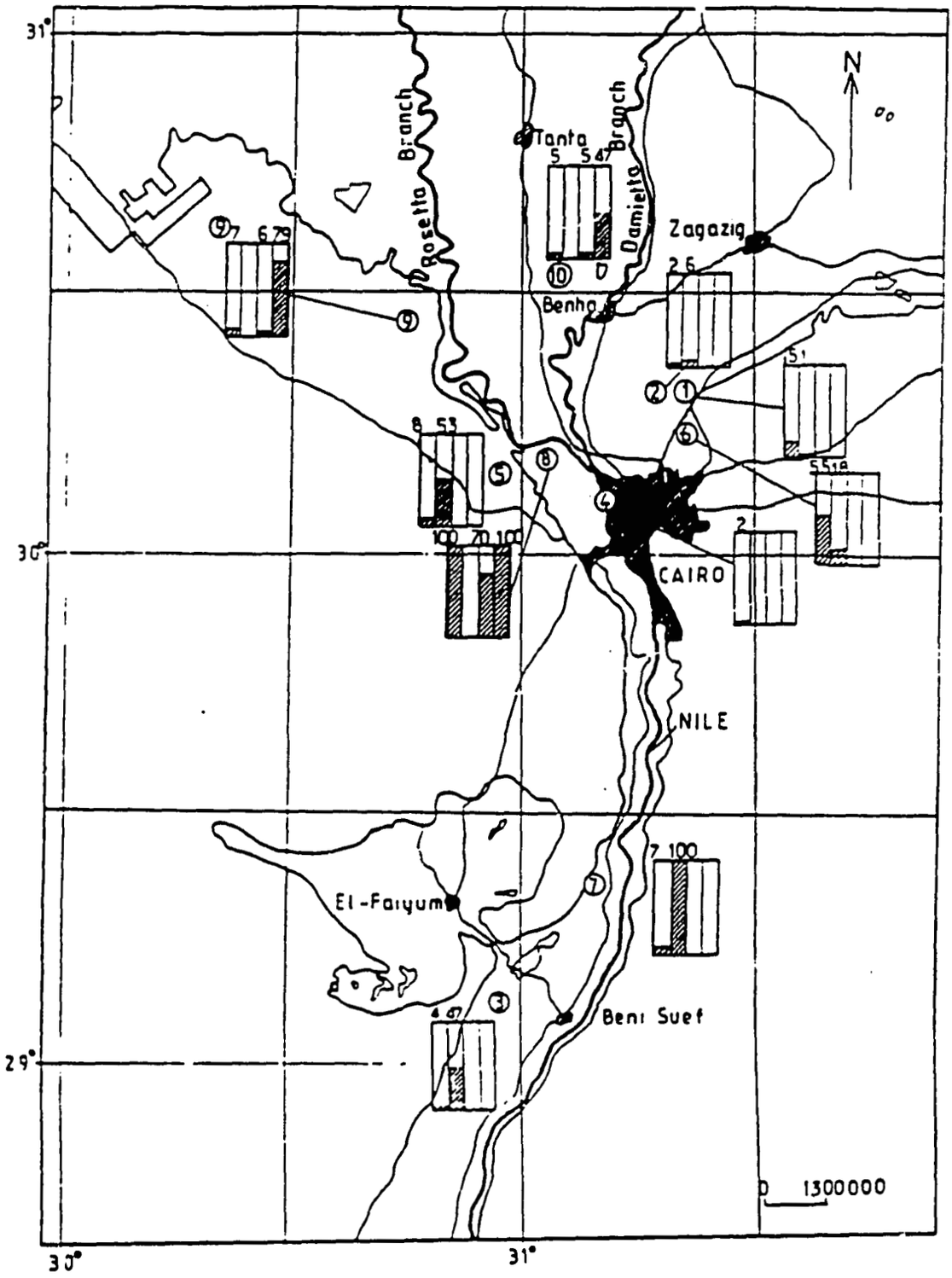

Figure III.1 Location Map of the Study Areas

The types of pesticides used have changed during the last 25 years from organo-chloro-pesticides to organo-phosphates. The use of various organo-chloro-pesticides is now prohibited as they accumulate in the food chain and have highly toxic properties. Fertilizer application has generally increased after the completion of Aswan High Dam and is believed to be used in high doses.

The main aim of the investigation was to trace the vertical distribution of fertilizers and pesticides in the groundwater system. Groundwater samples are extracted from hand pump and production wells. A total of 21 wells were sampled. The main parameters analyzed in the laboratory are the ammonium, nitrate, phosphate (total), organo-chloro pesticides, and organo-phosphates. Table III.3 summarizes the results of the laboratory analysis.

Table III.3. Summary of Laboratory Analysis for Agricultural Pollution of Groundwater

AREA	NUTRIENTS (mg/l)		PESTICIDES (Ug/l)		
	NH4+	MP3-	PO43-	CHLORO	PHOSPHORUS
8. MANSURIYA					
• shallow groundwater	2.9	110	0.03	5.7	5.3
• deep groundwater	4.1	2.5	0.02	8.1	1.5
9. TAHRIR/BUSTAN					
• shallow groundwater	1.9	8	0.02	0.5	4.2
• deep groundwater	2.7	4	0.01	0.6	3.4
10. BENHA					
• shallow groundwater	1.6	6	0.01	0.4	2.5
• deep groundwater	1.8	10	0.01	0.3	0.6

The groundwater in the area near Mansuriya contains high concentrations of both nutrients and pesticides. This is probably due to a combination of long-term cultivation and sandy soils. The recent cultivation of the desert areas of Tahrir/Bustan did not include the application of organo-chloro-pesticides. However, the impact of human activities already appears in the nitrate and organo-phosphates concentrations, which are on the same order of magnitude as in the Mansuriya area.

The higher concentrations of ammonium in deeper groundwater indicate the occurrence of denitrification. Total phosphate concentrations remain low in all situations, probably due to strong adsorption to the soil. The thick layers of clay prevent a serious migration of pollutants to the aquifer near Benha, with adsorption and cation exchange probably being the responsible processes.

The type and extent of pollution from agricultural activities as presented in this section is representative of different types of aquifers with similar characteristics in the Nile flood plain.

C-III.2 Domestic Activities

Domestic sewage could be considered either a diffuse source or a point source. At the location known as El Gabal El Asfar, irrigation depends on raw sewage (diffuse); while in Belbeis, the main source of pollution is a wastewater drain. Other locations appearing in Figure III.1 are point sources. The main characteristics of the seven studied locations for wastewater pollution are shown in Table III.2.

The average number of wells sampled in the seven selected locations is seven. The key parameters analyzed are: the total coliform, faecal coliform, and nitrate. Table III.4 summarizes the average analytical results of the key parameters for each area.

Table III.4. Summary of Laboratory Analysis for Domestic Sewage Pollution of Groundwater

AREA	(mg/l)		COLIFORM (MPN/100ml)		
	TDS	K	NO3	total	faecal
BELBEIS	1340	24	16	216	1 (60%)
SHEBIN EL KANATER	1120	8	1	1200	8 (30%)
BENI SUEF	1240	97	4	65	63 (60%)
IMBABA (CAIRO)	1800	13	2	12	0 (10%)
ABU RAWASH	930	33	9	378	72 (50%)
EL GABAL EL ASFAR	1420	15	61	352	25 (40%)
GIZA	820	12	8	450	135 (100%)

The concentration for nitrate and the count of faecal coliform are tracers of pollution from domestic sewage. The following trends can be concluded from the results:

1. A high level of faecal coliform is encountered in the urban areas with sandy or thin upper soils (Beni Suef, Abu Rawash, Giza). The nitrate concentrations are slightly higher in these locations.

2. A low to medium level of faecal coliform in sandy areas with wastewater drains and wastewater irrigation (Belbeis and El Gabal El Asfar). The nitrate concentration in theses areas shows a considerable increase.

3. Low levels of contamination with both faecal coliform and nitrate take place in urban areas with a thick covering clay-silt layer and, accordingly, a deep screen (Shibin El Kanater and Imbaba).

Previous investigations carried out in Egypt by the RIGW show similar tendencies in groundwater quality figures in urban areas. Most of these investigations indicated a sharp decrease in faecal coliform with depth in both unconfined and semi-confined aquifers. The survival time of faecal coliform is generally less than a year in groundwater due to the low velocity of groundwater flow. Under phreatic (unconfined) conditions, the travel time to the

aquifer is shorter; but the relatively long exposure to air increases die-off rates. One explanation to the existence of faecal coliform in groundwater could be its movement through the well itself or its sides (unsealed wells), as shown in Figure III.2.

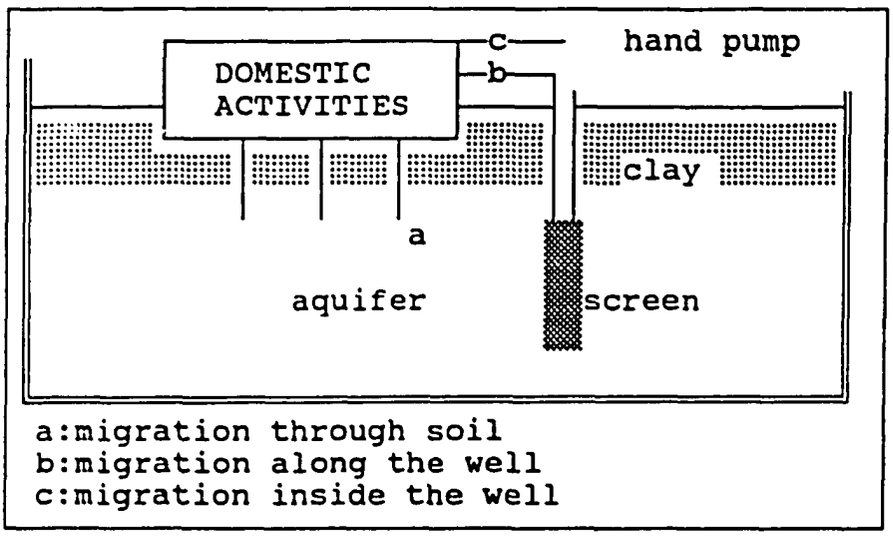

Figure III.2. Illustration of the Migration of Bacteria Near a Hand Pump

C-III.3 Industrial Pollution

Industries or industrial activities are mainly distinguished by the materials used or those produced during the production process. Materials are released as solids or liquids. Pollution from solid materials generally reaches the groundwater through percolation due to rain or irrigation. This threat is small in Egypt as rainfall is limited and disposal areas are far from agricultural activities. On the other hand, industrial liquids might seriously threaten the groundwater quality.

Figure III.3 illustrates some possibilities of leakage and pollution at industrial sites; while Table III.5 summarizes the pollutants that can be released with liquid materials and wastes from industrial working fields. The quantity as well as the type of wastewater differs from one industry to another.

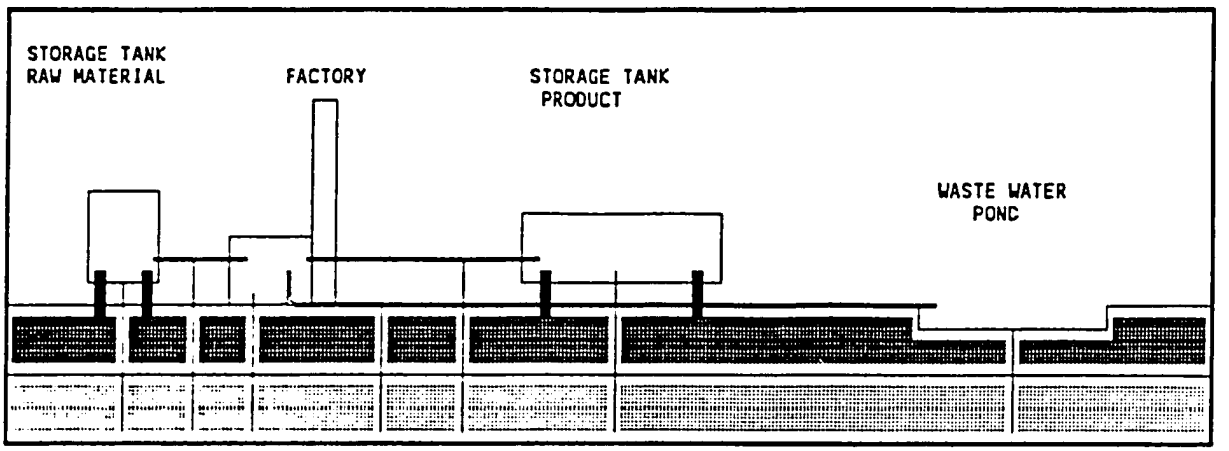

Figure III.3. Pollution at Industrial Sites

Table III.5. Pollutants from Industrial Activities

INDUSTRY	POTENTIAL POLLUTANTS	
	PRIMARY	SECONDARY
1. FOOD PRODUCTION	NON-CHEMICAL HYDROCARBONS AS PROTEIN	AMMONIA, OIL PRODUCTS
2. TEXTILE INDUSTRY		AROMATIC HYDROCARBONS, HEAVY METALS
3. WOOL, PAPER, AND GRAPHICAL INDUSTRY	AROMATIC HYDROCARBONS	MINERAL OILS, HEAVY METAL PHENOLS
4. CHEMICAL INDUSTRY	AROMATIC HYDROCARBONS, CHLORINATED HYDROCARBONS, ACIDS, ETC.	HEAVY METALS, PHENOLS, CYANIDE, ETC.
5. OIL AND SOAP INDUSTRY	MINERAL OILS, AROMATIC HYDROCARBONS	HEAVY METALS
6. METAL AND MACHINE INDUSTRY	HEAVY METALS	ACIDS (AROMATIC HYDROCARBONS), MINERAL OILS
7. ENERGY PRODUCTION INDUSTRY	MINERAL OILS	POLYCYCLIC HYDROCARBONS
8. CONSTRUCTION SUPPORTING INDUSTRY		MINERAL OILS
9. SMALL SCALE SERVICE	MINERAL OILS	AROMATIC HYDROCARBONS

1. Oil and oil products are often at the basis of industrial processes and are the most widespread pollutants in soil and groundwater. The most common representatives are aliphatic hydrocarbons (mineral oils), and aromatic hydrocarbons (benzene, toluene, xylene).

2. Heavy metals are not as widespread as the oil products but their release is very severe for certain types of industries (metal industry, graphical industry); especially acid wastewater which may contain heavy concentrations of specific heavy metals.

3. Chlorinated hydrocarbons (trichloro-ethane, tetrachloro-ethane) are basic products in the plastic industry. These products are used extensively worldwide as cleaning liquids (diluters of fats, oils, etc.), and can very often be found in the groundwater. It is unknown to what extent they are used in Egypt. If used, they are a serious threat to groundwater quality.

4. Other chemical substances used in Egypt with specific types of industrial processes include phenols, pesticides, cyanide, and polycycline hydrocarbons such as naphthalene.

In general, no direct recharge of industrial effluent is taking place to the aquifer system in Egypt. Industrial effluents are disposed either to the surface water conveyors or to the drains. The risk of pollutants reaching the groundwater depends on the hydrogeologic conditions and the vulnerability of groundwater to pollution.

SUPPLEMENTARY ANNEX C-IV

NITROGEN SURVEY IN THE DELTA REGION
RESULTS OF ANALYSIS FOR INDIVIDUAL SUBREGIONS

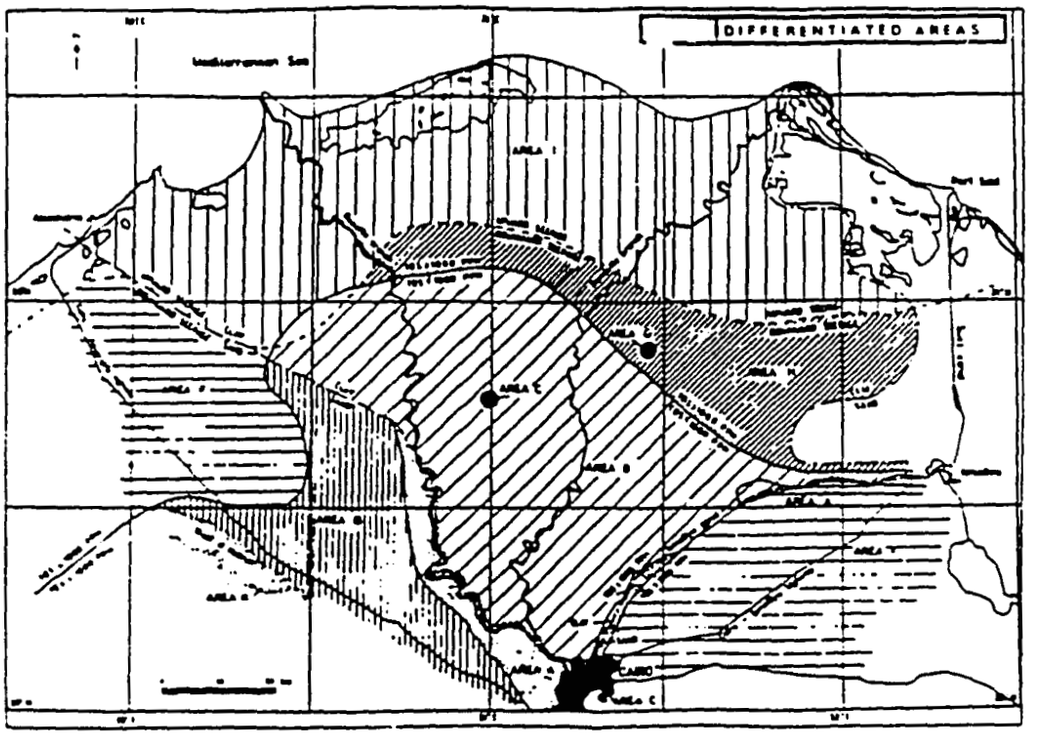

FIGURE IV.1 DIFFERENTIATED HOMOGENEOUS SUBREGIONS

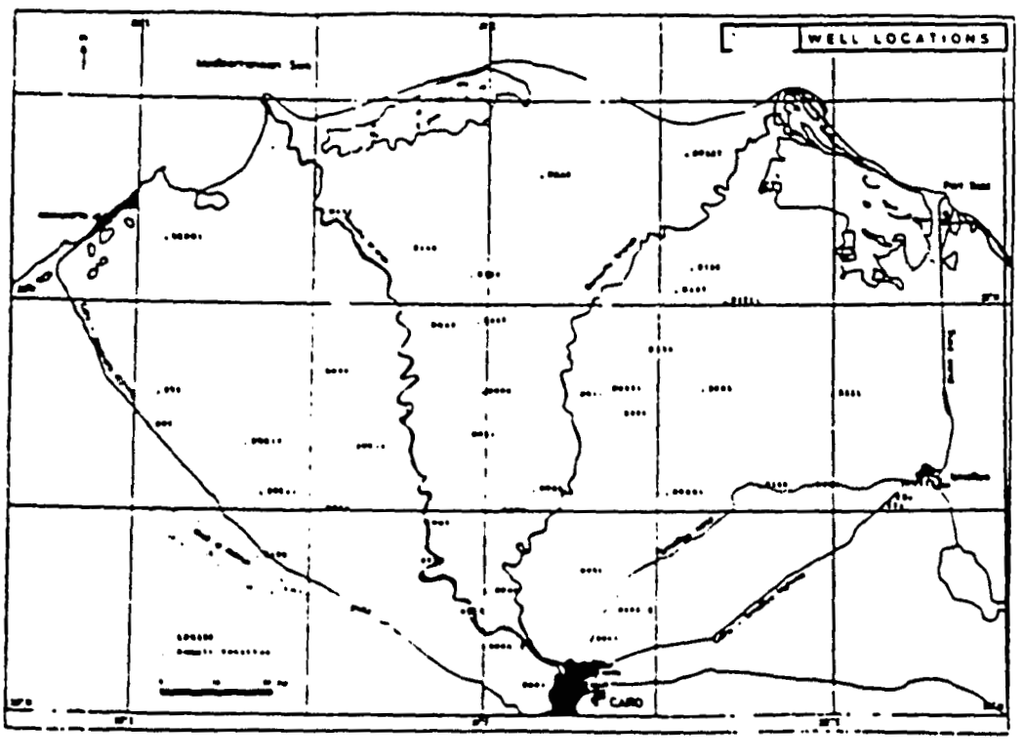

FIGURE IV.2 LOCATION OF OBSERVATION POINTS

AREA A

WELL	LOCATION	NUMBER AND TYPE OF WELLS
D085	KAFR DAWOOD	5 OBSERVATION WELLS
D095	ABU RAWASH	12 SHALLOW HAND PUMPS
D099.X	BIQUASH	6 IRRIGATION PUMPS
D109	EL HAYAKLA	2 DRINKING WATER PUMPS
D202.X	ABU ZAABAL	
D216	EL MANAYEF	
DWK6	EL QATTA	

DEPTH (m-GL)	EC (US/cm)	NH4- (mg/l)	NO2- (mg/l)	NO3- (mg/l)	Fe (mg/l)	Mn (mg/l)
WL-15	975	0.01	0.1	20.2	0.10	0.10
15-40	795	0.20	0.1	25.1	0.03	0.21
40-80	790	0.07	0.0	15.8	0.18	0.42

AREA B

WELL	LOCATION	NUMBER AND TYPE OF WELLS
DWK7	EL KHATATBA	3 OBSERVATION WELLS
DWK9	BIRIGAT	2 SHALLOW HAND PUMPS
DWK10	EL TAHADI	4 IRRIGATION PUMPS
DINA	DINA FARMS	2 DRINKING WATER PUMPS

DEPTH (m-GL)	EC (US/cm)	NH4- (mg/l)	NO2- (mg/l)	NO3- (mg/l)	Fe (mg/l)	Mn (mg/l)
WL-25	1240	0.00	0.1	73.6	0.50	0.06
25-50	705	0.10	0.1	14.5	0.01	0.05
50-100	1238	0.00	0.1	11.2	0.05	0.01
>200	330	0.00	0.0	2.2	0.03	0.01

AREA C

WELL	LOCATION	NUMBER AND TYPE OF WELLS
D010	ROXI/HELIOPOLIS	3 OBSERVATION WELLS
D020	TANTA	1 SHALLOW HAND PUMPS
D042	KOBA/CAIRO	1 DRINKING WATER PUMP

DEPTH (m-GL)	EC (US/cm)	NH4- (mg/l)	NO2- (mg/l)	NO3- (mg/l)	Fe (mg/l)	Mn (mg/l)
WL-35	765	0.70	0.1	4.6	-	-
35-70	900	0.80	0.0	6.6	-	0.0

AREA D

WELL	LOCATION	NUMBER AND TYPE OF WELLS
D011	BISHLA	14 OBSERVATION WELLS
D024	TALA	27 SHALLOW HAND PUMPS
D026	BURDEIN	5 IRRIGATION PUMPS
D028	QOUWEISNA	7 DRINKING WATER PUMPS
D036	SUBK EL AHAD	
D044	BAHTIEM	
D063'	SANAFA	
D070	KAFR EL BAGUR	
D108	MAZARA	
D205	MIT KINANA	
D247	EL KUNAYISA	
D248	BASYUN	
D320	EL QARADA	
D337	KAFR EL LIBBA	

DEPTH (m-GL)	EC (US/cm)	NH4- (mg/l)	NO2- (mg/l)	NO3- (mg/l)	Fe (mg/l)	Mn (mg/l)
WL-13	805	0.10	0.0	5.3	0.13	0.79
13-29	560	2.90	0.0	7.5	0.48	0.55
29-48	575	0.70	0.0	4.6	0.04	0.14
48-70	825	4.30	0.0	1.6	0.43	0.41
70-85	785	0.80	0.0	7.5	0.18	0.22
85-120	550	0.80	0.0	1.8	-	-

AREA F

WELL	LOCATION	NUMBER AND TYPE OF WELLS
DW5	BEHEIRA	4 OBSERVATION WELLS
DW9	BEHEIRA	2 IRRIGATION PUMPS
DWK11	BUSTAN EXTENSION	
DWK12	SHARAWAY	
EMA	EL MANAIF	
ESA	EL SAIDA	

DEPTH (m-GL)	EC. (US/cm)	NH4- (mg/l)	NO2- (mg/l)	NO3- (mg/l)	Fe (mg/l)	Mn (mg/l)
25-55	3665	0.00	0.1	7.2	0.34	0.07
55-100	2256	0.10	0.0	11.4	0.00	0.06

AREA G

WELL	LOCATION	NUMBER AND TYPE OF WELLS
D120	EL SIMBILLAWEIN	1 OBSERVATION WELL

DEPTH (m-GL)	EC (US/cm)	NH4- (mg/l)	NO2- (mg/l)	NO3- (mg/l)	Fe (mg/l)	Mn (mg/l)
50	2400	19.40	0.0	7.0	-	0.09

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AREA H

WELL	LOCATION	NUMBER AND TYPE OF WELLS
D065	KAFR SAKR	3 OBSERVATION WELLS
D148	EL GHUNEMY	2 SHALLOW HAND PUMPS
DSAL	EL SALHIYA	1 IRRIGATION PUMP

DEPTH (m-GL)	EC (US/cm)	NH4- (mg/l)	NO2- (mg/l)	NO3- (mg/l)	Fe (mg/l)	Mn (mg/l)
WL-15	1223	0.00	1.6	41.8	1.75	0.09
15-50	950	0.40	0.0	7.0	0.01	0.06
50-110	2195	0.30	0.0	3.1	-	0.58

AREA I

WELL	LOCATION	NUMBER AND TYPE OF WELLS
D121'	BENI EBEID	7 OBSERVATION WELLS
D125	DIKIRNIS	
D187	EL SADIYA	
D193	FUWA	
DHAM	EL HAMUL	
DKD31	KAFR EL DAWAR	
DWAST	EL WASATANE	

DEPTH (m-GL)	EC (US/cm)	NH4- (mg/l)	NO2- (mg/l)	NO3- (mg/l)	Fe (mg/l)	Mn (mg/l)
WL-10	10340	3.90	0.0	3.9	0.00	17.38
25-50	18800	12.10	0.0	3.1	-	0.88
50-90	17850	7.70	0.0	0.9	-	2.28
90-120	9300	12.90	0.0	9.7	-	0.42

AREA J

WELL	LOCATION	NUMBER AND TYPE OF WELLS
WADN	WADI EL NATRUN	1 IRRIGATION PUMP

DEPTH (m-GL)	EC (US/cm)	NH4- (mg/l)	NO2- (mg/l)	NO3- (mg/l)	Fe (mg/l)	Mn (mg/l)
39-50	1630	0.00	0.0	27.7	0.00	0.04
50-75	1030	0.00	0.0	9.7	0.04	0.06

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ANNEX D

SURFACE WATER QUALITY MONITORING

by

Amal El-Sherbini

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ANNEX D
SURFACE WATER QUALITY MONITORING

A. Past Monitoring Programs

A1. The Water Research Center Program

The Nile Research Institute (NRI) of the Water Research Center has carried out a monitoring program for the River Nile since 1976. NRI, with the Ministry of Health, carried out the prior monitoring program from 1976 to 1986 for the River Nile from Aswan to the Mediterranean Sea. Special programs were also carried out between NRI and the Water and Soil Sciences Department, Faculty of Agriculture, Alexandria University, for specific water quality studies on the Rosetta and Damietta Branches in 1987 and 1989.

To design any water quality monitoring program four questions must be considered. Why? Where? What? When? What are the program objectives, the program sampling locations, the program parameters, and the program frequency, respectively?

A1a. The Objectives

The main objective of monitoring the pollutants along the River Nile between 1976 and 1986 was to determine their effects on the water quality in its different uses.

In 1987, the sampling program on the Rosetta Branch studied change in water quality during the closure period (high flow) as it related to future projects for the storage of surplus water in the Northern Lakes. In 1989, the objectives of other sampling programs on the Rosetta and Damietta Branches were to:

- Evaluate the water quality of the Rosetta and Damietta Branches with respect to time and space,
- Evaluate the water quality and quantity of all point sources of pollution located along the two branches,
- Evaluate the water quality of the two branches for its different uses, and
- Calculate the quantity of surplus water to be stored in the Northern Lakes.

A1b. The Sampling Locations

The intensity of these water quality sampling campaigns lies in the space rather than in the time domain. In the River Nile from Aswan to the Delta Barrages (952 km), 398 points were sampled, some only once, during the eight years. They fall into two categories:

- 270 sampling sites every 10 km on the river, within 200 m upstream and downstream of all waste discharge points; and

- 128 sampling points at waste discharges, 72 of which are agricultural drains. These collect excess irrigation water from cultivated lands and return it to the River Nile. It has been recognized that many also receive municipal or industrial effluents. Figure 1 shows the distribution of the agricultural drains along the River Nile. The remaining 56 sampling points (of the 128) represent discharges of industrial or municipal effluents. Figure 2 shows their distribution along the River Nile.

Not all 398 points of the network were sampled in each campaign. Table 1 shows the total number of sampling points considered.

Thirty-five sampling points on the Rosetta Branch were considered for the campaigns of 1984, 1985, 1986, and 1987. These included 27 sites on the branch itself and eight located at the mouth of agricultural drains or industrial outfalls. Similarly, for the Damietta Branch, 31 sampling points were considered. These included 25 sites in the branch itself and six sampling points located at the mouth of the agricultural drains or at the industrial outfalls.

For the 1989 sampling campaign the network of points on the Rosetta Branch was reduced to 19 sites on the branch itself and eight located at the mouth of the agricultural drains or at industrial outfalls. On the Damietta Branch, 12 points were on the branch and six at the mouth of agricultural drains or industrial outfalls. In general, the sampling sites along both branches are located downstream of major point sources and downstream of large towns or cities.

The Parameters. All samples collected during the nine campaigns for the River Nile from Aswan to the Delta Barrages between 1979 and 1986 were analyzed for pH, temperature, conductivity, dissolved oxygen, carbon dioxide, ammonia, nitrite, nitrate, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids, ash of total dissolved solids, suspended matter, ash of suspended matter, total alkalinity, total hardness, calcium hardness, magnesium hardness, major anions and cations, oil and grease, phosphates, carbonates, sulphur, and fecal coliform. In addition, in 1986, the determination of five heavy metals was added to the parameters for the agricultural and some industrial drain effluents.

On the Rosetta and Damietta Branches, all samples collected during the four campaigns for 1984, 1985, and 1986 were analyzed for the same parameters measured in the River Nile from Aswan to Delta Barrages. Results for each parameter were obtained from composite samples over the cross section and all point sources of pollution.

For the 1987 and 1989 campaigns there were two major differences:

- Analyses also included pesticides and heavy metals in addition to the above parameters; and

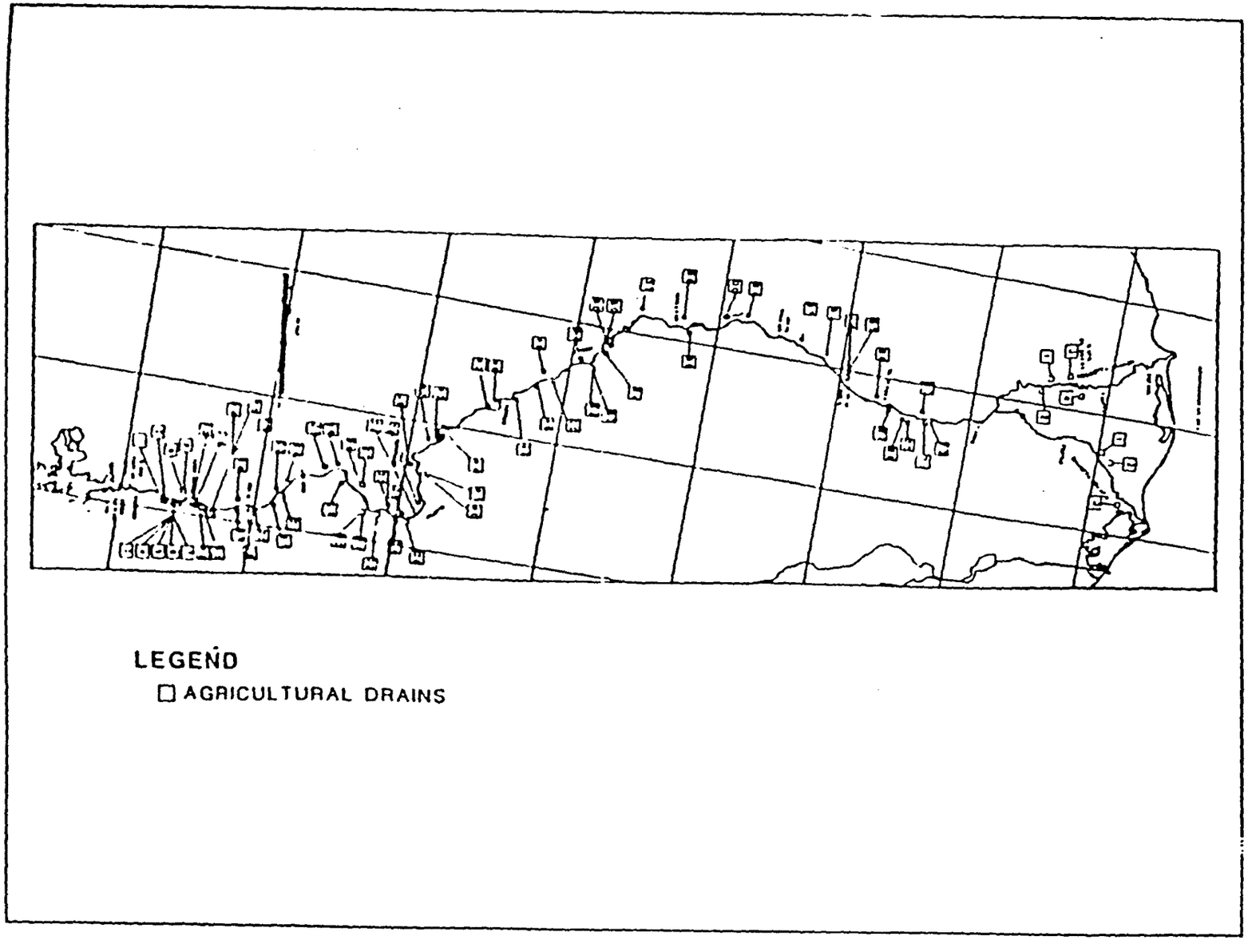
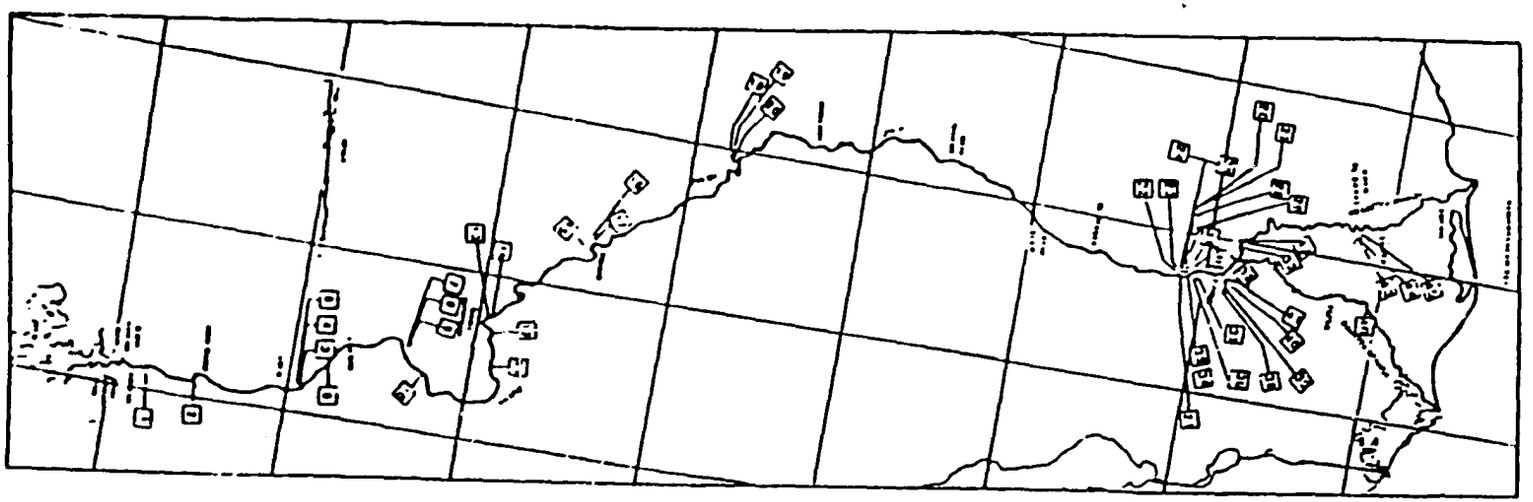


Figure 1. Agriculture drains entering the River Nile.



LEGEND

INDUSTRIAL OUT-FALL

Figure 2. Industrial sources of pollution entering the River Tyne.

Table 1. Number of Sampling Points per Campaign

	Location					
	Aswan to Delta		Rosetta Branch		Damietta	
	in river	at pollution points	in river	at pollution points	in river	at pollution points
1976	88	43				
1977	142	48				
1978	153	70				
1979	110	73				
1984	158	71	25	7	22	3
	176	66	25	6	20	3
1985	193	72	16	6	18	3
1986	203	82	21	8	22	3
1987			19	8	-	-
1989			19	8	12	6

- Water quality was determined for depth-integrated samples taken at various locations in the lateral direction in addition to comsat samples over cross sections.

The Frequency. The monitoring program was conducted during two periods. During the first period, between 1976 and 1979, samples were taken once a year by HADSERI and the Central Laboratories of the Ministry of Health. However, an analysis of the data showed that the purity of the water changed from year to year along the River Nile. Therefore, during the second period starting in 1984 samples were to be taken twice a year for five years. These data were expected to give a clear picture of the Nile water and enable a projection to be made for changes in the water quality. However, this program, conducted by NRI and the Occupational and Environmental Health Center of the Ministry of Health, was carried out twice during 1984 and only once a year in 1985 and 1986.

The dates of the various campaigns between Aswan and the Delta Barrages are detailed in Table 2.

Field Sampling Procedures

- At each sampling site in the river, a composite sample was obtained over the cross section by mixing the grab samples taken at 50 cm below the surface and at 70 cm

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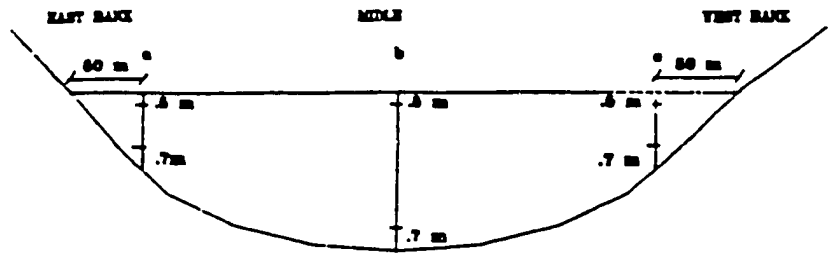
Table 2. Dates of Sampling Campaigns from Aswan to the Sea

	Location					
	Aswan to Delta		Rosetta Branch		Damietta Branch	
Year	from	to	from	to	from	to
1976	22 Jun	3 Jul				
1977	11 Oct	22 Oct				
1978	11 Aug	23 Aug				
1979	19 Mar	30 Mar				
1984	1 Mar	15 Mar	23 Jul	25 Jul	30 Apr	6 May**
	21 Oct	9 Nov	29 Aug	3 Sep	18 Aug	22 Sep
1985	21 Jul	3 Aug	23 Aug	24 Aug	19 Aug	22 Aug
1986	14 Sep	27 Sep	20 Oct	22 Oct	15 Oct	19 Oct
1987			19 Jan	24 Jan		
			23 Apr	25 Apr		
1989			2 Jan	6 Jan	5 Feb	8 Feb
			12 Jan	17 Jan	30 May	31 May
			20 Jan	24 Jan		
			10 Feb	13 Feb		
			24 May	28 May		

*Not all samples taken
**includes 2 days off

above the bed at three locations in the lateral direction, i.e., at 50 meters from each bank, and at the middle (Figure 3-A).

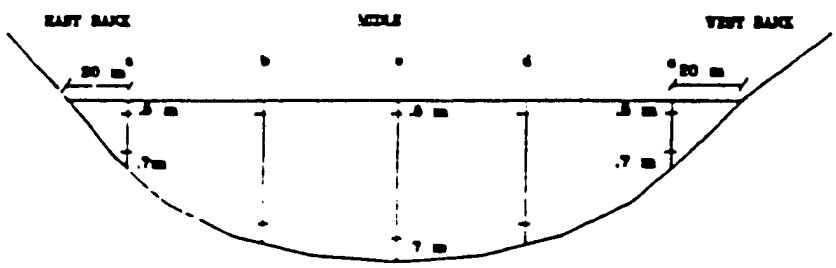
- A grab sample was taken from all point sources at the middle of the source.
- Depth and flow velocity was measured at the three sampling locations along the cross section.
- The grab samples were mixed on the boat to form the composite samples. Temperature, pH values, dissolved oxygen, and conductivity were determined in the boat as in-situ parameters.



Note

Velocity at .2 and .8 the depth of the water for each sampling location

Figure 3-A. Sampling procedures on the River Nile during 1976-86.



Note

Velocity at .6 the depth of the water for each sampling location

Figure 3-B. Sampling procedures on the River Nile during 1987-89.

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- Part of each composite sample was sent to the nearest regional laboratory for the analysis of BOD, COD, and coliforms; the remainders were periodically sent by car to the laboratory in Cairo.

- In the 1987 sampling campaign, the surface and subsurface lateral samples at each location were analyzed separately.

- In the 1989 sampling campaign, two types of water samples were collected:

  - Three to five vertical integrated samples were collected from certain locations in the river (Figure 3-B), and

  - Composite water samples were formed from these vertical integrated samples for each site.

Therefore, from four to six samples were analyzed from each site.

All the analyses were carried out from 1976 to 1979 by the Central Laboratory in Cairo and the regional laboratories of the Ministry of Health. However, from 1984 to 1986, all analyses were carried out by the Environmental and Occupational Health Center and the regional laboratories of the Ministry of Health. In 1987 and 1989, all the analyses were carried out by Soil and Water Department, Faculty of Agriculture, University of Alexandria. A group of specialists from NRI conducted all the sampling processes for the above programs by using the institute's facilities, such as boats, current meters, and samplers.

A2. The Irrigation Sector

The MPWWR Irrigation Sector, with advice from the Supreme Committee for the River Nile, had started, through the local irrigation departments with the cooperation of the Ministries of Interior and Health, a plan to implement Law 48-1982 concerning the River Nile and its waterways. This plan was to protect against pollution through inspections and enforcement of the law. However, it was not feasible to implement this law because of the high cost of the treatment units.

The Sampling Locations

- Sampling and analyses of drinking water intakes to treatment plants
- Sampling and analyses of drinking water supplies, either surface or ground
- Sampling and analyses of industrial and municipal wastes

The Parameters. The parameters monitored are those mentioned in Law 48/82.

The Frequency. All the samples and analyses were done regularly. All analyses were carried out in the Central Laboratory in Cairo and the regional laboratories of the Ministry of Health. The Supreme Committee of the River Nile gave the people responsible

for discharging effluents many deadlines by which they were supposed to treat their wastes in order to meet the specifications of the law.

The last deadline was the end of June 1986. MPWWR departments reported about 4,000 penalties for different industries whose wastes did not meet specifications. However, only 1,700 of these industries completed the requested improvements; 23,000 are still discharging their wastes into the River Nile without treatment. Most of these industries are related to the public sector, and municipal and domestic wastes.

A3. Egyptian Academy of Scientific Research and Technology

In 1975, The Egyptian Academy of Scientific Research and Technology, in collaboration with the University of Michigan, initiated research investigations on the River Nile.

A3a. The Objectives

The main goal of these studies has been to assess current and future water quality and aquatic ecosystem characteristics with emphasis on the effects of the Aswan High Dam, river flow controls, and agricultural and industrial development programs. This includes public health and socioeconomic implications. The overall aim is to provide the policy and decision makers in Egypt with factual information on present conditions, predictions of future trends, and strategy alternatives for lake and river resource management.

A3b. The Sampling Locations.

The River Nile was divided into segments as follows:

- Lake Nasser and Aswan Reservoir
- Aswan segment
- Assiut segment
- Cairo segment
- Zifta segment
- Faraskour segment
- Rosetta segment

A3c. The Parameters

The study provides a wide range of water quality parameters and a variety of biotic factors. The water quality analyses include physiochemistry, bacteriology, benthos, phytoplankton, zooplankton, fish, hydrophytes, and aquatic shore plant.

A3d. The Frequency

During 1975 and 1976, the program was carried out monthly, some time later, the program was carried out quarterly until the end of 1980. In 1981 and 1982, the program was carried out once a year.

All the analyses were carried out in the NRC's Water Pollution Control Department in Cairo.

B. Current Monitoring Programs

B1. Ministry of Public Works and Water Resources Water Research Center

The NRI has carried out a monitoring program for the River Nile since 1976. The analysis of data has indicated that the River Nile from Aswan to the Mediterranean Sea is suffering from pollution in some locations. This result highlights the need to establish a permanent water quality monitoring program along the river. The permanent water quality monitoring is designed as discussed below:

B1a. The Sampling Objectives

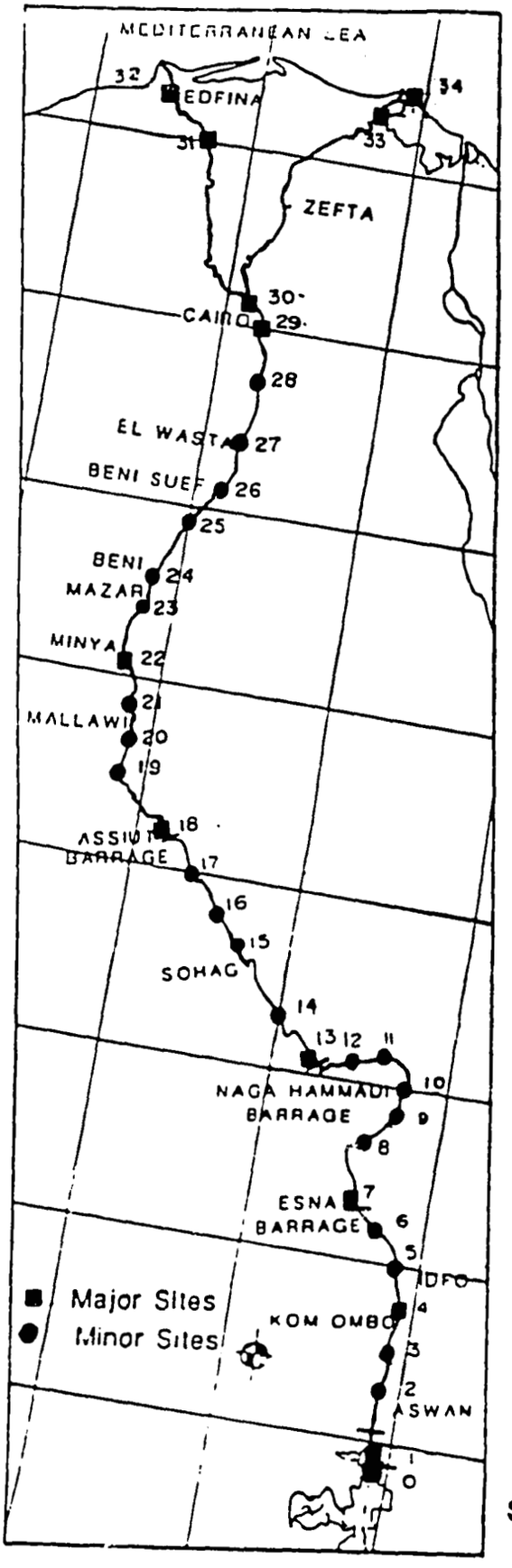
The laboratory will serve as a general reference for water quality conditions in the whole river, detect stream standard violations and maintain effluent standards, and determine the quantitative seasonal variations of the water quality in the river and the point sources.

B1b. The Sampling Locations

The location of permanent sampling sites is probably the most critical factor in designing a monitoring program for water quality. The River Nile system will be divided into four main reaches in addition to the branches as follows:

- Aswan to Isna Barrage (km 0 to km 167)
- Isna Barrage to Nag Hammadi Barrage (km 167 to km 359)
- Nag Hammadi Barrage to Asyut Barrage (km 362 to km 544)
- Asyut Barrage to Delta Barrage (km 544 to km 952)
- Rosetta Branch
- Damietta Branch

Along the River Nile from Aswan to the Mediterranean Sea, there are 35 sampling sites (Figure 4). The number and location of the sites were selected to minimize the sampling effort to obtain a maximum of spatial information while minimizing the number of sampling sites, and to get comprehensive information at specific sites that are important point sources of pollution.



Sampling Locations

Figure (4)

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Priority was given to 13 major sites out of the 35. These 13 include sites at barrages, and in the major industrial areas, intensive agricultural areas, and large cities (Figure 4). The other 22 sites were selected at fixed, well known points along the River Nile in order to fill the gaps between the major sites and to present different stages along the river. In addition to the 35 sampling sites, all the point sources of pollution were sampled (Figures 1 and 2).

B1c. The Parameters

Parameters measured by the water quality monitoring program are highly dependent upon the objectives, basin characteristics, and the budget required. A group of basic parameters (Table 3) is measured in all samples (i.e., in the river or point sources) in addition to some specific parameters depending on the type of effluents and the importance of the site.

A list of the major agriculture or industrial effluents was determined by considering the type and concentration of pollutants, waste load, and some other specific criteria such as location and area served for agricultural drains and type of industry for industrial outfalls.

B1d. The Program Frequency

The sampling frequency at each permanent sampling site within a river basin is a very important consideration in the design of a water quality monitoring program. In the case of the River Nile, constant frequencies overall at sites and samples from point sources may be the only practical means to implement a sampling program.

The sampling frequencies are planned in three stages as follows:

Short-term (one year)

- Once a year for minor point sources of pollution
- Twice a year for all river sites (35) and the major point sources of pollution
- Monthly for five river sites which are:
  - Upstream of the High Aswan Dam
  - Downstream of the High Aswan Dam
  - Upstream of the Delta Barrage
  - Upstream of the Idfina Barrage
  - Upstream of the Damietta Dam

Medium-term (two years)

- Twice a year for the minor point sources of pollution
- Four times a year for all river sites (35) and the major point sources of pollution
- Monthly for the five river sites as mentioned in the short term

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Table 3. Parameters to Be Used for Monitoring the River Nile

All Samples (Basic parameters)	Major River Sites(12)	All Agricultural Drains	All Industrial Outfalls	All Sites
* pH-value	All parameters	Calcium	Sulfide	Algal density
* Temperature		Magnesium	Acidity	Chlorophyll A
* Conductivity		Sodium	Calcium	
* Dissolved oxygen		Potassium	Magnesium	
*Total alkalinity		Oil and Grease	Sodium	
*Turbidity		Phenols	Potassium	
Kjeldahl nitrogen		Pesticides	Oil and grease	
Ammonia (dissolved)		Surfactant	Phenols	
Nitrite (dissolved)		Total copper	Surfactant	
Ortho-phosphorus		Total lead	Total lead	
Total phosphorus		Total zinc	Total zinc	
Biochemical oxygen demand			Total chromium	
Chemical oxygen demand			Total arsenic	
Total suspended solids			Total mercury	
Total dissolved solids			Total calcium	
Chlorides			Iron	
Sulphates			Manganese	
Carbonates			Cyanide	
Bicarbonates			Total nickel	
E.coli Fecal coliform				

* Field parameters

** Should also include dissolved oxygen, temperature and conductivity profile at mid-channel.

Long-term (three years and above). In addition to the medium-term work, special studies could be done for specific areas or certain drains for modelling purposes, or on the bottom sediment for the major sites. The seasonal sampling will be adjusted according to the thermograph.

B1e. Field Procedures

To get representative sampling sites, some general recommendations should be followed.

At all sites, depth integrated samples (from three to five samples) will be taken. Composite samples will be formed from all the integrated samples, taking into consideration the depth adjustment for the volume being contributed to the composite for each point in the cross sectional. Sampling points can be expanded beyond five if a considerable number of point sources have inflows upstream of the sampling site (Figure 5).

Field, biological, and bacteriological measurements will be determined in all vertically integrated samples for all sites. The rest of the measurements will be conducted on the composite samples for all samples in the laboratory.

Flow velocity measurements will be obtained in the lateral direction at each sampling point at six-tenths of the depth measured from the water surface.

A grab sample will be taken from all point sources and flow velocity measurements will be obtained.

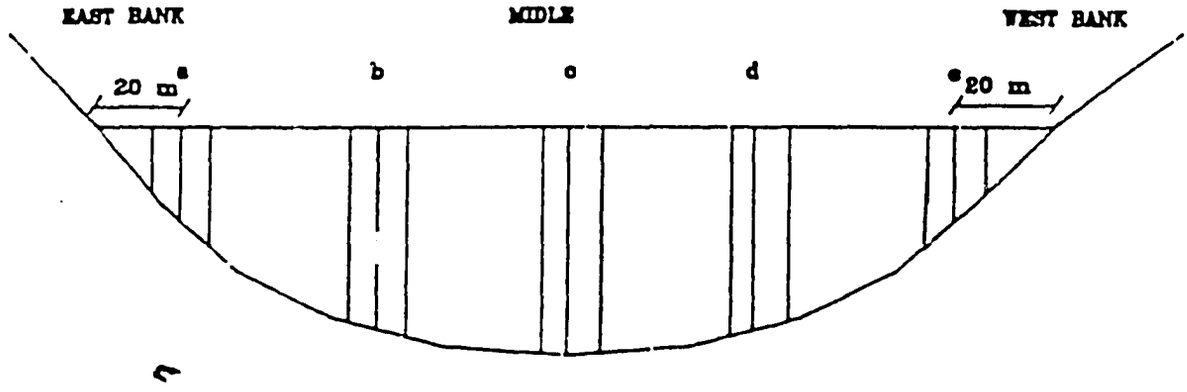
B1f. The Implementation

The program sampling campaign was implemented for the first time in July 1991 for all 35 river sites and major point sources of pollution. In addition, a special study was carried out on the Rosetta and Damietta Branches during the winter closure period of 1990/91.

This study was carried out four times for eight sites and eight point sources of pollution on Rosetta Branch and only one site on Damietta Branch. All the analyses of these campaigns are carried out at the new NRI laboratory at Qanater.

B2. Ministry of Health

MOH is responsible for public health. Since the Nile provides most of the drinking water, Nile water pollution control is one of the ministry's main concerns. The executing departments of MOH and their responsibilities are described below.



Note

Velocity at .6 the depth of the water

Figure(5)New sampling procedures on the River Nile.

B2a. Environmental Health Department

EHD is responsible for sampling drinking water treatment plants, sanitary sewage and industrial discharges, according to the specifications and laws, and establishing standards of water for various uses, in addition to standards for polluting effluent and receiving water bodies. All analyses are carried out in the central laboratory in Cairo and the MOH regional laboratories.

B2b. Environmental and Occupational Health Center

EOHC, established about five years ago, is responsible for environmental monitoring (water, air, and soil). Two years ago the EOHC started, in cooperation with the Egyptian Environmental Affairs Agency, to establish a national network for a water pollutant monitoring program for the River Nile and its main canals. The program has already been implemented in its main canals using nine laboratories in governorates in Upper Egypt and the Nile Delta.

The work plan for 1988/89 for this program has the following objectives:

- To monitor the water quality of the River Nile channel and its branches and to follow the changes,
- To follow and control the different sectors along the River Nile that face pollution problems,
- To determine and identify pollution sources and monitor their quality and quantity, and
- To ensure the effectiveness of policy for pollution abatement.

The network is served by nine labs of Upper Egypt and the Delta in the governorates of Aswan, Assiut, Minia, Beni-Sewif, Greater Cairo, Gharbia, Dakahlia, Damietta, and Alexandria. In each area, the sampling points were located in all waterways such as the main channel of the river and its branches, main canals, agricultural drains, and industrial effluent points. The distribution of sampling points is as follows:

- 83 points along the main river channel
- 87 points along the main canal
- 90 points from the point sources

Sampling Locations

- Upstream and downstream discharge points along the River Nile system and main irrigation canals,

- Upstream of the intakes of water treatment plants along the river system and main canals,

- Upstream and downstream of some towns and villages located along the River Nile system and main canals which discharge their wastes directly into the water, and

- All point sources along the River Nile system and main canals.

All samples taken were composites.

The Program Parameters

- DO, BOD, COD
- pH, alkalinity, hardness
- So4, Cl, PO4 (ortho and total), S2, SiO2
- Conductivity, TDS, TSS
- NH4, NO2, NO3
- Na4, K, Ca, Mg, Fe, Mn
- Bacterial count

The Central Lab of the EOHC will help prepare and measure the heavy metals, organochlorine compounds, and detergents.

Sampling Frequency. All samples from each discharge point will be taken every three months. However, all sampling points on the River Nile and its main canals will be taken monthly.

C. Availability and Reliability of Information

Hydrological and water quality data on the River Nile and groundwater in Egypt are currently scattered among various government agencies, municipalities along the river, universities, and research institutes. The majority of this information is found in reports or published articles prepared by the respective agencies. Too often these data are considered to have served their purpose once they become a part of a specific study on a particular situation, and appear frequently in the appendix of a report.

Furthermore, water quality and flow data currently generated by the various agencies in Egypt are not easily accessible and, if made available, cannot be readily used by other agencies.

The data collected by NRI through its monitoring programs since 1976 are stored in tables format on computers using the available software, LOTUS 1-2-3. These tables include data on the sampling locations, the river characteristics, field information, field measurements, and laboratory measurements. They are stored on floppy disks and computer printouts.

Recently, NRI established its own water quality database, an ongoing activity. The stored data will be transferred from LOTUS 1-2-3 to Data Base IV soon.

Another important concern to the user is the reliability and validity of data. Little of the data stored on LOTUS 1-2-3 have been screened or evaluated, and most of the reviewed data is published.

Therefore, NRI will include in the new system storage of the water quality data in Data Base, a data quality control and validation program that confirms the reliability and validity of the water quality data collected or stored by NRI.

However, the data collected by other agencies will probably be stored in the computers or as hard copies on the reports.

D. Sources of Pollution

Along the River Nile from Aswan to the Mediterranean Sea are 88 agricultural drains located on both sides. Besides the irrigation excess water, these drains receive municipal wastes and 59 receive outfall from industries such as sugar, chemicals, and pulp and paper.

Either the agricultural drains or the industrial outfalls discharged their wastes with little or no treatment. All point sources of pollution located along the River Nile are listed according to their distance from Aswan in Table 4.

D1. Flow Rates and Type of Contaminants

Flow rates are measured in most agricultural drains located along the River Nile from Aswan to the Mediterranean Sea. Total discharge is mcm/dy from Aswan to Delta Barrage from the agricultural drains located along the Nile that discharge their wastes directly into the river is shown in Table 5.

In addition to the flow rates, the samples are measured for a group of contaminants such as TDS, PO4, NH3, NO2 in the vicinity of the drains. However, the flow rates for the industrial outfalls are recorded whenever available, and the same contaminants are also measured at the final discharge. The load in ton/d was calculated for each contaminant.

Table 4. List of Drains and Industrial Effluents

Serial No.	Km From Aswan	Name	Description
1	6.000	Aswan SewerageDrain	Sewarage Drain
2	9.900	Khour El Sail Drain	Agricultural Excess Water R.B.
3	37.250	El Tawansa Drain	Agricultural Excess Water R.B.
4	42.500	El Sheikh Ibrahem Drain	Agricultural Excess Water R.B.
5	46.550	El Ghaba Drain	Agricultural Excess Water R.B.
6	47.150	Abu Wanas Drain	Agricultural Excess Water R.B.
	47.500	G.B.Drain *	Agricultural Excess Water R.B.
7	48.000	El Shatb Drain	Agricultural Over Flow From Canal R.B.
8	48.850	Main Draw Drain	Agricultural Excess Water R.B.
9	49.100	EL Berba Drain	Agricultural Excess Water R.B.
10	50.000	Kom Ombu Sugar Ind.	Industrial Effluent R.B.
11	51.000	Kom Ombu Drain *	Agricultural Excess Water R.B.
12	53.000	Benban Drain	Agricultural Excess Water L.B.
13	55.000	Meneha Drain *	Agricultural Excess Water R.B.
14	57.650	Main Ekleet Drain	Agricultural Excess Water R.B.
15	63.600	Ekleet Power Station	Power Station
16	64.650	Berak El Raghama Drain	Agricultural Excess Water R.B.
17	70.450	Fatera Drain	Agricultural Excess Water R.B.
18	70.750	Khour El Sail Drain	Mixed From Water & Ind. R.B.
19	73.850	Selesla Drain	Agricultural Excess Water R.B.
20	75.750	Kagouk Drain *	Agricultural Excess Water R.B.
21	76.000	Awarta Drain *	Agricultural Excess Water R.B.
22	99.850	Radisia Drain	Agricultural Excess Water R.B.
23	101.750	Hasia Drain *	Agricultural Excess Water L.B.
24	109.250	Hager Drain *	Agricultural Excess Water L.B.
25	116.200	Edfu Drain *	Agricultural Excess Water R.B.
26	119.600	Kalh Power Station	Power Station
27	122.450	Edfu Paper Pulp A	Industrial Effluent L.B.
28	122.500	Edfu Paper Pulp B	Industrial Effluent L.B.
29	123.000	Edfu Sugar Ind	Industrial Effluent L.B.
30	135.600	El Mahameed Drain	Agricultural Excess Water R.B.
31	139.500	Houd El Sabaia	Agricultural Excess Water L.B.
32	143.100	Hagz El Bahary Drain	Agricultural Excess Water R.B.
33	147.000	Seba Phosphate drain	Industrial Effluent R.B.
34	149.100	Hagar El Sebia	Agricultural Excess Water L.B.
35	187.700	Mataana Drain *	Agricultural Excess Water L.B.
36	196.700	Ghoreara Drain	Agricultural Excess Water L.B.
37	204.500	Armant Sugar Ind 1	Industrial Effluent L.B.
38	204.505	Armant Sugar Ind.2	Industrial Effluent L.B.
39	204.510	Armant Sugar Ind.3	Industrial Effluent L.B.

* To Be Checked

Table 4. List of Drains and Industrial Effluents (continued)

Serial No.	Km From Aswan	Name	Description
40	209.000	El Salamia Drain *	Agricultural Excess Water R.B.
41	220.800	El Mraibia Drain *	Agricult.Excess Water From Canal L.B.
42	220.850	El Rayayna Drain	Agricultural Excess Water L.B.
43	224.500	Outlet Louxor Water Treatment *	Industrial Effluent
44	236.000	El Zeinia Drain	Agricultural Excess Water R.B.
45	237.700	Habail El Sharky Drain	Agricultural Excess Water R.B.
46	245.100	El Shanhoria Drain	Agricult.Excess Water From Canal R.B.
	246.850	Ques Sugar Ind. *	Industrial Effluent R.B.
47	251.550	Danfik Drain	Agricultural Excess Water L.B.
48	265.300	Sheikhia(El Hagaza) Drain *	Agricultural Excess Water R.B.
49	265.400	Grinding Mill *	Industrial Effluent L.B.
50	270.700	El Ballas Drain	Agricultural Excess Water L.B.
51	275.900	Kaft (Qift) Drain	Agricultural Excess Water R.B.
52	286.750	El Tramasa Drain	Agricultural Excess Water L.B.
53	288.800	Khour El Sail Qena *	Mixed From Agr.& Ind. R.B.
54	299.750	Bahari Dandra Drain *	Agricult.Excess Water From Canal R.B.
55	314.000	Deshna Sugar Ind.	Industrial Effluent R.B.
56	331.200	Hamad Drain *	Agricultural Excess Water R.B.
57	333.500	Salamia Drain *	Agricultural Excess Water R.B.
58	337.500	Alumenium Ind. *	Industrial Effluent
59	340.350	Magrour Hoe Drain	Agricultural Excess Water L.B.
60	343.200	Naga Hammadi Sugar Ind.A.	Industrial Effluent L.B.
61	343.250	Naga Hammadi Sugar Ind.B.	Industrial Effluent L.B.
62	363.000	Abu Homar Power Station	Power Station
63	377.800	Naga Hamadi Drain	Agricultural Excess Water L.B.
64	384.000	Abu Shousha Drain *	Agricult.Excess Water From Canal L.B.
65	392.750	Mazata Drain	Agricultural Excess Water R.B.
66	432.700	Essawia Drain *	Agricult.Excess Water From Canal L.B.
67	443.200	Onion Ind.	Industrial Effluent L.B.
68	444.550	Souhag Drain	Agricultural Excess Water L.B.
69	445.600	Souhag Oil Ind	Industrial Effluent L.B.
70	445.605	Cocacola Ind	Industrial Effluent L.B.
71	454.700	Seflak Drain	Agricultural Excess Water R.B.
72	473.850	Ekheem Drain	Agricultural Excess Water R.B.
73	486.400	Raaina Drain *	Agricult.Excess Water From Canal R.B.
74	486.700	Tahta Drain	Agricultural Excess Water L.B.

* To Be Checked

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Table 4. List of Drains and Industrial Effluents (continued)

Serial No.	Km From Aswan	Name	Description
75	520.800	Abu Teeg Drain	Agricultural Excess Water L.B.
76	525.400	El Badary Drain	Agricultural Excess Water R.B.
77	525.850	El Metmar Drain	Agricult.Excess Water From Canal R.B.
78	536.000	Assuit Power Station *	Power Station
	537.000	Assuit Water Treatment Plant *	Industrial Effluent
79	541.600	Selim Drain *	Agricultural Excess Water L.B.
80	544.250	Marawana Drain *	Agricultural Excess Water R.B.
81	550.200	El Zenar Drain	Agricultural Excess Water L.B.
82	552.200	Mankabad Pipe 1	Industrial Effluent L.B.
83	552.205	Mankabad Pipe 2	Industrial Effluent L.B.
84	552.210	Mankabad Pipe 3	Industrial Effluent L.B.
85	588.600	Bany Shaker Drain *	Agricultural Excess Water L.B.
86	637.400	El Rayamoun Drain	Agricultural Excess Water L.B.
87	642.750	Abu Henis Drain	Agricultural Excess Water R.B.
88	682.000	Minia Water Treatment Plant *	Industrial Effluent
89	682.500	Makoussa Drain	Agricultural Excess Water L.B.
90	701.100	Etsa Drain	Agricultural Excess Water L.B.
91	752.150	El Sheikh Zied Drain	Agricultural Excess Water L.B.
92	780.500	Ebsug Drain *	Agricultural Excess Water L.B.
93	807.000	Beni Suif Water Plant *	Industrial Effluent
94	807.200	Ahnasia Drain	Agricultural Excess Water L.B.
95	808.000	El Saayda Drain	Agricultural Excess Water L.B.
96	841.000	El Zawia Drain	Agricultural Excess Water L.B.
97	848.900	Khour El Sail Atfih Drain	Agricultural Excess Water R.B.
98	865.200	El Dessamy Drain *	Agricultural Excess Water R.B.
99	871.300	kafr Gazara (El Saaf) Drain	Agricultural Excess Water R.B.
100	879.600	El Masanda Drain	Agricultural Excess Water R.B.
101	884.500	Ghamaza El Soghra Drain	Agricultural Excess Water R.B.
102	888.950	Ghamaza El Kobra Drain	Agricultural Excess Water R.B.
103	898.100	El Tibeen Drain	Mixed From Agricultural & Ind.R.B.
104	901.000	Tibeen Power Station *	Power Station
105	904.000	Hawamdia Chemical 1 *	Industrial Effluent L.B.
106	904.080	Hawamdia Chemical 2 *	Industrial Effluent L.B.
107	904.300	Hawamdia Chemical 3 *	Industrial Effluent L.B.
108	904.350	Hawamdia Chemical 4 *	Industrial Effluent L.B.
109	909.200	Helwan Power Station *	Power Station
110	910.150	Khour Sail El Badrashin	Mixed From Agricultural & Ind.R.B.

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Table 4. List of Drains and Industrial Effluents (continued)

Serial No.	Km From Aswan	Name	Description
111	911.400	Chemical Ind.	Industrial Effluent L.B.
112	911.900	Hawamdia Sugar Maulas	Industrial Effluent L.B.
113	912 100	Hawamdia Sugar Pipe 1	Industrial Effluent L.B.
114	912.105	Hawamdia Sugar Pipe 2	Industrial Effluent L.B.
115	912.115	Hawamdia Sugar Pipe 3	Industrial Effluent L.B.
116	912.120	Hawamdia Sugar Pipe 4	Industrial Effluent L.B.
117	912.125	Hawamdia Sugar Pipe 5	Industrial Effluent L.B.
118	912.130	Hawamdia Sugar Pipe 6	Industrial Effluent L.B.
119	912.900	Khour Sail El Masara Drain	Mixed From Agricultural & Ind.R.B.
120	916.550	Kotsica Starch&Glucose Dr.	Industrial Effluent R.B.
121	916.551	Kotsica Starch&Glucose Dr.	Industrial Effluent R.B.
122	939.600	El Nasr Glass tube 1	Industrial Effluent R.B.
123	939.605	El Nasr Glass tube 2	Industrial Effluent R.B.
124	939.610	El Nasr Glass tube 3	Industrial Effluent R.B.
125	939.615	El Nasr Glass tube 4	Industrial Effluent R.B.
126	939.620	El Nasr Glass tube 5	Industrial Effluent R.B.
127	946.250	Sakeel Power Station	Power Station
128	947.900	Delta Cotton at Kanater	Industrial Effluent
R1	962.850	El Rahawy Drain	Mixed From Agricultural & Ind.R.B.
R2	1024.400	Sabal Drain	Agricultural Excess Water R.B.
R3	1039.500	El Tahreer Drain	Agricultural Excess Water L.B.
R4	1053.700	Zaweit El Bahr Drain	Agricultural Excess Water L.B.
R5	1073.400	Tala Drain	Agricultural Excess Water R.B.
R6	1074.500	Pesticides Company	Industrial Effluent R.B.
R7	1074.505	El Malaya Company	Industrial Effluent R.B.
R8	1074.510	Salt&Soda Company	Industrial Effluent R.B.
D1	1098.000	Talkha 1 Fertilizers	Industrial Effluent L.B.
D2	1098.120	Talkha 2 Fertilizers	Industrial Effluent L.B.
D3	1124.500	Batra Drain	Agricultural Excess Water R.B.
D4	1125.200	High Serw1	Agricultural Excess Water L.B.
D5	1135.300	High Serw Power Station	Power Station R.B.
D6	1166.000	Faraskour	Industrial Effluent R.B.

Table 5. Total Discharge in mcm/dy from Aswan to Delta Barrage

Years	Total Discharge in mcm/dy from Aswan to Delta Barrage	
1977	10.398	in October
1979	5.088	in October
1984	5.4149	in March
1985	11.8845	in July
1986	11.101	in September
1991	9.300	in July

Source: NRI

D2. Point Sources of Pollution

All the point sources of pollution are listed according to their locations in Tables 6-a through 6e for the years 1979, 1984, 1985, 1986, and 1991. Information on the industrial outfalls discharging into the Nile directly, from a report provided by GOFI, 1985, is presented in Table 7 as waste discharges and contaminants such as BOD, COD, TSS, and TDS.

Another summary table format was available for all industrial point sources of pollution in Egypt, discharged either into the Nile or any waterways or public sewers. This information is available from the report by GOFI, 1985, in Table 8.

E. Laboratories Conducting Water Quality Analyses

The water quality laboratories serve as support units in any organization. They support either research works or routine monitoring programs.

A review mission took place for the water quality division with the Nile Research Institute, a general survey was done for some water quality laboratories conducting water analyses in October 1989.

These laboratories are described in Table 9 in terms of activities, facilities, sampling program, personnel, QC/QA, method of analyses, and responsible agencies.

This survey indicated that QC/QA did not take place for most of these laboratories at that time. Few of them conduct information exchanges except for publishing or presenting their technical papers in national and international seminars, journals, and conferences.

Table (6-a) Parameter Concentrations and Loads

YEAR 1979

KM.from Aswan	COMMENTS	Discharge mm3/day	TDS mg/l	TDS Ton/day	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
9.90	INKhour El sail drain	0.013		0	0.623	0.0081	5	0.065		0		0
37.25	INTawansa drain.	0.007	1270	16.51	0.374	0.0049	0.001	0.00001	0.001	0.00001	0.001	0.00001
42.50	INEl Sheikh Ibrahim drain	0.013	620	8.06	0.935	0.0122	0.001	0.00001	0.001	0.00001	0.001	0.00001
46.55	INEl Ghaba drain		330		0.312		<0.001		<0.001		<0.001	
48.85	INMain Daraw drain	0.058	510	6.63	0.249	0.0032	0.001	0.00001	0.001	0.00001	0.001	0.00001
49.10	INEl Berba drain		430		1.013		<0.001		<0.001		<0.001	
51.00	INKomombo drain *1		390		0.623		<0.001		<0.001		<0.001	
53.00	INBenban drain.		330		0.312		<0.001		<0.001		<0.001	
57.65	INMain Ekleet drain *2	0.027	450	5.85	0.187	0.0024	0.001	0.00001	0.001	0.00001	<0.001	0.001
63.60	INEkleet(pump station)dr.	0.0317	495	6.435	0.125	0.0016	0.001	0.00001	0.001	0.00001	<0.001	0.001
64.65	INBerak El Raghama drain	0.081	410	5.33	0.249	0.0032	0.001	0.00001	0.001	0.00001	<0.001	0.001
70.45	INFatera drain	0 657	745	9.685	0.467	0.0061	0.001	0.00001	0.001	0.00001	<0.001	0.001
70.75	INKhour El sail drain	0.104	970	12.61	0.467	0.0061	0.001	0.00001	0.001	0.00001	<0.001	0.001
73.85	INEl Selsela drain *3		750		0.218		<0.001		<0.001		<0.001	
75.75	INKagoug drain	0.009	580	7.54	0.249	0.0032	0.001	0.00001	0.001	0.00001	0.001	0.00001
99.85	INEl Radisia drain *4		570		0.374		<0.001		<0.001		<0.001	
116.20	INEdfu drain *5		1720		0.249		<0.001		<0.001		<0.001	
119.60	INKalh drain		540		0.467		0.2		<0.001		<0.001	
122.45	INEdfu Paper pulb A						1.5		<0.001		<0.001	
123.00	INEdfu Suger drain.		350		2.804		1.2		<0.001		<0.001	
135.60	INMahameed drain	0.002	260	3.38	0.312	0.0041	0.1	0.0013	0.001	0.00001	0.001	0.00001
143.10	INEl Hagz El Bahary dr.*6		685		0.312		<0.001		<0.001		<0.001	
149.10	INHagar El Sebaia drain	0.049	655	8.515	0.249	0.0032	<0.001	0	0.001	0.00001	0.001	0.00001
187.70	INMataana drain	0.289	750	9.75	0.374	0.0049	0.1	0.0013	0.001	0.00001	0.001	0.00001
196.60	INGhoreare drain	0.008	310	4.03	0.156	0.0020	0.1	0.0013	0.001	0.00001	0.001	0.00001

Table (6-a) Contnd. Parameter Concentrations and Loads

YEAR 1979

KM.from Aswan	COMMENTS	Discharge mm3/day	TDS mg/l	TDS Ton/day	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
204.50	INArmant Suger ind. pulb1		340		4.362		1.3		<0.001		<0.001	
204.51	INArmant Suger ind. pulb2		240		0.156		5		<0.001		<0.001	
204.51	INArmant Suger ind. pulb3		240		0.312		0.4		<0.001		<0.001	
209.00	INEl Salamia drain.		220		0.312		<0.001		<0.001		<0.001	
220.85	INEl Rayayna drain *1		780		0.467		0.2		<0.001		<0.001	
221.65	INLoxor outlet water treatment		190		0.312		<0.001		<0.001		<0.001	
237.60	INEl Habail El Sharky dr.		530		0.374		<0.001		<0.001		<0.001	
245.10	INEl Chanhoria drain.		215		0.312		<0.001		<0.001		<0.001	
256.85	INQues suger drain		340		2.181		1.2		<0.001		<0.001	
266.75	INQena water plant *2		200		0.374		<0.001		<0.001		<0.001	
286.75	INTaramsa drain		260		0.467		0.1		<0.001		<0.001	
299.75	INBahari Dandra drain *3		240		0.467		0.1		<0.001		<0.001	
314.00	INDeshna suger drain		240		2.181		0.5		<0.001		<0.001	
331.20	INHamad drain	0.014	853	11.089	0.312	0.0041	0.1	0.0013	0.001	0.00001	0.001	0.00001
340.35	INMagrour Hoe drain		210		0.310		<0.001		<0.001		<0.001	
343.25	INNaga Hamadia suger Ind.		340		8.720		0.5		<0.001		<0.001	
363.00	INAbu Homar(pump staion)	0.418	210	2.73	0.150	0.0020	0.001	0.00001	0.001	0.00001	0.001	0.00001
377.80	INNag.Hamadi drain.	0.349	380	4.94	0.240	0.0031	0.001	0.00001	0.001	0.00001	0.001	0.00001
384.00	INAbu Shousha drain.	0.054	210	2.73	0.180	0.0023	0.001	0.00001	0.001	0.00001	0.001	0.00001
392.75	INMazata drain *1		210		0.150		<0.001		<0.001		<0.001	
443.20	INOnion Industry drain		510		0.467		2.2		<0.001		<0.001	
444.55	INSouhag drain	0.479	380	4.94	0.467	0.0061	0.5	0.0065	0.001	0.00001	0.001	0.00001
445.60	INSouhag oil drain		700		0.374		<0.001		<0.001		<0.001	
454.70	INSeflak drain *2		170		0.156		0.1		<0.001		<0.001	
473.85	INElkhmeem drain	0.238	220	2.86	0.374	0.0049	0.2	0.0026	0.001	0.00001	0.001	0.00001

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Table (6-a) Contnd. Parameter Concentrations and Loads

YEAR 1979

KM.from Aswan	COMMENTS	Discharge mm3/day	TDS mg/l	TDS Ton/day	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
486.70	INTahta drain	0.059	670	8.71	0.467	0.0061	<0.001	0	0.001	0.00001	0.001	0.00001
521.00	INMain Abu Teeg drain		235		0.218		0.1		<0.001		<0.001	
525.40	INBadary drain	0.246	215	2.795	0.187	0.0024	<0.001	0	0.001	0.00001	0.001	0.00001
525.85	INEl Metmar drain *3		185		0.249		<0.001		<0.001		<0.001	
542.85	INAssuit treatmant plant.		190		0.156		<0.001		<0.001		<0.001	
543.00	INAssuit power station		190		0.156		0.2		<0.001		<0.001	
552.20	INMankabad super Phosphate		364		0.270		0.1				<0.001	
682.00	INMinia water treat plant.		208		<0.001		<0.001		<0.001		<0.001	
682.50	INMakousa drain *1		212		<0.001		2		<0.001		<0.001	
701.10	INEtsa drain *2		246		0.600		1		<0.001		<0.001	
752.15	INSheikh Zied drain		212		<0.001		<0.001		<0.001		<0.001	
807.20	INE[illegible]asia drain *3		318		0.033		0.2		<0.001		<0.001	
809.00	INBeni Suif water plant.		208		<0.001		<0.001		<0.001		<0.001	
879.60	INMasanda drain	0.341	390	5.07	0.134	0.0017	0.2	0.0026	0.001	0.00001	0.001	0.00001
884.50	INGamaza El soghra drain		220		0.034		<0.001		<0.001		<0.001	
898.10	INEl Tibeen drain *1		360						<0.001			
909.00	INHelwan Power Station *2		300		0.535		<0.001		<0.001		<0.001	
911.40	INChemicals Hawamdi Ind.		1268		0.803				<0.001		<0.001	
911.90	INHawamdia Sugar Moulase In		2084		1.070				<0.001		<0.001	
912.10	INHawamdia Sugar Ind.		380		0.033				<0.001		<0.001	
916.55	INKotsica Starch Ind.		288		5.352		1		<0.001		<0.001	
939.60	INEl Nasr glass Ind.tube1		292		2.141		3		<0.001		<0.001	
939.61	INEl Nasr glass Ind.tube2		290		0.033		2.5		<0.001		<0.001	
939.61	INEl Nasr glass Ind.tube3		396		0.033		1		<0.001		<0.001	
947.00	INPower station		218		0.033		<0.001		<0.001		<0.001	

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Table (6-b) Parameter Concentrations and Loads

YEAR 1984 MAR.

KM.from	COMMENTS	Discharg mm3/day	TDS mg/l	TDS on/da	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
9.90	INKhour El sail drain	0.087	378	32.88	9.37	0.8152	22	1.914		0	5	0.435
37.25	INTawansa drain	0.087	814	70.81	1.606	0.1397	0.6	0.0522	0.001	0.00008	0.001	0.00008
42.50	INEl Sheikh Ibrahim drain	0.003	550	47.85	0.134	0.0117	0.001	0.00008	0.001	0.00008	0.001	0.00008
46.55	INEl Ghaba drain	0.0105	698	60.72	1.2024	0.1046	0.001	0.00008		0	0.4	0.0348
47.15	INAbu Wanas drain	0.059	416	36.19	1.338	0.1164	0.8	0.0696	0.001	0.00008	0.001	0.00008
48.85	INMain Daraw drain	0.0361	536	46.63	0.134	0.0117	0.001	0.00008	0.001	0.00008	0.001	0.00008
49.10	INEl Berba drain		498		8.03		0.8				<0.001	
53.00	INBenban drain	0.076	428	37.23	1.34	0.1166	0.001	0.00008	0.001	0.00008	0.001	0.00008
55.00	INMeneha drain		196		0.2676		0.001		<0.001		<0.001	
57.65	INMain Ekleet drain	0.0596	578	50.28	1.07	0.0931	0.001	0.00008	0.001	0.00008	0.001	0.00008
63.60	INEkleet pump station dr.		512		1.61		0.001		<0.001		<0.001	
64.65	INBerak El Raghama drain	0.031	484	42.10	0.2676	0.0233	0.001	0.00008	0.001	0.00008	0.001	0.00008
70.45	INFatera drain	0.253	792	68.90	0.268	0.0233	0.001	0.00008		0	0.001	0.00008
70.75	INKhour El sail drain		950		0.402		0.001		<0.001		<0.001	
73.85	INSelsela drain	0.037	982	85.43	0.268	0.0233	0.001	0.00008	0.001	0.00008	0.001	0.00008
75.75	INKagoug drain		748		<0.001		0.001		<0.001		<0.001	
99.85	INRadisia drain	0.173	2648	230.3	<0.001	0.0000	0.65	0.05655	0.2	0.0174	0.001	0.00008
119.60	INKalh (P.S) drain		842		0.134		<0.001		<0.001		<0.001	
123.00	INEdfu Suger Ind.pipe 1		3420		<0.001		<0.001		<0.001		<0.001	
123.01	INEdfu Suger Ind.pipe 2		912		16.06		1.2				9.6	
135.60	INMahameed drain		1216		1.34		<0.001		<0.001		<0.001	
139.50	INHoud El Sebaia drain	0.008	442	38.45	0.268	0.0233	0.001	0.00008	0.001	0.00008	0.001	0.00008
147.00	INSebia phosphate drain.		212		21.41		0.001		<0.001		<0.001	
149.10	INHagar El Sebaia drain	0.016	240	20.88	0.535	0.0465	0.001	0.00008	0.001	0.00008	0.001	0.00008
187.70	INMataana drain	0.116	688	59.85	0.268	0.0233	0.001	0.00008	0.001	0.00008	0.001	0.00008

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Table (6-b) Contnd. Parameter Concentrations and Loads

YEAR 1984 MAR.

KM.from	COMMENTS	Discharg mm3/day	TDS mg/l	TDS on/da	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
196.60	INGhoreare drain	0.003	408	35.49	2.68	0.2332	0.001	0.00008	0.001	0.00008	0.001	0.00008
204.50	INArmant Suger ind.pipe 1		412		26.76		4		<0.001		1.4	
204.51	INArmant Suger ind.pipe 2		320		0.268		2.2		<0.001		<0.001	
209.00	INSalamia drain.	0.021	580	50.46	0.268	0.0233	0.001	0.00008	0.001	0.00008	0.001	0.00008
220.85	INEl Rayayna drain	0.092	680	59.16	0.268	0.0233	0.001	0.00008	0.001	0.00008	0.001	0.00008
237.60	INHabail drain	0.343	482	41.93	0.268	0.0233	0.001	0.00008	0.001	0.00008	0.001	0.00008
256.85	INQues suger drain		1020		8.028		2.2		<0.001		<0.001	
275.90	INKaft drain		680		0.268		<0.001		<0.001		<0.001	
314.00	INDeshna suger drain		240		0.268		0.8		<0.001		<0.001	
331.20	INHamad drain	0.243	398	34.62	0.268	0.0233	0.001	0.00008	0.001	0.00008	0.001	0.00008
340.35	INMagrour Hoe drain	0.082	324	28.18	0.268	0.0233	0.001	0.00008	0.001	0.00008	0.001	0.00008
343.20	INNag.Hammdi Sugar pipe 1		482		0.535		1.6				<0.001	
343.21	INNag.Hammdi Sugar pipe 2		742		10.704		2				<0.001	
377.80	INNag.Hamadi drain	0.074	318	27.66	0.268	0.0233	0.6	0.0522	0.001	0.00008	0.001	0.00008
392.75	INMazata drain	0.021	460	40.02	0.803	0.0699	0.8	0.0696	0.001	0.00008	0.001	0.00008
444.55	INSouhag drain	0.605	988	85.95	1.6056	0.1397	2.2	0.1914	0.001	0.00008	0.001	0.00008
445.60	INSouhag oil drain		840		0.268		<0.001		<0.001		<0.001	
473.85	INElkhmeem drain	0.281	320	27.84	0.268	0.0233	0.001	0.00008	0.001	0.00008	0.001	0.00008
486.70	INTahta drain		1020		0.268		2		<0.001		<0.001	
521.00	INMain Abu Teeg drain		310		0.268		<0.001		<0.001		<0.001	
525.40	INBadary drain	0.431	398	34.62	0.268	0.0233	0.4	0.0348	0.001	0.00008	0.001	0.00008
552.20	INMankabad drain											
637.40	INRayramoun drain	0.01	328	28.53	0.134	0.0117	0.001	0.00008	0.001	0.00008	0.001	0.00008
642.75	INAbu Henis drain	0.005	320	27.84	0.134	0.0117	0.4	0.0348	0.4	0.0348	0.001	0.00008
682.50	INMakoussa drain	0.044	464	40.36	0.134	0.0117	0.001	0.00008	0.001	0.00008	0.001	0.00008

Table (6-b) Contnd. Parameter Concentrations and Loads

YEAR 1984 MAR.

KM.from	COMMENTS	Discharg mm3/day	TDS mg/l	TDS on/da	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
701.10	INEtsa drain	0.972	806	70.12	0.2676	0.0233	1.2	0.1044	0.001	0.00008	0.001	0.00008
752.15	INSheikh Zied drain	0.024	386	33.58	0.134	0.0117	0.001	0.00008	0.001	0.00008	0.001	0.00008
780.50	INEbsug drain	0.043	502	43.67	2.68	0.2332	1.6	0.1392	0.001	0.00008	0.001	0.00008
807.20	INEhnasia darin	0.748	640	55.68	2.676	0.2328	2	0.174		0	3.4	0.2958
879.60	INMasanda drain	0.082	860	74.82	1.34	0.1166	0.4	0.0348		0	4.6	0.4002
884.50	INGamaza El soghra drain		480		0.903		<0.001		<0.001		<0.001	
898.10	INTibeen drain		1092		1.34		3.2				4.8	
901.00	INHelwan Power Station		208		0.054		<0.001		<0.001		<0.001	
910.15	INKhour El sail Bad. dr.		214		0.536		1.6		<0.001		<0.001	
912.10	INHawamdia Suger pipe 1		3668		1.338		4.8				6	
912.11	INHawamdia Suger pipe 2		540		0.268		2.6		<0.001		1.2	
912.12	INHawamdia Suger pipe 3		298		0.0268		2.6		<0.001		2.4	
912.12	INHawamdia Suger pipe 4		288		0.0268		24		<0.001		4.6	
912.13	INHawamdia Suger pipe 5		304		0.0268		2.4		<0.001		2.8	
912.13	INHawamdia Suger pipe 6		326		0.027		3		0.001		3	
912.90	INKhour El sail Maasara dr.	0.047	986	85.78	0.268	0.0233	3.8	0.3306		0	0.001	0.00008
916.55	INKotsicaStarch&glucose 1		668		8.028		6.2				<0.001	
916.56	INKotsicaStarch&glucose 2		312		0.375		3				2.8	
939.60	INEl Nasr glass tube 1		310		1.87		<0.001		<0.001		<0.001	
939.61	INEl Nasr glass tube 2		286		1.07		<0.001		<0.001		<0.001	
936.61	INEl Nasr glass tube 3		1460		1.07		<0.001		<0.001		<0.001	
936.62	INEl Nasr glass tube 4		326		0.54		<0.001		<0.001		<0.001	
936.62	INEl Nasr glass tube 5		312		0.81		<0.001		<0.001		<0.001	
947.00	INPower station		220		0.27		<0.001		<0.001		<0.001	

Table (6-c) Parameter Concentrations and Loads

YEAR 1985

KM.from Aswan	COMMENTS	Discharg mm3/day	TDS mg/l	TDS Ton/day	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
6.00	INAswan Sewerage drain		386		4		4		0.08		<0.001	
9.90	INKhour El sail drain	0.0045	486	2.187	2.5	0.01125	30.6	0.1377	10.8	0.0486	26	0.117
37.25	INTawansa drain	0.024	962.00	4.329	1.85	0.00832	0.03	0.00011	0.05	0.00022	0.14	0.00063
42.50	INEl Sheikh Ibrahim dr.		692.00		2.20		0.01		<0.001		<0.001	
46.55	INEl Ghaba drain	0.07	308.00	1.386	0.80	0.0036	0.00	0.00000	0.10	0.00045	0.82	0.00369
47.15	INAbu Wanas drain	0.15	288.00	1.296	1.00	0.0045	0.28	0.0012[illegible]	0.15	0.00067	0.40	0.0018
48.00	INEl Shatb drain		782.00		2.00		1.40		2.80		2.80	
48.85	INMain Daraw drain	0.16	724.00	3.258	1.50	0.00675	0.03	0.00013	0.07	0.00031	3.30	0.01485
49.10	INEl Berba drain	0.118	906.00	4.077	3.10	0.01395	1.88	0.00846	0.50	0.00225	0.001	0.000004
53.00	INBenban drain	0.035	498.00	2.241	1.12	0.00504	0.80	0.0036	0.10	0.00045	0.001	0.000004
57.65	INMain Ekleet drain	0.11	682.00	3.069	2.10	0.00945	0.001	0.00000	0.001	0.00000	0.001	0.000004
63.60	INEkleet (P.S) drain		296.00		1.15		2.80		0.60		6.60	
64.65	INBerak El Raghama dr.	0.19	688.00	3.096	0.91	0.00409	0.12	0.00054	0.05	0.00022	0.001	0.000004
70.45	INFatera drain	0.83	980.00	4.41	0.98	0.00441	0.05	0.00022	0.05	0.00022	0.001	0.000004
70.75	INKhour El sail dr.	0.44	1216.00	5.472	1.32	0.00594	0.15	0.00067	0.001	0.00000	0.001	0.000004
73.85	INSelsela drain		1200.00		2.00		0.01		0.01		<0.001	
99.85	INRadisia drain	0.98	3896.00	17.532	0.90	0.00405	0.08	0.00036	0.01	0.00002	0.62	0.00279
101.75	INHasia drain	0.092	512.00	2.304	2.00	0.009	0.10	0.00045	0.05	0.00022	1.20	0.0054
109.25	INHager drain	0.045	714.00	3.213	3.00	0.0135	0.16	0.00072	0.01	0.00004	1.20	0.0054
116.20	INEdfu drain		1426.00		2.50		0.10		0.05		<0.001	
119.75	INKalh (P.S) drain	0.27	826.00	3.717	2.90	0.01305	0.10	0.00045	0.08	0.00036	0.001	0.000004
122.45	INEdfu Paper pulb A		402.00		5.00		6.00		3.50		2.80	
122.50	INEdfu Paper pulb B		398.00		3.00		2.50		0.60		1.20	
123.00	INEdfu Suger		420.00		1.50		0.60		0.05		0.80	

Table (6-c) Contnd. Parameter Concentrations and Loads

YEAR 1985

KM.from Aswan	COMMENTS	Discharg mm3/day	TDS mg/l	TDS Ton/day	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
149.10	INHagar El Sebaia dr.	0.14	1820.00	8.19	2.62	0.01179	1.00	0.0045	0.05	0.00022	0.80	0.0036
187.70	INMataana drain	0.45	1180.00	5.31	1.65	0.00742	0.02	0.00009	0.01	0.00002	0.001	0.000004
196.60	INGhoreare drain	0.05	386.00	1.737	1.70	0.00765	0.50	0.00225	0.01	0.00002	0.001	0.000004
204.50	INArmant suger Ind dr.		286.00		0.75		0.82		0.01		1.20	
209.00	INEl salaima drain	0 02	368.00	1.656	1.30	0.00585	0.10	0.00045	0.01	0.00002	0.001	0.000004
220.85	INEl Rayayna drain	0 47	892.00	4.014	1.25	0.00562	0.16	0.00072	0.001	0.00000	0.80	0.0036
237.60	INHabail drain	0 07	592.00	2.664	1.10	0.00495	1.20	0.0054	0.04	0.00018	0.80	0.0036
251.55	INDanfik drain		292.00		0.76		0.10		0.01		<0.001	
256.85	INQues suger drain		282.00		0.85		0.10		0.10		<0.001	
265.30	INSheikhia(El Hagagra)dr.	0.12	762.00	3.429	1.90	0.00855	0.10	0.00045	0.01	0.00004	0.001	0.000004
270.70	INBallas drain	0.034	262.00	1.179	0.80	0.0036	0.20	0.0009	0.16	0.00072	0.10	0.00045
286.75	INTaramsa drain		282.00		1.00		0.10		<0.001		<0.001	
314.00	INDeshna suger drain		492.00		32.00		1.20		0.86		<0.001	
331.20	INHamad drain		362.00		0.32		0.80		0.05		1.00	
340.35	INMagrour Hoe drain	0.26	284.00	1.278	0.40	0.0018	1.20	0.0054	<0.001	0	0.80	0.0036
377.80	INNag Hamadi drain	0.21	490	2.205	1.2	0.0054	0.1	0.00045	0.06	0.00027	<0.001	0
392.75	INMazata drain	0.25	462	2.079	1.35	0.00607	3.2	0.0144	0.5	0.00225	<0.001	0
443.20	INOnion Industry drain		968		10.2		4.2		0.5			
444.55	INSouhag drain		624		0.42		1.2		<0.001		<0.001	
445.60	INSouhag oil drain		1206		0.82		1		0.26		<0.001	
445.61	INCocacola Ind. waste		1892		4.25				0.002			
454.70	INSeflak drain	0.01	906	4.077	2.2	0.0099	1	0.0045	<0.001	0	<0.001	0
473.85	INEkhmeem drain	0.09	402	1.809	0.82	0.00369	0.43	0.00193	0.05	0.00022	0.03	0.000135
486.70	INTahta drain		1282		0.65		0.04		0.13		2.1	
521.00	INMain Abu Teeg drain		322		0.58		0.11		0.32		0.05	
525.40	INBadary drain		486		0.9		0.6		0.3		1.3	
550.20	INZenar drain	0.39	402	1.809	0.45	0.00202	0.18	0.00081	0.11	0.00049	0.43	0.001935

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Table (6-c) Contnd. Parameter Concentrations and Loads

YEAR 1985

KM.from Aswan	COMMENTS	Discharg mm3/day	TDS mg/l	TDS Ton/day	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
552.20	INMankabad dr. tube A		496.00		10.20		0.08		0.08		0.20	
552.21	INMankabad dr. tube D		500.00		9.00		0.09		0.06		0.40	
552.21	INMankabad dr. tube C		264.00		0.46		0.01		0.17		0.04	
637.40	INRayramoun drain		308.00		0.65		0.40		0.10		0.26	
642.75	INAbu Henis drain	0 002	382.00	1.719	0.56	0.00252	0.10	0.00045	0.13	0.00058	0.19	0.000855
682.50	INMakoussa drain		270.00		0.20		<0.001		0.01		0.01	
701.10	INEtsa drain	0 59	468.00	2.106	0.88	0.00396	0.70	0.00315	0.17	0.00076	0.37	0.001665
752.15	INSheikh Zied drain	0.01	310.00	1.395	1.45	0.00652	0.35	0.00157	0.01	0.00002	0.01	0.000045
780.50	INEbsug drain	0.36	788.00	3.546	0.92	0.00414	0.001	0.00000	0.01	0.00004	0.47	0.002115
807.20	INEhnasia darin	1.54	416.00	1.872	5.00	0.0225	0.001	0.00000	0.01	0.00004	0.52	0.00234
808.00	INSaida drain	0.035	702.00	3.159	1.12	0.00504	0.08	0.00036	0.01	0.00002	0.02	0.00009
841.00	INEl Zawia darin		916.00		1.92		0.03		0.08		0.55	
865.20	INEl Dessamy drain		276.00		0.80		<0.001		0.01		0.04	
879.60	INMasanda drain	0.25	704.00	3.168	2.20	0.0099	0.001	0.00000	0.02	0.00006	0.07	0.000315
884.50	INGamaza El soghra dr.	0.022	262.00	1.179	0.42	0.00189	0.001	0.00000	0.01	0.00004	0.14	0.00063
888.95	INGamaz El kobra drain	0.019	2686	12.087	0.18	0.00081	0.04	0.00018	0.024	0.00010	0.18	0.00081
898.10	INTibeen drain		940		0.4		0.01		1.6		2.2	
910.15	INKhour El sail Bad. dr.		234		0.4		<0.001		0.005		0.04	
911.40	INHawamdia Chemical dr.		980		0.55		<0.001		0.005			
911.90	INHawamdia suger Moulase		2960		0.26							
912.10	INHawamdia suger drain		412		0.5		0.2		0.015		0.26	
912.90	INKhour Sail ELmaasara dr.	0.004	998	4.491	2.75	0.01237	0.01	0.00004	0.6	0.0027	1.7	0.00765
916.55	INKotsica starch&glucose dr		496		22.8				0.095			
939.60	INEl Nasr glass tab1		462		1.4		0.03		0.02		0.12	
939.61	INEl Nasr glass tab2		380		0.5		<0.001		0.04		0.16	
939.61	INEl Nasr glass tab3		368		0.42		0.06		0.025		0.28	
947.00	INPower station		284		0.3		<0.001		0.005		0.1	

Table (6–d) Parameter Concentrations and Loads

YEAR 1986

KM.from Aswan :	COMMENTS	Discharg mm3/day	TDS mg/l	TDS Ton/day	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO3 mg/l	NO3 Ton/day	NO2 mg/l	NO2 Ton/day
6.00 :	INAswan sewerage drain		342		9.5		1		<0.001		0.45	
9.90 :	INKhour El Sail drain	0.128	764	97.792	8.3	1.0624	0.31	0.03968	0.27	0.0345	0.1	0.0128
37.25 :	INTawansa drain	0.042	980	41.16	0.8	0.0336	0.001	0.00004	0.001	0.0000	0.08	0.0033
42.50 :	INEL Sheikh Ibrahim dr.	0.046	740	34.04	1.2	0.0552	0.001	0.00004	2.29	0.1053	0.17	0.0078
46.55 :	INEL Ghaba drain	0.247	826	204.02	1.2	0.2964	0.001	0.00024	2.26	0.5582	0.4	0.0988
47.15 :	INAbu Wanas drain	0.062	620	50.34	1.3	0.1066	0.001	0.00008	1.31	0.1074	0.48	0.0393
48.85 :	INMain Daraw drain	0.185	604	111.74	1.1	0.2035	0.001	0.00018	0.83	0.1535	0.85	0.1572
49.10 :	INEL Berba drain	0.051	684	34.884	1.6	0.0816	0.001	0.00005	1.95	0.0994	1	0.051
50.00 :	INKom Ombu Sugar Ind.		208		0.25		0.001		<0.001		1.8	
53.00 :	INBenban drain	0.078	478	37.284	1.7	0.1326			0.43	0.0335	0.62	0.0483
57.65 :	INMain Ekleet drain	0.221	364	80.444	0.8	0.1768	0.01	0.00221	1.84	0.4066	0.035	0.0077
63.60 :	INEkleet (P.S) drain	0.04	380	15.2	2.1	0.084	0.01	0.0004	1.35	0.054	0.007	0.0002
64.65 :	INBerak El Raghama dr.	0.148	406	60.088	1.5	0.222	0.01	0.00148	1.75	0.259	0.08	0.0118
70.45 :	INFatera drain	1.068	860	918.48	1.25	1.335	0.022	0.02349	2.6	2.7768	0.11	0.1174
70.75 :	INKhour El Sail drain	0.232	728	168.89	2.1	0.4872	0.011	0.00255	0.93	0.2157	0.04	0.0092
73.85 :	INSelsela drain		684		2.5		0.01		0.96		0.023	
75.75 :	INKagouk drain		964		2.1		0.052		0.55		0.045	
76.00 :	INAwarta drain		212		0.35		<0.001		<0.001		0.015	
99.85 :	INRadisia drain	0.027	3260	88.02	3	0.081	0.015	0.00040	3.7	0.0999	0.15	0.0040
101.75 :	INHasia drain	0.05	468	23.4	2	0.1	0.01	0.0005	2.7	0.135	0.07	0.0035
109.25 :	INHager drain	0.075	612	45.9	3.7	0.2775	0.03	0.00225	0.001	0.0000	0.08	0.006
116.20 :	INEdfu drain	0.206	1240	255.44	3.1	0.6386	0.028	0.00576	3.12	0.6427	0.045	0.0092
119.60 :	INKalh (P.S) drain	0.33	694	229.02	4.6	1.518	0.03	0.0099	1.183	0.3903	0.09	0.0297
122.45 :	INEdfu Paper Pulp A dr.		608		0.9		0.05		0.106		0.051	
122.50 :	INEdfu Paper Pulp B dr.		512		1		0.07		0.177		0.05	
123.00 :	INEdfu Sugar Ind.		228		0.1		<0.001		0.394		0.03	
135.60 :	INMahameed drain	0.02	708	14.16	0.4	0.008	0.01	0.0002	0.168	0.0033	0.072	0.0014
139.50 :	INHoud El Sebaia		946		1		0.012		2.6		0.125	
143.10 :	INHagz El Bahary drain	0.083	988	82.004	1.1	0.0913	0.01	0.00083	0.53	0.0439	0.24	0.0199

Table (6-d) Contnd. Parameter Concentrations and Loads

YEAR 1986

KM.from Aswan	: COMMENTS	Discharg mm3/day	TDS mg/l	TDS Ton/day	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO3 mg/l	NO3 Ton/day	NO2 mg/l	NO2 Ton/day
149.10	: INHagar El Sebia drain	0.074	1360	100.64	1.7	0.1258	0.01	0.00074	1.9	0.1406	0.34	0.0251
187.70	: INMataana drain	0.504	1204	606.81	1.1	0.5544	0.025	0.0126	0.75	0.378	0.068	0.0342
196.60	: INGhoreara drain	0.034	216	7.344	0.5	0.017	0.01	0.00034	1.85	0.0629	0.162	0.0055
204.50	: INArmant Sugar Ind. dr.		242		1.6		0.025		0.42		0.006	
209.00	: INEL Salamia drain	0.024	296	7.104	1.2	0.0288	0.011	0.00026	0.33	0.0079	0.246	0.0059
220.85	: INEl Rayayna drain	0.053	236	12.508	0.4	0.0212	0.02	0.00106	0.45	0.0238	0.624	0.0330
236.00	: INEl Zeinia (Ashia) dr.		310		0.4		0.01		0.11		0.082	
237.60	: INHabail El Sharky dr.	0.07	530	37.1	1	0.07	0.25	0.0175	0.17	0.0119	0.08	0.0056
251.55	: INDanfik drain		640		2.1		0.1		0.23		0.086	
256.85	: INQues Sugar Ind. drain		520		1.5		0.02		0.38		0.06	
	: INGrinding Mill (Ques)		1840		18		0.14		0.56		0.068	
265.30	: INSheikhia(El Hagaza) dr.	0.225	994	223.65	13.6	3.06	0.04	0.009	0.51	0.1147	0.008	0.0018
270.70	: INEl Ballas drain		224		0.5		0.02		0.12		0.002	
314.00	: INDeshna Sugar Ind. dr.		286		0.7		<0.001		0.86		0.18	
331.20	: INHamad drain		230		0.72		0.02		0.3		0.05	
340.35	: INMagrour Hoe drain	0.21	226	47.46	0.5	0.105	0.25	0.0525	0.28	0.0588	0.12	0.0252
343.20	: INNaga Hamadi Sugar dr.A		268		0.5		<0.001		0.2		0.062	
343.25	: INNaga Hamadi Sugar dr.B		510		1		0.07		0.22		0.008	
377.80	: INNaga Hamadi drain	1.14	508	579.12	2.9	3.306	0.008	0.00912	0.75	0.855	0.002	0.0022
392.75	: INMazata drain	0.048	486	23.328	3.4	0.1632	0.25	0.012	0.45	0.0216	0.052	0.0024
443.20	: INOnion Ind. drain		888		1.2		0.05		0.55		0.062	
444.55	: INSouhag drain	0.701	640	448.64	0.35	0.2453	0.001	0.00070	0.65	0.4556	0.62	0.4346
445.60	: INSouhag Oil Ind. dr.		1280		3.4		0.26		0.9		0.66	
445.61	: INCocacola Ind. drain		1060		6.6		<0.001		1.1		0.42	
454.70	: INSeflak drain	0.019	594	11.286	0.4	0.0076	0.03	0.00057	2	0.038	0.046	0.0008
473.85	: INEkhmeem drain	0.161	238	38.318	1.4	0.2254	0.4	0.0644	0.52	0.0837	0.52	0.0837
486.70	: INTahta drain	0.092	906	83.352	0.4	0.0368	0.26	0.02392	2	0.184	0.064	0.0058
521.00	: INAbu Teeg drain		310		1.6		0.1		0.075		0.05	
525.40	: INEl Badary drain	0.422	308	129.97	6.5	2.743	0.12	0.05064	0.43	0.1814	0.024	0.0101

Table (6-d) Contnd. Parameter Concentrations and Loads

YEAR 1986

KM.from Aswan :	COMMENTS	Discharg mm3/day	TDS mg/l	TDS Ton/day	PO4 mg/l	PO4 Ton/day	NH3 mg/l	NH3 Ton/day	NO3 mg/l	NO3 Ton/day	NO2 mg/l	NO2 Ton/day
550.20 :	INZenar drain	0.076	280	21.28	1.1	0.0836	0.2	0.0152	0.25	0.019	0.08	0.0060
552.20 :	INMankbad drain		980		2.2		0.05		0.04		0.004	
588.60 :	INBany Shaker drain		720		2.2		0.4		0.02		0.006	
637.40 :	INEl Rayramoun drain	0.011	234	2.574	0.5	0.0055	0.02	0.00022	0.085	0.0009	0.005	0.0000
642.75 :	INAbu Henis drain	0.003	342	1.026	0.5	0.0015	0.015	0.00004	0.02	0.0000	0.054	0.0001
682.50 :	INMakoussa drain	0.102	360	36.72	0.7	0.0714	0.015	0.00153	0.3	0.0306	0.008	0.0008
701.10 :	INEtsa drain	1.466	410	601.06	1	1.466	0.17	0.24922	0.6	0.8796	0.062	0.0908
752.15 :	INEl Sheikh Zied drain	0.026	364	9.464	1.3	0.0338	0.02	0.00052	0.16	0.0041	0.06	0.0015
780.50 :	INEbsug drain	0.596	468	278.92	0.5	0.298	0.001	0.00059	0.8	0.4768	0.001	0.0005
807.20 :	INAhnasia drain		686		0.04		0.005		0.7		0.7	
808.00 :	INEl Saayda drain	0.016	396	6.336	0.4	0.0064	0.006	0.00009	0.475	0.0076	0.475	0.0076
841.00 :	INEl Zawia drain	0.411	910	374.01	1.4	0.5754	0.05	0.02055	0.5	0.2055	0.005	0.0020
865.20 :	INEl Dessamy drain	0.792	340	269.28	1.1	0.8712	0.025	0.0198	0.6	0.4752	0.25	0.198
879.60 :	INEl Masanda drain	0.161	806	129.76	0.6	0.0966	0.035	0.00563	0.3	0.0483	0.12	0.0193
884.50 :	INGhmaza El Soghra dr.	0.095	240	22.8	0.4	0.038	0.02	0.0019	0.75	0.0712	0.08	0.0076
888.95 :	INGhamaza El Kobra dr.	0.003	730	2.19	0.9	0.0027	0.025	0.00007	0.21	0.0006	0.46	0.0013
898.10 :	INEl Tibeen drain	0.208	328	68.224	2.8	0.5824	0.12	0.02496	0.1	0.0208	0.05	0.0104
910.15 :	INKhour Sail El Badrashin		316		0.5		0.01		0.14		0.05	
911.40 :	INChemicals Ind. drain		606		0.5		0.03		0.05		0.074	
911.90 :	INHawamdia Sugar Moulas		2360		2.5		<0.001		<0.001		0.004	
912.10 :	INHawamdia Sugar Ind. dr.		4800		55		<0.001		<0.001			
912.90 :	INKhour Sail El Maasara	0.009	940	8.46	2	0.018	0.025	0.00022	0.04	0.0003	0.03	0.0002
916.55 :	INKotsica starch&Glucose		1760		2.8		0.06		<0.001		0.05	
939.60 :	INEl Nasr Glass dr.tube 1		420		1.4		0.004		0.6		0.25	
939.61 :	INEl Nasr Glass dr.tube 2											
939.61 :	INEl Nasr Glass dr.tube 3		510		0.1		0.04		0.4		<0.001	
947.00 :	INPower Station		360		<0.001		0.03		0.1		0.06	

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Table (6-e) **Parameter Concentrations and Loads**

July 1991

	Name of Point Sources of Pollution	Location From Aswan K m	Discharg mm3/day	TDS mg/l	TDS Ton/day	PO4-P mg/l	PO4-P Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
1	Khour El Sail Drain.(Aswan)	009.900	0.0657	501	32.9157	0.252	0.0166	59.000	3.8763	6.000	0.3942	84.00	5.51
2	El Twansa Drain.	037.250	0.0192	1174	77.1318	0.017	0.0011	0.030	0.00197	0.023	0.0015	5.00	0.32
3	El Ghaba Drain.	046.550	0.2864	667	43.8219	0.023	0.0015	0.010	0.00065	0.030	0.0020	34.00	2.23
4	Main Draw Drain.	048.850	0.0936	504	33.1128	0.252	0.0166	0.010	0.00065	0.040	0.0026	14.00	0.91
5	Komombu Sugar Ind.	050 000	0.0422	628	41.2596	0.130	0.0085	0.610	0.04007	0.350	0.0230	9.00	0.59
6	Fatera Drain.	070 450	1.0439	567	37.2519	0.097	0.0064	0.300	0.01971	0.065	0.0043	28.00	1.83
7	Khour El Sail Drain (Komombu)	070 750	0.3099	477	31.3389	0.037	0.0024	0.030	0.00197	0.055	0.0036	12.00	0.78
8	Edfu Drain.	116.200	0.2459	269	17.6733		0.0000	0.100	0.00657	0.067	0.0044	26.00	1.7[illegible]
9	Edfu Paper Pulp A.	122.500		580		0.154		0.100		1.100		2.20	
10	Edfu Sugar Ind	123 000	0.0002	123	8.0811	0.161	0.0106	0.010	0.00065	0.010	0.0007	0.80	0.052
11	El Mahameed Drain	135 600		>1980		0.073		0.170		1.300		21.00	
12	Mataana Drain	187.700	0.3175	600	39.42	0.200	0.0131	0.850	0.05584	0.260	0.0171	5.80	0.381
13	Armant Sugar ind.1	204 500	0.0004	166	10.9062	0.008	0.0005	1.100	0.07227	0.150	0.0099	1.85	0.121
14	Armant Sugar ind 2	204 505	0.0002	138	9.0666	0.009	0.0006	1.200	0.07884	0.120	0.0079	1.60	0.105
15	Armant Sugar ind.3	204.510	0.0002	160	10.512	0.016	0.0011	1.000	0.0657	0.180	0.0118	1.50	0.098
16	Ques Sugar Ind.	246.850		167		0.042		1.300		0.200		1.80	
17	Khour El sail Qena Drain	288.800		196		0.029		0.650		<0.01		2.00	
18	Deshna Sugar	314.000		189		0.042		<0.01		0.250		1.20	
19	Naga Hammadi Drain.	377.800	0.7620	332	21.8124	0.049	0.0032	0.020	0.00131	0.150	0.0099	8.00	0.52
20	Souhag Drain.	444.550	0.6940	377	24.7689	0.148	0.0097	0.013	0.00085	0.600	0.0394	2.20	0.144
21	Souhag Oil Ind.	445.600	0.0002	895	58.8015	0.025	0.0016	0.01	0.00065	0.500	0.0329	4.00	0.26
22	EL Badary Drain.	525.400	0.6321	301	19.7757	0.088	0.0058	0.017	0.00111	0.560	0.0368	4.20	0.275
23	ManKabad Pipe 1.	552.200	0.0002	244	16.0308	0.396	0.0260	0.030	0.00197	0.720	0.0473	0.90	0.059
24	Etsa Drain.	701.100	0.8837	290	19.053	0.332	0.0218	0.020	0.00131	0.086	0.0057	4.00	0.26
25	Ahnasia Drain.	807.200	0.8380	564	37.0548	0.400	0.0263	0.800	0.05256	0.088	0.0058	6.20	0.407
26	EL Zawia Drain.	841.000	0.1160	927	60.9039	0.086	0.0057	0.300	0.01971	0.118	0.0078	22.00	1.44
27	EL Dessamy Drain.	865.200	0.0272	201	13.2057	0.052	0.0034	0.015	0.00098	0.018	0.0012	2.00	0.13
28	EL Tebeen Drain	898.100	0.1590	750	49.275	0.444	0.0292	0.100	0.00657	0.180	0.0118	15.00	0.98
29	[illegible] Hawamdia Chemicals Ind.1	904.040		483		0.123		0.180		0.020		1.50	
30	[illegible]micai Ind	911.400		5724		0.218		1.800		0.500		[illegible]	

Table (6–e) Contnd. Parameter Concentrations and Loads

July 1991

	Name of Point Sources of Pollution	Location From Aswan K m	Discharg mm3/day	TDS mg/l	TDS Ton/day	PO4-P mg/l	PO4-P Ton/day	NH3 mg/l	NH3 Ton/day	NO2 mg/l	NO2 Ton/day	NO3 mg/l	NO3 Ton/day
31	Hawamdia Sugar Maulas	911.900		335		4.400		0.018		1.000		2.30	
32	Khour Sail El Maasara	912.900	0.0130	921	60.5097	1.160	0.0762	0.020	0.00131	0.010	0.0007	30.00	1.97
33	kotsica Starch & Glucose Ind. 1	916.550		208		0.062		0.030		0.010		2.60	
34	kotsica Starch & Glucose Ind. 2	916.555		438		2.620		1.000		0.012		2.50	
35	kotsica Starch & Glucose Ind. 3	916.560		399		2.380		0.950		0.022		3.20	
36	EL Nasr Glass 1.	939.600		233		0.098		0.350		0.018		8.00	
37	EL Nasr Glass 5.	939.605		310		0.099		0.600		0.015		7.00	
38	EL Rahawy Drain (Rosetta Br.)	962.850	2.4580		0	1.290	0.0848	2.000	0.1314	0.038	0.0025	6.00	0.394
39	Sabal Drain (Rosetta Br.)	1024.400	0.2710	782	51.3774	0.532	0.0350	11.000	0.7227	0.165	0.0108	30.00	1.97
40	EL Malya Ind	1074.505	0.0130	1153	75.7521	14.700	0.9658	0.920	0.06044	0.145	0.0095	10.00	0.65
41	Salt & Soda Ind	1074.510		1828		0.760		0.140		0.128		26.00	
42	Talkha Fertilizers 1 (Damietta Br.)	1098.000		493		0.124		38.000		0.672		250.00	
43	Talkha Fertilizers 1 (Damietta Br.)	1098.12		1012		0.268		1100.000		0.025		100.00	

Source: NRI

Table 7. Industrial Outfalls According to the GOFI Report, 1985

	Name	Q (m3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	TDS (mg/l)
1	Cairo Oil & Soap	2200	oil wast 80	89.2	240	3690
	Badrasheen		cooling 20	50.1	70	4280
2	Nile Cotton,Oil,Soap Campany	24000	-	-	-	-
3	Nile Oil & Soap Co.	14500	80	198	158	872
	Enteraction & my drogenation					
4	Egyptian Sugar & Dist. Co.	168000	580	890	380	598
	Sugar Co.	120000	380	740	464	444
5	Suger Co. (4)	14400	-	-	-	-
6	Suger Co.	169200	890	780	220	482
7	Suger Co.	84000	530	840	404	460
8	Suger Co.	76500	205	450	344	380
9	Suger Co.	50400	148	286	50	580
10	Egyptian Starch & Glucose	10560	1450	3100	70	-
11	El- Nasr Dehydration	125	296	620	360	572
12	Egyption Ind. & Finances	2100	10	14	22	790
	Chem. Product Co.					
13	El Nasr Coke & Chem. Comp.	600	10	44	38	440
14	Kima Co.	7200	14	35	58	652
15	Egyptian Ind. & Finances Comp.	1000	6	10	22	840
16	Kafr El-Zayyat & Praticide Comp.	2100	36	44	66	470
17	Hawamdia Fermentaion Dist. Fact.	18800	7500	13790	1210	10645
18	Hawamdia Ch. Fact.	9600	140	205	64	350
19	Pulp Factory of Eg.	13200	1880	4020	3580	4680
	Sugar & Distillation Co.					
20	Egypt Wood Working Co.	134	-	-	-	-
21	Delta Cotton Ginning Comp.	55	-	-	-	-
22	Arab Cotton Ginning Comp.	90	-	-	-	-
23	Arab Cotton Spining and Weaving	150	-	-	-	-
24	Abu. Nol. Carpet Factory	14	190	420	352	650
25	El- Nasr Steel Pipe Fitting	5500	120	220	76	350
26	El-Nasr Cost Iron Comp.	246	-	-	-	-
27	Al-Ahrar Ice. of Refrrigeration	200	-	-	-	-
28	Alkishwai Ice.	157	-	-	-	-
29	Glass Factory	1495	-	-	-	-
30	Helwan Portland	2000	-	-	-	-
31	Tura Prtland	2044	-	-	-	-
32	Cairo (South)	844479.	-	-	-	-
33	Tebeen	134413.	-	-	-	-
34	Assiut	318479.	-	-	-	-
	Total	2100000	(m3/d)			

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Table 8. Summary of Wastewater Characteristics for Egyptian Industries (GOFI Report, 1985)

Industrial Sector	No. of Plants	Wastewater Q (million m3/yr)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	TDS (mg/l)
Oil & Soap	24	42.1	520	700	770	3000
Tanneries	10	1.83	1300	2250	1175	1800
Sugar	8	108.4	415	700	360	480
Starch, Yeast & Glucose	3	9.9	725	1560	380	900
Dairy Product	3	0.53	1330	2400	2100	4400
Soft Drinks	6	2.4	–	–	–	–
Beer	2	1.6	285	375	200	570
Canning &Freezing	5	2.6	670	840	400	850
Tobacco	6	0.05	95	140	120	600
Grain Milling &Processing						
– Rice	5	0.2	–	–	–	–
– Flour	24	2.3	45	90	310	275
Food Dehydration	4	0.15	300	620	370	575
CHEMICALS						
– Fertilizers	7	30.3	40	100	50	800
– Plastic & Rubber	5	0.9	120	200	50	540
– Pesticides	2	0.9	70	100	150	450
– General Chem.	12	27.2	350	825	1250	5000
– Petrochemical	3	72.1	240	460	280	4200
– Pharmaceutical	5	1.8	100	165	70	1000
– Matches	3	0.3	120	180	60	–
PULP & PAPER	18	31.4	1270	2300	1360	1590
Motor Veh. Product	6	1.4	40	50	10	–
TEXTILE						
– Cotton Ginning	39	1.8	–	–	–	–
– Flax & Jute	5	0.5	4100	4900	2200	1450
– Spinning Weaving	181	69.6	350	720	375	1650
IRON & STEEL	16	60.8	95	170	80	726
ALUMINUM	1	1.1	–	–	–	–
MISCELLANEOUS	21	5.3	100	200	200	850
GLASS/BRICKS etc.	11	0.7	70	150	750	320
CEMENT	4	1.78	40	75	1500	2400
POWER GEN.	13	2.597	–	–	–	–

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Table (9) **Water laboratories conducting water quality analysis**

Name of Lab & Responsible Agency	Activities	Laboratory facilities	Sampling Program	Methods & Analyses	QC/QA	Personnel	Comments
1- Central Lab of Industrial pollution Research El-Tebbin Ministry of Industry	*Research & routine monitoring of major industrial effluents.	*Advanced GLC units *TOC atomic absorbtion *Instruments for physical-chemical & bacterio logical analyses	Undefined	Standard Methods	Undefined	4 B.SC Chemistry 2 B.SC Microbiology with no experience	The lab is under the Supervision of Metallurgical Research Institute
2- Alexandria Regional River Nile Monitoring Lab	*Monito-ring Alex. Intake canal & Rosetta Branch	*Adequate instrument for conventional parameters but no toxic & micro-organics	7 Sampling stations sampled monthly.	Standards Methods, 81 conventional parameters such as TS,SS,Mg, Ca, H2S, NH3,BOD, DO,PH Hard, Alk. Po4, NO3, NO2	None	1 M.SC Sanitary chemistry 2 B.SC Chemists	Raw data reported to central water lab. in Alex. No Research
3- Alex.water Authority Lab	Routine Monitoring of Rosetta & Special intake Canal	Adequate instruments for physical chemical & bacteriological analyses	5 sampling stations	Standard methods 85 conventional, non conventional, Bacteriology (Total &fecal coliforms) algal counts	None	1 Dr.p.H Bacteriology 4 D.p.H chemistry 4B.SC chemistry	Data interpretation & Research are limited.

4- Water & Soil lab Faculty of Agricultu-re, Alex University	Research program	Adequate for con-ventional analyses. No advanced instruments for TOC, toxic metals & micro-organics	Intensive sampling program on Rosetta & Damietta with NRI	Standard Methods 77 Conventio-nal non Conventio-nal & mi-crobiology	None	1p.hD soil chemistry 4 Research assistants	Data Interpr e-tation is limited
5- Wastewater Research Lab. National Research Center	Research in water quality monitoring industrial effluents Domestic waste water	Adequate for Research & routine monitoring	Capable of performing 20-30 samples per month.	standard methods 85 Full physical chemical bacterio-logical analyses	None	5 ph-D chemistry 2 ph-D Bacteriology 1 ph.D biology 10 B.Sc. Res. Assistants.	full inter-pretati on of finding & recomme n-ded actions .
6- Lab of Environ-mental Health Dept. Institute of Public Health, Alex.	Research in water & waste water.	Adequate for Research & special services	Capable of full ana-lyses of 20 samples month	Standard Methods 85	None	5 ph-D chemistry 5 ph-D Engin-eering 3 ph.D Env.Health 20 Res. Assistants	Full interpr e-tation & recomme n-dations

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7- Central Lab, water Dept. Ministry of Health	Regular monitoring of water intakes of municipal treatment works, industrial effluents in Cairo, Giza, Kaliobia & Behera Governorates	inadequate & unsiffi-cient to meet the designated tasks	undertaken by local health Dept.	Standard methods 81	None	16 B.SC chemistry	Violation reported to the concerned local health dept.

8- Rowd El Farag water treatment works. General organization for water in Greater Cairo	Regular monitoring of water intake	Modern & adequate including atomic absorbtion & facilities for bacteriological analyses	the samples are under taken once a day	Standard Methods,81	none	5 B-SC chemistry	The organization operates 12 labs in the Greater Cairo area, In house reports for routine monitoring
9 - Occupational & Environmental Health Center, Ministry of Health	*Research related to water quality. *operation of National water & Air monitoring networks. training of water analyses.	Modern & adequate instruments for conventional & advanced analyses	Capable of full analyses for 200 sample/month in central & regional Labs	standard methods 85	None	3 B.SC Senior chemists 5 B.SC chemists 4 B.SC Bacteriology 2 B.SC Biology 3 lab. assistants	no data interpretation, reporting to funding agencies.
10- Water Research lab, Greater Cairo water Authority	Research & monitoring specific constituent in intakes & distribution saystems	Excellent lab facilities	As needed for special studies	standard methods 85	limited to trace metals analyses	2 B-SC senior chemists 4 B-SC chemist	Reporting to water authority management

11- Nile research Institute lab Water Research Center, Ministry of Public works & water Resources	Research, monitoring of the Nile river & point sources of pollution & special studies	Excellent lab facilities for conventional & heavy metals & bacteriological analyses	35 sampling sites and 140 point sources of pollution planned to be sampled every 3 months & closure period study	standard methods 89	limited for a few parameters & full program is in consideration	1 ph-D in instrumental analysis 1 B-SC senior biologist 2 B-SC Biology 1 B-SC chemical engineer 3 B-SC chemistry	Reporting as research & papers
12- Drainage Research Institute Lab water Research Center, Ministry of Public works & water Resources.	*Chemical & biological analyses for water samples *Physical * chemical analysis for soil sample *chemical & biological analyses for plants	Excellent facilities for non conventional parameters Also heavy metals & bacteriological analyses	200 water samples per month 300 soil samples per month 50 plant sample per month	standard methods 89	None	1 ph-D in soils science 3 chemists 5 agricultural engineer 2 technicians	-Year books -technical reports & papers

F. The River Nile Water Quality Conditions

F1. Water Quality Index of the River Nile

Little effort has been made to keep the general public informed in simple and understandable terms. Indices are one of the more effective ways to communicate information on water quality to policymakers and the general public.

In formulating the water quality index (WQI), the importance of the variable depends on the intended use of the water. In this paper we calculate the WQI based on stream water quality criteria with regard to all uses: raw water intake to produce drinking water, recreational and aesthetics, fresh-water aquatic life, agricultural uses, and industrial water supplies (Bhargawa, 1985).

We have used the standards stated in the Egyptian regulation, Decree No. 8 for 1983, Article 60, whenever available. In some cases, when the Egyptian regulation has not set up standards, we have used the standards recommended by the U.S. Environmental Protection Agency (EPA) or surface water standards suggested by Hammer (1986).

A critical study of Figure 6 reveals many interesting features regarding the quality of the Nile and variations in quality along its course from Aswan to Delta Barrage. First, we observe that the AWQI at site 0, upstream from the High Aswan Dam, varies from 21 at site 11 to 108 at site 14. Another interesting feature of Figure 2 is that at most sampling sites the indices are below 100, the exception being site 14. Also, about 90 percent of the sites have an index below 50.

Second, the highest levels of pollution were observed at a few locations only (sites 13 and 14). This is most likely the result of high pollutant loads from the point sources (industry, major agricultural drains, and urban centers) located immediately upstream from these sites.

In the third place, we found that the AWQI varies from site to site according to the specific water quality parameter contribution (Figure 7). For example, dissolved oxygen seems to be a problem mainly immediately downstream from the High Aswan Dam. Coliforms are an important contributing factor at only some sites, especially at site 14.

In order to rank the water quality parameters according to their contribution to the WQI, we have given 1 for the parameter with the highest contribution and 10 for the parameter with the lowest contribution. This was done at each site. Theoretically, the parameter with the highest contribution would have a rank of 31 (i.e., scoring 10 at all 31 sites).

The water quality parameters were ranked in descending order, according to their contribution to the overall water quality index. Chemical and biochemical oxygen demand rank as the most important parameters, mainly because they contribute significantly at all

Average Water Quality Index (AWQI)
along the River Nile
July,1991

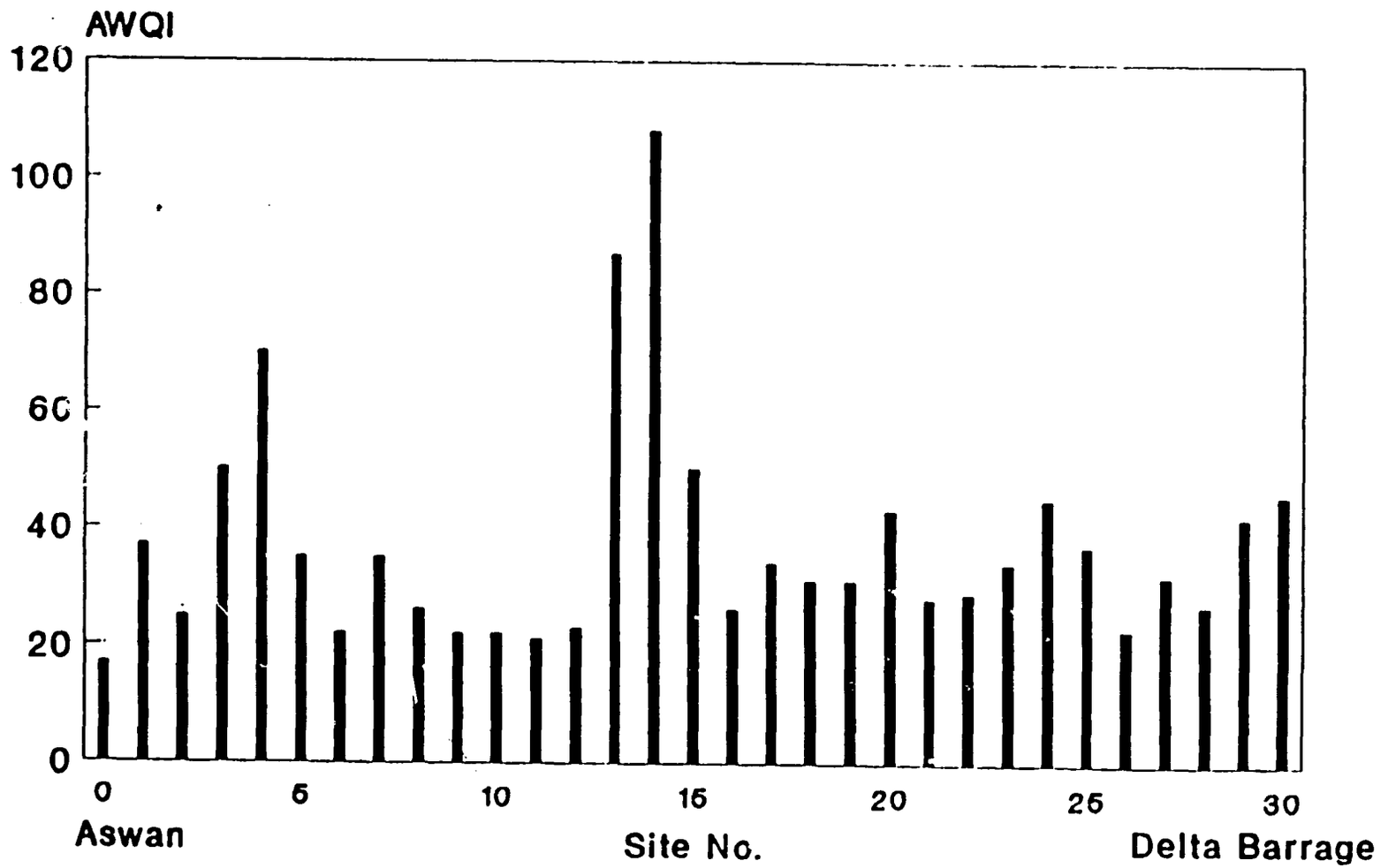

Figure (6)

Water Quality Parameters Contribution

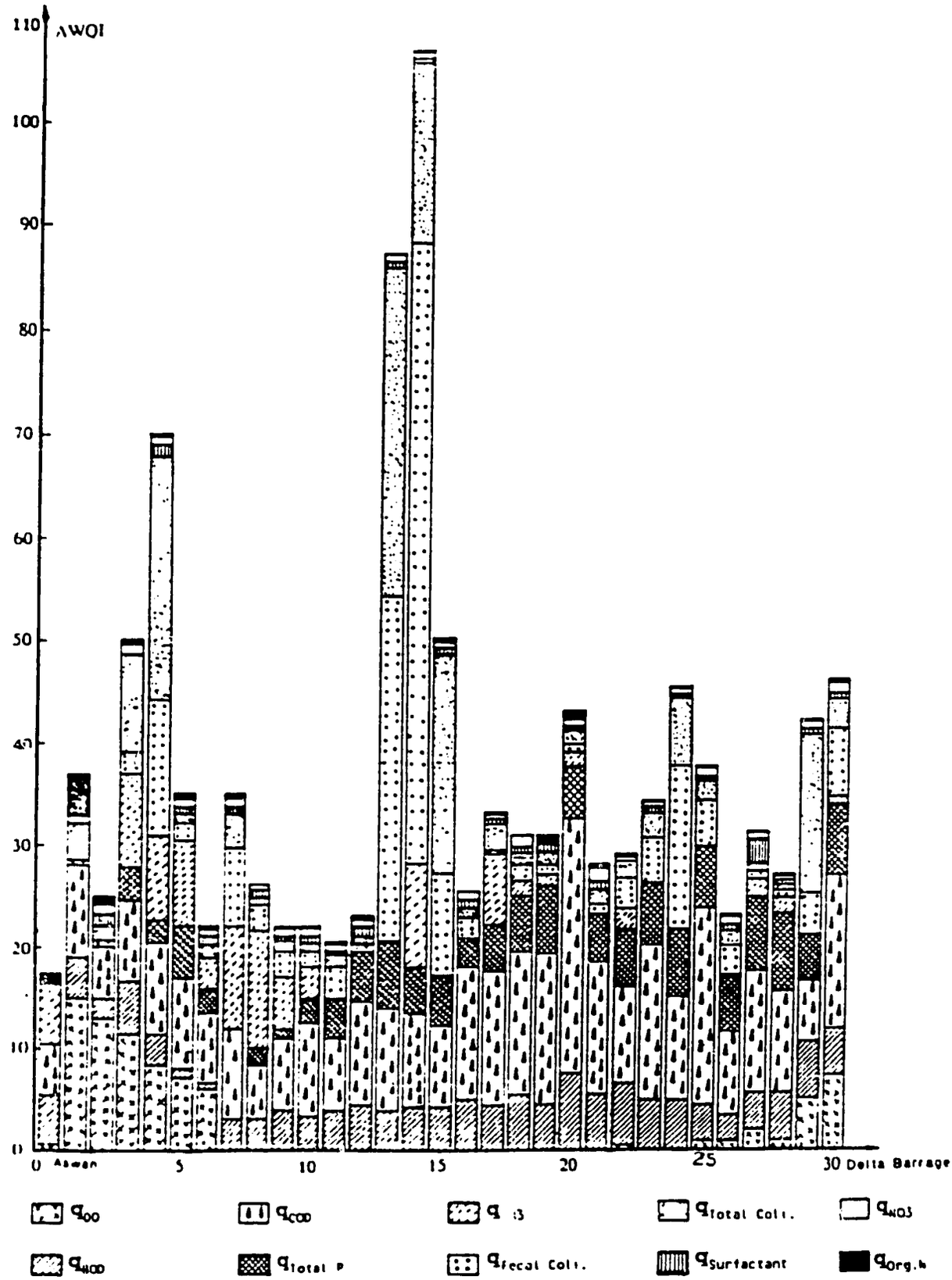

Figure (7)

Source: NRI

stations, while surfactant, nitrate, and organic nitrogen values were never observed to be above stream standards.

F2. Variations in Water Quality Parameter Values Along the River Nile

The water quality parameters varied along the entire course of the River Nile from Aswan to Delta Barrage as shown in Table 10.

F3. Recommendations to Enhance the River Nile Water Quality

F3a. Improved Agricultural Practices

After the High Aswan Dam construction, Egyptian lands lost much of their natural fertility, which created the need for chemical fertilizers.

The irrigation system also changed, which increased weed growth and resulted in the use of insecticides and herbicides. Thus, during the last few decades, these modern agricultural activities have introduced several polluting substances such as organic matter, chemical fertilizers, insecticides, and herbicides into the river through surface runoff, erosion, and drainage systems.

To decrease this pollutant load, the existing agricultural practices must be improved through an efficient, optimal and economical use of chemicals, erosion control in the fields, and recycling of organic wastes back onto agricultural lands.

F3b. Wastewater Treatment

Several industrial outfalls discharge their wastes directly into the Nile with little or no treatment. These wastes should undergo appropriate treatment before their final disposal. Otherwise, the industries should be advised to reduce their waste load generation through the following:

- Efficient use of raw materials in the industrial production
- Application of the technologies and modifications most appropriate to local conditions, and recycling of wastewater

F4. Water Quality of Rosetta Branch and Its Point Sources of Pollution

To evaluate water quality along the Rosetta Branch, the Water Quality Department of the NRI, as part of its monitoring program, collected data during winter and summer of 1990-91. The Rosetta Branch receives wastewater from the following sources:

Table (10)
#Variation of Water Quality Parameters Values.

Parameters	Standard Value	Min. Value	Max. Value	Remarks
COD mg/l	10	5	25	65%
BOD mg/l	6	0.4	4.7	100%
Total P mg/l	0.1	0	0.08	100%
Fecal Col. MPN/100ml	2000	14	12000	90%
Total Col. MPN/100ml	10000	76	33600	84%
NH3 mg/l	0.5	0.01	0.6	97%
DO mg/l	5	3.1	9.5	87%
Surfactant mg/l	0.5	0.008	0.06	100%
NO3 mg/l	45	0.87	3.8	100%
Org.Nitrogen mg/l	1	0.01	0.08	100%

Source: NRI

- Rahawy Drain — Km 35.850 from El Roda
- Sabal Drain — Km 97.400 from El Roda
- Tahreer Drain — Km 112.500 from El Roda
- Zaweit El-Bahr Drain — Km 126.700 from El Roda
- Tala Drain — Km 146.400 from El Roda
- Malia and Senaie Company
- Industrial Waste — Km 147.505 from El Roda
- Salt and Soda Company
- Industrial Waste — Km 147.515 from El Roda

The water quality in these sources is generally poor for several reasons:

- All agricultural drains receive mixed wastes from point sources and non-point sources of pollution, in addition to receiving the excess irrigation water from the cultivated land. The wastes in these drains contain high levels of suspended and dissolved solids, oil, and grease, nutrients, and organic matter.

- The use of agricultural pesticides has grown dramatically in recent years. Among the pesticides, residues of many organochlorine compounds were detected.

- Rahawy drain represents the worst condition among all sources of pollution, since it receives a large proportion of raw municipal and domestic wastes from Cairo, in addition to the water from El Moheet Drain.

- The industrial waste effluents discharging into the Rosetta Branch without treatment from both the Malia and Senaiea Chemical Industry and the Salt and Soda Company at Kafr El Zayat contain extremely high levels of total solids, oil, and grease.

The Rosetta Branch, as a fresh water ecosystem, receives wastewaters from different sources. This system involves complex physical and biochemical interactions. Accordingly, the water quality characteristics of the branch determined during the sampling campaign of 1990/91 will be discussed in Table 11 below:

Table 11. Water Quality Characteristics of Rosetta Branch

Parameters						
	Max	Min.	Max.	Min.	Max	Min
TDS	838	279	334	217	505	209
DO	9.02	0.23	11.5	3.5	12.5	1.5
3 OD	4.1	2.2	19.8	5.1	42	2.5
COD	144	9	78	18	88	12
NH3	8	0.35	1.6	0.005	8	0.002
Org.Nitrogen	0.70	0.08	0.21	0.005	0.5	0.005
NO3	12,4	1.5	8.20	3.5	11.4	2.7

Source: NRI

Table 11 shows that most parameters have higher concentrations during the first and fourth runs (low flow conditions than during the second run (high flow condition).

F5. Salt Balance Loading

The salt loading is calculated for the River Nile from Aswan to Cairo. The salt loads for both Aswan and El Khasass station near Cairo were calculated at different periods of time to present three different flow regime patterns. Table 11 indicates that during the low flow and high flow, the system seems to be assimilating the salt load (i.e., the constituents are retained within the system). During the winter closure period, however, the salt load at El Khasass was higher than the salt load at Aswan, which means that the system is affected by significant point or non-point sources of pollution, or material was derived from the main channel itself. These salt loads were calculated at Aswan and El Khasass for three different periods of time using data collected in 1991 (Table 12).

Table 12. Salt Load Calculation in 1991 for the River Nile

Location	Winter Closure period January 1991			Lower Flow condition April 1991			High Flow Condition July 1991		
	TDS mg/L	Q m. m3/d	Salt Load ton/d	TDS mg/L	Q m. m3/d	Salt Land ton/d	TDS mg/L	Q m m3/d	Salt Load ton/d
Aswan	108	70	7560	143	140	20020	137	220	30140
El Khasass	217	75.6	16405	209	94.3		203	132	

Source: NRI

Similar calculations were done for loads at Delta Barrage, Rosetta, and Edfina for the three different periods of time, as indicated in Table 12.

Table 13. Salt Load Calculation in 1991 for Rosetta Branch

Location	Winter Closure Period January 1991			Low Flow Condition April 1991			High Flow Condition July 1991		
	TDS mg/L	Q m. m3/d	Salt Load ton/d	TDS mg/L	Q m m3/d	Salt Load ton/d	TDS MG/l	Q m m3/d	Salt Load ton/d
Delta Barr. Rosetta)	217	65.95	14311	209	8.4	1756	203	132	2283
Ed-fina Barr.	288	65.70	18921	377	0.2	75.4	336	0.2	67.2

Source: NRI

The conclusion which can be drawn for Rosetta Branch from Table 13 is similar to that for the River Nile, which is discussed above.

Other salt loading calculations were considered, taking into account the average TDS per month and the average daily flow per month for Aswan and El Khasass stations over the following years: 1976, 1979, 1985, 1986, and 1991, as indicated in Table 14.

Table 14 indicates that the annual salt loading at El Khasass is less than the annual salt loading at Aswan, which also confirms that the system is assimilating (i.e., the TDS constituents are retained within the system).

G. Conclusions and Recommendations

G1. Existing Pollution Problems and Future Trends

The data analysis, either through reports or published papers issued by NRI, indicates that the River Nile and its two branches are suffering from pollution problems in some locations. These problems have appeared and increased due to the discharge of municipal wastes from most villages along the River Nile which have no wastewater treatment facilities; most industrial effluents are discharged into the Nile, the drains, or even the canals with little or no treatment. To these must be added the diffused pollution, namely nutrients and pesticides from agricultural activities and the contamination of surface and groundwater by the disposal of industrial toxic water for which there are no controls.

Data collected in Egypt during the 1980s clearly justify the growing concern with the deterioration of water quality in the Nile system. Major problems include accumulation of heavy metals in the river sediments; presence of toxic organic components in fish tissues

Table (14)

Average Salt Loading for the River Nile

Aswan

Date	TDS mg/l	Q m.m3/d	Salt Loading 1000 ton
Jan.	108	114	382
Feb.	134	139	522
Mar.	160	141	699
Apr.	143	142	609
May.	160	163	808
Jun.	178	220	1175
Jul.	137	221	939
Aug.	206	194	1239
Sep.	206	147	908
Oct.	180	134	748
Nov.	192	128	737
Dec.	150	126	586
Total			9352

El-Ekhsass

Date	TDS mg/l	Q m.m3/d	Salt Loading 1000 ton
Jan.	217	104	700
Feb.	215	89	536
Mar.	214	95	630
Apr.	209	96	602
May.	207	100	642
Jun.	206	136	840
Jul.	203	147	925
Aug.	212	134	881
Sep.	230	104	718
Oct.	224	96	667
Nov.	224	92	618
Dec.	220	98	668
Total			8426

Source: NRI

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from the Nile; symptoms of eutrophication in different stretches of the river; and high BOD loading from most agricultural drains discharging into the Nile.

With the increased water demand for domestic, agricultural, and industrial uses, the quantities of wastewater effluent requiring treatment and disposal are increasing rapidly. A variety of waste effluents and runoffs are frequently discharged directly into the Nile at several locations. Eighty-eight agricultural drains and 59 industrial outfalls discharge their wastes directly into the Nile.

With increasing population, industrialization, and awareness of the importance of the quality of water and its effects on public health in Egypt, research on water quality has become a major concern.

Monitoring is the first step in water quality assessment and pollution control. NRI has monitored the quality of Nile water annually between 1976 and 1986.

Water quality samples were taken in sectors every 10 kilometers and within 200 meters downstream from the point sources of pollution. In addition, samples were taken from all the point sources of pollution. Each sample was analyzed for physical, chemical, and biological parameters. Since 1987, a special study took place on the Rosetta and Damietta Branches during the winter closure period. The analyses using available data indicated that the River Nile is suffering from pollution, and permanent water quality monitoring is needed. The Nile Research Institute designed a permanent water quality monitoring program along the river to be implemented every three months for 35 sampling sites and major point sources of pollution. Besides the work done by NRI, several programs were carried out by other agencies, some of which are still operating. All the data are stored in the computers or in hard-copy reports.

This report identifies the different point sources of pollution along the River Nile and its branches, either agricultural or industrial effluents. It also presents the available flow rates and water quality parameters for the point sources of pollution for different years.

In addition, information on the flow rates and some contaminants are presented for all industrial outfalls in Egypt, according to the type of industry.

A survey was done in 1989 in the different laboratories conducting water quality analyses. The activities, equipment, personnel facilities, sampling programs, and methods of analysis of these laboratories are presented.

A general assessment of water quality was done on the River Nile and its branches using the more recent available data collected by NRI from January 1991 to May 1991 on the branches and in July 1991 on the River Nile. The River Nile water quality analyses, using the water quality index to discriminate between the stations, indicated that the dissolved oxygen seems to be a problem mainly immediately downstream from the High Aswan Dam. The data also indicated that chemical and biological oxygen demand is the greatest contributor for all stations, and coliforms are an important factor at the critical stations. The

discussion of the water quality parameters along Rosetta Branch during the winter closure period indicated that the concentrations of most parameters are higher during the first and fourth runs (low flow conditions) than during second run (high flow condition).

G2. Gaps of Information

Gaps in the data and information appear in the following areas:

- Sediment quality
- Industrial outfall flow rates located at the Nile or any other waterways
- Type of processes used in each factory
- Raw materials and products for each type of industry
- Treatment facilities
- Exchange between the different agencies working in the field of water quality
- Municipal wastes discharged to the River Nile or any waterways
- The power station

To fill these gaps, WRC must establish a data bank for all water quality data collected by its different institutes and also that collected by organizations working in the field of water quality. In addition, regional water quality laboratories should be established to analyze the urgent parameters tha need to be analyzed on the same day; otherwise a mobile lab should be available. However, other solutions could be found by preparing a basic laboratory in the accommodation boat.

G3. Management Strategies for Protection of Surface Water

To protect Egypt's surface water, various studies and research should take place. We suggest that appropriate mathematical models to simulate water quality issues be developed. A simple water quality model should be attempted first. Cooperation among concerned authorities, universities, and research institutes should be encouraged. The following study topics are suggested:

- Impact of domestic and industrial wastewater on surface water resources, and measurements to reduce this impact.
- Special Environmental impact studies for major irrigation and drainage projects such as:
  - Storage of fresh water in the Northern lakes,
  - Re-use of drainage water that carries a large load of domestic and industrial wastes, conversion of Northern lakes to agricultural lands,
  - El Salam canal and the transport of Nile water to Sinai, and
  - Integrated development of the region surrounding the High Aswan Dam.

G4. Ongoing and Future Studies

Water quality and pollution control are the most important issues in water resource management in Egypt. In 1988, many actions were undertaken to address water quality problems.

Egypt's five-year environmental plan, 1987-92, includes three priority projects related to water pollution control:

G4a. Project to Protect the Nile and Other Waterways from Hazardous Industrial Waste

Steps that have been taken include treatment of effluent from some industrial outfalls discharging their wastes to the Nile. The protection program started in 1985 with 25 treatment operations at 19 priority factories at a cost of 30 million pounds. The remaining factories are scheduled to be covered during the coming five-year plan, at a total cost of 500 million pounds. In addition, treatment units have been installed in all 800 vessels of the commercial Nile fleet.

G4b. Project to Protect Rural Environment

The objective is to protect soil and waterways from the harmful effects of applied fertilizers and pesticides. The project will last two years and cost 250,000 Egyptian pounds.

G4c. Environmental Monitoring Network Project

The project aims to provide the national monitoring network with the necessary equipment to direct pollution control efforts. The project is expected to last for five years and cost 4 million pounds.

G5. Monitoring and Environmental Setting Identification

a. Monitoring the water quality of the Nile canals and drains should be given adequate attention and human and financial resources.

b. All water bodies should be monitored for pertinent water quality parameters. Sampling sites, techniques, methods, and facilities of analysis should be thoroughly studied. Short- and long-term planning is greatly needed to provide new facilities and upgrade existing facilities.

c. All discharge points for municipalities and industries should be carefully examined, and permissible flows, concentrations of various pollutants, and treatments should be shown on the permits.

d. It is recommended that a national data bank for water resource quality be established. Coordination among all concerned authorities is extremely important.

G6. Training and Education

a. Educational programs for farmers and villagers are suggested to warn them about dangers of the misuse of the irrigation and drainage system and the risks from contact with contaminated water.

b. Training is required for personnel of agencies in charge of sampling and analysis.

c. Training is also recommended for the personnel of the irrigation department who are in charge of granting discharge permits and detecting violations.

G7. Public Awareness

Educational programs and seminars for the public are encouraged to inform people of the dangers of polluted water.

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