Ministry of Water Resources and Irrigation

US Agency for International Development

Egypt Water Policy Reform
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Task Order 815

NILE RIVER WATER QUALITY MANAGEMENT STUDY

Report No. 67

June 2003

Development Alternatives, Inc.

INTERNATIONAL RESOURCES GROUP

Egypt Water Policy Reform
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Principal: Development Alternatives, Inc.
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Acronyms

AHD	Aswan High Dam
APRP	Agricultural Policy Reform Program
BOD	Biological Oxygen Demand
CIDA	Canadian International Development Agency
COD	Chemical Oxygen Demand
DAI	Development Alternative, Inc.
DRI	Drainage Research Institute
DSS	Decision Support System
DO	Dissolved Oxygen
EPIQ	Environmental Policy Indefinite Quantity
EEAA	Egyptian Environmental Affairs Agency
EIA	Environmental Impact Assessment
FC	Fecal Coliform
FtC	Facing the Challenge (National Water Resource Plan)
GOE	Government of Egypt
IRG	International Resources Group, Ltd.
MALR	Ministry of Agriculture and Land Reclamation
MISD	Matching Irrigation Supply and Demand
MOSEA	Ministry of State for Environmental Affairs
MOHP	Ministry of Health and Population
MPN	Most Probable Number (unit in measurement for bacterial count)
MPWWR	Ministry of Public Works and Water Resources
MSL	Mean Sea Level
MVE	Monitoring, Verification and Evaluation Unit
MWRI	Ministry of Water Resources and Irrigation
NAWQAM	National Water Quality and Availabiltiy Management
NRI	Nile Research Institute
NWRC	National Water Research Center
NWRC	National Water Resources Plan
PPM	Parts per Million
PS	Pump Station
TDS	Total Dissolved Solids
USAID	United States Agency for International Development
WHO	World Health Organization
WPAU	Water Policy Advisory Unit
WPRP	Water Policy Reform Project
WQIC	Water Quality Information Center
WTP	Wastewater Treatment Plant

1. Introduction

Collaboration between USAID and MWRI dates back to the late 1970s. The partnership has continued without interruption, most recently through the Water Policy Reform Program (WPRP), a component of the larger Agricultural Policy Reform Program (APRP). In recent years, WPRP-sponsored work has focussed on three interconnected themes for improving management in the water sector: water use efficiency, public participation in decision making, and reducing water pollution.

This report is concerned with the third theme, water quality. Quality of water in the main stem, drains, and canals-- collectively the Nile River system -- has deteriorated in the past few decades because of increases in population, several new irrigated agriculture projects, industrial growth, etc. Without well-conceived interventions to address this problem, this trend can be expected to continue. It could even intensify since, as plans to expand out of basin land areas under irrigated agriculture move forward, the dilution capacity of the Nile River system will diminish at the same time that growth in industrial effluents and municipal wastewater increase the volume of pollutants discharged to the Nile.

1.1 Background

In order to address the pollution problem, it was considered necessary to better understand the characteristics of the Nile River system and how pollution affects the system. This work was completed in part with the release by WPAU of a ***Survey of the Nile System Pollution Sources Report No. 64*** in September, 2002. The objective of that study was to identify and characterize the sources of pollution discharges to the Nile River system. This current study is a follow-up presenting additional information, pointing to major issues, and suggesting options for dealing with them. It was undertaken with funding from USAID under a Water IQC task order.

The objectives of this study are to:

- Further understand the characteristics of Nile River system pollution,
- Assess on a preliminary basis using case studies the physical feasibility of temporarily separating portions of the collector drainage system and the fresh water delivery system,
- Provide a tentative assessment of the impact on overall dilution capacity and quality of water in the Nile system if water is permanently diverted out of the system,
- Make recommendations looking towards the development of an integrated water quality management program.

1.2 Scope of Work

The Scope of Work for this study was divided into six tasks which are described briefly below:

1.2.1 Task 1: Review of Existing Work and Collection of Supplemental Information

As a follow-up to the pollution survey mentioned above, this task was designed to fill in to the extent possible data gaps involving strength and characteristics of pollutants being discharged, volumes of pollutants discharged, and types of industries using water for waste disposal. From the data and information obtained from the MWRI, other Ministries, and projects, the Nile River system was evaluated in terms of water quality indices indicating those areas having relatively good quality waters and those that are polluted. Recommendations were made to fill in information gaps and a schematic map was produced showing areas within the Nile River system that are particularly polluted or susceptible to pollution from industrial, agricultural, sewerage, or other point and non-point sources.

1.2.2 Task 2: Assess Feasibility of Separation of Drainage and Canal Water

This task was originally designed to assess the physical feasibility of permanent separation of portions of the collector drainage system and the fresh water delivery system. Options that were to be reviewed included the diversion of low-quality drainage water to designated sites for use on approved crops or, in the lower Delta, for direct disposal to the sea. On review of the existing collection system, it became quickly apparent that due to the complexity of the canal/drain system and the lack of temporal water quality data such an analysis may not be practical or even applicable. However, it was felt that, by understanding the environmental and economic problems of typical collection systems, conclusions could be drawn about kinds of interventions (including the separation of fresh and contaminated water) that could be used in the short-term to improve environmental conditions.

1.2.3 Task 3: Mass Balance Study

This task was designed to assess the impact on overall dilution capacity and quality of water in the Nile system if low quality drainage water is permanently or temporarily diverted out of the system. The impacts of water diversions out of the Nile River system for the new land reclamation projects also are assessed as part of the study. This task was accomplished through working with the Planning Sector of the MWRI and using models developed by them to:

- Assess the impact on overall dilution capacity and quality of water in the Nile system of permanently diverting fresh or contaminated water out of the system.
- Perform a preliminary assessment of the impact of such diversion on the environment due to the use of contaminated water for new land reclamation projects.

In addition, areas within the Nile River system that will be particularly impacted by removal of water from the system are noted.

1.2.4 Other Tasks

Other tasks include:

Task 4: Preparation of a Draft Report
Task 5: Conduct of a Workshop
Task 6: Preparation of Final Report

1.3 Questions That Need to be Answered

To carry out this study, several questions about pollution sources, drainage waters, and potential impact of pollution abatement interventions have to be answered. Questions by category include:

1.3.1 Pollution Sources

1. Is pollution source elimination the only method of removing water contaminated with domestic and industrial effluent from the Nile Rive system?
2. Can we locate industries which discharge wastewater and assign a priority ranking to each according to the toxicity of their waste streams?
3. Do any Egyptian industries generate a waste stream that may have value?
4. Based on the work done to date, can we prioritize areas which contribute most pollutants to the Nile River by category (i.e. trace metals, nutrients, COD, BOD, etc.)?
5. Are canals mainly polluted from agricultural, domestic, or industrial wastewater?
6. How does one evaluate on-farm pollution sources? Education, construction of treatment lagoons, proper design and construction of septic tanks, etc.?
7. Is EEAA doing its job in wastewater management? If not, why not?

1.3.2 Drainage Water

1. Can existing contaminated drainage water eventually be cleaned up or is it hopeless due to economic constraints?
2. For non-point pollution sources, is on farm treatment a viable alternative?
3. Can treatment occur within drainage canals using wetland type vegetation?
4. Are there drains that should be protected from industrial and domestic wastewater contamination? If so, which ones?
5. Can we effectively separate drains that have been impacted by urban wastewater from those with agricultural drainage water?
6. How many pump stations used for mixing drainage water and canal water have been shut down due to high levels of contamination in the drainage water?
7. Where have these pumps been shut down?
8. Have steps been taken to respond to the problem upstream from the intakes?
9. How much does it cost to build a pump station, and isn't this investment worth protecting?
10. What steps are being taken by the GOE to protect these canals and drains?

11. In terms of protection of drinking water and new land reclamation, which canals and associated drains are of priority concern?

1.3.3 Impact

1. What would be the impact on the water balance in the Delta if drainage water contaminated with urban pollution is permanently separated?
2. How will this study make an impact on current wastewater management practices in Egypt?
3. What would be the impact on new lands development if contaminated water low in salinity is used for irrigation?

The answers to some of these questions come easy. The answers to others are complex and beyond the scope of this study. However, this report provides insights about how best to approach these questions in a pragmatic way.

1.4 Approach

This study was undertaken in close cooperation with the Water Policy Advisory Unit (WPAU) in the Egyptian Ministry of Water Resources and Irrigation (MWRI). A team approach was taken. The team consisted of Eng. M. Nasser Ezzat (Team Manager), Eng. Alaa Hassan (WPAU), Eng. Hisham Shehab (WPAU), Dr. Fatma El-Gohary (Water Quality Consultant), Dr. Shaden Abdel-Gawad (Water Quality Consultant)**,** Dr. Emad H. Imam (Drainage Consultant), Dr. Mohamed Tawfic (Water Reuse Consultant), and Phillip E. Brown (International Resources Group). The work was completed under the guidance of Eng. Gamil Mahmoud (Chairman, WPRP Steering Committee).

The team took a very pragmatic approach in carrying out this study. More specifically, it:

- Reviewed existing information and held a series of meetings with water quality specialists within the NWRC, EEAA, and Ministry of Industry. These meetings followed up on the work done previously by the WPAU in the "Survey of the Nile System Pollution Sources" ***Report No. 64*** in September, 2002.

- Carried out data analysis and an impact assessment using existing data and information.

- Completed case studies for Upper Egypt and the Delta to evaluate the impact of separating contaminated drainage water and canal water. The results of this work were then applied in general terms to all of Egypt.

- Worked with the Planning Sector of MWRI to develop conceptual and mass balance models to determine the impact of separating fresh and drain water.

- Drew maps and schematic diagrams presenting study results.

1.5 Organization of this Report

The report presents the results of this work. It is divided into five sections with this Introduction being Section 1. The second section presents a brief overview of previous work done by the WPAU. It defines priority areas of concern in terms of strategic importance and water quality issues involved with drains and canals. The third section addresses the potential impacts of diverting water to large-scale reclamation projects and the importance of protecting drain water for potential reuse. This section includes a volume and mass balance study for the Nile River System. Section 4 describes current water quality management practices used for drains. Section 5 evaluates methodologies that could be used to manage drain water and to protect the Nile River system. In Section 6, concepts are presented looking toward integrated water quality management and conclusions are outlined.

2. EXISTING WATER QUALITY SITUATION

2.1 General

This section presents a brief overview of the work done in Phase I of this study and presented in WPAU's "Survey of the Nile System Pollution Sources" ***Report No. 64*** dated September, 2002 as well as more recent information gathered during this study. In general, the SOW was to survey existing Nile River system data (post-1995) to: 1) identify the main sources of pollution discharges to the system, 2) describe the source, i.e. name and type of source, such as municipal or industrial point sources, and, if possible, diffuse agricultural sources, 3) characterise the discharges as chemical or biological, 4) define the location of each source, and 5) prepare a graphical presentation of the pollution sources by displaying them on a map of suitable scale or on a schematic of the Nile system.

Considerable efforts were made to review existing work, contacting various Ministries and organizations involved in water quality monitoring. In addition to that work presented in **Report 64,** more recently acquired data used for the preparation of this report are as follows:

EGYPT'S WATER RESOURCES

Water resources in Egypt are limited to the Nile River, groundwater in the Delta, Western deserts and Sinai, rainfall and flash floods as well as drainage and wastewater.

The Nile is the predominant source of fresh water in Egypt. Presently, it's flow rate relies on the available water stored in Lake Nasser to meet needs within Egypt's annual share of water, which is fixes at 55.5 Billion Cubic Meters (BCM) annually by an agreement signed with Sudan in 1959.

Groundwater exists in aquifers underlying the western desert, the Sinai, and in the Nile River Alluvium. In the western desert, 200,000 BCM of deep, fresh, and nonrenewable groundwater is found within in the Nubain sandstone. Groundwater in Sinai exists in the shallow and deep aquifers. The Nile River and Delta alluvial aquifer is recharged by seepage losses from the Nile, the irrigation canals and drains, and percolation of irrigation water. This aquifer is estimated to store 500 BCM with a maximum renewable amount of around 7.5 BCM of which about 4.8 BCM/year is abstracted.

Rainfall on the Mediterranean coastal strip decreases eastward from 200 mm/year at Alexandria to 75 mm/year at Port Said. It also declines inland to about 25 mm/year near Cairo. Rainfall occurs only in the winter season in the form of scattered showers and is not considered a dependable source of water. However, some seasonal rain-fed agriculture is practiced in the northern coast to the west of Alexandria and in Sinai. Flash floods from short duration, high intensity rainfall events are also a minor source of fresh water.

Other water resources include agricultural drainage water, desalinisation of brackish groundwater and/or seawater, and treated municipal wastewater.

- Monitoring data for the year (2001) (provided by the NWRC).
- Results of the analysis of the drains discharging into the main Nile basin for the year (2002).
- Water quality reports issued by EEAA (1999-2002).
- Monitoring data published by the Ministry of Health and population for the year (2001).

2.2 Sources Contributing to Pollution

Degradation of water quality is a major issue in Egypt. The severity of water quality problems in Egypt varies among different water bodies depending on: flow, use pattern, population density, extent of industrialization, availability of sanitation systems and social and economic conditions. Discharge of untreated or partially treated industrial and domestic wastewater, leaching of pesticides and residues of fertilizers; disposal of solid wastes; and navigation are often factors that affect the quality of water.

2.2.1 Industrial Wastewater

The industrial sector is an important user of natural resources and a major contributor to pollution of water and soil. There are some 24,000 industrial enterprises, about 700 of which are major. In Egypt, manufacturing facilities are often located within the boundaries of major cities, in areas with readily available utilities, supporting services and workers. In general the majority of heavy industry is concentrated in Greater Cairo and Alexandria.

Industrial use of water in the year 2000 has been estimated to be 7.6 billion cubic meters (BCM). By the year 2017, it is expected to reach 10.6 BCM. Consequently, an increase in the volume of industrial wastewater is expected (NWRP, 2002). Such an increase in water usage without proper controls (i.e. enforcement of laws regarding discharge, improved recycling of water in plants, etc.) will most likely lead to increased pollution loading to receiving waters as well as groundwater. This increased loading places the current reuse of drain water strategy in jeopardy as well as posing increased risks to human health and the environment.

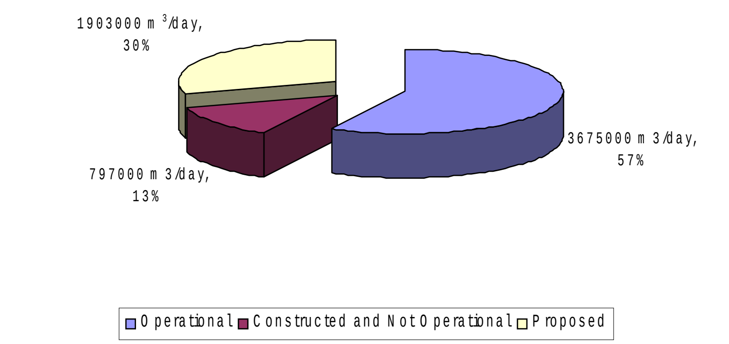
2.2.2 Municipal Wastewater

Currently there are 59 primary or secondary treatment plants operating with a total capacity of 6.2 mcm/day (or 2.3 bcm/year). As presented in Table 2-1, these sewage treatment plants in 1997 served 18 million of the 60 million people of Egypt or 30% of the population. Based on population studies and rate of water consumption, by the year 2017, coverage is expected to increase to serve 39 million of an estimated 83 million people or 47% of the population. (National Water Resources Plan, 2002). Although the capacity increase is significant, it will not be sufficient to cope with the future increase in wastewater production from municipal sources. Therefore, the untreated loads that will reach water bodies are not expected to decline in the coming years.

Table 2-1: Projections of Sanitation Coverage

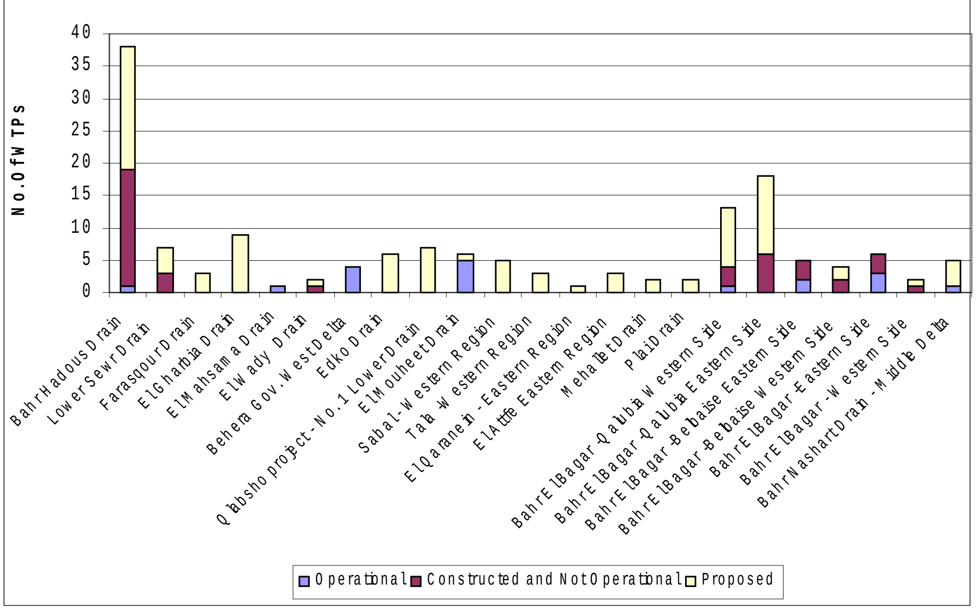
Year	Population	People served	People not served
1997	60 Million	18 Million	42 Million
2017	83 Million	39 Million	44 Million

Figure 2-1: ESTIMATED CAPACITY OF EXISTING NILE DELTA WASTEWATER TREATMENT PLANTS
Operational (YR 2000), Not Operational, or Proposed



In the Delta Region, there are18 plants operating, 40 plants constructed and not operational, and 94 proposed. As illustrated in Figure 2-1 (MWRI, 2000), plants in operation have the capacity to treat approximately 57% of the wastewater. As presented in Figure 2-2 (MWRI, 2000), currently there is no treatment of municipal wastewater in numerous drain catchment areas throughout the Delta

Figure 2-2: Proposed and Operating WTPs in the Nile Delta



The constituents of concern in domestic and municipal wastewater are: pathogens, parasites, nutrients, oxygen demanding compounds and suspended solids. In Greater Cairo and other cities, the sewerage systems also serve industrial and commercial activities. Therefore, instances of high levels of toxic substances in wastewater have been reported. As these toxic substances (heavy metals & organic micro-pollutants) are mainly attached to suspended material, most accumulate in the sludge. Improper sludge disposal and/or reuse may therefore lead to contamination of surface and ground water.

In general, the bulk of treated and untreated domestic wastewater is discharged into agricultural drains. Total coliform bacteria reach 10^6 MPN/100 ml as recorded in many drains in the Delta, which is considerably higher than the Egyptian standard of 5000 MPN/100. It is important to mention that all drains in Upper Egypt flow back into the Nile. Moreover, it has become a national policy to maximize the reuse of drainage water by mixing it with canal water. Many irrigation canals may be contaminated with pollutants from domestic sources as a result.

2.2.3 Agricultural Drainage Water

Apart from being the largest consumer of water, agriculture is also a major water polluter. Drainage water seeping from agricultural fields are considered non-point sources of pollution. These non-point sources are, however, concentrated through collecting agricultural drains to form point sources of pollution for the River Nile, the Northern Lakes and irrigation canals in case of mixing water for reuse. Moreover, agricultural non-point sources of pollution may also affect groundwater quality. Major pollutants in agricultural drains are salts, nutrients (phosphorus & nitrogen), pesticide residues (from irrigated fields), pathogens (from domestic wastewater), and toxic organic and inorganic pollutants (from domestic and industrial sources).

2.2.4 Navigation

The river fleet, which is comprised of over 9000 units, also contributes to river pollution, i.e. oil and grease, as well as domestic waste. Oil and grease are often toxic to aquatic life and through decay may deplete oxygen in the river.

2.2.5 Solid Waste

Illegal polluting practices are numerous and widespread where there is little or no possibility of direct control. Sources range from intentional dumping of night soil, garbage, washing of animals and domestic utensils, to seepage from landfills, run-off from animal farms and accidental releases of chemicals.

2.3 Water Quality Assessment

Since the construction of the Aswan High Dam (AHD), water quality of the Nile in Egypt has become primarily dependent on the water quality characteristics of the reservoir (Lake Nasser), and less dependent on water quality fluctuations of its upper reaches. Water released from Lake Nasser generally exhibits the same seasonal variation and the same overall characteristics from one year to another.

Downstream changes in river water quality are primarily due to a combination of land and water use as well as water management interventions such as: (a) different hydrodynamic regimes regulated by the Nile barrages, (b) agricultural return flows, and (c) domestic and industrial waste discharges, including oil and wastes from passenger and river boats. These changes are more pronounced as the river flows through the densely populated urban and industrial centers of Cairo and the Delta region.

The following presents the most recent data available on the water quality of the Nile River system. NWRC 2001 and 2002 survey data were used to prepare a water quality assessment for the Nile. To assess the water quality of agricultural drains, limited recent data were supplemented with older data out of necessity.

2.3.1 Nile River Aswan to Delta Barrage

Agricultural Drain Point Source Discharges

According to the National Water Research Center (NWRC, 2001), the Nile River from Aswan to Delta Barrage receives wastewater discharges from 67 agricultural drains of which 43 are considered major drains which have been sampled. Physico-chemical characteristics and fecal coliform counts of these major drains at their tail ends, before discharge into the Nile are presented in (Tables 2-2, 2-3 & 2-4). The parameters that are non-compliant with Law 48 are shaded in the tables. The data indicate that out of the 43 drains sampled only a few are complying with the consent standards set by Law 48/1982 (Article 65) regulating the quality of drainage water which can be mixed with fresh water. All other drains exceed the consent standards in one or more of the parameters. The worst water quality is that of Khour El-Sail Aswan, Kom Ombo, Berba and Etsa drains. The highest organic load is discharged from Etsa drain (57.0 ton COD/d, 21.7 ton BOD/d). This is followed by Kom Ombo drain (21.0 ton COD/d; 5.8 ton BOD/d), (Table 2-2).

Industrial Point Source Discharges

According to EEAA (2002), all factories along the reach between Aswan and the Delta Barrage have already either constructed pre-treatment plants which discharge into the sewerage system or complete treatment plants which discharge into the Nile River system.

Assessment of Ambient Water Quality Status from Aswan to Delta Barrage

The results of the monitoring campaigns carried out by EEAA (2002) and NRI (Feb. 2001) are presented in Tables 2-5 and 2-6, respectively. Shading of values in Table 2-6 denotes non-compliance with standards. From the available data, it can be concluded that there is a great variation in the spatial distribution of fecal coliform (FC) counts. Levels are very high around the catchment areas of Kom Ombo, El-Berba, Main Ekleet and Fatera drains. It is worth mentioning that the FC counts in the water samples taken from the specific river bank where the drain water is pumped are even higher. This indicates the presence of untreated human wastes in these drains, a situation which requires special attention. Also, there is a gradual build up of salinity as one goes north. But the organic loads are still within the natural carrying capacity of the river. It should be noted that along this reach, the Nile meets Egyptian Water Quality Consent Standards for most inorganic parameters, and is comparable in terms of pollution loading to other major rivers in the world. This is primarily because of the high dilution effect and the fact that sediments tie up trace metals and other constituents.

Table 2-2: Water Quality of Drains in 2001

Drain Name	Location (KM) from AHD	Discharge mm3/day	COD mg O_2/l	BOD mg O_2/l	DO mgO_2/l	TDS mg/l	FC MPN/100ml	Heavy Metals
GOE Consent Standard			**15 mg/l**	**10 mg/l**	**5 mgO_2/l**	**500 mg/l**	**5.00E+03**	**3**
Khour El sail Aswan	9 9	0 10	102	32 80	1 91	1190	3 25E+04	0 31
El Tawansa	37 3	0 01	8	1 01	6 16	710	3 50E+03	0 50
El Ghaba	46 6	0 19	11	1 00	7 8	570	1 85E+03	0 75
Abu Wanass	47 2	0 20	7	1 28	7 03	463	3 00E+03	0 39
Main Draw	48 9	40 l/s	17	1 48	7 34	460	3 00E+04	0 61
El Berba	49 1	0 15	113	42 70	3 85	414	2 25E+04	0 70
Kom Ombo	51 0	0 14	151 6	41 50	2 25	325	2 25E+04	2 15
Menaha	55 0	-	4	1 52	7 86	285	7 50E+03	0 26
Main Ekleet	57 0	0 02	4	1 53	9 21	340	1 50E+03	2 44
El Raghama	64 7	0 04	10	1 55	8 56	390	1 75E+03	0 30
Fatera	70 5	0 78	5	2 04	7 7	564	3 50E+03	0 54
Khour El sail	70 8	0 17	2	1 05	9 07	500	2 00E+03	0 34
Selsela	73 9	50 l/s	3	1 25	6 38	380	3 20E+03	1 26
Radisia	99 9	0 13	16	3 06	9 02	1430	2 30E+03	0 22
Edfu	116 2	0 27	15	1 59	9 49	817	3 00E+03	2 37
Houd El Sebaia	139 5	0 05	16	1 83	6 77	495	1 75E+04	0 76
Hegr El Sebaia	149 1	0 05	19	2 55	7 82	670	4 50E+03	0 51
Mataana	187 7	0 12	39	3 15	6 45	613	1 75E+04	1 29
El Zeinia	236 0	NA	NA	NA	*	*	*	NA
Habil El Sharky	237 7	0 08	30	1 78	8 45	560	4 00E+02	1 06
Danfik	251 6	0 01	34	2 52	8 51	367	1 50E+03	1 05
Sheikia	265 3	0 06	37	1 72	7 55	662	3 75E+03	4 68
El Ballas	270 7	0 01	144	10 78	9 17	1395	1 50E+04	0 59
Qift	275 9	0 03	30	1 60	9 11	375	2 50E+03	0 39
Hamed	331 2	0 07	11	1 00	7 18	1015	9 00E+02	0 35
Magrour Hoe	340 4	0 06	21	3 24	8 2	185	1 60E+03	1 05
Naga Hammadie	377 8	0 21	13	2 17	8 11	375	3 30E+03	1 67
Mazata	392 8	0 01	10	2 19	8 37	495	2 50E+02	0 23
Essawia	432 7	0 07	9	2 43	6 61	200	1 50E+03	0 51
Souhag	444 6	0 05	9	2 81	7 42	440	8 00E+02	0 38
Tahta	486 4	0 01	21	2 01	7 86	980	1 40E+03	0 29
El Badary	525 4	0 12	6	3 27	7 25	255	9 00E+02	0 48
Bany Shaker	588 6	0 02	13	2 25	7 47	485	1 00E+04	0 30
El Rayamoun	637 4	NA	21	15 85	2 77	290	1 50E+03	0 16
Etsa	701 2	0 57	100	38 00	1 58	575	3 50E+04	0 19
Absoug	780 5	0 19	29	1 89	7 34	640	3 00E+03	0 34
Ahnasia	807 2	0 54	14	1 31	7 08	610	3 75E+03	0 26
El Saff	871 3	NA	NA	NA	*	*	*	NA
El Massanda	879 6	0 14	45	4 99	5 57	715	3 00E+03	0 19
Ghamaza El Soghra	884 5	0 06	42	2 52	6 37	235	9 50E+02	0 46
Ghamaza El Kobra	885 0	0 05	32	3 79	7 39	290	7 50E+02	0 28
El Tibeen	898 1	0 02	25	15 20	3 71	840	3 25E+04	0 39
Khour Sail Badrashin	910 2	NA	NA	NA	*	*	*	NA

Source: NWRC (2001) ***Shaded cells indicated not in compliance***

Table 2-3: Loads of organic and inorganic pollutants discharged into the Nile from Upper Egypt drains.

No.	Drain Name	Location (KM) From AHD	Discharge mm3/day	COD ton/day	BOD ton/day	Heavy metals ton/day
1	Khour El sail Aswan	9.9	0.1	10.08137	3.241854	0.030333075
2	El Tawansa	37.25	0.01	0.08	0.01	0.003245242
3	El Ghaba	46.55	0.19	2.134957	0.194087	0.146341598
4	Abu Wanass	47.15	0.2	1.393427	0.254798	0.078330504
5	Main Draw	48.85	0.003	0.058752	0.005115	0.002106432
6	El Berba	49.1	0.15	16.95	6.4	0.10720323
7	Kom Ombo	51	0.14	21.2	5.81	0.309122726
8	Menaha	55	NA	0	0	0
9	Main Ekleet	57	0.02	0.080664	0.030854	0.049174791
10	El Raghama	64.65	0.04	0.44712	0.069304	0.013346532
11	Fatera	70.45	0.78	3.89746	1.590164	0.418197458
12	Khour El sail	70.75	0.17	0.340774	0.178906	0.058016774
13	Selsela	73.9	0.004	0.01296	0.0054	0.005454
14	Radisia	99.85	0.13	2.0912	0.399942	0.02908075
15	Edfu	116.2	0.27	4.0335	0.427551	0.63742745
16	Houd El Sebaia	139.5	0.05	0.783824	0.08965	0.037256135
17	Hegr El Sebaia	149.1	0.05	0.941279	0.12633	0.02524114
18	Mataana	187.7	0.12	4.777461	0.385872	0.158207459
19	El Zeinia	236	NA	0	0	0
20	Habil El Sharky	237.7	0.08	2.37357	0.140832	0.084222176
21	Danfik	251.55	0.01	0.279616	0.020724	0.00865576
22	Sheikia	265.3	0.06	2.21371	0.102908	0.279794995
23	El Ballas	270.7	0.01	0.919152	0.068809	0.003788311
24	Qift	275.9	0.03	0.97911	0.052219	0.012744749
25	Hamed	331.2	0.07	0.737748	0.067068	0.023239062
26	Magrour Hoe	340.35	0.06	1.232889	0.190217	0.061497678
27	Naga Hammadie	377.8	0.21	2.7937	0.466333	0.35920535
28	Mazata	392.75	0.01	0.05868	0.012851	0.001329102
29	Essawia	432.7	0.07	0.667818	0.180311	0.037731717
30	Souhag	444.55	0.05	0.4275	0.133475	0.01826375
31	Tahta	486.4	0.01	0.131796	0.012615	0.001829454
32	El Badary	525.4	0.12	0.71964	0.392204	0.05703147
33	Bany Shaker	588.6	0.02	0.254826	0.044105	0.005968809
34	El Rayamoun	637.4	NA	0	0	0
35	Etsa	701.15	0.57	57.0	21.66	0.105359548
36	Absoug	780.5	0.19	5.637194	0.36739	0.066965977
37	Ahnasia	807.2	0.54	7.583128	0.709564	0.138933738
38	El Saff	871.3	NA	0	0	0
39	El Massanda	879.6	0.14	6.3666	0.705985	0.02624454
40	Ghamaza El Soghra	884.5	0.06	2.503872	0.150232	0.027214704
41	Ghamaza El Kobra	884.95	0.05	1.537152	0.182056	0.013618206
42	El Tibeen	898.1	0.02	0.50425	0.306584	0.007795705
43	Khour Sail Badrashin	910.15	NA	0	0	0
sum				516.6321	157.8541	3.449520092

Source: NRI (2001) ***Shaded cells indicated not in compliance***

Drain Name	Location Km (AHD)	pH (units)	DO (mg/l)	E.C (uS/cm)	NH_3-N (mg/l)	NO_3-N (mg/l)	NO_2-N (mg/l)	Total-P (mg/l)	COD (mg/l)	BOD (mg/l)	TDS (mg/l)	TSS (mg/l)	F.C MPN/100ml)	T.C MPN/100ml
Khour Sail Aswan	9.9	8.97	1.12	1554	96	220.0	5.25	2.3	375	204	995	184	35000	65000
El-Tawansa Dr.	37.25	7.99	6.22	1126	0.19	5.7	0.016	0.23	35	5.01	721	41	700	2000
El-Ghaba Dr.	46.55	8.1	5.73	939	0.05	74.4	0.04	0.19	39	6.45	629	48	300	1800
Abu Wanass Dr.	47.15	8.02	7.16	714	0.07	45.3	0.037	0.19	8	1	500	13	2000	3500
Main Draw Dr.	48.85	7.82	6.56	737	0.11	38.0	0.032	0.23	14	1.07	516	23	3000	3500
El Berba Dr.	49.1	5.55	1.74	591	0.09	1.5	0.028	0.62	1380	410	378	330	45000	95000
Kom Ombo Dr.	51	5.6	3.4	551	0.08	1.8	0.04	2.1	1320	380	350	190	20000	27000
Fetera Dr.	70.45	7.88	7.45	928	0.11	46.4	0.025	0.19	9	2	594	22	10000	17500
Khour El Sail Dr.	70.75	7.92	6.05	660	0.11	18.8	0.029	0.15	8	1	462	12	350	2000
Radisia Dr.	99.85	7.64	6.02	3320	0.14	243.0	0.059	0.15	17	4	2125	16	750	2500
Edfu Dr.	116.2	7.8	7.15	1265	0.11	37.5	0.029	0.15	7	1	810	9	1500	4000
Houd El Sebaia Dr.	139.5	8	7.06	1210	0.08	7.3	0.025	0.32	19	1.3	774	22	1750	4000
Mataana	187.7	8.02	5.65	958	0.09	7.1	0.029	0.22	13	1.57	613	45	3000	4500
Habil El Sharky Dr.	237.7	7.71	4.44	1250	0.11	19.2	0.029	0.17	22	6.24	800	12	600	1000
Sheikhia Dr.	265.3	7.86	5.35	1220	0.12	9.1	0.038	0.37	12	3.68	781	25	3000	10000
El Ballas Dr.	270.7	7.92	3.45	2230	0.09	6.2	0.068	0.31	32	4.88	1427	22	5000	15000
Hamed Dr.	331.2	7.56	5.9	315	0.06	1.2	0.014	0.2	12	2.12	202	15	2350	3500
Magrour Hoe Dr.	340.35	7.9	6.33	298	0.08	1.4	0.015	0.21	16	2.25	191	26	25000	60000
Naga Hammadie Dr.	377.8	8.25	6.79	286	0.09	1.7	0.017	0.2	12	1.13	183	13	200	600
Mazata Dr.	392.75	7.53	6.21	1113	0.15	5.3	0.015	0.35	17	1.27	712	14	4500	8000
Esawia Dr.	432.7	8.19	6.81	311	0.12	1.8	0.02	0.29	20	2.36	199	11	500	5000
Souhag Dr.	444.55	7.85	5.87	770	0.09	5.8	0.038	0.31	22	2.86	493	8	3250	7000
Bany Shaker dr.	588.6	8.45	8.3	811	0.05	2.5	0.036	0.38	20	2.21	519	17	150	2200
El Rayramoun Dr.	637.4	7.27	4.2	509	0.07	1.3	0.014	0.49	21	4.9	326	31	6000	8000
Etsa Dr.	701.15	7.36	2.43	846	0.3	4.1	0.018	1.06	95	61.8	541	110	30000	50000
Ahnsia Dr.	807.2	7.68	5.95	1166	0.12	7.2	0.014	0.35	18	2.4	746	24	3000	5000
El Massanda Dr.	879.6	7.74	3.56	1198	0.26	9.5	0.19	0.7	13	4.4	767	21	1300	3000
Ghamaza El Soghra Dr.	884.5	7.82	4.94	374	0.08	1.0	0.02	0.22	18	3	239	25	1800	4500
Khour Sail El Tibeen Dr.	898.1	7.17	1.98	898	0.46	2.0	0.008	0.7	28	8.6	575	7	17500	30000

Source: NWRC (2002)

Table 2-5: Water Quality of the Nile River

Code	Sampling Site	DO (mg/l)	TDS (mg/l)	TSS (mg/l)	COD (mg/l)	BOD (mg/l)	Nitrite-N (mg/l)	Nitrate-N (mg/l)	Phosphate (mg/l)	Fe (mg/l)
31	Lake Nasser		137	18	40			1.3	<0.1	
39 C	Aswan City		109	3.5	8			2	<0.1	
38 C	Kom Omb city		193	7.3	8			0.4	<0.1	
36 C	Luxor City		126	6.4	8			2	<0.1	
33 C	Sohag City		146	4	10			1	<0.1	
32 C	Assuit City		135	7	5			25	<0.1	
22 C	Beni Sweif City		168	19	4			4.5	<0.1	
28	Before shoubra El-Khema DWTP	7.2	177	13			0.08	0.08		0.22
26	Before Roud El-Farag DWTP	7.5	162	12	5.7	3.7	0.15	0.15		0.75
25 G	Before Giza DWTP	7.1	278	14	7.5	4.9	ND	ND		0.64
24 G	Fostat DWIP (intake)	7.1	266	16	6.4	3.1	ND	0.02		1.2
24	Before El Fostat DWTP	7	199	23	3.8	2	ND	0.15		0.84
11 T	El-Kanater	6.5	173	10	10	3.8	ND	0.15	0.16	0.39
10 T	Fowa	7.2	344	8	7	5.1	0.01	1.35	0.33	0.26
10	Desouk	7.1	202	4	10.5	5.9	<0.01	1.22	0.35	0.35
9 T	Basyoun	3.9	184	6	9.3	4.7	ND	0.15	0.35	0.46
9	Kafr El-Zayat	4.5	278	5	6.9	4.6	0.01	1.65	0.5	0.35
6	Agaa	6.2	253	8	4.5	2	ND	0.26	0.14	0.31
5	Miet Ghamr	7.3	212	13	5.8	3.5	ND	0.14	0.13	0.31
4	Sherbin	7.3	266	12	19.6	9.5	0.15	1.45	0.14	0.18
3 M	Miet Khamis (Intake DWTP)	7.1	283	16	51	5.5	<0.01	0.45	0.16	0.45
3	Mansoura	7.7	265	28	9.8	4.5	0.2	1.55	0.18	0.31
S5	Suez (intake DWTP)	6.1	426	20	3.7	2.2	<0.01	0.07	0.36	1.73
S4	Suez Shandoura Village	6.5	387	55	7.8	3.8	<0.01	0.07	2.35	2.96
S3	Suez El-Omda Village	6.7	387	26	9.4	4.2	<0.01	0.09	4.75	1.55
S2	Suez, Amer Village	5.4	555	12	8.9	2.6	<0.01	0.05	0.35	1.53

Source: EEAA (2002)

Table 2-6: River Nile Water Quality

Location	Distance from AHD	COD	BOD	TDS	FC
GOE Law 48 Consent Standard		**10 mg/l**	**6 mg/l**	**500 mg/l**	**1000****
Aswan-Down stream of HAD	5	7	1.25	171	1.6E+02
Aswan-Upstream Gezirat El-Kobania	21	10	1	170	3.5E+02
Kom-Ombo-Downstream Kom-Ombo Sugar	53.8	15	1.45	169	6.5E+02
Kom-Ombo-Between Kom-Ombo and Edfo	83.4	15	1	175	1.2E+03
Edfo-US Edfo drinking water supply intake	110	7	1	188	4.0E+02
Esna-Downstream Phosphate industry	148	22	1.46	184	1.2E+03
Esna-US Irrigation water intakes at Esna	168	12	1.23	183	5.0E+01
Armant-DS Armant Sugar factory	206.9	5	1.37	186	2.5E+03
Luxor-US Luxor drinking water supply intake	222	14	1.72	189	3.0E+03
Qena-US Qena drinking water supply intake	277	6	2.36	190	6.0E+02
Qena-US Marashda irrigation PS	311	9	2.86	191	1.6E+02
Naga-Hammadi-DS Naga-Hammadi Barrage	361	10	2.26	194	4.0E+02
Naga-Hammadi-US Pumping station	397	12	1.56	197	3.5E+02
Souhag-US Souhag drinking water supply	448	5	2	198	1.5E+02
Ekhmeem-DS Tahata drain	489	11	1.92	202	5.0E+02
El-Badary-at El-Badary	512	10	2.6	204	5.0E+02
Qebly Assiut-US Assiut drinking water supply	532	9	2.34	208	7.5E+02
Assiut-US Irrrigation water intakes at Assiut	545	14	2.46	205	6.0E+02
Bahry Assiut-US Bany Shaker drain	587	14	2.46	200	8.0E+02
Mallawi-US Mallawi drinking water supply	635	14	2.5	204	4.0E+02
Menia-US Menia drinking water supply intake	683	27	2.19	205	6.5E+02
Bani-Mazar-at Bani-Mazar	617.6	18	2.2	209	1.0E+02
Bani-Suef-at Sharona town	748	16	1.86	211	8.0E+01
Bebba (Bani-Suef)-1 km US Geziret Bebba	792	8	1.8	213	9.0E+01
Bani-Suef-US Bai-Suef drinking water supply	815	12	1.99	216	8.0E+02
Korimat-US korimat irrigation pumping	832	14	2.37	220	3.0E+01
El-Ekhsas-US Laisy irrigation PS	874	17	2.47	229	3.5E+02
El-Ekhsas-Water entering Cairo	888	15	3.25	231	1.6E+02
Helwan-US Helwan drinking water supply	902	22	2.51	248	8.0E+02
Maadi-US Maadi drinking water supply intake	922	17	3.5	235	1.2E+02
Shoubra-US Ismailia canal intake	938	15	3.31	235	1.0E+03
Saqil-US Delta Barrage	967	24	3.28	240	6.5E+02

** all parameters in mg/l except FC which is MPN/100 ml ** = WHO standard for unrestricted agriculture*

Source: NWRC (Feb. 2001)

2.3.2 The Damietta and Rosetta Branches

The Damietta branch

Damietta branch begins at the Delta Barrage and ends 220 km downstream at Faraskour dam near Damietta. Major sources of pollution to Damietta branch are Talkha fertilizers factory, Upper Serw 1 Drain and Upper Serw Power station.

Assessment of the results of the monitoring trip which was carried out by the NWRC during February, 2001 indicates the following:

- Dissolved oxygen concentrations ranged from 7.8 mgO_2/l in its southern section to 6.2 mgO_2/l in the northern part. This indicates that pollution loading is depleting oxygen levels as the river moves down stream.

- Nutrients concentrations (nitrogen & phosphorus) were within the permissible limits.

- Chemical oxygen demand exceeded the consent standard set by Law 48/1982. However, the concentrations were similar to those of the Nile water from Aswan to Delta Barrage, (Table 2-7).

- BOD values complied with the Egyptian Water Quality consent standard, except at one location at the end of the branch.

- Total dissolved solids (TDS) increased from 240 mg/l up to 372 mgO_2/l, but the values are still within the permissible limits.

- FC counts exceeded the World Health Organization (WHO) Guidelines at almost all sampling sites. This is an indication of the discharge of human wastes into Damietta Branch.

Table 2-7: Damietta Branch Water Quality

Location	**Distance from AHD (km)**	**COD (mg/l)**	**BOD (mg/l)**	**TDS (mg/l)**	**FC (MPN/100 ML)**
GOE Law 48 Consent Standard		**10 mg/l**	**6 mg/l**	**500 mg/l**	**1000***
US Irrigation intakes at Zefta Barrage	1058	7	1.91	240	9.0E+02
US Mansoura drinking water supply intake	1096	14	1.73	279	1.0E+03
US El-Salam canal intake	1150	23	2.55	365	1.5E+03
at Farasqur	1166	20	2.26	358	1.2E+03
US Damietta dam	1180	13	2.22	357	1.5E+03

Source: NWRC (Feb. 2001) **** = WHO standard for unrestricted agriculture***

Rosetta Branch

Rosetta Branch, starting downstream of Delta Barrage receives relatively high concentrations of organic compounds, nutrients and oil & grease. Major sources of pollution are Rahawy drain (which receives part of Greater Cairo wastewater), Sabal drain, El-Tahrrer drain, Zawiet El-Bahr drain and Tala drain. At Kafr El-Zayat, Rosetta branch receives wastewater from Maleya and salt and soda companies.

Ambient water quality status of Rosetta Branch is presented in Table 2-8. Dissolved oxygen concentrations, as indicated by the results of the February, 2001 monitoring trip, ranged from 5.1 mgO_2/l at the southern part to 6.3 mgO_2/l at the northern part of the branch.

Nutrient concentrations are within the permissible limits. COD and BOD values exceeded the consent standards, but were similar to those recorded for Damietta branch.

TDS ranged from 240 at Delta barrage up to 400 mg/l at the end of the branch.

With regard to FC, high counts were detected at Kafr El-Zayat, after which the water complied with the WHO Guidelines (1989) for unrestricted irrigation.

Table 2-8: Rosetta Branch: Water Quality

Location	Distance from AHD	COD (mg/l)	BOD (mg/l)	TDS (mg/l)	FC (mpn/100 ml)
GOE Law 48 Consent Standard		**10 mg/l**	**6 mg/l**	**500 mg/l**	**1000***
US Menofia drinking water supply intake	1077	22	7.42	372	1.3E+03
US Disuq drinking water supply intake	1123	14	4.59	388	2.5E+02
US Fowa irrigation PS	1136	15	6.73	415	6.0E+02
US Edfina Barrage	1156.5	25	7.73	370	1.7E+02

Source: NWRC (Feb. 2001)

2.3.3 Canals & Rayahs

Water quality monitoring campaigns conducted to date have included irrigation canals to a very limited extent. In general, canals have water quality similar to that at the point of diversion from the Nile. The flow in the canals varies with irrigation demands. Most of these canals are sources for drinking water treatment plants.

Twelve canals and rayahs were monitored during the February 2001 campaign. Available data indicate that dissolved oxygen, BOD and total solids concentrations in all surveyed canals and rayahs are within the permissible limits (Table 2-9). With regard to COD values, only El-Lahoun and Sakoula complied with the standard values. With the exception of Ibrahimia Canal and El-Beherri Rayah, fecal coliform counts in all surveyed canals exceeded the WHO Guidelines (1000 MPN/100 ml). In Monoufi and Nasery Rayahs, the fecal coliform counts were 10^4. This indicates the presence of human wastes. Heavy metals concentrations in canals and rayahs were within the permissible limits.

Table 2-9: Results of Field Analysis for Canals and Rayahs

Canal & Rayah	DO (mg/l)	COD (mg/l)	BOD (mg/l)	RDS (mg/l)	TSS (mg/l)	FC (mpn/100 m/l)
Consent standards	5	10	6	500	NA	1000*
Menoufi Rayah	5.97	16	3.02	225	29	10000
El-Beherri Rayah	7.58	14	1.74	220	6	1000
El Nasery Rayah	6.71	12	3.96	220	16	10000
Asfoun Canal	7.03	11	1.82	200	8	1600
Kelabia Canal	7.57	15	1.71	205	12	1500
East Naga Hamadi Canal	6.31	25	5.78	213	9	1750
West Nagahamadi Canal	7.22	18	4.32	200	6	2500
Ibrahimia Canal (Dairot)	7.84	37	3.55	200	8	2000
Ibrahimia Canal (El-Minia)	8.12	23	3.08	200	17	650
Ibrahimia Canal (Beni-Suef)	7.38	21	2.01	230	12	1500
Bahr-Yusef at El-Lahoun	7.08	10	1.89	305	12	5000
Bahr-yusef at Sakoula	6.98	10	2.68	280	40	1100

Source: NWRC (Feb. 2001)   ** WHO (1989) Guidelines for Unrestricted Irrigation*

2.3.4 Agricultural Drains in the Delta

Delta drains are mainly used for discharge of predominantly untreated or poorly treated wastewater (domestic & industrial), and for drainage of agricultural areas. Therefore, they contain high concentrations of various pollutants such as organic matter (BOD, COD), nutrients, fecal bacteria, heavy metals and pesticides.

Drainage water is becoming more saline; on average its salinity increased from 2400 g/m^3 in 1985 to 2750 g/m^3 in 1995. But there are local variations. For example, in the southern part of the Nile Delta drainage water has salinity between 750 and 1000 g/m^3, whereas the salinity in the middle parts of the Delta reaches about 2000 g/m^3 and in the northern parts between 3500 and 6000 g/m^3.

In a recent study published by DRI (2000), it was estimated that the Delta and Fayoum drains receive about 13.5 BCM/year. Almost 90% of this amount is from agricultural diffuse source, 6.2% from domestic point sources, 3.5% from domestic diffuse sources and the rest (3.5%) from industrial point sources (Table 2-10). Bahr El-Baqar receives the greatest amount of wastewater (about 3 BCM/year), followed by Bahr Hados, Gharbia, Edko and El-Umoum, each with an average flow of 1.75 BCM/year. The wastewater received by the rest of the drains is less than 0.5 BCM/year for each. In terms of organic loads, as expressed by COD and BOD values, Bahr El-Baqar drain receives the highest load followed by Abu-Keer drain. Also, El-Gharbia Main receives significant amounts of organic pollutants.

Table 2-10: Effluent (m3/day) discharged to drains

Drain	Domestic point Sources m^3/day	Industrial Point Sources m^3/day	Domestic Diffuse source m^3/day	Agricultural Diffuse source m^3/day	Total m^3/day
Bahr El-Baqar	184000.0	64268.0	122795.0	4521678.0	6548741.0
Bahr Hados	80000.0	6135.0	207754.0	4836000.0	5129889.0
Faraskour	2490.0	0.0	13272.0	186758.0	202520.0
El-Serw El-Asfal	7710.0	0.0	18769.0	508515.0	534994.0
El-Gharbia Main	156500.0	44460.0	293315.0	3927556.0	4421831.0
Tala	179.0	300.0	45076.0	1087148.0	1134318.0
Sabal	79000.0	0.0	39925.0	1196384.0	1315309.0
No. 8	0.0	0.0	42428.0	469848.0	512276.0
Bahr Nashart	22000.0	13968.0	108915.0	968859.0	1113742.0
No. 7	12500.0	0.0	39778.0	390056.0	442334.0
No. 1	39350.0	20960.0	78329.0	1204654.0	1343293.0
No. 9	0.0	0.0	88029.0	595644.0	683673.0
Zaghloul	0.0	0.0	1838.0	122890.0	124728.0
Edko	20000.0	7470.0	57346.0	4232034.0	4316850.0
Borg Rashid	0.0	0.0	0.0	311246.0	311246.0
El-Umoum	25000.0	0.0	81890.0	5163208.9	5270098.9
Abu-Keer	0.0	22897.0	15803.0	621592.2	660292.2
El-Batts	22396.0	0.0	26213.0	1468340.8	1516949.8
El-Wadi	3000.0	0.0	13272.0	1600340.6	1616612.6
Total (m^3/day)	2311740.0	180458.0	1294747.0	33412752.5	37199697.5
Total Billion m^3/year	0.84	0.066	0.47	12.2	13.6
% ratio	6.2%	0.5%	3.5%	89.7%	

Source: DRI (2000)

In conclusion, assessment of the available data indicates the following:

1. The main Nile River ambient water quality does not exhibit high pollution levels that create health risks at present, except for some locations where the presence of Fecal Coliform Bacteria indicates unsafe levels of pollution for direct use in irrigation and fisheries.

2. The major sources of pollution directly to the Nile from Aswan to Delta Barrage are the following drains which receive contaminated loading from agricultural lands and industries :
   - Khour El-Sail Aswan
   - El-Berba drain
   - Kom-Ombo drain
   - Etsa drain

   In addition, numerous sugar factories in upper Egypt and Giza, oil & soap factories in Sohag, and other manufacturing plants discharge wastewater with little or no treatment directly into the Nile.

3. Although the impact of discharges of these wastes on ambient water quality of the Nile has not been significant in recent years due to high dilution and the high self assimilation capacity of the Nile water, special attention should be given to mitigate pollution from these sources as their effects may become significant during low flow years.

4. Major sources of pollution of Rosetta branch are El- Rahawy drain in the southern part and industry at Kafr El-Zayat.

5. Damietta branch is receiving, and is adversely affected by, industrial wastewater from Talka fertilizers factory.

6. Delta drains receive high concentrations of organic and inorganic pollutants from industrial, domestic and diffuse agricultural wastewater. High priority should be given to those drains receiving high loads of pollution such as: Bahr El-Baqar, Bahr Hadous, El-Garbia Main, El-Rahawy and El-Umoum.

It should be noted that, while the MWRI, EEAA, and other have gone a long way in evaluating water quality problems in the Nile River system, there is still a lot of work to do. The results of this study point out the following:

1. As indicated in ***Survey of the Nile System Pollution Sources, Report No. 64*** (EPIQ, 2002) , twenty-five agencies under seven ministries are involved in water quality monitoring programs. However, most of these monitoring activities are not conducted on a regular basis. Also, there are many gaps in geographical coverage such as:
   - Monitoring the canals has only recently been started.
   - Information about water quality along the length of drains in Upper Egypt is missing.
   - The monitoring programs do not cover sediments, phytoplankton and fish.
   - A great deal of data is collected about conventional parameters while limited data are available about parameters such as pesticides and hydrocarbons.

2. There is a lack of intra- and inter-ministerial cooperation and data sharing. Many available reports related to water quality issues relied on old water quality data, which reduces their value.

3. Most of the available studies assume that the organic loads received by drains are from domestic and industrial sources while the effect of diffuse agricultural discharges from irrigated fields has been neglected.

4. The use of animal manure, dredged sediments from drains and sludge as fertilizers is practiced in Egypt. Leaching of part of these bio-fertilizers, which contain high concentrations of pathogens, heavy metals, organic compounds and nutrients, is a major source of pollution. This is confirmed by the low water quality of drains in spite of the high dilution factor (9:1 diffuse agricultural water to domestic

wastewater). Data about this source of pollution are scarce. This is a subject that should be studied (EPIQ, 2002).

5. Illegal use of drainage water for irrigation is a major concern in terms of potential human health effects.

As a positive aspect, in 1999 a national water quality management program was developed and implemented by NWRC for surface and groundwater, which is based on an integrated approach to water quality data collection, analysis, interpretation, management and coordination. This program is designed to contribute data and information, and to strengthen capacity. These elements provide building blocks for the water resources planning and operation system in Egypt. The program provides a strong scientific basis for sound decision making and assists in the development of strategies to reduce current and avoid future water quality problems. In the national program a monitoring network was developed as well as sampling frequencies -- monthly for irrigation and drainage canals, seasonally for the Nile River, and annually for groundwater. The range of parameters sampled for each of the water bodies and the required analytical techniques have been identified. The network currently is comprised of 245 locations for monitoring surface water and 195 locations for groundwater.

2.4 Prioritization

Prior to the evaluation of any *workable* pollution abatement programs for contaminated drainage water, it was felt that it was important to rank drains in terms of strategic importance for irrigation and their water quality. This will make it possible to select pilot programs that, if implemented appropriately, can demonstrate how to reduce pollution loading in the Nile River system in an environmentally and economically acceptable fashion.

2.4.1 Strategic Importance of Drains

The scarcity of water, which is badly needed to meet needs that are rapidly growing because of population growth, rising standards of living, and expanding industry, has highlighted the need to integrate water resource planning into national development plans. Water planners and decision makers are being increasingly involved in devising ways to optimize the use of the available water supplies as well as to augment them, using conventional and non-conventional sources. The latter category includes two programs: reuse of agricultural drainage water and reuse of treated sewage effluent, mainly for irrigation purposes.

Agricultural drainage water has emerged as the most attractive type of unconventional resource to supplement available water for many practical and economical reasons. This is especially true in arid climate countries like Egypt, where reuse of drainage water may contribute more towards future water availability than any other technological means of increasing water supplies. Due to water shortages and increased demands for fresh water in Egypt, the Ministry of Water Resources and Irrigation (MWRI) has also included drainage water reuse in its water resources planning. The MWRI has already taken a number of steps towards integrated management of drainage water as part of the available annual water budget for meeting increasing demands. These efforts include establishing quantity and quality monitoring networks, data bases and information systems; developing simulation models; drawing guidelines for the safe use of such water; developing pollution control plans; and setting in place strict regulations and legislation. With the increasing need for water for vertical and horizontal agricultural expansion, and with the scarcity of new water resources, the Ministry of Water Resources and Irrigation (MWRI) has, over the past decades, thoroughly considered the issue of reusing drainage water. This has now become national policy. It calls for pumping drainage water from main and branch drains and mixing it with fresh water in canals. The criteria for mixing are based on the sustainability of the blend for irrigation of crops.

Most of the drainage water from the Nile Valley (Upper Egypt) flows back by gravity to the Nile as return flow. Such flows are estimated at about 2.5 bcm annually. This slightly affects the quality of Nile water from Aswan to Cairo. In the Nile Delta, the drainage system is rather extensive and drainage water is discharged into the Northern Lakes or the Mediterranean Sea. Presently, these discharges amount to 13-14 bcm/year. The Fayoum region has a deep depression forming a closed basin and about 0.6 bcm of drainage water is discharged annually into Lake Qaroon, where water is only lost by evaporation.

The Drainage Research Institute of the Ministry of Water Resources and Irrigation was entrusted in the early 1980's to carry out a long-term monitoring program to provide information to decision and policy makers about the quantity and quality of drainage water and its locations.

The current monitoring network in the Nile Delta and Fayoum consists of 140 sites for monitoring the quantity and quality of drainage water in the main and branch drains on a monthly basis. Thirty-one water quality parameters are analyzed, taking into consideration toxicological, microbiological, oxygen budget related and extended ions, metals and trace elements as well as the classic parameters.

Data are now available about drainage water quantity and quality in the Nile Delta for the last 20 years. Many important decisions regarding drainage water reuse were taken on the basis of these data. Table 2-11 shows the quantity of water reused (and its salinity), and outflow to the sea from 1990/91 to 1999/2000.

Table 2-11: Status of Drainage Water

Year	Reused		Outflow	
	Q (mcm)	**TDS (ppm)**	**Q (mcm)**	**TDS (ppm)**
1990/91	4223	1098	12873	2904
1991/92	4120	1091	13005	2704
1992/93	3862	1024	12146	2248
1993/94	3398	1049	12463	2698
1994/95	3917	1110	12210	2774
1995/96	4266	1152	12408	2798
1996/97	4433	1172	12441	2883
1997/98	4170	1083	13210	3148
1998/99	5060	909	14288	2627
1999/2000	4735	1126	15105	2340

Source: NWRI, 2001

2.4.2 Most Polluted Drains

With increased water demands and an expanding population, the demand for drainage water has increased dramatically. At the same time, pollution loads to drains also increased as treatment and sewerage system capacity growth did not keep pace with growing water use.

Water quality cannot be stated as a single parameter. Rather, it is a combination of parameters that must be interpreted and assessed to determine the conditions that promote or degrade water quality. Thus, the concept of a Water Quality Index (WQI) has become used all over the world. Basically, it is an overall indicator of water quality obtained by aggregating certain water quality parameters into one numerical value. Water quality indices provide a simple and practical method that allows the assessment and identification of water quality changes and trends. There are several forms of water quality indices available in the literature.

In this study, the UNDP method is applied to all drains in Upper Egypt, the Delta region and Fayoum so that the most polluted drains can be identified. Nine parameters were selected to comprise the index. These are dissolved oxygen (DO), biological oxygen demand (BOD), total dissolved salts (TDS), fecal coliform, pH, temperature, turbidity, nitrites and phosphorus. The method provides an index of the quality of drainage water as follows:

0 - 25	very poor
26 - 50	poor
51 - 70	good
71 - 100	very good

The WQI results are tabulated in Tables 2-12 and 2-13 for the annual averages of the nine selected parameters for the years 1999, 2000, 2001, and 2002.

The water quality index (WQI) analysis carried out on 40 agricultural drains in Upper Egypt that discharge their water directly to the Nile shows that 2 drains, namely Khour El-Sail

Aswan and Kom Ombo, are classified as very poor, 3, namely El-Berba, El Ballas and Etsa, are classified as poor, 8 are good and 27 are very good. The analysis shows that the quality of water in the drains deteriorates as it moves downstream to the Delta region, which is characterized by intensive agricultural activities and dense population resulting in increased pollution loads. The index value of the 26 monitored drains in the Delta shows that 83%, 69% and 71% of the drains have very poor to poor water quality in Eastern, Middle and Western Delta respectively (Table 2-13).

The water quality index analysis results are consistent with the monitoring results of single parameters carried out by NAWQAM project (NWQM Component, 2001). These latter results clearly indicate that the most polluted drains in Upper Egypt are Khour El Sail Aswan, El Berba and Etsa and, in the Nile Delta, Bahr El Baqar in Eastern Delta, Gharbia in Middle Delta and Abu Keer, Mouheet and Umoum drains in Western Delta.

Table 2-12: Classification of drains water quality by WQI in Upper Egypt

Region	Drains	very poor	poor	Good	very good
Upper Egypt	Khour El sail Aswan	✓			
	El Tawansa				✓
	El Ghaba				✓
	Abu Wanass			✓	
	Main Draw			✓	
	El Berba		✓		
	Kom Ombo	✓			
	Menaha				✓
	Main Ekleet				✓
	El Raghama				✓
	Fatera				✓
	Khour El sail DEKA				✓
	Selsela				✓
	Radisia			✓	
	Edfu				✓
	Houd El Sebaia			✓	
	Hegr El Sebaia				✓
	Mataana				✓
	Habil El Sharky				✓
	Sheikia			✓	
	El Ballas		✓		
	Qift				✓
	Hamed				✓
	Magrour Hoe				✓
	Naga Hammadie			✓	
	Mazata				✓
	Essawia				✓
	Souhag				✓
	Tahta				✓
	El Badary				✓
	Bany Shaker				✓
	El Rayamoun			✓	
	Etsa		✓		
	Absoug				✓
	Ahnasia				✓
	El Saff				✓
	El Massanda				✓
	Ghamaza El Soghra				✓
	Ghamaza El Kobra				✓
	El Tibeen			✓	

Source: NWQM Component, 2001

Table 2-13: Classification of drains water quality by WQI in Fayoum and the Delta

Region	Drains	very poor	poor	Good	very good
Fayoum	Batss	✓			
	El-Gharaq			✓	
	Rayan			✓	
Eastern Delta	Bahr-Baqr	✓			
	Farasqur	✓			
	Bahr Hadus		✓		
	Matareya		✓		
	Serw		✓		
	Mahsama			✓	
Middle Delta	Drain No.1		✓		
	Drain No. 2		✓		
	Drain No.11		✓		
	Drain No.7		✓		
	Drain No.8		✓		
	Brullus area		✓		
	Garbeia Drain	✓			
	Tala Drain			✓	
	Omer Bek Drain	✓			
	Nashart Drain			✓	
	Sabal Drain			✓	
	Tira Drain	✓			
	Zaghlol Drain			✓	
Western Delta	Abu-Keer	✓			
	Barsik		✓		
	Borg-Rashid			✓	
	Edko		✓		
	Mouheet	✓			
	Nubaria			✓	
	Umom	✓			

Source: NWQM Component, 2001

2.4.3 Management Priorities

In the development of a water quality management program for the drains, it is important that priorities be set. The following priorities are based in part on size of catchment, reuse potential, and susceptibility to pollution. In addition, Appendix A presents a map delineating areas within the Nile River system that are considered "hot spots", or areas of particular concern in terms of pollution characteristics.

First Priority – Reuse Drains for the El-Salam Canal

Drainage water supplied to El-Salam canal is estimated to be 2 bcm/year. This quantity is harvested from Bahr Hadous, and Lower and Upper Serw together. This drainage water will be mixed with another 2 bcm/year freshwater drawn from Damietta Branch for a total discharge of 4 bcm in order to supply enough water to irrigate 200,000 feddans in the western Suez canal region and 420,000 feddans north of the Sinai Governorate.

Since the catchment area of Bahr Hadous and Upper and Lower Serw are located in highly populated areas, all drain systems within the region are susceptible to pollution from legal and illegal dumping of domestic and industrial wastewater. The current proposed mixing ratio of 1:1 between drainage and freshwater might be enough to reduce pollution to acceptable levels.

Most of the water received by Bahr Hadous drain (94.3%) is from agricultural diffuse sources. Although domestic diffuse sources are only 4% of the total discharge, they contribute 94.7% of the organic load received by Bahr Hadous, expressed as BOD. No information is available about input from industrial sources.

Assessment of the available data indicates that fecal coliform counts in the water of the three drains exceed the WHO and Egyptian standards for use of water for unrestricted irrigation. Hadous data indicate especially high fecal coliform counts (92000 MNP/100). It is worth mentioning, however, that a substantial reduction of the counts takes place downstream of the points of mixing along El-Salam canal, which indicates the importance of self-purification in surface water bodies. The same observation applies to physico-chemical characteristics. However, all samples showed exceedingly high intestinal helminth eggs, particularly ascaris, taenia, hookworms, and hymenolepis diminuta, a situation which needs great attention and continuous monitoring (EPIQ, 2002).

Second Priority - El-Gharbia Drain

Gharbia drain has a catchment area estimated at 700,000 feddans, covering a heavily populated area in Gharbia and Kafr El-Sheikh Governorates. It has two mixing pump stations downstream from El-Segaeia. The first is El-Hamoul, which has a discharge of 1.5 million cubic meters (mcm) per day, reaching 1.8 mcm/day in summer to supply Bahr Terra canal. The second, Botteta, supplies Rowaina canal with 600,000 m^3/day. However, at present, Botteta is not operational due to heavy pollution coming from the wastewater effluent of the sugar beet factory.

The current quantity of reused drainage water from Gharbia drain is estimated to be about 1 bcm/year, which is a considerable amount of water when considered in the context of total reuse in Egypt. This is in addition to the large quantity of unofficial drainage use, which puts the Gharbia drain into the highest priority category for protection from pollution.

At present, El-Gharbia drain receives very high organic loads from domestic diffuse sources, -- 61.1% of the BOD load received by this drain is from domestic diffuse sources, 21.4% from domestic point sources and the rest from industrial sources -- which indicates low coverage of sanitation systems in this catchment area (EPIC, 2002).

Third Priority - Edko Drain

Edko drain in Behera Governorate supplies El-Mahmoudia canal with water in order to cover irrigation needs along the canal and for drinking water for Alexandria city. Like all drains in the Delta, Edko has a drain catchment area including a highly-populated governorate in which the quality of water in the drain system (main drain and its branches) is getting worse due to legal and illegal dumping of domestic wastewater.

Most of the organic load received by this drain is from domestic diffuse sources (90.2 %). Domestic point sources represent only 3.2% and the rest (6.7%) is contributed by industrial sources.

Fourth Priority - Mouheet Drain

El Mouheet drain in Giza is considered one of the most polluted main drains, coming second to Bahr El-Baqar drain in the Eastern Delta. The problem of El Mouheet drain differs from Bahr El-Baqar as it dumps its water into the Nile (Rossetta Branch) via Rahawy drain while Bahr El-Baqar empties into Lake Manzala. The total length of the drain is 70.2 km from the beginning to Rahawy pump station. The main drain starts at El-Badrasheen and ends at Mansouria. The drain system discharges into the Nile through Rahawy Pump Station on the Rossetta Branch. This pump is not working now since the water is flowing to the Nile by gravity, due to high water levels. Two main treatment plants, Abu Rawash and Zenein, are located within the drainage basin of El Mouheet drain with maximum capacities to treat effluents of 700,000 and 400,000 m^3/day, respectively. There are limited treatment plants within the drain catchment area.

Fifth Priority - Bahr El-Baqar Drain

The Bahr El-Baqar drain is 106 km long and has two main branches: the 73.2 km Qalubia drain and the 66 km Belbaise drain. The total catchment area of Bahr El Baqar drain system is 760,000 feddans, including 300,000 feddans for Qalubia drain, 60,000 feddans for Belbaise drain and 400,000 feddans for Bahr El-Baqar drain downstream from the intersection of the two main branches. The total discharge pumped to Lake Manzala is 1.4 bcm/year.

Bahr El-Baqar drain basin is located in a very densely populated area of the Eastern Delta passing through Qalubia, Sharkia and Ismailia Governorates. The water of Bahr El-Baqar is used unofficially for irrigation and contributes much to groundwater pollution in the Sharkia Governorate.

All sewage and industrial wastewater, treated and untreated, from the eastern zone of Greater Cairo is discharged into the Belbaise drain through the effluents of both Gabal Asfar and

Berka treatment plants. The capacity of Gabal Asfar plant is 1,500,000 m^3/day, while that of the Berka treatment plant is 600,000 m^3/day.

The state of the Qalubia main drain is more serious than that of the Belbaise drain. Qalubia's main 14 branches (intermediates) collect treated and untreated wastewater from the heavily populated area of Shobra El-Khemma and its large industrial area, together with the urban communities of Qalubia and Sharkia Governorates. Because of the good quality of Bahr El-Baqar drain water with respect to salinity (800 ppm), some mixing pump stations were constructed to cover the shortage of water in canals supplying irrigation water for legal and illegal rice. Rice covers almost 80% of Sharkia Governorate lands in summer. The main mixing pump station on the Qalubia drain is called El Wady, located at the end of the drain, before the connection to Bahr El-Baqar drain. This pump station was constructed to supply El Wady canal with 307 mcm/year. El Wady canal has a maximum freshwater discharge of 2.0 mcm/day.

Bahr Al-Baqar drain receives very high organic loads from domestic (point & diffuse sources) and industrial sources (Table 2-10).

3. Effect of New Reclamation Projects on Nile Water Quality

Planned major agricultural developments will require changes in the allocation of fresh Nile water for the various regions of Egypt. Table 3- 1 shows irrigation areas in 1997 and the planned expansion of these areas that depend on Nile water for the year 2017 (NWRP TR25, 2002).

Flows in the main stem and the branches of the Nile will change as a result of the new water allocations or diversions. Such flow changes will impact the capacity of these streams to dilute and assimilate pollution loads. The impact of water diversion on water quality is compounded by the impact of other changes and measures, such as the: change in cropping patterns in the future, increased level of drainage water reuse, increase in pollution loads from municipal, industrial, and agricultural sources, and increase in the percent of wastewater treated, and the efficiency of the treatment.

Table 3-1: Irrigation areas that depend on Nile water in 1997 and 2017 (NWRP TR25, 2002)

Region	Irrigation Area (in 1000 feddans)	
	1997	**2017**
New Valley(Toshka)	0	540
Upper Egypt	1,307	1,728
Middle Egypt	1,093	1,085[1]
Fayoum	360	378
East Delta	2,131	2,446[1]
Middle Delta	1,551	1,525
West Delta	1,473	1,886[1]
Sinai (Surface Water)	0	695
Total	7,915	10,263

[1] These areas include a total of 250,700 feddans to be irrigated with treated wastewater.

This section provides an overview of the impact of planned water diversions on water quality in the Nile assuming that the changes in the other activities follow the probable development scenario developed for the year 2017 by the ***National Water Resources Plan: Facing the Challenge*** (NWRP, Discussion Paper 3, January 2003). Working with the Planning Sector of MWRI, possible scenarios have been evaluated in terms of the flow characteristics of the Nile River system and other water quality implications. The following presents a brief description of the Decision Support Model used, the modeled scenarios, and the potential impacts.

3.1 The Decision Support Model

The WPAU has worked closely with the MWRI's National Water Resource Plan project supported by the Governments of Egypt and the Netherlands. The main objective of this project is "to develop the National Water Resources Plan (NWRP), that describes how Egypt will safeguard its water resources in the future both with respect to quantity and quality, and how it will use these resources in the best way from a socio-economic and environmental point of view." As part of this project, strategic planning procedures were developed within MWRI that have enabled an appropriate level of analysis of water sector policies and investments, taking into account available water resources in terms of their quantity and quality.

The NWRP-Decision Support System (DSS) is the main planning tool for assessing the impacts of different strategies on the water resources system. The DSS consists of a series of databases, models, and simulation and analytical tools which can be used to compare the results of alternative strategies. Databases consist of water quantity and quality data over time as well as information on cropping patterns and to other factors that describe the characteristics of the water resources system.

Models include:

RIBASIM (River Basin Simulation Model) which is a model that balances water demands and supply during each time step. RIBASIM is based on a network concept, which includes nodes that are connected by links configured in ways to reflect the spatial relationships between the various elements of the water resources system. These elements include natural or man-made water related infrastructure (reservoirs, rivers, canals, pipelines, drains, pumping stations, diversions, etc.) and water users (agriculture, M&I, aquaculture, hydropower, navigation, etc.).

SIWARE (Simulation of Water Management of Arab Republic of Egypt) model was developed to simulate the water management in the three Nile Delta segments (West, Middle and East). SIWARE delta models are updated to allow for the evaluation of different water management strategies. Each model combines three different functions allowing for water allocation to different main canals, simulation of water distribution within irrigation command areas, and simulation of on-farm water management for representative field conditions. Various flow components computed in SIWARE include:

- Agricultural drainage
- Spillway losses
- Discharges of municipal and/or industrial origin
- Leakage to or seepage from groundwater
- Official reuse of drainage water by the irrigation authority
- Unofficial reuse of drainage water by farmers
- Average volume of irrigation water for all section of the canals

WLM (Waste Load Model) consists of two modules: a Waste Load Production Module (WLPM) and a Waste Load Treatment Module WLTM). The WLPM specifies how, where and what kinds of waste loads are produced in particular study areas. The WLTM specifies the kind of treatment in place in terms of capacity, efficiency, and location. Towards this end, in the WLM pollution source and treatment nodes are identified as:

- Domestic waste load production
- Agricultural waste load production
- Industrial waste load production

- Treatment of wastewater through wastewater treatment plants
- Natural assimilation of wastewater for septic tanks and in stream.

DELWAQ (Delft Hydraulics water quality model) determines the concentration of substances in the water. The transport of these substances is governed by an advection-diffusion equation. The substances and the processes influencing concentration levels of the substances are available from a built-in database consisting of more than 100 substances (chemical constituents) and more than physical and chemical 1,000 processes. Physical processes include settling of suspended particulate mater, water movement, and volatilization. Chemical processes include biochemical conversions, algal growth, and chemical reactions. The substance enters the modeled area as boundary concentration or as dry waste loads. The DELWAQ model produces three output files, namely:

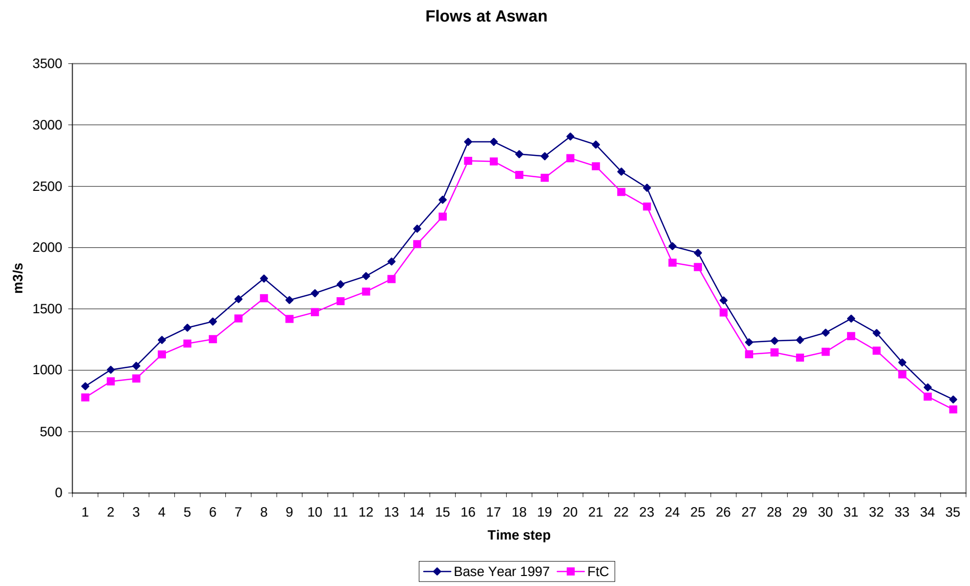
1. The concentration of all modeled substances in time and space.
2. Abstracted information from the first file.
3. Mass balance information.

3.2 Impacts to Nile Flow System

3.2.1 Flow Hydrograph

Diversion of fresh Nile water into Shiekh Zayed canal to supply new irrigation areas in the new valley, Toshka, (540,000 feddans) will reduce water available from releases from the High Aswan Dam by the same amount. Figure 3-1 shows the simulated monthly releases from the High Aswan Dam (HAD) below the outtake for the Toshka Project in 1997 and the anticipated releases in 2017 under the ***Facing the Challenge (FtC)*** scenario – which assumes full development of Toshka -- based on 10-day time steps beginning in January. The annual release from the AHD will decrease by 4.2 BCM/year, an annual reduction of 7.4 percent. The monthly flow of the Nile in January will decrease from 870 million cubic meter per day (MCM/d) to 778.5 MCM/d; i.e. a reduction of nearly 10 percent. The flow during the first part of January and the last part of December in the Nile provide the lowest dilution capacity of the year in the main stem of the Nile.

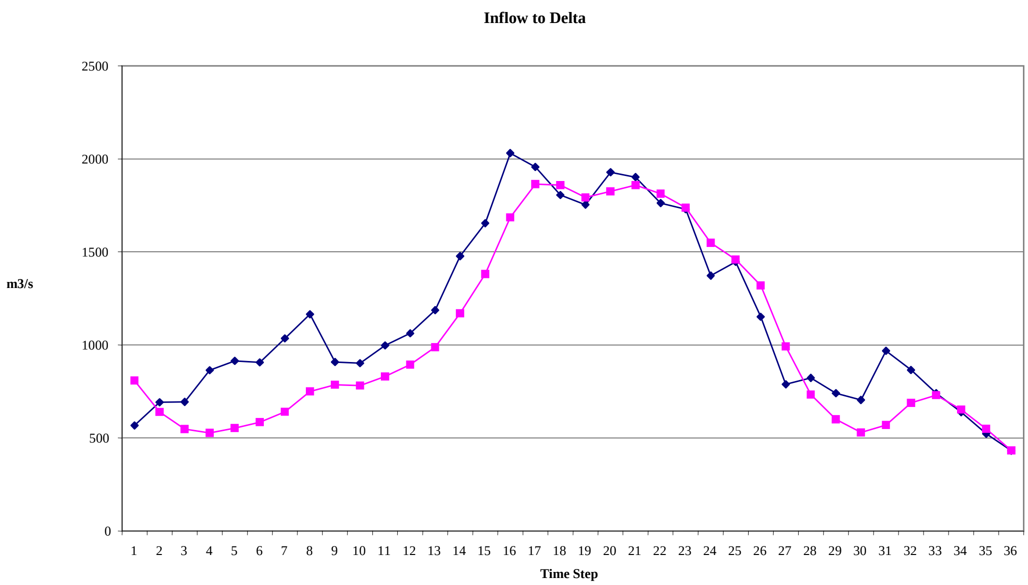
Figure 3-1: Discharge from Aswan High Dam



FtC = Facing the Challenge (Yr2017)

The irrigated areas in Upper Egypt will increase from 1.307 to 1.728 million feddans. Such an increase may tend to further increase the diversion of fresh Nile flow to the regions of Upper Egypt. However, it is anticipated that a shift will take place in this region from growing sugarcane, which has high irrigation requirements, to other crops. Also the development scenario anticipates water shortages in new irrigated areas (NWRP TR25). The irrigated areas in Middle Egypt and Fayoum will remain nearly constant. Figure 3-2 shows the Nile flowing into the Delta Barrage bifurcation point.

Figure 3-2: Total Nile Flow into the Delta (outflow from Cairo)

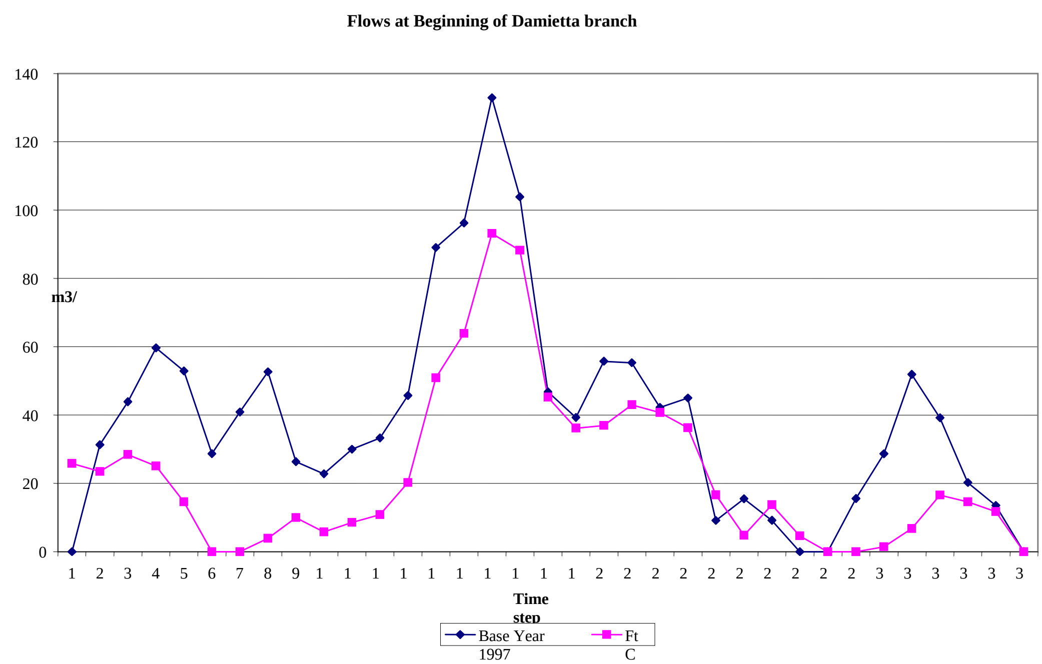


Blue = Yr 1997 (baseline) FtC = Yr 2017 (Facing the Challenge)

It can be seen from Figure 3-2 that in 2017 low flows will take place for a longer period, February and March, in addition to October to December. In a few decades flows may be reduced by nearly 40% from those of 1997. However, the yearly releases into the Delta will not decline to the same degree as the annual flow, decreasing from 35.7 BCM to 32.1 BCM, i.e. only by about 10 percent.

As illustrated in Figure 3-3, the Damietta Branch will also experience flow changes in year 2017. The allocation of 2 BCM/year for the El Salam canal reclamation project should be contributing to improving its dilution, flushing, and assimilation capacity. However, the change in the cropping pattern in the Eastern Delta and the reduction in rice area, accompanied by increased drainage water reuse will lead to a shift in the flow hydrograph entering the Damietta Branch.

Figure 3-3: Inflow to Damietta Branch in 1997 and 2017



FtC = Facing the Challenge

3.2.2 Water Quality

Diversion of fresh Nile water into Shiekh Zayed canal to supply new irrigation areas in the new valley, Toshka, will also modify the overall dilution capacity of the Nile River and change the water chemistry. To evaluate the impact of this action, two cases were modeled using the Decision Support Model. These case studies included evaluating the impacts of the Toshka diversion on the water quality of the Main Stem of the Nile between Aswan and Esna, and in the Damietta Branch.

Aswan to Esna

Inputs to the model are presented in Tables 3-2 and 3-3.

Table 3-2: Industrial Discharges to the Nile – Aswan to Esna.

ID	Name	Discharge m3/yr	
		1997	2017
I079	Chemical industry co. (kima)Aswan	2,921,000	3,505,200
I080	Misr Co. for Food & Milk ProductsAswan-Kom Ombo	30,000	36,000
I081	El nasr bottling (Coca Cola)Aswan	0	0
I082	Egyptian ferroalloys Co.Aswan-Edfu	11,400,000	13,680,000
I084	Egyptian Sugar & Integrated Industries Aswan-Edfu	9,875,000	11,850,000
I086	Egyptian Sugar & Integrated Industries Aswan-Kom Ombo	15,725,000	18,870,000
I087	Egyptian Sugar & Integrated Industries Aswan-Edfu	9,875,000	11,850,000
I314	Egyptian Sugar & Integrated Industries Aswan-Kom Ombo	15,725,000	18,870,000
I315	Egyptian Co. for Refractories Aswan	0	0
I316	El Nasr Phosphates Co.Aswan	0	0

Table 3-3: Rural and Urban Discharges – Aswan to Esna

Rural Nodes							
		1997			**2017 (FtC)**		
Node ID	**Name**	**Pop. (capita)**	Industry discharge (m3/yr)	Agricultural area (fd)	Pop. (capita)	Industry discharge (m3/yr)	Agricultural area (fd)
9	Toshka						540000
15	Aswan	61575	479092	15450	70651	574910	14733
34	KomOmbo	83894	1215043	39183	99271	1458052	37364
168	El Tawaisa	166922	1001072	32283	198976	1201286	90786
179	Selsela	138977	1073983	34633	162645	1288780	33026
181	EdfuEast	166738	855881	27600	198662	1027057	26319
183	EdfuWest	136422	1005203	32417	162542	1206244	50912
		754528		181567			253140

Urban Nodes							
		1997			**2017 (FtC)**		
Node ID	**Name**	**Pop. (capita)**	**Industry discharge (m3/yr)**	**WWTP capacity (l/s)**	**Pop. (capita)**	**Industry discharge (m3/yr)**	**WWTP capacity (l/s)**
156	Ua_Aswan_town	219600	5630274	613	285700	6756329	1314

Node id = Computer code for discharge point

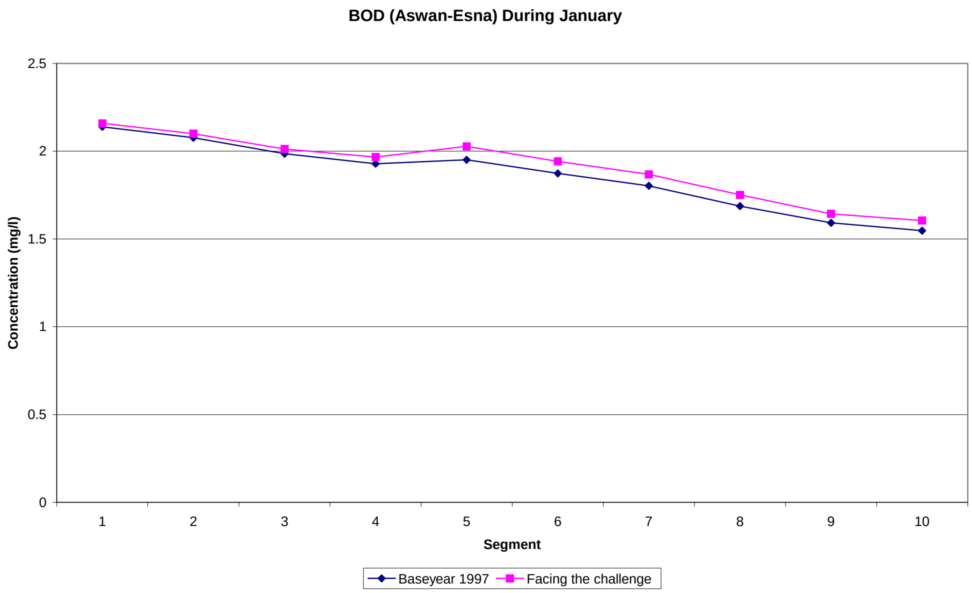
The flow in the Nile reach between Aswan and Esna will decrease in 2017 as a result of water diversion to Toshka. The months of December and January are projected to have especially low flows (less that 1000 cubic meters/second), which represent the lowest dilution capacity in the year. Therefore, water quality problems are expected to be most critical during these months, assuming that pollution loads are rather steady year round. Figures 3-4 through 3-7 present the results of the modeling effort in terms of the impact on water quality of the Nile due to diversion of water for Toshka. These results are described as follows:

1. Figure 3-4 presents the simulated BOD levels along the 10 segments of the Aswan-Esna reach during January of 1997 and January of 2017. The figure shows that BOD levels both in the base year (1997) and in 2017 are low (less than 2.2 mg/l). The dilution capacity of the Nile is high in relation to the loads. BOD decreases further downstream in the reach indicating high in-stream purification. The BOD level in 2017 is slightly higher than that in 1997, but to a lesser extent than the reduction in the river flow.

2. Figure 3-5 shows the impact of the organic loads discharged into the Nile and the levels of dissolved oxygen in the Aswan –Esna reach. It can be seen that water has low DO as it is discharged from the deeper layers of Lake Nasser upstream of the High Aswan Dam. Within the first segment of the reach the DO exceeds 6 mg/l and then continues to rise to near saturation levels by the end of the reach. It can also be observed that DO is not materially less than the 1997 level.

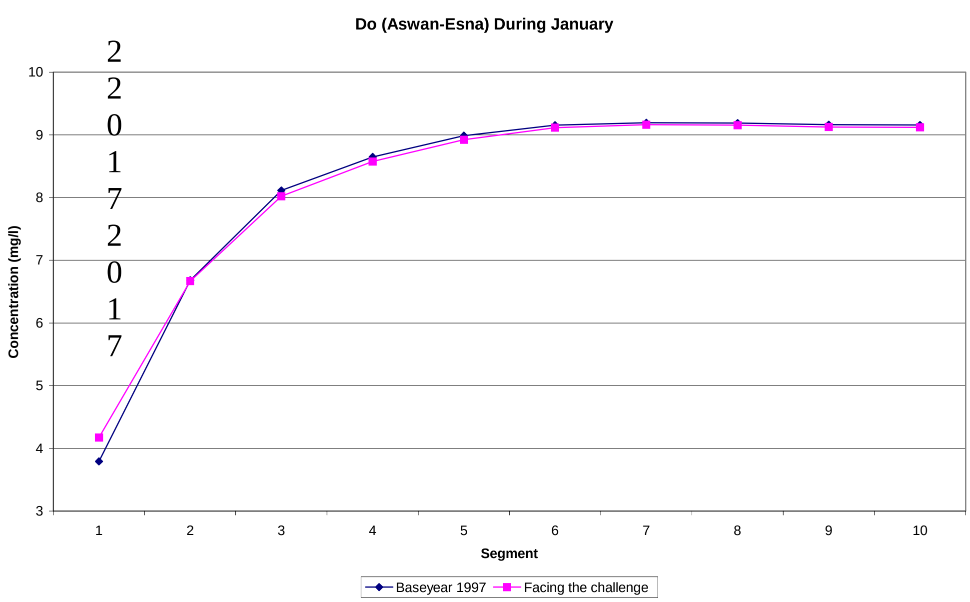
3. Figure 3-6 shows the concentration of chlorides in the Aswan-Esna reach during January 1997 and 2017. This water quality parameter is affected more than others by the change in flow rate and pollution loads from irrigated agriculture. However, the increase in salt levels will not interfere with use of the water for any purpose. Figure 3-7 shows the yearly average simulated values for chloride concentration along the Aswan-Esna reach. It can be observed that the increase in chloride concentration from 1997 to 2017 is less than would be expected because the dilution effect in other months is higher than January.

Figure 3-4: Simulated Changes in January Biological Oxygen Demand – Main Stem Nile River 1997 and 2017



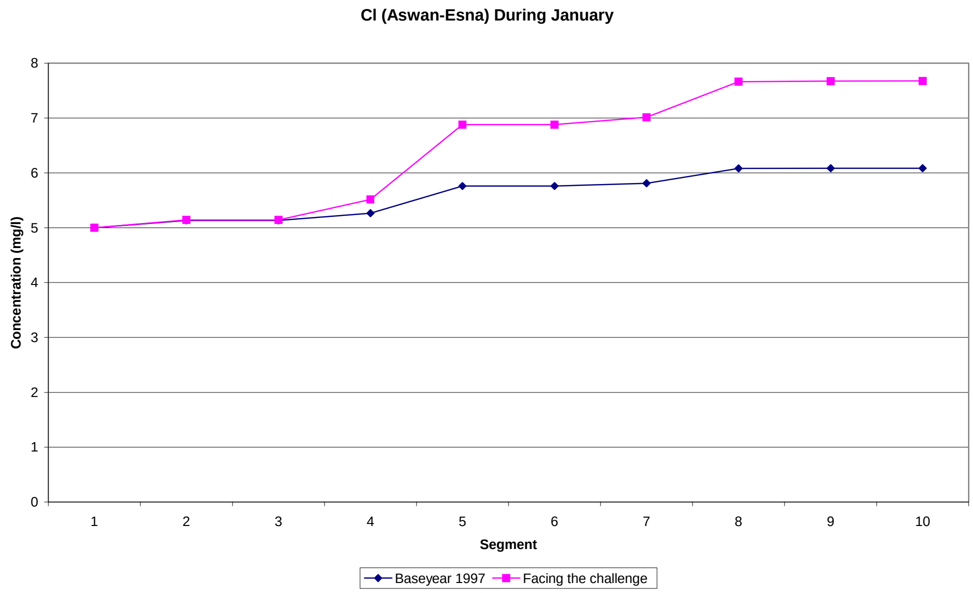
FtC = Facing the Challenge (Yr 2017)

Figure 3-5: Simulated Changes in Dissolved Oxygen – Main Stem Nile River 1997 and 2017



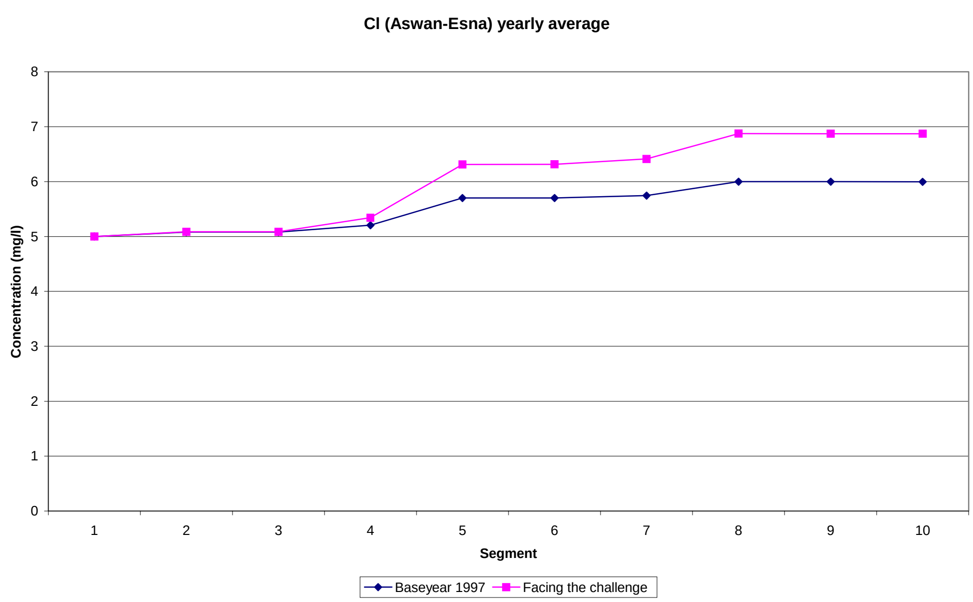
FtC = Facing the Challenge (Yr 2017)

Figure 3-6: Simulated Chloride Concentrations along the Aswan-Esna Reach - 1997 and 2017 [TDS in mg/l ≈35 Chloride]



FtC = Facing the Challenge (Yr 2017)

Figure 3-7: Simulated Yearly Average Chloride Concentration levels long the Aswan-Esna Reach – 1997 & 2017 [TDS in mg/l ≈35 Chloride]



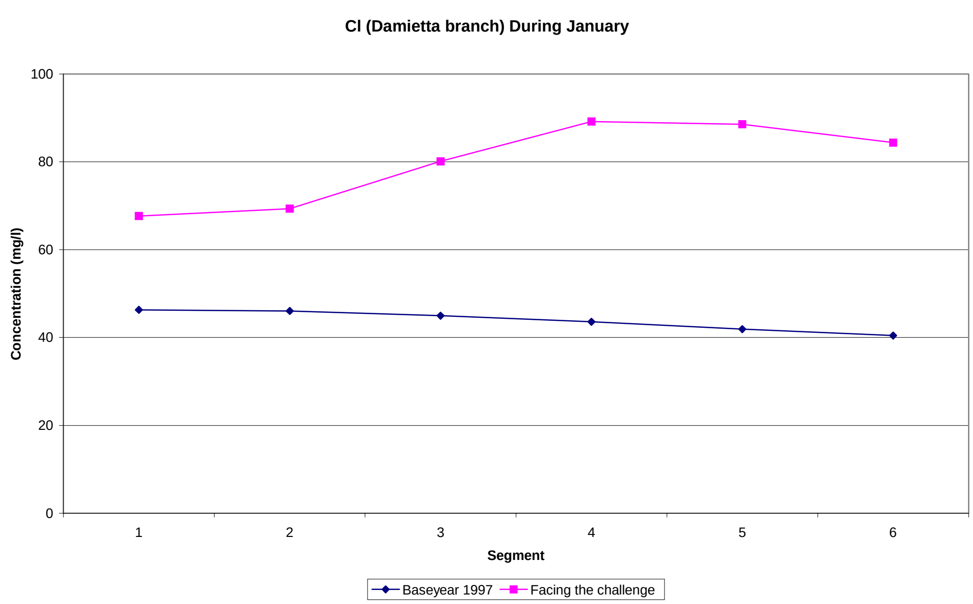
FtC = Facing the Challenge (Yr 2017)

Damietta Branch

A model using the Decision Support System was also completed to evaluate potential changes in water quality in the Damietta Branch from the base year (1997) to year 2017 given the development scenario portrayed in ***Facing the Challenge***, including diversion of water from the Nile to the Toshka project. These simulation results can only be considered preliminary since the models of the Nile valley and the Delta are still being refined, and are not fully compatible with each other. However, model results do show meaningful trends, which is the purpose of the study. The results of this modeling effort are presented below.

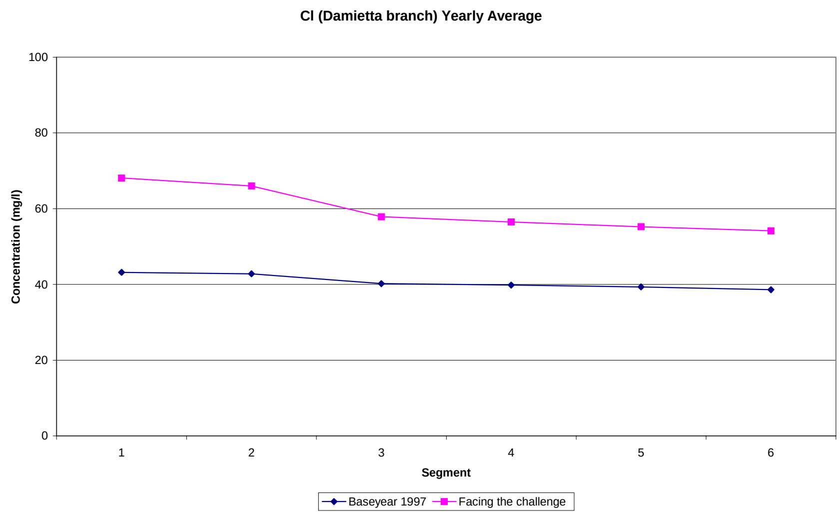
Figure 3-8 shows the simulated chloride concentration levels along the Damietta Branch during January of the base year, 1997, and 2017. These values show significant accumulation of salt as compared to the Aswan-Esna reach. The degradation from 1997 to 2017 is very likely due to the expansion in irrigated areas and increased level of reuse. Figure 3-9 shows the yearly average chloride levels in the Damietta Branch for 1997 and 2017. It can be seen that dilution and flushing is poor in January, particularly for the most downstream segments.

Figure 3-8: Simulated Chloride Concentrations along Damietta Branch during January of 1997 and 2017



FtC = Facing the Challenge (Yr 2017)

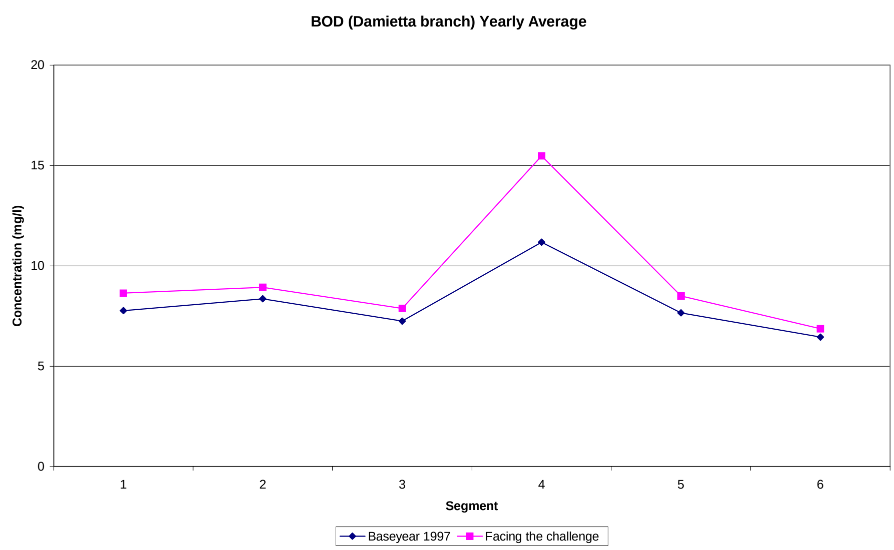
Figure 3-9: Simulated Yearly Average Chloride Concentration along Damietta Branch during 1997 and 2017



FtC = Facing the Challenge (Yr 2017)

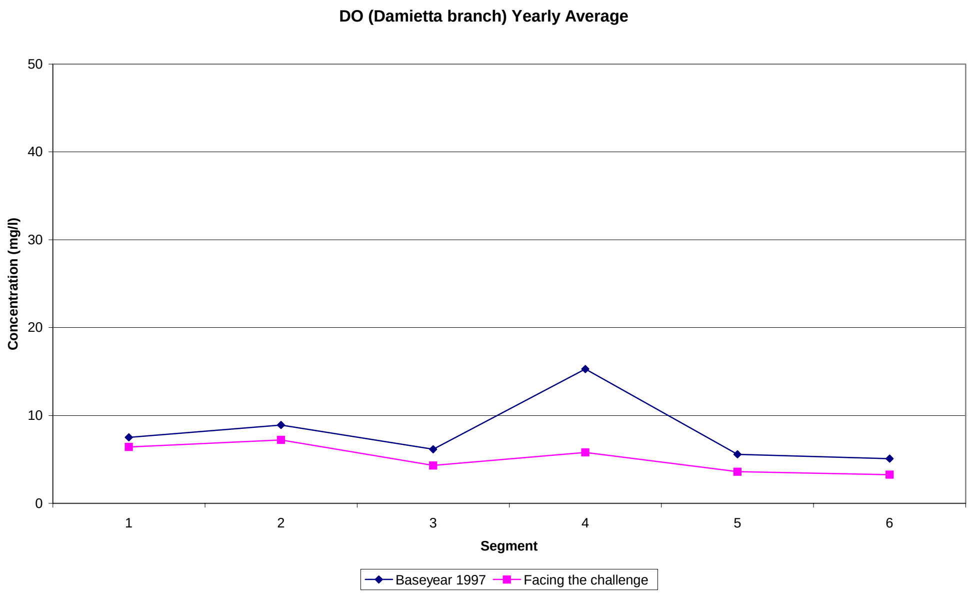
Figure 3-10 shows the BOD levels along the Damietta Branch during the base year 1997 and 2017. It can be seen that segment 4 will experience much higher levels of BOD in 2017 as compared to 1997. BOD in excess of 15 may occur by 2017, as compared to values of 2 in the Aswan-Esna reach. The effect of this high level of BOD is reflected in the simulated DO levels in segments 4, 5 and 6, and indicates increased organic pollution loading in these segments, most likely due to increased municipal wastewater discharge. As shown in Figure 3-11, DO in the same segments decreases substantially in the 2017 simulation, as expected.

Figure 3-10: Yearly average simulated BOD in the Damietta Branch during 1997 and 2017



FtC = Facing the Challenge (Yr 2017)

Figure 3-11: Yearly average simulated DO in the Damietta Branch during 1997 and 2017



FtC = Facing the Challenge (Yr 2017)

In general, the results of the modeling efforts for both the Main Stem of the Nile and the Damietta Branch indicate that the Toshka project and development in general will have some impact on the water quality of the Nile River system. However, the results of these simulations do not confirm the worst-case scenarios that have been put forward. That said, the simulation results are predicated on the assumption that planned improvements in municipal and industrial wastewater treatment will be completed. If that does not happen, and if sound policies relating to water quality management for the Nile River are not implemented, the discharge of raw effluent from industries and municipalities will continue to adversely affect the quality of Nile River water so that results could be considerably worse than those modeled.

The DSS gives the MWRI a good tool to evaluate various scenarios in terms of pollution loading and variation in flow. However, at this time, limited data on the quality and quantity of industrial and municipal discharges into drains and into the Nile make it very difficult to run realistic simulations. As more data become available, “what-if” scenarios can be simulated, and the fate and transport not only of BOD, DO, and salts, but also of trace metals can be modeled more accurately.

4. Current Drain Water Management Practices

As indicated in Section 2, large drains are likely to accumulate pollution loads discharged into their contributing branch drains. The pollution loads increase significantly with the rural population density represented by the number of villages, ezbas, and towns existing in the catchment area of the drains. In addition, industrial pollution sources are likely to exist as the drain catch increases. Organic matter and bacteriological pollution from sewage are the main concerns, although chemical pollution can be a problem in some areas depending on the industries present. Drain water is either discharged directly to the Nile River for potential reuse downstream, discharged into the Northern Lakes and eventually to the Mediterranean, or mixed with fresh water at reuse pump stations.

Current water quality management of drains throughout Egypt is rather limited. The Drainage Research Institute of the National Water Research Center maintains a rather comprehensive water qualit monitoring program in the Delta and Fayoum. Parameters monitored are based on landuse in the catchment area and the potential for pollution. Information from this system is used to assist in the management of reuse pump stations.
Management practices are therefore germane to official and unofficial reuse of drain water, and to the new concept of intermediate reuse. The following presents an overview of these practices and evaluates how effective an "intermediate reuse" pilot project in Abou Hammoud has been in separating high quality drain water from a highly contaminated drain.

4.1.1 Official Reuse

The total official reuse of drainage water in 1997 was about 4.5 BCM, as shown in Table 4-1. Potential drainage water reuse in the Nile Delta based on year 99/2000 data is presented in Table 4-2. From the table, the following conclusions can be drawn:

Eastern Delta:

- Currently drainage water reuse is 1.774 bcm/year.
- Planned drainage water reuse by the year 2017, according to the horizontal expansion program, will be 3.639 bcm/year.
- With proper management, an additional 0.554 bcm/year may become available.

Middle Delta:

- Currently official drainage water reuse is 1.891 bcm/year.
- Planned drainage water reuse by the year 2017, according to the horizontal expansion program, will be 3.159 bcm/year.
- With proper management, an additional 0.84 bcm/year may become available.

Western Delta:

- Currently drainage water reuse is 0.637 bcm/year.

- Planned drainage water reuse by the year 2017, according to the horizontal expansion program, will be 1.670 bcm/year.
- With proper management, an additional 0.217 bcm/year may become available.

Summing up the current, planned and possible future drainage water reuse brings the maximum drainage water quantity to be reused in the Nile Delta to about 10.048 bcm/yr.

Table 4-1 : Drainage water reuse in 1997 and targets for 2017

Region	1997 reuse (Mm^3/yr)	2017 target (Mm^3/yr)	Target Increase (Mm^3/yr)
Eastern Delta	1,774	3,639	1,865
Middle Delta	1,891	3,159	1,268
Western Delta	637	1,670	1,033
Fayoum	241	396	155
Total	4,543	8,864	4,321

Source: NWRP, TR23 July 2002

Table 4-3 lists the large-scale reuse pumping stations in the Delta and their current usage (2001). Table 4-4 presents their anticipated use in year 2017 (NWRP, TR23, July 2002). Official reuse is achieved by 29 main pumping stations and a number of gravity feeders from drains to tail ends of irrigation canals in the Middle Delta. Since 1997, five reuse pump stations (highlighted in Table 4-3) were shut down due to poor water quality in the drains. These are El Mahsma and Wadi pumping stations in Eastern Delta, Upper no. 1 and Boteita pumping stations in the Middle Delta, and the new El Umum station.

Table 4-2: Potential Drainage Water Reuse in the Nile Delta

Region	Location	Available Drainage Water (Mm^3/yr)	Currently Reused (Mm^3/yr)	Planned Reuse 2017 (Mm^3/yr)	Possible Reuse (Mm^3/yr)	Flowing To
Eastern Delta	Hanut P S	100	100			Mois Canal
	Geneena P S	265	265			El Gabs Canal + Bahr El Saghier Canal
	Saft P S (30%)	579	174		203	
	Wadi P S	208	-		208	El Dafan Canal
	Bahr Baqar Irr P S	53	53			Wadi El Sharki Canal
	Blad El Ayed P S	127	127			El Salhia Canal
	Farasqur P S					Wadi El-Sharky canal
	Upper Serw P S	2393	942	1308	143	
	Lower Serw P S					El Salam Canal
	Bahr Hadous Outfall					
	Mahsama P S	125		125		
						Ismailia Canal
Sub-Total Reuse			1661	1433	554	
Middle Delta	Upper P S No 1	50			50	Dimetta Branch
	East Menufeya P S	86	86			Bahr El Abasy Canal
	Mahallet Ruh P S	105	105			Mit Yazid Canal
	Gharbia Outfall	1643	1101	340		(Nile+Tira+Khasha+Ohters) Canals
	P S No 11	684	205	170		El Nour Canal + Abo Ismiel Canal
	Nashart Drain	587	-	230	190	
	Gamasa Drain	1728	-	530	600	
	Mahallet Kubra P S	131	131			Damietta Branch
	Sabal Outfall	99	99			Rositta Branch
	Tala Outfall	164	164			Rositta Branch
Sub-Total Reuse			1891	1270	840	
Western Delta	Etay Baroud P S	76	76			El Khandak El Sharki Canal
	Edko Irrigation P S	156	156			Mamoudia Canal
	Dilingat P S	223	223			El Hager Canal + Frahash Canal
	El-Khandak El-Gharby P S	79	79			Abo Diab Canal
	Drain no 1	220	220			Nubaria Canal
	Drain no 2	233	233			Nubaria Canal
	Boustain P S	70	70			Nubaria Canal
	Dilingat Ex P S	80	80			Nubaria Canal
	Mariut Khalt P S	45	45			Nubaria Canal
	Abu-Homous P S					
	Shereshra P S	1217	-	1000	217	Umoum Project
	Troga P S					
	Barsiq P S	323				Edko Lake
	Edko Drain outfall	1082				Edko Lake
Sub-Total Reuse			1182	1000	217	
Overall Delta	Total Average		4735	3703	1611	

Source: NWRP, TR23 July 2002

Table 4-3: Year 2001 Operation and Non- Operation Reuse Pumping Stations

Pumping Station	Drain	Mixing Location	Annual Discharge (MCM)	Current Status
East Delta				
Wadi	Qalubia	East Wadi	200	NO
Bahr Elbaqa	Bahr El Baqar	El Bateekh	20	O
Belad El Ayed	Belad El Ayed	East Wadi	150	O
Hanout	Hadous	Bahr Mouis	250	O
Geneina	Emoum El Beheira	El Bahr El Saghir	215	O
Saft	Saft El Bahry	Daffan	130	O
El Mahsama	El Mahsama	Ismailia	200	NO
Uper Elserw	Serw	Damietta Branch	275	O
El Salam 1	Lower Serw	El Salam	650	O
El Salam 3	Hadous	El Salam	1350	O
Middle Delta				
Upper No. 1	No. 1	Damietta Branch	60	NO
East Menoufia	El Qarenien	Abbasi Rayah	50	O
Mahalet Rouh	Mahalet Roh	Mit Yazid	90	O
El-Hamoul	Gharbia Main	Bahr Tira	400	O
El- Gharbia	Gharbia Main	Bahr Tira	800	O
El Mahalla El Kobra	Omar Bey	Damietta Branch	100	
Boteita	Gharbia Main	El Zawia	100	NO
West Delta				
El Emoum Itay El Baroud	El Emoum	Nobaria	1000	NO
Itay El Baroud	Itay El Baroud	East Khandak	60	O
Idkou	Idkou	Mahmoudia	90	O
Dalangat	Dalangat	El Hager	235	O
West Khandak	West Khandak	Abou Deyab	60	O
Bostan	Bostan	Nobaria	55	O
Dalangat Ext.	Balangat Ext.	Nobaria	80	O
Mariout	El Emoum	Nobaria	60	O
Fayoum				
El Bats	El Bats	Bahr Wahbi	80	O
El Tagen	El Tagen	Bahr El Nazla	100	O
El Gharak	El Gharak	Bahr El Nazla	45	O

Soruce: MWRI, 2002 O = Operating, NO = Not Operating

Table 4-4: 2017 Targeted reuse pumping stations

	Pumping Station	From Drain	To Canal	2017 Mm3/yr
East Delta				
1	Wadi P.S.	Qalubia	Wadi El Sharky	183
2	Blad El Ayad P.S.	Bahr Baqar br.	Wadi El Sharky	121
3	Bahr Baqar Irr P.S.	Bahr Baqar	Battikh	22
4	Hanut P.S.	Saft El Qibly	Mois	253
5	Saft P.S.	Saft	Daffan	123
6	Mahsma P.S.	Wadi	Ismailia canal	37
7	New Kassasin P.S.	Wadi	Ismailia canal	0
8	Upper Serw P.S.	Serw	Damietta Branch	260
9	Farasqur P.S.	Farsqur	El Salam canal	300
10	Salam 1 (lower Serw)	Serw	El Salam Canal	435
11	Salam 3	Bahr Hadus	El Salam canal	1905
Middle Delta				
12	Mahall El Kubra P.S.	Upper Gharbia	Damietta Branch	100
13	Upper No 1 P.S.	No.1	Damietta Branch	21
14	Outflow No.1&No.2	No.1&2	Khasha area	1000
15	East Menufeya P.S.	Menufi	Rayah Abbasi	57
16	Mahalet Ruh P.S.	Upper Gharbia	Mit Yazid	77
17	Hamul P.S.	Gharbia End	Tira	390
18	Gharbia Outfall	Gharbia End	Tira, El Nil	970
19	No 11 P.S.	No.11 drain	El Nour+Abo Ismiel	178
20	Nashart	Nashart dr		236
21	Tilla (Gravity)	Tilla	Rosetta Br	61
22	Sabal (Gravity)	Sabal	Rosetta Br.	69
Western Delta				
23	Etay Barud P.S.		El Khandak El Sharki	55
24	El Khandak El Gharbi P.S.		Abo Diab	58
25	Edko P.S.	Edko	Mahmoudia	88
26	Dilingat P.S.		El Hagar+Frahash	245
27	Dilingat Ext. P.S.		Nubaria canal	78
28	Maryut Khalt P.S.	Umoum	Nubaria canal	n.a
29	Umum Reuse P.S.	Sherehra	Nubaria canal	1100
30	Bustan P.S.	Nubaria	Nubaria canal	46
31	Drain 3 (Gravity)	Drain 3	Nubaria canal	
32	Drain 6 (gravity)	Drain 6	Nubaria canal	
Total				8.468 BCM/yr

Source: NWRP, TR23, July 2002

4.1.2 Local Unofficial Reuse

Drainage water reuse also takes place at the farm level. Tail end farmers pump water directly from drains if canal supply is not sufficient. Estimates for "unofficial reuse" in the Delta indicate the use of 2.7 BCM in 1997 (NWRP, TR23). The environmental implications of unofficial reuse differ from those of official reuse. When contaminated water is "officially" reused, it is mixed with cleaner water from the canal allowing for dilution. This dilution in most cases brings the reuse water up to acceptable standards for irrigation, and when used properly has a minimum impact on land and the ecology. On the other hand, unofficial reuse is usually very local, and contaminated drain water is used by farmers without regard to human health or ecological consequences. As long as unofficial reuse is occurring, it is difficult to implement effective management programs for drain water.

THE BAHR BAGAR DRAIN

The Bahr Bagar drain, considered to be one of the most contaminated drains in Egypt, starts from the northeastern border of Greater Cairo, extends 180 km to the north, and ends at Lake Manzala on the northeast edge of the Delta.

In the south, the Qalubyia and Belbeise drains, which feed into Bahr Bagar, receive a large amount of urban sewage from Gabal El Asfar and Burka wastewater treatment plants. Additionally, the Qalubyia drain receives Shoubra El Kheima's industrial wastewater. In the north, Bahr Bagar collects drainage flows from the newly reclaimed lands along the El Salam Canal. The drain water is very saline, and reuse is not yet envisioned.

The middle Bahr Bagar basin in contrast is a typical agricultural area and there are no industrial or municipal wastewater sources. Many branch drains show low salinity (500-600 ppm) and relatively good water quality. These waters, however, flow into Bahr Bagar and become too contaminated for reuse.

4.1.3 Intermediate reuse

A basic strategy is to intercept good quality drain water and reuse it before it reaches highly contaminated drains. Termed intermediate reuse, this strategy, if implemented properly, could be an effective tool in separating good quality drain water from bad, thereby augmenting supplies of usable water.

As part of this study, a case study was identified and carried out. The study follows-up on work on ***Intermediate Drainage Reuse in the Bahr Bagar Drain Basin*** (EPIQ, 1999) that was completed in June, 1999 under the USAID-supported Agricultural Policy Reform Program through the Environmental Policy and Institutional Strengthening Indefinite Quantity Contract (EPIQ).

Figure 4-1 shows the layout of Bahr El Baqar drain and its tributaries. The text box highlights the sources of pollution affecting the various sub-catchments of the drain.

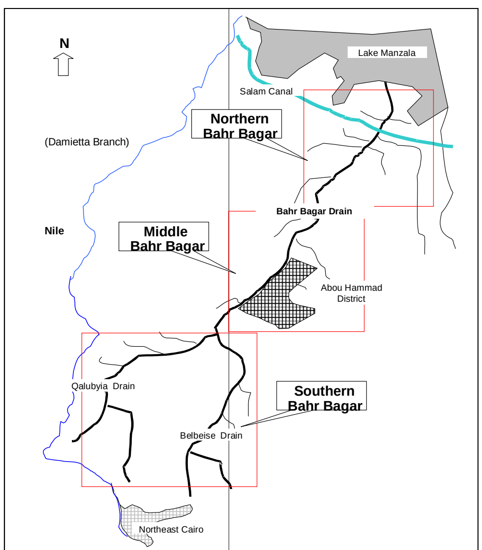


Figure :4-1 The Bahr Bagar Drain Basin

As part of the initial intermediate reuse study, a strategy was developed to intercept drainage water of acceptable quality in the middle portion of the drain. before it reached the main Bahr Bagar. This intermediate drainage reuse was considered to have good application potential for irrigation in the middle Bahr Bagar basin.

This case study explores work that has been done to date in implementing the strategy, and what constraints, if any, inhibit full implementation. Progress is noted and design modifications are suggested to improve financial viability. In addition, the potential environmental impacts as presented in the original document are revisited and modified to be consistent with the new design suggestions.

The EPIQ study consisted of eight tasks defined as follows:

1. Selecting a pilot district and identifying potential intermediate reuse sites.
2. Conducting drainage studies
3. Assessing drainage reuse potential of Abou Hammoud
4. Designing pump stations and operating schedules
5. Organizing two social surveys
6. Conducting an economic assessment
7. Organizing an environmental assessment
8. Establishing a vision of pollution control and drainage management in the Bahr Bagar drain basin

For the case study, Abou Hammad, an irrigation district in the middle Bahr Bagar basin, was selected. Seven drain locations (plus two existing pump stations) were identified as potential drainage pumping sites. Towards this selection, a drainage-monitoring program was conducted in Abou Hammad from August 15 1998 to May 15 1999. The monitoring included weekly measurements of drain flows, daily observations of drain water levels, and three-time measurements of selected water quality parameters at selected drain locations. Based on a water balance approach for various areas (north and south) and two seasons (summer and winter), it was determined that the summer and winter seasons have different canal rotations, canal deliveries, irrigated crops, and unofficial reuse situations. In addition, the southern part of Abou Hammad receives large amounts of canal leakage from the Ismailia Canal. This is not the case in the northern part. It was also determined that, for northern Abou Hammad, unofficial reuse was 5-7% of the area's canal inflow and intermediate drainage reuse is desirable to provide the proper pump capacity and operation schedule to replace a major part of this unofficial reuse.

Other conclusions from the study included:

- Small drains may not have adequate flows for continuous pumping and the storage capacity of drains and the impact on water table levels should be considered. For effective drain water capture, drain weirs must be constructed downstream of the pumping sites to store nighttime drain flows.

- The operation of intermediate reuse stations must be consistent with canal rotations. In the case of Abou Hammad, intermediate reuse stations will operate a maximum of 110 days in the summer and 90 days in the winter, for 200 working days a year. Two daily operation shifts were designed for reuse pumping. The morning shift will operate all installed pumps to maximize the capture of drainage stored during the nighttime, and the afternoon shift will use only one pump to handle the smaller regular drain flow.

- The pump station design is based on the continuous operation of pumping units in each working shift and for the pumps to handle the capacities of the drain to prevent flooding of channels.

- Based on an achievable reuse goal in Abou Hammad equivalent to 5% of the area's canal inflow, detailed engineering designs (including a project bidding document) were prepared for seven potential fixed pump stations in Abou Hammad at a total capital cost of about LE 1.16 million. These costs are equivalent to the cost of drilling one groundwater well in the Farafa Oasis (covering a smaller area), and indicate that intermediate drainage reuse is an economically attractive alternative.

- In the winter season, drainage pumping can be used to substitute canal supplies which will result in smaller production of drainage. Analysis indicates that a 10% reduction in canal supplies is acceptable, given the selected pump facilities.

- Economic viability of intermediate reuse is particularly sensitive to the size of the area served and the value of the saved water. It appears that for canals with areas of less than 1,000 feddans, alternatives to fixed intermediate reuse should be considered. A financial analysis suggested that farmers were generally unable to pay the full operation and maintenance

ABOU HAMMAD DISTRICT

The Abou Hammad District is one of the irrigation districts in the middle of Bahr El Baqar drain basin. It has a cultivated area of 48,000 feddans served by the Saidia and East Wadi canals. The Bahr El Baqar drain runs along the district to the west and drains the entire district by many branch drains. The district is a typical agriculture based area without much industrial development or urbanization. Abou Hammad is the only town where collection and trading of local agricultural products are important activities. The area has mixed clay and sandy soils. Clay soil covers the old lands between Saidia canal and Bahr El Baqar drain, and sandy soil covers the new lands east of Saidia canal. Rice is the major summer crop in the area covering 35 – 40 % of the total cultivated area. Clover and wheat are the major winter crops, taking 39% and 38% of the area respectively. More than half of Abou Hammad 's lands participated in the Irrigation Improvement Project (IIP). Many branch canal off – taking points are equipped with downstream flow control gates and water user associations have been established in many villages

Average salinity concentration in branch drains in Abou Hammad is 500 ppm or less. Farmers use drain water even without mixing it with canal water. Village domestic sewage transports mainly organic pollutants to the drains and has not caused serious contamination of the drain water quality. Currently, the sewage of Abou Hammad city discharges into Elazzazi drain. However, the city has a wastewater treatment plant under construction, and in any event the moderate volume of sewage effluent does not have a significant effect on the water quality of Elazzazi drain. In general, branch drain water quality is adequate for irrigation. Unofficial reuse is practiced during rice season in Abou Hammad. In the case of Omm Elhagar canal and its associated drain of Elharami, at least 10% of the canal command area encounters canal supply shortage problems and farmers must pump drainage water in the summer season. Assuming that about half of the area's farmers have their own pumps, there may be 4 -5 pumps in operation in the area (one pump per mesqa). A farmer's pump usually has a capacity of 5 – 6 horsepower and lifts 0.02 m^3 / s of water. Accordingly, the area would have an unofficial use of 0.08 – 01.0 m^3/ s, or even more. This suggests an average unofficial reuse of 2^{5} m^3/s/fed (or 1.73 m^3/day/feddan).

(O&M) costs, and the government should be responsible for the major part of the capital and O&M costs of the intermediate reuse program. Only those farmers whose summer production is increased by using drainage water would possibly be willing to share part of the pump station O&M costs.

- Environmentally, the dominant agricultural land use, and the consequent good quality of drain water in Abou Hammad, will be sustained with the reuse of intermediate drainage.
- Intermediate drainage reuse is favored by a majority of farmers surveyed. Farmers prefer government ownership of and responsibility for pump facilities and operations. It was recommended in the case study report that the GOE (MPWWR[1]) pay all the costs, own the properties, and contract private companies to operate and maintain the intermediate reuse facilities until such time as there is a significant change in farmers' socio-economic status. The socio-economic assessment also highlighted village women's role in drain water quality protection, and the consequent need for including women as full partners in future drainage water management.

On our field visit we learned that several intermediate reuse pumping stations were constructed and are in operation. However, the Abou Hammad irrigation inspectorate could not track the history of the project. An inspectorate official indicated that several similar intermediate reuse pumping stations have been constructed in other parts of his district.

The project served as a pilot. Observations show the soundness of the scheme, although it is being used only in limited, peak demand periods. It seems to be viewed as a reserve water source. Local farmers appreciate the system, but are not able to finance its operation and maintenance. The irrigation department also is confronting difficulties in financing and performing operation and maintenance tasks.

It has now been three and one-half years since this project was proposed and designed. It is felt that prior to recommending any future intermediate reuse projects or even the reuse of more contaminated drainage water, it was important to revisit this proposed project and determine the following:

- Has the project been implemented and if so with what success or failure?
- If not, what constraints inhibit full implementation?
- Have any other alternatives been implemented?
- Could water of lesser quality be used in selected areas on selected crops?
- What would be the impact of the use of such water?
- How acceptable would this be to local farmers?
- Are there problems with local dumping of septic wastes in the drains, and if so are the reuse drains protected (and how)?
- Would it be possible to protect some drains from unacceptable waste disposal while turning a blind eye to others?

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[1] Ministry of Public Works and Water Resources, subsequently renamed the Ministry of Water Resources and Irrigation.

A detailed description of the project's impacts is included in EPIQ, 1999 (***Intermediate Drainage Reuse in Bahr El Baqar Drain Basin***, Report No. 20, Annex 3: Environmental Assessment, Samia Galal and Ibrahim El Assiouti, June, 1999). Because the project was never fully implemented and monitoring has not been on-going, it is difficult to say if the situation has improved. In general terms, the following negative and positive impacts were anticipated (but have not been observed):

1. The Influence of Intermediate Reuse on Dilution Capacity During Low Flow Regime (Negative Impact)

The original report points out that intercepting water for intermediate reuse will reduce the water flow at all downstream points. This will ultimately reduce the capability of the drain system to dilute various kinds of pollutants, whether from point or non-point sources. Since the project does divert some of the drain's flow, there could be some significant downstream effects. These would include reduction in wetlands habitat and less water available downstream for reuse in agriculture. Moreover, a reduction in natural river flow, together with a discharge in of low quality drainage water, can have negative impacts on downstream users.

Similarly during periods of low flow, an increase in concentration of suspended particles and nutrients in the water resulting from soil erosion and run off could cause some damage to downstream areas. Suspended particles may block modern hardware used in drip and sprinkler irrigation. In extreme cases, such particles may cause canals to be blocked, and deposit of the particles and nutrients on irrigated crops and land. Increased nutrients can increase aquatic weeds that impede irrigation and cause some significant loss of water. The Bahr El Baqar drain ends up in El Manzala Lake, one of the biggest wetlands in North Africa. Changes in the water flow regime, and the various nutritional and ecological changes that follow, may have some long-term impacts on this wetland system.

At this time, the net negative impacts of this intermediate reuse project cannot be quantified. Observations in the field indicate that the project managers see only the short-term positive impacts of the project. Lack of data downstream makes it difficult to evaluate negative impacts, such as changes in the overall chemistry of the Bahr El Baqar drain.

2. Positive Impacts

Potential positive impacts of intermediate reuse:

- With the poor conditions of the current delivery system, water shortages often occur at canal tails. This has generated a trend among farmers to augment their supplies with drain water in recent years. Organized intermediate reuse at the district level will mitigate the negative impacts of unofficial reuse of drainage water.

- Intermediate drainage reuse would lead to periodically lowered water levels in drains, which would allow increased sunlight penetration and better prevention of parasites and snails. Furthermore, the facilities required for intermediate drainage reuse are less sophisticated that those required in main drain mixing stations.

- With intermediate drainage reuse, unofficial reuse would be reduced. The MWRI will have more flexibility in implementing its strategies for drain water allocation in the Delta.

- In the current water delivery system, a branch canal serves a number of mesqas. The intakes of mesqas located at the end of the canal are often higher than the operational water level at the canal during peak irrigation demand period. Farmers suffering from supply shortage have to pump drainage water from nearby drains to augment supplies for their crops. Because of the spontaneous nature of the unorganized use of drain water, farmers may pump more that what is actually needed, or use drain water of a quality which should not be used. In this case organized intermediate reuse could be applied to pump nearby drain water to raise the canal water level and deliver the properly mixed supply to the mesqas.

- Intermediate drainage reuse should provide enough irrigation water to stop the current use of groundwater to augment water needs in many parts in the study area. Regular and extensive use of groundwater could have some significant impacts on the quantity of groundwater if recharging rates are not comparable to water withdrawal.

- Securing a stable supply of water would help increase the yield of major summer crops. Based on interviews conducted with local farmers and reported in previous studies (Zhu et al, 1999), cotton, rice, maize and vegetable yields are expected to increase.

- Water deliveries to the canals would be reduced by the amount of the water pumped in the winter season and would be available for use in other locations.

- The reuse of drainage wastewater in irrigation is governed by who can get the biggest share first. Farmers upstream were able to get their share any time they need it while others downstream end up with little. The introduction of intermediate drainage reuse should imply a more equal distribution of reused drainage water.

Based on our review of this project, the following criteria could be used to guide the selection of other sites for intermediate drainage water reuse:

- Water quality in branch drain is acceptable with minimum municipal and industrial pollution sources. Drains crossing villages and other residential areas are likely to receive illegal waste loads, and are therefore not good candidates for intermediate reuse.
- Size of drain is sufficiently large to enable a sustained reuse rate of drainage water pumped into canals
- Canals receiving supplemental drainage water should not supply municipal water treatment plants; i.e. they should serve only irrigation purposes.

- The drain should be close to the canal to minimize on the cost of the delivery pipes. This is achieved for a drain running parallel to a canal, and where a canal terminates into a drain. The latter case requires that the canal be fed from its tail.

Typical locations where intermediate reuse is appropriate include the Nubaria area, El Tahrir, and El Bustan. A key consideration in the selection of a site is that the command area for the drain should be larger than that for the canal. Command areas for canals should not be less than 1000 feddans, and preferably should be 2000 to 4000 feddans to facilitate mixing, and increase the duration of operation of the reuse pumps.

5. Development of Drain Water Management Strategies

Over the last few years, the MWRI has been working hard to develop policies to improve water quality in the Nile River system. With time these policies will hopefully be fully implemented and improvements will be seen. In the interim, there is agreement that reuse of drain water will have to be maximized. Therefore, it is important to explore methods which could be used to protect both fresh and drain water, and to optimize the use of both. It is felt that any program has to be designed in terms of:

- What MWRI can achieve with limited funds in the near term and with limited dependence on the cooperation/coordination of other ministries and agencies
- That interventions, including the separation of contaminated and fresh water, should be viewed as short to medium -term solutions and not as substitutes for long-term actions also required to achieve sustainability.
- That the present environmental status can be immediately improved, though partially, instead of waiting for full improvement.
- That appropriate interventions may vary from one region in Egypt to another; e.g. Upper Egypt, Delta, Northern Delta, Newly Reclaimed Lands.

Presently drainage water receives pollution loads from domestic, industrial, and agricultural sources. In Upper Egypt drainage water flows back into the Nile and threatens the water supply to most surface water treatment plants and the ecology of the river. In Middle Egypt and the Delta drains suffer the same problem, but to an even larger extent due to greater population density and the presence of more industries. Low quality drainage water reduces the potential for large scale reuse by pumping drainage water into irrigation canals or the Nile branches. Major water treatment plants suffer from polluted raw water supply; Ismailia canal is an example where El Wadi and El Mahsma reuse pumping stations had to cease operating to protect the raw water sources for Ismailia and Suez cities.

Minimizing the discharge of municipal and industrial pollution into the irrigation canals via the reused drainage water would go far to protect water quality for irrigation and other uses. This can be achieved through several strategies that vary in terms of required financial resources, technological capacity, and enforcement of laws and regulations. These strategies include:

1. Treatment of domestic and industrial wastes prior to discharge;
2. Separation of drainage water which is excessively mixed with domestic and industrial wastewater and reusing it in certain areas for selected crops;
3. Use of low cost in stream treatment technologies to improve water quality in drains prior to its reaching receiving waters.

The first strategy is the long- term ideal solution which the GOE should plan to achieve through securing the necessary financial and technical resources and, where needed, putting in place appropriate institutions, laws and policies. The second and third can be considered in the short or medium term. In the second strategy, low quality drainage water would not be pumped into the fresh water system (Nile, branches, or irrigation canals). Instead, it would be used locally, either after mixing with fresh water from minor canals, or directly from drains. The application of this strategy will differ between Upper Egypt and the Delta. The strategy finally selected should be one that is low cost and could be implemented in specific sites in the near future.

The potential consequences of the diversion of drain water are discussed below, and a case study is presented showing how diversion and use of low cost, in stream treatment could be implemented, and the potential consequences of these interventions.

5.1 Diversion of Drain Water

One potential strategy is diversion of low quality drain water away from fresh water resources. This strategy is used in many parts of the world where drain water can be put to beneficial use, such as for irrigation of approved crops. Impacts of separating low-quality drainage water include:

- Changes in water quality and quantity of the Nile (main stem and branches)
- Changes in water quality of the main irrigation canals fed from the Nile
- Changes in the soil as it is irrigated by more polluted (low quality) water
- Changes in the quality of ground water as a result of deep percolation and leaching.

If a diversion strategy is adopted, the mass balance of the pollutants indicates the following principles:

- The pollution loads generated from agriculture, municipal and industrial sources remain the same.
- The pollution loads will accumulate in the drain catchment areas as a result of reuse of drainage water (separately or mixed with supplemental fresh water).
- The process of self-purification of pollutants will take place in the catchment area of the drains (in channel, in soil).
- Oxygen demanding substances and bacterial contamination vary considerably by location and ecological balance is possible if their loads are compatible with the system's assimilative capacity.

- Salt and chemical pollutants will accumulate in the soil and may reach growth inhibiting levels if not leached.

- Transport of salinity and chemical pollution into groundwater is very probable, threatening groundwater supplies for municipal and industrial uses, and may reach the Nile stream with the groundwater influx.

5.1.1 Upper Egypt

In Upper Egypt, drains usually flow back into the Nile. Therefore, discharges into the Nile from those drains designated as low quality will have to stop (with their water fully used locally, supplemented by additional fresh water to meet mismatches between supply and demand, while maintaining minimum desirable water quality).

Under this strategy, the water quality in the Nile will be maintained similar to the water released from the High Aswan Dam with additional in-stream purification. This situation will improve those water treatment plants supplied from the Nile or from irrigation canals fed from the Nile and not affected by the cycle of pollutants within the catchment. Fish habitat and river ecology will be significantly improved.

On the other hand, soils in the drain catchment area will degrade due to the application of pollutants and their accumulation. Quality of crops will be threatened, with a possible shift to other crops safe for the irrigation water quality. Risk to farmers will increase. Groundwater may be negatively affected with a threat to groundwater abstraction for municipal and industrial uses. The flow back of polluted groundwater into the Nile could transport part of the original pollution loads into the Nile again.

5.1.2 The Delta

In the Delta, another strategy would be to managet drainage water. A management scheme could include:

- Identification of drains with low quality water from municipal and/or industrial sources;

- Identification and protection from further deterioration of relatively unpolluted drains, those with the potential for providing water for unrestricted reuse;

- Local reuse of low quality drainage water; or

- Transport of low quality drainage water for discharge to a sink (the sea or the northern lakes).

Several conveyance systems will exist:

- The irrigation canal network
- Regular "unpolluted drains"
- Low quality drains with interconnections with the irrigation canals for local reuse on certain crops.
-
- Low quality drains draining northerly to a sink.

Numerous crossings will be required to maintain the above network of channels. The operation of these networks will be challenging. Table 5-1 summarizes the nature of impacts of this strategy on the environment.

Table 5-1: Diversion of Drain Water in the Delta – Impact Analysis

Water Bodies	Nile Branches	Improvement in water quality due to the stopping of discharging of low quality drainage water
	Irrigation canals	Improvement in water quality due to the stopping of discharging of low quality drainage water
	Regular Drains	Improvement in water quality due to the stopping of the M & I indirect discharges.
	Low quality drains-Local reuse	Concentration of most of the M& I pollution load
	Low –quality drains-discharge to sinks	Concentration of most of the M&I pollution load
	Coastal lakes/sea	Concentrated pollution loads
Soil	In the catchment area where reuse of low quality drainage water is applied (Areas LQDWR)	▪ Accelerated accumulation of pollutants ▪ Lower value of land
	In other areas than LQDWR	Less pollution loads applied
Crops	In LQDWR areas	▪ Reduction in quality ▪ Restriction on certain crops
	In other areas than LQDWR	Improvement in quality
Farmers	In LQDWR areas	Severe heath risks to farmers
	In other areas than LQDWR	Reduced health risk to farmers

5.2 Case Study – the Berba Drain

BERBA DRAIN BASIN DESCRIPTION

Topography

The area is arid, with almost no rain. Elevation is 200 – 1000 m higher than the Nile, with a tendency to increase towards the east.This tendency to eastward elevation would necessitate pumping water to reach the different parts of the designated area.

Local Geology

In East Kom Ombo area, the desert landforms are affected by the great drainage basin of Wadi Kharit. This basin occupies an area of more than 10,000 km^2. The surface slopes gently westward and is underlain by a sandstone section which is interbedded with clay and iron stone beds. The surface section, having a thickness of more than 100 m, continues eastward in the direction of the elevated Red Sea mountains and rises to more than 500 m above sea level. This surface continues also westward, across the Nile Valley, but the ground elevation hardly exceeds 300 m above sea level. In the valley of Wadi Kharit as well as in the area of the Nile Valley, the sandstone rocks, belonging to the Cretaceous are overlain by young, non-consolidated sediments belonging to the Quaternary. Major fractures and fault lines observed in the East Aswan area may be considered as belonging to two very broad age groups termed as the older and younger fractures and faults.

Soil Properties and Land Forms

Dominant types of soil in the area range from deep sand to loamy sandy soil with a tendency of sandstone type of soil toward the east. The soil is made of gavel, sand and occasionally some silt. Soil has a rather salty nature. With high level of salinity, it would need thorough washing with fresh water in order to remove salts prior to agriculture. The soil is very poor in organic matter. Dominant land forms are river terraces, wadis and plains. Wadi Kharit and Wadi Natash are among the most well known wadis in the area.

The groundwater contains high levels of salts, with the salinity of groundwater at Esna, north Kom Ombo in the range of 2000 ppm. At Esna, groundwater is flowing, while in Wadi Khrait it has no pressure.

If managed properly, low quality drain water can be reused in the development of new lands or irrigation of currently cultivated fields. The result will be reduction of pollution flowing into receiving water bodies. However, poor management of low quality water can cause health problems, contamination of groundwater and surface water posing large environmental impacts, and can lead to considerable economic loss. It is important to effectively and economically reuse low quality water in areas where positive impacts outweigh negative effects.

By way of example, a review of the pollution sources affecting the river Nile in Upper Egypt (EPIQ, 2002) shows that Berba drain discharges large industrial pollution loads, mixed with domestic and agricultural pollution loads. Initial review of the physical characteristics indicated that by using low cost interventions to improve water quality, using a combination of reuse strategies and in-stream treatment, a program could be developed to decrease the pollution load entering the Nile and threatening the supply to the water treatment plants for the city of Kom Ombo. This took an understanding of sources of pollution, the quality of drain waters, current environmental degradation caused by the discharges, the conceptual design of interventions to reduce pollution loading, and an evaluation of the environmental concerns of such a program.

5.2.1 Sources of Pollution

The Berba drain discharges its water at Km 49.1 downstream from the High Aswan Dam on the right bank. It receives the flow from a branch drain called El Ganyan at Km 1.4, right bank. El Ganyan drain is nearly 2 kilometers long and has a command area of 760 feddans. It receives a large, partially treated industrial effluent at its start. This effluent is generated from the Sugar and Integrated Industries Company – the Kom Ombo Plant. The industrial effluent is generated during the juicing of the sugarcane, which takes place over a period of six months, from December to June. During the remainder of the year, the plant converts baggase into wooden boards. The water used by the plant is estimated to be 18 million cubic meters per year, nearly 15 million cubic meters of which are used for sugar production. Although the effluent discharge is not measured, it is estimated to be as high as 83,000 cubic meters per day; i.e. 3,470 cubic meters per hour, and averages around 41,000 cubic meters per day, i.e. 1,700 cubic meters per hour. The plant is reported to have a wastewater treatment plant with a capacity of 100 cubic meters per hour. i.e. nearly 3 % of the generated effluent. However, the efficiency of the treatment plant and its unit processes are not monitored.

The Berba drain is nearly 4 kilometers long, and has a command area of 1000 feddans prior to the inflow of El Ganyan drain. The agricultural drainage flow rate can reach 21,000 cubic meters per day.

The Berba drain also receives the untreated wastewater generated from the slaughterhouse of Kom Ombo city. This source has a large organic load and coliform count. In addition, the Berba drain receives solid and municipal wastewater discharges as it crosses the residential area between Km 1.400 and 2.600.

EPIQ Report No. 64 reports a flow rate of the Berba drain of 150,000 cubic meters per day.

5.2.2 Quality of Drain Discharge

According to NWRC (2001) the effluent of Berba drain is categorized as highly polluted: BOD = 42.7 mg/l; COD= 113 mg/l, Fecal coliform = 22,500 /100ml; TDS =414 mg/l, heavy metals= 0.7 mg/l. An analysis of water samples taken from El Ganyan drain in May 2002 yielded the following readings: BOD = 300 mg/l, pH= 6.5, color = yellow, suspended solids = 256 mg/l, SO_4 =0.32 mg/l. Other measurements of sugar mill effluents range between 96 to 228 mg/l for BOD. The DO in the effluent is 3.85,which is considered excessively low because the drain is relatively long and has a steep bottom slope which promotes re-aeration.

5.2.3 Environmental Impact of Drain Discharge

The effluent from the Berba drain has a negative impact on the water quality of the River Nile. Its high fecal coliform count threatens the water supply of the city of Kom Ombo. The water treatment plant for the city has been recently upgraded by a joint Government of Egypt and USAID activity financed through Grant 263-0236. The old and new water treatment plants (WTP) for the city are located near the city, and are supplied indirectly by Nile water through Cassel canal. The capacity of the old WTP is 17,280 cubic meters per day (200 l/sec); the newly constructed facility has a similar capacity. The intake and pumping station of Cassel canal is located immediately downstream of the outfall of the Berba drain on the same right bank. Therefore, it is expected that the dilution effect of the Nile flow on the Berba effluent will be limited, and that the Nile water diverted to Cassel canal be of poorer quality than that of the middle stream of the Nile. The biological pollution caused by the Berba drain threatens the fish population in the Nile. The odor and debris of the effluent negatively affect the tourist cruises usually crossing and berthing near the outfall.

5.2.4 Proposed Interventions

Pollution problems in the Berba drain are typical of those in Upper Egypt and the Delta. The conventional interventions to reduce the pollution load of the industrial sugar mill waste have not been successful. The Sugar and Integrated Industries Company has technical and financial constraints that make it difficult to introduce full treatment of its wastes. Presently, it only treats around 3 % of its wastes. To expand on the capacity of its treatment plant, an estimated investment of some 50 million Egyptian pounds is required; assuming that the company takes no additional pollution reduction measures within its plant. It appears that the company, which belongs to the Holding Company for Food Industries, cannot easily secure such an amount. Technically, the current plant does not manage its wastes in a sound environmental way. The efficiency of its wastewater treatment is questionable. The Ministry of Water Resources and Irrigation has imposed penalties in May 1994, June 1995, September 1997, January 1998, April, 1999, July 1999, November 2000, February 2001, August 2002, April 2002 with no positive response.

As presented in Figure B-1 in Appendix B, an intervention that can be implemented immediately is to re-route the sugar mill waste into another drain where the negative environmental impacts would be less. Under this intervention, the sugar mill should discharge its wastes underneath Cassel canal and into the beginning of West Swares drain, which subsequently discharges into Berak El Raghama drain. The sugar company used to discharge part of its wastes through this route via a siphon underneath Cassel canal. The siphon could not be presently detected as it may have deteriorated and been buried when it was abandoned. Therefore, this intervention may require the rehabilitation of the siphon or even the construction of a new one. Such a siphon may require a budget of three million Egyptian pounds if constructed by mini-tunneling techniques under the Cassel canal.

The proposed new route of the industrial waste of the sugar mill through west Swares and Berak El Raghama is longer and the drain flow is greater, which means better dilution and higher in-stream assimilation. The length of Berak El Raghama drain from the point of discharge of West Swares up to its outfall into the Nile is 6.6 Km. The length of West Swares drain is 1.73 Km. Therefore, the combined length of the new route is 8.33 Kms, nearly two and one half times the older El Ganyan –Berba route (3.4 Kms). The channel gradient in West Swares is 80 cm/km and that of Berak El Raghama varies from 40 cm/km to 65 cm/km. These gradients can maintain relatively high channel velocities and smaller depth, and better re-aeration rates.

The design of West Swares has an allowance for discharge from the sugar mill of 150,000 cubic meters per day. The command area of west Swares is 600 feddans and that of Berak El Raghama is 3000 feddans. Thus, its discharge excluding the industrial waste is 150 percent of the Berba drain.

In other words, the proposed intervention, which would be simultaneously accompanied by the operation of the Kom Ombo Sewerage system, has better dilution, more in-stream assimilation, and discharges into the Nile downstream of the intake of the Cassel canal. It should be noted that the outfall of Berak El Ragham is at Km 64.7 which may have some impact on the El Bowier water treatment plant with its intake at Km 67.000. El Bowier water treatment plan has a capacity of 14,400 cubic meters/day.

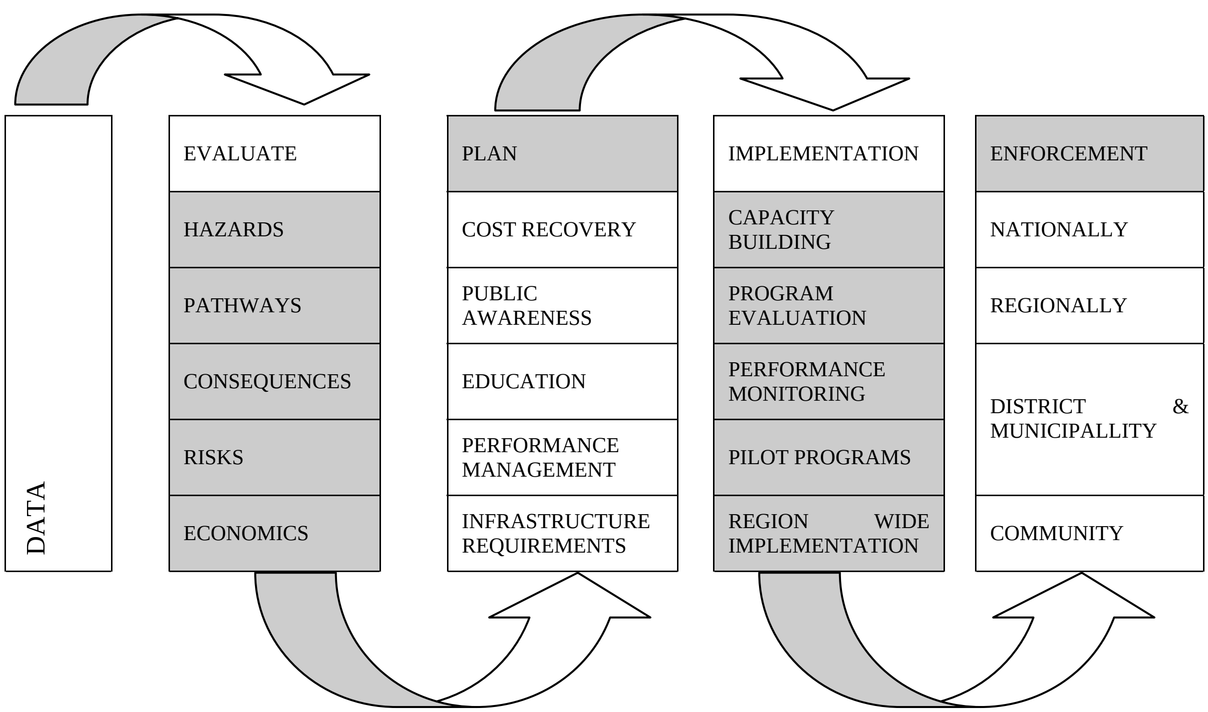
A sewerage system is under construction in the city of Kom Ombo that is designed to collect sewage from the residential area. An enquiry was made to the city council regarding the possible discharge of the slaughterhouse wastes into the sewerage system. It appears that the design of the sewerage allows for connection of the slaughterhouse. The completion and operation of the sewerage system will relieve the Berba drain from its major biological pollution source.

Collected sewage from Kom Ombo and the adjacent towns of Daraw and Nasser El Nuba will be pumped to a regional wastewater treatment plant under construction in El Balyana. Treated effluent from the plant will be reused to irrigate 1000 feddans of the adjacent desert land. This regional wastewater management system will be executed by the Government of Egypt with support provided by USAID under the Secondary Cities Project. The reuse of domestic and mixed domestic and industrial wastewater in irrigating newly reclaimed desert land for carefully selected crops is gaining acceptance. This practice minimizes the impact of inadequately treated wastewater on crops and consumers.

6. Towards Integrated Water Quality Management

Important steps have been, and are being, taken by the GOE—sometimes with support from USAID, CIDA, the Dutch or other donors -- to devise policies and management practices aimed at protecting Egyptian waters. Many of these reforms are in their infancy. Experience elsewhere in the world suggests that successful implementation of new policies aimed at better water quality management requires a strategic approach and close cooperation between policy analysts, planners and implementers. Since the policy process is a circular one that moves from monitoring to analyzing/ predicting the consequences of actions, to modifying policy responses and back, cooperation is needed in policy design, policy implementation and evaluation of policy intervention outcomes. Planners and policy analysts must have the capability to monitor and verify the consequences of policy actions, and implementers must have the capability and flexibility to implement policy changes, making mid-course adjustments as necessary.

As illustrated in Figure 6-1, integrated water quality management is based on developing an understanding of the potential hazards to water quality, the pathways of these hazards to the environment, and their potential consequences. This allows for current management approaches to be monitored and evaluated. Keys to a successful program include good data to inform decisions, and monitoring to ensure long-term sustainability.
Figure 6-1: Conceptual Approach to Integrated Water Quality Management



Toward the implementation of an integrated management approach, the MWRI has created a Water Quality Unit. Numerous other programs have also been implemented, including pilot studies on intermediate reuse and management of waters draining into the El Salam canal. Any future programs must be designed and implemented to compliment these existing programs. Because of time constraints, it was not possible to evaluate each of the water quality management programs being conducted by MWRI and the National Water Research Center. However, it is believed that the following interventions could assist the GOE in implementing policies regarding integrated water quality management.

These interventions would foster better sharing of data/information and performance monitoring of areas that involve protecting the Nile River system, wastewater treatment, and provide for infrastructure cost recovery and management. Because water quality issues cross numerous sectors, experience in Egypt and elsewhere dictates that success of the programs outlined below depends on the ability of various ministries to work together toward common goals. It is, therefore, important to understand the concept of integrated water management and what benefits any particular program would provide for the Egyptian people.

6.1 Concept 1: The Development of a Water Quality Information Center (WQIC)

In preparing this report, the team found it difficult to collect the necessary data and information to draw sound conclusions. Concerns about data management and monitoring stated in ***Survey of the Nile System Pollution Sources, Report No. 64*** (EPIQ, 2002) and restated on Section 2 of this report, indicate the need for intra- and inter-ministerial data sharing. Additionally, most water quality databases are limited in the amount and kinds of data available to policy makers. Moreover, past attempts by USAID and other donors to work with the GOE to develop systems for sharing data have failed to meet expectations. A case in point is the 1995 PRIDE D.O. #10 project which set out to design and to develop a "clearinghouse" of information through a National Water Quality Conservation Unit (NWQCU) within the NWRC. Although this project accomplished many things, including a design for a EWAQIS (Egyptian Water Quality Information System), it could not be considered successful because it did not achieve its information sharing goal.

Recently, constructive changes in perspectives within the GOE concerning sharing water quality data have been noticed. This is encouraging because, with the development of "new lands" (and the consequent need for increased reuse of drain water), and for public health reasons, the need to share water quality information so that good drain management and policy decisions can be made and effectively implemented has never been greater. The changed perspectives alluded to above, together with the advent of new technologies, such as the Internet, may be instrumental in fostering strong synergies to get various organizations working together and sharing information. Towards that end, we suggest that the MWRI, acting through the WPAU and the WQU, consider creating a "clearinghouse" for water quality information to assist in developing and monitoring sound water quality policy. The following presents a strategic approach toward the development of a Water Quality Information Center (WQIC).

1. The Vision

The vision for the WQIC as illustrated in Figure 6-2 is relatively simple. The WQIC would be operated within the MWRI, but would be comprised as well of members from the EEAA, Ministry of Industry, Ministry of Health, NGOs, and other organizations interested in water quality issues. Information processed through the WQIC would consist of technical reports and output from various databases concerned with the environmental health of the Nile River. The WQIC would present status reports on the Nile River to a technical advisory committee for project evaluation. The committee in turn will recommend water quality management options to concerned ministers.

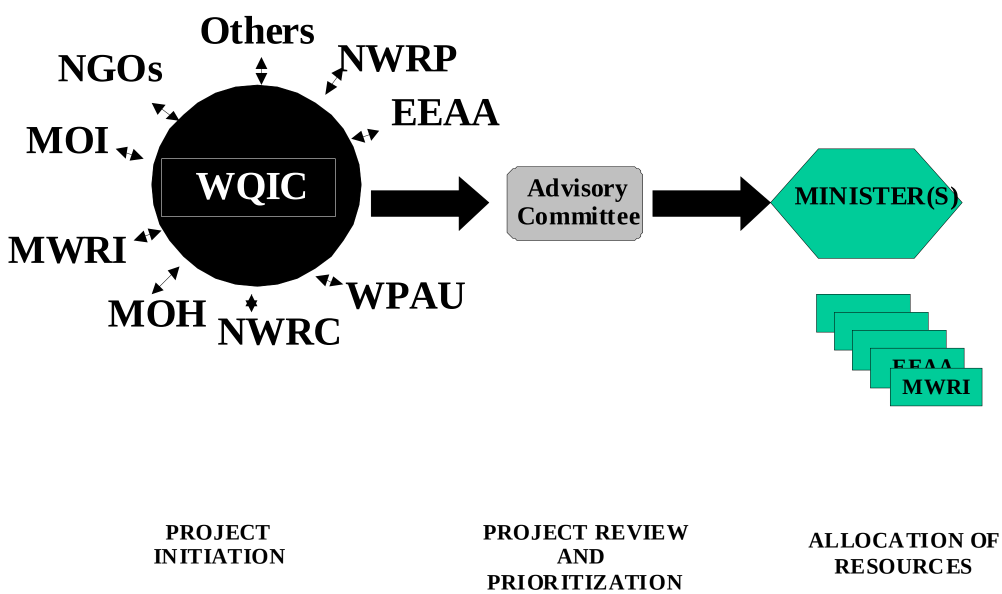


Figure 6-2: Vision for the Water Quality Information Center

Achieving this vision will not come easily. Past disappointments due to the reluctance of various agencies and institutes to work together and share information gives rise to major concerns. Concept 4 may help to address this concern by laying out a pathway for the decentralization of water quality monitoring from the central government to the districts and governorates. If that approach is adopted, the WQIC could play a role in integrating water quality data collected locally.

2. Strategic Objective

Prior to the development of the Center, it will be important that its mission is well defined. In general terms, this mission could be stated as follows:

The Quality Information Center (WQIC) will act as a "clearinghouse" of environmental, natural resource, and other information collected pertaining to water quality management of the Nile River system. This Center will be the focal point for the dissemination of this information to interested parties, including the public at large, to the extent possible. We believe that if the Center achieves this objective, a major step will have been taken toward implementation and continuous monitoring and review of constructive water quality policies in Egypt.

3. Achieving this Objective

Based on past experience, several roadblocks stand in the way of the WQIC being successful. To overcome them, it is important to define a "step-wise" approach, described as follows:

6.1.1 Step 1: Know Where WQIC is Going

- Define strategic objectives.
- Determine what data/information is available (start with public domain and move from there).
- Understand "user needs."
- Develop a program to best use what is available to meet "user needs" and to assist decision makers.
- Go beyond what is available to meet objectives.

6.1.2 Step 2: Obtain Staff and Equipment

- To meet strategic objectives.
- To serve members of GOE, technical organizations, and decision makers.
- To interact with the public.

6.1.3 Step 3: Invest in Consensus Building

- Develop a leadership role.
- Identify member organizations that will take part in the running of the center.
- Develop a steering committee.
- Develop an understanding of how information can be collected, organized, and presented to best advantage.
- Keep interested members updated on events through planning meetings.
- Develop protocols for data collection, georeferenced information development, and data sharing among members, technical non-members, and the public.

6.1.4 Step 4: Start Sharing Information

- Write periodic reports on what is happening environmentally in the Nile River Basin.
- Develop "fact sheets" on topics regarding water quality.
- Obtain a domain name and create a web page.
- Design and install a simple web database with basic, readily available information.

- Get members participating in these activities.

6.1.5 Step 5: Improve Information Dissemination & Decision Support Using Georeferenced Information

- Link WQIC to data and information centers to develop a member-wide georeferenced information network.
- Develop georeferenced information skills within WQIC.
- Determine how georeferenced information can be used to assist analysis in terms of visualization, management, and policy development.

6.1.6 Step 6: Make Georeferenced Information Accessible

- Through a LAN, have members interactively provide and share georeferenced information.
- Incorporate the georeferenced information into the web database, with appropriate firewalls to protect sensitive data.

Toward meeting this objective, the National Water Research Center has proposed a Fast Response Unit (FRU). The primary objective of the FRU is to respond to requests for information from the NWRC from the Minister, the Cabinet, the President, and the public, accessing information and data sets in the NWRC. In addition, FRU would act as NWRC's open gate of information to the researchers of NWRC and civil organizations in Egypt and abroad. Creating such a Unit is a very important first step. However, the concept presented above is more far reaching in that it aims to foster broader sharing of data across all organizations involved in water quality management as required for integrated management and facilitating wide access to all available water quality information.

6.2 Concept 2: The Development of a Centralized Performance Monitoring Program for all Water Quality Improvement Projects

As mentioned earlier, the policy implementation process is a circular one that moves from monitoring to analyzing/ predicting the consequences of actions, to modifying policy responses, and back. In a report written by EPIQ under the APRP entitled ***Assessment of the Impacts of the Water Policy Reform Program***, the following conclusion was drawn:

"The lack of consistent data sets over the life of the project is a serious impediment to an overall evaluation such as this one. The fact that policy change is a lengthy process and that changes in measurable national indicators of impacts are not expected in the short term, suggests that data collection should be a long-term activity. Monitoring programs, like the Monitoring, Validation and Evaluation (MVE), should be established for all major projects and activities of USAID. Monitoring is often a costly process, but without it, only anecdotal evaluations are possible. Moreover, the ability to develop and maintain a monitoring and evaluation process over the long term should be as much a part of a project's legacy as other reforms."

Observations made during the conduct of both of our case studies indicate that maintaining a monitoring program for water quality improvement projects is currently not being given priority within the MWRI, or any other government agency. At Abo Hammoud, the pilot program for intermediate reuse was underutilized and marginally effective. In Kom Ombo, reuse of wastewater for irrigation is being initiated with little planning, and with no way to evaluate long-term performance. In addition, limited data from wastewater treatment plants on municipal, industrial, and farm level pollution make it very difficult to determine how effective developments at the plants are for improving water quality in Egypt. It is, therefore, clear that the development of monitoring programs within the WPAU that allow for evaluation of programs at all levels is important for implementing sound water quality policies.

The Vision

The vision of such a program is to develop a Monitoring, Verification, and Evaluation (MVE) Section in the WPAU of the MWRI to evaluate projects, programs, data collection, and other activities regarding water quality of the Nile River system. The Section would develop performance indicators and a monitoring protocol within a defined framework to be established. The Section would have an advisory committee comprised of members from the MWRI, EEAA, MOH, MOI, and other organizations interested in water quality. This committee would give advice on performance indicators to be developed, monitoring techniques, and protocols.

Strategic Objective

The objective of the MVE is to keep ministers and other policy makers aware of progress (or lack of progress) being made under programs on a national, community, and industrial/farm level toward improving water quality in the Nile River system. An annual "report card" would be presented to the ministers on the status of programs designed to improve the water quality of the Nile River system. Such a program would go beyond what has been done in the past by developing performance indicators which would provide information on success or failure of water quality projects. Ultimately, programs could be evaluated and budgeted as determined by their performance. Finally, a status report of water quality improvement activities could be posted on the web through the WQIC.

Achieving This Objective

Table 6-1 presents a preliminary list of requirements and benefits of such a project. It is expected that requirements will vary slightly for each level of government that is being evaluated. Key programs for each level will be the development of performance indicators, databases, and monitoring and inspection programs. Organizations at various levels of government would also have to dedicate personnel to the program and training would have to be provided. In addition, it will be very important to conduct community outreach programs for industrial and community leaders to ensure that the program could be carried out.

Table 6-1: Requirements and Benefits of Performance Management Program

LEVEL OF GOVERNMENT	REQUIREMENTS	SHORT-TERM BENEFITS	MEDIUM-TERM BENEFITS	LONG-TERM BENEFITS
FEDERAL LEVEL	**Performance Monitoring and Mgmt Program Design Performance Indicators Database Development Performance Budgeting Monitoring And Inspection Training WQIC**	**Justification For Policies And Laws Improved Efficiency of Water Quality Monitoring Accountability To Government Cost Savings By Consolidating Efforts Trained Personnel Improved Data And Information Sharing**	**Improved Monitoring Networks For Drains, Canal, And Main Stem Of The Nile Improved Enforcement Activities Better Knowledge Of The Nile River System**	**Improved Water Quality Of The Nile River System Lower Cost Of Water Treatment Less Environmental Impact**
COMMUNITY LEVEL	**Community Awareness Development of Performance Indicators Conceptual Approach Towards Getting Wastewater Treatment Performance Mgmt Training Monitoring And Inspection Wastewater Treatment Plants Operational**	**Cost recovery Trained Management Personnel More Treatment Plants Operational**	**Improved Community Relationships Transference Of Knowledge For The Construction Of More Systems Improved Water Quality of Drains and the Main Stem of the Nile River**	**Cost recovery for Wastewater Systems Improved Water Quality In Drains, The Main Stem Of The Nile River And Shallow Groundwater**
LOCAL LEVEL (INDUSTRIAL AND FARM)	**Community Awareness Development Of Performance Indicators Training Incentives Intervention Design And Pilot Studies Monitoring And Inspection**	**Trained Personnel Model For Future Development Improved Efficiency of Water Usage Cost Savings**	**Improved Water Quality In The Nile Drains, And Shallow Groundwater Industries Becoming Better Corporate Citizens**	**Higher Standard of Living**

6.3 Concept 3: Development of Programs or Interventions for Nile River Protection, Wastewater Treatment, and Infrastructure Management/ Cost Recovery

The implementation of Concepts 1 and 2 would go a long way toward integrated water quality management of the Nile River system. However, in and of themselves, these do little to solve the fundamental problems that face Egypt in terms of Nile River protection, wastewater treatment, and infrastructure management/cost recovery. Critical problems in terms of water quality include:

- Lack of enforcement of laws and regulations;
- Lack of wastewater treatment capacity, with numerous plants being planned or constructed but not operating;
- Lack of training in water quality issues for field engineers working in irrigation and drainage that would promote a better appreciation of the need for, and requirements of, integrated management; and
- Numerous other factors.

Table 6-2 presents a set of programs that could be developed within the MWRI, together with performance goals, related to protection of the Nile River, wastewater treatment, and infrastructure management/cost recovery. It is recognized that there may be a certain redundancy between these programs and those presented in Concepts 1 and 2, and perhaps with programs currently underway within the various ministries.

6.4 Concept 4: Decentralization of Water Quality Data Collection and Implementation of Water Quality Improvement Programs.

Review of existing information sources indicates that current water quality management programs are costly and difficult to implement. The NWRC is carrying out an integrated program at the national level to provide information and data useful to all water users and managers and, through research, to provide insights to inform policy decisions. Other programs, such as those performed by EEAA are geared toward central government reporting requirements However, as good as these programs may be, day to day water quality management decisions should be made on a local level. This is so because there is a need for timely decisions reflecting local circumstances in the case of such events as accidental spills or factories illegally discharging wastewater.

Existing wastewater treatment programs for both municipal and industrial discharges are formulated on a national level and are difficult to implement locally because of cost considerations, inadequate level of training of professionals, and other factors. The approach taken can often be characterized as all or nothing, making it difficult for local authorities to develop low cost, short-term solutions, such as those presented in Section 5 of this report. For these reasons, we present a concept that looks toward the decentralization of water quality monitoring and project implementation activities.

Table 6-2: Conceptual Performance Targets and Analytical Programs by Sector

SECTOR	TARGET PERFORMANCE	ANALYTICAL OR PROJECT REQUIREMENTS
Nile River Protection	Reduce environmental impacts to water supply	1. Prioritization of pollution sources and the determination of how those that pose a high risk to water supply may be controlled and or eliminated through a systematic risk assessment. 2. Development of a discharge elimination system. 3. Development of a Water Quality Information Center to enhance the formulation of Policies and Laws.
	Assure effective/reliable water supply of suitable quality for urban areas, agriculture and new lands development.	1. Definition and evaluation of sources for water supply for domestic, industrial, and agricultural uses. 2. Evaluation of existing and potential threats to the water system 3. Estimation of human health threats using risk assessment.
Wastewater Treatment	Maximize treatment efficiency based on current and future loading	1. Evaluation of current municipal and industrial wastewater treatment plants. 2. Determination of future treatment requirements. 3. Evaluation of potential interventions (in-stream treatment) that can in the near-term reduce contamination mixing with the Nile or canal water.
	Minimize treatment requirements for influent waters	1. Determination of the most cost effective approaches to optimize treatment of industrial and industrial wastewater systems. 2. Determination of advantages/disadvantages of intermediate reuse of drainage water, separation of fresh water sources and drain water, and other interventions that minimize wastewater treatment requirements. 3. Development of strategies to work with industry and local communities to minimize the amount of untreated wastewater
Management& Cost Recovery	Maximize cost recovery, cost coverage and facilitate capital availability for sustainable service	1. Determination of the manner in which wastewater and drainage services are currently funded 2. Definition of the manner for and extent of cost recovery 3. Definition of sources of capital expenditures required for system sustainability 4. Definition of willingness to pay for improved and effective collection services
	Establish effective performance management and measure of accountability	1. Determination of the manner irrigation distribution system/ wastewater treatment plants are monitored 2. Determination of problems with the existing irrigation and drainage systems in terms of efficiencies, system outages, water quality, and other factors. 3. Definition of the manner in which issues and problems are addressed (means of system troubleshooting) 4. Evaluation of management structure and hierarchy for current system 5. Definition of the manner in which public feedback/and complaints are received and processed 6. Evaluation of enforcement procedures for municipal and irrigation systems (reuse, illegal, primary and secondary uses) as well as for commercial/industrial sources
	Develop an effective asset accounting and management system	1. Determination of a asset inventory system including: well pumps, lift stations, surface water intakes,, etc. 2. Definition of system maintenance programs and evaluation of effectiveness 3. Determination of the manner in which obsolete assets are replaced or new assets are procured for service expansion
	Optimize private sector involvement	1. Definition of current private sector involvement in water and wastewater treatment sectors 2. Definition of opportunities for private sector integration

The Vision

Under the proposed WQIC and Performance Monitoring Units within the MWRI, a program would be prepared to develop local water quality monitoring programs for drains and canals, interfacing with larger scale monitoring programs of the National Water Research Center and small scale programs in two districts being developed by the Water Quality Unit within the MWRI. This program will be simple in design and consist of periodic water sampling for field parameters (quantity, pH, temperature, specific conductance, etc.), less frequent water quality sampling for laboratory analysis, and the use of continuous recording of temperature, specific conductivity, and/or specific ion probes. It will be developed and carried out on a local basis based on the ambient water chemistry of the drains and canals, the strategic importance of each drain, and the nature of discharges (industrial or municipal). Data collected will be placed in a relational or web based database for access by all interested parties.

A program will also be designed to locally evaluate ongoing water quality improvement projects (agricultural, industrial and municipal) and make recommendations for low cost interventions to reduce pollution at the source, direct reuse of discharge water, divert drain water for reuse, treat pollutants in stream, etc. These interventions will be developed for short to medium term implementation.

Strategic Objective

The objective of this work is to improve water quality of canals, drains, and the Nile River by implementing low cost and low technology interventions and, through the development of a water quality monitoring program, evaluate the performance of these interventions for future improvement. In addition, the implementation of the water quality monitoring program will set the stage for interagency cooperation in data and information sharing and allow local water managers access to data to assist in management decisions.

Achieving These Objectives

To achieve these objectives, it is important to develop an understanding within the MWRI of:

- The level of expertise available on the local and governorate levels.
- Training requirements for local personnel.
- Equipment requirements (water quality field meters, flow meters, continuous recorders, etc.)
- The need for monitoring (as presented in Section 2) water quality, recognizing that quality concerns vary between different locations.
- The need to design and implement pilot programs. It is recommended that the Berba Drain (addressed in Section 5) would be a good place to start in Upper Egypt. In the

Delta, consideration should be given to the drains that feed the El Salaam canalwhich, as mentioned in Section 2, is the number 1 priority in terms of water quality protection.

6.5 Concept 5: Other Considerations

There are numerous other programs that could be implemented to further integrated water quality management of the Nile River. These are larger scale and could include:

1. Development of a detailed human health risk assessment of the Nile River based on existing water quality data.

2. Development of a biological monitoring program to assist in determining the long-term biological health of the Nile River system.

3. Improved education of local government personnel and citizens on the relationship between water quality and health.

4. Evaluation of all wastewater treatment plants that are constructed but not operating to determine what went wrong, what is needed to get them operating, and what can be done in the near-term to reduce discharges.

5. Development of a program to evaluate and classify drains, not only on water quality criteria, but also based on use and assimilation capacity.

6. Further evaluation of intermediate reuse in terms of overall impacts on water quality.

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APPENDIX A:

PRIORITIES FOR POLLUTION MITIGATION IN EGYPT AND NATURE OF DISCHARGES INTO DRAINS

Figure A-1: Egyptian Priorities for Pollution Mitigation

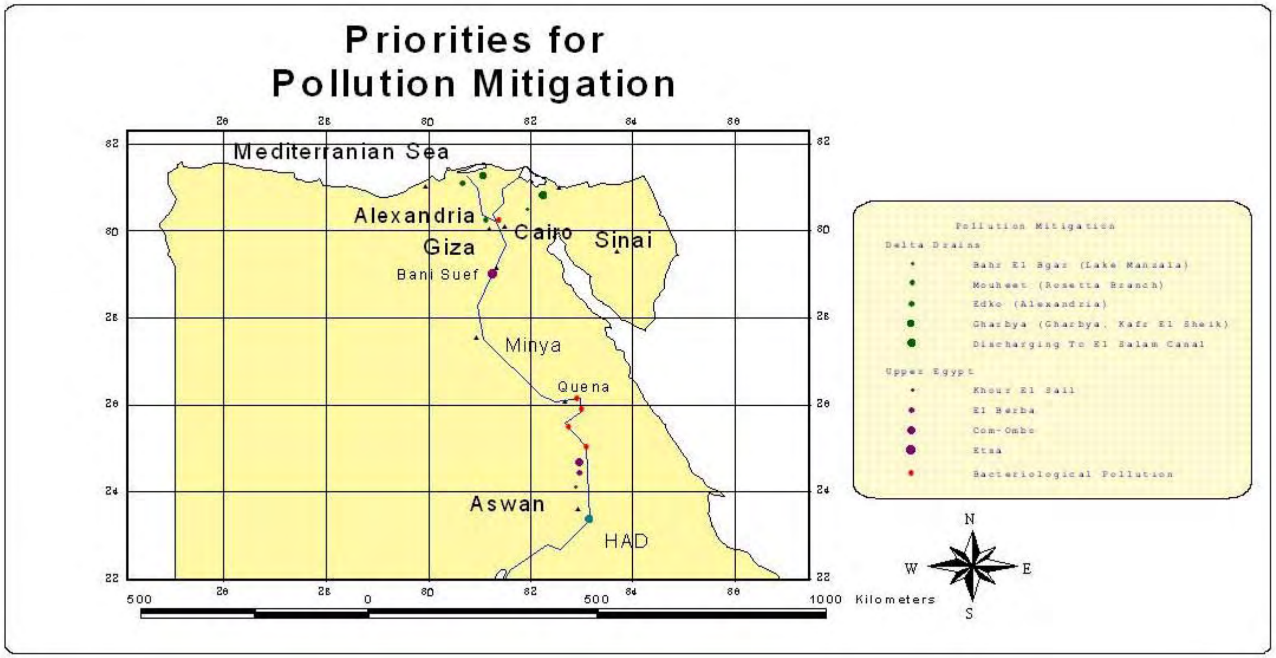


Figure A-2: Abu Keer Drain System

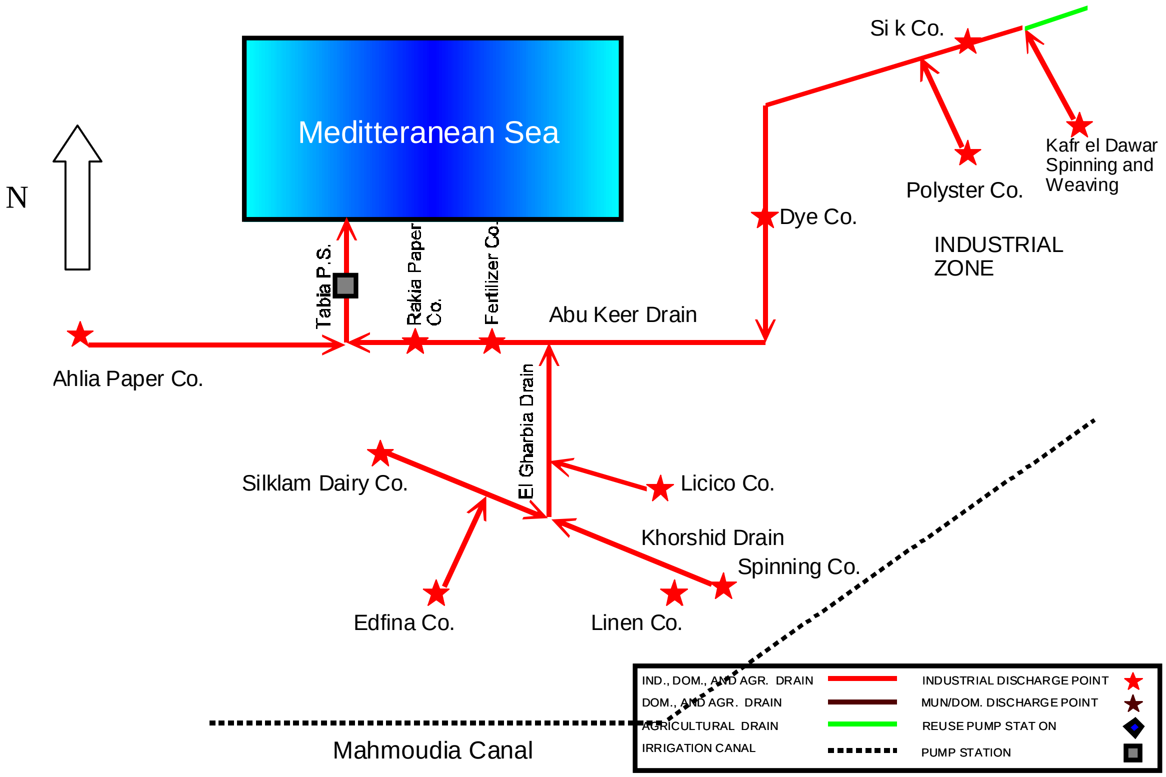


Figure A-3: El Bagar Drain System

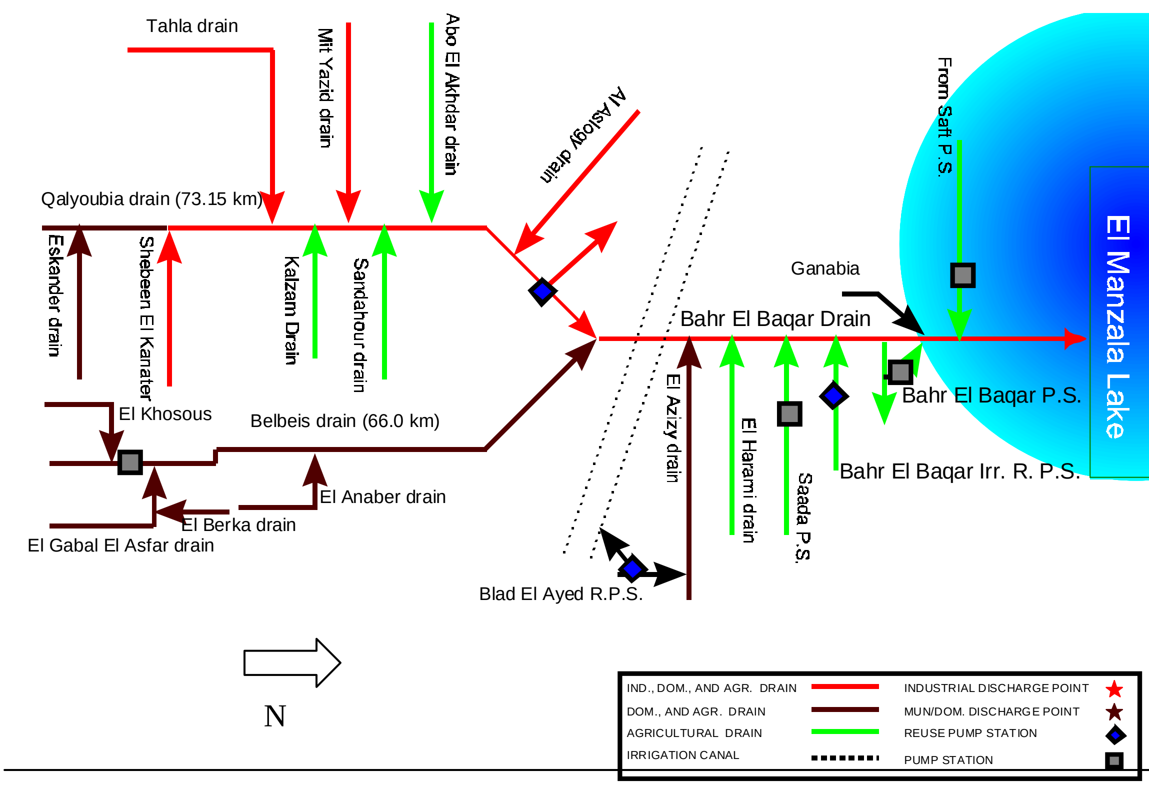


Figure A-4: Lake Brullus Drain System

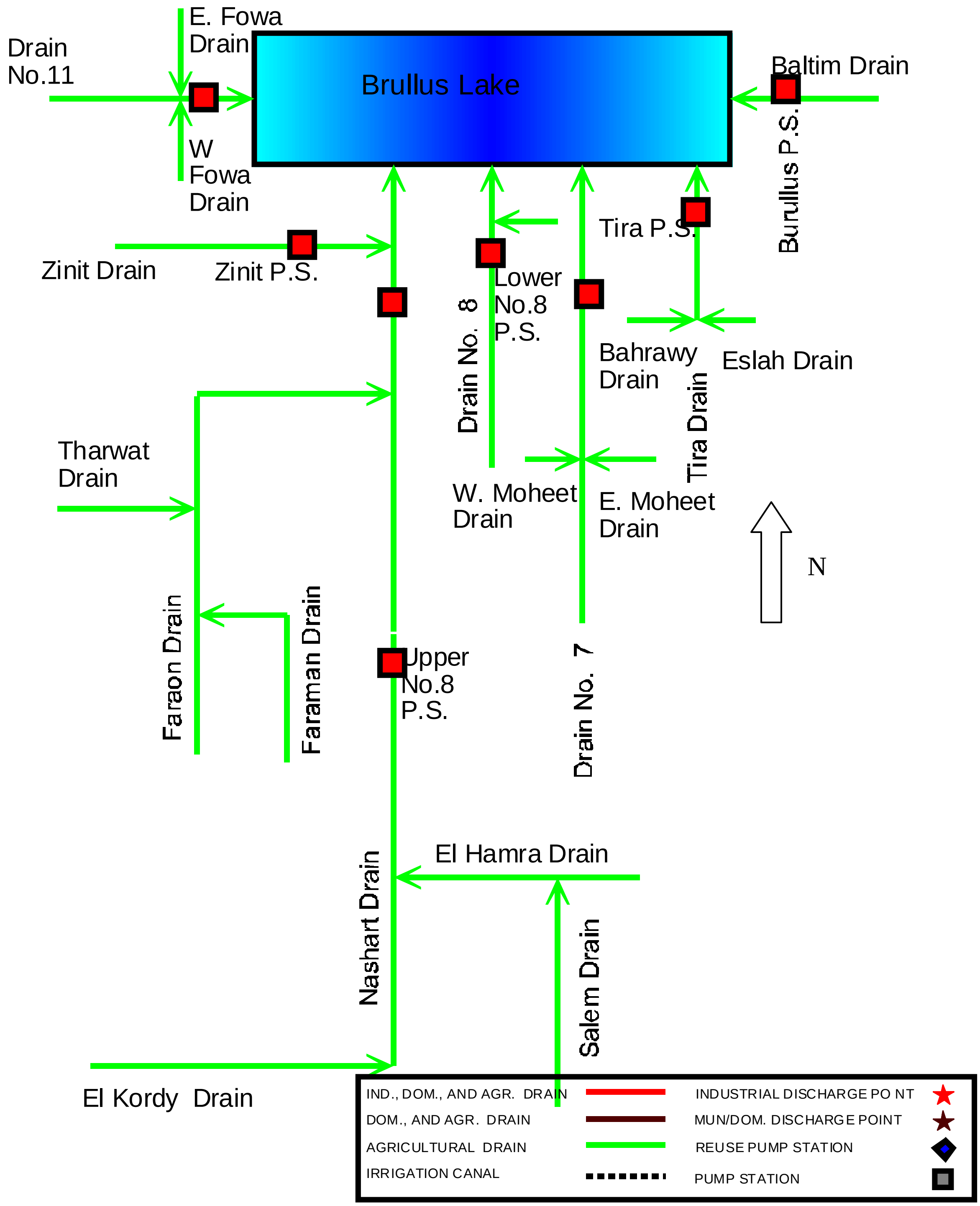


Figure A-5: Edko Drain System

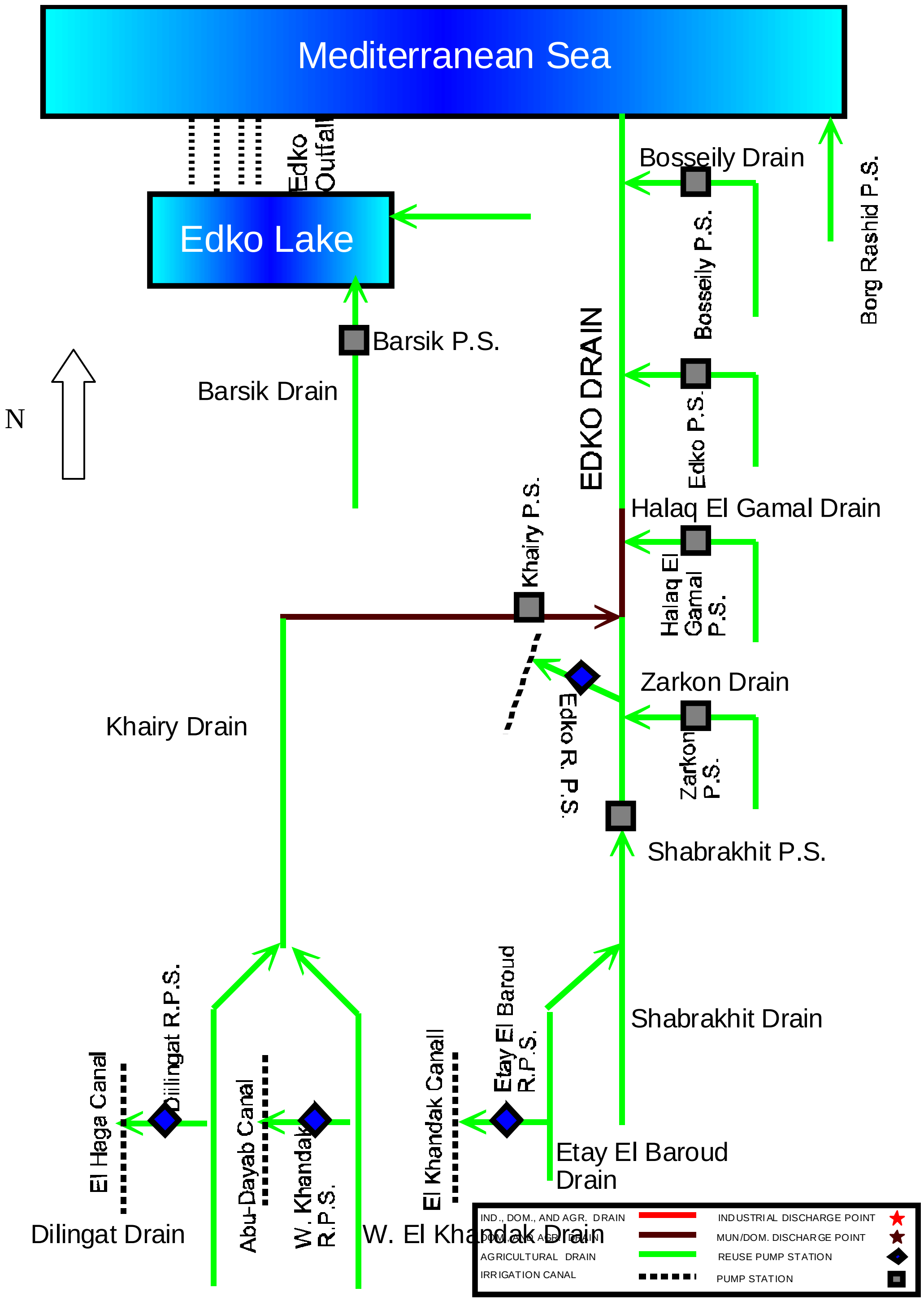


Figure A-6: Gharbia Drain System

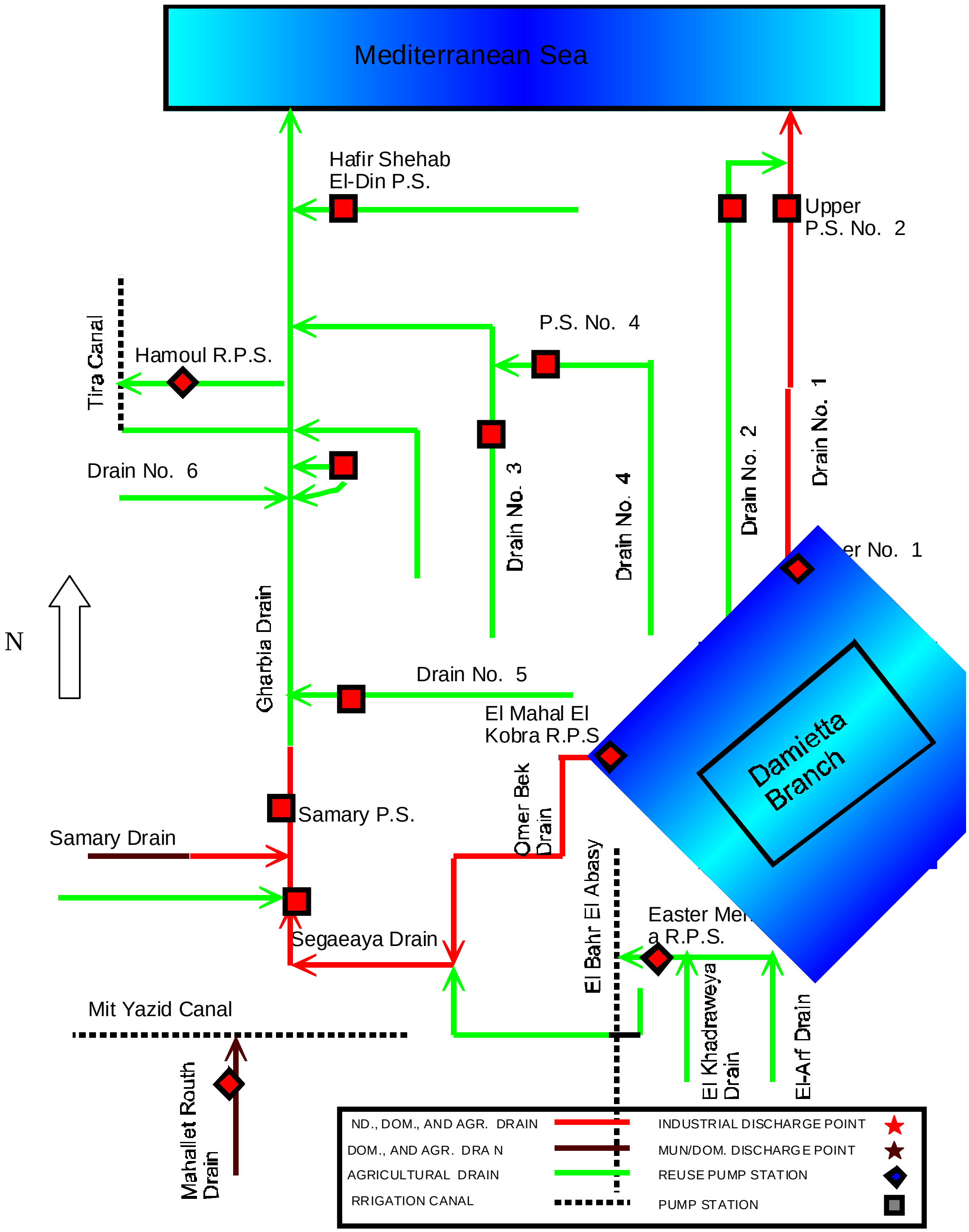


Figure A-7: Bad Hadous Drain System

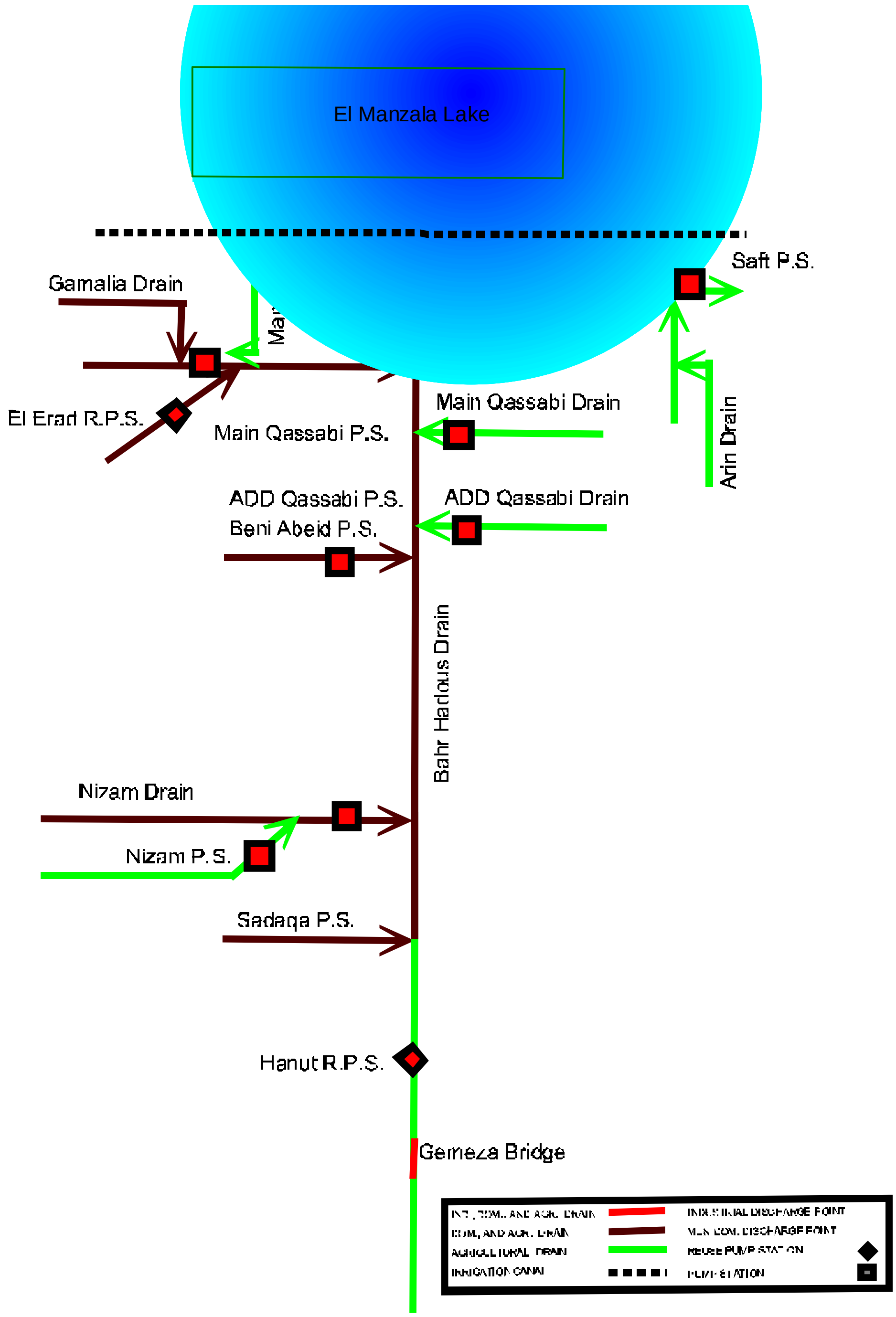


Figure A-8: Nubaria Drain System

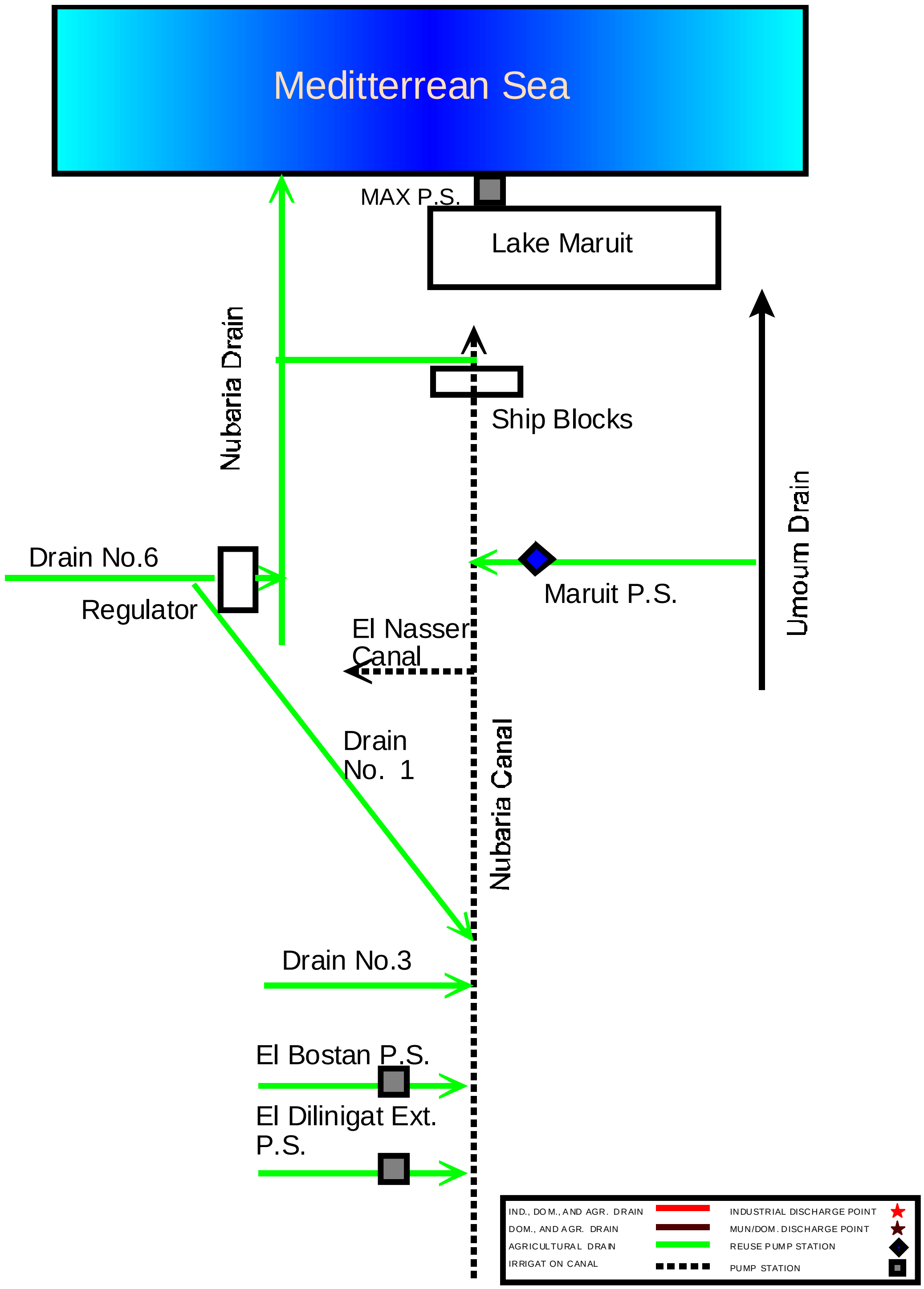


Figure A-9: Sewr Drain System

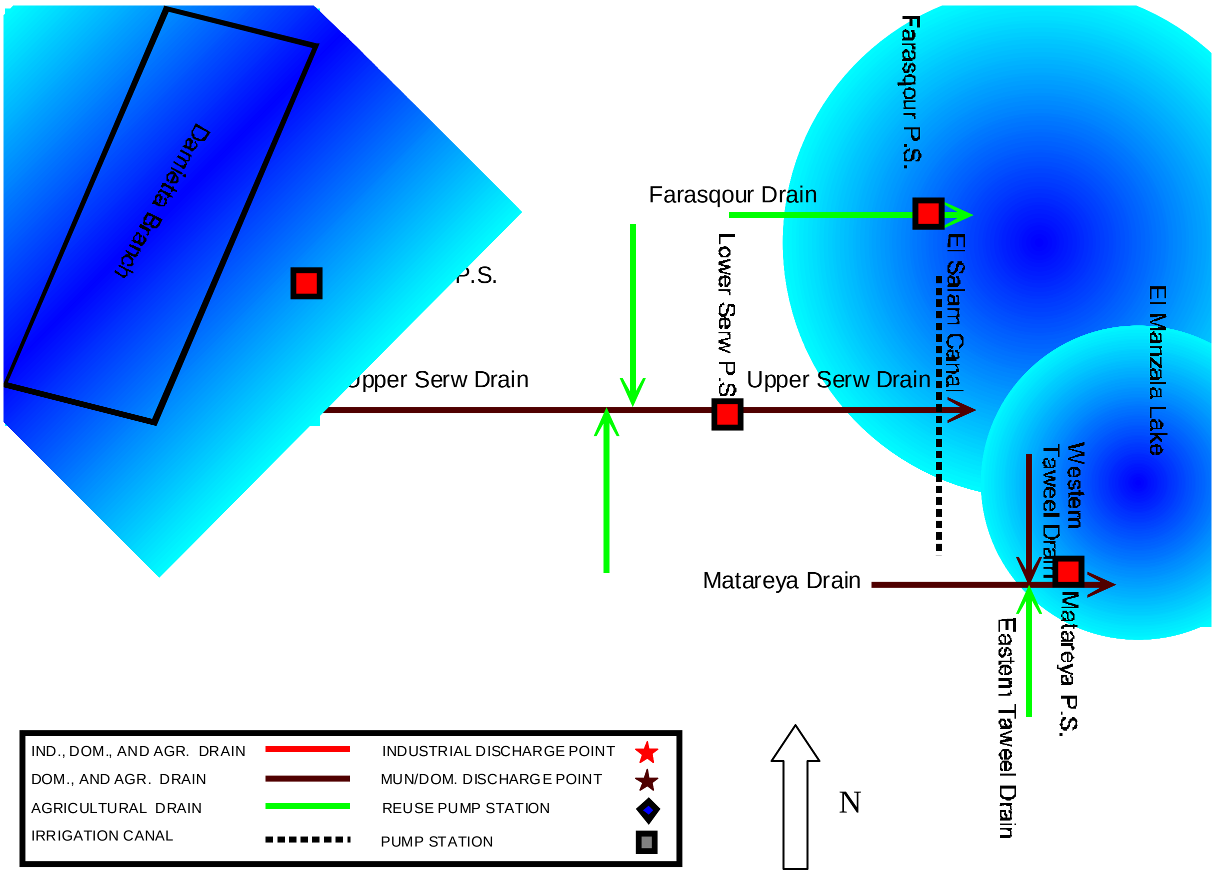


Figure A-10: Umoum Drain System

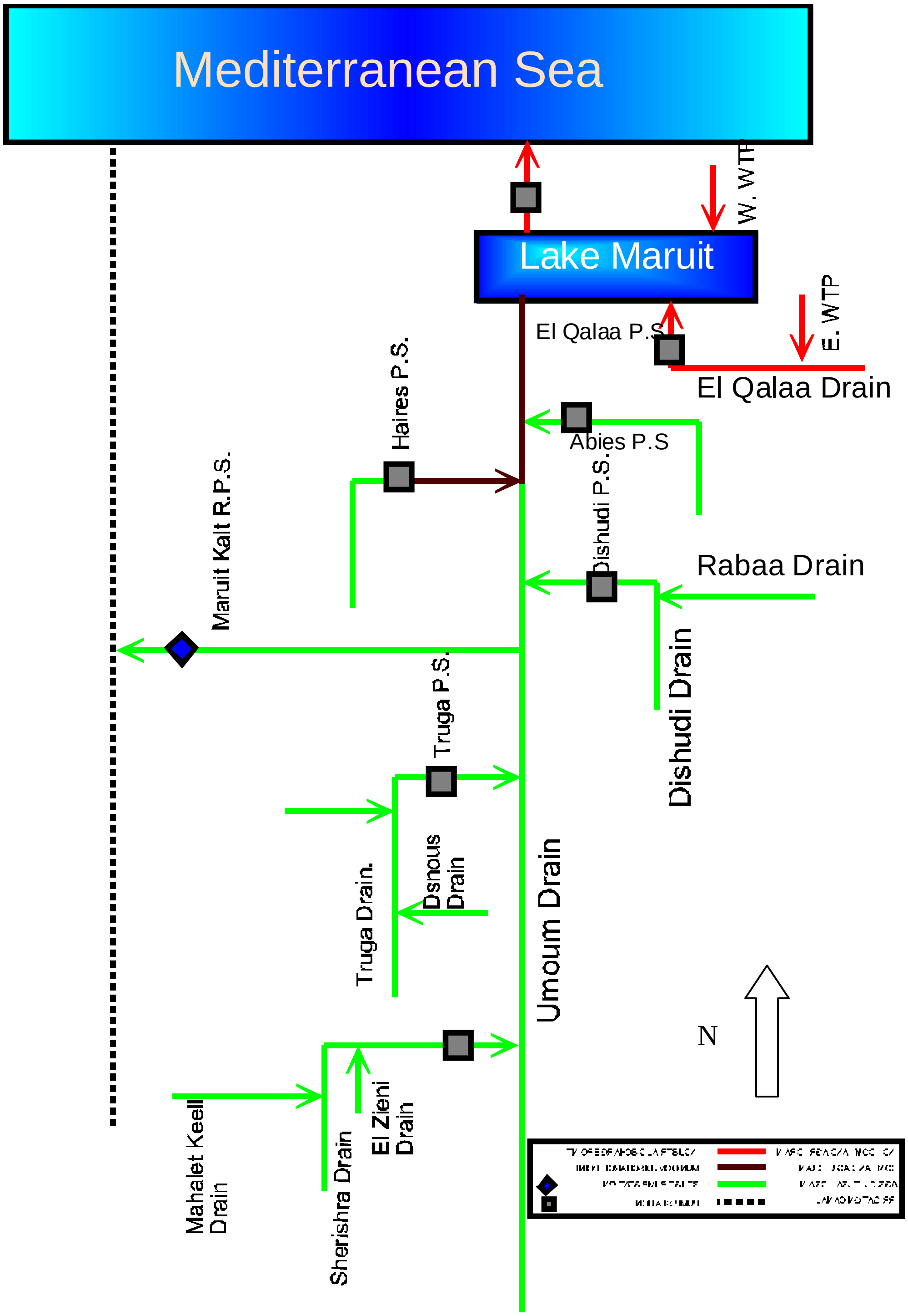


Figure A-11: Wadi Drain System

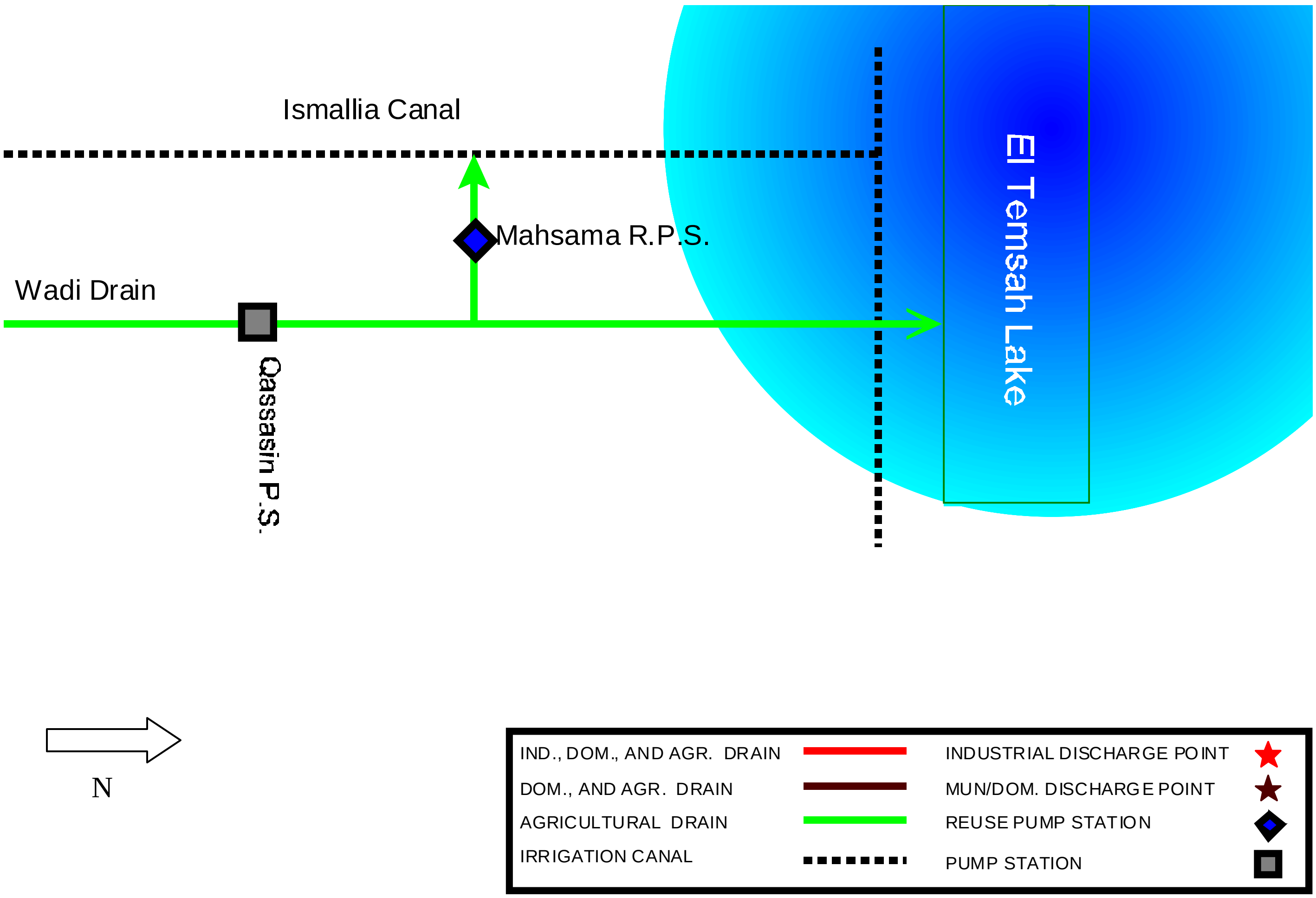


Figure A-12: Fayoum Drain System

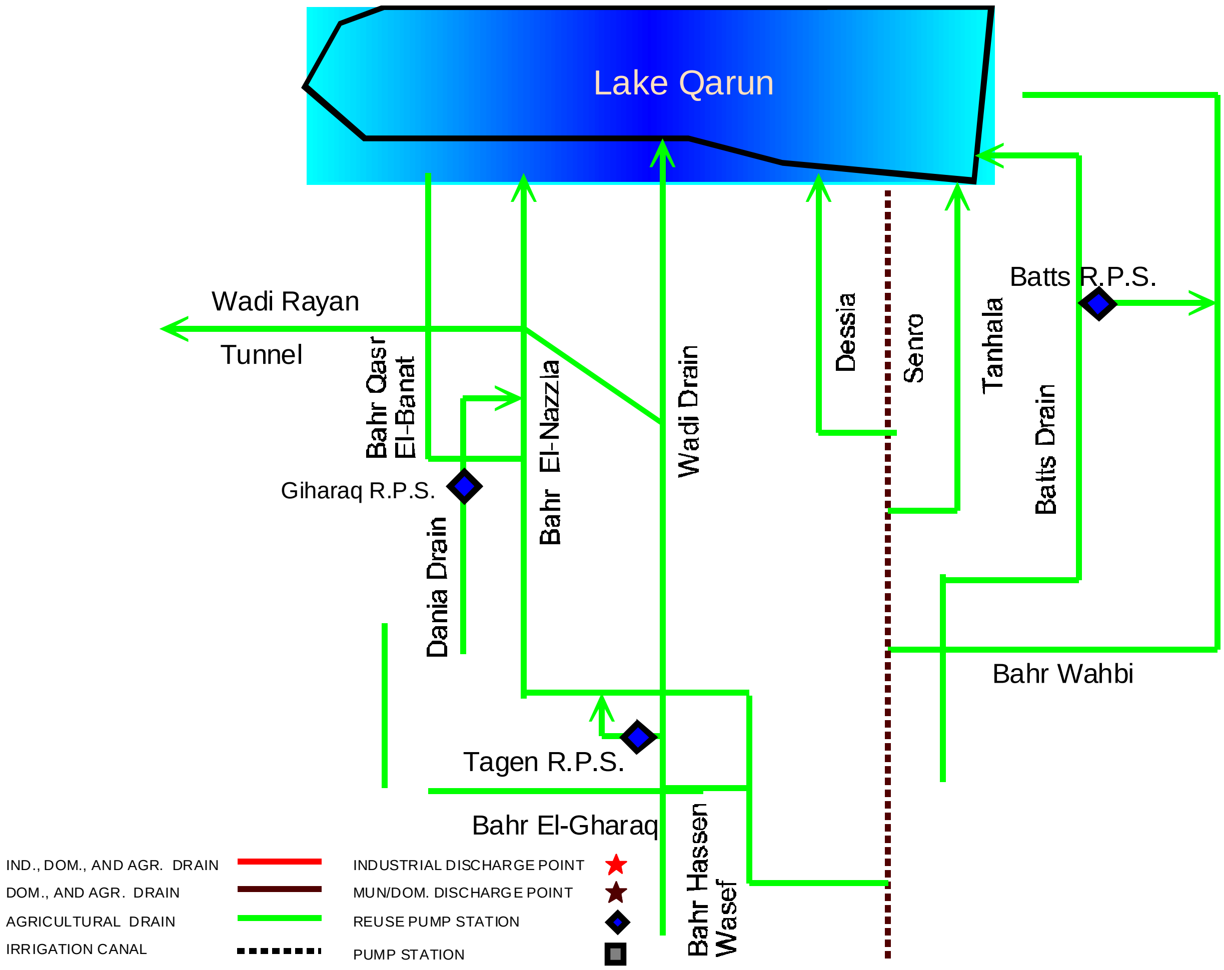
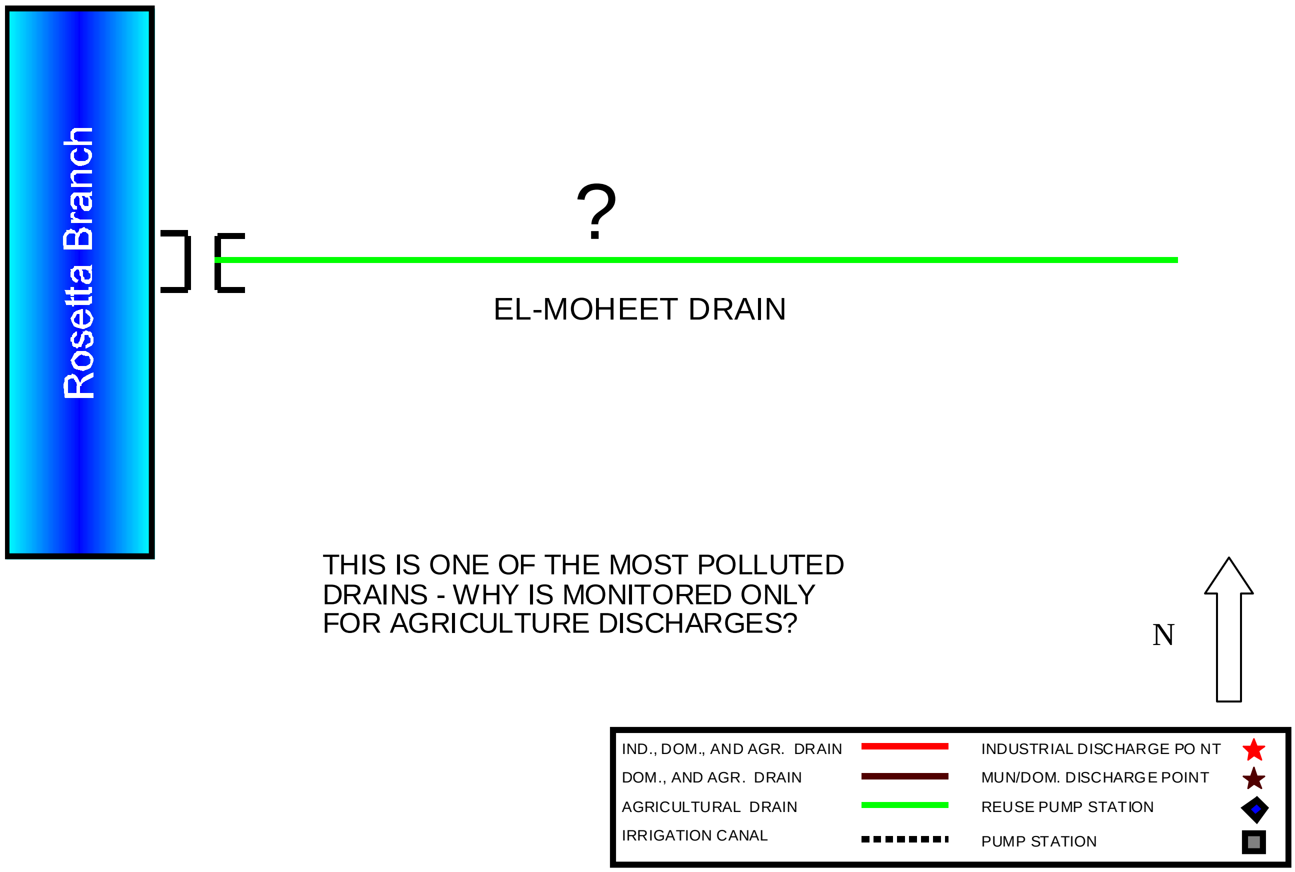


Figure A-13: Moheet Drain System



APPENDIX B

SCHEMATIC SHOWING PROPOSED ROUTING OF THE COM OMBO SUGAR MILL EFFLUENT

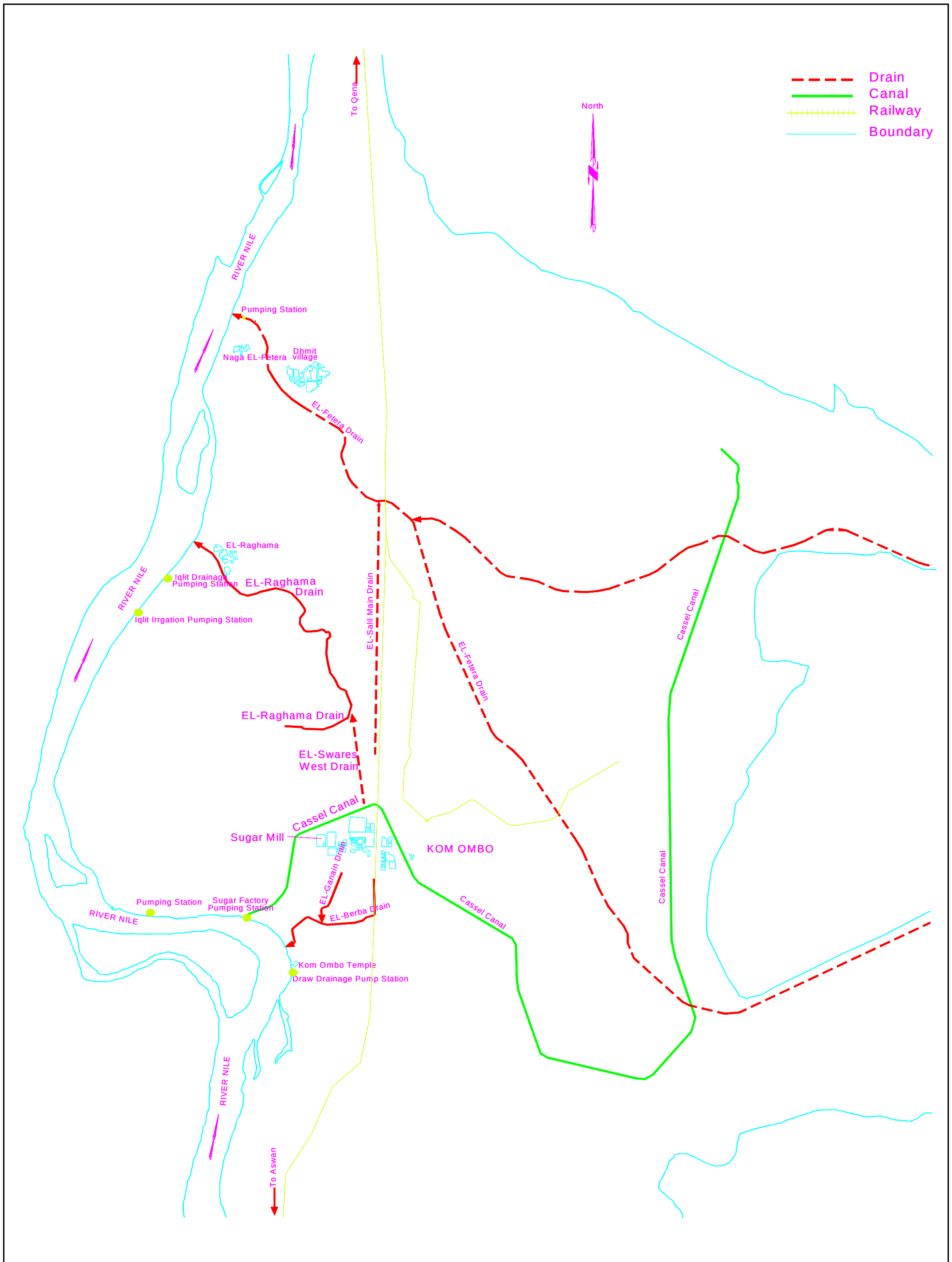


Figure 3:2 New route for sugar mill effluent - Swares/El-Raghama

Figure B-1: Proposed Routing of the Com Ombo Sugar Mill Effluent