Arab Republic of Egypt
Ministry of Development And New Communities

PORT SAID
WATER AND WASTEWATER
FACILITIES MASTER PLAN

Final Report
Volume 4 – Receiving Waters Study

HAZEN AND SAWYER
in association with
ECG-ENGINEERING CONSULTANTS GROUP

هيزن أند سويرز بالاشتراك مع جماعة المهندسين الاستشاريين

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برقيا : هندسقوى – القاهرة

July 26, 1979

Engineer Soliman Abd El Hai, Chairman
Advisory Committee for Reconstruction
Ministry of Development and New Communities
1 Ismail Abaza Street
Cairo, Egypt

Port Said Water and Wastewater
Facilities Master Plan

Dear Engineer Abd El Hai:

In accordance with our Contract with the Advisory Committee for Reconstruction, we submit herewith Volume 4 of the Master Plan Final Report.

The report is organized in four volumes as follows:

Volume 1. Executive Summary (English and Arabic)

Volume 2. Water Facilities

Volume 3. Wastewater Facilities

Volume 4. Receiving Waters Study

We have enjoyed the opportunity of serving the Advisory Committee for Reconstruction in preparation of the Master Plan. We look forward to successful implementation of the recommended programs.

Very truly yours,

HAZEN AND SAWYER

David Walrath

David Walrath
Resident Project Director

ENGINEERING CONSULTANTS GROUP

Ashraf Allouba
Principal-in-Charge

DW:em

ACKNOWLEDGEMENTS

We wish to take this opportunity to express our thanks to the following persons:

- The personnel of the Suez Canal Authority, the Governorate of Port Said and the Oversea's Research Institute for their cooperation during the field studies and preparation of this report.
- The staff and students of the Department of Oceanography and Fisheries of Alexandria University, in particular Doctors Sharaf El Din and Altaf Abd El Ezzat for their assistance in data gathering and preparation of the report.
- Dr. Stephen P. Murray of the Coastal Studies Institute of Louisiana State University for providing previously unpublished oceanographic data on the Mediterranean Sea near Port Said.
- Mr. Steven Bartlett of Ocean Surveys, Inc. for his assistance in preparing this report.
- Mr. John St. John of Hydroscience, Inc. for the collection and review of existing data and his input to the survey program design.

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ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
cm	Centimeters
CPUE	Catch per unit effort
cu m/day	Cublic meters per day
gr	Grams
ha	Hectares
kg	Kilograms
km	Kilometers
Knots	Nautical miles/hour (0.5 m/sec)
lcpd	Liters/capita/day
lps	Liters/sec
m	Meters
mg/l	Milligrams/liter
mg/kg	Megaliters/day
Mld	Megaliters/day
mm	Millimeters
MPN	Most probable number
ppb	Parts per billion
ppt	Parts per thousand
mg/l	Micrograms/liter
sec	Second
STDO	Salinity, Temperature and Dissolved Oxygen
yr	Year

CHAPTER I

SUMMARY

1.1 INTRODUCTION

Hazen and Sawyer, in association with Engineering Consultants Group (ECG), entered into a contract with the Advisory Committee for Reconstruction (ACR) on October 27, 1977 to develop a master plan for the waterworks and wastewater facilities at Port Said. As part of the contract scope, we were to evaluate the overall impact on potential receiving waters, specifically, the Mediterranean Sea, Lake Manzala, and the Suez Canal, from the discharge of treated/untreated sewage effluent.

The first task was an analysis of existing data to determine its adequacy. The results of this study were presented in Special Report No. 1 - Oceanographic Studies, prepared by Mr. John St. John of Hydroscience Inc., with the section on biological and fishery characteristics by Mr. J. Taylor of Hazen and Sawyer, dated April 1, 1978. The principal conclusion of Special Report No. 1 was that the available scientific and engineering data were of value for definition of the basic characteristics of the potential receiving waters but insufficient for the engineering evaluation of the disposal alternatives. A program to study the sea, lake and canal was devised and the commitment in time, manpower and costs described.

Discussion with ACR in May 1978 revealed that there was apprehension over discharging sewage effluent (even after treatment) in the Mediterranean Sea because of potential periodic, negative impact on the beaches. We were directed, therefore, to concentrate on the lake and canal and a shorter, less expensive program was proposed. This program, known as the Receiving Waters Study, was authorized by a letter of intent on July 1, 1978.

Field studies were conducted between 16 July and 17 October by engineers and scientists from the consultants' staffs, by Egyptian specialists and by an oceanographic team supplied by Ocean Surveys Inc. As shown on Figure 1-A, the study area included the surf zone of the Mediterranean, Lake Manzala, the Suez Canal and Lake Mallaha. The latter lake was studied because it potentially was a disposal area for Port Fouad. Data reduction was completed in January 1979.

1.2 RESULTS

The data collected in the Receiving Waters Study were analyzed for those characteristics important to wastewater disposal. The analysis included evaluation of assimilative capacity, dilution factors, coliform die-off, general water quality and potential effects on the area's fishery.

Dilution Factors

In Lake Manzala dilution is limited by the lack of water movement and depths of less than 1.5 meters. Average current velocities are generally below 2 cm/sec and influenced by wind direction. Vertical dispersion of wastewater is not limited by salinity gradients in Lake Manzala. However, because of the shallow depth, significant dilution does not occur. These conditions tend to limit the area effects of wastewater discharges by promoting the rapid settling of sewage matter.

In the Suez Canal, conditions were significantly different than in Lake Manzala. Dilution in the canal is primarily a function of horizontal dispersion. Horizontal dispersion caused by flow provides dilutions of 100 to 1 in an hour. Diffusion rates vary from 6.69 x 10^{-4}/sec to 1.35 x 10^{-3}/sec. No density stratification exists in the canal near Port Said. The entire water column is available for dilution of subsurface discharges.

Assimilative Capacity

The ability of Lake Manzala and the Suez Canal to assimilate wastes was calculated using methods developed by Streeter and Phelps. The following factors were considered: diurnal variations in ambient oxygen deficits; variance of deoxygenation and reaeration coefficients; and maintenance of sufficient oxygen to protect the fishery. Accounting for diurnal variations in dissolved oxygen, the waters of Lake Manzala can support increases in ambient BOD_5 levels of 6.0 mg/l without adverse effects on the fishery. In the Suez Canal the acceptable BOD_5 load is 5.1 mg/l.

Coliform Die-Off

Coliform die-off rates in Lake Manzala are high, between 3.9/day and 5.5/day. In the Suez Canal die-off rates are 1.4/day to 2.0/day.

Toxics

Benthic concentrations of heavy metals and pesticides are high. It is likely that public health problems with bio-accumulation in edible fish and shellfish exist in the study area.

Nutrients

Major inorganic nutrients occur at levels sufficient to promote algae blooms. Moderate cell counts are maintained through cropping by zooplankton and fish.

Dissolved Oxygen

The oxygen levels in all receiving waters are sufficient to support fish life with exception of Zone A of Lake Manzala, the area affected by the existing discharge from Mazrah sewage treatment plant.

Bacteriology

The USEPA coliform criteria for bathing water (200/100 ml MPN) is met throughout the area's waters with the exception of Zone A of Lake Manzala, the Junction Canal and the Suez Canal near the Junction Canal.

Fishery Characteristics

Population studies indicate the Lake Manzala fishery is over-fished. Present sewage discharges have little effect on the fishery other than the loss of about 200 hectares of habitat near the Mazrah sewage treatment plant. This 200 hectares represents less than 0.15 percent of the total lake area (140,000 hectares). Studies indicate the Heterophydiasis, a helminthic parasite related to sewage, is not being transmitted by Lake Manzala fish.

1.3 RECOMMENDATIONS

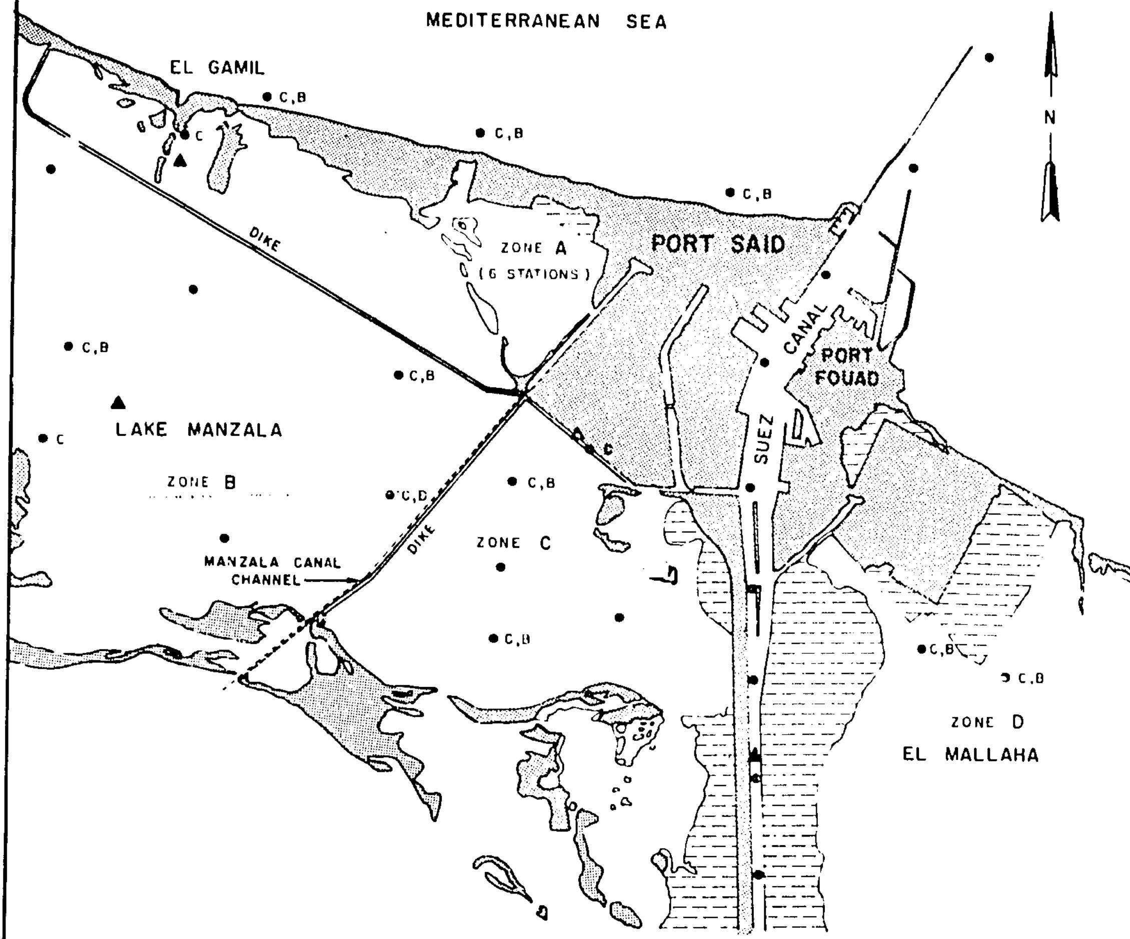
Wastewater disposal alternatives are discussed in detail in Chapter 8 of this report. The following disposal options are recommended.

Lake Manzala

By the year 2000, 171,500 cu m/day of sewage will be generated in Port Said and the future fishing village at El Gamil. The sewage should be discharged to Lake Manzala. We recommend conventional primary treatment with a 1.5 km outfall/diffuser. No disinfection is recommended because of potential adverse effects of chlorine and chlorinated organics. Helminthic parasites common to Port Said cannot survive in the brackish water environment of the Lake. Proper outfall location will allow natural die-off to reduce bacterial levels sufficiently to protect the public's health. The outfall/ diffuser should be located 3.5 kilometers from residential areas to the southeast and oriented perpendicular to the predominant currents in Zone B of the Lake.

Suez Canal

Sewage from Port Fouad should be discharged to the Suez Canal. The sewage should receive primary treatment without disinfection. A subsurface outfall at 15 meters depth should be used. The discharge should be located no closer than 2 km to any area used for swimming. A potential outfall location is shown in Figure 8-A.



LEGEND

- ● SALINITY TEMPERATURE AND DISSOLVED OXYGEN (STDO).
- C CHEMISTRY
- B BIOLOGY AND SPECIAL CHEMISTRY
- ▲ CURRENT METER.
- DRY LAND
- INTERMITTENTLY FLOODED AREAS

APPROX. SCALE: 1=100,000

0 1.0 2.0 3.0 4.0 Km.

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RECEIVING WATER PROGRAM
STUDY AREA

VOL.4
FIG.
1-A

N52321

CHAPTER 2

METHODS AND MATERIALS

2.1 INTRODUCTION

To support the development of the Port Said Water and Wastewater Master Plan an intensive program of Receiving Water Studies was undertaken. The survey work was performed during the period 16 July to 17 October 1978.

The specific objectives of the Receiving Water Study are as follows:

- to establish background values of physical, chemical and biological water quality parameters throughout the study area;
- to provide information for use in the design of a wastewater outfall system; and
- to generate a data base which will enable investigators to predict the environmental impact of a discharge of wastewaters on the lake and canal.

To realize these objectives, field investigations were conducted of local circulation patterns, current velocities, diffusion rates, hydrographic and water quality parameters, plankton and benthos, and the local meteorology. Data were collected on conditions along the Mediterranean Sea shorelines during the summer-early fall recreational period. Also investigated was the Suez Canal during its annual summer southern net flow, and a period during which chemical characteristics of Lake Manzala have been observed to be dynamic in the past.

This chapter describes the equipment and procedures used for sample collection and analysis. Results of physical, chemical and biological water quality studies are presented in Chapters 3 through 5. An analysis of fishery characteristics and their relation to sewage discharges is presented in Chapter 6. Conclusions related to wastewater planning are described in Chapter 7. Recommendations for sewage disposal and areas requiring further study are presented in Chapter 8.

Tabulated data too lengthy for inclusion in the text are included as Appendices.

2.2 DATA COLLECTION

Data collection activities in the Port Said Receiving Water Study include:

- location of stations
- in situ current velocity monitoring
- current speed cross-sections
- drogue studies
- dye diffusion studies
- depth soundings

- salinity, temperature, and dissolved oxygen measurements
- diurnal temperature and dissolved oxygen measurements
- water quality sampling for nutrients, BOD, oil and grease, chlorinity, bacteria and chlorophyll A
- visibility/turbidity determinations
- plankton sampling
- sediment and benthic sampling
- wind velocity monitoring
- coliform die-off studies
- benthic demand studies
- fishery population sampling.

Surveys were conducted in three general areas considered to be potential receiving waters for wastewater discharge; Lake Manzala, El Mallaha and the Suez Canal, as shown in Figure 2-A. In addition, limited sampling of the Mediterranean surf zone was performed to establish existing water quality.

Studies in Lake Manzala were concentrated in the northeast section of the lake, a 50 square kilometer area bounded by El Gamil outlet on the west and the island chain including Kom Tanis to the south. The Lake Manzala study area includes the region affected by the present wastewater discharge (Zone A) and the areas which may be affected by discharges in the future (Zones B and C).

The primary area of interest and study concentration in the Suez Canal was the northernmost section of the canal in the vicinity of Port Said. However, studies in the Suez Canal were extended as far as 75 km south of Port Said. In El Mallaha, studies were conducted in an area south of the Port Fouad salt works.

Data collection activities started on July 23, 1978 and finished on October 15, 1978, as shown in Table 2.1.

2.3 METHODS OF DATA COLLECTION

Location of Sampling Points

Positioning in the Suez Canal was determined with Cubic Autotape electronic locating equipment. The transmitter was installed at the Port Said lighthouse, which is used as the zero reference point for canal work. A receiver was mounted in the sampling vessel. Distances to selected stations were measured and logged. Existing distant markers were checked by autotape for accuracy to kilometer +15.0 and found satisfactory for locating sampling stations.

Sampling stations in Zones A and B of Lake Manzala were located by triangulation using the autotape system. Transmitters were located at a mosque in Kabbutti and at the Infectious Disease Hospital near the Mazrah Treatment Works, as shown in Figure 2-A. Stations in Zone C of Lake Manzala and Zone D of El Mallaha were located by bearing cuts to landmarks.

In Situ Current Monitoring

Water currents were monitored by La Grangian (measuring flow by tracking a particle of water) and Eulerian (measuring flow past a fixed point) techniques. Eulerian measurements were obtained using in situ recording current meters. La Grangian data were collected using free drifting drogues.

Endeco Type 105 current meters were used in the Port Said project. The method of deployment varied with location. In the Suez Canal meters were deployed for 48 consecutive hours each week. The moorings consisted of 15 meters of 7 mm diameter stainless steel cable. The cable bottom was weighted with 34 kilograms of lead and a small Danforth. The cable was then attached to a large Norwegian fishing buoy at the water surface. Meters were attached to the cable at 5 and 10 meters below the water surface. The meters were deployed at the canal center. During convoy passages the mooring was moved to the edge of the canal. Convoys and individual ship passages were logged to aid in interpretation of data.

In Lake Manzala meters were deployed for one month with bi-monthly servicing. Moorings were 9.5 mm steel pipe anchored in cement. Meters were attached to the pipe by adjustable collars at mid-depth and trimmed for low salinity waters. All moorings were attended during the monitoring period.

Drogue Studies

Drogues used at Port Said were fabricated based on a design recommended by the Chesapeake Bay Institute of Johns Hopkins University. The design provides maximum response to currents with minimal wind influence. The drogues expose 9,000 square cm of area to a 38 cm vertical section of water column as shown in Figure 2-B. Where use of the drogues was precluded by shallow water depth, movement of surface floats were tracked. Drogues were tracked using a cubic autotape electronic positioning system or by bearing strikes to landmarks.

Velocity Cross-Sections

Velocities were measured in the El Gamil channel and the Suez Canal across the width at mid-depth. In both cases, a recording current meter was in the line of cross-sectioning at the time of measurement. Velocities were measured using a GO flowmeter tethered at mid-depth by a nylon rope. The flowmeter was placed in situ for 5 minutes, removed and read as the boat was maneuvered to the next station.

Dye Diffusion

A 20 percent solution of Rhodamine WT, a fluorescent dye, was used in dye diffusion studies. Rhodamine WT is detectable to 0.1 parts per billion and is non-toxic. Movement of the dye with time was monitored with a Turner Designs Model 10 fluorimeter. Sampling runs were taken along the centerline of the plume and several sections perpendicular to the centerline. The fluorimeter intake was positioned at about 30 cm below the water surface. Vertical profiles to 2 meters below the surface were taken in the concentrated area of the plume. The plume was located using the Cubic autotape positioning system.

Wind Monitoring

Wind velocity and direction were monitored continually during the study using a Meteorology Research Inc. recording instrument. The instrument was located at about 15 meters above sea level in Port Fouad as shown on Figure 2-A.

Salinity, Temperature, Dissolved Oxygen Profiles

A Beckman RS5-3 temperature/conductivity, salinity meter was used exclusively throughout the project. The meter was standardized to chlorinity and conductivity determinations on water samples obtained at the location. A YSI model 51 oxygen meter was used during one diurnal study in "Zone C" of Lake Manzala. Except for this one instance, all dissolved oxygen determinations were accomplished with a Hydrolab TD02 dissolved oxygen unit. Light penetration was measured using an eight-inch oceanographic secchi disc.

The lakes averaged one meter in depth and often the soundings at sampling stations were less. It was quickly determined that there was little if any stratification, and sampling techniques were to hold the instrument probe at mid-depth. The Suez Canal, with an average sounding of 18 meters was vertically sampled at depths of 2 m, 5 m, 10 m, 15 m and bottom. In the conductivity mode, the Beckman RS5-3 gives a clear indication of proximity to bottom by meter deflection. Measurements designated as bottom were made out of this field, approximately one meter above the bottom.

Plankton Collection

Phytoplankton was collected using a standard oceanographic water sampling bottle by Wildco. Zooplankton hauls were made at all lake stations using a 35 cm diameter plankton net with 560 micron mesh. A one liter glass bottle was filled with sample and treated with 40 ml of formalin solution. All hauls were vertical.

Benthic Samples

A Peterson grab sampler was used in obtaining bottom samples in both the Suez Canal and lake studies. A two liter plastic jar was filled with collected material. In cases where little or no sample was obtained from Suez Canal stations due to a rocky bottom, what little could be collected was retained and a description was entered in the oceanographic log. Samples were frozen during storage.

Water Quality Samples

Water samples were collected for nutrients, BOD, oil and grease, chlorinity, bacteria, and chlorophyll A. No samples were field treated with a fixative agent, nor were any bottles sterilized. Samples were turned over within six hours of collection to local laboratory facilities. Preparation of composites and sample preservation were done at the lab using accepted standard methods listed in Table 2.3.

Fish Population

Samples of fish populations were taken on five occasions. Professional fishermen were hired and observed. All equipment employed was examined. Nets were measured for length and mesh size. Actual time of fishing and location were noted.

2.4 DATA ANALYSIS

Chemical, Biological and Bacteriological

Water and sediment samples collected during the survey were analyzed for seventeen parameters as shown on Table 2.2. Proposed and actual numbers of determination are shown. Total coliform analysis was eliminated early in the program since initial analyses indicated only fecal coliforms were present. The number of determinations were less than proposed for benthal demand, heavy metals and pesticides. Several benthic samples were unsuitable for analysis. For all other parameters the number of actual determinations exceeded those proposed.

All chemical and biological analyses were performed using commonly accepted techniques. Parameters examined, analytical techniques and sources are summarized in Table 2.3.

Physical Characteristics

About 95 percent of potential current meter data was retrieved. Meter malfunction occurred on a two day deployment in the Suez Canal. Film current meter records were processed by the manufacturer into printed computer outputs. Frequency distributions for current speed and direction were prepared.

Data from drogue and dye transport studies, current cross-sections, and climatological were analyzed by accepted oceanographic procedures.

Fishery Characteristics

Fishery population characteristics were examined using techniques employed in recent studies of Lake Manzala and the Delta Lakes. The analysis is described in detail in Chapter 6.

TABLE 2-1

SCHEDULE OF RECEIVING WATER PROGRAM, 1978

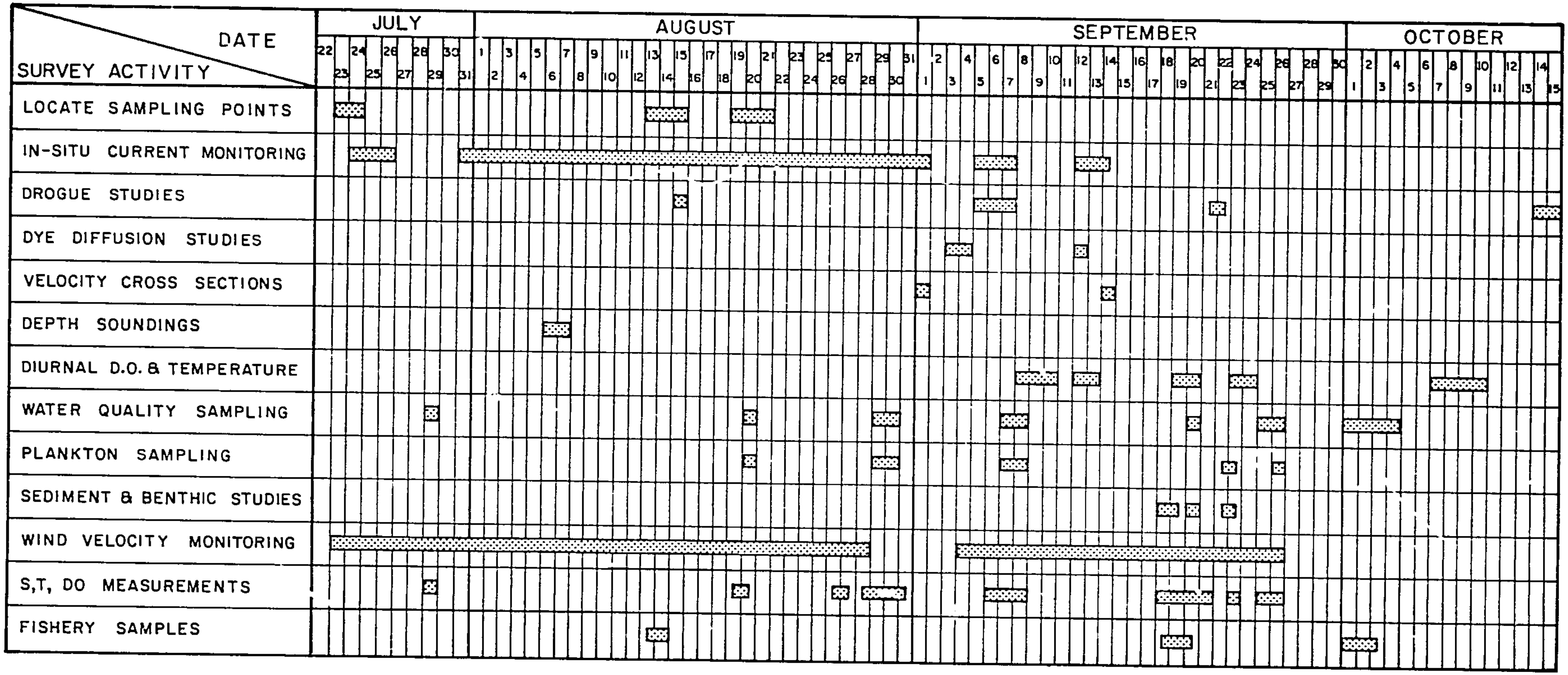


TABLE 2.2

CHEMICAL AND BIOLOGICAL ANALYSES
NUMBER OF DETERMINATIONS
PROPOSED (ACTUAL)

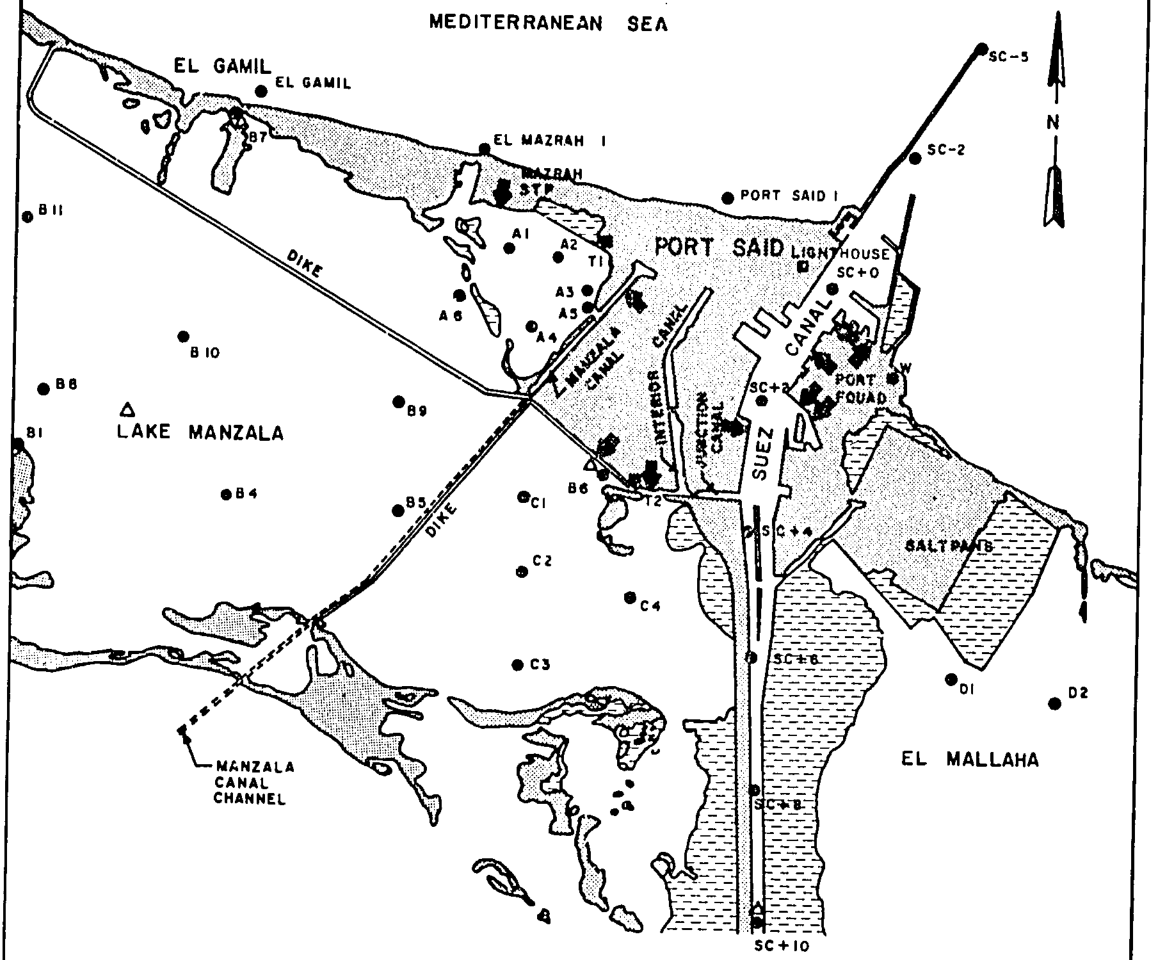
	Test	Mediterranean Sea	Suez Canal	Lake Manzala	Agricultural Return Drains	Total
1.	Total Coliform	6 (6)	16 (0)	51 (16)		73 (22)
2.	Fecal Coliform(iii)	6 (6)	16 (16)	51 (56)		73 (78)
3.	BOD	3 (6)	16 (16)	51 (37)		70 (79)
4.	Suspended Solids	3 (6)	16 (16)	51 (55)		70 (77)
5.	pH	3 (3)	16 (13)	51 (55)		70 (71)
6.	Nitrogen Series(i)	3 (3)	16 (16)	51 (60)		70 (79)
7.	Total Phosphate	3 (2)	16 (16)	51 (59)		70 (77)
8.	Ortho Phosphate	(3)	(16)	51 (60)		70 (79)
9.	Silicon Dioxide	3 (3)	16 (16)	51 (60)		70 (79)
10.	Chlorophyll 'a'	3 (0)	16 (15)	51 (57)		70 (73)
11.	Oil and Grease	3 (0)	16 (16)	51 (60)		70 (76)
12.	Benthal Demand		8 (6)	11 (11)		19 (17)
13.	Heavy Metals(ii)	3 (3)	8 (6)	11 (10)	3 (0)	27 (22)
14.	Pesticides	3 (3)	8 (8)	11 (9)	3 (3)	25 (20)
15.	Phytoplankton	3 (3)		22 (25)		25 (28)
16.	Zooplankton	3 (3)		22 (25)		25 (28)
17.	Benthic Animals	3 (3)		11 (11)		14 (14)

Notes:
(i) Ammonia, nitrate and nitrate nitrogen
(ii) Cu, Cd, Zn, Mn, Fe
(iii) Totals do not include coliform dieoff studies.

TABLE 2.3

METHODS OF CHEMICAL AND BIOLOGICAL ANALYSES

	Parameter	Method	Source
1.	Total Coliform	Multiple Tube Fermentation	American Public Health Association (APHA), American Water Works Association (AWWA), Water Pollution Control Federation (WPCF), 1975 Standard Methods for the Examination of Water and Wastewater, Fourteenth Edition, APHA, Washington, D.C.
2.	Fecal Coliform	Multiple Tube Fermentation and Membrane Filer	APHA *et al*, 1975
3.	BOD	BOD	APHA *et al*, 1975
4.	Suspended Solids	Total Suspended Matter	APHA *et al*, 1975
5.	pH	pH	APHA *et al*, 1975
6.	Nitrogen Series	Ammonia: Indophenol Blue Nitrite: Diamine Nitrate: Sulfuric Acid	Strickland, J.D.H. and T.R. Parsons, 1968, A Practical Handbook of Seawater Analysis, Bull. Fish. Res. Can. No. 167
7.	Total Phosphate	Unfiltered, Digested, Ascorbic Acid	Strickland and Parsons, 1968
8.	Ortho Phosphate	Filtered, Ascorbic Acid	Strickland and Parsons, 1968
9.	Silicon Dioxide	Filtered, Metro-sulphite reduction	APHA *et al*, 1975
10.	Chlorophyll 'a'	Acetone Extraction	APHA *et al*, 1975
11.	Oil and Grease	Sochlet Extraction Method	APHA *et al*, 1975
12.	Benthal Demand	Oxygen Transfer in Waste	APHA *et al*, 1975
13.	Heavy Metals	Nitric Acid Evaluation	Riley, J.P. and Taylor, 1968
14.	Pesticides	Gas Chromotography	U.S. Federal Register, 1973, Volume 38
15.	Phytoplankton	Plankton	APHA *et al*, 1975
16.	Zooplankton	Plankton	APHA *et al*, 1975
17.	Benthic Animals	Benthic Macroinverbates	APHA *et al*, 1975



LEGEND

- DRY LAND
- INTERMITTENTLY FLOODED AREAS
- ● A1 WATER QUALITY SAMPLING STATION
- △ CURRENT METER
- ■ T1 TRANSMITTER-AUTOTAPE LOCATING EQUIPMENT
- ● W WIND RECORDING EQUIPMENT
- ➡ SEWAGE OUTFALL

APPROX. SCALE: 1:100,000

0 1.0 2.0 3.0 4.0 Km.

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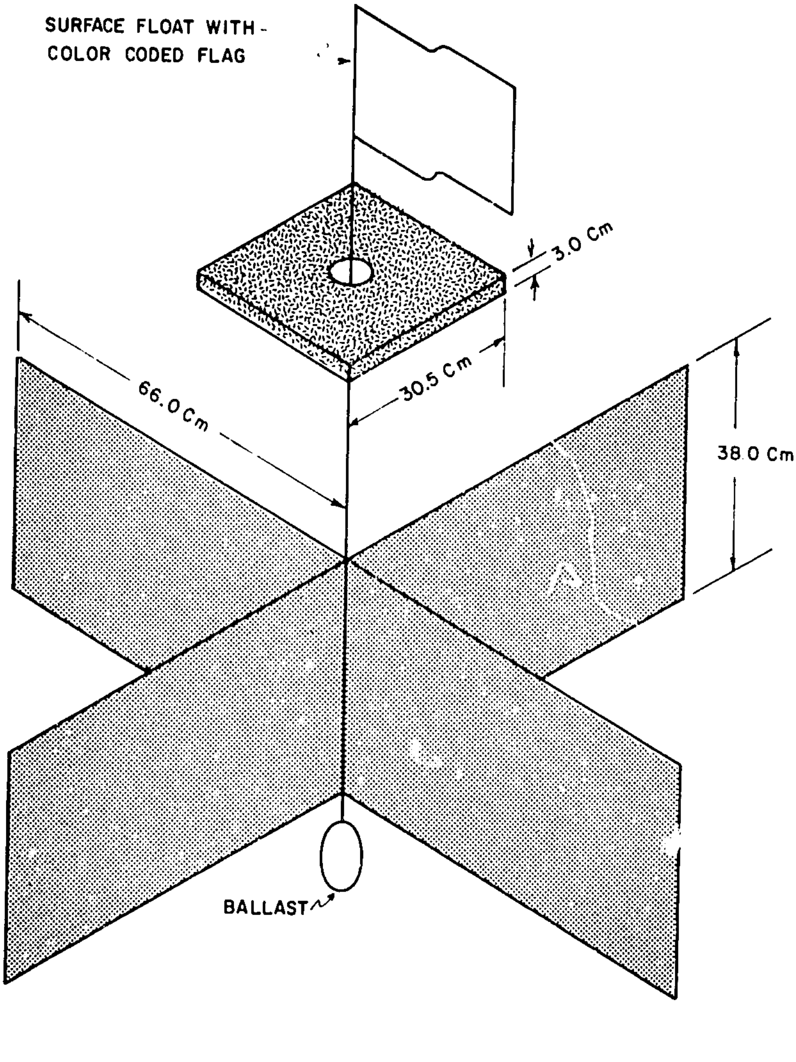
SAMPLING LOCATIONS
PORT SAID RECEIVING WATERS

VOL. 4 FIG. 2-A



NOTE: DROGUE PANELS MOUNTED PERPENDICULAR.

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PORT SAID
WATER AND WASTEWATER FACILITIES MASTER PLAN

MODIFIED JOHNS HOPKINS UNIVERSITY DROGUE DESIGN

VOL.4 FIG. 2-B

N32321

CHAPTER 3

PHYSICAL CHARACTERISTICS OF THE RECEIVING WATERS

3.1 INTRODUCTION

Evaluation of potential wastewater discharge locations requires an understanding of the physical characteristics of the receiving waters. Data on currents, net circulation and flow patterns are needed to assess transport of waste materials. Transport and dilution can be determined from current meter and drogue study data. Physical structure in terms of vertical stratification defines dispersion or the degree of mixing. Dispersional characteristics are assessed from dye studies and salinity distributions.

3.2 GENERAL CONSIDERATIONS

Available data indicate that climatological conditions, particularly wind direction and speed, are significant in determining circulation patterns in Lake Manzala, El Mallaha and the surf zone of the Mediterranean. In the Suez Canal, net current direction is apparently determined by the relationship of mean sea levels in the Mediterranean and Red Seas. Appropriate data on these aspects of the physical environment were collected during the study.

Climatology

Climatological data were collected to evaluate the principal influences on currents and circulation. Daily records were obtained from two stations located in Port Said and Suez City. Included in the daily records are: precipitation, wind speed and direction, air temperature, barometric pressure, relative humidity and cloud cover. In addition, wind speed and direction were monitored continuously during current and transport studies. The monitoring equipment was located in Port Fouad at an elevation of about 15 meters above mean sea level. Records are tabulated as hourly averages in Appendix I, Tables D and E. Wind direction was generally from the northern quadrants during the study period. Average daily wind speed varied from 5 to 12 knots as shown in Figure 3-A. During late July and August winds are from the northwest in over 80 percent of readings as shown in Figure 3-B. Wind speeds are generally less than 8.5 knots. Wind conditions during September are similar. Direction is most frequently from the northeast quadrant as shown in Figure 3-B. Wind velocities are lower in September than during the July-August period.

Daily average air temperatures are shown in Figure 3-A. Highest air temperatures occur during August reaching daily averages of 28°C. Water temperature follows a similar pattern, increasing during July to maximum daily averages of 27°C in August and early September.

Daily mean values of atmospheric pressure are shown in Figure 3-C. Atmospheric pressure increased gradually from 1 July to late August. Atmospheric pressure increased rapidly for the remainder of the study period.

Daily mean values for humidity are generally 70 percent with minimal variation ranging between 65 and 80 percent as shown on Figure 3-C.

No measurable precipitation occurred during the period of investigation. Cloud cover was minimal.

Sea Level and Tides

Average monthly mean sea levels in Port Said varied from 18.046 meters to 18.229 meters above the Suez Canal Authority datum as shown in Figure 3-D. Sea levels are highest in Port Said during summer, July through August. The high sea levels are thought to be caused by low barometric pressures and effects of northern winds. Climatological data collected during the study confirm the relationship. In July, August and September, sea levels at Port Said are higher than at Port Tewfik, as shown in Figure 3-D. This difference in sea level is responsible, in part, for the southerly net flow in the Suez Canal found in the current meter studies. Tidal effects on sea level at Port Said are minimal. Tidal range at neap tides is about 10 cm and about 30 cm during spring tides. Observed wave characteristics during the study were 10 to 20 cm height with a wave period of 5 to 10 seconds.

3.3 SUEZ CANAL

Physical Structure

Salinity, temperature, and dissolved oxygen (STDO) profiles were taken at sixteen stations in the Suez Canal on four occasions. The results are tabulated in Appendix I, Table A. The survey area extends from the Mediterranean Sea in the north to Lake Timsah in the south. Salinity and dissolved oxygen vary considerably in the survey area as shown in Figures 3-E, 3-F, and 3-G. Highest values for salinity and dissolved oxygen occur at the ends of the survey area, reflecting the influence of the waters of the Mediterranean and Lake Timsah which are saline and well oxygenated. Spatial distributions of salinity and dissolved oxygen are also affected by the brackish water and sewage inflow from the Junction Canal at kilometer +3.4. Vertical dispersion of the brackish water/sewage mixture is limited to the upper meter of the canal water column as shown in Figures 3-E, 3-F and 3-G. Horizontal dispersion is dependent on current velocities and direction.

Currents

Currents were monitored for 48 continuous hours on eight occasions. Deployment dates are listed on Table 3.1. Meters were installed at depths of 5 and 10 meters at kilometer +10.0. Frequency distributions for current speed and direction are shown on Tables 1 through 15 of Appendix B. Current velocities range from 0 to 35 cm/sec. Flow directions are predominantly south with periodic reversals to northerly flow. Flow reversals occur at intervals of approximately 12 hours indicating the influence of semi-diurnal tides. The tidal effect is more notable at 10 meters depth than in the upper 5 meters.

Evidence of two layer flow is exhibited in the data. It is most significant in the earliest deployment as shown in Tables 1 and 2 of Appendix B. Principal current direction at 5 meters depth is south at 170 to 180 degrees. In the lower layer, flow is predominantly north. In subsequent records, southerly flow is predominant for both meters. It is possible that the July 25-27 records represent the transition from net northerly to net southerly flow in the Suez Canal. Sea level records (shown in Figure 3-D) for Port Said and the Suez Bay at Port Tewfik confirm this possibility.

Later current meter deployments illustrate limited periods in which upper and lower current directions are opposite. Opposing currents most frequently occur during tide induced current reversals.

Vessel passage during meter deployments were logged to assess the effect on current meter records. The influence on the current meter records was found to be minimal.

Velocity Measurements Across the Canal

Velocities were measured across a cross-section of the Suez Canal at kilometer +10. Current speeds measured at mid-depth varied only slightly (10.0 to 11.8 cm/sec) from the west bank towards the east. However, at Station 4, approximately 30 meters from the east shoreline, the current velocity was considerably higher at 24.1 cm/sec. The higher velocity at Station 4 is attributed to convergence of the stream lines along the east bank. Currents were to the south at all stations.

Dye Diffusion Study

A batch release dye diffusion study was performed to assess the dilution and transport characteristics of sewage/brackish water flow from the Junction Canal to the Suez Canal. The results are presented in Table 3.2. The data exhibit several distinct characteristics: elongated plume shape, rapid initial dilution following release of the dye, and slow transport by ambient currents. Dye was released on the surface at the confluence of the Suez Canal and the Junction Canal. Soon after release the dye plume assumed an elongated shape. The longitudinal axis of the plume is generally aligned with the direction of transport. The plume shapes depicted in Figure 3-H are graphically reconstructed on the basis of two sampling transects - one oriented along the longitudinal axis of the plume, and one run across the plume.

A 20 percent aqueous solution of Rhodamine WT dye was used in the study. By 1330 hours, 18 minutes after the dye release, the maximum measured concentration is 19.0 parts per billion, represents a dilution factor of 1.05×10^6. Subsequent dilution occurs at a more gradual rate. By 1545 hours, 153 minutes after dye release, the maximum measured concentration is 1.0 parts per billion, representing dilution by a factor of 2.0×10^8.

The dye plume is transported to the south at an average speed of 23 cm/sec. That speed is consistent with speeds recorded by the in situ current meters deployed at kilometer +10 during the dye study.

Plume lengths enclosed by "n" ppb concentration contours are listed in Table 3.2. Change in length of the major axis of the plume with time represents the net effect of two opposing mechanisms: (1) the dispersion characteristics of a receiving water body, which cause an increase of the area within a given concentration contour; and (2) dilution of a dye plume as it mixes with the receiving water, which acts to decrease the area enclosed by a concentration contour.

Vertical profiles of dye concentrations were done twice during the study to assess vertical dispersion. Examination of the data indicates that little vertical dispersion occurs. Over 80 percent of the dye is limited to the upper 20 centimeters of the water column and over 95 percent in the upper 40 centimeters.

The data indicate that advection (dilution due to flow) is the primary mechanism of dilution in the canal.

3.4 LAKE MANZALA

Physical Structure

No distinct spatial variations in salinity, temperature and dissolved oxygen are found in Lake Manzala or El Mallaha as shown in Table B, Appendix A. Conditions are typical of shallow lakes. Salinity profiles taken on three survey days indicate the lakes are isohaline. Vertical profiles of oxygen show no distinct pattern. Oxygen levels are often higher at the bottom than at the surface. Algal production likely defines the oxygen distribution. Plankton move vertically in the water column in response to light intensity. Field logs for STDO sampling show that high surface oxygen values occur in the morning and late afternoon, the periods of low sunlight intensity. High bottom oxygen levels generally occur during hours of highest light penetration. Temperature is generally higher at the surface than bottom. Differences are less than 0.5°C.

Evidence of density gradients are found at El Gamil (Station B7) and the Junction Canal Station (Station B6). At El Gamil, the connection of Lake Manzala with the Mediterranean Sea, salinities range from 8.87 ppt at the surface to 13.6 ppt at 3.0 meter depth. Similar conditions occurred in the Junction Canal with salinity values of 8.78 ppt at the surface and 14.24 at the bottom.

Current Meter Studies

Current meters were deployed for 1 month at three locations in Lake Manzala as shown in Figure 2-A. Data was retrieved at two-week intervals.

The meter deployed in Zone B of Lake Manzala did not record any measurable current speed or direction data during either two-week record intervals. Average ambient current speed at the location are less than the meter impeller threshold of 2.6 cu/sec. Results of drogue studies supported the absence of significant currents.

Average current velocities recorded at the El Gamil outlet from Lake Manzala are considerably higher than current velocities in the Suez at kilometer +10. The range of current speeds recorded at El Gamil was 0 to 60 cm/sec. as shown in Tables 16 and 17 of Appendix B.

El Gamil also shows evidence of semi-diurnal tides, although the tidal influence varied considerably during the monitoring period. Analysis of the data record for 31 July to 20 August reveals alternating north-south currents, with the northerly currents predominating. During the period of 21 August to 28 August, the flow direction was consistently northward with isolated exceptions. From 29 August to 1 September, current directions at El Gamil again alternate between north and south, with northerly flows occurring approximately 70 percent of the time.

Current speeds monitored in the Junction Canal at Kabbutti are only 50 percent of the rates observed at the El Gamil outlet. The range of current speeds in the Junction Canal is 0 to 30 cm/sec. as shown in Table 18 of Appendix B.

Current directions monitored in the Junction Canal exhibited distinct variation during the 30 day deployment period. From August 2 to 11, flows alternate between west-northwest and east-southeast at about 12 hour intervals. From August 12 to 21, currents were predominantly southeast although flow direction continued to alternate. After 21 August currents were continuously to the southeast to the Suez Canal.

Both the El Gamil outlet and Junction Canal velocity data exhibit a transition from alternating flow directions to a continuous flow out of Lake Manzala. This is most likely a result of sea level imbalance between Lake Manzala, the Suez Canal and the Mediterranean Sea. Since this imbalance appears to undergo seasonal change, a thorough examination of tidal records would be helpful for further interpretation of these current data.

Current Cross-Section

Current speeds were measured at three stations at El Gamil as shown on Figure 4 of Appendix I. Depth soundings were also taken. The maximum depth measured along this cross-section is 3.0 meters at Station No. I. The maximum current speed (12.5 cm/ sec.) was also recorded at Station I. The current speeds measured with the flow meter at Station Nos. I and 2 are consistent with the current speeds of 16 cm/sec. recorded by the in situ current meter during the cross-sectional velocity study. At Station No. 3 outside the main channel, the current velocity is considerably lower (5.0 cm/sec.). Current direction at all stations was north.

Cross-sectional depth profiles were taken at three locations on the Junction Canal as shown on Figure 3-I. Depths vary from 107 to 185 centimeters. The channel is generally trapezoidal. Average daily flow from Lake Manzala to the Suez Canal, is approximately 1,460 mld, based on the channel cross-sections and average net current velocities of 10.5 cm/sec.

Transport Studies

Surface transport studies were conducted using drogues in Zone B of Lake Manzala. In Zone A where depth prohibited use of drogues, surface transport studies were performed using woodchips.

Drogue studies were conducted on three occasions in Zone B of Lake Manzala. During a 5-hour survey on August 15, drogue speeds are low from 2.8 to 3.6 cm/sec. Transport direction varied from 116°C to 130°C as shown on Figure 3-J. Wind during the survey varied from I to 10 knots from the northwest quadrant. The data indicates transport is related to minor wind induced surface currents.

Drogue speeds during a four-hour survey on 6 September, exhibit more variation than the 15 August data. Speeds of two of the drogues were nearly identical (2.9 and 3.0 cm/sec.), while the speed of the third drogue, deployed farthest to the west, averaged 5.7 cm/sec. as shown on Figure 3-J. Winds were from the north-northeast at only 3 knots. Drogue directions on 6 September varied from 111°C to 180°C in response to the wind direction. A variation from this general "pattern" can be observed in the transport direction of the drogue deployed nearest the Junction Canal. The trajectory of this drogue was nearly 90 degrees east of the wind direction. This may be a result of circulation patterns which carry water east into the Junction Canal from Lake Manzala.

On October 15, two drogues were released at a point 1.5 kilometers southwest of the Junction Canal. One drogue was the standard Johns Hopkins design used in previous transport studies. The second was an unballasted surface float subject to currents in the upper two centimeters of the water column. Wind speeds were generally less than 5 knots and extremely variable in direction. Both drogues were transported in the direction of the predominant wind between readings. The speed of the standard drogue was similar to the earlier studies (2 to 6 cm/sec.) while the speed of the surface float was higher (10 to 50 cm/sec.).

Depths of less than 20 centimeters in Zone A of Lake Manzala precluded the use of standard drogues. "Solid dye" studies using woodchips were conducted to determine transport in Zone A. The results are shown graphically in Figures 5, 6, 7 and 8 of Appendix A. Under light south-southwesterly winds on 7 September, the woodchips were transported to the north into Zone A at 1.17 to 6.7 cm/sec. During the 21 September study, with 8 to 10 knot north-northwesterly winds, the woodchips traveled in a southeasterly direction out of

Zone A to the Manzala Canal. Woodchip drift speeds on 21 September averaged 3.3 to 20 cm/sec., significantly greater than the drift speeds during the 7 September study.

Although the data are not conclusive, woodchip transport during both survey days appeared to result from wind-driven surface currents.

3.5 MEDITERRANEAN SEA

Short term studies conducted by Louisiana State University in May of 1978 included vertical profiles of salinity and temperature at six stations as shown in Figure 3-K[(1)]. No evidence of vertical stratification was found at any station with the exception of "Suez Canal III". Salinity increases rapidly from 38 ppt to over 40 ppt at 8 meters depth. Current studies at the site indicated hypersaline flow from the Suez Canal as the cause of the gradient.

Currents were monitored at all six stations with depth. Dr. Murray of L.S.U. found in a preliminary analysis that surface currents show a general onshore component in the easterly drift as shown in Figure 3-K. While the surface current at Station III was negligible the bottom currents at Station III show strong offshore flow associated with hypersaline water from the canal. All other stations show an offshore component to the general easterly flow of bottom waters. The bottom motion was weak at Station K and strong at Stations H and N. This suggests a "coherant north-northeasterly bottom flow down the shore". Salinity profiles confirm this idea. The offshore component in the bottom waters of Station M and Z were the usual offshore flow produced in the current field by the onshore winds from the north-northwesterly winds.

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(1) Personal communication: Stephen P. Murray, Asst. Director and Professor, Coastal Studies Institute, Louisiana State Univ.

TABLE 3.1

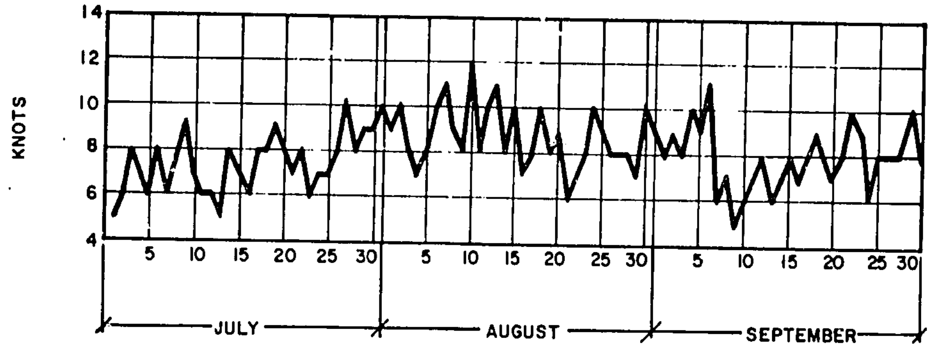
SCHEDULE OF IN SITU CURRENT MONITORING

Location	Depth	Deployment Interval
Suez Canal	5 & 10 meters	25 July - 27 July 2 August - 4 August 9 August - 11 August 16 August - 18 August 23 August - 25 August 29 August - 31 August 5 September - 7 September 12 September - 14 September
Lake Manzala (Zone B)	Mid	8 August - 1 September 12 September - 14 September
El Gamil Outlet	Mid	31 July - 1 September
Junction Canal	Mid	2 August - 1 September

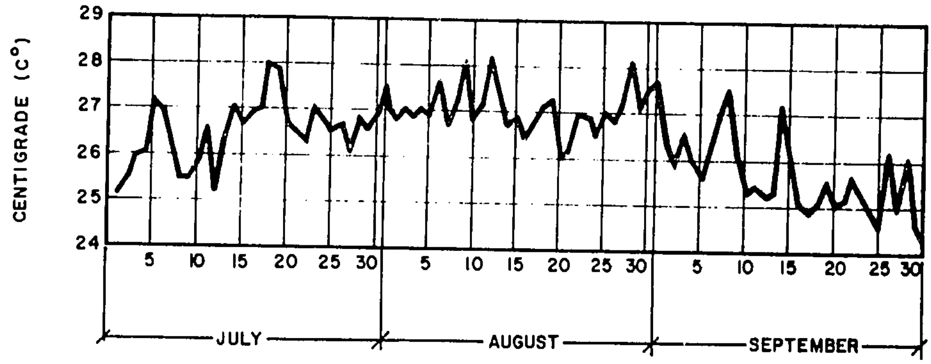
TABLE 3.2

DYE PLUME CHARACTERISTICS
SUEZ CANAL 5 SEPTEMBER 1978

Hour	Time After Dye Release (Minutes)	Length of Dye Plume Isopleths, Meters					Maximum Measured Concentration ppb
		0.1 ppb	0.5 ppb	1.0 ppb	5.0 ppb	10.0 ppb	
1130	18	330	280	250	172	127	19.0
1421	69	453	370	255	132	-	9.5
1502	110	692	665	610	-	-	2.7
1545	153	Intermittent					1.3



WIND SPEED



AIR TEMPERATURE

DAILY AVERAGE VALUES FOR
PORT SAID - 1978

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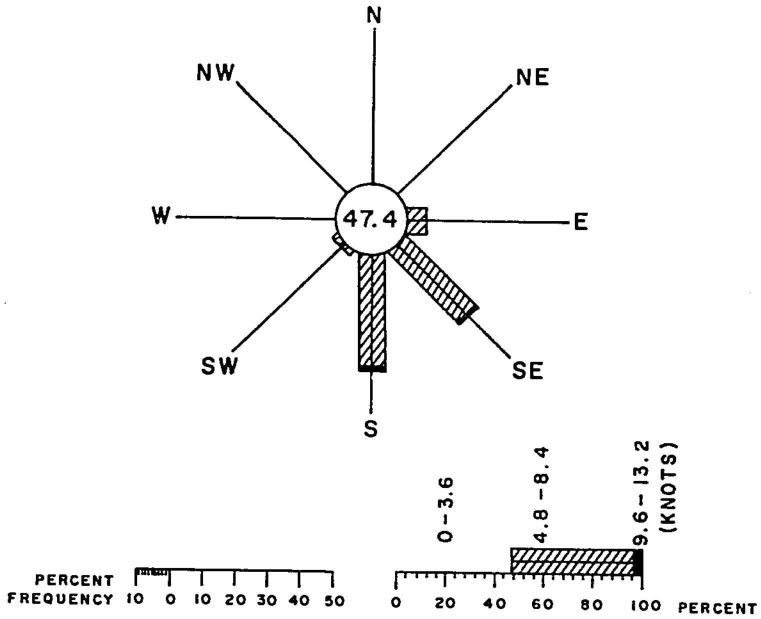
WIND SPEED AND
AIR TEMPERATURE

VOL.4
FIG.
3-A

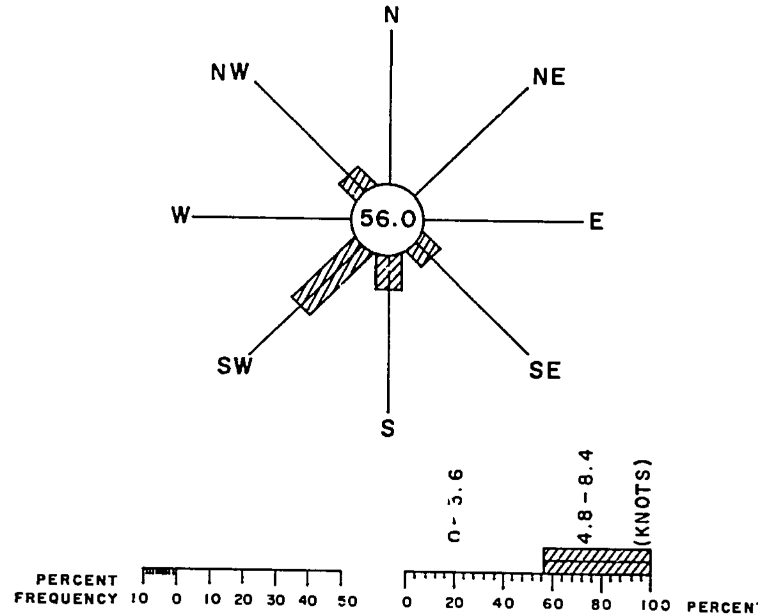
WINDS
JULY – AUGUST



ROSE SCALE
1" = 25%

SUMMARY
ALL DIRECTIONS

WINDS
SEPTEMBER



ROSE SCALE
1" = 25%

SUMMARY
ALL DIRECTIONS

DATA OBTAINED IN PORT FOUAD

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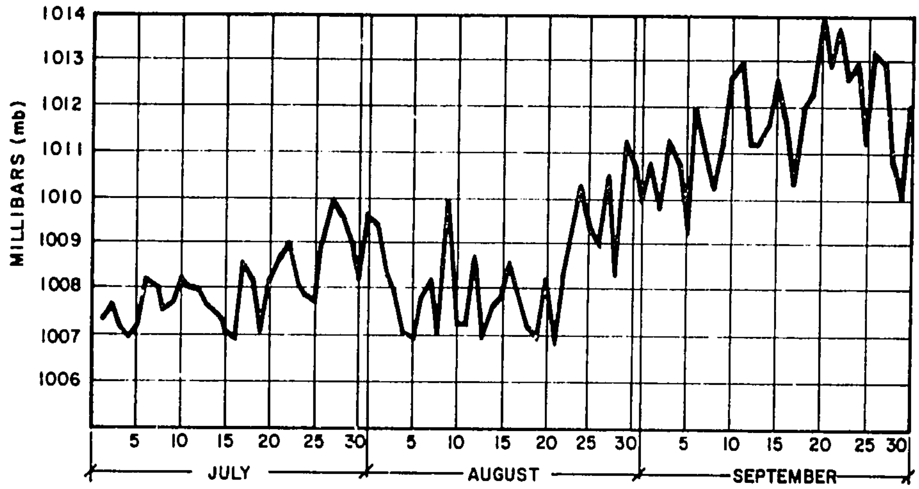
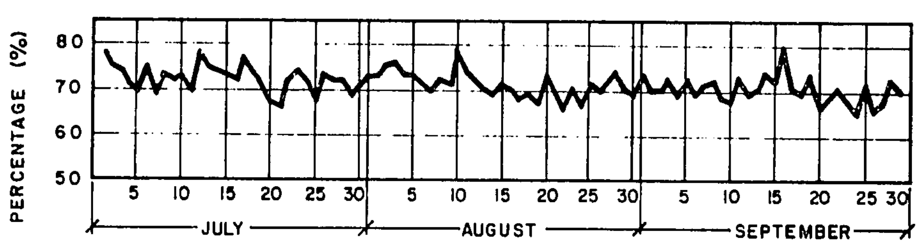
WIND ROSETTES
1978

VOL. 4
FIG.
3-B



ATMOSPHERIC PRESSURE



RELATIVE HUMIDITY

DAILY AVERAGE VALUES FOR
PORT SAID - 1978

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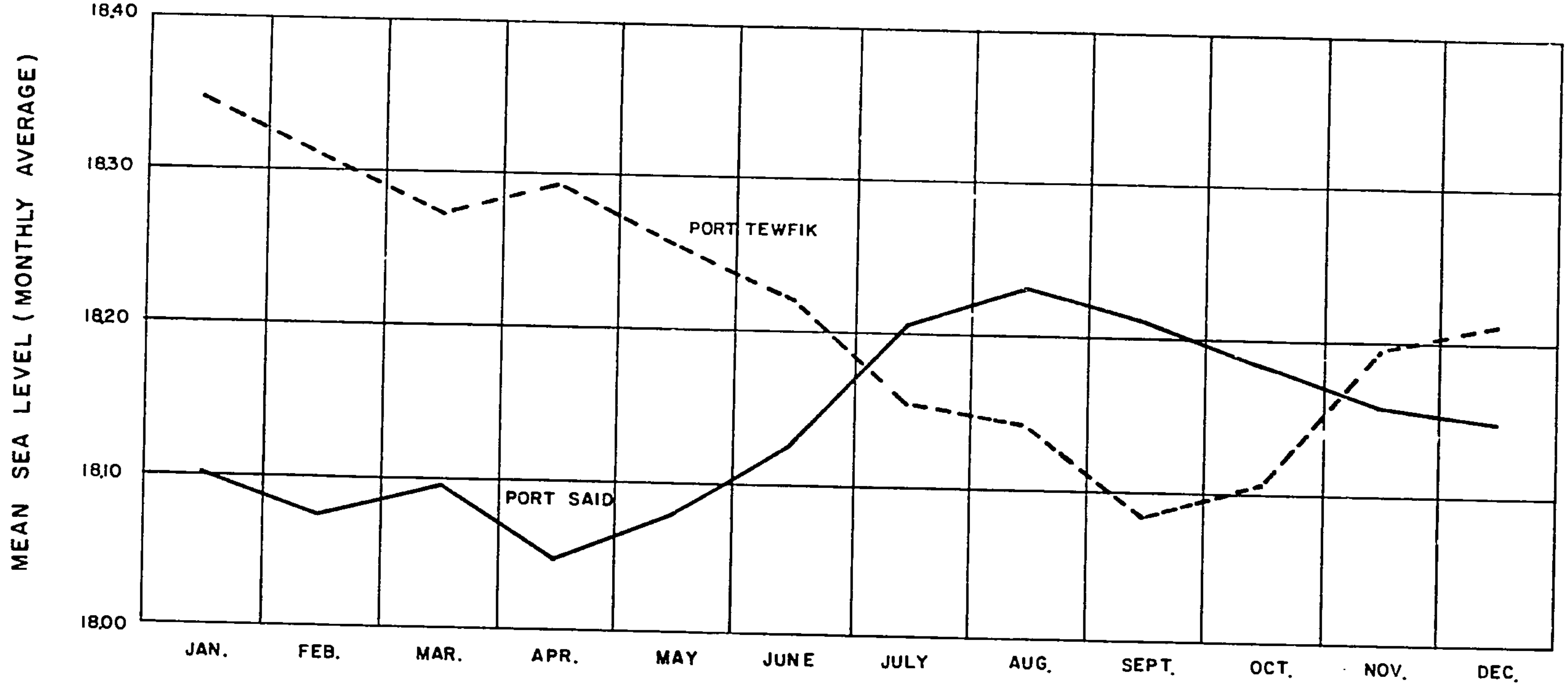
PORT SAID WATER AND WASTEWATER FACILITIES MASTER PLAN	
ATMOSPHERIC PRESSURE AND RELATIVE HUMIDITY	VOL. 4 FIG. 3-C



NOTE: MEAN SEA LEVELS IN METERS FROM SUEZ CANAL AUTHORITY DATUM. MONTHLY AVERAGE CALCULATED FROM TEN YEARS DATA.

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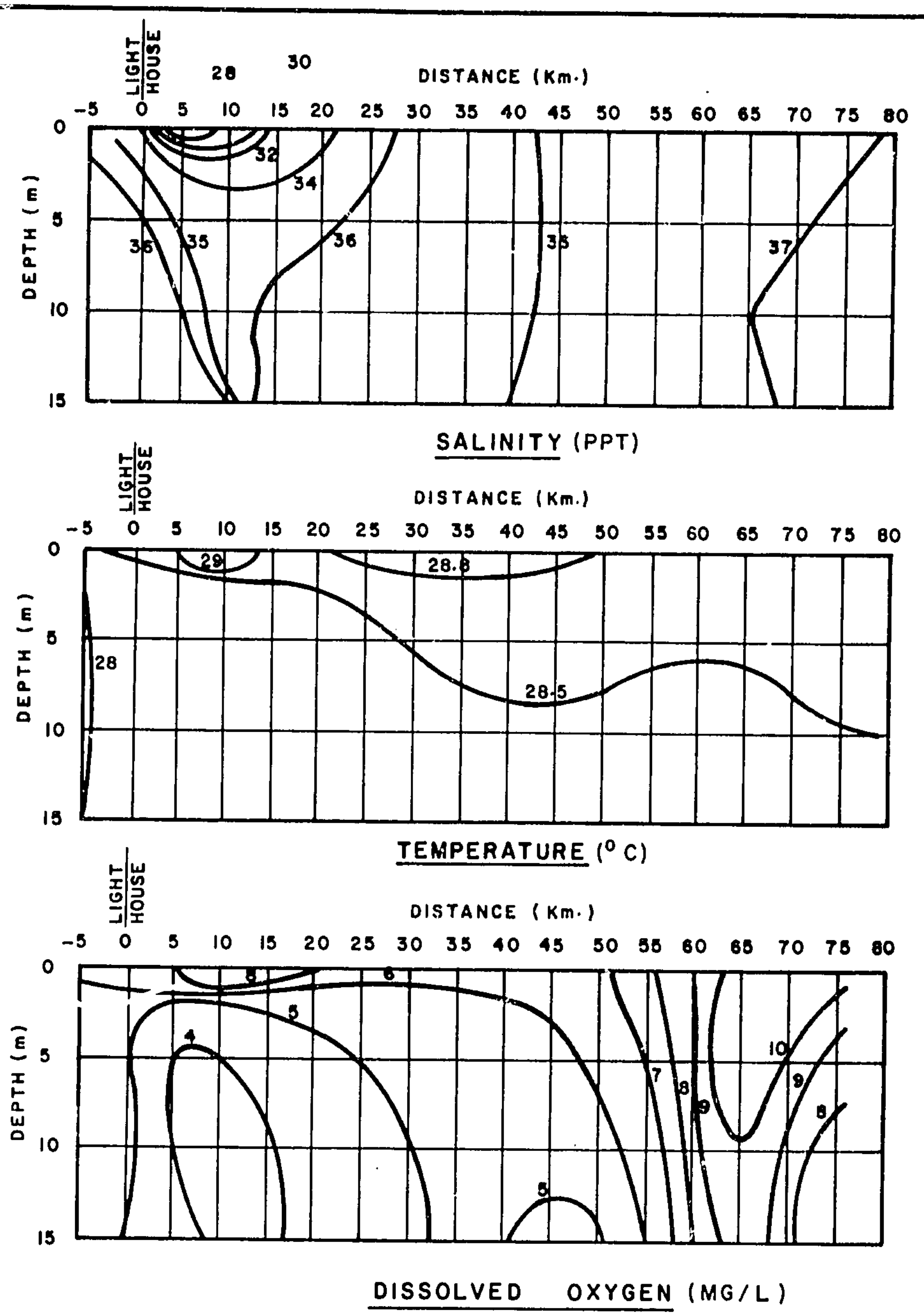
MEAN SEA LEVEL - MONTHLY AVERAGE

VOL.4 FIG. 3-D



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PHYSICAL STRUCTURE -
SUEZ CANAL
AUGUST 27, 1978

VOL.4
FIG.
3-E

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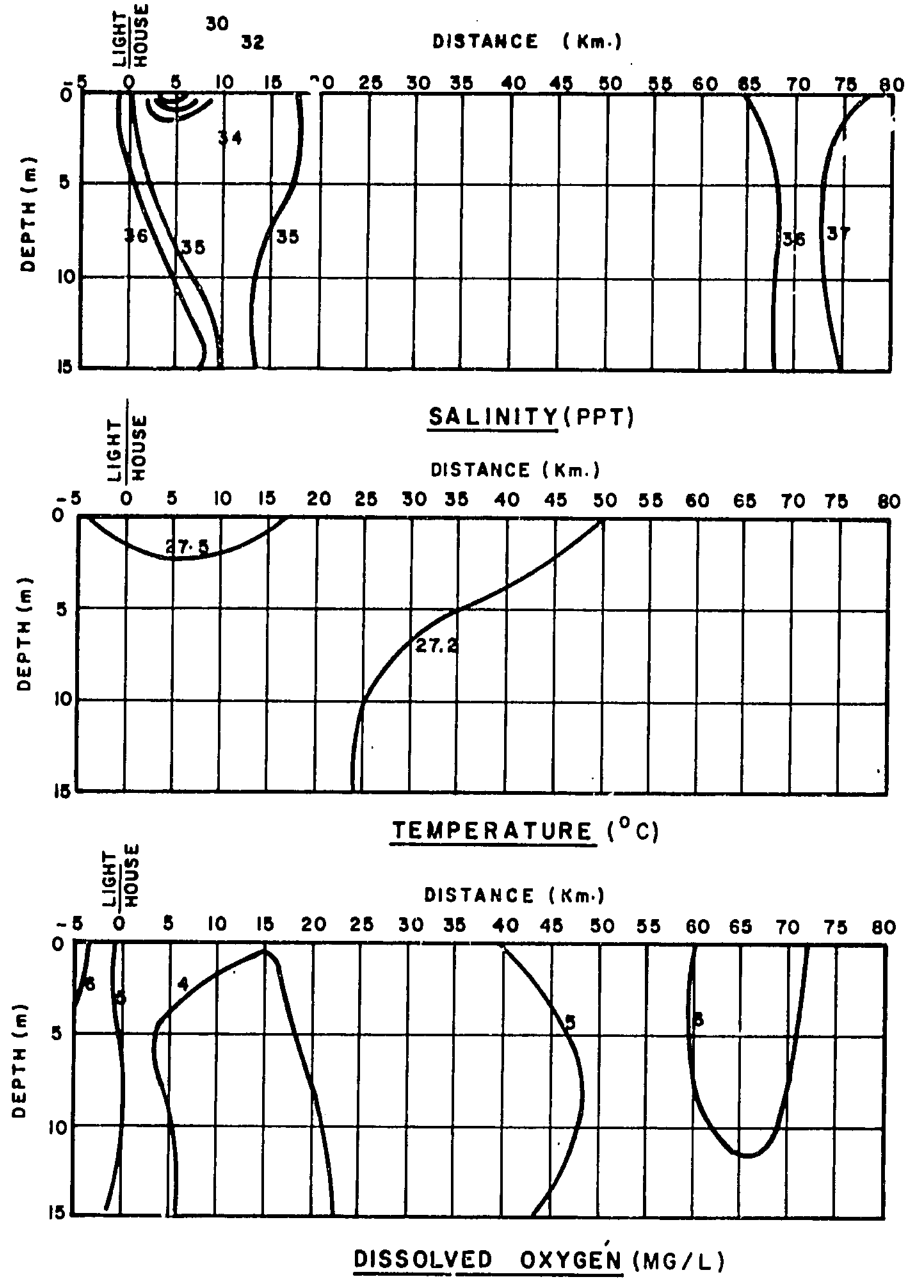

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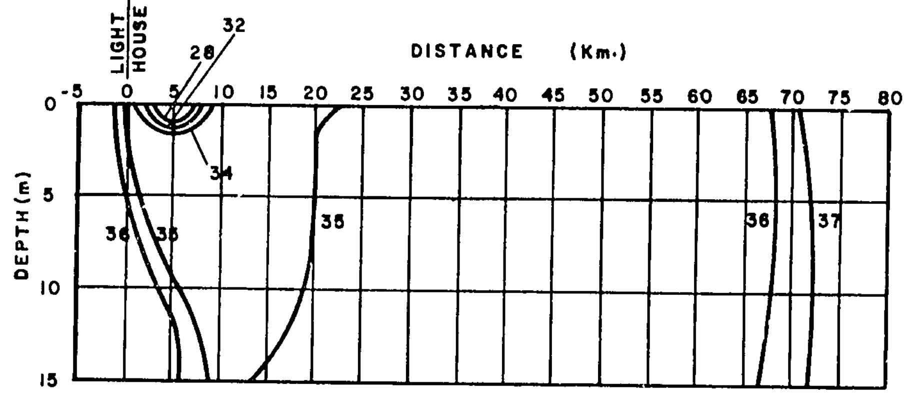
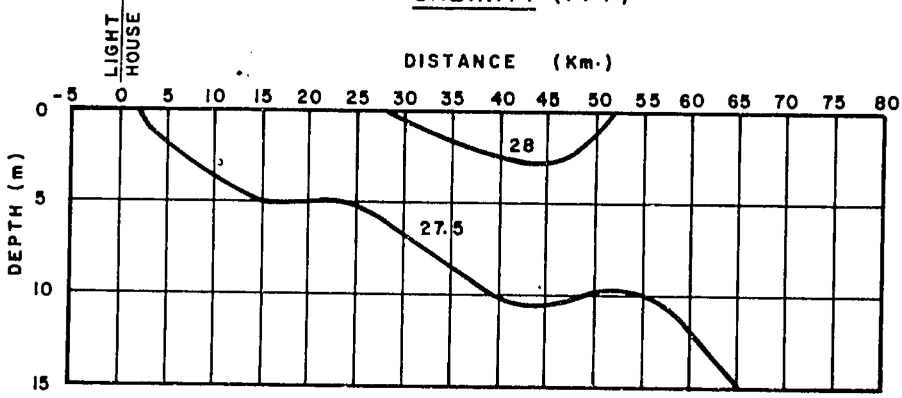
PHYSICAL STRUCTURE -
SUEZ CANAL
20 SEPTEMBER, 1978

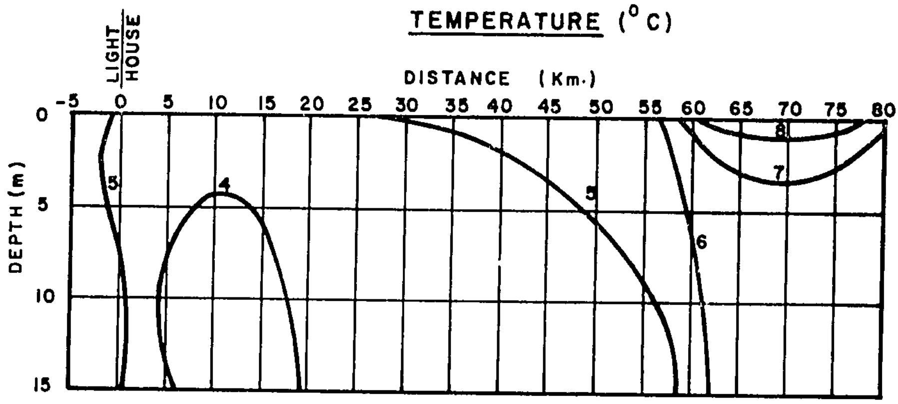
VOL.4
FIG.
3-F



SALINITY (PPT)



TEMPERATURE (°C)



DISSOLVED OXYGEN (MG/L)

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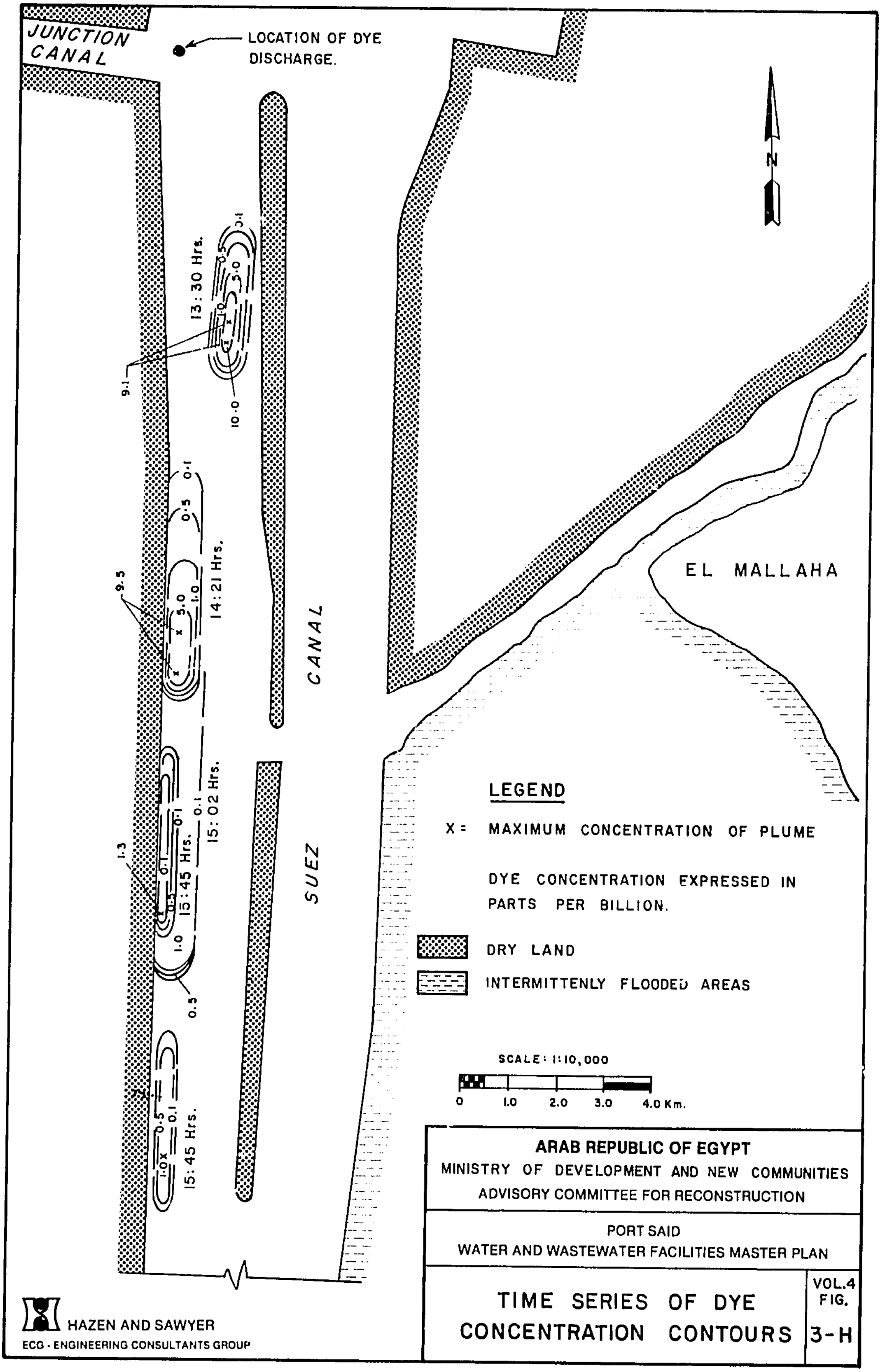
PHYSICAL STRUCTURE - SUEZ CANAL SEPTEMBER 21, 1978

VOL.4 FIG. 3-G



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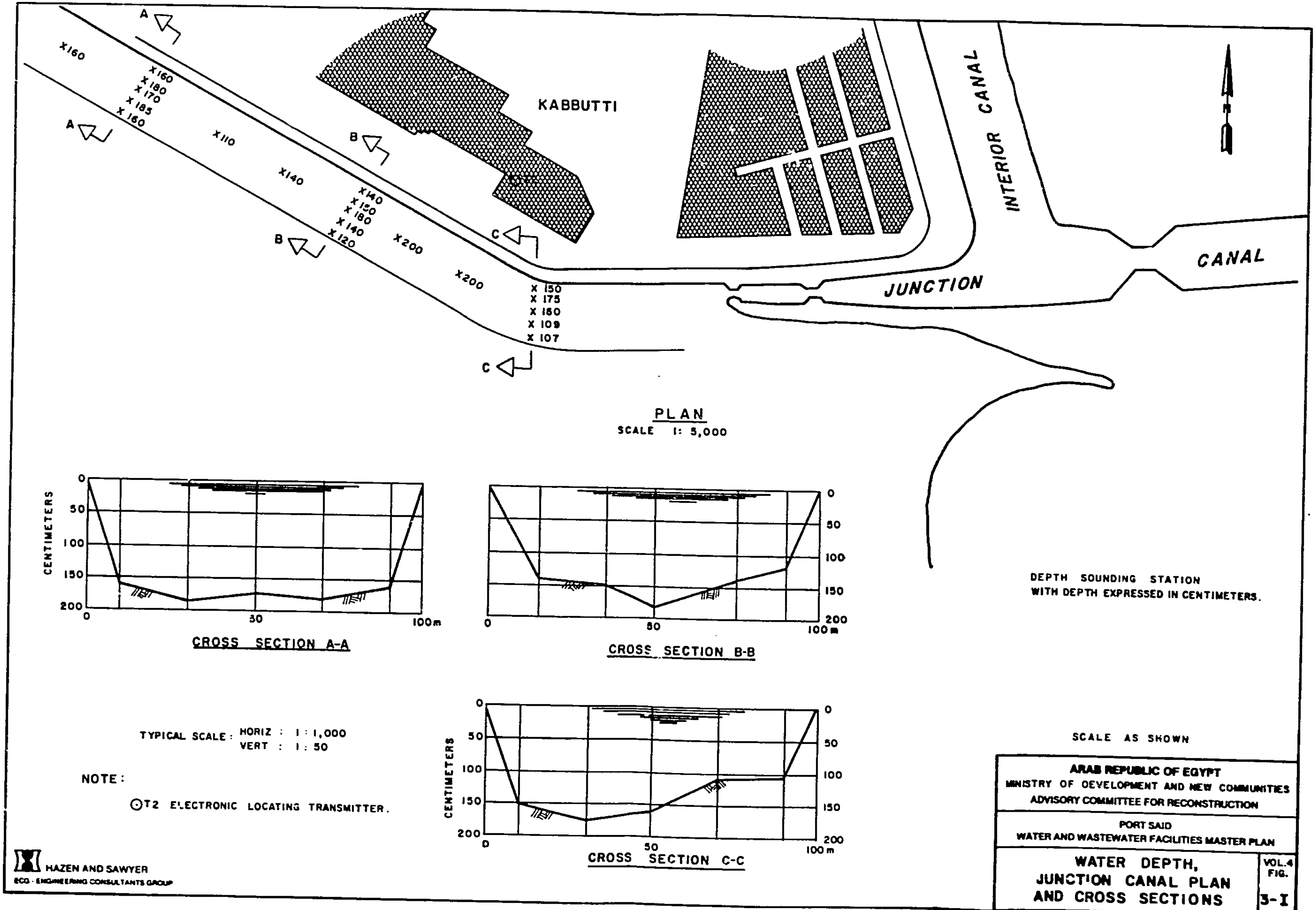
TIME SERIES OF DYE CONCENTRATION CONTOURS

VOL.4 FIG. 3-H



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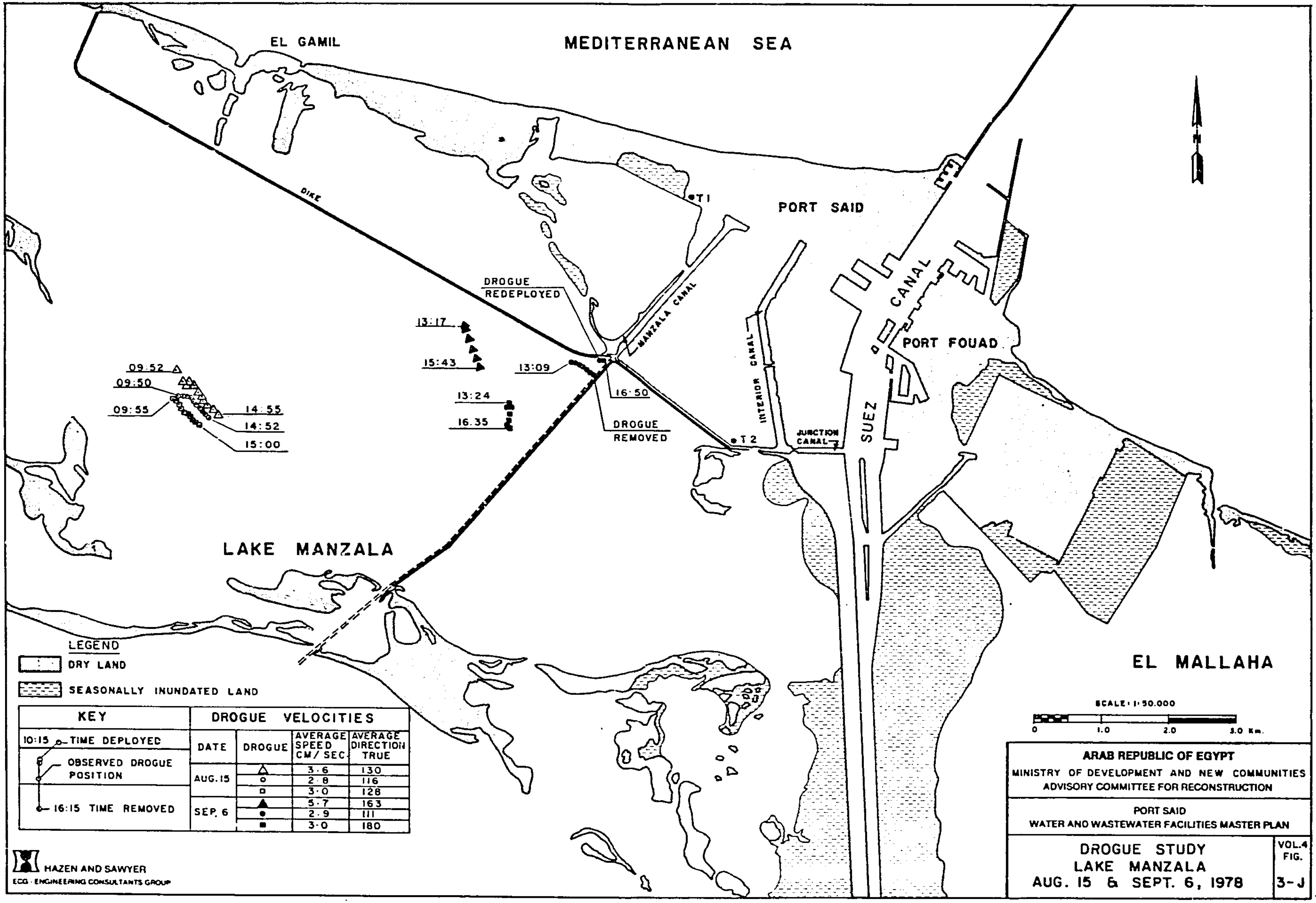
WATER DEPTH, JUNCTION CANAL PLAN AND CROSS SECTIONS

VOL.4 FIG. 3-I



DROGUE VELOCITIES

DATE	DROGUE	AVERAGE SPEED CM/SEC	AVERAGE DIRECTION TRUE
AUG. 15	△	3·6	130
	○	2·8	116
	□	3·0	128
SEP. 6	▲	5·7	163
	●	2·9	111
	■	3·0	180

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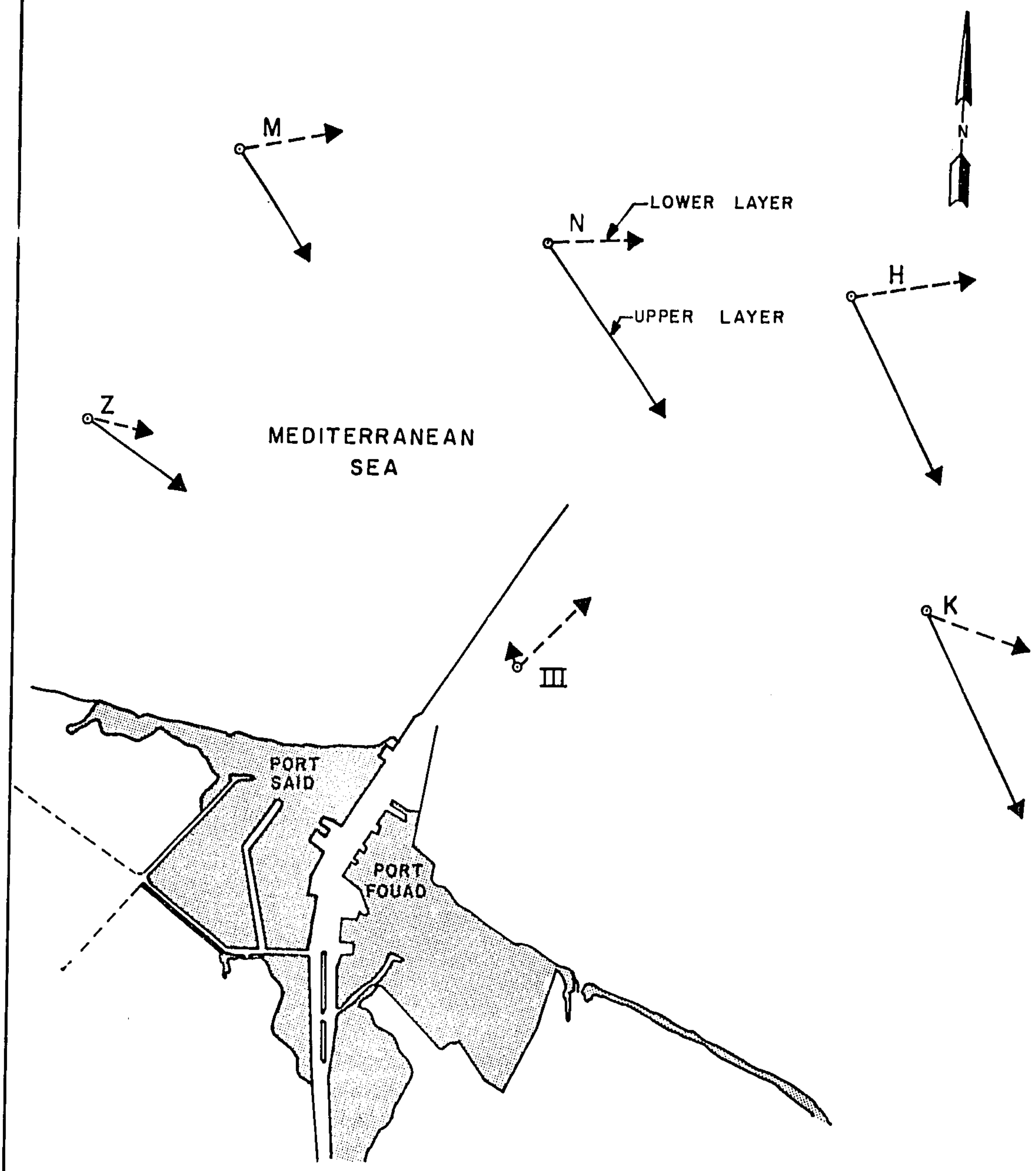
DROGUE STUDY
LAKE MANZALA
AUG. 15 & SEPT. 6, 1978

VOL.4 FIG. 3-J



APPROX. SCALE: 1=125,000

0 1.0 2.0 3.0 4.0 Km.

CURRENT VELOCITY 0 2 4 6 8 10 CM/SEC

⊙ CURRENT, SALINITY AND TEMPERATURE TURBIDITY PROFILES

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MEDITERRANEAN SEA CURRENT CHARACTERISTICS MAY, 1978

VOL. 4 FIG. 3-K

CHAPTER 4

CHEMICAL WATER QUALITY

4.1 INTRODUCTION

To assess the effects of future wastewater discharges, data on present background water quality and the impact and spatial extent of existing discharges are required. Water column samples at over 30 stations and benthic samples at 20 stations were collected. In addition, diurnal profiles of oxygen and temperature were collected and laboratory studies of benthic demand were performed.

4.2 GENERAL WATER QUALITY

General water quality parameters examined were pH, BOD_5, suspended solids, salinity, temperature, dissolved oil and grease.

Average levels of pH in the receiving waters (7.7 to 9.1) are typical of estuarine systems. In the Mediterranean Sea pH is generally between 7.7 and 7.9 with the exception of near El Gamil where the pH is 8.3 due to the more alkaline waters of Lake Manzala. The lake waters have pH values of 8.5 to 8.7 in Zones B and C. The greatest variability is in Zone A of Lake Manzala, apparently due to carbon dioxide utilization during the day and production at night by algae.

Average concentrations of BOD_5 in Lake Manzala reflect the existing wastewater discharges as shown on Figure 4-A. In Zone A, the area most affected by the raw sewage discharge at Mazrah, average BOD_5 values range from 8.5 to 58. In Zone B average levels are less (3.2 and 5.2 mg/l) with the exception of Stations B5 and B6. BOD_5 values at Station B5 are influenced by wastewater from Zone A and a pump station overflow to the Manzala Canal. At Station B6 the higher BOD_5 values (14.7 mg/l) are due to the raw wastewater discharge at Kabbutti. In Zone C of Lake Manzala average BOD_5 concentrations of 10.5 to 13.3 mg/l are found. Lower BOD_5 levels in the Suez Canal (less than 5 mg/l) indicate a smaller effect of wastewater pollution and there appears to be no effect in El Mallaha.

Suspended solids data are summarized in Table 4.1. The spatial distribution of solids was similar to BOD_5 with the highest concentrations (103-264 mg/l) in Zone A of Lake Manzala and the lowest in El Mallaha (20-32 mg/l). Solids levels found in the Mediterranean are shown in Figure 4-B. Suspended solid levels in the Suez Canal ranged from 30 mg/l at Station +2 km to 1,344 mg/l at Station +10 km. Because of dredging activities during the study, the solids data probably do not represent normal conditions.

Salinity, temperature and dissolved oxygen values in Lake Manzala, the Suez Canal and Mediterranean are discussed in detail in Chapter 3, Physical Water Quality, and Section D of this chapter. Salinity values were unavailable for El Mallaha. Conductivity data indicate salinities well above that of seawater as shown in Table 4.1.

With the exception of Zone A of Lake Manzala, oil and grease are not visible in Lake Manzala or El Mallaha and concentrations measured in most areas were less than 0.09 mg/l. The oils are thought to be due to phytoplankton and other natural vegetable oils. At stations near existing sewage discharges (Stations B9, B5 and C1) average concentrations are understandably higher due to the sewage and to dense phytoplankton populations. Oil and grease levels in the Suez Canal are also low. Higher concentrations in the Canal near the Mediterranean Sea (kilometers -5.0 and -2.5 of the Suez Canal) probably reflect shipping activities. No oil or grease is visible in the canal or along the Mediterranean shoreline.

4.3 NUTRIENTS

Measurements were made of soluble nitrogen in the forms of nitrate, nitrite, and ammonia. Soluble orthophosphate, total phosphate (soluble and insoluble in all chemical forms) and soluble silicate were also measured. Soluble nitrogen and orthophosphate are required for the growth of phytoplankton, zooplankton and bacteria. Silicon is used for phytoplankton growth especially diatoms. At times nutrients may be tied up as insoluble forms in the water column or in the sediments as often occurs with phosphate.

Sources of nitrogen, phosphorus and silicon include agricultural drainage, geological sources, and the recycling of organic material. Nitrogen and phosphorus are also derived from sewage and nitrogen may be fixed from the atmosphere as well.

Throughout Lake Manzala, nutrient concentrations are well above those levels required for high plankton productivity. High levels of ammonia, nitrite, phosphate and silicate occur in Zone A and near the Junction Canal (Stations B6 and C1) due to the proximity of sewage outfalls. In Zones B and C average concentrations are in the order of 0.6 mg/l NO_3-N, 0.08 mg/l NH_3-N, 0.01 mg/l NO_2-N, 0.1 mg/l total PO_4-P, 0.01 mg/l ortho-PO_4-P, and 4.0 mg/l SiO_2-Si.

Nitrate nitrogen levels are four times higher than maximum values reported in 1967 in an area 3 kilometers west of Zone B. This may indicate a general rise in lake nutrient levels due to agricultural drainage water, or to a localized increase from the oxidation of ammonia nitrogen as it enters Zones B and C. Soluble nitrogen to phosphate mole ratios are very high at over 100 to 1. The relatively low soluble phosphate concentration, as well as the higher total phosphate concentrations, indicate that most phosphate is probably bound to organic matter in the water column and the sediments. In addition the high iron concentrations in the lake sediments may be tying up some of the phosphorus as insoluble ferric phosphate.

Soluble nitrogen and phosphate levels in El Mallaha are also high. Although there are no sewage or agricultural drains to El Mallaha, the high rate of evaporation could account for the high nutrient levels. Silica levels are lower than in Lake Manzala.

Concentrations of nitrogen, phosphorus and silicon containing compounds in the Mediterranean Sea are high and are similar to those in Zones B and C of Lake Manzala as shown in Table 4.1. Concentrations of nitrate and phosphate are higher than those recorded during the non-flood periods before the Aswan Dam was built. Since the currents along the coast run toward the east, these relatively high concentrations may be partially due to the lake waters exiting at El Gamil.

Concentrations of nutrients in the Suez Canal are also ample for phytoplankton production. Maximum concentrations of total and ortho-phosphate, silicate, and nitrite occurred near kilometer point 10.0 as shown in Table 4.1. Ammonia is highest at 4.0 kilometers, near the Junction Canal, while the maximum nitrate concentrations occurred at -2.5 kilometers.

Peak concentrations are similar to Junction Canal levels indicating that this may be a major source of nutrients in the canal. Peak values of phosphates, silicate and nitrate at the 10 kilometer station could also be due to seepage from the Port Said raw water canal which is also high in ammonia, phosphates, and silicate.

4.4 DIURNAL OXYGEN AND TEMPERATURE STUDIES

Diurnal sampling of dissolved oxygen (D.O.) and temperature were performed to assess the effects of sewage discharge on the oxygen levels in Lake Manzala. The in situ diurnal profiles of dissolved oxygen were supplemented with BOD_5 data, chlorophyll A data and benthic demand studies. Diurnal sampling was performed in Zone A, the area most affected by raw sewage from Mazrah, and Zones B and C, areas relatively unaffected by sewage. Four diurnal runs for D.O. and temperature were made as shown in Table 4.2.

Dissolved oxygen and temperature were measured every 15 to 60 minutes. The periods between 10:00 and 16:00 not covered during these diurnal runs were supplemented with data gathered from the salinity, temperature and dissolved oxygen (STDO) runs.

The results of these studies are shown on Figure 4-C. There is a wide variation in dissolved oxygen (D.O.) concentrations in Lake Manzala during any 24-hour period. Concentrations that could be potentially harmful to fish life occur at night in many locations in the study area. The variation is most pronounced in Zone A where D.O. commonly ranges from zero to 20.0 mg/l over a day. D.O. ranges during the diurnal runs in Zones C and B were smaller (3 to 6 mg/l). Similar variations occurred in both surface and bottom samples.

During the early morning hours before sunrise, low levels of dissolved oxygen, 3.5 mg/l or lower, occur in all three zones. In Zone A, D.O. is usually totally depleted in areas near the sewage outfall. Dissolved oxygen levels commonly remain at zero in the plume until early afternoon. Offensive odors from hydrogen sulfide are suppressed. On the days of the diurnal runs, the Area C lows occurred at about 6:00 a.m. and the Area B minimum occurred at 3:00 a.m. The cause of this depletion is the oxidizable organic and nitrogenous material in the water column, as indicated by the high BOD levels (approximately 30 mg/l in the Zone A station and 12 mg/l in the Zones B and C stations). Phytoplankton respiration also accounts for a portion of the oxygen deficit. Bench scale studies indicate that benthic demand is a minor source of oxygen demand.

During the afternoon oxygen is restored to levels at or above saturation in most of the study area due to photosynthetic production. In parts of Zone A outside the sewage plume, levels of over 270% saturation occur. Here maximum values are reached around noon. Supersaturation also occurs in Zone C, peaking at concentrations over 200% saturation on some days. In Zone B, maximum dissolved oxygen levels are usually near saturation values during the later summer. Peak concentrations as well as peak deficits are proportional to the amount of chlorophyll in the area. This is due to the fact that the major source of D.O. is the oxygen produced by photosynthesis and the major demand is the respiration of phytoplankton and the oxidation of decaying phytoplankton.

Diurnal temperature ranges in the early fall are about 6°C at mid-depth in Zone A, 3-6°C at the surface of Zone C and 2°C at the surface of Zone B. Bottom ranges are slightly less than at the surface. Maximum temperatures occur in the afternoon and minimum temperatures occur in the early morning.

4.5 TOXICS

Heavy Metals

Nineteen benthic sediment samples were analyzed for heavy metals including: copper, zinc, cadmium, manganese, and iron. Heavy metal concentrations are similar to those found in polluted estuaries such as New York City Harbor.

In Lake Manzala spatial distribution of the metals is correlated to the distance from the Mazrah effluent with higher concentrations occurring near the outfall. It is doubtful, considering the absence of industrial activity in Port Said, that this is due to industrial loads. A more feasible explanation is that the concentration of metals in phytoplankton, which eventually settle to the bottom, is responsible for the distribution of benthic metals. For example, diatoms concentrate iron 135 times to 1. High chlorophyll A levels are correlated to high metal concentrations. The distribution of metals in the Suez Canal reflects loading from Lake Manzala through the Junction Canal.

Benthic levels of heavy metals in the surf zone of the Mediterranean vary little from station to station. This indicates minimal contribution of metals from Lake Manzala through the El Gamil connection.

Results of the heavy metal analysis are summarized in Table 4.3.

Pesticides

Sediment samples for pesticide analysis were taken at twenty stations. Two samples were unsuitable for analysis. The remaining samples were analyzed by gas chromatography techniques outlined in the USEPA Pesticide Analytical Manual (1974). Lindane, B-BHC (an isomer of Lindane), DDE and DDD (metabolates of DDT) were found as shown in Table 4.4. Lindane and DDT have been commonly employed against agricultural pests in Egypt for several years.

Lindane is found at ten of the twenty stations. Concentrations range from 11.6 to 93.8 parts per billion. In the Suez Canal, Lindane is found at three stations; +2 km, +14 km and +25 km. Concentrations range from 23.4 to 38.3 ppb. No Lindane is found in the benthos of El Mallaha. In Lake Manzala Lindane is found at six stations. Concentrations ranged from 11.6 to 58.6 ppb. Levels of Lindane are lowest in Zone C and highest in Zone B. The distribution of Lindane in Manzala suggests that the source is the agricultural drains in the south. Water column samples taken in the agricultural drainage system to the El Bakar drains confirm this theory as shown in Table 4.5. The highest recorded level of Lindane was found at El Gamil indicating transport through Manzala in the water column.

An isomer of Lindane, B-BHC, is found in 14 of the 20 benthic samples. Concentrations in the Suez Canal range from 11.6 to 46.6 ppb, with the highest value occurring at kilometer -2.4. Unlike Lindane, B-BHC is found in El Mallaha at concentrations of 46.6 ppb as shown in Table 4.4. In Lake Manzala, B-BHC is found at all stations. Benthic levels vary from 35 ppb in Zone A to 93.2 ppb at Station B8 in Zone B. Distribution of B-BHC is similar to Lindane.

The pesticide DDT is not present at any of the sampled stations. The DDT metabolate, DDD, is found at only one station, kilometer +45 in the Suez Canal. Another DDT metabolate, DDE, is found at all sampled stations. Concentrations ranged from a low of 22 ppb in the Suez Canal to 190.9 ppb in Zone B of Lake Manzala. In the Suez Canal, levels were highest at the northern stations near Port Said as shown in Table 4.4. The higher concentrations near Port Said are probably due to the inflow from Lake Manzala through the Junction Canal. Concentrations of DDE were high throughout Lake Manzala and El Mallaha. The distribution suggests no specific source.

TABLE 4.1

CHEMICAL CHARACTERISTICS BY STATION AND PARAMETER

Area	Station	pH	Suspended Solids mg/l	Turbidity NTU's	Conductivity Millimhos/cm at 25°C	Biochemical Oxygen Demand (BOD) mg/l	Oil and Grease mg/l	Ammonia Nitrogen mg/l-N	Nitrate Nitrogen mg/l-N	Total Phosphate mg/l-P	Ortho-Phosphate mg/l-P	Silica mg/l-Si
Lake Manzala												
Zone A	A1	7.9	220	57	6.9	29	0.134	1.70	0.734	1.66	0.750	5.79
	A2	9.0	260	80	10.0	53	0.239	1.31	0.477	1.59	1.165	8.06
	A3	8.3	264	84	10.1	56	0.097	1.32	0.552	1.26	0.870	8.00
	A4	9.1	241	78	9.4	40	0.089	1.00	0.385	1.08	0.685	6.04
	A5	8.6	230	60	8.9	34	0.103	1.36	0.634	1.08	0.753	5.84
	A6	8.7	103	52	7.9	9	0.028	0.82	0.715	0.72	0.489	5.62
Zone B	B1	8.6	55	30	5.1	5	0.172	0.01	0.717	0.12	0.013	3.85
	B4	8.6	53	30	4.3	3	0.116	0.10	0.672	0.09	0.015	4.07
	B5	8.7	58	31	4.8	12	0.071	0.04	0.785	0.09	0.014	3.45
	B6	8.6	45	31	8.8	15	0.053	0.12	0.739	0.14	0.057	5.34
	B7	8.6	15	13	5.0	3	0.067	0.12	0.536	0.05	0.007	2.78
	B8	8.7	120	64	4.5	4	0.064	0.04	0.592	0.07	0.006	3.52
	B9	8.7	24	25	4.2	5	0.024	0.09	0.584	0.06	0.008	4.13
Zone C	C1	8.5	52	20	16.6	13	0.108	0.07	0.622	0.14	0.014	9.16
	C2	8.6	48	22	16.7	12	0.075	0.04	0.351	0.11	0.012	5.36
	C3	8.6	58	22	15.4	11	0.090	0.10	0.647	0.09	0.012	4.18
	C4	8.4	42	15	10.4	11	0.051	0.04	0.619	0.08	0.013	4.13
El Mallaha												
Zone D	D1	8.1	20	2	61.6	1	0.083	0.05	0.727	0.02	0.010	0.39
	D2	7.9	32	2	61.1	1	0.055	0.07	0.899	0.03	0.008	0.34
Suez Canal	-5	7.9	60	-	-	0	0.078	0.01	0.475	0.01	0.002	0.25
	-2.5	7.9	1344	-	48.8	3	0.081	0.07	1.050	0.18	0.009	0.79
	0	7.9	462	-	49.1	2	0.042	0.01	0.575	0.01	-	0.28
	2	7.9	30	-	49.5	3	0.023	0.06	0.825	0.05	0.003	0.56
	4	8.0	55	-	46.9	3	0.029	0.10	0.550	0.08	0.014	0.70
	6	8.0	118	-	46.4	3	0.029	0.18	0.750	0.09	0.013	0.53
	8	7.8	710	-	48.2	1	0.041	0.16	0.440	0.11	0.008	0.76
	10	7.9	394	-	52.1	3	0.043	0.09	0.799	0.25	0.021	1.54
	12	7.9	45	-	48.6	1	0.052	0.10	0.750	0.04	0.016	0.84
	14	-	50	-	-	2	0.078	0.09	0.825	0.03	0.011	0.81
	25	7.9	141	-	55.5	1	0.049	0.001	0.601	0.04	0.010	0.73
	35	-	52	-	-	5	0.021	0.01	0.825	0.05	0.004	0.11
	45	7.9	52	-	57.7	1	0.021	0.01	0.665	0.04	0.010	0.76
	55	7.9	35	-	60.3	3	0.019	0.03	0.675	0.03	0.005	1.49
	65	-	42	-	59.1	2	0.026	0.21	0.440	0.004	0.003	0.51
	75	8.0	216	-	59.5	3	0.037	0.004	0.750	0.12	0.016	1.35
Mediterranean Sea												
Port Said Beach		7.7	82	-	-	1	-	0.09	0.475	0.04	0.005	0.62
El Mazrah Shore		7.9	39	-	-	2	-	0.15	0.525	-	0.053	0.67
El Gamil Shore		8.3	60	-	-	4	-	0.22	0.300	0.05	0.014	3.37

TABLE 4.2

DIURNAL STUDIES OF DISSOLVED OXYGEN

		From		To	
Station	Depth	Time	Date	Time	Date
A1	mid	16:45	23 Sept	8:44	24 Sept
B1 (near B5)	top & bottom	18:55	12 Sept	9:45	13 Sept
C2	top & bottom	16:15	9 Sept	8:00	10 Sept
C2	top & bottom	14:00	19 Sept	8:00	20 Sept

TABLE 4.3

BENTHIC LEVELS OF HEAVY METALS

Locations	Concentrations (Dry Sediments)				
	Cu	Zn	Cd	Mn	Fe
	Mg/Kg		Mg/g		
Suez Canal					
+65 Km	2	53	2.2	18	0.7
+45 Km	4	8	2.3	24	1.3
+25 Km	41	86	3.6	570	2.6
+14 Km	Sample unsuitable for analysis				
+10 Km	16	55	2.2	574	3.0
+ 6 Km	Sample unsuitable for analysis				
+ 2 Km	37	87	3.0	378	3.5
-2.5 Km	58	115	5.0	1007	8.5
Lake Manzala					
A1	158	355	7.9	506	5.6
A2	54	198	10.4	502	6.2
A3	41	130	8.5	238	5.6
A4	83	219	3.0	504	7.6
B5	43	100	6.1	495	3.8
B6	13	22	3.8	159	3.3
B9	65	110	8.7	900	8.3
C2	61	108	3.8	785	5.4
C4	55	123	5.5	741	5.9
El Mallaha					
D2	39	72	3.8	569	4.5
Mediterranean					
El Gamil	13	59	3.0	322	2.5
El Mazrah	10	50	3.1	262	2.3
Port Said	14	50	3.2	334	2.5

TABLE 4.4

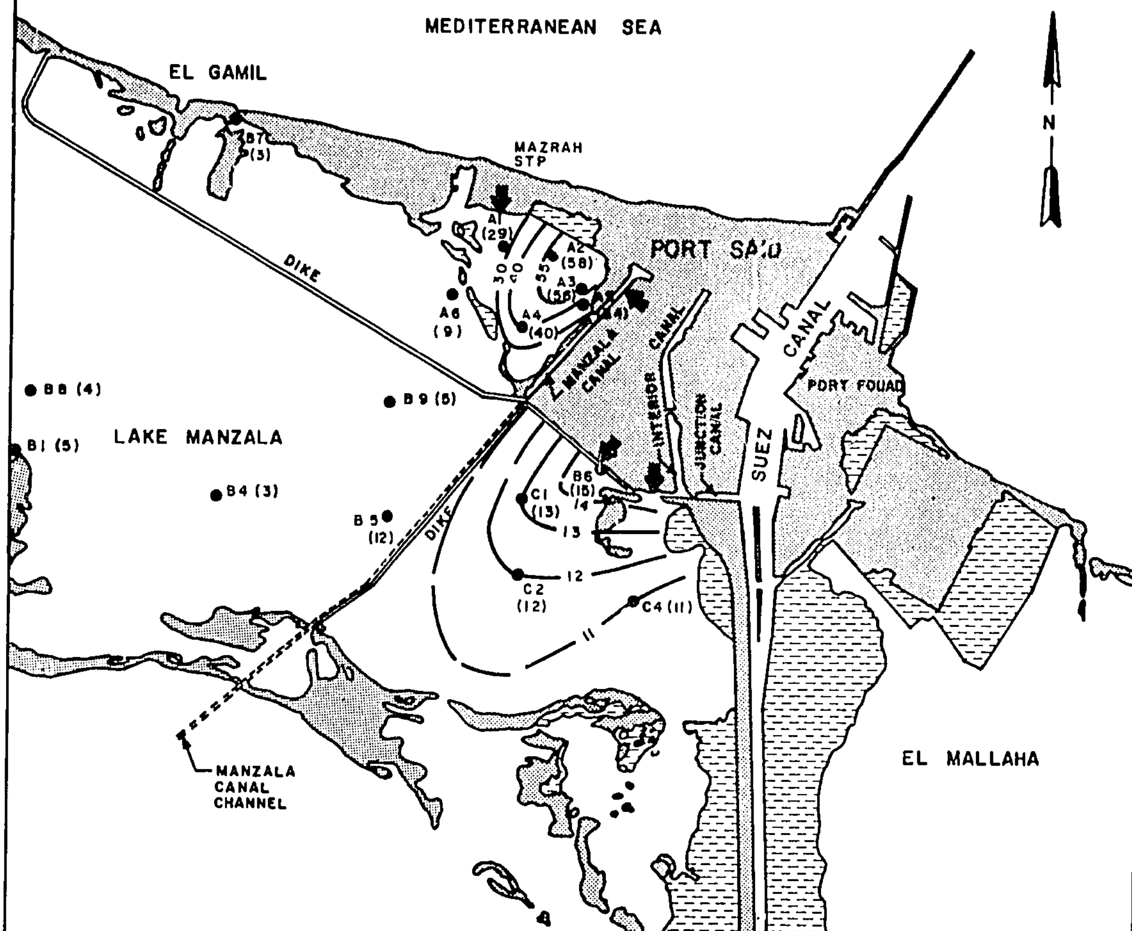
BENTHIC LEVELS OF PESTICIDES
IN PARTS PER BILLION (PPB)

Location	Pesticide				
	Lindane	B-BHC	DDE	DDD	DDT
Suez Canal					
+65 Km	-	-	76.4	-	-
+45 Km	-	30	22	160	-
+25 Km	28	-	89.1	-	-
+14 Km	23.4	-	89.1	-	-
+10 Km	-	23.3	101.8	-	-
+ 6 Km		No sediments (rocky)			
+ 2 Km	38.3	11.6	152.1	-	-
-2.5 Km	-	46.6	168	-	-
Lake Manzala					
A3	46.6	82	178.2	-	-
A2	23.4	46.6	165.4	-	-
A4	-	35	152.7	-	-
B5	-	70	190.9	-	-
B8	58.6	93.2	190.9	-	-
B9	40	70	114.5	-	-
C2	11.6	58.6	190.9	-	-
C4	19.8	-	156.4	-	-
El Mallaha					
D2	-	46.6	152.7	-	-
Mediterranean					
El Gamil	93.2	35	44.5	-	-
El Mazrah	-	58.6	31.8	-	-

TABLE 4.5

PESTICIDE LEVELS IN THE AGRICULTURAL DRAINAGE SYSTEM

Code Number	Location	Lindane	DDE
Ag F30/9	Field Furrow	2.4	1.0
Ag D30/9	Field Drainage Channel	4.1	0.7
El Bakar 30/9	Bahr El Bakar Drain	7	1.2



LEGEND

- DRY LAND
- INTERMITTENTLY FLOODED AREAS
- SEWAGE OUTFALL
- (3) mg/l BOD_5

APPROX. SCALE: 1:100,000

0 1.0 2.0 3.0 4.0 Km.

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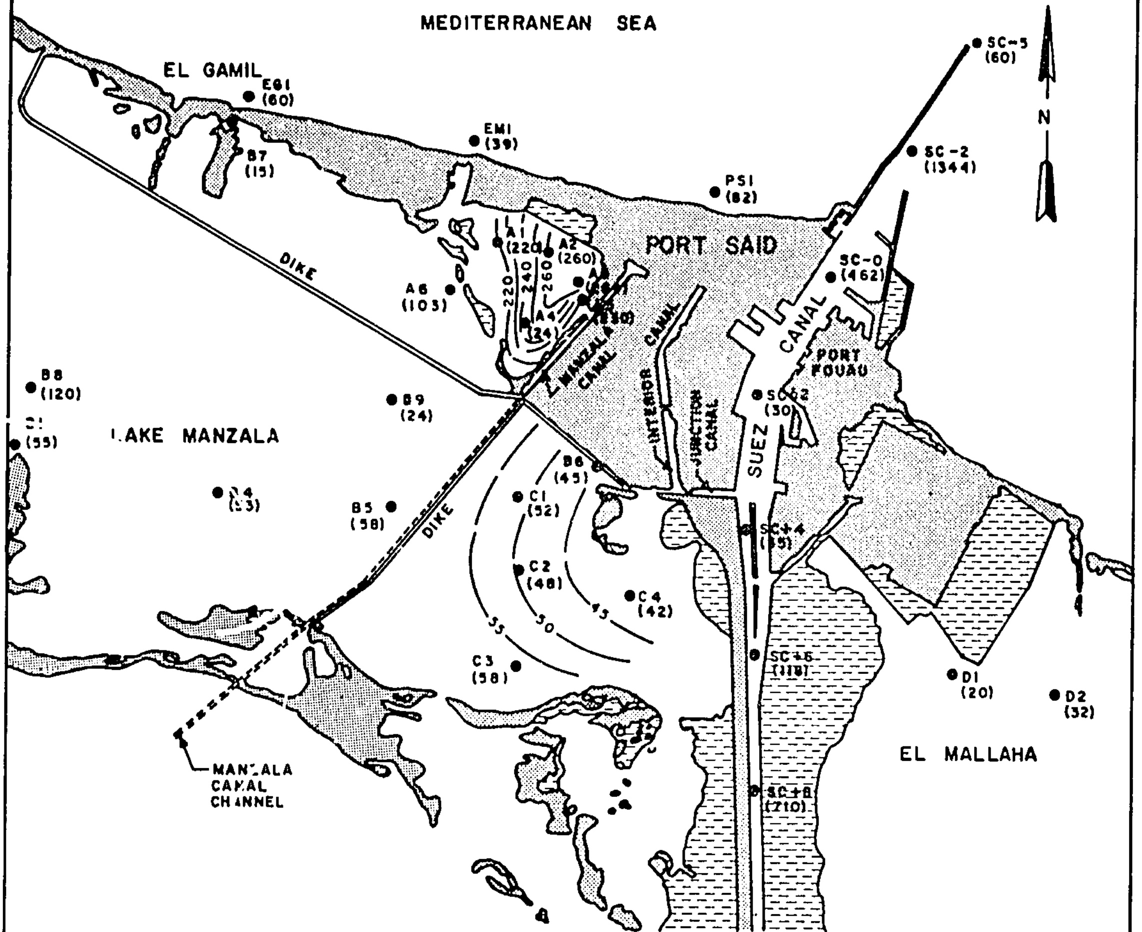
WATER AND WASTEWATER FACILITIES MASTER PLAN

CONCENTRATION OF BOD_5 IN LAKE MANZALA

VOL.4 FIG. 4-A



LEGEND

DRY LAND

INTERMITTENTLY FLOODED AREAS

(220) mg/L SUSPENDED SOLIDS

APPROX. SCALE: 1:100,000

0 1.0 2.0 3.0 4.0 Km.

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CONCENTRATION OF SUSPENDED SOLIDS

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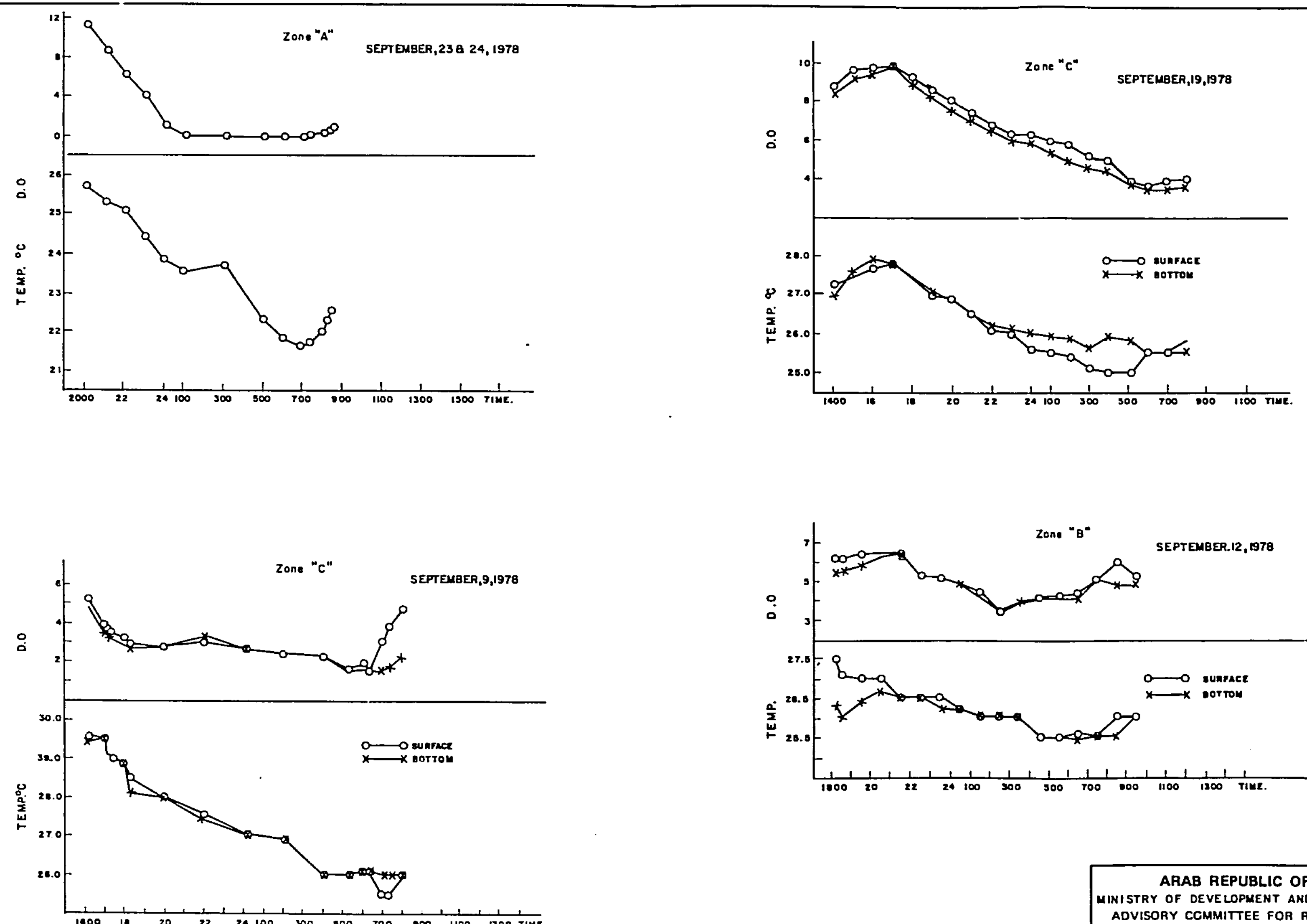

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DIURNAL VARIATION OF TEMPERATURE AND DISSOLVED OXYGEN

VOL.4 FIG. 4-C

CHAPTER 5

BIOLOGICAL CHARACTERISTICS OF THE RECEIVING WATERS

5.1 INTRODUCTION

During preparation of Special Report No. ' is was discovered that there was no data defining the general biological characteristics of the Port Said receiving waters. In order to assess the impact of existing wastewater discharges and those proposed for the future, it was necessary to collect additional biological data.

Water column samples were collected and analyzed for phytoplankton and zooplankton biomass, and for identification and enumeration of major species. Benthic samples were obtained for identification and enumeration of benthic invertebrates.

Samples for bacteriological analysis were taken at all stations to determine the bacterial impact of existing raw sewage discharges. Coliform die-off studies were performed both in situ and in the laboratory to serve as a basis for predicting the impacts of future wastewater discharges.

5.2 PHYTOPLANKTON

Grab samples for phytoplankton and chlorophyll A were taken in Lake Manzala, El Mallaha, and the surf zone of the Mediterranean Sea.

Lake Manzala

Samples from Zone A of Lake Manzala, the site of the Mazrah discharge, could not be analyzed. High levels of nutrients and phytoplankton made stabilization of samples with formalin impossible without destroying the algal cell's integrity. Chlorophyll A data indicate phytoplankton biomass in Zone A is about ten times that in other areas of the lake (see Figure 5-A). A sample analyzed at the site indicates plankton populations in Zone A are dominated by diatoms such as the Melosira genus.

In Zone B of Lake Manzala, diatoms also dominated. Three examples of the Centricae and nine of the Pennatae were identified. One example of the dinoflagellates, Prorocentrum adriatica was found. Average phytoplankton densities in Zone B were 77 x 10^5 cells per cubic meter while chlorophyll A values ranged from 7.2 to 13.3 mg/l. Highest phytoplankton diversity occurred at Stations B9 and B5, the most eastern stations. Zone B phytoplankton populations in this area are probably supplemented by plankton from Zone A carried down the Manzala Canal. Genera peculiar to the eastern stations are Grammatophora spp. and Tropidoneis spp. indicating their presence in Zone A.

The phytoplankton community of Zone C in Lake Manzala is comprised entirely of diatoms. Six genera were found as shown in Table 5.1. The dominant genera are Cosinodiscus spp. and Melosira spp. representing 54 percent and 32 percent respectively of the cell densities. Average cell densities were 28 x 10^5 cells per cubic meter, about one-third of the Zone B production. Diversity is consistent throughout the zone.

El Mallaha

El Mallaha, Zone D, is the least productive of the areas sampled. Average cell densities were 22.8 x 10^5 cells per cubic meter although chlorophyll A values were higher than in other lake zones (see Figure 5-A). Comparison of individual cells from El Mallaha showed a generally larger cell and chloroplast size. This indicates that chlorophyll A is not a suitable standard for comparing productivity in the two receiving waters.

Mediterranean Sea

Examinations of samples taken from the Mediterranean surf zone of Port Said indicate low productivity. Cells are rare and only diatoms and dinoflagellates are present. Cell densities were less than 20 x 10^5 cells per $meter^3$.

5.3 ZOOPLANKTON

Vertical hauls for zooplankton were taken in Lake Manzala, El Mallaha, and the surf zone of the Mediterranean Sea.

Lake Manzala

In Lake Manzala 19 species of zooplankton were identified. Only three organisms were identified in Zone A, the area most affected by the raw wastewater discharge from Mazrah. The Zone A plankters include; the freshwater form Harpacticoida, the euryhaline Nauplius larvae of Cyclops, and an unidentified fish fry.

In Zone B of Lake Manzala 14 genera were identified as shown in Table 5.2. The dominant freshwater form is Diaphanosoma at 4.14 x 10^5 organisms per cubic meter. Marine forms are dominated by the Protozoan Titinnipsis spp. at 5.14 x 10^5 organisms per cubic meter. Less abundant were freshwater cladocera such as Moina spp. and neritic (shallow coastal or marine littoral) copepods such as Ascartia latisetosa. Population diversity was highest near El Gamil where chlorosity concentrations (5.5 to 13.0 ppt) are within tolerance levels for freshwater forms such as Moina spp. (1.06 - 5.69 ppt) and forms of marine origin such as Nauplii of cirripede (0.70 - 24.73 ppt). Chlorosity at other stations in Zone B are generally below tolerance levels for marine species other than the neritic copepods.

In Zone C of Lake Manzala zooplankton populations were dominated by Cyclops spp. The dominance of marine organisms is consistent with the lack of freshwater flow to the area and high salinities in the summer. Similar characteristics of summer populations have been noted in other studies of Lake Manzala plankton. Diversity is highest near the Zone C connection with the Junction Canal. Density of zooplankton is also higher near the Junction Canal, probably due to availability of food in the form of phytoplankton. Zooplankton productivity, like phytoplankton, is lower in Zone C than in Zone B as shown in Table 5.2.

El Mallaha

The high salinities of the El Mallaha environment are reflected in its zooplankton population. The dominant species, Oithona nana, is a marine species favored by chorosities of 11.91 to 24.73 ppt. Oithana nana represents about 60 percent of individuals counted. The remainder of the population is comprised of other marine copepods such as Cyclops spp., Euterpina acutifrans, larval and copepodite life stages and ostracods such as Cyprideis spp.

Mediterranean Sea

Zooplankton found in the surf zone of the Mediterranean were limited to the copepods. Major genera were Calanus spp., Calocalanus spp., Ascartia spp., Oithona spp., Corycaeus spp. Quantitative analysis was not performed on the Mediterranean samples.

5.4 BENTHIC ANIMALS

Benthic samples were taken by Peterson Dredge in the Suez Canal, Lake Manzala, El Mallaha and the surf zone of the Mediterranean Sea.

Lake Manzala and El Mallaha

Benthic populations, in terms of diversity and numbers of organisms, varied little throughout the lake. Populations were dominated by the molluscs, Cardium spp., Hydrobia spp. and Venus spp.

In Zone A of Lake Manzala few living specimens were taken. Nine genera were identified from shells as shown in Table 5.3. Two genera of the Polychaetes, Hydroides spp. and Merceriella spp. were identified. These genera are abundant only at Station A3, the station least affected by the raw sewage discharge from Mazrah. Five genera of the mollusca were found in Zone A. The molluscs Cardium spp. and Hydrobia spp. were dominant at most stations with the exception of Station A4 where Venus spp. was domiant. Diversity was highest at Station A3 (nine genera) where the water is best within the zone. A representative of the Cirripedea, Balanus spp. was found throughout the zone except at Station A4.

In Zone B of Lake Manzala, six genera of benthic fauna were found. The polycheate, Merceriella spp. was found in small numbers at all stations. Molluscs are represented by four genera as shown in Table 5.3. Cardium spp. and Venus spp. were abundant at the three stations sampled. The Cirripea, Balanus spp., was identified at only Station B5.

Benthic populations in Zone C of Lake Manzala are similar in species composition to those of Zone B. Five genera were identified with the mollusc, Cardium spp., the dominant organism.

El Mallaha benthic populations were low as shown in Table 5.3. The dominant organism was Hydrobia spp.

Suez Canal

Six stations were sampled for benthic organisms in the Suez Canal. Four samples were devoid of benthic invertebrates as shown in Table 5.4. At station +2 km, four genera were found, all molluscs. Three of these genera, Cardium, Hydrobia, Venus, are abundant in Lake Manzala. Brackish water flowing from the lake to the Suez Canal lowers salinities sufficiently to allow colonization by these species at the +2 km station. Examination of the benthic substrate at station +2 km showed it to be similar to the lake substrate. Organic content is higher than at other Suez Canal stations where the substrate is generally sand and rock. Donax spp., common in the Mediterranean, was also found. Two genera were identified at station +55 km as shown in Table 5.4.

Mediterranean Sea

Benthic samples were taken at all three Mediterranean surf zone stations. The data indicate the population diversity and numbers decrease with higher salinities, although changes in benthic substrate are at least partly responsible. At the El Gamil station where the influence of Lake Manzala's brackish water is highest, diversity and numbers are highest. Five genera were found at the El Gamil station as shown in Table 5.4. At the El Mazrah site about 5 km east of El Gamil, the effect of the brackish water outflow from Lake Manzala is still significant. Five mollusc genera were found. Like the El Gamil station, Donax spp. is dominant. At the Port Said station, 10 km east of El Gamil, salinities are unaffected by outflow from Lake Manzala. Only two genera were found at this station. Productivity at the Port Said station was low (233 organisms per square meter) compared to 372 per square meter at El Gamil.

5.5 BACTERIOLOGY

Lake Manzala and El Mallaha

El Mallaha is relatively free from sewage-related bacterial contaminants. Lake Manzala receives bacterial loads from raw sewage discharges at El Mazrah, at the Manzala Canal, and at Kabbutti on the Junction Canal as shown in Figure 5-B. However, these discharges have only local effects. There is no significant contamination in the study area from the discharge of the agricultural drains located on the southern end of the lake. Most of Zones B and C in Lake Manzala and Zone D in Lake Mallaha have fecal coliform densities (geometric means) well below the USEPA bathing criteria (200 per 100 ml), as shown on Figure 5.2.

Localized contamination occurs at Zone A stations that are at times located in the effluent plume from El Mazrah (Stations A1, A2, A5 and A6) or near the Manzala Canal (Station A5). At these stations, levels of 10^5 to 10^6 fecal coliforms per 100 ml occur. Outside the plume coliform levels reduce rapidly to less than 200 MPN/100 ml. This reduction is due to dilution and die-off from the effects of high temperatures, solar radiation, salinity, and antagonistic marine life. Reductions due to die-off alone are between 90 percent and 99 percent per day in Zone A, based on laboratory simulations.

In the Junction Canal high levels of over 10^6 fecal coliform/100 ml are found near the sewage outfall at Kabbutti. Due to dilution and die-off, coliform levels are reduced to less than 10^4 per 100 ml before they reach the Suez Canal. Occasionally Zone C is affected by the contamination due to the opening of the dike across from the outfall. Levels at Station C1 are significantly higher than other stations in Zone C as shown in Figure 5.2.

Mediterranean Sea

The waters of the Mediterranean Sea along the Port Said coast are safe for bathing from a bacteriological standpoint. As noted on Figure 5-B, samples taken off the Port Said beach, near the El Mazrah outflow and near El Gamil, show fecal coliform geometric mean levels well below the recommended USEPA bathing criteria (200 per 100 ml).

Suez Canal

The Suez Canal between the Mediterranean Sea and the 65 km milepoint is free from sewage-related bacteria, except in the vicinity of the Junction Canal. Due to the raw sewage discharge at Kabbutti in the Junction Canal, fecal coliforms at the +4 km station are over 2800 MPN/100 ml. Dilution and die-off reduce the bacterial levels to 5 and 3 MPN/100 ml at points two km north and south respectively from this station. The remaining stations are free of coliform bacteria.

TABLE 5.1

PHYTOPLANKTON DENSITIES

(cells per cubic meters x 10^5)

ORGANISMS	CELL DENSITIES		
	LAKE MANZALA		EL MALLAHA
	Zone B	Zone C	Zone D
CENTRICAE			
Consinodiscus spp.	6.67	15.00	1.20
Melosira spp.	22.67	9.00	10.40
Cymbella spp.	3.33		
Actinoptychus spp.			
PENNATAE			
Nitschia spp.	18.67	0.50	6.80
Navicula spp.	10.67	1.00	2.80
Grammatophora spp.	1.00		0.80
Pleurosigma spp.	2.67		
Tropidoneis lepidoptera	0.67		
Asterionella spp.	1.00	0.50	
Rhabdonema adriatica	0.67		
Surirella spp.	0.67		
Thalassionema nitzshoides			1.60
Cymbella spp.	3.33		
DINOFLAGGELLATES			
Prorocentrum adriatica	4.33		
OTHERS			
Bacillaria spp.		2.00	2.00
Codmellopsis spp.	0.67		

TABLE 5.2

ZOOPLANKTON BY SPECIES DENSITIES

(in organisms per cubic meter x 10^5)

	LOCATION			
	LAKE MANZALA			EL MALLAHA
	Zone A	Zone B	Zone C	Zone D
CLADOCERA				
Diaphanosoma spp.		0.14	0.75	
Moina spp.		0.71	0.50	
Daphnia spp.		0.43		
OSTRACODA				
Cyprideis spp.		0.41	2.50	1.50
COPEPODA				
Acartia latisetosa			3.00	
Oithona nana				19.00
Cyclops spp.		1.43	8.50	3.00
Euterpina acutifrons				2.30
Cyclops (copepidite stage)			0.50	
Nauplias larval of opepoda	0.49	0.57	1.00	1.00
CIRRIPIDAE				
Nauplius larvae				1.50
Cypris larvae		0.14	0.25	1.00
DECAPODA				
Mysis larvae of *Leander squilla*			0.50	
Mysis larvae (unidentified)			8.25	1.50
PROTOZOA; TINTINOIDEA				
Titinnopsis spp.		5.14		
Favella spp.		0.29		
ROTIFERA				
Rotifers (unidentified)		0.43		
CHAETOGNATHA				
Spinoid larvae of Polychaeta			0.50	
Veliger larvae of Lamelli branch		0.29	0.25	
OTHERS				
Eggs of Crustacea				3.00
Harpacticoida	0.21	0.43	1.50	
Calanoida			0.50	

TABLE 5.3

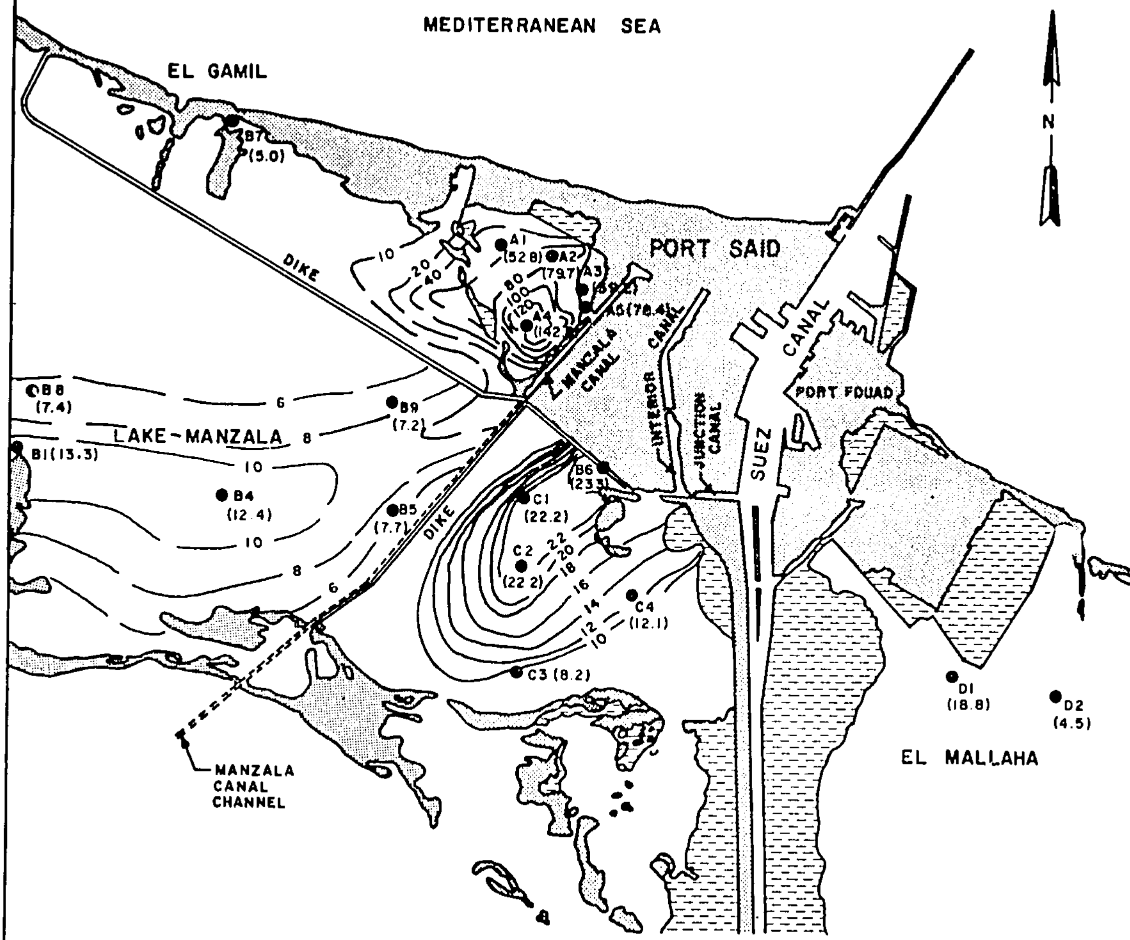
BENTHIC FAUNA OF LAKE MANZALA AND EL MALLAHA
(Organisms per square meter)

ORGANISMS	ZONE A				ZONE B			ZONE C		ZONE D
	A1	A2	A3	A4	B5	B8	B9	C2	C4	D2
POLYCHAETA										
Hydroides spp.			abundant							
Merceriella spp.		rare	abundant	rare	rare	rare	rare	rare		
MOLLUSCA										
Bollinus spp.			17							
Cardium spp.	69	209	97	33	244	350	139	484	327	11
Corbicula spp.		56	33		28	19	53	41		
Hydrobia spp.	50	289	233		67	94	327	169	211	183
Venus spp.	36	383	78	6	155	50	214	292	261	11
CIRRIPEDIA										
Balanus spp.	11	11	33		11					
ASCIDIANS										
Colonies of *Potrellus*			abundant							

TABLE 5.4

BENTHIC FAUNA OF THE SUEZ CANAL AND MEDITERRANEAN SEA
(Organisms per square meter)

ORGANISM	MEDITERRANEAN SEA			SUEZ CANAL					
	EL GAMIL	EL MAZRAH	PORT SAID	+55 KM	+25 KM	+14 KM	+10 KM	+2KM	-2.4 KM
POLYCHAETA									
Merceriella enigmatica	rare	-	-	-	-	-	-	-	-
Unidentified spp.	-	-	-	17	-	-	-	-	-
MOLLUSCA									
Bollinus spp.	-	11	-	-	-	-	-	-	-
Cardium spp.	17	-	-	11	-	-	-	67	-
Corbicula spp.	28	11	-	-	-	-	-	-	-
Donax spp.	305	122	89	-	-	-	-	100	-
Hydrobia spp.	22	17	144	-	-	-	-	67	-
Venus spp.	-	22	-	-	-	-	-	56	-
BRYOZOA									
Shezoporella spp.	-	-	-	-	-	rare	-	-	-



LEGEND

DRY LAND

INTERMITTENTLY FLOODED AREAS

(12.4) ug/L CHLOROPHYLL "A"

APPROX. SCALE: 1:100,000

0 1.0 2.0 3.0 4.0 Km.

ARAB REPUBLIC OF EGYPT

MINISTRY OF DEVELOPMENT AND NEW COMMUNITIES
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PORT SAID
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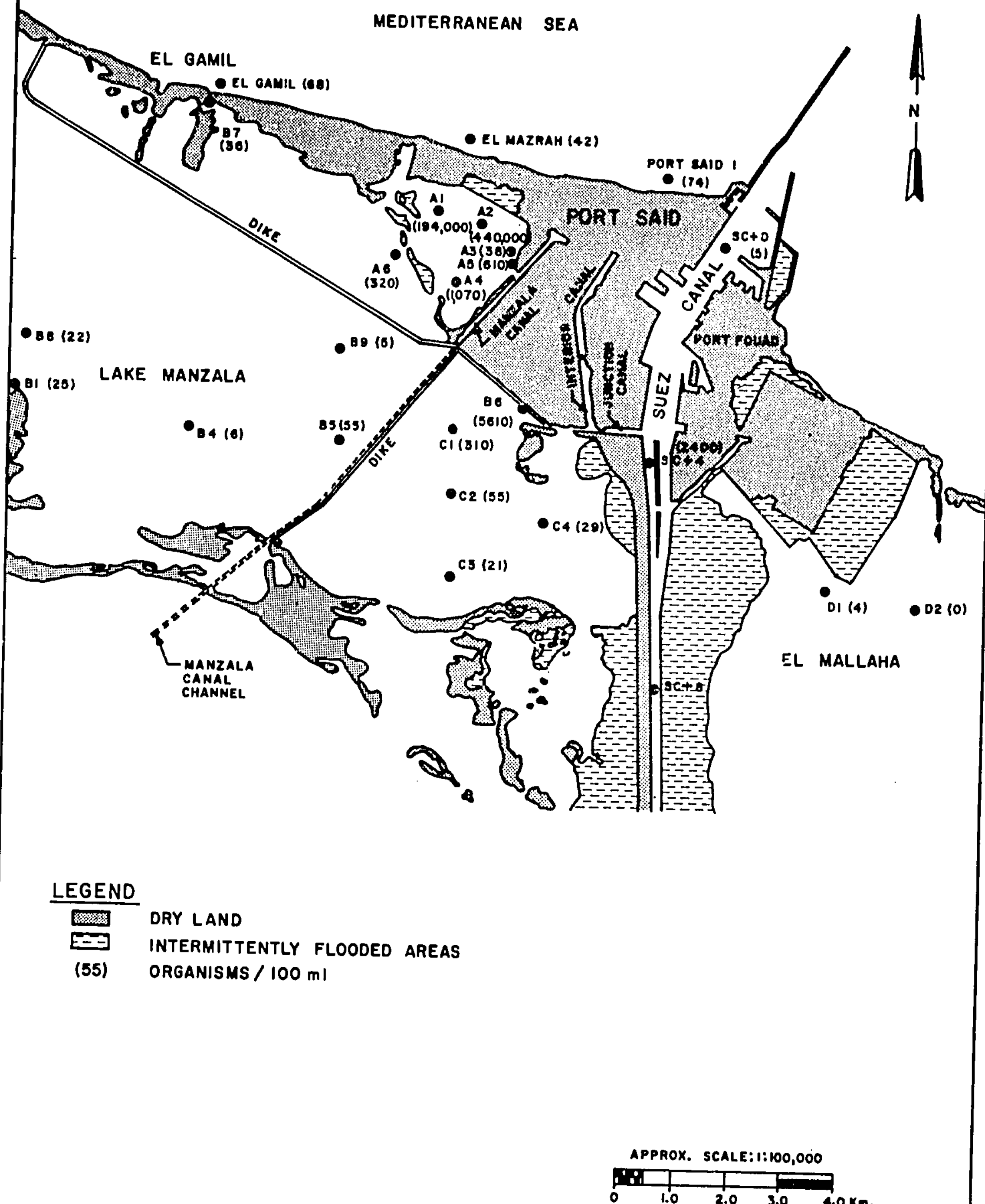
CONCENTRATION OF CHLOROPHYLL "A" IN LAKE MANZALA AND EL MALLAHA

VOL. 4 FIG. 5-A



LEGEND

DRY LAND

INTERMITTENTLY FLOODED AREAS

(55) ORGANISMS / 100 ml

ARAB REPUBLIC OF EGYPT

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ADVISORY COMMITTEE FOR RECONSTRUCTION

PORT SAID
WATER AND WASTEWATER FACILITIES MASTER PLAN

CONCENTRATION OF FECAL COLIFORMS IN LAKE MANZALA AND EL MALLAHA

VOL.4 FIG. 5-B

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CHAPTER 6

PORT SAID FISHERIES

6.1 INTRODUCTION

The impact of wastewater discharges on the Port Said fisheries is a major consideration in assessing potential disposal options. In this chapter the condition of the fisheries, the relationship to existing sewage discharges, and the potential beneficial and adverse effects of future wastewater discharges are assessed.

6.2 HISTORICAL TRENDS IN THE PORT SAID FISHERIES

The Port Said fisheries include the Mediterranean Sea, Lake Manzala and El Mallaha. The historical data base was reviewed to establish trends in yield and fishery exploitation. Poor management by overfishing or use of overselective gear can create fishery conditions similar to those caused by sewage pollution. Information was collected to distinguish between poor fishery management and unfavorable conditions due to sewage pollution.

Mediterranean Sea

The Mediterranean Sea fishery in the Port Said area supports commercial quantities of finfish, shrimp and crabs.

Finfish catches are comprised of pelagic and demersal species. Exploitation of the demersal finfish stock is generally by Italian trawl. Demersal species, primarily the Mullidae, Serranidae, and Sparidae comprise 60% of the annual fish catch. Marine forms like the Mullidae have increased in commercial importance since the Aswan Dam was completed. Another 8% of the total catch or 21% of the trawl catches are Red Sea species such as *Siganus signanus* which have migrated to the Eastern Mediterranean through the Suez Canal. The remainder of the catch is comprised of pelagic species. Important pelagic species are caught by either mullet nets (*Mugil capita*, *M. cephalis*), longlines (Scombroides), or gillnets (*Sardinalla aurita*, *S. maderensis*).

The Mediterranean shrimp catches are comprised of five principal species as shown in Table 6.1.

Shrimp catches are confined to depths of less than 100 meters. Yields are 33.3 kg/hr at depths less than 50 meters, 22.7 kg/hr at depths between 50 and 100 meters and 0.0 kg/hr at depths greater than 100 meters. Composition of shrimp populations varies with depth. Catches at 25 meters depth are comprised mainly of *Metapenaeus* and *Parapenaeus* species. At 50 meters, the majority of the catch is *Penaeus* species. Extended fishery pressure at a particular depth could irreversibly alter the species character of the shrimp populations and should be considered in future management proposals.

The Mediterranean crab fishery of Port Said is comprised of two species, *Neptunus pelagicus* and *Callinectes sapidus*. Since the building of the Aswan Dam, populations of stenohaline *N. pelagicus* have increased while populations of *C. sapidus*, a euryhaline species, have declined.

Production in the Port Said Mediterranean fishery has declined by over 90% since 1962 to current levels of approximately 575 tons/year as shown in Figure 6-A. Production decreases are due to a number of factors.

Construction of the Aswan Dam and cessation of the Nile floods have caused a decline in the sardine fishery. Sardine catches which once comprised 48% of the total production declined from 18,000 tons (1962) to 460 tons in 1968 for Egypt's Mediterranean fisheries. This effect may not be too significant for the Port Said fishery since the majority of sardine harvest occurred west of Damietta.

Declines have occurred in the shrimp fishery because of over-fishing of stocks. Production in the shrimp fishery decreased from 8,000 tons in 1962 (27% of catch) to 1,130 in 1969 (13% of catch). Steps have been taken to reverse this trend in recent years by banning shrimp fishing in the brackish water Delta Lakes.

Another reason for the decline in Mediterranean production is the significant decrease in fishing activity. In 1964, before the effects of overfishing and the Aswan High Dam became evident, 650 motorized vessels were used for fishing. The number of fishing trips per year was approximately 35,000. Each vessel produced approximately 42 tons/year of fish and shrimp. By 1970, the number of motorized boats had declined to 59 and fishing trips to 16,000 per year principally out of Alexandria. The unit effort catch remained relatively constant at 44.2 tons/year for each vessel.

Management potential is good since 95% of exploitation is by cooperatives and 5% by the Northern Fishery Company. This gives the Government of Egypt an indirect control of operations. However, it is doubtful that the Mediterranean fishery of Port Said could sustain past optimal yields even with effective management. Although some hope is expressed that migrating Red Sea species may offset the effects of overfishing and reduced Nile flows, this is doubtful. The Mediterranean Sea fishery will continue to be resource limited.

Lake Manzala

Although productivity is low, Lake Manzala produced over 29,000 tons of fish in 1975, which is 75% of the production of the Delta Lakes and over 26% of the production of all Egyptian fisheries. Lake Manzala is fished by sailboat using small trammel nets. The principal catch are the mullets and tilapia. Approximately 85% of the catch is composed of Tilapia nilotica, T. galilae, and T. zilli. The remainder of the catch are Mugil, Clarius, Anguilla, Labeo and Barbus. The eels (Anguilla), mullets (Mugil) and shrimp species use the lake primarily as feeding areas, returning to the sea during their respective spawning periods.

Productivity of Lake Manzala is lower than any of the Delta Lakes with the exception of Lake Burillos. Productivity in Lake Manzala, 162 kg/ha/yr, is significantly less than in Idku Lake (587 ka/ha/yr) and Lake Muriut (1002 kg/ha/yr). The relative productivity of the lakes correlates well with nutrient supplies, Manzala's being the lowest.

Fishing pressures on Lake Manzala originates primarily in the village of El Matariya located on the southwest coast of the lake. Exploitation of the lake fisheries has been regulated for over 40 years. Equipment such as net mesh size and vessel types are regulated as well as fishing locations and seasons. Of particular interest in Lake Manzala is the prohibition of skiffs. The prohibition is apparently designed to protect spawning areas and fry during growth in shallow areas. However, there is no scientific data to support this policy.

El Mallaha

Little historical data are available on the fishery of El Mallaha. However, it is known to be an important mullet fishery under intensive management and exploitation by the Overseas Research Institute. Facilities are located on the eastern shore near the salt works canal.

6.3 CURRENT STATUS OF PORT SAID FISHERIES

Data was collected on the Port Said fisheries during August and September 1978. Production and exploitation information for the Mediterranean Sea and El Mallaha was obtained from the Overseas Research Institute. Information on production and exploitation in Lake Manzala was collected in the field and through interviews with local fishermen. Catches were taken monthly in Lake Manzala for analysis of population characteristics and parasite presence.

Mediterranean Fisheries of Port Said

Data was obtained from the Overseas Research Institute for the months of August and September 1978. An example of the available records is shown on Table 6.2. Approximately 48 percent (106,690 kg) of catches are comprised of the sardine species *Sardinella aurita*. Shrimp of the *Metapeneus* genus represent another 14 percent. The remaining catch includes demersal genera such as *Epinephelus* (Grouper) and pelagic genera such as *Mullus*. A breakdown of August's monthly catch by area and species is included in Table 6.3.

An average of 8 motorized vessels and 22 unmotorized vessels exploit the Port Said Mediterranean fishery on a daily basis. Normal crew size ranges from 1 to 13 men. The majority of the motorized vessels employ Italian trawl for exploitation, although long lines, mullet nets and gill (trammel) nets, and Habla fishing gear are used. No data were available on total square feet of net used or mesh size.

The most commonly used fishing gear in the Port Said area are trammel nets, wire traps and hooks. Trawlers usually fish east of Port Said while hooks and lines are used north of Port Said. In August 1978, the amount of fish caught by one fishing effort with hooks was 0.012 kg/hour/boat/man. For trawls, the weight of fish per hour per boat per man is about 0.19 kg. For Haba gear one fishing effort yielded 0.21 kg/hour/ boat/man.

Catch per unit effort (CPUE) during the study period may be projected to an annual yield of 12.9 tons/vessel compared to an average annual yield of 44.2 tons/vessel for the Egyptian Mediterranean fishery in 1975.

Average retail value of the catches is approximately LE 1 per kilogram. Average daily catch is 48 kilograms and average crew size of 8.6. On this basis, daily earnings of individual fishermen is approximately LE 6 minus operating expenses. Retail incomes of the Port Said Mediterranean Fishery for August 1978 is estimated to be approximately LE 223,000.

Lake Manzala Fishery

Fishing operations in Lake Manzala are conducted by professional fishermen. Operations in Port Said originate from Kabbutti located near the Junction Canal. Types of fishing gear used are variable, including trawl nets, gill nets and trammel nets. The gill nets are the most commonly used form of apparatus. Length of the gill nets used range from 600 to 900 meters. Mesh size is about 36 mm. Based on field observations, 30 to 50 boats from Kabbutti are on the Lake daily. Crew size varies between 1 and 4 men.

Commercial catch records for August 1978 were reviewed to establish yield and species composition of Lake Manzala landings. Total landings for August are 328,249 kilograms. Tilapia species including T. galilae, T. nilotica comprise 57% to 83% by weight of recorded daily catches. Mullets (M. cephalus and M. saliens) represented 8 to 17% of the landings. Marine fish (3.6 to 10.6%) and freshwater fish (3.2 to 5%) other than Tilapia spp. are the remainder of the catch. A list of species taken from Lake Manzala is presented in Table 6.4.

To supplement the available catch records, local fishermen were hired to fish as normal and were observed. Catch per unit efforts (CPUE) for the Lake Manzala mullet fishery are 0.14 kg/man/vessel/hr during experimental captures. For Tilapia, the CPUE is 0.20 kg/man/vessel/hr. Observations probably slowed down the fishing activity and travelling to and from fishing sites accounted for up to half the vessel trip time. Actual CPUE's are likely 2 to 2.5 times the experimental value.

Catches were examined for population characteristics and presence of parasites. Five fish samples were taken, two during the day for Tilapia and three night operations for mullets. Locations are shown on Figure 6-B. The observed population characteristics are as follows:

Genus Mugil

Length of Mugil capito caught during the short survey in the lake varies between 16 and 23 cm total length. Mean weight varies between 26 gm and 121 gm. The condition factor is between 1.18 and 0.99. The condition factor* is low for small fish but increases at lengths more than 18 cm. Table 6.5 shows the length frequency of the commercial catch of M. capito from the lake.

Length distribution of the M. capito ranges from 11 to 20 cm with modal lengths occurring at 13 and 16 cm. According to recent literature, the fish of age Class I should be approximately 13 to 15 cm and age Class II, 17 to 22 cm in length. However, age composition studies of the M. capito samples indicate that the population is dominated by age Class O fish rather than the expected age Class I fish, as shown in Table 6.6.

The data would normally indicate that the present method of exploitation is either selective for the earlier age class or that overfishing has occurred. However, the lake is commonly used as a feeding ground for young fish which may yield the observed catch characteristics.

In the Mugil capito population, males were predominant at 56.6 percent. Since the Lake Manzala population represents future spawning stock, a trend to low productivity may be indicated. The mean condition factor at 0.95 was lower than other species examined as shown in Table 6.7. This indicates that relative health of the species is lower. The length/weight relationship for the species is $\log W = -0.14 + 2.99 \log L$.

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*The condition factor, a coefficient, is a convenient way of comparing the relative health of populations. The higher the factor the higher the weight or biomass for any particular age class of fish.

Mugil cephalus (grey mullet) represented approximately 7% of the experimental catches. The length of fish caught varied between 12 and 29 cm with the average of 13 cm. The majority, 78% of the catch belonged to the 0 age class. No fish of the Class III age group were found, indicating overfishing. The condition factor increases with age, favoring older individuals. However, intensive expolitation does not allow fish to reach this age.

Sex composition of the species is female predominant at 60 percent indicating a normal productive population. The length/weight relationship for the species is represented by:

$$\log W = -1.30 + 2.48 \log L$$

Captured individuals of Mugil auratus were predominantly female (70 percent). Sample size was too small to determine whether this was due to the agility of the males, or accumulation of females at the capture site.

Age class distribution was: Class II, 12%; Class I, 76%; Class 0, 12%. The condition factor varies between 0.85 and 1.50. This factor varies with age, highest for the Class I age group and declining as the fish approaches sexual maturity. This data may indicate a population response to the predominance of females, potential overcrowding and population stunting.

Length distribution of the commercial fish landed is 11 and 19 cm total length with a mode around 16 cm. Average weight is 36.1 grams. The length weight formula is the following:

$$\text{Log } W = 0.97 + 2.14 \log L$$

Standard length is about 83% of the total length, head length is 22% of the total length while body depth is about 20% of the total length as shown in Table 6.7.

Only 11 fish of the M. chelo species occurred in the experimental captures. The majority were 13 cm total length. The mean condition factor was 1.4. Most fish in the sample were females. Fish age group I predominated.

Morphometric indices are summarized in Table 6.7.

The Mugil seheli species were represented by only 3 individuals. They were females about 16 cm total length and a total weight of about 45 gm. Age of these fish was I year.

Sample size of M. saliens was limited to 10 fish, of total length varying from 12 to 16 cm. Total weight varied between 29 and 33.5 gm. Mean conditions factor was about 1.2.

Most fish in this sample belong to age group I. Sex ratio shows predominance of females (57% females against 43% males).

Morphometric indices show that standard length is about 82% of the total length, the head length is about 21.8% of the total length and the body depth is about 20.0% of the total length.

Fecundity. No individual of the Mugil genera was found to be ripe in the present sampling. The majority of examined samples were however sexually mature.

Genus Dicentrarchus

Sample size of Morone punctata was limited to 24 fish. Total length ranged from 12 to 15 cm, with a mode of 14 cm. Weights vary between 21.9 and 38.75 gm. The mean condition factor is about 1.13. In the sample examined, the males predominate (29.1% female against 70.9% males).

Standard length is about 82% of the total length, head length is about 27% of the total length and the body depth is about 21% of the total length.

Twenty individuals were identified as Morone labrax. Total length of fish examined vary between 13 and 20 cm. Weights vary between 26 and 75.5 gm. The mean condition factor is about 1.18. Morphometric indices show that head length is about 27% of the total length, while standard length is about 83% of the total length, and the body depth is about 23.5% of the total length.

Males predominate in the sample accounting for 62.5% of the total.

Genus Tilapia

Three major species of Tilapia exist in the lake. There are T. galilae, T. nilotica, and T. zilli. Of these only T. galilae and T. nilotica occurred in significant numbers in the sample collections. Tilapia zilli occurred only rarely.

Fifty-four individuals of T. nilotica were examined. Total length of the examined fish varied between 13 and 28 cm. while the weight varied between 52.6 and 45.6. Most of the fish caught are about 14 cm total length. Mean condition factor is about 2.23. Males (64%) exceed females (36%).

The standard length is 80% of the total length, the head length is about 27% of the total length and the body depth is 34.6% of the total length.

The Tilipia gallilae was represented by 27 fish. Total length of examined fish varied between 8 and 25 cm. Total weight varied between 10 and 320 grams. Mean condition factor is 1.6. Of the examined fish, 51.9% were females while 48.1% were males.

Morphometric indices show that the head length is about 29% of the total length, and the body depth is about 33% of the total length.

The economic value of the Lake Manzala Fishery in Port Said is not well documented. Equipment costs are fairly high, LE 475 for the commonly used sailboats and LE 400 for a 600 meter mullet net. Mugil and Morone species have a retail value of about LE 1.0 per kilogram. Tilapia have a retail value of LE 0.50 per kilogram for fairly large fish. Tilapia is more commonly sold for fertilizer at LE 0.25/wet kilogram or 0.40/dry kilogram. The fish are dried on the dike bordering the Junction Canal. Using these figures as a basis, projected annual income to Port Said Lake fishery is about LE 2,000,000.

El Mallaha

El Mallaha produces well over 90% of the mullets (*Mugil spp.*) excluding *Mugil capito* in the Port Said Fishery. August landings were 57,835 kilograms as compared to 2,806 kilograms in Lake Manzala. The El Mallaha fishery is managed. No data, however, exist on the type or effectiveness of the management practices.

6.4 CONCLUSIONS

The Port Said fisheries are less productive than expected for a marine-estuarine system of this type. Population characteristics determined from experimental catches indicate overfishing as the cause rather than pollution related effects. Catches are limited to young fish generally in the first or second year. Sex ratios generally favor females indicating a trend toward reproduction. This condition is common in populations reacting to high levels of cropping. High condition factors indicate relatively good health in the population. If lethal conditions caused by sewage pollution were present there would be lower condition factors. Examination of samples for the presence of the Heterophydiasis parasite were negative, which is evidence that there is minimal direct contact with the fish to sewage.

Current wastewater discharges in Port Said have no significant effects on the fishery. Effects are limited to the loss of one square kilometer of habitat at the Mazrah discharge. Low productivity and population characteristics are a function of poor fishery management.

Potential benefits of using wastewater to supplement low nutrient levels are discussed in Chapter 7.

TABLE 6.1

PRINCIPAL SHRIMP SPECIES

Penaeus trisulcatus

P. japonicus

P. semisulcatus

P. stebbingni

Metapenaeus monoceros

TABLE 6.2

ESTIMATION OF FISH LANDED BY SAMPLING METHOD

Fourth Grade Ships

Serial Number (1)	License Number (2)	Number of Fishermen (3)	Fish Gear (4)	Date and Time of Beginning of Fishing Trip: Date (5)	Hrs/Min (6)		Fish Caught: Types (7)	Net Wt. kgm (8)
1	544 519	8	Habla	17/9/78	4	-	Sardinella spp.	50
2	564	5		"	4	-	Sardinella spp.	65
3	825	9	Habla	"	3	50	Mugil capita	25
	651						Sardinella spp.	35
4	565 806	13	Habla	"	3	50	Mugil capita	40
5	626 666	10	Habla	"	4	-	Sardinella spp.	70
6	620 593	8	Habla	"	3	40	Sardinella spp.	30
7	549 550	8	Habla	"	3	30	Mugil capita	45
8	592	8	Habla	"	4	-	Sardinella spp.	70

Fifth Grade Ships

Serial Number (9)	License Number (10)	Number of Fishermen (11)	Fish Gear (12)	Date and Time of Beginning of Fishing Trip: Date (13)	Hrs/Min (14)		Fish Caught: Types (15)	Net Wt. kgm (16)
1	650	1	Hook	17/9/78	4	-	Sciaena aguilda	2
2	686	4	Trawling	"	4	-	Mugil capita	12
"	"	"	Trawling	"	4	-	Sciaena aguilda	4
3	636	2	Hook	"	4	30	"	5
4	617	2	Long lines	"	4	-	"	7
5	729	1	Hook	"	4	10	"	3
6	781	4	Trawling	"	4	-	Mugil capita	17
7	649	3	Long lines	"	4	25	Sciaena aguila	8
8	657	3	Hook	"	4	-	Epinephelus	5
"	"	"	"	"	4	-	Sciaena aguilda	3
9	586	1	Hook	"	4	30	"	2
10	772	1	Hook	"	4	30	"	3
11	501	1	Hook	"	4	35	"	4
12	808	2	Hook	"	4	-	Sciaena aguilda	5
13	735 610	7	Gill Nets	"	6	-	Mugil capita	20
14	510	1	Hook	"	4	45	Spirus auratus	2
15	779	1	Hook	"	4	45	Spirus auratus	3
16	656	2	Hook	"	5	30	Epinephelus	3
17	647	3	Long lines	"	5	-	Sciaena aguilda	7
18	797	2	Hook	"	5	30	"	5
19	672	3	Long lines	"	4	-	"	8
20	658	3	Hook	"	4	20	Epinephelus	7
21	639	4	Trawling	"	4	-	Mugil capita	25
22	823	4	Trawling	"	4	-	"	22
23	823	4	Trawling	"	4	-	Sciaena aguilda	10

TABLE 6.3

PORT SAID FISHERY PRODUCTION (in kg)

AUGUST 1978

Species	Mediterranean Sea: Port Said Harbor	Mediterranean Sea: Port Said Shore	Mediterranean Sea: Port Fouad Shore	El Mallaha	Lake Manzala Kabbutti
Epinephelus spp.	4,837			10	
Mullus barbatus	9,382				
Sciaena aquilla	8,342	510	165	262	5,369
Mugil spp.	476	342	20	57,835	2,806
Sparis auratus	1,086	20	10	1,795	
Morone Labrax				252	
Pagrus spp.	2,029				
Solea solea	750				
Sardinella aurita	68,125	20,595	17,970		
Sepia spp.	3,977				
Neptunus pelagius	1,275	60	17		
Metapenaeus spp.	30,997				
Tilapia					267,307
Mugil capito					37,024
Anguilla vulgaris					222
Bagrus bagrus					2,862
Clarius spp.					4,178
Unidentified Species (fish)	7,316	8,135	40		8,390
Unidentified Species (shrimp)	30,348	4,745	2,200	31,218	
TOTALS	167,960	34,457	20,522	91,372	328,249

TABLE 6.4

FISH SPECIES OCCURRING IN LAKE MANZALA COMMERCIAL CATCHES

Epinephelus sp.

Sargus sargus

Sargus annularis

Serranus scriba

Sciaena aquilla

Mugil cephalus

Mugil capito

Sparus auratus

Crabs (Callinectes sapidus)

Shrimps (Metapaennaeus stebigni)

Temnodon saltator

Morone labrax

Morane punctata

Pagrus pagrus

Solea solea

Saurida

Sardinella auritus

Sepia

Together with:

Tilapia nilotica

Tilapia galilae

Mugil saliens

Lates niloticus

Clarias lazera

Bagrus hayad

Mugil auratus

TABLE 6.5

LENGTH/FREQUENCY DISTRIBUTION

MUGIL CAPITO

Length (cm)	Individuals	Percent Frequency
11	2	0.89
12	19	8.52
13	46	20.63
14	29	13.06
15	40	17.94
16	45	20.18
17	18	8.07
18	15	6.75
19	5	2.24
20	4	1.79

TABLE 6.6

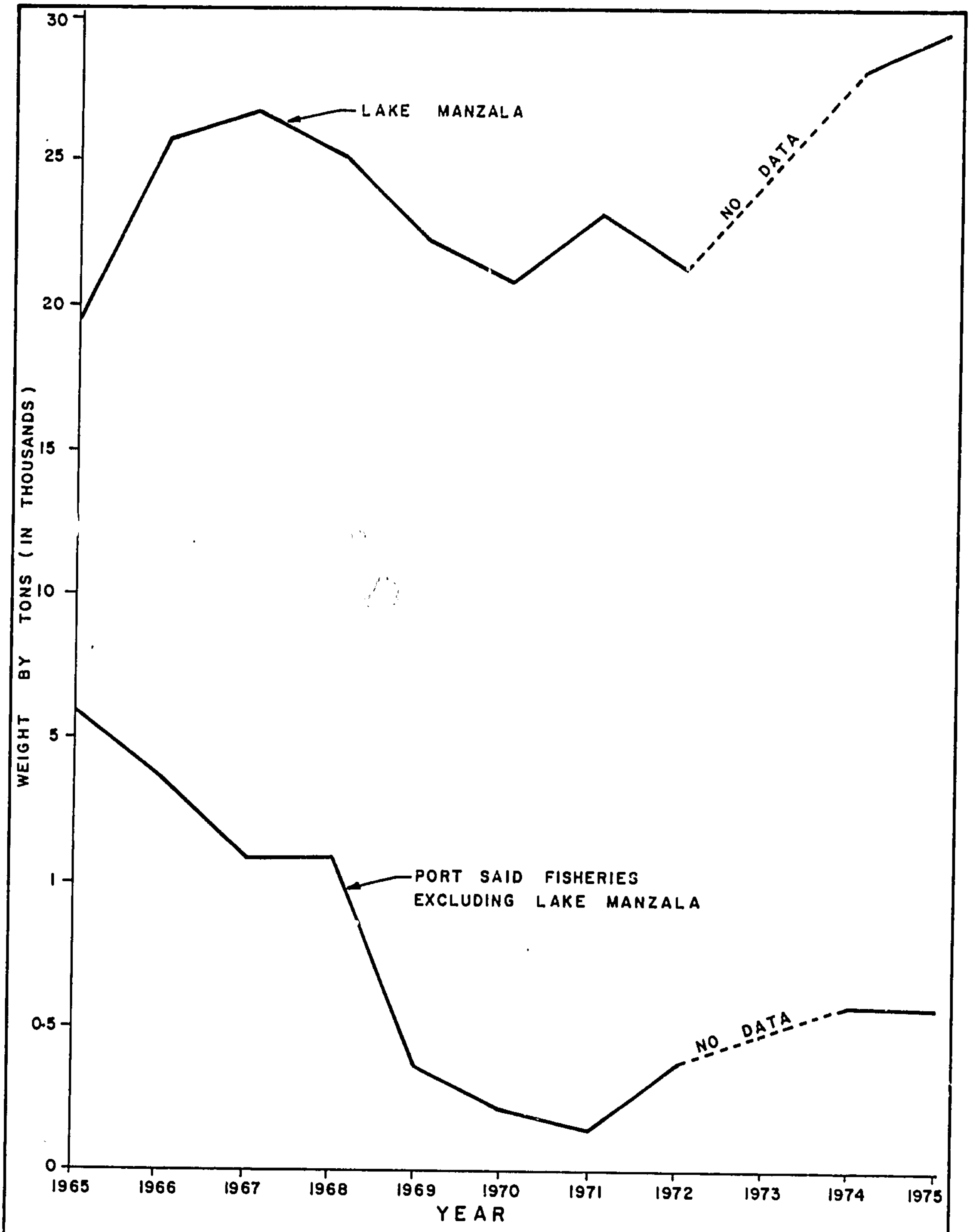
AGE COMPOSITION OF M. CAPITO

Age Class	Individuals	Percent Frequency
0 (0 to 1 year)	81	52.26
I (1 to 2 years)	55	35.48
II (2 to 3 years)	18	11.61
III (3 to 4 years)	1	0.65

TABLE 6.7

BIOLOGICAL STATISTICS OF LAKE MANZALA FISH
(Means)

Species	Standard Length (Centimeters)	Standard Length Index	Head Length (Centimeters)	Head Length Index	Body Depth (Centimeters)	Body Depth Index	Weight (grams)	Condition Factor R
Mugil capito	14.3	83.2	3.5	20.4	3.1	17.9	52.8	1.0
Mugil chelo	10.6	82.3	2.8	22.9	2.7	21.0	27.8	1.4
Mugil cephaulus	13.9	84.2	3.3	20.1	3.2	19.0	79.3	1.2
Mugil salians	11.5	80.8	3.0	21.8	2.7	2	30.4	1.2
Mugil auratus	12.3	82.7	3.2	21.8	2.9	20.0	36.1	1.1
Morone punctatus	11.1	82.3	3.7	26.7	2.9	21.3	28.4	1.1
Morone Labrax	13.4	83.2	4.4	27.0	3.5	23.5	53.2	1.2
Tilapia galilae	-	-	4.2	29.0	4.6	33.18	69.6	1.6
Tiplapia nolitica	14.7	80.44	4.88	27.4	6.3	34.6	174.1	2.2



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ANNUAL PRODUCTIVITY OF THE PORT SAID FISHERIES

VOL.4 FIG. 6-A

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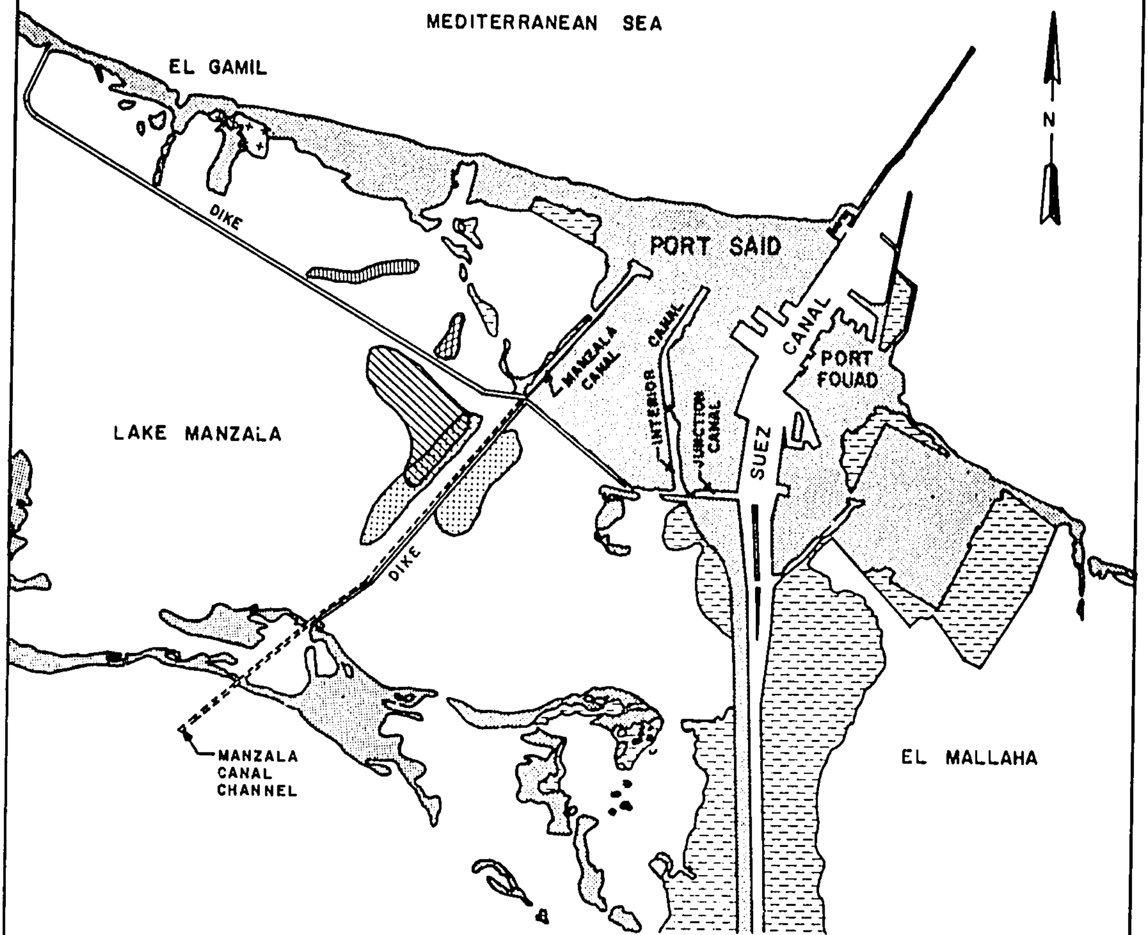

LEGEND

- DRY LAND
- INTERMITTENTLY FLOODED AREAS
- DAY FISHING (TILAPIA) 8-15-78
- NIGHT FISHING (MULLETS) 8-16-78
- DAY FISHING (TILAPIA) 9-20-78
- NIGHT FISHING (MULLETS) 9-21-78
- NIGHT FISHING (MULLETS) 10-2-78

APPROX. SCALE: 1=100,000

0 1.0 2.0 3.0 4.0 Km.

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FISHERY SAMPLE LOCATIONS

VOL. 4 FIG. 6-B

CHAPTER 7

CONCLUSIONS

7.1 INTRODUCTION

Data collected in the Receiving Water Study were analyzed for those characteristics important to wastewater disposal. Dilution factors, assimilative capacity, bacterial water quality, general water quality and condition of the area's fishery were evaluated as a basis for projection of the impact of future wastewater discharges.

7.2 DILUTION FACTORS

Field investigations (current monitoring, velocity cross-sections, dye and drogue studies) were conducted in Lake Manzala and the Suez Canal and the data analyzed to establish dilution factors and transport characteristics.

Dilution is a function of vertical and horizontal dispersion and advection (dilution due to flow). In Lake Manzala, dilution is limited by the shallow depth and the lack of water movement. Current studies indicate mid-depth velocities of less than 2.5 cm/sec. Drogue and surface float studies show velocities increasing to 5.7 cm/sec at twenty centimeters depth and up to 50 cm/sec at the surface. Average current velocities were found to be 1 percent of the wind velocity during a particular time period. In Lake Manzala advection provides dilutions of approximately 3 to 1 in an hour. While vertical dispersion of wastewater was not limited by salinity gradients in Lake Manzala significant dilution does not occur because the available depth is less than 1.5 meters.

Conditions in Lake Manzala tend to limit the areal effects of wastewater discharges by confining the plume and promoting settling of sewage matter.

Transport in Lake Manzala was assessed from drogue and dye studies. Transport is generally in the direction of prevailing winds with the exception of the area near the Junction and Manzala Canals. In this area, a counter-clockwise eddy occurs as shown in Figure 7-A.

In the Suez Canal, conditions are significantly different than in Lake Manzala. Dilution in the Suez Canal is primarily advection as shown by the elongated plume shape found in dye studies. Advection results in concentration reductions of about 100 to 1 in an hour with current velocities of 23 cm/sec. Diffusion rates vary from 6.69×10^{-4}/sec to 1.35×10^{-3}/sec. Dilution of a continuous surface wastewater discharge is expected to be significantly less. Chemical and bacteriological data indicate that continuous wastewater discharges tend to form narrow surface band along the shore of the discharge with little horizontal dispersion across the canal. Sewage strength remains high in the plume.

High salinity limits the vertical dispersion of surface wastewater discharges to less than one meter. Dye studies indicate that vertical dispersion may be even more significantly limited with 95 percent of the dye occurring in the upper 20 centimeters.

Transport in the canal is related to current speed and direction. During dye studies, the plume travelled south at 23 cm/sec a speed consistent with current meter records.

Vertical profiles of salinity in the Suez Canal indicate no noticable pycnocline (density gradient). The absence of a pycnocline ensures that the entire water column is available for the dilution of a subsurface wastewater discharge. Initial dilutions of 43:1 can be achieved with a discharge at 15 meters depth. Current velocities, although variable, are generally sufficient (6 to 15 cm/sec) to guarantee a continuous source of clean water over an outfall.

7.3 ASSIMILATIVE CAPACITY

Studies of the raw sewage discharge at Mazrah indicate rapid assimilation of organic carbon, nitrogen and phosphorus into plankton biomass. Ambient BOD_5 levels are 30 to 50 mg/l, exceeding the assimilative ability of the receiving water and causing anaerobic conditions at night.

Maintenance of aerobic conditions is critical to the Lake Manzala fishery. The minimum dissolved oxygen level is 3 mg/l to ensure survival of indigenous fish species. Allowable BOD_5 loading for Lake Manzala can be calculated using the following formula:

$$La/Dc = f\,e^{(ktc')}$$

La = initial BOD

Dc = critical oxygen deficit

f = self-purification ratio

tc' = critical time.

Worst case conditions are summer when ambient water temperatures are highest (29.5°C) and oxygen saturation levels lowest (7 mg/l). Under these conditions, to maintain dissolved oxygen levels of 3 mg/l, the acceptable increase in the Lake's BOD_5 level is is 6 mg/l (see Appendix C).

The dilution required of an outfall system depends upon the degree of sewage treatment provided. For example, effluent from "primary" treatment at Mazrah could contain 210 mg/l of BOD_5 while the effluent from a conventional activated sludge plant could contain 25 mg/l of BOD_5. The "primary" effluent requires 35 to 1 dilution while the "secondary" effluent requires only 4 to 1 dilution to maintain dissolved oxygen greater than 3 mg/l.

Phytoplankton production of oxygen is affected by changes in water column solids and light penetration. The USEPA has recommended that wastewater discharges of solids be limited to that amount that reduces compensation depth (the maximum depth at which photosynthesis can take place) by not more than ten percent. Considering the ambient suspended solids concentration of 55 mg/l the change in ambient solids concentrations is limited to 5 mg/l. For "primary" effluent (130 mg/l suspended solids) a 15 to 1 dilution is required based on mass balance calculations while no dilution of a "secondary" effluent is needed since the suspended solids are less (25 mg/l) than the ambinet concentrations.

Assimilative capacity in the Suez Canal appears to be poor based on observations of existing surface discharges. The discharge plume is confined and maintains its fresh-water characteristics. This condition is likely to be unsuitable for the marine plankton and bacterial types present in the Suez Canal since it prevents assimilation of carbon and nutrients. Lack of settling due to the salinity gradient prevents decomposition of sewage material by benthic bacteria.

The allowable BOD_5 loading in the Suez Canal is approximately 5 mg/l. A "primary" effluent requires a dilution of 42 to 1 to maintain 3.0 mg/l of dissolved oxygen in the canal. Current meter studies indicate periods of minimal net flow in the canal. Therefore advection cannot be depended on to provide significant dilution. Dilution requirements for primary effluent can be met with a subsurface discharge at 15 meters depth.

7.4 BACTERIOLOGICAL WATER QUALITY (COLIFORM DIEOFF)

Receiving water bacteria levels at any given point are determined by concentrations in the wastewater effluent, initial dilution, physical dilution, and aftergrowth and dieoff. Fecal coliform dieoff studies performed in situ and under laboratory conditions indicate significant dieoff in Lake Manzala waters. In situ dieoff determined from field samples and calculated travel times ⌐ e nearly 100% in 5 to 12 hours. Laboratory studies indicate Lake Manzala dieoff rates vary with the initial coliform concentration. For effluent loads of 10^6 organisms/100 ml the decay rate (k) is 0.23/hr or 5.5/day. At concentrations of below 1,000 organisms/100 ml, the decay rate is 0.16/hr or 3.9/day.

Dieoff rates in the Suez Canal appear to be significantly lower. Low observed dieoff rates in the canal are probably due to lack of protozoan predators and the high nutrient content of the plume. Based on studies of similar waters, bacterial decay rates in the Suez Canal are estimated to range between 1.4 and 2.0/day.

The physical and geometric patterns of an outfall or diffuser system and the observed reaction rates allow the calculations of the probable bacterial concentrations at any distance from the discharge by the following formula:

$$C = Co\ e^{-kt}\ \mathrm{erf}\left[\frac{3/2}{\left(1 + \frac{8\,Eo^{x}}{Ub^{2}}\right)^{3}}\right]^{1/2}$$

C = concentrations along x - axis of the effluent field in the direction of the current

Co = concentrations at x = o

x = distance along x axis of the effluent field

U = current velocity along x - axis

b = initial width of effluent field above the diffuser and normal to the current

Eo = lateral dispersion coefficient

The deviation of the formula and rate constants are discussed in Appendix IV.

Because of dissolved oxygen considerations, disposal of "primary" effluent to Lake Manzala requires an outfall with a one kilometer diffuser section to maintain acceptable water quality. Assuming a worst case condition (effluent concentration of 1,000,000 organism/100 ml) coliform levels would fall below 100 organisms/100 ml within 3 kilometers of the discharge.

In the Suez Canal, initial dilutions of approximately 50 to 1 are expected. Concentrations gradients for unchlorinated effluent loads of 1,000,000 organisms/100 ml are shown in Figure 7-B.

7.5 GENERAL WATER QUALITY

Toxics

Benthic concentrations of heavy metals and pesticides are high in Lake Manzala, El Mallaha and the Suez Canal. In estuarine areas with similar toxic levels in other parts of the world, public health problems with bioaccumulation in edible fish and shellfish are well documented. Hence it is likely that the fatty tissues of predatory fish such as the eel Aquilla vulgaris contain significant levels of pesticides. Also the gills and hepatic tissues of the plankton feeders (Tilapia spp.) probably concentrate metals. We speculate that the presence of toxics may be partially responsible for the low observed productivity of the Lake.

Nutrients

Major inorganic nutrients occur at levels sufficient to promote algae blooms in all the waters of the study area. Moderate cell counts are maintained through cropping by zooplankton and fish. Introduction of additional nutrients should increase plankton production but if the water quality is kept suitable for fish, additional feeding will maintain the water column plankton concentrations near present levels.

Dissolved Oxygen

The oxygen levels of all receiving waters, with the exception of Zone A are sufficient to support fish life. Diurnal variation in oxygen is limited and appears to be a function of algae production and respiration. Except for Zone A of Lake Manzala, benthic demand is low.

7.6 FISHERY CHARACTERISTICS

The fishery of Lake Manzala was examined to assess the effect of present raw sewage discharges. Data on population characteristics were collected and selected samples were examined for Heterophydiasis, a helminthic parasite related to sewage.

Data collected on length/weight ratios, age and catch per unit effort are typical of overfished populations. The population is comprised primarily of fish in the first year class. Length/weight ratios are high. In several cases populations of a particular species were predominantly female. These conditions indicate a response to overcropping of the fish beyond year class I. Over selectivity of fishing gear used in exploitation of the fishery is normally the cause of the population characteristics described.

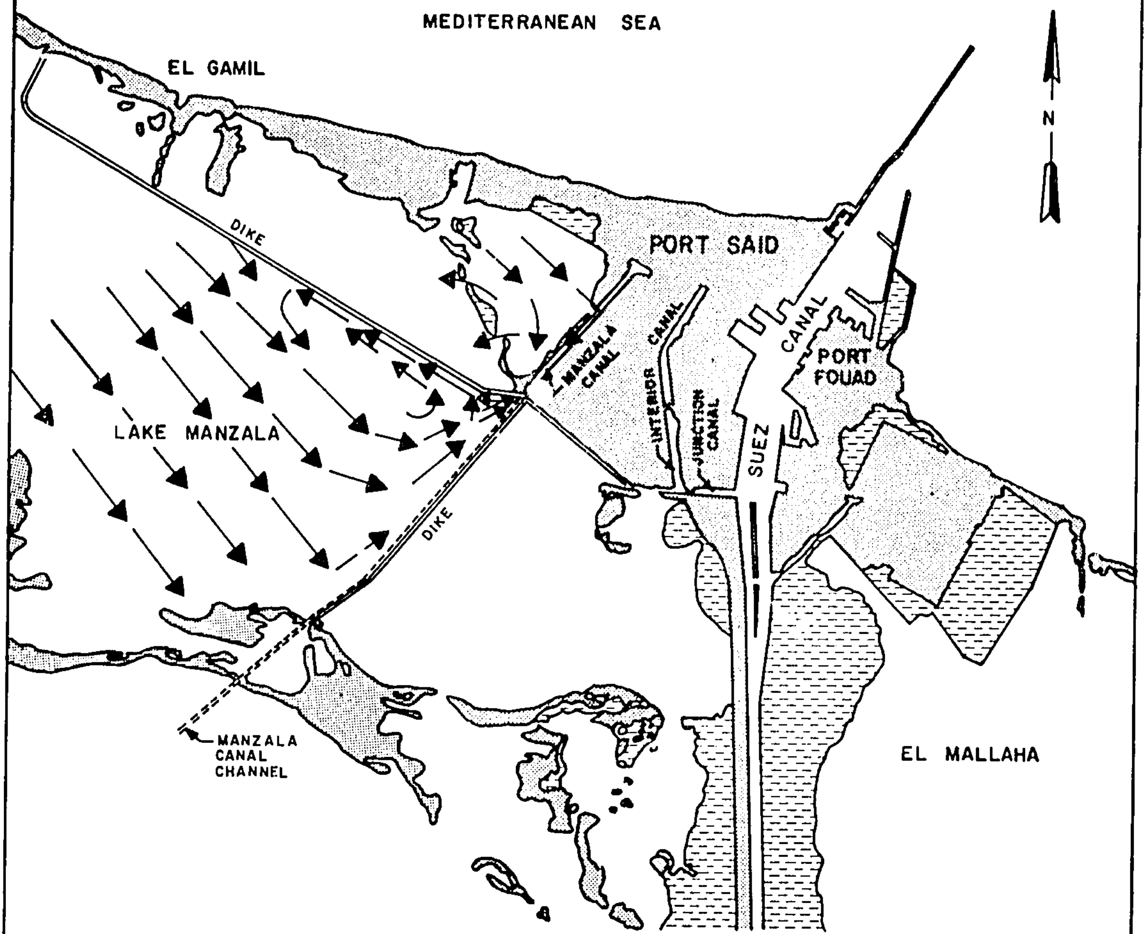
The present sewage discharge appears to have a limited effect on the Lake Manzala fishery other than the loss of approximately two square kilometers of habitat in Zone A. No indications of Heterophydiasis were found in fish taken by Kabbutti fishermen.

It should be noted that sewage discharges can be beneficial to fishery populations provided acceptable water quality is maintained. Nutrients stimulate plankton growth providing additional food resources.

7.7 PUBLIC HEALTH

Discharge of unchlorinated wastewater to the Suez Canal or Lake Manzala is expected to have beneficial public health effects. Generally, the infective stage of the helminthic parasites endemic to Port Said occur in soils and cannot survive for extended periods on brackish/saline water environments.

No problems with schistosomiasis will be caused by discharge of unchlorinated effluents to Lake Manzala or the Suez Canal. The brackish water or marine environment is unsuitable for the survival of the snail host or the supportive vegetation of the snail host. Absence of the snail host breaks the reinfection cycle by preventing the formation of the cercariae in the infective stage of the parasite.



LEGEND

- DRY LAND
- INTERMITTENTLY FLOODED AREAS

APPROX. SCALE 1:100,000

0 1.0 2.0 3.0 4.0 Km.

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CIRCULATION PATTERNS IN LAKE MANZALA ZONES "A" AND "B"

VOL.4 FIG. 7-A

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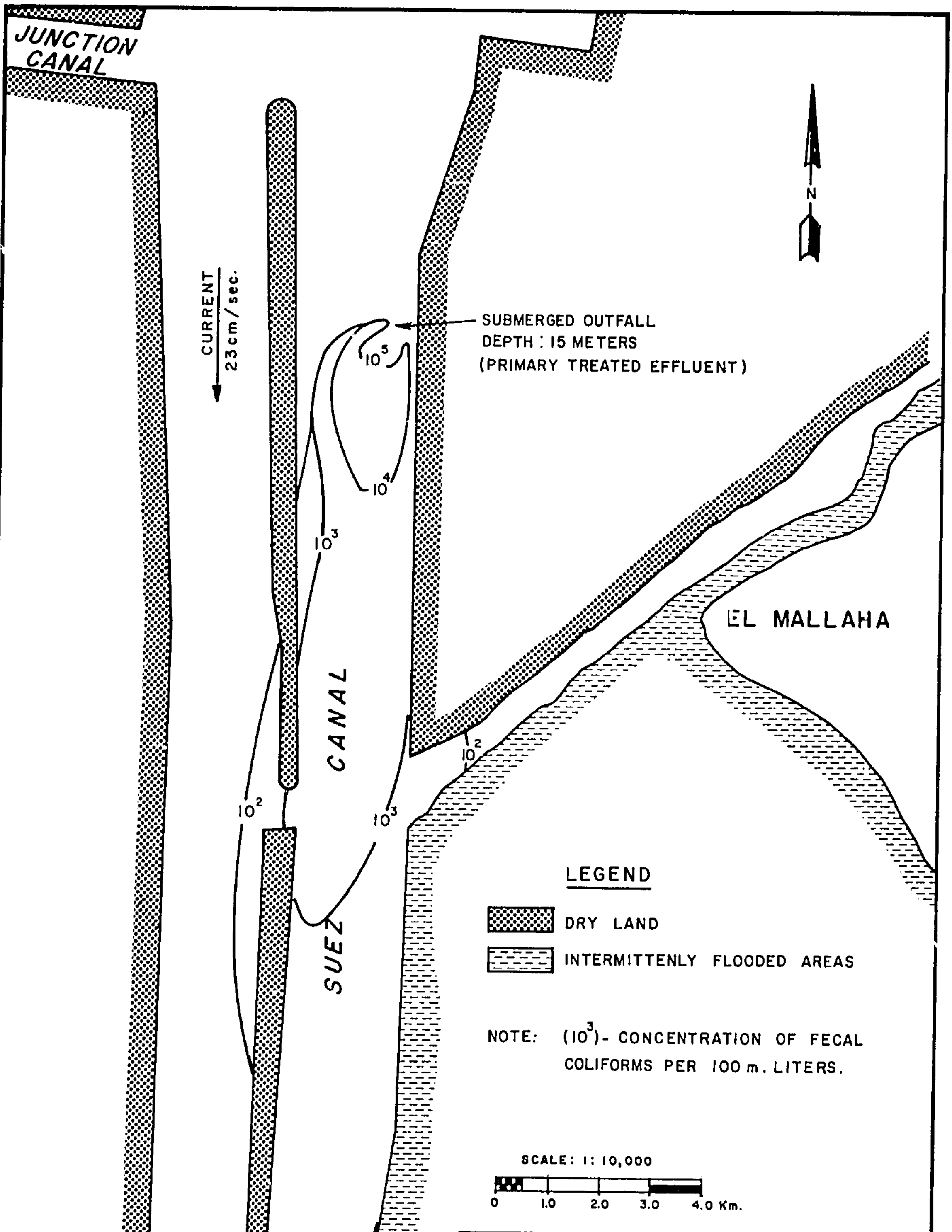

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THEORETICAL CONCENTRATIONS OF FECAL COLIFORMS

VOL.4 FIG. 7-B

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RECOMMENDATIONS

8.1 WASTEWATER DISPOSAL

Disposal must be arranged for approximately 189,000 cu m/day of sewage from Port Said, Port Fouad and the planned fishing village at El Gamil, by the year 2000.

Outfall discharges to the Mediterranean Sea were rejected by the Advisory Committee of Reconstruction (ACR) prior to initiation of the Receiving Waters Study.

Discharge to Lake Mallaha is precluded by planned expansion of salt beds and active mullet fishery management and exploitation.

Recommendations on wastewater disposal techniques and locations are therefore limited to Lake Manzala and the Suez Canal. These recommendations are based on: 1) discharge to Lake Manzala of sewage from Port Said and El Gamil; 2) about 17,500 cu m/day of sewage from Port Fouad either combined with the Port Said sewage or discharged separately to the Suez Canal after treatment.

The critical parameter in determining treatment requirements for discharge to Lake Manzala and the Suez Canal is BOD_5 loading and its impact on dissolved oxygen (DO).

Outfall locations are also determined by the physical and bacteriological conditions of the receiving waters.

The point of discharge should be oriented to allow maximum dilution.

Lake Manzala

Three treatment alternatives for discharge to Lake Manzala were examined:

1) Anaerobic lagoons followed by oxidation ponds

2) Conventional primary treatment with a diffuser at the end of an outfall

3) Conventional secondary treatment with an open ended outfall or diffuser

In evaluating the alternatives, priority was given to protection of the Lake Manzala fishery. The oxidation ponds would have to be constructed in the lake because land is unavailable. Construction of the ponds would preempt 500 ha of fishery habitat for enclosed processes which, with proper design, could proceed as well in the open lake. By comparison, the present untreated discharge at Mazrah eliminates some 200 hectares from fishery use. Treatment by oxidation ponds was therefore eliminated from consideration as a result of the Receiving Waters Study.

The fish species common in Lake Manzala (Tilapia and mullets) can survive for extended periods in waters with DO levels of less than 2.0 mg/l. To ensure efficient growth and reproduction in the fishery, however, oxygen levels should exceed 3.0 mg/l at all times. It was calculated early in the Receiving Waters Study that if the proposed wastewater discharge increased the ambient BOD_5 by no more than 6.0 mg/l (resulting in

BOD_5 concentrations of about 9.0 mg/l in Zone B of Lake Manzala), the minimum DO criteria of 3.0 mg/l would be met. Later field data indicated that this calculated BOD_5 increase limit was conservative. Areas of the lake with ambient BOD_5 levels of 13 to 14 mg/l support productive biological communities, despite short periods of anaerobic conditions during the night. On this basis, the disposal alternative selected for wastewater discharge should increase ambient BOD_5 levels in the lake by no more than 10 to 11 mg/l.

Evaluation of the projected water quality impacts of treatment/outfall structure alternatives for a year 2000 flow of 171,500 cu m/day is detailed in Appendix D. The distribution of BOD_5 in Lake Manzala was projected for: primary treated effluent with diffusers of 500, 1000, 1500, 2000, and 2500; secondary treated effluent with an outfall and a diffuser of 500 m. The projected BOD_5 increases indicated that to meet the conservative limitation of 6.0 mg/l in all areas of the lake, primary treated effluent would require a 1500 m diffuser. A secondary treated effluent would require a 250 m diffuser.

Further examination of the BOD_5 increase projections showed that with primary treatment and a 1000 meter diffuser, a maximum BOD_5 increase of 10.3 mg/l would occur. This satisfied the minimum acceptable BOD_5 increase of 10 to 11 mg/l derived from field data.

With a 1000 meter diffuser, adverse impacts of primary effluent on the lake would be minimal. The benefits of higher treatment levels would be marginal at best.

Projections of receiving water coliform levels for the alternative outfall structures (summarized in Table D-2) indicated decreases to below 1000 MPN/100 ml within 2500 m downstream of the discharge and to about 100 MPN/100 ml within 3500 meters. We therefore recommend that the discharge point be no closer than 3.5 kilometers to any residential area in the southeast, the predominant direction of transport.

To achieve maximum dilution, the diffuser should be oriented perpendicular to the predominant currents. Current flow is generally southeast at bearings of 120 degrees to 130 degrees. The recommended location and orientation of the outfall and diffuser are shown on Figure 8-A.

<u>Suez Canal</u>

The Suez Canal is about 18 m deep in the area of Port Said. Salinity is generally 35 to 36 parts per thousand. With the exception of the Suez Canal/Junction Canal confluence, vertical salinity profiles show no significant density stratification. Initial dilution, assuming a discharge at 15 m depth, is about 43 to 1. Current velocities are sufficient to provide continuously a 43 to 1 dilution of the projected year 2000 flow of 17,500 cu m/day from Port Fouad.

Assuming a primary treated effluent with BOD_5 concentrations of 210 mg/l BOD_5, ambient BOD_5 at the surface of the canal above the discharge would increase by 4.8 mg/l. It was calculated that the Suez Canal can assimilate increases of 5.1 mg/l BOD_5. This indicated that the assimilative capacity of the canal is sufficient to accept the 17,500 cu m/day of "primary" treated effluent from Port Fouad with no adverse impacts.

Projected coliform distributions for the subsurface discharge indicated that the discharge should be located no closer than 2 km to any area in the canal used for swimming, as shown in Table D-4. Primary effluent concentrations of 10^6 MPN/100 ml would be reduced to 23,000 MPN/100 ml by initial dilution. With Suez Canal current velocities of

23 cm/sec, horizontal dispersion would reduce coliform levels to about 100 MPN/100 ml in one hour or 2000 m downstream of the discharge. A suitable location is shown on Figure 8-A.

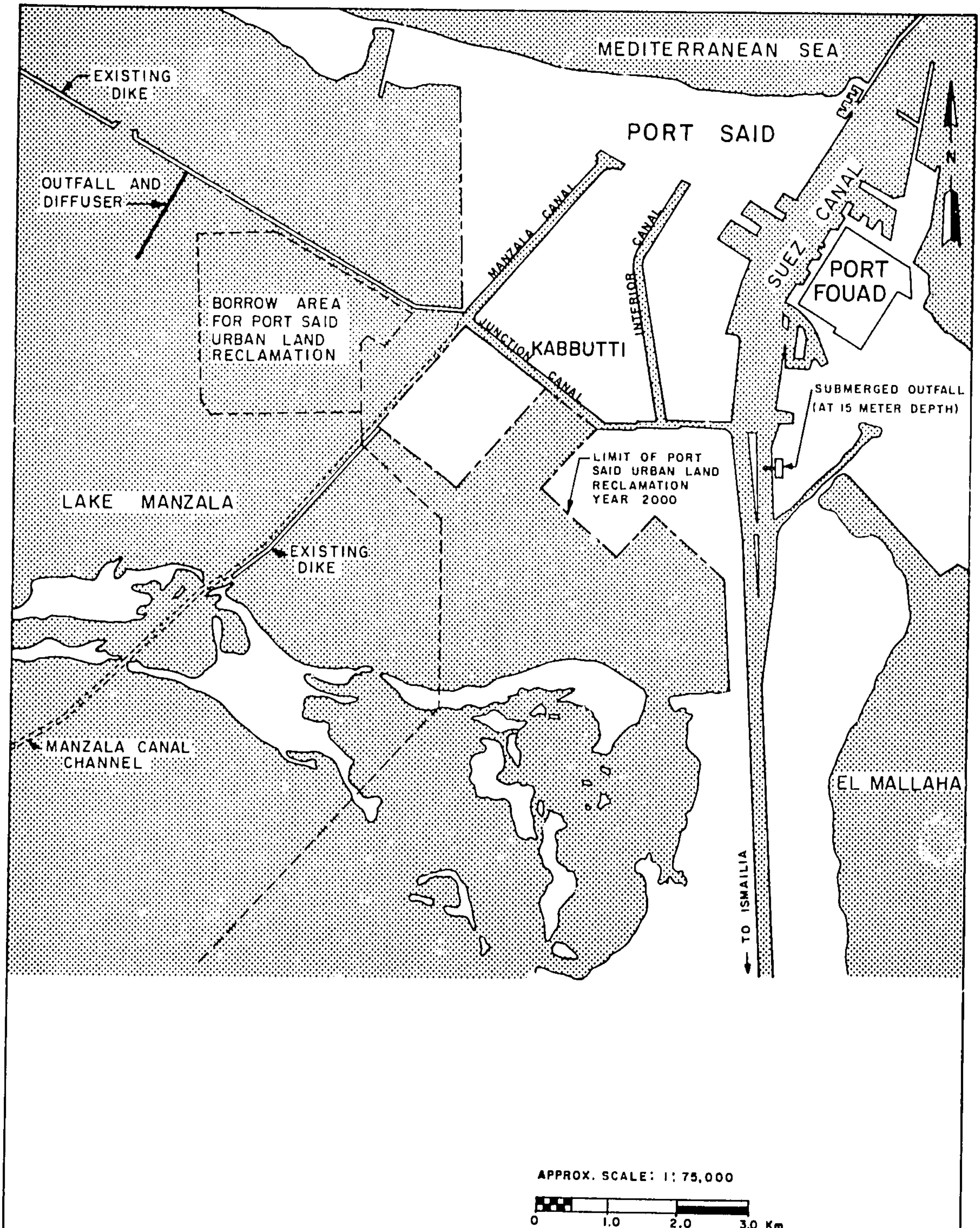
8.2 FUTURE STUDIES

Toxics

Although we doubt that wastewater disposal planning would be significantly affected by toxics, it is recommended that further research on the presence of toxics be conducted. Benthic heavy metal and pesticide concentrations are high in Lake Manzala, El Mallaha and the Suez Canal. Accumulation of these substances in fish and shellfish represent a public health hazard. In addition, sublethal effects on fish can disturb reproduction and growth processes. Further studies on the public health and fishery implications of the toxics should be performed.

Lake Manzala Fishery

The fishery is over-exploited at present. Detailed studies of present management practices should be conducted to develop future policies.



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RECOMMENDED LOCATIONS FOR OUTFALLS

VOL.4 FIG. 8-A

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APPENDIX A

HYDROGRAPHIC AND METEOROLOGICAL DATA
Prepared by Ocean Surveys, Inc.

TABLE A

SALINITY, TEMPERATURE, DISSOLVED OXYGEN PROFILES

SUEZ CANAL

29 July 1978

27 August 1978

20 September 1978

21 September 1978

SITE: SUEZ CANAL

DATE: 29 July 1978

Station No.	Distance	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
1	75 km	1154	Surface	29.5	7.5
			10 m	29.0	5.9
			Bottom	29.0	6.0
2	65 km	1244	Surface	29.6	6.7
			10 m	29.3	6.5
			Bottom	29.2	5.9
3	55 km	1315	Surface	29.5	7.0
			10 m	29.5	6.0
			Bottom	28.9	5.9
4	45 km	1435	Surface	29.8	---
			10 m	28.5	---
			Bottom	28.4	---
5	35 km	1502	Surface	30.1	7.3
			10 m	28.9	6.3
			Bottom	29.0	6.3
6	25 km	1544	Surface	29.3	7.6
			10 m	28.5	5.3
			Bottom	28.5	4.9
7	14 km	1618	Surface	29.2	4.2
			10 m	29.8	---
			Bottom	29.5	---
8	12 km	1719	Surface	28.4	4.3
			10 m	27.9	3.2
			Bottom	27.9	2.7
9	10 km	1732	Surface	28.3	3.2
			10 m	28.2	3.0
			Bottom	28.0	2.5
10	8 km	1756	Surface	28.5	7.2
			10 m	28.7	3.4
			Bottom	28.9	2.7

Station No.	Distance	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
11	6 km	1809	Surface 10 m Bottom	27.7 28.2 28.5	7.4 1.3 1.2
12	4 km	1830	Surface 10 m	27.5 27.8 27.5	6.4 1.8 1.8
13	2 km	1844	Surface Bottom	28.0 28.0	6.8 5.3
14	0 km	1945	Surface 10 m Bottom	27.9 27.2 27.9	--- --- ----
15	-2.5 km	2004	Surface 10 m Bottom	27.9 27.2 27.0	5.7 5.3 3.5

SITE: SUEZ CANAL

DATE: 27 August 1978

Station No.	Distance	Time (Local)	Sampling Depth, Meters	Temp °C	Salinity 0/00	Dissolved Oxygen PPM	Visibility cm
1	-5 km	1209	Surface	28.34	34.66	6.2	80
			2 m	27.66	26.48	4.7	
			5 m	27.68	36.54	2.5	
			10 m	27.91	36.75	5.5	
			14 m	27.76	36.98	5.5	
		1237	20 m			5.2	
2	-2.4 km	1249	Surface	28.71	34.78	6.0	90
			2 m	28.47	35.62	5.2	
			5 m	28.29	36.33	5.0	
			10 m	28.08	36.80	5.1	
		1259	18 m	29.32	36.16	4.9	
3	0 km	1307	Surface	28.67	35.12	6.1	110
			2 m	28.37	35.36	5.4	
			5 m	28.10	36.16	5.2	
			10 m	28.03	36.88	5.8	
		1314	13 m	28.10	36.82	5.5	
4	2 km	1320	Surface	28.60	34.03	6.4	130
			2 m	28.10	34.59	6.1	
			5 m	27.90	35.96	4.8	
			10 m	27.93	36.52	4.9	
		1328	14 m	27.91	36.82	4.9	
5	4 km	1333	Surface	28.75	27.28	6.6	80
			2 m	27.90	34.40	4.2	
			5 m	27.90	35.45	4.2	
			10 m	27.95	36.44	4.4	
		1342	14 m	28.04	36.50	4.5	
6	5 km	1351	Surface	29.50	26.22	6.5	80
			2 m	27.78	33.78	3.8	
			5 m	27.76	35.04	3.2	
			10 m	27.87	35.79	3.5	
			14 m	28.05	36.36	4.1	
		1357	Bottom	-----	-----	1.5	
7	8 km	1403	Surface	29.68	28.15	7.5	90
			2 m	27.96	33.73	4.4	
			5 m	27.79	34.75	3.9	
			10 m	27.92	35.58	3.8	
		1434	14 m	27.96	36.14	3.5	

Station No.	Distance	Time (Local)	Sampling Depth, Meters	Temp °C	Salinity 0/00	Dissolved Oxygen PPM	Visibility cm
8	10 km	1439	Surface	29.74	29.10	8.8	100
			2 m	28.00	33.78	5.3	
			5 m	28.03	34.49	4.8	
			10 m	28.09	35.11	4.5	
		1444	14 m	28.25	35.41	4.3	
9	12 km	1450	Surface	29.05	31.25	7.9	110
			2 m	28.28	33.45	4.9	
			5 m	27.83	34.40	4.4	
			10 m	27.85	34.60	3.9	
		1457	14 m	28.24	34.85	3.7	
10	14 km	1502	Surface	28.94	32.63	7.5	115
			2 m	28.25	33.99	5.2	
			5 m	27.94	34.36	4.2	
			10 m	28.10	35.31	3.8	
		1508	14 m	28.30	35.40	3.8	
11	25 km	1541	Surface	28.85	34.79	6.7	110
			2 m	28.76	34.90	5.4	
			5 m	28.25	35.21	4.8	
			10 m	28.39	35.36	4.7	
		1548	14 m	28.18	35.45	4.5	
12	35 km	1609	Surface	28.88	35.68	6.3	105
			2 m	28.74	35.65	6.1	
			5 m	28.60	35.75	5.7	
			10 m	28.34	35.79	5.3	
		1618	14 m	28.52	35.80	5.1	
13	45 km	1636	Surface	29.06	36.24	6.3	100
			2 m	29.06	36.20	6.0	
			5 m	28.88	36.08	5.8	
			10 m	28.55	36.15	5.3	
		1646	14 m	28.61	36.17	4.8	
14	55 km	1705	Surface	28.52	36.60	7.5	110
			2 m	28.56	36.55	7.3	
			5 m	28.49	36.56	6.8	
			10 m	28.03	36.62	6.5	
		1713	14 m	28.24	36.84	6.0	
15	65 km	1735	Surface	28.42	37.10	11.0	130
			2 m	28.52	37.03	11.0	
			5 m	28.42	36.93	10.8	
			10 m	28.46	37.00	10.4	
			14 m	28.36	36.96	9.7	
		1744	18 m Bottom	-----	-----	9.6	

Station No.	Distance	Time (Local)	Sampling Depth, Meters	Temp °C	Salinity 0/00	Dissolved Oxygen PPM	Visibility cm
16	75 km	1810	Surface	28.43	36.85	10.4	140
			2 m	28.56	36.95	9.5	
			5 m	28.57	37.02	8.5	
			10 m	28.54	36.82	7.6	
		1818	14 m	28.43	37.15	6.9	

SITE: SUEZ CANAL

DATE: 20 September 1978

Station No.	Distance	Time (Local)	Sampling Depth, Meters	Temp °C	Salinity 0/00	Dissolved Oxygen PPM
1	-5 km	0830	0	27.25	36.85	5.2
			2	27.27	36.82	5.9
			5	27.19	36.85	5.8
			10	27.24	36.95	5.9
		0915	13(Bot)	27.40	37.08	5.6
2	-2.4 km	0927	Surface	27.83	36.13	6.8
			2 m	27.74	36.34	5.3
			5 m	27.68	36.54	5.3
			10 m	27.51	36.85	5.3
		0940	12(Bot)	27.54	36.88	5.3
3	0 km	0950	Surface	27.72	35.04	4.9
			2 m	27.56	35.84	4.8
			5 m	27.58	36.04	4.7
			10 m	27.47	36.46	5.1
		1011	14 m	27.40	36.64	5.1
4	2 km	1026	Surface	27.64	32.74	4.8
			2 m	27.53	34.47	4.3
			5 m	27.58	35.79	4.3
			10 m	27.62	36.16	4.5
		1059	15(Bot)	27.56	36.40	4.2
5	4 km	1040	Surface	27.05	27.49	4.8
			2 m	27.37	34.97	4.0
			5 m	27.41	35.08	3.9
			10 m	27.57	35.66	4.0
		1059	15(Bot)	27.56	36.40	4.2
6	6 km	1103	Surface	28.09	25.03	6.1
			2 m	27.55	34.86	4.3
			5 m	27.49	35.01	4.0
			10 m	27.55	35.36	3.8
			15 m	27.54	35.36	3.7
			16.5(Bot)	----	----	3.6
7	8 km	1118	Surface	27.65	34.87	4.9
			2 m	27.38	34.82	5.3
			5 m	27.32	34.81	4.0
			10 m	27.36	34.90	3.8
			15 m	27.61	35.81	3.6
		1140	17(Bot)	-----	-----	3.55

Station No.	Distance	Time (Local)	Sampling Depth, Meters	Temp °C	Salinity 0/00	Dissolved Oxygen PPM
8	10 km	1149	Surface	27.67	34.77	4.7
			2 m	27.58	34.76	3.9
			5 m	27.34	34.74	3.9
			10 m	27.34	34.74	3.9
		1156	15 (Bot)	27.34	34.80	3.8
9	12 km	1201	Surface	27.99	34.69	4.4
			2 m	27.51	34.71	4.1
			5 m	27.38	34.70	3.9
			10 m	27.39	34.79	3.8
			15 m	27.41	34.90	3.7
		1221	15.75 (Bot)	---	----	3.7
10	14 km	1226	Surface	28.27	34.70	4.3
			2 m	27.90	34.74	4.0
			5 m	27.60	34.80	3.9
			10 m	27.44	34.91	3.8
			15 m	27.48	35.08	3.7
		1234	16.5 (Bot)	----	-----	3.6
11	25 km	1316	Surface	27.71	35.06	4.4
			2 m	27.61	35.16	4.3
			5 m	27.50	35.16	4.3
			10 m	27.41	35.30	4.2
			15 m	27.47	35.27	4.2
		1337	20 (Bot)	-----	-----	3.9
12	35 km	1357	Surface	28.37	35.45	5.0
			2 m	27.84	35.40	4.8
			5 m	27.60	35.41	4.6
			10 m	27.45	35.45	4.5
			15 m	27.51	35.54	4.4
		1404	17 (Bot)	-----	-----	4.3
13	45 km	1424	Surface	28.10	35.70	5.2
			2 m	28.12	35.63	5.1
			5 m	27.81	35.64	4.8
			10 m	27.56	35.65	4.7
			15 m	27.48	35.62	4.7
		1443	19 (Bot)	-----	-----	4.7
14	55 km	1502	Surface	27.94	35.62	5.5
			2 m	27.91	35.59	5.2
			5 m	27.56	35.59	5.0
			10 m	27.36	35.59	5.0
			15 m	27.34	35.59	4.9
		1509	20 (Bot)	-----	-----	4.9

Station No.	Distance	Time (Local)	Sampling Depth, Meters	Temp °C	Salinity 0/00	Dissolved Oxygen PPM
15	65 km	1531	Surface	27.82	35.74	8.1
			2 m	27.63	35.79	7.1
			5 m	27.53	35.88	6.8
			10 m	27.61	35.87	6.8
			15 m	27.59	35.87	6.6
		1550	18 (Bot)	-----	-----	6.6
16	75 km	1609	Surface	28.0	37.50	8.1
			2 m	27.95	37.60	7.0
			5 m	27.92	37.60	6.8
			10 m	27.81	37.77	6.3
			15 m	27.81	37.93	5.9
		1615	18 (Bot)	-----	-----	5.9
17	Lake Timsah	1620	Surface	28.42	35.87	9.2
			2 m	28.00	37.20	6.6
			5 m	27.76	38.01	5.7
			10 m	27.78	37.51	4.8
			15 m	27.78	38.05	4.4
		1631	18 (Bot)	-----	-----	4.4

SITE: SUEZ CANAL

DATE: 21 September 1978

Station No.	Distance	Time (Local)	Sampling Depth, Meters	Temp °C	Salinity 0/00	Dissolved Oxygen PPM	Visibility cm
1	75 km	0606 0616	Surface 2 m 5 m 10 m 15 m	26.96 26.70 26.68 27.47 27.47	36.96 37.12 37.14 37.74 > 38	5.7 5.3 5.2 4.8 2.6	150
2	65 km	0656 0703	Surface 2 m 5 m 10 m	27.08 27.18 27.14 27.15	36.00 35.96 35.99 35.95	6.8 6.8 6.8 6.7	150
3	55 km	0732 0738	Surface 2 m 5 m 10 m 15 m	26.92 26.92 26.86 27.00 26.92	35.82 35.78 35.78 35.82 35.78	5.4 5.2 5.2 5.3 5.2	100
4	45 km	0802 0818	Surface 2 m 5 m 10 m	27.37 27.23 27.24 27.24	35.88 35.90 35.80 35.80	5.3 5.0 5.0 4.9	60
5	35 km	0841 0847	Surface 2 m 5 m 10 m 15 m	27.30 27.30 27.23 27.30	35.68 35.66 35.69 35.64	4.9 4.9 4.6 4.4 4.4	40
6	25 km	0915 0929	Surface 2 m 5 m 10 m 15 m	27.17 27.24 27.20 27.21 27.21	35.39 35.35 35.36 35.36 35.38	4.4 4.3 4.4 4.4 4.2	100
7	14 km	0959 1023	Surface 2 m 5 m 10 m 15 m	27.54 27.43 27.35 27.39 27.40	34.90 34.88 34.90 35.08 35.18	3.9 3.7 3.6 3.5 3.4	80
8	12 km	1029 1035	Surface 2 m 5 m 10 m 15 m	27.38 27.42 27.31 27.38 27.30	34.84 34.86 34.82 34.90 34.90	4.1 4.0 3.9 3.6 3.6	60

Station No.	Distance	Time (Local)	Sampling Depth, Meters	Temp °C	Salinity 0/00	Dissolved Oxygen PPM	Visibility cm
9	10 km	1055	Surface	27.63	34.84	4.1	60
			2 m	27.42	34.86	4.0	
			5 m	27.31	34.82	3.9	
			10 m	27.27	34.92	3.7	
		1101	15 m	27.31	34.90	3.7	
10	8 km	1106	Surface	27.68	34.87	4.3	90
			2 m	27.54	34.84	4.1	
			5 m	27.25	34.95	3.9	
			10 m	27.39	35.00	3.8	
		1111	15 m	27.38	35.15	3.7	
11	6 km	1118	Surface	27.65	30.94	4.9	120
			2 m	27.48	34.92	4.2	
			5 m	27.25	34.90	3.9	
			10 m	27.46	35.62	3.6	
		1133	15 m	27.42	36.06	3.7	
12	4 km	1151	Surface	27.22	29.41	4.6	60
			2 m	27.38	35.01	4.0	
			5 m	27.41	35.43	3.8	
			10 m	27.40	36.17	4.1	
		1157	15 m	27.41	36.40	4.4	
13	2 km	1204	Surface	27.46	34.40	4.6	110
			2 m	27.47	35.12	4.4	
			5 m	27.36	35.65	4.4	
			10 m	27.35	36.45	4.8	
		1220	15 m	27.39	36.77	5.1	
14	0 km	1229	Surface	27.71	35.44	4.5	110
			2 m	27.60	35.62	4.4	
			5 m	27.56	36.29	4.6	
			10 m	27.40	36.78	5.0	
		1236	15 m	27.52	36.81	4.9	
15	-2.4 km	1308	Surface	27.81	36.11	5.8	105
			2 m	27.50	36.38	5.4	
			5 m	27.48	36.82	5.5	
			10 m	27.39	36.95	5.6	
		1320	12 m	27.34	37.03	5.6	
16	-5 km	1329	Surface	27.21	32.56	6.7	190
			2 m	27.37	36.73	6.1	
			5 m	27.29	36.98	5.9	
			10 m	27.13	37.16	5.8	
		1325	15 m	27.11	37.24	5.7	

TABLE B

SALINITY, TEMPERATURE, DISSOLVED OXYGEN MEASUREMENTS

LAKE MANZALA

20 August 1978	(Zone B)
30 August 1978	(Zone B)
31 August 1978	(Zone A)
8 September 1978	(Zones C & D)
18 September 1978	(Zone D)
19 September 1978	(Zone C)
23 September 1978	(Zones A & B)
25 September 1978	(Zone C)
26 September 1978	(Zone D)

SITE: LAKE MANZALA

DATE: 20 August 1978

Station No.	Time (Local)	Sampling Depth	Temp °C	Salinity 0/00	Dissolved Oxygen PPM	Visibility cm
B 6	1050	Surface Bottom (1.25)	29.9 28.0	8.78 14.24	7.6 2.8	20
B 5	1230	Surface Bottom (0.9 m)	31.4 30.2	5.39 5.92	11.4 8.6	10
B 7	1450	Surface Bottom (3.0 m)	30.4 30.1	8.87 13.06	6.8 5.9	35

SITE: LAKE MANZALA

DATE: 30 August 1978

Station No.	Time (Local)	Sampling Depth	Temp °C	Salinity 0/00	Dissolved Oxygen PPM	Visibility cm	Water Depth cm
B 6	1143	mid	28.88	5.9	8.9	30	
B 5	1215	mid	29.25	3.2	7.7	35	
B 4	1248	mid	29.31	3.34	6.7	35	130
B 1	1322	mid	29.45	1.62	7.4	30	100
B 8	1343	mid	29.76	2.95	7.4	35	105
B 11	1405	mid	30.10	3.38	7.2	40	100
B 7	1440	Surface Bottom	29.87 29.64	3.8 6.7	7.2 7.0	30	300
B 10	1501	mid	29.76	3.11	8.5	30	100
B 9	1521	mid	29.93	3.45	10.2	35	120

SITE: LAKE MANZALA -- ZONE A

DATE: 31 August 1978

Station No.	Time (Local)	Sampling Depth	Temp °C	Salinity 0/00	Dissolved Oxygen PPM	Visibility cm	Water Depth cm
A 5	1419	mid	32.53	11.41	> 20	10	32
A 4	1445	mid	32.30	11.14	> 20	10	45
A 3	1513	mid	31.55	10.79	19.5	10	35
A 2	1535	mid	31.38	9.48	3.5	10	50
A 1	1553	mid	30.79	10.21	3.5	6	65
A 6	1633	mid	30.96	6.21	3.5	15	45

SITE: LAKE MANZALA

DATE: 8 September 1978

Station No.	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM	Visibility cm	Water Depth cm
D 1	1247	Surface Bottom	30.9 30.7	6.5 7.4	87	87
D 2	1314	Surface Bottom	30.5 30.4	6.8 6.8	72	72
C 1	1423	Surface Bottom	30.4 28.0	7.8 10.5	30	95
C 2	1441	Surface Bottom	31.2 28.5	11.4 8.7	35	100
C 3	1457	Surface Bottom	33.0 29.1	10.6 11.0	30	95
C 4	1519	Surface Bottom	32.5 28.9	13.0 9.6	25	87

SITE: LAKE MANZALA

DATE: 18 September 1978

Station No.	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
D 2	0952	Surface Bottom	25.0 25.0	6.4 6.9
D 1	1020	Surface Bottom	24.9 24.6	6.4 6.2

SITE: LAKE MANZALA

DATE: 19 September 1978

Station No.	Time (Local)	Sampling Depth	Temp °C	Salinity 0/00	Dissolved Oxygen PPM	Visibility cm
C 4	1220	Surface Bottom	26.9 26.5	11.1 12.2	8.6 8.2	30
C 2	1315	Surface Bottom	27.1 26.3	11.9 12.1	9.2 8.4	35

SITE: LAKE MANZALA

DATE: 23 September 1978

Station No.	Time (Local)	Sampling Depth	Temp °C	Salinity 0/00	Dissolved Oxygen PPM	Visibility cm
B 9	0956	Surface Bottom	25.1 24.9	3.9 3.8	5.8 5.4	15
B 8	1056	Surface Bottom	25.0 25.0	2.7 2.5	6.1 6.1	35
B 1	1131	Surface Bottom	25.2 25.0	2.3 2.4	7.4 7.2	30
B 5	1212	Surface Bottom	26.1 25.5	2.7 2.4	8.3 7.7	35
A 4	1304	Surface Bottom	26.5 26.1	6.9 6.7	18.3 17.1	5
A 3	1320	Surface Bottom	26.9 26.5	6.6 6.7	18.4 18.0	5
A 2	1356	Surface Bottom	27.1 27.0	6.5 6.5		5
A 1	1423	Surface Bottom	27.2 27.0	6.7 6.6	6.4 5.7	10

SITE: LAKE MANZALA

DATE: 25 September 1978

Station No.	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM	Visibility cm
C 1	1140	Surface Bottom	24.4 23.3	6.1 3.2	35
C 2	1213	Surface Bottom	23.5 22.5	7.9 3.2	30
C 3	1225	Surface Bottom	23.5 23.5	7.9 7.6	30
C 4	1251	Surface Bottom	23.5 23.3	7.6 7.3	45

SITE: LAKE MANZALA

DATE: 26 September 1978

Station No.	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
D 2	1625	Surface Bottom	28.9 28.9	7.5 9.5
D 1	1649	Surface Bottom	26.7 26.7	11.0 11.4

TABLE C

DIURNAL TEMPERATURE AND DISSOLVED OXYGEN MEASUREMENTS

LAKE MANZALA

9-10 September 1978 (Station C-2)

12-13 September 1978 (Station B)

19-20 September 1978 (Station C-2)

23-24 September 1978 (Station A-1, A-2, A-3)

SITE: LAKE MANZALA -- ZONE C   STATION C-2

DATE: 9 - 10 September 1978

Measurement No.	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
	9 SEP			
1	1615	Surface Bottom*	29.6 29.5	5.2 4.8
2	1700	Surface Bottom	29.5 29.5	4.9 4.4
3	1715	Surface Bottom	29.1 29.1	3.7 3.2
4	1730	Surface Bottom	29.0 29.0	3.5 3.2
5	1800	Surface Bottom	28.9 28.9	3.2 3.2
Sunset	1804			
6	1830	Surface Bottom	28.5 28.1	2.9 2.7
7	2000	Surface Bottom	28.0 28.0	2.7 2.7
8	2203	Surface Bottom	27.5 27.4	3.0 3.1
	10 SEP			
9	0015	Surface Bottom	27.0 27.0	2.5 2.5
10	0200	Surface Bottom	26.9 26.9	2.3 2.3
11	0400	Surface Bottom	26.0 26.0	2.1 2.1
12	0530	Surface Bottom	26.0 26.0	1.5 1.4

*Depth of water at Station C-2 = 90 cm.

Measurement	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
Sunrise	0531			
13	0600	Surface Bottom	26.1 26.1	1.8 1.5
14	0630	Surface Bottom	26.1 26.1	1.5 1.5
15	0700	Surface Bottom	25.5 26.0	3.0 1.5
16	0700	Surface Bottom	25.5 26.0	3.7 1.6
17	0800	Surface Bottom	26.0 26.0	4.6 2.2

SITE: LAKE MANZALA --- ZONE B STATION B

DATE: 12 - 13 September 1978

Measurement No.	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
	12 SEP			
Sunset	1802			
1	1815	Surface Bottom	27.5 26.3	6.3 5.5
2	1845	Surface Bottom	27.1 26.0	6.2 5.5
3	1945	Surface Bottom	27.0 26.4	6.5 5.9
4	2045	Surface Bottom	27.0 26.7	6.5 6.4
5	2145	Surface Bottom	26.5 26.5	6.5 6.5
6	2245	Surface Bottom	26.5 26.5	5.3 5.3
7	2345	Surface Bottom	26.5 26.2	5.1 5.2
	13 SEP			
8	0045	Surface Bottom	26.2 26.2	4.9 4.8
9	0145	Surface Bottom	26.0 26.0	4.4 4.2
10	0245	Surface Bottom	26.0 26.0	3.4 3.5
11	0345	Surface Bottom	26.0 26.0	3.8 3.9
12	0445	Surface Bottom	25.5 25.5	4.1 4.1

Measurement No.	Time (Local)	Sampling	Temp °C	Dissolved Oxygen PPM
Sunrise	0531			
13	0545	Surface Bottom	25.5 25.5	4.2 4.1
14	0645	Surface Bottom	25.6 25.5	4.3 4.1
15	0745	Surface Bottom	25.5 25.5	5.0 5.0
16	0845	Surface Bottom	26.0 25.5	5.9 4.7
17	0945	Surface Bottom	26.0 26.0	5.2 4.7

SITE: LAKE MANZALA -- ZONE C   STATION C-2

DATE: 19 - 20 September 1978

Measurement No.	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
	19 SEP			
1	1400	Surface Bottom*	27.3 27.0	8.8 8.5
2	1500	Surface Bottom	27.5 27.6	9.7 9.2
3	1600	Surface Bottom	27.7 27.9	9.8 9.5
4	1700	Surface Bottom	27.8 27.8	9.8 9.7
Sunset	1748			
5	1800	Surface Bottom	27.4 27.5	9.3 8.8
6	1900	Surface Bottom	27.0 27.1	8.6 8.1
7	2000	Surface Bottom	26.9 26.9	8.0 7.4
8	2100	Surface Bottom	26.5 26.5	7.4 6.9
9	2200	Surface Bottom	26.1 26.2	6.7 6.5
10	2300	Surface Bottom	26.0 26.1	6.2 5.8
11	2400	Surface Bottom	25.6 26.0	6.2 5.7

*Depth of water at Station C-2 = 90 cm.

Measurement No.	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
	20 SEP			
12	0100	Surface Bottom	25.5 25.9	5.8 5.1
13	0200	Surface Bottom	25.4 25.9	5.6 4.8
14	0300	Surface Bottom	25.2 25.6	5.0 4.4
15	0400	Surface Bottom	25.0 25.8	4.8 4.3
16	0515	Surface Bottom	25.0 25.8	3.7 3.5
Sunrise	0540			
17	0600	Surface Bottom	25.5 25.5	3.5 3.2
18	0700	Surface Bottom	25.5 25.5	3.6 3.2
19	0800	Surface Bottom	25.8 25.5	3.9 3.5

SITE: LAKE MANZALA

DATE: 23 - 24 September 1978

Measurement No.	Time (Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
		Station A-2		
	23 SEP			
1	1637	mid	27.3	7.6
		Station A-1		
2	1654	mid	27.6	20.0
		Station A-3		
3	1707	mid	27.1	0.0-0.2
		Station A-2		
4	1800	mid	26.9	1.3
5	1900	mid	25.9	0.0
		Station A-1		
6	1917	mid	26.5	13.5
7	2000	mid	25.7	11.4
8	2100	mid	25.6	8.6
9	2200	mid	25.1	6.1
10	2300	mid	24.4	4.1
11	2400	mid	23.8	0.9
	12 Sep			
12	0100	mid	23.5	0
13	0300	mid	23.7	0
14	0500	mid	22.3	0

Measurements No.	(Local)	Sampling Depth	Temp °C	Dissolved Oxygen PPM
		Station A-1 Cont.		
15	0600	mid	21.8	0
16	0700	mid	21.6	0
17	0730	mid	21.7	0.2
18	0800	mid	22.0	0.3
19	0826	mid	22.3	0.6
20	0844	mid	22.5	0.9

TABLE D

WINDS

PORT SAID

23 July - 29 August 1978

WINDS

PORT SAID, EGYPT

Date July 23, 1978			Date July 24, 1978			Date July 25, 1978			Date July 26, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000			0000	4	E	0000	4	SE	0000	2	SE
0100			0100	5	E	0100	6	E	0100	2	SE
0200			0200	6	E	0200	4	E	0200	1	SE
0300			0300	4	E	0300	4	E	0300	2	E
0400			0400	4	E	0400	2	E	0400	1	E
0500			0500	4	E	0500	2	E	0500	1	E
0600			0600	4	E	0600	2	E	0600	1	E
0700			0700	4	E	0700	2	E	0700	1	E
0800			0800	4	E	0300	2	E	0800	3	E
0900			0900	4	E	0900	3	E	0900	4	E
1000			1000	5	SE	1000	4	E	1000	5	E
1100			1100	6	SE	1100	5	E	1100	5	E
1200			1200	6	SE	1200	6	SE	1200	4	SE
1300			1300	6	SE	1300	8	SE	1300	6	S
1400			1400	7	SE	1400	7	SE	1400	4	S
1500			1500	8	SE	1500	8	S	1500	4	S
1600			1600	8	SE	1600	8	S	1600	5	S
1700			1700	8	SE	1700	8	S	1700	6	S
1800			1800	8	SE	1800	8	S	1800	6	S
1900	4	SE	1900	8	SE	1900	7	S	1900	7	SE
2000	4	SE	2000	6	SE	2000	6	SE	2000	6	SE
2100	4	SE	2100	6	SE	2100	5	SE	2100	6	SE
2200	4	SE	2200	7	SE	2200	4	SE	2200	6	SE
2300	5	SE	2300	5	SE	2300	3	SE	2300	6	SE

Location: PORT SAID, EGYPT	Number of Observations: 888
Data period: July 23, 1978-August 29, 1978	By: BRC

WINDS

PORT SAID, EGYPT

Date July 27, 1978			Date July 28, 1978			Date July 29, 1978			Date July 30, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	5	SE	0000	2	SE	0000	4	SE	0000	4	S
0100	4	SE	0100	1	SE	0100	2	SE	0100	4	SE
0200	2	E	0200	2	SE	0200	2	SE	0200	4	SE
0300	2	E	0300	2	SE	0300	1	E	0300	2	SE
0400	2	E	0400	1	E	0400	0	E	0400	2	SE
0500	2	E	0500	2	E	0500	2	E	0500	2	SE
0600	1	E	0600	2	E	0600	4	E	0600	1	SE
0700	2	E	0700	2	E	0700	2	E	0700	1	SE
0800	4	E	0800	4	E	0800	4	E	0800	1	E
0900	4	E	0900	4	SE	0900	4	E	0900	2	E
1000	5	E	1000	5	SE	1000	6	E	1000	2	SE
1100	4	SE	1100	5	SE	1100	6	E	1100	4	SE
1200	4	SE	1200	5	SE	1200	5	E	1200	4	SE
1300	5	SE	1300	7	SE	1300	4	SE	1300	4	E
1400	6	SE	1400	9	S	1400	5	SE	1400	5	S
1500	6	SE	1500	8	S	1500	6	SE	1500	6	S
1600	7	S	1600	9	S	1600	5	S	1600	5	S
1700	6	S	1700	8	S	1700	6	S	1700	5	S
1800	6	S	1800	8	S	1800	7	S	1800	5	S
1900	6	S	1900	8	S	1900	6	S	1900	4	S
2000	5	S	2000	6	S	2000	6	S	2000	4	S
2100	4	S	2100	6	S	2100	6	S	2100	4	S
2200	4	SE	2200	6	SE	2200	4	S	2200	4	S
2300	2	SE	2300	5	SE	2300	4	S	2300	3	S

Location: PORT SAID, EGYPT	Number of Observations: 888
Data period: July 23, 1978 - August 29, 1978	By: BRC

WINDS

PORT SAID, EGYPT

Date July 31, 1978			Date August 1, 1978			Date August 2, 1978			Date August 3, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	1	S	0000	4	SE	0000	4	SE	0000	4	SE
0100	0	VAR	0100	4	SE	0100	3	SE	0100	3	SE
0200	0	VAR	0200	5	SE	0200	2	SE	0200	3	SE
0300	0	VAR	0300	4	SE	0300	2	SE	0300	2	SE
0400	1	SE	0400	4	SE	0400	1	SE	0400	2	SE
0500	2	SE	0500	4	SE	0500	0	VAR	0500	2	SE
0600	1	SE	0600	4	SE	0600	1	E	0600	2	SE
0700	1	SE	0700	2	SE	0700	1	NE	0700	1	SE
0800	2	SE	0800	2	SE	0800	2	NE	0800	2	E
0900	3	SE	0900	2	SE	0900	2	NE	0900	2	E
1000	2	SE	1000	3	SE	1000	2	NE	1000	2	SE
1100	3	SE	1100	2	SE	1100	3	NE	1100	2	SE
1200	4	S	1200	2	SE	1200	3	NE	1200	2	SE
1300	2	S	1300	4	S	1300	6	E	1300	2	SE
1400	3	S	1400	4	S	1400	5	E	1400	4	S
1500	4	S	1500	4	S	1500	4	SE	1500	4	S
1600	4	S	1600	4	S	1600	4	S	1600	4	S
1700	4	S	1700	5	S	1700	4	S	1700	4	S
1800	4	S	1800	4	S	1800	3	S	1800	4	S
1900	4	S	1900	4	SE	1900	2	S	1900	4	S
2000	2	S	2000	4	SE	2000	1	S	2000	3	S
2100	2	SE	2100	4	SE	2100	2	SE	2100	2	SW
2200	4	SE	2200	4	SE	2200	2	SE	2200	1	SW
2300	3	SE	2300	3	SE	2300	2	SE	2300	0	S

Location:	Number of Observations:
PORT SAID, EGYPT	888
Data period: July 23, 1978 - August 29, 1978	By: BRC

WINDS

PORT SAID, EGYPT

Date August 4, 1978			Date August 5, 1978			Date August 6, 1978			Date August 7, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	0	S	0000	1	S	0000	1	S	0000	1	SE
0100	1	S	0100	1	SE	0100	0	S	0100	1	SE
0200	1	S	0200	1	SE	0200	0	VAR	0200	0	SE
0300	1	S	0300	1	SE	0300	0	VAR	0300	0	SE
0400	0	S	0400	0	SE	0400	0	SE	0400	1	SE
0500	1	S	0500	1	SE	0500	0	SE	0500	0	E
0600	0	S	0600	1	SE	0600	0	SE	0600	1	E
0700	0	S	0700	0	SE	0700	1	SE	0700	1	E
0800	1	S	0800	2	E	0800	2	SE	0800	1	E
0900	1	S	0900	2	E	0900	2	SE	0900	2	E
1000	2	S	1000	2	E	1000	2	E	1000	2	SE
1100	4	S	1100	2	E	1100	3	E	1100	2	SE
1200	3	S	1200	2	E	1200	3	SE	1200	3	SE
1300	4	S	1300	4	SE	1300	4	SE	1300	3	SE
1400	4	S	1400	4	SW	1400	4	SE	1400	4	S
1500	4	S	1500	4	SW	1500	4	SE	1500	4	S
1600	4	S	1600	4	SW	1600	4	S	1600	4	S
1700	4	S	1700	5	SW	1700	4	S	1700	4	S
1800	4	S	1800	4	SW	1800	4	S	1800	4	S
1900	4	S	1900	4	SW	1900	3	S	1900	4	SW
2000	4	S	2000	3	SW	2000	4	S	2000	2	SW
2100	2	S	2100	2	SW	2100	5	S	2100	2	SW
2200	1	S	2200	2	SW	2200	2	S	2200	1	SW
2300	1	S	2300	1	SW	2300	2	S	2300	0	SW

Location: PORT SAID, EGYPT	Number of Observations: 888
Data period: July 23, 1978 - August 29, 1978	By: BRC

WINDS

PORT SAID, EGYPT

Date August 8, 1978			Date August 9, 1978			Date August 10, 1978			Date August 11, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	1	SW	0000	3	S	0000	4	SE	0000	2	SE
0100	0	VAR	0100	2	S	0100	2	SE	0100	4	SE
0200	0	VAR	0200	1	S	0200	1	SE	0200	3	SE
0300	0	VAR	0300	0	S	0300	1	SE	0300	4	SE
0400	0	VAR	0400	0	VAR	0400	0	SE	0400	5	SE
0500	0	VAR	0500	0	VAR	0500	0	E	0500	4	SE
0600	0	VAR	0600	0	VAR	0600	0	E	0600	4	SE
0700	0	S	0700	0	SE	0700	0	E	0700	2	SE
0800	0	S	0800	0	SE	0800	3	E	0800	3	E
0900	1	S	0900	2	SE	0900	4	SE	0900	3	E
1000	2	SW	1000	1	SE	1000	4	SE	1000	4	SE
1100	2	SW	1100	2	S	1100	4	SE	1100	3	SE
1200	2	SW	1200	2	S	1200	5	SE	1200	4	SE
1300	4	S	1300	4	S	1300	5	SE	1300	4	S
1400	4	S	1400	4	S	1400	5	SE	1400	6	S
1500	4	S	1500	3	S	1500	5	SE	1500	6	S
1600	4	S	1600	4	S	1600	7	SE	1600	6	S
1700	4	S	1700	5	S	1700	8	SE	1700	8	S
1800	4	S	1800	5	S	1800	8	SE	1800	6	S
1900	4	S	1900	5	SE	1900	8	SE	1900	6	S
2000	4	S	2000	6	SE	2000	5	SE	2000	4	S
2100	2	S	2100	5	SE	2100	3	SE	2100	4	S
2200	3	S	2200	6	SE	2200	4	SE	2200	4	S
2300	3	S	2300	4	SE	2300	2	SE	2300	2	S

Location: PORT SAID, EGYPT	Number of Observations: 888
Data period: July 23, 1978 - August 29, 1978	By: BRC

WINDS

PORT SAID, EGYPT

Date August 12, 1978			Date August 13, 1978			Date August 14, 1978			Date August 15, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	2	S	0000	4	SE	0000	6	SE	0000	5	SE
0100	2	S	0100	3	SE	0100	6	SE	0100	4	SE
0200	2	SE	0200	4	SE	0200	6	SE	0200	4	SE
0300	2	SE	0300	4	SE	0300	5	SE	0300	2	SE
0400	2	SE	0400	4	SE	0400	4	SE	0400	2	SE
0500	2	SE	0500	4	SE	0500	5	SE	0500	3	SE
0600	1	SE	0600	4	SE	0600	4	SE	0600	2	SE
0700	2	SE	0700	4	SE	0700	3	SE	0700	2	SE
0800	2	SE	0800	4	SE	0800	4	SE	0800	2	SE
0900	3	SE	0900	4	SE	0900	4	SE	0900	3	SE
1000	3	SE	1000	6	SE	1000	6	SE	1000	4	SE
1100	4	SE	1100	5	S	1100	5	SE	1100	5	SE
1200	4	S	1200	6	S	1200	5	SE	1200	4	SE
1300	4	S	1300	6	S	1300	5	SE	1300	4	S
1400	4	S	1400	6	S	1400	6	S	1400	5	S
1500	5	S	1500	6	S	1500	6	S	1500	5	S
1600	6	S	1600	8	S	1600	6	S	1600	5	S
1700	6	S	1700	7	S	1700	7	S	1700	6	SE
1800	7	S	1800	7	S	1800	6	S	1800	6	SE
1900	6	S	1900	8	S	1900	8	S	1900	8	SE
2000	4	S	2000	8	S	2000	7	SE	2000	6	SE
2100	5	S	2100	6	SE	2100	6	SE	2100	5	SE
2200	5	S	2200	6	SE	2200	6	SE	2200	4	SE
2300	4	SE	2300	6	SE	2300	4	SE	2300	4	SE

Location: PORT SAID, EGYPT	Number of Observations: 888
Data period: July 23, 1978 - August 29, 1978	By: BRC

WINDS

PORT SAID, EGYPT

Date August 16, 1978			Date August 17, 1978			Date August 18, 1978			Date August 19, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	3	SE	0000	4	SE	0000	1	SW	0000	2	S
0100	3	SE	0100	3	SE	0100	0	VAR	0100	1	S
0200	4	SE	0200	2	SE	0200	0	VAR	0200	2	S
0300	3	SE	0300	1	E	0300	0	VAR	0300	2	S
0400	4	SE	0400	2	E	0400	0	VAR	0400	2	S
0500	4	SE	0500	1	SE	0500	0	VAR	0500	2	S
0600	3	SE	0600	1	SE	0600	0	VAR	0600	1	S
0700	3	SE	0700	3	SE	0700	0	VAR	0700	1	S
0800	4	SE	0800	4	SE	0800	0	S	0800	1	S
0900	4	SE	0900	2	SE	0900	2	S	0900	2	S
1000	4	SE	1000	2	SE	1000	2	S	1000	2	S
1100	4	SE	1100	1	VAR	1100	2	S	1100	3	S
1200	4	SE	1200	2	SW	1200	2	S	1200	4	S
1300	4	SE	1300	4	SW	1300	2	S	1300	3	S
1400	6	SE	1400	4	SW	1400	4	S	1400	4	S
1500	5	S	1500	4	SW	1500	4	S	1500	4	S
1600	4	S	1600	4	S	1600	4	S	1600	4	S
1700	5	S	1700	4	S	1700	4	S	1700	4	S
1800	6	S	1800	4	S	1800	4	S	1800	4	S
1900	6	S	1900	4	SW	1900	3	S	1900	4	S
2000	6	SE	2000	4	SW	2000	4	S	2000	3	S
2100	6	SE	2100	3	SW	2100	3	S	2100	2	S
2200	4	SE	2200	4	SW	2200	3	S	2200	1	S
2300	3	SE	2300	2	SW	2300	2	S	2300	1	S

Location: PORT SAID, EGYPT	Number of Observations: 888
Data period: July 23, 1978 - August 29, 1978	By: BRC

WINDS

PORT SAID, EGYPT

Date August 20, 1978			Date August 21, 1978			Date August 22, 1978			Date August 23, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	2	SE	0000	4	S	0000	2	SE	0000	2	SE
0100	2	SE	0100	3	S	0100	1	SE	0100	2	SE
0200	2	SE	0200	3	S	0200	1	SE	0200	3	SE
0300	2	SE	0300	2	S	0300	1	SE	0300	2	SE
0400	1	SE	0400	1	S	0400	2	SE	0400	3	SE
0500	1	SE	0500	0	S	0500	2	SE	0500	3	SE
0600	0	SE	0600	0	S	0600	1	SE	0600	2	SE
0700	1	SE	0700	0	S	0700	1	SE	0700	1	E
0800	1	SE	0800	1	S	0800	2	SE	0800	4	E
0900	2	SE	0900	2	S	0900	4	SE	0900	4	E
1000	3	SE	1000	2	S	1000	4	SE	1000	4	E
1100	2	SE	1100	2	S	1100	3	SE	1100	4	E
1200	2	SE	1200	3	S	1200	4	SE	1200	4	E
1300	4	S	1300	4	S	1300	4	SE	1300	4	SE
1400	4	S	1400	4	S	1400	4	S	1400	4	SE
1500	4	S	1500	4	S	1500	4	S	1500	4	S
1600	4	S	1600	4	S	1600	4	S	1600	4	S
1700	4	S	1700	4	S	1700	5	S	1700	5	S
1800	5	S	1800	4	S	1800	6	S	1800	5	S
1900	4	S	1900	4	S	1900	6	SE	1900	4	SE
2000	4	S	2000	2	S	2000	5	SE	2000	4	SE
2100	3	S	2100	2	S	2100	5	SE	2100	3	SE
2200	4	S	2200	2	SE	2200	4	SE	2200	2	SE
2300	3	S	2300	2	SE	2300	3	SE	2300	2	S

Location:	Number of Observations:
PORT SAID, EGYPT	888
Data period: July 23, 1978 - August 29, 1978	By: BRC

WINDS

PORT SAID, EGYPT

Date August 24, 1978			Date August 25, 1978			Date August 26, 1978			Date August 27, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	2	SE	0000	2	S	0000	2	SE	0000	2	S
0100	1	SE	0100	0	S	0100	1	SE	0100	2	SE
0200	0	SE	0200	0	VAR	0200	1	SE	0200	2	SE
0300	1	S	0300	0	VAR	0300	1	SE	0300	2	SE
0400	1	SE	0400	0	VAR	0400	1	SE	0400	2	SE
0500	1	SE	0500	0	VAR	0500	1	SE	0500	2	SE
0600	2	SE	0600	0	VAR	0600	1	SE	0600	2	SE
0700	4	SE	0700	1	SE	0700	2	SE	0700	3	SE
0800	4	SE	0800	2	SE	0800	3	SE	0800	2	SE
0900	4	SE	0900	4	SE	0900	4	SE	0900	4	SE
1000	4	SE	1000	4	SE	1000	2	SE	1000	4	S
1100	4	SE	1100	4	SE	1100	3	SE	1100	4	S
1200	4	SE	1200	3	SE	1200	4	S	1200	4	S
1300	3	SE	1300	4	S	1300	4	S	1300	4	S
1400	5	SE	1400	5	S	1400	4	S	1400	4	S
1500	4	S	1500	4	S	1500	4	S	1500	4	S
1600	6	S	1600	5	S	1600	6	S	1600	4	S
1700	5	S	1700	4	S	1700	6	S	1700	4	S
1800	4	S	1800	4	S	1800	6	S	1800	4	S
1900	5	S	1900	4	S	1900	6	S	1900	4	S
2000	4	S	2000	4	SE	2000	6	S	2000	4	S
2100	2	S	2100	4	SE	2100	4	S	2100	3	S
2200	2	S	2200	4	SE	2200	4	S	2200	4	S
2300	2	S	2300	3	SE	2300	3	S	2300	3	S

Location: PORT SAID, EGYPT	Number of Observations: 888
Data period: July 23, 1978 - August 29, 1978	By: BRC

WINDS

PORT SAID, EGYPT

Date: August 28, 1978			Date: August 29, 1978			Date			Date		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	2	S	0000	2	S	0000			0000		
0100	3	S	0100	2	S	0100			0100		
0200	2	S	0200	2	S	0200			0200		
0300	2	S	0300	2	S	0300			0300		
0400	2	S	0400	2	S	0400			0400		
0500	2	S	0500	1	S	0500			0500		
0600	2	S	0600	2	S	0600			0600		
0700	2	S	0700	1	S	0700			0700		
0800	1	S	0800	2	S	0800			0800		
0900	2	S	0900	2	S	0900			0900		
1000	2	S	1000	2	SW	1000			1000		
1100	4	S	1100	3	SW	1100			1100		
1200	4	S	1200	3	SW	1200			1200		
1300	4	S	1300	4	S	1300			1300		
1400	4	S	1400	4	S	1400			1400		
1500	4	S	1500	4	S	1500			1500		
1600	4	S	1600	4	S	1600			1600		
1700	4	S	1700	4	S	1700			1700		
1800	4	S	1800	2	S	1800			1800		
1900	3	S	1900			1900			1900		
2000	2	S	2000			2000			2000		
2100	2	S	2100			2100			2100		
2200	2	S	2200			2200			2200		
2300	2	S	2300			2300			2300		

Location: PORT SAID, EGYPT	Number of Observations: 888
Data period: July 23, 1978 - August 29, 1978	By: [illegible]

TABLE E

WINDS

PORT SAID

6 September - 27 September 1978

WINDS

PORT SAID, EGYPT

Date September 6, 1978			Date September 7, 1978			Date September 8, 1978			Date September 9, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000			0000	0	VAR	0000			0000		S
0100			0100	0	VAR	0100			0100		
0200			0200	0	VAR	0200			0200		
0300			0300	0	N	0300			0300		
0400			0400	0	N	0400			0400		
0500			0500	0	N	0500			0500		
0600			0600	1	N	0600			0600		
0700			0700	1	N	0700			0700		
0800	3	NW	0800	2	N	0800			0800		
0900	3	NW	0900	2	N	0900		NW	0900		
1000	4	NW	1000	2	N	1000		NW	1000		SW
1100	4	NW	1100		NW	1100		NW	1100		SW
1200	3	W	1200		NE	1200		NW	1200		S
1300	4	SW	1300		E	1300		W	1300		S
1400	4	SW	1400		W	1400		W	1400		S
1500	3	S	1500		W	1500		W	1500		S
1600	3	S	1600		NW	1600		SW	1600		S
1700	2	S	1700		W	1700		W	1700		S
1800	1	S	1800		S	1800		W	1800		S
1900	1	S	1900			1900		W	1900		S
2000	1	S	2000			2000			2000		S
2100	2	S	2100			2100			2100		S
2200	0	VAR	2200			2200		S	2200		S
2300	0	VAR	2300			2300		S	2300		S

Location: PORT SAID, EGYPT	Number of Observations: 439
Data period: September 6, 1978-September 27, 1978	By: BRC

/

WINDS

PORT SAID, EGYPT

Date Sept. 10, 1978			Date September 11, 1978			Date September 12, 1978			Date September 13, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000			0000	2.0	S	0000	2.0	SW	0000	2.0	SW
0100			0100	2.0	SE	0100	1.0	SW	0100	2.0	SW
0200			0200	2.0	S	0200	2.0	S	0200	1.0	W
0300			0300	2.0	SE	0300	1.0	SW	0300	2.0	W
0400			0400	2.0	SE	0400	1.0	SW	0400	2.0	W
0500			0500	3.0	SE	0500	1.0	SW	0500	1.0	W
0600			0600	4.0	SE	0600	1.0	SW	0600	1.0	W
0700			0700	6.0	SE	0700	1.0	SW	0700	2.0	NW
0800			0800	3.0	SE	0800	2.0	SW	0800	4.0	NW
0900			0900	4.0	SE	0900	4.0	SW	0900	4.0	NW
1000	4.0	SW	1000	4.0	S	1000	3.0	W	1000	4.0	NW
1100	5.0	SW	1100	4.0	S	1100	4.0	W	1100	4.0	NW
1200	5.0	SW	1200	4.0	SW	1200	4.0	SW	1200	4.0	NW
1300	6.0	SW	1300	4.0	SW	1300	4.0	SW	1300	4.0	NW
1400	5.0	SW	1400	4.0	S	1400	4.0	SW	1400	3.0	SW
1500	5.0	SW	1500	4.0	SW	1500	4.0	SW	1500	4.0	SW
1600	4.0	SW	1600	4.0	SW	1600	5.0	SW	1600	4.0	SW
1700	4.0	SW	1700	4.0	SW	1700	4.0	SW	1700	4.0	SW
1800	2.0	SW	1800	2.0	SW	1800	4.0	SW	1800	3.0	SW
1900	2.0	SW	1900	2.0	SW	1900	2.0	SW	1900	2.0	W
2000	3.0	SW	2000	2.0	SW	2000	2.0	SW	2000	1.0	W
2100	2.0	SW	2100	2.0	SW	2100	2.0	SW	2100	2.0	NW
2200	2.0	S	2200	2.0	SW	2200	2.0	SW	2200	1.0	NW
2300	2.0	S	2300	2.0	SW	2300	2.0	SW	2300	1.0	NW

Location:	Number of Observations:
PORT SAID, EGYPT	439
Data period: 9/6/78-9/27/78	By: [illegible]

WINDS

PORT SAID, EGYPT

Date September 14, 1978			Date September 15, 1978			Date September 16, 1978			Date September 17, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	2.0	NW	0000	8.0	NW	0000	0.0	S	0000	2.0	SW
0100	2.0	NW	0100	6.0	NW	0100	0.0	S	0100	2.0	S
0200	2.0	NW	0200	4.0	NW	0200	2.0	S	0200	1.0	S
0300	3.0	NW	0300	3.0	NW	0300	1.0	S	0300	1.0	S
0400	4.0	NW	0400	1.0	NW	0400	1.0	SW	0400	1.0	S
0500	4.0	NW	0500	1.0	NW	0500	1.0	SW	0500	1.0	S
0600	4.0	NW	0600	2.0	NW	0600	1.0	SW	0600	1.0	S
0700	4.0	NW	0700	4.0	NW	0700	1.0	SW	0700	2.0	SE
0800	4.0	NW	0800	5.0	NW	0800	2.0	NW	0800	5.0	SE
0900	5.0	NW	0900	6.0	NW	0900	2.0	NW	0900	3.0	S
1000	5.0	NW	1000	6.0	NW	1000	4.0	NW	1000	5.0	SE
1100	5.0	NW	1100	6.0	NW	1100	4.0	NW	1100	4.0	S
1200	5.0	NW	1200	4.0	NW	1200	4.0	SW	1200	4.0	S
1300	6.0	NW	1300	5.0	SW	1300	4.0	SW	1300	4.0	S
1400	5.0	NW	1400	5.0	SW	1400	4.0	SW	1400	5.0	S
1500	4.0	NW	1500	6.0	SW	1500	4.0	SW	1500	6.0	S
1600	4.0	NW	1600	6.0	SW	1600	4.0	SW	1600	5.0	S
1700	3.0	W	1700	6.0	SW	1700	4.0	SW	1700	4.0	S
1800	3.0	W	1800	5.0	SW	1800	3.0	SW	1800	4.0	S
1900	4.0	W	1900	4.0	SW	1900	3.0	SW	1900	4.0	S
2000	4.0	W	2000	2.0	SW	2000	3.0	S	2000	4.0	S
2100	6.0	NW	2100	2.0	SW	2100	2.0	S	2100	4.0	S
2200	9.0	NW	2200	2.0	SW	2200	2.0	S	2200	3.0	SE
2300	8.0	NW	2300	0.0	SW	2300	2.0	SW	2300	4.0	SE

Location: PORT SAID, EGYPT	Number of Observations: 439
Data period: 9/6/78-9/27/78	By: BRC

WINDS

PORT SAID, EGYPT

Date September 18, 1978			Date September 19, 1978			Date September 20, 1978			Date September 21, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000			0000	2.0	SE	0000	2.0	SW	0000	2.0	SW
0100	3.0	SE	0100	1.0	SE	0100	0.0	VAR	0100	1.0	SW
0200	4.0	SE	0200	1.0	SE	0200	0.0	VAR	0200	0.0	SW
0300	4.0	SE	0300	2.0	SE	0300	0.0	VAR	0300	0.0	SW
0400	3.0	SE	0400	2.0	SE	0400	0.0	VAR	0400	0.0	SW
0500	3.0	SE	0500	2.0	SE	0500	0.0	VAR	0500	0.0	SW
0600	2.0	SE	0600	1.0	SE	0600	0.0	VAR	0600	0.0	SW
0700	2.0	SE	0700	2.0	SE	0700	1.0	SW	0700	0.0	SW
0800	4.0	SE	0800	2.0	SE	0800	1.0	SW	0800	1.0	S
0900	4.0	SE	0900	4.0	SE	0900	2.0	W	0900	2.0	SE
1000	4.0	SE	1000	3.0	S	1000	4.0	MW	1000	3.0	S
1100	4.0	SE	1100	2.0	SW	1100	4.0	W	1100	4.0	S
1200	4.0	SE	1200	2.0	SW	1200	4.0	W	1200	4.0	SW
1300	5.0	S	1300	4.0	SW	1300	3.0	SW	1300	4.0	SW
1400	5.0	S	1400	4.0	SW	1400	4.0	SW	1400	4.0	SW
1500	6.0	S	1500	4.0	SW	1500	4.0	S	1500	4.0	SW
1600	6.0	S	1600	4.0	SW	1600	4.0	SW	1600	4.0	SW
1700	6.0	S	1700	4.0	SW	1700	4.0	SW	1700	4.0	SW
1800	4.0	S	1800	3.0	SW	1800	2.0	SW	1800	2.0	SW
1900	5.0	S	1900	2.0	SW	1900	2.0	SW	1900	3.0	SW
2000	4.0	S	2000	3.0	SW	2000	2.0	SW	2000	2.0	S
2100	2.0	S	2100	2.0	SW	2100	2.0	SW	2100	2.0	SW
2200	2.0	S	2200	2.0	SW	2200	2.0	SW	2200	3.0	S
2300	2.0	SE	2300	2.0	SW	2300	2.0	SW	2300	2.0	S

Location: PORT SAID, EGYPT	Number of Observations: 439
Data period: 9/6/78-9/27/78	By: BRC

WINDS

PORT SAID, EGYPT

Date September 22, 1978			Date September 23, 1978			Date September 24, 1978			Date September 25, 1978		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	2.0	S	0000	0.0	S	0000	2.0	SW	0000	2.0	S
0100	2.0	S	0100	0.0	SE	0100	2.0	SW	0100	2.0	S
0200	2.0	S	0200	1.0	E	0200	2.0	SW	0200	2.0	S
0300	2.0	S	0300	1.0	SE	0300	2.0	SW	0300	2.0	S
0400	2.0	S	0400	1.0	SE	0400	2.0	SW	0400	2.0	S
0500	2.0	S	0500	1.0	SE	0500	2.0	S	0500	2.0	SW
0600	1.0	S	0600	2.0	SE	0600	2.0	S	0600	2.0	S
0700	1.0	SE	0700	3.0	SE	0700	3.0	SW	0700	3.0	SW
0800	3.0	SE	0800	4.0	SE	0800	4.0	SW	0800	2.0	SW
0900	5.0	SE	0900	5.0	SE	0900	4.0	SW	0900	3.0	SW
1000	6.0	SE	1000	6.0	SE	1000	4.0	SW	1000	3.0	SW
1100	4.0	S	1100	6.0	SE	1100	4.0	S	1100	4.0	SW
1200	4.0	S	1200	6.0	SE	1200	4.0	S	1200	4.0	SW
1300	4.0	S	1300	6.0	S	1300	4.0	S	1300	5.0	SW
1400	4.0	S	1400	4.0	S	1400	6.0	S	1400	4.0	SW
1500	5.0	SW	1500	5.0	SW	1500	5.0	S	1500	4.0	SW
1600	5.0	SW	1600	4.0	SW	1600	4.0	SW	1600	4.0	S
1700	4.0	SW	1700	4.0	SW	1700	4.0	SW	1700	3.0	S
1800	3.0	S	1800	4.0	SW	1800	3.0	SW	1800	2.0	S
1900	2.0	S	1900	4.0	SW	1900	4.0	SW	1900	2.0	S
2000	2.0	S	2000	3.0	SW	2000	3.0	SW	2000	1.0	SE
2100	2.0	S	2100	2.0	SW	2100	3.0	SW	2100	0.0	SE
2200	1.0	SW	2200	2.0	SW	2200	2.0	S	2200	0.0	S
2300	2.0	SW	2300	3.0	SW	2300	2.0	S	2300	0.0	SW

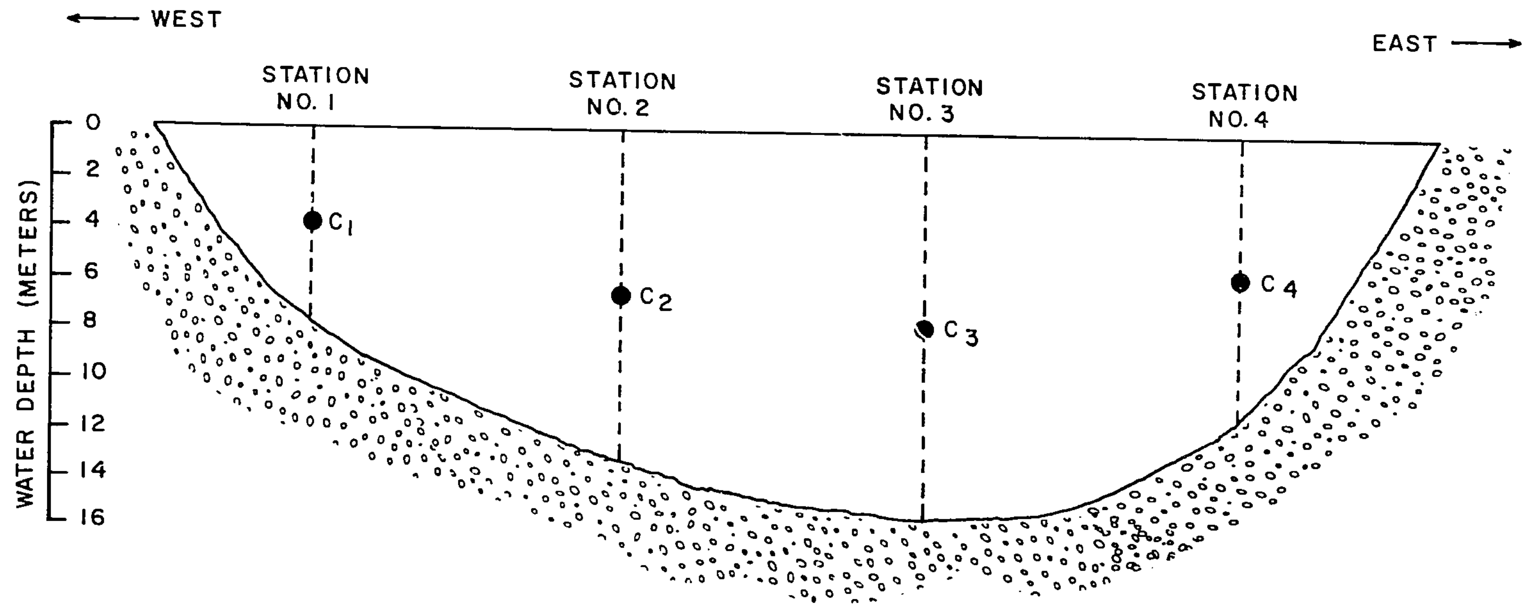
Location: PORT SAID, EGYPT	Number of Observations: 439
Data period: 9/6/78-9/27/78	By: BRC

WINDS

PORT SAID, EGYPT

Date September 26, 1978			Date September 27, 1978			Date			Date		
Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True	Time EST	Speed MPH	Dir. True
0000	0.0	VAR	0000	4.0	S	0000			0000		
0100	0.0	VAR	0100	2.0	SE	0100			0100		
0200	0.0	VAR	0200	1.0	SE	0200			0200		
0300	0.0	VAR	0300	1.0	SE	0300			0300		
0400	0.0	SE	0400	1.0	SE	0400			0400		
0500	0.0	SE	0500	4.0	SE	0500			0500		
0600	1.0	SW	0600	3.0	SE	0600			0600		
0700	4.0	SW	0700	3.0	SE	0700			0700		
0800	4.0	SW	0800	4.0	SE	0800			0800		
0900	4.0	SW	0900	6.0	SE	0900			0900		
1000	4.0	SW	1000	4.0	SE	1000			1000		
1100	4.0	SW	1100	4.0	SE	1100			1100		
1200	4.0	SW	1200	4.0	S	1200			1200		
1300	4.0	SW	1300	4.0	S	1300			1300		
1400	4.0	SW	1400			1400			1400		
1500	3.0	S	1500			1500			1500		
1600	4.0	SW	1600			1600			1600		
1700	4.0	SW	1700			1700			1700		
1800	3.0	SW	1800			1800			1800		
1900	2.0	SW	1900			1900			1900		
2000	2.0	SW	2000			2000			2000		
2100	2.0	SW	2100			2100			2100		
2200	1.0	SW	2200			2200			2200		
2300	3.0	S	2300			2300			2300		

Location: PORT SAID, EGYPT	Number of Observations: 439
Data period: 9/6/78-9/27/78	By: BRC



MID-DEPTH CURRENT SPEEDS

$C_1 = 10.0$ CM/SEC

$C_2 = 11.5$ CM/SEC

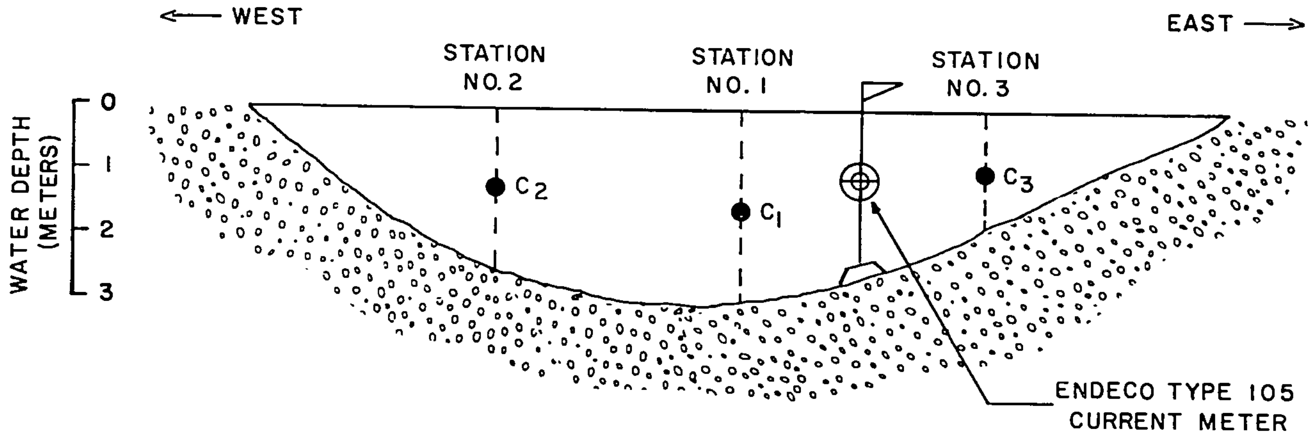
$C_3 = 11.8$ CM/SEC

$C_4 = 24.1$ CM/SEC

KEY

● CURRENT SPEED MONITORING & DEPTH SOUNDING STATION

OCEAN SURVEYS, INC. OSI OLD SAYBROOK, CONNECTICUT	MID-DEPTH CURRENT SPEEDS, C SUEZ CANAL CROSS SECTION AT +10 KM.
HAZEN & SAWYER-PORT SAID, EGYPT	SCALE HORIZONTAL 1:1000, VERTICAL 1:250
	DRAFTED BY BRC | SURVEY DATE 9/1/78 (1200) | FIG. 3



MID-DEPTH CURRENT SPEEDS

C_1 = 12.5	CM/SEC
C_2 = 12.0	CM/SEC
C_3 = 5.0	CM/SEC

KEY

● CURRENT SPEED MONITORING & DEPTH SOUNDING STATION

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT

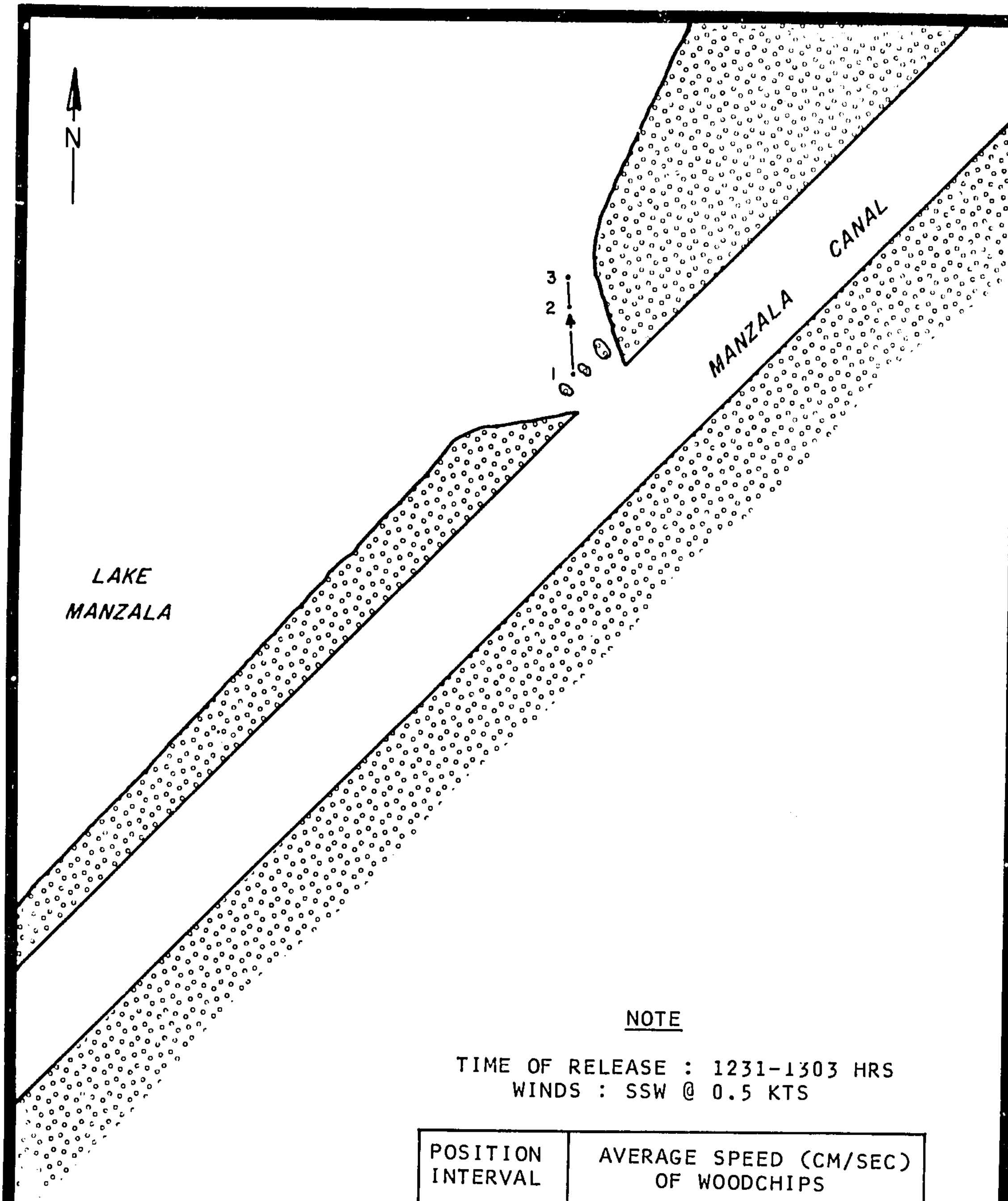
OSI

HAZEN & SAWYER - PORT SAID, EGYPT

MID-DEPTH CURRENT SPEEDS, C
EL GAMIL OUTLET CROSS-SECTION

SCALE HORIZONTAL 1:1000, VERTICAL 1:100

DRAFTED BY BRC | SURVEY DATE 9/14/78 (1000) | FIG. 4



NOTE

TIME OF RELEASE : 1231-1303 HRS
WINDS : SSW @ 0.5 KTS

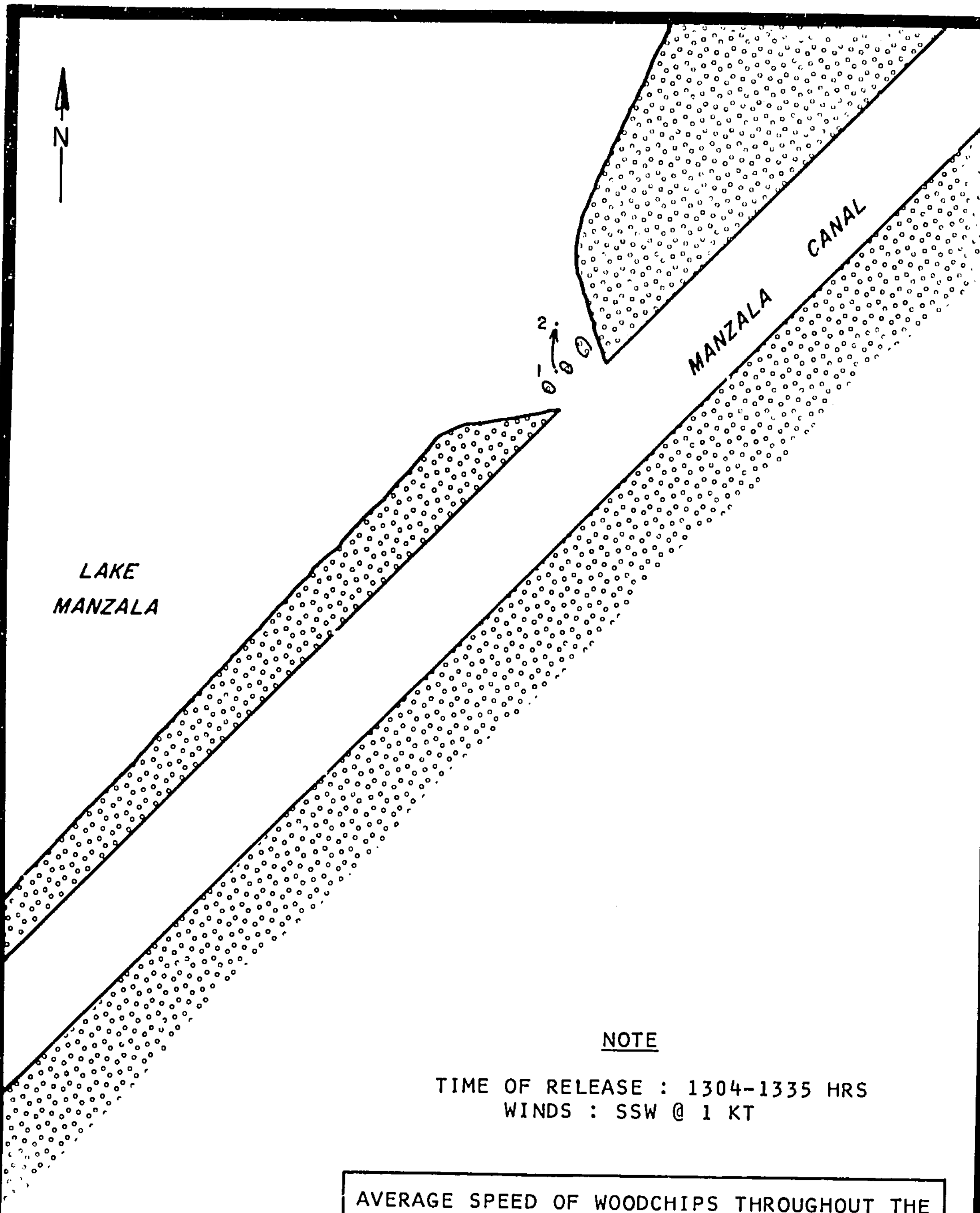
POSITION INTERVAL	AVERAGE SPEED (CM/SEC) OF WOODCHIPS
1-2	6.7
2-3	2.7

SCALE = 1:5000

WOODCHIP DRIFT STUDY
LAKE MANZALA - ZONE A

SURVEY DATE 7 SEPT 78 | FIG.5

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT



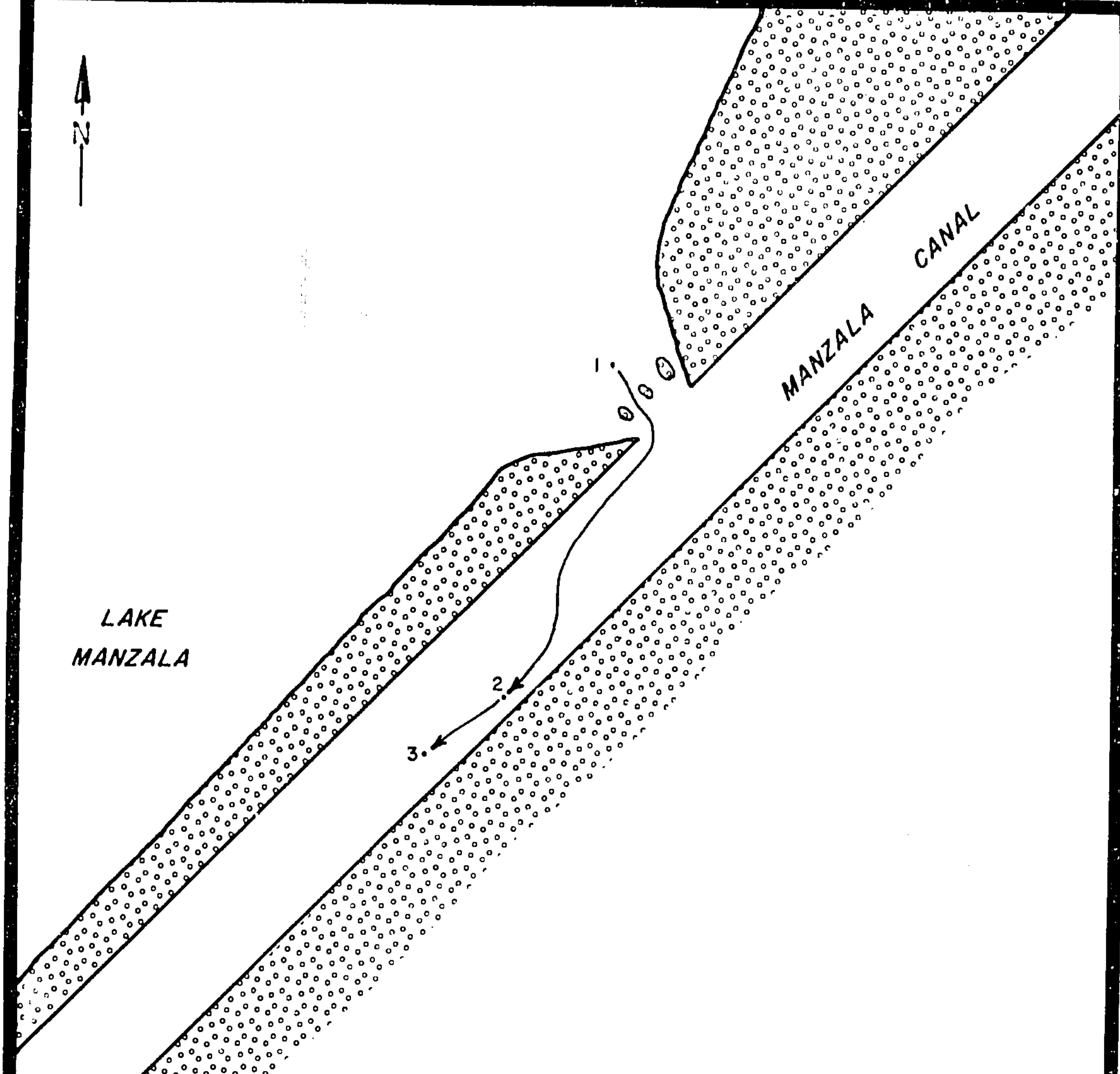
NOTE

TIME OF RELEASE : 1304-1335 HRS
WINDS : SSW @ 1 KT

AVERAGE SPEED OF WOODCHIPS THROUGHOUT THE RELEASE : 1.7 CM/SEC

SCALE = 1:5000

WOODCHIP DRIFT STUDY LAKE MANZALA - ZONE A	OCEAN SURVEYS, INC. OLD SAYBROOK, CONNECTICUT
SURVEY DATE 7 SEPT 78 — FIG. 6	OSI



NOTE

TIME OF RELEASE : 1315-1415 HRS
WINDS : NNW @ 8 KTS

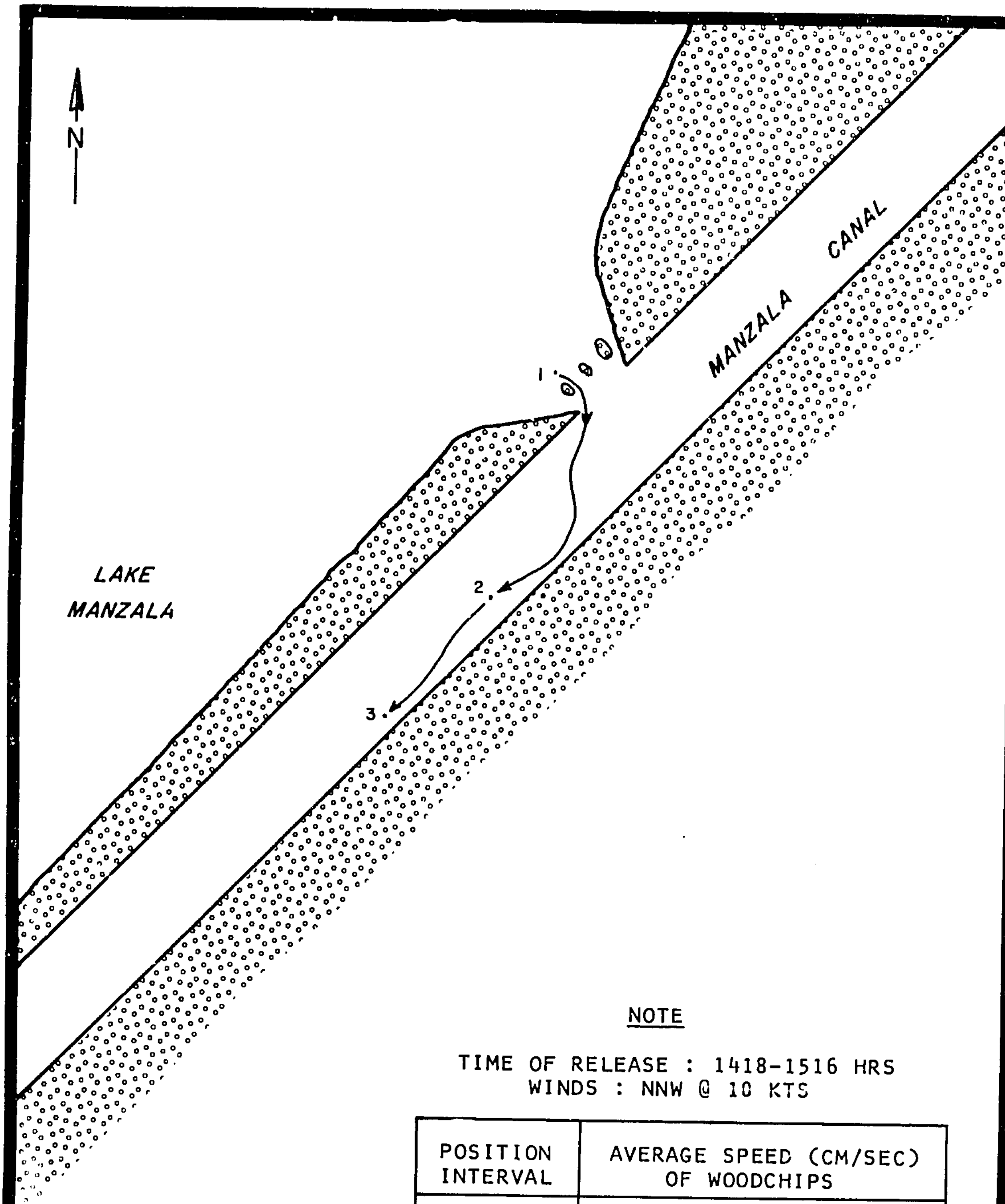
POSITION INTERVAL	AVERAGE SPEED (CM/SEC) OF WOODCHIPS
1-2	20.0
2-3	3.3

SCALE = 1:5000

WOODCHIP DRIFT STUDY
LAKE MANZALA - ZONE A

SURVEY DATE 21 SEPT 78 | FIG. 7

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT



NOTE

TIME OF RELEASE : 1418-1516 HRS
WINDS : NNW @ 10 KTS

POSITION INTERVAL	AVERAGE SPEED (CM/SEC) OF WOODCHIPS
1-2	16.7
2-3	6.7

SCALE = 1:5000

WOODCHIP DRIFT STUDY
LAKE MANZALA - ZONE A

SURVEY DATE 21 SEPT 78 | FIG. 8

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT

APPENDIX B

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Prepared by Prof. S. H. Sharaf El Din

TABLE – I FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCU DATE: 25-27 JULY 78

SPEED (m/sec X 10^{-2})

CALM = 6.15

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10													
11-20													
21-30	3.16	1.05											4.21
31-40	1.05	1.05											2.10
41-50													
51-60													
61-70													
71-80													
81-90	1.05												1.05
91-100			1.05										1.05
101-110													
-120													
-130		1.05											1.05
-140													
-150	1.05												1.05
-160	1.05	3.16											4.21
-170	6.34	1.05											7.39
-180	5.28	7.38	2.10	1.05									15.81
-190	2.10	5.28	4.38	4.21	3.16								19.13
-200		1.05	1.05			2.10							4.20
-210	2.10												2.10
-220	3.16												3.16
-230													
-240													
-250	2.10												2.10
-260		1.05											1.05
-270													
-280													
-290													
-300													
-310	1.05												1.05
-320		1.05											1.05
-330		1.05											1.05
-340	3.16		2.10	1.05									6.31
-350		3.16	3.16	3.16	2.10								11.58
-360	2.10	1.05		1.05	1.05								5.25
TOTAL	34.75	28.43	13.84	10.52	6.31	2.10							100.00

TABLE-2 **FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION**

METER: SCL DATE: 25-27 JULY 78

SPEED (m/sec $\times 10^{-2}$)

CALM = 5.26

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10	4.21	5.26	5.26	4.21	2.10	3.15	1.05						25.24
11-20	1.05	5.26	1.05										7.36
21-30	3.15												3.15
31-40	4.21	1.05			1.05								6.31
41-50	1.05												1.05
51-60		1.05											1.05
61-70													
71-80	1.05												1.05
81-90	1.05												1.05
91-100													
101-110			1.05										1.05
-120	1.05	1.05											2.10
-130	1.05				1.05								2.10
-140	1.05		1.05										2.10
-150	1.05												1.05
-160		1.05											1.05
-170		1.05	1.05										2.10
-180	2.10												2.10
-190			1.05										1.05
-200		1.05											1.05
-210	1.05												1.05
-220													
-230													
-240													
-250	1.05												1.05
-260													
-270													
-280													
-290	5.26												5.26
-300													
-310													
-320													
-330	2.10	3.15											5.25
-340													
-350		2.10		1.05	1.05								4.20
-360	11.72	3.15	1.05	1.05									16.97
TOTAL	43.25	25.22	11.56	6.31	4.20	3.15	1.05						100.00

TABLE – 3 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCU DATE: 2-4 AUGUST 78

SPEED (m/sec $\times 10^{-2}$)

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10													
11-20	3.23												3.23
21-30		1.075											1.075
31-40													
41-50													
51-60	1.075												1.075
61-70													
71-80													
81-90													
91-100													
101-110													
-120													
-130	1.075												1.075
-140													
-150													
-160													
-170	2.15	1.075											3.23
-180	5.38	4.30	9.675	3.23	1.075								23.75
-190		1.075	1.075	8.60	5.38	4.30	5.38						25.81
-200					5.38	2.15							7.53
-210													
-220		1.075											1.075
-230													
-240													
-250													
-260													
-270													
-280													
-290													
-300		1.075											1.075
-310	1.075												1.075
-320			1.075										1.075
-330	3.23	2.15	2.15										7.53
-340	2.15	10.63	2.15										14.93
-350		1.075		1.075									2.15
-360	2.15	2.15											4.30
TOTAL	21.515	25.68	16.125	12.905	11.385	6.45	5.38						100.00

TABLE – 4 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCL DATE: 2-4 AUGUST 78

SPEED (m/sec X 10^{-2})

CALM = 4.288

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10													
11-20													
21-30	1.053	1.053											2.106
31-40	1.053	1.053											2.106
41-50	1.053												1.053
51-60													
61-70		1.053											1.053
71-80													
81-90	1.053												1.053
91-100		1.053	1.053										2.106
101-110													
-120													
-130													
-140													
-150													
-160													
-170	2.105												2.105
-180	8.40	5.24	3.159	2.105									18.925
-190	3.155	8.40	7.363	8.40	1.053	1.053	1.053						30.486
-200		2.105		3.159			2.105						7.369
-210													
-220													
-230		2.105	1.053										3.158
-240			2.105	1.053	1.053								4.211
-250			1.053										1.053
-260													
-270													
-280		1.053											1.053
-290													
-300													
-310													
-320													
-330													
-340													
-350		2.105	1.053										3.158
-360	3.158	8.40		1.053	2.105								14.48
TOTAL	21.035	33.641	16.844	15.791	4.211	1.053	3.158						100.00

TABLE-5 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCU DATE: 9-11 AUG.78

SPEED (m/sec X 10^{-2})

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10			1.515	1.515									3.030
11-20													
21-30	1.515												1.515
31-40	4.545												4.545
41-50	7.576												7.576
51-60	1.515	1.515											3.030
61-70	1.515												1.515
71-80	3.030	1.515	1.515										6.060
81-90	1.515		1.515	1.515									4.545
91-100													
101-110													
-120													
-130													
-140													
-150													
-160													
-170	6.060												6.060
-180	10.606	10.606											21.212
-190	6.060	6.060	4.545	4.545	3.030	1.515							25.755
-200	1.515	4.545			1.515								7.575
-210													
-220													
-230													
-240													
-250													
-260													
-270													
-280													
-290													
-300													
-310													
-320													
-330													
-340													
-350													
-360	1.515	3.030	3.030										7.575
TOTAL	46.967	27.27	12.12	7.575	4.545	1.515							100.00

TABLE-6 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCL DATE: 9-11 AUGUST 78

SPEED (m/sec X 10^{-2})

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10	7.143	2.041											9.184
11-20	1.02												1.02
21-30		1.02											1.02
31-40													
41-50													
51-60													
61-70		1.02											1.02
71-80													
81-90													
91-100													
101-110	1.02												1.02
-120													
-130													
-140													
-150	5.102	1.02											6.122
-160		1.02											1.02
-170	1.02												1.02
-180	2.041		1.02										3.061
-190		4.082	1.02										5.102
-200	8.163	1.02	2.041										10.204
-210	1.02												1.02
-220	1.02	2.041											3.061
-230													
-240	1.02	1.02											2.04
-250		1.02											1.02
-260													
-270					1.02								1.02
-280													
-290	1.02												1.02
-300													
-310	2.041	2.082	1.02										7.143
-320		3.061											3.061
-330		1.02											1.02
-340				1.02									1.02
-350				1.02									1.02
-360	11.234	9.182	3.061	2.041									25.52
TOTAL	42.867	32.653	8.163	4.163	1.02								100.00

TABLE-7 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCL DATE: 16-18 AUGUST 78

SPEED (m/sec X 10^{-2})

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10													
11-20													
21-30	2.083	1.042		1.042									4.167
31-40	3.125		1.042										4.167
41-50	2.083												2.083
51-60													
61-70		1.042											1.042
71-80		1.042											1.042
81-90													
91-100													
101-110													
-120		1.042											1.042
-130	3.123	1.042											4.165
-140													
-150			2.083										2.083
-160	1.042												1.042
-170	2.083	1.042	1.042										4.167
-180	2.083	5.208	1.042	2.083									10.416
-190		2.083	4.167	3.125	2.083								11.458
-200	1.042	4.164	4.167	2.083	2.083								13.536
-210	2.083	1.042	1.042	1.042									5.209
-220				1.042									1.042
-230			1.042										1.042
-240													
-250													
-260													
-270													
-280													
-290	1.042		1.042										2.084
-300			1.042	2.083									3.126
-310			1.042	2.083	3.125	1.042							7.292
-320			1.042										1.042
-330						2.083							2.083
-340			1.042			1.042							2.083
-350	1.042	3.125	1.042										5.209
-360		4.167	2.083										6.250
TOTAL	20.833	26.041	23.959	14.583	7.291	4.167							100.00

TABLE – 8 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCU DATE: 23-25 AUGUST 78

SPEED (m/sec X 10^{-2})

CALM = 0.98

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10													
11-20	1.961	7.845	4.902										14.708
21-30	0.98												0.98
31-40	0.98												0.98
41-50		0.98											0.98
51-60	0.98												0.98
61-70	0.98	0.98	0.98										2.94
71-80													
81-90													
91-100													
101-110													
-120													
-130	1.961												1.961
-140													
-150	0.98												0.98
-160		0.98											0.98
-170	1.961	0.98			0.98								3.921
-180	2.941	7.845	10.784	2.941									24.521
-190	5.883	4.902	5.863	1.961									18.629
-200	3.924	2.941	0.98										7.845
-210	0.98												0.98
-220		0.98											0.98
-230													
-240			1.961										1.961
-250	0.98												0.98
-260	0.98												0.98
-270													
-280	0.98	0.98											1.96
-290	1.961			0.98									2.941
-300	1.961	1.961											3.922
-310	1.961												1.961
-320	0.98	0.98											1.96
-330													
-340													
-350													
-360													
TOTAL	34.314	32.354	25.490	5.882	0.98								100.00

TABLE-9 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCL DATE: 23-25 AUGUST 78

SPEED (m/sec X 10^{-2})

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10		0.98											0.98
11-20	0.98	2.941											3.921
21-30		0.98											0.98
31-40		0.98											0.98
41-50													
51-60													
61-70													
71-80													
81-90		1.961											1.961
91-100	1.961	0.98											2.941
101-110	2.941	0.98											3.921'
-120	1.961												1.961
-130	4.902												4.902
-140	6.868												6.868
-150	4.902												4.902
-160	2.941	0.98											3.921
-170	4.903	4.903	0.98										10.786
-180	5.883	5.883	0.98										12.746
-190		3.922	0.98	0.98									5.882
-200													
-210		0.98											0.98
-220													
-230	1.961												1.961
-240													
-250													
-260	1.961												1.961
-270	0.98	0.98											1.961
-280													
-290													
-300	3.922												3.922
-310		3.922											3.922
-320	0.98												0.98
-330		1.961	0.98										2.941
-340	5.883	2.941											8.824
-350	0.98												0.98
-360													
TOTAL	54.909	36.274	3.92	0.98									100.00

TABLE-10 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCU DATE: 29-31 AUGUST 78

SPEED (m/sec X 10^{-2})

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10													
11-20		1.09											1.09
21-30	1.09	1.09											2.18
31-40	2.17	1.09											3.26
41-50	1.09												1.09
51-60	1.09												1.09
61-70													
71-80													
81-90	1.09												1.09
91-100													
101-110	1.09												1.09
-120		1.09											1.09
-130													
-140													
-150													
-160	1.09	2.17		1.09									4.35
-170			1.09										1.09
-180	3.26	4.35	7.59	5.43	3.26	2.17							26.06
-190	3.26	5.43	2.17	8.70	10.85	1.09							31.50
-200	2.17												2.17
-210													
-220													
-230													
-240	1.09												1.09
-250													
-260	1.09												1.09
-270													
-280	1.09												1.09
-290													
-300	1.09	1.09											2.18
-310		1.09											1.09
-320	1.09	1.09											2.17
-330													
-340													
-350	1.09	2.17	4.35	4.35	1.09								13.05
-360			1.09										1.09
TOTAL	23.94	21.75	16.29	19.57	15.20	3.26							100.00

TABLE - 11 **FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION**

METER: SCL DATE: 29-31 AUGUST 78

SPEED (m/sec $\times 10^{-2}$)

CALM = 2.17

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10													
11-20		1.09	2.17										3.26
21-30			1.09										1.09
31-40													
41-50													
51-60													
61-70	2.17												2.17
71-80		1.09											1.09
81-90		1.09											1.09
91-100	1.09												1.09
101-110	1.09												1.09
-120													
-130	2.17												2.17
-140	2.17												2.17
-150	4.35												4.35
-160		2.17											2.17
-170	4.35	9.77	4.35										18.48
-180	1.09	6.51	5.43	5.44									18.47
-190		5.43	3.26	11.96									20.65
-200			1.09										1.09
-210													
-220													
-230	1.09												1.09
-240													
-250		1.09											1.09
-260													
-270													
-280	1.09												1.09
-290													
-300	1.09												1.09
-310		2.17											2.17
-320		1.09											1.09
-330		1.09											1.09
-340		4.35											4.35
-350	1.09	2.17	1.09										4.35
-360													
TOTAL	22.86	39.11	18.49	17.40									100.00

TABLE-12 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCU DATE: 5-7 SEPT. 78

SPEED (m/sec X 10^{-2})

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0													
11-20			1.031										1.031
21-30													
31-40													
41-50													
51-60													
61-70													
71-80													
81-90													
91-100	1.031												1.031
101-110													
-120													
-130													
-140													
-150													
-160													
-170	2.062	3.093											5.155
-180	1.031	3.093	17.526	14.433	6.186								42.264
-190	2.062	1.031	1.031		1.031	1.031							6.186
-200	1.031												1.031
-210	1.031	1.031											2.062
-220		1.031											1.031
-230	1.031												1.031
-240													
-250	1.031												1.031
-260													
-270													
-280	1.031												1.031
-290													
-300		1.031											1.031
-310		1.031											1.031
-320		1.031											1.031
-330	2.062	1.031	2.062										5.155
-340			2.062										2.062
-350	4.124	5.155	5.155	2.062									16.496
-360		4.124	4.124	1.031	1.031								10.31
TOTAL	17.527	2? 682	32.98	17.526	8.248	1.031							100.00

TABLE-13 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCL DATE: 5-7 SEPT. 78

SPEED (m/sec X 10^{-2})

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10													
11-20													
21-30													
31-40													
41-50	1.031												1.031
51-60		1.031											1.031
61-70													
71-80													
81-90													
91-100													
101-110													
-120													
-130													
-140	1.031												1.031
-150	1.031												1.031
-160													
-170	3.093	1.031											4.124
-180	2.062	12.369	11.318	5.155	3.093								33,997
-190	1.031	4.124	9.278	2.062	1.031								17.526
-200	2.062												2.062
-210	1.031												1.031
-220													
-230													
-240	3.093												3.093
-250	2.062												2.062
-260													
-270													
-280	1.031												1.031
-290													
-300													
-310	1.031	2.062											3.093
-320	1.031		2.062										3.093
-330	5.155	2.062											7.217
-340		6.186	5.155										11.341
-350		2.062	1.031										3.093
-360													
TOTAL	25.775	30.927	28.844	7.217	4.124								100.000

TABLE-14 **FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION**

METER: SCU DATE: 12-14 SEPT. 78

SPEED (m/sec $\times 10^{-2}$)

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10													
11-20			1.10										1.10
21-30		2.20											2.20
31-40													
41-50		1.10							1.10	1.10			3.30
51-60													
61-70													
71-80													
81-90													
91-100		1.10											1.10
101-110	2.20												2.20
-120													
-130													
-140													
-150													
-160													
-170	1.10												1.10
-180	3.29	2.20	7.29	9.89	12.08	1.10							36.25
-190	1.10	4.39	2.20	4.39		1.10							13.18
-200	1.10	1.10											2.20
-210		1.10											1.10
-220													
-230	1.10												1.10
-240													
-250													
-260	1.10	1.10											2.20
-270													
-280													
-290													
-300													
-310													
-320	2 20	1.10											3.30
-330	1.10		1.10										2.20
-340		1.10											1.10
-350		1.10	2.20	1.10	3.29								7.69
-360		2.20	2.20	14.28	2.20								20.88
TOTAL	14.29	19.79	16.49	29.66	17.57	2.20			1.10	1.10			100.00

TABLE-15 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: SCL DATE: 12-14 SEPT. 78

SPEED (m/sec $\times 10^{-2}$)

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10			3.19										3.19
11-20	3.19		1.06	1.06									5.31
21-30													
31-40													
41-50													
51-60													
61-70	1.06												1.06
71-80													
81-90	1.06												1.06
91-100													
101-110	2.13	1.06											3.19
-120													
-130	1.06												1.06
-140	2.13												2.13
-150	3.19	1.06											4.25
-160													
-170		1.06											1.06
-180		2.13	1.06	1.06	2.13								6.38
-190	2.27	4.27	4.27	10.64	9.58								30.03
-200	2.13	1.06	1.06	1.06									5.31
-210													
-220													
-230	1.06												1.06
-240													
-250	3.19												3.19
-260	2.13												2.13
-270													
-280													
-290													
-300		1.06											1.06
-310													
-320	1.06												1.06
-330		1.06											1.06
-340		1.06	1.06										2.12
-350		2.13		1.06									3.19
-360		7.46	9.58	1.06									18.08
TOTAL	27.66	23.31	21.18	15.94	11.71								100.00

TABLE-16 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: EG1 **DATE: 31 JULY-15 AUG. 78**

SPEED (m/sec $\times 10^{-2}$)

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10	0.40	0.13	0.26	0.13	0.13	0.26			0.26	0.30			1.87
11-20	6.20	5.49	5.40	7.14	7.14	7.01	5.40	6.20	4.72	1.72	0.54	0.13	57.09
21-30		0.45		0.13	1.34	1.07	1.21	1.21	0.54	0.26			6.21
31-40													
41-50													
51-60													
61-70													
71-80													
81-90			0.13										0.13
91-100													
101-110			0.13										0.13
-120		0.13											0.13
-130													
-140													
-150													
-160		0.13											0.13
-170	0.13												0.13
-180			0.26	0.26			0.13						0.65
-190	1.74	1.48	0.94	1.34	2.01	1.48	2.33	1.34	0.94	0.13			13.73
-200		0.54	0.94	1.21	1.51	0.94	1.74	0.94	1.07	0.40	0.13		9.42
-210	0.26	0.13	0.26	0.13	0.26	0.40	0.13	0.26					1.83
-220								0.13	0.13				0.26
-230		0.13							0.13				0.26
-240	0.13												0.13
-250	0.13												0.13
-260	0.13												0.13
-270													
-280	0.13	0.13											0.26
-290													
-300	0.13			0.13									0.26
-310	0.13		0.13	0.13									0.39
-320	0.54	0.26	0.54										1.34
-330		0.26	0.40		0.13								0.79
-340	0.26	0.26		0.26	0.26								1.17
-350			0.13	0.40	0.26	0.13							0.92
-360			0.26	0.13									0.39
TOTAL	10.31	9.52	9.78	11.39	13.04	11.29	11.07	10.08	7.79	2.81	0.67	0.13	100.00

TABLE-17 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: EG1 DATE: 16 AUG.-1 SEPT. 78

SPEED (m/sec $\times 10^{-2}$)

CALM = 0.51

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10							0.13		0.38				0.51
11-20	1.39	1.52	2.15	2.03	2.92	4.82	7.22	4.44	2.28	0.89	0.13		29.79
21-30	0.63	0.63	2.03	2.15	2.41	5.32	7.10	12.91	12.27	4.18	0.14	0.13	49.90
31-40		0.25				0.25	0.38	0.76	0.76				2.40
41-50													
51-60													
61-70													
71-80													
81-90													
91-100													
101-110													
-120													
-130													
-140													
-150	0.13	0.13											0.26
-160			0.13										0.13
-170	0.13	0.13					0.13						0.39
-180	0.89	0.63	0.38		0.13			0.13					2.16
-190	0.51	1.14	0.51	0.63	0.76	0.76	0.25	0.13		0.25			4.94
-200	0.51	0.51	0.51	1.14	0.63	1.14	0.38	0.13	0.25				5.20
-210		0.13			0.51			0.13					0.77
-220													
-230	0.13												0.13
-240													
-250													
-260		0.13											0.13
-270													
-280		0.13											0.13
-290	0.25												0.25
-300	0.38		0.13										0.51
-310		0.13	0.13										0.26
-320	0.25												0.25
-330	0.25	0.13											0.38
-340													
-350													
-360													
TOTAL	5.45	5.59	5.97	5.95	7.36	12.29	15.59	18.63	15.94	5.32	0.27	0.13	100.00

TABLE-18 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: JC DATE: 21 AUG. - 1 SEPT. 78

SPEED (m/sec X 10^{-2})

CALM= 3.64

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10				0.19									0.19
11-20													
21-30													
31-40													
41-50													
51-60	0.19												0.19
61-70													
71-80													
81-90	0.38												0.38
91-100	0.96	1.15											2.11
101-110	1.15	8.43	8.62	3.46	0.19								21.85
-120	2.87	12.46	18.98	12.26	2.49								49.06
-130	2.68	3.67	4.21	3.83	0.96								15.35
-140	0.96												0.96
-150	0.38												0.38
-160	0.19												0.19
-170	0.19												0.19
-180													
-190													
-200													
-210													
220	0.19												0.19
-230													
-240													
-250													
-260	0.19												0.19
-270	0.19												0.19
-280	2.11	0.19											2.30
-290	0.96	0.38											1.34
-300		0.57											0.57
-310	0.19	0.38											0.57
-320	0.19												0.19
-330													
-340													
-350													
-360													
TOTAL	13.97	27.23	31.81	19.74	3.64								100.00

TABLE-19 FREQUENCY DISTRIBUTION OF CURRENT SPEED & DIRECTION

METER: INSIDE THE LAKE DATE: 2-21 AUGUST 78

SPEED (m/sec X 10^{-2})

CALM = 5.05

DIRECTION	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	TOTAL
0-10													
11-20													
21-30	0.44												0.44
31-40	0.11												0.11
41-50													
51-60	0.11												0.11
61-70													
71-80	0.22												0.22
81-90	0.77												0.77
91-100	0.44												0.44
101-110	2.42	1.76	0.66	0.22									5.06
-120	5.72	8.81	7.04	2.86	0.22	0.22							24.87
-130	6.95	7.82	6.62	3.85	1.65	0.11							27.00
-140	1.98	2.75	1.43		0.22								6.38
-150	1.32	0.88											2.20
-160	0.44	0.11											0.55
-170	0.33	0.11											0.44
-180	0.44												0.44
-190		0.11											0.11
-200	0.44	0.22											0.66
-210	0.11												0.11
-220	0.22												0.22
-230	0.11	0.11											0.22
-240													
-250													
-260	0.11												0.11
-270													
-280	1.10	0.33											1.43
-290	1.75	1.65	0.77										4.17
-300	1.75	2.20	0.22										4.17
-310	1.21	2.09	1.87										5.17
-320	1.10	2.20	1.98	0.11									5.39
-330	0.22	0.33	0.33	0.22									1.10
-340	0.33	0.99	0.77	0.11									2.20
-350	0.44	0.11	0.11										0.66
-360													
TOTAL	30.58	32.58	21.80	7.37	2.09	0.33							100.00

APPENDIX C

CALCULATION OF ASSIMILATIVE CAPACITY

A. INTRODUCTION

A formula developed by Streeter and Phelps was used to calculate the allowable pollution load for the Port Said receiving waters. The formula

$$La/Dc = f \exp (ktc') \quad (1)$$

is based on the interaction of deoxygenation and reaeration in the receiving water. La, the allowable load is determined by: the deoxygenation rate (k); the self purification ratio (f); the critical deficit (Dc) and the initial deficit (Da).

B. LAKE MANZALA ZONE B

The deoxygenation constant for Lake Manzala was calculated from approximately thirty BOD_5 analyses for Zone B, the location of the proposed outfall. The average rate of deoxygenation was 1.30 mg/l per day. This corresponds to a k value of 0.26/day. Theriault found that variations in the proportion of first stage demand reached in BOD_5 analyses effect the accuracy of calculated k factors. Calculated k values are generally 55.1 to 97.0% of the true value. The actual k value for Lake Manzala may vary from 0.27 to 0.47.

The "self purification" ratio is the ratio of the reoxygenation factor (r) to the deoxygenation rate (k). The reoxygenation factor was determined from diurnal oxygen profiles. The oxygen deficit at any time is a function of algal respiration/production, benthal demand, and the deoxygenation (and reoxygenation) rates of the receiving water. Algal respiration/production rates were established by light and dark bottle analyses. Similarly, benthic demand was determined in laboratory experiments. By controlling for benthic demand and algal activity the average reoxygenation during the diurnal studies was found to be 0.059 mg/l per hour, an "r" value of 0.35/day. The self purification ratio (f = r/k) of Lake Manzala ranges from 0.74 (k = 0.47) to 1.30 (k = 0.27).

For given values of k, f, and the critical deficit (Dc) the boundary conditions for the allowable BOD_5 loading are determined by the initial deficit Da. The boundary conditions are reflected in the ktc' term of formula (1). The initial deficit (Da) in a diurnal cycle varies from 0.0 to 4.0 mg/l in Zone B of Lake Manzala. The critical time for an initital deficit of 0.0 mg/l is calculated by the following formula:

$$tc' = \frac{2.3 \ (\log f)}{k \ (f-1)} \quad (2)$$

Critical time is dependent in the magnitude of the k and f values. For Zone B of Lake Manzala, tc' values range from 3.23 days (k = 0.47, f = 0.74) to 2.45 days (k = 0.27, f = 1.30). An initial deficit of 4.0 mg/l is equal to the critical deficit (Dc) described in Chapter 7. Under these conditions tc' is zero.

Using formula (1) the maximum and minimum allowable loading may be calculated. Based on variations of the k, f, and tc' values, the maximum allowable loading for Zone B of Lake Manzala is 9.35 to 12.43 mg/l and the minimum 2.96 to 4.60 mg/l. For comparison of disposal alternatives, an average value of 6.0 mg/l was selected to represent an approximation of steady state conditions.

C. SUEZ CANAL

Assimilative capacity in the Suez Canal was estimated using accepted(1) deoxygenation and reaeration constants for large streams of low velocity.

k = 1.23/day
r = 0.29/day
f = 1.275

No supportive data (diurnal oxygen profits) was available to determine the maximum initial deficit occurring in a diurnal cycle. To simulate worst case conditions, the initial deficit Da was assumed to be equivalent to the critical deficit Dc. Under these conditions, the critical time tc' is zero and the term exp (ktc') drops out of equation (1). Therefore, the minimum allowable load is equivalent to the self purification constant (f) times the critical deficit Dc.

The critical deficit (4.0 mg/l) is determined by subtracting the minimum acceptable dissolved oxygen concentration (3.0 mg/l) from the oxygen saturation level (7.0 mg/l) at the ambient water temperature (29.5°C).

The allowable load (La) in the Suez Canal for worst case conditions is then 5.1 mg/l.

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(1) Fair, Geyer, Okun; Water and Wastewater Engineering; Volume 2; John Wiley and Sons, Inc. 1963.

APPENDIX D

DILUTION AND BIOLOGICAL CONSIDERATIONS IN PROJECTING WATER QUALITY

A. INTRODUCTION

To assess the water quality effects of a sewage discharge several factors must be considered. Physical, chemical, and biological factors, each of which contribute to the total dilution achieved, determine the concentrations of contaminants in the nearby aquatic environment.

Physical factors to be considered include dilution of the sewage with the receiv ing water and dispersion which causes spreading of the effluent field. For chemical constituents of the sewage the decay rate may be important in establishing contaminant concentrations with bacteria aftergrowth. Die-away and predation may be significant in determining the water quality effects of the discharged sewage.

B. PHYSICAL DILUTION

Initial Dilution

Initial dilution occurs as the bouyant effluent rises to the receiving water surface from a submerged outfall structure, as shown in Figure D-A. As the effluent rises to the surface ambient water is entrained, reducing the concentration of sewage. When currents are sufficient to provide adequate supplies of uncontaminated dilution water above the discharge, initial dilution may be calculated by the following equation:

$$S_aQ = Ubh \quad (1)$$

where:

Sa = average dilution in the effluent field

Q = effluent discharge rate

U = prevailing current velocity

b = width of the effluent field normal to the current direction

h = thickness of the effluent field

The equation developed by Rawn, Bowerman, and Brooks (1961) is based on flux balance. The analysis is generally accurate in characterizing effluent behavior provided the appropriate effluent field thickness is selected. Field thickness (h) generally ranges from 1/12 to 1/2 of the total depth increasing as current velocities decrease. In the Suez Canal the field thickness was assumed to be 1/12 of the total depth or 1.5 meters. Dye studies conducted on a sewage/brackish water plume in the Suez Canal confirm the selected field thickness (see Chapter 3). The field thickness in Lake Manzala is assumed to be 0.75 meters (1/2 the available depth) because of low current velocities.

Equation I assumes a continuous supply of dilution water above the outfall structure. In certain situations, such as slack tide when the net current flow is zero, a sewage field forms over the outfall or diffusor. Formation of the field lowers the amount of uncontaminated water available for dilution. This condition, called blocking phenomenon, has been analysed in detail by Brooks (1972). The blocking phenomenon is incorporated in the following equation.

$$Sy = St \left(\frac{1}{(1 + p)} \right) \quad (2)$$

where:

Sy = centerline division at height y
St = centerline dilution assuming no blocking

$$p = \frac{2\ Qs\ St}{U\ b\ y\ max}$$

Blocking phenomenon has little impact on initial dilution in Lake Manzala and the Suez Canal. For this reason equation I was used for calculation of steady state initial dilutions. The results of the calculations using year 2000 effluent discharge rates are summarized in Table D-1.

Physical Dilution

Following initial dilution the principal factor involved in far field dilution is horizontal dispersion. Figure D-A illustrates an idealized surface effluent field as it is transported from the diffusor structure by receiving water currents (Hazen and Sawyer, 1978). In the vicinity of the diffusor the initial concentration (Co) of the contaminant is uniform across the width (b) of the field. Further away from the diffusor structure a concentration gradient develops across the field which is related to the longtitudinal distance (x) and the lateral spread (y) of the effluent field. Physical dilution has been mathmatically represented by Brooks in the following equation.

$$O = \frac{d}{dy} \left(Ey \frac{dc}{dy} \right) - U \frac{dc}{dx} \quad (3)$$

where:

y = lateral width of effluent field

x = longtitudinal distance along the centerline

c = concentration of any conservative substance in the effluent field

Ey = lateral dispersion coefficient

U = current velocity

The equation assumes no vertical or longtitudinal dispersion. Lateral dispersion is assumed to vary as a function of field width as described by:

$$E = \alpha L^{4/3} \quad (4)$$

where:

E = lateral dispersion coefficient
L = width of field

α = an emperical constant

Brooks integrated formula (3) with appropriate boundary conditions to yield:

$$C = Co \; erf \left[\frac{3/2}{\left(1 + \frac{8 Eo x}{Ub^2}\right)^3} \right]^{1/2} \quad (5)$$

where:

C = concentration along x - axis of the effluent field

Co = concentration at x = 0

x = distance along x axis of the effluent field

b = initial field width

E_o = lateral dispersion coefficient

Equation 5 defines the pattern and concentration of the effluent field for a specific diffusor system.

C. CHEMICAL AND BIOLOGICAL FACTORS

Equation (5) applies only to physical factors which affect dilution and dispersion of an effluent field. All sewage constituents are subject to physical dilution. Other constituents such as organics and bacteria are subject to reactions which cause decay. These reactions may be included as an addition term in Equation (5) where k, is a first order reaction rate for decay or in the case of bacteria aftergrowth. The resultant equation is:

$$C = Co \; e^{-kt} \; erf \left[\frac{3/2}{\left(1 + \frac{8 Eo x}{Ub^2}\right)^3} \right]^{1/2} \quad (6)$$

where the error function erf (a) is defined by the intearal

$$erf(a) = \frac{2}{\sqrt{\pi}} \int_0^a \exp(-v^2)\, dv$$

D. PROJECTION OF RECEIVING WATER QUALITY IN PORT SAID

Tables D-2 through D-4 summarize oxygen and bacteria water quality impacts for the proposed wastewater discharges to Lake Manzala and the Suez Canal. The results calculated using equation (5) are discussed in Chapter 8.

Reaction rates for bacterial dieoff for Lake Manzala and the Suez Canal were determined from in situ laboratory experiments. Development of the reaction rates for BOD are discussed in detail in Appendix C.

TABLE D-1

INITIAL DILUTION CALCULATIONS

Receiving Water	Effluent Discharge Rate Q max cu m/day	Prevailing Current Velocity U m/sec	Width of Effluent Field b meters	Thickness of Effluent Field h meters	Initial Dilution Sa	Comments
Lake Manzala	171,500	0.054	500 1000 1500 2000 2500	0.75	10.2:1 20.4:1 30.6:1 40.8:1 51.0:1	Current velocity U is an average through the 0.5 meter thick effluent field (see Chapter 3). Width of effluent field assumed to be same as diffuser length.
Suez Canal	17,500	0.23	-	1.50	42.8:1	Width of effluent field unknown. Initial dilution taken from nomograph figure 33-6 pg. 33-32 of reference no. 3. Outfall pipe size 42 cm.

TABLE D-2

PROJECTED COLIFORM DISTRIBUTIONS FOR LAKE MANZALA

Distance From Outfall (meters)	Time (hrs)				Outfall Structure Alternatives		
		Outfall 2 meters	Diffuser 500 M	Diffuser 1000 M	Diffuser 1500 M	Diffuser 2000 M	Diffuser 2500 M
0	0.0	10^6*	98,000	49,000	33,000	25,000	20,000
100	0.5	140,000	87,000	43,000	29,000	23,000	18,000
200	1.0	51,000	73,000	37,000	26,000	20,000	16,000
300	1.5	24,000	57,000	32,000	23,000	17,000	13,000
400	2.1	14,000	48,000	29,000	20,000	15,000	12,000
500	2.6	10,000	38,000	25,000	16,000	13,000	11,000
1000	5.1	6,700	13,000	9,400	6,700	5,800	5,000
1500	7.7		5,100	4,000	3,200	2,700	2,400
2000	10.3		2,100	1,700	1,400	1,300	1,100
2500	12.9		800	750	680	570	540
3000	15.4		420	360	290	260	240
3500	18.0		190	160	150	130	120
4000	20.6	0	100	80	70	60	50

Die-off rate K = 3.9/day (see Chapter 7)
*All values are coliforms in MPN/100 mls

TABLE D-3

PROJECTED BOD_5 INCREASES IN LAKE MANZALA FOR TREATMENT/DISPOSAL ALTERNATIVES

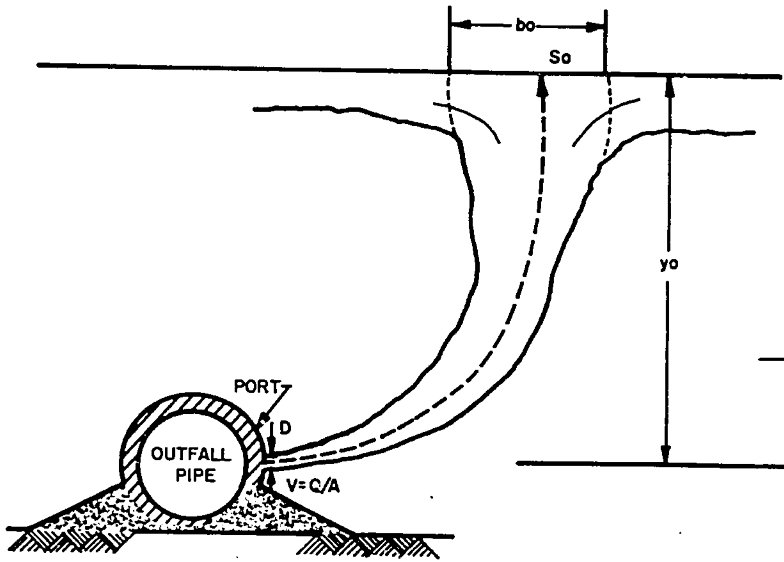
Distance From Outfall (meters)	Time (hrs)	Primary Treatment: Outfall 2 meters	Primary Treatment: Diffuser 500 M	Primary Treatment: Diffuser 1000 M	Primary Treatment: Diffuser 1500 M	Primary Treatment: Diffuser 2500 M	Secondary Treatment: Outfall 2 Meters	Secondary Treatment: Diffuser 500 M
0	0	210.0*	20.6	10.3	6.9	4.1	25.0	2.5
100	0.5	31.2	20.3	10.1	6.8	4.0	3.7	2.4
200	1.0	13.1	18.9	9.9	6.7	4.0	1.5	2.4
300	1.5	6.1	17.2	9.5	6.6	3.9	0.7	2.3
400	2.1	4.2	15.4	9.0	6.4	3.9	0.5	2.2
500	2.6		13.7	8.4	6.0	3.7		2.1
1000	5.1		12.0	5.9	4.5	3.0		1.4
1500	7.7		5.8	4.3	3.5	2.3		1.0
2000	10.3		4.0	3.3	2.7	2.0		0.8
2500	12.9		3.2	2.5	2.2	1.6		0.6
3000	15.4		2.4	2.0	1.7	1.4		0.5
3500	18.0		1.9	1.6	1.5	1.1		0.4
4000	20.6		1.6	1.4	1.2	0.9		0.3

Decay Rate K = 0.47/day (see Appendix C)
*All concentrations are mg/l BOD_5

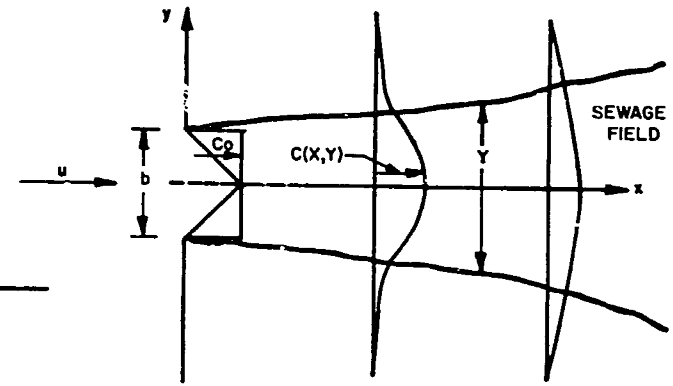
TABLE D-4

PROJECTED COLIFORM DISTRIBUTION
SUEZ CANAL

Distance From Outfall (M)	Time (hr)	Dieoff Term e^{-kt}	Dilution Term erf ( )	Coliform MPN
0	0.0	1.0	1.0	23,000
100	0.12	0.932	0.182	3,900
200	0.24	0.869	0.079	1,580
300	0.36	0.815	0.048	900
400	0.48	0.748	0.032	550
500	0.60	0.687	0.024	380
1000	0.72	0.650	0.016	240
1500	0.84	0.606	0.015	210
2000	0.96	0.559	0.008	105
2500	1.08	0.517	0.007	83
3000	1.20	0.487	0.006	67
3500	1.80	0.339	0.003	23
4000	2.40	0.237	0(appr.)	0



INITIAL DILUTION



PHYSICAL DILUTION

ARAB REPUBLIC OF EGYPT
MINISTRY OF DEVELOPMENT AND NEW COMMUNITIES
ADVISORY COMMITTEE FOR RECONSTRUCTION

PORT SAID
WATER AND WASTEWATER FACILITIES MASTER PLAN

DIAGRAM OF INITIAL AND PHYSICAL DILUTION

VOL.4 FIG. D–A

HAZEN AND SAWYER
ECG - ENGINEERING CONSULTANTS GROUP