CHAPTER 186

Shore Protection Plan for the Nile Delta Coastline

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A Shore Protection Master Plan (SPMP) for the Nile Delta Shoreline, extending from 30 kms west of the city of Alexandria (Arab Republic of Egypt) to 30 kms east of Port Said, is developed and reported. The SPMP was developed in three stages: (1) collection and analysis of relevant data to identify existing and future coastal problems and limits of needed shore protection, (2) development of shore protection alternatives with costs and economic evaluations, and (3) detailed design and technical specifications for the selected shore protection schemes along the SPMP zone. This paper summarizes Tetra Tech, Inc./Honeywell work and achievements on this project while under contract with the Egyptian Shore Protection Authority (SPA). The SPMP considered the Egyptian Government and the SPA national needs to the year 2000.

Introduction and Background

The Nile Delta coastline extending from the western borders of the city of Alexandria to the eastern side of the Port Said (see Figure 1), is presently experiencing some coastal changes. The existing two branches of the River Nile (Rosetta and Damietta) have succeeded over the years in forming two natural sea defense protrusions by depositing a rich supply of sediment load from each branch. In the previous century, the supply of sediment exceeded the natural losses due to wave and current action, and thus resulted in relative land gain from the sea. This trend was reversed around the turn of the 19th century with observed losses from both protrusions.

The principal cause of the shoreline changes presently occurring along the Nile Delta coastline is generally accepted to be the loss of sediments resulting from the construction of control works along the River Nile. Chronic erosion was first observed at the end of the 19th century at several important points along the coast, including the promontories at the mouths of the Rosetta and Damietta branches. This erosion continued during the first half of the 20th century, coinciding with the installation of the first dam at Aswan and the development of

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other dams and barrages, and the increasing diversion of river water for irrigation.

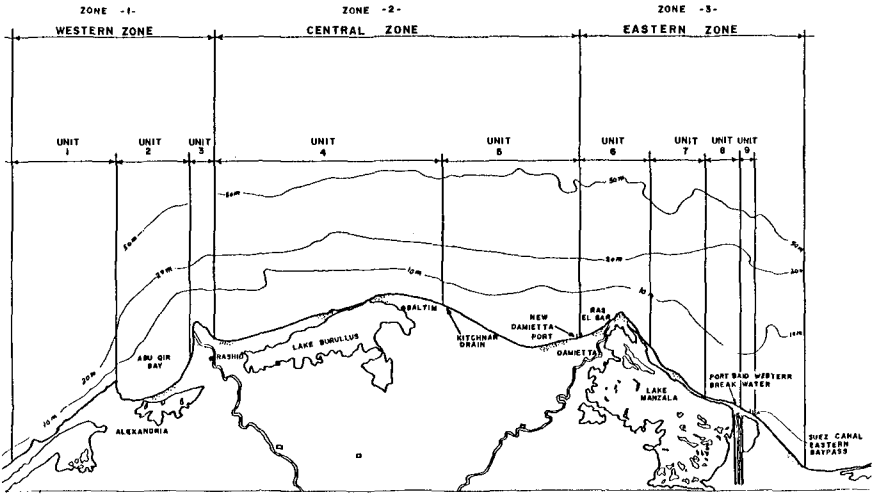


Figure 1. Shore Protection Master Plan Zones and Locations

After the completion of the Aswan High Dam in 1966, erosion along some locations of the Delta coastline accelerated. This erosion has resulted in the loss of resort beach property and flooding of coastal villages. Economic damage to date has been substantial and further serious economic loss is expected if erosion is not controlled. Figures 2 and 3 give examples of the shoreline changes along Rosetta Promontory since 1800 to 1983 (Tetra Tech Progress Report No. 1, ref. 1).

In recognition of the importance of the coastal zone, the Egyptian Government quickly instituted a plan to conduct studies and formulate approaches to manage shoreline erosion. The agency within the Egyptian Government which oversees shore protection projects is the Shore Protection Authority (SPA) of the Ministry of Irrigation formed in 1981. The SPA's responsibilities cover:

1) Planning and design of shore protection works for both short- and long-term considerations.
2) Maintenance and repair work for existing coastal structures.
3) Development and implementation of a shore protection Master Plan for the Nile Delta Coast.

To understand, quantify and assess the recent changes along the Nile Delta Coastline, the Egyptian Government has undertaken many studies since the early 1960's. In 1971, this effort was greatly enhanced when the Egyptian Government secured assistance from the United Nations

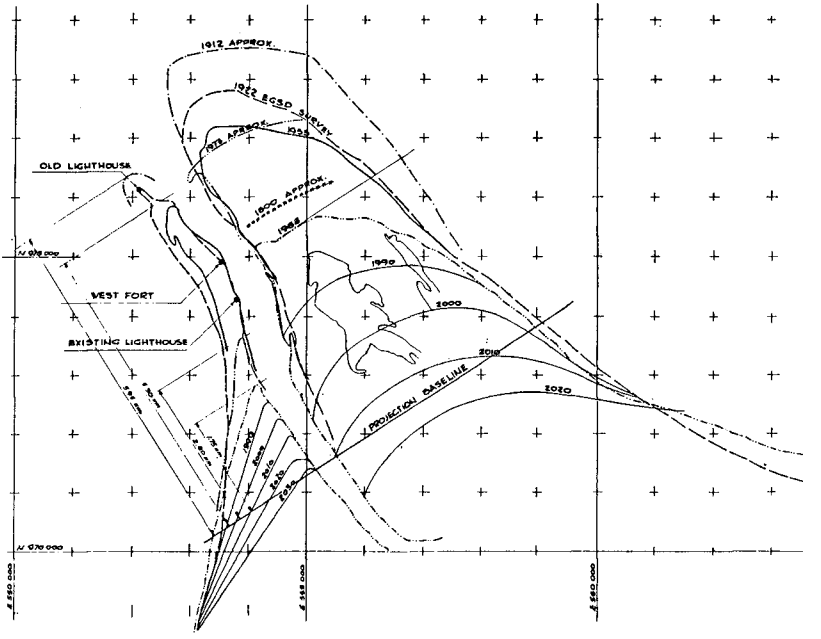


Figure 2. Shoreline Changes along Rosetta Promontory (1800-1983)

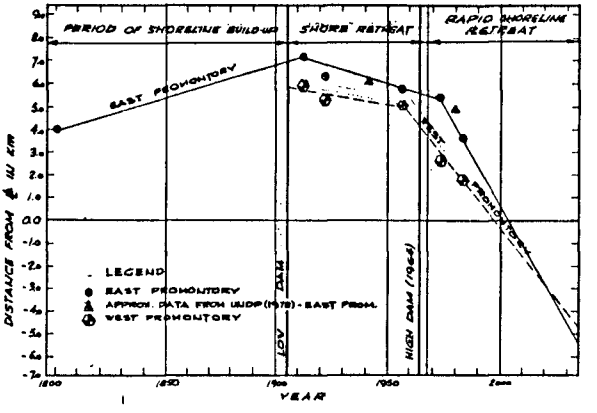


Figure 3. Effect of the Aswan Low and High Dams on Shoreline Changes at Rosetta

Development Programme (UNDP). The UNDP project, which lasted for seven years (1972-1978), conducted geographical, geological, geomorphological, oceanographic, meteorological and hydrodynamic studies of coastal processes along the study area. Coupled with the above effort, the Egyptian Government created the Coastal Research Institute (CRI) to act as the focal point for collection, analysis and monitoring of field information. The CRI has assumed additional responsibilities to assist in the planning and design of a number of shore protection projects along the Delta Coast.

Since its initiation in 1981, the SPA has undertaken many shore protection and maintenance projects and in 1984 awarded a contract to Tetra Tech, Inc. of Pasadena, California, U.S.A., to develop a Shore Protection Master Plan for the Nile Delta Coastline, which is the subject of this paper.

Overall Objectives and Tasks

The objective of this project is to prepare a Shore Protection Master Plan (SPMP) for the Nile Delta Shoreline to manage existing and projected shoreline erosion problems to the year 2000, with special attention to some specific and critical areas such as the Alexandria Coast, Rosetta Promontory, Burullus inlet, Baltim Beach, Ras El Bar, and the coastal strip from Damietta to Port Said. This plan is developed through tasks which were carried out in four stages:

Stage 1 - Collection and Review of Relevant Data
a) Review and evaluation of available data.
b) Detailed field reconnaissance survey.
c) Identification of additional data necessary for the development of the Shore Protection Master Plan.
d) Data analysis and problems definition.

Stage 2 - Preparation of Alternative Shore Protection Schemes
a) Development of alternative shore protection schemes.
b) Assistance to the SPA in the economic evaluation of alternative schemes.
c) Selection of viable shore protection schemes (by SPA).

Stage 3 - Detailed Design of Selected Schemes
a) Elaboration on the detailed design of the selected schemes with technical specifications and tender documents.
b) Identification of needed physical models.

Stage 4 - Final Report
This includes preparation of a comprehensive report describing the detailed aspects of the Master Plan resulting from the analysis of the above activities covering design documents and technical specifications for the selected schemes.

Establishment of SPMP Zoning

Development of the Shore Protection Master Plan for the study area considered three main factors: (a) the existing coastal problems, (b) the proposed uses of the coastal areas; and (c) the physical changes

within each area due to natural and "man-induced" morphological changes. Based on the analysis of these factors, the SPMP was divided into three main planning zones and a number of sub-zones as depicted in Figure 1 and summarized below:

a) Western Zone
The Western Zone extends from Alexandria Western Harbor to the Rosetta Promontory and includes: Alexandria Western Harbor, Alexandria Eastern Harbor, Alexandria Beaches, Montaza Cove, Mamura Beach, Abou Quir Point and Abou Quir Bay and Rosetta Promontory.

b) Central Zone
The Central Zone extends from the east of the Rosetta Promontory to the new Port of Damietta and includes: the saddle area east of Rosetta to Burullus Estuary, Burullus Inlet, El Burg Village, Baltim Beach, 45 kms reach between Baltim and Gamasa and the 20 kms reach from Gamasa to Damietta Port.

c) Eastern Zone
The Eastern Zone extends from the new port of Damietta to 30 kms east of the Port Said area and includes: the new port at Damietta, Ras El Bar Beaches, Damietta Estuary, Damietta Eastern Promontory, Lake Manzala Coastal Barrier, El Gamil area, Port Said Beaches, Port Foad Beaches and the area east of the Suez Canal Eastern Bypass.

Problem Identification

An important aspect of the SPMP development, is the identification of the existing coastal problems along the different planning zones and sub-units. The areas with specific shore protection needs were identified and their problems summarized in Table 1.

Table 1 Summary of SPMP Existing Problems

Planning Sub-units	Specific Problem Definition
	1) WESTERN ZONE
Alexandria western harbor	No major shore protection problem identified.
Alexandria Eastern Harbor	Mooring problems and wave overtopping of parts of the Corniche during storm wave activity.

Table 1 (Continued)

Planning Sub-units	Specific Problem Definition
Alexandria Beaches,	1) Shatbi/Ibrahimiya Lack of recreational beach area due to narrow beach width.
	2) Camp chezar beach Local scour and storms wave action is being corrected by the placement of 1.8m concrete blocks. This effort should continue.
	3) Stanley beach Lack of recreational area and heavily congested beach during summer seasons.
	4) El Asafra beach Recreational and bathing beach areas are very narrow or non-existent.
	5) Mandara beach Beach widths fronting the cabins are narrow and the beach is heavily congested during the summer season.
	6) Montaza Cove a) Inadequate bathing beach area. b) Debris pollution problems adjacent to the Palestine Hotel.
	7) Mamura beach Beach widths are adequate for recreational uses and no erosion problems are identified, however, monitoring is recommended.
Abou Quir point and Abou Quir Bay	1) Abou Quir beaches The beaches are narrow and suffering from the ongoing pollution caused by unauthorized dumping of sewage.
	2) Idku Outlet Sedimentation problem along the navigation channel was corrected by the 2 groins constructed in 1985. Future performance of the outlet should be monitored to evaluate project effectiveness.
	3) Mohamed Ali Seawall Maintenance and monitoring of the existing and ongoing protection is essential for this industrialized area.
Rosetta Promontory	The Rosetta promontory has experienced severe erosion since 1966 and beyond. In 1986 the SPA started a shore protection project using dolosse and stone protection.

Table 1 (Continued)

Planning Sub-units	Specific Problem Definition
	2) CENTRAL ZONE
Saddle area and Lake Burullus coastal barrier	Most of the length of this reach is experiencing accretion, which is expected to continue for at least the next 20 years or so period. Two local areas along the coastal barrier are vulnerable to breaching during severe storm activities, which would affect the existing tidal dynamics of Lake Burullus. Monitoring of this reach is recommended.
Burullus inlet,	The navigation channel in the existing inlet shoals and meanders causing a hazard to navigation.
El Burg area	The existing seawall needs maintenance and rehabilitation. SPA is presently undertaking an extensive rehabilitation program at this reach which seems to be adequate.
Baltim Beach Resort	Long term shoreline observations have indicated an average net recession rate of 4m/year, with superimposed short-term fluctuations of up to 60 m threatening resort property.
Baltim to Gamasa	No coastal engineering problems are identified for this reach.
Gamasa to New port at Damietta	No shore protection problems are identified except for the possibility of some local scour caused by the recently constructed Damietta breakwaters.
	3) EASTERN ZONE
New port at Damietta	Adjustment in shoreline planforms of the shore areas adjacent to the new breakwaters is expected as a result of the adverse effects of these breakwaters.
Ras El Bar	Erosion and storm damages to Ras El Bar summer resort coastal area have resulted in building damages, loss of recreational bathing beach area, and lost tourism and economic development opportunities.
Damietta Estuary	Shoaling along the navigation channel.
Damietta Eastern Promontory	Since 1966, this reach has been deprived from the rich supply of sediment by the Damietta Nile branch. Consequently, the Damietta promontory has experienced continuous erosion.

Table 1 (Continued)

Planning Sub-units	Specific Problem Definition
Lake Manzala coastal barrier	The coastal barrier located to the southeast of Damietta promontory is a low lying sandy area subjected to a strong easterly longshore transport. The spit area next to Damietta promontory is expected to supply Lake Manzala barrier with sediment for many years in the future. The barrier shorelines are, however, unstable and erosional/ accretional fluctuations are occurring along this reach.
El Gamil area	1) Flooding of the Port Said-Damietta road between km 6 to km 10 as measured from Port Said western breakwater. 2) Near km 9, storm waves could damage the road shoulders over a length of 600 m due to the proximity of the road, at this area, to the sea.
Port Said	This Port Said beach area extends from the Suez Canal west breakwater westward, over a shore length of about 6 km. This reach is slowly accreting as longshore sediment transport is impounded by the west breakwater. No shore protection problems are identified for this reach.
Port Foad area	The 2 kms Port Foad area has undergone progressive erosion prior to the construction of the eastern Suez Canal bypass channel and protective breakwaters. However, the above works were completed in the late 1970's, the Port Foad beach area has been confined and is expected to adjust to an equilibrium plan form within the next few years. Consequently, no shore protection work is identified for this area except for some monitoring requirements.
Eastern side of the Suez Canal new bypass	Shoreline retreat is expected due to the adverse effect of the recently constructed Suez Canal breakwaters. No known developments exist in this area and needs for shore protection are not warranted for the next 10-15 years except for shoreline monitoring.

Development of Alternative Solutions

A total of 38 alternative shore protection projects were developed for locations with identified needs or beach enhancement opportunities as shown in Table 1. The development of these alternatives considered the existing problem, beach restoration opportunities, and projections of expected damage under the "no action" alternative. Cost for each of the 38 developed alternatives was estimated and their economic evaluations were computed by the SPA, with Tetra Tech's assistance. Table 2 summarizes the developed shore protection alternative for each planning location.

Table 2 Summary of Developed Shore Protection Alternatives (a)

Main Zone	Planning Location	Alternatives
Western Zone	Alexandria Eastern Harbor	1) 180m Extension of the West Breakwater (b)
		2) 240m Detached Offshore Breakwater
		3) 300m long Corniche Protection
	Chatby/ Ibrahimiya Beach	1) 700m Beachfill retained by detached break-waters
		2) 700m Beachfill retained by segmented break waters
		3) 700m Beachfill retained by 75m eastern end groin (b)
		4) 1200m Beachfill
	Stanley Beach	1) Beach restoration to add 4,600m^2 of bathing area (b)
	El-Asafra	1) Beachfill retained by west-end groin
		2) Beachfill retained by west end groin and groin pier (b)
	Mandara Beach	1) 700m Beachfill with detached breakwaters (b)
		2) 700m Beachfill
	Montaza Cove	1) 200m wide Beachfill
		2) 50m wide Beachfill with pier extension
		3) Annual Dredging
		4) Dredging with Groin retained Beachfill (b)
Central Zone	Burullus Inlet	1) Trained Eastern Channel
		2) Trained Western Channel (b)
		3) Maintenance dredging
	Baltim Beach Resort	1) Coarse sand nourishment
		2) Beach nourishment from offshore sand sources
		3) Fine sand beach nourishment
		4) T-Groins with sand nourishment
		4A) Above, but sand from offshore sources
		5) Offshore breakwaters and sand nourishment (b)
		5A) Above, but with sand from offshore sources
Eastern Zone	Ras El Bar	1) Groin field starting from existing second groin with Beachfill
		2) Groin field starting from existing third groin with Beachfill
		3) Offshore breakwaters with Beachfill (b)
		4) Artificial Headland
	Damietta Eastern Promontory	1) 11 kms of revetment
		2) 6 kms of revetment (b)
	Lake Manzala Coastal Barrier	Three alternatives are suggested: Shoreline revetment, regulation of construction and relocation, and groins or offshore break-waters.
	El Gamil Area	1) Revetment and flood dike (b)
		2) Revetment and raise road elevation
		3) Groins field

(a) For more details, see Tetra Tech's Progress Report 2 dated December 1985, Ref. 2.
(b) SPA selected alternative.

Detailed Design and Technical Specifications

Detailed engineering drawings and technical specifications were developed for the 13 selected shore protection projects along the SPMP zones. The engineering designs followed the latest established international and U.S.A. standards. The technical specifications considered the practical application of the International and American specifications to local conditions, including reference to the use of the Egyptian Standard Specifications (ESS) as may be applicable. Both the engineering drawings and technical specifications for each project are given in Reference 3. Examples of some developed projects are shown in Figure 4.

Setting Priorities for Projects Execution

An important element of the SPMP is the establishment of a framework of implementation priorities for the developed projects. This framework should consider a set of measurable objectives such as: a) gains to the national economy; b) encouragement to tourism; (c) degree of protection to valuable developments and land, and (d) the Egyptian government national needs and plans.

As a result of the economic analysis and based on the needed degree of shore protection or beach restoration afforded, the following recommendations are reached:

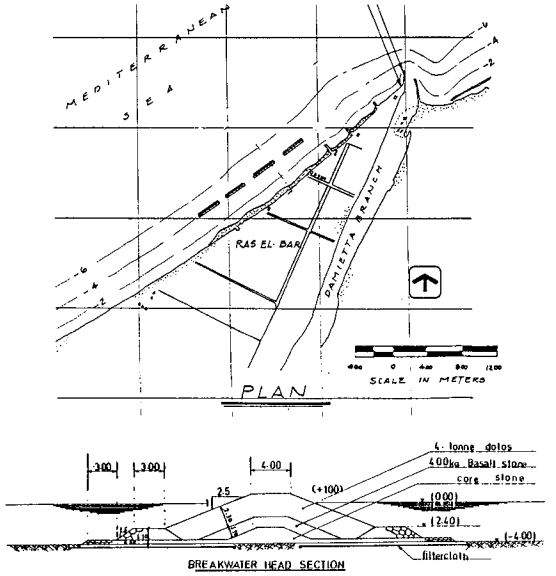
(1) Projects which may be characterized by "first priority projects" are:

a) With the exception of the Alexandria Eastern Harbor West Breakwater Extension Project, all of the developed beach restoration projects along the Alexandria and Abou Quir area are economically feasible and their implementation should have first priority.

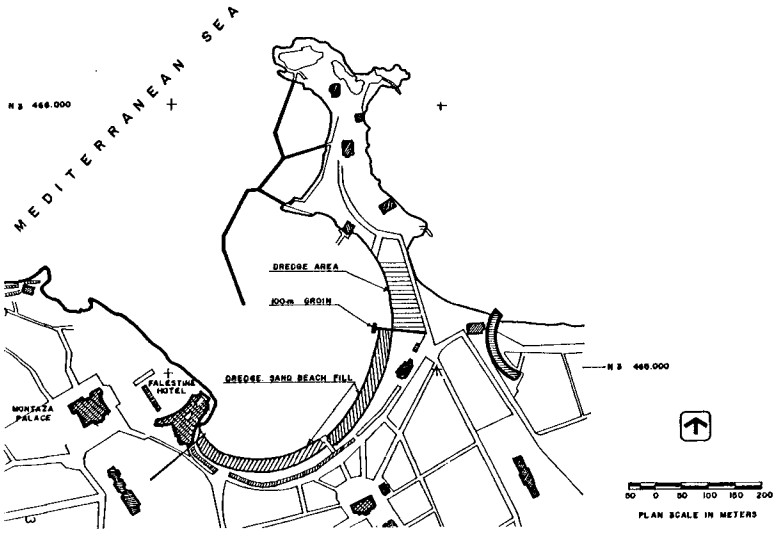
b) Ras El Bar Shore Protection
This relatively exposed and eroding beach, at Ras El Bar, is in urgent need of a shore protection scheme without compromising the availability of bathing areas. The selected project, using detached breakwater and sand nourishment, would solve this problem and enhance the present economic and tourism opportunities.

c) El Gamil Shore Protection and Flood Control Works Project
This project will protect a critical stretch of the Port Said/ Damietta road against flooding and localized erosion. Therefore, its implementation should be given first priority.

d) Burullus Inlet Stabilization and Channel Deepening Project
The economy of the Burullus fishing village is centered around securing safe and uninterrupted navigation through this troubled



(a) Ras El Bar detached BW and sand nourishment



(b) Montaza Cove groin and dredging and sand nourishment

Fig. 4 Example of Shore Protection Projects

inlet. The present hydraulic and sediment situation needs immediate correction to insure safe navigation through a trained channel to check the present sedimentation problem and control channel meandering. This project deserves first priority considerations.

(2) Projects which may be characterized as "second priority projects" are:

a) Alexandria Eastern Harbor West Breakwater Extension
Presently, the Alexandria Eastern Harbor is utilized only by small fishing boats and few pleasure crafts. Under the present level of harbor utilization, additional sheltering is not warranted and only the protection of the Corniche road against spraying and overtopping by waves appears justified. Until future plans for the commercial utilization of the inner harbor area are identified and developed, the economic viability of the selected and designed project would be difficult to justify.

b) Baltim Beaches Replenishment and Stabilization
Due to the complexity of the coastal processes along this beach, the behavior of sand nourishment along this rapidly changing near-shore beach cannot be confidently predicted without further investigations. In addition, the SPA's selected scheme of detached breakwater system could possibly have adverse effects on the surrounding shorelines. It is suggested that before the implementation of the designed project, the SPA has to consider:

- An additional sand nourishment pilot project, with accurate monitoring to gain better understanding of the ongoing beach behavior.

- Employ the use of physical and numerical models combinations to test the relative performance of the other alternatives developed in Tetra Tech's Progress Report No. 2.

The results obtained from the above would give direction for implementation or modification of the designed project. It is therefore recommended that this project deserves a second priority classification until the above additional studies are completed.

c) Damietta Eastern Promontory Shore Protection Project
The Eastern Damietta Promontory is an erosional area supplying sediment to the downdrift sand spit located to the east. Very little information is available on the economic value and the location of the development to be protected along this reach. Priorities of implementation of the developed project lie with the SPA and should consider the Egyptian government overall national interest.

Identification of Model Test Requirements

Table 3 summarizes the SPMP model test requirements and their objectives. These model tests are needed to assist in the alignment of the

protective structures, check their performance and refine the design section's stability and their run-up characteristics.

To date, none of these models have been conducted with the exception of a model for Ras El Bar. It is anticipated that some preliminary model test results could be made available in the near future.

Table 3 Model Test Requirements

Project	Model test requirements and objectives
Alexandria Eastern harbor west breakwater extension (model 1)	* 2-D stability test for the designed cross-section(s). * 3-D physical model to check the alignment of the west breakwater extension and optimize its length.
Asafra and Mandara beach restoration and retention (model 2)	* 3-D physical model with the use of tracers to study the relative performance of the retention structures using variable alignments, spacings and lengths.
Montaza Cove restoration (model 3)	* 3-D fixed bed model with tracers to study wave agitation and circulation conditions under the selected scheme and assist in proper location alignment and extension of the retention groin.
Baltim Beaches Replenishment and stabilization (model 4)	* 3-D physical model with tracers (dye and light density materials) to check the relative performance of a number of alignments, lengths and spacings of the selected protective structures. * For this complex problem, and due to the limitations of the reliability of the available techniques of describing and modeling sedimentation mechanisms in numerical models, their use should be limited as a compliment to the physical model results only with possible future calibration using field and laboratory data on the performance of the executed projects. Another purpose of using numerical models would be the advancement and introduction of related technologies and "state of art" to the SPA technical staff in this field.
Ras El Bar shore protection (model 5)	Same as for Baltim beaches (model 4, above).

Development of a Comprehensive Field Monitoring Program

In coastal engineering, more than one shore protection scheme can be developed to solve the same coastal problem for a given location. The wisdom and merit of using either physical or numerical models or both to assist in the evaluation of these schemes, can be debated for ages before an agreeable and convincing conclusion is reached. This is basically true due to the present degree of complexity of this subject and the practical and academic factors influencing the decision making and the people concerned. Most of these problems can be relaxed if useful field data are available on the performance of similar projects.

There is too much to learn from a well developed and implemented field monitoring program. In addition, monitoring the performance of any selected coastal protection scheme will have considerable benefits in future modifications, maintenance and models calibrations of that scheme.

It is, therefore, essential to carry out a field monitoring program to check, analyze and modify the performance of each project, on an as-needed basis. The field program should be supported by periodic controlled aerial photography for the entire shore protection Master Plan area at, say, 5 year intervals.

"Set-Back Lines"

The so-called "Set-Back Line" or "Red Line" is a concept of delayed and deterent protection. It is used along some areas where long-term future developments are anticipated along eroding shorelines or other areas which could be affected by the adverse effects of projected shore protection structures. In most cases, the establishment of a "Set-Back Line" is based on historical data on shoreline change and its future projections, previous experience on the performance of executed protective structures and other judgmental factors. In this scheme, further projected developments or relocation of existing ones should be regulated or placed at a safe distance back from the existing shoreline.

Other Requirements and Recommendations

Other requirements and recommendations include:

(a) Geotechnical investigations.
(b) Near-shore beach profiling for Alexandria and Abou Quir beaches.
(c) Identification of sand sources for beach nourishment. Presently, the only proven sources of relatively coarse sand (D 50 $\approx$ 0.5mm) are land sources (Khatatba, Ismailia and others). The costs of mining and transporting this sand to the different project sites are expensive (20-22 LE/m^3). It is estimated that about 1.6×10^6 m^3 of this sand would be needed in the implementation of the SPMP projects. It is, therefore, essential for SPA to consider other sources of medium or coarse sand. Specifically, both offshore and on land sand deposits should be surveyed and the economy of these sources studied, including transportation costs considering available local transportation means, river and inland navigation possibilities, and offshore dredging.

(d) Funding for the SPMP projects
The SPA may elect to approach some of the international financing organizations to secure necessary funds for some of the SPMP aspects. Funding support could consider such subjects as model testing, training, numerical modeling techniques and computer applications and assistance in projects execution, monitoring and construction management.

(e) Other coastal areas outside the present SPMP Zones
It is recommended that the SPA extend the SPMP to the other Egyptian northern coastlines such as the area west of Alexandria to Saloum, the Sinai coasts, and the Red Sea coasts.

(f) Research and developments
The SPA, in cooperation with the Coastal Research Institute, should involve local Egyptian Universities and institutes in sponsoring specialized research and studies on subjects related to the SPMP activities.

(g) Guidelines for coastal developments
SPA should establish guidelines for construction and development regulations along the SPMP Zones guided by the recommended "Set-Back Lines" and coordinate that effort with the concerned Governorates.

(h) Survey and monitoring facilities
SPA should secure the necessary equipment, survey instruments and hydrographic survey facilities at each of the three SPMP Zones.

Acknowledgment

The authors express their appreciation to the UNDP and the U.S. TDP for their financial assistance with this study.

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