2.1.3 Major Pollution Sources

The major environmental problems in the Gulf are possibly generated by oil and human activities, although effects of them on ecosystem are generally not well known yet. It may be recognized that shoreline of the Arabian Gulf has become the repository zone of waters. Serious major ecological problems have arisen from production loss/degradation of production coastal habitats due to coastal landfill, dredging and sedimentation.

The distributions of main pollution sources are shown in Figure 3 and 4. The outlines of these major pollution sources are described below.

(1) Oil Pollution

Linden et al. (1990) suggested that the most inputs of oil to the marine environment in the Gulf originate from tanker and ship traffic.

Input from tanker and ship traffic originate primarily from discharge of dirty ballast water and other oily water, which during 1986 ranged from 400,000 to 750,000 tones in 1986 in the Gulf (Linden et al. 1990). The entire Arabian Gulf is a major oil tanker and commercial shipping area. Large industrial ports along the Arabian Gulf coast are located at Tanaquib, Saffaniya, Jubayl, Ju'aymah, Ras Tanura and Damman.

The rest of the marine oil pollution originates principally from refining, industrial and urban sources. Well blowouts during drilling and as a consequence of war activities, can also be a source of oil pollution.

Major oil refineries and related facilities such as gas plant, tank farm etc., are located in Zuluf field, Marjan field, Saffaniya field, Tanaquib, Manifah, Abu Ali, Al-Jubayl, Berri, Ras Tanura, Al Juaymah, Dhahran and Ras al Qulayah.

(2) Wastewater Pollution

Numerous sources contribute to wastewater pollution in the coastal area of the Gulf.
Of domestic and urban sources, untreated sewage and abattoir wastes are discharged at several localities. For instance, in the Saudi Arabian towns of Al-Khobar and Al-Qatif daily inputs of the sewage into the Gulf may be as high as 40,000m^3, equivalent to production by 175,000persons (IUCN 1987). Effects include unsightly solids and grease mats, local eutrophication, increasing biological oxygen demand (BOD) and algal blooms. Sewage treatment plants are helping to alleviate some of these problems.

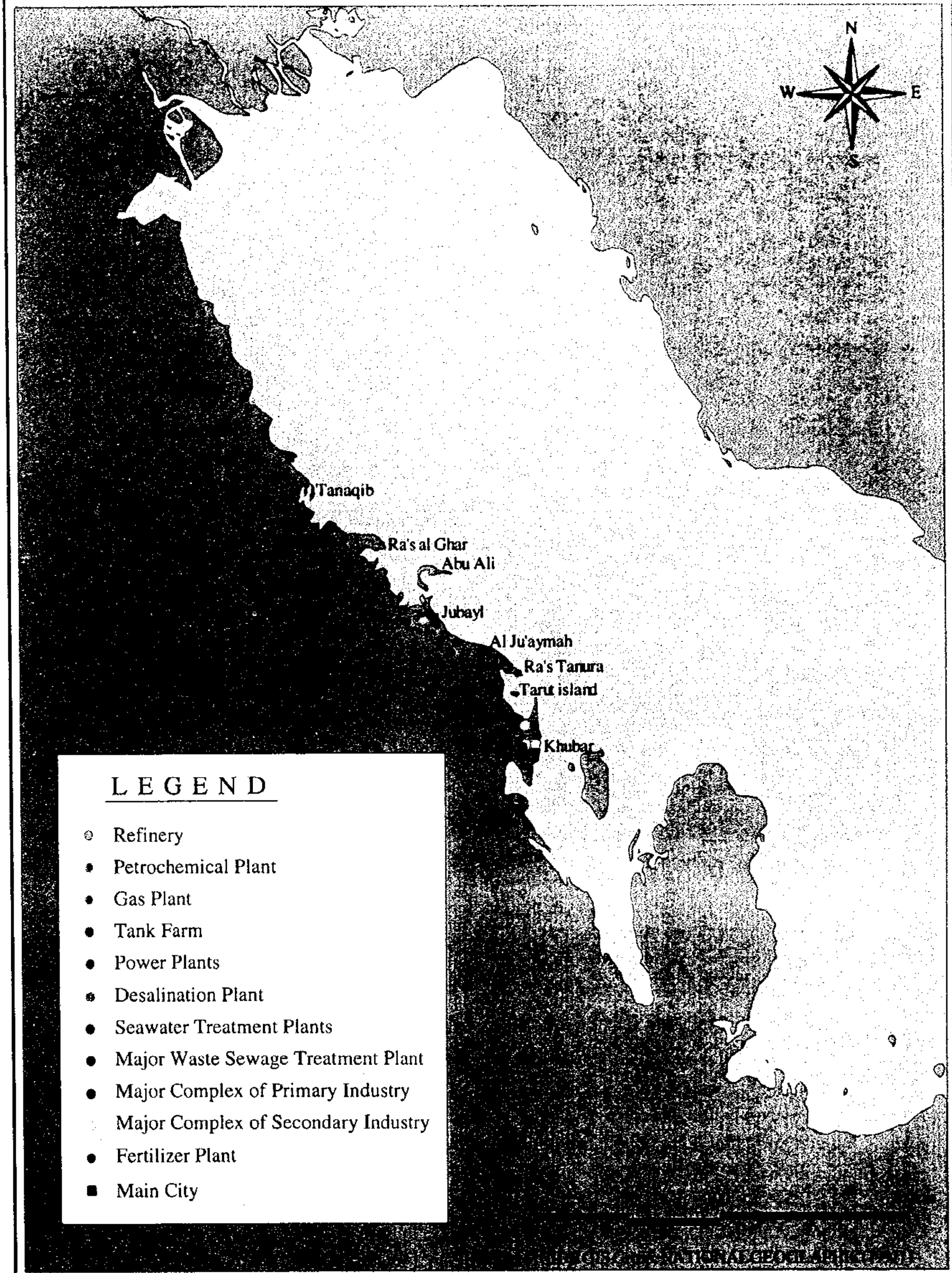


Figure 3 Distribution of Main Pollution Sources

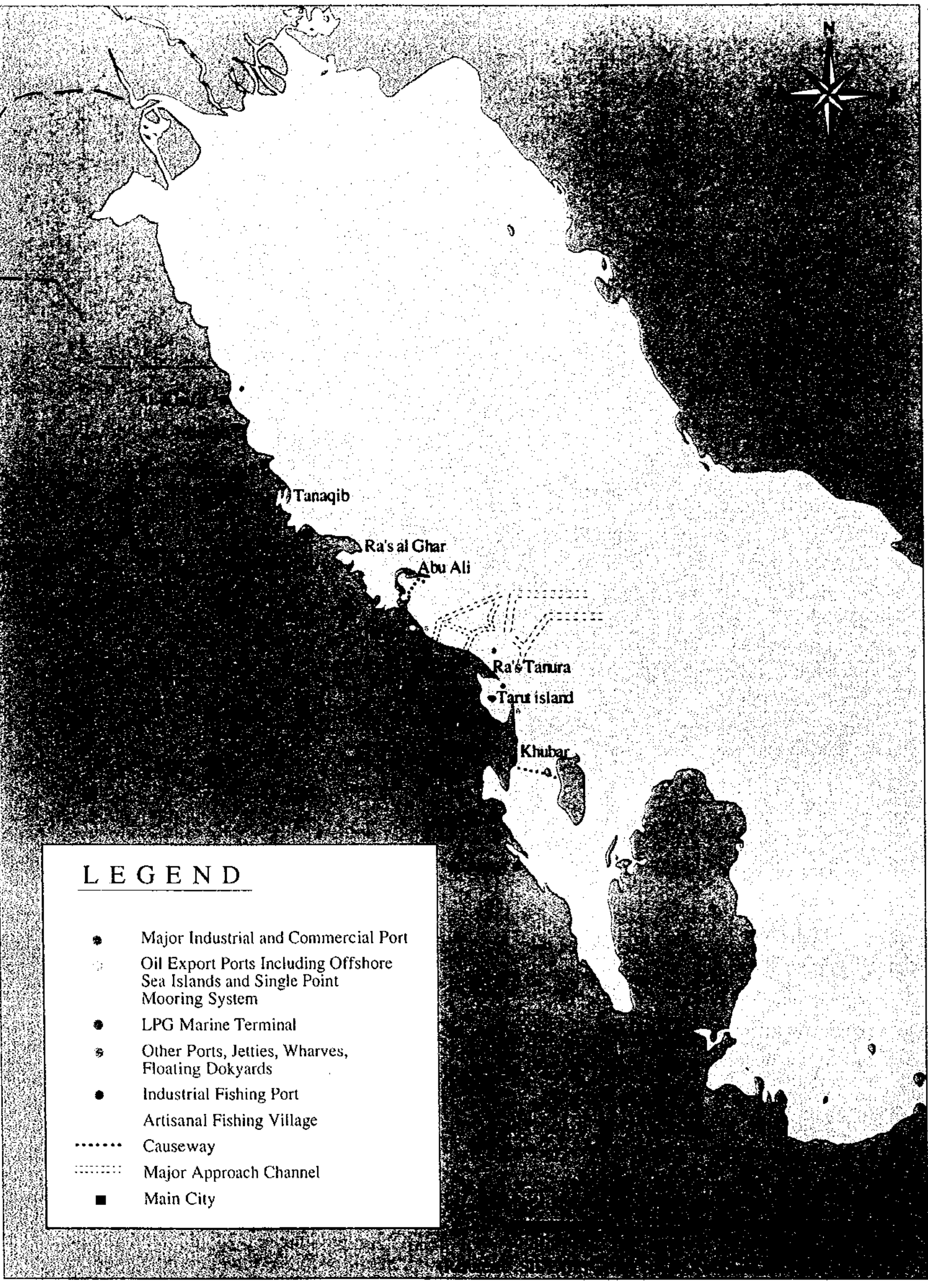


Figure 4 Distribution of Main Ports and Harbours

Domestic wastes and pollution are becoming an increasing problem in Oman (Salm et al. 1988).

Industrial facility is also possibly to be significant pollution sources. Industrial facilities are concentrated around Jubayl, Saffaniya, Ju'aymah, all around Tarut Bay including Ras Tanura, Qatif, dammam, and Al Khubar. Industrial developments in these areas include refineries, petrochemical plants, power plants, desalination plants, waste water treatment plants, and other primary and secondary industries.

Among the industrial wastewater from fertilizer plants and refinery and other industrial effluents may contain heavy metals. Elevated concentrations of lead, mercury and copper in bivalves and fish have been reported around some ports and industrial areas. High levels of cadmium, zinc and vanadium have been found in sediments (Linden et al. 1990). However, a recent study revealed that copper and vanadium levels, although comparable to values elsewhere in the Gulf, were an order of magnitude lower than heavily polluted areas in some other part of the world (Coles and McCain1990).

(3) Commercial and Residential Development

Along the Arabian Coast, commercial and residential developments are clustered around urban areas. Such developments need transportation systems, water, electricity, sewage and solid waste disposal, and other services, with the cumulative effects causing significant pressure on coastal areas. Moreover, the residents of the coast have an increasing need for recreation facilities, particularly near these urban areas.

On the Arabian Gulf coast, the developments around Jubayl and further south around Tarut Bay/Dammam/Al Khubar are responsible for a great deal of the coastal land development.

(4) Fishing and Aquaculture

The fishing industries in the Arabian Gulf utilize the coastal land. However, these uses generally do not create significant disturbances to the environment. Numerous small fishing villages are scattered along the coast and the industrial fishing ports and processing facilities are clustered near the urban areas.
On Tarut Island, there are number of small artisanal fishing villages such as Darin Sanabis and Zur. Near Qatif, there are also two smaller artisanal fishing villages: Saihat and Safwa.

Anchor damage to coral reefs is now highlighted to be a problem on Jurayd island and possibly elsewhere. In addition to fishing, hunting of bird eggs is intensive in some areas. Agriculture appears not to be causing major coastal environmental problems, but further studies are needed.

(5) Coastal Reclamation

Together with dredging, coastal reclamation probably represents one of the most significant impacts on the coastal and marine environment of the Arabian Gulf. Reclamation has been undertaken for residential development, ports, bridges, causeways, cornishe roads and other purposes. Favored areas often have included intertidal flats often with mangroves, shallow embayments and other biologically productive areas, whose true bioeconomic value is seldom recognized by developers. Coastal development and in filling has been far greater along the Gulf coast than in the Red Sea or other par of the Arabian region, where its occurrence is more localized (IUCN 1987). Approximately 40% of the Saudi Arabian Gulf coast has been developed (IUCN 1987), involving extensive infilling and reclamation. Only an estimated 4km^2 of mangroves now remain along these shores (Price et al. 1987a).

Apart from the direct and permanent loss of habitat, landfill usually increases sedimentation. This may directly smother habitats, or may limit photosynthesis of communities such as algal mats, seagrasses and coral reefs (IUCN/UNEP 1985a). Whether this has had measurable effects on the fisheries is not known, but nevertheless has caused concern (IUCN/UNEP 1985a).

(6) Dredging

Dredging provides much of the infill material needed for coastal reclamation hence the two activities often occur simultaneously. The former also takes place to deepen shipping channels and harbors. Like landfill, dredging has taken place most extensively in the Gulf. As a result of projects in Jubayl and Dammam, an estimated 46.5km^2 of coastal habitats have been dredged; and for landfill the residential and industrial areas of modern Jubayl City, more than 200million m^3 of sediments adjacent to the development site (IUCN 1987) were removed. During construction of the Saudi-Bahrain causeway, nearly 60 million m^3 of mud and sand were dredged (Linden et al. 1990).

The ecological effects of dredging are similar to those described above for coastal reclamation, and include both direct habitat loss and various secondary effects. In parts of the Gulf, sedimentation stimulated by dredging has created the soft substrate feeding areas for some species such as waders (IUCN 1987). Some fauna (e.g. birds) may have benefited from new habitats created by sedimentation, for instance in Tarut Bay (IUCN

1987). In general, however, ecological effects of dredging are undoubtedly more adverse than beneficial.

(7) Solid Waste Pollution

Throughout much of the region the coastal zone has become a repository for large quantities of industrial, commercial and residential trash and other solid waste (IUCN1987). Often this takes the form of plastics, metal containers, wood, tires and even entire scrapped automobiles at some localities (IUCN 1982,1987). In the Gulf, oil sludge constitutes the most important type, in terms of quantity, of solid waste (Linden et al. 1990). Much of the lighter debris has become spread along widespread tracts of shoreline through wind and water movements. During a recent survey, solid waste was encountered at 87% of 53% sites inspected along the Gulf coast (Price et al. 1987b, Price 1990). In recreational areas, solid waste can have ecological as well as aesthetic consequences. In areas containing extensive metal and industrial debris, the potential exists for toxic substances to leach into the marine environment. Wooden pallets and driftwood may form a physical barricade to female turtles crawling up beaches to nest. Further, if such debris becomes impacted by an oil slick, the problem becomes compounded, and also increases dramatically the cost of any future oil clean-up operations. For this reason, several offshore coral islands in the Gulf, where turtles and birds nest in high densities, were cleared of debris shortly after the 1991 war.

2.1.4 Ecological Condition

(1) Coastal and Marine Habitats

The combination of high temperatures and unusually high salinity makes the Arabian Gulf a stressful environment for marine organisms.
Under such environment, generally, the distribution of organism is not uniform, but mainly confined to particular habitats. So, it is more important to protect the habitats in the Arabian Gulf than common sense.

According to the IUCN/MEPA's report (1988), the principal habitats of the Arabian Gulf were found in the areas of following lands;
1) Coastal wetlands,
2) Intertidal flats,
3) Beaches,
4) Subtidal sand,
5) Subtidal mud,
6) Seagrasses,
7) Coral reefs,
8) Other hard-bottomed biotopes, including rock and artificial structures, particularly oil rigs, and
9) "Restricted environments" of very high salinity.

(2) Key Species

The key species (and/or important species) in the Arabian Gulf are described as follows;

1) Birds

Arabian Gulf, particularly the intertidal flats, is one of the most important habitats in the world for both resident and migratory birds. An estimated 1-2 million birds overwinter or stop on migration (Taylor 1991) and at least 70 species of coastal and marine birds have been observed during winter counts in the Gulf region.

2) Marine Turtles

Two marine turtles species, Green Turtle (*Chelonia mydas*) and Hawksbill Turtle (*Eretmochelys imbricata*) are common, and are widely distributed (Basson et al. 1977, Miller 1989) in the Arabian Gulf. However, their nesting area is restricted geographically and seasonally. Most nesting areas were recorded on the offshore islands although a few were found on the mainland. In the Saudi Arabian Gulf, most of the population breeds on offshore islands include Karan, Kurayn, Jana, Harqus, and Jurayd. Particularly Karan and Jana are the primary nesting site for these species (IUCN/MEPA 1987).

3) Marine Mammals

The marine mammals found in the Arabian Gulf include several species of dolphins, whales (Pilot, humpback, killer, fin) and dugong (IUCN/MEPA 1987).

4) Sea Snakes

At least nine species of sea snake (*Hydrophiidae*) occur in Gulf waters (see list below). A further two species are present in the Arabian Sea (northern Indian Ocean) and might also occur in the Gulf.

(3) Ecologically Sensitive Area

The Saudi Arabian Government in association with IUCN-The World Conservation Union, has drawn up an extensive list of important marine and coastal nature conservation areas in the country (IUCN/MEPA 1987).

The following is a list of the environmentally sensitive areas (ESAs) and their habitats/resources.
1) Saffaniya/Manifah Bay Complex
Coral reefs, Important mangroves and seagrass beds, nesting site for green turtles, pearling banks, and fishery resources
2) Harqus Island
Key sites for nesting green turtles and birds.
3) Arabiyah Island
Well-developed coral reefs
4) Karan Island
Primary nesting site for marine turtle (Green Turtle and Hawksbill Turtle), nesting site for birds.
5) Kuayn Island
Key sites for nesting green turtles and birds.
6) Jana Island
Key sites for nesting green turtles and birds.
7) Jurayd Island
Key sites for nesting green turtles and birds.

8) Abu'Ali/Dawhat Dafi/ Musallamiyah Complex
Seagrass bed, coral reefs, pearling bank, and fishery resources.
9) Tarut Bay Complex
Coral reefs, critical mangrove areas, well developed seagrass beds, habitat of Dugong or sea cows and sea turtles, pearling bank, fishery resources
10) Al'Uqayr Bay
Primary breeding area of Socotra Cormorant (threatened bird species).
11) South Gulf of Salwah
Seagrass bed, Habitat of Dugong or sea cows and sea turtles, fishery resources.

The distribution of these ecologically sensitive areas are shown in Figure 5.

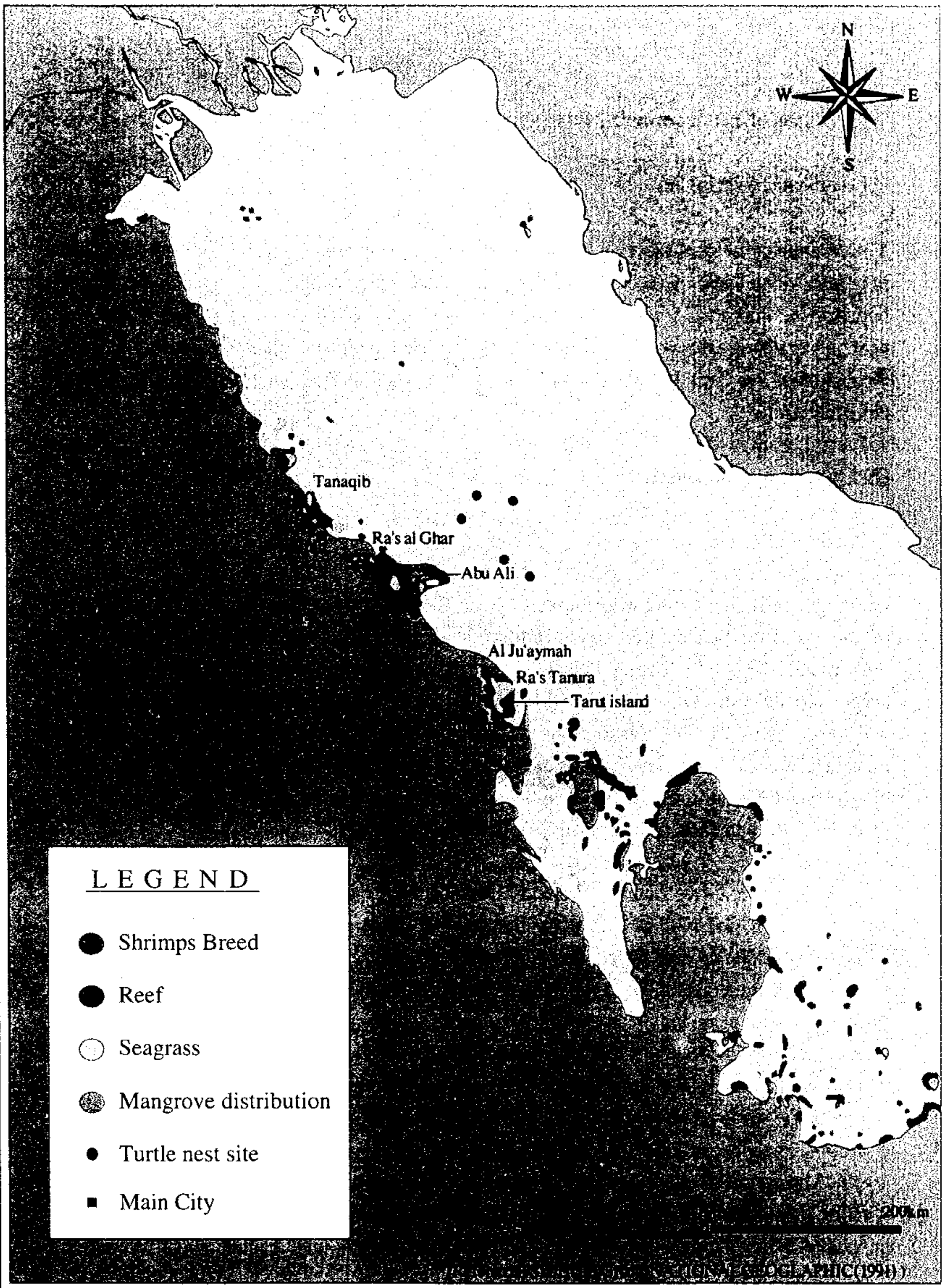


Figure 5 Distribution of Ecologically Sensitive Areas

2.1.5 Status of Environment Management

(1) General Description

The Islamic principles teach man that the Universe was created in balance by God, and that man as steward of God should manage all the created beings fairly and equally to enhance the universal common good of them not only for the current generation but also next generations. Based on the Islamic taught, the people of the Kingdom of Saudi Arabia had lived on the benefits of the nature, paying due attentions to the natural environment.

(2) Governmental Activity

1) National Policy

Geographically the Kingdom is flanked by the Red Sea on the west and the Arabian Gulf on the east. Both are featured as semi-closed seas, oil producing sites and busy passage of tankers and ships which carry out and carry in a tremendous amount of oil and general cargoes to and from all over the world. On top of that, there were a number of conflicts and wars* between the surrounding countries which imposed serious damages to the natural environment. The Saudi Government well realizes the vulnerability of the environmental conditions of the Kingdom and emphasizes the importance of protection of its land, seas and air from any environmental hazards.

In 1981, the Government created Meteorology and Environment Protection Administration (MEPA) as a directly responsible entity for the environment under the Ministry of Defense and Aviation by Royal Decree No. 7/M/8903 to control pollution, protect environment and set up standards related to pollution control and environment protection and also in 1986, similarly created National Commission for Wild Life Conservation and Development (NCWCD) by Royal Decree No. M/22 specifically to protect wildlife including national fauna and flora in danger of extinction. Along with the two entities, the government established in 1981 " Environment Protection Coordination Committee" to coordinate among the ministries and governmental departments, and in 1990 "Ministerial Committee for Environment" as the highest level directorate to deal with environment affairs on the national level in the Kingdom. Lately the system has been partially amended for strengthening of the system (see Figure 6 Environment Protection System of Saudi Arabia).

*Ex.: Iran-Iraq War in 1980, Gulf War in 1991

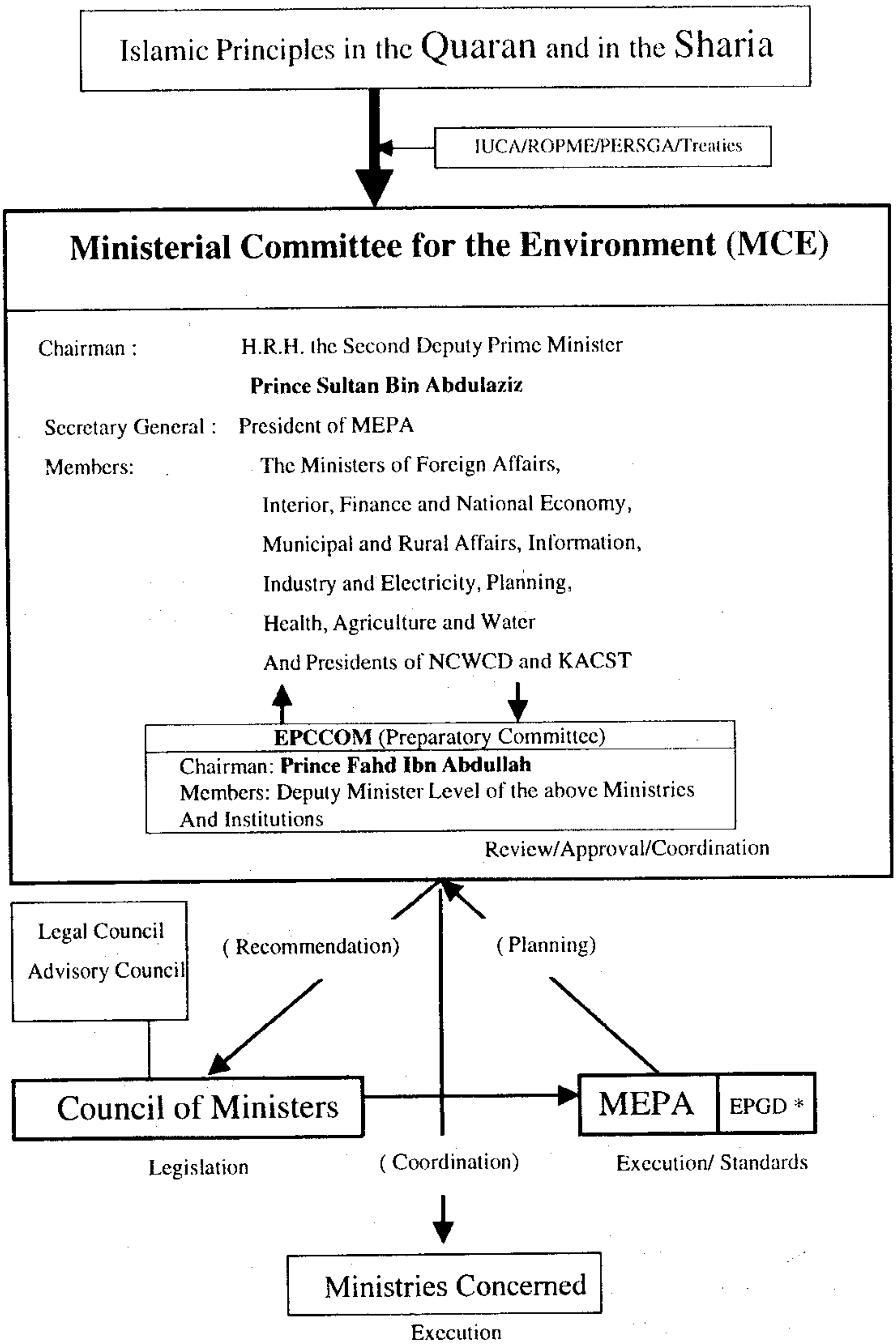


Figure 6 Environment Protection System of Saudi Arabia

2) Environmental Laws and Standards

Although the draft of National Legislation for protection of the environment is yet to be formalized, the Islamic principles have been philosophically effective to date over the mind of Saudi Arabian people. According to the Holy Koran, " God created all species in balance and thus man is obliged to observe moderation and avoid anything that may affect the environmental balance".

The Islamic rules are interpreted by MEPA and The World Conservation Union (IUCN) as guidelines of Moslems for the environment protection. The book is titled "Environment Protection in Islam" 2nd revised edition in 1994.

Besides the Islamic principles, the Saudi Government issued a number of administrative orders in the forms of royal decrees, royal orders, ministerial resolutions, and MEPA standards as follows:

-Royal Decree No.M/22(3/5/1398H:1979G) which defines the natural range-lands.
-Royal Decree No. M/26(25/5/1398H:1979G) which regulates birds and wildlife hunting system.
-MEPA No. 1401-01 Environmental Standards which were put into effect as of the 1 /11/ 1402(1982)
-Ministerial Resolution No.271(23/11/1404H:1984G) which regulates for industrial activities (cement and gypsum).
-Royal Order 1182/8(5/7/1405H:1985G) which regulates for forest protection.
-Ministerial Resolution No. 157(20/11/1411H:1991G) which regulates against sea pollution.
-Royal Decree No.A/90(27/8/1412H:1992G) which delegates specific roles to the governmental departments.

In addition to the above, the Kingdom has extensively participated in regional and international organizations , and/or signed several important agreements with them for cooperation in environment protection and preservation such as:

-United Nations Environment Program (UNEP)
-United Nations Development Program (UNDP)
-The World Conservation Union (IUCN)
-Inter-governmental Oceanographic Commission (IOC)
-The Arab League Decisions 1407H(1986) which adopted "the Arab Declaration on Environment and Development"

-The Advisory Committee on Protection of the Sea (ACOPS)
-Decision of the Heads of State of the Gulf Cooperation Council 1407H(1983)
-Regional Organization for the Protection of the Marine Environment (ROPME) signed by eight states on the Arabian Gulf and Oman.
-Saudi Sudanese Joint Red Sea Commission
-Regional Organizations of the Red Sea and Gulf of Aden (PERSUGA)
-Center for Environment and Development for Arab Region and Europe (CDARE)

3) Environment Related Authorities

The governmental authorities directly involved in environmental protection management are MEPA and NCWCD namely;

MEPA: Meteorology and Environmental Protection Administration.
NCWCD: National Commission for Wildlife Conservation and Development.

In addition, the central government clearly described the responsibility of each ministry and other government departments in environmental protection by Royal Decree No.A/90 dated 27/8/1412H (1992) as follows:

- Ministry of Agriculture & Water:
It implements the national plans concerning use of pasturages, forest and agricultural land, and development of desalination plants on the coast of both the seas ; Red Sea and Arabian Gulf, and also it is responsible for organizing, developing and observing the land, water, pasturages and forests besides issuing any permits related to agricultural water resources and fishing.

- Ministry of Finance and National Economy:
It provides the necessary funds for the environmental projects that the governmental departments propose.

- Ministry of Petroleum and Mineral Resources:
It implements several environmental activities through Saudi Aramco Co. (a government company working under this ministry) and the Arabian Oil Co. which has been recently (Mar.2000) transferred to the control of Aramco from this ministry. All the environmental activities of this ministry are to be coordinated with MEPA.

- Ministry of Health:

Its responsibilities are represented in provision of health care and control of environment and professional health conditions

- Ministry of Industry and Electricity:

It issues the industrial projects licenses besides its responsibility for electricity.

- Ministry of Interior:

It takes over the duties of evaluating the chemical, radioactive, military and natural hazards.

- Ministry of Transportation:

It assumes the responsibility of transporting the dangerous wastes, besides preventing oil spillage from ships and any sea pollutants.

- Ministry of Planning

It defines the objectives of the economic, social and environmental development through the Kingdom quinuennial development plans.

- Ministry of Municipal and Rural Affairs:

It controls the works of water and sanitary systems, besides disposal of solid wastes (industrial, medical, construction). It has a department for environment affairs taking over the public health matters.

- Ministry of Information

It promotes awareness of the nationals for environment protection.

- Ministry of Trade

Its responsibility includes the establishment of standards for merchandise to protect the environment.

- Royal Commission for Jubail and Yanbu:

According to an understanding memorandum with MEPA, the Royal Commission assumes all responsibilities related to environmental protection in the industrial cities of Jubail and Yanbu. The Royal Commission observes the environmental issues, air pollution and wastes control according to a strict system similar to MEPA systems.

- The Higher Committee for Riyadh City Development

Its responsibility includes planning and implementing the development programs of Riyadh city on continual basis and in coordination with MEPA.

- King Abudulaziz City for Science and Technology

It deals with improvement and better usage of national resources.

4) MEPA's Activity

a. History

In line with fast economic development in the Kingdom, the problem of environmental pollution was becoming an area of concern. Specifically oil spills were continuously threatening the Saudi territorial water of the Gulf. To cope with such situations, in 1981 the Government reorganized the ever existing "General Directorate of Meteorology" to "Meteorology and Environmental Protection Administration" under the Ministry of Defense and Aviation by Royal Decree No. 8903 dated 21/4/1401.

b. Organization

As historically seen above, the environment protection administration department was newly added to the meteorology administration department under the Ministry of Defense and Aviation. Although MEPA belongs to the military organization, the personnel and function are regarded totally as civilians. The MEPA Head Office organization chart is shown in Figure 7.

c. Role and Responsibility

MEPA is assigned to undertake the following activities:

- Conduct environmental surveys and monitoring to define problems and recommend environmental standards and measures.
- Recommend practical measures necessary to deal with emergency situations affecting the environment.
- Recommend protection regulations and measures dealing with environmental problems and do environmental assessment.
- Assess existing environmental pollution levels and future variations (such information to be documented for easy retrieval).
- Keep abreast with development in the field of environmental protection on the regional and international levels.
- Establish environmental standards and specifications for pollution control and environmental protection, in a definite and stable form to be considered by the appropriate authorities when issuing permits for industrial and agricultural projects which may have an environmental impact.

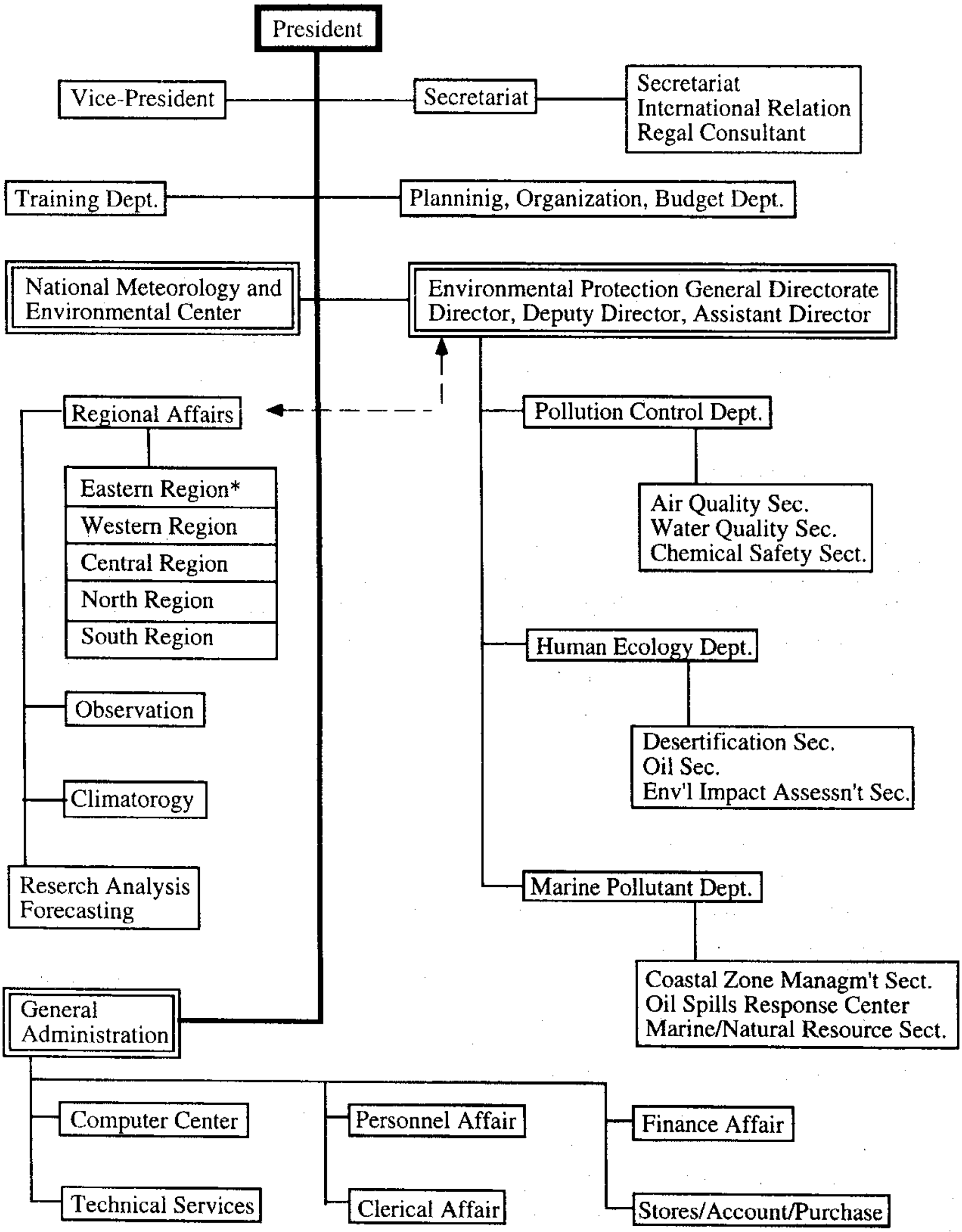


Figure 7 MEPA Head Office Organization

5) Practical Activities of MEPA's Eastern Province

a. Organization

From the MEPA head office organization, MEPA Eastern Province Office (Eastern Office) is situated under National Meteorology and Environmental Center, not under Environmental Protection General Directorate. As seen in Figure 8 MEPA Eastern Province Organization, the number of personnel at Meteorology Division of the Eastern Office is much more than at Environmental Protection Division.

b. Role and Responsibility

Since there is no written document available about designated responsibilities of the Eastern Office, only assumption can be made from the organization chart and interviews with the staff members as follows:

(1) Meteorological observation
(2) Meteorological record keeping and analysis
(3) Deal with marine pollution
(4) Deal with hazard waste management
(5) Deal with air pollution
(6) Deal with oil spill problems
(7) Laboratory
(8) Maintenance of facility and equipment
(9) Any other items designated by MEPA head office.

c. Laboratory condition

For the laboratory space, approximately $450m^2$ in total is allocated in the Eastern Office building. The space is divided into several sections including manager's office, stock room and laboratories. The laboratory has tap water, sinks, experimental stands. However MEPA EP had few equipment and chemicals so that it was difficult to carry out the Project with these equipment. JICA provided the Eastern Office with necessary equipment and chemicals. In order to implement the monitoring and analytical work in the laboratory,

MEPA needed to assign several specialists as counterparts to carry out the analytical work of the Project and direct recipients of the technology transfer.

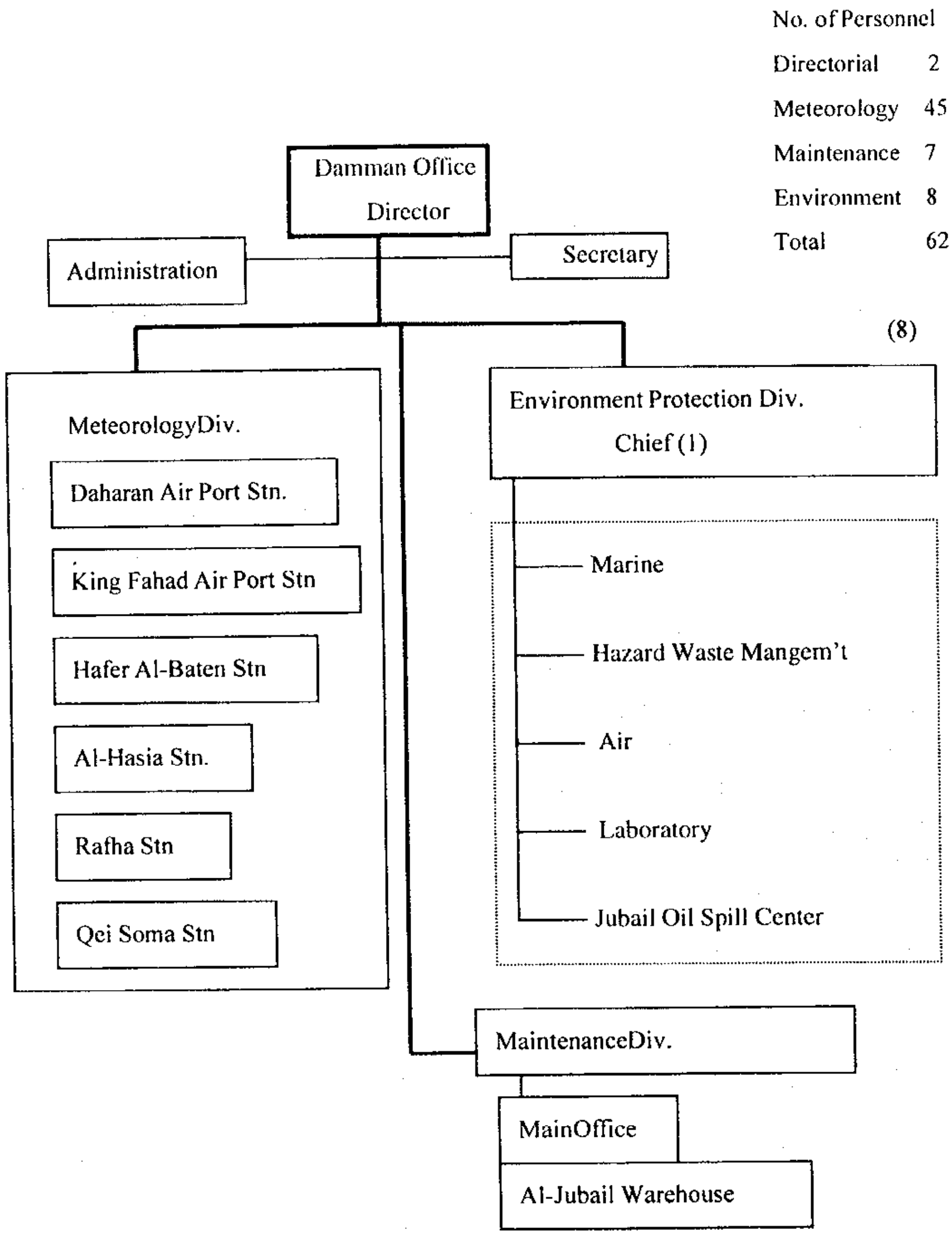


Figure 8 MEPA Eastern Province Organization

d. Budget Condition

It is assumed that all expenditures of the Eastern Office are controlled by the head office. For example, the expenses accrued on routine works such as salary and maintenance cost are already determined by its head office and expenses accrued on ad-hoc basis are basically reimbursed by the head office if they are permissible within the budget of the head office. Since there is no separate budget for laboratory and laboratory management and maintenance is directly under the control of contract department of MEPA (The Planning, Organization Budget Department shown in the Figure 7). So MEPA E. P. do not have authority to maintain or to purchase any kind of chemical/spare parts or even small equipment unless it is approved by the contract department.

2.2 Marine Monitoring Survey

For the purpose of understanding the pollution condition of the intensive study area (see Figure 9), the 1st marine monitoring survey was carried out in October and November 1999, the 3rd work stage.

A total of 34 sampling sites were selected for the 1st marine monitoring survey (Stage 3 monitoring survey). The locations of these sampling sites were determined based on the results of field studies by previous programs in the whole Arabian Gulf area, and a preliminary survey within the intensive study area which was conducted during the 2nd work stage in KSA (Stage 4 monitoring survey).

The results of the 1st monitoring survey are being used to help identify problem areas in the Intensive Study Area. For example, in some limited area land-based source discharges, elevated concentration of nutrients (i.e. nitrogen and/or phosphorous) were detected (see Figure 10 and Table 6, which indicates the result of both 1st and 2nd monitoring survey).

This result suggests that some effluents may affect the surrounding water body and could promote undesirable eutrophication events in the future. For better understanding and prediction of the influence of nutrients, it is necessary to know the temporal trend of water quality degradation, including possible seasonal changes.

A key aspect of the 2nd marine monitoring survey is that all practical works, such as field monitoring and laboratory works, is planned to be executed by MEPA staff, with the. team members providing technical support and advice as and where necessary.

MEPA also tried to conduct marine monitoring over 15 points from January to February 2000 by itself. This would have increased awareness of potential problems and understanding to conduct monitoring work smoothly. The 2nd monitoring survey expected to benefit from this effort.

A range of laboratory, analyses were executed during the 3rd work stage. Because of the shortage of the laboratory technicians, MEPA and the Team were required to reduce the scope of the 1st monitoring plan and decrease the number of sampling sites from 47 to 34.

These reductions did not affect the scientific quality of the project. However, the laboratory analyses required a large work effort and lack of time made it difficult to accomplish sufficient technology transfer of key aspects of laboratory practice, including analytical methods, data analysis and QA/QC (Quality Assurance/Quality Control) procedures etc.

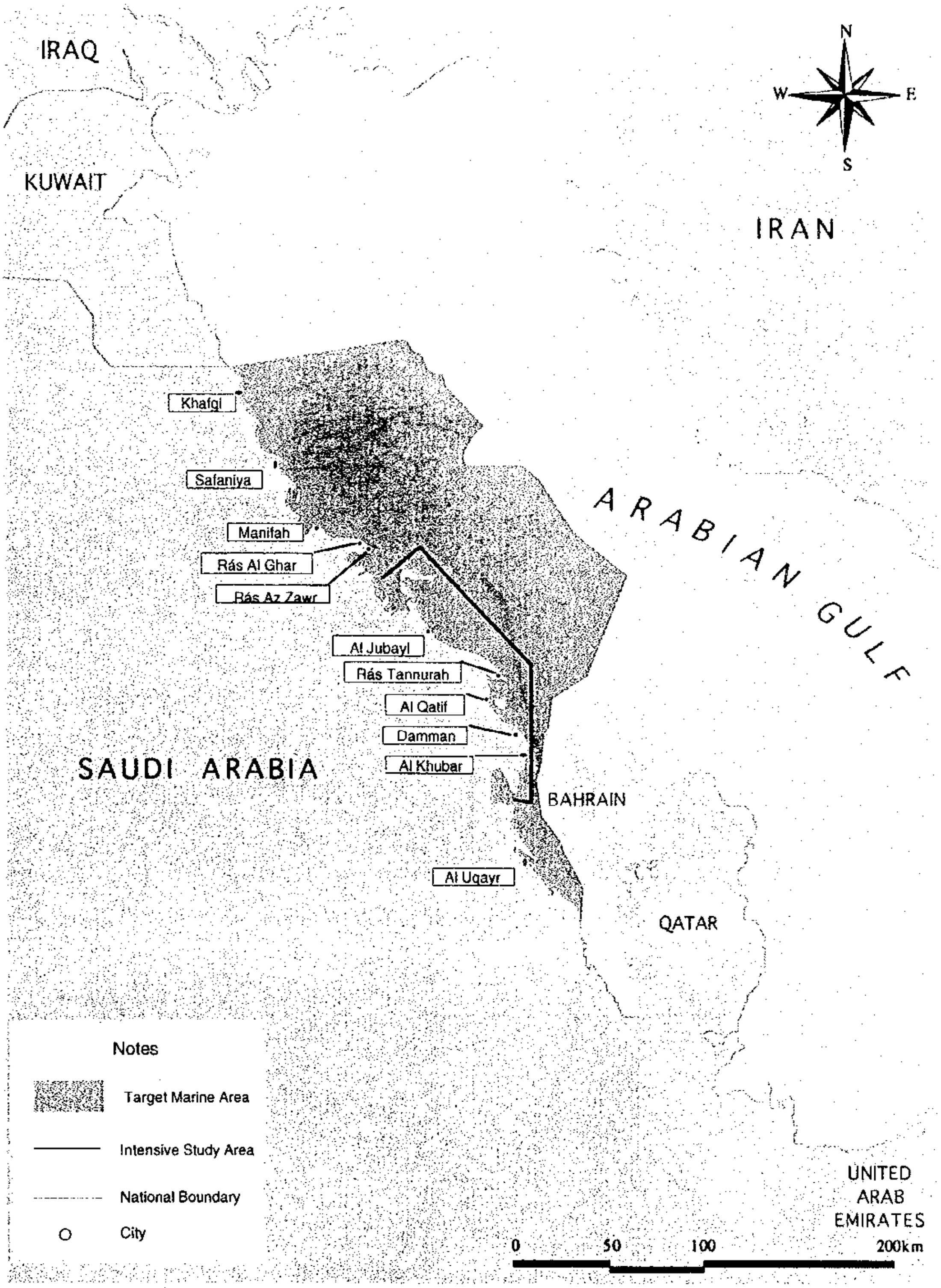
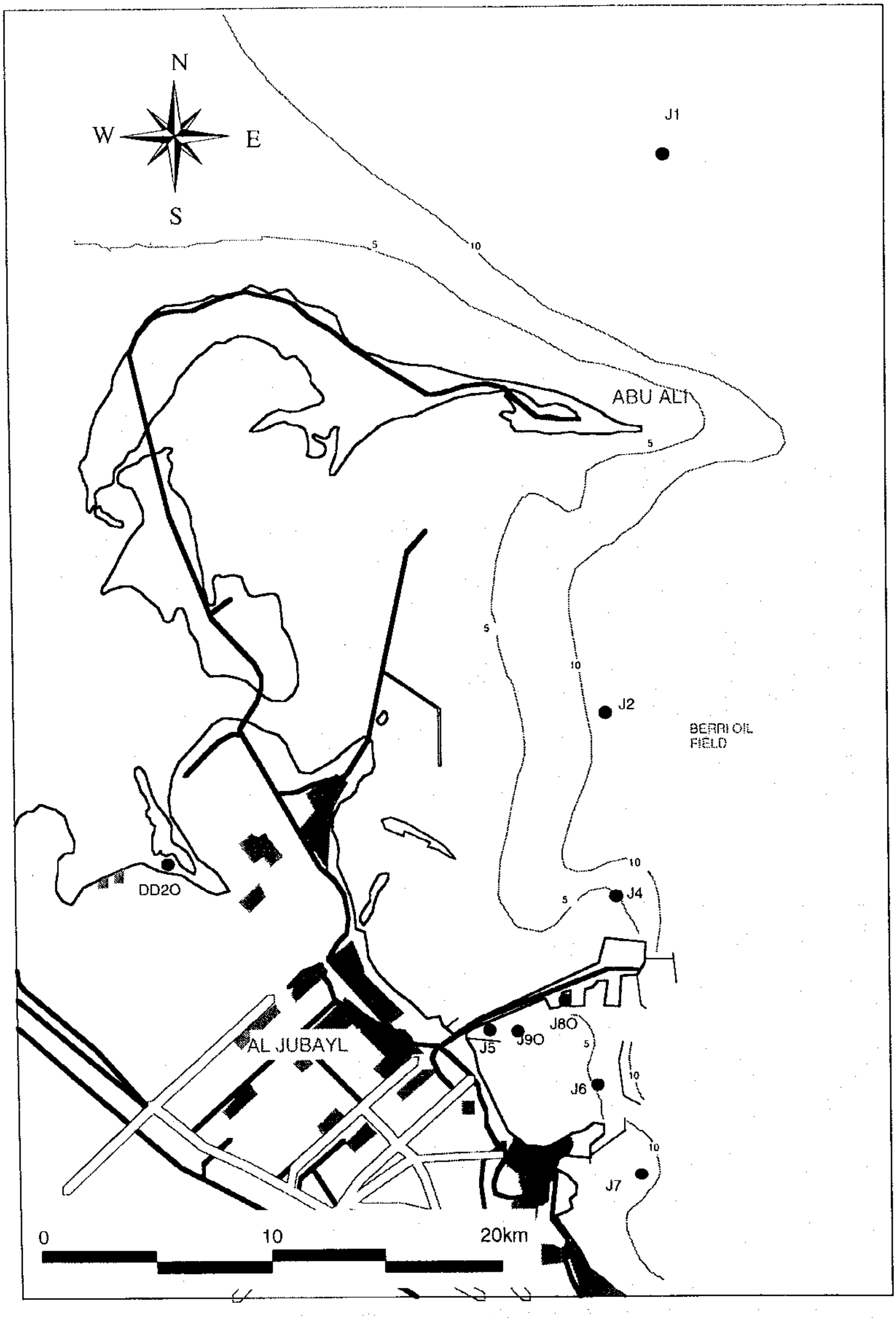


Figure9 Study Area



Fugure 10 (1) SAMPLING LOCATIONS

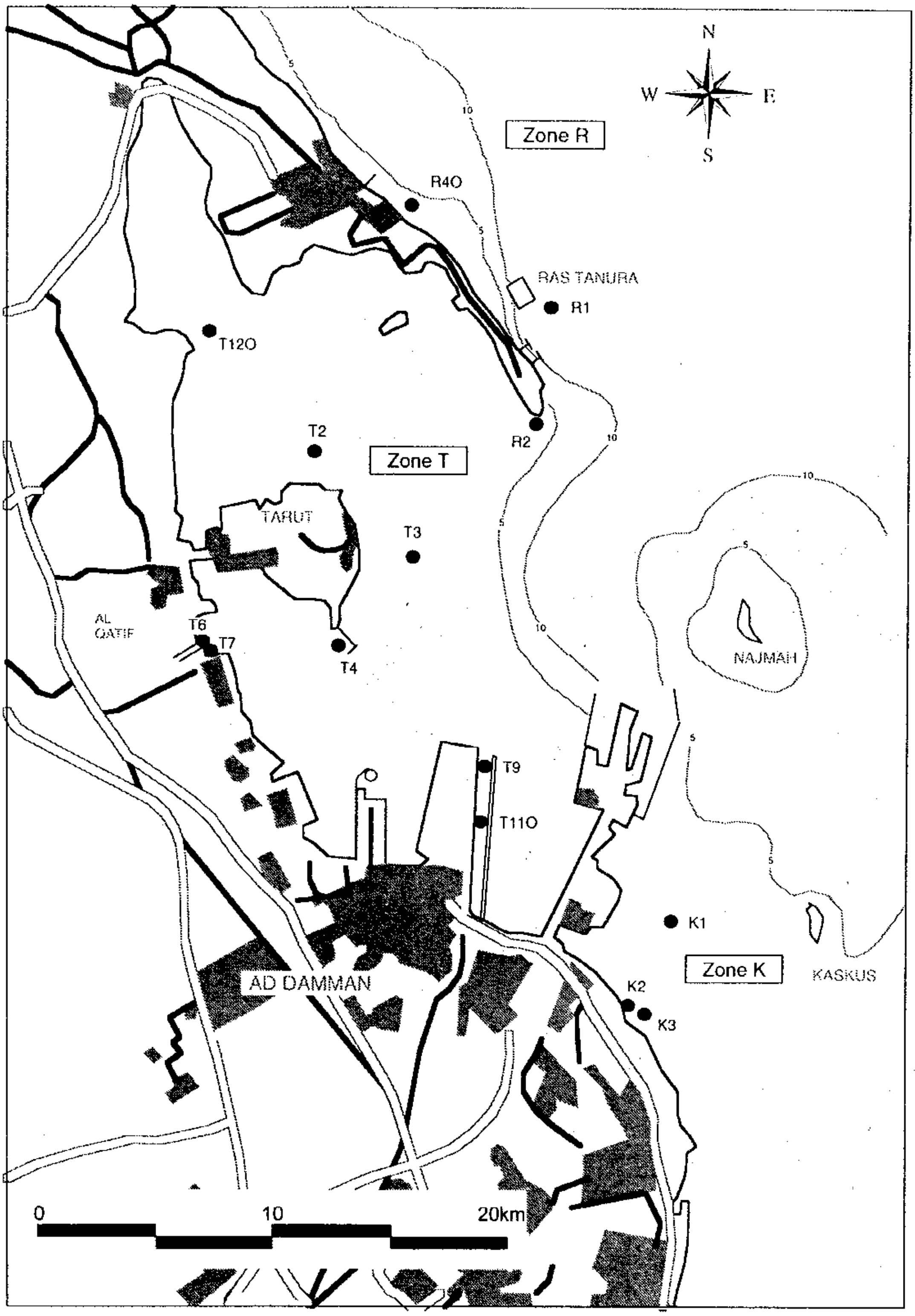


Figure 10 (2) SAMPLING LOCATIONS

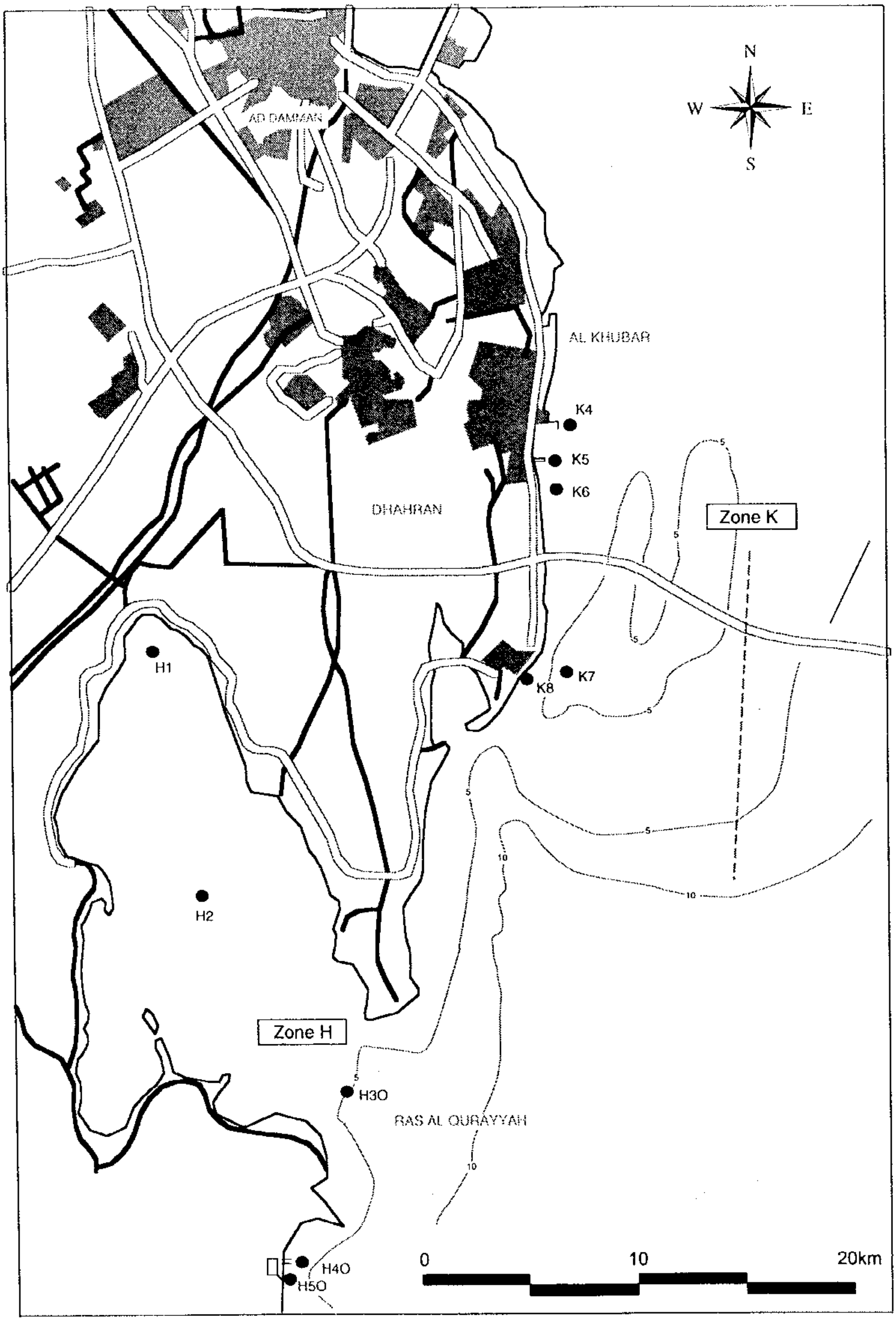


Figure 10 (3)   SAMPLING LOCATIONS

Table 6 (1) Evaluation of Water Pollution

Field Measurements (Including Hydrolab DS4 Multiprobe Meter Measurement)

Indicator		Temp.	Salinity	pH	DO	Turbidity	Clarity	Odour	Sheen	Flotsam	Residual Chlorine
Unit		℃	(g/L)	-	mg/L	NTU	m	+/-	+/-	+/-	Total (ug/L)
Detection Limit		+-0.1	0.2	0.1	0.2	2	0.3	na	na	na	10
Monitoring Results with location	Stage 3 Survay	34.8	59.3	7.4 / 8.4	2.2 / 9.2	na	<0.3 / 11.5	++	-	+	180
		J5	H2	T6 / J1	T6 / T7	na	T6 / J2	T7	-	J5	H50
	Stage 4 Survay	40.0	61.04	7.43 / 8.2	1.69 / 4.5	20/0	0.3 / 15.7	+	-	+	380/20
		K2	H1	T6 / K6	J7 / T120	T120/K1	T6 / J2	T6	-	J4,J5,J7,J90,R1, T2,T3,T7,K1,K5, K6,K7,K8,H50	T3/DD20,K1, K3,K6
Location, of Which value indicates higher than ES in Stage 3 Survay		-	-	-	-	-	-	-	-	-	-
Location, of Which value indicates higher than ES in Stage 4 Survay		-	-	-	-	-	-	-	-	-	-
Effluent standard (ES)	H1401-01	na	na	<6-9>	na	na	na	na	na	na	500
	RCJY	na	na	<6-9>	na	na	na	na	na	na	500
Location, of which value indicates higher than ASQS in Stage 3 Survay		J5,K2,H50	-	-	-	na	T6	T7	-	-	R40,T120,T9, K2,K4,K5,K8, H40,H50
Location, of which value indicates higher than ASQS in Stage 4 Survay		J5,K2,H50	-	-	-	T6,T110, T120,K5	T6	T6	-	-	J6,R40,T2,T3, T4,T6,T120,H 2,H40,H50
Ambient Seawater Quality Standard (ASQS)	RCJY (10%)	na	na	<6.8-8.5>	<4.0	na	na	na	na	na	na
	RCJY (50%)	na	na	<6.8-8.6>	<5.0	na	na	na	na	na	na
	Japanese Standard (class A)	na	na	<7.8-8.3>	<5.0	na	na	na	na	na	na
	Study 'alart' value	>3 ambient	>70	<7.2-8.4>	<4.0	15	<0.5	++	+	+	100

*Water Quality 'alert' values are derived for local conditions from normal background range and from marine water quality guidelines recommended by US-EPA, ANZECC, Canada etc. for the protection of marine aquatic ecosystems.

na = not applicable

Table 6 (2) Evaluation of Water Pollution

aboratory Analyses

Indicator		TDS	TSS	TOC	TKN	NH4	Til P	Chl A	As	Cr	Hg	Mg	Cd	Co
Unit		g/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	g/L	ug/L	ug/L
Detection Limit		0.2	1	0.5	0.1	0.2	10	0.1	10	50	5	0.05	10	50
Monitoring Results Max/min. records with location	Stage 3 Survay	67.6	12	48	130	90	1,030	54	<10	200	<0.1*	1.9	<2*	<30*
		H1	T7	K2	K2	K2	K5	T6	-	-	-	K8	-	-
	Stage 4 Survay	na	25	19	100	71	1,500	12	<10	<50	<0.1	2.8	<2	<30
			T6	T6	K2	T7	T6	T6	-	-	-	K8	-	-
Location, of Which value indicates higher than ES in Stage 3 Survay		-	-	-	K2	K2,T7	K5	-	-	-	-	-	-	-
Location, of Which value indicates higher than ES in Stage 4 Survay		-	-	-	K2	K2,T7	T6	-	-	-	-	-	-	-
Effluent standard (ES)	H1401-01	na	15	50	5	na	1,000	na	100	100	1	na	20	na
	RCJY	na	25	50	5	13	1,000	na	100	100	1	na	10	100
Location, of which value indicates higher than ASQS in Stage 3 Survay		-	T4,T6,T7, T120,K3, K2,K5	J1,J5,T2,T4, T6,T7,K2,K 3,K4,K5,K6 ,H50	T6,T7,K2, K5	K2,T6,K5	T6,T7,K2 ,K4,K5	T2,T6,T7, T120	-	-	-	-	-	-
Location, of which value indicates higher than ASQS in Stage 4 Survay		-	T4,T6,T7, T110,K2, K5	All sites in which samples were collected	T6,K2,K3, K5	K2,T6,K5	T6,T7,K2 ,K4,K5, H30	T6,T7	-	-	-	-	-	-
Ambient Seawater Quality Standard (ASQS)	RCJY (10%)	na	na	3.4	na	13	8	na	10	na	0.1	na	na	100
	RCJY (50%)	na	na	2.4	na	5	1	na	5	na	<0.1	na	na	50
	Japanese Standard (class A)	na	na	na	na	na	na	na	<10	<50	<0.5	na	<10	na
	Study 'alart' Value*	75	5	1	2	2	50	2.5	20	50	0.1	3	2	30

Table 6 (3) Evaluation of Water Pollution

Laboratory Analyses

Indicator		Cu	Ni	Pb	Zn	Oil & Grease	TPH	Benzen	Toluene	Ethylene	Xylene	Phenol	Cyanogen
Unit		ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Detection Limit		50	50	100	10	0.2	0.1	10	10	10	10	5	10
Monitoring Results with location	Stage 3 Survay	<5*	<15*	<9*	200	0.6	0.2	<10	<10	<10	<10	<5	<10
		-	-	K7	K2	K2	T110	-	-	-	-	-	-
	Stage 4 Survay	<5	<10	<5	<10	0.8	<0.1	<10	<10	<10	<10	<5	<5
						K2							
Location, of Which value indicates higher than ES in Stage 3 Survay		-	-	-	-	-	-	-	-	-	-	-	-
Location, of Which value indicates higher than ES in Stage 4 Survay		-	-	-	-	-	-	-	-	-	-	-	-
Effluent standard (ES)	H1401-01	200	200	100	1,000	8	na	na	na	na	na	0.1?	50
	RCJY	200	200	100	2,000	8	na	na	na	na	na	0.1?	50
Location, of which value indicates higher than ASQS in Stage 3 Survay		-	-	K7	-	K2	T110	-	-	-	-	-	-
Location, of which value indicates higher than ASQS in Stage 4 Survay		-	-	-	-	K2	-	-	-	-	-	-	-
Ambient Seawater Quality Standard (ASQS)	RCJY (10%)	na	na	10	100	na	na	na	na	na	na	5	10
	RCJY (50%)	na	na	na	20	na	na	na	na	na	na	1	5
	Japanese Standard (class A)	na	na	<10	na	na	na	<10	na	na	na	na	<10
	Study 'alart' Value*	5	15	5	50	0.5	0.1	10	10	10	10	5	10

*Water Quality 'alert' values are derived for local conditions from normal background range and from marine water quality guidelines recommended by US-EPA, ANZECC, Canada etc. for the protection of marine aquatic ecosystems.

na = not applicable

As a countermeasure to the above problem, the Team made a priority request to MEPA for the mobilization of more laboratory technicians having background in chemistry to participate in the technology transfer program and perform laboratory work smoothly and safely. Responding to this request, MEPA Headquarters promised to dispatch 3 technicians for chemical analysis to MEPA Eastern Province (hereinafter referred to a MEPA E.P.) from February 2000, and therefore the burden of laboratory analysis for the 4^{th} Stage for training purpose was expected to be reduced.

MEPA recognized the manpower difficulties for their laboratory. To help resolve the problem, MEPA requested the Team to send two experts of chemical analysis for the purpose of continuing laboratory work at one month before the start of Stage 4. In response to this request, JICA dispatched one specialist for technology transfer of chemical analysis during the 4^{th} work stage. However, MEPA could not arrange enough member of trainees.

The water quality results of field measurement and laboratory analyses during the site work in Stage 4 are described below (see Table 6).

It was found that little difference of results of between Stage 3 and Stage 4 were existed and that the only concentrations of nutrient in the stage 4 were smaller than that in the Stage 3 at several locations.

The pollution condition of each location was evaluated, based on the classification of evaluation was defined as follows;

- Level 4: more than 4 times of measurement or more than 4 parameters being more than the Ambient Seawater Standard

- Level 3: more than 3 times of measurement or more than 3 parameters being more than the Ambient Seawater Standard

- Level 2: more than 2 times of measurement or more than 2 parameters being more than the Ambient Seawater Standard

- Level 1: less than 2 times of measurement or less than 2 parameters being more than the Ambient Seawater Standard

The observed condition of pollution can be summarized as follows;

- Severe pollution can be recognized to exist at Tarut Bay and Khobar.

- In Tarut Bay, the pollution trend with time has to be carefully monitored since the bay itself is closed and pollution sources such as a wastewater discharge outfalls and a fishery port are existing along the coast.

- The pollution condition of water in Khobar Area is not so serious in comparison with Tarut Bay, since the water current is usually fast. However, existing important source facilities such as Fertilizer Plant and Wastewater Treatment Plant may require careful monitoring of seawater in the future.

According to the guideline of USEPA, three alert levels have been determined based on algae cell counts:

- alert level I
  500 - 2000 potentially toxic blue-green algal cells per mL

- alert level II
  2000 - 15000 potentially toxic blue-green algal cells per mL; any cell count over 2000 cells per mL is regarded as a level of concern for drinking-water supplies

- alert level III
  greater than 15000 potentially toxic blue-green algal cells per mL)

In this study, the cell number of *Trichodesmium* (belonging to blue-green algae) was counted below alert level.

Diversity of plankton is usually between 1 and 2.5 in coastal waters, generally being low in estuarine or polluted areas. Values from 3.5 to 4.5 are most frequently measured in the oceanic plankton.

Plankton Diversity Index estimated from the results of this study indicated 1.44-2.9 in Stage 3 and 0.93-2.5 in Stage 4, varying within the normal value, except for the location of site K3 and Jubail Area in 3rd sage.

Results from the Stage 3 and Stage 4 surveys of the Intensive Study Area indicate the following six conclusions.

- Coastal water quality was poorest and impacts on biological resources such as seagrasses and coral reefs were highest in some shallow, near shore and/or partly enclosed areas. These include parts of Tarut Bay (particularly on the north-east side of Tarut Island), and inshore areas south of Dammam Port and also near Al Khobar. Most of the deterioration can be directly related to land-based sources and point discharges that contain high levels of suspended solids, nitrogen, phosphorus and coliform bacteria.

- Fishing harbors that service relatively large fishing fleets (e.g. Darin Jetty at Tarut Island) are also the source of poor water and sediment quality due to the lack of sanitation facilities on these vessels.
- With one exception, the effect on coastal water quality from the four major industrial discharges that were examined in the region (Jubail Shared Outfall; SAFCO (Dammam) factory, Aziziyah Desalination Plant, Al Qu'raiyah Power Plant;) appears to be very low. The exception was the shoreline outfall of the SAFCO fertiliser factory, which is located south of Dammam Port.
- The contaminant concentrations of coastal sediments and water in the offshore were observed generally to be below national and other international Water Quality and Sediment Quality standards and guidelines. These finding are also supported by the results of the Satellite Image Analysis by this project.
- While the offshore waters may be close to a 'near-pristine' condition for much of the time, it appears that the 'background' concentration of certain trace metals in offshore seafloor sediments (e.g. nickel and probably vanadium and barium) may be a little elevated compared to the era before major oil field development. In other words the elevation in certain trace metals can be related to the past 50 years of oil production, tanker traffic and spills within the Gulf.
- The Stage 3 and Stage 4 field monitoring surveys were undertaken in October 1999 and June 2000 respectively. Therefore, the maximum and minimum values of parameters such as water temperature, salinity and dissolved oxygen were not obtained since the lowest and highest values probably occur in very shallow inshore waters during early August and early February respectively. This means that the field monitoring surveys in both August and February may have to be implemented at the earliest opportunity by MEPA.

2.3 Satellite Image Analysis

Satellite data covering Arabian Gulf were analyzed and the following maps which helped elucidate some of the water quality issues were prepared during the 1st work stage in Japan.

-Suspended Solid (SS) Distribution map
-Chlorophyll Distribution map
-Oil Sheen Distribution map

During the 3rd work stage, the Team showed how to use satellite image analyses for water monitoring. The Team also presented the results of the LANDSAT/TM data analysis implemented so far at the workshop on November 17, 1999.

The apparent trends of SS and Chlorophyll distribution evident in the maps corresponded to the results from the 1st monitoring survey results. However, the possible oil sheen estimated from the maps did not correspond to the survey results. To get more effective and robust satellite image analysis of the intensive study area, satellite images will be acquired during the period of the actual Third Stage monitoring work conducted during October and November, 1999. MEPA requested the Team to continue the technology transfer of satellite image analysis and to conduct the analysis using MEPA HQ's computer facilities in Jeddah during the 4th work stage. In response to this request, JICA dispatched a specialist for satellite image analysis to MEPA during the 4th work stage.

In addition to the above plan, MEPA requested that sea surface temperature should be undertaken and equipped the original database of them. Quantitative comparisons between the results of the satellite image analyses and field monitoring data obtained in the Intensive Study Area were also requested.

To accomplish many analyses as mentioned above, another image processing operator has been added to the Team, plus purchase of additional LANDSAT scenes covering the period of the 1st monitoring survey.

The following are the outline of results implemented by jointly works between MEPA and the Study Team in MEPA Headquarters.

The LANDSAT Thematic Mapper (TM) satellite image analysis was performed at the Geographical and Remote Sensing Unit of the MEPA, Jeddah (21 June to 12 July, 2000) for preparing the distribution maps of the temperature, suspended solids, chlorophyll and coastal areas of the intensive study area. The general approach involved the acquisition of LANDSAT TM data (coincided with the sampling duration of the water quality data), followed by extraction of digital numbers (DNs) from TM Bands, development and verification of correlation of selected water quality variables to the spectral data, application of the models to the entire intensive study area, and the production of color coded resultant images, each depicting the distribution for the selected water quality variable. Three TM scenes – Path/Row 164/041, 12 Oct 1999, full scene; Path/Row 164/042, 12 Oct 1999, sub-scene; and Path/Row 163/042, 21 Oct 1999; were utilized for the analysis.

The geo-referencing, re-sampling (25m resolution/pixel) and initial spectral enhancements of the TM data were performed in Japan and data were brought to the KSA for the sea water quality analysis in MEPA, Jeddah. The data were loaded to the hard disks of the MEPA's workstations and the following analyses were carried out by the ERDAS IMAGINE image processing software.

The temperature distribution for Path/Row164/041-042 ranged from a minimum of 23.5°C to a maximum of 30.6°C. For Path/Row 153/042 the range varied from 23.5 to 26.9°C. The overall temperature range of 26.5 to 27.5°C was observed from northeast (NE) to southern regions. Small patches of higher temperatures were distributed particularly in shallow areas and along the vicinities of the coastal regions where more industrial and residential activities are located (e.g., Jubail shared outfalls, SAFCO outfall etc.).

The distribution range for the TSS varied from 0.45 to 6.77 mg/l for the TM image of 12 October 1999. The results showed higher distribution values along the coastal regions (e.g., the 3.16 to 4.51 mg/l was most common in the shallow water inshore areas). TSS range of 1.36 to 3.15 mg/l was widely distributed in mostly the offshore area. Although there was a time lag between the TM images and sample collection for a few days, a satisfactory distribution was observed for the region.

The distribution was divided into five categories ranging from 0.00 to 1.52 microgram/l for Path/Row 164/041-042 and 0.00 to 1.24 microgram/l for Path/Row 163/043 TM data, respectively. The quantitative analysis showed good correlation between the parameters. Generally low chlorophyll concentration were found for most of the whole intensive study area. Higher concentrations were present very close to the coastal sites, such as the northeast of Tarut Bay, the northeast side of Tarut Island, and Al Azaziz.

Medium range (0.47 to 0.64 microgram/l) was observed in the NE parts of the image.

The classified image shows that the largest distribution was the general "shallow water" followed by "very shallow" and "muddy/silty" areas. Most of the coastal areas (more than 50%) comprise modified habitats. The present classification shows the existing situation for the coastal areas, e.g., land fills, built-up areas, dredgged channels etc. Mangroves and coral reef occupied very small areas.

3. STUDY FOR THE RECOMMENDATION ON FUTURE MONITORING SYSTEM

3. STUDY FOR THE RECOMMENDATION ON FUTURE MONITORING SYSTEM

3.1 Existing monitoring Sysmtems

During the 2nd and 3rd work stages, existing monitoring systems were reviewed using collected data and information. In order to construct closer collaboration with other organizations, workshops were also held in both June and November, 1999, satisfactorily. Only one case of long term continuous marine monitoring occurs in the Arabian Gulf. This is conducted by the Royal Commission mainly in the Jubayl area. JICA Study Team requested through MEPA that the Royal Commission could cooperate with the marine monitoring survey by providing their monitoring data where comparisons would be beneficial to both MEPA and the Royal Commission.

During the 4th and 5th work stages, a future monitoring system in the Gulf was discussed. Table 7 indicates the results of discussion with MEPA. The key is to have developed step-wise procedure in order for MEPA to be able to realize.

The purpose of this action plan are;

(1) To establish the integrated system of seawater monitoring,
(2) To strengthen the capability of laboratory analysis, and
(3) To strengthen the management capability to conduct the seawater monitoring.

In order to approach to these purposes, four steps are assumed as follows;

Phase I: The present phase which MEPA/JICA project is completed,
Phase II: The phase to consolidate the system developed in the previous phase,
Phase III: The phase to enhance the developed system and to apply to other areas, and,
Phase IV: The final phase to complete all components proposed.

All these phases are planned to be completed for a period of two years.

The Study Team and MEPA understand that the intention of implementing MEPA's duty and the support of donors like Japan will be highly required to realize the above plan.

3.2 Recommendation on the future monitoring system in the Arabian Gulf

Future marine monitoring programs by MEPA should be discussed based on the results of the proposed program and conditions in the Arabian Gulf. Both water quality variation

Table7(1) Proposed Development of Gulf Coastal Water Management and Monitoring Plan

Indicative Period	1999-2000	2001-2002		2003-2004		2005-2006
Phase of Development	**Phase I** **Implementation and Planning (Completed)**	**Phase II** **Consolidation**	Chk	**Phase III** **Growth and Enhancement**	?	**Phase IV** **Maturation and Focus**
Aims of Phase	JICA assisted upgrade of MEPA Laboratory sampling and analytical equipment at the Eastern Province Office (Damman). Upgrade includes marine monitoring technology transfer and training via implementation of: Baseline Regional Water Monitoring Program, including analyses by MEPA Laboratory of water and sediment samples.	Consolidate Basic Water Quality Monitoring, Planning and Execution Capability by: - Completion of Laboratory staffing and training program - Organisation of Laboratory and Field Monitoring Task Teams - Development and MEPA HQ approval of annual budgets for Laboratory and Field Sampling Operations. - Demonstrated regular use and maintenance of laboratory equipment - Expansion of Regional Baseline Water Quality Monitoring Program - Commencement of Specific Monitoring Tasks (Planning & Implementation)	AUDIT OF PROGRESS	Grow and strengthen coastal water monitoring and management capabilities by: - Undertaking Collaborative Monitoring Tasks with External Agencies. - Introducing quantitative monitoring designs with statistical power and hypothesis testing. - Enhancing MEPA Laboratory's Analytical Capabilities. - Confirming Laboratory Quality Assurance/Quality Control by Independent (External) Checks - Prioritising and Contracting Investigative/Research Tasks to External Specialist Groups.	REVIEW RESULTS, TRENDS AND NEEDS	Depending on the Review's Conclusions and Recommendations and calibre/expertise of staff, Phase IV Aims could include: - Laboratory specialisation. For example, to be a Gulf 'Centre of Excellence' for: * analyses and modelling of nutrient species/biostimulants; * sediment/water partionining and bioavailability of metal species (Vn, Ni, etc) * ecotoxicity testing; * extraction and assay of contaminants from marine plant and animal tissues * marine bacteria culture, assay and disease identification * phytoplankton taxonomy, growth conditions and red-tide toxicity studies.
Monitoring Program — **Monitoring Activity**	Basics of monitoring design, planning, safety, navigation, sampling and sample handling and transport - via 'hands-on' training and background theory. Implementation of Regional Baseline Monitoring in the Central Zone (= 'Intensive Study Area'; Half Moon Bay to Abu Ali). Two water and sediment quality monitoring sampling and analysis exercises conducted (October 1999/June 2000), with most samples analysed at MEPA Laboratory (OCL-POPS and metals in water samples contracted to external laboratory).	Extend Baseline Regional Monitoring Program to determine basline trends and 'hot spot' areas in the North (Abu ali - Kafji) and South (Gulf of Salwhat) sectors of KSA Gulf Coast. Complete seasonal monitoring surveys in Central Zone KSA. Plan and implement following Specific Monitoring Tasks: - Characterise dispersal, fate and effects of nutrients from fertiliser factory outfall. - Characterise amount, dispersal and fate of organic matter and nutrients discharged by Al Khobar STP (collaborate with external biostatisticians on sampling design) - Identify and characterise all point source inputs of nutrients into environmentally significant areas of Tarut Bay. - Photographically document types and distribution of Shoreline Marine Litter and Rubbish. Archive material for use in public awareness/education campaign. (e.g. schools in coastal towns to be part of national coastline survey of beach litter). - Ground-truthing for the satellite-based fine-scale mapping of sabkah, mangroves, seagrass bed, coral reef and artificial/deepened/modified shorelines - for long term coastal habitat status monitoring in Central, North and South regions of KSA Gulf.	ALL PHASE II MONITORING TASKS AND ACTIVITIES IMPLEMENTED?	Continue Regional Baseline Monitoring Program (e.g. spatial and temporal gap-filling, and prioritised follow-up on any hot-spot areas discovered in Phase II). Implement Quantitative Sampling Designs and Statistical Data Analyses. Achieve by (a) securing collaborative agreement with biostatistician familiar with analysis of repeated measures, multiple control BACI designs by ANOVAR/MANOVA and MDS methods; and/or (b) appointing a biostatistician to assist and help train all MEPA staff responsible for robust environmental monitoring using statistical design and analysis techniques (preferable). Complete the sampling, analysis and interpretation steps of the Specific Monitoring Tasks that were planned and implemented during Phase II. Continued ground-truthing for satellite mapping study.	IDENTIFY NEEDS AND FUTURE DIRECTION	Regional Baseline / Surveillance monitoring Program continues - but modified/optimised in accordance with recommdendations by the "End of Phase III" Review. It is likely that one or more highly-focussed investigative studies may be required. These should be undertaken in close collobaration with pertinent agencies and organisations, or even contracted out to specialist research groups depending the nature and duration of the task/s.
Monitoring Program — **Sampling Equipment**	Supply, training and use of: GPS units (2), portable electromagnetic water current meters (2), Hydrolab Multiprobe (1), Van Dorn water samplers (3), Eckman grabs (3), Van-Veen grab (1), polycarbonate soil corers (5), plankton nets (2), secchi discs (2), sounding leads (2).	Field sampling equipment at MEPA Damnam is sufficient for Phase II work		Sediments: Vertical Drop Core sampler; Dredge sampler. Sedimentation sampler (sediment trap/collector). Water current velocity/direction: Purchase or hire of two time-averaging programmable data loggers (e.g. S4 buoy, Anderaa type current meter). Portable tide gauge.		Trailerable 6-7 m inshore vessel for MEPA's Sampling and Research tasks. DGPS system. Other field equipment depends on direction/needs of coastal monitoring program.
Monitoring Program — **Numerical Modelling**	None.	Specific Tasks require development of 2D/quasi-3D Hydrodynamic Model of water movement and flushing rate for the coastal sectors at Al Khobar-south Dammam and Tarut Bay to determine dispersal patterns (grid resolution no more than 500 m). This modelling needs to be subcontracted to specialist firm/group.		Completion of field calibrated 2D/3D Models for Al Khobar and Tarut Bay-Dammam. Contracted supplier provides training in the understanding, interpretation, application and constraints of model results.		Modelling requirements will depend on level of convenient external support (e.g. KFUPM) versus in-house requirements and desirable project time-lines.
Monitoring Program — **Satellite Image Analysis**	Basic techniques and information from Satellite Image Analysis conducted of Central Zone (ISA) transferred to MEPA.	Obtain images for North and South sectors of KSA Gulf coast. Development of GIS database system in combination with the above satellite image and monitoring results.		Commence detailed GIS-based 'Coastal Habitat Distribution Map' showing present distribution of key habitat types (see above). Further development of GIS database system.		Continued development of GIS database system; Obtain and process 2nd round of satellite images for long term coastal habitat monitoring.
MEPA Laboratory — **Staff**	Four MEPA staff assigned (laboratory chemist and three laboratory assistants). Four more staff with good chemistry background required.	Appointment of Laboratory Manager and two more laboratory technicians with suitable chemistry background. These are required as soon as possible for consolidation of laboratory operations via training for routine analysis work. Advisors from outside organization will be required.	STAFFING AND TRAINING ACHIEVED?	MEPA appointment of one deputy laboratory manager (a chemistry technician responsible for QA/QC control) and 1 more technician with chemistry background. This will meet Phase III requirements (i.e. four technician specialists for inorganic analyses (1), nutrient analyses (1), other organic analyses (1) and bacteriological (1), under one Laboratory Manager).	REVIEW FUTURE NEEDS / DIRECTION	Same as Phase II, except possibly one more laboratory technician for specialist preparative work of samples (depending on future analytical needs and direction of MEPA coastal water monitoring requirements).
MEPA Laboratory — **Equipment**	Laboratory Facilities Audit and Upgrade (including fridge and fume cupboard) Installation and initial training on use and maintenance of: Gas Chromatography Unit (GC-FID) Atomic Absorption Spectrometer (AAS) Total Organic Carbon meter (TOC) Distillation Apparatus (several) and spectrophotometer for sample preparation Oil Content Meter	No major new equipment items required <u>Minor equipment:</u> Microwave for sample treatment and teflon containers for acid digestion Camera adapter and 1 Low-power widefield stereomicroscope for macroplankton ID and counting Hollow Cathode Lamp (for Varian AAS)		Installation of: Nitrate-nitrite Autoanalyser Electron Capture Detector for Gas Chromatography Unit (GC-ECD) Flameless Atomic Absorption Spectrometer (FL-AAS) Ion Chromatography (IC) Clean Bench to improve speed and reliability of bacteria colony media preparation and culture		Depending on outcome of Review of Future Direction/Specialisation of MEPA Laboratory, one or more the following equipment items may be required: High Performance Liquid Chromatography (HPLC) Gas Chromatographic - Mass Spectrometer (GC-MS) Inductively Coupled Plasma Mass Spectrometer (ICP-MS) Clean Room for assays of low level trace substances
MEPA Laboratory — **Comment**	Equipment sufficient to sample and analyse key sea water/effluent quality parameters, including CTD, DO, pH, TSS, nutrients, organic content, sediment metal levels, TPH, bacterial coliforms, plankton.	Analyses for metals in water samples and for POPS (persistent organic pollutants such as PAH, PCB and organo-halides) to continue to be subcontracted to external laboratory.		Installation of the above advanced equipment will permit accurate measurement of important nutrient species and trace substances which occur at very low but environmentally significant concentrations (parts per billion; ug/L).		Advanced equipment enabling adequate resolution of trace toxic substances (eg. POPs, dioxins, etc) may need to be installed, unless satisfactory arrangements with one or more commercial laboratories can be secured.
Estimated Funding Requirements	COMPLETED	**MEPA Laboratory oerations: SR 45,000** **MEPA Laboratory Minor Equipment: SR 10,000** **Field Sampling Logistics: SR 8,000** **Hydrodynamic Modelling Study (part 1): SR 15,000** **Satellite Image Purchase (north and south regions): SR 3,000**		**MEPA Laboratory oerations: SR 90,000(for Baseline monitoring)** **Field Sampling Logistics: SR 24,000** (for Baseline monitoring) **MEPA Laboratory Equipment: SR 700,000**		**MEPA Laboratory oerations: SR 90,000 (for Baseline monitoring)** **Field Sampling Logistics: SR 24,000 (for Baseline monitoring)** **MEPA Laboratory Equipment: SR 1,900,000**

Table 7 (2) Proposed Development of Gulf Coastal Water Management and Monitoring Plan (Continue)

Indicative Period		1999-2000	2001-2002		2003-2004		2005-2006
Phase of Development		Phase I Implementation and Planning (Completed)	Phase II Consolidation	Chk	Phase III Growth and Enhancement	?	Phase IV Maturation and Focus
Organization Structure	Technical training/ education system	Three staff and two managers from MEPA Eastern Province receive training in Japan. JICA Study Team completed technology transfer with on-job training, seminars, preparation of field and laboratory manuals, and documentation.	MEPA staff develop self-training system. Advisors from outside organizaitons will be needed to provide further training to ensure MEPA personnel can fulfil sampling and analysis requirements of water quality monitoring program.	Good Organisational Support & Database?	The Phase II review and initial Phase III equipment purchases will highlight the specific training requirements for this Phase.	REVIEW ORGANISATIONAL NEEDS	MEPA has sufficient skilled personnel with technical know-how to identify and organise its own training requirements, as well as swopping skills and training advice with other organizations and laboratories
	Information	Basic monitoring database system established by using Microsoft-Excel. Procedures and technical reference books were provided. Information on local suppliers and prices of chemicals and consumables gathered.	Accummulation of spatial and seasonal data. Commence obtaining computer file copies of relevant marine monitoring data from Royal Commission of Jubayl, ARAMCO and Regional Organisations (ROPME, etc) for entry on database, so MEPA can become a regional data centre and repository of historical water quality information.		Continue collation and archiving of spatial and temporal monitoring data. Synthesise and plot data to identify general spatial and seasonal trends, and to identify areas requiring more intensive sampling to elucidate apparent pollutant 'hot spots' and/or previously unknown important point source inputs.		Monitoring results are synthesised into 'State of Coastal Environment Reports' supplied to Government, coastal stakeholders and general public to help gain support for policy development, decision-making and future funding. MEPA strives to ensure all monitoring results collected are reliable and used to provide robust, scientifically-sound advice, including feedback on success of the Coastal Zone Management Plan.
	MEPA organizaion	MEPA managers started planning a new organization for the work. MEPA assigned 5 specialists. MEPA Head Office finished financial arrangement for 2 new chemists. MEPA H.O and E.P started discussion for the goal.	Apply organisational framework at MEPA Eastern Province for management of field monitoring and laboratory teams, and progress in MEPA's water quality monitoring system and capabilities. Secure adequate annual budgets for laboratory operations, field monitoring logistics and assignment of specialists. MEPA may request to obtain advice and support by dispatching an advisor from outside organizations including JICA.		MEPA implements schedule for the Coordinated Coastal Zone Management Program, with a policy for achieving urgent action at key areas (e.g. inside Tarut Bay) to prevent further water quality deterioration.		MEPA receives additional regulatory powers to develop and implement, in collaboration with other agencies, factory and municipal outfall licences, plus appropriate self-monitoring by the operators to confirm that discharges meet the specific licence conditions set for each outfall.
	Co-operation with other organization	MEPA started communications with relevant outside agencies and third parties by meetings and workshops. Capability of universities, private institutes and other laboratories in Eastern Province determined.	Maximise collaboration opportunities with other agencies, municipalities and third parties during the various data collation and liaison tasks that form part of the Phase II marine monitoring tasks.		MEPA Eastern Province seeks support from all relevant government agencies, municipalities, factories and other commercial organisations, and encourages them to play active roles in the Coordinated Coastal Zone Management Program for protecting coastal waters and resources.		MEPA utilizes outside institute and laboratories for specific purposes such as QA/QC, staff training, and/or for answering specific questions that require specialist research or modelling. This strategy allows MEPA to deal with a wide range of monitoring and analysis requirements.

and estimation of effects from discharges need to be taken into consideration when planning future marine monitoring program. In addition, data and information collection (to help further the understanding of existing conditions and the planning of future marine monitoring programs by MEPA E.P.) should be continued. Consideration of the future monitoring program will benefit from the results of the satellite image analyses implemented in the 2nd to the 4th work stages.

Based on the experience obtained by this project in the Intensive Study Area, water quality monitoring activity will have to be developed in other areas not only along the Gulf Coast, but also the Red Sea. The point is that the only MEPA among many governmental organizations can implement this type of work in KSA in accordance with the present governmental policy.