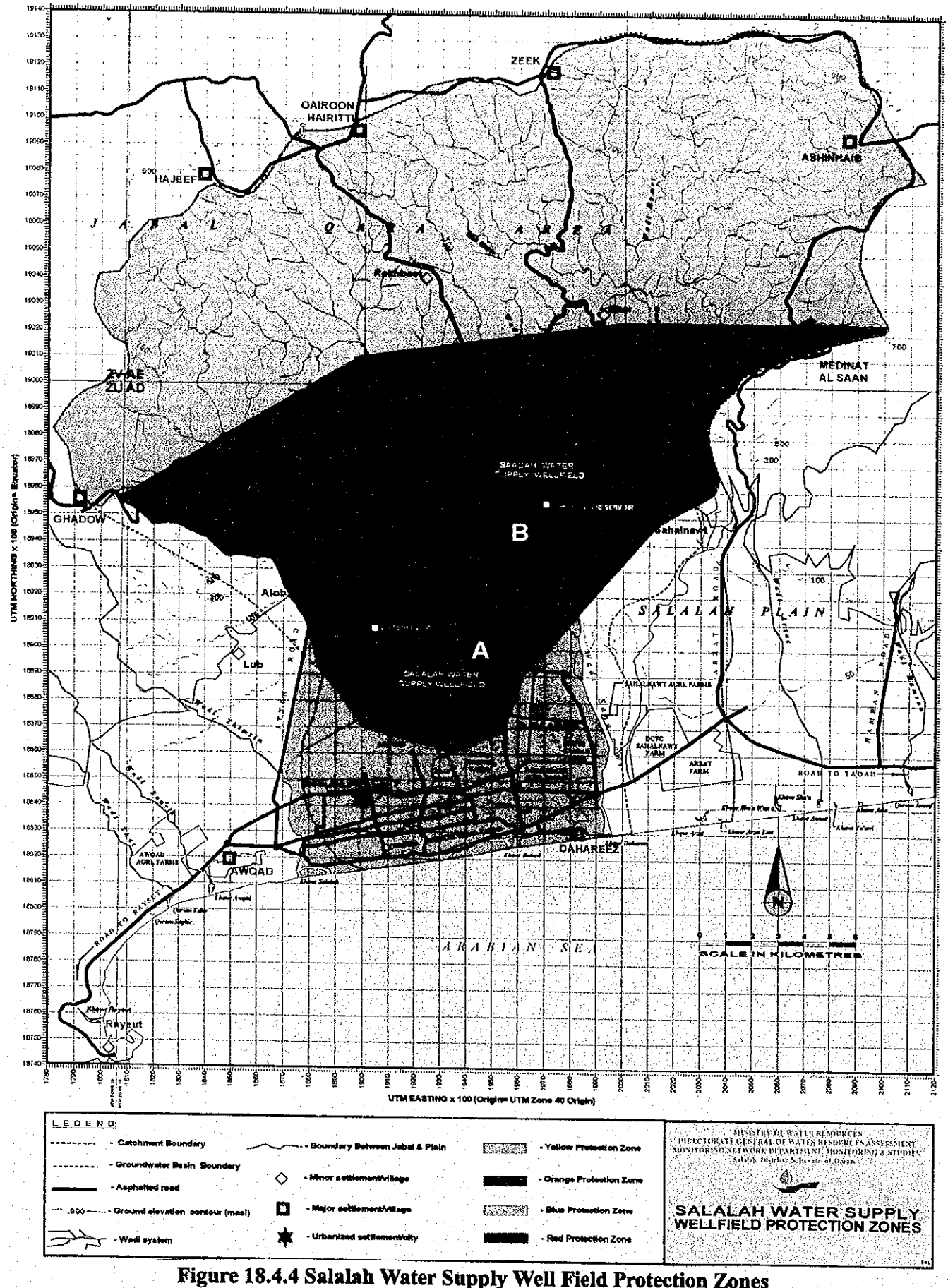


Figure 18.4.4 Salalah Water Supply Well Field Protection Zones

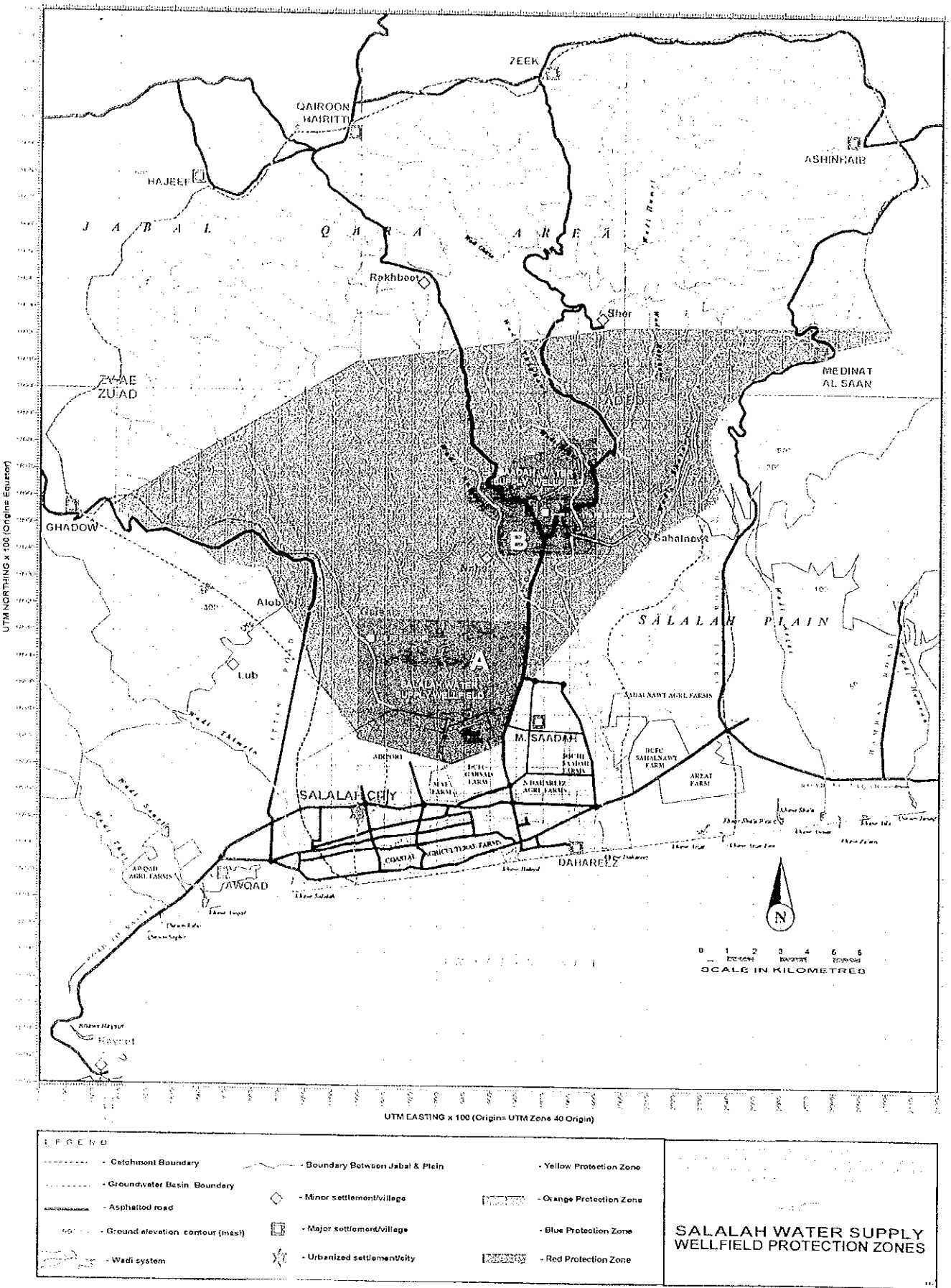


Figure 18.4.4 Salalah Water Supply Well Field Protection Zones

Table 18.4.3 (1) Well Field Protection Zones Regulations

ITEM			YELLOW ZONE	BLUE ZONE
1	Ban on all development which is not directly related to government groundwater management, except for approved non-hazardous small businessess.	Ban on all industrial sites with high potential for pollution.		
2	Ban on any extension of existing developments unrelated to government groundwater management, or change of use, unless approved by government.	Ban on extension of existing developments or change of use with high potential for pollution.		
3	Ban on the costruction of new private or commercial wells.	Drilling or digging of new wells only by permit from the MWR with limits on discharge rate or total abstraction.	Drilling or digging of new wells only by permit from the MWR.	Drilling or digging of new wells only by permit from the MWR with limits on discharge rate or total abstraction.
4	Ban on all solid and liquid waste disposal . Only sewage holding tanks acceptable.	Ban on liquid disposal, non-hazardous solid waste only with government permit. Only sewage holding tanks acceptable.	All cesspits and septic tanks should be replaced by holding tanks.	All cesspits and septic tanks should be replaced by holding tanks.
5	Ban on the disposal of all hazardous waste within the zone. Safe containment of all stores of potentially hazardous toxic substances.	Ban on the disposal of all hazardous waste within the zone.	Ban on the disposal of all hazardous waste within the zone.	Ban on the disposal of all hazardous waste within the zone.
6	Ban on all burials.			
7	Ban on all sand and gravel quarrying and mining.			
8	Ban on the use of chemical fertilizers, insecticides, pesticides, and herbicides unless approved, biodegradable and non-persistent.	Ban on the use of chemical fertilizers, insecticides, pesticides, and herbecides unless approved, biodegradable and non-persistent.		
9	Ban and the infilling of all existing underground storage tanks.	Underground tanks only with government permit.		
10	Protected roads only by government permit.	Unprotected roads only by government permit.		
11	Replacement of all transformers containing potentially hazardous toxic substances.	Replacement of all transformers containing potentially hazardous toxic substances.	Replacement of all transformers containing potentially hazardous toxic substances.	Replacement of all transformers containing potentially hazardous toxic substances.
12	Metering and quality monitoring of all groundwater abstractions.	Metering of all groundwater extractions.		Metering of all groundwater extractions.
13	Monitoring on the volume and quality of surface water flows.	Monitoring on the volume and quality of surface water flows.		
14	MWR access to all past, present, and future well or borehole drilling, construction, monitoring and production records.	MWR access to all past, present, and future well or borehole drilling, construction, monitoring and production records.	MWR access to all past, present, and future well or borehole drilling, construction, monitoring and production records.	MWR access to all past, present, and future well or borehole drilling, construction, monitoring and production records.
15	Immediate implementation of best practices.	Immediate implementation of best practices.	Immediate implementation of best practices.	Immediate implementation of best practices.
16	Installation of markers every 50 m. to delineate the protection zone, where physically possible.			
17	Installation of road signs delineating the protection zone.	Installation of road signs delineating the protection zone.	Installation of road signs delineating the protection zone.	Installation of road signs delineating the protection zone.

Source: Water Resources Protection Department, MWR DG Water Resources Management.

Table 18.4.3 (1) Well Field Protection Zones Regulations

ITEM	RED ZONE	ORANGE ZONE	YELLOW ZONE	BLUE ZONE
1	Ban on all development which is not directly related to government groundwater management, except for approved non-hazardous small businessess.	Ban on all industrial sites with high potential for pollution.		
2	Ban on any extension of existing developments unrelated to government groundwater management, or change of use, unless approved by government.	Ban on extension of existing developments or change of use with high potential for pollution.		
3	Ban on the costruction of new private or commercial wells.	Drilling or digging of new wells only by permit from the MWR with limits on discharge rate or total abstraction.	Drilling or digging of new wells only by permit from the MWR.	Drilling or digging of new wells only by permit from the MWR with limits on discharge rate or total abstraction.
4	Ban on all solid and liquid waste disposal . Only sewage holding tanks acceptable.	Ban on liquid disposal, non-hazardous solid waste only with government permit. Only sewage holding tanks acceptable.	All cesspits and septic tanks should be replaced by holding tanks.	All cesspits and septic tanks should be replaced by holding tanks.
5	Ban on the disposal of all hazardous waste within the zone. Safe containment of all stores of potentially hazardous toxic substances.	Ban on the disposal of all hazardous waste within the zone.	Ban on the disposal of all hazardous waste within the zone.	Ban on the disposal of all hazardous waste within the zone.
6	Ban on all burials.			
7	Ban on all sand and gravel quarrying and mining.			
8	Ban on the use of chemical fertilizers, insecticides, pesticides, and herbicides unless approved, biodegradable and non-persistent.	Ban on the use of chemical fertilizers, insecticides, pesticides, and herbecides unless approved, biodegradable and non-persistent.		
9	Ban and the infilling of all existing underground storage tanks.	Underground tanks only with government permit.		
10	Protected roads only by government permit.	Unprotected roads only by government permit.		
11	Replacement of all transformers containing potentially hazardous toxic substances.	Replacement of all transformers containing potentially hazardous toxic substances.	Replacement of all transformers containing potentially hazardous toxic substances.	Replacement of all transformers containing potentially hazardous toxic substances.
12	Metering and quality monitoring of all groundwater abstractions.	Metering of all groundwater extractions.		Metering of all groundwater extractions.
13	Monitoring on the volume and quality of surface water flows.	Monitoring on the volume and quality of surface water flows.		
14	MWR access to all past, present, and future well or borehole drilling, construction, monitoring and production records.	MWR access to all past, present, and future well or borehole drilling, construction, monitoring and production records.	MWR access to all past, present, and future well or borehole drilling, construction, monitoring and production records.	MWR access to all past, present, and future well or borehole drilling, construction, monitoring and production records.
15	Immediate implementation of best practices.	Immediate implementation of best practices.	Immediate implementation of best practices.	Immediate implementation of best practices.
16	Installation of markers every 50 m. to delineate the protection zone, where physically possible.			
17	Installation of road signs delineating the protection zone.	Installation of road signs delineating the protection zone.	Installation of road signs delineating the protection zone.	Installation of road signs delineating the protection zone.

Source: Water Resources Protection Department, MWR DG Water Resources Management.

Table 18.4.3 (2) Well Field Protection Zones Action Plan

ACTION	WADI ADAI	AL KHAWD	SALALAH/SAADAH
REMOVAL		Oriental Crusher Al TURK Cement Products	
REMEDIAL MEASURES	Dual carriageway with protective measures through the gorge.	Build STPs for Faniah, Bid Bid, Luzugh and Al Khawd to take and treat all liquid wastes.	Sewerage connection to the main line (yet unbuilt) for cement factory and Roads Department Workshop.
	Build main sewerage system through the gorge with enforced connection of those businessess with existing sewerage systems.		Spillage control measures along main Muscat Road near Saadah wellfield.
			Spillage control measures along the new bypass.
REGULATIONS			
IMMEDIATE ACTION (1 YEAR)	Implementation and enforcement of best practices in the red and orange zones.	Implementation and enforcement of best practices in the red and orange zones.	Implementation and enforcement of best practices in the red and orange zones.
	Closure and infilling of all underground storage tanks in the red zone.	Closure and infilling of all underground storage tanks in the red zone.	Closure and infilling of all underground storage tanks in the red zone.
	Ban on all new development which is not directly related to government groundwater management in the red zone.	Ban on all new development which is not directly related to government groundwater management in the red zone.	Ban on all new development which is not directly related to government groundwater management in the red zone.
	Ban on any extension of existing developments or change of use in the red zone, unless approved by government.	Ban on any extension of existing developments or change of use in the red zone, unless approved by government.	Ban on any extension of existing developments or change of use in the red zone, unless approved by government.
	Installation of road signs delineating the protection zones.	Installation of road signs delineating the protection zones.	Installation of road signs delineating the protection zones.
GENERAL (3 YEARS)	Implementation and enforcement of all the new regulations.	Implementation and enforcement of all the new regulations.	Implementation and enforcement of all the new regulations.
	Replace all septic tanks and cesspits with holding tanks.	Replace all septic tanks and cesspits with holding tanks.	Replace all septic tanks and cesspits with holding tanks.

Source: Water Resources Protection Department, MWR DG Water Resources Management.

b) Water Quality

(i) The water quality on the Salalah Plain varies, with a tongue of freshwater in Salalah Central Plain flanked by brackish water (Western and Eastern Brackish zones).

(ii) Over the past 10 years, the zone of freshwater has progressively declined partly because of over abstraction, resulting in saline intrusion from both the brackish zone as well as from the sea. Fig. 18.4.5 shows the water table and zones of blackish water on the Salalah Plain.

(iii) The municipal well field and major agriculture users are currently abstracting from the freshwater zone.

(iv) Within Salalah Plain West water quality is blackish, typically below 6,000 μ S/cm but increases further west where it ranges between 10,000 to 43,000 μ S/cm.

(v) Monitoring records indicates that salinity levels have been increasing in irrigating areas nearer the coast.

c) Water Demand

(i) Based on the inventory of wells (NWIP) in the mid 1990s, there is approximately 1, 559 hectares of irrigated land on the Plain with a total water demand of 57. 5Mm^3/year.

(ii) Most of the water demand is within the Salalah Plan Central (1, 231 ha), while less volume is needed in Salalah Plain West (260 ha) and Salalah Plain East (68 ha), respectively.

d) Water Balance

(i) The water resources of the Salalah Plain have come under increasing pressure over the past twenty (20) years due to increasing water demand in all sectors.

(ii) Estimates of water supply and demand, as well as the monitoring of groundwater levels and water quality, indicate the balance is in deficit.

Table 18. 4. 4 is shown the water balance in Salalah Plain

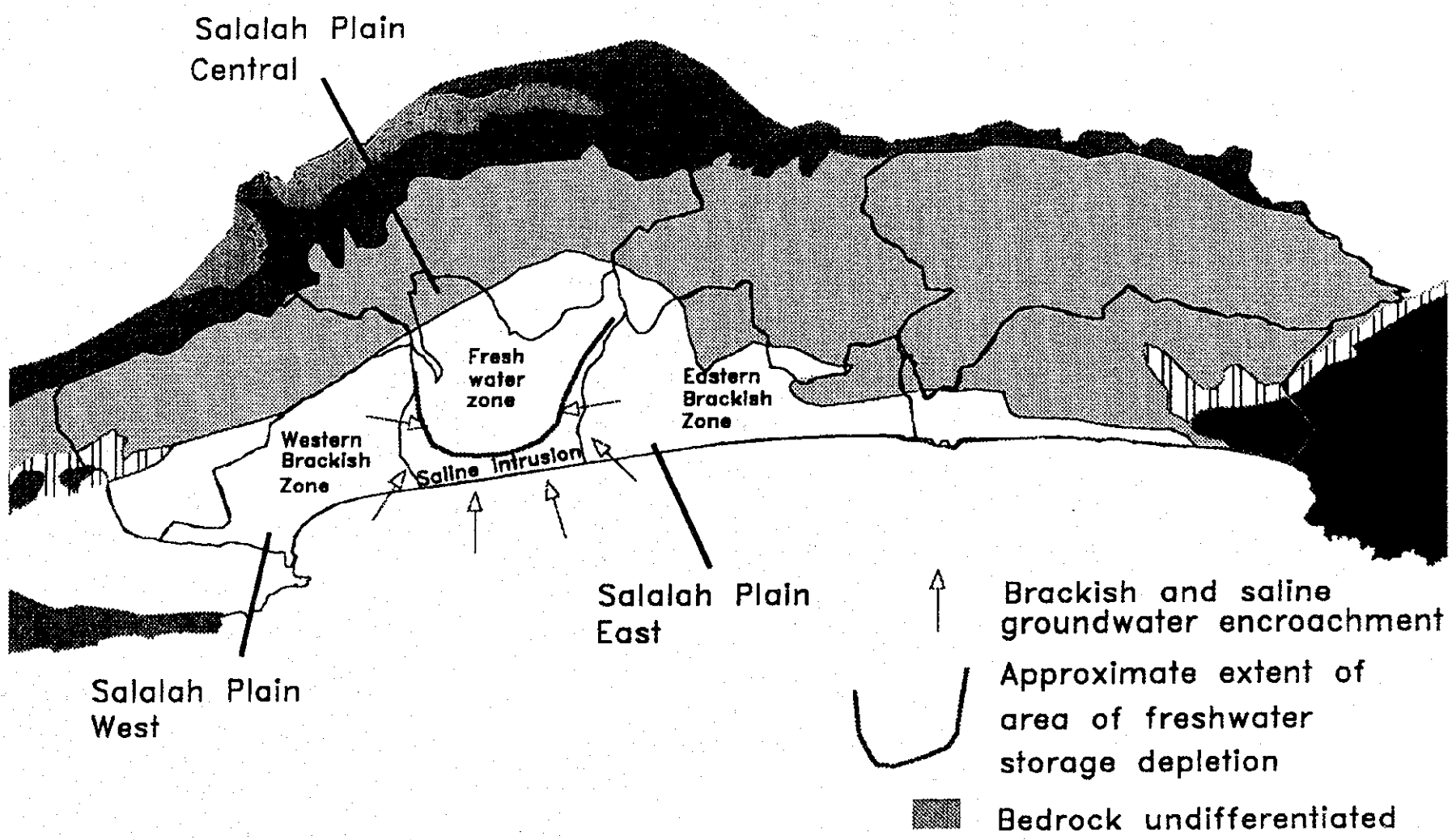


Figure 18.4.5 Salalah Plain: Areas of Deficit or Surplus

Table 18.4.4 Water Balance Salalah Plain

Water Balance Element	Water Assessment Unit Area			
	Salalah Plain West	Salalah Plain Central	Salalah Plain East	TOTAL
INFLOW Direct & indirect recharge	**8. 60**	**37. 30**	18. 10	**64. 00**
OUTFLOW				
Use				
Agriculture	5	39. 77	12. 69	57. 46
Domestic	0. 002	4. 1	0. 02	4. 122
Industrial	<0. 001	0. 25	0. 004	0. 25
Groundwater transfers	2. 25	0	2. 25	4. 5
Groundwater outflows to sea				
Total outflow	2. 2	2	4. 8	9
	9. 45	46. 12	19. 76	75. 35
DEFICIT	***- 0. 85***	***- 8. 82***	- 1. 66	**- 11. 34**
Deficit components				
Seawater intrusion	0. 6	3. 3	1. 1	5
Storage depletion	0. 25	5. 5	0. 6	6. 35
TOTAL	**0. 85**	**8. 8**	1. 7	**11. 35**

(UNIT: Mm^3 /yr)

2) Future Demand Prospect

(a) Supply

a) Status

The Salalah Plain of water table has been over committed with evidence from monitoring of ground water levels and water quality indicate that it is in deficit annually already.

b) Most in Balanced Area

The deficit of water supply currently reaches more than 8 Mm^3 /year at Salalah Plain Central.

(b) Demand

Increasing demand in domestic and industrial sector is rapidly rise over the next 20 years. Without developing new water sources such as the Nejd or other alternative development of desalination plant and also conducting priority use of the domestic sector, MRW warn that further development hasten the deterioration of the freshwater resources.

18.5 Social and Human Activities

(1) Land Use

1) Present Situation

Some apparent distinction on land use was recognized in the Study Area. These are,

- Concentration of residential, commercial and business areas in the center of Salalah.
- Clear division of land use in the west Salalah to Salalah Port area: Raysut Industrial Estate and port facility are located except one residential area along the road to Mughsail. These industrial estate and Port areas are separated from the residential area by enough distance: over 3 km form the outbound of residential area of Salalah city near Hotel Hilton from the nearest industrial estate.
- Sewerage treatment pond, landfill type solid waste dumping site, and heavy/hazardous industry are located to the north-west Raysut Industrial Estate, isolated from the residential area

The following descriptions are the base of land use recognized in the Study Area.

(a) Base Element of Development

a) Plans

(i) Past Planning

Since 1970's, various planning efforts have been undertaken in Salalah. These include the first Salalah Structure Plan in 1983 and 1985, residential subdivision plans prepared for certain large areas, and sector development plans and all their specific policies and proposals embodied to the present proposed planning as the base elements of development.

(ii) Present Proposed Planning

The Salalah Structure Plan (1995- 2015) by Ministry of Housing (1998, presently MOTH) is the base of present existing planning for land use and development in Salalah.

(iii) Some Base Element Committing Present Development

In the Salalah Structure Plan, they listed major seven (7) of base elements which comprise some important policies. A part of them are as follows.

i) Reservation of land adjacent to the port for residential, commercial, and industrial uses, a self sustained development

ii) Reservation of developable area to the north-west of the Raysut Industrial Estate for heavy/hazardous industries

iii) Some of the special uses are recommended for appropriation to facilitate urban development, depending on the development strategy.

(b) Present Land Use Constraint

a) Existing Land Use Composition

In 1995, the survey for existing land use survey was conducted for entire Salalah region and summarized as the following Table 18.5.1 and Fig.18.5.1. Some of the features of present use of land are as follows.

(i) Commercial development is concentrated in the Central Salalah.

(ii) There are two (2) distinct industrial areas in Salalah: New Industrial Area and Raysut Industrial Estate.

(iii) Salalah Port is regarded as important features of the urban development of Salalah expecting contribution to the local economic development.

(iv) Spatial distribution is inefficient: residential area is 28%, however, both industrial and public & semi-public uses are about 20% each of the total urban area.

Table 18.5.1 Existing Land Use Composition (1995)

Land Use Category	Land Use Area (ha)	Share in Total Development Area (%)
Residential	1,180.33	8.30
Commercial	67.90	0.50
Industrial	810.29	5.70
Public & Semi-Public Facilities	979.49	6.90
Transportation	3,784.83	26.60
Open Spaces	128.45	0.90
Special Uses	3,917.70	27.60
Agriculture	2,513.66	17.70
Wadi, Khawrs, Environmental / Historical Sites	831.00	5.80
TOTAL DEVELOPED AREA **Share in Total Area**	**14,214.65**	**100.00** **22.50**
VACANT LAND **Developable / Undevelopable, Designated / Undesignated**	**48,885.35**	**77.50**
TOTAL AREA	**63,100.76**	**100.00**

Source: The Salalah Structure Plan (1995- 2015) by Ministry of Housing (1998, presently MOTH)

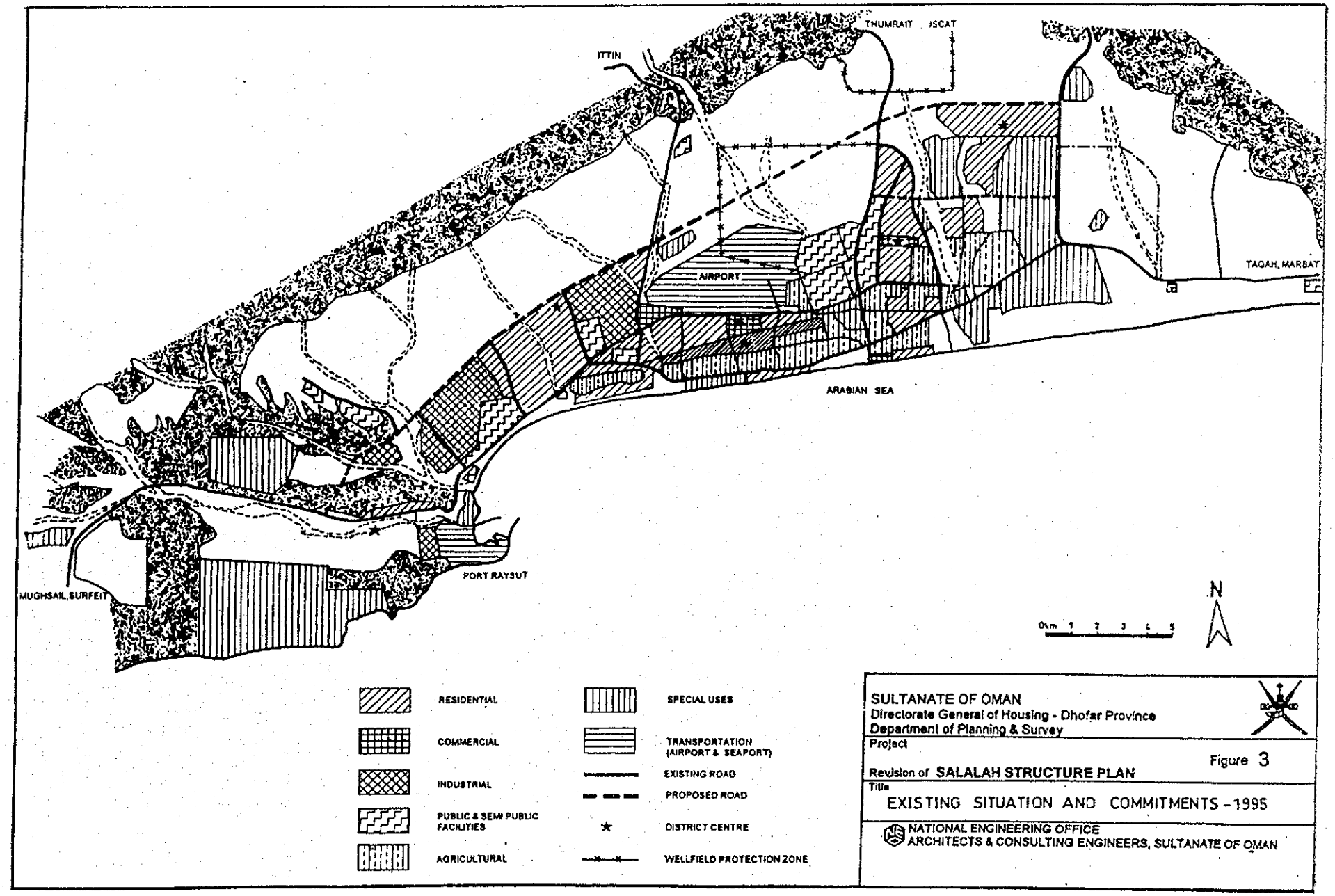


Figure 18.5.1 Existing Situation and Commitments (1995)

b) Problems and Constraints

Ten (10) of major problems and constraints related development related to utilize land are pointed out by the Salalah Structure Plan (1998). These are summarized as follows.

(i) Access means and routes are quite limited since its locality separated from major centers of Oman.

(ii) An existence of an additional seasonal / varying demand on the urban infrastructure.

(iii) An existence of mono-centric development, etc. causes inefficient and uneconomic pattern of urban development.

(iv) An existence of very slow rate of development. The infill capacity is as much as 35 to 50 %.

(v) An existence of high dependencies on expatriate workforce due to Omani's population and educational status.

(vi) An existence of very low sustainability of commercial development.

(vii) An existence of under-utilized or misutilized land use for industry.

(viii) Insufficient to none development of infrastructure such as drinking water and sewage system as well as distinct hierarchy of roads in the town.

c) Existing Potentials

Seven (7) of major potentials of existing development related to land use are summarized by the Salalah Structure Plan (1998). These are summarized as follows.

(i) Concentration of the administrative and service functions in Salalah due to its locality generates significant employment and attracts investments.

(ii) Currently committing large scale capital-intensive projects such as Salalah Port expansion, Raysut Industrial Estate expansion, and sewage treatment plant and network construction, etc. will improve the infrastructual provision and support economic growth.

(iii) Omanisation process will create an opportunity of employment for the local workforce.

(iv) Systematic provision of tourist facilities can strengthen the potential and establish tourism as an important economic sector.

(v) Implementation of improvement of road sector near future such as dualization and improvement of various roads, design and construction of by-pass and/or internal roads, etc.

(vi) Natural environment element will be suitably protected by regulations.

(c) Zoning Regulations and Land Use

a) Existing Regulation and Problem

(i) Planning Standards in the Oman

Available standard facilitating buffers zones between residential and industrial areas is the planning standards used in the Oman: a residential location should be at least 1.5 km from any mineral extraction activities.

(ii) Administrative Concern

MOTH (2000) recommended that buffer zones are a must between these two lands uses depending on the level of industrial activities.

2) Future Planning

(a) Proposed Plan

The Salalah Structure Plan (1995 - 2015) proposed the final structure plan as final target year of 2015. This plan has adapted existing development plan in Salalah to change its trends to be more diversified one.

Eighteen (18) of features are described their Plan, and some of their features related to the Study are listed as follows.

a) Total area available for urban development is about 650 ha, in which, about 5,000 residential plots or 30,000 populations can be accommodated.
b) No residential development has been proposed within a distance of 3 km from the Raysut Industrial Estate.
c) In the western part of Raysut, about 400 ha of land could be available for urban development which can accommodate about 3,200 residential plot or about 20,000 population.
d) Area of north-west of Raysut Industrial Estate has been reserved for heavy/hazardous industrial development.
e) Area west of Salalah Port has been reserved for port related industrial/commercial/residential/other uses.
f) It is recommended that low intensity, higher level public & semi-public uses shall be developed in the designated environmental areas along the sea-coast, east of Razat farm.

This plan will be implemented in four (4) phases that has five (5) year planning system for each period starting form 1996. The First (1996-2000) and Second (2001-2005) phases are assigned for developing economic and infrastructural sectors including on-going project. The Third (2006-2010) and Fourth (2011-2015) phases are assigned for implementation of capital intensive projects stimulating export oriented commercial and industrial activities.

(d) Proposed Land Use

Based on the above planning scheme, the land use composition in year 2015 was proposed as shown in Table 18.5.2 and Fig. 18,5.2, respectively. These are gross land areas which include local facilities and services, local open spaces and local circulation; moreover, these also include the existing as well as committed areas in the base year (1995).

Table 18.5.2 Proposed Land Use Composition (2015)

No.	Land Use Category Designation	Gross Area (ha)	Share in % of sub total (A)
A1	Residential	5,722.60	18.20
A2	Residential – Agricultural	1,102.20	03.50
A3	Commercial	650.80	02.10
A4	Industrial	3,053.40	09.70
A5	Public & Semi-Public Facilities	2,383.00	07.60
A6	Open Spaces	129.40	00.40
A7	Special Uses	5,168.60	16.40
A8	Agricultural	1,056.70	03.40
A9	Transportation	6,461.00	20.60
A10	Environmental	5,072.30	18.10
A	***Sub total***	***31,430.00***	***100.00 50.65 %of E***
B	**Rural Settlements**	**2,435.10**	**0.390% of E**
C	**Long Term Reserve for Residential**	**1,941.80**	**0.315% of E**
D	**Vacant Developable and Undevelopable**	**26,243.10**	**42.30% of E**
E	***GRAND TOTAL***	***62,050.00***	***100.00***

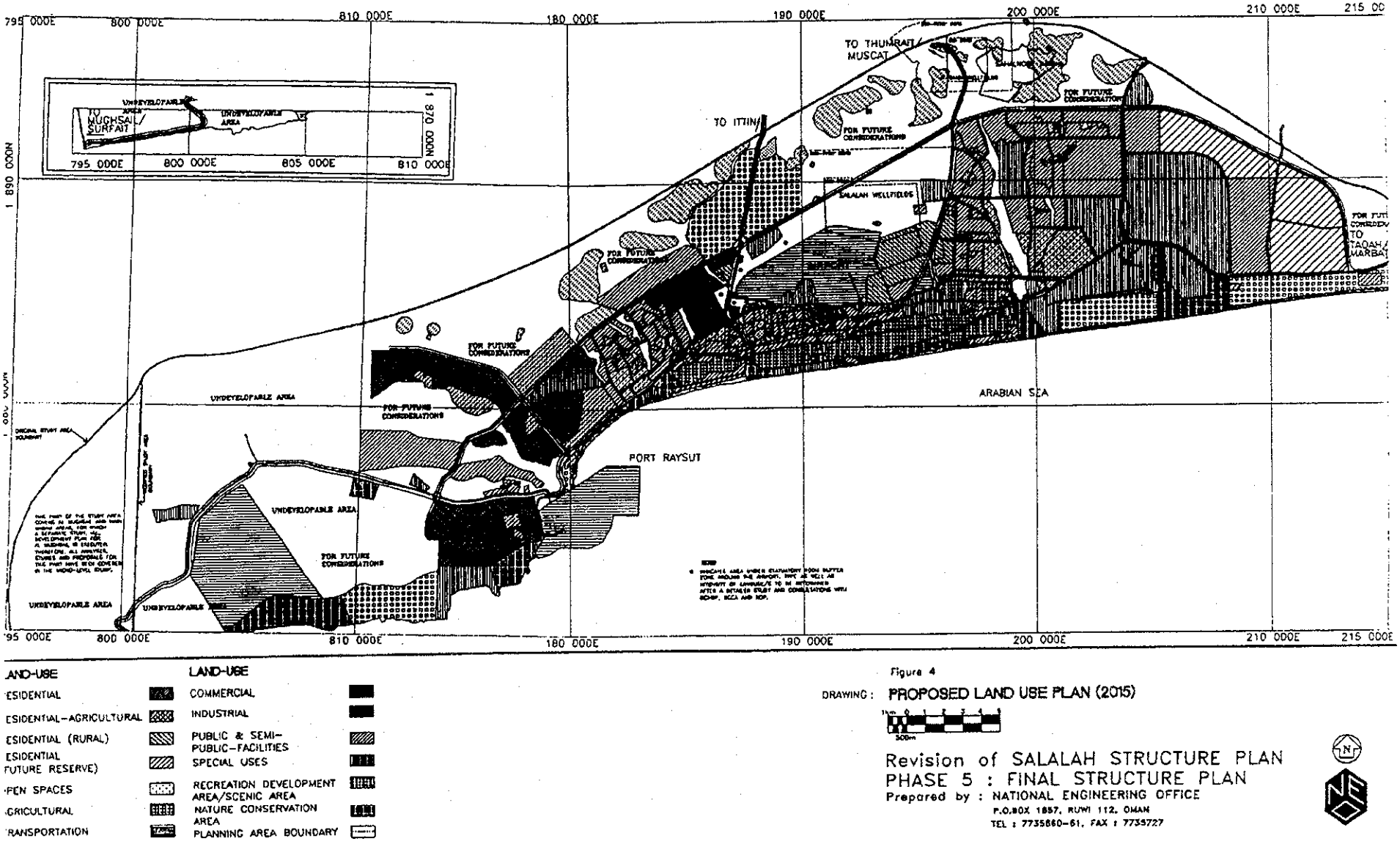


Figure 18.5.2 Final Structure Plan

(2) Waste Management

1) Solid Waste

The collection, transportation, and disposal of solid waste in the Study Area are the responsibility of Dhofar Municipality. The following descriptions are the main components of the present solid waste management system in Salalah described in the Salalah Structure Plan and a current data of year 1999 obtained by the Study.

(a) Present Situation

a) Type

Generating solid wastes are classified into the following five (5) categories:

(i) Domestic waste
(ii) Commercial waste
(iii) Industrial waste
(iv) Agricultural waste
(v) Other waste

b) Quantity

(i) Available Data and Trends

The details on composition solid waste and describing trends of quantity are not available at present.

(ii) Annual Amount in 1995

A year 1995, the quantity of collected solid waste was about 154,000 tones according to the report of the Salalah Structure Plan (1998).

(iii) Amount for each Solid Wastes collected in 1999

There is only one data obtained by the Study. Based on this, the collected solid wastes at Salalah in the year of 1999 were as follows.

i) Household waste: 8,588 tones
ii) Industrial waste: 7,412 tones
iii) Agricultural waste: 8,874 tones
iv) Construction waste: 55,699 tones
v) From slaughter house: 9,310 tones
vi) Mud with materials: 1,125 tones
vii) Dead animal: 2,000 tones
viii) Heavy-duty scrap (aluminum): *recycled and ship to Dubai*

c) Collection System

Current collection system of solid wastes are classified into the following three (3) levels:

(i) Level-1: Primary Collection

The garbage is put into a polythene bags or some other suitable means and is collected by the designated municipal staff at various parts/specific uses.

(ii) Level-2: Secondary Collection

The garbage is collected in the garbage bins, trolley containers, drums, or other equipments placed by the municipality at various locations about 3,500 (capacity: 7 / 3.3 / 1.5 m^3) such bins in the entire Salalah.

(iii) Level-3: Tertiary Collection

The garbage is collected by the municipal trucks. The municipal presently has 49 such trucks, and the collection by these trucks is normally daily or weekly depending on the area of need and amount. Average trips per vehicle per day are generally twice (2).

d) Disposal Site

(i) Location

All collected garbage is transported to the disposal site at Wadi Qaftawt that is located about 8 km northwest of Salalah. Fig. 18.5.3 shows the location of the dumping site.

(ii) Type and its Capacity

The site was opened in 1987 as a landfill type dumping site for solid waste which has a capacity of 26 ha and sufficient to use up to next 25 years.

(iii) Status of Disposal Conditions

i) No segregation and separate collection except metal scrap, organic waste, oil and grease, automobile tubes and tires.

ii) No separation of hazardous and toxic wastes that is a current concern for MRME in the Study Area.

iii) No mechanism of recycling: only aluminum waste is purchased and exported to U.A.E.

iv) No mechanism of incineration

The conditions of dumping sites described above are shown in Fig. 18.5.4.

e) Standards for Collection and Disposal

The Physical Planning Standards for the Sultanate of Oman was base for the standards for solid waste generation, collection and disposal described as follows.

(i) Average per capita solid waste generation is taken as 1.60 kg/day considering domestic and non-domestic sources.

(ii) A residential area is served as a place for collection bin, and its peak factor is to be 1.25.

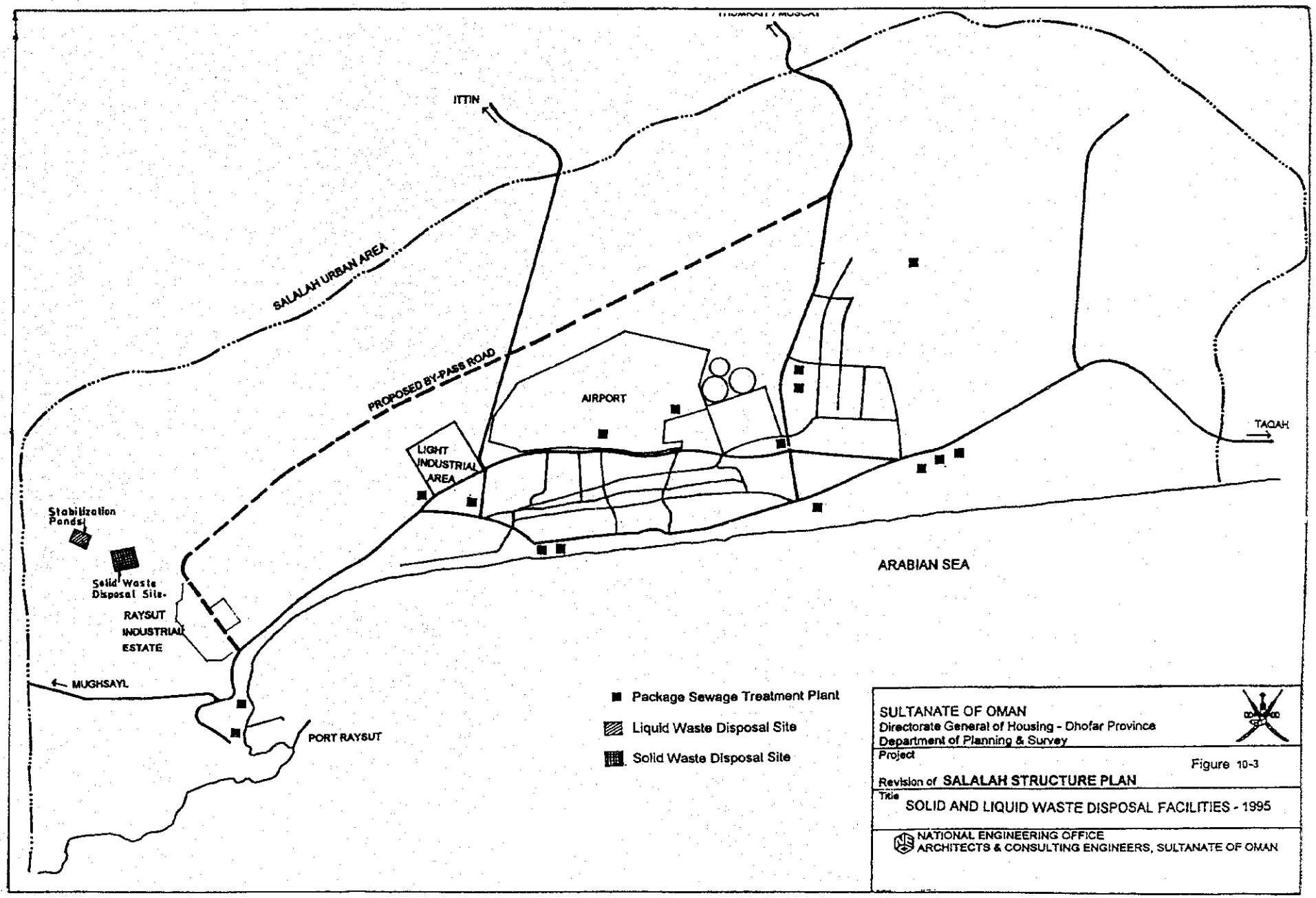
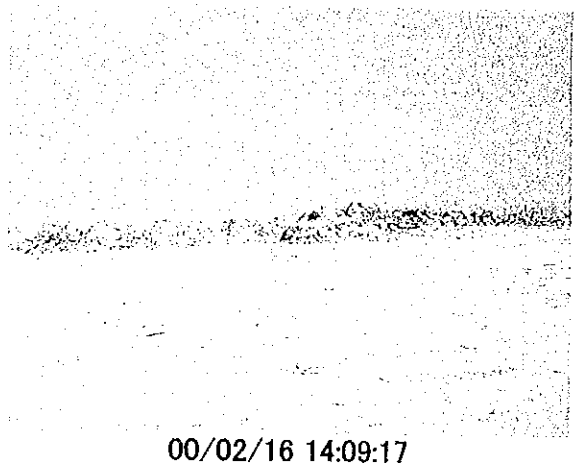


Figure 18.5.3 Location on the Waste Dumping Site



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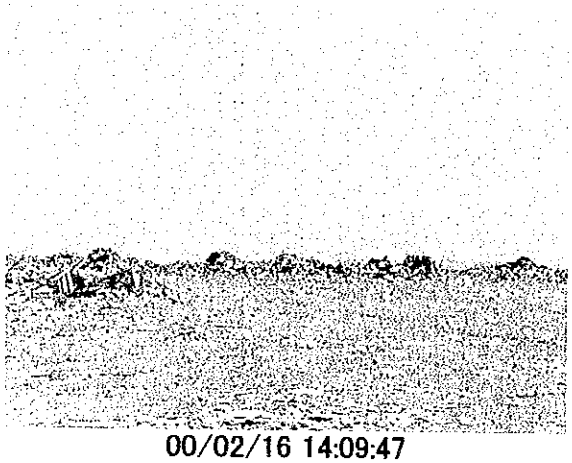

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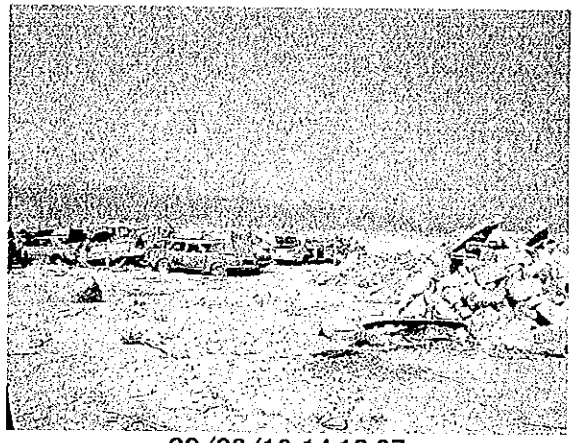

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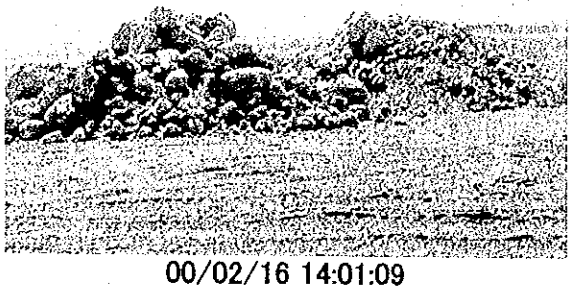
Figure 18.5.4 Conditions on Dumping Site(1/2)
(Site Visit in February 2000)



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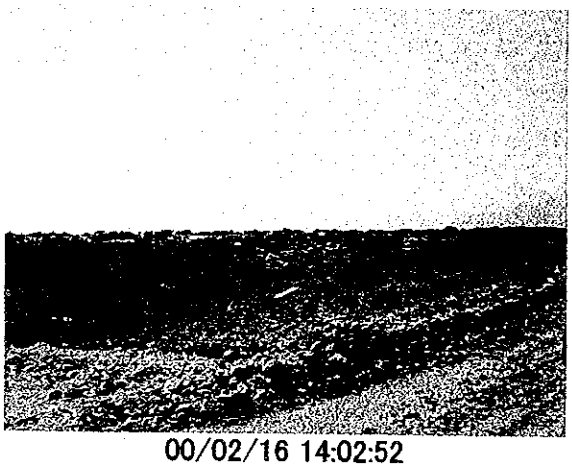

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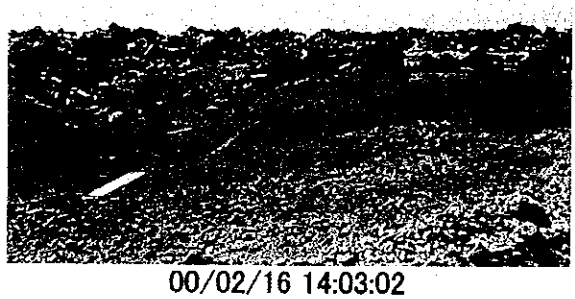

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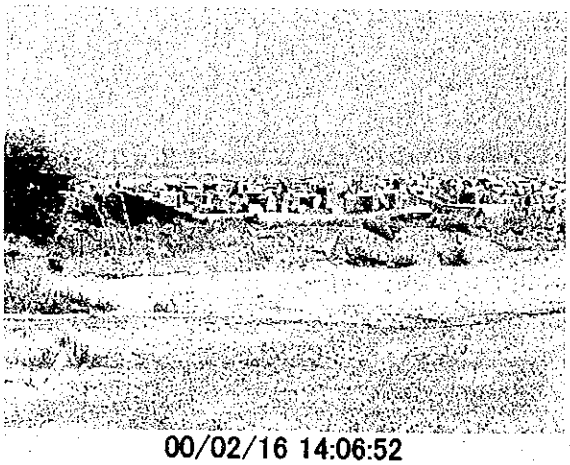

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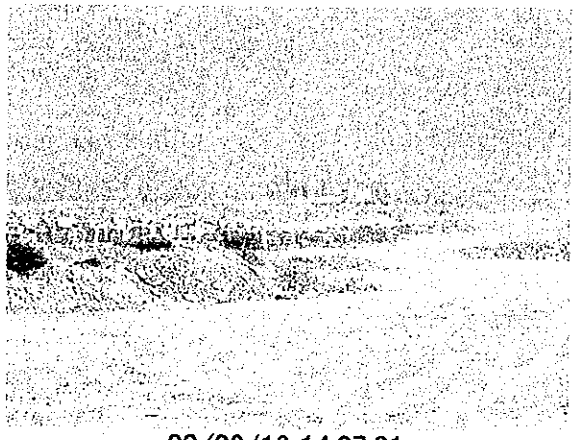

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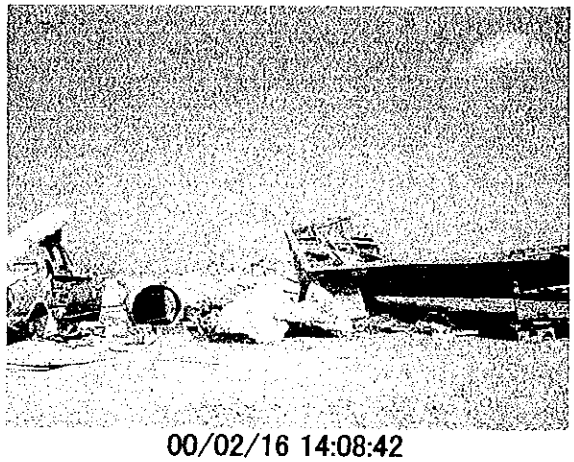

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Figure 18.5.4 (2/2)

(b) Proposed Solid Waste Management System

a) Expecting Situation

Based on the assumption of the future expansion of Salalah by the developing plan of the Salalah Structure Plan, a solid waste generation in the entire Salalah is estimated to reach nearly 400 tones per day.

b) Recommending Policies and Proposed Project

The Salalah Structure Plan proposed the following policies and recommendations to the solid waste management in future Salalah.

(i) Strengthen the resources of waste management system to meet the future requirements such as increasing in number of collection bins, trucks, frequencies, etc.

(ii) Facilitating an appropriate mechanism for hospital and industrial wastes.

(iii) Adopting the process of waste segregation and compaction at the disposal site.

(iv) Implementation on comprehensive study on solid waste management.

(v) Launching a campaign to draw public awareness to encourage public participation effectively.

2) Waste Water

(a) Present Situation

a) Volume

In 1995, the generation of sewage in the entire Salalah was estimated based on the Water and Waste Water Master Plan (WWWMP, 1992) findings. This is calculated by the Salalah Structure Plan Study and is the base of the wastewater treatment of Salalah, currently committing program. Table 18.5.3 shows the estimated generation of sewage in 1995.

Table 18.5.3 Sewage Generation in 1995

SL No.	Source	Water Consumption (Million l/day)	% Wastewater Generated (Million l/day)	Total Wastewater Generated (Million l/day)
1.	**Government** (including government/ institutional)	11.27	60	*6.76*
2	**Private** (including domestic/commercial/ industrial)	8.14	85	*6.92*
	TOTAL	**19.41**	-	*13.68*

b) Treatment System

(i) Existing Facility

Salalah has not been covered by a municipal sewage system yet. Current sewage facilities are domestic sewage, package sewage treatment plants, and sewage stabilization ponds. Fig. 18.5.3 shows the locations of existing facilities.

(ii) Status

i) Domestic waste water is discharged to holding tanks, soak pits, and cement block or perforated concrete tanks which could seepage through the ground.

ii) Septage and waste water from the holding tanks and other sources are collected by tankers and transported to the Raysut Septage Stabilization Pond Site which is located about 8 km northwest of Raysut Industrial Estate Area.

iii) The stabilization pond has designed to treat up 1,500 m^3/day, and its operation is almost full to slightly over the design flow. Presently proposing the rehabilitation and upgrading its facility to treat in maximum design flow of 4,000 m^3/day. The present facility includes anaerobic ponds, facultative ponds, and maturation pond with chlorinated treatment for effluent. This effluent is discharged form the facility but only 3 km of the discharging point it percolates to the ground.

iv) Capacity of wastewater transportation is about 600 m^3 combined with around 60 suction / haulage tankers belonging to municipal and other government and private companies. Maximum daily haulage is about 1,200 m^3 by doubling the trucks trip per day.

v) Treat wastewater at this track haulage and the stabilization pond only deal with about 9 to 13 % of total domestic wastewater in Salalah.

vi) Other treatment plants are 16 package sewage treatment plants that serve only for government establishments. The total capacity is about 2,240 m^3 day and has aeration and chlorination of effluent facility mostly. The effluent is soaked into soak-away or reused for landscaping irrigation, partly.

vii) Regular monitoring has been carried out onto the most of plants stated above by MRME, and mostly operated well, except governmental hospital presently inoperative its facility.

c) Commitments

(i) As recommendations in WWWP, Dhofar Municipality has commenced implementation of a sewage treatment plant at Wadi Daha site, which has 43 ha and will be 40 million litters per day design flow capacity in year 2020.

(ii) Presently this plan has already completed its construction with its design flow in 20,000 litters per day in 1998 and being waiting its full operation in July 2001 after the completion of construction for the first phase sewage network system in Salalah.

(b) Proposed Sewerage Network

a) Expecting Situation

The estimated sewage generation by WWMP in the year 2015 is 50.50 Million litters per days, which is about 75% of the total estimated water consumption in the year 2015 by the Salalah Structure Plan.

b) Recommending Policies and Proposed Project

The Salalah Structure Plan proposed the following recommendations.

(i) Sewage Collection and Conveyance System

Two types of systems are proposed: "Central wastewater system" and "Wadi Qaftawt sewage system". Central system of Wadi Daha plant will collect domestic and commercial wastewater, while the Wadi Qaftawt system will collect trucked and industrial liquid wastes.

(ii) Installation of Septic Tank Effluent Drains (STED)

This is a temporal measure for low population pressure area and used until it is significantly developed.

(iii) Fully operational all planned entire sewage system in year 2015 is recommended in accordance with the projected population growth by the Salalah Structure Plan.

(iv) Adoption on the wastewater and management on the following aspects are recommended.

i) Management of Industrial waste
ii) Wastewater reclamation
iii) Sludge management
iv) Effluent disposal
v) Other special design provision such as environment protection, public health issues, etc.
vi) Strengthened existing haulage system to cater to 80% of daily load.

19. Descriptions of the Environmental Conditions

19.1 Water Quality

19.1.1 Existing Data and Standards

There are no available data archives describing details on water quality, and also there are no standard and/or index of water quality for coastal region to evaluate present conditions as well as predicting water quality in the Study Area for future expansion of Port as well as its hinterland.

Regarding the present situation as described above, the following survey scheme was planned.

(1) For acquisition of baseline data to evaluate water quality of the Study Area, the following two (2) criteria for water sampling were selected. These are normally used in Japan routinely for water quality survey for water quality conservation.

Table 19.1.1 Water Quality Sampling Items

	Items of Observations
1	Temperature
2	Color
3	Electrical Conductivity
4	PH
5	Oxygen
6	Transparency
7	Depth

	Items of Laboratory Test
1	PH
2	Coriform group
3	Fecal coriform group
4	Surface active agent
5	Oil (Hexan Extracts)
6	Phenol
7	Oxygen
8	Oil (Total)
9	Suspended solids
10	Copper (Cu)
11	Cadmium (Cd)
12	Lead (Pb)
13	Chromium (Cr)
14	Nickel (Ni)
15	Zinc (Zn)
16	Iron (Fe)
17	Total Mercury
18	Manganese (Mn)
19	Fluoride (F)

Table 19.1.2 Pollution Load

	Items of Observations
1	Temperature
2	Color
3	Electrical Conductivity
4	PH
5	Oxygen
6	Depth
7	COD (Cr / Mn)
8	T-Nitrogen
9	T-Phosphate

	Items of Laboratory Test
1	PH
2	Coriform group
3	Fecal coriform group
4	Oxygen
5	Suspended solids

(2) Predictive models of current circulation and water pollution were constructed based on the results of a 15 days long term current mooring and the water sampling results. For evaluating water pollution by the modeling in the Study Area, one of index of water quality was selected: COD. By referring COD, the prediction of water quality in the Study Area was conducted.

19.1.2 Implemented Survey Scheme

(1) Sampling Time

The water sampling was conducted twice on the following seasons:

1) NE monsoon season: February 4th and 5th, 2000
2) SW monsoon season: June 12th and 13th, 2000

(2) Sampling Location

The water sampling was conducted at the following five (5) sampling points as shown in Table 19.1.3 and shown in Figure 19.1.1, respectively.

Table 19.1.3 Position of Water Sampling

(Datum: WGS 84)

Location	Latitude (N)	Longitude (E)
P1	16° 55' 19.2"	54° 00' 12.0"
P2	16° 55' 26.8"	54° 04' 05.9"
P3	16° 58' 44.2"	54° 03' 51.5"
P4	16° 57' 49.0"	54° 00' 54.1"
P5A	16° 56' 48.0"	54° 00' 53.0"

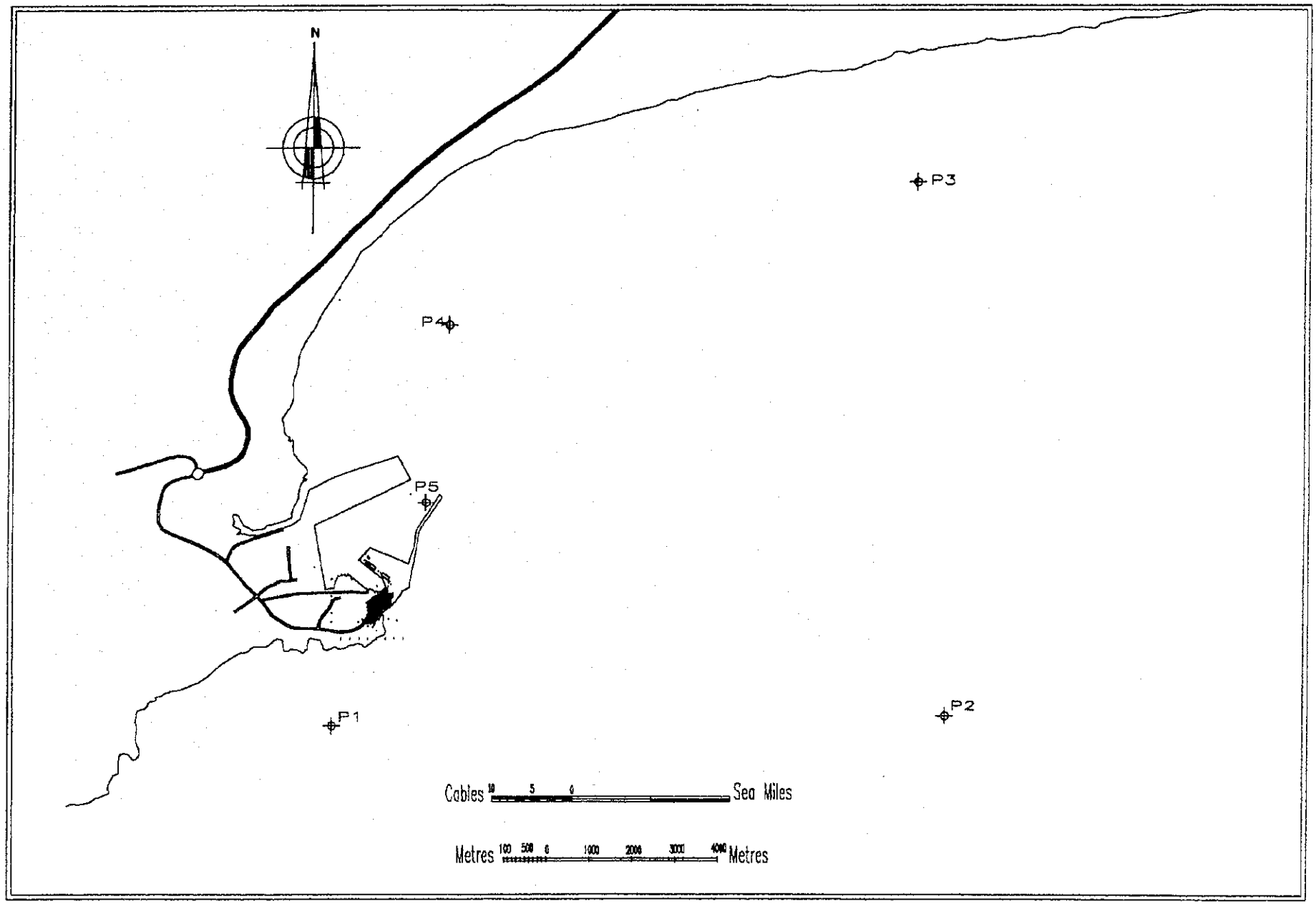

Figure 19.1.1 Sampling Points Locations

The purpose for locating each sampling stations P1 through P5A are as follows.

1) The stations P1 and P2 were designed to monitor a relative deepwater where influence of offshore water and current to the Study Area were expected.
2) P3 and P4 were placed in shallow water where influence of coastal ocean climate was expected.
3) P4 was just adjacent to the future Port expansion planning area that would expect good monitoring results evaluating the influence before and after the port expansion.
4) P5A was located at near the existing Port entrance expecting influence of present port activities.

(3) Sampling Method

Samples were obtained at the following layers per location:

1) 0.5 meters below the sea surface
2) 10 meters below the sea surface

Where the depth was shallower than 10 meters, the sample was collected one (1) meter above the seabed

The recovered samples were transported to lab for analysis with carefully controlled the ambient to keep the sample in good conditions.

19.1.3 Survey Results

(1) Sampling and Sample Analysis Results

1) Table 19.1.4 and Table 19.1.5 show the results of water sampling and sample analysis for NE monsoon season.
2) Table 19.1.6 shows the results of water sampling and sample analysis for SW monsoon season.

(2) Discussion on the Results

1) General
   (a) No Inflowing Effluent from Coast
   As described in Chapter 18, there is no river runoff, and only dry "wadis" are recognized along the coast; therefore, it is estimated that almost no source of pollution that brings effluent of domestic, industrial, livestock, and agro-origin that may impact the marine environment, normally.

Table 19.1.4 Water Qulaity in NE Monsoon (Flood Tide)

WATER QUALITY SAMPLING

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	Temperature	°C	CTD profiler SBE 19	23.29	23.2	23.34	23.23	23.48	23.24	23.29	23.11	23.45	23.23
2	Color	Pt Co	HACH	3	4	2	2	4	2	3	3	4	6
3	Salinity	‰	CTD profiler SBE 19	39.15	39.21	39.16	39.14	39.09	39.07	39.15	39.18	39.15	39.07
4	pH		CTD profiler SBE 19	8.168	8.13	8.017	8.022	8.169	8.179	8.165	8.179	8.168	8.174
5	DO	Mg/lt	CTD profiler SBE 19	4.02	4.61	4.08	4.17	4.02	4.42	4.18	4.34	4.02	4.35
6	Transparency	m	Secchi's disk	5	5	9	9	8	8	8	8	4	4
7	Depth	m	Echosounder	26.5	26.5	35.5	35.5	13.5	13.5	9.9	9.9	16.7	16.7

RESULTS OF LABORATORY TEST

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	pH		pH meter	7.92	7.90	7.94	7.99	8.00	7.98	8.00	7.96	8.01	8.00
2	Coliform group		AWWA	8	Absent	Absent	Absent	Positive	Positive	Absent	Absent	Absent	Positive
3	Fecal coriform group		AWWA	1	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Positive
4	Surface active agent		AWWA	0.04	0.05	0.07	0.04	0.05	0.04	0.06	0.07	0.06	0.04
5	Oil (Hexan Extracts)	mg/L	AWWA 5520 D	8	5	8	10	5	7	8	3	2	4
6	Phenol	mg/L	HACH Calonmeter	0.04	0.07	0.08	0.06	0.04	0.03	0.03	0.05	0.05	0.06
7	Oxygen	mg/L	AWWA 4500 -°C	8.8	8.7	8.6	8.7	8.6	8.5	8.6	8.8	8.6	8.3
8	Oil (Total)	mg/L	2530 C	10	8	14	14	11	13	13	9	5	9
9	Suspended solids	mg/L	HACH	1	2	1	1	3	2	1	1	1	2
10	Copper (Cu)	mg/L	AA	0.09	0.071	0.076	0.077	0.058	0.069	0.084	0.097	0.091	0.081
11	Cadmium (Cd)	mg/L	AA	0.064	0.050	0.058	0.059	0.052	0.060	0.074	0.070	0.042	0.044
12	Lead (Pb)	mg/L	AA	0.44	0.56	0.33	0.30	0.25	0.40	0.51	0.43	0.34	0.45
13	Chromium (Cr)	mg/L	AA	0.063	0.049	0.083	0.094	0.082	0.080	0.045	0.048	0.037	0.050
14	Nickel (Ni)	mg/L	AA	0.55	0.73	0.57	0.59	0.549	0.567	0.385	0.263	0.177	0.256
15	Zinc (Zn)	mg/L	AA	0.049	0.061	0.034	0.042	0.049	0.051	0.056	0.062	0.063	0.098
16	Iron (Fe)	mg/L	AA	0.21	0.21	0.20	0.18	0.19	0.22	0.23	0.18	0.31	0.25
17	Total Mercury	mg/L	AA	0.010	0.024	0.061	0.019	0.025	0.057	0.018	0.004	0.004	0.006
18	Manganese (Mn)	mg/L	AA	0.040	0.040	0.050	0.040	0.040	0.040	0.040	0.050	0.060	0.070
19	Fluoride (F)	mg/L	HACH	1.32	1.35	1.35	1.27	1.30	1.79	1.33	1.29	1.28	1.43

POLLUTION LOAD

ITEMS OF OBSERVATIONS

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	Temperature (°C)	°C	CTD profiler SBE 19	23.29	23.2	23.34	23.23	23.48	23.24	23.29	23.11	23.45	23.23
2	Color	Pt Co	HACH	3	4	2	2	4	2	3	3	4	6
3	Salinity	‰	CTD profiler SBE 19	39.15	39.21	39.16	39.14	39.09	39.07	39.15	39.18	39.15	39.07
4	pH		CTD profiler SBE 19	8.168	8.13	8.017	8.022	8.169	8.179	8.165	8.179	8.168	8.174
5	Oxygen	Mg/lt	CTD profiler SBE 19	4.02	4.61	4.08	4.17	4.02	4.42	4.18	4.34	4.02	4.35
6	Depth	m	Echosounder	26.5	26.5	35.5	35.5	13.5	13.5	9.9	9.9	16.7	16.7
7	COD	mg/L	AWWA 5220 -B	52	48	60	52	52	56	56	56	52	56
8	T-Nitrogen	mg/L	4500 N-B	0.86	0.55	0.82	0.86	0.36	0.52	0.72	0.58	0.56	0.76
9	T-Phosphate	mg/L	4500 P-C	0.05	0.04	0.04	0.06	0.06	0.06	0.06	0.05	0.04	0.06

RESULTS OF LABORATORY TEST

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	pH		pH meter	7.92	7.90	7.94	7.99	8.00	7.98	8.00	7.96	8.01	8.00
2	Coliform group		AWWA	8	Absent	Absent	Absent	Positive	Positive	Absent	Absent	Absent	Positive
3	Fecal coriform group		AWWA	1	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Positive
4	Oxygen	mg/L	AWWA 4500 -°C	8.8	8.7	8.6	8.7	8.6	8.5	8.6	8.8	8.6	8.3
5	Suspended solids	mg/L	HACH	1	2	1	1	3	2	1	1	1	2

Table 19.1.5 Water Quality in NE Monsoon (Ebb Tide)

WATER QUALITY SAMPLING

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	Temperature (°C)	°C	CTD profiler SBE 19	23.48	23.4	23.48	23.39	23.41	23.3	23.60	23.6	23.48	23.16
2	Color	Pt Co	HACH	2	2	3	3	3	2	4	2	2	4
3	Salinity	‰	CTD profiler SBE 19	39.19	39.21	39.17	39.16	39.17	39.18	39.21	39.23	39.24	39.28
4	pH		CTD profiler SBE 19	8.146	8.14	8.150	8.15	8.068	8.086	8.094	8.10	8.113	8.036
5	DO	Mg/lt	CTD profiler SBE 19	4.43	4.62	4.47	4.52	4.29	4.37	4.47	4.46	4.29	4.25
6	Transparency	m	Secchi's disk	6	6	9	9	8	8	8	8	4	4
7	Depth	m	Echosounder	26.3	26.3	35.9	35.9	13.9	13.9	8.8	8.8	16.9	16.9

RESULTS OF LABORATORY TEST

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	pH		pH meter	7.91	7.92	7.94	7.98	7.99	8.01	8.01	8.00	7.98	7.30
2	Coliform group		AWWA	Absent	Absent	Absent	Absent	Absent	Positive	Absent	Absent	Absent	Positive
3	Fecal coriform group		AWWA	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
4	Surface active agent		AWWA	0.04	0.04	0.05	0.07	0.08	0.06	0.08	0.08	0.06	0.06
5	Oil (Hexan Extracts)	mg/L	AWWA 5520 D	7	7	6	12	2	5	6	4	1	6
6	Phenol	mg/L	HACH Calorimeter	0.09	0.05	0.07	0.06	0.06	0.03	0.04	0.08	0.05	0.062
7	Oxygen	mg/L	AWWA 4500 -°C	8.8	8.9	8.5	8.8	8.8	8.5	8.8	8.8	8.5	8.5
8	Oil (Total)	mg/L	2530 C	10	12	8	15	5	12	12	11	5	16
9	Suspended solids	mg/L	HACH	1	2	1	2	1	2	1	2	3	3
10	Copper (Cu)	mg/L	AA	0.08	0.076	0.077	0.054	0.053	0.040	0.089	0.097	0.121	0.092
11	Cadmium (Cd)	mg/L	AA	0.065	0.068	0.053	0.041	0.043	0.050	0.065	0.053	0.069	0.050
12	Lead (Pb)	mg/L	AA	0.59	0.57	0.60	0.43	0.74	0.60	0.35	0.40	0.53	0.41
13	Chromium (Cr)	mg/L	AA	0.052	0.096	0.079	0.084	0.051	0.069	0.030	0.045	0.033	0.050
14	Nickel (Ni)	mg/L	AA	0.71	0.44	0.51	0.48	0.543	0.523	0.327	0.220	0.213	0.296
15	Zinc (Zn)	mg/L	AA	0.044	0.037	0.032	0.034	0.028	0.068	0.057	0.037	0.052	0.126
16	Iron (Fe)	mg/L	AA	0.25	0.21	0.18	0.26	0.18	0.16	0.22	0.25	0.24	0.24
17	Total Mercury	mg/L	AA	0.060	0.026	0.022	0.031	0.035	0.032	0.008	0.008	0.004	0.018
18	Manganese (Mn)	mg/L	AA	0.030	0.050	0.040	0.050	0.040	0.050	0.040	0.050	0.070	0.090
19	Fluoride (F)	mg/L	HACH	1.33	1.31	1.37	1.18	1.15	1.69	1.20	1.02	1.30	1.31

POLLUTION LOAD

ITEMS OF OBSERVATIONS

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	Temperature (°C)	°C	CTD profiler SBE 19	23.48	23.4	23.48	23.39	23.41	23.3	23.60	23.6	23.48	23.16
2	Color	Pt Co	HACH	2	2	3	3	3	2	4	2	2	4
3	Salinity	‰	CTD profiler SBE 19	39.19	39.21	39.17	39.16	39.17	39.18	39.21	39.23	39.24	39.28
4	pH		CTD profiler SBE 19	8.146	8.14	8.150	8.15	8.068	8.086	8.094	8.10	8.113	8.036
5	Oxigen	Mg/lt	CTD profiler SBE 19	4.43	4.62	4.47	4.52	4.29	4.37	4.47	4.46	4.29	4.25
6	Depth	m	Echosounder	-	-	-	-	-	-	-	-	-	-
7	COD	mg/L	AWWA 5220 -B	52	56	52	60	48	56	60	52	52	60
8	T-Nitrogen	mg/L	4500 N-B	0.86	0.58	0.88	0.88	0.42	0.68	0.76	0.62	0.76	0.58
9	T-Phosphate	mg/L	4500 P-C	0.03	0.04	0.06	0.06	0.08	0.08	0.05	0.08	0.10	0.05

RESULTS OF LABORATORY TEST

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	pH		pH meter	7.91	7.92	7.94	7.98	7.79	8.01	8.01	8.00	7.98	7.30
2	Coliform group		AWWA	Absent	Absent	Absent	Absent	Absent	Positive	Absent	Absent	Absent	Positive
3	Fecal coriform group		AWWA	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
4	Oxygen	mg/L	AWWA 4500 -°C	8.8	8.9	8.5	8.8	8.8	8.5	8.8	8.8	8.5	8.5
5	Suspended solids	mg/L	HACH	1	2	1	2	1	2	1	2	3	3

Table 19.1.6 Water Quality in SW Monsoon

WATER QUALITY SAMPLING

ITEMS OF OBSERVATIONS

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	Temperature (℃)	℃	Digital Thermometer	24	24	24	24	24	24	24	24	24	24
2	Color	ptCo	HACH	5	2	1	3	6	3	6	2	4	4
3	Salinity	‰	AWWA 5220 A	38.6	36.5	39.5	34.2	40.0	35.6	40.7	34.0	34.8	39.2
4	pH		pH meter	7.9	8.0	7.9	7.9	7.8	7.8	7.9	7.7	7.8	7.8
5	Oxygen		AWWA 4500-℃	8.9	8.8	8.9	8.9	8.9	8.8	8.7	8.8	8.8	8.9
6	Transparency		HACH	-	-	-	-	-	-	-	-	-	-
7	Depth		-	-	-	-	-	-	-	-	-	-	-

RESULTS OF LABORATORY TEST

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	pH		pH meter	7.90	8.00	7.90	7.92	7.90	7.80	7.90	7.70	7.80	7.80
2	Coliform group		AWWA	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
3	Fecal coriform group		AWWA	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
4	Surface active agent		AWWA	0.01	0.01	0.02	0.02	<0.01	<0.01	0.03	0.02	0.02	0.02
5	Oil (Hexan Extracts)	mg/L	AWWA 5520D	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
6	Phenol	mg/L	HACH Calorimeter	0.01	<0.01	0.02	0.02	0.01	<0.01	0.03	0.01	<0.01	<0.01
7	Oxygen	mg/L	AWWA 4500-℃	8.9	8.8	8.9	8.9	8.7	8.8	8.7	8.8	8.9	8.8
8	Oil (Total)	mg/L	2530C	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
9	Suspended solids	mg/L	HACH	4	2	2	1	6	4	6	2	4	4
10	Copper (Cu)	mg/L	AA	0.07	0.06	0.04	0.06	0.06	0.05	0.06	0.04	0.05	0.03
11	Cadmium (Cd)	mg/L	AA	0.050	0.080	0.080	0.090	0.070	0.090	0.080	0.070	0.090	0.080
12	Lead (Pb)	mg/L	AA	0.33	0.40	0.48	0.49	0.52	0.51	0.46	0.42	0.43	0.49
13	Chromium (Cr)	mg/L	AA	0.070	0.050	0.040	0.030	0.040	0.030	0.050	0.040	0.020	0.060
14	Nickel (Ni)	mg/L	AA	0.61	0.48	0.45	0.45	0.45	0.45	0.44	0.41	0.47	0.47
15	Zinc (Zn)	mg/L	AA	0.070	0.060	0.050	0.050	0.050	0.100	0.050	0.050	0.050	0.050
16	Iron (Fe)	mg/L	AA	0.30	0.20	0.24	0.24	0.23	0.25	0.21	0.17	0.22	0.19
17	Total Mercury	mg/L	AA	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001
18	Manganese (Mn)	mg/L	AA	0.010	0.040	0.040	0.040	0.040	0.050	0.050	0.030	0.040	0.040
19	Fluoride (F)	mg/L	HACH	1.08	1.01	0.96	0.98	1.12	1.01	1.21	0.96	0.97	0.92

POLLUTION LOAD

ITEMS OF OBSERVATIONS

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	Temperature (℃)	℃	Digital Thermometer	24	24	24	24	24	24	24	24	24	24
2	Color	ptCo	HACH	5	2	1	3	6	3	6	2	4	4
3	Electrical Conductivity	mS/cm	AWWA 5220 A	56.70	54.00	57.90	50.93	68.45	52.83	69.47	50.67	51.82	57.53
4	pH		pH meter	7.90	8.00	7.90	7.90	7.80	7.80	7.90	7.70	7.80	7.80
5	Oxygen		AWWA 4500-℃	8.9	8.8	8.9	8.9	8.9	8.8	8.7	8.8	8.8	8.9
6	Depth		-	-	-	-	-	-	-	-	-	-	-
7	COD	mg/L	AWWA 5220 -B	32	32	40	36	32	32	48	44	32	40
8	T-Nitrogen	mg/L	4500 N-B	0.10	0.11	0.18	0.15	0.17	0.14	0.28	0.18	0.15	0.21
9	T-Phosphate	mg/L	4500 P-C	0.10	0.08	0.07	0.08	0.08	0.10	0.11	0.09	0.10	0.12

RESULTS OF LABORATORY TEST

ITEMS	Test		METHOD	P1/0.5m	P1/10m	P2/0.5m	P2/10m	P3/0.5m	P3/10m	P4/0.5m	P4/10m	P5/0.5m	P5/10m
1	pH		pH meter	7.90	8.00	7.90	7.90	7.80	7.80	7.90	7.70	7.80	7.80
2	Coliform group		AWWA	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
3	Fecal coriform group		AWWA	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
4	Oxygen	mg/L	AWWA 4500-℃	8.9	8.8	8.9	8.8	8.9	8.8	8.7	8.8	8.8	8.9
5	Suspended solids	mg/L	HACH	4	2	2	1	6	4	6	2	4	4

Furthermore, it is strictly regulated the factory effluent running off to the marine environment by Regulation MD 8/84 in the Sultanate of Oman.

(b) No Data Archive but First Piece of Database

Since seasonally and/or long term observed data and scientific literature describing physical and chemical features in the Study Area are scarce, it is rather difficult to evaluate the results of the Study whether it is connected with pollution event or natural composition.

(c) Some Trends

a) Salinity was relatively high due to its climate and no fresh water discharge in NE monsoon.

b) COD (Cr) was same level of the Gulf region and has some seasonal variations.

c) The clear seasonal distinction was found in mean TN: TP ratio: 13:1 in NE monsoon and 2:1 in SE monsoon.

d) Coliform group and fecal coriform group were fairly low to undetectable.

e) Metal concentrations of lead (Pb), chromium (Cr), and total mercury were relatively high.

2) Interpretations on the Results using Standards or Index related to the Preservation of Living Environment and Protection of Human Health in Japan

(a) Environmental Quality Standards Related to the Preservation of Living Environment and Protection of Human Health

The following Table 19.1.7 shows the Standards used in Japan for evaluation of present condition of water quality as well as its prediction by computer simulation or hydrographic modeling.

Table 19.1.7 Environmental Quality Standards related to Preservation of Living Environment and Protection of Human Health

Type		A	B	C
Filed in Applicable		- Fishery 1st grade - Bathing Conservation Natural Environment - Filed of Type B and C	-Fishery 2nd grade -Industrial water -Filed Type C	Environmental Conservation
Standard	PH	7.8 to 8.3	7.8 to 8.3	7.0 to 8.3
	COD (Mn)	Less than 2 mg/l	Less than 3 mg/l	Less than 8 mg/l
	DO	Over 7.5 mg/l	Over 5 mg/l	Over 2 mg/l
	Coriform Group	1,000 MPN/less than100ml/l	-	-
	Hexane Extracts	Not detected	Not detected	-

As the results of COD cross check in Japan, the conversion factor of COD (Cr) to COD (Mn) was turned out be 0.037. Based on this factor, we calculated the data of COD in Table 19.1.4 through Table 19.1.6 and found that COD (Mn) were between 1.8 to 2.2 ml/l in NE monsoon and 1.2 to 1.8 in SW monsoon.

(b) Water Quality Index related to the Protection of Human Health

The following Table 19.1.8 shows the Index used in Japan as same purpose as described previous section.

Table 19.1.8 Water Quality Index related to the Protection of Human Health

Items of Index	Standard Value
Cadmium (Cd)	Less than 0.01 mg/l
Cyanide (Cn)	Not detected
Organophoshorus (P)	Not detected
Lead (Pb)	Less than 0.1 mg/l
Chromium (Cr)	Less than 0.05 mg/l
Arsenic (As)	Less than 0.05 mg/l
Total Mercury	Less than 0.0005 mg/l
Alkyl Mercury	Not detected
PCB	Not detected

Based on this index, the results of lab test on Pb, Cr, and total mercury were relatively high; however, their cause are not certain at this level of the Study.

19.2 Sea bed Materials

19.2.1 Existing Data and Standards

There are no available data archives describing details on seabed materials for coastal region to evaluate present conditions as well as predicting seabed material in the Study Area for future expansion of Port as well as its hinterland.

Regarding the present situation as described above, the following survey scheme was planned.

For acquisition of baseline data to evaluate seabed material of the Study Area, the following criterion for seabed material sampling was selected. These are normally used in Japan routinely for seabed sampling.

Table 19.2.1 Seabed Materials Sampling Items

	Items of Observation
1	Air Temperature
2	Sample Temperature
3	Color
4	Material
5	Odour
6	Mixture
7	Depth

	Items of Laboratory Test
1	Water content
2	Ignition loss
3	COD sed
4	Copper (Cu)
5	Cadmium (Cd)
6	Arsenic (As)
7	Chromium (Cr)
8	Lead (Pb)
9	Nickel (Ni)
10	Zinc (Zn)
11	Iron (Fe)
12	Total Mercury
13	NH4-N
14	Manganese (Mn)
15	Total CN
16	Total Sulfide
17	Total Nitrogen
18	Total Phosphorus
19	Fluoride (F)

19.2.2 Implemented Survey Schedule

(1) Sampling Time

The seabed sampling was conducted on the following season:

1) NE monsoon season: February 4th and 5th, 2000

(2) Sampling Location

The seabed sampling was conducted at the following ten (10) sampling points as shown in Table 19.2.2 and shown in Figure 19.2.1, respectively.

Table 19.2.2 Position of Seabed Sampling

(Datum: WGS 84)

Location	Latitude (N)	Longitude (E)
P1	16° 55' 19.2"	54° 00' 12.0"
P2	16° 55' 26.8"	54° 04' 05.9"
P3	16° 58' 44.2"	54° 03' 51.5"
P4	16° 57' 49.0"	54° 00' 54.1"
P5A	16° 56' 48.0"	54° 00' 53.0"
P6	16° 57' 57.7"	54° 00' 11.8"
P7	16° 58' 43.4"	54° 01' 00.0"
P8	16° 59' 08.7"	54° 02' 27.0"
P9	16° 58' 15.8"	54° 02' 44.4"
P10	16° 57' 23.7"	54° 02' 44.8"

The purpose for locating each sampling stations P1 through P10 are as follows.

(1) The stations P1 and P2 were designed to monitor a relative deepwater where influence of offshore water and current to the Study Area were expected.
(2) P3, P4, and P9 were placed in shallow water where influence of coastal ocean climate was expected.
(3) P4 was just adjacent to the future Port expansion planning area that would expect good monitoring results evaluating the influence before and after the port expansion.
(4) P5A was located at near the existing Port entrance expecting present influence of port activities.
(5) P6, P7, and P8 were placed very near shoreline areas that would expect influence of coastal activities and land base sources pollution.
(6) P10 was placed to the port approach channel.

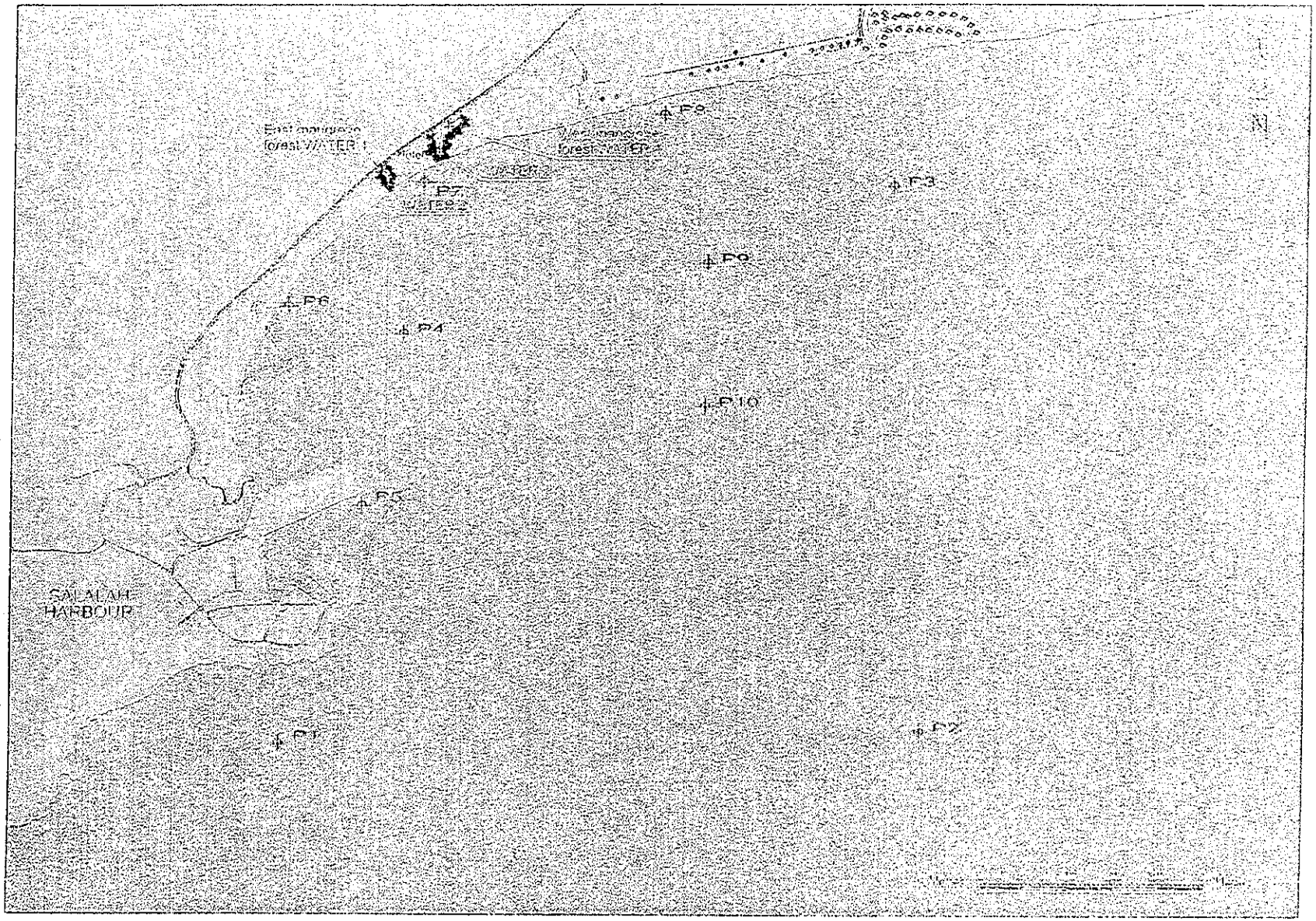

Figure 19.2.1 Sampling Points Locations

(3) Sampling Method

Grab sampler were used to obtain bottom sediment above ten (10) locations, and the recovered samples were transported to lab for analysis with carefully controlled the ambient to keep the sample in good conditions.

19.2.3 Survey Results

(1) Sampling and Sample Analysis Results

Table 19.2.3 shows the results of seabed sampling and sample analysis for NE monsoon season.

(2) Discussion on the Results

1) General

(a) No Inflowing Effluent from Coast

As described in previous section 19.1, there is no river runoff, and only dry "wadis" are recognized along the coast; therefore, it is estimated that almost no source of pollution that brings effluent of domestic, industrial, livestock, and agro-origin that may impact the marine environment, normally. Furthermore, it is strictly regulated the factory effluent running off to the marine environment by Regulation MD 8/84 in the Sultanate of Oman.

(b) No Data Archive but First Piece of Database

Since seasonally and/or long term observed data and scientific literature describing physical and chemical features in the Study Area are scarce, it is rather difficult to evaluate the results of the Study whether it is connected with pollution event or natural composition.

(c) Some Trends

a) P1 and P2 consisted of fine sand sediment mostly; however, P2 contained biodetritus.

b) P3, P4, and P9 were hard bottom; therefore, no catchments was archived.

c) P6, P7, and P8 consisted of coarse sand with mud that was finest sediment.

d) P5 had only different character that had a gray colored sulphydric odor consisted of mud.

e) P7 showed relatively a high test results among other points; however, it is not clear about the cause of this results.

f) Metal concentrations of cadmium (Cd), arsenic (As), chromium (Cr), lead (Pb), and total mercury were relatively high.

Table 19.2.3 BOTTOM SEDIMENT SAMPLING

ITEMS OF OBSERVATIONS													
ITEMS	ANALISYS ITEM		METHOD	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
1	Air temperature	°C	Digital Thermom.	28°C	30°C	30°C	29°C	27°C	28°C	28°C	28°C	28°C	28°C
2	Temperature/sample	°C	Digital Thermom.	19°C	18°C	-	-	22°C	23°C	23°C	23°C	-	-
3	Color		Visual	Beige	Light beige	-	-	Grey	Beige	Beige	Beige	-	-
4	Materials		Visual	Fine sand with low percent of mud	Coarse sand with biodetritus, very low percent of mud	Hard bottom	Hard bottom	Muddy-sandy bottom	Coarse sand with biodetritus, very low percent of mud	Coarse sand and mud	Coarse sand and mud	Hard bottom	Hard bottom
5	Odour			None	None	-	-	Sulphydric	None	None	None	-	-
6	Mixture		Visual	70% sand, 30% other finest sediment	80% sand, 20% other finest sediment	-	-	60% mud, 40% sand	80% sand, 20% other finest sediment	60% sand, 40% other finest sediment	60% sand, 40% other finest sediment	-	-
7	Depth	m	Echosounder	26.5	35.5	13.5	9.2	16.7	2.5	2.4	2.2	11.0	15.0

RESULTS OF LABORATORY TEST													
ITEMS	Test		METHOD	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
1	Water content	% by weight	Oven dry	29.85	36.74	36.37	27.77	47.74	38.38	32.75	24.46	43.00	49.89
2	Ignition loss	% by weight	at 1000oC	1.87	2.02	3.2	3.22	3.6	2.9	3.8	1.76	3.1	3.8
3	COD sed	mg/kg	Refluxion method	3360	3480	4240	3640	4160	3960	4440	2620	2830	2940
4	Copper (Cu)	mg/kg	AA	0.36	0.52	0.52	0.4	0.62	0.69	0.67	0.2	0.44	0.22
5	Cadmium (Cd)	mg/kg	AA	0.16	0.46	0.38	0.65	0.47	0.04	0.60	0.34	0.40	0.44
6	Arsenic (As)	ppb	Cold Vapour	62.0	43.0	32.0	32.5	13.5	53.0	60.0	11.0	20.0	72
7	Chromium (Cr)	mg/kg	AA	1.79	2.97	2.64	2.03	3.35	4.26	4.64	0.64	1.10	1.62
8	Lead (Pb)	mg/kg	AA	5.70	5.60	6.50	7.40	4.10	7.00	9.00	5.50	4.20	67.4
9	Nickel (Ni)	mg/kg	AA	2.52	2.53	2.66	2.60	2.75	1.26	1.55	3.12	3.60	1.84
10	Zinc (Zn)	mg/kg	AA	0.79	0.80	1.06	0.79	0.76	0.83	0.98	0.61	0.88	1.420
11	Iron (Fe)	mg/kg	AA	1.90	1.10	3.10	1.10	2.10	2.60	3.10	1.00	2.20	4.000
12	Total Mercury	ppb	Cold Vapour	85.70	25.90	22.90	51.50	10.00	47.30	40.00	8.10	0.20	222.00
13	NH4-N	mg/kg	Distillation	22.85	22.65	21.65	22.60	22.80	23.60	23.40	23.10	26.20	25.800
14	Manganese	mg/kg	AA	2.05	0.66	3.29	3.16	4.25	3.97	5.12	2.92	0.92	2.520
15	Total Total CN	mg/kg	HACH	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
16	Total Sulfide	mg/kg	Gravimetric	30.4	9.6	32.8	32.8	28.8	23.2	25.6	32.8	34.3	32.20
17	Total Nitrogen	mg/kg	kjeldahl	97.8	109	94.9	138	106	81.2	110.6	119.2	108.9	89.000
18	Total Phosphorus	mg/kg	Gravimetric	5450	2240	13700	13200	1970	15800	11900	15600	8600	9200.00
19	Fluoride (F)	mg/kg	HACH	0.99	0.95	0.85	0.88	1.01	0.87	0.85	0.82	1.10	1.12