PART 2: APPENDIX

1. Study Area and Field Survey

Appendix 1. Study Area and Field Survey

1.1 Study Area (Before Revision)

1.2 List of Study Area (Before Revision)

Study Area		Mangrove Area (ha)	Site conditions	Community involvement
Mangrove Sites	1) Khawr Shinas	53		Planning to use as a park
	2) Bandar Khairan	83		Picnic ground for barbecue and camping
	3) Quriyat	80	Browsing by animals	Illegal dumping of construction waste
	4) Sur (Sukeira)	58	Planting mangrove (1.2 ha)	Fodder for camel, fuel wood for community, recreational use as a park
	5) Film-Mahawt	172	Used for fodder, gillnets are set	Temporary houses for fishermen (population increase during the fishing season)
	6) Salalah (Taqa)	1.6	Heavy browsing by camel	Protection area (access limitation)
	7) Salalah (Khawr Kabir and Khawr Saghir)	5.9	Browsing by camel, Mangrove nursery construction started	Fodder for camel
Potential Khawrs	1) Khaburah	0		
	2) Suwaiq (2 Khawrs)	0		
	3) Al-Sawadi	0	Mangrove planting (1,16 ha)	Development plan for hotel, broken fence
	4) Barka (2 Khawrs)	0		Developed as community park
	5) Seeb	0		
	6) Ras Al-Hadd (Khawr Ai-Hajar)	0		Near to a hotel site
	7) Umm Al-Rusay (Masirah Island)	0		
	8) Duqm	0		
	9) Salalah (4 Khawrs)	0		

1.3 Results of Quick Survey at 47 Sites (1/3)

Site Name & Number on TOR	No. of Quick Survey	Location			Mangrove (ha)	Natural Conditions						Social Condition	Note and Comments		
		Region	Study Site	GPS Positioning		Tidal Condition	Wave/Wind	Flood	Salinity	pH	Soil Conditions	Usage Pressure/Social Impact	Technical comment on forest and plantation	Advice by JICA expert	Review and request by Omani side (DG, Nature Conservation)
	1	Khawr Kalba	Khawr Kalba		??	Tidal action is disturbed.	Calm in summer						No need to plant. Some care like thinning may be effective to calm stress which assumed to be brought by disturbance in tidal range at the month.		Agree to omit.
1-4. Shinas	2	Shinas	Khawr Shinas		53.0	Normal at present.	Calm in summer. Drifted sand damaged seaward fringe.	Rare	4.0 - 3.5	7.8 - 8.1	Sandy soil with aerobic condition at seaside, silty and muddy surface soil with anaerobic condition at deeper khaws.	Developing the area as a municipal park. Access road to the area is constructed.	Possible to plant mangrove along the khawr streching to the city. Some care like thinning may be good for the damaged parts.	Possible to plant near river month.	OK.
	3	Liwa	Khawr Harmul & Nabr		??	Endangered by sand deposition at mouth in Harmul. Nabr has been dried up.	Calm in summer, but sand in killing Nabr forest. Need to know effects of wind in winter.	Rare			Strongly sedimented area in beach, uplanded mangrove area, sandy soil along beach, silty surface soil in inner khawrs.	Developing the area as a municipal park.	No need to plant. Need urgent support to the dried up forest of Nabr. Difficult to control sand.	Possible to plant near river month and seaside. Sedimentation by the construction of new Sohar port?	OK.
	4	Saham	Khawr Hamam	N24° 08'40.0" E56° 54'36.6"	0.0	Dried up.	Protected by sand bank.	Once in a while.					Impossible to plant.		Agree to omit.
2-5. Khaburah	5	Bani Khalid	Khawr Milh	N24° 02'39.0" E57° 01'53.5"	0.0	Embanked brackish water swamp.	Protected by sand bank.	Once in a while.	??		Silty surface soil with aerobic condition.		Possible to plant m. in a line, but difficult to keep them alive against flood.		Agree to omit.
	6	Khaburah	North Khaburah		0.0	Dried up.	Protected by sand bank.	Once in a while.			Sandy soil near beach, silty surface soil in lower places of khawr, no water in khawr.		Impassible to plant.		Agree to omit.
	7		Khawr Za'ab	N24° 00'33.3" E57° 04'32.7"	0.0	Embanked high saline swamp with HWS inflow.	Protected by sand bank.	Once in a while.	6.4		Silty and humic surface soil near khawr water, sandy soil near beach and other area, humic surface water.		Impassible to plant.		Agree to omit.
2-4. Suwaiq (2Khawars)	8	Suwayq	North Suwayq	N24° 52'10.5" E57° 21'50.3"	0.0	Dried up.	Protected by sand bank.	Once in a while.			Sandy soil with aerobic condition, no water.	Fishing village. Many goats are grazing.	Impassible to plant.	Difficult to use. Necessary to construction works to use.	Agree to omit.
	9		Khawr Qizmi	N24° 51'37.0" E57° 24'30.1"	0.0	Embanked high saline swamp with HWS inflow.	Protected by sand bank.	Once in a while.	6.2		Sandy soil near beach, silty and humic soil in surface near khawr water humic surface water.		Impassible to plant.		Agree to omit.
2-2. Sawadi	10	Suwadi	Khawr Suwadi	N23° 45'.55.5" E57° 47'27.0"	0.0	Normal tidal innundation on a huge tidal flat.	Calm in summer, but drifted green algae spoils seedlings.	Rare			Sandy soil with aerobic condition at sea shore, silty surface soil with anaerobic condition at some water stream area.	Existing recreational area of the local people. New development plan for large-scale tourism.	Soft ground within 1 hundred meters width along the channels is the most hopeful.	Plan to plant in Jan. ~ Feb. 2003.	OK, but at the second last priority because the development plan has been accepted.
2-3. Barka (2Khawars)	11	Barka	Khawr Hafri		0.0	Filled up by flood in '95.	Protected by sand bank.	Filled up			Sandy soil at whole area no water in khawr.		Impassible to plant. This is the land.	Plan for park	Agree to omit.
	12		Khawr Haradi	N23° 42'24.7" E57° 55'17.6"	0.0	Embanked saline swamp with limited inflow at HWS.	Protected by sand bank.	Once in a while.	4.8		Blackly and silty surface soil near surface water, sandy soil near beach and other area humic surface water.	Many goats are grazing. Garbages are dumped from the housing area.	Impossible to plant, because of salt concentration and anaerobic mechanism in soil.		OK.
2-8. Seeb	13	Sib	Wadi Buhayyis	N23° 40'51.7" E58° 11'35.8"	0.0	Artificially reformed ponds with stone banks.	Protected by sand bank.	??	0.2/inner 1.3/seaside		Rock protection surounding khawrs.	Municipal park area surrounded by houses.	Impossible and no need.		Agree to omit.
	14	Qurm	Khawr Qurm		??	Generally normal, disturbed partially.	Calm in summer.	Violent flood once in a while.				Decreared as nature reserve in 1975.	No need to plant. This is the most complicated forest in Oman due to the history of flood run through. Good for studies and technical development.		OK, we support.
1-5. Bandar Khairan	15	Bandar Khayran	Bandar Khayran		83.0		Calm in summer.	Once in a while.				Used as recreational spot for camping and diving			OK, we support.
1-7. Quriyat	16	Quryat (Quryiat)	Quryay (Quryiat)		80.0	No innundation after embanked completely in '96, surviving on rich ground water.	Protected by sand bank.	Once in a while.	4.5	8.1	Strongly sedimented area in beach, sandy soil at seaside and high lands with aerobic condition, silty and organic surface soil around khawrs with anaerobic condition.	Development plan of shrimp cultivation Illegal dumping of construction wastes.	The forest is suviving on hard an special condition difficult to improve. No need to plant at present, but need to find out regeneration technique for future.	Heavy damage by grazing. Walking path for local residents. Plan to construct dumping yard fro construction waster in Jan.	OK, but at lower priority.
			Daghmar												No need to study.
	17	Dibab			0.0	Normal.	Calm in summer.	Once in a while.					Difficult and no need to plant.		No need to study.

Results of Quick Survey at 47 Sites (2/3)

Site Name & Number on TOR	No. of Quick Survey	Location			Mangrove (ha)	Natural Conditions						Social Condition	Note and Comments		
		Region	Study Site	GPS Positioning		Tidal Condition	Wave/Wind	Flood	Salinity	pH	Soil Conditions	Usage Pressure/Social Impact	Technical comment on forest and plantation	Advice by JICA expert	Review and request by Omani side (DG, Nature Conservation)
	18	Sur	Maqraymatayn		0.0	Normal tidal flats.	Well protected and calm.	None	7.4/mud 4.1/sand		Sandy at Sukeikra area, more silty surface soil and salty soil condition at deeper khawrs.		Possible. Difficulty varies depending on the salinity and oxygen supply.		Agree to omit.
1-3. Sur (Sukeikra)	19		Qurm a'Skaykira		58.0	Normal.	Well protected. Calm in summer	None	4.6/nurs. 4.2/Q-E	8.5/nurs.		Housing development is planned.	No need to plant. Forests are growing healthy.		OK.
	20		Sukaykira		0.2	Normal tidal flats.	Calm in summer, but not necessarily well protected.	Once in a while.				Area is development as recreational park. Landfill by local people for house construction.	Hopefull to plant. Wind may disturb growth in winter.	Plant to plant.	OK.
	21	Ras Al Hadd	Khawr Jaramah		??	Probably normal.							No need to put high priority at present.		Agree to omit.
2-1. Ras Al-Hadd (Khawr Al-Hajar)	22		Khawr Quq		0.0	Normal tidal flat.	Well protected throughout the year.	None	3.9	8.2		Tourim development is planned.	Good for plantation, well protected from wind.		OK, the best place to plant.
	23		Khawr Hajar 1) North Shore 2) Northeast Shore 3) East Shore 4) Southeast Shore		0.0	Normal tidal flats.	Calm in summer, may be harder in winter.	None	3.6/sea 3.6-3.8/ inner	8.2/sea 8.2-8.3/ inner	Sandy soil at whole khawr shallow soils at rocky surface areas.	Recreational use is seasonal. Hotel is under construction.	Possible. Soil thickness above rocky layer in bottom and wind in winter may limit the success. Be conscious of various usage by abundant birds.	Plant to plant in Jan. ~ Feb. 2003? In the tourism area.	OK, we support. Mangrove will provide shelters to birds. A comprehensive plan for tourism development is on going which includes air port construction.
2-9. Umm Al-Rusay (Masirah Island)	24	Masirah	Umm a'Rusays	N20° 27'51.9" E58° 46'55.8"	0.0	Normal tidal flats.	Rather calm in summer. Probably not so hard in winter.	None			Sandy at whole sea shore, harder soil in north-west and softersoil in south-east area.		Possible, but not very suitable due to human activities.		Agree to omit.
	25		Wadi Muraysis	N20° 25'20" E58° 45'04"	0.0	Normal wide tidal flats.	Calm in summer, may be harder in winter.	Not direct			Sandy at whole sea shore, harder soil in north-west and softersoil in south-east area.	Fishing village with temporary population increase.	Probably good for plantation. Wind and wave in winter may limit success.	Diversity of fishing resources.	OK.
	26		Jazirat Muraysis (Jazirat a'Shaghaf)		??	Exposed/outer, embanked/inner.	Exposed to winds, though protected from rough waves by coral reefs.	None	3.9		Shallow and sandy soil along beach, high salt contensts in upper Mangrove areas.		Leave as it is. However, better to start study for the support in regeneration of the mangroves here.		Agree to omit.
	27	Barr al Hikman	Khawr Barr al Hikman		10.0		Exposed to winds, though protected from rough waves.	None					Insuficient observation		
			Ra's Kanasah - Ra's Shajrit										No observation.		
	28	Haj	Wadi Halfayn		0.0	Occasional innundation may occur	Well protected throughout the year.		2.5	8.1		Seasonal fishing village	Impossible due to lack of soil over the rocky bottom.	Damade by grazing and deforestation	
		Ghubbat Hashish	(East of Mahawt)										No observation.		Remote and beautiful place with mangrove.
1-1. Filim-Mahawt	29		Filim (Eastern Beach)		10.0	Normal tide on very flat tidal zone which calms wave energy.	Exposed to strong wind in summer, calm in winter.	Rare	3.8	8.2	Sandy soil in east sea shore.	Fishery and commercial shrimp fishery are operated.	Possible to plant on the risk and limitation due to strong wind in summer, Probably need to limit grazing.		OK, strongly support.
	30		Filim (Western Beach)		5.0	Normal tide on very flat tidal zone.	Exposed to strong wind in summer, calm in winter.	None	3.8	8.2	Clayic soil with anaerobic condition in west sea shore		Probably possible to plant on the risk and limitation by summer wind.		There existed many old stumps of big mangrove tees. Forest should be reestablished. Camel grazing and fodder collection are baned.
	31		Mahawt		162.0			None						Necessary to protect from inadequate usage by Bedwin.	OK, strongly support. Ministry stopped a plan to connect Mahawt with a causeway prepared by MOAF.

Results of Quick Survey at 47 Sites (3/3)

Site Name & Number on TOR	No. of Quick Survey	Location			Mangrove (ha)	Natural Conditions						Social Condition	Note and Comments		
		Region	Study Site	GPS Positioning		Tidal Condition	Wave/Wind	Flood	Salinity	pH	Soil Conditions	Usage Pressure/Social Impact	Technical comment on forest and plantation	Advice by JICA expert	Review and request by Omani side (DG, Nature Conservation)
2-6. Duqm	32	Duqm	Sabkha a'Duqm		0.0	Half embanked tidal pools and flats at HW level	Exposed to wind, but protected from waves in summer. Probably not so calm in winter.	??	4.9	8.7	Sandy soil along beach, relatively hader soils in tidal pools.	Small port is located. Temporary huts for fishermen are scattered.	Possible to plant. But we have too little observation to estimate the potential area.		OK, but at the last priority, because a feasibility study is undertaken for constructing a first class port with a dry dock.
	33		Ras a'Duqm		0.0	Embanked tidal pools with limited HWS inflow.	Exposed to strong wind in summer.	None	7.0	8.7			Impossible to plant.		Agree to omit.
2-7. Salalah (4 Khawrs)	34	Hino	Khawr Hino	N16° 57'29.7" E54° 44'53.1"	0.0	Half embanked lagoon with HW inflow.	Protected by sand bar. Monsoon waves spill	Once in a while.	4.0	8.0	Sandy soil along beach.	Eco-tourism is developed and hotel is constructed.	Possible but no need to plant, respecting original vegetation.	Plan for tourism development.	Agree to omit.
	35	Mirbat-Taqah	Al Demer (Sand dune)		0.0		Strong wind is calmed by steep face of sand.	Once in a while.							OK, strongly support.
	36	Taqah	Khawr Rowri	N17° 02'20.0" E54° 22'36.3"	0.0	Half embanked lagoon with occasional fresh water supply.	Protected by the front sand bar. Monsoon waves spill in.	Once in a while.	1.0-1.6 /branch	7.9/branch	Blackly and silty surface at deeper khawr, Sandy soil, silty surface soil.	Designated as nature reserve in 1997 and as world heritage in 2001.	Possible to plant, if necessary, on limited sites down streams, but plantation seems better to be avoided in this special khawr.	Scenic conservation, tourism development, heritage. No need to plant.	OK, support. Mangroves should not be planted, because it has historical importance as well as its unique wildlife.
	37		Khawr Taqah		0.0	Embanked swamp with rich ground water supply.	Protected by sand bar. Monsoon waves spill in at long interval.	Once in a while.	0.3	7.7	Silty and organic surface with anaerobic condition, humic surface water.		Possible, but difficult to keep mangrove forest against leed propagation on this condition.		Agree to omit.
1-6. Khawr Taqa W	38		Khawr Taqah-west		1.6	Embanked brackish water swamp.	Protected by the front sand bar. Monsoon waves spill in.	Once in a while.	2.0		Silty surface soils along khawr.	Livestock forming of camels.	No need to plant, but need to protect forest from camel grazing. Plantation thereafter may be helpful for regeneration.	Heavy damage by grazing Nature Reserve	OK.
2-7. Salalah (4 Khawrs)	39	Salalah	Khawr Sawli		0.0	Embanked fresh water lagoon in usual, innundated by sea recently.	Protected by sand bar. Monsoon waves spill in at long interval.	Once in a while.		8.1	Silty and organic surface with anaerobic condition, humic surface water.		Possible, but difficult to keep mangrove forest against leed propagation on this condition.	No need to plant.	Agree to omit.
	40		Khawr Jnawf		??	Half embanked keeping water at HW level, affected by food.	Protected by sand bar. Monsoon waves spill in.	Once in a while.	4.2	8.2	Silty and organic surface with anaerobic condition, humic surface water.	Many camels are found.	No need to plant, but need to protect forest from camel grazing, then comes assisting plantation for regeneration.		Agree to omit.
	41		Khawr Jnawf-west		??	Half embanked, with frequent tidal inflow.	Protected by sand bar. Monsoon waves spill in.	Once in a while.	3.9	8.1	Silty and organic surface with anaerobic condition, humic surface water.	Many camels are found.	No need to plant, but need to protect forest from camel grazing, then comes assisting plantation for regeneration.		Agree to omit.
	42		Khawr Shaah		??	Half embanked.	Protected by sand bar. Monsoon waves spill in.	Once in a while.	3.9	7.9	Silty and organic surface with anaerobic condition, humic surface water.	Many camels are found.	No need to plant, but need to protect forest from camel grazing, then comes assisting plantation for regeneration.		Agree to omit.
	43		Khawr Dahariz		0.0	Embanked sweet lagoon usually, recently half opened to the sea.	Protected by the front sand bar. Monsoon waves spill in.	Once in a while.	3.4	8.1	Sandy soil at beach side, Many P.juliflora at deep khawr.	Houses are constructed around and along the beach.	Possible in necessary, but plantation will be limited in a line along banks.		
	44		Khawr Balid		0.0	Embanked brackish water lagoon usually.	Protected by sand bar. Monsoon waves spill in at long interval.	Once in a while.	2.1	7.8	Silty and organic surface with anaerobic condition in khawr.	Recreation area including park, historical ruins.	May be good for small botanical garden of mangrove species for education, study and seed stock.		OK. Support the idea to establish a small botanical garden of mangrove species for educational and seed providing purpose for
	45		Khawr Awqad		0.0	Embanked brackish water lagoon usually.	Protected by sand bar. Monsoon waves spill in at long interval.	Once in a while.	2.6				Possible if necessary, but plantation will be limited in a line along banks.		
1-2. Salalah (Khawr Kabir and Khawr	46		Khawr (Qurm) Kabir		5.9	Half Embanked with inflow at HW.	protected by the front sand bar. Monsoon waves spill in.	Once in a while.	3.5COD +ppm/ khawr 3.9 COD	7.8/khawr 8.2/sea	Sandy soil with aerobic condition at seaside, Silty soil and organic matter in surface with anaerobic condition at deeper khawr.	Designated as nature reserve and next to the Hilton Hotel. Pooled water becomes sludge.	Experimental plantation should be undertaken to support regeneration disturbed by grazing.	Nursary is constructed. Offensive odor in the Khawr. Necessary of scenic conwservation.	OK.
1-2. Salalah (Khawr Kabir and Khawr Saghir)	47		Khawr(Qurm) Saghir		??	Embanked brackish water swamp. Contaminated by flood.	Protected by the front sand bar. Monsoon waves spill in.	Once in a while.	1.3	7.4	Silty and organic matter in surface with anaerobic condition at deeper khaw, Smelling water and many floaing organic matters by flooding.	Tourism development. Camels browzing mangroves.	Leave as it is in order to understand the forest's ability in recovery from damage and regeneration. But need to remove drifts of flood and algae spoiling the habitat.	Necessary of scenic conwservation.	OK.

1.4 List of Plants

Aizoon	*canariensis*	Aizoonaceae	coastal plain	
Chara	sp	alga	lagoon	low salinity
Enteromorpha	sp	alga	lagoon	saline/seawater
Lynbya	majuscula	alga	lagoon	seawater
Heliotropium	*fartakense*	Boraginaceae	coastal plain	
Heliotropium	*kotschyi*	Boraginaceae	coastal plain	
Arthrocnemum	*macrostachyum*	Chenopodiaceae	khawr edge	
Atriplex	*farinosa*	Chenopodiaceae	beach	
Atriplex	*leucoclada v. inamoena*	Chenopodiaceae	lagoon edge	
Cornulaca	*monacantha*	Chenopodiaceae	coastal plain	
Halocnemum	*strobilaceum*	Chenopodiaceae	coastal plain	
Halopeplis	*perfoliata*	Chenopodiaceae	coastal plain	
Salsola	*drummondii*	Chenopodiaceae	coastal plain	
Salsola	*imbricata*	Chenopodiaceae	coastal plain	
Suaeda	*aegyptiaca*	Chenopodiaceae	coastal plain	
Suaeda	*monoica*	Chenopodiaceae	coastal plain	
Suaeda	*moschata*	Chenopodiaceae	coastal plain	
Suaeda	*vermiculata*	Chenopodiaceae	coastal plain	
Eclipta	*alba*	Compositae	khawr edge	
Pluchea	*ovalis*	Compositae	Khawr edge	
Cressa	*cretica*	Convolvulaceae	coastal plain	
Ipomoea	*pes-caprae*	Convolvulaceae	sea beach	
Cyperus	*conglomeratus*	Cyperaceae	coastal plain	
Juncellus	*laevigatus*	Cyperaceae	khawr edge	low salinity
Schoenoplectus	*litoralis*	Cyperaceae	khawr edge	
Genus	Species	Family	Habitat	salinity
Aeluropus	*lagopoides*	Gramineae	coastal plain	
Halopyrum	*mucronatum*	Gramineae	sand dune	
Paspalum	*vaginatum*	Gramineae	khawr edge	low salinity
Phragmites	*australis*	Gramineae	khawr edge	low salinity
Sporobolus	*virginicus*	Gramineae	khawr edge	
Urochondra	*setulosa*	Gramineae	coastal plain	
Juncus	*rigidus*	Juncaceae	coastal plain	
Najas	*marina*	Najadaceae	lagoon	low salinity
Limonium	*axillare*	Plumbaginaceae	coastal plain	
Limonium	*stocksii*	Plumbaginaceae	coastal plain	
Halodule	*uninervis*	Potamogetonaceae	Tidal channel	saline/seawater
Halophila	*ovalis*	Potamogetonaceae	Tidal channel	saline/seawater
Potamogeton	*pectinatus*	Potamogetonaceae	lagoon	low salinity
Ruppia	*maritima*	Potamogetonaceae	lagoon	saline/seawater
Bacopa	*monniera*	Scrophulariaceae	khawr edge	
Typha	*angustata*	Typhaceae	khawr edge	low salinity
Avicennia	*marina*	Verbenaceae	khawr edge	saline/seawater
Zygophyllum	*qatarense*	Zygophyllaceae	coastal plain	
Ceratophyllum	*demersum*		lagoon	low salinity

Source: TS-PCDEGD 1993, National Herbarium Database 2003

Plants Recorded from Khawrs of Oman, 2003

Algae kindly identified by Dr B Jupp, MRMEWR

Genus	Species	1	2	3	4	5	6	7	8,9	10	11	12	13	14	15	16	17	18	19	20	21	Family	Habitat
Aizoon	*canariensis*														x			x				Aizoonaceae	coastal plain
Chaetomorpha	*crassa*													x								algae	lagoon
Chara	sp																x					algae	lagoon
Cladophora	sp (cf prolifera)																	x				algae	lagoon
Enteromorpha	*flexuosa*																			x		algae	lagoon
Feldmannia	*irregularis*								x													algae	channel
Lyngbya	*majascula*								x				x									algae	lagoon
Ulva	*fasciata*													x								algae	channel
Pentatropis	*nivalis*																x					Asclepiaceae	khawr edge
Heliotropium	*fartakense*																x	x		x	x	Boraginaceae	coastal plain
Heliotropium	*kotschyi*							x														Boraginaceae	coastal plain
Polycarpaea	*spicata*														x							Caryophyllaceae	coastal plain
Ceratophyllum	*demersum*															x						Ceratophyllaceae	fresh khawr
Arthrocnemum	*macrostachyum*	x	x			x		x						x				x	x			Chenopodiaceae	khawr edge
Atriplex	*farinosum*																		x			Chenopodiaceae	beach
Atriplex	*leucoclada v. inamoena*									x												Chenopodiaceae	khawr edge
Cornulaca	*monacantha*	x	x	x				x														Chenopodiaceae	coastal plain
Halocnemum	*strobilaceum*		x																			Chenopodiaceae	coastal plain
Halopeplis	*perfoliata*			x	x	x		x						x								Chenopodiaceae	coastal plain
Salsola	*drummondii*							x														Chenopodiaceae	coastal plain
Salsola	*imbricata*	x																				Chenopodiaceae	coastal plain
Suaeda	*aegyptiaca*					x												x	x			Chenopodiaceae	coastal plain
Suaeda	*monoica*													x								Chenopodiaceae	coastal plain
Suaeda	*moschata*												x	x								Chenopodiaceae	coastal plain
Suaeda	*vermiculata*	x	x		x	x	x	x	x	x	x						x	x	x	x	x	Chenopodiaceae	coastal plain
Eclipta	*alba*																	x			x	Compositae	khawr edge
Pluchea	*ovalis*																		x			Compositae	Khawr edge
Cressa	*cretica*															x	x	x		x	x	Convolvulaceae	coastal plain
Ipomoea	*pes-caprae*														x			x	x			Convolvulaceae	sea beach
Cyperus	*conglomeratus*	x	x			x									x		x	x	x	x	x	Cyperaceae	coastal plain
Juncellus	*laevigatus*															x	x		x			Cyperaceae	khawr edge
Schoenoplectus	*litoralis*															x	x					Cyperaceae	khawr edge
Indigofera	*oblongifolia*					x																Fabaceae	sandy plain
Aeluropus	*lagopoides*	x	x			x		x								x	x			x	x	Gramineae	coastal plain
Halopyrum	*mucronatum*	x	x	x	x	x									x				x			Gramineae	sand dune
Paspalum	*vaginatum*															x		x				Gramineae	khawr edge
Phragmites	*australis*															x	x	x	x	x	x	Gramineae	khawr edge
Sporobolus	*spicatus*														x		x	x	x	x		Gramineae	coastal plain
Sporobolus	*virginicus*						x									x	x	x	x	x	x	Gramineae	khawr edge
Urochondra	*setulosa*														x		x	x	x	x	x	Gramineae	coastal plain
Halophila	*ovalis*			x									x	x								Hydrocharitaceae	channel
Juncus	*rigidus*	x	x			x											x	x				Juncaceae	coastal plain
Najas	*marina*																		x			Najadaceae	lagoon
Limonium	*axillare*															x		x				Plumbaginaceae	coastal plain
Limonium	*stocksii*			x		x	x	x														Plumbaginaceae	coastal plain
Halodule	*uninervis*												x	x								Potamogetonaceae	channel
Potamogeton	*pectinatus*															x					x	Potamogetonaceae	lagoon
Ruppia	*maritima*																x					Potamogetonaceae	lagoon
Thalassodendron	*ciliatum*													x								Potamogetonaceae	lagoon
Bacopa	*monnieri*															x	x					Scrophulariaceae	khawr edge
Typha	*angustata*															x			x			Typhaceae	fresh khawr
Avicennia	*marina*	x	x			x	x	x	x				x	x			x			x	x	Verbenaceae	khawr edge
Zygophyllum	*qatarense*	x							x	x	x											Zygophyllaceae	coastal plain
TOTAL		10	9	5	3	11	4	9	5	3	2	0	5	10	7	12	17	17	15	11	11		

1=Shinas, 2=Harmul, 3=Suwadi, 4=Haradi, 5=Qurm, 6=B. Khayran, 7=Quriyat, 8,9=Sur, 10=Quq, 11=Hajar, 12=Muraisis, 13=Filim, 14=Mahawt, 15=Demer, 16=Rawri, 17=Taqah, 18=Dahariz, 19=Balid, 20=Kabir, 21=Saghir

1.5 List of Water Birds and Associated Species

Common Name	1. Shinas	2. Liwa	3. Sawadi	4. Haradi	5. Qurm	6. Bandar Khayran	7. Qurayyat	8. Sur	9. Hajar/Quq, + Jaramah	10. Sur Masirah	11. Filim/Barr al Hikman	12. Duqm	13. Al Demer	14. Rowri	15. Taqah	16. Dahariz
Little Grebe	r			~	u	~	r	u					~	c	u	a
Great Grested					v						v			v		v
Black-necked Grebe		r	r		f		u	u			r			f	r	f
Cormorant	c	f	c		c		c	c	u	f	c	u		c	u	f
Bittern	r				r					r				r	r	r
Little Bittern		r			u				r					u	u	f
Yellow Bittern														r	r	f
Night Heron	u		u		u		u	r	u		r			c	f	f
Striated Heron	c	a	u		a		f	f	u	r	u			u	f	u
Squacco Heron	f	u			c		u		u		r			c	c	c
Indian Pond Heron	f	u			c		f		r		r			u	u	u
Cattle Egret					c		r	r			r	r		c	f	c
Western Reef Heron	a	a	a		a		a	a	a	c	a	a		a	a	a
Little Egret	c		u		a		c	c	u	u	u	r		a	a	a
Black Egret															v	
Intermediate Egret	r	r			r		r	r			r	r		u	r	f
Great White Egret	c	u	u		a		c	c	c	f	c	c		c	f	f
Grey Heron	a	a	a		a		a	a	a	f	a	a		a	a	a
Purple Heron	u	r	u		c		u	r						a	a	a
Goliath Heron					v		v				v					
Black-headed Heron															v	v
Black Stork															v	
Abdim's Stork															u	r
White Stork	r		u		r		f	r	r	r				r	r	r
Glossy Ibis			r		u		u	r						a	a	a
Sacred Ibis																v
Spoonbill	c	r	u		f		f	c	u	f	c	c		a	c	c
African Spoonbill														v	v	v
Greater Flamingo	u		f		u		c	c	a	c	a	a		a	a	a
Lesser Flamingo								r						v	v	v
Fulvous Whistling Duck																v
Lesser Whistling Duck															v	v
Mute Swan							v									
Bewick's Swan														r		
White-fronted Goose					r		r							r		r
Lesser White-fronted Goose																
Greylag Goose					r					r				r		
Ruddy Shelduck	r						r							u	r	r
Shelduck							u				r			r	r	u
Comb Duck																v

Common Name	1. Shinas	2. Liwa	3. Sawadi	4. Haradi	5. Qurm	6. Bandar Khayran	7. Qurayyat	8. Sur	9. Hajar/Quq, + Jaramah	10. Sur Masirah	11. Filim/Barr al Hikman	12. Duqm	13. Al Demer	14. Rowri	15. Taqah	16. Dahariz
Cotton Teal														c	r	f
Wigeon	u		r		r		f	u		r	r			c	u	f
Gadwall	u				u		u							f	r	u
Teal	u	r	u		c		f	u		r				c	f	c
Mallard	r				c		f	u			r			c	u	f
Pintail	u		u		u		f	u	r	r	r	r		a	f	c
Garganey	u		u		c		f	u	r	r	r			a	c	a
Shoveler	u				u		f	u						c	f	a
Red-crested Pochard	u				r									r	r	r
Pochard	r				r		r	r						f	r	f
Ferruginous Duck					r		r							c		u
Tufted Duck	r	u			r		u	r						f	r	f
Red-breasted Merganser			v		v										v	
Pallas's Fish Eagle														v		
Egyptian Vulture	r	r	f		u		a	c	r	f	r	r		r	r	r
Marsh Harrier	f	u	u		a		r	f	u	f	c	f		c	c	a
Hen Harrier					r					r				r	r	r
Pallid Harrier					r		r			u	u			u	u	r
Montagu's Harrier			u		r		r	r		f	r			u	u	r
Osprey	c	f	c		c		c	c	c	f	a	c		a	c	a
Hobby	r		r		r		r	r			r	r		r	r	r
Sooty Falcon			c		c		u				r			r		
Peregrine Falcon	r		u		r		r	r		f	u	r		u	u	u
Water Rail	r	r			r										r	
Spotted Crake					r		r							r	r	r
Little Crake					r									r	u	r
Baillon's Crake					r		r							u	u	r
Corncrake					r									r		
White-breasted waterhen							r							r	r	
Moorhen					c		u	r						a	a	a
Allen's Gallinule														v	v	v
Purple Gallinule					v											v
Coot					r		u	r			r			a	f	a
Red-knobbed Coot6																v
Common Crane	r													r	r	r
Demoiselle Crane								r								r
Houbara Bustard	r									r						
Pheasant-tailed Jacana							r							c	f	c
Painted Snipe																
Oystercatcher	f	f	c		f		c	c	c	c	a	a		f	f	a
Black-winged Stilt	u				c		f	f	r		u	f		a	f	a
Avocet	r		u				u				u	f		r	u	u
Crab Plover	u		u		u		u	r	a	c	c	c		r	u	r

Common Name	1. Shinas	2. Liwa	3. Sawadi	4. Haradi	5. Qurm	6. Bandar Khayran	7. Qurayyat	8. Sur	9. Hajar/Quq, + Jaramah	10. Sur Masirah	11. Filim/Barr al Hikman	12. Duqm	13. Al Demer	14. Rowri	15. Taqah	16. Dahariz
Stone Curlew					r		r							r		
Spotted Thick-knee											r			r		r
Great Stone Plover	u				r		r									
Cream-coloured Courser					r		r			r	r	r		r	r	
Collared Pratincole					r		r	r						r	r	u
Black-winged Pratincole					v											
Little Pratincole														r	r	r
Little Ringed Plover	u	r	r		f		u	r	r	u	r			f	f	c
Ringed Plover	u	f	f		c		u	c	u	u	c	f		c	f	a
Kentish Plover	c	c	c		a		c	c	c	c	a	f		c	a	a
Lesser Sand Plover	c		c		a		c	c	a	c	a	c		f	f	c
Greater Sand Plover	c	f	c		a		c	c	c	c	c	f		u	f	f
Caspian Plover					r		r			r	r			r	r	r
Pacific Golden Plover	u	u	f		c		f	f	u	f	u	u		f	f	f
European Golden Plover					v									v		v
Grey Plover	c	u	c		a		c	c	a	c	a	c		c	f	c
Spur-winged Plover															r	r
Red-wattled Plover	f	f	f		c		a	u						r	r	r
White-tailed Plover					r		r				r			r	u	r
Lapwing					r		r								r	r
Great Knot					r						u					
Knot			r													v
Sanderling	c	c	c		c		f	u	u	c	a	f		u	f	c
Little Stint	f		f		a		c	c	c	c	a	c		c	c	a
Temminck's Stint	u		u		f		u	r	r	r	r	r		c	c	f
Long-toed Stint														r	r	u
Pectoral Sandpiper														v		
Sharp-tailed Sandpiper															v	
Curlew Sandpiper	u	u	f		c		f	f	u	f	c	u		f	f	f
Dunlin	c	u	c		a		c	c	c	f	c	f		c	f	f
Broad-billed Sandpiper	u		u		u		u	u	u	f	c	r		u	u	u
Ruff	u	u	r		a		f	f	u	r				c	c	a
Jack Snipe					r									u	u	r
Common Snipe	u		r		c		u	r		r	r			c	f	c
Great Snipe					v											
Pintail Snipe					r									u	u	r
Long-billed Dowitcher															v	
Black-tailed Godwit	u		u		u		u	f		u	r	r		c	f	f
Bar-tailed Godwit	c	c	c		a		c	c	a	c	a	c		f	f	f
Whimbrel	c	f	f		a		c	c	a	c	c	f		u	f	f
Slender-billed Curlew											v					
Curlew	a	c	c		a		c	c	a	c	a	c		c	c	f
Far Eastern Curlew											v					

Common Name	1. Shinas	2. Liwa	3. Sawadi	4. Haradi	5. Qurm	6. Bandar Khayran	7. Qurayyat	8. Sur	9. Hajar/Quq, + Jaramah	10. Sur Masirah	11. Filim/Barr al Hikman	12. Duqm	13. Al Demer	14. Rowri	15. Taqah	16. Dahariz
Spotted Redshank		r			r		u		r		r			u	u	u
Redshank	a	a	c		a		c	c	a	c	a	c		c	a	a
Marsh Sandpiper	u	r	u		u		u	f	u	r	u			f	f	f
Greenshank	c	c	c		a		c	c	c	f	c	f		a	a	a
Green Sandpiper	u	u	u		c		f	r	u	r	r			c	f	f
Wood Sandpiper	r		r		c		f	f	r					c	c	c
Terek Sandpiper	c	f	c		a		c	c	a	c	c	u		f	f	c
Common Sandpiper	c	c	f		a		c	c	u	f	f	u		a	a	a
Turnstone	f	f	f		f		c	c	f	c	a	f		u	f	f
Wilson's Phalarope															v	v
Red-necked Phalarope	u		u		u		u	u	r	u	r	r		r	r	r
Grey Phalarope					v									v		
Pomarine Skua			u		r		u	r	r	f	r	r		r	r	r
Arctic Skua	u	r	u		r		u	f		f	u	r		r	r	r
Long-tailed Skua					v											
Sooty Gull	c	a	c		a		c	c	u	c	a	a		a	a	a
Great Black-headed Gull	c	f	c		c		c	c	u	f	c	c		u	u	f
Black-headed Gull	f	u	c		c		c	c	u	f	f	f		f	f	f
Brown-headed Gull															c	
Slender-billed Gull	c	c	c		a		c	c	c	c	c	c		f		c
Common Gull								r								
Baltic Gull							r	r			r					r
Caspian Gull	a	a	a		c		a	a	u	a	a	a		a	a	a
Siberian Gull	u	u	f		u		f	f	u	a	a	a		a	a	a
Kittiwake															v	
Gull-billed Tern	u		u		r		u	f	c	f	c	f		u	f	f
Caspian Tern	f	u	c		f		f	c	c	c	c	c		r	f	f
Swift Tern	c	a	a		a		a	c	c	f	c	a		c	a	a
Lesser Crested Tern	c	a	c		c		c	c	r	f	c	f		r	f	f
Sandwich Tern	c	a	a		a		a	c	c	f	c	c		f	c	a
Roseate Tern			u		r		u			u	r				r	r
Common Tern	c	u	f		f		f	u	u	u	r	r		f	f	f
White-cheeked Tern	c	f	c		c		c	f	u	f	u	r		u	f	f
Bridled Tern	u		u		r		f	u		u	r	r		u	u	u
Little Tern	r				r			r	r					r	r	r
Saunders's Tern	f	u	f		r		u	r	u	c	c	f		u	f	f
Whiskered Tern	u		r		u		u	u	r	r	r	r		a	f	a
Black Tern															v	
White-winged Black Tern	r				r		u	r			r	r		c	u	f
Common Noddy			u				r			r	r			r		r
Indian Skimmer					v											
White-collared Kingfisher	u	u			r						r					
Grey-headed Kingfisher														u	r	r

Common Name	1. Shinas	2. Liwa	3. Sawadi	4. Haradi	5. Qurm	6. Bandar Khayran	7. Qurayyat	8. Sur	9. Hajar/Quq, + Jaramah	10. Sur Masirah	11. Filim/Barr al Hikman	12. Duqm	13. Al Demer	14. Rowri	15. Taqah	16. Dahariz
Common Kingfisher	c	c	u		a		c	r	r		u			r	u	r
Pied Kingfisher														v		
Water Pipit	r				r						r			r		r
Yellow Wagtail	u				c		u	u	r	r	u			c	f	f
Citrine Wagtail	u				u		u	u	r					c	f	f
Grey Wagtail					r		r			r				r	r	r
White Wagtail	u		u		c		f	u		r	f			f	f	f
Graceful Prinia	c	u	u		a		c	u						u	a	a
Scrub Warbler							r									
Grasshopper Warbler					v											v
Savi's warbler					v											
Moustached Warbler																
Sedge Warbler					r										r	r
Marsh Warbler	r				r		r							u	u	r
European Reed Warbler	u				r			r			r			r	u	f
Clamorous Reed Warbler	c	c			a		r	r	r		u			f	f	f
Great Reed Warbler					r									r	r	r
Olivaceous Warbler	u		u		u		r	r	r	r	r			u	r	r
Sykes's Warbler	u	u														
Upcher's Warbler			u		r		r	r			r			r		r
Menetries's Warbler			u		u		u	r		r	r			r		r
Desert Warbler	r	r	u		u		u			r	u			r		
Arabian Warbler														u	r	r
Orphean Warbler	r		u		r		u	r						r		
Barred Warbler					r											
Lesser Whitethroat			r		r		r			u				r	r	r
Desert Lesser Whitethroat	u	u	u		u		f	u	u	r				r	r	
Whitethroat					u		u	r		u	r			u	r	r
Wood Warbler	r				r					r	r			r	r	
Plain Leaf Warbler							r									
Chiffchaff	f	u	u		f		r		r	f	u			u	r	r
Willow Warbler					r					r				r	r	
Spotted Flycatcher	r		f		f		u	u		r	r			u	u	u
Arabin Babbler	u		f		a		c	r			r					
Purple Sunbird	c	u	f		a		c	f								
Shining Sunbird														f	u	f
Palestine Sunbird														u	u	u
White-breasted White-eye														u	r	r
Oriental White-eye											r					

Source: Oman Bird Record Database.
a=abundant; c=common; f= fairly common; uncommon; r=rare; v=vagrant

1.6 List of Fish from Mangroves and Khawrs of Oman

Genus	Species	Qurm	Mahout	Dhofar	Harmul	All sites
Taeniura	lymma		1			
Tenualosa	*toli*			1		
Nematolosa	*nasus*	1		1		
Sardinella	*sp*			1		
Sardinella	*longiceps*		1			
Stelophorus	*indicus*		1			
Thryssa	*mystax*		1			
Elops	*machnata*			1		
Megalops	*cyprinoides*			1		
Anguilla	*sp*			1		
Chanos	*chanos*	1	1	1	1	1
Arius	*thallasinus*		1			
Plotosus	*lineatus*			1	1	
Hemiramphus	*far*		1			
Hyporhamphus	*sp*			1		
Hyporhamphus	*dussumieri*	1				
Aphanius	*dispar*	1	1	1	1	1
Cociella	*crocodila*	1				
Platycephalus	*indicus*	1	1		1	
Atherinomorous	*lacunosus*			1		
Ambassis	*gymnocephalus*	1			1	
Ambassis	*natalensis*	1	1	1		1
Terapon	*jarbua*	1	1	1	1	1
Terapon	*theraps*			1		
Apogon	*spp*		1			
Sillago	*sihama*		1			
Pomatomus	*saltatrix*		1	1		
Echeneis	*naucrates*	1	1			
Carangoides	*malabaricus*			1	1	
Caranx	*ignobilis*			1		
Caranx	*sexfasciatus*	1	1	1		1
Trachinotus	*africanus*			1		
Trachinotus	*blochii*			1		
Scomberoides	*tol*			1		
Lutjanus	*argentimaculatus*			1	1	
Lutjanus	*coeroleolineatus*	1	1			
Lutjanus	*ehrenbergi*	1	1		1	
Lutjanus	*sp*			1		
Gerres	*abbreviatus*	1	1			
Gerres	*oyena*	1	1		1	
Gerres	*filamentosus*	1	1	1	1	1
Leiognathus	*fasciatus*		1	1	1	
Argyrops	*spinifer*		1	1		
Argyrosomus	*heinii*			1		
Otolithes	*ruber*			1		
Monodactylus	*argenteus*	1		1	1	

Genus	Species	Qurm	Mahout	Dhofar	Harmul	All sites
Pomadasys	*argenteus*			1	1	
Pomadasys	*commersonnii*	1	1			
Pomadasys	*kaakan*			1		
Pomadasys	*multimaculatum*	1	1	1		
Acanthopagrus	*berda*	1			1	
Acanthopagrus	*bifasciatus*	1	1			
Acanthopagrus	*latus*				1	
Rhabdosargus	*sarba*	1	1			
Rhabdosargus	*haffara*				1	
Plectorhinchus	*gaterinus*			1		
Plectorhinchus	*gibbosus*			1		
Plectorhinchus	*sordidus*			1		
Plectorhinchus	*pictus*			1		
Plectorhinchus	*schotaf*			1		
Plectorhinchus	*sp*				1	
Mulloides	*flavolineatus*	1	1			
Chelon	*persicus*				1	
Moolgarda	*perdaraki*				1	
Liza	*subviridis*			1		
Liza	*macrolepis*	1		1		
Liza	*tade*			1		
Mugil	*cephalus*	1		1		
Valamugil	*seheli*	1	1	1		1
Sphyraena	*barracuda*	1		1		
Sphyraena	*jello*			1		
Parapercis	*nebulosus*			1		
Ophiocara	*porocephala*			1		
Istiblennius	*lineatus*	1	1			
Amoya	*grisea*	1				
Cryptocentroides	*sp*	1	1			
Favonigobius	*rechei*	1	1			
Favonigobius	*sp*	1				
Gobius	*nebulosus*	1	1			
Glossogobius	*biocellatus*	1	1			
Istiogobius	*decuratus*	1	1			
Bathygobius	*sp*				1	
Gobiidae	*spp*			1		
Oxyurichthys	*opthalmonema*	1	1			
Periopthalmus	*koelreuteri*		1			
Siganus	*canaliculatus*	1				
Trichiurus	*lepturus*		1			
Bothus	*sp*	1	1			
Solea	*elongata*	1				
Arothron	*immaculatus*		1			
Chilocmycterus	*orbicularis*	1	1			
Total		40	41	47	21	7

Source: TS-PCDEGD 1993, Fouda 1995, Fouda & Muharrami 1996, Atkins 2001

1.7 List of Crustacea Recorded for Oman Khawrs and Mangroves

Genus	Species	Family	Dhofar	Mahawt	Qurayyat	Qurm 94	Qurm 96	Harmul	Shinas
Balanus	*amphitrite*	Balanidae				1			
Balanus	*sp*	Balanidae		1			1		1
Chthamalus	*malayensis*	Balanidae		1	1		1		1
Mutata	*lunaris*	Calappidae	1		1	1	1	1	
Callichirus	*sp*	Callianassidae	1						
Alpheus	*crassimanus*	Caridea			1				
Alpheus	*lobidens*	Caridea	1					1	
Cardisoma	*carnifex*	Geocarcinidae	1						
Chiromanthus	*sp*	Grapsidae	1			1			
Grapsus	*albolineatus*	Grapsidae	1	1		1	1		1
Grapsus	*granulatus*	Grapsidae		1			1		1
Grapsus	*kukuhar*	Grapsidae		1			1		
Grapsus	*tenuicrustatus*	Grapsidae		1			1		
Helice	*leachii*	Grapsidae	1			1			
Metapograpsus	*frontalis*	Grapsidae		1			1		
Metapograpsus	*messor*	Grapsidae	1	1	1		1		1
Metapograpsus	*thukuhar*	Grapsidae		1		1	1		
Perisesarma	*guttatum*	Grapsidae				1			
Ligia	*exotica*	Isopoda	1						
Cleistosoma	*sp*	Ocypodidae		1					
Dotilla	*sulcata*	Ocypodidae			1	1			
Macrophthalmus	*depressus*	Ocypodidae	1	1	1	1	1		
Macrophthalmus	*grandidieri*	Ocypodidae				1			
Macrophthalmus	*messor*	Ocypodidae				1			
Macrophthalmus	*sp*	Ocypodidae		1					
Metaplax	*indica*	Ocypodidae		1		1	1		1
Ocypode	*ceriatopthalmus*	Ocypodidae					1		
Ocypode	*saratan*	Ocypodidae	1	1	1	1	1		
Scoperimera	*scabricauda*	Ocypodidae			1	1			
Uca	*arculata*	Ocypodidae		1			1		
Uca	*inversa*	Ocypodidae	1	1	1	1	1	1	
Uca	*lactea*	Ocypodidae		1		1	1		
Uca	*tetragonon*	Ocypodidae		1			1		1
Uca	*thulusca*	Ocypodidae		1			1		1
Uca	*vocans*	Ocypodidae				1			
Coenobita	*scaevola*	Paguridae	1			1			
Diogenes	*sp*	Paguridae		1	1	1			
Nematopagurus	*sp*	Paguridae		1			1		
Metapenaeus	*monoceros*	Penaedae	1	1		1			
Penaeus	*indicus*	Penaedae	1	1		1	1	1	
Penaeus	*semisulcatus*	Penaedae	1	1		1		1	

Genus	Species	Family	Dhofar	Mahawt	Qurayyat	Qurm 94	Qurm 96	Harmul	Shinas
Portunus	*pelagicus*	Portunidae		1	1	1	1	1	1
Scylla	*serrata*	Portunidae	1	1	1	1	1	1	1
Thalamita	*adenete*	Portunidae					1		
Thalamita	*crenata*	Portunidae			1		1		
Thalamita	*edwardsi*	Portunidae					1		
Clappa	*hepotica*	Xanthidae		1					
Eurycarcinus	*orientalis*	Xanthidae			1	1			
Exanthid	*sp*	Xanthidae			1				
Leptodius	*exaratus*	Xanthidae	1						
Ozius	*gutatus*	Xanthidae						1	
Callinectes	*sapidens*			1			1		
Nasima	*dotilleformis*					1			
Pisidia	*sp*			1					
Pterolithes	*sp*			1					
Serenella	*leachii*					1			
Total			18	30	15	27	27	8	10

Source: Salm 1985, TS-PCDEGD 1993, Hywel-Davies 1994, Fouda and Muharrami 1996, Atkins 2001, Gibb 1993

Crustacea Recorded from Khawrs of Oman, 2003

N.versicolor & *P.plicatum* kindly identified by Dr P.J.Hogarth, York University, UK

Genus	Species	1	2	3	4	5	6	7	8,9	10	11	12	13	14	15	16	17	18	19	20	21	Family
Alpheus	*sp*	x					x	x			x											Alpheidae
Callichirus	*sp*			x		x	x				x						x			x		Callianasidae
Cardisoma	*carnifex*																	x		x	x	Geocarcinidae
Helice	*leachii*							x														Grapsidae
Metaplax	*indica*												x									Grapsidae
Metopograpsus	*messor*	x				x					x			x								Grapsidae
Metopograpsus	*thukuhar*	x	x			x	x		x					x								Grapsidae
Neoepisesarma	*versicolor*													x								Grapsidae
Parasesarma	*plicatum*													x								Grapsidae
Perisesarma	*guttatum*	x	x			x	x		x				x	x								Grapsidae
Macrophthalmus	*depressus*	x				x	x	x			x	x	x	x			x					Ocypodidae
Macrophthalmus	*grandidieri*													x								Ocypodidae
Nasima	*dotilliformis*	x				x							x	x								Ocypodidae
Leptochryseus	*kuwaitense*													x								Ocypodidae
Ocypode	*jousseaumei*									x	x											Ocypodidae
Ocypode	*rotundata*	x	x	x																		Ocypodidae
Ocypode	*saratan*									x				x	x	x	x	x	x	x	x	Ocypodidae
Scopimera	*crabricauda*			x								x										Ocypodidae
Serenella	*leachii*	x				x	x		?				x	x								Ocypodidae
Uca	*vocans*					x	x															Ocypodidae
Uca	*inversa*	x			x	x		x	x			x		x								Ocypodidae
Uca	*annulipes*	x	x			x	x	x	x	x	x		x	x								Palaemonidae
Palaemon	*sp*					x								x				x	x			Penaedae
Penaeus	*sp*						x															Pilumnidae
Eurycarcinus	*orientalis*	x	x			x	x		x				x	x								Portunidae
Portunus	*pelagicus*					x						x	x	x								Portunidae
Thalamita	*crenata*		x				x															Portunidae
Scylla	*serrata*					x																Portunidae
Total		11	6	3	1	14	11	5	6	3	6	4	8	16	1	1	3	3	2	3	2	

1=Shinas, 2=Harmul, 3=Suwadi, 4=Haradi, 5=Qurm, 6=B. Khayran, 7=Quriyat, 8,9=Sur, 10=Quq, 11=Hajar, 12=Muraisis, 13=Filim, 14=Mahawt, 15=Demer, 16=Rawri, 17=Taqah, 18=Dahariz, 19=Balid, 20=Kabir, 21=Saghir

1.8 List of Molluscs from Mangroves of Oman

Genus	Species	Family	English	Qurm	Mahawt
Acteon	*affinis*	Acteonidae	Acteons	1	
Aplysia	*cornigera*	Aplysiidae	Sea hare	1	
Barnardaclesia	*cirrhifera*	Aplysiidae	Sea Hare	1	
Architectonica	*laevigata*	Architectonicidae	Sundials	1	
Acar	*plicata*	Arcidae	Ark shells	1	1
Barbatia	*helblingii*	Arcidae	Ark shells	1	1
Barbatia	*obliquata*	Arcidae	Ark shells	1	1
Engina	*mendicaria*	Buccinidae	Whelks	1	1
Cerithium	*caeruleum*	Cerithidae	Ceriths	1	
Cerithium	*scabridum*	Cerithidae	Ceriths	1	1
Cerithium	*columna*	Cerithidae	Ceriths	1	
Clypeomorus	*bifasciatus*	Cerithidae	Ceriths	1	
Mitrella	*cartwrightii*	Collumbellidae	Dove shells	1	
Corbula	*modesta*	Corbulidae	Basket clam	1	
Vexillum	*acuminatum*	Costellaridae	Miter shells	1	
Cypraea	*felina fabula*	Cypraeidae	Cowries	1	
Cypraea	*gracilis*	Cypraeidae	Cowries	1	
Cypraea	*turdus*	Cypraeidae	Cowries	1	1
Dentallium	*octagulatum*	Dentaliidae	Tusk shells	1	1
Latirus	*nassatula forskali*	Fasciolariidae	Latirus	1	1
Diodora	*bombayana*	Fissurellidae	Key hole limpet	1	
Fissurella	*townsendi*	Fissurellidae	Key hole limpet	1	
Atys	*cylindrica*	Hamineidae	Paper bubble	1	1
Isognomon	*legumen*	Isognomonidae	Tree Oyster	1	
Nassarius	*albescens gemmuliferus*	Nassariidae	Dog whelk	1	
Nassarius	*arcularius plicatus*	Nassariidae	Dog whelk	1	
Nassarius	*deshayesiana*	Nassariidae	Dog whelk	1	
Natica	*pulicaris*	Naticidae	Moon shell	1	1
Polinices	*tumidus*	Naticidae	Moon shell	1	1
Nerita	*abicilla*	Neritidae	Nerites	1	1
Nerita	*ademensis*	Neritidae	Nerites	1	
Ancilla	*scaphella*	Olividae	Olives	1	1
Oliva	*bulbosa*	Olividae	Olives	1	1
Alectryonella	*plicatula*	Ostreidae	Oysters	1	1
Saccostrea	*cucullata*	Ostreidae	Oysters	1	1
Pinna	*muricata*	Pinnidae	Pen shells	1	1
Planaxis	*sulcatus*	Planaxidae	Planaxis	1	
Cerithidea	*cingulata*	Potamididae	Horn shell	1	1
Pirinella	*conica*	Potamididae	Horn shell	1	1

Genus	Species	Family	English	Qurm	Mahawt
Terebralia	*palustris*	Potamididae	Horn shell	1	1
Gari	*occidens*	Psammobiidae	Sunset shells	1	
Pinctada	*radiata*	Pteriidae	Wing oyster	1	1
Strombus	*decorus persicus*	Strombidae	Conch	1	1
Strombus	*gibberulus*	Strombidae	Conch	1	1
Thais	*tissoti*	Thaididae	Rock shell	1	
Umbonium	*vestiarium*	Trochidae		1	1
Callista	*erycina*	Veneridae	Venus clam	1	1
Callista	*lilacina*	Veneridae	Venus clam	1	1
Circe	*corrugata*	Veneridae	Venus clam	1	1
Circenita	*callipyga*	Veneridae	Venus clam	1	1
Dosinia	*alta*	Veneridae	Venus clam	1	1
Marcia	*ceylonensis*	Veneridae	Venus clam	1	1
Vermetus	*sulcatus*	Vermitidae	Venus clam	1	
Bullaria	*ampulla*			1	1
Chiton	*peregrinus*		Chiton	1	
Euchelus	*asper*			1	1
Onchididium	*daemelli*				1
Thracia	*adenensis*			1	1
Venerupis	*deshayesii*			1	1
Total				58	35

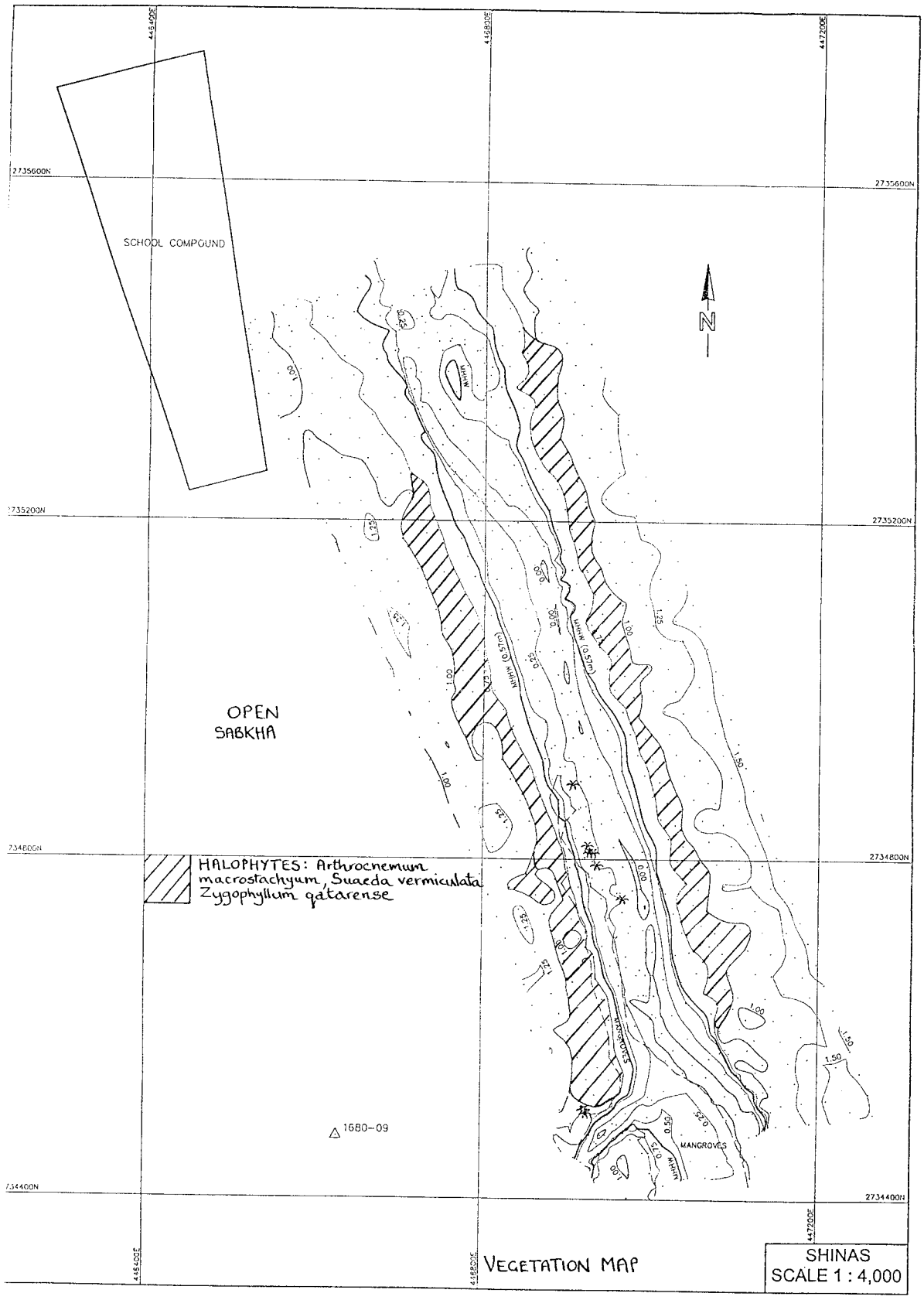
Source: Smythe 1983, Fouda and Muharrami 1996

Molluscs Recorded from Khawrs of Oman, 2003

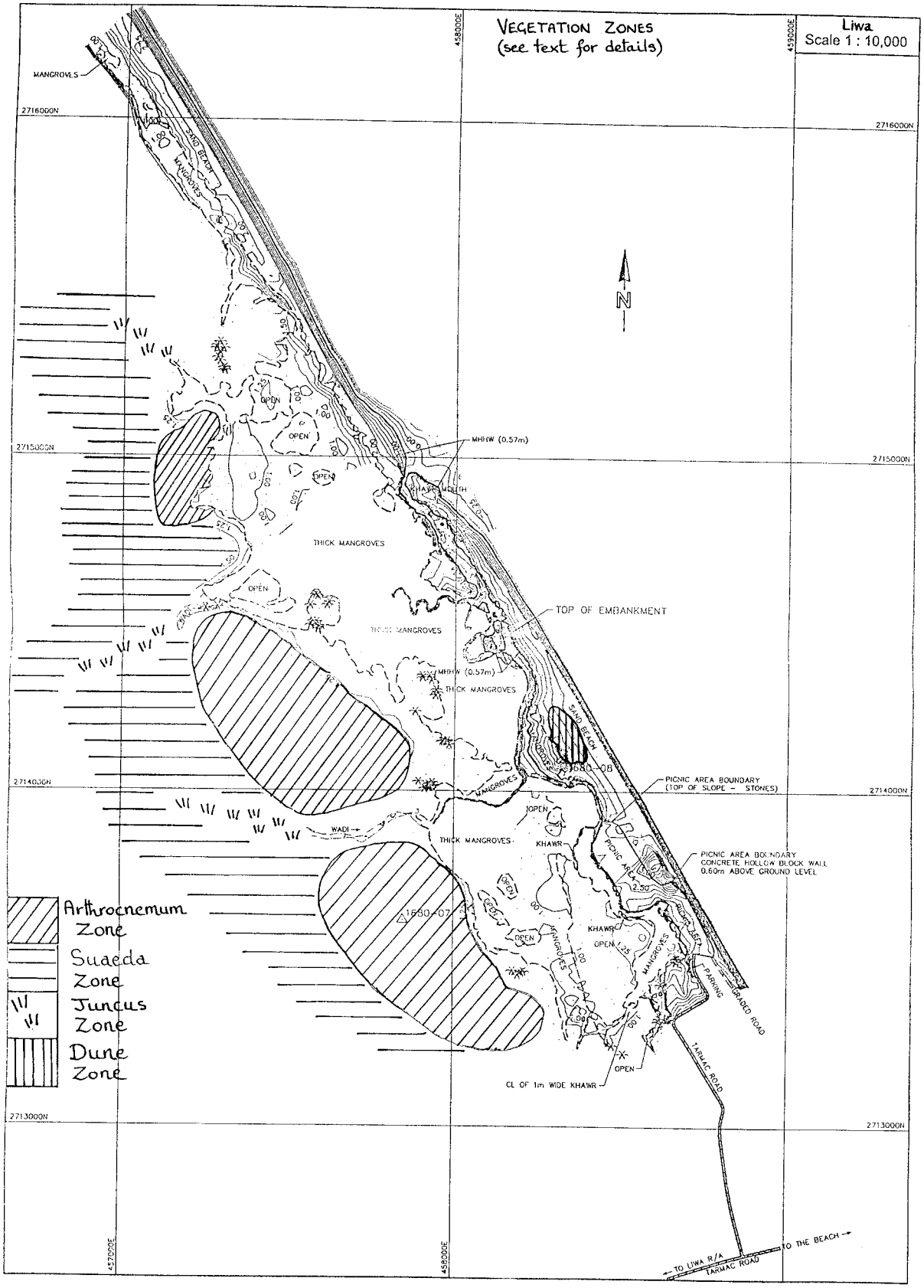
Genus	Species	1	2	3	4	5	6	7	8,9	10	11	12	13	14	15	16	17	18	19	20	21	Family
Bivalves																						
Plagiocardium	*pseudolima*													x								Cardidae
Isognomon	*legumen*					x																Isognomonidae
Laternula	*erythraensis*	x	x									x										Laternulidae
Modiolus	*sp*	x																				Modiolinae
Musculista	*senhousta*																	x		x		Mytilidae
Alectryonella	*plicatula*					x								x								Ostreidae
Saccostrea	*cucullata*	x				x	x		x	x	x											Ostreidae
Tellina	*arsinoides*												x	x								Tellinidae
Tellina	*valtonis*										x											Tellinidae
Dosinia	*alta*	x	x			x			x	x	x	x	x									Veneridae
Dosinia	*contracta*			x																		Veneridae
Marcia	*opima*					x			x					x								Veneridae
Gastropods																						
Cerithium	*caeruleum*					x																Cerithidae
Cerithium	*scabridum*	x				x								x								Cerithidae
Clypeomorus	*bifasciatus*					x																Cerithidae
Mitrella	*blanda*						x					x	x									Columbellidae
Hydrobia	*sp*																	x	x	x		Hydrobiidae
Nassarius	*albescens gemmuliferus*					x					x											Nassariidae
Nassarius	*arcularius plicatus*					x	x				x	x	x	x								Nassariidae
Nassarius	*coronatus*					x					x											Nassariidae
Nerita	*abicilla*	x				x																Neritidae
Planaxis	*sulcatus*					x								x								Planaxidae
Cerithidea	*cingulata*	x	x	x		x	x	x	x	x	x	x	x	x								Potamididae
Pirinella	*conica*					x																Potamididae
Terebralia	*palustris*	x	x			x																Potamididae
Umbonium	*vestiarium*	x		x		x					x		x	x								Trochidae
Pulmonate																						
Onchididium	*peronii*					x								x								Onchididae
Total		9	4	3	0	18	4	1	4	3	8	5	6	10	0	0	0	2	1	2	0	

1=Shinas, 2=Harmul, 3=Suwadi, 4=Haradi, 5=Qurm, 6=B. Khayran, 7=Quriyat, 8,9=Sur, 10=Quq, 11=Hajar, 12=Muraisis, 13=Filim, 14=Mahawt, 15=Demer, 16=Rawri, 17=Taqah, 18=Dahariz, 19=Balid, 20=Kabir, 21=Saghir

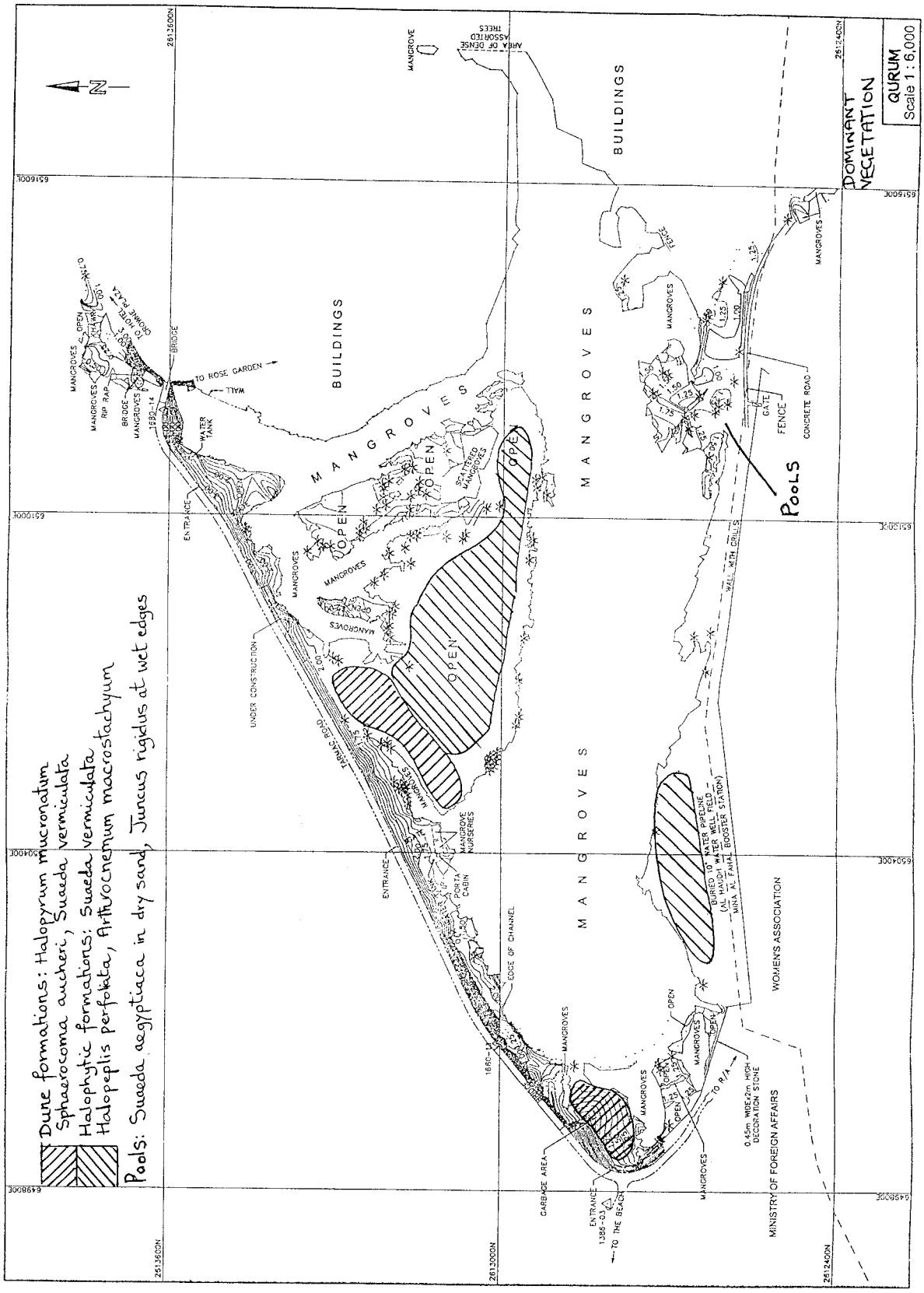
1.9 Vegetation Maps



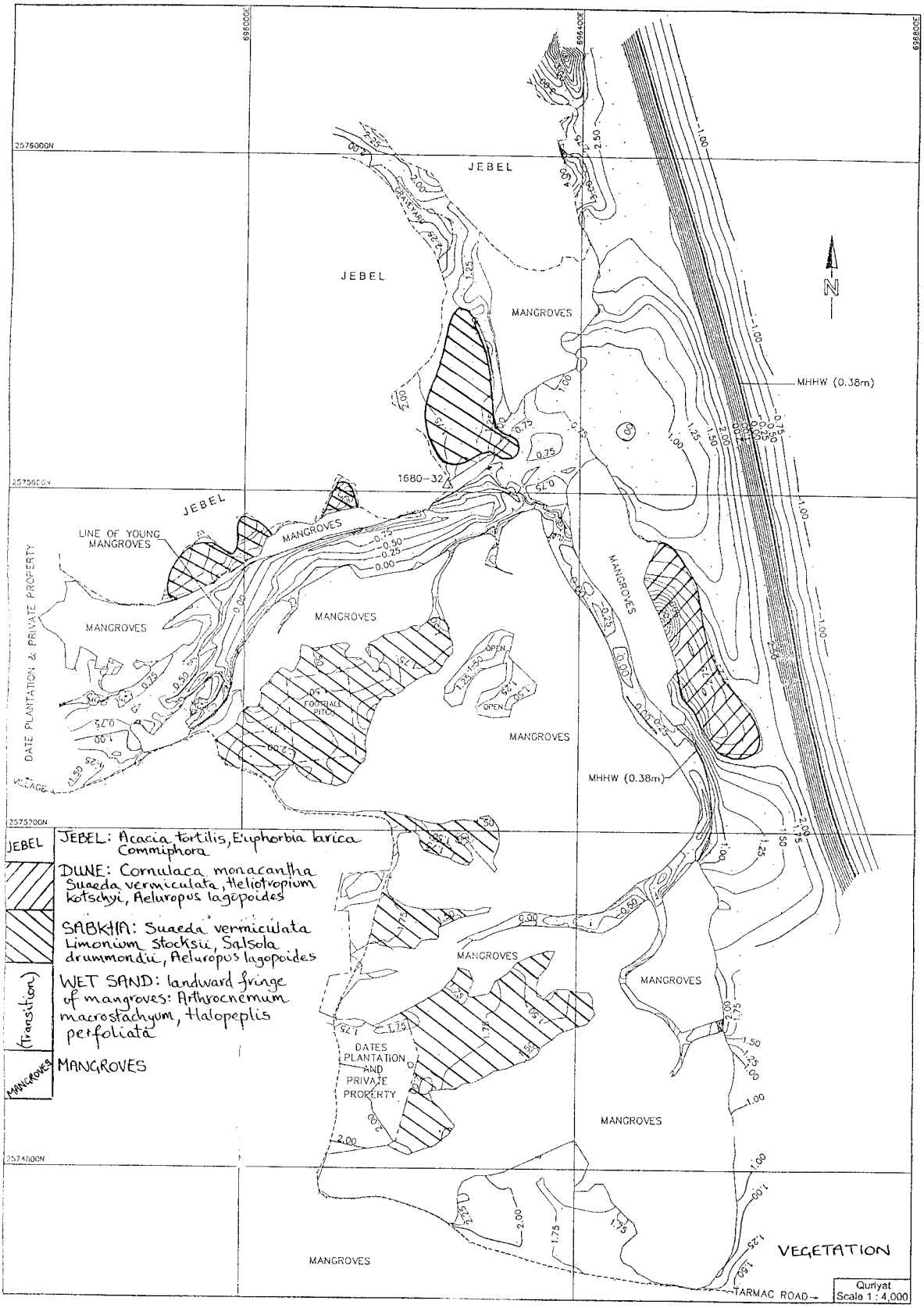
Vegetation Map of Khawr Shinas



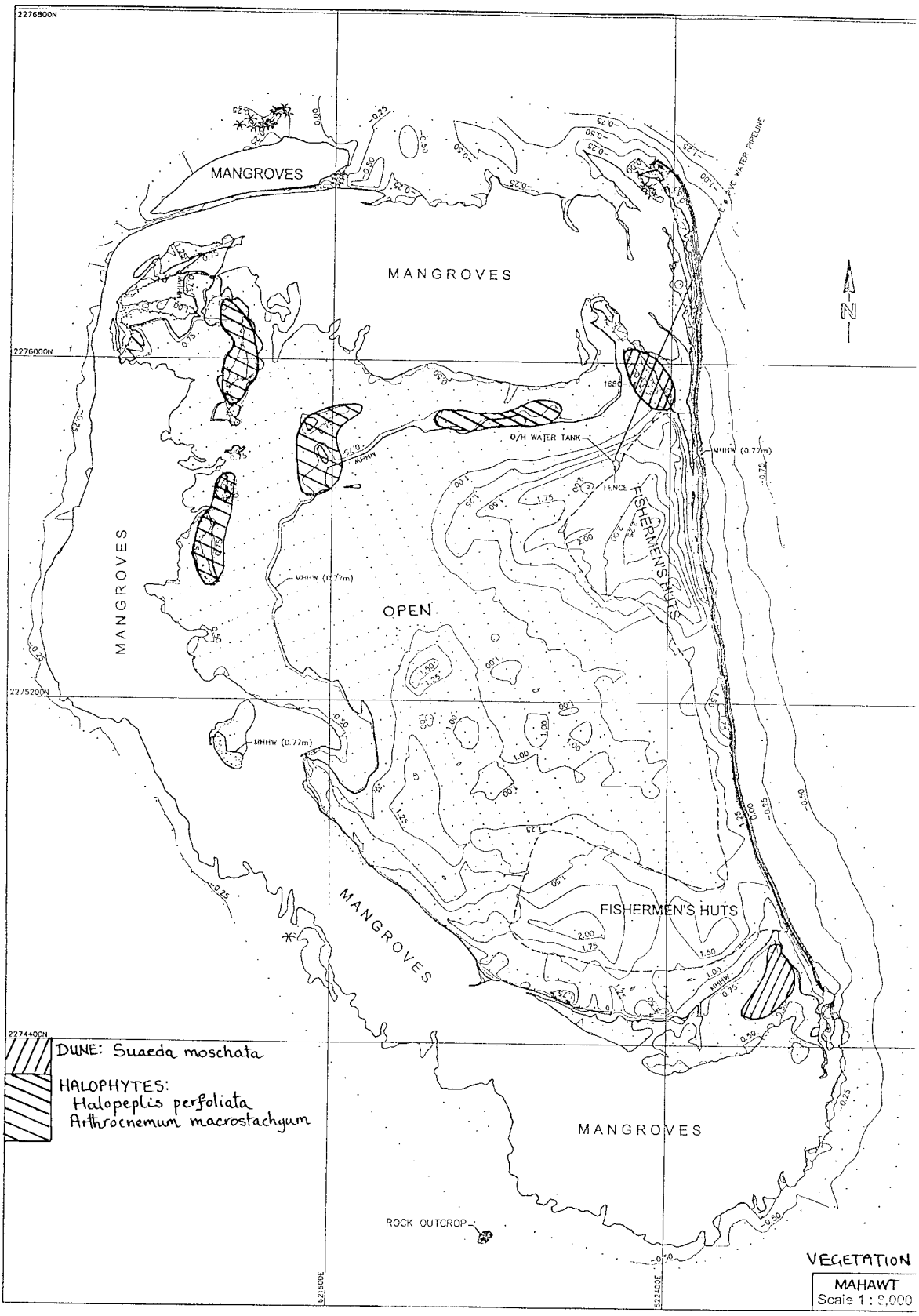
Vegetation Map of Khawr Harmul & Nabr



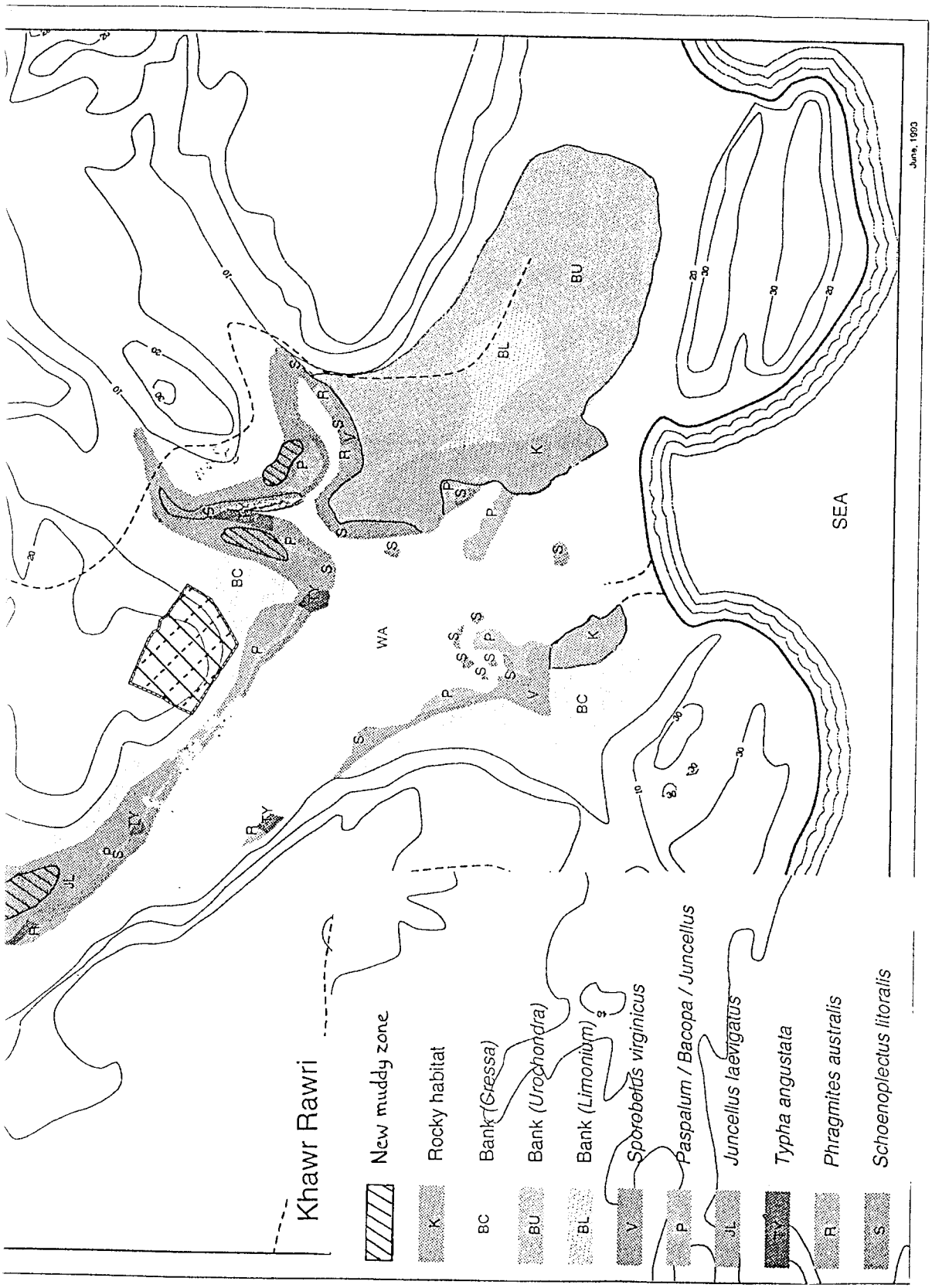
Vegetation Map of Khawr Qurm



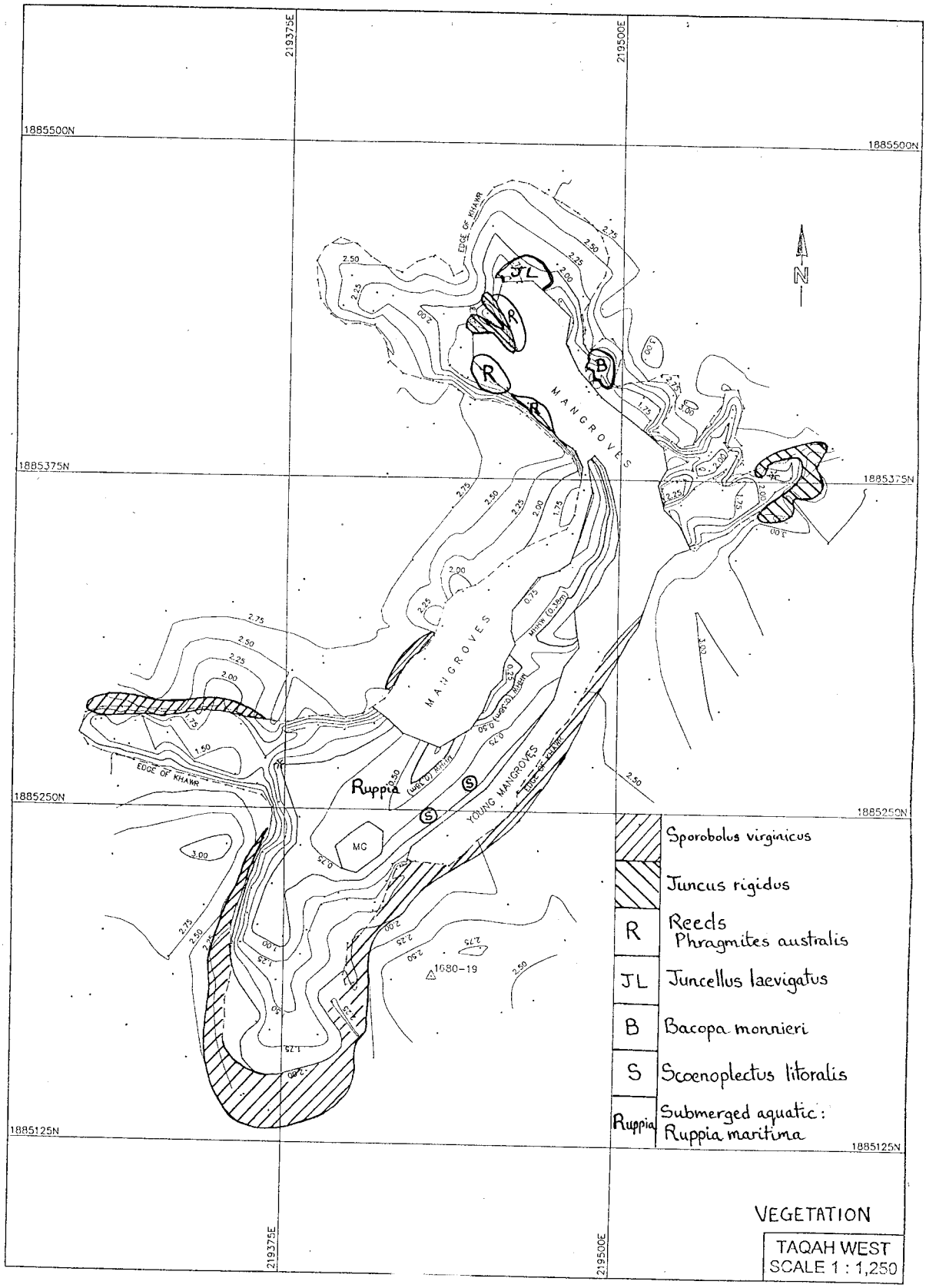
Vegetation Map of Khawr Qurayyat



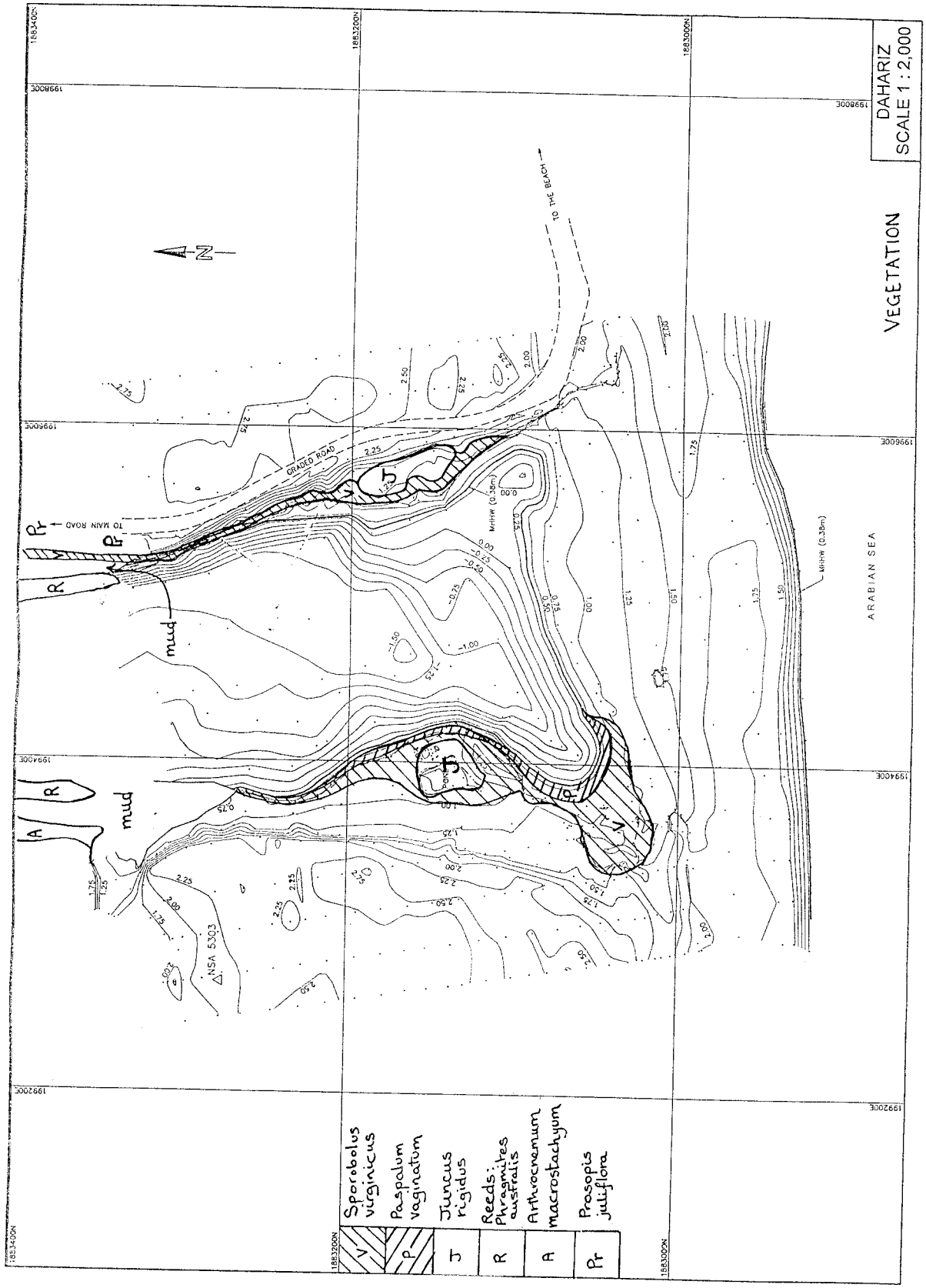
Vegetation Map of Mahawt Island



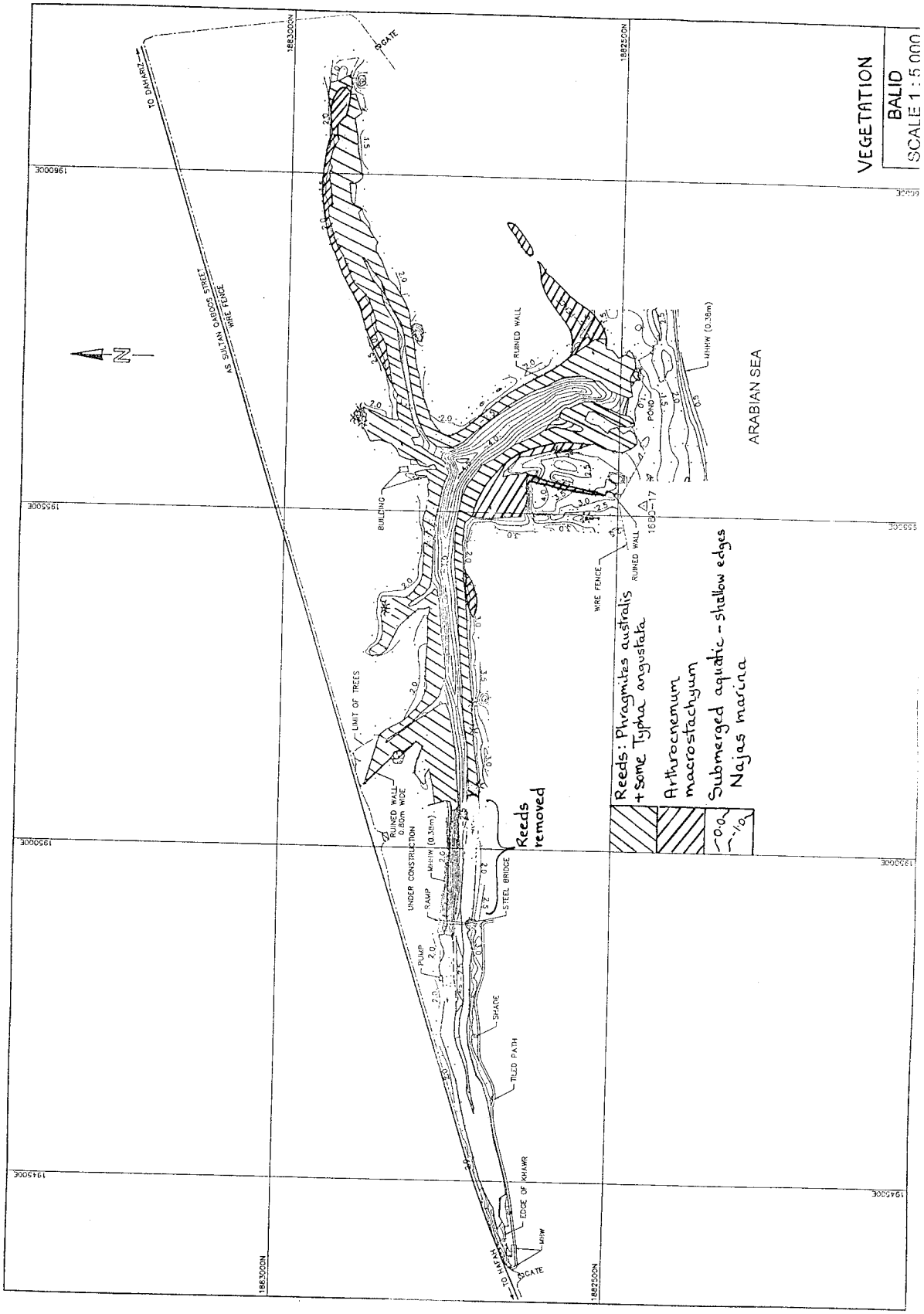
Vegetation Map of Khawr Rowri



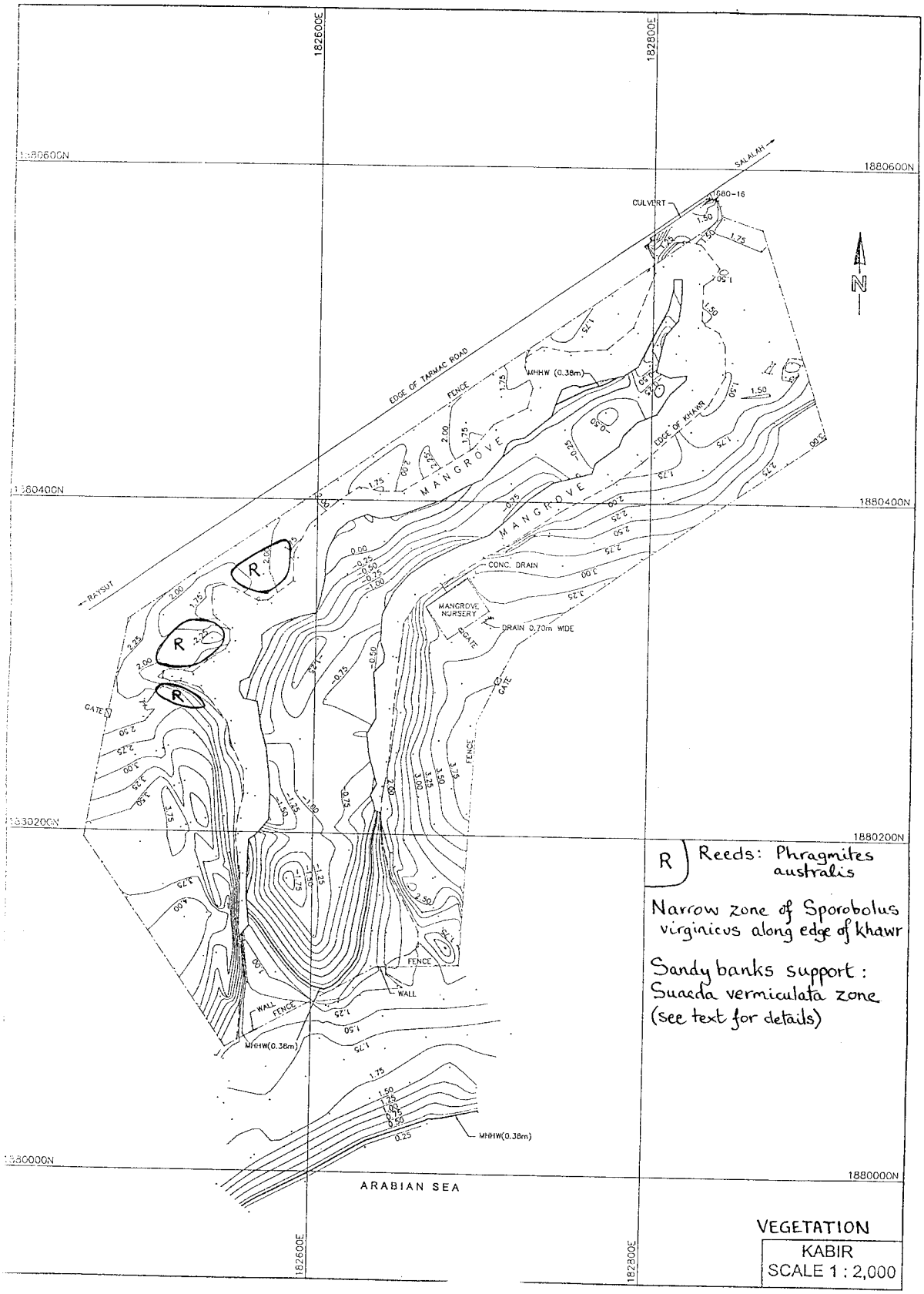
Vegetation Map of Qurm Taqah



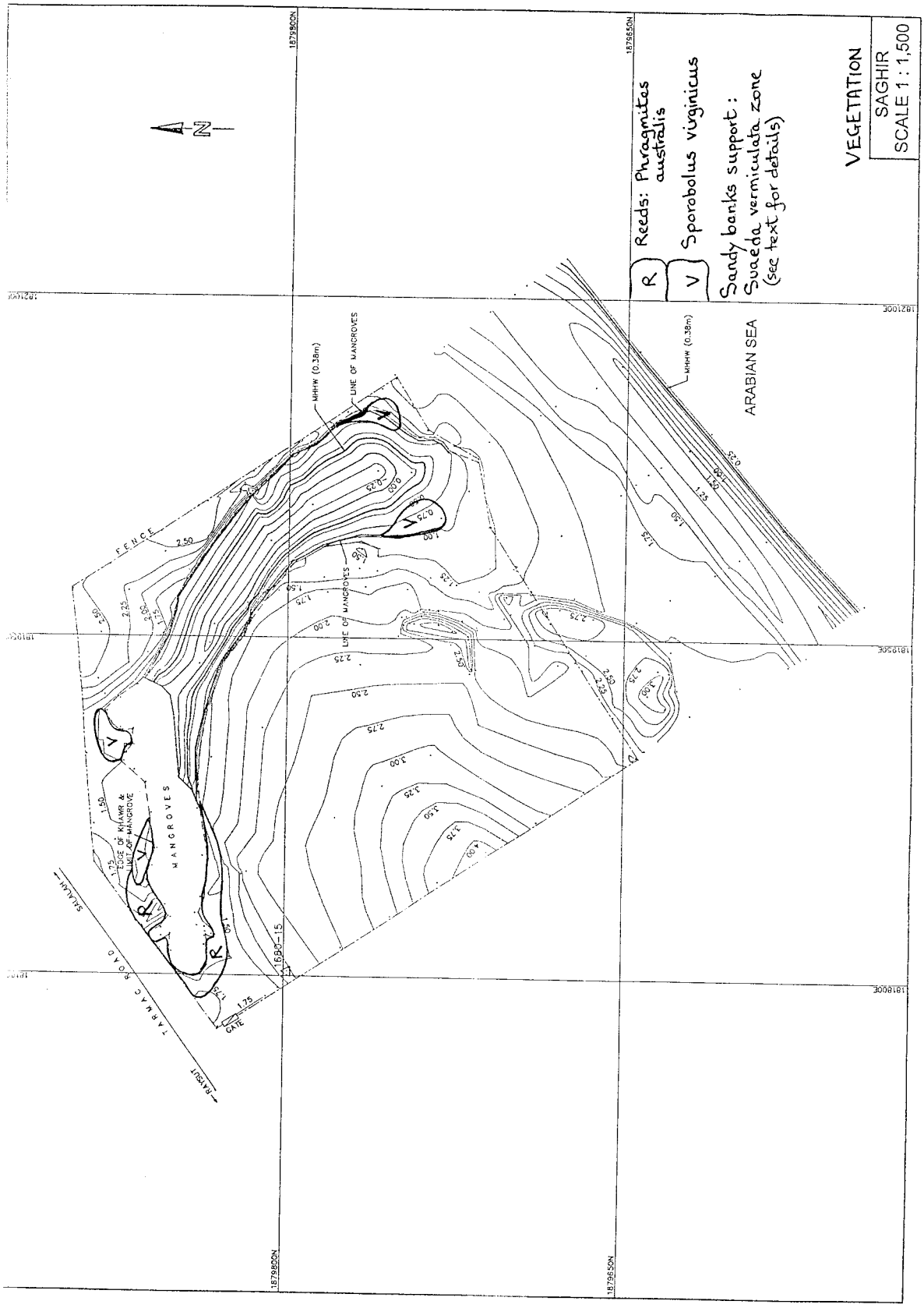
Vegetation Map of Khawr Dahariz



Vegetation Map of Khawr Balid



Vegetation Map of Khawr Kabir



Vegetation Map of Khawr Saghir

2. GIS on Restoration, Conservation and Management of Mangrove

Appendix 2 GIS on Restoration, Conservation and Management of Mangrove

2.1 Preparation of GIS

In order to organise the information collected during the current master plan study, a GIS was prepared mainly based on the survey data on topography, mangrove trees, soil property and water quality. This system can be utilised as baseline data for the future monitoring practice. There is, therefore, including various information such as survey results, panoramic views of remarkable points and the photographs of selected monitoring trees for all survey sites. Monitoring data should be added to this system for observing the changes of selected environmental elements. The system should thus be developed along with the availability of survey data during the monitoring period. For the effective sharing of the information, it is recommended to upload the system to Internet through IMS (Internet Map Server) as a future programme.

2.2 Structure of GIS

ArcView (Version 3.2) was selected as the most prevailing GIS software for the operation of the system. All the information collected during the study were stored in the following manner and the details are shown in Table A2.1.

Main Directory	Sub-Directory		Files
C:¥mangrove	¥project		Project files for each mangrove site and the distribution of all sites prepared by Arc View
	¥image		Geo-referenced remote-sensing image for each site based on Ikonos or LandSat Image
	¥data	¥existingforest	Polygon data of existing mangrove forest prepared by the GIS section
		¥general	General information on administrative border, population, road network and major towns
		¥faunaflora	Description of present condition on fauna, flora and pollution for each mangrove site
		¥mapdata	Topographic survey data prepared under the subcontract of master plan study
		¥panoramadata	Photographs of panoramic view taken at the remarkable points in each site
		¥sitephoto	Photographs of each site on general condition, mangrove condition and soil condition
		¥soildata	Results of soil analysis such as texture, color, hardness of sample soil and underground water condition
		¥soilprofile	Description of soil profile for typical soil pits in each site
		¥treedata	Results of tree survey such as height, diameter and remarks on each sample tree
		¥treephoto	Photographs of distant and near view of sample trees selected for future monitoring
		¥waterdata	Results of water analysis such as color/visibility, pH, salinity, temperature, DO, COD and NO_3

Project files and the information available in different levels are shown in Figure A2.1.

Table A2.1 GIS Directories for Mangrove Project

Main Directory	Sub-directories		File Name	Type	Data Source
c:¥mangrove	¥project		¥aldemer	.apr	
			¥attina	.apr	
			¥balid	.apr	
			¥batah	.apr	
			¥dahariz	.apr	
			¥filim	.apr	
			¥hajar	.apr	
			¥haradi	.apr	
			¥kabir	.apr	
			¥khayran	.apr	
			¥liwa	.apr	
			¥mahawt	.apr	
			¥muraysis	.apr	
			¥oman	.apr	
			¥quq	.apr	
			¥qurayyat	.apr	
			¥qurm	.apr	
			¥rowri	.apr	
			¥saghir	.apr	
			¥sawadi	.apr	
			¥shinas	.apr	
			¥taqah	.apr	
	¥image		¥aldemerimage	.bil	.hdr
			¥attinaimage	.bil	.hdr
			¥balidimage	.bil	.hdr
			¥batahimage	.bil	.hdr
			¥daharizimage	.bil	.hdr
			¥filimimage	.bil	.hdr
			¥hajarimage	.bil	.hdr
			¥haradiimage	.bil	.hdr
			¥khayranimage	.bil	.hdr
			¥liwaimage	.bil	.hdr
			¥mahawtimage	.bil	.hdr
			¥muraysisimage	.bil	.hdr
			¥quqimage	.bil	.hdr
			¥qurayyatimage	.bil	.hdr
			¥qurmimage	.bil	.hdr
			¥rowriimage	.bil	.hdr
			¥saghir_kabir_image	.bil	.hdr
			¥sawadiimage	.bil	.hdr
			¥shinasimage	.bil	.hdr
			¥taqahimage	.bil	.hdr
	¥data	¥existingforest	¥balidmangrove	.shp	
			¥batahmangrove	.shp	
			¥kabirmangrove	.shp	
			¥mahawtmangrove	.shp	
			¥quqmangrove	.shp	
			¥qurayyatmangrove	.shp	
			¥qurmmangrove	.shp	
			¥saghirmangrove	.shp	
			¥sawadimangrove	.shp	
			¥shinasmangrove	.shp	
			¥taqahmangrove	.shp	

Main Directory	Sub-directories	File Name	Type	Data Source
	¥faunaflora	¥aldemerfaunaflora	.tif	.pdf <- .doc
		¥attinafaunaflora	.tif	.pdf <- .doc
		¥balidfaunaflora	.tif	.pdf <- .doc
		¥batahfaunaflora	.tif	.pdf <- .doc
		¥daharizfaunaflora	.tif	.pdf <- .doc
		¥filimfaunaflora	.tif	.pdf <- .doc
		¥hajarfaunaflora	.tif	.pdf <- .doc
		¥haradifaunaflora	.tif	.pdf <- .doc
		¥kabirfaunaflora	.tif	.pdf <- .doc
		¥khayranfaunaflora	.tif	.pdf <- .doc
		¥liwafaunaflora	.tif	.pdf <- .doc
		¥mahawtfaunaflora	.tif	.pdf <- .doc
		¥muraysisfaunaflora	.tif	.pdf <- .doc
		¥quqfaunaflora	.tif	.pdf <- .doc
		¥qurayyatfaunaflora	.tif	.pdf <- .doc
		¥qurmfaunaflora	.tif	.pdf <- .doc
		¥rowrifaunaflora	.tif	.pdf <- .doc
		¥saghirfaunaflora	.tif	.pdf <- .doc
		¥sawadifaunaflora	.tif	.pdf <- .doc
		¥shinasfaunaflora	.tif	.pdf <- .doc
		¥taqahfaunaflora	.tif	.pdf <- .doc
	¥general	¥administrative wilayat shp	.shp	
		¥asphalt road	.shp	
		¥batinah	.shp	
		¥batinahroad	.shp	
		¥batinahtowns	.shp	
		¥dhofar	.shp	
		¥dhofarroad	.shp	
		¥dhofartowns	.shp	
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		¥mangrovesite	.shp	
		¥muscat	.shp	
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		¥muscattowns	.shp	
		¥omanpopulation	.dbf	.xls
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		¥sharqiyahtowns	.shp	
		¥sitelocation	.dbf	.xls
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		¥wustaroad	.shp	
		¥wustatowns	.shp	
	¥mapdata	¥attina1	.dwg	
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		¥attina3	.dwg	
		¥attina	.dxf	
		¥balid	.dwg	
		¥batah1	.dwg	
		¥batah2	.dwg	
		¥batah	.dxf	
		¥dahariz	.dwg	
		¥filim	.dwg	

Main Directory	Sub-directories		File Name	Type	Data Source
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			¥haradi	.dwg	
			¥kabir	.dwg	
			¥khayran	.dwg	
			¥liwa	.dwg	
			¥mahawt	.dwg	
			¥muraysis	.dwg	
			¥quq	.dwg	
			¥qurayyat	.dwg	
			¥qurm	.dxf	
			¥rowri	.dwg	
			¥saghir	.dwg	
			¥sawadi	.dwg	
			¥shinas	.dwg	
			¥taqah	.dwg	
		¥panoramadata¥panoramashp	¥attinapanprama	.shp	
			¥balidpanorama	.shp	
			¥batahpanorama	.shp	
			¥daharizpanorama	.shp	
			¥filimpanorama	.shp	
			¥hajarpanorama	.shp	
			¥kabirpanorama	.shp	
			¥khayranpanorama	.shp	
			¥liwapanorama	.shp	
			¥mahawtpanorama	.shp	
			¥muraisyspanorama	.shp	
			¥quqpanorama	.shp	
			¥qurayyatpanorama	.shp	
			¥qurmpanorama	.shp	
			¥rowripanorama	.shp	
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			¥shinaspanorama	.shp	
			¥taqahpanorama	.shp	
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			¥attinasiteb	.tif	.jpeg
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			¥balidnorthbank	.tif	.jpeg
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			¥batahslaymiyah	.tif	.jpeg
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			¥daharizmouth	.tif	.jpeg
			¥filimsite1	.tif	.jpeg
			¥hajareastshore	.tif	.jpeg
			¥hajarsouthshore	.tif	.jpeg
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			¥kabirwestbank	.tif	.jpeg
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			¥muraysisnortheastbeach	.tif	.jpeg
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			¥qurayyatmouth	.tif	.jpeg
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			¥rowrimouth	.tif	.jpeg
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Main Directory	Sub-directories	File Name	Type	Data Source
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		¥muraysissoil	.shp	.dbf <- .xls
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		¥omansoil	.shp	
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		¥sawadisoil	.shp	.dbf <- .xls
		¥sharqiyahsoil	.shp	
		¥shinassoil	.shp	.dbf <- .xls
		¥taqahsoil	.shp	.dbf <- .xls
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		¥batah2soilprofile	.jpeg	.pdf <- .doc
		¥daharizsoilprofile	.jpeg	.pdf <- .doc
		¥filimsoilprofile	.jpeg	.pdf <- .doc
		¥hajarsoilprofile	.jpeg	.pdf <- .doc
		¥haradisoilprofile	.jpeg	.pdf <- .doc
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Main Directory	Sub-directories		File Name	Type	Data Source
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			¥omantree	.shp	
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			¥khayrantree3a	.tif	.jpeg
			¥khayrantree3b	.tif	.jpeg
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			¥mahawttree3a	.tif	.jpeg
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Main Directory	Sub-directories		File Name	Type	Data Source
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			¥qurmtree1a	.tif	.jpeg
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			¥taqahtree1b	.tif	.jpeg
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			¥batahwater	.shp	.dbf <- .xls
			¥batinahwater	.shp	
			¥daharizwater	.shp	.dbf <- .xls
			¥dhofarwater	.shp	
			¥filimwater	.shp	.dbf <- .xls
			¥hajarwater	.shp	.dbf <- .xls
			¥kabirwater	.shp	.dbf <- .xls
			¥khayranwater	.shp	.dbf <- .xls
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			¥mahawtwater	.shp	.dbf <- .xls
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			¥muscatwater	.shp	
			¥omanwater	.shp	
			¥quqwater	.shp	.dbf <- .xls
			¥qurayyatwater	.shp	.dbf <- .xls
			¥qurmwater	.shp	.dbf <- .xls
			¥rowriwater	.shp	.dbf <- .xls
			¥saghirwater	.shp	.dbf <- .xls
			¥sawadiwater	.shp	.dbf <- .xls
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			¥shinaswater	.shp	.dbf <- .xls
			¥taqahwater	.shp	.dbf <- .xls
			¥wustawater	.shp	

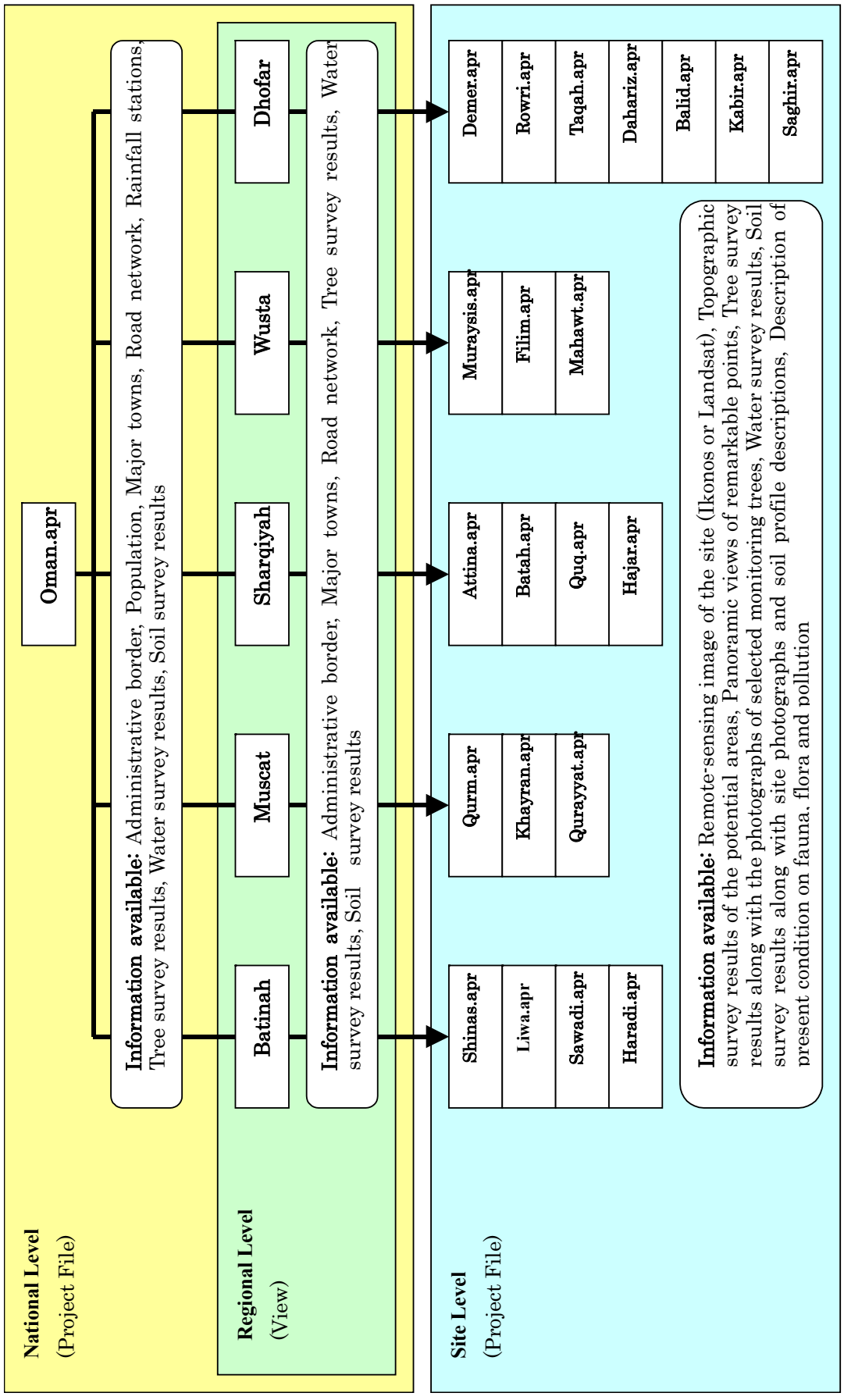


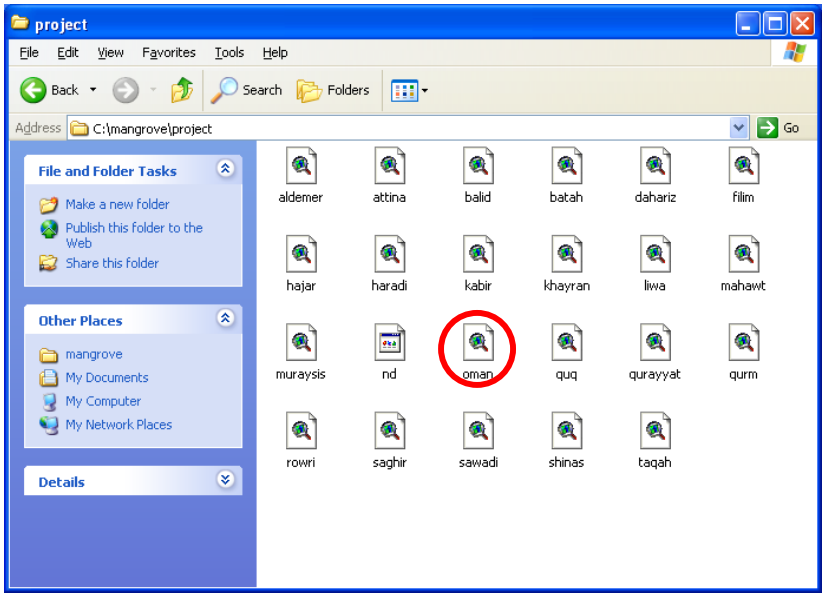
Figure A2.1 Project Files and Information Available in Different levels

2.3 Operation of GIS

2.3.1 Selection of the Project File for the Target Mangrove Site

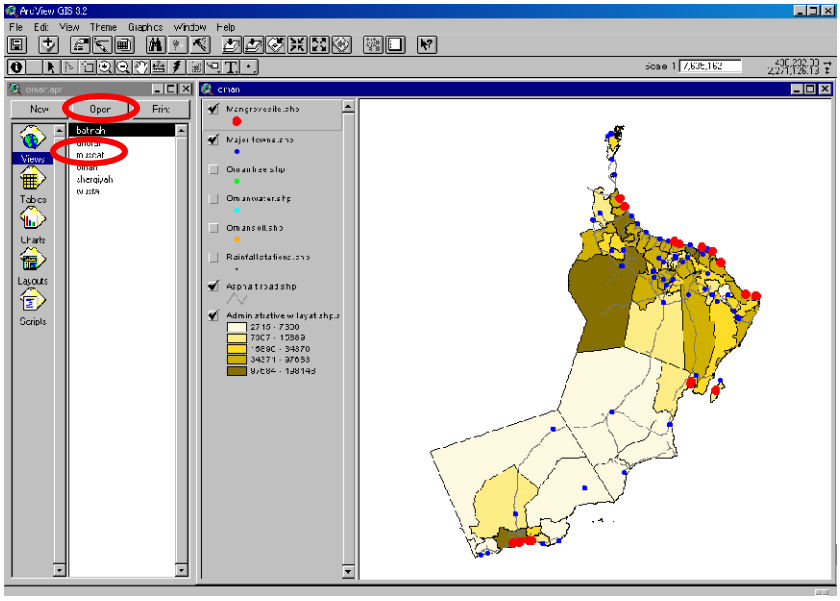
a. Open main menu by selecting "oman.apr" from project folder:

The main menu ("oman.apr") provides the general information such as administration border and the road network of the country together with the distribution of survey sites.



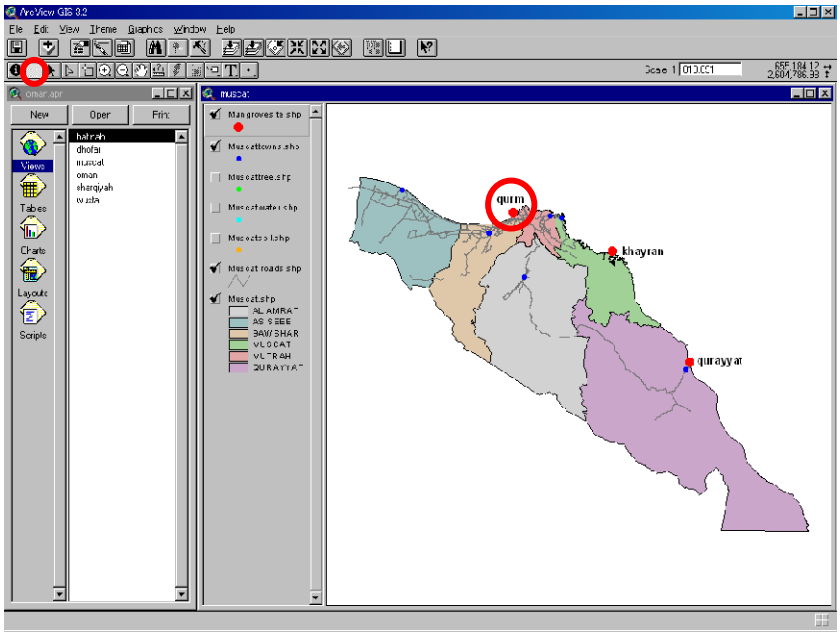
b. Selection of survey zone:

Survey zone will then be selected from views in order to investigate the distribution of mangrove sites within the selected zone.



c. Selection of mangrove site:

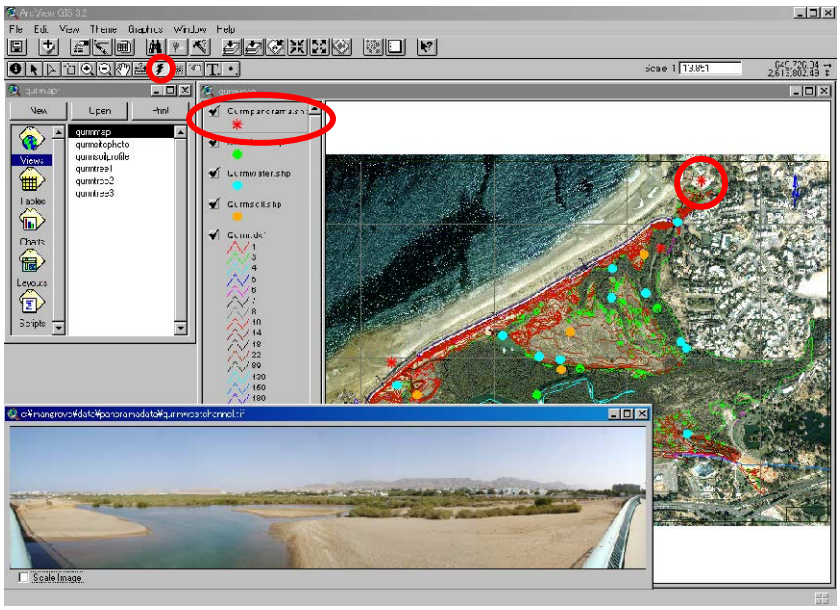
Select the target mangrove site by clicking the button shown below and then enclose the point of target site by arrow. New project file for the selected mangrove site will automatically be opened as a separate ArcView file.



2.3.2 Exploration of Detailed Information for the Selected Mangrove Site

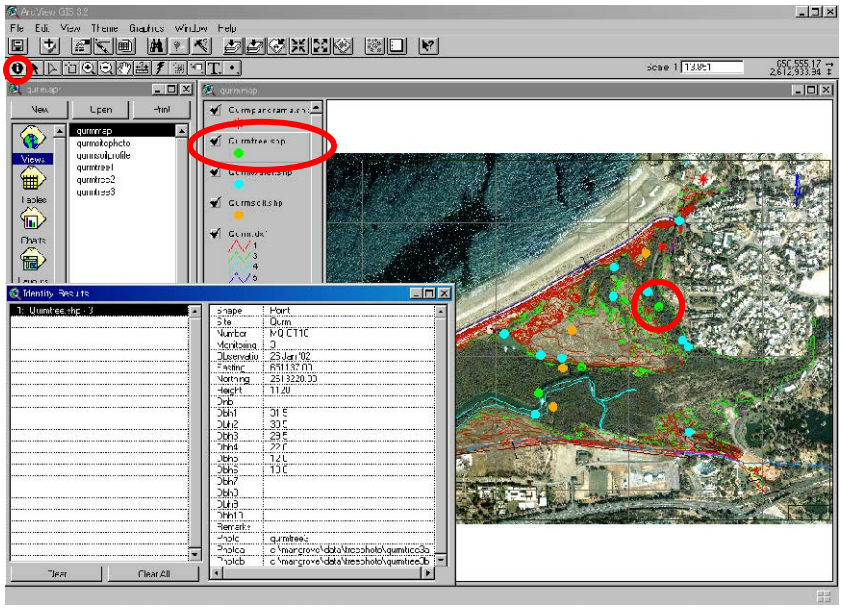
a. Panoramic View:

Panoramic view can be used as stationary observation of mangrove forests and can be shown on screen by clicking theme, hotlink button and target point as shown below.

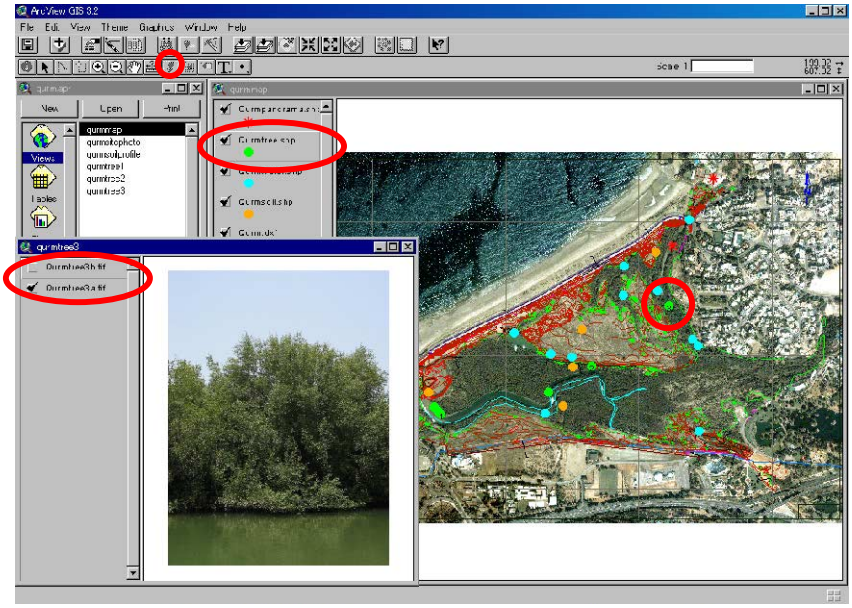


b. Tree Survey Data:

Tree survey results can be shown on screen by clicking theme, information button and target point as shown below.

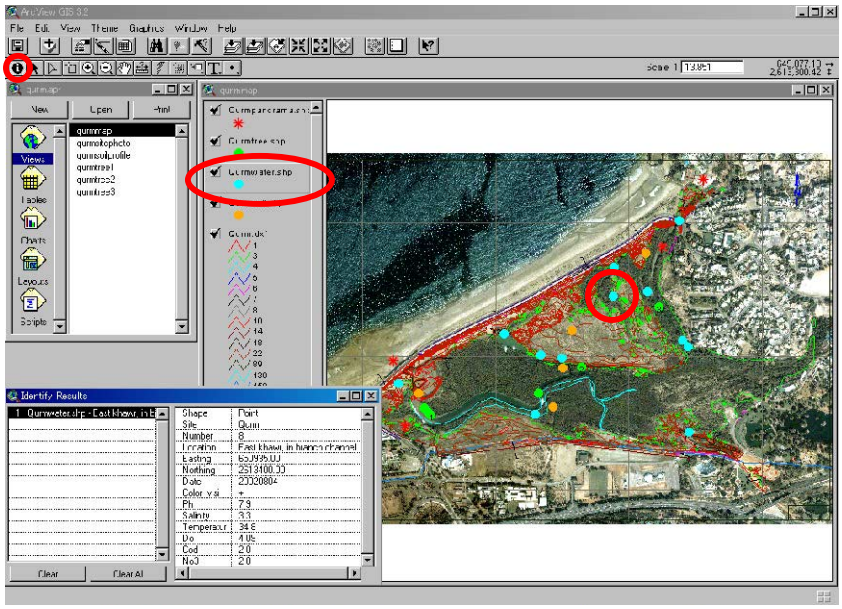


The photograph of monitoring tree can be shown on screen by clicking theme, hotlink button and target point as shown below. Furthermore, distant view and near view can be switched by clicking the theme of tree view.



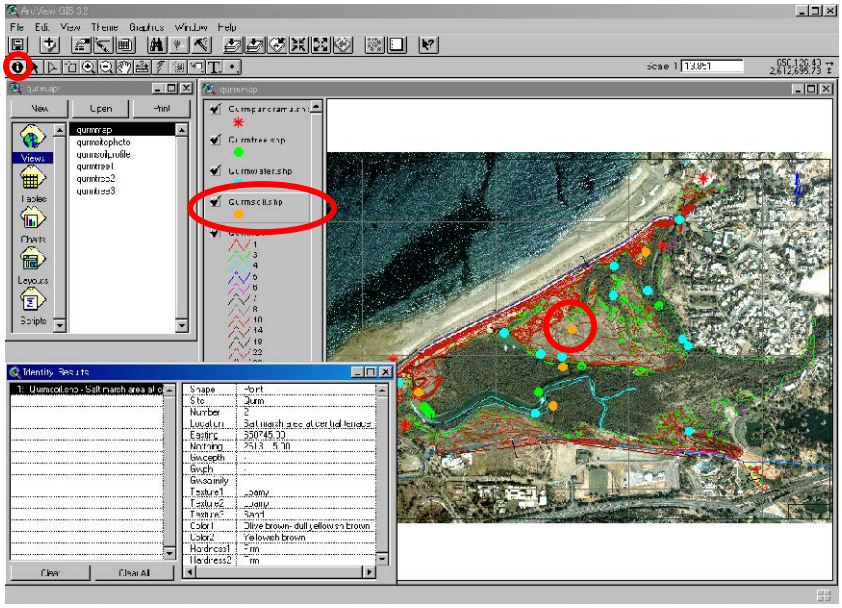
c. Water Survey Data:

Water survey results can be shown on screen by clicking theme, information button and target point as shown below.

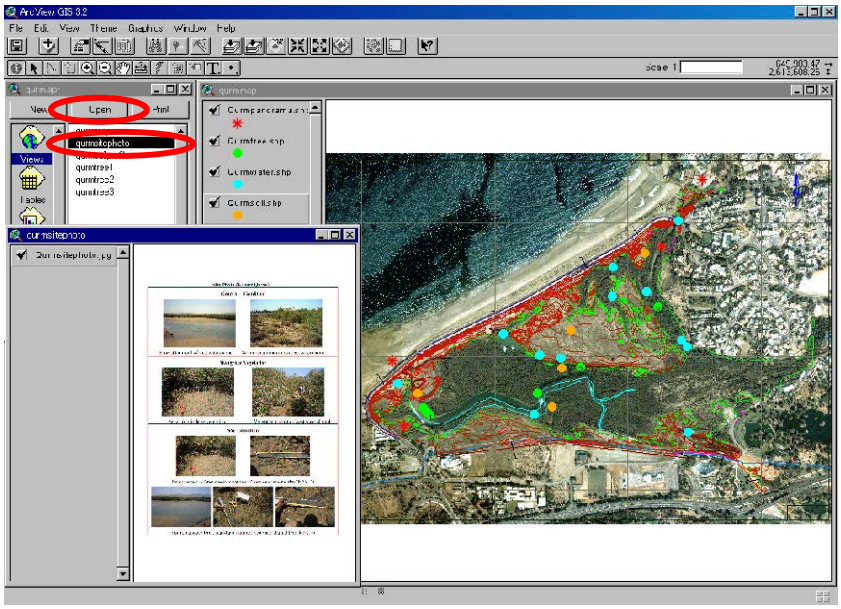


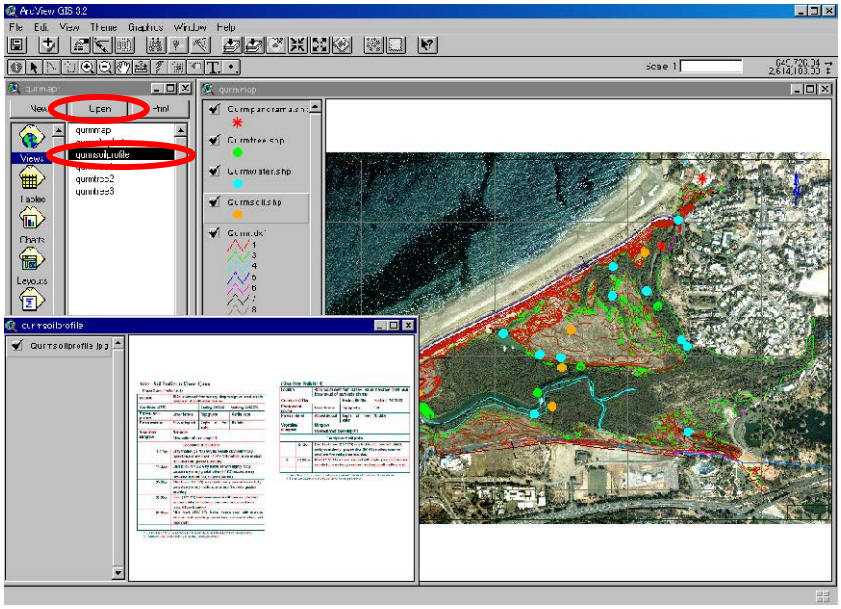
d. Soil Survey Data:

Soil survey results can be shown on screen by clicking theme, information button and target point as shown below.



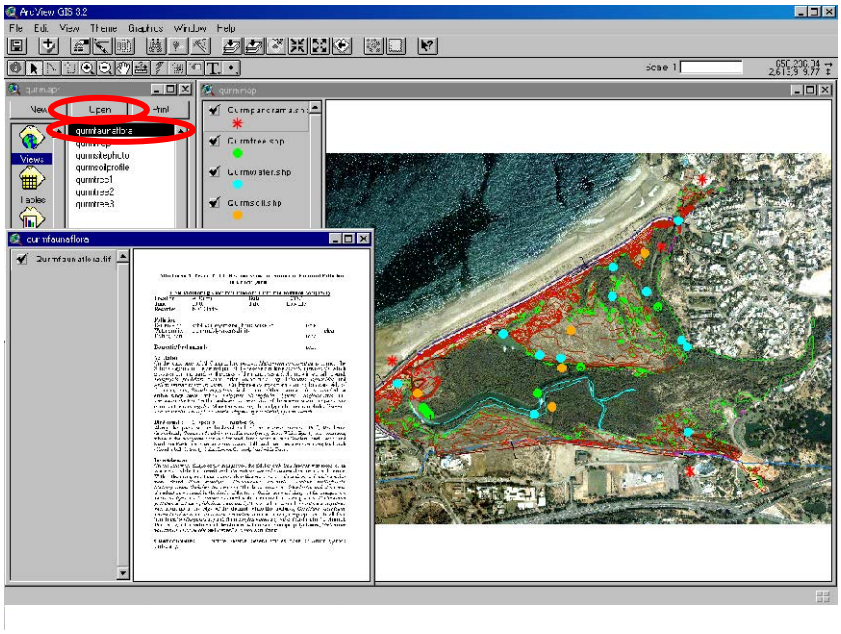
Site photo and typical soil profile description can be shown on screen by clicking target view and open button as shown below.





e. Fauna and Flora:

The description on fauna and flora can be shown on screen by clicking target view and open button as shown below.



2.3.3 Proceed to the Next Mangrove Site:

Go back to the main menu ("oman.apr") by simply closing the current project file and select the next mangrove site in the same manner of process 1.2 and 1.3.

3. Results of Social Survey

Appendix 3 Results of Social Survey

3.1 Preliminary Survey of the Sites

3.1.1 Characteristics of Social Condition in the Study Area

The 22 khawrs are characterised as shown in the following table. This information outlines all sites visited based on the observation and quick interview during the field visit.

Table A3.1 Socio-economic Characteristics of the Study Sites

Study Site	Governorate/ Region	Wilayat	Livelihood of the Local People	Infrastructure	Community Intervention with the Area
1) Khawr Shinas *	Al Batinah	Shinas	Fishery and agriculture. Potential for apiculture.	Near Shinas Town. Access road by car near the site is constructed. A school is located near the site.	Developing the area as a municipal park. Some trees are planted and the bank is fixed by rocks and soils.
2) Khawr Harmul & Nabr *	Al Batinah	Liwa	Fishery and agriculture.	Sohar Port is constructed nearby.	Developing the area as a municipal park.
3) Khawr Sawadi *	Al Batinah	Barka	Fishery and agriculture. Resort area and potential for large tourism development.	Some communities are adjacent. Road near the beach, islands, and Sawadi cape. Mangrove is planted by MRMEWR and JICA.	Concession is given to German investor for hotel and marina development. They are interested in mangrove planting for landscaping.
4) Khawr Haradi *	Al Batinah	Barka	Fishery and agriculture. Livestock farming (many goats are found).	Houses, sports ground, school are near the site. Garbage is dumped in the water.	Development as municipal park.
5) Khawr Qurm *	Muscat	Mutrah	Tourism business and fishery	Road and tourism facilities, and park	Declared as nature reserve in 1975. Many people utilise for recreational purpose.
6) Bandar Khayran *	Muscat	Muscat	Fishery and agriculture (dates garden and goats)	Road is constructed along the water. Football pitch is near the mangrove. Hotel is planned.	Used as recreational spot for camping, picnicking and diving.
7) Qurayyat *	Muscat	Qurayyat	Fishing village in eastern rocky coast. Most extensive agricultural development, encroachment by dates plantations.	Fishing harbor was constructed. Walking path for local people. Football pitch is near the mangroves.	Development plan of shrimp cultivation. Overgrazing of mangroves by goats. Illegal dumping of construction wastes.
8) At Tina ***	Ash Sharqiyah	Sur	Fishery	Area is developed as recreational park.	Landfill by local people for house construction. MRMEWR issued warning for this activity.
9) Batah ***	Ash Sharqiyah	Sur	Fishery	Residents near the site. Nursery is established.	Housing development plan
10) Khawr Quq *** (Ras Al Had)	Ash Sharqiyah	Sur	Fishery	Palace of Abu Dhabi Princess is located.	Tourism development is planned.
11) Khawr Hajar- East Shore *** (Ras Al-Had)	Ash Sharqiyah	Sur	Fishery	Few houses but some houses are located. Desalination plant is located.	Beach Hotel is under construction. Recreational use is seasonal, with number of overnight campers dropping off drastically during summer. Ras al-Had is a town with an

Study Site	Governorate/ Region	Wilayat	Livelihood of the Local People	Infrastructure	Community Intervention with the Area
					important fishing boat harbour, a variety of recreational activities including turtle-watching.
12) Wadi Muraysis ***	Ash Sharqiyah	Masirah	Fishery	Fishing port	Big fishing village, seasonal movement of the people in fishing season; in other times, people live inland.
13) Filim - Eastern Beach ***	Al Wusta	Mahawt	Fishery, commercial shrimp fishery.	Bedouins village is located along the beach. Desalination plant is located. Water supply by municipality for free.	Development plan of tourism in future. Camels browsed before. After issuance of regulation to stop cutting mangrove, trees have been regenerated.
14) Mahawt Island***	Al Wusta	Mahawt	Fishery (Women catch fish, crabs in the mangrove forest)	Temporary huts for fishermen are located along the beach. Water pipe from Film and water tower.	Camels browsing, cutting for construction wood, firewood and fodder stopped after issuance of regulation.
15) Sabkha a'Duqm ***	Al Wusta	Duqm	Fishery	Shrimp farm site. Fish processing factory is near the beach.	Major big harbour with dry dock is planned and now under feasibility study.
16) Al Demer Beach **	Dhofar	Mirbat		Recreational facilities (picnic and resting shade)	Recreational use by local people.
17) Khawr Rowri **	Dhofar	Taqah	Fishery	Archaeological area is located. Nature conservation area in 1997. Designated as World Heritage site in 2001.	Signs of severe overgrazing are still evident.
18) Qurm Taqah **	Dhofar	Taqah	Fishery. Livestock farming of camels. Agriculture with large cultivation of date-palm.	Taqah Town has fishing port. Proclaimed as a nature reserve with great scenic, historic and wildlife values.	Place for recreation (picnic areas causing car tracks and litter). Heavy grazing by camels and additional livestock is brought from the mountains during the monsoon.
19) Khawr Dahariz **	Dhofar	Salalah	Fishery.	Houses are constructed around and along the beach.	Recreational use. Population increase within the boundary of Salalah town.
20) Khawr Balid **	Dhofar	Salalah	Fishery and Agriculture (irrigation with crops)	Archaeological area is located in the protected area and close to Holiday Inn. Houses are being built on the west side of the graded track.	Population increase
21) Khawr Kabir **	Dhofar	Salalah	Fishery. Livestock faming of camels, goats. Tourism.	Hilton Hotel adjoins. Nature reserves are protected by fences. There is evidence of grazing of mangroves by camels but stopped and regenerated after fenced. Pooled water becomes sludge and smells bad without any treatment.	
22) Khawr Saghir **	Dhofar	Salalah	Tourism. Fishery and livestock farming of camels and goats.	Khawr is fenced and grazing is not allowed.	Off-the-road driving is extensive.

Note) Social environment survey toward municipalities: * The 1st survey, ** The 2nd survey, *** The 3rd survey

Table A3.2 Impacts of People's Activities and Land Use on the Selected Study Sites

No.	Study Site	Agriculture	Fishing	Livestock	Recreation	Archaeological Site	Residential Area	Conservation Area	Infrastructure Development	Tourism Development	Impact on Mangrove (Coastal Area)
1	Khawr Shinas	L	L	L	H		L		H	M	H
2	Khawr Harmul & Nabr	L	L	L	H		L		H	L	H
3	Khawr Sawadi	L	H	L	H		L		H	H	H
4	Khawr Haradi	L	M	H	H		H		H	L	H
5	Khawr Qurm	L	M	L	H		H	X	H	H	H
6	Bandar Khayran	L	H	M	H		L		H	H	H
7	Qurayyat	H	H	H	H		H		H	M	H
8	At Tina	L	H	L	H		H		H	L	H
9	Batah	L	H	L	H		H		H	L	H
10	Khawr Quq	L	L	L	L		L	X	H	H	H
11	Khawr Hajar-East Shore	L	H	L	H		L	X	H	H	H
12	Wadi Muraysis	L	H	L	L		L		L	L	L
13	Filim-Eastern Beach	L	H	H	H		L		L	L	M
14	Mahawt Island	L	H	M	H		M		M	H	H
15	Sabkha a'Duqm	L	H	L	H		L		L	L	M
16	Al Demer Beach	L	L	L	H		L		H	M	M
17	Khawr Rowri	L	H	H	H	X	L	X	H	H	H
18	Qurm Taqah	L	L	H	H		L	X	H		H
19	Khawr Dahariz	L	H	M	H	X	H	X	H	H	H
20	Khawr Balid	H	L	L	L	X	H	X*	H	H	H
21	Khawr Kabir	L	L	L	M			X*	H	H	H
22	Khawr Saghir	L	L	L	L			X*	H	H	H

Use: High=H, Medium=M, Low=L Archaeological Site: Exist=X
Conservation Area: Designated as Nature Reserve=X, *=fenced area

3.1.2 Specific Characteristics related to the Mangrove Ecosystem of the Study Sites

Governmental staff and local people were interviewed regarding the study sites and the following table summarises what they had to say. Their views were referred to select the sites for socio-economic survey and target groups of interviewees, and to structure the questionnaires.

a. Governmental Staff

Governorate/ Region	Past and Present Conditions of the Study Site	Desirable Conditions in Future
Al Batinah	- Local people living inland are not familiar with mangrove. They regard it as a useless tree compared with other cash trees, even though they do not know the name of "mangrove". They have no consciousness of mangrove conservation. - People living along the coast have utilised the mangrove, catching crabs, squid and small fish, and collecting honey for selling at the local market. - Since environmental awareness activities by the government were done in Liwa, the people there stopped cutting mangroves.	- Awareness programmes of mangrove ecosystem are necessary.
Muscat	- The closed sandbar and the decrease of water level are due to construction of harbour in Qurayyat. - Illegal dumping of construction wastes has increased and nobody cares about cleaning the area except the inhabitants close to the mangrove.	- Public awareness among the people to stop illegal dumping should be increased.
Dhofar	- Mangrove areas were heavily used by livestock (goats and camels) grazing and fishing before, but stopped since the issue of regulation to prohibit cutting green trees. - The fenced areas are protected from browsing by camels but other areas are still damaged. - There is less awareness of mangrove value among the local people because it is not recognised as an economic tree like coconut palm. - The local people observe the decree for nature reserve areas without understanding the reasons for the restraint.	- Inside the conservation/reserve area should be kept as it is. However, some benefits to the local people should be created through development of the surroundings. - Development for recreational purposes such as park, picnic area and eco-tourism should be considered.

b. Local People

Interview Site	Economic Activity	Living Conditions	Need for Future
Qurayyat	- Fishery (harbour was constructed 5 years ago. Since then, amount of fish and water level has decreased.) - Agriculture (dates, vegetables, crops) - Livestock farming (goats, sheep and cows) - Apiculture (small-scale)	- Because of lack of water, many people who have lived near the mangrove area moved to the village and town. There was no rain for the last 2 years. - Water for dates garden is also lacking. - Sewerage is disposed of in septic tank.	- Paved roads - Parabola
Filim-Eastern Beach	- Many fishermen have temporary huts in Mahawt Island and go fishing almost every day depending on the weather. - Only men go fishing by boat. Women work on the beach to catch small fish and crabs.	- The people started to immigrate here from Mahawt Island 52 years ago because of lack of water, school and other facilities. The present population here is almost stable. - Living in the shabby huts made with timber, palm fronds and some plastic sheets. - Water is provided by municipality for free. - Sewerage is discharged into the ground. Garbage drums in front of each house are collected by the municipality every 3 or 4 days. - Income depends only on the fish catch (sometimes nothing). - Children go to school in Haj.	- House made by concrete in this place (they do not want to move)

Interview Site	Economic Activity	Living Conditions	Need for Future
Mahawt Island	- Men go fishing for fish and shrimp by boat, women catch crabs, small fish in beach and in mangrove forest. Women also catch cuttlefish in coral reef out of the mangrove area. - Fishing is done almost every day but depends on the weather. Sept.-March is good season and during June-July, fishing stops. - Catch of fish has decreased because of the increased number of fishermen. Low tide limits their fishing time. - Middlemen of the catch get a large profit from the local fishermen.	- Among the total 80 or so houses, 20-30 are settled, and the rest is used temporarily for coming and going from/to Filim and Haj. - Children live in parents' or relative's houses in Filim and Haj during school time and come back on holidays. - Water is supplied by municipality for free since December 2002. - Garbage drums are collected by municipality once a month. - Income heavily depends on fishing and is unstable. - Increase of population (children) is serious. - They spend 2 months (June-July) for vacation in Shinaw and other areas for collecting dates for self-consumption.	- Harbour (jetty) to reach their boats even in low tide. - Concrete houses with bedrooms, kitchen and toilets in the Island (they do not want to move). - Bridge from Filim to the island for car and/or walking. - Eco-tourism development - Clinic and school

Hearing Site	Change of Mangrove Ecosystem	Significance of Mangrove to the Local People	Comments for Future
Qurayyat	- Sandbar was closed 4 years ago. - The boat cannot access to the house, the amount of crab and fish decreased. - Mangrove area was filled with water and many trees found in the hill behind the mangrove area before. - Goats are grazing mangrove leaves, plants and seeds. Some villagers take goats to the mangrove area everyday.	- Provide more fish and crabs and birds, if the mangrove area is wider. - Without the mangroves, scenery becomes miserable. Green area is necessary for scenic beauty. - Mangrove area is often visited by the inhabitants for recreational purpose. - Grazing of goats is small portion and does not provide much damage to the mangroves.	- Mangrove grows naturally and not necessary to be planted. However, if there is plantation programme, they are willing to participate.
Filim-Eastern Beach	- In the low tide, camels walked around browsing before. - Women cut mangrove for houses, fuel wood and fodder. Since 1992, no cutting, which expands mangrove area. - Flat boat like a raft was made of mangrove. - Turtle meat and eggs of birds in the mangrove area were eaten but not now.	- There is a custom not to cut green trees. - Mangrove provides habitat of shrimp, fish and mangrove crabs. - Green mangroves provide beautiful view.	- Mangrove germinates naturally and not necessary to be planted by the people. However, if there is plantation programme, they want to join. - Filim should be full of mangrove trees like Mahawt Island to increase fish and provide attractive scenic view.
Mahawt Island	- Many camels were taken by Dhow to the mangrove area and many mangrove trees were brought back. Now, some goats are grazing. - Mangrove was utilised as fuel wood. Many were cut and brought by boats going to Africa. - Mangrove area developed vastly since cutting stopped.	- Mangrove provides good places for fish and crabs. Also, gives nice view. - Fodder for goats (women and children cut a bunch of mangrove every 4 days). - Mangroves can play a role of breakwater. - There is a custom of not allowing any natural resources to be taken from here without permission of the local people and/or benefit to the inhabitants.	- If there is plantation programme, they are willing to participate voluntarily. - Eco-tourism of mangrove ecosystem (some inhabitants objected because of negative impacts of tourists) - Mangrove grows quickly if only small branches are cut for fodder.

3.1.3 Issues, Potentials and Necessary Conditions for the Restoration, Conservation and Management of Mangrove Ecosystem

From the socio-economic viewpoint, the following issues and potentials to restore, conserve and manage the mangrove ecosystem were identified during the Survey.

a. Issues

- Awareness level of the local people for the mangrove ecosystem varies from place to place. Generally, in the area far from the mangroves and with no or few mangrove, people's awareness is very low.
- Local people prefer the fruit-bearing trees like dates, coconuts, mangoes and others to mangrove. The mangrove is sometimes considered a tree without value and even its name is not known.
- Grazing by camels and goats is not controlled and this practice is overlooked. Mangroves are still cut for fodder in some areas in spite of prohibition of cutting green trees. People's excuse is that a small part/amount of mangroves will not cause too much damage.
- Local people heavily rely on the government to improve their living conditions and area. Without strong government initiatives and without increasing people's motivation, the inhabitants are not likely to go into action.
- Population increase and urbanisation in the survey site and hinterland increase pressures on the mangrove ecosystem, especially in the case where housing area and farmland are located nearby and recreational usage is intensive such as parks, picnic sites and football pitches. Vehicle-use in the area and recreation facilities are not controlled. In the picnicking areas, there are car tracks and litter left behind.

b. Potentials

- Some of the local people have a traditional custom, e.g. helping one another and working for the common good of all in the area. Also, the custom of protecting natural resources in their territory from outsiders is strong.
- Especially, in Mahawt Island, women work in mangrove forest to collect fish and crabs every day. They are familiar with mangroves and know the significance of the mangrove ecosystem.
- Some areas are conserved as nature reserve and people observe the regulation; those in violation of the regulation are penalized.
- In school education, students are taught how to conserve the environment in general.

- People have strong admiration of green and water, which seems a national character. People appreciate the scenic value of mangrove area, i.e. providing a beautiful and relaxing view. The pleasant green surroundings are favorite recreation grounds for both residents in town and village and tourists.

c. Necessary Conditions

The necessary conditions in terms of socio-economy to restore, conserve and manage the mangrove ecosystem are considered as follows based on the issues and potential.

- Awareness programmes for not only the inhabitants but also officers at regional and wilayat levels.
- School students and staff should be involved in the awareness and afforestation programme.
- Infrastructure for nearby inhabitants such as garbage disposal and sewerage is necessary to decrease the negative impact on the mangrove ecosystem.
- Grazing of mangroves by goats and camels and cutting of mangrove for fodder should be controlled by increasing the awareness of the livestock farmers (pasturage).
- In the area to be utilised for recreational purpose and archaeological parks, some guidelines and strategic development plan should be prepared to mitigate negative impacts on the mangrove ecosystem. Development of visitor facilities should be minimised for environmental and scenic impact. Barriers should be extended to prevent off-the-road driving.

Issues, Potentials and Necessary Conditions
from the Socio-economic Viewpoint

Area	Issues	Potential	Necessary Conditions
Al Batinah, Muscat	Low awareness, some do not know even the name of mangrove Population increase in town and villages Overgrazing by goats Recreational use and tourism development without regulation and guideline Relying on governmental services by local people	People admire view of green and water Environmental education is done in schools	Public awareness increase of both local government staff and people Control of grazing by goats Strategy of sustainable tourism/recreational area development
Ash Sharqiyah	Low awareness of mangrove Population increase Recreational use and tourism and housing development without regulation and guideline		Public awareness increase of both local government staff and people Regulation and guideline for sustainable tourism/recreational development and housing development

Area	Issues	Potential	Necessary Conditions
Al Wusta	Grazing by goats and fodder collection Population increase Relying on governmental services Attachment to land is very strong	Moderate level of awareness Women's activities in mangrove area in Mahawt Many are conscious of mangrove significance Admire view of green and water Strong relationship among the inhabitants	Public awareness increase involving women Control of grazing by goats and fodder collection Strategy of sustainable tourism development
Dhofar	Low awareness Population increase Grazing pressures on mangroves by goats and camels and heavy grazing by additional livestock from the mountains during the monsoon Recreational use and tourism development without regulation and guideline	Admire view of green and water Nature Reserves and archaeological sites	Public awareness increase both of local governmental staff and people Strategy of sustainable tourism/recreational development Control of grazing by livestock

In consideration of the above points, the socio-economic survey will be conducted in the 2nd year to find out various measures for mangrove conservation.

3.2 Socio-economic Survey

3.2.1 Results of Socio-economic Survey

a. Background of the Survey

(a) Objectives

The objectives of the survey are:

- To understand the social structure, socio-economic activities, traditional customs, etc. of the community in/around the study site,
- To clarify and characterise the relationship between the local people and mangrove and khawr ecosystem as well as coastal ecosystem, their significance and people's awareness of their conservation in the past and at present,
- To understand the potentials and constraints for the local involvement into the conservation and management activities of mangrove and khawr ecosystem,
- To understand the level of information on mangrove, experience and technique of mangrove planting and management by the local people, and
- To identify the beneficiaries and benefits from the implementation of the project of restoration, conservation and management of mangrove and khawr ecosystem.

(b) Selected Survey Sites

Ten sites for this social survey are selected, as shown in the table below, from among the 21 study sites of the Master Plan. These 10 sites are considered representative of all 21 sites, which can be categorised based on the area of the mangrove, intervention by local people, socio-economic characteristics etc.

No.	Site	Governorate/ Region	Mangrove Area (ha)	Present Usage of the Area
1	Khawr Shinas	Al Batinah	53	municipal park, recreational site, fishing for fun
2	Khawr Qurm	Muscat	74	Nature Reserve, recreational site, plant nursery
3	Bandar Khayran	Muscat	83	recreational site, fishing village
4	Khawr Qurayyat	Muscat	80	browsing by goat, recreational fishing
5	Batah	Ash Sharqiyah	58	housing development, plant nursery
6	Wadi Muraysis	Ash Sharqiyah	0	fishing village, wild bird nest
7	Filim/Mahawt Island	Al Wusta	10/162	fishing village, wild bird nest
8	Qurm Taqah	Dhofar	1.6	Nature Reserve, browsing by camel and goat
9	Khawr Balid	Dhofar	0	archaeological park, recreational site
10	Khawr Kabir	Dhofar	4.2	Nature Reserve, hotel nearby, plant nursery

b. Methodology

(a) Approaches

The survey was conducted by semi-structured interviews with the stakeholders in the related areas. The interviewees included local government staff, sheiks, elders, other key informants in the area, and local people living and/or working in and around the sites. They were interviewed in their offices or homes. Through the interviews, the Study sought to understand local experience, ideas and attitudes regarding mangroves, solicit suggestions for solutions to mitigate adverse impacts and promote positive impacts for sustainable utilisation and management of the area. The interview interaction itself might be helpful to create awareness of mangrove protection among the people somewhat.

(b) Sampling

The total number of samples is about 350 (5 groups consisting of an average of 7 persons per group x 10 sites). Because of the timing for summer vacation and little experience of social survey in this country, it was difficult to find samples. Additionally, since the background information of each site (already acquired through the repeated field surveys by the JICA Study Team and hypothesis) and proposal of the necessary measures were available for the different types of sites, the contents of the interviews were intensive and focused.

(c) Team Composition

One team was consisted of 2 Omani surveyors with some experience of socio-economic survey. Members of JICA Study Team and counterparts from

Ministry of Regional Municipalities, Environment and Water Resources also joined the survey.

(d) Schedule

The survey was conducted according to the following schedule.

Activity \ Week	24 May ～	31 May ～	7 June ～	14 June ～	21 June ～	28 June ～
Formation of the team	―					
Preparation of questionnaire	――					
Arrangement of the interviewees	――					
Interview Survey						
Qurm Taqah		―				
Khawr Balid		―				
Khawr Kabir		―				
Khawr Qurayyat			―			
Filim/Mahawt Island			―			
Wadi Muraysis			――			
At Tina/ Batah			――			
Khawr Qurm				―		
Khawr Shinas				――		
Bandar Khayran				――		
Compilation of the results					――	
Preparation of the report					――	――
Submission of the report						▲

c. Site Characteristics

Results of the survey are summarised below. Details and additional information can be referred to the attachment.

1. Khawr Shinas

A. Community Profile

Demographic Information	- Population has been sharply increasing.
Economic Activity	- Agriculture is the main source of income and employment. - Governmental employment is second followed by fishery.
Social Services/ Infrastructure	- Water for drinking: provided by municipal water wagon and some wells are used - Water for agriculture: well is used but salinity is a problem - Fuel for cooking: Gas, trees from wadi in case of banquet - Wastewater: collected by private company - Garbage: collected by the municipality every day
Social Structure	- Women's group for healthcare - Fishermen's group of young fishermen for catching, delivering, bidding of the catch, etc. - Fishermen's groups owned by big processing factories

(a) Demographic Characteristics

The population of Wilayat of Shinas (53,000 in 2001) has been increasing sharply. More than 10 years ago, people from the UAE with camels vacationed here for 3-4 months during the summer, which increased the population seasonally.

(b) Economic Activities

Agriculture based on dates, fruits and vegetables is affected by water salinity. The catch of fish has been decreasing because many big ships with modern equipment from foreign countries engage in intensive fishing.

(c) Social Services and Infrastructure

Wells used for daily life and agriculture is a problem due to salinity increase. Electricity supply covers most of the area. Gas is mainly used for cooking fuel and sometimes the villagers use the collected trees from *wadi* when there is a big banquet.

B. Individual Interview

(d) Mangrove and Khawr Ecosystem

Value and Usage	**Past**	A. Fodder for camels and goats A. Fuelwood for cooking A. Construction wood for houses A. Fishing almost every day for sale B. Relaxing and enjoying the nature every day
	Present	A. Recreational fishing once a week A. Some dead branches for fuel in banquet cooking Walking, picnicking, swimming for fun once a week B. Cooling and shading under the mangrove trees B. Providing natural beauty
Changes	**Resources**	- There were a lot of fish but now a little. - Crabs, little lobsters and small fish are there, but smaller amount than before. - Big and small birds still can be seen but the number decreased.
	Size and Quality	- The number of mangrove trees has been rapidly increasing. - Prohibition of use by the government and reversed seawater flow make the expansion of mangrove area.
	Impacts on the Living	- The number of livestock animals decreased. - Damages of farmland from salt and wind are reduced. - Recreational usage increases.
Awareness of Protection		- The people know the process of mangrove growing naturally. - Many people want to protect and expand the mangrove area.
Potentials for Local Participation		- The people are willing to join the activities by collecting contributions from the villagers, providing labour and advice. - School students can be involved by utilising field activities.

Note) A: Direct use/value, B: Indirect use/value

i. Change of the Conditions

(i) Size and quality:

Most of the area was like a desert before but the number of trees has been rapidly increasing and the area has become the greenery of mangrove. One reason is the prohibition of use of mangrove by the government. Another reason is that growing mangrove stopped seawater from flowing into the farm and reversed it to the desert area.

(ii) Impacts on the people's living:

Villagers reduced their livestock because they had to spend more money and labour to feed their animals since mangroves can no longer be used. Farmers could mitigate the damage to their farmland from saline and wind because of expansion of the mangrove area. Additionally, the people could enjoy recreational activities such as swimming, fishing and picnicking in the mangrove area.

ii. Awareness of Protection/Management of Mangrove Ecosystem

Local people go to the park along the Khawr Shinas for recreation. Therefore, the park plays a role of attracting the people to touch nature. However, without signboards explaining wildlife including mangroves, people cannot become aware of mangrove.

The people have talked about change of the mangrove area and how to protect the area many times. The people know the process of mangrove growing naturally from their empirical knowledge. Many of the local people want to protect and expand the mangrove area because of its attractive scenic beauty.

iii. Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

The people desire the park area to be a tourism base. All respondents are willing to join the protection activities by collecting contributions from villagers, providing labour and advice to them, especially to the young people.

An idea of school nursery proposed by the JICA Study Team is accepted by the Director-General of Ministry of Education in Sohar Region and schools interviewed in Wilayat of Shinas. A nursery set up in schools near the Khawr Shinas will be monitored/managed by students from different schools by turns. All activities will be co-ordinated by teachers in the school near the Khawr Shinas. Also, extracurricular activities such as visiting fields and cleaning the beach and environmental club after classes can be utilised for the purpose.

2. Khawr Qurm

A. Community Profile

Demographic Information	- Population has been increasing sharply with urbanisation and many ethnic groups
Economic Activity	- Main economic activities are commerce and industry, and governmental employment.
Social Services/ Infrastructure	- The Khawr is designated as Qurm Nature Reserve. - Water for drinking: piped water - Fuel for cooking: Gas - Wastewater: collected by municipality - Garbage: collected by municipality

B. Individual Interview

(a) Mangrove and Khawr Ecosystem

Value and Usage	**Past**	A. Fodder for camels, goats and cows A. Fuelwood for cooking A. Fishing and hatchery for fish A. Wood for construction of houses and ships
	Present	B. Hatchery of fish B. Shading and resting under the trees B. Providing natural green beauty
Changes	**Resources**	- There were a lot of fish, crabs and little lobsters but now a little. - The number of wild birds decreased and some birds can be seen.
	Size and Quality	- The area of mangrove has expanded. But the condition of trees and flowers has deteriorated. - The seawater has been polluted by wastewater from nearby houses.
	Impacts on the Living	- The number of fish has been decreased because of the increased number of fishermen and ships. - Water level becomes lower at low tide and boats cannot sail near the jetty/
Awareness of Protection		- The people know the process of mangrove growing naturally. - Nobody knows there is a plant nursery of MRMEWR. - Many people want to protect and expand the mangrove area. - When they find illegal cutting of mangrove, they try to put a stop it.
Potentials for Local Participation		- The people are willing to join the activities by providing labour and advice and also trying to top illegal cutting. - Idea of Qurm Environmental Information Centre is welcomed.

Note) A: Direct use/value, B: Indirect use/value

i. Change of the Conditions

(i) Resources:

There existed a lot of fish, crabs and small lobsters before but now little can be found. Fishermen interviewed have never fished in the khawr. The local people think that the mangrove area has many snakes and poisonous creatures and they do not want to go there.

(ii) Size and quality:

The mangrove area expanded and became full of trees near the jetty. The water quality has been deteriorated because of houses around the khawr. Also, there is lots of garbage and bulky rubbish scattered around the jetty.

(iii) Impacts on the people's living:

Since the prohibition of use of mangrove, its role has been limited to indirect (non-consumptive) use/value such as providing fish hatchery, shade and nice view.

ii. Awareness

The mangrove area should be expanded more and protected because its scenic beauty attracts visitors. Respondents revealed that sometimes they come across some people cutting mangroves and they warn them to stop doing that. Everybody knows it has been designated Nature Reserve but nobody knows the existence of a plant nursery set up by MRMEWR. The respondents know that mangroves grow naturally after seeds drop based on their empirical observation.

iii. Potentials

The respondents are willing to join the protection activities by stopping the illegal cutting and cleaning the area. Also, the idea of Qurm Environmental Information Centre (QEIC) is welcomed because they consider education necessary for nature protection and if the QEIC is established they intend to visit to learn about mangrove ecosystem.

3. Bandar Khayran

A. Community Profile

Demographic Information	- Population has been increasing rapidly. - Immigration from the neighbouring villages for economic reason.
Economic Activity	- Fishery is major income source but the increased number of fishermen and ships from outside has been decreasing the catch per head. - Agriculture is based on dates plantation, damaged by salinity increase. - Livestock farming is damaged as cheap imported meats increased.
Social Services /Infrastructure	- Water for drinking: transported by trucks of Muscat Municipality. Desalination plant in the village will be open next month. - Water for agriculture is from wells. - Fuel for cooking is gas. - Wastewater and garbage is collected by the municipality. - There is one primary school. - Paved road expansion and hotel/restaurant construction are planned.
Social Structure	- Women's group for healthcare - Fishermen's group

(a) Demographic Characteristics

The population in the village of Bandar Khayran is about 1,000 (2001 data), and it is increasing rapidly. In-migration from the neighbouring villages is the major cause because many people come to find fishing activities.

(b) Economic Activities

Agriculture is based on dates plantation but the increase of salinity in water causes the decline of production and quality of dates. Livestock farming of

goats was operated widely before but the import of cheap goats depressed the goat farming and decreased profit and the number of goats. At present, dates and goats are consumed in the village. Fishery has been the most important industry in income earning and labour force. Other important economic sector is governmental employment. There are many foreign tourists coming from Muscat to islands near the village for picnic, diving and camping but most of them use boats arranged by tour companies in Muscat. It is rare that local fishermen are asked to use their fishing boats for tourism.

(c) Social Services and Infrastructure

There is one primary school in the village with more than 200 students. The secondary school is located 10 km from the village and school bus is operating. Roads are paved only inside the village. Paved road expansion and hotel and restaurants construction for tourism development are planned in this area.

B. Individual Interview

(d) Mangrove and Khawr Ecosystem

Value and Usage	**Past**	A. Fuelwood for cooking A. Construction wood for houses and boats A. Material making Omani cement A. Fodder for goats and cows A. Catching small fish, crabs and shrimps A. Collecting honey
	Present	A. Fodder for goats, cows and donkeys A. Collecting honey A. Fishing B. Providing nice green view
Changes	**Resources**	- There were a lot of fish, crabs, shrimps and shellfish but now a little and some species are extinct. - Still many wild birds can be seen.
	Size and Quality	- The area of mangrove has been expanding in the last 40 years.
	Impacts on the Living	- In spite of the increase of tourists, the villagers are not involved. - Tourism development is expected to provide job opportunities to the local people.
Awareness of Protection		- The people know the process of mangrove growing naturally. - Many people want to protect and expand the mangrove area. - Beauty of natural green is necessary to the villagers and tourists. - The area should be managed well by cleaning and trimming.
Potentials for Local Participation		- The people are willing to join the activities by providing labour and advice. - Field activities as environmental education of school include cleaning the beach, planting trees and observing wildlife.

Note) A: Direct use/value, B: Indirect use/value

i. Change of Conditions

(i) Size and quality:

The mangrove area has expanded for the last 40 years and the trees grew bigger and bigger except when one incident of water contamination 22 years ago by pesticide caused damage to the trees.

(ii) Impacts on the people's living:

The role of mangrove area was reduced to the place for fishing (though seldom happened), honey and fodder collecting and grazing by goats, cows and donkeys and to provide a nice green view. Despite more tourists visiting this area, the villagers have little chances to benefit from them. Rarely are fishing boats of local fishermen hired for tourism use (rate is R.O. 5/boat). The respondents expect that a large-scale development will benefit the whole village.

ii. Awareness of Protection of Mangrove Ecosystem

Every one thinks that the mangrove grows naturally after the flowers drop, and nobody has ever planted mangrove. However, the local people require the conservation and expansion of the mangrove area because its natural beauty attracts the other villagers and tourists. Some want this area to be a large-scale tourism development and some want it to be a natural garden for children. Therefore, the area should be managed well by cleaning, trimming branches and taking away dead trees.

iii. Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

All interviewees are willing to participate in the protection and expansion activities. The activities should be done by the local people. However, they need the governmental instruction and financial support. Field activities of school as environmental education (students go out on field once a month for cleaning the beach and living area, for planting trees and observing the wildlife, etc.) can be utilised for mangrove protection and expansion.

4. Khawr Qurayyat

A. Community Profile

Demographic Information	- Population has been increasing rapidly.
Economic Activity	- Fishery is major source of income and employment. - Agriculture of dates plantation and vegetables is the second major industry, damaged by water salinity increase. - Governmental employment is also important.
Social Services/ Infrastructure	- Water for drinking: supplied by tanks of Muscat Municipality. Some wells are also used. - Water for agriculture: from wells, but salinity is a serious problem. - Fuel for cooking: mostly gas, petroleum is also used. - Wastewater: discharged into the ground or collected by the Municipality. - Garbage : collected by the municipality - Construction of municipal waste dumping site and shrimp farm are planned.

(a) Demographic Characteristics

The population of Sahil village along the beach in 1993 was 5,000. The population at present is not known but it is assumed to increase very rapidly. This is caused by natural growth.

(b) Economic Activities

Fishery is the major economic activity. The increased number of fishermen and large ships with modern equipment from other areas has reduced the catch of fish per head with total fish catch remaining the same.

B. Individual Interview

(c) Mangrove and Khawr Ecosystem

Value and Usage	**Past**	A. Fodder for camels, goats and cows A. Fuelwood for cooking A. Fishing, catching crabs and shrimps A. Collecting honey by villagers and Bedouins Wood for building house, boats and fence of farmland A. Catching birds to eat B. Wild birds nest B. Hatchery of fish
	Present	A. Fishing for fun Browsing by goats A. Collecting honey B. Providing natural beauty and atmosphere with green and blue water
Changes	**Resources**	- There were a lot of fish, crabs and shrimps but now only few small fish. - The number of wild bird decreases, as that of fish decreases.
	Size and Quality	- The mouth of khawr was always open before 1980. - The area of mangrove and the khawr has decreased. - The closed mouth, mangrove without management, browsing by goats deteriorated the mangroves.
	Impacts on the Living	- The increase of water salinity damages agriculture and drinking water. - Depending on the condition of the khawr mouth, the number of fish and the area of mangrove, water quality, etc. is different.
Awareness of Protection		- The people know the process of mangrove growing naturally from their empirical knowledge. - Many people want to protect and expand the mangrove area. - Permanent open mouth is necessary for fishing and mangrove growing.
Potentials for Local Participation		- The people are willing to join the activities. - They can contribute through trimming, taking away dead trees, planting new seedlings, providing advice based on their experience.

i. Change of the Conditions

(i) Resources:

The khawr provided abundant fish, crabs, shrimp and lobsters before. Whenever the mouth of the khawr is closed, the number of fish reduces and birds also do not come. People used to set fishing nets and collect fish in the evening.

(ii) Size and quality:

The mangrove and the khawr became smaller because the mouth was closed, mangroves were not managed well, dead mangrove trees were left as they were and goats browsed mangroves. Once rain stops, water level becomes low, fish

dies, water quality deteriorates with bad smell and salinity increases. Before 1980, the mouth was always open. Since then, the mouth has opened and closed repeatedly. Once the mouth is open, it takes about 4-6 months to close again. The span between openings and the duration of opening depend on the strength of flood and *wadi* flow. Last opening was 5 to 6 years ago and it opened again in April 2003. Villagers sent request letters to the government to open the mouth permanently because they want many fish to come back to the khawr.

(iii) Sedimentation:

Many villagers consider that harbour construction gives some impacts on the mouth closure because a lot of sand produced from digging for the port flowed to the mouth. But some said that construction of harbour did not give any impacts on the mouth closure. When the mouth is open, the *wadi* water flows to the sea and there is no problem of sedimentation. When the sea is rough and waves carry seawater to the inland, the seawater together with interference from mangroves causes heavy sedimentation.

(iv) Customary:

Up to about 40 years ago, the mangrove area was managed by *wali* and sheiks of the area. Sheik monitored the condition of mangrove and reported to *wali*. *Wali* allowed the local people to use the mangrove on certain days based on the sheik's advice. During the opening of mangrove area to the people, they could use the mangrove as they wanted such as cutting and feeding their animals. If they used the mangrove area on other days, they were imprisoned.

ii. Awareness of Protection of Mangrove Ecosystem

Seeds of the mangrove drop and grow naturally, so people do not have any idea of mangrove planting. Protection of the mangrove area is very important because of its beauty, history and role in fish production. If flood comes, mangrove can play a role of bridge between sea and wadi. Some people want to expand the area of mangrove and also to open the mouth permanently.

iii. Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

Dead trees should be taken away, new seedlings should be planted and tips of the trees should be trimmed in order to grow mangrove healthily. The local people are willing to join the protection activities in any way, such as providing labour and advice.

The area can be utilised as a tourism spot with small café and boats. Tourism creates many jobs for Omanis. Therefore, the area and mangroves should be managed well and protected from flood from *wadi*.

5. At Tina & Batah

A. Community Profile

Demographic Information	- Population in Wilayat of Sur was 65,000 in 2001, and it has been increasing rapidly.
Economic Activity	- Fishery is major source of income and employment. - The number of farmers decreased rapidly. - Commercial and business is increasing.
Social Services/ Infrastructure	- Water for drinking: provided by water wagons from desalination station - Water for agriculture: from wells. - Fuel for cooking: mostly gas, kerosene is also used. - Wastewater: collected by sewerage disposal plant. - Garbage: collected by the municipality - Housing development plan is underway.
Social Structure	- Women's group for religious activities - Religious groups - Fishermen's group of young fishermen

(a) Demographic Characteristics

The population of Wilayat of Sur (53,000 in 1993, 65,000 in 2001) is increasing very rapidly with construction of many houses and business facilities.

(b) Economic Activities

West part of the area is based on agriculture and east area is based on fishery. There is a large number of foreign labour working in various sectors in the area. The number of ship carpenters is very small now.

(c) Social Infrastructure

The drinking water is transported increasingly from the other cities. Very few uses well but water is salty. Electricity is supplied to most of the area, fuel for cooking is gas and some use kerosene. Traditional villages in the southeast use fuelwood. There is no sewerage system in the area. Wastewater is collected and garbage is collected by government wagons to disposal site.

A proposal of "Natural Park Project" with duration of 10 years was submitted to the central government by Director-General of Ash Sharqiyah Region and it has been approved.

(d) Social Structure

There is one fishery co-operative consisting of 10 young fishermen; this is a very popular form of fishermen's group all over the country. The group has various activities such as fishing, dealing and bidding the catch.

B. Individual Interview

(e) Mangrove and Khawr Ecosystem

Value and Usage	**Past**	A. Fodder for camels Fuelwood for cooking A. Catching crabs (by Filipinos) Wood for building ships but brought from Mahawt
	Present	A. Fodder for camels and goats A. Catching crabs (by Filipinos) Providing nice green view B. Picnic, rest near the forest
Changes	**Resources**	- There were a lot of fish, crabs and mussels but the number decreased. - Still many wild birds can be seen. - There are many honeybees.
	Size and Quality	- The area of mangrove has been expanding with new mangroves in the last 20 years. - Sedimentation makes the bay shallower and smaller.
	Impacts on the Living	- Housing development is expected to impact the khawr ecosystem. - Prosperous shipbuilding operation becomes repairing and maintaining activities. - Sedimentation makes the ship sailing difficult more and more.
Awareness of Protection		- The people know the process of mangrove growing naturally. - Many people want to protect and expand the mangrove area. - Planting mangrove by school children, policemen, army was organised by MRMEWR.
Potentials for Local Participation		- The people are willing to join the activities by providing labour and advice. - Monitoring by the local people with government support is necessary.

Note) A: Direct use/value, B: Indirect use/value

i. Change of the Conditions

(i) Resources:

In the past there were many camels to carry the shipment and mangrove was used mostly as the camel feed. Mangrove for shipbuilding was from Mahawt Island, not from this area.

There were many big crabs and mussels (only kids could get these) but the number has decreased. One reason is that many foreigners (mostly Filipinos) caught crabs. There are still many migratory birds such as flamingos; also many honeybees can be seen.

(ii) Size and quality:

The mangrove area has expanded very rapidly in the last 20 years owing to decrease of the number of camels. The existing forest is mostly made of new mangroves. The mouth of the Sur Bay has been suffering from sand sedimentation for 6 years and most of ships will be unable to sail at low tide within 3-4 years. It may be caused by the lack of rain and flood as well as the bank construction.

(iii) Customary:

In the past, the villagers tried to manage the mangrove area by themselves. The cutting of mangroves was prohibited except the specific case such as fodder for baby and sick camels. It was applied to fuelwood in *wadi*. However, camels ate even young trees and seeds when the number of camels is large.

ii. Awareness of Protection of Mangrove Ecosystem

Everybody wants to protect and expand the mangrove area because it provides beautification appreciated by both residents and tourists. Also, the people regard the mangrove area as necessary for biodiversity, honey collection, filter of seawater and air and reduction of temperature in the town. People think that the mangrove grows naturally. Now, they want to make the bay full of mangrove greenery for beautification.

iii. Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

Elementary school students joined the 1st plantation activity organised by MRMEWR in February 2002. In the 2nd plantation in February 2003, policemen, army forces and secondary school students participated. The local people are happy to join the plantation workshop.

Policemen are co-operating to expand mangrove forest not only by planting but also by monitoring the mangrove. The local people do their share by reporting illegal activities to the authorities. This work needs governmental support and paid guards. The unemployed here with some payment can be useful for the protection activities

6. Wadi Muraysis

A. Community Profile

Demographic Information	- Total population in Wilayat of Masirah was 10,000 in 2001. - Since the Military Base was established, the population including foreigners has been increasing rapidly.
Economic Activity	- Fishery is major source of income and employment. - The number of farmers decreased rapidly. - Governmental employment and business sector are increasing.
Social Services/ Infrastructure	- Water for drinking: provided by water wagons from desalination station - Water for agriculture: from wells. - Fuel for cooking: mostly gas, kerosene is also used. - Wastewater: collected by sewerage disposal plant. - Garbage: collected by the municipality - Housing development plan is underway.
Social Structure	- Women's group for religious activities - Religious groups - Fishermen's group of young fishermen

(a) Demographic Characteristics

The military base was set up in this island after World War II, bringing with it a great deal of people and good infrastructure. The population has doubled in the last 20 years. Soldiers from the U.K. and U.S.A. as well as Oman are stationed at the base. Construction of the good infrastructure has attracted many Indians and Pakistanis as foreign labour.

(b) Economic Activities

Fishery is the main industry, followed by governmental employment and business. The number of farmers has decreased to half its size in 1997 because it has not rained much in this island since then. The military base is providing lots of jobs.

(c) Social Services and Infrastructure

Water for living is brought by water wagons from desalination and purification plant. Electricity covers most of the area. Fuel for cooking is gas and traditional villages in the southeast still use fuelwood (not mangrove). Wastewater is collected through pipes from each house to a sewerage disposal plant. Collected excrement is dried under sunshine and used as fertilizer. Garbage is collected by municipality and buried under the soil.

There is one primary school with 700 students, where boys and girls are educated together. There are 2 secondary schools, one for boys (650 students) and one for girls (683 students).

A big storm in 1977 destroyed lots of houses and fell down trees and mangroves and large waves washed them away. Roads expansion of 19 km and road lights expansion of 160 poles are underway. Underground Electric Wire Project is also in progress.

B. Individual Interview

(d) Mangrove and Khawr Ecosystem

Value and Usage	**Past**	A. Fodder for goats A. Fuelwood for cooking and lighting A. Wood for building houses and ships
	Present	B. Providing natural beauty
Changes	**Resources**	- There were a lot of fish and lobsters but now a little. - Coral reefs are damaged. - The number of migratory birds and turtles has decreased.
	Size and Quality	- Mangroves and other trees were destroyed by storm in 1997. - The beach retreated back to the land because of sand sedimentation.
	Impacts on the Living	- The number of livestock decreased because of lack of water. - The catch of fish and lobsters has decreased because of over-fishing.
Awareness of Protection		- The people know the process of mangrove growing naturally from their empirical knowledge. - Many people want to protect coastal ecosystem and expand the mangrove area.
Potentials for Local Participation		- The people are willing to join the activities by providing labour and advice. - Monitoring of the coastal area by the local people is necessary.

Note) A: Direct use/value, B: Indirect use/value

i. Change of the Conditions

(i) Resources:

After 1977, the catch of fish has decreased because of the increased number of modern ships from other countries. The catch of lobsters also has decreased because of over-fishing for the high value. Migratory birds and turtles have been decreasing because of disturbance of their habitats by cars and people.

(ii) Size and quality:

Anchors and trolling damage coral reefs. The beach has retreated about 20m inland.

(iii) Customary:

Sheiks were controlling villagers' utilisation of the mangrove to avoid overuse of the area in the past. Collecting dead trees and cutting only branches were allowed for fodder for goats, fuel for cooking and lighting. Only a little amount was used for building houses and ships.

(iv) Impacts on the people's living:

Lack of water makes the people spend more money for fodder and sell their livestock. The catch of the fishermen has decreased because of over-catching of fish and lobsters.

ii. Awareness of Protection of Mangrove Ecosystem

People want mangroves along with all the coastline of this island for fodder, shade and beauty. Also, they want to use mangrove for fuel to secure an alternative to oil in case of its depletion. In order to plant mangroves, the coastline should not be built with big hotels and other large facilities. Protection of coastal ecosystem has been discussed in many occasions such as sheik meeting and informal meetings of the residents.

A long time ago Masirah Island used to be called "*Seravis* (Green Island)", indicating that there were many trees. Now, the area is called "*umgraimtain*", which means " two trees of mangrove". Since there exist little trees in this area, many people have no idea of mangrove. They believe mangroves grow naturally.

iii. Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

The whole community will do everything they can do for coastal management. They also want a nursery of mangrove for plantation by themselves. Currently 5 monitors are working for coastal management but they are from other areas and not familiar with this area. Therefore, the interviewees prefer the people in this area or island for effective management of the island's nature.

7. Filim/Mahawt Island

A. Community Profile

Demographic Information	- There are about 80 houses in the Island. One-fourth is for semi-settled and the rest is used temporarily for fishing. - During June-August, the people move to towns for vacation and leisure.
Economic Activity	- Fishery is major source of income and employment but seasonal activity, followed by livestock farming. - The catch of fish and shrimp per head has decreased because of many large ships from other places.
Social Services/ Infrastructure	- Water for drinking: provided by water tanks and desalination station - Water for agriculture: from wells but salinity is a problem. - Fuel for cooking: mostly gas. - Wastewater and garbage: collected by municipality. - Housing development plan for the poor and road construction are underway.
Social Structure	- Women's group for healthcare - Environmental group - Fishery group

(a) Demographic Characteristics

Total population of Wilayat of Mahawt is about 10,000 (2001 data). Some people moved from the Mahawt Island to Filim and Hij because of lack of water, school and other social facilities. Still many families are semi-settled in the Island and some are coming only for fishing. From June to August, the inhabitants leave the island to spend their vacation in the other towns and dates plantation.

(b) Economic Activities

Fishery is a seasonal activity. During June-August fishing virtually stops because of hot weather and sea condition. The economic condition is unstable and serious depending on the condition on sea. There are some goats in the Mahawt Island and camels in Filim.

(c) Social Services and Infrastructure

The water from a desalination plant in Filim is supplied to the Mahawt Island through the underwater pipe. Water accumulated in a water tank has been distributed to the residents since December 2002. The people in the Mahawt Island live in temporary huts made with timber, palm fronds and some plastic sheets. Still old huts made with mangroves are used for shower room and storage. There are some deserted houses after relocation to Filim and Hij. A proposal of bridge construction across the channel between Filim and Mahawt is considered.

B. Individual Interview

(d) Mangrove and Khawr Ecosystem

Value and Usage	**Past**	A. Fodder for camels, goats and cows A. Fuelwood for cooking and lighting A. Fishing A. Wood for building houses and ships
	Present	A. Catching crabs and small fish A. Fodder for goats A. Fuel for cooking Providing natural beauty B. Stop a big wave
Changes	**Resources**	- There were a lot of fish, crabs and shrimps but decreased now. - Still many migratory birds and wild birds can be seen.
	Size and Quality	- The size of mangrove area in Filim and Mahawt has increased since prohibition of use by the government.
	Impacts on the Living	- The expansion of mangrove area stops big wave. - The ban of utilisation of mangroves makes the villagers spend for other materials.
Awareness of Protection		- The people know the process of mangrove growing naturally. - Many people want to protect and expand the mangrove area.
Potentials for Local Participation		- The people are willing to join the activities. - Monitoring of the mangrove area by the local people, especially women in the Mahawt Island, is preferable.

i. Change of the Conditions

(i) Size and quality:

The size of mangrove areas in Filim and Mahawt Island has increased rapidly since the governmental prohibition of usage of the mangrove. When the local people used mangrove a lot for various purposes, the area decreased.

(ii) Customary:

Around the 1960s and 1970s, sheiks were controlling the size and condition of mangrove (it is like in Qurayyat). Group policing for mangrove protection was also carried out in the island. Punishment was imposed after the warning to the illegal usage.

(iii) Impacts on the people's living:

The expansion of the mangrove area stops big waves and provides beauty to attract more tourists. The decreased catch of fish and prohibition of use of mangroves affect the economic situation because the villagers have to spend for things they did not used to before, e.g. feeds for livestock.

ii. Awareness of Protection and Management of Mangrove Ecosystem

The people want to plant and expand mangroves in Filim but to maintain the mangroves in Mahawt Island by trimming the trees. The villagers are excited to have a beautiful and wider mangrove area to attract more tourists to visit the area, which they believe will benefit them economically. They know that mangroves grow naturally.

iii. Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

School students compete for environmental achievement in His Majesty's Environment Cup in this country. The activities include planting trees and collecting garbage, etc. Also, since women in Mahawt Island often goes to the mangrove area for their living and are very familiar with the ecosystem, women can be in the front line for the activities.

8. Khawr Taqah-West

A. Community Profile

Demographic Information	- Total population in Wilayat of Taqah was 19,000 in 2001, and recent increase is rapid with urbanisation.
Economic Activity	- Agriculture is major source of income and employment, followed by governmental employment.
Social Services/ Infrastructure	- Water for drinking: piped water. - Water for agriculture: from wells and some springs. - Fuel for cooking : mostly gas. - Wastewater: discharged into the ground. - Garbage: collected by Salalah Municipality. - Tourism development plan includes this area.

(a) Social Infrastructure

High salinity of water for drinking and agriculture is a major problem in the area. There is a tourism development plan covering this area. Targets are historical remains such as the port and fort, and natural beauty of the mountains, beaches and khawr including the mangrove area. It is required that all development plans provide benefits to the local people.

B. Individual Interview

(b) Mangrove and Khawr Ecosystem

Value and Usage	**Past**	A. Fodder for camels and goats A. Fuelwood for cooking A. Fishing A. Wood for building ships
	Present	A. Recreational site for picnic A. Fodder for camels and goats B. Providing natural beauty of greens
Changes	**Resources**	- There were a lot of fish but decreased now - Still some birds can be seen but the number is smaller than before.
	Size and Quality	- The mangrove area has expanded since nobody touches it. - Condition of trees is not good without good care.
	Impacts on the Living	- The profit from livestock decreased because of increase of feeds bought in the market instead of mangrove. - The opportunities to visit the khawr have decreased because of prohibition of the use.
Awareness of Protection		- The people using mangroves know the importance and the process of mangrove growing naturally from their empirical knowledge. - Many people want to protect and expand the mangrove area because of its beauty.
Potentials for Local Participation		- The people are willing to join the activities by providing labour and advice.

Note) A: Direct use/value, B: Indirect use/value

i. Change of Conditions

(i) Size and quality:

Many of the respondents said the mangrove area has expanded since nobody touches mangroves anymore because they are protected as Nature Reserve. Some said that mangrove trees were larger before but now their size has become smaller because nobody trims and manages them well. The khawr has less water because of less rain.

ii. Awareness of Protection and Management of Mangrove Ecosystem

The respondents claim that the inhabitants who have never used the mangrove area think of the mangroves as useless trees because they do not bear fruits unlike other trees, e.g. coconut, mango, papaya, etc. Meanwhile, the camel holders and elders have recognised the importance of the mangrove. Protection of mangrove area is considered important because green is good to attract the people. However, fencing off the area is not preferable.

iii. Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

The villagers are willing to join the protection activities in some ways to assist the government. One idea is to have a designated community engage in some activities as a model.

9. Khawr Balid

A. Community Profile

Demographic Information	- Population around the khawr has been increasing.
Economic Activity	- Agriculture is major source of income and employment, followed by governmental employment and fishery.
Social Services/ Infrastructure	- Water for drinking: provided by municipal water wagon and some wells - Water for agriculture: from wells but salinity is a problem. - Fuel for cooking: mostly gas. - Wastewater and garbage: collected by municipality. - Tourism development and archaeological park construction are underway.

(a) Demographic Characteristics

Khawr Balid, surrounded by agricultural land, is under management of Salalah City. The city has a total population of 16,000 (2001 data). Around the khawr, new houses have been constructed and population here has been increased rapidly.

(b) Social Infrastructure

Salinity of water for drinking and agriculture increases and this is a major problem in the area. There is a tourism development plan covering this area.

Development of archaeological park and tourism facilities such as hotels and restaurants is underway.

B. Individual Interview

(c) Mangrove and Khawr Ecosystem

Value and Usage	**Past**	A. Fodder for camels, goats and cows A. Bathing and watering by cows, camels and goats A. Fishing during monsoon season B. Visiting to see water and greens
	Present	A. Recreational fishing
Changes	**Resources**	- There were many kinds of fish but decreased now. - Many grasses grown and given to livestock.
	Size and Quality	- Monsoon causes sand sedimentation and makes the khawr smaller and shallower. - Water level becomes lower because of dam in upstream.
	Impacts on the Living	- Salinity of water increases and damages farmland and reduces the catch of fish. - Fishermen go to sea even during monsoon season.
Awareness of Protection		- The people know the process of mangrove growing naturally. - All respondents want to protect and expand the mangrove area.
Potentials for Local Participation		- The people are willing to join the activities by providing labour and advice, if it is beneficial to the people.

i. Change of the Conditions

(i) Resources:

Many grasses grown in and around the khawr were given for goats, camels and cows. Some kinds of grasses and plants were even exported to India 50-60 years ago. There were many kinds of fish in the khawr until a few years ago.

(ii) Size and quality:

When khawr was wide open due to heavy monsoon and rainfall, saltwater fish went to the sea from the khawr. Salinity increases due to the dam and lack of rain damages farmland and reduced the catch of fish.

ii. Awareness of Protection and Management of Mangrove Ecosystem

Protection of the khawr and archaeological site is important but just fencing off the area is not preferable because it makes the local people feel separated from the area. Greenery view is tourism attraction. However, large-scale tourism facilities are not agreeable.

iii. Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

Benefits from the khawr and archaeological site should go to both the government and the local people. Therefore, the involvement of the local people should be considered. The people can contribute to khawr protection through providing labour and some advice.

10. Khawr Kabir

A. Community Profile

Demographic Information	- There are no residents around Khawr Kabir.
Economic Activity	- Fishery is major source of income and employment, followed by governmental employment in the nearest community, Dahariz village. - There are hotels, fishing port and industrial area with Salalah Port.
Social Services/ Infrastructure	- Water for drinking: provided by municipality. - Fuel for cooking: mostly gas. - Wastewater and garbage: collected by municipality. - Tourism development plan and industrial development are underway.

(a) Demographic Characteristics

Khawr Kabir is under Salalah Municipality. Around the khawr, there are no residents but Hilton Hotel is located between Khawr Kabir and Khawr Saghir. Especially Khawr Saghir is just next to the hotel.

B. Individual Interview

(b) Mangrove and Khawr Ecosystem

Value and Usage	**Past**	A .Fodder for camels and goats A. Fuelwood for cooking A. Fishing during monsoon season Wood for making boats
	Present	B. Providing natural beauty
Changes	**Resources**	- There were a lot of fish but decreased now.
	Size and Quality	- The size of mangrove area has increased since prohibition of use by the government. - Even the trees are smaller.
	Impacts on the Living	- Fishermen go out to sea even during monsoon season.
Awareness of Protection		- The people know the process of mangrove growing naturally. - Many people know the area designated as Nature Reserve - People want to protect and expand the mangrove area because of its beauty.
Potentials for Local Participation		- The people are willing to join the activities by providing labour and advice.

i. Change of the Conditions

(i) Size and quality:

Rain makes the khawr wider and then closed up. This movement is repeated until the size of the khawr no longer changes finally. Mangroves grew more previously but have now become smaller; they no longer look nice because nobody cuts and prunes the tip of the trees. The browsing by camels stopped after the area was fenced off.

ii. Awareness of the Protection and Management of Mangrove Ecosystem

Many of the respondents know that the khawr is designated as Nature Reserve but nobody knows there is a plant nursery in Khawr Kabir set up by MRMEWR.

The people know that mangrove grows naturally and nobody has ever planted them. Since nobody uses and even attempts to access the khawr and mangrove now, some respondents are afraid of everybody losing interest in the future of the khawr and mangrove. Everybody considers the protection of the mangrove area important.

iii. Potentials for the Local Participation to the Protection/Management of Mangrove Ecosystem

Most of them are willing to participate in protection activities in some ways. Some hope that the area will become a park with small facilities for visitors to benefit the local people.

Hilton Hotel is willing to assist in conservation of the khawr and mangrove, especially Khawr Saghir as one of the attractions for the guests. However, regarding the management of the Khawr Saghir, transfer of the property of the municipal land adjacent to the hotel is necessary.

d. Conclusion

According to the socio-economic survey at 10 sites, common situations in all sites and unique characteristics in the individual site can be found as summarised below. Also, the background conditions that might create such characteristics are observed and presumed by the local people.

Table A3.3 Common Situations to be Seen in All Sites

Items	Situations	Background to Create the Situations
Usage and Values - Past	1-A. Fodder for camels and goats 2-A. Fuelwood for cooking 3-A. Construction wood for houses and ships 4-A. Fishing	- There were many mangroves. - A large number of fish were living.
-Present	1-A. Recreation (fishing, picnicking) 2-B. Hatchery of fish 3-B. Providing beautiful natural view	Prohibit to use mangroves by law for the protection Green is attractive to the people.
Resources	The number of fishes, crabs and shrimps decreased. The number of wild birds decreased. The size of mangrove area has increased. Condition of mangrove trees is not good.	The khawrs become smaller. Habitats of wildlife have been damaged. The mangrove area is protected. Trees are not cared well such as trimming.
Impacts on the Living	The number of livestock decreased. Fishermen go to sea all year round.	Mangrove cannot be used for fodder. The khawr cannot be used because of protection.
Awareness	Many people know that mangroves grow naturally. Many people know the Nature Reserve designation.	Empirical knowledge with some relationship with mangroves. Governmental instruction and regulation are observed by the people.
Local Needs	Tourism development People want to protect and expand the mangrove area.	Villages expect benefits from the development. They consider that natural green beauty is attractive to the local people and visitors.
Potentials	The people are willing to join the activities by providing labour and advice.	Protection by the local people is important.

Note: A is for Direct Use, B is for Indirect Use/Value in column of "Usage and Values"

Table A3.4 Unique Characteristics in Individual Site

Items	Characteristics	Site	Background to Create the Characteristics
Usage and Values - Past	Materials for making Omani cement	Bandar Khayran	
	Collecting honey	Bandar Khayran / Qurayyat	
- Present	Collecting honey	Bandar Khayran / Qurayyat	There are no income sources other than fishery.
	Fishing using net	Bandar Khayran / Mahawt	Livestock are free to get feed by themselves and owners do not care.
	Browsing by goats	Bandar Khayran / Qurayyat / At Tina/ Batah/ Mahawt / Taqah-West	The mangrove area is protected and surrounded by fence.
	Browsing by camels	Taqah-West	
	No access by the people	Taqah-West Kabir / Taqah-West	
Resources	The number of turtles has decreased and coral reefs have been damaged.	Masirah / At Tina/Batah	Lack of environmental education and guidelines for coastal management to the local people
	Grasses grown around the khawr decreased.	Balid	Over-utilisation for fodder
Size and Quality	Water quality has deteriorated.	Qurm / Qurayyat	Wastewater and garbage are thrown into the sea and water level becomes lower.
	Mangrove area has decreased.	Qurayyat	Overgrazing by goats and camels
	Sedimentation is serious.	Qurayyat / At Tina/Batah / Balid	Management of trees is not enough.
			Harbour construction, dam construction, less rain are causes.
Awareness	Nobody knows the existence of plant nursery.	Qurm / Kabir / At Tina/Batah	- There are few opportunities to access the area and no information on the nursery.
	Local people try to stop illegal cutting.	Qurm	Local people have observed the regulation.
	When the mouth is open, the number of fish increases.	Qurayyat	People have empirical knowledge.
	Planting activities by school students	At Tina/Batah	The activities are informed well.
	Sheiks and the local people managed/controlled the area.	Qurayyat / Masirah / At Tina/Batah	The people knew the capacity of the mangrove and wanted sustainable use.
Local Needs	Permanent open mouth of the khawr	Qurayyat	The people need more fish and mangroves as in the old time.
	A bridge or a jetty from Filim to the Island	Mahawt	Low tide limits the people's life.
	The unemployed should be involved for the activities.	At Tina/Batah	There are many unemployed young and need job opportunities.
Potentials	Information Centre is welcomed.	Qurm	It will be a tourism spot.
	School participation is available.	Shinas / Bandar Khayran / At Tina/Batah	School activities in the field are frequent.
	Monitoring of the area by local people is required.	Masirah	Monitors from other areas are not familiar with the area.
	Monitoring of the area by women is recommended.	Mahawt	Women have used the mangrove area more than men and know the significance of the mangrove ecosystem.

In the past, the mangrove ecosystem and khawr system were utilised for multi-purposes and some of them were managed and controlled well by the local people to avoid over-utilisation. The changes of geographical conditions due to less rain and flood, sedimentation, etc. and of the lifestyle, and legal control have limited the usage accordingly. Especially, since the use was stopped by regulations, people's activities and feelings seem to have been away from the mangrove areas and khawrs. While the people have recognised the changes of the area, they long for the past and feel a little bit uncomfortable with the present estrangement and untouched conditions. This is because most of the interviewees know the past conditions well. Most of the people hope for the extension of the area and are willing to be involved in the activities.

During the survey, however, some interviewees were embarrassed, surprised and even wondered over the questions posed to them. For them, the purposes and real intentions of the interviews regarding the mangrove and khawr did not seem to be understandable, since they no longer have a relationship with the area.

Among the above characteristics, positive ones can be made good use of to promote the activities of protection and management of the mangrove ecosystem and for negative ones the ways of mitigation should be considered. The following table tries to find the measures to be taken.

Table A3.5 Measures to Utilise the Advantages and Disadvantages

	Characteristics	Countermeasures
Advantage	- The frequency of recreational use of the mangrove and the khawr ecosystem has increased. - Activities of seedling planting have been organised by MRMEWR. - There are school activities in the field as environmental education. - Women are closely related to the mangrove area for their living in some places. - People admire the natural beauty of green. - The local people know the Nature Reserve area and observe the regulation.	- Information of mangrove ecosystem and importance of protection should be provided to the visitors by setting up signboard and distributing brochure, etc. - Planting activities should be continued involving more local people, especially school students. - School field activities should be utilised for the purpose of providing information of mangrove ecosystem to students as well as school staff and families. - Women should be involved in the activities. - In order to attract more people to visit the area, the way of protection should be considered (not just fencing the area but creating a nice atmosphere).
Disadvantage	- The number of fish, turtles and birds has decreased. - Conditions of mangrove trees are not good in spite of the area expansion. - The existence of plant nursery is not known well among the local people. - Still browsing by goats and camels is a problem in some places. - The protected area is fenced and keeps the people away, which makes the people feel uncomfortable and uninterested in the mangrove ecosystem.	- Regulation and guidelines for protection of their habitats should be considered. - Regular management by the local people should be considered such as trimming, cleaning, and monitoring. - Information of the MRMEWR activities should be disseminated widely. - Guideline for feeding livestock can be considered. - Signboard and billboard explaining the mangrove ecosystem and importance of the protection (especially, the benefit to the people) should be set up and small facilities inviting the visitors should be considered. - The local people should be benefited through

	Characteristics	Countermeasures
	- In spite of many tourism development plans in various places, the involvement of the local people into the beneficiaries is not promoted yet. - Awareness level of the local people for the mangrove ecosystem varies from place to place. - With population increase, urbanisation and motorisation, coastal area including mangroves gets impacts.	employment and other ways. - Environmental education and enlightenment regarding mangrove should be flexible depending on the characteristics of the target groups. - Regulation and education for public awareness are necessary.

3.1.2 Regional Analysis

All 21 sites for Master Plan can be categorised into the types of mangrove area and present major usage as follows. According to the results of the 10 sites studied by socio-economic survey, 7 types of sites can be considered for countermeasures for restoration, conservation and management. Close attention should be paid to the people's opinions and experience regarding these types of sites as they pertain to socio-economic aspect.

Mangrove	Present Usage	Survey Site	Points to be Considered
Exist	Type A: Park Recreation - Tourism	Khawr Shinas	School activities
		Khawr Harmul/Nabr	Nearby Port, sand sedimentation
		Khawr Qurm	Nature Reserve since 1975, Plant nursery
		At Tina/Batah	Landfill for housing construction
		Bandar Khayran	Hotel construction plan
	Type B: - Catching crabs, fish	Film	Semi-nomadic lifestyle of the people, women's active role
		Mahawt Island	Semi-nomadic lifestyle of the people, women's active role
		At Tina/Batah	Plant nursery, fishing port, sand sedimentation
	Type C: - Browsing by camels and/or goats	Khawr Qurayyat	Mouth closure, illegal dumping of construction waste
		Qurm Taqah	Nature Reserve
	Type D: - No use	Khawr Saghir	Nature Reserve since 1997, next to Hilton Salalah
		Khawr Kabir	Nature Reserve since 1997, plant nursery
Not exist	Type E: Recreation Tourism	Khawr Sawadi	Plantation by MRMEWR
		Ras Al Had	Turtle reserve since 1996
		Al Demer Beach	Sand dune
		Khawr Rowri	Nature Conservation Area in1997, World Heritage Site in 2001, archaeological area, overgrazing by livestock
		Khawr Balid	Archaeological park
		Khawr Haradi	Water quality deteriorated by wastes from nearby houses, closed mouth
		Khawr Dahariz	Closed mouth, Nature Reserve
	Type F: - Fishing	Wadi Muraysis	Seasonal fishing population
	Type G: - No use	**Khawr Quq**	Tourism development plan

Note: Sites with bold letters were interviewed for the socio-economic survey.

- **Type A:** The mangrove area is used as a park and for recreational/tourism purposes.
  - Signboard providing information on mangrove and significance of protection of the area
  - Infrastructure and guidelines in order not to damage the mangrove area (garbage, wastewater, etc.)
  - Cleaning the area
  - Environmental education to increase public awareness of mangrove ecosystem protection
  - Studies of the environmental impacts of the developmental projects on the area
- **Type B:** The mangrove is used for the place of catching aquatic life.
  - Eco-tourism development guideline
  - Environmental education to protect mangrove ecosystem
- **Type C:** The mangrove is used for fodder for livestock animals.
  - Guideline for mangrove usage for fodder
  - Environmental education to increase awareness of mangrove protection
- **Type D:** The mangrove area is not used significantly any more.
  - Sign board for mangrove ecosystem and importance of the protection
  - Environmental education to the local people
- **Type E:** The area without mangrove is used for tourism and recreation.
  - Signboard showing the importance of khawr and coastal management
  - Cleaning the area
  - Infrastructure in order to mitigate the negative impact on the environment
  - Coastal management guideline
  - Environmental education to the local people
- **Type F:** The area without mangrove is used for fishing.
  - Coastal management guideline
  - Cleaning the area
  - Environmental education to the local people

- **Type G:** The area without mangrove is not used significantly any more.
  - Coastal management (e.g. to stop discarding unwanted fish) guideline
  - Cleaning the area
  - Environmental education to the local people

3.1.3 Back Data for Social Survey

a. Khawr Shinas

(a) Community Profile

i. Demographic Characteristics

The population of Wilayat of Shinas showed a sharp increase, from 44,000 in 1993 to 53,000 in 2001. More than 10 years ago, people from the UAE with many camels vacationed here for 3-4 months during the summer and increased *wilayat* population seasonally. Relatively well-represented tribes of this area are the *Al Maqbali*, *Al Maamary*, and the *Al Baluschi*.

ii. Economic Activities

Agriculture and fishery are the main economic activities, followed by governmental employment. Agricultural products (mainly dates) are damaged by increase of water salinity. Fish catch has suddenly started decreasing 4-5 years ago and this trend continues up to today. The reason seems that big ships from foreign countries are catching a huge amount of fish. Some of the fishing nets set by the local fishermen have been cut down accidentally by the foreign ships.

iii. Social Services and Infrastructure

Water for drinking is provided by water wagons of the municipality. Wells are also used but salinity is serious. Water for agriculture is from wells, which increases salinity. Electricity supply covers most of the area. Fuel for cooking is mostly gas. Sometimes the villagers collect trees from *wadi* in occasion of banquet. Wastewater is collected and transported by tank trucks of private companies. Garbage is collected by the municipality every day. There is a municipal park development plan; already the implementation is going on along the mangrove area.

(b) Interviewees' Characteristics

The interviewees come from a wide range of occupation such as fishermen, farmers, governmental staff, and sheiks, with ages from 30-60 years old.

(c) Usage of Mangrove Ecosystem

i. Resources

The local people could go fishing almost every day in the mangrove forest and many of the catch were sold because there used to be a number of fishes, shrimps, shells and crabs. But nowadays few small fish, crabs and lobsters can be found and the people fish just for fun once or twice a week. Fish catch per unit has decreased because many big ships with modern equipment come to get a lot of marine products. Some respondents stopped their fishing activities around 10 years ago.

In the past, a lot of mangroves were cut for construction wood for houses, fuelwood for cooking, and fodder for goats and camels (many from UAE during the summer vacation up to 10 years ago). Some amounts of dead mangroves are still sometimes used for firewood in banquets. The people used to visit the mangrove area for recreational purpose very often (relaxing and enjoying nature everyday or more than twice a week) but now it's just once a week at most for recreational fishing and walking. Big and small wild birds can still be seen but the number has decreased.

ii. Size and quality

Most of the site used to be like a desert (not tideland) before. But the number of mangrove trees has been rapidly increasing (from about 300 trees to thousands of them) and the area has become the greenery of mangrove. One of the reasons is that the government started to protect mangroves by prohibiting using and cutting them. Another reason is that growing mangroves stopped flowing seawater into the farm and reversed it to the desert area. This made good conditions for the mangrove growing.

iii. Impacts on the people's living

The number of livestock has decreased because instead of mangrove the farmers have to plant their feeds in farms or buy them in the *souq* and it caused to increase labour and costs for breeding animals. Meanwhile, farmers could reduce the damage to their farmland from salt and wind thanks to the mangrove expansion, which are beneficial to their agriculture. The people can cool themselves under the shade of mangrove trees. Kids can play in the mangrove forest, swim and fish in the khawr, and families can go for a picnic near the forest.

(d) Awareness of Mangrove Protection

Local people go to the park newly constructed along the Khawr Shinas for picnic, catch fish and crabs, smell mangrove flowers and sea breeze, etc. Therefore, the park plays a role of attracting the people to touch nature.

However, without signboard explaining wildlife including mangroves, people cannot be aware of them.

Some respondents have talked about change of the mangrove area and how to protect the area many times among the community, family and with children. The people know the process of mangrove growing naturally from their empirical knowledge. Some of them tried to transplant seedlings in farmland and gardens but they were not successful.

(e) Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

Many of the local people want to protect and expand the mangrove area because of its attractive scenic beauty. The people desire the park area to be a tourism base with fruit trees, rest houses, roads, hotels and restaurants. Information board is preferably set up to learn about the mangroves and other nature for the visitors. The respondents need a coastal road to approach the beach by 4WD car. They are willing to join the protection activities by collecting contributions from villagers, providing labour and advice to them, especially the young people, to protect the area.

(f) School in Shinas

There are 167 schools (elementary and secondary schools) in Sohar Region and 23 of them are in Wilayat of Shinas. Schoolteachers take students to the field for a one-day social activity once every month (this is an extracurricular field activity unified all over the country), such as port, fort, beach and mountain. The number of schools for boys is 16, which can participate in outdoor activities (it is difficult for girl students to participate in outdoor activities because of traditional circumstances).

An idea of school nursery proposed by JICA Study Team is acceptable by the Director-General (DG) of Ministry of Education of Sohar Region and Acting Director of Secondary Schools near the Khawr. The DG suggested that different students from different schools should be invited for monitoring of the school plant nursery every 2 weeks. Then, teachers in the school located near the mangrove area can be instructed all necessary techniques by the Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR); co-ordination of all teachers for the activities can be done by MRMEWR as well.

The students in the school near the Khawr Shinas are sometimes taken out by teachers to clean up the mangrove area. Also, an environmental club in school has activities after classes, such as cleaning the area, planting trees (not mangrove) near the school and observing wildlife. Teachers and students have no information on mangroves at present and no chance to learn about mangroves. Therefore, the schools will welcome the school nursery to be included as one of the field activities of school.

b. Khawr Qurm

(a) Community Profile

i. Demographic Characteristics

The population of Wilayat of Muscat increased from 41,000 in 1993 to 52,000 in 2001. Around the Khawr Qurm, population has been rapidly increasing with construction of houses, hotels, restaurants, offices and other buildings and facilities. There are many ethnic groups with urban lifestyle.

ii. Economic Activities

Main economic activities are commerce and industry, and governmental employment. There area some fishermen working in this area. There is a small jetty constructed by the Ministry of Agriculture and Fisheries Resources.

iii. Social Services and Infrastructure

The Khawr is designated as Qurm Nature Reserve, located in the centre of Muscat area. The highway is passing through the Qurm Natural Park along the shoreline and many people visit to enjoy nature of beach and greens. Many cars of recreational visitors are parked along the coastal roads in the evening. There is a plan of pedestrian promenade construction along the highway.

(b) Interviewees' Characteristics

It is very difficult to find the persons who know the area well because the inhabitants around the Khawr area are mostly newcomers. The young and old fishermen (from 20s to 70s of age) who are familiar with the past conditions of the Khawr were interviewed.

(c) Usage of Mangrove Ecosystem

i. Resources

There existed a lot of fish, crabs and little lobsters but now only a little can be found in the Khawr. Fishermen do not fish in and around the khawr but do inshore and offshore fishing. They feel that the total amount of fish has not been changed but the increased number of fishermen and big modern ships from many areas causes the less catch of fish per head. There are about 40 fishermen with 30 boats staying in this area. Some wild birds can be seen in the mangrove area. The local people believe that the mangrove area has snakes and other dangerous creatures and they are scared to go there. Even when they spent a day at the mangrove area for recreational purpose, it was once a month only. Now, since the area is fenced off, it is not possible to enter.

ii. Size and quality

The area of the mangrove has expanded since it was designated as Nature Reserve. The government planted more mangroves near the jetty located under the Gulf Hotel. But trees and flowers of mangroves are not in good condition compared to before (they consider that colour of flower is not clear yellow but brown because of disease). Some recognised that quality of water in the jetty has not changed but many said that quality has deteriorated because of sewerage from nearby houses and garbage thrown into the water and dumped around the jetty.

iii. Impacts on the people's living

In the past, the mangrove was utilised as fodder for camels, goats and cows, firewood for cooking and construction materials for houses and ships. Also, people did fishing in the area. They have thought that the khawr is the place for fish hatching. But since the prohibition of use of mangroves, their roles are reduced to provide fish, good shade for taking a rest and nice natural view of green.

When the wave is rough and tide is low, fishermen cannot move their boats in and out of the inlet. Therefore, they need wider and deeper jetty. Also, the small market for fish is preferable for them in front of the jetty in order to sell their fresh products.

(d) Awareness of Mangrove Protection

Younger generation has no idea of mangroves. A few of them know that mangrove area provides the place for fish hatchery.

Sometimes the respondents find someone cutting the mangrove and warn him to stop cutting trees. All know that the area is designated as Nature Reserve and the cutting and taking of trees are prohibited. However, nobody knows that there is a plant nursery prepared by MRMEWR in the mangrove area.

They want to expand the area to create more nature. One fisherman wanted green around the lake (in suburban area of Muscat) and he planted seedlings of mangrove near the lake but they did not grow. The people said that mangrove trees grow naturally after seeds drop from the tree. Therefore, some people replied that it is not necessary to plant seedlings.

(e) Potential for Local Participation to the Protection/Management of Mangrove Ecosystem

Fishermen are willing to join the activities. Also, if they see people cutting the mangroves, they will try to stop these people's activities by themselves. And they will report to the government if they cannot stop.

If the Qurm Environmental Information Centre is established, the people are willing to visit there to study about mangroves. They want to clean the area by

taking rubbish and large garbage out from the area of the jetty and the khawr to attract the people and wildlife. Also, the water quality should be improved.

c. Bandar Khayran

(a) Community Profile

i. Demographic Characteristics

The village of Bandar Khayran had a population of about 1,000 in 2001 (40% for male and 60% for female). Its population, which is mostly from the tribes of *Al Jabri* (75%), *Al Maamary* (20%) and *Al Wahanibi* (5%), has been rapidly increasing. This growth is caused by immigration from the neighbouring villages for economic reasons. People come to find income sources from fishery.

ii. Economic Activities

Fishery has been the most important industry in income earning and labour force. There are 45 boats in the village. Fishing nets are set near the island and also aquaculture using imported fry is operated in the bay. Daily fishing operation is generally from 5:00 a.m. –12:00 p.m. and 4:00 p.m. –8:00 p.m.

Agriculture is mainly date production but the production and the quality have decreased because of the increase of water salinity. Livestock farming of goats was operated widely before but the import of cheap goats decreased the profits from goats rearing and the villagers gradually gave up to have goats. These days, dates and goats are consumed mostly in the houses in the village. Other important economic sector is governmental employment because of the close location to Muscat.

Bandar Khayran is a popular picnic, camping and diving spot. There are many foreign tourists coming from Muscat to the inlet and islands near the village for a one-day trip or overnight camping but most of them use boats arranged by tour companies in Muscat. Only a few fishermen's boats are hired at R.O. 5 per boat.

iii. Social Services and Infrastructure

Water for living is provided by water trucks of the Muscat Municipality. Desalination plant in this village started operation in July 2003. Water for agriculture is from well. Electricity has been supplied since 1995. Fuel for cooking is gas. Wastewater and garbage are collected by the municipality. Garbage is transported and burned in Yitti village. There is one primary school in the village with more than 200 students. The secondary school is located 10 km from the village and school bus is operating. There are one youth club, one religious group and one fishery group. Paved road expansion and hotel and restaurant construction are planned in this area, mostly for tourism development.

(b) Interviewees' Characteristics

They are sheiks, fishermen and farmers with dates plantation and/or engaged in goats rearing, whose ages are in the 40s - 60s.

(c) Usage of Mangrove Ecosystem

i. Resources

There existed many fish, crabs, shrimps and shellfish including oysters in the mangrove area but now some species have been extinct. Especially, shrimps have not been found during the last 3 years. Some wild birds can be seen. Villagers got their eggs before but this activity is prohibited now.

ii. Size and quality

The area has expanded in the last 40 years, except one incident of water contamination by pesticide 22 years ago, and the trees became bigger. The spraying of pesticide on the greens by the Muscat Municipality is still continued in order to rid the residents of nuisance. One respondent has been working in a group to spray pesticide around the mangrove area, 8:00 a.m.-11:00 a.m. once every two weeks for 15 years. Quality and level of seawater have not changed.

iii. Impacts on the people's living

Mangrove area was used for fishing, collecting woods for construction of houses and boats, fuel for cooking, honey, fodder for goats and cows and raw material of Omani cement (burned mangroves were ground to powder and mixed with cement) 30 years ago. Mangrove was used only for the support of the house and base of the ship because of its strength and durability. The role of collecting fuelwood was generally assigned to women and some amounts of woods were sold. Men went fishing using fishing nets and collected woods to make Omani cement and honey. Sometimes women collected honey if they could find beehives during the collection of fuelwood. Goats prefer the flowers of mangrove. So, when mangroves are flowering, the people collect the flowers to feed their goats. All year round, the animals are left free to browse mangroves and grasses around the village.

Now, the mangrove area is used only for collecting honey and fodder and grazing by goats, cows and donkeys. Honey is sold at Muscat or self-consumed. Fish caught in the mangrove area is expensive and still sometimes sold in Muttrah. Then an increased number of fishermen (from the area and outside) and the big fishing ships with their modern equipment come to fish, making the catch per local fisherman increasingly smaller.

Many foreign tourists come to the inlets and islands near the mangroves in weekend for one-day trip or one-night stay in the islands. However, most tours are arranged including boats by the tour companies in Muscat and only a few

boats of local fishermen are hired. So far, the tourism has not provided any benefits to the local communities.

The old fishing huts made of small woods and date fronds on the beach are being rebuilt to concrete ones by the government because they have no durability and spoil the beautiful scenery.

(d) Awareness of Mangrove Protection

People know that mangroves grow naturally after the flowers drop. Therefore, nobody has planted mangroves. Also, nobody feels that the change of the mangrove area has provided impacts on their life.

The local people are eager to expand the mangrove area for increasing the nice green view and using mangroves as before.

(e) Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

The want the mangrove area to be a garden and the village to be a large-scale tourism spot like Muscat with hotels, restaurants and other modern facilities. The tourism development is expected to create the job opportunities to the villagers. In order to develop in this way, the mangrove area should be managed well by cleaning, trimming the branches and taking away the dead trees. The protection and expansion activities should be done by local people themselves but government assistance is needed through financial support and instruction.

d. Khawr Qurayyat

(a) Community Profile

i. Demographic Characteristics

The population of Wilayat of Qurayyat increased from 34,000 in 1993 to 43,000 in 2001. The population increase is attributed to natural increase inside the village.

ii. Economic Activities

Fishery is the most important industry in this area, followed by agriculture of dates, fruits and vegetables. Date palm plantation is located very close to the mangrove area and affected by water salinity. Governmental employment is also important.

iii. Social Services and Infrastructure

Water resource for living is water tank supplied by the Muscat Municipality. Well located in each house is also used. Agricultural water is from well and increase of water salinity is very serious. Fuel for cooking is gas mostly and petroleum is also used. Wastewater is discharged into the ground directly or

into the hole dug in the ground, then sucked by pump of the government car to carry at the site of the mountain area. Garbage is collected and transported to the dumping site by the municipality. The construction waste is dumped illegally near the mangrove area. There are plans of construction of municipal waste dumping site and shrimp farm (under consideration).

(b) Interviewees' Characteristics

They are municipality employees, businessmen, retirees, sheiks, fishermen and farmers whose ages are in the 40s – 70s.

(c) Usage of Mangrove Ecosystem

i. Resources

The khawr provided abundant fish, crabs, shrimps and lobsters before. Whenever the mouth of the khawr is closed, it is clear that the number of fish reduces. Villagers used to set fishing nets in the khawr by boat and catch fish in the evening. Condition of the seawater in quality and level is the same as before but the number of fishermen increases (coming from in and out of the area), which makes for fewer fish catch per head. Various species of birds including flamingos could be seen before and villagers could get eggs of wild birds to eat. Although bird watching is popular around this area, the number of birds hunting fish has decreased because of decrease of fish amount in the khawr.

For recreational purpose, some have been visiting the khawr to enjoy and look at the clear waters. Honey collecting is still done by villagers and Bedouins. Bedouins come to collect honey during May and June (mangrove flowering season), sometimes in November. Collected honey is sold at Muscat but the amount of honey collected has become less because of less rains.

ii. Size and quality

There have been times when the mangrove area and the khawr were smaller because the mouth was mostly closed, mangrove trees were not take care of well, dead mangrove trees were left as they were and goats browsed mangroves. Additionally, once rain stops, water level in the khawr becomes low, fish dies, smell of water turns bad, water quality deteriorates and salinity increases. Before 1980, the mouth was always open. Since then, the mouth has opened and closed repeatedly. When wadi was very strong, it opened for 3 months. The flood water sometimes reached a maximum of 2m. One flooding occurrence kept the mouth open for 4-6 months, but if flooding occurred in several areas at the same time, it is open for a longer period. In the past, the time between one flood to the next was shorter and the duration the mouth was open was longer. The most recent opening was in April 2003 following a medium level flood (the last time it was open was 6 years ago). There was no

rain for the last 2 years but it rained heavily in 2003. Villagers, after discussions with *wali*, sent request letters to the municipality to open the mouth permanently because they want many fish to come back to the khawr.

Trimming the mangrove makes the new branches grow well but now not cutting them at all makes the condition of the mangroves worse (branches of the mangrove are very dense and entangled and growing out in every direction). This is known by the people from experience at the time when they used mangroves for various purposes.

iii. Sedimentation

Many villagers consider that after building of fishing harbour at Wadi Afa, 1.8 km south of the khawr with mangroves, the mouth of the khawr closed due to sand sedimentation. Some replied that construction of harbour did not give any impacts on the mouth closure. When the mouth is open, the *wadi* water flows to the sea and there is no problem of sedimentation. When seawater is rough and waves carry seawater to the inland, both waters from *wadi* and sea interfere together with mangroves causing heavy sedimentation. Also, the beach line has been retreating because of sand sedimentation after port construction.

iv. Customary

Up to about 40 years ago, the mangrove area was managed by *wali* and sheik of the area. Sheik monitored and checked the condition of mangroves and reported to *wali*. *Wali* allowed the local people to use the mangrove for certain days (for example, 5 days) based on the sheik's advice. During the opening of mangrove area to the people, they could use the mangrove as they wanted such as cutting and feeding their animals. Many people came from many places to cut for firewood, fodder, construction wood, etc. with camels, goats, etc. Sheik and *wali* understood the amount of the branches to be cut based on the reproductive capacity of mangroves and the number of the people and animals using mangroves at that time. If they used the mangrove area in other days, they were imprisoned.

v. Impacts on the people's living

Mangrove area was used diversely for fishing, collecting woods for building boats, houses and fences of farmland and fuel for cooking, especially before 1970. Traditional houses were constructed using mangrove trees but only for foundation and fencing the house. In shipbuilding, mangrove was also used only for supporting the key points because of its durability and strength. Other raw materials have replaced the use of mangroves now. The present area is not utilised as variously and significantly as before and becomes only a component of the beautiful scenery. Herds of camels from the mountain area and cows and goats from in and out of the village came to browse the mangrove until 20 years ago. Camels did not come any more but goats still browse mangroves.

They are free to come or owners take them to the area every day. The villagers do not consider this impact seriously. Seeds are believed to make the goats produce more milk.

Some families living near the mangrove area with dates plantation have moved to the village and town because lack of water and water salinity has damaged dates plantation. When the mouth is open, fishing activities can be done and the small fishing boats can access to the houses located near the mangrove area. Fishermen can go to sea by boat easily without walking long.

Other problem in the mangrove area is the many stray dogs wandering about, which make the villagers feel scared and prevent them further from accessing the area.

(d) Awareness of Mangrove Protection

Most of the respondents know that seeds of the mangroves drop and grow naturally, so people do not know the mangrove planting technique. Protection of the mangrove area is very important because of its beauty, history and place for fish and shrimp nursery. If flood comes, mangroves can play a role of bridge between sea and *wadi*. Many people want to expand the area of mangroves.

The area is preferable to be utilised as tourism spot with a small café and boats. Tourism can attract this area and create many jobs for local Omanis. In order to achieve this idea, good management (taking away the dead trees and pruning) is necessary as well as protection against flood from *wadi*.

(e) Potential for Local Participation to the Protection/Management of Mangrove Ecosystem

Dead trees should be taken away and new seedlings should be planted in order to grow mangroves healthily. The respondents are ready to do these activities if requested. If they cannot participate by themselves to protect mangroves, they will ask the others to do that. Some people are willing to join any activities without payment.

e. At Tina & Batah (Sur)

(a) Community Profile

i. Demographic Characteristics

The population of Wilayat of Sur increased from 53,000 in 1993 to 65,000 in 2001. The rapid increase of population is brought about by urbanisation and commercialisation.

ii. Economic Activities

Fishery is the major activity in east area. Agriculture is also the major economic activity in west part of the area. There are many foreign workers in business/commercial sector. Ship carpenters living in Sur area are very few now and they are mainly repairing and maintaining the traditional ships. Tourism and apiculture are also operating but not in a large-scale.

iii. Social Services and Infrastructure

Water for living is transported from desalination water station. Transport of drinking water from other cities is increasing. Agriculture water is from well. Fuel for cooking is mainly gas and sometimes kerosene. Traditional villages in the southeast still use firewood (not mangrove). Wastewater is collected by sewerage disposal plant. Garbage is collected by waste wagons to the waste disposal site, located less than 1 km away from the town. Sur is the third largest city in Oman and the rapid urbanisation is in progress. Housing development plan is underway and landfill for housing is going on near the Khawr Sukaykira.

There are many women's groups for healthcare and fishery groups. One fishery group comprises 10 young fishermen and distributes various roles among the members such as fishing, delivering and bidding of their catch. This is the popular fishermen's group all over the country. Old fishermen do not join this kind of group. As to the other type of fishermen's group, big factory owners often have their own groups.

DG of MRMEWR of Ash Sharqiyah Region has submitted a proposal of 10-year "Natural Park Project" to the MRMEWR. This project includes construction of footpath around the bay, restaurants and other facilities for the visitors. According to the DG, the Minister and His Majesty have already agreed to the proposal.

(b) Interviewees' Characteristics

Interviewees are governmental officials, fishermen and ship carpenters in their 50s and 60s.

(c) Usage of Mangrove Ecosystem

i. Resources

There were many large crabs and mussels and children enjoyed catching them in the 1970s but the number has decreased. Foreigners (most likely Filipino) came to catch many crabs to sell at the market. Filipinos might have empirical knowledge about how to catch crabs in the mangrove forest since their home country has a vast amount of mangrove forests. Therefore, Omani children are not interested in catching crabs any more recently. There are still many

migratory birds such as flamingos. Honeybees are also useful for the people to do apiculture (setting boxes for beehives around the mangrove area) but activity is not stable (depends on the condition of flowers). Now, the mangrove provides good view and hatchery for fish. In the past, for shipbuilding, mangrove trees have been brought from Mahawt because trees in Sur were too small. Fodders for goats and camels until 1975 were required a lot. There were so many camels used for transportation that few trees were left for other purposes such as housing materials and fuelwood, after cutting for camel's fodder.

ii. Size and quality

The mangrove area has expanded very rapidly, especially in the last 20 years since the number of camels decreased and it has been providing a good scenic view because of less usage. These are new mangroves. The mouth of the Sur Bay has been suffering from sand sedimentation for 6 years. This may be caused by a lack of rain and flood as well as bank construction. In the past, hundreds of ships could stop in the Bay. However, nowadays, large ships cannot sail through the bay channel at low tide. The people think that most ships will be unable to sail at low tide in 3-4 years. Mangroves in the bay might also be damaged by the sedimentation. Cleaning and digging may be necessary.

iii. Impacts on the people's living

There were many camels to carry the shipment in the past. Mangroves were mostly used as the feed of those camels. There were a small number of mangroves and camels eat even young trees and seeds. At that time, villagers managed the mangrove area and prohibited to cut mangroves beyond the reproduction capacity and necessary amount of use. Specific cases were decided for baby and sick camels. This system was also applied to fuelwood collected in *wadi*. As cars replaced camels, the mangroves have played other roles. Some respondents (ship carpenters) do not want to use mangroves as raw material of ship construction even when the mangroves in the bay expand and become large enough in the future. The reason is that there exist many better alternatives to mangroves (e.g. glass fibers) in terms of cost and convenience.

(d) Awareness of Protection and Management of Mangrove Ecosystem

The people think that mangroves should be protected because of its biodiversity, for beautification to attract local people and tourists, honey collection, filter of seawater and air, and reduction of temperature in the town. Some of them want to fill the bay area with mangrove greenery for beautification.

Elementary school students joined the 1st plantation activity in February 2002 organised by MRMEWR. But the success rate of the plantation was not satisfactory. In the 2nd plantation in February 2003, policemen, army forces

and secondary school students as main labour brought to fore the previous lesson that small children cannot carry out the careful plantation. This boosted up the success rate to some extent. Policemen are co-operating to expand mangrove forest not only by planting but also by monitoring.

(e) Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

The DG considers that the villagers around the forest are expected to join the activity of mangrove protection and planting in the near future, although it seems to be not easy. It is necessary to have face-to-face meetings with villagers to inform clear benefits to them, utilise media to raise public awareness and to provide environmental education and meetings with young generation. There is a National Environmental Competition every year. This occasion can be used as a way to increase awareness of mangrove conservation.

Everyone is willing to join the plantation activity. Unemployed can be involved in the protection and expansion activities to provide income opportunity. Also, in order to protect mangroves, it is necessary to monitor them. If the local people witness illegal activities, they will inform the authorities to stop the illegal activities. However, they need governmental support and paid guards.

f. Wadi Muraysis (Masirah Island)

(a) Community Profile

i. Demographic Characteristics

Total population of Wilayat of Masirah was 10,000 in 2001 (8,000 in 1993). People living on Masirah are mostly from the tribes of *Al Junaibi*, and *Al Wheebah*. The people currently living on Masirah Island and Mahawt Island have usually a Bedouin origin in the Wusta Region. Since they moved to coastal areas, their nomadic habits were replaced by a more settled life in a fishing village, although in Mahawt Island, inhabitants still have semi-nomadic habits, only settling on the island during the fishing season. Military Base brought to the island many people and good infrastructure. Soldiers from the U.K. and U.S.A. as well as Oman are stationed there. As the development of infrastructure progressed, Indians and Pakistanis have come as foreign labour. The population has increased to double its size in the last 20 years.

ii. Economic Activities

In the past, the people of Masirah lived mostly from the only resources available on the island, fishery. However, after the installation of the Military Base (after World War II) and the BBC Re-transmitting station, different needs were set for the small village. Many locals found themselves jobs in the

governmental institutions, and gradually a different lifestyle is taking place in Masirah.

Fishery has the largest labour force and agriculture is the second. The catch of fish has decreased since many foreign ships and illegal ships came off shore. The number of farmers has decreased to half its size compared with that in 1997 because no rain has come inland since 1977. The wells have little water and salty. Government employment and business also have a large labour force. The military base is providing lots of jobs in this island.

iii. Social Services and Infrastructure

Water for living is provided by water wagon from a desalination and purification plant. There are only 2 wells for praying and washing. Electricity is supplied to most area. Fuel for cooking is gas and some traditional villages in the southeast use fuelwood. Wastewater is disposed of through pipes from each house to a manual sewerage disposal plant. Excrement is dried under the sun to kill germs and used for agriculture as fertilizer. Garbage is collected by municipality and buried under the soil. Roads of 19 km are paved and road lights of 160 poles are under construction. Underground Electric Wire Project is also in progress (due to short circuit caused by sea wind). Sewerage system is under study.

There is one primary school with 700 students (mixed girls and boys). There are 2 secondary schools, one for boys (650 students) and one for girls (683 students). There is one women's group for religious seminar and health education and two religious groups.

A long time ago Masirah Island used to be called "*Seravis*", which means "Green Island". The greenery was so dense that they could not see anything 5m ahead but now the land has fewer trees. "Masirah" means "difficult to come back to the beach" because of monsoon waves. A big storm in 1977 destroyed lots of houses and fell down trees and mangroves and large waves washed them away.

(b) Interviewees' Characteristics

Interviewees are governmental officials, sheiks, fishermen and retired persons, from ages 60-80 years old.

(c) Usage of Coastal/Mangrove Ecosystem

i. Resources

There were many types of trees in the island from Hammah to Kalban. Now, they have disappeared and died and some *wadis* have turned to desert and wells have dried up because of lack of rain. The people have to buy food for their cattle. Construction woods for houses were dates leaves, trees from *wadi* and mangroves in the past. For building ships, *wadi* woods and mangroves were

used. But nowadays they use imported trees for houses, and better alternatives (e.g. fiber glass) for ships. After 1977, the catch of fish decreased. It is likely due to many modern ships from other countries. In the past, they could catch so many lobsters in the northern area but discarded them back to the ocean because they did not know the value. Nowadays, however, they catch all of them and the amount of the catch of lobsters has decreased. In the past, they dried fishes and exported to Africa and India whereas nowadays mainly to U.A.E. Migratory birds and turtles have been decreasing in the last 20 years. Even after the governmental protection of hunting, birds and turtles keep decreasing due to blinding car lights and many people's disturbance of the habitats. People ate bird's eggs and even meat in the past but now they do not because it is prohibited by the government. Fishing becomes a hobby. Recreational visit is very few, once a month or once a year.

Now whales and sardines can be seen near this island. Provided that one of them is depleted, the other one will also disappear. People know that they depend on each other in the ecosystem.

ii. Size and quality

Anchors and trolling damage coral reef, which is home to various fishes. There will be no space for fishes to live in the future. Moreover, these days fishermen catch everything. Especially, young fishermen catch even small fish (they cannot wait until the fish grow big) and some fishermen are afraid of depletion of resources. This situation may be attributed to poor education. The beach retreated 20m back to the land 30-40 years ago.

iii. Impacts on the people's living:

There has been no strong rain and storm since 1997. Rain in 2003 up to now is not enough for wells and farmland. The people cannot provide feed for camels, goats and cattle from their farmland and buy fodder, which costs a lot nowadays. Therefore, the worse the situation becomes, the more people sell their livestock.

iv. Customary

Sheik was controlling villagers' utilisation of the mangroves and only collecting dead trees and cutting branches were allowed. The past usages were fodder for goats and fuel for cooking and lighting. Only little amounts were used for building ships and houses. They used to go to the site once a week.

(d) Awareness of Coastal/Mangrove Ecosystem Protection and Management

The people want mangroves along with all the coastline of this island for fodder, shade, beauty and fuel. As to fuel, they want to secure alternatives to oil in case of its depletion. But in doing so, the coastline should be free and not been built with big hotels and other large facilities. Whereas, residents need more

basic infrastructure such as piers and ports in the north to prevent strong waves and to facilitate fishing activities.

This area is called "*umgraimtain*", which means "two trees of mangrove". Since there are little trees in this area, the people are not aware of the mangrove and do not even think about the plantation. They consider the mangroves grow naturally.

Some respondents have talked to *wali* about coastal management and some discussed the topic in the sheik meeting. Also, the others have talked in informal settings. Many complain that young people do not know how to protect wildlife.

Some respondents worry that hotels in coastal area to be planned might destroy beaches and they do not want to see that happen. The coastal area seems to be getting drier by, say, ports. They want cleanness and beauty in the area and tourism development providing jobs for the local people.

(e) Potentials for Local Participation to the Protection/Management of Coastal/Mangrove Ecosystem

They will do everything they can do. They are willing to participate in coastal management activities. The people will advise everybody in the village to participate in the activities. They want a nursery of mangroves and fence around the site. Some respondents suggested that many people are ready to protect the coast if they are assigned by the government and paid for their activities.

Currently, five monitors in total are working for coastal management but all are from other villages and regions. They are not familiar with villagers' life and even with the nature in this village. They should be from the same village or at least from this island. Then, they should be directed by sheiks rather than by municipality offices in order to facilitate the reflection of villagers' opinions into monitoring activities. This management system will be more effective to protect the nature of this island.

g. Filim/Mahawt Island

(a) Community Profile

i. Demographic Characteristics

Total population in the *Wilayat* of Mahawt was about 10,000 in 2001 with 50% (3,752) male and 50% (3,508) female (7,000 in 1993). There was a total of 7,260 Omanis of the total 7,813 in 1993. Fifty-five percent of the total population is *Al Nahiba*, 30% is *Al Hakman* (this is the tribe in Mahawt) and 15% is *Al Jnaibi*. Rapid increase in number of children is obvious. In the 1940s and 1950s, there was a trend of emigration to Zanzibar since Oman was a

very poor country at that time. Mahawt Island used to be a place for emigrants to wait for ships for around two weeks to Zanzibar. The people started to move to Filim from the Mahawt Island 52 years ago because of lack of water, school and other social facilities in the island. Now, these people make one community and live in huts and go to the Island for fishing operation. In the Mahawt, 80 or so houses in total can be seen. Among them, 20-30 households are settled and the rest is used temporarily for coming and going from/to Filim and Hij. Children live in grandparents' or relative's houses in Filim and Hij during school time and come back to the island on holidays and weekends to stay with their parents.

ii. Economic Activities

Fishery is the major industry, followed by livestock farming. Fishery is operating almost every day except June-August. That time period fishing virtually stops because it gets too hot to go to sea with open boats and the sea is rough, and because this coincides with the breeding season. Almost the entire population of the Mahawt moves to towns (e.g. Sinaw) and dates plantation for rest and leisure. There are many people out of work, who are waiting for the prawn season in September-January. There are some goats in the Mahawt Island and camels in Filim.

iii. Social Services and Infrastructure

A water tank and a purification plant using seawater and underground water in Mahawt are providing water for living. The government has been providing 250 gallons of free drinking water every 20 days since December 2002 after long request by the residents. Although it is usually used up in 3 days, availability of water supply makes the residents' living condition better. A desalination plant of seawater in Filim supplies water to Mahawt Island and other small islands whereas Hij has another purification plant of underground water. In Hij, water wagons and a purification plant using only ground water are operating. There is no electricity service in Mahawt but one person owns a power generator. In Hij, electricity is supplied mostly. Cooking fuel is gas everywhere. Sometimes the people use trees from *wadi* as night lightings in Hij when they have a banquet for guests. Wastewater is discharged directly into the sea and ground in the Mahawt Island. Wastewater is collected by the municipal sewerage wagons to get rid of excrement in holes in Hij. Garbage is collected by municipal waste wagons in Hij and burned. In Mahawt Island, garbage drums in front of house are collected by the municipality once a month and in Filim, every 3 to 4 days. The municipality designates the disposal place both in Hij and Mahawt.

Still old huts made of mangroves are used for shower room and storage. Some families have already moved to the modern houses in Hij prepared by the government and deserted houses are left in the Island. Many fishermen have

temporary huts made with timbers, palm fronds and some plastic sheets in the Island; some are for semi-settlement and others just use them for storage of fishing equipment and come from other villages for fishing. The people in Filim and Mahawt Island spend summer for vacation in Sinaw and other areas mainly for collecting dates for self-consumption.

There are 3 primary schools with 750 students, 2 secondary schools with 1,700 students (one for boys and one for girls). There are many teachers from other countries such as Egypt and India. There are one women's group for healthcare, one environmental group discussing the environmental protection, and one fishery group, where members discuss fishery issues.

There are Residential Development Plan for the poor and Road Construction Plan. The houses prepared by the government are targeted for the poor families including the residents in the Mahawt Island. Also, the construction of a bridge across the channel between Filim and Mahawt is likely proposed. Some villagers want to have a bridge, and others want to construct a pier as long as 5 km in Filim. Both of them want to use their ships any time even at low tide. Low tide has not allowed them to use their ships for fishing and emergency case. The people who need a pier worry about cars because bridge has possible negative impacts from tourists on the mangrove ecosystem and the living of the people. However, they require that cars can drive on the pier to the end so that they can access their ships easily without walking long.

The respondents can migrate from the Island to the area in Filim if they are supplied with houses and basic infrastructure. However, they should be close to the beach to go easily to the island for fishing. Also, they do not want to give this island to the others. Their attachment to the island is very strong.

The area near Barr Al Hikman Peninsula is under process to become Protected Area. Also, there is a plan of municipal park development.

(b) Interviewees' Characteristics

They are fishermen, retired and housewives, 20-70 years old.

(c) Usage of Mangrove Ecosystem

i. Resources

There are many kinds of fish but the amount of catch decreases. There were many shrimps and blue crabs in the past but decreased now. There are many birds and some breed in the Island. Flamingos stay near the Island for 4 months and leave for Africa.

ii. Size and quality

The size of mangrove area has increased in Filim and the Mahawt Island. When they were using mangroves in the 70s and 80s as housing and ship building materials, fuel for cooking and lighting and fodder, mangrove area was

decreasing. However, after they changed materials from mangrove into date palm because of prohibition by the governmental protection, mangrove area started to expand. The number of trees is increasing rapidly because nobody uses the area, the number of camels and goats has decreased and gas is used instead of fuelwood and because of governmental regulation. The camels were moved from the Island to Filim and no longer exist in the Island.

Current usage of the mangrove area is setting gillnets to get fish and crabs, fuel for cooking and fodder for goats. Also, it provides beauty of nature.

iii. Impacts on the people's living

The expansion of the mangrove area stops the big wave and provides more beauty of nature for the people. This attracts more tourists to visit the Island. However, the local people lack resources for daily life.

iv. Customary

When the mangrove was used for fuel, women collected about 50 kg for 3-4 days, but this burden does not exist any more. Before the reign of His Majesty, which was in the 60s or 70s, sheiks were controlling the size and condition of mangroves just like in Qurayyat. Sheiks were prohibiting people from cutting many branches of mangrove trees in the island. At that time, mangroves were utilised mainly as housing materials and firewood. Group policing for mangrove protection was carried out. Punishment is meted out if warning is ignored.

(d) Awareness of Protection and Management of Mangrove Ecosystem

Now the mangrove area is considered important for the beauty it provides and fodder for goats. The people use the area in Filim for recreational purpose every day but children do not play in the forest. The villagers use the area for fishing, fuelwood collection, and picnic.

The people know that the mangrove grow naturally. Therefore, some of them think that planting is not necessary and just leave mangroves as they are. Some of them suggested that the mangroves in the Mahawt Island should be maintained and trimmed, whereas the area in Filim should be expanded for the shade, picnic, beauty, fodder of goats, small fish catch and protection from waves as well. Tourism development is welcomed by most of the respondents. They are proud of the island and are happy if many tourists come. Some are worried that tourists might leave lots of wastes and damage the island environment.

(e) Potentials for Local Participation to the Protection/Management of Mangrove Ecosystem

There is His Majesty's Environment Cup for students in this country. Students compete in the Cup by implementing environmental activities such as planting trees and collecting garbage. Schools also provide students with booklets on the importance of environmental protection.

Most of the interviewees are willing to join the activities, especially young women. They can do anything following the governmental instruction, especially cleaning and monitoring the area as well as informing the illegal cutting to the government. Women should be hired as guard because women go to the mangrove forest more frequently than men and there is a traditional custom that men listen to women's voice. Women guards can find a peaceful solution.

h. Qurm Taqah

(a) Community Profile

i. Demographic Characteristics

The population of Wilayat of Taqah was 19,000 in 2001 (16,000 in 1993). The recent increase is very rapid – 3% annual growth rate with urbanisation.

ii. Economic Activities

Agriculture is the main source of income and employment, followed by governmental employment.

iii. Social services and infrastructure

Water for drinking in most of the area of *wilayat* is covered by piped water system. Water for agriculture is mostly well and some springs are used. Well has a problem of water salinity increase. Electricity is supplied to all area. Fuel for cooking is gas. Wastewater is discharged into the ground directly. Garbage is collected by Salalah Municipality. There is a tourism development plan covering this area. Targets are historical remains such as port, fort, and natural beauty of mountain, beach and khawr including mangroves. It is required that all development plans provide benefits to the local people.

(b) Interviewees' Characteristics

There are many local people rearing camels that could be an impact on mangroves. Therefore, camel holders who settle in the town and who move from mountain area to the coastal land during the monsoon season were interviewed. There are also sheiks, farmers, government employees in the 20s-80s range.

(c) Usage of Mangrove and Khawr

i. Resources

Mangroves were cut for fodder, fuelwood for cooking and wood for shipbuilding before. Fallen seeds are still collected to feed the animals. People caught a lot of fish in the khawr before but now nobody goes fishing there because of the prohibition by the government and little fish. But still the mangrove is considered useful as fodder by owners of camels and goats. Most of the respondents said that the trees provide a nice view of green and beauty. There exist some wild birds in the khawr but the number has decreased.

ii. Size and quality

Many replied that nobody touches mangroves because of the protection as Nature Reserve and then the area has expanded. Meanwhile, some said that now the size of mangrove trees have become smaller because nobody trims and takes care of them well. They believe that cutting the tip of the branches make the trees grow more vigorously. The khawr has less water because of less rain.

iii. Impacts on the people's living

Hill tribes take herds of camels down from the mountain area to the coastal area during the monsoon (from June to September). They cut mangroves and feed their camels or leave camels free to get mangroves by themselves. When camels are left freely, they roam and browse mangroves and the owners do not control them. Now, all area is fenced and camels cannot access easily but some of them try to destroy the fence to get to the mangroves. Nowadays many grasses and fodder bought are fed to them, which increase the cost of rearing the camels and decrease profits from the livestock farming. Only a few people go to the khawr for picnic now and the relationship between the mangrove khawr and the local people has become weaker.

(d) Awareness of Protection and Management of Mangrove Ecosystem

When the people used mangrove ecosystem, they discussed and talked about mangroves but now they have stopped. The people who used mangroves know that the seeds drop and grow naturally. They claim that the people who have never used mangroves consider the mangrove as useless tree from the economic viewpoint because they do not produce any edible fruits like coconuts, mangoes, oranges, etc. All of the interviewees think that it is important to protect the mangrove area for different reasons (for practical reason or for beauty) but fencing the mangrove area without allowing access to the people is not agreeable by anyone.

(e) Potentials for Local Participation to Conservation and Management of Mangrove Ecosystem

All interviewees are willing to assist the government to protect and expand mangroves. If the local people receive some benefits (in economic and spiritual terms) from the activities, they will be happy working with the government. One idea proposed is that some communities should be designated first as a model of the activity.

i. Khawr Balid

(a) Community Profile

Khawr Balid is located in the Salalah city and under the management of Salalah Municipality. Salalah city had a total population of 16,000 in 2001. The khawr is surrounded by agricultural land with coconuts, bananas, mangoes, etc. Also, new houses have been constructed rapidly and population has increased. The area has been developed as an archaeological site at the west end, including a visitor centre. Also, there are large-scale tourism development projects near the khawr area with construction of the related facilities such as hotels, restaurants and shops.

(b) Interviewees' Characteristics

Old inhabitants have information about the past and the present conditions of mangroves and the khawr. Community around the Khawr Balid is newly established and any informants cannot be found. Therefore, all interviewees are sheiks, fishermen and the retired living in the old community, Dahariz Wilayat.

(c) Usage of Khawr Ecosystem

i. Resources

There were many kinds of fish in the khawr until a few years ago. During the monsoon season, rough sea made fishing difficult and fishermen worked in the khawr. People used to spend 6 months in a year in khawr for fishing. When khawr is wide open due to heavy monsoon and rainfall, saltwater fish swim to the sea from the khawr. So the khawr conditions have a large impact on fishing activity.

Mangroves grown in other khawrs were used for construction wood and Khawr Balid, which is without mangroves, was used for fishing mainly. Khawr was also used for bathing and watering by cows, camels and goats. Camels were fed mangroves before but gradually many people have sold them for building new houses. Grasses in and around the khawr were given to livestock. Some kinds of grasses and plants were even exported to India 50-60 years ago.

ii. Size and quality

Khawr Balid was a large port in olden times. Monsoon has caused sand sedimentation and made the khawr smaller and shallower. Also, there is now less water in the khawr because of dam construction in the upstream. Salinity increased due to the dam and lack of rain damaged farmlands and reduced the catch of fish.

iii. Impacts on the people's living

The khawr was an important place of economic activities but now few people use it. Net dropping in the khawr is prohibited but still some people set fishing nets at nighttime illegally. People sometimes visited the khawr with their family for recreational purpose before but now many people prefer to go to the mountain area at leisure time. Only recreational fishing is done.

(d) Awareness of Protection and Management of Mangrove Ecosystem

The mangrove is now considered a useless tree by the local people because they no longer use it. But the people who have used the khawr and mangroves recognise their importance and know that the mangroves grow naturally after their seeds drop from their empirical knowledge.

All interviewees agree with conservation and expansion of the mangrove and the khawr area. The archaeological site also should be protected for its historical significance and tourism attraction. The whole area should be developed to attract the local people and visitors. However, large-scale tourism development (large hotels, restaurants and other untidy facilities) and fenced area are not welcomed by the people, but small-scale development with its natural beauty intact providing benefits to the people is preferred.

(e) Potentials for Local Participation to the Protection and Management of Mangrove Ecosystem

Interviewees are willing to participate in conservation and management activities through providing labour and advice based on their experience. Benefits from the khawr and archaeological site should be provided both to the government and the local people. Therefore, the involvement of the local people in the conservation and management should be considered.

j. Khawr Kabir

(a) Community Profile

The Khawr Kabir is a suburban area west of Salalah City and is under the management of Salalah Municipality. There are no residents around the Khawr Kabir but an international hotel (Hilton Salalah), fishing harbour, industrial area with factories and Salalah Port are located in the west.

(b) Interviewees' Characteristics

There are no residents around the Khawr Kabir, and interviewees are selected in the Wilayat Dahariz, 10 km from the Khawr. Since the informative persons of mangroves are fishermen, all interviewees are fishermen with activities at the fishing port.

(c) Usage of the Mangrove and Khawr Ecosystem

i. Resources

In the 1950s, mangroves were used to make small wooden boats partly such as for fixing the keel and holding the boats tight. A lot of mangroves were also cut as fodder for camels and goats and fuelwood before. Browsing by camels was very serious until the area was fenced off. Amount and the kinds of fish have changed depending on the khawr conditions.

ii. Size and quality

Rain has made the khawr open wider and then closed intermittently. Mangrove trees grew more previously but they have now become small because nobody cuts the tip of the trees. After the protection over-browsing by camels was stopped by fencing off the area. The area is expanding and though the trees are regenerating they do not seem to grow healthily and nicely.

iii. Impacts on the people's living

In monsoon season, sea fishing became difficult and khawr fishing was important in olden times. During those times, the khawr was very important for them, and close attention was paid to the conditions of the khawr. Now, fishing activities are not carried out in the khawr at all. Fishermen go to sea all year round, even during the monsoon season.

(d) Awareness of Protection and Management of Mangrove Ecosystem

All interviewees know that the khawr is designated as Nature Reserve. This keeps the inhabitants away from the khawr further and as a result, they have lost interest in the khawr and mangroves. Therefore, no one knows that there is a plant nursery near the Khawr Kabir. Everybody considers that mangroves grow naturally; nobody planted mangroves and has ever tried to plant mangroves.

(e) Potentials for Local Participation to the Protection and Management of Mangrove Ecosystem

All interviewees are aware of the importance of protection and management of the mangroves and the khawr. It is because green mangroves can provide nice view. For this purpose, they are willing to co-operate through providing labour and advice based on their experience.

In order to sound out a private sector on protection and management of the khawr and mangroves, a Hilton Salalah representative was interviewed as a model. Hilton Hotel, located just next to the Khawr Saghir, is willing to assist in conservation of the khawr and mangroves near the hotel, especially Khawr Saghir. Khawr with mangrove is recognised as one of the target areas of sightseeing and eco-tourism, which can be introduced through hotel and travel agents. Regarding the management of the Khawr Saghir, there is an issue that the property of the land adjacent to the hotel belongs to the municipality. So, if the land property is transferred to the hotel, the hotel can have the responsibility to manage the khawr and mangroves, involving them in the hotel development. Also, the hotel is requiring the necessary instruction and obligation regarding the mangrove conservation and management. Small restaurant and promenade with signboard of mangrove information can be constructed around the khawr to attract the hotel guests and the visitors and to get them aware of mangroves.

k. Al Sawadi Beach Resort

As a case of possible involvement of the tourism industry, especially hotels, in the plantation and management of mangroves, a representative of Al Sawadi Beach Resort located near the Khawr Sawadi was interviewed.

The hotel's general manager, who is Austrian, has no idea about mangroves and never visited the planted area by MRMEWR. He provided the following information. The hotel was established in 1996 and currently has a staff of 90. Half of the hotel guests are local residents in Oman and the rest is from European countries. They stay at the hotel for two days in average in order to relax and/or enjoy diving and other marine sports near the hotel. Dimaniyat Island offshore, designated as Nature Reserve as sanctuary of wildlife of birds, turtle and fish, etc is a major place to visit.

Water resource for the hotel is supplied from a power plant in Barka. Fuel is gas. Wastewater is treated at the plant in the hotel and reused in the hotel. Garbage is collected by private company. They have not any impacts on the seawater so far. Land belongs to the hotel under a 75 years lease. Within five years, the area will be developed of new hotels, marina, golf course restaurant, etc for tourism.

The hotel manager is willing to co-operate with mangrove plantation and protection if he is provided with necessary information and technique. This hotel has already provided some co-operation through a diving shop in the hotel to beach clean-up campaign organised by MRMEWR and has high level of consciousness of environment. For divers who want to dive nearby island and sea, the hotel can provide appropriate advice and information in advance. If the hotel starts to participate in activities of planting and protecting mangroves, the hotel can disseminate information to the guests as one of the eco-tourism components.

4. Analysis of Microbes

Appendix 4 Analysis of Microbes

I. Survey Objective

The survey objective is to provide microbiological data and information on mangrove soil necessary for the formulation of the master plan on restoration, conservation and management of mangrove.

II. Implementation Method

II.1 Sampling

Samples were collected from the upper layer (aerobic layer) and lower layer (anaerobic layer) of both Site A (silty soil) and Site B (sandy soil) along mangroves at Khawr Qurm in Muscat. Table A4.1 shows the locations and time of sampling, and Figure A4.0 shows the sampling points, Figures A4.1 and A4.2 illustrate the image of sampling points.

Table A4.1 Sampling Locations and Time

Items	Site A	Site B
Date/Time	11 Jan 2003, 9:45	11 Jan 2003, 11:00
Coordinate (UTM) Easting	650471	649947
Coordinate (UTM) Northing	2613090	2612765
Upper Layer (Aerobic Layer)	13.8 DS/m	7.5 DS/m
Lower Layer (Anaerobic Layer)	13.0 DS/m	12.7 DS/m

Seawater around Site A: 23 DS/m, seashore: 46 DS/m.

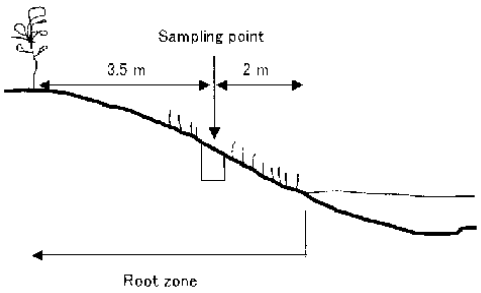


Figure A4.1 Site A

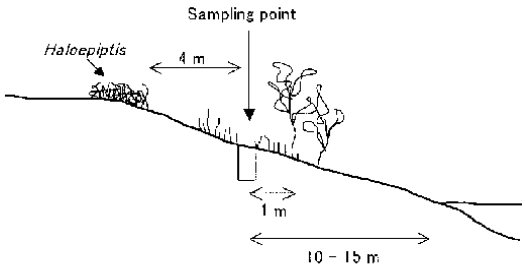
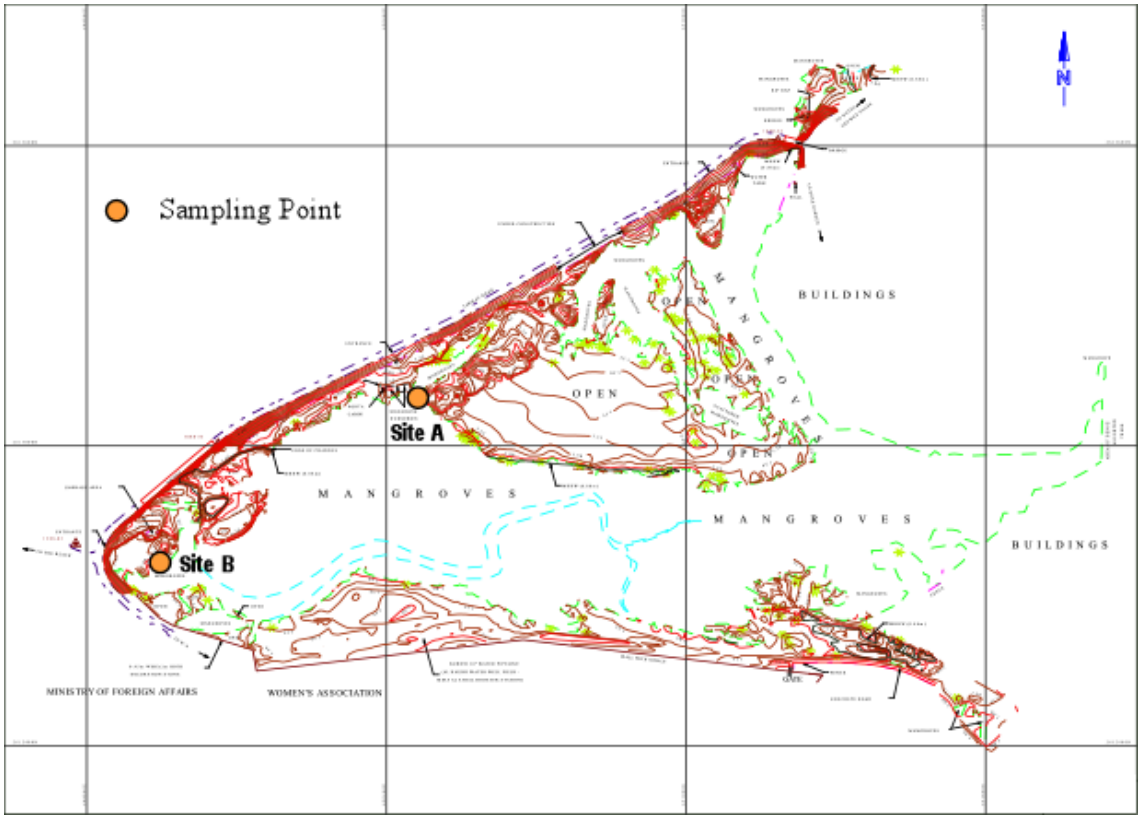


Figure A4.2 Site B

An acrylic corer with a diameter of 18 mm is stuck into the upper layer (aerobic layer) and lower layer (anaerobic layer), and samples were collected from the middle part of the corer. In other words, the samples were collected from soils 5 cm above and below the border between the upper and lower layers. They were hermetically sealed in a sterilized jar and kept cool. Pictures of the sampling sites were attached to this report (see Attachment 1: Pictures 1 to 10).

Figure A4.0 Sampling Point



III. Survey Methods

III.1 Ignition Loss

According to the sediment analytical method (No. 127 Ministry of Environment, 1988) II.4, samples were dried at 110°C, weighed, heated up for 2 hours at 600°C, cooled down in a desiccator, and weighed again to see how much their weight is reduced by heat.

III.2 The Number of Heterotrophic Bacteria (Aerobic Bacteria)

The number of heterotrophic bacteria was counted by applying the plate agar incubation method, according to Coastal Environment Manual (Vol. II Water Quality/Microbe) 4.2.3. About 1 gram of the sample was agitated in disinfected seawater. This suspension was then 10 times diluted with disinfected seawater, and 0.1ml of the suspension was put on three ZoBell 2216E incubation plates. They were incubated at 20°C. After incubated for 10 days, the number of colonies was counted, and the number of bacteria per 1 gram of dry soil was counted based on Equation 1. The samples of the upper layers (aerobic layers) of Site A and Site B were analyzed.

The number of bacteria = (volume of suspension x rate of dilution x the number of colonies) / (volume of sample x volume of wet soil x the number of plates x dry soil) ..... Equation 1

Table A4.2 Composition of Incubation Media of ZoBell 2216E

Reagent, etc.	Quantity
Bacto-peptone（Difco）	5.0g
Bacto-yeast-extract（Difco）	1.0g
$FePO_4$	0.1g
Bacto-agar（Difco）	15g
Seawater	1,000mL
pH	7.6～7.8

III.3 The Number of Anaerobic Bacteria

The sample was diluted with a dilute solution aerated by nitrogen gas. The diluted sample was put on incubation plates, and they were put in an anaerobic jar for incubation at 20°C. After incubated for 30 days, the number of colonies was counted, and the number of bacteria per 1 gram of dry soil was counted as same case as heterotrophic bacteria. The samples of the lower layers (anaerobic layers) of Site A and Site B were analyzed.

III.4 Sulfate Reducing Bacteria

The number of sulfate reducing bacteria was counted by applying MPN method in accordance with Coastal Environment Manual (Vol.II Water Quality/Microbe) 5.1.2. Table A4.3 shows the composition of culture media used to count the number of sulfate reducing bacteria. About 1 gram of the sample was agitated in disinfected seawater. This suspension was then 10 times diluted with disinfected seawater, and 1ml of each level of suspension was put into five test tubes. They were incubated at 30°C for 2 weeks. After 2 weeks, black precipitation can be observed in a test tube that identifies the sulfate reducing bacteria. The number of sulfate reducing bacteria was counted according to MPN table. Like heterotrophic bacteria, the number of sulfate reducing bacteria per 1 gram of dry soil was counted. The samples of the lower layers (anaerobic layers) of Site A and Site B were analyzed.

Table A4.3 Composition of Incubation Media for Sulfate Reducing Bacteria

Component	Quantity
Yeast extract	1.0g
Poly-peptone	2.0g
Sodium lactate	3.5g
K_2HPO_4	0.2g
$FeSO_4 \cdot 7H_2O$	0.2g
Sodium ascorbate	0.2g
Agar	3.0g
Filtered seawater	1,000mL
pH	7.5

III.5 Isolation and Identification of Bacteria

Bacteria colonies were observed, and isolated colonies, whose type was different from others, were picked up. The isolated colonies were put on an incubation plate of ZoBell 2216E. The colonies, which became isolated in the incubation plate, were separated and purely cultured. After isolates were identified by Gram's staining, they were observed under photomicroscope. Gram negative bacillus was bio-chemically tested by a test kit of Bio Merieux Industry Api 20NE and analyzed by a computer software, APILAB Plus (V3.3.3).

IV. Survey Result

IV.1 Ignition Loss

Table A4.4 shows the survey result of ignition loss, heterotrophic bacteria and sulfate reducing bacteria. The aerobic layer of Site A marks the highest loss, followed by the anaerobic layer of Site A, aerobic layer of Site B, and anaerobic layer of Site B.

Table A4.4 The Number of Bacteria and Ignition Loss

Samples		No. of Bacteria (CFU/g) [a)]	Sulfate Reducing Bacteria (MPN/g) [a)]	Ignition Loss (%)
Site A	Aerobic	6.8×10^6	N.T. [b)]	11.0
	Anaerobic	6.9×10^7	4.4×10^6	7.7
Site B	Aerobic	3.2×10^7	N.T.	6.5
	Anaerobic	4.8×10^6	3.9×10^4	5.6

a) : per dry soil
b) : Not tested

IV.2 The Number of Heterotrophic Bacteria (Aerobic Bacteria)

There were more heterotrophic bacteria at Site B than at Site A; the number of the bacteria at Site A was 6.8×10^6 CFU/g and 3.2×10^7 CFU/g at Site B.

IV.3 The Number of Anaerobic Bacteria

There were more anaerobic bacteria at Site A than at Site B; the number of the bacteria at Site A was 6.9×10^7 CFU/g as compared to 4.8×10^6 CFU/g at Site B.

IV.4 Sulfate Reducing Bacteria

There were 100 times more sulfate reducing bacteria at Site A than at Site B; the number of the bacteria at Site A was 4.4×10^6 CFU/g as compared to 3.9×10^4 CFU/g at Site B.

IV.5 Isolation and Identification of Bacteria

1. Separation of Bacteria and Type of Colonies

As same case as the heterotrophic bacteria, the sample suspension was diluted and put on an incubation plate for culture. Bacteria colonies on the plate were observed, and isolated colonies, whose type was different from others, were picked up. The isolated colonies were put on another incubation plate of ZoBell 2166E. The colonies, which become isolated in the plate, were separated. Figure A4.3 shows the colonies of Site A's sample formed on the incubation plate. Figure A4.4 shows the colonies of Site B's sample formed on the incubation plate.

Figure A4.3
Colonies: Sample of Site A

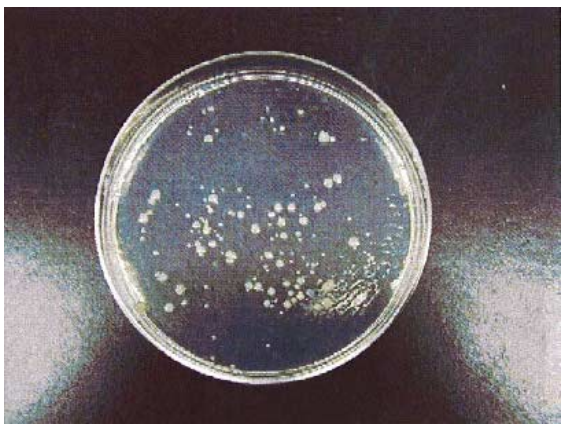


Figure A4.4
Colonies: Sample of Site B

It was difficult to obtain isolates from the sample of Site A because in the sample there were bacteria growing fast and covering the incubation plate before a type of other bacteria colonies become distinct. Nevertheless, the sample was repeatedly cultured, and six isolates were obtained. The six isolates were shown in Figures A4.5 to A4.10. Isolate A-A grows fast and thinly spreads into the incubation plate. Isolate A-B also spreads thinly, but grows more slowly than Isolate A-A. Isolate A-C creates glossy, smooth, yellowish brown colonies. Isolate A-D creates reddish brown colonies, grows very slowly, and rises spherically. The number of bacteria for Isolate A-A is 1.4 x 106 CFU/g, 6.5 x 10^5 CFU/g for Isolate A-B, and 2.1 x 10^6 CFU/g for Isolate A-C.

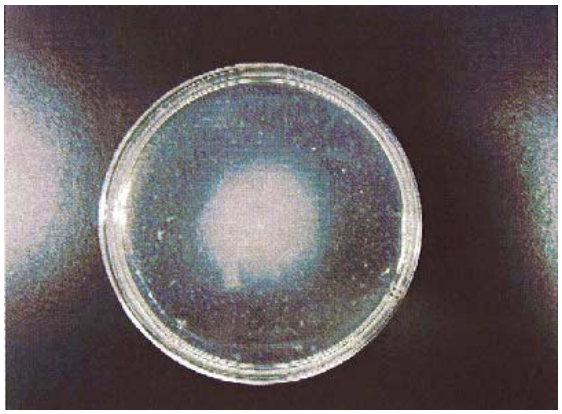


Figure A4.5 Isolate A-A

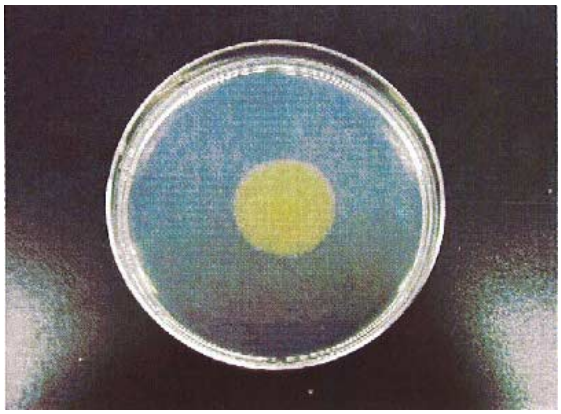


Figure A4.6 Isolate A-B

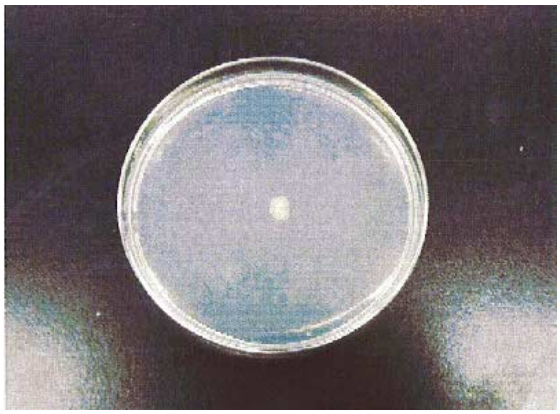


Figure A4.7 Isolate A-C

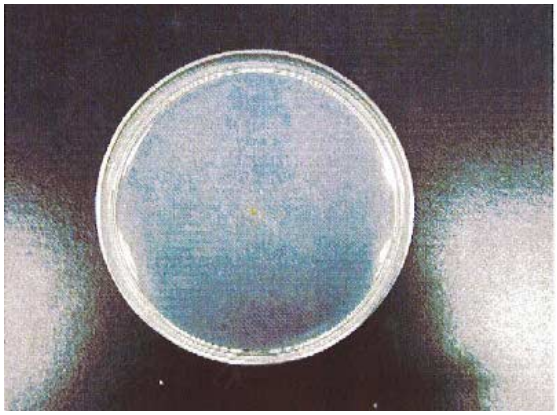


Figure A4.8 Isolate A-D

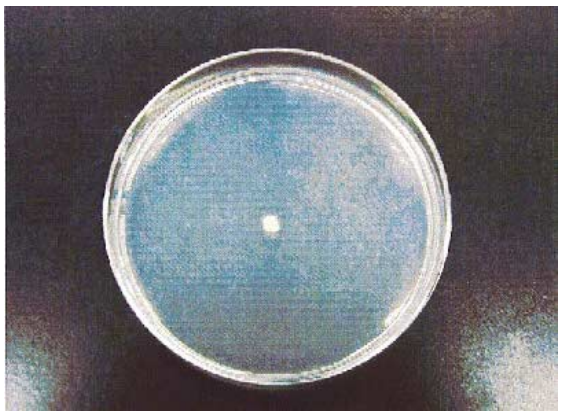


Figure A4.9 Isolate A-E

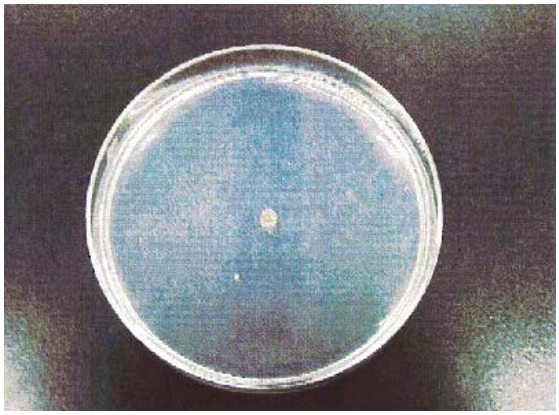


Figure A4.10 Isolate A-F

There were no fast growing bacteria at Site B, unlike Site A. Generally, bacteria at Site B grow slowly. For that reason, it takes time for colonies to be distinct, but 4 isolates were obtained as shown in Figures A4.11 to A4.14.

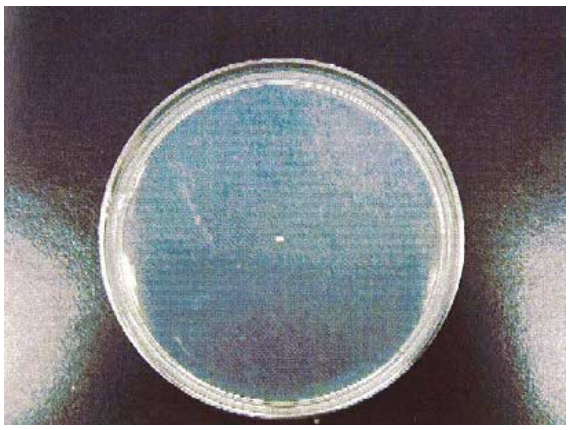


Figure A4.11 Isolate B-B

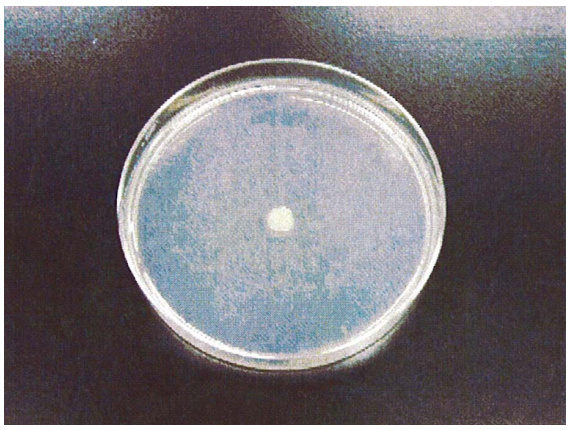


Figure A4.12 Isolate B-C

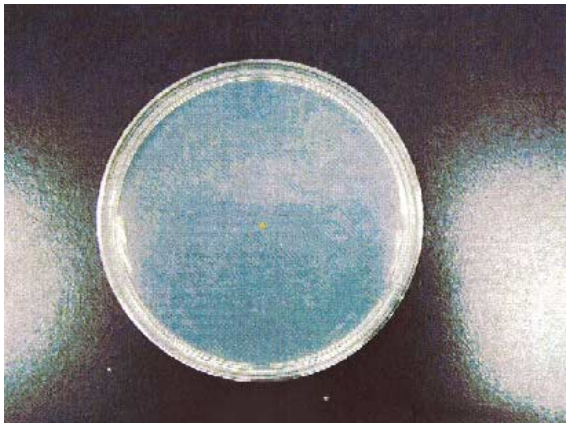


Figure A4.13 Isolate B-D

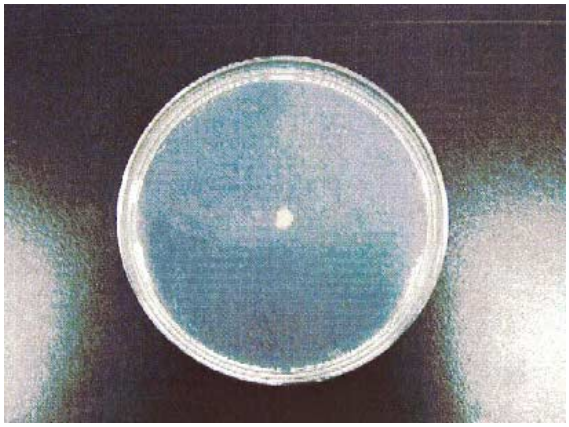


Figure A4.14 Isolate B-E

Isolates B-B and B-D grow very slowly. Anaerobic bacteria of both Sites A and B grow very slowly, and difference of each colony was not observed (Figures A4.15 and A4.16). Because anaerobic bacteria of Sites A and B grow very slowly, they cannot be isolated.

2. Gram‘s staining Characteristics of Isolates

Before bio-chemically tested, isolates, except Isolates B-B and B-D, were gram-stained, and their types were observed. Two isolates out of the analyzed 8 isolates were gram positive bacteria, and the other 6 isolates were gram negative bacteria. In addition, the all of 8 isolates were bacillus. Table A4.5 shows figures of the colonies and bacteria as well as the result of the Gram’s staining tests.

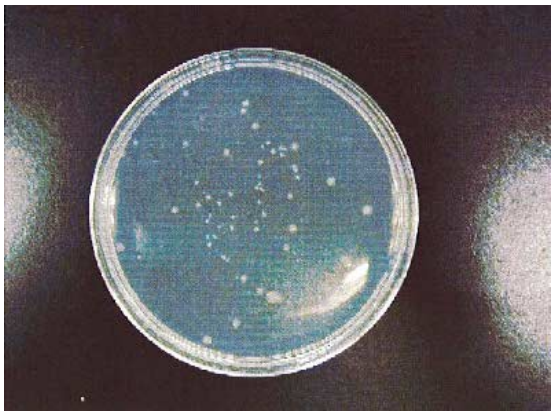
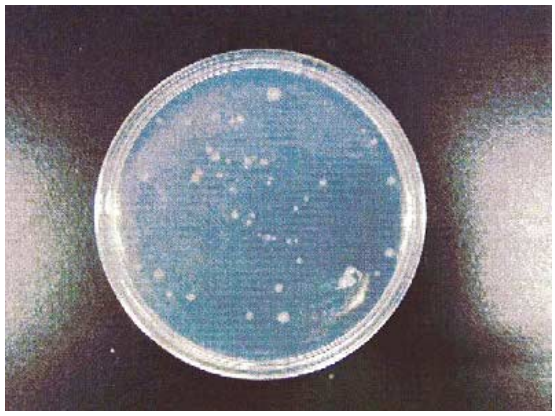


Figure A4.15
Anaerobic Colonies of Site A



FigureA4.16
Anaerobic Colonies of Site B

Table A4.5 Figures of Colonies and Gram-stained Characteristics

No. of Isolate	Type of Colonies	Gram-stained Characteristics	Type of Bacteria
A-A	Round shape, spread out well and thinly, peripheral area is transparent, the center is semitransparent, cream color, smooth surface, glossy, grow very fast.	Negative	Bacillus

No. of Isolate	Type of Colonies	Gram-stained Characteristics	Type of Bacteria
A-B	Round shape, yellow, semitransparent, spread out thinly, rough surface (the center is smooth.), glossy, grow fast.	Negative	Bacillus
A-C	Round shape, yellowish brown, smooth surface, glossy.	Negative	Bacillus
A-D	Round shape, reddish brown, smooth surface, glossy, isolate rises, peripheral area is semitransparent, grow very slowly.	Negative	Bacillus
A-E	Round shape, cream color to yellowish brown, rough surface, glossy, concentric circle lines at the peripheral area.	Positive	Bacillus
A-F	Round shape, thin colonies, rough surface, crinkled, not glossy, grow slowly.	Negative	Bacillus
B-B	Round shape, cream color, smooth surface, glossy, grow slowly.	N.T. [a)]	N.T.
B-C	Round shape, cream color, smooth surface, glossy, surface looks like wet.	Positive	Bacillus
B-D	Round shape, brow, smooth surface, glossy, isolate roundly rises, grow very slowly.	N.T.	N.T.
B-E	Round shape, cream color to yellowish brown, rough surface, glossy, crinkled between the center and peripheral.	Negative	Bacillus

a) N.T.: Not tested.

3. Biochemical Test and Identification of Isolates

Isolate A-E was identified as Bacillus sp. in accordance with its characteristics: it was aerobic, gram- positive and bacillus. Moreover, spores were observed under photomicroscope. Out of 6 isolates, which were gram- negative, five isolates, except Isolate A-D, were bio-chemically tested by a test kit of Bio Merieux Industry Api20NE. The growth of Isolate A-D was too slow to obtain samples for the biochemical test. Table A4.6 shows the test result.

Table A4.6 Biochemical Characteristics of Isolates

Test Items	Isolates				
	A-A	A-B	A-C	A-F	B-E
Deoxidization of nitrate	+	+	+	+	—
Indolum indole	+	—	—	—	—
Acidification of glucose	+	—	+	—	—
Arginine hydrolase	—	—	—	—	—
Urease	—	—	—	—	—
β-glucosidase	+	±	+	—	+
Protease	+	+	—	+	—
β-galactosidase	+	—	—	—	+
Assimilation of glucose	—	—	—	—	—
Assimilation of L-arabinose	—	—	+	—	—
Assimilation of D-mannose	+	—	—	—	—
Assimilation of D-mannitol	+	—	+	—	—
Assimilation of N-acetyl-D-gluconsamine	+	—	—	—	—
Assimilation of maltose	+	—	—	—	—
Assimilation of potassium gluconic acid	+	—	—	—	—
Assimilation of n-capric acid	—	—	—	—	—
Assimilation of adipic acid	—	—	—	—	—
Assimilation of dL-malic acid	+	—	+	—	—
Assimilation of sodium citric acid	—	—	—	—	—
Assimilation of phenyl acetate	—	—	—	—	—
Oxidase test	—	+	+	—	—

The result of the biochemical test was analyzed to identify isolates by a computer software, APILAB Plus (V3.3.3) of Bio Merieux Industry. As a result, Isolate A-A was identified as *Vibrio alginolyticus*, Isolate A-B as *Moraxella lacunata*, Isolate A-F as *Weekshella virosa*, and Isolate B-E as *Brevundimonas vesicularis*, respectively. Isolate A-C could not be identified. Although the four isolates could be identified as mentioned, the accuracy of the result was low for each of them.

Isolate A-B was identified as *Moraxella lacunata*, but Bergey's manual states that bacteria of the genus *Maraxilla* were not colored and were parasitic bacteria of warm-blooded animals. For that reason, it can be considered that the result was not reliable for the other isolates, too.

Isolate A-B was identified as Cytophagales due to the following factors: observation result under photomicroscope, the fact that cells for hyphae was found in Isolate A-B, a color tone of colonies, isolation, observation of colonies, which were left for a while, and the result of the biochemical test.

On the assumption that Isolate A-A belongs to other than *Vibrio alginolyticus*, the computer analysis shows that Isolate A-A belongs to bacteria of the genus *Aeromanas*. The genus *Aeromanas* belongs to the Vibrionaceae family and can be often found with the genus *Vibrio* in the sea. Therefore, it was identified that Isolate A-A belongs to the Vibrionaceae family. The other isolates could not be identified due to lack of information.

4. Characteristics of Anaerobic Bacteria

After the number of anaerobic bacteria was counted, the biochemical test was conducted by a test kit of Bio Merieux Industry Rapid ID32AApi, and a computer software, APILAB Plus (V3.3.3) of Bio Merieux Industry was used to identify the bacteria. However, the bacteria could not be identified. For that reason, the anaerobic bacteria were cultured in an incubation plate under the aerobic condition. As a result, most colonies grow, and they were proved to be facultative anaerobic bacteria. Because the characteristics of the colonies were not helpful to identify them, four colonies were gram-stained. As a result, the all colonies were proved to be gram negative bacillus. These colonies were bio-chemically tested by a test kit for gram negative bacteria, Api 20NE, and the result was the same as Isolate A-C.

V. Consideration

The reason why the ignition loss was highest at the upper layer of Site A was considered that the soil of Site A was silty, and that fine roots grow well at the upper layer.

There were heterotrophic bacteria of Site B about 5 times as many as ones of Site A. Because Site A was silty, and Site B was sandy, there was a possibility that air was diffused more easily at Site B than at Site A. Moreover, it was possible to be considered that despite the upper layer Site A was more anaerobic environment than

Site B due to influence of hydrogen sulfide coming from the lower layer. This was because at the lower layer there were sulfate reducing bacteria at Site A about 100 times as many as ones at Site B. However, the difference of 5 times is not bio-chemically large enough to be mentioned.

The reason why Site A contains more anaerobic bacteria than Site B seems that Site A was silty and contains more organic matter than Site B, which was sandy.

An identification test kit in the market was generally designed to identify bacteria particularly related to medical and food field. Even though the identification test kit used in this survey relatively covers many kinds of bacteria, it does not cover all kinds of bacteria in the environment. For that reason, it was not possible to identify all isolates.

Because colonies of heterotrophic bacteria of Site B were similar to ones of a sandy soil sample from the coastal tideland, it can be considered that the microflora of the upper layer (aerobic layer) at Site B is the microflora common at the tideland.

Although this survey uses one type of an incubation plate to isolate bacteria, it could be possible to obtain more different types of isolates by using several types of incubation plates. Particularly for Site A, it was highly expected that various bacteria unique to mangrove can be isolated because fine roots of mangrove seem to grow well.

VI. Bibliography

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2. Sneath, P. H. A., N. S. Mair, M. E. Sharpe, and J. G. Holt eds.: Bergrey's Manual of Systematic Bacteriology, 2. The Williams & Wilkins Co., Baltimore, 1986.

3. Staley, J. T., M. P. Bryant, N. Pfenning and J. G. Holt eds.: Bergrey's Manual of Systematic Bacteriology, 3. The Williams & Wilkins Co., Baltimore, 1989.

Attachment 1

Picture A4.1 Sampling Point of Site A

The sampling point is the left side of the picture where a shovel is stood. The left side of the picture is the shore.

Picture A4.2 Sampling Hole of Site A

The hole is about 50cm deep. The soil below about 25cm is black, which means the layer is anaerobic. It is observed that water comes out from the bottom.

Picture A4.3 Aerobic Sample of Site A

An acrylic corer with a diameter of 18 mm is stuck into the upper layer (aerobic layer) to collect sample soil. The length of the soil sample in the corer is about 10 cm. The sample is collected from the middle part of this corer.

Picture A4.4 Anaerobic Sample of Site A

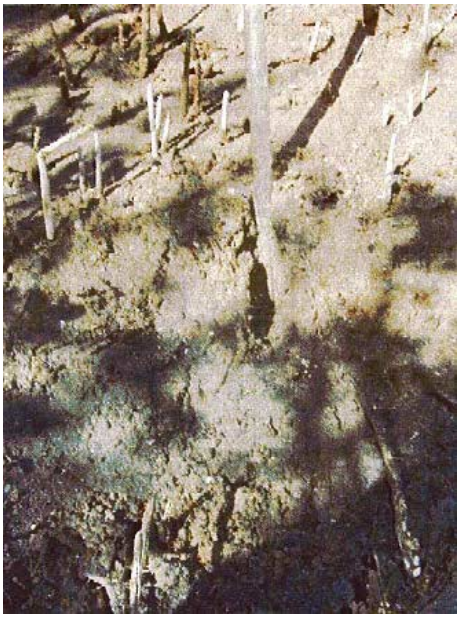
In comparison with the sample of the aerobic layer, this sample is blackish.

Picture A4.5 Sampling Point of Site B

The shore is over the mangroves. The place where a picture is taken is the hole of sampling. A community of Haloepiptis can be seen on the left side of the picture.

Picture A4.6 Sampling Hole of Site B

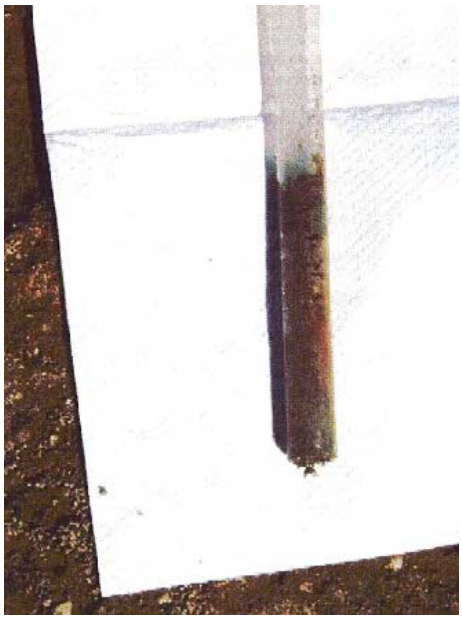
The brown aerobic layer is thinly accumulated at the lower shore and thickly accumulated at the upper shore.



Picture A4.7 Upper Layer's (Aerobic Layer's) Sampling at Site B

An acrylic corer is stuck into the aerobic layer to collect sample soil.

Picture A4.8 Lower Layer's (Anaerobic Layer's) Sampling at Site B



Picture A4.9
Aerobic Sample of Site A

Picture A4.10
Anaerobic Sample of Site B

5. Proposed Projects and Programmes by Study Site

Appendix 5 Proposed Projects and Programmes by Study Site

a. Batinah Region

(a) Khawr Shinas

i. Introduction and Site Description

(i) Introduction

Clarke (IUCN, 1986) recommended that this site should be included in a National Nature Reserve. The khawr is about 6 km long with a northern and southern arm.

(ii) Existing (Natural) Conditions

Plants

Khawr Shinas is surrounded by Sabkha, salt tolerant plants of the coastal plain. In an outer zone, furthest from the khawr, *Salsola imbricata* dominated, with *Juncus rigidus* growing in dry watercourses. Nearer the khawr on sand and beach rock, *Suaeda vermiculata* and *Cyperus conglomerata* form about 10 % plant cover. In wet sand nearest to the mangroves, a dense growth (about 50 % cover) of *Arthrocnemum macrostachyum* forms a narrow zone (5 - 10m wide). Along the north west arm of the khawr a zone of *Arthrocnemum, Suaeda vermiculata* and *Zygophyllum qatarense* forms a band of vegetation about 5 - 8 m wide along the edge. Dune vegetation included *Halopyrum mucronatum.*

Animals

Abundant small fish and crustaceans occur in the water channels of the mangroves. The crabs *Eurycarcinus* and *Metopograpsus* were recorded as particularly numerous by the channel (Salm & Jensen, 1991). They reported heavy recreational fishing for the mud crab *Scylla serrata,* as many as 20 crabs may be caught in a night.

During this study, *Uca inversa* was recorded on muddy sand, bordering the landward edge of the mangroves, with burrow densities of 50 - 200/m^2. Large mud snails, *Terebralia palustris,* were found in the shade reaching densities of 100/m^2 in the middle of the mangroves. Other crabs were abundant among the mangroves and on the channel edge (*Uca annulipes, Perisesarme guttatum, Metopograpsus thukuhar, Eurycarcinus orientalis*, *Nasima dotilliforme, Serenella leachii*). On the channel edge, snapping shrimps (*Alpheus* sp), mud crabs (*Marcrophtalmus depressus*), short crabs (*Metopograpsus messor*), and smaller specimens of Terebralia were found. The small species of mud snail, *Cerithidea cingulata* and *Cerithium scabrida* were common. Oysters (*Saccostrea cucullata),* Nerites (*Nerita albicalla*) and barnacles (*Balanus amphitrite*) were found on the mangrove trunks and aerial roots.

At the northwest arm of khawr Shinas, mangroves are smaller and scattered. Sieved samples ($0.1m^2$ at 20cm depth, using 2mm mesh) were taken from the wet sand along the edge of the channel. Animals were abundant (about $90/m^2$) and included Fiddler crabs (*Uca inversa*), lantern shells (*Laternula erythraensis*), *Dosinia alta*. *Umbonium Vestiarum* and *Certhidea cinlata* Hermit crabs (*Diogenes* sp) were common on the surface.

Over 10 years, 99 water bird species have been recorded for this site. Evans (1994) records significant numbers (>1% of world population) of Great Black-headed and Yellow-legged Gulls. The endemic Arabian collared kingfisher is recorded here, which is the closest site in Oman to its breeding site at Khawr Kalba on the border with Fegeira. The rare Sykes's Warbler is also recorded at this site.

(iii) Water Quality and Soil Condition

Khawr Shinas lies on the northern Batinah coastal beach where two Wadis, Fayd and Bid'ah, meet at the sea. Khawrs in Shinas are mainly branched into 2 streams. Mangroves cover all the southern khawrs and the mouth of the northern khawr. The northern khawr extended approximately 5km to the north. Halophytes forming salt marsh surround these khawrs.

Soil profiles were dug at 8 different locations in the southern khawr and 4 locations in the northern khawr. Water analysis was done at 16 locations. Soils in the mouth of khawrs show sandy layers, deep (more than 100cm), soft and aerobic conditions. In the midstream of south khawr, soils are relatively silty in surface but sandy in sub-surface samples. The soils in the deepest inner khawr are clayey, deep and soft through the layers. The mangroves situated on these soils have developed many aspiratory roots. The data of soil Eh shows also low mV values (negative values) in the layers of sub-surface soil. Salinity of ground water is ranging from 4.3 to 5.6 %.

In north khawr, a survey for soil depth was carried out to identify the potential for mangrove afforestation as well as soil profile observation. Soils of this khawr are basically deep but shallow soils are observed in some areas with hard rock bed. Soils are more silty and clayey in the inner khawr, and sandy near the mouth of the khawr. Salinity of ground water in the northern khawr is ranging from 5.1 to 7.6 %. The salinity of surface water in khawrs is ranging from 3.7 to 4.8 %. The visibility of water is high downstream and low upstream.

According to the present condition, the plantation of mangrove will be applicable on the north khawr for the extension of existing vegetation. The areas of sandy and deep soils on the north khawr will be suitable land for new plantation.

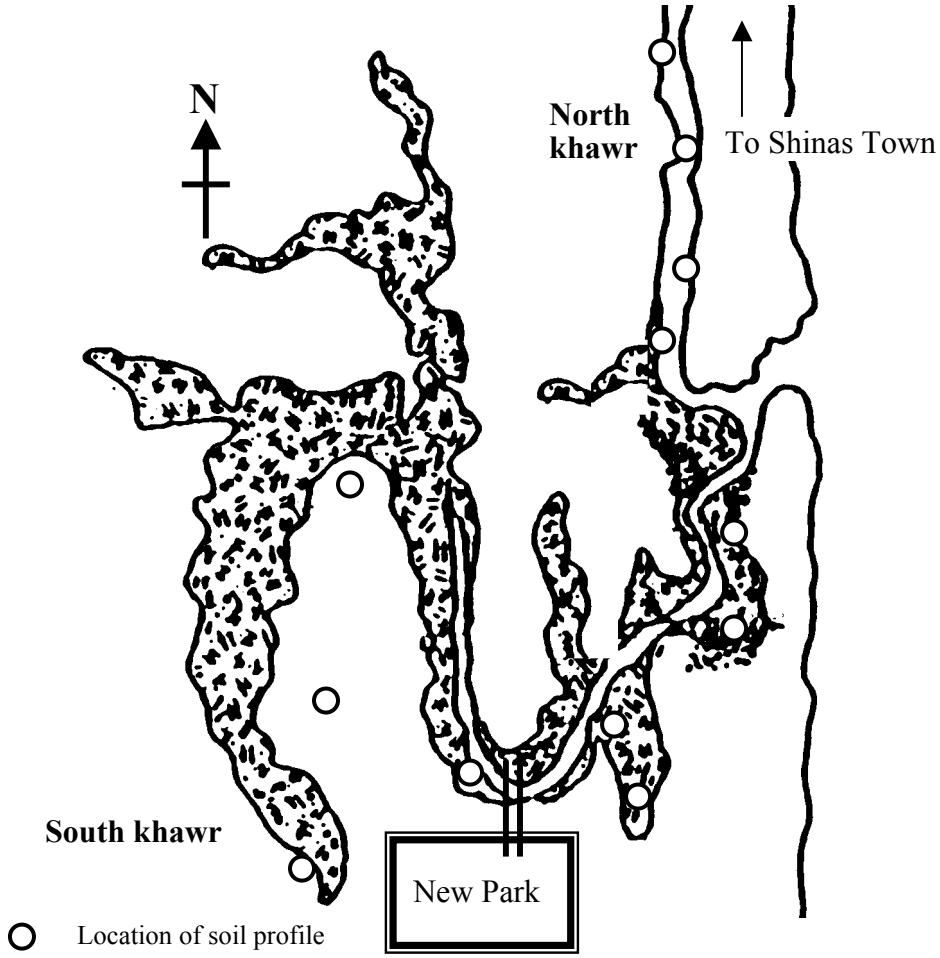


Figure A5.1 Schematic Map in Khawr Shinas

ii. Issues

(i) Recreation Facilities

During construction of the current car park and picnic site, fill material was bulldozed onto the edge of the mangroves covering roots and the natural bank. The footbridge foundations constrict the channel and the metal frame has bent making it unsafe.

(ii) Mangrove Planting

The mangroves on the eastern arm are in good condition next to the channel. Further from the channel and inland they are smaller, crowded and suffer from dieback due to water stress. On the western arm regeneration is occurring on the landward side. There is potential for monitoring and planting of mangroves in this area.

iii. Proposed Programme/Management Actions

(i) Recreation Facilities

The site should be legally protected as a National Nature Reserve. Further development that will affect the site should be reviewed for environmental

impact. A new design for the footbridge is required that does not constrict the channel or damage trees. In the long term a board walk and bird hide could serve as a nature trail. A setback to prevent buildings near the mangroves should be observed (MD 20/90 gives a set back of 150m).

(ii) Mangrove Planting

The pupils and teachers near this khawr, and the authority concerned have the willingness to join the mangrove planting activities. The west arm offers opportunities for planting of seedlings and could involve the local schools. A school environmental education programme could monitor the mangroves in conjunction with Directorate of Environment.

(iii) Reconstruction of Bridge

The pedestrian bridge is reconstructed to improve the water environment in the existing mangrove area.

iv. Implementing Agencies

The Ministry of Regional Municipalities, Environment and Water Resources should be responsible for overseeing the implementation of this Action Plan.

(b) Khawr Harmul and Nabr

i. Introduction and Site Description

(i) Introduction

At Liwa there are two khawrs close to each other. Khawr Harmul to the east is open to the sea, but the western arm is mostly dry and no longer connects to the smaller, now dry khawr Nabr to the west. On the beach side, the mangroves are partly buried in sand.

From the mouth of Khawr Harmul the tidal channel extends southeastwards, parallel to the shore, for about 5 km. Mangrove growth follows the main channel and also extends inland where three or four smaller channels connect to the khawr. Development of the harbour at Sohar has affected sand deposition in the area (Atkins monitoring studies).

(ii) Existing (Natural) Conditions

The mangrove growth and abundance of animal life appeared to be less here than at Khawr Shinas (Clarke, 1986). Evans (1994) records significant numbers (>1% of world population) of Black-headed and Yellow-legged Gulls. The Arabian collared kingfisher visits this mangrove site and may be more numerous than at Shinas. The other speciality of the Liwa mangroves is Sykes's Warbler, which breeds in small numbers (Erikson *et* al, 2001). A total of 24 fish species was recorded during the environmental monitoring of the Sohar Port development. Turtle nesting activity was reported by Salm &

Jensen (1991) near the mangroves. The following description is from surveys in 2003 unless where stated otherwise.

Plants

The mangroves at Khawr Harmul branch in two main directions from the channel mouth. The main growth follows the permanent water channel to the southeast. To the north west, the water channel is shallow and is only flooded at high tide. Here mangroves have become covered by sand on the beach side and many appear to be dying. On the landward side mangrove trees follow minor watercourses joining the main khawr. Further inland clumps of *Juncus rigidus* and a few *Prosopis cineraria* trees occur. In general, the mangroves are young trees although the forest has been in existence for a long time.

Surrounding sand flats supported salt-tolerant plants. On the beach (south east end) and next to the road, drier shelly sand supports well-spaced spiny succulent shrubs (*Cornulacea monacautha*). On more consolidated ground, often with beach rock, *Suaeda vermiculata*, (= fruticosa, *Miller & Cope* 1996) and *Cyperus conglomerates conglomeratus* dominat. Small depressions behind the mangroves were filled with the grass *Aeluropus lagopoides,* while a patch of *Halocnemum strobilaceum* occurred near the road.

The central large open areas on the landward side between mangroves channels were either bare sand or supported small succulent shrublets of *Arthrocnemum macrostachyum,* which reached up to 30 % plant cover. This plant was in poor condition (winter 2003) becoming smaller the further away from the mangroves with very short branches and appeared very dry.

Animals

On the landward side of the mangroves in wet sand fiddler crabs (*Uca inversa*) were found (burrow density of 15/m^2). In the mangroves, the mud snail *Terebralia palustris* was common, but crabs seemed to be scarce. Three crabs (*Perisesarme guttatum, Metapograpsus thukuhar, Eurycarcinus orientalis*) were collected. In the khawr channel below the picnic site, small hermit crabs (*Diogenes*) were common and swimming crabs (*Thalamita crenata, Thalamita* sp) were seen. The snails*, Terebralia,* and *Cerithidea cingulata* were common on the surface, while the bivalves, *Dosinia alta* and *Laternula arseneoides* occurred in small numbers buried in the sand. The sand pyramids and burrows of the ghost crab (*Ocypode saratan*) were abundant on the sea beach. Wading birds and seabird species use this inlet and 108 birds were counted belonging to 13 species.

(iii) Water Quality and Soil Condition

Khawrs Harmul and Nabr are located north of the new port in Sohar. The Khawr is open to the sea and water flows in a southern direction. In previous times, the khawr was connected to Wadi Nabr but no connection was observed

during this survey. The khawr is surrounded by halophytes on salt-marsh land. Soil profiles were dug at 8 different locations. Water analysis was done at10 locations.

This khawr has been strongly affected by sedimentation on the seaward side due to the shifting sand from the beach. This situation has occurred over the last few years. Soils at the mouth of khawr are sandy and deposits of sand were observed. Along the course of the khawr and at inner flat areas under the mangrove vegetation, surface soils with a fine texture were observed. Salinity of ground water was 3.8 - 4.2 % at profiles near beach areas and 4.8 - 6.7 % at profiles around areas of mangrove vegetation. There are no suitable areas to plant mangroves at this site. However, the conservation and management of the mangrove area against sedimentation by sand will be required.

ii. Issues

(i) Sedimentation

Deposition of sediment has occurred at the channel mouth, which seems to be related to the Sohar Port development. The Environmental Monitoring (Atkins, Report Two, July 2001, Final Report, September 2002) for Sohar Port, measured beach profiles and used aerial photographs to monitor changes at Harmul. Beach erosion has occurred at Harmul village while sediment has increased at the mouth of the mangrove khawr. There is a risk that this could change the tidal flow of water into the creek and eventually destroy the mangroves.

(ii) Recreation Facilities

The picnic and car park area has encroached onto the channel edges. The fill material (gravel and stones) has covered the natural habitat and may affect the natural environment.

(iii) Mangrove Planting

There are enough young trees so that planting is not required. If the sandbar continues to grow it may be possible to plant seedlings along the inside of the channel (too steep on seaward side).

iii. Proposed Programme/Management Actions

(i) Sedimentation

This needs further study and the Atkins monitoring programme (Sohar Port Project) should establish the cause of increased sand deposition at the mouth and propose mitigation measures if needed.

(ii) Recreational Facilities

Unfortunately, the Municipality has spoilt part of the edge to the khawr. Plans for development need to be assessed for environmental impact and when carried out the bulldozer driver needs to be supervised.

(iii) Environmental Information

Display boards explaining the mangroves and their importance would be useful here and at Shinas.

(iv) Construction of Bridge

The pedestrian bridge is constructed to protect the water environment in the existing mangrove area.

(v) Implementing Agencies

The Ministry of Regional Municipalities, Environment and Water Resources should be responsible for overseeing implementation. The Port Authority at Sohar (Ministry of Transport & Communications) needs to study changes in the movement of sediments.

(c) Khawr Sawadi

i. Introduction and Site Description

(i) Introduction

Studies by the IUCN (1986-1992) recommended this popular resort area to be managed as Ras Suwadi National Recreation Area and Scenic Reserve. The reserve boundaries included the khawr, the surrounding Sabkha and the beaches, as well as the group of 7 rocky offshore islands located just off the headland. The proposed reserve has the greatest concentration of nesting reef herons in the capital area, a major nesting site for sooty falcons and important coral habitat around the islands.

(ii) Existing (Natural) Conditions

Plants

Khawr Sawadi is surrounded by a large sandy plain with salt tolerant plants. Three species were recorded: *Halopeplis perfoliata, Limonium stocksii* and *Cornulaca monacantha*. Total plant cover was about 5 % on dry shelly sand. Nearer the *Khawr Halopeplis* become dominant with about 10 % total plant cover on moist sand. Seagrasses and filamentous algae grew in the channel near the mouth. On the seaward side, the dune grass, *Halopyrum mucronatum*, dominates the bead vegetation.

Animals

On the wet sandy bank, bordering the khawr channel, the hermit crab (*Coenobita scaevola*) and the large ghost crab (*Ocypode rotundata*) were found. On the lower bank, small ocypodid crabs (*Scopimera scabricauda*) form small burrows (12 - 30/m^2) surrounded by sand feeding balls. In the khawr channel nearby, small hermit crabs (*Diogenes*) were very abundant using small horn shells (*Cerithidea cingulata*) for protection. The small snail *Umbonium vestiarium* was fairly common. Sediment samples from the channel revealed burrowing callianassid shrimps, isopods (*Eurydice*), amphipods, bivalves (*Dosinia contracta*), nereid worms and several tube-forming annelids.

Wading birds and seabird species use this inlet and 51 birds were counted belonging to 12 species.

An area near the mouth of the tidal inlet was chosen for experimental planting of mangrove seedlings.

(iii) Water Quality and Soil Condition

Khawr Sawadi has a wide tidal area with few halophytes. The courses of streams are meandering in the khawr. But two main courses flow in, one east and another west. Soil profiles were dug at 19 different locations. Water analysis was done at 33 locations and at different times.

Soil depths at all sites areas are deep and textures are almost sandy in all layers except water courses. The soils of the watercourse were silty in surface and sandy in sub-surface samples and the accumulation of organic matter in surface samples was observed. The eroding bank was higher than the depositing bank, which had softer surface layers. The soils upstream, shown by the rectangular frame in the aerial photo, are redder in colour than downstream areas of the khawr. Mottling in sub-surface layer in these areas was also observed. Salinity of ground water shows higher values ranging from 5.0 % to 8.1 % than other khawrs.

As mentioned above, the soils in this khawr are deep and sandy in texture. These results show that Khawr Suwadi has the potential for planting of *Avicennia marina*. The areas of depositing banks along the water courses have the highest potential for plantation.

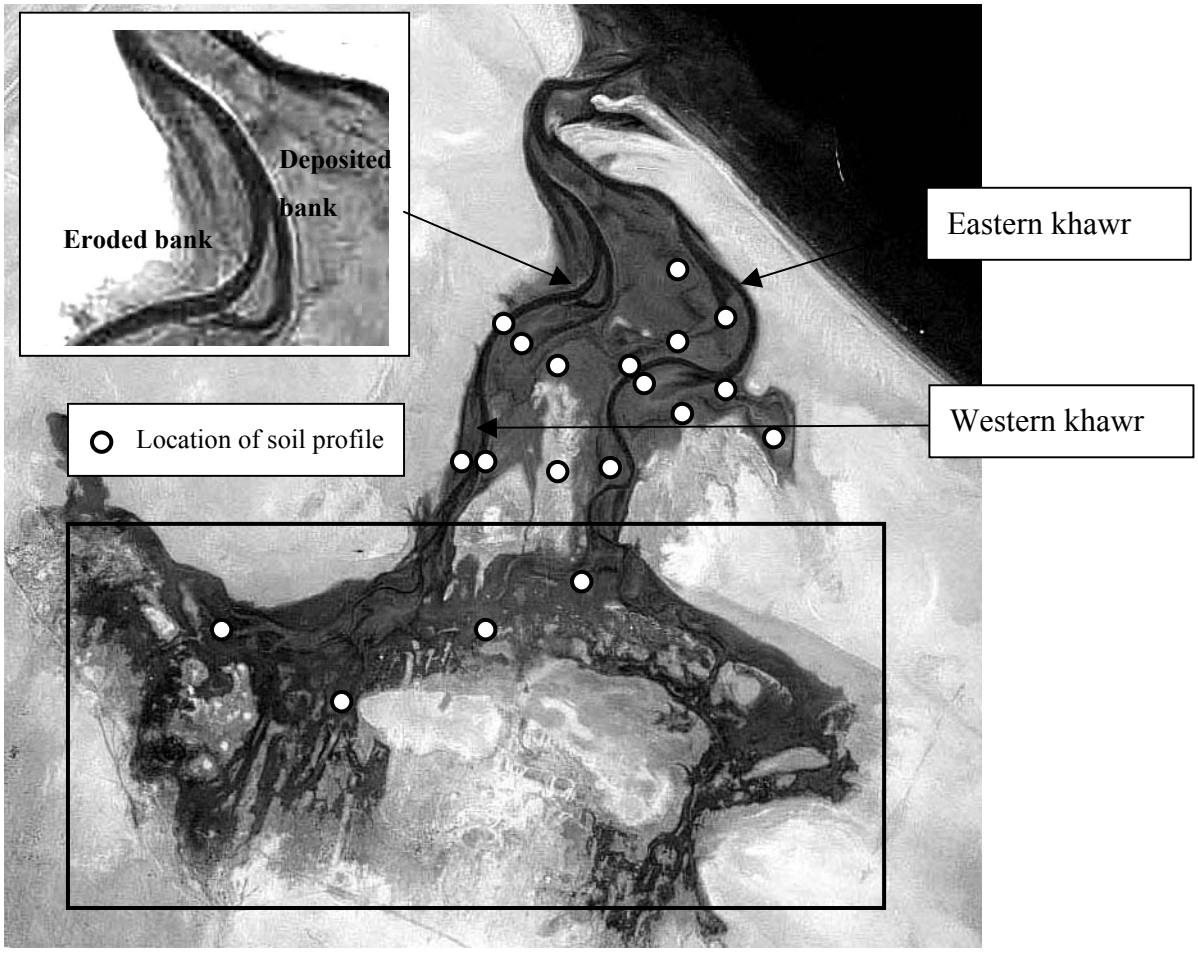


Figure A5.2 Aerial Photo in Khawr Suwadi

ii. Issues

(i) Tourism development

The scenic beauty and open space needs to be maintained to keep the tourist attraction of this site. The muddy sand supports molluscs and crustacea, which attract wading birds. If the nearby rocky islands at Ras Suwadi are included then it becomes a good site to see wildlife for guests at the nearby hotel. The breeding birds on the island (Western Reef Heron and Sooty Falcon) and the khawr need protection from disturbance.

(ii) Mangrove planting

Experimental planting of mangroves appears to be successful.

iii. Proposed Programme/Management Actions

(i) Tourism development

The Pre-feasibility study of tourism development at Suwadi by Entec (1995) for the Directorate of Tourism recommended that the islands off Ras Suwadi and

the Khawr Suwadi should form part of a scenic reserve. Trails and bird hides would allow visitors to enjoy the wildlife. Detailed management strategies for the whole area are outlined in the report.

(ii) Mangrove planting

Further planting should follow the contours of the channel to give the most attractive appearance. Monitoring of the khawr (invertebrate and bird studies) would provide useful information about the environmental conditions.

(iii) Implementing Agencies

The Directorate General of Nature Conservation of the Ministry of the Environment should monitor the site. The Ministry of Commerce & Industry should ensure that serious environmental impacts caused by development are avoided.

(d) Khawr Haradi

i. Introduction and Site Description

(i) Introduction

Near Barka, this khawr is closed by a sandbar and only opens to the sea after flood events from the wadi. The khawr receives seawater from very high tides over the sand bar. The houses, roads and gardens around the khawr may have changed freshwater drainage patterns. A recharge dam has reduced water flow and the sediments are saline. There is no mangrove and there may not be adequate freshwater inflow to allow planting to take place.

(ii) Existing (Natural) Conditions

The khawr is very sparsely vegetated with salt tolerant shrubs at the edges (*Suaeda vermiculata, Halopeplis perfoliata*). The sea beach supports limited dune grass, *Halopyrum mucronatum.* A few fiddler crabs (*Uca inversa*) occupy the small area of wet sand along the edges of the water. A band of wet sand about 5 m width contained about 15 burrows/m^2. Birds numbered 73 belonging to 10 species, (Gulls 40, herons 3, and waders 30) were seen in small numbers. Goats are numerous in the area.

(iii) Water Quality and Soil Condition

There is no mangrove vegetation in this khawr. The khawr is almost dried up and no flooding in decades because of the construction of a water-recharge dam occurred for upstream of wadi Haradi. The water will only be replenished during flood tide. Soil profiles were dug at 7 different locations. Ground water from the soil profiles was not observed except for the stagnant water area near the mouth of khawr. The khawr is shown in the schematic map and photo.

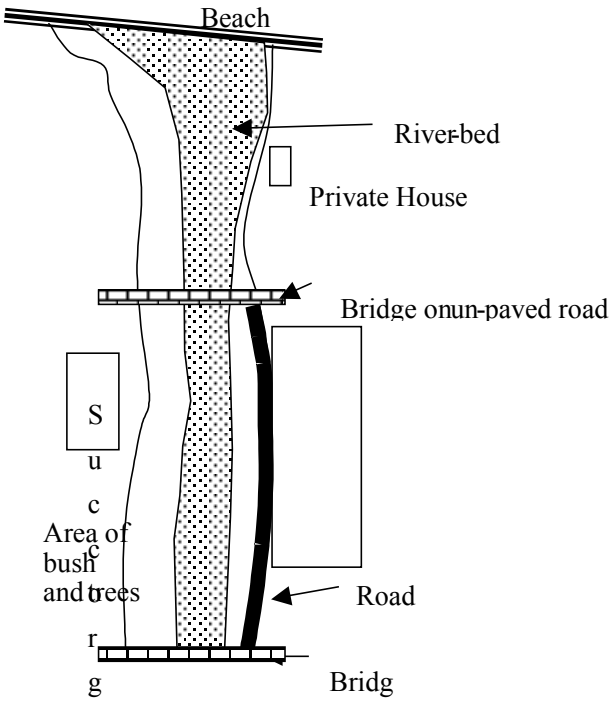


Figure A5.3 Schematic Map of Khawr Haradi

The soils in the water course are basically sandy. Near the area of stagnant water at the mouth of the khawr, a thin algal layer covers the soil surface. The soil is black in colour and anaerobic conditions were observed in sub-surface samples. The stagnant water had extremely high salinity, with more than 10 % through evaporation.

The banks of the khawr upstream were covered by bush. The banks downstream were used as a playground. The soils in these banks were relatively silty with more aerobic conditions than in the wadi-bed. In Khawr Haradi, there is no potential for mangrove plantation. Alternative land use will be required on this area.

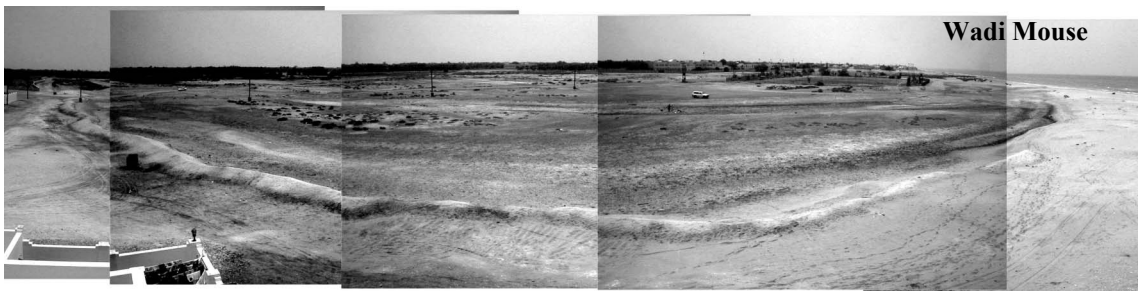


Figure A5.4 Area of Wadi Mouth of Khawr Haradi

ii. Issues

(i) Recreation Facilities

This khawr does not have high conservation value and it would be necessary to open it to the sea artificially to plant mangroves and this would not be economical. The area may be suitable for recreational development

iii. Proposed Programme/Management Actions

(i) Recreation Facilities

The mouth of this khawr is almost closed by the sandbar. The illegal dumping and waste water discharging have occurred in this khawr, and caused the water pollution. Recreational facilities including football ground are recommended to be allocated based on adequate landuse at Khawr Haradi.

(ii) Implementing Agencies

The local Municipality with the Ministry of the Environment should develop the site for recreation.

(e) Khawr Qurm

i. Introduction and Site Description

(i) Introduction

As a national nature reserve Khawr Al Qurm should be protected. Several studies have been made at this site within Muscat.

(ii) Existing (Natural) Conditions

<u>Plants</u>

Kurschner, (1986) and Al-Maamary, (1994, Thesis for SQ University) described and mapped the different vegetation zones of the Nature Reserve.

On the dune side of Al Qurm nature reserve, *Halopyrum mucronatum* is found. Where vegetation grows on the Sabkha deposits in the central part of the reserve, *Suaeda vermiculata* is dominant. At the edges of the mangroves and channels in wet saline sand, *Halopeplis perfoliata*, *Aeluropus lagopoides* and *Arthrocnemum macrostachyum* occur. On drier sandy areas mainly on the landward side of the mangroves, *Suaeda aegyptiaca* is dominant. Other common plants recorded on stable sandy areas include *Indigofera oblongifolia, Cyperus conglomeratus,* and *Limonium stocksii.* On the landward southeast side of the reserve along the pools, large clumps of *Juncus rigidus* follow the edges of the watercourse. More terrestrial vegetation typical of wadis includes *Tamarix, Acacia tortilis, Prosopis cineraria, Ziziphus spina-christi* and *Lycium shawii.*

Animals

A summary by Fouda and Al-Muharrami (1996) listed 194 species of birds, 27 species of crustaceans, 48 species of molluscs and 40 species of fish. Further studies have recorded more species of invertebrates and their zonation (Hywel-Davies 1994). On the landward fringe of the mangroves, the fiddler crab *Uca inversa* was recorded in wet sand, while the hermit crab *Coenobita scaevola* occurred in drier sandy areas. Within the mangrove trees burrow densities were very high and several crab species were found (*Uca lactea annulipes, Eurycarcinus orientalis, Nasima dotilleformis, Metapograpsus thukuhar, M. messor*). The large mud snail (*Terebralia palustris*) was abundant on wet sand in the shade of the trees, but did not usually occur in drier areas or in the open sun. On the seaward fringe of the mangroves, *Uca annulipes* and *U. vocans* occurred with other small burrowing crabs (*Perisesarma guttatum* and *Macrophthalmus depressus*). The small mud snail, *Cerithidea cingulata,* was abundant at the edge of the channel, while the molluscs, *Cerithium caeruleum, Planaxis sulcatus* and *Saccostrea cucculata* occurred among the prop roots. Small fish, hermit crabs (*Diogenes* sp) and shrimps (*Palaemon* sp) were abundant in the channel. Burrowing in the sediment of the channel, callianassid shrimps, polychaetes, *Umbonium vestiarium, Dosinia alta* and *Pirinella conica* were found.

Along the pools at the landward end of the reserve, waders (Ruff, Redshank, Greenshank, Common Sandpiper) and herons (Grey, Great White Egret) were common, while in the mangrove channels Striated Heron occurred with Western Reef Heron, and Sand and Kentish plovers on sandy edges. Gulls and Terns are common along the beach (Slender-billed, Sooty Gulls, Lesser Crested, Sandwich Tern).

(iii) Water Quality and Soil Condition

The western khawr has larger mangroves than the eastern khawr. Sandy soils lie on the seashore and inlet of both khawrs. Soils are finer and have more humus in the upper stream in surface layers. In the midstream and upper stream of the khawr, the surface soils are silty and clayey with humus accumulation, but sandy soils were recognised in shallower sub-surface soil around 60 to 70cm depth midstream of the khawr. Most of the inner stream of the khawr shows similar soil development to the midstream areas. But some areas along the channel upstream of the khawr are covered by clayey soil more than 1m deep. The central terrace areas at Qurm National Park are covered by salt marsh with halophytes. Soils in this area are deep and sandy. Compact sandy soils occur at the surface and soft sandy soils lie underneath. In the eastern khawr most of eastern shore and some areas upstream of the western shore are covered by beach rocks.

Water salinity in the khawr is lower in the upper stream than downstream. The salinity in midstream and downstream was ranging from 3.0 to 3.9 % and upstream was about 2 %. Dissolved oxygen in water was about 5mg/l in the khawr mouth and 3.5mg/l up stream. The value of COD increased towards the upper khawr but its value was less than 4mg/l.

ii. Issues

(i) Qurm Information Centre

A plan to develop the site on the open Sabkha area has been proposed. Further developments within the boundaries of the Qurm may lead to damage from trampling (car parks and visitors) and pollution (toilets and garbage).

(ii) Maintenance of the reserve

Some garbage, fill material and bulldozed piles occur at the back of the mangroves. Muscat Municipality would monitor the impact by coastal road development.

iii. Proposed Programme/Management Actions

(i) Qurm Environmental Information Centre

(See Appendix 5)

b. Sharqiyah Region

(a) Bandar Khayran

i. Introduction and Site Description

(i) Introduction

Bandar Khayran is a large sheltered shallow tidal bay enclosed by steep rocky sides. At low tides (e.g. 1.0m) extensive muddy sand flats are exposed attracting waders and herons. Clarke (1986) proposed this area as a National Nature Reserve, including the inlet with mangroves, adjacent coastal hills, islands and shallow inshore water. There are records of two species of sea turtle (Green and Hawksbill) nesting on the small beaches and a colony of White-cheeked Tern nesting in the area. Management guidelines were given by Salm (IUCN 1986). The following description is based on surveys in 2003.

Plants

Most of the mangroves growing around the steep-sided bay form a narrow zone only one or two trees wide with limited height. The best growth of mangroves occurred on the flatter terrain of small bays and near the main village. Small islands of mangroves include some large trees. Many of the old trees have been cut and regenerated and have sent out branches that have rooted. Older trunks often appeared sooty black as if burnt but this is thought to be due to a

harmless black fungal growth (Mangrove Forests of the Malay Peninsula, J.G. Watson, 1928). There is only sparse vegetation near the water edge, *Limonium stocksii* grew behind the mangroves, while in another area *Suaeda vermiculata* was found.

Animals

Fiddler crabs (*Uca inrersa, U.annulipes, U.vocans*) were abundant among the trees and muddy sand flats. The purple crab, *Eurycarcinus orientalis*, was also found and barnacles (*Balanus amphitrite*) were attached to lower branches. Small grapsoid crabs (*Perisesarma guttatum, Metapograpsus thukuhar*) were abundant among the trees and burrowing crabs (*Marcrophtalmus depressus, Serenella leachii*) were common at the channel edges. Swimming crabs (*Thalamita creuata*) and shrimps (*Penaeus, Alpheus, Callichirus*) were abundant in the channel and pools. The insect *Halovelia* occurred on the surface of small water channels. Molluscs included the small mud snail (*Cerithidea cingulata*) as well as *Nassarius arcularius plicatus*, *Mitrella blanda* and oysters. Numerous brown jellyfish (cf *Crambionella orsini*) were found stranded on the mud. Several dead shells of the large mud snail (*Terebralia palustris*) indicate that this species lived here in the recent past. It is characteristic of the mangrove sites further to the west (*Shinas, Harmul, Qurm*) and it appears that this species used to be more widespread. Invertebrate species recorded included 14 Crustacea and 3 Molluscs and numerous annelids. The extensive mud and sand flats, creeks and pools support waders, herons and kingfishers; 37 birds were counted belonging to 11 species. The rocky sides of the bays support oysters and numerous fish (especially mullet) can be seen in the clear water.

The numerous goats from the village have created a browse line on the outer mangrove trees. The biological diversity and productivity appeared high at this site, which combined with the attractive scenic values means the area deserves Nature Reserve Status.

Soil and Water Quality

Bandar Khayran has a deeply indented coastline and is surrounded by calcareous rock outcrops. Many small wadis flow into this area. Coarse and deep sands cover the tidal area located in the front of fishing boats. Some isolated mangrove trees are growing on this land. Northern parts of this tidal land are stony sand and difficult to dig. The area under biggest mangrove cover on the eastern part of the bay has a gentle slope. The soils under mangroves are loamy down to 80 cm and sandy below. The soils under mangrove bush are sandy at the surface and loamy below. Soils behind the mangroves are sandy but shallow with bedrock below. The soil below the narrow line of mangrove trees at the foot of rocky hills is shallow, clayey and stony. The soils under vegetation of scattered coves are silty and/or loamy in surface but soil depth is

rather shallow with less than 85cm. Salinities of groundwater in this area ranged from 3.8 to 6.5 %. Salinities of the upper terrace are relatively high.

Salinities of surface water in front of the fishing beach ranged from 2.8 to 4 %. Water coming from wadis was low in salinity (less than 2 %). There were no significant constraints on DO (about 5mg/l) and COD (less than 2.0mg/l).

ii. Issues

(i) New Coastal Road

The new road will have various impacts on the area. Construction should avoid damage to the edges of the bay and use adequate culverts for the small drainage channels entering the bay. It is likely to increase the number of visitors to the area and provision should be made for parking in the least sensitive areas. An environmental impact assessment has been carried out for the Ministry of Communications which recommends routing the road around the back of the coastal hills to avoid damage to the edges of the bay.

(ii) Recreation/Tourism Development

Visitors to Bandar Khayran normally arrive by boat from Muscat. However, if car access is improved, more visitors may want boat rides. This will allow the local fishermen to hire out their boats and participate in tourism. However, the constant movement of boat within the Bandar Khayran bay area is undesirable as it will cause erosion of the shallow muddy sediments and disturb birds and other wildlife. In this case, it is desirable to direct cars and recreational boats to a rocky bay outside the mangrove areas. Similarly, any visitor facilities are best located outside the enclosed bay areas to avoid pollution and disturbance.

(iii) Fish Resource Use

Results of the social survey indicate that fishermen from surrounding areas have moved to Bandar Khayran and fishing pressure has increased. The catch per unit effort is decreasing and some regulation of fish catches may be required by Ministry of Agriculture and Fisheries.

(iv) Livestock Damage

The trees next to the village show signs of heavy browsing on the landward edge but overall grazing is moderate at this khawr and may be sustainable because trees on the seaward side are protected.

iii. Proposed Programme/Management Actions

(i) Declaration as a National Nature Reserve

One way to have better control over development in a sensitive environmental area is to declare it a Nature Reserve. The boundaries would exclude the village and make the fishermen's beach where huts are built and boats are hauled

out a utility zone. The mudflats and mangroves are valuable wildlife habitat that can be damaged by too much boat traffic and overuse.

(ii) New Road and Recreation Facilities

These require careful planning to avoid pollution and disturbance to the enclosed bays. The Muscat Municipality have carried out an Environmental Impact Assessment for the coastal road (Atkins 2003). This report recommends that the original alignment should be changed to avoid Bandar Khayran completely. It returns to the coast further south and crosses the road to the village on the landward side.

If people are visiting the area they can take the road to the small bays north of Bandar Khayran, thus avoiding the mangrove bays and the village. This is where small boats giving rides to tourists could also operate from to avoid the shallow mudflats and mangroves further south.

(iii) Fisheries Resources

Ministry of Agriculture and Fisheries need to regulate fishing in the area. One method is to close certain areas to allow stocks to recover and eventually repopulate surrounding areas.

(iv) Livestock Damage

There is no urgent need to plant mangroves but young seedlings should be monitored as well as the extent of the forest. It may be necessary to provide some form of temporary protection from goats to selected areas if regeneration is not occurring.

(v) Implementing Agencies

The Directorate of Conservation at the DG of Environment (Governorate of Dhofar) should be responsible for establishing the area as a National Nature Reserve. Ministry of Agriculture and Fisheries need to monitor fish catches and set limits or reserve areas if necessary. Plans for tourism development should be assessed for impacts to the environment and the natural landscape values.

(b) Qurayyat

i. Introduction and Site Description

(i) Introduction

Mangroves grow at the northern khawr Majlis at Qurayyat. The ground level is relatively high. Floods coming down the wadi bring fine silt which is deposited among the mangroves. The best growth of trees follows the main channel and four smaller ones. The banks between the channels remain dry. The water level fluctuates depending on freshwater flow and connection to the

sea. There are enough young trees and mangrove planting is not considered necessary at this time.

(ii) Existing (Natural) Conditions

Plants

The mangroves seedlings need shallow water to establish but water level can then change and seedlings can drown. Trees next to the channels remain healthy but dieback is evident along raised banks due to water stress. On the landward side of the mangroves some wadi vegetation such as *Tamarix* and *Prosopis cineraria* is found while the flatter sandy areas had salt tolerants shrubs, *Halopeplis perfoliata*, *Suaeda vermiculata*, *Cormulaca monacantha* and *Salsala drummondii* reaching 15 % cover but often in poor condition due to trampling. In wet areas next to mangrove the succulent shrub *Arthrocnemum macrostachyum* was found. The surrounding rocks on the north side of the mangroves supported *commiphora*, Acacia, *Euphorbia larica*, *Capparis spinosa*, *Indigofera*, *Cassia italica* and flowering plants of *Limonium stocksii*.

The sand dunes on the beach in front of the mangroves supported shrubs of *Suaeda vermiculata, Cornulaca monacantha, Heliotropium kotschyi* and the grass, *Aeluropus lagopoides.*

No submerged aquatic vegetation was observed in the channel even though the salinity was low. Mats of green algae were floating in the channel parallel to the beach before the flood of May 2003. After the flood the khawr was flushed by the tide and algae were absent.

Animals

Salm made a preliminary survey of this area for the Department of Tourism in 1985. The mangrove channel contained abundant fish (mullet), crabs (4 species) and snails (*Cerithidea cingulata)*. Waders and herons inhabited the mangroves and the proximity of the other khawrs, woodland and farmland, added to the diversity of bird life. In 1993, an environmental impact study for the construction of the harbour at Wadi Afa was carried out (Gibb & Partners Ltd, 1993). An alga, *Rhizoclonium implexum*, formed mats in places and the snail, *Cerithidea cingulata*, was abundant. This study recorded 15 species of crustaceans, including barnacles, burrowing crabs (*Uca inversa, Scopimera scabricauda, Dotilla sulcata, Macrophthalmus depressus, Metapograpsus messor* and *Eurycarcinus natalensis*), shrimps and swimming crabs. Seven species of molluscs commonly associated with mangroves and numerous annelid worms were recorded. Fish included the resident estuarine species, *Aphanius dispar*, and marine species such as *Liza macrolepis, Acanthopagrus berda, Gerres oyena* and *Therapon jarbua*, which use the mangroves as a nursery area and breed in the sea.

When the site was visited in 2002, the environment showed a great change. The khawr had been closed to the sea for several years and the water was fairly fresh (0.2 % at the top of the main channel). The water level was much lower than the mangrove roots and there was no sign of crabs or molluscs living there. In the main water channel a few small mud snails (Cerithidea) were seen on the surface of the mud. No marine species were found in the black sediment. Only one species of crustacean and one species of mollusc were recorded.

Birds included 3 herons (western reef, great white and little egret), 12 waders (redshank, godwit, sandpiper, sandplover), 16 wigeon, 2 shovellers, 2 tufted duck, 5 black-necked grebes and 1 common kingfisher (12 species, 41 birds).

In May 2003, however, a flood came down the wadi and broke through the sandbar. The khawr was still connected to the sea when visited in July 2003 and colonisation by marine species had begun. Abundant crabs (5 species of crustacean) and fish (*Aphanius,* and *Chanos*) were evident. A gill net was being used to catch swimming crabs (*Portunus*) and fish (*Chanos*).

Soil and Water Quality

Qurayyat lies on the coastal alluvial plain and deep beach sand covers the coastal area. Mangrove vegetation is located on the northern part of this flat alluvial area and bordered by calcareous rock outcrops on the north. Many agricultural farms reach the mangrove vegetation on the west. The soils under mangroves are basically sandy except the small areas along the upper stream of the water channel. The soils of these areas are fine (silty to clayey) layers. In parts of the central area of mangroves halophytes were observed. The soils of this area have sand to loamy sand at the surface and loamy sand to silty loam in subsurface samples. Deep coarse sands transported by onshore winds are deposited on mangrove vegetation at the front of the beach. Salinity of groundwater in mangrove bush is not so high, as much as 4 %, and depths of ground water are deep (70 - 90 cm).

The salinities of surface water in khawr were ranging from 3.4 to 4.2 %. Water quality near khawr mouth was good but stagnant water at upper khawrs showed relatively low DO (3 - 4mg/l) and high COD (about 5mg/l) values.

ii. Issues

(i) Connection to the sea

The lack of connection to the sea for at least 3 years (possibly 7 years) led to a fall in populations of marine species and stagnation of the water. The building of the harbour at Wadi Afa 1.8 km south of the mangrove khawr (Wadi Majlas) may have affected the pattern of sedimentation at the mouth.

(ii) Sustainable use

Khawr Quriyat is impacted by the nearby village and date palm plantations. Further, buildings should not be allowed close to the khawr mangroves.

Generally, plantations affect the landward sides of the mangroves, while tracks and football pitches have compacted the Sabkha. People use the area for recreation. The southwest side of the mangroves is heavily browsed by goats and dogs are common.

iii. Proposed Programme/Management Actions

(i) Study of the connection to the sea

Monitoring of the khawr mouth is needed to record when the mouth opens to the sea. Modelling of sedimentation patterns between the harbour and the mangrove khawr should be carried out. It may be beneficial to artificially open the khawr to the sea. As a trial, a bulldozer could be used at low tide. If the mouth stays open for a few weeks then this could be repeated at regular intervals (e.g. twice a year). Otherwise training dykes could be constructed to maintain a connection to the sea. This would be more expensive and require maintenance.

(ii) Sustainable Use

A setback to prevent further buildings near the mangroves is needed (MD 20/90 gives a set back of 150m). Boats and fishing equipment should be kept at the back of the khawr next to the houses. It is important to maintain the area in a healthy condition so that it can function as a provider of fish, fodder and recreation. In the future, the mangroves may form part of the scenic attractions for tourism. A community ranger is required to advise people on the best use of the khawr. Goats should be kept away from the overgrazed eastern side, while fodder can be collected from the healthy trees along the channels. Garbage should be collected and dogs should be removed, as they constitute a health risk (attacks on children and rabies).

(iii) Construction of Training Dyke

Concrete culvert or training dyke should be constructed.

(iv) Implementing Agencies

The Ministry of Regional Municipalities, Environment and Water Resources should be responsible for overseeing the implementation of this Action Plan.

(c) At Tina & Batah

i. Introduction and Site Description

(i) Introduction

This large tidal inlet exposes shallow mudflats at low tide. Mangrove forest is limited to the central southern edges with some regeneration of young trees at the mouth of other small khawrs.

(ii) Existing (Natural) Conditions

Plants

On sandy areas around Sur lagoon two species of halophytic plants (*Suaeda vermiculata, Zygophyllun gatarense*) were collected, however, Khawrs Qurm a'Sukaykira and Sukaykira were surrounded by a rocky shoreline or open sandflats and sabkha without vegetation. The drainage channels with mangroves along the edges contained blue-green algal mats (Lyngbya majasula) especially near the entrance to the bay. These were blown in from across the bay and smothered young mangroves and the mudflats especially in the winter. Another golden-brown alga, *Feldmannia irregularis*, was found attached to the base of aerial roots in wet mud and pools. The mangrove structure appeared more developed at Qurm a'Sukaykira where a nursery for mangrove seedlings has been built. The ground is more level here. At Sukaykira to the east, there are several water channels and the ground forms raised banks between them where mangrove bushes are still quite small.

Animals

The landward zone around the mangroves contained holes of fiddler crabs (*Uca inversa*) in densities of about 100/m^2, while among the mangrove prop roots, the mud snail *Cerithidea cingulata* and holes of another fiddler crab (*Uca annulipes*) and the mud crab (*Macrophthalmus depressus*) occurred. Other species of crab were also recorded here, (*Eurycarcinus orientalis, Metapograpsus thukuhar, M. messor, Perisesarme guttatum*).

In the main channels, filamentous algal mats were abundant (*Lingbya* sp), covering the edges and becoming thicker towards the entrance to the bay. Under the algae the sediment of compact shelly sand and mud was a black anoxic layer. Only annelid worms were found in the sediment. Mud snails (*Cerithidea cingulata*) occurred on the surface and alpheid and penaeid shrimps and annelid worms occurred in side pools.

Where the khawrs reach the main bay small areas of rocks are covered by oysters (*Saccostrea cucullata*) up to the high tide level. In the deep sandy substrate of the open Sur lagoon the bivalves, *Dosinia alta*, and a large venus shell (*Marcia opima*) were collected. The abundant Marcia opima biralves were collected and eaten by local people in the past.

During winter, several hundred gulls and terns roosted on sandbanks in the middle of the lagoon while greater flamingos, waders and herons were numerous at the mouth of each khawr (17 species, 265 birds).

Fishing nets were common in the main channels of the mangroves.

Soil and Water Quality

Natural dense mangrove vegetation has grown on these khawrs. Generally, the upper khawr has deep and fine soils, loamy soil at the surface and sandy below, but where there is no vegetation, soils have a clayey texture. At the front of mangrove vegetation on the bay side, fine sandy soils lie on the surface with a cover of algae. Salinity of groundwater in the upper khawr is higher (5 - 10 %) than the area under mangrove and bay side (4.5 %).

Water was clear. The water channel under mangroves was 4.5 % in salinity, 6.9mg/l in DO and less than 2mg/l in COD.

ii. Issues

(i) Water quality and sedimentation

The main issue at Sur is water quality in the lagoon. Any leakage of domestic sewage into the lagoon will increase nutrients in the water and lead to degradation of the environment with algal growth and deoxygenation. The mats of filamentous algae are already a sign that nutrients may be too high. The levels of sediment deposition may also affect the lagoon.

(ii) Development Controls

Building houses, landfill and garbage dumping are potential problems in the lagoon.

(iii) Mangrove Planting

Regeneration of mangroves is occurring at the study sites and other places in Sur lagoon. This is thought to be because the use of mangroves is declining. Old mangrove stumps in areas at the mouths of khawrs to the east of the study sites (Naseem area) provide evidence that mangroves were once more widely distributed around the lagoon. Some areas to the west side of the lagoon may not receive enough flushing by seawater, while other areas need to be cleared of algae regularly.

iii. Proposed Programme/Management Actions

(i) Water quality and sedimentation

Management of waste discharge into the lagoon is required. The old septic tanks in old Sur town and old sewage pipelines need to be assessed and sealed if leakage is found. The new housing development proposed on the headland between Qurm a'Sukaykira and Sukaykira should have a sewage collection system that prevents any leakage into the lagoon. Water quality needs to be measured on a regular basis to monitor nutrient levels and coliform bacteria counts. Sedimentation rates should be monitored to determine if the lagoon is becoming shallower.

(ii) Development Controls

A setback to prevent further buildings near the mangroves is needed (MD 20/90 gives a set back of 150m). Landfill and garbage should not encroach onto the lagoon.

(iii) Mangrove Planting

Various sites have been used for mangrove planting trials. More transects are needed to determine the best locations and water levels. As well as the north side (Atteenah area), there is some scope for planting on the southeast side at the mouths of smaller wadis. Regular clearing of algae will prevent seedlings being smothered. Ideally seeds from the trees in Sur lagoon should be used.

(iv) Implementing Agencies

The Ministry of Regional Municipalities, Environment and Water Resources should monitor water quality. The local municipality should monitor house plots.

(d) Khawr Quq

i. Introduction and Site Description

(i) Introduction

The turtle reserve, which was proclaimed by Royal Decree 25/96, encloses 120 square km and includes Khawr Hajar, Quq and Jaramah. It is managed by the Directorate General of Nature Conservation of the Ministry of Regional Municipalities and Environment. The management plan details a programme of use with minimum disturbance to turtle nesting beaches involving the local community in tourism projects and the sustainable use of resources.

(ii) Existing (Natural) Conditions

Plants

Most of khawr Quq is surrounded by a rocky shoreline without vegetation but some sandy areas supported three halophytic plants, *Suaeda vermiculata, Atriplex leucoclada var. inamoena* and *Zygophyllum qatarense*. Total plant cover was about 15 % in drier sandy areas.

No mangroves occur in Khawr Hajar but they do occur in nearby Khawr Jaramah.

Animals

The rocks are covered by oysters (*Saccostrea cucullata*) up to the high tide level. The sand was coarse grained with shell fragments. A white shelly sandbar supported beach ghost crabs (*Ocypode saratan*) while wet sand contained burrows of another species (*Ocypode jousseaumei*). Slightly more

muddy sand contained many small burrows of fiddler crabs (*Uca annulipes*). A tube-building worm and bivalves (*Dosinia alta*) were found in the sediment. Birds included Waders (Godwit, Whimbrel, Sand Plover) and Grey Heron.

Soil and Water Quality

The tidal area of Khawr Quq has deep sandy soil layers. But soil depths of the southern coast adjacent to a rocky hill are shallow (less than 10 cm) up to about 5 m away from rock outcrops. Soil at the innermost khawr is relatively fine textured. The areas planted with mangrove trees by this Study Team have a gentle slope. Salinities of ground water are not much different from surface water (approximately 4 %). Salinity of water in the khawr was about 4 %. The values of DO were more than 7mg/l. There were no significant constraints from water quality.

ii. Issues

(i) Mangrove Planting

Potentially a half or two-thirds of this small bay is suitable for trial planting of mangrove seedlings. When a small number were planted there was a 70 % survival rate.

(ii) Development Controls and Recreation Facilities

Tourism activities include hotels, campsites, turtle watching and snorkelling. The area is being developed further for tourism and this relies on the natural resources remaining in good condition.

iii. Proposed Programme/Management Actions

(i) Mangrove Planting

If compatible with the management plan, trial planting of mangrove seedlings could take place in Khawr Quq. Ideally seeds would come from Khawr Jaramah and grown separately at Sur nursery.

(ii) Development Controls and Recreation Facilities

The khawrs within the turtle reserve are important bird protection sites. Traditional use of the khawr can continue but tourism development projects, including roads, within the reserve boundaries need to be assessed for environmental impact (RD 6/2003).

(iii) Implementing Agencies

The management of the Turtle Reserve is complex and requires agreement with several stakeholders such as representatives of the village, and the Ministry of Agriculture & Fisheries. The Ministry of the Environment is the responsible authority for conservation and drafting relevant legislation.

(e) Khawr Hajar – East Shore

i. Introduction and Site Description

(i) Introduction

The northern and southern parts of the reserve consist of limestone rock and the khawrs have Sabkha along their south and west shores. Khawr Hajar serves as a harbour for fishermen using smaller boats and dhows. No gill nets are allowed in the khawrs. More than half of Khawr Hajar dries up during low spring tides exposing extensive sand and mudflats.

(ii) Existing (Natural) Conditions

Plants

Most of Khawr Hajar is surrounded by a rocky shoreline without vegetation but some sandy areas support large clumps of halophytic plants with a total plant cover of about 10 %. The dominant species was *Zygophyllum qatarense*, the trees near the coastal area were mainly *Prosopis cineraria*. No mangroves occur in Khawr Hajar but they do occur in Khawr Jaramah.

Animals

At the east end of the khawr the sand is fine grained with some silt and clay. Near the water line with shallow water and wet sand, 2 species of crab were collected (*Macrophthalmus depressus* and *Metapograpsus messor*) and two species of shrimp (*alpheus sp* and *callianassid*). Small fish (blennies) were also observed. Further up the beach in wet sand, snails were abundant (*Cerithidea cingulata, Nassarius coronatus, N. arcularia plicatus* and *N. albescens gemmuliferus*) as well as hermit crabs (*Diogenes* sp). Buried in the sediment three species of molluscs (*Dosinia alta, Umbonium vestiarium* and *Tellina valtonis*) and annelids were found. At the top of the beach, fiddler crabs (*Uca annulipes*) and the ghost crab (*Ocypode jousseaumei*) occurred.

Many (4-500) gulls and terns roosted on sandbanks in the middle of Khawr Hajar. During the winter, waders were numerous (60) along the waterline and 15 herons were observed.

Soil and Water Quality

The eastern shore of Khawr Hajar is divided into 2 bays by a small rock outcrop. The south part has a wide and very gentle slope and extends to rocky coast to the south. This area is covered with deep and coarse sands under anaerobic conditions. Soil colours are bright yellowish to brownish at the surface and dull yellowish grey at the subsurface. The soils near the rock outcrop are relatively shallow. Soils within 50 m of the southern rocky coast are very shallow (less than 50 cm). The salinity of ground water ranged from 4.4 to 6.3 %. The salinities at the southern beach near rock outcrops showed

relatively high values. There were no significant constraints on water quality. Water was clear. The value of salinity and DO was 3.9 % and 8.25mg/l respectively.

ii. Issues

(i) Mangrove Planting

The eastern bays have soft sediment suitable for trial planting of mangrove seedlings.

(ii) Development Controls and Recreation Facilities

The turtle reserve, which was proclaimed by Royal Decree 25/96, encloses 120 square km and includes Khawr Hajar and Khawr Jaramah. The management plan details a programme of use with minimum disturbance to turtle nesting beaches involving the local community in tourism projects and the sustainable use of resources. Tourism activities include hotels, campsites, turtle watching and diving. The area is being developed further for tourism and this relies on the natural resources remaining in good condition. Roads need to be constructed with minimum disturbance to the natural landscape values of the area. Large-scale developments near the sea, such as big hotels, will damage the natural resources, increased lighting will cause turtle nesting to decline and local involvement will be lost.

iii. Proposed Programme/Management Actions

(i) Mangrove Planting

If accepted in the management plan, trial planting of mangrove seedlings could take place in the eastern bays of Khawr Hajar. Ideally seeds would come from Khawr Jaramah and raised separately at Sur nursery. The south shore is less suitable for planting with less sediment and algal mats blown from across the bay.

(ii) Development Controls and Recreation Facilities

The management plan for the Ras al Had reserve includes Khawr Hajar as an important bird protection area. Traditional use of the khawr can continue but tourism development projects within the reserve boundaries need to be assessed for environmental impact (RD 6/2003). Borrow pits for fill material along roads should be correctly sited and their use supervised. If large-scale hotel development is considered financially feasible it should be planned outside the reserve boundaries away from the natural and scenic values of the area. Inside the reserve, small-scale accommodation could be provided by villagers in Ras al Had.

(iii) Implementing Agencies

The management of the Turtle Reserve is complex and requires agreement with several stakeholders such as representatives of the village, the Ministry of Agriculture & Fisheries, and the Ministry of Tourism. It is managed by the Directorate General of Nature Conservation of the Ministry of Regional Municipalities and Environment. The Ministry of the Environment is the responsible authority for conservation and drafting relevant legislation.

c. Wusta Region

(a) Wadi Muraysis

i. Introduction and Site Description

(i) Introduction

The wide shallow beach at Umm Muraysis is exposed to strong monsoon winds in the summer.

(ii) Existing (Natural) Conditions

Plants

Maraysis Island is fringed by succulent halophytic bushes except at the northern tip where mangrove trees form a narrow band in patches. The dune halophytes included *Atriplex farinosa, Suaeda moschata* (endemic to Oman) and the large woody shrub, *Suaeda monoica*, which has long narrow succulent yellow-green leaves. The bright orange-yellow flowers of *Cistanche tubulosa* were seen at the top of the beach, where it parasitizes the root system of *Suaeda* species. Next to the mangroves, *Arthrocnemum macrostachyum* occurred. In the middle of the island there is sandy Sabkha without any vegetation. The waves occasionally overtop the dunes and seawater floods the central sandy area. This gradually drains away through channels that go through the dunes on the west side. The raised vegetated dune areas are used as summer nesting sites for terns, while roosting gulls occupy the central sandy area.

Along the western shore mats of blue-green algae (*Lyngbya majascula*) covered the beach and were also washed over the island where mangroves occurred.

Animals

The mangrove trees formed a narrow band and invertebrate life was poorly developed in the shelly sand substrate. Mats of dead algae smothered some areas on the exposed west side. Burrows and pyramids of large ghost crabs (*Ocypode saratan*) were observed at the top of the beach. On the more sheltered east side, the small mud snail (*Cerithidea cingulata*) was abundant in the intertidal zone.

Birds were extremely abundant along the shoreline. Hundreds of waders, including bar-tailed godwits, oystercatchers and crab plovers were observed. Herons (western reef heron 100, great white egret 70, grey heron 40) were abundant perched in the mangrove trees or rocky promontories). Hundreds of terns were roosting along the narrow sand bar at the northern tip of the island. Osprey and Marsh Harriers were also observed.

Conservation Importance

Muraysis Island (Shaghpah Island on map) is an important roosting and nesting site for birds and should be designated a bird sanctuary. Jensen and Salm (IUCN 1992) recorded estimated numbers of breeding birds as follows:

Western Reef Heron (*Egretta gularis*)	20-30 nests
Crested Tern (*Sterna bergii*)	100's nests
White-cheeked Tern (*Sterna repressa*)	1,000 nests
Roseate Tern (*Sterna dougallii*)	few nests
Bridled Tern (*Sterna anaethetus*)	15,000 nests
Sooty Gull (*Larus hemprichii*)	5,000 nests
Crab Plover (*Dromas ardeola*)	85+nests (nesting in burrows)

(iii) Water Quality and Soil Condition

This widely spreading area of intertidal zone has a very gentle slope. Soils are basically deep coarse sand. Surface soils down to 30cm are soft and compact sand while soil layers below this have abundant shell fragments. The soils in channels are silty. Shallow soil with beach rock is found in front of the small rock hill located on the central part of the area.

Water salinity in this area shows high values. The salinities of groundwater at a depth of 10cm in the central area of inter tidal zone ranged from 7 to 8 %. The salinity of ground water at a depth of 20-30cm on the high tidal zone shows more than 10 %. The values for seawater were salinity 4.1, pH 8.3, and DO 6.9mg.l.

ii. Issues

(i) Mangrove planting

There seems to be potential for mangrove planting although the sediment is not very deep. Protection from strong winds is required. Seeds should be obtained from the mangroves growing on Muraysis Island (Shagpah) and grown in small temporary protected nurseries. Date palm fronds are used locally to build fences and these could be used on a trial basis. Protection from wind will be required until the trees are quite large (2m height).

iii. Proposed Programme/Management Actions

(i) Mangrove planting

This is a difficult site due to strong winds and water currents but using barriers to protect the seedlings may allow some success.

(ii) Implementing Agencies

The Directorate General of Nature Conservation of the Ministry of the Environment should monitor the site.

(b) Filim-Eastern Beach

i. Introduction and Site Description

(i) Introduction

The beaches at Filim form a very wide expanse of mudflats at low tide. The fine silty sand is quite hard and compacted and shows dark colouration, indicating low oxygen, below the surface.

(ii) Existing (Natural) Conditions

Plants

The beach at Filim is surrounded by Sabkha, saline sandy soils with very little vegetation. The succulent shrub in this area, *Suaeda moschata,* is endemic to Oman, and replaces *Suaeda vermiculata.* In the intertidal zone, scattered low bushes of *Avicennia marina* about 10 m apart are found across the mudflats. In shallow water below low tide two species of seagrass are common (*Halophile ovalis, Halodule uninervis*).

Animals

The small mud snails, *Cerithidea cingulata,* were abundant on the surface (50 - 200/m^2), the other common snail was the fast moving *Nassarius arcularia plicatus*. The most abundant animals in the mud were annelid worms. Two species of bivalves were common in the sediment (*Tellina arsinoensis, Dosinia alta*) where surface water run-off occurred. Small crabs (including *Serenella leachii* and *Macrophthalmus depressus)* were found in the mud. The crab *Eurycarcinus orientalis* was recorded among the larger mangrove trees and *Metaplax indica* occurred in the soft mud at low tide. Occasional swimming crabs (*Portunus pelagicus*) and the venus bivalve (*Marcia opima*) were found in channels. Hermit crabs (*Diogenes sp*) were common moving along the water edge as the tide came in.

Hundreds of thousands of migrant waders visit this area from August to May, attracted to the rich feeding areas on the mudflats. Flamingos also occur in large numbers.

Mangroves are regenerating in the area. The mudskipper fish (previously only recorded on Mahawt) has already colonised the larger trees in the rocky inlet next to the desalination plant (July 2003).

(iii) Water Quality and Soil Condition

The area has beach rock, which goes down into the beach sand, but the sand is more than 1m deep at about 30 m from the bare rock. Most of the seashore areas are covered by fine sandy soils. These soils are deep and soft. But there is a compact layer with crushed shells 20-30 cm beneath. The soils on the channels and upper seashore become finer in soil texture. Salt accumulation where surface soil colour changes to white is observed on the high flat areas of seashore.

The quality of seawater is 4.6 % salinity, pH 8.5, DO 5.9mg/l and COD approx. 2mg/l. However, the surface water on the seashore shows 6 to 7 % and ground water is ranging from 7 to 10 %. This high salinity indicates that the salts come from the upper Sabkha.

According to observations of the field survey, there are no serious constraints for the transplantation of *Avicennia marina* from the viewpoint of soil texture except in the areas of channel and upper limit of the tidal area. However, the high water salinity of surface water and groundwater on the intertidal zone will affect the transplantation and growth of *Avicennia marina.*

ii. Issues

(i) Mangrove planting

The mangroves are regenerating along the bays around Filim. There seems to be less camel grazing in the area and potential for mangrove planting exists to speed up recovery of the forest.

(ii) Development Controls

Studies have shown (Weidleplan 1991) this to be an important fisheries and wildlife area and development plans should take into account any environmental impacts.

iii. Proposed Programme/Management Actions

(i) Mangrove planting

Mangrove planting may speed up the recovery of the trees at this site. Potentially this could become the largest mangrove forest in Oman. Many mangrove species would quickly colonise the area from Mahawt as demonstrated by the mudskipper.

(ii) Development Controls

The coastal areas around Filim, Bar al Hikman and Mahawt Island are part of a proposed protected area (2003). Proper environmental impact assessments are required for any development in the area.

(iii) Implementing Agencies

The Directorate General of Nature Conservation of the Ministry of the Environment should monitor the site and carry out planting activities as resources allow. Ideally seeds collected from Mahawt Island should be used. Small field nurseries could be constructed using fences in the mud to protect against algal mats. Later the seedlings can be transplanted over a wider area.

(c) Mahawt Island

i. Introduction and Site Description

(i) Introduction

Bar al Hikman and Ghubart al Hashish are proposed as protected areas to ensure management of the valuable fishery resources and outstanding wildlife. Mahawt Island lies within the boundaries of this proposal. Declaration is expected in 2003, with management under the authority of the Ministry of Regional Municipalities and Environment. The management plan will be agreed after the declaration although management studies have been carried out (Weidleplan 1991).

(ii) Existing (Natural) Conditions

Mahawt Island is surrounded by shallow water with rich sediments and seagrass beds that provide important nursery areas for shrimp and fish. The mangroves on the island form the best-developed mangrove forest in Oman. The following description is based on visits during 2003.

Plants

The Island is fringed by mangrove forest about 400-500 m wide on the north, west and south sides. The southwest side is exposed to wave action especially during the monsoon season. This makes it difficult for seedling establishment and younger trees grow on the inner landward side. On the northeast side where exposure is reduced, young trees are found on the seaward side. Generally, the mangroves are healthy and there is no need for planting.

In the middle of the island a sandy Sabkha exists without any vegetation. On the east side there is a sandy beach. Fishermen's huts occupy the middle section of the beach but at each end vegetation consisted of the halophytic shrub *Suaeda moschata,* which is endemic to this region of Oman. Along the landward edges of the mangroves there are several species of halophytes

(*Suaeda monoica, Halopeplis perfoliata, Arthrocnemum macrostachyum* in wetter sand. On the mud at the outer edge of the mangroves a narrow band of blue-green algae was observed, while a flat green alga (*Ulva fasciata*) occurred in wet mud among the small mangrove bushes and a filamentous green alga (*Chaetomorpha crassa*) was abundant on the seaward side of the mangroves. The mangrove forest was made up of large trees on the seaward side of the island becoming progressively smaller and more spaced out towards the land over a distance of about 400 - 500 m.

Animals

On the landward side of the mangroves an outer zone of wet sand with clay has large regular mounds formed by fiddler crabs (*Uca inversa*). Other burrowing crab species occurred nearer smaller mangrove bushes (*Leptochryseus kuwaitense, Macrophthalmus depressus, Serenella (Paracleistostoma) leachii*). A small species of shrimp (Crangonidae) occurred in shallow pools.

Towards the sea the bushes gradually change to tall trees and the canopy closes. Crab holes are numerous (90 - 300holes/m^2) with at least 4 other crab species present (*Perisesarma guttatum, Metapograpsus thukuhar, Uca annulipes, Nasima dotilliformis*). Three large grapsoid crab species (*Metopograpsus messor, Parasesarma plicatum,* and *Neoepisesarma versicolor*) were found climbing among the mangrove branches. The last of these species, a marsh crab, is a new record for Oman. Small mud snails (*Cerithidea cingulata)* occurred on the surface, while in pools, shrimp (*Palaemon* sp) and small gobies were found. The mudskipper (*Periopthalmus koelreuteri* - only found on Mahawt) occurred throughout the mangroves and the soft pulmonate gastropod, *Onchidium peronii*, was found on larger branches. Molluscs included *Cerithidea cingulata, Nassarius arcularia plicatus, Cerithium scabridum, Planaxis sulcata,* and *Tellina arsinoensis*. Old, apparently semi-fossilized shells, of the mud snail, *Terebralia palustris*, were found in sand banks on the west side, indicating a population that has now disappeared. Mounds of empty shells next to houses that had been collected for food were mainly of *Murex scoloplax and Thais mutabilis*. These molluscs live in shallow water on reef flats and sandbars.

The small bird, the white-eye, is considered to be an endemic subspecies found only on Mahawt. A pair of White-collared Kingfishers and Clamorous Reed Warblers were calling in the summer (July 2003). Winter birds included: 40 Gulls, over 100 herons (Grey, Western Reef, and Great White Egret) and 30 waders (Redshank and other small species).

Occupied Red Fox holes occur on the north west sandbanks of Mahawt as well as on the small island of A'raq. Feral cats are numerous on Mahawt.

(iii) Water Quality and Soil Condition

The areas of seashore in southeast and north east of Mahawt Island are covered by deep sandy soil. The soils occurring on the other western seashores have more silty formations. That is the clayey and silty soils with humic substances cover the surface with sand below. These humic substances have accumulated with the developing mangrove forest. The surface soils are deep in the north and are relatively shallow (50-80cm) in the west and south shores of the island. Shallow soils with rocks under the soil are seen on the southern part of the island. The depth of soil in these areas is approximately 30cm.

Water quality at the seashore shows salinity 4.2 %, pH 8.2, DO 6.7mg/l and COD approx. 2mg/l. The water quality at the channel in the northern part of the forest shows salinity 5.3 % and pH 8.2.

ii. Issues

(i) Conservation and Fishery Importance

Mahawt Island represents the biggest and best-developed mangrove forest in Oman. There are several unusual species including the mudskipper, the white-eye bird, the White-collared Kingfisher, the soft gastropod (*Onchidium*), and the marsh crab (*Neosarmatium meinerti)*. The trees also form an important roosting area for birds and including Abb Island provide nesting areas for the Reef Heron, Sooty gull and four Tern species. Seagrass beds dominated by *Halodule uninervis* and *Halophila ovalis* grow in shallow subtidal areas around Mahawt Island (Jupp 1995). Green, Loggerhead and Hawksbill turtles are common.

The seagrass beds and coral growth in the Ghubbat Hashish combine with the mangroves to support a productive local shrimp fishery. Plankton samples from Mahawt waters found larvae of *Penaeus indicus* and *P. semisulcatus* (Marine Science Centre, 1999). The occurrence of all larval stages indicated that Mahout Bay is the main spawning ground for most of the shrimp species found in Masirah Bay. A total of 28 species of fish eggs and 47 species of fish larvae was also recorded from this area. In some countries, spawning grounds are often closed to fishing in order to conserve stocks and this area has been proposed as a special protection zone for nature by the DG of Nature Conservation.

(ii) Development Controls

A water pipeline connects the desalination plant at Filim to Mahawt Island. There has also been a request for a road/bridge connection to be built. This would have negative environmental impacts (changing current patterns, increasing development pressures on the island eco-system) and should be avoided. The road would also lead to social impacts with anybody being able

to drive onto the island and exploit the resources, bringing camels and goats to feed on the mangroves. The area has potential for eco-tourism but this depends on natural and landscape values remaining intact.

iii. Proposed Programme/Management Actions

(i) Conservation and Fisheries Importance

The natural system around Mahawt Island needs protection to prevent the loss of species and productivity from over-utilisation, pollution and damage from development projects. The protected area status should allow proper management and is expected to be proclaimed soon (2003).

(ii) Development Controls and Recreation Facilities

The local governmental regulation prohibits people to live in the Mahawt Island. However, there are many illegal residents in this area, and the pressure of development is brought out for the promotion of tourism. The local government is also planning the development of transport system including road or causeway constructions between Mahawt island and the mainland. A road proposed to allow access to the island would be very costly and would damage the productive ecosystem. Improved facilities on the mainland would be preferable to a road. Instead of a road to improve access, it is recommended that long jetties be built on the island, either at Filim or Bar al Hikman. A development plan for the area needs to be produced.

(iii) Implementing Agencies

The management of Mahawt Island is complex and requires agreement with several stakeholders such as representatives of the inhabitants, the Ministry of Agriculture & Fisheries and the Ministry of the Environment.

d. Dhofar Region

(a) Al Demer Beach

i. Introduction and Site Description

This is an excellent example of relatively unspoilt sand dune supporting vegetation dominated at the seafront by dune grass, *Halopyrum mucronatum*. Other plants included *Urochondra setulosa, Cyperus conglomeratus, Ipomoea pes-caprae, Polycarpae spicata, Aizoon canariense, Indigofera* sp. and *Sporobolus spicatus.*

(i) Water Quality and Soil Condition

The proposed area is located on the beach sand area beside the road to Mirbat from Salalah. This area was proposed for afforestation to prevent the wind shifting sand across the road during the monsoon season in summer. The sand covering the road makes traffic conditions hazardous. The proposed area is

covered by coarse sand more than 1m deep. Water can penetrate and drain quickly. The salinity (soil: water=1.1) of these sandy soils shows low values ranging from 475 to 730 μ S/cm in surface soil and less than 200 μ S/cm in sub-surface soil.

Alternative afforestation strategies will be considered with 1) linear afforestation along the road, and 2) zoned afforestation covering the south beach sand area. The selection of tree species will be considered for the purpose of prevention of sand shifting and windbreak formation.

(b) Khawr Rowri

i. Introduction and Site Description

(i) Introduction

This khawr is the largest and most diverse freshwater system in the Salalah area and it forms an important wildlife area as well as a tourism and recreation resource. The Khawr was designated as a Nature Reserve by Royal Decree 49/97 dated 28/6/97 with the Ministry of Regional Municipalities and Environment as the managing authority and the Directorate General of Nature Conservation as the implementing agency. The management plan provides for sustainable use of the natural resources and the protection of the very important archaeological site at Samharam. Provision will be made for visitor facilities to provide information on the historical site. The vegetation will be protected as representative of the natural flora of the gravel plain.

(ii) Existing (Natural) Conditions

The following description refers to surveys during 2003 unless otherwise stated. Khawr Rowri has steep rocky terrain on the western side while the east side is more sandy. Freshwater flows from the landward side and salinity varied from 0.4 % in the middle to 1.4 % at the mouth.

Plants

Submerged rooted plants in the water were common (e.g. *Potamogeton pectinatus*), while the edge of the water was lined mostly by the sedges (*Schoenoplectus litoralis*) and reeds (*Phragmites australis*). The northern arm has fresher water where reedmace, *Typha angustata*, is dominant. Where the reeds and sedges are near the land they are heavily grazed. Grass (*Paspalum vaginatum*) grows in the water next to the sedges. A muddy area often separated the water from the bank and sometimes had *Juncellus laevigatus* and *Bacopa monnieri* growing on it. The drier bank vegetation was dominated by a grass (*Sporobolus virginicus*) nearest to the water and by *Cressa cretica,* and *Aeluropus lagopoides* on raised areas.

Compared with studies in 1993 (TS-PCDEGD), the khawr has similar vegetation zones but a muddy gap has developed between the vegetation in the water and the bank and the extent of *Sporobolus virginicus* is reduced. This may be the combined effect of recent floods (May 2002) and heavy grazing. Many camel camps are present nearby in the summer.

The planting of mangroves is not recommended at Khawr Rowri, as it represents a unique lagoon system.

Animals

A few holes of ghost crabs (*Ocypode*) were seen. Fish were abundant. Unfortunately, an exotic species of fish (*Oreochromis niloticus*) has found its way into the khawr. It was introduced into Wadi Darbat to control mosquitoes, although the small native pup fish (*Aphanius dispar*) should be just as effective. The *Oreochromis* prefers the fresher water at the north end and will probably be impossible to eradicate from this nature reserve and may well spread to other khawrs and water bodies.

Winter Birds included: 80 flamingos, 140 ducks (mallard, teal, shoveller, wigeon, garganey, pochard, pintail, tufted), 50 waders, 28 herons, black-necked grebe, cormorant, marsh harrier and eagle. Summer birds included grey heron, reef heron, and moorhen.

(iii) Water Quality and Soil Condition

Khawr Rowri, one of the most famous tourism khawrs in Salalah, is connected to "Darbat Falls", which sometimes has floods. The khawr is usually cut off by a sandbar from sea. There are two side-branches at the east of main khawr. Many shores of the khawr are bound by bare beach rock. In general, the soils on the shores are shallow. Where the reeds are growing soils are silty with humic substances in the surface and sand and/or rocks in the sub-surface. The terrace soils on the west shore of the castle ruins are shallow with 40-50cm depths. Sand bars are stretching to the south at the mouth of the main khawr.

The salinity of water in the khawr is low ranging from 1.0 to 1.4 %. The values of DO at several places were more than 8mg/l.

ii. Issues

(i) Livestock Damage

Grazing is heavy at this khawr and is not sustainable. Some protection along the edges of the khawr where muddy tracks have developed would be beneficial. The surrounding vegetation representing the natural vegetation of the coastal plain also needs protecting.

(ii) Threat from Alien Species

The invasive tree, *Prosopis juliflora*, is appearing within the boundaries of the reserve.

(iii) Recreation Facilities

Visitors need to be guided to less sensitive areas to avoid damage to the archaeological site and the natural resources.

(iv) Use of fish resources

Fishing is common within the khawr usually by gill net.

(v) Manure Collection and Distribution

Cattle and camel dung is brought down from the jebels and stored in large piles at the north east side of the khawr. These piles are then bagged up and sent by truck to Muscat and Dubai for agricultural fertiliser. If the area is to be developed for tourism an alternative site should be found for this activity.

iii. Proposed Programme/Management Actions

(i) Livestock Grazing

Some areas along the eastern and western sides of the khawr where muddy tracks have formed would benefit from protection from livestock grazing for at least a few years. Selected areas of the surrounding vegetation should also be protected in rotation. Dead *Prosopis juliflora* (without seeds or pods) could make an effective thorn barrier next to the water in these areas.

A fence on the boundary of the protected area is proposed in the management plan. If this is carried out a permit system could allow local livestock owners to collect fodder while the vegetation is monitored.

(ii) Threat from *Prosopis juliflora*

These invasive trees should be removed from nature reserves. Because of the sensitive environment this should be done by hand or using a systemic poison in the nature reserve, not by using a bulldozer.

(iii) Recreation Facilities

The management plan discusses the need for information and proper trails to guide visitors to the archaeological site.

(iv) Fishing

Small-scale use of gill nets can continue by permit although the catch and fish populations should be monitored to ensure that they are used sustainably.

(v) Manure collection and distribution

An alternative site should be proposed and discussions with the people involved need to be undertaken to shift this activity outside the Nature Reserve boundaries.

(vi) Implementing Agencies

The Directorate General of Nature Conservation should be responsible for overseeing the implementation of management of the natural resources for this site. The Ministry of Heritage & Culture has responsibilities for the development of facilities at the archaeological site but these must be assessed for environmental impact by the Ministry of Regional Municipalities, Environment and Water Resources under the new law on Nature Reserves and Wildlife Conservation, 6/2003.

(c) Qurm Taqah

i. Introduction and Site Description

(i) Introduction

The Khawr was designated as a Nature Reserve by Royal Decree 49/97 dated 28/6/97 with the Ministry of Regional Municipalities and Environment as the managing authority. Khawr Taqah was proclaimed as a reserve for the protection of its natural resources and its scenic value. The management plan provides for the protection of these entities as well as the sustainable utilisation through consumptive use of the plants as well as the non-consumptive use in the form of recreation for visitors, with development aiming at the minimum disturbance.

The management proposals/activities presented here are consistent with the approved management plan.

(ii) Existing (Natural) Conditions

Qurm Taqah is just west of Khawr Taqah. A sandbar separates the water from the sea but some small fluctuation in water levels may be related to tidal changes. The salinity on 7th January 2003 was about 1.8 %; floods in May 2002 presumably caused an input of freshwater. Previous records in 1993 gave salinities between 1.6-3.1 %. On 16th July 2003, small quantities of sea water in the form of an intermittent stream, were entering the khawr as a result of heavy monsoon waves.

The vegetation and animal records below refer to January 2003 unless otherwise stated.

Vegetation

A submerged, rooted aquatic plant, *Ruppia maritima,* formed beds in shallow water. Two small clumps of the sedge, *Schoenoplectus litoralis,* occurred in shallow water on the east side. The mangroves show evidence of heavy grazing by camel and cattle and many of the young seedlings are at risk. At the back of the mangroves on the landward side, the reed, *Phragmites australis,* occurs, often growing in pools. If growing on the bank, it shows evidence of grazing with bitten stems and branching side shoots bearing small spiky leaves. A climbing asclepiad (*Pentatropis nivalis*) grew on the bank and among the reeds. In wet mud at the back of the mangroves, *Juncellus laevigatus* and *Bacopa monnieri* were found. The grass, *Sporobolus virginicus,* forms a zone on the landward edge of the water. In January 2003, at the mouth of the khawr behind the sandbar, an extensive area of S. *virginicus* grass indicated that the sandbar had not been broken recently. On raised edges of side channels and behind the mangroves dense growth of *Juncus rigidus* occurred. The vegetation of the drier sandy banks comprised the normal plant association for this zone (*Suaeda vermiculata, Cyperus conglomeratus, Urochondra setulosa, Aeluropus lagopoides, Sporobolus spicatus, Cressa cretica, Heliotropium fartakense*).

Animals

Burrowing shrimp holes (*Callichirus* sp.) were seen but only a few holes of mud crabs (*Macrophthalmus*) and ghost crabs (Ocypode) were observed. Damsel, dragonflies and mosquito larvae (*Anopheles coustani*) were seen. Annelid worms (Capitellidae) occurred in wet margins. The freshwater/brackish water fish, *Aphanius dispar, Ophiocara porocephala* and *Anguilla* sp. were common but marine species were not seen in the winter of 2002. In the summer, 2003, marine species (e.g. *Terapon jarbua*) were brought into the khawr by high tides flowing over the top of the sandbar.

Birds recorded included: 1 moorhen, 30 redshank, 16 small waders, 1 common snipe, 9 teal, 1 little green heron, (3 night heron, including one juvenile, were recorded on 15 July 2003 and had been previously recorded). Weaverbird nests were hanging from mangrove branches.

(iii) Water Quality and Soil Condition

Qurm Taqah lies on a flat plain. The khawr is cut off by a sandbar from the sea. The inner areas of this khawr are covered by Avicennia marina. The soils under the vegetation are deep and silty with humic substances. The soil at the shores near the mouth of the khawr are deep sand, and are covered by young plants.

Salinities of water in the khawr are 1.1 % at the mouth and 1.6 % at the inner khawr. The COD shows relatively high values (10 - 20mg/l). Green alga was found in the water of the khawr.

ii. Issues

(i) Livestock Damage

The main issue at this site is the negative impact of browsing by livestock, especially camels. Where mangroves are adjacent to deeper water and line the inner side of the khawr and are inaccessible to livestock, their condition is good. However, on the outer side of the khawr, where mature mangroves are accessible to livestock, the lower branches have been heavily browsed and consist mostly of bare wood devoid of young stems and leaves. Younger mangroves (the oldest probably less than 10 years old) occur as small shrubs in shallow water near to the banks of the more southerly (seaward) parts of the khawr and are also heavily browsed. A small number of recently germinated seedlings were also present in open muddy areas in the southerly fringes; some of these had lost their growing tips, while others were not properly rooted – quite possibly as result of feeding and trampling by camels. Very few of these younger mangroves and seedlings are likely to survive, under the present browsing pressure. At the time of the site visit (15 and 16 July 2003) browsing was intensifying, being the start of the monsoon when camels leave the Jabal and large numbers are found on the Salalah Plain (Jerbeeb); in the order of 80 camels were in the immediate vicinity of the khawr on 15 July.

(ii) Threat from *Prosopis juliflora*

In the MRMEWR management plan for Khawr Taqah, *Prosopis juliflora* was also identified as a threat to the other, native species of vegetation that occur in and around the nature reserve. Attempts to eliminate (at best) or control this invasive species from the Salalah Plain are underway, and large numbers of trees between Khawr Taqah and the Salalah-Taqah road have already been uprooted/knocked over (by bulldozer) and burnt. However, MRMEWR and the JICA Study Team are aware that this eradication campaign is a major task that may require sustained effort over several years. On the positive side, it was noted that some small, dead Prosopis trees remained near to or on the banks of the khawr and that the grass, *Sporobolus virginicus*, was growing well under and through these dead trees, being protected by their thorns.

(iii) Mangrove Planting in Khawr Taqah West and Khawr Ali bin Hamad

These two small lagoons to the west of Qurm Taqah are presently devoid of mangrove vegetation but may have supported mangroves in the past; they do not appear to be at the mouth of large wadis and previous studies (PCDEGD, Survey and Monitoring Studies Section 9, Marine Crustacean Macrofauna 1993)

indicate that their salinities vary, sometimes becoming hyper-saline. They may provide scope for mangrove restoration activities.

(iv) Recreation Facilities

Qurm Taqah should not become 'ecologically' isolated from the main lagoon of Khawr Taqah i.e. the integrity of the various components of the Khawr Taqah Nature Reserve should be maintained. Therefore, any recreation facilities (if required) should not be established between Qurm Taqah and the main part of Khawr Taqah.

iii. Proposed Programme/Management Actions

(i) Thorn Fence Protection

Urgent action is required to provide at least temporary protection (for 2-5 years) to the younger mangroves and seedlings, so that they can become fully established, and to the mature mangroves, so that re-growth of the damaged parts can take place. If at least temporary protection can be provided then the ability of the mangroves to provide browse (leaves) for livestock should increase i.e. the primary production of mangroves will increase. When healthy growth, of the mangroves has been re-established, then controlled access by camels, and/or harvesting of stems and leaves for use as camel feed, should be viable – without endangering the future survival of the mangroves and the khawr ecosystem.

Since fencing (i) can be costly (ii) can result in tensions with local land users (camel owners) because perceived as the government permanently preventing free access to the khawr and its resources (iii) can spoil the visual appearance of a natural area, an alternative method of protection is proposed on a trial (experimental) basis.

It is proposed that a thorn fence be established adjacent to selected parts of the khawr. The thorn fence should consist primarily of dead Prosopis juliflora trunks, branches and twigs that would otherwise have been burnt as part of the eradication campaign. It is essential that the dead trees selected and collected for this purpose do not bring with them seed pods and seeds from living (or dead) P. juliflora trees i.e. younger trees that have not yet fruited and/or trees that have already been ‘bulldozed’, and from which seed pods have already fallen, should be used. Most of the trees could be collected from the Ayn Humraan to Taqah area. In order to obtain local support for this task, it is recommended that the traditional users of the area are employed (temporarily), and are also paid to provide vehicles (pick-ups) to transport the dead trees to the site. The livestock owners have skills in making enclosures from tree branches which can be applied to this ‘thorn fence’ and the height and thickness (width) of the fence should be agreed with them. As part of the recruitment process, the purpose of the task (to improve the condition of the mangrove vegetation and

allow subsequent controlled exploitation) would be discussed with these users; suggestions made by them should be taken into consideration.

(ii) Monitoring and Evaluation at Qurm Taqah

Regular monitoring and evaluation (at least monthly) of the thorn fence condition and of the mangrove growth (especially seedlings) should be undertaken. Repairs to the thorn fence should be made as appropriate. For at least 18 months after protection, it is recommended that no mangrove seeds are planted in order to ascertain the effectiveness of the natural regeneration process. If after 18 months the natural process of seedling establishment appears not to be working well, then consideration could be given to planting mangrove seedlings grown in a nursery or thinned from another site; only seeds and seedlings of Salalah Coast origin should be used.

(iii) Mangrove Planting in Khawr Taqah West and Khawr Ali bin Hamad

These lagoons should be considered as potential sites for mangrove planting trials, using only *Avicennia marina* seeds/seedlings of pure Dhofari provenance. Adjustments to the ground level (as at Khawr Qurm Saghir) could be made if this might enhance the extent and survival of the mangroves, without damaging the coastal vegetation (i.e. only areas where the vegetation has already been destroyed by overstocking).

(iv) Recreation Facilities

As per the original Land Use, Development and Management Proposals (PCDEGD, 1993) any recreation facilities (if required) should not be established between Qurm Taqah and the main part of Khawr Taqah, but should be sited to the east of Khawr Taqah and immediately adjacent to the settlement of Taqah. Here the facilities will be more easily accessible to the inhabitants of Taqah and should not interfere with the natural attributes of the Khawr system.

(v) Implementing Agencies

The Directorate of Conservation at the DG of Environment (Governorate of Dhofar) should be responsible for overseeing the implementation of this Action Plan. The involvement of the Directorate-General of Local Affairs (Office of the Minister of State and Governor of Dhofar) and the Directorate-General of Agriculture (Governorate of Dhofar) may be required with respect to the selection and participation of the livestock owners in the scheme. With respect to the removal and use of *Prosopis juliflora* co-ordination may be necessary with the Committee assigned to address the eradication of this invasive species (e.g. the "eradication" activities of the organisations that are members of this Committee could provide the raw material for the thorn fences).

(d) Khawr Dahariz

i. Introduction and Site Description

(i) Introduction

The Khawr was designated as a Nature Reserve by Royal Decree Royal Decree 49/97 dated 28/6/97 with the Ministry of Regional Municipalities and Environment as the managing authority. It is an important bird site and the resources should be used sustainably. The management proposals/activities presented here are consistent with the approved management plan.

(ii) Existing (Natural) Conditions

Khawr Dahariz has fairly rocky terrain on the western side while the east side is loose sand. Fresh sand is deposited at the khawr mouth washed in by the sea. The salinity was about 1.5 % in January 2003, within the range observed in 1993 (0.8-2.6 %). The following description is from observations in 2003 except where stated otherwise.

Plants

Submerged plants were not seen, although filamentous green algae were present (*Chaetomorpha* sp and *Enteromorpha* sp). The edge of the water was lined by reeds (*Phragmites australis*) except at the seaward end. In the water behind the reeds, a zone of the grass, *Paspalum vaginatum,* occurred. An open gap of wet mud about 2m wide then separated the water from the bank edge. On the eastern side the grass, *Sporobolus virginicus,* dominated the bank edge, while on the western side, the woody succulent *Arthrocnemum macrostachyum* was abundant. Occasional clumps of the rush, *Juncus rigidus,* occurred behind the reeds in the same places as in 1993. At the mouth of the khawr behind the sandbar fresh sand has been deposited over the grass zone recorded in 1993. Only wet bare sand occurred here with occasional plants of *Eclipta alba*. The drier sand bank vegetation consisted of *Suaeda vermiculata, Urochondra setulosa, Cyperus conglomerates, Sporobolus spicatus, Cressa cretica, Limonium axillare, Ipomoea pes-caprae* and *Heliotropium fartakense*. On dry shelly sand *Suaeda aegyptiaca* and *Aizoon canariensis* occurred. At the landward end, the tree, *Prosopis juliflora,* now occurs along both sides.

Compared with studies in 1993, the khawr is similar but a muddy gap has developed between the vegetation in the water and the bank probably due to trampling and grazing. The succulent bush, *Arthrocnemum,* has increased its distribution and the tree, *Prosopis juliflora,* has also spread.

This site is not recommended for mangrove planting as it represents a unique coastal environment.

Animals

A few large holes that could belong to *Cardisoma* crabs were seen. Other smaller holes probably belonged to juvenile ghost crabs (*Ocypode*). No evidence of *Uca* fiddler crabs (recorded in 1993) or *Callichirus* shrimps was seen. Caridean shrimps (*Palaemon* sp) were observed.

Sieving sand revealed a very small bivalve (cf *Musculista senhousia*) and small *Hydrobia* snails. Damselfly and dragonfly were common. The freshwater and saltwater tolerant fish, *Aphanius dispar,* was abundant. Fishing can continue on a small scale and should be monitored.

Winter Birds included: 8 coot, 2 moorhen, 3 common snipe, 7 teal, 4 shoveller, 3 mallard, 16 small waders, 5 herons (grey, purple, western reef, little egret) and 32 gulls on the beach. Summer birds included about 30 moorhen with juveniles, 7 grey herons, 17 waders (mostly whimbrel and Kentish Plover), and terns and gulls on the beach.

About 20 camels were seen close to the khawr.

(iii) Water Quality and Soil Condition

The tree of *Prosopis juliflora* covers upstream areas of Khawr Dahariz. The shores of midstream and downstream are covered by reeds. The khawr is slightly aligned to the west. On the east shore, a marsh grows on a wide depositing shore behind the reeds. The west shore is an eroded area and is narrow. The khawr is usually cut off by a sandbar from the sea. The soils on the sandbar and its surrounding area up to approximately 100m north of the sandbar are deep sand. The soils on the west shore are deep clayey with organic matter and humic substances. On the other hand, the soils on the east shore are shallow and silty with humic substances at the surface, and are sandy in the sub-surface. The soils on the west shore are mixed with eroded sandy soils supplied from the upper terrace. Small and medium sized gravels are found on the surface in the upper khawr.

Salinity of water in the Khawr ranged from 1.2 to 1.4 %. The values of DO were about 5mg/l.

ii. Issues

(i) Threat from *Prosopis juliflora*

This invasive species can displace natural vegetation.

(ii) Livestock Damage

Grazing is quite heavy at this khawr and may not be sustainable. Some protection along the edges of the khawr where muddy tracks have developed would be beneficial. The use of temporary bush fences made from dead *Prosopis juliflora* (without seeds) could be useful here.

(iii) Recreation Facilities

Shaded seating and a bird observation point could be made on the south-west side of the khawr if desired.

iii. Proposed Programme/Management Actions

(i) Threat from *Prosopis juliflora*

The spread of the exotic tree, *Prosopis juliflora,* is undesirable as it gradually displaces natural vegetation changing the eco-system. Removal of these trees (but not native species) is already a management objective. Because of the sensitive environment this should be done by hand not using a bulldozer.

(ii) Livestock grazing

Some areas along the eastern and western sides of the khawr where muddy tracks have formed would benefit from protection from livestock grazing at least for a few years. Dead *Prosopis juliflora* (without seeds or pods) could make an effective thorn barrier next to the water in these areas.

(iii) Recreation Facilities

The pressure of development is high, because this khawr is located near Salalah city. The adequate protection of ecosystem is required. Bird hide is recommended at the southwest area at Khawr Dahariz.

(iv) Implementing Agencies

The Directorate of Conservation at the DG of Environment (Governorate of Dhofar) should be responsible for overseeing the implementation of any actions in this Nature Reserve.

(e) Khawr Balid

i. Introduction and Site Description

(i) Introduction

The Khawr was designated as a Nature Reserve by Royal Decree 49/97 dated 28/6/97 with the Ministry of Regional Municipalities and Environment as the managing authority. The reserve now also includes the Al Balid archaeological site, which is one of the "Frankincense Trail" series of sites inscribed on the UNESCO World Heritage List. The site is therefore protected by the Convention Concerning the Protection of the World Cultural and Natural Heritage, the National Heritage Law and Royal Decree 16/2001.

In the context of the site's archaeological interest, a Development Concept Plan was prepared for "Al-Balid Archaeological Park" by the U.S. Department of the Interior National Park Service, Midwest Region (U.S. DINPS). For implementation of the **concept**, further research and detailed planning and design were envisaged by the U.S. DINPS. Some developments have taken

place recently and a new Visitor Centre and bridge over the khawr have been built, paths around the site created and landscaping and "cleaning" undertaken – under the auspices of the Office of the Adviser to H.M. the Sultan for Cultural Affairs (OACA). A Management/Co-ordination Committee exists for the World Heritage Site on which the MRMEWR is represented by the DG for Nature Conservation. However it is not known if a Management Plan for the World Heritage Site(s) exists and no detailed plans and designs for implementation of the "Concept" have been examined, though it is understood that these have been prepared for OACA.

The MRMEWR Management Plan recognises the archaeological value of the site and the 1995 Development Concept Plan and supports an approach that allows sustainable development for tourism while protecting the natural resources and archaeological attributes. The Development Concept Plan also recognised the value of the natural attributes of the site and recommended that a natural resources management plan be prepared to ensure the continuation of the site's flora and fauna.

(ii) Water Quality and Soil Condition

Khawr Balid is located on the flat plain south of Salalah. The northern areas of this khawr have been traditionally utilised for cultivation. The khawr is divided into two channels. The khawr is cut off by sandbar from the sea. Deep soil occurs at the sandbar near the mouth. Other shores are covered by reeds. The soils of these areas are deep and silty with humic substances. On the west, land behind the reeds is covered by halophytes and the soil of this area is relatively shallow with a gravel layer. Shallow soils on the bedrocks are widely seen on the south shores of the west channel.

Salinity of surface water in this khawr is about 0.8 %, which is the lowest salinity in the khawrs of the Salalah area. The water supplied from cultivated areas may affect the low salinity. DO of khawr water is more than 8mg/l and COD is 5-10mg/l.

Some arguments about the contamination by agricultural chemicals and heavy metals from surrounding cultivated areas have come up at this khawr.

(iii) Existing (Natural) Conditions

Khawr Balid is surrounded by agricultural land and rarely connects to the sea. It is a freshwater system and salinity was about 0.6 % in January 2003.

Vegetation

In the water, the rooted submerged plant, *Najas marina,* was abundant in shallower water along the edges. A filamentous green alga was also present. The edge of the water was lined by reeds (*Phragmites australis*), occasionally interrupted by *Typha angustifolia*. The grass, *Sporobolus virginicus,* grew on

the landward edge. In wetter muddy depressions behind the reeds the woody succulent *Arthrocnemum macrostachyum* was abundant. Clumps of the sedge, *Juncellus laevigatus,* occurred behind the reeds occasionally. To the west of the khawr mouth, mounds of vegetation consist of *Ipomoea pes-caprae, Sporobolus virginicus,* and *Suaeda vermiculata.* Compared with studies in 1993, the khawr is similar but the succulent bush, *Arthrocnemum,* has increased its distribution. Development of the historical site at the west end, involving building a visitor centre and footbridge, has removed large sections of reed bed and aquatic plants.

Along the beach on each side of the sandbar, dune vegetation consisted of *Halopyrum mucronatum, Atriplex farinosa* and *Ipomoea pes-caprae.* This vegetation was one of the best examples of dune vegetation in Salalah but was removed by bulldozer during 2003.

Experimental planting of mangroves has taken place with *Rhizophora mucronata* from Baluchistan (planted in 1983) on the south west side and *Bruguiera gymnorrhiza* from Japan (planted in 1983), *Lumnitzera racemosa* from Thailand (planted in 1984) and *Conocarpus erectus* from the Americas (unknown when planted) on the north east side near the pump house. Some *Avicennia marina* seedlings have recently been planted on the south east side of the khawr mouth.

Animals

Birds were abundant in January 2003, including: 8 moorhen, 2 pheasant-tailed Jacana (feeding on floating mats of Najas), 55 tufted ducks, 14 teal, and 4 pochard, 1 little grebe, 1 common sandpiper and 1 marsh harrier. The birds were very shy and flew up whenever approached. In the summer the moorhen is a common breeding resident.

Balid has a largely freshwater fauna with insects such as damselfly, dragonfly, pondskater and mosquito larvae. There are also small *Hydrobia* snails and amphipods. Caridean shrimps (*Palaemon* sp), Pup fish (*Aphanius dispar*) and the sleeper fish (*Ophiocara porocephala*) adapted to freshwater conditions. Holes of ghost crabs *Ocypode*) were present on the sandbar.

ii. Issues

(i) Vegetation Management

During the JICA Study Team visits of 15 and 16 July 2003, the provision of a Visitor Centre and paths at the archaeological site appeared to be making good progress, with the buildings nearing completion. However, it was noted that the results of 'cleaning' activities at two locations amounted to ***serious mismanagement*** of the natural vegetation of the site.

First, the natural vegetation covering the **small coastal dunes** along the southern boundary of the site had been almost completely removed (by

bulldozer); this had occurred since the previous visit in January 2003. This was one of the last areas where dune vegetation occurred in good condition in Salalah; the vegetation stabilises the dunes from wind and wave erosion and would have provided a useful and attractive educational resource for visitors. One section of dune has been replanted with coconuts (probably within the last 10 years) but it is considered this is not an appropriate practice for a Nature Reserve. The reason for removing the dune vegetation is not known; possibly the vegetation was mistakenly considered to be 'weeds' in need of 'cleaning', perhaps there is a plan to plant more coconuts.

Second, the reed (*rees*) vegetation had been completely removed from both the north and south banks of the western end of the west arm of the khawr, over a distance of approximately 1,000m. The affected banks of the khawr had then been covered in aggregate and soil and are now completely devoid of vegetation. Water birds (e.g. moorhen) use such reeds for nesting and they provide an attractive and protective green fringe to the khawr, but the exposed soil can now be washed into and pollute the lagoon. In addition, floating and submerged aquatic vegetation was in the process of being removed, by hand and boat, from the khawr itself – as part of the 'cleaning' of the site. This 'cleaning' activity seems rather pointless since the aquatic vegetation will re-grow and in any case the vegetation provides food for fish and birds (and shelter for fish) and therefore contributes to the interest of the site to visitors.

(ii) Mangroves, Botanic Garden and Environmental Education for Visitors

Since 1983, four species of mangroves have been planted at Khawr Balid; none of these are of local (Salalah) origin (see 1.2 for details); at least one specimen of each species can still be found. During the course of this JICA study, consideration had been given to introducing further species of mangrove to Khawr Al Balid, in order to promote awareness of mangroves at a location likely to be popular with visitors (because of the Visitor Centre). Accordingly, the JICA Master Plan Study Interim Report proposed the establishment of a "Mangrove Plantation Experimental Centre" on land in the south-east corner of the Khawr Balid Nature Reserve.

However, general agreement has now been reached between the JICA Study Team and MRMEWR that, in future, foreign species of mangrove should not be planted in Dhofar (or other parts of Oman). The reason is to avoid potential problems that alien species can cause, i.e. they can invade sensitive habitats and compete with and exclude indigenous species - as has happened with *Prosopis juliflora*. The need for the establishment of a "Mangrove Plantation Experimental Centre" therefore needs to be re-considered, especially at this location which is a Nature Reserve. The best use of the south-east corner needs to be discussed with the management committee to determine how environmental education might best be undertaken.

(iii) Institutional Issues – Implementing Agencies and Co-ordination

Khawr Balid is a Nature Reserve for which the DG of Nature Conservation of MRMEWR has responsibilities, a World Heritage Site for which the Ministry of Heritage and Culture has responsibilities and an Archaeological Park for which the Office of the Adviser to H.M. the Sultan for Cultural Affairs has responsibility. The Ministry of Agriculture and Fisheries also has responsibilities for the fodder farm and coconuts to the north of the Khawr. A Committee exists to facilitate co-ordination of plans and activities for the site, but the issues described above indicate that there is scope for improving communication and co-ordination.

iii. Proposed Programme/Management Actions

(i) Vegetation Management

Urgent action is required by MRMEWR to stop any further destruction and removal of terrestrial, coastal dune and aquatic vegetation, unless clearly justified and essential for the Visitor Centre and access to the archaeological site. If at certain points along the Khawr it is necessary to remove the vegetation to make space, e.g. a bridge, this would be acceptable, but at other sections where improved visibility was required it would be better just to cut to a low height the reed vegetation, making the cut material available to livestock. This would keep the border of the lagoon green and attractive, reduce erosion and provide some habitat for wildlife.

Such action has already been set out in the MRMEWR Management Plan. Therefore, as recommended in the U.S. DINPS Development Concept Plan a Natural Resources (including vegetation management) plan needs to be prepared by MRMEWR and explained to and agreed with OACA.

(ii) Mangroves, Botanic Garden and Environmental Education for Visitors

If only *Avicennia marina* is to be planted, in future, at Khawr Balid and since there is now a Mangrove Nursery at Khawr Qurm Kabir (Thet) and mangroves are growing well at that location (now that a fence provides protection from livestock), there is less need for the establishment of a "Mangrove Plantation Experimental Centre" (MPEC) with water being pumped from the sea to a series of ponds etc.

Instead a small "Botanic Garden", is proposed to display native plants and to include a nursery for their propagation. Since visitors will be entering the Park at its NE corner near the Visitor Centre, a small area could be allocated near here for this purpose (unless the Archaeological Park Plan has specified all the area for other essential uses).

The location proposed for the MPEC at the SE corner of the Nature Reserve is probably less suitable for a Botanic Garden (at least for plants from the Jabal

areas) being close to the sea and exposed to a salty atmosphere and soil; it is also too far (over 1 km) to be reached easily on foot from the Visitor Centre. If not proposed for other uses (e.g. exhibitions) by the detailed plan for the Archaeological Park then the natural vegetation for this area could be allowed to recover and be part of a "nature trail"; a bird hide could be included to provide views of the open water in the khawr. The nearby Crown Hotel may be interested in participating in such proposal. This would be consistent with the management of the site as a Nature Reserve.

To promote public awareness of the environment at the Archaeological Park, so that it can provide environmental education for both school children and visitors, a display should be developed at the Visitor Centre (if not already designed). This should focus on the coastal environment, including mangroves, and on the local (Dhofari) flora and fauna.

However, prior to implementing any such actions, the first step for MRMEWR is to obtain (i) from OACA (and/or Ministry of Heritage and Culture) any **Management Plan(s)** that may have been prepared for the **Frankincense Trail World Heritage Sites of Khawr Rowri, Al Balid and Wadi Dawkah** (since UNESCO normally require Management Plans to be prepared) and (ii) from OACA the **Detailed Designs for Buildings, Landscaping and Exhibitions**. A review of these will then provide the foundation for the development of the above proposals.

(iii) Mangrove Research Centre

Mangrove Research Centre should be constructed.

(iv) Implementing Agencies and Co-ordination

The existing Committee for Al Balid should meet on a regular basis and share plans and proposals to ensure the sound management of the site for both its natural and heritage attributes. This is especially important as tourism becomes important in Oman for which a high quality environment and well-displayed heritage are required.

(f) Khawr Kabir

i. Introduction and Site Description

(i) Introduction

The Khawr was designated as a Nature Reserve by Royal Decree 49/97 dated 28/6/97 with the Ministry of Regional Municipalities and Environment as the managing authority. The management plan aims to protect the mangrove trees while allowing controlled access for fodder collection. Sustainable fishing and the use of the area as a picnic site would also be allowed.

(ii) Existing (Natural) Conditions

The mangroves of Qurm Kabir were fenced in 2002 to allow the trees to recover from overgrazing by camels. In May 2002, a large cyclone produced floods around Salalah and Qurm Kabir received floodwater, which broke through the sandbar. This lowered the water level and allowed seawater to enter at high tide. The sandbar is now rebuilt and the salinity of the water is about 2.4 % (before it was about the same as seawater 34-37 %) and is expected to gradually increase again as seawater enters during the khareef. During the flood the sand banks along the channel nearer the sea collapsed in places, killing some smaller mangroves. This also has the effect of widening the channel and small mangroves that had germinated along the previous waterline were now surrounded by water about 1 metre from the shore.

A mangrove nursery has been established on the site using water pumped from the khawr. In 2003 the channel sides nearer the sea were shaped to allow mangrove seedlings to be planted. Ideally seeds should originate from the same khawr.

Plants

Algae were recorded in the water (*Chaetomorha crassa*, *Enteromorpha flexuosa*). The main plant zone along the edges of the khawr was the grass, *Sporobolus virginicus,* which was joined by the reed, *Phragmites australis,* along the drainage channels at the landward side of the mangroves. Some patches of reed near the road gate showed signs of previous heavy grazing with the main stem eaten and numerous side branches bearing small spiky leaves. The vegetation of the drier sandy banks comprised the normal plant association for this zone (*Suaeda vermiculata, Cyperus conglomeratus, Urochondra setulosa, Aeluropus lagopoides, Sporobolus spicatus, Cressa cretica, Heliotropium fartakense, Senra incana*).

Animals

Several large active holes of the land crab (*Cardisoma carnifex*) were found on the landward edge of the mangroves. Burrowing shrimp holes (*Callichirus* sp) were common (up to 400/m^2) in open sandy areas covered by shallow water. A few holes of ghost crabs (Ocypode) were present.

Sieved samples of sand near the mouth of the khawr behind the sandbar contained elements of marine (small mussels cf *Musculista senhousia*), estuarine (burrowing amphipods cf *Corophium* and small horn shells, *Potamides conicus*) and freshwater (chironomid larvae, *Hydrobia* snails) fauna. Mosquito larvae (*Anopheles coustani*) occurred in isolated pools. Small fish were abundant. Birds recorded in the winter were 1 moorhen, 1 little egret, 1 great white heron, waders (4 redshank, 1 wood sandpiper, 1 common sandpiper). In the summer,

10 night herons were counted roosting in the trees. These birds roost mainly in mangrove trees and are not normally found elsewhere.

Compared with studies in 1993, the khawr had a greater freshwater component but diversity was high.

(iii) Water Quality and Soil Condition

Khawr (Qurm) Kabir lies on the flat plain in the western part of Salalah. The khawr is usually cut off by a short sandbar from the sea. The soils of both sides at the mouth of khawr are deep sand as well as the narrow shore on the south side. On the other hand, the north shores of the khawr are steep and sandy soils are only found in limited areas. The inner shores on both sides of khawr are covered by mangrove of *Avicennia marina*. The soils under the vegetation are basically deep and silty with organic matter and humic substances. However, sandy soils adjacent to the mangrove vegetation were recognised. Gravels and stones, which were carried by flooding water through wadis, were seen at the extreme inner khawr.

Salinities of water in the khawr were 2.6 % at the mouth and 2.9 % upstream. COD was 5-10mg/l. Green algae were found in surface water of the khawr.

ii. Issues

(i) Use of Resources

The problem of overgrazing has been addressed in the management plan and fencing is in place. The fish are mainly marine species, which will grow in the khawr and then leave to breed in the sea when the khawr connects to the sea. At the same time more juvenile fish enter the khawr.

(ii) Recreation Facilities

Although the management plan for this khawr makes provision for visitors and picnic activities, it would be better if activities took place near the sea away from the trees. This would allow the birds using the trees to roost (e.g. night heron, little green heron) without disturbance. Previously reef herons may have used the trees to nest and they may return if disturbance is minimised. There may be scope to build a bird hide and board walk around the mangroves with the involvement of the Hilton Hotel.

iii. Proposed Management Actions

(i) Use of Resources

As stated in the management plan, when the mangroves and reeds recover, permits can be issued to allow local people to harvest fodder for livestock. This should be done through the local sheiks. Harvesting needs to be monitored. Some reeds and mangroves should be allowed to flower and set

seed each year. Leaves should only be cut from larger trees. Limited fishing can continue at the khawr using cast net.

(ii) Recreation Facilities

If facilities are needed the sea beach area is recommended. A route through the mangroves using boardwalks could be developed if disturbance to birds is minimised.

(iii) Implementing Agencies

The Directorate of Conservation at the DG of Environment (Governorate of Dhofar) should be responsible for overseeing the implementation of any actions in this Nature Reserve. If the Hilton Hotel is interested in developing a nature trail then this could be done under the supervision of DG of Nature Conservation.

(g) Khawr Saghir

i. Introduction and Site Description

(i) Introduction

The Khawr was designated as a Nature Reserve by Royal Decree 49/97 dated 28/6/97 with the Ministry of Regional Municipalities and Environment as the managing authority. The management plan aims to protect the mangrove trees while allowing controlled access for fodder collection. Sustainable fishing and the use of the area as a picnic site would also be allowed.

(ii) Existing (Natural) Conditions

The mangroves of Qurm Saghir were first fenced in 1996 to allow the trees to recover from overgrazing by camels. Floods damaged the fence, which was later repaired by 2002. In May 2002, a large cyclone produced floods and Qurm Saghir received considerable floodwater. However, the sandbar did not open to the sea and floating woody debris clogged the water, lowering the salinity and depleting the oxygen. This has now been cleared by bulldozer with some reshaping of the lower end to accommodate the planting of seedlings.

Plants

Some of the young mangrove trees were killed by the sudden change in salinity and oxygen levels and suffered from collapse of the sandy banks. The larger mangroves however looked very healthy with lush new growth and many of the smaller mangroves had recovered by July. Generally the plants on the edges of the khawr have benefited from the floodwater and reduced grazing. Submerged aquatic plants were absent in January 2003 but after clearing of the flood debris, clumps of *Potamogeton pectinatus* had appeared by July 2003. The grass and reeds (*Sporobolus virginicus* and *Phragmites australis*) showed

excellent growth particularly along the drainage channels at the landward side of the mangroves. The vegetation of the drier sandy banks comprised the normal plant association for this zone (*Suaeda vermiculata, Cyperus conglomeratus, Urochondra setulosa, Aeluropus lagopoides, Sporobolus spicatus, Cressa cretica, Heliotropium fartakense*).

There is some scope for planting mangrove seedlings at this khawr filling the gaps between existing trees. Ideally seeds from the same khawr should be used.

Animals

A few large holes of the land crab (*Cardisoma carnifex*) were found on the landward edge of the mangroves. Burrowing shrimp holes (*Callichirus* sp) were not seen but a few holes of ghost crabs (Ocypode) were present. Numerous amphipods were found among the debris near the sandbar in January. Damsel and dragonflies represented a freshwater element. No fish were seen. Birds recorded were 1 moorhen, 1 common sandpiper, 3 sand plover and 1 grey wagtail.

(iii) Water Quality and Soil Condition

Small-scale Khawr (Qurm) Saghir lies on the flat plain located west of Hilton Hotel in the western part of Salalah. The khawr is cut off by a short sandbar from the sea. The vegetation of *Avicennia marina* covers the inner khawr. Some young vegetation was seen on both sides midway along the khawr but most of these plants were in poor condition. Soil of this khawr is basically sand. Shallow (less than 10cm), silty and humic soil layers on sandy soils are found at the inner khawr where they are covered by vegetation. Shores are eroded and micro-topographically steep.

Salinity of surface water in khawr is 1.6 % at mouth and 1.1 % at inner side. COD is very high with 50-100mg/l. DO at mouth is less than 1mg/l and 1.75mg/l at inner khawr. There was a strong smell from surface water with floating debris. The surface of the khawr was almost covered by floating material including wood, leaves and rubbish, which was carried in during floods last spring.

ii. Issues

(i) Use of Resources

The problem of overgrazing has been addressed in the management plan and fencing is in place. The fish are mainly marine species, which will grow in the khawr and then leave to breed in the sea when the khawr connects to the sea. At the same time more juvenile fish enter the khawr.

(ii) Recreation Facilities

Although the management plan for this khawr makes provision for visitors and picnic activities, it would be better if they took place near the sea away from the trees. This would allow the birds using the trees to roost (e.g night heron, little green heron) without disturbance. Previously reef herons may have used the trees to nest and they may return if disturbance is minimised.

iii. Proposed Programme/Management Actions

(i) Use of Resources

As stated in the management plan, when the mangroves and reeds recover, permits can be issued to allow local people to harvest fodder for livestock. This needs to be monitored and leaves from young trees should not be cut. Limited fishing can continue at the khawr using cast nets.

(ii) Recreation Facilities

The mangrove at Khawr Saghir serves for the recreation of tourists, because it is located next to the Hilton Hotel. The manager of this hotel has intention to manage the mangrove area, if local government allows the hotel to use this area. A resthouse or coffee shop is recommended at eastern area next to Hilton Hotel at Khawr Saghir.

(iii) Implementing Agencies

The Directorate of Conservation at the DG of Environment (Governorate of Dhofar) should be responsible for overseeing the implementation of any actions in this Nature Reserve.

6. Qurm Environmental Information Centre (QEIC) Development Plan

1. Introduction

1.1 Background of the QEIC Development Project

Economic development and conservation of the natural environment and cultural/ historical heritage is one of the national development goals stated clearly in the National Development Plan. The Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR) has made efforts to conserve the natural environment their natural environment conservation. Mangrove forests in Oman have been recognised as an important environmental resource, and major mangrove forests located in the country have been designated as protected areas.

The Government of Japan (GOJ) through the Japan International Cooperation Agency (JICA) dispatched an expert for mangrove afforestation to the MRMEWR in April 2000, and the afforestation of *Avicennia marina* and technical transfer to Omani staff has been implemented. To manage mangrove forests, therefore, the Government of Oman (GOO) also requested technical co-operation from the GOJ. JICA also dispatched a study team for "The Master Plan Study on Restoration, Conservation and Management of Mangrove in the Sultanate of Oman" in June 2002. The Study is being carried out, and it will be finalised in August 2004.

The study recommended that conservation of the natural environment as well as restoration or plantation of mangrove areas should be implemented at various levels of administration, organisations and people of Oman. Participation and co-ordination of all relevant agencies and people are most important for the effective conservation activities. In these circumstances, the establishment of the **Qurm Environmental Information Centre (QEIC)** ("Qurm" means "Mangrove" in Arabic), that is intended by the Ministry, will provide the opportunity to co-ordinate activities at all levels of people and organisations. It should be noted that the MRMEWR of Oman will be a secretariat of mangroves for the Regional Organisation for the Protection of the Marine Environment (ROPME), of which the eight member states are Oman, UAE, Qatar, Bahrain, Saudi Arabia, Kuwait, Iran and Iraq.

The Government of Oman has also requested technical co-operation on Implementation of the QEIC project from the Government of Japan in August 2003. At the same time GOO has arranged the budget for the construction of the QEIC, and started the necessary actions for the implementation of the Project.

The JICA study team has carried out a feasibility study for the QEIC project at the request of the MRMEWR. The study result was compiled and submitted to the MRMEWR in January 2004. This report has been compiled based on that study and is a supporting document for the "Application for Japan's Technical Co-operation" submitted in August 2003.

The following are fields of Technical assistance requested to GOJ by the MRMEWR:

- Management of the QEIC
- Environmental monitoring and data management/analysis
- Training and educational programmes on mangrove ecosystem conservation
- Public awareness programmes and public relations for mangrove conservation

All of the above include preparation of manuals and materials together with the QEIC staff training.

1.2 Location of the QEIC Site

The ministry proposed to implement the QEIC development project and locate the QEIC at Khawr Qurm, designated as a Nature Reserve shown in Figure A6.1, and one of the most popular recreational areas in Muscat. The area of the proposed site of Khawr Qurm covers 100 hectares, of which 60 hectares are already covered by mangrove forest. In addition to that, the Muscat Municipality is implementing recreational development along the Muscat area coast. The site is an ideal location for the QEIC, because of the accessibility and surrounding environment.

Figure A6.1 Location of Qurm Nature Reserve in Muscat

2. Objective of the QEIC Development Project

Mangrove forests in Oman provide economic, cultural and social benefit to the people of Oman as well as visitors to the country. Nature Conservation is one of the most significant national issues and mangroves are symbolic coastal ecosystems. To establish real and sustainable protection and management of mangrove ecosystems in Oman is the primary objective of establishment of the QEIC.

The formulation of various forms of network, such as exchange of personnel and knowledge with international and domestic organisations regarding mangrove ecosystem conservation and other ecological activities, is a key to QEIC's management and operation. Adequate network enhances both overall goals of the project and sustainability after the completion of the project. In other words, network is described as an "engine" for a long-term development of human resources and physical infrastructures.

In order to develop the network, the QEIC should actively seek close relationships with associations and organisations related to environmental, ecological or mangrove ecosystem conservation and their affiliate members, who are International and domestic environmental NGOs, mangrove-related research agencies and eco-conscious private enterprises, for instance. Opening a website, exchanging relevant knowledge and personnel with its affiliates, publishing the QEIC periodicals to the public, establishing a mangrove foundation or society, hosting both domestic and international mangrove conferences on a regular basis, and so on should be considered as means of network building. To be recognised as a prominent member of international mangrove-related society is one of the most important elements to manage the QEIC sustainably, given that publicity boosts up the motivation of the QEIC staffs and its attraction for financial and technical affiliates. The QEIC, accordingly, needs to function as a window for exchanging any assistance and support to and from outside for a co-ordinated mangrove ecosystem conservation. These arrangements will lead the QEIC to more active and spontaneous management of mangrove ecosystem conservation

The QEIC will carry out the following activities:

(1) Establish an information and monitoring centre to collect and compile necessary information and data concerning conservation and management of the mangrove forests in Oman, including information on natural and socio-economic conditions of designated mangrove forest areas, as this is the most fundamental activity for the conservation management of the mangrove forest.

(2) Management of mangroves in an artificial pond, which is part of the plan for the QEIC site, and the management of mangrove and facilities in the Qurm Nature Reserve.

(3) Co-operate with or assist the people who study and investigate mangroves and the coastal environment of Oman. To provide basic equipment and facilities for environmental studies or field surveys of mangrove forest and other coastal ecosystems by researchers, students as well as ordinary citizens who are interested in the conservation of mangroves and nature, is an effective way of upgrading the data and information of the QEIC. This will contribute to pubic awareness through understanding of the mangrove environment by people in Oman as well as by foreign visitors. Advanced research and investigation will not normally be implemented in QEIC, but will be carried out at academic organisations or research institutes.

(4) Provide necessary facilities and materials for implementation of public awareness and educational programme on mangrove and coastal environments for school children as well as residents and visitors, tourists. Public awareness is the key for conservation activities. It is impossible to conserve mangrove forests without public understanding and co-operation, and

(5) Training and education of personnel engaged in the activities, concerning mangrove ecosystem conservation. Staff training and education is important to widen conservation activities in Oman. Personnel engaged in coastal environmental conservation should have the opportunity to have training courses relating to mangrove forests. Various levels of training courses should be provided.

3. Institutional Arrangement of Related Organisations

3.1 MRMEWR (Head Office, Branch Offices, Required Organisation)

For the implementation of the Mangrove Ecosystem Restoration, Conservation and Management Plan, it is necessary to make an institutional arrangement in the MRMEWR (Head office, Branch offices and other organisational levels). The Marine Pollution and Coastal Zone Management Section, hereinafter MPCZM, in the MRMEWR, which is the main governmental body in charge of the mangrove ecosystem conservation/ management, should continuously play a leading role. The QEIC will have many activities and should have enough authority and capability to perform its responsibilities by holding a key position in the MRMEWR. The QEIC could be part of MPCZM section of the Directorate General of Environmental Affairs, MRMEWR (Figure A6.2).

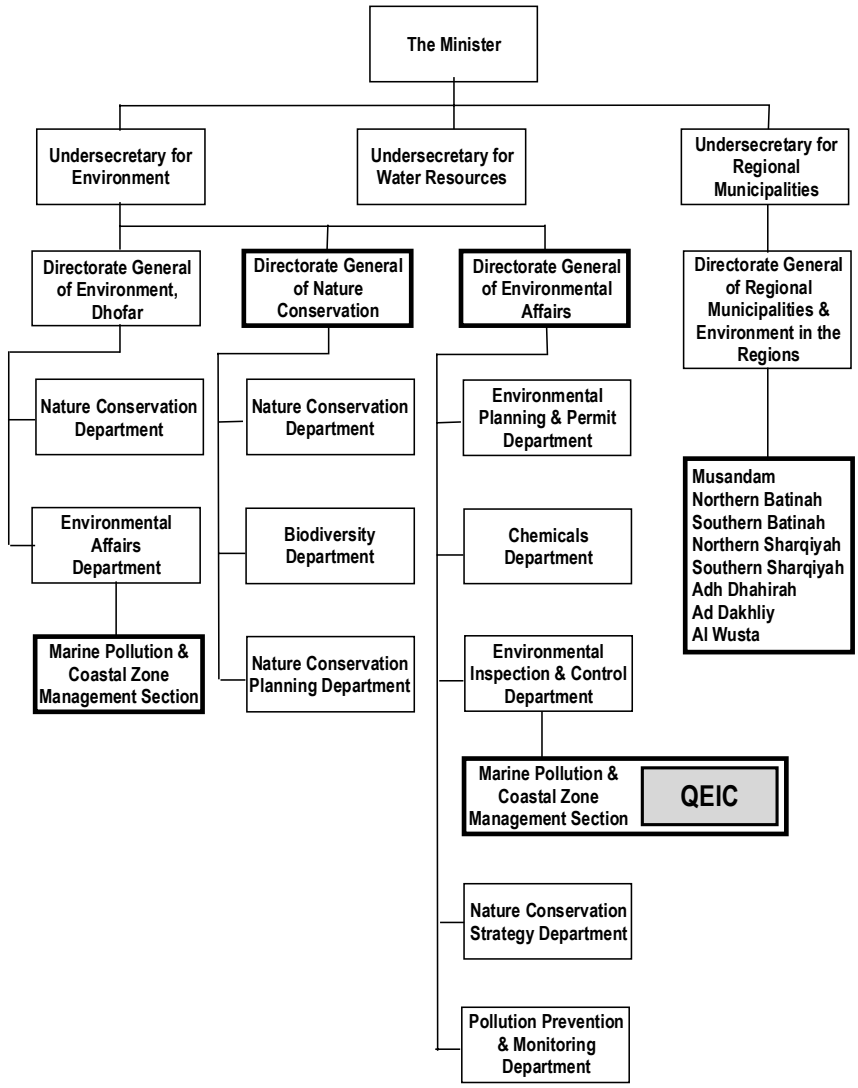


Figure A6.2 Arrangement of Organisation Chart of the MRMEWR

3.2 QEIC (Implementing Organisation)

The organisation of the QEIC will be as follows:

Name of Organisation: The Qurm Environmental Information Centre (**QEIC**)

Management Body: Directorate General of Environmental Affairs, MRMEWR

Sections in the QEIC: The following functional sections to be established,

- Monitoring and Information
- Training and Education
- Mangrove Plantation (experimental field operation and maintenance)
- Exhibition/ Public Relations

Personnel: The following personnel to be assigned,

- Director (one manager of the QEIC)
- Clerical staff (2 persons)
- Section Heads (4 persons)
- Assistants (3 persons)

Total of ten persons will be allocated for operation and management.

In addition to the above, technical advisors (2 persons) will be assigned to provide assistance to the director. The QEIC organisation chart is shown in Figure A6.3.

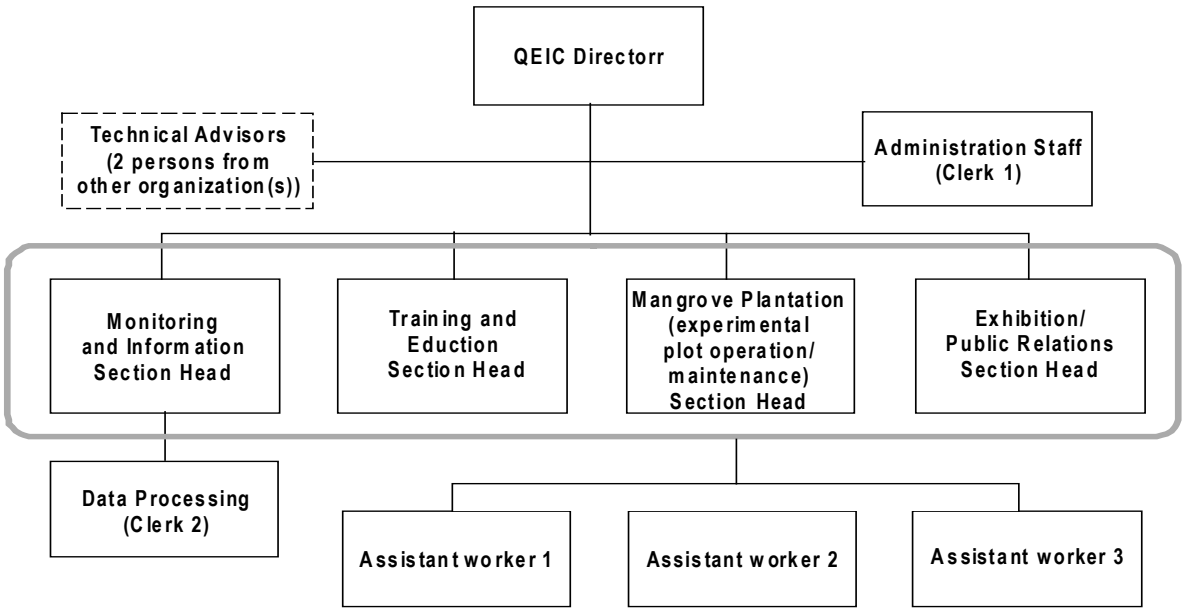


Figure A6.3 Organisation Chart of the QEIC

3.3 Activities and Sections of the QEIC

All activities should be carried out in a co-ordinated and integrated manner. Table A6.1 shows the main responsible sections and the cooperating sections relationship in QEIC.

Table A6.1 Activities of the QEIC

Section name of the QEIC / Activities	Monitoring/ Information Storing	Training and Education	Mangrove Plantation/ Experimental Field	Exhibition/ Public Relations
Regular data collection and compilation on natural and socio-economic conditions of designated mangrove areas	**Responsible Section**	Collects data as a part of educational Activities	Provides data & information	Provide materials for exhibition and Public relations
Necessary facilities, materials, personnel and services for implementation of public awareness and educational programmes	Provides data & information	Co-operates in preparation of education material	Assists and implements field activities	**Responsible Section**
Public awareness and educational programmes	Provides data & information	Co-operates in preparation of education material	Assists and implements field activities	**Responsible Section**
Planting and maintenance of mangrove in the designated sites and artificial pond to be constructed in the QEIC; Maintenance of mangrove and facilities in the Qurm Nature Reserve	Stores the information collected in database	Implements mangrove plantation training	**Responsible Section**	Prepares & maintains the experimental mangrove area at the QEIC
Necessary facilities, materials and personnel for implementation of training courses on mangrove plantation and conservation skills	Provides data & information	Co-operates in preparation of training material	**Responsible Section**	Provides materials for exhibition and public relations
Facilities and personnel for preliminary analysis and processing/ treatment of specimens for study on mangrove ecosystems	Stores the information collected in database	**Responsible Section**	Assists and implements field activities	Provides materials for exhibition and public relations
Training courses and manuals	Provides data & information	**Responsible Section**	Provides field training material	Provides materials for training & education

3.4 Relevant Agencies and Organisations:

The following agencies should be involved in the activities of the QEIC, as co-operation and co-ordination will ensure that the QEIC will achieve its objectives:

- Ministry of Education
- Sultan Qaboos University
- Ministry of Agriculture and Fisheries, including Marine Science Centre
- Ministry of Heritage and Culture

- Ministry of Commerce and Industry (Director General of Tourism)
- Diwan of Royal Court, Office of the adviser for Conservation of the Environment
- Muscat Municipality

Co-operating and supporting members should be organised for sustainable operation and management of the QEIC. A wide range of the network should be formulated in Oman as well including international members and organisations, such as

- Associations and Organisations concerning coastal environmental conservation as affiliate members, and
- Private enterprises conscious on the environment in Oman.

Oman will be a secretariat of mangrove section of Regional Organisation for the Protection of the Marine Environment (ROPME) in Gulf Co-operation Council (GCC).

4. Role and Functions of the QEIC

It is proposed that the QEIC will have the following four functional sections as described in Chapter 3.

- Monitoring and Information
- Training and Education
- Mangrove Plantation (experimental field operation and Maintenance)
- Exhibition/ Public Relations

These sections are proposed in accordance with discussions with the MRMEWR and a review of Wild Life Conservation Centres managed by the Ministry of Environment of Japan.

The following examples of Environmental/Wildlife Conservation Centres have a similar purpose and roles to those of the proposed QEIC.

The Ministry of Environment of Japan has 17 environmental information centres, which act for the Conventions on Biological Diversity, Ramsar (wetland) and World Heritage (UNESCO), and other international initiatives. Four of these centres relate to wetland and/or coastal ecosystem and work not only for ecosystem management and academic research but also public awareness, as shown in Table A6.2. There are three main activities for these information centres: Rehabilitation/ Management, Monitoring and Public Awareness.

Table A6.2 Environmental/Wildlife Conservation Centres in Japan

Names of Environmental Information Centre	Activities		
	Rehabilitation/ Management	Monitoring	Public Awareness
Kushiro-shitsugen Wildlife Centre	X	X	X
Sakata Waterfowl and Wetland Centre	-	X	X
Biwako Waterfowl and Wetland Centre	X	X	X
International Coral Reef Research and Monitoring Centre	-	X	X

In terms of Rehabilitation/ Management, Kushiro-shitsugen Wildlife Centre and Biwako Waterfowl and Wetland Centre provide medical treatment for wounded wild birds, especially rare species protected by law, and help their rehabilitation.

All centres conduct monitoring through regular field surveys on the condition of wildlife and wetlands. The International Coral Reef Research and Monitoring Centre operates a database management system and accumulates coral reef information from regular monitoring surveys.

Raising public awareness is carried out through exhibiting photos of wildlife and their survey results, and by arranging observation tours and lectures on the ecology of the areas. In addition, Sakata Waterfowl and Wetland Centre issues periodicals annually in order to announce updated status of the ecosystem, and distributes them among students in the region and visitors to the centre.

The role and functions of each section in QEIC are described below.

4.1 Monitoring and Information Section

Natural environmental information will be available to the public, government agencies and academic organisations. Monitoring and data collection, compilation and database maintenance should be carried out by the QEIC.

The compiled data and information will concern conservation and management planning of the mangrove forest, providing useful environmental information for development plans in the vicinity of the mangrove forest. Periodic and continuous observation monitoring of mangrove areas is one of the most important activities of the QEIC.

4.1.1 Monitoring Parameters

The following data and information will be collected/ monitored and compiled as a database. Geographical Information System, GIS, will be used for information management. Information targeted will be:

- Mangrove plantation,
- Fauna and flora,
- Soil and water quality, and
- Socio-economic conditions of surrounding areas

Specific sites for monitoring and data compilation will be designated as environment protected areas. The JICA Study Team has already collected data at 21 selected sites in Oman. These will be stored in a database, using GIS. This database should be expanded and updated in the future.

4.1.2 Monitoring Method

The principal method that will be applied at the QEIC is periodic observation and survey, which should be carried out by the QEIC monitoring section. In addition, it will also be considered that, as the part of training and educational programme carried out by the QEIC, data will be collected by schools visiting the site, by local government and other relevant agencies, or by the affiliate members.

Information and data collection on flora and fauna requires many persons specialized in various fields. Co-operation and support, which can be required from the following organisations or from affiliating members, should be considered.

Potential Institutions for involvement in the environmental monitoring are:

Birds:

- The Oman Birds Record Committee – maintains the database of bird records in Oman. The database is located at Sultan Qaboos University
- Directorate General of Nature Conservation of MRMEWR is a member of the Oman Birds Record Committee. Some data on Birds in wetlands in Oman are available also from the Directorate General of Environment of Dhofar.

Plants:

- Resources for the identification of plants are held at the National Herbarium, Natural History Museum, Ministry of Heritage and Culture
- Expertise on plant surveys can be found at the Biology Department, College of Science, Sultan Qaboos University
- Identification keys for the flora of Oman have just been published.

Inventories:

- Resources to aid the identification of invertebrates are held at the Natural History Museum, Ministry of Heritage and Culture
- Expertise on animal surveys can be found at the Biology Department, College of Science, and the Marine Science Department, College of Agriculture and Fisheries, Sultan Qaboos University
- Expertise is also available at the Marine Science Centre, Ministry of Agriculture & Fisheries

4.2 Training and Education

4.2.1 Objective

Human resources development for the conservation and restoration of mangroves is one of the most important issues for sustainable conservation activities. Training and education is an essential element of the QEIC. Training and educational programmes should also be provided and implemented for the staff of the QEIC in order to operate the QEIC properly. After the staff members are trained, they will work as catalysts of conservation activities in and out of the QEIC.

4.2.2 Target Groups

The target groups are the general public, especially schoolteachers, students, volunteers and other citizens.

In order to increase public awareness, the officials of local government, community leaders, school staff and students are most effective groups. Also, anybody who is involved or willing to participate in conservation activities (NGOs, universities, private companies, etc.) is welcomed and encouraged to attend the programmes. Trainees will acquire knowledge and learn techniques for mangrove ecosystem conservation through lectures and practices, which will include studying the conservation of coastal and natural environments.

4.2.3 Training and Educational Programmes Provided by the QEIC

A programme of 6 courses is proposed: 2 for Mangrove and Biology and Ecology, 3 for Mangrove Protection Techniques, and 1 for Training and Education. An outline of these courses is shown in Table A6.3.

Table A6.3 Training Provided by the QEIC

Field	Course Name	Target Trainees	Duration (days/course)	Capacity (persons/time)	Frequency (times/year) and type of training (a-d)*
Condition of Mangrove	1. Mangrove in Oman and Other Countries	- Leaders of communities - School teachers - Private sector - Students	1	30	4 a, b
	2. Significance of Mangrove Protection		1	30	2 a, b, d
Protection of Mangrove	1. Mangrove Plantation and Maintenance		1	30	4 a, b, c, d
	2. Monitoring Method		1	30	4 a, b, c, e
	3. Data Processing and Compilation		1	30	4 a, b
Training and Education	1. Methodology of Mangrove Protection		1	30	4 a, b
	2. Production of Educational Materials		1	30	4 a, b
	3. Evaluation of the Programme		1	30	4 a, b
Public Relations & Exhibition	1. Techniques of Public Relations and Exhibition		1	30	4 a, b

* a- lecture, b- exhibition, c- on-the-job training, d- field work

(1) Mangroves in Oman and Other Countries

The changes of mangrove conditions and areas in Oman will be presented from a historical perspective including changes in quality and quantity. The usage of mangrove in the locality will also be explained. Additionally, mangrove area and usage in other countries will be introduced for comparisons.

Goals:

- To understand the conditions in mangrove areas
- To understand the importance of mangrove protection
- To understand how to protect mangrove areas

(2) Significance and Methodology of Mangrove Ecosystem Conservation

The importance of the mangrove ecosystem conservation and conservation methodology will be taken into consideration in training programmes.

Goals:

- To understand the state of the environment and its problems
- To understand the legal and institutional framework in the Sultanate of Oman
- To understand the relationship between man and environment
- To understand the importance of mangrove ecosystem protection and how to protect it

(3) Mangrove Plantation and Maintenance

The technique of planting mangroves and maintaining trees and forest areas will be taken into consideration in training programmes.

Goals:

- To learn how to plant mangroves
- To learn how mangroves grow and how to maintain trees and surrounding areas

(4) Monitoring Methods

Techniques of monitoring the condition of mangrove trees, water and soil, fauna/flora and socio-economy of the area will be taken into consideration in training programmes. This training course aims at providing the trainees with the basic ideas and preliminary techniques for monitoring of mangrove and the related conditions of the area.

Goals:

- To get necessary knowledge of monitoring and quality analysis
- To get basic technique of manual sampling, to handle and evaluate quality

(5) Information and Data Handling

This course aims at offering the trainees the opportunity to learn the techniques and know-how to handle and analyse mangrove-related data and information including computer analysis.

Goals:

- To understand the state of the environment and identify damage to it
- To understand the objectives of environmental data processing
- To understand the characteristics of environmental data
- To acquire techniques for the application of statistical methods for environmental data processing
- To acquire technique to use personal computer as a tool of environmental data processing

(6) Training and Education

This course is expected to create the leaders of coastal environmental protection in communities, schools, government organisations and business societies.

Goals:

- To understand the subject to transfer to the people
- To get the technique of curriculum development
- To get the know-how of teaching and field study for effective education in mangrove ecosystem conservation

(7) Public Relations/Exhibition

These methods will increase awareness of mangrove ecosystem conservation among the community members (local residents, students, employees, etc.), government employees and foreign visitors.

Goals:

- To get know-how for effective public relations and exhibition of coastal environmental protection subjects
- To get know-how to evaluate the effects of Public Relations

4.2.4 Training Methodology

Methods to provide the above training courses are as follows:

- Lectures at the QEIC
- Exhibitions at the QEIC
- On-the-Job Training at the QEIC

- Field Work
- Seminars and Workshop at the QEIC

Seminars and workshops will be held at the QEIC in order to promote the spread of the experience on coastal environmental protection and its related areas. These seminars and workshops should be organised at local as well as national level. Additionally, there can be international ones in co-operation with relevant government agencies, foreign countries and international organisations. Seminars, workshops and symposia should occasionally be held as one of the permanent activities of the QEIC in order to promote the spread of the expertise on environmental protection. While training courses, requiring rather long periods, are set up to provide a small number of trainees with the expertise chiefly through practices such as laboratory exercises and case studies, the seminars and workshops should be short termed and provide a larger number of participants with up-to-date knowledge, ideas and strategies through lectures and discussions. Besides the regular courses, groups can participate in the courses upon their request (if the staff and facilities are available).

Field studies and experience should be the most effective way of public awareness and educational methods. This programme would be carried out in co-operation with the "Mangrove Plantation experimental field operation and Maintenance Section".

4.3 Mangrove Plantation (Experimental Plot Operation and Maintenance)

(1) Mangrove plantation

Mangrove plantation work of sites, designated as protected areas under the MRMEWR, would be carried out under supervision of the QEIC Mangrove Plantation Section. Operation and maintenance of the existing Nursery of Qurm including seed collection and growing seedlings will also be carried out by the QEIC.

Mangrove plantation carried out in the artificial pond would be an "Experimental Plot" in the QEIC.

(2) Experimental plot operation and maintenance

Maintenance of the whole area of Qurm Nature Reserve Area would be carried out. Major tasks to be implemented are:

- Seed collection in Qurm Nature Reserve
- Growing seedlings in the Nursery
- Supply seedlings to the designated planting sites
- Planting mangroves and care of existing plants in the artificial pond in the QEIC
- Provide necessary facilities for visitors coming for field studies and observations in the Qurm Nature Reserve. Trials/boardwalk, observation hides, information boards and guide signs to be provided in the reserve should be maintained.

(3) Technical assistance for mangrove plantation

Training and advice will be provided to any interested local and international agencies, organisations, groups and individuals who intend to participate in mangrove plantation and conservation activities. Manuals and guidelines will be provided for training and teaching mangrove plantation techniques.

(4) Supporting Fieldwork for training and education

Provide laboratory facilities for preliminary analysis and processing/ treatment of specimens for study and investigation for environmental education and research. A classroom for field studies for school children should also be available. Some basic equipment and tools for field survey and studies by researchers from various organisations and countries will be leased to support them.

Field studies and experience should be the most effective way of public awareness and educational methods.

4.4 Exhibition/Public Relations

Exhibition and events, lectures and presentations related to public relations and implementation of public awareness programmes will be held at the QEIC. At the same time experimental field study tours will be provided for natural environmental studies.

Co-ordination and support activities of individuals, governmental organisations and agencies, as well as private enterprises on coastal environmental conservation and pubic awareness events and programmes, will be provided. Various means of public relations as well as educational programmes will be provided targeted at all levels of visitors, not for advanced research groups.

Any activities and events relating to mangrove ecosystem conservation should be supported or co-ordinated by the QEIC. Seminars, gatherings, school tours and related activities will be organised.

The QEIC will play an important role in providing facilities and information for activities of ROPME, such as co-ordinating seminars, meetings and conferences. Information and data on technical and scientific subjects and management matters will also be compiled and made available to ROPME.

4.4.1 Exhibition

In the Exhibition hall of the QEIC, the QEIC will exhibit photos and survey results of not only Qurm Nature Reserve but also other mangrove ecosystems in Oman, which will be updated regularly by the staff of the Centre. They will show the latest condition of those areas and visitors will understand the importance of mangrove's roles in the ecosystem, which are protection against erosion and preservation of biodiversity. In addition, the exhibitions will focus on mangrove's socio-economic role, and visitors

will learn that mangrove ecosystems have not only natural functions, but also tourism and fisheries resource related functions.

4.4.2 Environmental Education

The QEIC will conduct tours for visitors not only in Qurm Nature Reserve but also in other mangrove areas. In the Qurm Nature Reserve, there will be boardwalks for visitors to walk around the mangrove swamp and observe mangroves closely, and an observation tower to see the whole mangrove area and enjoy a bird's-eye view. In addition, the QEIC will provide canoes in creeks and conduct tours to observe mangroves in areas away from boardwalks.

The QEIC will organise lectures and short films in the Training and Lecture room and Auditorium of the centre, which will orient visitors beforehand so that it will be easier for them to understand what they will observe. In the laboratory of the Centre, there will be short programmes for students to make simple experiments on mangrove ecosystem.

4.4.3 Conference Facility

Since the number of mangrove conservation studies and activities conducted in Oman is now quite considerable (and probably more than most other countries in the Gulf region), there is an opportunity for Oman to play a lead role in promoting and co-ordinating mangrove conservation on behalf of the Regional Organisation for the Protection of the Marine Environment (ROPME). It is being proposed that the MRMEWR take the necessary steps for the QEIC to become the ROPME "Lead" and Secretariat for Mangrove Conservation in the Gulf. The QEIC could also provide the office for Oman's Secretariat to the Ramsar Convention (on the Protection of Wetlands of International Importance especially as Waterfowl Habitat), as and when the Sultanate becomes a member. Regional meetings/conferences of these organisations could make use of the Lecture Hall and other facilities at the QEIC. The QEIC could also offer workshop/seminar/field excursion facilities to support International Environmental Conferences/Symposia, which are being hosted by Sultan Qaboos University.

5. Project Components

To fulfil the roles and functions stated above, the development of facilities at the QEIC is required. To realise the effective and sustainable operation and maintenance of the QEIC, staff training and financial arrangement are crucial issues. Furthermore, co-ordinated development of the facilities with Muscat Municipality is indispensable, because construction of the QEIC interacts with recreational and tourism development by the Municipality and should be implemented at the same time, to minimise the environmental impact to the site and to realise the efficient construction method.

Training and Education is another important function of the QEIC. Development of training programmes and implementation of programmes should be carried out.

This QEIC development project will provide the following types of training programmes:

- QEIC Staff training targeting those engaging in operations of the QEIC's activities
- Training and Education programmes to be developed for the general public, especially schoolteachers, students, volunteers and other citizens

5.1 Facilities Development

5.1.1 Artificial Pond and Wetland

Approximately 8 hectares of shallow artificial pond will be constructed at the Sabkah area in the Qurm Natural Reserve (QNR). The pond will function as wetland in the intertidal zone as shown in Figure A6.4. An experimental mangrove plantation will be carried out after completion of the pond. Some of the natural halophytic (Sabkha) vegetation will be preserved, since this habitat has been destroyed in nearby coastal areas and it will form part of the "natural trail" through the nature reserve, as shown in Figure A6.5.

The Muscat Municipality is planning to develop parking areas along the coastal highway that is located on the seaward side of QNR. Excavation work for the pond, land filling works at the building site and parking area, shown in Figure A6.4, should be implemented at the same time to balance the cut and fill volume of the soil to be moved, as shown in Figures A6.6 and A6.7.

5.1.2 The QEIC Building

The floor area of the QEIC building will be 1,500 sq.m, as shown in Figures A6.8 and A6.9, and the allocation of space to the designated sections, as shown in Figure A6.10, is listed in Table A6.4. Parking capacity for the QEIC will be 50 passenger vehicles and 5 buses, as shown in Figure A6.8.

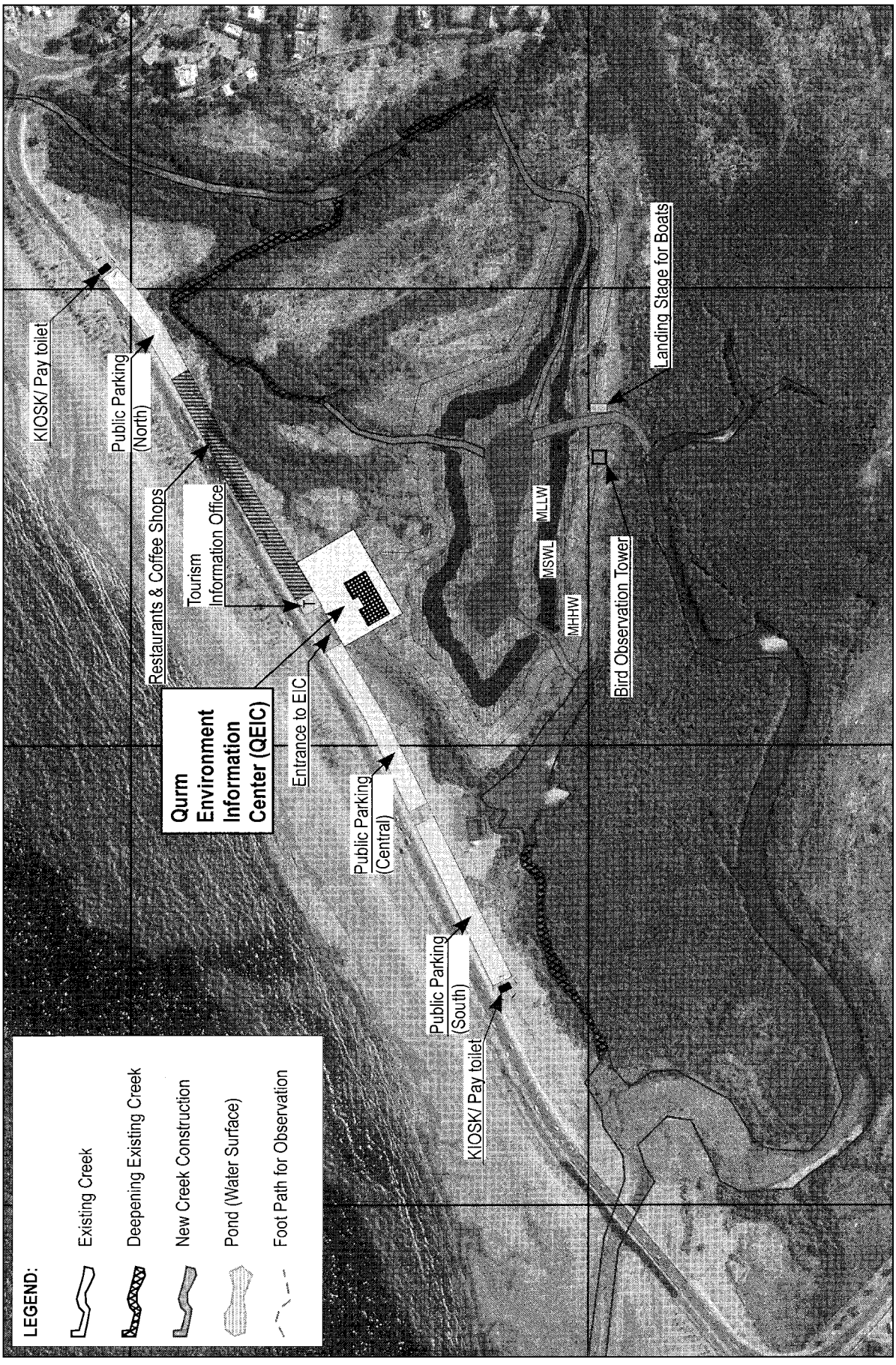
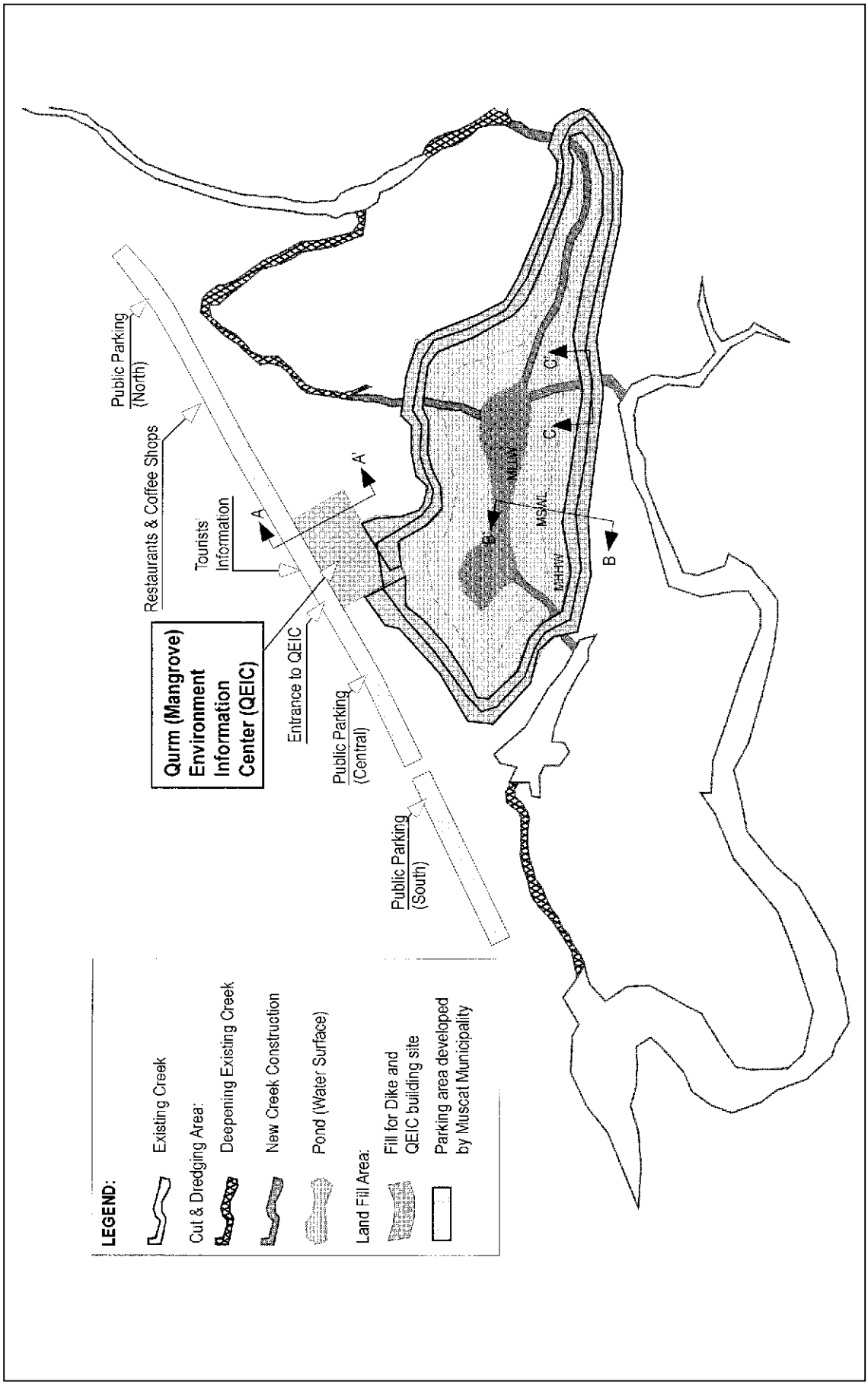


Figure A6.4 Qurm Nature Reserve Conservation and the QEIC Development (Site Plan)

Figure A6.5 Qurm Nature Reserve Conservation and the QEIC Development (Mangrove Plantation Plan)

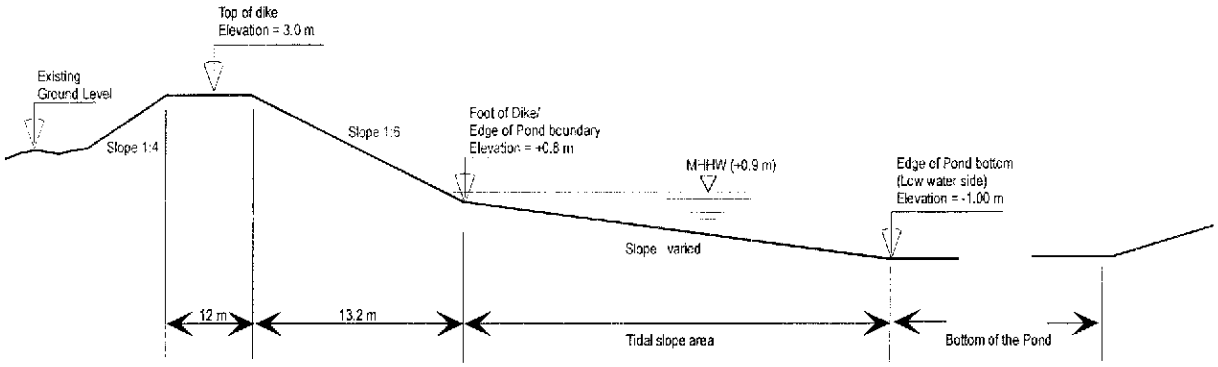


MLLW: Mean Low Low Water MSWL: Mean Sea Water Level MHHW: Mean High High Water A-A', B-B', C-C': See Sections (Figure A6.7)

Figure A6.6 Qurm Nature Reserve Conservation and the QEIC Development (Cut and Fill for Site Preparation)

Section A - A'

Section B - B'



Section C - C'

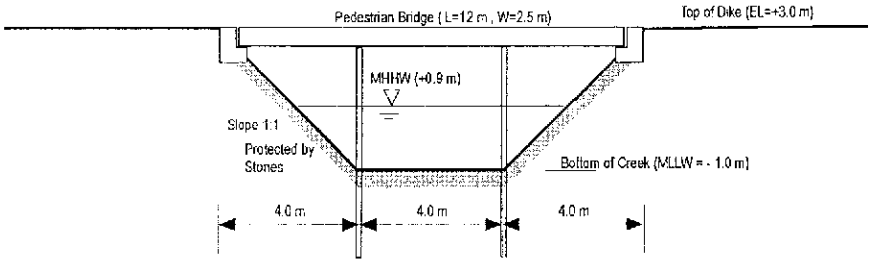


Figure A6.7 Cross Sections of the Cut and Fill for Site Preparation for the QEIC

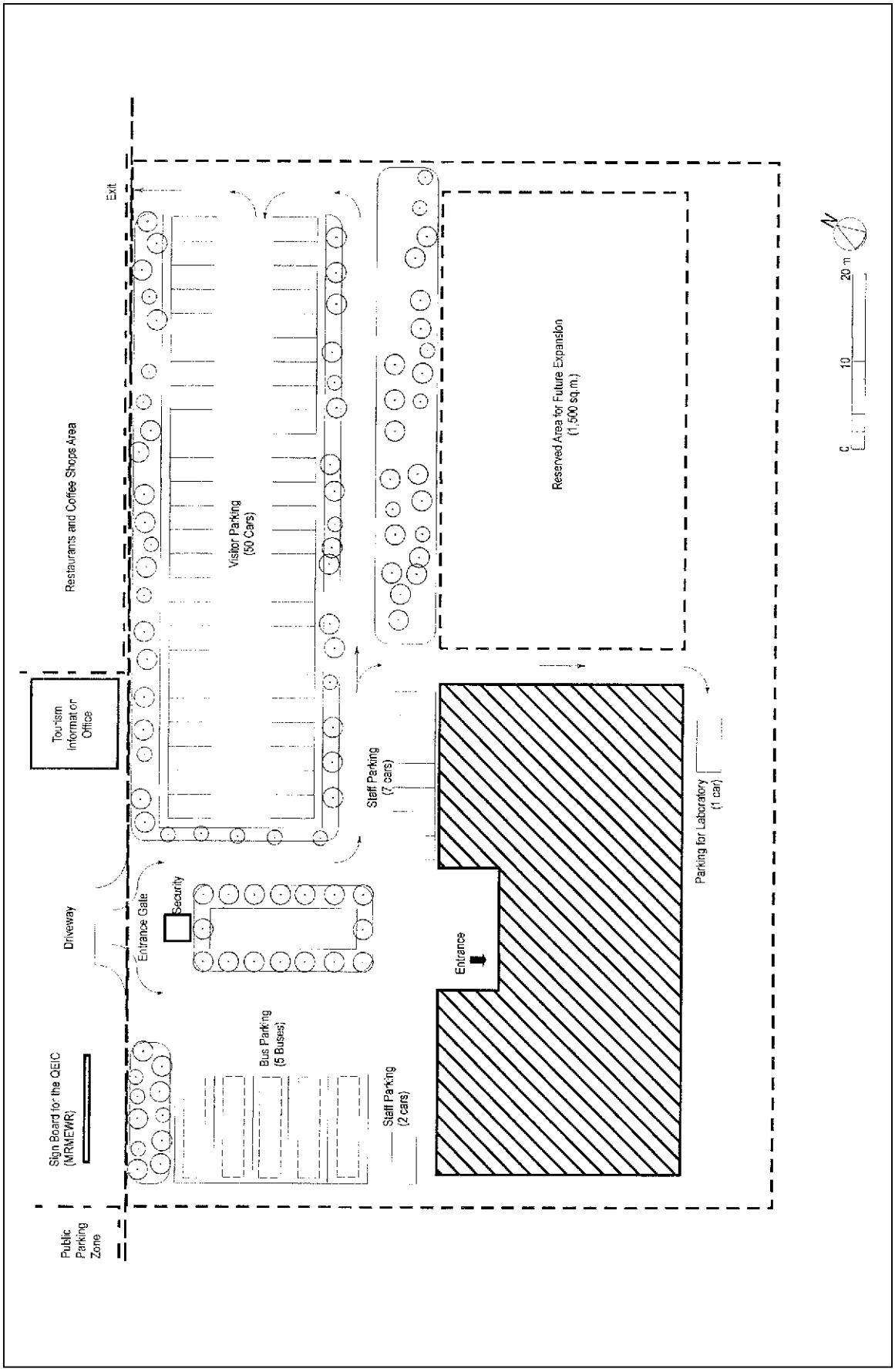


Figure A6.8 QEIC Site Plan

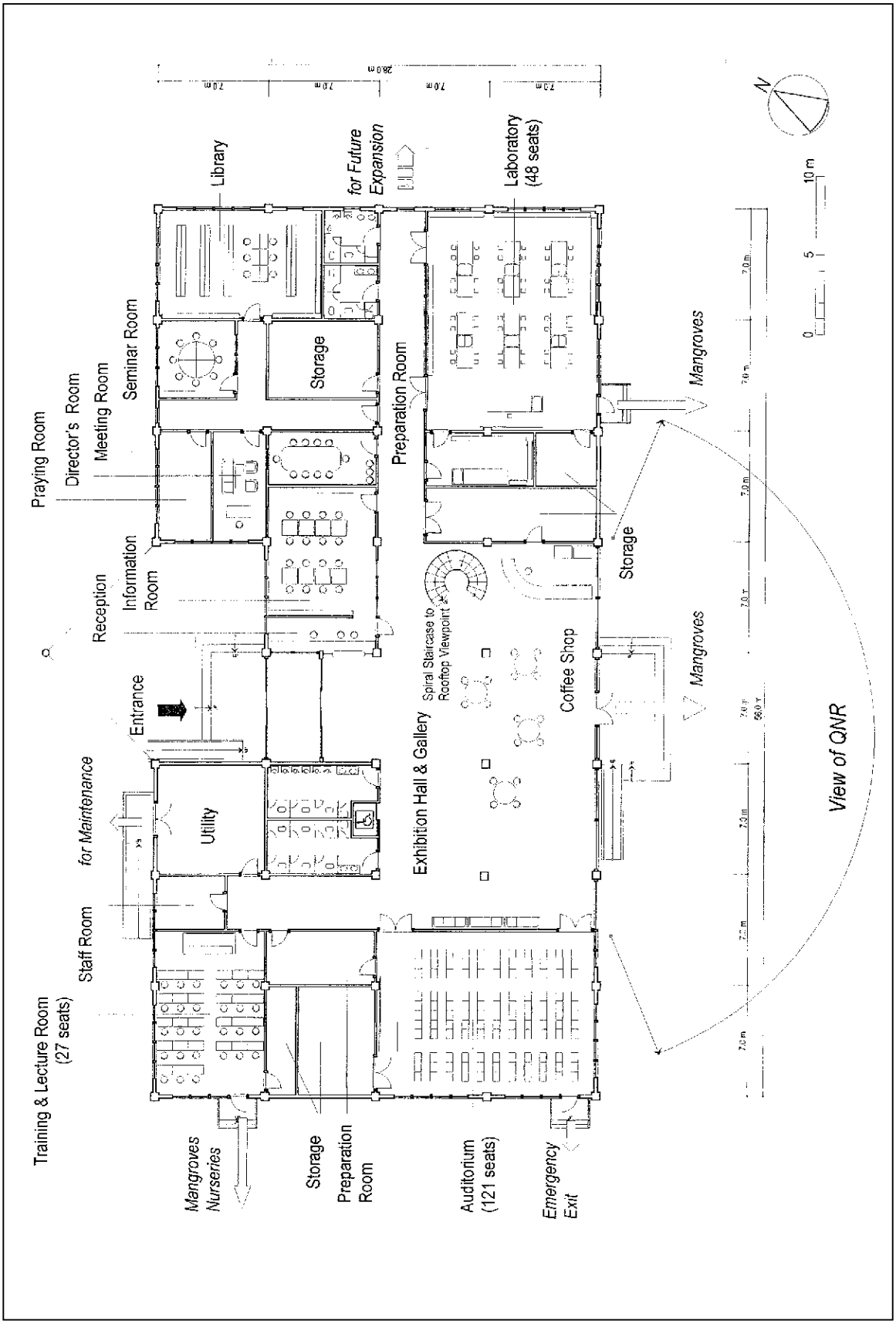
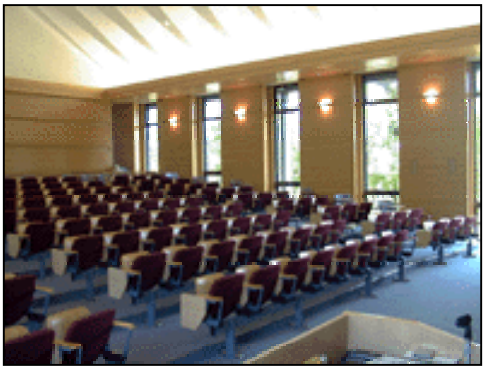


Figure A6.9 QEIC Ground Plan

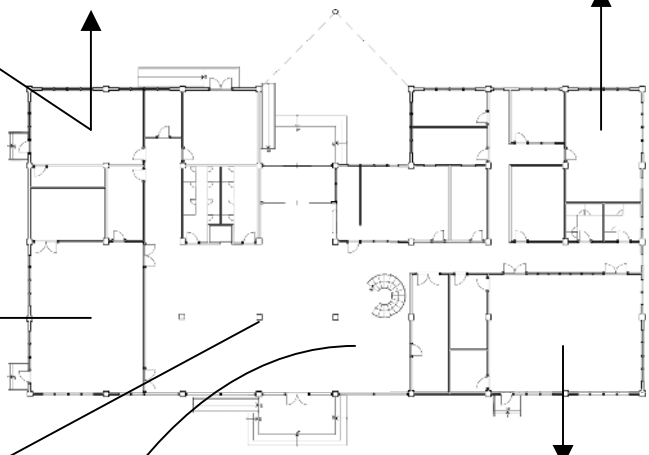
Training & Lecture Room
(for teaching)

Training & Lecture Room
(for showing films)

Library



Auditorium



Exhibition Hall & Gallery

Laboratory

Coffee shop
(facing Qurm Nature Reserve)

Figure A6.10 Reference Photos for each Room of QEIC

Table A6.4 Facility Plan of the QEIC

A Facilities

No.	Name of Zone	Area (sq.m)	Note
1	Training for Plantation	**105**	Mangrove plantation training
2	Laboratory	**195**	Laboratory for multi-purpose
3	Exhibition and Auditorium	**600**	Public awareness and public relations
4	Administration, Information room and Lib	**285**	Documents control and administration
5	Utility etc.	**315**	Excluding storage for mangrove nursery
	Total Floor Area	**1,500**	

B Room area in each zone

1	Training for Plantation		
a	Training/Lecture room	75	27 seats
b	Staff room	15	
c	Storage	15	
	Sub-total	**105**	
2	Laboratory		
a	Laboratory for Researchers/Students	155	48 seats
b	Preparation room	25	
c	Storage room	15	
	Sub-total	**195**	
3	Exhibition and Auditorium		
a	Exhibition Hall/Gallery/Foyer	350	a coffee shop included
b	Storage of Exhibition Hall/Gallery	40	
c	Auditorium	150	Lecture theater with 121 seats
d	Preparation room of Auditorium	25	
e	Storage of Auditorium	35	
	Sub-total	**600**	
4	Administration, Information room and Library		
a	Reception	15	
b	Administration office/Information room	60	
c	Meeting room for staffs	25	
d	Director's room	25	
e	Praying room for staffs	25	
f	Storage	35	
g	Library	75	
h	Seminar room	25	
	Sub-total	**285**	
5	Utility etc.		
a	Utility (air-conditioner, water etc.)	50	
b	W.C.	75	
c	Entracne and Aisles	190	
	Sub-total	**315**	

C	**Parking Area**	No. of Cars	
	For visitors	55	50 passenger cars and 5 buses
	For staffs	10	10 passenger cars

5.2 Staff Training and Educational Programme Formulation

5.2.1 Target Groups

Staff members engaged in operations of the QEIC are members of each section. Staff will learn necessary skills for administration, monitoring and data handling and training/education for mangrove ecosystem conservation, and will be responsible for public awareness.

5.2.2 Training Programme for Staff of the QEIC

Thirteen courses will be set up, comprising one for administration and operation, four for monitoring, two for data and information handling, three for training and education and three for public relations and exhibitions. An outline of these courses is shown in Table A6.5.

Table A6.5 Staff Training for the QEIC

Field	Course Name	Target Trainees	Duration (days per course)	Capacity (persons per course)	Frequency (times per year)	Goal
Administration & Operation of the QEIC	1. Administration & Operation of the Organisation	- Manager - Administrator - Section head	5	5	1	Techniques of administration and management of the QEIC
Monitoring of Mangrove Areas	1. Monitoring mangrove forests	Staff of all sections	5	7	2	Techniques of monitoring mangroves
	2. Monitoring Water & Soil	Staff of all sections	5	7	2	Techniques for monitoring water and soil
	3. Monitoring Fauna & Flora in mangrove ecosystems	Staff of all sections	5	7	2	Techniques for monitoring fauna and flora
	4. Monitoring Socio-economic Conditions at mangrove sites	Staff of all sections	5	7	2	Techniques for socio-economic survey
Handling of Data & Information	1. Planning & Implementation of Data Collection, Processing & Analysis	Staff of all sections	5	7	2	Techniques to collect data and information, to handle and process data for environmental management including analysis
	2. Mangrove Areas Conservation Planning	Staff of all sections	5	7	2	Techniques to make and evaluate plans based on collected data
Training & Education	1. Training Methodology	Staff of all sections	5	7	2	To disseminate expertise and educate people
	2. Production of Educational Materials	Staff of all section.	5	7	2	
	3. Evaluation of the programme efficiency	Staff of all sections	5	7	2	
Public Relations & Exhibition	1. Exhibition Techniques	Staff of all sections	5	7	2	
	2. Public Relations Methodology	Staff of all sections	5	7	2	
	3. Production of Materials	Staff of all sections	5	7	2	

(1) Subjects

(a) Administration and Operation of the Organisation

In order to operate and manage the QEIC as a whole, administration skills will be transferred. The trainees are mainly the manager of the QEIC and administrative staff.

Lectures:

- Administration and operation of the QEIC
- Case studies of other similar organisations
- Administration and operational practice

Goal:

- To administer and operate the QEIC

(b) Monitoring Method

Training will be provided on techniques for monitoring of conditions of mangrove ecosystems, trees, water and soil, fauna/flora and socio-economy of the area. This training course aims at providing all staff members with basic and practical techniques for monitoring mangroves ecosystems and evaluating conditions of the area. The trainees who finish this course are expected to be able to carry out analysis by themselves and also to instruct and supervise local organisations. Advanced monitoring courses might be provided to trainees who have mastered basic techniques for monitoring with advanced techniques if necessary.

Lectures:

- State of mangrove ecosystems
- Legal and institutional framework for mangrove ecosystem protection
- Analytical method for water, soils, mangrove and socio-economic conditions
- Flora and fauna identification and assessment
- Interpretation of data
- Effect of damages of mangrove ecosystems on the society
- Damaging effects of society on mangrove ecosystems

Practicals:

- Water and soil sampling
- Analysis of standard samples
- Planning monitoring
- Using field equipment
- Monitoring mangrove, water, soil and socio-economic conditions

- Flora and fauna identification (field trip, planning-sampling-analysis-data interpretation-evaluation)
- Calibration and maintenance of equipment
- Field case study of water and soil analysis and socio-economic survey (planning-sampling-analysis-data interpretation-evaluation)

Goals:

- Monitoring and quality analysis
- Sampling, handling and evaluating the quality of the data

(c) Information and Data Handling

Not only data collection skills will be transferred but also data handling and analysis. The formation of appropriate coastal environmental conservation policies and measures depend to some degree upon the reliable and well processed and analysed data. Also, necessary information for mangrove ecosystem conservation should be collected and analysed in order to provide a reliable basis for mangrove management. Therefore, this course aims at offering the QEIC's staff the opportunity to learn data analysis.

Lectures:

- Objective of environmental data processing and information collection
- Accuracy of environmental data
- Statistical analysis
- Statistical analysis of environmental data
- Computer programming

Practicals:

- Data handling (to order raw data and make tables and figures)
- Data analysis (basic statistics)
- Programming (to make an introductory programme)
- Computer analysis

Goals:

- To understand the state of environmental damages
- To understand the objectives of environmental data processing
- To understand the characteristics of environmental data
- To learn basic statistics
- To apply statistics to environmental data
- To use personal computers as a tool of environmental data processing

(d) Conservation Planning

Training will be provided on methods to formulate conservation plans. In this course, those who are responsible for planning, management or supervision of mangrove ecosystem conservation work will be educated and trained to be skilful planners and managers.

Goals:

- To develop necessary know-how to evaluate, revise and improve existing conservation plans and activities
- To be able to prepare an appropriate and comprehensive plan

(e) Training and Education

The staff trained through this course is expected to carry out a more intensive and systematic training to create the leaders of mangrove ecosystem protection in governmental offices, communities, schools and business societies.

Lectures:

- Environmental training and education for mangrove ecosystem conservation
- Field activities for mangrove ecosystem conservation
- Evaluation of training and education

Practicals:

- To make textbooks, leaflets and audiovisuals
- To use the above produced materials
- To hold field activities for mangrove ecosystem conservation
- To try to find out better ways of education and training through discussion on trainees experiences

Goals:

- To understand the subject to transfer to the visitors and people in general
- To get the know-how of teaching and field studies for effective education of mangrove ecosystem conservation

(f) Public Relations and Exhibitions

The method of public relations and exhibitions aims at creating and increasing awareness of mangrove ecosystem conservation and coastal zone management among the visitors of the QEIC.

Lectures:

- Objectives of public relations and exhibits for mangrove ecosystem protection
- Approaches of public relations and exhibitions
- Evaluation of public relations and exhibitions

Practicals:

- To find out appropriate solutions through group dynamics on the problems which trainees experienced in the process of implementation of the environmental policy, and forward possible measures
- To find out effective ways of public relations through the making of educational materials such as leaflets, through which trainees try to let the public know the importance of mangrove ecosystem protection

Goals:

- To get the know-how for effective public relations and exhibition for coastal environmental protection
- To get the know-how to evaluate the effects of public relations

(2) Training Methodology

Methods to provide the above training courses are as follows.

- Lectures at the QEIC
- Exhibitions at the QEIC
- On-the-Job Training at the QEIC
- Field Works
- Seminars and Workshops at the QEIC

(3) Materials to be used

- Textbooks
- Leaflets
- Audiovisuals (videos, photos, slides, etc.)
- Live and/or preserved specimens
- Equipment for planting and monitoring
- Computers
- Specific software for statistical analysis

5.2.3 JICA Experts to Provide Staff Training

(1) Japanese experts necessary for training and educational development

Experts from Japan are expected to play the following roles:

(a) To train staff members of the QEIC in charge of training/education and PR/exhibition to be self-motivated trainers and public relation promoters,

(b) To develop training and PR materials such as textbooks, leaflets and videos in co-operation with staff members of the QEIC,

(c) To run training courses together with staff members of the QEIC, and

(d) To transfer the administrative and technological experiences of Japan in the field of coastal environmental protection through the activities mentioned above.

Staffs of environmental NGOs, schoolteachers and consultants in the field of natural science are expected to be dispatched from Japan for this purpose. Details of the field of JICA experts are shown in Table A6.6.

Table A6.6 Experts to be Dispatched for Supporting QEIC

Field	Role
1. Project Manager/Institutional Management	- To supervise and co-ordinate the whole project and to teach institutional management (Expert should have wide knowledge and long-term experience in organisational operation and management.)
2. Monitoring	- To train and advise techniques of monitoring (Expert should have advanced monitoring technique of water and soil as well as long-term experience in monitoring and data processing.)
3. Computer Analysis and Data Handling	- To train and advise how to analyse the collected data in computer and data/information handling Expert should have advanced technique of data processing and analysis in computer.)
4. Training and Education	- To train and advise how to prepare the training and educational programmes, materials and methodology (Expert should have wide knowledge of environmental education and long-term experience in training and education.)
5. Public Relations and Exhibition	- To train and advise how to arrange the exhibition and public relations programme and materials (Expert should have wide knowledge of public relations and exhibition technique.)

(2) Training Methodology

JICA experts should be engaged in training activities through which Japanese technology in each field would be transferred to the Oman trainers. Then, Omani trainers will be qualified as self-reliant trainers. The training staff of the QEIC should initially work under guidance of JICA experts.

The programmes for education and training, textbooks and guidebooks for training courses should be developed and prepared in advance. For this, Japanese and other international administrative and technological experiences should be modified to fit the natural, social and economic conditions in Oman.

6. Implementation Schedule

6.1 Development Schedule

Development of the QEIC will be co-ordinated and integrated with relevant organisations and agencies as shown in Table A6.7. Agencies to be involved in the projects are the following:

- MRMEWR: formulation of the QEIC management plan, earthwork, pond and mangrove ecosystem development, the QEIC building phase-1 & phase-2, staff training of the QEIC
- Muscat Municipality: parking area development, commercial development
- Tourism department of Ministry of Commerce & Industry: tourist information office, promotion of private investors for restaurants and coffee shops

Table A6.7 The QEIC Development Schedule proposed by JICA Study Team

No.	Objectives	Years																			
		1				2				3				4				5			
	Quarters	I	ii	iii	iv	I	ii	iii	iv	I	ii	iii	iv	I	ii	iii	iv	I	ii	iii	iv
A.	**Planning and Design (MRMEWR & international assistance)**																				
1	Design and Tender Document for preparation of QEIC	■	■	■	■																
2	Formulation of QEIC Operation Plan & Training Program	▤	▤	▤	▤	▤	▤	▤	▤												
3	Training of QEIC staff					▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤	▤				
B.	**Construction of QEIC - (MRMEWR & Omani Contractors)**																				
1	Site preparation (excavation works)					■	■	■	■												
2	Pond construction							■	■	■	■	■	■								
3	QEIC buiding construction							■	■	■	■	■	■								
4	Mangrove plantation									■	■	■	■	▥	▥	▥	▥	▥	▥	▥	▥
										planting work to be done as a part of Operation & Maintenance											
C.	Operation of QEIC including Maintenance of the all facilities											■	■	■	■	■	■	■	■	■	■

■ : Responsible Ministry/Municipality

▤ : International Aid and/or Assistance

▥ : Responsible Ministry/Municipality and Supporting Organization/Members

6.2 Cost Estimation

The development cost is estimated in line with the development stages mentioned above.

- Planning and design of the QEIC
- Construction of the QEIC
- Training and education programme formulation
- Operation and Maintenance of the QEIC
- Construction works to be carried out by others

6.2.1 Planning and Design of the QEIC

Costs include design work of the QEIC, operation plan formulation and training of the staff of the QEIC, and the following conditions are also considered:

- The Architect/ Engineer at Omani side will carry out design and tender document preparation of the QEIC. It is also possible to apply a design and construction contract package.
- QEIC operation plan will include administration/ institution management plan, the mangrove-monitoring plan, and data/ information processing plan in conjunction with mangrove ecosystem conservation and restoration planning. Laboratory operations management, public awareness and educational programmes should be formulated. The training programme of visitors of the QEIC should be prepared. This can be carried out by foreign assistance such as Japan International Cooperation Agency (JICA) or other international co-operation agencies.
- QEIC staff should be trained prior to the start of QEIC operation. Material for the QEIC staff training and programme should be prepared. Purchasing equipment for the QEIC operation such as monitoring, data processing and Laboratory operations should be carried out.

6.2.2 Construction Cost of the QEIC

This is direct investment cost for the QEIC buildings and related facilities, which is a responsibility of the MRMEWR. The cost includes the following:

- Site preparation, which is mainly earthwork of excavation of pond and creek, and filling work of the QEIC building site, dyke for pond and parking development area
- Pond construction that include grading of the pond and levelling of the pond bed and creek bed. Construction of footpath with necessary pedestrian bridges and boat riding decks as well as signs and information boards along the footpath.

- The QEIC building construction includes necessary utilities and accessories such as staff parking and visitor parking.

6.2.3 Training and Education

(1) QEIC Staff Training

Training schedule of the QEIC staff and Training to be provided by the QEIC is shown in Table A6.8. Basically, QEIC staff should be trained at the stage of the "Formulation of the QEIC Operation and Training Programme" of the QEIC Development Schedule. Staff will be trained continuously along with other staff training 2 and 3 until the middle of the 4th year. Training 2 focuses on other environmental staff of the MRMEWR such as Nature Conservation Department and 3 Governorate Offices (Muscat, Dhofar and Musandam) in order to back up QEIC activities. This training will start in the 2nd year. Training 3 is for environmental staff in regional and wilayat offices starting in the 3rd year, when most QEIC staff will be already trained and with the help of foreign assistants could form local experts.

Table A6.8 Training Programme and Implementation Schedule

Work Item	Years																			
	1				2				3				4				5			
Quarter	i	ii	iii	iv	i	ii	iii	iv	i	ii	iii	iv	i	ii	iii	iv	i	ii	iii	iv
A. Staff Training																				
1. Training of QEIC Staff			■	■	■	■	■	■	■	■	■	■	■	■						
2. Training of MRMEWR (Central and 3 Governorate Levels)							■	■	■	■										
3. Training of Staff in charge of Environment in Regional and Wilayat Levels											■	■	■	■						
B. Training to be provided by QEIC																				
1. Training for Environment-related Ministries and their Local Offices													■	■	■	■	■	■	■	■
2. Training for School Teachers													■	■	■	■	■	■	■	■
3. Training for Private Sector													■	■	■	■	■	■	■	■
4. Training for School Children																	■	■	■	■

Training courses to be implemented for staff training are summarised in Table A6.9.

Table A6.9 Training Courses to be Carried Out at QEIC

Training Course	Target Group	No. of Trainees (ind.)
1. The QEIC Operation and Management	- Staff of the QEIC (excluding 3 assistant workers)	**7**
2. Strengthening of Capacity at Central and Governorate Levels	- Staff in charge of environment in central MRMEWR and offices of Muscat, Dhofar and Musandam Governorates	- Central MRMEWR: 10 - 3 Governorate offices: 3 x 3=9 **Total 19**
3. Capacity Building at Regional and Wilayat Levels	- Staff in charge of environment in regional and wilayat offices	- 5 regions x 2=10 - 59 wilayats x 2=118 **Total 128**

(2) Training and Education Programme Formulation

Training to be provided by the QEIC consists of four components, that is, for staff working at ministries and local offices, on environment-related subjects, schoolteachers, private sector and interested students. Teachers in all schools in Oman are expected to be trained at QEIC over the period of 10 years. Selected schools will be targeted every year. Schools are selected from each wilayat of Muscat Governorate every year and those numbers will escalate from year to year. Finally, a total of 6,000 students will be expected to attend the training courses at the QEIC over the period of 10 years. Other students can visit the QEIC with their teachers.

Training schedule and description of courses are summarised in Table A6.10.

Table A6.10 Training Courses to be Implemented at the QEIC

Training Course	Target Group	No. of Trainees per year	Remarks
1. Environmental Education for the Environment-related Governmental Agencies	- Staff of environment-related Ministries and their local offices including: *Ministry of Construction *Ministry of Transport and Communications *Ministry of Heritage and Culture *Ministry of Education *Ministry of Higher Education *Ministry of Commerce and Industry *Ministry of Agriculture and Fisheries *Ministry of Information *MRMEWR	**100 governmental officials**	- Total target trainees are 216 *Central office: 8 x 3=24 *Local office: 8 regions x 8 x 3=192 - Training will be provided once every two years
2. Environmental Education for Schoolteachers	- Schoolteachers in charge of natural science in general education	**300 teachers**	- 10-15 selected schools in each region per year - Total 3,423 teachers (1,141 schools x 3)

3. Environmental Education for the Private Sector	- Staff working for the following fields: *Construction *Media *Transportation and Tourism *Energy	**80 persons**	- 4 fields x 20=80
4. Environmental Education for Students	- Students from model schools	**300 students**	- 60 students from 5 schools each (5 wilayats of Muscat) in the 1st year - 60 students from 10 schools in Muscat Governorate in the 2nd year - Total 6,000 students over 10 years

The cost for training and education programme formulation is estimated based on the cost of foreign expatriates and related equipment required to carry out training courses.

6.2.4 Operation Cost of the QEIC

Operation and maintenance cost of the QEIC is estimated as an annual cost. This includes salaries and allowances for QEIC staff, utility usage charge, office supplies and other necessary costs for QEIC operation, such as the following:

- Administration/ management
- Monitoring
- Data processing and information compilation
- Public Relations and events
- Training and education
- Laboratory operation and maintenance

Mangrove plantation and maintenance costs are also estimated for plantation work or seedling supply for mangrove ecosystem conservation works in Oman.

Maintenance costs for the QEIC is also estimated including maintenance costs per year.

6.2.5 Cost of Activities for Relevant Agencies and Enterprises (covered by others)

The Muscat Municipality plans to develop parking areas and restaurants/ coffee shops along the highway located between the beach and Qurm Nature Reserve. The implementation of this project will enhance activities of the QEIC as well as tourism and recreational activities in the area.

Land filling is necessary to develop the parking area, and the fill material can be made from the pond excavation for the QEIC. Project implementation should be co-ordinated between parking development and the QEIC construction.

Since the surrounding area of the project site is a popular tourist site and recreational area, many tourists are expected to visit the QEIC. Establishment of a tourism promotion facility such as Tourism Information Office is proposed for the site.

The QEIC project implementation together with Parking area, restaurants and Tourism Information Office should be integrated and co-ordinated.

Table A6.10 shows the cost estimation of the QEIC.

Table A6.11 Cost Estimation of the QEIC Project (Direct Cost)

No.	Work Item	unit	quantity	unit cost (OR	direct cost (1,000 OR)	Implementation
A.	**Planning and Design of the QEIC**					
1	Design and Tender Document preparation					MRMEWR assisted by
a	Basic design and BQ preparation	M/M	18	5	90	Local consultants
b	Tendering	M/M	3	5	15	
c	contract agreement and process	M/M	3	2	6	
	Total of item A - 1		24		**111**	
2	Formulation of QEIC Operational Plan & Training Program					MRMEWR with foreign assistance
a	Administration management plan	M/M	6	10	60	
b	Monitoring and information processing plan	M/M	4	10	40	
c	Training room operation and PR planning	M/M	4	10	40	
d	Training and educational program formulation	M/M	8	10	80	
	Total of item A - 2		22		**220**	
3	Training of QEIC staff					MRMEWR with foreign assistance
a	Training material preparation	LS	1	50	50	
b	Equipments (include training room equipment)	set	1	100	100	
c	Training execution	M/M	37	10	370	
d	Training overseas	staffs	9	5	45	
	Total of item A - 3				**565**	
	TOTAL of item A				**896**	

No.	Work Item	unit	quantity	unit cost (OR)	direct cost (1,000 OR)	Implementation
B	**Construction of QEIC**					
1	Site preparation (earth work)					
a	excavation of pond and creek	cu.m	120,000	0.5	60	MRMEWR
b	filling and grading of QEIC site	cu.m	40,000	1.0	40	
c	filling and grading of dyke arround pond	cu.m	80,000	1.0	80	
	Total of item B - 1		240,000		**180**	
2	Pond construction					MRMEWR
a	grading and levelling of pond	sq.m	80000	0.1	8	
b	relevant facilities and structures	LS	1	100,000	100	
	Total of item B - 2				**108**	
3	QEIC buiding construction					
a	building construction	sq.m	1500	160	240	MRMEWR
b	utilities and appliances for building	LS	1	60,000	60	
c	parking lot and landscaping	sq.m	10000	10	100	
	Total of item B - 3				**400**	
4	Mangrove plantation					MRMEWR
a	preparation work	sq.m	40000	na	na	(caried out by O/M)
b	planting	pcs	40000	na	na	(caried out by O/M)
	Total of item B - 4					
	TOTAL of item B				**688**	

C.	**Operation of QEIC including Maintenance of all the facilities**					
1	QEIC operation (annual cost)	LS	1 year	70	70	MRMEWR
2	mangrove plantation and maintenance (annual cost)	LS	1 year	12	12	
3	maintenance of the facilities (annual cost)	LS	1 year	30	30	
	Total of item C				**112**	

Note: M/M: Man Month
LS: Lump Sum

Source: JICA Study Team

7. Financial Arrangement and Operation of the QEIC

7.1 Investment Schedule

Based on the cost estimation and project implementation schedule, the investment schedule is formulated as shown in Table A6.12. The cost indicated here is the direct cost for the project implementation. Indirect cost, such as administration costs for ministries, tax and duties and cost escalation are not included. The Schedule for other organisations is also included for reference.

The total investment cost for construction of the QEIC is O.R. 1,584 thousand for the MRMEWR including planning and design cost. The direct cost for construction of the QEIC building is O.R. 688 thousand.

Work items A-2 and A-3 of Planning and Design cost could be applied for international aid or assistance, especially for QEIC staff training.

Table A6.12 Investment Schedule of the QEIC Development Project (Direct Cost)

No.	Work Item	Direct Cost Total (1,000	Consecutive Years									
			1	2	3	4	5	6	7	8	9	10
A.	**Planning and Design**											
1	Design and Tender Document preparation (includes EIA) Formulation of QEIC	111	111									
2	Operation Plan & Training Program	220	140	80								
3	Training of QEIC staff	565	100	180	200	85						
	Total of A	**896**	**351**	**260**	**200**	**85**						
B	**Construction of QEIC**											
1	Site preparation (excavation works)	180		180								
2	Pond construction	108		108								
3	QEIC buiding construction	400		200	200							
4	Mangrove plantation											
	Total of B	**688**		**488**	**200**							
QEIC	**TOTAL of A+B**	**1,584**	**351**	**748**	**400**	**85**						
C	**Operation of QEIC including Maintenance of all facilities**	112/ year		43	70	112	112	112	112	112	112	112

Source : JICA Study Team

Note: * O/M cost required for staff training in 1st & 2nd year also.

7.2 Financial Arrangement

(1) Initial Investment by MRMEWR

Investment on (1) Planning and Design and (2) construction of the QEIC shall be financed by the MRMEWR as shown in Table A6.13. It may be possible to find some agencies willing to provide technical assistance or for formulation of the QEIC Operational Plan and Training Programme. Training of QEIC staff prior to starting operations at the QEIC probably needs foreign experts' aid or assistance including for training material preparation and equipment handling

Table A6.13 Investment by the MRMEWR in the QEIC

No.	Work Item	Direct Cost Total (1,000 OR)	Source of Finance		
			Responsible Ministry/ Municiparity	International Aid and/or Assistance	Supporting organsation or members
A.	**Planning and Design**				
1	Design and Tender Document preparation (include EIA)	111			
2	Formulation of QEIC Operation Plan & Training Programme	220			
3	Training of QEIC staff	565			
	Sub-total	**896**	111	785	na
B	**Construction of QEIC**				
1	Site preparation (earth work)	180			
2	Pond construction	108			
3	QEIC buiding construction	400			
	Sub-total	**688**	688		
	TOTAL (A+B)	**1,584**	**799**	**785**	na

(2) Operation and Management Cost of the QEIC

To operate the QEIC in a proper and sustainable way, allocation of funds annually by MRMEWR is necessary. Average annual operation and maintenance costs are estimated at O.R. 112 thousand, which would be shared by several national and international agencies, as shown in Table A6.14.

Table A6.14 Source of Funding for the QEIC

No.	Work Item	Direct Cost Total (1,000 OR)	Source of Funding				
			Responsible Ministry/ Municiparity	Foreign Aid and/or Assistance	Private organisation /enterprises	Fees & charges	Supporting organisations
C	Operation of QEIC including Maintenance of all facilities	112/ year	**O**	**X**	**X**	**X**	**X**

Source : JICA Study Team Note: The cost is tentative and rough

O : indicates investment by **X** : indicates investment by other than

8. Project Evaluation and Recommendations

8.1 Beneficiaries

One of the overall goals of this project is to provide benefits for school children and teachers, mangrove researchers and planters, and domestic and international tourists; 200,000 visitors expected in a year. In 2001, approximately 100,000 children were enrolled at schools in Muscat alone. Oman also received 145,000 visitors and this number is expected to increase since tourism is being given priority as a source of income.

The educational functions of the QEIC are to spread knowledge, skills and understanding of mangrove ecosystems to all levels of the public beyond the boarders of gender, generations and nationalities. Economically, the QEIC has a potential to contribute good returns. In an environmentally friendly way, the QEIC can contribute to the sites in role as one of the main tourism spots in Muscat, given the location of the QEIC, i.e. surrounded by many hotels, beautiful beaches and tourism attractions. Moreover, the success of mangrove protection and plantation at a number of sites in the country will bring not only economic and recreational benefits to local residents but also boost their morale.

Expected beneficiaries from the QEIC development project are the following:

- Local residents near the QEIC
- Visitors to the area (both national and international)
- School staff and students
- Government staff/officials
- Private companies
- Academic institutions
- Researchers

8.2 Impacts on Society

The direct impact of the QEIC development on society is the increase of public awareness among the people of environmental conservation and eco-tourism. The visitors to the QEIC can obtain information on coastal and natural ecosystems and become aware of the importance to preserve biodiversity and natural landscape from displays and other materials.

The QEIC will organise awareness-raising activities about nature/ environmental conservation and wise use of natural resources providing the target groups with training and education. It will serve as a stimulus to promote the value and importance of conservation of nature in Oman and of mangroves in particular. Trainees who finish the courses provided by the QEIC can play a leading role in protecting the environment in their localities, increasing the number of people who are aware of and working for

mangrove ecosystem protection. Because of the limitation of the government to manage all mangrove areas in the country, these trainees can play a leading role. The more local people can become involved in environmental protection activities, such as regular monitoring and planting, the greater will be the quality and quantity of mangrove forests, and environmental protection can be conducted in a more effective way. The public support for mangrove ecosystem and coastal protection will be strengthened when community leaders realise the importance of mangrove ecosystems through environmental education. Elementary, junior and senior school classes would also participate in environment educational programmes presented by QEIC staff as part of their school education and grow more concerned about environmental quality in the future.

This site will also function as a tourist facility. In addition to that, on mangrove forest areas with beaches, residents and visitors can enjoy the landscape. Furthermore, the accumulated data and information from regular monitoring can be utilised by researchers and university students, who can contribute to the promotion of research and studies on mangrove ecosystems and their protection in particular, and of natural ecosystems at large.

8.3 Environmental Impact Assessment

The proposed development at the QEIC will have some effect on the environment of the Qurm Nature Reserve, which is protected by law, and the surrounding area. In order to comply with Omani environmental legislation and procedures, and to determine how best to reduce the impact of the QEIC, it will be necessary to undertake an Environmental Impact Assessment (EIA) study; the study report will be attached to the Application Form for an Environmental Permit. The "scope" of the study will be agreed with the DG of Environmental Affairs and is likely to include the methods for controlling pollution (including run-off of water and soil, leading to siltation, from earthwork), for minimising destruction of natural vegetation during construction, determining the best shape and depth of the pond that will be created, identifying particularly sensitive areas which can be studied by researchers but should not be open to the general public etc.

The EIA should also include an outline of Construction Environmental Management Plan (CEMP) that should be finalised at the Detail Design (DD) phase, prior to construction of the QEIC. The CEMP will show not only the implementation schedule of mitigation measures indicated in the EIA, but also the inspection/ monitoring system that will be put in place during the construction period. It is recommended that JICA, the MRMEWR, Consulting Engineer or Contractor assign one of their staff to be an "Environmental Manager", on a part-time basis, to brief/ train the workforce and check that they are complying with the CEMP. Therefore, the CEMP would ensure that the building contractor's activities, especially earthmoving, will be carefully planned/supervised, and will cause neither unplanned damage to the soil, vegetation and wildlife of the site, nor pollution of surface water or groundwater.

It is also recommended that Royal Decree No. 75/38, which declared Khawr Qurm a Nature Reserve, is updated in due course by a new Royal Decree. The new Royal Decree will clarify the boundary and that MRMEWR is the legal owner and manager of the Nature Reserve. The Royal Decree will require that a Management Plan is prepared for the whole Nature Reserve; this management plan can be prepared by the JICA Experts in co-operation with the MRMEWR.

8.4 Overall Evaluation and Recommendations

Conservation of natural environment as well as restoration through the plantation of mangrove areas should be implemented at various levels of administration, organisation and people of Oman. Participation and co-ordination of all relevant agencies and people are most important for effective conservation activities. The QEIC can provide the opportunity to co-ordinate activities at all levels of people and organisations. This is the best way to establish the QEIC, where the necessary knowledge, experiences and techniques should be systematically transferred for the benefit of all people and of the natural environment.

Also, the accumulation of reliable monitoring data related to mangrove areas will allow evaluation of present mangrove ecosystem conservation policies, which may be improved.

Monitoring techniques provided to schoolteachers and students can also be utilised for environmental education in schools, which could be responsible for monitoring activities in some areas. The record of those data and manuals produced can be compiled for transferring to other GCC countries, which could apply the model. It is also suggested that the QEIC could become an information centre for coastal management in Oman. Then the QEIC would play a significant role in the environmental administration in the Sultanate of Oman.

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