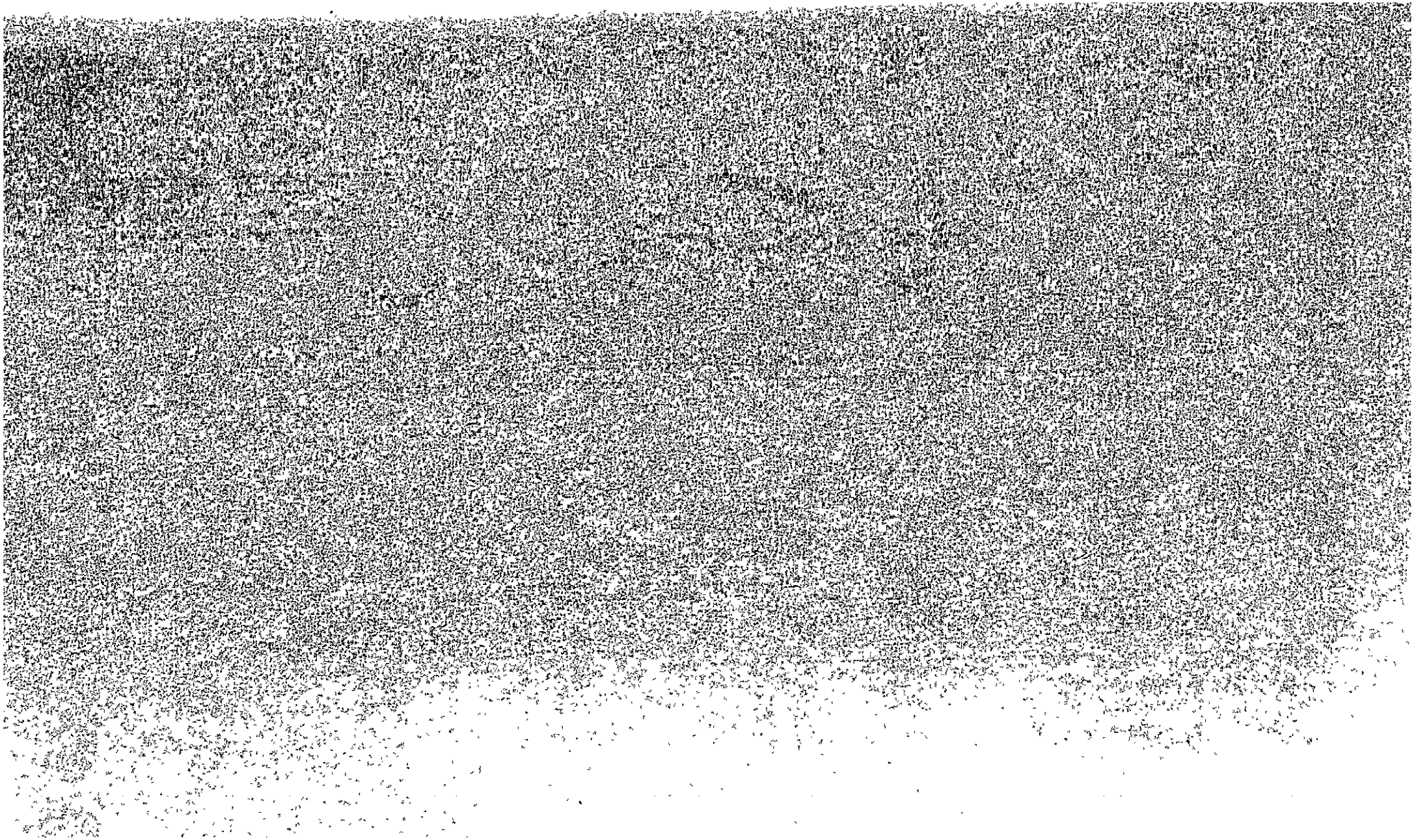
APPENDIX E. SOIL



APPENDIX E SOIL

Annex Profile Description and Laboratory Analysis Data

1. Description of Representative Soil Profiles Examined in the Project Area

2. Soil Pit Survey on Water Resources Development Project - Northern Oman (ILACO, 1975)

3. Agricultural Development Program (FMC Agr. Survey, 1975)

4. Development of New Land for Irrigated Agriculture (Soil Consultant, 1977)

E-1 Introduction

Reclamation of the waste lands for increasing agricultural production under reasonable supply of irrigation water would be a very important prerequisite for successful contribution to national food security.

Aiming at a maximum possible extension of the lands along the Sohar coastal region, the Wadi Jizzi Agricultural Development Project has been scheduled involving exploitation of the water resources and the other field surveys relevant to the Project. The soil survey has been carried out during the First Stage Study of the Project which has been extended from the end of March to the end of April, 1981.

The surveyed Area has been confined within the comparatively flat lands between the seashore and the alluvial plain below the detrital fan.

The object of the survey are as follows:

1. To conduct the soil profile observation and the field analysis of the soil samples.
2. To classify the soils into Soil Series - Soil Types with their extent in the Project Area.
3. To identify potentially most suitable lands for agricultural development by classifying their suitability under irrigation through the evaluation of soil characteristics.

No systematic soil studies had been performed of the northern Batinah in the Sultanate of Oman before 1973 when ILACO, a consultant of the Netherlands, initiated the water resources development project on the Batinah Coastal Plain in addition to the Oman Mountains and the Interior Plain.

The present study has taken special concerns with the soil salinity and the available depth because of the prevailing salinity problem and the gravelly character of the soils in Sohar Area.

The Study Team owes a debt of gratitude to both the staff of Ministry of Agriculture and Fisheries and of Agricultural Research Station, Rumais, Government of the Sultanate of Oman, for their helpful cooperation in the field investigation and data collection during the study term.

E-2 Physical Conditions of the Project Area

Sohar coastal region has a specific feature though very common to everywhere along the Batinah Coast. The feature is characterized by Wadi-dissected topography and hot and arid climate with poor vegetation. Since the detailed physical conditions of the Project Area are reported in Appendices A to D, descriptions in this chapter will be limited to the subjects especially pertaining to the soil genesis and its distribution.

2.1 Location and Geomorphology

The Project Area is situated in the north latitude from 23°50' to 26°10' and east longitude from 55°50' to 56°50' along the Batinah Coast. The Area was decided from view points of execution of soil survey effective to find better extensible lands. Within the Area the highest elevation is around 50 m, very slowly graduating down to the sea level with a slope of less than one percent. Besides scattered small sand dunes and seashore strip, many lands are almost flat owing to flood deposition by the braided wadi channels.

The Sohar Coastal Plain are subdivided into three sedimentation zones as follows:

1. Coastal complex - series of coastal sand-bars, lagoons and sebkhas.

2. Accumulation plain - dominant zone of current alluvial deposition.

3. Wadi fan - accompanied by rock outcrops and dissected ancient terraces.

Figure E-0 illustrates the geomorphological feature of the Coastal Plain around Sohar Area.

Geological observation realizes that the coast line has been emerging seawards by five to ten meters above sea level. This is the main condition where the coastal "sebkha" had developed. Sebkha is a Arabic name for a saline depressed land. It had formed on a lagoon through marine and coastal sedimentation. Only one lagoon is now seen between sohar and Sallan. Wind erosion also has affected deflation and redeposition of sand and the finer particles.

Behind the Coastal Complex an Accumulation Plain of five to six km is found. The sedimentation in the plain has been originated principally from alluvial materials transported by wadis and by sheet floods, too. Aeolian sands and loams are interbedded with wadi gravels. These sands are often deflated, and most of the surface layers are covered with gravels only.

The gravels and sands mostly of alkaline property have been derived from the mountain rocks of igneous and metamorphic formation. These are called Semail ultra-basic complex that dominantly consists of gabbros, periodorites and serpentinites.

Sedimentary rocks mainly composed of limestones and marls of Tertiary ages form the piedomont topography, also taking an important role in soil genesis on the lower plain and coast areas.

The Wadi Fan zone was eliminated from the present survey schedule because of its no prospect of agricultural development.

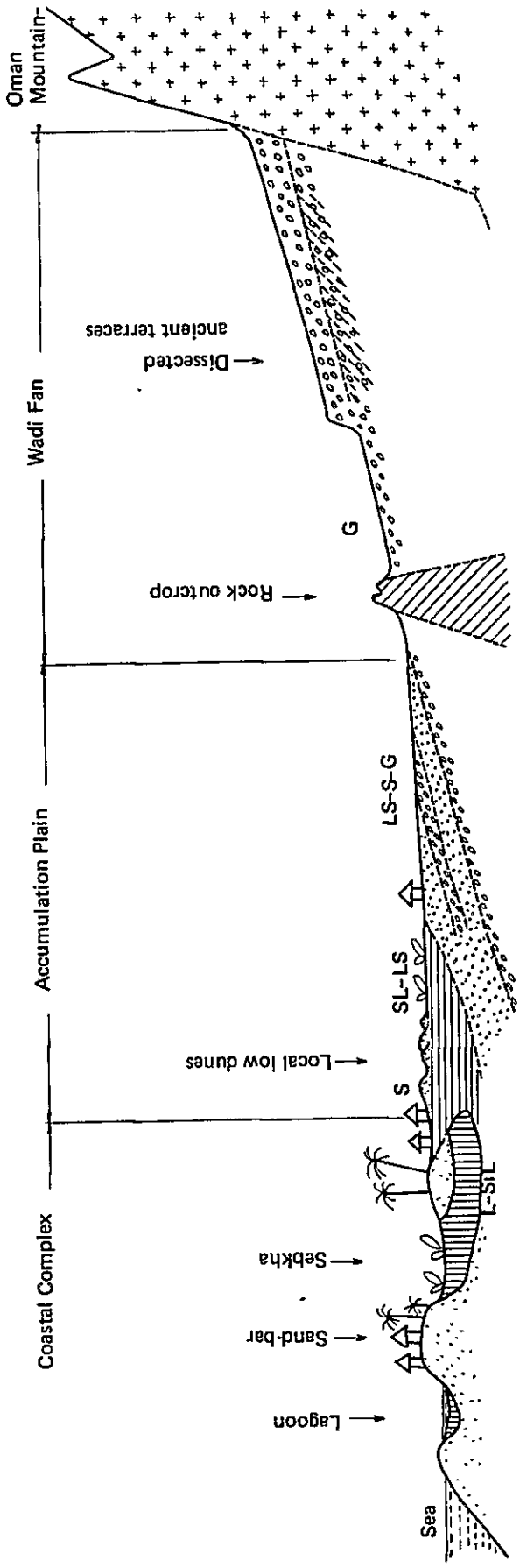


FIGURE E – 0 SCHEMATIC GEOMORPHOLOGICAL DIAGRAM OF SOHAR AREA

2.2 Climate

The Batinah Coastal Plain belongs to an arid climate zone of subtropical region in the world, the annual mean precipitation being less than 100 mm.

According to the meteorological data in Sohar Station of Water Resources Department, in the past eight years a big rainfall has been recorded during December to April. It is so uneven depending on the year that it is usually very difficult to predict the month when it will occur. Once happens, there is no way to protect the land against the wadi flood that will carry in or flush out the coarse particles from the land. This is one of the soil forming factors.

In the dry season from May to September, the average meteorological values assume the higher ranges as follows as compared with the annual average:

			Annual mean
Air temperature	(C°)	: 28.4 - 32.2	25.5
Relative humidity	(%)	: 58.0 - 78.6	72.8
Evaporation	(mm/day)	: 6.1 - 8.8	5.7
Sunshine hours	(hrs/day)	: 8.5 - 9.9	8.6
Wind velocity	(km/day)	: 75.6 - 90.1	68.8

It is obvious during this season, wind erosion and aeolian deposition happen frequently, resulting in a complex soil formation in the coastal and plain areas. Moreover, the high temperature and the relatively high humidity have lost the hours for humus formation in the soil.

E-3 Soil Survey

The soil survey conducted for the Project Area consisted of the soil profile observation and the field analysis of soil samples. The soil pits for examining profile characteristics were made mostly

to the depth of one meter from the surface owing to the presence of hard cemented silt layer or gravel layer. The field analysis was attempted to obtain fundamental data of the soil profile for classifying the soils and their land suitabilities to irrigated agriculture. The analysis items therefore were limited to those which could be determined with ease by means of the portable instruments.

3.1 Survey Method

For the soil survey of Wadi Jizzi Project Area, 1:100,000 scaled geographical maps and 1:10,000 scaled aero-photographs (BKS, 1978) were provided by the Oman Government, though the latters did not cover the northernmost parts of the Area near Amq because of the lack of strip extension.

3.1.1 Soil Profile Observation

a) Pit and Bore

Soil pits were made at a detailed reconnaissance survey level, that is, one pit per 400 ha for the present and future agricultural areas.

Depth of pit was 80 to 120 cm with a width of 100 cm as far as soil compactness allowed digging. The following Table E-1 is a profile survey sheet used in the field, arranging items in the order of observation. The soil profile description followed the method and terms defined in the FAO Guidelines for Soil Profile Description which is now of wider use in the world. The results are rearranged in the table which is listed in the later paragraph, being added with those of the other tests and analyses.

Boring was tried in case of need to find border lines among Soil Types using a common hand auger (post-hole type), as well as to survey further the lower layers of the pit.

Table E - 1 Soil Profile Survey Sheet

File No.

SOIL PROFILE DESCRIPTION

Surveyer:

Pit No. Soil classification: (Soil type) Climate: Date:

Location:

Elevation: m Relief: Slope: Direction: m Parent material: Surface stones: Land use:

Crops:

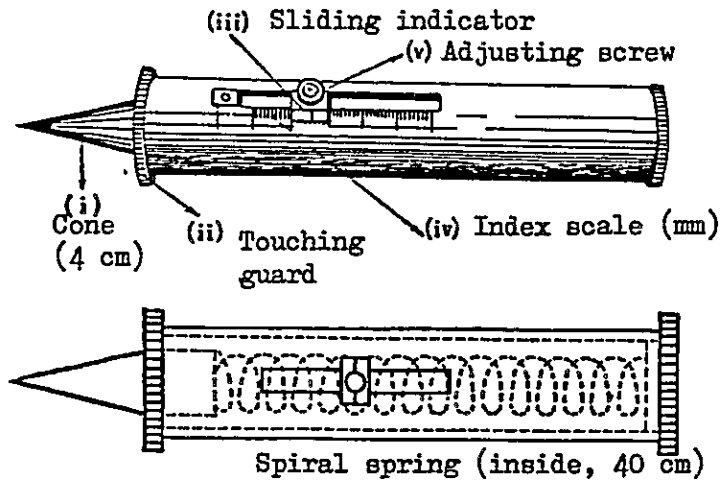
Drainage: Ground water: cm, deep Permeability: Erosion: Growth status & others:

Layer No.	Horizon	Depth cm	Boundary	Texture	Humus (Peat)	Soil color Dry	Soil color Moist	Mottling concretion	Structure	Compact-ness	Sticki-ness	Wetness (Gush-water)	Root distri-bution	Remarks

b) Soil Hardness Test

The Tester was devised by Dr. K. Yamanaka for measuring soil hardness (compactness or strength). It has been used extensively in the soil survey in Japan. Its mechanics are same as those of a cone penetrometer. It is equipped inside with a spiral spring of eight kg strength as is shown in Figure E-1.

FIGURE E - 1 DESIGN OF THE SOIL HARDNESS TESTER



(Cited from: Bulletin of the National Institute of Agricultural Sciences, Japan, Series B, No. 14, p. 285, 1964)

Soil hardness is expressed by an index of cone penetration (mm) into the vertically cut solum surface; the index value can be read as a resistance (kg/cm^2) in the convertion table. The Tester is handy and portable for the field survey. Compactness of the soil layers is of much importance to investigate workability of a land for the potentiality classification as well as to distinguish genetic differences in the soil classification.

c) Reagent Test

Reagent test is quite good for detecting special elements in the soil. It is often helpful to classify soils and their potentiality in the soil survey.

Three reagents were used to assist profile observation.

1) Dilute hydrochloric acid: 1 N Ncℓ solution. In profiles derived from calcium carbonate, effervescence with this reagent is visible in the order of carbonate content. Other salts such as gypsum and soluble crystallines are roughly differentiated from the carbonates.

2) Benzidin solution: One percent solution of pp'-diamino-diphenyl salt in ten percent acetic acid solution. Oxidized manganese such as MnO_2 form contained in soil material soon develops a dark blue color by benzidin oxidation reaction when sprayed on the profile surface.

The color development though not quantative gives an information of the oxidative status of the profile and a rough estimate of manganese which can be active with the changes in oxido-redox potential of the soil. This active manganese has been considered to include available form to crops.

3) Dipyridyl solution: 0.05% solution of $\alpha\alpha'$-dipyridyl in ten percent acetic acid solution. This reagent reacts with ferrous iron (Fe^{++}) so sensitive that can be used for its quantitative analysis in the laboratory. In the field survey the reagent serves in finding the reduced status of soil material by spraying it on the layer surface. Prompt development of pink-red color will indicate a highly progressed reduction potential of the solum, that is, a gleyic horizon or a remarkable high content of ferrous iron.

3.1.2 Soil and Water Sampling

About two kg of soil samples were taken from every soil layer distinguished on the profile; three to five samples were collected from each pit. These were air-dried, broken to pieces and sieved to pass two mm-sieve for the analysis in the camp of Oman Sun Farm.

Groundwater was sampled, too, at every time when it came out sufficiently in the pit or available in the well and falaj which are characteristic in all over Northern Batina coastal areas. Sampling was done as many times as possible on the way of soil survey.

3.1.3 Field Analysis

Soil and water samples were tentatively analysed for some items in the base camp to check the soil properties in the coarse of the field survey.

a) Gravel Content and Bulk Density

Gravels separated after sieving the soil sample were sieved further by five mm-sieve. Two parts of gravels (2-5 mm and > 5 mm in diameter) were weighed and expressed as percent on air-dry weight basis though water content of the samples would be less than five percent.

Bulk density was measured for the soil part passed through the two mm-sieve.

b) pH and EC

Tentative measurment of pH and EC (electrical conductivity) was conducted using Portable Glass Electrode pH Meter (HM-IK) and portable Electrical Conductivity Meter (CM-IK), respectively.

In case of soil samples, 1:5 soil-water suspension was made for pH determination and its supernatant clear extract was subjected to

EC Meter. This soil-water ratio follows National Standard of Soil and Water Analysis in Oman (1976) because of difficulty in preparing saturation extract of the soil outside of the laboratory.

EC values of the 1:5 extracts (Ec_5) can be converted to those of the saturation extract (ECe) from Figure E-2 or the following correlatioin formula for standardizing or international relations among soil units.

Batinah Area: $ECe = 6.05 + EC_5^{0.9}$ ($r = 0.92$, $B(1) = 0.91$)
(Gibb and ILACO, 1975)

The other convertion formula has been available, too, for Interior Region in Oman.

In the calculating salt percentage (g/100g), the assumption that 1 mmho salinity corresponds to 0.65 g/ℓ salt content is available based on the analytical data of soils in the north and northeast of Oman.

Most of the soil samples did not apply to the laboratory analysis because of some available data in the existing reports. Only the samples taken from the several sites where intake rate was measured and a new extension area was serched were sent to Agricultural Research Station, Rumais for detailed physical and chemical analyses.

3.2 Survey Results

In this paragraph only data obtained with the soil survey are presented. Discussions and analyses of them will be given in the following paragraphs.

3.2.1 Soil Profile Survey

The field survey was conducted from first to 15th of April, 1981, taking Oman Sun Farm as a base camp. The Project Area including water resources is so vast that the soil survey was forcussed upon the lands

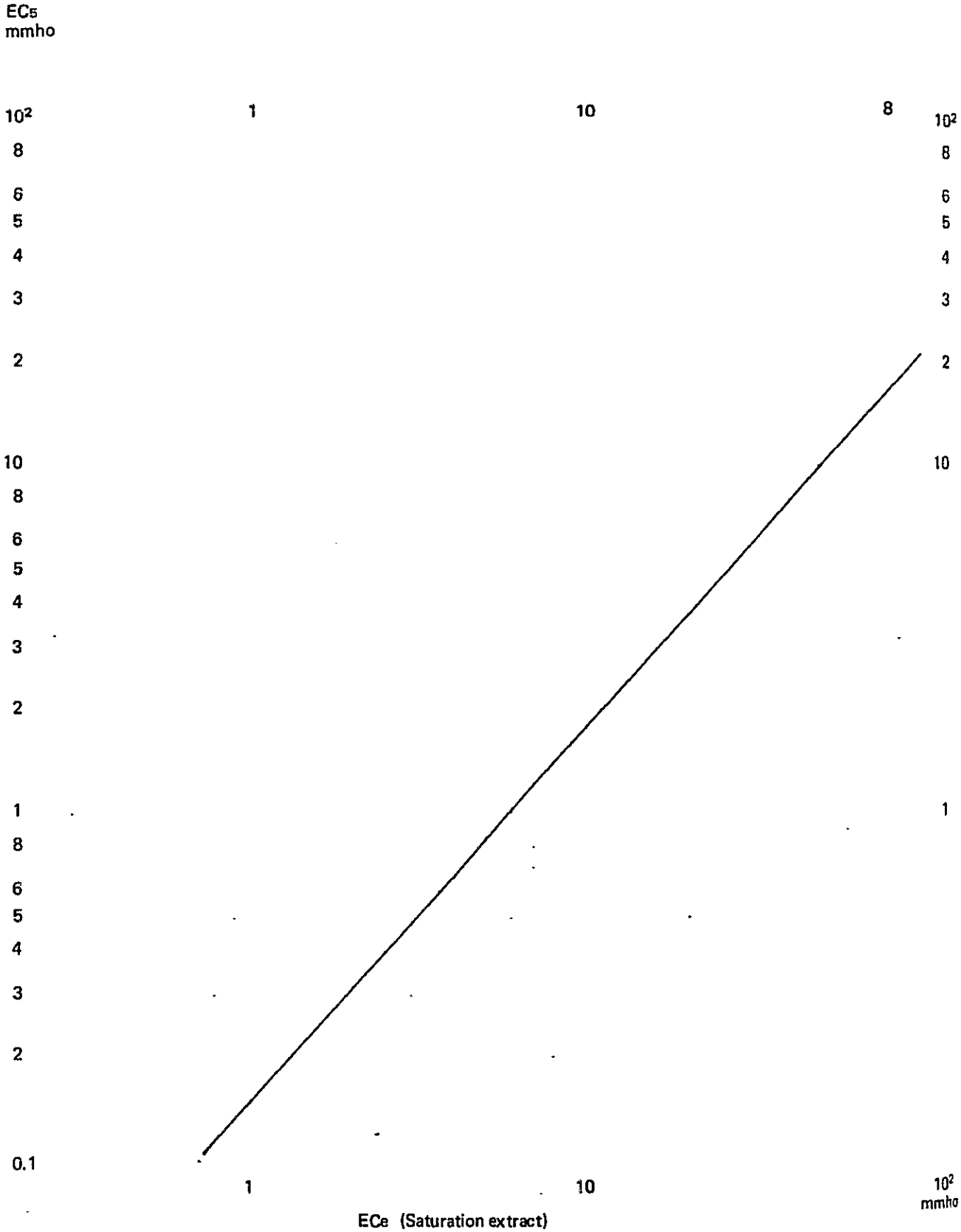


FIGURE E – 2 CORRELATION OF 1:5 SOIL-WATER EC AND SATURATION EXTRACT EC FOR SOILS OF OMAN (Gibb, 1975)

of existing or promissing farming in Sohar Area due to the limited survey term. Mr. Abdulla Soud Al-Hassni, soil engineer of Agricultural Research Station, Rumais cooperated with the Study Team during the field survey.

a) Survey Extent and Sites

Areas with a definitely unsuitable topography for irrigation, such as rocky or gravel plains and heavily wadi-dissected lands, were eliminated from the survey excent. As a result, taking Wadi Jizzi river course in the center, a rectangle-like zone of 13,850 ha between the coastal line of about 17 km from Amq to Hillat ash Shaykh and the inland line parallel to and about 9.5 km from the coast was subjected to the survey.

More than one third of the extent belongs to the gravel plain of Wadi Jizzi stream where agricultural potentiality is not expected. Accordingly, the soil pits were selected mainly along National Highway and the coastal zone. Being favoured with a good weather, the survey progressed so smoothly on schedule that 32 pits in total could be made during the term. Their locations are shown in Figure E-3 as well as those of well water sampled. Profile survey density is thus one pit per around 220 ha within the survey-focussed areas, being equal to a detailed reconnaissance level.

The whole Project Area was accessible without any obstacles except the cases when the farm gate was closed since the owner was absent for his daily work in the town. One four-wheel drive jeep was very helpful to travel the wadi plain zone having almost no traffic facilities, but it often got stuck in a deep sandy place.

b) Soil Profile Description

Table E-2 gives outlines of the profile properties including results of the field analysis of the soil samples. Topographical features of the surveyed sites are omitted in the Table because

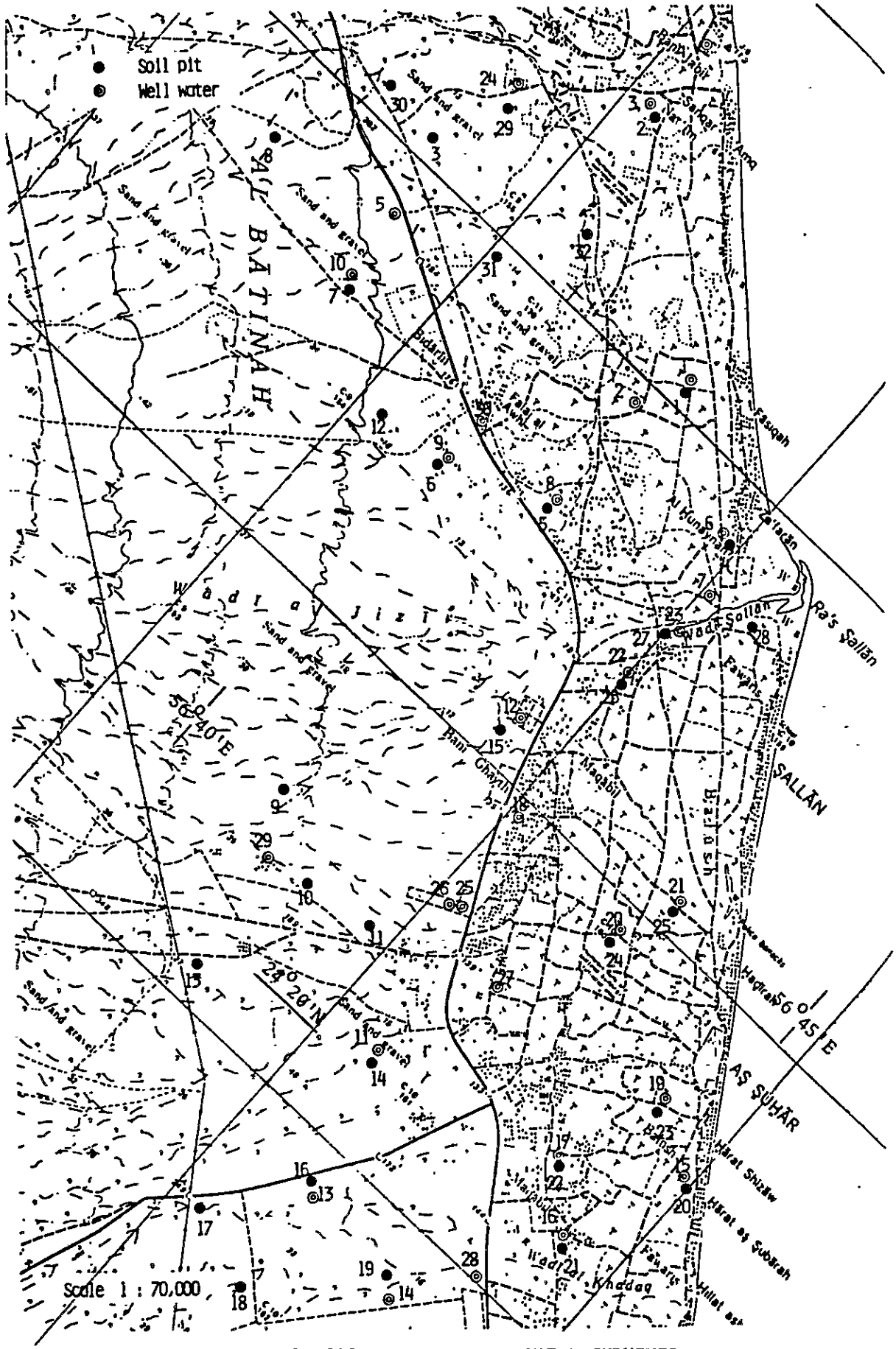


FIGURE E - 3 LOCATION OF SOIL PIT AND WELL WATER SURVEYED IN WADI JIZZI PROJECT AREA

Table E - 2 Field Analysis of Soil Samples

Taken from the Pit Profiles Surveyed in Wadi Jizzi Project Area

Pit No. (Elevation,m)	Location and Land Use	Layer No.	Depth (cm)	Texture[1]	Bulk Density	Gravel Content (%) 2-5mm	>5mm	Total	PH (1:5)	EC (1:5) (mmho,25°c)	Salt Content[2] (%)
1	Fasiqah, near	1	0-10	SL	1.38	0.5	-	0.5	8.75	6.71	2.18
(4.0)	Abdulla M.	2	10-65	SiL	1.33	trace	-	-	9.60	1.86	0.605
	Farm, unused	3	65->100	SiL	1.23	trace	-	-	9.55	1.71	0.556
2	Amq, near	1	0-0.5*	SL-LS	1.83	59.2	-	59.2	8.80	40.3	13.10
(6.0)	Mohammed	2	0.5-60	SiL	0.96	8.9**	-	8.9	10.25	1.31	0.426
	Solim Farm	3	60-77	SiL	0.89	19.6**	-	19.6	10.24	0.81	0.263
	(Al Gabri), used	4	77->100	SiL-L	0.90	trace	-	-	10.20	0.53	0.172
3	Amq, Gefra,	1	0-2*	SL	1.36	2.9	3.3	6.2	8.80	0.17	0.055
(13.5)	unused	2	2-15	SCL-SL	1.26	trace	-	-	9.10	0.60	0.195
		3	15-100	SCL-SL	1.23	trace	-	-	8.50	2.00	0.650
4	Al-Hushbah,	1	0-18	LS	1.82	-	-	-	8.30	0.11	0.036
(5.0)	near seaside,	2	18-70	S	1.71	-	-	-	8.60	0.10	0.033
	few date palms	3	70->100	S	1.75	-	-	-	8.75	0.12	0.039
5	Ibid, Massabeh	1	0-23	SL	1.63	-	-	-	8.80	0.11	0.036
(11.0)	Rashed Farm,	2	23-75	LS	1.58	-	-	-	9.00	0.13	0.042
	uncultivated	3	75->100	SL-SCL	0.97	3.3**	7.2**	10.5	9.90	0.61	0.198
6	Bidarin,	1	0-20	SL	1.47	trace	-	-	8.80	0.11	0.036
(15.0)	fenced Land,	2	20-42	S	1.69	0.2	-	0.2	8.20	0.12	0.039
	uncultivated	3	42-75	SiL	1.56	-	-	-	9.00	0.13	0.042
		4	75->100	LS	1.64	-	-	-	8.80	0.12	0.039
7	2.5km west of	1	0-35	SL	1.68	2.5	0.6	3.1	7.80	0.10	0.033
(22.0)	Bidarin, near	2	35-78	S(G)	1.72	8.2	19.2	27.4	-	-	
	Mohammed Bin Khalid Farm, unused	3	78->100	S(G)	1.62	3.7	6.0	9.7	7.65	0.09	0.029
8	2.5km south-	1	0-15	G(LS)	1.75	6.6	42.3	48.9	8.60	0.13	0.042
(23.0)	east of Bani	2	15-65	G(S)	1.90	8.3	66.3	74.6	-		
	Jabir, unused	3	65-75	S	1.69	1.9	3.8	5.7	-		
9	Near edge of	1	0-10	SL(G)				(20)			
(21.0)	Wadi Jizzi	2	10-42	G(S)				(50)			
	Stream, unused	3	42-48	S				-			
		4	48-100	G(S)				(50)			
10	2km south-west	1	0-30	G(S)	1.63	7.9	32.8	40.7	-		
(19.0)	of Bahi	2	30-75	G(S)	2.00	14.3	57.0	71.3	-		
	Ghayth, unused	3	75-95	SL(G)	1.49	6.2	6.9	13.1	8.60	0.13	0.042
		4	95->150	G(S)							

Pit No. (Elevation, m)	Location and Land Use	Layer No.	Depth (cm)	Texture[1]	Bulk Density	Gravel Content (%) 2-5mm	>5mm	Total	PH (1:5)	EC (1:5) (mmho, 25°c)	Salt Content[2] (%)
11	1km south-west	1	0-30	LS	1.30	trace	trace	-	8.60	0.15	0.049
(14.0)	of Bahi Ghayth,	2	30-75	LS	1.45	trace	-	-	8.50	0 10	0.033
	unused	3	75-95	LS	1.41	trace	-	-	8.62	0.10	0.033
		4	95->120	SL	-	**			8.75	0.10	0.033
12	Al-Ohi, 1km	1	0-20	LS	1.60	trace	8.4	8.4	8.50	0.11	0.036
(18.0)	south from	2	20-37	G(S)	2.00	5.8	39.8	45.6	-		
	High way,	3	37->100	G(S)	1.97	7.8	48.4	56.2	-		
	unused										
13	Al-Mowaleh,	1	0-12	LS							
(26.0)	near Al-Halti	2	12-24	G(LS)		**		(>50)			
	gravel road,	3	24-30	SL							
	unused	4	30->70	G(S)		**		(>50)			
14	Al-Wagabeh,	1	0-15	SL	1.23	-	-	-	8.62	0.15	0.049
(16.0)	1km south	2	15-38	SL-SiL	1.26	-	-	-	9.02	0.20	0.065
	from High way,	3	38-68	SiL	1.15	-	-	-	8.20	1.06	0.345
	unused	4	68->100	SiL	1.24	-	-	-	-		
15	0.5km west	1	0-30	LS	1.81	-	10.8	10.8	7.70	0.13	0.042
(10.5)	from High way,	2	30-50	G(S)	1.77	5.2	69.4	74.6	-		
	opposit side	3	50-75	G(S)	2.26	15.9	32.1	48.0	-		
	of Maqabil	4	75->100	G(S)	2.05	5.4	57.6	63.0	-		
	unused										
16	Near Ali Humod	1	0-13	SiL	1.13	-	-	-	8.75	0.15	0.049
(21.0)	Farm, 2km	2	13-35	SL	1.20	-	trace	-	8.73	0.16	0.052
	South-west	3	35-55	SL	1.45	0.1	-	0.1	8.85	0.13	0.042
	from High way,	4	55->100	S	1.68	1.4	1.2	2.6	-	-	
	unused										
17	Beside Hibi	1-3	0-35	SiL-S				-			
(24.5)	gravel road,	4	35-46	G(S)				(>50)			
	4km south-west	5-7	46->100	SiL-S							
	from High way,										
	unused										
18	Butha Swahreh,	1	0-10	SiL							
(22.5)	5km from High	2	10-32	S							
	way. wadi bed,	3	32-45	S(SiL*)				(20**)			
	unused	4	45-54	SL							
		5	54->100	S(G)				(25)			
19	Al-Himbar, 0.5	1	0-9	SL	1.64	-	-	-	8.60	0.13	0.042
(16.5)	km north of	2	9-47	SiL	1.33	-	-	-	8.80	0.13	0.042
	Oman Sun Farm,	3	47->100	SL	1.51	-	-	-	-		
	unused										

Pit No. (Elevation,m)	Location and Land Use	Layer No.	Depth (cm)	Texture[1]	Bulk Density	Gravel Content (%) 2-5mm	>5mm	Total	PH (1:5)	EC (1:5) (mmho,25°c)	Salt Content[2] (%)
20	Sohar Town,	1	0-10	SL	1.56				8.45	3,73	1.22
(3.0)	0.3km from	2	10-38	SL	1.34				8.85	2.54	0.826
	sea coast,	3	38-120	S	1.71				-	-	
	near date palm	4	120-147	SL	1.39				9.52	0.30	0.098
	forest, unused	5	147-200	GR	-			(>80)	-	-	
21	Al-Himbar, 1km	1	0-7*	SL	1.56	-	-	-	8.76	0.97	0.315
(9.0)	from sea coast	2	7-37	SiL	1.18	-	-	-	9.40	2.21	0.718
	of Hillat Ash	3	37-66	SiL	1.09	-	-	-	9.68	4.01	1.30
	Shaykh, unused	4	66->90	SiCL	0.95	-	-	-	10.05	3.11	1.01
22	Ibid, Saleh	1	0-10	SiL	1.03	-	-	-	8.70	35.1	11.4
(10.5)	Bin Hamdan	2	10-30	SiL	1.01	-	-	-	8.95	3.67	1.19
	Farm (date palm), cultivated	3	30->90	SiL	0.96	-	-	-	9.25	4.21	1.37
23	Ibid, Nasser	1	0-5*	SL	1.17	-	-	-	8.95	2.63	0.855
(3.5)	Suliman Farm	2	5-17	SiL-SL	1.19	-	-	-	8.55	0.78	0.254
	(date palm), cultivated	3	17->90	SiL-SL	1.10	-	-	-	9.30	1.61	0.523
24	Trafe, Brahime	1	0-25	SL	1.21	-	-	-	8.85	0.15	0.049
(7.0)	Mohammed Farm	2	25-66	SL	1.47	-	-	-	8.75	0.12	0.039
	(date, mango, banana) cultivated	3	66->90	SL	1.43	-	-	-	8.85	0.09	0.029
25	Al-Mohsoodi,	1a	0-20	SL	1.13	-	-	-	8.65	0.51	0.166
(5.0)	Sohar, Brahime	1b	10-20	SL	1.08	-	-	-	8.90	0.25	0.081
	Mohammed Farm (date, vegetables) cultivated	2	20->80	SiL-SL	1.15	-	-	-	-	-	
26	Al-Traif,	1	0-13*	SL	1.45	-	-	-	8.85	0.13	0.042
(6.0)	Sohar,	2	13-48	LS	1.62	-	-	-	9.80	-	
		3	48->90	SiL	1.17	-	-	-	9.80	0.35	0.114
27	Near Wadi	1	0-27	SL(S)	-				-	-	
(5.0)	Sallan,	2	27-30	SiL	1.60				9.52	0.86	0.28
	unused	3	30-42	SiL	-				-	-	
		4	42-65	SL	-				-	-	
		5	65-100	S	1.47				9.02	0.14	0.046
		6	100->130	GR	-			(>80**)	-	-	
28	Ibid, 0.7km	1	0-5*	SL	1.04	-	-	-	8.70	47.6	15.5
(5.0)	from sea coast,	2	5-25	LS	1.40	-	-	-	8.85	1.96	0.637
	scattered date	3	25-65	SiL	1.04	-	-	-	9.00	2.71	0.881
	palms and	4	65-100	S	1.41	0.9	-	0.9	8.86	0.61	0.198
	bushes	5	100->120	G(S)	-			(>50)	-	-	

Pit No. (Elevation, m)	Location and Land Use	Layer No.	Depth (cm)	Texture[1/]	Bulk Density	Gravel Content (%) 2-5mm	>5mm	Total	PH (1:5)	EC (1:5) (mmho, 25°c)	Salt Content[2/] (%)
29	3km east of	1	1-10	SiL(G)	1.31	1.6	10.9	12.5	8.70	0.25	0.081
(11.0)	Falaj Al-	2	10-35	SL	1.16	-	-	-	7.82	1.71	0.556
	Qabail, 2.5km	3	35-44	LS	1.49	-	-	-	8.00	1.83	0.595
	from sea coast, scattered acasias and bushes	4	44->90	SCL	1.19	-	-	-	8.56	2.79	0.907
30	2.5km south-	1	0-26	S(G)	1.72	7.5	19.5	27.0	8.00	0.15	0.049
(16.0)	east of Falaj	2	26-40	G(S)	1.71	20.1	33.2	53.3	8.00	0.14	0.046
	Al-Qabail,	3	40-110	L-SiL	1.35	trace	-	-	9.30	0.48	0.156
	near Wadi Suq bed, many acasias, unused	4	110-160	S	-	-	-	-	-	-	
31	2.5km east of	1	0-11	LS(G)	1.64	9.7	9.7	16.0	8.50	0.16	0.052
(15.0)	Pit 30, 1.2km	2	11-37	LS	1.53	3.0	1.3	4.3	8.30	0.13	0.042
	north-east	3	37-70	SL-L	1.23	-	-	-	8.80	0.17	0.055
	from High way, scattered acasias and bushes unused	4	70->90	S	-	-	-	-	-	-	
32	Midway between	1	0-22	LS	1.63	-	1.6	1.6	8.22	0.15	0.049
(9.0)	Amq and Falaj	2	22-55	SiL	1.13			**	8.80	0.26	0.085
	Al-Awhi, some	3	55-80	SL	-				-	-	
	acasias and bushes, unused	4	80->100	SiL	-			**	-	-	

Remarks: 1/ Other textural Layer inserted is given in parenthesis.

2/ EC (1:5) x 0.65 x 100 / 200

* Salt-consolidated layer or with consolidated silty surface

** Weathered $CaCO_3$ fragments (>2mm)

they are almost flat with slopes not steeper than 0.2 percent. A few sites are located on the undulating lands such as wadi edge and sea coast as shown in the topographical location map, Figure E-3.

Some profiles in inner coastal zone give a silty texture and are characteristic with salt-consolidated surface, showing fairly high EC values. Those on the west side of National Highway become more gravelly with the distance from the sea coast or to the wadi streams.

For more detailed informations, refer to Annex 1 in which typical soil profiles are described in relation to Soil Types.

3.2.2 Field Analysis

a) Soil

1) Gravel Content and Bulk Density

As mentioned above, gravel content are remarkably high on the Wadi Jizzi plain and edge of braided wadi streams running through the coastal zone. Round gravels more than five mm in diameter frequently occupy the most part of sublayers. Consequently, bulk density is reasonably very high as 1.5 to 2.3 in these layers. Even silt loam layers give higher densities greater than 1.2 in most cases in accordance with extremely low accumulation of organic matter in the profile under the hot and arid climate conditions.

2) pH and EC

High pH more than 8.5 are quite common with the 1:5 soil-water suspensions. One profile (No.2) observed in Amq Farm shows pH higher than 10.2 with the subsoil which is overlaid with salt consolidated surface soil. This tendency may correlate with calcium-rich soil materials which were derived from the mother rocks mainly consisting of limestones and serpentines.

It must be considered, however, that in such alkaline soils the higher becomes the ratio of soil-water suspension like 1:5 the more

increases the pH value. Therefore, the ratio would be better less than 1:2.5.

High EC values occur in the profiles near the sea coast and inner coastal zone, so-called "Sebkha" area. In the other area the EC_5 ranges from 0.1 to 0.3 mmhos/cm at 25°C, corresponding to about 0.8 to 2.5 mmhos in saturation extract. Soil salinity as expressed on average EC values within one meter depth of the profile can be grouped in five grades. In Figure E-4 a rough distributioin of lands is mapped giving various salinity groups in the Project Area.

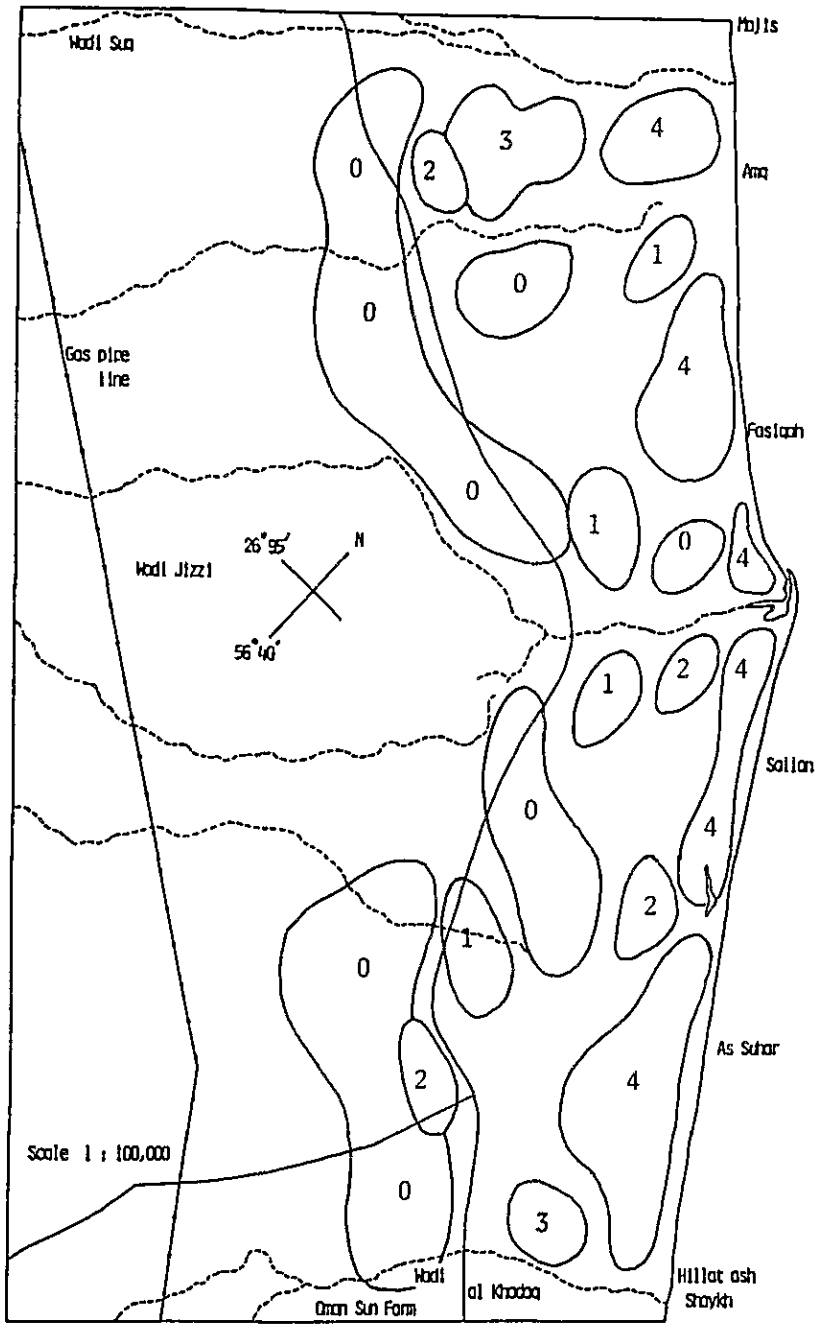
The grades designated in number in this figure seem to be slightly strict criteria on soil salinity, but in view of the irrigated agriculture common in the Area it will need a severe consideration for future menace of the salinity damage.

b) Well Water

Well water samples collected in the Area are 30 in total; most of them are from Farm irrigation wells nearby the soil pits and some from drinking water well, too, including one falaj spring. Their locations are already shown in Figure E-3. Results of the water analysis are summarized in Table E-3. Elevation of the sites was estimated from the topographical map scaled at 1:50,000 which has been newly made by PASCO International Inc., Japan. Groundwater level was inferred mostly by inhabitants' informations.

Similarly as the soils, values of pH are all at alkaline side ranging from 8.0 to 9.2. EC in mmho is higher than 0.5 in all samples and exceeds 0.75 in over 50 percent of them. Since 0.75 mmho is generally defined as a critical value in water quality and its use for irrigation, there may be expected saline conditions unless adequate leaching and drainage managements are taken.

Figure E-5 shows the water salinity groups in which five grades are set for EC values. Their distribution is not so different from



Legend: EC of 1:5 soil-water extract

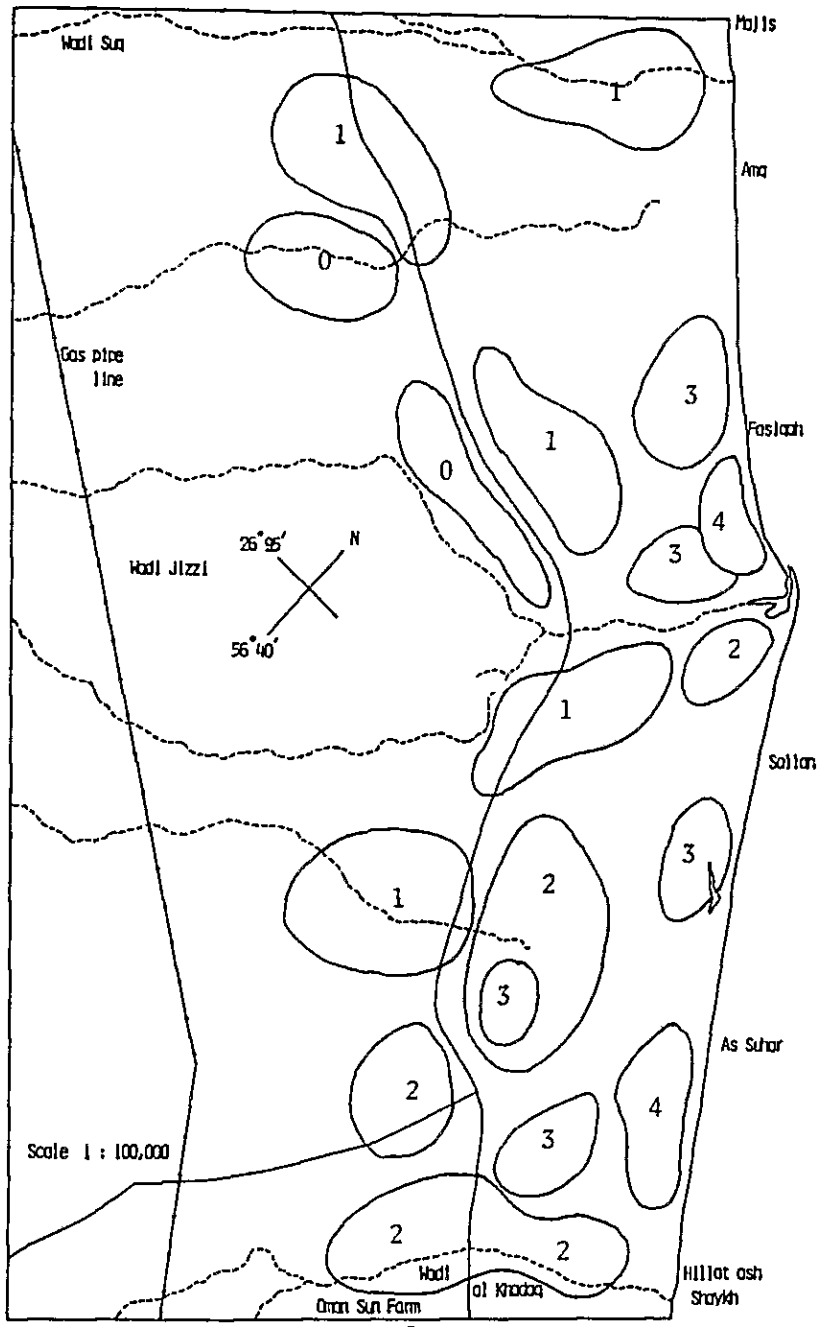
Grade	mmhos/cm, 25°C
0	<0.2
1	0.2 - 0.5
2	0.5 - 1.0
3	1.0 - 2.0
4	>2.0

FIGURE E - 4 SOIL SALINTTY DISTRIBUTION IN PROJECT AREA

Table E - 3 Analysis of Water Samples Collected in Wadi Jizzi Area

Sample No.	Location (Nearby Pit No.)	Elevation (m)	Groundwater Level (m)	pH	EC (mmho, 25°C)	Salt Content* (ppm)
1.	Zainele Khawi Farm (1)	4	7	8.00	1.75	1,138
2.	Farm,1 km North-west of Pit 1	4	7.5	7.96	1.32	858
3.	Mohammed Solim Farm (2)	6	8	8.15	0.72	468
4.	Farm, Amq-Majis	10	13	8.20	0.74	481
5.	Farm, beside High Way	19	13	8.40	0.61	397
6.	Farm, Al Zafarah	4	2.5	7.85	4.60	2,990
7.	Farm, Al-Hushbah (4)	5	3	8.15	1.70	1,105
8.	Mossabeh Rashed Farm (5)	11	10	8.20	0.68	442
9.	Fenced Farm. Bidarin (6)	15	15	8.80	0.44	286
10.	Mohammed Bin Khalid Farm (7)	22	15	8.15	0.51	332
11.	Farm Al-Waqabeh (14)	16	13	7.90	0.87	566
12.	Shakh Khalifah Farm (15)	10.5	12	8.50	0.44	286
13.	Ali Humod Farm (16)	21	11	8.40	0.76	494
14.	Salim Bin Fadhel Farm (19)	16.5	8	8.28	0.83	540
15.	House Well, Sohar Town (20)	3	3	9.05	2.10	1,365
16.	Ali Al-Sarhoni Farm (21)	9	8	9.15	0.94	611
17.	Saleh Bin Hamdan Farm (22)	10.5	5	8.60	1.62	1,053
18.	Ali Abaid Garden, B. Ghayth	11.5	7	8.70	0.94	611
19.	Nasser Suliman Farm (23)	8	8	8.30	2.90	1,885
20.	Brahime Mohammed Farm (24)	7	6	8.65	1.10	715
21.	- Ibid - (25)	5	6	8.22	1.60	1,040
22.	Farm, Al-Traif (26)	7	7	8.60	0.68	442
23.	House Well, Wadi Sallan (27)	6	5	8.62	0.76	494
24.	Farm, Opposite Side of Wadi (29)	11	9	8.30	0.64	416
25.	Farm, near High Way (11)	15	10	8.40	0.56	364
26.	- Ibid -	15	10	8.40	0.65	423
27.	Farm, near Bahi Ghayth	12	8	8.35	1.20	780
28.	Farm near Oman Sun Farm	12	10	8.30	1.12	728
29.	Well of Gas Pipe Camp	21	15	8.40	0.51	332
30.	Spring of Falaj Al Awhi	16	0	8.50	0.58	377

* EC x 650 ppm



Legend: EC, mmhos/cm, 25°C

Grade	
0	<0.4
1	0.4 - 0.8
2	0.8 - 1.2
3	1.2 - 2.0
4	>2.0

FIGURE E - 5 WELL WATER SALINITY IN WADI JIZZI PROJECT AREA

that of soil salinity (Figure E-4) but the salinity grades seem slightly higher presumably due to the characteristics of groundwater.

3.2.3 Laboratory Analysis

Four soil pits specially examined around new Extension Area were located as shown in Figure E-6. This area belongs to the lower accumulation plain where many small wadis run through and meet. Therefore, soils are mostly sandy with the least clay accumulation and Table E-4 gives the results of soil analysis done by the laboratory of Agricultural Research Station, Rumais. The characteristics are described from the Table as follows:

1) Texture is mainly loamy sand (LS) except pit No.1 and gravel content is high only in pit No.3.

2) pH (1:1) seems too low as compared with the results of other soil analyses.

3) EC (1:5) and gypsum content are very low but very high is the lime content.

4) Exchangeable Na is very small in content as well as CEC value.

5) Available P varies irregularly, and K is too small.

Consequently, only the area surrounding pit No.1 can be recommended for new extension purpose in view of the finer soil texture. Land class evaluation and its managements are referred to in the later paragraph.

Some other results of laboratory analysis on the Sohar Area soils reported by ILACO (1975) and other consultants have come to hand and are printed for reference in Annex 2.

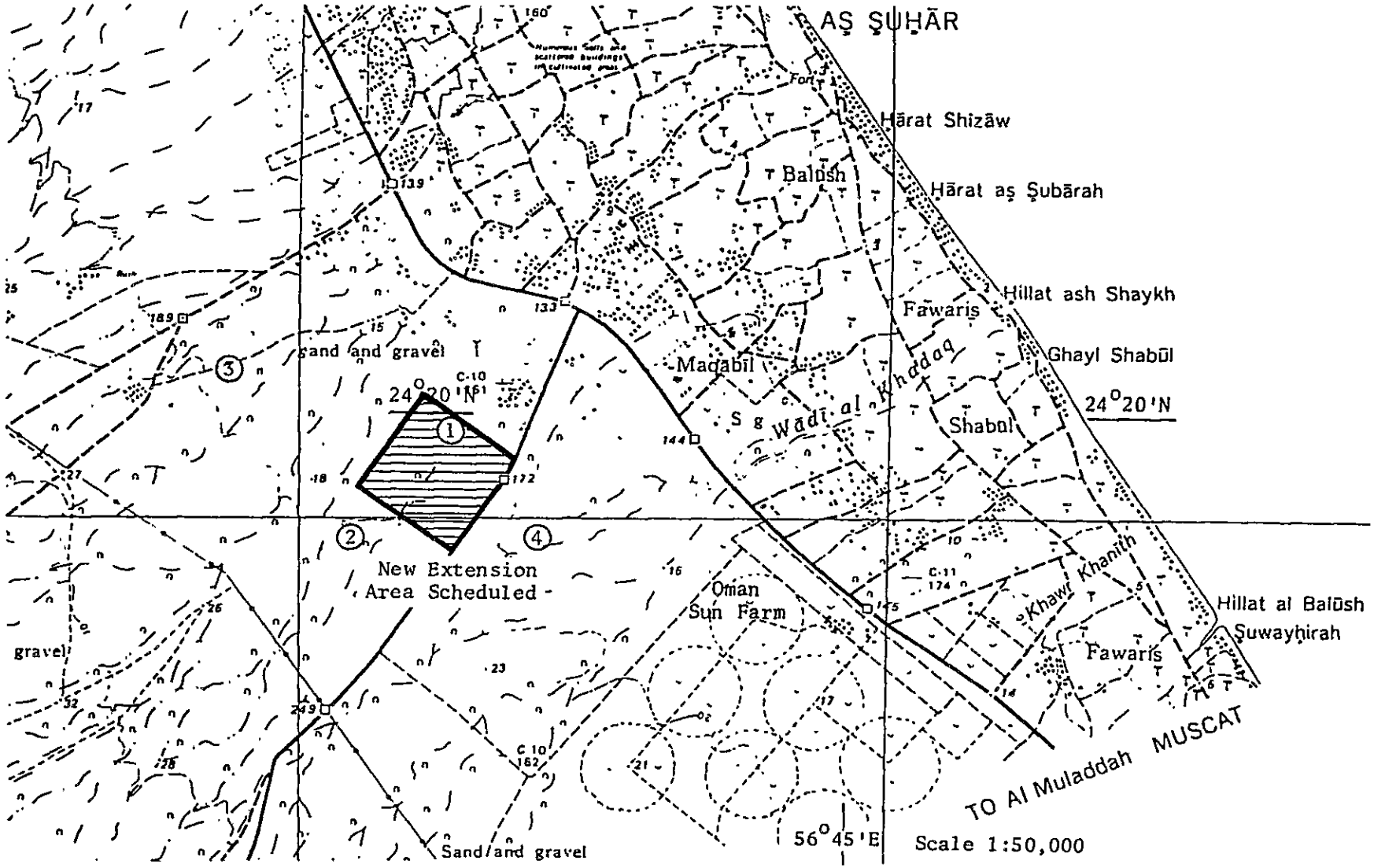


FIGURE E - 6 LOCATION OF SOIL PITS AROUND THE NEW EXTENSION AREA

Table E - 4 Laboratory Analysis of Soil Samples Taken from the Pits Around the New Extension Area

Pit No.	Sampling depth (cm)	Mechanical Analysis Sand (%)	Silt (%)	Clay (%)	Texture	Gravel Content (%)
	0 - 5	83.0	9.9	7.1	LS	1.0
1	20 - 30	67.0	19.9	13.1	SL	1.1
	50 - 60	77.0	11.9	11.1	LS	2.2
	0 - 10	79.0	11.9	9.1	LS	0.3
2	20 - 30	75.0	13.9	11.1	LS	4.2
	40 - 50	93.0	1.9	5.1	S	7.9
	0 - 10	83.0	5.9	11.1	LS	30.2
3	20 - 30	92.9	1.7	5.4	S	37.3
	40 - 50	72.9	11.3	15.8	SL	5.0
	0 - 10	84.9	5.7	9.4	LS	0.4
4	30 - 40	84.9	3.7	11.4	LS	3.8
	50 - 60	84.3	8.3	7.4	LS	1.2

Pit No.	pH (1:1)	EC (1:5) (mmhos)	CEC (me/100g)	Exchangeable Na (me/100g)	Available P (me/100g)	Available K (me/100g)	Lime ($CaCO_3$) (%)	Gypsum (%)
	6.2	0.14	9.6	0.52	20	0.10	11.1	0.018
1	6.6	0.16	8.6	0.68	10	0.12	11.9	0.013
	6.7	0.20	8.4	0.96	10	0.07	11.1	0.018
	6.7	0.15	8.4	0.86	10	0.04	12.2	0.018
2	6.7	0.15	7.6	0.70	2	0.02	11.5	0.013
	6.5	0.16	3.5	0.70	10	0.02	3.6	0.013
	6.6	0.16	7.4	0.63	10	0.06	10.9	0.013
3	6.6	0.11	6.0	0.60	10	0.06	8.1	0.013
	6.5	0.11	11.4	0.68	1	0.08	10.7	0.007
	6.7	0.15	7.6	0.76	20	0.07	9.6	0.013
4	6.8	0.09	5.6	0.44	20	0.03	5.3	trace
	6.8	0.14	6.3	0.52	30	0.05	8.3	0.007

Note : Analytical methods, refer to "National Standards of Soil and Water Analysis in Oman".

E-4 Soil Classification

Soil classification is formally made in the soil unit from great soil groups to smaller orders. This is not so necessary in such a small area development plan as the Wadi Jizzi Project. The idea is particularly so in the agricultural area where almost all tracts of land have been under groundwater irrigation for long years and where irrigation is indefinitely needed to develop new farms. Under these circumstances, the classification will be focussed on the final step of soil unit, that is, Soil Type from view points of practical utilization of the lands.

4.1 Great Soil Group

According to Soil Map of the World compiled by FAO-UNESCO (VII-1, 1977), soils of the Project Area are illustrated to be one Soil Unit of Haplic Yermosols (see Figure 3-7). Since the map symbol shows the most dominant soil in the area, each Soil Unit is usually associated with and/or includes some Other Units.

Haplic Yermosols cover most part of the sea coast and peneplain areas. On mountains Lithosols are dominant and associated Yermosols in the north of Oman. The Yermosols on the Project Area are described as follows:

Map Symbol	Associated Soils	Inclusions
Yh 22-1ab	Qc (Cambic Arenosols)	Rc (Eutric Regosols)
(Haplic Yermosols, coarse textured, level to hilly)	Yk (Calcic Yermosols)	Jc (Calcaric Fluvisols)
		Z (Solonchaks)

Yermosols are so called "Desert Soils", sandy, stony and mostly shallow, but in some spots they are deep, yellowish loams. [Haplic] is connotative of soils with a simple, normal, horizon sequence. The other cartographic representation can be found in Volume I and VII-1 of the above publication.

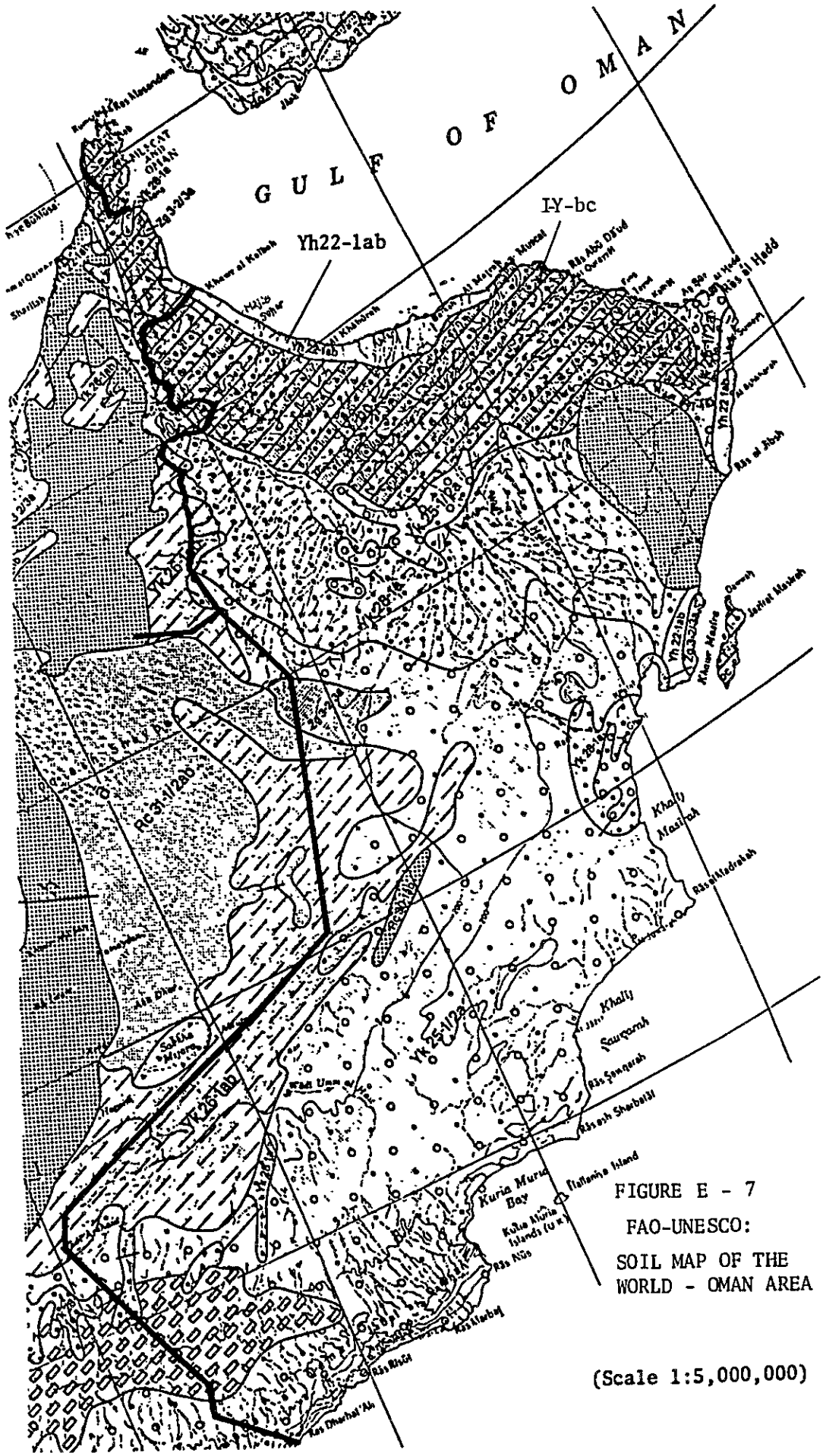


FIGURE E - 7

FAO-UNESCO:

SOIL MAP OF THE WORLD - OMAN AREA

(Scale 1:5,000,000)

4.2 General Soil Features

The Project Area consists of coastal complex and accumulation plain of less than 25 m elevation on the Batinah Coastal Plain. The former comprises coarse sandy soils on the sand-bars and saline finer-textured inland soils on the "sebkhas". The coastal sebkhas have been developed with marine sediments of medium and fine particles transported on coastal lagoons by the tidal floods. Sebkha is a Arabic name for a low-lying saline area often inundated. The salt-crusted surface is an excellent feature of the sebkha soils under the arid climate condition.

The latter plain has the average width of 5 to 6 km and received sediments of loam to gravel size transported by wadi sheet floods; the soils are not saline but frequently shallow and gravelly immatured under the influence of the many braiding recent wadi channels.

Although so many types of layer sequence are observed, the soils prevailing in the Project Area are in general coarce textured and have almost no organic matter and rather compact with very weak structures if developed; they are mostly alkaline in reaction giving pH 8 to 9, very calcarous with a strong effervescence with dilute HCl and usually deficient in nutrients except for calcium and magnesium which would have been derived from mother rock of the mountains, being rich in supentinized materials. Mineral composition of the fine sand and silt of soil profiles indicates this genetic circumstance as is shown in Table E-5.

Soil colour varies little from 10YR 7/2 to 10 YR 5/3 dry with an increase in particle size; no mottling was observed in inland areas while some weathered limstone fragments were incorporated into the strata often in the sebkha area.

Strong bubbling with dilute HCl solution appeared in almost all soil layers. This indicates a high content of carbonates which combine mainly with calcium. Color development with benzidin

Table E - 5 Quantitative Mineralogical Analysis of 50 - 200μ Fraction of Soil Profiles

(Unit : %)

Physiographic Unit and Origin	Depth (cm)	Opaque	Limonite	Quartz	Opal (SiO_2)	K-feldspar	Albite	Basic-Interm. Plagioclase	Chlorite	Biotite	Calcite	Epidote	Olivine	Enstatite	Tremolite Actinolite	Hornblende	Diopside	Miscellaneous	Serpentinized Materials	Undefinable Alterites	Rock Fragments (Compounds)	Association 1/
Coastal	0 - 28	-	1	14	5	2	3	4	2	-	21	3	1	2	3	-	-	-	26	1	12	S-C-A
Sebkha	28 - 40	1	-	7	3	10	-	3	4	-	24	4	1	2	10	1	-	-	24	6	-	S-C-A
Harmul	40 - 70	1	1	8	-	10	1	-	5	-	29	2	1	-	8	-	-	-	23	6	5	S-C-A
Pit A	120 - 180	3	4	2	-	7	-	1	-	-	1	5	1	9	1	-	2	-	62	-	2	S-E
Accumulation	0 - 20	-	-	7	-	11	-	1	-	-	18	7	3	8	-	1	-	-	32	7	5	S-C-E
Plain	40 - 60	2	1	10	1	8	-	-	3	-	13	2	9	9	1	-	-	1	26	11	3	S-C-E
Sohar, Pit M	80 - 120	-	2	6	-	7	-	-	1	-	19	1	8	8	-	1	-	1	36	7	7	S-C-E
Accumulation	0 - 32	2	-	3	1	-	5	10	-	-	18	5	4	10	-	5	-	2	35	-	-	S-C
Plain	32 - 68	-	-	7	-	3	3	2	5	-	16	5	5	5	-	2	-	2	37	7	1	S-C
Saham	68 - 106	-	2	8	-	3	1	1	5	-	16	2	1	5	-	3	-	1	36	5	11	S-C
Pit F	134 - 180	1	-	4	-	2	1	3	5	2	15	2	6	7	-	1	-	-	42	3	8	S-C

Source : Water Resources Development Project - North Oman, Interim Report, Vol.2, Annex C, ILACO (1975)

Note : 1/: S; Serpentine, C; Calcite, A; Actinolite, E; Enstatite.

reagent was generally weak, showing a small content of active manganese. Reaction with dipyridyl solution which proves the presence ferrous iron was entirely not recognized with the profiles. It was very strong only in the silty or clayey subsoils around the lagoons. No clear gypsum crystalline was detected in subsoils. In the sebkha area near the lagoon an earthernware pot was discovered (see Pit No.21 in Annex 1.). The pot seems an artefact as old as thousands years with its weathering color of rainbow.

Vegetation is also quite characteristic to the arid soils with a scarce rainfall and a slightly higher salinity. Well-growing Acacia arabica, acacia tortilis and low shrubs of Tamarix indica are seen most commonly in the gravelly plains. In some places they make a plant community consisting of one or a few species which may suit to the soil condition there. More than 80 main species have been listed by Gibb and ILACO's soil survey (1975) in Batinah and Interior Region of Oman. During the present survey a beautiful flora of Aloe sp. (Liliaceae) was found on the northern coastal zone where soil media is arid and sandy. Vegetation is an useful tool for predicting soil species because it frequently provides a reliable indication of the local ecology including soil conditions.

4.3 Soil Type Classification

Soil classification for northern Oman area has been attempted for the first time by Gibb and ILACO (1975). They divided the area soils into four great classes following French C.P.C.S. System (1967).

(1) Row mineral soil

(2) Slightly developed soil

(3) Calci-magnesic soil

(4) Sodic soil

These classes were further divided to groups, sub-groups, faces and series, successively, in which salinity, soil depth and erosion

were taken as classifying factors. Finally 35 soil series were set up in making soil maps. Correlation with the American (Seventh Approximation) and FAO classifications was also proposed in a table.

In the present soil survey, the lower orders from Soil Series to Soil Types are adopted from the edaphological points of view and also due to the following two reasons:

(1) A comprehensive soil classification and mapping survey cannot be conducted in such a short time span as two weeks or so.

(2) A more detailed study for identifying the higher order classes is very difficult because of the scarce analytical data available for the Project Area.

4.3.1 Classification Process

As already decribed, soils in the Project Area are in general very poor in organic matter and structural development, without any other special profile features. Therefore, a simple classification is intended using texture sequence and gravel content in the profile. Location, topography and salinity are also complementary factors for estimating higher orders of the soil groups.

Table E-6 gives the classified soil categories, Unit, Series and Types. In view of the recent alluviums and their weak horizon formation, Calcaric Fluvisols were adopted to some of the soils. Although Solonchahs actually develop in the finer-textured soil near wide mouth to the sea, fairly parts of the coatal sand dune area should be classified to the same unit, too. Dystric Regosols cover most of the gravelly plain and Haplic Yermosole occur in the intermediate zone.

Series and types were divided by the textural difference in the lower and upper soil layers, respectively, so as to allow

Table E - 6 Classified Soil Types in Wadi Jizzi Project Area

Category	Unit	Series (Texture of Lower 50-100cm)	Type (Texture of Upper 0-50 cm)	Symbol No.	Location	Areas (ha)	Areas (%)
Solonchaks	Orthic	SiL	SiL	1.	Behind sandbars along sea coast, "Sebkha"	1,720	12.4
Yermosols	Haplic	SiL	SL/SiL	2.	Higher deposits than (1)	2,560	18.5
Yermosols	Haplic	SiL	S(G1-3)	3.	Along or nearby small wadis	210	1.5
Fluvisols	Calcaric	SL	SiL	4.	Deposits between wadis	410	3.0
Fluvisols	Calcaric	SL	SL	5.	Alluvial and aeolian Sandy areas around Wadis	1,050	7.6
Regosols	Calcaric	SL	S(G1-3)	6.	Nearby and along Wadis	370	2.7
Regosols	Calcaric	LS(S,G)	SL(LS)	7.	Sandy dunes behind sea coast and nearby wadi beds	1,180	8.5
Solonchaks	Orthic	LS(S)	SL	8.	Sea coast sandy areas	640	4.6
Regosols	Dystric	S(G3)	LS	9.	Between wadis and behind (7)	1,080	7.8
Regosols	Dystric	S(G3)	S(G3)	10.	Wadi beds of coarse deposits	4,630	33.4
Total						13,850	100.0

Remarks : G1-3 give average gravel contents(0.2 - 7.5 cm) of 2 - 15, 15 - 50 and more than 50% of the profile, respectively.

direct evaluation of their land suitability. With these combitations ten Soil Types were taken up in total by investigating the results of profile examinations and sample analyses. Relative arrangement of these types are simply illustrated in Figure E-8 in terms of particle size, sequence of sedimentation and topography.

Table E-7 gives main characteristics of each type, which are used for classification and significant for land classification, too. Soils of type 1 to 3, mainly found on the sebkha and sebkha-like areas, are reasonably saline due to their genetic formation.

4.3.2 Mapping and Area of Soil Types

Because of the repeated deflation and redeposition of alluvial and marine materials and in addition to wind-borne deposition, the soils show very complicated features particularly along wadi bed, making it difficult to complete the precise soil map.

Extent of each Soil Type is outlined by checking the locations of the belonging soil pits and their land forms which can be grasped on the topographical map scaled at 1:50,000. Table E-8 gives numbers of soil pits divided into each Soil Type. The soil map thus drawn is shown in Figure E-9, the scale of which is reduced to 1:70,000 for convenience' sake in printing.

Hectarages of Soil Types are measured on the map by means of a linear planimeter taking the Gas Pipe line as a southeastern boundary. These are listed in Table E-6 on its right column.

Near half of the Area is occupied by Type 9 and 10, followed by Type 1 and 2 which are the finest-textured and saline, giving as high as 30% prevalence mostly in the inland Sebkha areas.

4.4 Soil Type Description

In this paragraph charateristics of each Soil Type are outlined of its profile, salinity, alkalinity, distribution and so on. Typical

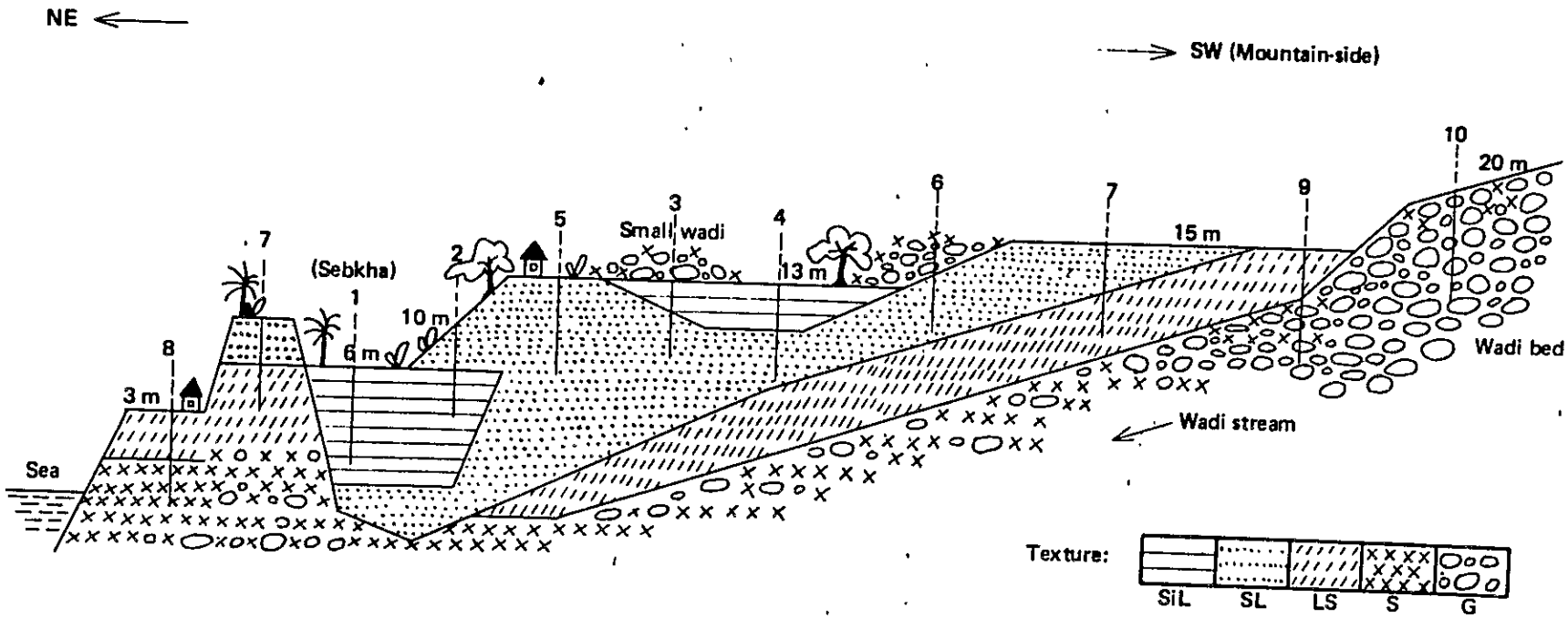


FIGURE E – 8 PARTICLE SIZE DISTRIBUTION AND TOPOGRAPHICAL POSITION OF THE SOIL TYPES IN WADI JIZZI PROJECT AREA

Tabel E - 7 Characteristics of Soil Types in Project Area in Relation to Land Classification

Soil Type No.	Texture (S) (Lower-Upper)	Gravel Content(v) (%)	Hardness[1/] (e)	Available Soil Depth(g) (cm)	Salinity (EC_5, n) (mmhos)	Topography (t)
1	SiL - SiL	0	10 - 30	> 100	1.5 - 4.0	Almost flat, "Sebkha"
2	SiL - SL/SiL	0	15 - 20	> 100	0.1 - 0.5	Almost flat (alluvial deposits)
3	SiL - S(G1-3)	10 - 50	5 - 18	30 - 50	0.3 - 2.0	Flood plain ridges, undulating
4	SL - SiL	0	10 - 30	> 100	0.2	Almost flat (alluvial deposits)
5	SL - SL	0	10 - 15	> 100	0.3	Almost flat (alluvial deposits)
6	SL - S(G1-3)	10 - 60	15 - 25	0 - 20	0.1	Flood plain ridges, undulating
7	LS(S,G) - SL(LS)	0 - 15	20 - 25	30 - 50	0.1	Sandy dunes, slightly sloping
8	LS(S) - SL	0	10 - 20	0 - 40	3.0 - 16.0	Sandy coast and dunes
9	S(G3) - LS	30 - 60	23 - 27	0	0.1	Almost flat (wadi edges)
10	S(G3) - S(G3)	50 - 100	25 - 30	0	0.1	Wadi beds, undulating

Remarks : For evaluation criteria of each item refer to Table E - 8.
1/; Figures show index values as measured by Soil Hardness Tester.

Table E - 8 Soil Profile Numbers Belonging to Each Soil Type Found in Wadi Jizzi Project Area

Soil Type No.	Soil Profile No.
1	1*, 2*, 3, 21*, 22,
2	5, 6, 14, 23*, 25, 26*, 28, 32
3	29, 30*
4	16*, 19*, 27
5	11, 24*
6	31*
7	4, 7*, 17, 18
8	20*
9	12, 15*
10	8, 9*, 10, 13

Note : * The Profile descriptions are given in Annex.

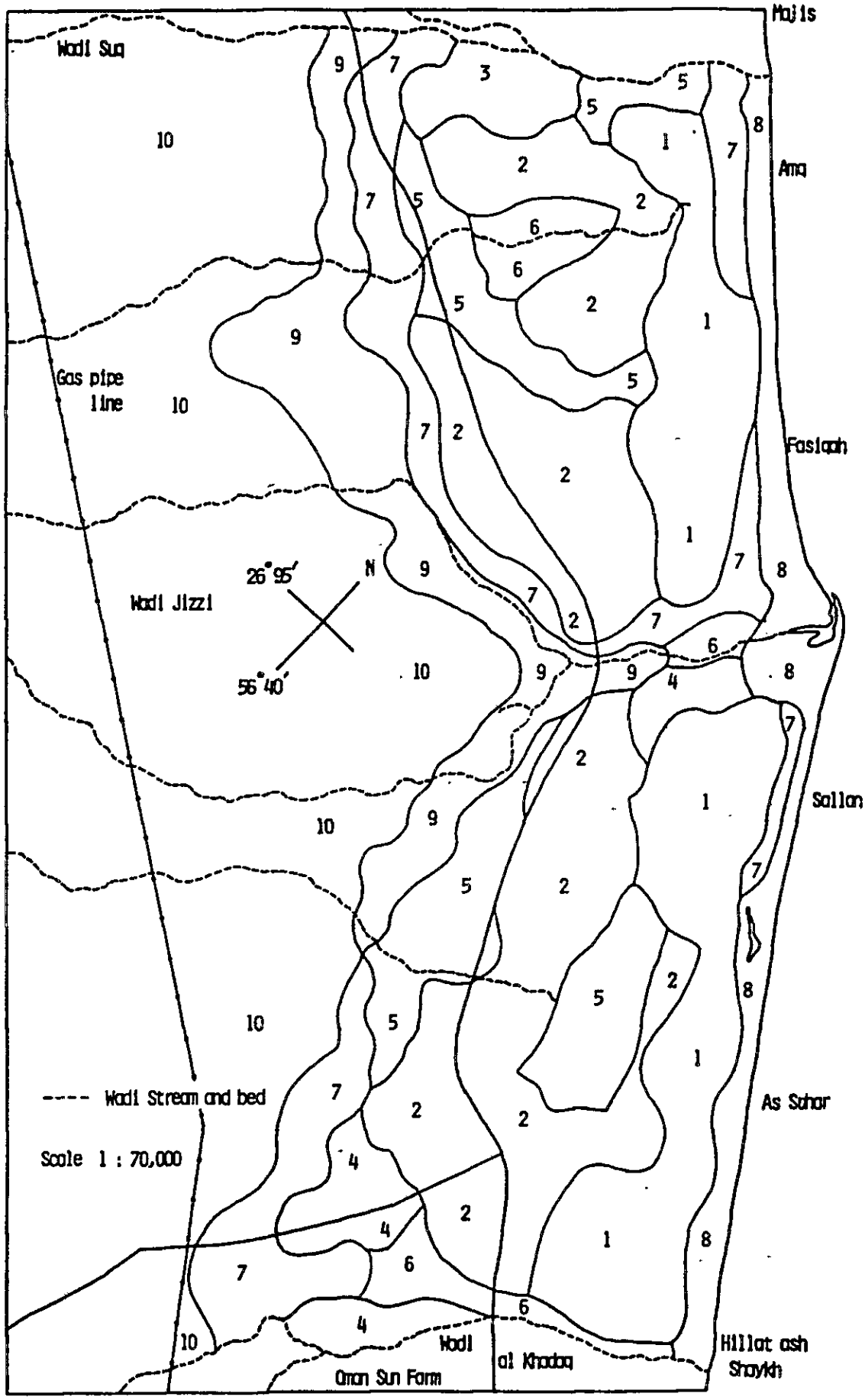


FIGURE E - 9 MAP OF SOIL TYPES IN WADI JIZZI PROJECT AREA

soil profiles are selected and arranged in Annex 1. Common properties to all Types are omitted in the following explanations.

4.4.1 Soil Type 1

This Soil Type forms in deep-calcareous silt loam deposits which are found in "sebkhas' depressions all the way inside the coastal dunes. It shows almost no structural development (single or massive), but extremely high compaction. Salinity ranges 1.5 - 4 mmhos (1:5 soil-water extract) except of surface salt-crust layer which is often observed in this Type. pH exceeds 8.5 (1:5 suspension) in most cases, sometimes more than 10.0, assuming a high alkalinity. Calcaric Solonchaks may comprise this type of soils.

It prevails on almost flat lands. The extent is 1,720 ha in the surveyed area, occupying 12.4 percent of the total 13,850 ha. It has been used as date farm and partly mixed crop farm so far as irrigated, but the growth is generally very poor due to high salinity, nutrient definiciency and low permeability under insufficient irrigation management.

4.4.2 Soil Type 2

This Soil Type forms in similar fine-textured deposits as Type 1, but its top layer (0-50cm) is mainly sandy loam. No structure, and high pH as Type 1. Salinity is not so strong, ranging 0.1 - 0.5 mmhos. Surface is frequently crusty with lime substances.

This Type is situated on almost flat land along sebkha zone. Its elevation is a little higher than that of Type 1. It extends in 2,560 ha which corresponds 18.5% of the total Area and provides both mixed crop farm and residencial land for sohar Town area. The other areas are still vacant on Majis side and westward of the Highway except a few farms newly reclaimed on the latter side.

4.4.3 Soil Type 3

This is the third Type in Soil Series of silt loamy subsoil. It is overlaid with sand-textured upper layer (0 - 50 cm) with a high content of gravels. These deposits have been transported by wadi floods, showing a slight stratification of coarse sand. It contains much salt in subsoil, but has pH lower than that of Type 1. Together with Type 2, this Type may be included in the group of Haplic Yermosols though not based on analytical data.

It has developed along small wadis (see Figure E-8), occupying an area very small as 200 ha on Majs side. Judging from the genetic feature, such small patches must be found adjacent to every wadi bed, probably resulting in a bigger extension. It may be impossible, however, to delimit the patches on the Soil Map under the present survey level.

4.4.4 Soil Type 4

From this Type to Type 6, lower layer (50 - 100 cm) is sandy loam. Silt loam overlays in this Type, indicating a slow sedimentation on a flat area far from the wadi stream. This layer is sometimes interbedded by thin coarse sand laminations. Salinity is as low as 0.2 mmho. pH ranges 8.5 - 9.5. Structure is weak platy in surface layer. Silt loam horizon is very compact as a result of particle cementation with calcareous materials, imposing a lower permeability than the following Types.

Distribution is limited in a few areas about 400 ha in total, which are presently almost unused for agriculture.

4.4.5 Soil Type 5

This Soil Type differs from Type 4 only in the coarser texture of upper layer, that is, sandy loam. Consequenty, it is more permeable, less compact and almost not structured owing to insufficient evolution time under recent deposit formation. Both this Type and Type 4 are classified into Calcaric Fluvisols.

Areas of Type 5 are found on alluvial and aeolian sandy dune lands. The extent amounts to 1,050 ha, 7.6 percent of the whole Area. Only one area east of Sohar has been cultivated for mixed cropping.

4.4.6 Soil Type 6

Sandy loamy lower layer is overlaid by sand and gravel upper layers in this Type since it has formed with torrent deposits by wadis. Salinity is very low and pH is around 8.5. Because of its raw mineral materials of non-structure, this Type may belong to Calcaric Regosols. Its extent is 370 ha, occuring on slightly undulating lands nearby wadi bed.

The lands have been left unused due to the inferior soil conditions.

4.4.7 Soil Type 7

This Soil Type can be also classified to Regosols, but is caracterized by loamy sand lower soil which has been interbedded by gravels and superimposed by gravelly loamy sand or sandy loam layer. It forms on sandy dunes with some aeolian deposits. Non-saline and weakly alkaline.

This Type extends in 1,180 ha, occupying 8.5 percent of the total Area. The lands have been unused but only partly cultivated as date or fruit tree farms where surface is covered with less coarse-textured soil.

4.4.8 Soil Type 8

This Soil Type is sandy throughout the profile, prevailing all the way along the sea coast. It develops weak coase platy structure in upper layer. Salinity ranges 3.0 to 16.0 mmhos and pH exceeds 8.5. Lower layer is very compact, assuming massive structure. Considering extremely high salinity and no other special horizon, Orthic Solonchaks are applied to this Type.

It covers 640 ha of the sea coast zone, and supplies partly date farm and residencial space.

4.4.9 Soil Type 9

This Type develops upper side of Type 7, being situated along wadi beds.

Texture is sand in lower layer with more than 50 percents of gravels and loamy sand in upper layer. Non-structured and non-saline. With a very low nutrient potential, this Type is grouped in Dystric Regosols. In covers about 1,000 ha of the accumulation plains, so the lands could not have met any agricultural objects.

4.4.10 Soil Type 10

The last Soil Type is also a class of Regosols. Texture is sand with many gravels (actually gravel layer) which form wadi stream beds composing main part of the accumulation plains. The other soil properties are not different from those of Type 9. These bed areas will not by any means be developed for agricultural use.

E-5 Land Suitability Classification

In order to reclaim the land economically and cultivate rationally, the land should be subjected to the suitable crops and farm managements according to its soil characteristics.

Land suitability survey for irrigated agriculture is of paramount importance to identify new areas suitable for priority implementation of the agricultural projects as well as to investigate problems of land use in the existing farming. It is essential to take the best way of classification for successfully discriminating the classes among soil species found in the subject area.

5.1 Classification Method

Many processes of land suitability classification have been proposed in the agricultural development projects. In the present study, first investigated was how to select the main limiting factors for irrigated agriculture. Secondarily, it was attempted to decide land class by numerating evaluation of the limiting factors (hazards).

5.5.1 Suitability Criteria

Five items of the soil characteristics are chosen for the limiting factors from view points of land utility in the Project Area:

a. Texture (Symbol s)
b. Gravel content (%) (Symbol v)
c. Hardness (Symbol e)
d. Available depth (Symbol g)
e. Salinity (Symbol n)

Special concern has been paid to gravel content and hardness of the soil, which are considered to strongly affect the land use. Topography and drainage (permeability) are also important items, but these are omitted this time to avoid complication in the evaluation because of their less important prevalency in the Area.

Criteria for each factor are summarized in Table E-9. Its evaluation has five grades (values) from 0 to 4.

a) Texture

Soil texture is a major characteristic of the soil. It is correlated with important soil characters such as water holding capacity, aeration, water infiltration rate and many chemical properties related to soil fertility.

As shown in the table, ranges have some width of two successive textures, because upper 50 cm-depth must be evaluated with its

Table E - 9 Criteria of Soil Characteristics for Evaluating Land Classes of the Soils in Wadi Jizzi Project Area

Item	Value	Range	Remarks
Texture (s)	0	SiL - L (SiCL,CL)	Dominant texture within upper 50 cm depth
	1	L - SL	
	2	SL - LS	
	3	LS - S	
	4	S - S (GI-3)	
Gravel Content (%) (v)	0	< 2	Average within upper 50 cm depth
	1	2 - 15	slightly gravelly
	2	15 - 50	gravelly
	3	50 - 75	very gravelly
	4	> 75	gravel
Hardness (mm, index of Tester) (e)	0	< 8	soft
	1	9 - 15	slightly hard
	2	16 - 22	hard
	3	23 - 28	very hard
	4	> 29	extremely hard (pan)
Available Depth (cm) (g)	0	> 120	Depth to gravel or coarse sand layer
	1	90 - 120	
	2	60 - 90	
	3	30 - 60	
	4	< 30	
Salinity (EC, mmho per cm at 25°C) (n)	0	< 0.2	Average within 1 m; determined with 1:5 soil water extracts
	1	0.2 - 0.5	
	2	0.5 - 1.0	
	3	1.0 - 2.0	
	4	> 2.0	

dominat texture or combined ones. This depth may be sufficient for rating root-growing soil zone.

The more sandy is texture, the less value is given; sand only or gravelly sand is the strongest limitation not allowable for irrigation agriculture.

b) Gravel Content

No explanation is needed for the hazardous effect of gravels in the soil. High content of gravels limits not only the root-growing zone but also the tilth work which will be managed by agricultural machines in the near future. In mechanical farming it has been considered that gravels more than 20 mm in diameter would be obstacles to land reclamation and soil management as well. Reviewing the data of Table E-2, gravels bigger than 5 mm in diamter far dominate the smaller ones. In fact, most of the bigger gravels have a diameter of more than 20 mm in the accumulation plain, where the gravel content surpasses 30 percent. Problem is how to make ranges of the criteria in terms of gravel percent. The ranges arranged in the table are tentatively decided although have not been based on experimental data.

c) Hardness

Soil hardness (soil compactness or soil strength) is expressed in indexes of the Tester as was described in Appendix E-3. In the same manner as gravel, it behaves as a limiting factor in many way to crop production.

The criteria given in Table E-9 have been used in Japan for the soil capability classification in the national soil survey programs, being based on the survey results. In the research experiment, hardness of soil strata, if more than 23 (10 kg per square centimeter), could stop the root elongation of rice plants (Takijima, Y., 1977). Extremely firm subsoil frequently appearing in the coastal complex zone such as sebkha area will cause troubles on crop growth as well as field preparation efficiency.

d) Available Depth

This item is valuated with the depth where crop roots can penetrate, and usually does not include coarse sand layer or gravelly layer. Firmly cemented layer with calcium can be dealt with in the preceeding item.

e) Salinity

Salinity is the most important factor especially in the Project Area where saline problem has been involved because of some degraded date farms scattered along the coastal area.

Soil salinity expressed as EC is in general measured of the saturated water extract. In the present survey 1:5 soil-water extract was used for EC measurement. This EC_5 value is estimated very low, about seventh to tenth of the saturation extract, ECe. The criteria here are thus scaled from 0.2 to 2.0 mmhos of EC_5, which are largely equal to the criteria generally adopted.

Soil profile should be examined with both depth of surface and subsoil, respectively; Surface salinity is related to the existing crop damage and subsoil salinity may provide informations on the future risk in agricultural production. Yet this time average value on the whole profile is taken to make the process simple. Range 1.0 - 2.0 mmhos (3) which may correspond to around 8 - 16 mmhos of ECe have been assumed to be critical for normal crop growth.

5.1.2 Classification Process

Table E-10 is the results of classifying Soil Types on suitability for irrigated agriculture in the Project Area.

The process of land evaluation is as follows:

(1) First, read the value of each limiting factor on Soil Type.

(2) Totalize the values on each Soil Type.

Table E - 10 Evaluation of Limiting Factors and Land Class of Soil Types

Soil Type No.	Texture (s)	Gravel Content (v)	Hardness (e)	Available Depth (g)	Salinity (n)	Total	Land Class (Symbol)	Order of Land Class (Map Symbol)
1	0	0	3	0	4	7	Marginally suitable (S3en)	2
2	0	0	2	0	1	3	Highly suitable (S1)	1
3	4	2	1	3	3	13	Permanently unsuitable (U2sgn)*	4
4	0	0	2-3	0	1	3-4	Highly suitable (S1)	1
5	1	0	1	0	1	3	Highly suitable (S1)	1
6	4	3	3	4	0	14	Permanently unsuitable (U2sveg)**	5
7	3	1	2	3	0	9	Conditionally moderatly suitable (C2seg)*	3
8	4	0	2	3	4	13	Permanently unsuitable (U2sgn)*	4
9	4	3	3	4	0	14	" (U2sveg)**	5
10	4	4	3	4	0	15	" (U2sveg)**	5

Note : * - **; These express grade of topographical limitations.

(3) Decide the sphere of suitability with the total values considering relative importance among limiting factors.

According to FAO system, land suitability class is arranged as follows:

Order	Class	
S: Suitable	S1:	Highly suitable
	S2:	Moderately suitable
	S3:	Marginally suitable
C: Conditionally suitable	C2:	Conditionally moderately suitable
	C3:	Conditionally marginally suitable
U: Unsuitable	U1:	Currently unsuitable
	U2:	Permanently unsuitable

Subclass is further divided by attaching symbols of each factor when its value exceed 3.

As is clear in the table, numeration of total values is very convenient to decide each class and also to group the Soil Types of same class on the map by numbering in order of their suitabilities. Soil Type 6, 9 and 10 are only slightly different from Type 3 and 8 in sum of values, yet they are numbered 5 because of the worse topographical conditions.

5.2 Mapping of Land Classes

Land classes expressed as order number and subclass designation are mapped in Figure E-10. The best class, S1, distributes on both sides of the National Highway. The result can be compared with the map reported by ILACO (see Figure E-11). In this map, t and d in the marks of subclass indicate topography and drainage, respectively. Some descrepancies between two maps are recognized in method of classification and extent of subclasses on the map. It will be hoped to conduct more detailed soil survey when new extension areas are searched in future.

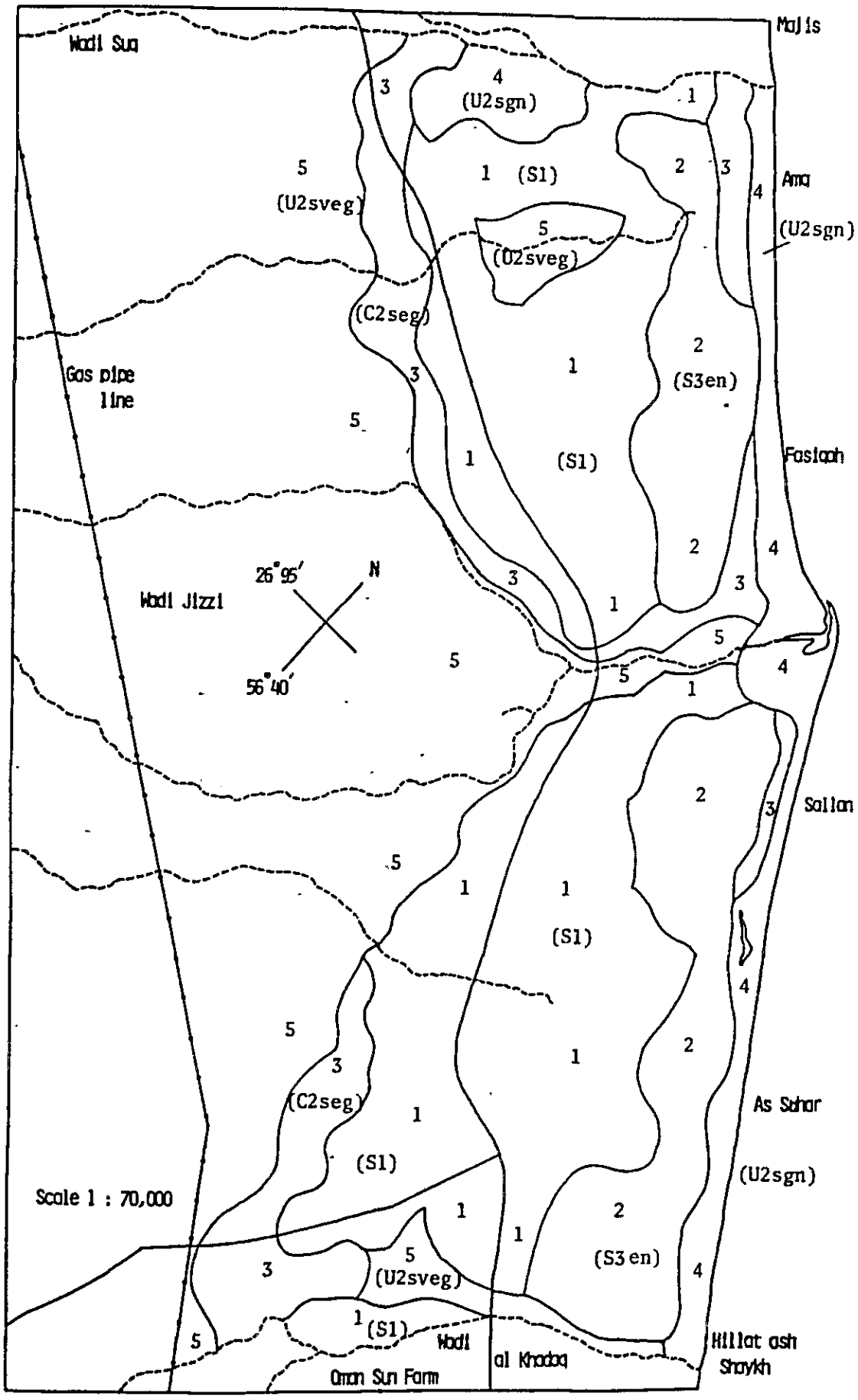


FIGURE E - 10 LAND CLASS MAP OF SOIL TYPES IN WADI JIZZI PROJECT AREA

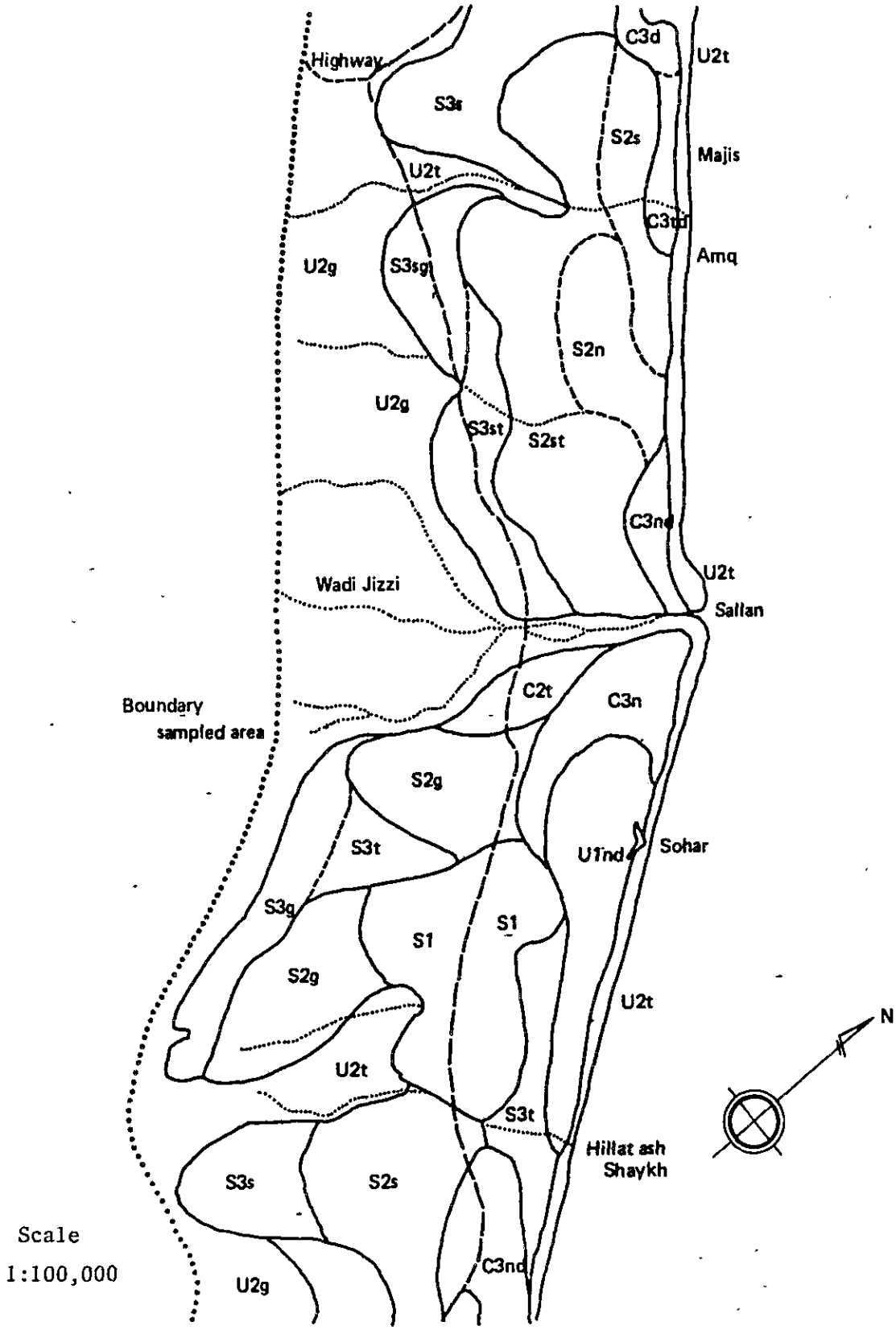


FIGURE E – 11 LAND SUITABILITY CLASSES FOR IRRIGATION REPORTED BY ILACO (1975)
– SOHAR AREA –

5.3 Area and Land Evaluation

The extent of each subclass Lands in hectarage is given in Table E-11. Results of land evaluation for land improvement and potential suitability are summarized in the same Table. Descriptions for each class are as follows.

5.3.1 Land Class S1

This class comprises lands of Soil Type 2.4 and 5. It covers 28.9% out of total and 4,020 ha in extent of the Area. Methodologically a land of this Class should not have any limitation. Yet these Soil Types have more or less limitations such as compactness or salinity though very weak in grade. No special land reclamation is now needed.

Range of crops suitable to be grown is so broad that cropping pattern is easily selected and the best beneficial return may be expected with proper farm managements.

5.3.2 Land Class S3en

Soil Type 1 is classified to this Class having moderate limitations in compactness and salinity. It is, therefore, marginally suitable for irrigated farming. This "sebkha" soil is silt loamy-textured and frequently very firm by cementation.

It needs deep plowing and a considerable amount of extra irrigation water in the first years to leach the accumulated salts, making the initial cost higher. Salt-tolerant tree crops such as date palm and citrus must be selected.

The lands have actually been used as main farm zone in Sohar town. Yet the production in mixed crop farm remarkably varies depending on the irrigation managements.

Table E - 11 Area and Land Evaluation of Soil Types in Wadi Jizzi Project Area

Land Suitability	Class and Subclass	Soil Type No. (Class order)	Area (ha)	Area (%)	Major Land Improvements Required: Intensive Levelling	Major Land Improvements Required: Leaching of salts	Potential Suitability 1/: Tree Crops: Dates	Potential Suitability 1/: Tree Crops: Fruit Crops	Potential Suitability 1/: Field or forage Crops	Potential Suitability 1/: Vegetable Crops
Highly suitable	S1	2,4,5 (1)	4,020	29.0			xxx	xxx	xxx	xxx
Marginally suitable	S3en	1 (2)	1,720	12.4		x	xxx	x	xx	x
	Sub-total		5,740	41.4						
Conditionally suitable	C2seg(t)	7 (3)	1,180	8.5	x				x	xx
Permanently unsuitable	U2sgn(t)	3,8 (4)	850	6.2						
	U2sveg(t)	6.9,10 (5)	6,080	43.9						
	Sub-total		6,930	50.0						
	Total		13,850	100.0						

Note : 1/: x; low, xx; medium, xxx; high.

5.3.3 Class C2seg

This Class includes only Soil Type 7 which is sandy-textured with fairly amount of gravels. Subsoil is very compact, limiting the available soil depth. Because of its terrain of sand dune character wind-protection measures will be necessary as well as sufficient and frequent irrigation. The land can be made suitable for some crops or vegetables on a flat topography so long as above inferior conditions are successfully met with good farm managements.

5.3.4 Class U2sgn and Class U2sveg

Class U2sgn comprises a land permanently unsuitable due to the strong limitations of soil that may not be surmounted with a reasonable expense.

Soil Type 3 and 8 are classified to this Class, their extent being small as totaling 850 ha and 6.2 percent of the Area. Limitations are coarse sandy texture, very shallow available depth and high salinity. In addition to these, topography is worse being located near wadi stream or along seashore.

Class U2sveg is definitely unsuitable with more limitations than the above Class. It includes Soil Type 6, 9 and 10, gravelly soils forming on wadi beds or along them. These lands have in fact been unused and may not be subjected almost permanently to any agricultural plan.

Area of Class U2 group reaches just 50 percent of total, if added with C2 lands, around 60 percent would not be cared for farm land consolidation for the time being.

The other Classes not listed this time such as S2, C3, U1 and so on will exist if more dense soil survey is conducted.

5.4 New Extension Areas Proposed

Extension of new agricultural areas well promised with source of irrigation water has been a permanent aspire in Oman to increase food production.

5.4.1 Existing Reports

Of the Sohar Area, land suitability surveys were carried out by ILACO as one of series of the Batinah Coastal Plain from 1973 to 1974 for six months. The results were summarized in 1975 as shown in Figure E-11. Taking the Wadi Jizzi as a center part, the Area was divided into nine suitable subclasses, three conditionally suitable and three unsuitable ones at a reconnaissance survey level. In the following semi-detailed soil surveys, the area situated between two small wadis near Sohar town was subjected to pit borings at a rate of one pit per 50 ha. The total hectarages surveyed were around 3,200 ha and out of them 1,600 ha uncultivated area were evaluated as suitable classes that would guarantee availability for future agricultural expansion. Figure E-12 illustrates the classified land distribution where S1, S2t, S2s, S2gt and S3t, S3g are grouped in areas available for expansion.

Afterwards in 1976 FAO reviewed the past data obtained by four consulting firms on soil and water management in Oman (Field Document No.4). In his document P.R. Hesse identified approximately 9,000 ha of suitable land be developed; 4,000 ha on the Batinah coast in the Saham, Sohar and Wadi Bani Kharus Districts. In the Sohar District about 770 ha of Class S1 land and 200 ha of Class S2 land were available for development based on the ILACO's report above mentioned.

Similarly in 1977 FAO soil consultant, Dr. M. El-Attar carried out a comprehensive soil study on the existing government production farms in the Batinah region in which he evaluated the Land suitability of the Sohar New Project Area. The area is shown in lower part of Figure E-13 together with the former area by Hesse. Laboratory

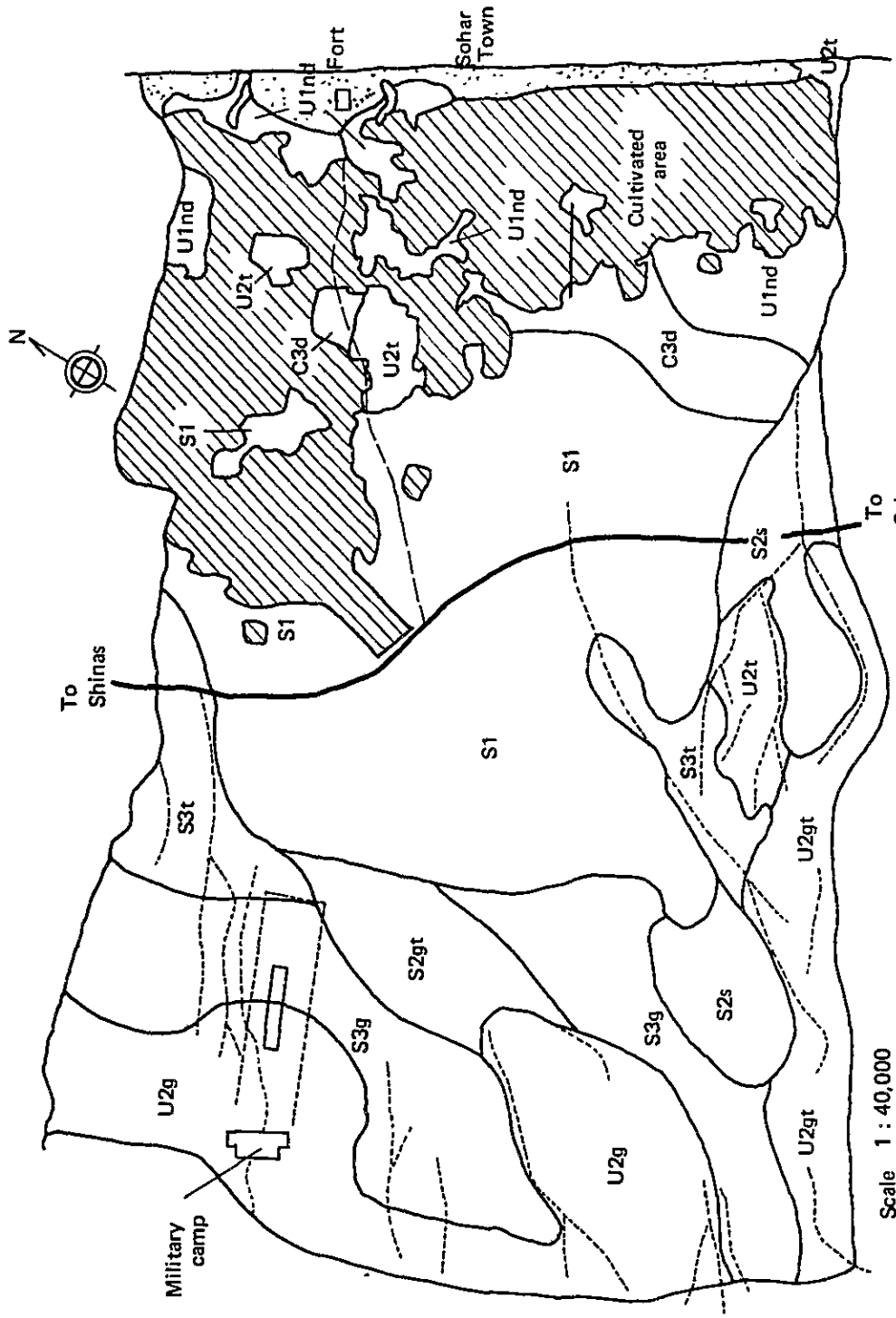
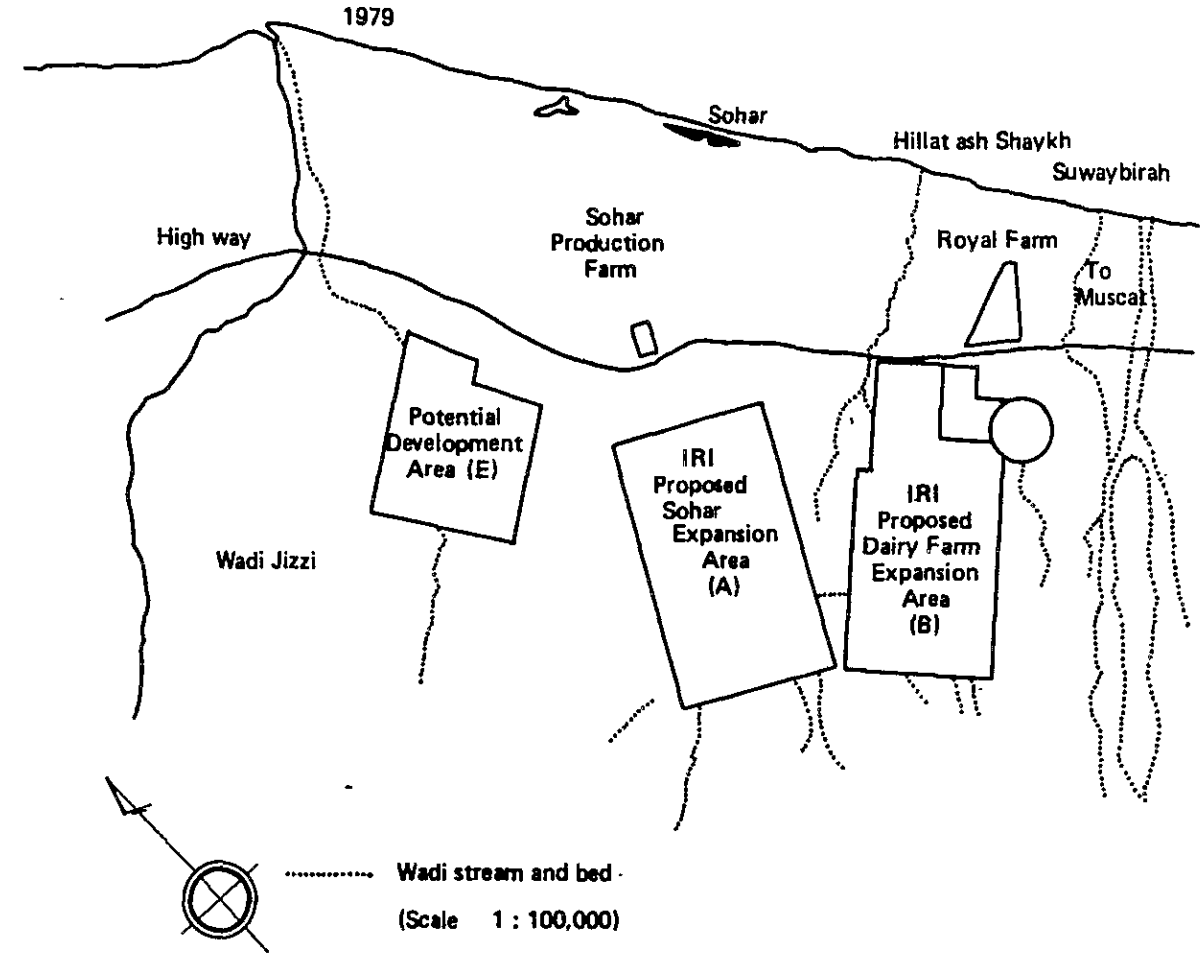


FIGURE E – 12 LAND SUITABILITY CLASS OF SOHAR AREA (ILACO, 1975)



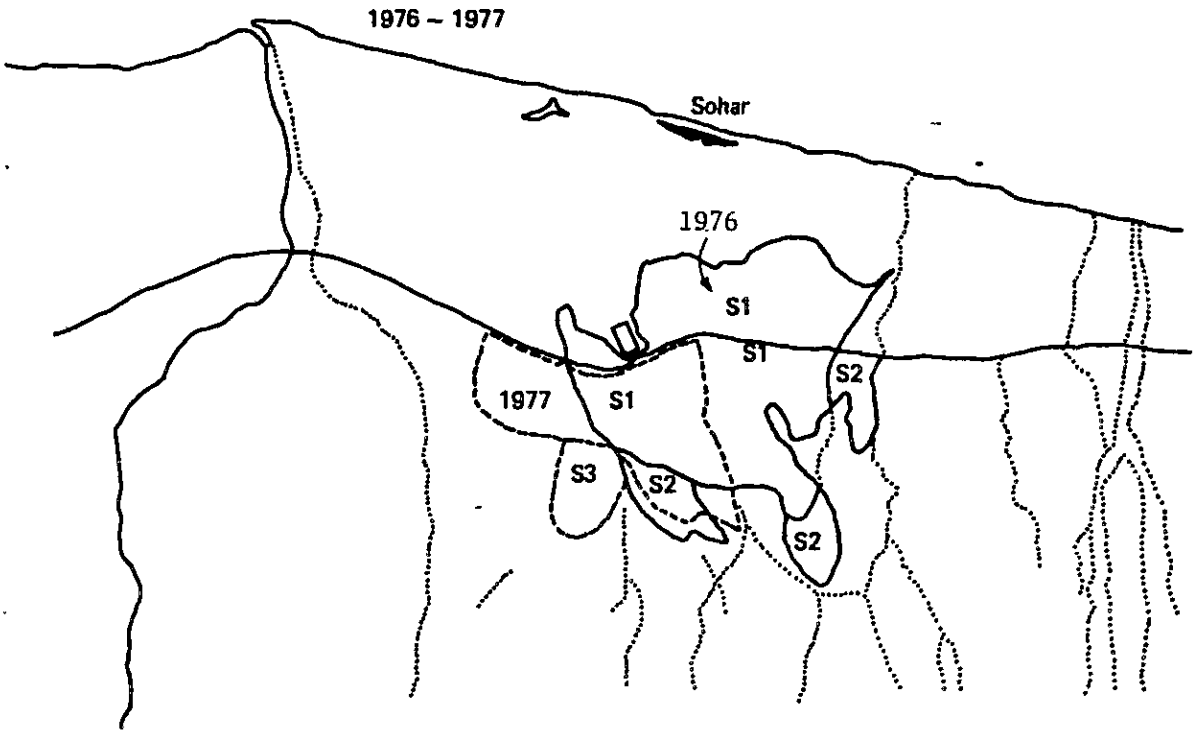


FIGURE E – 13 FORMERLY PROPOSED DEVELOPMENT AREA IN SOHAR DISTRICT (1976 – 1979)

analyses of the soil chemical properties were also made at Rumais Agricultural Research Station. The report (FAO, OMA/77/001) paid special attention to farming practice and fertilizer use from view points of the nutrient status of soil and well water.

More recently in 1979, FAO Project (OMA/77/001, Field Document No.12) also presented a map of the proposed development areas in the Sohar District which were compiled from the former reports as well. The areas are outlined in the upper part of Figure E-13.

These soil survey and land development planning on the Sohar Area have been thus focussed to the southwards area of the Wadi Jizzi, acrossing the National High Way (Muscat-Sohar Road) and stretching up to the sites of Oman Sun Farm and Royal Farm. In fact, Oman Sun Farm has been expanded with these recommendations to 550 ha.

5.4.2 Present Study

a) Project Area

In the present study it would be emphasized that the survey included the northward of Wadi Jizzi upto Amq. Table E-12 gives the whole areas of each Class land by dividing the Project Area into four sections with the lines of the Highway and Wadi Jizzi center stream. The Suitable Classes (S1 - C2) dominate in the eastward of the Highway, in total occupying nearly 50 percent of the Area. The Unsuitable lands, classified as U2 which are considered permanently so, comprise wadi bed, its vicinity, gravelly plain, and coastal area.

The net extent of the lands, however, available for agricultural development is much less than expected since most of the class order-2 lands (S3en) and nearly half of the Class order - 1 (S1) have been used for farms and houses. Only the class order - 3 lands remain undeveloped by around 60 percent because of their gravelly property. Figure E-14 illustrates these net lands still available to be developed. Their hectarages in four sections are measured and summarized in Table E-13.

Table E - 12 Sectinal Distribution of Land Classes in Wadi Jizzi Project Area

(Unit : ha)

Areal Section		1 S1	2 S3en	3 C2seg	4 U2sgn	5 U2sveg	Total	%
Left Side of Wadi Jizzi Stream	Westward of the Highway	280	0	350	0	3,510	4,140	29.9
	Eastward of the Highway	1,330	670	370	480	230	3,080	22.3
	Total	1,610	670	720	480	3,740	7,220	52.1
Right Side of Wadi Jizzi Stream	Westward of the Highway	1,070	0	410	0	2,250	3,730	26.9
	Eastward of the Highway	1,340	1,050	50	370	90	2,900	20.9
	Total	2,410	1,050	460	370	2,340	6,630	47.9
All Total		4,020	1,720	1,180	850	6,080	13,850	
%		29.0	12.4	8.5	6.2	43.9		100.0

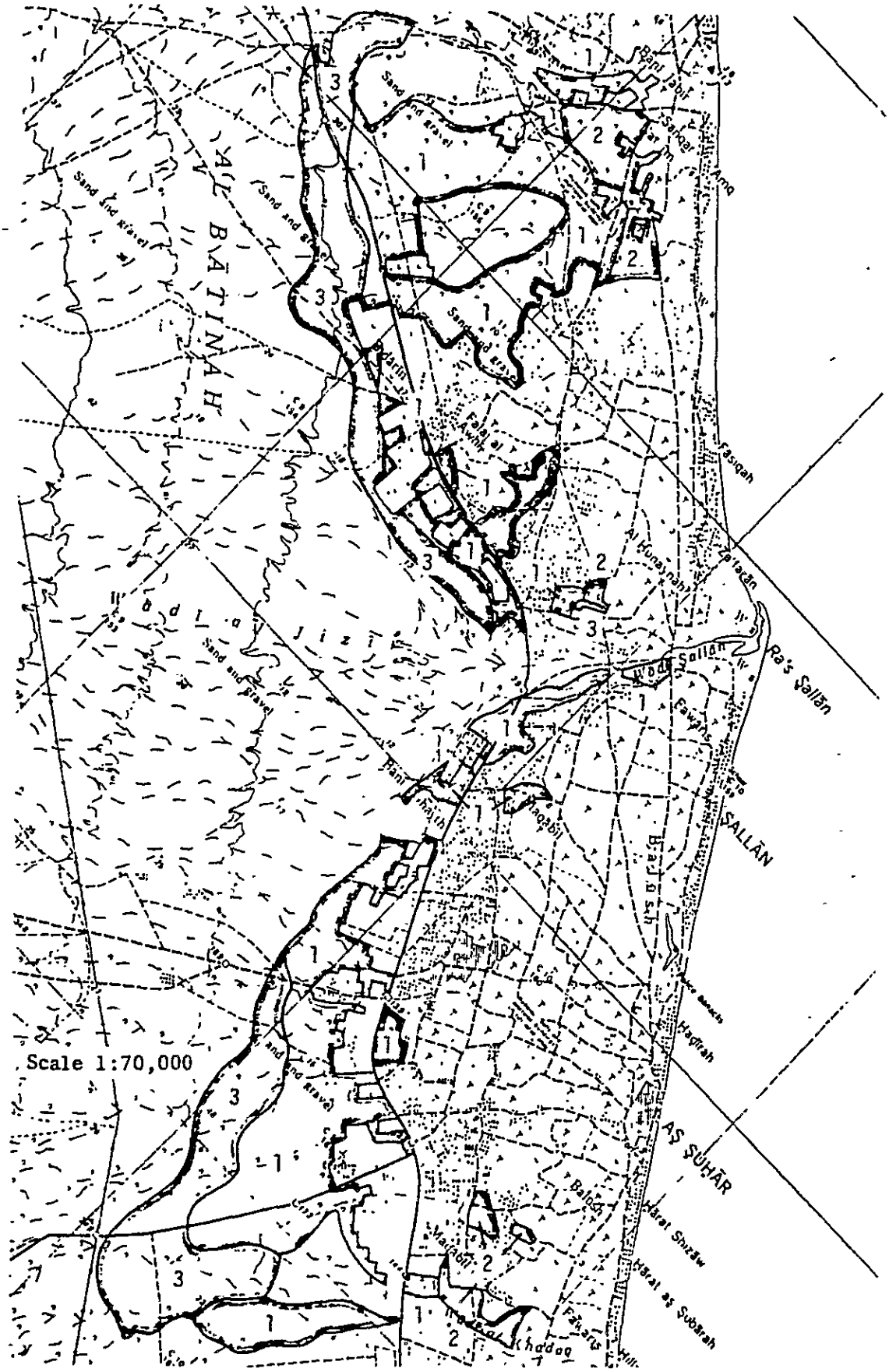


FIGURE E - 14 DISTRIBUTION OF SUITABLE CLASS LANDS NOT YET DEVELOPED IN THE PROJECT AREA

Areas are circled by grey color frame.
Numbers, 1-3, show the Class order.

Table E - 13 Net Hectarages of Extensionable Lands in Wadi Jizzi Project Area

(Unit : ha)

Areal Section		Land Class 1 (S1)	2 (S3en)	3 (C2seg)	Total
Left Side of Wadi Jizzi Stream	Westward of the Highway	132	0	327	459
	% of Class Area	47.1	0	93.4	
	Eastward of the Highway	643	169	7	819
	% of Class Area	48.3	25.2	1.9	
	Area Total (ha)	775	169	334	1,278
Right Side of Wadi Jizzi Stream	Westward of the Highway	702	0	410	1,112
	% of Class Area	65.6	0	100.0	
	Eastward of the Highway	109	63	0	172
	% of Class Area	8.1	6.0	0	
	Area Total	811	63	410	1,284
	Area All Total	1,586	232	744	2,562
% of Total Class Area		39.5	13.5	63.1	37.0

Note : Net area is vacant land excluding those already used as farms and residences.

The most promissing areas (S1) existing in groups are found both in the eastward and westward of the Highway being separated on the left and right side of Wadi Jizzi, respectively. These amount to 1,586 ha in total.

Considering the land encroaching progressing year by year by construction of new farms and dwellings in this Area, the agricultural development should be planned systematically without delay. This is particularly so with the dwellings which have invaded the vacant land untouchably.

b) New Extension Area

In the present study, the westward of the Highway on the right side of Wadi Jizzi is directed to a new extension area from view points of the limited water resources and the other technical problems and social circumstances as well (see Main Report).

As shown in Figure E-6, the area is scheduled to be 100 ha and is situated at Al-Wagabeh along Hibi Gravel Road. Investigating the results of the past and present soil survey described higherto where six pits and 10 bores have been examined around the site, distribution of Soil Types was mapped again. Figure E-15 is the revised map scaled at 1:10,000. As a result, there are seen some changes in border lines and newly set up of Type 5 which is not shown in the general soil map of the Area (See Figure E-9). Land Suitability Classes of these Soil Types existing there are as follows:

Soil Type No.	Land Class	Texture (Upper 50cm)-(Lower 50cm)	Sand or Gravel Layer (%)	Salinity
2	S1	SiL/SL - SiL	0 - 3	Slightly saline
4	S1	SiL - SL	0 - 3	Very slightly saline
5	S1	SL - SL/LS	0 - 10	Very slightly saline
7	U2seg	SL(LS) - LS(S,G)	0 - 10	Non saline

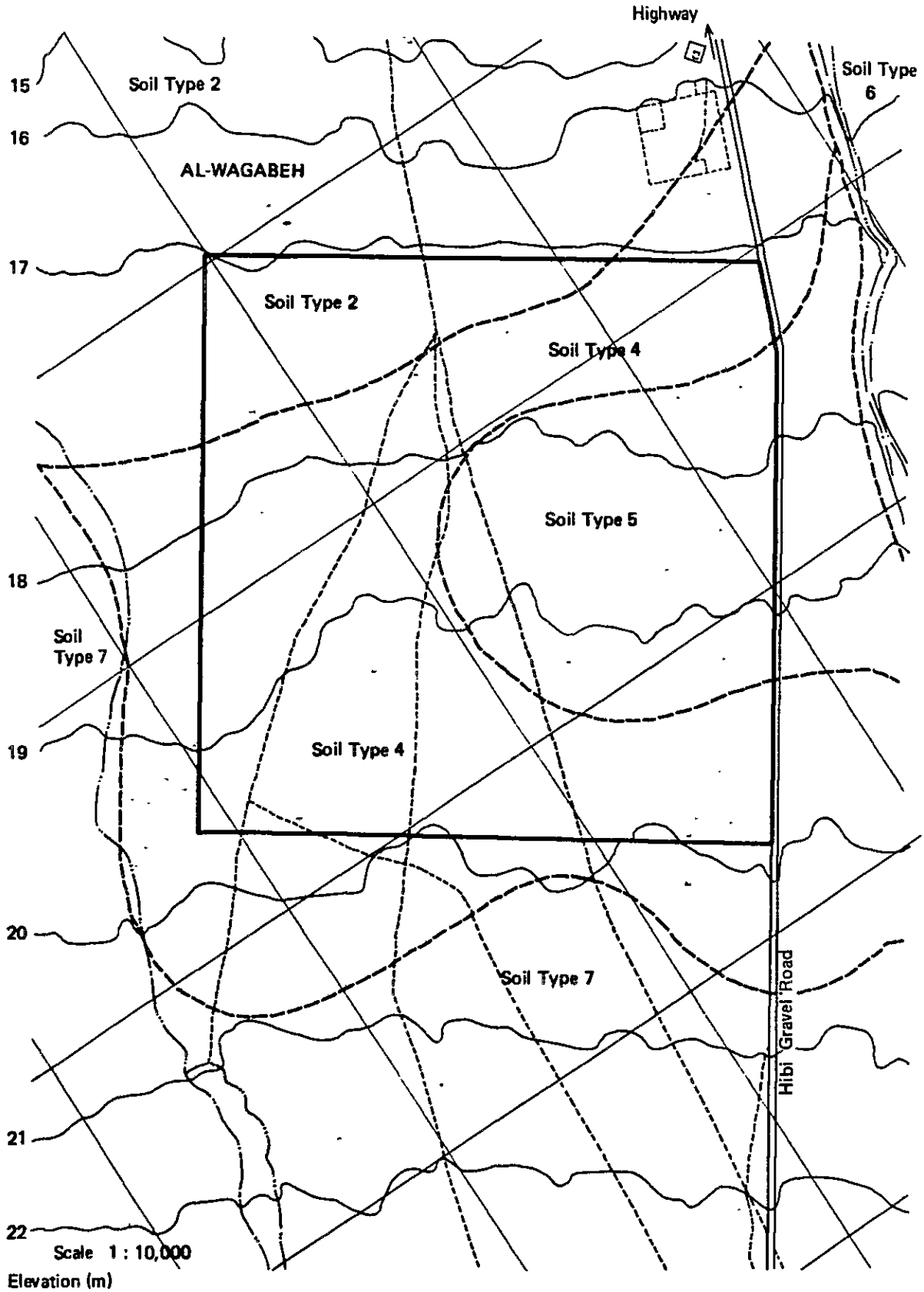


FIGURE E – 15 NEW EXTENSION AREA PROPOSED AND SOIL TYPES IN ITS VICINITY

Although most of the soils are classified to S1, their properties are not allways the best in texture, permeability and fertility. These will be refered to in the next paragraph. Anyhow, including the correct distribution of the soils, a more intensive survey must be carried out upon the farm establishment.

E-6 Problems and Recommendations

Soils of Batinah Coastal Plain are in general non-fertile and more or less have a saline and/or alkaline property, since they have developed near recently on the coarse alluvial deposits without any structural differenciation and any accumulation of organic matter under the supply of weathered products derived from basic rocks and the arid climatic conditions. Those found in the Project Area are not an exception, being unable to escape from these problems.

6.1 Soil Salinity

6.1.1 Salinity measurement

Saline status of the soil is one of the most important factors in the Area. Usually most of its interpretation has been made on the basis of electrical conductivity measured with water-saturation extract of the soil.

For routine work, particularly in the field test, however, this needs more or less tredious procedure and so 1:5 water extract is often used because it is more easily obtained by decantation. Problem is only how to estimate ECe(saturation) values from EC_5 (1:5 extraction) measurements.

To find the correlation between them, a simple test was attempted during the survey by synthesizing the samples of two different texture and two different salinities. Table E-14 gives the results and Figure E-16 plots the values on a double logarithmic graph together with those of one pit reported by ILACO (Harmul Pit A).

Table E - 14 Effect of Soil to Water Ratio on the Electrical Conductivity of Water Extracts Using the Sohar Soil Samples

Soil Sample	Texture	Salinity	Saturation Percentage	EC, mmhos/cm at 25°C Ratio of Water/Soil						ECe/EC$_5$	ECe/EC$_2$
				Saturated (ECe)	0.5	1	2 (EC$_2$)	3	5 (EC$_5$)		
1	SiL	high	38.0	21.9	-	10.0	4.90	3.36	2.42	9.0	4.5
2	SiL	low	43.6	2.41	2.22	0.71	0.49	0.40	0.27	8.9	4.9
3	LS	high	20.0	20.6	-	7.58	4.49	3.18	2.14	9.6	4.6
4	LS	low	24.0	0.76	0.34	0.14	0.10	0.09	0.08	9.5	7.6

Note : The samples were prepared by mixing several soil samples taken from the pits in the Area. Amounts of soil used at each determination ranged from 20 to 400 g with the decreasing ratios of soil to water. Supernatant solution or filtrate in case of saturated paste were measured on electrical conductivity with Portable EC Meter.

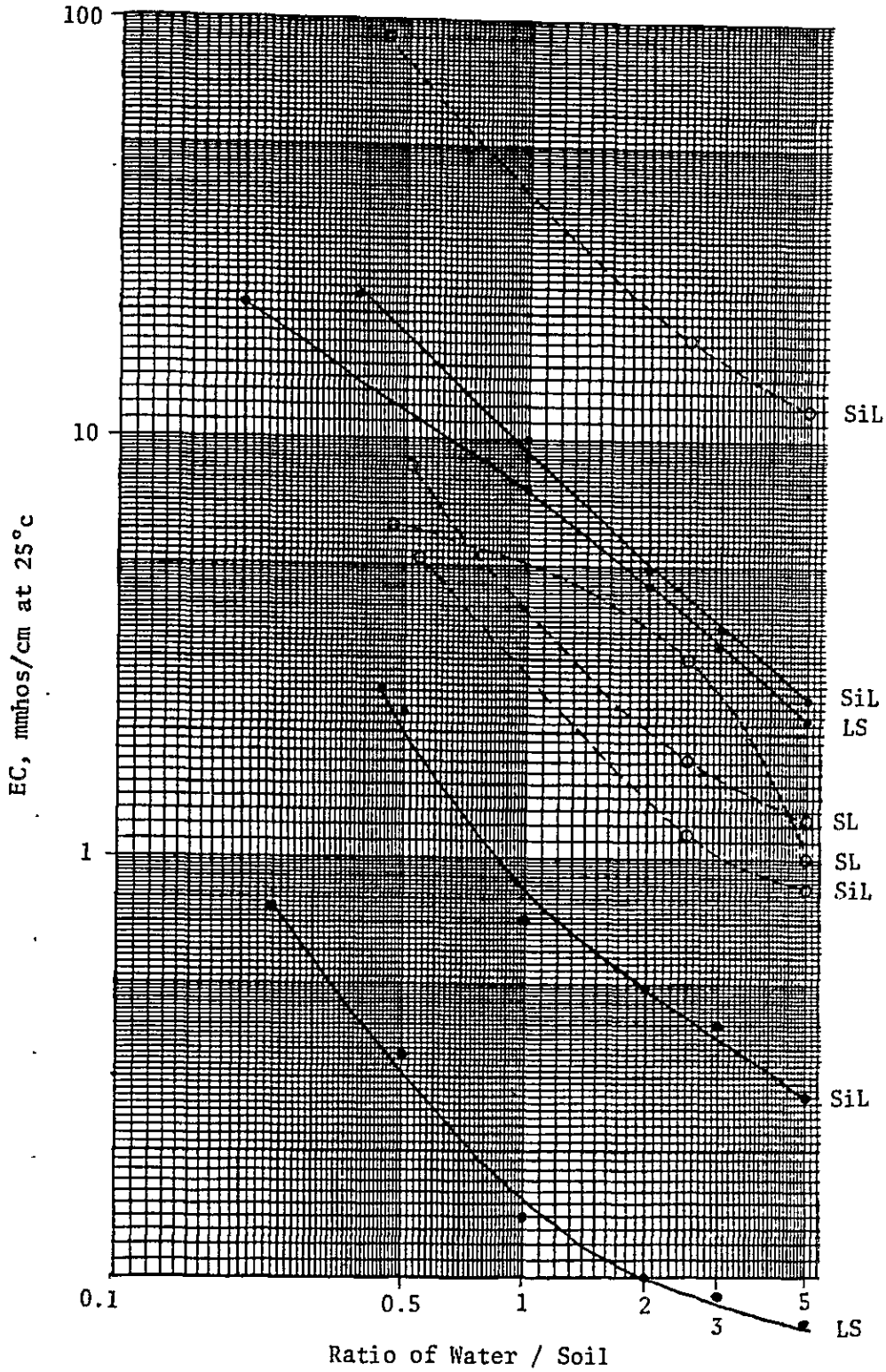


FIGURE E - 16 RELATIONSHIPS BETWEEN SOIL TO WATER RATIO AND ELECTRICAL CONDUCTIVITY OF ITS EXTRACT

According to the theory of ion adsorption equilibrium in the soil, nearly a linear correlation should be obtained as was shown in Figure E-2. Yet, if some gypsum is present, the line will remarkably change its angle because of increased solusion of the salt with the increasing soil to water ratio. Figure E-16 does not show the straight lines with all samples. The ratio of ECe/EC5 also varies from 6 to 9 among both soil groups. Therefore, to convert the EC measured at high soil to water ratio into the ECe, the convertion coefficients must be obtained from similar curves prepared for each textural group of the soils. With regard to soil to water ratio, 1:2.5 may be more adequate with most of the soils for the more accuracy of EC measurement. This is particularly probable with those soils in Oman.

In general the coarser texture is, the greater become the coefficient owing to the less saturation percentage and base exchanging capacity of the soil.

6.1.2 Salinity Damage

As a result of the land classification (Table E-10),Soil Types 1 and 3 have a fairly high salinity of the soil, prevailing on almost all existing farm lands. Poor growth of farm dates is in fact observable in some places near the sea coast and among thick farm areas more inland whatever would cause the damage. In spite of lack of hard evidences, most of the survey reports have suggested the threat of saline intrusion which might be resulted from local "upcoming" of sea water, and the cause has been assumed to be over-exploitation and over-draft of the whole aquifer.

Since a high soil salinity was found in the coastal stip areas under long time cultivation, Gibb and ILACO concluded in their Final Report (1975) that a delicate equilibrum has to be maintained between the pumpage of groundwater and the penetration of seawater. They also suggested that the results of the soil and water resources studies would favour a future development in which irrigated farms

are gradually relocated from the agricultural strip along the Batinah seashore to the new one a few kilometers more inward. Such comment is questionable, however, from the following reasons so far as the present survey results are concerned:

1) Worse growth of dates was visible only in the poorly water-managed farms in the problem area.

2) Soils of the better managed farms did not show any evidence of salt accumulation even when high saline well water more than 1.5 mmhos has been used for long time.

3) Such high soil salinity as measured in the survey can be decreased to below the critical value (4 mmhos) by means of leaching procedure using sufficient well water under reasonable soil managements.

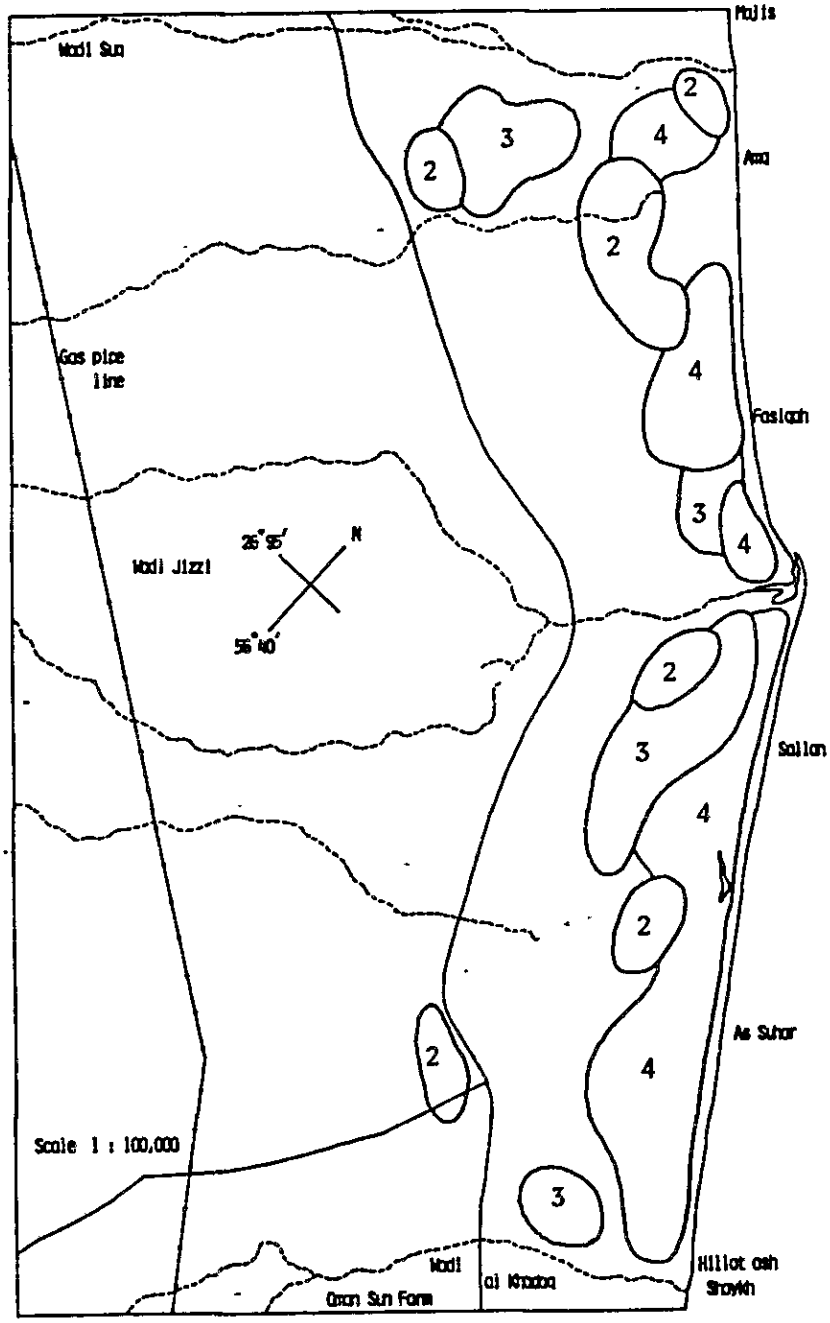
Reservation of the old farm lands is therefore of first importance because most of them had been reclaimed long beofre by farmers, occupying the best quality soils of finer textures. It is therefore quite necessary to obtain additional water resources by reserving the underground streams of the wadi.

Anyway it is not denied that salt damage may be a continual potential danger along the Batinah coast. A periodical monitoring of soil salinity by means of EC measurement with water extracts of soils must be scheduled as has been carried on in the Rumais region.

The areas to be especially monitored are estimated as presented in Figure E-17 by compiling the results of the study (Figure E-4) and ILACO's survey.

6.2 Irrigation Water Quality

In irrigated agriculture, quality as well as quantity of the irrigation water is of the greatest significance. Similarly as in



Legend:

Grade	EC, mmhos/cm at 25°c
1	< 4
2	4 - 8
3	8 - 16
4	> 16

FIGURE E - 17 DISTRIBUTION OF SOIL SALINITY TO BE MONITORED IN WADI JIZZI PROJECT AREA

the other areas in Batina Region, the existing agriculture and surely the future expansion can not change the position of relying all of the water sources on wells and falajs from which groundwater has been obtained.

Almost all well water samples were found saline to some degree according to the present survey. Especially in the coastal and "Sebkha" zones, the EC values frequently exceed 2 mmhos, far beyond the commonly accepted criterion, 0.75 mmho. In one farm at Al Zafarah, 4.6 mmhos was recorded of the well water, where very poor growth of date palm and other fruit trees were observed.

According to a rough estimation, the extent using irrigation water having the EC value over 0.75 mmho will amount to one third of the whole coastal zone covering most of the existing farms. On the wadi-gravelly plains, westward of the Highway, salinity is very low except at the side of Oman Sun Farm probably due to the bigger pumping after its establishment.

Thus, unless continuous vigilance is taken, there will be a threat to the expanded agriculture in deterioration of the soils. This requires also a monitoring system of irrigation water together with soil salinity. Simultaneously, sufficient linkage of the irrigation canals with the drainage systems must be facilitated.

However, detailed chemical analysis of the groundwaters mostly taken from the gravelly plain during the Second Stage Study has been reported in Appendix C, realizing moderate good quality for irrigation water use. Their EC values range from 0.4 to 1.0 mmho. Cation status is characterized by the predominancy of magnesium followed by natrium. As a result, SAR values are very low from 1 to 3. The water quality is ranked at C2-S1 of USDA Criteria and has no apprehension for long time irrigation so far as its source is gained from the groundwater running under the wadi bed area and the irrigation facilities are sufficiently equipped in newly extended farms.

In respect to salt content of the natural water, the convertion formulas from EC value to ppm or percent have been made available by Hesse for Alfaj and well water in each geographic area of north and north-east Oman. Based on Hesse's analysis of the collected data, chemical composition differs notably between falaj and well waters; as compared with falaj waters, well waters have a greater ratio of chloride to sulphate as well as that of chloride to hydrogen carbonate and of calcium to magnesium. The well waters also contain more sodium although no direct evidence for sea water contamination has been found.

6.3 Soil Alkalinity

So far as the soils surveyed are concerned, very high pH more than 8.5 is prevailing all over the Project Area. This is quite severe in the sebkha silt loamy area, often revealing extremely high pH more than 10 in the subsoils. The alkalinity is considered to be derived from the lime-rich parent materials, but remaining some suspicions that it might be partly caused by the cumultive enrichment of the soil with calcium and sodium salts resulting from the long year irrigation with poor drainage management. Particularly in the finer textured soils, sodium-rich water will react with their clay particles, cation exchange complexes, resulting in a higher exchangeable sodium percentage (ESP).

Such cases have an intimate relation to the sodium status of the water, called sodium adsorption ratio (SAR) which classifies the water for possible alkalinity hazard. There are reported so many evidences in other places of the World, where irrigated agriculture using high SAR water has suffered from the clay dispersion resulting in a poor permeability with subsequent lower productivity. Consequently, water quality should be analized chemically for each source. Alkalinization of the soil will be the second subject of monitory survey.

6.4 Soil Fertility

Poor nutrient availability has been pointed out for overall Oman

soils. Those of Sohar area are not an exception. Without any National Survey, however, only a few reports have dealt with laboratory analysis of the soil samples taken from several soil pits. These data are referred to in Annex 2 to 4.

Being lack of analytical values, varying depth and textures, averaging data is not practical, but summarizing them in terms of value ranges may be useful to investigate the soil fertility. Table E-15 gives the ranges of analytical values pertaining to the fertility. According to the respective criteria, most of the items are rated low or medium except available potassium. For example, one Sohar soil contained available nitrogen at a very deficient rate as 3 to 5 ppm as NO_3. Overall subsoils are poor in nutrients besides calcium and magnesium.

Such being the circumstances, not only chemical fertilizers bul also organic fertilizers, that is, compost and green manures are highly recommended. In case of chemical fertilizers, split application or combination of a drip or sprinkler irrigation must be practiced since the soils are in general very low in water - and nutrient - holding capacity and high in permeability due to the coarse texture and small cation exchange capacity (CEC).

Considering extremely high pH of the calcaric soils prevailing over the Project Area, physiologically acidic fertilizer, e.g. ammonium sulfate, can be better used.

Another concern must be taken about micro-nutrients which can be studied in the Research Stations. One problem is pointed out on their low content or scarse availability of zink, copper and manganese due to the high alkalinity of the soils. Content of active manganese seems very small as estimated by the reagent test in the survey. In fact, leaves of the lime trees grown on the mixed crop farms showed some symptons which seemed from deficiency in any micro-nutrient though unknown.

Table E - 15 Overall Fertility Properties of Sohar Area Soils

Item		Surface Soil (0 - 20 cm)	Subsoil (20 - 100 cm)
Organic Carbon	(%)	0.1 - 0.7	0.1 - 0.3
Nitrogen	(%)	0.01 - 0.06	0.01 - 0.03
CEC	(me/100g)	6 - 15	4 - 10
Available P_2O_5	(ppm)	5 - 20	1 - 8
Available K	(ppm)	70 - 180	40 - 100

Note : Interpretation Rating Chart for Soil Test Data

	Nutrients		
Rating	Organic Carbon (as a Measure of Available Nitrogen)	Available P	Available K
Low	Below 0.5%	Below 5 ppm	Below 50 ppm
Medium	0.5% - 0.75%	5 ppm - 12 ppm	50 ppm - 125 ppm
High	Above 0.75%	Above 12 ppm	Above 125 ppm

Excess of boron was on the contrary anticipated by El-Attar (1977) on the Sohar Production Farm where one of well water showed a high content of more than one p.p.m., inhibitory concentration to plant growth.

Study of micro-elements needs to be carried out in the near future for this Area.

6.5 Soil Managements

In saline farms, special care has been taken extensionally as well as empirically in selecting crops based on their salinity tolerance. The following Tables E-16 and E-17 are referred to how to decide the cropping pattern suitable to the field. If surface soil salinity become over 16 mmhos, the field must be leached inevitably, being followed by intense and frequent irrigation.

With regard to usual soil managements, plowing should be done carefully after wetting the dry soil to an adequate humidity which may decrease the soil consistency. Frequent plowing is not recommended because it will destroy the weak structure and aggregates. Sometimes deep plowing is effective to improve permeability of the subsoils when they are silty and hardly cemented in such soils as Type 1 and 3.

Table E - 16 The Tolerance of Some Crops to Soil Salinity in the Near East

Crop	EC of Soil Saturation Extract
Barley	17
Sugar beet	16
Cotton	12
Wheat	14
Oats	12
Corn	7
Tomato, Cabbage, Cauliflower, Lettuce, Potatoes, Carrots, Onion, Squash, Peas, Cucumber	5
Beans	4

Table E - 17 Relative Tolerance of Various Crops to Soil Salinity

(USDA Handbook No.60)

High Salt Tolerance ECe 10 - 16 mmhos	Mediun Salt Tolerance ECe 4 - 10 mmhos	Low Salt Tolerance ECe 2 - 4 mmhos
Date palms	Pomegranate, Fig, Olive, Grape, Cantaloup	Pear, Apple, Orange, Grapefruit, Lemon, Plum
Beet, Spinach, Asparagus	Toamto, Cabbage, Pepper, Cauliflower, Lettuce, Maize, Potatoes, Carrot, Onion, Peas, Squash, Cucumber	Radish, Celory, Green beans
Barley, Cotton	Wheat, Oats, Rice, Sorghum, Sunflower	Red clover, Peas, Sugar cane

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Annex. Profile Description and Laboratory Analysis Data

Annex 1. Description of Representative Soil Profiles
(Location of pits is referred to Figure E-3)

Annex 2. Report of Soil Pit Survey on Water Resources Development Project-Northern Oman (ILACO, 1975)

Annex 3. Report of Agricultural Development Program (FMC Agricultural Survey, 1975)

Annex 4. Report of Development of New Land for Irrigated Agriculture (Soil Consultants, 1977)

I	(a) Profile No. OS1		(d) Date Apr. 2, 1981	(e) Author Mr. A.S.Al-Hassni & Dr. Y.Takijima	(f) Province Sohar; (f) Country OMAN
I	(b) Soil Series Soil type 1	(c) Soil Class Calcic Solonchaks	(c) Land System	(f) Location Abdulla M. Farm, Fasiqah; 1km inland of sea coast	
I	(f) Latitude	(f) Longitude	(g) Elevation 10m; (h) Land form	(1) Physiografic position Slight depression	(2) Land form of surrounding country Almost flat; (3) Microtopography
I	(i) Slope 0.1%	(j) Vegetation Land use Uncultivated, surrounded by date farm with some fruit trees	(k) Climate	(k) Monthly mean temp.; (k) Annual rainfall	II (a) Parent materials Wadi Jizzi alluvium, calcareous
II	(b) Drainage Well drained	(c) Moisture condition dry to 10cm, moist below	(d) Ground water table 8m	(e) Surface stones rock outcrops None	(f) Erosion Slight water deposi; (g) Salt alkali Saline & alkaline; (h) Human influence

IV (a) Horizon	(b) Depth cm	(c) Colour moist (1)/(2) dry	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutans Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, ON %	(q) Content of roots.	(r) Nature of boundary	(s) pH H_2O	pH KCl $CaCl_2$	(t) Apparent Density	(u) Exch Acidity / Extract (v) K ppm	(w) CEC (x) B.S %	(y) E.C. micromho 1:5/past
	0–10	10YR 6/3	none	SL	single (salty crust of top 2cm)	non-sticky non-plastic very friable loose (5)	none	few very fine pores	none	very few minute fragments of fresh gravel	none	none	abrupt smooth	8.75		1.38			6.80
	10–65	10YR 5/4 / 10YR 6/3	none	SiL	massive (weak very coarse blocky)	sl. sticky non-plastic friable sl. hard (12)	none	few very fine pores	none	trace	none	none	abrupt smooth	9.60		1.33			1.95
	65–100	10YR 5/4 / 10YR 6/3	none	SiL	massive (weak very coarse blocky)	sl. sticky non-plastic firm sl. hard (16)	none	few very fine pores	none	trace	none	none		9.55		1.23			1.80

I	(a) Profile No. OS2		(d) Date Apr. 2, 1981	(e) Author	(f) Province Sohar	(f) Country OMAN
I	(b) Soil Series Soil type 1	(a) Soil Class Calcic Solonchaks	(a) Land System	Location (f) Mohammed Salim Al-Gabri, Amq; 1.5km inland of sea coast
I	Latitude (f)	Longitude (f)	Elevation (g) 5m	(h) Land form	Physiografic (1) position Slight depression	(2) Land form of surrounding country Slightly undulating	(3) Microtopography
I	Slope (i) 0.3%	(j) Vegetation Land use Uncultivated, near date farm with some fruit trees	Climate (k)	Monthly mean temp. (k)	Annual rainfall (k)	II (a) Parent materials Wadi Jizzi alluvium, calcareous
II	Drainage (b) moderately well drained	(c) Moisture condition slightly moist	(d) Ground water table 6m	(e) Surface stones rock outcrops moderate small pieces of shells	Erosion (f) weak sheet erosion	(g) Salt alkali Saline & alkaline	(h) Human influence

IV (a) Horizon	(b) Depth cm	(c) Colour moist (1) / (2) dry	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutans Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, OM %	(q) Content of roots.	(r) Nature of boundary	(s) pH H_2O	(s) pH KCl / $CaCl_2$	(t) Apparent Density	(u) Exch Acidity / Extract (v) K ppm	(w) CEC (x) B.S %	(y) E.C. micromho 1:5/past
	0.5	10YR 7/2; 10YR 5/4	none	SL	none	non-sticky non-plastic very friable firm	none	many very fine pores, weakly cemented	very frequent minute fragments of weathered lime stone --(59.2%) (0.2-0.5cm)	none	none	none	clear smooth	8.50		1.83			40.8 (118.0)
		10YR 7/2	none	SiC	massive	sl. sticky slightly plastic very firm very hard	none	few very fine pores	few minute fragments of weathered lime stone ---(8.9%) (0.2-1cm)	none	none	none	clear smooth	10.25		0.96			1.40
	60; 77	10YR 5/4; 10YR 7/2; 10YR 6/3	few fine to medium, distinct white mottles	SiL	very weak very coarse blocky	sticky slightly plastic ext. firm ext. hard (30)	none	few very fine pores, weakly cemented	frequent small fragments of weathered lime stone --(19.6%)	none	none	none	clear smooth	10.24		0.89			0.90 (0.17)
	100	10YR 7/3	none	SiL	massive	sl. sticky slightly plastic very firm very hard	none	few very fine pores, weakly cemented	trace	none	none	none	clear smooth	10.20		0.90			0.62
																			(frag-ments)

Depth scale (cm): 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160

I	(a) Profile No. OS21			(d) Date Apr. 8, 1981	(e) Author	(f) Province Sohar / (f) Country OMAN
I	(b) Soil Series Soil type 1	(a) Soil Class Calcic Solonchaks		(a) Land System	Location (f) Al-Himbar, near Ali Al-Savhori Farm;	
I	Latitude (f)	Longitude (f)	Elevation (g) 12m ?	(h) Land form / Physiografic (1) position	(2) Land form of surrounding country flat	(3) Macrotopography
I	Slope (i) 0%	(j) Vegetation Land use Uncultivated, some big acasia trees and small shrubs	Climate (k)	Monthly mean temp. (k)	Annual rainfall (k)	II (a) Parent materials Wadi Jizzi alluvium, calcareous
II	Drainage (b) moderately well drained	(a) Moisture condition moist below 60cm	(d) Ground water table 8m	(e) Surface stones rock outcrops almost none	Erosion (f) sl. wind or water er	(g) Salt alkali Saline & alkaline / (h) Human influence

IV (a) Horizon	(b) Depth cm	(a) Colour moist (1) / dry (2)	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutans Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, ON %	(q) Content of roots.	(r) Nature of boundary	(s) pH H_2O	(s) pH KCl $CaCl_2$	(t) Apparent Density	(u) Exch Acidity Extract (v) ppm K	(u) CEC (z) B.S %	(y) E.C. micromho 1:5/past
0	7	10YR 6/3	none	SL	single	non-sticky non-plastic friable loose (5)	none	many very fine pores	none	none	none	none	abrupt smooth	8.76		1.56			1.06
37		10YR 6/4	none	SiL	massive	sl. sticky slightly plastic very firm very hard (26)	none	few very fine pores, weakly cemented	none	none	none	none	gradual smooth	9.40		1.18			2.30
66		10YR 6/4	none	SiL	massive	sl. sticky slightly plastic very firm very hard (23)	none	few very fine pores	none	none	none	none	gradual smooth	9.68		1.09			4.10
100		10YR 7/3 10YR 3/4	none	SiCL	massive	sl. sticky slightly plastic very firm very hard (26)	none		none (artefacts; broken pieces of earthen-ware pot)	none	slighbly humic	none		10.05		0.95			3.20
160																			

I (a) Profile No. OS23 | (d) Date Apr. 9, 1981 | (e) Author | (f) Province Sohar | (f) Country OMAN

I (b) Soil Series Soil type 2 | (c) Soil Class Haplic Yermosols | (e) Land System | Location (f) Nasser Suliman Farm, Al-Himbar, 1km inland of sea coast

I Latitude (f) | Longitude (f) | Elevation (g) 10m | (h) Land form | Physiografia (1) position plain | (2) Land form of surrounding country flat | (3) Hierotopography

I Slope (i) 0.2 % | (j) Vegetation Land use poor dates | Climate (k) | Monthly mean temp. (k) | Annual rainfall (k) | II (a) Parent materials Wadi Jizzi alluvium, calcareous

II Drainage (b) | (a) Moisture condition sl. moist below 17cm | (d) Ground water table 8m | (e) Surface stones rock outcrops none | Erosion (f) sl. wind erosion | (g) Salt Saline & alkali alkaline | (h) Human influence

IV (a) Horizon	(b) Depth cm	(a) Colour moist (1) / dry (2)	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutans Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, ON %	(q) Content of roots.	(r) Nature of boundary	(s) pH H_2O	(s) pH KCl $CaCl_2$	(t) Apparent Density	(u) Exch Acidity Extract (v) ppm K	(u) CEC (x) B.S %	(y) E.C. micromho 1:5/past
0	5	10YR	none	SL	single (crusty)	non-sticky non-plastic friable sl. hard	none	few fine pores	none	none	none	none	abrupt smooth	8.95		1.17			2.72
10	17	10YR 7/3 / 10YR 7/2																	
20																			
30			none	SL	weak very coarse platy	non-sticky non-plastic very firm very hard (23)	none	few very fine pores	none	none	none	few very fine roots	gradual smooth	8.55		1.19			0.87
40		10YR 7/2 / 10YR 7/3																	
50																			
60			none	SL | SiL	massive	sl. sticky slightly plastic very firm very hard (25)	none	few very fine pores, very weak cemented	none (few small pieces (0.1-1cm) of shell)	none	none	few very fine roots		9.30		1.10			1.70
70																			
80																			
90		10YR 7/2																	
100	100																		
120																			
140																			
160																			

I	(a) Profile No. OS26	(d) Date Apr. 10, 1981	(e) Author
	(f) Province Sohar Wilayat	(f) Country OMAN	
I	(b) Soil Series Soil type 2	(c) Soil Class Haplic Yermosols	(c) Land System
	Location (f) Al-Troif, Sohar; about 1km south of Wadi Sallan		
I	Latitude (f)	Longitude (f)	Elevation (g) 10m ?
	(h) Land form	Physiografic (1) position	(2) Land form of surrounding country almost flat
	(3) Microtopography		
I	Slope (i) 0.2 %	(j) Vegetation Land use some big acasia trees and some bushes, uncultivated	Climate (k)
	Monthly mean temp. (k)	Annual rainfall (k)	II (a) Parent materials Wadi Jizzi alluvium, calcareous
II	Drainage (b) moderately well drained	(c) Moisture condition moist below 30cm	(d) Ground water table 9m
	(e) Surface stones rock outcrops none	Erosion (f) moderate wind erosion	(g) Salt alkali alkaline
	(h) Human influence		

IV (a) Horizon	(b) Depth cm	(c) Colour (1) moist / (2) dry	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutans Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, OM %	(q) Content of roots.	(r) Nature of boundary	(s) pH H_2O	pH KCl / $CaCl_2$	(t) Apparent Density	(u) Exch Acidity / Extract (v) K ppm	(v) CEC (x) B.S %	(y) E.C. micromho 1:5/past
	0–13	10YR 5/3	none	SL	weak coarse platy	non-sticky non-plastic very firm very hard (23)	none	common very fine pores, weak cemented	none	none	none	few coarse roots	abrupt smooth	8.85		1.45			0.16
	13–48	10YR 5/2 10YR 5/4	none	LS	massive	non-sticky non-plastic friable hard (21)	none	common very fine pores, weak cemented	none	none	none	few coarse roots	abrupt smooth			1.62			
	48–100	10YR 5/3	none	SiL	massive	sl. sticky slightly plastic very firm very hard (26)	none	few very fine pores	none	none	none	few coarse roots		9.80		1.17			0.44

I	(a) Profile No. OS30			(d) Date Apr. 12, 1981	(e) Author	(f) Province Sohar Wilayat	(f) Country OMAN
I	(b) Soil Series Soil type 3	(c) Soil Class Haplic ermosols		(c) Land System	Location (f) Falaj Al-Qabail (Sohar), about 1.5km south-east of Falaj		
I	Latitude (f)	Longitude (f)	Elevation (g) 12m ?	(h) Land form / Physiographic position (1) edge of wadi bed	(2) Land form of surrounding country slightly undulating	(3) Microtopography	
I	Slope (i) 3 %	(j) Vegetation / Land use Common big acasia trees and Tamarix bushes, uncultivated	Climate (k)	Monthly mean temp. (k)	Annual rainfall (k)	II (a) Parent materials Wadi Suq alluvium, calcareous	
II	Drainage (b) well drained	(c) Moisture condition dry throughout	(d) Ground water table 10m	(e) Surface stones / rock outcrops frequent fresh gravells (0.2-5cm)	Erosion (f) wind and water er.	(g) Salt alkali	(h) Human influence

IV Horizon (a)	Depth cm (b)	Colour moist (1) / dry (2) (c)	Colour Mottling (d)	Texture (e)	Structure (f)	Consistence 1) wet 2) moist 3) dry (g)	Cutans Pressure face Slicken side (h)	Pores (i) Cementation	Content of Rocks & Mineral fragments (k)	Content of Mineral nodules (m) Pans	Features biological origin (Peat) OC %, ON % (p)	Content of roots. (q)	Nature of boundary (r)	pH H_2O (s)	pH KCl $CaCl_2$ (s)	Apparent Density (t)	Exch Acidity Extract K (u) ppm	CEC (z) B.S % (v)	E.C. micromho 1:5/past (y)
0																			
10																			
20		10YR 6/3	none	S G2	weak coarse platy	non-sticky non-plastic sl. firm sl. hard (18)	none	few very fine pores	frequent fresh gravels (27%)	none	none	none	clear smooth	8.00		1.72			0.16
26																			
30																			
40		10YR 6/2	none	S G3	single	non-sticky non-plastic friable loose (5)	none	common fine pores	very frequent fresh gravels (53.3%)	none	none	none	abrupt smooth	8.00		1.71			0.16
50																			
60																			
70			none	L / SiL	weak very coarse blocky	sl. sticky slightly plastic very firm very hard (24)	none	few very fine pores, very weak cemented	none	none	none	none	abrupt smooth	9.30		1.35			0.56
80																			
90		10YR 7/3																	
100																			
110																			
120																			
140		10YR 5/3	none	S	single	non-sticky non-plastic friable loose (10)	none	few very fine pores	very frequent fresh gravels	none	none	none							
160	160																		

I	(a) Profile No. OS16	(d) Date Apr. 7, 1981	(e) Author	(f) Province Sohar Wilayar	(f) Country OMAN
I	(b) Soil Series Soil type 4	(c) Soil Class Calcaric Fluvisols	(a) Land System	Location (f) Beside Hibi gravel road, 2km west of High way (near Ali Humod Farm)	
I	Latitude (f)	Longitude (f)	Elevation (g) 15m ?	(h) Land form; Physiografia (1) position	(2) Land form of surrounding country almost flat; (3) Microtopography
I	Slope (i) 0 %	(j) Vegetation Land use: few big acasia trees and many small bushes of Tamarix	Climate (k)	Monthly mean temp. (k); Annual rainfall (k)	II (a) Parent materials Wadi Salahi alluvium, calcareous
II	Drainage (b) moderately well drained	(c) Moisture condition dry throughout	(d) Ground water table 11m	(e) Surface stones rock outcrops none; Erosion (f) wind & water erosion	(g) Salt alkali alkaline; (h) Human influence none

IV (a) Horizon	(b) Depth cm	(c) Colour moist (1) / (2) dry	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(n) Cutans Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, ON %	(q) Content of roots	(r) Nature of boundary	(s) pH H_2O	KCl $CaCl_2$	(t) Apparent Density	(u) Exch. Acidity / Extract (v) K ppm	(w) CEC (x) B.S %	(y) E.C. micromho 1:5/past
	0–13	10YR 7/3	none	SiL	moderate medium platy	slightly sticky slightly plastic firm sl. hard (15)	none	few very fine pores	none	none	none	common fine roots	abrupt smooth	8.75		1.13			0.18
	13–35	10YR 7/3	none	SL (CS--2cm)	massive	non-sticky non-plastic firm very hard (26)	none	common fine pores, weak cemented	almost none	none	none	few fine roots	abrupt smooth	8.73		1.20			0.19
	35–55	10YR 6/3	none	SL (CS--1cm)	massive	non-sticky non-plastic firm very hard (26)	none	common fine pores, weak cemented	almost none	none	none	none	abrupt smooth	8.85		1.45			0.15
	55–100	10YR 5/2	none	S (G1)	single	non-sticky non-plastic friable hard (20)	none	common fine pores	very few fresh gravels (2.6%)	none	none	none				1.68			

I	(a) Profile No. OS19		(d) Date Apr. 7, 1981	(a) Author	(f) Province Sohar Wilayat; (f) Country OMAN
I	(b) Soil Series: Soil type 4	(c) Soil Class: Calcaric Fluvisols	(a) Land System	Location (f) Al-Himbar, 1km north of Oman Sun Farm, Sohar	
I	Latitude (f)	Longitude (f)	Elevation (g) 20m ?	(h) Land form; Physiografic (1) position	(2) Land form of surrounding country: almost flat; (3) Microtopography
I	Slope (i) 0.2 %	(j) Vegetation Land use: common small bushes, uncultivated	Climate (k)	Monthly mean temp. (k); Annual rainfall (k)	II (a) Parent materials: Wadi Salahi Alluvium, calcareous
II	Drainage (b) well drained	(c) Moisture condition: dry throughout	(d) Ground water table: 8m	(e) Surface stones rock outcrops: none	Erosion (f) wind & water erosion; (g) Salt alkali: alkaline; (h) Human influence

IV (a) Horizon	(b) Depth cm	(c) Colour (1) moist / (2) dry	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutans Pressure face Sticken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, ON %	(q) Content of roots	(r) Nature of boundary	(s) pH H_2O	pH KCl / $CaCl_2$	(t) Apparent Density	(u) Exch. Acidity / Extract (v) K ppm	(w) CEC (x) B.S %	(y) E.C. micromho 1:5/past
	0–9	10YR 7/3	none	SL	weak very coarse platy	non-sticky non-plastic friable loose (10)	none	common fine pores	none	none	none	common fine roots	clear smooth	8.60		1.64			0.15
	9–47	10YR 7/3	none	SiL	massive	sl. sticky slightly plastic extremely firm extremely hard (30)	none	few fine pores, weak cemented	none	none	none	common fine roots	clear smooth	8.80		1.33			0.16
	47–100	10YR 6/3	none	SL	massive	non-sticky non-plastic firm very hard (25)	none	few fine pores	none	none	none	none				1.31			

I	(a) Profile No. OS24			(d) Date Apr. 8, 1981	(e) Author	(f) Province Sohar Wilayat	(f) Country OMAN
I	(b) Soil Series Soil type 5	(a) Soil Class Calcaric Fluviso_s		(a) Land System	Location (f) Trafe, Brahim Mohammed Farm (4ha), 2km west of sea coast		
I	Latitude (f)	Longitude (f)	Elevation (g) 10m ?	(h) Land form	Physiografic position irrigated potatoes plot	(2) Land form of surrounding country almost flat	(3) Microtopography
I	Slope (i) 0	(j) Vegetation Land use date, mango, banana trees and vegetables and grasses	Climate (k)	Monthly mean temp. (k)	Annual rainfall (k)	II (a) Parent materials Wadi Jizzi Alluvium, Calcareous	
II	Drainage (b) well drained	(a) Moisture condition moist throughout	(d) Ground water table 6m	(e) Surface stones rock outcrops none	Erosion (f) none	(g) Salt alkali alkaline	(h) Human influence

IV Horizon (a)	(b) Depth cm	(a) Colour moist (1) / dry (2)	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutans Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, ON %	(q) Content of roots.	(r) Nature of boundary	(s) pH H_2O	(s) pH KCl $CaCl_2$	(t) Apparent Density	(u) Exch Acidity Extract (v) ppm	(u) Exch Acidity Extract (v) %	(v) CEC (x) E.S %	(y) E.C. micromho 1:5/past
Ap	0	10YR 5/3	none	SL	single (plowed)	non-sticky non-plastic friable loose (6)	none		none	none	few very small pieces of shell	common very fine roots	gradual smooth	8.85		1.21				0.18
	25	10YR 4/4																		
	25		none	SL	massive	non-sticky non-plastic sl. firm sl. hard . 16)	none	common fine pores	none	none	few very small pieces of shell	common very fine roots	gradual smooth	8.75		1.47				0.14
	66	10YR 4/4																		
	66		none	SL	massive	non-sticky non-plastic firm hard (21)	none	common fine pores	trace of gravels	none	none	common medium roots		8.85		1.43				1.10
	100																			
	160																			

I	(a) Profile No. OS31		(d) Date Apr. 12, 1981	(e) Author	(f) Province Sohar Wilayat	(f) Country OMAN
I	(b) Soil Series Soil type 6	(a) Soil Class Calcaric Regosols	(a) Land System	Location (f) Falaj Al-Qabail, near small wadi, 3km inland of sea coast	(3) Microtopography	
I	Latitude (f)	Longitude (f)	Elevation (g) 15m ?	(h) Land form	Physiografia (1) position	(2) Land form of surrounding country almost flat
I	Slope (i) 0 %	(j) Vegetation Land use common big acasia trees and small Tamarics bushes, uncult.	Climate (k)	Monthly mean temp. (k)	Annual rainfall (k)	II (a) Parent materials Wadi Jizzi alluvium, calcareous
II	Drainage (b) moderately well drained	(a) Moisture condition dry throughout	(d) Ground water table 8m ?	(e) Surface stones rock outcrops common fresh gravels (<2cm)	Erosion (f) wind and water erosion	(g) Salt alkali alkaline; (h) Human influence

IV (a) Horizon	(b) Depth cm	(a) Colour moist (1) / (2) dry	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutane Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, ON %	(q) Content of roots.	(r) Nature of boundary	(s) pH H_2O	KCl $CaCl_2$	(t) Apparent Density	(u) Exch. Acidity Extract (v) X ppm	(v) CEC (x) B.S %	(y) E.C. micromho 1:5/paste
	0–11	10YR 6/3	none	LS G2	single	non-sticky non-plastic friable loose (0)	none	common fine pores	frequent fresh gravels (16.0%)	none	none	none	abrupt smooth	8.50		1.64			0.18
	11–37	10YR 6/3	none	LS (G1)	massive	non-sticky non-plastic sl. firm hard (16)	none	common fine pores	very few fresh gravels (4.3%)	none	none	none	abrupt smooth	8.30		1.53			0.16
	37–70	10YR 7/3	none	SL / L	massive	non-sticky non-plastic firm very hard (28)	none	common fine pores, weak cemented	none	none	none	none	gradual smooth	8.80		1.23			0.21
	70–100	10YR 5/2	none	S	single	non-sticky non-plastic loose sl. hard (10)	none	common fine pores	none	none	none	none							

I	(a) Profile No. OS7			(d) Date Apr. 5, 1981	(e) Author	(f) Province Sohar Wilayat / (f) Country OMAN
I	(b) Soil Series Soil type 7	(c) Soil Class Calcaric Regosols		(a) Land System	Location (f) near Mohammed Bin Khalid Farm, 1km west of High way	
I	Latitude (f)	Longitude (f)	Elevation (g) 20m ?	(h) Land form / Physiographic (1) position	(2) Land form of surrounding country almost flat	(3) Macrotopography
I	Slope (i) 0.1 %	(j) Vegetation Land use few small bushes of acasia, uncultivated	Climate (k)	Monthly mean temp. (k)	Annual rainfall (k)	II (a) Parent materials Wadi Jizzi alluvium, calcareous
II	Drainage (b) well drained	(c) Moisture condition dry throughout	(d) Ground water table 15m	(e) Surface stones rock outcrops frequent fresh gravels (0.2-7cm)	Erosion wind and (f) water erosion	(g) Salt alkali / (h) Human influence none

IV Horizon (a)	Depth cm (b)	Colour moist (1) / (2) dry (c)	Colour Mottling (d)	Texture (e)	Structure (f)	Consistence 1) wet 2) moist 3) dry (g)	Cutans Pressure face Slicken side (h)	Pores (i) Cementation	Content of Rocks & Mineral fragments (k)	Content of Mineral nodules (m) Pans (l)	Features biological origin (Peat) OC %, ON % (p)	Content of roots (q)	Nature of boundary (r)	(s) pH H_2O	(s) pH KCl $CaCl_2$	(t) Apparent Density	(u) Exch Acidity / Extract (u) K ppm	CEC (z) B.S %	(y) E.C. micromho 1:5 past
0																			
10					weak	non-sticky		few	very			few	clear						
20			none	SL	very coarse	non-plastic	none	fine	few	none	none	fine	smooth	7.80		1.68			0.12
30		10YR 6/3		(Gl)	blocky	firm		pores	fresh			roots							
	35					hard			gravels										
40									(3.1%)										
50						non-sticky													
			none	S	massive	non-plastic	none	few	frequent	none	none	none	clear			1.72			
60				G2		friable		fine	fresh				smooth						
70		10YR 5/3				hard		pores	gravels										
	78								(19.2%)										
80						non-sticky													
			none	S	single	non-plastic	none	few	few fresh	none	none	none		7.65		1.62			..11
90		10YR 5/3		(Gl)		friable		fine	gravels										
100	100					hard		pores	(9 7%)										
120																			
140																			
160																			

I	(a) Profile No. OS20	(d) Date Apr. 8, 1981	(e) Author	(f) Province Sohar Wilayat; (f) Country OMAN
I	(b) Soil Series Soil type 8	(a) Soil Class Orthic Solonchaks	(a) Land System	Location (f) Sohar town, 0.3km from sea side
I	Latitude (f)	Longitude (f)	Elevation (g) 5m; (h) Land form; Physiografia (1) position	(2) Land form of surrounding country almost flat; (3) Microtopography
I	Slope (i) 0.2 %	(j) Vegetation Land use Uncultivated, beside date palm farm	Climate (k); Monthly mean temp. (k); Annual rainfall (k)	II (a) Parent materials Wadi Jizzi alluvium, calcareous
II	Drainage (b) excessively drained	(a) Moisture condition dry to 100cm moist below; (d) Ground water table 3m	(e) Surface stones rock outcrops none; Erosion (f) water erosion sheet	(g) Salt alkali saline & alkaline; (h) Human influence digged up for water pipe

IV (a) Horizon	(b) Depth cm	(c) Colour (1) moist / (2) dry	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutans Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, OM %	(q) Content of roots	(r) Nature of boundary	(s) pH H_2O	(s) pH KCl / $CaCl_2$	(t) Apparent Density	(u) Exch Acidity / Extract (v) K ppm	(w) CEC (x) B.S %	(y) E.C. micromho 1:5/past
	0–10	10YR 5/2	none	SL	weak coarse platy	non-sticky non-plastic firm slightly hard	none	few fine pores	none	few small weathered fragments of lime stone	none	none	clear smooth	8.45		1.56			3.82
	38	10YR 6/2	none	SL	weak very coarse platy	non-sticky non-plastic firm very hard	none	few fine pores	very few fresh gravels	none	none	none	clear smooth	8.85		1.34			2.63
		10YR 5/2	none	S	single	non-sticky non-plastic firm hard	none	common fine pores	very few fresh gravels	none	few small pieces of shell	few big roots of date	clear smooth			1.71			0.35
	120, 145	10YR 6/2	none	SL	massive	non-sticky non-plastic firm very hard	none	common fine pores	none	none	none	none		9.52		1.39			2.10

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160

I (a) Profile No. OS15 | (d) Date Apr. 6, 1981 | (e) Author | (f) Province Sohar Wilavat | (f) Country OMAN

I (b) Soil Series Soil type 9 | (c) Soil Class Dystric Regosols | (a) Land System | Location (f) near Wadi Jizzi bed, 0.5km south-west of High way

I Latitude (f) | Longitude (f) | Elevation (g) 10m | (h) Land form | Physiografic (1) position | (2) Land form of surrounding country almost flat | (3) Microtopography

I Slope (i) 0.2 % | (j) Vegetation Land use few big acasia trees and small bushes of brasica | Climate (k) | Monthly mean temp. (k) | Annual rainfall (k) | II (a) Parent materials Wadi Jizzi alluvium

II Drainage (b) excessively drained | (a) Moisture condition dry, moist below 50cm | (d) Ground water table 8m | (e) Surface stones rock outcrops common small gravels | Erosion (f) wind & water erosion | (g) Salt alkali | (h) Human influence

IV (a) Horizon	(b) Depth cm	(c) Colour moist (1) / (2) dry	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutans Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, ON %	(q) Content of roots	(r) Nature of boundary	(s) pH H_2O	pH KCl $CaCl_2$	(t) Apparent Density	(u) Exch Acidity Extract (v) K ppm	(w) CEC (x) B.S %	(y) E.C. micromho 1:5/past
	0–30	10YR 6/3	none	LS G1	single	non-sticky, non-plastic, friable, loose	none		few fresh gravels (0.5-2cm) (10.8%)	none	none	none	abrupt smooth	7.70		1.81			0.15
	30–50	10YR 6/2	none	S G3	single	non-sticky, non-plastic, friable, hard	none		very frequent fresh gravels (1-5cm) (74.6%)	none	none	none	abrupt smooth			1.77			
	50–75	10YR 6/2	none	S G2	single	non-sticky, non-plastic, friable, hard	none		frequent fresh gravels (0.2-3cm) (48.0%)	none	none	none	abrupt smooth			2.26			
	75–100	10YR 6/2	none	S G3	single	non-sticky, non-plastic, friable, hard	none		very frequent fresh gravels (2-6cm) (63.0%)	none	none	none				2.05			0.44

I	(a) Profile No. OS9			(d) Date Apr. 5, 1981	(e) Author		(f) Province Sohar Wilavat	(f) Country OMAN
I	(b) Soil Series Soil tvpe 10	(a) Soil Class Dystric Regosols		(a) Land System	(f) Location near Wadi Jizzi bed, 0.5km south-west of gas pipe line			
I	Latitude (f)	Longitude (f)	Elevation (g) > 20m	(h) Land form	Physiografia (1) position	(2) Land form of surrounding country almost flat	(3) Microtopography	
I	Slope (i) 0.2%	(j) Vegetation Land use few small bushes of acasia		Climate (k)	Monthly mean temp. (k)	Annual rainfall (k)	II (a) Parent materials Wadi Jizzi alluvium	
II	Drainage (b) excessively drained	(c) Moisture condition dry thoughout	(d) Ground water table 15m	(e) Surface stones rock outcrops frequent small gravels (0.2-5cm)	Erosion wind & (f) water erosion	(g) Salt alkali alkaline	(h) Human influence	

IV (a) Horizon	(b) Depth cm	(c) Colour moist (1) / (2) dry	(d) Colour Mottling	(e) Texture	(f) Structure	(g) Consistence 1) wet 2) moist 3) dry	(h) Cutans Pressure face Slicken side	(j) Pores (i) Cementation	(k) Content of Rocks & Mineral fragments	(l) Content of Mineral nodules (m) Pans	(p) Features biological origin (Peat) OC %, OM %	(q) Content of roots.	(r) Nature of boundary	(s) pH H_2O	KCl $CaCl_2$	(t) Apparent Density	(u) Exch Acidity / Extract (v) K ppm	(w) CEC (x) B.S %	(y) E.C. micromho 1:5/past
	10	10YR 7/3	none	SL G1	massive	non-sticky non-plastic friable hard	none	few fine pores	few fresh gravels (1-3cm)	none	none	none	gradual smooth	(OS10) 8.60		(OS10) 1.49			(OS10) 0.14
	42 / 48	10YR 5/3	none	S G2	massive	non-sticky non-plastic friable hard	none	few fine pores	very frequent fresh gravels (1-4cm)	none	none	none	gradual smooth			1.63			
		10YR 5/3	none	S G3	single	non-sticky non-plastic friable hard	none	few fine pores	very frequent fresh gravels (1-5cm)	none	none	none	gradual smooth						
	100	10YR 5/3	none	S G3	massive	non-sticky non-plastic friable very hard	none	few fine pores	very frequent fresh gravels (1-5cm)	none	none	none	gradual smooth			2.00			

Depth scale (cm): 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160

Report: Soil Pit Survey on Water Resources Development Project - Northern Oman (ILACO, 1975)

PIT M - SOHAR FMC FARM

Date	:	8th November 1973
Location	:	2689.000 N, 475.000 E (Oman Sun Farm)
Topography	:	flat
Land form	:	accumulation plain
Parent material	:	aeolic material
Drainage	:	well drained
Vegetation	:	scattered Acacia arabica and Prosopis spicegera trees
Land use	:	uncultivated, to be irrigated in the future
Soil classification:		Haplic Yermosol
Land classification:		S_1 - highly suitable for irrigated agriculture

Soil description

0.00-0.38m IA_1 MS	Brown (10 YR 5/3, moist) silt loam with thin bands of very fine sandy loam, dry, moderate very thin platy structure, discontinuous, slightly hard consistence, common roots and pores, at 0.38 some fine gravels, abrupt smooth boundary to
0.38-1.48 m IC_1 M	Yellowish brown (10 YR 5/4, moist) sandy loam with thin bands of silt loam, dry, weak, medium, subangular blocky structure, slightly hard consistence, common roots and pores, abrupt smooth boundary to
1.48-1.70 m IIA_1 MS	Brown (10 YR 5/3, moist) silt loam, dry, moderate medium prismatic structure, hard consistence when dry, few roots and pores, clear and smooth boundary to
> 1.70 m IIC M	Yellowish brown (10 YR 5/4, moist) very fine loamy sand, weak, medium subangular blocky structure, slightly hard consistence, few roots and pores

All horizons strong reaction with HCl

Soil Analytical Data of PITM-SOHAR

Soil Profile		Pit M - Sohar		
Depth in cm		0-20	38-60	80-120
$CaCO_3$	%	12.0	14.1	14.0
Coarse sand	(200-2000 mu)	4.3	12.3	6.3
Fine sand	(50- 200 mu)	17.7	41.3	49.8
Coarse silt	(20- 50 mu)	16.1	22.7	24.5
Fine silt	(2- 20 mu)	48.7	17.1	15.2
Clay	(< 2 mu)	13.2	6.4	4.0
Textural class		silt loam	sandy loam	sandy loam
Carbon	%	0.40	0.14	0.08
Nitrogen	%	0.04	0.02	0.01
C/N		10	7	8
pH (1:2.5)	H_2O	8.6	8.5	8.8
	KCl	7.8	7.7	7.7
EC- (1:2.5)	(mmhos/cm)	0.17	0.26	0.29
CEC	(me/100 g)	11.5	11.2	11.7
Exchangeable cations me/100 g)	Ca	10.2	9.67	9.43
	Mg	3.99	3.99	5.33
	K	0.52	0.51	0.52
	Na	0.09	0.17	0.17
	Sum	14.8	14.3	15.5
ESP	%	1	2	2
BSP	%	>100	>100	>100
Available P_2O_5 (Olsen ppm)		10	3	2

SOHAR 10

Date	:	13th May 1974
Location	:	2691.800 N and 471.000 E
Topography	:	flat, very little levelling required
Land form	:	accumulation plain
Parent material	:	aeolic over alluvial (wadi) sediment
Drainage	:	well drained
Vegetation	:	few scattered Acacia arabica trees and Haloxylon salicornicum herbs
Land use	:	uncultivated
Soil classification	:	Haplic Yermosol
Land classification	:	S_1 - highly suitable for irrigated agriculture

Soil description

0.00-0.30 m (1)	Light-grey (10 YR 7/2, moist) silt loam with some thin (1-2 cm) loamy sand layers, slightly hard consistence, dry
0.30-0.38 m (2)	Very fine sand, same colour as above, loose, dry
0.38-0.55 m (3)	Light-grey (10 YR 7/2, moist) silt loam, slightly hard, dry, interbedded with loamy sand layers
0.55-1.00 m (4)	Light-grey silt loam as above
1.00-1.40 m (5)	Pale-brown (10 YR 6/3, moist) fine sand loam with fine gravel
>1.40 m (6)	Coarse wadi sand and gravel

Soil Profile		Sohar 10			
Depth in cm		0-30	30-55	55-100	100-140
$CaCO_3$	%	15.6	15.2	13.9	11.8
Coarse sand	(200-2000 mu)	0.6	0.2	0.7	24.2
Fine sand	(50- 200 mu)	28.5	40.8	17.0	40.9
Coarse silt	(20- 50 mu)	15.9	28.4	23.8	16.4
Fine silt	(2- 20 mu)	41.1	23.2	45.6	14.1
Clay	(< 2 mu)	13.9	7.4	12.9	4.4
Textural class		silt loam	silt loam	silt loam	silt loam
Carbon	%	0.29	0.26	0.25	0.10
Nitrogen	%	0.03	0.03	0.03	0.01
C/N		10	9	8	10
pH (1:2.5)	H_2O	8.9	9.0	8.4	8.6
	KCl	7.8	7.9	7.9	8.0
EC- (1:2.5)	(mmhos/cm)	0.18	0.24	0.90	0.46
CEC	(me/100 g)	13.5	10.3	7.50	7.68
Exchangeable cations (me/100 g)	Ca	11.7	8.07	6.58	4.79
	Mg	3.87	3.85	5.70	3.99
	K	0.55	0.23	0.18	0.15
	Na	0.09	0.09	0.09	0.09
	Sum	16.2	12.2	12.6	9.02
ESP	%	0.7	0.9	1.2	1.2
BSP	%	>100	>100	>100	>100
Abailable P_2O_5	(Olsen ppm)	6	1	2	2
Moisture content at (vol. %)	pF 0.5	53.9	54.2		
	pF 2.0	41.1	41.4		
	pF 2.7	28.3	25.5		
	pF 4.2	11.8	7.3		
Bulk density	g/cm^3	1.237	1.166		
Infiltration rate mm/hr	dry	78			
	wet	66			

SOHAR 13

Date	:	12th May 1974
Location	:	2693.000 N and 470.000 E, near small wadi
Topography	:	flat with many nebkhas, much levelling required
Land form	:	accumulation plain
Parent material	:	mainly alluvial
Drainage	:	moderately well drained (at 1.00 m slowly permeable layer)
Vegetation	:	few Acacia arabica and Haloxylon salicornicum
Land use	:	uncultivated, cultivated in ancient times
Soil classification	:	Haplic Yermosol
Land classification	:	S_3t - marginally suitable for irrigated agriculture

Soil description

0.00-0.25 m	Dark yellowish-brown (10 YR 4/4, moist) fine loamy sand with medium clean sand layer, loose, dry
0.25-0.40 m	Dark yellowish-brown (10 YR 4/4, moist) fine sand, loose dry
0.40-1.00 m	Dark yellowish-brown (10 YR 4/4, moist) fine sandy loam, soft, dry, at 0.90 m many carbonate mottles
1.00-1.50 m	Dark yellowish-brown (10 YR 4/4, moist) sandy loam to loam with common gravel, hard consistence, dry

Soil Profile		Schar 13		
Depth in cm		0-25	40-90	90-120
$CaCO_3$	%	12.6	15.9	16.9
Coarse sand	(200-2000 mu)	38.8	18.7	20.9
Fine sand	(50- 200 mu)	43.4	51.8	31.2
Coarse silt	(20- 50 mu)	7.2	13.3	12.9
Fine silt	(2- 20 mu)	6.8	10.0	22.1
Clay	(< 2 mu)	3.8	6.2	12.9
Textural class		loamy sand	sandy loam	sandy loam/loam
Carbon	%	0.12	0.10	0.09
Nitrogen	%	0.01	0.01	0.01
C/N		12	10	9
pH (1:2.5)	H_2O	9.0	8.9	9.2
	KCl	7.9	7.9	7.9
EC- (1:2.5)	(mmhos/cm)	0.10	0.12	0.18
CEC	(me/100 g)	7.88	7.68	8.87
Exchangeable cations (me/100 g)	Ca	5.78	6.56	6.12
	Mg	1.39	2.42	4.97
	K	0.38	0.41	0.52
	Na	<0.01	<0.01	0.09
	Sum	7.55	9.39	11.7
ESP	%	-	-	1
BSP	%	96	>100	>100
Available P_2O_5 (Olsen ppm)		5	2	2
Moisture content at (vol. %)	pF 0.5	37.4		
	pF 2.0	26.7		
	pF 2.7	14.7		
	pF 4.2	7.9		
Bulk density	g/cm^3	1.486		
Infiltration rate mm/hr	Dry	200		
	Wet	157		

SOHAR 62

Date	:	2nd June 1974
Location	:	Agricultural Farm Sohar, 2693.100 N, 471.000 E
Topography	:	flat
Land form	:	accumulation plain
Parent material	:	aeolic material interbedded with alluvium
Drainage	:	well drained
Vegetation	:	-
Land use	:	irrigated basins with annual crops
Soil classification	:	Haplic Yermosol - irrigated phase
Land classification	:	S_1 - highly suitable for irrigated agriculture

Soil description

0.00-0.25 m A_p	Brown to dark-brown (10 YR 4/3, moist) fine sandy loam, very friable consistence, moist
0.25-0.55 m AB	Brown to dark-brown (10 YR 4/3, moist) fine sandy loam with 2-cm thin band of silt loam, friable consistence, moist
0.55-0.90 m B_2	Dark yellowish-brown (10 YR 4/4, moist) loam, slightly hard consistence, dry
0.90-1.50 m B-C	Yellowish brown (10 YR 5/4, moist) fine sandy loam with fine loamy sand layers, soft consistence, dry
	All horizons strong reaction with HCl

Soil Profile		Sohar 62		
Depth in cm		0-25	25-55	55-90
$CaCO_3$	%	17.0	15.6	16.8
Coarse sand	(200-2000 mu)	3.7	4.0	3.5
Fine sand	(50- 200 mu)	61.8	64.8	45.9
Coarse silt	(20- 50 mu)	12.6	10.1	13.9
Fine silt	(2- 20 mu)	12.4	12.4	24.0
Clay	(< 2 mu)	9.5	8.7	12.7
Textural class		sandy loam	sandy loam	loam
Carbon	%	0.22	0.12	0.12
Nitrogen	%	0.03	0.01	0.02
C/N		7	12	6
pH (1:2.5)	H_2O	9.1	9.0	8.7
	KCl	8.1	8.1	7.9
EC- (1:2.5)	(mmhos/cm)	0.23	0.40	0.65
CEC	(me/100 g)	9.86	9.20	11.8
Exchangeable cations (me/100 g)	Ca	6.04	5.79	8.32
	Mg	4.14	3.44	3.85
	K	0.67	0.88	1.65
	Na	0.09	0.09	0.09
	Sum	10.9	10.2	13.9
ESP	%	1	1	0.7
BSP	%	>100	>100	>100
Available P_2O_5 (Olsen ppm)		20	1	3
Moisture content at (vol. %)	pF 0.5	40.7	-	46.8
	pF 2.0	35.6	-	35.8
	pF	17.6	-	26.5
	pF 4.2	10.0	-	13.3
Bulk density	g/cm^3	1.503	-	1.275

Report : Agricultural Development Program (FMC Agr. Survey, 1975)

pH, Conductivity, Organic Carbon, Available Phosphorous, Available Potassium, and Particle Size Distribution of Some Typical Soils (Auger Borings) of the Sultanate of Oman

Profile	Depth in	% clay	% silt + clay	% silt	% sand	% >2 mm	Textural class
3 SOHAR FARM The profile site is about two furlongs away from the sheds and nearer to the boundary (between shrubs and not on dunes)	0- 7	6	9	3	91	nil	Sand
	7-22	3	6	3	94	nil	Sand
	22-24	3	10	7	90	nil	Sand
	24 38	2	6	4	94	nil	Sand
	38-48+		3		97	nil	Sand
4 SOHAR FARM: The profile site is on the proposed farm area, in a diagonally opposite direction (approximately) to the construction site, and toward the boundary	0- 8	9	55	46	45	nil	Silty loam
	8-20		10		90	little	Loamy sand
	20-31		3		97	little	Sand
	31-45		13		87	little	Loamy sand
	45+		14		86	little	Loamy sand
5 SOHAR VILLAGE The profile site is in an old citrus garden approximately between the seashore and the main road, at a point between Sohar and Sallan	0- 8	3	20	17	80	little	Loamy sand
	8-18	5	22	17	78	nil	Loamy sand
	18-40	7	21	14	79	nil	Loamy sand

Profile/ Depth in in.	Bulk density g/cc	Volumetric % moisture retained at 1/3 bar	Volumetric % moisture retained at 15 bar	pH	Conductivity mmhs 25°C	% Organic Carbon	% Organic Rating*	Available P ppm	Available P Rating*	Available K ppm	Available K Rating
3 SOHAR FARM											
0 7	1 64	11 5	5 7	8 7	0 14	0 09	L	4 6	L	74	M
7 22	1 65	7 7	4 4	8 8	0 12	0 09	L	3 0	L	78	M
22 24	1.60	14 4	5 6	8 6	0 18	0 04	L	2 1	L	92	M
24 38	1.52	6 4	3 3	8 8	0 16	0 04	L	3 2	L	116	M
38-48	1 47	3.8	2 6	8 9	0 15						
4 SOHAR FARM											
0- 8	1.32	38 8	10 7	8 6	0 43	0 23	L	9.5	M	155	H
8 20	1 58	14 7	5 9	8 8	0 19	0 13	L	3 2	L	124	M
20 31	1 83	7.7	4 4	8 8	0 25						
31-45	1.51	32 9	11.9	8 5	0 92						
45+	1 56	21 1	7.9	8 5	0 92						
5 SOHAR VILLAGE	1 0[illegible]	19 4	10 4	8 6	0 75	1 03	H		H	84	M
	1 2[illegible]	20.5	10 5	8 5	0 32	0 35	L	16 5	H	59	M
	1.2[illegible]	25 6	13 8	8 2	0 60						

For rating of available nutrients, See Table E-15.

Sample/ Depth in in.	pH	Conductivity mmhos 25°C	% Organic		Available P		Available K		% Clay	% Silt + % Clay	% Silt	% Sand	% > 2 mm	Textural Class
			Carbon	Rating*	ppm	Rating*	ppm	Rating*						
1. SALALAH														
Sample 1	8.3	0 51	0.24	L	16 5	H	118	M	5	19	14	81	6	Loamy sand
Sample 2	8.4	0.46	0.37	L	16.5	H	115	M	5	19	14	81	6	Loamy sand
Sample 3	8.1	1.80	0.36	L	19.4	H	115	M	2	16	14	84	5	Loamy sand
2. NIZWA: FMC														
Proposed Farm site														
0- 8	8 8	0.25	0 32	L	12.7	H	92	M	3	22	19	78	16	Loamy sand
8-16	8 9	0.24	0.27	L	7 9	M	78	M	3	23	20	77	18	Loamy sand
16-24	8.9	0.25							3	17	14	83	16	Loamy sand
24-32	8.8	0 33							3	18	15	82	14	Loamy sand
32-40	8.7	0.44							2	12	10	88	17	Loamy sand
40-48	8 8	0.40							2	12	10	88	31	Loamy sand
3. SOHAR FARM:														
Nearer to the 1			0 36	L	8.8	M	113	M	10	66	56	34	nil	Silt
road and app at 2			0 12	L	4.2	L	99	M	3	24	21	76	1	Loamy sand
the beginning of 3									4	22	18	78	nil	Loamy sand
the boundary, while 4									11	15	4	85	nil	Sandy loam
proceeding from 5									2	21	19	79	nil	Loamy sand
Muscat to Sohar 6									4	43	39	57	nil	Silty loam
(a profile).														
4. SOHAR: Towards sea-shore (last garden).														
0- 8	8.7	V. High	0.36	L	18.6	H	197	H	19	44	25	56	nil	Loam/silty loam
8-16	9.2	3.61	0.27	L	6.2	M	162	H	17	56	39	44	nil	Silty loam
16-24	9.1	2.80							14	44	30	56	1	Silty loam
24-32	9.1	1.80							18	52	34	48	9	Silty loam
32-40	9.1	1.19							6	18	12	82	8	Loamy sand
6 SOHAR: In garden near Ag. Dept Office.														
0- 8	8.7	1 04	0.52	M	5 6	M	94	M	16	49	33	51	little	Silty loam
8-20	8 4	2 40	0 33	L	3 2	L	88	M	23	66	43	34	little	Silty loam
20-30	8.5	1 20							23	62	39	38	little	Silty loam
30-40	8 3	3 20							17	55	38	45	little	Silty loam

Report : Development of New Land for Irrigated Agriculture

(Soil Consultant, 1977)

SOIL PROFILE No. 27

Location: Sohar Production Farm.

Analyses	Sample depth cm				
	0–20*	20–40	40–70	70–100	100–120
Clay %	27	26	17	22	20
Silt %	30	33	14	22	19
Fine sand%	40	38	41	51	55
Coarse sand %	3	3	28	5	6
Texture	L	L	SL	SCL	SCL
Gravel %	5	1	10	4	2
$CaCO_3$ equivalent %	18	21	13	20	19
Org. matter %	0.1	0.3	0.3	0.2	0.2
Available P ppm	16	6	3	6	2
CEC meq/100 gm	-	-	-	-	-
pH water	8.5	8.4	8.5	7.9	7.9
EC 1:5 ext.u Mhos	381	381	266	399	354
Soluble salts meq/1					
Ca	0.2	0.2	0.3	0.1	0.1
Mg	0.5	0.3	0.2	0.4	0.3
Na	3.0	3.0	2.2	3.4	3.0
K	0.1	0.08	0.04	0.02	0.02
HCO_3	2.2	2.2	2.0	2.2	2.2
Cl	1.4	1.0	0.8	1.6	1.2
SO_4					

* Furrow crest sample showed high salinity.
The EC 1:5 = 6447 u mhos/cm at 28°C.

NaCl being the most dominant salt.

Pit 39

Location: Dairy Farm at Sohar.

- Uncultivated area in the south east corner (see sketch).

0–25 cm 10 YR 6/3 D, 4/3 M loamy sand weak platy to granular, slightly hard, slightly stickyand slightly plastic calcareous material of very strong effervescence. Common fine and medium roots.

25–40 cm Ditto silty loam of platy structure, hard friable, slightly sticky and slight plastic.

40–55 cm Ditto, silt loam, soft, friable, slightly sticky and slightly plastic massive to weak granular structure. Calcareous.

55–70 cm Ditto, sandy loam.

70–110 cm Ditto, clay loam, hard, friable, sticky and plastic calcareous material of platy structure. Strong effervescence may indicate relative accumulation of diffused carbonates.

110–140 cm Ditto, silty loam.

140+ cm Gravelly stony, loam.

Analyses	Sample depth cm				
	0–25	25–40	40–55	55–70	70–110
Clay %	10	13	10	10	14
Silt %	9	31	12	7	28
Fine sand %	74	50	70	76	51
Coarse sand %	7	6	8	7	7
Texture	LS	SL	SL	LS	SL
Gravel %	2	-	-	-	-
$CaCO_3$ equivalent %	13	16	15	11	17
Org.matter %	0.2	0.2	0.2	0.2	0.2
Available P ppm	2	1	3	1	2
CEC meq/100 gm	9	13	9	8	13
pH water	-	-	-	-	-
EC 1:5 ext.u Mhos	99	122	132	127	207
Soluble salts meq/1					

Pit 41

Location: Dairy Farm at Sohar.

The center of the area at which the proposed center pivot irrigation system will be installed.

Undulating topography.

0-10 cm 10 YR 6/3D, 5/4 M, sandy loam, platy, soft, friable slightly sticky and slightly plastic. Few roots of fine and very fine size. Strong effervescence.

10-50 cm Ditto, but of granular structure.

50-90 cm Ditto, loam blocky, hard, friable, sticky and plastic. Mottles of carbonate of powdary nature giving very strong reaction with dilute cold acid. Dense fine roots are present.

9-140 cm Ditto silty loam, granular; hard friable; slightly sticky and slightly sticky and slightly plastic. Strong effervescence.

140+ cm Ditto with gravells and stones.

Analyses	Sample depth cm			
	0-10	10-50	50-90	90-140
Clay %	17	16	20	15
Silt %	14	17	28	35
Fine sand %	55	53	47	45
Coarse sand %	14	4	5	5
Texture	SL	SL	SCL	L
Gravel %	2	-	-	-
$CaCO_3$ equivalent %	18	17	19	15
Org.matter %	0.2	0.3	0.2	0.3
Available P ppm	4	3	2	4
CEC meq/100 gm	10	10	15	16
pH water	-	-	-	-
EC 1:5 ext.u Mhos	113	113	310	603
Soluble salts meq/1	-	-	-	-

Pit 31

Location: Sohar New Project.

- 2500 m west of Heeby gravel road at about 900 m south to Muscat Sohar main road. North west boundary.
- Undulating to rough relief because of several wadi intersections in this area.

0–40 cm 10 YR 6/3 D, 5/4 M, clay loam, coarse granular to sub-angular blocky, slightly hard, friable, sticky and plastic. Strong reaction with dilute acid.

40–70 cm Clay loam blocky, compacted, hard sticky and plastic.

70–110 cm Sandy loam, loose and soft, slightly sticky and non plastic.

110–120 cm Sand band.

120–150 cm Loamy sand – strong effervescence.

Analyses	Sample depth cm		
	0–40	40–70	70–110
Clay %	25	23	16
Silt %	32	24	13
Fine sand %	38	47	51
Coarse sand %	5	6	10
Texture	L	SCL	SL
Gravel %	–	–	–
$CaCO_3$ equivalent %	20	22	15
Org.matter %	0.4	0.3	0.1
Available P ppm	10	7	6
CEC meq/100 gm	14.5	14.5	11
pH water	7.8	7.7	7.9
EC 1:5 ext.u Mhos	14.1	38.1	31.0
Soluble salts meq/1			
Ca	0.4	0.4	0.2
Mg	0.4	0.6	0.3
Na	0.6	2.6	2.2
K	0.2	0.02	0.02
HCO_3	0.2	0.02	0.02
Cl	–	1.6	1.0
SO_4	1.3	2.0	1.8

Pit 35

Location: Sohar New Project.

About 850 m west of Heeby gravel road at about 2700 m south of Muscat - Sohar main road.

Undulated topography. Scattered desert shrubs with scarce Acacia sp. and short weak grass.

8–20 cm 10 YR 6/3, 6/4D stratified (layered) loam of platy structure. Slightly hard, friable, sticky and plastic. Strong reaction with HC1. Common very fine roots.

20–35 cm Ditto but more compacted with very strong effervescence with a wavey boundary to

35–60 cm Gravelly plus stone layer.

60–100 cm Stratified loam with gravel and stone.

100–120 cm Sandy loam of granular structure.

120–140 cm Stratified loam with gravel and stone.

140 + cm Loam, fairly compacted, granular to blocky structure. Strong effervescence.

Analyses	Sample depth cm				
	0–20	20–35	35–60	60–100	100–120
Clay %	17	17	6	Gravel	16
Silt %	30	28	5	"	6
Fine sand %	48	47	17	"	41
Coarse sand %	5	7	72	"	37
Texture	SL	SL	S	-	SL
Gravel %	-	2	21	"	3
$CaCO_3$ equivalent %	19	16	5	-	8
Org.matter %	0.4	0.4	0.01	-	0.3
Available P ppm	19	2	2	-	1
CEC meq/100 gm	15	12.5	4.5	-	7
pH water	-	-	-	-	-
EC 1:5 ext.u Mhos	132	518	150	-	113
Soluble salts meq/1