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REPUBLIC OF YEMEN
MINISTRY OF CONSTRUCTION
GENERAL CORPORATION FOR
ROADS AND BRIDGES

FILE COPY

SAFIR - HADRAMOUT ROAD PROJECT

STUDIES RELATED TO
ENVIRONMENTAL ASSESSMENT
FEASIBILITY AND DETAILED DESIGN

EXECUTIVE SUMMARY

DRAFT

DECEMBER 1993

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EXECUTIVE SUMMARY

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ABBREVIATIONS

AASHTO	-	American Association of State Highway and Transportation Official
AC	-	Asphalt Concrete
ADT	-	Average Daily Traffic
CBR	-	California Bearing Ratio
CES	-	Consulting Engineering Services (India) Private Limited
CPO	-	Central Planning Organisation
CSA	-	Cumulative Standard Axles
DBST	-	Double Bituminous Surface Treatment
EA	-	Environmental Assessment
EIRR	-	Economic Internal Rate of Return
EMP&M	-	Environmental Management Plan and Monitoring
EPC	-	Environmental Protection Council
ERADA	-	Eastern Regional Agricultural Development Authority
ESA	-	Equivalent Standard Axle
GNP	-	Gross National Product
GCRB	-	General Corporation for Roads and Bridges
GDH	-	General Department of Hydrology
GOAMM	-	General Organisation for Antiquities, Manuscript and Museum
GPS	-	Global Positioning System
GVW	-	Gross Vehicle Weight
ha	-	Hectare
HDM-III	-	Highway Design and Maintenance Standard Model III
ICB	-	International Competitive Bidding
IDA	-	International Development Association
MAWR	-	Ministry of Agriculture and Water Resources
MMP	-	Mitigation Management Panel
MOLG	-	Ministry of Local Governorate
MOPAD	-	Ministry of Planning and Development
NGO	-	Non-Governmental Organisation
PDRY	-	Peoples Democratic Republic of Yemen
EPMC	-	Environmental Planning and Monitoring Committee
Q	-	Quintal
ROY	-	Republic of Yemen
RH	-	Relative Humidity
ROW	-	Right-of-Way
TOR	-	Terms of Reference
TRL	-	Transport Research Laboratory, UK
UNDP	-	United Nations Development Programme
VOC	-	Vehicle Operating Cost
WB	-	World Bank

EXECUTIVE SUMMARY

0.1 Background

The proposed Safir-Hadramout Road will traverse the central part of Republic of Yemen. The primary objective of this Project Road is to connect and integrate the Eastern Governorate of the Republic (erstwhile PDRY) with the capital Sana'a and Western/Northern Governorates of the country by providing a shorter and easier route. Other important objectives are :

- to serve the prospective oil concession blocks along the road;
- to provide outlet for the rich agricultural produce of the Hadramout valley and the horticultural produce of Marib and Al Jawf;
- to serve as a basic infrastructure to encourage development of habitations and agriculture/horticulture along the route and to assist industrial development in general and ancillary industries related to petroleum in particular;
- to provide easier access to the essential supplies and services like food, health and education to the estimated 100,000 Bedouin population wandering through areas where at present such services are conspicuous by their absence;
- to serve as an important strategic link and to improve the security of the country by virtue of being located close to the country's northern border;
- to help increase the flow of tourists to the historical and picturesque Hadramout valley and other places of interest in and around the area including the beautiful, but gaunt, desert landscape.

Considering the primary objectives of the Project and the large socio-economic benefits expected to accrue therefrom, the General Corporation for Roads and Bridges (GCRB) of the Republic of Yemen (ROY) had the feasibility and detailed engineering studies for the project carried out through the Consulting Engineering Services (India) Private Limited (CES) during the year 1992. The studies prepared by CES showed that the road would be economically viable. The study also indicated that the project would have significant positive environmental and social impacts.

Subsequently, the World Bank required a detailed environmental assessment and a review of engineering design and contract documents. The GCRB has engaged CES as the Consultants for carrying out these tasks.

0.2 The Project

The proposed road will be 311 km long connecting Safir to Al Makhaneg via Ghuwayriban, Al' Abr and Al Gauda (Fig. 0.2). It traverses two types of terrain, most of which (about 96.6 per cent) is on flat desert plateau and remaining (3.4 per cent) on rolling terrain.

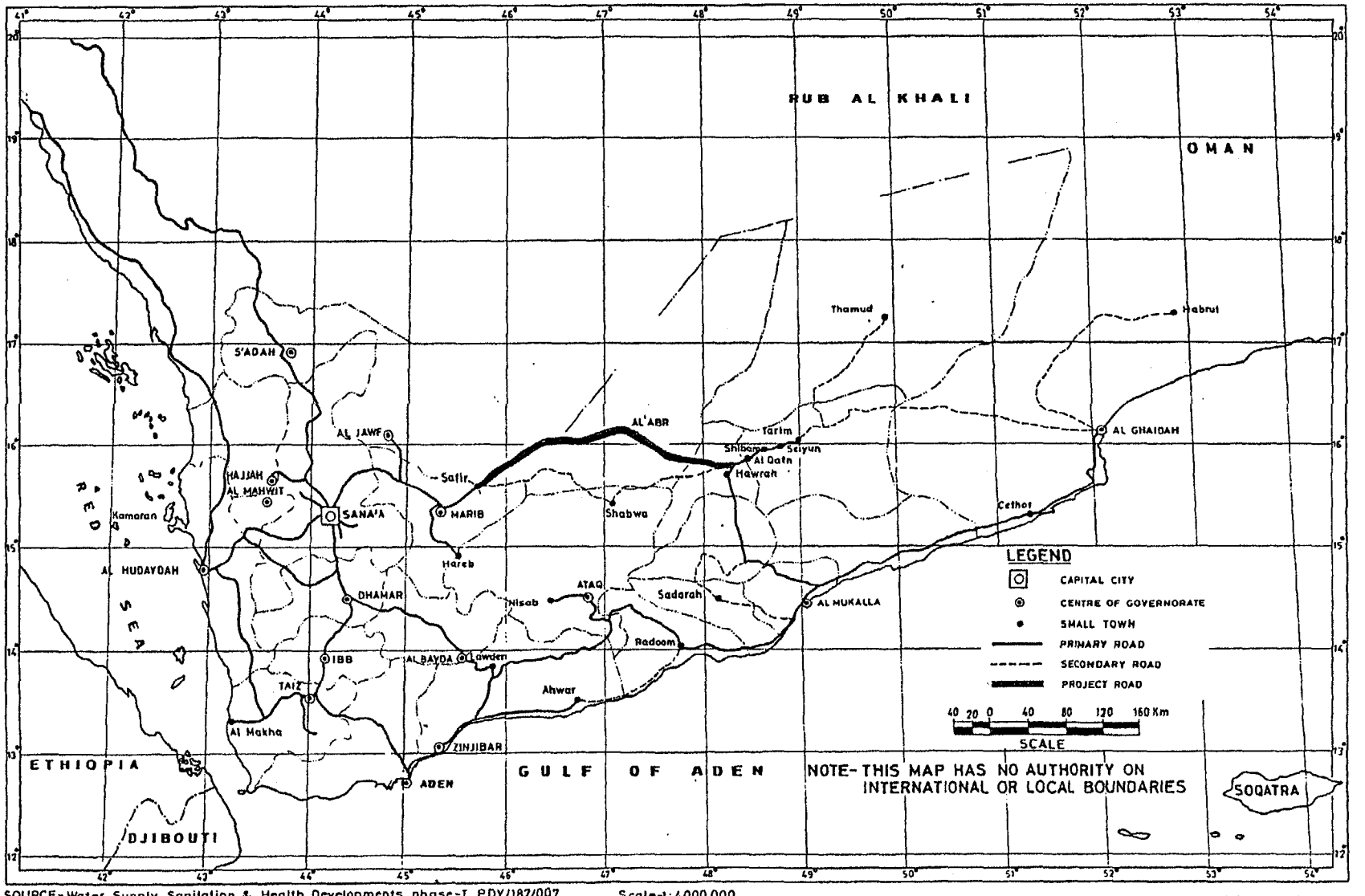
0.2.1 The project area has predominantly the character of a desert with hot and arid climate, characterised by high diurnal range of temperature and evaporation exceeding precipitation.

The average annual rainfall is low but wet months including cloud bursts might occur once in a few years and can cause flash floods.

The landscape is mainly a monotonous spread of featureless brown aeolian sand. Sand dunes occur in some stretches as also scattered low to moderately high hills. The landscape by and large is conspicuous by absence of any significant flora and fauna except that in and around wadi beds, there are small trees and shrubs inviting scattered camels and goats for grazing. The settlements are absent upto km. 180 with no ground water source present. There exists one settlement at Al' Abr (a district centre) and a few smaller scattered ones along the last 46 km length of the road from Bir Al Wahed to Al Makhaneg, the terminal point of the project road.

0.2.2 Key design features of the road are as follows:

Roadway	7 m wide 2-lane carriageway and 1.5 m wide granular shoulders on either side.
Pavement	50 mm thick asphalt concrete wearing course on 150 mm thick aggregate base, over 200 mm sub-grade layer using selected material (design CBR 25%) (Note: Pavement design is under review based on axle load survey and TRL Report)
Cross Drainage	Multi- and single-cell box culverts for crossing major wadis and small wadis respectively and low



SOURCE- Water Supply Sanitation & Health Developments phase-I PDY/187/007 Scale-1:4000,000

FIG. Nr. 0·2
INDEX MAP

	level Irish crossings for minor and shallow channels.
Side Slopes (V:H)	In embankment, 1:3 in stable terrain and 1:4 in areas where sand flow occurs by aeolian process. In sand dunes, 1:3 to 1:4.
Protection Works	Stone masonry and gabion retaining walls and slope protection by stone pitching where required; grouted rip-rap lining for side drains in areas with erosion potential
Road Furniture	Pavement markings, traffic signs, traffic lights and crash barriers at vulnerable locations with single galvanised steel guard rails 0.9 m high.
Construction Materials :	
- Embankment and Sub-grade	Road side borrow areas have been identified and suitable materials are available within moderate haulage distances.
- Base and Wearing Course, Aggregates and stones	Stone quarries for base and wearing courses including aggregates for concrete and protection works have been identified within reasonable haulage distances.

0.3 Environmental Assessment

Environmental Assessment (EA) study was carried out in three stages by a team of experts. Names of experts and their positions are included in Appendix 0.3.

Stage - I

This was a pre-Field study which included collection of available data, discussion with various Government Authorities and Ministries, review of relevant available literature, identification of data gaps and preparation of base information and finally submission of Inception Report.

Stage - II

This was a Field study and was jointly undertaken by all the experts along the entire legnth of the proposed road corridor for visual assessments and local enquiries and for meeting critical data gaps, and identifying potential

environmental and social impacts. This led to the division of the proposed road into 22 environmentally homogenous segments, for each of which the quality of environment was assessed and likely impacts due to road construction and actions for mitigating negative impacts (if any) were identified (see Fig. 0.3).

The significant attributes of environment along the proposed road alignment are shown in Table 0.3

Stage - III

This has included finalisation of EA report, documenting Stage I and II results and development of Environmental Management and Monitoring Plan for mitigating negative impacts identified.

0.4 Survey on Heritage : Archaeology & Prehistory

As part of the EA study, a field survey was conducted to locate the relics of prehistory and archaeology and to determine the extent to which such sites will be impacted by road construction. 35 sites have been identified as of archaeological importance and 50 of prehistoric importance, as indicated in Fig. 0.4. The other highlights of the findings are given below:

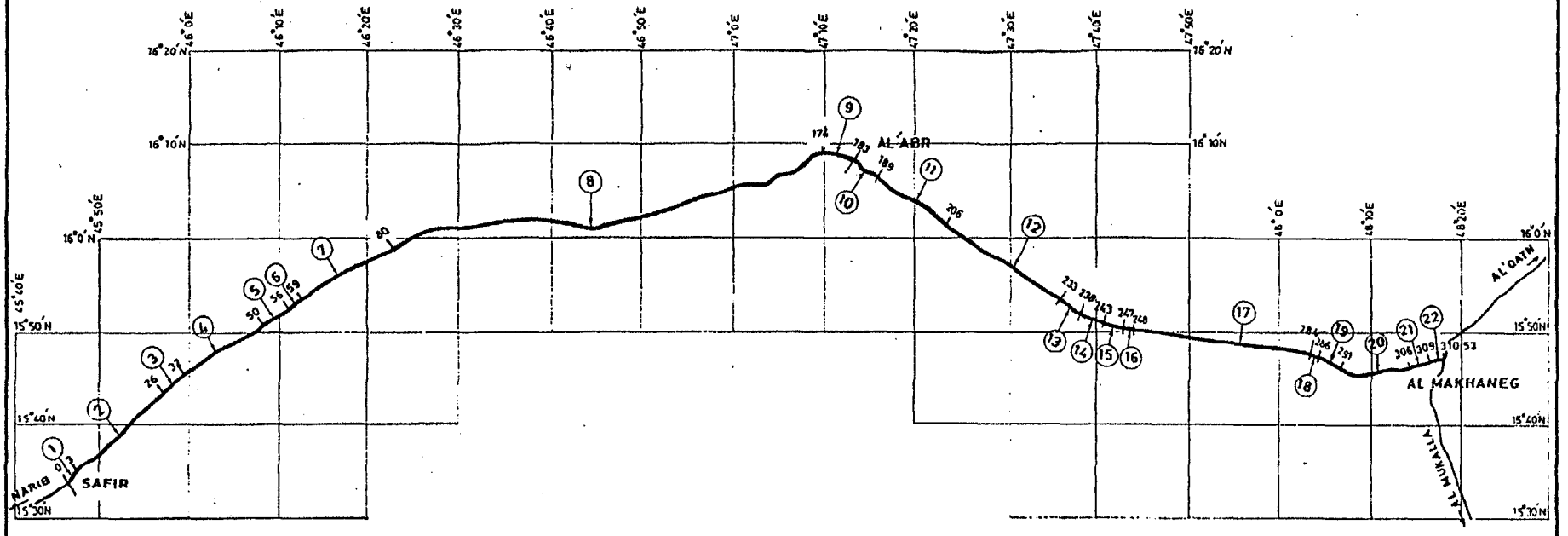
Archaeological Survey

35 archaeological sites have been identified. These are classified according to their indicative dates as follows:

Bronze Age	-	7 sites
South Arabic	-	1 site
Islamic	-	3 sites
Modern Bedouin	-	6 sites
No Clue	-	18 sites
		35 sites

The nature of archaeological sites can be classified as follows:

Related to burial	-	21 sites
Kiln	-	1 site
Settlement	-	4 sites
Stone circle	-	1 site
Undetermined	-	8 sites
		35 sites



NOTE:-

PACKAGE I km. 0·000 TO km.180·900
PACKAGE II km.180·900 TO km.310·500
OF CES ROAD ALIGNMENT DRAWINGS

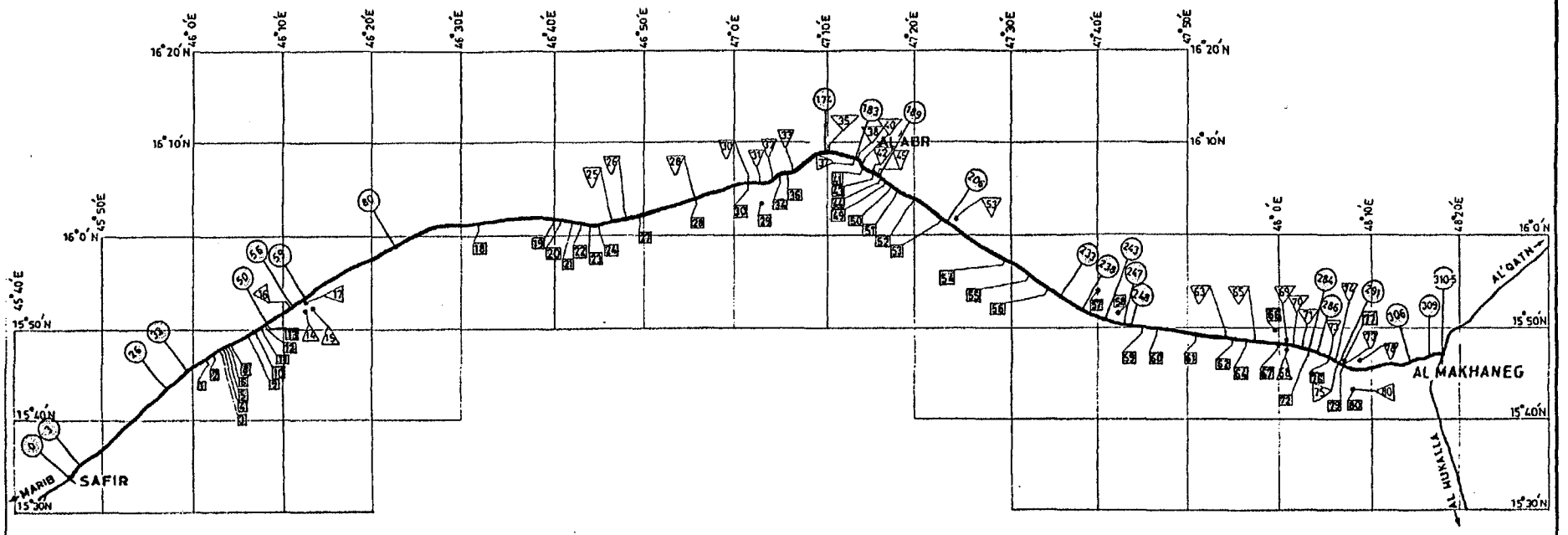
5 0 5 10 15 20 25 Km
SCALE

LEGEND:-

- EA SEGMENTS (km.) 80 174
- EA SEGMENTS (NR) (8)

FIG. NR. 0·3

LOCATION OF EA SEGMENTS ALONG THE PROPOSED ROAD

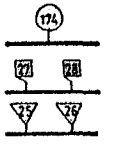


NOTE:-

1. PACKAGE I : km. 0·00 TO km.180·90
2. PACKAGE II km.180·90 TO km.310·50
3. SIGNIFICANT SITES ARE [33] AND ▽17.

LEGEND:-

- EA SEGMENT BOUNDARY (km).
- PREHISTORIC SITE LOCATIONS.
- ARCHAEOLOGICAL SITE LOCATIONS.



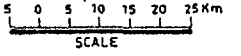


FIG.NR. 0·4

LOCATION OF ARCHAEOLOGICAL AND PREHISTORIC SITES ALONG PROPOSED SAFIR-HADRAMOUT ROAD

Table - 0.3

Significant Attributes of Environment of Road Alignment

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		1 (0-3)	2 (3-26)	3 (26-32)	4 (32-50)	5 (50-56)
A.	**Concerning Road Corridor**					
1.	Landform	Dune	Playa	Plain	Plain	Plain
2.	Stability	Shifting	Stable	Erosional	Depositional	Stable
3.	Lithology	Sand/Gravel	Gravel/Sand	Sand/Gravel	Sand/Gravel	Gravelly
4.	Wadi (Nos.)	-	-	-	-	-
5.	Surface Drainage	Free	Free	Impeded	Impeded	Free
6.	Ground Water Level (m)	90	105	105	120	125
7.	Expected Yield of Water	Profuse	Profuse	Profuse	Good	Good
8.	Prehistoric Site (Nos.)	-	-	-	4	-
9.	Archaeological Site (Nos.)	-	-	-	-	-
10.	Number of Cut Sections	10	20	11	22	2
11.	Average Length of Cut Sections (km)	0.126	0.076	0.091	0.174	0.079
12.	Number of Fill Sections	11	29	15	30	3
13.	Average Length of Fill Sections (km)	0.146	0.728	0.325	0.462	1.944
14.	Number of Irish Crossings	-	-	-	-	-
15.	Number of Box Culverts	2	7	2	10	3
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Grass	Grass	Grass	Grass	Grass
17.	Quality of Vegetative Cover	Scanty	Scanty	Scanty	Moderate	Poor
18.	Used for Grazing	-	-	-	-	-
19.	Used for Firewood Collection	-	-	-	-	-
20.	Used as Irrigated Farm Land	-	-	-	-	-
21.	Used as Period Fallow	-	-	-	-	-
22.	Name of Settlement	Safir	-	-	-	-
23.	Location of Settlement (km)	2 km off	-	-	-	-
24.	Primary Function of the Settlement	Industrial	-	-	-	-
25.	Water Source	Bore Well	-	-	-	-
26.	School	-	-	-	-	-
27.	Healthcare Centre	Private	-	-	-	-
28.	Administrative Office	-	-	-	-	-
29.	Prehistoric Site	-	-	-	8	-
30.	Archaeological Site	-	-	-	1	-

Table - 0.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		6 (56-59)	7 (59-80)	8 (80-174)	9 (174-183)	10 (183-189)
A.	**Concerning Road Corridor**					
1.	Landform	Low Hill	Plain	Plain	Dissected	Dissected
2.	Stability	Erosional	Depositional	Erosional	Erosional	Erosional
3.	Lithology	Schist/Sand	Gravel/Sand	Gravel/Gneiss	Alluvia/Gravel	Alluvia/Gravel
4.	Wadi (Nos.)	-	-	18	3	6
5.	Surface Drainage	Free	Free	Free	Free	Free
6.	Ground Water Level (m)	-	130	115-140	130	135
7.	Expected Yield of Water	-	Poor	Good	Fair	Fair
8.	Prehistoric Site (Nos.)	-	-	9	-	1
9.	Archaeological Site (Nos.)	1	-	4	-	1
10.	Number of Cut Sections	4	22	62	13	19
11.	Average Length of Cut Sections (km)	0.185	0.085	0.124	0.318	0.108
12.	Number of Fill Sections	6	25	101	14	14
13.	Average Length of Fill Sections (km)	0.380	0.726	0.802	0.283	0.133
14.	Number of Irish Crossings	-	-	18	3	6
15.	Number of Box Culverts	1	6	16	8	8
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Bare	Grass	Grass/Tree	Tree/Grass	Grass
17.	Quality of Vegetative Cover	-	Scanty	Moderate	Good	Negligible
18.	Used for Grazing	-	Occasionally	Occasionally	Occasionally	-
19.	Used for Firewood Collection	-	-	Occasionally	Frequently	-
20.	Used as Irrigated Farm Land	-	-	-	-	-
21.	Used as Period Fallow	-	-	-	Limited	-
22.	Name of Settlement	-	-	-	Al' Abr	Al' Abr
23.	Location of Settlement (km)	-	-	-	183	183
24.	Primary Function of the Settlement	-	-	-	Trade/Admn.	Trade/Admn.
25.	Water Source	-	-	-	Well	Well
26.	School	-	-	-	Yes	Yes
27.	Healthcare Centre	-	-	-	Yes	Yes
28.	Administrative Office	-	-	-	Customs Bldg	Customs Bldg
29.	Prehistoric Site	-	-	4	-	1
30.	Archaeological Site	3	-	8	-	-

Table - 0.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		11 (189-206)	12 (206-233)	13 (233-238)	14 (238-243)	15 (243-247)
A.	**Concerning Road Corridor**					
1.	Landform	Plain	Plain	Plain	Plain	Plain
2.	Stability	Erosional	Depositional	Stable	Erosional	Erosional
3.	Lithology	Colluvium	Sand/Gravel	Colluvium	Gravel/Sand	Gravel/Sand
4.	Wadi (Nos.)	-	-	-	-	-
5.	Surface Drainage	Free	Free	Free	Free	Free
6.	Ground Water Level (m)	150	170	160	140	130
7.	Expected Yield of Water	Good	Fair	Good	Good	Good
8.	Prehistoric Site (Nos.)	3	2	-	-	-
9.	Archaeological Site (Nos.)	2	-	-	-	-
10.	Number of Cut Sections	-	-	-	-	-
11.	Average Length of Cut Sections (km)	-	-	-	-	-
12.	Number of Fill Sections	2	1	1	1	1
13.	Average Length of Fill Sections (km)	8.5	27	5	5	4
14.	Number of Irish Crossings	-	-	-	-	-
15.	Number of Box Culverts	1	2	5	1	1
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Grass	Grass	Bare	Shrub/Legume	Shrub/Tree
17.	Quality of Vegetative Cover	Poor	Poor	-	Moderate	Fair
18.	Used for Grazing	Occasionally	Occasionally	-	Occasionally	Generally
19.	Used for Firewood Collection	-	-	-	-	Generally
20.	Used as Irrigated Farm Land	-	-	-	-	-
21.	Used as Period Fallow	-	-	-	-	-
22.	Name of Settlement	-	-	-	-	Bir Al Wahed
23.	Location of Settlement (km)	-	-	-	-	244
24.	Primary Function of the Settlement	-	-	-	-	Livestock
25.	Water Source	-	-	-		Bore Well
26.	School	-	-	-	-	Yes
27.	Healthcare Centre	-	-	-	-	Yes
28.	Administrative Office	-	-	-	-	-
29.	Prehistoric Site	3	1	1	-	1
30.	Archaeological Site	3	-	-	-	-

Table - 0.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		16 (247-248)	17 (248-284)	18 (284-286)	19 (286-291)	20 (291-306)
A.	**Concerning Road Corridor**					
1.	Landform	Wide Wadi Land	Plain	Dune	Plain	Plain
2.	Stability	Erosional	Depositional	Depositional	Depositional	Stable
3.	Lithology	Gravel	Silt/Gravel	Sand/Gravel	Silt/Gravel	Gravel/Silt
4.	Wadi (Nos.)	1	10	-	-	-
5.	Surface Drainage	Free	Free	Free	Free	Free
6.	Ground Water Level (m)	115	45	30	30	25
7.	Expected Yield of Water	Good	Profuse	Profuse	Profuse	Profuse
8.	Prehistoric Site (Nos.)	-	4	-	1	-
9.	Archaeological Site (Nos.)	-	4	-	3	-
10.	Number of Cut Sections	-	10	5	3	1
11.	Average Length of Cut Sections (km)	-	0.105	0.044	1.577	0.020
12.	Number of Fill Sections	1	25	6	4	4
13.	Average Length of Fill Sections (km)	1	1.348	0.283	1.157	3.723
14.	Number of Irish Crossings	2	10	-	-	-
15.	Number of Box Culverts	-	22	1	3	11
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Shrub	Grass	Shrub/Grass	Grass	Tree/Grass
17.	Quality of Vegetative Cover	Moderate	Good	Good	Fair	Good
18.	Used for Grazing	Occasionally	Frequently	Frequently	Frequently	Frequently
19.	Used for Firewood Collection	Occasionally	-	Occasionally	-	Frequently
20.	Used as Irrigated Farm Land	-	-	-	-	Some
21.	Used as Period Fallow	-	-	-	-	Some
22.	Name of Settlement	-	-	-	-	Al Khasha Al Gauda
23.	Location of Settlement (km)	-	-	-	-	290/305
24.	Primary Function of the Settlement	-	-	-	-	Farming/ Service
25.	Water Source	-	-	-		Bore Well
26.	School	-	-	-	-	Yes
27.	Healthcare Centre	-	-	-	-	Yes
28.	Administrative Office	-	-	-	-	-
29.	Prehistoric Site	-	4	-	2	-
30.	Archaeological Site	-	3	-	-	-

Table - 0.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)	
		21 (306-309)	22 (309-310)
A.	**Concerning Road Corridor**		
1.	Landform	Wadi	Plain
2.	Stability	Erosional	Erosional
3.	Lithology	Alluvia	Alluvia/Gravel
4.	Wadi (Nos.)	5	5
5.	Surface Drainage	Free	Free
6.	Ground Water Level (m)	20	20
7.	Expected Yield of Water	Profuse	Profuse
8.	Prehistoric Site (Nos.)	-	-
9.	Archaeological Site (Nos.)	-	-
10.	Number of Cut Sections	5	10
11.	Average Length of Cut Sections (km)	0.472	0.227
12.	Number of Fill Sections	6	8
13.	Average Length of Fill Sections (km)	0.309	0.226
14.	Number of Irish Crossings	5	5
15.	Number of Box Culverts	2	3
B.	***Concerning Adjacent Area***		
16.	Natural Vegetation Type	Shrub/Grass	Grass/Tree
17.	Quality of Vegetative Cover	Fair	Poor
18.	Used for Grazing	Frequently	Occasionally
19.	Used for Firewood Collection	Frequently	Occasionally
20.	Used as Irrigated Farm Land	Some	Some
21.	Used as Period Fallow	Some	Some
22.	Name of Settlement	-	Al Makhaneg
23.	Location of Settlement (km)	-	310
24.	Primary Function of the Settlement	-	Service
25.	Water Source	-	Bore Well
26.	School	-	-
27.	Healthcare Centre	-	-
28.	Administrative Office	-	-
29.	Prehistoric Site	-	-
30.	Archaeological Site	-	-

A summary of the actions recommended for the archaeological sites has been presented in the Basic Study 5, Report on Heritage. The number of sites classified by the types of recommended actions are as follows:

No action required	-	16 sites
Avoid quarrying	-	3 sites
Protect by fencing	-	8 sites
Realign road, if possible	-	1 site
GOAMM to exavate for further information	-	7 sites
GOAMM to monitor during road construction	-	7 sites
GOAMM to prepare maps before road construction	-	1 site
		43 sites

(Multiple actions suggested for some of the sites have raised the total from 35 to 43 sites.)

Of these, Site No. 17 has some importance from the cost angle, if it becomes a necessary to avoid this site and find an alternative alignment for the road. However, the expert opinion is that realignment is avoidable if the GOAMM take up excavation at the site to determine its real significance. Another alternative to realignment is to protect the site by fencing. Salvage by excavation or protection by fencing has been suggested for Site No. 45 also. In case of quarry sites of archaeological importance, the Consultants have selected alternative sources of materials.

Prehistoric Survey

50 sites have been identified as yielding evidences of prehistoric culture and these are classified as follows:

Lower Palaeolithic (Acheulean)	-	2 sites
Middle Palaeolithic	-	17 sites
Upper Palaeolithic	-	Nil
Neolithic	-	11 sites
Bronze Age	-	1 site
Undetermined	-	21 sites
		52 sites

(2 of the sites have multiple cultural classifications, which has increased the total of classified sites to 52.)

Assuming that the surveyed sites provide a useful sample of similar sites in the region traversed by the proposed road, the Consultants have determined the

order of potentials for encountering exposed prehistoric cultural resources in terms of the road segments in the following manner:

Low Potential : Segments 1,2,3,5,6,7,9,14,16,18,21 &22	87 kms
Low to Moderate Potential : Segments 10,12,13 & 15	42 kms
Moderate to High Potential : Segments 11, 17,19 & 20	72 kms
Very High Potential : Segments 4 and 8	110 kms
	311 kms

The observations given above regarding potential prehistoric importance of sites might serve as guide to future explorations in the adjoining regions. However this survey has attempted to identify exhaustively the prehistoric sites within the road corridor itself. The results show that some 78% of all the surveyed sites are located in just 4 of the road segments, namely 4, 8, 11 and 17. Amongst these, Segments 4 and 8 together account for 50% of the surveyed sites.

Not all of the 50 sites identified are wholly within the proposed road corridor. These are distributed as follows:

Wholly within the right of way	-	16 sites
Partially within the right of way	-	24 sites
Quarry area	-	8 sites
Outside Impact area	-	2 sites
		50 sites

EA studies indicate that all the vulnerable quarry sites can be avoided by exploiting alternative sources of construction materials.

As is to be expected, all the 50 sites are not equally significant from the prehistoric point of view. By taking into consideration a set of indicators like site integrity, uniqueness, research potential, regional importance and the quality of artefacts, a composite scoring was evolved to measure the order of significance of each site.

The Consultants have recommended to adopt proper mitigation measures for 3 sites having the highest score. These are Site Nos. 12, 13 and 62. Of these, Site Nos. 12 and 13 are located in Segment 4 of the proposed road. Site No. 62 is located in Segment 17. For the rest of the sites, the Consultants assess that no monitoring is necessary.

Site No. 12 lies well outside the proposed road corridor and as such will not be impacted by the proposed road construction activities. However, the order of

significance of this site calls for preservation and prevention of all future development activities upon or near it.

Site No. 13, however, falls partly within the proposed right of way. It is suggested that GOAMM may undertake further investigation at the portion of the site to be impacted by road construction activities to confirm if the present alignment is acceptable or a change of alignment is called for. It is further recommended that the portion of this site that is not impacted by construction activities be protected by fencing and by preventing all future developmental activities thereon.

Site No. 62 is located on talus slope and scree deposits at a proposed quarry location. Avoidance of this site as quarry is recommended. GOAMM may also consider conducting field investigations to assess the site's significance adequately.

0.5 Structure of the EA Report

Environmental Assessment Report (Volume I) has been structured in the following chapters:

		Executive Summary
Chapter I	-	Objectives and Approaches
Chapter II	-	Regional Environmental Set Up
Chapter III	-	Potential Impact and Mitigation
Chapter IV	-	Alternative Alignment Study
Chapter V	-	Environmental Management & Monitoring Plan
Chapter VI	-	Legal Framework and Institution

The report also includes following five (5) basic study reports to address the key issues:

1. Combating Desertification
2. Hydrology of the Inland Basin
3. Social Groups along the Proposed Road Corridor
4. Pattern of Regional Development
5. Heritage - Archaeology and Prehistory.

0.6 Environmental Impacts

The regional environmental set up of the Project area was studied in the light of orography, lithostratigraphy, dynamism in landscape formation, biotic environment (soil, flora and fauna), human response to environment and heritage - archaeology and prehistory.

Depending on significant attributes of the environment, the entire road corridor has been divided into 22 segments as earlier listed in Table 0.3. Environmental impacts on these segments are studied for the following three stages of the proposed road:

(a) Construction of camp sites
(b) During construction
(c) After construction and during operation.

Likely negative environmental impacts and mitigating measures are summarised in Tables 0.6(a), 0.6(b) and 0.6(c) respectively. A set of positive environmental impacts has also been identified, as summarised in Table 0.6(d).

Construction of Camp Sites

Considering the least possible negative impact, four (4) construction camp sites have been suggested alongwith measures to maximise the positive impacts and its enhancements. The recommended sites are as follows:

(1)	Segment 1	Near the junction of proposed corridor with Marib-Safir road at Safir.
(2)	Segment 9	5 to 7 km to the south-west of Al' Abr.
(3)	Segment 10	5 to 7 km to the south-east of Al' Abr.
(4)	Segment 22	Near the junction of proposed corridor with Al Mukalla-Seiyun road at Al Makhaneg.

Potentially significant impacts are (i) air pollution from asphalt plant; (ii) dust and noise pollution from crusher; and (iii) sanitation and waste disposal. Mitigating measures have been recommended, which are to be monitored during construction. [see Table - 0.6(a)]

Table 0.6(a)

Summary of Negative Environmental Impacts from Construction Camps and Their Mitigation

Sl. No.	Impacts	Order of Impacts Upon Road Segments (*)				Mitigating Measures	Actions
		1	9	10	22		
	DIRECT						
1.	Resettlement / land acquisition	0	0	0	0	None. According to available information camp sites can be located on government land	No action
2.	Destruction of vegetation	0	1	1	1	Establish camps away from vegetated areas. Where unavoidable plant trees in replacement of those cut	Include Special Condition in Tender Document. Monitoring during construction by GCRB/ Supervision Consultant
3.	Oil - grease spillage	1	1	1	1	Adopt good practice to avoid spillage and pursue collection and recycling	- do -
4.	Air pollution from asphalt plant	2	2	2	2	Select and maintain plant to satisfy pollution control criteria and locate plant at leeward edge of camp. This will be a local phenomenon confined to a few locations	- do -
5.	Dust and sound pollution from crusher	2	2	2	2	Locate plant at leeward edge of camp. No habitation other than the construction camp is likely to be affected	- do -
6.	Poor sanitation and waste disposal	2	2	2	2	Install lavatory; source separation of garbage; use of organic materials as compost; storage of non -bio- degradable materials	- do -
7.	Waste water	1	1	1	1	Irrigate camp site plantation	- do -
8.	Transmission of communicable disease	1	1	1	1	Periodic health check and medication	- do -
9.	Poaching	1	1	1	1	Control through terms of employment	- do -
10.	Obstruction to local communication	0	0	0	0	None	No action
11.	Archaeological and prehistory sites	0	0	0	0	Avoid significant sites as identified	Include special condition in Tender Document. Monitoring during construction by GCRB/ Supervision Consultant
12.	Social and cultural disruption	0	0	0	0	None	No action
	INDIRECT						
13.	Illegal timber cutting	0	1	1	1	Use liquid petroleum gas as fuel in kitchen	Include special condition in Tender Document. Monitoring during construction by GCRB/ Supervision Consultant

NOTE : * Order of impact implies : 0 = No impact; 1 = Mild; 2 = Moderate; 3 = High; 4 = Severe

Table 0.6(b)

Summary of Negative Environmental Impacts from Construction of Road and Their Mitigation

Sl. No.	Impacts	Order of Impacts (*)	Mitigating Measures	Actions
	DIRECT			
1.	Dislocation and compulsory resettlement of people living on the right of way	0	None. According to available information ROW is government land.	No action
2.	Poaching by construction workers	1	Prohibit poaching under terms of employment	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
3.	Reactivation of dunes	3	Wind screen and plantations	Wind screen construction and plantation programme implementation by ERADA/EPC. Monitoring by MMP
4.	Landscape disfiguration by high embankments and deep cuts	1	Road side plantation of trees and gentle slope at cut and fill sections	None for embankment but for cut section tree plantation. Programming and implementation by ERADA. Monitoring by MMP.
5.	Borrow areas and quarry sites	1	Systematic and controlled excavation/ quarrying of borrow/quarry areas preferably on windward side and backfilling by waste material from cut section. Avoid significant heritage sites	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
6.	Landslides, slumps and slips in road cuts	1	Provide drainage works and stabilise with retaining structures like concrete/masonry wall, gabions, grouted rip rap etc. where risk exists.	Necessary measures to be taken in design. Monitoring during construction by GCRB/Supervision Consultant
7.	Air, dust, fume, smoke and noise pollution to inhabited areas from construction equipment, crusher, blasting at quarries	1	Use pollution control for construction equipment, control blasting at quarries with precautionary measure at quarries during blasting. Avoid installations near inhabited areas.	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
8.	Interference with surface drainage	2	Provide ditches and cross drainage structures	Necessary measures taken in design. Monitoring during construction by GCRB/Supervision Consultant
9.	Erosion of or along road embankment by flowing water	2	Channelise water flow through drains. Provide drain lining and other erosion protection measures at vulnerable locations	Necessary measures to be taken in design. Monitoring during construction by GCRB/Supervision Consultant
10.	Alteration of sub-soil water table due to water abstraction	1	Controlled withdrawal of water from deep aquifer	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant.
11.	Alteration of hydrological regimes of wet lands	0	None	No action
12.	Destruction of vegetation and wildlife on the right of way	0	Regenerate vegetation in the neighbourhood plus roadside plantation. Do not disturb vegetation outside the area occupied by the road embankment or cut.	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant.

Table 0.6(b) (contd)

Sl. No.	Impacts	Order of Impacts (*)	Mitigating Measures	Actions
13.	Destruction of biological resources or eco-systems	0	None	No action
14.	Interruption of migratory routes for wild life and livestock	0	None	No action
15.	Creation of breeding habitats for mosquito by stagnant pools of water	0	Provide drainage or reuse water for vegetation. Facilitate quick fill up by sand by aeolian movement of the empty borrow pits	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
16.	Creation of a transmission corridor for diseases, pests, weeds and other undesirable organisms	0	None	No action
17.	Construction interferences to existing traffic	1	Provide markers, lights with warning signs for traffic diversion	Include Special Condition in Tender Documents for lights and warning signs. Monitoring during construction by GCRB/ Supervision Consultant
18.	Destruction of utility lines	0	Take precautionary measures and avoid moving construction equipment over or near the utility lines	Monitoring during construction by GCRB/Supervision Consultant
19.	Obstruction of routes from houses to farms	1	Provide suitable crossings	Special Tender provision for construction of diversion road and monitoring during construction by GCRB/Supervision Consultant
20.	Archaeological and prehistory sites	2	Avoid significant sites as identified. Significant sites to be protected by fencing. If necessary select alternative alignment	Measures taken in Alignment design and monitoring during construction by GCRB/GOAMM/Supervision Consultant/MMP
	INDIRECT			
21.	Accident risks associated with vehicular traffic	2	Design curves (horizontal and vertical) for high speed traffic; introduce emergency plan to contain damages from accidental spills.	Already measures taken in Geometric Design of road. Monitoring during construction by GCRB/Supervision Consultant
22.	Impairment of non-motorised transportation in the highway corridor	1	Include safe crossings and diversions where required	Special Tender provision for construction of diversion road. Monitoring during construction by GCRB/Supervision Consultant

NOTE : * Order of Impact implies

0=No impact; 1=Mild; 2=Moderate; 3=High; 4=Severe

Table 0.6(c)

Summary of Negative Environmental Impacts After Road Construction and Their Mitigation

Sl. No.	Impacts	Order of Impacts (*)	Mitigating Measures	Actions
	DIRECT			
1.	Air and noise pollution from increased vehicular traffic	1	None. The expected traffic level being low to moderate and the traversed area being largely uninhibited, no actual inconvenience is envisaged	No action
2.	Roadside litter	1	Provide roadside disposal facilities. Campaign for CLEAN YEMEN; strengthen local governments for proper conservancy service in towns and villages	Monitoring by EPC and local government
3.	Induced development of commercial, residential and industrial development	3	Plan for controlled development	Planning and monitoring by EPMC and concerned ministries
	INDIRECT			
4.	Impairment of non-motorised transportation economy due to increased availability of motorised alternatives	0	None	No action
5.	Unplanned timber cutting	1	Introduce fuel-yielding trees as a part of programme to arrest desertification. Enforce forest conservation laws.	Monitoring by EPC
6.	Unplanned land clearing and occupation	2	Plan for controlled development	Planning and monitoring by EPMC and concerned ministries

NOTE : * Order of Impact implies
0=No impact; 1=Mild; 2=Moderate; 3=High; 4=Severe

Table 0.6(d)
Summary of Positive Environmental Impacts

Stage	Sl. No.	Positive Impact	Actions
		DIRECT	
Construction of camp sites	1.	Local employment generation	Monitoring by local authorities
	2.	Additional consumption of local produce	- ditto -
During construction	3.	Local employment generation	Collecting employment statistics by EPMC
	4.	Enhancement of local skills (technology transfer)	- ditto -
After construction	5.	Elimination of multiple tracks on desert floor	Post-construction surveys by GCRB/EPMC
	6.	Local employment generation in road maintenance and transportation sectors	Keeping statistics by GCRB
	7.	Improve the access of Bedouins to social services like education, health, trade, livelihood and increase in social interaction between communities	Monitoring by local government/concerned ministries together with regional development
		INDIRECT	
Construction of camp sector	8.	Taking over camp buildings and associated facilities as maintenance depots, community centres or growth nucleus	Inserting special condition in contract regarding taking over camps
	9.	Utilisation of deep borewells for enhancing local water supply	- ditto -
All stages	10.	Improvement of security environment	Keeping chronological record of security related incidents by concerned government department
	11.	Activation of local economy due to improved access and security	Planning and monitoring by the concerned govt. departments

During Construction

During construction of road the potential significant impacts are as follows:

(1) Extraction and disposal of local construction materials.
(2) Reactivisation of dunes at Segment 1 (first 0-3 km of road section)
(3) Damage to archaeological and prehistoric sites.

The recommended mitigating measures are to be monitored during construction.[see Table 0.6(b)]

After Construction and During Operation

Potential significant impacts at this stage are as follows:

(1) Induced and uncontrolled development of commercial, residential and industrial units
(2) Unplanned land clearing and alienation
(3) Air and noise pollution from increased vehicular traffic.

The recommended mitigating measures are to be monitored by EPMC and other concerned ministries [see Table 0.6(c)].

0.7 Alternative Alignment Study

An alternative alignment study is suggested in the TOR for the last 25 km of the project road with a view to avoiding a few small settlements. Accordingly three alternative alignments (A, B, C) were studied in addition to the original alignment (D) chosen earlier (see. Fig. 0.7). A comparison of these alignments in terms of their impacts is shown in Table 0.7.

Considering all the factors mentioned in Table 0.7, Alignment D appears to be the best choice as it is short in length, crosses a buried channel at its narrowest width, avoids displacement of farm land and involves but little disturbance to vulnerable sand dunes.

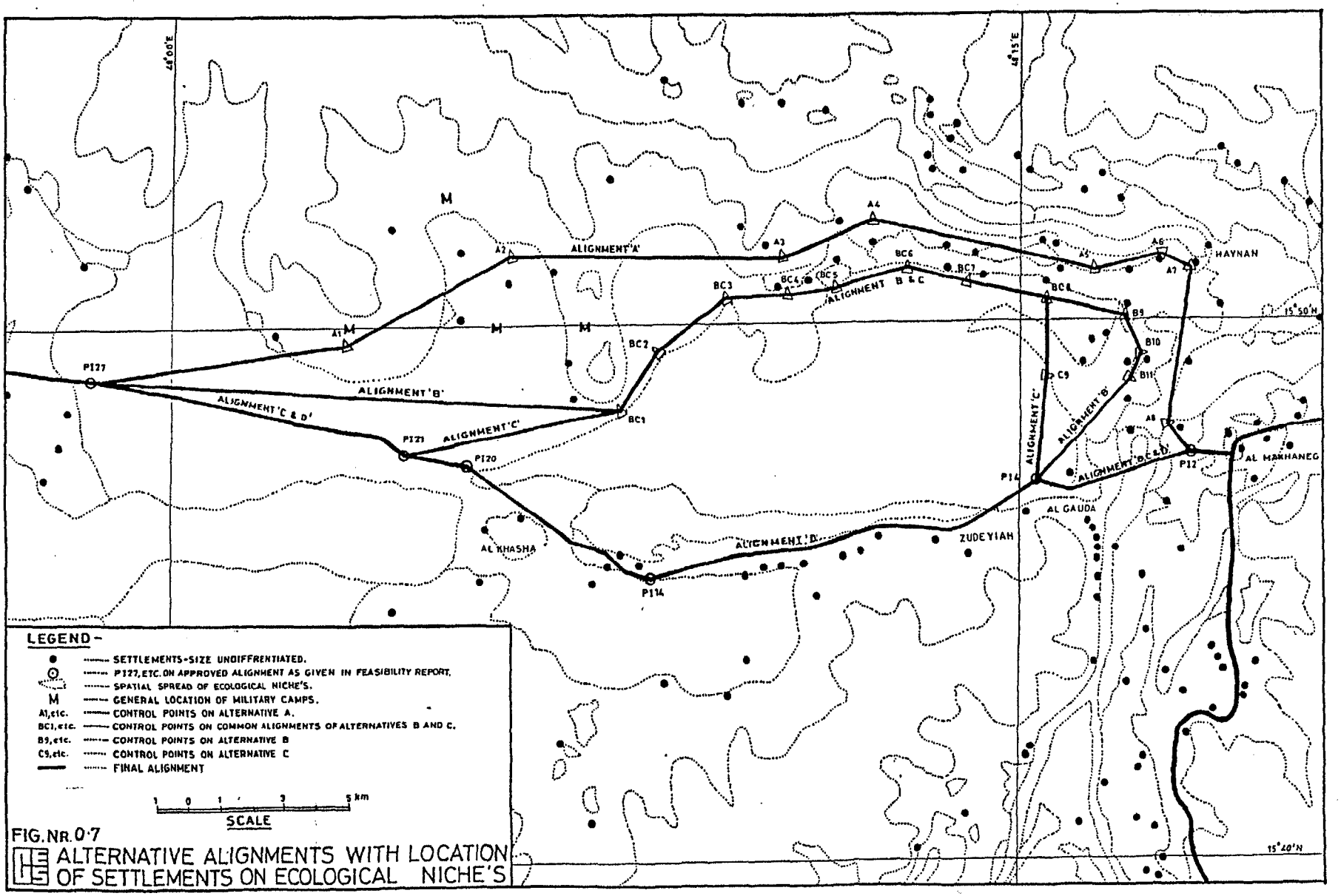


FIG. NR. 0·7

ALTERNATIVE ALIGNMENTS WITH LOCATION OF SETTLEMENTS ON ECOLOGICAL NICHE'S

Table 0.7

Magnitude of Impacts on Proposed Alternative Alignments

Sl. No.	Variables	Magnitude of Impact on Various Alternatives			
		Alternative A	Alternative B	Alternative C	Alternative D
1.	Length	Longer	Longest	Same as A	Shortest
2.	Horizontal Geometrics	Poor	Poorest	Poor	Smooth
3.	Vertical Geometrics	Fair	Poor	Poorest	Smooth
4.	Cross Drainage Structure	Maximum	Less	Less	Minimum
5.	Skirting of Unstable Sand Dunes	Minimum	Considerable	Maximum	Less
6.	Requirement of Sub-grade strengthening	Nil	Nil	Considerable	Nil
7.	Availability of Construction Materials	Nearest to Alignment	Farthest from Alignment	Farthest from Alignment	Near to Alignment
8.	Dislocation of Settled Population	Moderate	Moderate	Moderate	Nil
9.	Displacement of Farm land	Less	Considerable	Maximum	Minimum
10.	Serving of Settlements	Considerable	Considerable	Considerable	Considerable
11.	Cultural Endorsement of Potential Users	Considerable	Minimum	Minimum	Maximum
12.	Construction Cost	Maximum	Less	Less	Minimum
13.	Maintenance Cost	Less	Maximum	Considerable	Least

0.8 Enhancement Measures

It is recognised that the proposed road will have some positive impacts, which can further be channelled and enhanced in the desired directions e.g., by way of developing basic facilities for local communities and combating desertification. 6 locations have been selected along the road alignment as offering good potential in this respect, to start with. Since water constitutes a fundamental resource, the sites are identified near bore wells to be set up for construction purpose. These are as follows:

	Location	Recommended Facilities
1.	Segment 1 - near proposed road junction on Marib-Safir Road	Development of settlement with small commercial establishment, a primary health centre and a school. Construction camp to be transformed to maintenance office of GCRB and house the staff to develop roadside plantation and for combating desertification.

	Location	Recommended Facilities
2.	Segment 4 (Near km 50)	A small hotel for tourists interested in experiencing desert landscape, gas station and a provision store.
3.	Segment 9 (5-7 km to the South-West of Al' Abr)	The borewell for construction can be utilised later to enhance water supply for Al' Abr town. The construction camp may be used to house staff with the objective of promoting orchard development alongwith shelter belts.
4.	Segment 10 (5-7 km to South-East of Al' Abr)	Construction camp site may be used to house staff to be engaged for developing grazing ground and plantation for fire wood.
5.	Segment 15 (approx km 250 near Bir Al Wahed)	Bore well after construction can be used for development of road side orchard with shelter belts and grazing ground.
6.	Segment 22 (near proposed road junction with Al Mukalla-Seiyun Road at Al Makhaneg)	Construction camp site to be used by GCRB for maintenance of the proposed road. The site has the potential to develop into a significant urban centre. Landuse control measures should be taken up in advance.

0.9 Environmental Management and Monitoring Plan

The identified mitigating measures required to deal with the negative impacts directly arising out of road construction activities can be carried out through engineering design as stated in Tables 0.6(a) and 0.6(b) and costs on these accounts will be included in the cost estimates. These mitigating measures will be implemented through road construction contract and monitored by GCRB/Supervision Consultant by adhering to the design, specifications and construction methods. However, involvement of an EA Specialist in the Supervision team will be an added advantage, particularly from the point of view of dealing with modifications in mitigating measures. It is recommended that the implementation of the mitigation measures should be monitored and guided by a Mitigation Management Panel (MMP) to be formed in GCRB with experts from other concerned departments represented as members.

Other measures related to prehistory and archaeology, dune stabilisation and combating desertification, monitoring the behaviour of exploited aquifer, development of six public facilities along road towards enhancing the positive impacts, development of shelter belts, roadside orchards, administration of landuse control have been identified and actions are suggested to be taken by the concerned departments. These measures are intimately related to the policy-perspectives of the National Government. It is recommended to constitute a broad-based Environmental Planning and Monitoring Committee (EPMC) under EPC to evolve and get implemented a co-ordinated plan involving direct participation by the concerned departments, with their experts being represented in EPMC as members.

The job of EPMC would be to identify specific sub-project(s) on these recommended measures and guide the concerned departments to plan and implement them in consonance to their assigned powers and responsibilities. The EPMC would also have a role in securing allocation of funds to implement the specific projects. Some of these measures are to be taken up concurrently with the road construction such as actions related to significant prehistory and archaeological sites, dune stabilisation and roadside plantation.

It is suggested that both the monitoring bodies suggested above should have common representatives from the following Governmental institutions:

(a) EPC
(b) GCRB
(c) GOAMM
(d) MAWR
(e) ERADA and Agricultural Research Station at Seiyun
(f) Ministry of Planning and Development
(g) Ministry of Local Government.

In addition EPMC can include representatives from the Ministry of Finance and other organisations.

A flow diagram for the Environmental Management and Monitoring Plan in respect of mitigation measures arising out of construction is shown in Fig. 0.9. In respect of the other measures suggested as coming under EPMC, it is suggested that the EPMC be constituted first to serve as a forum for broad-based flow of information and decision making and to provide a basis for identification and prioritisation of projects, sourcing funds and chalking out a plan of action.

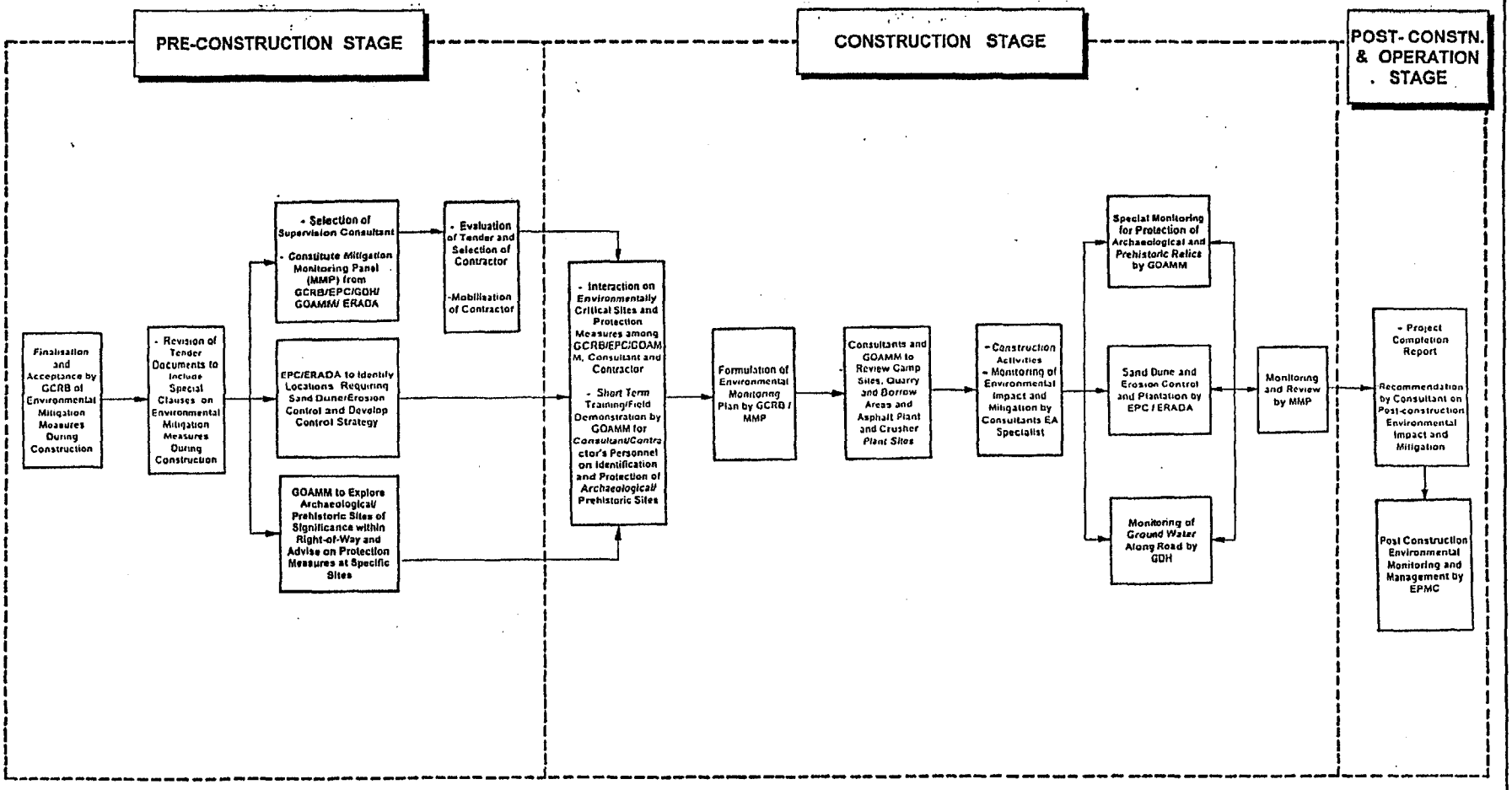


FIG. 0.9

FLOW DIAGRAM - ENVIRONMENTAL MANAGEMENT AND MONITORING

0.10 Conclusion and Recommendation

(a) Several categories of negative environmental impacts associated with road construction have been identified but these are mostly confined to particular locations or temporary in nature and are of an order which can be mitigated without difficulty.

There will be positive social and environmental impacts due to road construction some of which can be further enhanced through suitable planning and control strategies by the Government.

(b) Most of the identified direct and indirect impacts of the proposed road construction are to be taken care of in engineering design and can be monitored and implemented during road construction. However, the Supervision Consultants' team should be reinforced with an Environmental Specialist. These mitigation measures should be monitored by a MMP constituted under GCRB.

(c) Mitigating measures like combating desertification, restoration of archaeological and prehistoric sites, control of induced development, exploitation of ground water aquifer, development of six centres for enhancement of public facility should be taken as parallel projects co-ordinated and monitored by EPMC comprising multi-disciplinary experts from relevant Departments/Ministries of the ROY with EPC acting as the Co-ordinator.

(d) GOAMM needs to attach itself immediately to the project and carry out a set of investigations followed by a plan of action for protecting the relics of prehistory and archaeology at the identified significant sites before road construction is taken up.

(e) The findings of archaeology and prehistory do not adequately reveal the cultural ambiences of the observed artefacts in the absence of supplementary study on palaeo-geomorphology and palaeo-climatology. In case, the GOAMM desires to mount a project on more comprehensive survey on prehistory, it should attach a Palaeo-geomorphologist to a competent Prehistorian.

(f) During Construction of road it would stimulate certain expectations among the people who are aware of the opportunities that will be created. Water sources created for construction may become poles of attraction particularly for semi-nomadic bedouins to whom water is critical for existence. These may also become places for putting up shops, dwellings, services related to the modes of transportation and putting up of small enterprises. Moreover, people from the local communities are expecting to be employed in the construction work. It is suggested that arrangements may be made for appropriate sharing of water, land and labour employment to avoid conflicts between bedouins and other social groups

After the construction of the road there will be positive impacts in the sense that they would improve the quality of life and promote development of human resources amongst the local tribal communities, other social groups and Bedouins. It will increase the access of Bedouins to services like education, health, administrative, drinking water, trade, transportation and opportunities for employment created by the various kinds of development along the road. It may enable them to find new markets for selling their livestocks on better prices. It may also reinforce their interdependence with the market towns and permanent settlements. It may also increase opportunities for alternative employment in various activities which will grow at the various locations along the road.

Further it may reduce fragmentation and dichotomisation between the local groups because of their greater interaction and increasing interdependancy. It may induce a new spatial organisation in the form of linear development and may lead to new centralities around Al' Abr, Al Khasha and Al Makhaneg. In view of the location of Al' Abr and its particular status at the administrative and tribal levels, the tendency of its centrality would be enhanced by the demands made on it for services of various kinds, goods and transportation.

The road would link the local communities with the regional development processes. It will reinforce the linkage of the Hadramout region by providing an alternative to the Mukalla road within the national economy and will enhance the exchange of goods, ideas and widen the base of knowledge and information flowing from different parts of the country. It will enforce the process of unification and linkage with the national level administration.

(g) A Social Anthropologist specialised in Yemeni society and speaking Arabic be engaged to undertake the study on "Social Dynamism" in ROY.

(h) For combating desertification and associated action programme exposures may be necessary for training of planning personnel. The Central Arid Zone Research Institute (CAZRI) under the Ministry of Agriculture, Govt of India is identified as one such institution for imparting exposure training.

Acknowledgements

In carrying out this study, the Consultants received information and assistance from a large number of organisations and individuals, which is gratefully acknowledged and for which the Consultants express their sincere thanks. Specific acknowledgement is made and thanks expressed in particular to the following individuals who gave their time in holding discussions with CES team members and extended their help in providing base line as well as other pertinent data required for the study.

Ministry of Constrcution/GCRB:

Mr. F. Al Zuneid, General Director, Supervision Department
Mr. Hussain Rashid, General Director, Studies Department
Mr. A Said, General Director, Traffic Department
All Engineers of Traffic and Studies Department.

GOAMM:

Dr. M A Bafaqih, Director
Dr. A Batayi, Archaeologist
Dr. Al Ezy Mohammed
Dr. Abdul Aziz Bin Akil

EPC
Mr. Salem Abdulla

MAWR / ERADA:

Dr. Jamal Azir, Project Manager (Econ)
Dr. Md. Almen Al Gubati, Project Manager, Sand Dune Stabilisation, Forestry - Agroforestry
Dr. Ali Syed Md., Head, Plantation Section and Forester
Dr. Ahmed Sekh Salim, Economist
Dr. Kamal Abo Al Seoud, Engineering Consultant (World Bank) of ERADA

Agricultural Research Centre, Seiyun:

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Dr. Ahmed Salim Bataher, Head, Forestry Section
Dr. Essa A. Alkaff, Head of Laboratory
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Dr. Gaid Al Kirhiri, Irrigation Specialist

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Mr. U.S. Mohammed, Supervisor Documentation for Maps and Airphotos
Mr. Nelvi Jamal, Supervisor, Documentations for Maps and Airphotos Depatment of Mines

General Department of Forests, Range Management, Desertification:

Dr. Assad, Director General, Desertification, Forestry & Range Management
Dr. Mahmood Shediwa, General Director, Soil
Dr. Khaliga Nassor Khanil, Agroforester, Forest & Range Management
Dr. Ahmed Yehya Ali, Engineer
Dr. Azhari M. Bafiker, General Director

Ministry of Oil and Mineral Resources:

Mr. Ton Nagenmen, Chief Technical Adviser, General Department of Hydrogeology

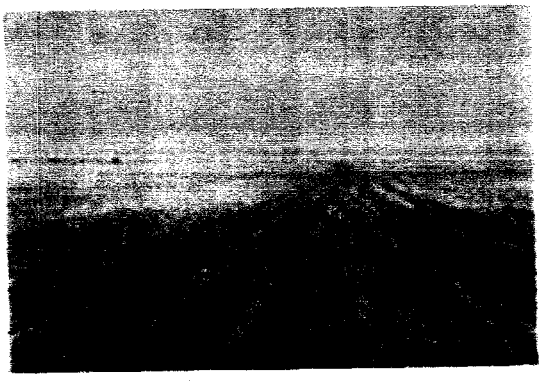
Public Consultation and Involvement of Local Agencies in the EA

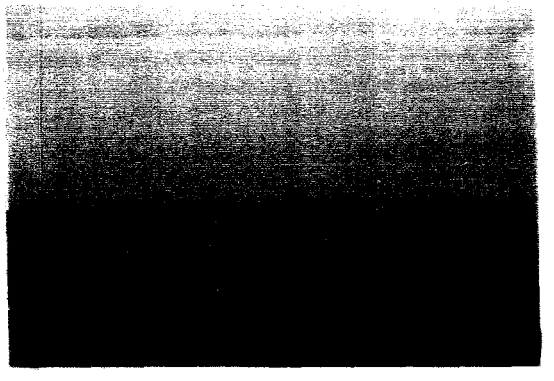
It is difficult to acknowledge individually the contributions made by the local people during public consultations in assessing the potential (both positive and negative) environmental impacts of the proposed road. The Team of Consultants had visited every nomadic, semi-nomadic and permanent settlements en route and met the local opinion leaders and other members of the resident population to organise these public consultations. In every such instance, the representatives of the GOAMM, EPC and GCRB and a local sociologist participated. The Consultants were particularly enlightened by the Eastern Regional Agricultural Development Authority at Marib and the Agricultural Research Station at Seiyun through sharing of their experience on all relevant aspects of combating desertification.

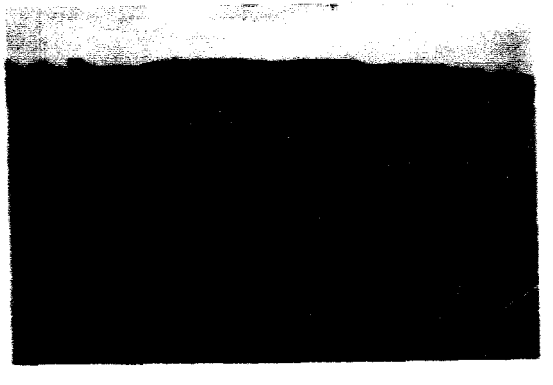
APPENDIX - 0.3

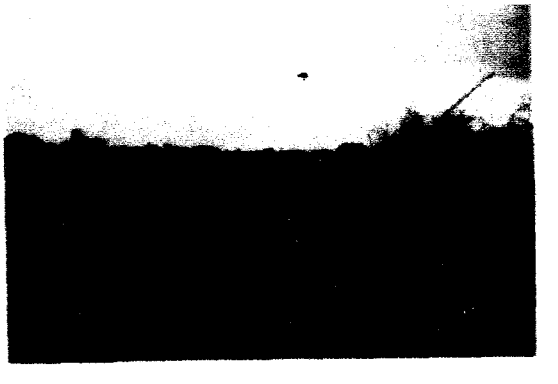
Name and Position of Experts

NAME	POSITION
A.K. Chakrabarti	Team Leader
H.T. Brocklebank	Principal Environmental Specialist
David A Warburton	Archaeologist
Jonathan R Sellars	Prehistorian
Dr. S C Chakraborty	Environmentalist cum Ecologist
B K Roy	Senior Highway Expert
H R Smith	Pavement Specialist
N C Bhatnagar	Hydrogeologist
S Saha	Regional Development Specialist
A K Sen	Desert Ecologist
Dr. T K Mazumdar	Social Anthropologist
Franck Mermier	Social Anthropologist
A Bandopadhyay	Highway Engineer
S Samanta	Highway Engineer
S Chaudhuri	Project Co-ordinator









REPUBLIC OF YEMEN

MINISTRY OF CONSTRUCTION

GENERAL CORPORATION FOR ROADS AND BRIDGES

SAFIR - HADRAMOUT ROAD PROJECT

STUDIES RELATED TO ENVIRONMENTAL ASSESSMENT FEASIBILITY AND DETAILED DESIGN

VOLUME - I
(Draft)

DECEMBER 1993

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SAFIR - HADRAMOUT ROAD PROJECT

STUDIES RELATED TO ENVIRONMENTAL ASSESSMENT FEASIBILITY AND DETAILED DESIGN

VOLUME I
ENVIRONMENTAL ASSESSMENT REPORT

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CHAPTER III	*POTENTIAL IMPACTS AND MITIGATING MEASURES*	*III-1 TO III-24*
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BASIC STUDIES

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ABBREVIATIONS

AASHTO	-	American Association of State Highway and Transportation Official
AC	-	Asphalt Concrete
ADT	-	Average Daily Traffic
bpd	-	Barrels Per Day
CBR	-	California Bearing Ratio
CES	-	Consulting Engineering Services (India) Private Limited
CPO	-	Central Planning Organisation
CSA	-	Cumulative Standard Axles
DBST	-	Double Bituminous Surface Treatment
EA	-	Environmental Assessment
EIRR	-	Economic Internal Rate of Return
EMP&M	-	Environmental Management Plan and Monitoring
EPC	-	Environmental Protection Council
ERADA	-	Eastern Regional Agricultural Development Authority
ESA	-	Equivalent Standard Axle
GNP	-	Gross National Product
GCRB	-	General Corporation for Roads and Bridges
GDH	-	General Department of Hydrology
GDP	-	Gross Domestic Product
GOAMM	-	General Organisation for Antiquities, Manuscript and Museum
GPS	-	Global Positioning System
GVW	-	Gross Vehicle Weight
ha	-	Hectare
HDM-III	-	Highway Design and Maintenance Standard Model III
ICB	-	International Competitive Bidding
IDA	-	International Development Association
MAWR	-	Ministry of Agriculture and Water Resources
MMP	-	Mitigation Management Panel
MOLG	-	Ministry of Local Governorate
MOPAD	-	Ministry of Planning and Development
NGO	-	Non-Governmental Organisation
PDRY	-	Peoples Democratic Republic of Yemen
EPMC	-	Environmental Planning and Monitoring Committee
Q	-	Quintal
ROY	-	Republic of Yemen
RH	-	Relative Humidity
ROW	-	Right-of-Way
TOR	-	Terms of Reference
TRL	-	Transport Research Laboratory, UK
UNDP	-	United Nations Development Programme
VOC	-	Vehicle Operating Cost
WB	-	World Bank
YAR	-	Yemen Arab Republic

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

0.1 Background

The proposed Safir-Hadramout Road will traverse the central part of Republic of Yemen. The primary objective of this Project Road is to connect and integrate the Eastern Governorate of the Republic (erstwhile PDRY) with the capital Sana'a and Western/Northern Governorates of the country by providing a shorter and easier route. Other important objectives are :

- to serve the prospective oil concession blocks along the road;
- to provide outlet for the rich agricultural produce of the Hadramout valley and the horticultural produce of Marib and Al Jawf;
- to serve as a basic infrastructure to encourage development of habitations and agriculture/horticulture along the route and to assist industrial development in general and ancillary industries related to petroleum in particular;
- to provide easier access to the essential supplies and services like food, health and education to the estimated 100,000 Bedouin population wandering through areas where at present such services are conspicuous by their absence;
- to serve as an important strategic link and to improve the security of the country by virtue of being located close to the country's northern border;
- to help increase the flow of tourists to the historical and picturesque Hadramout valley and other places of interest in and around the area including the beautiful, but gaunt, desert landscape.

Considering the primary objectives of the Project and the large socio-economic benefits expected to accrue therefrom, the General Corporation for Roads and Bridges (GCRB) of the Republic of Yemen (ROY) had the feasibility and detailed engineering studies for the project carried out through the Consulting Engineering Services (India) Private Limited (CES) during the year 1992. The studies prepared by CES showed that the road would be economically viable. The study also indicated that the project would have significant positive environmental and social impacts.

Subsequently, the World Bank required a detailed environmental assessment and a review of engineering design and contract documents. The GCRB has engaged CES as the Consultants for carrying out these tasks.

0.2 The Project

The proposed road will be 311 km long connecting Safir to Al Makhaneg via Ghuwayriban, Al' Abr and Al Gauda (Fig. 0.2). It traverses two types of terrain, most of which (about 96.6 per cent) is on flat desert plateau and the remaining (3.4 per cent) on rolling terrain.

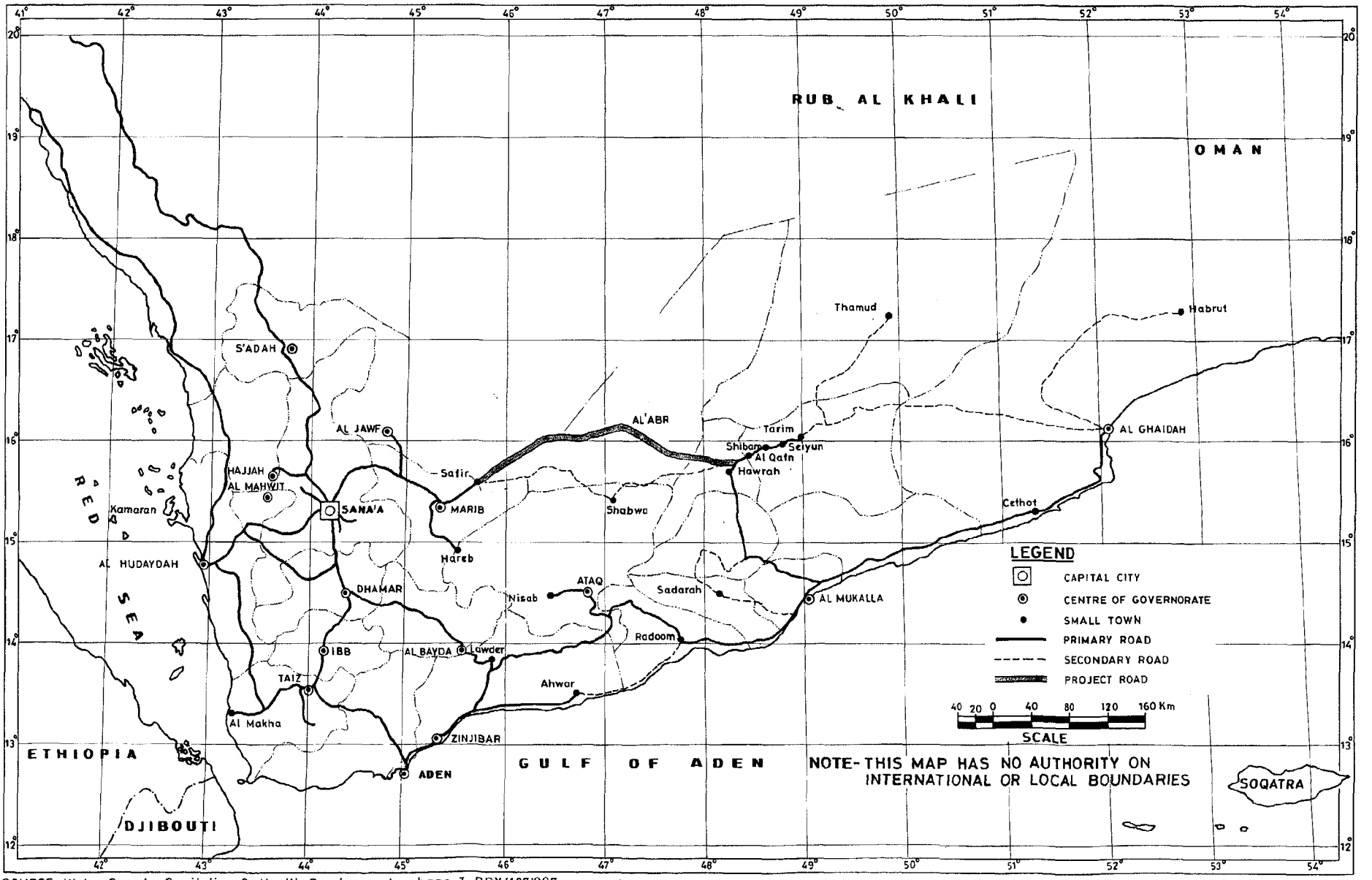
0.2.1 The project area has predominantly the character of a desert with hot and arid climate, characterised by high diurnal range of temperature and evaporation exceeding precipitation.

The average annual rainfall is low but wet months including cloud bursts might occur once in a few years and can cause flash floods.

The landscape is mainly a monotonous spread of featureless brown aeolian sand. Sand dunes occur in some stretches as also scattered low to moderately high hills. The landscape by and large is conspicuous by absence of any significant flora and fauna except that in and around wadi beds, there are small trees and shrubs inviting scattered camels and goats for grazing. The settlements are absent upto km. 180 with no ground water source present. There exists one settlement at Al' Abr (a district centre) and a few smaller scattered ones along the last 46 km length of the road from Bir Al Wahed to Al Makhaneg, the terminal point of the project road.

0.2.2 Key design features of the road are as follows:

Roadway	7 m wide 2-lane carriageway and 1.5 m wide granular shoulders on either side.
Pavement	50 mm thick asphalt concrete wearing course on 175 mm thick aggregate base, 150 mm granular sub-base, over 200 mm sub-grade layer using selected material (design CBR 15 to 29%)
Cross Drainage	Multi- and single-cell box culverts for crossing major wadis and small wadis respectively and low level Irish crossings for minor and shallow channels.



SOURCE- Water Supply Sanitation & Health Developments phase-I PDY/187/007 Scale-1:4000,000

FIG. Nr. 0·2
INDEX MAP

Side Slopes (V:H)	In embankment, 1:3 in stable terrain and 1:4 in areas where sand flow occurs by aeolian process. In sand dunes, 1:3 to 1:4.
Protection Works	Stone masonry and gabion retaining walls and slope protection by stone pitching where required; grouted rip-rap lining for side drains in areas with erosion potential
Road Furniture	Pavement markings, traffic signs, traffic lights and crash barriers at vulnerable locations with single galvanised steel guard rails 0.9 m high.
Construction Materials :	
- Embankment and Sub-grade	Road side borrow areas have been identified and suitable materials are available within moderate haulage distances.
- Base and Wearing Course, Aggregates and stones	Stone quarries for base and wearing courses including aggregates for concrete and protection works have been identified within reasonable haulage distances.

0.3 Environmental Assessment

Environmental Assessment (EA) study was carried out in three stages by a team of experts. Names of experts and their positions are included in Appendix 0.3.

Stage - I

This was a pre-Field study which included collection of available data, discussion with various Government Authorities and Ministries, review of relevant available literature, identification of data gaps and preparation of base information and finally submission of Inception Report.

Stage - II

This was a Field study and was jointly undertaken by all the experts along the entire length of the proposed road corridor for visual assessments and local enquiries and for meeting critical data gaps, and identifying potential environmental and social impacts. This led to the division of the proposed road into 22 environmentally homogenous segments, for each of which the quality of

environment was assessed and likely impacts due to road construction and actions for mitigating negative impacts (if any) were identified (see Fig. 3.1.2).

The significant attributes of environment along the proposed road alignment are shown in Table 0.3.

Stage - III

This has included finalisation of EA report, documenting Stage I and II results and development of Environmental Management and Monitoring Plan for mitigating negative impacts identified.

0.4 Survey on Heritage : Archaeology & Prehistory

As part of the EA study, a field survey was conducted to locate the relics of prehistory and archaeology and to determine the extent to which such sites will be impacted by road construction. 35 sites have been identified as of archaeological importance and 50 of prehistoric importance, as indicated in Fig. S5.1(b). The other highlights of the findings are given below:

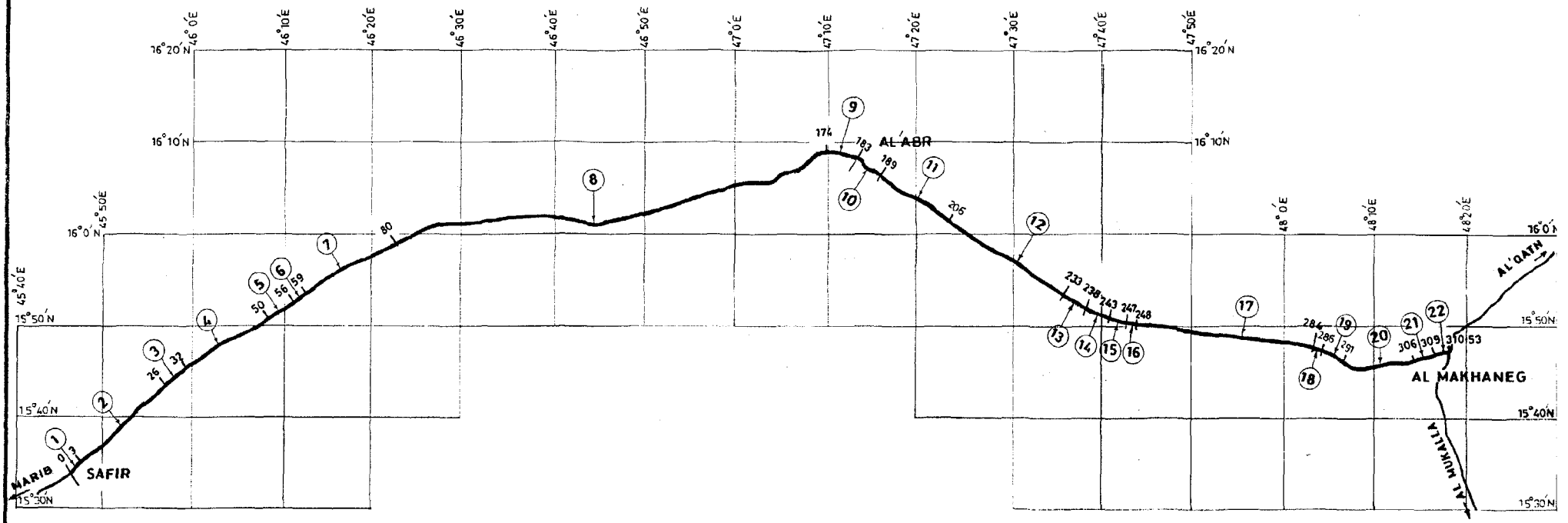
Archaeological Survey

35 archaeological sites have been identified. These are classified according to their indicative dates as follows:

Bronze Age	-	7 sites
South Arabic	-	1 site
Islamic	-	3 sites
Modern Bedouin	-	6 sites
No Clue	-	18 sites
		35 sites

The nature of archaeological sites can be classified as follows:

Related to burial	-	21 sites
Kiln	-	1 site
Settlement	-	4 sites
Stone circle	-	1 site
Undetermined	-	8 sites
		35 sites



NOTE:-

PACKAGE I km. 0·000 TO km.180·900
PACKAGE II km.180·900 TO km.310·500
OF CES ROAD ALIGNMENT DRAWINGS

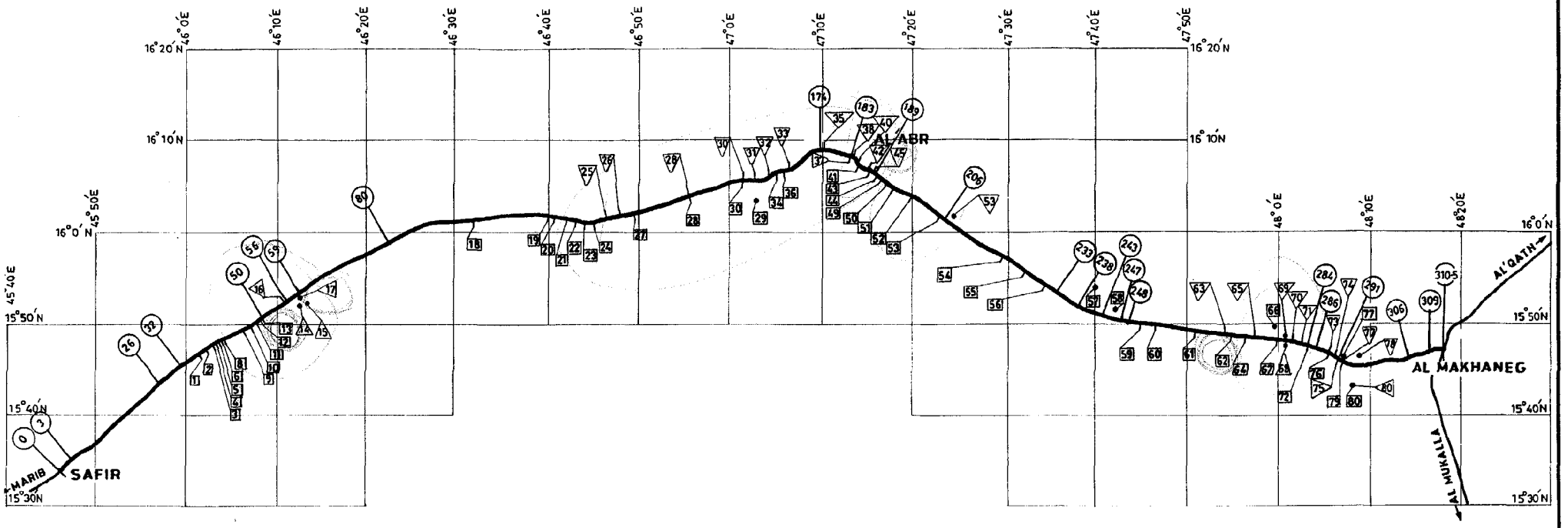
5 0 5 10 15 20 25 Km
SCALE

LEGEND:-

- EA SEGMENTS (km.) 80 174
- EA SEGMENTS (NR) (8)

FIG. NR. 3·1·2

LOCATION OF EA SEGMENTS ALONG THE PROPOSED ROAD



NOTE:-

1. PACKAGE I : km. 0·00 TO km.180·90
2. PACKAGE II km.180·90 TO km.310·50
3. SIGNIFICANT SITES ARE [13] AND ▽17.

LEGEND:-

- EA SEGMENT BOUNDARY (km).
- PREHISTORIC SITE LOCATIONS.
- ARCHAEOLOGICAL SITE LOCATIONS.

5 0 5 10 15 20 25 Km
SCALE

FIG.NR. S5·1 (b)

LOCATION OF ARCHAEOLOGICAL AND PREHISTORIC SITES ALONG PROPOSED SAFIR-HADRAMOUT ROAD

Table - 0.3

Significant Attributes of Environment of Road Alignment

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		1 (0-3)	2 (3-26)	3 (26-32)	4 (32-50)	5 (50-56)
A.	**Concerning Road Corridor**					
1.	Landform	Dune	Playa	Plain	Plain	Plain
2.	Stability	Shifting	Stable	Erosional	Depositional	Stable
3.	Lithology	Sand/Gravel	Gravel/Sand	Sand/Gravel	Sand/Gravel	Gravelly
4.	Wadi (Nos.)	-	-	-	-	-
5.	Surface Drainage	Free	Free	Impeded	Impeded	Free
6.	Ground Water Level (m)	90	105	105	120	125
7.	Expected Yield of Water	Profuse	Profuse	Profuse	Good	Good
8.	Prehistoric Site (Nos.)	-	-	-	4	-
9.	Archaeological Site (Nos.)	-	-	-	-	-
10.	Number of Cut Sections	10	20	11	22	2
11.	Average Length of Cut Sections (km)	0.126	0.076	0.091	0.174	0.079
12.	Number of Fill Sections	11	29	15	30	3
13.	Average Length of Fill Sections (km)	0.146	0.728	0.325	0.462	1.944
14.	Number of Irish Crossings	-	-	-	-	-
15.	Number of Box Culverts	2	7	2	10	3
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Grass	Grass	Grass	Grass	Grass
17.	Quality of Vegetative Cover	Scanty	Scanty	Scanty	Moderate	Poor
18.	Used for Grazing	-	-	-	-	-
19.	Used for Firewood Collection	-	-	-	-	-
20.	Used as Irrigated Farm Land	-	-	-	-	-
21.	Used as Period Fallow	-	-	-	-	-
22.	Name of Settlement	Safir	-	-	-	-
23.	Location of Settlement (km)	2 km off	-	-	-	-
24.	Primary Function of the Settlement	Industrial	-	-	-	-
25.	Water Source	Bore Well	-	-	-	-
26.	School	-	-	-	-	-
27.	Healthcare Centre	Private	-	-	-	-
28.	Administrative Office	-	-	-	-	-
29.	Prehistoric Site	-	-	-	8	-
30.	Archaeological Site	-	-	-	1	-

Table - 0.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		6 (56-59)	7 (59-80)	8 (80-174)	9 (174-183)	10 (183-189)
A.	**Concerning Road Corridor**					
1.	Landform	Low Hill	Plain	Plain	Dissected	Dissected
2.	Stability	Erosional	Depositional	Erosional	Erosional	Erosional
3.	Lithology	Schist/Sand	Gravel/Sand	Gravel/Gneiss	Alluvia/Gravel	Alluvia/Gravel
4.	Wadi (Nos.)	-	-	18	3	6
5.	Surface Drainage	Free	Free	Free	Free	Free
6.	Ground Water Level (m)	-	130	115-140	130	135
7.	Expected Yield of Water	-	Poor	Good	Fair	Fair
8.	Prehistoric Site (Nos.)	-	-	9	-	1
9.	Archaeological Site (Nos.)	1	-	4	-	1
10.	Number of Cut Sections	4	22	62	13	19
11.	Average Length of Cut Sections (km)	0.185	0.085	0.124	0.318	0.108
12.	Number of Fill Sections	6	25	101	14	14
13.	Average Length of Fill Sections (km)	0.380	0.726	0.802	0.283	0.133
14.	Number of Irish Crossings	-	-	18	3	6
15.	Number of Box Culverts	1	6	16	8	8
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Bare	Grass	Grass/Tree	Tree/Grass	Grass
17.	Quality of Vegetative Cover	-	Scanty	Moderate	Good	Negligible
18.	Used for Grazing	-	Occasionally	Occasionally	Occasionally	-
19.	Used for Firewood Collection	-	-	Occasionally	Frequently	-
20.	Used as Irrigated Farm Land	-	-	-	-	-
21.	Used as Period Fallow	-	-	-	Limited	-
22.	Name of Settlement	-	-	-	Al' Abr	Al' Abr
23.	Location of Settlement (km)	-	-	-	183	183
24.	Primary Function of the Settlement	-	-	-	Trade/Admn.	Trade/Admn.
25.	Water Source	-	-	-	Well	Well
26.	School	-	-	-	Yes	Yes
27.	Healthcare Centre	-	-	-	Yes	Yes
28.	Administrative Office	-	-	-	Customs Bldg	Customs Bldg
29.	Prehistoric Site	-	-	4	-	1
30.	Archaeological Site	3	-	8	-	-

Table - 0.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		11 (189-206)	12 (206-233)	13 (233-238)	14 (238-243)	15 (243-247)
A.	**Concerning Road Corridor**					
1.	Landform	Plain	Plain	Plain	Plain	Plain
2.	Stability	Erosional	Depositional	Stable	Erosional	Erosional
3.	Lithology	Colluvium	Sand/Gravel	Colluvium	Gravel/Sand	Gravel/Sand
4.	Wadi (Nos.)	-	-	-	-	-
5.	Surface Drainage	Free	Free	Free	Free	Free
6.	Ground Water Level (m)	150	170	160	140	130
7.	Expected Yield of Water	Good	Fair	Good	Good	Good
8.	Prehistoric Site (Nos.)	3	2	-	-	-
9.	Archaeological Site (Nos.)	2	-	-	-	-
10.	Number of Cut Sections	-	-	-	-	-
11.	Average Length of Cut Sections (km)	-	-	-	-	-
12.	Number of Fill Sections	2	1	1	1	1
13.	Average Length of Fill Sections (km)	8.5	27	5	5	4
14.	Number of Irish Crossings	-	-	-	-	-
15.	Number of Box Culverts	1	2	5	1	1
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Grass	Grass	Bare	Shrub/Legume	Shrub/Tree
17.	Quality of Vegetative Cover	Poor	Poor	-	Moderate	Fair
18.	Used for Grazing	Occasionally	Occasionally	-	Occasionally	Generally
19.	Used for Firewood Collection	-	-	-	-	Generally
20.	Used as Irrigated Farm Land	-	-	-	-	-
21.	Used as Period Fallow	-	-	-	-	-
22.	Name of Settlement	-	-	-	-	Bir Al Wahed
23.	Location of Settlement (km)	-	-	-	-	244
24.	Primary Function of the Settlement	-	-	-	-	Livestock
25.	Water Source	-	-	-		Bore Well
26.	School	-	-	-	-	Yes
27.	Healthcare Centre	-	-	-	-	Yes
28.	Administrative Office	-	-	-	-	-
29.	Prehistoric Site	3	1	1	-	1
30.	Archaeological Site	3	-	-	-	-

Table - 0.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		16 (247-248)	17 (248-284)	18 (284-286)	19 (286-291)	20 (291-306)
A.	**Concerning Road Corridor**					
1.	Landform	Wide Wadi Land	Plain	Dune	Plain	Plain
2.	Stability	Erosional	Depositional	Depositional	Depositional	Stable
3.	Lithology	Gravel	Silt/Gravel	Sand/Gravel	Silt/Gravel	Gravel/Silt
4.	Wadi (Nos.)	1	10	-	-	-
5.	Surface Drainage	Free	Free	Free	Free	Free
6.	Ground Water Level (m)	115	45	30	30	25
7.	Expected Yield of Water	Good	Profuse	Profuse	Profuse	Profuse
8.	Prehistoric Site (Nos.)	-	4	-	1	-
9.	Archaeological Site (Nos.)	-	4	-	3	-
10.	Number of Cut Sections	-	10	5	3	1
11.	Average Length of Cut Sections (km)	-	0.105	0.044	1.577	0.020
12.	Number of Fill Sections	1	25	6	4	4
13.	Average Length of Fill Sections (km)	1	1.348	0.283	1.157	3.723
14.	Number of Irish Crossings	2	10	-	-	-
15.	Number of Box Culverts	-	22	1	3	11
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Shrub	Grass	Shrub/Grass	Grass	Tree/Grass
17.	Quality of Vegetative Cover	Moderate	Good	Good	Fair	Good
18.	Used for Grazing	Occasionally	Frequently	Frequently	Frequently	Frequently
19.	Used for Firewood Collection	Occasionally	-	Occasionally	-	Frequently
20.	Used as Irrigated Farm Land	-	-	-	-	Some
21.	Used as Period Fallow	-	-	-	-	Some
22.	Name of Settlement	-	-	-	-	Al Khasha Al Gauda
23.	Location of Settlement (km)	-	-	-	-	290/305
24.	Primary Function of the Settlement	-	-	-	-	Farming/ Service
25.	Water Source	-	-	-		Bore Well
26.	School	-	-	-	-	Yes
27.	Healthcare Centre	-	-	-	-	Yes
28.	Administrative Office	-	-	-	-	-
29.	Prehistoric Site	-	4	-	2	-
30.	Archaeological Site	-	3	-	-	-

Table - 0.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)	
		21 (306-309)	22 (309-310)
A.	**Concerning Road Corridor**		
1.	Landform	Wadi	Plain
2.	Stability	Erosional	Erosional
3.	Lithology	Alluvia	Alluvia/Gravel
4.	Wadi (Nos.)	5	5
5.	Surface Drainage	Free	Free
6.	Ground Water Level (m)	20	20
7.	Expected Yield of Water	Profuse	Profuse
8.	Prehistoric Site (Nos.)	-	-
9.	Archaeological Site (Nos.)	-	-
10.	Number of Cut Sections	5	10
11.	Average Length of Cut Sections (km)	0.472	0.227
12.	Number of Fill Sections	6	8
13.	Average Length of Fill Sections (km)	0.309	0.226
14.	Number of Irish Crossings	5	5
15.	Number of Box Culverts	2	3
B.	**Concerning Adjacent Area**		
16.	Natural Vegetation Type	Shrub/Grass	Grass/Tree
17.	Quality of Vegetative Cover	Fair	Poor
18.	Used for Grazing	Frequently	Occasionally
19.	Used for Firewood Collection	Frequently	Occasionally
20.	Used as Irrigated Farm Land	Some	Some
21.	Used as Period Fallow	Some	Some
22.	Name of Settlement	-	Al Makhaneg
23.	Location of Settlement (km)	-	310
24.	Primary Function of the Settlement	-	Service
25.	Water Source	-	Bore Well
26.	School	-	-
27.	Healthcare Centre	-	-
28.	Administrative Office	-	-
29.	Prehistoric Site	-	-
30.	Archaeological Site	-	-

A summary of the actions recommended for the archaeological sites has been presented in the Basic Study 5, Report on Heritage. The number of sites classified by the types of recommended actions are as follows:

No action required	-	16 sites
Avoid quarrying	-	3 sites
Protect by fencing	-	7 sites
Realign road, if possible	-	1 site
GOAMM to exavate for further information	-	7 sites
GOAMM to monitor during road construction	-	7 sites
GOAMM to prepare maps before road construction	-	1 site
		42 sites

(Multiple actions suggested for some of the sites have raised the total from 35 to 42 sites.)

Of these, Site No. 17 has some importance from the cost angle, if it becomes a necessary to avoid this site and find an alternative alignment for the road. However, the expert opinion is that realignment is avoidable if the GOAMM take up excavation at the site to determine its real significance. Another alternative to realignment is to protect the site by fencing. Salvage by excavation or protection by fencing has been suggested for Site No. 45 also. In case of quarry sites of archaeological importance, the Consultants have selected alternative sources of materials.

Prehistoric Survey

50 sites have been identified as yielding evidences of prehistoric culture and these are classified as follows:

Lower Palaeolithic (Acheulean)	-	2 sites
Middle Palaeolithic	-	17 sites
Upper Palaeolithic	-	Nil
Neolithic	-	11 sites
Bronze Age	-	1 site
Undetermined	-	21 sites
		52 sites

(2 of the sites have multiple cultural classifications, which has increased the total of classified sites to 52.)

Assuming that the surveyed sites provide a useful sample of similar sites in the region traversed by the proposed road, the Consultants have determined the

order of potentials for encountering exposed prehistoric cultural resources in terms of the road segments in the following manner:

Low Potential : Segments 1,2,3,5,6,7,9,14,16,18,21 &22	87 kms
Low to Moderate Potential : Segments 10,12,13 & 15	42 kms
Moderate to High Potential : Segments 11, 17,19 & 20	72 kms
Very High Potential : Segments 4 and 8	110 kms
	311 kms

The observations given above regarding potential prehistoric importance of sites might serve as guide to future explorations in the adjoining regions. However this survey has attempted to identify exhaustively the prehistoric sites within the road corridor itself. The results show that some 78% of all the surveyed sites are located in just 4 of the road segments, namely 4, 8, 11 and 17. Amongst these, Segments 4 and 8 together account for 50% of the surveyed sites.

Not all of the 50 sites identified are wholly within the proposed road corridor. These are distributed as follows:

Wholly within the right of way	-	16 sites
Partially within the right of way	-	24 sites
Quarry area	-	8 sites
Outside Impact area	-	2 sites
		50 sites

EA studies indicate that all the vulnerable quarry sites can be avoided by exploiting alternative sources of construction materials.

As is to be expected, all the 50 sites are not equally significant from the prehistoric point of view. By taking into consideration a set of indicators like site integrity, uniqueness, research potential, regional importance and the quality of artefacts, a composite scoring was evolved to measure the order of significance of each site.

The Consultants have recommended to adopt proper mitigation measures for 3 sites having the highest score. These are Site Nos. 12, 13 and 62. Of these, Site Nos. 12 and 13 are located in Segment 4 of the proposed road. Site No. 62 is located in Segment 17. For the rest of the sites, the Consultants assess that no monitoring is necessary.

Site No. 12 lies well outside the proposed road corridor and as such will not be impacted by the proposed road construction activities. However, the order of

significance of this site calls for preservation and prevention of all future development activities upon or near it.

Site No. 13, however, falls partly within the proposed right of way. It is suggested that GOAMM may undertake further investigation at the portion of the site to be impacted by road construction activities to confirm if the present alignment is acceptable or a change of alignment is called for. It is further recommended that the portion of this site that is not impacted by construction activities be protected by fencing and by preventing all future developmental activities thereon.

Site No. 62 is located on talus slope and scree deposits at a proposed quarry location. Avoidance of this site as quarry is recommended. GOAMM may also consider conducting field investigations to assess the site's significance adequately.

0.5 Structure of the Report

0.5.1 Environmental Assessment Report

Environmental Assessment Report (Volume I) has been structured in the following chapters:

		Executive Summary
Chapter I	-	Objectives and Approaches
Chapter II	-	Regional Environmental Set Up
Chapter III	-	Potential Impact and Mitigation
Chapter IV	-	Alternative Alignment Study
Chapter V	-	Environmental Management & Monitoring Plan
Chapter VI	-	Institution and Legal Framework

The Volume I (EA) report also includes following five (5) basic study reports to address the key issues:

1. Combating Desertification
2. Hydrology of the Inland Basin
3. Social Groups along the Proposed Road Corridor
4. Pattern of Regional Development
5. Heritage - Archaeology and Prehistory.

0.5.1 Engineering Report

The Engineering Report is presented in Volume II containing Chapter VII through to Chapter XII.

0.6 Environmental Impacts

The regional environmental set up of the Project area was studied in the light of orography, lithostratigraphy, dynamism in landscape formation, biotic environment (soil, flora and fauna), human response to environment and heritage - archaeology and prehistory.

Depending on significant attributes of the environment, the entire road corridor has been divided into 22 segments as earlier listed in Table 0.3. Environmental impacts on these segments are studied for the following three stages of the proposed road:

(a) Construction of camp sites
(b) During construction
(c) After construction and during operation.

Likely negative environmental impacts and mitigating measures are summarised in Tables 0.6(a), 0.6(b) and 0.6(c) respectively. A set of positive environmental impacts has also been identified, as summarised in Table 0.6(d).

Construction of Camp Sites

Considering the least possible negative impact, four (4) construction camp sites have been suggested alongwith measures to maximise the positive impacts and its enhancements. The recommended sites are as follows:

(1)	Segment 1	Near the junction of proposed corridor with Marib-Safir road at Safir.
(2)	Segment 9	5 to 7 km to the south-west of Al' Abr.
(3)	Segment 10	5 to 7 km to the south-east of Al' Abr.
(4)	Segment 22	Near the junction of proposed corridor with Al Mukalla-Seiyun road at Al Makhaneg.

Potentially significant impacts are (i) air pollution from asphalt plant; (ii) dust and noise pollution from crusher; and (iii) sanitation and waste disposal. Mitigating measures have been recommended, which are to be monitored during construction. [see Table - 0.6(a)]

Table 0.6(a)

Summary of Negative Environmental Impacts from Construction Camps and Their Mitigation

Sl. No.	Impacts	Order of Impacts Upon Road Segments (*)				Mitigating Measures	Actions
		1	9	10	22		
	DIRECT						
1.	Resettlement / land acquisition	0	0	0	0	None. According to available information camp sites can be located on government land	No action
2.	Destruction of vegetation	0	1	1	1	Establish camps away from vegetated areas. Where unavoidable plant trees in replacement of those cut	Include Special Condition in Tender Document. Monitoring during construction by GCRB/ Supervision Consultant
3.	Oil - grease spillage	1	1	1	1	Adopt good practice to avoid spillage and pursue collection and recycling	- do -
4.	Air pollution from asphalt plant	2	2	2	2	Select and maintain plant to satisfy pollution control criteria and locate plant at leeward edge of camp. This will be a local phenomenon confined to a few locations	- do -
5.	Dust and sound pollution from crusher	2	2	2	2	Locate plant at leeward edge of camp. No habitation other than the construction camp is likely to be affected	- do -
6.	Poor sanitation and waste disposal	2	2	2	2	Install lavatory; source separation of garbage; use of organic materials as compost; storage of non -bio- degradable materials	- do -
7.	Waste water	1	1	1	1	Irrigate camp site plantation	- do -
8.	Transmission of communicable disease	1	1	1	1	Periodic health check and medication	- do -
9.	Poaching	1	1	1	1	Control through terms of employment	- do -
10.	Obstruction to local communication	0	0	0	0	None	No action
11.	Archaeological and prehistory sites	0	0	0	0	Avoid significant sites as identified	Include special condition in Tender Document. Monitoring during construction by GCRB/ Supervision Consultant
12.	Social and cultural disruption	0	0	0	0	None	No action
	INDIRECT						
13.	Illegal timber cutting	0	1	1	1	Use liquid petroleum gas as fuel in kitchen	Include special condition in Tender Document. Monitoring during construction by GCRB/ Supervision Consultant

NOTE : * Order of impact implies : 0 = No impact; 1 = Mild; 2 = Moderate; 3 = High; 4 = Severe

Table 0.6(b)

Summary of Negative Environmental Impacts from Construction of Road and Their Mitigation

Sl. No.	Impacts	Order of Impacts (*)	Mitigating Measures	Actions
	DIRECT			
1.	Dislocation and compulsory resettlement of people living on the right of way	0	None. According to available information ROW is government land.	No action
2.	Poaching by construction workers	1	Prohibit poaching under terms of employment	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
3.	Reactivation of dunes	3	Wind screen and plantations	Wind screen construction and plantation programme implementation by ERADA/EPC. Monitoring by MMP
4.	Landscape disfiguration by high embankments and deep cuts	1	Road side plantation of trees and gentle slope at cut and fill sections	None for embankment but for cut section tree plantation. Programming and implementation by ERADA. Monitoring by MMP.
5.	Borrow areas and quarry sites	1	Systematic and controlled excavation/ quarrying of borrow/quarry areas preferably on windward side and backfilling by waste material from cut section. Avoid significant heritage sites	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
6.	Landslides, slumps and slips in road cuts	1	Provide drainage works and stabilise with retaining structures like concrete/masonry wall, gabions, grouted rip rap etc. where risk exists.	Necessary measures to be taken in design. Monitoring during construction by GCRB/Supervision Consultant
7.	Air, dust, fume, smoke and noise pollution to inhabited areas from construction equipment, crusher, blasting at quarries	1	Use pollution control for construction equipment, control blasting at quarries with precautionary measure at quarries during blasting. Avoid installations near inhabited areas.	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
8.	Interference with surface drainage	2	Provide ditches and cross drainage structures	Necessary measures taken in design. Monitoring during construction by GCRB/Supervision Consultant
9.	Erosion of or along road embankment by flowing water	2	Channelise water flow through drains. Provide drain lining and other erosion protection measures at vulnerable locations	Necessary measures to be taken in design. Monitoring during construction by GCRB/Supervision Consultant
10.	Alteration of sub-soil water table due to water abstraction	1	Controlled withdrawal of water from deep aquifer	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant.
11.	Alteration of hydrological regimes of wet lands	0	None	No action
12.	Destruction of vegetation and wildlife on the right of way	0	Regenerate vegetation in the neighbourhood plus roadside plantation. Do not disturb vegetation outside the area occupied by the road embankment or cut.	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant.

Table 0.6(b) (contd)

Sl. No.	Impacts	Order of Impacts (*)	Mitigating Measures	Actions
13.	Destruction of biological resources or eco-systems	0	None	No action
14.	Interruption of migratory routes for wild life and livestock	0	None	No action
15.	Creation of breeding habitats for mosquito by stagnant pools of water	0	Provide drainage or reuse water for vegetation. Facilitate quick fill up of the empty borrow pits by aeolian sand movement	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
16.	Creation of a transmission corridor for diseases, pests, weeds and other undesirable organisms	0	None	No action
17.	Construction interferences to existing traffic	1	Provide markers, lights with warning signs for traffic diversion	Include Special Condition in Tender Documents for lights and warning signs. Monitoring during construction by GCRB/ Supervision Consultant
18.	Destruction of utility lines	0	Take precautionary measures and avoid moving construction equipment over or near the utility lines	Monitoring during construction by GCRB/Supervision Consultant
19.	Obstruction of routes from houses to farms	1	Provide suitable crossings	Special Tender provision for construction of diversion road and monitoring during construction by GCRB/Supervision Consultant
20.	Archaeological and prehistory sites	2	Avoid significant sites as identified. Significant sites to be protected by fencing. If necessary select alternative alignment	
	INDIRECT			
21.	Accident risks associated with vehicular traffic	2	Design curves (horizontal and vertical) for high speed traffic; introduce emergency plan to contain damages from accidental spills.	Already measures taken in Geometric Design of road. Monitoring during construction by GCRB/Supervision Consultant
22.	Impairment of non-motorised transportation in the highway corridor	1	Include safe crossings and diversions where required	Special Tender provision for construction of diversion road. Monitoring during construction by GCRB/Supervision Consultant

NOTE : * Order of Impact implies

0=No impact; 1=Mild; 2=Moderate; 3=High; 4=Severe

Table 0.6(c)

Summary of Negative Environmental Impacts After Road Construction and Their Mitigation

Sl. No.	Impacts	Order of Impacts (*)	Mitigating Measures	Actions
	DIRECT			
1.	Air and noise pollution from increased vehicular traffic	1	None. The expected traffic level being low to moderate and the traversed area being largely uninhibited, no actual inconvenience is envisaged	No action
2.	Roadside litter	1	Provide roadside disposal facilities. Campaign for CLEAN YEMEN; strengthen local governments for proper conservancy service in towns and villages	Monitoring by EPC and local government
3.	Induced development of commercial, residential and industrial development	3	Plan for controlled development	Planning and monitoring by EPMC and concerned ministries
	INDIRECT			
4.	Impairment of non-motorised transportation economy due to increased availability of motorised alternatives	0	None	No action
5.	Unplanned timber cutting	1	Introduce fuel-yielding trees as a part of programme to arrest desertification. Enforce forest conservation laws.	Monitoring by EPC
6.	Unplanned land clearing and occupation	2	Plan for controlled development	Planning and monitoring by EPMC and concerned ministries

NOTE : * Order of Impact implies
0=No impact; 1=Mild; 2=Moderate; 3=High; 4=Severe

Table 0.6(d)
Summary of Positive Environmental Impacts

Stage	Sl. No.	Positive Impact	Actions
		DIRECT	
Construction of camp sites	1.	Local employment generation	Monitoring by local authorities
	2.	Additional consumption of local produce	- ditto -
During construction	3.	Local employment generation	Collecting employment statistics by EPMC
	4.	Enhancement of local skills (technology transfer)	- ditto -
After construction	5.	Elimination of multiple tracks on desert floor	Post-construction surveys by GCRB/EPMC
	6.	Local employment generation in road maintenance and transportation sectors	Keeping statistics by GCRB
	7.	Improve the access of Bedouins to social services like education, health, trade, livelihood and increase in social interaction between communities	Monitoring by local government/concerned ministries together with regional development
		INDIRECT	
Construction of camp sector	8.	Taking over camp buildings and associated facilities as maintenance depots, community centres or growth nucleus	Inserting special condition in contract regarding taking over camps
	9.	Utilisation of deep borewells for enhancing local water supply	- ditto -
All stages	10.	Improvement of security environment	Keeping chronological record of security related incidents by concerned government department
	11.	Activation of local economy due to improved access and security	Planning and monitoring by the concerned govt. departments

During Construction

During construction of road the potential significant impacts are as follows:

(1) Extraction and disposal of local construction materials.
(2) Reactivisation of dunes at Segment 1 (first 0-3 km of road section)
(3) Damage to archaeological and prehistoric sites.

The recommended mitigating measures are to be monitored during construction.[see Table 0.6(b)]

After Construction and During Operation

Potential significant impacts at this stage are as follows:

(1) Induced and uncontrolled development of commercial, residential and industrial units
(2) Unplanned land clearing and alienation
(3) Air and noise pollution from increased vehicular traffic.

The recommended mitigating measures are to be monitored by EPMC and other concerned ministries [see Table 0.6(c)].

0.7 Alternative Alignment Study

An alternative alignment study is suggested in the TOR for the last 25 km of the project road with a view to avoiding a few small settlements. Accordingly three alternative alignments (A, B, C) were studied in addition to the original alignment (D) chosen earlier (see. Fig. 4.3.1). A comparison of these alignments in terms of their impacts is shown in Table 0.7.

Considering all the factors mentioned in Table 0.7, Alignment D appears to be the best choice as it is short in length, crosses a buried channel at its narrowest width, avoids displacement of farm land and involves but little disturbance to vulnerable sand dunes.

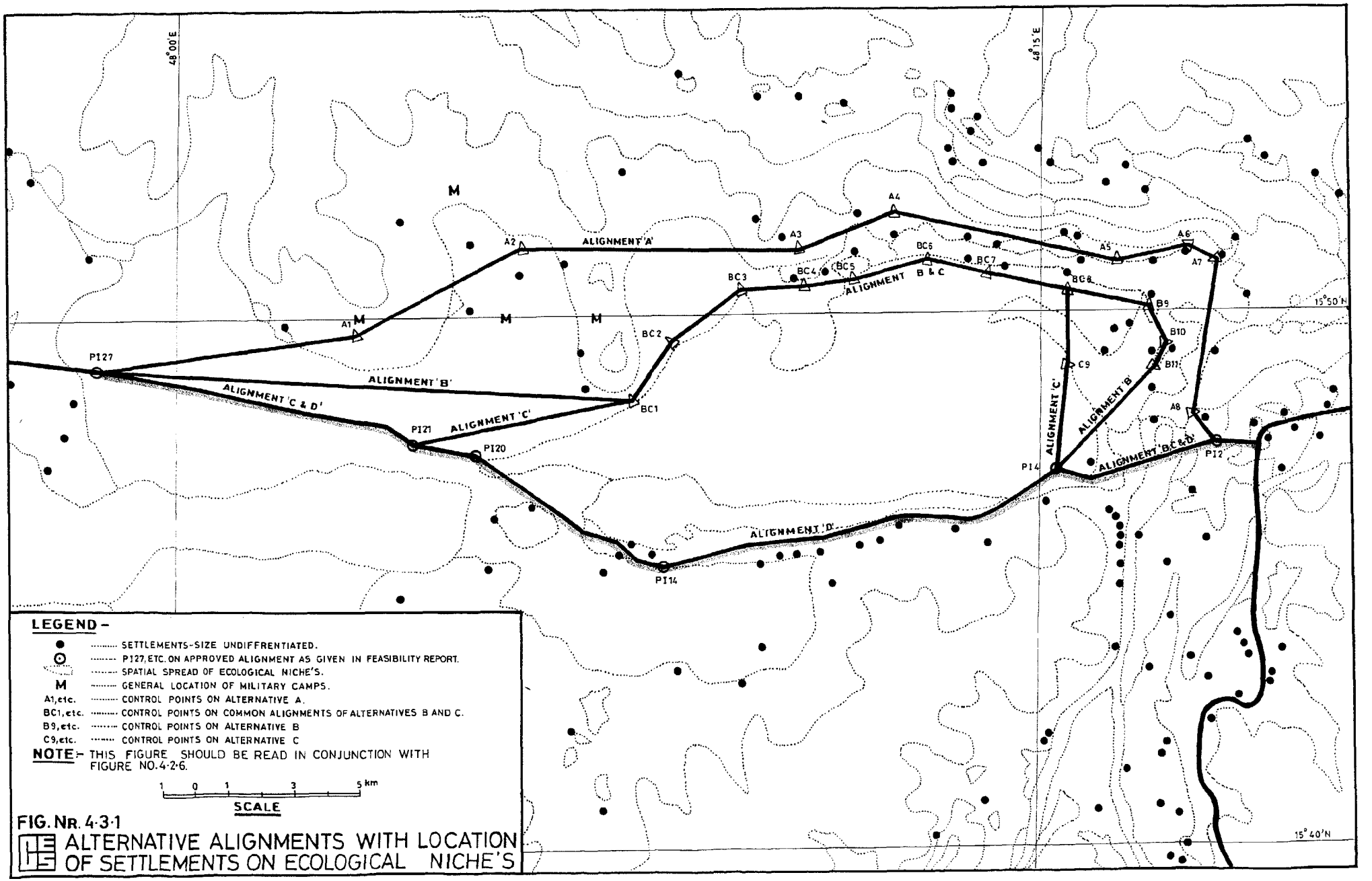


FIG. NR. 4·3·1

ALTERNATIVE ALIGNMENTS WITH LOCATION OF SETTLEMENTS ON ECOLOGICAL NICHE'S

Table 0.7

Magnitude of Impacts on Proposed Alternative Alignments

Sl. No.	Variables	Magnitude of Impact on Various Alternatives			
		Alternative A	Alternative B	Alternative C	Alternative D
1.	Length	Longer	Longest	Same as A	Shortest
2.	Horizontal Geometrics	Poor	Poorest	Poor	Smooth
3.	Vertical Geometrics	Fair	Poor	Poorest	Smooth
4.	Cross Drainage Structure	Maximum	Less	Less	Minimum
5.	Skirting of Unstable Sand Dunes	Minimum	Considerable	Maximum	Less
6.	Requirement of Sub-grade strengthening	Nil	Nil	Considerable	Nil
7.	Availability of Construction Materials	Nearest to Alignment	Farthest from Alignment	Farthest from Alignment	Near to Alignment
8.	Dislocation of Settled Population	Moderate	Moderate	Moderate	Nil
9.	Displacement of Farm land	Less	Considerable	Maximum	Minimum
10.	Serving of Settlements	Considerable	Considerable	Considerable	Considerable
11.	Cultural Endorsement of Potential Users	Considerable	Minimum	Minimum	Maximum
12.	Construction Cost	Maximum	Less	Less	Minimum
13.	Maintenance Cost	Less	Maximum	Considerable	Least

0.8 Enhancement Measures

It is recognised that the proposed road will have some positive impacts, which can further be channelled and enhanced in the desired directions e.g., by way of developing basic facilities for local communities and combating desertification. 6 locations have been selected along the road alignment as offering good potential in this respect, to start with. Since water constitutes a fundamental resource, the sites are identified near bore wells to be set up for construction purpose. These are as follows:

	Location	Recommended Facilities
1.	Segment 1 - near proposed road junction on Marib-Safir Road	Development of settlement with small commercial establishment, a primary health centre and a school. Construction camp to be transformed to maintenance office of GCRB and house the staff to develop roadside plantation and for combating desertification.

	Location	Recommended Facilities
2.	Segment 4 (Near km 50)	A small hotel for tourists interested in experiencing desert landscape, gas station and a provision store.
3.	Segment 9 (5-7 km to the South-West of Al' Abr)	The borewell for construction can be utilised later to enhance water supply for Al' Abr town. The construction camp may be used to house staff with the objective of promoting orchard development alongwith shelter belts.
4.	Segment 10 (5-7 km to South-East of Al' Abr)	Construction camp site may be used to house staff to be engaged for developing grazing ground and plantation for fire wood.
5.	Segment 15 (approx km 250 near Bir Al Wahed)	Bore well after construction can be used for development of road side orchard with shelter belts and grazing ground.
6.	Segment 22 (near proposed road junction with Al Mukalla-Seiyun Road at Al Makhaneg)	Construction camp site to be used by GCRB for maintenance of the proposed road. The site has the potential to develop into a significant urban centre. Landuse control measures should be taken up in advance.

0.9 Environmental Management and Monitoring Plan

The identified mitigating measures required to deal with the negative impacts directly arising out of road construction activities can be carried out through engineering design as stated in Tables 0.6(a) and 0.6(b) and costs on these accounts will be included in the cost estimates. These mitigating measures will be implemented through road construction contract and monitored by GCRB/Supervision Consultant by adhering to the design, specifications and construction methods. However, involvement of an EA Specialist in the Supervision team will be an added advantage, particularly from the point of view of dealing with modifications in mitigating measures. It is recommended that the implementation of the mitigation measures should be monitored and guided by a Mitigation Management Panel (MMP) to be formed in GCRB with experts from other concerned departments represented as members.

Other measures related to prehistory and archaeology, dune stabilisation and combating desertification, monitoring the behaviour of exploited aquifer, development of six public facilities along road towards enhancing the positive impacts, development of shelter belts, roadside orchards, administration of landuse control have been identified and actions are suggested to be taken by the concerned departments. These measures are intimately related to the policy-perspectives of the National Government. It is recommended to constitute a broad-based Environmental Planning and Monitoring Committee (EPMC) under EPC to evolve and get implemented a co-ordinated plan involving direct participation by the concerned departments, with their experts being represented in EPMC as members.

The job of EPMC would be to identify specific sub-project(s) on these recommended measures and guide the concerned departments to plan and implement them in consonance to their assigned powers and responsibilities. The EPMC would also have a role in securing allocation of funds to implement the specific projects. Some of these measures are to be taken up concurrently with the road construction such as actions related to significant prehistory and archaeological sites, dune stabilisation and roadside plantation.

It is suggested that both the monitoring bodies suggested above should have common representatives from the following Governmental institutions:

(a) EPC
(b) GCRB
(c) GOAMM
(d) MAWR
(e) ERADA and Agricultural Research Station at Seiyun
(f) Ministry of Planning and Development
(g) Ministry of Local Government.

In addition EPMC can include representatives from the Ministry of Finance and other organisations.

A flow diagram for the Environmental Management and Monitoring Plan in respect of mitigation measures arising out of construction is shown in Fig. 5.2.8. In respect of the other measures suggested as coming under EPMC, it is suggested that the EPMC be constituted first to serve as a forum for broad-based flow of information and decision making and to provide a basis for identification and prioritisation of projects, sourcing funds and chalking out a plan of action.

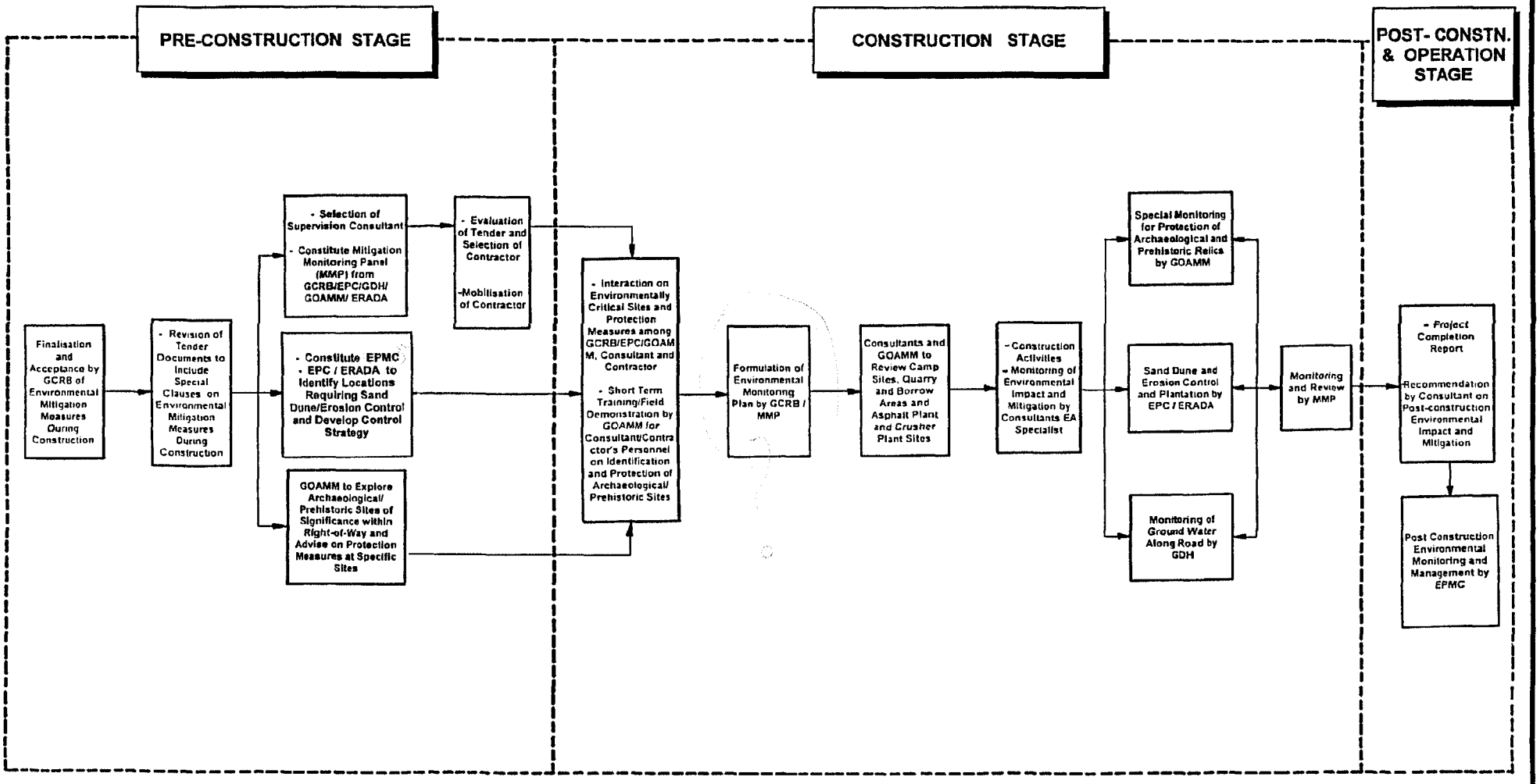


FIG. 5.2.8

FLOW DIAGRAM - ENVIRONMENTAL MANAGEMENT AND MONITORING

0.10 Conclusion and Recommendation

(a) Several categories of negative environmental impacts associated with road construction have been identified but these are mostly confined to particular locations or temporary in nature and are of an order which can be mitigated without difficulty.

There will be positive social and environmental impacts due to road construction some of which can be further enhanced through suitable planning and control strategies by the Government.

(b) Most of the identified direct and indirect impacts of the proposed road construction are to be taken care of in engineering design and can be monitored and implemented during road construction. However, the Supervision Consultants' team should be reinforced with an Environmental Specialist. These mitigation measures should be monitored by a MMP constituted under GCRB.

(c) Mitigating measures like combating desertification, restoration of archaeological and prehistoric sites, control of induced development, exploitation of ground water aquifer, development of six centres for enhancement of public facility should be taken as parallel projects co-ordinated and monitored by EPMC comprising multi-disciplinary experts from relevant Departments/Ministries of the ROY with EPC acting as the Co-ordinator.

(d) GOAMM needs to attach itself immediately to the project and carry out a set of investigations followed by a plan of action for protecting the relics of prehistory and archaeology at the identified significant sites before road construction is taken up.

(e) The findings of archaeology and prehistory do not adequately reveal the cultural ambiences of the observed artefacts in the absence of supplementary study on palaeo-geomorphology and palaeo-climatology. In case, the GOAMM desires to mount a project on more comprehensive survey on prehistory, it should attach a Palaeo-geomorphologist to a competent Prehistorian.

(f) During Construction of road it would stimulate certain expectations among the people who are aware of the opportunities that will be created. Water sources created for construction may become poles of attraction particularly for semi-nomadic bedouins to whom water is critical for existence. These may also become places for putting up shops, dwellings, services related to the modes of transportation and putting up of small enterprises. Moreover, people from the local communities are expecting to

be employed in the construction work. It is suggested that arrangements may be made for appropriate sharing of water, land and labour employment to avoid conflicts between bedouins and other social groups

After the construction of the road there will be positive impacts in the sense that they would improve the quality of life and promote development of human resources amongst the local tribal communities, other social groups and Bedouins. It will increase the access of Bedouins to services like education, health, administrative, drinking water, trade, transportation and opportunities for employment created by the various kinds of development along the road. It may enable them to find new markets for selling their livestocks on better prices. It may also reinforce their interdependence with the market towns and permanent settlements. It may also increase opportunities for alternative employment in various activities which will grow at the various locations along the road.

Further it may reduce fragmentation and dichotomisation between the local groups because of their greater interaction and increasing interdependancy. It may induce a new spatial organisation in the form of linear development and may lead to new centralities around Al' Abr, Al Khasha and Al Makhaneg. In view of the location of Al' Abr and its particular status at the administrative and tribal levels, the tendency of its centrality would be enhanced by the demands made on it for services of various kinds, goods and transportation.

The road would link the local communities with the regional development processes. It will reinforce the linkage of the Hadramout region by providing an alternative to the Mukalla road within the national economy and will enhance the exchange of goods, ideas and widen the base of knowledge and information flowing from different parts of the country. It will enforce the process of unification and linkage with the national level administration.

(g) A Social Anthropologist specialised in Yemeni society and speaking Arabic be engaged to undertake the study on "Social Dynamism" in ROY.

(h) For combating desertification and associated action programme exposures may be necessary for training of planning personnel. The Central Arid Zone Research Institute (CAZRI) under the Ministry of Agriculture, Govt of India is identified as one such institution for imparting exposure training.

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CHAPTER I

OBJECTIVES AND APPROACHES

CHAPTER - I
OBJECTIVES AND APPROACHES

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Appendix 1.3.2 Terms of Reference

Figure 1.0.2 Orientation of the Proposed Road Alignment
Figure 1.2.1(a) Typical Cross-sections of the Proposed Road
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CHAPTER - I

OBJECTIVES AND APPROACHES

1.0 Introduction

1.0.1 This study is a detailed environmental assessment for the proposed Safir-Hadramout Road. The environmental assessment has been carried out by specialists from Consulting Engineering Services (India) Private Limited. The names of the experts have been shown in Appendix 1.0.1.

1.0.2 The project intends to construct an asphalt concrete road to link up Safir in the Marib Governorate with the Al Mukalla-Seiyun road in the Hadramout Governorate of the Republic of Yemen (ROY). The proposed alignment takes off at 15°33' N : 45°46' E, approximately some 2 kms before the road from Marib reaches the Safir Petroleum Refinery. Initially it extends in a north-easterly direction to Jabal Ghuwayriban (15°57' N : 46°21' E). Then it follows a east by north-easterly direction through Jabal Zuwaybi (16°06' N : 47°04' E) to Al' Abr (16°08' N : 47°15' E), the administrative centre of the Al' Abr District under the Hadramout Governorate. After Al' Abr the alignment goes into a south-easterly direction to join the Al Mukalla-Seiyun road at Al Makhaneg (15°35' N : 48°18' E) about 7 kms north of the settlement of Hawrah. The orientation of this alignment has been approximately marked in Figure 1.0.2 in terms of the orographic features of the ROY.

1.0.3 The total length of the proposed road will be 310.53 km. The length of the individual segments given by the co-ordinates noted in para 1.0.2 are as follows:

(a)	Safir to Ghuwayriban	80.00 kms
(b)	Ghuwayriban to Zuwaybi	43.73 kms
(c)	Zuwaybi to A'l Abr	57.20 kms
(d)	Al' Abr to Al Makhaneg	129.60 kms
	Total	310.53 kms

1.1 Aims of the Project

1.1.1. The proposed Safir-Hadramout Road has the primary objective of connecting and integrating the Eastern Governorate and the Western/Northern Governorates with Sana'a by providing a shorter route. Significant benefits of the proposed road include

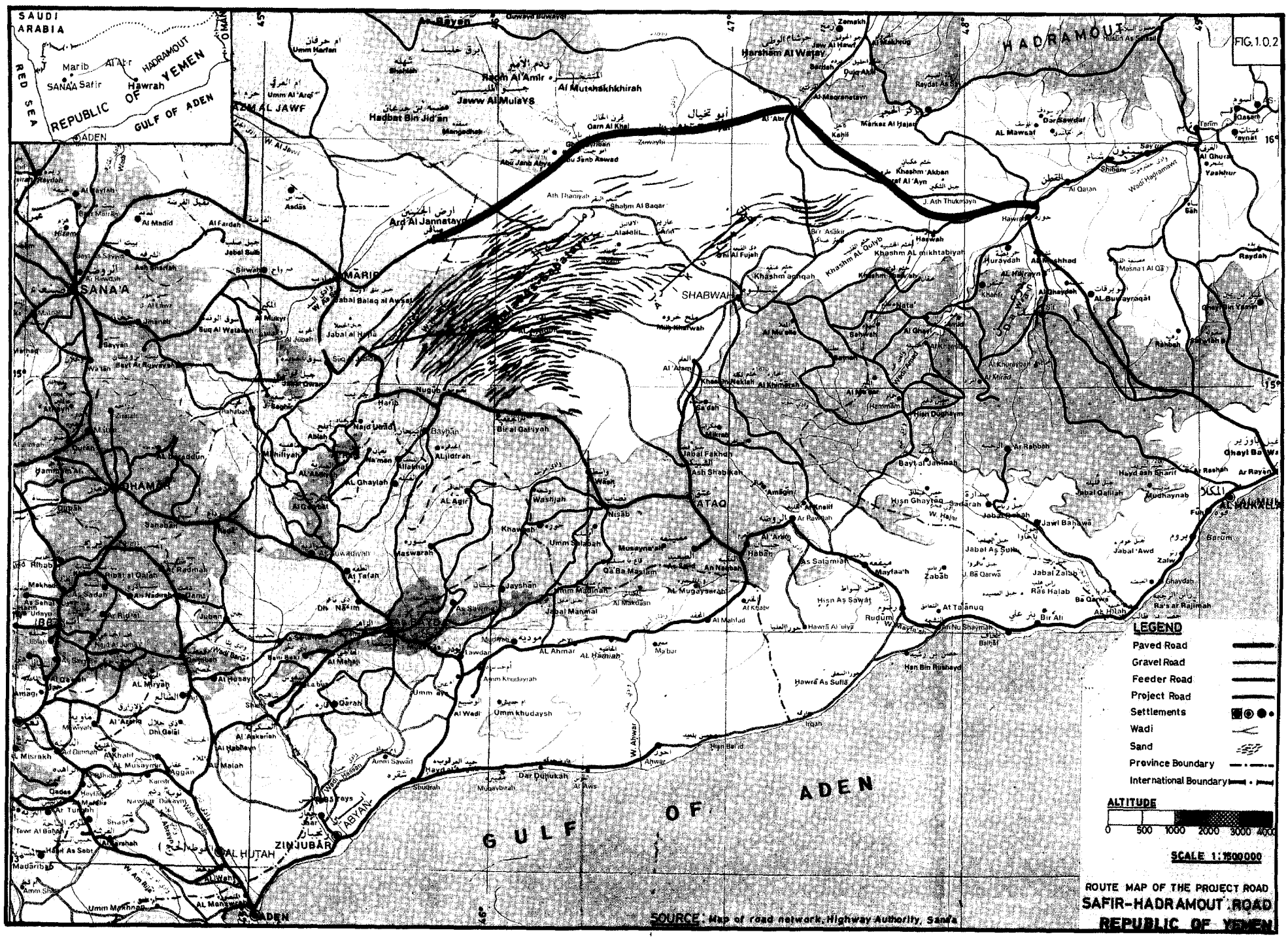


FIG. 1.0.2
SAUDI ARABIA
RED SEA
REPUBLIC OF YEMEN
GULF OF ADEN
SANA'A
MARIB
SHABWAH
HADRAMOUT
ADEN
GULF OF ADEN
ZINJUBAR
ABYAN
AL HUTAH
LEGEND
Paved Road
Gravel Road
Feeder Road
Project Road
Settlements
Wadi
Sand
Province Boundary
International Boundary
ALTITUDE
0 500 1000 2000 3000 4000
SCALE 1:1500000
ROUTE MAP OF THE PROJECT ROAD
SAFIR-HADRAMOUT ROAD
REPUBLIC OF YEMEN
SOURCE: Map of road network, Highway Authority, Sana'a

(a) reducing transport distance from the rich agricultural area of the Hadramout valley,

(b) providing access to the potentially rich oil bearing area of Yemen,

(c) encouraging provision of essential services and supplies to nomadic and resident people,

(d) serving as an important strategic link being located close to the country's northern border,

(e) leading to improvement of security conditions of the area, and

(f) attracting tourists to historical and picturesque sites of Hadramout valley and other places of interest including beautiful, though gaunt, desert landscape.

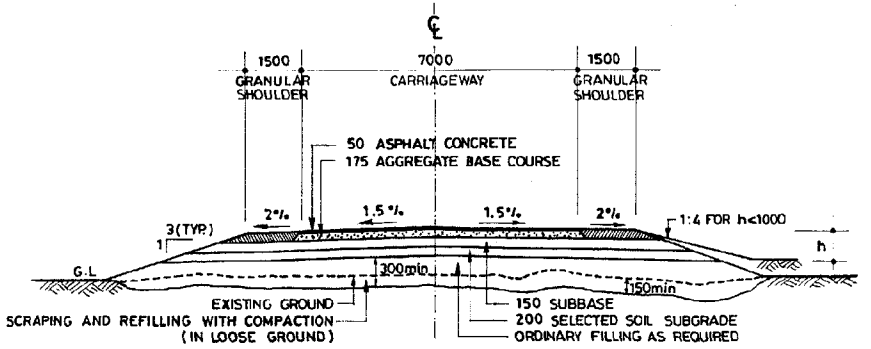
1.2 Engineering Description of the Project

1.2.1 Carriageway

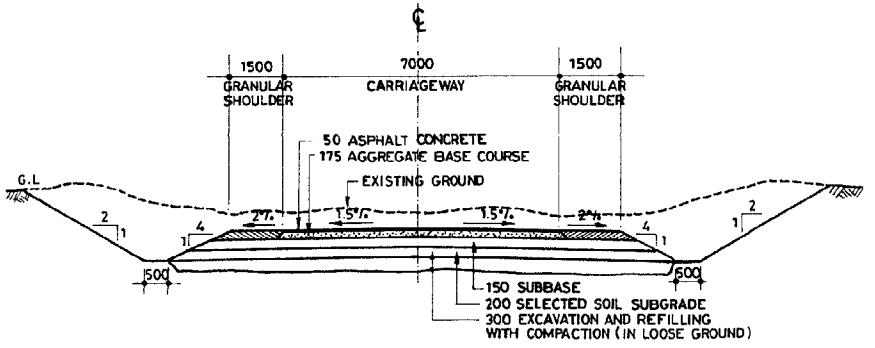
(a) The road will be a two lane carriageway with a total paved width of 7 m and 1.5 m wide granular shoulders on either side. Typical cross-sections for the road are shown in Figure No. 1.2.1(a).

(b) Broad design standards for the road are given in Table 1.2.1.(b). In practice, radii of horizontal and vertical curves indicated in this table are exceeded in view of the considerable length of the road in flat terrain which will facilitate high speed traffic.

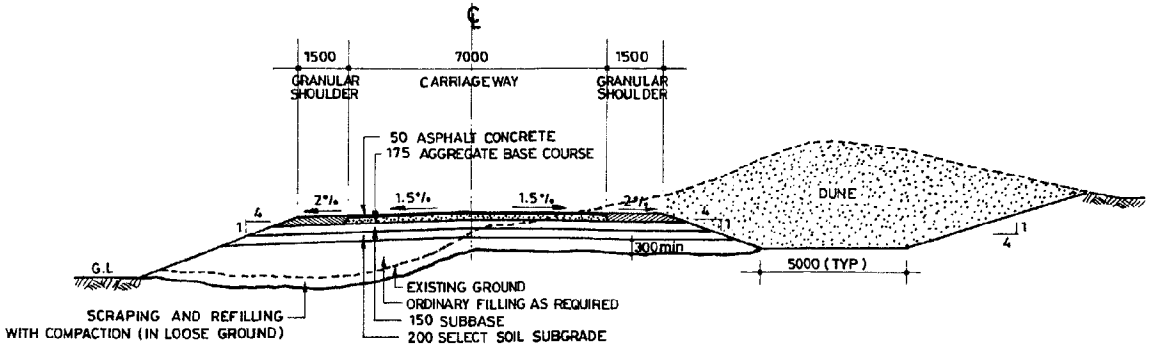
(c) Current design proposals are for a pavement for a design life of 10 years. The pavement composition is 50 mm thick asphalt concrete, wearing course on 175 mm aggregate base course and 150 mm thick sub-base, over 200 mm thick layer of selected subgrade having a minimum soaked CBR of 15 to 29%.



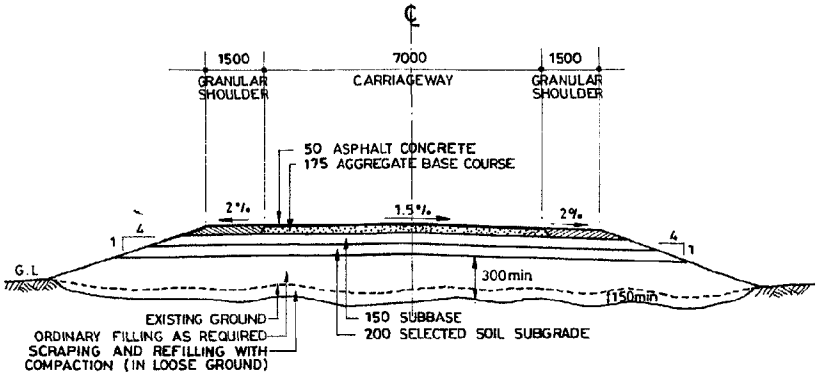
1. CROSS-SECTION IN FILL IN SANDY AREA



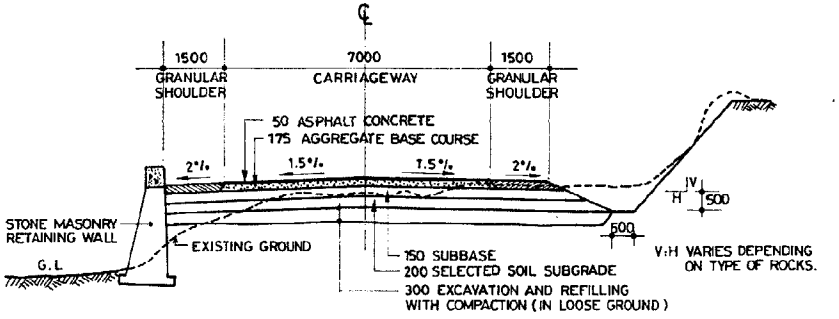
2. CROSS-SECTION IN CUT IN SANDY AREA



3. CUT AND FILL SECTION IN DUNE AREA



4. CROSS SECTION IN SAND FLOW STRETCHES



5. CROSS-SECTION IN ROLLING TERRAIN WITH RETAINING WALL ON ONE SIDE

NOTES.

1. ALL DIMENSIONS ARE IN MILLIMETRES.

FIG. Nr. 1.2.1 (a)

TYPICAL PAVEMENT CROSS-SECTIONS

Table 1.2.1(b)
Geometric Design Standards

Design Elements		Type of Terrain	
		Flat	Rolling
Design Speed (km/hr)		120	80
Min. Raidus of Horizontal Curve (m)		1000	150
Min. Radius of Vertical Curve (m)		10,000	3,500
Maximum Super-elevation %		7	7
Gradient :	Maximum (%)	5	7
	Minimum (%)	0.4	0.4
Width of Asphaltic Carriageway (m)		7	7
Width of Granular Shoulder (m)		1.5	1.5
Crossfall, Crowned for Carriageway %		1.5	1.5
Crossfall, Shoulder %		2.0	2.0
Standard Axle Load		8.2	8.2
Live Load Standards for Design of Drainage Structures		BS : 5400-HB Loading 30 Units	

1.2.2 Drainage

(a) The road is located in an arid desert terrain having an annual average rainfall of less than 200 mm. The porous sand covered terrain causes surface water to get lost rapidly through percolation. These drainage channels are locally called the Wadis. Active degradation of the hills around Al' Abr has resulted in the formation of numerous wadis close to the proposed road alignment. These carry intermittent flow of water resulting from flash floods occurring once in 7 to 10 years. To accommodate intermittent surface water flow, the scheme incorporates multi-cell/single cell reinforced concrete box culverts with wing walls where the main drainage channels are reasonably well defined in shape and Irish type (bed level) crossings for shallow channels.

(b) Surface water runoff across the road constructed on embankment will discharge across 1.5% gradients on the paved areas, 2% gradients on the granular shoulders and across embankment slopes to free draining natural geological formations. When the road is constructed in shallow cut, surface water will be discharged into unlined ditches 0.5 m wide. The ditches will be lined by stone in localised situations to prevent erosion.

1.2.3 Side Slopes

(a) Embankment slopes will be typically 1 in 3 in stable terrain. Slopes of 1 in 4 will be adopted in areas where sand flow occurs by aeolian processes to ensure that the embankment does not act as a barrier and cause sand deposition to occur around the road construction.

(b) Slopes in cutting will be made to suit the ground conditions. Generally slopes will be 1 in 2, reducing to 1 in 4 in sand dune areas. Additional measures will be taken to control sand movement where cuts are in sand dunes to prevent encroachment on the road through wind action.

1.2.4 Road Furniture

(a) Crash barriers will be constructed at vulnerable locations on the outside bends of the road using concrete posts and single galvanised steel guard rails 0.9 m in height.

(b) There are no proposals to fence off the road except around the archaeological sites.

(c) A range of signs using steel posts and mountings to display mandatory warning and information signs are proposed.

(d) Delineator posts shall be fixed at 25 m apart displaying white off side and red on the near side of the road. These posts will be concrete and painted white. Concrete kilometre posts will be provided every 5 km. Written information on signs and posts will be in Arabic and English.

1.2.5 Pavement Markings

(a) Centre line markings will be a dotted white line and edge of carriageway will be marked by continuous yellow lines on each side.

(b) Stop lines at junctions are provided as a standard detail.

1.2.6 Junctions

Junctions are detailed for the connection of the proposed road to the existing road network on the Safir to Marib road and the Al Mukalla-Seiyun road. The location of the other junctions will be decided later.

1.2.7 Construction Materials

(a) **General** : Material required to construct embankment can be obtained from adjoining areas of cut and from roadside borrow areas. Most of the materials will come from borrow areas at the roadside but outside ROW. Practically all the material available along the road are suitable for embankment construction.

(b) **Subgrade** : Coarse granular material will be selected to have soaked CBR in the range of 15 to 29%.

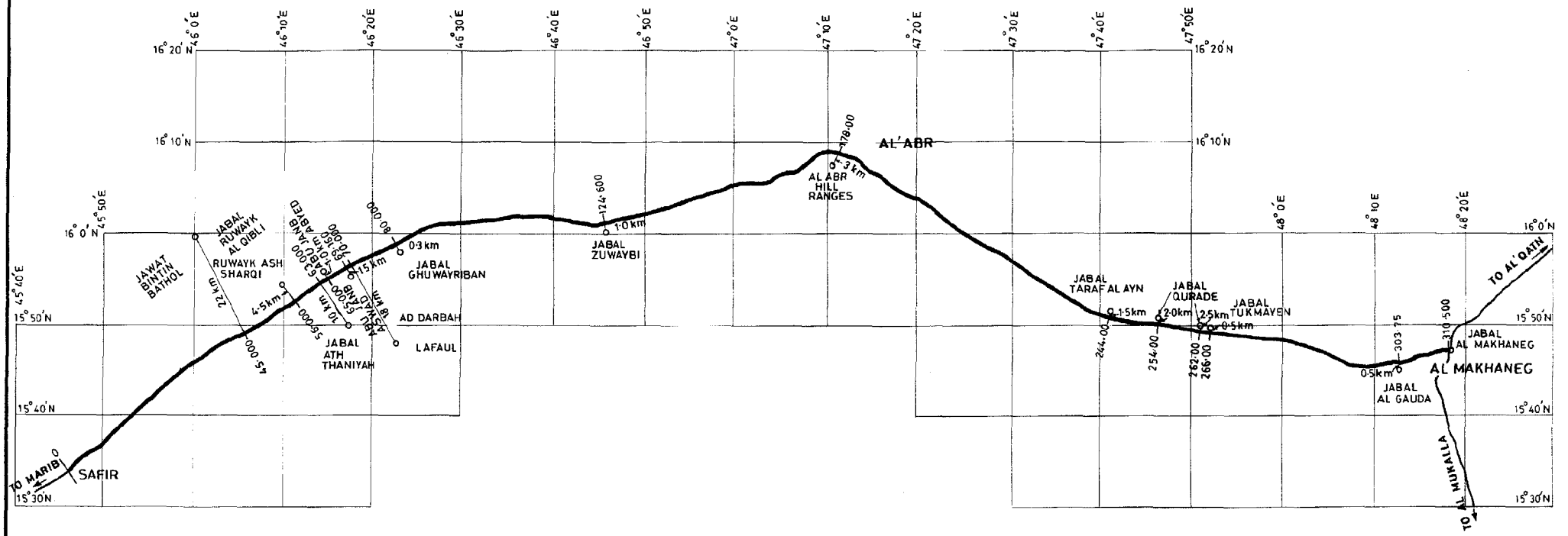
(c) **Subbase Course** : Coarse gravel granular material will be selected to have a minimum soaked CBR of 30% and specified grading.

(d) **Base and Wearing Course, Aggregates for Concrete and Stones for Protection Works** : Base course materials comprise gravels or crushed rock. Coarse aggregates for asphalt concrete may be obtained from crushed rock while coarse aggregate for cement concrete can be obtained from screened gravels and crushed rock. Sand will be used as fine aggregate in cement concrete, mortar and asphalt concrete. Stones will be used for masonry and protection works. The source of all these materials are described in Table 1.2.7(d) and their locations are shown in Figure No. 1.2.7(d).

1.3 Objectives of Environmental Assessment

1.3.1 Consulting Engineering Services (India) Private Limited (CES) prepared a feasibility study and detailed design report in 1992 which presented a comprehensive engineering, traffic and economic analysis for the road scheme including preparation of contract documents. The World Bank required a detailed environmental assessment and review of engineering designs and contract documents to take into account comments raised in Aide Memoires during project preparation missions of 18-23 December 1992 and 10-23 May 1993.

1.3.2 The Terms of Reference (TOR) adopted for this assignment are those prepared by the World Bank Project Preparation Mission of 10-23 May 1993. In response to the request from the Executing Agency for the project, the General Corporation for Roads and Bridges (GCRB), the Ministry of Construction, in their letter No. 2896 dated 7th June 1993, invited CES to prepare and submit technical and financial proposals for carrying out the environmental assessment, which are the basis for this study. Subsequently GCRB engaged CES as the Consultants and executed a consultancy agreement on 4th September 1993 for undertaking the studies related to Environmental Assessment, Feasibility and Detailed Design for



NOTES:-

- LATERAL DISTANCES ARE INDICATIVE ONLY.
- ALL DISTANCES AND CHAINAGES ARE IN KILOMETRE.

FIG. NR. 1·2·7 (d)

IDENTIFIED QUARRY LOCATIONS

the proposed road. The Terms of Reference and the two World Bank Aide Memoires referred to above are placed in Appendix 1.3.2.

Table 1.2.7(d)
Location and Types of Borrow Areas

EA Segments	Location of Borrow Areas	Use of Borrow Material			Base Course	Stones for Protection Works, Masonry, Gabions
		Fine Aggregate	Coarse Aggregate			
			Asphalt Concrete	Cement Concrete		
	Sand					
1	Wadi Bed km 7.4m near Safir	*	--	--	--	--
8	Wadi Salil Al Khal	*	--	--	--	--
8	Wadi Al Yemani	*	--	--	--	--
8	Wadi Askalia	*	--	--	--	--
8	Wadi Al Malsaq	*	--	--	--	--
9	Wadi Al' Abr	*	--	--	--	--
10	Wadi Al Mahweet	*	--	--	--	--
17	Wadi As Sur	*	--	--	--	--
21	Wadi Amad	*	--	--	--	--
21	Wadi Doan	*	--	--	--	--
	Gravels					
3	Jabal Milh	--	--	--	*	*
9	Wadi Al' Abr	--	*	*	*	*
	Crushed Rocks					
7	Ath Thaniyah	--	*	*	*	*
7	East of Jabal Ath Thaniya	--	*	*	*	*
6	Ruwayk Ash Sharqi	--	*	*	*	*
7	Abu Janb Abyed	--	--	*	*	*
7	Abu Janb Aswad	--	*	*	*	*
7	Jabal Ghuwayriban	--	*	*	*	*
4	West of Jabal Ruwayk Al Qibli	--	*	*	*	*
8	Zuwaybi	--	*	*	*	*
9	Al' Abr Hill Ranges	--	*	*	*	*
15	Jabal Taraf Al Ayn	--	*	*	*	*
17	Jabal Qurade	--	*	*	*	*
17	Jabal Tukmayen	-	*	*	*	*
20	Jabal Al Gauda	--	*	*	*	*
22	Jabal Al Makhaneg	--	*	*	*	*

* available

1.3.3 The primary objectives of the EA are as follows:

a) determine the baseline environmental conditions for the physical, biological, social and cultural environment and locate archaeological and historical sites;

b) evaluate the potential environmental impacts, direct and indirect, including identification of opportunities for environmental enhancement;

c) prepare an environmental management plan to recommend feasible and economic measures to reduce or prevent negative environmental impacts to acceptable levels and to enhance and support the potential benefits of environmental and social aspects of the project; and

d) develop an environmental monitoring plan to monitor the implementation of environmental management actions and the impacts of the project during construction and operation.

1.3.4 These aspects are to be considered taking into account the engineering description of the proposed project and the legal framework in Yemen including pertinent regulations and standards governing environmental issues such as environmental protection, rights to property, water and common land.

1.4 Methodology

1.4.1 General

In general, the broad methodology as stated in the Technical proposal has been followed to complete the study. A brief summary of the methodology of the environmental impact assessment of various aspects is given hereunder.

1.4.2 Pre-Field Stage

(a) On the basis of available maps and information a base map has been prepared at 1:250,000 scale. Thematic maps at smaller scale are presented based on secondary data to highlight important issues noted from reconnaissance.

(b) Satellite imagery and aerial photographs have been studied to relate their interpretation to field observations/ investigations. Thus ground features observed during reconnaissance surveys have been used to prepare the resource inventory. Accordingly maps on land, soil, landuse capability,

present land use and some other environmental components have been prepared as necessary.

(c) Three schedules were prepared to collect information in the field in connection with the study of land unit, soil and nomadic/sedentary population which are essential to study desert ecology to formulate environmental impact.

1.4.3 Field Stage

Field stage study was undertaken by all the experts along the entire length of the proposed road corridor for visual assessment and local enquiries and for meeting the critical data gaps, and identifying potential environmental and social impacts. This helped in understanding the regional environmental and ecological processes as acting in the project area. This led to the identification and division of the proposed road into environmentally homogenous segments for each of which the quality of environment was assessed and likely impacts due to road construction and actions for mitigating negative impacts (if any) were identified.

1.4.4 Post-Field Stage

a) **Dynamics of Desert Environment :**

To assess the impact of the road construction on environment and on land degradation/desertification, studies have been undertaken in the context of natural/biotic (anthropogenic) intervention, over exploitation of resources etc. The presence of desertification/land degradation has been identified with reference to:

i) movement of sand in broad terms;
ii) deflation of fine material - increase in coarse materials;
iii) degradation of marginal lands - removal of top soil and grass cover;
iv) enlargement of rock outcrops or bare areas to indicate degrees of erosion;
v) decreasing or disappearance of vegetative cover;
vi) rise and fall of water tables; and
vii) the practice of cutting trees.

b) **Geology and Hydrogeology :**

The geology and hydrogeology study between Safir and Hadramount was carried out to determine the availability of road building materials and

ground water all along the road alignment for the purposes of road construction on the one hand and normal human activities on the other. The studies have also been made to assess the likely adverse effects of ground water abstraction on the ground water regime. In order to achieve the objectives of the study, activity has been planned as follows:

i) Collection and review of existing geological and hydrogeological data and reports covering the study area (UNDP and Department of Hydrogeology in the Ministry of Oil and Mineral Resources).

ii) Study of topographic maps with ground contours, drainage channels and orientation with heights of sand dunes.

iii) Study of sub-surface geology as obtained through the bore wells for identifying the aquifer zones and their aerial distribution.

iv) Study of depth to water maps to identify the occurrence of ground water.

v) Study of water table contour maps to identify the areas of recharge and discharge as also to find out the movement and gradient of ground water.

vi) Study of hydrochemistry of surface and ground water.

vii) Study the aquifer characteristics as determined through pumping tests for various aquifer parameters to work out water balance.

viii) Study of rainfall record for working out the rainfall infiltration.

ix) Study of ground water development and its effects on the ground water regime on a long term basis.

c) **Regional Development :**

For the regional planning and development strategy, the following sequential tasks have been carried out:

i) The initial project objectives are to be seen in the context of the overall policies and programmes of the Republic of Yemen and in particular of the Governorates of Marib and Hadramout as the proposed road passes through these two Governorates.

ii) A resource inventory and data base has been prepared for all natural resources as well as man made features to understand the biophysical, socio-economic and cultural environment in the regional perspective. Major sectoral resources inventory namely water, soils and minerals, agriculture, livestock and animal husbandry, flora and fauna, oil and energy have been undertaken alongwith physical and social infrastructure and linkages and communication systems.

iii) The above was then analysed to determine the environmental status and the settlement systems, whereby identification of the development issues and growth potentials would be possible.

d) **Social and Cultural Dynamism :**

For the study of social and cultural impacts of nomadic, semi-nomadic and settled bedouins along the proposed Safir-Hadramout road alignment, the Consultants undertook the following activities through compilation of information from published and unpublished secondary sources as well as computation from selective questionnaires and interviews and supplemented by personal observations. The objectives have been as follows:

i) Profiles of the social organisation and cultural patterns of the major nomadic, semi-nomadic and other settled social groups and their spatial distribution in the project were done. In addition, a study was undertaken to assess the social perspective on development and response to the changing use of human resources. The analysis of these dimensions will reveal the nature of their expectations and priorities, movement and settlement patterns.

ii) As corollary to the above, it will be possible to indicate the anticipated clustering of people and activities along the proposed road alignment. This will enable the requirements of social and economic infrastructure, in response to the probable spatial arrangement of people and activities to be determined. Based upon the evaluation of social and cultural impacts, measures for addressing environmental impacts have been formulated.

e) **Institutional Study :**

Care has been taken to study organograms of the National and Governatorial administration highlighting the powers and responsibi- lities of the different departments. Law regarding right to land property, access to water, landuse controls, etc., were also referred to. The views of the Government of ROY on developmental prospects were also considered.

The work done by some of the area developmental authorities and agricultural research stations were studied during field visits. On the basis of these studies, the imperatives of the Environmental Management Plan and the tasks of the monitoring unit have been formulated.

f) **Segmentation of Road Alignment for Impact Assessment:**

Field studies were conducted jointly by all the experts along the entire length of the proposed road corridor. This led to the identification of and partition of the road into 22 segments, for each of which the quality of environment was assessed and actions for mitigating negative impacts were identified. The quality of road-segment environment was reviewed against the regional environmental setting. As a result, the actions required to enhance the environment were identified. This has been used to prepare the Environmental Management and Monitoring Plan.

g) **Alternative Alignment :**

Field survey for selecting alternative alignment at the Hadramout sector has been carried out and three alternatives were identified. Initial Environment Examination (I.E.E.) on these three alternatives have been compared with the chosen alignment.

1.4.5 Prehistoric/Archaeology Resource Study

The following methodology was adopted for this study.

(a) **Pre-field Stage :**

The pre-field stage consisted of a comprehensive literature review of published and unpublished documents relevant to the prehistory and archaeology of the general project area. Included in this stage are reviews of archaeological literature, unpublished field notes and inspection of available geologic, topographic and other maps of the project corridor. Archival materials, including artefacts and manuscripts, have been inspected at the GOAMM museum and library in Sana'a.

(b) **Field Stage - Project Corridor Survey :**

This stage of the project consisted of a comprehensive field survey of the proposed road construction corridor and designated borrow areas and stone quarries. The goal of the survey, which has been undertaken primarily at the pedestrian level, was to locate and record prehistoric and other archaeological sites within the proposed impact corridor. Identified

archaeological and prehistoric sites have been accurately plotted through the use of topographic maps and a Magellan model 5000 GPS (global positioning system) unit. A standardised reporting form has been completed for each identified site. This standardised form has ensured consistent recording of data for each site. Information collected included site location, temporal and cultural data, site geology/geomorphic setting, relationship of site to proposed impact corridor and site elevation. Individual site maps have been prepared, as deemed appropriate by the field personnel. A limited collection of diagnostic artefact classes has been collected from most sites. Artefact collections have been labelled with provenance data and returned to the laboratory for analysis and curation. Additionally, identified sites have been documented by photography.

(c) **Site Testing :**

Upon completion of the site identification and reporting survey, limited site testing has been required at several sites. The site testing, if deemed appropriate, has been implemented in order to address site significance. Site parameters (vertical and horizontal), site integrity and presence/ absence of in-situ cultural materials have been considered during testing procedures.

(d) **Data Analysis/Report Preparation :**

This stage of the archaeological investigations included analysis of recovered artefacts and preparation of a report. Collected artefacts have been analysed and documented through photography and/or drawings and the collected materials have been catalogued and prepared for curation at GOAMM facilities in Yemen. A comprehensive report on Basic Study - 5 has been prepared to document all activities and findings of the field investigations. The report contains individual site assessments as well as a statement of significance for the encountered archaeological sites. Recommendations for future work have also been included in the report which also includes site maps, photographs and artefact illustrations. Special attention has been focused upon the environmental impacts of the proposed road construction activities upon the cultural resources identified during field stage survey. As part of the environmental assessment, the significance of individual archaeological/prehistory sites and the expected impact(s) from the proposed construction project upon the sites have been evaluated. The evaluation has included specific recommendations regarding environmental impact of the proposed construction activities upon the identified cultural resources.

(e) **Determination of Site Significance**

Criteria utilised to assess site-significance include the following :

i) Site integrity and the presence or absence of in-situ cultural materials.

ii) Relative uniqueness of the site.

iii) Importance of site in addressing current academic research questions.

iv) Regional and local importance of the site.

v) Proportion of site that will be impacted by the proposed road construction activities.

vi) Association of site with important historical events and/or persons.

Recommendations have been based on site significance with consideration of the proposed impact at each site location.

1.5 Presentation of the Results of EA Study

1.5.1 The outputs of this study can be broadly classified into two types, such as, a set of Basic Studies and a set of specific notings for EA. The Basic Studies are required to understand the rationality of environmental assessment made, the significance of the mitigation measures suggested and the opportunities available for enhancement of the quality of road-defined environment to let the society derive feasible benefits. The specific observations on EA, on the other hand, are to be seen in the context of the given TOR.

1.5.2 The report on EA has been structured in an easily readable form with the emphasis on easy referencing at the time of project implementation. The second chapter, therefore, discusses the regional environment to provide a background to the EA given in the third chapter. In the third chapter, the entire length of the proposed road alignment has been segmented as stated para 1.4.4(f) and the typology of environment encountered in each segment has been defined.

1.5.3 These environmental types are but sub-types of the regional environment. Therefore, the significance of the EA and the suggested mitigation measures can be appreciated if chapter two is read carefully. The third chapter yields the various components of mitigation measures and the diverse types of actions required to

enhance the quality of the road-defined environment. To appreciate the significance of the actions on enhancement, the Basic Studies, placed at the end of EA report, will prove useful. The fourth chapter deals with the alternative alignment in the Hadramout sector. The fifth chapter deals with Environment Management Plan and Monitoring along with indication on actions required to enhance the quality of the environment. This chapter deals with the options available to strengthen the concerned institutions with regard to this project. The sixth chapter deals with Institution and Legal Framework. These six chapters meet the requirements of the TOR for EA fully and adequately.

1.5.4 After the six chapters constituting the EA report the following five basic studies have been placed.

(a) Basic Study - 1 Combating Desertification
(b) Basic Study - 2 Hydrology of the Inland Basin;
(c) Basic Study - 3 Social Groups Along the Proposed Road Corridor;
(d) Basic Study - 4 Pattern of Regional Development;
(e) Basic Study - 5 Report on Heritage : Archaeology and Prehistory

With the above, Volume I - Environmental Assessment Report containing Chapters I through to VI and Basic Studies 1 through to 5 has been presented.

1.5.5 All sections and paragraphs in this report have been numbered. Figures, Tables and Appendices bear the same number of the paragraph where these are first referred to. This is expected to facilitate referencing.

1.6 Presentation of Engineering Report

The Engineering Report is presented in Volume II containing Chapter VII through to Chapter XII.

Name and Position of Experts

NAME	POSITION
A.K. Chakrabarti	Team Leader
H.T. Brocklebank	Principal Environmental Specialist
David A Warburton	Archaeologist
Jonathan R Sellars	Prehistorian
Dr. S C Chakraborty	Environmentalist cum Ecologist
B K Roy	Senior Highway Expert
H R Smith	Pavement Specialist
N C Bhatnagar	Hydrogeologist
S Saha	Regional Development Specialist
A K Sen	Desert Ecologist
Dr. T K Mazumdar	Social Anthropologist
Franck Mermier	Social Anthropologist
A Bandopadhyay	Highway Engineer
S Samanta	Highway Engineer
S Chaudhuri	Project Co-ordinator

REPUBLIC OF YEMEN
Safir-Hadramout Road Project
Studies Related to Environmental Assessment, Feasibility & Destailed Design

TERMS OF REFERENCE

1. These are the terms of reference for the various studies and necessary adjustments to the feasibility study and design documents including the environmental assessment for the proposed Safir-Hadramout road as required under the World Bank Operational Directives 4.01, Environmental Assessment.

Background Information

2. The proposed project aims to integrate the rich agricultural areas of the Hadramout Valley with the Northern Governorates by the construction of a 311 km long road link, the Safir Hadramout Road. The project is expected to generate very significant benefits for Yemen's economy and population by reducing transport distances for agricultural products of the Hadramout Valley sold in the Northern Governorates; improving communications between Sana'a and the Hadramout; improving access and reliability of transport for oil exploration and production activities; improving the maintenance of Yemen's road network; improving road safety; creating job opportunities during and after road construction; improving access to social services for the Bedouin tribes that inhabit the area; and reducing the negative impacts on the desert ecosystems of the existing multiple vehicle tracks.

Objectives

3. The objectives of this assignment are to prepare a detailed Environmental Assessment (EA) and to update the feasibility study and detailed design of the project to take into account the comments of the World Bank project preparation missions of December 18-23 and May 10-23. Primarily, the assignment is for an EA to : (a) evaluate the environmental and social impacts of the proposed project; (b) evaluate the impacts of the road construction and (c) to prepare an environmental management plan for the affected areas identifying mitigating measures and considering design alternatives. In addition, the Consultant would modify the road design bid documents and economic analysis in line with the findings of the EA and the comments of the World Bank missions referred to above.

Scope of Work

A. Environmental Assessment

4. Study Area for EA. The road will cross desert terrain in the north-eastern part of the country connecting Safir to Al Makhanid via Ath Thaniyah, Al'Abr and Hawrah. With the exception of a few sand dune areas totalling about 10 km, a few wadis (stream beds) and rocky areas, most of the most alignment is on flat terrain (96%) and only 3.4% is on rolling terrain. Most of the area through which the road passes is sparsely inhabited. Settlements include the town of Al'Abr which serves as a customs post and trading centre for nomadic Bedouin tribes in the area, and several small settlements in the last 60 kms as the road approaches the Hadramout. The study area should cover the road site, and the potential area of influence of the road for ecological and social impacts including the quarry pits and back fill areas, and the wells drilled to provide water during construction.

5. The EA should cover : (a) the existing environmental baseline conditions; (b) the potential environmental impact, direct and indirect, including opportunities for environmental enhancement; (c) an environmental management plan, specifying preventive, mitigatory, and compensatory measures and institutional arrangements; and (d) monitoring. The EA report should be concise and limited to significant environmental issues. The main text should focus on findings, conclusions and recommended actions, supported by summaries of the data collected and citations for any references used in interpreting those data. The contents of the EA should include but not be limited to :

   (a) Description of the Proposed Project, including the following information, location of the road, general layout and technical specifications, expected volume and types of traffic, construction activities and schedule; facilities and services; operations and maintenance activities; required off-site investments; and life span.

   (b) Description of the Environment providing baseline data on the relevant environmental characteristics of the study area. This would focus on :

      i) Physical environment: geology (location of major features,wadis), dune stability, surface and groundwater hydrology (groundwater availability) and quality, heavy rains and flash floods, recharge areas for aquifers), salinity of soils, climatic factors (wind conditions, temperature), significant landscapes.

ii) Biological environment : ecologically important or sensitive habitats, migration routes of wildlife and herds (camels, goats, sheet) location of significant grazing fields and water sources.

iii) Social and cultural environment : population distribution, community structure, tribal people, landuse, land tenure, existing settlements, infrastructure and services, public health and employment.

iv) Archaeological and historical sites of significance : prehistoric and hostoric remains, including artifacts such as flints and ceramic material, monuments such as tombs and hydraulic structure as evidence of early agriculture.

It is suggested that the archaeological survey in (iv) above be carried out in two phases, which may overalp, depending on the material found. Phase One would be a reconnaissance of the full legnth of the road alignment, with particular attention to the segment stretching from Al'Abr into the Hadramout Valley where there has been more intense human occupation. The quarry and other material sties, backfilling areas, camp sites, and potential well sites would also be examined. Phase Two would be concerned with the recording and possible protection (including fencing) of significant archaeological material. All work is to be carried out with the agreement of the General Organisation of Archaeology, Museums and Manuscripts. It is expected that Phase One could be carried out in about 15 days and Phase Two, depending on the extent and condition of material found in another 15 days. Aerial photographs preferably Landsat 5 at a scale of 1:10,000 would be needed for the area of the road alignment in addition to standard equipment such as cameras, picks, trowels etc., the use of a GPS would be advantageous.

c) Legislative and Regulatory Considerations : Describe the pertinent regulations and standards governing environmental issues and the protection of sensitive areas. Special attention should be given to water and land rights and customary law practices.

d) Determination of the Potential Impacts of the Proposed Project : The direct and indirect impacts of the propsoed road alignment and construction should be identified. An effort should be made to obtain the views of the affected social groups, concerned government agencies and NGOs. Key areas of concern to be addressed include :

i) impacts of the drainage patterns and risks of soil erosion and destabilization of dunes;

ii) impacts on water availability and quality both for road construction and for economic activities in the region;

iii) impacts of extraction of building material and backfilling;

iv) effects of the disposal of wastes and used oil during road construction and operation; risks of transport of hazardous/toxix materials;

v) impacts on sensitive habitats, grazing areas, and animal migration routes;

vi) impacts of tribal people and local settlemments;

vii) impacts on land acquisition and potential resettlement needs;

viii) impacts on archaeological and historical sites; and

ix) impacts on induced development along the road and in the regions.

e) Development of Environment Management Plan : Recommend feasible and cost effective measures to prevent or reduce significant negative impacts to acceptable levels and enhance and support the potential environmental and social benefits of the project. This includes the identification of alternatives in design, construction techniques, phasing and modifications of alignment. Also ensure that basic facilities for local communities at the location of wells and base camps established during construction are provided. Estimate the impacts and costs of these measures and of the institutional and training requirements to implement them. Consider compensation to affected parties for impacts which cannot be mitigated with special attention to the depletion of water resources. Prepare a management plan consisting of a proposed work programme, budget estimates, schedules staffing and training requirement and other suport services needed to implement the mitigating measures.

f) Development of a Monitoring Plan : Prepare a detailed plan to monitor the implementation of environment management actions and the impacts of the project during construction and operation. Special attention should be given to possible chance archaeological finds during construction and their recording and protection.

Outputs

An Inception Report should be prepared within one moth from the start of the study presenting a detailed work programme, comments and clarifications to the TOR and environmental assessment methodology. This report shall be forwarded to the Government and IDA for review. The actual studies will be carried out in close contact with the Government in order to take their comments into consideration as the study progresses. The Draft Final Report shall be submitted within four months of the start of the study, and should be provided simultaneously to the Government and IDA for comments in order to save time. The Final Report incorporating all comments shall be submitted within one month of receiving the comments of the Government and IDA.

CHAPTER II

REGIONAL ENVIRONMENTAL SETUP

CHAPTER - II
REGIONAL ENVIRONMENTAL SETUP

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CHAPTER - II

REGIONAL ENVIRONMENTAL SETUP

2.0 Introduction

2.0.1 The objective of this chapter is to identify the different attributes of the regional environment and their spatial differentiation. Based on the commonality and differentia between these attributes, an attempt will be made to identify the basic environmental units and their spatial orientation. This will help Environmental Assessment (EA) by way of providing understanding about the specific attributes of the environmental units that the proposed road will traverse. In this sense, scoping for EA shall be facilitated. Since all environmental units are but sub-types of the regional environment, the chosen approach will provide understanding about the relationship obtaining between the adjacent environmental units leading to identification of the processes affecting their spatial orientations.

2.0.2 One of the most lingering impressions that one would carry about the environment of the inland basin of Yemen is its fragility, conditioned as it were by its climate. Here, evaporation far exceeds precipitation and the sun shines dazzlingly hot. The days are always warm and the nights are cooler, which keeps the diurnal range of temperature greater than the monthly or annual ranges. Rains bring relief and often disasters in the shape of sudden cloud bursts, causing flash floods down the channels but which are soon lost into the parched land. The landscape wears a brownish hue almost everywhere and the monotony is broken here and there by black lava or patches of green vegetation sustained by erratically flowing water or by irrigation from canals or wells. Then there are the persistent winds scooping out loose dust and sand, frequently churning these to form columns in the air to amazing heights before throwing the gathered materials over a wide area. So, there is dust everywhere. Dry air seems to crumble everything - stones, mud flats, dunes and even the houses - and, thus armed, etches grooves into everything else. The parched dust is constantly shifted from one place to the other, threatening the heritage of mankind. It is indeed a fragile ambience.

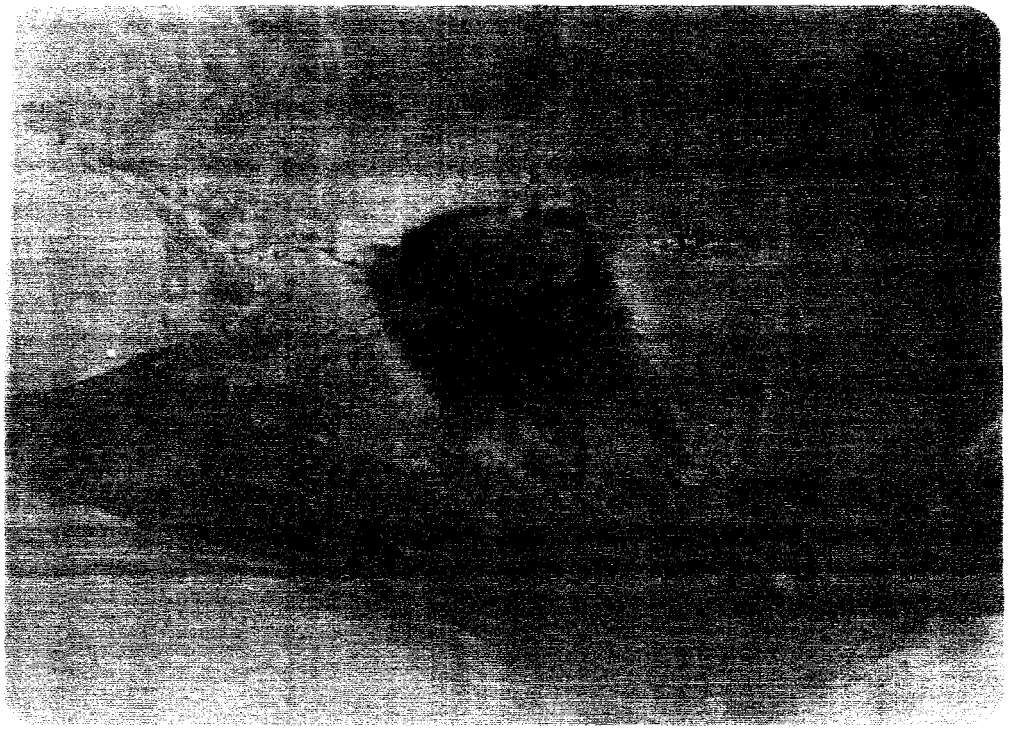
2.0.3 The so sculpted landscape does not, however, appear erratic in form. One carries a haunting suspicion about the existence of some organised processes working in this region to bring order within chaos. There are the long high dunes, but not everywhere. These are confined within some tracts. There are also the mountains which at the base are skirted by screes sloping gently with the size of

the broken rocks gradually declining towards the valleys of the ancient regimes. The faulted and jointed rocks shelter the flowing water. Decidedly this environment represents a system that bears a regional order conditioned by what happened in the past. To discern its attributes is the objective of this chapter.

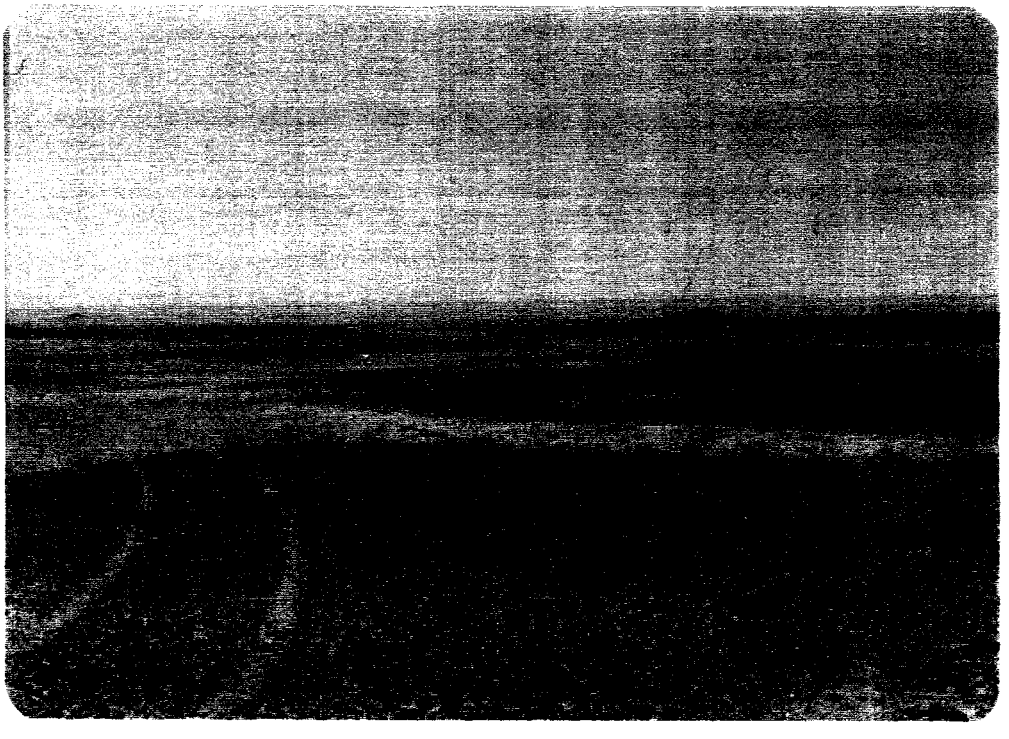
2.1 Orography

2.1.1 A persual of Figure 1.0.2 would indicate that the proposed alignment of the road is confined within a large inland basin with elevation ranging between 500 m and 1000 m. This inland basin is separated from the coastal plains of the Gulf of Aden by a broad and nearly uninterrupted mountainous terrain with elevations ranging between 1000 m and 3000 m. In the north also the basin is bounded by two large stretches of mountains with elevations between 1000 m and 2000 m. The tract between these two blocks of the northern mountains have been eroded by the surface drainage systems flowing north and south. In the past, these streams use to carry greater volumes of water than what they do today. The watershed zone between these two spatial systems of drainages is clearly visible. To the west, the high mountains of Sana'a totally cuts off the basin from the coastal tracts of the Red Sea. The Sana'a mountain forms a continuous rampart joining the southern and the northern mountains. This has elevations ranging between 1000 m and 3000 m. To the east, the northern and the southern mountains tend to close in, but remains separated by the valley of Wadi Masila. This wadi acts as an outlet for inland water to flow into the Gulf of Aden or the Arabian Sea. It also provides a reasonably easy passage for transhipment of men and materials from the inland basin into the coastal plain. There are, of course, many other passages built through the encircling mountains for roads. The network of roads provides a rough idea of the valley defined passages, which can be guessed from the information given in Figure 1.0.2.

2.1.2 For purposes of scoping for EA,one could perhaps exclude the western and the southern hills from further analysis, because the proposed alignment of the road passes through terrains removed from these two orographic units. It would, however, be injudicious to exclude these two units at this stage of enquiry, because on geo-tectonic considerations the orientation of the inland basin appears to be related to the formation of these mountain ramparts. The orography of the ROY has acquired its complexity by virtue of its location at the junction of the Red Sea and the Gulf of Aden rift structures. These two rift valley systems have influenced the shape of land forms, orientation of surface hydrography, occurrence of ground water, disposition of aquifer units, the flow of wind and the general climate of this large region.



1. AERIAL VIEW OF CRATER ON SOUTHERN HILLS SHOWING PAST VOLCANIC ACTIVITY



2. PLUVIAL STAGE OF PLEISTOCENE PERIOD - GRAVEL-SAND DEPOSIT ALONG THE ROAD ALIGNMENT

2.1.3 The Arabian Peninsula is a part of the Afro-Arabian massif. Their current segmented disposition are the products of extensive rift faulting, leading to the formation of Red Sea and the Arabian Sea. These two rift faults are nearly perpendicular to one another and have contributed in each instance to the formation of a series of cross faults on the territory covered by the ROY. These cross faults have given rise to blocks of horsts and grabbens, provided passage for extrusion of lava, differential subsidence and upliftment of blocks of land and lateral sliding of these blocks in many parts of Yemen. The inland basin was not spared by these mega-tectonic forces, much of their manifestations having remained burried under recent and sub-recent lithofacies. To get a proper idea about the effects of these processes and their manifestations, it is necessary to examine the lithostratigraphy and hydrography.

2.2 Lithostratigraphy

2.2.1 The region we are concerned with is a part of the Afro-Arabian massif formed of Pre-Cambrian metamorphic rocks. This is often referred to as the basement complex. Nowhere in the inland basin are these Pre-Cambrian formations exposed as outcrops.

2.2.2 The Afro-Arabian massif was subjected to erosion for extended periods leading to the formation of peneplains, upon which were deposited the sediments in the Proterozoic and Mesozoic periods. These sediments are mostly terrestrial derivatives (sandstones) and occasinally marine in origin (limestone). These do not represent any uninterrupted sequence of sedimentation but reveal many unconformities. In the late Cretaceous and early Eocene period, this massif was affected by epirogenic movement leading to upwarping around the Sana'a mountain and pitching down at the Hadramout end. This led to block faulting, basaltic lava flows, dykes, etc. Then followed sedimentation through the Tertiary era. During the Pliocene period, there took place a change in sea level, causing a rise of about 150 m above the present level. Volcanic activity continued leading to reactivated tectonic activity in the late Tertiary era. Volcanic activity also continued into the early Quarternary era but not inducing any tectonic activity. Clastic and argillaceous sediments were deposited during the Quarternary period in the shape of wadi deposits, alluvial fans, alluvial flats, etc. During the pluvial stage of the Pleistocene period, mass wasting and sheet wash brought down gravels of earlier origin into the inland basin leading to the formtion of mixed layers of gravel and sand, lacustrine sediments and often marine deposits in the coastal areas. In the Holocene period, due to climatic change, the sedimentary lithology contributed towards the formation of aeolian deposits of sandy plains and various types of sand dunes.

2.2.3 The lithostratigraphic succession has been diagramatically presented in Figure 2.2.3. This is based on the maps prepared by the Natural Resources Project : Geologic Map under the Ministry of Oil and Mineral Resources, Republic of Yemen. One can identify from this diagram the types of rocks deposited during the successive geological eras, the periods of suspension of deposition (unconformities), and the effects of igneous and tectonic activities.

2.2.4 The Proterozoic lithofacies consists of migmatite,amphibolite, paragneiss,schist, marble, metadolomite, graphitic schist and quartzite. Igneous activities have produced basic, intermediate and acid metavolcanics, which took place towards the end of the Proterozoic era. The tectonic effects are, however, associated with almost the entire Proterozoic era leading to the formation of orthogneiss, syntectonic gabbro, ultramafic rocks, syntectonic diorite, syntectonic synogranite, syntectonic granite, late syntectonic to post tectonic diorite and granite. Most of the Proterozoic formations are not exposed on the surface of the proposed road alignment except along an axis formed by Jabal Ruwayk Al Qibli (15° 58' N : 46° 03' E) through Jabal Abu Mabani (15° 55'N : 46° 8' E) and Jabal Ath Thaniyah (15° 48' N : 46° 20'E). The rocks along this axis are orthogneiss, syntectonic diorite, schist, marble and metadolomite, some of which can provide good road building materials.

2.2.5 The importance of this axis should also be seen as a barrier to the groundwater flow from the Sana'a mountain eastwards. The Proterozoic deposits are probably underlying the younger formations along the rest of the road alignment from Safir to the axis mentioned above and may thereby act as a receptacle for ground water. The tract between the Sana'a mountain and the axis of surface exposure of the Proterozoic lithofacies is probably forming a basin upon which the rocks of the Mesozoic era had been deposited. This is surmised from the fact that Jurassic deposits are flanking the north-western margin of the Sana'a mountain as well as the south-eastern edge of the axis mentioned above. Ground water exploration have also identified the Cretaceous deposits overlying the Jurassic formations. Most of the tract is, however, burried under recent and sub-recent deposits.

2.2.6 The deposits of the Mesozoic era came during two distinctly separated periods. The older formations belong to the Jurassic period and consist of marl, limestone, conglomerates, sandstone, bituminous marls and limestones, limestones with gypsum and dolomitic marls. All these indicate a marine environment for deposition. During this period igneous and tectonic activities were absent. One is, however, not certain how much of brine or salt deposits are still intermingled

GEOLOGICAL PERIODS		LITHOFACIES		IGNEOUS FORMATION		TECTONIC EFFECTS	
CENOZOIC	QUARTERNARY	Q_{11}	ACTIVE ALLUVIUM : SAND & GRAVELS IN THE MAIN WATER COURSES.	6	BASALTIC LAVAS.		
		Q_{10}	OLDER ALLUVIUM : CONGLOMERATES & COARSE GRAVELS IN LOWER REACHES OF MAJOR WADIS.	5	TRACHYTIC FLOW & DOMES		
		Q_9	GRAVEL IN AREAS OF LOW RELIEF ON STONEY SURFACE.	4	BASALTIC PYROCLASTIC DEPOSITS		
		Q_8	AEOLIAN DEPOSITS : BARCHAN DUNES.				
		Q_7	AEOLIAN DEPOSITS : LINER SAND DUNES.				
		Q_6	LOESS & ANCIENT DUNES.				
		Q_2	COLLUVIUM : SCREE OVER DISSOLUTION OF SALT DIAPERS.				
		Q_1	LACUSTRINE DEPOSITS IN AREAS OF INLAND DRAINAGE.				
	TERTIARY	Ts	SHIHR GROUP : UNDIFFERENTIATED.				
		Tr	RUS FORMATION : THIN BEDDED DOLOMITES, LIMESTONES, MARLS, GYPSUM & ANHYDRITE.				
		Tj2	NODULAR & FLINTY LIMESTONES WITH THIN BEDS OF BROWN & GREY SHALES.				
		Tj1	INTERBEDDED LIGHT GREY SHALES & MARLY LIMESTONES.				
		Tu2	THINLY BEDDED DOLOMITIC LIMESTONES.				
		Tu1	SCARP FORMING LIMESTONES & DOLOMITIE WITH MARLS & SHALES.				
MESOZOIC	CRETACEOUS	K	UNDIFFERENTIATED.			K-c4	ALKALINE TO ULTRAMAFIC DIATREMES.
	JURASSIC	Jn	BITUMINOUS LIMESTONE, DOLOMITIC MARLS.				
		Je, Jm	BITUMINOUS MARLS & LIMESTONES WITH SOME GYPSUM / MARL & LIMESTONE WITH INTERMITTENT BASALT CONGLOMERATES.				
		Js	LIMESTONES & MARLS WITH SOME SANDSTONES.				
		Jk	SANDSTONES CALCAREOUS SANDSTONES & CONGLOMERATES.				
						y1	LATE SYNTECTONIC TO POST-TECTONIC GRANITE.
						d3	LATE SYNTECTONIC TO POST-TECTONIC DIORITE.
PROTEROZOIC		q	QUARTZITE.	3	ACID METAVOLCANICS.	y2	SYNTECTONIC GRANITE.
		gt	GRAPHITIC SCHIST.	2	INTERMEDIATE METAVOLCANICS.	y3	SYNTECTONIC SYENOGRANITE.
		c	MARBLE & METADOLOMITE.	1	BASIC METAVOLCANICS.	d2	SYNTECTONIC DIORITE.
		m	SCHIST.			X	ULTRAMAFIC ROCKS.
		g	PARAGNEISS.			V2	SYNTECTONIC GABBRO.
		A	AMPHIBOLITE.			G	ORTHOGNEISS.
		M	MIGMATITE.				

FIG. Nr. 2.2.3

LITHOSTRATIGRAPHY OF INLAND BASIN OF THE REPUBLIC OF YEMEN

with these sedimentary parent rocks. Towards the end of Jurassic deposition, the region experienced a period of erosion till the start of the Cretaceous period.

2.2.7 Cretaceous deposits are mostly formed of sandstone passing into shales and limestones and are found as outcrops to the east of the axis of Proterozoic deposits mentioned in para 2.2.4 above. These are highly faulted and fractured, which indicate tectonic movements. Such tectonic movements have produced in some small areas alkaline to ultramafic diamtremes. The older Cretaceous deposits are exposed on the surface in the west. To the east, these Cretaceous deposits are found underlying the Tertiary deposits at the base of the northern as well as the southern mountains.

2.2.8 The obscured as well as visible fault lines together suggest that the Al' Abr region is a highly disturbed area, tectonically speaking. The regional expressions of such tectonic disturbances suggest as if the basin of sedimentation became deeper in the east to let accumulation of the Tertiary lithofacies. It also means that the younger Cretaceous deposits, acting as the major aquifers, especially the Mukalla series formed of loosely cemented fine to medium grained sandstones, had also gone deeper below the surface.

2.2.9 From around 47° 38' E, the hills formed primarily of Tertiary deposits tend to close in, making the intermontane valley increasingly narrow to the east. The older rocks of the Tertiary period are conspicuous by their ability to form scraps made of limestones and dolomites. The environment of deposition was decidedly marine, for we find also dolomite, limestone, marls and gypsum as the primary constituents of the younger Tertiary formation. Here again, only the older Tertiary beds are exposed on the surface in the west, which are overlain by the younger deposits in the east, suggesting that the basin of sedimentation sloped eastwards.

2.2.10 The Tertiary formations are criss-crossed by faults. The pattern of faulting is rather complex. The dominant axis of the faults on the southern outcrops is from south-west to north-east. In contrast, the dominant axis of the faults on the northern outcrops is from north-west to south-east. These two tend to meet in the Hadramout valley. One should, however, note that most of the tributary wadis are not primarily fault guided. This suggests that the drainage system in this part of the world were antecedent to the formation of faults. This could also be true for the Hadramout wadi as it cuts across many faults of both the northern and southern blocks with an oblique transverse orientation. It could thus be fairly surmised that the Hadramout trough is simply an exhumed valley and not a result of rift faulting.

2.2.11 To summarise the observations made so far on the lithostratigraphy from the Proterozoic to the Tertiary eras, Figure 2.2.11 has been constructed. Here all the Proterozoic formations have been lumped into one. However, the identities of the Jurassic and the Cretaceous formations, both belonging to the Mesozoic era, have been retained. This map covers the tract along the proposed road alignment, not exceeding 25 kms on either side of it. This has been done for the purpose of scoping for EA.

2.2.12 Figure 2.2.11 does not identify the Quarternary deposits. The formations during this period generally represent the more fragile elements of the present day environment and, therefore, deserve close attention. To facilitate this, Figure 2.2.12 has been constructed along the same corridor as represented in the previous map, but showing the different types of lithofacies of the Quarternary period.

2.2.13 The Quarternary deposits have formed in response to three different types of physical forces. There are the deposits from fluvial processes, for example, lacustrine deposits, colluvial deposits as scree, gravel mixed with sand and silt, older alluvium mixed with conglomerates and coarse gravels, and the newer alluvium of silt, sand and small gravels in the wadi beds. These together cover a substantial part of the inland basin. Equally substantial in extent are the deposits formed by aeolian processes. These are the loess and ancient dunes, linear sand dunes of considerable length and height and small crecent shaped barchan dunes. In addition, there are deposits of volcanic and igneous origin, like basaltic pyroclastic deposits, trachytic flow and domes and basaltic lava. Igneous activities had also metamorphosed many of the fluvial, aeolian and pre-quarternary formations. Their areal extent is difficult to map, because in most cases these thinly laid metamorphosed materials have been broken down into smaller pieces due to later weathering and are now found mixed with the other kind of deposits.

2.2.14 The diagram given in Figure 2.2.3 may suggest as if the aeolian deposits (Q7 and Q8) are representing an older geomorphological process than the fluvial deposits (Q10 and Q11). This would be a misleading ideation. One should consider that the aeolian processes are now re-sculpturing the fluvial formations. One should think that these two processes - - the aeolian and the fluvial - - are now simultaneously active and are modifying the land forms produced by each.

2.2.15 Speaking on regional terms, one could believe that the lacustrine deposits were much more extensive in the past than seen today. Only at two places at the western margin of the Hadramout wadi, there now exist exposed to the surface

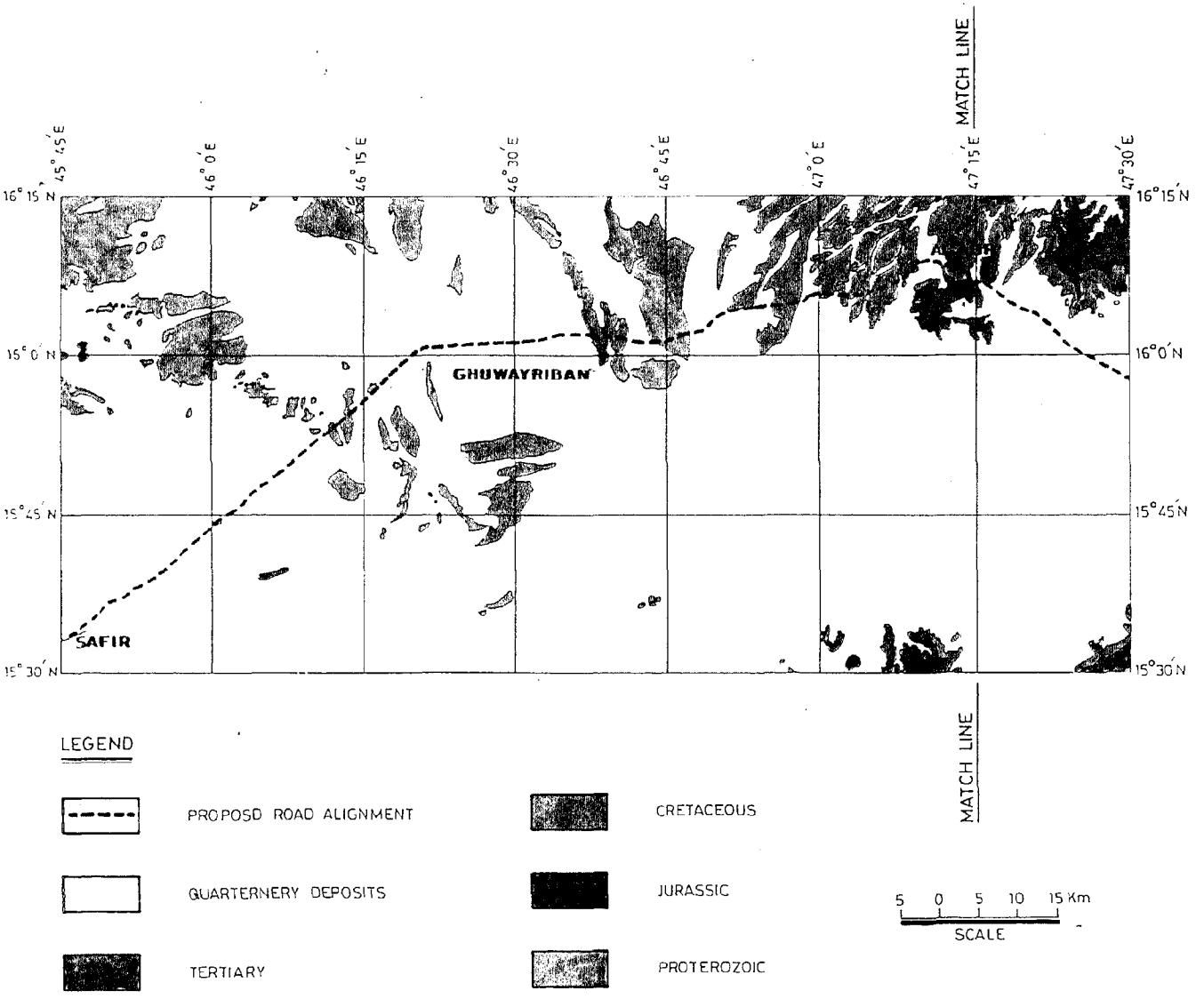


FIG. NR. 2.2.11

PRE-QUARTERNARY LITHOLOGY ALONG PROPOSED ROAD ALIGNMENT

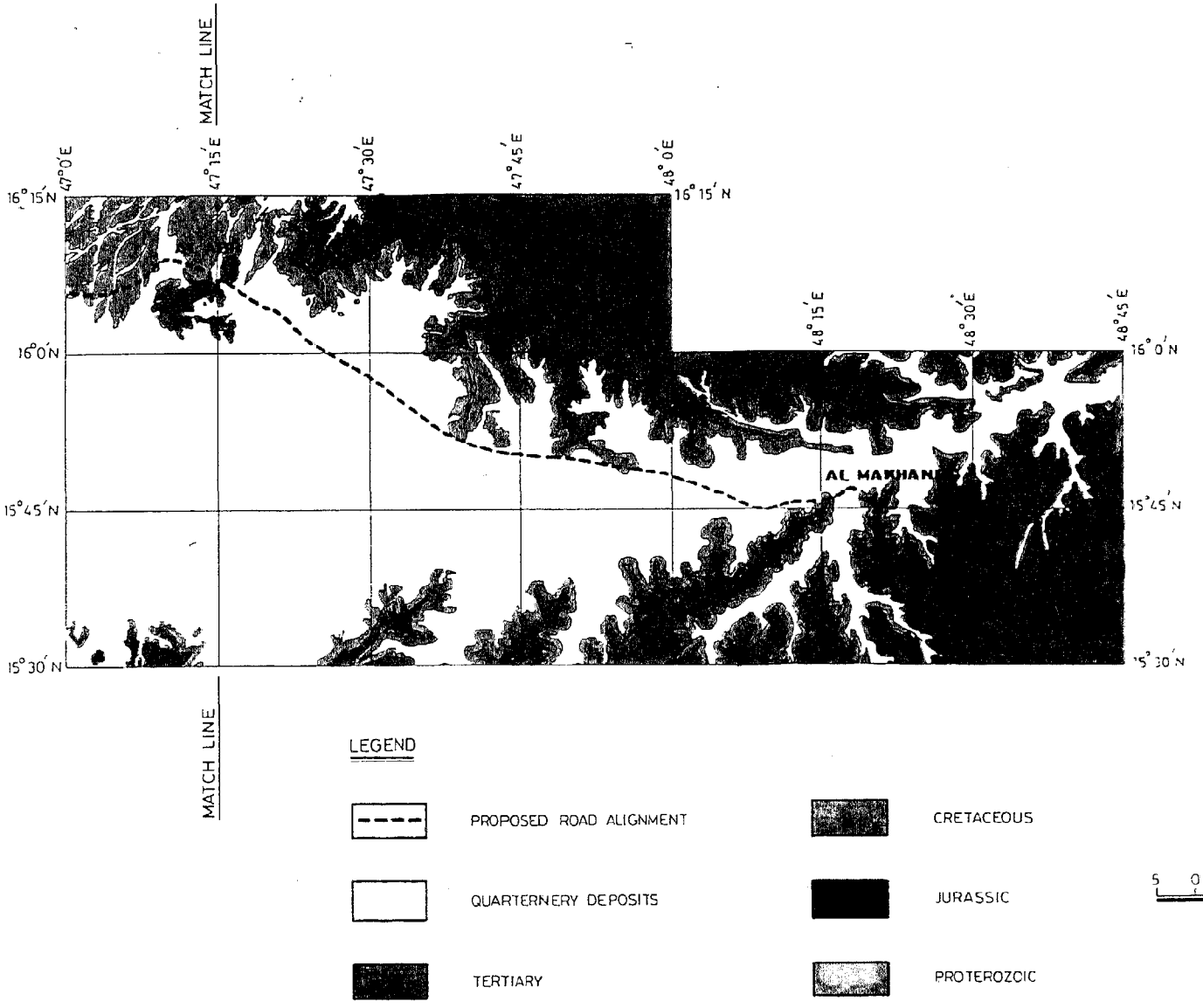
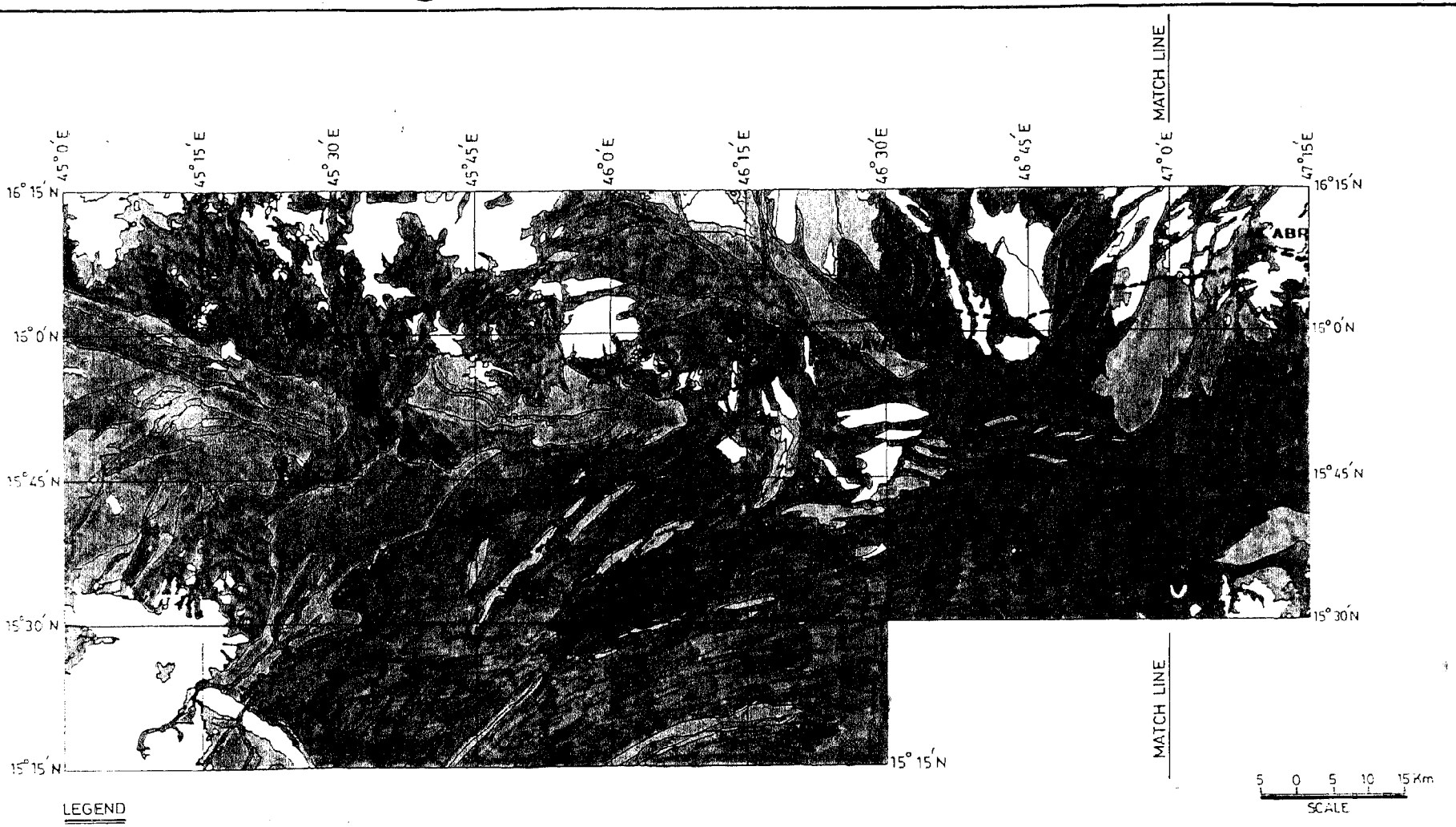


FIG Nr. 2.2.11

PRE-QUARTERNARY LITHOLOGY ALONG PROPOSED ROAD ALIGNMENT



LEGEND

- PROPOSED ROAD ALIGNMENT
- ACTIVE ALLUVIUM
- OLDER ALLUVIUM
- GRAVEL & SAND
- AEOLIAN DEPOSITS
- DUNE CRESTS
- LOESS & ANCIENT DUNES (Not Represented)
- COLLUVIAL DEPOSITS (Not Represented)
- LACUSTRINE DEPOSITS
- PRE-QUARTERNARY FORMATION

FIG. NR. 2.2.12

QUARTERNARY LITHOLOGY ALONG PROPOSED ROAD ALIGNMENT

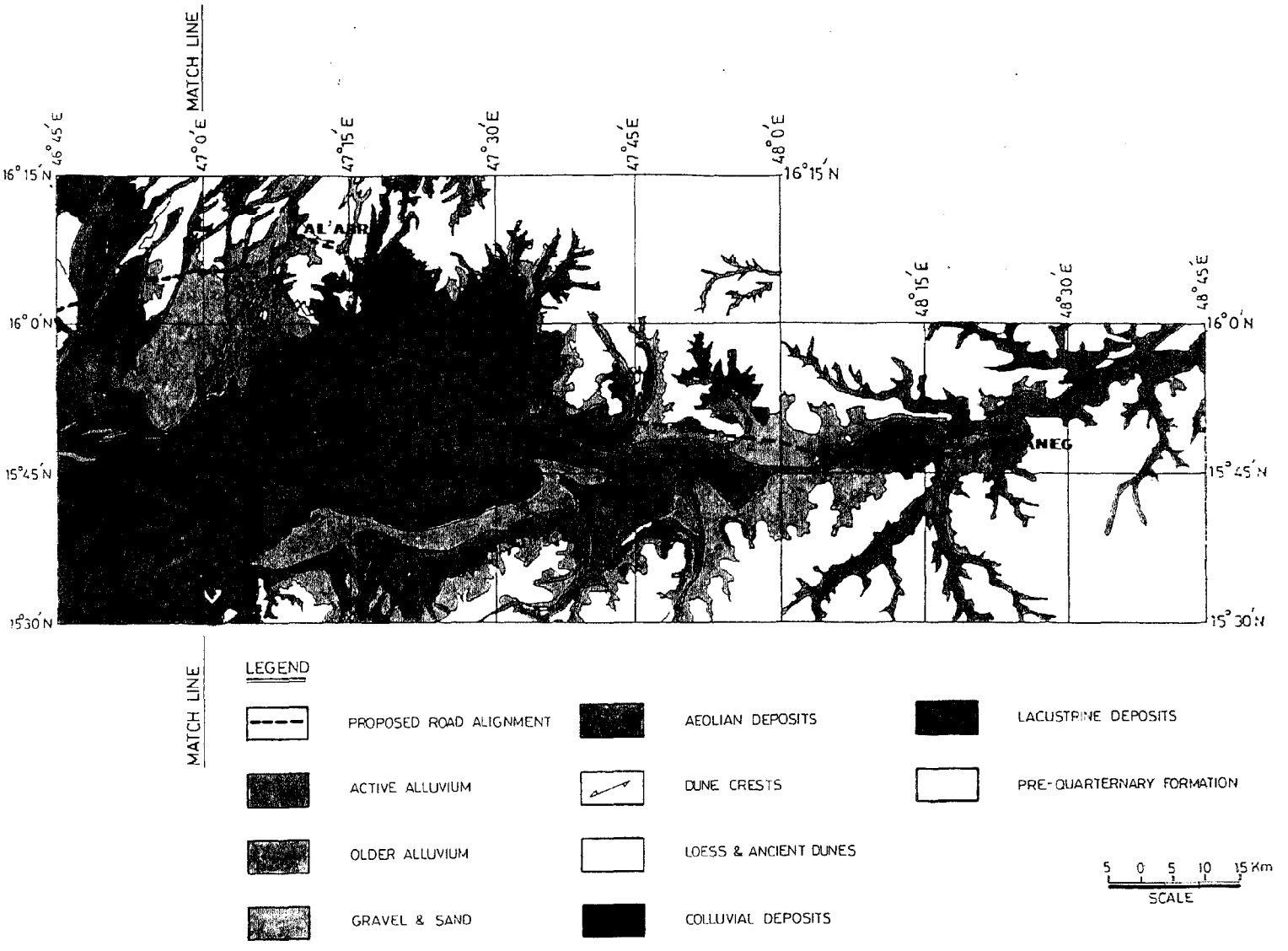


FIG. NR 2.2.12

QUARTERNARY LITHOLOGY ALONG PROPOSED ROAD ALIGNMENT

small patches of lacustrine deposits. However, in many other places, such as in and around Al Abr at or near the floor of exhumed wadi channels one can find lacustrine deposits. Below the beds of gravel and sand or even underneath some sand dunes digging revealed lacustrine deposits.

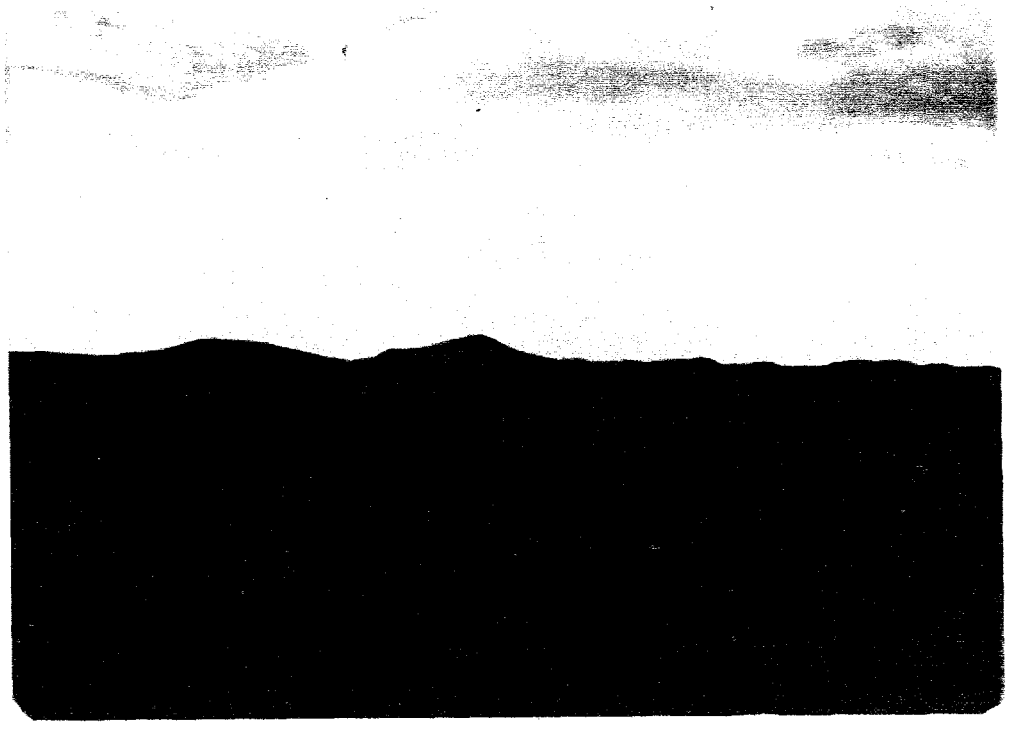
2.2.16 The outcrops of the fluvial deposits are currently oriented in terms of the wadis. The general arrangement is that colluvial deposits cover the pediments when the Wadi channel is near the hills. At a greater distance, smaller gravels skirt the colluvial deposits. The older alluvium made of compact silt, often mixed with conglomerates and gravels of varying sizes, are generally found on the flanks of wadi (ancient or recent) courses. Probably these used to form river terraces after rejuvenation of the cycles of fluvial erosion. Consequently these appear dissected, yet retaining compactness from the cementing materials derived from limestone or dolomite from the rocks of the older periods. The active alluvia are, in contrast, found on the wadi beds that are subjected to fluvial planation during flood.

2.2.17 Older and newer alluvium as also the gravel and sand outcrops have also been found under the sand dunes of diverse descriptions. The aeolian deposits cover the most extensive area in the southern part of the western segment of the inland basin. The most notable of which is the Ramlat As Sab'atayan. Here the dunes are high with longitudinal co-ordinates from north-north-east to south-south west. Almost all other sand dunes maintain the same direction for its length, although it is less discernible with the barchanoid types of sand dunes. These barchan types flank the high long dunes (seifs). Behind them are the hummocky dunes formed around stubbles of grasses. Then there is the sandy coverage, thin in depth but stable in orientation, beyond the hummocky tracts. Since such distinctions are difficult to show on a map, all types of dunes (Q7 and Q8) have been grouped together in Figure 2.2.12. Further classification of these will be made in the next section. Before concluding, it is observed that dune formation is now a pervasive activity by way of covering colluvium, screes and flanks of mountains with sand.

2.3 Dynamism in Landscape Formation

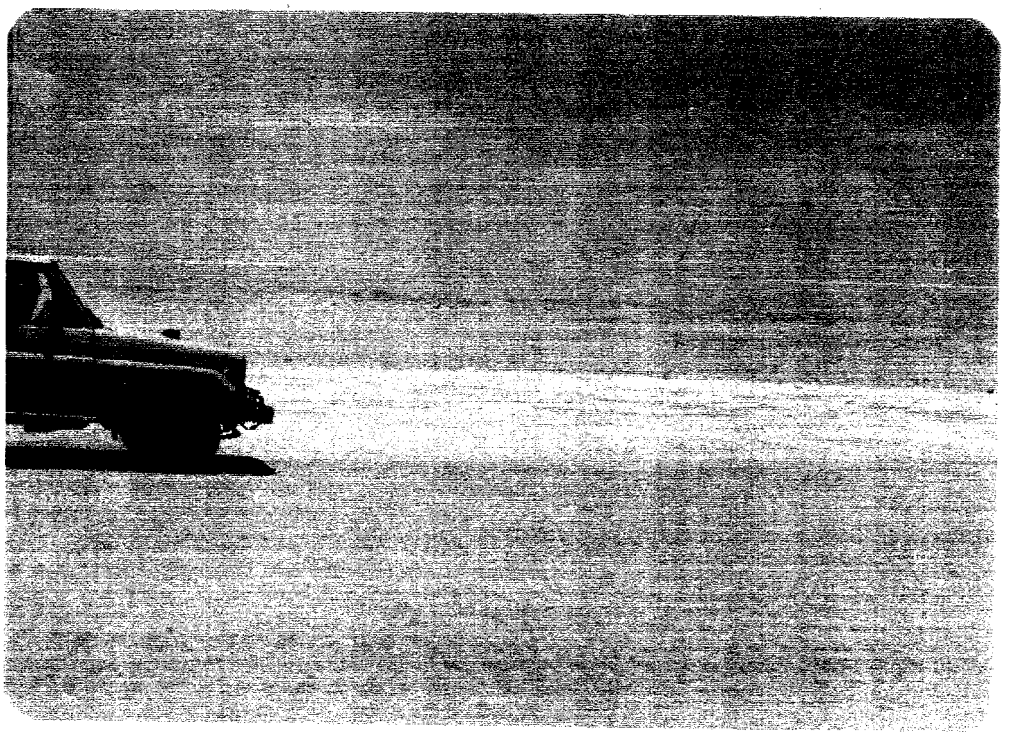
2.3.1 The landscape of the inland basin, seen purely in terms of orography, would decidedly appear as the products of flowing water and the geologic (lithographic) structure. But the details within it are primarily the products of wind acting upon the landforms of ancient regimes. The explanations of the simultaneous occurrence of fluvial and aeolian landscape is given by the history of climatic change that this region experienced.

3. PROTEROZOIC FORMATION - JABAL RUWAYK AL QIBLI
(KM. 59)



4. SAND DUNE (SEIFS) - AEOLIAN LANDSCAPE
NEAR START OF ALIGNMENT

5. HUMMOCKY DUNES - AEOLIAN LANDSCAPE
(NEAR BIR AL WAHED)



6. INTER-DUNAL PLAYA (KM 30)

2.3.2 Scholars working on the water resources of Yemen believe that the climate of Yemen has changed over the last 12 thousand years. The period of high rainfall came to an end about 10 or 11 thousand years ago and the secular trend since then has been towards declining rainfall with two periods of relatively higher rainfall in between -- one around 5000 and the other around 2000 years before the present. The climatic conditions over the last 2000 years have been characterised by very low rainfall. Circumstantial evidence is given by the amount of recent and sub-recent debris covering the pre-Tertiary lithology in the inland basin. These debris are obviously the products of mass-wasting caused during the pluvial periods. Erosion and removal of the section of the northern hills between Rub Al Khali and Ramlat As-Sab'atayn near Al' Abr may have taken place during these pluvial periods. Wind gaps found on the northern and the southern mountains also indicate that the rate of erosion in the lower reaches of the inland basin was more vigorous than in the tributary valleys. The direction of the flow of water within the inland basin was decidedly from west to east, which sorted out the clastic materials and carried those towards the east leaving more of argillaceous materials in the west. The proportions of silts in valley bottom deposits increase from west to east.

2.3.3 Inspite of paucity of data, the present day climatic situation can be said to represent arid and hyper-arid conditons in different parts of the inland basin. One example would reveal the basic features of the present day climatic conditon. In Table 2.3.3 are given the data on annual rainfall and evaporation over eight years at Seiyun located in the eastern part of the inland basin. It shows that on the average, evaporation exceeds precipitation and this relationship varies from year to year. There are at least two years out of eight when precipitation exceeded evaporation, suggesting as if the factors contributing to humidity and aridity are poised as opponents in this part of the world.

Table : 2.3.3
Rainfall and Evaporation Rates
Station Seiyun; Location : 16°0'N: 48°47'E; Alt. 600 m

Variables / Years (in mm)	1985	1986	1987	1988	1989	1990	1991	1992	Av. Over Eight Years
Rainfall	9.0	68.0	110.3	8.4	175.6	72.7	44.0	74.2	70.3
Evaporation	95.2	91.4	85.7	89.9	85.8	94.1	88.4	90.0	90.1

Source : Agricultural Research Centre, Seiyun.

2.3.4 There are several distinctive features of rainfall in Yemen. In the first instance, rainfall is higher in the west and south than in the east or north. This is discernible from Figure 2.3.4 which shows the regional variation of estimated mean annual rainfall in Yemen. It may be observed that the inland basin falls in the rainshadow zone of the western and the southern mountains. One may also surmise that a part of the precipitation is received through mechanics of orographic rainfall.

2.3.5 The second distinctive feature of rainfall is that the quantity varies from year to year as well as from month to month. For example, Table 2.3.5 (A) reveals how the annual rainfall has varied between 5 consecutive years in the three stations of Seiyun, Beihan (14°50'N:45°42'E; 1100 m high) and Marib (15°26'N: 45°20'E; 1100 m high). Table 2.3.5(B) on the other hand shows the mean monthly rainfall of the same set of stations along with range of departure from the mean over the years of observations.

Table 2.3.5(A)
Variation of Annual Rainfall (in mm)

Station	Years					Range	Average
	1984	1985	1986	1987	1988		
Seiyun	22.2	9.0	68.0	110.3	8.4	101.9	43.58
Beihan	81.8	50.3	48.7	162.9	24.1	138.8	73.58
Marib	0.0	28.3	146.4	133.1	69.1	146.4	75.38

Source : Civil Aviation and Meteorological Authority, ROY

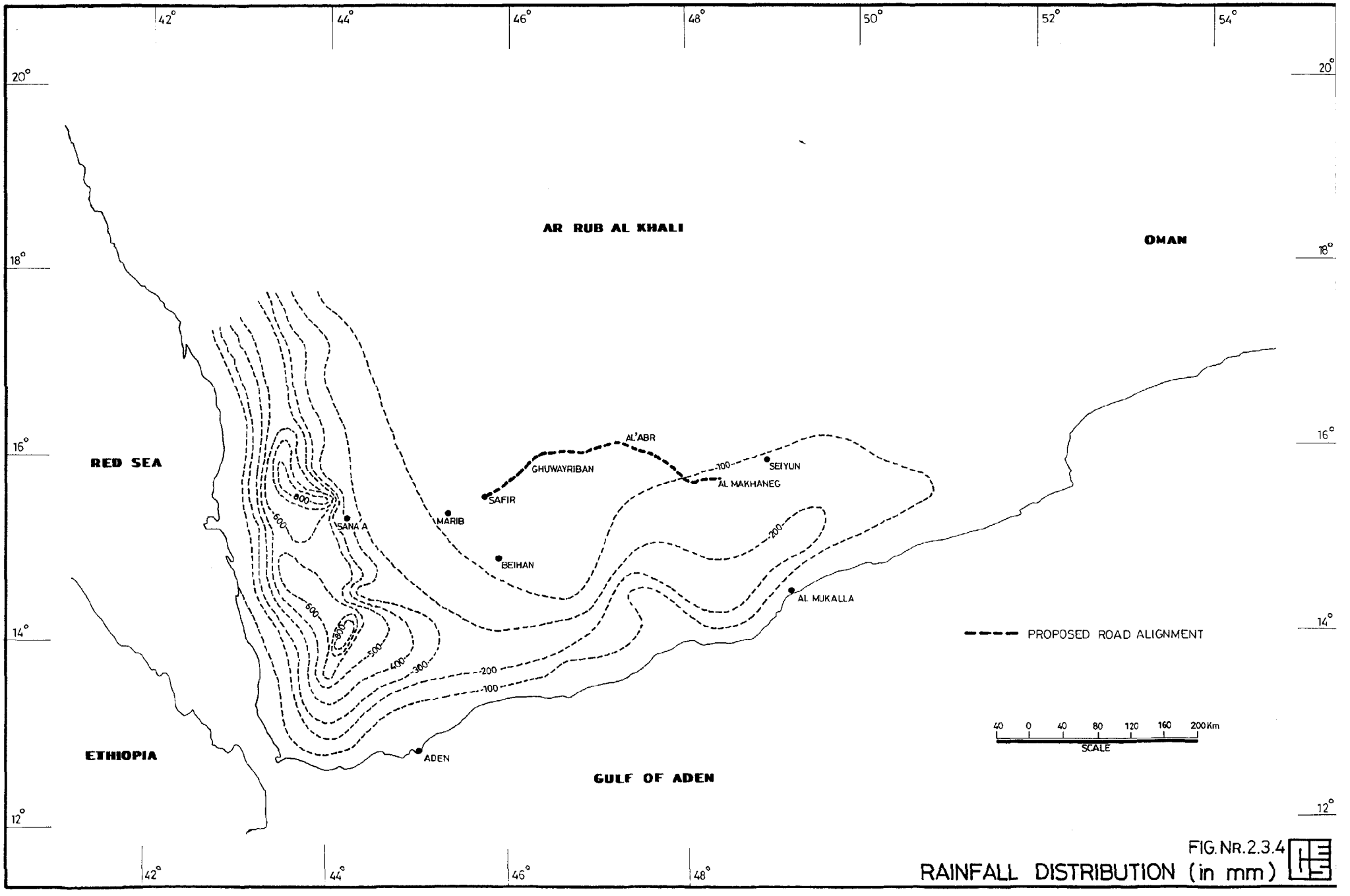


FIG. NR. 2.3.4

RAINFALL DISTRIBUTION (in mm)

Table 2.3.5(B)
Variation of Monthly Rainfall (in mm)

Station (Years of Observation)	Variable	MONTHS											
		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Seiyun (15 Years)	Mean	3.0	5.5	19.3	13.6	1.3	1.8	5.2	12.6	0.5	0.9	0.5	0.3
	Max.	33.0	57.4	111.5	61.3	16.0	23.0	34.5	78.1	6.0	12.8	4.5	2.5
	Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beihan (7 years)	Mean	0.0	2.6	8.37	36.1	18.5	1.3	4.9	8.4	1.3	0.0	0.9	0.0
	Max.	0.0	18.1	39.3	94.7	62.4	8.9	11.3	23.5	7.6	0.0	6.0	0.0
	Min.	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Marib (7 years)	Mean	0.0	6.3	14.80	38.2	1.0	0.6	1.7	2.0	1.5	0.0	0.0	2.7
	Max.	0.0	24.4	68.8	117.7	5.0	2.3	7.0	5.1	9.0	0.0	0.0	13.0
	Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source : Civil Aviation & Meteorological Authority, ROY and Agricultural Research Centre, Seiyun

2.3.6 One may surmise from Tables 2.3.5 (A&B) that drought may a be seasonal or annual feature in any part of the inland basin. This is however, a common attribute of tropical desert climate. More important is the fact that a single cloud burst may cause more phenomenal variation in the rainfall regime than anything else in this part of the world as is revealed from Table 2.3.6.

Table 2.3.6
Variation in Monthly Rainfall Caused by Cloudburst (in mm) in Marib

Year	Elements	MONTHS											
		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
1985	Total	0.0	0.0	0.0	23.3	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Max in 24 hrs	0.0	0.0	0.0	9.5	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1986	Total	0.0	20.0	9.0	111.7	0.0	1.5	0.0	0.0	0.0	0.0	0.0	4.2
	Max in 24 hrs	0.0	14.0	5.7	49.9	0.0	1.5	0.0	0.0	0.0	0.0	0.0	4.2
1987	Total	0.0	0.0	68.8	46.2	0.0	0.0	0.0	5.1	0.0	0.0	0.0	13.0
	Max in 24 hrs	0.0	0.0	56.0	14.5	0.0	0.0	0.0	1.5	0.0	0.0	0.0	13.0
1988	Total	0.0	24.4	0.0	28.5	0.0	0.0	3.4	3.8	9.0	0.0	0.0	0.0
	Max in 24 hrs	0.0	23.0	0.0	19.1	0.0	0.0	3.0	2.0	5.4	0.0	0.0	0.0
1989	Total	0.0	0.0	11.8	33.2	0.0	2.3	7.0	2.8	0.0	0.0	0.0	2.0
	Max in 24 hrs	0.0	0.0	3.8	13.6	0.0	1.5	3.2	1.5	0.0	0.0	0.0	1.0

Source : Civil Aviation and Meteorology Authority, ROY

2.3.7 After the cloud bursts, flash floods run down the beds of streams in the mountains and then spread out through many distributaries on reaching the ground of gentler slopes. Within a variable distance, depending on the volume of discharge and the porosity of the surface, the streams lose their flow. Water percolates into the deeper layers. These stream beds are called Wadis. In Figure 2.3.7 have been shown the locations and orientations of the major mountain streams and the wadis of the inland basin. The tracts covered by surface run-off generally have alluvium made of fine sand, silt or loam and are found to support richer vegetation.

2.3.8 There are two interesting regional features of the Wadi system that deserve attention. The areal extent of active alluvium shown in Figure 2.2.12 is much more than the tracts receiving surface flow in the wadis at present. This means that the impacts of wadis on landscape formation, especially in the western half (Ramlat As-Sab'atayn) of the inland basin have become less pronounced over the years. The second important fact to note is that the Wadis in the eastern half (Hadramout) of the inland basin carry more water than the rainfall would account for. This suggests that there exists some burried channels under the sand that carries water from the wadis of the west into the Hadramout valley. In Figure 2.3.8, the possible locations of some of the burried channels have been speculated upon. Verification of the existence of the suspected burried channels, however, must wait till more extensive exploration on hydro-geology are carried out.

2.3.9 Flash floods also cause stream bank erosion, shifting of finer grained particles from the colluvial deposits and their accummulation in the lower grounds. Cloud bursts together with under towing during flash floods also cause rock-falls in the mountains, which contribute towards the formation of escarpments and of screes with colluvial and alluvial fans at the base.

2.3.10 The types of landforms mentioned so far, for example, the wadis, the alluvial flats, the alluvial and colluvial fans, the escarpments and the hills are the products of fluvial processes upon the parent lithology. The terrain within the inland basin also contains many different types of landforms which are the products of aeolian processes upon the parent rock, including the constituents of fluvial landforms. The motor of the aeolian process is once again the climate of the region.

2.3.11 Table 2.3.11 shows the monthly variation of humidity level of air for the two stations of Seiyun (15 year data series) and Beyhan (7 years data series). It also shows the highest and the lowest recorded values of air humidity in any year within the time series. This shows that air can become bone dry in several months

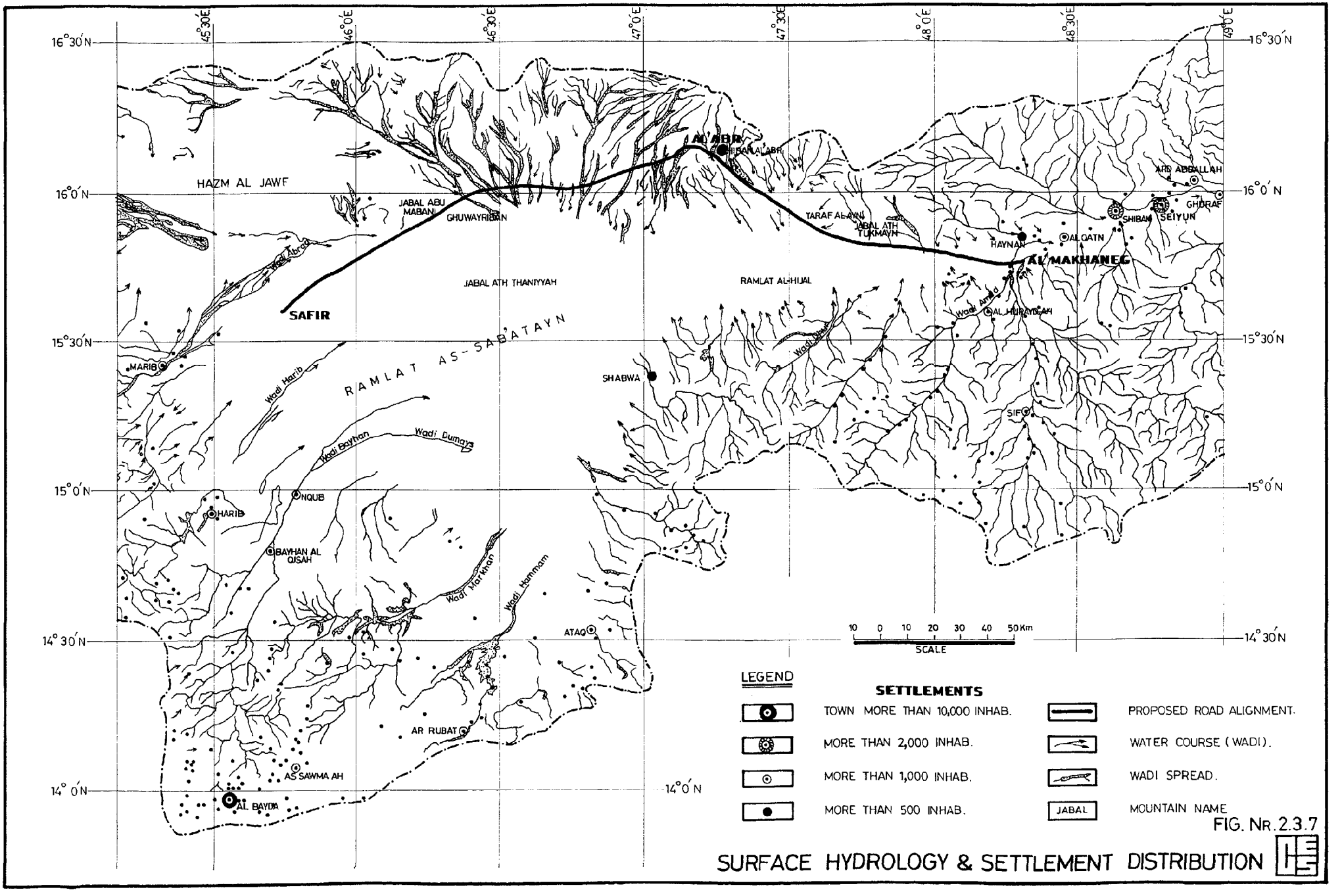


FIG. Nr. 2.3.7

SURFACE HYDROLOGY & SETTLEMENT DISTRIBUTION

B. MARCOLONGO, ITALIAN ARCHEOLOGICAL MISSION IN YEMEN, CENTRE OF RESCEARCH ON ARCHEOLOGY, C.N.R.S., PARIS, 1992 BASED ON SOYUZ SATELITE IMAGES.

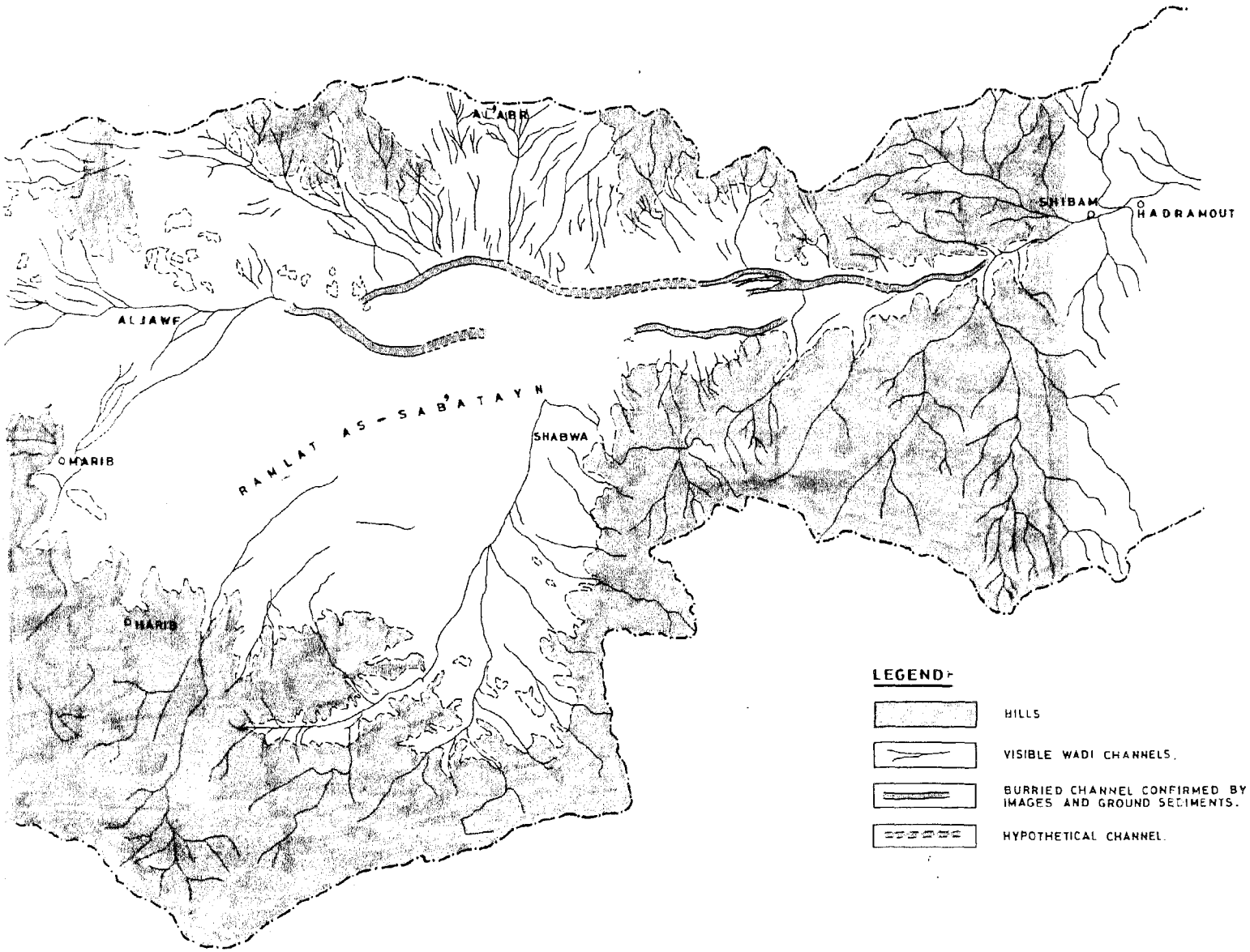
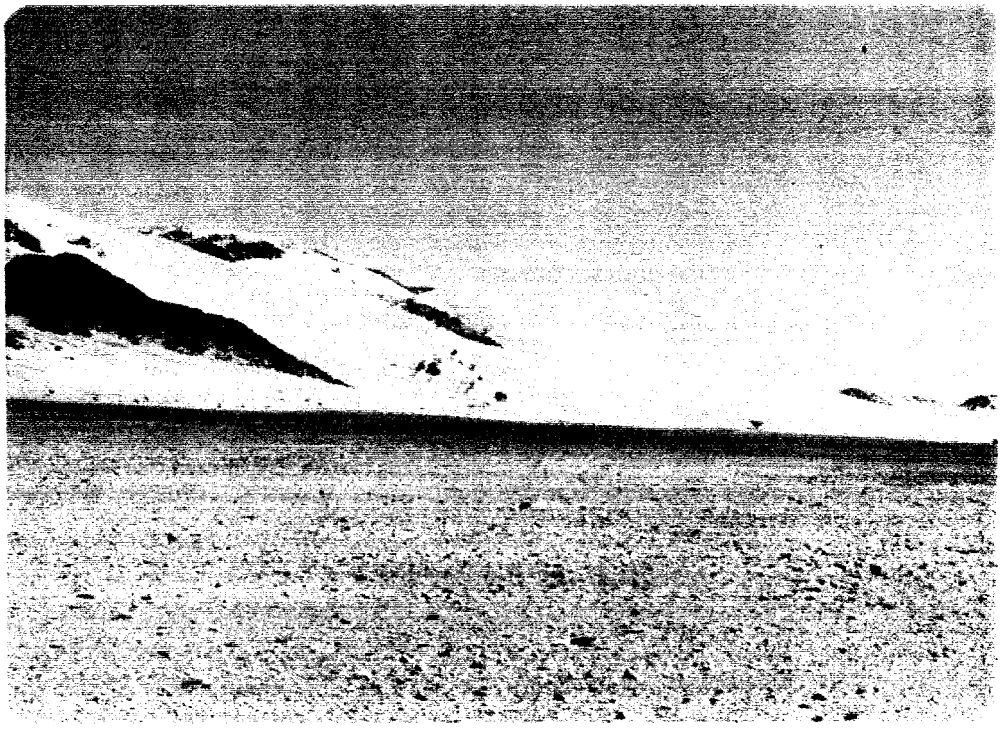


FIG. Nr. 2.3.8

PALEO-HYDROGRAPHY OF RIVER FLOWS IN THE INLAND BASIN OF REPUBLIC OF YEMEN



7. DEPOSITS OF MOVING SAND ON HILL SLOPE
(NEAR GHUWAYRIBAN)

8. TYPICAL HILL SLOPE PROFILE IN AL' ABR-HADRAMOUT
SECTION WITH ESCARPMENTS AND SCREES (KM 305)

in a year. It also states that in no month does air-humidity reach saturation level. These two features clearly indicate that precipitation is caused by the mechanics in the upper layers of the atmosphere, either by orographic deflection or local whirlwinds. Otherwise, the ground materials remain dry on the surface to facilitate their air-borne transhipment, provided there is wind.

Table 2.3.11
Monthly Variation of Air Humidity (in per cent)

Station	Variable	MONTHS												Average over 12 months
		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	
Seiyun	Average	55	49	42	43	41	33	30	36	33	38	43	42	40
	Max.	78	79	66	70	82	53	22	21	53	63	70	75	
	Min.	27	0	0	22	15	17	0	0	0	0	0	0	
Beyhan	Average	37	34	40	33	27	24	32	26	27	32	37	38	32
	Max.	50	46	62	44	38	37	62	38	38	42	48	51	
	Min.	0	0	32	0	0	0	0	0	0	0	0	0	

Source : Agricultural Research Centre, Seiyun

2.3.12 Table 2.3.12 shows that there is wind with variable velocity in all months. The yearly average velocity is higher in the west (Marib) than in the east (Seiyun). There is enough energy in any month to lift fine and coarse dust from one place and to deposit these in other places. Since the dominant direction of wind is from the north-east to south-west, aeolian erosion is higher in the east and deposition is higher in the west, and this vector is just the opposite of what pertains to fluvial processes. This will perhaps explain why most of the higher dunes covering the larger land surfaces are found in the western half of the basin especially in the Ramlat As-Sab'atayn region. This will also explain why the larger sand dunes are found near the southern mountain in the western part of the inland basin and near the northern mountains in the eastern part. The prevailing direction of wind seems to cut the basin obliquely.

Table 2.3.12
Average Monthly Wind Velocity (m/sec)

Station	MONTHS												Average over 12 months
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	
Seiyun	1.78	1.95	2.05	2.26	2.34	1.91	2.56	2.46	2.46	1.94	1.48	1.21	1.97
Beihan	0.85	1.05	1.61	0.68	1.10	0.52	0.75	0.38	0.93	1.30	1.31	0.88	0.95
Marib	2.4	2.8	3.3	2.8	3.2	3.7	3.9	4.4	3.8	3.0	2.5	2.9	3.2

Source : Civil Aviation & Meteorology Authority, ROY and Agricultural Research Centre, Seiyun

2.3.13 As in the case of precipitation, where sudden atmospheric turbulences cause cloud burst, the dry wind is also subjected to similar turbulances causing thunder storms, dust storms, whirlwinds, etc., apart from loading the air with suspended particulate. Table 2.3.13 will provide some idea on how frequent such turbulances can be at a given station.

Table 2.3.13
Frequency & Types of Air Turbulances at Marib over 4 Years

Types and Turbulance	Year				Average for the period
	1985	1986	1987	1988	
Thunder Storm	1	2	8	3	3.5
Sand/Dust Storm	14	6	16	33	17.25
Dusty Wind	25	32	3	10	17.50
Haze	21	58	60	60	49.75
Hail, fog etc.	8	11	3	0	5.50

Source : Civil Aviation & Meteorology Authority, ROY

2.3.14 Features of wind erosion are pervasive. These affect all types of land surfaces, including those formed by fluvial processes. Features of wind borne deposition are, however, distinctive and of diverse forms. There are the thinly covered sandy plains underlain by more compact land surface. Where there are stubbles of grass or dwarf shrubs, sands gather around to give rise to hummocky surfaces. Then there are the crescent shaped barchan types of dunes which are extremely mobile. Sometimes, these barchanoid dunes have coalesced to form low long

dunes with snaky tops. There are also the more stable high dunes, called seif in vernacular. Ramlat As-Sab'atayn is a huge area formed of seifs.

2.3.15 In addition to the types of landforms mentioned above, two other types are found in this inland basin. One type is formed of the outcrops of older rocks, like dykes, lava flows and residual hills formed of schists, granites, para-gneisses, marbles or metadolomites. These are highly eroded and often covered by thin layers of sand in patches. These cover very small areas, relatively speaking. The other type of land form is constituted of highly compacted gravel and sand supporting flat surfaces. The origin of these gravel and sand flat land is shrouded in mystery.

2.3.16 The gravel and sand flats are conspicuous for the highly mixed nature of stones. These are the derivatives of all types of rocks forming the older (pre-Quarternary) lithofacies. These were once water borne, revealed by their smooth patinated surfaces. Underlying the gravel cover, exists highly calcinated compact alluvium. These contain roots of plants in highly calcinated state. In some places, below the calcinated bed are found river-borne silts and fine sand. All these together suggest that the gravel and sand flats are representing fossil alluvial landform created during the earlier pluvial periods. Nevertheless these provide excellent surfaces for road building.

2.3.17 From the angle of road construction, the above mentioned landforms appear fragile in different degrees. Amongst the aeolian landforms, the most fragile are the barchanoid dunes because these are mobile by nature. The seif dunes are less fragile, if no transverse road section is involved. The low grounds between the parallel seifs are quite stable if the design of the road does not produce cut sections. Other types of dunes or sand covered land forms are quite stable provided the road embankment is not higher than 1.5 m from the ground level and these embankments are given a minimum outward slope of 1:3. Amongst the fluvial landforms, the most fragile are the alluvial flats within wadi beds. The colluvial and alluvial fans are also fragile for cut sections in a road. Their fragility can however, be handled by rebutment on the rising slopes. The most stable land form is the gravel and sand flats. Amongst the land forms constituted of pre-Quarternary lithology, the most fragile area are the escarpments. The residual hills referred to in para 2.3.15 are very stable in the context of road building. The tablelands on the northern and southern flanks of the inland basin are also stable, but the proposed alignment does not traverse such surfaces.

2.3.18 For purpose of scoping for EA, Figure 2.3.18 has been constructed to show the types of landforms found in the proposed road corridor.

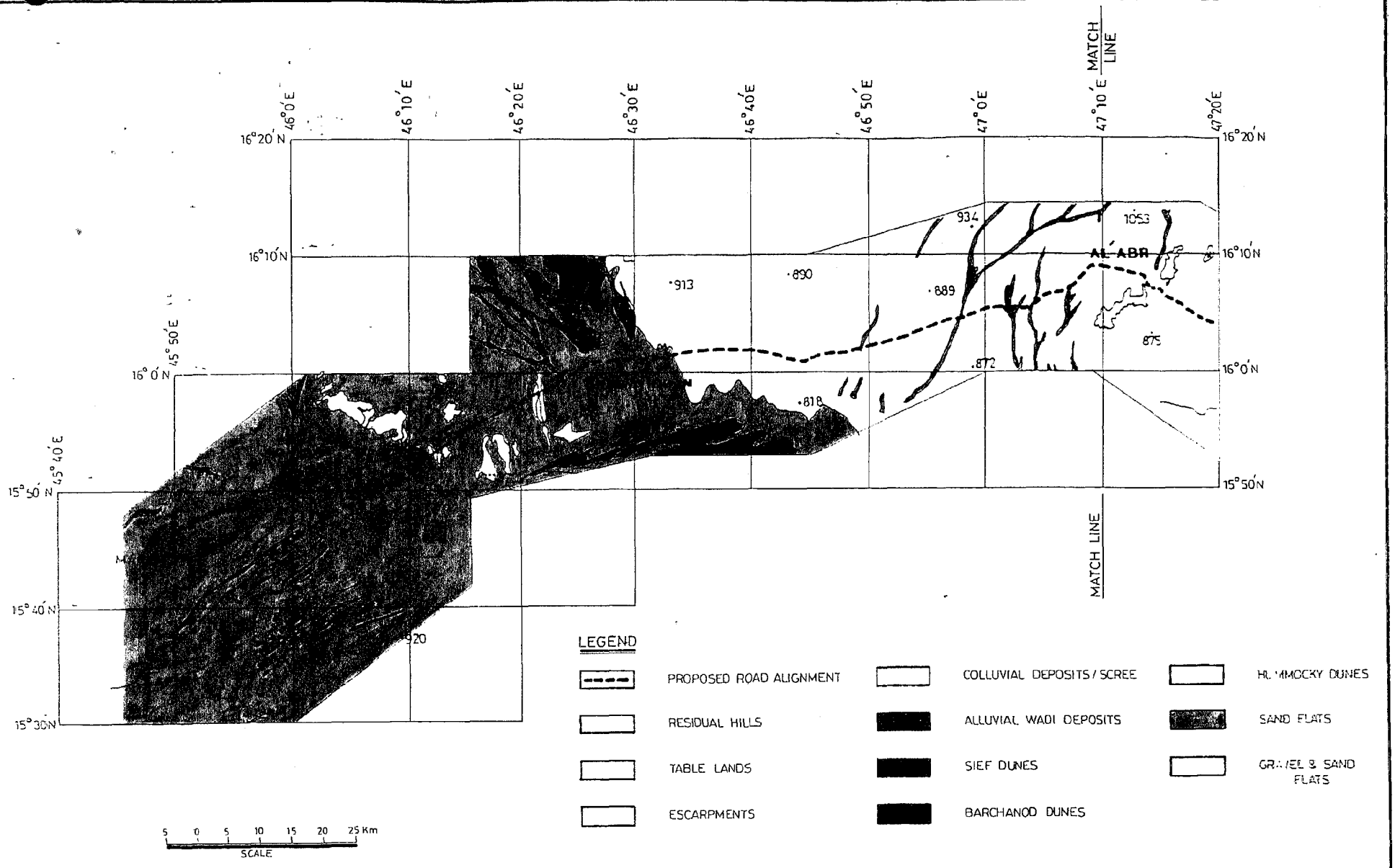
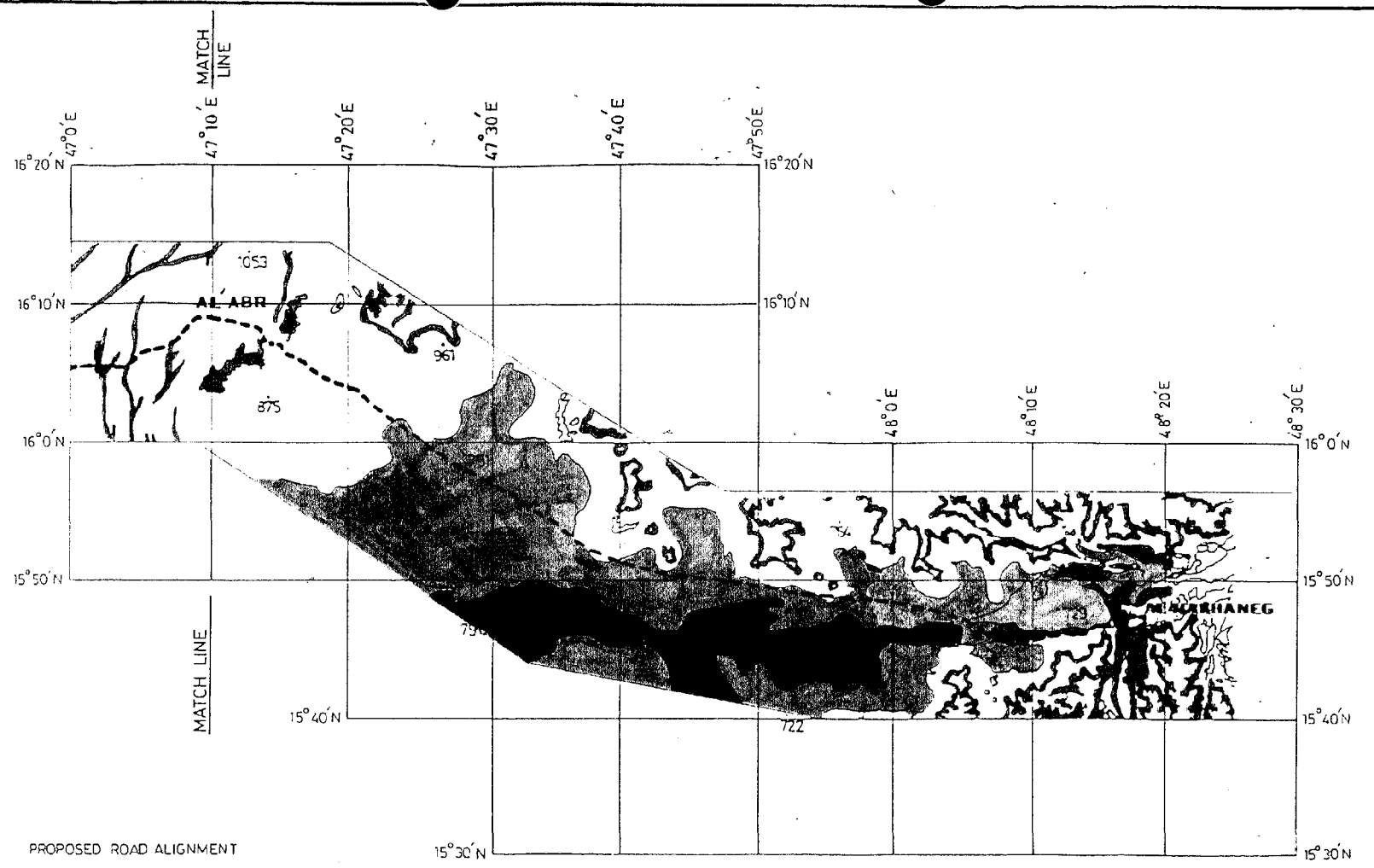


FIG. Nr. 2.3.13

LANDFORMS ALONG ROAD CORRIDOR



LEGEND

- PROPOSED ROAD ALIGNMENT
- RESIDUAL HILLS
- TABLE LANDS
- ESCARPMENTS
- COLLUVIAL DEPOSITS / SCREE
- ALLUVIAL WADI DEPOSITS
- SIEF DUNES
- BARCHANOID DUNES
- HUMMOCKY DUNES
- SAND FLATS
- GRAVEL & SAND FLATS

5 0 5 10 15 20 25Km
SCALE

FIG. NR. 2.3.18

LANDFORMS ALONG ROAD CORRIDOR

2.4 Biotic Environment : Soils

2.4.1 Perhaps the best linkage between the non-living and the living environment is provided where the geomorphological processes lead to the formation of soils. The materials composing soils are the derivatives of parent lithology conditioned by the agents of weathering (inclusive of erosion, transportation and deposition) and enriched by biota. Erosion leads to truncation of the profiles of soils formed earlier and provides materials for accretion elsewhere. Transportation assists in areal spread of biota of vegetative origin. Deposition leads to the formation of soils of repetative horizons in soil profile unless erosion had been reactivated meanwhile. Only the in-situ soils show variagated soil profile as manifestations of the process of leaching, sorting by size of grain and accumulation of distinctive chemicals. However, in no part of the ROY have the in-situ soils remained unaffected by the geomorphological processes like reactivated fluvial and aeolian erosion, transportation or accretion of the present time. The dynamism in land form formation are also operating in soil formation in this part of the world.

2.4.2 Unfortunately, the available literature on the soils of the ROY are rather sketchy with limited regional coverage. Therefore, the comments on the soils of the inland basin will lean heavily on the geomorphological conditions as descriptors based on field observation. The so collected information will not, however, yield any map to show the regional coverages of the different types of soils as identified in this section.

2.4.3 Considerations on geomorphology can be used to construct a typology of soils having three units and eight sub-units in it as shown in Table 2.4.3.

Table 2.4.3
Major Soil Types

Units	Sub Units
A. Non-accreting deposits above present flood level	1. Volcanic derivation 2. Other hard rock derivatiom 3. Older alluvial formations
B. Accreting alluvium subject to inundation	4. Volcanic derivation 5. Other hard rock derivation 6. Derivations of older alluvium
C. Soil of Aeolian Regimes (Accreting alluvium)	7. Major dunes 8. Minor dunes and hummocky dunes

2.4.4 Non-Accreting Deposits above Present Flood Level

All the pedologic formations under this group are the products of a period when sufficient water flowed through this region to form shallow lakes. How old is this pluvial period is a mater of speculation for want of reliable studies. One can, however, assume that this pluvial phase is as old as 8000 to 12000 years before the present and contemporary to the well recorded features over the continent of Africa. Some such assumption is necessary to account for the accumulation of essentially alluvial materials within the inland basin covering up practically the whole of the Proterozoic and Mesozoic formations, except the youngest layers of the Cretaceous period over most parts. Such an assumption is also necessary to account for the textural gradient from coarse to finer debris extending from the hill margins towards the inner parts of the valley over all parts of the inland basin. Present day hydrology would be insufficient to cause such sieving. Then, there exist some outcrops of lacustrine deposits within the study area. There are also the extensive formations of rounded and sub-rounded gravels formed of all kind of rocks lying mixed with sand and suggesting vigorous fluvial activities as to their origin. These are presenting the formations of older times, because their overall gradient is steeper than the present day deposits and lie above the present flood levels. The fluvial deposits of today are seen in valleys cut into the older fluvial materials. These non-accreting fluvial formations can, however, be classified into three sub-groups and the distinctive features of their composition are stated below:

(a) **Sub-type - 1 :** Non accreting alluvium of volcanic derivation form coarse textured soils varying from sandy gravel to gravelly sandy loam character. These are found close to the volcanic outcrops in the shape of fans as well as in the upper reaches of small wadis therein. Some of the sandy materials found in it have decidedly been wind borne in the recent time. Rains have pushed these sands to fill up the interstitial spaces between the gravels. Hence the original stratification of these deposits have been partially destroyed. Permeability and infiltration rates are rather high, which have sustained leaching. Soft calcium carbonate desseminated through soils hang as pendants below the stones. In some instances, these are weakly saline. Nutrient status of the soil is moderate to low. Owing to their coarse texture and high gravel content, such soils have low water holding capacity and offer little potential for farming or for supporting any rich coverage of natural vegetation.

(b) **Sub-type - 2 :** Non-accreting alluvium of other hard rock derivations are formed of gravels mixed with skeletal loams or fine sand. These cover extensive grounds in many parts of the inland basin in large patches or as

small terraces along the upper reaches of the large wadis. Leaving aside the terraces, these gravel beds within the extinct lake appear highly consolidated as the underlying soils are loamy and highly calcinated. In deeper layers are often found silt and fine sand of lucastrine/riverine origin. These are highly permeable formations, but can retain moisture for a longer period than the non-accreting soils of volcanic origin. These are non-saline in character. In the past, these used to support vegetation as indicated by the presence of roots in the calcinated loamy layers. Far away from the mountains, these yield ground water from perched aquifers. These are not very attractive soils for farming. Natural vegetation cover is also very sparse.

(c) **Sub-type - 3** : The third variety of non-accreting alluvia are represented by older coarse silty to fine silty soils. These are found on the flanks of dry wadis, often in the shape of terraces. These are also calcinated and appear hard and consolidated. These are non-saline in character. When ploughed, this type of soil turns friable and yields dust during atmospheric turbulance. These are permeable, but can retain considerable water. It supports good farming under irrigation. If left untampered, these can support a fair amount of natural vegetation.

2.4.5 Accreting Alluvium Subject to Inundation

Within the active flood channels of the wadis are found three types of soils, all of which are derivations of the non-accreting alluvia. Since the cloud bursts cause flash floods, nearly all sections of the wadis experience deposition of sorted materials. The grain size of the deposits vary according to the velocity of the flowing water and the distance travelled. The other differentiating factor is given by the nature of the parent material as the descriptions of the sub-types will reveal.

(a) **Sub-type - 4 :** These are found in the upper reaches of the wadis as extensions from the non-accreting soils of volcanic origin. Their texture varies from sandy skeletal through loamy skeletal to sandy varieties as the flood water loses velocity down the wadi channels. These are non-saline and non-alkaline in reaction and are stratified with high permeability due to the presence of gravels in deeper layers. These have very low retention capacity for both water and nutrients. Gravelly beds reduce root development. Although poor from considerations of agriculture, these can support a significant amount, but sparsely spaced, of natural vegetation.

(b) **Sub-type - 5 :** The texture once again varies from skeletal sandy through coarse loamy to coarse silty types in consonance with decrease of velocity of flowing water down the wadis. These are the derivations of non-accreting

alluvia of other hard rock formations. Due to fluvial actions, the gravels sink into lower depths leaving a layer of finer grained material as ground cover. Such soils are highly stratified with no clearly definable structure. When the moisture level goes down, the top soil turns friable. The soils are weakly calcarious. After the periodic rains, this type of soil can support quick maturing crops. In periods of drought, these are left fallow. Hence these can be described as Period Fallow farmland. Having very low water and nutrient capacity, these have limited agricultural use. These can, however, support closely spaced natural vegetation having long roots since the lower level remains moist for a considerable period of time. But the gravels in the lower depth can impair root development.

(c) **Sub-type - 6** : This type of soils are the derivations on the non-accreting older alluvium and often appear away from the main channel of the given wadi. Due to flooding, these may be found encroaching upon the other two types of accreting alluvia. These are highly stratified, but with no clear structure. These are non-saline and non-alkaline in reaction. The fine silty varieties can retain water and nutrients. Therefore, these are favoured for permanent farming subject to availability of water. For this reason, the natural vegetation cover has been largely removed except for wind breakers at the margin of individual farms. Many farmers construct obstructions across the wadi flows to enrich the top soil with fine loam and silt.

2.4.6 Soils of Aeolian Regimes

As has been mentioned earlier the wind movement is quite strong and persistent over the region. These scour the surfaces and carry the scooped materials over great distances to form dunes of different types. The sources of materials are both non-accreting and accreting alluvia. The flow is from north-east to south-west and accordingly the proportion of silt yield place to fine to coarse sand in that orientation. One can subdivide these types of soils into two major groups as described below.

(a) **Sub-type - 7 :** These are the major seif type of dunes with elevations varying from 3 m to 30 m from the ground level. Between the dunes have formed playa like features, in which are deposited the finer grained materials through wash. Quite often, the upper layers of these playas are covered with small lumps of calcium carbonate and hence are generally devoid of natural vegetation. But on the edges of the playa, dwarf shrubs and grasses grow. The sand dunes cover many types of outcrops at the base. But their effects on the chemical character of the dunes are not discernible. This sub group of soils are unsuitable for farming and support little vegetation. In some places, the sand movement has been reactivated,

leading to the formation of barchanoid types of dunes. These are highly shifting type causing the underlying soils to become exposed. On these soils, grasses grow to act as barriers to soil movement and causing the barchanoids to coalesce to form snaky types of seif dunes. Thus once stablished, the grass cover can invite thorny bushes and later the deep rooted xerophytic trees.

(b) **Sub-type - 8** : The aeolian processes have also formed small dunes adjacent to the accreting alluvia. The natural vegetation cover obstructs free sand movement and causes fine silty materials to gather around the stubs as mounds. This gives rise to the formation of hummocky types of dunes. Some of these vegetation continue to grow at or near the same rate as silt accumulation and remain visible. In areas, where the vegetation is incapable of growing quickly enough, the ground remains covered with fine sand and silt. On such surfaces, very quick growing herb type of plants grow shortly after rain and die out as the weather turns dry. These soils are also highly unsuitable for farming.

2.4.7 Along the road corridor are represented the following sub-types of soils with variable extents:

(a) Barchanoid dune soil;
(b) Inter-dune playa soil;
(c) Non-accreting alluvium covered thinly with sand;
(d) Soils of Aeolian Regimes covered thinly with sand;
(e) Hummocky dunes; and
(f) Non-accreting silty older alluvium.

2.4.8 The non-accreting alluvium of volcanic derivation and high seif sand dune soils are not represented in the road corridor.

2.5 Biotic Environment : Flora and Fauna

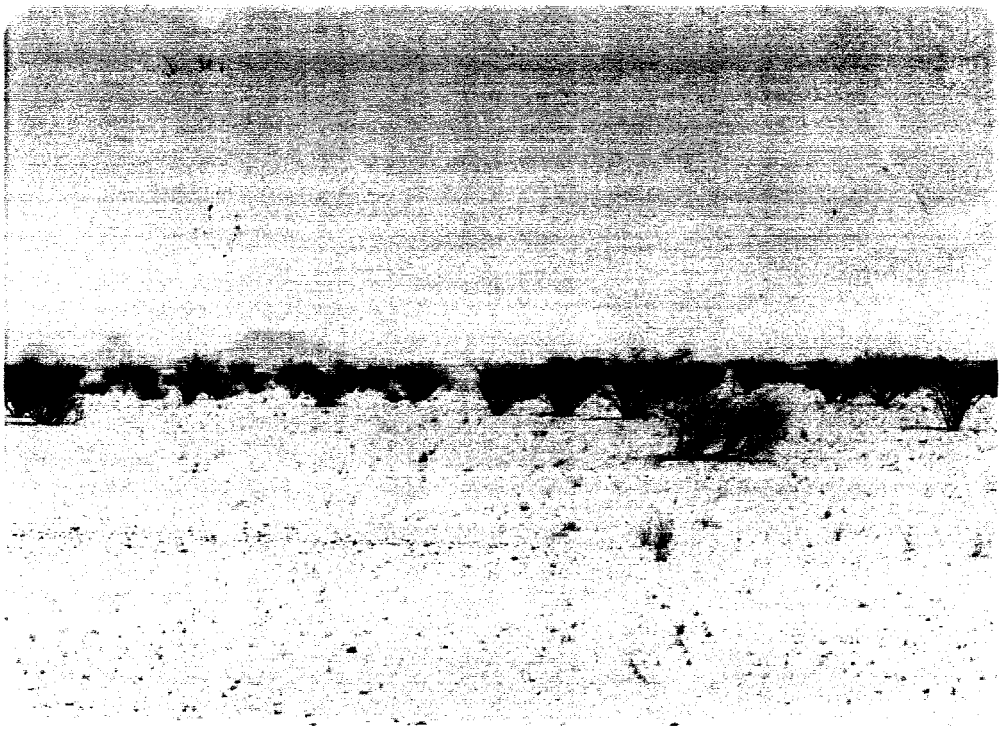
2.5.1 Unlike the case with soils, the available literature on the flora and fauna of the ROY is rich in terms of taxonomic details. But as in the case of soils, this information has not been regionally classified. The Woodland Resources Mapping Project under the Ministry of Agriculture and Water Resources, ROY, has undertaken a systematic survey on the regional orientation of natural vegetation. But the maps and reports so far produced are not yet available for public use. Even if these were made available for the EA at hand, little advantage could be derived as the terrain through which the alignment of the proposed road extends has not been covered in this project, except over a small stretch at the

Hadramout end. Hence, the information given below are based on field observation. Here again, the team of Consultants were seriously handicapped due to the absence of a systematic Botanist or Zoologist amongst them. Samples of leaves together with photographs proved poor as materials to prepare any elaborate taxonomy of vegetation seen during field survey. Even then some 64 types of plants could be identified. With the fauna, the placement of the team of Consultants was less fortunate, because collection of samples and photography of the fleeting creatures proved beyond their competence. Hence the team had to depend on the knowledge shared by the local people in this regard.

2.5.2 The constraints mentioned above should not be seen seriously compromising the EA. This is because the proposed alignment passes through tracts of very poor vegetative cover varying from very degraded forms of savana type of vegetation to very nude terrains except for the ephemerals (short lived perennials) and shrubs. The alignment would certainly destroy some of these ephemerals and shrubs, but not a single tree. This will leave the tree covered tracts untouched and lots of undisturbed ground to let the ephemerals and shrubs retain the resources of the Republic.

2.5.3 The 64 varieties of plants identified during the field study are all xerophytic in type, as is to be expected in such a tract getting less than 200 mm of annual rain, with an evaporation rate far exceeding precipitation. Varietal diversity of plants is richer on accreting alluvial soils not touched by farming. These are better preserved on the hummocky sand dune zones. Tracts with thick sand cover have the poorest range of plant species. Gravel beds covered thinly with sand generally support ephemeral legumes, herbs, weeds and grasses along with very sparsely distributed dwarfed acacia. At the edge of farmland, some of the varieties of trees have been retained to act as fences or wind barriers. No large scale activity for plantation to arrest desertification was observed in any part of the road corridor.

2.5.4 The data so collected does not yield any mapping to show their regional boundaries. In fact, the same species of plants were seen to exist across the boundaries of different types of landforms given by differences in lithology, soil and moisture fund. In more hostile circumstances, the relatively taller plants become short in height leading to blurring of distinction that is ordinarily made between trees and shrubs. Keeping this in view, the range of identified vegetation has been broadly grouped into tree types and ground covers. The latter type includes legumes, herbs, weeds and grasses.



9. TYPICAL SHRUBS ON WADI BED
NEAR AL' ABR

10. TYPICAL TREES AND SHRUBS
(WEST OF HADRAMOUT VALLEY - NEAR ROAD CORRIDOR)

2.5.6 To provide some understanding about the regional spreads of the different types of plants, the occurrence of each species have been shown in terms of the basic landforms. So classified data has been presented in Tables 2.5.6(A) and 2.5.6(B) for trees and other ground covers respectively.

2.5.7 Careful examination of Tables 2.5.6(A) & (B) will reveal two important features of regional differences in the floristic wealth. It shows that the hills and the flood plains have the largest varietal diversity of flora. The inter-dunal playas have the poorest floral wealth. These tables also indicate that some plants grow on larger varieties of terrains than the others. One should however, note that the floral wealth of ROY is richer than what these tables show. The data does not show how much ground is covered by these species of plants jointly or severally.

2.5.8 Information on the wild fauna is still poor for reasons stated above. However, the Consultants were told by the local people that there exist some deer (Gazella doras), desert cats (Felis libyca), desert fox (Vulpes v. pusila) and very few wolves (Camis lupus). Desert rats (Gerbillus gleadowi and Gerbillus nanus) are more numerous as are the lizzards (Abophylax turberculatus). The existence of snakes was also detected during the field study. Birds are few and are mostly found near human settlements. The common varieties of birds are Oeud capensis, Athone noctra, Nectavinic metalicus, Melcrax metabates, Merops orientalis, Peardise flycalden, Passer domesticus and Ploceus jalbula.

Table 2.5.6 (A)

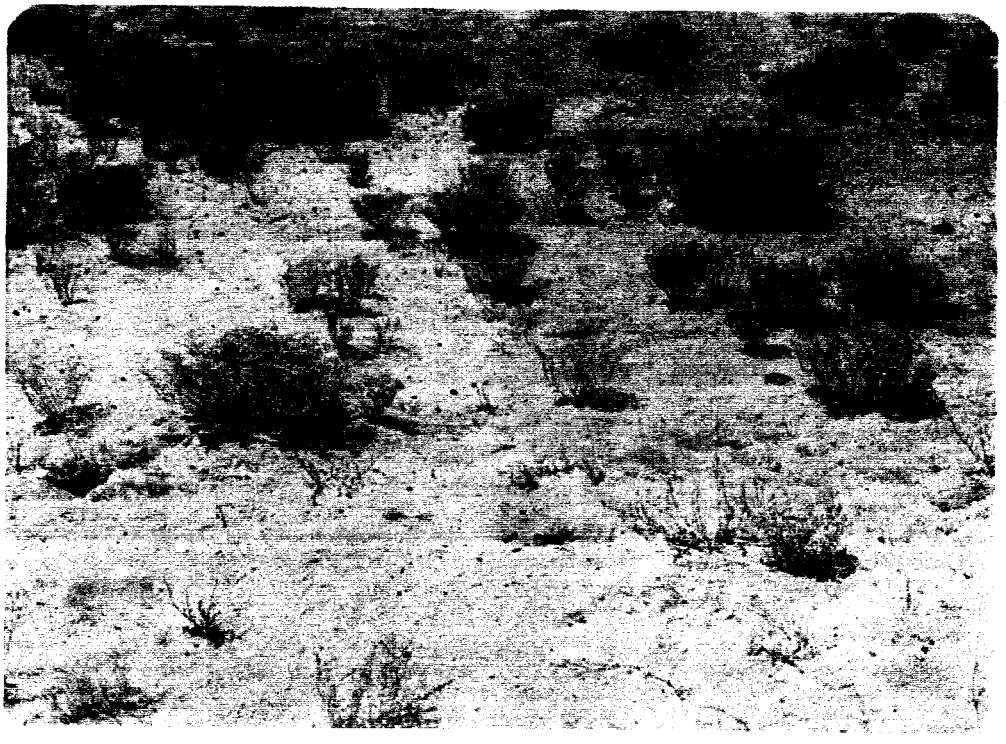
Occurrence of Plants Classified by Major Types of Landforms : Trees

Sl. No.	Name of Plants	Types of Landforms					
		Hills and Foothills	Gravel Plain	Sandy Plain	Sandy Dunes	Flood Plain	Inter-dune Playas
1.	Acacia albida			•			
2.	Acacia arabica	•					
3.	Acacia commiphora	•					
4.	Acacia ehrenbergina					•	
5.	Acacia hamulosa	•	•			•	
6.	Acacia mellifera		•				
7.	Acacia monilifer	•					
8.	Acacia oerfota	•					
9.	Acacia seyal	•					
10.	Acacia tortolis	•	•	•		•	
11.	Aerva persica					•	
12.	Anogessius pendula		•				
13.	Aristada funiculata						
14.	Aristada adscensionis						
15	Azadirichta indica				•		
16.	Calatropis procera		•			•	
17.	Calligonum polygonides			•			
18.	Calligonum Commosum			•			
19.	Capparis decidua					•	
20.	Cassia auriculata					•	
21.	Chenopodium album				•		
22.	Dipterygium glaucum					•	
23.	Euphorbia balsamifera	•					
24.	Eucalyptus spp.	•			•		
25.	Haloxydon ammodendron	•					
26.	Leptademia pyrotechnica		•	•		•	
27.	Lycium shawaii	•					
28.	Oleas africa	•					
29.	Panicum turgidum						
30.	Parkinsonia aculata	•		•			
31.	Pistacia atlantica	•					
32.	Prosopis cineraria			•			
33.	Prosopis juliaflora				•		
34.	Prosopis spicigera	•					
35.	Salvadora persica			•	•	•	
36.	Tamarix articulata			•		•	
37.	Tamarix indica			•		•	
38.	Zizyphus jujuba					•	
39.	Zizyphus nummeleria					•	
40.	Zizyphus spina christi	•				•	
41.	Zygophyllum simplex				•		
	Variety of Trees	16	6	10	6	15	0

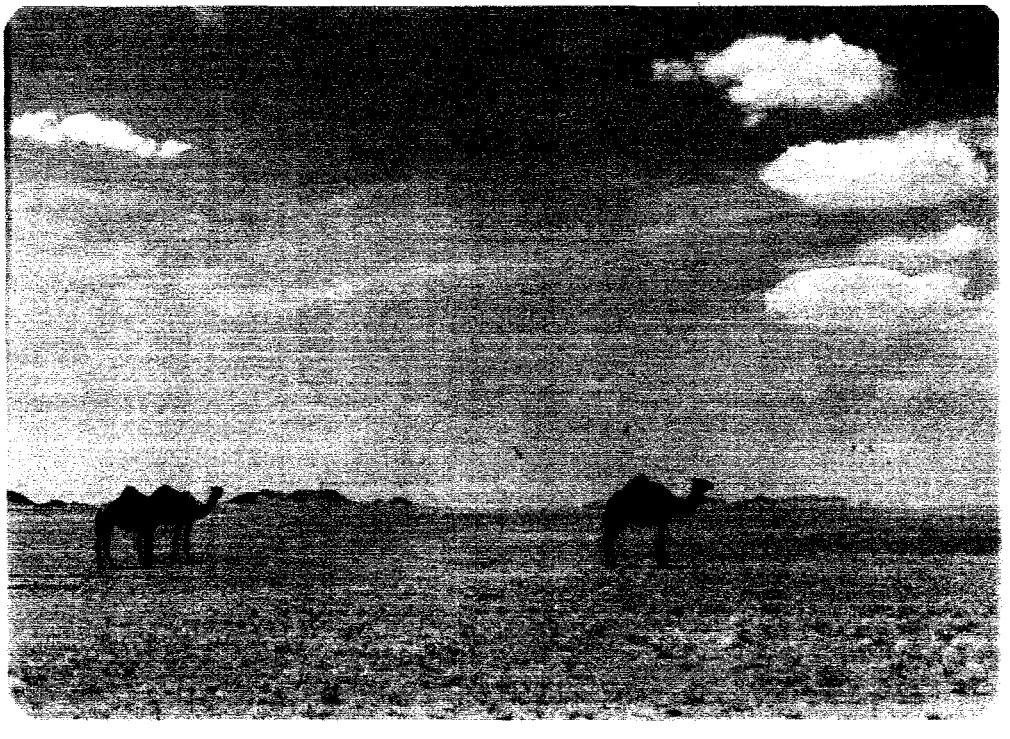
Table 2.5.6(B)

Occurrence of Plants Classified by Major Types of Landforms : Groundwater

Sl. No.	Name of Plants	Types of Landforms					
		Hills and Foothills	Gravel Plain	Sandy Plain	Sandy Dunes	Flood Plain	Inter-dune Playas
1.	Baleria acanthoides	•					
2.	Cymbogan jawarcanius	•					
3.	Cambogan parkerii	•				•	
4.	Cymbogan scheonanthus	•				•	
5.	Cynadon dectylon	•		•	•		
6.	Digitaria spp.					•	
7.	Eragotis aegyptiaca			•	•		
8.	Eragotis termula	•					
9.	Erypos spp.	•					
10.	Eagonia cretica		•			•	
11.	Haloxydon salicormicum						•
12.	Helotropium bacciferum	•					
13.	Heliotropium rariflorum	•					
14.	Indigofora cordifolia		•			•	
15	Indigofora linifolia		•			•	
16.	Jutiopha spp.	•					
17.	Odyssea mueronata				•		
18.	Pulicaria wightiana		•				
19.	Rhazia stricta					•	
20.	Salosola baryosma			•		•	•
21.	Suaeda fruticosa			•		•	•
22.	Tephorsia purpurea		•			•	
23.	Tephorsia petrosa		•			•	
Variety of Plants		10	6	4	3	11	3



11. TYPICAL BURROWS OF DESERT RATS
(NEAR FOOTHILLS AND OUTSIDE ROAD CORRIDOR)



12. TYPICAL GRAZING LAND (KM 50)

2.6. Human Responses to Environment

2.6.1 Like the other members of the biotic world, human beings have also evolved over time. On account of their ingenuity to carry out organised actions, the human beings have now emerged as the climax biota. While extracting resources through application of technology, they have introduced many new elements into the landscape, like sedentary and shifting settlements, towns and villages, houses and tents, farm lands and grazing grounds, orchards of citrus fruits and dates, roads and tracks, mines and industries, etc. These man-made objects are generally referred to as the elements of cultural landscape, which reveal the material base of culture.

2.6.2 The individual elements of cultural landscape are functionally interdependent and together reveal the strength and weakness of organised actions taken by a given society to sustain themselves within a given environment. These have imparted upon the society variable orders of internal strength not only to replicate their acquired life-styles, but also to venture into the future in response to their perceived opportunities lying unattended or inadequately used in the world external to the concerned social groups. Through the process of realising their perceived goals, these social groups bring about restructuring the earlier social organisation, facilitating the absorption of new technology and newer ways of doing things. It is against such a societal dynamism that the Safir-Hadramout Road Project has to be seen. This project is an expressed desire to acquire a new artefact to consolidate their sense of security within an environment that is fragile in many respect.

2.6.3 It is necessary to understand the social processes that have stimulted the desire to have roads as also the manner in which such an artefact induces social change. Such an approach provides a focus to examine the nature of human responses to environment as obtaining within this inland basin of the ROY. Otherwise, the subject is too complex to deal within the framework of EA. In dealing with this issue, one has to be selective and sacrifice comprehensiveness.

2.6.4 The average carrying capacity of the environment is poor, although better than the purely sandy desert. However, the fertility-rate sustained by indigenous society is remarkably high. Coupled with it has run a long-term climatic process of increasing dessication. This had stimulated a sustained process of out-migration of people, mainly the men, of the ROY. Remittances from these emigrants gave the people left behind a level of purchasing power more than what the local economy could generate. Strengthened by this added purchasing power, the resident population has been indulging in consumption of many varieties of imported goods, leading to absorption of a large work force in trade,

commerce, transport and storage sectors of the regional economy. Such a process has caused the emergence of nucleated settlements acting as centres of trade and a rising need for efficient communication system. They have acquired a phenomenally large fleet of motorised vehicles exclusively through imports. The exploitation of the petroleum deposits have assisted the process. What they need is road that would assist smooth vehicular travel.

2.6.5 Indulgence in trade and commerce is a part of the historical experience of this society. They have been participating in it over many centuries. The process of monetisation had penetrated deep into the society and, therefore, its membership was culturally prepared to participate in the emerging scenario. Even a nomadic Bedouin is a compulsive trader. What is relatively new in the present day scenario is the consistent rise of internal trade in substitution of external trade. Hence they require many more centres of trade than before. They have accommodated this need in many different ways, the most revealing example of which is given by the services offered by gas-stations located in the remoter parts of the country. These not only service the motorised vehicles, but also contain a grocery stocked with a rich array of consumer goods. The gas-station is, therefore, an example of the agility of the people to restructure its social organisation in response to their perceived opportunities.

2.6.6 The example of the gas-station located on the edge of a sandy desert unconnected by any mentionable road also illustrates an element of false consciousness about the deeper implications of the long-term processes operating within the physical environment. In this country, a litre of gas is cheaper than a litre of potable water as sold in the market. The motor-vehicles acquired by this society are powerful enough to travel across sandy deserts, across dunes, over the rocky screes, up along steep inclines, etc. Thus they seem to have conquered distance; but they do not see that their tracks trample over the meager desert vegetation, especially the succulents eaten by the animals. Since there are no roads, the number of track marks left by the moving vehicles are many indeed. Therefore, the rate of depletion of the natural pastures is disproportionate to the number of traversing vehicles. To an ecologically conscious person, such a negative impact upon the natural environment would appear mitigatable through the construction of a road. The road would at least reduce the ground coverage of destructive vehicular traffic by keeping it within a confined zone. Such a consciousness is there within some segments of this society who would like the Government to invest on road building.

2.6.7 However, there are many other social groups who have not perceived the correct mitigative measure and, therefore, suffer from the consequences. Take for

example, the Bedouins, who keep herds of animals and are on the look out for natural pastures. They are now required to get information on the occurrence of rainfall over a very wide area and to shift their animals as quickly as possible to the grazing grounds segmented by these regionally confined infrequent precipitations. Unfortunately, not all the grazing grounds have the sources of potable water which the Bedouins need. They are meeting this need by carrying water in plastic containers and by transporting these over great distances in motorised pick-up vans. This has also caused a transformation in their economy for the better or worse. The Bedouins are no longer to be seen as keepers of large herds of camels. These animals have lost their place as "ships of the desert", as beast of burden, to the motorised vehicles. Some number of camels are still found with the Bedouin groups as a source of milk and probably as hangovers of the earlier symbols of social prestige. Now the animal stock is predominantly composed of goats and sheep, reared mainly for sale to the sedentary communities living in and around the nucleated settlements of trade and commerce. But they do not necessarily realise that the closer they come to a sedentary society the greater would be the need for agriculture to support animal husbandry by way of cultivating fodder. Nor do they see the importance of growing fire-wood.

2.6.8 The changes obtained in the composition of animal stock is basically an expression of adaptation to the changing scenario. But such acts of adaptation do not quite match their perceived opportunities. All the Bedouin groups encountered during the field study wanted to have a dependable and easily accessible source of potable water. Reinforced by their experience, this need they believe is within the realm of the possible. Many Bedouin groups frequenting the area around Al' Abr, for example, draw water from the bore-well of that township and tranship it over considerable distances in motorised vehicles. The numerous military outposts set up within the true desert are serviced by pipelines carrying water. The roaming Bedouin groups draw water from these military outposts while remaining close to the grazing land. They also draw water from the traditional dug-wells constructed for public use in villages within accessible distance from a natural grazing ground. So, these groups of Bedouins know the range of available technologies to get potable water in their camps. What they do not have is the financial resource to create such a resource.

2.6.9 What these Bedouin groups are not presently stating is that such sources of potable water should be created within the fragmented environmental domains at or near the natural pasture land. Nor are they presently stating their intent to use the so available water to produce fodder by irrigation either to sustain more vigourous growth of natural vegetation or to cultivate richer fodder. To arrive at

13. PUMP HOUSES FOR GROUND WATER ABSTRACTION
FOR MILITARY USE AND DISTRIBUTION
TO BEDOUINS (KM 240)

14. WATER SUPPLY BY PIPE TO SETTLEMENTS
(IN HADRAMOUT VALLEY) NORTH OF ROAD ALIGNMENT

a state of mind to recognise all these as needs is also within the realm of the possible, for they have seen so many Bedouin families settling down to sedentary life-styles with the backing of the state policies. These recently settled Bedouin families are now combining animal husbandry with agriculture by way of cultivating grains and vegetables along with fodder. Their stock of animals consists of goats, sheep and chicken. Since they are habitual traders, adoption of sedentary life-style and interactions with sedentary communities as buyers of their farm products have posed little social problems. However, the most important point to note is that the technology of lift irrigation acts as the foundation for this process of social transformation and integration.

2.6.10 It is pointless to speculate upon the different stages through which the presently nomadic tribes must pass through before becoming truely sedentary communities. Suffice it be to recognise that it won't come about in a straight forward manner, although it may come eventually. Given this assumption, it would be worthwhile to examine the process through which the technology of lift irrigation has become an essential part of the process of social transformation in this inland basin.

2.6.11 The most critical resource setting the limit of sustainability of the environment in the inland basin is water. Much less restrictive are the other resources like availability of fallow land, level ground, fertile soil, etc. Scarcity of water has restrained the flourishing of the biotic world, be it the natural vegetation or human occupance of land for agricultural, industrial or settlement development.

2.6.12 While rainfall ensures renewability, water resources of this region are found in two types endowments. One is the ground water resources in the Mukalla standstone (Cretaceous formation), which have mostly accumulated during earlier pluvial regimes and partly from percolation in the present time. The other endowment is the wadi flood plains. Of the amount received from precipitation, a part (about 40%) is lost through evaporation. Another part (about 35%) sinks into the ground, which primarily enriches the shallow aquifers and partly the deeper ones. The rest flows down the wadis, mostly in the shape of flash floods. It is this surface flow that has sustained the permanent human habitations. By reducing the velocity of run-off through intervention structures and by enlarging the water spread area by other types of structures, the resident population have demonstrated their ability to get the best out of an otherwise unpromising reality. Dams (temporary or permanent), conduits, water-courses, etc. are the manifestations of their skill in this regard. The more successful they have been in doing this, by progressively moving up the valley to harvest water immediately after rainfall, for example, the shorter has become the lengths of the wadis

15. BEDOUIN FAMILY RESIDENCE SHOWING DESIRE TO SETTLE DOWN (NORTH OF HADRAMOUT VALLEY)

16. NOMADIC BEDOUIN BEING INTERVIEWED (SOUTH EAST OF AL' ABR)

carrying flood. Commensurate with it has been the fall in the quantum of recharge in the aquifer and the rise in loss through evaporation. The dug wells, tapping the shallower aquifer beyond the innundated surfaces of wadis dry up sooner. It is within such an emerging realm of regional hydrology that the techniques of using energised pumps have been developed (see Figure 2.6.12).

2.6.13 Annual rainfall is low. But more importantly, precipitation is associated with atmospheric turbulance (like cloud bursts) and is regionally uncertain. These have been conditioned by orography, geology and wind to produce significant regional variations in the endowment of surface water. The highlands, formed mostly of hard rocks, experience much higher rates of run-off than of percolation. So almost all the channels forming the wadis run down the flanks of the hills. The southern mountain receives the highest rainfall and, therefore, sustains the largest wadis (Al Jawf, Al Adhana etc). Next in importance are the southern hills, which sustain the rest of the major wadis. The northern hills are poorly endowed with rainfall. These have given rise to wadis, but carrying little run-off. The surface flows of all these wadis percolates under the sands of the inland basin. Most of the age-old settlements are found near the wadis where the slopes of the mountains of the west and south meet the plains. This belt is also conspicuous for agricultural development. From this agricultural region and the settlements are originating the impetus for economic development upon the adjacent drier land by putting into use the technology of ground water exploitation. Instead of dug wells, bore-wells attached to energised pumps are tapping the deeper aquifers. For reasons stated earlier, this might affect sooner or later recharge into the deeper aquifers. In fact, indications are that the exploitation of ground water has probably reached its limit in Marib Jawf basin lying to the west of the alignment, since the present rate of extraction has already acquired the character of water mining , being not limited to the quantum of annual renewal or recharge.

2.6.14 Apprehensions about the limits of ground water exploitation has not, however, become a part of social consciousness. Traditional practices of spate irrigation is still followed by many farmers, leading to wasteful and risky uses of water and soil respectively. The early signs of soil-salinization is being reported in several places. It would be unfortunate, if the idea of conservation of water resources is not accepted soon as a necessary means to extend the horizons of future opportunities. However, there are signs of optimism in this regard. Such a consciousness is bound to emerge sooner than later. Even the technologically advanced society of California in the USA realised it rather late.

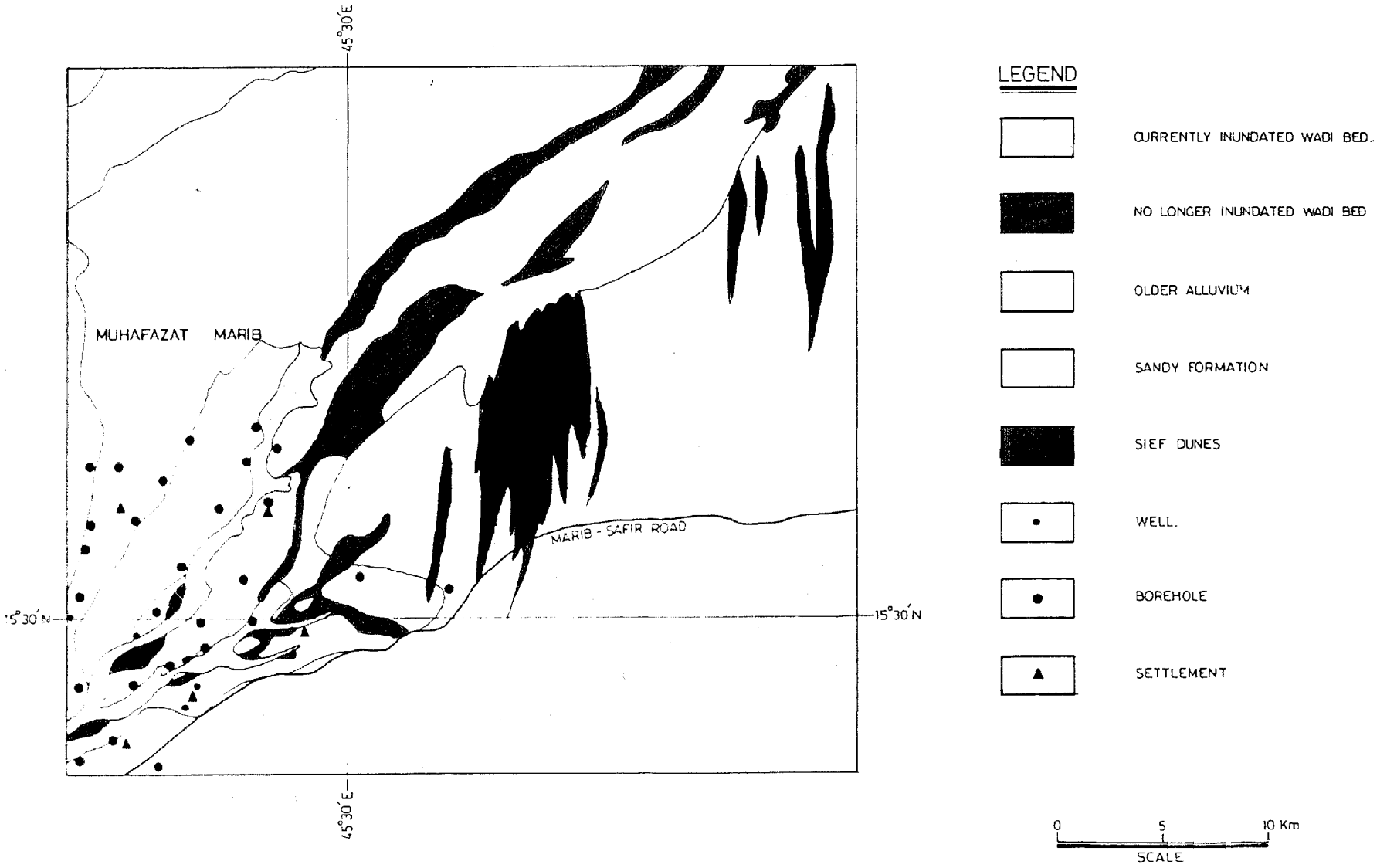


FIG. NR. 2.6.12

EFFECTS OF GROUND WATER EXPLOITATION ON SURFACE HYDROLOGY IN MARIB-SAFIR REGION

2.6.15 The signs of optimism mentioned above are many indeed. In the larger societal context, the new technology of tapping the deeper aquifers is making water an element of private property. A well or a bore hole is an expensive structure and not all can afford to build one. Assymetry in wealth requires a part of the users to buy water from the other part. This is making the buyers of water increasingly cost sensitive. The wealthier owners of such infrastructure are by nature cost sensitive. So also are the managers of industries, even if the price of fuel is unrealistically low. Although the low fuel price has assisted ground water exploitation, the difference between the price of one litre of potable water (12 Rials) and an equivalent amount of petrol (6 Rials) is stark enough to make anybody cost-sensitive.

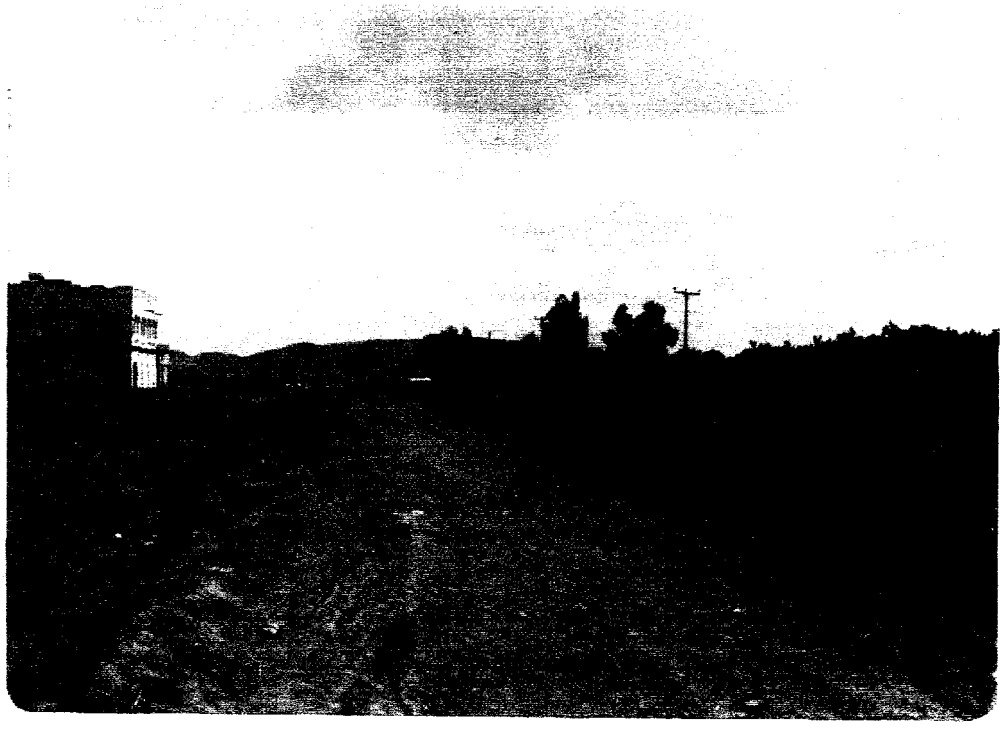
2.6.16 Between the state of being sensitive and that of being responsive, there subsists a hiatus, which one can hope to overcome by organising actions through adoption of appropriate technology. The action required is to develop farms with an accent on conservative use of water. Technology that may achieve it is drip irrigation or sprinkler irrigation, both of which are expensive to install and, therefore, currently only accessible to the wealthier extrepreneurs. Their effectiveness is more prounced with orchards than for raising grains. It is not surprising that a large number of orchards have been established in the tracts irrigated by pumps attached to wells.

2.6.17 Within this inland basin, due to variations in temperature conditions, two types of orchards have developed. In the western part, the emphasis has been on citrus fruit growing. In the eastern part, dates are more extensively raised. The output from both types of orchards far exceeds the absorptive capacities of local markets. Hence roads are needed to reach the distant markets. Some of the orchards have installed processing and canning facilities to add value to and to preserve the products. This has also increased the need for roads.

2.6.18 The orchards are often located along the roads and act as living fences of trees as a defence against the aeolian processes. This has indirectly contributed to a reduction of hazards upon the roads by way of restricting sand flows. The whole process has enlarged the base of social participation for fighting desertification. Where road side orchards do not exist, the investments in plantations are borne by the state and are limited by budgetary constraints.

2.6.19 One may argue that road side plantation is essential for maintaining roads. However, one may apprehend that this may not come about without involving the society. The society can expect to respond, if the measures yield private dividends. The example of road side orchards is one option available in this regard. Other options may emerge if the species of plants chosen for wind

17. SAND FLOW ACROSS PAVED ROAD, MARIB-SAFIR SECTION IN STRETCH WITHOUT PLANTATION



18. ROADSIDE PLANTATION BY FARMERS (MARIB - SAFIR ROAD)

barriers have meaningful economic importance. Encounters during field study indicated that the local people are aware of the economic importance of a few varieties of trees as indicated in Table 2.6.19. The point is to increase social consciousness about the economic importance of many other plants. An example is given by the fact that many farmers have tree-line wind barriers around farms growing grains, vegetables, even fodder.

Table 2.6.19
Perceived Utility of Some Trees by the Residents

Sl. No.	Botanical Name	Local Name	Utilities
1.	Acacia ehrenbergina	Saim	Leaves as fodder; firewood and charcoal
2.	Acacia tortolis	Sumer Hen Thelleh	Leaves as fodder; firewood and charcoal
3.	Azadiricha indica	Not known	Source of pesticide, non-edible oil and oil-cake manure
4.	Calligonum commosum	Al urdah	Charcoal making
5.	Eucalyptus occidentals	Caynah quiriba	Construction timber
6.	Eucalyptus microtica	Caynah microtheea	Construction timber
7.	Prosopis cineraria	Not known	Leaves as fodder; firewood and charcoal
8.	Prosopis juliaflora	Not known	Leaves as fodder; construction timber, firewood & charcoal
9.	Salvadora persica	Al arak	Fodder; yields oil of medicinal value for treating dermatitis
10.	Zizyphus spina christi	Al sader	Construction timber; sources of honey

2.6.20 The idea of wind breakers along the edge of farm land is generally an acceptable proposition, but not along roads passing through permanent settlements. Here visibilty is held at a premium for defence against brigandage and for contacts with the potential customers amongst the passers by. The shops occupy the ground floors of the roadside buildings. Hence the value of land declines away from the road. Dust from traffic makes little difference since dust is suspended in the

persistent wind. Hence bare roads passing through dense settlements are welcome facilities. Their perceptions are different from those of the developed western countries.

2.6.21 The farmers also have their own methods to assess the sustainability of land. Where the water resources are relatively assured, the permanent farms are located. Where it is less assured while the soil is good, farming takes place soon after rain, leaving the prospect of harvesting as a matter of chance. These can be described as period fallow land. Beyond these two types of land extend the gravelly or stoney waste land where no attempt is made to intervene upon hydrology. These waste lands extend up to the base of the hills and the run-off therefrom sustains agriculture at the lower end. Since the period fallows are never defended with wind breaks (tree lines), the incessant wind churns off the soil to build dunes or sand covered land. These are then left unused. In Figure 2.6.21, an attempt has been made to classify the land by their various orders of sustainability as seen by the local people in a section of Hadramout valley.

2.6.22 Farmers use the land to raise different types of crops according to their idea about sustainability. Up in the valleys of the southern and central mountains are grown wheat and barley, the latter grown on plots poorly endowed with water such as in the period fallow land. In the lower valleys, sorghum and millets are grown, the latter grown on plots poorly endowed with water such as in the period fallow land. Various types of vegetables like potato, tomato, onion, okra, squash, carrot and broad beans are raised with the support of irrigation. On the other hand, melons are grown on the period fallow land. The orchards get irrigation and raise citrus fruits, date, figs, guava, etc. On the cooler heights are grown grape vines.

2.6.23 As the pressure of population is mounting, the demand for water is rising. More and more water is being extracted. This has contributed towards an increase in the area under permanent farm lands, supported as these are by assured irrigation. The same process has, however, contributed towards reduction of the area under period fallow, being pushed towards the realm of increasing aridity caused by increasing exploitation of water elsewhere. The bare period fallow lands supply sand and silt for the churning winds to carry away.

2.6.24 The above observations on the human responses to environment refer to the processes that are traditional. Today, however, the entire society here is poised around the expectation to strike oil. Along the entire alignment of the proposed road, oil-concessions have been granted as can be seen from Figure 2.6.24. If oil is struck, there will inevitably be changes of such a force that would overcome the strengths of all the tradition bound processes. Depending on the quantum of

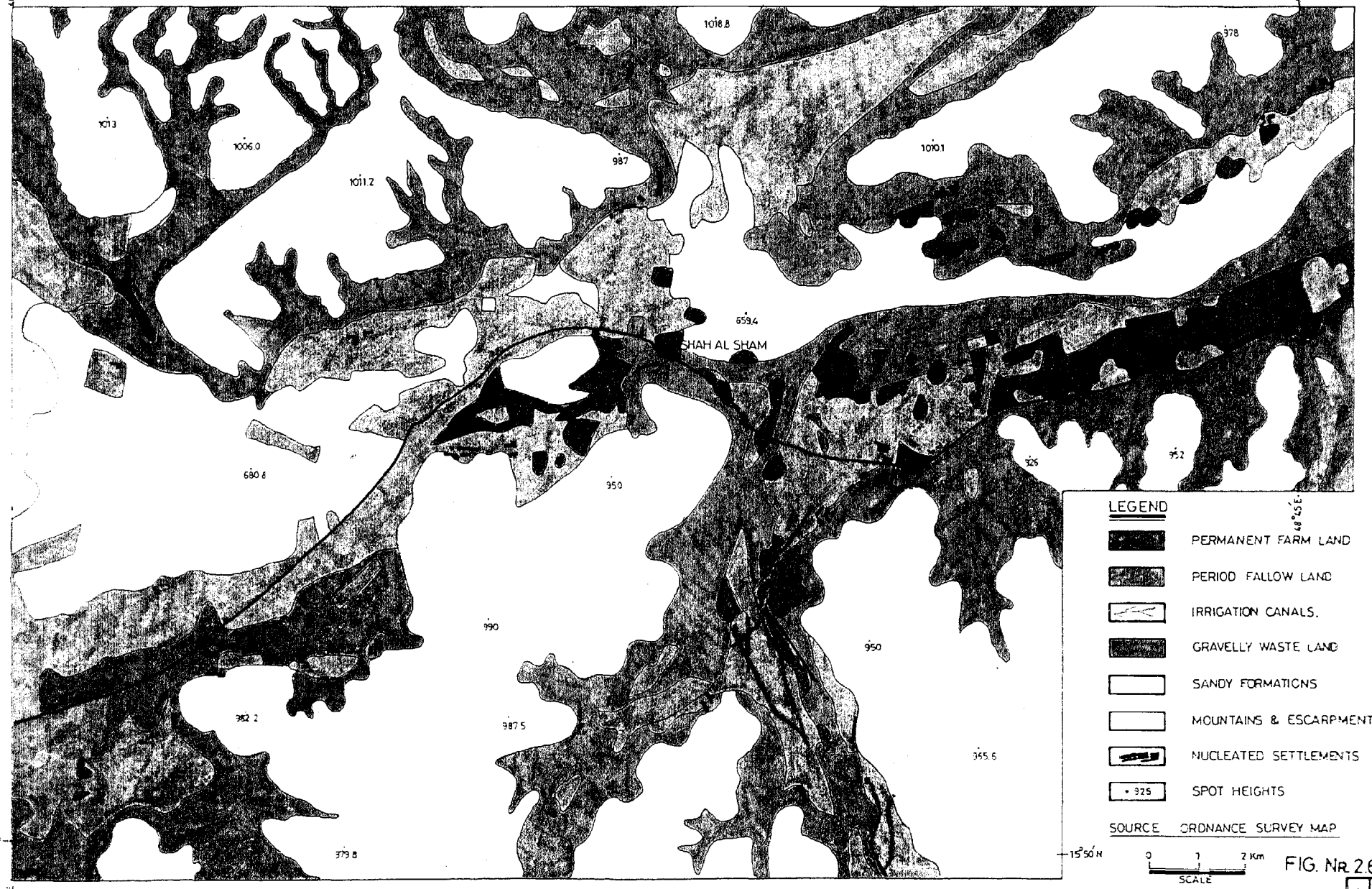


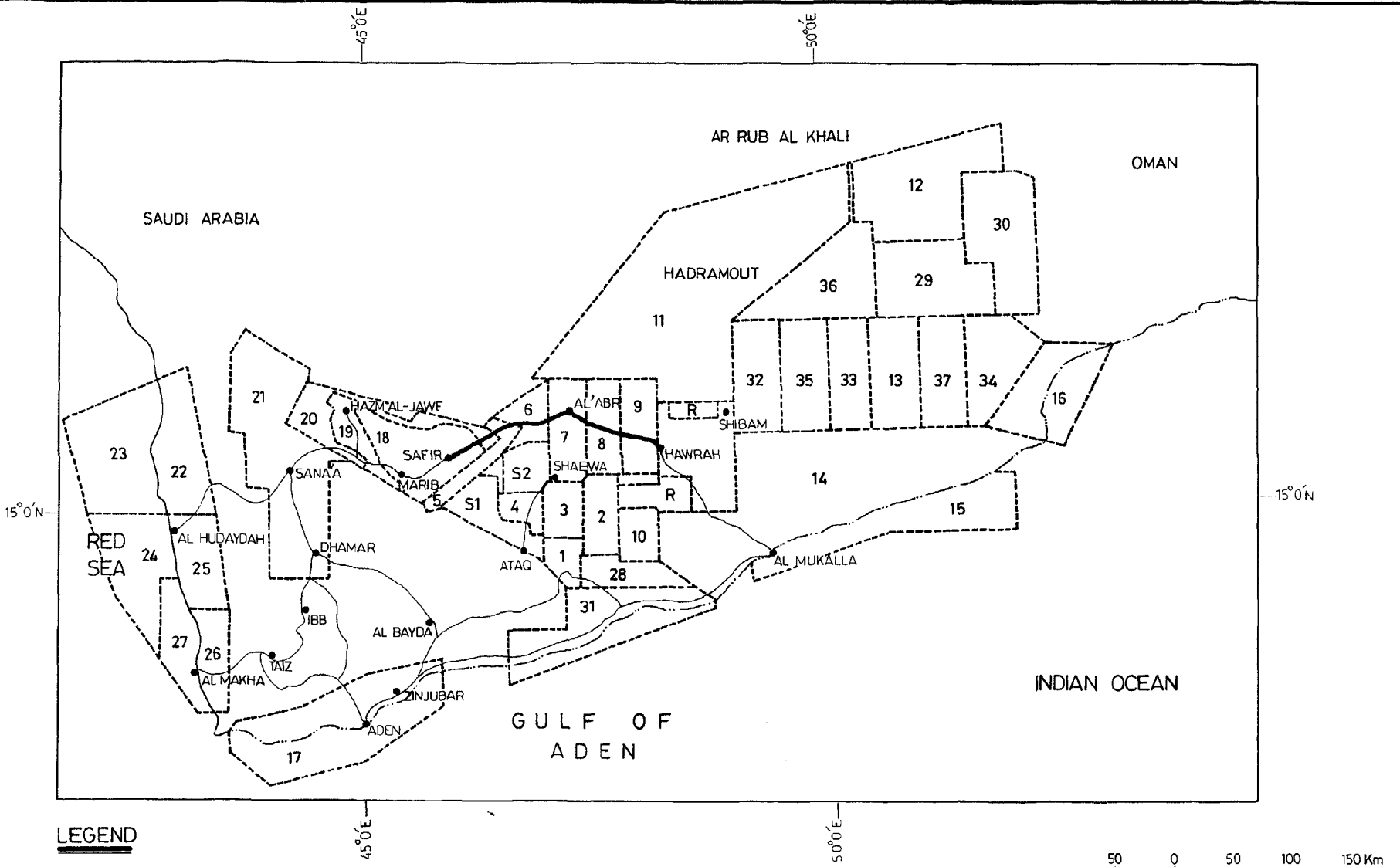
FIG. Nr. 2.6.21

SPATIAL ORIENTATION OF FARM LAND IN HADRAMOUT WADI

oil extracted, there will be either increased movement of oil-tankers along the proposed road or pipelines crossing the desert. On this turning point of the economy of the region, any speculation on the future of man and environment relationships will be unreliable, to say the least.

Table 2.6.24
List of Oil Concession Blocks (as on January 1992)
(For Locations, See Figure 2.6.24)

BLOCK	BLOCK NAME	OPERATOR	AREA (SQ.KM)
1	Anakeen	Sunoil	2,182
2	Al Mabar	Crescent	4,019
3	Jardan	Chevron	2,953
4	Ayadh	N.P.C.	1,951
5	Jannah	Total	2,180
6	Iryan	Strake	3,224
7	Barqa	B.P.	4,942
8	Asakir	B.P.	4,735
9	Malik	Crescent	4,728
10	East Shabwah	Total	11,864
S-1	Danis	Shell	3,879
S-2	Uqla	Occidental	2,809
11	Sirr Hazar	ELF	47,217
12	North Sanau	Binham	15,940
13	Al Arnah	Open	7,417
14	South Hastela	Canadian Oxy	35.548
15	Mukalla	Open	6,954
16	Qanar	N.P.C.	10,404
17	Aden/Abyan	Open	19,375
18	Marib / Al Jawf	Yemen Hunt	8,445
19	2nd Rel. Area	Open	4,223
20	1st Rel. Area	IPL/Philips	4,222
21	Central Highlands	Open	22,660
22	Al Zaydiah	Open	9,015
23	Antufash	B.P.	13,040
24	Al Kathib	Open	9,972
25	Hudaydah	Open	6,015
26	Moccha	Open	4,020
27	Al Janbiya	Open	5,250
28	North Belhaf	Jalik	3,771
29	South Sanau	N.P.C.	11,055
30	Habroot	Petrocanada	12,083
31	South Belhaf	Open	13,014
32	Howarine	Clyde	6,924
33	Al Furt	N.P.C.	6,017
34	Jeza	Open	7,943
35	Hood	Lasmo	7,395
36	Thamud	Open	10,660
37	Marait	Open	6,966
R	Relinquished Area		



LEGEND

2	Nr. OF OIL CONCESSION BLOCK
	PROPOSED ROAD ALIGNMENT
	COAST LINE
	IMPORTANT TOWNS
	MAJOR ROUTES

50 0 50 100 150 Km
SCALE

FOR DETAILS OF BLOCK NOS. REFER TABLE 2.6.24.

FIG. Nr. 2.6.24

MAP SHOWING OIL CONCESSION BLOCKS IN YEMEN

CHAPTER III

POTENTIAL IMPACTS AND MITIGATING MEASURES

CHAPTER - III
POTENTIAL IMPACTS AND MITIGATING MEASURES

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CHAPTER III

POTENTIAL IMPACTS AND MITIGATING MEASURES

3.0 Introduction

3.0.1 The proposed alignment of the road from Safir to Al Makhaneg via Al' Abr passes through a terrain that is composed of different types of desert sustaining different orders of fragility. Most of the terrain is uninhabited, except for the nomadic Bedouins driving their animal stock in search of ephemeral grazing grounds. At the edge of this desert are located a few towns and villages, permanent in nature, offering different types of economic services. Located near the south-eastern end of the proposed alignment is the townshipship of Safir based on petroleum refinery. In the north is Al' Abr, a centre of district administration and trading across the border of the ROY. In the east are the villages of Bir Al Wahed, Al Khasha, Dar Al Naser, Al Zudeiyah, Al Gauda and Al Makhaneg.

3.0.2 The six eastern settlements are distributed over a length of 46 kms at the Hadramout end of the alignment and all are basically rural in economic pursuit. However, these are not identical in character. Bir Al Wahed has attracted the Bedouins wishing to adopt sedentary livelihood. Al Gauda has a considerable number of families drawing sustenance from trade, commerce and services. Al Makhaneg is servicing transport economy sustained by the Al Mukalla-Seiyun road. The rest are rural settlements of different sizes. All these six settlements are attracting immigrants in the recent years, possibly with the expectation that the proposed road will be constructed soon. The whole situation suggests as if the society at the Hadramout end is poised for conquest of the desert as is practicable within the limits of their traditional technology and associated production relations.

3.0.4 The pursuers of traditional production relations based on relatively low technology and those of modern production relations based on relatively high technology need not necessarily be seen as disperate groups. Fortunately, the required bridge between the two cultures already exists in this part of the world, ordained as it were by its history. The society here has already learnt the advantages of substituting reciprocal relationship by transactional relationship as the objective of production and has internalised the related value premises. Hence they are natural traders, willing to extract profit from adoption of new technology and through offering new services wherever opportunities emerged. Therefore, the

prospects of striking oil need not promote any apprehension about social rift. They will integrate themselves with such changes, even if the new systems displace some old pursuits. This is not where the problem lies in the context of assessing the potential impacts of the proposed road. The real issue is nested within the false consciousness that this segmented society carries, jointly and severally, about the order of sustainability of this fragile environment.

3.0.5 Some examples will perhaps reveal the nature of false consciousness shared by the different social groups. Safir petroleum refinery is decidedly an example of the shape of things to come. It was established at a place covered under seif dunes. The dunes were excavated to create level ground and the waste was disposed off beyond the edge of the property. Persistent wind has reactivated this dump of rubbish to give rise to shifting dunes of barchanoid type. These have invaded the adjacent land spoiling some good work done by the Eastern Regional Agricultural Development Authority to arrest sand movement by tree plantation. Currently, blowing sands roll across the Safir-Marib road with winds of moderate velocity. The entrepreneurs were probably not aware of the long term environmental processes that make the terrain fragile and that these can spoil the objectives of the very enterprise. Similar examples of actions based on false consciousness are being carried out by the oil prospectors west of Bir Al Wahed. Two to three metre deep sand is being excavated and the spoils deposited to make a boundary barrier for the operational site. These dumps of sand are being blown away to the adjacent land to increase the depth of sand cover. Both these modern entrepreneurs have not taken any mitigative measures, probably to exclude the costs as items for internal accounts. Such instances of cost-exclusion do not contradict the value premises of transactional relationship.

3.06 With the other group are the instances of over-grazing, conditioned by wanton destruction of the biota by the wheels of motorised vehicles. The need for using motorised vehicles emerged over a considerable period of time to establish transactional relationship based on trade between the social groups of the Eastern and the Western Governorates and based on the relationship of defence of the country between the Northern and the Southern Governorates. The vehicles traversing through this flat desertic land belong to the army, the traders and also the Bedouins to respond to their respective needs by indulging in cost-saving practices by way of avoiding ruts cut into the sand by the earlier travellers. So one can say that the destructive marks of the vehicles cover more than necessary ground had the objective been to preserve to the utmost the fragile natural pastures. The saving of internal cost has thus accumulated into a large social cost, to neglect which would mean accentuation of the intensity of desertification. Similar acts based on false consciousness have already been

reported in Para 2.6.12. Here the farming community is causing deserts to advance upon the flood plains of the wadis by extracting more and more of ground water without internalising the value premises of conservation of this scarce resource. They practice spate irrigation as a cost saving device in preference to drip irrigation. The social cost is manifest through the shrinkage of the area under inundation by surface run off.

3.0.7 Since every action taken upon the environment produces reactions, good or bad, the objective of Environment Assessment should be to make the society aware of the full range of consequences. The assessor carries an additional responsibility to reveal the range of choices available to mitigate the adverse consequences of the action envisaged and to enhance the utility of the good ones. The final option must, however, rest with the society promoting the given action. In the context of conducting EA for the proposed road, such a role the Consultants have accepted for themselves. To reveal their findings is the objective of this chapter.

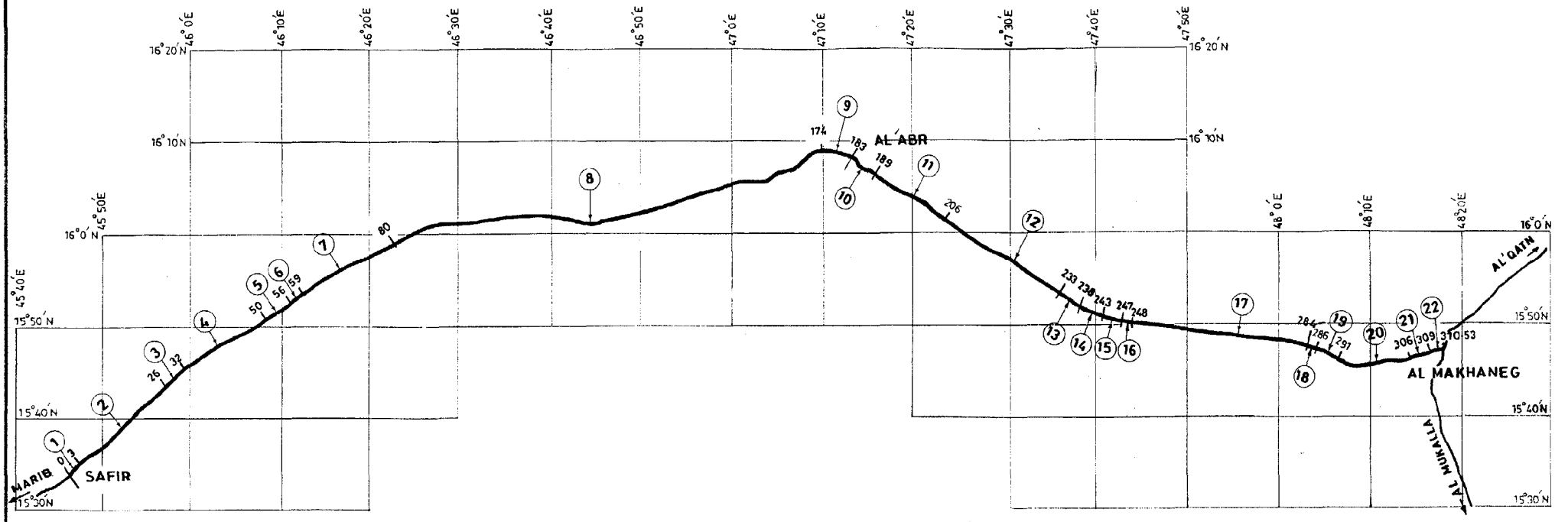
3.1 Methodology for EA

3.1.1 The road, if constructed through this road-less desert, can by itself be a mitigative measure against the consequences of vehicular movement across the natural pastures. It will confine destruction by facilitating traffic along a relatively narrow corridor. It will facilitate the movements of oil tankers, if petroleum is struck in any or all the oil concessions. Even if oil is not struck, the road will also help the movements of men and materials between the Eastern, Northern and Southern Governorates of the ROY as projected in the Feasibility Report prepared in 1992. But, these are not the only items of the balance-sheet.

3.1.2 The alignment crosses many different types of terrains, where the very act of construction could produce negative or positive impacts of varying order. Hence the balance-sheet must include the actions necessary to mitigate the adverse consequence and to enhance the desirable advantages. Therefore, it is useful to begin with segmentation of the entire length of the proposed alignment in terms of the significant attributes of the environment. It has been found convenient to divide the whole road length into 22 segments, which are shown in Figure 3.1.2. The distance of each break point between the segments have been shown in terms of the proposed junction on Marib-Safir Road.

3.1.3 The steps through which the EA has been carried out are as follows:

a) Highlight the significant attributes of the environment of the different segments with accent on factors producing their fragility.



NOTE:-

PACKAGE I km. 0·000 TO km.180·900
PACKAGE II km.180·900 TO km.310·500
OF CES ROAD ALIGNMENT DRAWINGS

5 0 5 10 15 20 25 Km
SCALE

LEGEND:-

- EA SEGMENTS (km.) 80 174
- EA SEGMENTS (Nr) 8

FIG. Nr. 3·1·2

LOCATION OF EA SEGMENTS ALONG THE PROPOSED ROAD

(b) Assess the negative impacts that the proposed road could produce upon different elements of physical and cultural environment for each relevant segment and suggest the mitigating measures; and

(c) Identify the measures necessary to enhance the quality of positive impacts for each segment.

3.1.4 The findings on each step of investigation are presented in the following sections in the order stated above. At the end a summary statement has been added to highlight the elements of environment which are to be handled with more care than the others over the entire length of the proposed road.

3.2 Significant Attributes of Environment

3.2.1 Identification and definition of the environmental attributes have been made by drawing reference to three sources of information, namely :

a) findings from Chapter II of this report;

b) the Third volume of the Tender Document prepared by the Consulting Engineering Services (India) Private Limited in 1992 for the project under review; and

c) field reconnaissance along the road corridor carried out by the team of Consultants.

3.2.2 The members of the team of Consultants carefully selected an optimum number of descriptors of the environment to highlight the specificities of each segment so as to obtain meaningful differentiation between these. The common attributes of the environment over all the 22 segments of the proposed alignment are as follows:

(a) the rate of evaporation exceeds precipitation in all months over each year;

(b) the diurnal range of temperature exceeds the annual range in all places along the alignment;

(c) the annual average rainfall decreases from less than 200 mm to around 60 mm from south to north;

(d) atmospheric turbulances may cause cloud bursts and dust storms of variable intensity;

(e) the surface drainage systems carry flash floods following cloud bursts and remain dry at other times; and

(f) the landforms are getting sculpted intermittently by fluvial processes and consistently by aeolian processes, leading to both erosion and deposition with varying intensities over the different parts of the road alignment.

3.2.3 The differentiating factors have been listed in Table 3.2.3 against which the specificities of each road-segment have been noted. These differentiating factors have been classified into two groups - one set refers to the conditions along the road alignment and the other to the adjacent areas. Some of the critical details on engineering designs have also been included to assist assessment of impacts of road construction upon the environment, upon which comments have been given in the following sections of this chapter.

3.3 Assessment of Potential Impacts of the Project

3.3.1 The key issues of concern to be addressed to asses the potential impacts of the project have been listed under para 5(d) of the TOR issued by the GCRB of ROY. In pages 5 and 6 of the Aide Memoire of May 10-23, 1993, the World Bank Project Mission has given some interpretations on these key issues. These two documents together provide the perspective of the clients. While the information given in the previous section, especially in Table 3.2.3, describes the pertinent features of the environment, it would be useful to bear in mind the points mentioned in Table 9.2 of Chapter IX of the Environmental Assessment Source Book (World Bank Technical Paper No. 140; 1991) in this regard.

3.3.2 A close examination of the key issues listed by the GCRB should indicate that some of these are related to the actions to be taken for the construction of the road itself. The remaining issues relate to speculations about the nature of impacts that this road after construction are likely to cause upon the regional economy and the environment adjacent to the road corridor. Methodologically, it would be useful to first address the issues belonging to the construction stage. In this context, it would be necessary to take into account the contents of the Feasibility Report along with the drawings placed under Tender Document of 1992 prepared by the CES.

Table 3.2.3

Significant Attributes of Environment of Road Alignment

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		1 (0-3)	2 (3-26)	3 (26-32)	4 (32-50)	5 (50-56)
A.	**Concerning Road Corridor**					
1.	Landform	Dune	Playa	Plain	Plain	Plain
2.	Stability	Shifting	Stable	Erosional	Depositional	Stable
3.	Lithology	Sand/Gravel	Gravel/Sand	Sand/Gravel	Sand/Gravel	Gravelly
4.	Wadi (Nos.)	-	-	-	-	-
5.	Surface Drainage	Free	Free	Impeded	Impeded	Free
6.	Ground Water Level (m)	90	105	105	120	125
7.	Expected Yield of Water	Profuse	Profuse	Profuse	Good	Good
8.	Prehistoric Site (Nos.)	-	-	-	4	-
9.	Archaeological Site (Nos.)	-	-	-	-	-
10.	Number of Cut Sections	10	20	11	22	2
11.	Average Length of Cut Sections (km)	0.126	0.076	0.091	0.174	0.079
12.	Number of Fill Sections	11	29	15	30	3
13.	Average Length of Fill Sections (km)	0.146	0.728	0.325	0.462	1.944
14.	Number of Irish Crossings	-	-	-	-	-
15.	Number of Box Culverts	2	7	2	10	3
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Grass	Grass	Grass	Grass	Grass
17.	Quality of Vegetative Cover	Scanty	Scanty	Scanty	Moderate	Poor
18.	Used for Grazing	-	-	-	-	-
19.	Used for Firewood Collection	-	-	-	-	-
20.	Used as Irrigated Farm Land	-	-	-	-	-
21.	Used as Period Fallow	-	-	-	-	-
22.	Name of Settlement	Safir	-	-	-	-
23.	Location of Settlement (km)	2 km off	-	-	-	-
24.	Primary Function of the Settlement	Industrial	-	-	-	-
25.	Water Source	Bore Well	-	-	-	-
26.	School	-	-	-	-	-
27.	Healthcare Centre	Private	-	-	-	-
28.	Administrative Office	-	-	-	-	-
29.	Prehistoric Site	-	-	-	8	-
30.	Archaeological Site	-	-	-	1	-

Table 3.2.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		6 (56-59)	7 (59-80)	8 (80-174)	9 (174-183)	10 (183-189)
A.	**Concerning Road Corridor**					
1.	Landform	Low Hill	Plain	Plain	Dissected	Dissected
2.	Stability	Erosional	Depositional	Erosional	Erosional	Erosional
3.	Lithology	Schist/Sand	Gravel/Sand	Gravel/Gneiss	Alluvia/Gravel	Alluvia/Gravel
4.	Wadi (Nos.)	-	-	18	3	6
5.	Surface Drainage	Free	Free	Free	Free	Free
6.	Ground Water Level (m)	-	130	115-140	130	135
7.	Expected Yield of Water	-	Poor	Good	Fair	Fair
8.	Prehistoric Site (Nos.)	-	-	9	-	1
9.	Archaeological Site (Nos.)	1	-	4	-	1
10.	Number of Cut Sections	4	22	62	13	19
11.	Average Length of Cut Sections (km)	0.185	0.085	0.124	0.318	0.108
12.	Number of Fill Sections	6	25	101	14	14
13.	Average Length of Fill Sections (km)	0.380	0.726	0.802	0.283	0.133
14.	Number of Irish Crossings	-	-	18	3	6
15.	Number of Box Culverts	1	6	16	8	8
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Bare	Grass	Grass/Tree	Tree/Grass	Grass
17.	Quality of Vegetative Cover	-	Scanty	Moderate	Good	Negligible
18.	Used for Grazing	-	Occasionally	Occasionally	Occasionally	-
19.	Used for Firewood Collection	-	-	Occasionally	Frequently	-
20.	Used as Irrigated Farm Land	-	-	-	-	-
21.	Used as Period Fallow	-	-	-	Limited	-
22.	Name of Settlement	-	-	-	Al' Abr	Al' Abr
23.	Location of Settlement (km)	-	-	-	183	183
24.	Primary Function of the Settlement	-	-	-	Trade/Admn.	Trade/Admn.
25.	Water Source	-	-	-	Well	Well
26.	School	-	-	-	Yes	Yes
27.	Healthcare Centre	-	-	-	Yes	Yes
28.	Administrative Office	-	-	-	Customs Bldg	Customs Bldg
29.	Prehistoric Site	-	-	4	-	1
30.	Archaeological Site	3	-	8	-	-

Table 3.2.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		11 (189-206)	**12** (206-233)	13 (233-238)	14 (238-243)	**15** (243-247)
A.	**Concerning Road Corridor**					
1.	Landform	Plain	Plain	Plain	Plain	Plain
2.	Stability	Erosional	Depositional	Stable	Erosional	Erosional
3.	Lithology	Colluvium	Sand/Gravel	Colluvium	Gravel/Sand	Gravel/Sand
4.	Wadi (Nos.)	-	-	-	-	-
5.	Surface Drainage	Free	Free	Free	Free	Free
6.	Ground Water Level (m)	150	170	160	140	130
7.	Expected Yield of Water	Good	Fair	Good	Good	Good
8.	Prehistoric Site (Nos.)	3	2	-	-	-
9.	Archaeological Site (Nos.)	2	-	-	-	-
10.	Number of Cut Sections	-	-	-	-	-
11.	Average Length of Cut Sections (km)	-	-	-	-	-
12.	Number of Fill Sections	2	1	1	1	1
13.	Average Length of Fill Sections (km)	8.5	27	5	5	4
14.	Number of Irish Crossings	-	-	-	-	-
15.	Number of Box Culverts	1	2	5	1	1
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Grass	Grass	Bare	Shrub/Legume	Shrub/Tree
17.	Quality of Vegetative Cover	Poor	Poor	-	Moderate	Fair
18.	Used for Grazing	Occasionally	Occasionally	-	Occasionally	Generally
19.	Used for Firewood Collection	-	-	-	-	Generally
20.	Used as Irrigated Farm Land	-	-	-	-	-
21.	Used as Period Fallow	-	-	-	-	-
22.	Name of Settlement	-	-	-	-	Bir Al Wahed
23.	Location of Settlement (km)	-	-	-	-	244
24.	Primary Function of the Settlement	-	-	-	-	Livestock
25.	Water Source	-	-	-		Bore Well
26.	School	-	-	-	-	Yes
27.	Healthcare Centre	-	-	-	-	Yes
28.	Administrative Office	-	-	-	-	-
29.	Prehistoric Site	3	1	1	-	1
30.	Archaeological Site	3	-	-	-	-

Table 3.2.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)				
		16 (247-248)	**17** (248-284)	18 (284-286)	19 (286-291)	**20** (291-306)
A.	**Concerning Road Corridor**					
1.	Landform	Wide Wadi Land	Plain	Dune	Plain	Plain
2.	Stability	Erosional	Depositional	Depositional	Depositional	Stable
3.	Lithology	Gravel	Silt/Gravel	Sand/Gravel	Silt/Gravel	Gravel/Silt
4.	Wadi (Nos.)	1	10	-	-	-
5.	Surface Drainage	Free	Free	Free	Free	Free
6.	Ground Water Level (m)	115	45	30	30	25
7.	Expected Yield of Water	Good	Profuse	Profuse	Profuse	Profuse
8.	Prehistoric Site (Nos.)	-	4	-	1	-
9.	Archaeological Site (Nos.)	-	4	-	3	-
10.	Number of Cut Sections	-	10	5	3	1
11.	Average Length of Cut Sections (km)	-	0.105	0.044	1.577	0.020
12.	Number of Fill Sections	1	25	6	4	4
13.	Average Length of Fill Sections (km)	1	1.348	0.283	1.157	3.723
14.	Number of Irish Crossings	2	10	-	-	-
15.	Number of Box Culverts	-	22	1	3	11
B.	**Concerning Adjacent Area**					
16.	Natural Vegetation Type	Shrub	Grass	Shrub/Grass	Grass	Tree/Grass
17.	Quality of Vegetative Cover	Moderate	Good	Good	Fair	Good
18.	Used for Grazing	Occasionally	Frequently	Frequently	Frequently	Frequently
19.	Used for Firewood Collection	Occasionally	-	Occasionally	-	Frequently
20.	Used as Irrigated Farm Land	-	-	-	-	Some
21.	Used as Period Fallow	-	-	-	-	Some
22.	Name of Settlement	-	-	-	-	Al Khasha Al Gauda
23.	Location of Settlement (km)	-	-	-	-	290/305
24.	Primary Function of the Settlement	-	-	-	-	Farming/ Service
25.	Water Source	-	-	-		Bore Well
26.	School	-	-	-	-	Yes
27.	Healthcare Centre	-	-	-	-	Yes
28.	Administrative Office	-	-	-	-	-
29.	Prehistoric Site	-	4	-	2	-
30.	Archaeological Site	-	3	-	-	-

Table 3.2.3 (contd)

SL. NO.	ATTRIBUTES	SEGMENT NUMBER WITH CHAINAGE (KMS)	
		21 (306-309)	22 (309-310)
A.	**Concerning Road Corridor**		
1.	Landform	Wadi	Plain
2.	Stability	Erosional	Erosional
3.	Lithology	Alluvia	Alluvia/Gravel
4.	Wadi (Nos.)	5	5
5.	Surface Drainage	Free	Free
6.	Ground Water Level (m)	20	20
7.	Expected Yield of Water	Profuse	Profuse
8.	Prehistoric Site (Nos.)	-	-
9.	Archaeological Site (Nos.)	-	-
10.	Number of Cut Sections	5	10
11.	Average Length of Cut Sections (km)	0.472	0.227
12.	Number of Fill Sections	6	8
13.	Average Length of Fill Sections (km)	0.309	0.226
14.	Number of Irish Crossings	5	5
15.	Number of Box Culverts	2	3
B.	**Concerning Adjacent Area**		
16.	Natural Vegetation Type	Shrub/Grass	Grass/Tree
17.	Quality of Vegetative Cover	Fair	Poor
18.	Used for Grazing	Frequently	Occasionally
19.	Used for Firewood Collection	Frequently	Occasionally
20.	Used as Irrigated Farm Land	Some	Some
21.	Used as Period Fallow	Some	Some
22.	Name of Settlement	-	Al Makhaneg
23.	Location of Settlement (km)	-	310
24.	Primary Function of the Settlement	-	Service
25.	Water Source	-	Bore Well
26.	School	-	-
27.	Healthcare Centre	-	-
28.	Administrative Office	-	-
29.	Prehistoric Site	-	-
30.	Archaeological Site	-	-

3.4 Assessment of Impact During Construction

3.4.1 There are many pertinent issues to be considered. These can be examined in two stages. First are the issues concerning the locations of construction camp sites and their impacts upon the environment. Second are the issues concerning construction of the road along the proposed alignment and their impacts upon the environment. These two sets of issues are examined below. In each instance, an impact matrix has been created by following the World Bank Guidelines given in their Environmental Assessment Source Book (Chapter-IX). To help appreciate these impact matrixes, detail discussions of the considerations have been placed.

3.4.2 Issues Concerning Construction Camp Sites

The term "construction camp" is taken to include, besides administrative and residential accommodation, plant and installations, workshops, garages, storage space and other stationery facilities required to keep the construction going smoothly. In the Feasibility Report no site has been specifically mentioned for the construction camps since, in general, this also depends upon the contractor's convenience and logistics. However, there are environmental considerations common to construction camps in general, as are addressed in the following arguments.

(a) **Required Number of Sites for Construction Camps** : Considering that there are few settlements on the road corridor and that the environment is hostile, it would be advantageous to engage two contractors to initiate road construction along the proposed alignment simultaneously from Safir and Al Makhaneg. This will be in tune with the suggestion of the World Bank. Al' Abr emerges as the natural choice for the two construction sections to meet. In that case, the total length of the proposed road will be split into two unequal parts - one covering 180.90 km between Safir and Al' Abr and the other stretching over 129.60 km from Al Makhaneg to Al' Abr. Each contractor should be expected to set up at least two sites for construction camps and create the facilities according to the provisions specified in Volume II of the Tender Document (1992). The issue to be resolved is about the choice of locations for these four sites with the objective of minimising negative impacts upon the environment and maximising opportunities to enhance the pace of future development along the road corridor. The Consultants recommend that the following sites will meet the above objectives:

(i) Near the proposed junction of the road with Marib-Safir road at Safir;

(ii) 5 to 7 km to the south-west of Al' Abr;

(iii) 5 to 7 km to the south-east of Al' Abr; and

(iv) Near the proposed junction of the road with Al Mukalla-Seiyun road at Al Makhaneg.

(b) **Rationale for Choice of Sites for the Four Construction Camps** : The sites chosen for setting up the construction camps are considered optimal for the following considerations:

(i) the contractors will find it advantageous to mobilise plants and machineries along the existing road corridors between Marib and Safir and between Al Mukalla and Seiyun;

(ii) in both the places, i.e., Safir and Al Makhaneg, groundwater is available in sufficient quantities, although at variable depths and some skeletal service infrastructure exists;

(iii) by acquiring a substantial amount of land for these two sites at Safir and Al Makhaned close to the two proposed road junctions, it would be easier to administer controls over the prospects of future settlement development therein;

(iv) two sites will be needed near Al' Abr because a rugged hilly range extends southwards to keep the road from Safir unapproachable from the road from Al Makhaneg till one comes to Al' Abr;

(v) the existing infrastructure of Al' Abr would come under extreme pressure unless the camps are set up a little away from it;

(vi) both the sites near Al' Abr can draw ground water of reasonable quantities;

(vii) after construction, these two ground water sources will stimulate future development of Al' Abr;

(viii) buildings in the four camp sites can be used for promoting four different types of development along the road corridor, the nature of which will be described later in this chapter; and

(ix) it is expected that the camps at Safir and Al Makhaneg will serve as the base camps.

(c) **Impact Matrix** : The recommended sites are located near Segment 1 (approximately), Segment 9, Segment 10 and Segment 22. In Table 3.4.2(c), the negative impacts of the camp sites upon the environment of these segments and required mitigating measures have been shown.

3.4.3 Issues Concerning Road Construction

Once again, one has to consider a variety of issues, which can be conveniently grouped under three sets. The first set would include factors governing extraction and disposal of local construction materials along with options available to avoid causing negetative impacts upon environment. The second set refers to slope stabilisation methods to be adopted for roads along with mitigating measures on the negative impacts. The third set will consider the effects of the road upon surface drainage alongwith mitigating measure. These are discussed below. At the end is given an impact matrix in consonance with the guidelines of the World Bank given in their Environmental Source Book (Chapter-IX).

(a) Extraction and Disposal of Local Construction Materials

Four different types of materials are locally available for construction of road. These are, (a) materials for embankment construction, (b) materials for sub-grade, (c) materials for base-course and wearing course and (d) water. The first two types of materials are envisaged to be collected from the borrow pits along or close to the road alignment (but outside the right-of-way width). The third type of materials are to be obtained from quarries, the available locations of which in relation to the road alignment have been identified. Water has to be drawn from the deeper aquifers. Spoils can be generated from the cut-sections, unless used for the fill-sections. Therefore, negative impacts may be caused, i.e., if (a) waste materials are not properly disposed off, (b) borrow pits and quarries containing relics of pre-history and archaeology are not substituted for, (c) scars on account of digging/mining in the borrow pits/quarries are left unattended and (d) water is extracted in such quantities as to cause injury to the local users. None of these problems are apprehended as far as this proposed road is concerned, as the following computations and arguments reveal.

Table 3.4.2(c)

Negative Environmental Impacts from Construction Camps and Their Mitigation

Sl. No.	Impacts	Order of Impacts Upon Road Segments (*)				Mitigating Measures	Actions
		1	9	10	22		
	DIRECT						
1.	Resettlement / land acquisition	0	0	0	0	None. According to available information camp sites can be located on government land	No action
2.	Destruction of vegetation	0	1	1	1	Establish camps away from vegetated areas. Where unavoidable plant trees in replacement of those cut	Include Special Condition in Tender Document. Monitoring during construction by GCRB/ Supervision Consultant
3.	Oil - grease spillage	1	1	1	1	Adopt good practice to avoid spillage and pursue collection and recycling	- do -
4.	Air pollution from asphalt plant	2	2	2	2	Select and maintain plant to satisfy pollution control criteria and locate plant at leeward edge of camp. This will be a local phenomenon confined to a few locations	- do -
5.	Dust and sound pollution from crusher	2	2	2	2	Locate plant at leeward edge of camp. No habitation other than the construction camp is likely to be affected	- do -
6.	Poor sanitation and waste disposal	2	2	2	2	Install lavatory; source separation of garbage; use of organic materials as compost; storage of non -bio- degradable materials	- do -
7.	Waste water	1	1	1	1	Irrigate camp site plantation	- do -
8.	Transmission of communicable disease	1	1	1	1	Periodic health check and medication	- do -
9.	Poaching	1	1	1	1	Control through terms of employment	- do -
10.	Obstruction to local communication	0	0	0	0	None	No action
11.	Archaeological and prehistory sites	0	0	0	0	Avoid significant sites as identified	Include special condition in Tender Document. Monitoring during construction by GCRB/ Supervision Consultant
12.	Social and cultural disruption	0	0	0	0	None	No action
	INDIRECT						
13.	Illegal timber cutting	0	1	1	1	Use liquid petroleum gas as fuel in kitchen	Include special condition in Tender Document. Monitoring during construction by GCRB/ Supervision Consultant

NOTE : * Order of impact implies : 0 = No impact; 1 = Mild; 2 = Moderate; 3 = High; 4 = Severe

(i) **Embankment Materials** : Even if it is assumed that no part of the excavated materials from cut section will be suitable for this purpose, which is indeed an extreme assumption, Table 3.4.3(i) shows that enough opportunity will remain to avoid digging up the sites containing the relics of pre-history or archaeology. In each section a lot of suitable sites for materials will remain surplus.

Table 3.4.3(i)
Requirement of Borrow Pits for Embankment Construction

Stretch of Road	Assessed Quantity of Materials Required (m^3)	Length of Borrow Pits Necessary to meet the need *	Assessed Length of Borrow Pit Available	Surplus Length
Safir to Al' Abr	822109	20.53 km	32 km	11.47 km
Al' Abr to Al Makhaneg	736572	18.40 km	104 km	85.60 km
TOTAL	1558681	38.93 km	136 km	97.07 km

Note : * Assumed size of borrow pits : 20 m wide x 2 m deep x length. Borrow pits can be wider at favourable locations e.g., to utilize better quality deposits and to facilitate equipment operation, subject to not interfering with archaeological/prehistoric sites.

(ii) **Sub-grade Materials** : Even it is assumed that no part of the excavated materials from cut section will be suitable for this purpose, which is once again an extreme assumption, Table 3.4.3(ii) shows that enough opportunities will remain to avoid digging up the sites containing the relics of prehistory and archaeology. The surplus length of sites of suitable materials support this assumption.

Table 3.4.3(ii)
Requirement of Borrow Pits for Sub-grade Construction

Stretch of Road	Assessed Quantity of Materials Required (m^3)	Length of Borrow Pits Necessary to meet the need *	Assessed Length of Borrow Pit Available	Surplus Length
Safir to Al' Abr	485140	12.15 km	48 km	35.85 km
Al' Abr to Al Makhaneg	298527	7.50 km	24 km	16.50 km
TOTAL	783667	19.65 km	72 km	52.35 km

Note : * Assumed size of borrow pits : 20 m wide x 2 m deep x length. Borrow pits can be wider at favourable locations e.g., to utilize better quality deposits and to facilitate equipment operation, subject to not interfering with archaeological/prehistoric sites.

(iii) **Disposal of Excavated Materials** : Holding on to the earlier assumption that no part of the excavated materials from the cut-sections will be used for road construction and all of these should be disposed off, Table 3.4.3(iii) shows that the available cavities of the borrow pits will prove more than adequate for this purpose. However, there still will remain some unfilled borrow pit cavities. Moreover, as usual in construction practice, a good proportion of the excavated material is likely to find use in embankment construction (constituting together what is known as cut and fill method).

Table 3.4.3(iii)
Length of Borrow Pit Cavities Required for Disposal of Waste Materials

Stretch of Road	Assessed Quantity of Ecavated Material (m^3)	Length of Borrow Pit Cavities Required for disposal *	Assessed Length of Borrow Pit Cavities Available *	Surplus
Safir to Al' Abr	571300	14.25 km	32.68 km	18.43 km
Al' Abr to Al Makhaneg	221000	5.50km	25.90 km	20.40 km
TOTAL	792300	19.75 km	58.58 km	38.83 km

Note : * Assumed size of borrow pits : 20 m wide x 2 m deep x length. Borrow pits can be wider at favourable locations e.g., to utilize better quality deposits and to facilitate equipment operation, subject to not interfering with archaeological/prehistoric sites.

(iv) **Mitigating Measures for Borrow Pit Cavities** : Considering that the road construction contractors will look for cost effective solutions by way of minimising the lead for transporting usable and disposable materials, the assumed sizes of the borrow pits might vary by way of extending the width. This will be particularly necessary for disposal of excavated materials. Similarly, the excavated materials should be reused if found suitable, for construction of embankment or sub-grades. To that extent, the actual lengths of the borrow pit cavities will get reduced but some borrow pit cavities might still remain as scars. However, such scars will soon disappear as wind carries a lot of sand at all hours. To assist the deposition of wind blown sand, the borrow pits should generally be located on the windward side of the road and the bottom of the pits should slope gently from the windward to the leeward side offering a near vertical face at the end. This will assist the filling up process by quickening the pace, i.e. by shortening the time required.

(v) **Base Course and Wearing Course Materials** : The assessed materials requirements are 335,000 m^3 for Safir to Al' Abr and 275,000 m^3 from Al' Abr to Al Makhaneg. In the eastern section, i.e., from Al' Abr to Al Makhaneg, suitable rocks are available relatively close to the proposed road alignment. This is not so with the western section, i.e., from Safir to Al' Abr, where good quality materials would be available within a 45 km lead from the proposed road alignment starting from 60 km and upto 170 km from Safir. In the eastern section, the suitable rocks form escarpments (TU_2 of the Tertiary formations). Care should be taken to locate the quarries at least 5 km away from the road alignment from the point of view of not disfiguring the landscape as seen from the road. In the western section, suitable rocks are available in the shape of low hills or slightly raised grounds. For the western section, syntectonic granite, ortho-gneiss and para-gneiss should be preferred. Here the quarries may not be made deeper than 4 m. The Cretaceous formations (K_2) should not be disturbed, because these constitute the recharge surfaces of the deep aquifers. Similarly, the marbelite formations (Proterozoic) in particular and Jurassic deposits in general should not be used. None of these outcrops contain any relic of prehistory or archaeology. The road construction contractor will have the option to bring stones from the established quarries near Marib to cover the first 30 km of the alignment from Safir. Boulders and gravels from the Wadi beds can also be used. However, for the eastern section, many of the screes and the colluvial deposits contain relics of prehistory or archaeology and these should not be disturbed.

(vi) **Extraction of Water** : The requirements of water for domestic consumption at construction camps and for road construction have been estimated. Assuming that the entire length will get constructed over 4 years, then the per day requirement shall gradually rise to stabilise at 245 m3. This amount of water has to be extracted from the deep aquifers so that no interference is introduced into the pattern of established use of water by the local communities. In Table 3.2.3, the depth of groundwater has been given for all segments of the road. The yield rate however varies between the segments. Based on the estimated yield rates and the available gradient of the land for piped transmission or tankers the likely favourable locations of the wells have been indicated in Table 3.4.3(vi) to meet the requirements per average day. This will leave sufficient elbow room for varying operation time for each well. However, the actual locationing of borewells and their yield potential for specific sites will have to be based on appropriate hydrogeological assessments supplemented with trial borings, where required.

Table 3.4.3(vi)
Approximate Locations of Bore-wells with Estimated Yield/Sec. and Total Yield on 10 hour Operation Per day

Locations by Road Segments	Estimated Yield Per Second (Litres)	Estimated Extraction Potential Per day (m^3)
Safir Camp Site	7	252
2 or 3	6	216
4	5	180
8	4	144
9	3	108
10	3	108
15	40	1440
22	50	1800

(b) **Cut and Fill Sections**

In Table 3.2.3 have been shown the number of cut and fill sections along with their average length for each segment of the road. To take care of the various types of disturbances these might cause, the engineering designs should provide for appropriate types of slope stabilisation methods. As further mitigation measures, road side plantation of suitable varieties of trees is recommended, especially where the dunes will be disturbed. Especially in Segment 1, the barchanoid dunes will have to fully excavated and the materials deposited elsewhere, such as in Segment 2 or on the leeward side of the road at Segment 1. The established aeolian processes will sooner or later recreate these dunes. To prevent such reactivation, a barrier wind screen in the form of Palm Frondes palisade or with HDPE strips hung from 5 m high poles spaced at 4 to 5 m interval may prove useful if constructed on the windward side of the road along the entire length of the excavated dunes. This will confine dune formation for some time, say at least for 5 years, before the road is engulfed. During this period, tree plantations should be established to arrest encroachment of road by dunes. The wind screen should be placed at least 30 m away from the outer limit of the right of way. Preferably, these plantations be located on the outer edges of the designed right of way wherever possible.

(c) **Interference Upon Surface Drainage**

In Table 3.2.3 has been shown the number of wadi crossings, Irish crossings and box Culverts for each segment of the road. It will indicate that no interference to surface drainage will be caused. The engineering designs for the Irish Crossings and Box culverts should take care of their stability against future erosion and siltation.

(d) **Impact Matrix**

The impact matrix covering all aspects of negative impacts of road construction activities have been shown in Table 3.4.3(d). The fuller implications of the mitigating measures suggested in the impact matrix can be appreciated if read in conjunction with the preceeding discussion.

3.5 Assessment of Impacts After Road Construction

3.5.1 The processes of road construction will improve the quality of regional infrastructure, demands for which already exists. Naturally clustering of consumers of these facilities will take place soon after these are created. There are a number of issues to be considered to avoid the negative impacts or to administer appropriate mitigating measures in this regard. These are addressed to in the following paragraphs.

(a) **Clustering Around Construction Camps**

The two larger camp sites at Safir and Al Makhaneg will tend to get serviced by small entrepreneurs, who will inevitably give rise to shanty type settlements. They should be given an option to keep themselves in readiness to shift into the camp sites soon after the labour force is taken to Al' Abr sites or else face the consequences of demolition of the shanty. This means that supplementary investments must be made to develop a planned settlement at the two camp sites at Safir and Al Makhaneg. Similar strategy should not be followed for the two camp sites at Al' Abr, because the environment is more fragile there. Instead, investments to develop a planned town of Al' Abr should be made before the camps get set up. In and around, the two camp sites, measures to prevent the growth of shanty town should be strictly administered. This will require the construction contractors to draw their supplies from the town of Al' Abr which will assist growth in trade and commerce in that town.

(b) **New Sources of Water**

From Table 3.4.3(vi) it will appear that 8 new sources of water will get created. Each one of these will attract consumers, especially the Bedouins. As long as water will be drawn from these bore-wells, supplies to these visiting consumers should be given free of charge, but with a warning that some of these must be shut down after construction of the road. On consideration of the fragility of environment, the bore well at Segment 2 or 3 must be shut down after road construction. The other seven bore-wells may continue to function commensurate with the strategy of enhancement described in the following section.

Table 3.4.3(d)

Negative Environmental Impacts from Construction of Road and Their Mitigation

Sl. No.	Impacts	Order of Impacts (*)	Mitigating Measures	Actions
	DIRECT			
1.	Dislocation and compulsory resettlement of people living on the right of way	0	None. According to available information ROW is government land.	No action
2.	Poaching by construction workers	1	Prohibit poaching under terms of employment	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
3.	Reactivation of dunes	3	Wind screen and plantations	Wind screen construction and plantation programme implementation by ERADA/EPC. Monitoring by MMP
4.	Landscape disfiguration by high embankments and deep cuts	1	Road side plantation of trees and gentle slope at cut and fill sections	None for embankment but for cut section tree plantation. Programming and implementation by ERADA. Monitoring by MMP.
5.	Borrow areas and quarry sites	1	Systematic and controlled excavation/ quarrying of borrow/quarry areas preferably on windward side and backfilling by waste material from cut section. Avoid significant heritage sites	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
6.	Landslides, slumps and slips in road cuts	1	Provide drainage works and stabilise with retaining structures like concrete/masonry wall, gabions, grouted rip rap etc. where risk exists.	Necessary measures to be taken in design. Monitoring during construction by GCRB/Supervision Consultant
7.	Air, dust, fume, smoke and noise pollution to inhabited areas from construction equipment, crusher, blasting at quarries	1	Use pollution control for construction equipment, control blasting at quarries with precautionary measure at quarries during blasting. Avoid installations near inhabited areas.	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
8.	Interference with surface drainage	2	Provide ditches and cross drainage structures	Necessary measures taken in design. Monitoring during construction by GCRB/Supervision Consultant
9.	Erosion of or along road embankment by flowing water	2	Channelise water flow through drains. Provide drain lining and other erosion protection measures at vulnerable locations	Necessary measures to be taken in design. Monitoring during construction by GCRB/Supervision Consultant
10.	Alteration of sub-soil water table due to water abstraction	1	Controlled withdrawal of water from deep aquifer	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant.
11.	Alteration of hydrological regimes of wet lands	0	None	No action
12.	Destruction of vegetation and wildlife on the right of way	0	Regenerate vegetation in the neighbourhood plus roadside plantation. Do not disturb vegetation outside the area occupied by the road embankment or cut.	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant.

Table 3.4.3 (d) (contd)

Sl. No.	Impacts	Order of Impacts (*)	Mitigating Measures	Actions
13.	Destruction of biological resources or eco-systems	0	None	No action
14.	Interruption of migratory routes for wild life and livestock	0	None	No action
15.	Creation of breeding habitats for mosquito by stagnant pools of water	0	Provide drainage or reuse water for vegetation. Facilitate quick fill up by of empty borrow pits by aeolian movement of sand	Include Special Condition in Tender Documents. Monitoring during construction by GCRB/Supervision Consultant
16.	Creation of a transmission corridor for diseases, pests, weeds and other undesi-rable organisms	0	None	No action
17.	Construction interferences to existing traffic	1	Provide markers, lights with warning signs for traffic diversion	Include Special Condition in Tender Documents for lights and warning signs. Monitoring during construction by GCRB/ Supervision Consultant
18.	Destruction of utility lines	0	Take precautionary measures and avoid moving construction equipment over or near the utility lines	Monitoring during construction by GCRB/Supervision Consultant
19.	Obstruction of routes from houses to farms	1	Provide suitable crossings	Special Tender provision for construction of diversion road and monitoring during construction by GCRB/Supervision Consultant
20.	Archaeological and prehistory sites	2	Avoid significant sites as identified. Significant sites to be protected by fencing. If necessary select alternative alignment	
	INDIRECT			
21.	Accident risks associated with vehicular traffic	2	Design curves (horizontal and vertical) for high speed traffic; introduce emergency plan to contain damages from accidental spills.	Already measures taken in Geometric Design of road. Monitoring during construction by GCRB/Supervision Consultant
22.	Impairment of non-motorised trans-portation in the highway corridor	1	Include safe crossings and diversions where required	Special Tender provision for construction of diversion road. Monitoring during construction by GCRB/Supervision Consultant

NOTE : * Order of Impact implies

0=No impact; 1=Mild; 2=Moderate; 3=High; 4=Severe

(c) **Linear Settlement Development**

It is apprehended that all along the road corridor stretching from Al Makhaneg to Al Khasha, residential-cum-commercial buildings are likely to come up. Land planning actions should be initiated to control setbacks and plot sizes to avoid congestion in future.

(d) **Impact Matrix**

The considerations stated above would yield an impact matrix, which is placed as Table 3.5.1(d)

3.6 Enhancement Measures

3.6.1 In the May 10-23, 1993 Aide Memoire (Para 2 - Component B) of the World Bank Project Mission a suggestion has been made to develop basic facilities for local communities at about 6 selected locations along the road alignment. This is also included in the TOR [para 5(e)]. This suggests that some additional investments be made to facilitate public participation for economic development along this road. Since water constitutes a fundamental facility, it is suggested that these sites be located near the bore-wells to be set up in Segments 1, 4, 9, 10, 15 and 22. However, the use to which these resources be assigned to should be given by the order to fragility of the environment in their neighbourhood. These are specified below.

(a) **Segment 1**

The camp site near the proposed road junction on Marib-Safir road should be allowed to develop into a small urban settlement. It will service both the Safir refinery community and the users of the Safir-Al' Abr-Al Makhaneg road. It should have commercial establishments dealing with eating houses, provisions and groceries, gas station and vehicle repair facilities. The building constructed by the road contractors should be used by the GCRB staff engaged in the maintenance of the road. It may also house the staff to develop road side plantations and to carry out other measures to combat desertification. It should have a primary health centre and a school.

Table 3.5.1 (d)

Negative Environmental Impacts After Road Construction and Their Mitigation

Sl. No.	Impacts	Order of Impacts (*)	Mitigating Measures	Actions
	DIRECT			
1.	Air and noise pollution from increased vehicular traffic	1	None. The expected traffic level being low to moderate and the traversed area being largely uninhibited, no actual inconvenience is envisaged	No action
2.	Roadside litter	1	Provide roadside disposal facilities. Campaign for CLEAN YEMEN; strengthen local governments for proper conservancy service in towns and villages	Monitoring by EPC and local government
3.	Induced development of commercial, residential and industrial development	3	Plan for controlled development	Planning and monitoring by EPMC and concerned ministries
	INDIRECT			
4.	Impairment of non-motorised transportation economy due to increased availability of motorised alternatives	0	None	No action
5.	Unplanned timber cutting	1	Introduce fuel-yielding trees as a part of programme to arrest desertification. Enforce forest conservation laws.	Monitoring by EPC
6.	Unplanned land clearing and occupation	2	Plan for controlled development	Planning and monitoring by EPMC and concerned ministries

NOTE : * Order of Impact implies
0=No impact; 1=Mild; 2=Moderate; 3=High; 4=Severe

(b) **Segment 4**

At this site, the most attractive investment may come through setting up a small hotel (30 rooms) for the tourists interested in experiencing the beautiful, though gaunt, desert landscape. It should have in addition a gas station and a small provision store attached to it. The buildings may not be more than one-storeyed in structure surrounded by walls and tree lines. The hotel should be owned by the Government, but operated by private entrepreneuers at prescribed rates.

(c) **Segment - 9**

This will be a construction camp site. This facility should house the staff assigned with the task of promoting orchard development with shelter belts from Al' Abr side into the desert as far as the bore well can command after supplying water to Al' Abr town. This is a highly dissected terrain and cannot support grain farming. The soil is rather rich and may not be used for developing grazing ground. However, if the demand for grazing land emerges, then a new well can be set up in Segment 8 and the practices recommended for Segment 10 be followed therewith.

(d) **Segment 10**

This will be a construction camp site. This facility be used to house the staff to be engaged for developing the grazing grounds. Periodic watering with seeding should be practiced. Preference for succulents and legumes is emphasised. Trees of xerophytic order can also be planted as sources of fire-wood. However, emphasis should be put to let the neighbourhood population, say at Al' Abr, to use LPG instead of wood in their kitchens.

(e) **Segment 15**

This bore-well can be used to encourage the development of road-side orchards with shelter-belts extending towards east and south-east and for developing grazing grounds towards west as far as the available water can command. The nearby settlement of Bir Al Wahed has the other necessary facilities.

(f) **Segment 22**

This site will initially be used as a construction camp site. This facility should house the staff of the GCRB for maintenance works in future. But this site has the potential to develop into a significant urban centre of the type found

along the Al Mukalla-Seiyun road. Private investments are likely to come quickly. Hence, land planning measures should be designed and implemented in advance.

3.6.2 The above mentioned six activity centres will meet the objectives of the World Bank Project Mission and TOR. But care should also be taken for the stretch of the road from Wadi Amad to the village of Al Khasha. In this area, incentives should be given to encourage the development of road side orchards with shelter trees, but with the support of private wells. The sooner such a programme is initiated, the easier it will be to control linear development of residence-cum-commercial buildings along the road.

3.6.3 In addition to enhancement measures stated in para 3.6.1, a set of positive impacts are identified during all stages of construction of the road. These are given in Table 3.6.3 along with suggested actions and monitoring.

3.6.4 While designing the action progrmames of the nature stated above, it would be useful to study all the Basic Studies appended to this report.

Table 3.6.3

Summary of Positive Environmental Impacts

Stage	Sl. No.	Positive Impact	Actions
		DIRECT	
Construction of camp sites	1.	Local employment generation	Monitoring by local authorities
	2.	Additional consumption of local produce	- ditto -
During construction	3.	Local employment generation	Collecting employment statistics by EPMC
	4.	Enhancement of local skills (technology transfer)	- ditto -
After construction	5.	Elimination of multiple tracks on desert floor	Post-construction surveys by GCRB/EPMC
	6.	Local employment generation in road maintenance and transportation sectors	Keeping statistics by GCRB
	7.	Improve the access of Bedouins to social services like education, health, trade, livelihood and increase in social interaction between communities	Monitoring by local government/concerned ministries together with regional development
		INDIRECT	
Construction of camp sector	8.	Taking over camp buildings and associated facilities as maintenance depots, community centres or growth nucleus	Inserting special condition in contract regarding taking over camps
	9.	Utilisation of deep borewells for enhancing local water supply	- ditto -
All stages	10.	Improvement of security environment	Keeping chronological record of security related incidents by concerned government department
	11.	Activation of local economy due to improved access and security	Planning and monitoring by the concerned government departments

CHAPTER IV

ALTERNATIVE ALIGNMENT STUDY

CHAPTER - IV
ALTERNATIVE ALIGNMENT STUDY

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CHAPTER - IV

ALTERNATIVE ALIGNMENT STUDY

4.0 Introduction

4.0.1 In Section B (Para 6) of the TOR, it is specified that the Consultant will carry out a study of various alignment variations on the last 25 km of the project at the Hadramout end before Hawrah. The objective of this review of alignment has been specified as :

(a) to look into the possibilities of avoiding the small settlements (villages) along the cobble-stone road following the right bank of the Wadi Hadramout as chosen in their Feasibility Report by the Consultant;

(b) to look at minor alignment adjustments at each settlement;

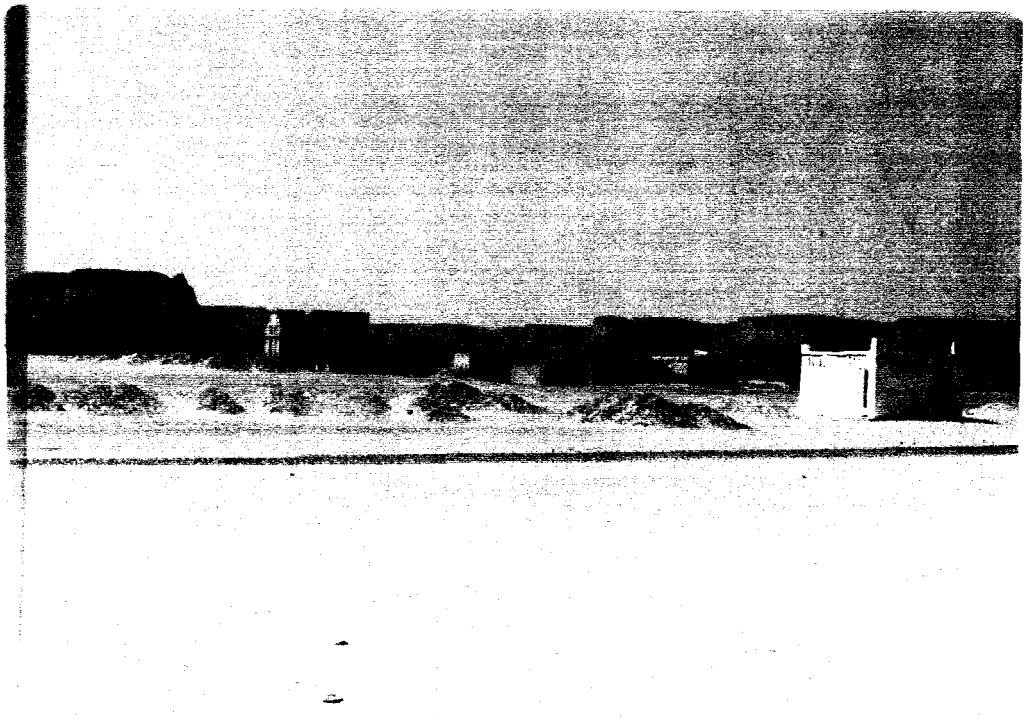
(c) to review the possibility of moving the general location of the alignment towards or on the other side of the sand-dune area;

(d) to establish at the same time a better connection with the proposed continuation of the project towards Seiyun; and

(e) to carry out this work with close co-operation with EA specialists.

4.1 Organising the Study

4.1.1. The Consultants had mobilised a team of highway engineers and an EA team (comprising two environment specialists, one desert ecologist, one hydro-geologist, one regional planning expert and two highway engineers) to carry out studies along the alternative alignments. For this purpose, this team visited the area in the first week of October, 1993. The teams also carried out a study in the form of Initial Environment Examination (IEE) of the tract bounded by the two mountains in the Wadi Hadramout over a length of 45 kms from Al Makhaneg. The objective of IEE was to take stock of the relevant environmental factors as may be impacted upon by one or the other possible alternative alignments. In consultation with the highway engineers, the EA specialists selected several control points for three possible alignments along this terrain and using the



19. SETTLEMENTS IN AL KHASHA ALONG EXISTING COBBLE TRACK (KM 295)

20. SETTLEMENTS IN DAR AL NASER ALONG EXISTING COBBLE TRACK (KM 297)

control points, three alternative highway alignments were identified for environmental study.

4.1.2 Along the three alternative alignments identified as above, a team consisting of two social anthropologists visited the tracts with a view to assessing the perceptions of the people of the region regarding comparative utility of the chosen alternative alignments. Another team consisting of one pre-historian and one archaeologist visited the area. The pre-historian felt that prehistoric relics would be found abundantly along the base of the northern hills as he had observed along the base of the southern hill. One should also note that Haynan is as old as Shibam as an important trading station between Arabia and Hadramout.

4.1.3 All these expert views have been used to assess the merits and demerits of all the alternative alignments by way of comparing those with the alignment chosen by the Consultant in their Feasibility Report. The final selection of the alignment has been made in favour of that one which is

(a) likely to cause least injury to environment;

(b) like to involve least cost for road construction;

(c) likely to demand least effort on road maintenance;

(d) likely to induce least dislocation of the currently pursued economic activities of local people through land acquisition; and

(e) likely to obtain cultural endorsement of the potential users of the road.

4.1.4 The objective of this chapter is to explain the implications of the information examined by the EA specialists and the highway engineers.

4.2 Hydrological and Physiographic Features

4.2.1 The optimum location for connecting the proposed Safir-Al' Abr-Hadramout Road with the Al Mukalla-Seiyun Road is available at Al Makhaneg from considerations of minimising road length. In their Feasibility Report, the Consultants have chosen this point quite correctly. Any other point between Al Makhaneg and Hawrah or between Al Makhaneg and Seiyun would increase road length considerably. Hence the eastern boundary of the tract chosen for IEE study is located near Al Makhaneg. The TOR has suggested that the alternative alignments should avoid the first 25 km of the proposed road as per the Feasibilty

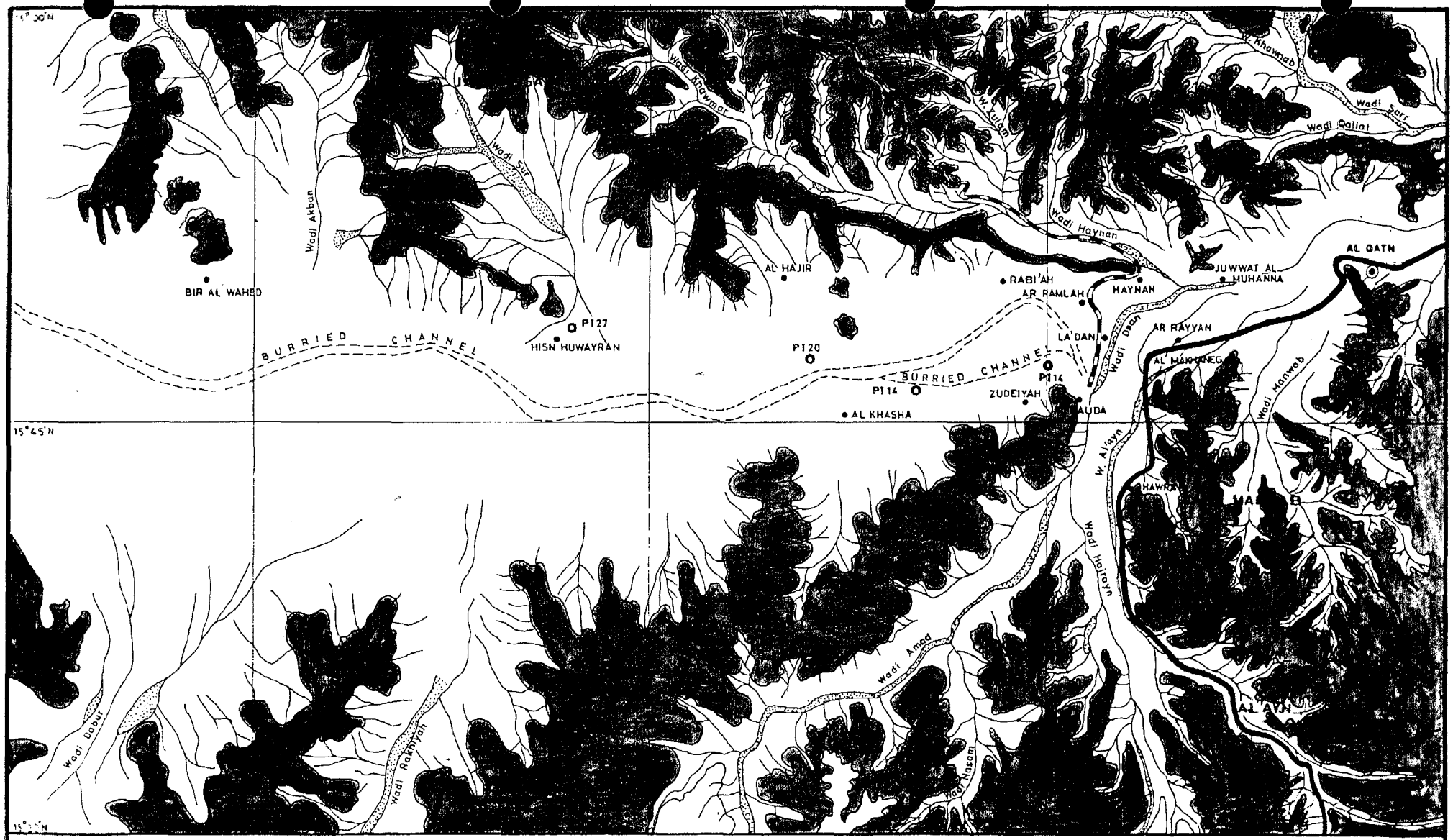
Study proceeding from Al Makhaneg towards Al' Abr. This means that the alternative alignment should take off from PI-20 of the proposed road. The EA specialist considered it safer to go a little to the west of PI-27, which is about 38 km from Al Makhaneg, to fix the western boundary of the tract chosen for IEE study. The northern and southern boundaries are generally given by the two hill ranges flanking the Wadi Hadramout.

4.2.2 During their study on EA over the entire length of the proposed Safir-Al' Abr-Hadramout road, the EA specialists noticed that hydrological and physiographic layout of the terrain in this part of the world defines more or less the diverse ecological niches. In Figure 4.2.2 has been shown the disposition of the sub-surface and surface orientations of the water courses vis-a-vis the mountains and the valley.

4.2.3 There is a buried water course, carrying water from west to east, following more or less the mid-section of the Wadi Hadramout. The presence of this buried channel is discernible from the satellite images. Inspection of the water table in the various wells also confirms the alignment of this buried water course as shown in Figure 4.2.2. It may be noted that this buried channel bifurcates somewhere between PI-20 and PI-14 and the two meet again before joining the Wadi Amad. Bounded between these bifurcated channels, the ground is covered by barchanoid type of sand-dunes, which the TOR has identified. It will be shown later that there are the other types of sand-dunes in this terrain beyond this barchanoid tract.

4.2.4 There are a large number of wadis flowing from the northern and the southern hills. Of these, the important left bank tributary wadis are the Wadi Akban, Wadi Sur and Wadi Haynan. Of the right bank tributary wadis, mention should be made of Wadi Dabur, Wadi Rakniyah, Wadi Amad, Wadi Hajrayn, Wadi Doan and Wadi Al Ayn. Like in the case of other smaller wadis, surface flows from Wadi Akban, Wadi Sur, Wadi Dabur, Wadi Rakniyah and Wadi Al Ayn disappear as sub-surface flows from high rate of percolation through accumulated sand in this part of Hadramout valley. However, the surface flows are seen in this valley as of Wadi Amad, Wadi Hajrayn, Wadi Doan and Wadi Haynan after cloud bursts.

4.2.5 Within 3 km from the villages of Ar Ramlah and Juwwat Al Muhanna on the left bank and between PI-14 and Al Makhaneg on the right bank of the Hadramout valley the water courses of the two buried channels (of para 4.2.3) meet and also the two surface channels of Wadi Haynan from the left bank and Wadi Amad from the right bank. The combined flows of the two buried channels and Wadi Amad form the Wadi Doan. It should be noted further that during flash floods, water



LEGEND:-

- HILLS
- VISIBLE WATER COURSES
- BURRIED CHANNEL
- MARKERS ON ALIGNMENT AS PER FEASIBILITY REPORT — PI 27
- AL MUKALLA-SEIYUN ROAD
- HAYNAN-AL GAUDA COBBLE ROAD
- SETTLEMENTS

5 0 5 10 km

SCALE

FIG. Nr. 4-2-2

TOPOGRAPHY AND HYDROLOGY AT HADRAMOUT END OF PROPOSED ROAD

overflows from Wadi Al Ayn to mix with Wadi Doan. The Wadi Hajrayn, a tributary to Wadi Amad, also drains a large area. When cloud bursts sychronise in these valleys, flood conditions prevail over several days in the valley of Hadramout down-stream of the line joining the villages of Haynan on the left bank and Al Makhaneg on the right bank. In the first week of May 1992 such a synchronisation took place. Further downstream, slow water-logging conditions prevailed over a number of more days. Hence the EA specialist considered that any alternative alignment passing to the north of the sand dunes should not try to cross the Hadramout valley east of Haynan- Al Makhaneg line.

4.2.6 The eastern limit for placing the alternative road alignments has been marked on Figure 4.2.6, which otherwise show the spatial orientation of various ecological niches, conditioned as these are by lithofacies, geomorphological processes and disposition of hydrology. In a way, these ecological niches represent diverse physiographic micro-provinces.

4.2.7 Not all the physiographic provinces are good for road building purposes, for various reasons. For example, the hills present difficulties on account of differences of elevation between these and the rest of the road alignment. Then amongst the various types of dunes, the barchanoids are the worst. These are mobile in the sense that sands shift to give rise to coalescing dunes. Moreover, these types of dunes at the windward side usually have soft uncompacted ground materials. The hummocky dunes are better than the barchanoids in the sense that the ground is firm and compacted. Unless protective measures are taken, cleared hummocky dunes may give rise to shifting dunes. The seif dunes, in contrast, remain stable unless the roads cut through these in transverse sections. Sand covered flat lands pose no problem for road construction. The spatial orientation of all these types of dunes have been shown in Figure 4.2.6.

4.2.8 The best ground surface for road construction is offered by the piedmont zone. Here the ground is firm and the required road building materials are found from the adjacent hills. In the terrain under consideration, there are two piedmont zones running parallel to the valley on either side. The northern zone is, however, narrower and steeper than the southern one. Since the southern piedmont has been used by the Consultant for laying an alignment in their Feasibility Report, the northern zone was chosen to run an alternative alignment with provision to use the old cobble stone road connecting Haynan with Al Makhaneg.

4.2.9 It may be noted that agricultural land extends along the northern and the southern margins of the barchanoid dunes. These follow the orientations of the two buried channels mentioned in para 4.2.3. To the east these two tracts merge to form a

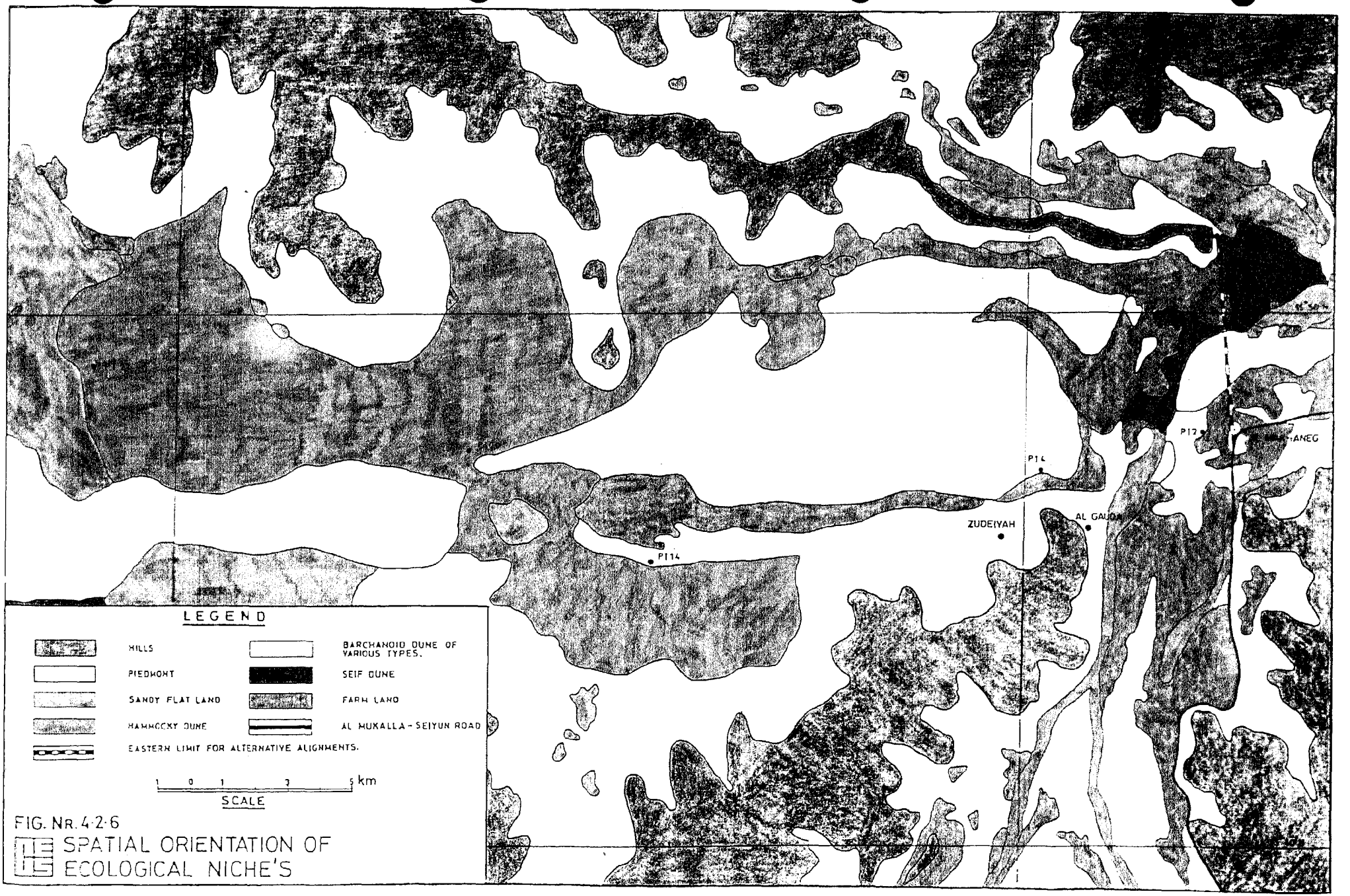


FIG. Nr. 4·2·6

SPATIAL ORIENTATION OF ECOLOGICAL NICHE'S

large continuous area of farm land with islands of piedmont type of land. It was decided to run two alternative alignments along the northern edge of the barchanoid dunes close to the hummocky dunes and farm lands with provisions to join PI-4.

4.2.10 Along all the three possible alternative alignments, a series of control points were chosen on the basis of information available from the 1987 - topographic maps at 1:100,000 scale to guide the search for acceptable alignments. The changes obtaining in the orientations of the different physiographic provinces and locations of habitations in the terrain were noted for being shown in the highway alignment plan.

4.3 Evaluation of the Four Alignments

4.3.1 The alternative alignments have been plotted together with habitations and the boundaries of ecological provinces as shown in Figure 4.3.1. However the survey could not be carried out along the middle part of Alternative A due to the existence of military camps. This map shows that none of the alignments can completely avoid proximity to the small habitations. Nevertheless, the data collected permit comparative evaluation between all the alignments.

4.3.2 Considered purely in terms of road length from PI-27, Alternative B appears to be the worst choice. It would have a length of about 47 km. Alternative D (i.e., the alignment chosen in the Feasibility Report) will have, on the other hand, the shortest length of 38 km. Alternatives A and C will have lengths of 44 km in each instance.

4.3.3 The old cobble stone road between Haynan and Al Makhaneg (forming part of alternative Alignment A) has mostly been eroded away. The explanation of this phenomenon may come from the assumption that water piles up in the buried channel when the flow along Wadi Amad and Wadi Doan is high, leading to subsidence of the embankment. This alignment cuts through seif dunes in transverse sections and also farm land. It has to cross Wadi Amad between Segments A7 and A8. To satisfy horizontal geometrics at A7, a considerable area under habitation and farm land will have to be displaced. In addition, the number of required cross drainage structures along the piedmont zone will be very high as the width of this zone is very narrow and slopes are steep due to their proximity to the hills. On these considerations, Alignment A is rejected.

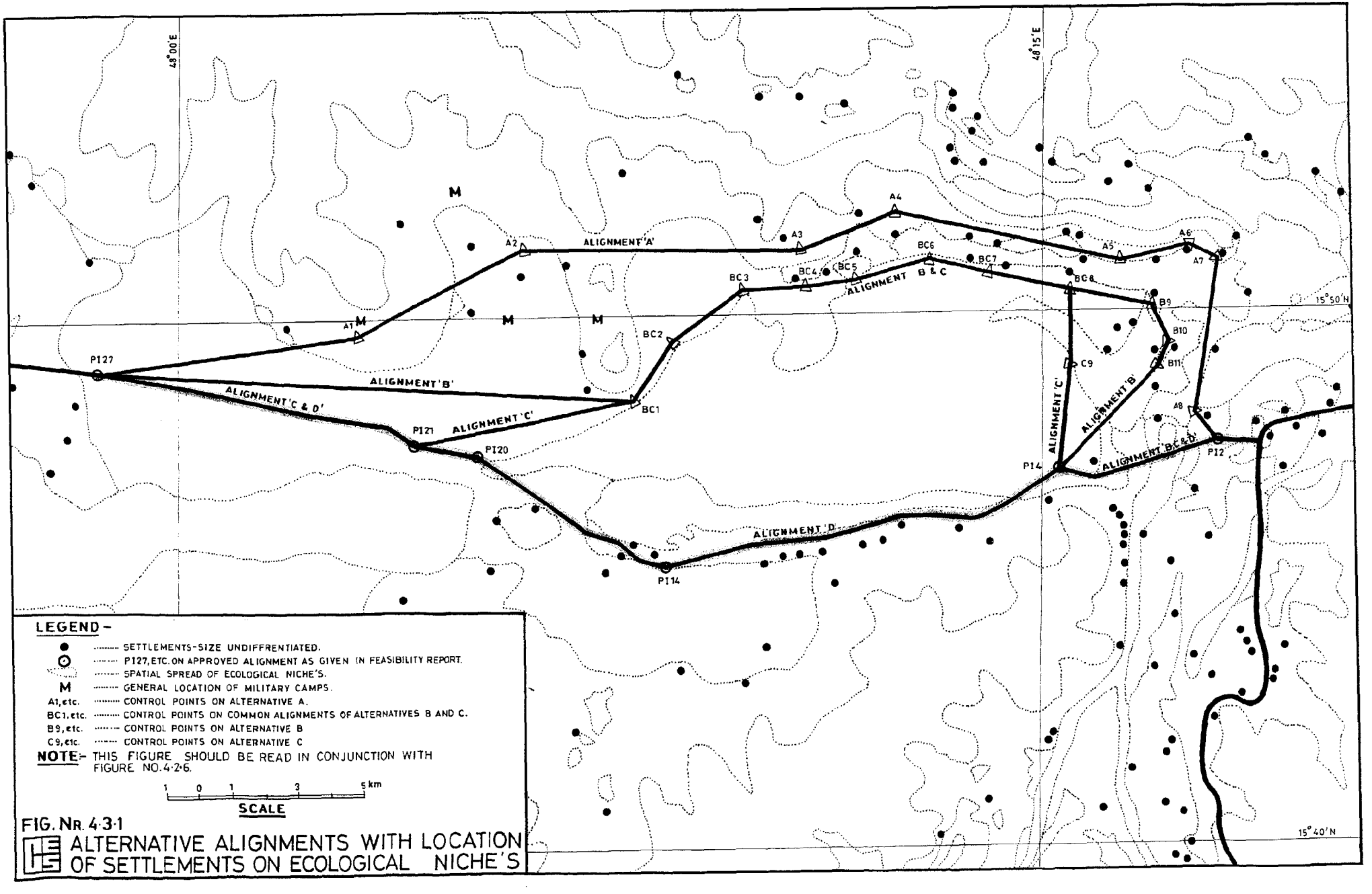


FIG. NR. 4·3·1

ALTERNATIVE ALIGNMENTS WITH LOCATION OF SETTLEMENTS ON ECOLOGICAL NICHE'S

4.3.4 Alignment B and C follow a common line between Segments BC1 to BC8. Amongst these from Segment BC5, this common alignment cuts through a hummocky dune zone, which is an acceptable proposition on the assumption that dune stabilisation actions will be taken up along with road construction. But in Segments BC5 to BC8 the proposed alignment cuts through barchanoid dunes to avoid the small habitations located along the margin of the farm land and the barchanoid dunes. It should be noted that excavation of barchanoid dunes causes unpredictable consequences. There is no effective method for stabilising disturbed barchanoid dunes. Hence Segments BC5 to BC8 cannot be supported from the environmental angle. Also the alignment should not be shifted any closer to the farm land to the north.

4.3.5 It may be further noted that Segment BC8 to B9 of Alignment B cuts through barchanoid dunes. This also happens in the last stretch of Segment B11 and PI-4. It is considered that this portion of the alignment should be avoided, otherwise a considerable amount of farm land will have to be displaced between Segmenets B9 and B10 and between B10 and B11, which should also be avoided.

4.3.6 Alignment C has a common length with Alignment D between PI-27 and PI-21. But between PI-21 and BC1, the proposed alignment cuts through shifting dunes. It may be noted that this shifting dune was not there in the 1987 topographic map. Its origin may be related to the actions taken by the military authority by way of clearing the hummocky dunes to the north of this zone without taking any mitigative measures. If this alignment is to be chosen, then the shifting dunes should be excavated with immediate mitigative measures like wind screen and tree plantation. Environmental evaluation of the common segments of alignments B and C between BC1 and BC8 have already been noted under para 4.3.5 above. Segments BC8 to C9 and C9 to PI-4 cut through a long length of barchanoid dunes and a short stretch of farm land. This should be avoided. It may be further noted that the ground in the segment between C9 and PI-4 is soft as is expected to occur on the windward side of barchanoid dunes.

4.3.7 To summarise, none of the four alignments can avoid nearness to small habitations; Alignment A, B and C causes displacement of considerable amount of farm land. The horizontal curves are also very sharp with Alignments A, B and C. Further, the Alignments B and C cut through barchanoid dunes, which is a rather risky proposition. The cost of mobilising road building materials for Alignments B and C will be higher than either alignments A and D.

4.3.8 Considering all the factors mentioned above, Alignment D is found to be the best available choice. This is the alignment chosen in the Feasibility Report in 1992. It is shortest in length. It crosses the buried channel at its narrowest point (between PI-20 and PI-14). It avoids displacement of farm land. It does not disturb the vulnerable dunes. It, however, passes close to habitations, which in any case is not avoided by any of the other alignments.

4.3.9 The Social Anthropologists in the survey team observed that roads are seen by all communities as a welcome facility. As soon as an alignment is flagged, the price of land goes up, declining away from the road, which has already happened with Alignment D. Investments will lead to linear settlement development along any alignment that is chosen. What is needed, therefore, is the strict enforcement of landuse control measures.

4.3.10 The Prehistorian and Archaeologist in the team believe that relics will not be found along Alignments B or C. However along Alignment A, there are distinct possibilities of finding such resources subject to detailed surveying involving additional cost. But such surveys can not be undertaken since the central part of the alignment corridor is presently occuped by the military.

4.3.11 In Table 4.3.11 a comparative statement of various alternatives highlighting magnitude of environmental impacts has been presented.

Table 4.3.11

Magnitude of Impacts on Proposed Alternative Alignments

Sl. No.	Variables	Magnitude of Impact on Various Alternatives			
		Alternative A	Alternative B	Alternative C	Alternative D
1.	Approx. Length (km)	44	47	44	38
2.	Horizontal Geometrics	Poor	Poorest	Poor	Smooth
3.	Vertical Geometrics	Fair	Poor	Poorest	Smooth
4.	Cross Drainage Structure	Maximum	Less	Less	Minimum
5.	Skirting of Unstable Sand Dunes	Minimum	Considerable	Maximum	Less
6.	Requirement of Sub-grade strengthening	Nil	Nil	Considerable	Nil
7.	Availability of Construction Material	Nearest to Alignment	Farthest from Alignment	Farthest from Alignment	Near to Alignment
8.	Dislocation of Settled Population	Moderate	Moderate	Moderate	Nil
9.	Displacement of Farm land	Less	Considerable	Maximum	Minimum
10.	Serving of Settlements	Considerable	Considerable	Considerable	Considerable
11.	Cultural Endorsement of Potential Users	Considerable	Minimum	Minimum	Maximum
12.	Construction Cost	Maximum	Less	Less	Minimum
13.	Maintenance Cost	Less	Maximum	Considerable	Least

CHAPTER V

ENVIRONMENTAL MANAGEMENT PLAN AND MONITORING

CHAPTER - V
ENVIRONMENTAL MANAGEMENT PLAN AND MONITORING

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Fig. 5.2.8 Flow Diagram - Environmental Management and Monitoring Plan

CHAPTER - V

ENVIRONMENTAL MANAGEMENT PLAN & MONITORING

5.0 Introduction

5.0.1 In the TOR under paragraphs 5e and 5 f, the GCRB has specified that the EA study should include an Environmental Management Plan (EMP) as also a plan for monitoring the activities related to the EMP. In other words, the EMP and the monitoring plan (MP) are inter-related issues. The GCRB has also specified that the EMP should also include a cost estimate for carrying out all the mitigative and enhancement activities. To address these issues is the objective of this chapter.

5.1 Scope of Monitoring

5.1.1 In Chapter III of the EA study report, all the mitigative measures required to deal with the significant negative impacts arising from road construction have been identified. Most of the mitigative measures can be carried out through engineering designs related to slope stabilisation, cross-drainage structures, borrow- pit excavation methods, handling of quarry sites, disposal of wastes, etc. The cost on this account has been included in the detailed Project Cost Estimates as presented in Volume II.

5.1.2 It is envisaged that the road construction will be carried out with strict adherence to the approved engineering designs, which would incorporate the mitigative measures. However, the Supervisor-Consultant should be authorised to recognise the need for admitting marginal modification of the approved designs as this need always arises at the time of construction. To judge whether the modifications are really marginal in nature, the supervision team must have thorough acquaintance about the environmental factors of the given terrain. Attachment of an EA specialist to the office of the Supervisor-Consultant may, no doubt, be of help. However, this responsibility can be discharged better by the original design consultants, because they have had a thorough exposure to the EA processes.

5.1.3 The point to note is that the objective of monitoring is to ensure that environmental mitigation measures are properly identified and implemented during construction, to intervene upon the processes going wrong and to suggest needs as they arise for changes in environmental impact mitigation measures.

5.1.4 In the EA study report, a number of other measures have been suggested, which are supplementary to road design and construction as such, but are intended to enhance the potential environmental and social benefits of the road project. In fact the heritage of this society can hardly be preserved without those actions. Accordingly for enhancing the quality of environment as also to facilitate regional development processes, a number of measures have been suggested in the EA study report. To recount, such measures relate to actions concerning significant sites of prehistory and archaeology, monitoring the behaviour of the exploited aquifer, sharing of water with the local communities, development of six centres for enhancing public facilities along the proposed road corridor, dune stabilisation away from the road corridor, development of shelter belts, range land and roadside orchards as measures to combat desertification and administration of landuse control measures adjacent to the right of way.

5.1.5 All the measures noted under para 5.1.4 above are feasible and desirable. However, these measures are in the nature of follow-up measures for extending the benefits of improved road access and are not within the purview of road design and construction as such. On the other hand, these are intimately related to the policy - prespectives of the National Government. There are departments of the Government which are assigned with related responsibilities and powers and thus have the required expertise in these subject areas. The concerned Government departments will, therefore, have to plan and implement the social and environmental enhancement measures indicated in para 5.1.4. It is desirable, however, that their activities are co-ordinated and monitored within an overall action plan.

5.1.6 The monitoring activities in terms of 5.1.1 to 5.1.3 will be essentially carried out in parallel with construction supervision, whereas those envisaged in 5.1.4. will have a longer-term horizon, essentially concerned with extending the benefits of the road after it is in operation. Thus, there are two distinct aspects of environmental monitoring involved, though these might be inter-related to some extent during the construction period itself. It is accordingly suggested to constitute a broad-based Environmental Planning and Monitoring Committee (EPMC) comprising experts from all the concerned departments with its Chairman provided by the Environmental Protection Council (EPC), to oversee planning and monitoring of mitigating activities related to road use and its social impacts.

In addition EPMC can also include representatives from Ministry of Finance and other related organisations. The job of EPMC would be to initiate and oversee specific sub-projects on these measures through the concerned Government departments in consonance with their assigned powers and responsibilities and to secure allocations of funds to implement the approved sub-projects in accordance with the rules and regulations of budgeting of the ROY.

A separate Mitigation Monitoring Panel (MMP) may be constituted to monitor and advise on measures specifially for mitigating the impacts of road construction activities, under the Chairmanship of GCRB with members drawn from other concerned departments.

5.1.7 In the following section, some guidelines are being suggested for the different constituents of the MMP.

5.2 Constituents of the Mitigation Monitoring Panel and Their Role

5.2.1 The GCRB, being the sponsor of the road project, shall have persistent role to play. Its major areas of involvement are as follows:

(a) to get the MMP constituted to attend to the environmental impact mitigation comprehensively;

(b) to approve the Project Completion Report in consultation with MMP; and

(c) to assume responsibilities for road maintenance.

5.2.2 It is encouraging to note that the Government of ROY is concerned about environment management and has constituted the Environment Protection Council in that context. The EPC should also play a persistent role in this road project. Its major areas of involvement should be as follows:

(a) to attach itself with MMP for the road project from the very beginning;

(b) to act as catalyst between the different specialists in MMP with a view to enlighten them about the nature of their interdependence; and

(c) to make available the experiences of other groups of specialists not represented in MMP (when required).

5.2.3 Amongst the specialist departments, the GOAMM will need to attach itself to the project first of all. It has to carry out a set of works for protecting the relics of prehistory and archaeology at the identified significant sites before road construction programmes start. The manner of attending to this task has been described in detail in the Basic Study No. 5 of this EA report. Then, the GOAMM has to assist the Supervision Consultant and the contractors on how to identify the relics while constructing the road and when to report their findings. On the basis of this, the GOAMM may collect all the available information from such sites without delaying the road construction programme. Since there is the possibility of finding more of these relics beyond the road corridor, the GOAMM may design on the basis of their findings a more detailed survey later on. It may be noted that the surveys done on prehistory and archaeology is poor in the sense that the findings do not adequately reveal the cultural ambiences of the observed artefacts in the absence of supplementary studies on palaeo-geomorphology and palaeo-climatology. In the event the GOAMM decides to mount a project on a more comprehensive survey on prehistory, it should attach a palaeo- geomorphologist to work with a competent prehistorian.

5.2.4 It may be noted that the proposed road construction programme will need to moblise water. It has been suggested that at least at eight sites attempts should be made to tap the aquifer. One has to note further that most of the proposed sites are located in such places about which the geo-hydrological data base is rather poor. The Ministry of Agriculture, Water Resources and Minerals (MAWR) should take the opportunity to attach itself to the monitoring panel from the beginning so as to enable itself to analyse the bore-hole data, observe yield rates, the draw-down effects, piezometric surface, etc. All these will form the basis of water- extraction schedules, not only during road construction, but also for supporting the schedules of later utilisation patterns of water. This will also enrich the ROY with knowledge about the strengths and weaknesses of regional water resource endowment.

5.2.5 The MAWR will need a number of sub-projects to implement not only to protect the road, but also to enhance the quality of environment after road construction. These include the use of vegetation for development, like roadside plantations, shelter belt development, enriching natural pastures, promotion of road side orchards, dune stabilisation, reduction of sand movements, etc. Since the projects will be of technical nature, it would be advisable to attach the technical wings of this Ministry to the programme. The Eastern Regional Agricultural Development Authority (ERADA) located at Marib will be a suitable agency for the works related to the road between Safir and Al' Abr. Similarly, the Agricultural

Research Station at Seiyun may be given the responsibility for the road between Al' Abr and Al Makhaneg.

5.2.6 The Consultants have not been able to locate the existence of any landuse control regulation within the Government of the ROY. However, the Ministry of Planning and Development appears to be the most appropriate body to formulate these regulations. The point to note is that formulation of the norms alone will not be adequate. The Government has to see that these norms are enforced. For this prupose, the Ministry of Local Government appears to be the most appropriate enforcing body.

5.2.7 The discussions given in this section thus suggest that the Monitoring Panel should have respresentation from the following Governmental institutions:

(a) GCRB - Co-ordinator
(b) EPC;
(c) GOAMM;
(d) MAWR
(e) ERADA and Agricultural Research Station at Seiyun;
(f) Ministry of Planning and Development; and
(g) Ministry of Local Government.

5.2.8 A flow diagram for the Environmental Management and Monitoring Plan in respect of mitigation measures arising out of road construction is shown in Fig. 5.2.8. In respect of the other measures suggested as coming under EPMC, it is suggested that EPMC be constituted first to serve as a forum for broad-based flow of information and decision making and to provide a basis of identification and prioritisation of sub-projects, sourcing funds and chalking out a plan of action.

5.3 Some Additional Comments

5.3.1 Most of the mitigative measures mentioned above are related to the physical elements of the environment. Although these mitigative actions will ultimately benefit the society, some comments on the socio-political environment would be useful to make the EMP comprehensive. The objective might be seen as to facilitate road construction works. However, there are deeper reasons to become more aware of this reality.

5.3.2 In their Aide Memoire of May 10-23 (para 5), the World Bank Mission has mentioned about the repeated instances of theft of vehicles and equipment and

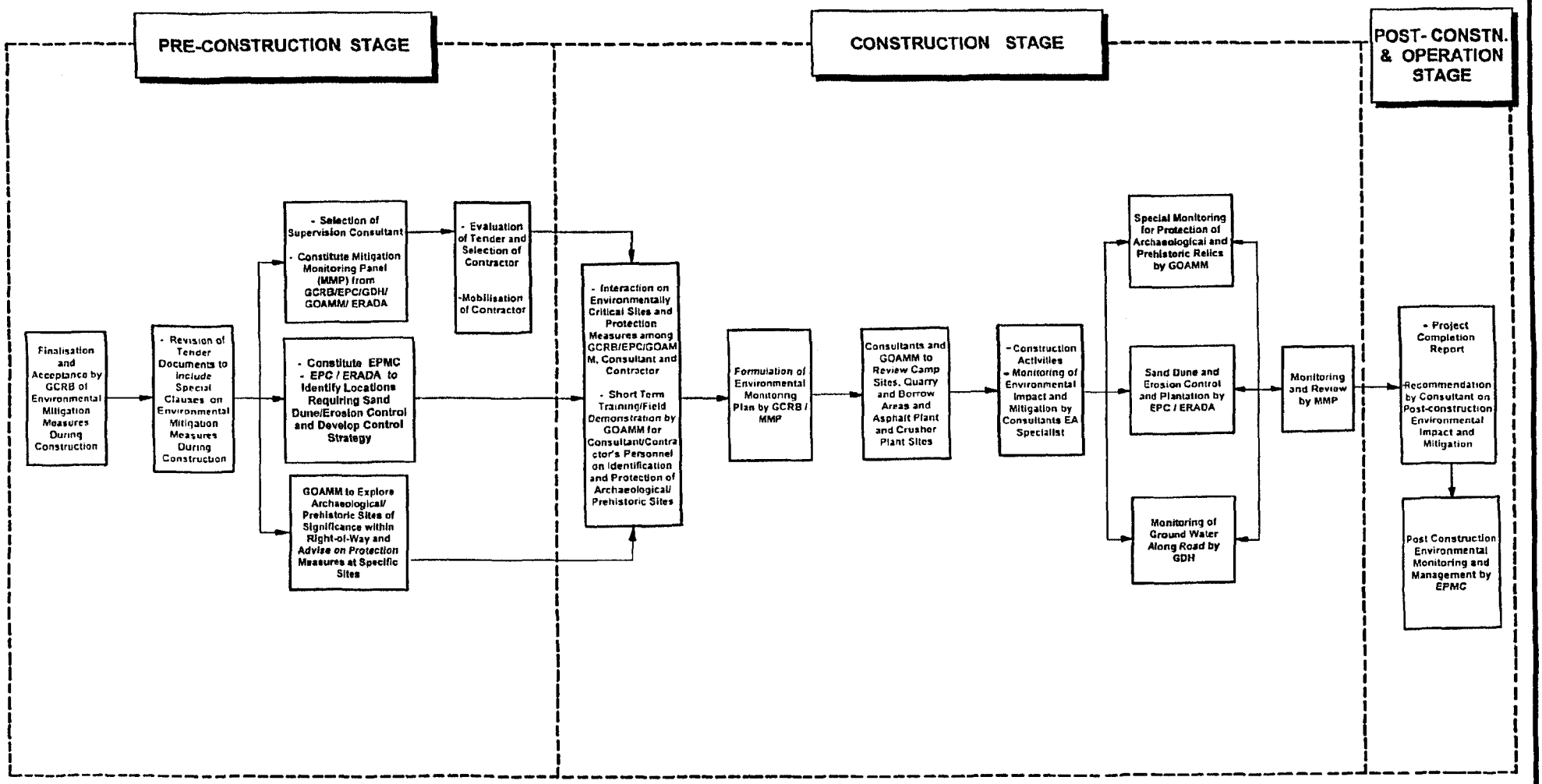


FIG. 5.2.8

FLOW DIAGRAM - ENVIRONMENTAL MANAGEMENT AND MONITORING

has suggested that some additional contingency for the cost of guards and losses of such plants and machineries be provided for in the Project Cost Estimate. The assumption is that such security problems, through temporary suspension of work, may lead to time over-run and escalation of project cost. Although the Consultants do not have any data to prove how such problems could have influenced bid rates, they have had the experience of having been left in the lurch after their car was forcibly taken away at gun point. From such experiences, the Consultants would recommend that the road construction contractor and the road supervision consultant should be provided with cellular telephones/walkie talkies to get them in touch with their base camps as soon as such upsets occur. Otherwise they will remain vulnerable in remote and hostile localities. The Consultants further suggest that these telephones should have a minimum range of 100 kms. This facility the workmen should have in addition to the provision of contingency mentioned by the World Bank Mission in their Aide Memoire under reference.

5.3.3 The above provision of cellular phones/walkie talkies is just an amiliorative measure. It does not touch the root of the problem. The Consultants believe that such acts of theft or hindrances may be reflecting an underlying feeling of uncertainty leading to record protest, though mis-directed, arising from failure to cope with the changed circumstances. It is necessary that the causes of social discomfort and the measures necessary to remove those causes be studied in depth, instead of simply providing monetary compensation to the victims of brigandage and intimidation. It is suggested that a social anthropologist, specialised in Yemeni society and speaking Arabic, be engaged to undertake this study.

5.3.4 It has been mentioned in Basic Study-3 that the cohesiveness of the tribal social organisation is undergoing rapid changes in the recent decades. Nevertheless, the concept of tribal territorial domain still persists, which enjoys collective recognition. A road intends to connect many such domains to help integration of local identities with a national one. The road could, therefore, be seen both as an alien entity as well as an object for maximising opportunity. Both types of identities may stimulate brigandage, if the society fails to use the idioms of political democracy. At least, these can split the society into collaborators and obstructionists, the latter having failed to understand the utility of endorsing a culture of helping relationship to secure advantages for themselves or, more simply, having failed to formulate such claims. Studies on social dynamism in Yemen are very few. Without such studies the object of realising national identity by the society may continue to suffer from hindrances or obstructions.

5.3.5 The job of the social anthropologist as suggested in para 5.3.3 should then be

(a) to demarcate the diverse territorial domains of the social groups along the road corridor;

(b) to identify the structure of authority granted within each domain to person or persons to negotiate the terms for maximising opportunities for the communities as a whole;

(c) to identify the general nature of supplementary investments required to advance the interest of the largest numbers amongst these communities; and

(d) to help the Government to negotiate in this regard.

5.3.6 It may be noted that every developmental action leads to fragmentation of the affected society. Culturally this may cause pain. To help the beneficiaries to take care of the neglected may not be seen as an unwholesome objective of a truely comprehensive EMP.

5.3.7 The issue of providing maximum benefit to the largest number is expected to emerge repeatedly in the context of designing sub-projects for combating desertification. For example, should the available water be used for enriching natural pastures for use by many pastoralists or for spate irrigation for raising grains by a few are the general nature of questions that the project formulators will face. Similarly, could the act of promotion of roadside orchards be a substitute for restricting the development of roadside strip-commercials, could be a question to be settled between two different types of planners. They can settle such questions if they have a comprehensive exposure to developmental alternatives in a desertic region. If such exposures are felt necessary, then these planning personnel should be sent for training. The Central Arid Zone Institute (CAZRI) under the Ministry of Agriculture, Government of India appears to be one such institution for obtaining exposure training.

5.3.8 To provide on the job training to local Yemeni staff to gain experience in implementing environmental mitigation measures and monitoring of construction requirements on a large project, it is recommended that appropriate individuals from a relevant agency, for example EPC, local government or other ministry, are seconded to the EA Specialist to assist and learn by direct experience on the Safir-Hadramout Road Project. This experience would benefit the individual and provide necessary experience to the supporting agency for future projects, whilst

at the same time providing needed assistance to the EA Specialist on such a large project.

5.4 Concluding Remarks

5.4.1 The cost estimates of same type of projects involving use of vegetation to combat desertification have been collected by the Consultants. These are presented in Appendix 5.4.1.

DETAILED COSTS FOR SAND DUNE FIXATION

1. Cost of Foredune Construction:

- Mechanical Construction (Bulldozer):
  - Base length — 6 m
  - Height — 3 m
  - Volume / km — 9,000 m^3
  - No. of hrs needed to transport 9000 m^3 — 9000:200 = 45 hrs/km
  - Cost of bulldozer work — 600 YR/hour
  - Cost of foredune built up — 600x45 = 32,400 YR
  - Miscellaneous — 1500 YR

Total = 33,900 YR = 2825 US $ per km

2. Palm Frondes Palisade:
- 5 palm frondes/m or 4000 palm frondes/km
- Cost of the palm frondes 400 YR / 1000
- Cost of palm frondes / km 4000 x 400 / 1000 = 1600 YR
- Transport (Marib area cannot provide the project with sufficient palm frondes)
  Cost of transport 8000 YR
- Wire (5 mm dia, 2000 m/km) 7000 YR
- Poles : 200 poles / km
  200 poles x 200 YR 40,000 YR / Km
- Labour (3 Nos per 10 poles) 200/10 x 3 x 200 = 12,000YR
- Foundation for Poles (0.125 m3 @ YR 450/pole) = 0.125x450x200=11250 YR

Total : 1600+8000+7000+40,000+12,000+11250 = 79,850 YR / Km.
Say : 80,000 YR / Km.

Cost of palisade with palm frondes = 80,000 YR / Km.

3. HDPE Film Sheets:

- 10 nos. 75 mm wide sheet (3 m length) + 10 nos. 75 mm wide sheet (1.5m length) may be considered to be equivalent to 15 Nos. 75 mm wide sheet (3 m long sheets) per metre length of fencing.

- Cost of HDPE sheets 15 x 1000 Nos. 3 m long sheet/km	= (15000 x 5.625) =	YR 84,375 / Km
- Cost of cutting HDPE sheets	=	YR 5,000 / Km
- Wire	=	YR 7,000 / Km
- Poles	=	YR 40,000 / Km
- Labour	=	YR 12,000 / Km
- Foundation	=	YR 11,250 / Km
Grand Total		YR159,625 / Km
	Say :	YR160,000 / Km.

AFFORESTATION COST ANALYSIS

1.	Cost of establishment of one ha equivalent of plantations of Eucalyptus spp. inclusive of two years irrigations and maintenance	YD 1,044,860
2.	Cost of establishment and maintenance of one ha of 7 years old Eucalyptus plantations	YD 1,227,450
3.	Cost of establishment and irrigation of one kilometre single row windbreak on flattened sand dunes	YD 952,500
4.	Cost of establishment of one kilometre windbreak single row within an agricultural area	YD 268,000

Source : Baladi, A. Saleh and Bazara, M.A. (1991)
"Wind Erosion Problems in Yemen" Proce. Seminar on the Status of the Environment. E.P.C. Sana'a pp 119-125

COST OF ESTABLISHMENT OF ONE KILOMETRE OF ROADSIDE PLANTATION WITH SINGLE ROW ON EITHER SIDE OF ROAD

Sl. No.	Kind of Work	Man Days	Cost of Man Days in YR	Cost of Materials in YR
1.	Marking the planting site	1.5	200 x 1.5 = 300	--
2.	Digging pits (1 m dia, 20 cm depth, 6 pits/hour	6.0	200 x 6.0 = 1200	--
3.	Cost of seedlings (5 m between seedlings: 200 seedlings/km at 10 YR/seedling)	--	--	2,000
4.	Planting of seedlings (10 seedlings/ labour)	3.5	200x3.5 = 400	--
5.	Transport of seedlings	--	--	3,000
6.	Distribution of oil drums	2	200x2.0 = 400	--
7.	Removing drums (6/hour)	6.0	1200	500
8.	Cost of sticks of support of seedlings	8.0	1600	--
9.	Planting (12 trees/hour)	3.0	600	--
10.	Pest Control	2.0	400	500
11.	Miscellaneous	--	150	--
12.	TOTAL	32.0	6550	6000

Total Cost Y.R. 12,550

Source : Baladi, A. Saleh and Bazara, M.A. (1991) "Wind Erosion Problems in Yemen" Proce. Seminar on the Status of the Environment. E.P.C. Sana'a pp 119-125

COST OF ESTABLISHMENT OF ONE KILOMETRE OF ROADSIDE SHELTERBELT

Grid for Shelterbelt 5 m x 4 m

Sl. No.	Kind of Work	Man Days	Cost of Man Days in YR	Cost of Materials in YR
1.	Marking the planting site	1.5 x 50	200 x 1.5 x 50 = 15,000	--
2.	Digging pits (1 m dia, 20 cm depth, 6 pits/hr/labour)	6.0 x 50	200 x 6.0 x 50 = 60,000	--
3.	Planting of seedlings (@ 5 m c/c - 50 rows - 200 x 50 / km) @ YR 10/seedling	--	--	100,000
4.	Plantation of seedling (@ 10 seedling/ labour/hr)	165	165 x 200 = 33,000	--
5.	Transport of seedlings	--	--	150,000
6.	Distribution of oil drums	100	200 x 100 = 20,000	--
7.	Removing drums (6/labour/hour)	300	200 x 300 = 60,000	--
8.	Cost of sticks for support of seedlings (including labour charges)	8.0 x 50 = 400	200 x 400 = 80,000	25,000
9.	Planting (12 trees/hour)	140	140 x 200 = 28,000	--
10.	Pest Control	100	200 x 100 = 20,000	--
11.	Miscellaneous	--	7500	--
	TOTAL		323,500	275,000

Total Cost of shelterbelt = (323,500 + 275,000) = 598,500 YR
Say = YR 600,000

MENSURATIONAL DATA ON GROWTH RATES AND WOOD PRODUCTION ESTIMATES

AGE	SPECIES	STEMS/KM	VOLUME / KM / M^3	M.A.I. / KM/ M^3
5 Years	Prosopis cineraria	333	101.9	20.38
	Albizia lebbek	333	47.95	9.59
	Azadirachta indica	333	21.31	4.86
	Conocarpus lancifolius	333	24.31	4.86
	Parkinsonia aculeata	333	8.33	1.67

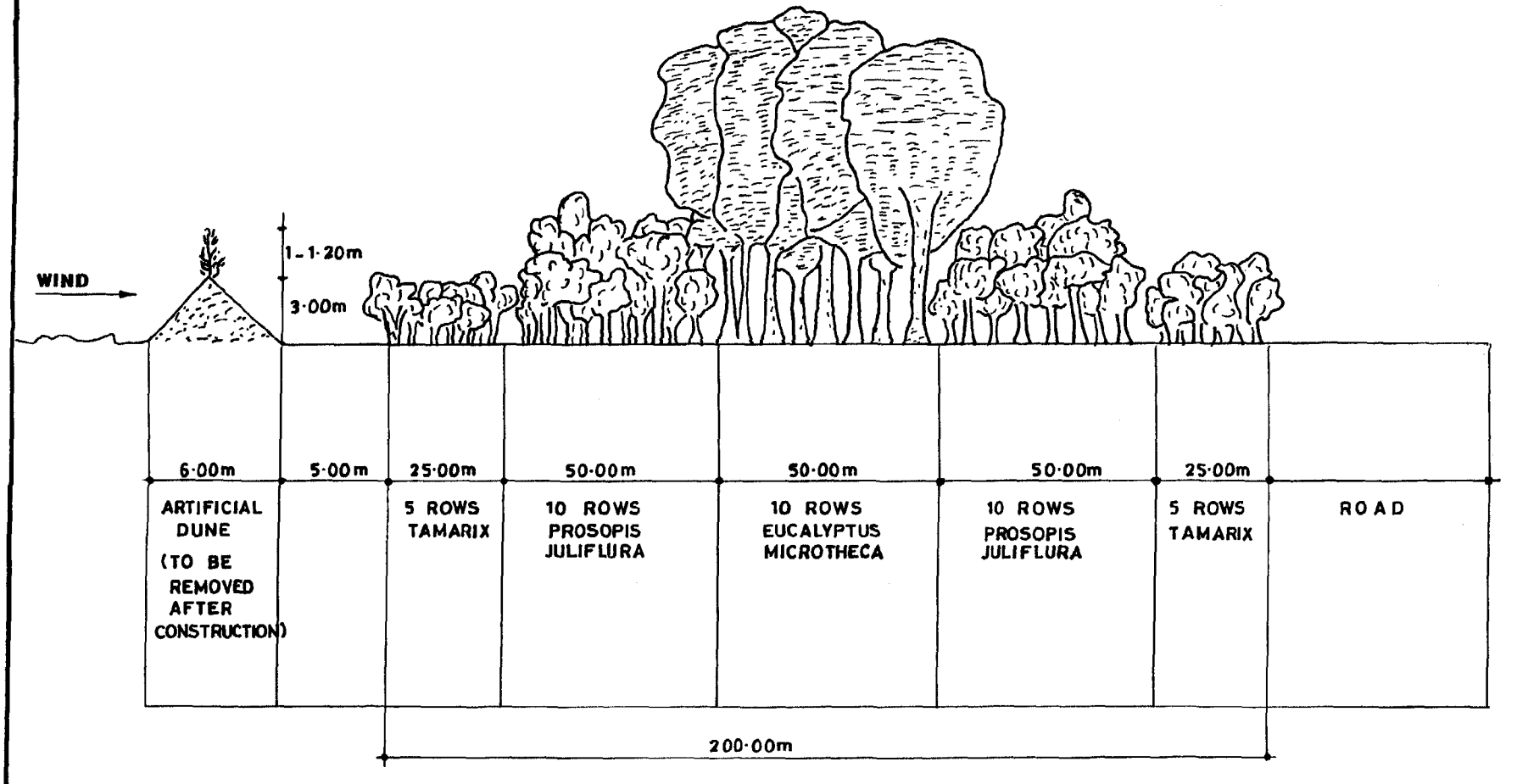
AGE	SPECIES	STEMS/KM	DBH./CM	HT.M.	TREEVOL. O.B.M^3	M.A.I. / KM/M^3
4 Years	Eucalyptus camldulensis	500	20.5	15.5	0.0221	27.6
	Casuarina equesitifolia	300	15.7	11.3	0.114	8.5
	Conocarpus lancifolius	300	13.9	8.9	0.0085	6.7
	Azadirachta indica	300	13.4	7.9	0.064	4.8
	Albizia lebbek	200	20.5	13.1	0.205	13.3

Note:

Average yield of Prosopis cineraria is 80 kg/tree and the estimated annual fodder production per kilometre of plantation could be as high as 18 tonnes which could provide the major part of the diet of 50 sheep or goat although supplementary feeding would be required to provide a balanced diet.

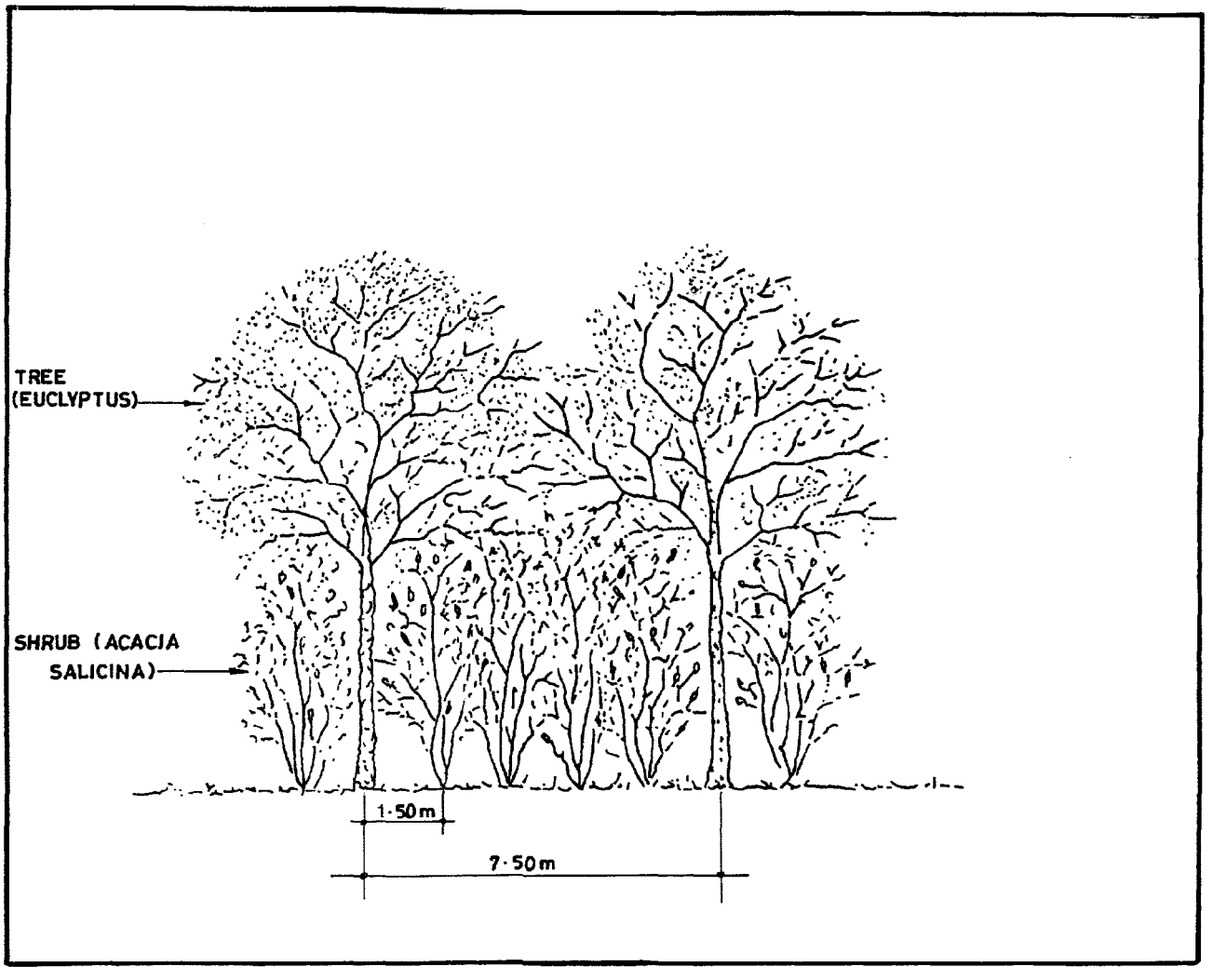
M.A.I. = Mean Annual Increment

Source : Baladi, A. Saleh and Bazara, M.A. (1991)
"Wind Erosion Problems in Yemen" Proce. Seminar on the Status of the Environment. E.P.C. Sana'a

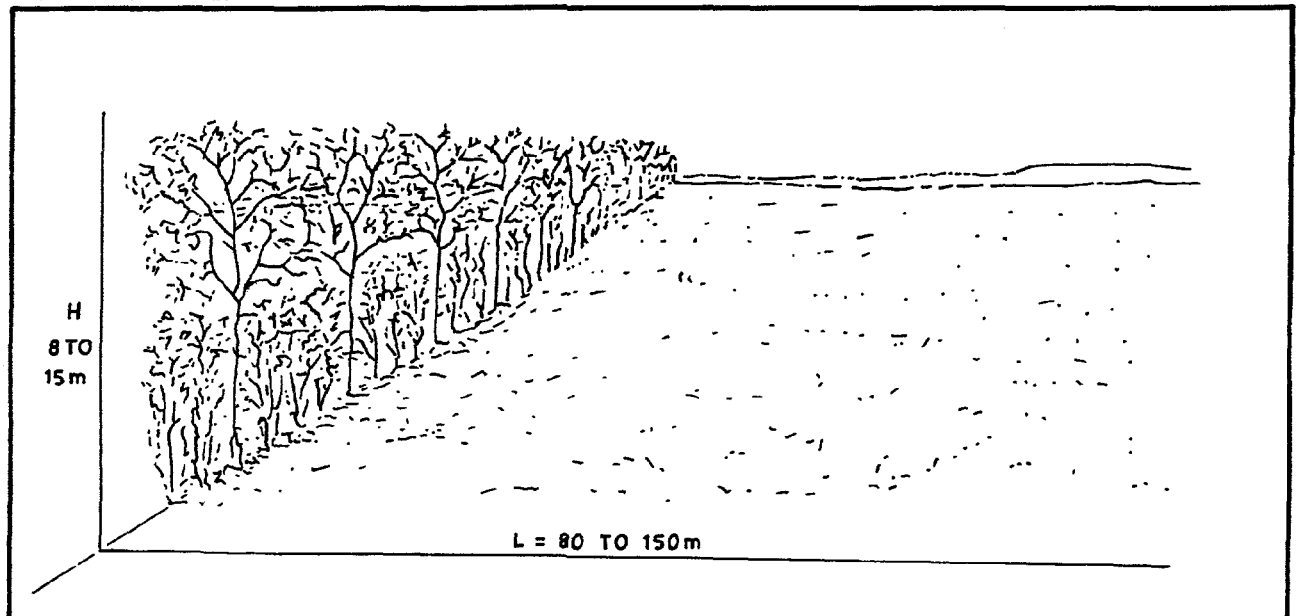


SHELTERBELT CROSS SECTION TO PREVENT SAND ENCROACHMENT

STRUCTURE



ESTABLISHMENT



PROTECTED AREA

CHAPTER VI

INSTITUTIONS AND LEGAL FRAMEWORK

CHAPTER - VI
INSTITUTIONS AND LEGAL FRAMEWORK

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Fig. 6.2.1 Organogram for General Corporation for Roads and Bridges
Fig. 6.3.1 Organogram of General Organisation of Archaeology, Museums and Manuscripts (GOAMM)
Fig. 6.10.2 Organogram of the Environmental Protection Council

Table 6.15.2 Draft Environmental Protection Law (Summary of the Main Components that could be applicable to Safir-Hadramout Road Project in the event of Ratification)
Table 6.15.10 Draft Environmental Protection Law (Summary of Environmental Impact Assessment Procedure)

References

CHAPTER VI

INSTITUTIONS AND LEGAL FRAMEWORK

6.0 Introduction

6.01 This section of the report describes the organisation of government, the responsibilities of the concerned Ministries and the legislative and regulatory considerations pertinent to the project to satisfy the requirement of the World Bank and the Terms of Reference item 5c.

6.1 Organisation of Government

6.1.1 On 22nd May 1990, the Yemen Arab Republic (YAR) and the People's Democratic Republic of Yemen (PDRY) were united to form the Republic of Yemen (ROY). After the general election on 27th April 1993 a new Cabinet was announced.

6.1.2 According to the Constitution of the Republic of Yemen, which is valid and in force since the unification of Yemen, the Cabinet is the Central Government of the Republic. Under the Constitution each Minister shall undertake the supervision of all the affairs of his Ministry and shall direct its departments and branches in ROY. The Minister is responsible to implement the general policy of the Government in his Ministry. Part of the Constitution provides for local authority organisation whereby the ROY is divided into administrative units which have legal entity and are an integral part of the state authority.

6.1.3 The Republic of Yemen is divided into 18 Governorates. Marib and Hadramout Governorates are the relevant local authorities for the project road. Each Governorate has a Governor who implements Cabinet resolutions and is responsible and accountable to the Cabinet. Most of the Ministries have branches in the Governorates and the Ministry of Construction has branches in all of the Governorates.

6.1.4 Construction of road is a central government issue controlled by the Ministry of Construction. The duty of the Marib and Hadaramout Governorates is to facilitate and assist in the implementation of such projects as construction of project roads. The central authority in Sana'a is responsible to solve any problem or dispute as

it comes within its authority and jurisdiction according to the prevailing laws in the ROY. The National Government laws are enforced in all Governorates and the local government in the Governorates is in fact the local administration which has no right to impose different types of duties or dues apart from national government laws. It is National Government which is the Central Government with branches throughout ROY which are for local administration with their finance controlled from Sana'a. Local Government in the Governorates is expected to be established later when the National Government approves the powers and functions of such Local Government in the Governorates.

6.2 Ministry of Construction (MOC) and General Corporation for Roads and Bridges (GCRB)

6.2.1 The Ministry of Construction is responsible for construction and maintenance of public buildings and non-urban engineered roads in Yemen. All road construction and maintenance works are carried out by the General Corporation for Roads and Bridges (GCRB), a separate arm of MOC, through direct labour or contractors. Related planning and design is also carried or managed by GCRB. The general organisational structure is illustrated in Fig. 6.2.1

6.2.2 The GCRB has objectives and functions which are detailed in the Resolution of its establishment but there is nothing specifically mentioned concerning the protection of the environment. However the Ministry of Construction has objectives and functions which are specified in the Executive Regulation issued by the Republican Resolution No.31 of 1993 dated 11th April 1993 concerning the Protection of Environments which are the following:

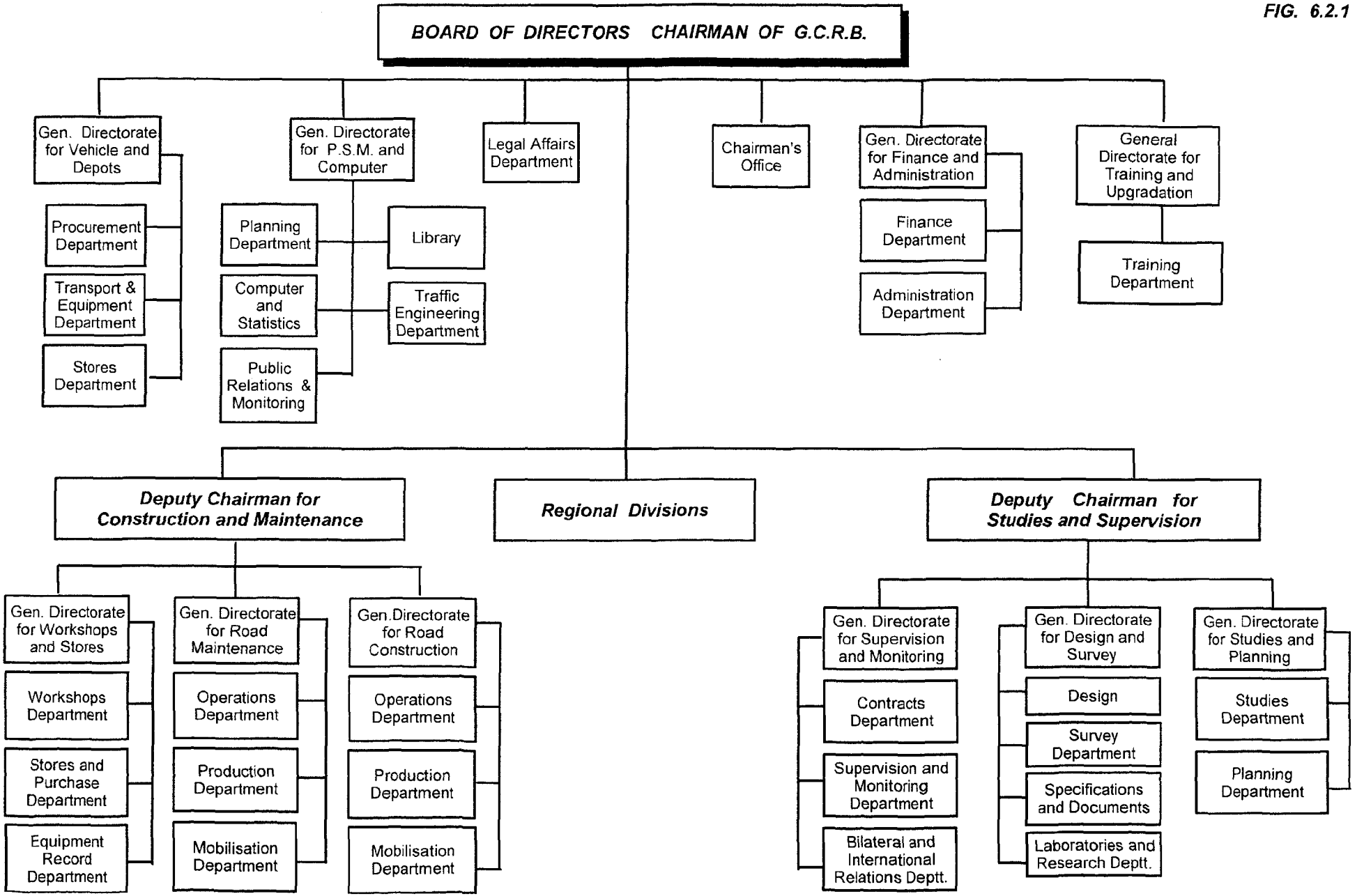
(a) Preparation of studies and technical research and designs and specifications for all projects of the Government and direct supervision on its implementation and its maintenance.

(b) Supervision on all Technical studies and specifications and designs related to projects which are to be carried out by foreign parties.

(c) The Ministry has the right to propose establishments of Corporations to carry out special functions e.g., GCRB.

ORGANOGRAM FOR GENERAL CORPORATION FOR ROADS AND BRIDGES

FIG. 6.2.1



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6.3 General Organisation of Archaeology, Museums and Manuscripts (GOAMM)

6.3.1 This is part of the Ministry of Culture and Tourism. This organisation is established mainly to maintain and preserve old cities, e.g., the old Sana'a and Shibam in Hadramout and to protect monuments and to establish museums. The protection of the common heritage whether cultural, architectural is their responsibility. The responsibility for advising on protection of archaeological sites rests with the General Directorate of Antiquities as shown in the organogram for GOAMM in Fig. 6.3.1

6.4 Ministry of Agriculture and Water Resources (MAWR)

6.4.1 This Ministry has 8000 staff, many are directly or indirectly active in the environmental field. The Ministry is engaged in a number of environmental issues including irrigation, water resources management, desertification, afforestation, plant production and protection, pesticides, soils, plant classifiction, livestock etc. With respect to water resources management, present activities are restricted to water drilling and irrigation techniques and skilled manpower is not available to run a comprehensive water resources managemnt such as has been carried out by the General Department of Hydrology of the Ministry of Oil and Mineral Resources.

6.4.2 The Ministry of Agriculture and Water Resources has its own laboratory in Sana'a to carry out analysis on soil and water.

6.4.3 This Ministry has the Executive regulation which is issued by the Republican Resolution No. 26 of 1993 dated 11 April 1993 which provides the following.

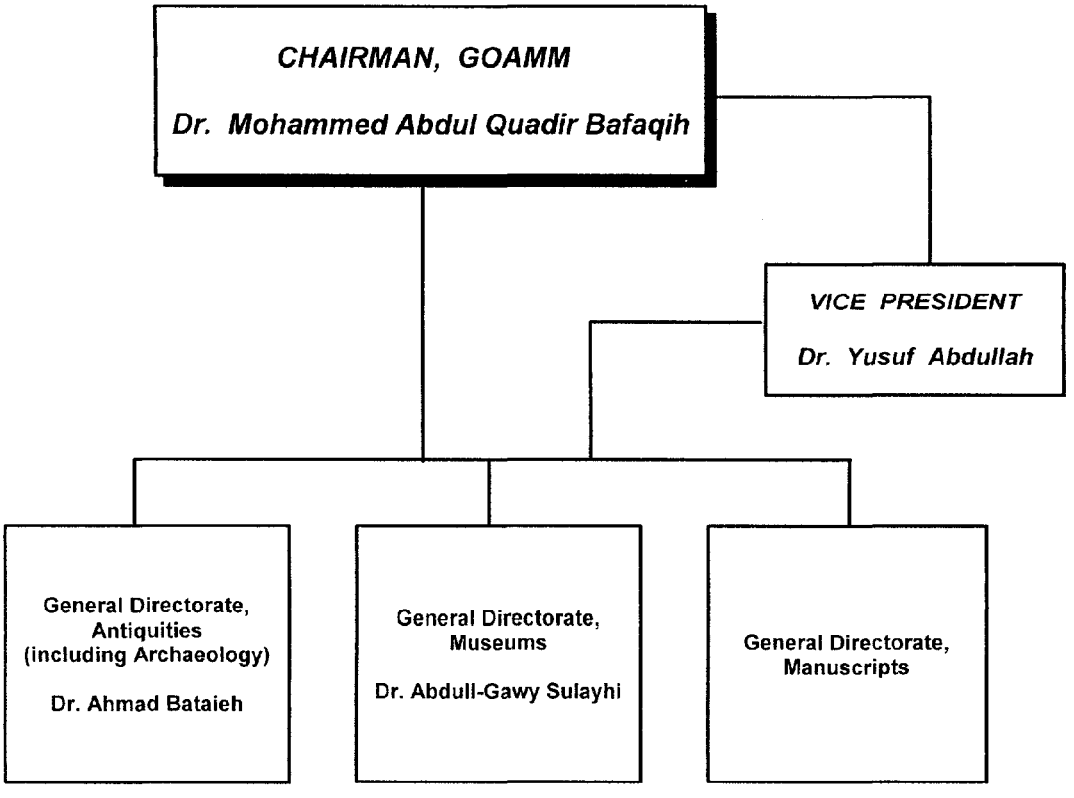
(a) The Ministry shall propose the policies and legislation for water and to prepare plans for the utilisation of water and management of water resources and its protection and development.

(b) Protection of the land from desertification

(c) Establishment of forests and grazing lands and protection to ensure preservation of the environment from desertification.

FIG. 6.3.1

ORGANOGRAM OF GENERAL ORGANISATION OF ARCHAEOLOGY, MUSEUMS AND MANUSCRIPTS (GOAMM)



6.5 Eastern Regional Agricultural Development Authority (ERADA), Marib

6.5.1 This organisation is part of the Ministry of Agriculture and Water Resources and is involved in the water resources management study in the Marib area through their departments of hydrogeology, dam operations and maintenance, agriculture, livestock, horticulture and crops. They have also experimented at Marib techniques of sand dune fixation, wind shelter belts and roadside plantations.

6.5.2 ERADA has been established recently to support the agricultural sector in Marib area with the main objective to initiate and accelerate rural development and to strengthen planning, budgeting and monitoring carried out by Ministry of Agriculture and Water Resources at the provincial level.

6.6 Agricultural Research Station in Seiyun

This research station, established in 1972, has sections in agronomy, horticulture, plant protection, soil and irrigation, afforestation and range management and farming systems. It has its own nursery with research being crop oriented and geared to the mid altitude area in Hadramout and some districts near Shabwa.

6.7 General Department of Hydrogeology (GDH) of the Ministry of Oil and Mineral Resources

This department carries out the programme "Water Resources Assessment Yemen Arab Republic " (WRAY) with the assistance of Netherlands TNO. Many studies have been carried out within WRAY in the former YAR involving processing data by means of a relational data base system. Plans exist to expand their activities into the whole of the ROY. More recently a water resources management study was completed in Wadi Adhanah and Marib area using a systems approach to analyse water resource management options in relation to economic benefits, areas of irrigation by surface water, sustainability of groundwater use and achieving an equitable distribution of water related benefits.

6.8 Ministry of Planning and Development

6.8.1 The Ministry has introduced the environmental impact assessment (EIA) recently in all projects. This is due to the pressure of the World Bank and other specialised organisations. The Ministry is co-ordinating with the EPC in this direction.

6.9 Local Government

6.9.1 The Municipality law is in fact related to the local government and mainly deals with sanitation and health environment. So the Local Government is not concerned with the protection of the environment except the sanitation and health environment. EPC and its branches is responsible for that although EPC has not opened branches in all the Governorates. In fact Local Government is not effective enough and change is forthcoming in this direction.

6.10 Environmental Protection Council

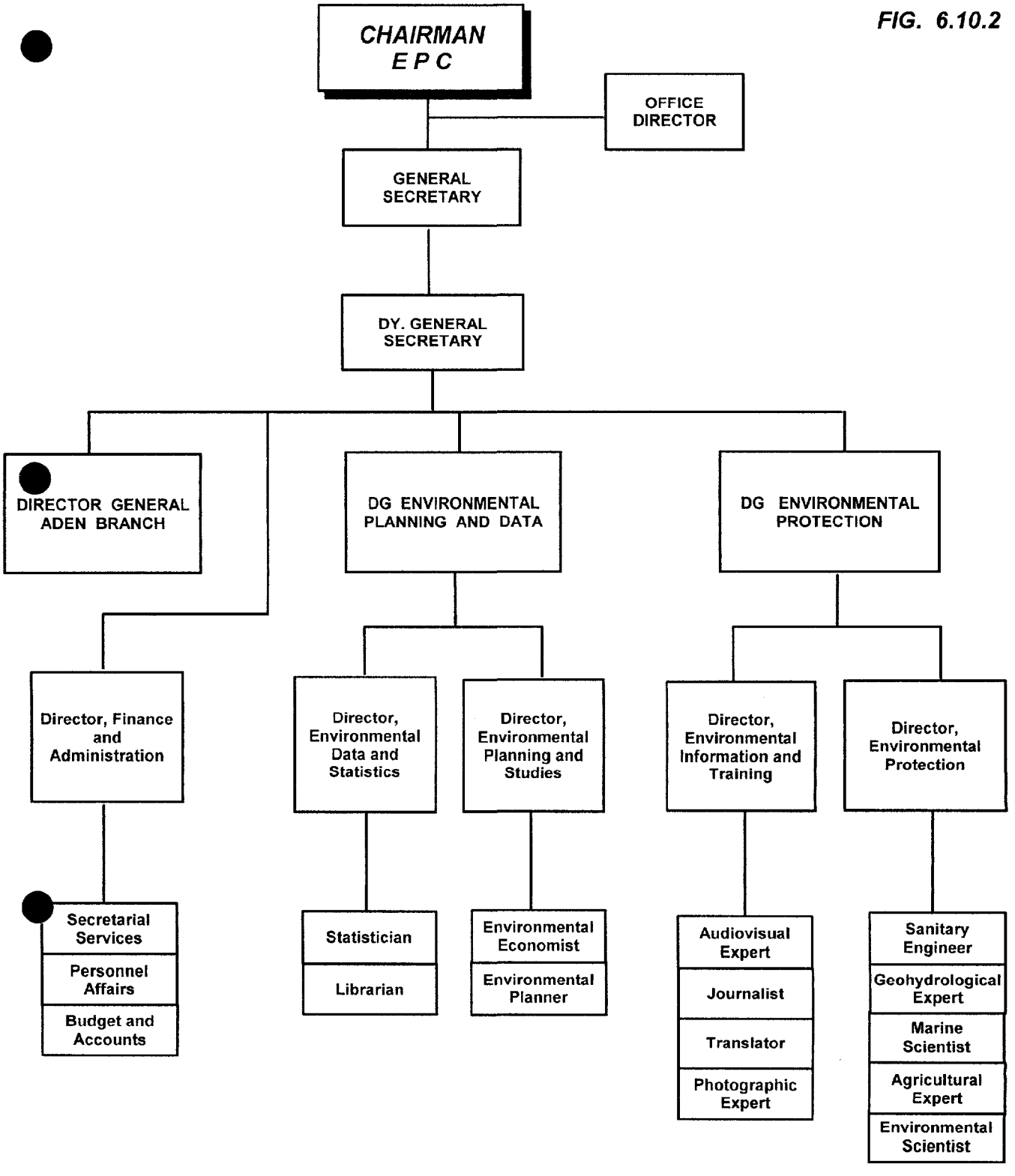
6.10.1 Following unification of Yemen the Environmental Protection Council (EPC) was formed by Prime Minister Decree 94/1990, replacing the former two councils in YAR and PDRY. The EPC is the central organisation responsible for protection of the environment. It is attached to the Minister of State reflecting its importance as the policy making agency. Aims and objectives of EPC include formulation of environmental policies and strategies, the enhancement of environmental education and awareness, the co-ordination and organisation of information exchange in the field of environment among the different concerned agencies and co-ordination with related agencies at regional and international levels.

6.10.2 EPC is made up of members from appropriate Ministries including Agriculture and Water Resources, Industry, Planning and Development. Appropriate Ministries and organisations are required to co-operate with EPC for the purpose of protecting the environment and EPC supervises and co-ordinates the works of the various sectoral units. An organogram is presented in Fig.6.10.2 to illustrate the organisational structure of EPC. The tasks required to be undertaken by EPC as stated in the decree are as follows:

(a) Propose the general policy to protect the environment and the observance of environmental research as the general frame for basic treatment of pollution problems in the marine, rural and urban areas.

ORGANOGRAM OF THE ENVIRONMENTAL PROTECTION COUNCIL

FIG. 6.10.2



(b) The co-ordination among the concerned agencies and follow-up and assess their activities, as well the co-ordination with regional and international organisations concerned with the protection of the environment in order to make use of their capabilities, experiences and scientific research.

(c) Set-up the standards that are capable in protecting the environment from pollution and act on making use of the modern scientific principles in this issue that assure the combatment of industrial pollution and protection of the animal, plant and marine ecology treasures and protect the land from desertification.

(d) Prepare the necessary laws, regulations and projects to protect the environment and follow up their implementation. As well study the regional and international agreements concerning the environmental protection and put forward the opinion on possibilities of joining them or make use of their regulations.

(e) Set-up effective programmes for international co-operation on environment protection in general and study the resources and enhance and accommodate them to the new priorities with the aim of executing them in accordance within the general principles and directives of the country.

(f) Enhance the abilities of the environment programmes by collecting the information and undertake assessments and prepare reports on the situation of the environment and work on setting up a system for environment monitoring that secures the finding of suitable solutions to combat pollution.

(g) Set up the general framework for environment education and awarenes amongst the public and induce them individually and collectively to participate in the protection of the environment.

(h) Record the variation occurring in the condition of the environment and the natural resources in the Republic of Yemen; and evaluate and inform the Cabinet about them by means of regular reports.

(i) Prepare a national plan to qualify Yemeni cadres in the various environment fields and give scope for specialised studies and make use of the available training programmes and supports.

(k) Organise local seminars and deliver lectures concerning environmental protection as well represent the Republic of Yemen in attending the regional

and international conferences and seminars and maintain contacts regarding this issue.

6.11 Legislative and Regulatory Considerations

6.11.1 Under the following sections consideration will be given to laws relating to land and water, customary law, tax law and regulations and standards applicable to environmental issues.

6.12 Rights regarding Water and Land

6.12.1 Construction of roads is the duty of the state as represented by the Ministry of Construction in Sana'a. For the Ministry to implement construction, Law No. 25 of 1992 concerning the Rights of the State to possess land for the public good, authorises the State as represented by the Ministry of Construction to possess land from citizens, to construct roads and to drill wells to extract water for the purpose of construction of roads, provided there is fair compensation.

6.12.2 Water can be sold by owners of private wells, but the community owning a spring or well as common property as in Marib and Hadramout Governorates offer water free without charging for it. It is only a gesture of courtesy to get prior permission and to submit prior notification before drawing water from such sources as common property of the community or tribe.

6.12.3 Civil laws provide that water is open and free for all and is not to to owned privately except in case of transfer of occupation. Drilling a well to get water is to be considered entitlement to that well through occupation. The right to have free water is subject to priority, although it is not permitted for anyone to enter any area owned by others to take water except with the owner's permission or approval or in case of custom. It is not permitted to inflict any damage to the owner of the well while taking water.

6.13 Customary Law

6.13.1 All tribes respect the prevailing customary law which contain a significant element of landuse practices and environmental protection measures which are applicable at the local level. Grazing land and water resources are considered common property for the tribe whereas agricultural land is considered common property

for families. The customary law is that lands and grazing areas are owned by the tribes and agricultural areas by families. Customs and traditions govern and regulate the use of such land by the tribe. Grazing lands are common property for the tribe and each tribe defines the boundaries of their grazing land. Cutting trees on grazing land is prohibited even if such trees are owned privately. It is only permitted to cut such trees when it is necessary in case of drought.

6.13.2 In rural areas where the tribes are owners and at the same time users of the land they feel it is their duty as owners of the tribe to work on the land. The exception to this is in farms for agricultural production, such as fruits, where the owner is responsible for providing services, equipment and other materials while the user of the land works on it and earns a quarter to a third of the value of the agricultural products. Traditionally, a contract is concluded between the owner and user defining the rights of each party.

6.13.3 The proposed road crosses sparsely populated rural areas and outsiders cannot utilise water and land resources since the tribe is a community, but the state has the legal right to acquire any land for construction of roads and to extract water.

6.14 Tax Liability

6.14.1 It is anticipated that construction of the Safir-Hadramout road will encourage regional development and be of direct benefit to the local communities. In these circumstances commercial and trading activities are likely to develop resulting in potential benefit to the government in the form of taxes collected under the Income Tax Law. Tax is collected from the following sources:

(i) Commercial, Service and Industrial business profits
(ii) Wages and salaries
(iii) Net income of non-commercial and non industrial professions
(iv) Real estate revenue
(v) Income derived from real estate sales and dealings.

6.14.2 There are important exceptions to some of the above sources of tax particularly in relation to the rural character of the project corridor. For example, tax on profits is exempted on co-operatives in agricultural societies, on income generated from the exploitation of the land in agriculture, gardening, forestry, shepherding, poultry and others and on profits generated from exporting agricultural products of Yemeni origin. Income tax is not collected on wages of Yemeni manpower engaged in agricultural, fishing and house holding services. Disposal or sale of agricultural land is exexmpted from real estate sales tax. Generally, the people

of Yemen do not pay tax on grazing or agricultural land but tax is paid by other business and when houses are built on their land and rented. There are other exemptions for protected groups such as charities, government property, hospitals, health centres, daily wages earners.

6.14.3 Zaqat is an important social principle derived from Islam whereby Muslims are required to pay annually 1/40th (i.e., 2.5%) of the value of property, whether it be cash, money or other product that yields profit. According to Islamic principles Zaqat revenue is paid to the poor, needy, charities, charitable projects, refugees etc. and is a means of establishing a society that lives in harmony with those less fortunate. In Yemen today taxes are collected by the State.

6.15 Regulations and Standards on Environmental Issues

6.15.1 Before the Environmental Protection Council was established in 1990 regulations governing environmental issues were scattered in different laws in erstwhile YAR and PDRY. At this time environmental laws covered such matters as drainage, refuse removal, infectious diseases, health, marine protection but there were no requirements for environmental impact assessment. One of the functions of EPC is to propose and submit drafts of environmental laws on all aspects of environmental issues and specifying standards. To this end the Draft Environmental Protection Law has been prepared and approved by the Cabinet and ratification by Parliament is awaited, which is expected to be ratified soon.

6.15.2 Although this bill has not yet been fully ratified to become law, the main elements likely to affect the road project are discussed to take into account the possibility of ratification during implementation of the project and its ramifications. Table 6.15.2 lists the key points of the law that could be applicable to the road project.

6.15.3 The bill forms a comprehensive framework for all activities and aspects of the environment. In Part One, Chapter One of the Bill, definitions of terms such as environmental damage, environmental effect, waste, dangerous waste, environmental protection are generally in accordance with internationally accepted definitions. The second chapter describes the objectives of the law as protecting the environment, combating pollution and maintaining natural resources. Plans for economic development must consider environmental impact assessment. Responsibility for protecting the environment falls on state, public and private corporations as well as individuals. Anyone causing harm to the environment takes the responsibility of all costs to repair environmental damage plus compensation.

Table 6.15.2
Draft Environmental Protection Law
Summary of the Main Components that could be applicable to Safir-Hadramout Road Project in the event of Ratification

PART NO.	CHAPTER NO.	TITLE	KEY POINTS
I - General Regulations	I	Definitions	Terms such as environmental effect, waste, dangerous waste, environmental damage are relevant
	II	Aims and General Basis	Objectives to protect the environment, prevent and combat pollution, maintain natural resources. Economic plans must include EIA. Responsibility rests with public and private institutions and individuals.
	III	Environmental Protection Council	Responsibilities of EPC determined including making national policy, supervision of projects through concerned authorities etc.
II - Protection of Water and Soil and Use of Eradicative Substances	I	Protection of Water and Soil and Establishment of Natural Protectorates	Protection of surface and deep water, develop water resources water wells etc. Landuse planning must take into account environmental elements Limit damage to soil Agricultural lands are protected against commercial and industrial development Permit required for road construction, erection of buildings Prohibited to cause harm to existing plant cover that may lead to desertification
	II	Use of Eradicative Substances	Control and use of pesticides
III - Activities Harmful to Environment	I	Control of activities harmful to environment	Prevention of dumping collection, discharging or burying environmental pollution
			Designation of areas, green places and preserved areas to be clear of pollution
			Protection of natural resources etc.
	II	Environment Specifications, Standards and Magnitude	Aim to protect the environment, especially surface and deep water, air, sea and noise.
			EPC shall decide specification standards and parameter limits.

Table 6.15.2 (contd..)

PART NO.	CHAPTER NO.	TITLE	KEY POINTS
III - Activities Harmful to Environment (contd..)	III	Permits for Projects and Evaluation of Environmental Effects	All projects and establishments which are source of pollution or may harm the environment must be given a permit Definition of environmental impact assessment process and procedures (see Table 6.15.2 for further detail) Submission of EIA for existing projects, establishments and activities within period of 6 months from when law becomes effective Procedures for possibility of dangerous pollution
	IV	Circulation of Dangerous Materials and Waste	List of dangerous and poisonous substances, their control, prohibition . Prohibition of public or private party to import store or dispose of dangerous, poisonous or radioactive substances
	V	Environmental Protection and Economical Development	Economic plans must take into account environmental factors Projects must not be approved if they damage the environment
	VI	Environmental Monitoring	EPC or other authorities may supervise and operate construction of environmental monitoring networks EPC may impose monitoring on projects and onwers and keep registers of the results
IV - Marine Pollution	I	Sea Water Pollution	Not relevant to road project
	II	Registration, Information, Insurance Condition	
	III	Management and Executive	
V - Violations and Environmental Harm Compensation	I	Legal Prosecution Authority	Appointment of Environmental Inspectors
	II	Responsibility and Compensation for Environmental Damage	Polluter is responsible for dealing with environmental damage and for compensation
	III	Criminal Punishment	
VI - Miscellaneous	N.A.	Final Regulations	Information authorities must support education on environment
			Provision for training, curriculum and syllabuses must include environmental input

NOTE: This summary is prepared in good faith from a draft English version provided by a third party. Some terms have been reworded for the sake of clarity

6.15.4 The third chapter provides that the Environmental Protection Council (EPC) shall be responsible for making the national policy to protect the environment and combat pollution. The tasks required to be undertaken by EPC have already been described previously (see Section 6.10.2). One point to emphasise here is that EPC has the role to supervise all private and public projects to make sure that the environmental mitigation measures are implemented and adhered to. The supervisory role of EPC shall be executed through co-ordination with the relevant sectors or government departments.

6.15.5 Part Two of the bill deals with protection of water, soil and the use of pesticides including the establishment of special areas of protection termed as Natural Protectorates. Of particular importance in Chapter One is that the concerned authority, in this case the Ministry of Agriculture and Water Resources, "has to protect the surface and deep water, to develop water resources, water wells and to set strict rules and regulations for the same, to prohibit the misuse of water resources and its wastage or the causes of its pollution and to subject the use and storage of water to the conditions of the concerned Authority".

6.15.6 Also it is prohibited to exercise any activity which may harm the quantity and quality of the plant cover in any area which may lead to desertification. Construction of the road through sand dune terrain needs to address the potential for destabilising the sand dunes by stabilisation measures.

6.15.7 Chapter Two deals with methods and ways of how to use pesticides which is not considered further in this report.

6.15.8 Part Three deals with activities that are considered harmful to the environment, the measures to regulate such activities and procedures to grant licenses for projects. Chapter One required that no Ministry, Board, Corporation, Public or Private company should use the Yemeni environment for dumping, collecton, discharging or burying polluted materials which may harm the environment. Every person who designs or operates a project must comply with this law.

6.15.9 Chapter Two provides that EPC has the responsibility to determine the environmental standards, specifications and Chapter Three provides that the council of Ministers issues a resolution specifying standards for the evaluation of the environmental impact assessment, including preparing lists of projects, processes, areas of special importance, types of resources and environmental problems. At the present time such lists are not available, however Chapter Three requires that all projects which are a source of pollution or may harm the

environment must be given a permit to proceed unless an environmental impact study has been completed.

6.15.10 The elements of a detailed environmental impact study (EIA) are defined in the draft law and are summarised in Table 6.15.10. The EIA for this project has been conducted in accordance with World Bank requirements which include the elements listed in Table 6.15.10. The only exception is (v) Effects on areas outside the national sovereignty from the project. Clearly for a road scheme no environmental effects on territory outside Yemen is expected.

6.15.11 One area in the EIA process which is not specifically mentioned in the draft law is public participation. This process permits the authorities to consult with the general public either through private or public meetings or publications as to the public views on the proposed project. There was no formal requirement to do this in the TOR for this project, however experts in anthropology and regional development conducted interviews with various local groups of people in the villages and Bedouin encampments. These proved very useful in obtaining the generally positive feedback received from the local people directly affected by the project.

6.15.12 Table 6.15.10 finally summarises the decision making process by which an application for a project is reviewed and accepted or rejected.

6.15.13 Chapter Three continues with requirement for permits to be issued to projects including those in place before the law is ratified. Controls are imposed for handling storing and disposing of hazardous material which may be applicable to certain processes during construction of the road. There will be a requirement for economic development to take into account environmental factors which has been the case for this project.

6.15.14 EPC or other authorities may have a role to supervise and operate environmental monitoring networks. The proposed management plan provides a full role for EPC and other relevant authorities to be fully involved in environmental monitoring in compliance with the draft environmental law.

Table 6.15.10
Draft Environmental Protection Law
Summary of Environmental Impact Assessment Procedure

	Elements of Detailed EIA :
1.	Description of the Project or Proposed Activity
2.	Description of the Environment that may be affected by the project
3.	Description of the proposed alternative activity
4.	Evaluation of the proposed environmental effects expected as a result of the proposed project or activity and alternatives including the direct and indirect effects in the long and short term and accumulating effects.
5.	Effects from the project on areas outside the national sovereignty.
	Decision Making Process:
1.	Application is reviewed within 3 months by the authorities
2.	The decision of acceptance or rejection is notified, and in the event of rejection with reasons given for rejection.
3.	Applicant may complain within 1 month
4.	Decision can be contested in primary court within a minimum period of 1 month. Court gives final ruling within a period not exceeding 6 months.

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BASIC STUDIES

BASIC STUDY - 1

COMBATING DESERTIFICATION

BASIC STUDY - 1

COMBATING DESERTIFICATION

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BASIC STUDY - 1

COMBATING DESERTIFICATION

S1.0 Introduction

S1.0.1 To develop a desert, construction of a network of communication system is a must. In this case the construction of the proposed Safir-Hadramout road will be of great help as it will serve as an outlet for the rich agricultural produce of the Hadramout valley as well as of petroleum from the oil bearing areas of Yemen. What is more important is that the road will provide easier access to the Bedouin population and other inhabitants of this desert terrain to the essential services and an opportunity to make an all round development of this arid zone besides attracting tourists. This vast arid terrain, which is now almost barren, has a rich resource potential, particularly to develop range land, horticulture and extraction of buildings stones, oil etc. Hence the construction of road will overcome some of the hindrances to development.

S1.0.2 Environment in a desert is, however, a fragile entity and water is the limiting factor for the sustenance of biota including the human beings. Crossing the limit set by local endowments of water initiates a process of desertification. There are evidences that such acts of over-exploitation of the resources are happening in this part of the world. Unless this is arrested, the promises offered by the proposed road may become difficult to attain. To exposit the basis of this apprehension is one of the objectives of this study. How to combat the observed processes of desertification is the other objective.

S1.1 Common Causitive Factors of Desertification

S1.1.1 Desertification is not an exclusive feature of the ROY. It has happened in many parts of the world. The factors contributing to desertification are to some extent comon across the countries, although their intensities vary regionally as well as between the countries. It is useful to recount the common factors which operate over tropical hot deserts of the world leading to desertification, since the deserts of the terrain under consideration belong to that type.

S1.1.2 The terrain under consideration is confined between 15°30'N to 16°45'N and 45°45'E to 48°20'E comprising an area of about 20,000 sq.km and includes parts of Marib, Shabwa and Al Jawf and Hadramout governorates. The climate is typically arid to hyper arid. For the area as a whole the estimated annual rainfall ranges between 50 and 200 mm, which is less than average potential evaporation. Hence the terrain is considered hyper arid (Hadri 1992 and Uil et al 1992) or desert like. The terrain experiences erratic scanty rainfall, extremes of temperature with large diurnal variation accompanied by high wind and high sunshine. All these factors together fail to support any appreciable vegetation, which is generally of thorny forest type. However, there are the wadis providing flash floods of considerable quantities. These support flood plains with richer vegetation cover. In short, not all parts of the terrain appear desolate and devoid of vegetation.

S1.1.3 There are, no doubt, some tracts with rich biotic resources within the terrain under consideration. However, the viability of these richer tracts is dependent upon how effectively the interface between the human resource exploitation system and the given ecological system is managed. Over stepping the limits of the natural ecosystem may cause desertification, which is a process of transformation of non-desertic land into desert like entity. Needless to mention that also within the deserts there are the variations in the richness of natural ecological systems where the principle of effective management of the above mentioned interface plays important role. Intensification of desertic condition in one part of the terrain can cause desertification in the neighbouring parts, because the process operates regionally encompassing many tracts.

S1.1.4 Within the terrain under consideration, the process of desertification is operating through the following vectors:

(a) High wind velocity leading to deflation, loss of soil cover, soil erosion, sandstorms, abrasion of land, deposition of shifted material and formation of sand dunes of various types;

(b) Sudden cloud bursts leading to soil erosion, flash floods, deposition of debris in the lower courses of the wadis, widening of channel width, stream bank erosion, inundation of land, loss of property, etc.;

(c) Periodic draught leading to crop failure on ploughed land with loose soil and making these susceptible to wind erosion;

(d) Use of heavy machinaries in crop farming leading to destruction of soil structure and increased friability;

(e) Over exploitation of water resources leading to lowering of ground water table and decrease in the area receiving flash floods;

(f) Cultivation of marginal land in response to population growth;

(g) Over dependence on poorly endowed forage/stover resources for animal husbandry leading to formation of exposed ground and accentuation of aeolian and fluvial erosion;

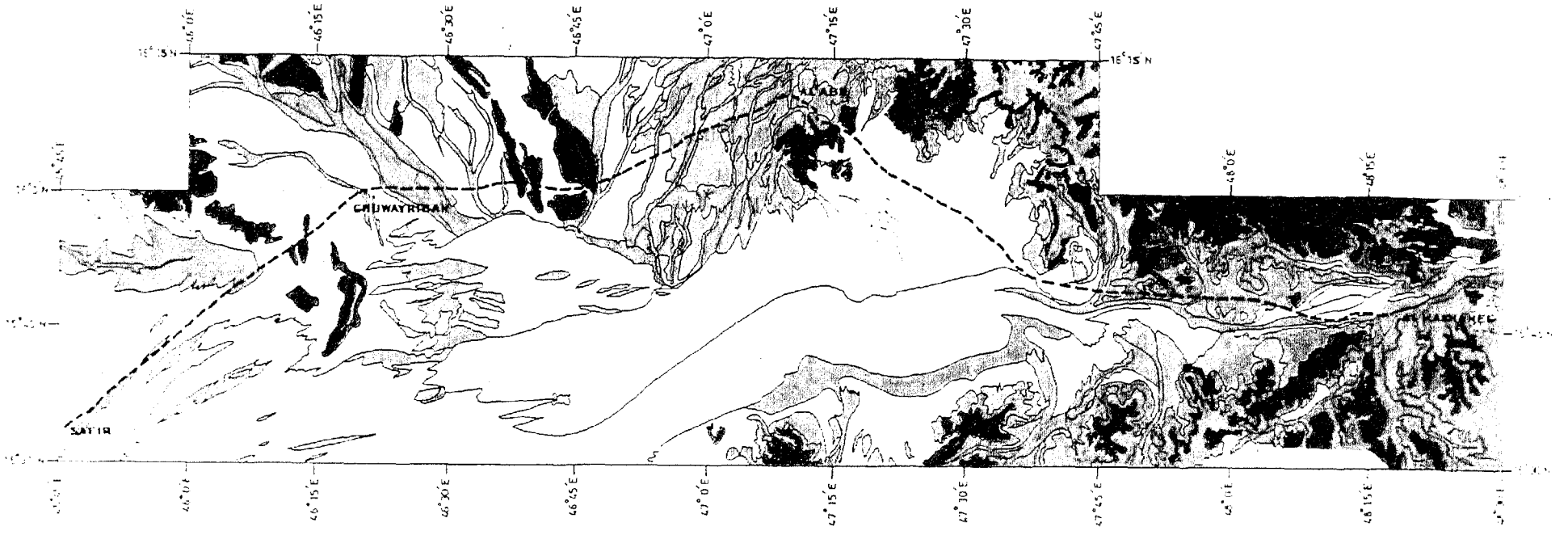
(h) Unrestricted movement of nomads practising animal husbandry over poorly endowed natural pasture leading to over-grazing and formation of exposed surfaces for active aeolian and fluvial erosion; and

(i) Over exploitation of trees for fuel.

S1.1.5 The above enumeration of the causitive factors of desertification are related to both the natural and the cultural environment. The specific attributes of these environments and their inter-relationship have been described in details in Chapter II of the Environmental Assessment Report. These may not be repeated here. However, Figure S1.1.5 summarises the information of the regional orientation of the bio-physical resources of the project area terrain. Some pointed observations on the uses made of land may serve as an introduction to identifying various orders of desertified land in this part of the world.

S1.2 A Short Comment on Land Utilisation Pattern

S1.2.1 Comprehensive studies on the pattern of landuse of this terrain are lacking. Published statistical data give very approximate ideas about the terrain pertaining to the proposed road alignment. However, the reconnaissance survey yielded an observable order of relationship between physiographic units and dominant character of landuse. In Table S1.2.1, the findings from the above survey have been presented.



L E G E N D

LAND TYPE	VEGETATION	SOIL
Hills, Foot Hills and Rocky land	Mixed Xerophytic Thorn Forest : Tree : *Acacia Arabica - Acacia Tortolis - Zizuphus Spina Christi Parkinsonia Aculeta* Ground : *Cymbopogon Jirarcuscus - Cynodon Dactylon Heliotropium bauiferum - Erioys Barleria Acanthoides*	*Lithosols* and *Regosols* subject to wind and water erosion. Shallow hard layers with concreteous and people
Wadi Beds and Flood Plain	Tree : *Acacia Tortolis - Zizyphus Spina Christi - Ziziphus Jujuba - Z Nummelaria - Tamarix sp Salvadora Persica - Aerva Persica - Caparis Decidua - Laptadenia Pyrotechnica* Ground : *Rhazia Stricta - Cassia Auriculata - Tephorsia Petrosa Indigofera Cordifolia - Cymbopogon Schoenthus - C. Parkersilinofolia - Aristida Funiculata - A. Adscentionis - Salsola Baryosma - Suaeda Fruitcosa Fagonia Cretica* (Economic Importance : Ziziphus for bees Catha eduhus (Qat)	Marib Sector : Loamy skeletal. More silt - highly permeable - non saline, non alkali Safir-Al' Abr-Hawrah (Desert Sector) Sandy and Sandy skeletal - non saline - non alkali - highly permeable with low water holding capacity - weekly calcareous
Sandy Undulating Plain with Occasional Gravel	Mixed Xeromorphic Wooded Desert Tree : *Calligonum Polygonides - Laptadenia Pyrotechnica - Acacia Tortolis - P Cineraria - Calligonum Commosum - Salvadora Persica - Tamarix Articulata* Ground : *Cynodon dactylon - Eragrotic Aegyptiaca - Panicum Turgidum - Calligonum Commosum*	Pale brown to yellowish brown deep sandy soil - single grained - highly calcareous - loose - light textured - susciptible to wind erosion.

LAND TYPE	VEGETATION	SOIL
Gravelly Land Mixed with Sand	Semi Shrub Desert Vegetation Tree: *Acacid Tortolis - Aniogessus Pendula - Calatropis Procera* Ground : *Indigofora Cordifolia - Tephorsiam Purpurea - Cassia Auriculata - Fagonia Cretica - Rahizautricta*	Shallow to moderate deep pale brown to dark brown loamy soil underlain by gravelly and calcareous strata - susciptible to wind erosion
Saline Depression and Saline Flats(Playa)	*Halocylon Salicornicum - Salsola Baryosma - Suaeda Fruitcosa*	Medium to heavy textured saline soil underlain by gypsiferous and calcareous materials on the colluvial deposits
Sand Dunes	Mixed Xerothermic Thorn Forest: Tree: *Salvadora Persica - Calatropes Procera - Zygophillum Simplex Dipterygium Glaucum* Ground : *Panicum Turgidum - Calligonum Commosum - Eragrostis Aegyptiaca - Dipterygu Glaucum* Introduced : *P. Juliflora - Azadaricta Indica*	Pale brown to yellowish brown very deep loose, fine grained, slight to mild calcareous - devoid of base concretions Susceptible to wind erosion

5 0 5 10 15 20 25 km
SCALE

(NOTE: THE BOUNDARIES OF THE ZONES ARE TENTATIVE)

FIG.NR S 11.5

BIOPHYSICAL RESOURCES OF THE PROJECT AREA

Table S1.2.1
General Landuse Pattern in the Project Area

Physiographic Units	Landuse in Proposed Safir - Hadramout Road By Sections			
	Safir-Ghuwayriban Section	Ghuwayriban-Zuwaybi Section	Zuwaybi- Al' Abr Section	Al' Abr - Al Makhaneg Section
Hills and Foot-hills	Rocky wastes; occasional mining (Quarry around Safir and Hadramout Section), occa-sional grazing, sandy wastes	Fallow - occasional grazing during rain (by Bedouin community)	Fallow - occasional grazing, scattered trees and bushes - afforestation	Scattered trees and bushes around Al' Abr; rocky wastes - scattered woodland
Sandy undulat-ing older alluvial plains	Long fallow and sandy wastes; occational grazing by Bedouins during rain	Long fallows and sandy wastes - occasional grazing during rain	Fallow and sandy waste - occasional grazing	Settlement (Al'Abr and round Haynan) cultivation (intensity 40%); grazing; horticulture(eastern sector); Long/short fallows (eastern sector) sandy wastes (Al'Abr-Al Khasha tract)
Gravelly Land	Gravelly waste and occasional grazing during rain, scat-tered grass, shrubs	Sandy - gravelly waste - occasional grazing during rain	Fallow and sandy waste- occasional grazing	Occasional culti-vation (intensity 20-40%); grazing, horticulture, long/ short fallows, gravelly waste
Sand Dunes	Sandy waste with sparse vegetation	Sandy waste with sparse vegetation	Sandy waste with sparse vegetation	Sandy waste with sparse vegetation
Wadis & Flood Plain	Dry, sandy waste	Dry, sandy waste	Sandy waste but cultivated during favourable rain	Rain fed farming with supplementary irrigation, short fal-lows, horticulture

S1.2.2 Excluding the urban-industrial population, the users of land in this part of the world can be broadly grouped under three types, viz., (a) nomads; (b) semi-nomads; and (c) settled farmers. Each of these groups have their specific cultural identities, which influences the manner in which land is utilised. It is important to be aware of such relationships.

S1.2.3 The cultural attributes of the social groups living along the proposed road alignment have been described in details in the Basic Study 3. For the present, it would be sufficient to note that the relative importance of livestock rearing vis-a-vis farming distinguishes the three types of social groups mentioned above. The sedentary farmers, as the name suggests, depend on agriculture as their principal source of sustenance. But they also rear livestock to some extent. In contrast, the nomads derive their sustenance primarily from livestock management, although they also raise some crops, given the opportunity. The semi-nomads are those recently adopting to sedentary life-style, who allocate nearly equal importance to crop farming and livestock rearing. The livestock rearing practices, however, differ significantly between these three social groups. Considering that there is a general deficiency of fodder/stover resources, livestock rearing assumes critical importance in stimulating the process of desertification in this part of the world.

S1.2.4 Published statistical information on livestock resources do not differentiate between the above mentioned social groups. Nor are such distinctions made in the matter of cultivation of fodder crops. Both types of data are tabulated in terms of the governoratorial territories, which also do not reveal the specificities of the terrain traversed by the proposed road alignment. Nevertheless, these indicate some of the attributes of the problematique in hand. For example, from Table S1.2.4(a) one can note that between 1988 and 1990, the number of goats has increased by 6.9%, sheep by 6.25%, cattle by 3.9% and camel by 9.34%. Table S1.2.4(b), on the other hand, shows production of fodder in 1990. The amount of fodder grown is inadequate to sustain the existing number of livestock. Two conclusions are inevitable : one that these animals are under nourished and two that the non-cultivated biotic resources are used for maintaining the livestock. More importantly, one may note that the three social groups mentioned above do not depend upon cultivated fodder in equal degree.

S1.2.5 The truely pastoral social groups are often referred to by a generic term of the Bedouins. They are divided into many clans, each clan carrying a sense of belongingness to a terrain as its domain of operation, which is honoured by the others. Together they cover the Rub-Al-Khali, Shabwa and Hadramout regions, i.e., the western part of the project area.

Table S1.2.4(a)
Livestock Resources (1988-90)
(Livestock in number)

Governorate	Goat			Sheep			Cattle			Camel		
	1988	1990	% increase	1988	1990	% increase	1998	1990	% increase	1988	1990	% increase
Marib	170318	173182	1.68%	197032	202871	2.96%	14257	14685	3.00%	6201	6604	6.50%
Hadramout	454517	496316	9.20%	195344	213218	9.15%	3411	3680	7.89%	35907	39615	10.33%
Al Jawf	115276	117214	1.68%	133172	127119	2.96%	6224	6411	3.00%	10019	10671	6.15%
Shabwa	194313	212183	9.20%	179846	196312	9.15%	1176	1269	7.90%	10682	11785	10.32%
Total	934424	998895	6.90%	705394	749520	6.25%	25068	26045	3.90%	62809	68675	9.34%

Source : Agricultural Statistical Yearbook, 1990, ROY

Table S1.2.4(b)
Production of Fodder (1990)
(Prod. in T. : Area in ha. & Yield Kg/ha.)

Governorate	Grass			Sorghum Fodder			Alfalfa		
	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield
Marib	40	8	5000	17280	1728	10000	1884	314	6000
Hadramout	77	5	15400	2944	205	14360	23495	1045	22483
Al Jawf	-	-	-	33200	3320	10000	14862	2654	5600
Shabwa	-	-	-	20885	1453	14374	9110	385	23662
Total	117	13	-	74309	6706	-	49351	4398	-

Source : Agricultural Statistical Yearbook, 1990, ROY

A typical group consists of a number of families and possesses on the average 40 goats, 7 sheep and 2 camels. The animals secure their feed from the ranges, however poor the biotic resources might be there. After rain the rate of vegetative growth increases in these ranges. Since rainfall varies from place to place, these nomads move elsewhere as better rains are reported. Some groups, especially those of Hadramout region keep the ranges closed for some months after the rain. Grazing is not permitted then. This is known as the "Hema" system and is more widely followed in the north than in the south. In other words, efficiency of range management varies regionally. As the natural pastures prove inadequate, most of these people purchase fodder of sorghum and alfalfa from those who produce these. The groups not having the required purchasing power either take recourse to over grazing of natural pastures or pursue trading to reduce dependence on animal rearing. These nomadic people are also seen to be using increasing number of motorised vehicles as are the other communities, in response to trading. Driving across the trackless desert further reduces the productivity of the natural pastures. All these factors taken together are contributing to increased desertification.

S1.2.6 The social groups pursuing agriculture are also contributing to desertification, but not through animal husbandry. These groups also keep animals, more of goats and less of camels than the typical Bedouin. They also raise birds (chicken). The feed for the birds and animals is generally obtained from their own farms. This is reflected in Table S1.2.6(a) if read in conjuction with Table S1.2.4(b). They raise varieties of grains as well as fodder crops for themselves as also for their birds and animals. Only the surplus is sold. However, these are not the only items of their production that goes into trading. They produce miscellaneous cash crops as well as fruits as is shown in Tables S1.2.6(b) and S1.2.6(c) respectively. All these together mean intensive use of land with the support of irrigation.

S1.2.7 However, water is the scarcest resource in this part of the world. Then, the traditional method of spate irrigation also leads to excessive consumption of water. The two combine to reduce the area under flood in the wadi beds to let the desert advance there upon. The practice has now reached a stage in the western part of the terrain under consideration where the quantum of water withdrawn exceeds the volume of recharge into the aquifer. So a part of the farm land has to remain without irrigation. This is revealed from Table S1.2.7. Dry farms are vulnerable when draught sets in and are affected by the processes of desertification.

Table S1.2.6(c)
Horticulture : Production of Fruits (1990)
Prod. in T. : Area in ha. & Yield Kg/ha.)

Governorate	Grapes			Dates			Banana			Citrus			Papaya			Water Melon			Apricot		
	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield
Marib	862	96	8779	55	11	5000	--	--	--	7943	445	1789	--	--	--	27341	993	27534	--	--	--
Hadramout	--	--	--	6550	4599	1424	1647	75	21960	90	28	3214	52	3	1733	567	178	3185	--	--	--
Al Jawf	3114	556	5601	952	136	7000	128	21	6095	1112	27	41185	343	68	5044	28280	1510	18729	23	15	1533
Shabwa	--	--	--	86	30	2866	--	--	--	82	24	3417	--	--	--	338	45	7511	--	--	--
Total	3976	652	--	7643	4776	--	1775	96	--	9257	4536	--	395	75	--	56526	2726	--	23	15	--

Source : Agricultural Statistics Year Book (1990), ROY : Ministry of Agriculture & Water Resources

Table S1.2.7
Cultivated and Uncultivated Land in the Project Area (1990)

Governorate	Uncultivated		Cultivated Land (Area in ha. and % to Total Cultivated Land)								Total Cultivated Land	
			Dry Farming		Irrigated Farming							
	Area in Ha.	% to Total Area	Area in Ha.	% to total Cult. land	Floods or Spate Area in Ha.	%	Spring Area in Ha.	%	Well Area in Ha.	%	Area in Ha.	% to Total Area
Marib	12368	19	8285	15	19642	34	258	1	25637	48	53822	81
Hadramout	24444	61	- -	-	3201	60	--	-	2147	40	5348	39
Al Jawf	44774	64	514	2	6187	25	2813	11	15307	62	24821	36
Shabwa	15668	74	--	-	2038	37	--	-	3509	63	5547	26
Total for Project Area	97254	47	8799	8	44376	40	3071	3	55231	50	111477	53
Total for R.O.Y.	51037	31	684609	61	100977	9	25450	2	309570	27	1120605	69

Source : Agricultural Statistics Year Book (1990), ROY : Ministry of Agriculture & Water Resources

Table S1.2.6(a))
Production of Cereals in the Project Area (1990)
(Prod. in T. : Area in ha. & Yield Kg/ha.)

Governorate	C E R E A L S														
	Wheat			Maize			Sorghum			Millet			Barley		
	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield
Marib	1970	1215	1620	2842	2009	1410	28635	36081	800	--	--	--	70	84	830
Hadramout	7093	4833	1470	--	--	--	2173	2266	960	259	270	959	--	--	--
Al Jawf	9681	7367	1310	100	80	1250	4036	4203	960	--	--	--	956	956	1000
Shabwa	1015	748	1360	--	--	--	455	479	950	460	485	948	411	286	1440
Total	19759	14163	--	2942	2089	--	35289	43029	--	719	755	--	1437	1326	--

Source : Agricultural Statistics Year Book (1990), ROY : Ministry of Agriculture & Water Resources

Table S1.2.6(b)
Production of Cash and Miscellaneous Crops in Project Area (1990)
(Prod. in T. : Area in ha. & Yield Kg/ha.)

Governorate	Vegetables			Pulses			Coffee			Sesame			Cotton			Tobacco		
	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield	Prod.	Area	Yield
Marib	34008	1379	24660	19240	1590	12100	12	49	250	1834	3007	610	54	68	794	--	--	--
Hadramout	11542	1480	7800	130	129	1008	--	--	--	85	270	315	--	--	--	475	151	3146
Al Jawf	45136	2841	15880	23630	994	23773	--	--	--	698	1194	586	--	--	--	--	--	--
Shabwa	8794	882	9970	--	--	--	--	--	--	386	747	517	--	--	--	12	19	632
Total	99480	6582	--	43000	2713	--	12	49	--	3003	5218	--	54	68	--	487	170	--

Source : Agricultural Statistics Year Book (1990), ROY : Ministry of Agriculture & Water Resources

S1.2.7 The semi-nomads are those trying to adopt sedentary life-style. They are half-way between the pastoral nomads and the sedentary farmers. With them, animal rearing and crop farming assume nearly equal importance. Very few of them own irrigated farms as they are accepted only to settle on the margin of the wadis. So they have not been able to give up seasonal travelling. Sometime the male members leave their villages to work as labourer in the farms of other people, leaving the women members to attend to the animals. When the fodders grown by them prove inadequate, the animals are taken to the natural grazing grounds or into the land with trees to consume leaves and twigs. Such a marginal state of existence favours the process of desertification to advance upon their habitat.

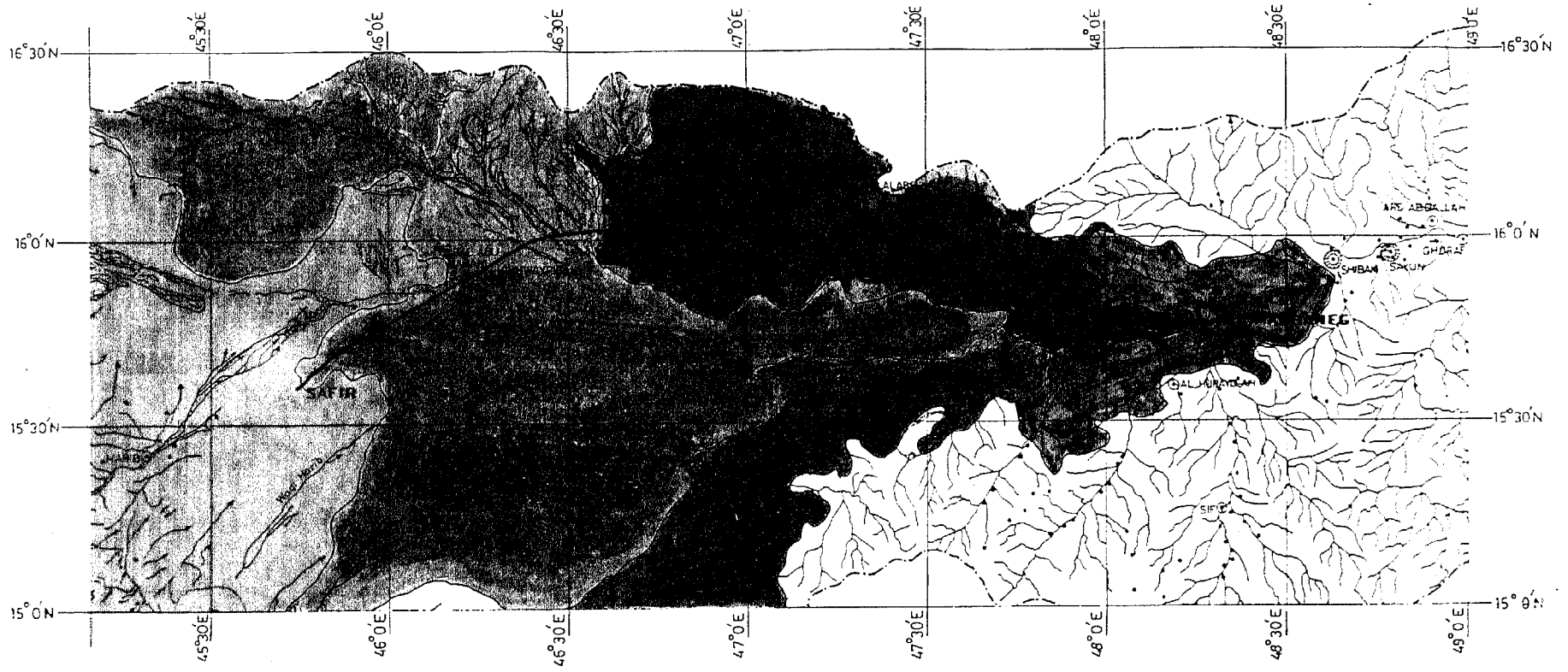
S1.2.8 Over arching all these complexities is the habit of the people to burn wood as domestic fuel. The sedentary villagers, however, protect the trees around their houses, for these provide shelter against sand bearing wind. The owners of orchards also protect their shelter belts. But all go out to plunder the trees found elsewhere, say in the woodland set up by the state. The consequences favour desertification.

S1.3 Regional Pattern of Desertification

S1.3.1 There are thus the natural processes intermingled with anthropogenetic interventions to cause desertification. However, the intensities of desertification vary regionally. An attempt has been made to capture this regional pattern of variation of the order of desertification in Figure S1.3.1. The area covered in this map extends many kilometres beyond the proposed road alignment. This has been done on the consideration that actions for combating desertification are to be taken where the process originates.

S1.3.2 Sand movement, resulting out of aerodynamic forces and biotic interference, is occurring throughout the terrain causing desertification/land degradation of various intensities. Sand dune is progressing and invading increasingly larger area used in the past for grazing natural vegetation.

S1.3.3 More than 30 per cent of the area in the project is affected by sand movements of various types. The dunes dominate the landscape over a vast area extending from Safir to the last segment of the road alignment (upto 255 km) in a belt and for a considerable area just towards the south-east of Ghuwayriban. Elsewhere dunes also occur in isolated way. Another belt of extension is traced along the end of the alignment in the environ of Haynan-Al Makhaneg. Four types of dunes are identified:



LEGEND

- Free or very slightly affected (0-10%) due to movements of Bedouins with their resources; reactivisation of dunes, aeolian activities
- No hazard or slightly affected (0-20%) by sand movement, flash flood; wind erosion
- Slight to moderately affected (10 to 30%) due to sand movement, reactivated sand, movement of Bedouins
- Moderately affected (20 to 40%) due to sand movement, wind and water erosion
- Moderately affected (40 to 60%) by flash flood, wind erosion, reactivated sand, overutilisation of resources
- Moderately affected (50 to 60%) by reactivated sand, wind and water erosion; biotic interferance (urban and industrial activities, pollution)
- Moderately affected (50 to 70%) reactivisation of aeolian activities, wind erosion, sand movement, biotic activities (over utilisation of resources) spate irrigation
- PROPOSED ROAD ALIGNMENT
- SETTLEMENT
- WATER COURSE (WADI)
- WADI SPREAD

10 0 10 20 30Km
SCALE

FIG. Nr. S1.3.1

(NOTE : THE BOUNDARIS OF THE ZONES ARE TENTATIVE)

CURRENT STATUS AND INTENSITY OF DESERTIFICATION

(a) **Seif or the Parabolic and Longitudinal Dunes** : These dunes are located on the West, South and South-East of the region. Some old fixed sand dunes are associated with the same. Dune chains form a rolling topography. The dunes are mostly 20-60 m high and transverse dunes attain 10-50 m height.

(b) **Parabolic Dunes** : Some of stabilised dune crests have massive fresh sand deposits, causing the base and the crest to grow and to meet the nearby dune. These are parabolic dunes and attain about 6 to 10 metres height.

(c) **Barchan or the Crescent Shaped Dunes** : These are few in this region, occupying the interdunal plains in the extreme west, but recently developing in the Hadramout sector. These dunes are most dangerous, as these move along the prevailing wind direction, invade new areas, settlements and contain very fine sand (0.06 to 0.1 mm diameters). These active sand dunes intensify desertification process in alarming proportions and are common in Safir (petroleum refinery area) and Haynan-Al Khasa area.

(d) **Sandy Hummocks** : These dunes are of 0.5 to 1.5 m height, often formed in scattered ways around shrubs and grasses in sandy alluvial and interdunal plains. These are Nebha type or shrub coppice dunes having the size of sand grains 0.12 - 0.20 mm. These dunes contain more water and support grasses/shrubs like Panicum turgidium and Calligonum commosum species.

S1.3.4 Apart from the dunes, sand is covering many square kilometres of flat land surface. Here the sand is under constant motion, being both deposited and deflated by the prevailing wind. Then, there are deposits of sand on the hills, along the fractures, i.e., almost everywhere. Wherever sand is accumulated, the vegetative wealth gets degraded.

S1.3.5 The proposed alignment of the road traverses many types of desertified territories. The process is active. Hence it is important to assess the nature of impacts that this process of desertification is going to cause upon the road. While more studies are needed to quantify the expected impacts, it is possible to apprehend the general nature of these. This is being attempted below.

(a) **Safir-Ghuwayriban Section** : This is located at the western part of the terrain. Fairly high barchanoid dunes are to be cut across in the first three kilometres. Then there are linear dunes with interdunal playas. Then over

a considerable distance along proposed road alignment the terrain is mostly free of sand dunes. However during strong winds and dust storms shifting and deposition of fresh aeolian sands is a regular phenomenon. The desertification hazard is of high to medium order in the initial part of the alignment due to biotic interference and of slight to medium order in the rest of the legnth. Such hazards are of course not alarming as the movement of sand can be controlled by adopting silvi-pastoral management. However, where dunes are to be cut, protective screen made of masonry wall or other materials should be raised before tree plantation starts.

(b) **Ghuwayriban-Zuwaybi-Al' Abr Section** : Sandy undulating plain are being affected by wind borne sand. The movement of nomadic tribes along with their automobiles and animals is leading to degradation of fragile soil and is causing sand movement and desertification. Silvi-pastoral system, roadside plantations, wind and shelter belt are the means to be adopted to avert the processes. At Al' Abr the causitive agents of desertification, besides sand movement and wind erosion, are gully and rill erosion along the hills. Near villages like Al' Abr the natural vegetation cover has been removed in many places for fuel wood. The Al' Abr town is not under immediate threat of sand dune encroachment and aeolian hazard due to its location at a relatively high elevation. However, constant movement of automobiles, it being a trading centre, intense biotic activities may be expected to cause land degradation in future. Therefore a shelter belt should be established stretching along the wadis. Roadside plantation is also needed along the settlement.

(c) **Al' Abr - Al Makhaneg Section** : Towards the immediate east of Al' Abr - the tract is practically free from desertification hazard except sand movement caused by dust storms and nomadic/transhuman livestock farming. The area is subjected to normal sand movement. The alignment is however free from the direction of the sand movement. However, to the east, the tract is affected by various biotic interferences. Here the land is cultivated by spate and well irrigation and hold good potential for agricultural development. There is a relatively rich natural vegetation cover in this area. Near villages, the natural vegetation cover has been removed through continuous cutting for fuel wood and expansion of area under agriculture. Sand movements are unfortunately well advanced for some sites like Haynan. Sand is reactivated and picked up by the wind overloading the nearby areas. Although the settlements are not immediately endangered by sand dune encroachment, individual shelter belts have to be planted upwind to stop sand incursion. The number of livestock appears at present to be sufficiently fed as lucerne and sorghum are cultivated as fodder.

S1.4 Measures Required for Protection of Road Alignment

S1.4.1 It is clear that desertification is manifested through sand movement and formation of mobile sand dunes. To arrest this, one has to monitor the process and to adopt appropriate mitigative measures. This can be organised in three sequential types of activities : (i) the identification and location of the areas to be monitored; (ii) to identify the problem areas where combating measures are to be adopted; (iii) repeated observations of these area which constitute the monitoring proper. The specific combating measures are as follows.

S1.4.2 The roadside is likely to be affected by moving sand/sand depostiion. Protection is possible through adoption of silvi-pastoral management system. For this purpose action has to be taken at places serving as source of sand. Sand dune fixation at Shabwa and Haynan is suggested as a necessity. Then it will be necessary to create shelter belt and wind break along the road from Safir to about 32 km. Work should be started at the time of construction of the road and be maintained after construction. Roadside plantation would be necessary along the alignment from Ghuwayriban to Wadi Gharr Al Yamani. Afforestation and green belt should be needed around Al' Abr. Beyond Bir Al Wahed upto Al Makhaneg, emphasis should be put on road side orchards with shelter belts. Options available regarding species selection and techniques are given in Appendix A.

S1.5 Technology for Regional Development

S1.5.1 The construction of the proposed road will open up newer opportunities for regional development. Pertaining to measures to combat desertification, a variety of action programmes appears implementable in this region. These are noted below.

S1.5.2 **Range Land Development :** The vast sandy undulating tracts, gravelly land, and foot hills are mostly suitable for range land development to support pastoralism. Current systems of uncontrolled grazing are leading to overutilisation of the grazing lands leading to soil erosion/ desertification. To combat it, proper range management is necessary. Some techniques like inter-cropping of grasses-legumes may be practiced as this often give 20-30% increase in forage production under desertic condition. High yielding selected strains of grasses may be multiplied and supplied to the different entrepreneurs for forage cultivation under different edaphic and agro-climatic conditons.

S1.1 ROADSIDE PLANTATION TO ARREST SAND MOVEMENT (MARIB - SAFIR ROAD)

S1.2 AGRICULTURAL LAND PROTECTION BY PLANTATION (MARIB)

S1.5.3 **Fence to Resist Grazing** : For protection against uncontrolled foraging, angle iron posts (6'x1 1/2" x 1 1/4") with barbed wire (four to five strands) fencing has proved to be most durable and economical in the long run although the initial cost may be high. Under the condition of Indian desert, it has been evident, that the forage yield on range lands, after two years of protection, increased by 148, 92 and 116 per cent in poor, fair and good range lands respectively. (Paroda, Mann, Verma 1980).

S1.5.4 **Adoption of Soil and Water Conservation Measure** : Contour furrows (60.96 cm wide and 22.86 cm deep) with cross section of 929 sq.cm at a distance of 8-10 m across the slope have invariably proved to be more effective than other measures like bunds and staggered contour trenches. Contour furrows help in increasing forage production from an average 4% per ha to 15- 20% per ha in a period of 10-15 year in Indian arid zone (Paroda et al 1980). The same techniques may be followed in the terrain under consideration.

S1.5.5 **Reseeding in Range Lands** : For large scale development programme, placement of seeds on the top (not below 1-2 cm) of the mound prepared through tractor mounted disc plough and also broadcasting just before or at the onset of first effective showers is suggested as it may prove effective.

S1.5.6 **Choice of Species** : Selection of species should be made through extensive research on agrostology. Improved strains of grasses have the genetic production potential of even higher than 40 Q/ha and therefore should be used for reseeding programme. Cenchrus ciliaris; C. Setigerus; L. Sindicus (exotic) and D. Anulatun may show both stability for production as well as better persistence over years at some locations like Haynan, Al' Abr, Shabwa, Ghuwayriban, etc.

S1.5.7 **Legume Introduction to Upgrade Quality of Herbage from Grassland** : Grasses are low in nutritive value (4 to 5% crude protein) even in early growth stages which decline to hardly 2% in the ripe stage. For the well being of animal in this arid environment, a minimum of 7 to 9% crude protein is considered essential. This can be achieved by introducing a legume component in the natural grassland. Species should be selected judiciously. Besides indigenous species introduction of *Dolichos lablab* var *dignosus* (giving a spacing of 45 cm) or *Cassia auriculata* (indigenous) of 45 cm for every two rows of *Lasiurus sindicus* (exotic) using a seed rate of 48 kg/ha may give a good legume stand. The mixed grass legume lay is more nutritious when compared with grass alone and gives overall increase in dry matter production. It has the additional advantage of adding to the fertility status of the soils.

S1.5.8 **Adoption of Deferred - Rotational Grazing for Sustained Grassland Production :** The aim of grazing management should be to give early nutritious grazing to animals but allow for periods of rest to enable grasses to recoup vigour. Deferred grazing in a three compartment scheme is one such compromised management technique. This consists in dividing the area into three compartments. The third compartment is deferred first for two thirds of the season and the animals are grazed rotationally in 1st and 2nd compartments until 70% utilisation is achieved. In the 2nd year, 1st compartment is deferred and grazing rotationally in 2nd and 3rd compartments. The grass in deferred compartments are cut and stored as hay for using during lean season. Such a grazing management enable to support more grazing days than the traditional continuous grazing system. In addition to above management, water holes and the like are provided at suitable places to avoid spot grazing. In view of water scarcity in this tract suitable storage may be constructed.

S1.5.9 **Planting Fodder cum Fuel Trees** : In order to bridge the gap of lean period when no grass is available, top feed species would be of immense value. The top feed species besides providing fodder in lean periods will also provide shade to the grazing animal. Some of the important top feed species in tract area are : *Accacia tortolis; Prospis cineraria; Zizyphus spina christi.* The spacing for planting these trees may be carried out at 5 m x 5 m interval.

S1.5.10 **Agroforestry** : Feasibility studies on agroforestry has already been initiated by ERADA at Marib area and Agricultural Research Station, Seiyun in the Hadramout area to ascertain the nature of competition obtaining between forage crops on forage trees and vice-versa. For regional development, agroforestry is recommended at Safir, Shabwa, Al' Abr, Al Makhaneg, Haynan areas and environ and areas of flood plains of wadis in different sector as this is an economically productive landuse system. The objective is to find out suitable tree grass combination. In the wadi areas orange + lemon + *Ficus saliciforia* + *Ziziphus-spina christi* shows that a satisfactory production of grasses is possible. Experiments have also been conducted with wheat + *Salvadora persica* in wadi areas. The possibilities of the extension of agroforestry system should be examined.

S1.5.11 **Arid Horitculture :** This system is practiced in Marib area (citrus) and Hadramout area (date palm) extensively. Arid horticulture system will be economically productive in the terrain. Water scarcity is a problem. But even where water is limited and of poor quality, drip irrigation system, which is not affected by winds, offers efficient alternative. Besides water economy, the other advantages of the system are use of saline water, fertilizer economy, restriction

of weed growth, avoidance of land levelling and higher yields. As the cost of installation is rather high, the sytem seems to have potential in high value crops like fruits and vegetables. Here water use efficiency is twice as high with other methods of water application. A 50 per cent saving in water is observed in Marib and Hadramout area. In desert sandy soil, daily irrigation is suggested. Researches should be conducted to find our other fruit crops like *Ber (Z. memerularia)* etc.

Some Useful Techniques for Afforestation in Arid Zones

Some of the well known techniques used for afforestation are mentioned below. Choice of right species plays an important role in deriving economic advantage. Some of these are explored below.

For all tree plantation programme there should be ample stock of healthy seedlings to meet demands. Temporary nurseries should be located near the plantation site. More permanent facilities may be created in more advantageous locations. Afforestation programmes may be designed on the basis of decisions taken on the following:

For Sandy plain sites :

Choice of Species: *Accacia tortolis; Prosopis cineraria; Celligonum polygonides; Calligonum commosum; Salvadora persica.* Exotic species like *Azadirachita indica; Albezia lebbeck; Tamarix indica; Tamarix articulata* may also be tried.

Soil Work : Dig 60 cubic cm pits and fill to half with loose weathered soil before planting; perforate the pan to a depth of 90 to 100 cm. After ripping open the pan, loose weathered soil should be filled in the pits before planting. Errect microwind break, in case of mobile sand or sand drift, or small barriers across the wind direction 2 to 5 metres apart along the contours on the slope and also as per wind velocity. Suitable bush woods locally available to the site, like *Z. spina christi; Cynadon dactylon; Panicum turgidum; Calatropes procera* etc. Selection of species should be made after proper examination of soil and quality of ground water.

Spacing : For arid zone afforestation 5 m x 5 m and for energy plantation 2 m x 2 m species are suggested.

Planting : Plant sturdy seedling of 9 to 10 months old with the onset of rain. In case of sand dunes, plant trees in strips of 20 m to 30 m wide at 40 m to 50 m apart across the wind direction for planting grasses in between these wider tree canopies.

Maintenance and after care : Protect from biotic interference by wire fencing or thorn fencing round the plantation. Illicit entry of livestock and tree passers is to be checked. Replace the casualties within the same year.

Felling for fuel wood : The rotation may be fixed for 10 years. The technology should be examined according to economics/cost benefit and local conditions and may be suitably modified accordingly.

For Sand Dune Fixation, Wind Break Shelter Belts and Road Side Plantations:

These are experimented at Marib, Shabwa area by the Eastern Region Agricultural Development Authority (ERADA), Ministry of Agriculture and Water Resources under UNDP programme (Hadri 1992). The technique are well known to Yemeni silviculturists. Researches should be conducted and necessary modification may be made if required. The techniques are well described (Hadri 1992) and need not be repeated. The same may be applied to protect the proposed road in case it is affected by sand movement.

The following salient points may be examined:

Shelter Belts: Plant straight, tall growing trees in the central row flanked with medium sized trees and bushy shrubs on the outer rows to provide a triangular cross section to the shelter belts.

No pruning or lopping of branches to be done within the shelter belts. Gap filling within the shelter belt is to be done in the same season as gaps in shelter belts would create wind tunnels and cause more hazards on the leeward side.

Benefits from Shelter Belt: These cut down wind velocity, protect crops; orchards, protection to livestock, provide fuel and small wood for consumption, reduce evaporation by about 40%, increase soil moisture content to 7.5% from 1 to 2% and increase the RH by 4 to 8%. It effectively checks the movements of sand drift and aeolian depositions.

Choice of Species : Besides local species following exotics are also suggested to be examined :

	Central Row	Outer Row
1st belt :	*Azadirachta indica*	*Cassia siamea*
2nd belt :	*Albizzia lebbeck*	*Accqcia tortolis*
3rd belt :	*Eucalyptus camaldulensis*	*Prosopis juliflore*

Wind Break Technique

Experiments are being made at Marib area.

Technique Applied:

Wind break of 1 row of trees has been planted around the boundaries of the farms

- Spacing between trees - 2m
- Spacing in the row is variable
- Rows are not always planted in continuous form
- Wind break are often planted very close to fruit trees
- Wind breaks to reduce wind velocity and protect agricultural crops.
- Reduce transpiration from plants
- Moderate external temperature
- If well extablished may lead to 30% increase in crop production.

Species selected for wind break and suitable in the project area are :

Accacia cyanophylla; A. milotica; A. tortolis, A salicinia, E. occidentails, E. camaldulenisis, E. microtheca and *E. gomophcephala*

Experiments may also be made with *Azadirachta indica and Tamarix sp.; Prosopis cineraria and P juliflora* which are likely to be suitable in this area. *Parkinsonia aculeta, Casia auriculta* may also be tried.

Roadside Plantation

Benefit : Controls the sand movement, reduce wind velocity, increase soil moisture and protect roads and infrastructure from aeolian deposits.

Choice of Species : Along with local species some exotic species should also be examined.

Trees : *Azadirachta indica; Accacia nilotica; Albezzia lebbek*
Cassia siamea Parkinsonia annula; Accacia tortolis
Prosopis cineraria; Prosopis juliflora, Accacia nilotica
Ec. S; A. saliena

Shrubs : *E. camaldulensis*
E. hybrid

The species suggested for shelter belt could also be tried.

Tree planting is to be carried out in three staggered rows on either side of the road. The technique to be adopted may be as follows:

Circular trench with central planting pit of 30^3 cm showed promising results in consolidated land types. In loose sandy stretches this type of soil working ceased to be effective as the trench round the plant gets filled up by blowing sand and in such areas tree guards prove better. In the project area besides Safir environ and Hadramout sector this technique is suggested. The first row is to be aligned at a distance of 10 m from the centre of road. The plantations grow remarkably and stand sentinel along the road. Acute problem is the protection of plantations from animals and villagers.

Sand Dune Stabilisation :

It is necessary for wind erosion control, farmland protection and, to protect against immediate threat of sand encroachment in crop lands, settlements, roads etc. Selection of sites should be made after examining the direction of sand movement. Achievement of a sustainable stablisation of sand sheets or dunes can only be obtained by a vegetation cover (biological stablisation). Mechanical stablisation by means of fencing or wall construction may aggravate the problem in the long run.

The success of sand dune fixation depends on -

i) selection of right indigenous species
ii) planting sturdy stocks
iii) planting in time and deep, timely replacement of casualties and their after-care
iv) suspension of biotic interference
v) use of drought resistant species.

Under the condition of project area following species appear to be most fruitful:

	Prosopis juliflora
Accacia tortolis	*Prosopis cineraria*
Salvadora persic'a	*Tamarix sp.*
Ziziphus spina christi	*Eucalyptus microtheca*
	Parkinsonia aculeata

For short term fixation UNDP (Hadhri 1992) recommend the direct sowing of-

Ricinus communis, Sosbania aegyptiaea (with irrigation)
Atriplex halinus; Atriplex caneseens

Spacing : 4 m x 5 m representing 500 trees/ha.

Planting : Root systems of seedlings could be uncovered by wind erosion and exposed sand dunes. So deep planting (20 cm) is recommended.

Planting Period - rainy season.

Considering the rainfall below 75 mm in the terrain, survival of tree will depend on irrigation during the first year. It has been proposed (Hadri 1992) -

1 watering prior to planting	=	1
2 watering monthly during 3 months	=	6
1 watering 1 months interval during 9 months	=	9
Total		16

Water quantity 20 litre/tree/irrigation

Diameter of cutting	1 - 2 cm
Length of cutting	80 cm
Period of soaking pre planting	5 days
Length of cutting above soil level	5 cm

Certain exotic species like *Camludulensis, Casurina sp. Parkinsonia aculeata* are also suggested.

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BASIC STUDY - 2

HYDROLOGY OF THE INLAND BASIN

BASIC STUDY 2

HYDROLOGY OF THE INLAND BASIN

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BASIC STUDY 2

HYDROLOGY OF THE INLAND BASIN

S2.1 Introduction

S2.1.1 The mountain ranges of ROY form three principal water-shed regions : (i) the westerly flowing drainage from the central ridge to the Red Sea; (ii) the easterly flowing drainage from the Central plateau towards Ramlat-As-Sab'ayatn into Hadramout and (iii) drainage in the southerly direction slopes through deep and narrow wadis with steep gradient to the Gulf of Aden and to the Arabian Sea. The proposed road alignment is contained within the second drainage basin. It is bounded by Western, Northern and Southern Escarpments.

S2.1.2 Eastern drainage basin is essentially an inland basin because of its configuration. Originating from the slopes of western escarpment with relatively low rainfall and extensive areas of run-off absorbing zones, the drainage passages through Marib-Jawf basin, Rub-Al-Khali, Ramlat-As-Sab'atayan desert expanse and then passes on to the Wadi Hadramout. Numerous wadis originate from the northern and southern peripheral hills and flow towards the basin only to die out at short distances because of sand suffocation (Figure 2.3.7 Surface Hydrology and Settlement Distribution). A perusal of the Figure 2.3.8 (Palaeo Hydrography of river flows in the Inland basin of Republic of Yemen) very clearly brings out the Palaeo channels. A hypothetical extension of these indicate that in the geological past a major wadi was traversing through the area to join Wadi Hadramout. Perhaps the channel might still be maintaining a sub-terranian flow through the burried channel. The Wadi Amad and Wadi Haynan join Wadi Hadramout towards the eastern end of the project area. It may be of interest to note that stable agriculture in the wadi starts from about this point of confluence of the Wadi Hadramout with Wadi Amad and Wadi Haynan.

S2.1.3 The wadis traversing the area are ephemeral in nature. In response to rains they flow over the rocky part of the wadi, and as soon as the water reaches the recent unconsolidated alluvia it sinks downwards. On occasions of cloud bursts the wadis get flooded and the flash flood is diverted for covering large area by creating small barriers across the channel to facilitate agriculture. The velocity of the flow is so high that it does not get enough time to be absorbed. The water moves downwards into the Recent alluvia and recharge the near surface groundwater, perhaps under perched conditons. Even when the wadis flow, the water is laden with sediments and is muddy. The low and erratic rainfall coupled

with the ephemeral nature of the streams are evidence enough to show that the area is poorly endowed with surface water. It is, therefore, but natural that groundwater is receiving greater attention for its development as an alternate and dependable source to sustain life and economy.

S2.2 Regional Orientation of Economic Development

S2.2.1 A perusal of the Figure 2.3.7 (Surface Hydrology and Settlement distribution) show that all settlements of importance are located at the base of mountains and near the wadis. Economic development in the country was, therefore, restricted to the flanks of the mountains.

S2.2.2 With the discovery of oil and establishment of refinery such as at Safir, the peripheral settlements are generating impulses for economic development and move for newer pastures towards north- east and east. Consequently the demand for water is increasing day by day and all viable economic activity will be dependent upon groundwater only.

S2.2.3 That Wadi Hadramout is a store house of groundwater is known from historical past. Groundwater exploitation has been a continuous process in Marib-Jawf basin, where with the development of the resource without any restrictions, have set in the mining of the groundwater. It is, therefore, but natural that areas little known for groundwater be explored to meet the requirements for economic development. Further where water resources have not reached the saturation point such as Wadi Hadramout, measures be introduced now itself, so that the groundwater regime remains nearly stable for contributing its part for the socio-economic uplift of the people of ROY.

S2.3 Status of Knowledge on Groundwater

S2.3.1 Although in varying details, most of the areas where groundwater development is taking place, have been investigated. Further, in more important areas like Sana'a, Marib-Jawf plains and Wadi Hadramout, mathematical modelling has been carried out for precise information on hydrogeological conditions and water balance (Reference Papers 3, 6 and 7). Depth to water, elevation of water table, flow direction, recharge and discharge areas are fairly well known in Marib and Hadramout areas. Sub-surface geology of these two areas alongwith aquifer parameters are also known. There is, however, no monitoring of water levels after the completion of any project study and thats a big gap. Areas of recharge and rate of recharge are also not known for large areas.

S2.3.2 In the Ramlat-As-Sab'atyan and Rub-Al-Khali wells drilled by oil companies and water supply agencies have contributed very significantly in proving the presence of Mukalla sandstone under the alluvial and sand cover of the desert which is a very promising aquifer for future groundwater development. Mention must be made that data on quality of groundwater are very inadequate. UNDP has brought out a report compiling all information from the previous reports (Ref. 6). For Marib area, General Department of Hydrogeology with the assistance of TNO Institute of Applied Science brought out very good reports (Ref. 5 and 7) giving hydrogeological conditions and management strategies.

S2.4 Geology, Hydrogeological Characteristics of Rock Types and Structures

S2.4.1 Simplified geology along with hydrogeological characteristics of rock types and their occurrence is shown in Table S2.4.1. A perusal of this table shows that the principal water bearing formations in the study area is Quarternary alluvial deposits and Cretaceous Mukalla sandstone of Tawilah group. Besides these two formations minor role is also played by Quarternary volcanics and limestones as also by Tertiary volcanics.

S2.4.2 The Arabian Peninsula is a part of extensive Afro-Asian Massif formed of Pre-Cambrian metamorphic rocks. The ROY particularly the Northern Governorates has a complex structure and geology because of its position at the junction of the Red Sea and Gulf of Aden Rift valleys. This complexity is also reflected in the occurrence of groundwater, the distribution of aquifer units and often the aquifer characteristics. Numerous fault zones, often creating horst and graben structures occur. The two main structural trends that can be distinguished in this part of the country are;

i) a NW-SE trend of strike slip faults parallel to Gulf of Aden rift valley perhaps follow earlier Basement Complex fault trends.

ii) a NNW-SSE trend parallel to the Red Sea Rift which mainly affects the region west of Sa'dah-Sana'a-Rada. The larger intermontane plains along or just east of the divide have mainly originated from the influence of this trend.

The Al Jawf graben follows a WNW-ESE trend and extends beyond into the Wadi Hadramout in the Southern Governorate.

Table S2.4.1
Simplified Geology and Hydrogeological Characteristics of Rock Formations

Age	Formation	Description	Occurrence	Hydrogeological Characteristics
Pliocene - Recent	Wadi Fills / Aeolian Deposits	Alluvium/Wadi Fills/Desert aeolian deposits. Generally unconsolidated	Wadi fills, highly variable in extent and thickness. Ramlat-As-Sab'atayn, Rub Al Khali, Intermontane valleys, coastal plains etc.	Wadi fills with primary porosity widely developed as groundwater source in wadi bottoms and coastal desert plains
	Volcanics	Lavas, pyroclastics	Volcanics of very limited outcrop in southern catchment	Though groundwater occurrence in recent volcanics is generally undocumented it occurs in localised areas in secondary porosity provided by joints and fissures
Eocene	Habshiya Rus Group Jeza (Hadramout)	Limestones with marls. Shales and marls dominant in lower half Interbedded gypsum, anhydride and limestones Alternations of marls, shales and thin limestones	Formations outcrop only within east of area in Hadramout/Mahrah Governorates	Contains very limited exploitable groundwater resources as outcrops mainly in low rainfall area, often gypsiferous and of highly variable hydraulic potential on account of secondary porosity
Palaeocene	Umm er Radhuma	Limestone and dolomites	Extensive outcrop with Hadramout before dropping beneath Eocene	Important local aquifer but this formation receiving majority of recharge to Hadramout regional groundwater reservoir
	Volcanics	Lavas and pyroclastics	Volcanics outcrop within western Highlands and Midlands	Of localised importance. Predominantly secondary porosity form good aquifers in Sana'a Basin.
Cretaceous	Sharwayn Mukalla Harshiyat (Tawilah Group)	Shales, limestones with sandstone interbeds Loosely cemented fine to medium grained sandstone Sandstone	Underlies entire area of eastern Governorates becoming deeper towards east where overlain by Hadramout Group units. Outcrops in dissected topography of Wadi Hadramout and tributaries	Mukalla sandstone is important regional aquifer containing primary and secondary porosity. Harshiyat believed to form basal unit to regional sandstone aquifer.

Table S2.4.1 (contd)

Age	Formation	Description	Occurrence	Hydrogeological Characteristics
Jurassic	Naifa, Madbi, Shugra (Amran Group)	Variable sequence of bedded crystalline limestone, shaly limestones and marls. Salt domes in Sab'atayn	Negligible outcrop. Occurs at depth below Cretaceous units. Sporadic outcrop in western Highlands	Of undocumented potential although of local importance within the northern Governorates. Formations generally too deep for exploitation in east and probably receive negligible recharge
	Kohlan	Arkosic sandstones	As above	
Permian	Akbara Shales	Shales	Yemen Highlands	No primary porosity. Formation normally devoid of groundwater
Ordovician	Wajid Sandstone	Cross bedded sandstones, light coloured. Ferruginous dark coloured sandstone	Outcrops limited to northern basin occurring estensively in Najran catchment with occasional outliers in eastern part of Rub-Al-Khali catchment. Also occurs in Wadi Mawr	Forms main aquifer in Sa'dah graben. Possesses primary and secondary porosity. A reasonably good water bearing formation.
Basement	Comprises lower Palaeozoic and Pre-Cambrian Units	Highly metamorphosed sedimentary and igneous rocks	Main outcrop of western Highlands and Midlands	No primary porosity. Groundwater occurs in weathered residium and secondary porosity provided by faults, fissures and joints.

Source : Adopted from UNDP Report - YEM/88/001

S2.4.3 The western part of the Southern Governorate corresponding to the south-western, southern and Ramlat-As-Sab'atayn catchment lies within the immediate influence of the tectonic activity which is associated with the formation of Red Sea, Ethiopian and Aden Rift Systems. The topographically elevated areas, which form the southern highlands and midlands in this area represent the up- warped land mass which is intensively faulted. Major fault trends relate to the Red Sea (NNW-SSE), Gulf of Aden (E-W) and the East African Rift Systems (N-S).

S2.4.4 The dominant structural features of the eastern part of the inland basin are the gently dipping west-east parallel anticlines forming the north and south plateaux which are underlain by Tertiary and Cretaceous strata. The Wadi Hadramout follows the intervening syncline. The northern anticline extends eastwards into Oman and in the west it flattens out and disappears in the Ramlat-As-Sab'atayn. The southern anticline is truncated on its eastern extension by the coast. To the west, it is truncated by WNW-ESE trending faults in the vicinity of Wadis Mayfa'ah and Hajr. The southern limb of the southern anticline is intensively faulted and gives rise to complex geological block faulting of the coastal mountain range.

S2.4.5 The range of geological formations and the structural history of the two areas give rise to a variability of ground water occurrence and movement as also the recharge zones. Each of the tectonic feature acts as a line of recharge whenever it comes under or along the passage of flow.

S2.5 Groundwater

S2.5.1 General

Based on the general aquifer and water shed characteristics the study area from west to east lies under the Marib-Jawf Basin, Ramlat-As-Sab'atayn, Rub-Al-Khali and Hadramout valley (Ref. Figure S2.5.1). In fact at and near Al'Abr, hydrogeological characteristics of Ramlat-As-Sab'atayn, Rub-Al-Khali and Hadramout are in close proximity or juxtaposition.

S2.5.2 Marib-Jawf Basin

The Marib area in Wadi Adhanah is located in the catchment area of the Wadi Hadramout. The area consists of two very distinct geographical zones - the eastern "Marib plains" a part of Jawf- Marib Basin near the south westerly boundary of extensive Arabian Desert, Rub-Al-Khali, and the mountainous catchment area of the Wadi Adhanah to the west of Marib city.

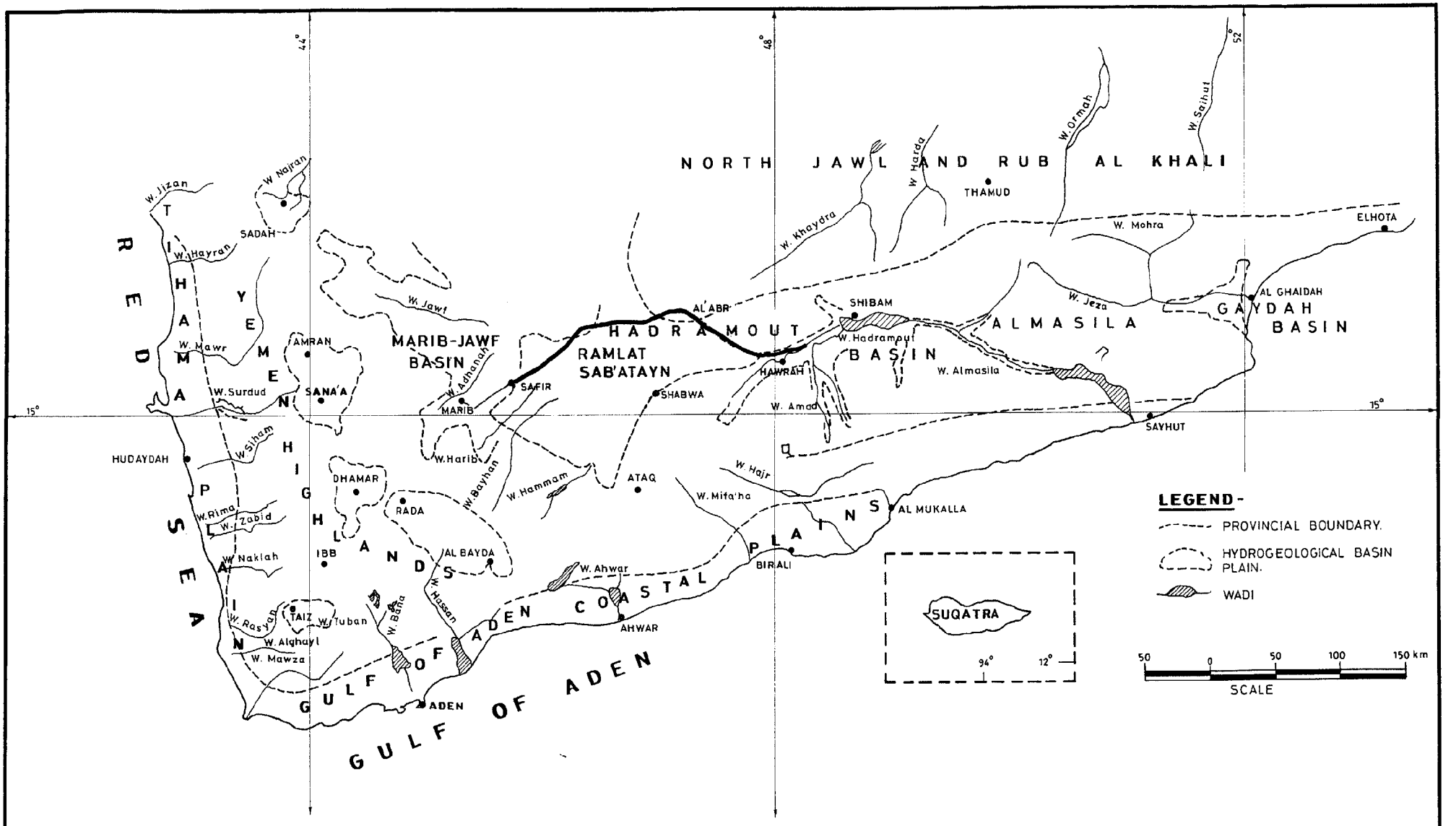


FIG. Nr. S2·5·1

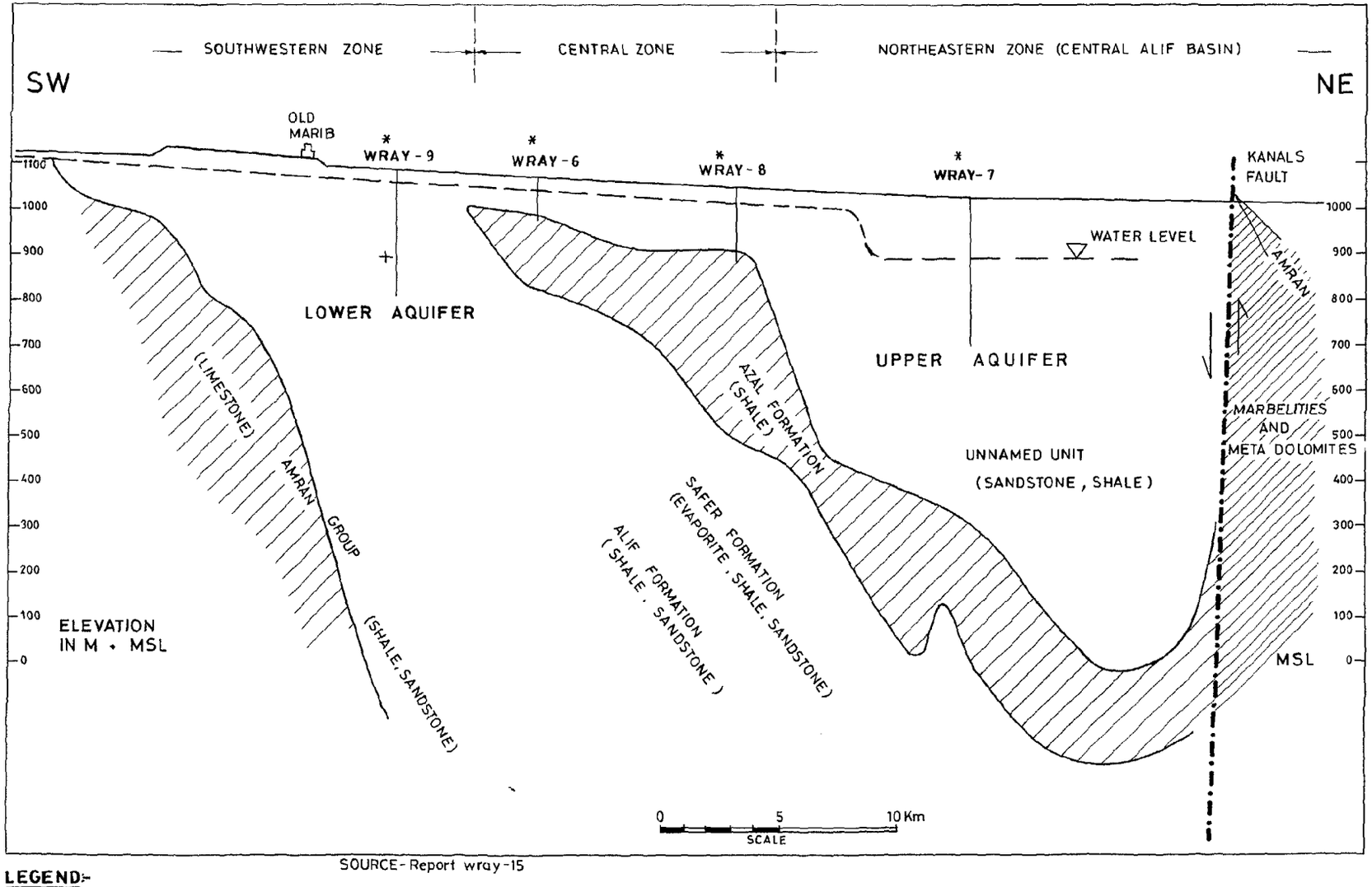
PRINCIPAL HYDROGEOLOGICAL PROVINCES IN YEMEN

SOURCE-National Water Resources policies I Water resources-Pt. II

The catchment is characterised by low rainfall in the main part of the area and is drained by the Wadi Adhanah's tributary system. The Central Highlands in the western part of the catchment receive moderate amounts of rainfall. Under the normal rainfall conditions, however, they do not contribute to the discharge of the Wadi Adhanah because of their internal drainage system.

The Marib-Jawf basin is a structural trough trending north west- south east. The basin has one outlet in the north-east where it is connected with the Wadi Hadramout and in other parts it is by and large encompassed by metamorphic basement rocks and limestones. The whole basin remained a mute witness to the tectonic activities which resulted in a number of faults trending east-west and south-east-north west. These faults have formed a number of sub-basins having influences on the groundwater. The basin is underlain by a sequence of classtic sediments and evaporite. The sedimentary deposits consist of sandstones, siltstones, shales and limestones and in the upper part with semi- consolidated sand and silts. These formations are overlain by recent alluvial and aeolian sediments.

Ground water occurs in all the formations in the Marib-Jawf basin. On a regional scale the basin could be considered as one hydrological unit since the ground water reservoir belong to the hydraulically interconnected basin fill deposits. During the course of hydrogeological investigations in Marib project area, it has been opined that the upper aquifer is formed by Quarternary alluvial sediments and semi-consolidated deposits of the Unnamed Unit Mukalla Sandstone belonging to Tawilah Group (Cretaceous). Water rests at depths varying from a few metres to about 50 metres below ground level upto central zone. Proceeding north-east of Safir it was observed that the alluvial deposits are unsaturated and the water table lies in the semi-consolidated sandstone formation of the Unnamed Unit of Cretaceous period. The project authorities observed a discontinuity in the depth to water near the boundary of the central and north eastern zones. It has been observed by them that over a relatively short distance of a few kilometres the groundwater level goes down by about 75 m [Figures S2.5.2(a) and S2.5.2(b)]. It was opined by them that perhaps groundwater has to flow through a zone of low transmissivity before it enters the principal sub-basin where the groundwater levels are dependent upon the hydraulic conditions of the semi consolidated sands of the Unnamed Unit. It has been reported that the hydraulic gradient flattens towards the north-east to a clear "low" gradient. Further north-east the gradient increases because of the "barrier" formed by the Azal Shale.



SOURCE- Report wray-15

LEGEND:-

AQUIFER UNIT (RELATIVELY PERMEABLE)

AQUITARD (IMPERMEABLE ROCK)

(* Section line. Figure Number S1.5-3)

FIG. Nr. S2·5·2(a)

HYDROGEOLOGICAL CROSS-SECTION THROUGH THE MARIB AREA

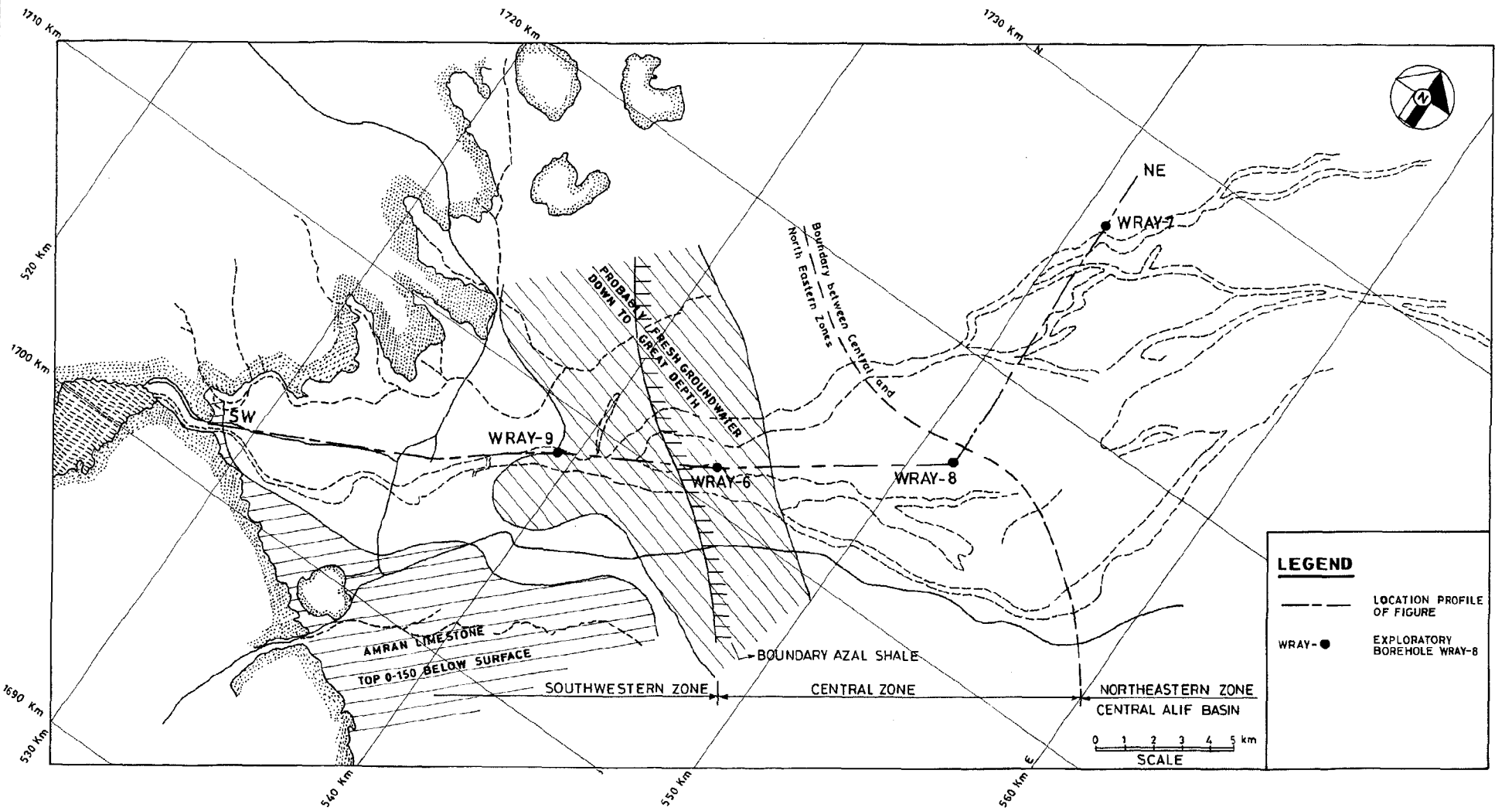


FIG. NR.S2·5·2 (b)

CHARACTERISTIC GROUNDWATER ZONES IN MARIB AREA

SOURCE- Report wray-15

Tubewells constructed by the oil companies and for Military authorities in the depth range varying between 120 and 200 m below land surface have depth to water/piezometric surface at a depth varying from 69 to 140 m but generally ranging around 90 m below land surface. There are many wells in the Marib-Jawf basin for domestic and agricultural purposes owned by private individuals. These wells are completed in a depth of 40 to 60 m below land surface. Most of the deeper wells have been drilled by the oil companies for their water requirements and Military authorities for their camp. Deeper wells have been constructed in the sandy desert of Ramlat-As-Sab'atayn.

The yield of these wells is substantial. The wells completed upto 60 m in Marib plains have a discharge of about 1 to 10 litres per second. No drawdown data are available from the private wells, but from the data of the wells drilled for the project studies and otherwise, it appears that the discharge of 5 to 10 litres per second is obtained for drawndowns ranging from a few metres to 30m.

Recharge to ground water takes place through the following processes:

(i) by infiltration and subsequent percolation of stream flow through the wadi beds;

(ii) by return flow from irrigation water;

(iii) by infiltration and subsequent percolation of local rainfall;

(iv) by ground water inflow.

Discharge of ground water takes place through the following processes:

(i) Groundwater withdrawal for agricultural, industrial and domestic use.

(ii) Direct evapotranspiration. This could only take place through wadi beds where the water table is close to the land surface.

(iii) The natural groundwater outflow.

Quality of groundwater, in general, is reported to be good. Higher concentrations of electrical conductivity about 2000 mm ohm/sec at 25°C occur towards the areas underlain by limestones at shallow depths, south-western margin and towards Wadi Masil. In areas where evaporites occur, groundwater show higher salinity. Salinity could perhaps be also related to volcanic activity. Where the

water levels are at shallower depth return flow from irrigation could also be a cause of salinity.

It has been estimated that total abstraction from the basin for the period between 1986-88 was of the order of 592 M. m^3 (million cubic metre), Total recharge to ground water body for a period from 1986 to 1988 was estimated to be approximately 266 M. m^3 and this indicates a depletion of the reservoir. The declining trends in water levels over the years with the progress of constructing new wells and abstraction of water is a proof enough of the draft being more than the recharge i.e., a process of mining of groundwater has set in. Even though the flow direction of groundwater from topographic highs is towards north-east, abstraction first in Sana'a basin and thereafter in Marib-Jawf plains more than the recharge will preclude any possibility of water from this area going down the gradient. It has in fact been seen that the areas which were earlier getting flooded when it rained has substantially reduced because of absorption in the upper reaches.

S2.5.3 Ramlat-As-Sab'atayn

The Ramlat-As-Sab'atayn is the southernmost catchment within the eastern basin and drains into the Rub-Al-Khali desert. The Ramlat-As-Sab'atayn lying west of Jawf graben has a relatively subdued relief and slopes north-north eastwards from about 2000 m above mean sea level (masl) to about 1000 masl at the edge of Jawf graben. The eastern part of the catchment is a desert area with a general relief and an elevation of about 1000 masl.

The main catchments of the Ramlat-As-Sab'atayn are Wadi Nissah, Wadi Bayhan, and Wadi Markhah. These drain north-eastwards but die out before reaching northwards into the part of Ramlat-As- Sab'atayn forming the study area. (Table S2.5.3).

Geologically the area is underlain by Basement Complex formation overlain by Jurassic and Cretaceous formations which in the study area as also in greater part of the Ramlat-As-Sab'atayn are covered by desert sands, and at places with the hardpan of sand and gravel. Approaching Al' Abr the Wadis are seen traversing through the area and before reaching Al' Abr wadi deposits along with lacustrine deposits are seen to occur in the cut sections.

Table S2.5.3
Summarised Statement of Groundwater Cathments, Occurrence & Utilisation

Geographic Unit	Catchment	Groundwater Occurrence	Groundwater Development	Further Potential	Special Requirement
A. Ramlat - As - Sab'atayn	Wadi Markhah	Catchment underlain by Basement, Groundwater principally within wadi fills and alluvial plains between Hajar and Lagafah	Last documented inventory during 1982. At the time, approximately 13 Mm^3/year ground water abstracted mainly for agriculture. Groundwater levels not reported to be in decline over 2 year period of monitoring	Estimated that there is 15 Mm^3/year groundwater recharge to plains in addition further unquantified resources from surface flows passing through catchment. Subject to determination of current abstractions is considered that further limited potential exists	Essential updating of current abstractions and ground water level trends.
	Wadi Beyhan	Main exploitable groundwater within unconsolidated fills of wash bottoms and lower catchment plains around Nugub.	Extensive development within lower plains and has progressively increased without control. Estimated gross abstractions in 1986 of 75 Mm^3/year within lower plains. Documentation of abstraction within upper catchment is sporadic	In 1979, concluded that ground water in lower plains is over-exploited. Significant development has occurred since. Ground water levels declining within area. On the basis of previous inventories within upper catchment considered that negligible or no further abstraction potential	
	Wadi Nissab	Underlain by Basement. Main source of groundwater in unconsolidated fills of wadis and lower plains within Wadi Hamman and Nissab area	Gross abstractions from plains were approximately 15 Mm^3/year in 1982. Estimated to be less than 6% of total catchment rainfall. Evidence of possible groundwater level decline, although inconclusive	Inventory data related to 1982 and not possible to evaluate level of recent abstractions. By comparing uncontrolled development in Bayhan it is possible that groundwater resources are fully utilised. Requires confirmation	Essential updating of current abstractions and groundwater level trends.
B. Rub-Al-Khali	Northerly oriented wadis towards fringes of Rub-Al-Khali	Main exploitable groundwater occurs within regionally extensive Cretaceous sandstone and Palaeocene limestones	Groundwater abstractions are small and dispersed and predominantly within sandstones in west and limestones towards east.	Recharge likely can accommodate envisaged future developlment. Subject to verification, there is likelihood that additional capacity exists within both sandstones and limestones	Quality of data from northern area is poor. Essential that careful control during proposed desert boreholes forming part of Northern Areas development programme.

Table S2.5.3 (contd)

Geographic Unit	Catchment	Groundwater Occurrence	Groundwater Development	Further Potential	Special Requirement
C. Wadi Hadramout	Wadi Hadramout and tributary wadis	Groundwater occurs in thick wadi infills of alluvials and partially cemented conglomerates. Hydraulic continuity or partial continuity occurs between these and regional aquifers of Mukalla sandstone (Cretaceous) and Umm-er Radhuma limestones (Palaeocene)	Abstractions were traditionally made from wadi fills and springs merging within tributary wadis. Abstractions have increased substantially and are mainly from Mukalla sandstone by deep boreholes. Estimated abstractions of 170 Mm^3/year have been inventoried. Groundwater levels are declining at approximately 0.1 m per year although numerical modelling indicates a general balance between regional ground water convergence towards Hadramout and abstraction.	Groundwater reservoir is extensive and not fully defined. Numerical modelling suggests that further abstractions (excess of 50 Mm^3/year) are possible. It is predicted that equilibrium will be established over 20-30 years as the cone of influence expands.	Piezometry and aquifer character needs definition towards regional boundaries. Urgent need to obtain available groundwater data from oil company activities. Need to routinely update numerical modelling activities for evaluation of management options and definition of further exploratory needs.

NOTE: During a personal discussion, the Chief Technical Advisor, General Department of Hydrogeology, Ministry of Oil and Mineral Resources, Sana'a, Yemen informed that the Oil companies in Marib - PSA oil fields encompassing Marib-Jawf basin and Ramlat-As-Sab'atayn have met Cretaceous Tawilah group sandstones and wells tapping these aquifers within a depth of 200 m are yielding good quality of water. Exploitation of this aquifer has shown no significant changes in the water levels. Recharge to this aquifer takes place from Central Highlands and the Eastern Mountains.

(Source : Adopted from UNDP Report - YEM/88/001)

Groundwater in the southern part of the Ramlat-As-Sab'atayn traversed by Wadis, and in the areas influenced by Wadis occurs between the depths of 10 to 30 m below land surface. Unless recharged it has been observed that the Wadi part of the Ramlat-As-Sab'atayn in the absence of rains become unsaturated. A number of wells have been drilled by the oil companies operating in the area and it has been observed from their data of the bore wells that the depth of the wells is restricted down to 200 m with water levels in the depth range of 69 and 140 metres below land surface. From the records in the General Department of Hydrogeology (GDH) of ROY, it was found out that in Arein area which lies a few kilometres north of the road alignment, two tubewells have been drilled down to the depths of 352 m and 350 m below ground level. The well drilled to a depth of 352 m taps water from sandstones (Mukalla). Depth to water in this well is 100 m. Its discharge was recorded as 2.3 litres/second for a drawdown of 30 m. The other well drilled down to a depth of 350 m has been constructed in a depth of 334 m. The depth zones screened in this particular well have been recorded as (i) 221-233 m, (ii) 245-251 m, (iii) 263-267 m, (iv) 287-293 m, (v) 310-316 m and (vi) 328-334 m. Thus a total thickness of 40 m of aquifer has been tapped in the well. The depth to water in the well was at 116 m below surface. No other details were available.

Recharge to the aquifers close to the wadis takes place through wadi seepages when flowing in response to precipitation, return flow from irrigation waters and direct infiltration from rainfall in the catchment areas of the wadis. As has been said in the preceeding paragraphs that Mukalla sandstones exposed in the Highlands and dipping north-eastwards receive recharge through the Marib-Jawf basin through natural flow. Discharge from this area is essentially restricted to the withdrawals by the oil companies. The estimates of withdrawals are not available as also the resources available within this hydrologic unit. No data on the behaviour of groundwater regime is known. It has, however been reported that the abstraction being very limited, no effect has yet been made on water levels etc. In the wadi parts of the Ramlat-As-Sab'atayn outside the study area it has been estimated that total volume of storage is of the order of 1200 M. m^3 and it has been opined that 75% of this storage is not of potable quality both for domestic and irrigation purposes. Quality of water has been reported to be good from the tubewells in the central and northern parts of Ramlat-As-Sab'atayn.

S2.5.4 Rub-Al-Khali

Nothern part of the study area, north of the northern arch of Hadramout valley covered with desert is known as Rub-Al-Khali. Here the Basement complex is over lain by Mesozoic and Tertiary sedimentary formations which form part of the

northern limb of anticline. These formations dip gently towards the north east. Surface outcrops of Paleocene limestones (Umm er Radhuma) occur in the west and dip below the younger deposits and, but for that the whole area covered with desert sand, Basement Complex is weathered to a certain depth but highly fractured. Fractures and joints are generally tight below a depth of 60 m. The structural pattern has influenced the wadi courses. (Ref. Table S2.5.3)

Groundwater on a small scale is being obtained from shallow dug wells in the alluvial channel deposits for domestic water supplies and livestock requirements. Recharge to the groundwater could perhaps be only through rainfall if and when received. No specific rainfall data are available but it is reported that the annual rainfall is less than 60 mm and therefore, the possibilities of large ground water resource are remote. Approximately 90 boreholes lying under Shabwa, north Hadramout and Mahrah Governorates have been constructed but no details are available. It has been surmised that units of Mesozoic and Tertiary period known for groundwater may be occurring in Rub-Al- Khali perhaps at greater depths. Mukalla sandstones outcrop in the extreme west and it is reported to be occurring towards north and east upto a depth of 1000 m.

Number of tube wells have been drilled in this formation in depths ranging from 250 to 450 m. The wells are reported to yield 5 to 20 litres per second. Hydrogeologist believe that groundwater occurs under confined conditions but there is no confirmatory evidence. Groundwater flow pattern is not known and no relationship with the flow of groundwater in Hadramout valley could be established. However, it has been reported that limited data suggests a north easternly flow. Though Al' Abr is located in Rub-Al-Khali it is probably at the junction of the Ramlat-As-Sab'atayn and Wadi Hadramout. In the wadi at Al' Abr, a number of dug wells are seen in its length and water level occurs at a depth of about 10 m from the wadi bed. There is a tube-well also at Al' Abr but no information about its depth, depth to water and yield etc. is available and local enquiries could not provide any information. It was, however, reported that the well functions in two stages i.e., it works for about 4 hours at a stretch and then allowed to rest and recoup for 2 hours to work again for another 4 hours. All requirements for domestic and livestock are met through this tube well. People from the small settlements around Al' Abr draw their supplies from this well. Estimated consumption in Al' Abr is of the order of 0.142 M. m^3 per year and 1.264 M. m^3 per year respectively. Recharge has been estimated to be in the vicinity of 15 M. m^3 per year to 24 M. m^3 per year. In the absence of any large scale withdrawl no deleterious effect on the groundwater regime could be possible. The quality of groundwater is good.

A few kilometres east of Al'Abr towards Hadramout there is a military tubewell in Wadi Akhban. It was reported that the depth to water rests at a depth of 170 m below land surface and quality of water is potable.

S2.5.5 Wadi Hadramout

Eastern extension of the project area east of Al' Abr lies in Wadi Hadramout. Transition from Ramlat to Wadi deposits are imperceptible on the surface. The presence of shrubs and trees and a little further eastwards settlements of human beings humming with activity particularly that of agricultural practices is a proof enough that an area with sufficient groundwater to meet the normal requirements of life has been reached and is being traversed.

Hadramout uplands are characterised by high level plateaux relatively well dissected. Highest elevation in the Hadramout Governorate is about 1500 masl in the west to 1000 masl in the east. Wadi Hadramout separates the two plateaux of South Jawl occupying the area between the plain and the southern coastal mountains and the North Jawl gently sloping to the Rub-Al-Khali desert. Major anticlinal axis of the north and south Jawl plateaux which are commonly known as Northern and Southern Hadramout arches coincide approximately with the watershed limiting the catchment of Hadramout-Al Masilah basin. Shallow east-west trending anticlinal and synclinal axis plunging gently to the east are the main folded structures. The main synclinal axis runs immediately south of Hadramout valley. Main valley and several tributary velleys of Hadramout cut deeply into the limestones which constitute the Jawl plateaux. The main valley and the lower tributary valleys also cut very deeply into more than 100 m thick underlying sandstone formation. The alluvial thickness is about 100 m.

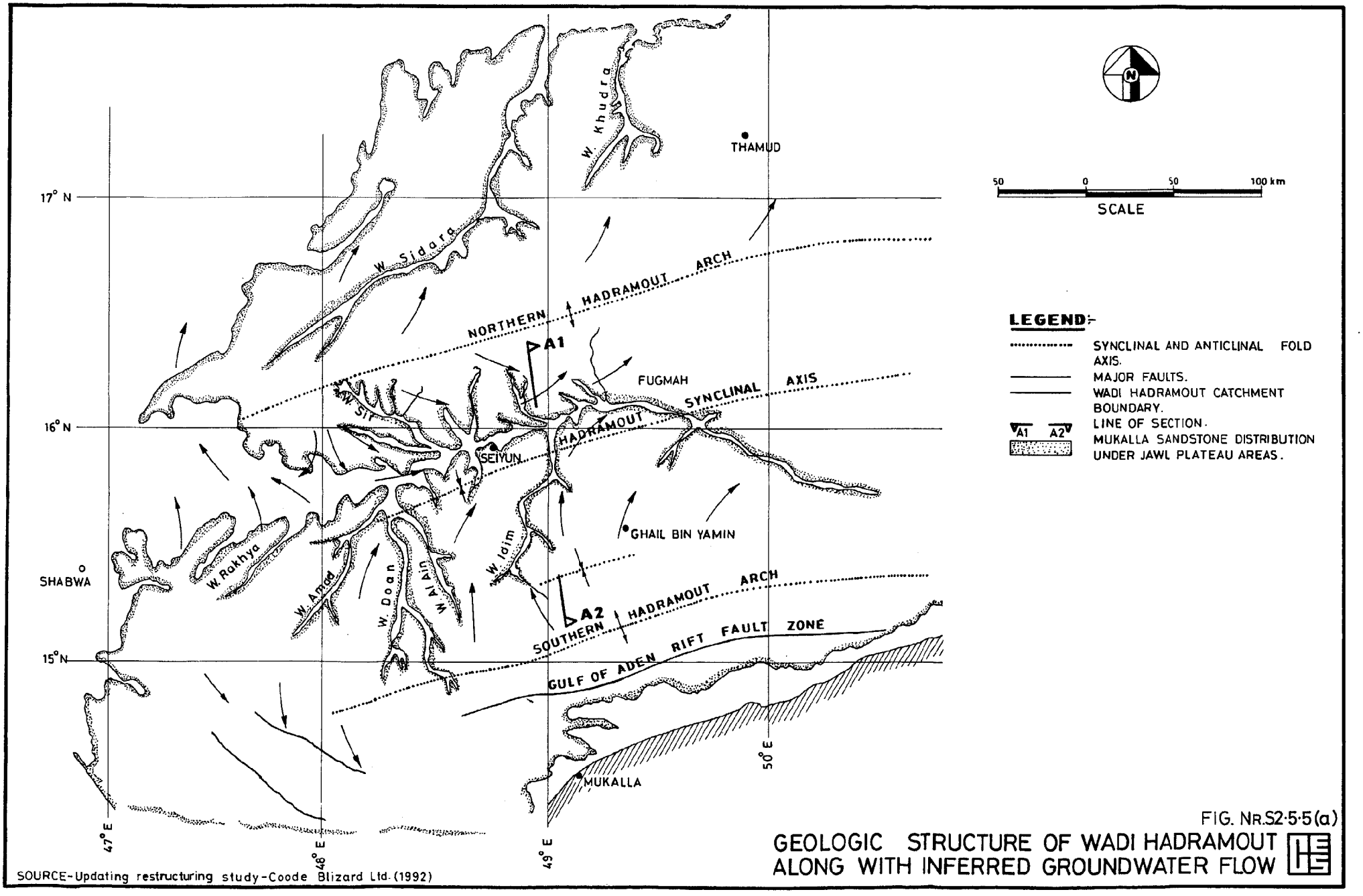
Considerable work has been done for developing the groundwater resources in Hadramout Valley and therefore, quite a good information about the hydrogeological setting is known (Ref 3, 4 and 6). The valley is underlain by three aquifers (Ref. Table S2.5.3). The two superficial aquifers are the alluvium and Neogene conglomerates and a deep aquifer - the Mukalla sandstone. The alluvium comprises inter-bedded silts, sands, gravels and wadi bed deposits. Neogene conglomerates underlying the alluvium is formed of re-cemented limestone boulders and detrital material derived from the valley sides. Conglomerates essentially have secondary porosity. Mukalla sandstone of Tawilah formation is a stratified aquifer of regional importance on the Plateaux. The Mukalla sandstones are overlain by Umm er Radhuma limestone formations. Karstic in nature, locally it also forms an aquifer under favourable hydrogeological conditions.

A map showing Wadi Hadramout with general structure, catchment boundary and distribution of Mukalla sandstone is shown in Figure S2.5.5(a). This figure also shows a section line on which a cross- section of the hydrogeology is shown. Though the section [Figure S2.5.5(b)] is from outside the study area, it gives a good generalised idea of the hydrogeological conditions existing and likely to be met in the parts of Hadramout valley under study.

Groundwater occurs in all the formations met with in the area and various formations of the Mesozoic and Tertiary period are of more regional extent and constitute extensive ground water reservoirs. It is under water table conditions in the alluvium but in the conglomerates and Mukalla sandstones it is under semi-confined to confined conditions. The Cretaceous Mukalla sandstones directly underlie the area and contain accessible groundwater supplies from within the wadi bottoms. The Palaeocene limestone and dolomites of Umm er Radhuma formations form a regional cap to the plateaux.

Near surface groundwater in the alluvium lies at depths varying from 15 to 25 m below land surface. The conglomerates which immediately under lies the alluvium in the central part of the wadi and lower sections of the side wadi, as also Mukalla sandstones, piezometric surface is reported to be resting at depths varying from 10 to 45 m. In the valley, small head differences have been observed between the three aquifer groups with a small upward hydraulic gradient. Measured piezometric levels in the sandstone aquifer of upto 1 m higher than the alluvium have been recorded earlier. On the plateau very large head differences occur between the Mukalla sandstone and the perched aquifers in the overlying Umm er Radhuma limestones, reflecting the lack of hydraulic continuity between the two formations.

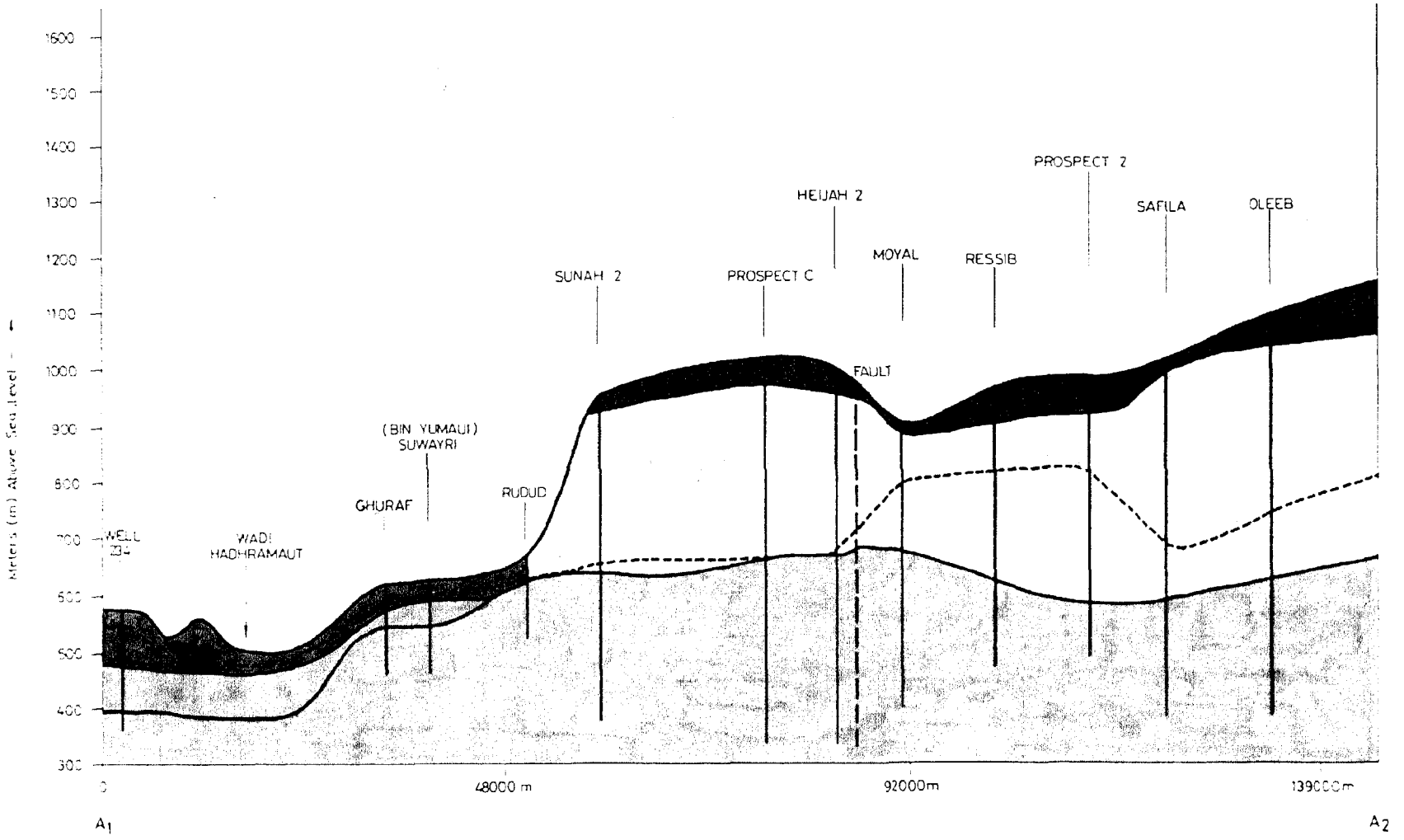
In the part of the area inventoried, the piezometric head was reported to be lying at or near a depth of about 30 m from the surface, and the depth of the wells was reported to be varying from 75 m to 121 m below land surface. In the central part of the valley, wells are constructed in depths varying from 152 to 250 m. In general, the wells are restricted in a depth range of 152-174 m below land surface. In the central part of the wadi, greater thickness of limestone conglomerates are met. The discharge from these tube wells range from 50 to 75 litres/second. On an average the yield from wells was found to be 61 litres/ second. The drawdowns for the discharges vary from 5 to more than 20 m. In general, however, the draw downs range between 5 and 10 m.



SOURCE-Updating restructuring study-Coode Blizard Ltd.(1992)

FIG. Nr.S2·5·5(a)

GEOLOGIC STRUCTURE OF WADI HADRAMOUT ALONG WITH INFERRED GROUNDWATER FLOW



LEGEND

- ALLUVIUM
- CONGLOMERATE
- JEZA FORMATION
- UMM ER RADHUMA
- MUKALLA SANDSTONE
- FAULT
- REGIONAL WATER TABLE

FIG. Nr. S2.5.5(b)

(SOURCE : COODE BLIZARD LTD 1992)

SUB-SURFACE GEOLOGY ALONG SECTION A1 - A2

Soviet-Yemeni Project prepared a piezometric map [Figure S2.5.5(c)] of the entire Wadi Hadramout aquifer system. A perusal of this map shows the regional flow pattern with ground water flow converging towards the Hadramout valley which forms a discharge zone for the sandstone aquifers underlying both the parts of Jawl plateau. Piezometric gradients under the plateau vary from 1:1000 to 1:750 steepening towards the east. In the valley the gradients are very flat at the western end adjacent to Ramlat-As-Sab'atayn and increase eastwards from 1:2000 near Batna to 1:1300 near Shibam, 1:900 in the central part of the valley and 1:650 downstream of the mouth of Wadi Idim.

Recharge of the aquifers takes place through the following :

i) direct infiltration from the rainfall on the rock or soil surface

ii) infiltration of run off on the plateau to wadi alluvium overlying the Umm Er Radhuma and thence via the limestones and the Sharwayn aquitard to the Mukalla sandstones underlying the plateau regions

iii) infiltration of run off to the deeply incised side wadis to join the lateral extensions upto the valleys of the main valley alluvial/sandstone aquifers

iv) deep percolation of water from flood waters as a result of cloud burst for spate irrigation on the side wadis

v) deep percolation of flood waters on the main wadi as also flood flow divisions for spate irrigation

vi) reinfiltration of spring flows to wadi alluvium and thence to main aquifer complex

vii) return flows from irrigation water

viii) sub-surface inflow from the west.

Discharge is mainly affected through the abstraction by wells and tube wells and that forms the largest component of ground water discharge. Smaller quantities of water leave the aquifer system through lateral flow and minor amounts may be lost by evapotranspiration where the water table occurs at shallow depths. Pumping for irrigation is seasonal with more water abstracted during the winter months (November to February) than in the hotter months (May to August).

FIG. NR. S2·5·5(c)

(SOURCE : SIR M. McDONALD AND PARTNERS, 1988)

PIEZOMETRIC CONTOURS IN HADRAMOUT VALLEY (1980)

Coode Blizard Limited (1992) report that Soviet-Yemeni Project show potential ground water outflows to the west along the main valley towards Shabwa. Sogreah, however, in their groundwater model have a distant inflow of 100 M. m^3 per year from the west. MMP (Sir M. McDonald & Partners) believe the indications are evident that groundwater flow from Mukalla sandstone could be northwards in the Wadi Sar area. On recharge and flow considerations they believe that inflows to the south-western areas of the Wadi from Southern Jawl rather than from the north-western areas of the Northern Jawl. They, however, say that there is little evidence to support the view but this mechanism would allow substantial groundwater outflow from the catchment as some modelling results imply (Reference Paper 3). It has been believed that any groundwater outflows from the wadi Hadramout catchment combines with the equally massive flows from the Yemeni highlands in the west to maintain these positive gradients.

Quality of groundwater from deeper aquifers is good. Shallower aquifers which are being extensively utilised for a very long period may show higher salinity because of return flow from irrigation water. Groundwater in zones just above the salt domes and salt infested sand gravel pans show higher salinity which could perhaps only be used for livestock in the absence of adequate water supplies of potable quality water.

Estimates of groundwater abstraction in the Hadramout valley was made by Coode Blizard (1982) and they opined that in 1990 it was of the order of 173.11 M. m^3 per year. Of this 1% is for public water supplies, the remainder being for irrigation and private water supply. On the basis of an assumed 20% return to the aquifer system of irrigation water, the net abstraction was estimated to be 138 M. m^3 per year.

Modelled Water Balance was carried out by Coode Blizard in 1992. The water balances as shown below were calculated from steady state model runs with the balance being independent of aquifer storage.

Inflows	198 M. m^3 per year
Recharge	118 M. m3 per year
Total	316 M. m3 per year
Outflows	98 M. m^3 per year
Abstraction	243 M. m3 per year
Total	341 M. m3 per year

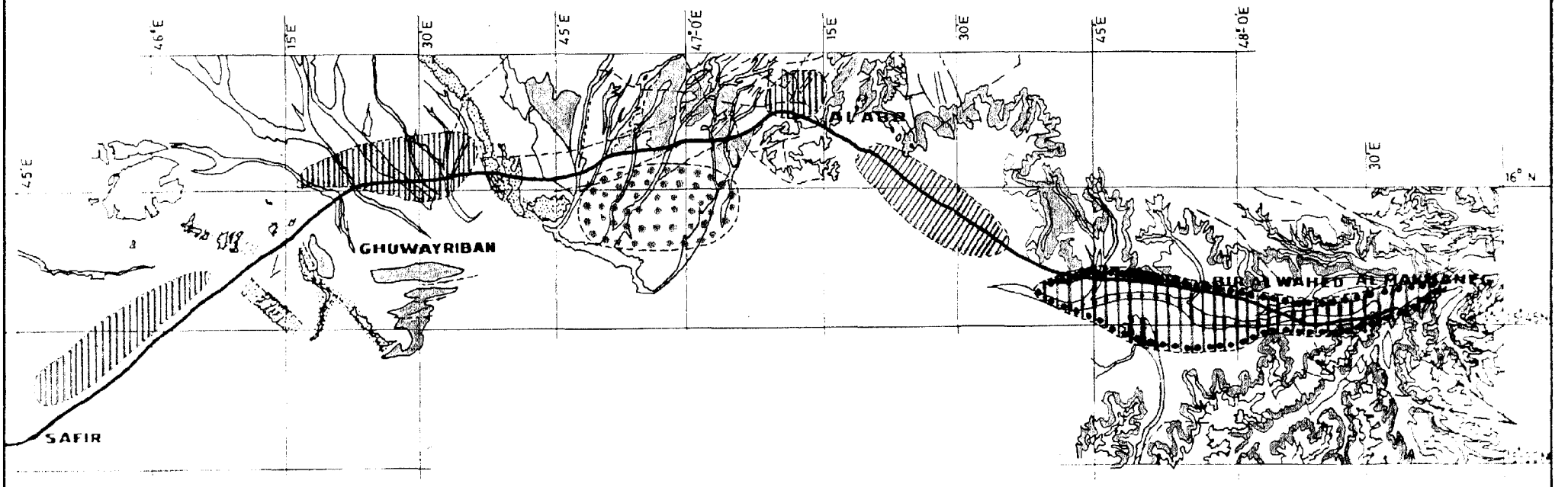
The cause of the imbalance of 25 M. m^3 per year they opined could be because of an underestimate of recharge, and added that an increase of overall recharge of 13.5 mm over the catchment would restore the imbalance.

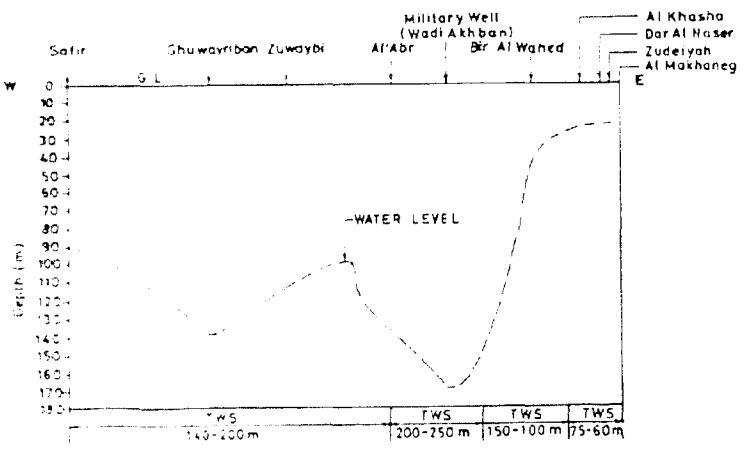
In more recent modelling aquifer behaviour under increasing abstractions has been evaluated using numerical modelling techniques. It has been concluded that anticipated abstraction are close to, if not in excess of, the estimated seasonal recharge occurring within the Wadi Hadramout surface drainage area. On account of the extensive area of the regional aquifers, it has been concluded that the anticipated abstractions can be sustained even after applying conservative recharge and boundary conditions. The actual long term aquifer response and potential for further development will however, be sensitive to the storage characteristics of the main water bearing units and the actual extent and character of aquifer system and neither of them are clearly understood. With the lack of factual data and application of modelling techniques, defining the further developlment and management of the Wadi Hadramout system will be based on judgement.

After the completion of work on Phase 2 of development of groundwater, water level data monitoring and abstraction data showed that the drawdowns in the Mukalla sandstone and the near surface aquifers to be less than half that was predicted. It has also been opined that the maximum fall in water levels that have been observed is just of the order of 0.1 m per year.

S2.6 Areas Suitable For Groundwater Abstraction Structures

From the review of the available literature it is apparent that in the study area encompassing the road from Safir to Al Makhaneg, Mukalla sandstone is an extensive aquifer with large ground water in storage. Tubewells tapping this aquifer in the entire length of the road alignment could be constructed at hydrogeologically suitable sites (Figure S2.6.1). A perusal of this Figure shows that upto Al'Abr there are four areas suitable for groundwater abstraction. The first area north of the road a little beyond Safir, is suitable for tubewells to be drilled between the depths of 140 and 200 m below ground level. The second area west of Ghuwayriban is suitable for shallow tube wells and with infiltration galleries. In the flood plain of wadis perched water levels are likely to be met at depths shallower than the depth to water from Mukalla sandstones to be met within 100 m from surface. At Al'Abr in the wadi beds infiltration wells are possible along with tubewells in a depth of 150 m below land surface. A little beyond Al' Abr into the valley of Hadramout, initially the tubewells may have to be constructed between 200 and 250 m below land surface but then from Bir Al Wahed wells





NOTE - In active wadis depth to water lies between 10 to 25 m b.g.l. (Perched Condition).

SCHEMATIC DIAGRAM SHOWING DEPTH TO WATER ALONG ROAD ALIGNMENT

Scale - HOR 1cm=28km, VER. 1cm=27m)

LEGEND:-

RECHARGE ZONES

- SHALLOW AQUIFER
- DEEP AQUIFER

CAUSING DISCONTINUITY IN GROUNDWATER FLOW

- APPROXIMATE STRUCTURAL BARRIERS TO GROUNDWATER FLOW.
- FAULTS.

POTENTIAL AREAS FOR GROUNDWATER EXPLOITATION

- THROUGH DEEP TUBE WELLS (WATER LEVELS FROM 90 TO 140m)
- THROUGH DEEP TUBE WELLS (WATER LEVELS AROUND 170m)
- THROUGH DEEP TUBE WELLS (WATER LEVELS AROUND 100m) AND SHALLOW TUBE WELLS/ INFILTRATION WELLS IN WADI BEDS
- THROUGH SHALLOW TUBE WELLS/ WELLS WITH INFILTRATION GALLARIES (WATER LEVELS FROM 15 TO 45m) CONSISTS OF PERCHED AQUIFERS ALSO

5 0 5 10 15 20 Km

SCALE

FIG. Nr. S2.6-1

GENEARLISED GROUNDWATER RECHARGE ZONES & AREAS SUITABLE FOR GROUNDWATER ABSTRACTION ALONG ROAD ALIGNMENT

could be constructed between the depths of 100 and 150 m in the Mukalla sandstones, sparing the dug well zone in the alluvium and shallow well zone both alluvium and Neogene conglomerates for the farmers who are tapping these zones for their tubewells. Wells have to be located at hydrogeologically favourable sites. In locating a well for the road it has to be seen that no other tubewell exists within 500 m to avoid mutual interference.

S2.7 Environmental Impacts of the Proposed Road

1. The depth to water in the entire length of the proposed road from Safir to Al Makhaneg is deep enough to experience any effect. Since the groundwater flow on a regional scale is towards north east, and the alignment of the road more or less follows the same trend there will be no effect on the flow pattern to retard its movement and building up of the water levels so as to come as close to the surface as to cause land degradation through water logging or soil salinity.

2. The proposed road negotiates wadis in section between Ghuwayriban and Al' Abr and then upto Al Makhaneg. Depending upon the behaviour of these wadis in case of rains/cloud burst enough precausions have been taken by way of providing Irish crossing and RCC box culverts so that the road does not affect the movement of the flash floods.

3. The environmental affects if any, could be as a consequence of greater agricultural and human activity with the introduction of a facility which would open up the area for agricultural and industrial activity through faster and safer movement.

4. More settlements, urban/rural may cause pollution because of organic, solid and bituminous wastes. Areas where water levels are deep,chances of pollution would be much less as the temperatures being high will degrade the organic wastes and others will take considerable time to reach the ground water body being at greater depths. In Hadramout valley, however, necessary precautions may have to be taken to avoid contamination of near surface aquifer which is likely to contribute to the other two aquifers lying below it particularly in areas where the piezometric head of the other two aquifers is below the water table.

S2.8 Conclusions

(1) Inspite of the fact that areas suitable for groundwater abstraction have been identified, it is apparent from the review of data that there exist large gaps for drawing precise conclusions in regard to sub-surface geology, and hydrogeological conditions occurring in the area for recommending well field and well design to avoid, perhaps, wasteful expenditure.

(2) It must be recognised that the conclusions and recommendations in this study have been based on a limited data. However the hydrogeological conditions that have been interpolated for the study area should hold good for their characteristics exhibited in the known areas.

(3) Infiltration wells are normally constructed in saturated sandy horizon. It has a main collector well with a diameter of 5 m with a depth of 10 m below the water table. Between the water level and the depth of the well laterals are driven upto a horizontal length of 30 m with 15 cms diameter slotted pipes to allow groundwater to move towards the collector well to withstand pumping.

(4) A generalised borehole design is given in Figure S2.8.4. After the drilling is over geophysical borehole logging may be done to precisely lift the depths of aquifers as also to know the chemical quality of formation water. This will help in providing the required length of the screen section.

(5) There are two aquifers between Safir and Al' Abr, viz., the top alluvium and underlying Mukalla sandstone of Cretaceous period. The alluvium is restricted to wadi beds and the Mukalla sandstone is of wide occurrence below the aeolian sands of the desert. Between Al' Abr and Al Makhaneg there are three aquifers in the Hadramout valley. The alluvium is the top most aquifer followed by Neogene conglomerates and the Mukalla sandstones.

(6) In the sector between Safir and Al' Abr tubewells constructed in the Mukalla sandstones between the depths of 140 and 200 m below land surface have piezometric level lying between the depths of 70 and 140 m, but generally ranging around 90 m below land surface. The yield of these tubewells vary from 1 to 10 litres per second. Flow of water in the sandstones is towards north- east.

(7) In the northern part of Ramlat-As-Sab'atayn extending into Rub-Al- Khali several tubewells have been drilled in the depth of 250 and 450 m. with

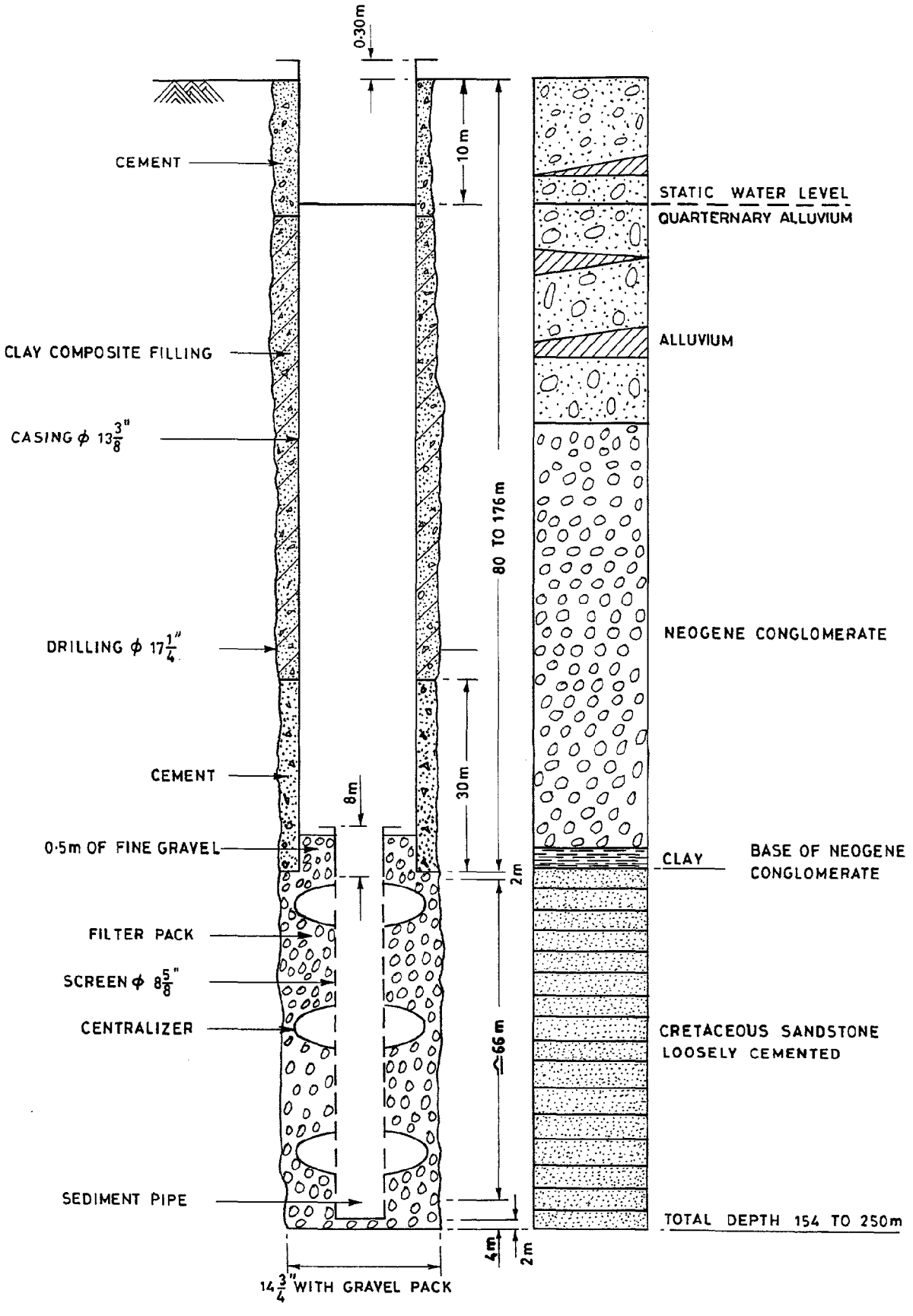


FIG. NR. S2.8.4

GENERAL DESIGN OF TUBE WELL

yields varying from 5 to 20 litres per second. At Al' Abr the depth to water in the Wadi beds is about 10 m below the wadi bed.

(8) There is enough water in the storage to meet the water requirements for the construction of the proposed Road.

(9) Quality of ground water in the Mukalla sandstones as also in the Neogene conglomerate is good both for domestic and irrigation purposes and therefore it shall pose no problems in the construction of the proposed Road. Quality of ground water in the alluvium in Wadi beds is good. It is however, saline in the central part of Hadramout valley and in areas where salt domes and salt encrustations associated with sand and gravel occur.

(10) Road causes no adverse environmental effect.

(11) Road on being constructed will be good life line for movement and industrialisation for socio-economic uplift of the people of ROY.

S2.9 Recommendations

1. A perusal of the available literature shows that inspite of the fact that substantial work has been done, there is no continuity in the work and no basic data are provided with the reports or easily available.

2. Before taking up drilling for the construction of tubewells the sites be selected on hydrogeological considerations.

3. There appears to be no central repository for data and reports, and that is a requirement for better planning of groundwater resources.

4. Systematic hydrogeological surveys be carried out and the open wells and tubewells plotted on the map. Once the systematic surveys are over, suitably placed wells be monitored for the behaviour of groundwater regime once towards the end of summers and then after the rains are over. Chemical quality of groundwater be examined once a year towards the end of summers. From the water levels maps showing depth to water and thereafter changes in water levels be prepared.

5. Water level elevations above the mean sea level at the observation stations be used for the preparation of water table contours which would show the groundwater flow pattern and areas of recharge and discharge.

6. Lithological logs of the boreholes be used for the preparation of a fence diagram of an area as a whole to establish the aquifer geometry.

7. All hydrogeological data as above and the data of pumping tests both step-draw-down and aquifer performance be kept in computers for immediate retrieval. The data would be useful for calculating the water balance through mathematical modelling.

8. Draft is a very important parameter and therefore it is essential that a census is first taken for all ground water abstraction structures and thereafter any one going in for a well should register with a central authority and provide all data regarding lithology, water level, discharge, drawdown, quality and aquifer tests, if done.

9. Sample survey of abstraction structures be done for arriving at a norm of discharge from each type of structure to calculate the total abstraction.

10. Area wise preferably a geomorphic unit or a wadi (basin) as a whole be studied. Reports containing all hydrogeological information and interpretations be made which will help in future planning and management of the resource.

11. Based on the availability of water and the consideration that water is a scarce commodity to be utilised judiciously, consider change in cropping pattern and introduction of sprinkler/drip irrigation wherever considered necessary.

12. In constructing a tubewell, the upper two aquifers in the Hadramout valley will not be screened and its utilisation be left for the farmers.

13. In constructing tubewells the zone formed by Mukalla sandstone be only tapped to avoid any leakage to the alluvium or conglomerate zone.

14. Infiltration tests may be conducted on different soil types/geomorphological units at a few locations for determination of rate of infiltration for the purposes of calculation of recharge an important parameter for water balance.

15. Under the General Department of Hydrogeology, all groundwater work be done, including monitoring of behaviour of ground water regime. The department may consider issuing yearly reports. The data and reports be kept both at the Central and Governorate levels, as also in any other office of the department located in any part of the ROY.

16. After the Project is over the tubewells constructed for road construction be utilised for road side plantation, drinking water supplies for the settlements to come, or for any activity which may benefit the people.

S2.10 Acknowledgements

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BASIC STUDY - 3

SOCIAL GROUPS ALONG THE PROPOSED ROAD CORRIDOR

BASIC STUDY - 3

SOCIAL GROUPS ALONG THE PROPOSED ROAD CORRIDOR

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BASIC STUDY - 3

SOCIAL GROUPS ALONG THE PROPOSED ROAD CORRIDOR

S3.0 Introduction

S3.0.1 The study of the social and cultural impacts of the proposed road has been mainly confined to the communities located along and near the proposed road alignment. It has focussed on :

a) general background of the social organisation and identification of tribal communities in the concerned region of Marib and Hadramout;

b) identification of the local communities along the proposed road alignment;

c) living patterns of the settlements and some Bedouins camps near the proposed road alignment; and

d) assessment of social impacts on the communities and Bedouins camps studied.

S3.1 Methodology

S3.1.1 This study is based on compilation of relevant information from available published and unpublished documents and fieldwork through visit to all the settlements along the road alignment and three Bedouin camps. The objectives stated in the terms of reference require a more detailed fieldwork to produce an indepth understanding of the communities likely to be affected by the construction of the proposed road and the nature of impacts, both positive and negative, on the social, economic and cultural life of the concerned communities. Within the limits of the time available, the field work had to be mainly focussed on broad observations and interview of few selected informants from various local communities. The documentation was also very limited and mostly outdated. The present report suffers from these two limitations. It is suggested that efforts may be made to conduct a somewhat more detailed enquiry with at least two months of fieldwork which is necessary for an anthropological enquiry for a more satisfactory analysis of the likely impacts.

S3.1 A VISIT TO SETTLED BEDOUIN HOUSE
(MARIB)

S3.2 A BEDOUIN CAMP - SOUTH EAST
OF AL' ABR

S3.1.2 The information collected through field investigations is as follows:

a) Identification of nomadic tribes and settled communities which are located along and near the road alignment;

b) Identification of economic resources and patterns of living of local communities and Bedouin encampments in the project area;

c) Use and representation of space (patterns of movement);

d) Access to educational, health and other social services including drinking water;

e) Relationships between local communities; and

f) Questions directly related to the road, e.g., what are the expectations of the inhabitants of the various communities in the Project area from the road in terms of opportunities during and after its construction?

S3.2 Social Organisation & Distribution of Tribes

S3.2.1 The tribe is the basic unit of social, economic and political organisation of the Yemen society. Territory is the basis of social, economic and political organisation of the tribe. Each tribe has its own territory, a base for socio-political action, recognised agricultural lands and grazing grounds, and markets towns where it carries its trading and commercial activities.

S3.2.2 Each tribe claims to have a common descent. Both the size and internal structure of tribes vary from case to case. They are divided into sub-groups or fractions which also trace their origin from a common ancestor. The name of the tribe or its fraction is that of the "ancestor".

S3.2.3 Each tribe or its fraction has a Sheikh (tribal leader) who usually comes from established family of Sheikhs. The extent of power of the Sheikhs is largely dependent on their individual capacities. The Sheikh has no rights over the tribesmen or over their lands. The function of the Sheikh is mainly that of guarantor. He has to keep peace between his own followers and regulate relationships with other tribes. His role as an arbitrator is performed within the scope of customary laws.

S3.2.4 The traditional occupation of the tribesmen in Yemen is agriculture, but within the same tribe, we can find fractions or sub-divisions which are engaged in pastoralism. They can be sedentary, nomadic or semi-nomadic. From an anthropological point of view, Bedouinism implies specialisation in herding large flocks of dormedaries. These constitute the Bedouin's main resource, on which to a very large extent depends his mode of existence. In contradistinction, the herding of small flocks of goats, sheeps and camels coexist with other patterns of occupation like transportation of goods, trade, agricultrual and construction labour constitute today the way of life for many tribal groups of the concerned regions. In terms of anthropological definition, nomadism as an exclusive mode of production seems to have almost disappeared in Yemen.

S3.2.5 Pastoralism is a way of exploitation of environment and a form of society, based upon herding of flocks of animals, that induce nomadism. This gets articulated in a type of relationship with a territory and a conception of space that is perceived, in a strict sense, as a distance. The pristine sense of geography of the nomads represent a circulation- space which includes a town i.e., the linkage with the place which controls other forms of spaces as production territories. The town is a place which is included in the composition of a nomad-territory if we take into account the value of circulation and not only the production space. Towns in tribal territory are often accorded a special status. In Northern Yemen, they are sometimes associated with non-tribal people, with the people of the market and with men of religion. The effects of cash economy led the tribesmen into commerce and many of them while settled in towns keep their links with their villages and lands.

S3.2.6 One of the major tribes of the Marib region is the tribe of Abida which comprises the fractions of Al Rashid bin Munif, Al Jalal, Al Hitayk, Al Shiwan, Al Hafri, Al Fijayj, and Al Kamil. The traditional occupation of the Abida was transportation of salt by camels from Safir to Marib. There are also the fractions of the tribe of Murad which are Al Sayyad, Al Musali, Al Bajij, Al Mufalaha, Al Kathir, and Al Qaradi'a. What is important to stress here is the these two tribes, Abida and Murad do not belong to the two tribal confederations of highlands of Yemen, namely Hashid and Bakil. The tribe of Abida has traditional alliance with the tribe of Nahd of the Hadramout region. Thus their autonomy can go further than the other tribes, even if many of them have only an informal linkage with their confederation. There is also the tribes which belong to the great confederation of Bakil, such as the tribe of Al-Dhawi which is subdivided between Al Mamur, Al Mahdi, Al Ghanim, and Al Jabir. We also find tribes which belong to Khawlan Al-Aliya. They are the Banu Zabyan and the Banu Jabar. Khawlan Al-Aliya does not belong to the confederation of Bakil.

S3.2.7 In the Hadramout region, the town of Al-Qatn is inside the territory of Nahd tribe which is settled on both sides of the Wadi Hadramout. The towns of Al Makhaneg and Al-Hudhba were their fortresses in the past. The limit of its territory extends to the wadi Akban in the west and the wadi Duhr in the east. The town of Hisn Al' Abr is inside the territory of the Al Abd Al-Qadir who belongs to the tribe of Al Burayyik, a tribe of a higher status because of its claim to a sacred genealogy linking it to the Prophet's family. Another important tribe of the region is the tribe of Say'ar which inhabits the desertic areas of the north-western Hadramout. It is subdivided into two fractions, the Al Hatim and the Al Ali Bal Hayth. The first fraction subdivided itself into eight sub-fractions (Bani Jarbua, Bani Milhi, Bani Saybani, Al-Awn, Al-Masadisa, Al Hataish, Al Ma'aruf, and Al Abdullah b. Awn). Most of these sub-fractions are nomads and live west of Raydat Al-Say'ar which is the only village market of the whole tribe. The second fraction, the Al Ali Bal Hayth, comprises ten sub-fractions (Bani Rumaidan, Al Kasalin, Hawallan, Bani Shamlan, Al Khamis, Al Asakir, Bani Al-Tarjin, Al Msellum, Al Baqi Msellum, and Al Ali). The Al Ali Bal Bayth are semi-nomads who live east of Raydat Al-Say'ar. They are specialised in the transportation of goods between North Yemen and the market towns of Hadramout, principally Shibam and Shabwa. The chief of the whole tribe, is called the hakim and not the muqaddam like with the other Hadrami tribes. He is traditionally elected, but his power is less important than the one of the Al Hatim chief.

S3.2.8 The project area around the alignment from Al' Abr to Safir (a stretch of about 180 kms) is uninhabited except a Bedouin semi-nomadic camp near Ghuwayriban, a military camp at Jabal Ath Thaniyah, Yemen Hunt Oil refinery and Assad Al Kamel Gas plant at Safir, and some Bedouin semi-nomadic camps at some distance from the oil refinery and few shops including a repair workshop for motor vehicles. On the other hand at the Hadramout end there are eight settlements (Al Makhaneg, Munbaith, Al Gauda, Al Zudeiyah , Dar Al Naser, Al Khasha, Bir Al Wahed and Al' Abr). Seven of these are distributed over the last stretch of 46 km of the road alignment. These settlements include small scattered dwelling clusters within their respective boundaries. Except the township of Al' Abr, all the other are rural settlements. Besides these settlements, there are semi-nomadic Bedouin camps spread across the area between Al Khasha and Al' Abr.

S3.2.9 Local communities in the concerned region belong mainly to two tribes, namely the Al Nahd and the Say'ar. The name of the Al Nahd territory is Kasr. The well of Al Hayra divides the limits between Al Nahd and the Sey'ar tribes. The territory Al Nahd begins at Al Mardia near Shabwa. The Nahd tribe is divided into four principal fractions : Ramdan (of the settlement of Gauda) Maghrum (of the

settlement of Al Batina and Madhur), Yazid (of the settlement of Zudeiyah), Zulfan (of the settlement of Al Khasha) and Yemna (Wadi Sur including the villages of Al Shersh, Al Jard, Al-Gidfira where the Sheikh of this fraction lives, Al-Sumakh, Bir Al Wahed, Al Dhinayba).

S3.2.10 The territory of Say'ar tribe stretches east of the village of Bir Al Wahed. It is dispersed from Al Qatn to the border of Saudi Arabia cutting across the Ramlat As Sab'atayn. The principal socio-political centres of this tribe are Al' Abr and Raydat Say'ar. That of Nahd tribe is Al Gauda, the residence of its chief Sheikh. He belongs to the Sheikh family of Ibn Ajjaj. Two other settlements of the Nahd tribe, Al-Munbaith (between Al-Makhaneg and Al Gauda) and Muryghat (near Husn Al Kuwayr) act as neutral places where different fractions meet to settle their conflicts. The tomb of Al bin Umar is located inside the mosque of the village Munbaith and acts as a pilgrimage centre for the people within and outside the Nahd territory.

S3.2.11 Al' Abr seems to have replaced Raydat Al Say'ar as the principal market town inside the Say'ar territory. However this settlement is also inhabited by other tribal groups such as Al Burayyik, and Al-Kurub tribe (who are principally located in the Shabwa region). The saint, Salah b. Shaybana, who is burried there, belongs to this tribe and his tomb was erected in early 1930s,

S3.2.12 It was observed that each of the tribe, mentioned in the preceeding paragraphs, is segmented into various models of social and economic organisation like farmers, nomads, semi-nomads and sedentary nomads. The basis of tribal social indentity consists of several patterns with territory being the defining element. The primary frame of reference for identifying is the settlement which is followed by a fraction territory which is constituted of a group of settlements. The fraction of a tribe has a clear perception of boundaries of territorial domains. Within these perceived boundaries of the fractions, Bedouinism becomes a social marker indicative of social, cultural and economic distinctiveness even for those groups who are permanently settled.

S3.3 Living Patterns in the Settlements

S3.3.1 **The Village of Al-Makhaneg** (Mudiriyyat Al-Qatn)

This village is located at the junction of the proposed road with Al Mukalla-Seiyun road. In the past, it contained one of the fortresses of the Nahd tribe. At present, it is a linear settlement on the edge of the road extending over half a kilometre. It consists mainly of two restaurants, one hotel, ten shops and repair service

workshops for the motor vehicles and trucks engaged in transportation of goods and passengers. It is a typical road side settlement geared to servicing transport and marginally to the local economy. The shops sell consumer goods and provisions for the adjoining villages of Munbaith and Ajlaniyya. Tourists also stop at this place for refreshments and sometimes for staying at the hotel, which serves as a meeting place for the people of the adjacent settlements as well. Some dwelling units of shop-keepers and farmers are located here, who cultivate small rainfed agricultural fields.

S3.3.2 The Village of Munbaith

This village, typical of the region in many respect, is located about four hundred metres from the proposed road alignment. It consists of seventy houses which have a population of nearly seven hundred people who claim to have descended from four families, namely Wasil, Askar, Iran and Ja'far. They do not consider themselves to be tribal people even if their village is located inside the territory of the Nahd tribe. Members of ten families of this village have emigrated to Saudi Arabia. Most of the agricultural lands belong to the tribal settlement of Al Gauda Most of the population of this village work as share-croppers and a few families act as of agricultural workers. Most families have livestocks consisting of goats, sheep, camels (mainly for milk) and donkeys (for transportation). Families possess goats and sheeps ranging from forty to hundred. Some of the families have 2-3 camels. They sell these goats and sheeps at Al Qatn and sometimes to Bedouins who, in turn, sell them to Saudi Arabia. Share-croppers can be divided into two categories, one based on pump-irrigated cultivation, the other on rainfed agriculture. The share of the produce in the first category is divided between the landlord and the share-cropper in the ratio of 3:1. In the rainfed farms, the landlord deducts ten per cent and the remaining produce is equally shared between him and the share-cropper. Share-cropper's rights on the land are passed from father to son. The share-cropping family form the basic social unit of production. Some of the share-cropping families have small holdings of agricultural land. The share cropping families possess considerable economic strength. They first meet the basic needs of grain and then invest on fodder for livestock. Livestock fetches good prices in the markets of Al Qatn, Shibam and Seiyun. This pattern of share-cropping is followed in the rest of the settlements along the proposed road and in the rest of the settlements in the adjoining regions. There are three motor-pump wells in and outside the village. One in the village is meant for domestic use whereas the other two are mainly for irrigation. The water for domestic use is carried by pipes. The wells for irrigation have been constructed by the Sheikh of Al Gauda. Water though privately owned is shared by the community for both irrigation and domestic purposes.

There are no schools and health centres in the village. The people send their children to the primary school at Al Gauda and for secondary school at Al Qatn. For medical facilities they go to Al Qatn which is about twenty-five kms from Al Makhaneg.

S3.3.3 The Village of Al Gauda

This village is located about a kilometre from the proposed road. The chief Sheikh of Nahd tribe, Abdul Hakim Ibn Ajjaj lives here. It is estimated that nearly two thousand inhabitants live in the principal village of Al-Gauda and dwelling clusters around the village. There are substantial number of emigrants who have returned from Saudi Arabia after the Gulf war. Most of land is owned by the Sheikh and families related to the Sheikh. The village consists of share croppers. Like the share croppers of Munbaith, they also depend on livestocks economy. They are also migrant agricultural workers living in this village. The land holdings vary from a maximum of five feddans to a minimum of a quarter of feddan. Nearly fifty percent of the agricultural land is rainfed and the rest is irrigated by motor water pumps. There are two primary schools, one for girls, one for boys. It has three mosques, a police post, a pharmacy, a consumer cooperative store and a sub-office of Al-Qatn municipality. The people of this village go to Al Qatn for secondary schools, health services and trading needs including selling goats and sheep. The village has a water tank located at the top of the adjoining hillock from where water is carried through pipes to individual houses and to the adjoining dwelling clusters (upto the small settlements of Ramla, Ard Huways and Bahran). There are two wells, one operated by electrical pump, the other by diesel-pump which are mainly used for domestic purposes. There is a small unit producing concrete cement blocks for housing construction. Most of the workers for house construction come from Tarim.

S3.3.4 The Village of Al Zudeiyah

This village consists of nearly thirty houses, which are inhabited by families related to the same ancestor, Al Ruwaymi. Their principal activities are agriculture and trade. The traders have business establishments and shops in the cities of Aden, Mukalla and Seiyun where they mostly sell imported goods of various kinds. The traders expressed that they have a strong interest in the development of the village as a whole. They have already built four diesel pump operated wells for domestic and irrigation uses. Each well costs an amount of 500,000 Rials including drilling and pumping equipment. The cost of operation for each well for 8 to 10 hours per day is 70 Rials. An attendant is paid 5000

Rials per month for maintaining and operating the pump. They said that they are going to invest money in constructing six more diesel operating pump wells next year in anticipation of the road being built. Most of the agricultural lands are cultivated by share croppers. There are no educational and health facilities. The residents go to Al Qatn to avail these facilities.

S3.3.5 The Village of Dar Al Naser

The inhabitants of this settlement belong to the fraction of Rawdan in the Nahd tribe. There are twenty houses in this village. Their principal activity is the raising of livestocks, mainly goats. They also practise agriculture. Their land extend upto the boundaries of Al Khasha. There are two diesel pumps and two dug wells. The water from these wells is used for domestic purposes, agriculture and livestock. The water is found at a depth of thirty metres in this village. Some of the villagers are traders and have shops in Seiyun and Mukalla. They sell their livestocks mainly in Al Qatn. Their children go to school at Al Khasha. There are no health facilities in this village.

S3.3.6 The Village of Al Khasha

This village is scattered over a wide area, between the mountain of Al Jizan and the mountain of Lasalab, and is mainly inhabited by sedentary Bedouins who are from the Nahd tribe and owe alliegance to the Nahd Sheikh of Al Gauda. The village has a population in the range of 500 to 600. They are mostly engaged in agriculture supported by livestock economy. The Bedouin landowners employ labourers from within the village for cultivating their land. There are two schools up to six standard, one of which has since been closed. There is also a small pharmacy. For grazing livestock, they go up to Al' Abr. They sell goats and sheeps to Al Gauda, Al Qatn, Shibam and Seiyun and also to the bedouins of Al Say'ar tribe who sell it at Al Sharura in Saudi Arabia. There are few shops run by the Bedouins who sell gas cylinders, provisions and other consumer goods.

S3.3.7 The Village of Bir Al Wahed (Mudiriyyat Al' Abr)

It consists of nearly fifty houses built in 1975 and inhabited by Bedouins who call themselves Bedouins of the countryside. Their old location was at Husn Al-Ghuwayran, which has since been deserted. The main activity of the village is livestock raising and subsistence agriculture which is mostly rainfed. Some of the lands of this village belong to people from Al Yemna tribal fraction. There is one primary school, two mosques and one small pharmacy. There are two diesel pump wells which are mainly used for domestic purposes, providing water to the

livestock, growing fodder and some cash crops. The depth of the water is said to be 70 metres. They sell their livestock to Al Qatn. They have planted date palm trees. There is a petrol station which belongs to a person of Yemna tribal fraction. The houses are made of mud-clay and cement concrete blocks.

S3.3.8 The Township of Al' Abr

The small township of Al' Abr with a population ranging between 1000 and 1500 is located in the Al Say'ar tribal territory. It is mostly inhabited by sedentary Bedouins who have constructed houses using corrugated iron-sheets and cement concrete blocks. It was reported that many residents have emigrated to Saudi Arabia and are likely to return when the road is built and water is provided for domestic use as well as for the livestock. The main activities of Bedouins are trading, transportation of goods and people and raising of livestock. They sell their livestock to Al Qatn and to Al Sharura in Saudi Arabia and bring various kinds of consumer goods. These are sold to the villagers in the region and in the towns of Al Qatn and Seiyun. The shops in the township cater to the needs of consumer goods and provisions of the Bedouins living in the settlements at the foot hills of the wadi of Sawm Al Ashriqa. It was reported that a project to find ground water in Al' Abr did not succeed. Rain water is stored for domestic uses which is supplemented by water from a small well. The township has one mosque, one primary school, one guest house of the mudiriyya, one police station and one custom post and one petrol station.

S3.3.9 Bedouins Encampments

A number of Bedouin camps were visited. Their natures are as follows:

(a) **Camp at Safir:**
The camp consists of about 30 to 40 families who are scattered over a wide area grouped in 8 to 10 families forming a kinship who trace their ancestry to a common parentage. Bedouins in this camp belong to Abida tribe and come from Shabwa. Some fractions, like Abu Algath, Mosabeen, belonging to Alganess tribe of Shabwa also visit this area. Inhabitants of this camp are semi-nomadic and depend on livestock economy. The size of the herd is small. Each family keeps about 20-30 goats and 4-5 sheeps. The camp as a whole has few camels. The camels are kept for milk and for breeding calves which are sold to the villagers in the Marib Nahiya and in the town of Marib. The camp is reported to be located in this area for about 10 years, although some individual families or small group of families move annually to other sources for grazing their livestock, although they continue to maintain social and economic links with the main group. The pattern of

movement is conditioned by rainfall pattern, but is confined within a radius of 30-40 kms. Each family, consisting of 8 to 10 members lives in own tent. Most of the families have collapsible white tent made of canvas tarpulin. A small number of families live in huts made of twigs and wild vegetation or of cultivated plants like date palms, sorghum and millet stems. Some shelters were made of corrugated aluminium or tin sheets in this semi-permanent encampment. Pens for goats and sheep are made of branches of trees, sorghum and millet stems and wild bushes. The main source of livelihood of a large number of families is sale of goats and sheep in the market town of Marib or to the villages in the adjoining Marib Nahiya. However, a substantial number of Bedouins in this camp have taken to transportation of goods and people, or as workers as construction labour and in the agricultural field - labour for land preparation and harvesting. They take water for domestic use from the bore well put up by the oil refinery which is also shared by the nearby military camp. Motorised vans are replacing the camel for movement. It is used for transportation of goods for trade, for collecting water and carrying children to school. The Bedouins in this camp send their children to school in Marib town where they also avail of modern medical facilities. Other indicators of social modernisation include changes in dietary habits which includes wheat, bread, cheese, tinned milk, soft drinks etc., possession of transistor radios, watches, rubber mattresses and a variety of other consumer goods. There is also tendency to establish semi-permanent encampment near the market town or permanent village settlement so that their access to the asphaltic road from Marib to Safir is assumed.

(b) **Other Camps**

Between the well of Khashm Al Ayn set up by the army and the township of Al' Abr, there is a Bedouin camp of thirteen tents whose inhabitants belong to the tribe of Kurub. The Shayak of this tribe, whose territory is in the Shabwa region, lives in Saudi Arabia. Nearly one hundred persons live in this camp. They principally raise goats and some camels and move between Al Makhaneg, Al' Abr and the regions of Shabwa. They sell goats in Al Qatn. They fetch water for domestic use and for the cattles from the bore well of Khashm Al Ayn. They send their children to school at Al' Abr. They buy some of their food and other goods like gas cylinders from Al Qatn, but tents equipment and furniture come from Saudi Arabia. They own Toyota vans which are used for transportation. They would prefer to live in houses. Their food consists of camel milk, bread, rice and meat. The women and the girls graze goats and sheeps while the raising of camels is reserved for men who also work in transportation. Near the mountain of Al Qaim, other Bedouins settlements from the Nahd tribe are located. They raise cattle, mainly goats and some camels and cultivate sorghum and lucerne for the cattle. Each of the family lives in his own tent. Stock raising

for this group is supplementary part of their economy, the main means of subsistence being agriculture in the fixed habitation.

A small group from one of the settled village has moved to a temporary encampment about 10 km from Al Khasha for grazing their herd. They have one motor van which is used for transporting their collapsible tents and other possessions when they move. It was also being used for fetching water from Al Khasha, buying consumer goods and provisions from Al Qatn and transporting goods and people from one place to another. Water for domestic use and petrol for the motor vehicle are stored in big plastic containers. In both the encampments, the grazing area for the livestock is confined to a radius of ten to fifteen kms from their location.

S3.4 Dynamics of Social Changes

S3.4.1 Over the last two decades, the Yemeni society has been undergoing a process of social and economic transformation. The revolution of 1962 in Northern Yemen and independence of South Yemen in 1967 from British colonialism resulted in the establishment of stable governments in the two parts of Yemen. Both of them set themselves onto building developed modern society and creation of viable economy. The unification of the two parts of Yemen in 1990 has further reinforced the new political and institutional context for improving the quality of life. The emergence of modern state bureaucracy may have weakened the traditional system of authority and tribal autarky. The economic role of the tribes and their relationship with the government have undergone significant changes.

S3.4.2 Yemen being a rural society, where over 80 per cent of people make their living from land, contemporary development processes are predominantly manifested in the changes affecting the traditional agrarian system and the territorially defined tribal social structure though changes in other spheres of socio- economic life cannot be overlooked. The major sources of change can be stated as follows:

a) The introduction of new technology like farm mechanics in agriculture and irrigation that have altered the pattern of relationship between people, land, water and animal and induced changes in the close knit organic pattern of social organisation of tribal peasantry based on family and kinship relations and lineage interacting with land and water ownership and use patterns.

b) Commercialisation and penetration of market economy inter-twined with the development of local social formation and changes in the social relations of production.

c) Expansion of educational facilities, health care systems and other basic social services like electricity and drinking water resulting in the exposure of local communities to social modernisation and value placed on accessibility to basic services.

d) Expansion of transportation networks leading to improved access to people, goods, services and ideas and new settlement patterns along their routes breaking the centuries long physical and cultural isolation.

e) Urbanisation and industrialisation providing opportunities for social mobility, alternative occupations, increased wages and acquisition of new skills.

f) Emigration affecting cultural, social and economic life particularly the structure of agricultural production, establishment of new economic activities, changes in consumption patterns, life styles and social relations.

g) Collective impact of changing economic, social, technological and institutional conditions on identification of individual with the tribe and social segmentation.

h) The recent discovery of high quality oil deposits in the Marib and Hadramout regions.

S3.4.3 The field-study along with perusal of other research studies do yield a few generalisation about the vectors of change obtaining with the societies of Yemen. Some awareness about these processes may help in comprehending the nature of impacts that the proposed road is possible to cause. These are being stated below as an overview, only to stimulate thoughts and speculations.

S3.4.4 Traditional pattern of the tribal community is based on patrinineal genealogical groupings. These groupings are divided into clans and sub-clans. Each group has a specific territory over which it exercises social, economic and political control. The settlements predominantly consist of inhabitants of one sub-section, though a mix of various sub-sections of the same kinship unit is also found. The most common type of family is the patrilocal extended family followed by a family nuclei of two or more brothers. There is also neclear family consisting of parents/ parent with or without unmarried children. The proportion of different types of families varies from one settlement to another, though the magnitude of each type of the family can not be ascertained. Social differentiation is based on the

social standing of the lineage, land ownership, occupation and social power. Social relations are based on reciprocal kinship obligations. In general the distribution of resources is managed at group level consisting of several extended families.

S3.4.5 Until recently, the population of the region has been overwhelmingly dependent on cultivation of grain on rainfed fields and animal husbandry. The rural economy has been based on the inter-relationship of its land, grains, animals and rain cycle. Another feature of this economy is that the primary production unit has been the extended patrilocal household. Within the household, men and women have divided production tasks. Women are engaged in livestock activities, harvesting and fodder cutting. Household production strategies have been geared for use economy. The market economy is limited to small scale exchange. The exchanges have been closely involved with social relations of kinship and propinquity. A notable feature of the tenure system has been the widespread practice of share cropping (already described in the preceeding pages) notwithstanding the fact that land is owned in small parcels by most households.

S3.4.6 Data on existing land holding patterns are not available. The three basic legal categories in which land can fall includes "mulk" which is privately owned; "miri" or "amlak" which is either state owned or communal and "Waqf" which is land held under trust, usually for religious purposes. Land not suitable enough for grazing has no definite ownership by individuals and is considered collective property of the kinship group or tribe. Waste or fallow land is considered open grazing for all households in the concerned settlement until it is cultivated. The right to use water is regulated by the regime of the land. Only water from private land (mulk) is subject to owners authority. However those who own private bore or dug wells reported that they share the water with others. Customary laws regulate the use of water on communal or state owned lands. Most dwellings in the settlements studied have electricity. Drinking water is primarily obtained from wells.

S3.4.7 It is within the context of this semi-enclosed society and economy that changes are taking place. The sources of change as documented at para S3.4.2 have led to a growing sense of individuality strengthened by opportunities for social mobility. This has affected the kinship system around which revolves all social life. The core of the system is the co-operation of a large number of agnatic relations in constituting one corporate economic unit in which the personality of the individual is entirely submerged by group interests. The increasing opportunities of economic independence by following various alternative occupations other than agriculture or raising of livestock for many individual

members of a tribe or a fraction within it, have led to the shrinkage of this kin group and larger lineage segments. The fact that tribesmen are joining occupations their fathers despised is also an indication of willingness to break with tradition.

S3.4.8 In the Hadramout region, the civil servants replaced the chiefs of tribes and tribal groupings in the role of buffer between the people and the Government. Over time, many of the traditional tribal characteristics have been weakened and are in the process of acquiring some of the traits of a peasant society. Social identity is increasingly becoming a matter of special location than a matter of near or remote kinship. As the traditional role of Shaykhs in preserving social solidarity along tribal loyalties weakened, customary laws also seem to have lost their importance. Nevertheless, tribal leaders play an increasing political role since unity. Tribe as a frame of reference continue to act as an important social unit but as a frame of mobilisation, his importance varies on the political and economical resources of his leaders. Tribes cannot any longer be conceived as a pyramidal hierarchy of social units but as a pattern of relationship amongst kinship units which has come to be characterized by flexibility and permanent negotiation.

S3.4.9 People living in the area have recently begun to participate in commercial agriculture largely due to the introduction of diesel pumps and deep bore wells. It was observed that each of the settlements covered in the field inquiry had at least two to three deep bore wells. A market oriented agricultural economy is gradually evolving out of a production system mainly concerned with direct consumption by the community or its livestock. This process is not only changing the pattern of agricultural production from grain to more profitable horticultural crops and raising of livestock for sale as a specialised activity but also leading to new arrangements for the use of water since this "new" resource cannot be covered by traditional social control and co-operation. Though not explicitly revealed by the selected informations contacted, other evidences collected suggest that recourse is often made on rental or outright purchase of water by the cultivator, who may be a landowner or a tenant. It seems that in future, sale of water may become more profitable than agriculture and provide a new opportunity for entrepreneurial activity.

S3.4.10 Monetisation of economy have also affected the social relations of production. The reciprocal relations of exchange determined by kinship obligations are giving way to transactional relations based on cash payment rather than in kind. It has also increased the demand for cash employment. Tribesmen now engaged in marketing vegetables, fruits, groceries and other local products. Competition

among the tribesmen under transition from agriculture to commerce has given a new economic slant to the tribal system and encouraged a social separation of traditional status categories from economic relations.

S3.4.11 Majority of the population in the concerned region is now participating to some degree in the market economy at least to the extent that farming households are becoming more dependent upon consumption of goods through the market exchange system. The acquisition of trucks and other vehicles by local people signifies increased participation in the region's commerce. Another important indicator of the trend are the several desert tracks that have grown across the entire area from Safir to Hadramout from the movement of trucks and other vehicles carrying goods and people from place to place in this region. Cash earning in transport, trade, construction and other off-farm activities are inducing people of younger generation to move away from the parental house in the village not only for the economic pursuit but also for having independence from a subordinate role in the household to a dominant role in the external world.

S3.4.12 Emigration to Saudi Arabia and other Gulf states contributed further to the deepening of cash economy and monetisation as the migrants remitted their earnings. Increase in the money supply from these remittances led to the development of consumer goods. These range from better clothing, furniture, household goods, canned milk, frozen chicken, white flour, rice, drilling rigs, electric generating pumps, video-recorders, colour televisions, fertilizers, pesticides, soft drinks and many other goods. Remittance encouraged the growth of merchandising these goods which offered large scale opportunities for the people in the villages to make money from trading activities. Changes brought in agriculture as a result of emigration led to an increase in the number of participants in the market economy. The need for cash to buy various goods have induced a general tendency to look for new sources of income outside agriculture. The availability of large sums of money have changed people's tastes, consumption patterns, life styles and dwelling construction both in terms of building materials and architectural expression. Further, emigration as a factor has helped in the weakening of the old social structure, while at the same time facilitated in stimulation of a new set of value premises to define social relations. The other forces that are activising social modernisation of the local communities are increasing access to schools, health and other social services and communication technology, radio and television. The real effects of the emerging pattern of transformation that is taking place particularly, in the investigated local communities are more subtle and run deeper than the ones described. They are found in the increasing demands for electricity, water, roads, schools, modern

health care, communication, other social services and alternative sources of employment. All these however refer to the sedentary societies.

S3.4.13 For the Bedouins, who are not a homogenous group, the process of change is arising through other vectors. They comprise nomads, semi-nomads and sedentary groups. According to the available information, a total of 93 thousand Bedouins live in the region included in the Hadramout Governorate whereas it was estimated that 0.8 per cent of the total population of 225,805 of Marib Governorate in 1975 consisted of Bedouins. The district of Marib comprises 2000 Bedouins. It has not been possible to ascertain the population of Bedouins in the delineated study area of the proposed road alignment. However, some inferences from the available documentation indicate that the population of Bedouins in the encampments spread across the area between Safir to Al' Abr may be in the range of 1000 to 1500. Another 3500-4000 Bedouins are estimated to inhabit in the settlements of Bir Al Wahed, Al Khasha, township of Al' Abr, temporary encampments between Al Khasha and Al' Abr and settlement near the mountain of Al Qaum.

S3.4.14 The Bedouins located in the area between Safir and Al' Abr are nomadic and semi-nomadic groups. It may be pointed out that the "pure" or full nomadic Bedouins dependent on economic - ecological specialisation of herding with particular concentration on camel herding to the exclusion of all other means of livelihood constitute a very small part of the Bedouins of Yemen. A very large majority among them are semi-nomadic. The habitat of the nomadic Bedouins is the desert extending from the edges of Ar-Rub' Al Khali to Ramlat As Sab'ayatn. The Bedouins in the area extending from Al' Abr to Al Khasha including the foot hills of Al Qaum, are sedentary farmers and semi-nomadic.

S3.4.15 The semi-nomadic Bedouins in both the Safir to Al' Abr and Al' Abr to Al Khasha regions depend on pastoralism but are also engaged in transportation, trade, agriculture and construction works and also work as drivers in trucks, other motor vehicles and tractors and other subsidiary occupations. Most of the semi-nomadic Bedouins in Al' Abr to Al Khasha region lead a transhumance type of existence. Besides pastoralism they depend partially on agriculture using rainfall water and engage in various other occupations. The main characteristics of these semi-nomadic Bedouins is that they live in the same encampments for considerably long period sometimes extending to over 10 years, though some of the families among them, mostly nuclear, set off for new grazing grounds to form new hamlets. However the movements are confined within a radius of 20 to 30 kilometres. The settled Bedouins depend more fully on agriculture using both well and rain water. They engage in trade, transportation and other subsidiary

occupations as well as work as agricultural and construction workers. They continue to raise small herds of goats and sheep as supplementary to agriculture.

S3.4.16 It has been observed that the patterns of living of semi-nomadic Bedouins are changing. Pastoralism is no longer the typical marker attribute. The variability and erratic nature of rainfall, meagerness of the availability of sub-terranean sources of water supply and shrinking grazing grounds impose serious limitations on herding activities. This has resulted in the reduced size of livestock. On an average a Bedouin family keeps no more than 20-30 goats and sheep. Only few families amog the Bedouins keep 2 to 3 camels primarily for milk and selling their calves to farmers in nearby settlements or townships. It was noticed during the field inquiry that they brought water in big plastic containers from long distances not only for domestic use but also for their livestock. The Bedouins living in the encampments between Al' Abr and Al Khasha draw water from the bore wells at Khashm Al Ayn and the village of Al Khasha and transport it in motorised vehicles. The other Bedouin groups in the desert area between Safir and Al' Abr draw water from pipelines carrying water to several military outposts. They also fetch water from the dug wells meant for public use in the villages near their encampments. The important point to stress here is that Bedouins are increasingly sharing the available sources water created by other groups while remaining close to their grazing grounds. Another dimension of their interaction and interdependence with settled communities is employment and the transactions over the sale and purchase of goats, sheeps, consumer goods, petrol and other items of daily consumption. Such close involvement with wider society beyond their area of movement gets further reinforced from the necessity of finding supplementary sources of livelihood in a situation where dependence on pastoralism seems to be insufficient for their subsistence.

S3.4.17 The changes occurring in the living patterns of semi-nomadic Bedouins are further characterised by their acquisition of motorised vehicles which have replaced camels as the means of transportation. Modern merchandise and consumer goods have penetrated into the life of Bedouins. Gas cylinders are being used in place of firewood. Transistor radios and cassette recorders can be heard playing in their encampments. Bedouin women own manual sewing machines and wear dresses made of synthetic materials. The white collapsible tents, and shelters made of corrugated aluminium or iron sheets are substituting the black tents and shelters made from the twigs, wild bushes and such other materials. The children in all the Bedouin encampments covered during the field study go to schools. Motivation behind schooling of the children is the expectation of their parents that they will be in a better position to find alternative employment. They are also availing modern facilities of health care and other services. Their desire

for cash, for security and for consumer goods are having far reaching impacts on their modes of living and life styles.

S3.4.18 In brief, semi-nomadic Bedouins are involved in the complex interaction of physical, social and economic forces operative in the wider society. The greater the length of time they live in the encampments taking up variety of paid jobs and trade, the greater would be the need for cash for the changed consumption patterns and for possessing motor vehicles and other modern consumer goods. Exposure to social modernisation and increased contacts with settled communities and people in towns and cities are all symptomatic of a general tendency towards sedentarisation among the semi-nomadic Bedouins.

S3.5 Probable Impacts of the Road at Local, Regional and National Levels

S3.5.1 **During Construction** : The road is a process. As the road gets constructed in segments, it would stimulate certain expectations among the people who are aware of the opportunities that will be created, particularly in a country where transportation networks are inadequate. Some of the critical issues are discussed below:

a) As the new sources of water get located or explored for digging bore wells, the claims for water supplies by the different groups for drinking, agriculture and livestock would be made. Sources of water supply may become poles of attraction particularly for semi-nomadic bedouins to whom water is critical for existence. These may also become places for putting up shops, dwellings, services related to the modes of transportation and putting up of enterprises like construction of concrete cement blocks. In anticipation of these opportunities, people have already started to buy lands near the proposed road alignment. Efforts have already been initiated by affluent and influential members of the local communities to dig bore wells in some selected places along the route of the road alignment.

b) During the construction of the road, labour will be needed. People from the local communities are expecting to be employed in the construction work, transportation and operating the machinery to be used for the construction of the road.

c) It is suggested that arrangements may be made for appropriate sharing of water, land and labour employment to avoid conflicts between bedouins and other social groups. It is also suggested that bore wells for the construction of road may be dug at places especially from Safir to Al' Abr

to cater to the needs of the bedouins who have been visiting this project area. In the section of the road from Al' Abr to Al Makhaneg, appropriate studies related to the different needs of water for different communities should be undertaken not only to maximise the use of water but also for equitable sharing.

S3.5.2 **After Road Construction** : Since there is no reference to time variable speculations can be arranged with reference to different levels of spatial hierarchy.

S3.5.3 **At Local Level** : The following issues are worthy to note. The impacts mentioned below would be positive in the sense that they would improve the quality of life and promote development of human resources amongst the local tribal communities, other social groups and Bedouins.

a) Most induced developments are likely to take place in Al' Abr to Al Makhaneg section particularly in the last forty six kms from Bir Al Wahed to Al Makhaneg. The primary beneficiaries of the induced development of the road such as new sources of water supply, opening of shops, setting up of repair workshop for motor vehicles, petrol station, restaurants and tea shops and possibilities for marketing the agricultural products and livestock would belong to the existing settlements. This would require land use planning, judicious location of bore wells for the road construction and negotiations with various local territorial claims of tribal communities and fractions within them.

b) It will increase the access of Bedouins to services like education, health, administrative, drinking water, trade, transportation and opportunities for employment created by the various kinds of development along the road. It may enable them to find new markets for selling their livestocks on better prices. It may also reinforce their interdependence with the market towns and permanent settlements. It may also facilitate the purchase of variety of goods as fodder and gas cylinders whose use is increasing as a replacement of firewood. It may increase the pace of social modernisation and sedentarisation.

c) The main sources of livelihood in this area are agriculture, livestock, trade and transportation. The local people expect that the construction of the road will extend the market of the local agricultural products like onions, garlic, tomatoes and other vegetables and increase the trade transactions and transportation of goods and passengers. It may also increase opportunities for alternative employment in various activities which will grow at the various locations along the road.

d) The road may bring varieties of consumer goods offering a wider selection to the local communities and could consequently lead to new consumption patterns including a wider diffusion of the consumption of qat which may be available at lower prices because of easier and quicker transportation from the producing regions.

e) The road may reinforce the linkage of local groups with cash and market economy. It may also induce emigrants from Saudi Arabia and Gulf countries to invest more money in this region particularly in dwelling construction, in bore wells, in trade and commerce and agricultural improvement. Investments in these activities will generate more employment. It could also reinforce the current trend in construction for the use of new materials such as cement, steel, corrugated aluminium and steel sheets in place of mud, clay and wood. It may induce immigration of construction workers from outside the local communities and thus provide the skills that are not available in the local communities.

f) The road may enhance the process of social modernisation by facilitating access to education, health, agricultural extension services and other social services. It will increase the links between the people and the State administration. Further, it may reduce fragmentation and dichotomisation between the local groups because of their greater interaction and increasing interdependancy. It may induce a new spatial organisation in the form of linear development and may lead to new centralities around Al' Abr, Al Khasha and Al Makhaneg. In view of the location of Al' Abr and its particular status at the administrative and tribal levels, the tendency of its centrality would be enhanced by the demands made on it for services of various kinds, goods and transportation.

g) The road will enlarge the developmental space by increasing access of local people to a wider area in terms of goods, people, ideas, cultural life styles, economic opportunities. It may generate a perception of road as a mechanism in which both individuals and communities are able to participate in outside world and the process may reinforce the trends of social and economic changes.

S3.5.4 At the Regional Level

The road would link the local communities with the regional development processes. It will not only connect Marib and Hadramout regions but also Hadramout and the Hodeidah city which is the main harbour of the country, in brief, the Red Sea and the Indian Ocean. The flux of goods and people between the regions will increase and also migration to larger urban centres like Marib and

Sana'a. The possibilities of agglomeration of settlements may generate demands for services which will be directed to the State to be provided. It will also lead to a greater interaction and interrelationship between the communities around the influence area of the road and other communities outside of it and interlink the local and regional economies.

S3.5.5 At the National Level

It will reinforce the linkage of the Hadramout region by providing an alternative to the Mukalla road within the national economy and will enhance the exchange of goods, ideas and widen the base of knowledge and information flowing from different parts of the country. It will facilitate the access to high levels of services in the national capital of Sana'a like university and technical education, specialised medical facilities. It may also lead to greater democratisation through broadening the frame of political reference. It will reinforce the process of unification and linkage with the national level administration.

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BASIC STUDY 4

PATTERN OF REGIONAL DEVELOPMENT

BASIC STUDY 4

PATTERN OF REGIONAL DEVELOPMENT

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BASIC STUDY 4

PATTERN OF REGIONAL DEVELOPMENT

S4.0 Introduction

The objective of this study is to discuss some of the salient features of regional economic development in the region around the proposed Safir-Hadramout Road corridor as shown in Fig. S4.0.

S4.1 Administrative Divisions

The Republic of Yemen (ROY) is now an independent state that came into being on May 22, 1990 as a result of the unification of the former YAR and PDRY. It consists of 17 Governorates. Each Governorate is divided into several districts (Mudriahs), which are subdivided into sub-districts (Narkaz). The Uzlahs are made up of a number of villages and scattered dwelling groups called Mahalla. The census report has clearly stated that the boundaries of Uzlahs are generally not clearly defined. Marib Governorate is divided into six districts viz., Marib, Jubah, Bani Dabyan, Harib, Naaman and Abdiyah. It has a population of 95,326 as per 1986 census. Hadramout Governorate is divided into eight districts viz., Al Mukalla, Al Hazar, Al Sahr, Seiyun, Al Qat'n, Doan, Thamud and Al' Abr. It covers a land area of 28% of the ROY, but has a low population of 626,395 (as per 1988 census) or about 5% of the total population of the country. The proposed road is fully contained within the Governorates of Marib and Hadramout and runs through the districts of Marib, Al' Abr and Al Qat'n.

S4.2 Demography

S4.2.1 According to census figures, population growth in the country is one of the fastest in the world 3.1%* annually (Table S4.2.1). This means the population of Yemen will double every 30 years. The estimated total population for the ROY in 1990 was about 11 million with an expected increase of 6 million during the nineties.

The average overall population growth rate in the Northern Governorates is slightly less than the Southern Governorates.

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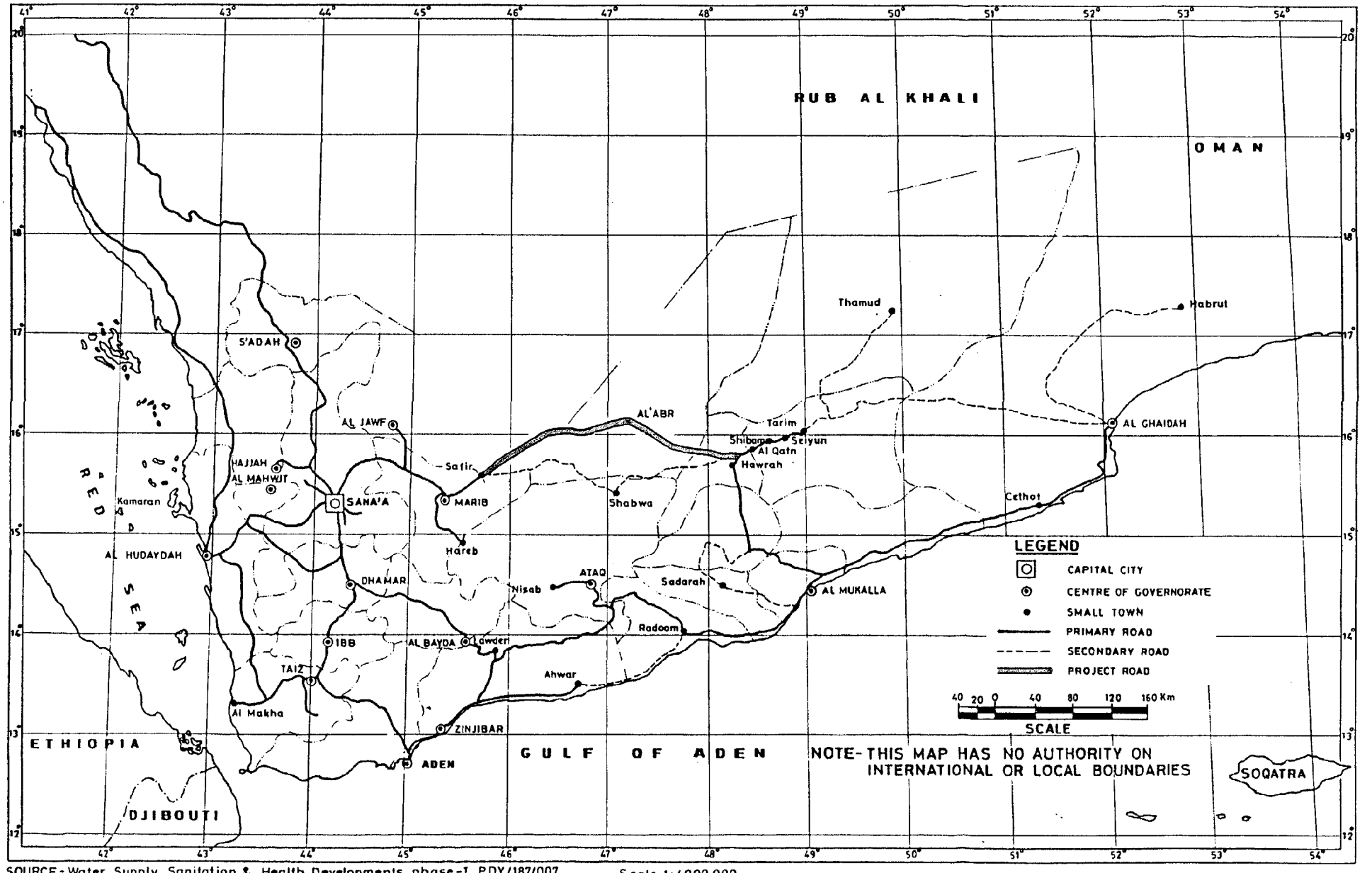
* From the National Report of Republic of Yemen on Environment and Development : Chapter 5, Special Issues (1992)



SOURCE- Water Supply Sanitation & Health Developments phase-I PDY/187/007 Scale-1:4000.000

FIG. Nr. S 4.0
INDEX MAP

Table S4.2.1
Total Population of Yemen According to 1986 and 1988 Census

CATEGORY	Population of Southern Govt. According to 1988 Census			Population of Northern Govt. According to 1986 Census		
	Total	Female	Male	Total	Female	Male
Population within the Country	2107120	1077978	1029142	7826750	3989232	3837518
Un-enumerated Population for Technical and Social Reasons	--	--	--	376743	334231	42512
Population outside the country	238150	41177	196973	1168199	364192	804007
Total Population	2345270	1119155	1226115	9371692	4687655	4684030

S4.2.2 Birth Rate

The crude birth rates in the Northern Governorates as taken from 1986 census is 54.3 living births * per 1000 of the population annually. The live births at the end of the fertility age equals to 8.8% births in the Northern Governorates and that for the Southern Governorates was estimated at 6.7% in the year 1988. It clearly indicates that the fertility rate is among the highest in the world.

Despite a relatively lower rate of fertility in the Southern Governorates, the fertility situation is, however, not very much different from the whole Republic, where it reached on average 8.3% for every woman (1988 estimates).

S4.2.3 Mortality Rate

Available statistics confirm that a relative decrease in mortility rate has been obtained in the recent years. Life expectancy at birth has increased from an average 39.5 years in 1975 to 44.5** years in 1986**.

S4.2.4 Socio-Economic Indicator

Statistics indicate that more than 50%* of the total population don't have access to clean drinking water and more than 40% of the children below the age of 5 suffer from different forms of malnutrition, 30% suffer from serious diaorrhea cases while most of the population face the danger of epidemic. Moreover, the rate of illiteracy amongst women in the Northern Governorates is estimated at 91% which is 51% in the Southern Governorates. It is a clear indication of low standards of living prevailing in the Republic.

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* & ** From the National Report of Republic of Yemen on Environment and Development : Chapter 5, Special Issues (1992)

The demographic structure indicates that Yemen has inherited a sizeable young population leading to a wider base for the population pyramid. The percentage of Yemen population under 15 years is estimated at 47% in 1975, increased to 50% in 1981 and to 51% in 1988.

The population data shows that 72% of the population is rural and the female population contributes 51% of overall population. The population density is 21 persons per square kilometre and the available labour force is 2.6 million constituting 21% of the total population.

S4.2.5 The number of people, households and housing units for Marib and Hadramout Governorates are given in Table S4.2.5. The population growth rates for Marib Governorate at 1% is much lower than the national average of 3.1%; however, the equivalent figure of 2.6% for Hadramout is much nearer the national average. Another distinct difference is that while Marib has a low figure of 6% of the population living in urban areas (1986 census), the corresplonding figure for Hadramout is 35% in urban areas. However, there is no statistical data indicating the rate of migration of people from rural to urban areas in these Governorates.

TABLE S4.2.5
Population, Households and Housing Units

Marib Governorate

Sl. No.	Particulars		Numbers in Year		Annual Average Growth Rate (%)
			1981	1986	
1.	Population :	Urban	5,319	5,434	1.00
		Rural	85,498	89,892	
		Total	90,817	95,326	
2.	Households		-	15,465	
3.	Housing Units		-	17,027	

Hadramout Governorate

Sl. No.	Particulars		Numbers in Year		Annual Average Growth Rate (%)
			1973	1986	
1.	Population :	Urban	172,075	240,234	2.60
		Rural	319,229	445,675	
		Total	491,304	685,909	
2.	Households		-	122,464	
3.	Housing Units		-	82,350	

Source : Statistical Year Book of 1983 and 1990 for Republic of Yemen (1986 census), and of 1988 for PDRY and of Hadramout for 1988-89.

S4.1 MUD - BRICKS MANUFACTURING IN TARIM
(IN HADRAMOUT VALLEY)

S4.2 MUD - BRICK HOUSES IN SHIBAM

S4.3 Manpower and Economy

S4.3.1 The economy of Yemen is largely based on traditional agriculture, livestock and fishing along with remittances by the expatriate Yemenis working and living outside the country. Local manpower is estimated in the country at 2.6 million people. Without considering the number of recently returned Yemeni emigrants, there are 299,000 unemployed and 37,000 expatriates.

The migration of Yemeni men to other countries in search of work peaked during the late seventies and early eighties. World oil prices increased dramatically during this period and generated unprecedented wealth for a number of oil producing Arab states. Much of the new found wealth was invested in infrastructure development in these countries and this necessitated a mass importation of labour. Wage levels in these countries attracted an estimated 1.3 million Yemeni workers in 1975 and this number rose to a peak of 1.6 million by 1981. Shortly thereafter, world oil prices declined and then stabilized for the remainder of the eighties. The decline in world oil prices resulted in reductions in development spending in the oil rich Arab states which in turn reduced the number of migrant Yemeni workers to 1.2 million for the duration of the eighties.

The migrant Yemeni labour force has significantly affected in Yemen economy as well as their families back home. Remittances sent home by the expatriate workers represent a major economic contribution to the gross national product (GNP) of the Republic as well as for balance of payments. The portion of the remittance that is sent to the families of migrant workers has helped to improve their standard of living.

On the negative side, the massive out-migration of workers caused severe labour shortages at home, particularly in the agricultural sector. This problem has been addressed with limited success through a greater integration of women and children into the domestic labour force and by importation of foreign labour. Inspite of these efforts, agriculture production has declined noticeably and this created a detrimental effect on gross domestic production as well as exports and export revenues.

The recent Gulf war had a set back on the economy of the country. About one million Yemenis working in oil rich Arab countries had to return home, which caused sudden tapering off of the remittances by the workers causing a serious balance of payment situation for the country.

S4.3.2 Agriculture

In the Republic, only about 3% of the area is arable. Agriculture and fishing constitute only about 25% of GDP though this combined sector employs 60% of the population (employing about 70% of the labour force). The agricultural activities are at subsistence level and the production till to date is largely dependent upon rainfall. By the mid-80's farming and fishing had failed to produce as expected or proportionately to the investments made in these sectors. The government had hoped that through investments on irrigation and by bringing new land under cultivation, crop production would increase. For a variety of reasons this did not happen and farm outputs have shown no appreciable growth since the early 70's. Although the country is producing nearly all vegetables it consumes, it produces only about 40% of the food grains consumed. Hence, the country is still a net importer of food grains.

(a) Local Economy

The traditional economy of Marib region has been based upon subsistence agriculture and more than 90% of the Marib population is engaged in agricultural activities. Interestingly, agriculture as a dominating economic activity is decreasing in the Yemen. In 1975 nationwide, 72% of the population were farmers compared to 64% in 1988 but this trend seems to have hardly affected the Marib area.

Women form a large pool of agricultural labour. Women are engaged in mainly in agriculture and/or animal husbandry together (80%); their special tasks being cutting of fodder for livestock. Children are also an important labour force and contribute to the household income. They have the same tasks as the women; children assist especially in irrigation and harvesting, but also with animal husbandry and fodder collection. Farmers are mainly landowners with few share croppers and tenants.

Land is mainly inherited although it is reported that land has been purchased in the more upstream areas.

In recent past, however after the completion of the Marib Dam and Marib-Safir road, a number of horticulture farms growing citrus and other fruits (cash crops) have come up.

In Hadramout, due to the rugged terrain, arid climate and sparse natural vegetation, agriculture is largely carried out at subsistence level using centuries old practices. Historically, the main crops included grains (sorghum, wheat, millet), vegetables (tomatoes, onions, potatoes), fruits

(melons, bananas, dates), cotton, tobacco, coffee and qat. Honey is also collected which is rated to be among the best in the world. The crops are sold in the local markets as well as markets throughout the Hadramout. Only cotton, raw tobacco, canned fish and fruit are currently exported to other countries.

Two generalised landuse and cropping patterns are apparent according to the origin of the water supply. The first pattern relies on the erratic bimodal rainfall system and/or spate irrigation system. The second system depends on ground water pumping to supply water for the production. This system being utilised in the other areas of the region, has been reported to have cropping intensitites ranging from 38-65% (100% representing one crop/year). The higher intensities are generally related to having a higher population of perennial crops in the cropping system.

In most cases, the cultivated land is privately owned. In addition to arable agriculture, livestock are kept by the farmers in the area. Other than the use of manure, plus inorganic nitrogen and phosphorus fertilizer to a limited extent, improved husbandry practices are generally not being employed in the area. Consequently the yield per unit area is below optimum levels.

(b) **Livestock**

Animal husbandry is a traditional activity in the Marib Governorate and the livestock consists of mainly sheep, goat and some camels. Camels, which are kept as draught animals, have been substituted mainly by machines and four wheelers.

A similar pattern is observed in the Hadramout Governorate as well. The livestock is dominated by goat and sheep with camels and chickens being kept to a limited extent. The animals feed are typically crop residue as well as alfalfa and sorghum when available. In addition, the herds graze in the areas in the project road region. The timing and location of the grazing varies with the rainfall and farmers simply use the resource as it becomes available. It emerges that, a land tenure system related to grazing areas for domestic animals does not exist and farmers simply utilise the surrounding expanse of land as opportunities arise.

S4.3.3 Oil and Minerals

During the seventies and early eighties, oil and gas exploration in the former PDRY was carried out with limited success by the Soviet and other international petroleum companies. Small reservoirs of oil were discovered but the

development of the reserves were impeded by the marginal return on investment, when all development costs were taken into consideration.

The first major oil find in the country was in the year 1984 at Safir where production was started in the year 1987. A pipeline with a capacity of 400,000 bpd has been laid between Safir and Salif port on the Red Sea for export. The total proven recoverable reserves in the field is estimated to be around 1 billion barrels although the current production is of the order of 200,000 bpd.

The prospect changed further, when a large reservoir of oil was discovered in the Masila block of oil concession in the Hadramout Governorate in the late eighties. The pipeline and marine terminal would be operational by the end of 1993.

In addition to the petroleum discoveries, there are significant known reserves of natural gas in Yemen. In 1989, estimated reserves totalled 283,000 million cubic metres (cu.m.) but actual reserves are thought to be much higher. Two gas plants are being constructed in As Sad Al Kamel field with a capacity of about 17 million cu.m. per day for condensing gas to extract oil and LPG for domestic use. Plans are being developed to start exporting natural gas in 1994.

To date, the Republic of Yemen has not been intensively explored for mineral resources. Salt, limestone, clay, gypsum and silica have all been found in significant quantities. These minerals have a variety of domestic and industrial uses. Deposits of coal, iron ore, gold, copper, titanium, molybdenum and marble have also been discovered * but so far have not proved to be economically exploitable.

S4.3.4 Non Agricultural Activities

In the Marib region where almost 95% of the labour force is engaged in agriculture as its main activity, employment opportunities outside this sector are very limited. Petty trade is an additional economic activity of some of the inhabitants. It is often related to farming activities. It is known, that many goods leave and enter the area unrecorded due to unprotected boundaries and lack of administrative power. These activities may contribute considerably to the individual's income. It is also noted that qat, which is not cultivated in the Marib area is exported against consumer goods including television, cars. Exact figures regarding the extent of these activities and the impact which the Gulf crisis might have had on this activity were not possible to obtain.

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* Reported in the Environmental Studies Programme Report of Canadian Occidental Petroleum Limited on Masila Export Project (March 1993)

The situation in Hadramout is no different as non-agricultural sectors particularly manufacturing which is the key to urbanisation has faced serious constraints. The limited natural resources being exploited has resulted in industrialisation focussing on processing of farm and fish products.

Manufacturing of agricultural products includes a textile mill, a cigarette factory, a flour mill, a tomato paste cannery, a hide tannery and dairy products processing. Fish processing facilities include canneries and fishmeal plants but the fishmeal plants proved to be uneconomical and have been closed down. Building products manufacturing, particularly cement blocks and plaster manufacturing are undertaken in most communities. Chemical manufacturing including paints, plastic products and plastic foam is carried out in Al Mukalla, the capital of the Governorate.

Therefore it emerges that the prospects for expansion of industrial employment are not very encouraging [Table S4.3.4(a)]. The oil industry is characterised by a high capital intensivity and will therefore require few new employees. Other industrial production will be faced with a depressed local market. Employment in the public service is limited by the precarious financial position of the Government, leaving little room to expand its labour force. So it may be assumed that the real wage levels will drop.

Table S4.3.4(a)
Industrial Statistics of Hadramout

INDICATORS	UNIT OF MEASURES	1992	1991
Bread Product	Ton	3451.9	3536.3
Sesame	Ton	83.2	21.9
Fish Canned	'000 Pcs.	3248.1	2713.3
Chalk and Gypsum Extracting	Ton	--	--
Tiles	'000 Unit	597.9	305.6
Cement Bricks	'000 Unit	7265.7	5779.7
Nora	Ton	2622.0	2000.0
Metallic Industries	Sq. M.	2263.0	4674.34
Wood and Wood Products	'000 Pcs.	33.3	34.5
Dates	Ton	163.2	388.4

Source : Hadramout in Figures (p.10), Hadramout Office, CSO, ROY, 1993

The prospect for growth of the general economy of these two Governorates as well as the country hinges heavily on the success of oil prospecting which at present is being pursued intensively and extensively. Success in this field would have a far reaching effect on the economy by way of employment generation, larger incomes, greater demand for agricultural and consumer items. The activities in progress and expected developments particularly in the proposed road area are listed in the appended Table S4.3.4(b).

Table S4.3.4(b)
Project Area Development Activities

Sl.No.	Project Area	Status and Sector
1.	Safir	+ Oil and Mineral Resources + Refinery * Petroleum ancillary Industries
2.	As Sad Al Kamel (30 km off the project road)	+ Oil and Mineral Resources * Petroleum Ancillary Industries
3.	Al' Abr	+ New Oil and Mineral Resources * Future Agriculture Development + Water Resources, Govt. Services * Housing and Social Facilities * Trade, Transport & Communications
4.	Hawrah	+ New Oil and Mineral Resources * Water Resources * Agriculture Development * Trade, Transport & Communications * Oil Ancillary Industries
5.	Hadramout Governorate in general	+ Oil and Minerals + Water Resources + Agriculture + Trade - on going + Tourism (Shibam, Sayun)

+ In Progress * Expected Developments

Source : Compilation by the Consultant from various reports.

S4.3.5 Manufacturing and Industries

The limited natural resources of Yemen have resulted in industrialisation being largely focussed on the processing of farm and fish products. However, other types of manufacturing are undertaken in the country in order to reduce dependence on imported foreign products. Unfortunately, the small domestic markets, low incomes, dispersed population and inadequate road network and transportation have prohibited economics of scale in most manufacturing processes. In addition, the focus on public ownership and the government's shortage of funds and foreign exchange has limited investment in manufacturing.

Inspite of these constraints, manufacturing appears to be growing slowly but steadily. In 1986, manufacturing contributed 8% of the GDP of the former PDRY. The significant types of manufacturing in the former PDRY are petroleum refining, agriculture and fish products, building materials, beverages, tobacco and chemical products. A study of the manpower figure shows that agriculture and fishing employs about 60% of the population, while social services including the public sector employes only 16% of the available manpower.

Work opportunities increased in the public sector during the last few years and the civil service is still by far the biggest employer while the private sector only provided a constant rate of job opportunities during the past few years. The private sector in the Southern Governorate provided greater opportunities during the two years preceeding the unification. Work opportunities, however grew in the small scale enterprises and in the privately owned companies which were recently able to respond to the changes to prices of raw materials and the unlimited increases in demand.

However, the economies of the Northern and the Southern Governorates equally suffered from a shortage of skilled labour until the late eighties. Employment was only recognised as a problem for the first time in 1988 and by mid-1990, more than 10.5% of the labour forces in ROY were considered unemployed. The increasing number of returning Yemeni emigrants only compounded the problem and raised the number of the unemployed to 700,000 people.

Forecast is that most of the growth will take place in the agricultural sector which is expected to contribute about 50% of the total job opportunities from the existing 46%. The increase in this sector will not be because the need for additional labour, but because the agricultural sector would be the only one which has the capability to absorb the surplus labour which may be quite contradictory as in most nations, development usually ends up in taking away the labour force

working in agriculture. Even, if an overtly optimistic view is taken, a large increase in unemployment rate is bound to take place.

S4.3.6 Tourism

The ROY may be regarded as one of the most attractive countries for the visitor, in view of its ancient origins, the beauty of its mountains, the magnificence of its natural scenary, the geological open-book, the rich heritage and the unique architecture which characterises it. The tourism sector in Yemen is underdeveloped as recorded in Tables S4.3.6(a) and S4.3.6(b) but it has promising growth potential.

Table S4.3.6(a)
No. of Incoming Tourists in North Governorates, Tourist Nights and Tourist's Expenditure During 1986 - 1990

YEAR	TOTAL EXPENDITURE OF TOURIST		AV. EXP.OF TOURIST/ NIGHT US$	TOTAL OF TOURIST NIGHTS	AVERAGE NIGHTS/ TOURIST	TOTAL OF INCOMING TOURISTS
	Y.R.	US $				
1986	154269495	15241100	70	217730	5	43546
1987	175424046	16303350	70	232505	5	46581
1988	169297548	17363850	70	248055	5	49611
1989	214843200	22035200	80	275440	5	55088
1990	192033918	16002827	88	182095	5	31163

Source : Ministry of Culture and Tourism and as recorded in the Statistical Year Book 1990, CSO, Ministry of Planning & Development, ROY published in 1991

Table S4.3.6(b)
No. of Incoming Tourists in South Governorates, Tourist Nights and Tourist's Expenditure for 1990

COUNTRIES	TOTAL EXPENDITURE OF TOURIST		AVERAGE EXP. OF TOURIST/ NIGHT	TOTAL OF TOURIST NIGHTS	AVERAGE NIGHTS/ TOURIST	TOTAL OF INCOMING TOURISTS
	Y.R.	DINAR				
Arabic Countries	12804038	492463	65	7622	2	5034
Asian Countries	5143788	197838	65	3062	1	2612
European Countries	20104786	773261	65	119968	1	10136
African Countries	1323738	50913	65	788	1	730
American Countries	273676	10526	5	2075	1	1936
Occeanian Countries	1535404	59054	65	914	4	238

Source : Ministry of Culture and Tourism and as recorded in the Statistical Year Book 1990, CSO, Ministry of Planning & Development, ROY published in 1991

According to the statistics released by the Yemen General Tourism Corporation, more than 40,000 visitors came to Yemen in 1985. the majority, some 4200 people arrived from France, closely followed by Germany, UK, USA and Italy. Visitors from Europe alone increased by 25.5% compared to the previous year. In the later years there has been a slight dip in the number of tourists particularly noticeable in 1990 and 1991 as indicated in Table S4.3.6(c) but there is evidence that some of these needs are being addressed.

The General Organisation for Tourism proposes to promote tourism all over the country by fully exploiting its potential. The project components are to undertake a comprehensive tourism survey of the country, planning for touristic development of the selected areas and to market the tourist attractions regionally and internationally. It also includes opening of a tourism and hotel management school and institutional support for the tourism companies.

Externally the European and American tourist companies are offering package tours to the coastal areas as well as Hadramout areas. In addition, negotiations are underway to increase the number of flights into the country and development of the airports to higher standards. Tourism infrastructure is also being developed simultaneously.

The above summarises the manpower and the economy of the country and the potentials and prospects of the major sectors which are vital to the development of the nation.

Table S4.3.6(c)
No. of Incoming Tourists, Tourist Nights and Tourist's Expenditure for 1988 - 1991, ROY

YEAR	TOTAL EXPENDITURE OF TOURIST		AV. EXP.OF TOURIST/ NIGHT US$	TOTAL OF TOURIST NIGHTS	AVERAGE NIGHTS/ TOURIST	TOTAL OF INCOMING TOURISTS
	Y.R.	US $				
1988	205357425	21062300	70	300890	5	60718
1989	254233200	26075200	80	325940	5	65188
1990	236431440	19702120	95	207396	4	51849
1991	251458560	20954880	120	174624	4	43656

Source : Ministry of Culture and Tourism

S4.4 Social Infrastructure

S4.4.1 Education

The illiteracy rate in ROY is extremely high. The general schooling system in the former YAR part consists of -

- the first stage of elementary school (3 years)
- the second stage of elementary school (3 years)
- preparatory school (3 years) and
- secondary school (3 years)

In addition to this general school system a more specialised secondary educational system exists:

- commercial secondary school
- technical secondary school
- agricultural secondary school.

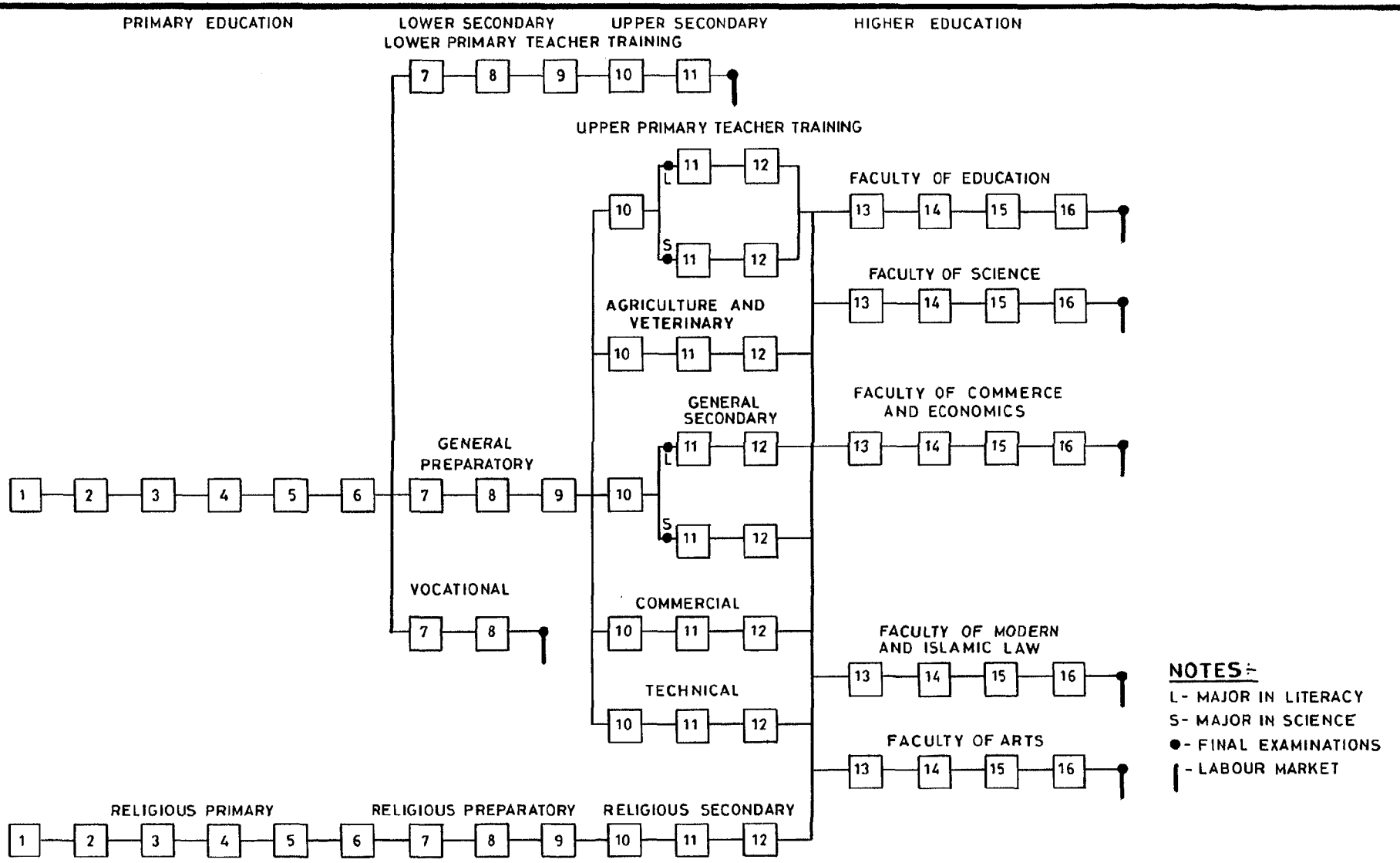
Further details of the education system is appended in Fig. S4.4.1.

A non-formal education component has been created to lower the illiteracy rates and establishment of a basic district centre in each district of the country is one of the basic goals.

S4.4.2 Health and Nutrition

The general standard of health in the Governorates cannot be ascertained accurately but some deficiency in nutrition, particularly in the case of babies and children may be related to the food habits and possibly cropping pattern.

General health statistics of the ROY is shown in Table S4.4.2. During the household questionnaire survey some questions were asked to fill the data gap. Some additional observations were made to understand the general situation.



Source: World Bank; YAR Special Study of Education, Administration and Finance, p.30, 1982

FIG. NR. S.4·4·1

STRUCTURE OF THE EDUCATIONAL SYSTEM IN THE FORMER YAR

Table S4.4.2

General Health Statistics of the ROY

Governorate	Population in 1990	Hospitals		Hospital Centre with Bed		Hospital Centre without Bed	Health Units	Phar.	Maternity Centres	
		No.	Beds	No.	Beds	No.	No.	No.	No.	Beds
Sana'a	1894954	10	1863	18	258	62	134	308	1	30
Aden	436500	6	1466	2	34	--	11	--	--	--
Taiz	1648815	9	1244	5	120	77	64	254	1	10
Lahej	531743	8	635	6	180	--	94	--	--	--
Ibb	1425283	6	378	8	160	30	31	119	--	--
Abein	352972	6	433	2	55	--	77	--	--	--
Hodeidah	1172498	4	405	4	220	30	99	90	--	--
Shabouh	225643	4	255	2	50	--	42	--	--	--
Hajah	80790	3	116	13	203	20	60	75	--	--
Hadramout	677398	7	605	9	190	--	134	--	--	--
Dhamar	771551	1	150	7	140	18	54	61	--	--
Maharah	99719	1	88	3	70	--	16	--	--	--
Beidah	338329	2	85	1	20	11	25	47	--	--
Mahweet	290976	1	35	4	40	7	10	23	--	--
Saadah	353656	3	117	4	92	9	22	21	--	--
Mareb	108084	3	95	3	37	17	22	20	--	--
Jawf	47020	--	--	3	52	17	16	11	--	--
	11,183,090	74	8044	93	1921	398	912	1029	2	40

Source : Population and Health in the Republic of Yemen, Vol. I (p.227), Ministry of Planning and Development, CSO, Republic of Yemen (December 1992)

(a) Common Sickness

Malaria is probably endemic in most of the region. Fever (although could not be classified) and snake bites are common. Diarrhoea and many kinds of parasitical infections (of the gut) are not uncommon.

(b) **Diseases Related to Water**

The most commonly endemic diseases in the governorate are water borne or water related. These include Malaria and intestinal disorders. Infants are susceptiable to diarrhoea and dehydration which is an all too frequent cause of death. Drinking water used is often contaminated at source or during supply and transmits parasites. Illiteracy together with lack of health education adds to the cause of spreading these diseases.

(c) **Health Issues Related to Tradition and Customary Behaviour**

Among many problems the following may be regarded as the most important :

Although women do perceive that there is a relationship between water and health and they use a set of culturally specified concepts to sort out water for different purposes, still they have health problems of their own. Their nutrition is poor both because they eat after men and because there is little recognition of women's extra nutritional needs during pregnancy and lactation. A male doctor is usually unacceptable to examine and treat women resulting in fewer health services for women because female health working are in minority.

Babies are swaddled and protected from sunlight. The resulting vitamin D deficiency from lack of sunlight sometimes causes bone deformation.

Hygiene in general is extremely poor which is related to lack of education. The sanitation facilities are poor or non-existent resulting in a living environment which promotes the danger of infection.

Qat is most widely and commonly chewed for its stimulating effect. Apart from its constipation effect and loss of appetite caused, it leads presumably to a lower intake of nutritious food specially for lower strata of the society, since they may spend money mostly on kat rather than food.

(d) **Health Issues Related to Nutrition**

It is evident that even if the agricultural productivity has not increased but more food is available than in the past, probably caused by importation (noted in the national scenario and economy). The consumption of basic food items such as grain and vegetables, by the average rural household has probably risen steadily. Along with the rise in the consumption of imported food a distinct shift has come in dietary patterns (e.g., sorghum and millet replaced by wheat, rice and refined flour). The general nutritional

impact of this dietary shift is debatable. On the one hand, the nutritional content of most traditonal foods is much higher than the imported substitutes and on the other hand, consumption of more quantities of imported food may negate any nutritional disadvantages.

(e) **Health Issues Arising from Modern Development**

Most villages and hamlets tend to view health issues in terms of curative medicine. Preventive health measures such as the organisation of village sanitation, garbage disposal or the immunisation of children rarely receive serious community attention. There has been a general shift away from traditional medicine and the almost unquestioning acceptance of the use of pharmaceuticals.

(f) **Existing Health Facilities**

Government health centres generally provide medical treatment but they are few and far between. In addition, they are understaffed and suffer from shortages in supplies and equipment.

It is often supplemented by drug stores which supplies drugs, injections and even sometimes minor treatments. The drug store operators only require a government license and generally do not have any formal training.

There are practically no health facilities in most of the settlements.

Since there is no transport facilities in the project area, available hospitals and health centres only serve those communities within a short radius of their location. People in other areas receive no medical attention except in serious cases travel to Marib and Al Qatn.

The planning for health facilities is carried out by the Ministry of Health and since its managerial and implementation is not fully developed, it is supported by a number of multilateral and bilateral organisations. Existing health services are too widely dispersed and lack medical staff, equipment and medicines.

S4.4.3 Post and Communications

The postal service is not well developed as letters are delivered in post boxes only. However, telecommunication system of ROY is satisfactory and gradually developing.

S4.4.4 Road Network

The ROY's transport system is inadequate as compared to its size, landscape and scattered population. Many outlying villages and district centres are still remote and inaccessible with poor links to the main road network. There is no railway network.

The present road network in ROY as on 1993 consists of 5730 km of main road (paved), 4000 km secondary road (gravel) and 44,300 km feeder roads (tracks). Of these GCRB controls all paved road and about 10,000 km of other roads (of which 2000 km are gravel roads). Local Associations control the tracks. The Northern Governorates (former YAR) are better connected and have a density of road as 0.2 km/sq.km whereas the Southern Governorates (former PDRY) have only 0.08 km/sq.km. This difference is attributed to lower population and lower development of infrastructure in the Southern Governorates. The main northern cities of Sana'a, Taiz and Hodeidah are linked by a triange of roads from which connections to other cities spread out. In the South the central network is confined to two branches both originating from Aden; one connects Taiz towards the north and the other one connects Mukalla and Seiyun towards the east. The transport connections between east to west and south are poor. The project road will to some extent remove this deficiency.

S4.4.5 Transport

The motor vehicle fleet of ROY grew at an average annual rate of 4.8% between 1984 and 1988 but there is a falling trend in the later years as can be seen in Table S4.4.5. In the wake of Gulf crisis in recent past (1990-91), about one million Yemeni while returning to the country brought with them around 60,000 mostly passenger vehicles. The present strength of motor vehicle fleet of the country is of the order of 500,000 giving an approximate ownership ratio of one vehicle to 25 persons. Besides, the registered vehicles, Highway Master Plan (HMP) for YAR prepared in 1983-84 estimated that 25% of vehicles in erstwhile YAR are unregistered.

Table S4.4.5
Growth of Motor Vehicles in ROY

Vehicle Type	No. of Vehicles in Year			Av. Annual Growth Rate (%)	
	1984	1988	1991	1984 - 88	1988 - 91
Motor Car, Jeep	131,010	155,403	165,438	4.4	2.1
Bus	1,520	1,845	2,223	5.0	6.4
Truck	179,100	218,521	235,734	5.1	2.6
Total	311,630	375,769	403,395	4.8	2.4

Source : Data compiled by Consultants from published report and from GCRB

S4.5 Settlements

S4.5.1 Industrial Centre

The only industrial sector located near to the road is the Safir Oil Refinery located approximately 1 km south of the proposed road at km 3 + 000. This complex is self contained with its own workforce accommodation, healthcare centre and well. No other settlement development is closely associated with it. It was understood that there may be plans to develop this refinery further with petroleum ancillary industries. No residential or other commercial development should be permitted near this refinery because of considerations of safety to the public and security for effective operation of the refinery.

S4.5.2 Urban Communities

At the western end, the road passes through the Marib district (Mudriah) and then through Al' Abr and Al Qatn districts in the centre and to the west. Although the areas adjoining the route are essentially rural in character with most of the population located in scattered villages, some 35% of population in Hadramout Governorate and 6% in Marib Governorate live in urban areas (Table S4.2.5).

The main urban area in Marib Governorate is Marib City and is located 45 km south east of Safir. Originally wealth was built up through trade in incense and tax levies. Now Marib is an important urban centre with its historical interest and varied archaeological remains which are tourist attractions, and its range of services provided to support the surrounding agricultural areas.

Towns in Hadramout Governorate near the road are generally small although more numerous in the region, but no less important at the local level. Al' Abr is located towards the centre of the road and Al Qatn is located on the Al Mukalla to Seiyun road some 20 km west of the end of the new road. Al' Abr and Al Qatn towns provide services to a network of 3 or 4 sub-districts (Markaz) and numerous villages, Bedouin and nomadic settlements. Al Qatn supports 506 villages and 32 Bedouin and nomadic settlements in its administrative hierarchy and the corresponding figures are 68 and 42 respectively for Al' Abr as shown in Table S4.5.2.

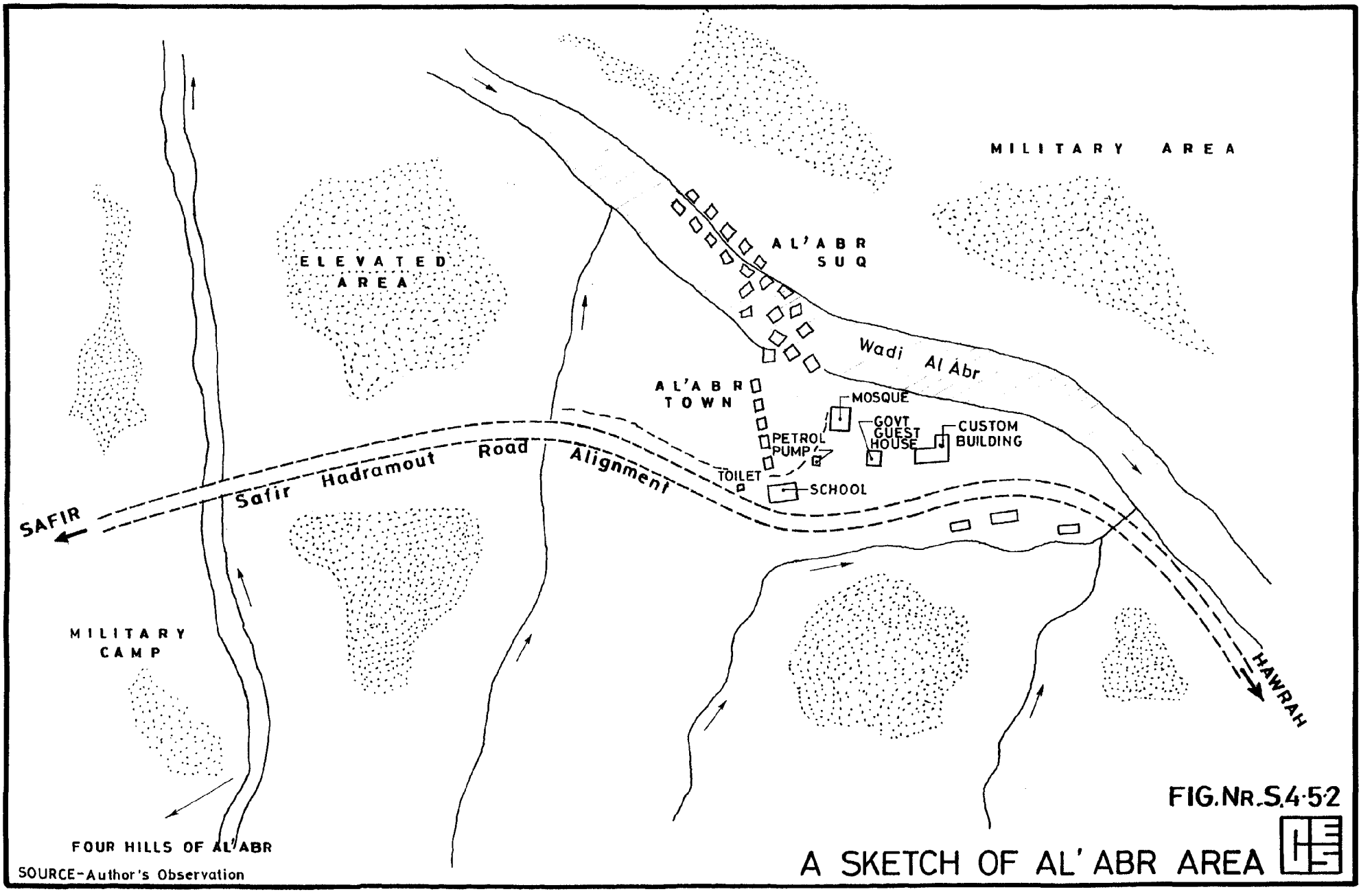
Table S4.5.2
Administrative Hierarchy of Hadramout Governorate

SL. NO.	MUDRIAH	MUDRIAH CAPITAL	NO. OF MARKAZ	NO. OF VILLAGES	BEDOUIN AND NOMADIC SETTLEMENTS
1.	Al Mukalla	Al Mukalla	3	197	91
2.	Al Hajr	Al Joul	4	184	26
3.	Al Sahr	Shaher	4	187	153
4.	Sayun	Sayun	5	602	45
5.	Al Qatn	Al Qatn	4	506	32
6.	Doan	Harida	5	625	39
7.	Thamud	Thamud	3	-	98
8.	Al Abr	Al' Abr	3	68	42
			31	2369	526

Source : Figures from Central Statistical Organisation, Sana'a

The small town of Al' Abr lies directly adjacent to the road and has a population ranging between 1000 and 1500. It is mostly inhabited by sedentary Bedouins who have constructed houses using corrugated iron-sheets and cement concrete blocks. Many residents were reported to have emigrated to Saudi Arabia and are likely to return once the road has been constructed. Main activities include trading, transportation of goods and people and raising of livestock. Livestock is sold to Al Qatn and to Al Sharura in Saudi Arabia. Shops in the town cater for consumer goods and provisions of the Bedouins. Facilities include wells, storage of rain water, one mosque, one primary school, one guest house of the Mudiriyya, one police station, one custom post and one petrol station. A sketch of the Al' Abr area is given in Fig. S4.5.2.

With high population growth rates particularly as noted in Hadramout, Yemen is experiencing a rapid and extensive trend in urbanisation. Construction of the new road will further increase the urbanisation trend.



SOURCE-Author's Observation

FIG.NR.S.4·5·2

A SKETCH OF AL' ABR AREA

4.5.3 Villages

The only villages located along the route are at the eastern end from km 244 + 000 km to 310 + 000 km. Travelling from west to east the villages are encountered as follows: Bir Al Wahed, Al Khasha, Dar Al Nasser, Al Zudeiyah, Al Gauda, Munbaith and finally Al Makhaneg. The road passes through the villages with the exception of Munbaith and the majority of Al Gauda which are located off the road to the south of the alignment. The new road closely follows the alignment of an existing cobbled track from Al Khasha (km 288 + 350) to Al Gauda (km 305 + 000). The track is partly eroded at Wadi Amad and Doan near Al Gauda and appears again towards Al Makhaneg.

Details of the villages including location, present status, estimated size, present day facilities and activities are scheduled for convenience and comparison for each village in Table S4.5.3.

Typically the villages have 20 to 70 houses in this region and facilities may include a school, small pharmacy, a mosque, small shops, a petrol pump and sources of water usually in the form of a pumped or dug well system.

The larger centre at Al Gauda has several mosques, a consumer co-operative store, a police post and a small unit for manufacturing concrete cement blocks and is becoming an urbanised village through its size and range of trade, commerce and services. The village at Al Makhaneg is different in character in that it occurs as a linear settlement along the existing Al Mukalla-Seiyun road and is geared towards servicing transport with repair workshops, accommodation and restaurants. Activities of the other villages principally involve livestock rearing and agriculture. Livestock consist of goats, sheep or camels (mainly for milk) and occasionally donkeys for transport. Trading of livestock takes place mainly in Al Qatn from Dar Al Nasser and villages to the east, whereas trading from Al Khasha and Bir Al Wahed is also in Al' Abr. Bir Al Wahed has attracted Bedouins wishing to adopt a sedentary life. Share cropping is important at Munbaith, Al Gauda and the other settlements along the route, either based on pump irrigated cultivation or on rainfed agriculture. The share cropping family forms the basic social unit of production, with some families having small holdings of agricultural land. They first meet their basic needs of grain and then invest in fodder for livestock which fetches good prices in the markets. Some villages also have migrant agricultural workers. Those villages without their own school tend to use the school in the nearest villages at primary level. For example children living in Dar Al Nasser go to school at Al Khasha. To obtain secondary education or medical services involves travelling to larger centres such at Al Qatn.

Table S4.5.3
Emergent Major Needs/Centres Along Safir-Hadramout Road Project

Settlement	Segment No./(Ch. kms)	Present Status	Est. Population/ No. of Dwellings	Present Facilities	Principal Activity	Future Role
Al' Abr	9 / 10 (183)	Town/District Capital	Population 1000-1500	Primary School, Health Care Centre, Mosque, Shops of Various Types, Petrol Station, Guest House, Police Post, Customs Post, Well, Military Camps, Landing Strip	Training, trasportation of goods, raising livestock, administration	District Centre Transport Node
Bir Al Wahed (Mudiriyyat Al Abr)	15 (244)	Village	50 houses	Primary School, Small Pharmacy, 2 Mosques, Shops, Petrol Pump, 2 Diesel Pump Wells	Livestock, subsistence agri-culture	Regional Service Centre
Al Khasha	19 (290)	Village Scattered over wide area	Population : 500-600 30 houses	School, Small Pharmacy, Shops, Petrol Pump	Agriculture and livestock	Regional Service Centre
Dar Al Nasser	20 (297)	Small Village	20 houses	2 Diesel Pumps, 2 Dug Wells, Shop, Water Tank	Livestock and some agri-culture	Local Service Centre
Al Zudeiyah	20 (300)	Small Village	30 houses	Shops, Water Tank, 4 Diesel Pump Wells	Agriculture and trade	Local Service Centre
Al Gauda	20 (305)	Urbanised Village (1 km from road)	Population : 2000	2 Primary Schools, Consumer Co-operative Store, Various Shops, 3 Mosques, Concrete Cement Block Unit, Pharmacy, Policy Post, Petrol Pump, Water Tank, Water Pumps, 2 Wells	Livestock, agriculture, share cropping, sub-office for administration from Al Qatn	Regional Service Centre
Munbaith	21 (308)	Village (400 m from road)	Population : 700 - 70 houses	Wells	Share cropping, livestock	Local Service Centre
Al Makhaneg (Mudiriyyat Al Qatn)	22 (310)	Village	Linear scattered 500 m long on Al Mukalla-Seiyun Road	1 Hotel, 2 Restaurants, 10 Shops, Repair Workshops for Vehicles and Trucks	Trading, transport, servicing, accommodation	Regional Service Centre Transport Node

S4.5.4 Transport

The existing road network of Marib and Hadramout Governorates can be seen in connection with the country's road network in Fig. S4.0. Marib is connected to Sana'a by double lane asphalt road. Another road between these places passes through Jihanah and Sirwah and is under construction. Towards the south a road between Marib and Bayhan through Harib is nearing completion, and thus will give a direct connection to the main road network in the Southern Governorates.

In Hadramout, the project road will join the Ar Rayan-Seiyun-Tarim asphalt road near Hawrah. This asphalt road meets the east-west coastal highway (Aden - Al Mukalla) to connect with the country's main road network.

The project road will thus be well integrated with the country's main road network and will become one of the important primary roads running east-west to link the Eastern Governorates with the capital Sana'a and the other Western and Northern Governorates.

On a more local scale provision of the new road will make transportation of goods and people much easier and more rapid than is currently possible through open desert and along the existing cobbled track from Al Khasha to Al Gauda, which is in a bad condition. The new road is likely to bring social benefits such as improved access to health care and education facilities and improved opportunities in trade.

S4.5.5 Trade

The knowledge that the new road will be constructed and as the segments are completed in due course, certain expectations and awareness of opportunities will be created. This is particularly the situation in remote areas with inadequate transportation networks.

The market and shops in towns such as Al Qatn provide the essential distribution sytems in rural areas for trading goods. Road building and the resulting traffic flow provide improved access to markets. A further development could be the concentration of markets on sites with particularly good communications.

Interviews conducted by social anthropology experts revealed that in some areas such as Al' Abr many residents have emigrated to other countries such as Saudi Arabia. It is reported that these emigrants are likely to return when the road is built and water is provided for domestic use as well as for livestock. It has been

documented in other areas of Yemen that when emigrants return from overseas the local economy is stimulated by new ideas, crafts and perhaps local industry. It becomes possible for workers who at one time concentrated on agriculture to diversify in to other sectors. On their return the emigrants may invest their hard earned cash in local housing or other enterprises and hence stimulate trading activity.

The local economies in Marib and Hadramout are dominated by subsistence agriculture and livestock husbandry. Recent completion of the Marib dam, Marib-Safir Road and the oil extraction and refining activities have resulted in a boost to the local economy in the form of horticultural farm development, development of diversified support and ancillary services and employment opportunities. In Hadramout there are a number of plantation orchards, concentrating mainly on palm dates which are growing in areas of pumped water. When production output exceeds local demand, good roads are needed for transport of either the raw goods to suitable markets or if a canning industry started then roads are also needed to transport canned goods to the markets.

The prospect for growth in trade in these two Governorates hinges heavily on the success of oil prospecting which is being actively pursued. Although the outcome is unpredictable at this stage, success in this field would have far reaching effects on employment generation particularly in support services, demand for agricultural produce and other consumer items. Typical developments that are expected to occur in the proposed area have been discussed in section S4.3.4 and Table S4.3.4(b).

S4.6 Prospects for Regional Economic Development

S4.6.1 General

Prospects for regional growth are effected by money factors both at national and local level. At the national level there is an overall foreign trade deficit because of a relatively small agricultural and manufacturing base combined with the problem of growing domestic demand for consumer goods. Export receipts are mainly in oil, canned fish and processed foods and the government wants to exploit further potential in these areas. Cereal production does not satisfy domestic requirements. Whilst the government is keen to reduce dependence on imports and improve exports through processing agricultural products, particuarly as Yemen has fertile soil and the best natural water resources of the countries in the Arabian peninsula, there are problems which manifest

themselves. Success is threatened by the dominance of qat production, local problems of water supply, trends in desertification and the possibility of salinisation of soils through over irrigation.

The government is prepared to make investment in public roads construction and water supply projects whilst at the same time trying to encourage foreign investment into key areas of potential export e.g., oil exploration. At the local level the road will improve transportation for goods and people but there needs to be planning and environmental controls to maximise the opportunities and ensure development proceeds on a basis that is sustainable.

S4.6.2 Regional Service Centres

Principal facilities and activities are described in sections S4.5.2 and S4.5.3 for Al' Abr and each village located along the Safir-Hadramout Road. These have been summarised in Table S4.5.3 which also considers the likely future role anticipated for each centre.

Al' Abr is a township and district capital which in view of its central location on the proposed road, is likely to develop further as an administrative centre and transport node. The larger existing villages of Bir Al Wahed, Al Khasha, Al Gauda and Al Makhaneg could develop into regional service centres. New or additional services might include water supplies, opening of shops, setting up of repair workshops for motor vehicles, petrol stations, perhaps restaurants and new possibilities for marketing agricultural products and livestock. The smaller villages could also develop further as local service centres.

To channel and enhance development into a preferred strategy the EA report has identified 6 locations along the route where basic facilities for local communities should be improved and where measures to combat desertification can be implemented. These sites are located near bore wells to be set up for construction purposes.

In addition to the above enhancement measures, the road will increase access of Bedouins to services such as education, health, trade, transportation, drinking water and to opportunities of employment created by various kinds of development along the road.

Consumer goods may be brought into the area providing local communities with a wider choice. Undoubtedly links betwen the people and the state administration will increase.

The road may induce a new spatial organisation in the form of linear development along the new road. This trend should be resisted by appropriate planning controls. Prevention of uncontrolled development is considered necessary to prevent development on to land that could be used for agriculture. The draft environmental protection law requires that agricultural lands are protected against commercial and industrial development. Also uncontrolled development must be prevented to stop harm to existing plant cover that if destroyed may lead to increased desertification.

A further problem that may arise if linear development is allowed to proceed unchecked is that traffic speed controls will be required over longer lengths through inhabited areas, which would reduce the effectivenes of the road as a path for rapid transit.

All these factors emphasise the importance of the environmental management plan which is to be implemented by the Environmental Planning and Monitoring Committee (EPMC), a broad based committee formed from EPC, GCRB and other interested parties such as MAWR, ERADA, Ministry of Planning and Ministry of Local Government. When set up opportunities will be available to manage development in a structured manner at the road post construction and operation stage to the benefit of all on a sustainable basis and without causing environmental problems.

S4.6.3 Prospects for Regional Agricultural Development

The prospects for improvement to agricultural development in a fragile desert ecosystem on a regional scale are dependent on four key factors.

i) Combating desertification

ii) Provision of adequate supplies of water and efficient usage

iii) Applying agricultural technology appropriate to the environmental conditions

iv) Knowledge of market conditions and access to approriate markets for selling goods at the right price.

Items (i), (ii) and (iii) have already been considered in detail in Basic Study 1, Combating Desertification and Basic Study 2, Hydrology of the Inland Basin.

For the present it is sufficient to note that any regional development of agriculture should address measures to combat desertification which is manifested through such factors as high wind velocity, unrestricted animal husbandry leading to over grazing, over exploitation of trees for fuel and resulting in sand movement which degrades the land.

With respect to water, systematic hydrogeological surveys are needed to collect and map data on all open wells and tubewells. A programme of monitoring water levels and water quality should be put in hand to provide better planning of ground water resources. Considerations should be given to using water more efficiently as it is a scarce resource. Changing cropping patterns and introduction of sprinkler or drip irrigation should be considered where necessary.

As Bedouins become more sedentary there is a need for agriculture to provide fodder for livestock, vegetables and wood for fuel. Action programmes in agriculture might involve applying technology in range land development, agroforestry and arid horticulture and other techniques. Feasibility studies on agroforestry have already been initiated by ERADA in Marib and by the Agricultural Research Station, Seiyun in Hadramout area. Similarly arid horticulture is practiced extensively in Marib for citrus orchards and in Hadramout area for date palms. The objective should be to find suitable combination of trees in orchards for fruit production and grasses for provision of fodder to livestock. Techniques in range management are needed to combat current systems of uncontrolled grazing which are leading to over utilisation, soil erosion by aeolian processes and desertification. A variety of techniques could be researched for example intercropping with grasses-legumes, fencing to resist grazing, reseeding range lands and choice of species. These aspects are fully described in section S1.5 of the Basic Study 1.

Construction of the new road will provide new opportunities for implementing regional development and provide access to more distant markets. However agricultural development must proceed on a sustainable basis to avoid environmental problems for future generations.

As an example of adopting sustainability as a criteria for agricultural development, unless proper water management is followed salts can accumulate in irrigated soils due to removal of pure water by evapo-transpiring crops. Concentration and composition of salts in the soil can be influenced by numerous factors including composition of irrigation water, rates of water application and leaching, dissolution and precipitation of soil solution constituents and rate of drainage. There are indications that irrigated areas such as in Marib and Hadramout can be vulnerable

to salinity. Poor quality irrigation water could be considered as one of the major reasons for soil salinisation. Inappropriate water management techniques includes uneven distribution of water in fields, excessive or insufficient application, untimely application in relation to crop needs, excessive losses in conveyance from well to point of application. Soil salinisation deserves special attention as it is cheaper to prevent than cure. Particular care is justified with groundwater near salt domes or with shallow groundwater which may show higher salinities because of return flow of irrigation water.

As an initial and urgent step incentives should be provided for development of road side orchards with shelter belt trees supported by pumped wells. The sooner this is implemented the easier it will be to control unplanned linear development of residential and commercial property.

For agricultural development to proceed on a regional scale it is crucial to have co-ordination between various Government Ministries at the post construction and operation stage of the road project. The broad-based Environmental Planning and Monitoring Committee (EPMC) recommended to be formed as part of the Environmental Management Plan would provide the means for such co-ordination.

S4.7 Need for Landuse Control and Water Conservation

It has been indicated that regional development may induce linear development along the road as population increases and new housing is constructed. Also agricultural development is dependent on utilising appropriate land, soils, agricultural techonology and water supply. There is the need therefore for land use control and conservation of water which is a scarce commodity.

Urban development should not encroach on agricultural land nor should development worsen the desertification process.

Water should be conserved by applying irrigation practices in a manner to minimise loss through evaporation or leakage. Traditional irrigation by the spate method leads to excessive consumption of water. Recycling of water from buildings should be considered for agricultural use. There should be awareness that over irrigation can lead to salination of the soils.

It is known that in the Marib area an explosion has occurred in construction of tube wells in recent years resulting in usage of water exceeding recharge. It is therefore natural that areas along the route little known for groundwater are explored for economic development, with extraction determined preferably on a sustainable basis. In Hadramout, although extraction of water resources is thought to not yet exceed natural recharge, water conservation measures should be introduced to keep the groundwater regime stable for future generations.

It should be recognised that when operating in a fragile desert environment that a certain balance in agricultural practices is required to combat desertification. Much property that is in common usage by the community is managed and regulated by local users taking into account customary law. Local people have to be adaptable to deal with variable environmental conditions as conditioned by geology, geomorphological processes, hydrology, climate etc. The desert environment whilst seeming to be static in the short term, is in fact continually adjusting to natural and man-made changes of various kinds. Successful development is dependent on recognising and promoting interdependence of the various component parts thus ensuring integrated development.

As a warning, various kinds of policy are presented which can in effect result in encouraging unsustainable agricultural practices. Comments are provided suggesting ways of overcoming the problems to make development sustainable, such that the development would meet the needs of the present without compromising the ability of future generations to meet their own needs.

(a) Uncontrolled settlement development could lead to unsuitable land use such as intensive food cropping which could quickly deplete soil fertility. Appropriate agricultural practices should be applied taking into account soil fertility, landuse control and water conservation measures.

(b) Commercialisation of agriculture to produce cash crops for export can lead to reduction in dry season grazing and loss in valuable manure potential. A proper balance is required between commercialisation of, for example, fruit growing in orchard plantation and growth of grass to provide fodder for livestock.

(c) Fuelwood pricing could encourage continued cutting of the limited tree resource for use as fuel, whereas use of alternative fuels which are less environmentally damaging should be encouraged.

(d) Over zealous application of irrigation can lead to depletion of scarce water resources and salinisation of soils. Irrigation should be planned and designed carefully after due consideration of soils, water supply, water quality, irrigation management practices, maintenance and the need to provide advice at the local level on appropriate irrigation schedules and types of crops.

(e) Well intentioned livestock projects have had undesirable environmental effects due to temporary concentrations of stock destroying young trees and overgrazing sparse pasture. These problems can be overcome by implementing a proper range management system.

(f) If grazing becomes intensive around a limited number of wells, overgrazing could result in degradation of the pasture lands. This situation should be monitored carefully and kept under review to determine the need to reduce localised pressure on the water supplies by construction of new wells elsewhere.

Once a regional development programme is planned through co-ordination of the efforts of the appropriate agencies, it is important to monitor both the implementation of the programme and the long terms changes to the environment so that there is flexibility for adjustment or corrective measures to be implemented and thus prevent long term damage to the eco-systems.

Landuse planning and water conservation should be implemented through the EPMC whose function would be to initiate and oversee specific sub-projects through the appropriate government departments. It is important to draw on the fund of existing local knowledge and expertise in ERADA and at the Agricultural Research Station in Seiyun.

S4.8 Prospects of Oil Strikes

Oil prospecting is being pursued with vigour in the remote regions of Yemen. Plans for regional development should be flexible to take into account changing circumstances if oil is struck in specific areas. Enterprises in oil extraction and refining are inevitably breaking with tradition, yet this process has already begun leading to impacts on the local economy and a degree of diversification in trading opportunities.

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BASIC STUDY - 5

REPORT ON HERITAGE - ARCHAEOLOGY & PREHISTORY

SAFIR-HADRAMOUT ROAD PROJECT

STUDIES RELATED TO ENVIRONMENTAL ASSESSMENT

REPORT ON HERITAGE : ARCHAEOLOGY AND PREHISTORY

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SECTION 5.1

SUMMARY

SECTION 5.1
SUMMARY

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BASIC STUDY - 5

HERITAGE : ARCHAEOLOGY & PREHISTORY

S5.0 Summary

S5.1.1 Introduction

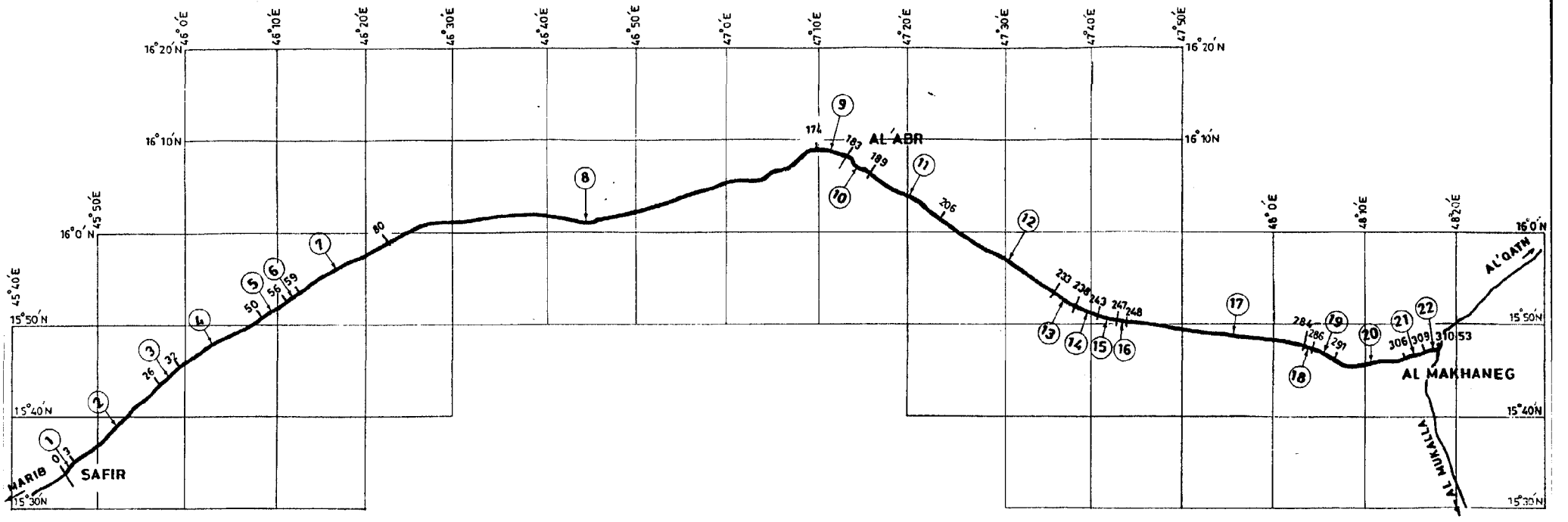
This report on Heritage is presented in three sections. This First Section (i.e., The Summary) describes the background and highlight of the studies in respect of Archaeology and Prehistory undertaken by the Consultants. In the Second Section the Study on Archaeological Survey has been presented. The Third Section contains the Study on the Prehistoric Cultural Resources Survey. The experts belonging to the team of Consultants found it judicious to carry out the two surveys together on the consideration that the boundary conditions between prehistory and archaeology are not sharply definable and that it would be proper to locate the two types of sites as decided by the experts in identical maps to facilitate the actions to be taken by the GOAMM later. Hence 80 identified sites carry sequential numbers (marked as MHT-1, MHT-2 etc.) proceeding from Safir through Al'Abr to Al Makhaneg. For convenience of referencing with the other components of the EA study, the proposed road alignment was divided into 22 segments - Fig. S5.1(a). The locations of the 36 archaeological sites and 56 prehistoric sites of variable orders of significance as distributed between the 22 road segments are shown in Fig. S5.1(b). It means that there are 6 sites of both archaeological and prehistoric significance of variable order.

S5.1.2 Highlights of Archaeological & Prehistoric Survey

1) Archaeological Survey

(a) The probable age of the 35 archaeological sites have not been possible to establish. Only their indicative dates have been noted in Table S5.2.3. These can be classified as follows:

Bronze Age	-	7 sites
South Arabic	-	1 site
Islamic	-	3 sites
Modern Bedouin	-	6 sites
No Clue	-	18 sites
		35 sites



NOTE:-

PACKAGE I km. 0·000 TO km.180·900
PACKAGE II km.180·900 TO km.310·500
OF CES ROAD ALIGNMENT DRAWINGS

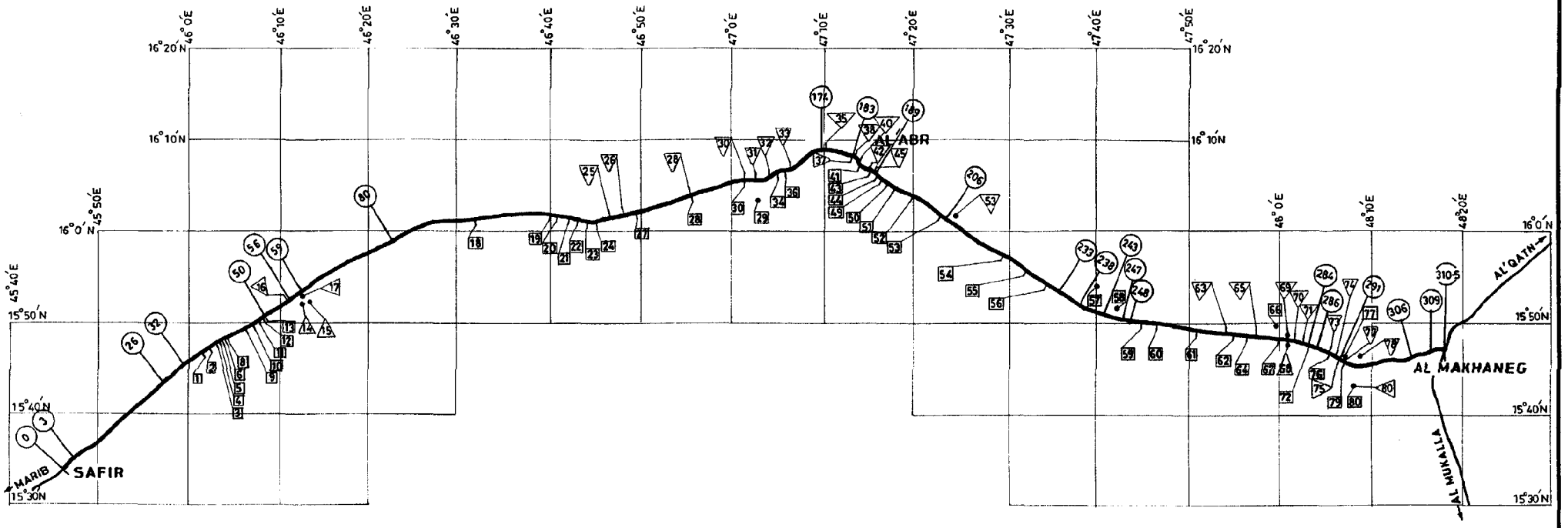
5 0 5 10 15 20 25 Km
SCALE

LEGEND:-

- EA SEGMENTS (km.) 80 174
- EA SEGMENTS (NR) (8)

FIG. NR.S5·1 (a)

LOCATION OF EA SEGMENTS ALONG THE PROPOSED ROAD



NOTE:-

1. PACKAGE I : km. 0·00 TO km.180·90
2. PACKAGE II km.180·90 TO km.310·50
3. SIGNIFICANT SITES ARE [13] AND [17].

LEGEND:-

- EA SEGMENT BOUNDARY (km).
- PREHISTORIC SITE LOCATIONS.
- ARCHAEOLOGICAL SITE LOCATIONS.

5 0 5 10 15 20 25 Km
SCALE

FIG.NR. S5·1 (b)

LOCATION OF ARCHAEOLOGICAL AND PREHISTORIC SITES ALONG PROPOSED SAFIR-HADRAMOUT ROAD

(b) The nature of archaeological sites can be classified as follows:

Related to burial	-	21 sites
Kiln	-	1 site
Settlement	-	4 sites
Stone circle	-	1 site
Undetermined	-	8 sites
		35 sites

(c) A summary of the actions recommended for the archaeological sites has been presented in Table S5.2.3 placed in the main report. The number of sites classified by the types of recommended actions are as follows:

No action required	-	16 sites
Avoid Quarrying	-	3 sites
Protect by fencing	-	7 sites
Realign road, if possible	-	1 site
GOAMM to exavate for further information	-	7 sites
GOAMM to monitor during road construction	-	7 sites
GOAMM to prepare maps before road construction	-	1 site
		42 Sites

NOTE: Multiple alternative actions have raised the total from 35 to 42.

(d) The information given in Para 5.1.2(1)(c) above should suggest that for some sites more than one action has been suggested as alternative. Of these, Site No. 17 assumes critical importance when seen against the cost of finding an alternative alignment for the road. However, the expert opinion is that this action of realignment is avoidable if the GOAMM excavates the site to determine its real significance. This also can be avoided by protecting the site by fencing. Alternatives between excavation and protection by fencing have been suggested for Site No. 45 also. Regarding all quarry sites, the Consultants have selected alternative sources of materials.

2) Prehistoric Survey

(a) The 50 sites yielding evidences of prehistoric culture can be classified as follows:

Lower Palaeolithic (Acheulian)	-	2 sites
Middle Palaeolithic	-	17 sites
Upper Palaeolithic	-	Nil
Neolithic	-	11 sites
Bronze Age	-	1 site
Undetermined	-	21 sites
		52 sites

Note: There were the presence of 2 multiple cultural component occupations.

(b) Assuming that the surveyed sites provide a useful sample of similar sites in the region traversed by the proposed road, the Consultants have determined the order of potentials for encountering exposed prehistoric cultural resources in terms of the road segments in the following manner:

Low Potential: Segments 1,2,3,5,6,7,9,14,16,18,21 &22	87 kms
Low to Moderate Potential : Segments 10,12,13 & 15	42 kms
Moderate to High Potential : Segments 11, 17,19 & 20	72 kms
Very High Potential : Segments 4 and 8	110 kms
	311 kms

(c) While the observations given in para 8 above are to be seen as guide to future explorations in the adjoining regions, the survey itself has exhaustively identified all the prehistoric sites within the road corridor. The results show that between the road segments 4, 8, 11 and 18 some 78% of all the surveyed sites are located. Amongst these, Segments 4 & 8 together account for 50% of the surveyed sites.

(d) Not all the sites are wholly within the proposed road corridor. These are distributed as follows:

Wholly within the right of way	-	16 sites
Partially within the right of way	-	24 sites
Quarry area	-	8 sites
Outside Impact area	-	2 sites
		50 sites

(e) EA studies indicate that all the quarry sites can be avoided by procuring suitable construction materials from other sites.

(f) The Consultants consider that all the 50 sites are not equally significant for prehistoric investigation. By taking into consideration a set of indicators like site integrity, uniqueness, research potential, regional importance and the quality of artefacts, a composite scoring was evolved to measure the order to significance of each site. These 50 sites can be grouped according to range of composite score as follows:

1-5 score point	-	23 sites	: average score	= 3.43
6-10 score point	-	24 sites	: average score	= 8.04
11-15 score point	-	3 sites	: average score	= 14.67
		50 sites	: average score	= 6.32

(g) The Consultants have recommended to adopt proper mitigation measures with reference to the three sites having the highest score. These are Site Nos. 12, 13 and 62. Of these Site Nos. 12 and 13 are located in Segment 4 of the proposed road. Site No. 62 is located in Segment 17. For the rest of the sites, the Consultants do not consider that even monitoring is necessary. However, a brief training to road construction supervisors as to the nature of prehistoric sites and the types of artefats likely to be encountered has been considered useful by the Consultants for strict adherence and enforcement of World Bank guidelines regarding this issue. This may help the GOAMM to carry out excavation or collection of artefacts during road construction.

(h) The Consultants further observed that Site No. 12 lies well outside the proposed road corridor and will not be impacted by the proposed road construction activities. However, the order of significance of this site calls for preservation and prevention of all future development activities upon or near it.

(i) Site No. 13, however, falls partly within the proposed right of way. Shifting the proposed alignment by 100 to 150 m south is the best solution for preserving the site intact. If it is considered impractical or uneconomical, then GOAMM should consider to undertake further investigation and data recovery at the portion of the site to be impacted by road construction activities. It is further recommended that the portion of this site that is not impacted by construction activities be protected by fencing and by preventing all future developmental actions thereupon.

(j) Site No. 62 is located on talus slope and scree deposits at a proposed quarry location. Avoidance of this site as quarry is recommended. GOAMM may also consider conducting field investigations to assess the site's significance adequately. This is particularly emphasised because alternative quarry sites have been found in the neighbourhood.

SECTION 5.2

STUDY ON ARCHAEOLOGY

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C O N T E N T S

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S5.2 Archaeology

S5.2.1 Nature of the Task

(a) Field Work

As programmed, the survey of prehistoric and archaeological sites was carried out in two phases : September 27 to October 6, from Marib; October 12 to October 17 from Seiyun. During each phase, the same basic procedures were employed, stopping at virtually every potential site. During the course of this work, 80 sites were discovered, dating from the Lower Palaeolithic to modern Bedouin. The representative of GOAMM was associated during the entire period of field work.

At each identified site, some artefacts were collected and the reading of position was noted, wherever possible. At each site an attempt was made to assess the significance of the site as to whether the site would be affected by the road or not. If the site was found to be affected by the road construction, an attempt has been made to assess whether the loss of site would be of archaeological significance. In the event that the Consultants judged the construction project to be a threat to a site of significance, an attempt has been made to establish in what way the preservation of the site would be compatible to the road project.

(b) Analysis

The prehistorian assumed responsibility for all of the sites dating to the Palaeolithic and Neolithic. The archaeologist took responsibility of all sites with architecture and/or pottery. In the notes below, the eventual conclusions of this analysis are listed for each site under two headings : one identifying the type of site in the broadest terms, and one incorporating the recommendations for action.

(c) Practical Significance of the Work

The Consultants established that virtually no important sites will be threatened by the construction project. Only one detour site MHT-17 at Km 59.43 (of tens of metres) may be advised in view of the archaeological work. In one case, an alternative quarry has been suggested, where the quarry area originally envisioned turned out to be a significant cemetery. Monitoring by the GOAMM may be essential at several sites, primarily in order to confirm that nothing of significance remains at the sites in question. Some small excavation work may be necessary. The primary concern could be putting up fencing at certain places in order to avoid destruction of sites by workers seeking rocks.

In virtually no case was it possible for the surveyors to establish exactly where a service road would be placed in order to provide access to the quarry from the corridor. This means that a superficial survey of the areas will have to be carried out at the time of construction. In most cases, this will be little more than a nominal activity, as there is little chance that anything important escaped during the survey.

The Consultants are convinced that virtually every significant site along the corridor has been identified and that following recommendations will produce necessary actions with respect to the archaeological heritage. Needless to say, more time would have permitted a more exhaustive survey, potentially increasing the number of known sites, but most probably not the number of significant sites.

S5.2.2 Prehistoric Background

The archaeological history of South Arabia begins with Homo erectus crossing from Africa to Arabia, perhaps across the Bal al-Mandab straits some 2 million years ago, and thus the oldest artefacts yet found in Yemen belong to the developed Oldawan industry. It would appear that South Arabia has known virtually all of the subsequent cultures, with the possible exception of the late Palaeolithic and Epipalaeolithic industries familiar in the Levant. Thus the archaeological history of Yemen virtually parallels that of humanity, for the Oldawan industries are the oldest known.

The Lower and Middle Palaeolithic industries are known from Yemen, and it is possible that the Middle Palaeolithic technical traditions survived into the chronological Palaeolithic. In any case, the Middle Palaeolithic is virtually immediately followed by the Neolithic, of which the representative varieties in Yemen parallel those of the Rub Al-Khali Neolithic.

The Neolithic was followed by a Bronze Age of indeterminate length at an unclear point in time. During the Bronze Age, many of the subsequently prevalent funerary customs developed, particularly the construction of burial tumuli commonly called cairns. Such cairns are known from throughout the Arabian peninsula, although Yemeni cairns would appear to have been primarily tombs with single burials, while multiple burials are more frequent elsewhere on the peninsula. The dolmens and ritual platforms familiar from the eastern part of the peninsula are also present in Yemen.

The traditional cultures of South Arabia emerged during the second millennium BC., creating irrigation systems and introducing monumental rectangular architecture. With the invention of writing and control of the caravan routes using the camel to transport incense and spices upto the Mediterranean world, their kingdoms grew wealthy and established outposts on the western part of the peninsula.

For several centuries they were able to control the aromatics trade, until Greek and Roman traders discovered a method of exploiting the monsoon winds, and were thus able to reach India themselves. This undermined the trading capability of the South Arabian Kingdoms and shifted control from the cities ringing the desert to the mountain kingdom of Himay, which controlled the port of Muza. Prosperity was short-lived as the Christian world abandoned traditional religious practices and the demand for incense was reduced (although not altogether eliminated).

The advent of Islam found Yemen at the forefront, one of the first countries to accept Islam, and the pagan temples were used as templated for the Yemeni mosuqes. For several centuries of the Renaissance and the Enlightenment, the international traders found Yemen to be strategically placed and later discovered the virtues of coffee. Competition between ports has been a constant feature of Yemeni development but the general openness of the southern ports and adjacent territories has been matched by a contrasting reticence of the northern rulers ever since the introduction of Zaydi Islam at the end of the first millennium AD. Thus, late Ming shards will be found on the southern coast, but not in the northern capital at Sana'a. The Islamic states were the first real system of states in the Middle East as a whole, replacing the South Arabian Kingdoms and transforming the trade routes.

The present survey covered a key area joining the eastern and western parts of Yemen.

No Oldawan material was identified during the survey. The possibility that mankind crossed from Africa to Arabia at two different points, both Sinai and the Bal al-Mandab straits may be strengthened by the fact that developed Oldawan material is found at the southwestern and northwestern corners of the peninsula, but not in between. It is however stretching the speculative thought encouraged by this modest survey to draw any firm conclusions, but it does suggest that additional research could in fact reveal a break in the distribution patterns of the culture. If developed Oldawan material were to be found along the entire western coast, but not on the eastern coast, the significance of the finds would remain

unclear until more precise dating for the known sites is found. The absence of sites is a hint, but no more.

The Lower and Middle Palaeolithic material is representative of that found elsewhere in Yemen. The Neolithic is unquestionably the Rub Al-Khali Neolithic, and representative of the desert rather than the mountain tradition. During part of the Neolithic period, the desert was moister and sites established on lakes between the dunes. These transient sites usually have no depth.

The Neolithic led into the Bronze Age and many of the burial cairns discovered during the survey can be assigned to the Bronze Age, but the chronological distribution of these cairns is not clear. The combination of sites discussed in detail below would suggest that the cairns be dated as early as the Neolithic period. This survey did not reveal any dolmen type structures, but virtually only cairns, and cairns with tails. The cairns seemed to be both the type with an internal box of vertically set stone slabs and the type with corbelled vaulting. Very few of the cairns had upright stele at their entrances, but many were so seriously damaged by plundering that it is difficult to assert that these were rare. What is clear is that the rectangular tradition of tomb known from eastern Arabia, and into the eastern Hadramout was not present, and that the distribution pattern of these tombs stops to the North and East of the area surveyed.

Whether these tombs can be dated into the period of the wealthy South Arabian trading kingdoms is unclear, but virtually no traces of any clearly South Arabian sites along the alignment of the road were found. In the Hadramout, several tombs typical of those associated with the city of Shabwa, capital of the Hadramout kingdom were found, but these were off the proposed alignment, and seriously damaged in any case. These tombs may however have been associated with one of the larger potentially Bronze Age or South Arabian sites.

The alignment crossed the desert just north of a mountain which is known to have lain quite close to the traditional routes crossing the desert but no trace of these remains were found during the survey. Any potential caravansaries apparently lay beyond the edge of the route.

With the Islamic period, the irrigation systems of the Hadramout began to recover, and some of the sites found may be dated to the early centuries of Islam. Bedouin burials of more recent date dot the deserts, and several of these were found. The brick kiln at Al' Abr should be dated to the last thousand years or so, but it is difficult to say exactly how old the structure was, or its purpose.

S5.2.3 Geographic Variations

The route of the road passed through several distinct geographical zones. Although the zones themselves were distinct, the transition from one zone to the next was hazy and thus it is impossible to say where one zone terminated and the other began, so that the lines on the maps are quite arbitrary. The distribution of the sites generally corresponded within each zone, so that the value of the zones is confirmed. The quarry areas could be interpreted as each belonging to an individual zone, as the topography of the zones and the adjacent quarry area was not the same, but this did not substantially change the interpretation.

In general the zones were :

Zone I : (no sites) dominated by the sands of the Ramlat As Sab'atayn:
Although there was occasional evidence that ancient surfaces were exposed due to dune shifting, no evidence of human presence was found in this area.

Zone II : (sites 1-6, 7-13) the northern edge of the dunes and the steppe beyond:
Most of the sites in this area were Neolithic in date, the traces of hunting camps on the lakesides of the environment as we know it to have been during the Neolithic. The one Bronze Age settlement may have been the successor to the nearby Neolithic settlement. It is interesting to note that the distribution would have been exclusively Neolithic if the surveyors had not stopped at one site, outside the corridor.

Zone III : (sites 14-17) the mountains and steppe:
Only cemeteries were found in this zone, cemeteries which are customarily dated to the Bronze age. The nature of the corridor will account for the lack of contemporary Bronze Age settlements, but it is possible that some of the tumuli may be Neolithic in date. One shard found in the corridor near a tomb is definitely Bronze Age in date.

Looking beyond the mere monuments themselves, one is struck by the unusual conjuction implied by sites 12, 13, 16 and 17. The cemeteries in Zone III should probably be related to the settlements in Zone II.

Zone IV : (no sites) the wadi beds of the desert steppe north of the mountains:
Although potentially fertile, the area was evidently not used by humans during the last few thousand years. The surface date back to the Palaeolithic, so it is suprising that no traces of human activity were noted. It is possible that the wadis swept away all traces.

Zone V : (sites 18-28) the waid beds of the steppe and mountains up to Al' Abr: With the exception of the modern Bedouin cemeteries, virtually all of the monuments here are scatters of Palaeolithic flints, representing a period during whch people returned to the same area during tens of thousands of years. The stone circles which are common throughout the southern edge of the Rub Al Khali and the northern part of the Ramlat As Sab'atayn are not easily identified or catagorised.

Zone VI : (sites 29-53) the mountains around Al' Abr:
Zones VI and VIII had the greatest variety of sites, from Palaeolithic knappings places and Bronze Age cemeteries to large settlements. This is the usual situation in an area where several zones meet, and Al' Abr is an unusual meeting place, where the topography and the prevailing climates compel traders and wanderers to meet.

Zone VII : (no sites) the desert to the East of Al' Abr
The same inhospitable desert which drives people to Al' Abr is responsible for the lack of sites.

Zone VIII : (sites 54-80) the dunes and steppe of the western Hadramout:
The great variety of sites in the entrance to the Wadi Hadramout reflects the history of the Hadramout itself, which has been settled since the earliest times. The sites range from Palaeolithic knapping places high on the slopes below the cliffs to Islamic settlements in the Wadi and Bronze Age cemeteries at the foot of the cliffs. It is only in the Wadi Hadramout itself that the surveyors encountered Islamic settlements which can be clearly identified as such indicating that the other zones were marginalised with the development of the major Islamic states, and no longer of value, with trade following other routes and the major centres far removed.

The locations of the sites have been shown in Figure S5.1(b). In Table No. S5.2.3, a summary has been presented. To permit cross-referencing with the rest of the report on EA, the proposed road alignment was divided into 22 segments.

5.2.4 Nature of Site

It is difficult to characterise the sites, but :

- virtually all of the **Palaeolithic** sites (ca. 100,000- 10,000 years BP?) can be divided into knapping areas on the slopes of the mountains, and flake scatters in the flat areas of the northwestern part of the area surveyed;

- virtually all of the **Neolithic** sites (ca. 10,000 - 5,000 years BP?) can be divided into hunting sites between the dunes in the northern edge of the Ramlat As Sab'atayn and similar sites characterised by flake scatters in the dunes of the western Hadramout;
- virtually all of the **Bronze Age** sites (ca. 5,000 - 3,000 years BP?) are cemeteries in the low mountains and hills, or below the slopes of the Hadramout;
- South Arabian sites (ca. 3,000 - 1500 years BP) were conspicuously absent;
- the **Islamic** (ca. 1500 years BP to present) sites are difficult to identify categorically, but several settelment sites remain;
- virtually all the **recent** sites (dated to this century?) are potentially modern Bedouin cemeteries (No attempt was made to classify the military positions encountered according to period, so that military sites will be found mentioned in the text, but not otherwise).

S5.2.5 Catalogue of Sites of Archaeological Interest

MHT 7 (15° 48' 00" N / 46° 09' 39" E)
Type of site : Three circular rock tumuli.

Recommendations for action before or during road construction:
The tombs do not appear to be directly threatened by the construction project, but these might be appealing sources for stones during construction, so that it might be advisable either to provide temporary fencing during construction, or to have them excavated prior to construction.

MHT 14 (15° 51' 40" N / 46° 12' 42" E)
Type of Site : Cemetery : Potentially Neolithic, but more probably Bronze age in date.

Recommendation for action before or during road construction:
Excavate one single tomb (which was already plundered in Antiquity), and use the site as a quarry.

This particular site appeared to be the only alternative quarry site in the area, as virtually all other conceivable sites had several cairns (tumuli) and thus deserved protection. The site has one tomb below a cliff which is quite suitable for use as a quarry. Sacrificing this tomb is a simple matter and the GOAMM will arrange for its exavation.

MHT 15 (15° 51' 43" N / 46° 13' 18" E)
Type of site : Cemetery : Potentially Neolithic, but more probably Bronze Age in date.

Recommendations for action before or during road construction:
This site should not be used as quarry.

During the survey a number of potential quarry sites in the area were visited and virutally all of them were unsuitable due to the presence of tomb tumuli. Eventually it was suggested that the mountain associated with MHT-14 be selected for use as a quarry.

MHT 16 (15° 53' 08" N / 46° 10' 38" E) cf. Map section at the end of report
Type of site : Cemetery : Potentially Neolithic, but more probably Bronze Age in date.

MHT-16 was originally proposed as a quarry site. It consists of a cemetery of the cairn tombs typical of South Arabia. The site itself consists of a small mountain which rises sharply to the West, and several lower volcanic mounds to the West. More than 35 tombs were identified, and it is extremely probable that many more tombs remain to be discovered, while the traces of tombs destroyed in antiquity are clear enough to indicate that the total number of tombs constructed at the site may have easily exceeded 100. As it rapidly became clear that the site could not reasonably be employed as a quarry, a thorough examination of the tombs was not undertaken, but a quick search indicated that cairn tombs without boxes or tails dominated the western part of the site (with one large prominent exception), and cairns with boxes and tails were more common on the eastern part of the site.

Recommendations for action before or during road construction:
The site should not be used as a quarry.

MHT 17 (15° 53' 01" N / 46° 12' 12" E)
Type of site : Cemetery : Potentially Neolithic and Bronze Age, but more probably exclusively Brone Age in date.

The site is astride the road itself and consists of a cemetery of tombs with the cairns typical of South Arabia. 14 tombs (with a total of more than 40 individual cairns) flank the proposed route of the road. The tombs at sites MHT 16 and 17 represent a wide selection of the forms available in South Arabia. Some have "tails" of small heaps of rocks aligned with the tomb (but not systematically

oriented in one cardinal direction), some have "boxes" of upright slabs within the tomb where the body was kept, some are merely corbel valults, some have stele in front of the "entrance", which is occasionally preserved in the form of upright slabs on one side of the tomb. These are customarily dated to the Bronze Age.

Tomb 1 : A simple rock mound.

Tomb 2 : Simple rock mound, possible with a fallen stele

Tomb 3 : Only the burial box of 6 upright standing stones is preserved. It is not clear if there was even a cairn covering the box.

Tomb 4 : Only the circle of 9 upright slabs remain visible.

Tomb 5 : Rock mound with tail of 5 dots. The main mound lies to the Northeast and the tail lies Southwest.

Tomb 6 : This is an unclear monument. Three of the four small cairns support an upright slab, but the fourth does not, and there is no trace of one. Assigning these four small cairns as dots to Tomb 5 would simplify their interpretation, as they are not otherwise associated with a large cairn, yet neither their alignment not structure would support the contention.

Tomb 7 : The main cairn lies to the Southwest, with the tail of six dots lying Northeast. The small dot cairn at the Northeast end of the tail still supports two upright slabs.

Tomb 8 : A well preserved mound with a circular alignment of stones within the interior, and an "entryway" facing Northwest.

Tomb 9 : Remains of a cairn, probably of box type.

Tomb 10 : Remains of a cairn, probably of box type.

Tomb 11 : Exemplary tomb of mound type with 5 dots in tail.

Tomb 12 : The barest remains of a box-type construction, with only six or so slabs scattered about, of which three or four may still be in situ.
Tomb 13 : The box type construction with nine upright slabs still visible. The "entryway" lines with two uprights faced roughly East.

Tomb 14 : Exemplary tomb of mound type with 8 dots in tail. The main mound may have had an "entryway" to the West, lined with two stones on each side. Just off the road route about 10 metres from Tomb 14 is a pot, from which several shards were recovered. These shards can provide a suggestion that part of the site can be dated to the Bronze Age.

Recommendations for action before or during road construction:
A minor detour of the route should be planned, with a view to reducing the danger to the tombs. It will be virtually impossible to find a suitable point for the road to pass through the mountains without being potential threat to tombs, so that the present course of the road should not be reconsidered, so much as the possibility of shifting it several metres either way, as the necessary places.

After the precise route has been selected, i.e., during construction, temporary fencing should be put up around all of the monuments to prevent their being pillaged during construction. The fencing should be removed after construction.

Depending upon the course of the proposed detour, it may be necessary to excavate one or the other of the monuments. During the quick survey it was established that at least one pot is in situ at the site, several metres from the nearest tomb. This pot could establish the date of an adjacent tomb and may provide information about funerary practices. This site is thus of the highest scientific value. The GOAMM should be consulted as soon as the decision to place the road in that particular area is considered. The GOAMM will arrange for the excavation.

MHT 25 (16° 02' 00" N / 46° 46' 02" E)
Type of site : Potential Stone circle.

Recommendation for action before or during road construction:
It is not necessary to preserve or protect the site. The GOAMM may prepare a drawing of the site before road construction.

MHT 26 (16° 02' 26" N / 46° 48' 00" E)
Type of site : Possible cemetery.

Recommendation for action before or during road construction:
Prior to construction it will be necessary to investigate this site to determine the presence or absence of material, perhaps by excavation. GOAMM will advise.

MHT 28 (16° 04' 36" N / 46° 55' 56" E)
Type of site : Probably a modern Bedouin cemetery.

Recommendation for action before or during road construction:
No measures necessary. During construction, it may be useful to discuss responsibility for the tombs with a notable to make sure that no one is offended. The tombs may have to be shifted to another site, although this is unlikely and poses no danger to the road.

MHT 30 (16° 06' 05" N / 47° 01' 59" E)
Type of site : Possible cemetery.

It would appear that three stones circles were present, one larger one with two smaller circles to the North and West.

A non-diagnostic potshard was found at this site, indicating that the site is in fact an archaeological site, but does not confirm that the circles are real archaeological structures, or indicate that the date is anything more specific than anytime since the end of the Neolithic .

Recommendation for action before or during road construction:
Prior to construction it may be necessary for GOAMM to investigate this site to determine the presence or absence of additional material perhaps by excavation.

MHT 31 (16° 06' 12" N / 47° 02' 58" E)
Type of site : Probably a modern Bedouin cemetery.

Recommendation for action before or during road construction:
No measures necessary

MHT 32 (16° 06' 33" N / 47° 04' 51" E)
Type of site : Probably a modern Bedouin cemetery.

Recommendation for action before or during road construction:
No measures necessary

MHT 33 (16° 06' 56" N / 47° 06' 51" E)
Type of site : Cemetery.

The tombs here are of the ancient tumulus type, one of them with a tail 40 metres long, but at least two of them have been reused in very recent times. As all of

them are prominently perched on the flat top of the hill or its edge, they are characteristic of the ancient monuments.

Recommendation for action before or during road construction:
No measures necessary. This site is not near the proposed road.

MHT 35 (16° 09' 16" N / 47° 10' 14" E)
Type of site : Single Cairn.

Recommendation for action before or during road construction:
The cairn should be protected during construction. During the original engineering survey of the road, the stele in front of the tomb was defaced with spray paint, when it was used as a bench mark point; but it was unavoidable under the circumstances. A fence is probably not feasible for technical reasons (as it may be necessary for the workers to have access to the point etc.). Excavating the cairn by GOAMM might be the easiest solution to the problem.

MHT 37 (16° 08' 10" N / 47° 14' 12" E)
Type of site : Probably a modern Bedouin cemetery.

Recommendation for action before or during road construction:
No measures necessary. Cf. Site MHT 28.

MHT 38 (16° 08' 03" N / 47° 14' 20" E)
Type of site : Kiln : Probably for making bricks and probably dating to the Islamic period.

A cone-lime hole sunk vertically into the local sandstone, with a side entrance. Melted material covers the walls and floor of the cone. There are neither potshards, bricks, nor glass fragments anywhere near the structure, so that an identification from corroborative evidence cannot be established. The shape of the structure is however clear. It would appear to be a kiln virtually identical to - but smaller than - those in use in Sana'a or the Tihama today, although the comparative examples are usually not cut into the rock. Normally, the wood or dung used for firing would be placed in the structure from the side entrance, which would also be used to supply the air. The objects to be fired would be piled up within, from the base and from above, until the structure was completely filled, at which point, the whole would be covered with mud.

The process described excludes the possibility of the structure being a glass-maker;s furnace, but leaves open the actual purpose of the kiln. It is normal to find waters (artefacts of over-fired pottery or melted glass) near production centres where small articles were manufactured, but there are none in the area. As the specimen recovered from the kiln corresponds far more to melted brick than to pottery, it is most probable that bricks were fired in the kiln. As the production of baked brick was a relatively late process, it is possible that the kiln dates to as late as, perhaps, 1500 AD. The presence of the kiln may have been related to a single project, and not an on-going business, as the demand for bricks in a place like Al'Abr cannot have been extraordinarily high.

Recommendation for action before or during road construction:
During construction the exact route of the road should be established and the kiln protected from construction related damage. No further attention is required, although the site is unique.

MHT 39 (reading not obtained; on top of hill at Southeast entrance to Al' Abr)
Type of site : Single cairn : The cairn was destroyed when a small rectangular structure of irregular stones was built. The traces of the cairn are however still visible, and the stones which once formed it are now probably integrated into the wall.

Recommendation for action before or during road construction:
The proposed quarry does not threaten this particular cairn, as the cairn is at the summit of the hill, and the quarry will affect no more than the flanks. Should any activity affect the top of the hill, the cairn should be protected during construction.

MHT 40 (16° 07' 54" N / 47° 14' 20" E)
Type of site : Probably a modern military structure or foundations.

Recommendation for action before or during road construction:
It should be assumed that the structure are modern, but attention should be paid - during construction - to the possibility that they are in fact ancient. The GOAMM will arrange for monitoring.

MHT 42 (16° 07' 26" N / 47° 14' 39" E)
Type of site : Potentially modern Bedouin tomb.

Recommendation for action before or during road construction:
As it is possible that the site is ancient and not modern, the GOAMM will arrange for monitoring.

MHT 45 (16° 07' 10" N / 47° 16' 00" E)
Type of site : Cairn : Typical circular structure with a box within.

Recommendation for action before or during road construction:
This cairn is well preserved, and should be protected during construction, if it is not right on the road bed. As there would be no point in making a detour for this single tomb, it may be necessary for the GOAMM to arrange for the exavation of this tomb prior to construction, if the tomb is directly affected. Otherwise, a temporary fence during construction should suffice.

MHT 46 (MHT-46 lie slightly west of 16° 07' 01" N / 47° 14' 53" E)
Type of site : Cemetery : There are at least six cairns and two stone circles, presumably ritual structures. One of the cairns has a tail, which was partially destroyed.

Recommendation for action before or during road construction:
Temporary fence during construction should suffice to protect these from being plundered, as the structures are not in the area threatened by the road.

MHT 47 (MHT 46-48 lie slightly west of 16° 07' 01" N / 47° 14' 53" E)
Type of site : Cemetery : There are at least two possible tombs, one of which may have had a typical trilith structure. Both have been damaged. The triliths are now firmly dated to the South Arabian period (unpublished sources), making their potentially the only South Arabian monument on the entire proposed route.

Recommendation for action before or during road construction:
Temporary fence during construction should suffice to protect these from being plundered, as the structures are not in the area threatened by the road.

MHT 48 (MHT 46-48 lie slightly west of 16° 07' 01" N / 47° 14' 53" E)
Type of site : Cemetery : There may have been a partially destroyed cairn here.

Recommendation for action before or during road construction:
It is unlikely that monitoring the site during construction would lead to any unexpected discoverie, so that this monument can probably be sacrificed. The GOAMM may advise on this point.

MHT 53 (16° 02' 20" N / 47° 24' 07" E)
Type of site : There are several cairns at this site. On the very top of the hill is one, several more are on the slopes facing the road and another one will be found on the southeastern flank. These relatively recent monuments are found in

association with a well preserved knapping site, used in both the Middle Palaeolithic and Neolithic periods.

Recommendation for action before or during road construction:
Qarn Dhiyab is intended as a quarry site, and it probably can be used as such without disfiguring the ancient monuments, but they will have to be protected during construction, probably by temporary fencing. The GOAMM should be consulted during this part of the operation and their representative alert to the use of the quarry throughout construction.

MHT 63 (15° 47' 50" N / 47° 53' 53" E)
Type of site : Definitely not a site : Although the objects found correspond to a Bronze Age date, they appear to have been lost here.

Artefacts
Lithics : 1 scraping tool
Pottery : 2 deliberately rounded shards

Recommendation for action before or during road construction:
No measures necessary.

MHT 65 (15° 48' 14" N / 47° 57' 31" E)
Type of site : Probably an Islamic settlement site covering several thousand square metres.

Artefacts
Lithics : 1 flake
Pottery : 1 rim shard (cf. Whitcomb 1988, Fig. 9g)
1 decorated body shard

Recommendation for action before or during road construction:
No measures necessary. The topography suggests that there is no depth to the site, and thus the surface collection basically erased all significant traces of the site, so that construction will not damage any ancient vestiges. The GOAMM should monitor progress, and perhaps put in a trench to confirm this hypothesis.

MHT 68 (15° 47' 40" N / 48° 01' 30" E)
Type of site : Most probably not a site. The fragments of one or two vessels were found in the sand, without any other indications that a site was actually present. The finds were made within ca. 1 metre square.

Artefacts

Pottery : 3 rim shards (cf. Whitcomb 1988, Fig. 9 q)
5 decorated shards (cf. Whitcomb 1988, Fig. 13 m)
ca 25 body shards

Recommendation for action before or during road construction:
No measures necessary.

MHT 69 (15° 47' 40" N / 48° 01' 14" E)
Type of site : On what was most probably an ancient surface, over an area of several thousand square metres, were flakes and shards suggesting a Bronze Age settlement.

Recommendation for action before or during road construction:
It may be assumed that no measures are necessary, but the GOAMM will monitor the site during construction, to test the hypothesis, that the settlement had no depth, and thus that no further documentation is possible.

MHT 70 (15° 47' 39" N / 48° 01' 30" E)
Type of site : An obscure concentration of potshards in the sand suggests that there may be a site buried below the sand, as sand frequently permits heavier objects to rise as the individual sand grains slip beneath an object. If it is a site, it is most probably a settlement, potentially Islamic.

Artefacts

Lithics : 2 flakes
1 fragment of retouched blade

Pottery 3 rim shards (cf. Whitcomb 1988, Figs. 18 b; 11 j; 6 h)
1 handle fragment
2 decorated shards (cf. Whitcomb 1988, Figs. 13 m)
15 body shards

Recommendation for action before or during road construction:
The GOAMM should attempt a sondage to determine that the above suggestion is mistaken. It is assumed that there is no site, and that the concentration of potshards had another origin, but a site might be present.

MHT 71 (15° 47' 32" N / 48° 02' 07" E)
Type of site : Modern : Potentially picnic site. The shards date to the earliest of their type imported into Yemen, probably the 1970s.

Recommendation for action before or during road construction:
No measures necessary.

MHT 73 (15° 46' 55" N / 48° 05' 31" E)
Type of site : Probably destroyed Islamic site : Beneath present road, which will be used for future road bed.

Artefacts
Pottery : 1 decorated rim shard
1 ordinary rim shard
17 body shards

Recommendation for action before or during road construction:
If the site has already been destroyed, or if it is virtually destroyed, it is most probable that no measures will be necessary, but the GOAMM should monitor activity there during construction.

MHT 74 (15° 46' 52" N / 48° 06' 28" E)
Type of site : Possibly Islamic site, but most probably not a site.

Recommendation for action before or during road construction:
The GOAMM will monitor activity during construction.

MHT 75 (15° 46' 50" N / 48° 07' 02" E)
Type of site : Bronze Age settlement : Between the dunes an ancient surface was exposed. The finds indicated a settlement, but the topography suggested that an accumulation of superimposed deposits was unlikely.

Artefacts:
Lithics 1 end-scraper
1 bladelet-core
1 retouched flake
10 flakes
1 fragment of flat circular milstone, with central hole
1 fragment of flat quern or whetstone (?)
(cf. de Maigret 1990, Fig. 132 b & 133 a)
1 fragment of triangular grinding stone.

Pottery 4 rim shards (cf. de Maigret 1990 Fig. 39:15; Fig. 68:6)
5 decorated shards (cf. de Maigret 1990, Fig. 79:7)

Recommendation for action before or during road construction:
It is doubtless not worth attempting to avoid the site, as others like it are spread throughout the region, and as the site probably has not depth, it is most probable that no measures will be necessary.

MHT 77 (15° 46' 30" N / 48° 07' 50" E)
Type of site : A (modern) machine-gun position at top. Lines of stones facing west indicate infantry support.

Artefacts:

Lithics	4 non Middle Palaeolithic flakes
Pottery	3 modern body shards 1 unidentifiable shard with white polished exterior surface interior irregular.

Recommendation for action before or during road construction:
No measures necessary.

MHT 78 (15° 46' 19" N / 48° 07' 55" E)
Type of site : Unclear, possibly Bronze Age or South Arabian, more probably Islamic. A mere scatter of shards

Recommendation for action before or during road construction:
No measures necessary.

MHT 80 (15° 43' 59" N / 48° 08' 51" E)
Type of site : At the top of the highest peak below the cliffs was a machine-gun nest with associated well, dug into the rock. The shards found here are most probably modern. Flint knapping probably took place here during the Neolithic, aside from the Middle Palaeolithic debris.

Recommendation for action before or during road construction:
No measures necessary. The cairn will not be threatened by the proposed quarry.

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Table S5.2.3

Summary Table on Archaeological Site & Actions Recommended (marked •)

Road Segment No.	Site Identification No.	Description of the Site	Dating	Required Action						
				None	Avoid Quarrying	Protect by Fencing	Realign if Possible	GOAMM to Excavate for further info.	GOAMM to Monitor construction	GOAMM to prepare Site Map
4	7	Tumuli	?			•				
5	14	Cemetery	Bronze Age ?					•		
6	15	Cemetery	Bronze Age ?		•					
5	16	Cemetery	Bronze Age ?		•					
7	17	Cemetery	Bronze Age ?			•	•	•		
8	25	Stone Circle	?							•
8	26	Cemetery	?					•		
8	28	Cemetery	Modern Bedouin ?	•						
8	30	Cemetery	?					•		
8	31	Cemetery	Modern Bedouin ?	•						
8	32	Cemetery	Modern Bedouin ?	•						
8	33	Cemetery	?	•						
8	35	Cairn	?					•		
9	37	Cemetery	Modern Bedouin ?	•						
10	38	Kiln	Islamic			•				
10	39	Cairn	?			•				
10	40	Undetermined	?						•	
10	42	Tomb	Modern Bedouin ?						•	
11	45	Cairn	?			•		•		
11	46	Cemetery	?			•				
11	47	Cemetery	South Arabic			•				
11	48	Cemetery	?	•						
11	53	Cairns	?		•				•	

Table S5.2.3 (contd)

Road Segment No.	Site Identification No.	Description of the Site	Dating	Required Action						
				None	Avoid Quarrying	Protect by Fencing	Realign if Possible	GOAMM to Excavate for further info.	GOAMM to Monitor construction	GOAMM to prepare Site Map
17	63	Undetermined	Bronze Age ?	•						
17	65	Settlement	Islamic	•					•	
17	68	Undetermined	?	•						
17	69	Settlement	Bronze Age ?	•					•	
17	70	Settlement	Islamic ?					•		
17	71	Undetermined	Modern Bedouin ?	•						
18	73	Undetermined	?	•					•	
19	74	Undetermined	?						•	
19	75	Settlement	Bronze Age ?	•						
20	77	Undetermined	?	•						
20	78	Undetermined	?	•						
20	80	Cairn	?	•						

SECTION 5.3

STUDY ON PREHISTORY

SECTION 5.3
STUDY ON PREHISTORY

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S5.3 Prehistory

S5.3.1 Introduction

The purpose of this report is to present the findings of a prehistoric cultural resources survey undertaken as part of an Environment Assessment (EA) associated with the proposed Safir-Hadramout Road in the Republic of Yemen. The prehistoric cultural resource field investigations were undertaken in September and October 1993 by the Consultant's team in co-ordination with the prehistoric-archaeological experts from the Republic of Yemen General Organisation for Archaeology, Museums and Manuscripts (GOAMM). Efforts were made to establish a close working relationship between the project prehistorian and project archaeologist in order to ensure that omissions and redundancy in reporting was minimised.

S5.3.2 Project Area

The project area for the cultural resources investigations focussed upon an approximately 311 km long corridor and associated borrow-quarry locations which will be impacted by the proposed Safir-Hadramout Road construction. A 100 m wide impact corridor (50 m on each side of the proposed road centreline) was inspected. Accurate project area parameters were ensured by the presence of existing survey markers on the proposed road centreline for its full length. Simultaneously, maps and blueprints were also utilised to ensure that the entire impact corridor was inspected.

S5.3.3 Scope of Prehistoric Investigations

The prehistoric cultural resources investigation presented in this report was designed and implemented to achieve two major goals. The principal goal of the investigation focussed upon the identification and evaluation of all significant prehistoric sites which will be directly impacted by the proposed road construction project. In addition, a secondary goal of the investigation was to utilise the information obtained for fulfilment of the primary goal to provide a database with which to provide expectations of site location, density and type for the landform regions adjacent to the inspected corridor.

Through consultation an agreement was made that, for the purpose of this project, prehistory is broadly defined as the study of cultures for which no written record exists. In Yemen, the prehistoric time frame encompasses sites from the Lower Paleolithic up to the end of the Bronze Age. The archaeological period, for the purpose of this report, is therefore defined as encompassing all post-Bronze Age

Manifestations, beginning with the Sabean period (ca. 3000 before present [B.P.]) for which historical records are available (cf. Muller 1988).

During the field investigation, what became apparent was that one of the frequently encountered site types, stone cairns and tumuli, could be assigned to either the prehistoric or archaeological time frames. This is because these types of sites have been identified in both prehistoric (Neolithic and Bronze Age) and archaeological (Sabean) contexts (Zarins et al 1980). Furthermore, the temporal affiliation of these cairns and similar sites is not readily apparent upon investigation at the pedestrian level, as most temporal - cultural data for these cultural phenomena has been obtained by excavation and not by survey. Faced with a common site type which could not be clearly assigned to either a prehistoric or archaeological context, it has been decided that all cairns and tumuli would be discussed in the archaeological report for this survey. Therefore, the focus of this prehistoric report is upon all sites with temporal affiliations up to the end of the Bronze Age, except for cairns and tumuli, which are discussed in the archaeological specialist report.

S5.3.4 Prehistoric Overview

In this section, a brief overview of the prehistoric period that is applicable to the present project is presented. This overview is preceded by a summary of previous prehistoric investigations in Yemen and adjacent areas, as it is this work which has provided the current knowledge of prehistory in this region.

1) Previous Research

The monuments and large sites of Yemen's South Arabic period have attracted the attention of adventurers, lay archaeologists and professional researchers for over 100 years (cf. Meulen and von Wissman 1932; Stark 1936; Philips 1955; Bowen and Albright 1958; Tindel 1984). Until recently, however, little attention was focussed upon the prehistoric cultures of Yemen which laid the foundation upon which the later civilizations were based.

The first identified prehistoric materials found in Yemen consisted of paleolithic tools recovered by Caton-Thompson in her 1937 field work in the Hadramout valley (Caton-Thompson 1953). Since Caton-Thompson's work, little attention was placed on Yemen's prehistoric past until the 1960s. In 1960, G. Lankester Harding collected some Neolithic artefacts from the Hadramout valley and from the edge of the Rub-Al-Khali northwest of Al' Abr (Harding 1964; Doe 1971 : 227).

The first systematic search for prehistoric and archaeological sites in Yemen was undertaken in 1961 and 1962 by Gus Van Beek and his associates for the Smithsonian Institution (Van Beek et al. 1963). Van Beek's survey resulted in the identification of Lower Paleolithic (Acheulean) material, Middle Paleolithic tools fabricated by Levallois technique, and some Neolithic sites (Van Beek et al. 1963 : 521-543). Outside of the Hadramout area, no sites with clear prehistoric affiliations were identified until 1969, when some Middle Paleolithic materials were identified by Garbini (Garbini 1970; Bulgarelli 1988 : 32).

In the 1970s, research into Yemen's prehistory continued at a relatively slow pace. A notable contribution during this period was made by Bayles des Hermens, who identified obsidian Neolithic materials at the site of Mariya in the Dhamar region (Bayles des Hermens 1976 : 29-30). Also in the late 1970s and early 1980s, more Paleolithic sites in the Hadramout valley were identified and investigated by Soviet prehistorians.

Since the early 1980s, much more attention has been focussed upon Yemen's prehistoric legacy. Italian prehistorians in particular have been very active in conducting much of the recent research in Yemen. The Italian Archaeological Mission in Yemen has conducted several comprehensive site surveys, particularly in northern and northwestern Yemen (De Maigret 1981, 1983; Fedele 1987). This survey work, together with a programme of limited excavation, has aided significantly in defining and understanding Yemen's prehistory, particularly the Neolithic period (Fedele 1988, 1987) and the Yemeni Bronze Age (Di Mario 1987; De Maigret 1984).

As the brief review presented above illustrates, it has been only in recent years that knowledge of Yemen's prehistoric past has begun to emerge. Despite some early work in the Hadramout valley and recent efforts, principally in northern Yemen, the prehistory of the country is still poorly understood. Fortunately, data from Yemen can be supplemented with information from the bordering countries of Saudi Arabia and Oman. There is a considerable corpus of prehistoric data available for the southern and southwestern provinces of Saudi Arabia, principally as a result of a comprehensive survey and site recording programme undertaken by the Saudi Arabian Department of Antiquities throughout the late 1970s and 1980s (Zarins et al. 1980, 1981, 1985). Limited site excavations (Zarins et al. 1985, 1986) and specialised studies (Edens 1982) have also been undertaken in this region.

An understanding of western Oman's past, by contrast, is only just beginning to emerge as a result of recent survey and excavation work. An outline for the South Arabic and Islamic periods in the Dhofar province of western Oman has been available for several decades (Phillips 1955), but prehistoric research in this area is still in its infancy. Except for the reporting of small surface finds and study of collections (Smith 1977; Pullar and Jackli 1978), systematic reporting of prehistoric sites in western Oman began only 3 years ago. Nevertheless, recent research in this area has documented large numbers of artefactually rich Neolithic and Bronze age occupations (personal observation; see also Zarins 1993).

The information provided by the previous prehistorical research in Yemen and bordering states summarised above has been utilised to assemble an overview of the prehistoric cultures which can reasonably be expected within the present project area.

2) Lower Paleolithic-Oldowan (ca. 2.5 M.Y. BP - 500,000 BP)

The Lower Paleolithic period includes the oldest known evidence of fossil human stone artefacts. The Lower Paleolithic is divided into two distinct phases, Oldowan and Acheulean. Oldowan, the oldest of the two phases, is typically associated with such fossil human ancestors as Australopithecus Robustus and Gracile forms, and Homo Habilis. Artefacts commonly found on Oldowan sites are large, crude lithic tools and debitage. Cobble tools such as simple choppers and scrapers are common, with more extensively worked tools such as spheroids, polyhedrons and picks being somewhat rare (Leakey 1934; Gilead 1975). In the later stages of the Oldowan tradition (i.e., Developed Oldowan), massive handaxes with unworked butts appear. In the Near East, relatively few Oldowan sites have been identified; most of the known sites are in the Levant, although several deflated Developed Oldowan occupations have been reported from Saudi Arabia (Zarins et al. 1980, 1983). No Oldowan sites have yet been reported from Yemen or Oman.

3) Lower Paleolithic - Acheulean (ca. 500,000 BP - 70,000 BP)

The Acheulean is somewhat better understood than the preceeding Oldowan tradition, due to the fact that more Acheulean sites have been identified and excavated. Typically associated with the Acheulean are fossil human forms such as Homo Erectus. The Acheulean is characterised by the presence of handaxes of which several varieties and forms have been identified.

Most Acheulean sites that have been identified in the Near East are open air occupations, although sites in natural shelters are also known (Gilead 1975). Acheulean sites have been identified in the Levant (Hours 1975), and sites of this type are also fairly common in Saudi Arabia (Parr et al. 1978; Zarins et al. 1980, 1981). At least one Acheulean site is known from Northern Yemen (Bulgarelli 1988) and sites of this age are also known from the Hadramout valley (Van Beek et al 1963).

The Acheulean has been divided into three temporal units (Lower, Middle, Upper) in the Arabian peninsula and the Levant. The Lower Acheulean is characterized by massive handaxes with unworked or partially finished butts, large numbers of chopping tools, and the presence of trihedrals and polyhedrons. In the Middle Acheulean, handaxes become a very frequent tool type, whereas trihedral and polyhedron forms disappear.

The late Acheulean is characterised by well-made completely flaked bifacial handaxes with sinuous edges and the appearance of Levallois flakes (cf. Whalen et al. 1983; Copeland and Hours 1978).

4) Middle Paleolithic - Levallois - Mousterian (ca 70,000 BP - 30,000 BP)

The Middle Paleolithic period in the Near East is characterised by the widespread utilisation of the Levallois technique in lithic reduction. In a Levallois technique, the form of a flake or tool blank is determined by the preparation of the upper surface of a core. Flakes and blank forms are then removed from the core by direct percussion (Bordes 1968). Middle Paleolithic tool assemblages are diverse and include Levallois points, burins, scrappers, well made bifacial handaxes, denticulates, and notches. Debitage for this stone working industry is very distinctive, and includes Levallois flakes and prepared flake or "tortoise" cores (cf. Jelinek 1981; Singer and Wymer 1982). Although Levallois - Mousterian lithic industries are classically associated with Homo Sapiens Neanderthalensis, a fossil human form, new data indicates that modern humans (Homo Sapiens Sapiens) may also have utilised Levallois technology in the Near East (see Trinkaus 1986).

Middle Paleolithic sites are fairly common in the Levant and in the western and central portions of the Arabian peninsula. However, these sites are unknown in the eastern portion of the peninsula. For example, many large Middle Paleolithic sites have been found in the Riyadh area of Saudi Arabia, and at numerous locations west of the city; sites east of Riyadh are very rare, however (Zarins et al. 1980, 1981). Similarly, numerous Middle Paleolithic sites have been reported

in Yemen's Hadramout valley by Russian Researchers, but no Middle Paleolithic sites are known from Oman (Zarins 1993; personal observation). While the apparent abundance of Middle Paleolithic occurrences in the western portion of the peninsula and the corresponding absence of these sites in the eastern part of the peninsula has yet to be adequately explained, several hypotheses have been suggested. Several researchers, noting that during Middle Paleolithic times climatic conditions were very moist and large wadis contained permanent flows of large volumes of water, have suggested that very large active rivers in the Rub Al Khali region may have effectively blocked human movement. While this hypothesis has merit, more research, particularly geologic/geomorphic, is necessary to resolve this issue (cf. Zarins 1993).

Although the distribution of sites with Middle Paleolithic associations in the Arabian peninsula is puzzling, Middle Paleolithic sites, when they do occur, have been well reported.

In western and central Saudi Arabia, huge scatters of Middle Paleolithic artefacts, sometimes encompassing several square kilometres, are known (Zarins et al 1980). Sites appear to be situated at two principal locations; along major wadi channels and at raw material (flint and basalt) outcrops. The large size of many of the reported sites is probably due to a number of factors, including higher population than preceeding periods, deflation and movement of artefacts over a larger area than where originally deposited, and reoccupation of the same areas by human groups for hundreds, perhaps thousands, of years (Zarins et al 1981, 1982; Parr et al. 1978).

5) Upper Paleolithic (ca. 30,000 BP - 11,000 BP ?)

The Upper Paleolithic period in the Near East is dominated by lithic assemblages based upon the production of blades and blade tools. This stone working technology was a radical departure from the flake/prepared core technologies of Middle Paleolithic times. The Upper Paleolithic also saw the emergence and expansion of modern humans (Homo Sapiens Sapiens). Unfortunately, Near Eastern Upper Paleolithic sites are relatively rare and appear to be confined to the Levant (Henry 1982). In fact, "no Upper Paleolithic industries have so far been identified in the greater Arabian peninsula" (Zarins and Badr 1987 : 10). The reasons for the absence of Upper Paleolithic occupational evidence are still unknown. However, low population density and dry, inhospitable conditions in the peninsula during this time period may be contributing factors. Another possibility, also speculative, is that modern humans in the Arabian peninsula

continued to utilise a Levallois-based "Middle Paleolithic" type of lithic reduction strategy during the Upper Paleolithic (Trinkaus 1986).

6) Epipaleolithic (ca. 12,000 BP - 9000 BP ?)

The Near Eastern Epipaleolithic period is roughly equivalent to the Mesolithic of Europe. This time period is characterised by bladelet and blade lithic industries, and the widespread use of small, microlithic tool forms. Several key developments took place in the Epipaleolithic, including population growth, the introduction of new technologies (i.e., bow and arrow : Henry and Garrard 1988), and the development of large, sedentary or semi-sedentary communities (i.e., the Natufian : Sellars 1989). Unfortunately, for reasons that may be similar to those listed for the Upper Paleolithic, Epipaleolithic sites have yet to be identified in the Arabian peninsula. The known site distribution is centered in the Levant, with only one known site in the Arabian peninsula - a Kebaran site on Saudi Arabia's border with Jordan (Zarins, personal communcation; Henry 1989).

7) Neolithic (ca. 8000 BP - 5000 BP)

Together with Middle Paleolithic sites, Neolithic occupations compose the most frequent type of prehistoric site encountered in southern Arabia. The Neolithic period is typically interpreted as a time that saw the transition from a mobile, hunter-gatherer based economy, to a more sedentary lifestyle with greater population aggregates. The first domesticated crops and animals are found during Neolithic times, indicating the means by which larger, more sedentary populations were made possible. Although domestication began in the Neolithic, not all human groups were involved in food production and animal husbandry. In the southern Arabian peninsula in particular, the available evidence indicates that a hunter-gatherer/foraging economy was practiced throughout most of the Neolithic period (Tosi 1986:471-475). In the Arabian peninsula, most investigations into Neolithic adaptations have been undertaken in south-central Saudi Arabia, in the southwestern and central portions of the Rub Al Khali desert. Work in the Rub Al Khali has involved not only site survey, but also extensive geomorphological and paleoenvironmental studies. Studies of the paleoenvironment and paleoclimate have indicated that a region wide climatic phenomenon known as the "Neolithic Wet phase" or the "Middle Holocene pluvial phase" (cf. Butzer 1976; Larsen 1980) had a great effect on environmental conditions in southern Arabia during this time period. The Neolithic wet phase was a prominent interval of moist conditions that lasted several thousand years during the Middle Holocene. In the region including the Rub Al Khali, these moisture conditions were expressed by the presence of many lakes, both large

and small, and a savannah-like grassland (McClure 1976). Studies of lake deposits in the region indicate that large populations of animals, especially those favouring steppe and open parkland environs, were present in the vicinity of the Rub Al Khali in Neolithic times. Included among the identified animal remains are Oryx, gazelle, bovids, equids and ostriches (Tosi 1986 : 472).

Given the large, diverse resource base available in the Rub Al Khali region during Neolithic times, it is not surprising that large human populations exploited this area. Human groups in the area seem to have practiced a hunter-gatherer/ foraging lifestyle, as evidenced by the type and distribution of investigated sites, as well as by the artefacts recovered from these occupations (Zarins et al. 1982).

Most Neolithic sites in the Rub Al Khali region have been found in association with fossil lake bed deposits. Sites are usually small and emphemeral, indicating a highly mobile population; though rare, larger occupations have also been noted, however (Zarins et al. 1980, 1981). Artefact inventories from these Neolithic sites are usually restricted to a few hearths and lithic implements and debitage. Edens (1982) has undertaken an in-depth analysis of the lithic industry; his data indicates that production of bifacially worked projectile points and blade-bladelet tools was the major focus of lithic reduction activities. Tool forms perhaps associated with the processing of game are also commonly encountered, including scrapers, awls, perforators, notches, and backed blades (Edens 1982 : 109-120). Raw material types for these tools are varied, including flint, basalt and quartzite. A reoccurring material types on many of the sites is obsidian. Obsidian from several Saudi Rub Al Khali Neolithic sites has recently been inspected by trace element analysis. Interestingly, the results of this analysis indicate a source in highland Yemen (Zarins 1987 : 526-527). Although most of the available data for the Neolithic period in the southern Arabian peninsula comes from Saudi Arabia, Neolithic occupations are also known from western Oman and Yemen.

In western Oman, Neolithic occupations appear to cluster around fossil lake beds, and also on fossil terraces of wadi valleys. As with the Saudi sites, bifacially worked projectile points and scrapers are very common, but tools made of obsidian are extremely rare (personal observation, 1993). In Yemen, Neolithic sites in the Wadi Danah region of the northern Yemen have been investigated by Italian Researchers (Fedele 1988). Based upon the results of survey and limited excavation, two "aspects" of Neolithic lithic industries have been suggested, the Quatran and the Tayylah. The Quatran aspect includes bifacial projectile points, stemmed points, scrapers and other tools that fall comfortably within the parameters defined for the Rub Al Khali Neolithic (Fedele 1987; Edens 1982). The Tayylah aspect has been characterised as lacking large projectile points,

but having a large and varied small tool assemblage, including scrapers, borers, and various cutting tools (Fedele 1987). The suggestion has been made that the Tayylah aspect tool kit may have served principally for processing of plant and animal remains; Fedele (1988 : 37) suggests viewing the Tayylah as part of an "Upland Neolithic Tradition."

8) Bronze Age (ca. 5000 BP - 3500 BP)

The Bronze Age in the Near East saw a rapid increase in the development and adoption of domesticated crops and animals. This period was also a "cultural climax" in the development of early pastoralism (Zarins 1986:49). The population appears to have increased and centralised, as evidenced by the discovery of large habitation sites and ceremonial centres (Tosi 1986:478).

Until recently, however, the nature and extent of Bronze Age adaptations in Yemen was unknown. No sites with clear Bronze Age affiliations were reported and none had been subjected to excavation. The Bronze Age in Yemen has recently been defined, however, as a result of survey and excavation work by the Italian Mission to Yemen (De Maigret 1981, 1984). Survey work in north Yemen has produced evidence of over 25 Bronze Age occupations, principally in the vicinity of Jabel Urqub. Both large and small sites have been identified, as have occupations with separate rooms and even fairly large public buildings (De Maigret 1984). In addition to structures, hearths and other features, the Bronze Age in Yemen includes both ceramic and lithic industries. Ceramics tend to be large, poorly fired vessels with large size temper grains, while the lithic industry includes both expedient flake tools as well as formal tools such as end scrapers, side scrapers, notches and perforators (Di Mario 1987; De Maigret 1984). Other artefact types known from the Italian investigations are large and small grinding stones, worked beads, and small polished axes or celts (De Maigret 1988). Perhaps most significant, however, was the identification of domesticated plants from seed casts on ceramic vessels and the presence of faunal remains that appear to represent domesticated animals. Seed impressions of domesticated wheat, sorghum and barley were identified, as were faunal remains of ovicaprids, bovids and pigs (De Maigret 1984, 1988).

S5.3.5 Study Methodology

1) Pre-Field Stage

The pre-field stage of the project consisted of a comprehensive literature review of published and unpublished documents relevant to the prehistory of the project area. In addition, topographic, geological and hydrogeological maps of the

project environs were also inspected. Aerial photographs of the proposed construction corridor were inspected at the Ministry of Petroleum in Sana'a. Also in Sana'a, archival materials including artefacts and manuscripts were inspected at the GOAMM museum and library.

2) Field Stage

Field work consisted principally of a comprehensive pedestrian level inspection of the proposed road construction corridor and the proposed quarry-borrow locations.

Prehistoric sites, when they were encountered, were accurately plotted on topographic maps through the utilisation of a Magellan Model 5000 Global Positioning System (GPS) unit. The Magellan GPS unit utilised was calibrated to an accuracy of ± 15 metres allowing for very accurate plotting of site locations.

At prehistoric site locations, observations regarding such issues as site size, artefact density and types of cultural materials present, relationship of site area to proposed impact corridor, geologic/geomorphic setting, and degree of site integrity were recorded. Information was collected in a standardised manner in order to ensure that all pertinent data was collected at each site location. Photographs were also taken of site locations. At many of the site locations, a limited sample of cultural materials exposed on the surface of the site was collected. Prehistoric artefacts were collected in a controlled, systematic fashion in order to ensure that a representative sample of the range of diagnostic and other cultural materials from the site area was obtained. Individual artefact collections from the identified sites were bagged separately with appropriate provenience data for cataloguing and analysis.

3) Post-Field Stage

Upon successful completion of the field investigations, all recovered prehistoric materials were cleaned and labelled with provenience data. As no standardised site numbering system has yet been introduced in Yemen, a system for assigning numbers to the sites encountered during the survey was devised by the project prehistorian and the project archaeologist. All site numbers were proceded by the acronym "MHT" which is a condensed form of Marib-Hadramout, the approximate beginning and end points of the survey. Site numbers were assigned on an individual basis, beginning at the western terminus of the project corridor at Safir and ending at the eastern end of the corridor at Al Makhaneg.

4) Artefact Analysis

Almost all the recovered prehistoric materials consisted of lithic artefacts. As such, the focus of the laboratory work was a lithic analysis of the recovered artefacts. In order to correlate attributes of a lithic assemblage with human behaviour, the various factors associated with the reduction of raw materials to their final forms must be considered (Henry 1977; Sellars 1989). These technological, stylistic, and functional factors (Sellars 1989, 1992; Henry 1977:231-232) were all considered for the present analysis. The technological analysis was designed with the goal of providing information with regard to the reduction strategy utilised to produce blanks or "potential tools" (Bradley 1979). Efforts were also made to identify and isolate stylistic (non-functional) attributes of the recovered assemblages, following the guidelines suggested by Close (1978). The functional analysis consisted of comparisons between tool classes from the individual sites with each other, and with previously reported prehistoric sites in Yemen and the southern portion of the Arabian peninsula. The study did not attempt to assign functional usage to the tool classes that were identified; however, comparisons between tool classes from various sites should allow identification of different activities, as function is the major controlling factor of a tool's final form (Sellars 1989:27-28).

All of the recovered lithic materials were subjected to analysis. Artefacts were sorted from collection bags into gross preliminary categories of tools, debitage (material with the potential to be modified into tool forms), and debris (lithic material without tool potential; waste). Also at this stage of the analysis, the type of reduction strategy was identified (i.e., blade-bladelet, flake-biface, prepared core tools, etc.). Various metric, qualitative and quantitative attributes of the debitage classes were observed and recorded in order to aid in the identification of the reduction strategy at a given site. When appropriate, metric attributes were measured in millimetres with the aid of Mitotoyo digital calipers. Tools, debitage and debris were classified through the utilisation of morphological typologies appropriate to their reduction technique. The typologies adopted for this study were selected principally upon the basis of their widespread use by the body of researchers studying prehistoric lithic assemblages in the Arabian peninsula and the southern Levant. Core tools and related debitage, typically representative of Lower Paleolithic assemblages, were classified following the typologies developed by Gilead (1975), Leakey (1934), and Whalen et al. (1983). Prepared core tools and debitage, typical of the Middle Paleolithic, were typed following Jelinek (1981), Singer and Wymer (1982), and Copeland (1981). Blade and bladelet industries were classified following the procedures defined by Sellars (1989, 1992), Tixier (1963, 1974) and Henry (1982, 1989). Bifacial tool, flake

production oriented lithic industries were identified and described following Edens (1982).

Upon completion of the lithic analyses, the results were summarised and considered on a site by site basis. Tool, debitage and debris classification summaries are included in the site inventory presented in the "Results" section. This section also contains cultural-temporal site affiliation data and site function information, which was obtained in large part from the lithic analysis of recovered materials.

Small quantities of ceramic materials were also recovered from some of the investigated prehistoric sites. For the identified ceramics, attributes including temper type and size, paste consistency, colour and surface treatment, and metric attributes were recorded. Such observations followed the procedures and definitions provided by Shepard (1957).

Upon completion of the artefact analyses, selected diagnostic materials were photographed and/or drawn. Following this procedure, the cultural materials were returned to provenience bags labelled with longitude-latitude data and site numbers. All recovered artefacts were delivered to the **General Organisation for Archaeology, Museums and Manuscripts, Republic of Yemen** for permanent curation with a prior approval of the GCRB.

S5.3.6 Results

This section of the report presents individual site data for the 50 prehistoric cultural resources identified during the Safir-Hadramout Road survey. A key to the various categories of information presented herein is listed below:

1) Project Segment

This category lists which of the 22 environmental unit segments [see Fig. S5.1(a)] in which the site is situated. Project segments are consistent with the environmental units described and utilised throughout the EA document.

2) Site Number

All site numbers are preceded by the acronym MHT, which is a shortened form of Marib-Hadramout. The MHT designation is followed by the individual site number. Prehistorical and archaeological sites were numbered consecutively

beginning at the western end of the project corridor and ending at the eastern end of the corridor.

3) Site Location

This entry lists the site legal location in lontitude and latitude units of degrees, minutes and seconds. In the case of sites with large areal extent, the locational data refers to the center of the site area. Site location was determined through the utilisation of a Magellan Model 5000 Global Positioning System unit, ensuring an accuracy of 10-20 metres in the given readings [see Figure S5.1(b)].

4) Temporal-Cultural Affiliation

Temporal and cultural information was determined by the analysis and identification of recovered diagnostic artefacts. Field notes, field observation of uncollected artefacts, and geomorphic data was also considered in determination of site affiliation. In some cases, insufficient information was available to make temporal-cultural assignments.

5) Site Type

A tentative assignment of site function is listed in this category. Site size, artefact density, type and distribution of recovered and observed cultural materials, and temporal-cultural data were all considered in assigning site type. Functional assignments are loosely based upon a format that has been successfully utilised in previous research to categorise prehistoric sites based upon a hunting-gathering and/or horticultural economy (cf. Sellars 1992).

6) Site Size

Site size is based principally upon the observed extent and distribution of cultural materials on the surface at the site location. Size was determined by a variety of methods, depending upon the relative extent of observed materials. Measuring methods included utilisation of a 50 metre tape and hand compass, use of a GPS unit, estimation from pedestrian pacing, and the use of professional surveying equipment.

7) Impact

The probable impact of the planned road construction activities, if implemented as currently planned, is listed in this category.

8) Materials Recovered

This category presents a listing and brief descriptions of the cultural materials that were collected during the field investigation and returned to the laboratory for analysis. The techniques utilised to analyse the recovered artefacts were described in the "Methodology" section of this report.

9) Comments

Additional site data and interpretations, as revealed by field observations and artefact analyses, are presented at the end of this section.

S5.3.7 Prehistoric Sites

As the "Results" section of the report has detailed, a total of 50 prehistoric sites were identified as a result of the Safir-Hadramout survey. Of the investigated sites, 21 (40.4%) did not yield sufficient diagnostic cultural materials to be temporally or culturally classified. Of the 29 sites that did offer temporal-cultural information, sites with Middle Paleolithic affiliations (32.6%, N=17) and those with Neolithic associations (21.2%, N=11) were most commonly encountered. Rarely encountered were Lower Paelolithic (Acheulean) sites (3.8%; N=2) and a single Bronze Age site (2.0%; Note that the site count is 52 due to the presence of 2 multiple component occupations). No Lower Paleolithic - Oldowan, Upper Paleolithic, or Epipaleolithic occupations were identified.

A summary for the respective temporal-cultural periods encountered during the survey is presented below. Summary information is based upon the findings of this survey; for futher background information, refer to the"Prehistoric Overview" (para S5.3.4) of the this section. For site specific information, refer to the "Results" (para S5.3.6) of this section.

1) Lower Paleolithic

Only two Lower Paleolithic sites were identified during the present survey. Site MHT-21 consists of a single trihedral pick found in a secondary context (a wadi bed), while site MHT-58 is a multiple component Lower Paleolithic - Middle Paleolithic tool and debitage scatter located on eroded talus and scree deposits in the Hadramout valley. Recovered from MHT-58 was a sample of highly patinated basalt tools and debitage with clear Acheulean associations. Tool forms including a cordiform handaxe, massive coppers, a large scraper, and a

trihedral pick were identified, as was a debitage collection dominated by massive flakes and occasional massive blades. Tools and debitage from both sites appear to have been fabricated exclusively through the utilisation of a hard hammer, direct percussion technique. The presence of a trihedral pick together with a handaxe with bifacial edge treatment at MHT-58 indicates a Middle Acheulean association for this site. The Middle Acheulean association is based upon evidence which suggests that Acheulean trihedral picks are extremely rare after Middle Acheulean times (Hours 1975), while bifacially worked handaxes with finished butts are rare before this time (Whalen et al. 1983).

2) Middle Paleolithic

Middle Paleolithic sites, as identified by distinctive tool forms and the presence of diagnostic Levallois prepared cores and debitage, were the most frequently identified type of site in the project area. The 17 identified Middle Paleolithic sites were found to be concentrated in two major landform areas of the corridor. Nine of the sites were found in segment 8 of the corridor, where the sites were clustered adjacent to, and in association with, the numerous wadi channels in this area. In this segment, numerous large wadis, oriented in an approximately north-south direction, cross the proposed impact corridor. Among the larger of these wadis are the Wadi Sakil Al Khal, Wadi Tineiphar, Wadi Dammam, Wadi Al Yemani, Wadi Karn As Samar, Wadi Al Hayda and Wadi Al Malsaq. Based upon the clustering of Middle Paleolithic materials around these wadis, it is likely that these drainages had an active flow during Middle Paleolithic times; the absence of later (i.e., Neolithic) sites in this area suggests that the wadis were not attractive to human groups after Middle Paleolithic times.

Most of the sites identified with the wadis in Segment 8 were very large. For example, site MHT-18, a lithic scatter adjacent to a tributary of the Wadi Sakil Al Khal, was found to cover over 750,000 square metre. Similarly, site MHT-24, located on a fossil terrace of the Wadi Al Yemani, encompassed over one million square metres (for similar size estimates for Middle Paleolithic sites in Saudi Arabia, see Zarins et al. 1980, 1981; Parr et al. 1978). Furthermore, the size estimates for these very large lithic scatters should be considered minimal figures. This is because the northern and southern boundaries of these sites were not established. For example, at site MHT-24 the prehistoric survey crew noted a continuous scatter of cultural materials for over 1.7 km in a north-south direction parallel to the wadi channel. Time constraints prohibited further investigation of the north-south parameters of the site.

Another illustration of the density of Middle Paleolithic remains in the wadi region of segment 8 is that site numbers were assigned only to locations that appeared to contain a high density of artefacts that bore minimal evidence of rolling and transportation (i.e., as revealed by rounded flake edges, location in wadi channels, etc.). In fact, a sparse, thin scatter of Middle Paleolithic debitage was recorded within the project corridor for almost 40 km. Beginning at the site MHT-18 location until the vicinity of site MHT-28 on the east bank of the Wadi Karn As Samar, occasional Middle Paleolithic debitage and debris was noted within the proposed impact corridor on an average of one artefact every 5 to 15 m. Although much of this thin scatter of material appeared rolled and weathered, suggesting that it had been transported (probably by water), the great extent of the scatter, together with the large average size of the recorded sites in this region all indicate a substantial use of this area and its wadis during Middle Paleolithic times.

Most of the other Middle Paleolithic occurrences identified during the survey were found on eroded jabel slopes, talus slopes, and scree deposits along the Hadramout valley escarpment. These locations, which were selected for use as quarry-borrow locations for the proposed road, often contained large quantities of unworked raw materials, including flint and basalt. The distribution of Middle Paleolithic sites observed in the Hadramout valley is apparently due to landform age, and is probably not a true reflection of the original use patterns of this area by Middle Paleolithic groups. This hypothesis is based upon the fact that much of the Hadramout valley floor is dynamic (i.e., subjected to both active erosion and deposition of silts). It is therefore suggested that Middle Paleolithic sites that may have been present on the valley floor have either been washed away by erosion or deeply buried by silts over the past 30,000 to 70,000 years.

Artefactually, the assemblages from the segment 8 wadi sites and those from the Hadramout valley are quite similar. A key difference seems to be in the selection of raw material types; in the wadi area, most tools and debitage were composed of medium to coarse grained quartzites, while in the Hadramout, most artefacts consisted of highly patinated, fine grained flint materials. In both areas, habitual use of a Levallois technique was indicated by the presence of prepared Levallois flake cores ("tortoise" cores), and by the occurrence of typical and a typical Levallois flakes in the recovered debitage. Both hard hammer and soft hammer flaking was employed in the reduction strategies in both areas, and the range of tools for both regions is similar. Among the common tool forms noted were choppers, scrapers (endscrapers, sidescrapers, unifacial scrapers), retouched flakes, bifacially worked fragments, and notches. An unexpected finding was that Levallois points, usually common in Middle Paleolithic assemblages, were rare

in the observed materials in both the wadi region and the Hadramout. Other rarely encountered tool forms included bifacially worked handaxes, denticulates, and retouched blades.

3) Neolithic

Neolithic sites were the second most frequently encountered site types found during the present survey. Utilising criteria developed by Edens (1982) and Zarins (1993) it was possible to divide some of the encountered Neolithic sites into Early and Late phases. Of the 11 identified sites, 2 were classified as Early, 2 as Late and 1 as containing both Early and Late materials. It was not possible to seriate further the remaining 6 Neolithic occupations. As was the case with the Middle Paelolithic sites, there is a definite pattern that can be observed in the distribution of Neolithic sites. Eight of the 11 encountered sites were found within landform segment 4, principally on old calcified gravel-sand areas between active, rolling sand dunes of relatively recent age. Although detailed Holocene geomorphic data is lacking for this area, the setting of the segment 4 Neolithic sites seems remarkably similar to the Rub Al Khali sites that were identified on calcified fossil lake deposits (see Zarins et al. 1980, 1981; Mc Clure 1976). Furthermore, at several of the identified segment 4 sites, small gastropod shells were noted - the possibility exists that these as yet unidentified shells may be of freshwater lacustrine origin.

Definitive answers to the geomorphic setting of the segment 4 sites can only be addressed by future research. However, what is clear is that the Neolithic sites identified in this area are closely related to those reported for the Rub Al Khali Neolithic. Seven of the 8 sites in segment 4 are small and contain limited quantities of cultural materials. No structures or obvious cultural features were identified at any of these sites. Six of the sites may be classified as temporary camps (MHT-2, 3, 4, 6, 8, 10), while another site (MHT-1) represents a resource procurement location. Artefactually, these segment 4 sites contain materials of striking similarity to those of the Rub Al Khali occupations (cf. Edens 1982). Many of the recovered lithic materials were fabricated of smoky black obsidian and most of the sites yielded ostrich shell fragments. Unifacially and bifacially worked ovate and stemmed projectile points were commonly recorded, as were retouched bladelets and endscrapers. Also present in the site inventories, though in small quantities, were burins, notches and retouched flakes. Obsidian appears to have been utilised primarily for the production of unifacial projectile points and bladelet tools, although a limited number of obsidian flakes and flake tools were observed at site MHT-10.

In contrast to the small, emphemeral sites identified throughout most of segment 4 is site MHT-13, a large Neolithic site located at the break between segments 4 and 5. Site MHT-13 is located on a low gravel hill that rises above the surrounding flat gravel plain. The site contains high densities of lithic tools, debitage and debris that encompass an area of approximately 60,000 square metre. Within the site area, numerous features, including circular hearths and roasting pits, circular (3.5 - 5 m. dia.) house or structure outlines, and concentrated areas of lithic debitage, which may represent flint working locations, were identified. The site appears to represent, on the basis of its size, features and distinctive artefact inventory, a base camp that was occupied in both the Early and Late Neolithic periods.

The observed artefact inventory at MHT-13 consists principally of chipped stone tools and related debitage and debris. A wide variety (over 9 types) of flint types were identified; this flint material was utilised to produce most of the identified tool forms. Obsidian and quartzite were also present, but in very small quantities. The tool assemblage at the site is dominated by simple, expediently produced retouched and utilised flakes. Also well represented are very finely crafted, bifacially worked projectile points of several styles. Points with an ovate morphology and lenticular cross section were commonly encountered, as were well made bifaces with parallel blade edges and convex distal and proximal treatment. Small triangular points form another projectile point class, although these tools were rare. Distinctive unifacially worked ovate points, common in the Early Neolithic were recovered, as were many different styles of scraping tools (i.e., end, side, core and strangulated scrapers). Also found in large quantities were broken bifacially worked fragments, and tool forms such as notches and perforators.

Technologically, the lithic debitage and debris recovered from MHT-13 suggests a reduction strategy aimed at the production of flakes and blades from globular and pyramidal flake and flake-blade cores. Debitage representative of the entire lithic reduction sequence was identified at the site, indicating that both initial trimming and shaping of lithic materials, as well as the finishing and refinement of tool forms, took place at the site. Hard hammer and soft hammer flaking was utilised to trim and shape raw materials, while pressure flaking retouch was most commonly utilised in the final stages of tool manufacture.

The artefacts collected at MHT-13 are notable in terms of their quantity and diversity. Tool forms that appear to be diagnostic of both the Early and Late Neolithic are present, as are forms that have been reported for both the Rub Al Khali Neolithic (Edens 1982) and the Yemeni Tayylah aspect (Fedele 1987).

Clearly a unique and important site, MHT-13 is the subject of further discussion in the "Significance" section of this report.

The remaining three Neolithic sites identified by the survey are located in the Hadramout valley. Site MHT-54, located in project Segment 12, is a resource procurement station from which a stemmed, bifacially worked projectile point was recovered. Site MHT-72, located in segment 17, is a small scatter of Neolithic style tools which are all fabricated of poor quality, coarse grained chalky flint. Recovered from MHT-72 was bifacially worked ovate projectile, retouched flakes and a variety of scraper forms (end, side, and tabular scrapers).

Site MHT-62, also located in segment 17, is a very large, multiple component, Neolithic and Middle Paleolithic site. This site is located on talus and scree deposits adjacent to the Hadramout valley escarpment. At MHT-62, moderate to high densities of cultural materials were found to be spread over a very large area of approximately one square kilometre in extent. Although Middle Paleolithic and Neolithic materials were mixed together within the site area, discrimination between the two artefact types was not difficult due to differences in patination between the respective lithic materials. Present at MHT-62, Neolithic component, were numerous cultural features, including rock filled oval roasting pits, hearths, and circular house foundations. The artefact inventory from this site is dominated by chipped stone tools. Included in the inventory of lithic tools are ovate bifaces, large numbers of scrapers (end, side, and circular), backed knives, and retouched flakes. Technologically, a lithic reduction strategy aimed at the production of flakes and blades from pyramidal and globular flake and flake-blade cores was undertaken. Large quantities of debitage, representative of the entire lithic reduction sequence, were observed at MHT-62. Interestingly, almost all tools and debitage were fabricated from the same raw material type - fine grained, brown coloured chalcedony. No obsidian was observed. MHT-62 is a large, artefactually rich site with clear Neolithic affiliations. It is interesting to note that this site does not appear closely related to the Rub Al Khali Neolithic, as defined by Edens (1982). Many similarities, including the lack of formal projectile point styles, do however exist with Fedele's (1987) Tayylah Neolithic Aspect that was defined in the northern Yemen highlands. Further research at sites like MHT-62 is required in order to define and explain Neolithic adaptations in the Hadramout valley. Site MHT-62 has great potential as a source of data for future research. More information regarding this site is presented in the "Significance" section of this report.

(4) Bronze Age

One Bronze Age site, MHT-12, was identified during the field research. This site, located within segment 4, lies outside the proposed impact areas; it was identified by field personnel while transiting between project areas. Site MHT-12 is fairly large, encompassing an oval shaped area of approximately 9600 square metre in size. Although no structures were identified within the site area, several hearths and a thick grey ash deposit were clearly visible. Artefact density at MHT-12 was high; ceramic, ground stone, chipped stone and fire cracked rock were noted throughout the site environs.

The chipped stone tool industry at the site is dominated by tool classes that are typical of the Yemeni Bronze Age (cf. Di Mario 1987), including retouched blades, backed knives, unifacially worked knives and retouched flakes. Also present, but in small quantities were endscrapers, notches and choppers. Technologically, the MHT-12 chipped stone industry appears to have been oriented towards the production of flakes and blades from globular and irregularly shaped single platform cores. Debitage representative of the entire lithic reduction sequence was observed at the site, indicating that all stages of tool manufacture took place within the site parameters. The recovery of several battered quartzite hammer stones from within the site area supports this interpretation.

A ground stone industry was also present at MHT-12. Several facetted hand stones or manos were identified at the site; these tools were fabricated on coarse grained porous pumice. A very finely crafted miniature celt or axe was also collected from the site. This small, polished piece was constructed from black basalt. The celt is identical in morphology and manufacture to small basalt celts recovered from Bronze Age sites in the Yemen highlands by Italian Researchers (De Maigret 1984; Di Mario 1987).

In addition to the stone tool industry, a considerable ceramic corpus was identified at MHT-12. All of the observed ceramic pieces were of thick red ware. The pottery was hand made, as evidenced by irregular wall thicknesses and finger impressions on some surfaces. Poor firing is evidenced by the presence of thick, organically rich cores on most inspected pieces. Grit and sand tempering materials were most frequently utilized, although chaff temper was also noted on several body sherds. All of the recovered ceramics were undecorated; wiped exterior surfaces with high temper protrusion were very common. Based on a preliminary inspection of the recovered pottery fragments, it is clear that both bowl and jar forms were utilised by the Bronze Age inhabitants of MHT-12.

The final category of cultural materials identified at the site was faunal remains. Several small , highly weathered bone fragments were observed on the surface of the site, as were numerous ostrich shell fragments. Site MHT-12 is an artefactually rich occupation with well preserved cultural remains. Furthermore, this site represents a Bronze Age occupation, a poorly understood period of Yemen's past. More discussion regarding this site is presented in the "Significance" section of the report.

(5) Undetermined

Twenty one of the identified sites did not yield sufficient diagnostic materials to be categorised by temporal or cultural affiliation. Most of these sites consisted of ephemeral scatters of lithic debitage and debris, although an occasional non-diagnostic tool form was also identified.

S5.3.8 Significance

Each of the 50 prehistoric sites identified by the survey was evaluated in terms of its individual significance. In order to evaluate significance, several categories of relevant considerations were incorporated into the analysis process. Criteria utilised to assess site significance included the following:

(1) Site Integrity

Site integrity and the presence or absence of *in situ* cultural remains was considered a key factor in significance evaluation. A prehistoric site with intact, discrete cultural remains that are in place has the potential to yield much more useful information than a site without intact deposits. Site integrity considerations were especially relevant to the present project, where many of the encountered sites were deflated, eroded, or in a secondary context. For example, cultural remains found in active erosional areas such as wadi beds were common. Also, several multicomponent sites were found to contain their respective artefact assemblages mixed together as a result of erosion and deflation of the original living surfaces.

(2) Site Uniqueness

The relative uniqueness of a site is an important consideration in evaluating significance because, all other factors aside, a site type of which there exists only one example is more important than another site type for which hundreds of examples exist. Evaluating site uniqueness was found to be a taxing process for

the present project, because so few prehistoric sites have been identified and investigated within the immediate project area vicinity and throughout the Republic of Yemen. Given the paucity of knowledge regarding prehistoric adaptations in the vicinity of the project area, what becomes apparent is that most of the encountered sites can be considered unique. However, some relevant information is available to assist in evaluating prehistoric site uniqueness. The 50 sites encountered by this survey constitute a respectable sample size for the project vicinity; thus the types and affiliations of sites encountered by this survey contribute to an understanding of relative site uniqueness. For example, many Middle Paleolithic sites were identified during the survey, but only two Lower Paleolithic occurrences were identified. Distinctions within a cultural-temporal period are also possible with the project site inventory. For example, many ephemeral Neolithic age temporary camps were identified, but only two large base-type camp sites were encountered.

In addition, site distribution information and ancillary data from other regions of both the Republic of Yemen and surrounding countries can be considered. For example, in southern and southwestern Saudi Arabia, extensive surveys have revealed the existence of many small Neolithic sites, but very few Bronze Age occupations (see "Prehistoric Overview" section of this report). Although great care must be taken when applying data from other regions to the present corridor, such supplementary information can assist in the evaluation of site uniqueness.

(3) Research Potential

An evaluation of the data that an individual site may yield that is of importance in addressing current academic and professional research issues is considered in this category. Although research interests of the many prehistorians working in the Arabian peninsula obviously differ, certain data must be present at a given site in order for the site to be of significant research potential. For example, sites with diagnostic artefacts are essential for research. Sites with well preserved floral and faunal materials offer many avenues of scientific enquiry, as do those sites containing materials amenable to radiometric or other forms of absolute dating. The presence of *in situ* deposits at a site is also an important consideration in establishing research potential - a prehistoric occupation that contains intact, discrete cultural features and artefacts has much greater potential to yield useful information than a disturbed or culturally mixed occupation.

(4) Regional Importance

The regional and local significance of an individual site considers the importance of the respective sites in terms of the immediate geographic or landform region in which the occupations are found. This significance category considers the individual sites in the context of the local environment in which they are found. As an illustration, it may be considered that hundreds of Neolithic sites have been identified in the Arabian peninsula in association with fossil lakes. However, very few Neolithic sites are known from jabel summits. Therefore, other criteria notwithstanding, a jabel top Neolithic site potentially has more local/ regional significance than a similar type of site found on a fossil lake bed.

(5) Artefacts

This category considers the artefact density and the presence or absence of diagnostic cultural materials at a site. Although this category overlaps some of the other significance categories (i.e., research potential), a decision was made to include consideration of the types and quantities of artefacts at a site as a separate category. This decision was based upon the critical role that individual artefacts may play in the production of useful information from a given cultural resource. A site that yields large quantities of diagnostic materials or unique and exotic specimens, has a potential information yield and significance that may override other considerations. Similarly, an occupation that contains previously unreported diagnostic artefact types may be of great significance, regardless of its integrity.

The significance categories described above were applied to all of the recorded prehistoric sites identified by the present survey. Each site was carefully evaluated; field notes, photographs, maps, artefact analysis results, and ancillary data including published and unpublished reports for Yemen and surrounding states were considered. Evaluations for each significance category were ranked from 0 (no significance) to 3 (high degree of significance) for each site. This ranking system, although utilising an arbitrary number scale, is a useful method by which to compare and contrast each site [Table S5.3.8(5a)]. As Table S5.3.8(5a) illustrates, scores were determined for each of the five significance categories, and then tabulated for an individual "site score". As the table shows, of the 15 possible points for each site, only three sites were found to have scores over 10. These three sites, MHT-12, 13 and 62 represent the most significant prehistoric occurrences identified during the present survey. As noted in Table S5.3.8(5a), many of the other recorded sites were found to be disturbed; deflation and erosion were found to be the two major factors that had contributed to

compromising site integrity. Other disturbance factors recorded were secondary contexts (i.e., materials found in wadi beds, etc.), and modern impacts (i.e., construction, impacts from vehicle tracks). Low artefact density and/or the absence of diagnostic cultural materials was another common finding at many sites that contributed to a low significance rating.

In addition to providing individual site information, the prehistoric occurrences identified by the survey have provided a useful sample from which to extrapolate data relevant to addressing issues including where potentially significant prehistoric sites may be encountered in the future. The distribution of identified sites by project landform segment for this project is presented in Tables 5.3.8(5b) and S5.3.8(5c). This site distribution data, together with a consideration and evaluation of the individual setting and type of sites within a given segment, allows the following interpretations:

- There is a low potential for encountering exposed prehistoric cultural resources in project segments 1, 2, 3, 5, 6, 7, 9, 14, 16, 18, 21 and 22.
- In segments 10, 12, 13 and 15, the potential for significant prehistoric occurrences is considered low to moderate.
- Segments 11, 17, 19 and 20 have a moderate to high potential to contain significant prehistoric cultural remains, especially at jabel slope, talus slope and scree deposit locations along the Hadramout valley wall escarpment.
- Segment 4 has a very high potential to contain prehistoric cultural resources, especially those occurrences dating to the Neolithic period. Sites will be exposed on old gravel-sand surfaces between dunes of relatively recent age. The potential for encountering <u>significant</u> prehistoric sites in Segment 4 should also be considered high.
- Segment 8 has a very high potential to contain prehistoric sites, especially those dating to the Middle Paleolithic. Sites will be found clustered adjacent to the major wadis in this segment. The present project's field research has illustrated that the Middle Paleolithic sites in this region are very large, but usually eroded or in secondary context. It is possible, however, that Middle Paleolithic sites exist in this project segment which contain intact cultural deposits. Such sites, if identified, would be potentially of great significance.

Table S5.3.8(5a)

Site MHT	Site Integrity	Site Uniqueness	Research Potential	Regional Importance	Artefacts	Score
	(A)	(B)	(C)	(D)	(E)	(F)
1	0	1	0	1	1	3
2	1	2	2	1	2	8
3	1	2	1	1	2	7
4	1	2	2	1	2	8
5	1	1	1	1	1	5
6	1	2	2	1	1	7
8	1	2	2	1	2	8
9	1	1	1	1	1	5
10	1	2	2	1	2	8
11	1	2	2	2	2	9
12	3	3	3	3	3	15 *
13	3	3	3	3	3	15 *
18	1	2	2	2	2	9
19	0	2	2	1	2	7
20	1	1	2	1	1	6
21	0	3	1	2	1	7
22	1	1	1	1	1	5
23	2	2	2	2	2	10
24	1	1	2	2	2	8
27	0	1	1	1	2	5
28	0	0	1	0	1	2
29	1	2	2	2	3	10
30	0	0	1	0	1	2
34	1	2	2	1	2	8
36	1	1	2	1	2	7
41	1	0	1	0	1	3

* Significant Sites - please refer para S5.3.9 - Recommendations

Table S5.3.8(5a) (Cont.)

Site MHT	Site Integrity	Site Uniqueness	Research Potential	Regional Importance	Artefacts	Score
	(A)	(B)	(C)	(D)	(E)	(F)
43	1	0	1	0	0	2
44	1	2	2	2	2	9
49	1	2	2	2	1	8
50	1	0	1	0	1	3
51	1	0	1	0	0	2
52	1	1	2	1	2	7
53	1	0	1	0	1	3
54	1	1	0	1	0	3
55	1	0	1	0	1	2
56	1	0	0	0	1	2
57	2	2	2	2	2	10
58	1	3	2	2	2	10
59	1	0	1	0	1	3
60	1	0	1	0	1	3
61	1	1	1	0	1	4
62	2	3	3	3	3	14 *
64	1	0	1	0	1	3
66	1	1	1	1	1	5
67	1	1	1	0	1	4
72	2	1	2	1	2	8
76	1	1	1	1	1	5
77	0	2	1	1	2	6
79	1	1	1	1	1	5
80	1	2	2	1	2	8

* Significant Sites - please refer para S5.3.9 - Recommendations

NOTES: A - Site Integrity; B - Site Uniqueness;
C - Research Potential; D - Regional Importance;
E - Artefact Density and Presence of diagnostic cultural materials;
F - Score (15 possible points)

Ranking : 0-None; 1-Low; 2-Moderate; 3-High

Table S5.3.8(5b)

Segment	No. of Prehistoric Sites	Percentage of Total Prehistoric Sites	
1	0	0.00	--
2	0	0.00	--
3	0	0.00	--
4	12	24.00	8 NEO, 1 BR, 3 UND
5	0	0.00	--
6	0	0.00	--
7	0	0.00	--
8	13	26.00	9 MP, 1LP, 3UND
9	0	0.00	--
10	2	4.00	2 UND
11	6	12.00	3 NEO, 3 UND
12	3	6.00	1 MP; 2 UND
13	1	2.00	1 MP
14	0	0.00	--
15	1	2.00	1 LP / MP
16	0	0.00	--
17	8	16.00	1 MP/NEO, 1 NEO, 6 UND
18	0	0.00	--
19	3	6.00	1 MP, 2 UND
20	1	2.00	1 MP
21	0	0.00	--
22	0	0.00	--
TOTAL	50	100.00	

NOTES : LP - Lower Paleolithic; MP - Middle Paleolithic
NEO - Neolithic; BR - Bronze Age; UND - Undetermined.

(6) Impacts

It may be noted that, thus far, the discussion of site significance for this project has made no mention of the potential impacts to these sites by the proposed construction activities. This omission was intentional, because the type of impact upon a given prehistoric site and that site's significance are independent considerations. The impact of development activities upon a cultural property has no bearing upon whether that property has significance. Rather, the nature of the impact determines, in part, the mitigating measures which should be undertaken at significant site locations.

For the present project, four types of impacts were noted for the investigated prehistoric sites. These impact categories are :

- No impact : Site will be unaffected by the proposed construction activities, if they are implemented as currently planned.
- Partial Impact : A portion of the given site will be directly or indirectly impacted by the proposed construction plans.
- Complete Impact : Implementation of the construction activities as planned will completely destroy the prehistoric site.
- Quarry Impact : The prehistoric site is situated within one of the proposed quarry-borrow locations. The site may be partially or completely impacted, depending upon the volume of quarry material that is taken from this location.

The anticipated impacts for each of the recorded sites are listed in the "Results" section of the report; this information is also summarized in Table S5.3.8(5c). As these sources detail, the implementation of the construction activities as currently planned will result in the following impacts:

No Impact	-	2 sites
Partial Impact	-	24 sites
Complete Impact	-	16 sites
Quarry Impact	-	8 sites.

Table S5.3.8(5c)

Site MHT	Project Segment	Temporal / Cultural Affiliation					Wholly within ROW	Partially within ROW	Quarry Area	Outside Impact Areas
		LP	MP	NEO	BR	UND				
1	4			*			*			
2	4			*			*			
3	4			*				*		
4	4			*				*		
5	4					*	*			
6	4			*			*			
8	4			*				*		
9	4					*	*			
10	4			*			*			
11	4					*	*			
12	4				*					*
13	4			*				*		
18	8		*					*		
19	8		*					*		
20	8		*					*		
21	8	*					*			
22	8					*		*		
23	8		*					*		
24	8		*					*		
27	8		*					*		
28	8					*	*			
29	8		*							*
30	8					*		*		
34	8		*					*		
36	8		*					*		
41	10					*	*			
43	10-Quarry					*			*	

ROW - Right of Way

Table S5.3.8(5c) - Contd...

Site MHT	Project Segment	Temporal / Cultural Affiliation					Wholly within ROW	Partially within ROW	Quarry Area	Outside Impact Areas
		LP	MP	NEO	BR	UND				
44	11		*					*		
49	11		*					*		
50	11					*	*			
51	11					*		*		
52	11		*					*		
53	11 Quarry					*			*	
54	12			*				*		
55	12					*		*		
56	12					*	*			
57	13 Quarry		*						*	
58	15 Quarry	*	*						*	
59	17					*		*		
60	17					*		*		
61	17					*	*			
62	17 Quarry		*	*					*	
64	17					*	*			
66	17 Quarry					*			*	
67	17					*	*			
72	17			*				*		
76	19					*		*		
79	19					*	*			
80	19 Quarry		*						*	
77	20 Quarry		*						*	

NOTE : LP - Lower Paleolithic; MP - Middle Paleolithic, NEO - Neolithic;
BR - Bronze Age; UND - Undetermined

ROW - Right of Way

S5.3.9 Recommendations

This section of the report provides specific recommendations for the 50 prehistoric sites encountered by the survey, followed by a series of more general recommendations pertinent to the proposed road construction project.

After careful consideration of the individual sites encountered during the field investigation, and after applying significance criteria to these sites, the opinion of the project prehistorian is that three of the prehistoric sites identified during the project are sufficiently significant to require special attention. These three (3) sites, MHT-12, MHT-13 and MHT-62 are considered to be highly significant because of factors such as their importance in addressing current research questions, their high degree of site integrity and their uniqueness in the known site inventory of the Republic of Yemen. The remaining forty seven (47) prehistoric sites identified by the survey do not adequately meet the significance criteria to the extent that further investigations or impact avoidance of these sites appears justified. No further work or special attention is recommended at these 47 sites.

Of the three sites found to be highly significant, two are located within segment 4 of the road corridor (Sites MHT-12 and MHT-13), while the other site, MHT-62, is located at a proposed quarry-borrow area within road segment 17.

Site MHT-12 is a dense scatter of cultural remains, including well preserved ceramics, chipped stone and ground stone tools and debitage, shell and bone remains. Diagnostic artefacts recovered from the site indicate a Bronze Age affiliation. This site, on the basis of the field inspection, appears to contain high densities of well preserved diagnostic cultural materials. Additionally, the site appears to have a high potential for containing *in situ* remains. Furthermore, MHT-12 represents a Bronze Age occupation, a very poorly understood period of Yemen's prehistoric legacy. Site MHT-12 lies well outside the proposed construction corridor and will not be impacted by the proposed road construction activities. Preservation of the site and avoidance of the site area by future developments is recommended.

Site MHT-13 is a large concentrated scatter of lithic materials identified on a low hill above the surrounding desert plain. The site was found to contain very high densities of chipped stone lithic materials dating to the Neolithic period. Also observed at the site were features such as circular house structure remains, hearths, roasting pits, and lithic reduction work areas. Site MHT-13 appears to represent a large Neolithic base camp. The site contains very high densities of

cultural remains, and - on the basis of the identified features - probably contains *in situ* cultural deposits. Furthermore, large Neolithic period base camps are a rare site type in Yemen and the southern Arabian peninsula. This site contains important information relevant to addressing many questions of human adaptation during the Neolithic period in Yemen.

Neolithic site MHT-13 encompasses an area of approximately 600 metres north-south by 100 metres east-west (60,000 sq.m.). On the southern edge of the site area, approximately 8000 sq.m. of cultural deposit lies within the proposed road construction corridor. Realignment of the proposed road to between 100-150 m south of its presently proposed route would avoid site MHT-13 and allow it to remain intact. Realignment of the proposed road may not be practical (see World Bank 1993). Therefore, if avoidance is not possible, further investigations and/or data recovery at the portion of the site to be impacted by construction activities is recommended. Such investigations could be undertaken by personnel from the GOAMM, Republic of Yemen, or a qualified consultant during a period of approximately 5-10 days of fieldwork. Regardless of whether avoidance or mitigation of a portion of the site area is selected, it is recommended that the portion of site MHT-12 that is not impacted by construction activities be protected by temporary fencing for the duration of construction activities. Additionally, planning measures should be implemented to protect the site area from future development and construction.

Site MHT-62 is a multiple component Middle Paleolithic and Neolithic occupation located on talus slope and scree deposits at a proposed quarry location in road segment 17. MHT-62 was found to contain moderate to high densities of cultural remains spread over a very large area (approx. 1 sq. km.). Features such as rock filled roasting pits, hearths and circular house foundations were noted within the site area. The large size of this site and the presence of numerous features indicates that the site contains intact cultural deposits. The rich artefact inventory at the site may yield data relevant to addressing many questions of adaptation by human groups in the Hadramout valley during both Middle Paleolithic and Neolithic times. Avoidance of this site and selection of a new quarry-borrow location is recommended. If preservation and avoidance is not possible, further investigations at the site will be required in order to make a definitive statement of significance and to determine the exact nature and extent of site mitigation operations. A definitive assessment of the site's significance could probably be achieved during a period of field investigations encompassing 3-5 days. Such investigations could be implemented by GOAMM personnel or by a qualified consultant.

In addition to these site specific recommendations, several general recommendations are made regarding the landform segments through which the proposed road will pass. It should be noted, however, that most of the following recommendations are based upon a close inspection of the proposed road corridor and inspection of the quarry-borrow areas. The field data was collected principally with the aim of identifying and evaluating prehistoric sites that will be impacted by construction activities. However, because the proposed impact areas cross and include the landform segments under consideration, it is possible to extrapolate from the impact corridor findings to provide tentative expectations for the remainder of the area encompassed in the respective environmental unit. Another caution should also be noted. Most of the recommendations presented here and throughout this report are based on a pedestrian survey of cultural resources visible on the present ground surface. No detailed evaluation of buried prehistoric cultural resources was possible, given time constraints and the paucity of Late Pleistocene/Holocene geomorphic data for this area. Therefore, the effects of deposition and erosion (which may vary within a given environmental unit) are not fully addressed.

Based upon the findings of the field survey, the following project segments appear to have the potential to contain high to very high densities of prehistoric sites; segments 4 and 8. The following segments appear to have the potential to contain moderate to high densities of prehistoric sites; segments 11, 17, 19 and 20. In these above mentioned project segments, the design and implementation of prehistoric cultural resource surveys is recommended prior to the undertaking of future developments, construction activities, or earth moving projects.

It should be noted that further monitoring for the presence of prehistoric sites in the road construction corridor under consideration in this report (Safir-Hadramout Road) is <u>not</u> recommended. In the opinion of the project prehistorian, the present field survey was sufficiently comprehensive and detailed to identify the significant prehistoric resources within the proposed impact zones. Although there may exist the potential for significant, deeply buried sites in the proposed construction corridor, monitoring before or during construction is not considered an adequate method by which to identify and/or mitigate these buried sites. The high cost of monitoring operations by a qualified prehistorian during construction does not seem justified. This recommendation is based upon this prehistorian's professional experience, having participated in numerous monitoring operations during road construction projects. It has been documented that construction monitoring rarely reveals all significant prehistoric sites, if they are present (Sellars 1993). The principal reason for this finding is that the methods utilised for constructing roads are aimed principally at efficient road construction, not at

the identifiction of prehistoric cultural resources. Furthermore, prehistoric sites are often only identified during monitoring after significant portions of the respective sites have been destroyed. This is because large mechanical equipment is used to remove and modify surface sediments during road construction, and many prehistoric sites are relatively small. Thus, the context of many prehistoric sites may be completely compromised by the construction equipment that allows its discovery.

In lieu of monitoring during construction, the following suggestions regarding site discovery are offered:

- Strict adherence and enforcement of World Bank guidelines regarding this issue, as detailed in the "Guidance for Environmental Assessments" (Section 10) of the Environmental Assessments Sourcebook (World Bank 1991:122). In order to effectively implement these guidelines, it may be useful to provide a brief training session to road construction supervisors as to the nature of prehistoric sites and the types of artefacts likely to be encountered.

- If the identification of, and assessment of, the potential for buried prehistoric sites is considered to be a major goal of an EA, a consultant geomorphologist/ geologist with a specialisation in Late Pleistocene/Holocene landform formation should be retained; such a specialist should work closely in conjuction with the project prehistorian to assess the potential and location of buried prehistoric sites.

- Funding should be allocated for absolute dating of recovered organic materials from prehistoric sites identified at the pedestrian level of the survey. Dating of suitable materials (i.e., bone, charcoal, ostrich shell) will allow an absolute date to be applied to specific sites and relative dates to be applied to the landform containing the site. Such data could directly assist in addressing questions pertaining to the potential for deeply buried cultural materials at a given site. Furthermore, such information would add greatly to issues of temporal and cultural site interpretation.

A final comment is offered with regard to the present prehistorical investigation. This prehistoric cultural resource survey has provided valuable site distribution information and a considerable quantity of site specific cultural-temporal data. This project has helped to shed light on the prehistory of an area of Yemen that heretofore had received very little attention. The World Bank and the Republic of Yemen are to be commended for funding this prehistoric survey. It is hoped that similar responsible attitudes will be demonstrated by the planners of future construction projects in this rapidly developing country.

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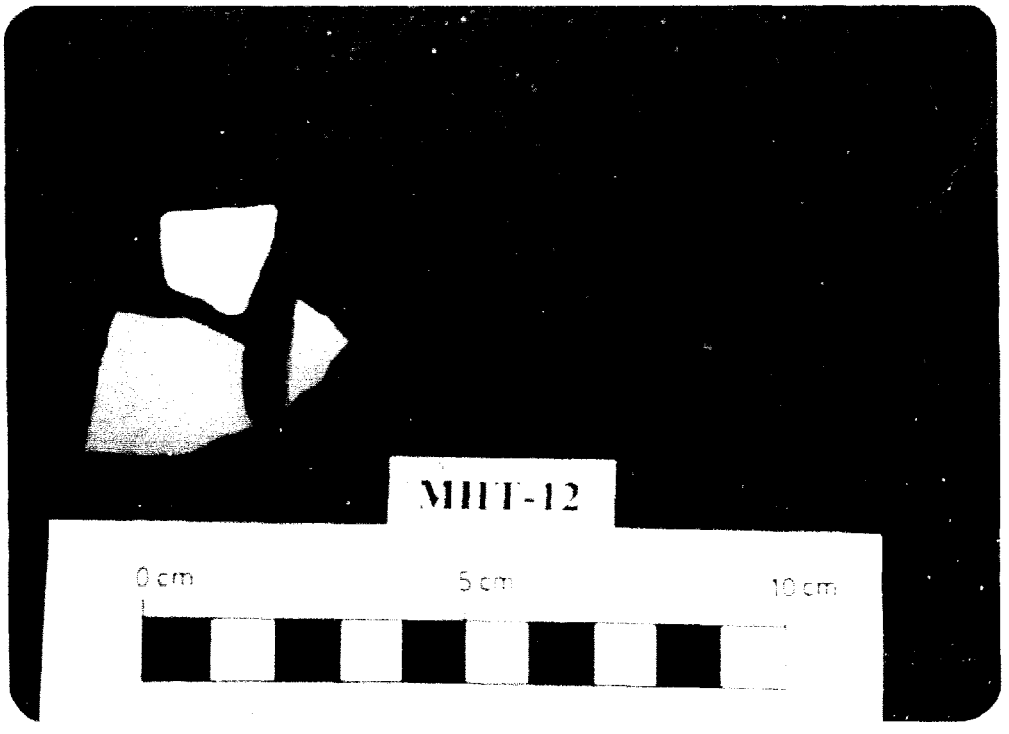
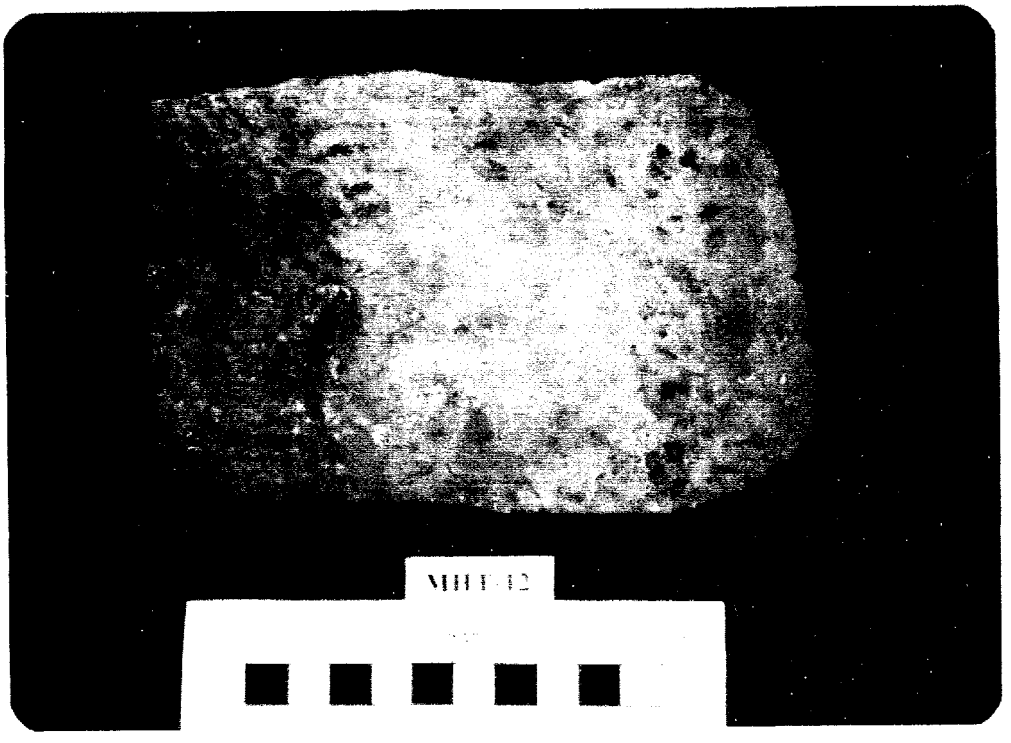
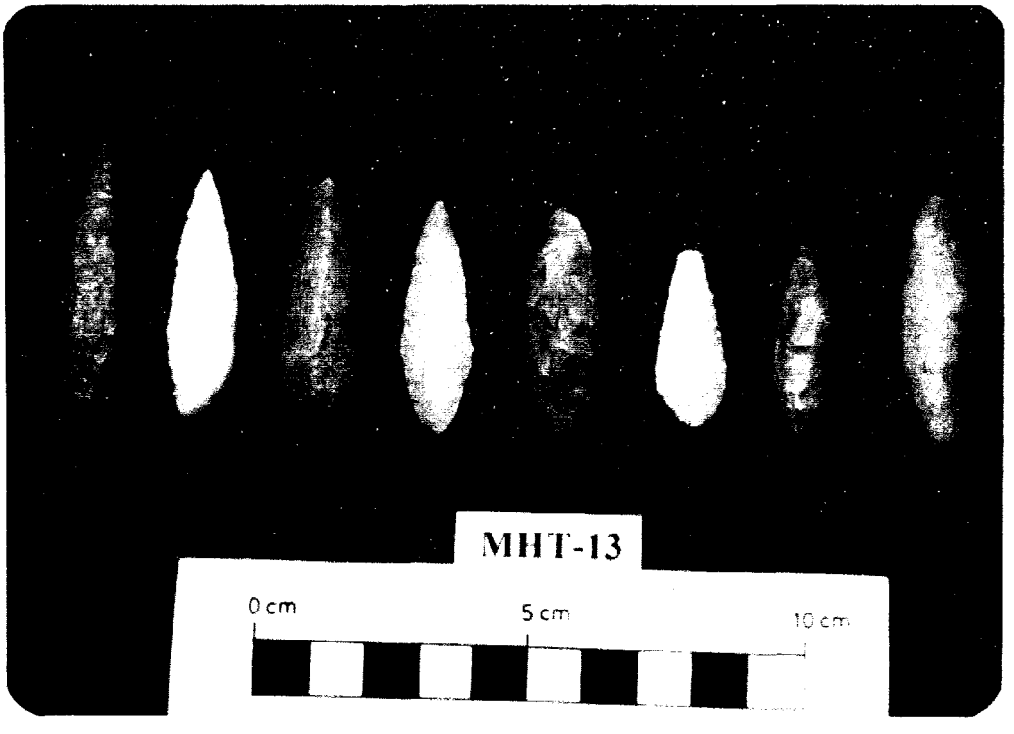


S5.3.1. ARTEFACT ILLUSTRATIONS, SITE MHT-12
LEFT - OSTRICH SHELL FRAGMENTS
RIGHT - POLISHED BESALT CELT

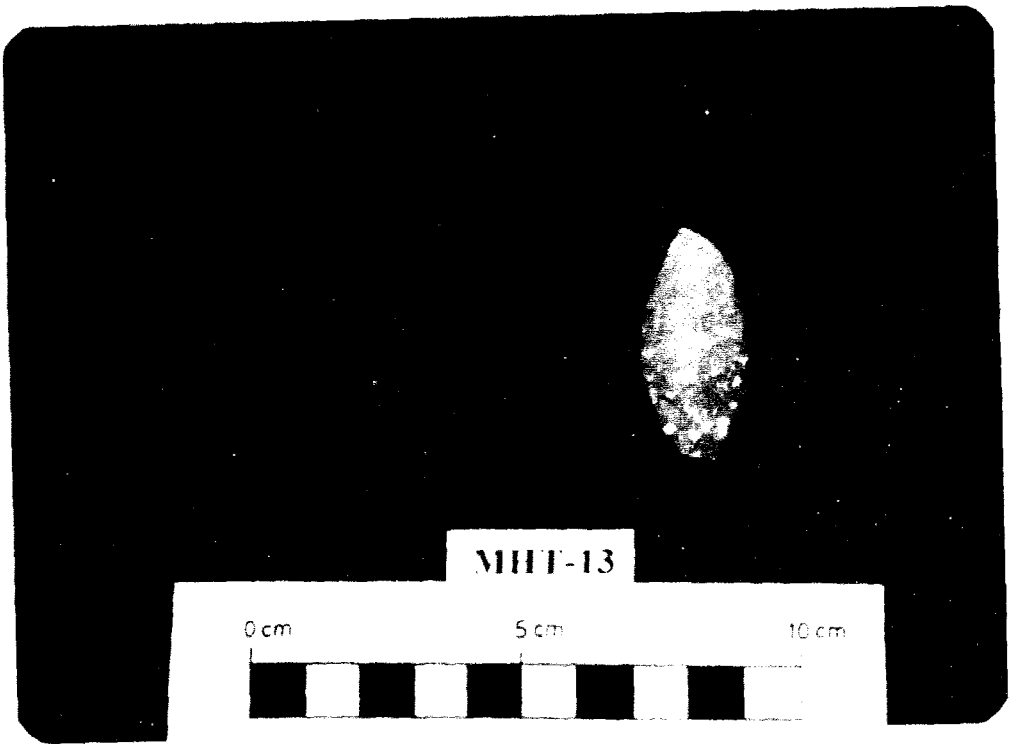
S5.3.2. SCRAPING AND CUTTING TOOLS FROM SITE MHT-12
LEFT TO RIGHT - SIDESCRAPER, BACKED KNIFE
SIDESCRAPER, RETOUCHED BLADE



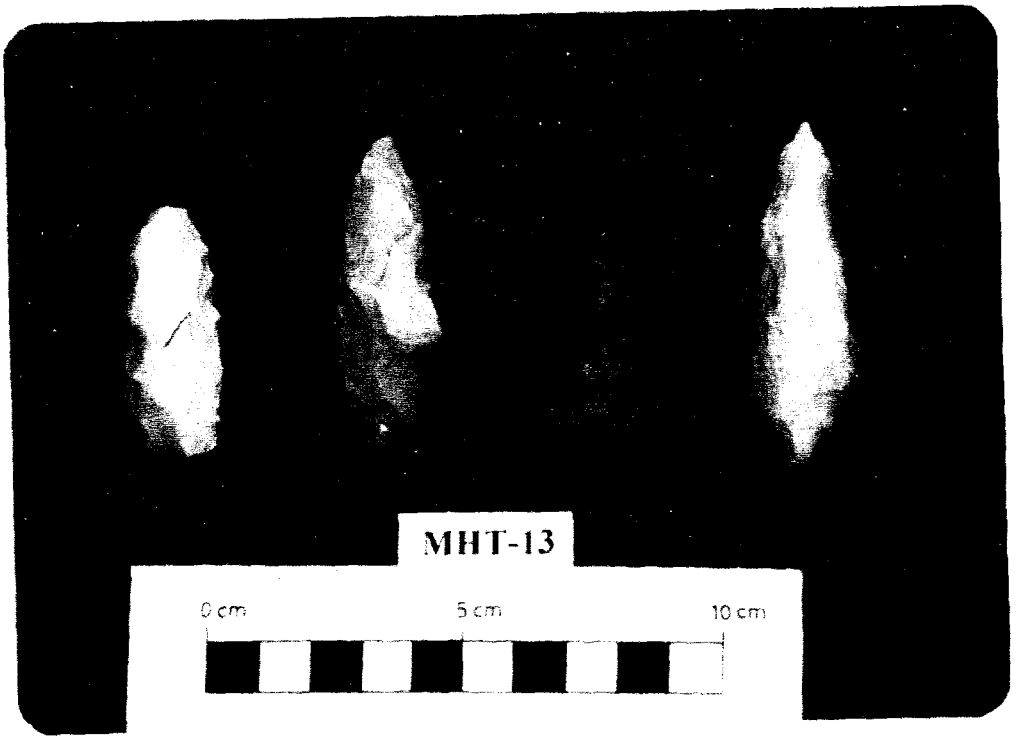
S5.3.3 KNIFE CERAMIC RIM SHERD FROM SITE MHT-12
NOTE TEMPER PROTRUSION



S5.3.4. NEOLITHIC BIFACIALLY WORKED PROJECTILE
POINTS FROM SITE MHT-13



S5.3.5 LEAF SHAPED BIFACES FROM SITE MHT-13



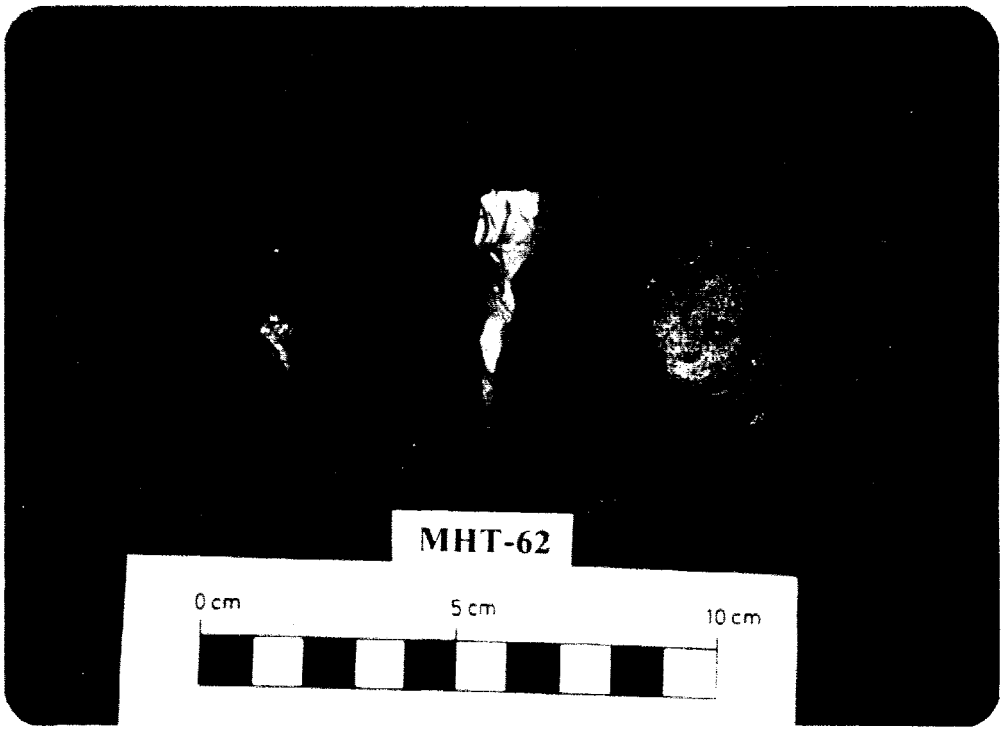
S5.3.6 BIFACIALLY WORKED SCRAPERS AND PERFORMS FROM SITE MHT-13

S5.3.7 REWORKED BIFACES AND FRAGMENTS FROM SITE MHT-13

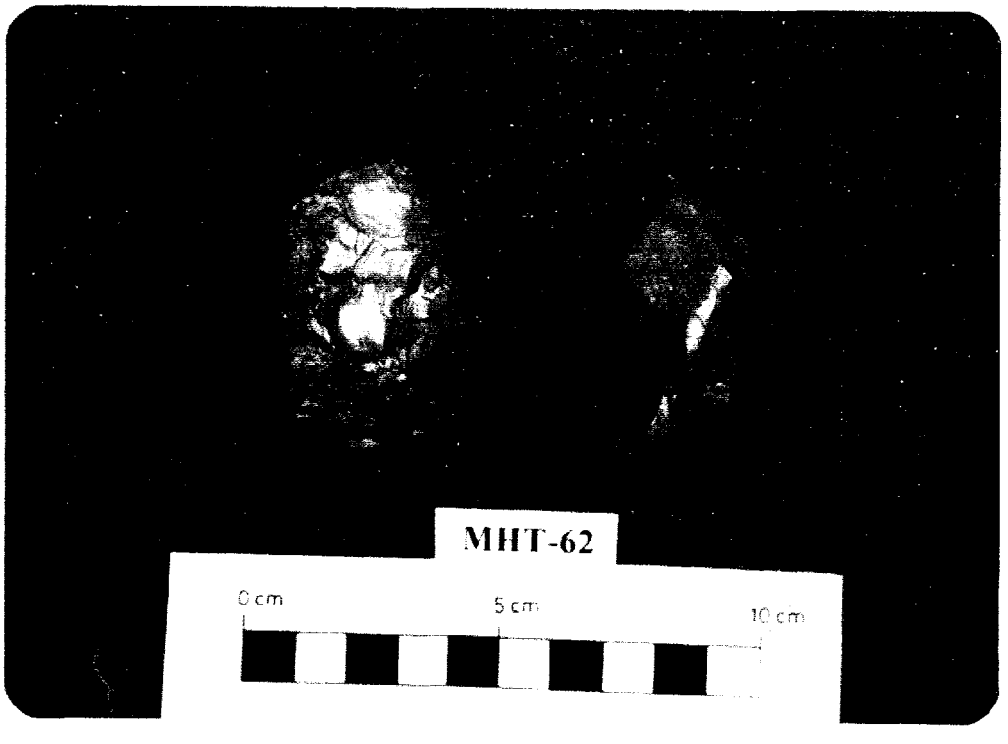
S5.3.8 RETOUCHED LEVALLOIS FLAKES SITE MHT-18

S5.3.9 BESALT PICK, SITE MHT-21

S5.3.10 MIDDLE PALAEOLITHIC CHIPPED STONE TOOLS FROM SITE MHT-52 - LEFT TO RIGHT : SIDESCRAPER, RETOUCHED LEVALLOIS FLAKE, NOTCH WITH RETOUCH, RETOUCHED BLADE

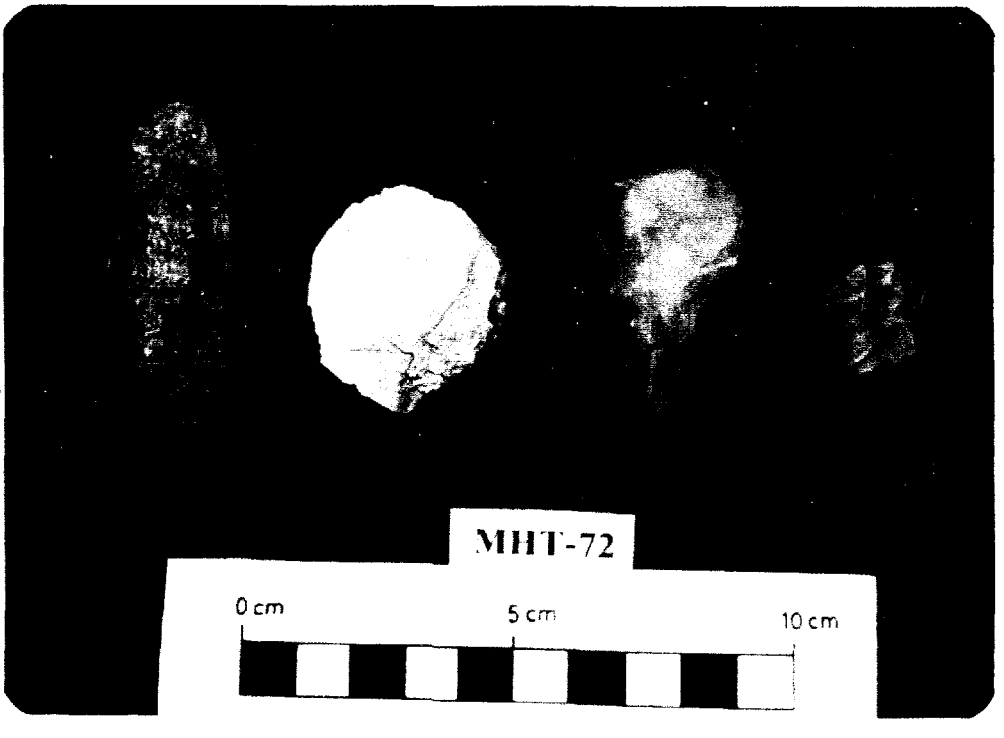


S5.3.11 CHIPPED STONE TOOLS FROM NEOLITHIC COMPONENT OF SITE MHT-62 - LEFT TO RIGHT : BIFACE, REOUTCHED ENDSCRAPER CIRCULAR SCRAPER



S5.3.12 NEOLITHIC TOOLS FROM SITE MHT-62
LEFT : BACKED KNIFE RIGHT : PERFORATOR

S5.3.13 CRUDELY FASHIONED BASALT HANDAXE FROM SITE MHT-58



S5.3.14 CHIPPED STONE SCRAPERS FROM SITE MHT-72

S5.3.15 LEVALLOIS TOOLS FROM SITE MHT-80
LEFT : LEVALLOIS POINT (UNFINISHED)
RIGHT : LEVALLOIS FLAKE EMBEDDED IN LIMESTONE MATRIX

SITE DATA SHEETS

SITE DATA SHEETS

Project Segment	:	4
Site Number	:	MHT - 1
Site Location	:	15° 47'11" N; 46° 02' 47" E
Temporal-Cultural Affiliation	:	Neolithic, Late
Site Type	:	Resource Procurement
Site Size	:	< 1m N-S, < 1m E-W, < $1m^2$

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	_____
- Complete Impact (All of Site area in Corridor)	X
- Within Quarry-Borrow Area	_____

Materials Recovered :

Lithic Tool:

1. Bifacially worked, stemmed projectile point (distal tip missing). Fine grained grey-brown flint

Comments:

The single projectile point recovered from this site is stylistically very similar to examples found in the Rub Al Khali Neolithic complex, where such point styles usually date to the Late Neolithic period.

Project Segment	:	4
Site Number	:	MHT - 2
Site Location	:	15° 47' 25" N; 46° 03' 06" E
Temporal-Cultural Affiliation	:	Neolithic, Early
Site Type	:	Temporary Camp
Site Size	:	20 m N-S, 100 m E-W; 2000 m^2

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	_____
- Complete Impact (All of Site area in Corridor)	X
- Within Quarry-Borrow Area	_____

Materials Recovered :

Lithic Tool:

1- Ovate, unifacially worked projectile point, fine grained tan flint
1- Small, stemmed projectile point with basal notches. Unifacially worked, tan flint
1- Retouched Bladelet, tan flint
1- Retouched flake fragment, brown flint

Lithic Debitage:

2- Bladelets
4- Interior Flakes
2- Tertiary Flakes

Comments:

The ovate, unifacially worked projectile point and the unifacial arrow point recovered from this site are typologically very similar to styles found in the Early Neolithic period of southern Saudi Arabia and northwestern Oman.

Project Segment	:	4
Site Number	:	MHT - 3
Site Location	:	15° 48' 17" N; 46° 04' 31" E
Temporal-Cultural Affiliation	:	Neolithic
Site Type	:	Temporary Camp
Site Size	:	70 m N-S, 250 m E-W; 17,500 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ____X____
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools:

1- Crude Biface, purple basalt
1- Angle Burin, fine grained tan flint
1- Notch with Retouch, brown flint
1- Retouched blade, Obsidian
7- Retouched flakes; 5 flint, 2 obsidian

Lithic Debitage and Debris:

1- Flake Core
1- Core Fragment
2- Core Rejuvenation flakes
7- Secondary Decortication flakes
8- Interior flakes
8- Bifacial thinning flakes
1- Flake Fragment
1- Core Tramming Element, Obsidian
7- Obsidian Flakes
3- Bladelets, Obsidian
12- Chips, Obsidian
1- Burin spall, Obsidian

Comments:

This site contains a small collection of Neolithic style tools and debitage. Raw material types are quite varied.

Project Segment	:	4
Site Number	:	MHT - 4
Site Location	:	15° 48' 29" N; 46° 05' 00" E
Temporal-Cultural Affiliation	:	Neolithic
Site Type	:	Temporary Camp
Site Size	:	30 m N-S, 100 m E-W; 3000 m^2

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	X
- Complete Impact (All of Site area in Corridor)	_____
- Within Quarry-Borrow Area	_____

Materials Recovered :

Lithic Tools:

1- Endscraper, very fine grained brown flint
2- Retouched Bladelets, Obsidian

Lithic Debitage and Debris:

1- Exhausted core
1- Tested Quartzite Cobble
6- Secondary Decortication Flakes
7- Interior Flakes
5- Bifacial Thinning flakes
5- Blades
3- Obsidian Chunks
4- Flake Fragments
2- Tertiary flakes
9- Chips

Other Materials :

3- Ostrich Shell Fragments

Comments:

The occurrence of obsidian bladelet tools with ostrich shell is typical of Neolithic sites in the southwestern portion of the Arabian peninsula.

Project Segment	:	4
Site Number	:	MHT - 5
Site Location	:	15° 48' 56" N; 46° 06' 20" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	75 m N-S, 80 m E-W; 6000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ___X___
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Debitage and Debris:

6- Primary Decortication Flakes
5- Secondary Decortication Flakes
15- Interior Flakes
7- Bifacial Thinning Flakes
3- Tertiary Flakes
3- Flake Fragments

Other Materials :

1- Ostrich shell fragment

Comments:

A small, sparse scatter of lithic debitage and debris, no diagnostic tools or similar artefacts were recovered from this site.

Project Segment	:	4
Site Number	:	MHT - 6
Site Location	:	15° 48' 57" N; 46° 06' 31" E
Temporal-Cultural Affiliation	:	Neolithic
Site Type	:	Temporary Camp
Site Size	:	10 m N-S, 30 m E-W; 300 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ___X___
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools:

1- Retouched Bladelet, Obsidian
1- Retouched Flake, tan colour flint

Lithic Debitage and Debris:

1- Pyramidal flake core
2- Core Rejuvenation flakes
5- Secondary Decortication flakes
4- Interior flakes
4- Tertiary flakes
7- Bladelets
4- Chips

Comments:

The presence of small obsidian bladelets, both as tool forms and as debitage, suggests a Neolithic affiliation for this site.

Project Segment	:	4
Site Number	:	MHT - 8
Site Location	:	15° 49' 00" N; 46° 06' 35" E
Temporal-Cultural Affiliation	:	Neolithic, Early
Site Type	:	Camp
Site Size	:	30 m N-S, 70 m E-W; 2,100 m^2

Impact

- No Impact (Outside Corridor)	
- Partial Impact (Portion of Site in Corridor)	X
- Complete Impact (All of Site area in Corridor)	
- Within Quarry-Borrow Area	

Materials Recovered :

Lithic Tools:

1- Endscraper, Fine grained tan flint
1- Ovate, Unifacially worked projectile point, obsidian
9- Retouched Bladelets, obsidian
1- Retouched flake, obsidian

Lithic Debitage and Debris:

2- Interior flakes
3- Bifacial Thinning Flakes
15- Obsidian Thinning Flakes
7- Flake Fragments
16- Bladelets
18- Chips
2- Primary Elements (Obsidian)

Comments:

A representative collection of tools and debitage with Early Neolithic associations was recovered from this site. It is notable that obsidian artefacts (tools and debitage) appear to have been reduced by a blade-bladelet technique, while flint artefacts appear to have been worked with a flake oriented reduction technology.

Project Segment	:	4
Site Number	:	MHT - 9
Site Location	:	15° 49' 03" N; 46° 06' 40" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	25 m N-S, 25 m E-W; 625 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ___X___
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Debitage and Debris:

4- Secondary Decortication flakes
8- Interior flakes
11- Bifacial Thinning flakes
12- Tertiary flakes
4- Chunks

Other Materials :

1- Ostrich Shell Fragment

Comments:

No diagnostic artefacts were recovered from this small site.

Project Segment	:	4
Site Number	:	MHT - 10
Site Location	:	15° 49' 22" N; 46° 07' 02" E
Temporal-Cultural Affiliation	:	Neolithic
Site Type	:	Temporary Camp
Site Size	:	70 m N-S, 35 m E-W; 2450 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ___X___
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools :

2- Endscrapers, Fine grained tan flint
1- Retouched Bladelet, fine grained tan flint
1- Retouched Flake, fine grained tan flint

Lithic Debitage and Debris:

3- Core Rejuvenation flakes
8- Secondary Decortication Flakes
10- Interior flakes
19- Bifacial Thinning Flakes
18- Tertiary Flakes
4- Chunks

Comments:

Obsidian debitage from this site is notable, as the material was found in flake form, rather than in blade or bladelet form.

Project Segment	:	4
Site Number	:	MHT - 11
Site Location	:	15° 49' 46" N; 46° 07' 41" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Temporary Camp
Site Size	:	12 m N-S, 25 m E-W; 300 m^2

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	_____
- Complete Impact (All of Site area in Corridor)	X
- Within Quarry-Borrow Area	_____

Materials Recovered :

Lithic Tools :

1- Sidescraper, fine grained brown flint
1- Endscraper, fine grained brown flint
1- Biface Fragment, fine grained brown flint
2- Retouched flakes, fine grained brown flint

Lithic Debitage and Debris:

1- Pyramidal flake core
1- Irregular flake core
1- Globular flake core
5- Primary Decortication flakes
5- Secondary Decortication flakes
10- Interior flakes
14- Bifacial Thinning flakes
6- Tertiary flakes
2- Flake fragments
3- Chunks

Comments:

Debitage and debris representative of the entire lithic reduction sequence was observed at this site. The site probebly represents either a Neolithic or Bronze Age occupation.

Project Segment	:	4
Site Number	:	MHT - 12
Site Location	:	15^{0} 50' 53" N; 46^{0} 06' 46" E
Temporal-Cultural Affiliation	:	Bronze Age
Site Type	:	Base Camp
Site Size	:	120 m N-S, 80 m E-W; 9,600 m^2

Impact

- No Impact (Outside Corridor) X
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools : (All fine grained flint except as noted)

12- Retouched Blades
5- Backed knives
1- Endscraper with Retouch
1- Multiple Notch with Retouch
5- Retouched flakes
2- Naturally Backed knives
1- Alternately Retouched Blade
5- Unifacially worked knives
1- Chopper
1- Ground stone, Basalt Celt
1- Ground stone, Hand stone ("Mano"), porous pumice
2- Hammer stones; white Quartzite

Lithic Debitage and Debris:

1- Globular flake core
1- Irregular flake core
4- Primary Decortication flakes
7- Secondary Decortication flakes
37- Interior Flakes
30- Bifacial Thinning Flakes
10- Tertiary flakes
7- Flake Fragments
3- Core Trimming Elements
1- Chip
9- Blades

Ceramics :
26- Red Ware Rim Sherds
4- Red Ware Base Fragments
9- Red Ware Body Sherds

Other Materials:
10- Ostrich Shell Fragments
2- Bone Fragments, weathered

Comments:

A diverse array of artefact types and raw material classes were recovered from this Bronze Age occupation. Large blade tools and naturally backed knives form an important aspect of the lithic industry, while thick walled, poorly fired pottery with chaff and grit temper dominate the ceramic corpus. This important site is discussed in detail in the "Summary" and "Significance" sections of this report.

Project Segment	:	4
Site Number	:	MHT - 13
Site Location	:	15° 50' 47" N; 46° 09' 17" E
Temporal-Cultural Affiliation	:	Neolithic, Late and Early
Site Type	:	Multiple Occupation Base Camp
Site Size	:	600 m N-S, 100 m E-W; 60,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools : (All fine grained flint except as noted)

10- Ovate, bifacially worked projectile points
2- Triangular, bifacially worked projectile points
4- Elongated, Ovate Bifaces
7- Bifaces with convex distal and proximal morphology
7- Pointed biface fragments
1- Circular biface
2- Biface fragments
13- Bifacial preforms
6- Unifacially worked projectile points
7- Endscrapers
3- Sidescrapers
1- Core Scraper
1- Strangulated scraper
6- Retouched Blades and Bladelets
22- Retouched and Utilized flakes
3- Single Notches
4- Multiple Notches
1- Perforator with Retouch
1- Worked Steatite fragment

Lithic Debitage and Debris:

3- Globular flake cores
2- Irregular flake cores
1- Pyramidal flake core
5- Core Rejuvenation flakes

39- Primary Decortication flakes
76- Secondary Decortication flakes
57- Interior flakes (1 is obsidian)
114- Bifacial Tinning flakes (3 are obsidian)
94- Tertiary flakes (5 are obsidian)
11- Blades
42- Flake fragments (2 are obsidian)

Comments:

Large quantities of formal tools, including several styles of projectile points and several scraper classes were recovered from this large site. The collected tool inventory extends the known range of variation in tool styles for the Late Neolithic period in Yemen. A large and important site.

Project Segment	:	8
Site Number	:	MHT - 18
Site Location	:	16° 02' 07" N; 46° 35' 20" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Undetermined
Site Size	:	>1000 m N-S, 750 m E-W; >750,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

MHT - 18

Lithic Tools : (All patinated tan quartzite)

3- Levallois points
2- Notches
1- Bifacially worked Handaxe
2- Large choppers
2- Sidesrapers
1- Denticulate (fragment)
3- Irregular Bifaces
2- Retouched flakes

Lithic Debitage and Debris:

2- Levallois ("tortoise") cores
1- Globular flake core
1- Irregular flake core
7- Levallois flakes, typical
5- Levallois flakes, atypical
16- Decortication flakes
15- Thinning flakes
5- Core Trimming Elements
2- Flake fragments

Comments:

Several large, thick blades were among the debitage collection from this large Middle Paleolithic site. In Saudi Arabia and the Levant, the presence of large blades in Middle Paleolithic assemblages has been interpreted as evidence of Middle Paleolithic/Levallois stone working strategies continuing into time frames equivalent to the Upper Paleolithic (Jelinek 1981; Zarins et al. 1981:15-17).

Project Segment	:	8
Site Number	:	MHT - 19
Site Location	:	16° 02' 19" N; 46° 41' 01" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Lithic Resource Procurement
Site Size	:	800 m N-S, 500 m E-W; 400,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ____X____
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools : (All patinated white to purple coloured quartzite)

1- Chopper
1- Sidescraper
1- Notch
1- Bifacially worked scraper (fragment)
1- Angle Burin
1- Retouched flake
1- Unifacial scraper
1- Biface fragment

Lithic Debitage and Debris:

2- Levallois flakes, typical
4- Levallois flakes, atypical
6- Decortication flakes
9- Thinning flakes
1- Core Trimming Element
3- Flake fragments
1- Chip
1- Natural flake

Comments:

The coarse grained quartzite of which this entire assemblage is composed occurs in abundance in wadi gravels adjacent to this site.

Project Segment	:	8
Site Number	:	MHT - 20
Site Location	:	16° 01' 52" N; 46° 41' 26" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Undetermined
Site Size	:	200 m N-S, 100 m E-W; 20,000 m^2

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	X
- Complete Impact (All of Site area in Corridor)	_____
- Within Quarry-Borrow Area	_____

Materials Recovered :

Lithic Tools : (All rolled, weathered quartzite)

3- Retouched flakes

Lithic Debitage and Debris:

1- Levallois core
1- Irregular flake core
3- Levallois flakes, typical
1- Levallois flakes, atypical
3- Decortication flakes
3- Thinning flakes
1- Core Trimming Element
1- Blade

Comments:

Project Segment	:	8
Site Number	:	MHT - 21
Site Location	:	16° 02' 12" N; 46° 41' 34" E
Temporal-Cultural Affiliation	:	Lower Paleolithic, Acheulean
Site Type	:	Undetermined
Site Size	:	< 1 m N-S, < 1 m E-W; < 1 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ____X____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools :

1- Trihedral pick, medium grained, chocolate brown coloured basalt.

Comments:

The trihedral pick recovered from this site is typologically identical to examples assigned to a Middle Acheulean context during recent investigations at the site of Ad-Dawadmi in Saudi Arabia (see Whalen et al. 1983). The tool from MHT-21 is highly patinated and weathered, indicating that it was probably transported by alluvial action.

Project Segment	:	8
Site Number	:	MHT - 22
Site Location	:	16° 02' 10" N; 46° 42' 14" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	50 m N-S, 60 m E-W; 3,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools (All coarse grained tan quartzite) :

1- Sidescraper
1- Endscraper
1- Notch with Retouch

Lithic Debitage and Debris:

1- Irregular flake core
2- Blades

Comments:

Project Segment	:	8
Site Number	:	MHT - 23
Site Location	:	16° 02' 24" N; 46° 42' 54" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Temporary Camp
Site Size	:	800 m N-S, 350 m E-W; 280,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools (All fabricated from medium to coarse grained white quartzite) :

1- Endscraper
1- Angle Burin with Retouch
1- Angle Burin
1- Retouched Blade
4- Retouched Flakes

Lithic Debitage and Debris:

3- Tested Cobbles
1- Levallois core
5- Levallois flakes, typical
5- Decortication flakes
10- Thinning flakes
2- Blades

Comments:

A diverse collections of Middle Paleolithic tool forms and debitage was recovered from this site.

Project Segment	:	8
Site Number	:	MHT - 24
Site Location	:	16^{0} 02' 29" N; 46^{0} 45' 05" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Undetermined
Site Size	:	>1700 m N-S, 600 m E-W; 1,020,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools (All patinated white quartzite) :

1- Bifacially worked chopper
1- Denticulate
1- Biface fragment
5- Retouched flakes

Lithic Debitage and Debris:

1- Prepared Levallois core
4- Levallois flakes, typical
5- Levallois flakes, atypical
6- Decortication flakes
5- Thinning flakes
1- Blade

Comments:

Distinctive debitage forms including a prepared "tortoise" core, clearly indicate habitual use of a Levallois technique at this Middle Paleolithic site.

Project Segment	:	8
Site Number	:	MHT - 27
Site Location	:	16° 02' 41" N; 46° 49' 35" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Undetermined
Site Size	:	40 m N-S, 40 m E-W; 1,600 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools (Fine grained, highly patinated tan coloured flint) :

5- Retouched flakes

Lithic Debitage and Debris:

1- Tested Cobble
1- Tabular flake core
2- Levallois flakes, typical
7- Decortication flakes
5- Thinning flakes

Comments:

Distinctive debitage forms at this site (Levallois flakes) allow its assignment to the Middle Paleolithic.

Project Segment	:	8
Site Number	:	MHT - 28
Site Location	:	16° 04' 36" N; 46° 55' 56" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	50 m N-S, 30 m E-W; 1,500 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ____X____
- Within Quarry-Borrow Area _____

Materials Recovered :

No materials collected. A sparse scatter of highly patinated, non-diagnostic flakes and debris was observed at the site location.

Comments:

Project Segment	:	8
Site Number	:	MHT - 29
Site Location	:	16° 04' 59" N; 47° 03' 37" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Temporary Camp (?)
Site Size	:	250 m N-S, 50 m E-W; 12,500 m^2

Impact

- No Impact (Outside Corridor) ___X___
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools (All patinated tan quartzite except as noted) :

1- Sidescraper
3- Retouched flakes (1 is brown coloured petrified wood)

Lithic Debitage and Debris:

1- Levallois core
2- Levallois flakes, typical
2- Decortication flakes
4- Thinning flakes
1- Blade
1- Core Trimming Element

Comments:

The presence of a retouched flake tool fabricated of petrified wood at this site is notable. This material is not common in the local wadi gravels and probably represents an exotic item that was transported by human action to the site.

Project Segment	:	8
Site Number	:	MHT - 30
Site Location	:	16° 06' 05" N; 47° 01' 59" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	250 m N-S, 50 m E-W; 12,500 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools:

1- Sidescraper, patinated fine grained tan flint
1- Denticulate, patinated very fine grained chalcedony

Lithic Debitage and Debris:

1- Core Rejuvenation flake
2- Decortication flakes
2- Thinning flakes

Comments:

A small collection of non-diagnostic lithic tools and debitage. All observed pieces were very highly patinated.

Project Segment	:	8
Site Number	:	MHT - 34
Site Location	:	16° 07' 59" N; 47° 08' 08" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Undetermined
Site Size	:	>200 m N-S, 200 m E-W; >40,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools (All patinated, medium grained white quartzite)

1- Sidescraper
1- Multiple Notch
1- Angle Burin
1- Retouched Flake

Lithic Debitage and Debris:

2- Levallois flakes, typical
1- Levallois flakes, atypical
2- Decortication flakes
3- Thinning flakes
2- Blades
1- Core Trimming Element

Comments:

A small, highly patinated and weathered collection of Middle Paleolithic artefacts was recovered from this site.

Project Segment	:	8
Site Number	:	MHT - 36
Site Location	:	16° 08' 35" N; 47° 08' 45" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Temporary Camp (?)
Site Size	:	25 m N-S, 25 m E-W; 625 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ____X____
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools :

3- Retouched blades, 2 are weathered white quartzite, 1 is patinated tan flint
1- Retouched flake, white quartzite
2- Notches, both white quartzite

Lithic Debitage and Debris:

2- Levallois flakes, typical
2- Decortication flakes
2- Thinning flakes

Comments:

Artefacts recovered from this site represent a small collection of highly patinated tools and debitage. The debitage from this site, all of which was reduced by hard hammer percussion, clearly indicates a Middle Paelolithic occupation.

Project Segment	:	10
Site Number	:	MHT - 41
Site Location	:	16° 07' 28" N; 47° 14' 31" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	20 m N-S, 40 m E-W; 800 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ____X____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools :

1- Endscraper, fine grained cream flint

Lithic Debitage and Debris:

1- Primary Decortication flake
1- Secondary Decortication flake
3- Interior flakes
2- Flake fragments

Comments:

Project Segment	:	10
Site Number	:	MHT - 43
Site Location	:	16° 07' 20" N; 47° 15' 09" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	20 m N-S, 20 m E-W; 400 m^2

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	_____
- Complete Impact (All of Site area in Corridor)	_____
- Within Quarry-Borrow Area	X

Materials Recovered :

Only a sparse scatter of non-diagnostic debitage and debris was observed at this site. No materials were collected.

Comments:

Project Segment	:	11
Site Number	:	MHT - 44
Site Location	:	16° 07' 18" N; 47° 15' 39" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Undetermined
Site Size	:	20 m N-S, 30 m E-W; 600 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools (All highly patinated, very fine grained brown chalcedony) :

1- Endscraper
1- Sidescraper
1- Biface fragment

Lithic Debitage and Debris:

1- Levallois flake, typical
2- Levallois flakes, atypical
3- Decortication flakes
4- Thinning flakes

Comments:

Project Segment	:	11
Site Number	:	MHT - 49
Site Location	:	16° 06' 51" N; 47° 15' 54" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Undetermined
Site Size	:	500 m N-S, 400 m E-W; 200,000 m^2

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	X
- Complete Impact (All of Site area in Corridor)	_____
- Within Quarry-Borrow Area	_____

Materials Recovered :

Lithic Tools (All highly patinated, fine grained tan flint, except as noted) :

1- Endscraper
1- Sidescraper
1- Pick, medium grained brown diorite
6- Retouched flakes, 1 is coarse grained white quartzite.

Lithic Debitage and Debris:

1- Levallois flake, typical
7- Decortication flakes
16- Thinning flakes

Comments:

A Middle Paleolithic assemblage with a tool inventory dominated by expediently produced retouched flakes.

Project Segment	:	11
Site Number	:	MHT - 50
Site Location	:	16° 06' 07" N; 47° 16' 52" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	20 m N-S, 20 m E-W; 400 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ____X____
- Within Quarry-Borrow Area _____

Materials Recovered :

No materials collected. A sparse, non-diagnostic flake scatter was observed at the site location.

Comments:

Project Segment	:	11
Site Number	:	MHT - 51
Site Location	:	16° 05' 38" N; 47° 17' 30" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	25 m N-S, 25 m E-W; 625 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

No materials collected. Non-diagnostic debitage and debris were observed.

Comments:

Project Segment	:	11
Site Number	:	MHT - 52
Site Location	:	16° 03' 45" N; 47° 20' 21" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Lithic Resource Procurement
Site Size	:	10 m N-S, 10 m E-W; 100 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools (All highly patinated, fine grained white flint) :

4- Retouched flakes
3- Sidescrapers
2- Retouched Blades
2- Notches

Lithic Debitage and Debris:

1- Globular flake core
2- Levallois flakes, typical
3- Levallois flakes, atypical
8- Decortication flakes
11- Thinning flakes
4- Blades
3- Flake fragments

Comments:

Hard hammer reduction of large, thick blades and Levallois flakes appear to have been the focus of activities at this site.

Project Segment	:	11
Site Number	:	MHT - 53
Site Location	:	16° 02' 20" N; 47° 24' 07" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	30 m N-S, 100 m E-W; 3000 m^2

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	_____
- Complete Impact (All of Site area in Corridor)	_____
- Within Quarry-Borrow Area	X

Materials Recovered :

A sparse scatter of highly patinated, non-diagnostic flints and debris was observed at this site. No materials collected.

Comments:

Project Segment	:	12
Site Number	:	MHT - 54
Site Location	:	15° 56' 17" N; 47° 31' 10" E
Temporal-Cultural Affiliation	:	Neolithic, Late
Site Type	:	Resource Procurement
Site Size	:	5 m N-S, 5 m E-W; 25 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools :

1- Stemmed, Bifacially worked Projectile point. Fine grained cream coloured flint

Lithic Debitage and Debris:

1- Core Trimming Element

Comments:

This site consists of a well made, bifacially worked projectile point with clear Late Neolithic affiliations.

Project Segment	:	12
Site Number	:	MHT - 55
Site Location	:	15° 55' 49" N; 47° 32' 02" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	20 m N-S, 20 m E-W; 40 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

No diagnostic materials observed or collected; only non-diagnostic debitage and debris were recorded.

Comments:

Project Segment	:	12
Site Number	:	MHT - 56
Site Location	:	15° 55' 12" N; 47° 32' 58" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	7 m N-S, 10 m E-W; 70 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ___X___
- Within Quarry-Borrow Area _____

Materials Recovered :

No materials collected.

Comments:

Project Segment	:	13
Site Number	:	MHT - 57
Site Location	:	15° 52' 11" N; 47° 38' 20" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Lithic Resource Procurement
Site Size	:	30 m N-S, 100 m E-W; 3.000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area ____X____

Materials Recovered :

Lithic Tools (All highly patinated, fossiliferous white flint) :

7- Retouched flakes
1- Sidescraper
2- Endscrapers
3- Retouched Blades
4- Notches
1- Core Scraper

Lithic Debitage and Debris:

2- Angular, irregular flake cores
1- Levallois flake core
1- Levallois flake, typical
2- Levallois flakes, atypical
10- Decortication flakes
9- Thinning flakes
2- Blades

Comments:

Rough, angular limestone cortex was attached to many of the pieces in this collection; similarly angular limestone was noted attached to unworked flint nodules in the site area. This information indicates that this site probebly functioned as a source for lithic raw materials.

Project Segment	:	15
Site Number	:	MHT - 58
Site Location	:	15° 51' 07" N; 47° 43' 59" E
Temporal-Cultural Affiliation	:	Lower Paleolithic, Middle Paleolithic
Site Type	:	Undetermined
Site Size	:	30 m N-S, 100 m E-W; 3,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area ____X____

Materials Recovered :

Lithic Tools (All medium grained dark brown basalt, unless noted) :

1- Cordiform Handaxe
1- Chopper
1- Trihedral pick
1- Scraper
1- Levallois point, fine grained tan flint

Lithic Debitage and Debris:

2- Massive flakes
1- Massive Blade
2- Levallois flakes, typical, fine grained tan flint
3- Massive Decortication flakes
4- Decortication flakes
4- Thinning flakes

Comments:

Most of this artefact assemblage consists of massive, crude tools and debitage that are representative of the Acheulen, a Lower Paleolithic Industry. Unfortunately, this site has been deflated, and the Acheulean materials are mixed with typical Middle Paleolithic artefacts, such as the Levallois point listed in the above inventory.

Project Segment	:	17
Site Number	:	MHT - 59
Site Location	:	15° 49' 54" N; 47° 45' 06" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	10 m N-S, 10 m E-W; 100 m^2

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	X
- Complete Impact (All of Site area in Corridor)	_____
- Within Quarry-Borrow Area	_____

Materials Recovered :

Only a thin scatter of non-diagnostic debitage and debris observed within site area. No materials collected.

Comments:

Project Segment	:	17
Site Number	:	MHT - 60
Site Location	:	15° 49' 49" N; 47° 46' 41" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	5 m N-S, 5 m E-W; 25 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools :

1- Possible ground stone fragment, tan coloured sandstone.

Lithic Debitage and Debris:

1- Thinning flake

Ceramic :

1- Small body sherd, orange colour with grit temper

Comments:

Project Segment	:	17
Site Number	:	MHT - 61
Site Location	:	15° 49' 35" N; 47° 48' 24" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	3 m N-S, 3 m E-W; 9 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ____X____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Debitage and Debris:

1- Interior flake
1- Bifacial Thinning flake

Ceramic :

1- Red ware body sherd, grit and sand temper.

Comments:

The well made, highly fired ceramic body sherd from this site appears to be of relatively recent origin.

Project Segment	:	17
Site Number	:	MHT - 62
Site Location	:	15° 49' 17" N; 47° 53' 26" E
Temporal-Cultural Affiliation	:	Middle Paleolithic Neolithic
Site Type	:	Middle Paleolithic - Lithic Resource Procurement Neolithic - Base Camp
Site Size	:	900 m N-S, 1000 m E-W; 900,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area ____X____

Materials Recovered :

Middle Paleolithic Component :

Lithic Tools (All medium grained, highly patinated tan flint) :

1- Notch with Retouch
2- Retouched flakes

Lithic Debitage and Debris:

1- Levallois Core
1- Flake Core
2- Levallois Flakes, typical
2- Levallois Flakes, atypical
5- Decortication flakes
4- Thinning flakes

Neolithic Component :

Lithic Tools (All very fine grained brown coloured chalcedony) :

4- Endscrapers
1- Circular scraper
1- Perforator
1- Ovate Biface
1- Bifacially worked Endscraper
2- Sidescrapers
1- Naturally Backed knife
1- Biface fragment
1- Multiple Tool; Angle burin on truncation with retouch
7- Retouched flakes

Lithic Debitage and Debris:

1- Pyramidal flake-blade core
1- Globular flake core
4- Primary decortication flakes
14- Secondary decortication flakes
10- Interior flakes
16- Bifacial thinning flakes
4- Tertiary flakes
5- Core Rejuvenation flakes

Comments:

A huge, rich site with both a Middle Paleolithic and Neolithic component. Large quantities of formal lithic tools were observed at this important site. MHT-62 is discussed in detail in the "Summary" and "Significance" sections of the report.

Project Segment	:	17
Site Number	:	MHT - 64
Site Location	:	15° 48' 25" N; 47° 55' 34" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	10 m N-S, 50 m E-W; 500 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ___X___
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Debitage and Debris:

5- Primary Decortication flakes

4- Interior flakes

Comments :

Project Segment	:	17
Site Number	:	MHT - 66
Site Location	:	15° 48' 05" N; 47° 58' 10" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Lithic Resource Procurement
Site Size	:	>100 m N-S, 100 m E-W; >10,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area ____X____

Materials Recovered :

Lithic Tools :

2- Retouched flakes, patinated tan flint

Lithic Debitage and Debris:

1- Primary Decortication flake
2- Secondary Decortication flakes
1- Interior flake
1- Flake fragment

Comments :

The testing and collection of lithic raw materials seems to have taken place at this site.

Project Segment	:	17
Site Number	:	MHT - 67
Site Location	:	15° 48' 00" N; 47° 58' 58" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	5 m N-S, 5 m E-W; 25 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ___X___
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools :

1- Biface fragment, fine grained tan flint
1- Retouched blade, fine grained tan flint

Lithic Debitage and Debris:

3- Tertiary flakes, Obsidian

Comments :

Project Segment	:	17
Site Number	:	MHT - 72
Site Location	:	15° 47' 12" N; 48° 03' 41" E
Temporal-Cultural Affiliation	:	Neolithic
Site Type	:	Temporary Camp
Site Size	:	100 m N-S, 125 m E-W; 12,500 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools (All medium grained white flint, unless noted) :

1- Ovate Biface
2- Backed sidescrapers
1- Tabular scraper, fine grained brown flint
4- Endscrapers
4- Retouched flakes

Lithic Debitage and Debris:

1- Pyramidal flake core
1- Irregular flake - blade core
1- Exhausted pyramidal flake core
6- Primary Decortication flakes
13- Secondary Decortication flakes
40- Interior flakes
36- Bifacial thinning flakes, 1 is obsidian
12- Tertiary flakes
9- Core Rejuvenation flakes
5- Flake granments
2- Chunks

Comments :

A site with typical Neolithic tool forms, most made on very poor quality flint.

Project Segment	:	19
Site Number	:	MHT - 76
Site Location	:	15° 46' 46" N; 48° 05' 22" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	30 m N-S, 100 m E-W; 3,000 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) ___X___
- Complete Impact (All of Site area in Corridor) _____
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools

1- Endscraper, coarse grained white flint

Lithic Debitage and Debris:

2- Primary decortication flakes
6- Secondary decortication flakes
12- Interior flakes, 1 is obsidian
16- Bifacial thinning flakes
25- Tertiary flakes, 2 are obsidian
3- Chunks
4- Chips

Comments :

Lack of diagnostic ceramics and lithic tools at this site hampers further analysis.

Project Segment	:	20
Site Number	:	MHT - 77
Site Location	:	15° 46' 30" N; 48° 07' 50" E
Temporal-Cultural Affiliation	:	Middle Paleolithic Neolithic (?)
Site Type	:	Undetermined
Site Size	:	40 m N-S, 150 m E-W; 6,000 m^2

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	_____
- Complete Impact (All of Site area in Corridor)	_____
- Within Quarry-Borrow Area	X

Materials Recovered :

Lithic Tools (All medium grained cream flint) :

1- Angle Burin
1- Sidescraper
1- Endscraper
5- Retouched flakes

Lithic Debitage and Debris:

4- Globular flake cores
2- Levallois flakes, typical
3- Levallois flakes, atypical
10- Primary decortication flakes
18- Secondary decortication flakes
10- Interior flakes
5- Thinning flakes
2- Flake fragments

Comments :

This site appears to contain Middle Paleolithic materials mixed with later (Neolithic ?) lithics.

Project Segment	:	19
Site Number	:	MHT - 79
Site Location	:	15° 45' 54" N; 48° 06' 43" E
Temporal-Cultural Affiliation	:	Undetermined
Site Type	:	Undetermined
Site Size	:	5 m N-S, 5 m E-W; 25 m^2

Impact

- No Impact (Outside Corridor) _____
- Partial Impact (Portion of Site in Corridor) _____
- Complete Impact (All of Site area in Corridor) ___X___
- Within Quarry-Borrow Area _____

Materials Recovered :

Lithic Tools :

1- Endscraper, medium grained grey flint

Ceramics:

2- Red ware body sherds, chaff and sand temper

1- Small ceramic crumb

Comments :

Project Segment	:	19
Site Number	:	MHT - 80
Site Location	:	15° 43' 59" N; 48° 08' 51" E
Temporal-Cultural Affiliation	:	Middle Paleolithic
Site Type	:	Lithic Resource Procurement (?)
Site Size	:	30 m N-S, 100 m E-W; 3,000 m^2

Impact

- No Impact (Outside Corridor)	_____
- Partial Impact (Portion of Site in Corridor)	_____
- Complete Impact (All of Site area in Corridor)	_____
- Within Quarry-Borrow Area	X

Materials Recovered :

Lithic Tools (all coarse grained cream coloured flint) :

1- Dihedral burin
3- Retouched flakes
2- Retouched blades
2- Endscrapers
1- Projectile Point preform

Lithic Debitage and Debris:

2- Levallois flakes, typical
3- Levallois flakes, atypical
18- Decortication flakes
23- Thinning flakes
2- Blades
1- Burin spall

Comments :

The assignment of this site to the Middle Paleolithic is based principally upon diagnostic attributes observed in the collected debitage.

CAPTIONS FOR EXHIBITS

S5.3.1 Artefact Illustrations, Site MHT-12. Left - Ostrich Shell Fragments. Right - Polished Basalt Celt.

S5.3.2 Scraping and Cutting tools from site MHT-12. Left to Right : Sidescraper, Backed Knife, Sidescraper, Retouched Blade.

S5.3.3 Knife Ceramic Rim Sherd from Site MHT-12. Note temper protrusion.

S5.3.4 Neolithic bifacially worked projectile points from Site MHT-13.

S5.3.5 Leaf-shaped bifaces from Site MHT-13

S5.3.6 Bifacially worked scrapers and preforms from Site MHT-13.

S5.3.7 Reworked bifaces and fragments from Site MHT-13.

S5.3.8 Retouched Levallois Flakes, Site MHT-18

S5.3.9 Basalt pick, Site MHT-21

S5.3.10 Middle Paleolithic Chipped Stone Tools from Site MHT-52. Left to Right : Sidescraper, Retouched Levallois Flake, Notch with Retouch, Retouched Blade.

S5.3.11 Chipped Stone tools from Neolithic Component of Site MHT-62. Left to Right : Biface, Retouched Endscraper, Circular Scraper

S5.3.12 Neolithic tools from Site MHT-62 - Left - Backed Knife. Right - Perforator.

S5.3.13 Crudely fashioned basalt handaxe from site MHT-58

S5.3.14 Chipped stone scrapers from site MHT-72

S5.3.15 Levallois Tools from Site MHT-80. Left - Levallois point (unfinished); Right - Levallois flake embedded in Limestone Matrix.